

Preparation of MTG era.

iSHAI product from MTG-I1 on MTG era



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Index of presentation. Info of iSHAI on NWC SAF web

- ✓ Introduction to iSHAI.
- ✓ iSHAI version 2025. First with MT-I1/FCI support:
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 - ✓ Bias BT correction in version 2025
 - ✓ iSHAI v2025 training and validation dataset
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iSHAI (i-mager Satellite Humidity and Instability)

<http://nwc-saf.eumetsat.int>

Direct link iSHAI info page:

http://nwc-saf.eumetsat.int/ishai_description



References

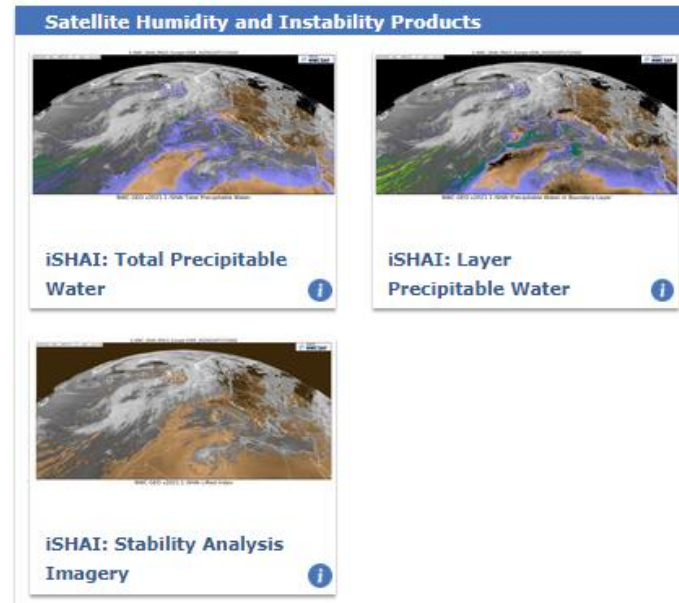
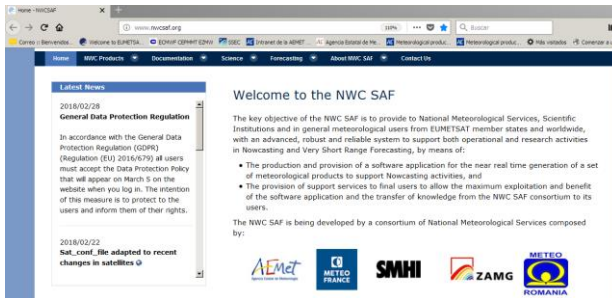
<http://nwc-saf.eumetsat.int/AemetWebContents/ReferenceSystem/GEO/HTMLContributions/iSHAI/references.html>

iSHAI on NWC SAF framework

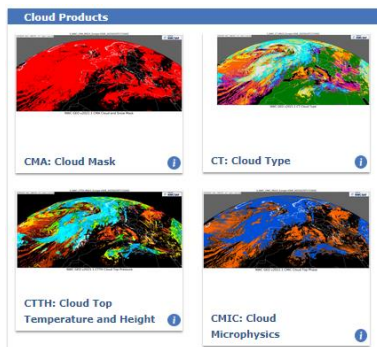
<http://nwc-saf.eumetsat.int>

iSHAI (i^mager S^attellite H^umidity and Iⁿstability)

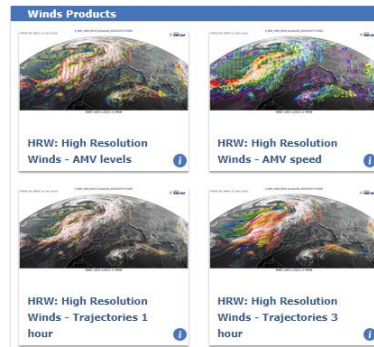
Former PGE13 SPhR(SEVIRI Physical Retrieval)



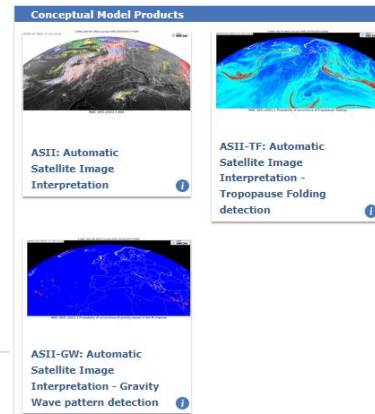
Cloud products



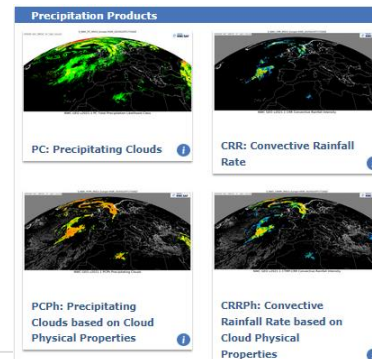
Winds Products



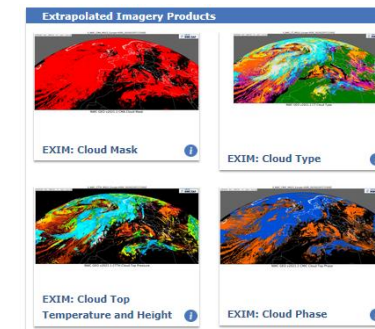
Conceptual Model Products



Precipitation Products



Extrapolated Imagery Products



Convection Products



ser's workshop 2023
idrid, 25-27 February 2025

iSHAI description

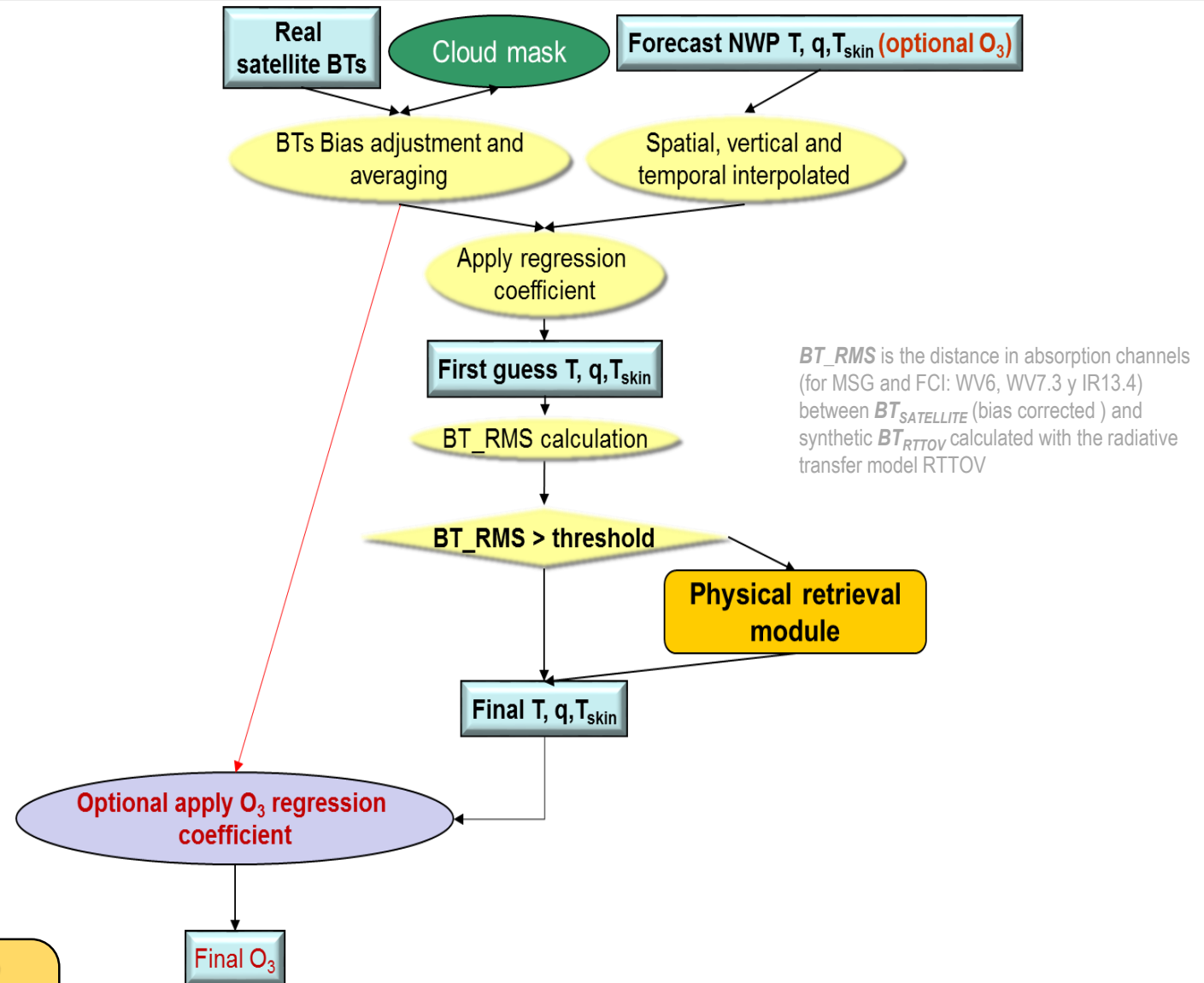
It is a combination of one statistical and one optimal estimation. **Only on clear air pixels** (or NxN boxes) it is made:

First step:

- Use of a non linear regression to built First Guess from collocated background NWP temperature and humidity profiles and bias corrected satellite BTs.

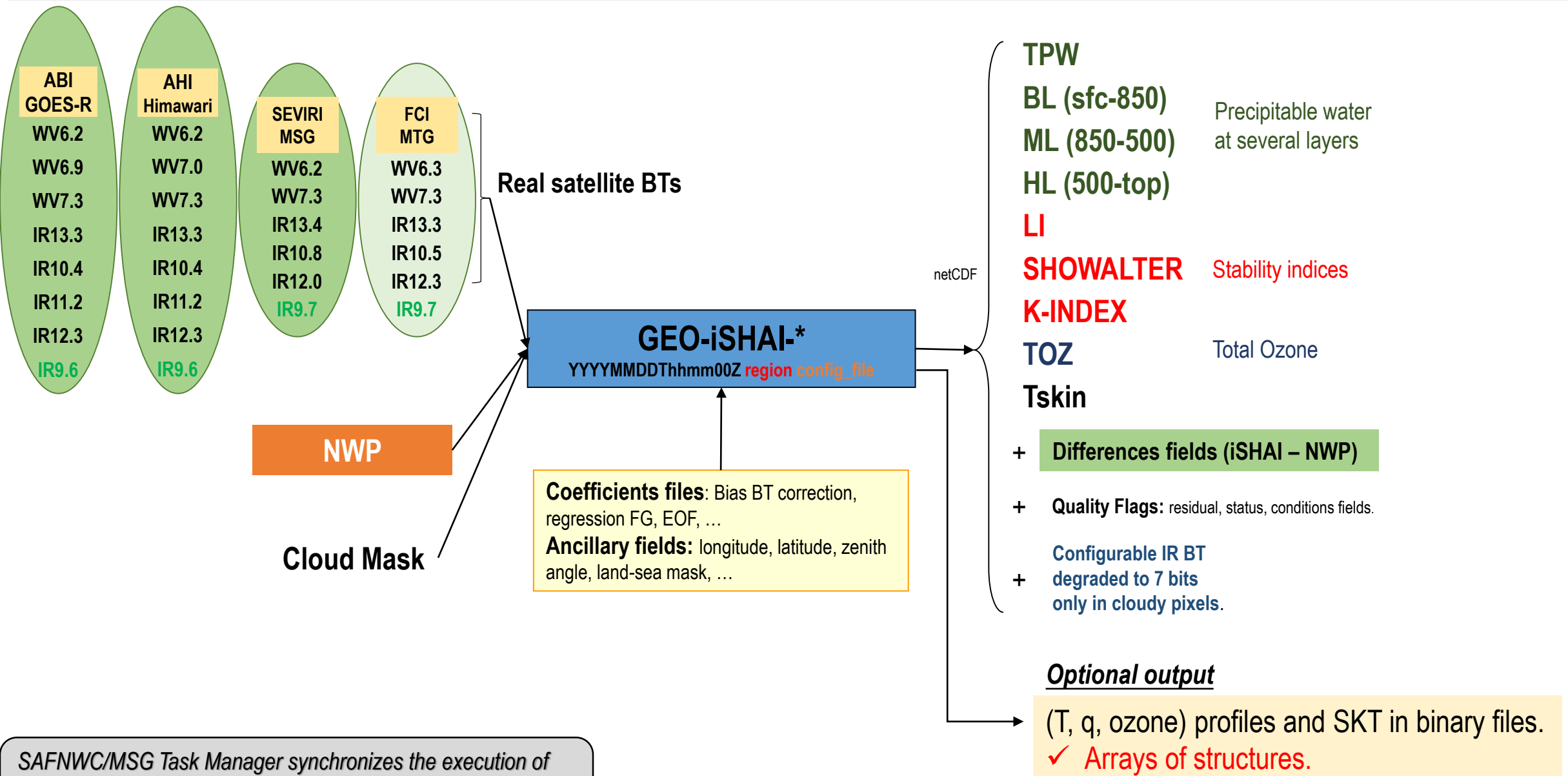
Second step:

- A physical retrieval algorithm (optimal estimation) with some improvements over the classical approach:
 - Use of EOFs to reduce the dimension of matrix and reduce the computation time:
 - 3 EOFs for T, 3 EOFs for q and 1 EOF for T_{skin}



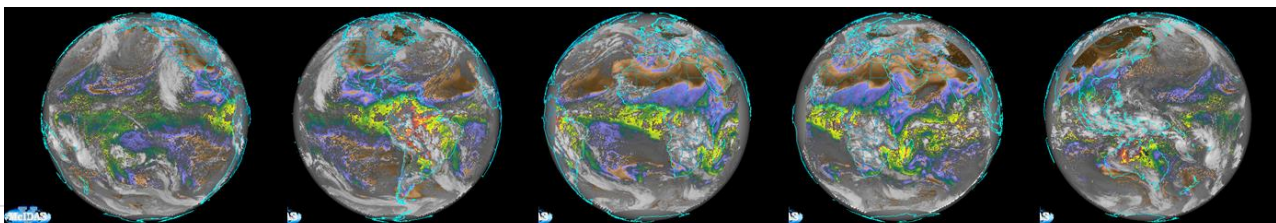
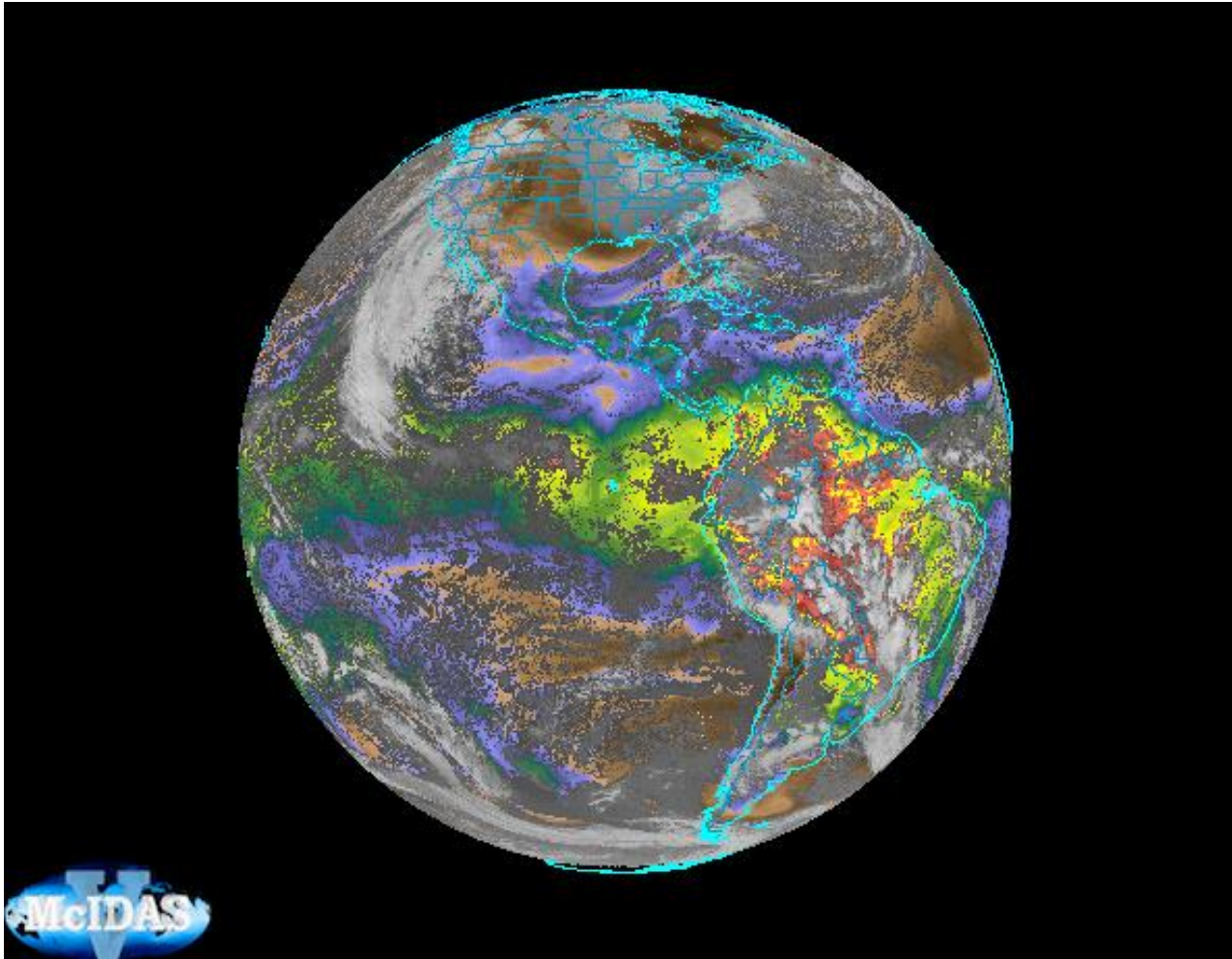
The algorithm is similar to that used by NOAA for the GOES-R. The base algorithm was provided by Dr. Jun Li of CIMSS-Wisconsin.

iSHAI inputs and outputs scheme on version v2025. First with MT-I1/FCI



SAFNWC/MSG Task Manager synchronizes the execution of the products and the first product that is generated upon the arrival of a new image is the cloud mask.

iSHAI on GEO ring. Training and validation datasets generation.



GOES-17

GOES-16

MSG-4

MSG-1

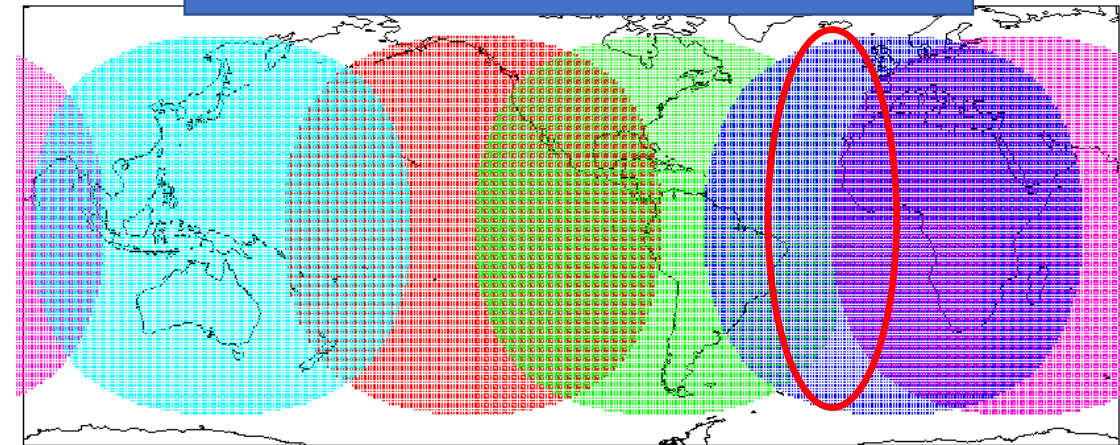
Himawari-8

ISHAI is available on the whole GEO ring.

Generation of training and validation dataset from bias BT correction datasets generation chains. A lot synergies can be get:

- ✓ Important the overlapping region of GOES-East (GOES-R class) and MSG 0° and MTG-I/FCI for cross validation of iSHAI products with the equivalent from NOAA.

Positions of records in bias BT estimations



iSHAI Model Configuration File: Main iSHAI configurable options and parameters

iSHAI is highly modular and configurable.

The options are activated through editing the iSHAI Model Configuration File (extension .cfm) in `$SAFNWC/config` that is an ASCII file with all the processing options. It is the third argument in iSHAI execution

The main options are:

- The window size for processing in boxes of M x M pixels (default 3 x 3).
- `BT_RMS_THRESHOLD` and `MAX_RESIDUAL` keywords. They control the level of the desired error between the bias corrected SEVIRI BTs and the RTTOV BTs.
- Number of iterations. Maximum number of iterations is 3 iterations.
- **TOZ calculation activation**
- The name of all coefficients files are keywords in the configuration files.
- Activation of optional writing of temperature, specific humidity and ozone profile and skin temperature at clear processed Fields of Regards (M x M pixels) or for all pixels are

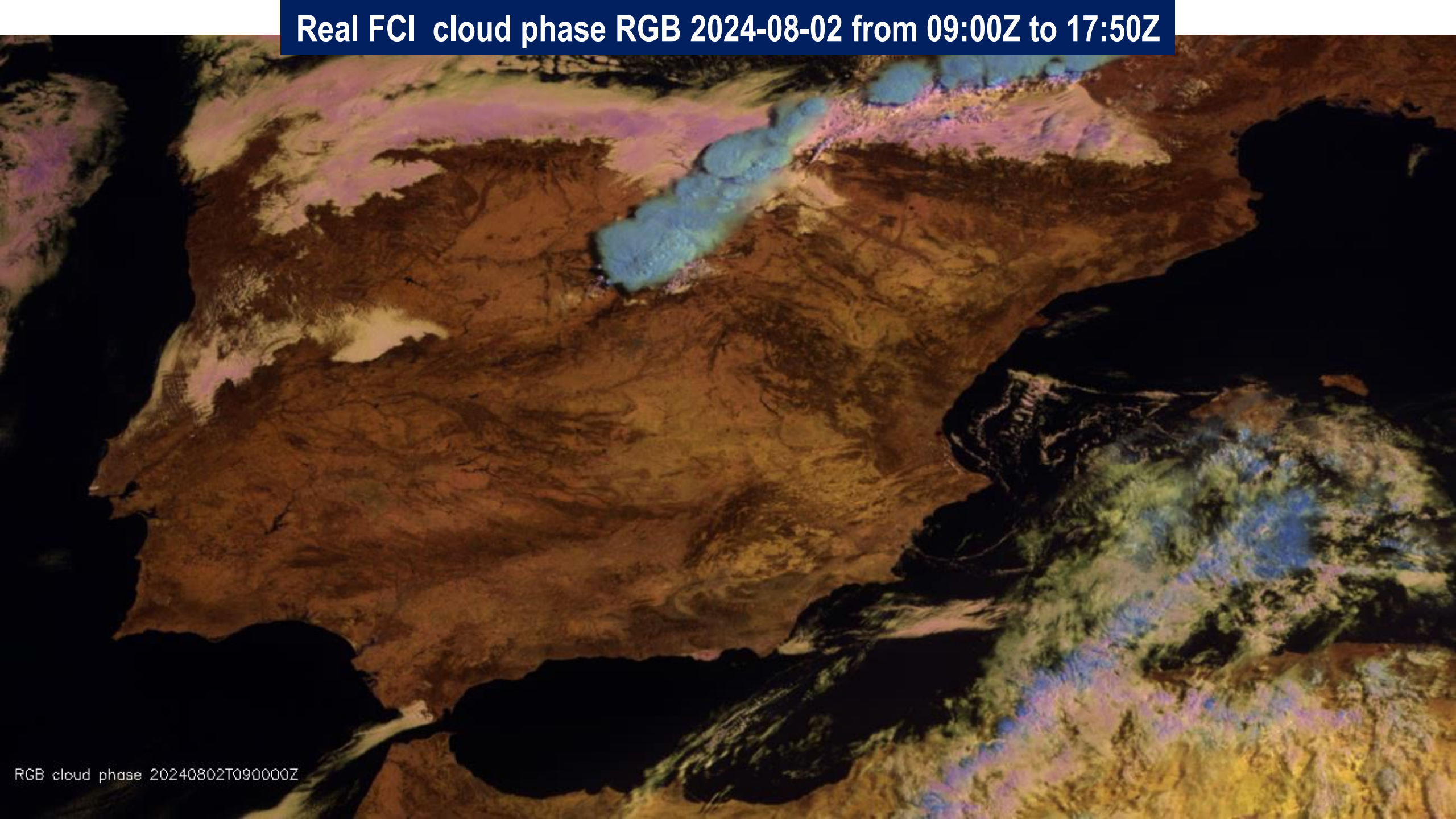
In iSHAI is important to use as background NWP input GRIB files with the best spatial, vertical and temporal resolution as possible.

In the case of ECMWF NWP model there is the possibility to use GRIB file on hybrid levels.

- The change from iSHAI **mode P** to iSHAI **mode Hybrid** is made changing in the iSHAI configuration file the keyword **`NWP_EXEC_MODE`** from **P** to **HYB**

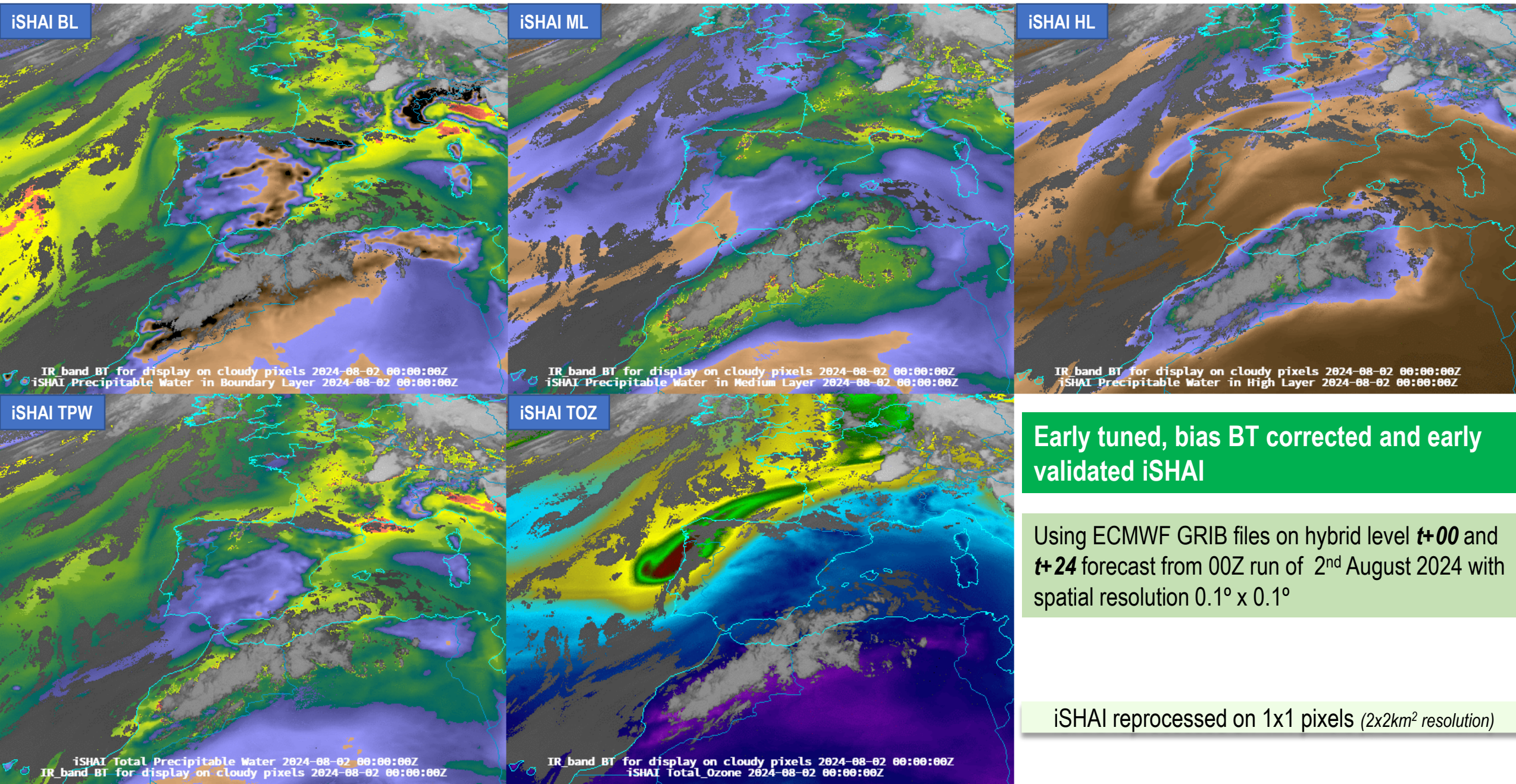
Note: Full details in the Product User Manual Document on the NWCSAF Help-Desk

Real FCI cloud phase RGB 2024-08-02 from 09:00Z to 17:50Z



RGB cloud phase 20240802T090000Z

Example of MTI1/FCI iSHAI images: 2nd August 2024

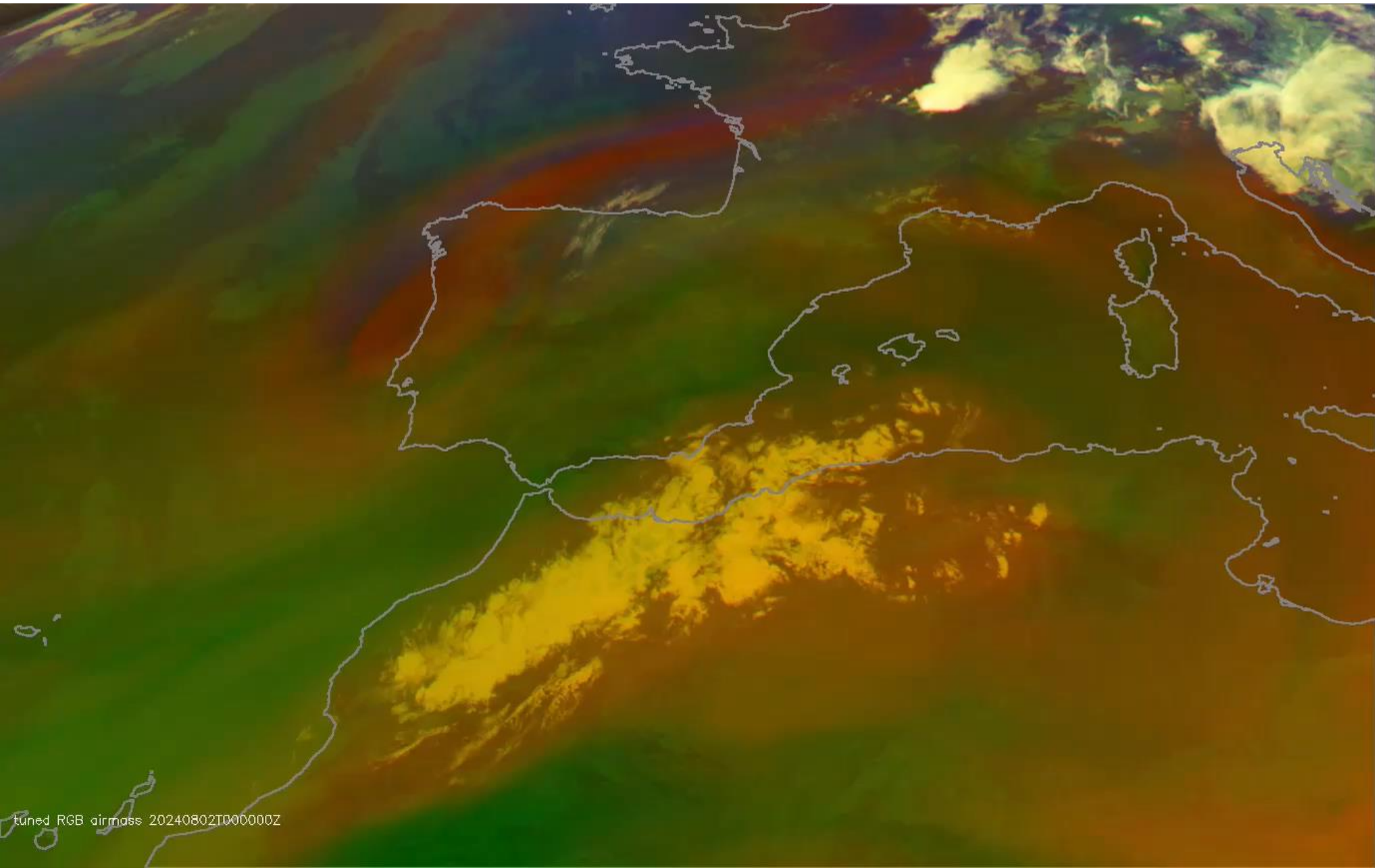


Early tuned, bias BT corrected and early validated iSHAI

Using ECMWF GRIB files on hybrid level ***t+00*** and ***t+24*** forecast from 00Z run of 2nd August 2024 with spatial resolution 0.1° x 0.1°

iSHAI reprocessed on 1x1 pixels (*2x2km²* resolution)

Real FCI airmass RGB 2024-08-02 from 00:00Z to 23:50Z



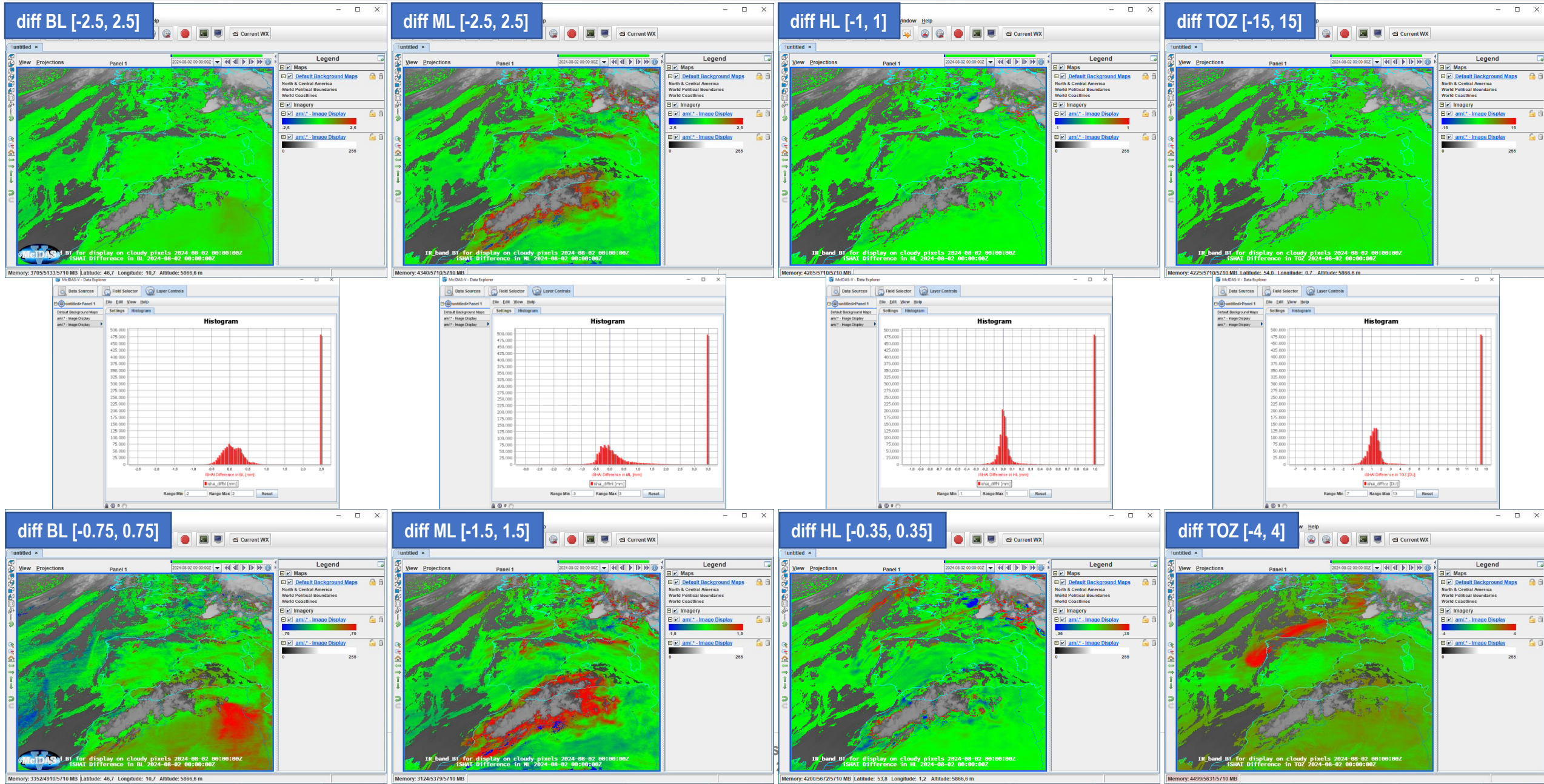
channels	Range	γ
WV6.3-WV7.3	[-23.92, -0.13] K	1
IR9.7-IR10.5	[-40.31, 4.13] K	1
WV6.3	[244.2, 208.86] K	1



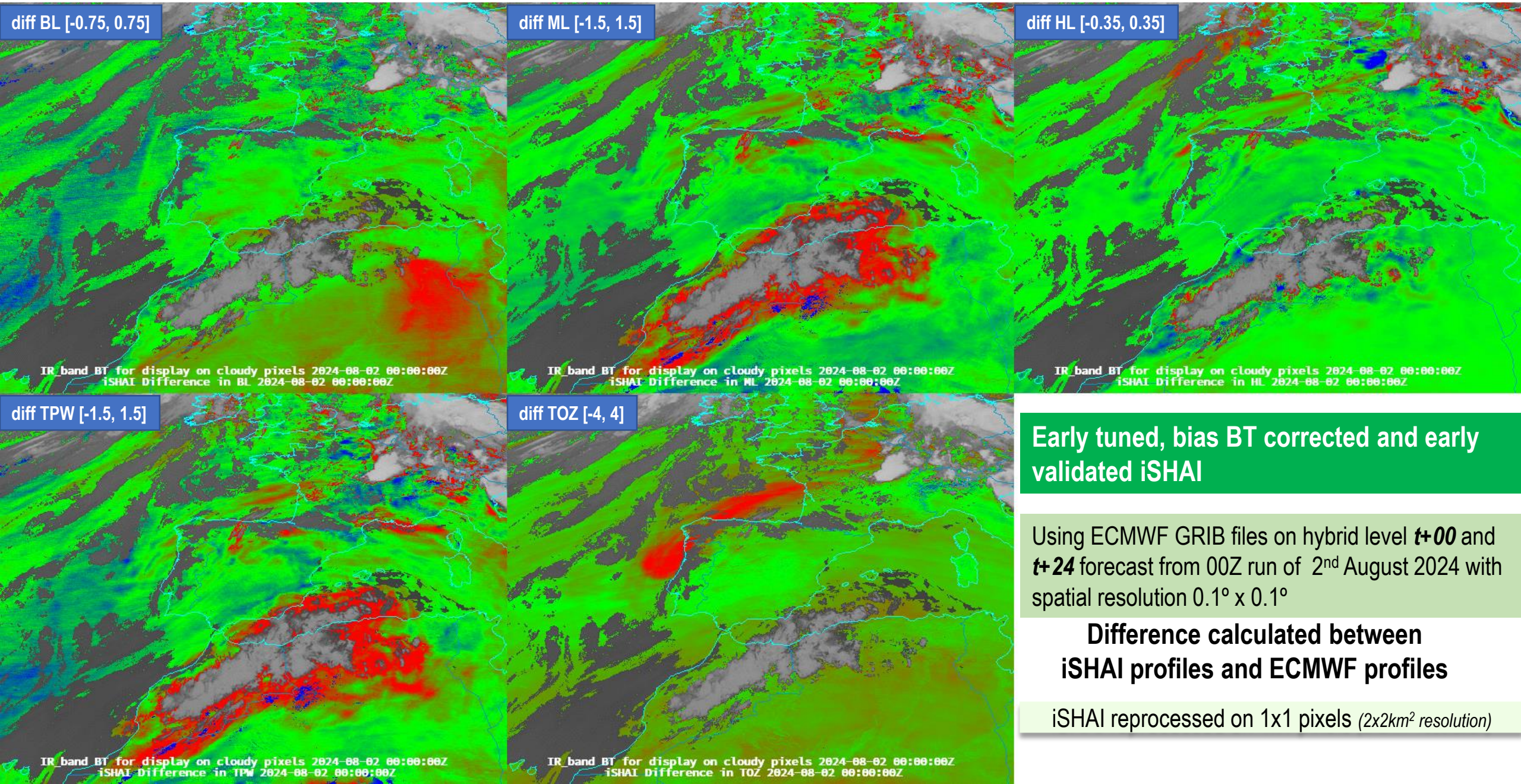
Early and provisional
new FCI airmass RGB

Generated using
regressions of MSG to
FCI. Then, applying
regressions original
threshold

Interactive scale range selection



Example of MTI1/FCI iSHAI images: 2nd August 2024



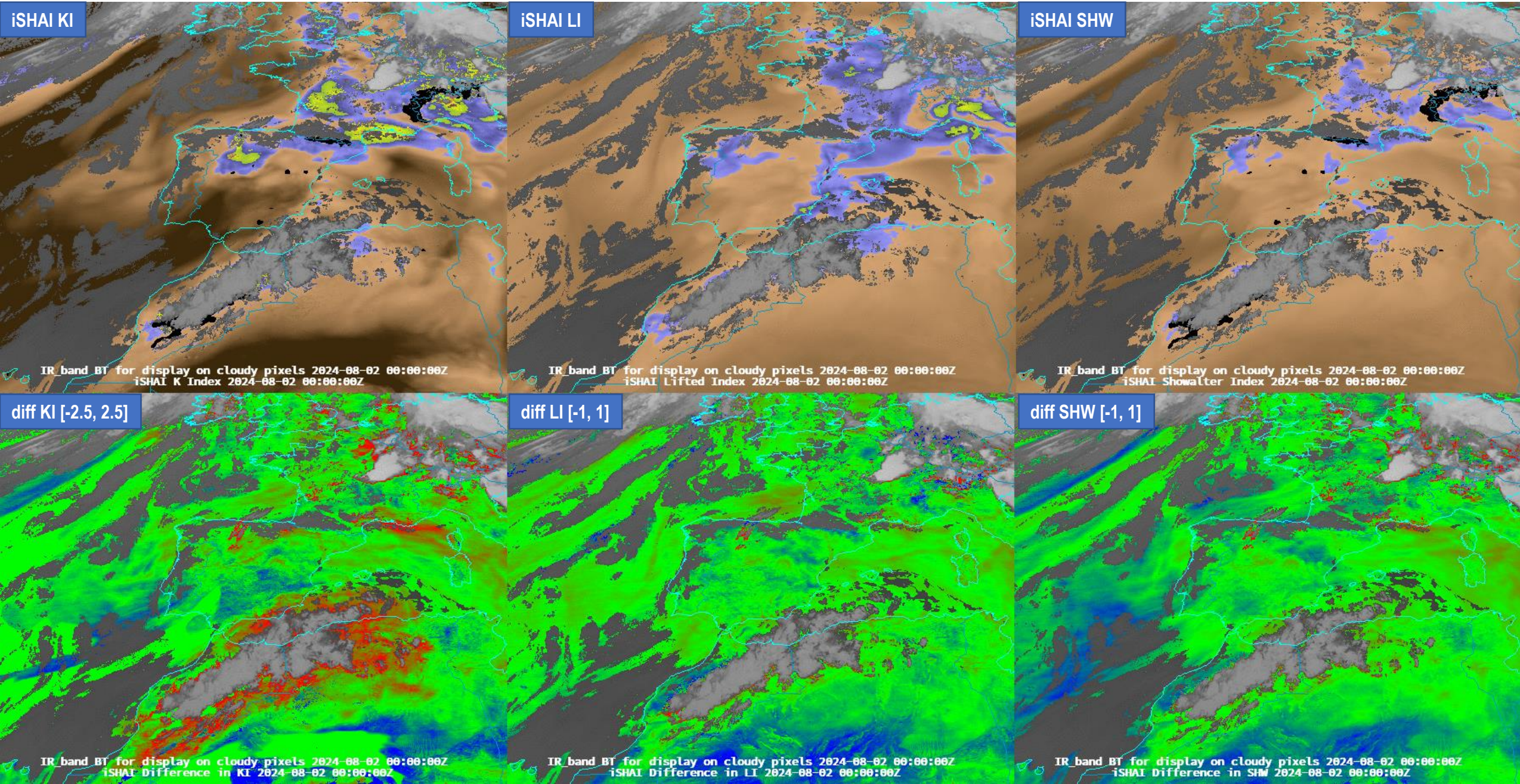
Early tuned, bias BT corrected and early validated iSHAI

Using ECMWF GRIB files on hybrid level ***t+00*** and ***t+24*** forecast from 00Z run of 2nd August 2024 with spatial resolution 0.1° x 0.1°

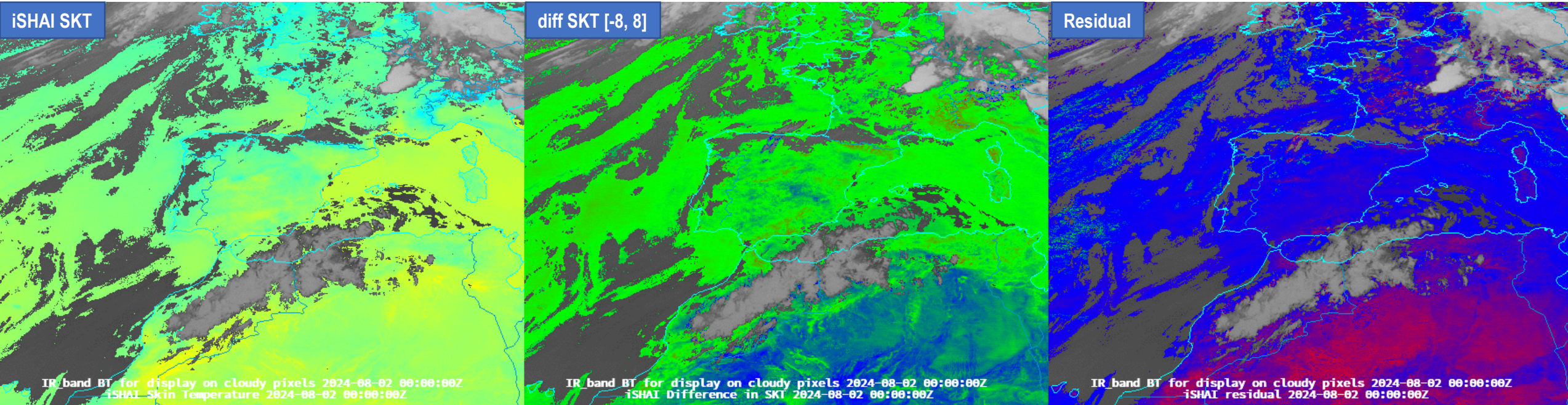
Difference calculated between iSHAI profiles and ECMWF profiles

iSHAI reprocessed on 1x1 pixels (*2x2km² resolution*)

Example of MTI1/FCI iSHAI images: 2nd August 2024



Example of MTI1/FCI iSHAI images: 2nd August 2024



iSHAI skin temperature introduced just for iSHAI performance and monitoring of iSHAI retrieval quality purposes.

iSHAI SKT is not SST or LST field.

Residual
Square root of sum
($BT_{seviri} - BT_{rttov}$)

Early tuned, bias BT corrected and early validated iSHAI

Using ECMWF GRIB files on hybrid level **t+00** and **t+24** forecast from 00Z run of 2nd August 2024 with spatial resolution 0.1° x 0.1°

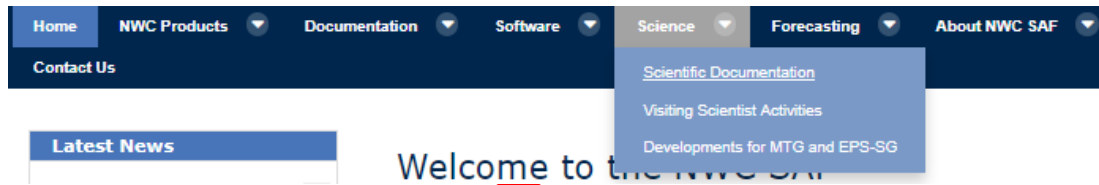
iSHAI reprocessed on 1x1 pixels (2x2km² resolution)

Bias BT correction & Training/Validation

Bias BT correction coefficients in NWC SAF web

<https://www.nwcsaf.org/>

Direct link should be <http://www.nwcsaf.org/web/guest/bias-bt-correction-coefficients>



Scientific Documentation

- NWCSAF/GEO Basic Documents
- NWCSAF/PPS Basic Documents
- NWCSAF/Auxiliary GEO Files

NWCSAF/Auxiliary GEO Files

- Bias BT correction coefficients
- HRW BUFR tables
- RDT BUFR tables

It will be added the Bias BT correction coefficients for version 2025.



Bias BT correction coefficients for operational satellites

Description	Link
Bias BT correction coefficients for NWC SAF GEO package v2021-v2018-v2016	
Files for MSG-3 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for MSG-2 IODC and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for Himawari-09 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for GOES-16 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for GOES-18 and ECMWF GRIBs in Pressure levels	biasBT PGE00P

Bias BT correction coefficients for reprocessing

Description	Link
Bias BT correction coefficients for NWC SAF GEO package v2021-v2018-v2016	
Files for MSG-4 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for MSG-3 at 0° and ECMWF GRIBs in Pressure levels (from Feb 2013 until January 2018)	biasBT PGE00P
Files for Himawari-08 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Files for GOES-17 and ECMWF GRIBs in Pressure levels	biasBT PGE00P
Bias BT correction coefficients for PGE13 SPHR product v2013	
Files for MSG-3 and ECMWF GRIBs in Pressure levels (until January 2018)	biasBT PGE13P
Files for MSG-3 and ECMWF GRIBs in Hybrid levels (until January 2018)	biasBT PGE13Hyb
Bias BT correction coefficients for PGE13 SPHR product v2013 (for MSG4 until October 2021)	
Files for MSG-4 and ECMWF GRIBs in Pressure levels	biasBT PGE13P
Files for MSG-4 and ECMWF GRIBs in Hybrid levels	biasBT PGE13Hyb
Files for MSG-1 IODC and ECMWF GRIBs in Pressure levels	biasBT PGE00P

PGE00 and iSHAI: biasBT dataset construction

To build a bias BT dataset with real satellite data, ECMWF model is an important task.

Every month is added to the bias BT dataset the previous month records. It is made reprocessing with PGE00 program at 00Z and 12Z only over a set of points (*a grid of $1^\circ \times 1^\circ$ positions and RAOB*) using ECMWF *t+00 (analysis)*.

Binary files allows to create a dataset of (T, q, O₃, ..) profiles collocated with real radiances, etc.

It is used for monthly calculation of bias BT correction coefficients published on NWCSAF web.

Since BT bias corrections coefficients are part of NWCLIB software => **The full set of IR channels of every imager are monitored.**

It allows to get the evolution of the **bias correction between real BTs and synthetic BT_RTTOV** over sea pixels. Differences between a mean value before and after the bias correction calculated for a “moving average” window.

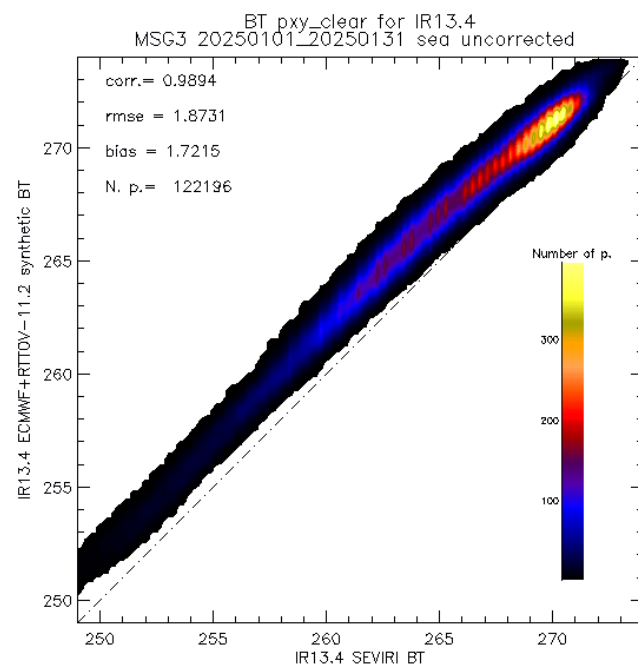


Figure: January 2025 MSG-3 biasBT correction for IR13.4 channel using RTTOV-11.2 and biasBT v2021 chain

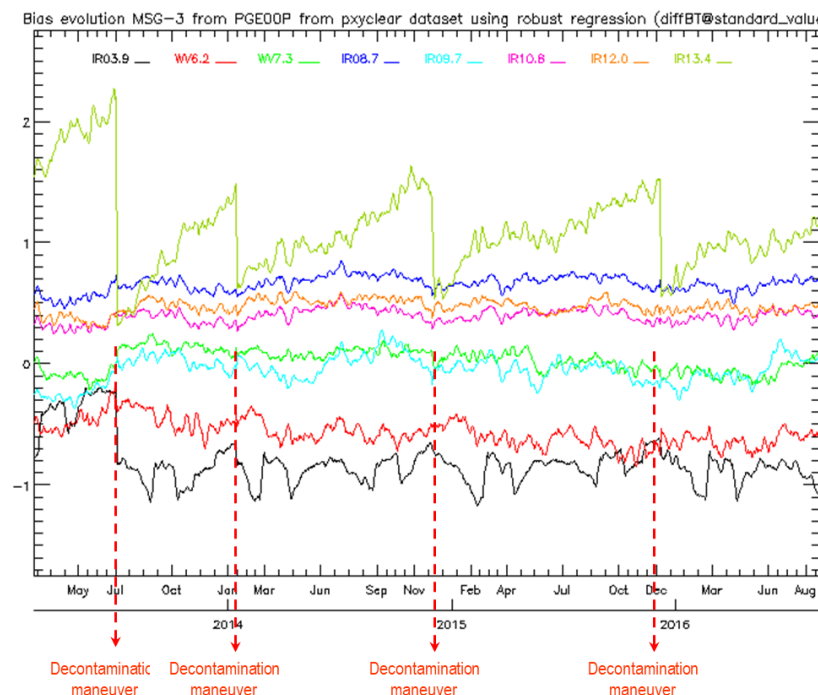
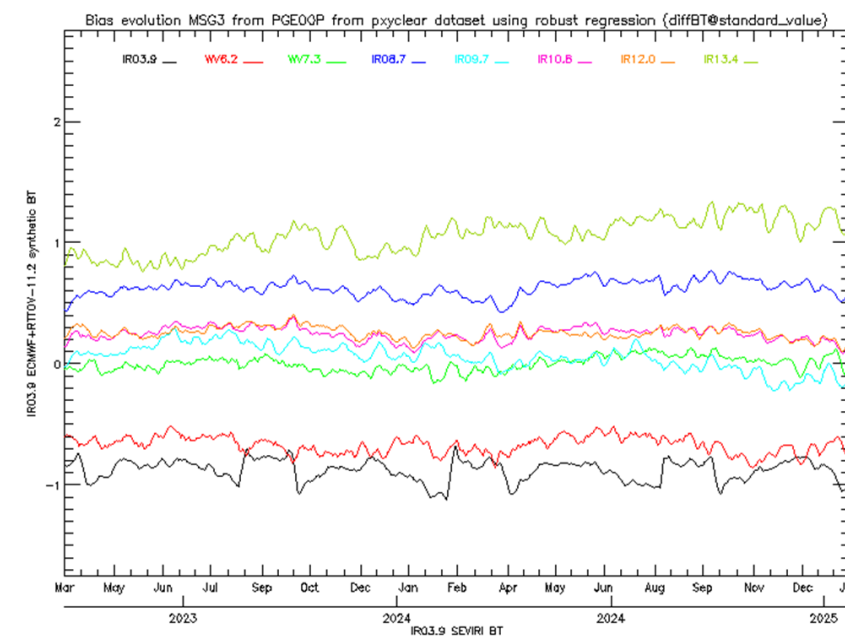


Figure: Evolution of MSG-3 biasBT with time



PGE00 and iSHAI: biasBT dataset construction with v2025

To migrate v2021 bias BT chain to v2025 bias BT chain is an important task. It has been migrated from v2021 to v2025 the bias BT PGE00 program for MSG-3. Using this it has been created the v2025 bias BT PGE00 for MTI1/FCI. Also the associated scripts, configuration files, etc has been updated from MSG-3 to MTI-1/FCI. It implies the change from RTTOV-11.2 and RTTOV-13.0. The process of migration to v2025 of GOES-R class and Himawari bias BT chain is ongoing. They will be used for monthly calculation of bias BT correction coefficients and they will be published on NWCSAF web.

Since BT bias corrections coefficients are part of NWCLIB software => **The full set of IR channels of every imager are monitored.**

It allows to get the evolution of the **bias correction between real BTs and synthetic BT_RTTOV** over sea pixels. Differences between a mean value before and after the bias correction calculated for a “moving average” window.

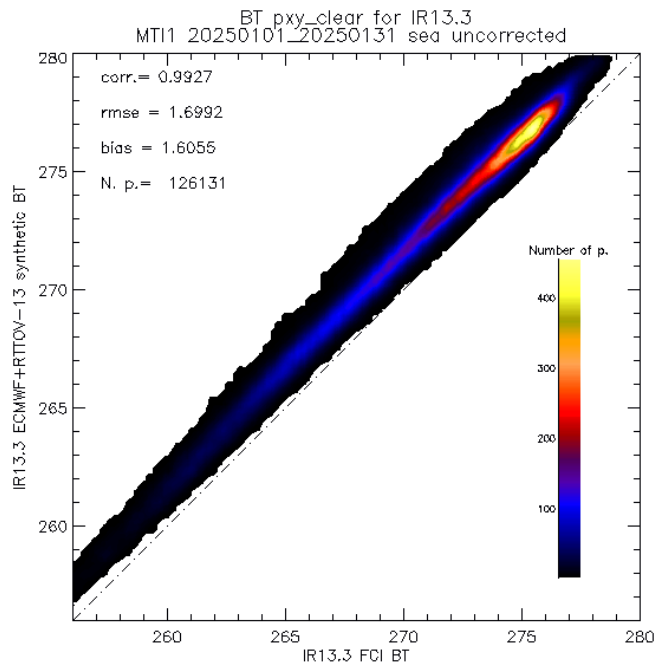


Figure: January 2025 MTI-1/FCI biasBT correction for IR13.3 channel using RTTOV-13.0 and biasBT v2025 chain

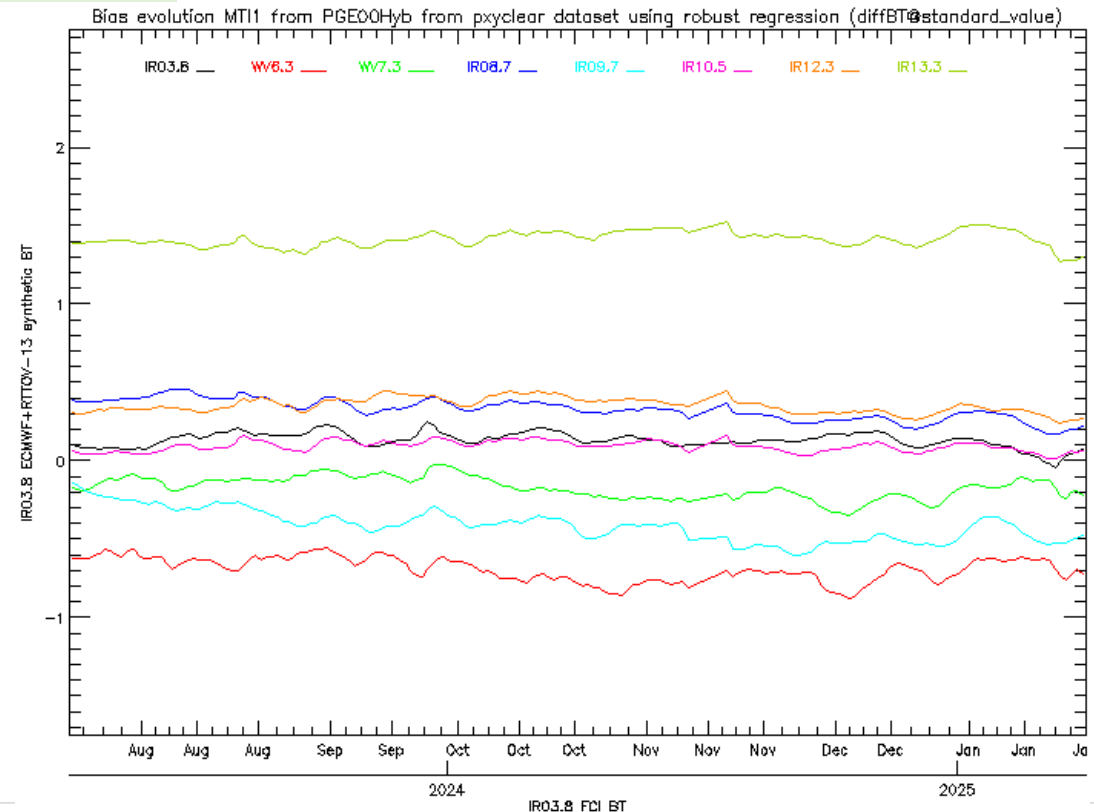


Figure: Evolution of MTI-1/FCI biasBT with time

From bias BT dataset to iSHAI training and validation dataset

To build a training and validation dataset with real MTG-I1/FCI, MSG-3/SEVIRI data and ECMWF NWP model is an important task.

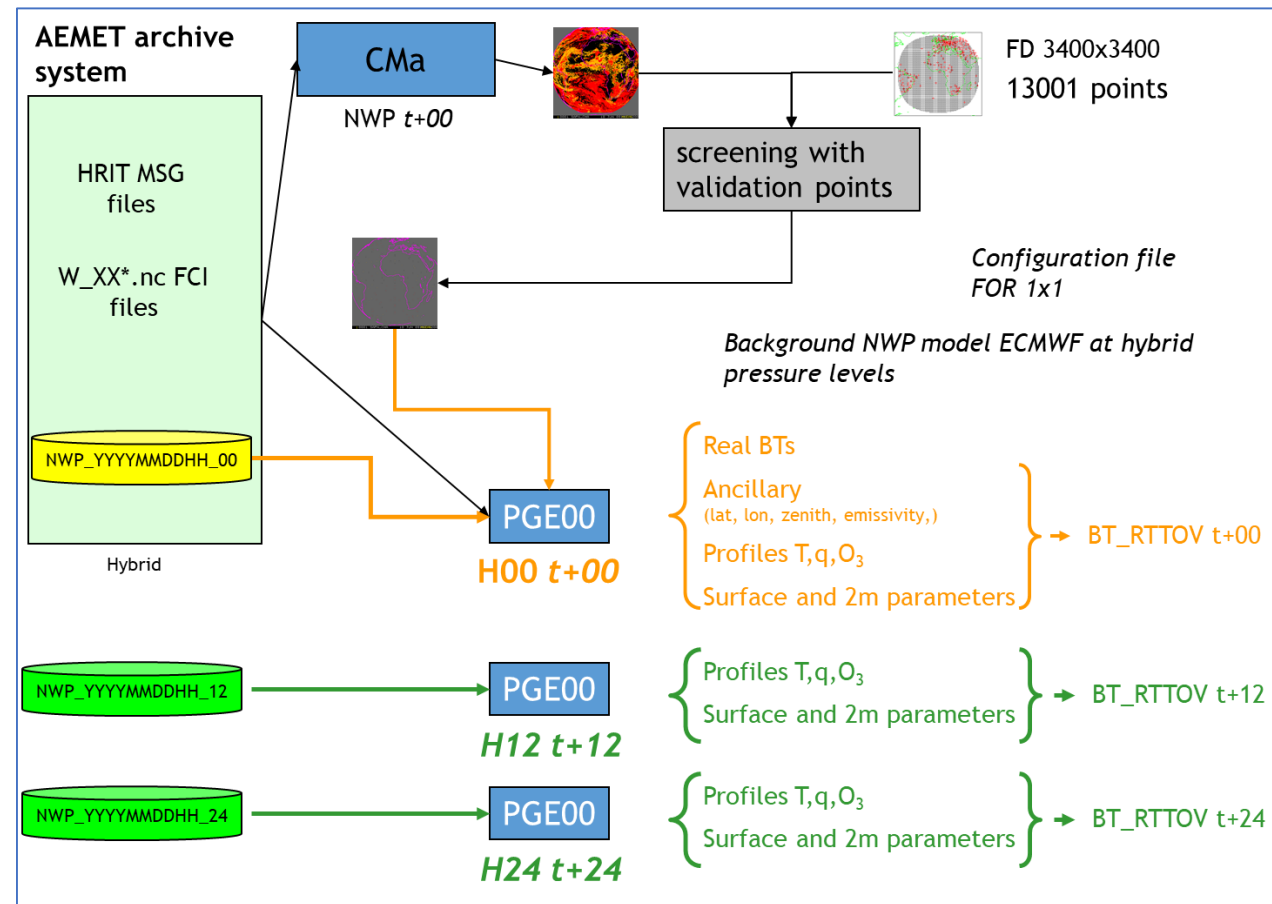
PGE00 binary files allows to create a dataset of (T, q, O₃, ..) profiles collocated with real radiances, etc.

It is based in a reprocessing using another PGE00 program to get collocated t+12 and t+24 forecast to the date and time of the records on the bias BT dataset and to calculate the BT_RTTOV for t+12 and t+24 profiles using ECMWF t+12 and t+24 forecast GRIBs files.

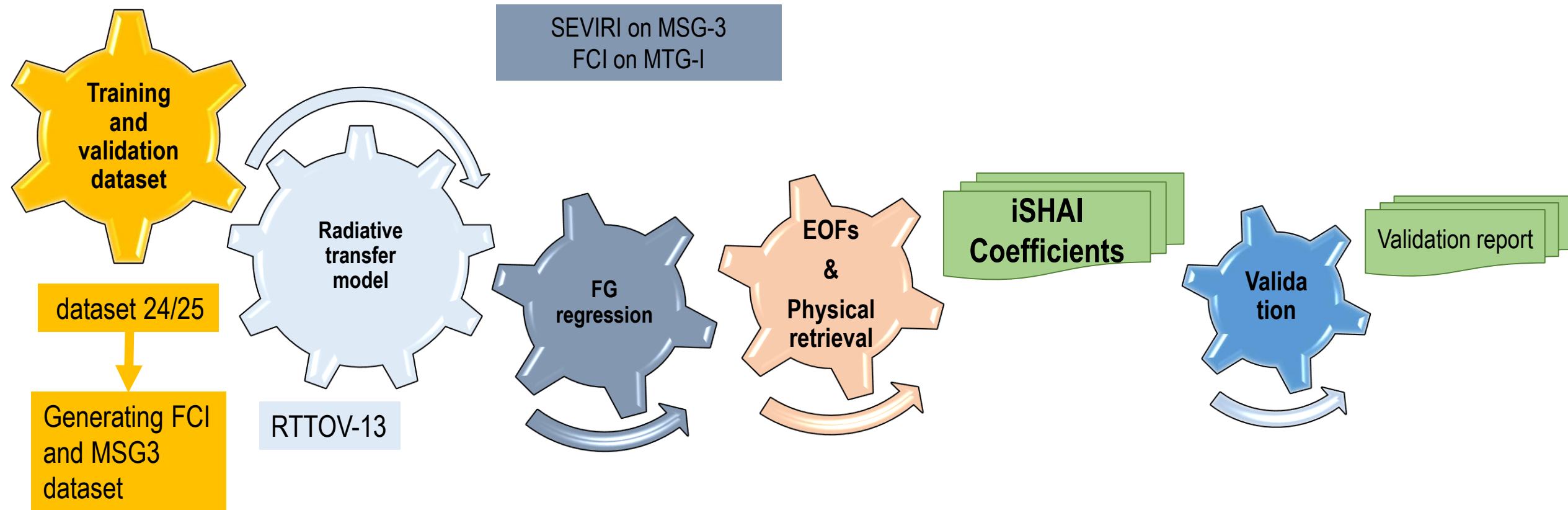
Binary files allows to create a dataset of (T, q, O₃, ..) profiles from t+00, t+12 and t+24 collocated with real and synthetic radiances, etc.

This early dataset contains profiles from 25 July 2024 to 31 January 2025.

The coefficients of version 2025 have been updated and calculated with profiles of this early iSHAI validation and training dataset. The 1 out of 3 observations with offset 0 has been used to build the training dataset. The 1 out of 3 observations with offset 1 has been used to build the validation dataset.



Training and validation activities on v2025



Physical retrieval coefficients generated

Regression coefficient file. This coefficient file contains 76 regression coefficients; each coefficient dataset corresponds to one local zenith angle ranging from 0 to 75 degrees

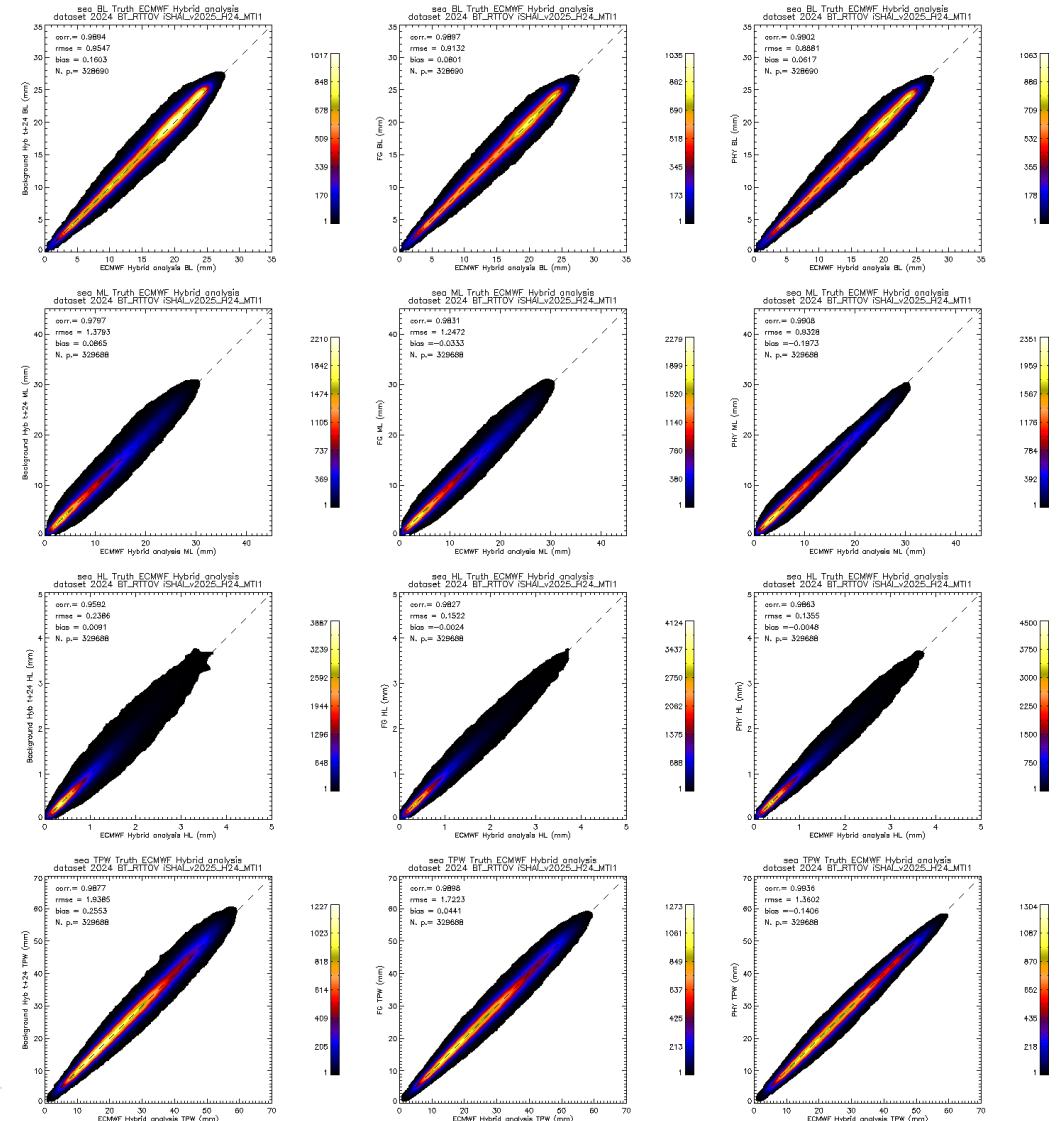
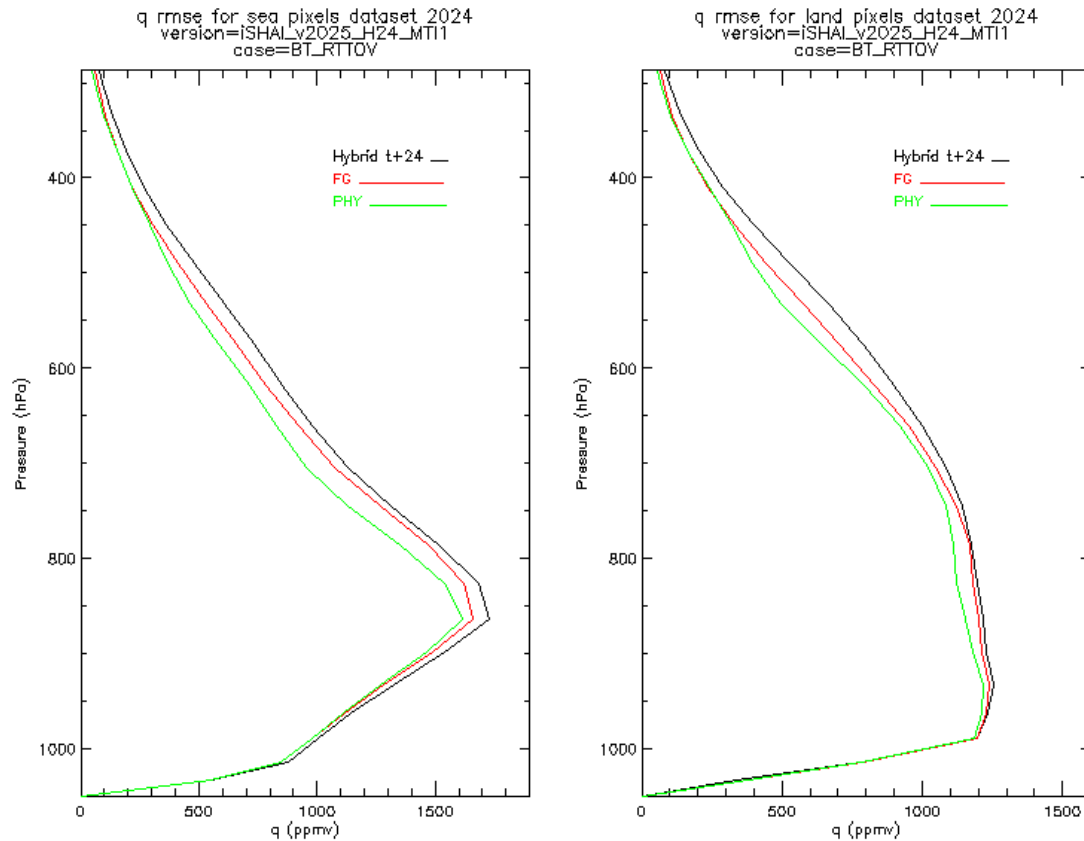
Inverse error covariance matrix of background and first guess (**B_{inv}**)

Inverse of error covariance of observation matrix (**E_{inv}**)

Empirical Orthogonal Functions coefficients.(**EOFs**)

Early validation of iSHAI FCI on MTG-I

The performance of MTG-FCI is similar to the MSG-SEVIRI one. Taking into account that MTG-FCI will have better spatial and temporal resolution than MSG-SEVIRI, the

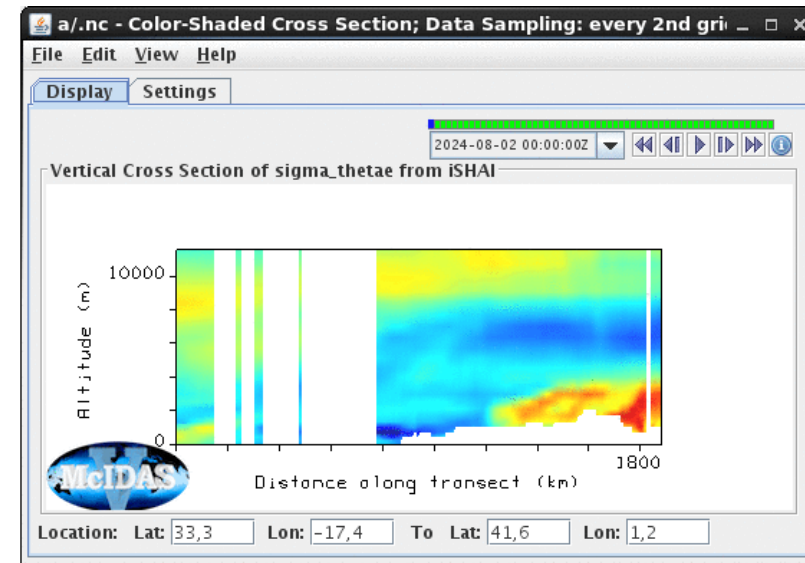
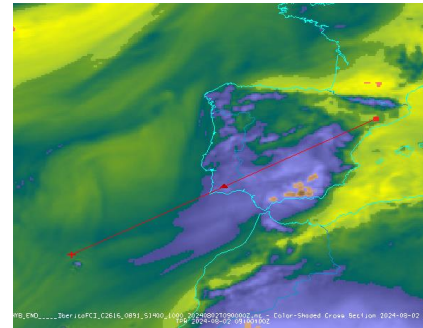


It is the basis to develop the future NWC SAF iSHAI MTG-FCI Day-1
MTG-I day1 algorithm will be tuned with first set of MTG/FCI data

iSHAI optional OUTPUTS: iSHAI binary files with the profiles at the different steps of physical retrieval algorithm.

Conversion to NetCDF format. Normalized 3D datacubes in McIDAS-V

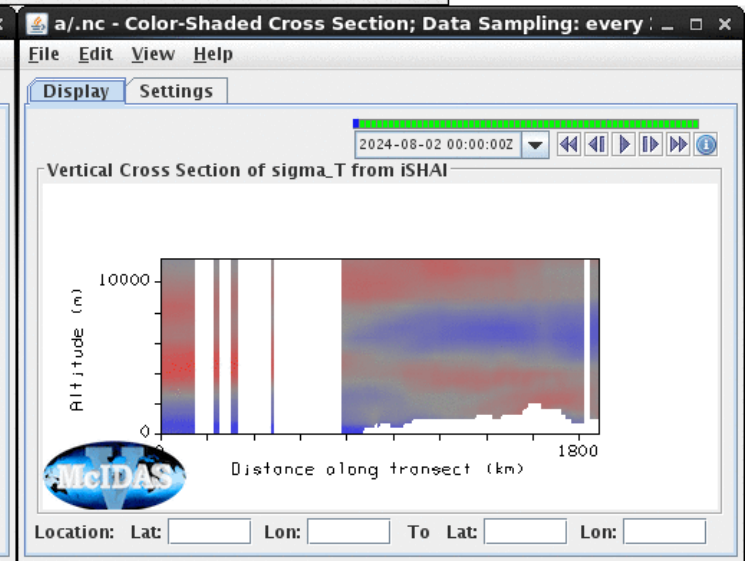
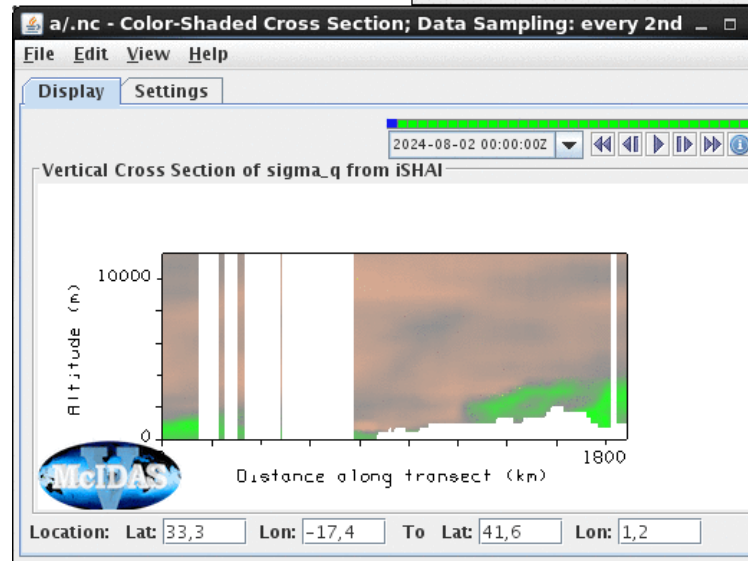
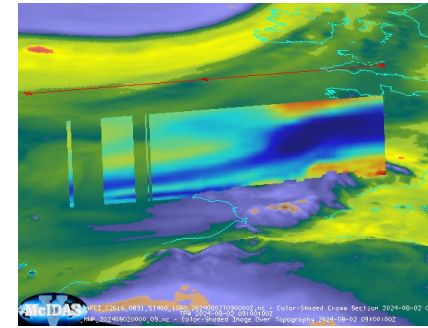
- As an **optional output**, the iSHAI retrieved profiles of temperature, humidity and ozone interpolated at 54 RTTOV levels may be written as another output on binary format. Also profiles from NWP and at FG step can be saved. The users **can activate it in the ASCII configuration file**. If activated the binary files will be written in the `$SAFNWC/tmp/iSHAI` directory.
- Since 2010 I have IDL software to convert them to NetCDF files that can be used on [McIDAS-V](#) or [IDV](#) tools.
- Due to the vertical differences in range on T and q 3D arrays are difficult to display directly. An approach is the generation of normalized by level 3D arrays.
- These normalized 3D datacubes are generated after calculation the mean and standard deviation on one slot at every layer and then create the normalized 3D cube subtracting the mean and dividing by the standard deviation at every layer. When display in 3D view or vertical cross section is direct to identify the regions and layers that are relatively wet/dry or hotter/colder than the mean.
- With adequate normalized 3D T color palette normalized T 3D the red structures => hotter than mean and blue structures => colder than mean.
- With adequate normalized 3D q color palette normalized q 3D the beige structures => drier than mean and green structures => wetter than mean.



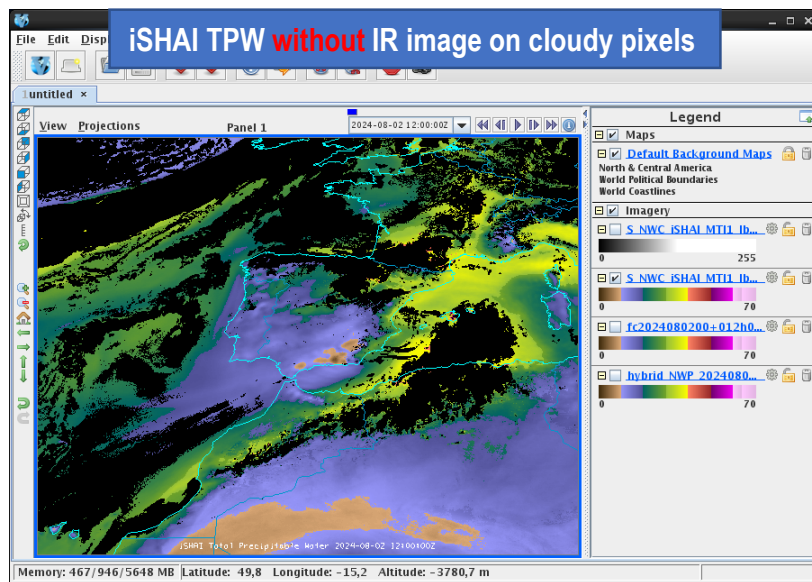
Generated with normalization of every level

Normalization=(field - mean_ref)/stdev_ref

Mean_ref stdev_ref calculated from t-12

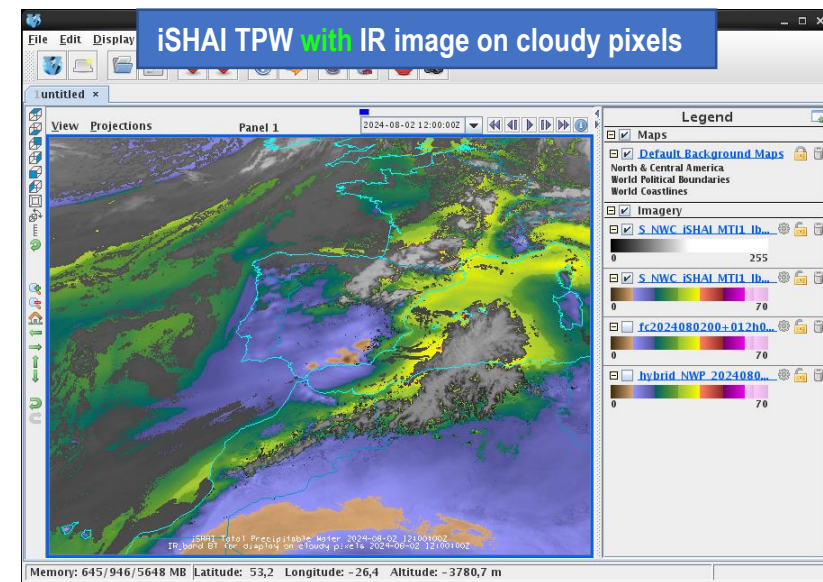


Other possibilities to display iSHAI

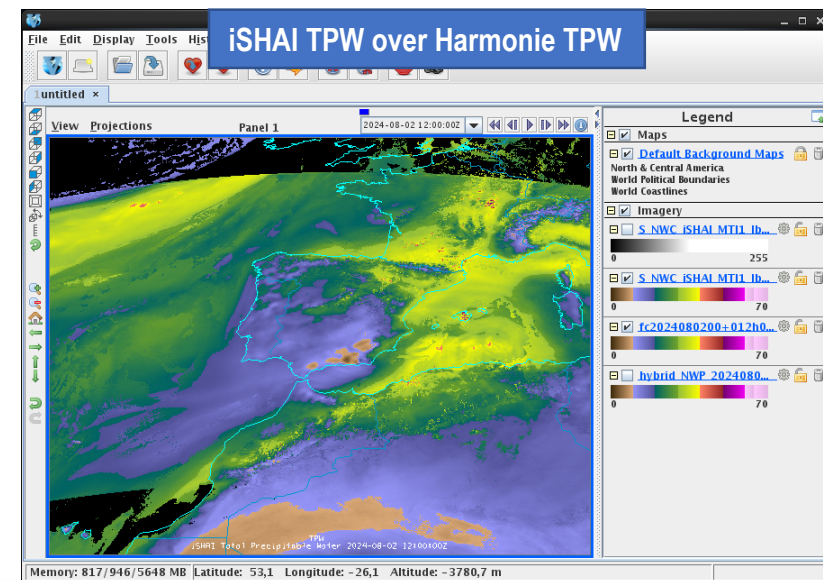
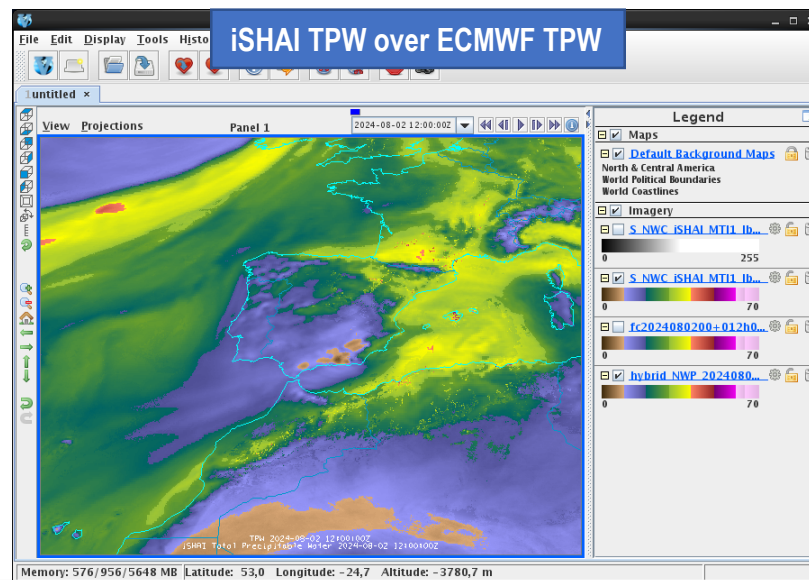


The IR image included in iSHAI netCDF is important to avoid the “black holes” in the display of the fields on cloudy pixels.

IR image helps to get consistency in loops.



Normally iSHAI fields are combined with clouds in cloudy pixels but there are other possibilities such as equivalent fields of numerical models.



Conclusions

- ✓ Version 2025 of NWCSAF includes clear air product iSHAI on FCI Day-1 support. It has been introduced the support of MTG-I1/FCI while maintaining the other GEO imager support. iSHAI available on the whole GEO ring.
- ✓ iSHAI provides useful spatial and temporal information. It could be used to detect disagreement between the background NWP model and the iSHAI outputs based on satellite observations.
- ✓ Validation and datasets generation is a continuous and important task. It is linked to bias BT correction task. Through the generation of training and validation dataset from bias BT correction datasets generation chains.
- ✓ The formats of the files are important. They should be as closer to the user tools as possible. The optimal format be one that will allow the users just “click and play” files.

Main improvements in iSHAI version 2025

- **Updated to version 2025 of NWCSAF library.** In this version the NWC SAF software has been improved and updated for FCI maintaining the support to the other GEO satellite processing.
- **Change of the version of RTTOV from RTTOV-11.2 to RTTOV-13.0.** it implies the recalculation of all the coefficients.
- **Maintained of Total Ozone as output.** This imply the addition of the ozone profiles in the training and validation datasets. **The IR9.7 channel is other input** (only used if TOZ calculation is activated).

iSHAI outlooks

Important the overlapping region of GOES-East (GOES-R class) and MTG/MSG at 0° for cross validation of iSHAI products with the equivalent from NOAA.

Possibility to check improvements of iSHAI and the performance of iSHAI from GOES-R class and from MTG/MSG.

Further there exist the possibility to create IR dual iSHAI products.

Use of tests of iSHAI with synthetic BTs as inputs.

Use of tests of iSHAI with high resolution NWP as background NWP.

**Exploration of synergies with other FCI channels. Specially the VIS0.9 and VIS0.8
See VIS0.9 presentation.**

Exploration of synergies with IRS-L1. See qlRS presentation.

Exploration of synergies with IRS-L2. See sSHAI-ES presentation.

Other business: use of the iSHAI training and validation dataset of collocated MSG-3/SEVIRI and MTI1/FCI for RGB tuning using both synthetic and real BTs.

Thanks for your attention