NWP SAF

AAPP-SG v1 Product Specification

Version 1.0

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This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 7 September 2021, 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, DWD and Météo France.

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Version	Date	Author / changed by	Remarks
1.0	04/08/2025	N C Atkinson	Based on NWPSAF-MO-DS-045 AAPP Version 9 Product Specification

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1. INTRODUCTION

This document defines the specification for Version 1 of the ATOVS and AVHRR Pre-processing Package – Second Generation (AAPP-SG), in accordance with the requirements of the NWP SAF. The Product Specification describes the deliverable from the point of view of the user.

The document draws heavily on the "AAPP Version 9 Product Specification" from May 2022 (see RD-4 below). At that time, the intention was that the Metop-SG-A pre-processing should be integrated in a new AAPP major release, AAPP v9. However, for practical reasons the NWP SAF has decided to create a new deliverable – AAPP-SG – specifically dedicated to pre-processing for Metop-SG-A series of satellites.

This document describes the features that are to be included in AAPP-SG.

1.1 Reference documents

[RD-1] NWP SAF Proposal for the Third Continuous Development and Operations Phase (CDOP-3) March 2017-February 2022

[RD-2] NWP SAF Proposal for the Fourth Continuous Development and Operations Phase (CDOP-4) March 2022-February 2027

[RD-3] NWPSAF-MO-DS-033, EPS-SG pre-processing in AAPP and MWIPP, available from https://nwp-saf.eumetsat.int/site/software/aapp/future-plans/

[RD-4] NWPSAF-MO-DS-045, AAPP Version 9 Product Specification, available from https://nwp-saf.eumetsat.int/site/software/aapp/future-plans/

2. USER REQUIREMENTS

2.1 General considerations

User requirements for AAPP and AAPP-SG are gathered by several methods:

- The NWP SAF planning process, specifically the CDOP-3 and CDOP-4 proposals which were agreed by the Steering Group and approved by EUMETSAT Council
- Discussions at conferences, particularly the Products and Software Working Group at International TOVS Study Conferences
- Discussions at meetings such as the DBNet Coordination Group
- Feedback from users via the NWP SAF Helpdesk
- Feedback from users in connection with NWP collaboration projects
- Surveys

Additionally, requirements can arise due to external constraints, e.g.

- Satellite launches, launch delays or termination of satellite missions
- Support for new software compilers, or cessation of support for old compilers
- Changes in external packages on which AAPP and AAPP-SG relies
- Availability of ancillary data

2.2 Input from the CDOP-3 and CDOP-4 proposals (RD-1 and RD-2)

RD-1 makes the following statements about AAPP future developments that were at the time to be included in AAPP v9, and are now relevant to AAPP-SG version 1:

1. The software is to include Metop-SG capability.
2. First release will be tested with simulated data; updates to follow as needed based on real data.
3. Prepare preprocessing support for the sounders on Metop-SG-A1, i.e. Microwave Sounder (MWS) and Infrared Atmospheric Sounding Interferometer - New Generation (IASI-NG). This will include ingest of level 1 files created by external DB software, re-mapping and filtering capability and BUFR encode/decode capability.
4. Implement the IASI-NG level1 processing, successor of the OPS-LRS. Port the EUMETSAT original software to the AAPP environment
5. Port EUMETSAT software for MWS and METImage to the AAPP environment
6. Plan and implement the cloud mask for Metop-SG-A1. It is intended that direct broadcast applications that require a cloud mask will use the cloud mask provided by NWC-SAF/PPS.The NWP SAF will ensure that level 1 IASI-NG processing for direct broadcast is compatible with the PPS cloud mask output.

It has since been clarified, and confirmed in RD-2, that direct broadcast level 1 processing will be carried out by dedicated software to be procured by EUMETSAT, i.e. *external to AAPP*. This software will be delivered in a new NWP SAF deliverable *EPSSGL1*. Thus, bullet points 4, 5 and 6 in the list above are no longer applicable to the AAPP-SG deliverable. Note that the PPS cloud mask will be an input to the IASI processing in EPSSGL1, it will not be an input to AAPP-SG.

The main new function of AAPP-SG v1 will therefore be the pre-processing of MWS and IASI-NG level 1 files.

2.3 Input from ITSC-23 (June 2021)

In preparation for ITSC-23, document RD-3 was prepared outlining a design strategy for the NWP SAF software to be prepared for EPS-SG and MTG. The document explains foreseen requirements for AAPP:

- To support the standard EUMETSAT level 1 products in netCDF format, applicable to the local (direct broadcast) mission
- To support EUMETSAT level 1 products that will be delivered in BUFR (applicable to global and regional mission dissemination)
- Requirement to perform spatial filtering and thinning for MWS, to improve its usefulness for NWP (as is done for ATMS)
- Requirement to generate standalone microwave scattering tests for MWS, updated versions of those originally devised for AMSU/MHS. A 229 GHz scattering test is proposed.
- Support Principal Components processing for IASI-NG; generate reconstructed radiances; spatial thinning; change the spectral resolution (i.e. convert IASI-NG to the resolution of IASI)
- Generate BUFR outputs that are optimised for NWP use.

These aspects (and others related to the other satellites) were presented in a talk[1] and user feedback was requested. The Products and Software Working Group (PSWG) was also informed of these developments.

No specific feedback was received from users. The PSWG did, however, give two recommendations related to the software packaging:

[1] http://cimss.ssec.wisc.edu/itwg/itsc/itsc23/presentations/oral.3.01.atkinson.pdf

New Recommendation PSWG-2: Software providers should, where possible, offer their software with a choice of either pre-built binaries or source code.

New Recommendation PSWG-3 to Software Providers: For software that will be built from source by the user, software providers should list recommended versions of required external (COTS) libraries.

2.4 Input from ITSC-24 (March 2023) and ITSC-25 (May 2025)

Discussions at these conferences generally supported those given above. No new requirements were identified, though the NWP Working Group at ITSC-25 specifically re-affirmed the requirement to be able to convert IASI-NG spectra to the spectral resolution of IASI First Generation.

NWP SAF plans were presented in posters at ITSC-24[2] and ITSC-25[3].

2.5 Met Office requirements

Met Office requirements for EPS-SG data reception and processing are given in SA Technical Memo number 104, dated 31st December 2019 (internal report). The pre-processing requirements for the sounders can be summarised as follows:

- Requirement to ingest netCDF and BUFR, depending on the origin of the data (global / regional / local)
- For global model, spatial filtering of MWS to approximately 40km is required, with corresponding noise reduction (as implemented for ATMS)
- For UK model, the MWS data will be used at full resolution (as for MHS)
- The processed data are to be stored in BUFR
- For IASI-NG, the day-1 requirement is to degrade the data to IASI-like spectral resolution (i.e. 0.25 cm^{-1} sampling) and to process as currently done for IASI.
- The software should be flexible enough to carry out this spectral manipulation for both full-spectrum input datasets and for PC-compressed datasets
- Store IASI-NG at full resolution for a limited region (near UK), and at reduced resolution globally (1 in 4 spots)
- The document suggests that mapping of MWS to IASI-NG could be needed. Subsequent discussion clarified that this is not a requirement for assimilation, though mapped MWS could be helpful in the IASI-NG thinning process.

There is no Met Office requirement for METimage data to be included in the MWS or IASI-NG products. METimage imagery will be generated for forecaster use, but that is outside the scope of AAPP and AAPP-SG.

2.6 DBNet requirements

[2] https://itwg.ssec.wisc.edu/wordpress/wp-content/uploads/2023/05/poster.6p.01.Atkinson-Nigel-Atkinson_itsc24.pdf
[3] https://itwg.ssec.wisc.edu/wordpress/wp-content/uploads/2025/06/poster.6p.02.Booton_itsc25.pdf

DBNet requirements are reviewed regularly at meetings of the DBNet Coordination Group[4]. Extension of DBNet services to support MWS and IASI-NG are planned. Specifically:

- EUMETSAT will be introducing their regional service for Metop-SG, for core stations, that is independent of AAPP – it will use the global processing infrastructure.
- All other DBNet stations will make use of the EPSSGL1 processors for MWS and IASI-NG, with the outputs feeding into NWP SAF software for BUFR encoding.
- It is not yet decided whether DBNet stations will run the PPS cloud mask operationally, to feed into IASI L1 processor. But this does not directly affect the AAPP-SG processing.

The main requirement for AAPP-SG as far as DBNet is concerned is that the BUFR products generated from AAPP-SG are consistent with the corresponding global product, in format and quality. The WMO “Guide to DBNet" states that

> *Global and local product processing shall be harmonized in that brightness temperature products derived from both paths agree within tolerances that are not greater than a few tenths (the goal is 10%) of the respective performance requirements for bias error at a reference brightness temperature.*

2.7 Requirements for inputs to retrieval packages

AAPP outputs are sometimes used as input to level 2 retrieval packages:

- IAPP[5] requires HIRS level 1d in AAPP format with mapped AMSU and MHS. AVHRR is not required.
- MIRS[6] requires AMSU and MHS level 1b in AAPP format (NOAA and Metop satellites).
- UW CrIS, AIRS and IASI Hyperspectral Retrieval Software (HSRTV)[7] requires IASI PFS format.
- CSPP_HEAP (NUCAPS)[8] software requires IASI PFS format and AMSU/MHS level 1b in AAPP format (Metop satellites)

We would expect that some of the above packages will be adapted for EPS-SG use, but no details have been announced.

Therefore, there are currently no constraints in this area for AAPP-SG.

2.8 Requirements for processing of historical data

This is not applicable to Metop-SG-A – which is a new satellite.

2.9 Summary of user requirements for AAPP-SG v1

Support for EPS-SG

AAPP-SG will be used to process data for the two sounder instruments on the Metop-SG-A satellite series: MWS and IASI-NG

[4] https://community.wmo.int/activity-areas/wmo-space-programme-wsp/dbnet
[5] http://cimss.ssec.wisc.edu/cspp/iapp_v1.1.shtml
[6] https://www.star.nesdis.noaa.gov/mirs/
[7] http://cimss.ssec.wisc.edu/cspp/uwhsrtv_edr_v2.0.shtml
[8] http://cimss.ssec.wisc.edu/cspp/heap_v2.0.shtml

Unlike AAPP for Metop first generation, AAPP-SG will not be required to carry out instrument calibration and navigation for direct broadcast applications. That function will be done in dedicated level 1 processors (EPSSGL1). Instead, AAPP-SG will need to ingest

- The level 1 data files that are created by the level 1 processors (netCDF format)
- Global and regional level 1 data, distributed by EUMETSAT (BUFR format).

Pre-processing should include:

- Spatial filtering for MWS
- Microwave scattering tests for MWS, including a 229 GHz scattering test
- Support for Principal Components for IASI-NG; generation of reconstructed radiances; spatial thinning; ability to change the spectral resolution (i.e. convert IASI-NG to the resolution of IASI)
- Generate BUFR outputs that are suitable for NWP use

Package delivery

Offer AAPP-SG v1 package as (i) source code and, if possible, (ii) executables built on a reference platform.

In the case of source code, recommended library versions should be given. In the case of executables, the necessary dynamic libraries should be included.

3. FUNCTIONALITY, INPUTS AND OUTPUTS

AAPP-SG v1 will provide the following main functions.

Raw data processing

- None

Ingest of externally-generated level 1 data (non-BUFR)

- Ingest level 1 MWS and IASI-NG data in netCDF format. This includes output from the EPS-SG direct broadcast software (EPSSGL1).

BUFR input and output

- Ingest level 1 MWS and IASI-NG data in BUFR format
- Convert level 1 MWS and IASI-NG data from netCDF to BUFR that is compatible with EUMETSAT products

Sounder preprocessing

- Generate microwave scattering indexes for MWS
- Pre-processing of MWS and IASI-NG: spatial filtering of MWS; map MWS to IASI-NG; spectral and spatial thinning of IASI-NG.
- Option to degrade IASI-NG data to IASI-like spectral resolution (i.e. 0.25 cm^{-1} sampling)

Cloud mask and imager analysis

- None

AAPP outputs

Different user applications require different output formats. Supported formats include:

- BUFR
- netCDF. Outputs may be appended to the input files where applicable.

4. SOFTWARE PROVISION AND BUILD

AAPP-SG will normally be supplied in the form of source code, downloadable from the NWPSAF web site (after user registration). The user will be expected to build the package, according to the instructions provided in the User Manual. The normal sequence is:

1. Build external any necessary external libraries, if not already installed (e.g. HDF5, netCDF, ecCodes). Guidance will be given, including recommended version numbers.
2. Configure AAPP-SG (specifying fortran compilers, etc.)
3. Make
4. Make install (optional for the user)

Data files and test cases will need to be downloaded from the NWPSAF web site.

The option will also be provided for users to receive AAPP-SG executables, built in a reference Linux system (e.g. Red Hat 9) and packaged with the necessary dynamic libraries.

5. SYSTEM REQUIREMENTS

5.1 Language

The AAPP-SG code will be written mainly in Fortran 90. The code will be capable of compilation on a range of Fortran 90 compilers.

Use will also be made of Bash shell. Python is envisaged as a display tool.

5.2 Operating system and hardware

AAPP-SG is required to run on commonly available 64-bit UNIX or Linux platforms.

Disk space requirements are driven largely by the data, not by the software. For example, IASI-NG level 1c files occupy about 150 MB per 3-minute granule = 3 GB per hour.

Memory requirements are to be determined.

5.3 Performance

Examples of run times, for the various components of AAPP, will be provided in the Test Log. There are no specific requirements on run-time, as run-times depend on processor speed, memory, etc. However, as a general principle, the preprocessing time should be at least an order of magnitude smaller than the time span of the input data.

5.4 Interface requirements

Where external libraries are required, AAPP-SG may rely only on free software libraries. The user will be given instructions on how to download them from a third party (e.g. ECMWF in the case of ecCodes)

6. DOCUMENTATION

A User Manual will provide information on

- How to install the software
- How to run the main programs
- Supplied test cases
- Science aspects
- The BUFR sequences that are used

On release of AAPP-SG, the User Guide and other relevant documents will be made available on the NWP-SAF web pages.

7. LIST OF REQUIREMENTS

This section details specific requirements to be addressed in the AAPP-SG v1 Test Plan.

7.1 The Release Note accompanying the package shall list the contents of the package and how to unpack the software.

7.2 A comprehensive User Manual shall be provided.

7.3 AAPP-SG v1 shall be successfully built from source, following the instructions in the User Manual, and linking in the required external libraries (including ecCodes, hdf5 and netCDF).

7.4 The software shall compile and run on Linux PC or server.

7.5 Developers will also aim to provide AAPP-SG v1 as executables, built on a reference Linux system, with dynamic libraries. This is not a mandatory requirement but has been recommended by users.

7.6 Test cases shall be created for MWS and IASI-NG, exercising the functionality of section 2.9. These will be initially based on pre-launch simulated data and will be defined more fully in the Test Plan. The software shall be capable of processing both data from the level 1 processors (EPSSGL1) and data from EUMETSAT's ground segment.

7.7 On release, appropriate test cases shall be made available to users via the NWP SAF web pages.