

Preparation of MTG era: status of proxy IRS data generation.

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Index of presentation and iSHAI in NWC SAF web

Index of presentation

- ✓ Updated PGE00s to NWCSAF vMTG_STRR library
 - ✓ Synthetic MTG-I/FCI data
 - ✓ Synthetic IASI as proxy of MTG-S/IRS data
- ✓ PGE00_1d: use of iSHAI training and validation dataset
- ✓ Past activities:
 - ✓ Syntheric IASI 22th July 2019 data on MSG/SEVIRI grid
- ✓ Next activities: synthetic MTG-S/IRS simulations
- ✓ Needs of EUMETSAT test data for NWCSAF

<http://nwc-saf.eumetsat.int> or <http://www.nwcsaf.org/>

Direct link iSHAI MTG page:

<http://www.nwcsaf.org/AemetWebContents/ReferenceSystem/GEO/HTMLContributions/iSHAI/MTG/index.html>



References

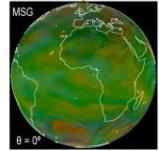
<http://www.nwcsaf.org/AemetWebContents/ReferenceSystem/GEO/HTMLContributions/iSHAI/references.html>

qIRS: Quick IRS products (past activities)

Start point 2010: MTG-IRS and IASI RGBs with MSG RGBs heritage

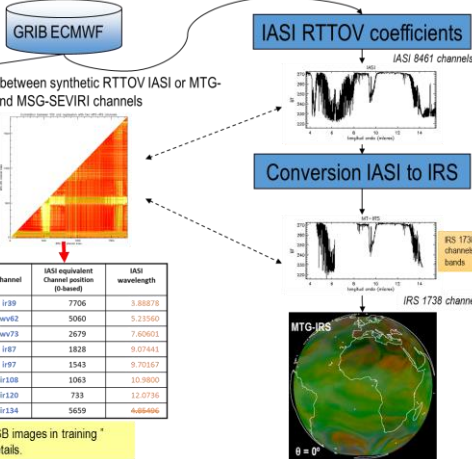
Which is the synthetic IASI channel nearest to every synthetic MSG IR channel?

MSG RTTOV coefficients



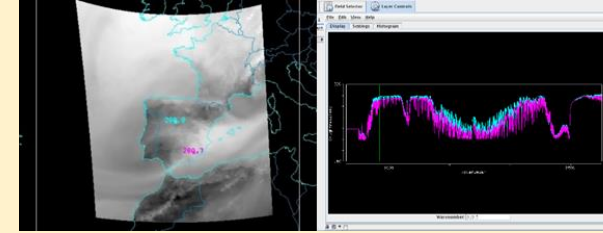
Search of IASI or MTG-IRS channels with lower mean square error and greatest correlation versus MSG-SEVIRI channels using the ECMWF analysis of 25th May 2009 at 12Z for MSG full disc region and RTTOV-9.3

See paper on 2010 Cordoba EUMETSAT Conference "Use of synthetic RGB images in training"
Miguel A. Martinez, X. Calbet, J. Prieto, S. Tjemkes for details.

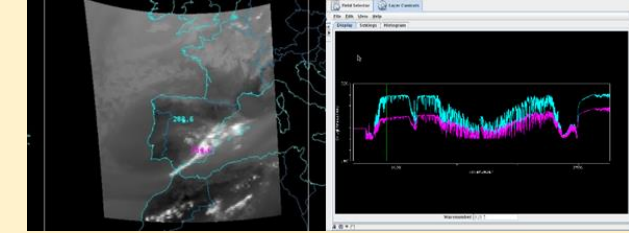


Examples with synthetic IASI images: using PGE00 to simulate IASI L1 spectra, convert to netCDF and display with McIDAS-V.

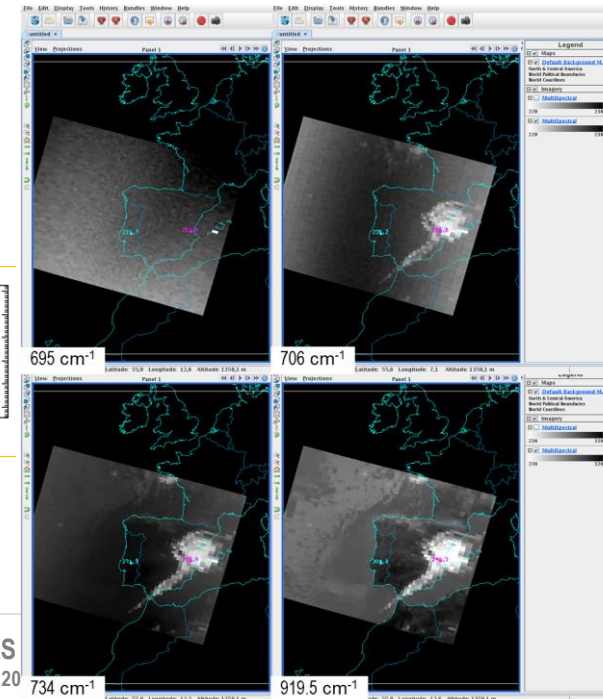
Clear air IASI simulations



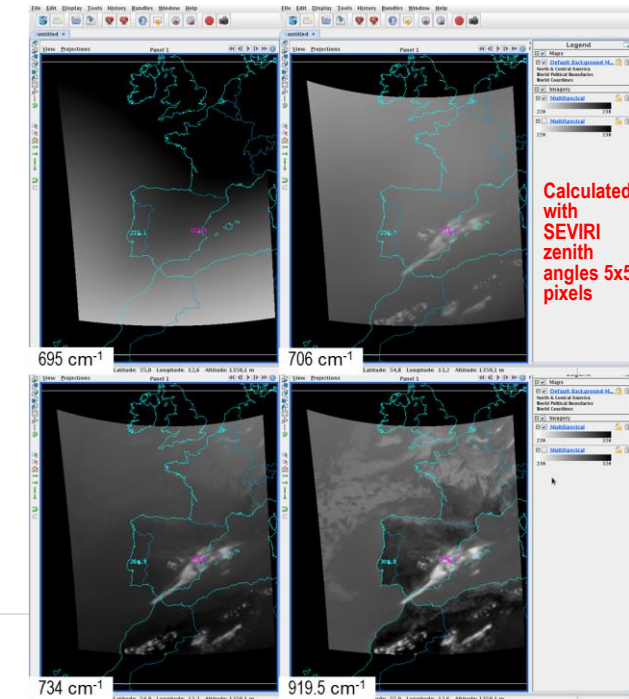
Cloudy air IASI



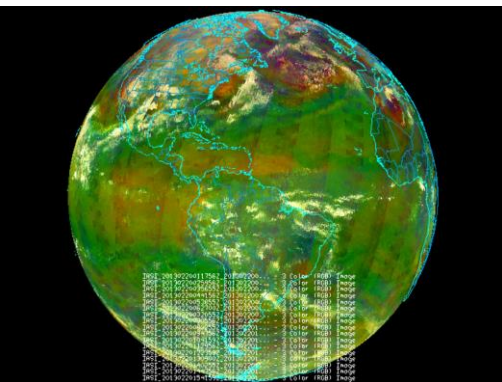
Real IASI METOP-B Image
2016-08-10T10:32:26Z



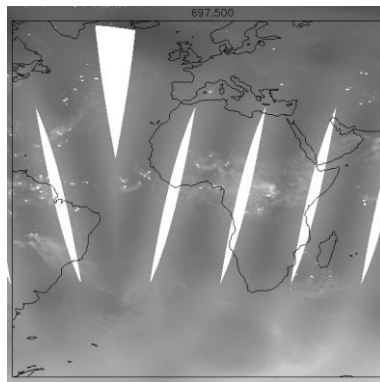
IASI Synthetic RTTOV-12.1
2016-08-10T12:00Z ECMWF t+12



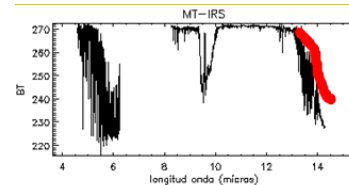
Early examples with real IASI images:
using converters from IASI L1 to netCDF



Real IASI airmass RGB 20-February-2013



top to down quick looks



IR absorption peaks on
[650 cm⁻¹, 824 cm⁻¹]

IRS
4 June 20

Updated PGE00s to NWC SAF vMTG_STRR library

The set of GEO-PGE00-* has been updated to use NWC SAF vMTG_STRR library. This is a beta version for MTG-I/FCI support (STRR revision) and it is **used RTTOV-12.3**.

GEO-PGE00-VISIR used to make **high quality simulation of MTG-I/FCI clear and clouds BTs** using:

- Implementation of read emissivities and BRDF atlases
- call to RTTOV direct using the clouds and solar options
- In version RTTOV-12.3 the scattering coefficients for clouds and aerosol are available for both Visible and IR channels
- Call to RTTOV direct using the clouds and solar options (Emissivities and BRDF from RTTOV atlases)

iSHAI and PGE00 are highly modular and configurable. Both are written in C and Fortran-90 (the core of the process is Fortran-F90).

The main options are:

- ✓ The window size for processing in boxes of **M x M** pixels.
- ✓ optional writing: all pixels or just a clear pixels or a set of pixels.
- ✓ To write the profiles at the different steps: a) just read at hybrid level, b) interpolated/extrapolated at RTTOV pressure levels (or user's set of fixed pressure levels in case PGE00 with simple modifications), c) after temporal interpolation, d) using a cloud mask (or a set of predefined pixels), d) calculation of BTs for different satellites.

**PGE00 is currently an AEMET internal tool
=> NWC SAF Extra tool**

It can be used at same time as NWP 4D (*pressure, time, longitude, latitude*) interpolator of NWP GRIB files to satellite positions.

2019-05-01
00:00Z

Synthetic MTG-I/FCI data

synthetic MTG-I/FCI air mass
RGB 2019-05-01

synthetic MTG-I/FCI dataset

- ✓ case study 2019-05-01
- ✓ FCI 16 channels (VIS and IR)
- ✓ every 10 minutes.
- ✓ 144 slots from 00:00Z to 23:50Z
- ✓ at IR FCI resolution (2x2 km nadir)
- ✓ Region: 1000 x 800 pixels

(displayed at 90%x90%)

[Loop available in an AVI file in this NWC SAF web page](#)

Updated PGE00s to NWCSAF vMTG_STRR library

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GEO-PGE00-hyper It could be used to make high quality simulation of IASI and in future MTG-S/IRS clear and clouds BTs using:

- Implementation of read emissivities atlases
- call to RTTOV direct using the clouds options
- In version RTTOV-12.3 the scattering coefficients for clouds and aerosol are available for IASI IR channels
- **Not visible contribution because only 8 VIS channel could be simulated at same time.**

It can be used at same time as NWP 4D (*pressure, time, longitude, latitude*) interpolator of NWP GRIB files to satellite positions.

iSHAI and PGE00 are highly modular and configurable. Both are written in C and Fortran-90 (the core of the process is Fortran-F90).

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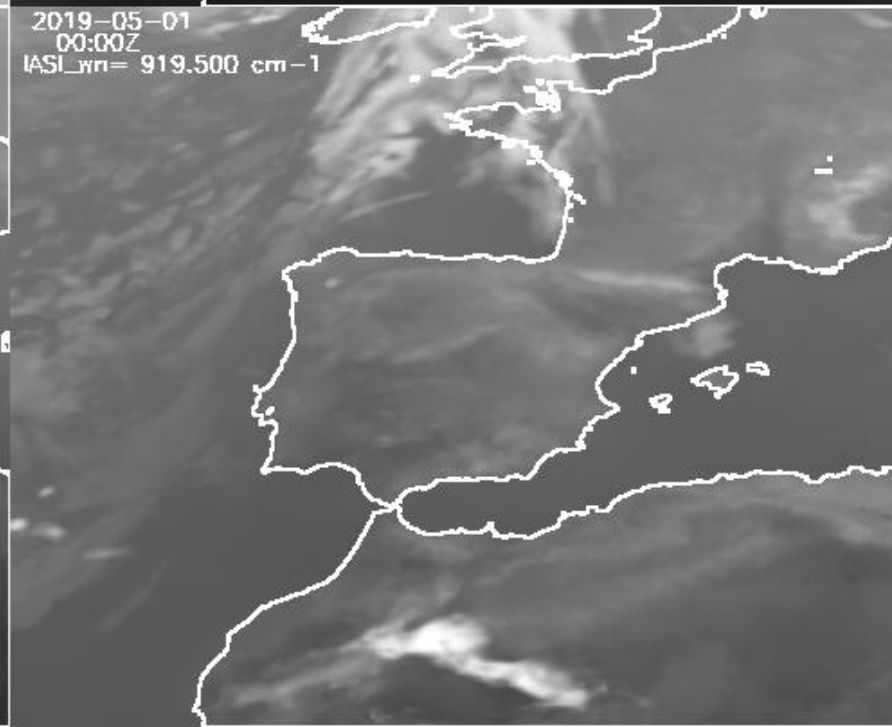
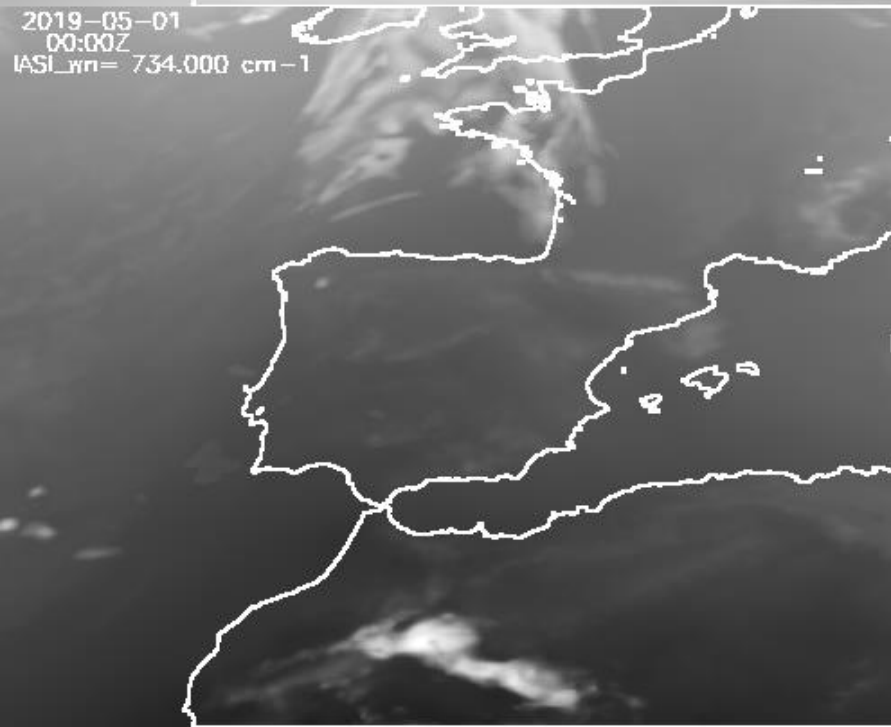
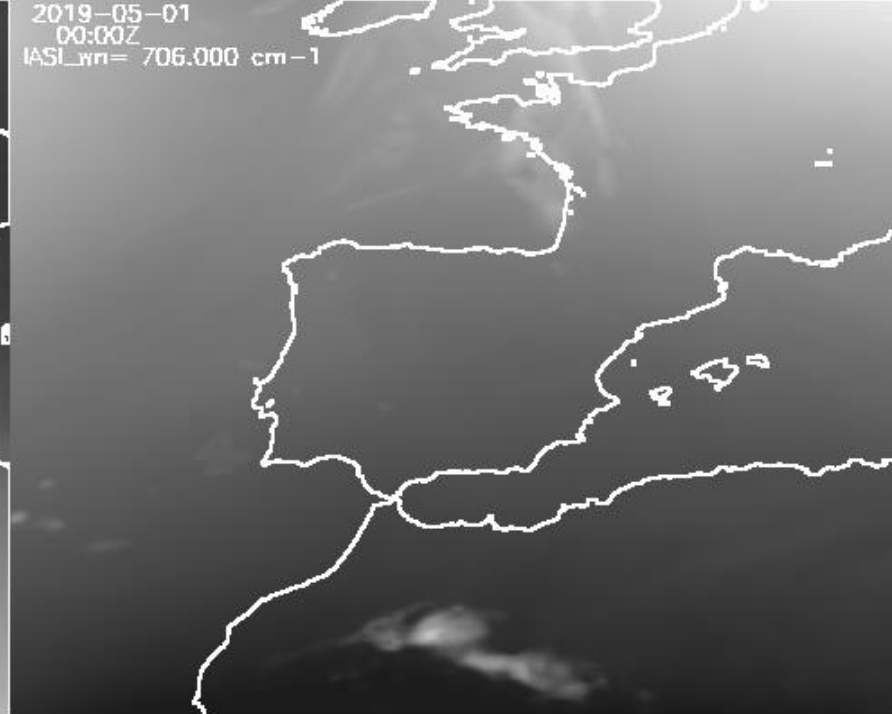
Synthetic IASI as proxy of MTG-S/IRS data

synthetic IASI on MTG-I/FCI
projection 2019-05-01

synthetic IASI dataset

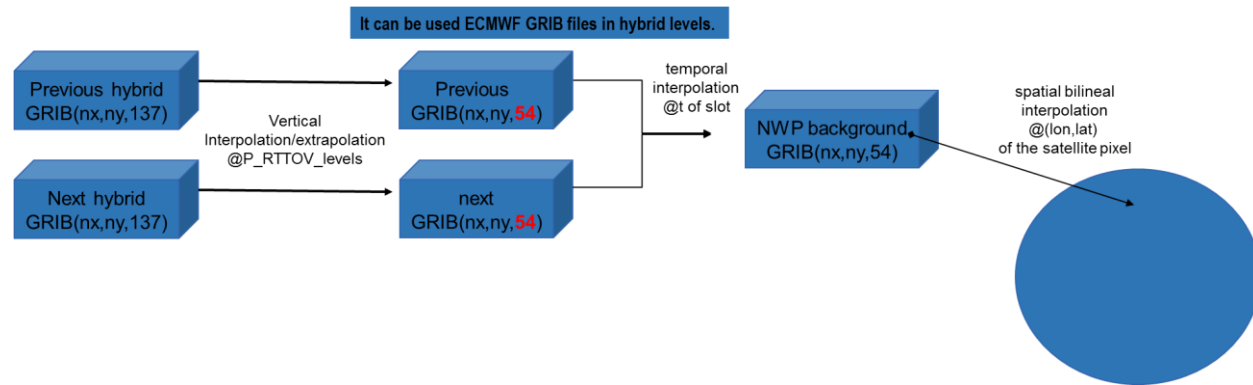
- ✓ case study 2019-05-01
- ✓ IASI 8461 channels
- ✓ every 30 minutes.
- ✓ **48 slots from 00:00Z to 23:30Z**
- ✓ at boxes **2x2** pixels IR FCI resolution => similar to theoretical IRS spatial resolution (**4x4** km nadir)
- ✓ Region: 500 x 400 pixels

See animated GIF in this [NWC SAF web page](#)



4D interpolation of the ECMWF to satellite

- The 4D interpolation (p, time, lon, lat) get vertical, time and spatially collocated NWP forecast temperature, moisture, ozone, **CC, CLWC, CIWC**, u, v profiles at the time and position of the satellite pixels (*here at the 54 RTTOV pressure levels*).
- ECMWF GRIB files on hybrid levels on regular representation (equidistant lon-lat) could be also used as inputs.
- 4D-Interpolation:
 - Vertical: from hybrid ECMWF levels to RTTOV pressure levels are interpolated/extrapolated to the 54 (or 101) RTTOV levels. **But could be adapted to a configurable set of pressure levels.**
 - Temporal: from previous and next GRIB file to date and time of the slot
 - Spatial: bilinear interpolation to satellite coordinates



- Since the lowest RTTOV-12 pressure levels have values greater than the lowest hybrid level at Psfc (especially on mountains pixels) **it has been implemented in GEO-PGE00 one extrapolation process based in the one made by ECMWF.** First, **it is made the extrapolation of the T profile** (starting at the RTTOV level just above of Psfc using formulas described in the ECMWF) and then **it is extrapolated the q profile maintaining the relative humidity at the surface pressure level.** *This allows get fields as 1000 hPa temperature.*
- In the case of HYB mode **all the NWP process is made inside the GEO-iSHAI code.** GEO-PGE00 opens directly the **previous** and **next** (relative to the time of the satellite image) ECMWF GRIB files on hybrid levels, **makes the vertical interpolation on ECMWF position to the 54 RTTOV-11.2 pressure levels, makes the temporal interpolation to the date+time of the image** and finally makes the **bilinear spatial interpolation just over the clear air processed FOR.**
- It has been used, **ECMWF hybrid GRIB files** with the profiles **between t+0 to t+24 hours range forecast (every 1 hour) with 0.1° x 0.1°**

PGE00 inputs and outputs scheme

Binary file with $N_x \times N_y$ records. Each record has:

ANCILLARY: longitude, latitude, zenith angle, topography,...

NWP:

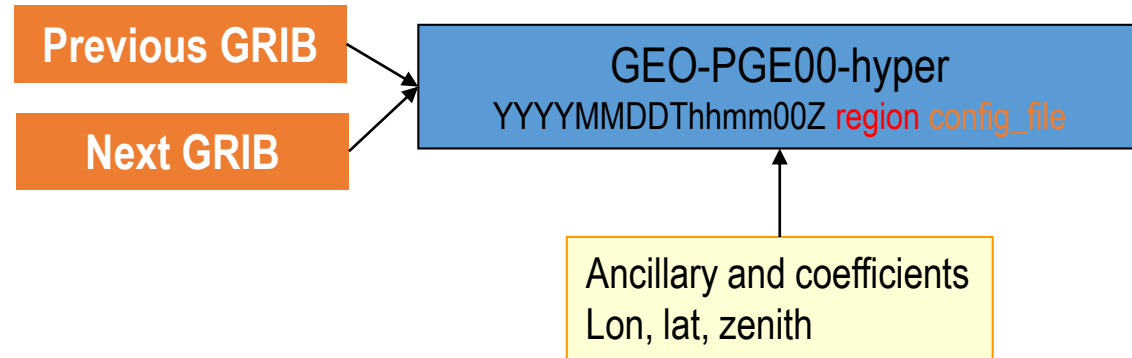
profiles arrays at [54] pressure levels:

P, T, q, ozone, **CC**, **CLWC**, **CIWC**, u, v

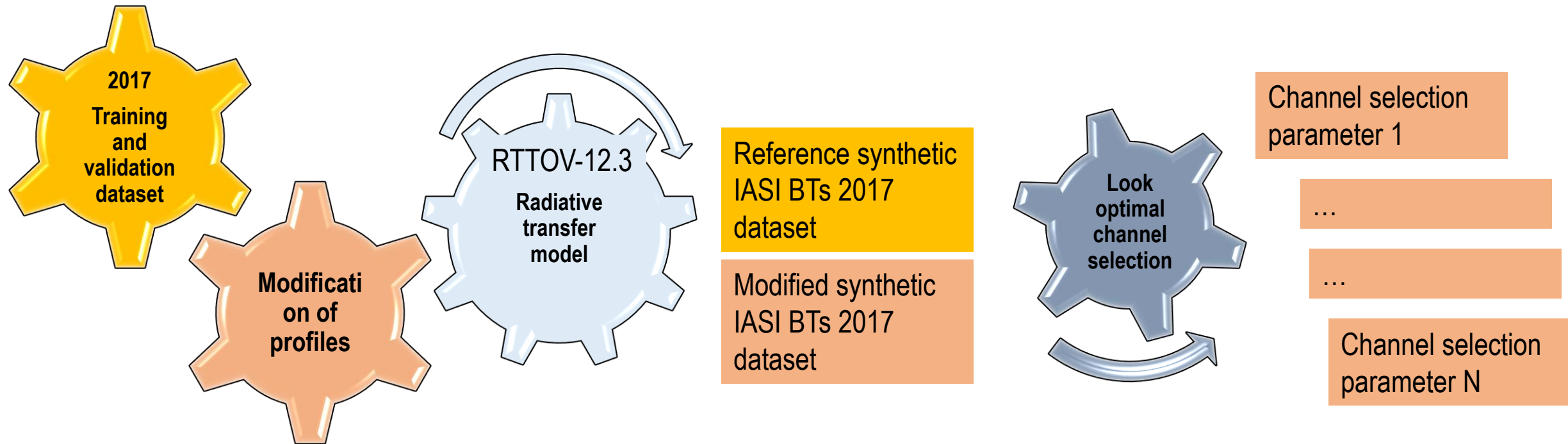
2D Fields: SKT, Psfc, Tsfc, qsfc, ...

BT_RTTOV_CLEAR: brightness temperatures in clear air.
Array[number of satellite channels]. 8461 in IASI

BT_RTTOV_CLOUDY: brightness temperature using cloud profile
Array[number of satellite channels]. 8461 in IASI



PGE00_1d: use of iSHAI training and validation dataset



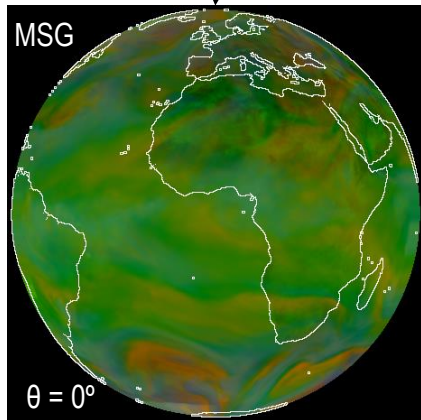
PGE00_1d: is Fortran only and it use as input full binary file and processing on record by record basis.

- ✓ Pending to modify for use RTTOV coefficients for cloud and aerosol support
- ✓ Pending to modify for use Principal Component RTTOV coefficients (It will speed up the calculation)

Start point 2010: MTG-IRS and IASI RGBs with MSG RGBs heritage

Which is the synthetic IASI channel nearest to every synthetic MSG IR channel?

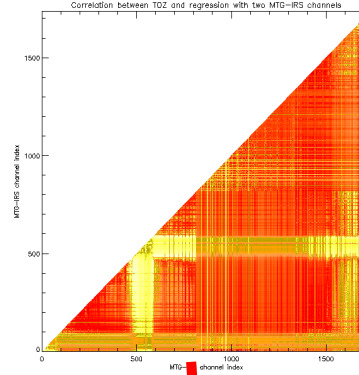
MSG RTTOV coefficients



Search of IASI or MTG-IRS channels with lower mean square error and greatest correlation versus MSG-SEVIRI channels using the ECMWF analysis of 25th May 2009 at 12Z for MSG full disc region and RTTOV-9.3

GRIB ECMWF

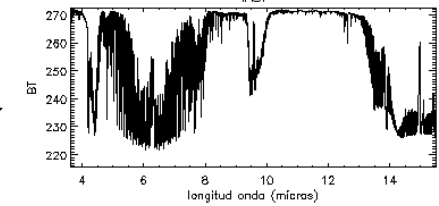
correlation analysis between synthetic RTTOV IASI or MTG-IRS and MSG-SEVIRI channels



MSG channel	IASI equivalent Channel position (0-based)	IASI wavelength
ir39	7706	3.88878
wv62	5060	5.23560
wv73	2679	7.60601
ir87	1828	9.07441
ir97	1543	9.70167
ir108	1063	10.9800
ir120	733	12.0736
ir134	5659	4.85496

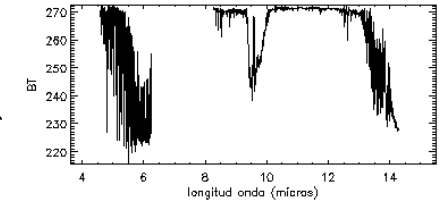
IASI RTTOV coefficients

IASI 8461 channels

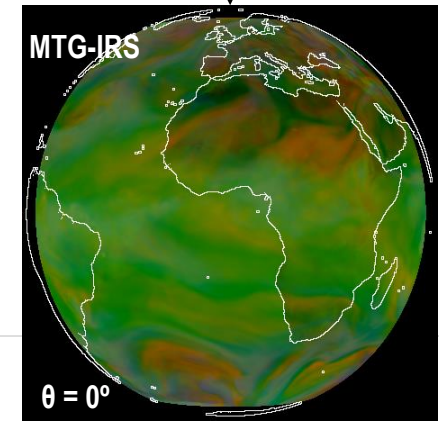


Conversion IASI to IRS

MT-IRS



IRS 1738 channels



See paper on 2010 Cordoba EUMETSAT Conference "Use of synthetic RGB images in training"
Miguel A. Martinez, X. Calbet, J. Prieto, S- Tjemkes for details.

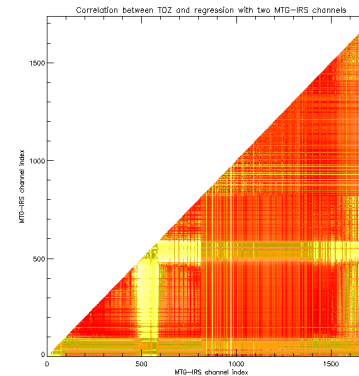
Revisit 2020: MTG-IRS and IASI RGBs with MSG RGBs heritage

Which is the synthetic IASI channel nearest to every synthetic MSG IR channel?

MSG RTTOV coefficients

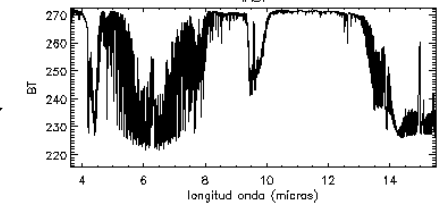
2017 training and validation dataset

correlation analysis between synthetic RTTOV IASI or MTG-IRS and MSG-SEVIRI channels



IASI RTTOV coefficients

IASI 8461 channels



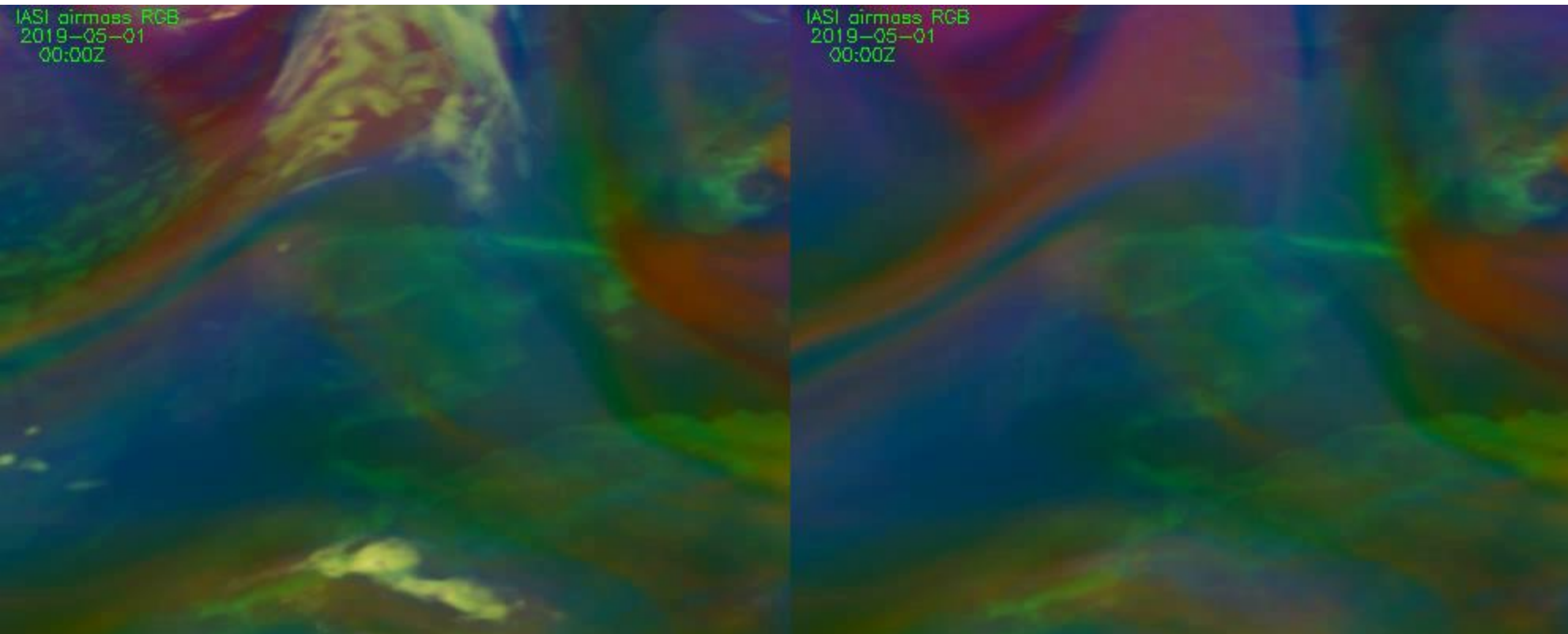
Conversion IASI to IRS

Pending further tests to publish equivalent IASI ↔ MSG table

Search of IASI or MTG-IRS channels with lower mean square error and greatest correlation versus MSG-SEVIRI channels using 2017 training and validation dataset for MSG full disc region and RTTOV-12.3

Synthetic IASI as proxy of MTG-S/IRS data

synthetic IASI air mass RGB 2019-05-01



IASI air mass RGB with synthetic RTTOV cloudy

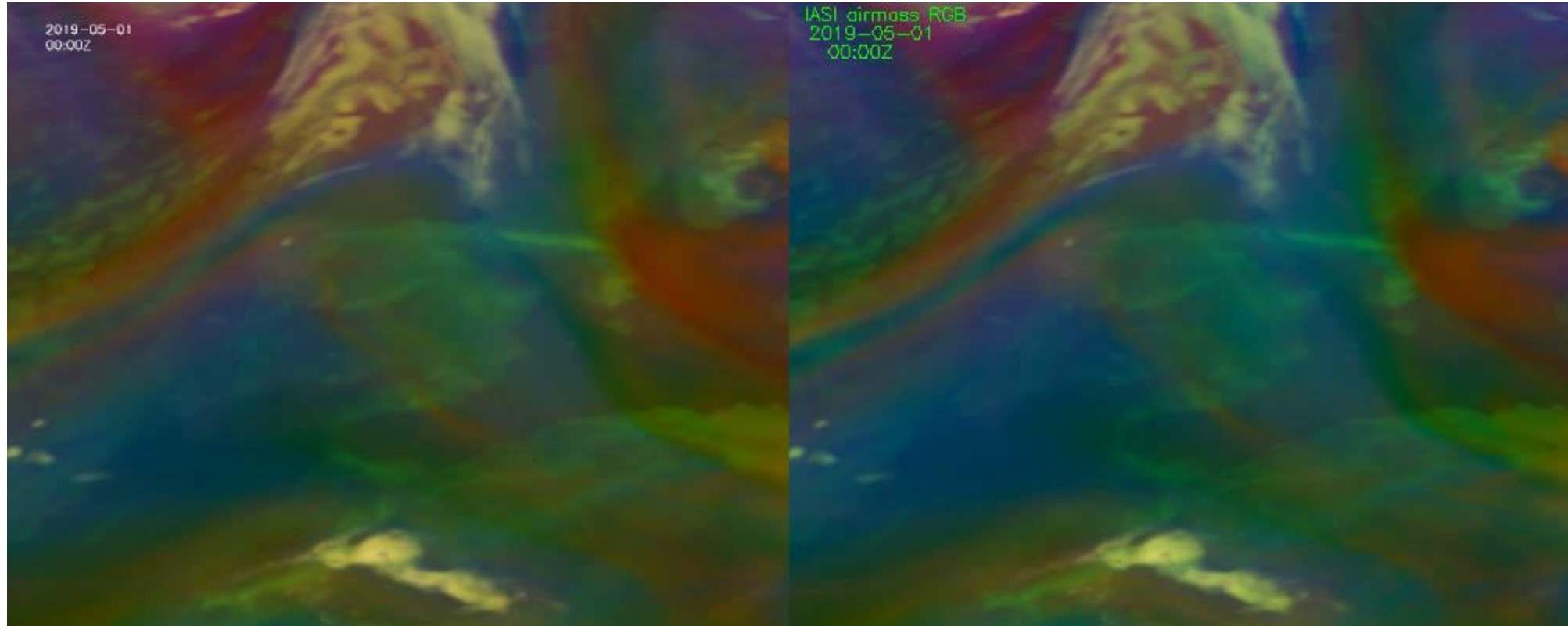
IASI air mass RGB with synthetic RTTOV clear air

Used the new table for IASI to nearest MSG channels selection

synthetic IASI dataset

- ✓ case study 2019-05-01
- ✓ IASI 8461 channels
- ✓ every 30 minutes.
- ✓ **48 slots from 00:00Z to 23:30Z**
- ✓ at boxes **2x2** pixels IR FCI resolution (**4x4 km nadir**)
- ✓ Region: 500 x 400 pixels

Comparison of MTG-I/FCI and MTG-S/IRS temporal resolution



MTGI/FCI air mass RGB with synthetic RTTOV cloudy

At 2x2 boxes every 10 minutes

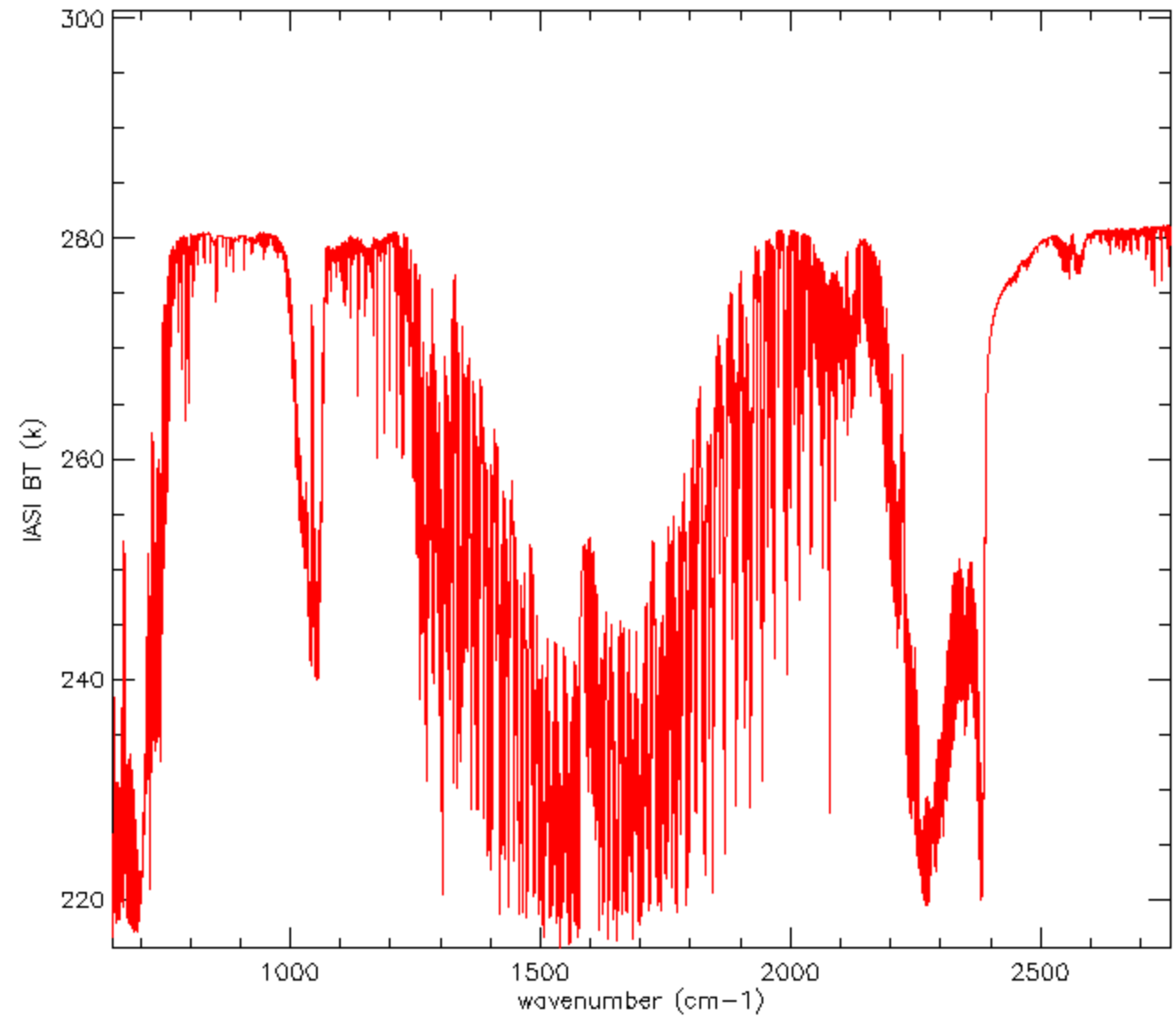
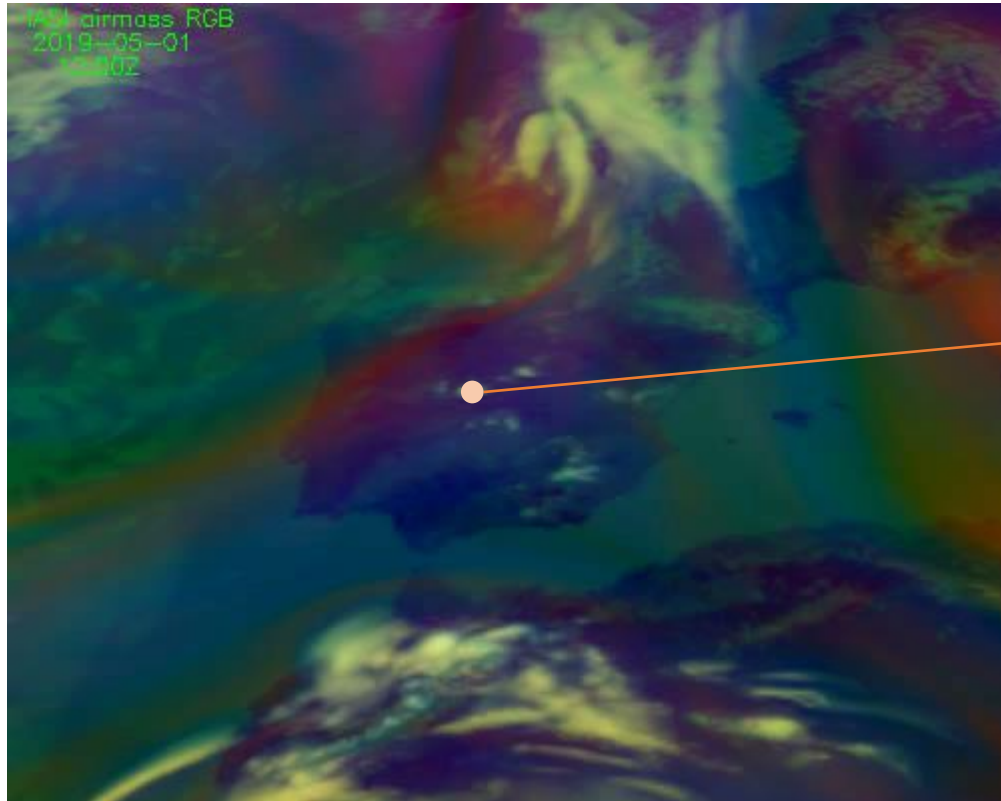
IASI air mass RGB

every 30 minutes

Black line clear air IASI spectra

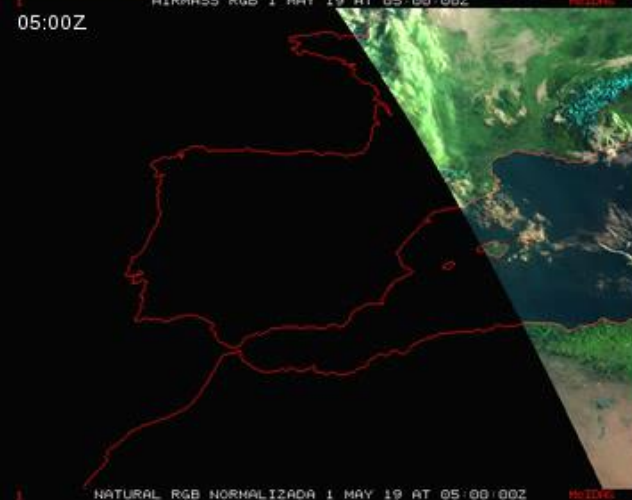
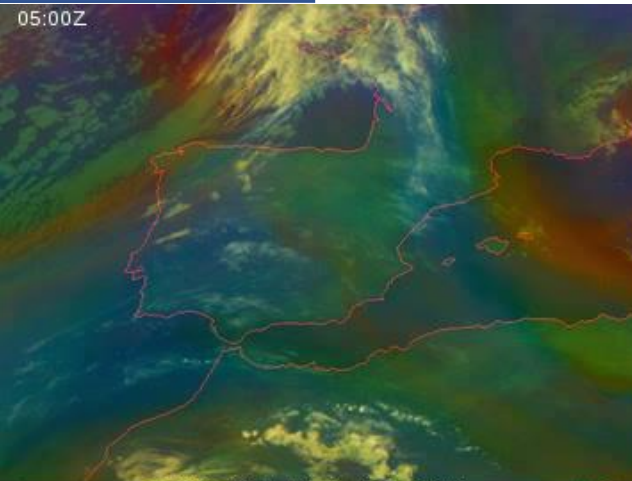
Red line cloudy IASI spectra

2019-05-01 00:00Z



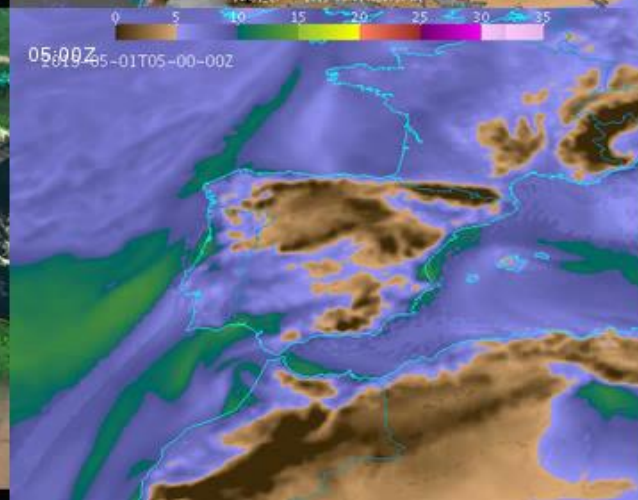
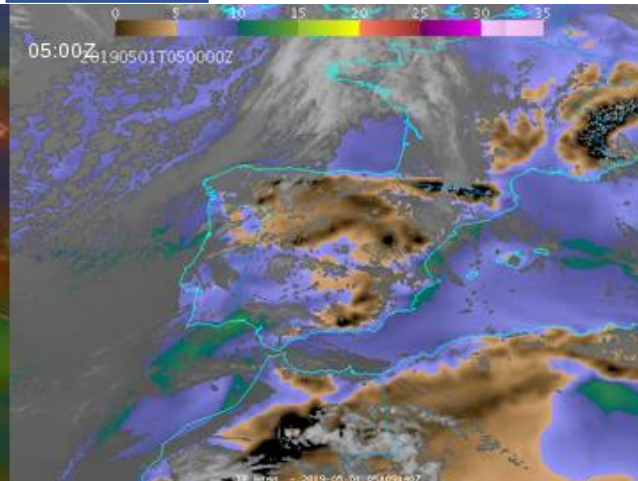
Case study: iSHAI, PGE00 and real RGB images from 1st May 2019

AIRMASS RGB



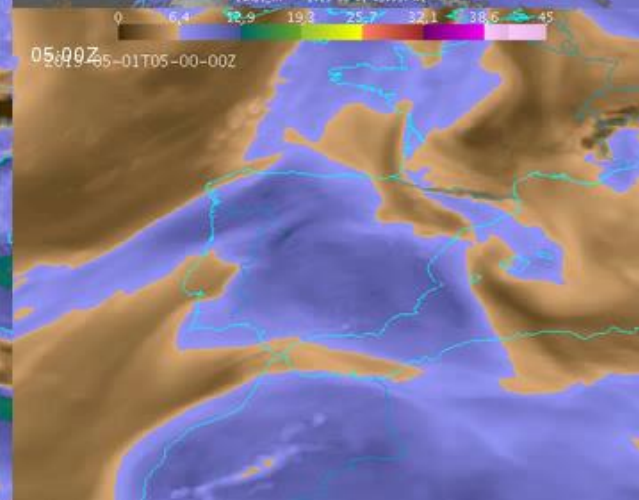
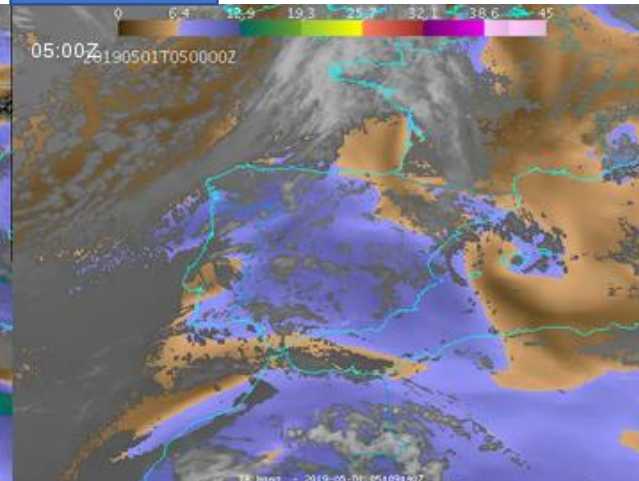
NATURAL RGB

iSHAI BL



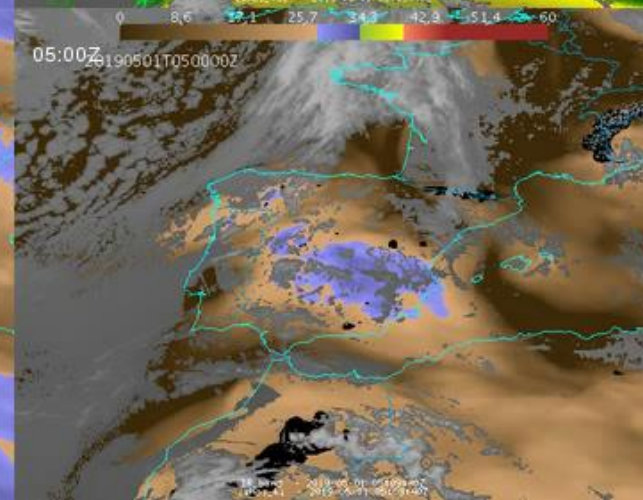
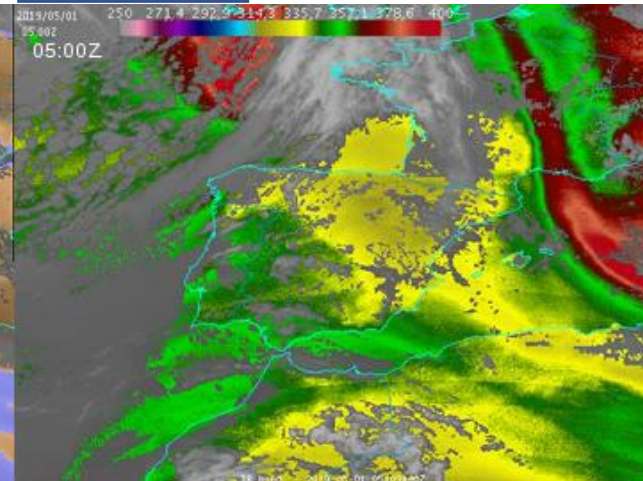
ECMWF BL

iSHAI ML



ECMWF ML

iSHAI TOZ



iSHAI KI

Corrected to same sun
zenith angle and hour

Past activities

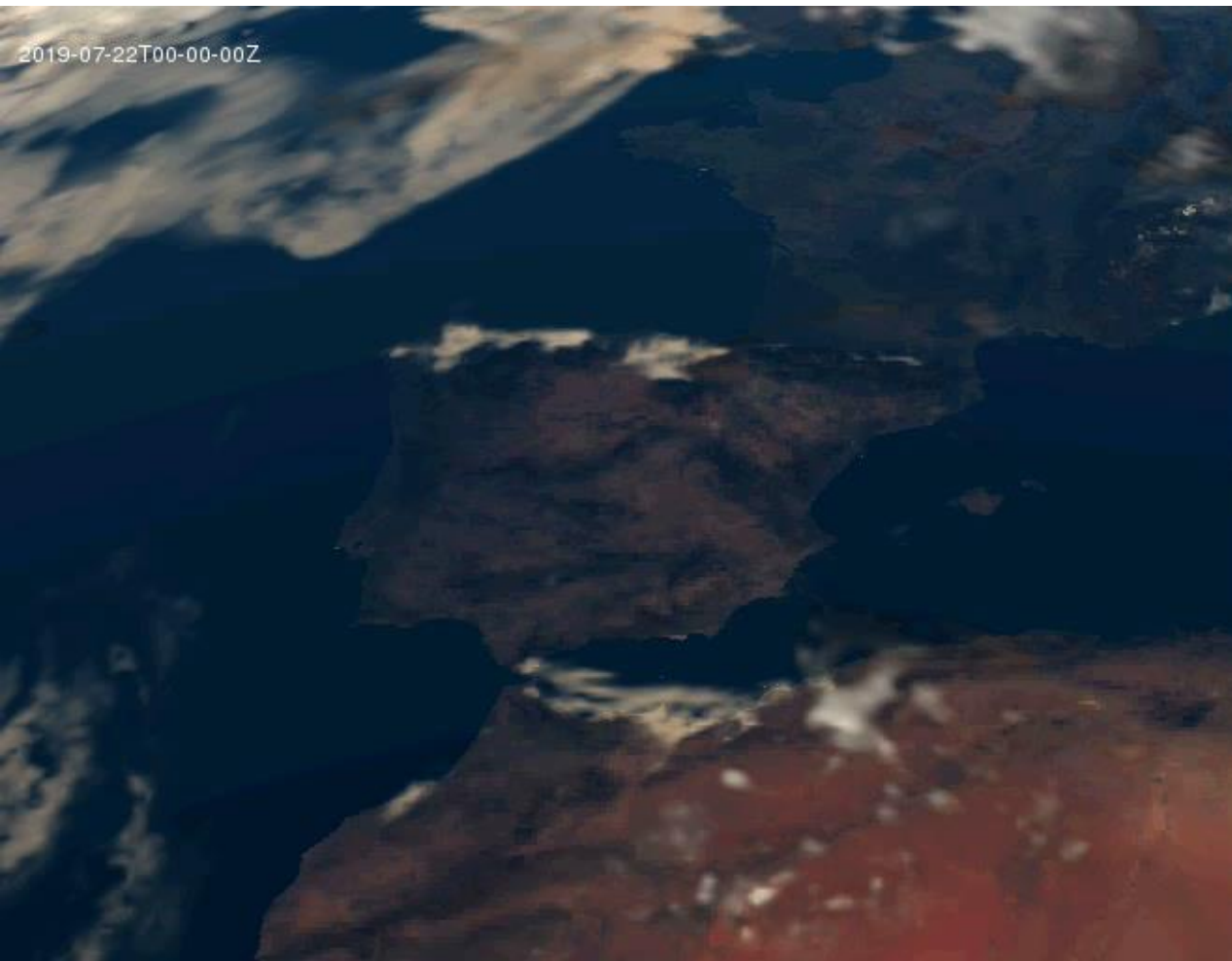
**Loop of IASI
synthetic RTTOV-12.1 BT**
2019-07-22 from 12:00Z to 18:00Z every 30 minutes

Calculated with:
SEVIRI zenith angles
SEVIRI resolution 1x1 pixels (3 x 3 km at nadir)

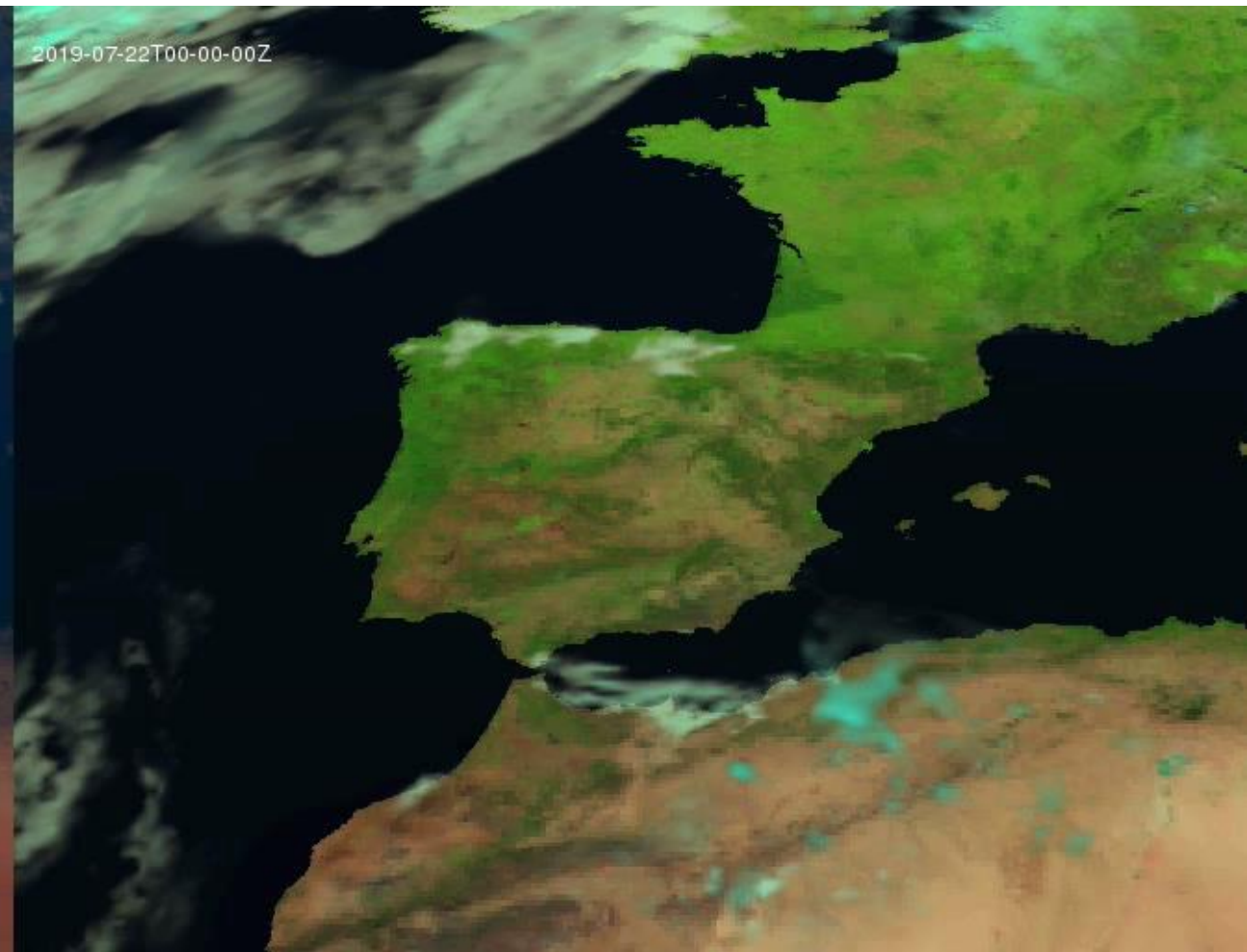
[Loop available as animated
GIF in this NWC SAF web page](#)

MTG-I FCI synthetic data: example 22th July 2019

PGE00 with RTTOV-12.1 simulation with high quality in IR and VIS clear or with clouds



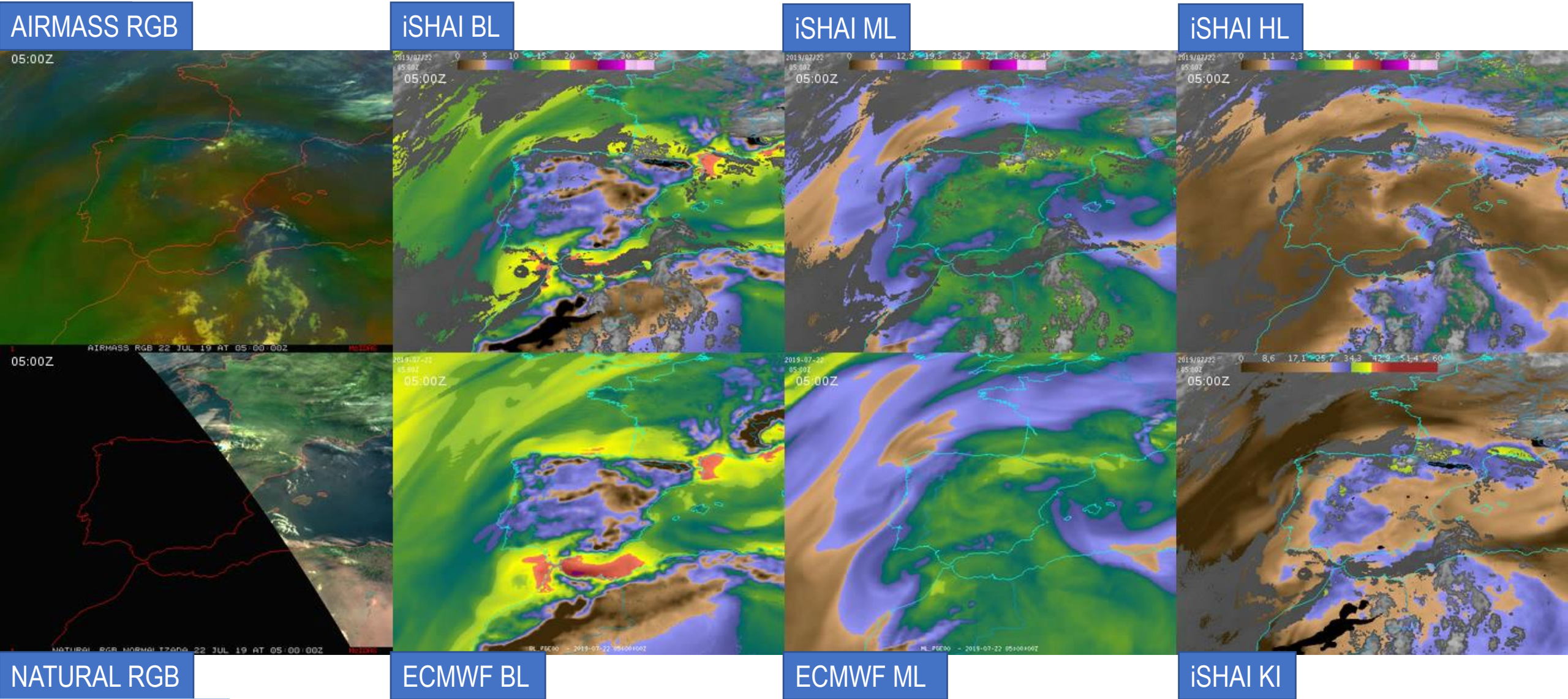
Synthetic MTG/FCI True color RGB



Synthetic MTG/FCI natural RGB

NWC SAF software package could be used to make the reflectance atmospheric correction to get high quality true color RGB images.

Example of combined use of iSHAI, PGE00 and real RGB images: 22th July 2019



Corrected to same
sun position and hour

BL
Precipitable Water in Boundary Layer
($P_{\text{sf}} - 850\text{hPa}$)

ML
Precipitable Water in Middle Layer
(850-500 hPa)

HL
Precipitable Water in High Layer
(500-0.1 hPa)

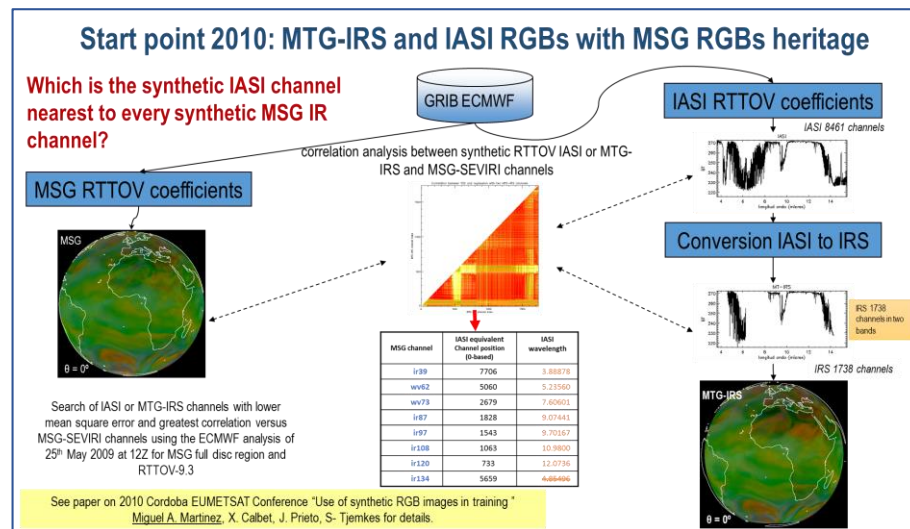
[Loop available in an AVI file
in this NWC SAF web page](#)

Next activities: synthetic MTG-S/IRS simulations

IASI2IRS

Software to convert pixel by pixel IASI spectra to IRS spectra
This way was used in 2010

It will be used for IASI => IRS after update to the new figures of IRS



MTG-S/IRS RTTOV coefficients

- No cloud and aerosol coefficients available
- The last MTG-S/IRS coefficient file (March 2020) does not have the proposed step of 0.6 cm^{-1} and it used the old one 0.6125 cm^{-1}
- The use of PC coefficient could speed the simulation (300 PCs against 8461/2000 channels) but it does not allow to simulate clouds just clear air.

Conversion to netCDF compatible with McIDAS-V

Needs of EUMETSAT test data for NWCSAF

- Full disk test data for several slots goal (or threshold 1 slot) for engineering purposes (identification of slots, time, ..) It would be acceptable if no scientifically correct
- LAC4 test data every 30 minutes test data for goal 1 day (threshold several slots) scientifically correct.
- Also needed at least 00 and 12 (close to EMCWF analysis) for same dwells 1 slot for previous day to make the training.

Summary, conclusions and future developments

Preparation for MTG-I/FCI and MTG-S/IRS

MTG-I/FCI and MTG-S/IRS should be considered as just one facility. It is needed to explore all the synergies between both instrument and with MTG-LI.

The use of PGE00 allows to generate synthetic test datasets from hybrid ECMWF GRIB files.

SHAI family will allow to exploit the synergy of MTG-FCI, MTG-IRS and NWP for the monitoring of key ingredients in pre-convective situations.

These test data could be used to explore ideas as Optical flows. Using the (u,v) 4D-interpolated profiles.

- Validation and datasets generation is a continuous and important task.
- Creation of collocated ECMWF and IASI, SEVIRI->FCI L1 and L2.
- Generation and/or get synthetic IRS L1 data.
- Training and validation of local statistical retrieval

TO BE CONTINUED

Thanks for your attention !

Questions ? Any feedback is welcome !

iSHAI MTG page:

<http://www.nwcsaf.org/AemetWebContents/ReferenceSystem/GEO/HTMLContributions/iSHAI/MTG/index.html>

Extra slides

Current activities

Improve of training database and software for quick-IRS L1:

- ✓ IASI clear synthetic BTs spectra for a reduce dataset from 2017 training dataset with original profiles. Also IASI clear synthetic BTs spectra after perturbation of T, q and ozone profile.
- ✓ IASI PGE00 VISIR Simulations from several cases studies very 30 minutes on 1x1 pixels on region with size of one IR dwell. Using ECMWF GRIB files on hybrid levels every 1 hour at 0.1x0.1° resolution on request to MARS. The cloud parameters from ECMWF on hybrid levels are used.

They will be used for:

- other determination of channels for RGB images.
- conversion to MTG-IRS while not updated RTTOV MTG-IRS coefficient
- Look for changes IASI spectra in instability

It has been made a reader for the test EUMETSAT IRS-L1 netCDF file and converted to a McIDAS-V compatible netCDF format

