NWP SAF Processing Packages to support EPS-SG and MTG

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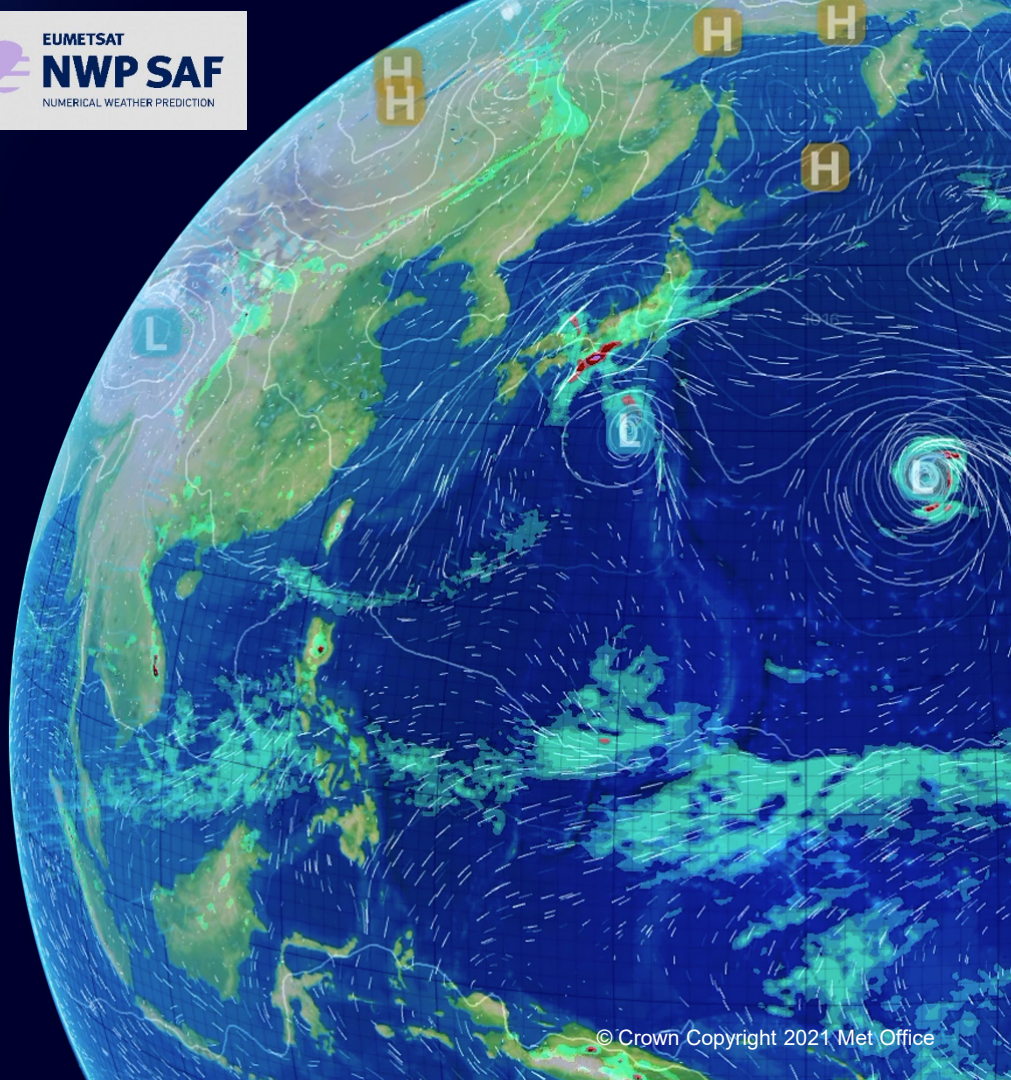
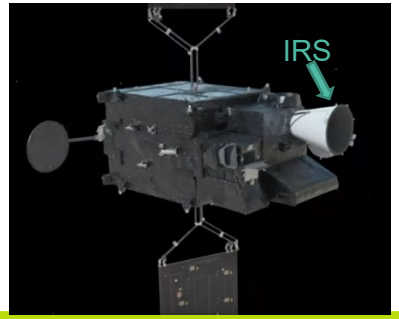


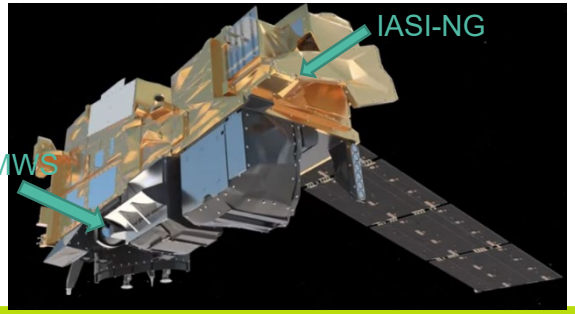
Introduction

- The NWP SAF is developing software to support Metop-SG-A, Metop-SG-B and MTG-S – all scheduled to launch around 2024
- This talk informs you about our plans
- We need feedback from ITWG on whether these plans will meet the needs of NWP users (i.e. review of user requirements)
- Instruments covered in this talk:

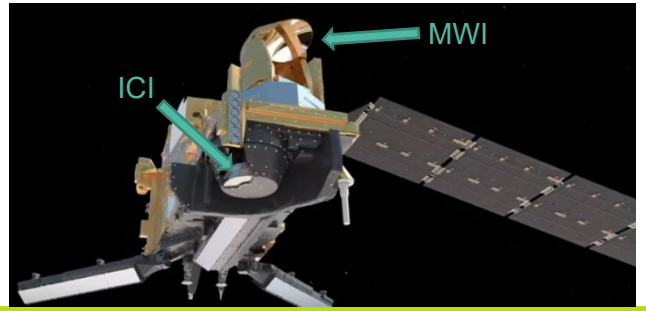
IRS (on MTG-S1)



MWS, IASI-NG (on Metop-SG-A1)



MWI, ICI (on Metop-SG-B1)



Aims of the NWP SAF

The NWP SAF aims *to improve and support the interface between satellite data/products and European activities in NWP*.

- One of several EUMETSAT Satellite Application Facilities
- Utilising specialist expertise from the Member States
- SAFs are dedicated centres of excellence for processing satellite data
- They form an integral part of the distributed EUMETSAT Application Ground Segment.

https://nwp-saf.eumetsat.int

Software packages for MTG and EPS-SG

Package	How it will support MTG and EPS-SG
EPSSGL1 (*new*)	Level 0 to level 1 processors for direct broadcast: • MWS, IASI-NG, METimage • MWI, ICI, SCA
AAPP	Extension, supporting MWS and IASI-NG, to be released as part of AAPP v9
MWIPP	Currently supports MWRI, GMI, AMSR-2, SSMIS. MWIPP v2 will add MWI and ICI support
IRSPP (*new*)	New package dedicated to MTG-IRS. Will include some functionality from the old IASI PCA package.

RTTOV and RadSim are also relevant to MTG and EPSSG – but these are not discussed in this talk

EPSSGL1: Direct broadcast processors

- To be procured by EUMETSAT. Distribution and user support by NWP SAF
- Most will be based on in-house prototypes (because global infrastructure was not scalable)
  - for MWS, METimage, MWI, ICI, SCA
  - IASI-NG to be provided by CNES (similar approach to OPS-LRS)
  - All contracted out to Industry for integration and packaging
- One package per instrument, they can be run independently
- Also a raw to level 0 processor (“METOP-SG-izer”)
- Outputs: standard Level 1 in netCDF

When?

Users can expect an initial version of each package 6 months before launch, and a final version 12 months after commissioning of each satellite

- Note: source code will be available (as per previous ITSC recommendations)

Pre-processing - common issues

- EUMETSAT's standard format for level 1 data is *netCDF* (v4) – which will ensure wide uptake within different user communities. Samples have been released via EUMETSAT web site.
- Some of these datasets are very bulky, and not optimised for NWP assimilation. Hence the need for pre-processing tools.
- Some data expected to be available in BUFR, either instead of or in addition to the netCDF (depending on instrument).
- Some data (not all) will be on the GTS

It's likely that NWP centres will need to do some pre-processing locally, e.g. –

- *Convert netCDF to BUFR*
- *Transform EUMETSAT's BUFR to something more suited for NWP*

Pre-processing software – technical aspects

Common features to the new modules: AAPP-EPSSG, MWIPP and IRSPP:

- All written in Fortran90 (the older parts of AAPP are still Fortran77, and likely to remain so)
- Have used the build system that is implemented in the current MWIPP: a shell configuration script, then *make*. Main advantage: it's easy to understand!
- External libraries are common to the three modules:
  - ecCodes, hdf5, netCDF (C and Fortran), LAPACK
  - A script will be provided to install these if not already available on your system
- Administrator privilege will *not* be required !

Mostly using netCDF Fortran API to read the instrument data, but variable length string attributes have to be read with the hdf5 Fortran API, using Fortran2003 constructs

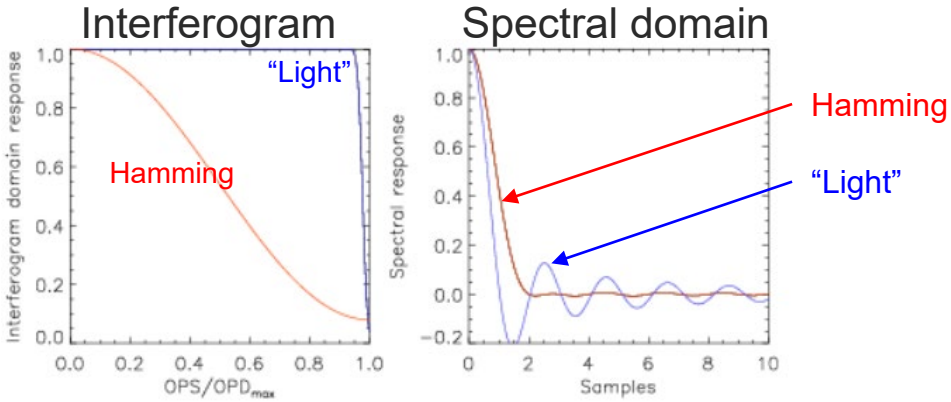
(We don't know any technical details about the EPSSGL1 packages yet)

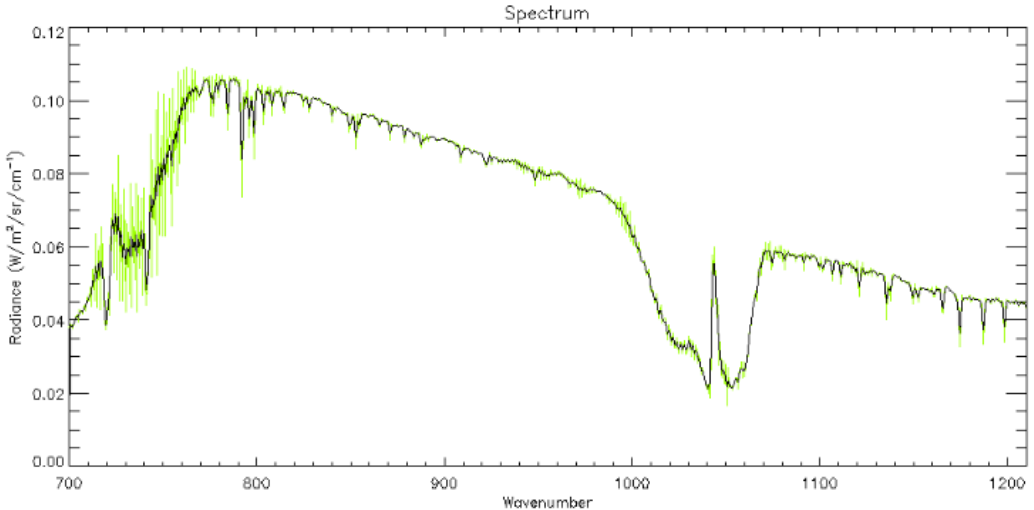
MTG-IRS

- EUMETSAT have 2 flavours of level 1 data
  - full spectra – not available in NRT, only from Data Centre
  - Principal Components (PC) – will be available in NRT. But likely too large to go on GTS.
- The *IRSPP* package will allow:
  - Generation of reconstructed radiances, for user-defined channel selection
  - Apodisation change (next slide)
  - BUFR encoding of PC scores and/or radiances
  - Various research tools (e.g. for generating your own PCs from full spectra)
- A design document (March 2021) is available at
  - https://nwp-saf.eumetsat.int/site/software/irspp/
- Planning a software release in late 2021 – so that users can try it out
- This is your last chance to influence the initial capabilities of the software! Please take a look.

Option to change apodisation

Easy to change apodisation when working with reconstructed radiances – just modify the eigenvectors





Some RT models struggle with negative sidelobes in the SRF

(Not an issue with HT-FRTC in RTTOV)

Options to change PC basis function

EUMETSAT's PC scores preserve information in the *observations*. Not necessarily optimal for NWP.

They can, if required, be transformed to an alternative basis function via a simple matrix multiplication

Two options for generating the transformation:

1. Use NWP SAF *Radiance Simulator* to generate covariance matrix from a training set of simulated spectra. Hence generate new eigenvectors and a transformation matrix
2. Transform EUM scores (150 in each band) directly into the PC basis function used by *HT-FRTC* (300 scores total, no distinction between bands)

More detail in the design document

MWS and IASI-NG

- Input data expected to be:
  - BUFR for NRT global stream
  - netCDF for local mission
- Will be supported via an add-on package to *AAPP*
- Planned to include:
  - Ingest
  - Spatial filtering of MWS (like ATMS)
  - NWP-independent microwave derived quantities as for AMSU/MHS … scattering indices, surface type, etc. See next slide.
  - Map MWS to IASI-NG (like AMSU to IASI, or ATMS to CrIS)
  - Generation of IASI-NG reconstructed radiances for channel selection (a selection of 500 channels has been defined by Francesca Vittorioso)
  - Or you can transform to the spectral resolution of the old IASI (Met Office will probably be doing this initially)
  - BUFR encode. We have drafted a IASI-NG sequence supporting PCs, radiances and mapped MWS. Similar to one proposed by EUMETSAT (in the L1B Product Format document), but containing extra info.

New for MWS: 229 GHz scattering index

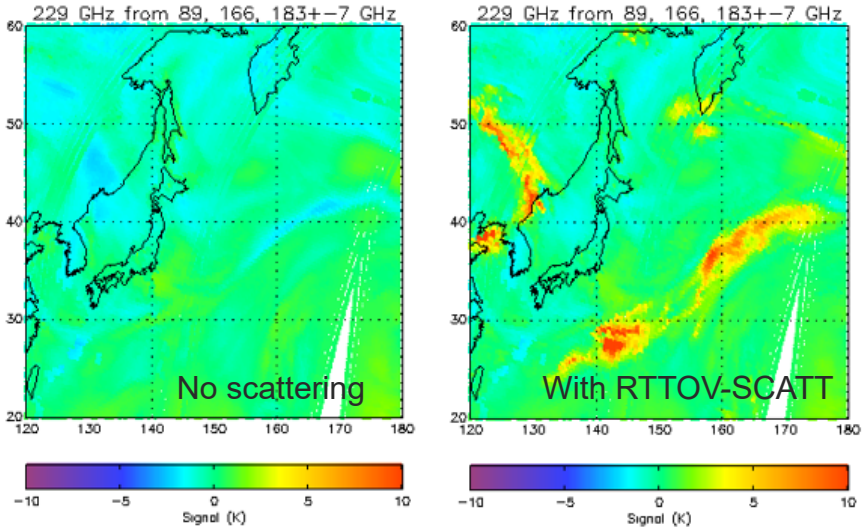
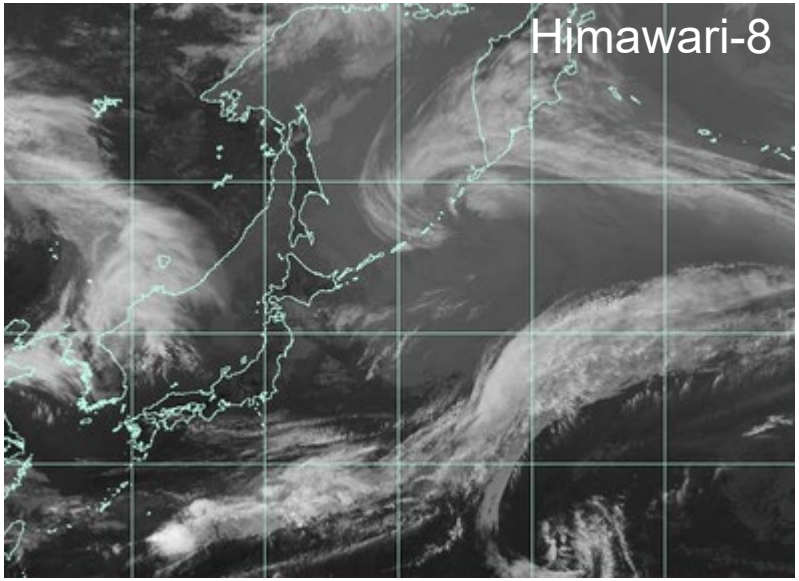


Figure 8: Signals over SE Asia for 20210601. Left: without RTTOV-SCATT, right: with RTTOV-SCATT turned on.



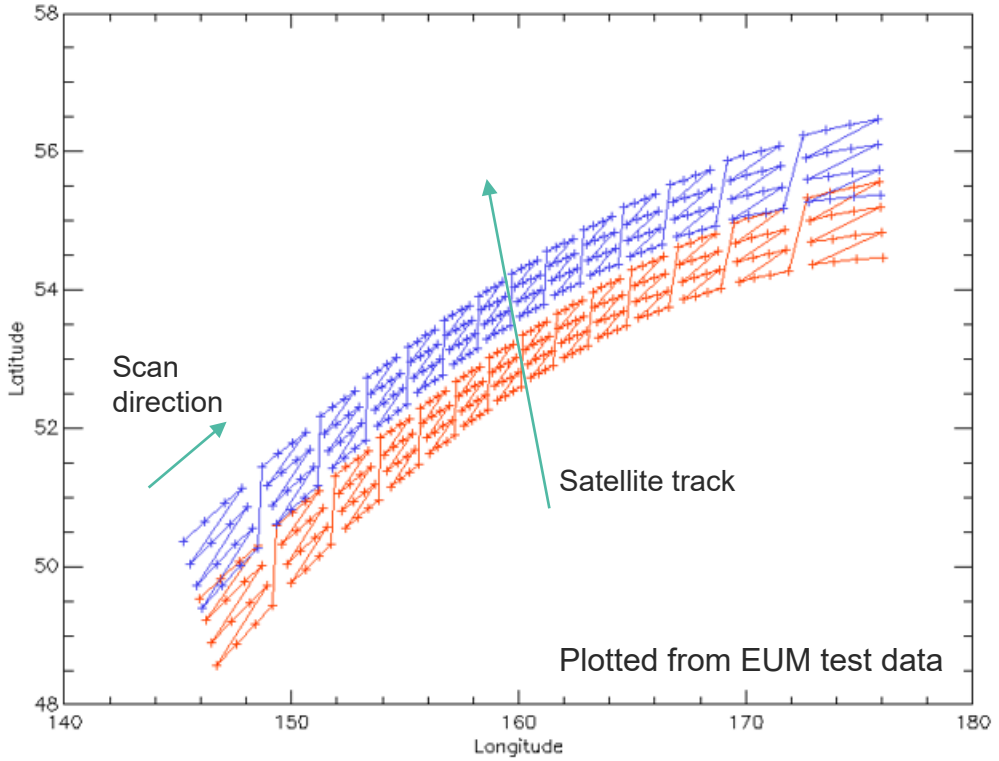
Used Radiance Simulator + RTTOV to generate predicted 229 GHz based on a scan-dependent linear combination of 89, 166 and 183±7 GHz, derived from clear air simulation

IASI-NG characteristics

	IASI-NG	IASI
Spectral samples	16921	8461
Bands	4	3
Fields of view	16	4
Fields of regard	14	30

Availability of global data:

- PC-compressed on EUMETCast satellite
- Full-spectra on EUMETCast terrestrial
- Channel selection on GTS



MWI and ICI

- Global level 1B distributed in netCDF and BUFR
- 8 feedhorns for MWI and 7 for ICI – all with different geolocation and heavily over-sampled in the scan direction (1.6km for all MWS channels – even those with footprint 50km!). Very bulky datasets (MWI+ICI = 1.5GB per orbit for netCDF)
- Pre-processing will be via *MWIPP*
- Planned to include:
  - Ingest
  - Spatial averaging to reduce noise
  - Map all channels to a defined feedhorn
  - Map ICI to MWI – creating a 39-channel super-instrument (26 MWI + 13 ICI)
  - Spatial thinning (e.g. to 10km) to reduce data volume to manageable levels
  - BUFR encode. A generic sequence is already available in MWIPP v1, a few additions are needed. Factor 20 decrease in data volume compared with 1B input. (Comparable with AMSR-2)

    NB: this is *not* the BUFR sequence described in EUMETSAT's MWI format document!

Smoothing

- First, we smooth the BT fields with a weighting

$$w = \exp(-r^2/(2\sigma^2))$$

(or use a boxcar)

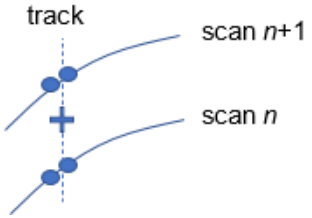
- where r is distance on the ground and σ is a width parameter, which can be defined for each channel

  - *Reduces noise (which is high because of the over-sampling)*
  - *Same approach was used for SSMIS*

Re-mapping

Next, MWIPP will map all FOVs to a specified MWI FOV

by default 118 GHz – in centre of cluster



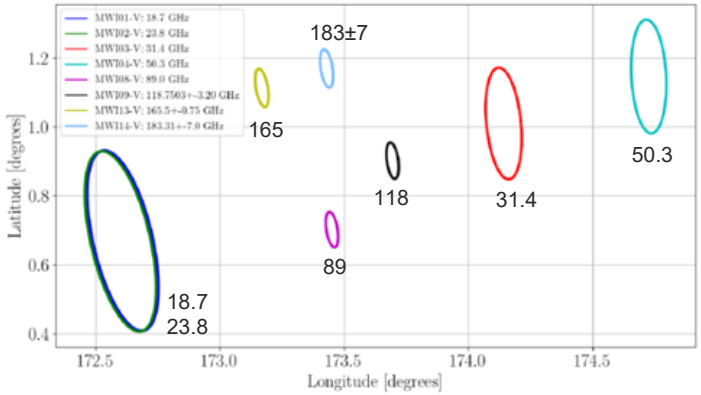


Figure 5: Fields of view for the MWI feedhorns (courtesy of EUMETSAT)

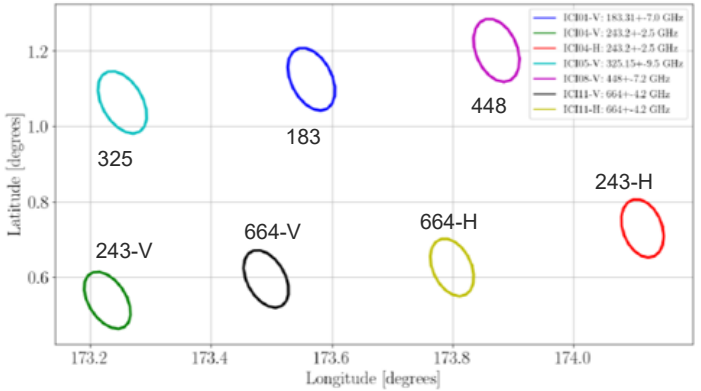
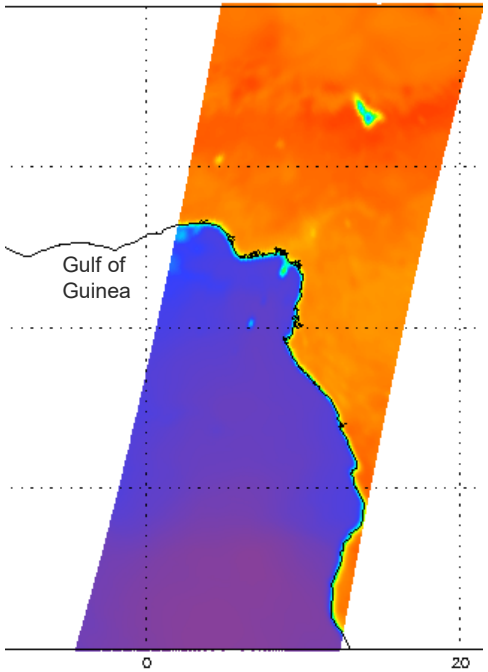


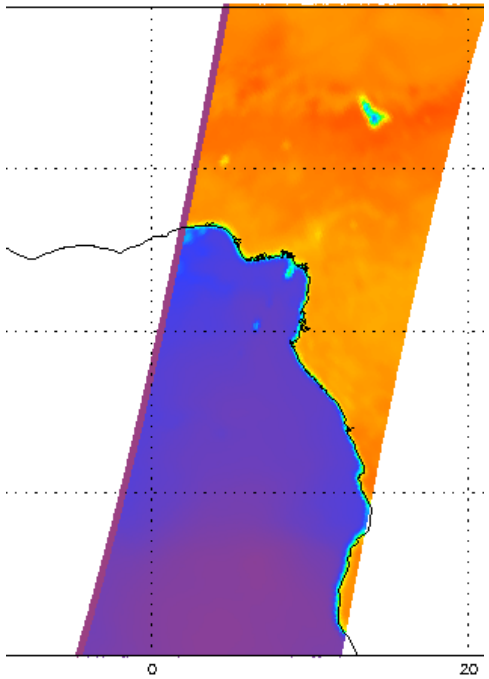
Figure 6 Fields of view for the ICI feedhorns (courtesy of EUMETSAT)

MWI re-mapping



Channel 1 with
its own geolocation

Channel 1 with
118 GHz geolocation
(error ~150km)



Channel 1 mapped to
118 GHz geolocation

Using the EUMETSAT test data

Next steps

- If you have an interest, please review the design documents at
  - https://nwp-saf.eumetsat.int/site/software/irspp/ (available since March 2021 – for IRSPP)
  - https://nwp-saf.eumetsat.int/site/software/mwipp/ (June 2021 – covers AAPP and MWIPP)

  (*NWP Working Group has taken an action to review these*)
- Have we included all the functionality that users are likely to need?
- Schedule:
  - IRSPP v1 scheduled for release in late 2021. *Beta testers needed – volunteers?*
  - Formal requirements reviews for AAPP v9 and MWIPP v2 at end of 2021
  - AAPP v9 and MWIPP v2 main releases in 2023 but beta versions can be made available earlier
- If you have comments, or would like to test the software, let me know.

Thank you!

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