NWP SAF

Satellite Application Facility for Numerical Weather Prediction

Document NWPSAF-MF-UD-002

Version 7.6, May 2015

AAPP DOCUMENTATION

SOFTWARE DESCRIPTION

AUTHORS : Tiphaine Labrot (Météo-France)
Nigel Atkinson (Met Office)
Pascale Roquet (Météo-France)

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 01 December 2006, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, KNMI and Météo France.

Copyright 2014, EUMETSAT, All Rights Reserved.

Change record			
Version	Date	Author / changed by	Remarks
4.0	April 03	T.Labrot	Version1 of the software description document of AAPP V4.0 (Follow the version of AAPP V3.0)
4.1	12 May 2003	K Whyte	Minor edit
5.0	March 2005	T.Labrot N C Atkinson P. Brunel	Update for AAPP V5
6.0	June 2006	T.Labrot N C Atkinson	Update for AAPP V6
7.0	Jan 2012	T.Labrot N C Atkinson	Update for AAPP V7
7.1	July 2012	P Roquet N C Atkinson	Insert sections on MMAM and modify atovin/atovpp descriptions, for release of AAPP v7.2.
7.2	Feb 2013	P Roquet N C Atkinson	Add sections on MAIA4
7.3	Feb 2014	P Roquet N C Atkinson	Add sections on NOAA/CLASS conversion tools and update MAIA4 section
7.4	Aug 2014	N C Atkinson	Updates for MWTS2, MWHS2 and IRAS
7.5	Dec 2014	P Roquet	Update for MAIA v4.2 release.
7.6	May 2015	N C Atkinson	Update section on hrptdc and add viirs_to_cris.

TABLE OF CONTENTS

Figures

1. INTRODUCTION

For many years the NOAA polar orbiting weather satellites have provided a sounding and imaging capability, with instruments operating in the visible, infra-red and microwave regions of the spectrum, and with a direct broadcast system to allow users access to the data in near real time.

In response to requests from the user community, EUMETSAT took the initiative in 1992 to start activities in the area of ATOVS software processing. The goal was to set up a standard package for the processing of locally received ATOVS data from the NOAA spacecraft, and as a result of this initiative the ATOVS and AVHRR Pre-processing Package (AAPP) was developed. The package is now maintained by the EUMETSAT Satellite Application Facility for Numerical Weather Prediction (NWP SAF).

The first satellite in the NOAA-KLM series (NOAA-15) was launched in 1998, replacing the earlier NOAA/TIROS-N series. In 2009, the last satellite in the follow-on NOAA-NN' series was launched (NOAA-19), and the AAPP package (versions 5 and 6) was extended to accept data from this series.

A next major development was the launch in 2006 of the first European METOP satellite. METOP is part of the EUMETSAT Polar System (EPS), which is the European contribution to a joint European-US polar satellite system called the Initial Joint Polar System (IJPS). METOP capability was added in AAPP v6. The ability to process imager data from the Chinese FY-1D satellite was also added as part of AAPP v6.

The first of the next generation of US operational polar-orbiting weather satellites is the NPP (NPOESS Preparatory Project), launched in October 2011. Future satellites in the series will be named JPSS (Joint Polar Satellite System). AAPP v7 is designed to pre-process data from the sounder and imager instruments on NPP, while continuing to support MetOp and the older NOAA satellites.

This document provides a software description of the AAPP package. It includes a description of the software modules for processing ATOVS and AVHRR data on METOP, but excludes the IASI level 0 to level 1c convertor, OPS-LRS, which is described in the OPS-LRS User Manual.

2. DOCUMENTS AND TERMINOLOGY

2.1. APPLICABLE AND REFERENCE DOCUMENTS

[1]: NESS 107: 'Data Extraction and Calibration of TIROS-N/NOAA Radiometer'. NOAA Technical Memorandum - Planet, 1988.

And the NOAA KLM user's guide on the web site http://www2.ncdc.noaa.gov/docs/klm/

[2]: 'General specifications for the AAPP preprocessing package related to NOAA polar orbiting weather satellites. Scientific part'. Météo France internal document- 1999.

[3]: 'General specifications for the AAPP preprocessing package related to NOAA polar orbiting weather satellites. Software description'. Météo France internal document - 1999.

[4]: 'AAPP Module Design' - 'AAPP Data Set Definition'. Documentation EUMETSAT - Vol1 and Vol2 - 1997.

[5]: 'Measurement of the AMSU-B Antenna Pattern'. T.J. Hewison & R. Saunders, IEEE Transactions of Geosciences and Remote Sensing, Vol. 34 No 2, Mars 1996.

[6]: 'Estimating the probability of rain in an SSM/I FOV using logistic regression'. Crosby, Ferraro & Wu, Journal of Applied Met., Vol 34 No 11, 1995.

[7]: Ardouin L., G. Monnier, L. Lavanant:'Adjustment, validation and implantation of MAIA2 in AAPP software'. Technical report..1999.

[8]: Derrien D., B. Farki. L. Harang, H. LeGléau, A. Noyalet, D. Pohic, A. Sairouni 'Automatic Cloud Detection Applied to NOAA-11/AVHRR Imagery'. Remote Sens. Envion. 46 :246-267, 1993

[9]: Derrien D, H. LeGléau 'Cloud classification extracted from AVHRR and GOES imagery'. Proceedings of Eumetsat Meteorological satellite data conference, 1999

[10]: Grody N. 'Classification of snow cover and precipitation using the Special Sensor Microwave Imager'. J. Geophys. Res., vol 96, 199.

[11]: Gutman G., D. Tarpley,A. Ignatov, S. Olson, The enhanced NOAA global dataset from the advanced very high resolution radiometer. Bulletin of the American Meteorological Society. 1995.

[12]: Lavanant L., H. LeGléau, M. Derrien, S. Levasseur, G. Monnier, L. Ardouin, P. Brunel, B. Bellec: AVHRR Cloud Mask for Sounding Applications. ITSC-10 proceedings, 1999.

[13]: Oort A.: Global Atmospheric Circulation Statistics. 1958 –1973.

[14]: Saunders R.: 'An automated scheme for the removal of cloud contamination from AVHRR radiances over western Europe'. Int. J. Remote sensing, 1986..

[15]: Saunders R.: 'An improved method for detecting clear sky and cloudy radiances from AVHRR data'. Int. J. Remote Sensing, 1988..

[16]: MAIA software documentation, version 2.1, 1999..

[17]: Brunel P. and Marsouin A., 2000, Operational AVHRR navigation results, *International Journal of Remote Sensing*, Vol. 21, No. 5, 951-972.

[18]: Rosborough G.W., Baldwin D. and Emery W., 1994, Precise AVHRR Image Navigation, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 32, No. 3, May 1994, 644-657.

[19]: Level 1B Notices, http://www.osdpd.noaa.gov/ml/ppp/notices.html

[20]: Brunel P. and Marsouin A., 2001, ANA-3 User's Manual, Meteo-France/DP/Centre de Meteorologie Spatiale, BP 147, 22302 Lannion, France.

[21]: Bordes Ph., Brunel P. and Marsouin A., 1992, Automatic Adjustment of AVHRR Navigation, *Journal of Atmospheric and Oceanic Technology*, Vol. 9, No. 1, February 92.

[22]: Marsouin A., Brunel P.,AAPP Documentation, Annex of scientific description, AAPP navigation, document NWPSAF-MF-UD-005, distributed with AAPP

[23]: Changyong Cao NESDIS, HIRS Calibration Algorithm Version 4.0

[24]: Changyong Cao and Pubu Ciren, Operational High Resolution Infrared Radiation Sounder (HIRS) Calibration Algorithms and Their Effects on Calibration Accuracy, ITSC XIII Proceedings (2003), cimss.ssec.wisc.edu/itwg/itsc/itsc13/session3/3_2_ciren.pdf

[25]: Bennartz, Thoss, Dybbroe and Michelson, 'Precipitation analysis using the Advanced Microwave Souunding Unit in support of nowcasting applications', *Meteorol. Appl.*, 9, 177-189, 2002

[26]: Lee, A.C.L. and Bedford, S., 'Support Study on IASI Level 1c Data Compression', Final Report, EUMETSAT Contract EUM/CO/-3/1155/PS, Feb 27, 2004

[27]: Goldberg et. al., "AIRS Near-Real-Time Products and Algorithms in Support of Operational Numerical Weather Prediction", IEE Trans. Geosci. Rem. Sens., vol. 41, no. 2, Feb 2003.

[28]: Collard, A.D., "Selection of IASI channels for use in numerical weather prediction", ECMWF Technical Memorandum 532, July 2007.

[29]: “OPS-LRS User Manual”, document NWPSAF-MF-UD-006, distributed with AAPP.

[30]: “AAPP Version 7 Top Level Design”, document NWPSAF-MO-DS-011, distributed with AAPP.

[31]: “EPS Programme Generic Product Format Specification”, document EPS-GGS-SPE-96167, available from www.eumetsat.int

[32]: “EPS/MetOp Technical Note on Orbit Prediction” Conzalo Garcia-Julian, Miguel M.Romany Merino - GMSA SA 1997

[33]: “Annex to AAPP scientific documentation: Pre-processing of ATMS and CrIS”, document NWPSAF-MO-UD-027, distributed with AAPP.

[34]: “IASI Principal Components in AAPP: User Manual”, document NWPSAF-MO-UD-022, distributed with AAPP.

[35]: “MAIA AVHRR Cloud Mask and Classification”, L. Lavanant, document MF/DP/CMS/R&D/MAIA3, 2002, available at www.meteorologie.eu.org/ici/maia/maia3.pdf

[36]: “NPOESS Common Data Format Control Book – External” volumes I to VIII, available at http://jointmission.gsfc.nasa.gov/science/documents.html

[37]: “Annex to AAPP scientific documentation: Pre-processing of ATMS and CrIS”, document NWPSAF-MO-UD-027

[38]: “VIIRS-CrIS mapping”, document NWPSAF-MF-UD-011

2.2. TERMINOLOGY

AAPP: ATOVS and AVHRR Pre-processing Package.

ADC: Analog to Digital Converter.

AIP: AMSU Information Processor.

AMSU: Advanced Microwave Sounding Unit.

ANA: Automatic Navigation Adjustment.

ARGOS: Name of the orbital bulletin emitted by CLS/ARGOS.

Ascending node (HNA) : equator satellite crossing when it comes from south pole.

ATMS: Advanced Technology Microwave Sounder

ATOVS: Advanced TIROS Vertical Sounder.

AVHRR: Advanced Very High Resolution Radiometer.

Attitude: Satellite orientation according the 3 axes (yaw, roll, pitch).

Bb: black body.

Brolyd (Brouver-Lyddane): Orbit extrapolation model algorithm for TBUS bulletin.

CMS: Centre de Météorologie Spatiale (Météo-France)

CNES: Centre National d'études Spatiales.

CrIS : Cross-track Infrared Sounder

DCS: Data Collection System.

Descending node (LNA) : equator satellite crossing when it comes from north pole.

DMSP: Defense Meteorological Satellite Program

DWSS: Defense Weather Satellite System

Earth's precession: Slow conical motion of the Earth rotation axis around a mean position corresponding to a normal direction to the ecliptic plane.

Ecliptic plane: The Earth orbital plane around the Sun.

ECMWF: European Center for Medium Weather Forecasting.

Ephemeris: The list of the times of various events as: ascending and descending nodes, start and end of acquisition by a station.

EPS: EUMETSAT Polar System

FOV: Field Of View.

GAC: Global Area Coverage.

HIRS: High Resolution Infra Red Sounder.

HRPT: High Resolution Picture Transmission.

IASI: Infrared Atmospheric Sounding Interferometer.

IFOV: Instantaneous Field Of View.

IJPS: Initial Joint Polar System

Image navigation: Conversion of line and pixel numbers into latitude and longitude.

IR: InfraRed.

IWT : internal warm target

LAC: Local Area Coverage.

Mapping : for sounders = computing sounder data to another sounder grid. For imaging radiometer = imaging radiometer data segmentation to sounder ellipse.

MetOp: Meteorological Operational satellite

MHS: Microwave Humidity Sounder

MIRP: Manipulated Information Rate Processor.

MSU: Microwave Sounding Unit.

µ-waves: microwaves.

Nadir: Satellite vertical direction.

NESDIS: National Environmental Satellite Data Information Service.

NOAA: National Oceanic and Atmospheric Administration.

NORAD: North American Aerospace Defense Command

NPP: NPOESS Preparatory Project

NWP SAF : Numerical Weather Prediction Satellite Application Facility.

Perigee: Satellite orbit point which is the nearest from the Earth (opposite apogee).

PM: Pulse Modulation.

POES: Polar Orbiting Environmental Satellite(s)

PRT: Platinum Resistance Thermometer.

Rg : Greenwich reference frame

Rl : local reference frame

Rs : spacecraft fixed reference frame

Rv : satellite local orbital frame

SDP4: Orbit extrapolation model for deep-space object Two-Line Element sets

SEM: Space Environment Monitor.

SGP4: Orbit extrapolation model for near-Earth object Two-Line Element sets

SSU: Stratospheric Sounding Unit.

SST: Sea Surface Temperature.

TBUS: Name of the orbital bulletin emitted by NOAA/NESDIS.

TIP: TIROS Information Processor.

TIROS: Television Infrared Observation Satellite

TLE: Two-Line elements, name of the orbital bulletin emmited by NORAD.

TOVS: TIROS Operational Vertical Sounder.

VIIRS: Visible/Infrared Imager/Radiometer Suite

VIS: Visible.

3. SOFTWARE ORGANISATION DESCRIPTION

3.1. SOFTWARE GENERAL ORGANISATION

AAPP version 7 presents three distinct components:

The core AAPP task, performing the same functions as AAPP version 6 (located under the directory AAPP) but now it includes NPP-specific routines.

Tools to interface the core AAPP with the specific formats of METOP data (located under the directory metop-tools).

A suite for processing IASI data to level 1c, based on the CNES-supplied IASI OPS (Operational Software), named OPS-LRS for Local Reception Station. The OPS-LRS package has its own self-contained directory structure, but to run it requires the use of a set of tools containing format libraries, conversion tools, etc. (located under the directory iasi-tools).

3.1.1. The core AAPP

The core AAPP can be broken down into seven major tasks:

Ingest step 1: Decommutation (only useful for direct acquisition of NOAA satellite data)

Ingest step 2: Calculation of calibration coefficients/satellite navigation/localisation

Preprocessing step 1 (atovin): Main function: Apply calibration coefficients, convert radiances to brightness temperatures.

Preprocessing step 2 (atovpp): Main function: Instrument mapping on another instrument grid.

Preprocessing step 3 (avh2hirs): AVHRR mapping on HIRS and cloud mask. This step is only available for HIRS, as the name shows.

A cloud mask at the full resolution of the AVHRR (maia3)

Tools to perform a range of tasks, including BUFR encode/decode, reading of HDF5 files, etc.

Ingest

DECOMMUTATION:

DECOMMUTATION performs the interface between acquisition system and processing. This function is specific to the AAPP installation site and can be modified by the user if the acquisition system doesn't respect HRPT format. This module calls **HRPTDC** to perform decommutation task.

HRPTDC reads the raw (level 0) HRPT data streams and puts data from the sounding instruments (HIRS, AMSU-A, AMSU-B, MHS, MSU) and from the AVHRR radiometer into separated files (level 1a).

SATELLITE AND IMAGES NAVIGATION - CALIBRATION COEFFICIENTS:

HIRSCL or HIRSCL_ALGOV4, AMSUACL, AMSUBCL, MHSCL, MSUCL perform the satellite navigation, the Earth localisation of the pixels, and the calibration coefficients calculation for each TOVS/ATOVS instrument. Two algorithms are available to calibrate the HIRS, the user has to choose between HIRSCL or HIRSCL_ALGOV4 at the AAPP installation.

AVHRCL performs the same tasks for the AVHRR radiometer.

At the end of this step, separated files of Earth located and calibration coefficients exist. Those (level 1b) files are archived.

Pre-Processing:

CALIBRATION:

ATOVIN applies the calibration coefficients calculated by the previous step (**HIRSCL or HIRSCL_ALGOV4, AMSUACL, AMSUBCL, MHSCL, MSUCL**) to the numeric counts for radiance conversion. Before, for AMSU-A data a moon detection/correction is done and for the AMSU-B bias corrections and antenna corrections are added. Then **ATOVIN** converts each channel radiance into brightness temperature for each TOVS/ATOVS instrument. At the end of this procedure, separated files of Earth located brightness temperature data exist. Those (level 1c) files are archived.

MAPPING:

ATOVPP recognises the data contaminated by precipitation and maps data between the measurement grids of the different instruments (for example: HIRS + AMSU-A + AMSU-B on HIRS grid, HIRS+MSU on HIRS grid, AMSU-A + AMSU-B on AMSU-B grid).

MAPPING - CLOUD MASK:

AVH2HIRS applies the calibration coefficients (calculated by **AVHRCL**) to AVHRR counts and converts radiance into brightness temperature, maps AVHRR data in HIRS FOV, and makes the cloud mask **MAIA_2.1** for AAPP version 3 and later) in the HIRS ellipse for contaminated pixels discrimination. At the end of this procedure, a level 1d file exists (HIRS level 1d).

MAIA3:

CALIBRATION:

AVHRRIN applies the calibration coefficients calculated by the previous step (**AVHRCL**) to AVHRR counts and converts radiance into brightness temperature (avhrr.l1c file)**.**

CLOUD MASK:

MAIA3_MAIN makes the cloud mask at full resolution of the AVHRR (avhrr.l1d file).

Specific libraries are associated at all this main modules.
Each module is described in more detail in the section 3.2.

3.1.2. METOP tools

To process the METOP data, a set of tools have been developed to interface the PFS level 0 format to the AAPP level 1a/1b format: One script/one main program by instrument: **DECOM-HIRS-METOP/HIRS-MAIN.EXE**, **DECOM-AMSUA-METOP/AMSUA-MAIN.EXE**, **DECOM-MHS-METOP/MHS-MAIN.EXE**, **DECOM-AVHRR-METOP/AVHRR-MAIN.EXE**.
Another tool (**AAPP-EPS_AVHRRl1B/EPS_AVHRRL1B-MAIN.EXE**) interfaces the AVHRR AAPP level 1b format to the AVHRR PFS level 1B format. The PFS resulting file has only partial contents and is primarily intended for use in IASI OPS-LRS processing. The AVHRR PFS level 1B format is used by EUMETSAT for distribution of global AVHRR data, therefore a tool **convert_avh1b** can be used to convert back to AAPP level 1b format (but with scaled radiances instead of raw counts).
To navigate METOP data, tools have also been developed to process ADMIN messages: **SPMING, SPMING.PL, SPMING.EXE, ADMIN-MAIN.EXE, ADMIN-MESSAGES.EXE**.
Specific libraries are associated with all these main modules.

3.1.3. IASI tools

Several modules and C libraries have been developed to handle the data related to the IASI OPS-LRS.

OPS-LRS needs several files as input:

an OBT file that includes the difference between the atomic time and the UTC time. The modules eps_metopl0-obt-xml.ksh/eps_metopl0-obt-xml.c create this file from the IASI PFS L0.
an OSV file that contains data related to satellite manoeuvres. messages-osv.ksh/messages-osv.pl create this file from the ADMIN message.
an SVM file that includes the start and the end of the shadow. satpos-svm.ksh/satpos-svm.pl create this file from the satpos file.

The following modules are used to switch delivered files from big-endian to little endian: cnes_iasi_brd-swapb.ksh/cnes_iasi_brd-swapb.c, cnes_iasi_grd-swapb.ksh/cnes_iasi_grd-swapb.c, cnes_iasi_ctx-swapb.ksh/cnes_iasi_ctx-swapb.c, cnes_iasi_odb-swapb.ksh/cnes_iasi_odb-swapb.c. A script convert_config_files.ksh may be used to check all the configuration files and convert them as necessary. Note that for OPS-LRS v6-0 onwards, the configuration files must be in big-endian format; for earlier versions they were required to be in native endian format.

Once the IASI PFS L1C has been generated, it is converted to an AAPP format to be ingested in the pre-processing step 2, atovpp. This task is done by convert_iasi1c.ksh/convert_iasi1c.c.

3.2. INTERFACES

Each step described above is followed by a reference level:

Level 0: HRPT data (NOAA) or PFS L0 (METOP): Raw telemetry data including house keeping and others raw data. Data of the different instruments are merged into a HRPT stream for NOAA. One file per instrument for METOP.

AAPP level 1a: separated data for each instrument

AAPP level 1b: Earth located and calibration coefficients (reversible: calibration coefficients are separated from raw data).

AAPP level 1c: Earth located and converted to brightness temperature data (non-reversible: calibration coefficients are applied to data)

AAPP level 1d: mapped and filtered data (with optional cloud mask in the case of HIRS).

PFS level 1B (for AVHRR): Earth located and calibration coefficients, flags.

PFS level 1C (for IASI): Gaussian-apodised, resampled radiance spectra, corrected for all geometrical and instrumental effects, with mapped AVHRR. Earth located.

For the NPP, JPSS and some other programmes (e.g. DMSP), NOAA adopt the following naming convention, and these names will be used in the AAPP documentation where applicable:

Raw data records (RDR): Raw data from the instrument
Temperature data records (TDR): Calibrated, geolocated antenna temperatures from microwave sounder (i.e. no correction for antenna pattern). Original instrument grid.
Sensor data records (SDR): Calibrated, geolocated brightness temperatures, radiances or reflectivities. In the case of microwave instruments, antenna correction has been applied. Either original instrument grid or re-mapped.
Environmental data records (EDR): Geophysical quantities.

For NPP and JPSS programmes, AAPP ingests the SDRs. These are in one of two formats: (i) the HDF5 format defined by the NPOESS Common Data Format Control Book [36], or (ii) a BUFR format whose contents closely reflects that of the HDF5 product.

3.3. DIAGRAMS

Different components of AAPP are used depending on the origin of the data.

In the following figures, the files that are created or modified by a process are noted. Summary files and fixed files are not noted.

3.4. DIRECT-READOUT OF NOAA SATELLITE DATA.

For NOAA direct readout, the interface to AAPP is at “Level 0”, i.e. the HRPT reception system is assumed to have the capability of receiving the NOAA HRPT data stream, as defined by NOAA [1].

AAPP_RUN_NOAA is the main module of the AAPP chain, for TOVS/ATOVS sounders and AVHRR radiometer on the NOAA satellites. It links up the different steps, ingest and pre-processing.

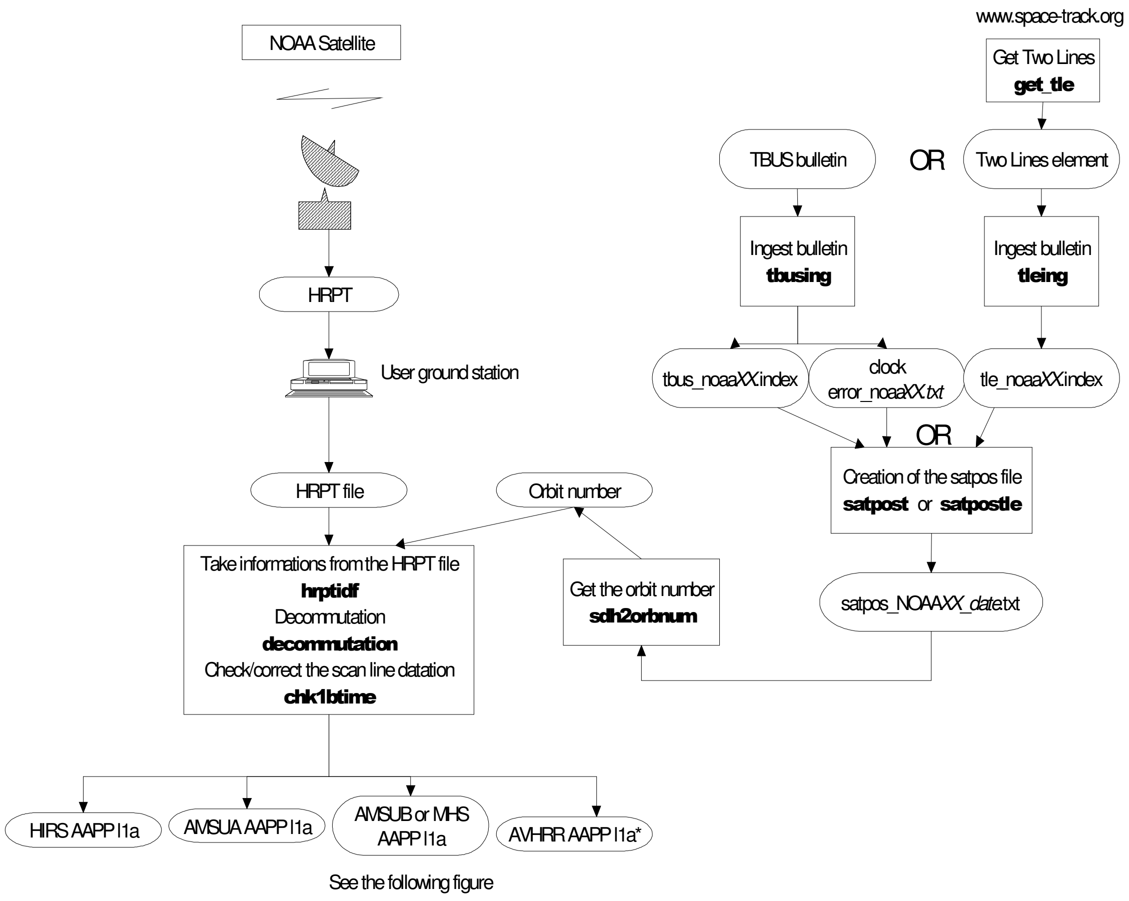


Figure 3-1 : First steps for treating NOAA data

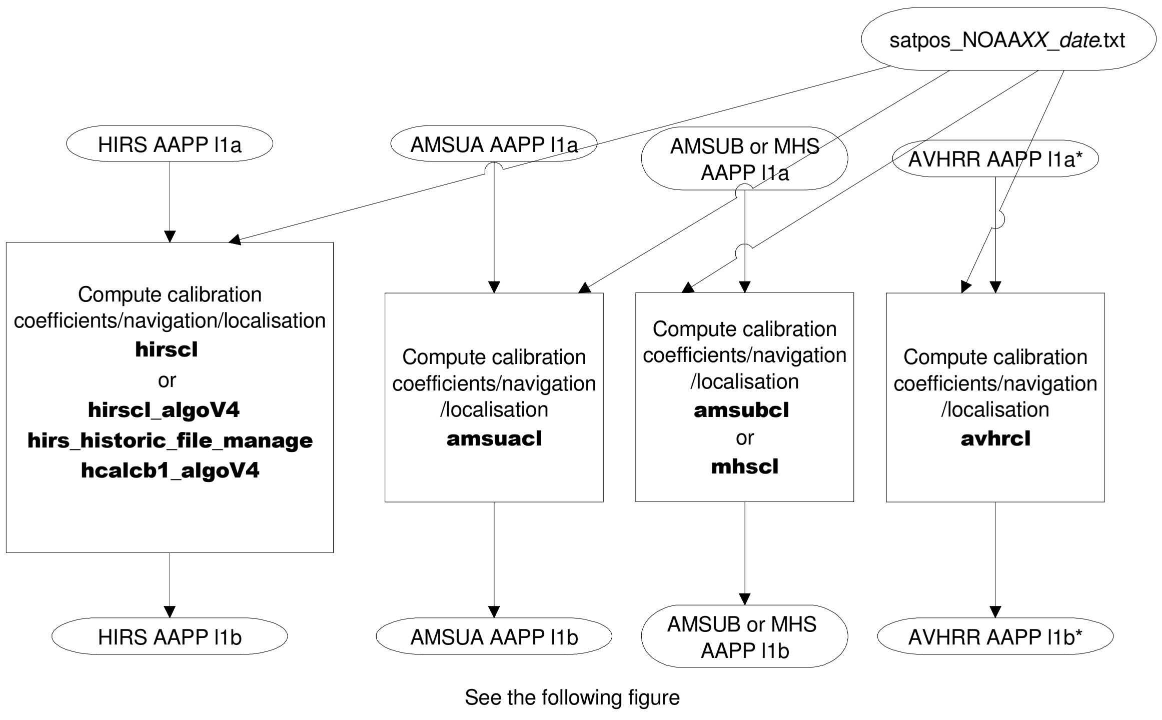

satpos_NOAAXX_date.txt
HIRS AAPP l1a
AMSUA AAPP l1a
AMSUB or MHS AAPP l1a
AVHRR AAPP l1a*
Compute calibration coefficients/navigation/localisation hirscl or hirscl_algoV4 hirs_historic_file_manage hcalcb1_algoV4
Compute calibration coefficients/navigation /localisation amsuacl
Compute calibration coefficients/navigation /localisation amsubcl or mhscl
Compute calibration coefficients/navigation /localisation avhrcl
HIRS AAPP l1b
AMSUA AAPP l1b
AMSUB or MHS AAPP l1b
AVHRR AAPP l1b*
See the following figure

Figure 3-2 : Second steps for treating NOAA data

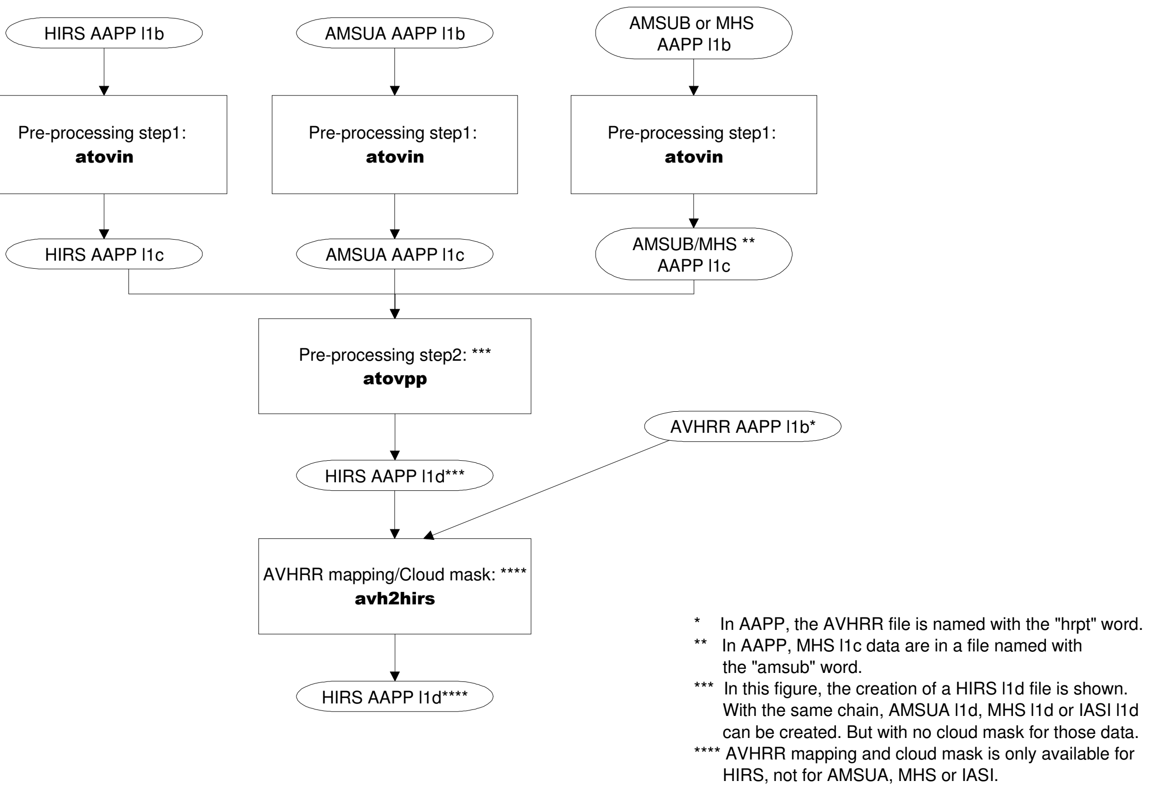

HIRS AAPP l1b
AMSUA AAPP l1b
AMSUB or MHS AAPP l1b
Pre-processing step1: atovin
Pre-processing step1: atovin
Pre-processing step1: atovin
HIRS AAPP l1c
AMSUA AAPP l1c
AMSUB/MHS ** AAPP l1c
Pre-processing step2: *** atovpp
AVHRR AAPP l1b*
HIRS AAPP l1d***
AVHRR mapping/Cloud mask: **** avh2hirs
HIRS AAPP l1d****
* In AAPP, the AVHRR file is named with the "hrpt" word.
** In AAPP, MHS l1c data are in a file named with the "amsub" word.
*** In this figure, the creation of a HIRS l1d file is shown. With the same chain, AMSUA l1d, MHS l1d or IASI l1d can be created. But with no cloud mask for those data.
**** AVHRR mapping and cloud mask is only available for HIRS, not for AMSUA, MHS or IASI.

Figure 3-3 : Pre-processing steps for NOAA data

3.5. DIRECT-READOUT OF METOP SATELLITE DATA.

For METOP direct readout, the interface to AAPP is at “EPS Level 0”, i.e. the HRPT reception system is assumed to have the capability of receiving the METOP AHRPT data stream and converting to EPS level 0 format, as defined by EUMETSAT [25]. In this format the various instruments are delivered as separate files, therefore there is no need for a decommutation task.

Software tools are supplied within the “metop-tools” section of AAPP to convert EPS level 0 format to AAPP level 1a format. Calibration, navigation and pre-processing then proceed in the same way as for the NOAA satellites.

For a general description of the METOP processing, see the AAPP v6 (or v7) Top Level Design document [24]

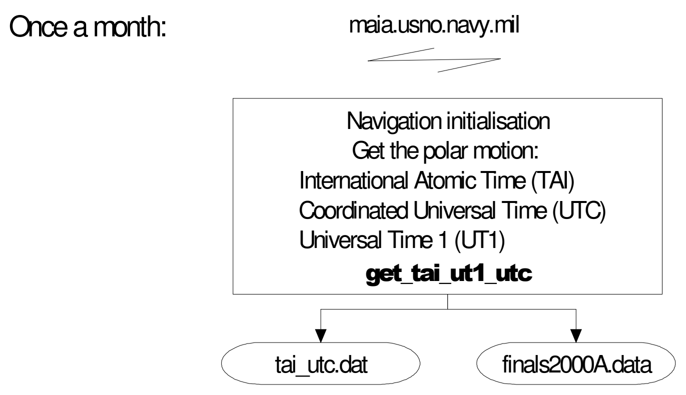


Figure 3-4 : Periodical step for treating METOP data

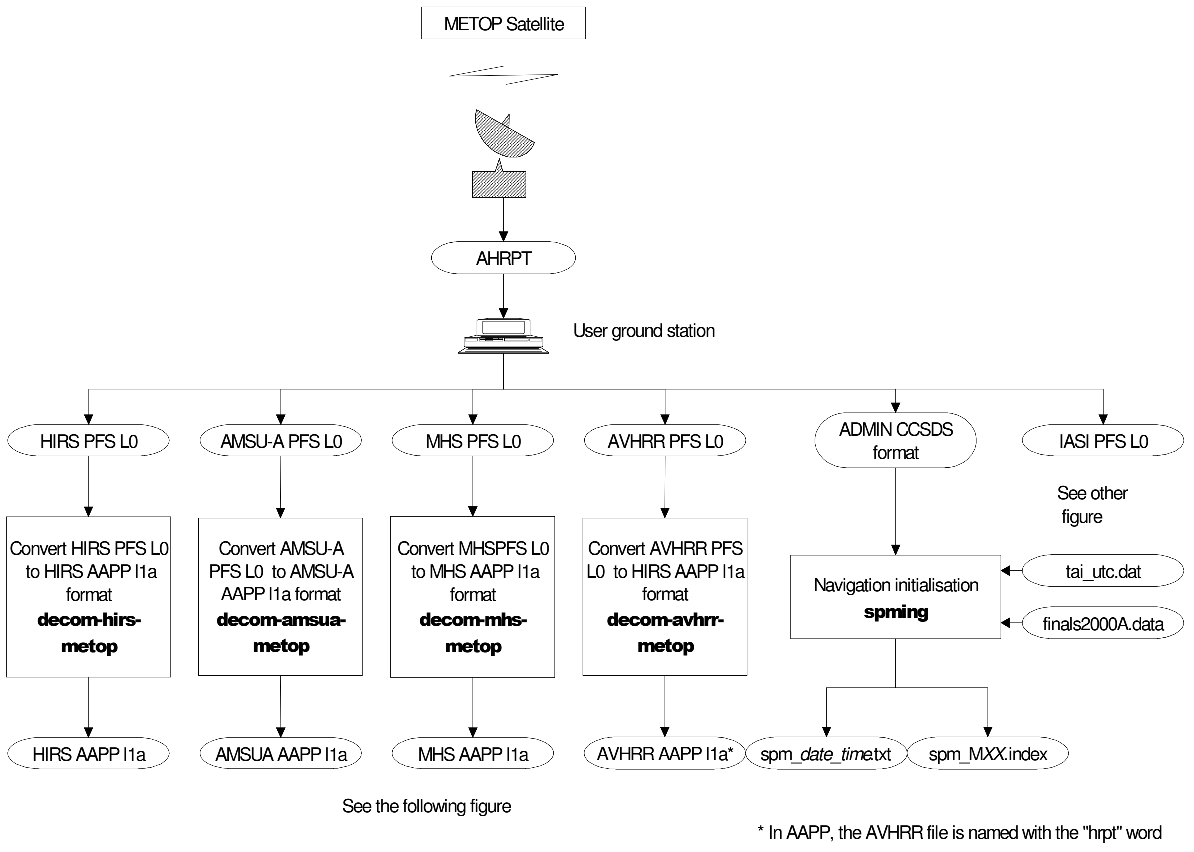

METOP Satellite
AHRPT
User ground station
HIRS PFS L0
AMSU-A PFS L0
MHS PFS L0
AVHRR PFS L0
ADMIN CCSDS format
IASI PFS L0
See other figure
Convert HIRS PFS L0 to HIRS AAPP l1a format decom-hirs-metop
Convert AMSU-A PFS L0 to AMSU-A AAPP l1a format decom-amsua-metop
Convert MHSPFS L0 to MHS AAPP l1a format decom-mhs-metop
Convert AVHRR PFS L0 to HIRS AAPP l1a format decom-avhrr-metop
Navigation initialisation spming
tai_utc.dat
finals2000A.data
HIRS AAPP l1a
AMSUA AAPP l1a
MHS AAPP l1a
AVHRR AAPP l1a*
spm_date_time.txt
spm_MXX.index
See the following figure
* In AAPP, the AVHRR file is named with the "hrpt" word

Figure 3-5 : First steps for treating METOP data (ATOVS part)

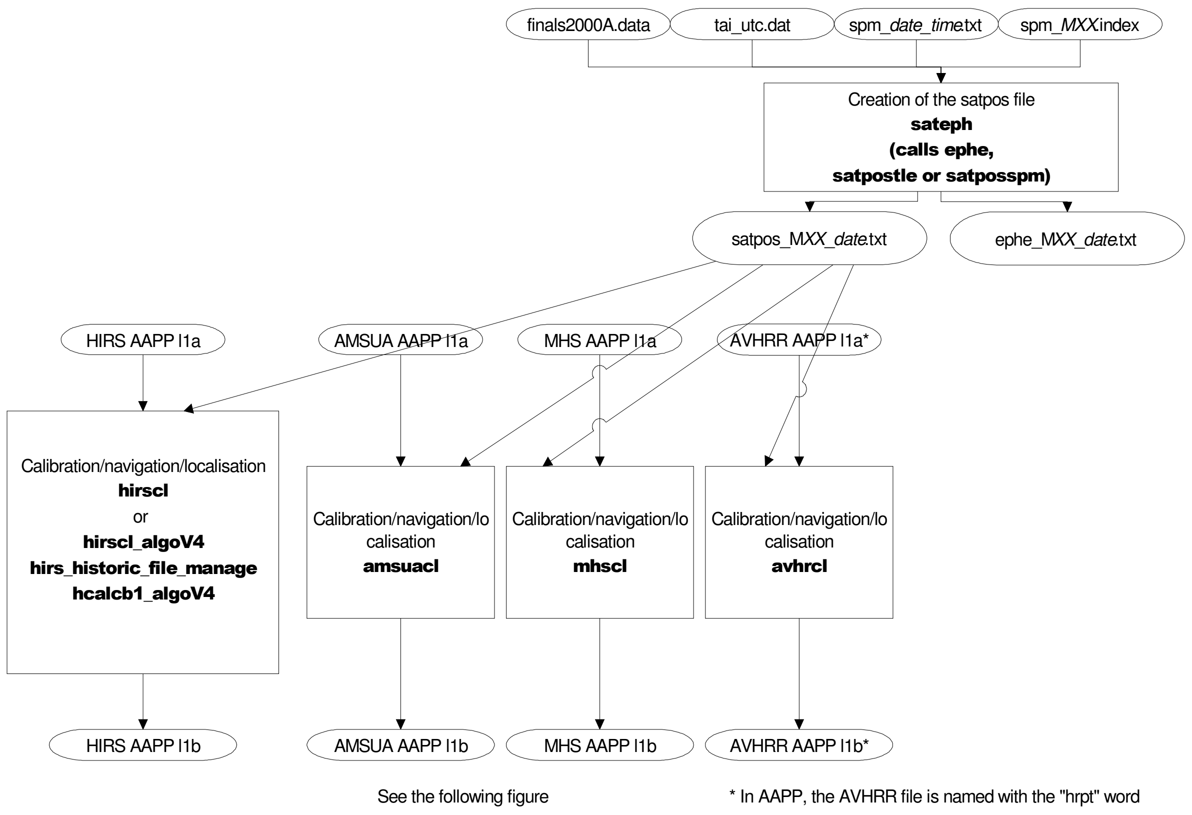


Figure 3-6 : Second steps for treating METOP data (ATOVS part)

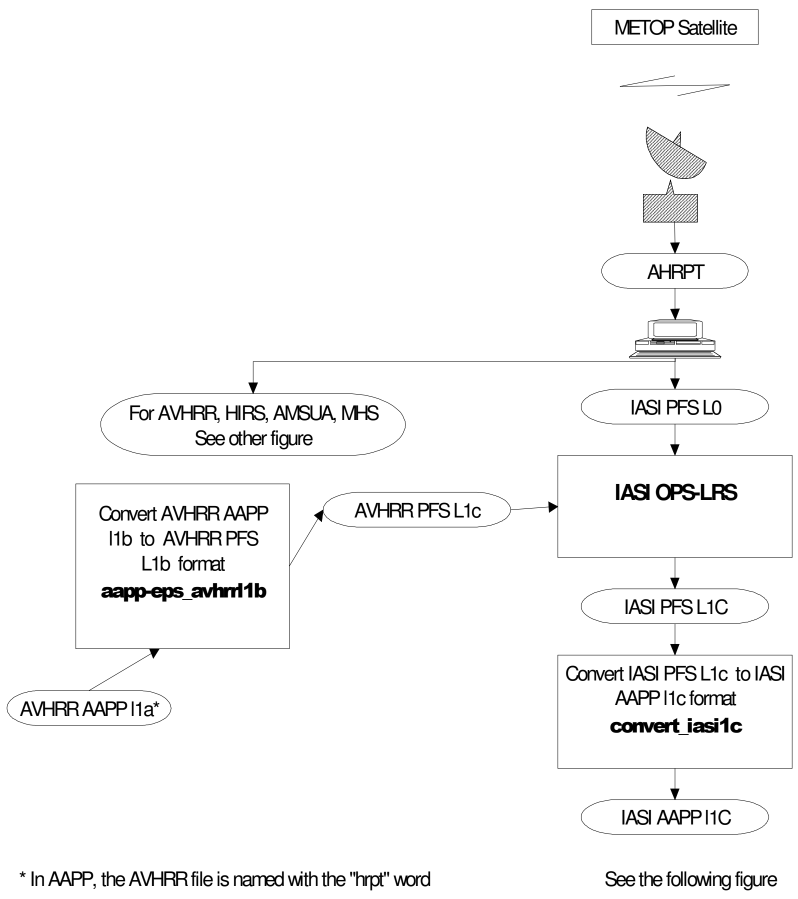
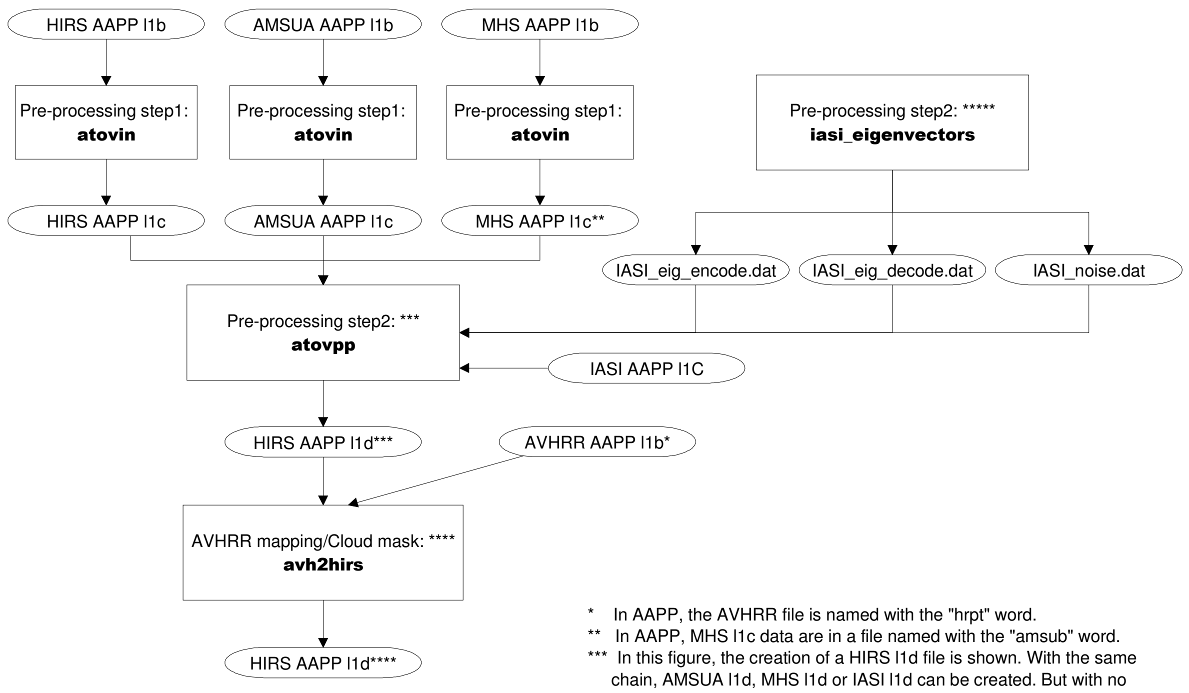

METOP Satellite
AHRPT
For AVHRR, HIRS, AMSUA, MHS See other figure
IASI PFS L0
IASI OPS-LRS
AVHRR PFS L1c
Convert AVHRR AAPP l1b to AVHRR PFS L1b format **aapp-eps_avhrrl1b**
AVHRR AAPP l1a*
IASI PFS L1C
Convert IASI PFS L1c to IASI AAPP l1c format **convert_iasi1c**
IASI AAPP l1C
* In AAPP, the AVHRR file is named with the "hrpt" word
See the following figure

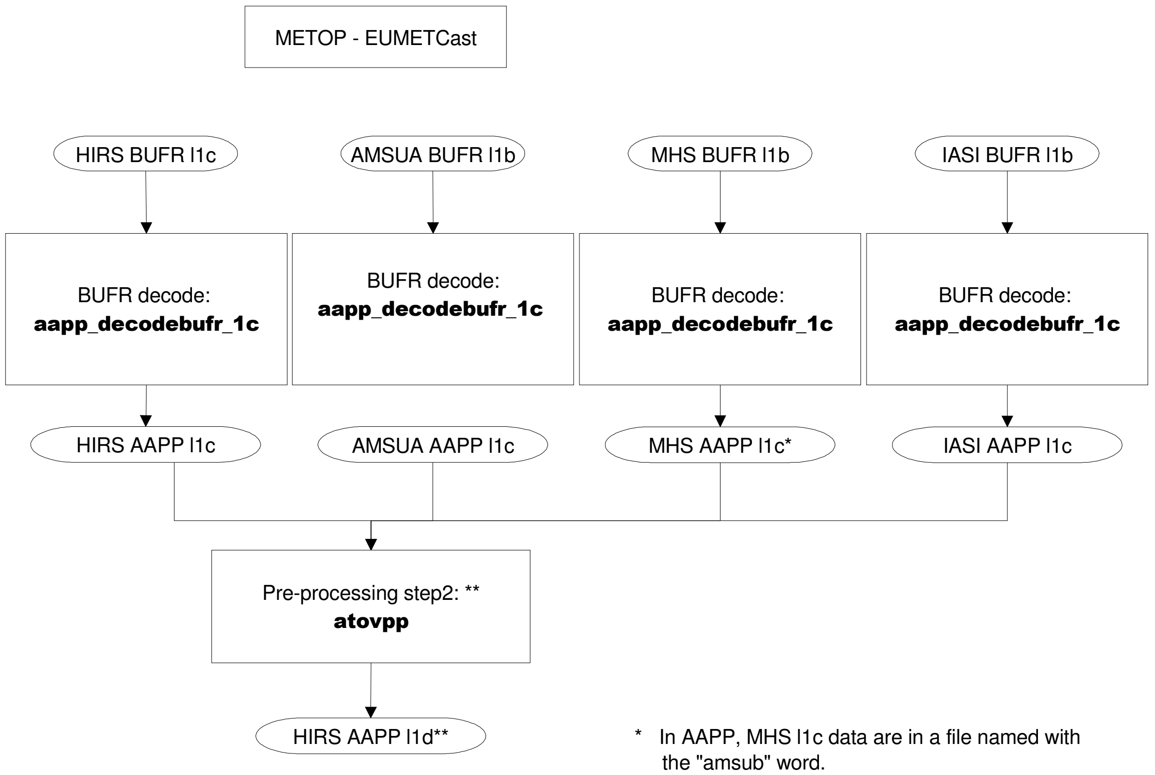
Figure 3-7 : First steps for treating METOP data (IASI part)


HIRS AAPP l1b
AMSUA AAPP l1b
MHS AAPP l1b
Pre-processing step1: atovin
Pre-processing step1: atovin
Pre-processing step1: atovin
Pre-processing step2: ***** iasi_eigenvectors
HIRS AAPP l1c
AMSUA AAPP l1c
MHS AAPP l1c**
IASI_eig_encode.dat
IASI_eig_decode.dat
IASI_noise.dat
Pre-processing step2: *** atovpp
IASI AAPP l1C
HIRS AAPP l1d***
AVHRR AAPP l1b*
AVHRR mapping/Cloud mask: **** avh2hirs
HIRS AAPP l1d****

* In AAPP, the AVHRR file is named with the "hrpt" word.
** In AAPP, MHS l1c data are in a file named with the "amsub" word.
*** In this figure, the creation of a HIRS l1d file is shown. With the same chain, AMSUA l1d, MHS l1d or IASI l1d can be created. But with no cloud mask for those data.
**** AVHRR mapping and cloud mask is only available for HIRS, not for AMSUA, MHS or IASI.
*****"iasi_eigenvectors" is called automatically by the **atovpp** script

Figure 3-8 : Pre-processing steps for METOP data

3.6. ACQUISITION OF METOP DATA VIA EUMETCAST


METOP - EUMETCast
HIRS BUFR l1c
AMSUA BUFR l1b
MHS BUFR l1b
IASI BUFR l1b
BUFR decode: aapp_decodebufr_1c
BUFR decode: aapp_decodebufr_1c
BUFR decode: aapp_decodebufr_1c
BUFR decode: aapp_decodebufr_1c
HIRS AAPP l1c
AMSUA AAPP l1c
MHS AAPP l1c*
IASI AAPP l1c
Pre-processing step2: ** atovpp
HIRS AAPP l1d**

* In AAPP, MHS l1c data are in a file named with the "amsub" word.

** In this figure, the creation of a HIRS l1d file is shown. With the same chain, AMSUA l1d, MHS l1d or IASI l1d can be created.

Figure 3-9 : Chain for treating METOP -ATOVS data received via EUMETCAST

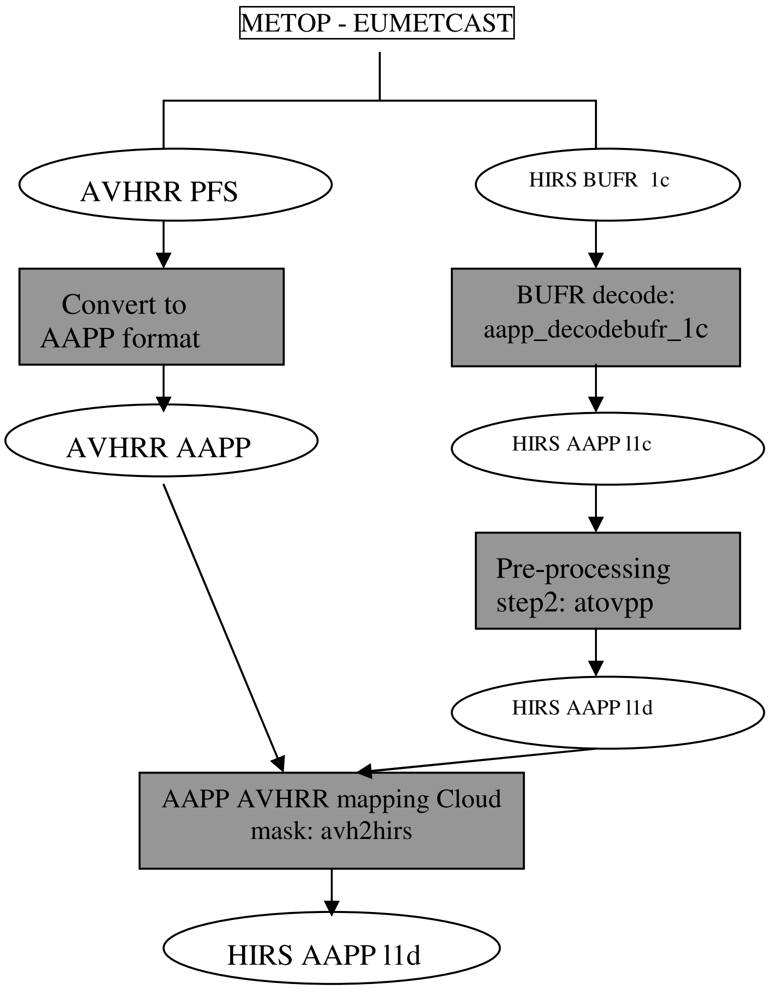


Figure 3-10 : Chain for treating METOP –AVHRR - HIRS data received via EUMETCAST

3.6.1. NOAA archived data

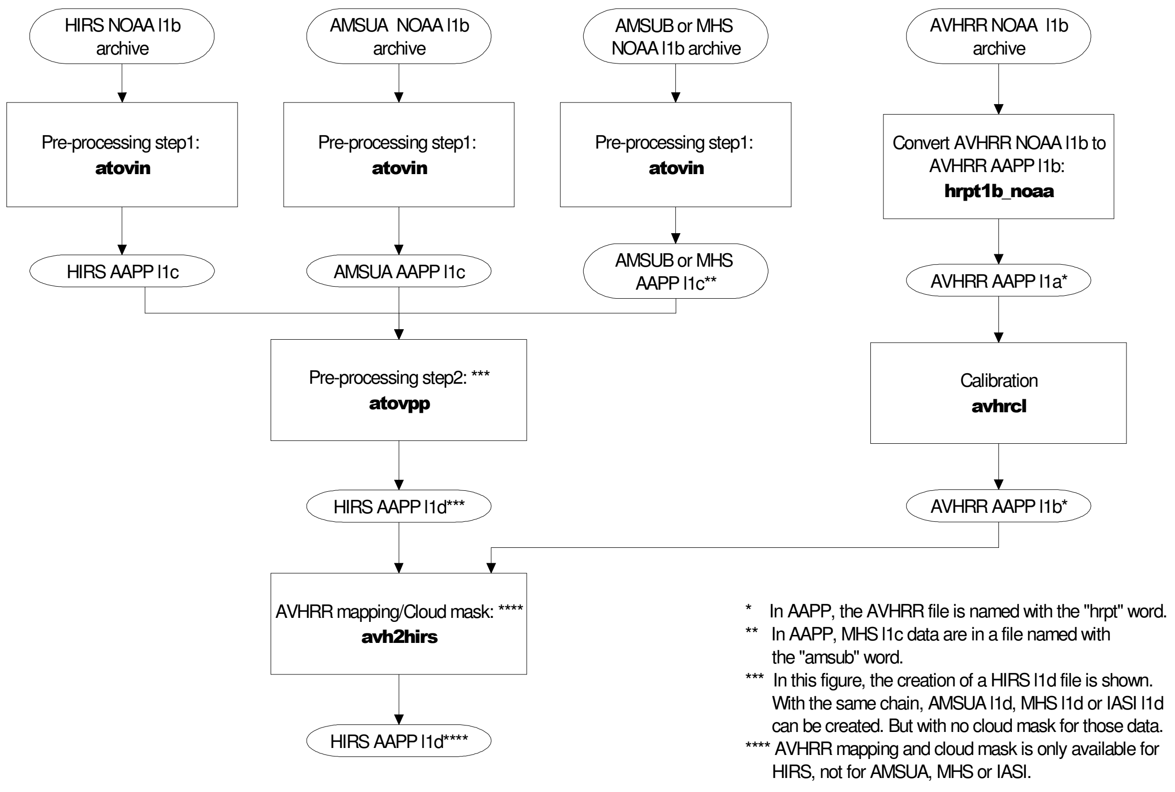

HIRS NOAA l1b archive
AMSUA NOAA l1b archive
AMSUB or MHS NOAA l1b archive
AVHRR NOAA l1b archive
Pre-processing step1: atovin
Pre-processing step1: atovin
Pre-processing step1: atovin
Convert AVHRR NOAA l1b to AVHRR AAPP l1b: hrpt1b_noaa
HIRS AAPP l1c
AMSUA AAPP l1c
AMSUB or MHS AAPP l1c**
AVHRR AAPP l1a*
Pre-processing step2: *** atovpp
Calibration avhrcl
HIRS AAPP l1d***
AVHRR AAPP l1b*
AVHRR mapping/Cloud mask: **** avh2hirs
HIRS AAPP l1d****
* In AAPP, the AVHRR file is named with the "hrpt" word.
** In AAPP, MHS l1c data are in a file named with the "amsub" word.
*** In this figure, the creation of a HIRS l1d file is shown. With the same chain, AMSUA l1d, MHS l1d or IASI l1d can be created. But with no cloud mask for those data.
**** AVHRR mapping and cloud mask is only available for HIRS, not for AMSUA, MHS or IASI.

Figure 3-11 : Chain for treating archived NOAA data

4. GENERAL DESCRIPTION

4.1. SOFTWARE MAIN COMPONENTS

4.1.1. Main module for direct-readout of NOAA satellites. AAPP_RUN_NOAA script

This module allows the user to link up the different steps of AAPP.

It receives as input the absolute pathname of the HRPT data file and the year of the data (this parameter is not present in the HRPT format).

With the tool **hrpidf.exe** , it extracts the satellite name, the day of the year and the time of the data.

The environment variables contained in the ATOVS_ENV7 file determine the selection of the orbital bulletins and model. Two different bulletins and corresponding models can be selected: TBUS and Two-Line.

Case of TBUS:

By calling the module **tbusing** , it checks and ingests the TBUS bulletins useful to navigate the satellite.

It creates the satellite position-velocity file for several days (**satpos** file) with the command satpost.

Case of Two-Line:

By calling the module **tleing** , it checks and ingests the TLE bulletins useful to navigate the satellite.

It creates the satellite position-velocity file for several days (**satpos** file) with the command satpostle.

With the date, the time of the data and the satellite position file, it gets the orbit number (**sdh2orbnum**).

It distinguishes the pre-NOAA-K data (TOVS data) from NOAA-KLM data (ATOVS data) and from NOAA-N,N' data.

Then, it calls different modules to make the decommutation, navigation/localisation, calibration, mapping, cloud mask tasks (**decommutation, hirscl/hirscl_algoV4, msucl, amsuacl, amsubcl, mhscl, avhrcl, atovin, atovpp, avh2hirs**).

For AVHRR, HIRS and MSU, before and after navigation/calibration task, AAPP_RUN calls tools (**prhavh, prhirs, prhmsu**) to write level 1B headers and first records into ASCII files (*phavh_before_calib.log*, *phavh_before_calib.log*, …).

At the end, it renames all output files to include information in the file names: Satellite name, date and time, orbit number.

4.1.2. Main module for direct-readout of MetOp satellite. AAPP_RUN_METOP script

This module allows the user to link up the different steps of AAPP or AAPP/OPS-LRS.

All files to be processed are in a single directory

One file per instrument (i.e. dump mode)

File names follow the EUMETSAT convention, e.g.

AMSA_xxx_00_M04_20020808181206Z_20020808195406Z_N_O_20020808201206Z
MHSx_xxx_00_M04_20020808181201Z_20020808195401Z_N_O_20020808201201Z
HIRS_xxx_00_M04_20020808181200Z_20020808195358Z_N_O_20020808201200Z
AVHR_xxx_00_M04_20020808181200Z_20020808182359Z_N_O_20020808201200Z
HKTM_xxx_00_M04_20020808181200Z_20020808195358Z_N_O_20020808201200Z
IASI_xxx_00_M04_20020808181200Z_20020808195358Z_N_O_20020808201200Z

Two steps:

- a first one to get AMSU/HIRS/AVHRR products out

- a second one to run IASI OPS-LRS and generate products on IASI grid OPS-LRS requires AVHRR l1b. IASI OPS-LRS is not automatically included in the AAPP v7 distribution. It must be requested by the user.

The environment variables contained in the ATOVS_ENV7 file determine the selection of the orbital bulletins and model.

Case of TBUS:

By calling the module **tbusing** , it checks and ingests the TBUS bulletins useful to navigate the satellite.

It creates the satellite position-velocity file for several days (**satpos** file) with the command satpost.

Case of Two-Line:

By calling the module **tleing** , it checks and ingests the TLE bulletins useful to navigate the satellite.

It creates the satellite position-velocity file for several days (**satpos** file) with the command satpostle.

Case of spot:

By calling the module **spming** , it checks and ingests the spm bulletins useful to navigate the satellite.

It creates the satellite position-velocity file for several days (**satpos** file) with the command satposspm.

Note that spot bulletins are being phased out by EUMETSAT and will not be included in the Admin Message for MetOp-B. Instead, the new Multi-Mission Administrative Message (MMAM) will include TLEs for multiple MetOp and NOAA satellites.

With the date, the time of the data and the satellite position file, it gets the orbit number (**sdh2orbnum**).

Optionally, get OBT/UTC correlation parameters from Admin message in HKTM file and

over-write VIADR in instrument files. (This step is not required if your station manufacturer has properly implemented the OBT-UTC handling).

Then, it calls different modules:

. to convert in AAPP format l1b (**decom-amsua-metop**, **decom-mhs-metop**, **decom-hirs-metop**, **decom-avhrr-metop**

- to make navigation/localisation, calibration (**hirscl/hirscl_algoV4, msucl, amsuacl, amsubcl, mhscl, avhrcl**).
- To make the preprocessing (**atovin, atovpp, avh2hirs**)

If OPS-LRS is present,

- OPS-LRS is called.
- the outfile is converted to AAPP 1C format
- the preprocessing **atovpp** and **avh2hirs** are called

At the end, it renames all output files to include information in the file names: Satellite name, date and time, orbit number.

4.1.3. Main module for FY1 imager data. AAPP_RUN_FY1 script

This module allows the user to extract and calibrate the five AVHRR-like channels of the MVISR instrument on the Chinese FY-1D satellite.

The first step is to convert the input data to pseudo-NOAA format by calling **convert_chrpt** script. the satellite identifier is checked. the default bulletin tle is maked.

Then the main script AAPP_RUN_NOAA is called with specific arguments.

AAPP_RUN_NOAA -C -i "AVHRR" -Y $YEAR -o $OUTDIR fy1.hrp

The level 1a file is re-named with “fy1-04” being replaced by “fy1d”. Finally the fy1cl script is run, to create a level 1b file (AVHRR format).

4.1.4. Satellite and image navigation initialisation: Ingest with TBUS bulletin,TBUSING script, TBUSING.EXE and satellite position and velocity: SATPOST script, SATPOST.EXE

Modules TBUSING, TBUSING.EXE

(See also reference manual pages: *tbusing.1* , *libtbus.3* , *tbus.5* , *clockerror.5* , *libbrolyd.3*)

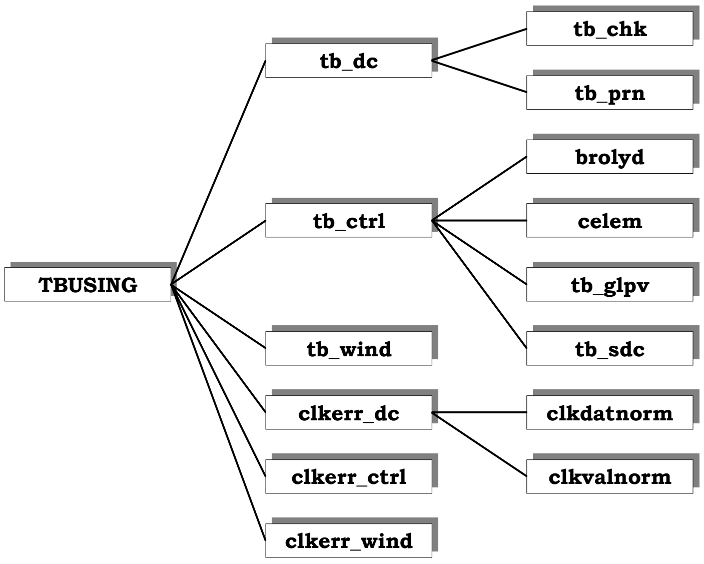


Figure 4-1 : Flow chart on the components of the TBUSING module

These modules allow the ingest of TBUS bulletin(s). They can process one or several satellites (option). The TBUS file name can be specified (option). By default all the tbus files which are newer than the last update of the index files corresponding to the satellite list are ingested.

For each satellite, 2 historical files are created or updated:

- TBUS index file : relative to the TBUS orbital parameters. Each record contains epoch time, quality, tbus filename
- clock error file : contains all the clock error information which has been validated

The TBUS epoch may be at any position in the historical files which means that an old TBUS can be inserted in the files.

To insert new information :

- clock error and orbital parameter have to be extracted from TBUS resources bulletin.
- the user chooses files in relation to satellites to treat (input configuration).
- quality controls are made to check new orbit continuity compared to the preceding orbit (the **brolyd** extrapolation model is used), and to compare clock errors with the preceding ones.

TASK 1 : INPUT PARAMETERS READING

tbusing gets :

- Home directory of the TBUS files and bulletin(s) name(s) which will be stored in the TBUS index file.
- The list of satellites to be considered
- Historical file names

TASK 2: INITIALISATION

It opens the TBUS bulletin(s).

TASK 3: TBUS BULLETIN DECOMMUTATION AND VALIDATION TESTS

For each satellite:

It opens (or creates if files do not exist) the historical index file and the clock drift error file.

It calls different subroutines :

tb_dc to decode the part IV of the TBUS bulletin to extract orbital parameters and to check that extracted parameters are in the authorised value area.

tb_ctrl to check the orbital parameters continuity (to compare them with the last valid parameters registered in the historical file), using the **brolyd** extrapolation model. The new TBUS file is declared OK if the errors are less than 6 km/day. The tests with the last preceding valid tbus are done only if the time difference is less than 7 days.

tb_wind to write the valid TBUS information record at the end of the historical file.

clkerr_dc to decode the clock error values stored in the plain language message at the end of the TBUS file Part IV and to check that extracted clock errors are in the authorised values area.

clkerr_ctrl to check the decoded clock values by comparing them to the preceding historical values.

clkerr_wind to write the valid clock error information record at the end of the clock drift data file, and on the standard input.

At the end, tbusing closes the different files.

Modules SATPOST ,SATPOST.EXE

(See also reference manual pages: *satpost.1* , *satpos.5* , *libbrolyd.3*)

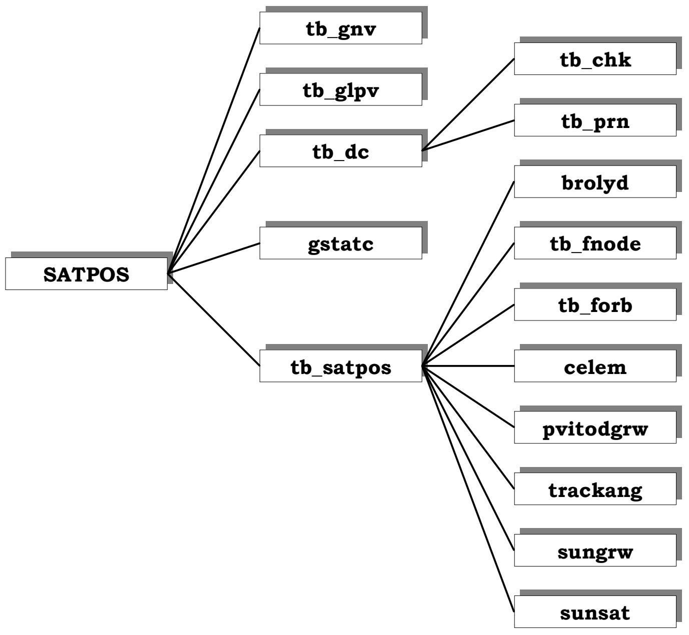


Figure 4-2 : Flow chart on the SATPOST module components.

These modules create a satellite position-velocity file (satpos file) for a given satellite, for a given station, a start time and a given duration. They search the TBUS bulletin file for the orbital parameters time closest to the given start time.

TASK 1: INPUT PARAMETERS READING

satpost gets :

- The satellite name and the station name
- The start time from which the orbital parameters are extrapolated.
- The time step and the number of days.
- The home directory for the TBUS files and the index file name.
- The criteria to search the TBUS bulletin (the nearest or the preceding one).

TASK 2: INITIALISATION

It finds, opens and reads the TBUS bulletin corresponding to the research criterion.

To find the file name of the valid TBUS bulletin, it calls the subroutune **tb_gnv** if the search criteria is the nearest to the start time. The searched TBUS date must be in a time interval. It calls **tb_glpv** if the search criterion is the last preceding valid TBUS filename from the index file. The index file is supposed to be chronological

tb_dc decodes the part IV of the TBUS bulletin to extract orbital parameters and to check that extracted parameters are in the authorised value area.

By calling **gstatc**, it initialises the station coordinates (latitude, longitude, altitude) from the file *stations.txt* (directory DIR_STATIONS defined in ~/ATOVS_ENV) and then converts them into Greenwich cartesian coordinates.

satpost returns information on standard output.

TASK 3: POSITION CALCULATIONS FOR ALL THE STEPS

tb_satpos does this task. It calculates the satellite position. The calculations are made since the start date during several days with a time increment. It begins by initialising the **brolyd** model with the current TBUS.

For each time the following calculations are performed (calculation loop):

the satellite position and velocity in the inertial reference frame using the **brolyd** extrapolation model.

conversion into a Greenwich reference frame (**celem** and **pvitodgrw**).

orbit number deduced from the z component

visibility from the station including refraction (**trackang**)

satellite in daylight or nighttime conditions if the satellite is seen from the station (**sungrw, sunsat**).

It writes the results on the standard output.

tb_satpos calls others subroutines to initiate variables useful to **brolyd** model:

- **tb_fnode** calculates nodal period (time interval between 2 successive ascending nodes) and ascending node time of the first orbit after the TBUS date.
- **tb_forb** calculates the orbit number for the given date (from the nodal period and the initial ascending node time).

4.1.5. Satellite and image navigation initialization with Two Line Element sets: GET_TLE script, TLEING script, TLEING.EXE and satellite position and velocity: SATPOSTLE script, SATPOSTLE.EXE.

Module GET_TLE

(See also reference manual pages: *get_tle.1 tleing.1* , *tle.5*)

This script allows the retrieval of the most recent Two-Line bulletin(s) (tle) from the web site Space-Track or Celestrak using the GNU command **wget**.

Default connection is to www.space-track.org and the file identification number 7 is retreived (number for weather satellites). All parameters are configured in the ATOVS_ENV file and are self documented. At time of writing default values are the only possible ones, except for the username and password that must be requested individually by the user to the Space-Track web site.

TASK 1 : INPUT PARAMETERS READING

get_tle gets :

- Home directory of the TLE files.
- The URL for login
- The URL for download
- The user name and password for Space-Track connection.
- The time-out for connections.

TASK 2: LOGIN

Sends a **wget** commands that logins and store cookies in a temporary file.

TASK 3: DOWNLOAD AND STORE

Sends a **wget** command to download selected file, and load login cookies

Uncompress the file with **gunzip** command

Store file in TLE directory

Modules TLEING, TLEING.EXE

(See also reference manual pages: *tleing.1* , *libtle.3* , *tle.5* , *libsgp.3f*)

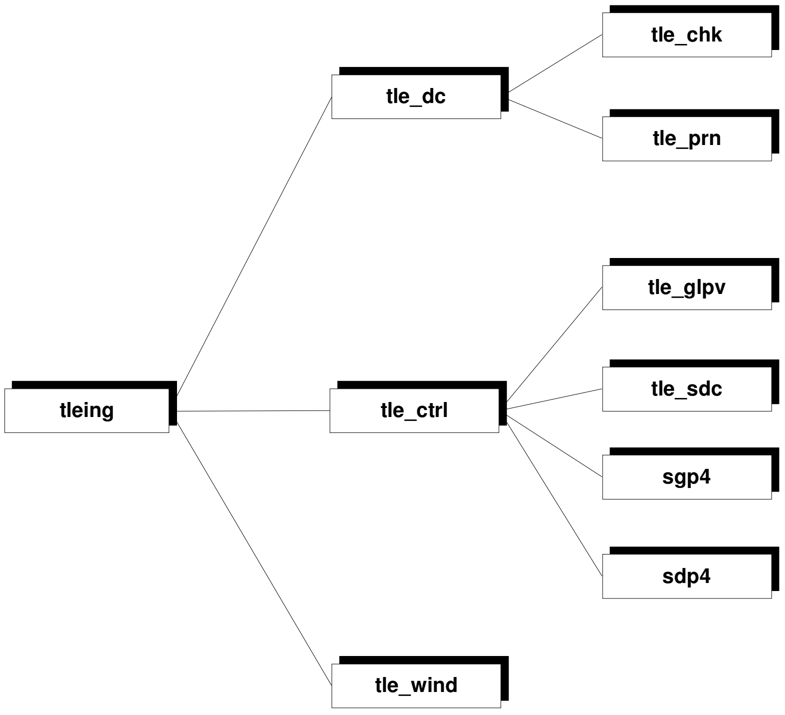


Figure 4-3 : Flow chart on the components of the TLEING module

These modules allow the ingest of Two-Line bulletin(s) (tle). They can process one or several satellites (option). The Two-Line file name can be specified (option). By default all the tle files which are newer than the last update of the index files corresponding to the satellite list are ingested.

For each satellite, one historical file is created or updated:

- TLE index file: relative to the TLE orbital parameters. Each record contains epoch time, quality, tbus filename

The TLE epoch may be at any position in the historical files which means that an old TLE can be inserted in the files.

To insert new information:

- orbital parameters have to be extracted from TLE resources bulletin.
- the user chooses files depending on which to satellites are to be processed(input configuration).
- quality controls are made to check new orbit continuity compared to the preceding orbit (the **sgp4** extrapolation model is used).

TASK 1 : INPUT PARAMETERS READING

tleing gets:

- Home directory of the TLE files and bulletin(s) name(s) which will be stored in the TLE index file.
- The list of satellites to be considered
- Historical file names

TASK 2: INITIALISATION

It opens the TLE bulletin(s).

TASK 3: TLE BULLETIN DECOMMUTATION AND VALIDATION TESTS

For each satellite:

It opens (or creates if files do not exist) the historical index file.

It calls different subroutines :

tle_dc to decode the TLE bulletin to extract orbital parameters and to check that extracted parameters are in the authorised value area.

tle_ctrl to check the orbital parameters continuity (to compare them with the last valid parameters registered in the historical file), using the **sgp** extrapolation model. The new TLE file is declared OK if the errors are less than 6 km/day. The tests with the last preceding valid tbus are done only if the time difference is less than 7 days.

tle_wind to write the valid TLE information record at the end of the historical file.

At the end, tleing closes the different files

Modules SATPOSTLE, SATPOSTLE.EXE

(See also reference manual pages: *satpostle.1* , *satpos.5* , *libsgp.3f*)

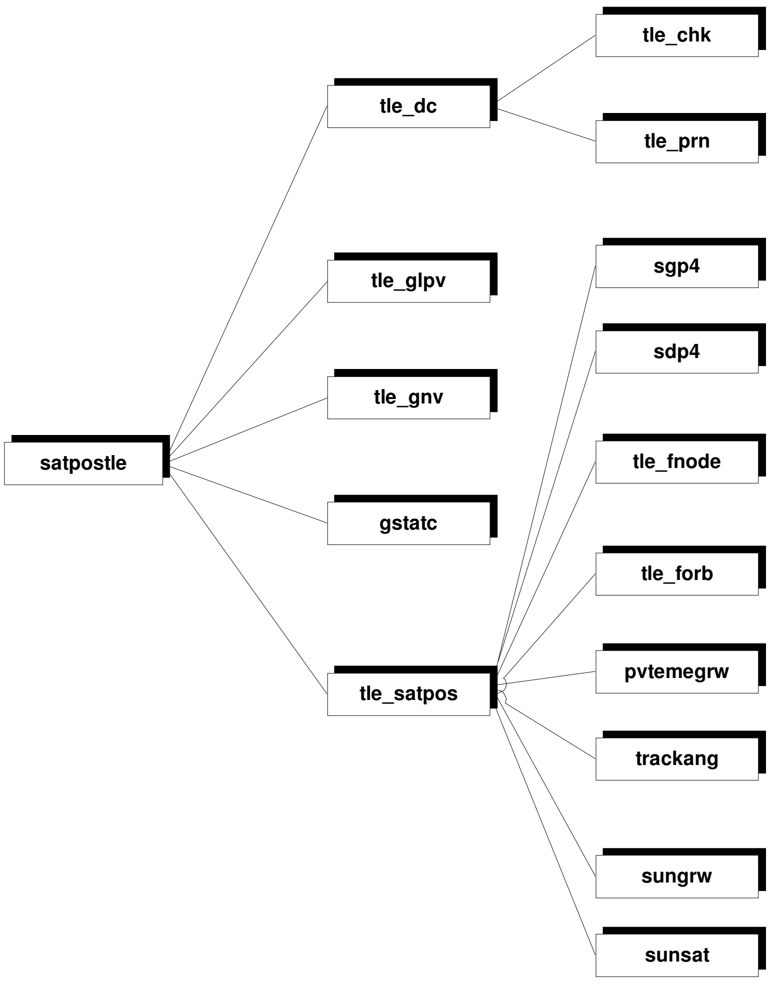


Figure 4-4 : Flow chart on the SATPOSTLE module components.

These modules create a satellite position-velocity file (satpos file) for a given satellite, for a given station, a start time and a given duration. They search the TLE bulletin file for the orbital parameters time closest to the given start time.

TASK 1: INPUT PARAMETERS READING

satpostle gets :

- The satellite name and the station name
- The start time from which the orbital parameters are extrapolated.
- The time step and the number of days.
- The home directory for the TLE files and the index file name.
- The criteria to search the TLE bulletin (the nearest or the preceding one).

TASK 2: INITIALISATION

It finds, opens and reads the TLE bulletin corresponding to the research criterion.

To find the file name of the valid TLE bulletin, it calls the subroutune **tle_gnv** if the search criteria is the nearest to the start time. The searched TLE date must be in a time interval. It calls

tle_glpv if the search criterion is the last preceding valid TLE filename from the index file. The index file is supposed to be chronological

tle_dc decodes the TLE bulletin to extract orbital parameters and to check that extracted parameters are in the authorised value area.

By calling **gstatc**, it initialises the station coordinates (latitude, longitude, altitude) from the file *stations.txt* (directory DIR_STATIONS defined in ~/ATOVS_ENV) and then converts them into Greenwich Cartesian coordinates.

satpostle returns information on standard output.

TASK 3: POSITION CALCULATIONS FOR ALL THE STEPS

tle_satpos does this task. It calculates the satellite position. The calculations are made since the start date during several days with a time increment. It begins by initialising the **sgp4/sdp4** model with the current TLE.

For each time the following calculations are performed (calculation loop):

the satellite position and velocity in the inertial reference frame using the **sgp4/sdp4** extrapolation model.

conversion into a Greenwich reference frame (**pvtemegrw**).

orbit number deduced from the z component

visibility from the station including refraction (**trackang**)

satellite in daylight or nighttime conditions if the satellite is seen from the station (**sungrw, sunsat**).

It writes the results on the standard output.

tle_satpos calls others subroutines to initiate variables useful to **sgp** model:

- **tle_fnode** calculates nodal period (time interval between 2 successive ascending nodes) and ascending node time of the first orbit after the TLE date.
- **tle_forb** calculates the orbit number for the given date (from the nodal period and the initial ascending node time).

4.1.6. Satellite and image navigation initialization with SPOT-5 element sets (METOP only): GET_TAI_UT1_UTC script, SPMING script, ADMIN-MAIN.EXE, ADMIN-MESSAGES.EXE and satellite position and velocity: SATPOSSPM script, SATPOSSPM.EXE.

Module GET_TAI_UT1_UTC

That module is requested by celestial reference frame conversions for SPOT-5 model. The conversion needs to know the values of the Polar motion and the conversions between Temps Atomique International (TAI), Coordinated Universal Time (UTC), Universal Time 1 (UT1). The script access the server **maia.usno.navy.mil** and retrieves two files **tai-utc.dat** and **finals2000A.data,** by default they are stored in the $DIR_NAVIGATION/orb_elem directory. All necessary variables are defined in the ATOVS_ENV. The polar motion and UT1-UTC data are predictable and the file **finals2000A.data** contains predictions for several weeks or months.

The user should run this command once a month.

Modules SPMING, SPMING.PL, SPMING.EXE, ADMIN-MAIN.EXE, ADMIN-MESSAGES.EXE

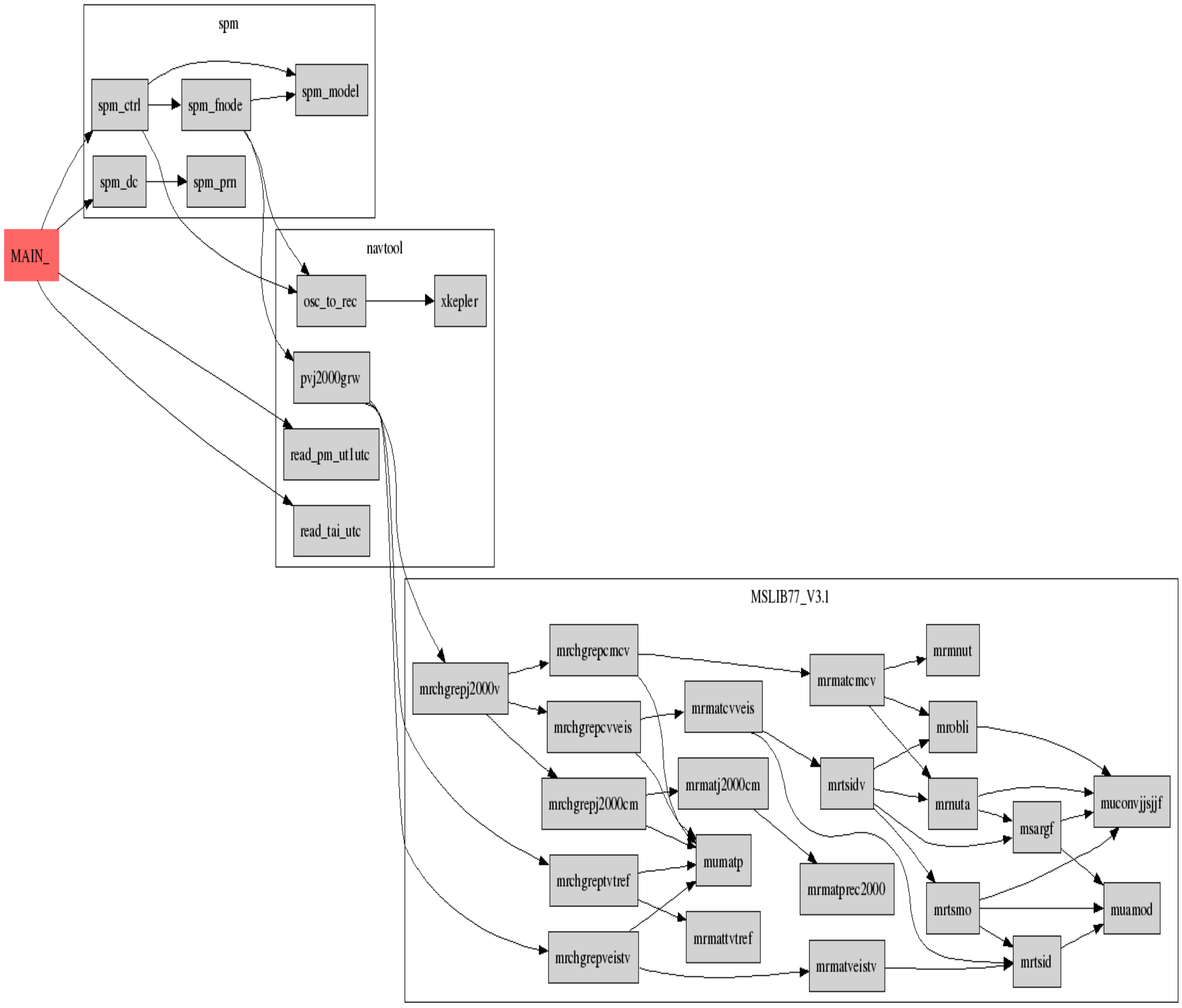


Figure 4-5 : Flow chart on the components of the SPMING module

These modules allow the ingest of SPOT-5 bulletin(s) (spm). SPOT-5 bulletins are available through METOP Administrative messages, these messages are part of the AHRPT data flow. But note that SPOT-5 bulletins are being phased out by EUMETSAT, and will not be available in the new Multi-Mission Administrative Messages (MMAM). These two modules can process only one satellite. The SPOT-5 file name can be specified (option). By default all the (spm) files which are newer than the last update of the index files corresponding to the satellite list are ingested.

For each satellite, one historical file is created or updated:

1. SPM index file: relative to the SPOT-5 orbital parameters. Each record contains epoch time, quality, spot-5 filename

The SPM epoch may be at any position in the historical files which means that an old SPM can be inserted in the files.

To insert new information:

2. orbital parameters have to be calculated from previous SPM resources bulletin.
3. the user chooses files depending on which to satellites are to be processed (input configuration).
4. quality controls are made to check new orbit continuity compared to the preceding orbit (the **spm** extrapolation model is used).

TASK 1 : DECODING ADMIN MESSAGES

This done by admin-main.exe; this program extracts SPOT bulletin from binary ADMIN messages and outputs an ASCII representation.

TASK 2 : INPUT PARAMETERS READING

spming gets:

5. Home directory of the SPM files and bulletin(s) name(s) which will be stored in the SPM index file.
6. Satellite to be considered
7. Historical file names

TASK 3: INITIALISATION

It opens the SPM bulletin(s).

TASK 4: SPM BULLETIN VALIDATION TESTS

Reads the index file and for each record that contains a negative orbit number it:

- calls **spm_dc** to decode the SPM bulletin, extract orbital parameters and check that extracted parameters are in the authorised value area.

- calls **spm_ctrl** to check the orbital parameters continuity (to compare them with the last valid parameters registered in the historical file), using the **spm** extrapolation model. The new SPM file is declared OK if the errors are less than 6 km/day. The tests with the last preceding valid SPM are done only if the time difference is less than 7 days. It returns the calculated orbit number at epoch.

For all records it writes to the output file the updated record (extrapolation error, flag, orbit) or input record depending on initial test.

TASK 5: EXTRACT ASCII MESSAGES FROM ADMIN MESSAGE

admin-messages.exe extracts the ASCII buffer of the ADMIN message and stores it in $DIR_NAVIGATION/messages/messages_satid_YYYYMMDD.txt.

Modules SATPOSSPM, SATPOSSPM.EXE

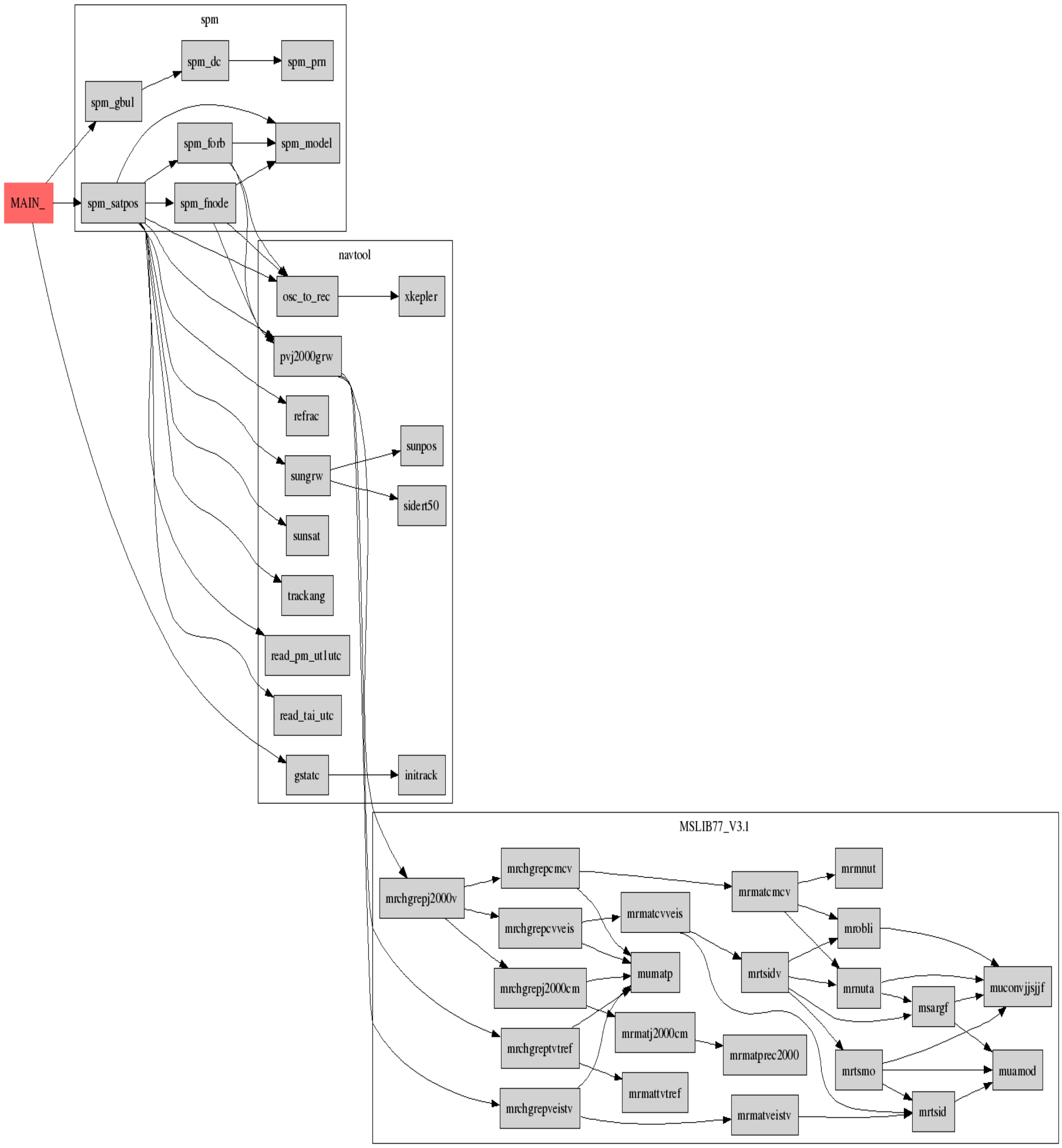


Figure 4-6 : Flow chart on the SATPOSSPM module components.

These modules create a satellite position-velocity file (satpos file) for a given satellite, for a given station, a start time and a given duration. They search the SPM bulletin file for the orbital parameters time closest to the given start time.

TASK 1: INPUT PARAMETERS READING

satposspm gets :

- The satellite name and the station name
- The start time from which the orbital parameters are extrapolated.
- The time step and the number of days.
- The home directory for the SPM files and the index file name.
- The criteria to search the SPM bulletin (the nearest or the preceding one).

TASK 2: INITIALISATION

It finds, opens and reads the SPM bulletin corresponding to the research criterion.

To find the file name of the valid SPM bulletin, it calls the subroutine **spm_gbul**. The searched SPM date must be in a time interval. The index file is supposed to be chronological. The subroutines also calls **spm_dc** in order to decode the SPM bulletin. Spm_gbul stores all valid bulletins in a time period.

By calling **gstatc**, it initialises the station coordinates (latitude, longitude, altitude) from the file *stations.txt* (directory DIR_STATIONS defined in ~/ATOVS_ENV) and then converts them into Greenwich Cartesian coordinates.

Routines **read_pm_ut1utc** and **read_tai_utc** returns the values of polar motion and time difference between UTC, UT1 and TAI.

satposspm returns information on standard output.

TASK 3: POSITION CALCULATIONS FOR ALL THE STEPS

spm_satpos does this task. It calculates the satellite position. The calculations are made since the start date during several days with a time increment. It begins by initialising the **spm** model with the current SPM.

For each time the following calculations are performed (calculation loop):

- check if the current bulletin is the best available for the time step.
- If time step day changes, update polar motion and UTC conversion by calling **read_pm_ut1utc** and **read_tai_utc**

the satellite position and velocity in the inertial reference frame using the **spm_model** extrapolation model and the conversion subroutine **osc_to_rec** from osculating to rectangular elements.

conversion into a Greenwich reference frame (**pvj2000grw**).

orbit number deduced from the z component

visibility from the station including refraction (**trackang**)

satellite in daylight or nighttime conditions if the satellite is seen from the station (**sungrw, sunsat**).

It writes the results on the standard output.

spm_satpos calls others subroutines to initiate variables useful to **spm** model:

- **spm_fnode** calculates nodal period (time interval between 2 successive ascending nodes) and ascending node time of the first orbit after the SPM date.
- **spm_forb** calculates the orbit number for the given date (from the nodal period and the initial ascending node time).

4.1.7. Decommutation modules: DECOMMUTATION script and DECOMMUTATION.EXE.

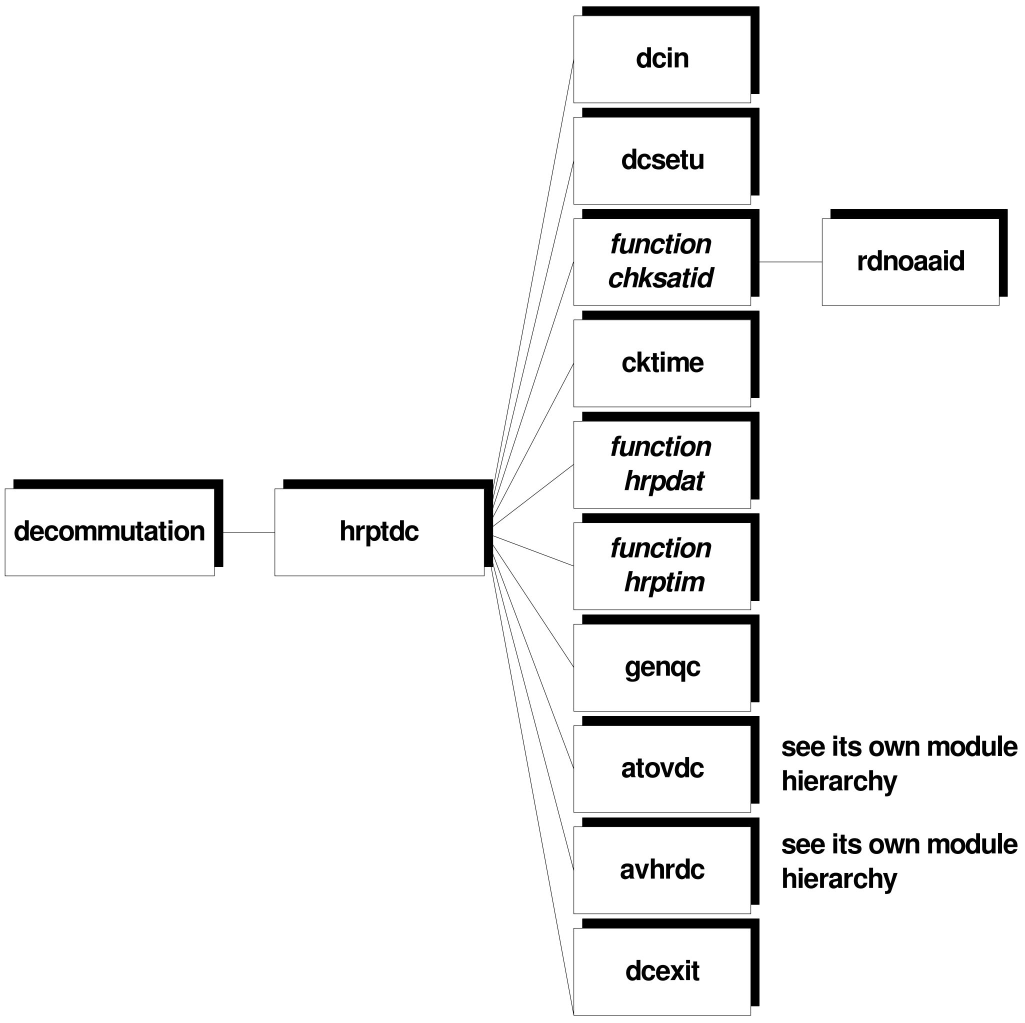


Figure 4-7 : DECOMMUTATION and HRPTDC module hierarchy.

To simplify the diagram, the calls to subroutines of the **libf7ml** , **libf7tp** , **libf7nl1b** libraries have not been written.

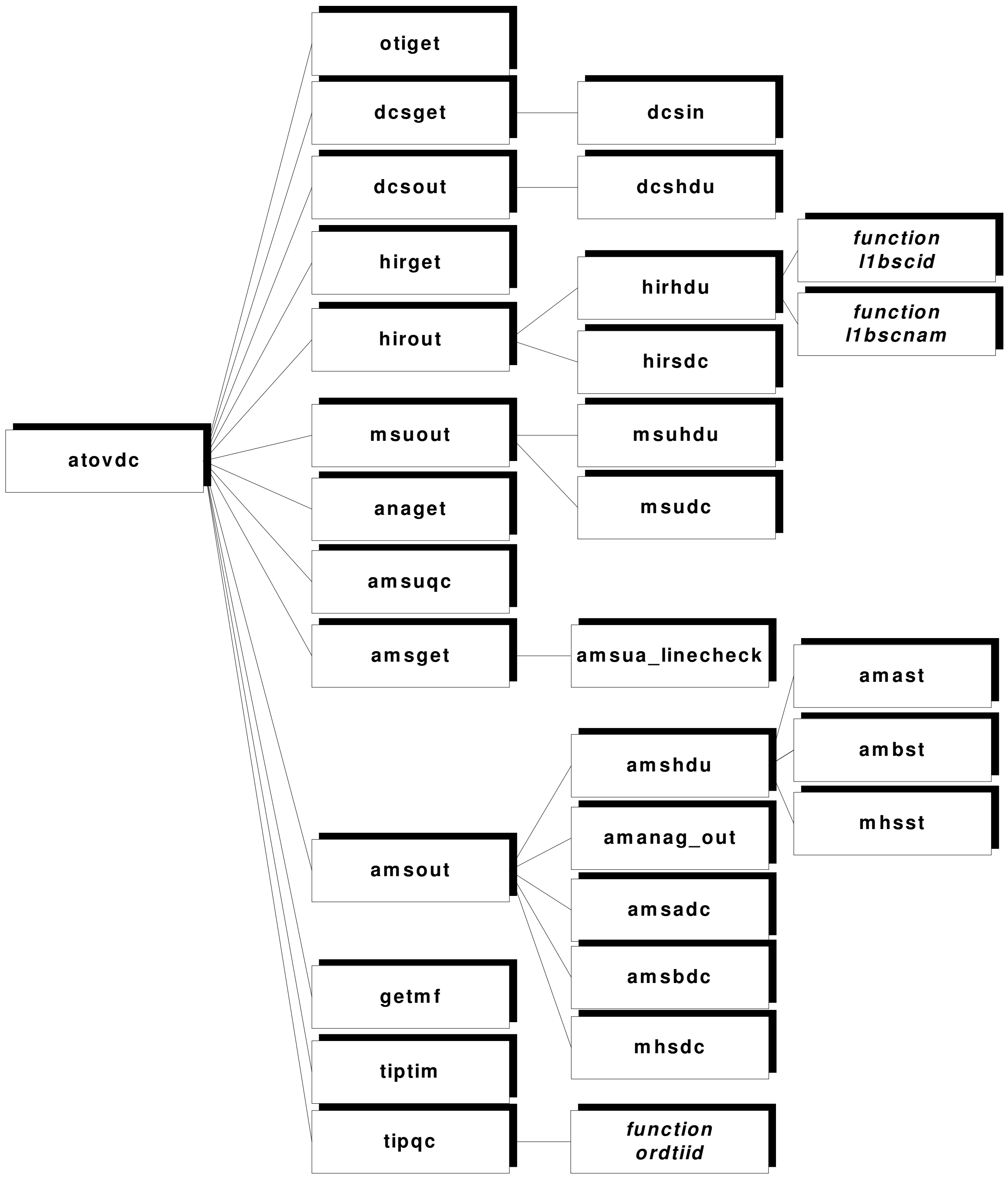


Figure 4-8 : ATOVDC components hierarchy.

To simplify the diagram, the calls to subroutines or functions of the **libf7ml**, **libf7tp**, **libf7gp**, **libf7nl1b** , **libf7cp** libraries have not been written.

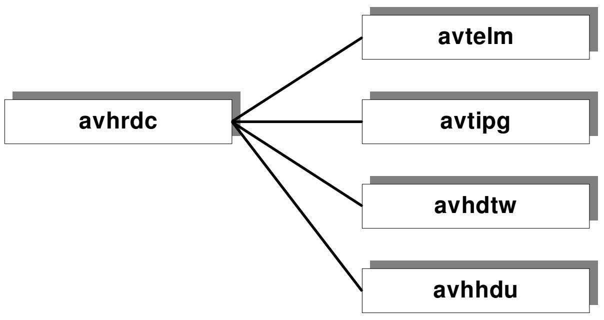


Figure 4-9 : AVHRDC components hierarchy.

To simplify the diagram, calls to the subroutines of the libraries like **libf7ml**, **libf7gp** have not be written

Decommutation modules perform the extraction task for several parts of the HRPT stream (level 0) which have to be processed by **avhrdc** (AVHRR decommutation task) and **atovdc** (TOVS/ATOVS decommutation task). The HRPT minor frames, numbered 1 to 3, are received by the center- specific routines and can be processed in real time from several local acquisition systems or read off-line from files coming from various centers. The HRPT minor frames are read by a center- specific routine. This is necessary as the extract format of the HRPT minor frames will depend on the hardware of the reception station.

After decommutation, there is one raw data file for each instrument. Those files represent the level 1a data.

TASK 1: INITIALISATION

hrptdc performs this task.

This module receives as an input the unpacked HRPT minor frame(s) coming from the center specific module closely connected to the hardware. The HRPT minor frame is an array of 11090 words made of the 10 bits HRPT words placed right justified in 16 bits words. **hrptdc** detects the end of HRPT stream.

hrptdc reads input options (**dcin**) and opens the various files (**dcsetu**).

It identifies the satellite (**chksatid**) by checking HRPT and TIP satellite Id coherence.

It checks good start condition: an HRPT minor frame equal to 1, with valid time and good time difference between consecutive HRPT minor frames (**cktime**). This means that under normal circumstances a few minor frames at the start of the pass will not be processed, as they are used for consistency checking. If it is known that there is no bad data at the start (e.g. when processing granules) then the consistency check can be disabled by setting an environment variable (SKIP_DECOM_CHECK=Y); in this case processing will start at the first minor frame number 1.

It performs general quality controls for one HRPT minor frame (**genqc**).

- Check the satellite identification at the first call
- Check of the number of the scan line
- Check of the date and time
- Check of the minor frame number
- Check of the TIP parity bits in the five consecutive TIP minor frames

- Check parity bits in every TIP word for ATOVDC and flag the relevant bits in the quality indicator

It computes the number of possible missing HRPT minor frames (= the number of possible missing AVHRR scan line).

It calls the routine **atovdc** that will extract HIRS, AMSU-A/B (or MSU if TOVS, MHS if NOAA-N,N') and DCS data from TIP/AMSU minor frames. TIP/AMSU minor frames are embedded in 3 consecutive HRPT minor frames. The first one contains 5 TIP minor frames, the second one contains 'backfill' (dummy data) and the third one contains 5 AMSU minor frames. For pre-NOAA-K satellite, each of the 3 consecutive HRPT minor frames contains the same 5 TIP minor frames.

It calls the routine **avhrdc** that extracts AVHRR data from one HRPT minor frame.

TASK 2: TOVS/ATOVS AND DCS DECOMMUTATION TASK

The module **atovdc** performs this task called by the **hrptdc**.

It receives as input from **hrptdc**:

- 5 TIP or AMSU minor frames (extracted from one HRPT minor frame).
- HRPT minor frame number (1,2 or 3)
- The number of the HRPT minor frame in the orbit (= AVHRR scan line in the orbit).
- The number of missing HRPT minor frame
- The satellite identifcation
- Various dates and times
- …

It determines if minor frames contain pre-NOAA-K data or not from the satellite ID, at the first call.

It removes 2 least significant parity bits: TIP/AMSU words are 8 bits words, HRPT words are 10 bits words.

It determines if minor frames contain TIP, AMSU or backfill data.

If TIP minor frame (=if HRPT minor frame number equal to 1) :

- Extracts TIP minor frame counter and TIP major frame counter (**getmf**)
- Extracts time from TIP word in TIP minor frame number 0 (**tiptim**)
- Performs quality controls (**tipqc**)
- Calls the routine **hirget** that extracts HIRS/3 words
- If pre-NOAA-K data, calls the routine **otiget** that extracts HIRS/2 and MSU words
- Calls the routine **dcsget** that extracts DCS words
- Calls the routine **hirout** when the HIRS scan line is full
- If pre-NOAA-K data, calls the routine **msuout** when the MSU scan line is full
- Calls the routine **dcsout** when DCS data is full

If AMSU minor frame (=if HRPT minor frame number equal to 3) :

- Extracts minor frame counter to find good conditions to start
- Performs quality controls (**amsuqc**)
- Calls the routine **amsget** that extracts AMSU-A1/A2 and B (or MHS) words
- Calls the routine **amsout** when the AMSU scan line is full

If HRPT minor frames are missing, it fills arrays.

If TIP minor frame, **atovdc** extracts analog housekeeping telemetry data (**anaget**).

Finally, on completion of the **atovdc** module, separated HIRS/3 (or HIRS/4), AMSU-A, AMSU-B (or MHS) & DCS level 1a files are obtained, or HIRS/2, MSU and DCS level 1a files in case of pre-NOAA-K TIP data.

<u>TASK 3: AVHRR DECOMMUTATION TASK</u>

The module **avhrdc** performs this task, called by **hrptdc.**

It receives as input from **hrptdc**:

- an array of HRPT minor frames (in actual fact this array contains only one HRPT minor frame in this version of AAPP).
- Miscellaneous variables : The minor frame number of the orbit (=the number of the AVHRR scan line), the number of missing HRPT minor frames (=the number of missing AVHRR scan lines), the HRPT minor frame number(=1 or 2 or 3), the satellite identification, the orbit number, dates and times,…

It fills the variables for one record of the AVHRR output file (=for one AVHRR scan line) :

- Variables of the scan line information part.
- Date and time
- Quality indicators from **genqc** results.
- Variables of the telemetry data part (**avtelm**).
- Variables of the video data.
- Variables of the TIP header data part and the CPU A and B telemetry part from TIP data (**avtipg**).

It calls the routine **avhdtw** which writes the direct access AVHRR output file, corresponding to the given scan line number.

It updates the header variables in the avh1bdh common (**avhhdu**.).

<u>TASK 4: CORRECT SCAN LINE DATATION FOR LEVEL 1 B FILES</u>

(See also reference manual pages *chk1btime.1*)

The module **chk1btime** checks and corrects the scan line datation for a given level 1a file that has been processed by **atovdc**. **chk1btime** is called for HIRS, MSU, AMSU-A and AMSU-B instruments. The AVHRR (hrpt.l1b file) does not require **chk1btime** correction.

*Note that **chk1btime** can not work for NOAA level 1b file because NOAA files have missing records. AAPP ones do not have missing records because AAPP fills records when scan lines are missing.*

The error in **atovdc** is to use the same date information for all instuments. The AAPP developers have preferred to correct the files than fixing the bug in the decommutation step.

This program is dependant on 1B format structure.

It trusts the time indicated in the 1st scan line of the file.

4.1.8. EPS level 0 to AAPP level 1a conversion for METOP: DECOM-AMSUA-METOP script and AMSUA-MAIN.EXE, DECOM-MHS-METOP script and MHS-MAIN.EXE, DECOM-AMSUA-HIRS script and HIRS-MAIN.EXE, DECOM-AVHRR-METOP script and AVHRR-MAIN.EXE.

These modules are to be found in the “metop-tools” directories. Each script takes two arguments: the name of the Level 0 input file and the name of the level 1a output file.

There is a script and a binary program associated with each instrument.

Instrument	*Script*	*Binary*
HIRS	decom-hirs-metop	hirs-main.exe
AVHRR	decom-avhrr-metop	avhrr-main.exe
MHS	decom-mhs-metop	mhs-main.exe
AMSUA	decom-amsua-metop	amsua-main.exe

In order to process level 0 data, each main program implements five routines; for instance, hirs-main.c contains the definition of the following routines:

- hirs_l1b_open
- hirs_l1b_write_header
- hirs_l1b_write_record
- hirs_l1b_write_dummy
- hirs_l1b_close

Each of these routines call the Fortran routines of AAPP; we list here what those routines are for each instrument:

	AVHRR	*HIRS*	*MHS*	*AMSUA*
l1b_open	Fortran open	Fortran open	Fortran open	Fortran open
l1b_write_header	avhhdw	hrshdw	mhshdw	amahdw
l1b_write_record	avhrdc	hirout	amsout	amsout
l1b_write_dummy	avhrdc	hirout	amsout	amsout
l1b_close	Fortran close	Fortran close	Fortran close	Fortran close

In common-main.c, the main loop for level 0 processing is implemented (subroutine common_loop). This processing loop is used for AVHRR, HIRS and MHS. AMSUA data processing requires its own loop, because of the two sub-instruments AMSUA1 and AMSUA2.

The processing loop reads level 0 data using the library libeps_metopl0 and passes instrument data packets to AAPP using the five routines described above.

CCSDS packets are decoded using libccsds, and UTC time is computed from OBT using libobtutc.

AAPP libf7tp and libsatid are used too.

4.1.9. Convert chrpt (FY1c and FY1d satellites)) to hrpt (NOAA satellites): convert_chrpt script and convert_chrpt.exe

These modules are to be found in the “AAPP/src/decommutation/bin” directories.
The aim is to convert CHRPT data from FY1 satellite to a form that is compatible with NOAA HRPT, taking just the AVHRR-like channels. Output can be fed into the AAPP decommutation routine. Some dummy TIP data are created in order to satisfy the AAPP error checks. Also some of the variables (target temps and warm cal counts) are stored in non-standard locations in the output file.

The input frame length is 27740 bytes at the Met Office. May be different for other receiver manufacturers. This represents 22180 10-bit words when unpacked. Alternatively, the script can accept an input file that has already been unpacked into 16-bit words.

Usage of the script:
convert_chrpt [-u] infile outfile day_of_year
with –u option for unpacked input

For details, see inside convert_chrpt.F file

4.1.10. Image navigation modules: HIRSCL script and HIRSCL.EXE, HIRSCL_ALGOV4 script and HIRSCL_ALGOV4.EXE, MSUCL script and MSUCL.exe, AMSUACL script and AMSUACL.EXE, AMSUBCL script and AMSUBCL.EXE, MHSCL script and MHSCL.EXE, AVHRCL script and AVHRCL.EXE.

(See also reference manual pages: *libnavnoaa.3*, *libnavtool.3, libsatid.3* and detailed navigation equations in [17])

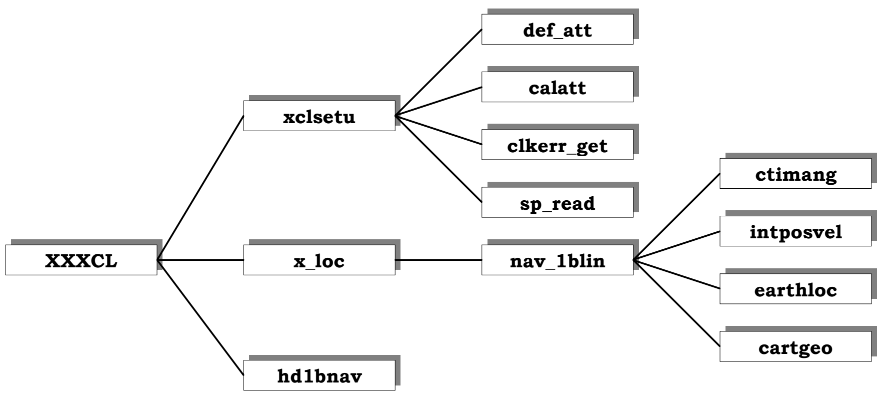


Figure 4-10 : general flow chart on the location module components : HIRSCL/MSUCL/AMSUnCL/MHSCL/AVHRCL

The image navigation converts the line and pixel into latitude and longitude for any pixel of the image. The task needs files: the level 1a file of the considered instrument, the SATPOS file, the CLOCK ERROR file. Modules are called for the different tasks.

TASK 1 : INITIALISATION

hclin/hclin_algoV4/mclin/amaclin/ambclin/mhsclin/avhclin get logical units of the files.

hclsetu/mclsetu/amasetu/amsubsetu/mhssetu/avhsetu :

- Open and read the level 1a file.
- Open the SATPOS file.
- **sp_read** reads the SATPOS file and tests if the input starting time is included into the SATPOS file, and if the satellite Id and memory are correct.
- If input attitude is missing, call **def_att** that returns the default attitudes value. Those values depend on satellite (see satid file).
- Open the CLOCK ERROR file.
- Call **calatt** that calculates the attitude error matrix for small yaw, roll and pitch angles. This matrix is allowed to change the reference: local orbital coordinates (Rv) (x: satellite vertical, y: normal to x and z, z: normal to x and to velocity vector) / coordinates (Rs) linked to the spacecraft structure.
- Get clock error data if the level 1a has not already been taken into account in level 1a (**clkerr_get**)
- Initialise navigation parameters.

TASK 2: CALCULATION OF THE IMAGE NAVIGATION PARAMETERS

h_loc/m_loc/ama_loc/amb_loc/mhs_loc check if the clock error has already been applied. If not applied, the time and clock flag control of every line of data are modified and updated for level 1b. They call the routine **nav_l1blin**.

nav_1blin computes the navigation variables of the level 1b, for one scanning line and for one instrument number. It calls the following routines and functions: **genattid**, **lptoviewvect, intposvel, snagre, earthpix**. All information on default attitude, misalignment and description of instruments scanning functions is stored in a satellite identification file (see satid.5 libsatid.3)

genscid and **genattid** returns the nominal attitude mode of the satellite. The different attitude modes that can be considered are:

local normal pointing mode

yaw steering mode

geocentric mode

lptoviewvect converts the line and pixel numbers into the viewed vector sm_{RS} in the spacecraft fixed reference frame Rs. (see [17] §4) This routines takes into account the scanning geometry of the instrument.

intposvel interpolates (a 3 order polynomial interpolation) the satellite position and (relative) velocity in Greenwich reference frame in the SATPOS file, for a given pixel time. This time is included into a [t2,t3] interval of which position and velocity are referenced into SATPOS. These 2 points are used as reference for the polynomial coefficients calculation. The orbit number is also determined for a given pixel. For ATOVS sounders, satellite position is recalculated for every pixel of each scan line. On the contrary, for AVHRR image data (HRPT, GAC), position is computed only for each scan line (assuming that the scanning of a line is instantaneous compared to the satellite velocity).

snagre calculates the conversion matrix between Earth fixed Greenwich reference frame Rg and nominal attitude reference frame Ra.

earthpix calculates the cartesian coordinates sm_{RG} in the Greenwich reference frame of the viewed pixel sm_{RS} detailled explaination is given in [17] § 5.

cartlalo converts cartesian coordinates sm_{RS} into latitude-longitude on the earth surface (i.e. altitude = 0)

zenazi calculates the zenith angle, azimut angle and distance of the spacecraft from the viewed point on the earth surface detailled explaination is given in [17] § 6.

sungrw calculates the sun position in Greenwich reference frame

zenazi calculates the zenith angle, azimut angle and distance of the sun from the viewed point on the earth surface.

After **nav_1blin** sets bit flags for variables of the level 1B file, does the conversions for the level 1B units. It computes the satellite altitude (in km*10) by calling **cartgeog** that converts (with iterations) cartesian coordinates (Rg) into geographic coordinates (lat/lon/alt). Satellite altitude is determined from the last computed position.

TASK 3: RESULTS UPDATING

h_loc updates navigation parameters and quality controls within the level 1b file.
hd1bnav updates navigation parameters within the level 1b file.

4.1.11. HIRS calibration modules (first algorithm): HIRSCL script and HIRSCL.EXE

(See also reference manual pages: *libhrscal.3*)

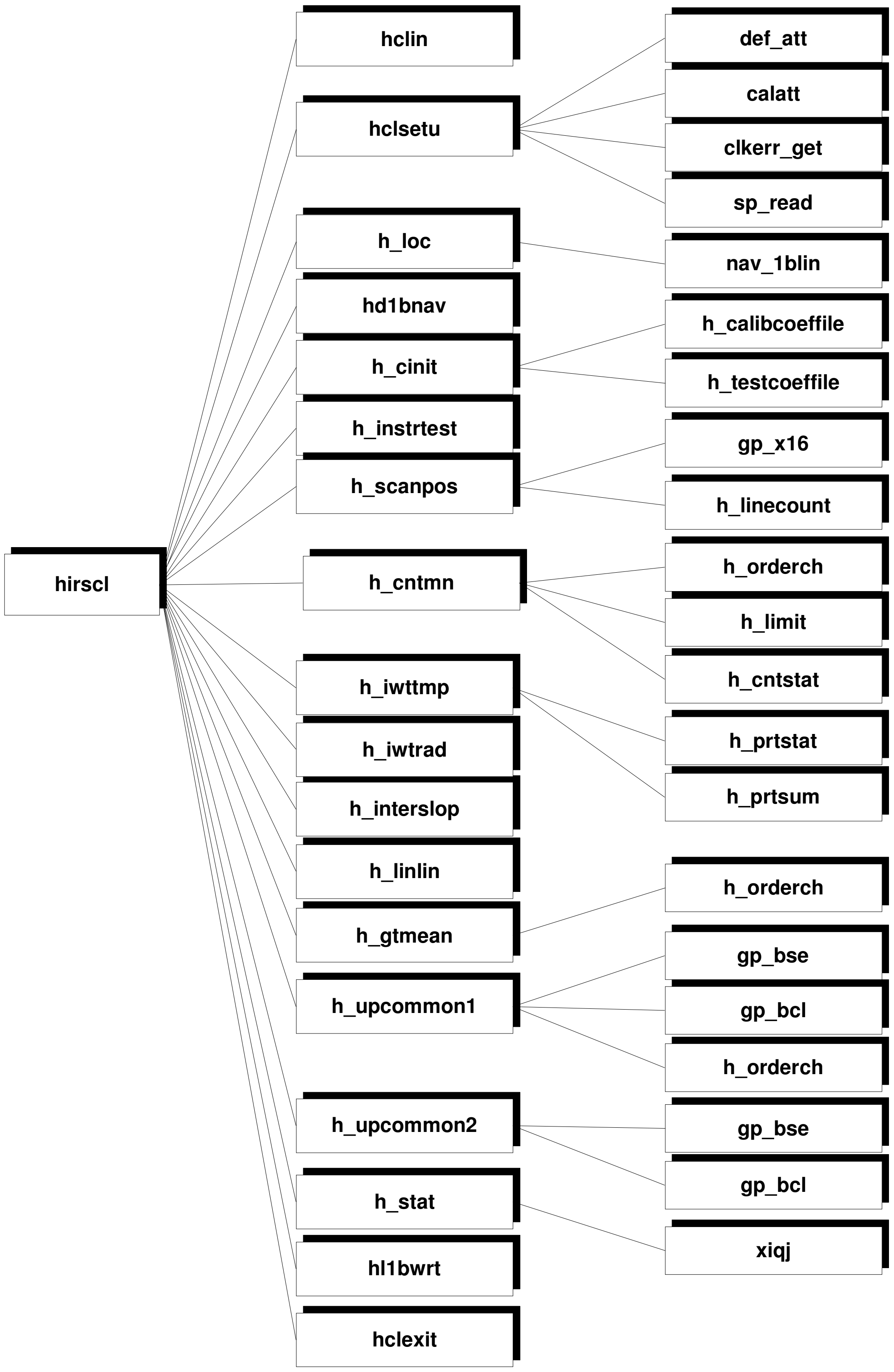


Figure 4-11 : Flow chart on the HIRSCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires HIRS level 1a, *calcoef.dat* and *testcoef.dat* resource files.

TASK 1: INITIALISATION

The user chooses his input options (script **hirscl** and **hclin).**

The main program is **hirscl** that calls many routines:

hclin reads the input options (tests some options coherence) and stores them into a table.

hclsetu opens the log/debug file *hirscl.log* if requested. It opens and reads the HIRS level 1a file (the data are ranged in commons *hrs1bhd* (include *hrs1bhd.h*, header), *hrs1bdts* (include *hrs1bdts*, data)).

h_cinit identifies the satellite. Then it calls **h_calibcoeffile** to open, read and close the *calcoef.dat* file containing the useful satellite specific parameters for calibration. The data are ranged in common *hrs_clcf* (include *cinit.h*). h_cinit by calling **h_testcoeffile,** opens, reads and closes the *testcoef.dat* file containing useful values and parameters for tests. The data are ranged in the common *hrs_tstcf* (include *cinit.h*). h_cinit opens the statistic file (if requested). A control quality parameter array is initialised and will be modified by the tests performed during the calibration processing. The satellite is identified.

h_instrtest checks the instrument status to define which scan line are usable (the first and the last usable lines). The control quality parameters array is updated.

TASK 2: CALIBRATION COEFFICIENTS CALCULATION

The result of this task is a calibration coefficient array (*calibcoef*) for each sounding channel and each scan line. **HIRSCL** calls many routines:

h_scanpos, for each scan line of each channel, checks the 56 encoder positions (quality bit 31 is checked), and keeps the numbers of lines of the calibration cycles (space lines array: *splintab* and internal warm target array: *iwtlintab*). h_scanpos checks if the calibration cycle is full or not and sets up the variable *calib* (number of calibration cycle full). If *calib* equals zero, processing goes directly to the task 3.

h_cntmn, for each calibration cycle of the orbit (for each space and internal warm target lines registered during an orbit) and for each channel, filters numerical counts (CN) and computes the CN mean. Those values are stored in arrays : *spcntmn* (space) and i*wtcntmn* (internal warm target).

h_iwttmp, for each calibration cycle, calculates the internal warm target (IWT) temperature. It computes the mean of a sample of PRT reading from the internal warm target scan line and from a specified number of scan lines before the IWT scan line and another specified number of scan lines after the IWT scan line. h_iwttmp tests the difference between the maximum PRT readings value and the minimum one which must be inferior to a limit before being used in the mean calculation. PRT readings means are converted to temperatures. The final IWT temperature is computed by averaging the temperature from the 4 individual active PRTs (array *iwttmp*). The quality control parameters array is updated.

h_iwtrad converts the IWT temperature (array *iwtrad*) (using the Planck function, applying bands correction) for each channel and each calibration cycle.

h_interslop for each calibration cycle and each channel, computes gain G and offset I (residual radiance equivalent to the space background noise viewed through the instrument channel) (array *calibcoef0*). The coefficients of the visible channel are not measured in flight. A third coefficient (order 2) is also designed for the calculation in addition to G and I. It is equal to zero for the moment and so it is not yet used.

h_linlin for each channel and each Earth viewing scan line, computes the (G,I) pairs (array *calibcoef*) by linear interpolation between 2 pairs of coefficients (G,I) calculated for 2 consecutive calibration cycles. For Earth viewing registered before the first calibration cycle there is no interpolation, coefficients of the first calibration cycle are directly applied. For Earth viewing registered after the last calibration cycle there is no interpolation, coefficients of the last calibration cycle are directly applied. The quality control parameters array is updated.

h_gtmean for each channel, computes the mean (array *calibcoefmn*) and the standard deviation (array *calibcoefstd*) of the coefficients (G,I). The header is updated in the level1b file.

TASK 3: RESULTS UPDATING

The result of this task is an update of calibration coefficients, and quality control parameters in the HIRS level 1b resource file. According to input options, statistics results are stored into the file *monhirs.txt*, and the log/debug file is updated.

h_upcommon1 or **h_upcommon2** finish updating the parameters in the commons *hrs1bhd*, and *hrs1bdts* (h_upcommon2 is called when there is no calibration).

h_stat computes final statistic of the HIRS calibration and writes the results into the statistic file, and then closes the file (according to input options).

hl1bwrt updates header and data in the HIRS level1b file.

hclexit close the log/debug file and the HIRS level1b file.

4.1.12. HIRS calibration modules (algorithm version 4): HCALCB1_ALGOV4 script and HCALCB1_ALGOV4.EXE, HIRSCL_ALGOV4 script and HIRSCL_ALGOV4.EXE

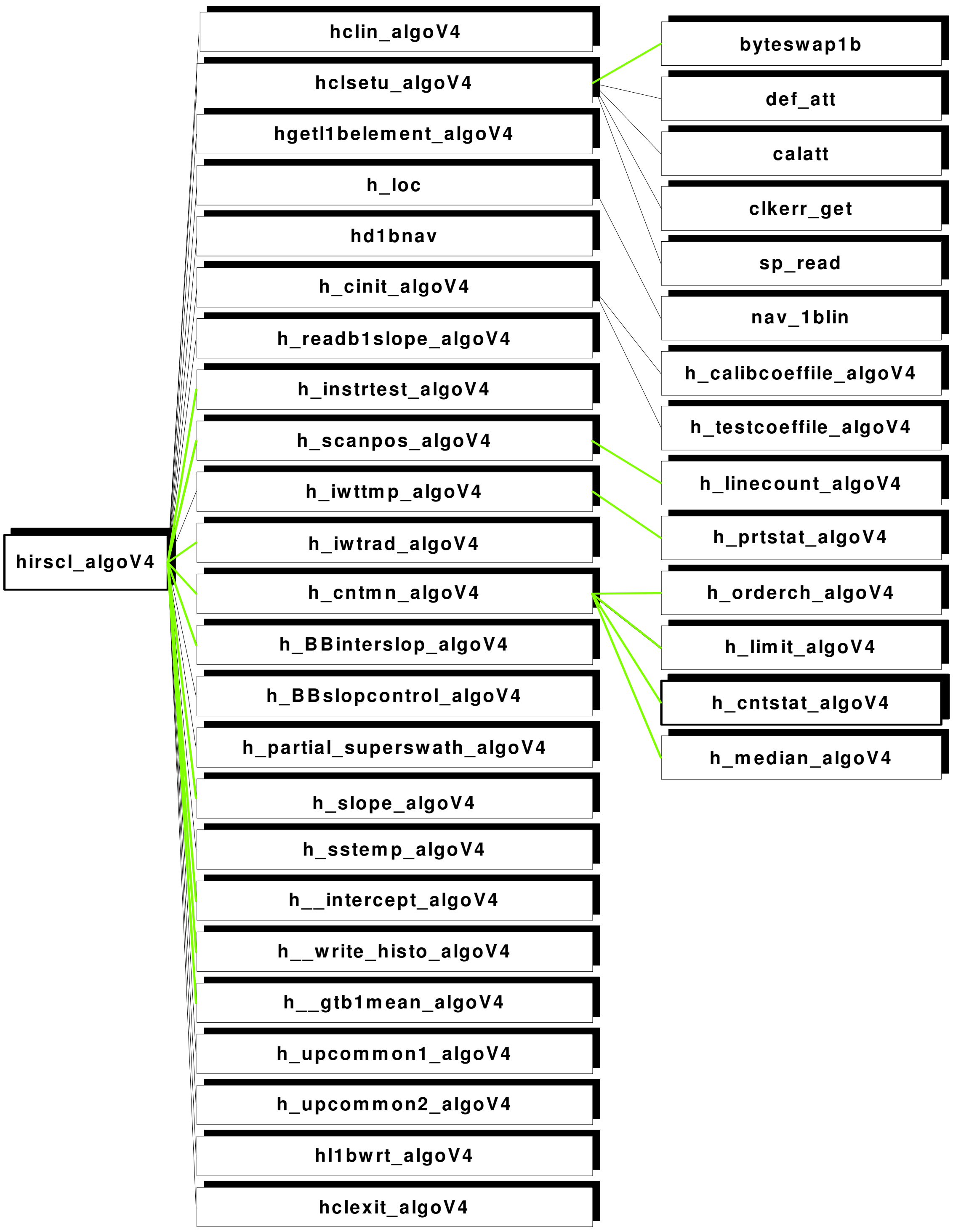


Figure 4-12 : Flow chart on the HIRSCL_ALGOV4 module components.

To simplify the diagram, the calls to subroutines or functions of the **libf7ml, libsatid, libf7gp, libf7tp** libraries have not been written

This version of the HIRS calibration doesn't work for the pre-NOAA-K satellites.

hirscl_algoV4 requires HIRS level 1a, *calcoef_algoV4.dat*, *testcoef_algoV4.dat* and *hirs_b1aslope.txt* resource files.

TASK 1: CREATE THE HIRS_B1ASLOPE.TXT FILE

The user chooses a reference date/time, a number of hours and the B1 coefficients and the average slopes will be computed using data of the period defined by [(the reference date/time – the number of hours) – (the reference date/time)]. The reference date/time is the input arguments of the script **hcalcb1_algoV4**. Note that **AAPP_RUN** calls the script **hcalcb1_algoV4** with the date/time of the current orbit. The number of hours is defined in **ATOVS_ENV**.

An other option is defined by the user in **ATOVS_ENV: HCALIB_B1ASLOP_FLAG**

(=0 if the user doesn't want to have the time taken into account to define the period; =1 if the user want to have the time (hours/minutes) taken into account to define the period).

The main program **hcalcb1_algoV4.exe** requires a hirs historic file. If the file doesn't exist, **hcalcb1_algoV4** creates it, it will be empty.

hcalcb1_algoV4.exe calls the routine **h_calcb1_algoV4** that reads the hirs_historic file (call to the routine **h_read_histo_algoV4)** and does the computations (call to the routines **moy_rms**, **reglin**).

hcalcb1_algoV4.exe manages the openings/writings/closings of the different files.

TASK 2: INITIALISATION

The script **hirscl_algoV4** must run with the argument "–c" for doing the calibration task (see **AAPP_RUN**).

The main program is **hirscl_algoV4.exe** that calls many routines:

hclin_algoV4 reads the input options (tests some options coherence) and stores them into a table.

hclsetu_algoV4 opens the log/debug file *hirscl.log* if requested. It opens and reads the HIRS level 1a file.

hgetl1belement_algoV4 gets the elements of the HIRS level 1b commons that are useful for the calibration task.

h_cinit_algoV4 identifies the satellite. Then it calls **h_calibcoeffile_algoV4** to open, read and close the *calcoef_algoV4.dat* file containing the useful satellite specific parameters for calibration. By calling **h_testcoeffile_algoV4,** it opens, reads and closes the *testcoef_algoV4.dat* file containing useful values and parameters for tests. It initializes the elements in the includes that will be updated during the calibration task.

h_readb1slope_algoV4 opens/closes and reads the 'b1/average slope' file to get the b1 values and the average slopes that will be used in the process.

h_instrtest_algoV4 checks the instrument status to define which scan line are usable (the first and the last usable lines). The control quality array of scan lines is updated.

TASK 3: CALIBRATION COEFFICIENTS CALCULATION

The result of this task is a calibration coefficient array (*calibcoef*) for each sounding channel and each scan line. **hirscl_algoV4** calls many routines:

h_scanpos_algoV4, for each scan line, checks the quality bit 31, the 56 encoder positions and the line counts. It keeps the numbers of lines of the calibration cycles (space lines array: *splintab* and internal warm target array: *iwtlintab*). It also checks if the calibration cycle is full or not, checks if one calibration cycle and the previous one are well separated by 40 scan lines, and sets up the variable *calib* (number of calibration cycle full). If *calib* equals zero, processing goes directly to the task 3.

h_iwttmp_algoV4, for each calibration cycle, calculates the internal warm target (IWT) temperature: For each individual active PRT, it gets a sample of PRT readings from the internal warm target scan line and from a specified number of scan lines before the IWT scan line and another specified number of scan lines after the IWT scan line. h_iwttmp_algoV4 tests the PRT readings before being used in the mean calculation. The mean of the PRT readings is converted to temperature. The final IWT temperature is computed by averaging the temperatures from the 4 (5 for NOAA-N) individual active PRTs (array *iwttmp*). The quality control parameters array is updated.

h_iwtrad_algoV4 converts the IWT temperatures into radiances (array *iwtrad*) (using the Planck function, applying bands correction) for each channel and each calibration cycle.

h_cntmn_algoV4, for each calibration cycle of the orbit (for each space and internal warm target lines registered during an orbit) and for each channel, filters numerical counts (CN) and computes the CN mean. Those values are stored in arrays : *spcntmn* (space) and i*wtcntmn* (internal warm target).

h_BBinterslop for each calibration cycle and each channel, computes the Black Body (BB) (or raw) slope (auto coefficient 1), the BB (or raw) intercept (auto coefficient 0) and third coefficient (auto coefficient 2) that is equal at zero for the moment (array *calibcoef0*). The coefficients of the visible channel are not measured in flight.

h_BBslopcontrol controls the quality of the Bbslopes.

h_partial_superswath_algoV4 determines the calib cycles which will be involved in the calculation of average slope for each superswath or partial superswath.

h_slope_algoV4 computes the calibration slopes for each channel and for each Earth view scan line.

h_sttemp_algoV4 computes the Second Telescope Temperature for all lines.

h_intercept_algoV4 computes the intercept for each channel and for each Earth view line.

TASK 4: RESULTS UPDATING

The result of this task is an update of calibration coefficients, and quality control parameters in the HIRS level 1b resource file.

h_write_histo_algoV4 stores calibration information of all calibration cycles in the hirs_ historic ASCII file.

h_gtb1mean_algoV4 computes the means and the standard deviations of the b1 coefficients of all the lines.

h_upcommon1_algoV4 or **h_upcommon2_algoV4** finish updating the parameters in the commons *hrs1bhd*, and *hrs1bdts* (h_upcommon2_algoV4 is called when there is only one or zero calibration cycle).

hl1bwrt_algoV4 updates header and data in the HIRS level1b file.

hclexit_algoV4 closes the log/debug file and the HIRS level1b file.

4.1.13. MSU calibration modules: MSUCL script and MSUCL.EXE

(See also reference manual pages: *libmsucal.3*)

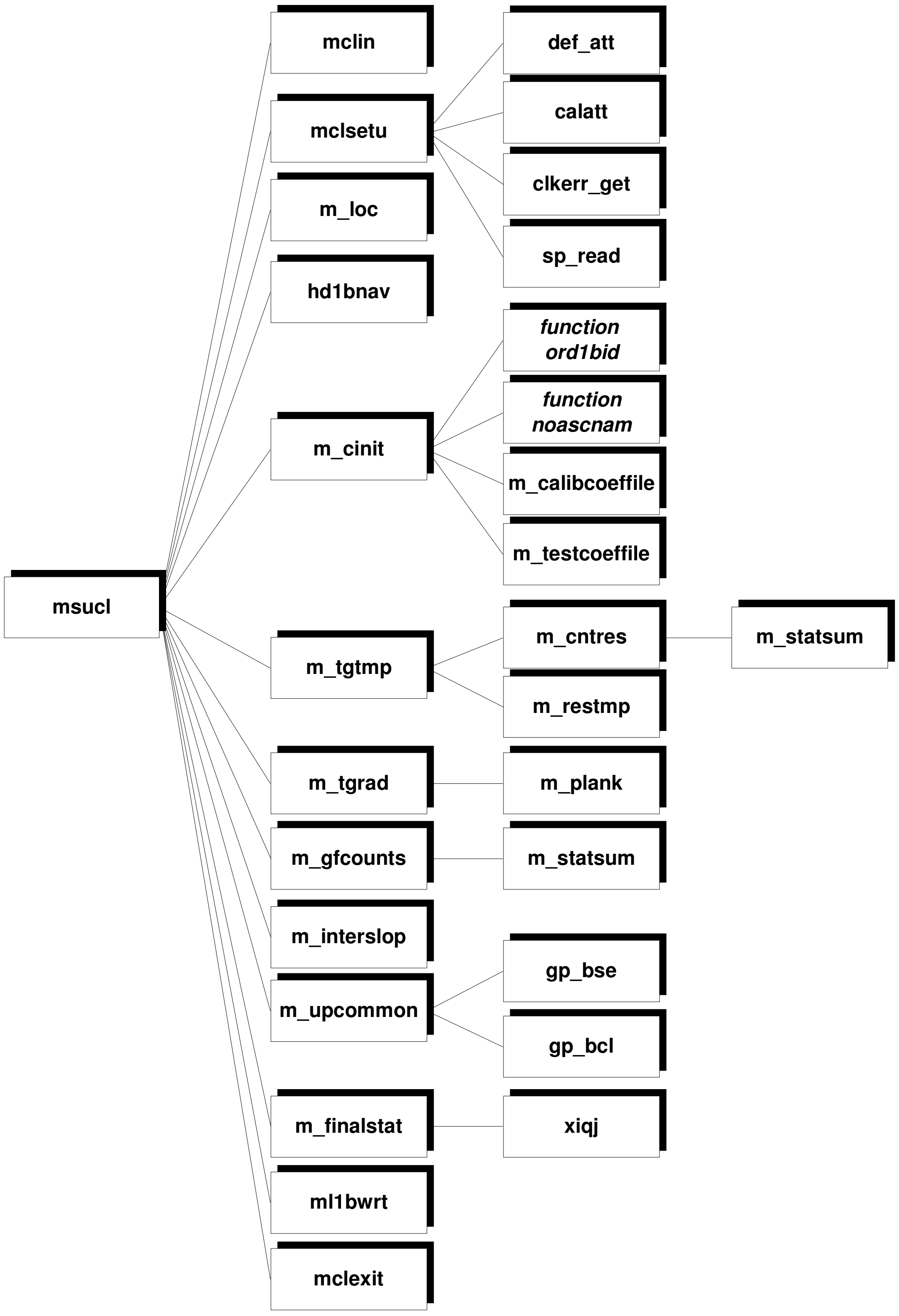


Figure 4-13 : Flow chart on the MSUCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires MSU level 1a, *calcoef.dat* and *testcoef.dat* resource files .

TASK 1: INITIALISATION

The user chooses his input options (script **msucl** and **mclin).**

The main program is **MSUCL** that calls many routines:

mclin reads the input options (tests some options coherence) and stores them in a table.

mclsetu opens the log/debug file *muscl.log* if requested. It opens and reads the MSU level 1a file msul1b (the data are ranged in commons *msu1bhd* (header), *msu1bdts*(data)).

m_cinit opens, reads and closes (**m_calibcoeffile**) the *calcoef.dat* file containing the useful satellite specific parameters for calibration. The data are ranged in common *msu_clcf* (include *mcinit.h*). m_cinit opens, reads and closes (**m_testcoeffile**) the *testcoef.dat* file containing useful values and parameters for tests. The data are ranged in the common *msu_tstcf* (include *mcinit.h*). m_cinit opens the statistic file (if requested). Two control quality parameters arrays are updated.

TASK 2: CALIBRATION COEFFICIENTS CALCULATION

The result of this task is two calibration coefficient arrays (slope, intercept) for each sounding channel. **msucl** calls many routines:

m_tgtmp, for each scan line, computes target 1 temperature and target 2 temperature, which are derived respectively from PRT 1A, 1B counts. Target 1 is viewed by channels 1 and 2, target 2 is viewed by channels 3 and 4.

To convert PRT count to temperature requires two steps :

- Convert count to resistance (call **m_cntres**)
- Convert resistance to temperature (call **m_restmp**)

Conversion parameters are tabulated in the *calcoef.dat* file. m_tgtmp tests the low (*tcallo*) and high (*tcalli*) values of the electronic reference points and sets a flag if values are out of limits. It tests the temperature calculated with a reference. If the difference is higher than a threshold value, then reference temperature is kept. Final temperature of each IWT is the mean of the two associated PRT temperatures (arrays *tg1* and *tg2*). Two control quality parameters arrays are updated.

m_tgrad, for each scan line, converts the target 1 temperature into radiance for MSU channels 1 and 2 (array *tgrad*) (apply Planck function). Same for the target 2 temperature but for the MSU channels 3 and 4.

m_gfcounts, for each scan line of each channel, applies the non linearity coefficients on the space view output counts and the target output counts. m_gfcounts applies a filter (abs(count - averaged count) compared to (2*standard deviation)) to eliminate counts out of limits. Different parameters are stored in the statistic file (if requested). Array 2 of quality control parameters is updated.

m_interslop, for each calibration cycle and each channel, computes the gain G and the offset I (residual radiance equivalent to the space background noise viewed through the instrument channel). The coefficients used afterwards (arrays slope and intercept), are averaged pairs (G,I) coming from the calculation of the mean of the (G,I) values associated to each scan line and each channel during an orbit.

TASK 3: RESULTS UPDATING

The result of this task is an update of the calibration coefficients and the quality control parameters in the MSU level 1b resource file. According to input options, statistics results are stored into the file *monmsu.txt*, and a log/debug file is updated.

m_upcommon updates the commons *msu1bhd* and *msu1bdts*.

m_finalstat computes the final statistic of the MSU calibration and writes the results into the statistic file, and then closes the file (according to input options).

ml1bwrt updates header and data in the MSU level 1b file.

mclexit close the log/debug file and the MSU level 1b file.

4.1.14. AMSU-A calibration modules : AMSUACL script and AMSUACL.EXE.

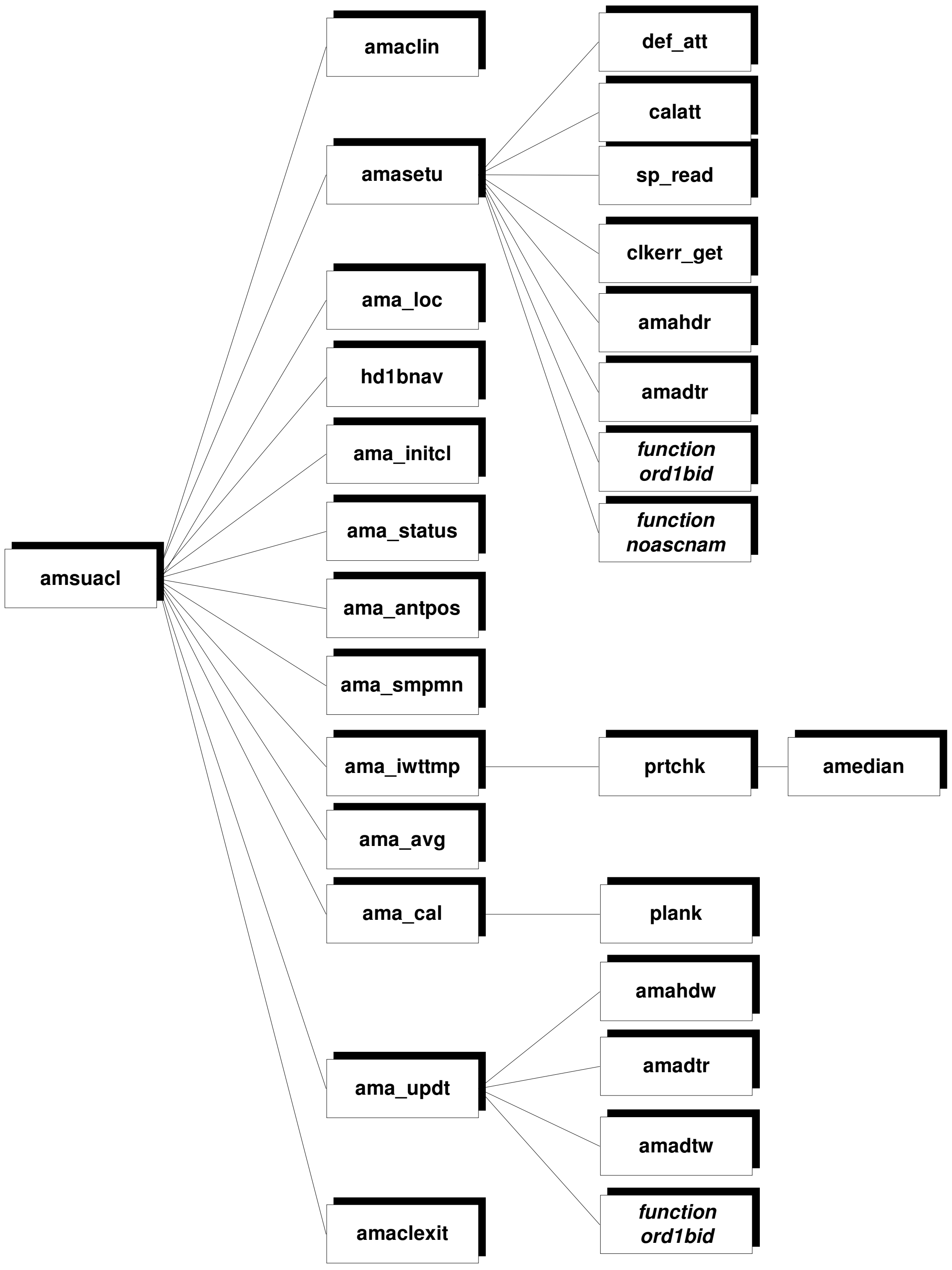


Figure 4-14 : Flow chart on the AMSUCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires the AMSU-A level 1a, *amsua_clcoefs.dat* and *amsua_clparams.dat* resource files.

TASK 1: INITIALISATION

The user chooses his input options (script **amsuacl** and **amaclin).**

The main program is **AMSUACL** that calls many routines:

amaclin reads the input options and stores them in a table.

amasetu opens the log/debug file *amsuacl.log* and the statistic file *monamsua.txt* (if requested). It opens and reads the AMSUA level 1a file (the data are ranged in commons *ama_1bhd* (include *ama1b.h*, header), and scan (include *amascn.h*, data). amasetu checks the satellite Id and data, and then set some control flags.

ama_initcl opens, reads and closes the *amsua_clparams.dat* file containing the useful parameters for calibration. The data are arranged in the common *ama_clcoef* (include *ama_cinit.h*). ama_initcl opens, reads and closes the *amsua_clcoefs.dat* file containing the values of the secondary calibration coefficients. The data are arranged in the common *ama_tstcf* (include *ama_cinit.h*). Quality control flags are updated.

ama_status determines if the instrument is OK and sets flags according to the results : checks scan lines quality, checks space viewing antenna positions, checks calibration counts and channels. If not OK, calibration coefficients are not computed for the bad scan line, but will be replaced by secondary coefficients (*amsua_clcoefs.dat*).

TASK 2: CALIBRATION COEFFICIENTS CALCULATION

The results of this task is the primary calibration coefficient for each sounding channel.

ama_antpos checks if the antenna pointing of the AMSU Earth view is not outside of the specified threshold.

ama_smpmn gets CN samples and computes the mean. For each channel and each scan line, these averaged values are stored in the arrays *spmean* (space) and *itmean* (ITW). Quality control flags are updated.

ama_iwttmp, for each scan line, converts PRT counts to temperature for IWT and instruments. Final temperature of each IWT is a weighted average of the temperatures extracted from their associated PRT. Arrays of averaged temperatures *targ_temp* and *inst_temp* are filled. Quality control flags are updated.

ama_avg computes mean counts for space and IWT. Averaging is performed on several consecutive lines for each channel. These mean values fill arrays *spavg* (space) and *itavg* (IWT). Quality control flags are updated.

ama_cal, for each line and each channel, computes calibration coefficients from space and IWT data: performs temperature/radiance conversion, deduces primary calibration coefficients (*a0,a1,a2*). Primary and secondary coefficients (*u0,u1,u2*) are stored in the commons *ama_1bhd* and *scan*. The quality control flags are updated.

TASK 3 : RESULTS UPDATING

The result of this task is an update of calibration coefficients and quality control parameters, in the AMSU-A level 1b resource file.

According to input options, statistics results are stored into the stat file and a log/debug file is updated.

ama_updt updates header and data in the AMSU-A level 1b.

amaclexit closes the log/debug file and the AMSU-A level 1b file

.

4.1.15. AMSU-B calibration modules: AMSUBCL script and AMSUBCL.EXE.

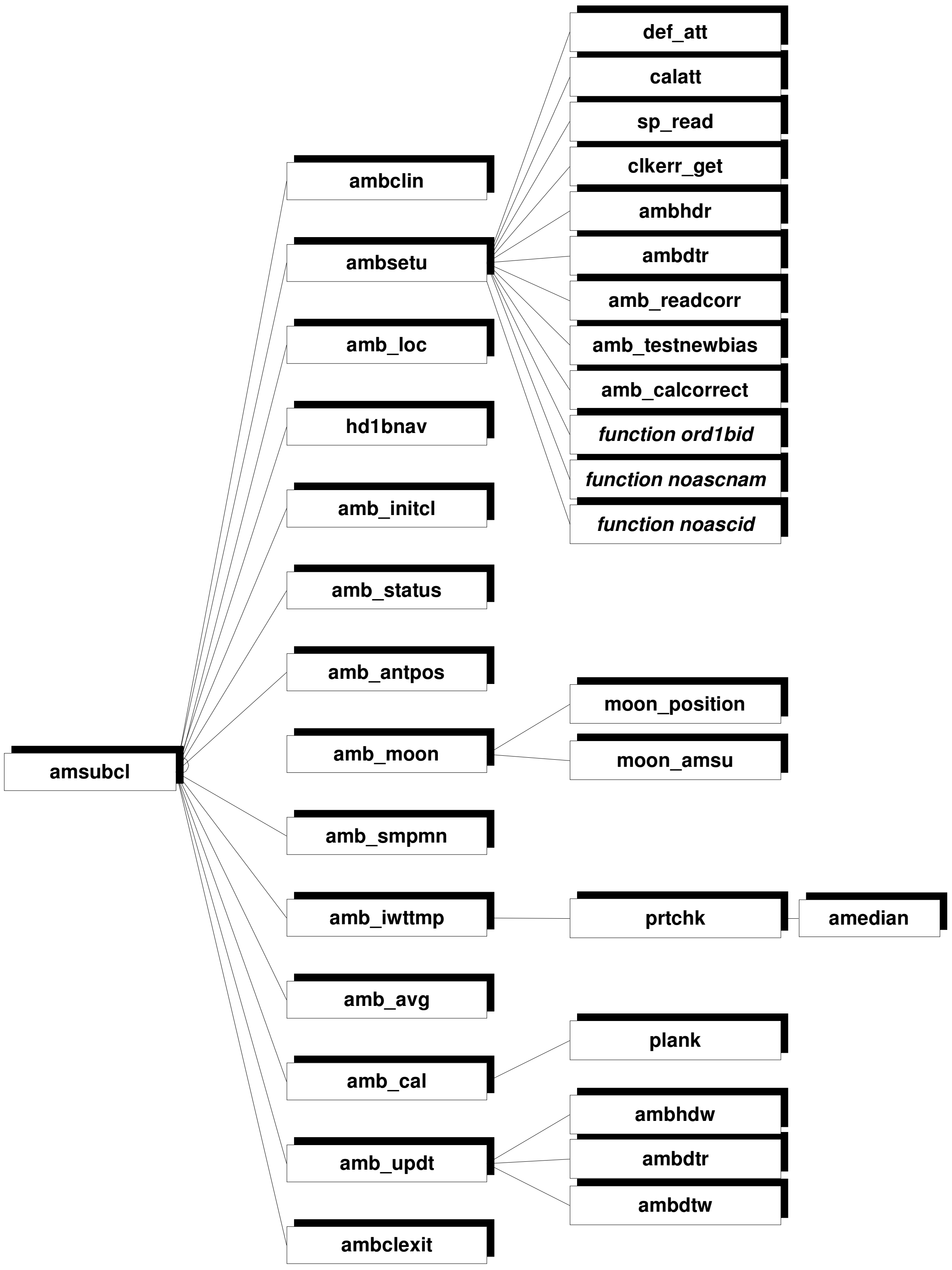


Figure 4-15 : Flow chart on the AMSUBCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires the AMSU-B level 1a, *amsub_clcoefs.dat*, *amsub_clparams.dat* and *amsub_bias.dat* resource files .

TASK 1: INITIALISATION

The user chooses his input options (script **amsubcl** and **ambclin).**

The main program is **AMSUBCL** that calls many routines:

ambclin reads the input options and stores them in a table.

ambsetu opens the log/debug file *amsubcl.log* and the statistic file *monamsub.txt* (if requested). It opens and reads the AMSU-B level 1a file (the data are ranged in commons *amb_1bhd* (include *amb1b.h*, header), and scan (include *ambscn.h*, data). ambsetu calls **amb_readcorr** to read bias correction tables and stores in level 1b header. It calls **amb_testnewbias** to detect presence of AMSU-B anomalous bias due to moding of STX-1 transmitter**.** Then, it calls **amb_calcorrect** to correct AMSU-B space and target counts for bias errors. ambsetu checks the satellite Id and data, and then sets some control flags.

amb_initcl opens, reads and closes the *amsub_clparams.dat* file containing the useful parameters for calibration. The data are arranged in the common *amb_clcoef* (include *amb_cinit.h*). amb_initcl opens, reads and closes the *amsub_clcoefs.dat* file containing the values of the secondary calibration coefficients. The data are arranged in the common *amb_tstcf* (include *amb_cinit.h*). Quality control flags are updated.

amb_status determines if the instrument is OK and sets flags according to the results : checks scan lines quality, checks space viewing antenna positions, checks calibration counts and channels. If not OK, calibration coefficients are not computed for the bad scan line, but will be replaced by secondary coefficients (*amsub_clcoefs.dat*).

TASK 2 : CALIBRATION COEFFICIENTS CALCULATION

The result of this task is the primary calibration coefficient for each sounding channel.

amb_antpos checks if the antenna pointing of the AMSU Earth view is not outside of the specified threshold.

amb_moon calculates the angles between the Moon and the AMSU-B space views for all scans, based on astronomical formulae.

amb_smpmn gets calibration samples and computes the mean. If any of the space samples are within a pre-defined angle to the Moon, they are excluded from the mean. For each channel and each scan line, these averaged values are stored in the arrays *spmean* (space) and *itmean* (ITW). Quality control flags are updated.

amb_iwttmp, for each scan line, converts PRT counts to temperature for IWT and instruments. Final temperature of each IWT is a weighted average of the temperatures extracted from their associated PRT. Arrays of averaged temperatures *targ_temp* and *inst_temp* are filled. Quality control flags are updated.

amb_avg computes mean counts for space and IWT. Averaging is performed on several consecutive lines for each channel. These mean values fill arrays *spavg* (space) and *itavg* (IWT). Quality control flags are updated.

amb_cal, for each line and each channel, computes calibration coefficients from space and IWT data: performs temperature/radiance conversion, deduces primary calibration coefficients (*a0,a1,a2*). Primary and secondary coefficients (*u0,u1,u2*) are stored in the commons *amb_1bhd* and *scan.* The quality control flags are updated.

TASK 3 : RESULTS UPDATING

The result of this task is an update of calibration coefficients and quality control parameters, in the AMSU-B level 1b resource file. According to input options, statistics results are stored into the stat file and a log/debug file is updated.

amb_updt updates header and data in the AMSU-B level 1b.

ambclexit closes the log/debug file and the AMSU-B level 1b file.

4.1.16. MHS calibration modules: MHSCL script and MHSCL.EXE.

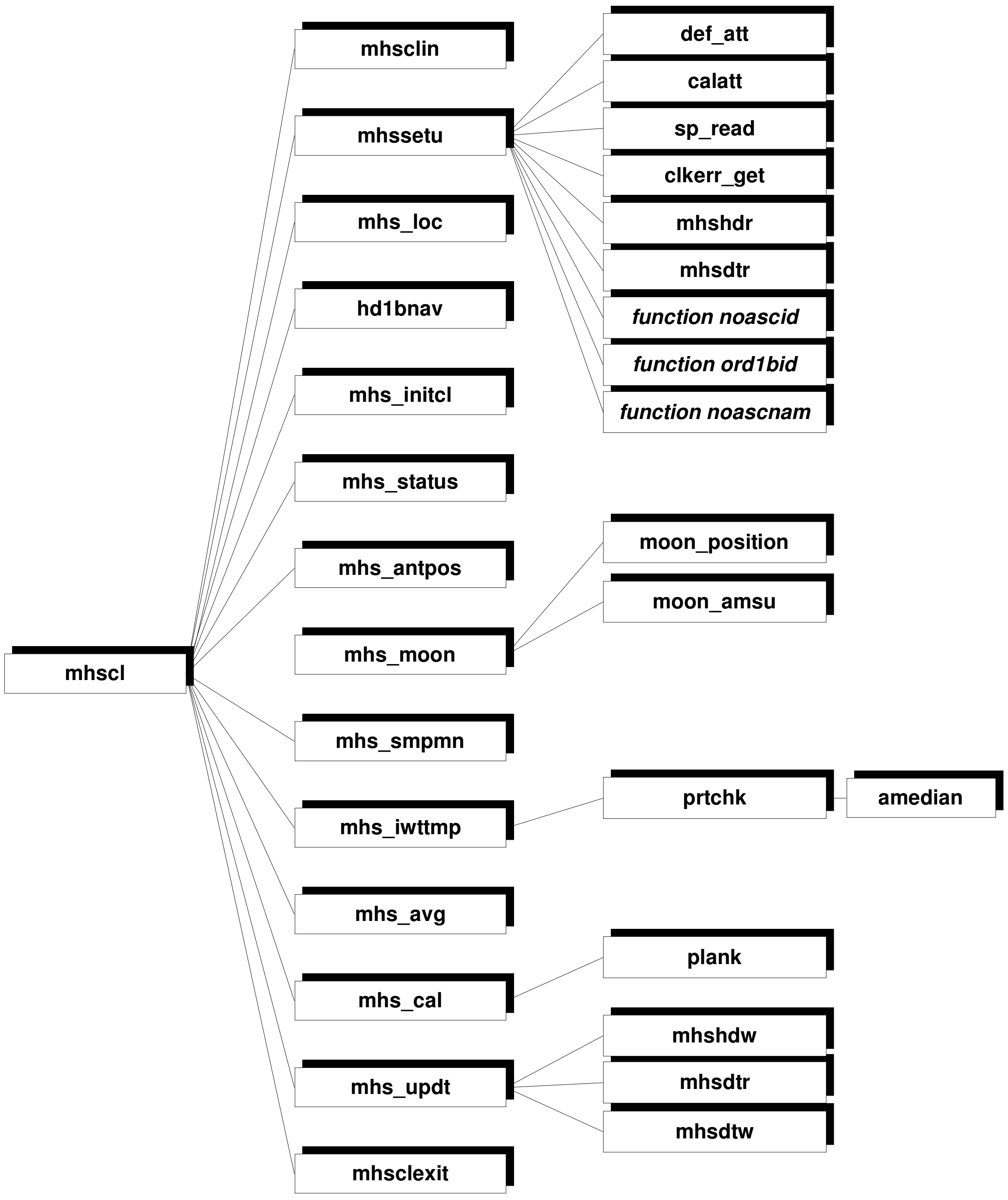


Figure 4-16 : Flow chart on the AMSUBCL and MHSCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires the MHS level 1a, *mhs_clcoefs.dat* and, *mhs_clparams.dat* resource files.

TASK 1: INITIALISATION

The user chooses his input options (script **mhscl** and **mhsclin).**

The main program is **MHSCL** that calls many routines:

mhsclin reads the input options and stores them in a table.

mhssetu opens the log/debug file *mhscl.log* and the statistic file *monmhs.txt* (if requested). It opens and reads the MHS level 1a file (the data are ranged in commons *mhs_1bhd* (include *mhs1b.h*, header), and scan (include *mhsscn.h*, data). mhssetu checks the satellite Id and data, and then sets some control flags.

mhs_initcl opens, reads and closes the *mhs_clparams.dat* file containing the useful parameters for calibration. The data are arranged in the common *mhs_clcoef* (include *mhs_cinit.h*). mhs_initcl opens, reads and closes the *mhs_clcoefs.dat* file containing the values of the secondary calibration coefficients. The data are arranged in the common *mhs_tstcf* (include *mhs_cinit.h*). Quality control flags are updated.

mhs_status determines if the instrument is OK and sets flags according to the results : checks scan lines quality, checks space viewing antenna positions, checks calibration counts and channels. If not OK, calibration coefficients are not computed for the bad scan line.

TASK 2 : CALIBRATION COEFFICIENTS CALCULATION

The result of this task is the primary calibration coefficient for each sounding channel.

mhs_antpos checks if the antenna pointing of the AMSU Earth view is not outside of the specified threshold.

mhs_moon calculates the angles between the Moon and the MHS space views for all scans, based on astronomical formulae.

mhs_smpmn gets calibration samples and computes the mean. If any of the space samples are within a pre-defined angle to the Moon, they are excluded from the mean. For each channel and each scan line, these averaged values are stored in the arrays *spmean* (space) and *itmean* (ITW). Quality control flags are updated.

mhs_iwttmp, for each scan line, converts PRT counts to temperature for IWT and instruments. Final temperature of each IWT is a weighted average of the temperatures extracted from their associated PRT. Arrays of averaged temperatures *targ_temp* and *inst_temp* are filled. Quality control flags are updated.

mhs_avg computes mean counts for space and IWT. Averaging is performed on several consecutive lines for each channel. These mean values fill arrays *spavg* (space) and *itavg* (IWT). Quality control flags are updated.

mhs_cal, for each line and each channel, computes calibration coefficients from space and IWT data: performs temperature/radiance conversion, deduces primary calibration coefficients (*a0,a1,a2*). Primary and secondary coefficients (*u0,u1,u2*) are stored in the commons *mhs_1bhd* and *scan.* The quality control flags are updated.

TASK 3 : RESULTS UPDATING

The result of this task is an update of calibration coefficients and quality control parameters, in the MHS level 1b resource file. According to input options, statistics results are stored into the stat file and a log/debug file is updated.

mhs_updt updates header and data in the MHS level 1b.

mhsclexit closes the log/debug file and the MHS level 1b file.

4.1.17. AVHRR calibration module: AVHRCL script and AVHRCL.EXE.

(See also the reference manual pages *libavhcal.3*)

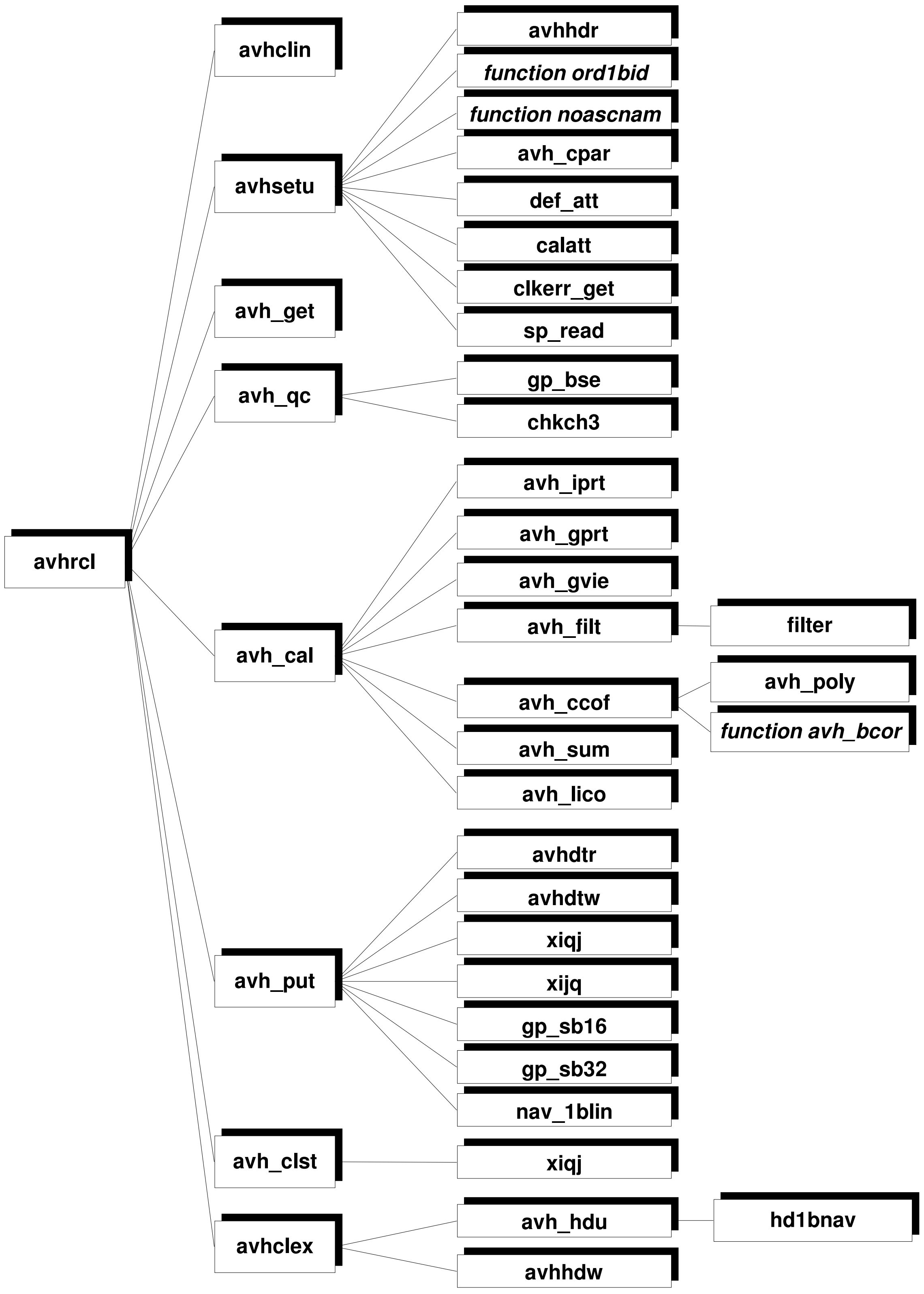


Figure 4-17 : Flow chart on the AVHRCL module components.

To simplify the diagram, the calls to subroutines of the **libf7ml** library have not been written

This task requires the AVHRR level 1a and *avhcal.txt* resource files.

TASK 1: INITIALISATION

The user chooses his input configuration (options). A statistic file is opened. Quality control flags are set and will be modified all along the program performance.

avhclin reads the input options and stores them in a table.

avhsetu opens the statistic file *monavhr.txt*, opens and reads the AVHRR level 1a file (the data are ranged in *avh1b.h*). Satellite Id is set. avhsetu opens, reads and closes the file *avhcal.txt* containing the useful parameters for satellite specific calibration.

avh_get reads the AVHRR level 1a file (only the part needed by calibration) and stores the data into memory.

avh_qc checks the quality of each AVHRR scan line from the file and flags the lines having bad scan numbers inside the level 1b file. Bad line numbers are corrected. avh_qc gets the first calibration sequence from the data.

TASK 2: CALIBRATION COEFFICIENTS CALCULATION

The result of this task is the calibration coefficients for each channel and each scan line.

avh_cal manages the main loop for AVHRR calibration :

- initialises thermistors PRT counts arrays (**avh_iprt**).
- for each calibration cycle, fills the count arrays for the 4 PRTs.
- fills the IWT count arrays and the space count arrays (**avh_gvie**).
- pass Gross and Sigma filters to eliminate noisy counts (**avh_filt**).
- computes coefficients for each AVHRR calibration cycle (converts mean PRT counts to mean IWT temperature, computes target radiance and deduces (G,I) coefficients (**avh_ccof**) and calibration coefficients (*k1,k2,k3*), and linearises (**avh_lico**) the coefficients for each scan line.

TASK 3: RESULTS UPDATING

The result of this task is an update of the calibration coefficients in the AVHRR level 1a resource file. Statistics results are stored into the file *monavhr.txt*.

avh_put updates data in the AVHRR level 1b file.

avh_clst finishes the statistic calculation relative to calibration, writes the results and closes the statistics file.

avhclex updates header and closes the AVHRR level 1b file.

4.1.18. ATOVS sounders calibration: ATOVIN script and ATOVIN.EXE

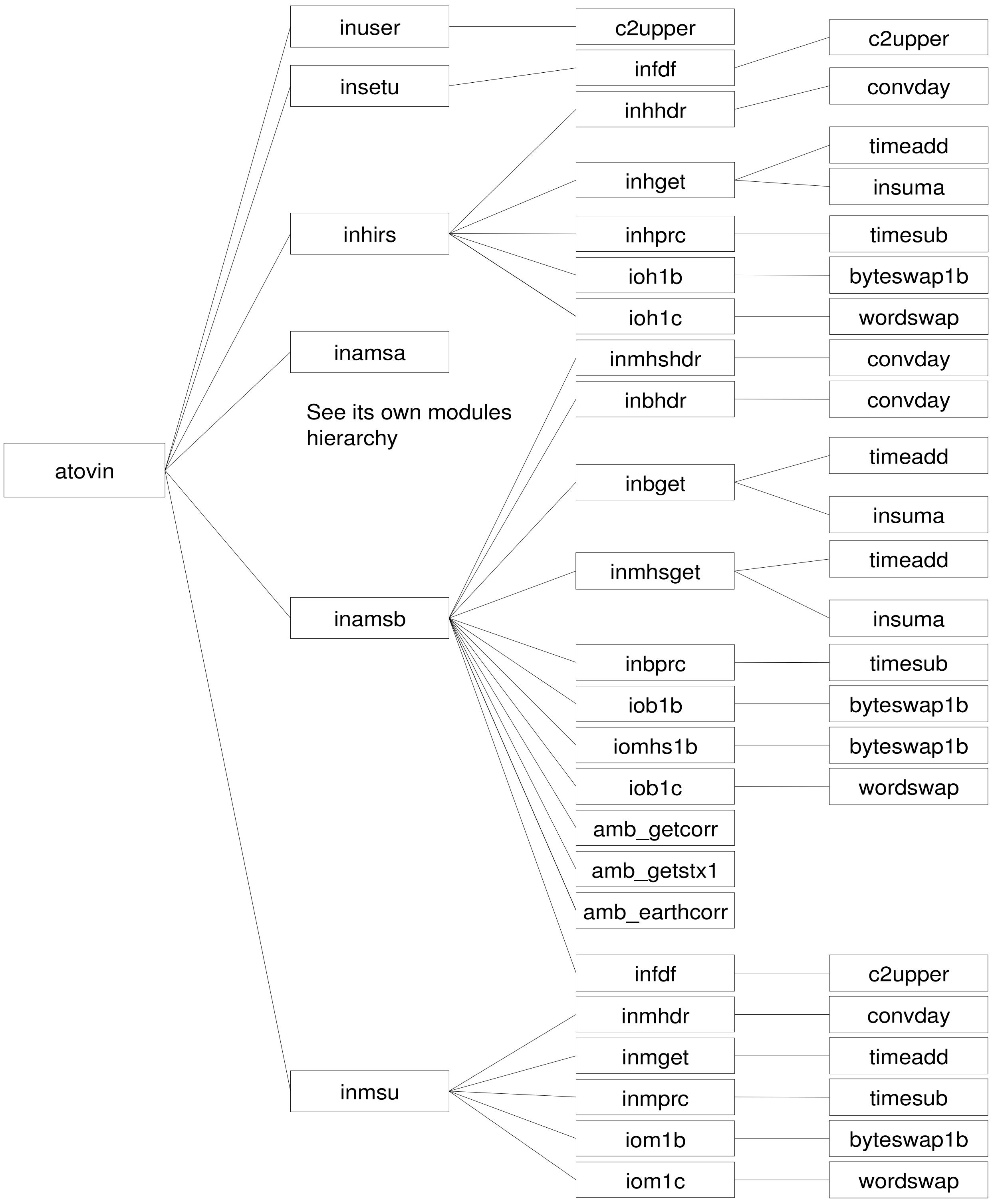


Figure 4-18 : ATOVIN module hierarchy

To simplify the diagram, calls to the **errorreport** subroutine and **numdays** function have not be written

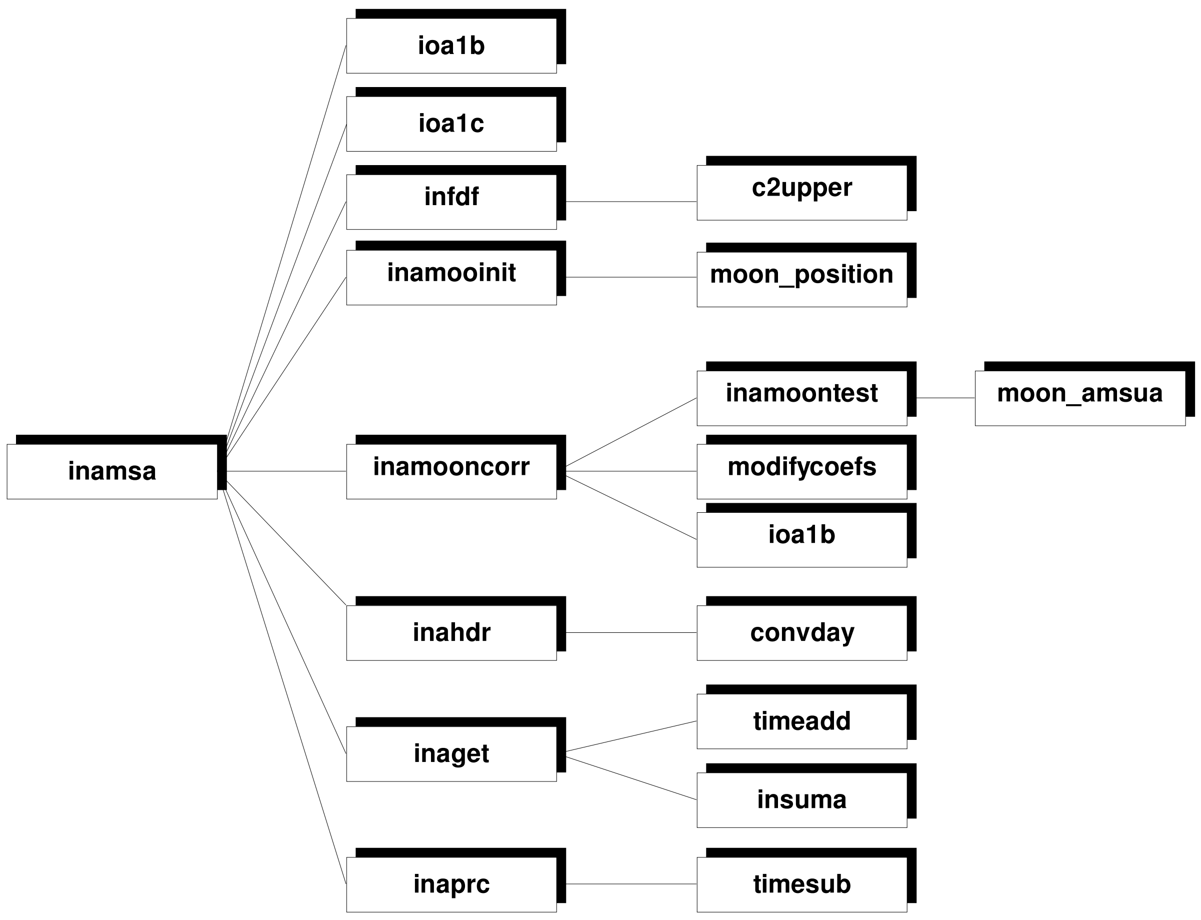


Figure 4-19 : INAMSA module hierarchy

This task requires the level 1b files of each instrument, together with *fdf.dat* and *stx1_mar99corr.dat* resource files.

It applies calibration coefficients (computed by **atovcl**) to output counts to produce radiances. Then it performs radiance conversion to brightness temperature (for each channel). This results in one file for each instrument containing navigated data converted to brightness temperature. Those files represent the level 1c of the processing chain.

TASK 1: INITIALISATION

This task performs all the set up operations for the program **atovin**.

The subroutine **inuser** performs the reading of the list of instruments to process from standard input. It performs also the set up of the logical units associated with the instruments data I/O files and the fixed data file (see next chapter).

The subroutine **insetu** performs all the initialisations needed for **atovin** processing. It performs fixed data file reading (**infdf**) and defines bit numbers (convention used in 1b & 1c files is that an integer*4 word has bits numbered 0-31, with bit 0 being the least significant bit. Some platforms take bit 31 as the low significant bit). Here we explicitly define the order of bits that we use, to keep the code portable.

The subroutine **infdf** reads the following data :

- list of satellite Ids (NESDIS, NOAA & WMO code).
- nominal satellite heights & orbit periods.
- AMSU-A & B and MHS antenna efficiencies for antenna corrections [5]
- MHS antenna reflectivity factors for scan-dependent correction (also available for AMSU-B if required)

This task returns to **atovin**: instruments to process, files logical units and initialised variables needed for processing.

TASK 2: CALIBRATION OF INSTRUMENT TO PROCESS

This task performs the following functions (data are to be processed one instrument at a time and one scan line at a time):

- it reads Earth-located counts and calibration in level 1B format for each instrument separately (HIRS, AMSU-A, AMSU-B, MHS, MSU).
- it applies the calibration coefficients and converts radiances to brightness temperature.
- it corrects AMSU-A & B and MHS radiances for antenna effects.
- it performs quality control including :
  - to check that the data set increments consistently in time (level 1b data should already have this attribute, and problem detected here indicates a problem with an earlier processing module).
  - to check that the brightness temperatures are within reasonable bounds, substituting missing values if they are not.
- it writes out, for each instruments separately, Earth-located brightness temperatures in level 1c format.

This task is performed by calling the subroutines **inhirs**, **inamsa**, **inamsb** and **inmsu** respectively for level 1b HIRS, AMSU-A, AMSU-B/MHS and MSU data.

In the following part the X depends on the sounder to process (X = h for HIRS, a for AMSU-A, b for AMSU-B, mhs for MHS and m for MSU).

First, it opens level 1b (**ioX1b**) and level 1c files (**ioX1c**), reads level 1b header and sets up level 1c header (**inXhdr**). For MHS, a dedicated subroutine is provided for 1b reading (iomhs1b), but the 1c format is shared with AMSU-B so there is no corresponding I/O routine for MHS level 1c.

Then, for each scan line read (**ioX1b**), it stores level 1b data into level 1c commons and arrays (**inXget**). It converts counts to radiance and then to brightness temperatures (**inXprc**). Finally it writes the scan line in the level 1c file corresponding to the processed sounder (**ioX1c**).

For HIRS, AMSU-A and AMSU-B routine **inXget** calls the subroutine **insuna**, to compute solar zenith and azimuth angles. Additionally, for AMSU-B, the subroutine **inamsb** calls the routines **amb_getcorr** to read and interpolate bias coefficients, **amb_getstx1** to read and interpolate antenna corrections, and **amb_earthcorr** to correct earth-view counts for bias errors. For AMSU-A, the subroutine **inamsa** calls different routines to apply a moon detection/correction. **inamooninit** generates initial fixed values. It calls **moon_position** that calcultates the position of the moon. **inamooncor** determines if the moon is in the AMSU-A ifov (**inamootest**). **modifycoefs** calculates gain and optionally over-write the calibration parameters.

To finish, the level 1c header is completed and written in the level 1c file and the files are closed (**ioX1b** and **ioX1C**)

4.1.19. Mapping of sounders: ATOVPP script and ATOVPP.EXE.

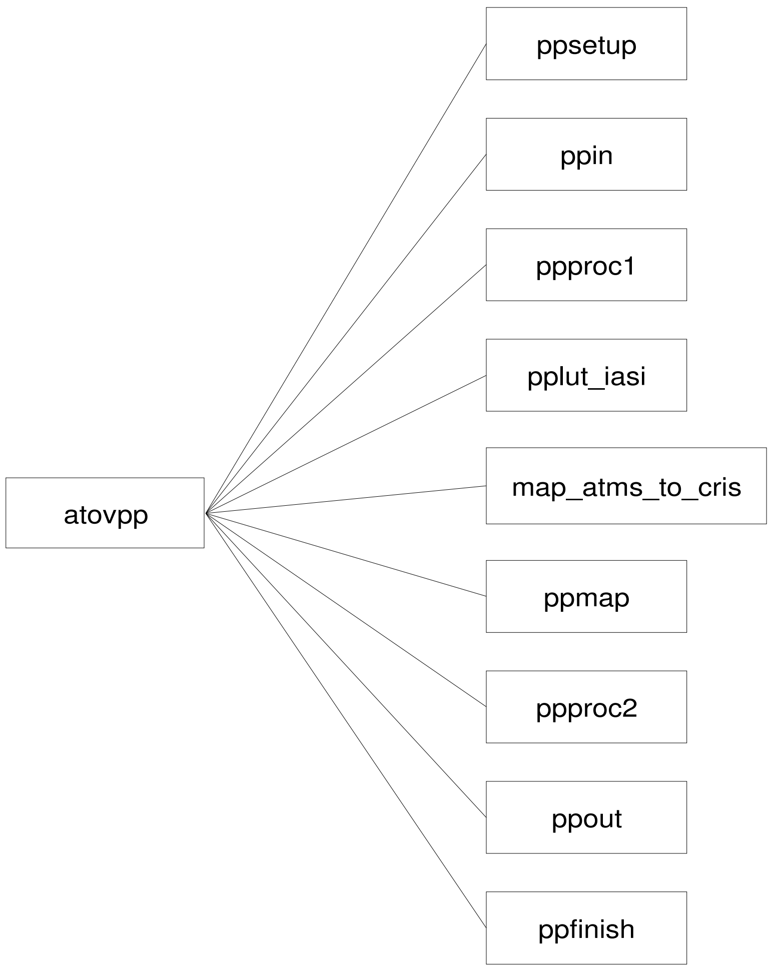


Figure 4-20 : ATOVPP modules hierarchy

This task requires the level 1c files of each instrument and several resource files.

The ATOVPP script creates links to the resource files and creates a text file atovpp.inp containing the mapping requirements for ATOVPP.EXE. It then checks the IASI.fdf file (in $DIR_IASI_PREPROC) to see whether a Principal Components analysis has been requested; if so, it creates the necessary binary eigenvectors files (from the supplied gzipped text files) via a call to IASI_EIGENVECTORS.EXE.

If ATMS is input, run **ATMS_BEAMWIDTH** script in order to modify the ATMS file *atms.l1c*, according to the required beamwidth specification.

ATOVPP.EXE identifies and flags data contaminated by precipitation and maps data of one sounder to the grid of another: e.g. HIRS + AMSU-A + AMSU-B to HIRS grid, AMSU-A + AMSU-B to AMSU-B grid, AMSU-A + MHS to IASI grid, ATMS to CRIS grid. Mapping is the process of calculating a representative value for the data of one instrument (the 'mapping' instrument) at the location of a field of view (fov) of a second instrument (the 'target' instrument). The process of mapping can be considered as three separate steps:

Pre-processing: sets quality flags for mapping fovs (precipitation).

Colocation: identifies mapping fovs 'close to' the target fov (using Look Up Tables (LUT)).

Estimation: calculates representative values (weights) of the mapping data at the target fov, using results of the colocation.

The fields of view of the two instruments create a pattern that repeats at regular intervals. This pattern is derived and then stored within a LUT which provides the location information.

After processing data become level 1d data.

If you need to generate output products at different ATMS resolutions, be sure to take a copy of the original level 1c file.

TASK 1: INITIALISATION

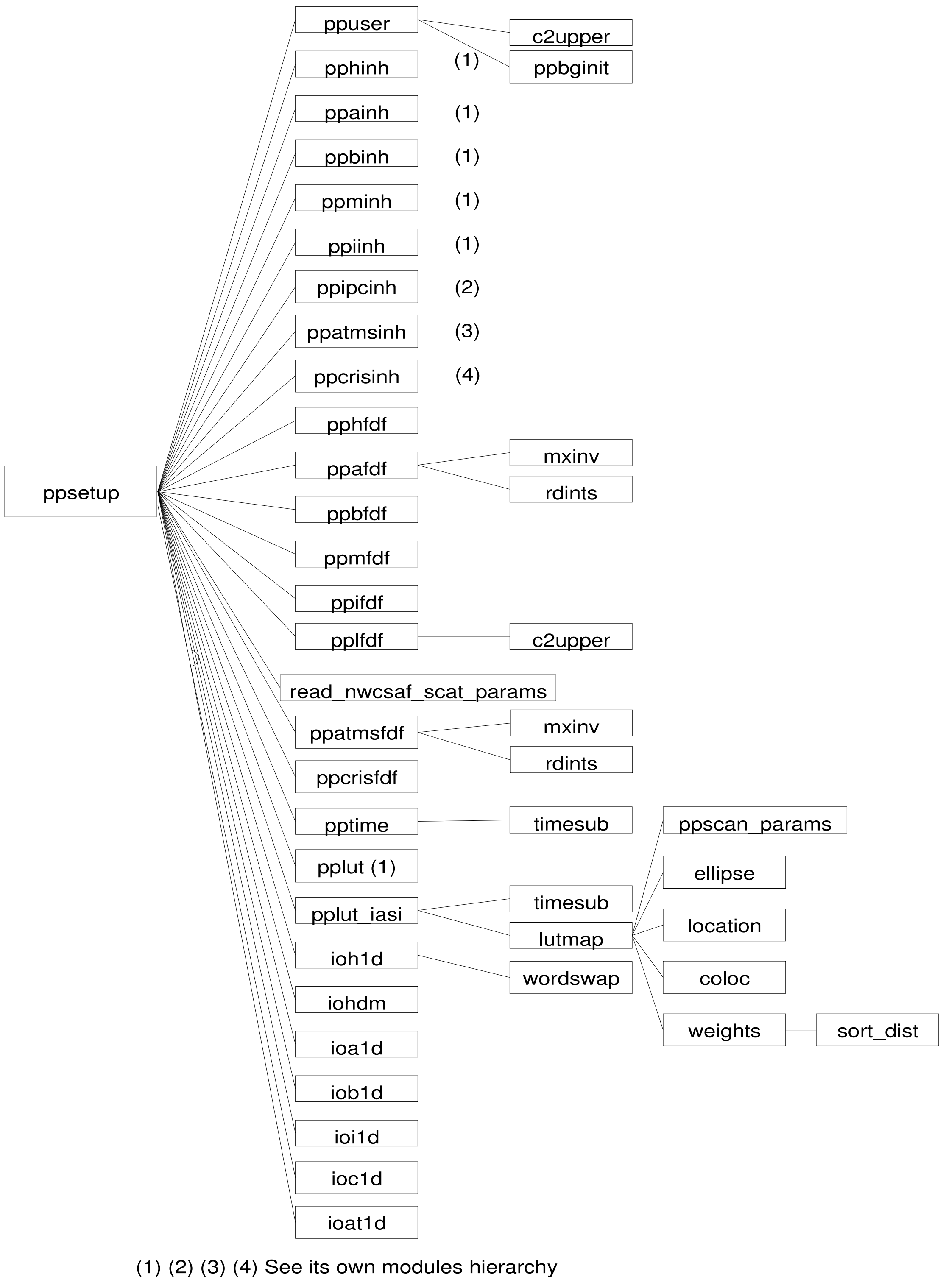
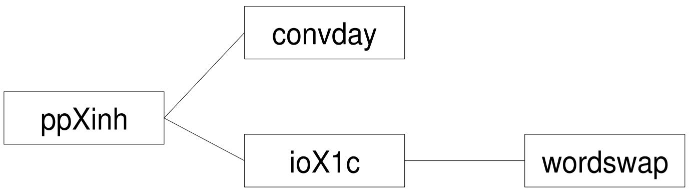


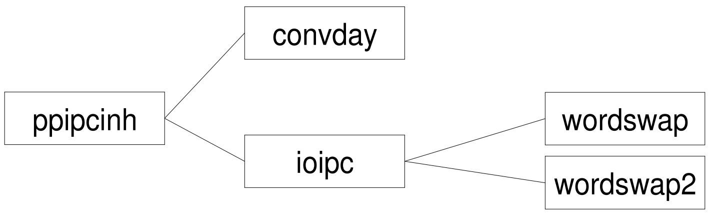
Figure 4-21 : PPSETUP modules hierarchy
To simplify the diagram, calls to the **errorreport** subroutine have not be written

(1)

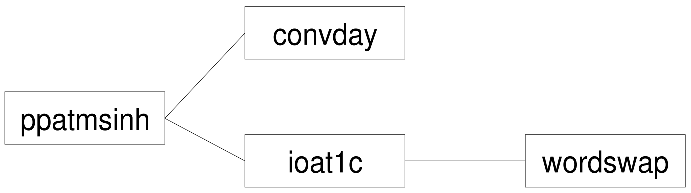


with X= h, a, b, m or i

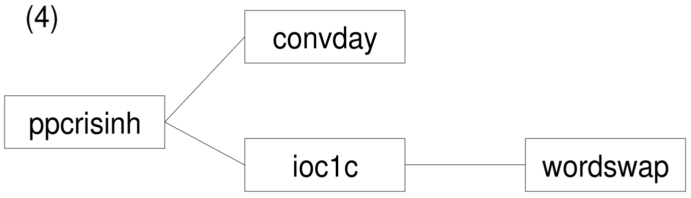
(2)



(3)



(4)



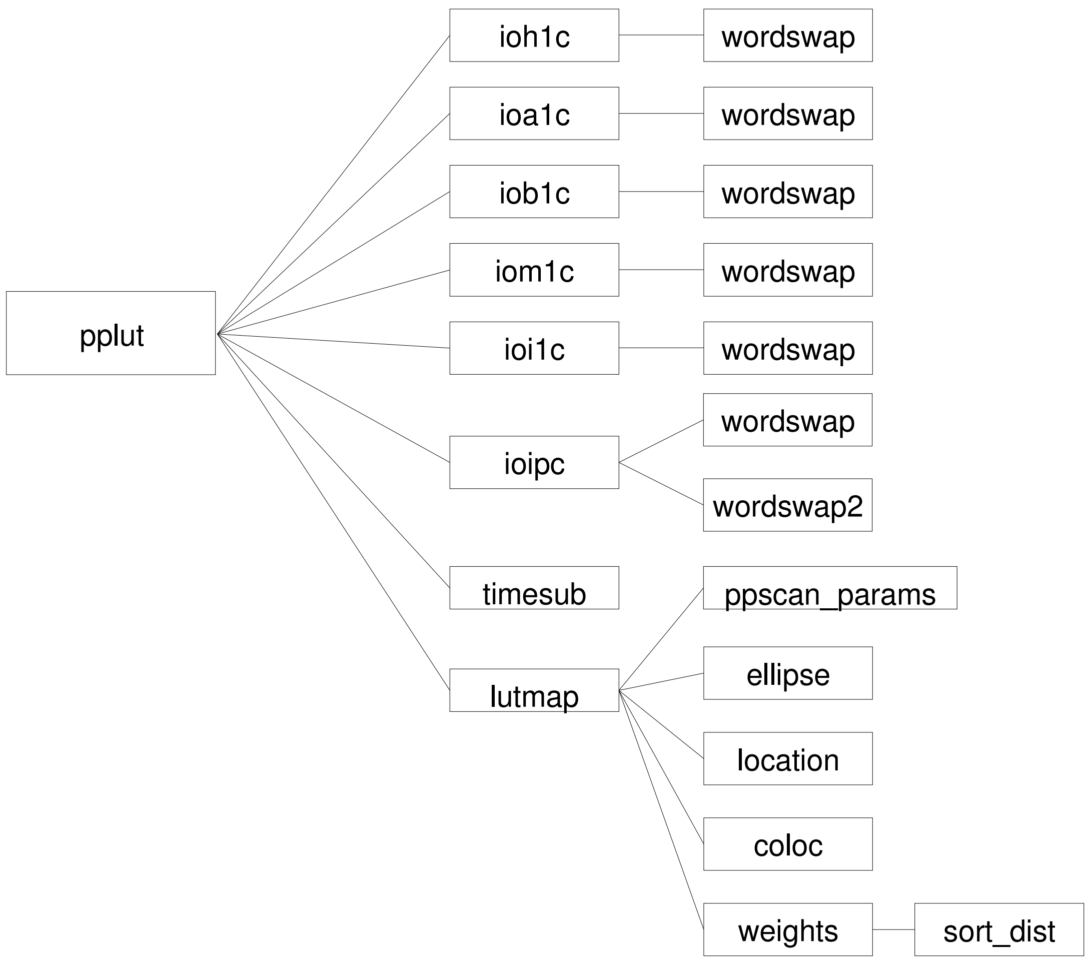


Figure 4-22 : PPLUT modules hierarchy

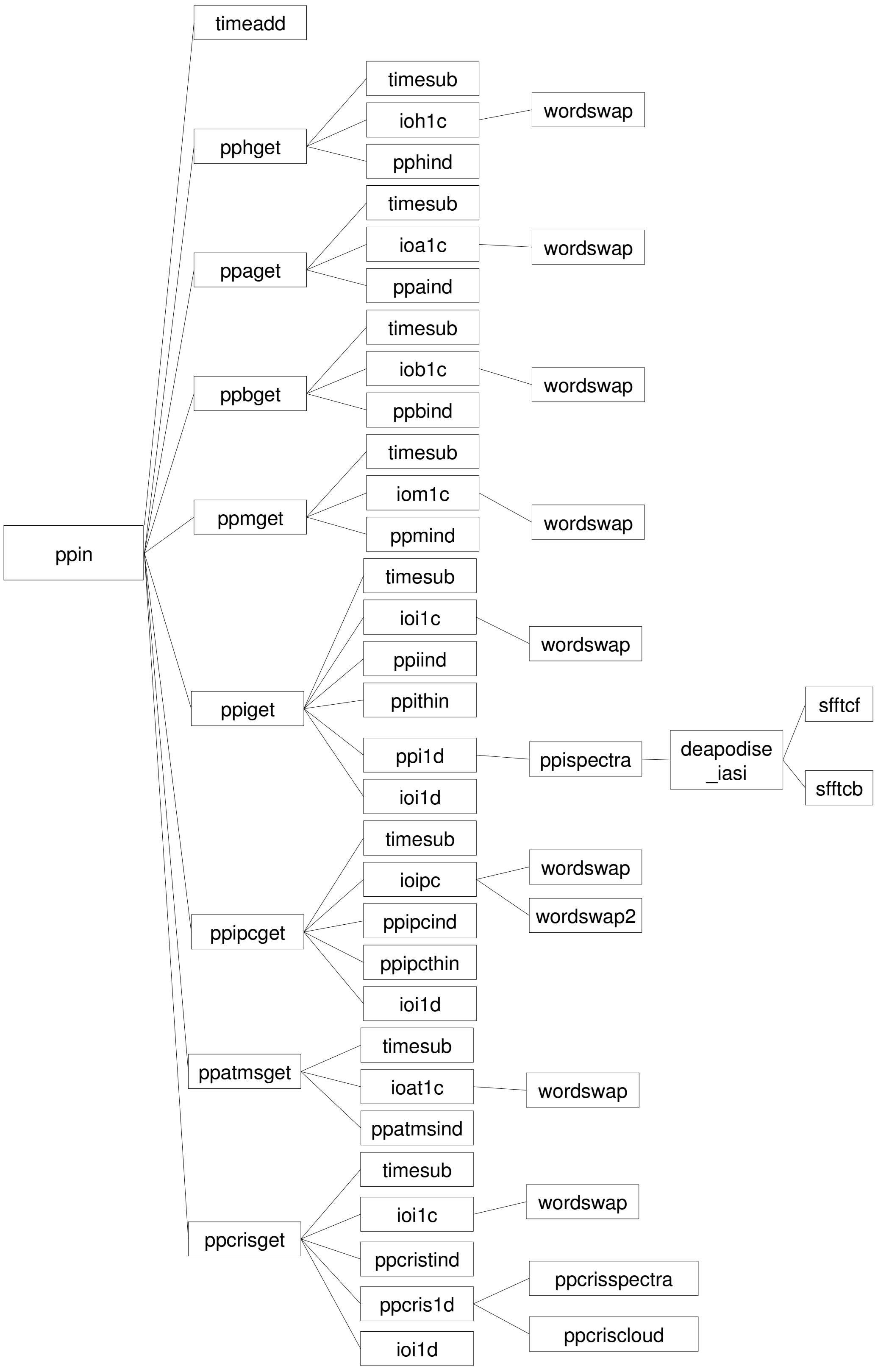


Figure 4-23 : PPIN modules hierarchy

This task performs all set up operations required for program **ATOVPP** (**ppsetup**).

First it reads user inputs (choice of mappings etc.) (**ppuser**). ppuser also defines unit numbers for all I/O, and calls **ppbginit** if Backus-Gilbert convolution has been selected for the AMSU-B to AMSU-A mapping.

Then it reads the level 1c headers and stores them in memory according to user inputs. One header-reading subroutine **ppXinh** corresponds to one instrument (X=a for AMSU-A, b for AMSU-B, m for MSU, h for HIRS, i for IASI, atms for ATMS and cris for CrIS).

It reads fixed data files and sets up fixed variables for each sounder (**ppXfdf**). Those data are described in the next chapter (it can be corrections to apply, parameters useful to processing, etc). There is a particular fixed data file for mapping ('LUT.fdf'), containing optional corrections and adjustments to perform for LUT initialisation. This file is read by the subroutine **pplfdf**, and its data are used by the subroutine **pplut**.

In the case of IASI, in addition to reading the IASI.fdf file, **ppifdf** also reads the files of reference eigenvectors (for Principal Components analysis). These are normally generated by EUMETSAT and distributed in HDF5 format. They include the noise normalization function. If required, a file giving the data required to transform from gaussian apodisation to self-apodisation can be read (referred to as an MTF – modulation transfer function – correction).

ppsetup also reads the AMSU-B scattering parameters that are used for the NWCSAF scattering and precipitation indices (**read_nwcsaf_scat_params**).

It then calculates start/end date/times for the processing and computes the number of blocks of data to process (**pptime**). Data are processed in blocks of time interval "dt". "dt" should be flexible, but the intention is that it should be as long as possible within memory limitations. It could be one complete overpass for locally received data (~15 minutes) or even one complete orbit for global data (~100 minutes), but for small machines it may be less than these. The value of "dt" is set in the include file '*ppparms.h*'.

Before pre-processing there is the creation of a LUT for each instrument by calling **pplut**. The main task of this subroutine is performed by the subroutine **lutmap**. It identifies those mapping fovs which are 'close to' (colocated with) target fovs (calls internal subroutines **ellipse**, **location** and **coloc**). The LUT also provide a representative value (a weight) for each mapping fov (internal subroutine **weights**) and for the appropriate mapping mode (nearest neighbour, bilinear interpolation (weighted average with the 4 corners), or spatial average (gaussian function or linear)). The resulting weight is applied to each colocated mapping fov to provide the mapped value. An appropriate LUT must be produced before running mapping routines. (Weights for Backus-Gilbert convolution are pre-calculated, and are read earlier by **ppbginit**. In the case of IASI, if only a single detector of the four is to be used then a call to **pplut_iasi** is made at this point. If all detectors are to be used then the call to **pplut_iasi** is delayed until later (see Task 3).

The mapping from ATMS to CrIS is performed using the actual geolocation latitudes/longitudes rather than look-up tables – see [37].

The following tasks (2, 3, 4 and 5) are performed on data blocks extracted from each instrument and stored in specific common blocks. This is done by calling subroutine **ppin** which reads data from each instrument (**ppXget**) according to input options and stores them in instrument-specific commons (**ppXind**).

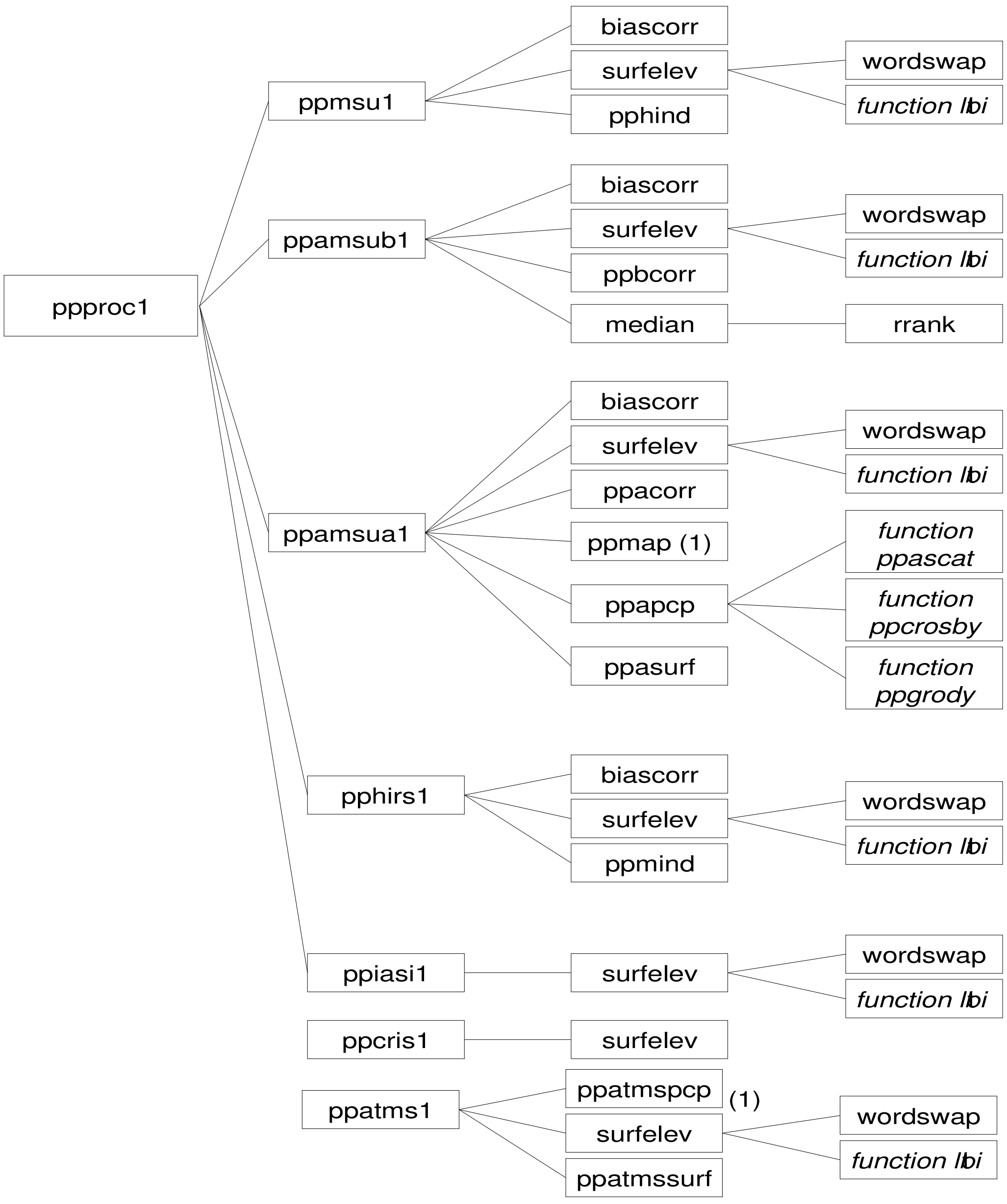
For IASI and CrIS, **ppiget/ppcrisget** do not attempt to store in memory all the channel data for a block. Instead they read in the data for a scan line, performs IASI/CrIS-specific pre-processing (see below), then write the data for that scan line to the output level 1d file. The pre-processing steps are as follows:

- If spatial thinning has been requested, determine the “best” detector to use for each spot (**ppithin/ppcristhin**).

- Copy selected data to the 1d common area (**ppi1d/ppcris1d**), e.g. latitude, longitude, radiance data for the channel selection specified in *IASI.fdf/CRIS.fdf* and, in the case of IASI, mapped AVHRR data.
- Compute Principal Component scores if this has been requested by the user (**ppispectra**, called from **ppi1d**; **ppcrisspectra**, called from **ppcris1d**).
- Write data to 1d file (**ioi1d/ioc1d**)

For the data block, the only IASI/CrIS data retained in memory (**ppiind/ppcrisind**) are the data that are required in the AMSU mapping process, i.e. the scan line numbers, scan line times, latitudes, longitudes and zenith angles.

TASK 2: PRE-PROCESSING BEFORE MAPPING (PPPROC1)



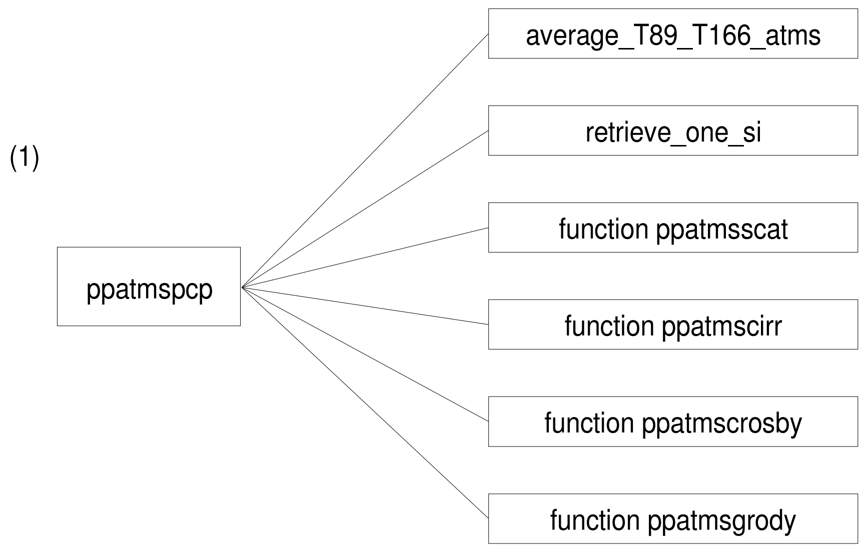


Figure 4-24 : PPPROC1 modules hierarchy.

To simplify the diagram, calls to the **errorreport** subroutine have not been written.

This task pre-processes a block of level 1c ATOVS data to level 1d before the mapping. The pre-processing differs for each ATOVS sounder, but has a common part. So, the main subroutine **ppproc1** calls a specific routine for each sounder instrument (**ppXXXX1** where XXXX = msu, amsua, amsub, hirs or iasi)

The common part of the pre-processing (general pre-processing) consists in performing bias corrections by calling subroutine **biascorr**. It adds a scan-dependent bias correction to level 1c brightness temperature. Values are added only where the BTs are not set to missing (i.e. within 4-400 Kelvin). Those values are read in the instrument-specific fixed data file, they are channel and scan-position dependent. If values are not provided in the instrument 'fixed data file' then values of zero are used.

Then, general pre-processing consists of extracting surface type and elevation for each fov by calling subroutine **surfelev**. It returns surface type (land/sea/mixed) and elevation for an array of lat/lon points, using the ITPP export package topography datasets (1/6th degree x 1/6th degree lat/lon, heights in 100s of feet). Height is for the nearest grid point, and is set to zero for sea spots. Surface type is found by examining all points within a box centred on the instrument field of view and approximately the same size as the field-of-view. The fov is classed land (or sea) only if every point in this box is land (or sea). Otherwise, the surface type is 'mixed'. If either latitude or longitude are out of range then values of -999999 are returned for both surface type and surface elevation.

For HIRS and IASI data no further pre-processing is done (**pphirs1**, **ppiasi1**). Subroutine **pphcorr** called at the end of the HIRS processing is a dummy routine and actually does nothing. It will correct 'limb' effects and surface emissivity.

For MSU data the next pre-processing step (**ppmsu1**) consists of subtracting the limb darkening curve read in the instrument fixed data file. This curve represents the expected difference (Kelvin) between the MSU brightness temperature of each HIRS fov and the one at nadir. There are two curves, one for the land and one for the sea. The aim is to help MSU mapping to HIRS (see scientific documentation). These curves are defined for each channel and for each HIRS scan angle. They are subtracted from MSU brightness temperatures at the MSU fovs before mapping, and added back at the HIRS fovs after mapping. This may reduce errors in the mapping. The subroutine **ppmcorr** called at the end of the MSU pre-processing is a dummy routine doing nothing presently. It will correct 'limb' effects and surface emissivity.

For AMSU-B data during the pre-processing step (**ppamsub1**), a median filter (**median**) is applied to the 89GHz channel to detect spikes which may reveal contaminated data (e.g. due to scattering). The central fov of the 3x3 box is flagged if it differs by more than 10K. Note that we do not act on this flag in mapping AMSU-A to AMSU-B. The subroutine **ppbcorr** called during the AMSU-B pre-processing is a dummy routine that does nothing. It will correct 'limb' effects and surface emissivity.

A more important pre-processing is applied to AMSU-A data (**ppamsua1**). Note that some pre-processing on the AMSU-A grid uses mapped brightness temperatures from AMSU-B. This mapping (**ppmap**) is done within the AMSU-A pre-processing, but is described below in the next task.

Some precipitation tests are performed during the AMSU-A and ATMS data pre-processing by calling the subroutines **ppapcp** and ppatmspcp. They look for precipitation signals in AMSU-A/ATMS and set flags accordingly.

The following paragraphs describe AMSU-A processing; there are equivalent routines for ATMS.

First, a scattering test (**ppascat**) is performed by computing and checking the scattering index. This test can only be used over the sea. It consists in estimating the AMSU-A channel 15 brightness temperature (BT) from channels 1, 2 and 3, and then determining the scattering index by differencing the observed and computed BT15. If the scattering index is > 10k or <-10K the fovs are flagged as scattering (see scientific documentation).

Then the Crosby logistic precipitation test [6] is performed by calling subroutine **ppcrosby**. This test is applied to AMSU-A channels 1 & 15 returns the probability of rain. This test, which is also only applicable over the sea, also uses the relative scattering by hydrometeors at high frequency to flag rain or deep ice cloud. The information is very similar to the scattering index and so this test may be redundant.

Lastly, the Grody light rain test is performed by calling **ppgrody**. This test is applied to the AMSU-A channels 1 & 2. It returns 'TRUE' if rain is detected (see scientific documentation).

After the precipitation tests, the remaining AMSU-A pre-processing consists of estimating the surface type of each fov from the brightness temperatures (**ppasurf**) using only selected channels 1, 2 and 3. The following surface types can be detected :

1 = Bare young ice (i.e. new ice, no snow)

2 = Dry land (i.e. dry with or without significant vegetation)

3 = Dry snow (i.e. snow with water content less than 2%, over land)

4 = Multi-year ice (i.e. old ice with snow [assumed dry] cover)

5 = Sea (i.e. open water, no islands, ice-free, wind < 14m/s)

6 = Wet forest (i.e. established forest with wet canopy)

7 = Wet land (i.e. non-forested land with a wet surface)

8 = Wet snow (i.e. snow with water content > 2%)

9 = Desert.

Note : If surface type is 1, 4 or 8 and channel 1 > 275K surface type is set to 9.

Flags are set if:

- the minimum value of the cost function exceeds the cloud-test threshold
- the estimated surface type is incompatible with topography
- the surface type is one which cannot be processed in the next steps (2, 3, 6, 7 and 9)

The subroutine **ppacorr** called during the AMSU-A pre-processing is a dummy routine that does nothing. It will correct 'limb' effects and surface emissivity.

TASK 3: MAPPING INSTRUMENTS (**PPMAP**)

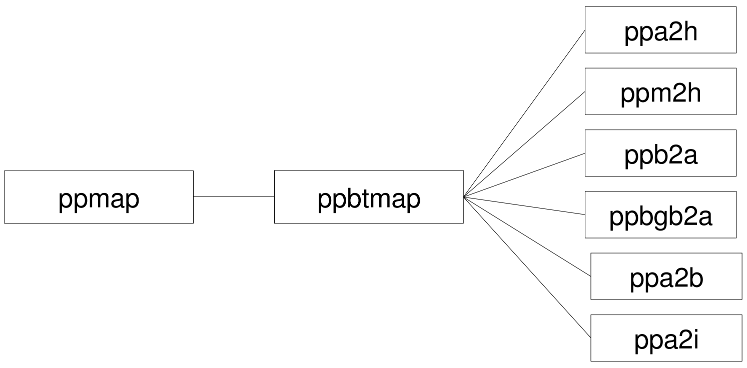


Figure 4-25 : PPMAP modules hierarchy.

This task maps data from one instrument grid to another via the subroutine **ppmap** which calls **ppbtmap** for each mapping to process.

For most instruments **ppmap** is called once per data block. However, for IASI **ppmap** and **pplut_iasi** are called up to four times per block – once for each IASI detector.

ppbtmap maps brightness temperatures between ATOVS instrument grids (Companion routine: **lutmap** see above). **lutmap** generates a look-up (LUT) which identifies those mapping fovs which are colocated with a target fov. The LUT also provides a weight for each mapping fov for each mapping mode (if bilinear interpolation or spatial average). The weights for the selected mode are applied to the corresponding BTs and the resulting sum provides the mapped value.

Note that a set of several observations is mapped with one call to **ppbtmap**.

Five mappings are available :

1. AMSU-A to HIRS (**ppa2h**).
2. MSU to HIRS (**ppm2h**).
3. AMSU-B to AMSU-A (**ppb2a** or **ppbgb2a**).
4. AMSU-A to AMSU-B (**ppa2b**).
5. AMSU-A to IASI (**ppa2i**).

The subroutines **ppa2h** and **ppa2i** map AMSU-A fovs to an individual HIRS or IASI fov. The routine selects mapping fovs from those given and derives brightness temperatures and other parameters at the specified target fov. After initialisation, the routine identifies 'good' mapping fovs by selecting only mapped fovs with valid brightness temperatures. It then calculates mapped

BTs using weights from the LUT and finally tests if all AMSU-A fovs have the same surface type and sets a flag accordingly.

Note : The method used here was considerably simplified from the one used in the earliest versions of AAPP, in which care was taken only to map AMSU-A fovs with the same surface type and cloud classification. The original method would often find only one suitable AMSU-A fov for each of several HIRS fovs, and so re-use it several times. The resulting mapped values were then "blotchy". The current method chooses all nearby AMSU-A fovs with a valid BT. It takes no account of surface type and cloud in the mapping, but flags are set if the AMSU-A fovs are not of identical surface type and if any is flagged for cloud.

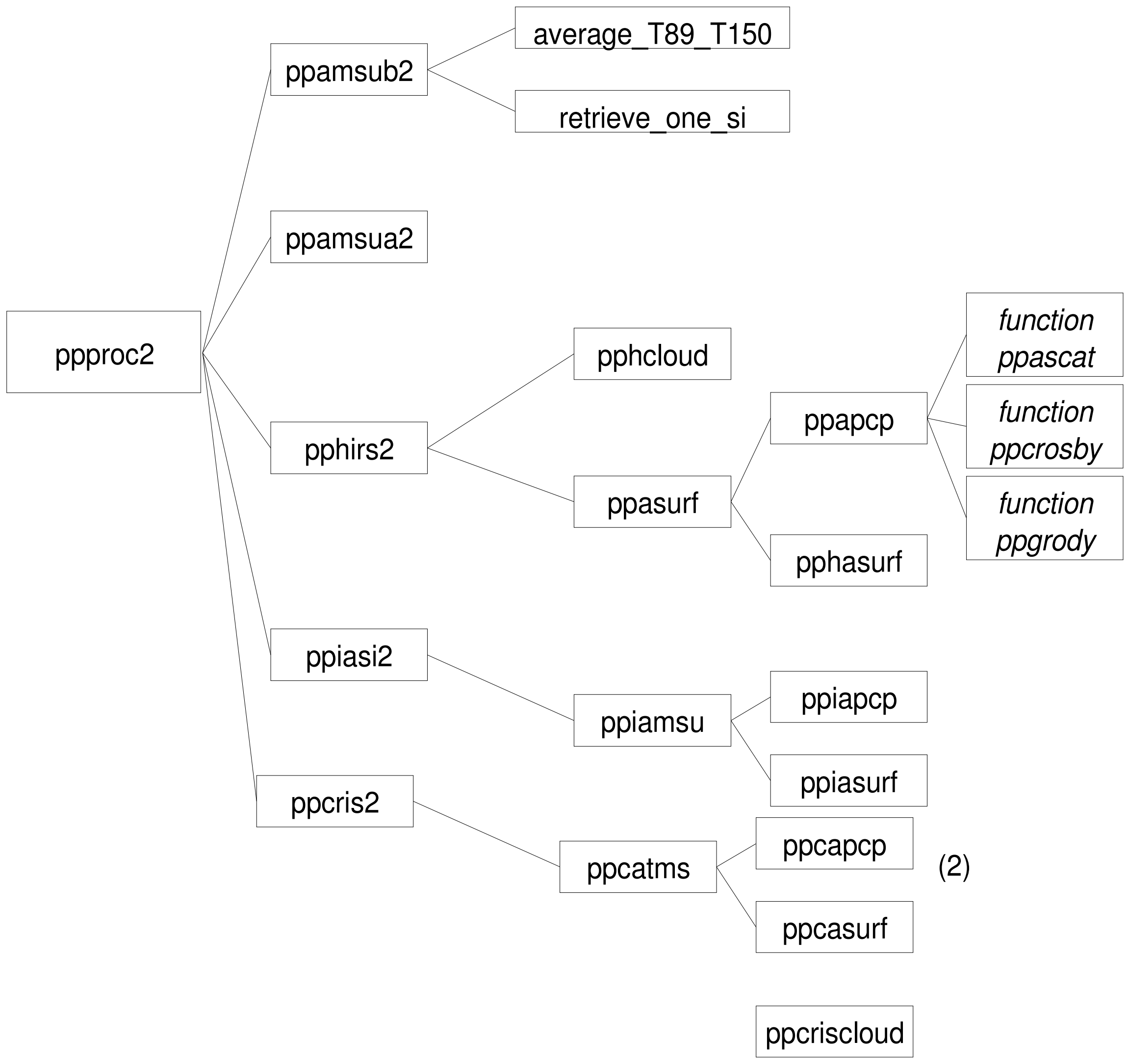
The subroutine **ppm2h** maps MSU fovs to an individual HIRS fov. It selects mapping fovs from those given and derives brightness temperatures and other parameters at the specific target fov. After initialisation, the routine first tries only those fovs with primary calibration. Otherwise it accepts those with secondary calibration. It sets flags and surface types before the calculation of mapped BTs. Note that MSU fovs are accepted irrespective of surface type, however a flag is set if the surface type of any of those selected differs from that of the HIRS fov.

The subroutine **ppb2a** (or **ppbgb2a**) maps AMSU-B fovs to an individual AMSU-A fov. It selects mapping fovs from those given and derives brightness temperatures and other parameters at the specific target fov. After initialisation, the routine first tries only those fovs with primary calibration. Otherwise it accepts those with secondary calibration. It checks the range of the 89GHz channel over the AMSU-A fov and finishes setting the flags and calculates mapped BTs. Note that only those AMSU-B fovs with the same surface type as the AMSU-A fov are mapped, unless AMSU-A fov is of mixed type, in which case all AMSU-B fovs are mapped.

The subroutine **ppa2b** maps values from AMSU-A grid to AMSU-B fov. Note that we are using the nearest AMSU-A fov only so this is a simple task. After initialisation, the routine derives brightness temperatures from AMSU-A to AMSU-B, and then maps pre-processing variables.

The mapping of ATMS to CrIS is performed by a separate subroutine **map_atms_to_cris**, called directly from the atovpp main program. It does not use **ppmap**.

TASK 4: PRE-PROCESSING AFTER MAPPING (**PPPROC2**)



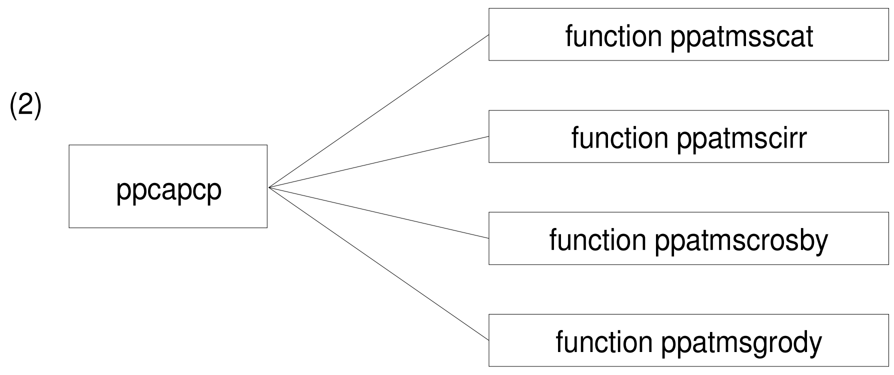


Figure 4-26 : PPPROC2 modules hierarchy.

To simplify the diagram, calls to the **errorreport** subroutine have not been written

This task pre-processes a block of level 1c ATOVS data to level 1d after mapping for each instrument.

The following pre-processing options are available :

1. AMSU-B pre-processing (**ppamsub2**)
2. AMSU-A pre-processing (**ppamsua2**)
3. HIRS pre-processing (**pphirs2**)
4. IASI pre-processing (**ppiasi2**)
5. CrIS pre-processing (**ppcris2**)

Note that an instrument is only processed here if output has been requested on that instrument grid. Currently pre-processing option 2 does nothing.

The subroutine **ppamsub2** pre-processes a block of level 1c AMSU-B data after mapping. It presumes that AMSU-A brightness temperatures have been already mapped to AMSU-B. It recalculates (with **ppascat**) the AMSU_A scattering index using the AMSU-B 89Ghz channel instead of AMSU_A. It flags where the AMSU-A and 89GHz channels differ. It then calls **ppacirr** to calculate the cirrus scattering index by estimating the AMSU-B 183GHz brightness temperature. Finally it computes the NWCSAF scattering and precipitation indices.

The subroutine **pphirs2** pre-processes a block of level 1c HIRS data after mapping. It first adds back the MSU limb darkening curves (different for land and sea) to HIRS fovs. These curves are defined for each channel and for each HIRS scan angle (see task 2 of 3.2.11). The subroutine then tests for cloud by calling the subroutine **pphcloud** (which currently does nothing). Lastly, **pphirs2** repeats pre-processing tests for AMSU-A but on the HIRS grid (**pphamsu**: see task 2 **ppamsua1**) :

- Looks for precipitation signal in AMSU-A mapped to HIRS grid and sets flags accordingly (**pphapcp**) : performs scattering test (**ppascat**), Crosby and Ferraro & Wu test (**ppcrosby**)and Grody light rainfall test (**ppgrody**).
- Estimates surface type and flags cloud liquid water using AMSU-A data mapped to the HIRS grid (uses AMSU-A and AMSU-B channels) by calling **pphasurf** (derived from **ppasurf** : see task 2).

The subroutine **ppiasi2** also repeats pre-processing tests for AMSU-A, but on the IASI grid (**ppiamsu**). Similarly, **ppcris2** repeats pre-processing tests for ATMS, but on the CrIS grid.

TASK 5: DATA WRITING TO 1D LEVEL FILES (**PPOUT**)

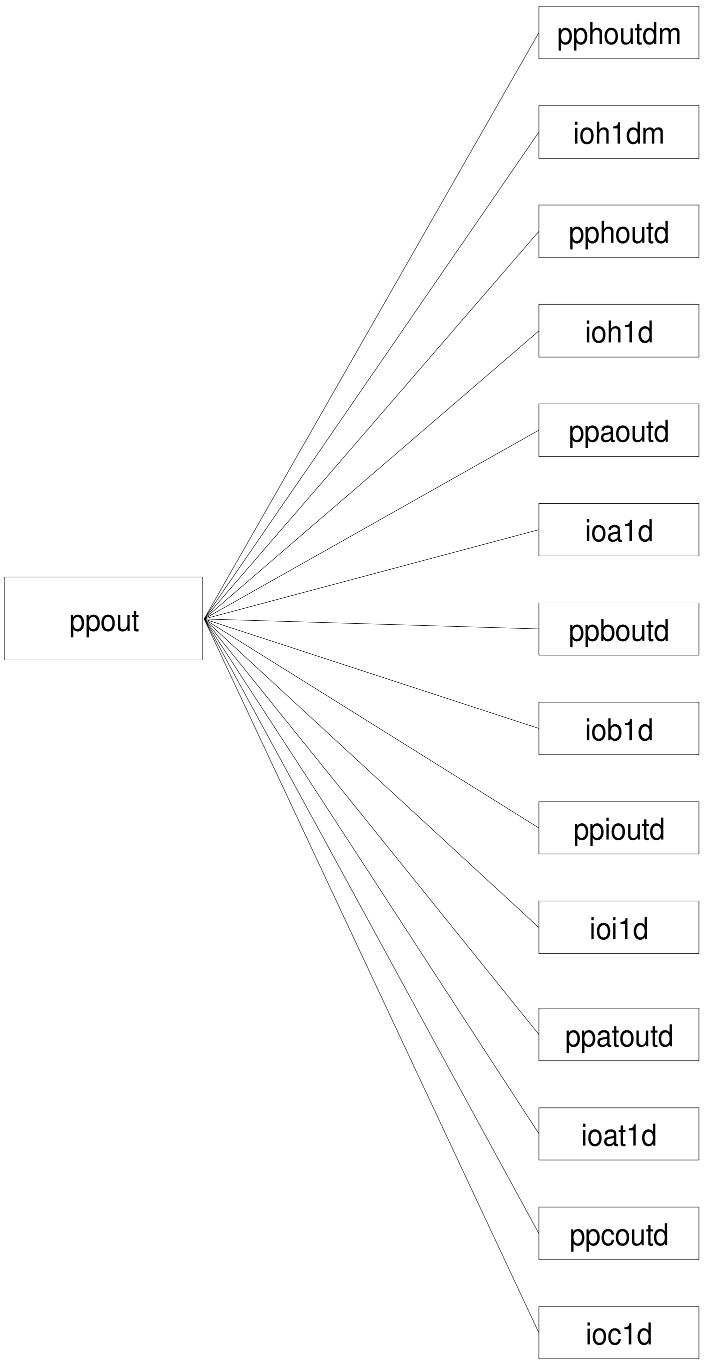


Figure 4-27 : PPOUT modules hierarchy.

This task creates level 1d records from memory stored values, and writes out to level 1d files **(ppout**). This program calls one different subroutine for each instrument to write :

1. HIRS (TOVS or ATOVS) (**pphoutdm** or **pphoutd**)
2. AMSU-A (**ppaoutd**)
3. AMSU-B (**ppboutd**)
4. IASI (**ppioutd**)
5. ATMS (**ppatoutd**)
6. CrIS (**ppcoutd**)

The subroutine **ppout** may overwrite the last record from the previous block, if the same scan line has been processed within this block. This is because the last scan line in a block is at a disadvantage in the pre-processing, e.g. when applying a horizontal filter. It is preferable to overwrite it with the same scan line from the next block. Similarly, the first scan line from the current block may not be written, if it was already processed as an " interior " line from the previous block.

ppout calls the subroutines **pphoutdm**, **pphoutd**, **ppaoutd**, **ppboutd**, **ppioutd**, **ppatoutd** and **ppcoutd** to transfer data from program arrays to a level 1d data record, and then write out the record by calling I/O routine for level 1D data **ioX1d**(**m**) (where X = a for AMSU-A, b for AMSU-B and h for HIRS and with m added for TOVS data).

TASK 6: HEADER WRITING TO LEVEL 1D FILES (**PPFINISH**)

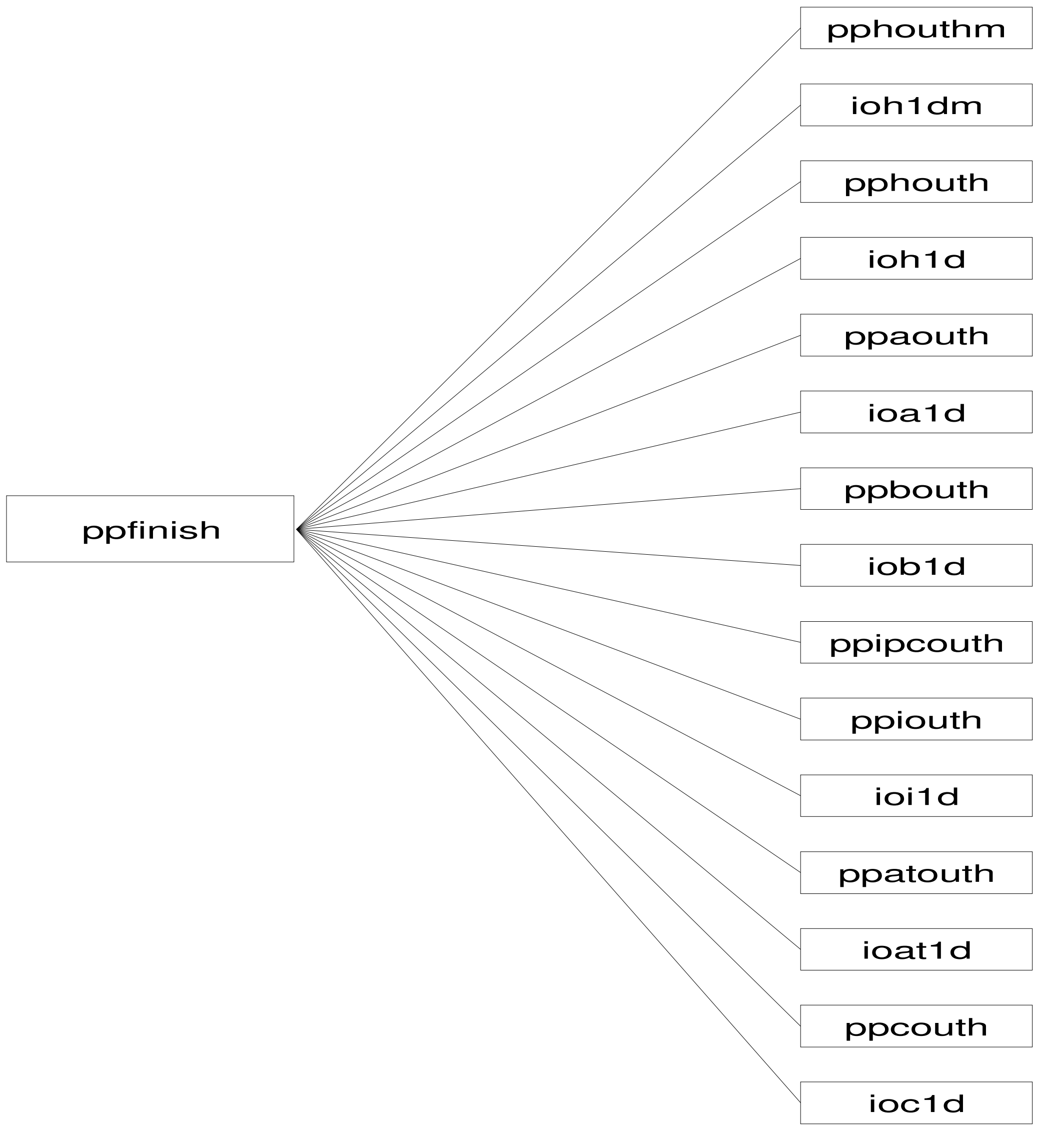


Figure 4-28 : PPFINISH modules hierarchy

This task writes out level 1d headers for each instrument. The main **ppfinish** calls one different subroutine for each instrument :

1. HIRS (TOVS or ATOVS) (**pphouth** or **pphoutm**)
2. AMSU-A (**ppaouth**)
3. AMSU-B (**ppbouth**)
4. IASI (**ppiouth**)
5. ATMS (**ppatouth**)
6. CrIS (**ppcouth**)

The subroutines **pphouthm**, **pphouth**, **ppaouth**, **ppbouth**, **ppiouth**, **ppatouth** and **ppcouth** have the same structure: set up the level 1d header using information from level 1c headers. Check that the format version number and data type level 1c header has already been read into common /xxx1chd/. Check that format of level 1c & level 1d include files (*xxx1c.h*, *xxx1d.h*) are compatible with the code of this subroutine (xxx=hrs for HIRS, ama for AMSU-A, amb for AMSU-B and iasi for IASI). Check that the format of level 1c file is compatible with this subroutine. Calls **ErrorReport** to print a warning if there is a problem. Lastly it sets up level 1d header. Writing is performed by calling the I/O routine for level 1d data **ioX1d**(**m**) (where X = a for AMSU-A, b for AMSU-B, h for HIRS and i for IASI, and m added if we process TOVS data).

4.1.20. Modify the ATMS beam width: ATMS_BEAMWIDTH script, ATMS_BEAMWIDTH.EXE

Modify the ATMS beam width for a level 1c file.

The input and output beam widths for each ATMS channel are specified in a data file given by environment variable $ATMS_BEAMWIDTH_FILE (default atms_beamwidth.dat, in $DIR_PREPROC). For more information on ATMS beam manipulation, see [37] document NWPSAF-MO-UD-027 (appendix to AAPP scientific documentation).

Note: If outfile is not specified then the input file is over-written..

4.1.21. Modify the MWTS2 or MWHS2 beam width: MWTS2_BEAMWIDTH and MWHS2_BEAMWIDTH scripts, MWTS2_BEAMWIDTH.EXE and MWHS2_BEAMWIDTH.EXE

Modify the MWTS2/MWHS2 beam width for a level 1c file.

The input and output beam widths for each channel are specified in a data file given by environment variable $MWTS2_BEAMWIDTH_FILE (default mwts2_beamwidth.dat, in $DIR_PREPROC), and similarly for MWHS2.

The method is similar to that used for ATMS. The default files specify 3x3 averaging.

4.1.22. Mapping AVHRR to HIRS + Cloud Mask: AVH2HIRS script , AVH2HIRS.EXE or AVH2HIRS_ATOVS.EXE.

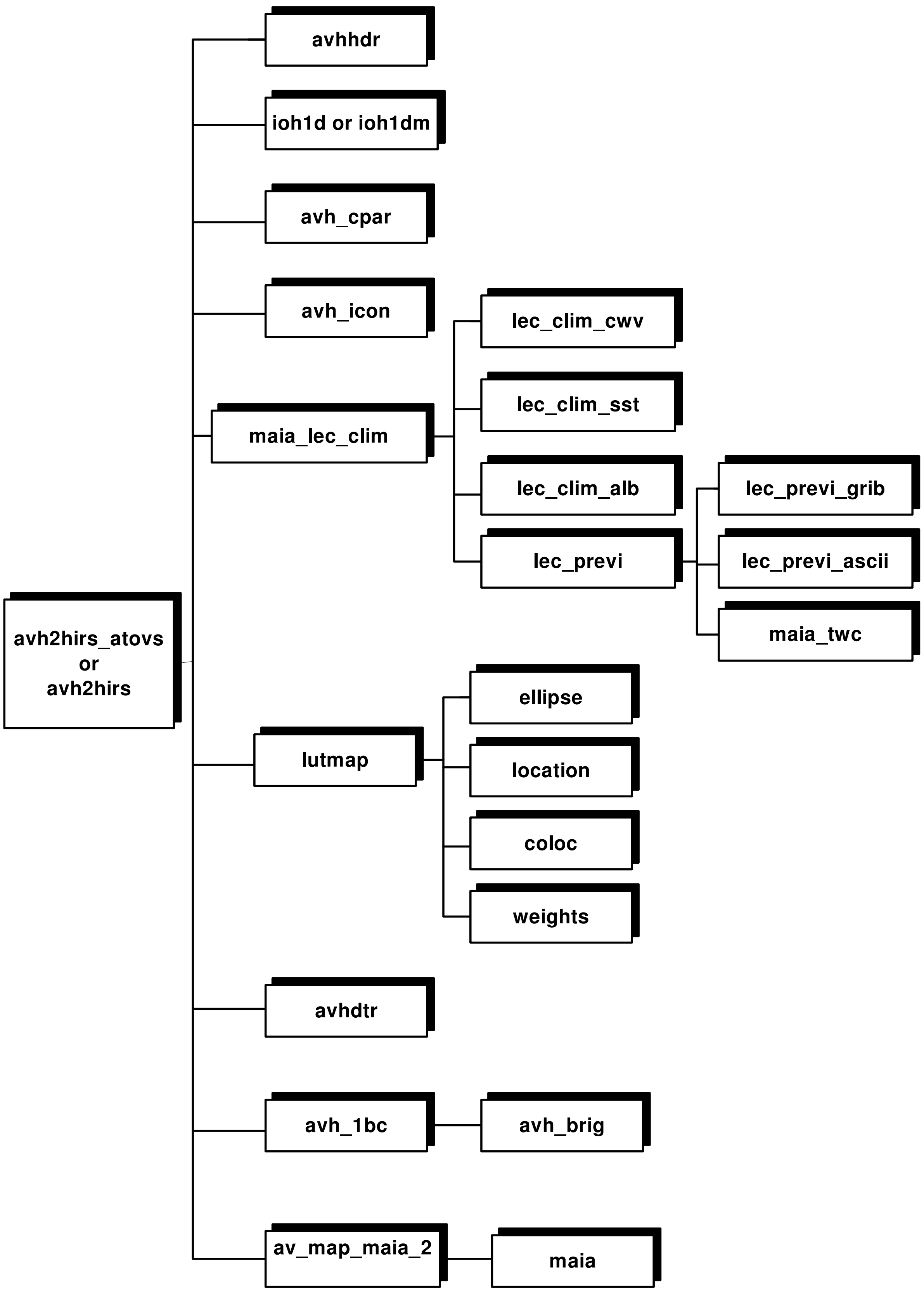


Figure 4-29 : AVH2HIRS_ATOVS/AVH2HIRS modules hierarchy

This task requires the HIRS level 1d file , the AVHRR level 1b file, and several resource files.

TASK 1: INITIALISATION

A part of the initialisation is directly coded inside the main program **AVH2HIRS** (**AVH2HIRS_ATOVS**), particularly for parameters used in the LUT generation, information and options for mapping (e.g. mapping mode is set to 2 and local is set to true). The surface option for mapping is set to 0 (mapping with no surface type requierement).

A number of the thresholds used to determine the cloud mask are set up in constants included in the file *maia.h*.

Dynamic initialisations involve reading the input files (data, calibration coefficients, climatology, corrections etc.), storing information into arrays or commons, computing various parameters, and setting up the LUT for mapping. All of this information will be essential to the processing.

First, the AVHRR header buffer is set up by calling the subroutine **avhhdr** which reads AVHRR level 1b file. Then, for each HIRS fov, the HIRS level 1d header and data records are read (**ioh1dm** or **ioh1d**), and the extracted viewing geometry and surface information are stored in arrays (*'targ_angles'* : latitude, longitude, solar and local zenith and azimuth angles ; *'targ_alt'* : surface elevation ; *'targ_surf'* : surface type).

The time and angle correction file for the LUT is then read and the extracted information is also stored in arrays (*'scan_angle_cor'* and *'time_cor'*)..

Then the tasks required to initialise the '*tconv*' look-up table to convert radiance into brightness temperature for the 3 AVHRR infrared channels by calling the subroutine **avh_icon** .

The initialisation of the climatological and forecast information and their storage into commons is performed by the subroutine **maia_lec_clim**. Different global files are read by specific subroutines:

1. **lec_clim_alb** : Reads the Albedo atlas and returns the array *'atlas_alb'* and all relative information in the common */c_atlas_alb/*.

2. **lec_clim_sst** : Reads the SST and returns the array *'atlas_sst'* and all relative information in the common */c_atlas_sst/*.

3. **lec_clim_cwv** : Reads the specific humidity profiles and returns the array *'clim_wv'* and all relative information in the common */c_atlas_wv/*.

4. **lec_previ** : Reads the forecast temperature at 2 meters, atmospheric temperature and humidity profile, plus the altitude of the grid nodes, then computes the total water wapor content and returns the array *'atlas_t2m'* and *'atlas_wv'* and all relative information in the common */c_atlas_t2m/*.

If the HIRS level 1d file contain mapped AMSU-A data, over sea, **avh2hirs** (**avh2hirs_atovs**) computes the total water vapor content with channels 23, 31 and 50Ghz and fills the common */wv_sat/*.

Lastly the initialisation of the look-up table (buffer '*lutbuf*') for mapping AVHRR to a HIRS data block (5 lines) is performed by calling the subroutine **lutmap**. Then it computes the minimum and maximum AVHRR line numbers for the 5 HIRS lines (corresponding to a block of HIRS data).

Note : the following tasks(2, 3) process an HIRS block of data.

TASK 2: MAPPING IN MODE 1 (GAC)

This task is performed for each HIRS pixel by the subroutine **av_map_maia_2.**

The output parameters are as follows for NESDIS definition from GAC:

1. percentage clear AVHRR in HIRS FOV (*100)
2. mean AVHRR channel 1 over HIRS FOV (albedo*100)
3. mean AVHRR channel 2 over HIRS FOV (albedo*100)
4. mean AVHRR channel 3 over HIRS FOV (degK*100)
5. mean AVHRR channel 4 over HIRS FOV (degK*100)
6. mean AVHRR channel 5 over HIRS FOV (degK*100)
7. mean clear AVHRR channel 1 over HIRS FOV (albedo*100)
8. mean clear AVHRR channel 2 over HIRS FOV (albedo*100)
9. mean clear AVHRR channel 3 over HIRS FOV (degK*100)
10. mean clear AVHRR channel 4 over HIRS FOV (degK*100)
11. mean clear AVHRR channel 5 over HIRS FOV (degK*100)
12. std AVHRR channel 4 over HIRS FOV (degK*100)
13. std clear AVHRR channel 4 over HIRS FOV (degK*100)

*Important note: In the delivered versions of AAPP the mode 1 is inactive because the variable mode is set to 2 in the **AVH2HIRS** and **AVH2HIRS_ATOVS** codes. If you set the variable mode to 1, only the 6 output parameters are well filled: numbers 2,3,4,5,6 and 12. The flag "clear" or "not clear" is not initialised, so no mean of clear pixels can be computed.*

First, for each target line **av_map_maia_2** calculates the line number relative to the look-up table from lutmap, and then calculates a mapping line offset between the mapping LUT line and the level 1c mapping line.

For each target fov of the line, it determines the co-located AVHRR fovs. For each co-located AVHRR fovs, it sums AVHRR albedo/brightness temperatures for the 13 HIRS level 1d parameters to set up. Those 13 parameters are then computed and stored in the data mapping array *'targ_bts'*. A quality control is performed for the line and the result is stored in the array *'targ_qc'*.

TASK 3: MAPPING IN MODE 2 (LOCAL)

This task is performed by the subroutine **av_map_maia_2**.

First for each target line, it calculates the line number relative to the look-up table from lutmap, and then calculates a mapping line offset between the mapping LUT line and the level 1b mapping line.

For all target fovs in the line, it creates three box arrays (pixels x lines) for AVHRR brightness temperatures (*'box_bts'*), radiance boxes (*'box_rads'*) and mapping (*'box_map'*). These boxes are centred on the HIRS target pixel (33 x 38 is a good size to include HIRS fov). Values of the mapping box are as follows : 0 = pixel inside the ellipse, 1 = outside, 2 for AVHRR missing line or bad pixels.

TASK 4: CLOUD MASK

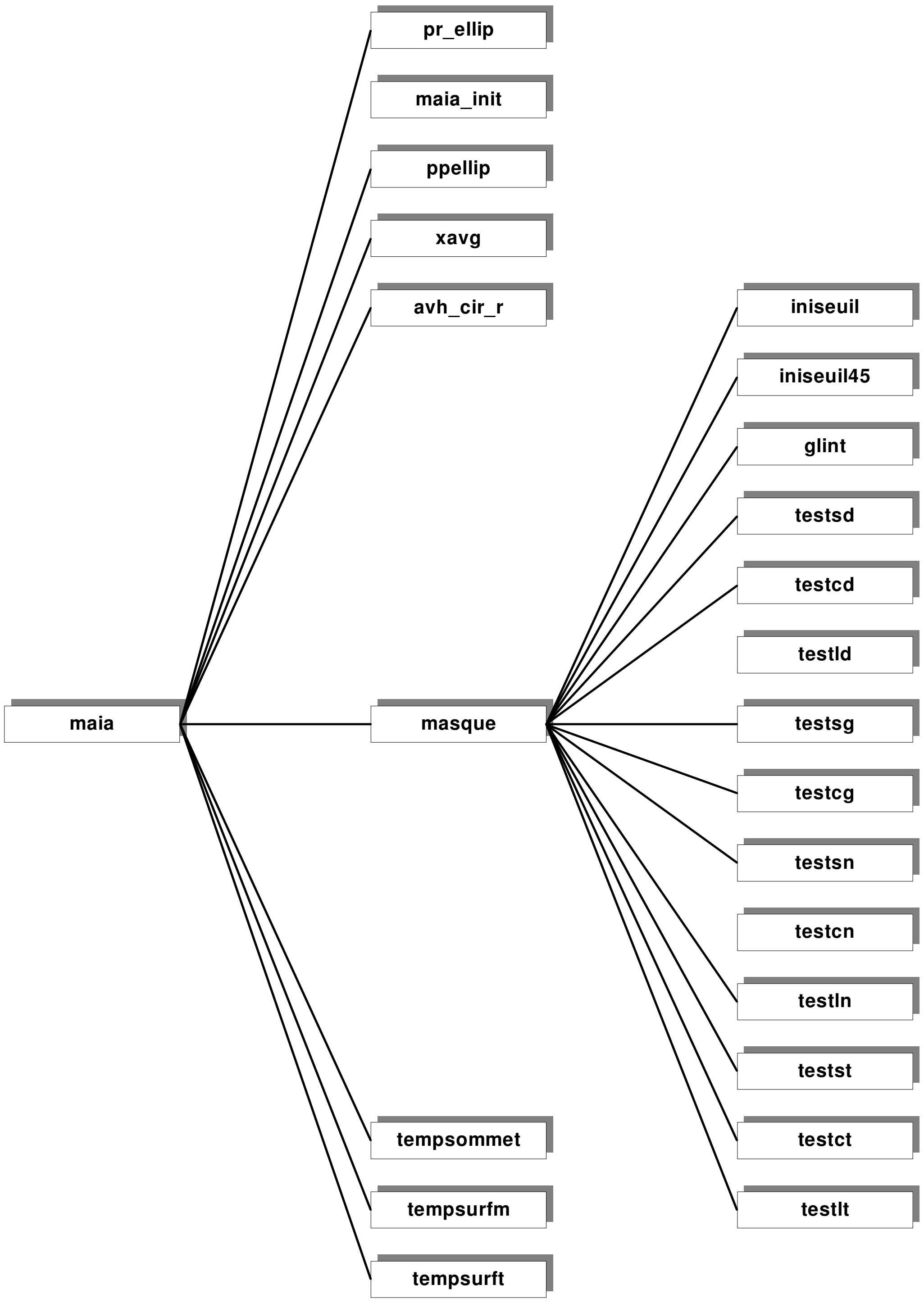


Figure 4-30 : MAIA modules hierarchy

For each HIRS target pixel, the **maia** cloud mask subroutine is called with the three box arrays in input. The mask is based on a threshold technique applied to every AVHRR pixel inside the HIRS ellipse. Threshold tests are applied to various combinations of channels. If the succession of tests is successful the pixel is considered as 'clear'. The combinations of channels used depend on the geographical location of the pixel (land, sea, coast), on the solar illumination, and the viewing geometry (daytime, night-time, dawn, sunglint). The thresholds are computed with empirical functions (of viewing angle, pixel BTs, total water vapour content of the atmosphere...), from climatological datasets of SST, albedo and specific humidities, and from NWP outputs (surface air temperature over land and twvc).

The longitudes for climatologies and forecast are systematically converted in the range [-180, 180].

First, **maia** gets the geometry and climatology (*albedo_clim*, *sst_clim*, *cwv_clim*) or (*t2m_prev* and *cwv_prev*) forecast information and the satellite *cwv_sat* at the HIRS location by calling the subroutine **maia_init**. The results are stored in the commons /*info_clim*/ and /*info_boite*/. Default values of 20% for Albedo, and of -9999 for the others information.

Air temperature from forecast ('*t2m_prev*') is computed using the 2 meters forecast temperature, the relief atlas and a slope of 0.65K per 100m. If missing the value of -9999 is given.

Then the subroutine **ppellip** creates 'ellipse arrays' from data of the box arrays decleared in the ellipse, for BTs ('*tavh_el*'), radiances ('*ravh_el*'), a look-up table ('*el_lut*'), and the local channel 4 standard deviation ('*sd33_el*'). Local standard deviations are computed on 3x3 AVHRR pixel boxes. **Maia** uses the ellipse arrays to compute the channel 4 maximum temperature ('*t4max_el*') and for each channel, albedo and BT averages and standard deviations (*xavg*). Information is stored in the array ('*tmoy_el*'),

Once all the pre-processing is performed, the subroutine **masque** applies the cloud mask on the BT ('*tavh_el*') and radiance ellipse arrays ('*ravh_el*').

The combinations of tests and the thresholds applied to generate the cloud mask depend on the surface type (sea, land or coast), the solar zenith angle - which determines the period of the day- (daytime, night-time, dawn) and whether or not there is specular refection during daytime (sunglint, determined by the subroutine **glint**).

There is a specific subroutine for each case :

- **testsd** (sea + daytime), **testcd**(coast + daytime), **testld** (land + daytime or sunglint)
- **testsg** (sea + sunglint), **testcg**(coast + sunglint)
- **testsn** (sea + night-time), **testcn** (coast + night-time), **testln** (land + night-time)
- **testst** (sea + dawn), **testct** (coast + dawn), **testlt** (land + dawn)

For more details on applied tests and thresholds see subroutines description or scientific documentation. A pixel is declared 'clear' if the combination of tests is successful. So, for each channel, temperatures ('*tavh_el*') and radiances ('*ravh_el*') of the pixel are transferred to the corresponding 'clear' arrays ('*tavh_cl*' and '*ravh_cl*').

Once the mask is applied, statistics are computed for 'clear' pixels : averages ('*tmoy_cl*') for each channel (**xavg**) and the channel 4 standard deviation ('*std4_cl*'). Using that, the 13 parameters of the local mode are computed for the HIRS target fov and stored into the array '*targ_bts*'. These 13 parameters are as follow :

1. percentage clear AVHRR in HIRS FOV (*100)
2. surface temperature (K*100)
3. climatological temperature or t2m (K*100)
4. mean AVHRR channel 3 over HIRS FOV (degK*100)

5. mean AVHRR channel 4 over HIRS FOV (degK*100)
6. mean AVHRR channel 5 over HIRSFOV (degK*100)
7. black body coverage in HIRS FOV (degK*100)
8. top cloud temperature over HIRS FOV (degK*100)
9. std top cloud temperature over HIRS FOV (degK*100)
10. mean clear AVHRR channel 4 over HIRS FOV (degK*100)
11. mean clear AVHRR channel 5 over HIRS FOV (degK*100)
12. std AVHRR channel 4 over HIRS FOV (degK*100)
13. std clear AVHRR channel 4 over HIRS FOV (degK*100)

TASK 5: WRITING OUTPUT FILES

Each HIRS data line is read from HIRS level 1d file and stored in the corresponding 1d common (**ioh1dm** or **ioh1d**). Then, for each of the 56 fovs of the HIRS target line, the 13 AVHRR parameters are set up with corresponding values of the array *'targ_bts'*. The result is stored in a buffer (*hrsd1d_avhrr(56,13)*) included in the common of the HIRS 1d line. This common is then written into the HIRS level 1d record (**ioh1dm** or **ioh1d**).

For each target fov, statistics are computed on the difference between brightness temperatures (BTs) of the HIRS channel 8 (H8) and mean BTs of the AVHRR channel 4 (A4). First, the following calculations are made on H8-A4 :

sum for each column and total sum
sum squared for each column and total sum squared.
count for each column and total count

Then the following calculations are made :

average for each column and total average
standard deviation for each column and total standard deviation

Then it writes to the standard output, and writes standard deviation for each column and total standard deviation to a formatted historical file.

Lastly, it writes AVHRR quality information to standard output ('good' and 'bad' lines, missing line etc.), and closes AVHRR level 1B and HIRS level 1D files.

4.1.23. AVHRR calibration: AVHRRIN script and AVHRRIN.EXE

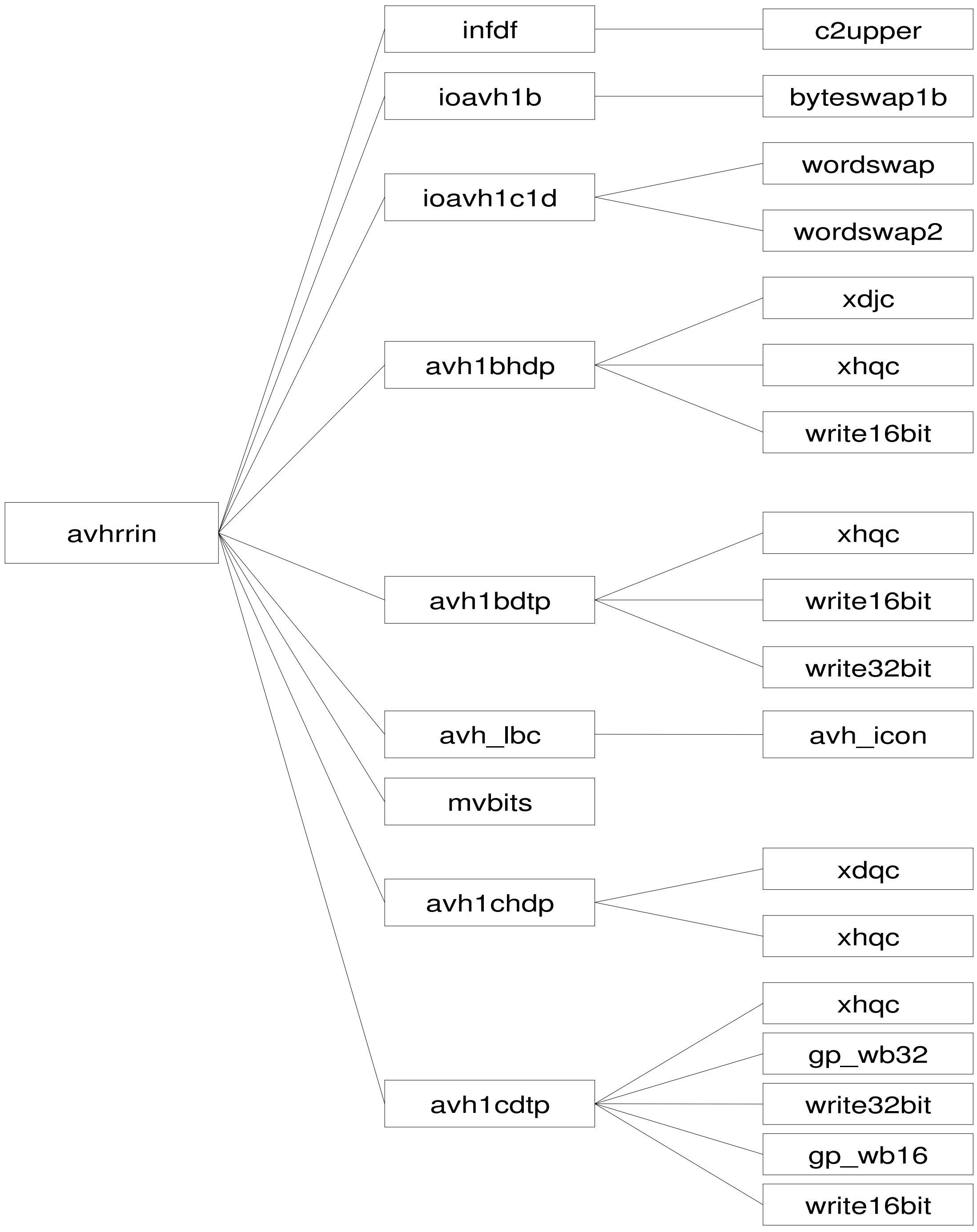


Figure 4-31 AVHRRIN modules hierarchy

This task requires the AVHRR level 1b file and the *fdf.dat* file. It applies calibration coefficients computed by **avhrcl** to output counts to produce reflectances and radiances. Then it performs radiance conversion to brightness temperature. The output file is an AVHRR level 1C file.

TASK 1: INITIALISATION

The program reads the input data and the options.
After it defines the bit numbers. The convention used in 1B & 1C files is that an INTEGER*4 word has bits numbered 0-31, with bit 0 being the least significant bit. Some platforms take bit 31 as the LSB. It is necessary to define the order of bits that we use, to keep the code portable.
Various tests are used.
Then the program reads the fixed data file (**call infdf**).

Task 2: AVHRR CALIBRATION
This task begins by opening the input and output files. It reads the header of the input file (**ioavh1b**) and sets up the header of the output file for writing it (**ioavh1c1d**).
After, it goes through all scan lines, reading (**ioavh1b**), appliing calibration coefficients (**avh_lbc**), writing into the output file (**ioavh1c1d**)

To finish, the files are closed (**ioavh1b** and **ioavh1c1d).**

4.1.24. MAIA3 CLOUD MASK: MAIA3 script and MAIA3_MAIN.EXE

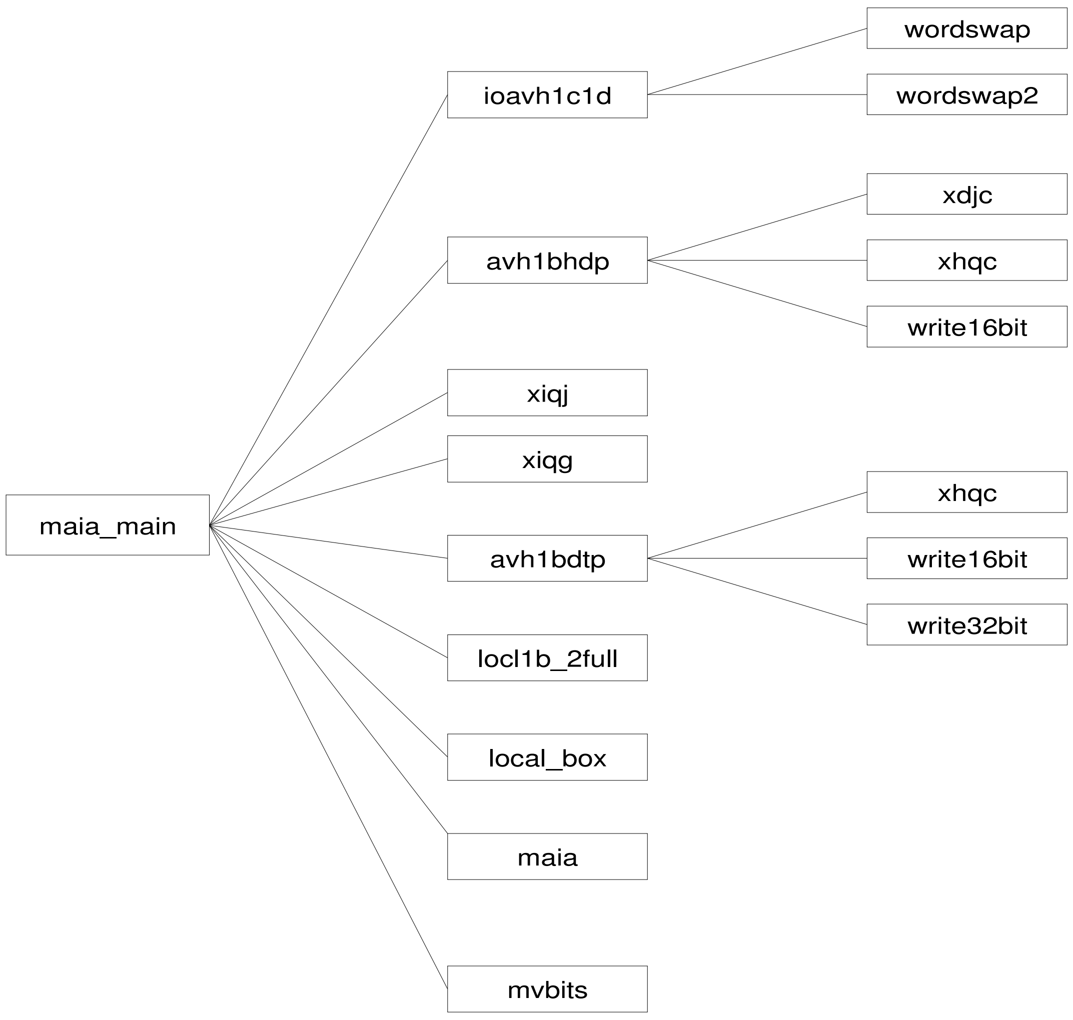


Figure 4-32 : MAIA_MAIN modules hiearchy

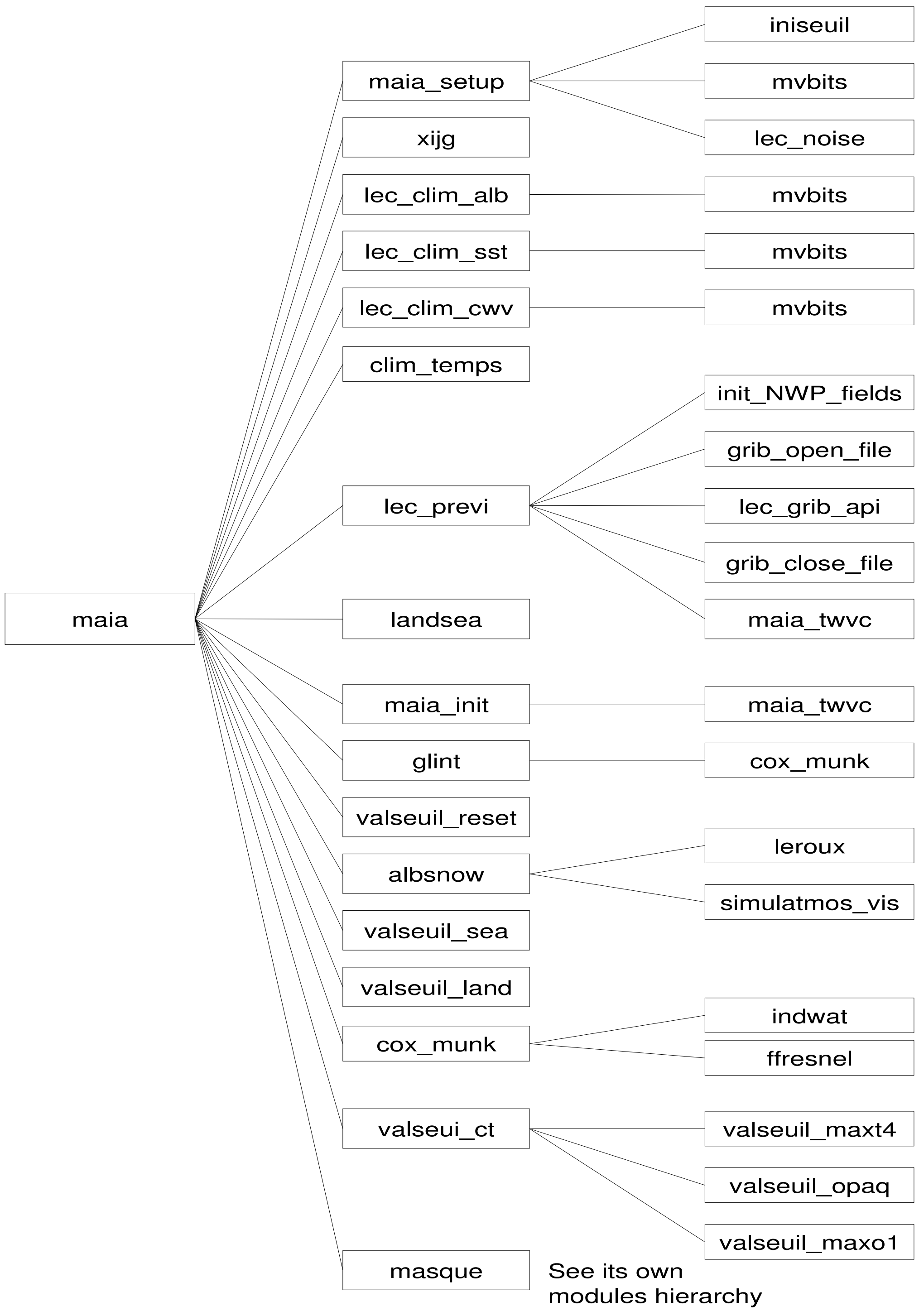


Figure 4-33 : MAIA modules hierarchy

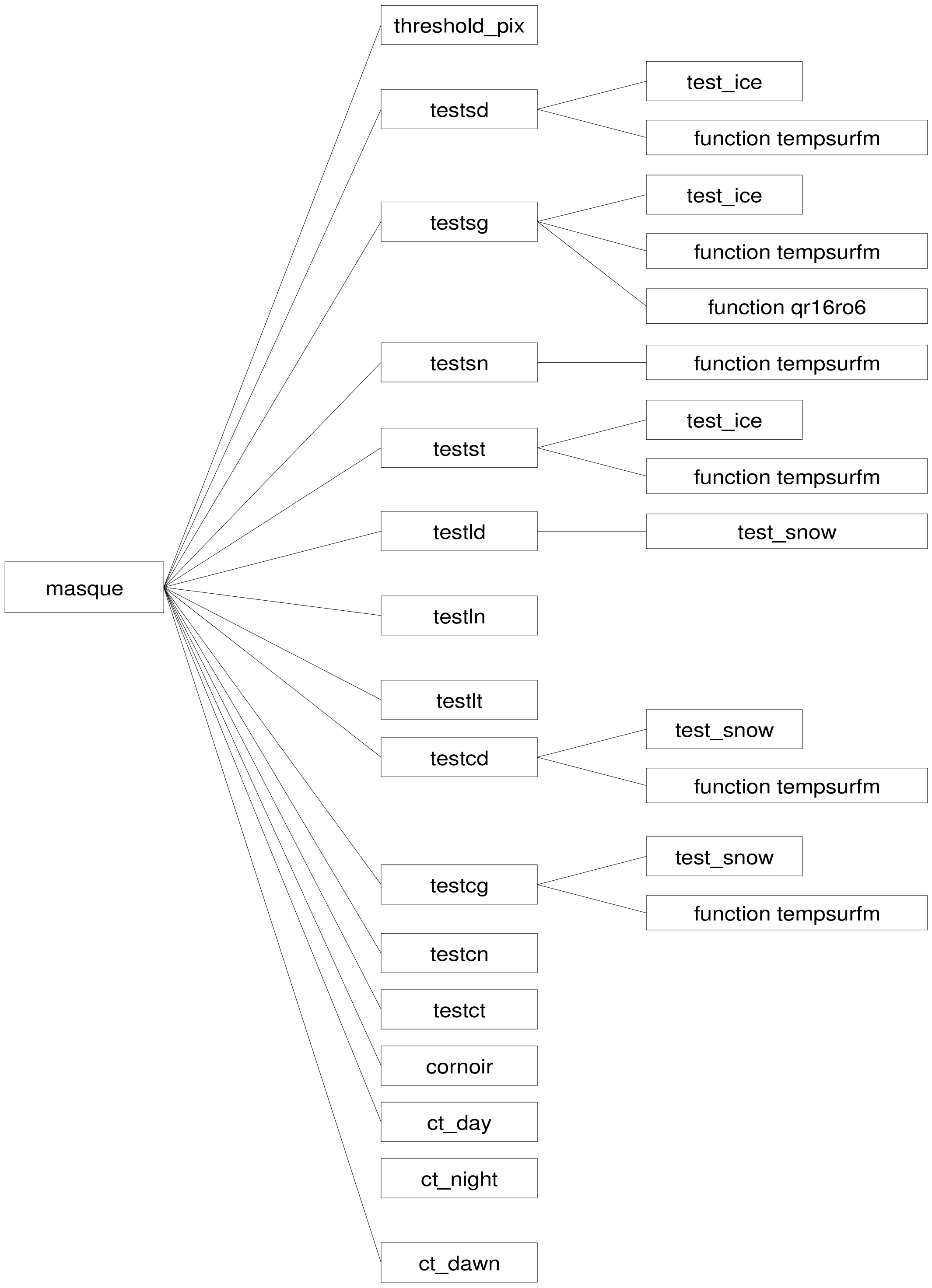


Figure 4-34 : MASQUE modules hierarchy

This sript and program provide a cloud mask on the AVHRR grid. They require the AVHRR level 1C file and several resource files to get prior information on the state of the atmosphere and the surface. Two possibilities; climatological fields or NWP model fields. We obtain best accuracy with the last one.

TASK 1: INITIALISATION

The program reads the input data and the options, opens the input and output files (**ioavh1c1d**) . Then it reads the header of the input file and updates the header of the output one.
Then it computes the total number of boxes whose size is defined by two environment variables. The boxes are created to spare running time to read the environment files (atlas, weatherforecast, …).

TASK 2: WORK ON AVHRR BANDS
Maia3_main.exe reads all the AVHRR lines of a band and makes some quality tests. Data are stored in tables. Geometry angles, latitude and longitude from the AVHRR level 1C resolution every 40 points are interpolated/extrapolated to each 2048 pixels of a line (**locl1b_2full**). Additional quality tests are done.

TASK 3: WORK ON AVHRR BOXES AND CLOUD MASK
Around each pixel of an AVHRR box is built another box named local box.
The subroutine **local_box** computes the local variability (standard deviation + maximum differences) for channels in the local box.
Then maia3_main.exe calls the main subroutine **maia.**
At the first call of **maia,** the subroutine **maia_setup** gets the name of all the useful files, opens, reads, closes the coefficients file usefull for the routine **tempsurfm**. It reads the threshold files to initialize the different thresholds (several calls to **iniseuil**), gets the coefficients for visible absorption (**lec_tabvis**), reads the landsea and elevation atlas. To finish, **maia_setup** calls **lec_noise** to get coefficients to compute the noise of the channels function of the surface temperature.
Always at the first call of **maia**, the climatology files are read (**lec_clim_alb, lec_clim_sst, lec_clim_cwv, clim_temps**) with only one argument, the month. Then **lec_previ** is called twice, one time for the weather forecasts files preceding the date/hour of the AVHRR data, the second time for the files following the date/hour of the AVHRR data. Interpolation is done between fields to be the nearest of the AVHRR date/time.
Now for all the calls to **maia,** altitude, surface type is defined (**landsea**), **maia_init** computes the geometry and climatology informations. The temperature of the surface is computed. Differents thresholds are computed:

- Thresholds sn16 over snow/ice (**albsnow**).
- IR thresholds over sea (**valseuil_sea**).
- IR thresholds over land (**valseuil_land**).
- Visible thresholds
- Thresholds for cloud type (**valseuil_ct**)

Some additional corrections for particular conditions are calculated. The subroutine **cox_munk** is called to compute the maximum reflextance over sea.

The cloud mask is computed in the subroutine **masque.** Series of tests are done:
If over sea

- testsd (if day)
- testsg (if sunglint)
- testsn (if night)
- testst (if twilight)

If over land

- testld (if day)
- testlg (if sunglint)
- testln (if night)
- testlt (if twilight)

If over coast

- testcd (if day)
- testcg (if sunglint)
- testcn (if night)
- testct (if twilight)

If the pixel is cloudy, the programs tests if it is a black body (**cornoir**).
Then it looks for the cloud type by calling to:

- ct_day (day conditions)
- ct_night (night conditions)
- ct_dawn (dawn conditions)

Then the 15 output parameters of maia are stored into th etable par_maia as follow:
maia_par(15) -- avhrr information parameters
1 - clear/cloudy/snow/ice flag (0= clear, 1= cloudy, 3= snow, 4= ice)
2 - surface temperature if clear (K*100)
3 - Tskin used: from climatology or forecast (K*100)
4 - CWV used: from AMSU, forecast or climatology (K*100)
5 - surface altitude (m*100)
6 - surface type (0=sea, 1=mixed, 2=land)
7 - cloud type
0 non-processed containing no data or corrupted data
1 cloud free land no contamination by snow/ice covered surface, no contamination by clouds ; but contamination by thin dust/volcanic clouds not checked
2 cloud free sea no contamination by snow/ice covered surface, no contamination by clouds ; but contamination by thin dust/volcanic clouds not checked
3 land contaminated by snow
4 sea contaminated by snow/ice
5 very low and cumuliform clouds
6 very low and stratiform clouds
7 low and cumuliform clouds
8 low and stratiform clouds
9 medium and cumuliform clouds
10 medium and stratiform clouds
11 high opaque and cumuliform clouds
12 high opaque and stratiform clouds
13 very high opaque and cumuliform clouds
14 very high opaque and stratiform clouds
15 high semitransparent thin clouds
16 high semitransparent meanly thick clouds
17 high semitransparent thick clouds
18 high semitransparent above low or medium clouds
19 fractional clouds (sub-pixel water clouds)
20 undefined (undefined by CMa)
8 - black-body flag (1= black-body)
9 - top cloud temperature if black-body (degK*100)
10- reflexion speculaire dcj

11 - clear cloudy marin flag (0= clear, 1= cloudy)
12 - Ts background : 0 for climatology used, 1 for forecast used
13 - WV content: 0 for AMSU used, 1 for forecast used, 2 for climatology used
14 - day_time 0 for Night, 1 for Twilight, 2 for Day, 3 for Sunglint
15 - qual_fl 0 for same CMA, 1 bad data 2 for different CMA, 3 for coast

TASK4: WRITING OUTPUT FILES
When the loops on local boxes, on boxes are closed, the program writes the AVHRR 1d data record of the band (**ioavh1c1d**) , removes dynamic memory allocation and closes the files.

4.1.25. Convert AVHRR AAPP l1b format to AVHRR PFS L1B format: AAPP-EPS AVHRRL1B script and EPS_AVHRRL1B-MAIN.EXE.

This script and its attached binary program converts AVHRR encoded in AAPP format to AVHRR in PFS 6.5 format.

Only a partial conversion is achieved, that is, only fields required by IASI OPS are filled:

- MPHR :
    - PARENT_PRODUCT_NAME_1
    - INSTRUMENT_ID
    - INSTRUMENT_MODEL
    - PROCESSING_LEVEL
    - SPACECRAFT_ID
    - PROCESSING_CENTRE
    - RECEIVING_GROUND_STATION
    - SENSING_START
    - RECEIVE_TIME_START
    - SENSING_START_THEORETICAL
    - SENSING_END
    - RECEIVE_TIME_END
    - SENSING_END_THEORETICAL
    - TOTAL_MPHR
    - TOTAL_SPHR
    - TOTAL_GIADR
    - TOTAL_RECORDS
    - DURATION_OF_PRODUCT
    - MILLISECONDS_OF_DATA_PRESENT
    - PROCESSING_TIME_START
    - PROCESSING_TIME_END

    - PRODUCT_NAME
- SPHR
    - EARTH_VIEWS_PER_SCANLINE
    - NAV_SAMPLE_RATE
- MDR_1B
    - EARTH_VIEWS_PER_SCANLINE
    - NUM_NAVIGATION_POINTS
    - DIGITAL_B_DATA
    - FRAME_INDICATOR
    - CALIBRATION_QUALITY
    - SCAN_LINE_QUALITY
    - NAVIGATION_STATUS
    - SCENE_RADIANCES
    - EARTH_LOCATIONS
    - EARTH_LOCATION_FIRST
    - EARTH_LOCATION_LAST
    - ANGULAR_RELATIONS
    - TIME_ATTITUDE
    - EULER_ANGLE
    - SPACECRAFT_ALTITUDE
    - COUNT_ERROR_FRAME

This program auto-detects the endianness of the AAPP input file. It make call to avh_lbc to convert digital data to radiances. Geolocation data is interpolated from 51 to 103 points.

Data is read sequentially from AAPP format and rewritten to a PFS file.

4.1.26. Convert IASI PFS L1C to IASI AAPP l1c : CONVERT_IASI1C, CONVERT_IASI1C.EXE and CONVERT_IASI1C_9.0.EXE

This program converts a IASI 1C PFS file in a AAPP IASI 1C file.

Data are read sequentially from the PFS file and written to AAPP format using the following Fortran subroutines:

- open1c : open AAPP file
- mdr1c : converts and writes a IASI 1c record
- mphr : converts and writes a IASI 1c record

- giadr : extracts information from GIADR record
- finish1c : close AAPP file

4.1.27. Convert NOAA l1b formats to AAPP l1b format: noaa_class_to_aapp script and associated executables

Introduced in AAPP v7.6. The script **noaa_class_to_aapp** ingests level 1B files from the NOAA archives and outputs AAPP level 1B format. The following formats and instruments are supported:

Tiros-N to NOAA-14:

- MSU
- HIRS/2
- AVHRR and AVHRR/2 LAC and GAC 10-bit format

NOAA-15 to NOAA-19:

- AVHRR/3 LAC and GAC 10-bit and 16-bit formats
- The other instruments are already in AAPP format

The satellite identifier is extracted from the input file name, so it must be in standard CLASS format, e.g. NSS.HIRX.N[A-P].D?????.*. If the input file includes an archive header, this is automatically detected and removed.

For GAC datasets, the GAC line spacing is retained (1 line per 3 instrument scans, i.e. 2 lines per second). Across track, the 409 GAC spots are fitted into 2048 output spots.

The following executables are called, depending on instrument: avhrr_gac_class_to_aapp_klm.exe, avhrr_lac_class_to_aapp_klm.exe, msu_class_to_aapp.exe, avhrr_gac_class_to_aapp_a-j.exe, avhrr_lac_class_to_aapp_a-j.exe, hirs2_class_to_aapp.exe.

Note: Prior to AAPP v7.6, a program **hrpt1b_noaa** was used for AVHRR. This program is now obsolete, but its description is included here for completeness: hrpt1b_noaa.exe opens the AVHRR NOAA level 1b file and the new AVHHRR AAPP l1a/l1b file (named hrpt.l1b). Reading the AVHRR level 1b file record by record, the first 22016 bytes of each NOAA record (22528 bytes) are written in the AAPP file. To get information in the format and with the scaling factors expected by AAPP, it was necessary to run avhrcl after getting the AVHHRR AAPP l1a/l1b file.

4.1.28. Convert AVHRR l1b in AAPP format to NOAA format: avhrr_aapp_to_class script and avhrr_aapp_to_class.exe

Introduced in AAPP v7.6. This tool converts AVHRR level 1B in AAPP format to NOAA 16-bit (KLM) format.

4.1.29. Initialisation before OPS-LRS software: SATPOS-SVM.KSH, SATPOS-SVM.PL

This module is used for creating a SVM file OPS, using a satpos file as input. Satpos file contain indication on the exposition of the satellite to the sun, and these informations are transcribed in the SVM file. Note that only UMBRA_END and UMBRA_START informations are actully filled in the SVM file.

4.1.30. Initialisation before OPS-LRS software: MESSAGES-OSV.KSH, MESSAGES-OSV.PL

This module is used for creating a OSV file for OPS, from messages extracted from the ASCII ADMIN buffer. Only messages reporting manoeuvres are actually transcribed to the OSV file.

4.1.31. Navigation tools:SATEPH script, LGEPHEING script and LGEPHING.EXE, LGEPHE script and LGEPHE.EXE, ALLEPH script and EPHE, TRACKING, ANTCNFT, DRIFTEPHE, TBUSDISP script, TBUSDISP.EXE, TLEPRINT script, TLEPRINT.EXE.

Those modules are not called by the script **AAPP_RUN_NOAA.**

Module SATEPH

(See also reference manual pages: *satpos.5, ephe.5)*

sateph module prepares a satellite position-velocity (satpos) file and an ephemeris (ephe) file for a given satellite and date. This module is of high interest and does some similar work as **alleph**, but the major purpose is that this module concerns only one satellite and creates the core navigation files for a given date, while **allpeh** creates also the tracking files.

Sateph should be started before any new pass or once a day. Suggestion is to start **sateph** between the series of passes (for a local station) in order to get benefit from the newest orbital elements (retrieved by **get_tle** or any similar tool); also start **sateph** before midnight for the next day (ie: *sateph -s noaa18 -d 1)*

sateph stores the outputs in the AAPP operational environment, satpos files in ${DIR_NAVIGATION}/satpos and ephemeris files in ${DIR_NAVIGATION}/ephe

TASK 1: INPUT PARAMETER READING

It gets:

- input command line parameters (satellite, bulletin type, date, number of days, station name ...)
- if bulletin type is missing it search in the global variable

TASK 2: INITIALISATION

If bulletin type is missing it search in the global variable PAR_NAVIGATION_DEFAULT_LISTEBUL the corresponding bulletin type for the satellite.

From bulletin type it defines

- the name of the satpos command (**satpost** for TBUS, **satpostle** for 2-Line, **spatposspm** for SPOT)
- the file name for the bulletin index

TASK 3: RESULTS

For each satellite of the list, **sateph** :

- execute the satpos command (see above) and stores the result in the “operational environment” with file name: ${DIR_NAVIGATION}/satpos/satpos_*ssss_yyyymmdd*.txt
- execute the ephe command and stores the result in the “operational environment” with file name: ${DIR_NAVIGATION}/ephe/ephe_*ssss_yyyymmdd.txt*

Modules LGEPHEING, LGEPHEING.EXE

(See also reference manual pages: *lgepheing.1, lgephe.5, ephe.5)*

They are navigation tools useful to ingest a TBUS bulletin for long term ephemeris calculations.

lgepheing opens or creates an historical ephemeris utilities file required by the ephemeris files (long-term), into which new informations included in TBUS bulletin will be inserted. For each satellite of the list, orbital parameters useful for the ephemeris calculation will be extracted from the TBUS bulletin. The user chooses files relative to the considered satellites (input configuration).

TASK 1: INPUT PARAMETER READING

It gets:

- home directory of the TBUS files and the short name of the TBUS file
- the satellite list
- the historical ephemeris utilities file name

TASK 2: INITIALISATION

It opens the TBUS bulletin to process.

TASK 3: HISTORICAL FILES UPDATING

For each satellite of the list, **lgepheing** :

- opens (or creates) historical files
- extracts useful parameters for TBUS part IV and checks that the extracted parameters are in the authorised value area.(**tb_dc**).
- writes a record in the historical ephemeris utilities file (**lge_wind**)

Modules LGEPHE,LGEPHE.EXE

(See also reference manual pages *lgephe.1, lgephe.5, ephe.5*)

They are navigation tools useful to produce an ephemeris file, which contains the times of the ascending and descending nodes, the times of start and end of acquisition. **lgephe** produces a long term ephemeris file, i.e. over several months , for one satellite (due to the historical ephemeris utilities file) and several stations. In this case, the satellite position is calculated by an approximate method assuming a circular orbit with linear variation of the nodal period and of the node longitude increment.

TASK 1: INPUT PARAMETER READING

It gets:

the satellite name
the start date and the number of days
the historical ephemeris utilities file name
the station names

TASK 2 : INITIALISATION

It opens the historical ephemeris utilities file and reads it by calling **lg_gelem**.

lg_gelem reads parameters preceding the stop time for the ephemeris in the historical ephemeris utilities file. It stores them in circular arrays of 30 elements (to be adapted according to the long term ephemeris duration). The stored values are used to compute linear regressions on the nodal period and longitude increment. Then it calculates the reference orbit that will be used for ephemeris calculations. This orbit contains the start time for the ephemeris.

It calls **gstatc** that gets the station coordinates (lat., lon., alt.) from the file *stations.txt* and then converts them into Greenwich cartesian coordinates.

TASK 3 : POSITIONS CALCULATION FOR ALL THE GIVEN TIME PERIOD

lgephe calls **lge_ephe** to calculate the ascending and descending node times, starting and ending acquisition time for each station of the list. Information are stored into the long term ephemeris file.

lge_ephe calculates (loop on every orbit from the reference orbit) the ascending and descending node times. Then, every orbit is cut out in calculation interval [t1,t2] with *tstep* duration, and we test for each station (loop on station) if there is a starting or ending time included in this interval. In that case, time and transition nature (starting or ending time into the reception area) is precisely determined.

To manage those tasks, **lge_ephe** calls subroutines :

satpoc calculates satellite position for each calculation step according to a circular orbit.

trackang calculates satellite position in local station coordinates, then test if the satellite comes into or leaves a station area (loop on stations).

instatc calculates (with a dichotomic method) starting or ending acquisition time into considered time interval, assuming circular orbit (loop on stations).

wephmes is called each time different ephemeris messages had to be writen into the output file.

Module ALLEPH

(See also reference manual pages: *alleph.1*)

allephe is the script that allows to run the NOAA ephemeris scheme for the short term. It runs for one acquisition station and loops on a satellite list. allephe calls **satpost.exe** (or **satpostle.exe** or **satposspm.exe** or **satposa.exe**) to create the satpos file (see above), **ephe.exe** for ephemeris, **tracking.exe** to compute tracking angles. Then mixes the satellites and identifies antenna conflicts by calling (**antcnft.exe,driftephe.exe**).

Module EPHE, EPHE.EXE

(See also reference manual pages: *ephe.1, lgephe.5, ephe.5*)

ephe is a navigation tool useful to produce an ephemeris file, which contains the times of the ascending and descending nodes, the times of start and end of acquisition. It produces a short term ephemeris file, corresponding to duration of the input SATPOS file, which is relative to one satellite and one station.

To do this, **ephe** calls a main subroutine **sp_ephe**.

TASK 1: INITIALISATION

sp_ephe reads the header of the SATPOS file, checks whether the input period of time is included in the SATPOS period of time (if not the error flag *ierr* it set to 1) and determines the position-velocity number of calculation steps to read.

sp_ephe calls **initrack** to calculate station values useful for the tracking angles calculations. The station is known in Greenwich reference frame by its geographic coordinates latitude, longitude, altitude. The viewing vector must be in the station local reference frame (zenith, south, east). So a transformation matrix from Greenwich to local reference frame has to be computed.

TASK 2: EPHEMERIS CALCULATION FOR THE GIVEN TIME PERIOD

sp_ephe calculates times of various events as :

sunset and sunrise for the station
ascending and descending nodes
station acquisition starting and ending
maximum elevation during the pass

Ephemeris are calculated for each position-velocity read in SATPOS (loop). Information is stored in the ephemeris output file.

To manage those tasks, **sp_ephe** calls subroutines :

sunriset calculates station sunrise and sunset times (depends on sun elevation angle) for a given day. So sunriset is called only once a day. Day test (to know if the day has changed) is made for each position-velocity read in SATPOS.

intnode calculates for a given time period (which must include equatorial pass), the relative time of the ascending or descending node from the satellite position-velocity for both limiting times of the period. The time where the z component of the satellite position is null, is determined with an iterative method, for which satellite position and velocity are calculated using a cubic interpolation. Since the node time is known, the satellite position-velocity is determined for that time and position is converted in longitude.

intstat calculates for a given time period, the relative time of the start and end of station acquisition from the satellite position-velocity for both limiting times of the period. Time where the satellite elevation angle from the station null is determined with an iterative method, for which the satellite position and velocity are calculated using a cubic interpolation. Since the acquisition time is known, satellite positions are determined for that time. Then, it is possible to deduce if the satellite came in or out of the station acquisition area.

wephmes is called each time different ephemeris messages must be written into the output file.

Module TRACKING, TRACKING.EXE

(See also reference manual pages: *tracking.1, tracking.5, lgephe.5, ephe.5*).

tracking is a navigation tool useful to produce the antenna tracking angle files corresponding to a satpos file. An antenna tracking angle file is produced for each orbit which is acquired by the station (even short acquisition). It contains the site (including a refraction correction) and azimuth values. The time step for calculations is an integer value expressed in seconds. It is defined as a data statement in the main program.

Note: The run is done for only one satellite due to the satpos file

TASK 1: INITIALISATION

tracking calls **sp_read** to read the SATPOS file between the start and end julian instants. If the start time equals 0, all file is processed.

TASK 2: CALCULATION OF THE ANTENNA TRACKING ANGLES

tracking calls **sp_track** to do this task:

sp_track begins to call **initrack** to calculate station values useful for the tracking angles calculations (see in this paragraph ephe/task1).

Then it tests if there is a new acquisition.

If a new acquisition is found, it computes the start of acquisition (**instat**, see in this paragraph ephe/task2). While the site is higher than a threshold, it computes the tracking angles (**intposvel** and **trackang** (see in this paragraph lgephe/task 3).). The sun position is calculated in Greenwich reference frame (**sungrw**).

sp_track calls **wephmes** (see in this paragraph lgephe/task 3).

Module ANTCNFT, ANTCNFT.EXE

(See also reference manual pages *antcnft.1, ephe.5*)

antcnft (ANTenna CoNFlicT) identifies the acquisition conflicts for a single antenna system. It processes an ephemeris file which contains several satellites and is valid for only one station.

The ephemeris file for each satellite has been produced by ephe and tracking, and the various files have been concatenated and the final file has been sorted to be strictly chronological.

antcnft modifies this file to identify the orbits which are considered as conflict orbits.

A priority rule is established for the list of satellites read on unit 10, the first one having the higher priority, the second the following... . When several orbits are overlapping the orbit with the higher priority is kept and the other ones are identified as conflict orbits. The orbit duration is not taken into account. No margin is considered to identify overlapping orbits. For conflict orbits the event field of the ephemeris message becomes "start_conflict" or "stop_conflict".

Module DRIFTEPHE, DRIFTEPHE.EXE

It drifts the time of start of acquisition for a number of seconds.

Modules TBUSDISP, TBUSDISP.EXE

(See also reference manual pages: *tbusdisp.1*)

tbusdisp.exe displays the content of a TBUS file for any satellite by calling **tb_gnv** that gets the nearest valid tbus filename from the index file**, tb_glpv** that gets the last preceding valid tbus filename from the index file, **tb_dc** that decodes the TBUS Part IV orbital elements, **clkerr_dc** that decodes the clock error values stored in the plain language message at the end of the TBUS Part IV.

Modules TLEPRINT, TLEPRINT.EXE

(See also reference manual page: *tleprint.1*)

tleprint.exe displays the content of a Two-Line file for any satellite by calling **tle_dc** that decodes the TLE orbital elements

4.1.32. BUFR tools (AAPP_DECODEBUFR_1C script and AAPP_DECODEBUFR_1C.EXE, AAPP_ENCODEBUFR_1C script and AAPP_ENCODEBUFR_1C.EXE)

These tools allow the decoding and encoding of BUFR level 1c data for AMSU, MHS, HIRS and IASI. BUFR format is used by EUMETSAT in their dissemination of global and regional ATOVS data. To use the tools, the ECMWF BUFR library must be installed (see AAPP Installation Guide).

Modules AAPP_DECODEBUFR_1C , AAPP_DECODEBUFR_1C.EXE

aapp_decodebufr can process either a single file or a list of files.

The output file name is constructed from the input file name, with the suffix changed to “.l1c”.

The following environment variable is required:
BUFR_TABLES – directory containing BUFR tables (required)
usage : aapp_decodebufr_1c [-i files] [-v] [instruments]
where files is a list of files to decode. Quotes " " are necessary if there is more than 1 file.

aapp_decodebufr calls **aapp_decodebufr_1c.exe** for each input file. It performs the following steps:

1. Opens the BUFR file
2. Reads each message and decodes it
3. For each message, examines the first word in the BUFR sequence to determine which instrument it contains
4. Calls subroutine **AAPP_GET_1C** to transfer the data to the AAPP 1c data structures

   AAPP_GET_1C calls different subroutines specific to each instrument **: aapp_get_1c_XXX.F with XXX =amsua, amsub, msu, atms, hirs, iasi, pciasi, cris, mwts, mwhs, mwts2, mwhs2, iras.**
5. On conclusion it updates the 1c header, writes to disk and closes all files

Modules AAPP_ENCODEBUFR_1C , AAPP_ENCODEBUFR_1C.EXE

The script can process either a single file or a list of files, files in AAPP l1c format or files in AAPP l1d format.

The output file name is constructed from the input file name, with the suffix changed to “.bufr”.

The script requires as arguments a list of instrument types corresponding to the input files (i.e. HIRS, AMSU-A, AMSU-B, MHS, IASI, PCIASI, CRIS, ATMS, CRIS1D, ATMS1D, HIRS1D, AMSUB1D, IASI1D, MWTS MWHS IRAS MWTS2 MWHS2 MWTS21D, MWHS21D). A list of input file names may also be supplied (otherwise it assumes defaults hrsn.l1c, aman.l1c, ambn.l1c, etc.)

The following environment variables may be used to define more precisely the encoding:
BUFR_TABLES – directory containing BUFR tables (required)
ORIGINATING_CENTRE – for Section 1 (default 254=EUMETSAT, or 74 for level 1d)
SUB_CENTRE – for Section 1 (default 0)
MESSAGE_SUBTYPE – locally defined subtype for section 1 (defaults vary with instrument)
MASTER_TABLE – version number of master table (default 13, or 15 for ATMS/CrIS)
LOCAL_TABLE – version number of local table (default 0, or 1 for level 1d)

CENTRE_ID – 1b/1c data originating centre, for section 4 (default 254=EUMETSAT)
BUFR_EDITION – BUFR edition number (default 4)
ENHANCED_IASI – set this to Y to use the "day 2" IASI sequence 3-40-007, otherwise defaults to 3-40-001
ATMS_THIN – (default 1) used to thin ATMS to 1 spot in *n* and 1 line in *n* in the BUFR output.
MWTS2_THIN – (default 1) used to thin MWTS2 to 1 spot in *n* and 1 line in *n* in the BUFR output
MWHS2_THIN – (default 1) used to thin MWHS2 to 1 spot in *n* and 1 line in *n* in the BUFR output
IRAS_THIN – (default 1) used to thin IRAS to 1 spot in *n* and 1 line in *n* in the BUFR output
Note: if ATMS_THIN, MWTS2_THIN, etc. is set to a negative value then thinning is only performed in the along-scan direction; every scan will be output.
USE_OB_TIME – set this to Y to set the time stamp in Section 1 to the time of the first observation; the default is to use the system time when the program is run.

aapp_encodebufr_1c script calls **aapp_encodebufr_1c.exe** for each instrument. It performs the following steps:

1. Defines the BUFR sequence descriptor(s) for the required instrument
2. Sets up the fixed parts of the message
3. Calls subroutine **AAPP_PUT_1C** to open the input file, read records into AAPP structures and copy data to the "VALUES" array

   AAPP_PUT_1C calls different subroutines specific to each instrument **: aapp_put_1c_XXX.F with XXX =amsua, amsub, msu, atms, hirs, iasi, pciasi, cris, etc.**
4. Encode each message and write to output file
5. On conclusion, close all files

4.1.33. HDF5 tools (CRIS_SDR script and CRIS_SDR.EXE, ATMS_SDR script and ATMS_SDR.EXE, MWTS_SDR script and MWTS_SDR.EXE, MWHS_SDR script and MWHS_SDR.EXE, AVH1B_TO_HDF5 script, AVH1B_TO_HDF5.EXE, etc.)

cris_sdr, cris_sdr.exe

Convert Sensor Data Record (SDR) in HDF5 to AAPP internal binary format and applies apodization.

Usage: `cris_sdr [-o Outputfile] [-g Geofile] [-H] [-B] [-N] SDRfile`

Default apodization is Hamming (`-H`); alternatives are Blackman-Harris (`-B`) or none (`-N`). If the geolocation file (Geofile) is not specified in the command then the program attempts to read the geolocation file specified in the SDR.

Note: the maximum number of granules expected in an SDR, and the number of scans per granule, are defined in cris_sdr.h (for C code) and also in cris_sdr_out.F. These may need to be changed to suit the incoming data.

atms_sdr, atms_sdr.exe

Convert ATMS Sensor Data Record (SDR) in HDF5 to AAPP internal binary format.

usage: `atms_sdr [-o Outputfile] SDRfile [TDRfile]`

Note: the maximum number of granules expected in an SDR, and the number of scans per granule, are defined in atms_sdr.h (for C code) and also in atms_sdr_out.F. These may need to be changed to suit the incoming data.

avh1b_to_hdf5, avh1b_to_hdf5.exe

Convert AVHRR level 1b AAPP format to HDF5.

Usage: avh1b_to_hdf.exe infile outfile

Read the whole AVHRR 1b file into memory. Convert raw counts to scaled radiance and reflectivities. Write out as HDF5.

mwts_sdr, mwts_sdr.exe

Convert MWTS SDR files in HDF-5 format to AAPP 1c format

This program ingests SDR files for the Microwave Temperature Sounder (MWTS) instrument on the Chinese FY-3 series. It converts from HDF5 to AAPP binary format (specified in “include” file mwts.h). The early releases of MWTS data by CMA suffered from limited quality control of the brightness temperatures and geolocation, therefore AAPP performs the following additional QC checks:

. Calibration slope: reject scans having a slope less than 99% of the median

. Latitude/longitude check: scan to scan consistency and difference across the scan

. Reject scans with lunar contamination in space view

usage: `mwts_sdr [-o Outputfile] SDRfile`

If `Outputfile` is not specified the name of the output file is the same as the name of the input file, except that the suffix is changed to “.l1c”.

mwts2_sdr, mwts2_sdr.exe

Convert MWTS2 SDR files in HDF-5 format to AAPP 1c format. Usage is as above, but for the MWTS2 instrument on FY-3C and later satellites. Quality control is limited to checking the geolocation.

mwhs_sdr, mwhs_sdr.exe

Convert MWHS SDR files in HDF-5 format to AAPP 1c format

This program ingests SDR files for the Microwave Temperature Sounder (MWHS) instrument on the Chinese FY-3 series. It converts from HDF5 to AAPP binary format (specified in “include” file mwhs.h). The early releases of MWHS data by CMA suffered from limited quality control of the brightness temperatures and geolocation, therefore AAPP performs the following additional QC checks:

. Space and black body viewing angles: reject scans with errors greater than 100 counts compared with nominal positions

. Check consistency of different time stamps within the dataset

. Latitude/longitude check: scan to scan consistency and difference across the scan

. Reject scans with lunar contamination in space view usage: `mwhs_sdr [-o Outputfile] SDRfile`

If `Outputfile` is not specified the name of the output file is the same as the name of the input file, except that the suffix is changed to ".l1c"

mwhs2_sdr, mwhs2_sdr.exe

Convert MWHS2 SDR files in HDF-5 format to AAPP 1c format. Usage is as above, but for the MWTS2 instrument on FY-3C and later satellites. Quality control is limited to checking the geolocation.

iras_sdr, iras_sdr.exe

Convert IRAS SDR files in HDF-5 format to AAPP 1c format.

4.2. INTERFACES

Formats are detailed in the NWPSAF-MF-UD-003 (AAPP documentation/data formats)

For the input options and arguments, see the paragraph 4.3 "dynamic articulation".

4.2.1. User input parameters in ATOVS_ENV/ATOVS_ENV7

In AAPP versions 1 to 5 the ATOVS_ENV file was located in the user's home directory. For AAPP version 6 or 7, ATOVS_ENV is now called ATOVS_ENV6 (or 7) and it is by default located in the installation top directory. This makes it easier to run different versions of AAPP on the same computer. However the built-in scripts do not source ATOVS_ENV6 (or 7) directly, they source a file ATOVS_CONF which tests to see whether an ATOVS_ENV6 (or 7) file exists in the users's home directory. If one does exist it will be used; if it does not exist the ATOVS_ENV6 (or 7) file in the installation top directory will be used. The user may customize ATOVS_CONF if necessary to modify this behaviour.

The ATOVS_ENV6 (or 7) file defines several environment variables. The user has to ensure of the set-up of the different variables.

The text, that follows, can make reference to those variables.

4.2.2. Inputs/outputs for TBUSING navigation initialisation

Inputs

TBUS_YYYYMMDD.TXT

TBUS bulletin, yyyy(year) mm(month) dd(day).
Located in the directory ${DIR_NAVIGATION}/tbus_db or orb_elem/yyyy-mm.
yyyymmdd is the date of transmission of the bulletin by NOAA.
Bulletins are classified by year and month of transmission.
More details are given in *tbus.5* .

Outputs :

TBUS_NOAAXX.INDEX

Historical TBUS index file for orbital parameters associated with a specific satellite, xx satellite number.
Located in the directory ${DIR_NAVIGATION}/tbus_db or orb_elem.
The first line (header line) contains the NOAA name of the satellite.
Each following line contains epoch time in the CNES julian days (day 0=01/01/50 00h), quality flag (zero is good data), orbit number, extrapolation errors of position (km/day, 2 values forward and backward), the time-string (dd/mm/yy hh:mm:ss.sss), and the name of the TBUS file (full name).
More details are given in *tbus.5*.

CLKERR_NOAAXX.TXT

Clock drift data file (ASCII) for each satellite, xx satellite number
Located in the directory ${DIR_NAVIGATION}/tbus_db or orb_elem.
The first line (header line) contains the NOAA name of the satellite.
The second line has the name of the fieldspresent in the following lines.
Each data line contains : an identification code (cerr, last, next, rate and plus bias for NOAA16), the date in CNES Julian days (day 0=01/01/50 00h), the value of cerr or last (in seconds) or rate (in ms/day) or bias (in seconds).
More details are given in *clockerror.5.*

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **tbusing.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.

4.2.3. Inputs/outputs for GET_TLE navigation initialization

get_tle retrieves the 2-Line orbital elements from a web site.

Inputs :

WEB SITE FOR 2-LINE ELEMENTS

- URL, user, password are defined in the ATOVS_ENV6 or ATOVS_ENV7 parameter file

Outputs :

TLE_YYYYMMDD_HHMN.TXT

- 2-Line elements retrieved on *yyyymmdd* at *hh:mn*

4.2.4. Inputs/outputs for GET_TAI_UT1_UTC navigation tool

get_tai_ut1_utc retrieves time conversion and polar motion values from a reference web site

Inputs :

WEB SITE FOR TAI, U1-UTC AND POLAR MOTION

- URLs are defined in the ATOVS_ENV6 or ATOVS_ENV7 parameter file

Outputs :

FINALS2000A.DATA

- Polar motion and UTC-UT1 values (observed and forecast) stored under directory $*DIR_DATA_TAI_UT1_UTC*

TAI-UTC.DAT

- TAI UTC time difference, stored under $*DIR_DATA_TAI_UT1_UTC*

4.2.5. Inputs/outputs for TLEING navigation initialisation

Inputs

TLE_YYYYMMDD_HHMN.TXT

TLE bulletin, yyyy(year) mm(month) dd(day) hh (hour) mn (minute).
Located in the directory ${DIR_NAVIGATION}/tle_db or orb_elem/yyyy-mm.
yyyymmdd hhmn is the date and time of reception of the bulletin.
Bulletins are classified by year and month of reception.
More details are given in *tle.5* .

Outputs :

TLE_NOAAXX.INDEX

Historical TLE index file for orbital parameters associated with a specific satellite, xx satellite number.
Located in the directory ${DIR_NAVIGATION}/tle_db or orb_elem.
The first line (header line) contains the NOAA name of the satellite.
Each following line contains epoch time in the CNES julian days (day 0=01/01/50 00h), quality flag (zero is good data), orbit number, extrapolation errors of position (km/day, 2 values forward and backward), the time-string (dd/mm/yy hh:mm:ss.sss), and the name of the TLE file (full name).
More details are given in *tle.5*.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Standard error output
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.

4.2.6. Inputs/outputs for SPMING navigation initialisation

Inputs

ADMIN

ADMIN file in CCSDS binary format. That file contains the METOP Administrative packet that, after decoding, and conversion to ASCII, will be stored in the navigation data directories for further use by satposspm.

Outputs :

SPM_YYYYMMDD_HHMN.TXT

SPM bulletin, yyyy(year) mm(month) dd(day) hh (hour) mn (minute).
Located in the directory ${DIR_NAVIGATION}/spm_db or orb_elem/yyyy-mm.
yyyymmdd hhmn is the date and time of reception of the bulletin.
Bulletins are classified by year and month of reception.

SPM_MXX.INDEX

Historical SPM index file for orbital parameters associated with a specific satellite, xx satellite number.
Located in the directory ${DIR_NAVIGATION}/spm_db or orb_elem.
The first line (header line) contains the name of the satellite.
Each following line contains epoch time in the CNES julian days (day 0=01/01/50 00h), order number, quality flag (zero is good data), orbit number, extrapolation errors of position (km/day, 2 values forward and backward), the time-string (dd/mm/yy hh:mm:ss.sss), and the name of the SPM file (full name).

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Standard error output
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.7. Inputs/outputs for SATPOST navigation initialisation

Inputs :

TBUS_YYYYMMDD.TXT

See input of tbusing

TBUS_NOAAXX.INDEX

See output of tbusing

STATIONS.TXT

ASCII file containing geographic coordinates of reception station
Located in the directory ${DIR_STATIONS}/stations.txt.
Each line contains the following information : latitude(deg)/longitude(deg)/altitude(km), elevation min. (deg) and name.

Outputs :

SATPOS_NOAAXX_YYYYMMDD.TXT

Satellite position-velocity ASCII file associated with a given station and a given satellite, xx (satellite number) yyyy(year) mm(month) dd(day).

Located in the directory ${DIR_NAVIGATION}/satpos.
Some dummy lines may exists at the beginning of the file. A line with the string #satpos indicates the actual beginning of the file.
The file header contains following information: names of satellite and station, start date, number of day, calculation time step, type, research criteria of the orbital bulletin and name of orbital bulletin, orbital parameters (date, semi-major axis (km), eccentricity, inclination (deg), perigee argument (deg), right ascension (deg), mean anomaly (deg), x,y,z positions (km), vx,vy,vz velocities (km/s)), ground station coordinates (latitude/longitude (deg), altitude (km), min. visibility (deg)).
Each data line contains : step number, position vector, inertial velocity vector, orbit number, satellite in daylight (0) or night-time (1) conditions, satellite seen from the station (0=yes, 1=no).
More details are given in *satpos.5*.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **satpost.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.8. Inputs/outputs for SATPOSTLE navigation initialisation

Inputs :

TLE_YYYYMMDD_HHMN.TXT

See input of tleing

TLE_NOAAXX.INDEX

See output of tleing

STATIONS.TXT

ASCII file containing geographic coordinates of reception station
Located in the directory ${DIR_STATIONS}/stations.txt.
Each line contains the following information : latitude(deg)/longitude(deg)/altitude(km), elevation min. (deg) and name.

Outputs :

SATPOS_NOAAXX_YYYYMMDD.TXT

Satellite position-velocity ASCII file associated with a given station and a given satellite, xx (satellite number) yyyy(year) mm(month) dd(day).
Located in the directory ${DIR_NAVIGATION}/satpos.
Some dummy lines may exists at the beginning of the file. A line with the string #satpos indicates the actual beginning of the file.
The file header contains following information: names of satellite and station, start date, number of day, calculation time step, type, research criteria of the orbital bulletin and name of orbital bulletin, orbital parameters (date, semi-major axis (km), eccentricity, inclination (deg), perigee argument (deg), right ascension (deg), mean anomaly (deg), x,y,z positions (km), vx,vy,vz velocities (km/s)), ground station coordinates (latitude/longitude (deg), altitude (km), min. visibility (deg)).
Each data line contains : step number, position vector, inertial velocity vector, orbit number, satellite in daylight (0) or night-time (1) conditions, satellite seen from the station (0=yes, 1=no).

More details are given in *satpos.5*.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text in standard output.
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.9. Inputs/outputs for SATPOSSPM navigation initialisation

Inputs :

SPM_YYYYMMDD_HHMN.TXT

See input of spming

SPM_MXX.INDEX

See output of spming

STATIONS.TXT

ASCII file containing geographic coordinates of reception station
Located in the directory ${DIR_STATIONS}/stations.txt.
Each line contains the following information : latitude(deg)/longitude(deg)/altitude(km), elevation min. (deg) and name.

Outputs :

SATPOS_MXX_YYYYMMDD.TXT

Satellite position-velocity ASCII file associated with a given station and a given satellite, xx (satellite number) yyyy(year) mm(month) dd(day).
Located in the directory ${DIR_NAVIGATION}/satpos.
Some dummy lines may exists at the beginning of the file. A line with the string #satpos indicates the actual beginning of the file.
The file header contains following information: names of satellite and station, start date, number of day, calculation time step, type, research criteria of the orbital bulletin and name of orbital bulletin, orbital parameters (date, semi-major axis (km), eccentricity, inclination (deg), perigee argument (deg), right ascension (deg), mean anomaly (deg), x,y,z positions (km), vx,vy,vz velocities (km/s)), ground station coordinates (latitude/longitude (deg), altitude (km), min. visibility (deg)).
Each data line contains : step number, position vector, inertial velocity vector, orbit number, satellite in daylight (0) or night-time (1) conditions, satellite seen from the station (0=yes, 1=no).
More details are given in *satpos.5*.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text in standard output.
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.10. Inputs/outputs for decommutation (DECOMMUTATION)

Inputs:

RAW DATA LEVEL0 :

Unpacked HRPT minor frame(s) coming from the center specific module closely connected to the hardware.
The HRPT minor frame is an array of 11090 words, made of the 10 bits HRPT words right justified in 16 bit words.
Different informations are getting from this input file by calling the **hrptidf** program.

AMSUA_CLPARAMS.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Used for AMSU-A decommutation and AMSU-A calibration
There is one file for all the satellites with different sections for :

- AMSU_A1 of NOAA15 ## AMSU-A1 FM1 DATA ## ## ID of instrument 9
- AMSU_A2 of NOAA15 ## AMSU-A2 PFM DATA ## ## ID of instrument 6
- AMSU_A1 of NOAA16 ## AMSU-A1 PFM DATA ## ## ID of instrument 5
- AMSU_A2 of NOAA16 ## AMSU-A2 FM1 DATA ## ## ID of instrument 10
- AMSU_A1 of NOAA17 ## AMSU-A1 FM2 DATA ## ## ID of instrument 13
- AMSU_A2 of NOAA17 ## AMSU-A2 FM2 DATA ## ## ID of instrument 14
- AMSU_A1 of NOAA18 ## AMSU-A1 FM3 DATA ## ## ID of instrument 33
- AMSU_A2 of NOAA18 ## AMSU-A2 FM3 DATA ## ## ID of instrument 18
- AMSU_A1 of NOAA19 ## AMSU-A1 DATA S/N 107 on NOAA-19 ##
- AMSU_A2 of NOAA19 ## AMSU-A2 DATA S/N 109 on NOAA-19 ##
- AMSU_A1 of METOP-A ## AMSU-A1 S/N 106 on METOP-A ##
- AMSU_A2 of METOP-A ## AMSU-A2 S/N 108 on METOP-A ##
- AMSU_A1 of METOP-B ## AMSU-A1 S/N 108 on METOP-B ##
- AMSU_A2 of METOP-B ## AMSU-A2 S/N 106 on METOP-B ##
- Values for Fundamental Constants are common for all the satellites.

The file must be modified in the following cases:

- Insertion of the parameters of a new satellite (furnished just before the launch).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 50 (see **decommutation.ksh**).
Located in the directory ../AAPP/src/calibration/libamsuacl and copied into the directory ${PAR_CALIBRATION_COEF}/amsua by the installation script.

Outputs:

LEVEL 1A DATA FILES :

Direct access and unformatted binary files separated for each instrument according to the input options (one file for one instrument).
Files are named :

hrsn.l1b msun.l1b aman.l1b ambn.l1b dcsn.l1b hrpt.l1b

Note that ambn.l1b can contain either AMSU-B or MHS data, depending on the satellite. Files are renamed at the end of **AAPP_RUN**

hirsl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

msul1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

amsual1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

amsubl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

hrpt_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

with SATIMG : satellite name (example noaa16)

YYYYMMDD.: year-month-day of data

HHMN : time of data

NNNNN : orbit number

Each file contains: 1 header record +1 data record for each scan line
The size of the record depends on the instrument

- 22016 bytes for AVHRR (does not respect 1B NOAA size, see AAPP documentation/data formats))
- 4608 bytes for HIRS
- 2560 bytes for AMSU-A
- 3072 bytes for AMSU-B/MHS
- 1024 bytes for MSU
- 10752 bytes for DCS

Calibration and location fields are set to zero.
Each data record for a level 1a line contains counts + time + housekeeping information.
For the HIRS, AMSU-A, AMSU-B and MHS, the level 1a files are very closed to the NOAA 1b formats. The differences are in some scaling factors.
For the MSU, AAPP has developed its own MSU.l1b format. It is very close to the HIRS, AMSU-A and AMSU-B formats.
For the AVHRR, the file is different from NOAA one (see AAPP documentation/data formats).
For all the instruments, there are no missing lines (different from NOAA format)
To get the details of the files, see the corresponding include files.
Associated with logical units (see **decommutation.ksh**):

11 for **hrsn.l1b**
12 for **msun.l1b**
13 for **dcsn.l1b**
14 for **hrpt.l1b**
15 for **aman.l1b**
16 for **ambn.l1b**

Located in the directory ${WRK}.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **decommutation.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.11. Inputs/outputs EPS level 0 format to AAPP level 1a format

Inputs:

See documents [25]

Outputs:

LEVEL 1A DATA FILES :

It is the same format that the Decommutation outputs.

Named : **hrsn.l1b msun.l1b aman.l1b ambn.l1b hrpt.l1b**
File **ambn.l1b** contains either AMSU-B or MHS data, depending on the satellite.
Outputs of the decommutation task.
Logical units used can differ following the instruments to process . See the corresponding scripts.
More often, the associated logical unit is 11.
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

4.2.12. Inputs/outputs ATOVS and AVHRR navigation (HIRSCL, HIRSCL_ALGOV4, MSUCL, AMSUACL, AMSUBCL, MHSCL, AVHRCL)

Inputs :

LEVEL 1B DATA FILES :

Named : **hrsn.l1b msun.l1b aman.l1b ambn.l1b hrpt.l1b**
File **ambn.l1b** contains either AMSU-B or MHS data, depending on the satellite.
Outputs of the decommutation task.
Logical units used can differ following the instruments to process . See the corresponding scripts.
More often, the associated logical unit is 11.
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

SATPOS_NOAAXX_YYYYMMDD.TXT

ASCII file.
Satellite position-velocity associated with a given station and a given satellite with xx satellite number, yyyymmdd start date of position-velocity calculation.
Ouput of the **satpost** or **satpostle** command.
Logical unit used can differ following the instruments to process . See the corresponding scripts. More often, the associated logical unit is 15.
Located in the directory ${DIR_NAVIGATION}/satpos.
More details are given in *satpos.5* .

CLKERR_NOAAXX.TXT

ASCII file.
Historical clock error file associated with a specific satellite, xx satellite number
Output of the **tbusing** command.
Logical units used can differ following the instruments to process . See the corresponding scripts.
More often, the associated logical unit is 16.
Located in the directory ${DIR_NAVIGATION}/tbus_tb or orb_elem.
More details are given in *clockerror.5* .

Outputs :

LEVEL 1B DATA FILES :

Files are named : **hrsn.l1b msun.l1b aman.l1b ambn.l1b hrpt.l1b**

Files are renamed at the end of **AAPP_RUN**

hirsl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

msul1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

amsual1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

amsubl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

hrpt_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

with	SATIMG : satellite name (example noaa16)
	YYYYMMDD.: year-month-day of data
	HHMN : time of data
	NNNNN : orbit number

Compared to level.1a structure, 'navigation' parameters have been updated.
Located in the directory ${WRK}.
More details, see outputs of **decommutation**

4.2.13. Inputs/outputs HIRS calibration (first algorithm) (HIRSCL)

Inputs :

HIRS LEVEL 1A DATA FILE :

Named **hrsn.l1b**.
Output of the decommutation task.
Associated with logical unit 11 (see **hirscl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

CALCOEF.DAT

Sequential file in ASCII text.
Contains calibration HIRS parameters.
Self-documented (lines of comments begin with "#").
One file for all the satellites (with 1 section for each).
C1 and C2 constants, used in the function of Planck are the same for all the satellites.
This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).
- When the range of values are too strict and excludes too many values (that's why sometime there is no calibration for a channel). So, modification of these values is needed. For example, lighting conditions of the satellite change according to the season. This phenomenon induces variations in the observed numerical counts (e.g. NOAA12 in May and September).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 12 (see **hirscl.ksh**)
Located in the directory ../AAPP/src/calibration/libhirscl and copied into the directory ${PAR_CALIBRATION_COEF}/hirs by the installation script.

TESTCOEF.DAT

Sequential file in ASCII text
Contains the values of the parameters used in calibration tests.
Self-documented (lines of comments begin with "#").
Common values for all the satellites.
The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 13 (see **hirscl.ksh**)
Located in the directory ../AAPP/src/calibration/libhirscl and copied into the directory ${PAR_CALIBRATION_COEF}/hirs by the installation script.

Outputs :

HIRS LEVEL 1B DATA FILE :

Named **hrsn.l1b**.

File is renamed at the end of **AAPP_RUN**.

hirsl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see **hirscl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONHIRS.TXT

Formated file in ASCII text.
Contains various statistics parameters showing the evolution of the calibration coefficient calculation.
Filled during the run of **hirscl.exe** if specified in input options. One record added for one run.
Associated with logical unit 14 (see **hirscl.ksh**).
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **hirscl.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}

4.2.14. Inputs/outputs HIRS calibration algorithm version 4 – part 1 (HCALCB1_ALGOV4)

Inputs :

HIRS_HISTORIC.TXT

Formated file in ASCII text.
Contains values of various parameters used into the calculation of the calibration coefficients.

Filled during the run of **hirscl_algoV4.exe** : 70 lines added for one qualified calibration cycle of an orbit.
If the file doesn't exist (after the launch of the satellite for example), the script hcalcb1_algoV4 create the file (empty file named hirs_historic).
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

outputs :

HIRS_B1ASLOPE.TXT

Sequential file in ASCII text of 22 lines
Contains the date and time of a reference time, the number of hours. The two parameters determines the period of the HIRS data used to compute the b1 coefficients and the average slopes. Contains the 19 b1 coefficients and the 19 average slopes.
Located in the directory ${WRK}.

4.2.15. Inputs/outputs HIRS calibration algorithm version 4 – part 2 (HIRSCL_ALGOV4)

Inputs :

HIRS LEVEL 1A DATA FILE :

Named **hrsn.l1b**.
Output of the decommutation task.
Associated with logical unit 11 (see **hirscl_algoV4.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

HIRS_B1ASLOPE.TXT

Sequential file in ASCII text of 22 lines
Contains the date and time of a reference time, the number of hours. The two parameters determines the period of the HIRS data used to compute the b1 coefficients and the average slopes. Contains the 19 b1 coefficients and the 19 average slopes.
Output of the script hcalcb1_algoV4 that must run before **hirscl_algoV4**.
Associated with logical unit 14 (see **hirscl_algoV4.ksh**).
Located in the directory ${WRK}.

CALCOEF_ALGOV4.DAT

Sequential file in ASCII text.
Contains calibration HIRS parameters.
Self-documented (lines of comments begin with "#").
One file for all the satellites (with 1 section for each).
C1 and C2 constants, used in the function of Planck are the same for all the satellites.
This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).
- When the range of values are too strict and excludes too many values (that's why sometime there is no calibration for a channel). So, modification of these values is needed. For example, lighting conditions of the satellite change according to the season. This phenomenon induces variations in the observed numerical counts (e.g. NOAA12 in May and September).

The version number and the date of the file allow to distinguish the successive versions.

Associated with logical unit 12 (see **hirscl_algoV4.ksh**)
Located in the directory ../AAPP/src/calibration/libhirscl_algoV4 and copied into the directory ${PAR_CALIBRATION_COEF}/hirs by the installation script.

TESTCOEF_ALGOV4.DAT

Sequential file in ASCII text
Contains the values of the parameters used in calibration tests.
Self-documented (lines of comments begin with "#").
Common values for all the satellites.
The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 13 (see **hirscl_algoV4.ksh**)
Located in the directory ../AAPP/src/calibration/libhirscl_algoV4 and copied into the directory ${PAR_CALIBRATION_COEF}/hirs by the installation script.

Outputs :

HIRS LEVEL 1B DATA FILE :

Named **hrsn.l1b**.

File is renamed at the end of **AAPP_RUN**.

hirsl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see **hirscl_algoV4.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

HIRS_HISTORIC.TXT

Formated file in ASCII text.
Contains values of various parameters used into the calculation of the calibration coefficients and later used to compute the b1 coefficients and the average slopes.
70 lines added for one qualified calibration cycle of an orbit.
Can contain values for several orbit runs.
The script hirs_historic_file_manage.ksh manges the file: When the file has a number of lines superior to a define number (see hirs_historic_file_manage.ksh), it is copied to hirs_historic.txt.0 file. If hirs_historic.txt.0 file already exists, it is moved to hirs_historic.txt.1 . to hirs_historic.txt.max can be stored (see hirs_historic_file_manage.ksh for max). The final part of ${HIST} is remained in ${HIST}.
Associated with logical unit 15 (see hirscl_algoV4.ksh).
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **hirscl.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}

4.2.16. Inputs/outputs MSU calibration (MSUCL)

Inputs :

MSU LEVEL 1A DATA FILE :

Named **msun.l1b**.
Output of the decommutation task.
Associated with logical unit 11 (see **msucl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

CALCOEF.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Contains calibration MSU parameters.
One file for all the satellites (with 1 section for each).
C1 and C2 constants, used in the function of Planck are the same for all the satellites.
This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).
- When the reference temperature is too far from the most computed temperatures. Messages are printed (see different examples in the comment section).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 12 (see **msucl.ksh**).
Located in the directory ../AAPP/src/calibration/libmsucl and copied into the directory ${PAR_CALIBRATION_COEF}/msu by the installation script.

TESTCOEF.DAT

Sequential file in ASCII text.
Contains the values of the parameters used in calibration tests.
Self-documented (lines of comments begin with "#").
Common values for all the satellites.
The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 13 (see **msucl.ksh**)
Located in the directory ../AAPP/src/calibration/libmsucl and copied into the directory ${PAR_CALIBRATION_COEF}/msu by the installation script.

Outputs :

MSU LEVEL 1B DATA FILE :

Named **msun.l1b**

File is renamed at the end of **AAPP_RUN**

msul1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see **msucl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONMSU.TXT

Formated file in ASCII text
Contains various statistics parameters showing the evolution of the calibration coefficient calculation.
Filled during the run of **msucl.exe** if specified in input options. One record added for one run.
Associated with logical unit 14 (see **msucl.ksh**).

Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **msucl.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}

4.2.17. Inputs/outputs AMSU-A calibration (AMSUACL)

Inputs :

AMSU-A LEVEL 1A DATA FILE :

Named **aman.l1b**.
Output of the decommutation task.
Associated with logical unit 11 (see a**msuacl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

AMSUA_CLPARAMS.DAT

Sequential file in ASCII text
Self-documented (lines of comments begin with "#").
Used for AMSU-A decommutation and AMSU-A calibration.
There is one file for all the satellites with different sections for :

- AMSU-A1 of NOAA15 ## AMSU-A1 FM1 DATA ## ## ID of instrument --> 9
- AMSU-A2 of NOAA15 ## AMSU-A2 PFM DATA ## ## ID of instrument --> 6
- AMSU-A1 of NOAA16 ## AMSU-A1 PFM DATA ## ## ID of instrument --> 5
- AMSU-A2 of NOAA16 ## AMSU-A2 FM1 DATA ## ## ID of instrument --> 10
- Values for Fundamental Constants are common for all the satellites.

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 12 (see **amsuacl.ksh**).
Located in the directory ../AAPP/src/calibration/libamsuacl and copied into the directory ${PAR_CALIBRATION_COEF}/amsua by the installation script.

AMSUA_CLCOEFS.DAT

Sequential file in ASCII text
Self-documented (lines of comments begin with "#").
Contains the values of the AMSU-A secondary coefficients used in calibration.
There is one file for all the satellites with different sections for :

- AMSU-A1 of NOAA15 ## AMSU-A1 FM1 DATA ## ## ID of instrument --> 9
- AMSU-A2 of NOAA15 ## AMSU-A2 PFM DATA ## ## ID of instrument --> 6
- AMSU-A1 of NOAA16 ## AMSU-A1 PFM DATA ## ## ID of instrument --> 5
- AMSU-A2 of NOAA16 ## AMSU-A2 FM1 DATA ## ## ID of instrument --> 10

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

The version number and the date of the file allow to distinguish the successive versions.

Associated with logical unit 13 (see **amsuacl.ksh**)
Located in the directory ../AAPP/src/calibration/libamsuacl and copied into the directory ${PAR_CALIBRATION_COEF}/amsua by the installation script.

Outputs :

AMSU-A LEVEL 1B DATA FILE :

Named **aman.l1b**

File is renamed at the end of **AAPP_RUN**

amsual1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see a**msuacl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONAMSUA.TXT

Formatted file in ASCII text.
Filled during the run of a**msuacl.exe** if specified in input options. One record added for one run.
With AAPP version 3, nothing is written into this file.
Associated with logical unit 14 (see a**msubcl.ksh**).
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **amsuacl.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.18. Inputs/outputs AMSU-B calibration (AMSUBCL)

Inputs :

AMSU-B LEVEL 1A DATA FILE :

Named **ambn.l1b**
Output of the decommutation task.
Associated with logical unit 11 (see **amsubcl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

AMSUB_CLPARAMS.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Used for AMSU-B calibration.
There is one file for all the satellites with different sections for :

- AMSU-B of NOAA15 ## AMSU-B PFM DATA ## ## ID of instrument → 4
- AMSU-B of NOAA16 ## AMSU-B FM2 DATA ## ## ID of instrument → 8
- AMSU-B of NOAA17 ## AMSU-B FM3 DATA ## ## ID of instrument →12
- Values for Fundamental Constants are common for all the satellites.

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 12 (see **amsubcl.ksh**).
Located in the directory ../AAPP/src/calibration/libamsubcl and copied into the directory ${PAR_CALIBRATION_COEF}/amsub by the installation script.

AMSUB_CLCOEFS.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Contains the values of the AMSU-B secondary coefficients used in calibration.
There is one file for all the satellites with different sections for :

- AMSU-B of NOAA15 ## AMSU-B PFM DATA ## ## ID of instrument → 4
- AMSU-B of NOAA16 ## AMSU-B FM2 DATA ## ## ID of instrument → 8
- AMSU-B of NOAA17 ## AMSU-B FM3 DATA ## ## ID of instrument → 12

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launching).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 13 (see **amsubcl.ksh**).
Located in the directory ../AAPP/src/calibration/libamsubcl and copied into the directory ${PAR_CALIBRATION_COEF}/amsub by the installation script.

AMSUB_BIAS.DAT

Sequential file in ASCII text
Self-documented (lines of comments begin with ";").
Contains the values of the AMSU-B bias correction for NOAA15
Associated with logical unit 17 (see a**msubcl.ksh**).
Located in the directory ../AAPP/src/calibration/libamsubcl and copied into the directory ${PAR_CALIBRATION_COEF}/amsub by the installation script.

Outputs :

AMSU-B LEVEL 1B DATA FILE :

Named **ambn.l1b**

File is renamed at the end of **AAPP_RUN**

amsubl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see a**msubcl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONAMSUB.TXT

Formatted file in ASCII text.
Filled during the run of a**msubcl.exe** if specified in input options. One record added for one run.
With AAPP version 3, nothing is written into this file.
Associated with logical unit 14 (see a**msubcl.ksh**)
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **amsubcl.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.19. Inputs/outputs MHS calibration (MHSCL)

Inputs :

MHS LEVEL 1A DATA FILE :

Named **ambn.l1b**
Output of the decommutation task.
Associated with logical unit 11 (see **mhscl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MHS_CLPARAMS.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Used for MHS calibration.
There is one file for all the satellites with different sections for :

- MHS of NOAA-N ## MHS PFM DATA on NOAA-18 ## ## ID of instrument → 1
- MHS of METOP-A and METOP simulator
- MHS for NOAA-N' and other METOP satellites will be added at a later date
- Values for Fundamental Constants are common for all the satellites.

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 12 (see **mhscl.ksh**).
Located in the directory ../AAPP/src/calibration/libmhscl and copied into the directory ${PAR_CALIBRATION_COEF}/mhs by the installation script.

MHS_CLCOEFS.DAT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Contains the values of the AMSU-B secondary coefficients used in calibration.
There is one file for all the satellites with different sections for :

- MHS of NOAA-N ## MHS PFM DATA ## ## ID of instrument → 1
- MHS of METOP-A and METOP simulator
- MHS for NOAA-N' and other METOP satellites will be added at a later date

This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launching).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 13 (see **mhscl.ksh**).
Located in the directory ../AAPP/src/calibration/libmhscl and copied into the directory ${PAR_CALIBRATION_COEF}/mhs by the installation script.

Outputs :

MHS LEVEL 1B DATA FILE :

Named **ambn.l1b**

File is renamed at the end of **AAPP_RUN**

amsubl1b_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 11 (see a**msubcl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONAMSUB.TXT

Formatted file in ASCII text.
Filled during the run of a**msubcl.exe** if specified in input options. One record added for one run.
With AAPP version 3, nothing is written into this file.
Associated with logical unit 14 (see a**msubcl.ksh**)
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **amsubcl.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt… write into it.
Located in the directory ${WRK}.

4.2.20. Inputs/outputs AVHRR calibration (AVHRCL)

Inputs :

AVHRR LEVEL 1A DATA FILE :

Named **hrpt.l1b**.
Output of the decommutation task.
Associated with logical unit 10 (see **avhrcl.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

AVHCAL.TXT

Sequential file in ASCII text.
Self-documented (lines of comments begin with "#").
Contains calibration parameters.
One file for all the satellites (with 1 section for each).
C1 and C2 constants, used in the function of Planck are the same for all the satellites.
This file must be modified in the following cases :

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

The version number and the date of the file allow to distinguish the successive versions.
Associated with logical unit 11 (see **avhrcl.ksh**).
Located in the directory ../AAPP/src/calibration/libavhrcl and copied into the directory ${PAR_CALIBRATION_COEF}/avhcl by the installation script.

Outputs :

AVHRR LEVEL 1B DATA FILE :

Named **hrpt.l1b**

File is renamed at the end of **AAPP_RUN**

hrpt_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 10 (see **avhrcl.ksh**)
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

MONAVHR.TXT

Formated file in ASCII text
Contains various statistics parameters showing the evolution of the calibration coefficient calculation.
Filled during the run of **avhrcl.exe** if specified in input options. One record added for one run.
Associated with logical unit 12 (see **avhrcl.ksh**).
Located in the directory ${PAR_CALIBRATION_MONITOR}/noaaXX with XX satellite number.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **avhrcl.log**.
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.21. Inputs/outputs sounders calibration application (ATOVIN)

Inputs :

LEVEL 1B DATA FILES :

Direct access and unformatted binary files separated for each instrument according to the input options.(one file per instrument).
These files come from HRPT raw data processed by the decommutation, navigation and calibration modules (output files of **hirscl**, **msucl**, **amsuacl**, **amsubcl, mhscl**).
Files are named :

hrsn.l1b msun.l1b aman.l1b ambn.l1b

From AAPP v7.2, the user may specify different input file names, via the “-f ” option.

Each file contains: 1 header record +1 data record for each scan line
The size of the record depends on the instrument:

- 4608 bytes for HIRS
- 2560 bytes for AMSU-A
- 3072 bytes for AMSU-B/MHS
- 1024 bytes for MSU

Each record contains calibration coefficients + counts + time + lat /lon + view angles, altitude and attitude + quality control information + housekeeping information.

For the HIRS, AMSU-A, AMSU-B and MHS the level 1b files are very close to the NOAA 1b formats. The differences are in some scalling factors.
For the MSU, AAPP has developed its own MSU.l1b format. It is very close to the HIRS, AMSU-A and AMSU-B formats.
For all the instruments, there are no missing lines (different from NOAA format)
To get the details of the files, see the corresponding include files.
Associated with logical units (see **atovin.ksh**)

- 11 for **hrsn.l1b**
- 12 for **aman.l1b**
- 13 for **ambn.l1b**
- 14 for **msun.l1b**

Located in the directory ${WRK}

FIXED DATA FILE :

Sequential file in ASCII text.
Named **fdf.dat** containing fixed data for **ATOVIN**.
One file for all the satellites (with 1 section for each).
Self-documented (lines of comments begin with "!").
Contains Satellite name, NOAA satid, nominal satellite height (km), orbit period (sec)
If ATOVS satellite, contains antenna efficiencies for Earth-, platform-, space-view (Ae, Ap, As). For details of the antenna efficiencies see [5].
Note that comment lines must not appear between the 'channel number' and the efficiencies, for each channel.
Optionally contains antenna reflectivity factors for use in the scan-dependent correction – primarily for MHS. See Scientific Description.
ATOVIN will not read beyond a line with 'END' as the first 3 characters.
This file must be modified in the following case:

- Insertion of the parameters of a new satellite (furnished just before the satellite launch).

Associated with logical unit 10 (see **atovin.ksh**).
Located Located in the directory ../AAPP/src/preproc/libatovin and copied into the directory ${DIR_PREPROC} by the installation script.

STX1_MAR99CORR.DAT :

Sequential file in ASCII text.
Contains March 99 STX-1 corrections for NOAA-15 AMSU-B data.
To get details of the format, see the module **amb_getstx1.F** (AAPP/src/preproc/libatovin) that reads the file.
Associated with logical unit 99 (see **atovin.ksh**).
Located in the directory ${DIR_PREPROC}.

Outputs :

LEVEL 1C DATA FILES :

Direct access and unformatted binary files separated for each instrument according to the input options (one file for one instrument).
Named **hrsn.l1c msun.l1c aman.l1c ambn.l1c**

From AAPP v7.2, if the user specifies input file names other than the default names, then the output file names will be based on the supplied input files, but with a suffix .l1c and with “l1b” converted to “l1c” in the file name.

Files are renamed at the end of **AAPP_RUN**

hirsl1c_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1c

msul1c_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1c

amsual1c_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1c

amsubl1c_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1c

with SATIMG : satellite name (example noaa16)

YYYYMMDD.: year-month-day of data

HHMN : hour of data

NNNNN : orbite number

Each file contains: 1 header record + 1 data record for each scan line.
the record size depends on the instrument:

- 6656 bytes for HIRS
- 3072 bytes for AMSU-A
- 4608 bytes for AMSU-B/MHS
- 512 bytes for MSU

Each record contains brightness temperatures + time + lat/long + view angles, altitude and attitude + quality control info.
Associated with logical units (see **atovin.ksh**):

21 for **hrsn.l1c**
22 for **aman.l1c**
23 for **ambn.l1c**
24 for **msu.l1c**

Located in the directory ${WRK}.
To get the details of the files, see the corresponding include files.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **atovin.log**.
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.22. Inputs/outputs sounders mapping(ATOVPP)

Inputs :

LEVEL 1C DATA FILES :

Named **hrsn.l1c msun.l1c aman.l1c ambn.l1c iasi.l1c**
Outputs of the **atovin** task.
Associated with logical units (see **atovpp.ksh**):

11 for **hrsn.l1c**
12 for **aman.l1c**
13 for **ambn.l1c**
14 for **msu.l1c**
15 for **iasi.l1c**

16 for **iasi.lpc**
17 for **atms.l1c**
18 for **cris.l1c**

Located in the directory ${WRK}
More details, see outputs of atovin.

From AAPP v7.2, the user may specify different input file names, via the "-f " option.

INSTRUMENT FIXED DATA FILES :

Sequential file in ASCII text.
One file for each instrument, named **HIRS.fdf**, **MSU.fdf**, **AMSUA.fdf, AMSUB.fdf, IASI.fdf** and containing fixed data for **ATOVPP**.
Data do not depend on the satellite.
Self-documented (lines of comments begin with "!").
Sections are identified by key words starting in column one: BIAS, PREPRO, MSULIMB . Lines before the start of sections are ignored. Some sections are optional in that if they are omitted, ATOVPP will use default values. Sections can be specified in any order.
Data in section BIAS are added to the brightness temperatures before any other processing occurs.
Data in section PREPRO are the coefficients, thresholds, and other numbers required for the various pre-processing tests and corrections.
Data in section MSULIMB, only in the MSU fixed data file, represents the expected differences (in K) between MSU brightness temperatures at each HIRS fov and at nadir. There are two curves, one appropriate for land and one for sea. The intention is to aid the mapping of MSU to HIRS.
ATOVPP will not read beyond a line with 'END' as the first 3 characters.
Associated with logical units (see **atovpp.ksh**):
41 for **HIRS.fdf**
42 for **AMSUA.fdf**
43 for **AMSUB.fdf**
44 for **MSU.fdf**
45 for **IASI.fdf**
54 for **ATMS.fdf**
55 for **CRIS.fdf**
Other data files for IASI:
46 for IASI_eig_encode.dat (eigenvectors to be used for Principal Components encoding)
47 for IASI_eig_decode.dat (eigenvectors to be used for decoding – not used in atovpp but generated automatically for down-stream use)
48 for IASI_noise.dat (IASI noise profile for all 8461 channels)
49 for DeApod_ratio.txt (data to allow de-apodisation of IASI data)
Located in the directory ../AAPP/src/preproc/libatovpp and copied into the directory ${DIR_PREPROC} by the installation script.

LUT FIXED DATA FILE

Sequential file in ASCII text
Named **LUT.fdf**, containing time/angle corrections for the mappings between instrument grids.
Data can depend on the satellite.
Self-documented (lines of comments begin with "!").
Time and angle corrections can be specified for any and all possible mappings. If corrections for a mapping are not specified in the file, then ATOVPP sets them to zero.
ATOVPP will read the file until it comes to a line that isn't a comment line ('!' in column one). It will interpret the line by looking for the satellite name (e.g. 14 for NOAA-14), and also picking out the

first two instrument names that it recognises. The first is taken as the mapping instrument, and the second as the target. It then reads the corrections.
ATOVPP will not read beyond a line with 'END' as the first 3 characters.
Associated with logical unit 50 (see **atovpp.ksh**).
Located Located in the directory ../AAPP/src/preproc/libatovpp and copied into the directory ${DIR_PREPROC} by the installation script.

TOPOGRAPHY FILES

Binary file
Named **maptopog.dat** and **mapbitls.dat**.
Derived from those provided with the CIMSS ITPP export package.
Are two complementary files: a land/sea bitmap and a dataset of surface elevations.
Data are given on a regular 1/6th degree x 1/6th degree lat/lon grid. The surface elevations are to the nearest 100 feet (=30.5metres) and are only specified for land points. This gives a considerable space saving but leads to inaccuracies in some areas (e.g. Lake Victoria).
(Subroutine **surfelev** gives some information).
Associated with logical units (see **atovpp.ksh**): 51 for **mapbitls.dat**
52 for **maptopog.dat**
Located in the directory ../AAPP/src/preproc/libatovpp and copied into the directory ${DIR_PREPROC} by the installation script.

PPBG2A.DAT

Sequential file in ASCII text.
Associated with logical unit 70 (see **atovpp.ksh**).
Located in the directory ../AAPP/src/preproc/libatovpp and copied into the directory ${DIR_PREPROC} by the installation script.

Outputs :

LEVEL 1D DATA FILE :

Direct access and unformatted binary files separated for each target instrument according to the input options (one file for each target instrument, for each instrument grid).
Instrument combinations

- HIRS + AMSU-A + AMSU-B/MHS data on the HIRS grid,
- AMSU-A + AMSU-B/MHS data on the AMSU-A grid,
- AMSU-A + AMSU-B/MHS data on the AMSU-B grid,
- AMSU-A + MHS data on the IASI grid,
- HIRS + MSU data on the HIRS grid.

In the standard AAAPP_RUN_NOAA script there is only one target instrument: HIRS. So only one output level 1D file: **hirs.l1d.** The User can modify the call to atovpp if other combinations are required.

From AAPP v7.2, if the user specifies input file names other than the default names, then the output file names will be based on the supplied input files, but with a suffix .l1d and with “l1c” converted to “l1d” in the file name.

File **hirs.l1d** is renamed at the end of **AAPP_RUN**

hirsl1d_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1d

with SATIMG : satellite name (example noaa16)

YYYYMMDD.: year-month-day of data

HHMN : hour of data

NNNNN : orbit number

Each file contains: 1 header record + 1 data record for each scan line
the record size depends on the instrument:

15872 bytes for HIRS

Each record contains pre-processed brightness temperatures + time + lat/long + satellite zenith angle + azimuth angle + altitude and attitude + quality control information + pre-processing flags + surface information.
Associated with logical unit 21 (see **atovpp.ksh**).
Located in the directory ${WRK}
To get the details of the file, see the corresponding include file.
Note: **atovpp** pre-processes brightness temperatures on grid of selected instruments: HIRS, AMSU-A, AMSU-B, IASI. This format of output on each grid (HIRS, AMSU-A, AMSU-B, IASI) is intended to be flexible. Some parts of the format are fixed, and other parts will be customised to fit the requirements of individual centers. The AMSU-A and B level 1d formats may need to be expanded to accommodate extra mappings. A change in format will require changes in the *ppXouth* an *ppXoutd* routines.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **atovpp.log**
The commands “print*” , “write(*,)” and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.23. Inputs/outputs for mapping cloud mask AVHRR to HIRS (AVH2HIRS)

Inputs :

USER INPUT PARAMETERS IN ATOVS_ENV :

Set up in the following run conditions :

DIR_FORECAST= source directory of the forecast

DIR_MAIA2_ATLAS= source directory of the climatologies

DIR_MAIA2_THRESHOLDS= source directory of the threshold files

FORECAST_FORMAT= ‘grib’ or ‘ascii’

NFORPERDAY= number of possible forecast per day (def=4)

HIRS LEVEL 1D DATA FILE :

Named **hirs.l1d**.
Outputs of the **atovpp** pre-processing task of mapping AMSU-A/AMSU-B or MSU into a HIRS grid.
Associated with logical unit 12 (see **avh2hirs.ksh**).
Located in the directory ${WRK}.
More details, see outputs of **atovpp**.

AVHRR LEVEL 1B DATA FILE :

Direct access and unformatted binary file.

Named **hrpt.l1b**.
Output of **avhrcl** AVHRR calibration and localisation task.
File contains: 1 header record + 1 data record for each scan line.
The size of the record: 22016 bytes (does not respect 1B NOAA size, see appendix A).
No missing line (different from NOAA format).
Each data record contains counts + time + calibration coefficients + lat/long + housekeeping information + quality control information.
Associated with logical unit 11 (see **avh2hirs.ksh**).
Located in the directory ${WRK}.
To get the details of the files, see the corresponding include files.

TIME AND ANGLE CORRECTION FILE :

Sequential file in ASCII text, including time and angle corrections for mapping.
Named **cor_nxx.dat**, xx satellite number (cor_n12.dat, cor_n14.dat, cor_n15.dat, cor_n16.dat).
Contains optional corrections and adjustments for mapping (used by **lutmap**). Zeros are used by default.
To get the details of the files, see modules **avh2hirs** or **avh2hirs_atovs** that read the file.
Associated with a constant logical unit lucor=50+xx, xx satellite number.
Located in the directory ../AAPP/src/preproc/libavh2hirs_maia_2.1 and copied into the directory ${DIR_PREPROC} by the installation script.

ALBEDO, SEA SURFACE TEMPERATURE (SST) AND SPECIFIC HUMIDITIES (WV) CLIMATOLOGIC FILES :

Binary file, direct access
Monthly climatologix files
Named atlas_albedo_${MM}.dat for albedo files
atlas_sst_${MM}.dat for SST
atlas_wv_${MM}.dat for WV
with MM month
Unit of the albedo is %*100.
Unit of the SST is Celsius*100
Unit of the specific humidity profiles is g/kg*100
The specific humidities is used to compute the total water vapor content.
To get the details of the files, see modules **maia_lec_clim**, **lec_clim_alb**, **lec_clim_sst**, **lec_clim_cwv** (src/preproc/libmaia_2.1).

Structure of these binary files is described in the header record that is read at the beginning of **lec_clim_alb**, **lec_clim_sst**, **lec_clim_cwv.**
The structure is determinated with the month (format I2.2), the record length (format I6), the latitude of the 1st pixel of the file (format F10.4), the longitude of the 1st pixel of the file (format F10.4), the lattitude increment (format F10.4), the longitude increment (format F10.4), the pixel size of the file (longitudes) (format I6), the line size of the file (latitudes) (format I6).

Associated with constant logical units: iualb=30 (see **maia2_env.ksh** and **maia_lec_clim.F**)
iusst=31
iuwc=33
Located in the directory ${ DIR_MAIA2_ATLAS}

FORECAST FILES :

Two formats are available for reading : GRIB (standard meteorological format) and formatted ASCII. Information is given in the AAPP documentation/data formats.
Named:

GRIB format: **YYYYMMDDHH00_0EC** where the date YYYYMMDDHH corresponds to the date of creation with the EC delay.

ASCII format: **previ_YYYYMMDD_HH00.txt** where the date corresponds to the date of the satellite observations (no need of a delay).

Contains the forecast air surface temperatures at 2 meters, precipitable water (if available), the atmospheric profile (needed if precipitable water is not available) and altitude of the nodes of the grid. To get the details of the files, see modules **lec_previ**, **lec_previ_ascii**, **lec_previ_grib_api** (src/preproc/libmaia_2.1).
Associated with constant logical units: iuforecast=32 (see **maia2_env.ksh**)
Located in the directory ${DIR_FORECAST}.

THRESHOLD CONSTANT FOR CLOUD MASK :

These local thresholds (for Lannion) are set up in the include file **maia.h**.
Units are K*100 or degres*100 when used in difference of 2 temperatures. (ex : cst_ir = 1000 is the constant in K for IR threshold ; cst_45s = 300 is the constant in degrees for the threshold used in the test of the temperature difference of channel 4 and 5 over the sea).

THRESHOLD FILES FOR CLOUD MASK :

ASCII files.
7 thresholds files named xx,satellite number

T45_mercot_-3:+3_noaaxx.dta	(sea coast day/night)
T35_mercot_-3:+3_noaaxx.dta	(sea coast day/night)
T43_mercot_-3:+3_noaaxx.dta	(sea coast day/night)
T45_veget_-10:+10_noaaxx.dta	(land (vegetation), day)
T45_ veget_-3:+5_noaaxx.dta	(land (vegetation), night)
T45_ veget_-3:+5_noaaxx.dta	(land (vegetation), night)
T45_ veget_-3:+5_noaaxx.dta	(land (vegetation), night)

Used to determine the thresholds depending of the total water vapor content and the secant of the zenith angle.
Associated with constant logical units(see **maia2_env.ksh**):

70 for t45_mercot_-3:+3_${SATIMG}.dta

80 for t35_mercot_-3:+3_${SATIMG}.dta

90 for t43_mercot_-3:+3_${SATIMG}.dta

71 for t45_veget_-10:-10_${SATIMG}.dta

72 for t45_veget_+3:+5_${SATIMG}.dta

82 for t35_veget_+3:+5_${SATIMG}.dta

92 for t43_veget_+3:+5_${SATIMG}.dta

Located in the directory ${DIR_MAIA2_THRESHOLDS}.

Outputs :

HIRS LEVEL 1D DATA FILE WITH CLOUD MASK :

Named **hirs.l1d**

File **hirs.l1d** is renamed at the end of **AAPP_RUN**

hirsl1d_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1d

with SATIMG : satellite name (example noaa16)

YYYYMMDD.: year-month-day of data

HHMN : hour of data

NNNNN : orbite number

Compared to **hirs.l1d** input file, the 13 'cloud mask' parameters have been updated for each HIRS target pixel.
Associated with logical unit 12 (see **avh2hirs.ksh**):
Located in the directory ${WRK}
More details, see outputs of **atovpp**.

STATISTICS FILE :

Statistics file in formatted ASCII text
Named **mapqual_${SATIMG}.txt**.
Filled at the end of **AVH2HIRS** processing.
Contains global H8-A4 standard deviations (F6.5) and H8-A4 standard deviation for each HIRS pixel (56F5.2). Start date (2I3.2) and orbit (I6) are written at the beginning of the file.
Associated with logical unit 22 (see **avh2hirs.ksh**).
Located in the directory ${WRK}.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **avh2hirs.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.

4.2.24. Inputs/outputs sounders calibration application (AVHRRIN)

Inputs :

LEVEL 1B DATA FILES :

Direct access and unformatted binary files separated for AVHRR instrument
The file comes from HRPT raw data processed by the decommutation, navigation and calibration modules
Named **hrpt.l1b**

File is renamed at the end of **AAPP_RUN**

hrpt_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Located in the directory ${WRK}.
The file contains: 1 header record +1 data record for each scan line
The size of the record depends on the instrument:

- 22016 bytes

Each record contains calibration coefficients + counts + time + lat /lon + view angles, altitude and attitude + quality control information + housekeeping information.
There are no missing lines (different from NOAA format)
To get the details of the files, see the corresponding include files.

Associated with logical units AVH1Bunit (see **ATOVS_ENV7**)

Outputs :

LEVEL 1C DATA FILES :

Direct access and unformatted binary files separated for each instrument according to the input options (one file for one instrument).
Named **avhrr.l1c** by default

File is renamed at the end of **MAIA3_RUN**

avh_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1c

with	SATIMG : satellite name (example noaa16)
	YYYYMMDD.: year-month-day of data
	HHMN : hour of data
	NNNNN : orbite number

The file contains: 1 header record + 1 data record for each scan line.
the record size: 29808 bytes
Each record contains brightness temperatures + time + lat/long + view angles, altitude and attitude + quality control info.
Associated with logical units AVH1Cunit (see **ATOVS_ENV7**)
Located in the directory ${WRK}.
To get the details of the files, see the corresponding include files.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **avhrrin.log**.
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.
File is renamed at the end of **MAIA3_RUN**
avhrrin_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.log

4.2.25. Inputs/outputs sounders calibration application (MAIA3_MAIN)

Inputs :

LEVEL 1C DATA FILES :

See output of AVHRRIN

Outputs :

LEVEL 1D DATA FILES :

Direct access and unformatted binary files separated for each instrument according to the input options (one file for one instrument).
Named **avhrr.l1d** by default

File is renamed at the end of **MAIA3_RUN**

avh_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1d

with	SATIMG : satellite name (example noaa16)
	YYYYMMDD.: year-month-day of data
	HHMN : hour of data
	NNNNN : orbite number

The file contains: 1 header record + 1 data record for each scan line.
The record size: 29808 bytes
Each record contains brightness temperatures + time + lat/long + view angles, altitude and attitude + quality control info.
Associated with logical units AVH1Dunit (see **ATOVS_ENV7**)
Located in the directory ${WRK}.
To get the details of the files, see the corresponding include files.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text.
Named **maia3_main.log**.
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.
Located in the directory ${WRK}.
File is renamed at the end of **MAIA3_RUN**
maia3_main_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.log

4.2.26. Inputs/outputs for conversion AVHRR AAPP l1b format to AVHRR PFSL1B format (aapp-eps_avhrrl1b)

Inputs :

AVHRR LEVEL 1B DATA FILE :

Named **hrpt.l1b**
File is renamed at the end of **AAPP_RUN**

hrpt_${SATIMG}_${YYYYMMDD}_${HHMN}_${NNNNN}.l1b

Compared to level.1a structure, 'calibration' parameters have been updated.
Associated with logical unit 10 (see **avhrcl.ksh**)
Located in the directory ${WRK}.
More details, see outputs of **decommutation**.

Outputs :

AVHRR PFS LEVEL 1B DATA FILE :

4.2.27. Inputs/outputs for SATEPH navigation tool.

sateph calls modules: satpos*xxx*.exe and ephe. For the different files, the origin of inputs and outputs have been specified.

Inputs :

TBUS_YYYYMMDD.TXT OR *TLE_YYYYMMDD_HHMN.TXT* OR *SPM_*.TXT*

- Input for satpost.exe satpostle.exe satposspm.exe
- See inputs/outputs for satpost, satpostle, satposspm

TBUS_SSSS.INDEX OR *TLE_SSSS.INDEX* OR *SPM_SSSS.INDEX*

- Input for satpost.exe satpostle.exe satposspm.exe
- See inputs/outputs for satpost, satpostle, satposspm

Outputs :

SATPOS_SSSS_YYYYMMDD.TXT

- output for satpost.exe or satpostle.exe or satposspm.exe
- input for ephe
- See inputs/outputs for satpost, satpostle, satposspm

EPHE_SSSS_YYYYMMDD.TXT

- Output of ephe
- Name of the ASCII ephemeris file associated with a given station and a specific satellite, xx satellite number, yyyymmdd start date of the ephemeris.
- Located in the directory ${DIR_NAVIGATION}/ephe.
- Each data line contains the following information : calendar date of the event (yyyy/mm/dd), time of the event (hh:mm:ss.sss), satellite name (noaaxx), orbit number, event code (start_acq : start of acquisition, stop_acq: end of acquisition, asc_node : ascending node, dsc_node: descending node, sun_rise : sun rise for station, sun_set: sun set for station), a text associated with the event (station name for start_acq/stop_acq, longitude of nodes (deg) for asc_node/dsc_node). No line of comments authorised.
- More details are given in *ephe.5*.

4.2.28. Inputs/outputs for LGEPHEING navigation tool

Inputs :

TBUS_YYYYMMDD.TXT

See above 3.3.2 (inputs/outputs for tbusing)

Inputs/Outputs :

LGEPHE_NOAAXX.INDEX

Name of the ASCII long-term ephemeris file associated with a given station and a specific satellite, xx satellite number.
Located in the directory ${DIR_NAVIGATION}/lgephe.
Contains all the needed orbital parameters for long ephemeris calculation.

- The first line contains the NOAA name of the satellite.

- Each data line contains the following information : epoch time of ascending node in CNES Julian day (day 0 = 01/01/50 0h), string for epoch time (yyyy/mm/dd hh:mm:ss.sss), orbit number, longitude of the ascending node (deg), longitude increment (deg), semi-major axis (km), inclination (deg), and nodal period (hh:mm:ss.sss).

More details are given in *lgephe.5*.

Outputs :

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **lgepheing.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.29. Inputs/outputs for LGEPHE navigation tool

Inputs :

STATIONS.TXT

Name of the ACII file containing geographic coordinates of reception station
Located in the directory ${DIR_STATIONS}.
Each line contains following informations : latitude(deg)/longitude(deg)/altitude(km), elevation min. (deg), and name.

LGEPHE_NOAAXX.INDEX

See 3.3.17 Inputs/Outputs for lgepheing navigation tools.

Outputs :

LGEPHE_NOAAXX_YYYYMMDD.TXT

Name of the ASCII long-term ephemeris file associated with a list of stations and a specific satellite, xx satellite number, yyyymmdd ephemeris start date.
Located in the directory ${DIR_NAVIGATION}/lgephe.
Each data line contains the following information : calendar date of the event (yyyy/mm/dd), time of the event (hh:mm:ss.sss), satellite name (noaaxx), orbit number, event code (start_acq : start of acquisition, stop_acq: end of acquisition, asc_node : ascending node, dsc_node: descending node,), a text associated with the event (station name for start_acq/stop_acq, longitude of nodes (deg) for asc_node/dsc_node).
No line of comments authorised.

SUMMARY FILE FOR PASS :

Sequential file in ASCII text .
Named **lgephe.log**
The commands "print*" , "write(*,)" and the calls to subroutines ml_wt.. write into it.

4.2.30. Inputs/outputs for ALLEPH navigation tool

alleph calls several modules: satpost.exe, ephe, tracking, antcnft. For the different files, the origin of inputs and outputs have been specified.

Inputs :

TBUS_YYYYMMDD.TXT

Input for satpost.exe
See above 3.3.2 (inputs/outputs for tbusing)

TBUS_NOAAXX.INDEX

Input for satpost.exe
See above 3.3.2 (inputs/outputs for tbusing)

Or

TLE_YYYYMMDD_HHMN.TXT

Input for satpostle.exe
See above 3.3.3 (inputs/outputs for tleing)

TLE_NOAAXX.INDEX

Input for satpostle.exe
See above 3.3.3 (inputs/outputs for tleing)

Outputs :

SATPOS_NOAAXX_YYYYMMDD.TXT

output for satpost.exe or satpostle.exe
input for ephe and tracking
See above 3.3.4 and 3.3.5 (inputs/outputs for satpost/satpostle)

EPHE_NOAAXX_YYYYMMDD.TXT

Output of ephe and tracking
Name of the ASCII ephemeris file associated with a given station and a specific satellite, xx satellite number, yyyymmdd start date of the ephemeris.
Located in the directory ${DIR_NAVIGATION}/ephe.
Each data line contains the following information : calendar date of the event (yyyy/mm/dd), time of the event (hh:mm:ss.sss), satellite name (noaaxx), orbit number, event code (start_acq : start of acquisition, stop_acq: end of acquisition, asc_node : ascending node, dsc_node: descending node, sun_rise : sun rise for station, sun_set: sun set for station, site_max: maximum site during the acquisition, short_acq: acquisition too short, start_conflict or stop_conflict: start/stop of conflict for one antenna acquisition system), a text associated with the event (station name for start_acq/stop_acq/start_conflict/stop_conflict, longitude of nodes (deg) for asc_node/dsc_node, site (deg) for site_max, acquisition duration (in minutes) for short_acq). No line of comments authorised. More details are given in *ephe.5*.

EPHE_YYYYMMDD.TXT

Input/output of antcnft
Name of the ASCII ephemeris file associated with a given station and several satellites, yyyymmdd ephemeris start time.
Located in the directory ${DIR_NAVIGATION}/ephe.
Same data lines as above.

TRACKING_NOAAXX_YYYYMMDD_OOOOO.TXT

Name of the ASCII tracking angle file associated with a SATPOS file, xx satellite number, yyyymmdd date at start of acquisition, ooooo is the orbit number at start of acquisition.
Located in the directory ${DIR_NAVIGATION}/tracking.
The header contains the NOAA name of the satellite, ground station latitude and longitude (deg), ground station altitude (km) and minimum site (deg), processing time and tracking start time (dd/mm/yy hh:mm:ss.sss), orbit number at start time, the time step value (in seconds), and text describing data lines.
Each data line contains the following information: site (deg), azimuth counted anticlockwise with origin at south direction (deg), corresponding date (dd/mm/yy hh:mm:ss.sss).
More details are given in *tracking.5*.

4.2.31. Inputs/outputs for TBUSDISP navigation tool

tbusdisp is an interactive script that displays the content of a TBUS message

Inputs :

TBUS_SSSS.INDEX

- index file for considered satellite *ssss*

INTERACTIVE COMMANDS

- satellite name
- date

Outputs :

STANDARD OUTPUT

- *TBUS displayed on standard output*

4.2.32. Inputs/outputs for TLEPRINT navigation tool

tbusprint is an interactive script that displays the content of a 2-Line message

Inputs :

INTERACTIVE COMMANDS

- file name of a 2 line file
- satellite name

Outputs :

STANDARD OUTPUT

- *2-Line displayed on standard output*

4.2.33. Inputs/outputs for EPHE, TRACKING, ANTCNFT, DRIFTEPHE navigation tool

All those scripts are dummy scripts in order to interface shell with fortran. See the relative commands ephe.exe tracking.exe antcnft.exe and driftephe.exe

4.3. DYNAMIC ARTICULATION

In this paragraph the text basic information parameters are :

-s : satellite (e.g. : noaa14)

-d : date (yyyymmdd) (e.g. :19980512)

-h : hour-minute (hhmm) (e.g. :1415)

-n : orbit number (nnnn) (e.g. :1750)

4.3.1. Description of the main script AAPP_RUN_NOAA

With the **AAPP_RUN_NOAA** korn shell, all the different steps hang together: From a HRPT data file, HIRS.l1b, MSU.l1b, AMSU-A.l1b, AMSU-B.l1b, MHS.l1b, HIRS.l1c, MSU.l1c, AMSU-A.l1c, AMSU-B/MHS.l1c, HIRS.l1d are created. It tests the satellite number to identify the type of data, TOVS or ATOVS data.

Usage is

AAPP_RUN_NOAA [**-D**] [**-Y** year] [-i instruments] [-g grids] [-o outdir] [-z] [-C] [-L] file_name

-D	: debug on
-Y year	: year of the HRPT data (default=current year)
-i instruments : from the list “AMSU-A AMSU-B HIRS MSU AVHRR DCS" (default all available)”	
-g grids	: from the list “AMSU-A AMSU-B HIRS” (default “HIRS”)
-z	: skip avh2hirs
-C	: skip calibration
-L	: skip Earth location
file_name	: HRPT data file (full path or relative to current)

-D and **-Y** are optional. But it is strongly recommended to specify the year of the HRPT data. By default, the year is the current year. Using YEAR-default can cause problems when processing later data from current year or earlier.

file_name is an obligatory parameter.

Calls other scripts :

tbusing, tleing, satpost, satpostle, decommutation, prhirs, hirscl, hirscl_algoV4, prhmsu, msucl, amsuacl, amsubcl, mhscl, prhavh, avhrcl, atovin, atovpp, avh2hirs,log_info, log_error

Calls executable files :

hrpidf.exe, sdh2orbnum.exe

4.3.2. Description of the script CHK1BTIME

Included in the decommutation.ksh file

The script **chk1btime** is activated with one obligatory argument: The level 1 b file name.

For example: chk1btime hirsl1a_noaa15_19980716_0715_00905.l1b

4.3.3. Description of the script TBUSING

(See also the reference manual man pages *tbusing.1*)

With the **tbusing.ksh** korn shell and after each performance of **tbusing.exe**, historical files (automatically determined by input satellites numbers) are updated.

Usage is:

tbusing [**-s** satellite] [**-f** tbus_file]

-s to specify the list of satellites to be considered

-f to specify the TBUS bulletin to process.

-s and **-f** are optional.

If no parameter is specified as an option, defaults are:

-s noaa09 noaa11 noaa12 noaa14

(see the variable PAR_NAVIGATION_DEFAULT_LISTESAT_INGEST_TBUS in the script)

-f : all the TBUS bulletins which are newer than the last update of the index files corresponding to the satellite list.

4.3.4. Description of the script GET_TLE

get_tle to retrieve current 2-Line orbital elements from a web site

The usage is : **get_tle**
all parameters are loaded from the configuration file

4.3.5. Description of the script GET_TAI_UT1_UTC

get_tai_ut1_utc to retrieve Polar motion and time conversion parameters

The usage is : **get_tai_ut1_utc**
all parameters are loaded from the configuration file

4.3.6. Description of the script TLEING

(See also the reference manual man pages *tleing.1*)

With the **tleing.ksh** korn shell and after each performance of **tleing.exe**, historical files (automatically determined by input satellites numbers) are updated.

Usage is:

tleing [**-s** satellite] [**-f** tle_file] [-c]

-s to specify the list of satellites to be considered

-f to specify the TLE bulletin to process.

-c to check presence of input 2lines files in final index file

-c -s and **-f** are optional.

If no parameter is specified as an option, defaults are:

-s : value of the variable PAR_NAVIGATION_DEFAULT_LISTESAT_INGEST_TLE in the ATOVS_ENV file)

-f : all the TLE bulletins which are newer than the last update of the index files corresponding to the satellite list.

4.3.7. Description of the script SPMING

With the **spming.pl** Perl shell and after each performance of **spming.exe**, historical files (automatically determined by input satellites numbers) are updated.

Usage is:

spming -s satellite **admin_ccsds**

-s to specify the satellite to be considered

admin_ccsds to specify the input Admin file (CCSDS binary format) which contains the SPM bulletin to process.

ATOVS_ENV file is loaded

4.3.8. Description of the script SATPOST

(See also the reference manual man pages *satpost.1*)

For a given satellite and a given acquisition station, the command creates a position-velocity file (SATPOS) using TBUS bulletins.

Usage is:

satpost [**-o**] [**-s** satellite] [**-S** station] [**-d** start date] [**-n** number of days] [**-i** increment in seconds] [**-c** search criteria]

-o -s -S -d -n -i –c are optional.

If no parameter is specified as an option, defaults are : noaa14, Lannion, today 0h, 1.0, 120.0, n (n= nearest, p = preceding).

The option **-o** specifies that the data will be stored in the file satpos_noaxx_yyyymmdd.txt. Output default is the standard output..

4.3.9. Description of the script SATPOSTLE

(See also the reference manual man pages *satpostle.1*)

For a given satellite and a given acquisition station, the command creates a position-velocity file (SATPOS) using TLE bulletins.

Usage is:

satpostle [**-o**] [**-s** satellite] [**-S** station] [**-d** start date] [**-n** number of days] [**-i** increment in seconds] [**-c** search criteria]

-o -s -S -d -n -i –c are optional.

If no parameter is specified as an option, defaults are : noaa14, Lannion, today 0h, 1.0, 120.0, n (n= nearest, p = preceding).

The option **-o** specifies that the data will be stored in the file satpos_noaxx_yyyymmdd.txt. Output default is the standard output..

4.3.10. Description of the script SATPOSSPM

For a given satellite and a given acquisition station, the command creates a position-velocity file (SATPOS) using SPM bulletins.

Usage is:

satposspm [**-o**] [**-s** satellite] [**-S** station] [**-d** start date] [**-n** number of days] [**-i** increment in seconds] [**-c** search criteria]

-o -s -S -d -n -i –c are optional.

If no parameter is specified as an option, defaults are : metop02, Lannion, today 0h, 1.0, 120.0, n (n= nearest, p = preceding).

The option **-o** specifies that the data will be stored in the file satpos_noaxx_yyyymmdd.txt. Output default is the standard output.

4.3.11. Description of the script DECOMMUTATION

decommutation.ksh reads the environment parameters in ATOVS_ENV7 to get the conditions of the run.

It associates the logical unit number with the needed fixed data *amsua_clparams.dat*.

It generates dynamically the user input options file *decommutation.inp* and the program is then launched with the user options file as input:

```
decommutation.exe < decommutation.inp
```

The log of the program execution is saved in the output file *decommutation.log*.

At the end, for HIRS, MSU, AMSU-A and AMSU-B, the script calls **chk1btime** script (inside decommutation.ksh file) to correct scan line datation for level 1 b files.

chk1btime script needs one argument: the complete name of the level 1b file (see also the reference manual man pages *chk1btime.1*).

The log file are saved in the output files *decommutation.log*.

Lastly, it deletes the input file *decommutation.inp* and the different links.

Usage is:

decommutation ${A_TOVS} decommutation.par ${FILE}

The 3 arguments are obligatory.

${A_TOVS} = TOVS for satellite number < or = 14

${A_TOVS} = ATOVS for satellite number > 14

In the decommutation.par file, options are written in this order:

```
$1,$2,$3,$4,$5, $6, $7, $8,$9,$10,$11,$12                        !OPTION NUMBERS
$lu1,$lu2,$lu3,$lu4,$lu5,$lu6,$lu7,$lu8,$lu9,$lu10,$lu11,$lu12   !STREAM NO.S
${YEAR}                                                          ! year of the data
0                                                                ! operational mode
${NNNNN},${NNNNN}                                                ! start and end orbit numbers
```

with

$1 = 0 or 1 for level of error logging

$2 = 0 or 1 for HIRS/3 or HIRS/4 (1 indicates extract HIRS/3 or HIRS/4 data)

$3 = 0 or 1 for AMSU-A1 (1 indicates extract AMSU-A1 data)

$4 = 0 or 1 for AMSU-A2 (1 indicates extract AMSU-A2 data)

$5 = 0 or 1 for AMSU-B/MHS (1 indicates extract AMSU-B/MHS data)

$6 = 0 or 1 for HIRS/2 (1 indicates extract HIRS/2 data)

$7 = 0 or 1 for MSU (1 indicates extract MSU data)

$8 = 0 or 1 for DCS (1 indicates extract DCS data)

$9 = 0 or 1 for SEM (1 indicates extract SEM data)

$10= 0 or 1 for SBUV (1 indicates extract SBUV data)

$11= 0 or 1 for SAR (1 indicates extract SAR data)

$12= 0 or 1 for AVHRR (1 indicates extract AVHRR data)

$lu1 is the logical unit of the log file

$lu2 is the logical unit of the HIRS/3 or HIRS/4.l1a output file

$lu3 is the logical unit of the AMSU-A1.l1a output file

$lu4 is the logical unit of the AMSU-A2.l1a output file

$lu5 is the logical unit of the AMSU-B.l1a output file

$lu6 is the logical unit of the HIRS/2.l1a output file

$lu7 is the logical unit of the MSU.l1a output file

$lu8 is the logical unit of the DCS.l1a output file

$lu9 is the logical unit of the SEM.l1a output file

$lu10 is the logical unit of the SBUV.l1a output file

$lu11 is the logical unit of the SAR.l1a output file

$lu12 is the logical unit of the HRPT.l1a output file

4.3.12. Description of the scripts HIRSCL, HIRSCL_ALGOV4, MSUCL, AMSUCL, AMSUBCL, MHSCL, AVHRCL

Those scripts can run alone, outside of the processing.

They read the environment parameters in ATOVS_ENV7 to get the conditions of the run.

For the navigation of the level 1b file,

They create the SATPOS file if it does not exist by calling the scripts **satpostle** or **satpost**.

They get previous or current orbit attitude values by calling the function **det_att**.

They define calibration and errorclock related files.

The scripts get the different parameters to generate the input parameters of **hirscl.exe**, **hirscl_algoV4.exe, msucl.exe**, **amsuacl.exe**, **amsubcl.exe**, **mhscl.exe**, **avhrcl.exe**.

The level 1b files and the required fixed data files are used without names within the executable. The names of the files are dynamically built inside the scripts.

The log files are saved in the output files *hirscl.log*, *msucl.log*, *amsuacl.log*, *amsub.log*, *mhscl.log*, *avhrcl.log*.

Lastly, all the links between the files and the associated logical units are deleted.

Usage is:

hirscl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

hirscl_algoV4 [**-c**] [**-l**] -**s** satimg -**d** yyyymmdd -**h** hhmm -**n** nnnnn source.l1b

msucl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

amsuacl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

amsubcl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

mhscl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

avhrcl [**-c**] [**-l**] **-s** satellite **-d** yyyymmdd **-h** hhmn **-n** nnnnn source.l1b

-c for calibration.

-l for Earth location.

-s -d -h –n are the basic information parameters (see above 4.2).

yyyymmdd: year/month/day, **hhmm**: hours/minutes, **nnnnn**: orbit number.

source.l1b : name of the level 1b file to process

-c -l are optional.

-s -d -h –n and the **source.l1b** are obligatory.

4.3.13. Description of the script ATOVIN

This script allows running of the **atovin.exe** program that processes level 1b TOVS/ATOVS to level 1c.

It reads the environment parameters in ATOVS_ENV7 to get the conditions of the run.

It generates dynamically the user input options file *atovin.input* including the instruments to process. Examples: HIRS MSU or HIRS AMSU-A AMSU-B.

It associates logical unit numbers with level 1b files to read, with level 1c files to write, and with required fixed data.

The program is then launched with the user options file as input.

```
atovin.exe < atovin.input
```

The log file is saved in the output file *atovin.log*.

Lastly, it deletes the input file *atovin.input* and the links between the level 1b and level 1c files and the associated logical units.

Usage is:

atovin [**-f** infiles] instruments

If input files are specified, they must be in the same order as the list of instruments, and must be enclosed in quotes if there is more than one instrument.

A companion script **atovin_antorr** is available to apply or remove the antenna correction for microwave instruments (AMSU/MHS). Usage is:

atovin_antcorr [**–f** infiles] [–z] instruments

In this case the input files are level 1c. If the –z option is supplied, the program will attempt to remove any antenna correction that is already present in the data.

4.3.14. Description of the script ATOVPP

The script allows running of the **atovpp.exe** program that processes level 1c TOVS/ATOVS and IASI to level 1d.

It reads the environment parameters in ATOVS_ENV7 to get the conditions of the run.

It associates logical unit numbers with level 1c files to read, with the HIRS level 1d file to write, and with the required fixed data files.

It generates dynamically the user input options file *atovpp.inp* (instruments to read and instrument grids to output depending on whether we have TOVS or ATOVS data).

The program is then launched with the user options file as input.

```
atovpp.exe < atovpp.inp.
```

The log file is saved in the output file *atovpp.log*.

Lastly, it deletes the input file *atovpp.inp* and the links between the level 1c files, the level 1d file and the associated logical units.

Usage is:

atovpp [**–f** infiles] [**–r**] **–g** grids **–i** instruments

where *grids* and *instruments* are sub-sets of "AMSU-A AMSU-B HIRS IASI" in the case of ATOVS, or "MSU HIRS" in the case of TOVS. Quotes are needed if there is more than one grid, instrument or file name. "MHS" can be specified instead of "AMSU-B". If input files are specified, they must be in the same order as the list of instruments.

An alternative syntax for backward compatibility with AAPP version 5 and earlier is

atovpp [A]**TOVS** [**h**]

in which case if the **h** argument is absent only the HIRS grid is generated. If the **h** argument is present, HIRS and AMSU-B grids are generated.

4.3.15. Description of the script AVH2HIRS

The script reads the parameters file ATOVS_ENV to get the conditions of the run.

It makes links in input with the following files (invokes **maia2_env** for forecast, climatologies, threshold files).:

- AVHRR level 1b
- HIRS level 1d: From the HIRS level 1d file, it determines the satellite and datation by using the command **l1didf** which opens the file and reads the header.
- Forecast: It uses the date to determine the time nearest theforecast file. Two format are possible: grib and ascii. Of course,to read the grib format, the user should first implement the grib library which could be requested at software.servicea@ecmwf.int. If no forecast file is available for the date, the command continues without forecast information and send a warning message. For users who get the grib forecast information in 2 separate files, the command makes the concatenation of the 2 files into a temporary file.
- Climatologies: the month of the level 1d acquisition is used to sopecify the correct climatologic files of albedo, sst and specific humidities.
- Threshold files: the satellite information from level 1d is used to determine the correct seven threshold files.

Time and angle correction: it also depends on the satellite.

Logical unit numbers associated with these files are set up in the script.

Then the script invokes the **avh2iasi.exe** command.

The log file is saved in the output file *avh2hirs.log*.

At the statistics file associated with the logical unit 22 is then saved with the name *mapqual.txt*. Links between logical unit to files are deleted at the end of the script.

4.3.16. Description of the script AVHRRIN.KSH

This script is invoked as:
avhrrin
Options can be specified
-i file_name1 : full pathname of the input hrpt/avhrr 1b file (default $WRK/hrpt.l1b)
-o file_name2 : full pathname of the output hrpt/avhrr 1c file (default $WRK/avhrr.l1c)

The script reads the parameters file ATOVS_ENV to get the conditions of the run.

Exit codes: 0 normal end

1 bad input parameters, input data, usage,...

2 bad output code for avhrrin.exe

4.3.17. Description of the script MAIA3.KSH

This script is invoked as:
maia3
Options can be specified
-i file_name1 : full pathname of the input hrpt/avhrr 1c file (default $WRK/avhrr.l1c)
-o file_name2 : full pathname of the output hrpt/avhrr 1d file (default $WRK/avhrr.l1d)

The script reads the parameters file ATOVS_ENV to get the conditions of the run.

Exit codes: 0 normal end

1 bad input parameters, input data, usage,...

2 bad output code for maia.exe

4.3.18. Description of the script MAIA3_RUN.KSH

This script is invoked as:
maia3_run file-name
where file-name is the full pathname of the input hrpt/avhrr 1b file (default $WRK/hrpt.l1b)

This script calls the scripts avhrrin (maia3 see above)

4.3.19. Description of the script EPS_AVHRRL1B-MAIN

This script is invoked as follows:

aapp-eps_avhrrl1b avhrr.l1b [avhrr.pfs]

Where avhrr.l1b is a calibrated and navigated avhrr AAPP file. The name of the ouput PFS file is optional; if it is not passed as an argument, then the program will use the standard PFS filename.

4.3.20. Description of the script EPS_CONVERT_IASIL1C

This script is invoked as:

convert_iasi1c iasi. pfs_iasi.l1c

where pfs_iasil1c is the IASI file at level 1c PFS format

4.3.21. Description of the script NOAA_CLASS_TO_AAPP

This script is invoked as:

noaa_class_to_aapp inputfile outputfile

where inputfile is the NOAA/CLASS file to be converted, in NOAA naming convention, e.g. NSS.HIRX.N[A-P].D?????.*.

4.3.22. Description of the script AVHRR_AAPP_TO_CLASS

This script is invoked as:

avhrr_aapp_to_class inputfile outputfile

where inputfile is the AAPP AVHRR level 1b file to be converted.

4.3.23. Description of the script SATPOS-SVM

This script is invoked as:

```
satpos-svm satpos.txt [ xxxx_SVM_... ]
```

The name of the SVM file is optional; if it is not present, then stdout is used.

4.3.24. Description of the script MESSAGES-OSV

This script is invoked as:

```
messages-osv messages.txt [ xxxx_OSV_... ]
```

The name of the OSV file is optional; if it is not present, then stdout is used.

4.3.25. Description of the script SATEPH

sateph to run the ephemeris scheme (short term)

The usage is : **sateph [-options]**

where options are:

-s	satellite_list
-S	station_name
-b	bulletin_list
-d	start_date
-n	number of days (real)
-i	increment in seconds (real)
-c	search criteria (n for nearest or p for preceding)

the date format can be a date or a date/hour string or an offset in days to the current day
for example -d 'dd/mm/yy hh:mm:ss.sss' (2 spaces between yy hh)

```
or    -d 'dd/mm/yy  hh:mm'
or    -d dd/mm/yy
or    -d '-3'   3 days ago
or    -d '4'    4 days after
```

4.3.26. Description of the script LGEPHEING

(See also the reference manual man pages *lgepheing.1*)

With the **lgepheing.ksh** korn shell and after each performance of **lgepheing.exe**, historical files (automatically determined by input satellites numbers) are updated. It must run before lgephe.

Usage is:

lgepheing [**-s** satellite_list] [**-f** tbus_file]

-s to specify the list of satellites to be considered.

-f to specify the TBUS bulletin to process.

-s and **–f** are optional.

If no parameter is specified as an option, defaults are:

-s noaa09 noaa11 noaa12 noaa14

(see the variable PAR_NAVIGATION_DEFAULT_LISTESAT_INGEST_TBUS in the script)

-f : all the TBUS bulletins which are newer than the last update of the index files corresponding to the satellite list.

4.3.27. Description of the script LGEPHE

(See also the reference manual man pages *lgephe.1*)

With the **lgephe.ksh** korn shell and after each performance of **lgephe.exe**, for a given satellite and several given stations, a long-term ephemeris file is created using the ephemeris index file.

Usage is:

lgephe [**-o**] [**-s** satellite_name] [**-S** station_list] [**-d** start date] [**-n** number of days]

-o -s -S -d –n are optional.

If no parameter is specified as an option, defaults are: noaa14, Lannion, today 0h, 10.0.

The option **-o** specifies that the data will be stored in the file *lgephe_noaxx_yyyymmdd.txt*.

4.3.28. Description of the script ALLEPH

(See also the reference manual man pages *alleph.1*)

With the **alleph.ksh** korn shell performs all the basic commands needed to generate SATPOS files, tracking angle files, ephemeris files etc.. It calls the commands satpos, ephe, tracking and antcnft.

Usage is:

alleph [**-s** satellite] [**-S** station] [**-b** bulletin] [**-d** start date] [**-n** number of days]

[**-i** increment in seconds] [**-c** search criteria] [-o antenna_steering_seconds]

-s -S -b -n -i –c -o are optional.

If no parameter is specified as option, defaults are:

- For the list of satellites: noaa14 noaa12 noaa11 noaa09
- For the station :Lannion
- For the list of bulletin: tbus tbus tbus tbus
- For the start date: today 0h
- For the number of days: 1.0
- For the increment: 120.0
- For the search criteria: n (n= nearest, p = preceding).
- For the antenna steering duration: 0sec

4.3.29. Description of the command EPHE

(See also the reference manual man pages *ephe.1*)

The command **ephe** creates an ephemeris file corresponding to the duration of the SATPOS file (for a specific station and a specific satellite). This file can be non chronological if the equator is inside the acquisition area of the station. It can be time-sorted with the unix command sort.

The command **ephe** is activated with the name of the files satpos_noaxx_yyyymmdd.txt and ephe_noaaxx_yyyymmdd.txt.

Usage is:

ephe <satpos_file> ephemeris_file

4.3.30. Description of the command TRACKING

(See also the reference manual man pages *tracking.1*)

For an antenna, the command **tracking** creates a file of angles and tracking from a SATPOS file (for all the orbits included and those which can be acquired). Ephemeris messages are directed to the standard output and possibly to an ephemeris file.

The command **tracking** is activated with the name of the files satpos_noaxx_yyyymmdd.txt and ephe_noaaxx_yyyymmdd.txt.

Usage is:

tracking <satpos_file> ephemeris_file

4.3.31. Description of the command ANTCNFT

(See also the reference manual man pages *antcnft.1*)

The command **antcnft** updates the ephemeris file and indicates if there are orbital tracking conflicts for a given antenna.

The command **antcnft** is activated with the name of the I/O file ephe_yyyymmdd.txt.

Usage is:

antcnft < ephemeris_file> ephemeris_file

4.3.32. Description of the command DRIFTEPHE

The command **driftephe** updates the ephemeris file.

It is activated with the name of the I/O file ephe_yyyymmdd.txt.

Usage is:

driftephe < ephemeris_file> ephemeris_file

4.3.33. Description of the script TBUSDISP

(See also the reference manual man pages *tbusdisp.1*)

The script **tbusdisp** is activated after the read of 3 arguments (interactive questions/answers):

* Satellite name (or end)

* Search method (nearest or last_preceding, default=nearest)

* Date dd/mm/yy or dd/mm/yy hh:mm:ss.sss

4.3.34. Description of the script TLEPRINT

(See also the reference manual man pages *tleprint.1*)

The script **tleprint** is fully interactive questions/answers:

1. enter 2-line bulletin filename
2. enter satellite name or end

until word “end” is entered

4.3.35. AVHRR and HIRS level 1b file verification : PRHAVH and PRHIRS

Usage is :

prhavh **-s** sss **-e** eee filename

prhirs **-s** ssss **-e** eee filename

-s sss : starting avhrr/hirs scan line

-e eee : ending avhrr/hirs scan line

filename : file to look at

The script generates dynamically the user input options files *prhavh.inp* , *prhirs.inp* .

The program is then launched with the user options files as input.

```
prhavh.exe < prhavh.inp
prhirs.exe < prhirs.inp
```

Lastly, it deletes the input files *prhavh.inp*, *prhirs.inp* .

4.3.36. MSU level 1b file header verification PRHMSU

Usage is :

prhmsu filename

with filename : file to look at

The script generates dynamically the user input options file *prhmsu.inp* .

The program is then launched with the user options file as input.

prhmsu.exe < prhmsu.inp.

Lastly, it deletes the input file *prhmsu.inp* .

4.3.37. DCS level 1b file verification PRHDCS

Usage is :

prhdcs **-s** sss **-e** eee filename

-s sss : starting dcs line

-e eee : ending dcs line

filename : file to look at

The script generates dynamically the user input options files *prhdcs.inp*.

The program is then launched with the user options files as input.

```
prhdcs.exe < prhdcs.inp
```

Lastly, it deletes the input files *prhdcs.inp*.

4.3.38. Source file identification: HRPTIDF

Usage is :

hrpidf [**-Y** yyyy] [**-s**] [**-d**] [**-h**] [**-n**] [**-i**] source

The script **hrpdidf** can be activated with basic information parameters (**-s -d -h -n**).

The **-i** option provides all the basic information about the source (hrpt format) in only one call.

Examples:

hrpidf -i hrpt_noaa1419961121_0036_09757.hrp returns noaa14 19961121 0036 09757

hrpidf -s hrpt_noaa1419961121_0036_09757.hrp returns only noaa14

4.3.39. Level 1b products identification: L1BIDF

Usage is :

l1bidf [**-s**] [**-d**] [**-h**] [**-n**] [**-t**] [**-i**] source

The **-t** option provides data type of the source in 1b format.

The**-i** option provides all the basic information about the 1b format source in only one call.

Examples:

l1bidf -i dcsl1b-noaa1419961121_0036_09757.l1b

returns noaa14 19961121 0036 09757 dcs cms

l1bidf -t dcsl1b-noaa1419961121_0036_09757.l1b

returns only dcs

4.3.40. Level 1c products identification: L1CIDF

Usage is :

l1cidf [**-s**] [**-d**] [**-h**] [**-n**] [**-t**] [**-i**] source

The **-t** option provides data type of the source in 1c format.

The**-i** option provides all the basic information about the 1c format source in only one call.

Examples:

l1cidf -i hirsl1c-noaa1419961121_0036_09757.l1c

returns noaa14 19961121 0036 09757 hirs cms cms

l1cidf -t hirsl1c-noaa1419961121_0036_09757.l1c

returns only hirs

4.3.41. Level 1d products identification: L1DIDF

Usage is :

l1didf [**-s**] [**-d**] [**-h**] [**-n**] [**-t**] [**-i**] source

The **-t** option provides data type of the source in 1d format.

The**-i** option provides all the basic information about the 1d format source in only one call.

Examples:

l1didf -i hirsl1d-noaa1419961121_0036_09757.l1d

returns noaa14 19961121 0036 09757 hirs cms cms

l1didf -t hirsl1d-noaa1419961121_0036_09757.l1d

returns only hirs

4.3.42. Write out a message: LIBLOG

Usage is :

Log_xxxx "text of the message"

With xxxx is the type of the message :

info notice	critical	
warning	debug	emergency
error	text	

Examples :

log_info "start of processing ${FILE}"

log_error "file should be given with a full path name"

4.3.43. Get the orbit number: SDH2ORBNUM

sdh2orbnum.ksh allows to get the orbit number for a NOAA satellite and for a given instant.

Usage is :

sdh2orbnum -s satid **-d** yyyymmdd **-h** hhmn

Executable called : **sdh2orbnum.exe**

4.3.44. Decode 1c BUFR files: AAPP_DECODEBUFR_1C

Usage is:

aapp_decodebufr_1c [**-i** files] [**-v**] [instruments]

where *files* is a list of one or more input files. Defaults to "hrsn.bufr aman.bufr ambn.bufr mhsn.bufr iasi.bufr".
If the –v option is present, the first observation is printed out in full.
The optional "instruments" argument is provided in case you have a BUFR file that contains more than one instrument and you want to specify which one to extract.

This routine calls the ECMWF BUFR library and uses the BUFR tables in directory $BUFR_TABLES. The BUFR tables are selected automatically according to the value of the Originating Centre and Sub-centre in Section 1 of the BUFR message. Please see the script for details.

4.3.45. Encode 1c BUFR files : AAPP_ENCODEBUFR_1C

Usage is:

aapp_encodebufr_1c [**-i** files] instruments

where *instruments* is a list of instruments, from the list: "HIRS AMSU-A AMSU-B MHS IASI ATMS CRIS HIRS1D AMSUB1D IASI1D ATMS1D CRIS1D"; *files* contains the input file names for each instrument. Defaults to "hrsn.l1c aman.l1c ambn.l1c mhsn.l1c iasi.l1c atms.l1c cris.l1c hirs.l1d amsub.l1d iasi.l1d atms.l1d cris.l1d".

There are several environment variables that can be used to fine-tune the BUFR encoding, e.g. to specify your Originating Centre ID. Please see the script for details.

This routine calls the ECMWF BUFR library and uses the BUFR tables in directory $BUFR_TABLES.

Note that the BUFR sequences for level 1d have several Met Office local descriptors; they are primarily intended for use either within the Met Office or by NWP Centres that use the Met Office's Unified Model.

4.3.46. Decode Sensor Data Record files for ATMS, CrIS, MWTS, MWHS, MWTS2, MWHS2, IRAS

Usage is :

atms_sdr [-o Outputfile] [-g Geofile] SDRfile [TDRfile]
cris_sdr [-o Outputfile] [-g Geofile] [-H] [-B] [-N] SDRfile'
mwts_sdr [-o Outputfile] SDRfile
mwhs_sdr [-o Outputfile] SDRfile
mwts2_sdr [-o Outputfile] SDRfile
mwhs2_sdr [-o Outputfile] SDRfile
iras_sdr [-o Outputfile] SDRfile

These tools convert the SDR files for ATMS, CrIS, MWTS, MWHS and IRAS into AAPP 1c format. They require AAPP to have been built with the HDF5 library.

For ATMS and CrIS, which have separate geolocation files, the user is able to specifiy the geolocation file explicitly. However, this is mainly useful for pre-launch test data and would only be necessary for operational data if the attribute “N_GEO_Ref” is missing or invalid.

The ATMS 1c format has space for both antenna temperatures and brightness temperatures. If required, the antenna temperatures may be read from a TDR file. However, most users will not need to do this.

The MWTS and MWHS tools (for the sounders on the Chinese FY-3 satellites) include some quality checking – including scan-to-scan consistency of the calibration slope; geolocation reasonableness test; antenna position check. The intention is that only reliable brightness temperatures will appear in the output 1c files.

4.3.47. FY-3 mapping tools: mwhs_to_mwts, mwhs2_to_mwts2, mwts2_to_mwhs2, mwts2_to_iras, mwhs2_to_iras

Usage (example) :
mwhs_to_mwts mwts_file mwhs_file

i.e. *program target_file source_file*

The tool maps the MWHS brightness temperatures to the MWTS grid and stores the results in the MWTS level 1c file. It uses the latitude/longitude information from the two files, i.e. it does not use pre-defined look-up tables.

For each MWTS spot, all MWHS spots are identified that are within a specified angular tolerance from the MWTS spot (tolerance specified in the source code). Then either the *median* brightness temperature is computed and stored for each channel, or the nearest neighbour brightness temperature is used.

In the case of mapping MWHS to MWTS, the median is always used, because this method was found to be robust when there are corrupt MWHS BTs (which were observed from time to time when the data were first distributed by EUMETSAT). Note that the MWHS beam width is much narrower than that of MWTS, so there will be many MWHS footprints within a MWTS footprint.

In the case of MWTS2 and MWHS2 (on FY-3C), the median is used only if the appropriate environment variable is set: MWHS2_USE_MEDIAN or MWTS2_USE_MEDIAN. By default, the nearest neighbour is used. MWTS2 and MWHS2 footprints are much more similar in size than is the case for MWTS and MWHS, therefore nearest neighbour mapping is usually more appropriate.

To map both MWTS2 and MWHS2 to IRAS, run the programs *mwts2_to_iras* and *mwhs2_to_iras* sequentially. The IRAS 1c format has space for 28 mapped channels: 13 MWTS2 followed by 15 MWHS2.

4.3.48. is-mmam .exe

The command **is-mmam.exe** verifies if a PFS l0 file (HKTM) or a CCSDS file includes a MMAM message
Usage is:
is-mmam.exe [-ccsds <ccsds file>| -pfsl0 <pfsl0_file>]

example :

```
$ is-mmam.exe -ccsds apid6.ccsds
TRUE
```

4.3.49. mmam-main .exe

The command **mmam-main.exe** extracts a MMAM compressed bz2 file from a PFS l0 file (HKTM) or a CCSDS file.
Usage is :
mmam-main.exe [-ccsds <ccsds file>| -pfsl0 <pfsl0_file>] <bz2_file>

example :

```
$ mmam-main.exe -ccsds  apid6.ccsds  mmam.bz2
```

4.3.50. print-mmam-obt-utc.pl

The script **print-mmamm-obt-utc.pl** extracts the OBT UTC correlation parameters (utc0 ccu-obt-0 clock-step) from a MMAM message and prints them.
Usage is :
print-mmam-obt-utc.pl <MMAM_file>
example :

```
$ print-mmam-obt-utc.pl MMAM_GENERATED_M02_215_20120612081404.xml
2012-06-12T07:02:58.285 2677315586 3906239944
```

4.3.51. patch-level0-from-mmam.exe

The command **patch-level0-from-mmam.exe** changes the VIADR records in a PFS level0 with OBT UTC correlation parameters utc0 ccu-obt-0 clock-step)
Usage is :
patch-level0-from-mmam.exe utc0 ccu-obt-0 clock-step ...._xxx_00_...
utc0 ccu-obt-0 clock-step : parameters as they are printed by print-mmam-obt-utc-.pl
example :

```
$patch-level0-from-mmam.exe 2012-06-12T07:02:58.285 2677315586 3906239944 \
AVHR_P13_00_M02_20120612084401Z_20120612085256Z_N_O_20120612085410Z
```

4.3.52. atms1c_print_nedt

The command atms1c_print_nedt prints a table of ATMS NEΔT values for warm and cold calibration views. The mean and standard deviation are displayed, for each channel and view.

Usage :
$ **atms1c_print_nedt** <ATMS 1c file>

4.4. VIIRS TOOLS AND MAIA4

This section describes the tools for handling VIIRS data, including MAIA4, that were introduced with AAPP v7.5.

4.4.1. Decode and concatenate Sensor Data Record granule files for VIIRS

Note: The tool "viirs_paste_sdr" was written before the release of hdf5 tool "nagg". It is strongly recommended to use nagg, as it is appreciably faster, especially on machines with limited memory .

Usage is :
viirs_paste_sdr.exe < viirs_paste_sdr.in
where viirs_paste_sdr.in contains the name of the output hdf5 file, followed by the names of all SDR VIIRS granule (M or I or DNB) to be read and concatenated and followed by the word "compress" or "uncompress".

viirs_paste_sdr.exe creates an hdf5 file with the same structure of the original VIIRS SDR files where all channels are present and all granules are concatenated.
If present, the scale factors for brightness temperature or reflectance are applied.

viirs_paste_sdr.exe must be called separately for either I, M or DNB channels.

This tool require AAPP to have been built with the HDF5 Fortran library.

Example :

```
list=`ls ${input_dir}/SVI*.h5 ${input_dir}/GITCO*.h5`

outfilename=viirs_i_${YYYYMMDD}_${HHMNSS}_${NNNNN}.h5

echo $outfilename > viirs_paste_sdr.in
for i in $list
do
echo $i >> viirs_paste_sdr.in
done
echo compress >> viirs_paste_sdr.in
viirs_paste_sdr.exe <viirs_paste_sdr.in
```

This tool is based upon the libaapp_viirs library.

4.4.2. Decode EDR IMG granule files for VIIRS

Usage is :

viirs_edr_img.exe < viirs_edr_img.in

where viirs_edr_img.in contains :

- iopt (1,2 or 3)
- the band name (I, M, or NCC)
- input file name
- channel (optional)

The last 2 items may be repeated several times if iopt=2.

if iopt=1 : One Band, One file, List of channels
if iopt=2 : One band, One file, All channels
if iopt=3 : One band, list of [file, channel]

The program provide an ascii file named “fort.20”.

viirs_img_edr.F90 is provided as an example of program which reads EDR IMG granules files.
Please note that this program has been tested only with the NPP pre-launch data tests with VIIRS I EDR IMG files from CLASS.

4.4.3. The Fortran90 aapp_viirs API

This library contains functions that enables you to read and write VIIRS SDR and IMG EDR files in a more user friendly way than using the hdf5 fortran90 API.

User level subroutine:

subroutine viirs_sdr_load(bandname, x, filenames, err, channels , geolocfile, no_geo)

Loads and pre-process all VIIRS data for a given Band according to options, returns x:
If only one filename, it will be used for all channels
If channels is present then corresponding channels will be read
if not, all channels of given Band are read from one file or from the list of files
If no_geo is present and false, or not present
geolocation file is loaded from geolocfile (if present) or from
the root attribute N_GEO_Ref, but same directory as filenames(1). Then geolocation is processed.

Input/output :

```
 character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
  type(viirs_sdr),  intent(inout) :: x
  character(len=*), intent(in) :: filenames(:) ! Name of file (one for all or one per channel)
  integer,         intent(out) ::err
  integer, optional, intent(in) :: channels(:) ! if present, the list of channels
  character(len=*), optional, intent(in) ::  geolocfile ! file name for geolocation
  logical, optional, intent(in) :: no_geo ! if TRUE geolocation is not loaded
  logical, optional, intent(in) :: clean  ! if TRUE remove unsed arrays
```

subroutine viirs_sdr_save(x, filename, err,compress)

Saves structure x to and HDF5 file
meta data per granule are not written
meta data for aggregate granule are written
Input/output :

```
  type(viirs_sdr),  intent(in) :: x
  character(len=*), intent(in) :: filename ! Name of file (one for all or one per channel)
   integer,         intent(out) :: err
   logical, optional, intent(in) :: compress
```

subroutine viirs_sdr_info(x, nchannels, npixels, nlines, nscans, ngranules, err)

returns number of pixels/lines/scans/granules
returns the real number of channels loaded

Input/output :

```
  type(viirs_sdr), intent(in) :: x
  integer,intent(out)::err
  integer, intent(out) :: nchannels, npixels, nlines, nscans, ngranules
```

subroutine viirs_edr_img_load(bandname, x, filenames, err, channels , geolocfile, no_geo, clean)

Loads and pre-process all VIIRS data for a given Band according to options, returns x:
If only one filename, it will be used for all channels
If channels is present then corresponding channels will be read
if not, all channels of given Band are read from one file or from the list of files
If no_geo is present and false, or not present
geolocation file is loaded from geolocfile (if present) or from
*the root attribute N_GEO_Ref, but same directory as filenames(1). Then geolocation is processed***.**

Input/output :

```
   character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
    type(viirs_edr_img),  intent(inout) :: x
    character(len=*), intent(in) :: filenames(:) ! Name of file (one for all or one per channel)

    integer,          intent(out) ::err
    integer, optional, intent(in) :: channels(:) ! if present, the list of channels
    character(len=*), optional, intent(in) ::  geolocfile ! file name for geolocation
    logical, optional, intent(in) :: no_geo ! if TRUE geolocation is not loaded
    logical, optional, intent(in) :: clean  ! if TRUE remove unsed arrays
```

subroutine viirs_edr_img_info(x, nchannels, npixels, nlines, nscans, ngranules, err)

returns number of pixels/lines/scans/granules
returns the real number of channels loaded

Input/output :

```
   type(viirs_edr_img), intent(in) :: x
    integer,intent(out)::err
    integer, intent(out) :: nchannels, npixels, nlines, nscans, ngranules
    integer :: channel, mchannels
```

Other subroutines:
subroutine viirs_sdr_load_channel(filename, bandname, channel, x, err)

loads "All_Data" for a given channel/band from file HDF5
loads root attributes
loads aggregate attributes

Input/output :

```
   character(len=*), intent(in) :: filename ! Name of file
    character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
    integer, intent(in) :: channel
    type(viirs_sdr), intent(inout) :: x
    integer,intent(out)::err
```

subroutine viirs_sdr_save_channel(filename, bandname, channel, x, err)

Saves "All_Data" for a given channel/band to an HDF5 file filename
saves root attributes
saves aggregate attributes
saves dataproduct attributes

Input/output :

```
type(viirs_sdr),  intent(in) :: x
character(len=*), intent(in) :: filename ! Name of file (one for all or one per channel)
integer,          intent(out) :: err
logical, optional, intent(in) :: compress
```

subroutine viirs_sdr_geo_load(filename, bandname, x, err)

loads Geolocation for a given band from HDF5 file filename

Input/output :

```
character(len=*), intent(in) :: filename
character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
type(viirs_sdr_geo), intent(inout) :: x
integer,intent(out)::err
```

subroutine viirs_sdr_geo_save(filename, bandname, x, err)

saves Geolocation for a given band to an HDF5 file filename

Input/output :

```
character(len=*), intent(in) :: filename
character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
type(viirs_sdr_geo), intent(in) :: x
integer,intent(out)          :: err
logical, optional, intent(in)   :: compress
```

subroutine viirs_sdr_data_proc(x, err)

processing of the data part of the structure viirs_sdr_data
applies scaling factors according to channels

Input/output :

```
type(viirs_sdr_data), intent(inout) :: x
integer,intent(out)::err
logical, optional, intent(in) :: clean  ! if TRUE remove unsed arrays
```

subroutine viirs_sdr_geo_proc(x, att, err)

processing of the geelocation structure viirs_sdr_geo
calculates the TAI offset and calculates the UTC time for each scan.

Input/output :

```
type(viirs_sdr_geo), intent(inout) :: x
type(jpss_meta_aggregate), intent(in) :: att
integer,intent(out)::err
```

subroutine viirs_sdr_checkaggregate(x, y, err)

verifies agg_att Y (viirs_sdr_agg_att) is the same as the one contained in X (viirs_sdr).

Input/output :

type(viirs_sdr), intent(inout) :: x
type(jpss_meta_aggregate), intent(inout) :: y
INTEGER, intent(out) :: ERR   ! Error code

subroutine viirs_edr_img_load_channel(filename, bandname, channel, x, err)

loads "All_Data" for a given channel/band from HDF5 file filename
loads root attributes
loads aggregate attributes

Input/output :

character(len=*), intent(in) :: filename ! Name of file
character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
integer, intent(in) :: channel
type(viirs_edr_img), intent(inout) :: x
integer,intent(out)::err

subroutine viirs_edr_img_geo_load(filename, bandname, x, err)

loads Geolocation for a given band from HDF5 file filename

Input/output :

character(len=*), intent(in) :: filename
character(len=*), intent(in) :: bandname ! VIIRS Band Name: I M or DNB
type(viirs_edr_img_geo), intent(inout) :: x
integer,intent(out)::err

subroutine viirs_edr_img_data_proc(x, err, clean)

processing of the data part of the structure viirs_edr_img_data
applies scaling factors according to channels

Input/output :

type(viirs_edr_img_data), intent(inout) :: x
integer,intent(out)::err
logical, optional, intent(in) :: clean ! if TRUE remove unsed arrays

subroutine viirs_edr_img_geo_proc(x, att, err)

processing of the geelocation structure viirs_edr_img_geo
calculates the TAI offset and calculates the UTC time for each scan.

Input/output :

type(viirs_edr_img_geo), intent(inout) :: x
type(jpss_meta_aggregate), intent(in) :: att
integer,intent(out)::err

subroutine viirs_edr_img_checkaggregate(x, y, err)

verifies agg_att Y is the same as the one contained in X, if any

Input/output :
type(viirs_edr_img), intent(inout) :: x
type(jpss_meta_aggregate), intent(inout) :: y
INTEGER, intent(out) :: ERR ! Error code

Low level subroutines :
For each fortran structure, 3 modules are automatically generated :

- definition modules (_def.F90) :
  contain the fortran structure definition.

- fortran I/O modules (_io.F90) :
  _rh subroutines : read HDF5
  _writea subroutines : write ASCII
  _wh subroutines : write HDF5

- memory modules (_mem.F90)
  free: free pointers structure
  init: initialise structure
  copy(x,y,..): copy structure y to x

Most structures contains arrays of pointers. The dimensions could be pixels/lines/scans/granules
The size of the dimensions are not part of the structure itself but could be easily given by the *size* fortran intrinsic routine, e.g.:

```
nlines    = size(x%BrightnessTemperature,2)
```

4.4.4. MAIAv4 CLOUD MASK : Run MAIAv4 on VIIRS SDR files

Usage is :
MAIA4_RUN viirs_sdr_directory
viirs_sdr_directory is the directory containing the VIIRS SDR files to be processed.

maia_Viirs.exe : main executable

This script and program provide a cloud mask on the VIIRS M grid. It requires VIIRS I and M SDR granule files and several resource files to get prior information on the state of the atmosphere and the surface. MAIAv4 needs NWP model fields. The location of the NWP model fields can be defined with the DIR_FORECAST environment variable. The format of the NWP model fields is supposed to be the GRIB format. TheECMWF GRIB_API package is used for reading of the GRIB files. ***This software cannot process VIIRS SDR aggregate files.***

For further information refer to the MAIA4 scientific user manual and “AAPP DOCUMATION DATA FORMATS”

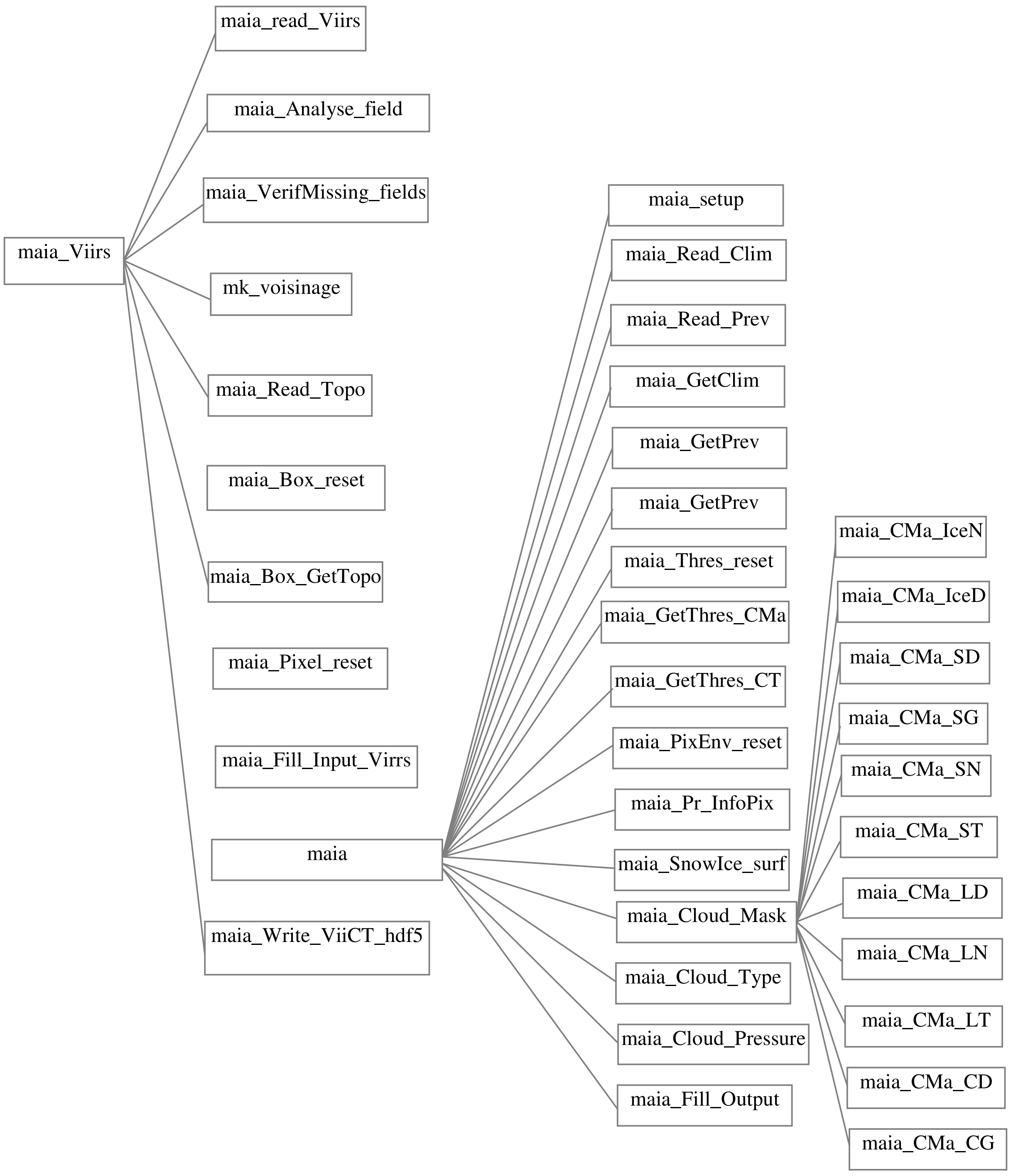


Figure 4-35 : MAIA4 components

USER INPUT PARAMETERS FOR MAIA4 IN ATOVS_ENV

DIR_FORECAST = source directory of the forecast
The forecast file default pattern is
YYYYMM/YYYYMMDDHHMN.ECH
surface constant file: YYYYMM/YYYYMMDDHHMN.CST (GRIB with parameters Geometrical height and Land-sea mask)

MAIA4_USE_GFS= if equal to “yes” GFS is used
MAIA4_REMOTE_GFS_DIR=URL where GFS files can be downloaded default value is "http://jpssdb.ssec.wisc.edu/cspp_v_2_0/ancillary"

If MAIA4_USE_GFS=”yes” the forecast file pattern is :
YYYY_MM_DD_CCC/gfs.press_gr.0p5deg_pt.YYYYMMDD_HH_ECH.npoess.grib2
Those files are downloaded from MAIA4_REMOTE_GFS_DIR if not present in the DIR_FORECAST directory.
DIR_FORECAST can be common with the CSPP EDR ancillary data directory (${CSPP_EDR_HOME}/anc/cache).

NFORPERDAY= number of forecasts per day (2 or 4, 4 by default)

DIR_MAIA4_THRESHOLDS= directory of the MAIA4 thresholds by default : ${AAPP_PREFIX}/AAPP/data_maia4/thresholds

DIR_MAIA4_ATLAS=directory of the MAIA4 atlas + topography files by default : ${AAPP_PREFIX}/AAPP/data_maia4/atlas

PAR_MAIA4_COMPRESS compression of viiCT files (0 : no compression, 1 compression)
MAIA4 box sizes :
MAP_BOX_PSIZE= box size for environment in pixel (default value : 16)
MAP_BOX_LSIZE= box size for environment in line (default value : 16)
LOCAL_BOX_NPB= local box size for variance in pixel (default value : 3)
LOCAL_BOX_NLB= local box size for variance in line (default value : 3)

maia4 file source codes description :

source code file dependencies :

AAPP/src/maia4/bin directory :

maia_Viirs.F : main program

MAIA4_RUN.ksh : main script for run maia4 on all VIIRS SDR granule in a directory, this script call the maia4.ksh script for each M geolocation SDR granule present in the input directory.

maia4.ksh : script to be run on an M geolocation SDR granule, I SDR and M SDR granule are supposed to be found in the same directory of the geolocation granule. Maia4.ksh can work either with GMODO files or with GMTCO files. maia4.ksh uses the korn shell functions of maia_env.ksh and maia4_date.ksh.

maia_env.ksh : script for initialising maia4 environment. Contains the following functions :
function get_forecast_file
function get_climatology_file
function maia4_env
function remove_maia4_env

maia_date.ksh : provides functions for date computations

read_maiaCT.F90 : this program is an example of how to read with the aapp_viirs API the maia cloud mask.
Usage is :

```
read_maiaCT.exe viiCT_file
```

This program creates 3 files :
fort.20 : with longitude latitude cloud_mask
fort.21 : with longitude latitide mask_confidence
fort.23 : with longitude, latitude, cloud_type, l,p

Libraries :

AAPP/src/maia4/libmaia4
contains the core of Maia4
source files :

maia.F90
SUBROUTINE maia (idbg, new_box, field_id, box, pix_id, pix, maia_par)

```
 owner        : MF/DP/CMS/R&D
 Authors      : lydie lavanant
 date         : 12/08/2011

 MAIA Cloud Detection
 input:
      idbg          debug level (info, debug)
      new_box       new information at a box resolution
      box           lat, lon, solar and satellite angles at the center of the box
      pix_id        latitude, longitude of the pixel
      pix           input observations (albedo en %, brightness temperature in K)
 output:
      maia_par(30)    maia output mask information
  type( debug ),   INTENT(in)          :: idbg
  type (field_info), INTENT(in)        :: field_id
  type( box_id ),  INTENT(inout)       :: box   ! lat, lon, solar and satellite angles at the center of the box
  type( pix_info), INTENT(inout)       :: pix_id        ! lat, lon, solar and satellite angles at the pixel
  type( pix_data), INTENT(in)          :: pix   ! pix observations (albedo in %, Tb in K)
  LOGICAL,         INTENT(in)          :: new_box
  REAL, INTENT(out)                    :: maia_par(30) ! mask outputs (see maia_Write_Output.f90)
```

maia_Analyse_Field.F90
SUBROUTINE maia_Analyse_Field (idbg, field_1b, field_id)
input/output :
Type(debug), intent(in) :: idbg
Type (field), intent(inout) :: field_1b
Type (field_info), intent(out):: field_id

maia_Box_reset.F90
subroutine maia_Box_reset (idbg, box)
input/output :
type(debug), INTENT(in) :: idbg
type(box_id),INTENT(inout) :: box box information

maia_CMa_CD.F90
SUBROUTINE maia_CMa_CD (idbg, pix_id, pix,box, thres, CMa)
Coast – day
input/output :
type(debug), INTENT(in) :: idbg
type(pix_info), INTENT(inout) :: pix_id
type(pix_data), INTENT(in) :: pix
type(box_id), INTENT(in) :: box
type(maia_thres), INTENT(in) :: thres
type(maia_CMa) , INTENT(inout) :: Cma

maia_CMa_CG.F90
SUBROUTINE maia_CMa_CG (idbg, pix_id, pix, box, thres, CMa)
Coast – day
Coast - Glint
input/output : input/output :
type(debug), INTENT(in) :: idbg
type(pix_info), INTENT(inout) :: pix_id
type(pix_data), INTENT(in) :: pix
type(box_id), INTENT(in) :: box
type(maia_thres), INTENT(in) :: thres

maia_CMa_ConfClear.F90
SUBROUTINE maia_CMa_ConfClear (idbg, ngroup, cc_group, CMa)
cc_group: individual clear confidence level from 1. (clear) to 0.(cloudy)

I	Emission Threshold	BTM15
II	Emission Difference	BTM12-BTM13
		BTM15-BTM12
		BTM14-BTM15
III	Reflectance Threshold	RefM1
		RefM5
		RefM7
		RefM7/RefM5
IV	Reflectance Thin Cirrus	RefM9
V	Emission Thin Cirrus	BTM15-BTM16
		BTM12-BTM16

input/output :

```
logical, INTENT(in)            :: idbg
 INTEGER, INTENT(inout)  :: ngroup(ngroups_max)
 real, INTENT(in)               :: cc_group(ngroups_max,ngroups_max)
 type( maia_CMa),INTENT(inout) :: CMa
```

maia_CMa_IceD.F90

SUBROUTINE maia_CMa_IceD (idbg, pix_id, pix, box, thres, CMa)

cloud detection over snow/ice surface - day

max_num_tests = 3

1. Perform the Emission Difference Test Group (Group II) tests listed below

· BTM12 – BTM13 Difference Test for latitudes between 60o S and 60o N

· BTM15 – BTM12 Difference Test

2. Perform the Reflectance Cirrus Test Group (Group IV) test listed below:

· RefM9 Test

input/output :

```
  type( debug ),      INTENT(in)  :: idbg
  type( pix_info), INTENT(in)   :: pix_id
  type( pix_data),  INTENT(in)  :: pix
  type( box_id ),     INTENT(in)  :: box
  type( maia_thres), INTENT(in)  :: thres
  type( maia_CMa ),  INTENT(out)  :: CMa
```

maia_CMa_LD.F90

SUBROUTINE maia_CMa_LD (idbg, pix_id, pix, box, thres, CMa)

land - day

!max_num_tests = 8

```
 Gr 1. Emission Threshold          :   . BT108                              !for coherence maiav3
 Gr 2. Emission Difference Tests   :   1 BT37 – BT40 for lat 60S-60N and TOC NDVI > 0.2
                                       2 BT108 – BT37 for TOC NDVI > 0.2
                                       3 BT87 - BT108                       !for coherence seviri
 Gr 3. Reflectance Threshold Tests :   4 Ref06 Test
                                       2 Ref08/Ref06 RatioTest
 Gr 4. Reflectance Thin Cirrus     :   . Ref13 Test                         !a la place du 1.6mm
 Gr 5. Emission Thin Cirrus Test   :   . BT108 – BT120
```

input/output :

```
  type( debug ),      INTENT(in)  :: idbg
  type( pix_info),  INTENT(in)  :: pix_id
  type( pix_data),  INTENT(in)  :: pix
  type( box_id ),     INTENT(in)  :: box
  type( maia_thres), INTENT(in)  :: thres
  type( maia_CMa ),  INTENT(inout) :: CMa
```

maia_CMa_LN.F90

SUBROUTINE maia_CMa_LN (idbg, pix_id, pix, box, thres, CMa)

land - night

max_num_tests = 5+1

```
 Gr 1. Emission Threshold         :   . BT108
 Gr 2. Emission Difference Tests   :   2 BT108 – BT37 for TOC NDVI > thres
                                      3 BT87 - BT108         !for coherence seviri
                                      5 BT37 – BT108
                                      6 BT87 - BT37          !over desert coherence seviri
                                      7 BT108 - BT87         !large satsen coherence seviri
 Gr 5. Emission Thin Cirrus Test   :   1 BT108 – BT120
 Gr 6. texture                     :   6 I4 et I43           !for coherence maiav3
 input/output :
  type( debug ),      INTENT(in) :: idbg
  type( pix_info),  INTENT(in) :: pix_id
  type( pix_data),  INTENT(in) :: pix
  type( box_id ),     INTENT(in) :: box
  type( maia_thres), INTENT(in) :: thres
  type( maia_CMa ),  INTENT(out) :: CMa
```

maia_CMa_LT.F90

```
SUBROUTINE maia_CMa_LT  (idbg, pix_id, pix, box, thres, CMa)
 land - day
 land - Twilight
max_num_tests = 8
 Gr 1. Emission Threshold         :   . BT108                        coherence maiav3
 Gr 2. Emission Difference Tests   :   1 BT37 – BT40 for lat 60S-60N and TOC NDVI > 0.2
                                      2 BT108 – BT37 for TOC NDVI > 0.2
                                      3 BT87 - BT108              !coherence seviri
                                      5 BT37 – BT108 & BT87 - BT108 !over desert coherence seviri
                                      6 BT87 - BT37               !over desert coherence seviri
                                      7 BT108 - BT87              !large satsen coherence seviri
 Gr 3. Reflectance Threshold Tests :   4 Ref06 Test
                                      2 Ref08/Ref06 RatioTest
 Gr 4. Reflectance Thin Cirrus     :   . Ref13 Test                    !a la place du 1.6mm
 Gr 5. Emission Thin Cirrus Test   :   . BT108 – BT120
 input/output :
  type( debug ),      INTENT(in)  :: idbg
  type( pix_info),  INTENT(in)  :: pix_id
  type( pix_data),  INTENT(in)  :: pix
  type( box_id ),     INTENT(in)  :: box
  type( maia_thres), INTENT(in)  :: thres
```

maia_CMa_SD.F90

```
SUBROUTINE maia_CMa_SD  (idbg, pix_id, pix,box, thres, CMa)
  sea - day
  max_num_tests = 9
  Gr 1. Emission Threshold         :   . BT108                        for coherence with maiav3
  Gr 2. Emission Difference Tests   :   1 BT37 – BT40 for lat 60S-60N
                                       2 BT108 – BT37
                                       3 BT87 - BT108
 Gr 3. Reflectance Threshold Tests :   1 Ref08 Test
                                       2 Ref08/Ref06 RatioTest
```

Gr 4. Reflectance Thin Cirrus : . Ref16 Test for coherence with maiav3
Gr 5. Emission Thin Cirrus Test : . BT108 – BT120
Gr 6. texture if not coast : 2 I2
5 I5
input/output :
type(debug), INTENT(in) :: idbg
type(pix_info), INTENT(in) :: pix_id
type(pix_data), INTENT(in) :: pix
type(box_id), INTENT(in) :: box
type(maia_thres),INTENT(in) :: thres
type(maia_CMa), INTENT(out) :: CMa

maia_CMa_SG.F90
SUBROUTINE maia_CMa_SG (idbg, pix_id, pix, box, thres, CMa)
sea - glint
max_num_tests = 6
Gr 1. Emission Threshold : . BT108 added for coherence with maiav3
Gr 2. Emission Difference Tests : 3 BT87 - BT108
Gr 3. Reflectance Threshold Tests : 1 Ref08 Test
2 Ref08/Ref06 RatioTest
3 LowCloudInSunGlint (06, 37-108)
Gr 5. Emission Thin Cirrus Test : . BT108 – BT120
input/output :
type(debug), INTENT(in) :: idbg
type(pix_info), INTENT(in) :: pix_id
type(pix_data), INTENT(in) :: pix
type(box_id), INTENT(in) :: box
type(maia_thres),INTENT(in) :: thres
type(maia_CMa), INTENT(out) :: CMa

maia_CMa_SN.F90
SUBROUTINE maia_CMa_SN (idbg, pix_id, pix, box, thres, CMa)
sea - night

max_num_tests = 5
Gr 1. Emission Threshold Test Group : . BT108 Test (SST or BT)
Gr 2. Emission Difference Test : 4. BT120 – BT37 for BT37 > BT37_limit (230K)
5. BT37 – BT108
2. BT108 – BT37
3. BT87 - BT108, seuil fct de 108-120
Gr 5. Emission Thin Cirrus Test : . BT108 – BT120

input/output :
type(debug), INTENT(in) :: idbg
type(pix_info), INTENT(in) :: pix_id
type(pix_data), INTENT(in) :: pix
type(box_id), INTENT(in) :: box
type(maia_thres),INTENT(in) :: thres
type(maia_CMa), INTENT(out) :: CMa

maia_CMa_ST.F90
SUBROUTINE maia_CMa_ST (idbg, pix_id, pix, box, thres, CMa)
sea - twilight
max_num_tests = 9
Gr 1. Emission Threshold
Gr 2. Emission Difference Tests
3 BT87 - BT108
4 BT37 - BT108 (low cloud detection) !for coherence with maiav3
5 BT120 â " BT37 !for coherence with maiav3
Gr 3. Reflectance Threshold Tests
2 Ref08/Ref06 RatioTest
Gr 4. Reflectance Thin Cirrus
Gr 5. Emission Thin Cirrus Test
Gr 6. texture
6 I4 et I43 !for coherence maiav3 et seviri
input/output:
```
 type( debug ),     INTENT(in)  :: idbg        !
 type( pix_info), INTENT(in)    :: pix_id      !
 type( pix_data), INTENT(in)    :: pix   !
 type( box_id ),    INTENT(in)  :: box   !
 type( maia_thres ),INTENT(in):: thres        !
 type( maia_CMa), INTENT(out) :: CMa
```

maia_CMa_quality.F90
SUBROUTINE maia_CMa_quality (idbg, max_num_tests, num_tests_done, qual_fl)
input/output :
```
  type( debug ), INTENT(in)    :: idbg          !
 INTEGER, INTENT(in)                :: max_num_tests, num_tests_done
 INTEGER, INTENT(out)               :: qual_fl  !=3 high
```

maia_CMa_texture.F90
SUBROUTINE maia_CMa_texture (idbg, box, pix_id, pix, CMa)
input/output :
```
 type( debug ),      INTENT(in) :: idbg         !
 type( box_id ),     INTENT(in)          :: box   !
 type( pix_info),  INTENT(in)  :: pix_id        !
 type( pix_data),  INTENT(in)  :: pix    !
 type( maia_CMa ),  INTENT(inout)    :: CMa
```

maia_CT_Fl_opaq.F90
SUBROUTINE maia_CT_Fl_opaq (idbg, pix, black)
determines if a pixel is opaque
input/output :
```
 type( debug ),       INTENT(in) :: idbg           !
 type( pix_data),   INTENT(in) :: pix    ! pix observations (albedo in %, Tb in K)
 INTEGER, INTENT(out)           :: black
```

maia_CT_dawn.F90
SUBROUTINE maia_CT_dawn (idbg, box, pix_id, pix, thres, CT)
Set Cloud Type in dawn condition
input/output :
```
 type( debug ),      INTENT(in) :: idbg           !
 type( box_id ),     INTENT(in)          :: box   ! info at the center of the box
 type( pix_data),    INTENT(in)          :: pix            ! pix observations (albedo in %, Tb in K)
 type( pix_info),    INTENT(in)          :: pix_id         ! lat, lon, solar and satellite angles at the pixel
 type( maia_thres), INTENT(in)           :: thres  !
 type( maia_CT),    INTENT(out)          :: CT             !
```

maia_CT_day.F90
SUBROUTINE maia_CT_day (idbg, box, pix_id, pix, thres, CT)
Set Cloud Type in day condition
input/output :
```
 type( debug ),      INTENT(in) :: idbg           !
 type( box_id ),     INTENT(in)          :: box   ! info at the center of the box
 type( pix_data),    INTENT(in)          :: pix            ! pix observations (albedo in %, Tb in K)
 type( pix_info),    INTENT(in)          :: pix_id         ! lat, lon, solar and satellite angles at the pixel
 type( maia_thres), INTENT(in)           :: thres  !
 type( maia_CT),    INTENT(out)          :: CT     !
```

maia_CT_night.F90
SUBROUTINE maia_CT_night (idbg, box, pix_id, pix, thres, CT)
Set Cloud Type in night condition
input/output :
```
 type( debug ),      INTENT(in)  :: idbg           !
 type( box_id ),     INTENT(in)  :: box   ! info at the center of the box
 type( pix_data),    INTENT(in)          :: pix    ! pix observations (albedo in %, Tb in K)
 type( pix_info),    INTENT(in)  :: pix_id  ! lat, lon, solar and satellite angles at the pixel
 type( maia_thres), INTENT(in)           :: thres !
 type( maia_CT),    INTENT(out)          :: CT    !
```

maia_Cal_AtmCorrVis.F90
SUBROUTINE maia_Cal_AtmCorrVis (idbg, box, thvis, A0, A1, A2, ic)
computes the coefficients used in the simulation of channels 0.65, 0.86 or 1.6 micron
6S version 4 was used to compute the tables
uses a continental aerosol of 35 km visibility
input/output :
```
INTEGER,          INTENT(in)  :: ic              ! channel number (1, 2, 3)
 type( debug ),   INTENT(in)  :: idbg            !
 type( box_id ),  INTENT(in)  :: box   ! lat, lon, solar and satellite angles at the center of the box
 type( maia_VISThresTables), intent(in) :: thvis   ! tabulated threshold (over sea or land)
 REAL,            INTENT(out)  :: A0,A1,A2      ! coefficients
```

maia_Cal_CoxMunk.F90
SUBROUTINE maia_Cal_CoxMunk (idbg, lambda, box, albmax)
computes the maximum reflectance over sea (Cox and Munck theory).
input/output :
```
REAL,           INTENT(in) :: lambda
```

```
 type( debug ),    INTENT(in)  :: idbg              !
 type( box_id ),   INTENT(in)  :: box    ! lat, lon, solar and satellite angles at the center of the box
 REAL,             INTENT(out) :: albmax            ! In %
```

maia_Cal_Fresnel.F90
SUBROUTINE maia_Cal_Fresnel (nr,ni,coschi, sinchi, R1)
to compute the Fresnel's coefficient of reflection (see for
example M. Born and E. Wolf, Principles of Optics, Pergamon Press, fifth
edition, 1975, pp 628
input parameters
nr=index of refraction of the sea water
ni=extinction coefficient of the sea water
coschi & sinchi=cosine and sine of the incident radiation with respect of the wave facet normal.
output parameter
input/output :

```
   REAL, INTENT(in) :: nr,ni,coschi,sinchi
   REAL, INTENT(out) :: R1
```

maia_Cal_LeRoux.F90
SUBROUTINE maia_Cal_LeRoux(idbg, box, ic,reflec, albmax)
computes the reflectance of the snow (thesis of Le Roux).
input/output :

```
 type( debug ),    INTENT(in)  :: idbg              !
 type( box_id ),   INTENT(in)  :: box    ! info at the center of the box
 INTEGER, INTENT(in)           :: ic
 REAL, intent(in)          :: reflec(nbreflecsol,nbreflecsat,nbreflecazi,3)
 INTEGER, INTENT(out)          :: albmax         !in %
```

maia_Cal_Roujean.F90
SUBROUTINE maia_Cal_Roujean (idbg, box, brdf)
computes the Roujean function (brdf des sols).
the reference albedo (in %) is used to define the coefficients for the model
input/output :

```
  type( debug ),    INTENT(in)  :: idbg              !
 type( box_id ),   INTENT(in)  :: box    ! infos at the center of the box
 REAL ,            INTENT(out) ::  brdf
```

maia_Cal_Texture.F90
SUBROUTINE maia_Texture_FromImager (idbg, pix, lig, box, field_I, pix_id)
computes the local texture (std + max diff) inside the Moderate resolution pixel
from the coregistered imaging channels
input/output :

```
 type( debug ), intent(in)                   :: idbg
 integer, intent(in)                         :: pix, lig
 Type (field),intent(in)            :: field_1b
 type( pix_info),intent(inout)      :: pixel_id
 Type (field),intent(in), optional           :: field_1b_prev
 Type (field),intent(in), optional           :: field_1b_next
```

maia_Cal_Twvc.F90

SUBROUTINE maia_Cal_Twvc (nbniv, pniv, psurf, hum_in, cwv)
Computes the total water vapor content
from the specific humidity profile and the surface pressure
input/output :

```
 INTEGER, INTENT(in) :: nbniv
 REAL, INTENT(in)    :: pniv(nbniv)   ! pressure on levels              (hpa)
 REAL, INTENT(in)    :: hum_in(nbniv)         ! specific humidity on levels      (g/g)
 REAL, INTENT(in)    :: psurf         ! surface pressure                (hpa)
 REAL, INTENT(out)   :: cwv           ! total water vapor content       (g/cm2 = cm)
```

maia_Cal_WaterIndex.F90
SUBROUTINE maia_Cal_WaterIndex (wl,xsal,nr,ni)
Correction to be applied to the index of refraction and to the extinction coefficients of the pure water to obtain the ocean water one (see for example Friedman). By default, a typical sea water is assumed (Salinity=34.3ppt, Chlorinity=19ppt) as reported by Sverdrup. In that case there is no correction for the extinction coefficient between 0.25 and 4 microns. For the index of refraction, a correction of +0.006 has to be applied (McLellan). For a chlorinity of 19.0ppt the correction is a linear function of the salt concentration. Then, in 6S users are able to enter the salt concentration (in ppt).
REFERENCES
Friedman D., Applied Optics, 1969, Vol.8, No.10, pp.2073-2078.
McLellan H.J., Elements of physical Oceanography, Pergamon Press, Inc., New-York, 1965, p 129.
Sverdrup H.V. et al., The Oceans (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1942, p 173.
input
xsal=salinity (in ppt), if xsal<0 then 34.3ppt by default
output
ni=extinction coefficient of sea water
input/output :

```
 REAL, INTENT(in)    :: wl,xsal
 REAL, INTENT(out)   :: nr,ni
```

maia_Cloud_Mask.F90
SUBROUTINE maia_Cloud_Mask (idbg, box, pix_id , pix, thres, CMa)
Cloud mask
tm=0
tm=1
tm=2
input/output :

```
 type( debug ),      INTENT(in) :: idbg          !
 type( box_id ),     INTENT(in) :: box           ! info at the center of the box
 type( pix_info ),  INTENT(in) :: pix_id   ! lat, lon, solar and satellite angles at the pixel
 type( pix_data),   INTENT(in) :: pix     ! pix observations (albedo in %, Tb in K)
 type( maia_thres),  INTENT(in) :: thres         !
 type( maia_CMa ), INTENT(out)  :: CMa
```

maia_Cloud_Pressure.F90
subroutine maia_Cloud_Pressure (idbg, box, pix_id, pix, t108_tcld, CT, CH)

input/output :
```
   type( debug ),     INTENT(in)    :: idbg          !
  type( box_id ),    INTENT(in)    :: box           ! info at the center of the box
  type( pix_info),   INTENT(in)    :: pix_id        ! lat, lon, solar and satellite angles at the pixel
  type( pix_data),   INTENT(in)    :: pix  ! pix observations (albedo in %, Tb in K)
  real, INTENT(in)                 :: t108_tcld(t_nb, sec_nb) ! tabulated threshold tables
(nb_wv,nb_secant)
  type( maia_CT),    INTENT(in)    :: CT
  type( maia_CH),    INTENT(out)   :: CH            !
```

subroutine maia_CloudTopTemp (satsec, bt108, t108_tcld, CloudTopTemp)
computation of the CloudTopTemp corrected with data in table
```
  real, intent(in)  :: satsec, bt108
  real, intent(in)  :: t108_tcld(t_nb, sec_nb)
  real, intent(out) :: CloudTopTemp
```

subroutine maia_CloudTopPres (CT, box, pix_id, CloudTopTemp, CloudTopPres)
computation of the CloudTopPres with a CloudTopTemp in input
verify temperature inversion
input/output :
```
  integer, INTENT(in) :: CT
  type( box_id ), INTENT(in)    :: box    ! info at the center of the box
  type( pix_info),   INTENT(in) :: pix_id           ! lat, lon, solar and satellite angles at the pixel
  real, INTENT(in)       :: CloudTopTemp           !
  real, INTENT(out)      :: CloudTopPres           !
```

subroutine Temp_2Pres (box, pix_id, Tcld, Pcld)
computation of the CloudTopPres with vertical profile from surface to tropopause
input/output :
```
  real, intent(in) :: Tcld
  type( box_id ),    INTENT(in)    :: box           ! info at the center of the box
  type( pix_info),   INTENT(in) :: pix_id           ! lat, lon, solar and satellite angles at the pixel
  real, intent(inout) :: Pcld
```

subroutine Temp_Subsidence (box, inver_p, inver_t, inver_cp, inver_ct, inver_type)
computation of the CloudTopTemp corrected with data in table
input/output :
```
  type( box_id ),  INTENT(in)   :: box         ! info at the center of the box
  real, intent(out)            :: inver_p, inver_t, inver_cp, inver_ct
  logical, intent(out)          :: inver_type
```

maia_Cloud_Type.F90
SUBROUTINE maia_Cloud_Type (idbg, box, pix_id, pix,thres, CT)
input/output :
```
  type( debug ),      INTENT(in) :: idbg             !
  type( box_id ),     INTENT(in) :: box              ! info at the center of the box
  type( pix_info),   INTENT(inout) :: pix_id       ! lat, lon, solar and satellite angles at the pixel
  type( pix_data),   INTENT(in) :: pix    ! pix observations (albedo in %, Tb in K)
  type( maia_thres),  INTENT(in) :: thres           !
  type( maia_CT),     INTENT(out) :: CT             !
```

maia_Cloud_Phase.F90

SUBROUTINE maia_Cloud_Phase (idbg, box, pix, Thres_Phase, CMa, CT, soft)
Determines a cloud phase for confidently cloudy pixels.
The following assignments are made to all pixels:

0: Not Executable
1: Clear (from Confidently Clear pixels)
2: Partly Cloudy (from Probably Clear and Cloudy pixels)
3: Water Cloud
4: Supercooled Water or Mixed Phase Cloud
5: Opaque Ice Cloud
6: Cirrus (Non-Opaque) Cloud
7: Cloud Overlap
8: uncertain

3 software sources:
soft=1 from Bryan A. Baum for further information email: bryan.baum@ssec.wisc.edu
soft=2 from:
Pavolonis, M. J., A. K. Heidinger and T. Uttal: Daytime Global Cloud Typing from AVHRR and VIIRS: Algorithm Description, Validation,and comparisons. Journal of Applied Meteorology, 2005.
VIIRS Cloud Mask ATBD. December 2011
soft=3 from:
Pavolonis M. J.: Advances in extracting cloud composition information from spaceborne infrared radiances- a robust alternative to brightness temperatures.
Part1: theory. Journal of Applied Meteorology, 2010.
input/output :

```
type( debug ),    INTENT(in)         :: idbg
type( box_id ),   INTENT(in)         :: box
type( pix_data),INTENT(in)           :: pix
type( maia_Thres_Phase), INTENT(in)   :: Thres_Phase  !
type( maia_CMa), INTENT(in)          :: CMa
type( maia_CT),INTENT(inout)  :: CT
integer,         INTENT(in)         :: soft
```

SUBROUTINE overlap_test (idbg, box, pix, Thres_Phase, ems_37, CMa, overlap)

input/output :

```
type( debug ),         INTENT(in)       :: idbg
type( box_id ),        INTENT(in)       :: box    ! info at the center of the box
type( pix_data),       INTENT(in)       :: pix    ! pix observations (albedo in %, Tb in K)
type( maia_Thres_Phase), INTENT(in)             :: Thres_Phase  !
real,                INTENT(in)  :: Ems_37
type( maia_CMa),          INTENT(in)    :: CMa
logical,                intent(out)    :: overlap
```

SUBROUTINE cirrus_test (idbg, box, pix, Reflec_37, Ems_37, cirrus)

input/output :

```
type( debug ),     INTENT(in) :: idbg    !
type( box_id ),    INTENT(in) :: box     ! info at the center of the box
type( pix_data), INTENT(in) :: pix       ! pix observations (albedo in %, Tb in K)
```

```
 real, INTENT(in)               :: Reflec_37, Ems_37
 logical, intent(out)           :: cirrus
```

SUBROUTINE mixed_phase_test (idbg, box, pix, Mixed_phase)

input/output :

```
 type( debug ),    INTENT(in) :: idbg
 type( box_id ),   INTENT(in) :: box
 type( pix_data), INTENT(in)  :: pix    ! pix observations (albedo in %, Tb in K)
 logical, intent(out)         :: Mixed_phase
```

SUBROUTINE Opaque_ice_test (idbg, box, pix, opaque_ice)

input/output :

```
 type( debug ),    INTENT(in) :: idbg   !
 type( box_id ),   INTENT(in) :: box    ! info at the center of the box
 type( pix_data), INTENT(in)  :: pix    ! pix observations (albedo in %, Tb in K)
 logical, intent(out)         :: opaque_ice
```

SUBROUTINE Cirrus2_test (idbg, box, pix, Reflec_37, Thres87_108, Thres13, Cirrus)

input/output :

```
 type( debug ),    INTENT(in) :: idbg
 type( box_id ),   INTENT(in) :: box
 type( pix_data), INTENT(in)  :: pix    ! pix observations (albedo in %, Tb in K)
 real, INTENT(in)             :: Reflec_37, Thres87_108, Thres13
 logical, intent(out)         :: cirrus
```

SUBROUTINE temp2rad (temp, rad)

maia_ConfTest.F90

SUBROUTINE maia_ConfTest (idbg, value, s_cld, s_mid, s_cl, confident_clear)

individual clear confidence level from 1. (clear) to 0.(cloudy)

input/ output :

```
 type( debug ),INTENT(in) :: idbg      !
 REAL, INTENT(in)    :: value
 REAL, INTENT(in)    :: s_cld, s_mid, s_cl
 REAL, INTENT(out)             :: confident_clear
```

maia_Fill_Input.F90

subroutine maia_Fill_Input_Virrs (idbg, pix, lig, field_1b, field_I, pixel_id, pixel, box)

input/output :

```
 type( debug ), intent(in)    :: idbg
 integer, intent(in)         :: pix, lig
 Type (field),intent(in)     :: field_1b
 Type (field),intent(in)     :: field_I
 type( pix_info),intent(out)  :: pixel_id    ! lat, lon, solar and satellite angles at the pixel
 type( pix_data),intent(out)  :: pixel      ! pixel observations (albedo in %, Tb in K)
 type( box_id ),intent(out)   :: box        ! lat, lon, solar and satellite angles at the center of the box
```

subroutine maia_Fill_Input_Avhrr (idbg, pix, lig, field_1b, pixel_id, pixel, box)

```
 input/output :
 type( debug ), intent(in)     :: idbg
 integer, intent(in)           :: pix, lig
 Type (field),intent(in)       :: field_1b
  type( pix_info),intent(out)  :: pixel_id    ! lat, lon, solar and satellite angles at the pixel
  type( pix_data),intent(out)  :: pixel       ! pixel observations (albedo in %, Tb in K)
  type( box_id ),intent(out)   :: box         ! lat, lon, solar and satellite angles at the center of the box
```

maia_Fill_Output.F90

```
SUBROUTINE maia_Fill_Output (idbg, topo, box, pix_id, pix, CMa, CT, CH, maia_par)
!------------------------------------------------------------------
 Write Output Cloud mask information in table maia_par(30)
!------------------------------------------------------------------
!     1  - Cloud Mask                summary of CMa
!                                          0= clear / 1= cloudy / 3= clear over snow /
!                                          4= clear over ice / 5= aerosol_dust_ash_fire
!     2  - Cloud Mask Quality              from the number of tests involved
!                                          3=high / 2=medium / 1=poor / 0=bad
!     3  - Cloud Mask Confidence     from the proximity of thresholds (before Cloud Adjacency)
!                                          3=confident clear / 2=probably clear /
!                                          1=probably cloudy / 0=confident cloudy

!     4  - Cloud Mask Adjacency      from cloud confidence evaluation of surrounding pixels
!                                          0=confident clear / 1=probably clear /
!                                          2=probably cloudy / 3=confident cloudy

!     5  - Surface temperature       for confident clear
!                                    over sea
!                                    over land
!     6  - Box size                  number of Moderate pixels/lines
!     7  - Box bg Tskin source       0= from climatology / 1= from forecast
!      8  - Box Bg Tskin used        (K)
!     9  - Box Bg WV Content source  0= from climatology / 1= from forecast
!     10 - Box Bg WV Content used    (g/cm2)
!     11 - Box surface altitude      (m)
!     12 - Box atlas surface type    0= sea / 1= mixed / 2= land / 3= desert
!     13 - Box day_time              0= Night / 1= Twilight / 2= Day / 3= Sunglint
!     14 - Box specular reflexion    0= no / 1= yes
!     15 - pixel surface altitude    (m)
!     16 - pixel surface type   0= sea / 1= mixed / 2= land / 3= desert / 4= ephemeral water
!     17 - pixel snow/ice          0= no / 1= yes
!                                    night
!                                    day
!      18 - cloud type               0  non-processed (no data or corrupted data)
!                                    1  cloud free land
!                                    2  cloud free sea
!                                    3  land contaminated by snow
!                                    4  sea contaminated by snow/ice
!                                    5  very low clouds
!                                    7  low clouds
!                                    9  medium clouds
!                                       11 high opaque clouds
!                                       13 very high opaque clouds
!                                       15 thin semitransparent clouds
!                                       16 meanly thick semitransparent  clouds
!                                       17 thick semitransparent clouds
!                                       18 semitransparent above low or medium clouds
!                                       19 fractional clouds (sub-pixel water clouds)
!                                       20 undefined (undefined by CMa)
!       19 - cloud phase                0 Not Executable
                                1 Clear (from Confidently Clear pixels)
                                2 Partly Cloudy (from Probably Clear and Cloudy pixels)
                                3 Water Cloud
                                4 Supercooled Water or Mixed Phase Cloud
                                5 Opaque Ice Cloud
                                6 Cirrus (Non-Opaque) Cloud
                                7 Cloud Overlap
!       20 - thin cirrus detected0= no /1= yes
!       21 - cloud shadow detected      0= no /1= yes
!       22 - cloud opacity              0= no /1= yes
!       23 - cloud top temperature      (K) for confident cloudy and opaque
!       24 - cloud top pressure         (hPa) for confident cloudy and opaque using NWP profile
!       25 - Heavy aerosol              0= no / 1= yes
!       26 - Dust                       0= no / 1= yes
!       27 - Volcanic Ash               0= no / 1= yes
!       28 - Smoke                      0= no / 1= yes
!       29 - Fire                       0= no / 1= yes
!       30 - Moderate pixel texture     0= no / 1= yes
```

input/output

```
 type( debug ),       INTENT(in) :: idbg            !
 type( topo_field),INTENT(in) :: topo  ! surface topography landsea and elev
 type( box_id ),      INTENT(in) :: box             ! info at the center of the box
 type( pix_info ),  INTENT(in) :: pix_id   ! lat, lon, solar and satellite angles at the pixel
 type( pix_data),   INTENT(in) :: pix    ! pix observations (albedo in %, Tb in K)
 type( maia_CMa),    INTENT(in) :: CMa        !
 type( maia_CT),     INTENT(inout) :: CT                  !
 type( maia_CH),     INTENT(in) :: CH             !
 REAL, INTENT(out)    :: maia_par(30)                    ! mask outputs
```

maia_Flag_Dust.F90

SUBROUTINE maia_Flag_Dust (idbg, box, pix, pix_id, thres, CT, CMa)

Determines a dust/sand flag transported out of deserts over continental and oceanic surfaces (North Africa and adjacent seas)

The night/sea test is based on the Sahara Dust Index using M12, M15, M16 (Merchant et al., 2006) The daytime tests are based on the M1/M5 ratio and M5 texture with adjacent M pixels and Bt differences M12-M15, M16-M15, M14-M15 *not applied for night/land*

```
  input/output :
  type( debug )                :: idbg       !
  type( box_id ),   INTENT(inout)     :: box   ! lat, lon, solar and satellite angles at the center of the box
  type( pix_info)                     :: pix_id      ! lat, lon, solar and satellite angles at the pixel
  type( pix_data)                     :: pix         ! viirs observations (albedo in %, Tb in K)
  type( maia_thres), INTENT(in)       :: thres       !
  integer                             :: CT
  type( maia_CMa),   INTENT(inout)    :: CMa         !
```

maia_Flag_ThinCirrus.F90

SUBROUTINE maia_Flag_ThinCirrus (idbg, box, pix_id, pix, CMa, Thin_Cirrus_flag)
Determines a thin cirrus flag
The tests consist of a brightness temperature difference threshold test in M15 – M16 at night and a reflectance threshold tests using band 13 in the daytime.

```
  input/output :

type( debug ),    INTENT(in)  :: idbg        !
  type( box_id ),   INTENT(in)  :: box       ! lat, lon, solar and satellite angles at the center of the box
  type( pix_info),  INTENT(in)  :: pix_id    ! lat, lon, solar and satellite angles at the pixel
  type( pix_data),  INTENT(in)  :: pix       ! pix observations (albedo in %, Tb in K)
  type( maia_CMa), INTENT(in)   :: CMa  !
  integer,          INTENT(out) :: Thin_Cirrus_flag
```

maia_Flag_VolcanAsh.F90

SUBROUTINE maia_Flag_VolcanAsh (idbg, box, pix, pix_id, thres, Cma)
Determines aV olcanic Ash flag

```
input/output :
 type( debug )                :: idbg       !
  type( box_id ),   INTENT(in) :: box    ! lat, lon, solar and satellite angles at the center of the box
  type( pix_info)              :: pix_id     ! lat, lon, solar and satellite angles at the pixel
  type( pix_data)              :: pix        ! viirs observations (albedo in %, Tb in K)
  type( maia_thres), INTENT(in)      :: thres       !
  type( maia_CMa),   INTENT(inout)    :: CMa        !
```

maia_GetClim.F90

SUBROUTINE maia_GetClim (idbg, box, clim)
Albedo outside the box array will have a value of 20%
SST outside the box array will have a value of 0c over coast and 0K over sea

```
 input/output :
  type( debug ), INTENT(inout)  :: idbg !
  type( box_id ),INTENT(inout)  :: box  ! box information
  type( clim_field ),intent(in) :: clim !
```

maia_GetGlint.F90

SUBROUTINE maia_GetGlint (idbg, box)

Sunglint is defined as

sea maximum reflectance(at 0.6 micron) > 10%

sun zenith angle less than 75 degres

Sea maximum reflectance is computed using Cox&Munck equations

dcj=1 sunglint

input/output :

```
  type( debug ), INTENT(in)      :: idbg   !
  type( box_id ),INTENT(inout):: box    ! box information
```

maia_GetPrev.F90

SUBROUTINE maia_GetPrev(idbg, box, pix_id, bg)

Tair is computed using the temperature at 1000hPa and a slope of 0.65K per 100m. If missing the value of 0K is given

input/output :

```
  type( debug ), INTENT(inout) :: idbg   !
  type( box_id ),INTENT(inout):: box    ! box information
  type( pix_info),INTENT(in)    :: pix_id            ! lat, lon, solar and satellite angles at the pixel
  type( nwp_field),INTENT(in)  :: bg(2)! forecast information
```

maia_GetThres_CMa.F90

SUBROUTINE maia_GetThres_CMa (idbg, box, pix, reflec, thvis_sea, thvis_land, &

input/output :

```
  REAL, INTENT(in) :: reflec(nbreflecsol,nbreflecsat,nbreflecazi,3)
  type( debug ),               INTENT(in) :: idbg      !
  type( box_id ),              INTENT(in) :: box       ! lat, lon, solar and satellite angles at the center of the
box
  type( pix_data),           INTENT(in) :: pix        ! pix observations (albedo in %, Tb in K)
  type( maia_VISThresTables),  INTENT(in) :: thvis_sea
  type( maia_VISThresTables),  INTENT(in) :: thvis_land
  type( maia_ThresTables_sea), INTENT(in) :: tabsea
  type( maia_ThresTables_land),INTENT(in) :: tabland
  type( maia_thres),          INTENT(inout):: thres            !
```

maia_GetThres_CMa_Land.F90

SUBROUTINE maia_GetThres_CMaLand (idbg, box, tabland, thres)

to compute the IR thresholds used over land

function of satsec_loc, wv, tsurf, alb

indsec from 1 to 16

satsec_loc

input/output :

```
  type( debug ),               INTENT(in) :: idbg      !
  type( box_id ),                      INTENT(in) :: box        ! lat, lon, solar and sat angles at the center of
the box
  type( maia_ThresTables_land),INTENT(in) :: tabland   ! tabulated threshold tables
(nb_wv,nb_secant)
  type( maia_thres ),       INTENT(inout):: thres   ! dynamic thresholds in (deg*100)
```

maia_GetThres_CMa_Sea.F90
SUBROUTINE maia_GetThres_CMaSea(idbg, box, tabsea,thres)
to compute the thresholds used over sea
input/output :
type(debug),   INTENT(in) :: idbg   !
type(box_id),   INTENT(in) :: box   ! lat, lon, solar and sat angles at the center of the box
type(maia_ThresTables_sea),INTENT(in) :: tabsea   ! tabulated threshold tables (nb_wv,nb_secant)
type(maia_thres),   INTENT(inout):: thres   ! dynamic thresholds in (deg*100)

maia_GetThres_CT.F90
SUBROUTINE maia_GetThres_CT (idbg, box, tabopaq, thres)
input/output :
type(debug),   INTENT(in)   :: idbg   !
type(box_id),   INTENT(in)   :: box   ! lat, lon, solar and satellite angles at the center of the box
type(maia_ThresTables_opaq),INTENT(in) :: tabopaq   ! tabulated threshold tables (nb_wv,nb_secant)
type(maia_thres),INTENT(out):: thres!

maia_GetThres_CT_max06.F90
SUBROUTINE maia_GetThres_CT_max06 (idbg, box, thres)
compute coefs leading to max. R06 (for cirrus) (sea or land)
input/output :
type(debug),   INTENT(in)   :: idbg   !
type(box_id),   INTENT(in)   :: box   ! lat, lon, solar and satellite angles at the center of the box
type(maia_thres),INTENT(out):: thres!

maia_GetThres_CT_max108.F90
SUBROUTINE maia_GetThres_CT_max108 (idbg, box, thres)
Set Cloud Type thresholds
input/output :
type(debug),   INTENT(in)   :: idbg   !
type(box_id),   INTENT(in)   :: box   ! lat, lon, solar and satellite angles at the center of the box
type(maia_thres),INTENT(out):: thres!

maia_GetThres_CT_opaq.F90
SUBROUTINE maia_GetThres_CT_Opaq (idbg, box, tabopaq,thres)
to compute the thresholds used for opaque clouds
function of satsec_loc, wv
indsec from 1 to 16
satsec_loc
input/output :
type(debug),   INTENT(in) :: idbg   !
type(box_id),   INTENT(in) :: box   ! lat, lon, solar and sat angles at the center of the box
type(maia_ThresTables_opaq),INTENT(in) :: tabopaq   ! tabulated threshold tables (nb_wv,nb_secant)
type(maia_thres),   INTENT(out):: thres   ! dynamic thresholds in (deg*100)

maia_GetThres_InPix.F90

```
SUBROUTINE maia_GetThres_InPix (idbg, thres)
  input/output :
  type( debug ),              INTENT(in) :: idbg     !
  type( maia_thres),          INTENT(out):: thres  !
```

maia_GetTopo.F90
SUBROUTINE maia_GetTopo (idbg, topo, lat, lon_in, psize ,lsize, tm, alt)

files are at the 0.02 degre resolution

```
   landsea=0      sea
   landsea=1      land
   landsea=2      desert
   landsea=3      permanent snow
   landsea=4      coast
  input/output :
  type( debug ), INTENT(in)      :: idbg  !
  type( topo_field), INTENT(in):: topo  ! surface topography landsea and elev
  REAL, INTENT(in)               :: lat, lon_in
  INTEGER, INTENT(in)                     :: psize ,lsize
  INTEGER, INTENT(out)                    :: tm, alt
```

maia_Get_AlbLand.F90

```
SUBROUTINE  maia_Get_AlbLand (idbg, num_can, box, thvis_land, albter)
  input/output :
 type( debug ),             INTENT(in)      :: idbg              !
  INTEGER,                   INTENT(in)  :: num_can
  type( box_id ),            INTENT(in)    :: box    ! info at the center of the box
  type( maia_VISThresTables), intent(in)           :: thvis_land      ! tabulated threshold
  real,                    INTENT(out)        :: albter ! reference albedo in %
```

maia_Get_AlbSea.F90

```
subroutine  maia_Get_AlbSea (idbg, num_can, box, thvis_sea, albmer)
  input/output :
  INTEGER,         INTENT(in)  :: num_can
  type( debug ),    INTENT(in)   :: idbg              !
  type( box_id ),   INTENT(in)   :: box    ! lat, lon, solar and satellite angles at the center of the box
  type( maia_VISThresTables), intent(in) :: thvis_sea    ! tabulated threshold
  real,           INTENT(out)          :: albmer           ! threshold in %
```

maia_Get_AlbSnow.F90

```
SUBROUTINE  maia_Get_AlbSnow (idbg, num_can, box, reflec, thvis_land, sn16)
input/output :
 INTEGER,         INTENT(in)  :: num_can
  type( debug ),    INTENT(in)   :: idbg              !
  type( box_id ),   INTENT(in)   :: box    ! lat, lon, solar and satellite angles at the center of the box
  REAL,            INTENT(in)     :: reflec(nbreflecsol,nbreflecsat,nbreflecazi,3)
  type( maia_VISThresTables), intent(in) :: thvis_land    ! tabulated threshold
  REAL,            INTENT(out) :: sn16
```

maia_Inland_Water.F90

SUBROUTINE maia_Inland_Water (idbg, pix_id, pix)
looks to small surfaces of water from imager channels from toa ndvi

input/ output:

```
  type( debug ) , INTENT(in)     :: idbg
  type( pix_info), INTENT(inout) :: pix_id
  type( pix_data), INTENT(in)    :: pix
```

maia_Interp_InGrid.F90
SUBROUTINE maia_Interp_InGrid (tab , rpg, rlg, value)
interpolation between the 4 nodes of the grid
input/output :

```
  REAL, INTENT(in)   :: tab(2,2)
  REAL, INTENT(in)   :: rpg, rlg
  REAL, INTENT(out)  :: value
```

maia_Interp_InLut.F90
FUNCTION maia_Interp_InLut (tab,difsec,difw,iw,isec)
input/output :

```
  REAL, INTENT(in) :: tab(nb_w,nb_sec)
  REAL, INTENT(in) :: difsec,difw
  INTEGER , INTENT(in) :: iw,isec
```

maia_Interp_Plog.F90
SUBROUTINE maia_Interp_Plog (pi,ti,pf,tf,ni,nf)
logarithm interpolation on pressures
input/output :

```
  INTEGER ,INTENT(in) :: ni,nf
  REAL, INTENT(in)   :: pi(ni),ti(ni),pf(nf)
  REAL, INTENT(out)  :: tf(nf)
```

maia_Lon_Norm.F90
subroutine maia_Lon_Norm (debug, data_id, Lon)
input/output :

```
   logical,    INTENT(in)          :: debug          !
  character(len=6), intent(in)     :: data_id        !
```

maia_PixEnv_reset.F90
SUBROUTINE maia_PixEnv_reset (idbg, landsea, elev, box, pix_id, CMa, CT, CH)
set environment and reset CMa, CT, CH output
input/output :

```
   type( debug ), INTENT(in)           :: idbg
   type( topo_field),INTENT(in)        :: landsea, elev  ! surface topography landsea and elev
   type( box_id ),INTENT(inout)        :: box            ! box information
   type( pix_info ),INTENT(inout)      :: pix_id         ! pix_id information
   type( maia_CMa ), INTENT(inout)     :: CMa
   type( maia_CT), INTENT(inout)       :: CT             !
   type( maia_CH), INTENT(inout)       :: CH
```

maia_Pixel_reset.F90

```
subroutine maia_Pixel_reset ( idbg, pix_id, pix )
  type( debug )        :: idbg        !
  type( pix_info)      :: pix_id      ! lat, lon, solar and satellite angles at the pixel
  type( pix_data)      :: pix  ! pix observations (albedo in %, Tb in
```

maia_Pr_InfoPix.F90

subroutine maia_Pr_InfoPix(pix_id, pix)
input/output :

```
  type( pix_info), intent(in)   :: pix_id       ! lat, lon, solar and satellite angles at the pixel
  type( pix_data), intent(in)   :: pix         ! pix observations (albedo in %, Tb in K)
```

subroutine maia_Pr_Thres(thres)
write the thresholds
input/output :

```
 type( maia_thres),INTENT(in) :: thres              !
```

maia_Read_Clim.F90

subroutine maia_Read_Clim (idbg, field_id, pix_id, clim_id, clim)
input/output :

```
   type( debug ),     INTENT(in) :: idbg              !
  Type (field_info),  INTENT(in)          :: field_id
  type( pix_info ),   intent(in)    :: pix_id          ! infos at the pixel
  character(len=6),   intent(in)    :: clim_id         !
  type( clim_field ), intent(out)   :: clim  !
```

subroutine read_data05_h5 (idbg, file_id, clim_id, nbline, latdeb, data, status)
Subroutine to read to HDF-5 file
input/output :

```
  type( debug ),    INTENT(in)   :: idbg              !
  INTEGER(HID_T), INTENT(IN)       :: file_id                     ! file identifier
  character(len=6), intent(in)     :: clim_id         !
  INTEGER , INTENT(IN)        :: nbline  , latdeb
  INTEGER , INTENT(OUT)               :: data(7200*nbline)
  INTEGER , INTENT(OUT)               :: status
```

maia_Read_GribApi.F90

subroutine maia_Read_GribApi (idbg, iuforecast, bg, all_ok)

```
!          grib units are
!          Tempe K                          Relative Humidity %
!          precipitable water         kg/m2
!          Pressure Pa                Altitude m
!          land/sea  0=sea 1=land
```

input/output :

```
  type( debug ),    INTENT(in)   :: idbg  !
  INTEGER,          intent(in)    :: iuforecast      ! input logical unit
  type( nwp_field),INTENT(out)            :: bg                ! forecast field information
  LOGICAL,          intent(out)   :: all_ok           ! true if all fields found
```

maia_Read_PrevConst.F90

SUBROUTINE maia_Read_PrevConst (idbg, bg)

Read the NWP constant parameters in GRIB API format
Units are: Altitude (m) / land/sea (0=sea 1=land)
input/output :

```
  type( debug ),    INTENT(in)   :: idbg
  type( nwp_field),INTENT(inout):: bg               ! forecast field information
```

subroutine maia_hutorm (p, t, hum, hutorm)
input/output :

```
  REAL, INTENT(IN) :: p, t, hum
  REAL, INTENT(OUT) :: hutorm
```

maia_Read_IRThres.F90
SUBROUTINE maia_Read_IRThres (tabsea, tabland, tabopaq)
reads the threshold files to initializes the different thresholds

```
 type( maia_ThresTables_sea ), intent(out) :: tabsea
                         ! tabulated threshold tables (nb_wv,nb_secant)
  type( maia_ThresTables_land), intent(out) :: tabland
                          ! tabulated threshold tables (nb_wv,nb_secant)
  type( maia_ThresTables_opaq), intent(out) :: tabopaq
                          ! tabulated threshold tables (nb_wv,nb_secant)
```

maia_Read_Prev.F90
subroutine maia_Read_Prev (idbg, filename, bg)
calls lec_grib_api to read the forecast fields:
the air 2m temperature ,
the surface pressure + altitude and the temperature+humidity profile
computes the total water vapor content from information of module mod_forecast
returns the arrays bg_t2m and bg_wv and all relative information in module mod_atlas
*unit for T is K and for WV in g/cm2*100*

```
 type( debug ),      INTENT(in)      :: idbg        !
  character (len=11),  intent(in)      :: filename
  type( nwp_field),    INTENT(out)      :: bg   ! forecast field
```

maia_Read_Topo.F90
subroutine maia_Read_Topo (idbg, field_id, topo)
read the 0.02 degree resolution Atlas

landsea=0	*sea*
landsea=1	*land*
landsea=2	*desert*
landsea=3	*permanent snow*
landsea=4	*coast*

input/output :

```
  type( debug ),     INTENT(in)  :: idbg              !
  Type (field_info), INTENT(in)           :: field_id
  type( topo_field), intent(out)    :: topo              ! surface topography landsea and elev
```

subroutine Read_LandSea_data (idbg,file_id_elev, nbline, latdeb, landsea, status)
Purpose: Subroutine to read to HDF-5 file
input/output :

```
  type( debug ),  INTENT(in) :: idbg      !
  INTEGER(HID_T), INTENT(IN) :: file_id_elev                  ! file identifier
  INTEGER , INTENT(IN)       :: nbline  , latdeb
  INTEGER , INTENT(OUT)      :: landsea(18000*nbline)
  INTEGER , INTENT(OUT)      :: status
```

subroutine Read_Elev_data (idbg,file_id, nbline, latdeb, elev, status)
Purpose: Subroutine to read to HDF-5 file
input/output :

```
  type( debug ),  INTENT(in) :: idbg      !
  INTEGER(HID_T), INTENT(IN) :: file_id                 ! file identifier
  INTEGER , INTENT(IN)       :: nbline  , latdeb
  INTEGER , INTENT(OUT)      :: elev(18000*nbline)
  INTEGER , INTENT(OUT)      :: status
```

maia_Read_VISThres.F90
SUBROUTINE maia_Read_VISThres (thvis_sea, thvis_land, reflect)
input/output :

```
  type( maia_VISThresTables), intent(out) :: thvis_sea          ! tabulated threshold
  type( maia_VISThresTables), intent(out) :: thvis_land         ! tabulated threshold
  REAL, intent(out) :: reflect(nbreflecsol,nbreflecsat,nbreflecazi,3)
```

maia_ReflRatio_ToObs.F90
SUBROUTINE maia_ReflRatio_ToObs (idbg, box, rnadtormes)
compute reflectances ratio after bidirectional effects simulation
the ratio of the reflectance (simulated for nadir) to
the measured one is computed knowing the satellite, the channel,
and the viewing conditions
input/output :

```
  type( debug ),   INTENT(in)  :: idbg             !
  type( box_id ),  INTENT(in)  :: box   ! lat, lon, solar and satellite angles at the center of the box
  REAL, INTENT(out) :: rnadtormes
```

maia_SST.F90
computes the sea skin surface temperature tempsurfm SST in K
input/output :

```
  type( debug ),   INTENT(in)   :: idbg             !
  type( pix_info), INTENT(in)   :: pix_id           !
  type( pix_data), INTENT(in)   :: pix    !
  REAL, INTENT(in)              :: TSclim           ! climatological value of SST (K)
  REAL, INTENT(out)             :: SST
```

maia_SnowIce_surf.F90
SUBROUTINE maia_SnowIce_surf (idbg, box, pix, snowice_surf)
input/output :

```
  type( debug ), INTENT(in)     :: idbg             !
  type( box_id ), INTENT(in)    :: box    !
  type( pix_data), INTENT(in)   :: pix    !
  integer , INTENT(out)         :: snowice_surf
```

maia_Thres_reset.F90
SUBROUTINE maia_Thres_reset (idbg, thres)
input/output :
```
  type( debug ),      INTENT(in)   :: idbg           !
  type( maia_thres), INTENT(inout):: thres         !
```

maia_ValMin.F90
subroutine maia_ValMin (idbg, tab, valmanq, valmin)
    computation of min value on the tab's.
    missing values are not used.
input/output :
```
  type( debug ), INTENT(inout)
  real, intent(in)            :: tab (nx,ny)
  real, intent(in)            :: valmanq
  real, intent(out)            :: valmin
```

subroutine maia_ValMin2 (idbg, tab, Nb_pixels, Nb_Lines, valmanq, valmin)
    computation of min value on the tab's.
    missing values are not used.
input/output :
```
  type( debug ), INTENT(in)
  integer, intent(in)          :: Nb_pixels, Nb_Lines         ! size of input tab
  real, intent(in)            :: tab (Nb_pixels, Nb_Lines)
  real, intent(in)            :: valmanq
  real, intent(out)            :: valmin
```

maia_ValMoy.F90
subroutine maia_ValMoy (idbg, nx,ny, tab, valmanq, moy)
    computation of mean on the tab's.
    missing values are not used in statistics.
input/output :
```
  type( debug ), INTENT(inout)
  integer, intent(in)          :: nx,ny
  real, intent(in)            :: tab (nx,ny)
  real, intent(in)            :: valmanq
  real, intent(out)            :: moy
```

maia_reset_CMa.F90
SUBROUTINE maia_reset_CMa (idbg, Cma)
 input/output :
```
  type( debug ),    INTENT(in) :: idbg     !
  type( maia_CMa), INTENT(out):: CMa           !
```

maia_setup.F90
SUBROUTINE maia_setup (idbg, field_id, tabsea, tabland, tabopaq, &
 input/output :
```
type( debug ),                INTENT(in) :: idbg
Type (field_info), INTENT(in)            :: field_id
 type( maia_ThresTables_sea ), intent(out) :: tabsea          ! tabulated threshold tables
(nb_wv,nb_secant)
```

 type(maia_ThresTables_land), intent(out) :: tabland   ! tabulated threshold tables
(nb_wv,nb_secant)
 type(maia_ThresTables_opaq), intent(out) :: tabopaq   ! tabulated threshold tables
(nb_wv,nb_secant)
 type(maia_VISThresTables), intent(out) :: thvis_sea   ! tabulated threshold
 type(maia_VISThresTables), intent(out) :: thvis_land   ! tabulated threshold

mod_maia_const.F90
  Module Purpose
 defines all const for maia

mod_maia_types.F90
Module Purpose
 defines all types for maia

maia_VerifMissing_fields.F90
subroutine maia_VerifMissing_fields (idbg, field_M, field_I, missing)
description :
Control if some fields are missing :
Night necessary channels : M8,M11,I4,I5
Day necessary channels : M3,M4,M11,I1,I2,I5
Twilight necessary channels : M3,M4,M11, I1,I2,I5
input/output :

```
  type( debug ), intent(in)     :: idbg         !
  Type (field),  intent(in)     :: field_M
  Type (field),  intent(in)     :: field_I
  logical, intent(out)          :: missing
```

mk_voisinage.F90
Local horizontal variations in the visible, near infrared or infrared channels are used to detect small broken clouds, thin cirrus or cloud edges. For VIIRS, the local textures are computed using the four pixels of the imaging channels (350m resolution) co-registered in the medium channels when these channels are available. When not available, the local textures are then computed from the eight closer medium channels (750m resolution) neighbors using the the "mk_voisinage" routine.
SUBROUTINE mk_voisinage (idbg, field_M)
input/output :

```
 type( debug ), intent(in)     :: idbg
  Type (field),intent(inout)    :: field_M
```

subroutine geogcart (lat,lon,pos)
description :
converts geographical coordinates into cartesian coordinates
input and output coordinates are expressed in Greenwich reference frame:
X: in equatorial plane toward Greenwich meridian
Y: in equatorial plane toward lon = 90 degrees east
Z: terrestrial polar axis

input/output :

```
  real(kind=8), intent(in) ::lat           ! geographic latitude        (rad)
  real(kind=8), intent(in) ::lon           ! longitude                  (rad)
  real(kind=8), intent(out) ::pos(3)       ! cartesian position         (km)
```

subroutine sort_distance(x, n, indx)
input/output :

```
  integer, intent(in) :: n
  real, intent(in) :: x(n)
  integer, intent(out) :: indx(8)
```

maia_Box_GetTopo.F90
SUBROUTINE maia_Box_GetTopo (idbg, pp, ll, field_id, field_1b, landsea, elev, box)
get the topography and elevation for the Box
input/output :

```
type( debug ), INTENT(in)     :: idbg !
```

```
  integer, intent(in)          :: pp,ll
  Type (field_info)            :: field_id
  Type (field),intent(in)      :: field_1b
  type( topo_field),INTENT(out) :: landsea, elev        ! surface topography ls and elev
  type( box_id ),INTENT(inout)  :: box  ! box information
```

AAPP/src/maia4/libmaia4IO
source files :
maia_read_Viirs.F90 :
subroutine maia_read_Viirs (idbg, field_M, field_I)

```
  Type( debug ), intent(in)    :: idbg       debug level (0,1,2)
  Type (field), intent(out)    :: field_M    M fied structure
  Type (field), intent(out)    :: field_I    I field  structure
```

Read in HDF5 format the contents of :
Read the VIIRS_M SDR and Geolocation
VIIRS_I SDR and Geolocation
fill the viirs_field structures

subroutine maia_Viirs_field_init (idbg, viirs)
subroutine maia_Viirs_field_init (idbg, viirs)

```
  type( debug ) , intent(in)        :: idbg
  Type (field), intent(inout)       :: viirs
```

initialise viirs field

maia_IO_Viirs_h5.F90
subroutine maia_Write_ViiCT_hdf5 (idbg, field_id, field_M, field_I, maia_par,compress)

```
  Type( debug ),    INTENT(in)  :: idbg     debug level (0,1,2)
  Type (field_info), intent(in) :: field_id   field info
  Type (field), intent(in)      :: field_M    M field structure
  Type (field), intent(in)      :: field_I    I field  structure
  REAL, intent(in)              :: maia_par(30, 3200,768)  maia-par structure
  LOGICAL, intent (in),optional :: compress   compression flag
```

Purpose: Subroutine to write Maia cloud mask to HDF-5 file

Ancillary files :
The ancillary files are in the AAPP/data_maia directory
The thresholds directory contains the different threshold files and the sst file.
The atlas directory contains the atlas files.

4.4.5. VIIRS to CrIS mapping

Usage is :

```
viirs_to_cris [-d|-D] [-t threshold] [-b band] [-m Maia4file] [-g Geofile] CrISfile VIIRSfile
```

where

band is a VIIRS band name I or M
Maia4file is a VIIRS MAIA 4 HDF5 file
Geofile is a VIIRS geolocation HDF5 file
Crisfile is a CrIS AAPP level 1c/1d file

VIIRSfile is a VIIRS SDR HDF5 file
-d debug level 1
-D debug level 2
threshold is the minimum percentage of valid VIIRS pixels for mapping

For further information please refer to the document “VIIRS-CrIS mapping” [38].