NWP SAF

MWIPP Version 2 Top Level Design

Version 1.0

17th May 2023

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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	17.05.23	A Booton	Initial Version

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1. INTRODUCTION

This document defines the Top Level Design for Version 2 of the Microwave Imager Processing Package (MWIPP), in accordance with the requirements of the NWP SAF. The Top Level Design should be read in conjunction with the MWIPP v2 Product Specification [RD-1].

It should be noted that the MWIPP software includes support for processing the SSMIS instrument, superseding that of the NWPSAF SSMIS_PP. As such the NWPSAF SSMIS_PP package will be retired upon the release of MWIPP v2.

1.1 Reference documents

[RD-1] NWPSAF-MO-DS-047, MWIPP version 2 Product Specification, v2.0, Oct 2022
[RD-2] NWPSAF-MO-DS-035, MWIPP version 1, Top Level Design Sept 2018
[RD-3] NWPSAF-MO-DS-044, MWIPP User Manual, v1.1/v1.2, Feb 2022/Feb 2023
[RD-4] Doxygen v1.9.7, https://www.doxygen.nl/ (accessed 15th May 2023).

1.2 Requirements summary

Version 2 of the MWIPP software will extend the capabilities of MWIPP v1 by providing:

- Support for MWI and ICI on EPS-SG[1]
- Support for AMSR-3 on GOSAT-GW

Specific requirements include:

- Processing of MWI and ICI BUFR (local sequence 3-10-081 and 3-10-080 respectively) as planned to be disseminated operationally by EUMETSAT.
- Update of MWI and ICI native netCDF file ingest (implemented in MWIPP v1.1, [RD-3]) to align with the instruments' file-format evolution.
- Ability to process MWI and ICI together to form a super-instrument (aka MWIICI).
- Processing of:
  - AMSR-3 BUFR (local sequence TBD), and
  - AMSR-3 native format (hdf5 or netCDF[2]) files

replicating the AMSR-3 product expected to be disseminated operationally by EUMETSAT.

This will benefit centres that do not have access to the EUMETSAT products but do have access to native data.

The processing will align with that implemented in MWIPP v1 [RD-1]. It will therefore include:

- Format conversion to hdf5 on the native instrument grid

[1] It is noted that support for simulated MWI and ICI data was introduced in MWIPP v1.1, however this only included ingest of netCDF files of test format. Full support appropriate for operational use will be implemented at MWIPP v2.
[2] The AMSR-3 native file format has yet to be announced. Here we assume it will be either hdf5 or netCDF4

- Spatial averaging per channel
- Remapping of the native instrument grid to a user-specified grid that is common to all channels

2. DESIGN

A high-level block diagram is shown in Figure 1. The system design is taken from the MWIPP v1 design, [RD-2] but has been updated to reflect the extensible nature of the code for adding multiple instruments. The "Level" of data processing is also highlighted, where the processing "Levels" are defined as:

- Level 1B: Unmodified brightness temperatures or radiances on the original instrument grid
- Level 1C: Processed product, on original grid
- Level 1D: Re-mapped product"

The facility for converting the MWI and ICI native netCDF files to EUMETSAT operational BUFR will be new in MWIPP v2.

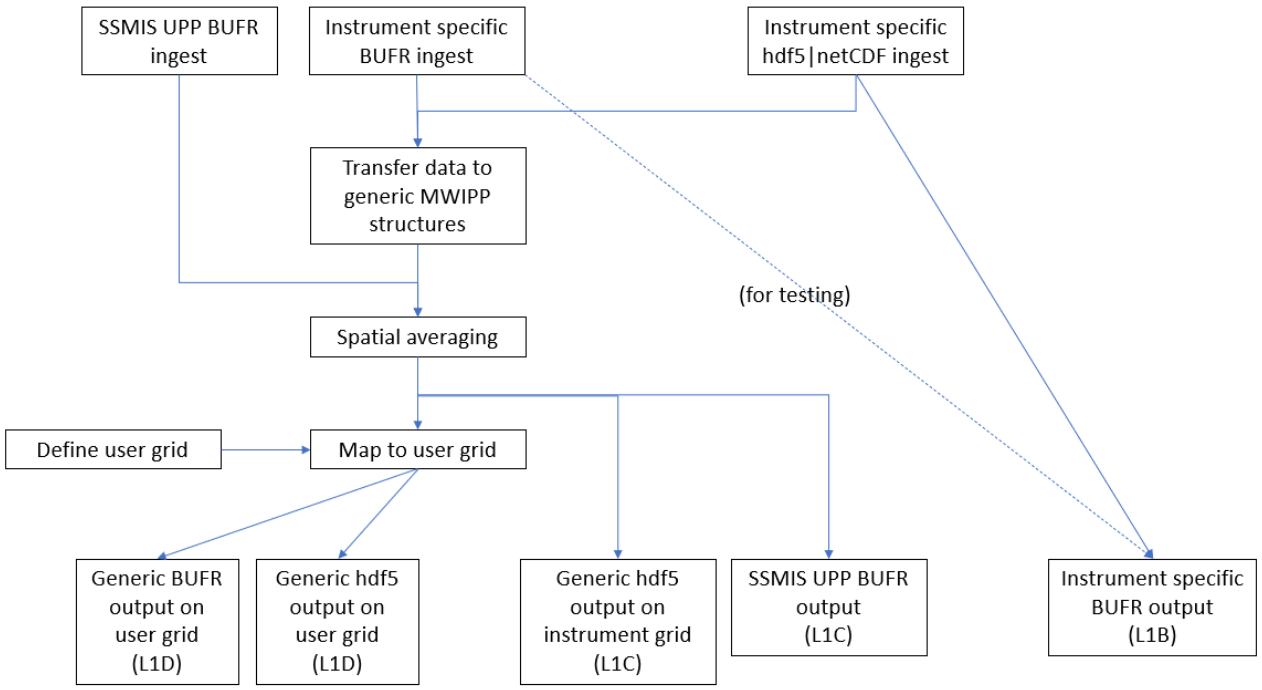

Figure 1: MWIPP block diagram. Note: "instrument specific" refers to any instrument except SSMIS UPP[3]. The "map to user grid" step can be utilised to apply further thinning as required. The dotted line indicates where files are used to ensure that the decode and encode routines are the inverse of each other.

[3] SSMIS UPP – Special Sensor Microwave/Imager Sounder Unified Pre-Processor, from the Naval Research Laboratory, USA.

Table 1 summarises the native file formats that MWIPP will accept for a given instrument type, and the output formats available (depending on the processing chain selected as shown in Figure 1).

Instrument	*Native File Formats Ingested, Level 1B*	*Output Data Formats: Level 1B*	*Level 1C*	*Level 1D*
SSMIS (UPP)	BUFR	-	BUFR	BUFR
AMSR-2	BUFR, hdf5	BUFR	hdf5	BUFR, hdf5
GMI	BUFR, hdf5	BUFR	hdf5	BUFR, hdf5
MWRI	BUFR, hdf5	BUFR	hdf5	BUFR, hdf5
MWI	BUFR*, netCDF4	BUFR*	-	BUFR, hdf5
ICI	BUFR*, netCDF4	BUFR*	-	BUFR, hdf5
AMSR-3	BUFR*, hdf5|netCDF*[2]	BUFR*	hdf5*	BUFR*, hdf5*

Table 1: Summary of the file formats ingested and output for the various instrument types.
***/blue – are due to be implemented in MWIPP v2.**

2.1 External libraries

As for MWIPP v1, ([RD-2], [RD-3]) the following libraries are required for processing all instruments:

- ecCodes
- hdf5 with Fortran90 and Fortran2003 interfaces

If processing data in netCDF, the following are also needed:

- netCDF C
- netCDF Fortran

(as described in MWIPP User guide [RD-3]).

2.2 Source code organisation

As for MWIPP v1, see [RD-2]. The user interfaces for the main program executables and the standalone hdf5 to BUFR executables [RD-3, section 3.1] will be reviewed (in lieu of the number of instruments now processed), and consolidated APIs will be provided if appropriate.

2.3 Build process

As for MWIPP v1, see [RD-2]. If technically possible, a Conda recipe will be supplied in addition to and as an alternative to the current “configure” and “make” installation method.

2.4 Spatial averaging

As for MWIPP v1, see [RD-2], and Appendix 3.1.

2.5 Mapping to a user (or other instrument) grid

As for MWIPP v1, [RD-2], remapping is achieved by interpolating geolocated nearest-neighbour observations from the instrument grid, to a target grid (either a user-defined grid, or a given instrument specific feedhorn grid). It is noted that:

- In the case of MWI and ICI, the 118 GHz feedhorn of MWI is chosen as the target common grid, since that is in the centre of the MWI cluster. Bilinear interpolation is used.
- For each MWI scan, the ICI scan that immediately precedes it in time is initially identified, prior to carrying out the interpolation described above.
- MWIPP also contains a facility to perform a nearest-neighbour mapping to a model grid defined in GRIB; this uses ecCodes (codes_grib_find_nearest).

The re-mapping for MWI and ICI is described in detail in [RD-3, section 5.5].

It should be noted that AMSR2, GMI, MWRI and SSMIS can be mapped onto a “user grid”. However, in the case of MWI and ICI, the ICI instruments are mapped onto the MWI grid thus co-locating the instruments forming a 39-channel super-instrument. To achieve this a different remapping module, `mwipp_remapping_mod`, is introduced to the code. See section 3.2.

2.6 BUFR output

As for MWIPP v1, [RD-2], the output BUFR files will be encoded to:

a) an existing EUMETSAT or WMO BUFR convention, or
b) the MWIPP software “generic BUFR sequence”

where the sequences in a) are level 1B (thus convey full instrument information), whilst b) is level 1C/1D are intended for use in NWP centres wishing to use the spatial averaging and/or data remapped to differing grid.
Details for the BUFR sequences are found in [RD-3, Appendix: BUFR Sequences].

2.7 hdf5 output

As for MWIPP v1, see [RD-2]. The output is generic and thus appropriate for AMSR-3.

2.8 Supplementary routines

The supplementary python “quick-look image” plotting routines used (see [RD-3, section 3.9]) in conjunction with the test cases will be Python 3 compatible. (Python 2 will no longer be supported).

3. APPENDIX

3.1 The Averaging code design

Details regarding the design of the averaging module are depicted in Figure 2. The averaging code design for MWIPP v2 will remain unchanged from that current implemented in MWIPP v1.2. The averaging calculation is computed by calling the following subroutines: `read_averaging_namelist`, `compute_distsq`, `compute_weights`, `modify_btemps`, as described in [RD-3, section 4.2.2].

It is noted that the Level 1B data is input to the averaging module. As the averaging method is by superobbing, the modified brightness temperatures of each observation are obtained by taking a weighted average from the surrounding points, and are then stored at the original location on the instrument grid. Hence the Level 1C output data is on the original instrument grid.

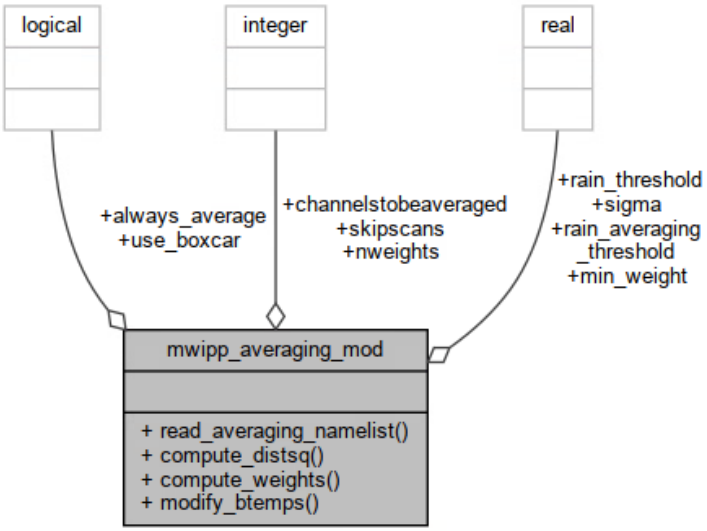

Figure 2: Collaboration diagram for the mwipp_averaging_mod. (Diagram was generated from the MWIPP v1.2 code using [RD-4]).

3.2 Map data to a user-defined (or other instrument) grid code design

The `mwipp_map_to_usergrid_mod` module is used to map an instrument onto a "user grid" defined in the `user_grid.nl` namelist, as described in [RD-3 section 4.3.5]. However, to remap the ICI instrument onto the MWI (to form the super-instrument) a new `mwipp_remapping_mod` module is introduced. Figure 4 summarises both modules described. It can be seen that the remapping coefficients for ICI are computed on the fly.

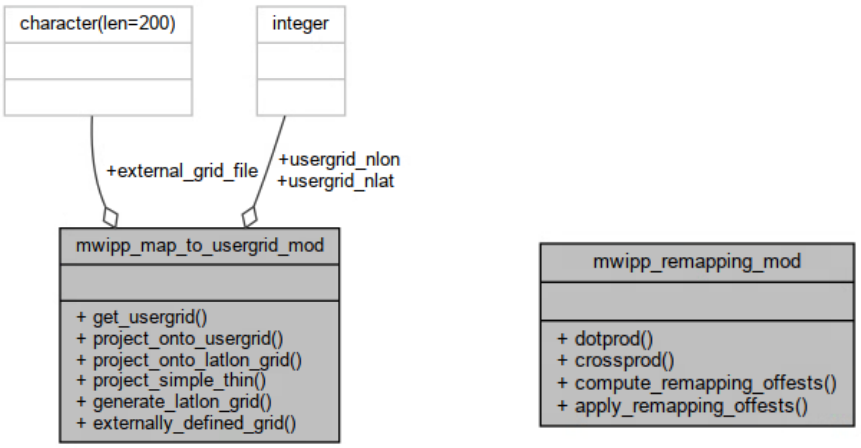

Figure 3: Collaboration diagram for a) the mwipp_map_to_usergrid_mod and b) mwipp_remapping_mod modules. (Diagram was produced using [RD-4]).

The call graph and caller graph for the mwipp_remapping_mod – compute_remapping_offsets routine, Figure 4 higlights that this remapping is only used for creating the MWI-ICI super-instrument.

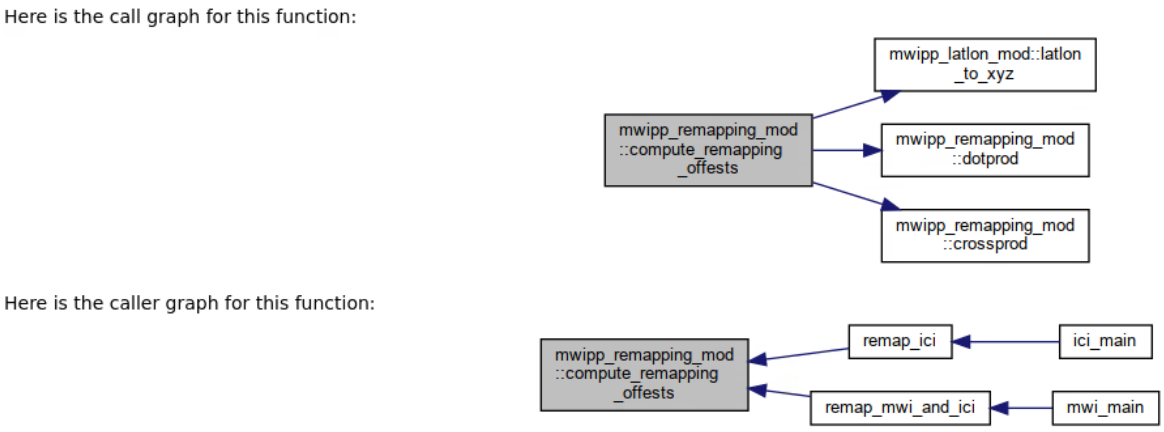

Figure 4: The call graph and caller graph for the mwipp_remapping_mod – compute_remapping_offsets routine. (Diagram was produced using [RD-4]).