NWP SAF

MWIPP Version 2 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.

Change record			
Version	Date	Author / changed by	Remarks
1.0	11/10/2022	Nigel Atkinson	

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1. INTRODUCTION

This document defines the specification for Version 2 of the Microwave Imager Processing Package (MWIPP), in accordance with the requirements of the NWP SAF. The Product Specification describes the deliverable from the point of view of the user.

1.1 Previous releases

Previous releases of MWIPP are documented on the MWIPP web page at https://nwp-saf.eumetsat.int/site/software/mwipp/. They are as follows:

- MWIPP v1.0 released in February 2019. Specification is given in [RD-3]. Supports SSMIS, AMSR-2, GMI, MWRI.
- MWIPP v1.1 released in March 2022. Functionality was extended to support MWI/ICI test data released by EUMETSAT in February 2021.

1.2 Reference documents

[RD-1] NWPSAF Proposal for the Fourth Continuous Development and Operations Phase (CDOP 4) March 2022-February 2027, Version 1.2, 29 March 2021

[RD-2] NWPSAF-MO-SW-002, Development Procedures for Software Deliverables, version 3.12, 04.05.2020.

[RD-3] NWPSAF-MO-DS-035, MWIPP Version 1 Product Specification, Version 1.0. 07.02.2018.

[RD-4] NWPSAF-MO-DS-044, Design proposals for EPS-SG pre-processing in AAPP and MWIPP, v1.0, 25.5.2022. Available on the MWIPP page on the NWP SAF web site.

[RD-5] EUM/LEO-EPSSG/SPE/14/767115, EPS-SG MWI Level 1B Product Format Specification, v3A, 29 June 2020

[RD-6] EUM/LEO-EPSSG/SPE/14/771723, EPS-SG ICI Level 1B Product Format Specification, v3A, 14 May 2020

Note that [RD-4] was written to assist the requirements gathering process for MWIPP v2, as it discusses the issues involved with processing MWI/ICI data and presents a design proposal for potential users to review.

2. USER REQUIREMENT REVIEW

2.1 General considerations

User requirements for NWPSAF software deliverables are defined in consultation with the NWPSAF Steering Group, taking into account (i) the tasks agreed in the relevant proposal for the phase of the SAF being undertaken (e.g. CDOP-4), (ii) any new requirements that have been identified by the methods described below, and (iii) the resources available.

User requirements are typically gathered by several methods:

- Discussions at meetings and conferences, such as the International TOVS Study Conferences
- 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 the NWPSAF deliverable relies
- Availability of ancillary data

2.2 Input from RD-1 (CDOP-4 proposal)

RD-1 makes the following statements about MWIPP. Key points are highlighted in blue:

Product description:

- The MWIPP is a generic pre-processor for MW imagers based on the capability of the SSMIS-PP package, developed during CDOP 1 and 2. The initial version of MWIPP, released in CDOP 3, processes SSMIS, AMSR-2, GMI and FY-3 MWRI. In CDOP 4 the MWIPP will be extended to handle data from MWI and ICI on EPS-SG.

User requirements

- Observations from microwave imagers are used at many NWP centres, and provide information on water vapour, cloud, precipitation, ocean surface winds and sea ice coverage. Current sensors include: SSMIS (F16-F18); AMSR-2; FY-3 MWRI and GMI. Within the timeframe of CDOP 4 it is expected that further imagers will be launched, including Metop-SG MWI and ICI. AMSR-3 (on Global Observation SATellite for Greenhouse gases and Water cycle (GOSAT-GW)) may also be launched in this time frame. MWIPP provides a general pre-processing capability to support the use of these sensors and should include, as a minimum, the ability to average over-sampled data. MWIPP shall be able to generate products both on the original instrument grid and also mapped to a common grid. Conversion from native format to BUFR is also an important function of MWIPP.

Product uniqueness:

- MWIPP is based on those elements of the SSMIS_PP that have not already been assimilated into the SSMIS Unified Pre-processor (UPP) maintained by the Naval Research Laboratory (NRL). Thus, MWIPP includes averaging and re-mapping functions that are not available elsewhere. Additional and unique new functionality will be added if supported by evolving NWP user requirements.

Product usage:

- MWIPP had 64 registered users on 15 October 2020. It is used at several NWP centres for (i) generating BUFR files for microwave imagers AMSR-2 and GMI, (ii) to reduce the noise in the SSMIS brightness temperatures from NRL Unified Pre-Processor (UPP) data. The data are assimilated into NWP models. MWIPP will be evaluated for potential use by the NWC SAF in the design of their PPS-MW package in CDOP 4.

Product evolution:

- Release of MWIPP v2 is foreseen close to the launch of Metop-SG-B1, to support MWI and ICI. Beta releases of MWIPP v2 will be provided in advance to the NWC SAF.

Product role in delivering the benefits of MTG and EPS-SG

- MWIPP will help users overcome the challenges of using data from 2 microwave imagers on the same platform, opening up the opportunity for NWP centres to exploit the new science capabilities of ICI.

2.3 Input from ITSC-23, June 2021

The proposed MWIPP was presented at ITSC-23[1] in a talk (3.01) and discussed in working groups. The design document (RD-4) was advertised and user feedback requested. In brief, the following approach was proposed:

- MWI and ICI level 1B data would be ingested in NetCDF or BUFR format
- The data would be smoothed in line with the approach implemented in MWIPP v1.0 for SSMIS.
- The data would be mapped onto a common grid defined as the grid of a reference feedhorn
- ICI would be mapped to MWI, creating a 39-channel super-instrument
- Spatial thinning (e.g. to 10km) would be carried out to reduce data volume to manageable levels
- The product would be BUFR-encoded, using an evolution of the BUFR sequence already available in MWIPP v1.0.

The NWP Working Group took an action

> Action DA/NWP-2 on WG Members
> *Please review the software design documents for ISPP and MWIPP/AAPP on the NWPSAF website and provide feedback to Nigel Atkinson by the end of July 2021.*

The MWIPP was also discussed in the Products and Software Working Group, though no specific action was formulated.

In the event, no feedback was received from ITWG working groups. It must therefore be assumed that the proposed approach is acceptable to users.

There was also a relevant recommendation from the Products and Software Working Group:

> Recommendation PSWG-2 to software providers
> *Where possible, offer their software with a choice of either pre-built binaries or source code.*

2.4 Input from NWC SAF

The document [RD-4] was shared in March 2021 with the NWC SAF (Anke Thoss), who made the following comments:

> What I can already say is that NWC SAF has a requirement for NetCDF as output.

[1] http://cimss.ssec.wisc.edu/itwg/itsc/itsc23/index.html

> I would like to discuss not only within our team, but also with our colleagues at Chalmers (who developed the ICI IWP retrieval for NWC SAF to be run centrally at EUMETSAT) and with H SAF. With HSAF we will start a very close collaboration on precipitation, where NWCSAF will make available HSAF algorithms as primarily Python software within the PPS-MW package. We will also collaborate scientifically on high latitude precipitation and snowfall retrieval.
>
> Is it OK for you if I share your document with Chalmers and HSAF?

2.5 Input from ECMWF

In June 2022, Alan Geer was asked to provide comments on [RD-4], following some discussion at the “MTG/EPS-SG User Days” held in Darmstadt (31 May to 2 June 2022):

> What you are saying sounds very sensible, especially if the BUFR format is so unwieldy. However I would like to think more about BT vs radiance; the problem is that when there are strong contrasts in a scene (and with cloud scattering or ocean surface emissivity the microwave/sub-mm is able to supply contrasts between 50K and 320K at the edge of clouds or along coastlines) then averaging TB is not a perfect option, and radiance is more exact.
>
> I do hope that the community can find a common way of working with MWI and ICI because that will make life easier for everyone; it doesn't have to be organised by EUMETSAT but their L2 product, if it contains the co-registered radiances, might be a very attractive product for some users. I have to think hard whether we should continue with our in-house superobbing tool or consider moving to MWIPP. I fully agree that it is good for the more advanced centres to have full control over the co-registration and smoothing of the data; for some applications (e.g. sea-ice) we might want to use the data in a very different way, e.g. with as much spatial resolution as possible. However, many users might just want an easy option, like the L1R(?) product for GMI.

In a subsequent email discussion it was agreed that errors resulting from averaging BT are negligible. It was also agreed that the rather specific requirements of ECMWF on superobbing can be handled within the ECMWF system, and don’t need to be integrated into MWIPP. Alan suggested some additions to the BUFR format, i.e. extra descriptors that might be useful. (The details of the BUFR format are outside the scope of a high-level product specification).

2.6 Requirements to maintain existing functionality

It is known that the original MWIPP v1.0 is used at several NWP centres, particularly the facility to convert AMSR-2 and GMI data from native ndf5 format to BUFR. This is particularly relevant to centres that do not receive the BUFR product routinely generated by EUMETSAT and distributed by EUMETCast.

These functions should be maintained in a future MWIPP v2.0.

2.7 Requirements for DBNet

MWRI data for FY-3D are already part of EUMETSAT’s EARS-VASS system and may be adopted by other networks. EUMETSAT currently use AAPP for converting from hdf5 to BUFR, but in the future they may use MWIPP. We are still waiting for CMA to define a proper WMO-accepted BUFR

sequence for MWRI, but this is expected to be in place by the time MWIPP v2 is released. MWIPP v2 will need to be able to create BUFR files in this format.

It is planned that MWI and ICI will also be added to DBNet. This will require conversion from NetCDF (EUMETSAT's official level 1B format) to BUFR, as part of MWIPP.

3. CONSOLIDATED REQUIREMENTS FOR MWIPP V2.0

3.1 High level requirements

The first release of MWIPP version 2 should have the following high-level capabilities:

Functionality present in MWIPP v1.0:

1. Ingest of native-format (hdf) data from AMSR-2
2. Ingest of BUFR data from SSMIS (UPP) and AMSR-2
3. Mapping to reference footprints or a user-supplied grid (generic)
4. Spatial filtering to a user-supplied reference beam width (generic)
5. Creation of BUFR and hdf5 (or NetCDF4) output files

Functionality present in MWIPP v1.1:

6. Ingest level 1B netCDF data (format defined by EUMETSAT) from MWI and ICI
7. Spatial smoothing for MWI and ICI (parameters configurable by the user)
8. Map MWI and ICI data to a common grid, either each instrument separately or mapping ICI to MWI footprints to create a 39-channel super-instrument
9. Spatial thinning (parameters configurable by the user)
10. Create output file in BUFR format, for use in NWP

New functionality required for MWIPP v2:

11. Ingest level 1B BUFR data for MWI and ICI (format defined by EUMETSAT), so that it can be used in downstream MWIPP processing
12. Convert level 1B from NetCDF to BUFR (both formats defined by EUMETSAT)
13. Support a WMO-approved BUFR sequence for MWRI, for both reading and writing.

Draft level 1B BUFR formats for MWI and ICI are defined in RD-5 and RD-6 respectively.

Other requirements (e.g. extension to other microwave imagers such as AMSR-3) may be added for incorporation into update releases, subject to approval by the NWP SAF Steering Group.

3.2 Software provision

The package will normally be distributed via the NWPSAF web site as source code, with separate data files as required.

Executables, built on RedHat Linux or equivalent, will also be provided as an option for users.

3.3 Language and structure

Fortran 90 is the language of choice for the main modules, following the standards described in [RD-2].

Additionally, C, Python, Perl, bash or ksh may be used where appropriate.

A suitable configure/build system should be included in the package.

Code should be modular where possible, to allow for possible integration of parts of the package in the user's own application.

3.4 Operating system and hardware

The software is required to run on a 64-bit Linux PC, running a current operating system such as CentOS7 or RHEL7.

3.5 Performance

The goal is to process 1 orbit of data for one instrument in less than 90 seconds.

Run-time examples should be included in the user documentation.

3.6 Interface requirements

Where external libraries are required, MWIPP may rely only on free software libraries. These libraries will either be packaged together with the relevant sections of MWIPP or the user will be given instructions on how to download them from a third party. Use of ecCodes (from ECMWF) is foreseen.

3.7 Test cases

Suitable test cases shall be prepared and made available to users, to exercise MWIPP functionality for all the supported instruments.

4. DOCUMENTATION

Scientific and technical documentation shall be written and supplied to users via the NWPSAF web pages. The documents should address:

- Product specification
- Top level design
- Test plan
- Science description
- Installation guide
- Operation guide

Two or more of the above may be combined into a single document, for example a User Manual.

5. REQUIREMENTS SUMMARY FOR MWIPP V2

The Test Plan should address the verification of the following requirements:

Identifier	Requirement	How to verify
MWIPP1	Documentation is clear, understandable and complete	Beta testing
MWIPP2	Code conforms to the requirements of [RD-4]: commented, understandable and modular	Inspection
MWIPP3	Any necessary external libraries are freely available	Inspection (e.g. examine the corresponding web sites for the external libraries)
MWIPP4	Code builds with no errors on a 64-bit Linux PC, running a current operating system such as CentOS7 or RHEL7. More than one Fortran compiler shall be tested.	Test
MWIPP5	Ingest BUFR files for SSMIS, AMSR-2, GMI, MWRI, MWI and ICI	Test
MWIPP6	Ingest native-format files for AMSR-2, GMI, MWRI, MWI and ICI	Test
MWIPP7	Spatial averaging capability (replicates SSMIS_PP)	Test
MWIPP8	Spatial thinning capability for MWI and ICI	Test
MWIPP9	For channels of a particular instrument, map to a user-defined grid or the grid of a specified channel	Test
MWIPP10	Map MWI and ICI together to form a super-instrument of 39 co-located channels.	Test
MWIPP11	Creation of BUFR output files for SSMIS, AMSR-2, GMI, MWRI, MWI and ICI.	Test
MWIPP12	Creation of hdf5 or NetCDF4 output files	Test
MWIPP13	Run times are documented in the test log, and are comparable with SSMIS_PP when processing SSMIS. For MWI and ICI, a goal is to achieve a run time of 90 seconds when processing 1 orbit.	Test and inspection
MWIPP14	Test cases for the users exist, have clear instructions and run correctly	Beta testing