NWP SAF

AAPP Version 8 Product Specification

Version 1.1

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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 December 2016, 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.

Change record			
Version	Date	Author / changed by	Remarks
1.0	21/04/2017	N C Atkinson	
1.1	24/08/2017	N C Atkinson	Imager clusters code to be introduced later as an update release. Obsolete code related to old Admin messages and Spot bulletins to be removed.

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1. INTRODUCTION

This document defines the specification for Version 8 of the ATOVS and AVHRR Pre-processing Package (AAPP), in accordance with the requirements of the NWP SAF. The Product Specification describes the deliverable from the point of view of the user.

It concentrates on those aspects of AAPP that are new in version 8 – for more details on the specification of previous versions of AAPP, see RD-9 and RD-10.

1.1 Reference documents

[RD-1]   NWPSAF-MF-UD-001, AAPP Documentation Scientific Description
[RD-2]   NWPSAF-MF-UD-002, AAPP Documentation Software Description
[RD-3]   NWPSAF-MF-UD-003, AAPP Documentation Data Formats
[RD-4]   NWPSAF-MO-UD-004, AAPP Overview
[RD-5]   NWPSAF-MO-UD-005, AAPP Installation Guide
[RD-6]   NWPSAF-MO-UD-036, AAPP User Guide
[RD-7]   NWPSAF-MF-UD-003, OPS-LRS User Manual
[RD-8]   NWPSAF-MO-UD-027, Annex to AAPP scientific documentation: Pre-processing of
              ATMS and CrIS
[RD-9]   NWPSAF-MO-DS-010, AAPP Version 6 Product Specification
[RD-10]   NWPSAF-MO-DS-014, AAPP Version 7 Product Specification

2. USER REQUIREMENTS

2.1 General considerations

User requirements for AAPP are gathered by several methods:
- 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 (an AAPP survey was made in Feb 2015)

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 relies
- Availability of ancillary data

2.2 Specific requirements for AAPP v8

The main areas proposed for change are detailed below. In this section we show how these are related to requirements.

MAIA v4 consolidation
Currently three versions of the MAIA cloud mask exist in AAPP v7: (i) MAIA2.1 for AVHRR mapped to the HIRS grid, (ii) MAIA3 for AVHRR on its native grid, (iii) MAIA4 for VIIRS.

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MAIA2.1 is becoming obsolete, as there no more HIRS instruments will be launched in the future, and the existing HIRS instruments are all degraded. There may still be applications in reanalysis. There is still value in retaining the AVHRR to HIRS mapping capability (mean and standard deviation of the AVHRR radiances), as this information can help with AMSU/MHS utilization.

MAIA3 is used in AAPP to generate a cloud mask on the AVHRR grid. It was originally designed to make use of background information from NWP fields (including water vapour) to optimise the cloud mask, though it can be run using a climatological background. However, MAIA3 *cannot* use GFS model fields.

MAIA4 is the newest version of MAIA. The AAPP version of MAIA4 only supports VIIRS, but the version being developed by Météo-France also supports AVHRR. MAIA4 *can* use GFS model fields, which are freely available via the internet, and this facility was introduced into AAPP in 2015 – including automatic download of the forecast files.

For AAPP, the best way of satisfying user requirements is through the release of a version of MAIA that supports both AVHRR and VIIRS, will be maintained with support for new satellites (i.e. Metop-C and JPSS series) and allows use of GFS model fields. The ability to map AVHRR to HIRS should be retained.

Imager clusters generation for hyperspectral sounders
This item addresses a recommendation from ITSC-20 DA/NWP-17: "Use the AVHRR cluster algorithm available in AAPP for all hyperspectral sounders".

The imager clusters generation will not be included in the first release of AAPP v8, but it is planned to introduce it via an update release.

The relevant code will be extracted from OPS-LRS, and an independent tool will be created which will allow the cluster generation with the "nuées dynamiques method for both VIIRS/CrIS and AVHRR/IASI sensors. The output will be (i) number of clusters, (ii) mean and standard deviation of the imager radiance, and (iii) cluster mapping – for each imager channel.

Support for ecCodes BUFR and GRIB libraries
In AAPP, there is a requirement to decode GRIB files (used in MAIA), and to decode and encode BUFR files (used to prepare data for NWP, and to handle DBNet data). External libraries are used, and a main requirement is that they should have long-term support and be reasonably easy to install.

In AAPP v7, GRIB decode facilities are provided by ECMWF's GRIB-API[1] library, and BUFR encode/decode facilities use BUFRDC[2]. ECMWF are developing a new package, ecCodes[3], to fulfil these functions. For GRIB, ecCodes is already sufficiently mature that users are being recommended to migrate. ECMWF have already replaced GRIB-API by ecCodes in their operational system (as of IFS Cycle 43r1, Nov 2016). For BUFR, there are some known performance issues, but it is expected that ecCodes will officially replace BUFRDC at some point in the life of AAPP v8.

Therefore, it is planned that in AAPP v8:

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[1] https://software.ecmwf.int/wiki/display/GRIB
[2] https://software.ecmwf.int/wiki/display/BUFR
[3] https://software.ecmwf.int/wiki/display/ECC/ecCodes+Home

- For GRIB, interfaces to ecCodes will replace interfaces to GRIB_API.
- For BUFR, interfaces to both ecCodes and BUFRDC will be available. Operational users can continue using BUFRDC initially, but as ecCodes matures then a migration process can start, and be handled via the normal AAPP update process.

Supported platforms and Fortran compilers
When Linux support was first introduced for AAPP (in 2004), one of the main freeware compilers in use was g77. This was the Fortran interface to gcc before version 4.0 (released in 2007), when g77 was replaced by gfortran. The NWP SAF now has no access to g77 or any other pure FORTRAN77 compiler, so no testing is possible. Therefore it is proposed to formally cease support for FORTRAN77 compilers.

This does not require any re-writing of the AAPP source code. The parts of AAPP that are currently written using FORTRAN77 formatting and constructs can be left as is, because these are all compatible with current compilers. (Note that interfaces to ecCodes will require fortran90 constructs).

Note that a few users of g77 were identified in the Feb 2015 AAPP Survey. Some of these users were anonymous, therefore they cannot be contacted individually, but general guidance can be given as part of the normal user support process.

No users of Solaris or HPUX platforms were found in the 2015 survey. These will be removed from the list of commonly used platforms, though the config files will be retained in case they are needed. AIX users will be supported on a best endeavours basis, but the NWPSAF no longer has access to a test platform running AIX. MacOS will be added to the list of supported operating systems.

Supported satellites
The FY-1D satellite ceased operating in 2012 and therefore it is proposed to remove it from the list of supported satellites. The code can remain in place, in case historical data need to be processed (considered unlikely).

Support for new satellites in an existing series (e.g. Metop-C, JPSS-1 and FY-3D) will normally be added via AAPP update releases.

Metop Admin Messages
Multi-Mission Administration Messages for Metop, which are XML-based, were introduced in 2012 and are now used for both Metop satellites. Therefore obsolete code related to the old Admin messages and Spot bulletins can be removed from AAPP.

2.3 Requirements for inputs to retrieval packages

AAPP outputs are sometimes used as input to level 2 retrieval packages. The requirements (reviewed in April 2017) are listed below.
- IAPP[4] requires HIRS level 1d in AAPP format with mapped AMSU and MHS. AVHRR is not required.
- MIRS[5] requires AMSU and MHS level 1b in AAPP format (NOAA and Metop satellites).
- UW Hyperspectral package[6] requires IASI PFS format.

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[4] http://cimss.ssec.wisc.edu/cspp/iapp_v1.1.shtml
[5] http://cimss.ssec.wisc.edu/cspp/mirs_v2.0.shtml

(Note that NUCAPS[7] software accepts only ATMS/CrIS SDR files, there are no interfaces with AAPP.)

3. FUNCTIONALITY, INPUTS AND OUTPUTS

AAPP v8 will provide the functionality of previous versions of AAPP, with the exception of the obsolete features detailed in 2.2. For NOAA and MetOp satellites it will be backward compatible in terms of user operation, input data and output data – as described in RD-1, RD-2, RD-3 and RD-4.

AAPP v8 will provide the following main functions. Features changed in v8 are shown in *italics*.

Raw data processing

- Ingest raw HRPT data files from the NOAA POES satellites. Input either big-endian or little-endian.
- Ingest "level 0" files from the Metop satellites.
- Calibrate and Earth locate the ATOVS and AVHRR instrument data (or TOVS and AVHRR data in the case of pre-NOAA-15 satellites[8]). The ATOVS instruments comprise AMSU-A, AMSU-B (or MHS) and HIRS. The TOVS instruments comprise MSU and HIRS.
- Level 1 processing for IASI (via the optional package OPS-LRS)

Ingest of externally-generated level 1 data (non-BUFR)
- Ingest level 1b AMSU, MHS, HIRS and AVHRR files from NOAA (e.g. from the CLASS archive). Includes handling of historical data.
- Ingest Sensor Data Records (SDRs) in hdf5 format from ATMS, CrIS and VIIRS on Suomi-NPP and JPSS satellites. AAPP will not process raw data for these satellites; external software packages are available.
- Ingest SDRs in hdf5 format from the sounders on FengYun-3 satellite series. AAPP will not process raw data for these satellites; external software packages are available.
- For AVHRR, convert between level 1b "PFS format" and AAPP format.

BUFR input and output
- Ingest level 1c BUFR files that comply with WMO sequences, for AMSU, MHS, HIRS, IASI, ATMS, CrIS, MWHS, MWHS-2, MWTS, MWTS-2, IRAS and MWRI.
- Generate level 1c BUFR files that comply with WMO sequences, for AMSU, MHS, HIRS, IASI, ATMS, CrIS, MWHS, MWHS-2, MWTS, MWTS-2, IRAS and MWRI.
- Generate other BUFR formats, e.g. level 1d used at Met Office.
- Interfaces to BUFRDC *and ecCodes*.

Sounder preprocessing
- For ATOVS, conversion of level 1b to level 1c (radiance) and level 1d (instruments mapped to a common grid).
- Pre-processing of IASI: map AMSU/MHS to IASI; spectral thinning (including Principal Components); spatial thinning.
- Pre-processing of ATMS and CrIS: map ATMS to CrIS; spatial filtering of ATMS; spectral and spatial thinning of CrIS.

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[6] http://cimss.ssec.wisc.edu/cspp/uwhsrtv_edr_v1.3.shtml
[7] http://cimss.ssec.wisc.edu/cspp/nucaps_v1.1.shtml
[8] Calibration is provided for NOAA-9 onwards.

- Pre-processing of FY-3 sounders: map MWHS-2 to MWTS-2.

<u>Cloud mask and imager analysis</u>
- MAIA cloud mask supporting AVHRR and VIIRS, with provision to download ancillary forecast files automatically from the internet. *A common version of MAIA for both AVHRR and VIIRS*.
- VIIRS to CrIS mapping
- AVHRR mapping to HIRS grid. *Optionally, the cloud information from MAIA4 may be mapped to the HIRS grid*.
- *Imager clusters generation for hyperspectral sounders*.

<u>AAPP outputs</u>
Different user applications require different output formats. Supported formats include:
- AAPP binary level 1b, 1c and 1d (details in RD-3)
- hdf5 versions of the level 1b, 1c and 1d formats, where the "header record" is used to set hdf5 attributes, and the "data records" are used to set hdf5 data arrays.
- Other hdf5 outputs (including MAIA4 products)
- BUFR
- PFS format (Metop-specific) for IASI level 1c and AVHRR level 1b

Note that several satellite launches are planned during the lifetime of AAPP v8 (MetOp-C, JPSS-1, FY-3D). Extension of AAPP to handle the data will be done through the normal AAPP update process and will not necessarily correspond with a new major release.

Processing of data from the hyperspectral sounder (HIRAS) on FY-3D may be added as a day-2 activity.

4. SOFTWARE PROVISION AND BUILD

AAPP 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 AAPP Installation Guide. The normal sequence is:

1. Build external any necessary external libraries, if not already installed (e.g. HDF5, BUFR and GRIB).
2. Configure AAPP (specifying fortran compilers, etc.)
3. Make
4. If required, build OPS-LRS, according to the instructions in the OPS-LRS user Manual (RD-7)

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

Orbital elements (if required) will need to be downloaded from external sources. Guidance is given in the AAPP User Guide (RD-6).

5. SYSTEM REQUIREMENTS

5.1 Language

As in previous versions of AAPP, the code will be written in a mixture of FORTRAN77, Fortran 90, C and C++. The code will be capable of compilation on a range of Fortran 90, C and C++ compilers.

Shell scripts will be based on the Korn shell and Perl and (optionally) Python.

5.2 Operating system and hardware

AAPP is required to run on commonly-available UNIX or Linux platforms. 64-bit systems are preferred. Based on past experience it is expected to run on 32-bit systems also, but the NWP SAF no longer has access to 32-bit test facilities.

Disk space requirements: the AAPP/OPS-LRS software and data files occupy about 9GB of disk space (or 4GB if you don't need to run MAIA4, the VIIRS cloud mask).

Memory requirements: there are no special requirements to run the core parts of AAPP (e.g. ATOVS/AVHRR processing). IASI processing requires at least 2GB of memory, but runs faster on systems with more memory, because more threads can be used. At least 6GB is recommended.

The core of OPS-LRS is parallelized using POSIX threads. Therefore OPS-LRS requires a platform where POSIX threads are implemented.

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, as run-times depend on processor speed, memory, etc.

In some cases, the run-time is determined by the performance of external software (e.g. ecCodes).

5.4 Interface requirements

Where external libraries are required, AAPP v8 may rely only on free software libraries. These libraries will either be packaged together with the relevant sections of AAPP v7 (e.g. xerces and fftw are packaged together with OPS-LRS) or the user will be given instructions on how to download them from a third party (e.g. ECMWF).

6. DOCUMENTATION

The AAPP scientific and technical documentation (RD-1 to 6) will be updated to include descriptions of the new capabilities.

On release of AAPP v8, the documents will be made available on the main AAPP web pages.

7. LIST OF REQUIREMENTS

This section details specific requirements to be addressed in the AAPP v8 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 AAPP v8 shall be successfully built, following the instructions in the Installation Guide. Where the user requires, it shall be possible to link external libraries to AAPP, including BUFRDC, ecCodes and HDF5.

7.3 The software shall compile and run on a range of Unix platforms including Linux PC and macOS.

7.4 NOAA and MetOp direct readout test cases for ATOVS, AVHRR and IASI shall run to completion, and shall have no unexpected differences between v7 and v8 in the accuracy or coverage of the output products. The Metop test case is to include OPS-LRS. Tolerances will be defined more fully in the Test Plan.

7.5 Test cases for MetOp BUFR and IASI principal components shall run to completion, and shall have no unexpected differences between v7 and v8 in the accuracy or coverage of the output products.

7.6 A test case for MAIA4 is required, which should run to completion and give results compatible with the reference results from Météo-France.

7.7 A test case for the imager clusters generation is required, which should run to completion and give results compatible with the reference results from Météo-France. [Not applicable to the initial release of AAPP v8]

7.8 BUFR test cases are required, allowing comparison of ecCodes performance with that of BUFRDC.

7.9 AAPP shall be capable of outputting the formats specified in section 2.3, for interfacing to level 2 retrieval packages. Testing of the retrieval packages themselves is outside the scope of the AAPP specification.

7.10 Appropriate test cases shall be made available to users via the NWP SAF web pages.