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AAPP Overview

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Met Office



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AAPP Overview

1. AAPP DESCRIPTION

AAPP (ATOVS and AVHRR Pre-processing Package) is a software package for the processing of sounder and imager data from polar-orbiter weather satellites. The package is intended for the ingestion and the pre-processing tasks of received data, up to the retrieval of the satellite brightness temperatures. It can be used for direct broadcast data or to ingest level 1 products derived from stored mission data.

AAPP performs complete level 1 processing for NOAA POES and Metop satellites, i.e. converts raw (or “level 0”) direct broadcast data to calibrated, geolocated brightness temperatures, for the following instruments:

- ATOVS (HIRS, AMSU-A, AMSU-B/MHS) and AVHRR data from the NOAA POES series (NOAA-15 to 19)
- TOVS (HIRS, MSU) and AVHRR data from NOAA satellites prior to NOAA15 (historic data).
- ATOVS (HIRS, AMSU-A, MHS), AVHRR and IASI data from the Metop satellites.

It can ingest output from other direct broadcast packages, for:

- Chinese FY-3 satellites (MWS, MWS-2, MWTS, MWTS-2, IRAS, MWRI)
- JPSS and Suomi-NPP (ATMS, CrIS, VIIRS)

AAPP can also perform ingest and pre-processing tasks for several other data types and formats, including:

- Level 1B ATOVS data from NOAA
- Radiances in BUFR format
- Radiances in HDF5 format

AAPP was developed by a number of European meteorological organizations (Météo France, UK Met Office, ECMWF, KNMI,...), and is now maintained as a deliverable of the EUMETSAT NWP SAF.

This overview document provides a summary of the AAPP capabilities. For more details, please see the full set of documentation that is available on the AAPP web pages: <https://www.nwpsaf.eu/site/software/aapp/documentation/>

2. PURPOSE AND SCOPE

AAPP contains software for the processing of raw HRPT data (level 0) successively to

- **level 1a:** separated data for each instrument.
- **level 1b:** geo-referenced and calibrated data (reversible: calibration coefficients are separated from raw data).
- **level 1c:** geo-referenced and calibrated temperatures and albedo (non-reversible: calibration coefficients are applied to numerical data). In the case of IASI, the spectra are apodized.
- **level 1d:** mapped and filtered data (optionally with cloud mask).

Levels 1a, 1b, 1c and 1d are internationally agreed data formats.

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AAPP contains modules for decommutation, navigation, calibration, pre-processing, mapping to a common instrument grid, and cloud-masking using imager data.

For NOAA satellites, Figure 1 shows schematically the data processing sequence through the different levels, and the data files that are used at the different stages of ATOVS and AVHRR processing. For pre-NOAA15 satellites, MSU files are used in place of the files for AMSU-A and AMSU-B, and a separate MSU calibration module is used.

The **decommutation** stage takes the raw HRPT data as input and generates the different level 1a data files for each instrument. The **preparation of navigation** stage (tbusing and satpost) takes the satellite orbital elements from the satellite navigation bulletins (TBUS or Two-Line Element) and generates predicted satellite positional data. This is then used by the **calibration** stage (hirscl, amsuacl, amsubcl, mhsccl, msucl, avhrccl) in adding navigational and calibration data to the level 1a data and writing it back as level 1b data to the same files.

The first stage of the **preprocessing** (atovin) applies the calibration data to generate a level 1c file of calibrated brightness temperatures for each of the (A)TOVS instruments. The second stage of the **preprocessing** (atovpp) then remaps the ATOVS instrument data to a common grid, normally the HIRS grid, and adds the results of various scientific tests. Finally the AVHRR data are processed by a **cloud mask** scheme to generate cloud information which is added to the HIRS level 1d file (avh2hirs).

AAPP v8 uses the MAIA4 cloud mask, and the mask can be generated either at the native resolution of the imager (AVHRR or VIIRS) or mapped to the sounder fields of view (HIRS or CrIS).

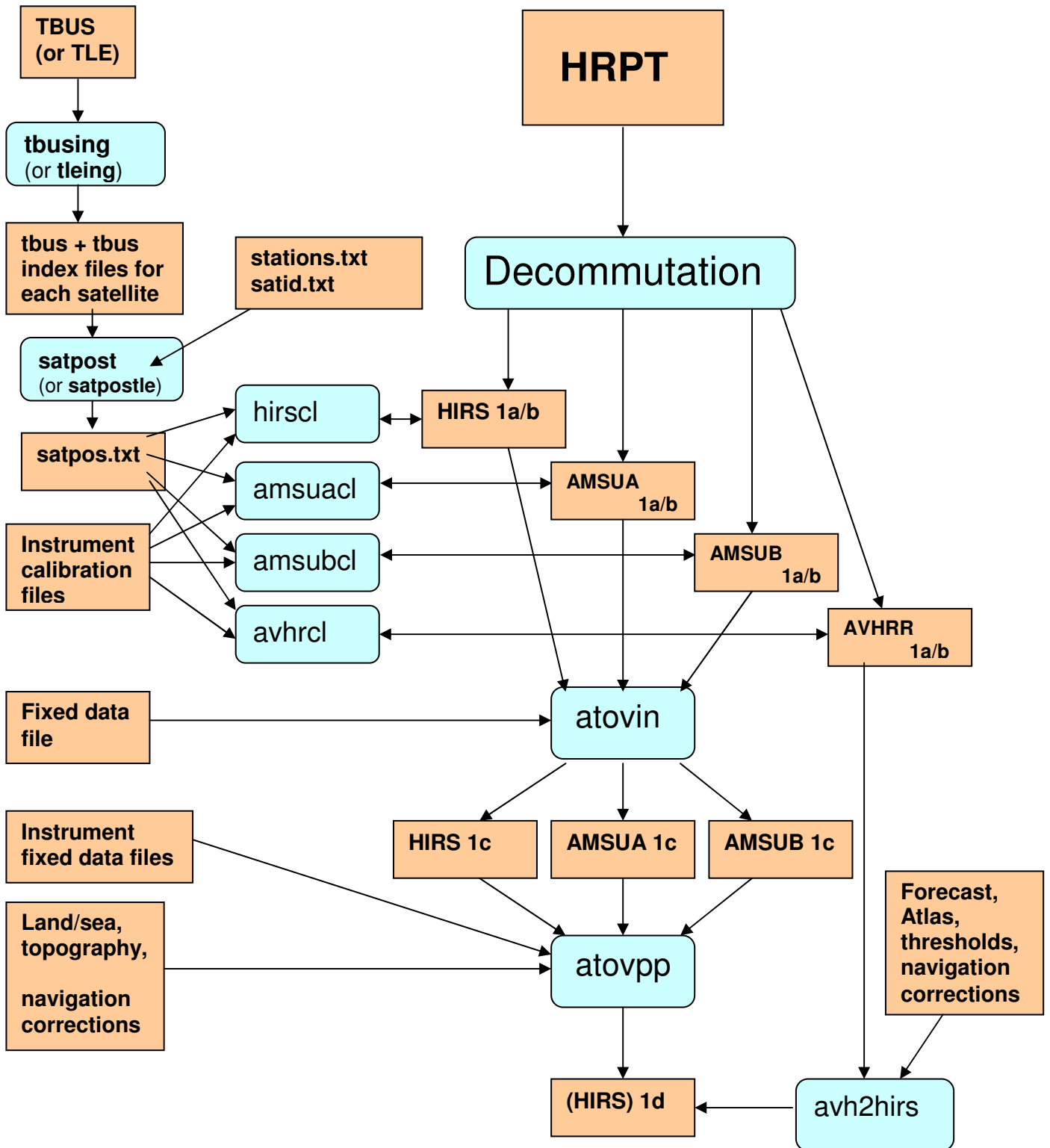


Figure 1: AAPP processing chain for direct readout from NOAA POES satellites

For METOP satellites, AAPP accepts ATOVS and AVHRR data in so-called “PFS Level 0” format, in which there is one file per instrument. There is therefore no decommutation task for METOP. Instead tools are provided to convert PFS level 0 to standard AAPP level 1a format, which can be processed as for the NOAA satellites.

The data for the IASI instrument on METOP are processed to level 1c by a separate program, called OPS-LRS (Operational Software – Local Reception Station). The interfaces between OPS-LRS and the other components of AAPP are shown in Figure 2. OPS-LRS requires, as input, a IASI L0 file and corresponding AVHRR L1b file. The output is a IASI level 1c (Gaussian-apodised) file, which can be further processed by AAPP.

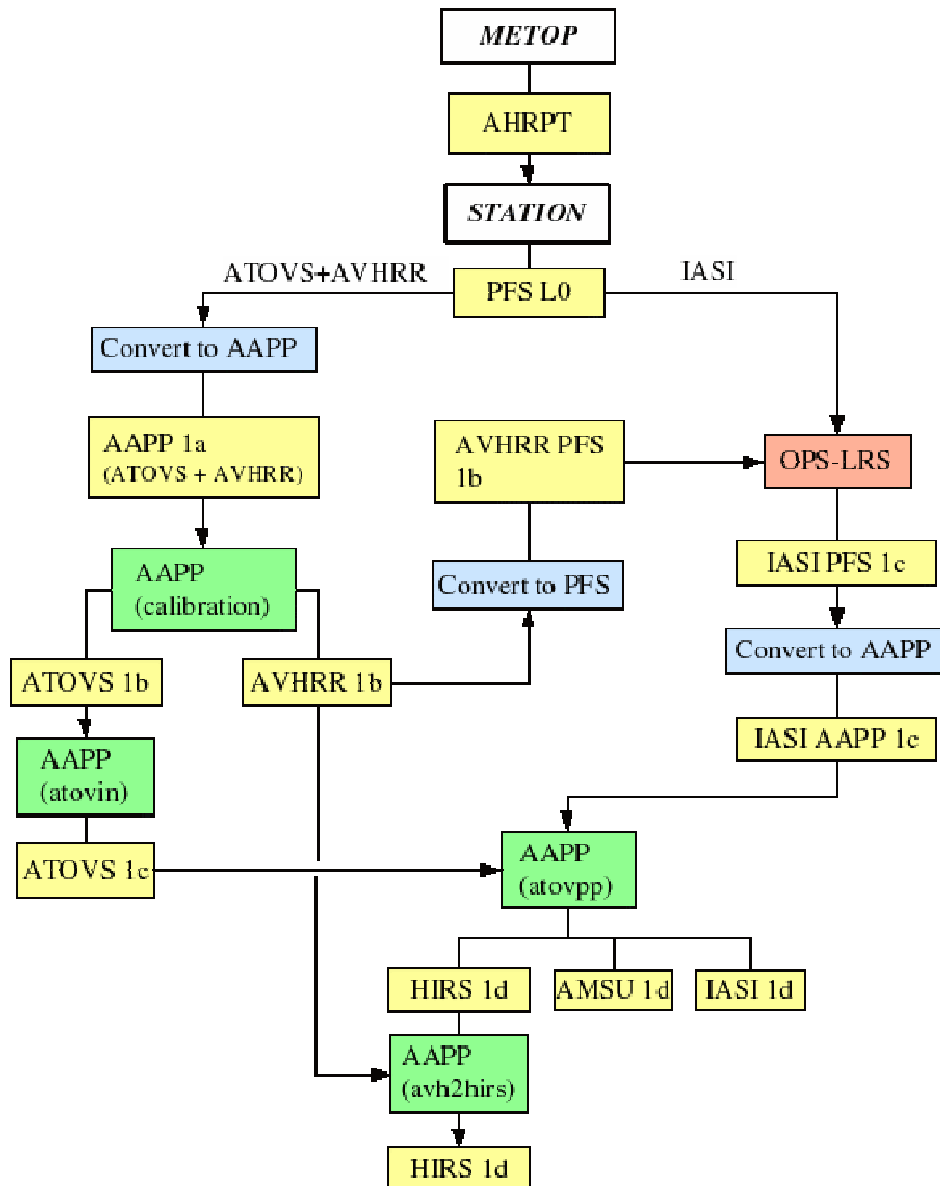


Figure 2: Data flows for processing the METOP AHRPT data stream. Core AAPP modules are shown in green; data files in yellow; METOP/IASI tools in blue; OPS-LRS in red. (figure taken from the AAPP v7 Top Level Design document, NWPSAF-MO-DS-015)

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In the case of Suomi-NPP, AAPP does not process the raw direct readout data. External packages are available to perform this task, such as NASA’s “International Polar Orbiter Processing Package” (IPOP) or the University of Wisconsin’s “Community Satellite Processing Package” (CSPP). AAPP can ingest the IPOP/CSPP output products and customize them for use in NWP – including mapping from ATMS to CrIS, spatial filtering on ATMS and generating microwave cloud products. For more information, see the document “Appendix - Pre-processing of ATMS and CrIS”, NWPSAF-MO-UD-027 (on the AAPP documentation web page). A VIIRS cloud mask can also be generated.

As mentioned previously, in AAPP v8 a single version of MAIA (“version 4”) is used to generate the cloud masks – on the AVHRR grid, the VIIRS grid or mapped to HIRS. A VIIRS to CrIS mapping is also available. The data flows for MAIA are shown in Figure 3.

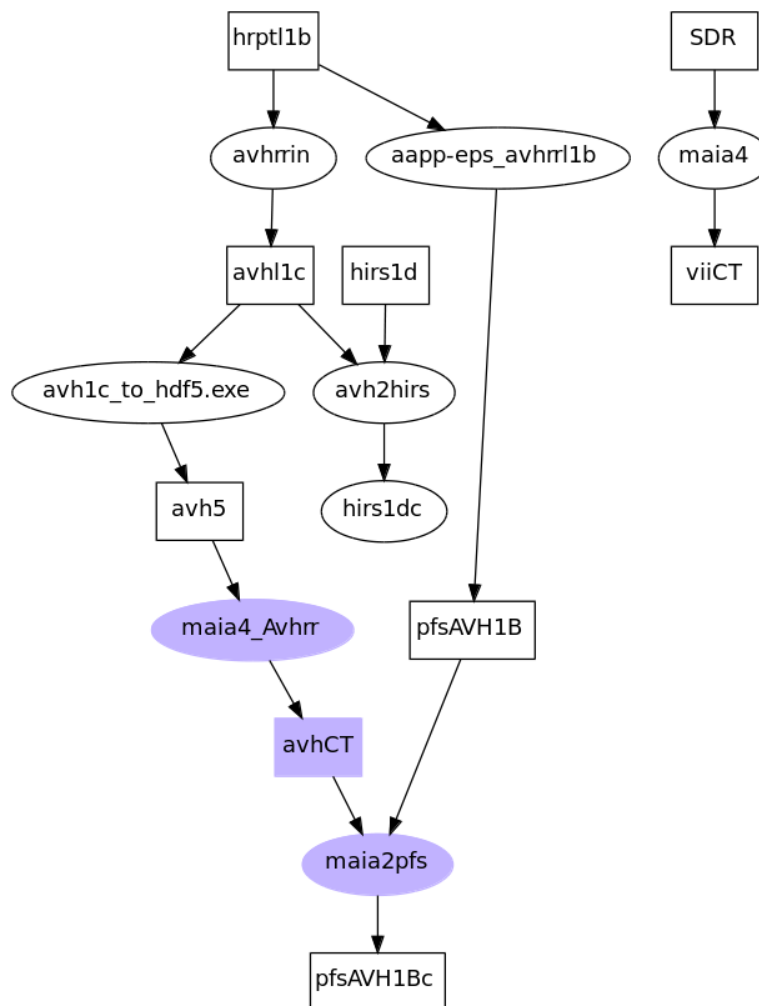


Figure 3: Data flow diagram for MAIA (taken from the AAPP v8 Top Level Design document, NWPSAF-MO-DS-034). Key:

- avh5**: AVHRR level 1c in hdf5 file format
- avhCT**: MAIA4 file for AVHRR (hdf5 file format)
- pfsAVH1Bc**: PFS AVHRR 1B with updated CLOUD_INFORMATION
- viiCT**: MAIA4 file for VIIRS (hdf5 file format)
- hirs1dc** : updated hirs1d

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3. AAPP MODULES

Decommutation:

The **decommutation** task performs the ingestion of the NOAA HRPT (level 0) data stream and the extraction of data particular to each instrument from the HRPT format. The data from each sounding instrument (HIRS, AMSU-A, AMSU-B, MHS or MSU) and from the imager (AVHRR) are put into separate files (level 1a).

The top-level calling routine of the decommutation task performs the interface between acquisition and processing system. This function is specific to the AAPP installation site and can be modified by the user if the user's acquisition system doesn't respect HRPT format exactly.

Preparation of Navigation:

The daily TBUS bulletins available on the GTS are read in by the **tbusing** ingest task and stored. The relevant orbital data are checked and an entry made in a separate index file for each required satellite. These data are subsequently used by the **satpost** task to calculate satellite positional data when this is required by a calibration task (see below). Alternatively, Two-Line Element data (TLE) can be used; these data are readily available via the internet or in the case of Metop from the direct broadcast itself. With TLE bulletins, the ingest task is **tleing** and the positional task is **satpostle**.

Calibration:

The (A)TOVS calibration tasks (**hirscl**, **amsuacl**, **amsubl**, **mhscl**, **msucl**) perform the Earth localisation of the pixels, and the calibration coefficients calculation for each TOVS/ATOVS instrument. The controlling script for each of these tasks uses the output of the **satpos** task (see above), and invokes **satpos** if necessary.

The AVHRR calibration task (**avhrcl**) performs the same tasks for the AVHRR radiometer.

At the end of this procedure, separated files of Earth-located data and calibration coefficients exist. Those (level 1b) files are normally written back to the same files which held the level 1a data.

Pre-processing - Application of Calibration:

The pre-processing task (**atovin**) achieves the conversion of the level 1b data (Earth and atmosphere VIS and IR radiance) into physical parameters (brightness temperature, albedo). First it applies the calibration coefficients calculated at the calibration stage to the numeric counts for radiance conversion. Then **atovin** converts each channel radiance into brightness temperature (or albedo) for each TOVS/ATOVS instrument, taking into account the sensors' geometries, scanning angles and solar angles.

At the end of this procedure, separated level 1c files of Earth located brightness temperature data exist.

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Pre-processing - Mapping:

The mapping task **atovpp** maps the level 1c 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, AMSU-A + MHS on IASI grid). In the script AAPP_RUN_NOAA (see below) supplied with AAPP, only the 2 first examples are done. At the end of this procedure all the ATOVS instrumental data is held in the HIRS level 1d file.

atovpp also carries out various scientific algorithms and stores indicators for cirrus, precipitation and surface type in the level 1d output. It also performs data reduction for IASI – spatial thinning, channel selection and spectral thinning using Principal Components.

atovpp can also be used to carry out mapping and filtering tasks on other instruments, for example: spatial filtering for ATMS, channel selection for IASI and CrIS, mapping ATMS to CrIS. Tools also exist for mapping MWHS-2 to MWTS-2, etc.

Pre-processing - Mapping and Cloud mask:

The AVHRR cloud mask and mapping task **avh2hirs** applies the calibration coefficients (calculated by **avhrc1**) to AVHRR counts and converts radiances into brightness temperatures, maps AVHRR data onto the HIRS grid, and calculates the cloud mask in the HIRS ellipse for contaminated pixels discrimination. The additional data are written into the HIRS level 1d file. This uses the “MAIA4” software developed by Météo-France.

A cloud mask on the AVHRR grid is also available, also using MAIA4. Cloud top height and temperature information from MAIA4 can also be used in the IASI processing.

Format conversion

AAPP has tools for encoding level 1c files into WMO BUFR format (Binary Universal Form for the Representation of meteorological data), and for decoding the BUFR files. For this, it uses one of ECMWF’s BUFR libraries: either BUFRDC or ecCodes. It also has tools to ingest satellite data in hdf5 format, and to convert the AAPP level 1c/1d products into hdf5.

The ability to generate BUFR files is of particular importance for the Direct Broadcast Network for NRT Relay of LEO Satellite Data (DBNet) – a system for near-real-time exchange of sounder data for NWP applications. The data are shared worldwide in BUFR format.

AAPP_RUN_NOAA and AAPP_RUN_METOP

The controlling scripts **AAPP_RUN_NOAA** and **AAPP_RUN_METOP** successively execute all parts of the data processing chain for AAPP, and can be adapted as required by the user.

4. INSTALLATION AND PORTABILITY

AAPP was written in Fortran77 for Unix systems, and has been updated for Fortran90 compatibility. The user interface to the majority of the main programs is via Korn shell

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scripts. Perl scripts are also used. The Metop and IASI tools and the HDF5 handlers use C routines. The IASI OPS-LRS uses a mixture of C and C++.

The package has been installed on a number of commonly used Unix and Linux platforms. Detailed instructions for installation can be found in the Installation Guide.

5. CONCLUSION

The above is just a brief overview of the operation and capabilities of the AAPP software package. For fuller information the user is referred to the full scientific and software documentation.