

<b>NWP SAF</b>	<b>IRSPP Version 2 Product Specification</b>	Doc ID : NWPSAF-MO-DS-051 Version : 1.0 Date : 16.07.2024
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## **NWP SAF**

# **IRSPP Version 2 Product Specification**

Version 1.0

16<sup>th</sup> July 2024

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## IRSPP Version 2 Product Specification

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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## 1. INTRODUCTION

This document defines the specification for Version 2 of the Infrared Sounder Pre-Processor (IRSPP), in accordance with the requirements of the NWP SAF. The Product Specification describes the deliverable from the point of view of the user.

The purpose of the package is to provide tools to facilitate processing of data from the Infrared Sounder (IRS) on Meteosat Third Generation (MTG).

Version 1 of the package was released before MTG-S1 launch, based on pre-launch test data. The first release was March 2022. Version 2 will be released after validation with post-launch data.

### 1.1 Reference documents

- [RD-1] CDOP-4 Proposal, version 1.2, 29.03.2021
- [RD-2] IRSPP v1 Product Specification, version 1.0, 11.04.2018
- [RD-3] IRSPP User Manual, version 1.3, 01.02.2023
- [RD-4] NWPSAF-MO-SW-002, Development Procedures for Software Deliverables, version 3.11, 26.05.2016.

## 2. USER REQUIREMENT REVIEW

### 2.1 General considerations

User requirements for NWP SAF software deliverables are defined in consultation with the NWP SAF 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 NWP SAF deliverable relies
- Availability of ancillary data

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

RD-1 makes the following statements about IRSPP:

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- The IRSPP will be developed to process hyperspectral sounding data from MTG. The data will be disseminated by EUMETSAT and the baseline is that Principal Components will be distributed. The main function of IRSPP is to ingest the PC files and generate reconstructed radiances for use in NWP.
- For IRSPP, the detailed requirements have been determined based on input from NWP users and advice from IRS Mission Advisory Group (MAG). The primary requirement is to provide a facility to ingest EUMETSAT's Network Common Data Form 4 (NetCDF4) PC Scores and convert to reconstructed radiances. Other requirements include: spatial and spectral thinning or averaging; format conversion (e.g. BUFR); ingest of full-spectrum datasets and generation of eigenvectors (as a research tool).
- IRSPP will not overlap with the data calibration or correction processes that will be carried out as part of Level 1 processing at EUMETSAT. There will be a little overlap with processing capability developed by the Satellite Application Facility on Support to Nowcasting and Very Short Range Forecasting (NWC SAF) (e.g. the handling of PC scores), but it is important to note that IRSPP will be primarily targeting NWP applications.
- For IRSPP, use will be made of the Principal Component handling capabilities currently available in other NWP SAF packages, notably AAPP and the IASI Principal Component Analysis (PCA) -based compression package. The software will be written to target the requirements of MTG-IRS. Coordination will be made with related activities of the EUMETSAT Central Facilities (CF) and the NWC SAF in this area.
- MTG-IRS data are expected to be widely used in global and regional NWP models that include the MTG coverage area. Most EUMETSAT Member States will therefore benefit from the development of the preprocessor IRSPP. The Satellite Application Facility on Atmospheric Composition Monitoring (AC SAF) has expressed an interest in using IRSPP in their planned IRS dust profiles feasibility study.
- Release of IRSPP v2 is foreseen during commissioning of MTG-S1. Launch is expected early 2024 [see comment below] and the commissioning phase will last 6 months.
- Dedicated pre-processing software for data from MTG-IRS (IRSPP) will enhance the uptake of these new data by NWP by providing a flexible package that will ingest the standard PC-compressed NetCDF format and allow users to create L1 products that suit their own requirements (e.g. reconstructed radiances for a defined channel selection).

This document addresses the v2 release of the package, referred to above, and due in CDOP-4. Note that the MTG-S1 launch is now expected in Q2 or Q3 2025 (later than envisaged in the CDOP-4 proposal).

### 2.3 Inputs from ITSC

IRSPP v1.2 was presented at ITSC-24 (Tromsø, March 2023) in a poster ([6p.01](#)). The v1.2 release is compatible with EUMETSAT test data released in November 2022.

The poster points out that the software supports the following operations for MTG-IRS data:

- Ingests EUMETSAT's netCDF files for PC scores (available in NRT) or full spectra (available from the Data Centre). Also ingests EUMETSAT-supplied eigenvector files.
- Computes reconstructed radiances for a user-defined set of channels
- Optionally thins the data. A "warmest field of view" mode is available. Thinning specifications are user-defined: the user may wish to make this dwell-dependent
- Encodes the reconstructed radiances and/or PC scores into BUFR
- As a research task, it can generate eigenvectors given full-spectra input files, or transform from one PC basis set to another

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There was no specific feedback received from ITSC-24 participants, suggesting that they are generally happy with the current capabilities.

## 2.4 Inputs from IRS MAG

The IRSPP v1 design was presented to the IRS MAG on 8<sup>th</sup> June 2021. See <https://www.eumetsat.int/irs-mission-advisory-group-irs-mag-june-2021>. At that meeting, EUMETSAT took an action to consider running IRSPP centrally and disseminate BUFR products. But it was concluded that such an approach is not compatible with the MTG ground segment. Therefore it is expected that NWP centres will want to run IRSPP themselves (as originally envisaged by the NWP SAF).

There has been much discussion in the IRS MAG about uniformization of the spectral response functions across the detector array. This step has now been included in the EUMETSAT ground segment, and therefore there is no requirement to perform this processing in IRSPP. If unexpected instrumental effects are observed in post-launch commissioning, then consideration could be given to making some corrections in IRSPP, if technically feasible.

At the April 2024 meeting of the IRS MAG, ECMWF confirmed that they have tested IRSPP v1.2 and it “works well”. Also, the Met Office presented its plans for running IRSPP routinely in the cal/val phase of the mission. EUMETSAT re-confirmed only PC scores (not full spectra) will be available in near-real-time. There were no requests from the MAG for additional functionality.

## 2.5 Discussions with ECMWF

In 2023, feedback was received from ECMWF concerning details of the BUFR sequence proposed for IRS. Some small modifications have been made to the development version of IRSPP to take this discussion into account. Generally, ECMWF are supportive of the functionality of IRSPP v1 and no new requirements have been identified.

## 2.6 Relevant functionality from other NWP SAF packages

The eigenvector generation capability from the IASI PCA-based Compression Package has been integrated into IRSPP v1. No changes are foreseen for IRSPP v2.

Similarly, the IASI processing functionality from AAPP (e.g. computation of reconstructed radiances and BUFR encoding) has been adapted for MTG-IRS and included in IRSPP v1. No changes are foreseen for IRSPP v2.

In RTTOV, the HT-FRTC capability has been “dormant” in RTTOV v12 and v13, and has been retired in the upcoming RTTOV v14. Instead, users who need to simulate Principal Component scores or reconstructed radiances are encouraged to use PC-RTTOV. This implies some minor technical changes to parts of IRSPP, to be discussed further in the Top Level Design, but no changes to the high level requirements.

# 3. CONSOLIDATED REQUIREMENTS FOR IRSPP

## 3.1 High level capabilities

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Taking account of the above requirements review, it is proposed that IRSPP version 2 should have the following high-level capabilities, which are essentially unchanged from IRSPP version 1 apart from the addition of capability k).

- a) Ingest of native-format (netCDF4) PC-score or full-spectrum data from MTG-IRS
- b) Code to convert PC scores to reconstructed radiances for specific channels, using externally supplied eigenvectors. Use of dynamic eigenvectors (included in the input file) shall be an option.
- c) Code to convert PC scores to an alternative basis function, using an externally-supplied transformation matrix
- d) Conversion of PC scores to BUFR
- e) Conversion of reconstructed radiances to BUFR
- f) Conversion of reconstructed radiances to NetCDF4
- g) Spatial sub-sampling (thinning), with optional selection of warmest field of view in order to maximise the number of clear spectra
- h) Ability to convert from “light” to “heavy” (e.g. Hamming) apodisation. For PC-score input, this shall be done by modifying the eigenvectors. For full-spectrum input, the spectra would need to be apodised explicitly.
- i) Facility to obtain ancillary information (e.g. eigenvectors) from EUMETSAT, where required
- j) Tool for generating eigenvectors from a base set of spectra, via a covariance matrix, incorporating the relevant functionality of the IASI PCA-based Compression Package.
- k) IRSPP v2 will have been validated prior to release using in-orbit data

The algorithms to be used will be specified more fully in the Top Level Design.

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

No requirement has been identified for cloud detection modules in IRSPP, because a basic cloud mask will be available as part of the level 1 product<sup>1</sup> (datasets cloud\_fraction and cloud\_signal).

### 3.2 Software provision

The package will normally be distributed via the NWP SAF web site as source code, with separate data files as required. Compiled executables, for a specified Linux distribution, may also be provided.

### 3.3 Language

Fortran 90 is the language of choice for the main modules, following the standards described in [RD-4].

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

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

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<sup>1</sup> MTG-IRS Level 1 Algorithm Theoretical Basis Document, EUM/RSP/TEN/16/878765, v1E Draft, 7 June 2017

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### 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 CentOS7/8 or RHEL7/8.

### 3.5 Performance

The goal is to achieve a system that can process MTG-IRS data in near real time, i.e. process a 15-minute LAC in a few minutes.

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

### 3.6 Interface requirements

Where external libraries are required, IRSPP may rely only on free software libraries. These libraries will either be packaged together with the relevant sections of IRSPP 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.

## 4. DOCUMENTATION

Scientific and technical documentation shall be written and supplied to users via the NWP SAF 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, if it makes things easier for the user.

## 5. REQUIREMENTS SUMMARY

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

Identifier	Requirement	How to verify
IRSPP1	Documentation is clear, understandable and	Beta testing

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	complete	
IRSPP2	Code conforms to the requirements of [RD-4]: commented, understandable and modular	Inspection
IRSPP3	Any necessary external libraries are freely available	Inspection (e.g. examine the corresponding web sites for the external libraries)
IRSPP4	Code builds with no errors on a 64-bit Linux PC, running a current operating system such as CentOS7/8 or RHEL7/8. More than one Fortran compiler shall be tested, subject to availability.	Test
IRSPP5	Ingest simulated MTG-IRS PC-product files in NetCDF4 format	Test
IRSPP6	Convert from PC scores to reconstructed radiance, using EUMETSAT-supplied eigenvectors	Test
IRSPP7	Convert from PC scores to an alternative basis set, using a user-defined transformation matrix	Test
IRSPP8	Creation of BUFR output files for the PC product	Test
IRSPP9	Creation of BUFR output files for reconstructed radiances	Test
IRSPP10	Creation of NetCDF output files for reconstructed radiances	Test
IRSPP11	Spatial thinning onto a user-defined grid (nearest neighbour)	Test
IRSPP12	Ability to define the apodisation of the output radiances	Test
IRSPP13	Facility to download ancillary information (e.g. eigenvectors) from EUMETSAT, where required	Test
IRSPP14	Tool to generate eigenvectors from a base set of spectra, via a covariance matrix	Test
IRSPP15	Run times are documented in the test log and are compatible with NRT use of the software	Test and inspection
IRSPP16	Test cases for the users exist, have clear instructions and run correctly	Beta testing
IRSPP17	Functionality validated using in-orbit data	Test during commissioning