GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE
AEMet
The EUMETSAT Network of Satellite Application Facilities
NWC SAF
Support to Nowcasting and Very Short Range Forecasting
EUMETSAT
Monitoring weather and climate from space
Surveiller le temps et le climat depuis l'espace

NWC/GEO version 2016

Instability indices and water content in clear air NWCSAF product

MIGUEL A. MARTINEZ

AEMET

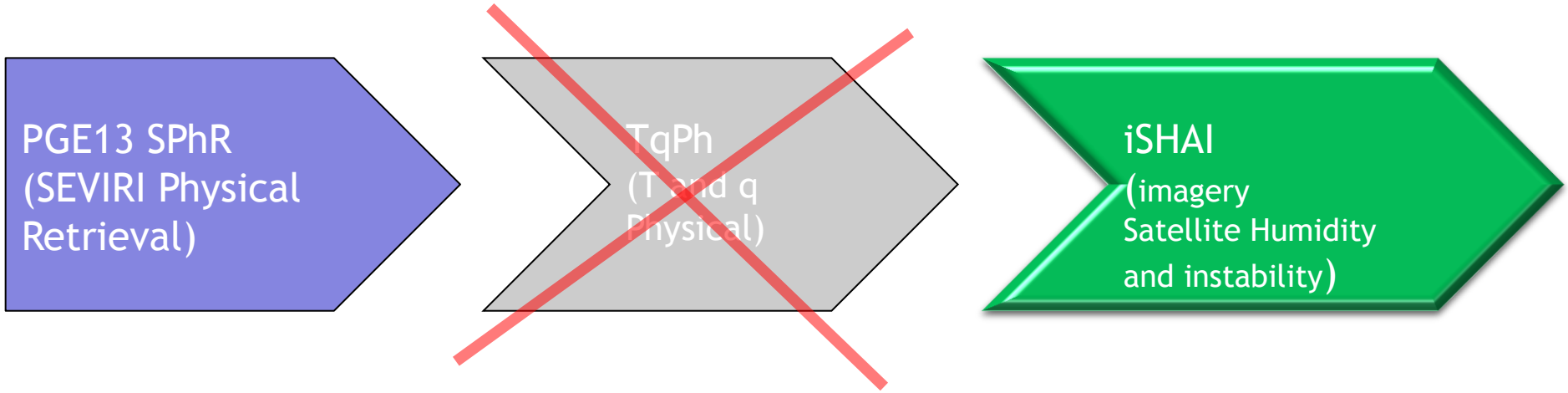
CWG Workshop
4-8 April 2016 - Florence

Index

- Introduction to version 2016 of NWC/GEO 2016
  - algorithm
  - Validation and iSHAI BT bias correction

- Case study 15th July 2015
  - Example of use optional binary files from iSHAI Hyb mode.

Change of name in the clear air product: iSHAI (imagery Satellite Humidity and instability)



Due to decision to remove PGEXX nomenclature and name contains SEVIRI

iSHAI algorithm

It is a combination of one statistical and one optimal estimation:

First step:

Use of a non linear regression to built First Guess from collocated background NWP Temperature and humidity profiles and bias corrected SEVIRI 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:

  2 EOFs for T, 3 EOFs for q and 1 EOF for T_{skin}

- Use of a regularization parameter.

Note: The base algorithm was provided by Dr. Jun Li of CIMSS-Wisconsin in 2007 and it was adapted to use NWP SAF RTTOV as radiative transfer model and SEVIRI. Jun Li is the PI for GOES-R algorithm and he legacy GOES-R algorithm is similar to iSHAI one

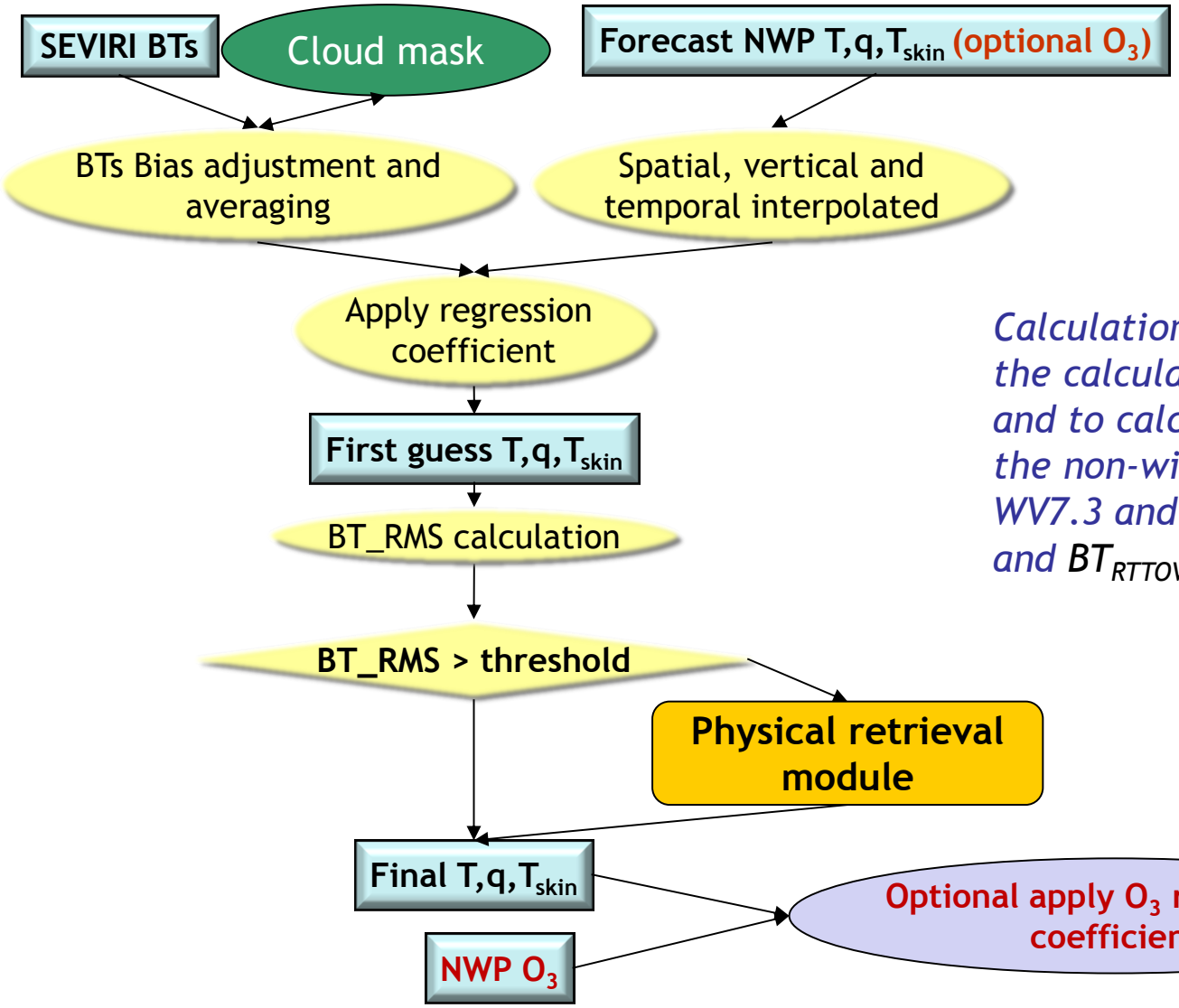
http://www.ssec.wisc.edu/~junl/

iSHAI version 2016

In this version the NWC SAF software has been improved and updated for GEO satellite processing. The main improvements in iSHAI for version 2016 are:

- **Change of the version of RTTOV from RTTOV-9.3 to RTTOV-11.2:** this change of version imply the change of the number of levels from 43 in the case of RTTOV-9.3 to 54 in the case of RTTOV-11.2. This imply the recalculation of all the coefficients and it has been improved the change of the extrapolation below the surface pressure level.
- **Update to version 2016 NWCSAF library**.
- **Introduction of Skin Temperature and Total Ozone as outputs.** 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).
- **Optimization of all components of the algorithm:**
  - Tests to get the value add of every component.
  - Jabobian calculations.
  - It will be updated periodically the bias BT for the operational satellite
- **Change to the netCDF format:** it include now navigation and it is CF compliant => it is possible to use with standard meteorological applications (as example IDV or McIDAS-V).

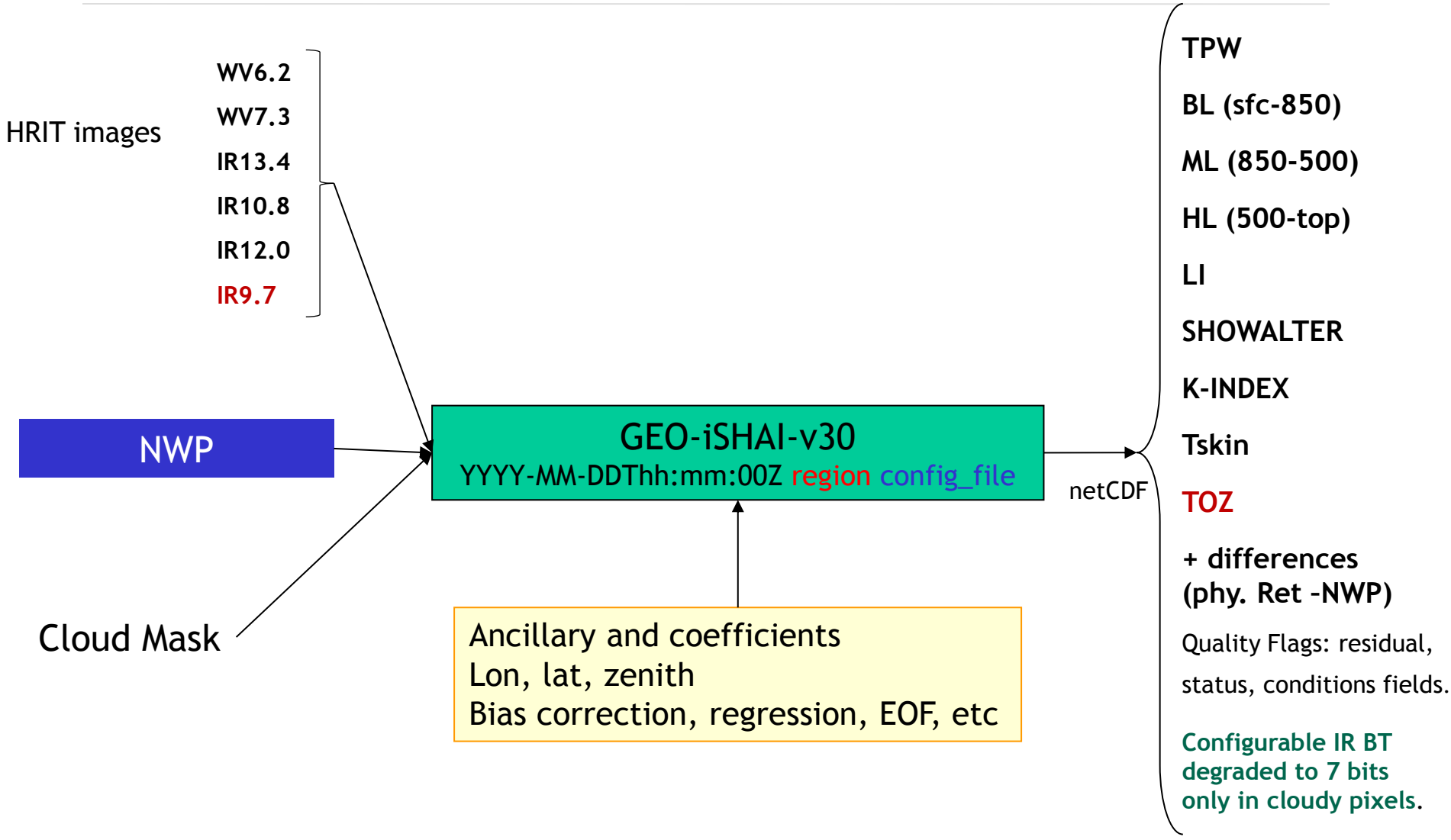
Flow chart of iSHAI



Calculation of BT_RMS is based in the calculation of BT_{RTTOV} from FG and to calculate the distance on the non-window channel (WV6.2, WV7.3 and IR13.4) between BT_{SEVIRI} and BT_{RTTOV}

Full details will be available in the ATBD on the NWCSAF Help-Desk Web page

iSHAI module: iSHAI inputs and outputs scheme on version with fixed pressure level



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.

Main iSHAI configurable options and parameters
iSHAI Model Configuration File

iSHAI is highly modular and configurable. In the execution the third parameter is an ASCII file with all the processing options. 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.
- 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**
- **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 the options are activated through editing the PGE13 Model Configuration File (extension .cfm).**

Note 1: SEVIRI BT bias corrections coefficients are now part of NWCLIB software
Note 2: Full details in the Product User Manual Document available on the NWCSAF Help-Desk Web page

iSHAI training and validation dataset

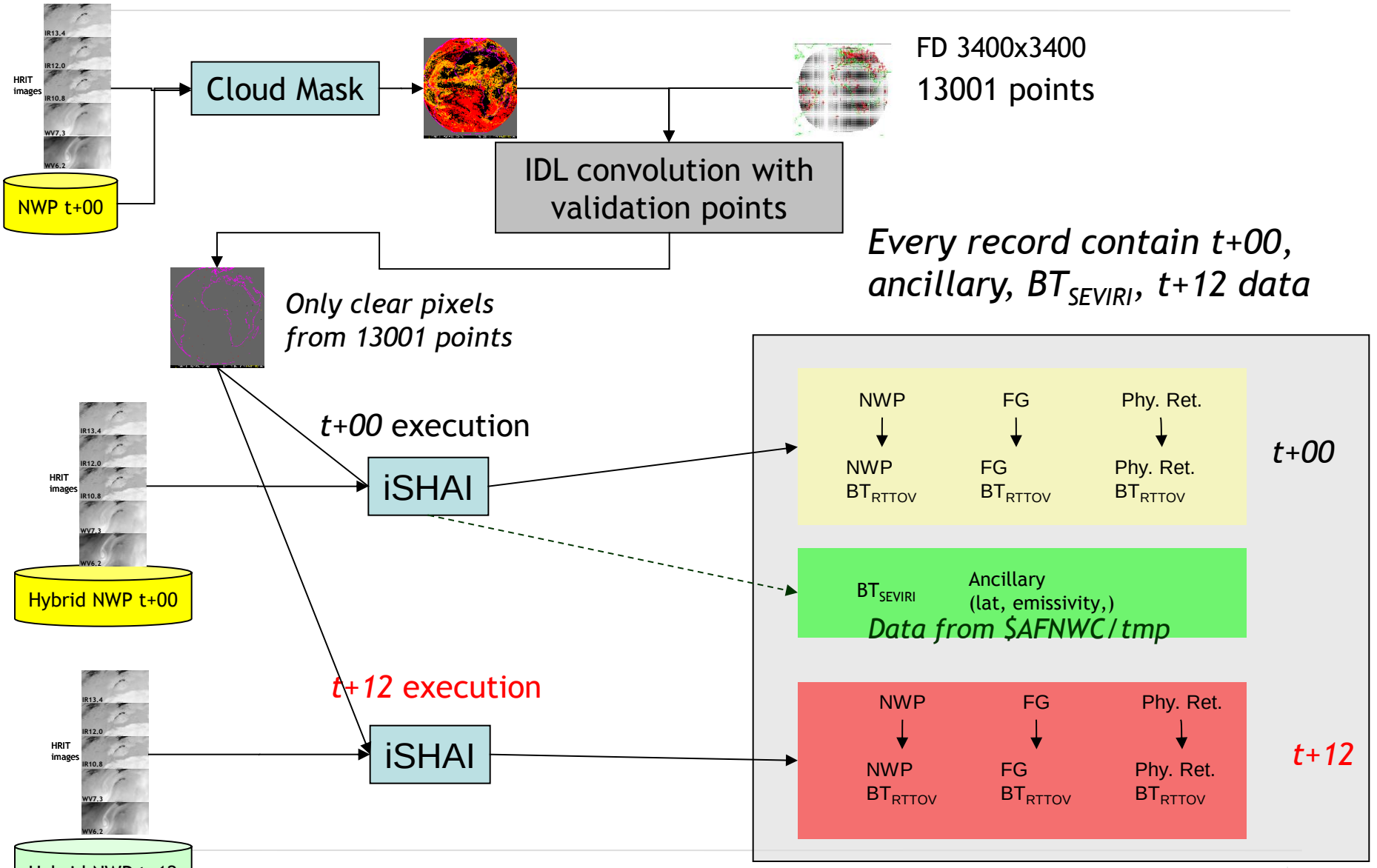
To build a training and validation dataset with the MSG data, ECMWF NWP model and radiosounding profiles is an important task.

This task is based in a continuous task of reprocessing at 00 UTC and 12 UTC with PGE13 only over a list of points (RAOB positions and a grid of 1ºx1º). Binary files allows to create a dataset of (T,q) profiles collocated with SEVIRI radiances, etc. **Now the dataset contains profiles from January 2008.**

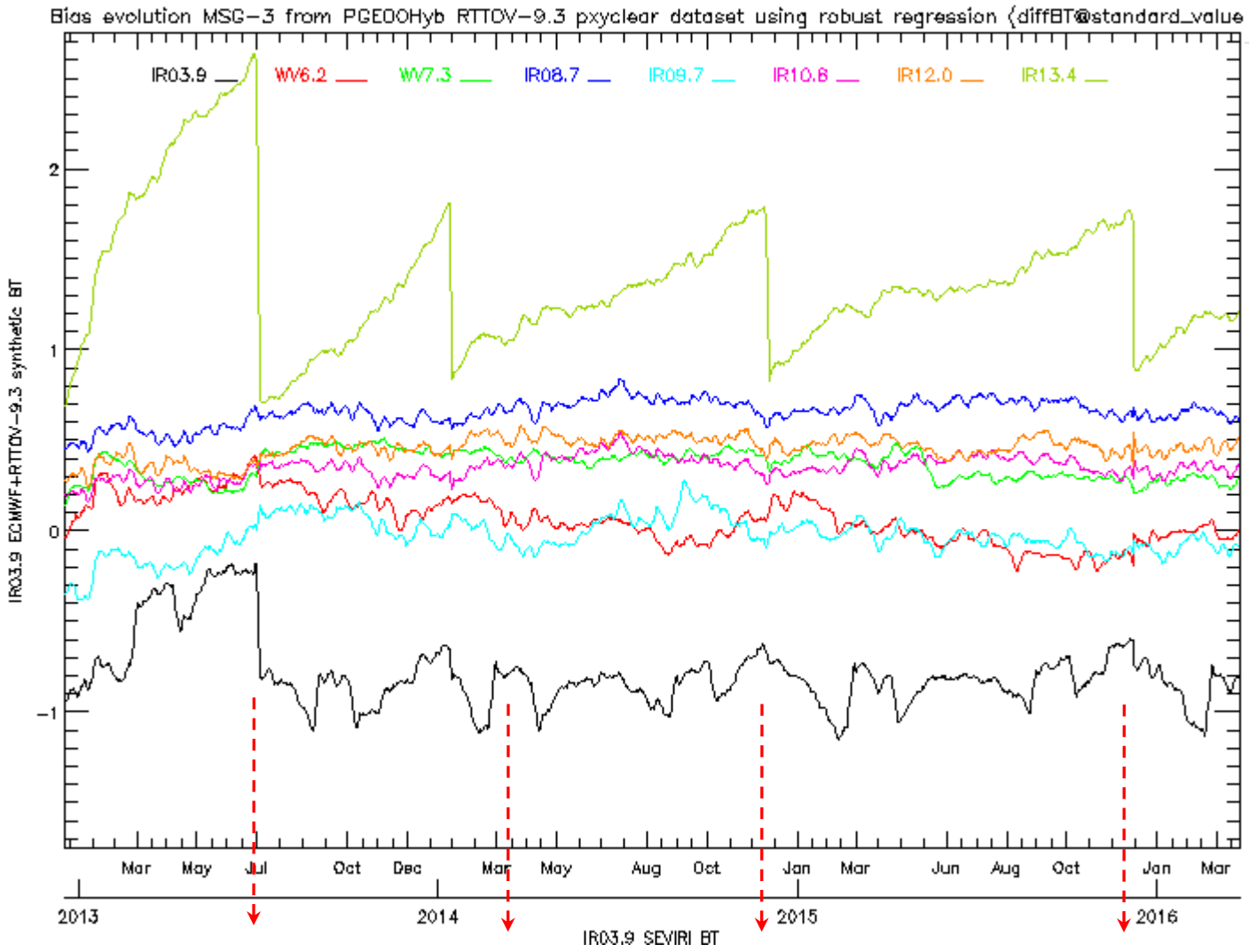
The coefficients of version 2016 have been updated and calculated with profiles from 2013 year of the iSHAI validation and training dataset. The 1 out of 2 observations of 2013 not used to build the training dataset have been used.

Writing of validation reports and training of new tuned physical retrieval coefficients is the other main use.

PGE13 training and validation dataset construction



Use of PGE13Hyb dataset to monitoring bias BT for MSG-3



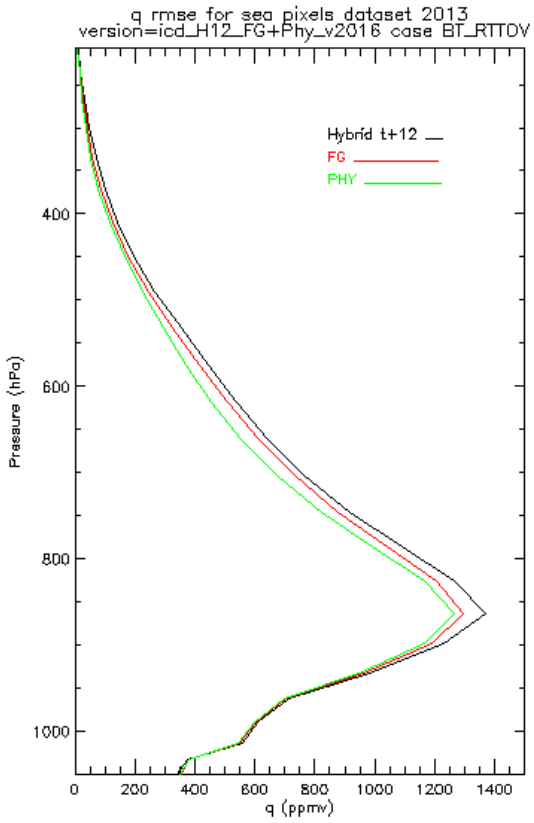
The eight SEVIRI IR channels are being monitored

It will be available a web page were coefficients would be updated.

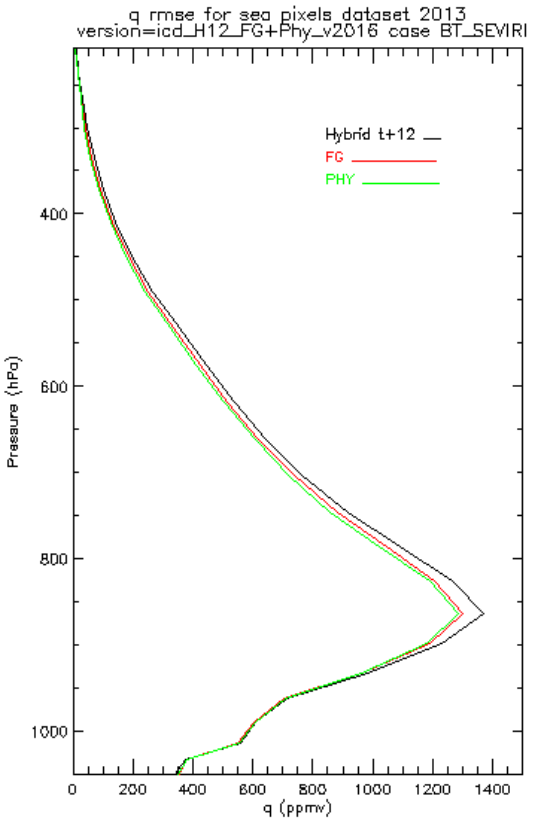
Evolution of the bias correction between BT_SEVIRI and synthetic BT_RTTOV over sea pixels. Differences between a mean value before and after the bias correction calculated for a "moving" window.

q rmse sea pixels: RTTOV-11.2 validation for version 2016

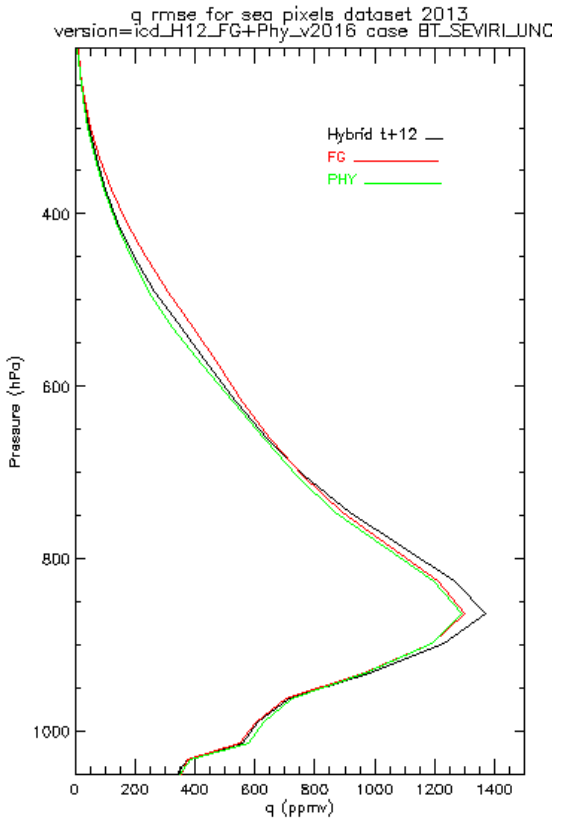
q For BTRTTOV case



q For BTSEVIRI case



q For uncorrected BT_{SEVIRI} case



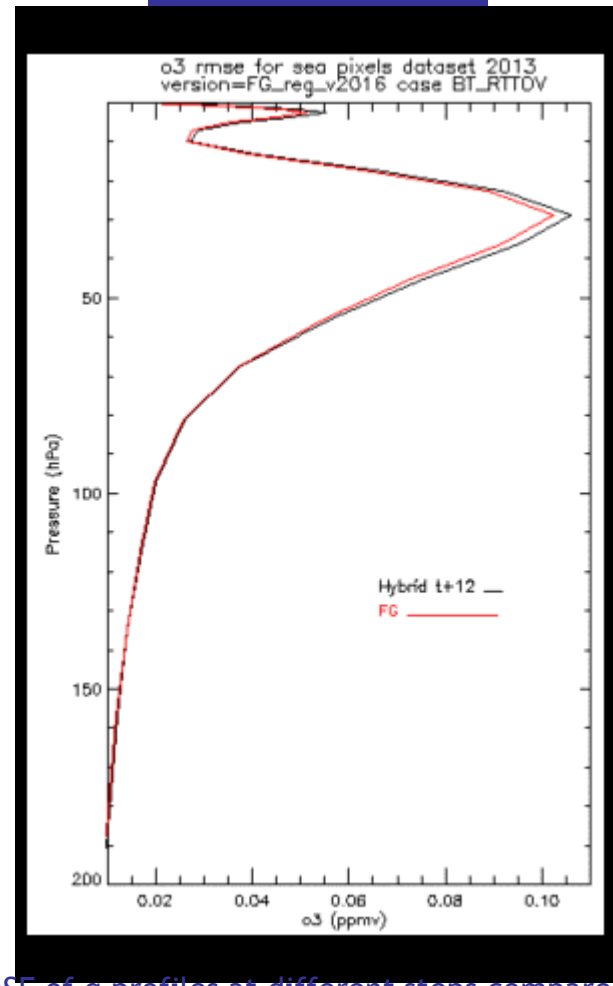
RMSE of q profiles at different steps compared with ECMWF analysis hybrid profiles over sea pixels in the Full Disk region after screening using synthetic RTTOV BTs

Background NWP model ECMWF at 91 hybrid levels

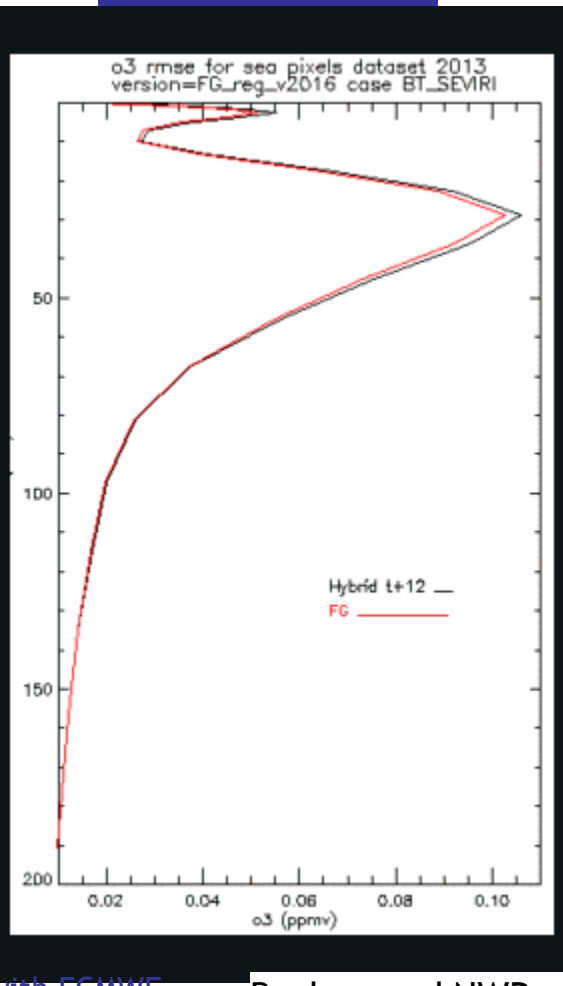
After screening of 5% pixels with the largest distance between RTTOV_BT and SEVIRI BT on non-window channels

Ozone rmse sea pixels: RTTOV-11.2 validation for version 2016

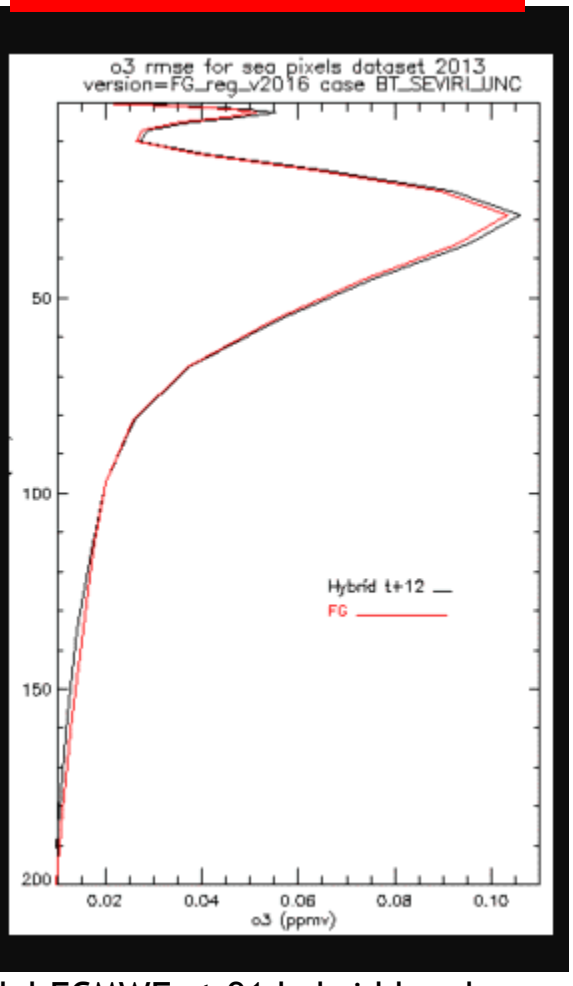
Ozone For BT_{RTTOV} case



Ozone For BT_{SEVIRI} case



Ozone For uncorrected BT_{SEVIRI} case



RMSE of q profiles at different steps compared with ECMWF analysis hybrid profiles over sea pixels in the Full Disk region after screening using synthetic RTTOV BTs

Background NWP model ECMWF at 91 hybrid levels

After screening of 5% pixels with the largest distance between RTTOV_BT and SEVIRI BT on non-window channels

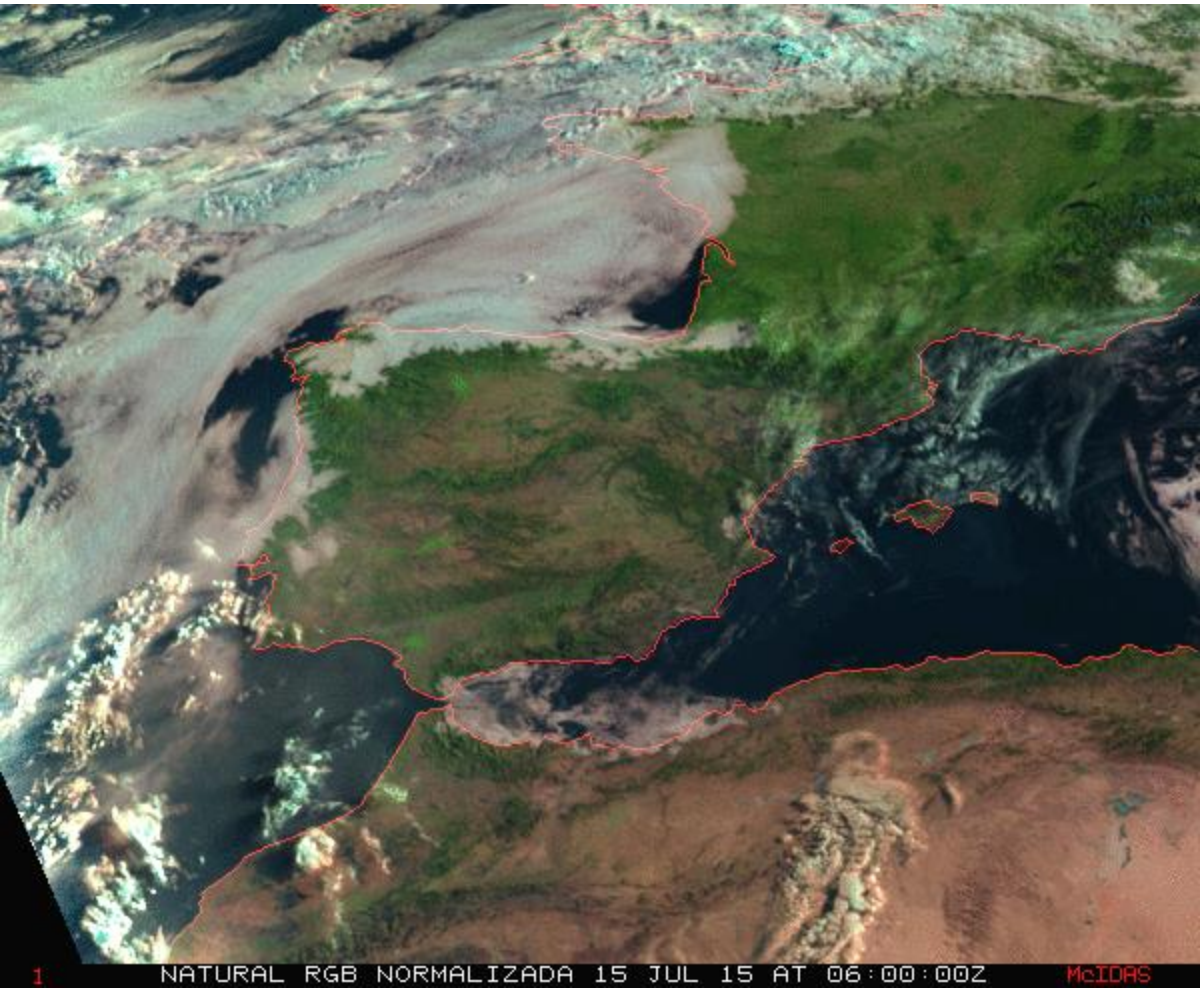
Testing software case study
15th July 2015

For monitoring convection on Iberian Peninsula the precipitable water at medium layer ML is very important. It is a good idea to have the possibility to show the differences with the background NWP.

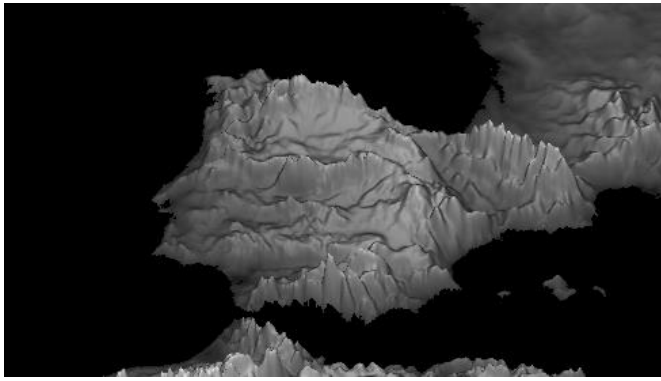
In the case to generate the retrieval using NWP with enough number of vertical levels is possible to use 3D tools to show the differences with the background NWP (*as example execution of PGE13Hyb with ECMWF GRIB files on hybrid levels*). Here one example on how to exploit the outputs is shown.

iSHAI outputs should be always used together with other sources of information as RGB images, RADAR images, lightning detectors, etc

Normalized natural RGB images
15th July 2015



Convection in the Peninsula Iberian Mountains

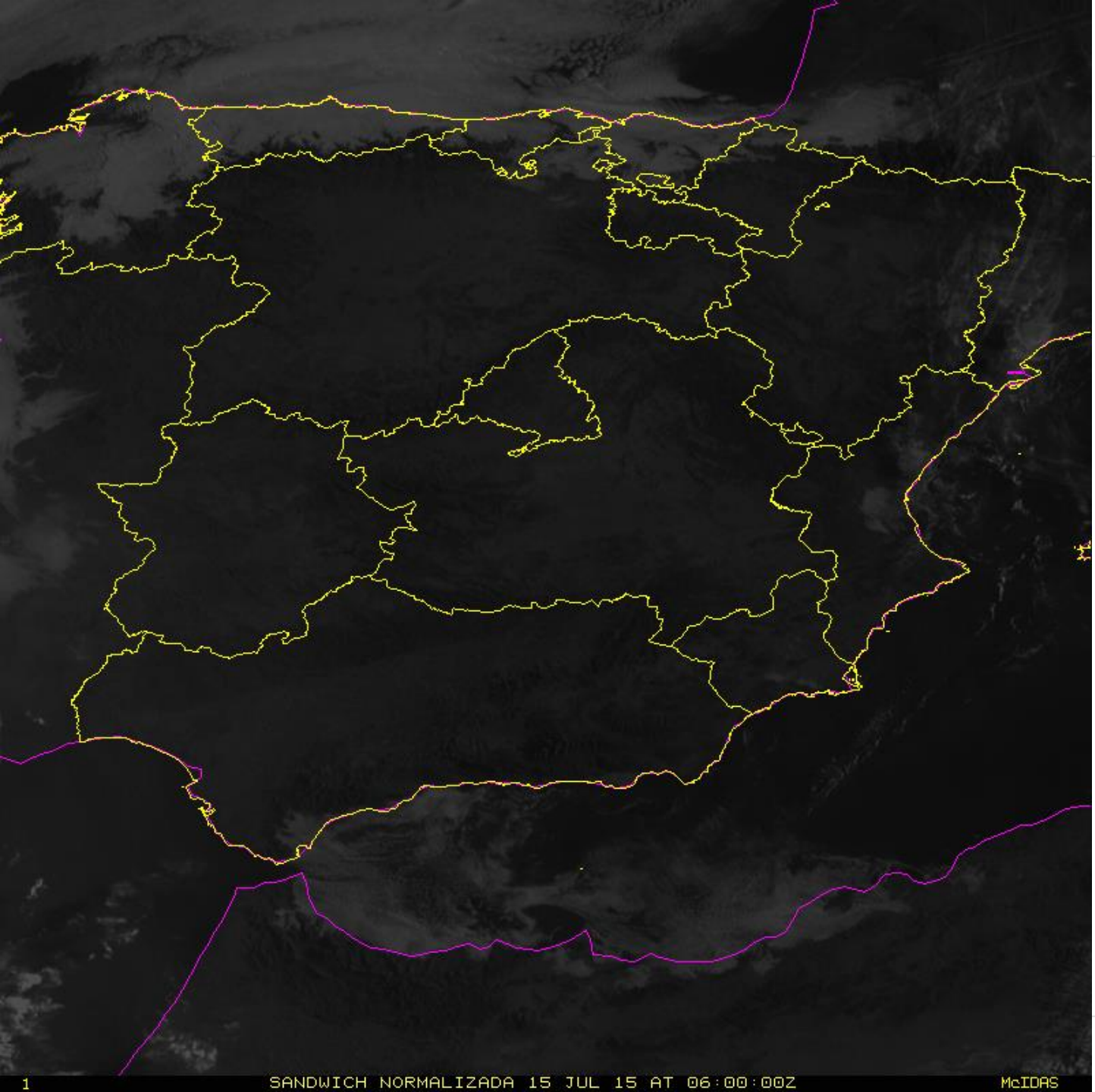


The VIS channels have been normalized in order to enhance the contrast at twilights.

The VIS channels radiances have been normalized to same sun zenith angle position using an AEMET McIDAS command.

	MSG
RED	IR1.6
GREEN	VIS0.8
BLUE	VIS0.6

Slight degraded colors due to animated GIF not video



Normalized sandwich images 15th July 2015

Convection in the Peninsula Iberian Mountains

The VIS channels have been normalized in order to enhance the contrast at twilights.

The VIS channels radiances have been normalized to same sun zenith angle position using an AEMET McIDAS command.

Slight degraded colors due to animated GIF not video

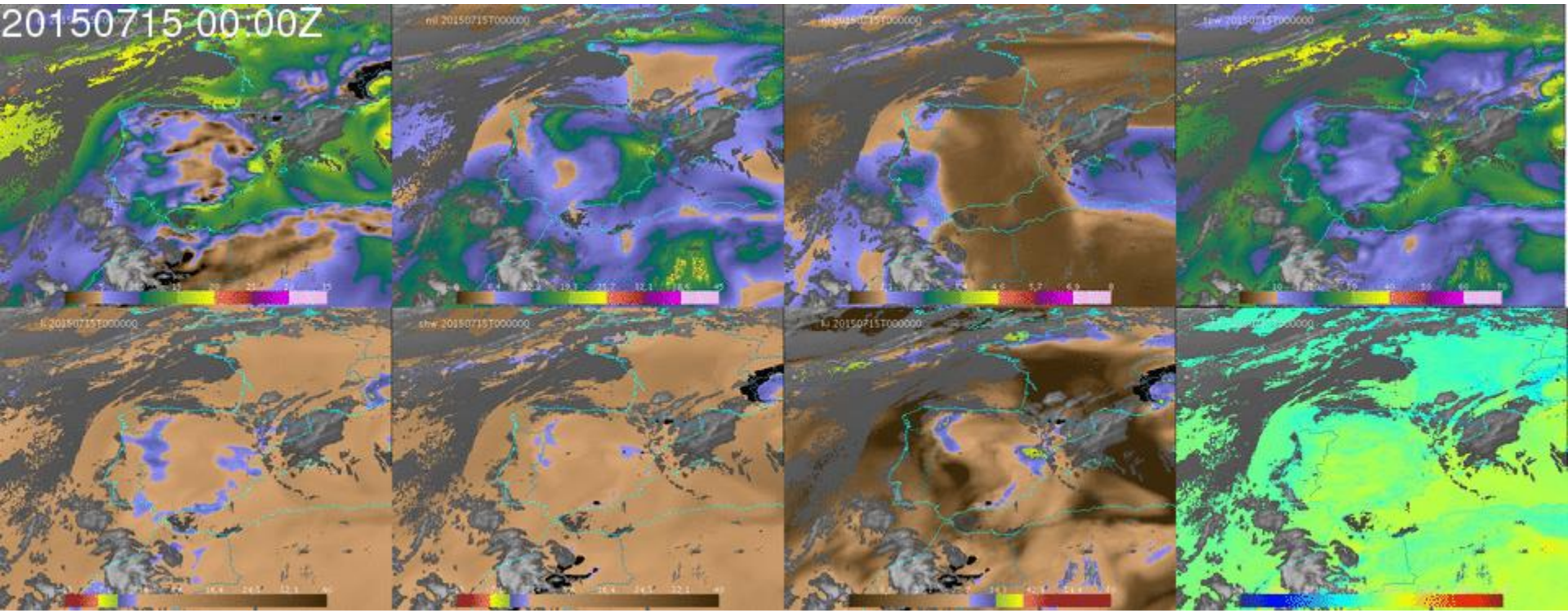
iSHAI outputs 15th July 2015: Precipitable water, instability indices and Skin Temperature fields

BL
Precipitable Water in Boundary Layer (P_{sfc}-850hPa)

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

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

TPW
Total Precipitable Water in Middle Layer (Psfc-0.1 hPa)



LI
Lifted Index

SHW
Showalter Index

KI
K-Index

SKT
Skin Temperature

iSHAI reprocessing at 1x1 with BT_RMS_THRESHOLD=0 and 1 iteration

The individuals images has been generated with McIDAS-V in batch mode after generation of bundle files and importing color palettes.

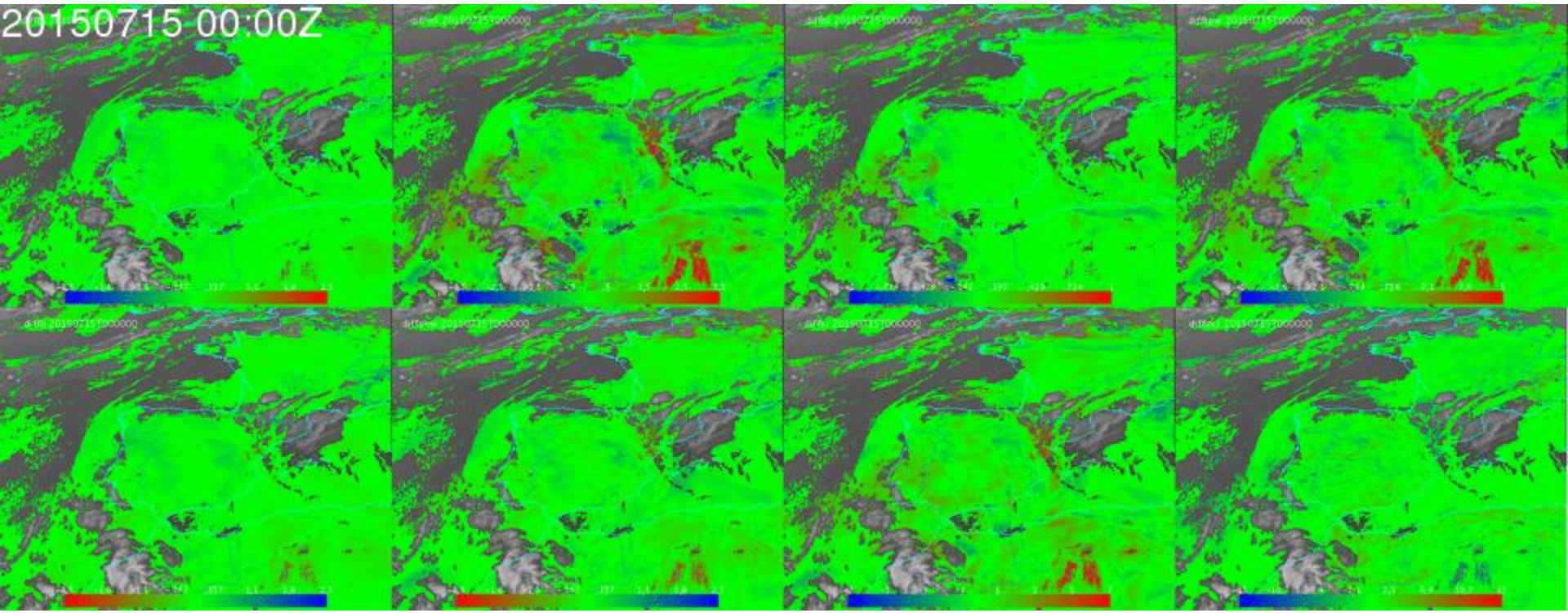
iSHAI outputs 15th July 2015: Precipitable water, instability indices and Skin Temperature fields

diffBL
Precipitable Water in Boundary Layer (P_{sfc}-850hPa)

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

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

diffTPW
Total Precipitable Water in Middle Layer (Psfc-0.1 hPa)



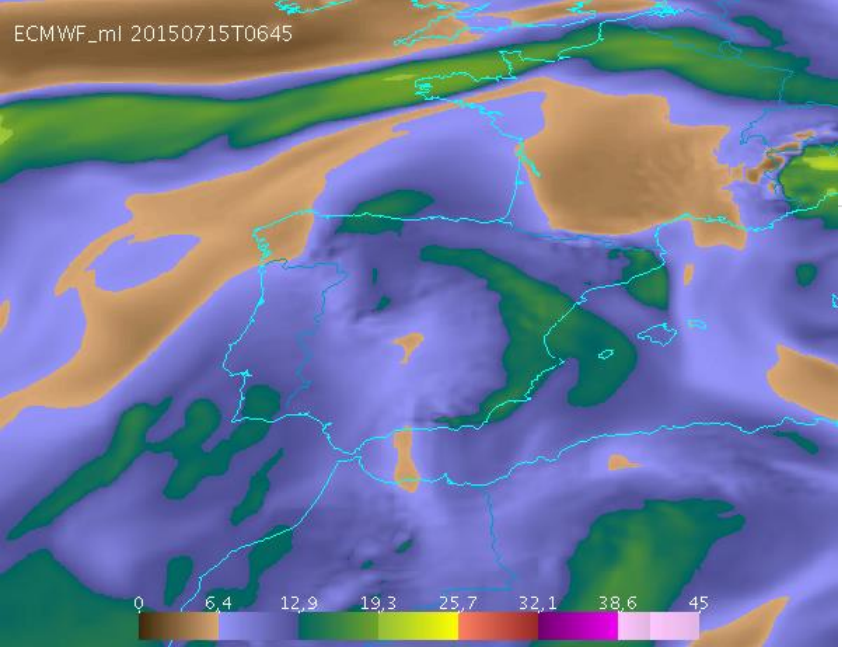
diffLI
Lifted Index

diffSHW
Showalter Index

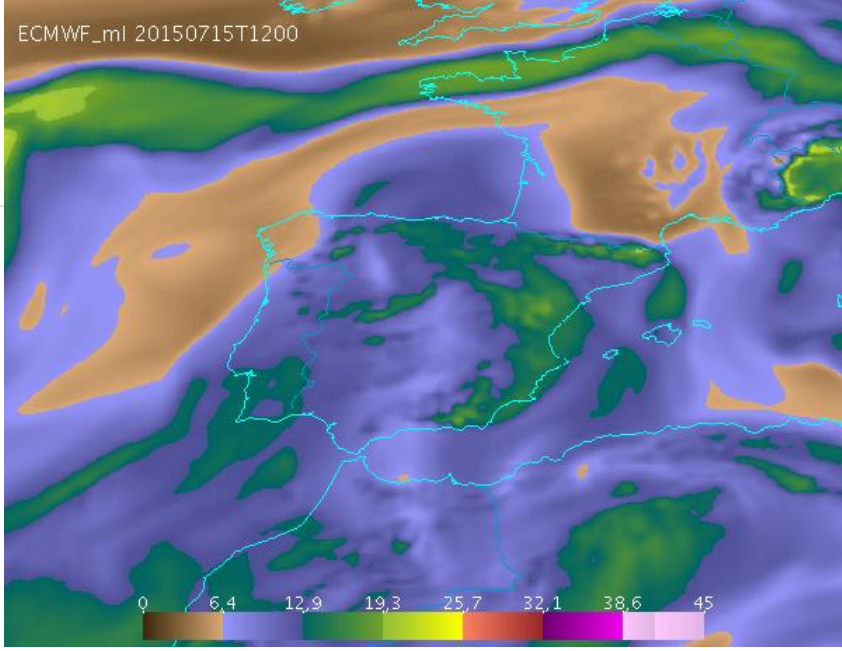
diffKI
K-Index

diffSKT
Skin Temperature

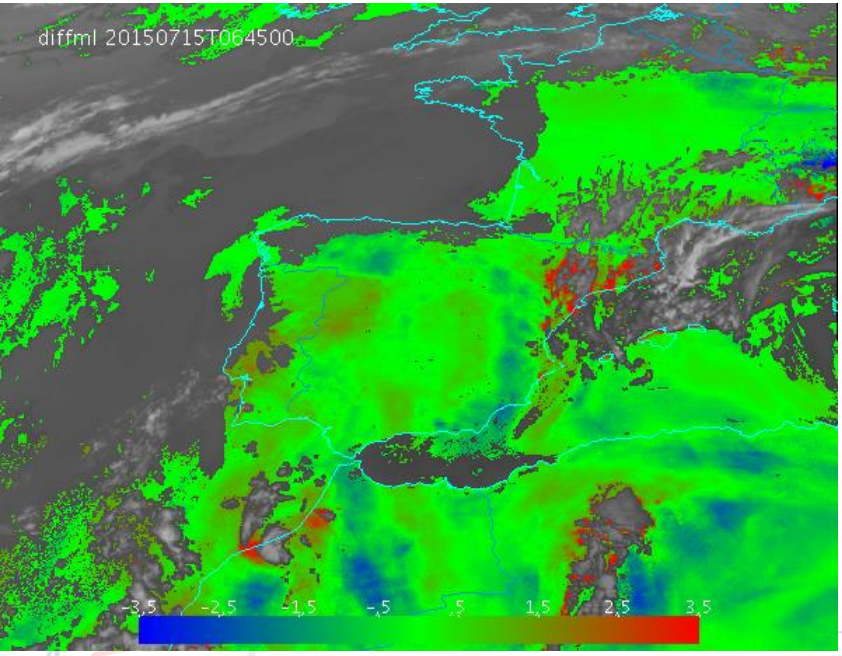
The individuals images has been generated with McIDAS-V in batch mode after generation of bundle files and importing color palettes.



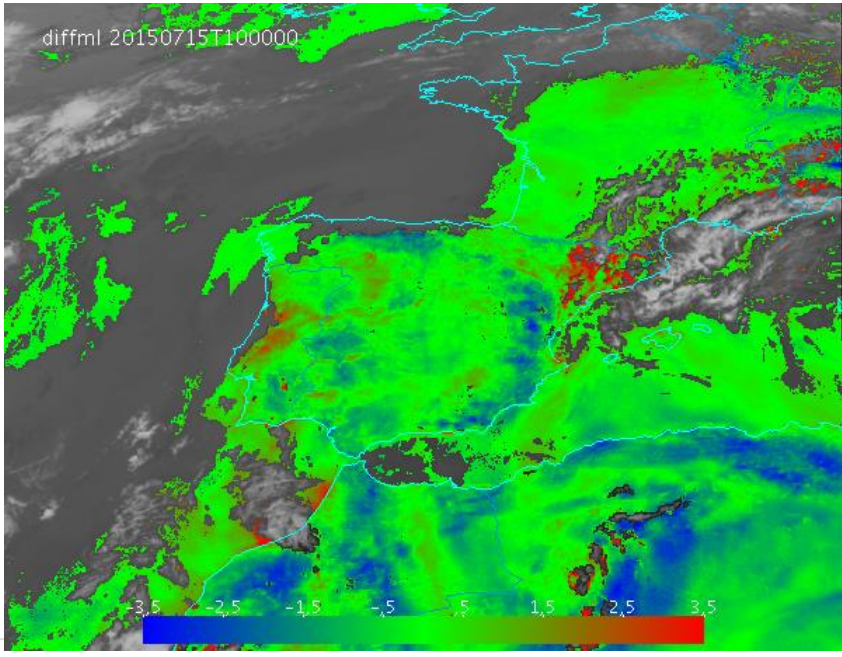
ML ECMWF t+18:45 from 14th July 12Z run



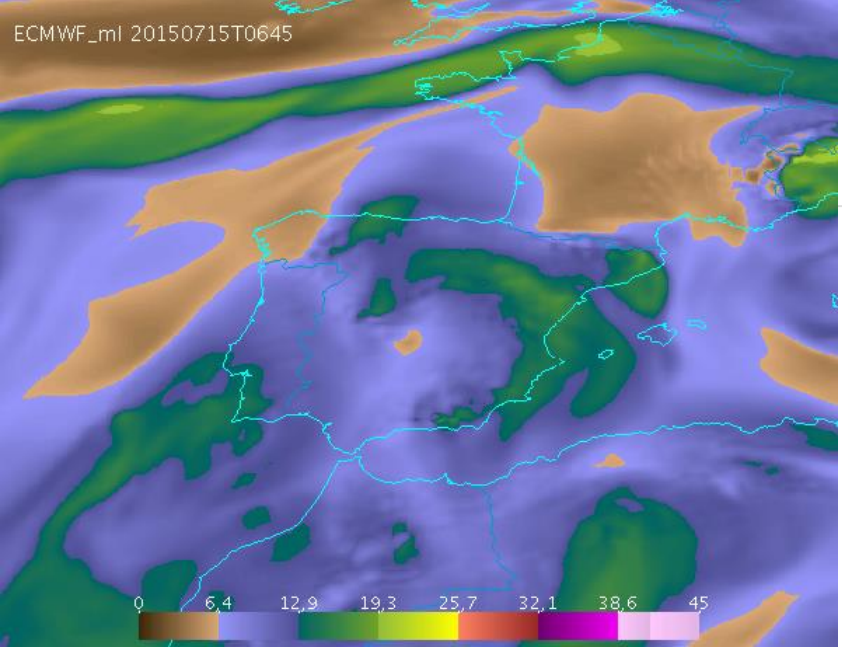
ML ECMWF t+24 from 14th July 12Z run



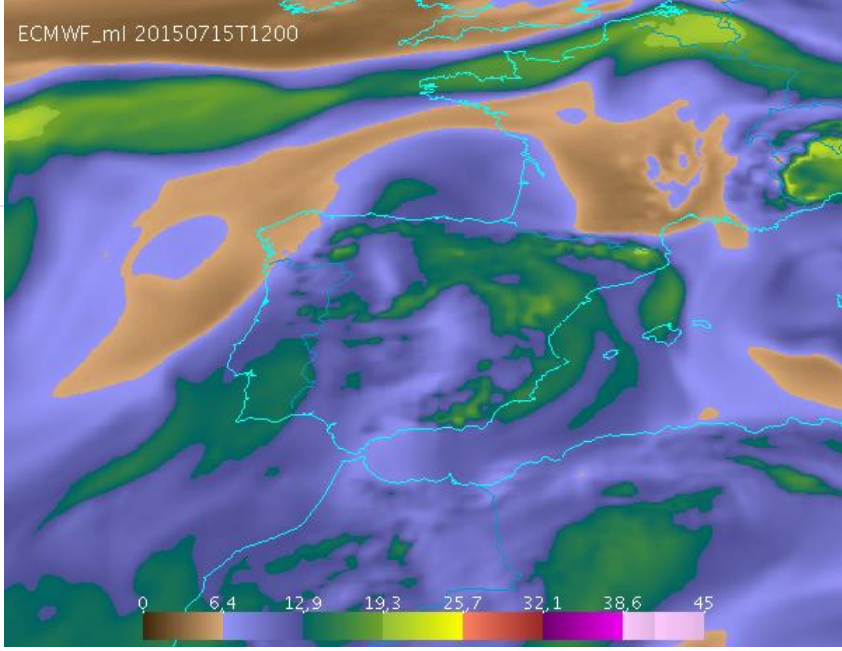
diffML iSHAI using t+18:45 from 14th July 12Z run



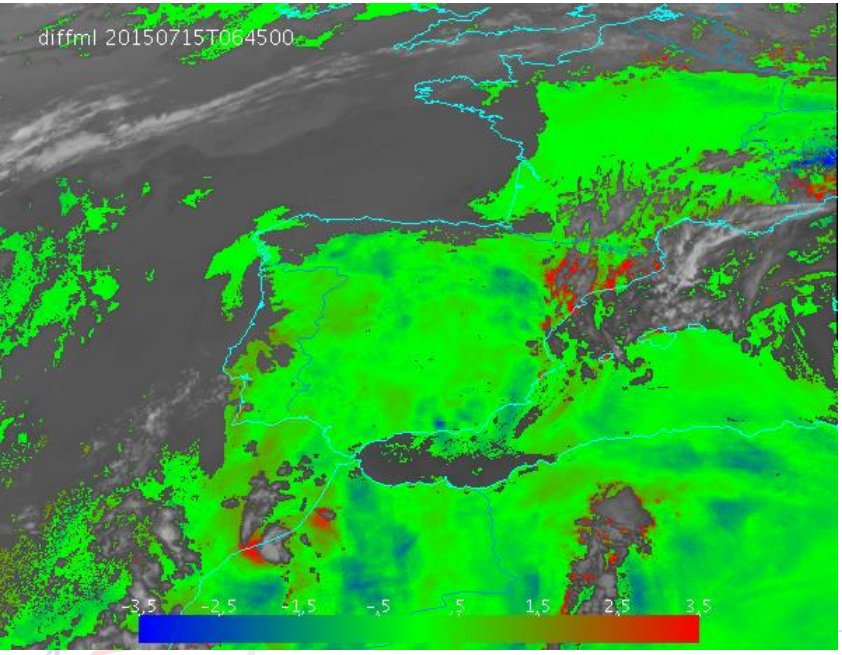
diffML iSHAI using t+24 from 14th July 12Z run



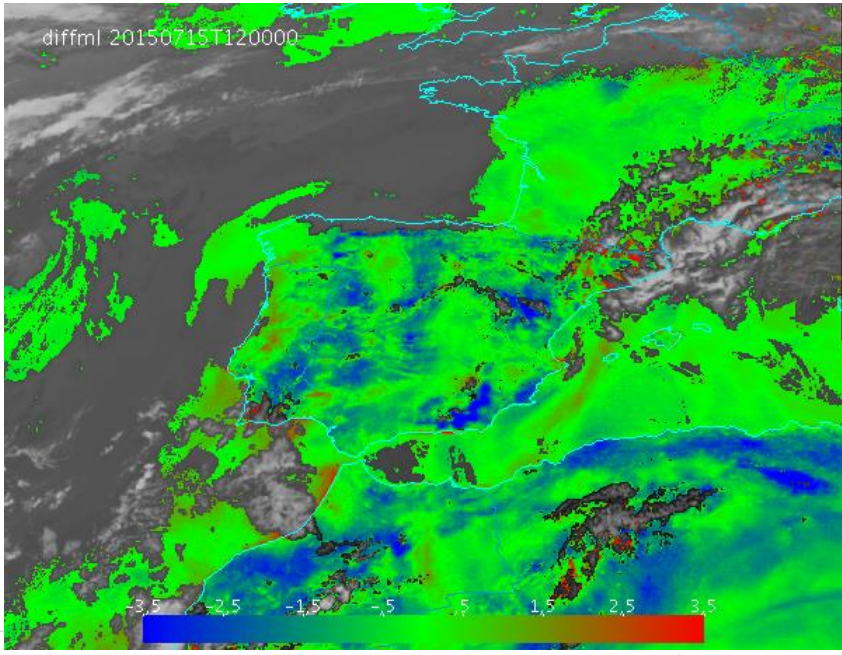
ML ECMWF t+6:45 from 15th July 00Z run



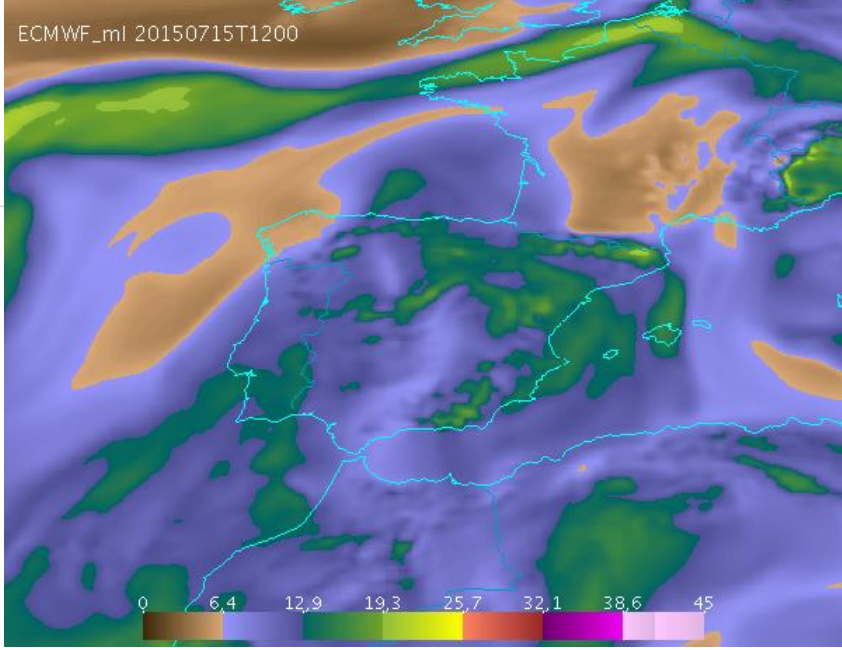
ML ECMWF t+12 from 15th July 00Z run



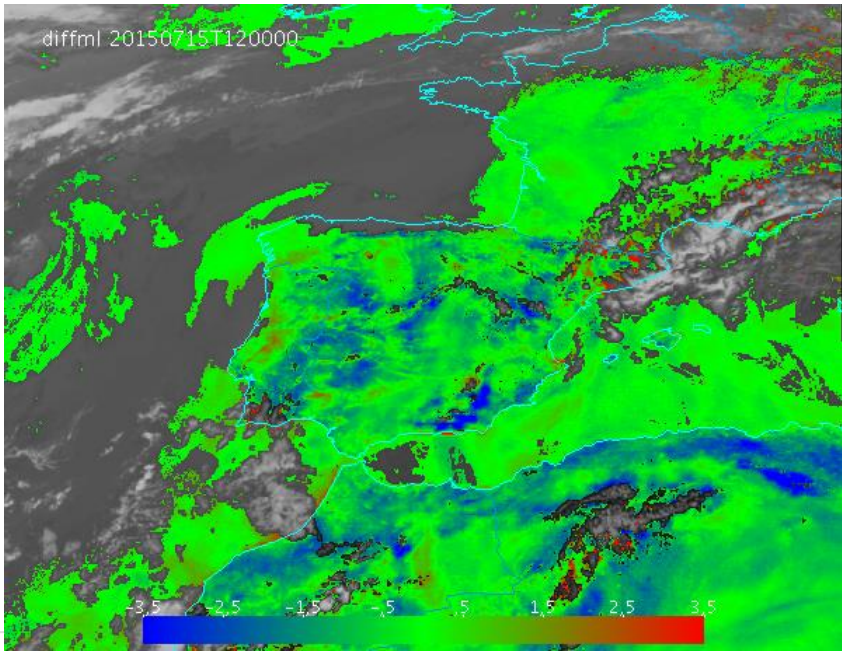
diffML iSHAI using t+6:45 from 15th July 00Z run



diffML iSHAI using t+12 from 15th July 00Z run



ML ECMWF t+00 from 15th July 12Z run



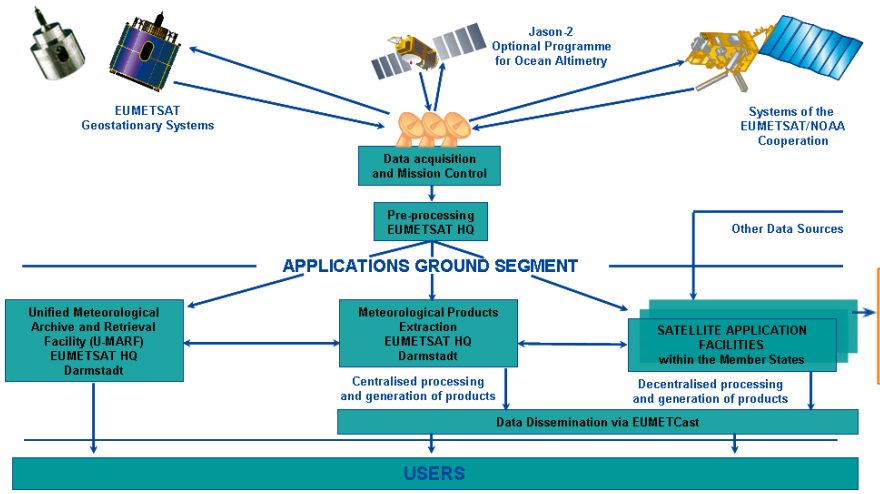
diffML iSHAI using t+00 from 15th July 12Z run

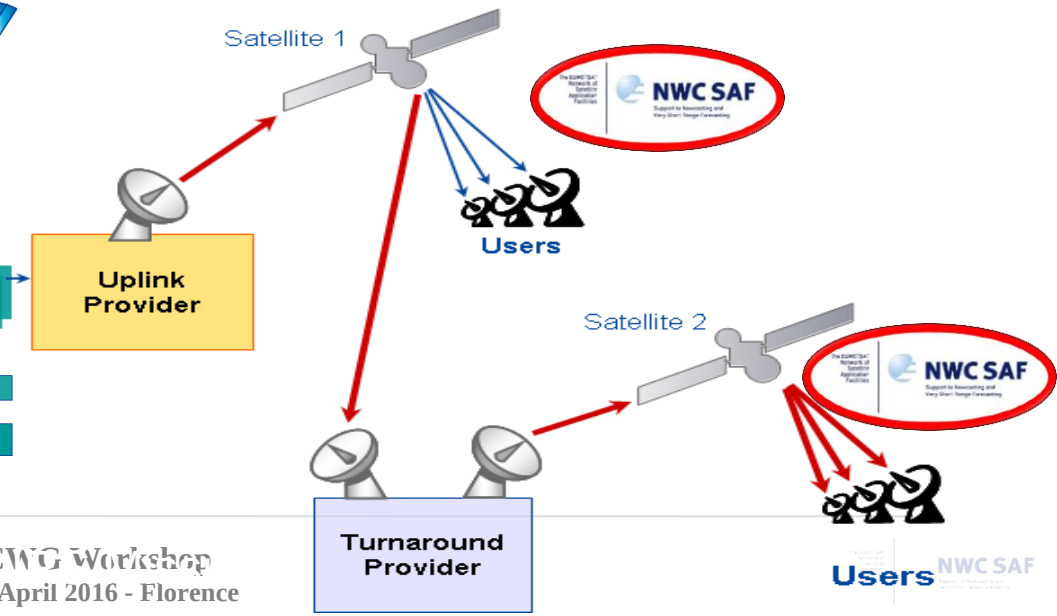
Ground Segment scheme: Distributed between Central Facilities and SAFs

NWC-SAF is one special SAF because it develops software.

NWC-SAF products are generated locally by users => No bandwidth constraints.

NWC-SAF is the SAF nearest to users. It works in the users side of the EUMETCast



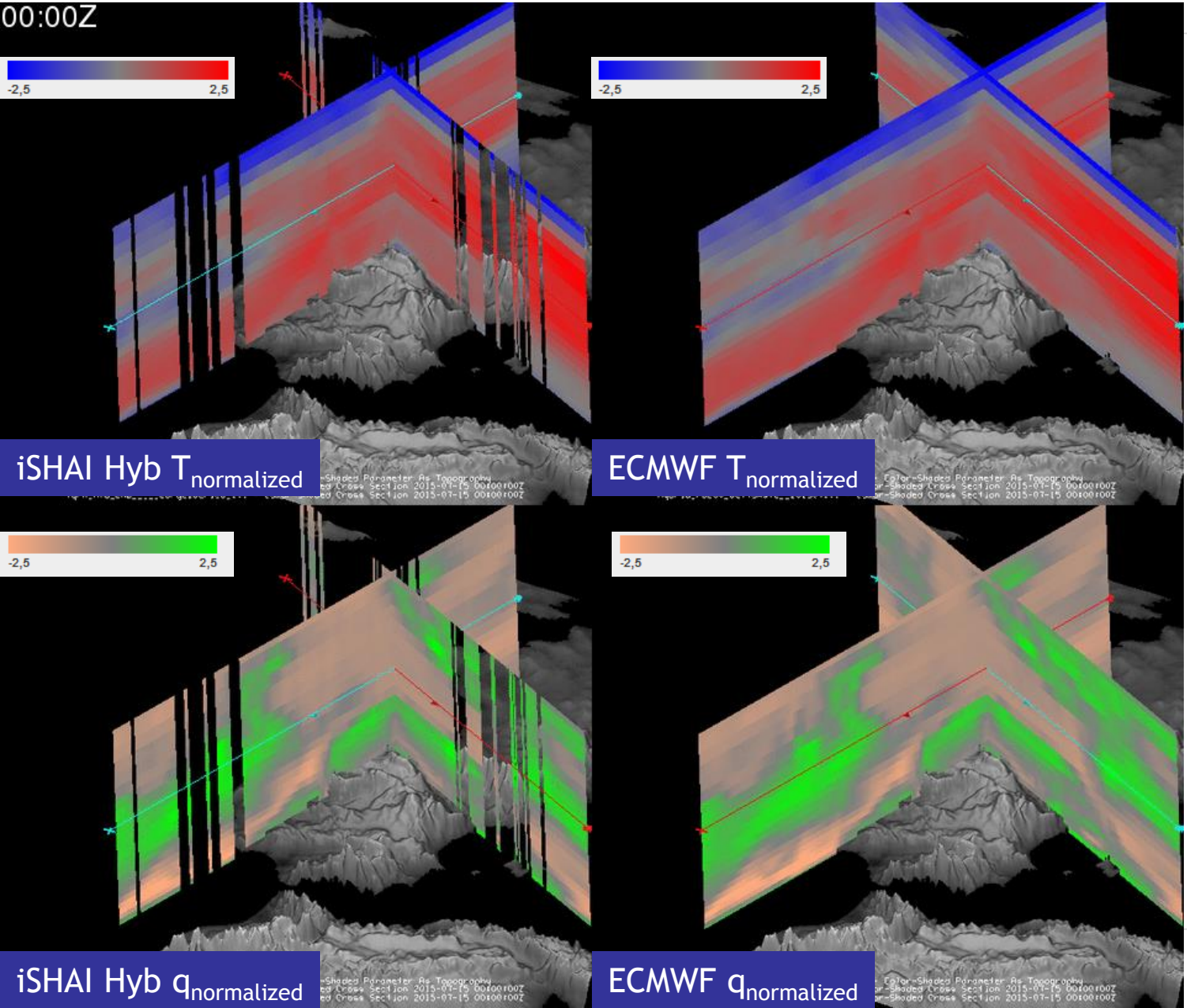


Conversion of iSHAI binary files to NetCDF format

- As an **optional output**, the intermediate and retrieved and the profiles from the NWP model interpolated at 54 RTTOV levels may be written as another output on binary format.
  - The users can activate it in the ASCII configuration file. Then the binary files will be written in the $SAFNWC/tmp directory. This allows users to debug their local implementation, to get access to the retrieved temperature and humidity profiles and to compare them with the background NWP profiles.
- It was written in 2010 an IDL procedure to convert to NetCDF format the optional PGE13 binary files. It would be easy migration to C or Fortran.
- Ancillary data (longitude, latitude, topo, emissivity, etc) are now included.
- It is supported as best effort basis. Currently on request to ***mmartinezr@aemet.es***
- These NetCDF files can be used on IDV and McIDAS-V (same structure that for IASI L2 and heritage of WRF outputs).

MCIDAS-V	http://www.ssec.wisc.edu/mcidas/software/v/
IDV	http://www.unidata.ucar.edu/software/idv/

Ideas for use of normalized T and q 3D arrays. Vertical cross section comparison with NWP



15th July 2015

Example of interactive use with McIDAS-V .

The T and q 3D array could be normalized.

For normalize them it is subtracted the mean on the level and divided by the standard deviation on the level for one slot.

Ideas for new instability indexes

Since interactive tools and new hardware could calculate any index from T and q profiles the possibility to use profiles and differences θ_e as instability indices could be studied following R. Petersen (U. Wisconsin) ideas.

$$\theta_e = T_e \left(\frac{p_0}{p}\right)^{\frac{R_d}{c_p}} \approx \left(T + \frac{L_v}{c_p} r\right) \left(\frac{p_0}{p}\right)^{\frac{R_d}{c_p}}$$

R. Petersen propose **$\theta_{e\ 850} - \theta_{e\ 500}$ as one instability index** and he has establish a relation with LI from parcel at 850 hPa (Showalter Index).

The idea is develop this 2D field and to have the possibility to uses the 3D structure with interactive tools on cross vertical section, profiles or 2D field.

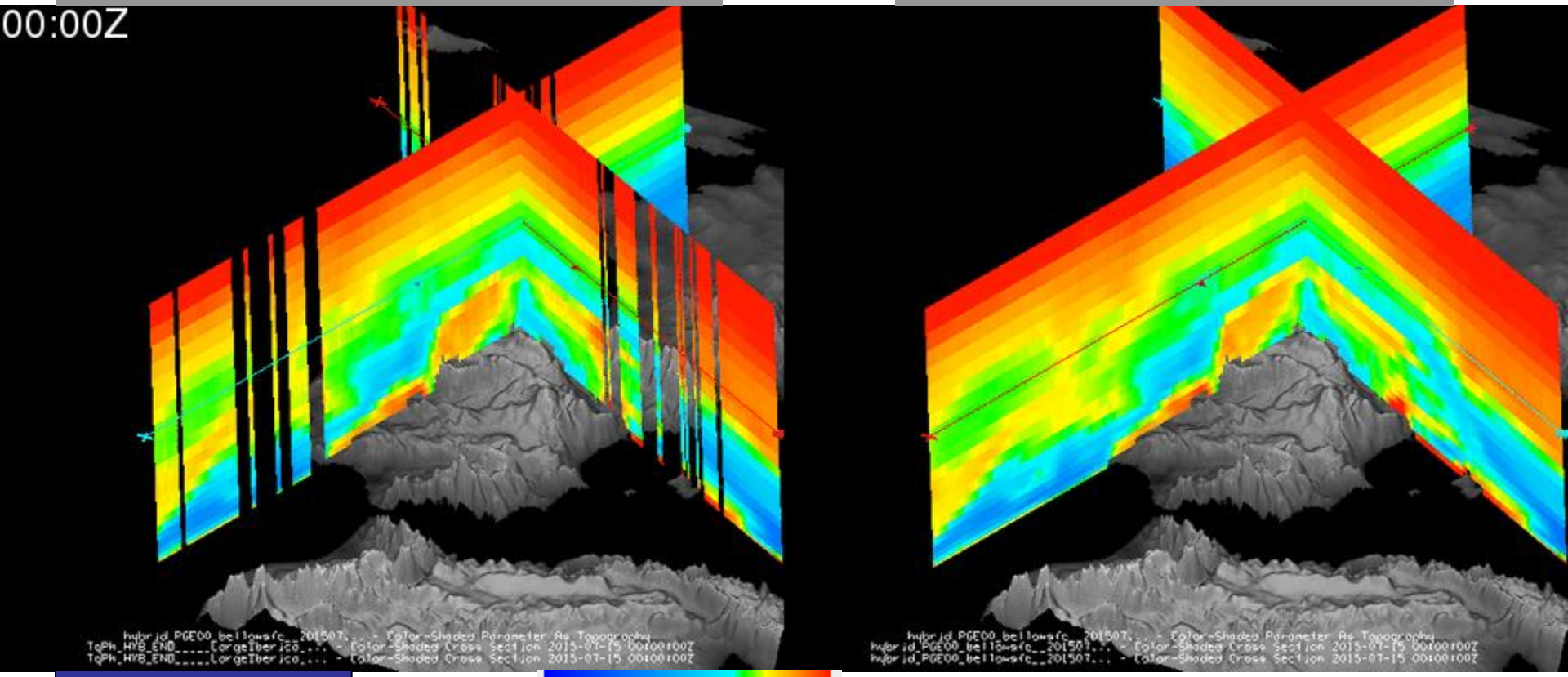
Objective: Determine sources of lower-level moisture/heat

• Equivalent Potential Temperature (θe) combines information about the temperature and moisture content (thermal energy) of air

θ_e vertical cross comparison of ECMWF and iSHAI physical retrieval

θ_e from 2016 iSHAI Hybrid version

θ_e from ECMWF



Example of interactive use in McIDAS-V of iSHAI Hyb and ECMWF binary files converted to netCDF.

15th July 2015

Vertical cross section using GRIB files in hybrid levels spatial, time and vertical interpolated to the 54 RTTOV pressure levels

Future developments in clear air products

In CDOP-3 the software for nowcasting products will be continuously improved and updated for MSG processing.

The software for Nowcasting products will be migrated to other GEO satellites (GOES-R, Himawari)

The equivalent product of the GOES-R is also based on the algorithm of Dr. Jun Li of CIMSS / Wisconsin. It will allow comparison of iSAHI for GOES-R using RTTOV and ECMWF with the legacy GOES-R outputs.

It will be explored ideas as “time continuity” (Jun Li idea) and Optical flows (It will explore the spatial and temporal resolution (gradients and trends between consecutive images).

Preparation for MTG:

see Xavier Calbet presentation

Summary and conclusions

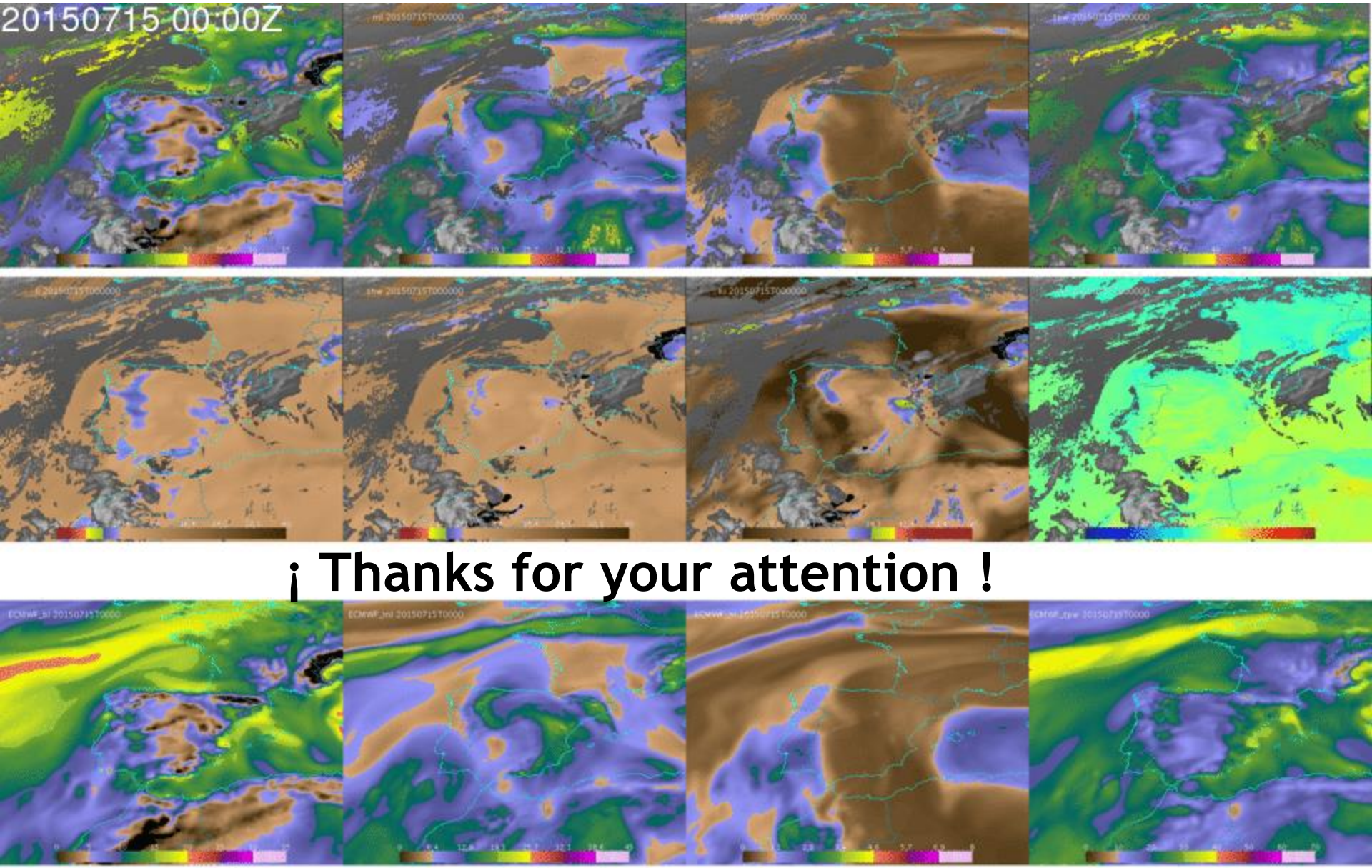
- iSHAI provides useful spatial and temporal information; especially to detect disagreement between the background NWP model and the iSHAI outputs based on MSG observations. The best results are obtained for humidity in medium layers due to the contribution of the two MSG water vapor channels. SEVIRI has limited information to improve the vertical information beyond the forecast, but does provide useful spatial information.

- Validation and datasets generation is a continuous and important task.

- Preparation for MTG era.

- 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.

mmartinezr@aemet.es



¡ Thanks for your attention !