Toward a better use of Infrared radiances over land in NWP models at global and meso scales

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Outline

1.Introduction

2. How to deal with surface parameters in NWP infrared radiances assimilation?

3. Enhancing the IASI assimilation over land
   i. In the global model
   ii. In the convective scale model

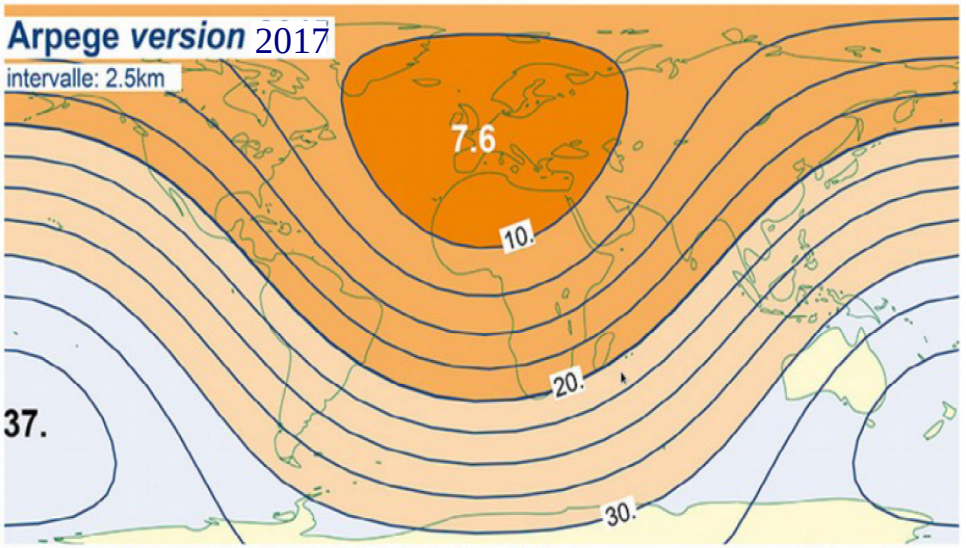
4. Summary and future works

1. Operational NWP models at Météo-France

Global model ARPEGE

Horizontal resolution: from 7.5 to 37 km

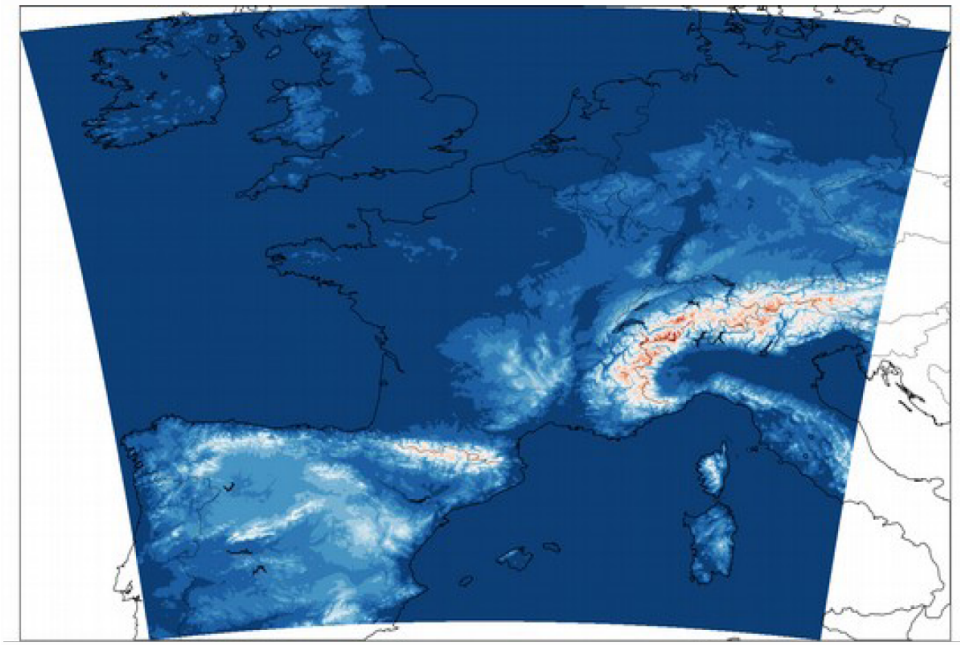
105 vertical levels (from 10 m up to 0.1 hPa)



Convective-scale model AROME

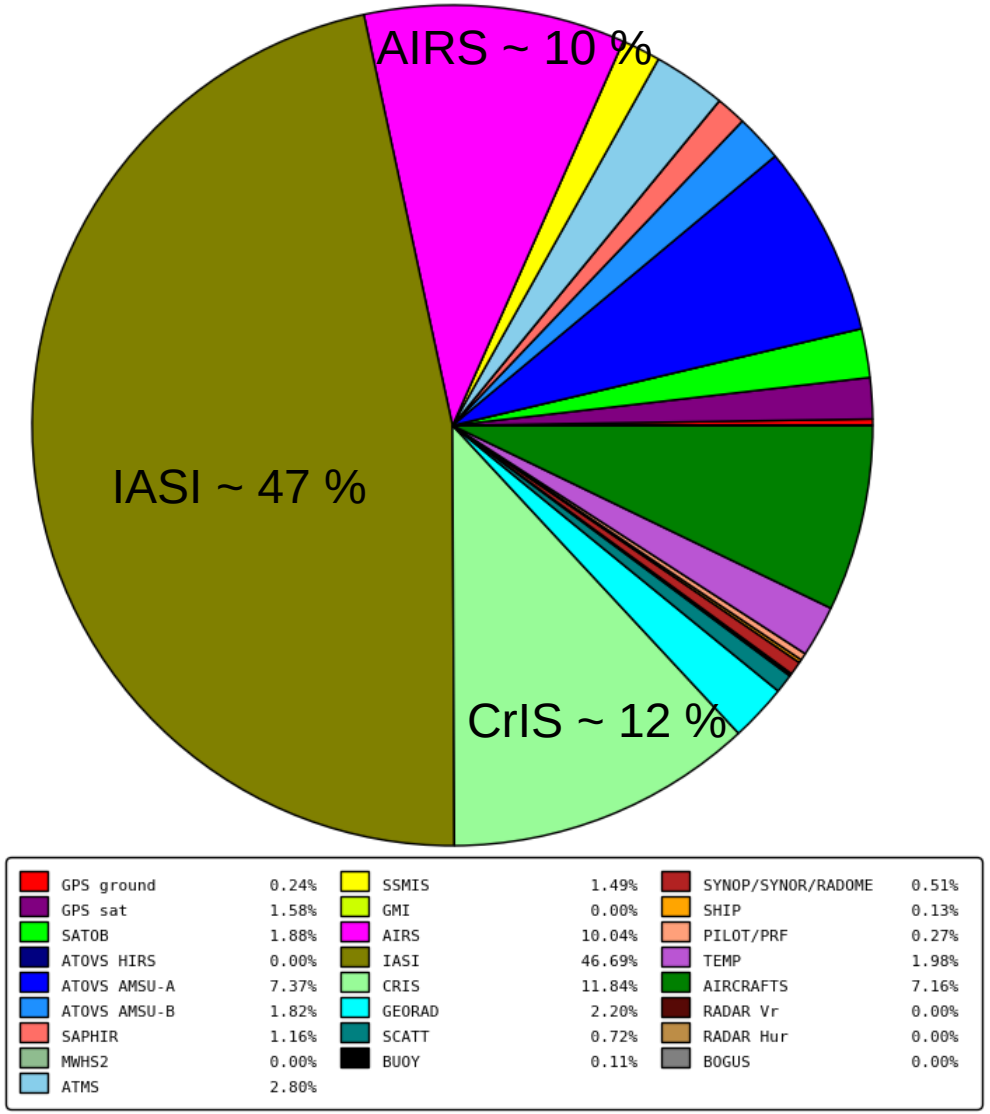
Horizontal resolution: 1.3 km

90 vertical levels (from 5 m up to 10 hPa)
57,3 % of grid points over land



+ regional models for over-seas regions

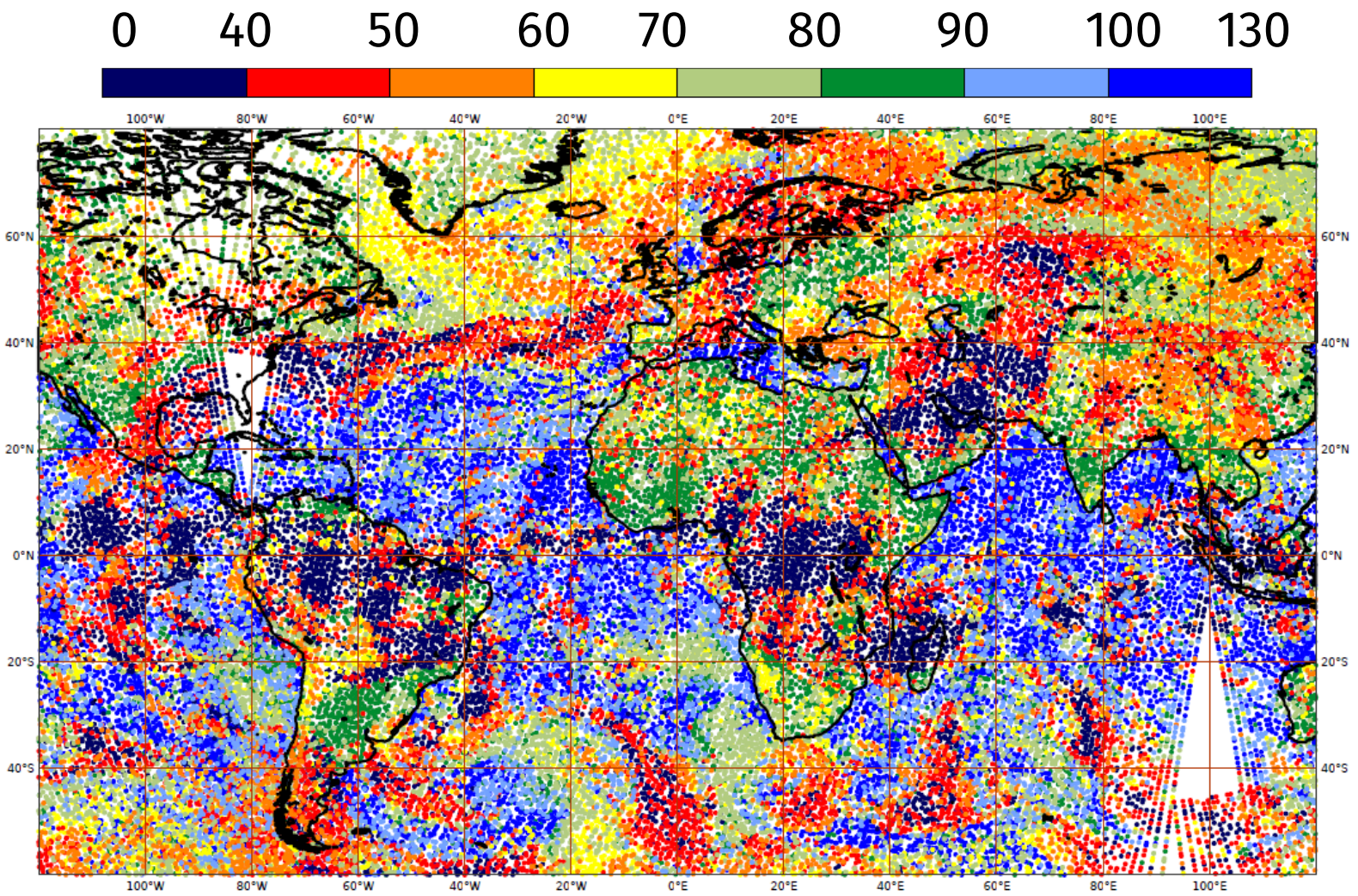
1. Current operational global model ARPEGE: Number of obs.



Hyperspectral IR ~ 69 %
MW ~ 15 %
Scatterometer ~ 0.7%
Aircraft + Radiosondes ~ 9 %

Hyperspectral data provide information on temperature and humidity in the atmosphere

1. Example of the number of IASI channels assimilated per observation point

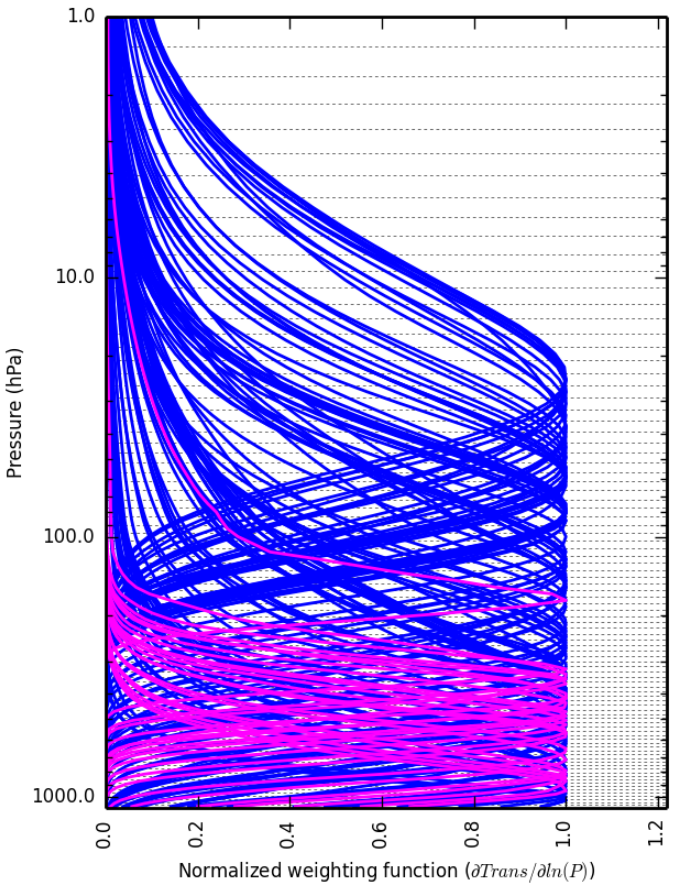


- Less channels used over land than over sea
- At most 123 channels assimilated over the sea.

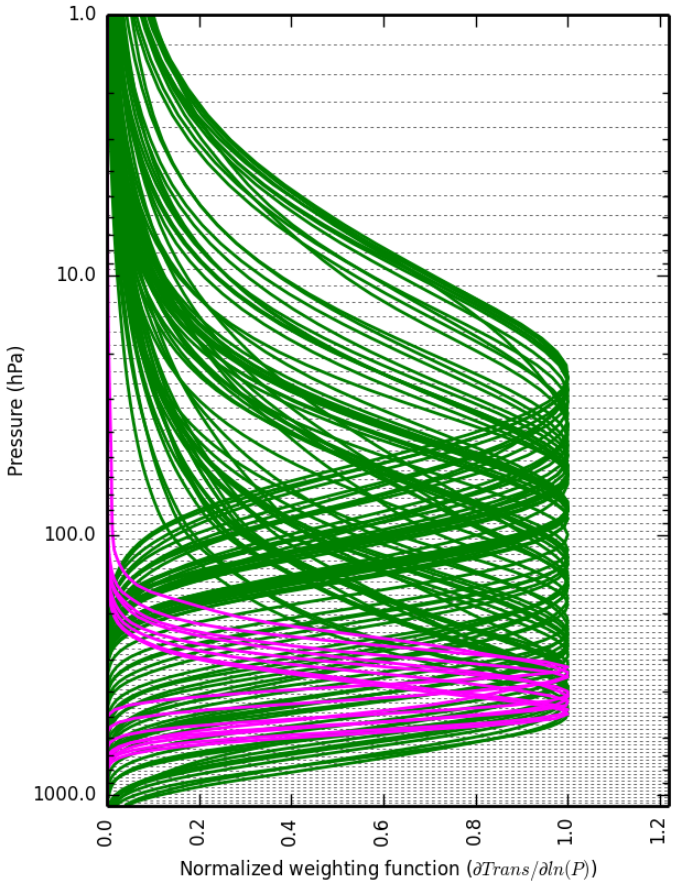
2. Enhancing channel selection over land

Weighting functions of IASI channels

Over sea 123 channels (102T+ 21 WV)



Over land 77 channels (69 T+ 8 WV)



Surface-sensitive channels are rejected over land because of surface incertainties in the NWP model.

2. Land surface parameters: Radiative transfer model

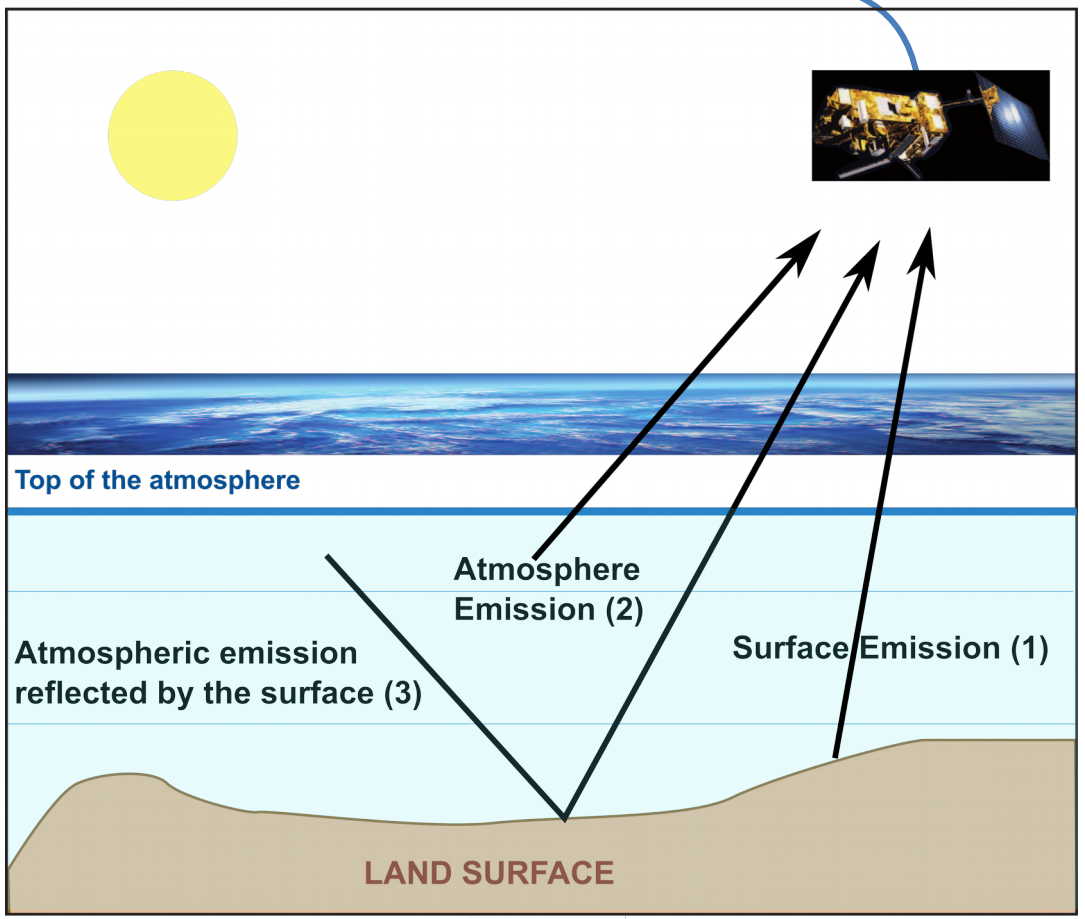
Observed brightness temperature:

$$Tb = T_s.\varepsilon.\Gamma + T_{\uparrow} + T_{\downarrow}.(1-\varepsilon).\Gamma$$

(1) (2) (3)

Surface temperature

Surface emissivity



In operations:

- Surface temperature computed by our surface model and initialised with obs of T 2m and RH 2 m.
- Constant surface emissivity (0,98)

Importance of a realistic surface modelisation

Karbou et al., 2006; Guedj et al., 2011

2. Land surface parameters: Methodology

For microwave observations, Karbou et al. (2006) have shown that surface-sensitive channels can be assimilated with an adequatly described surface

Objective: To provide realistic Land Surface Temperature and Land Surface Emissivity to improve IASI Bt simulations and assimilation over land

Step 1 : Retrievals of LST using IASI window channel 1194

Single-Channel method (inversion of the radiative transfer equation)

Step 2 : Allocate retrievals of LST to other IASI Bt simulations

Evaluation of Observations departures to Simulations

Step 3 : Assimilation experiments of surface-sensitive IR IASI observations over land

Impacts on analyses and forecasts skills

2. How to deal with surface parameter in NWP ?

We need to

- properly describe land surface **emissivity**

- use an accurate land surface/skin **temperature**

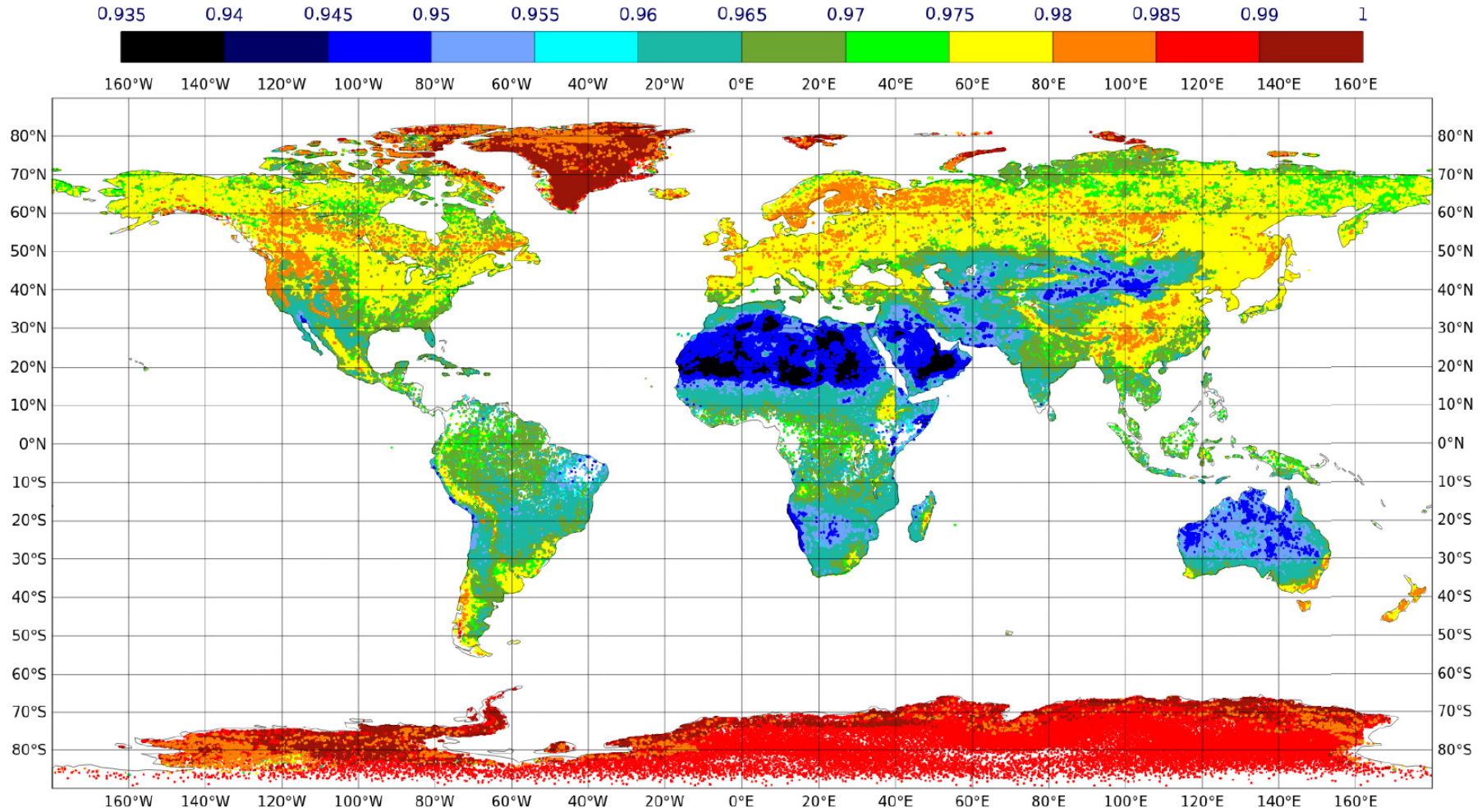
Use of the emissivity atlas of the University of Wisconsin (Seeman *et al*., 2008; Borbas *et al*., 2007)

Retrieval of the surface temperature by using IASI observations. Single-Channel method (inversion of the raditative transfer equation)

2. Land surface emissivity: atlas from UWisconsin

Atlas from the UW/CIMSS (Seeman et al, 2008 ; Borbas et al, 2007)

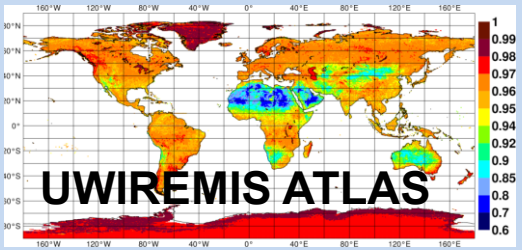
Example for January 2015, for channel 1194 (943.25 cm^{-1})



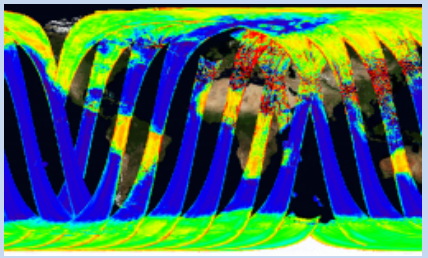
2. Land surface temperature: Retrieval from IASI

Inversion of the radiative transfer equation

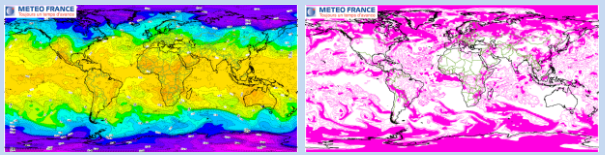
Emissivity atlas $\varepsilon(\nu)$



IASI 1194 BT(ν) Observations

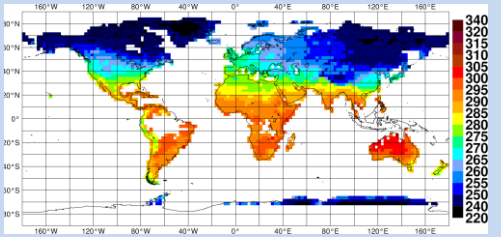


Short-term forecast of T, Q



Radiative transfer model
RTTOV

Surface temperature Ts

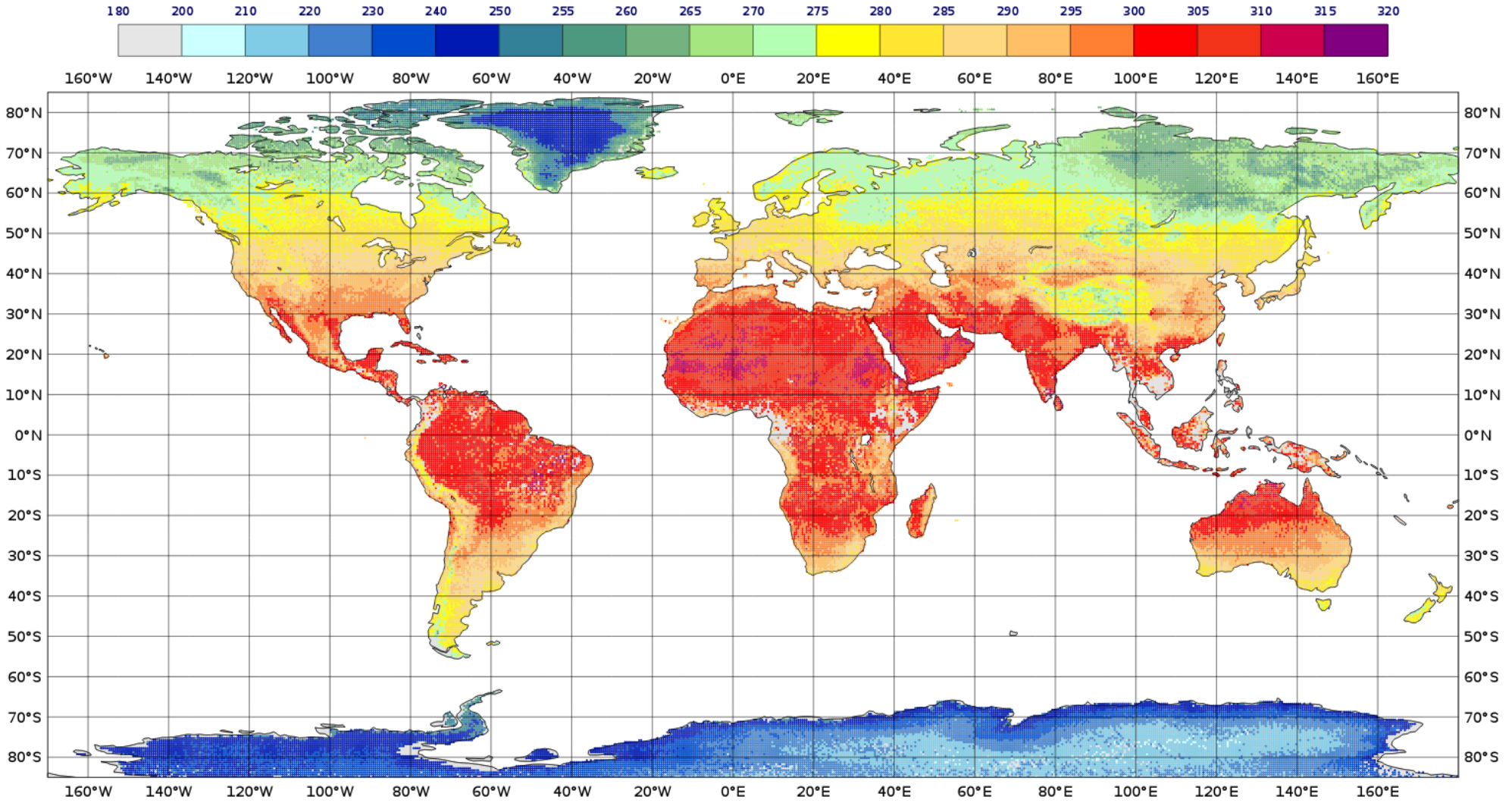


Used for the simulation of the others IASI channels

Methodology proposed by Karbou et al, (2006) applied.
Similar method also used in our system for the assimilation of geostationary infrared SEVIRI radiances in the AROME model.

2. Land surface temperature: retrieval from IASI

Average LST retrieved from IASI channel 1194 (943.25 cm^{-1})
20 September 2016 – 19 October 2016



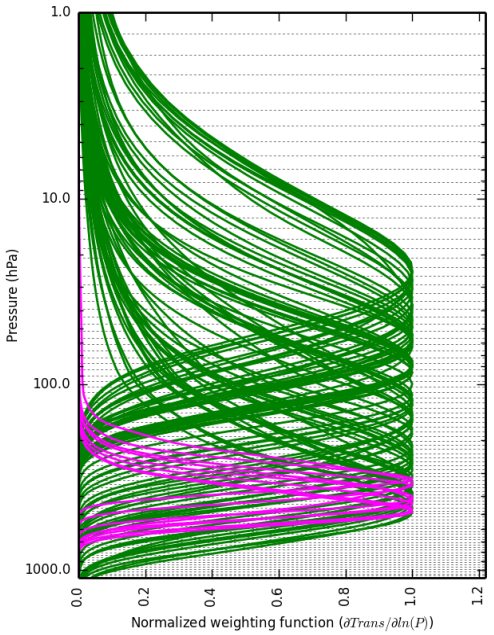
3. Enhancing IASI channel selection over land

Once we have

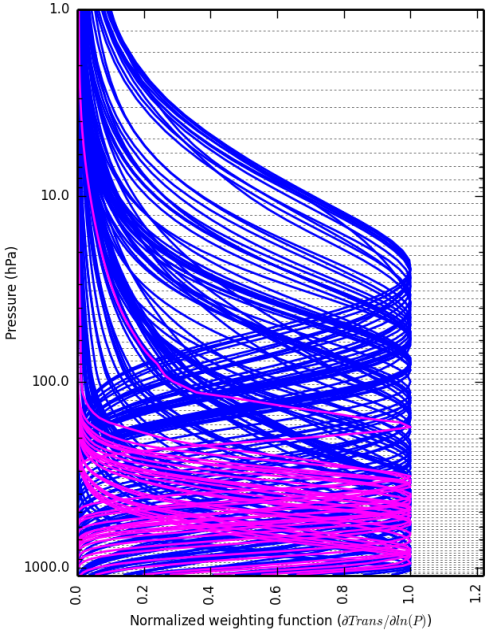
- properly described land surface **emissivity**

- used an accurate land surface/skin **temperature** for the simulation of the others channels

Then the same channel selection can be used over land and sea



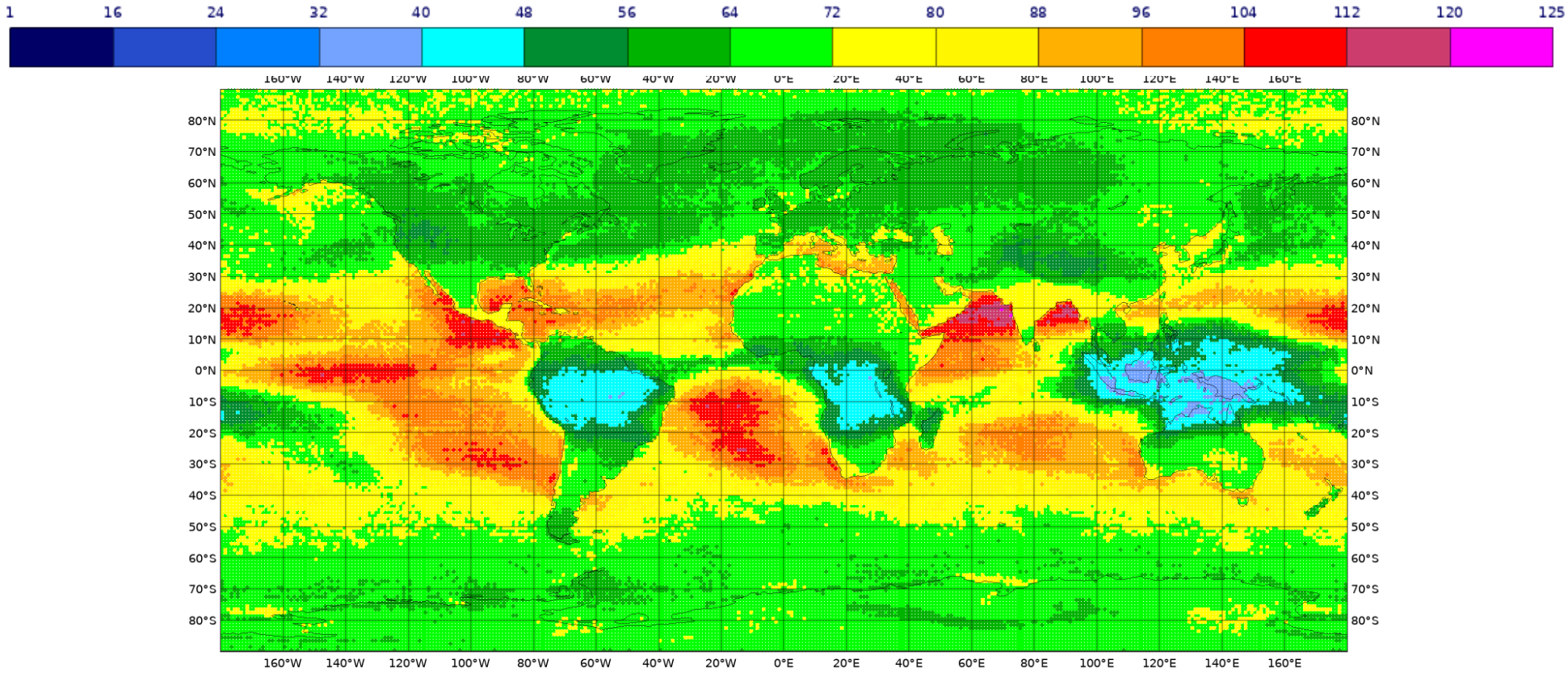
77 channels (69 T+ 8 WV)



123 channels (102T+ 21 WV)

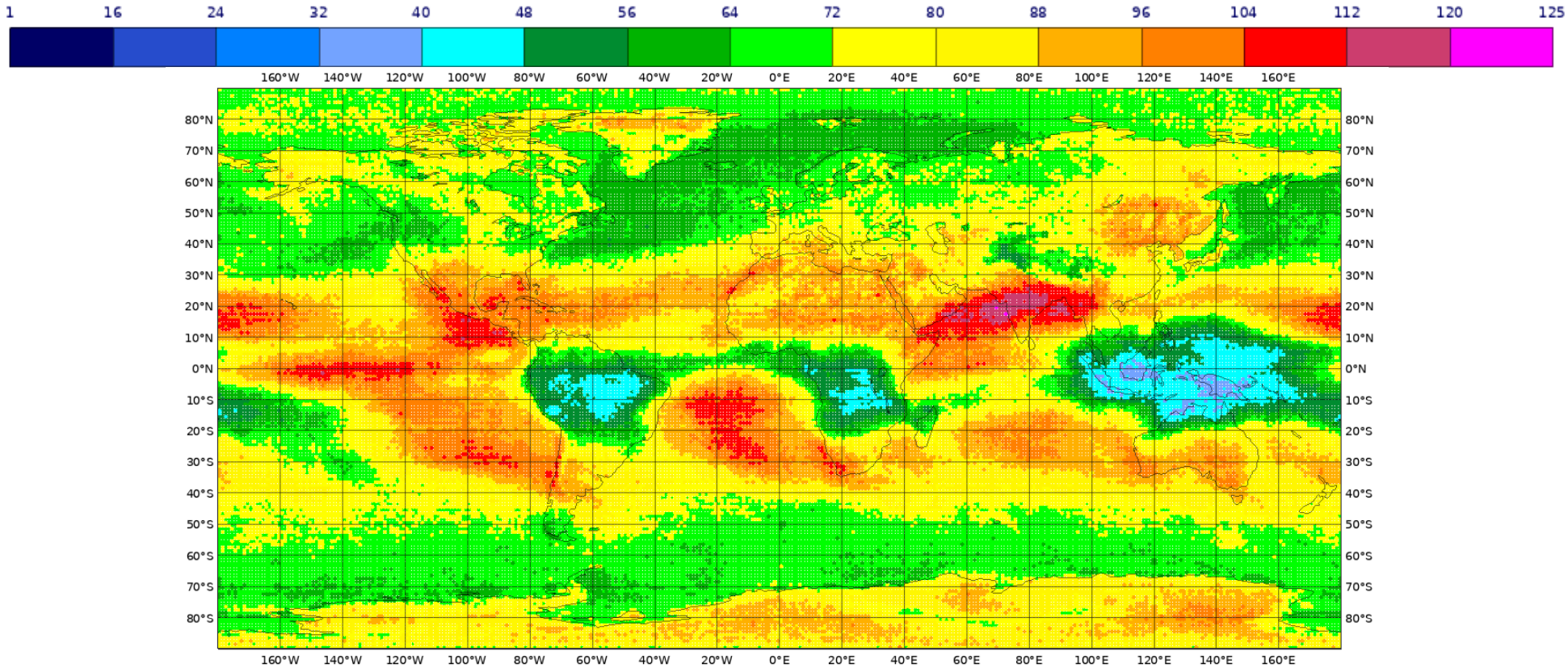
3. Assimilation of surface-sensitive channels over land

Average number of channels assim. per 1deg box - REFERENCE
01 January 2017 – 31 March 2017



3. Assimilate surface-sensitive channels over land

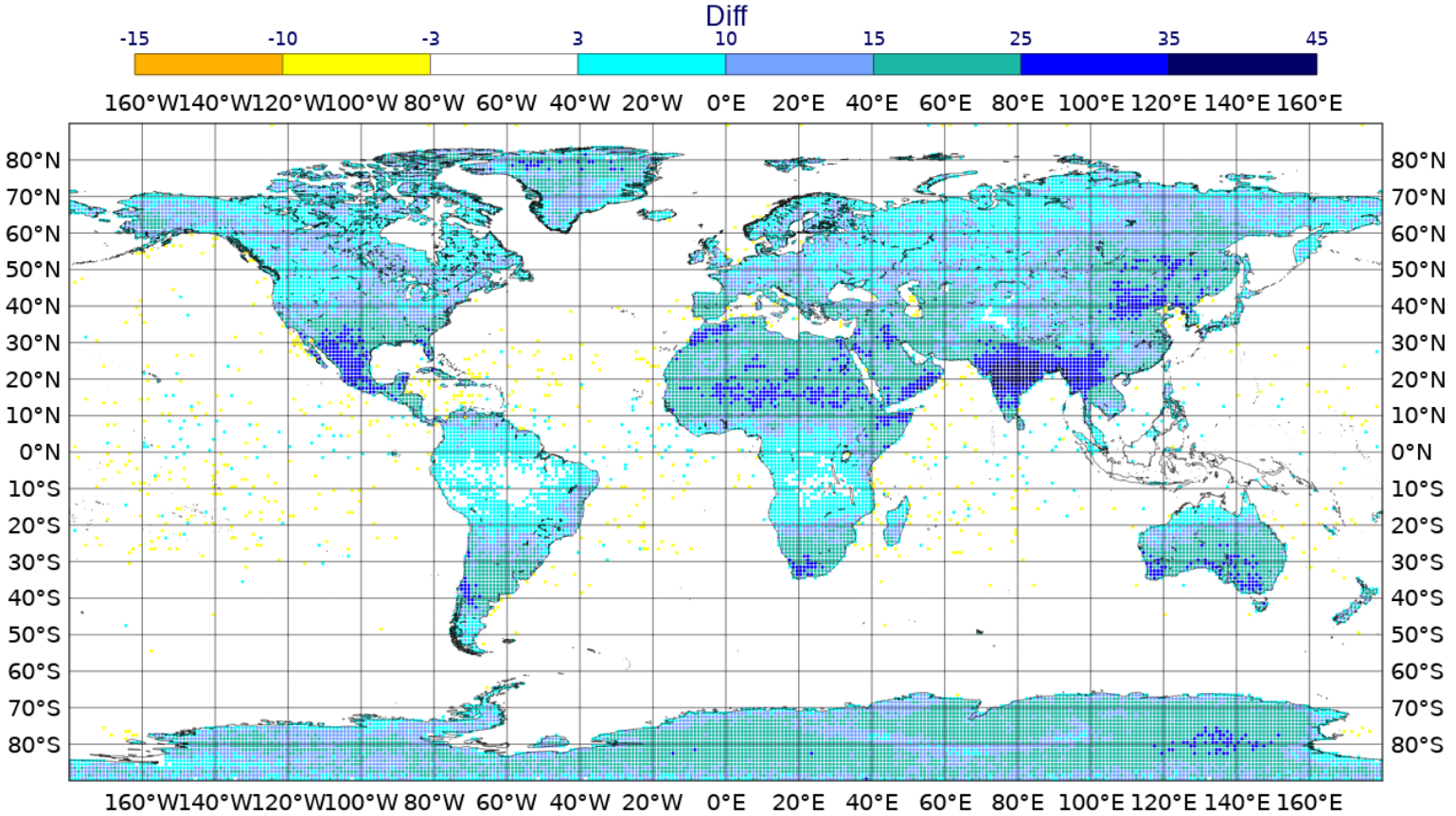
Average number of channels assim. per 1deg box - **NEW**
01 January 2017 – 31 March 2017



Increase of the number of assimilated channels over mid-latitude (tropical regions are cloudy).

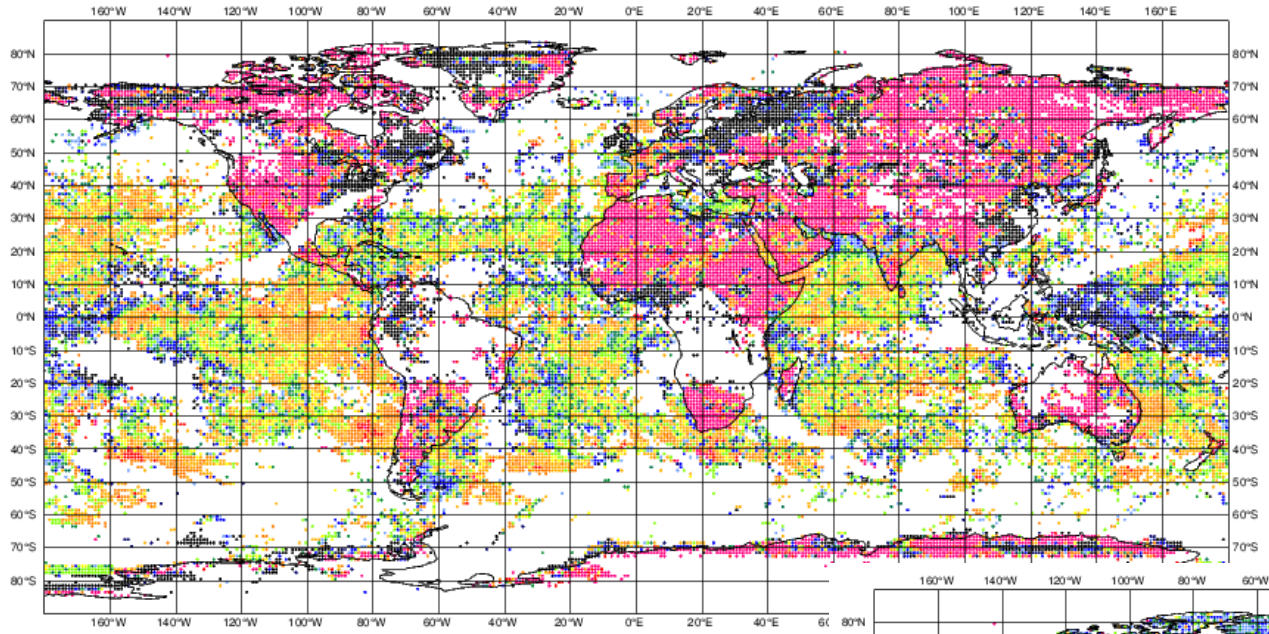
3. Assimilate surface-sensitive channels over land

Average number of channels assim. per 1deg box - **DIFFERENCE**
01 January 2017 – 31 March 2017



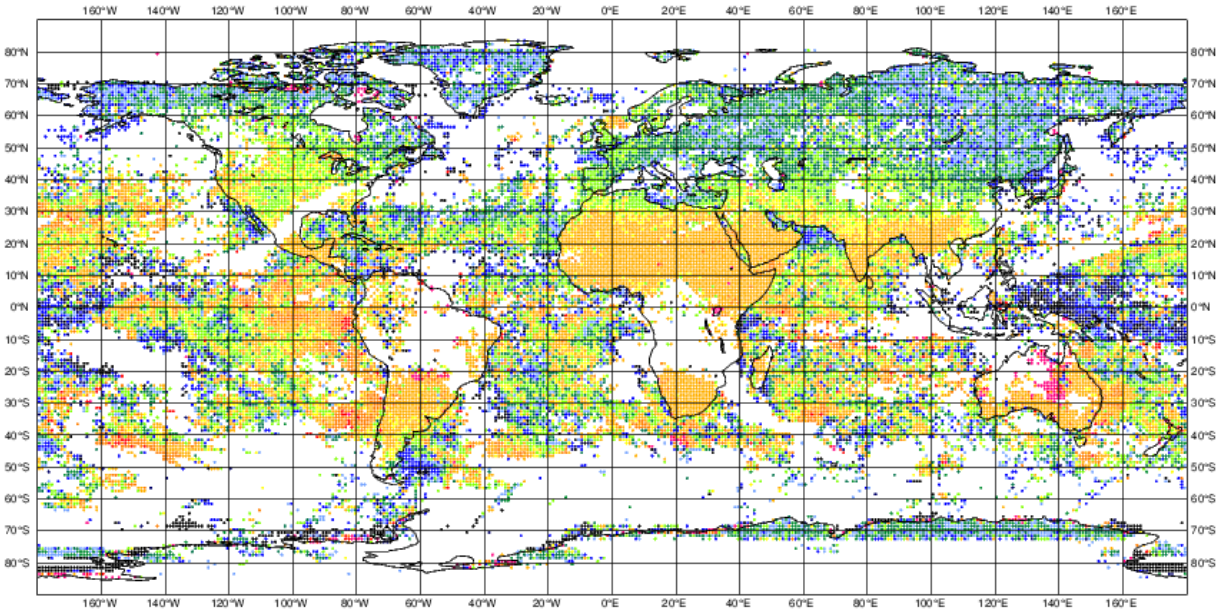
Increase of the number of assimilated channels over mid-latitude (tropical regions are cloudy).

Observation departures for surface channel 1191 (942.5 cm^{-1}) 01 January 2017 – 31 March 2017



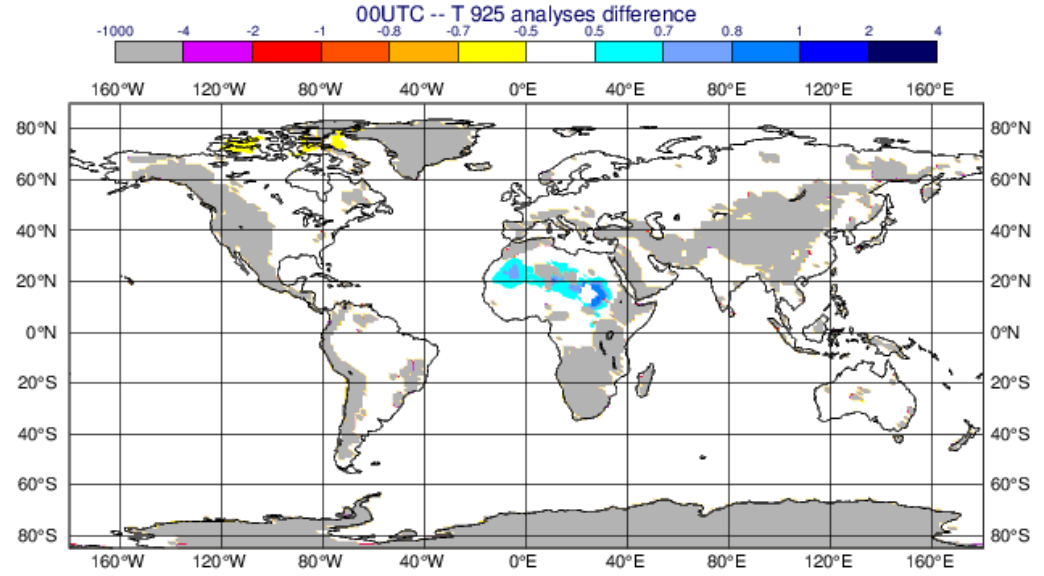
REFERENCE

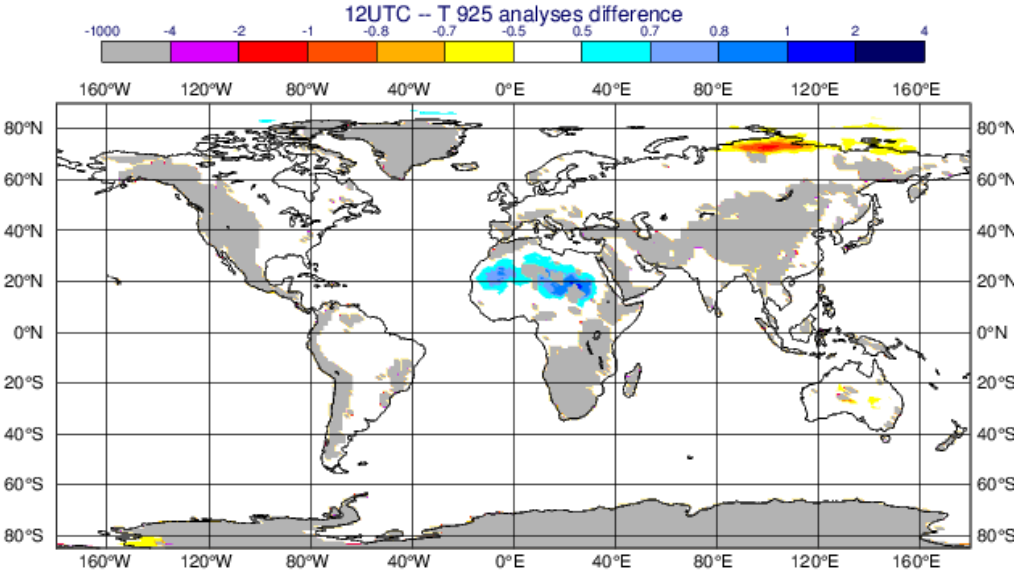
NEW

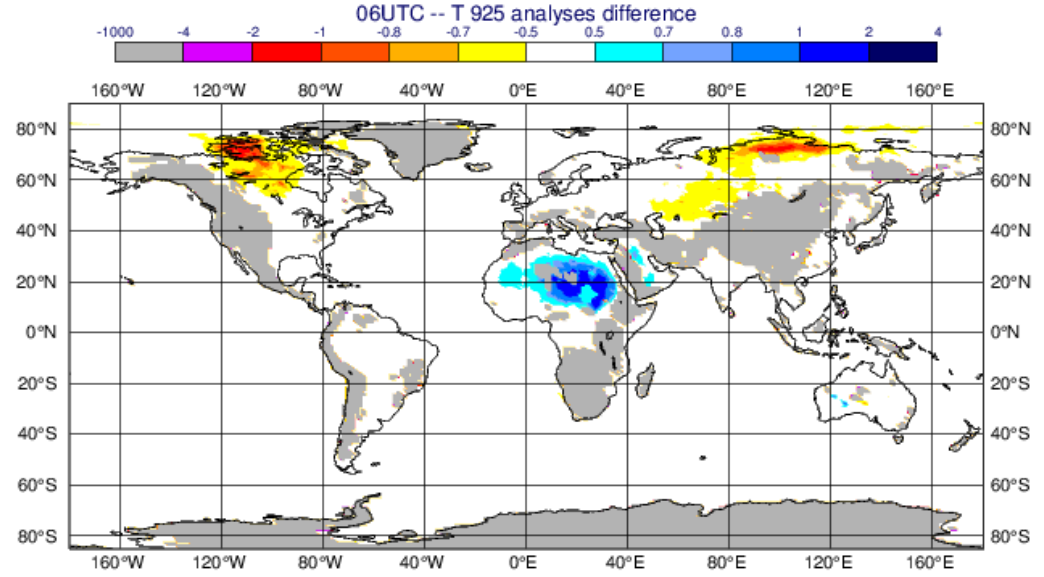


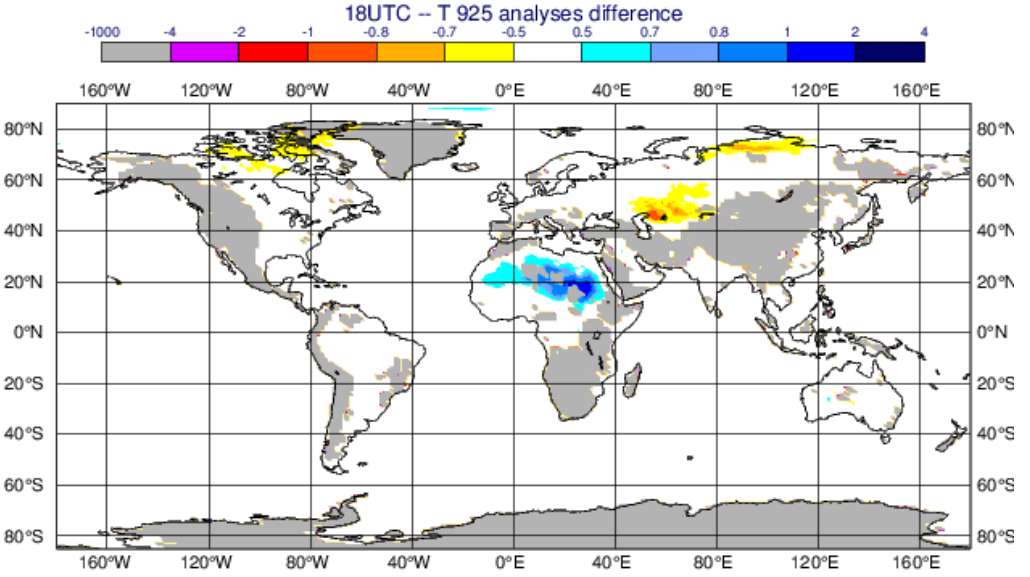
The differences (obs -simul) are strongly reduced with the retrieved LST from IASI.

Differences of analyses for T@ 925 hPa January 2017









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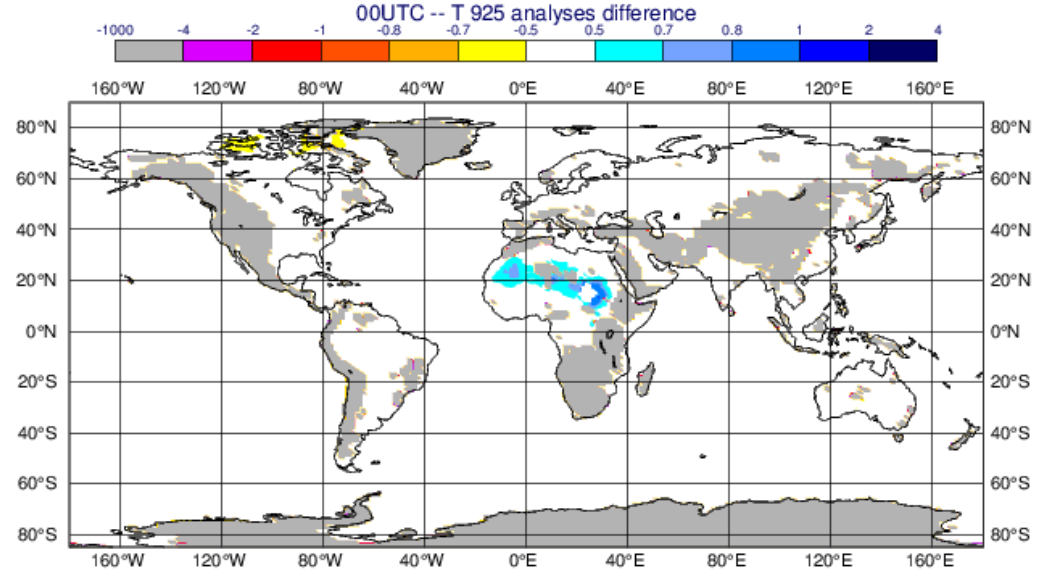
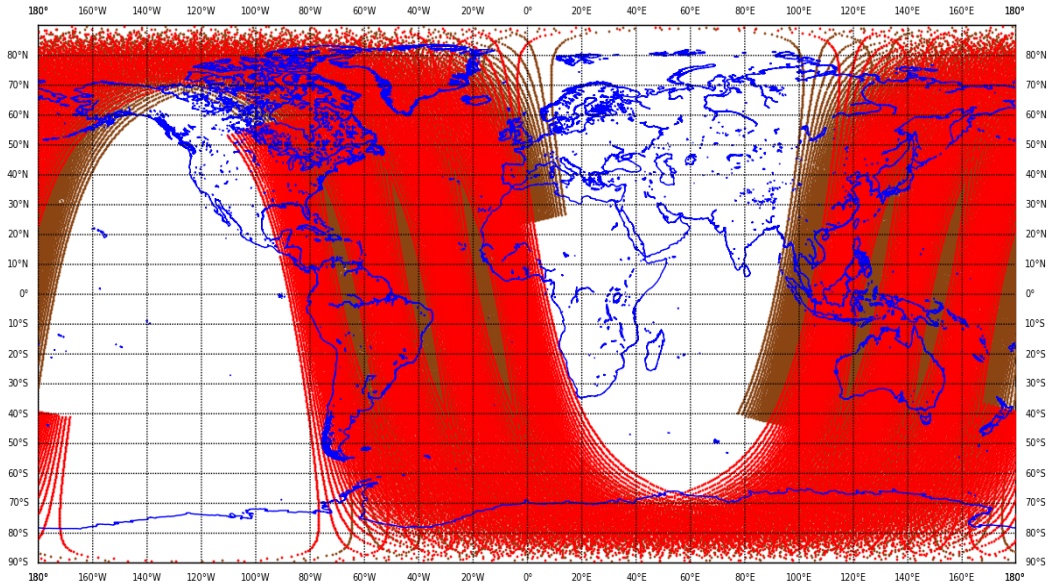
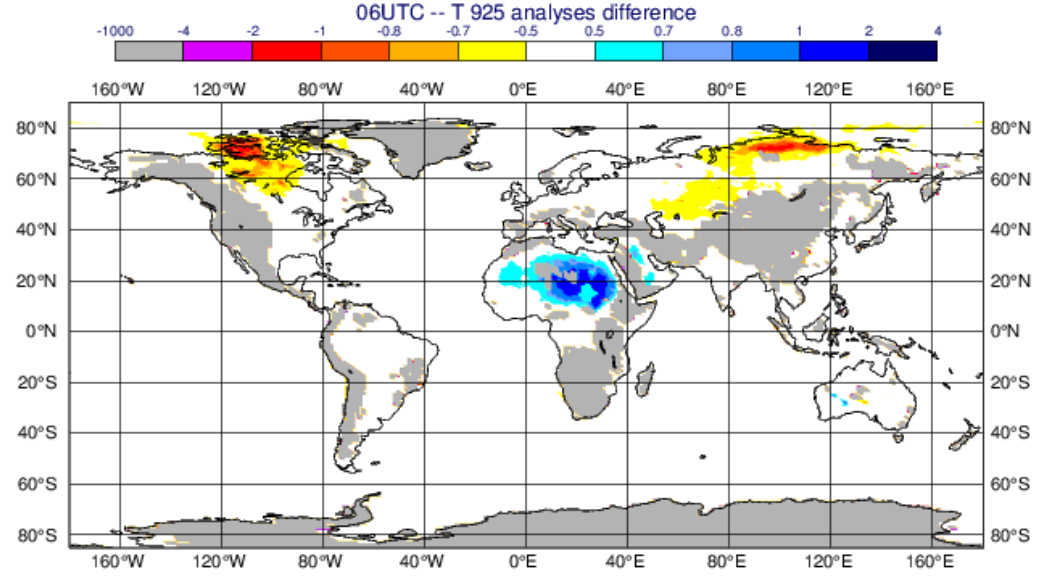
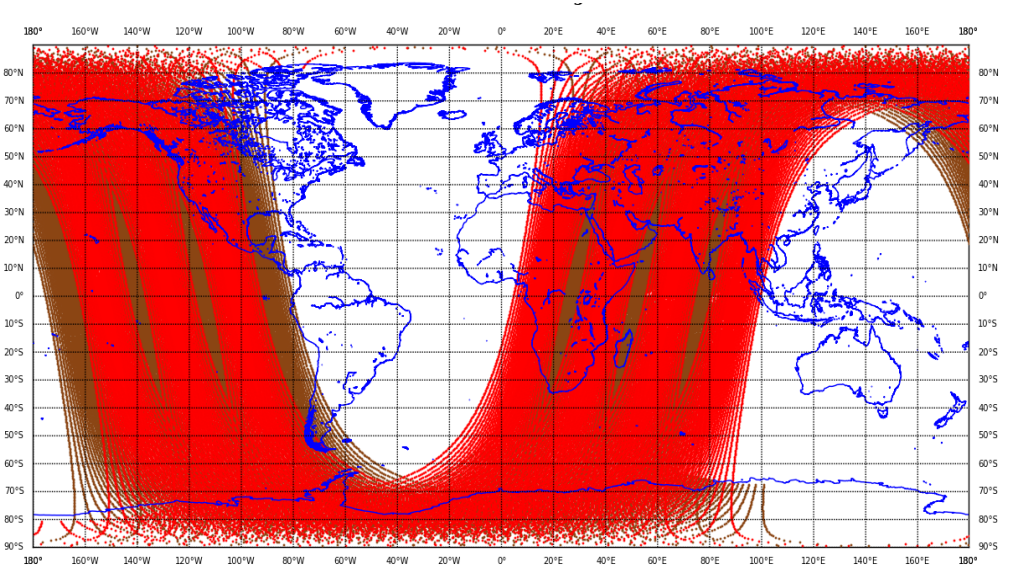


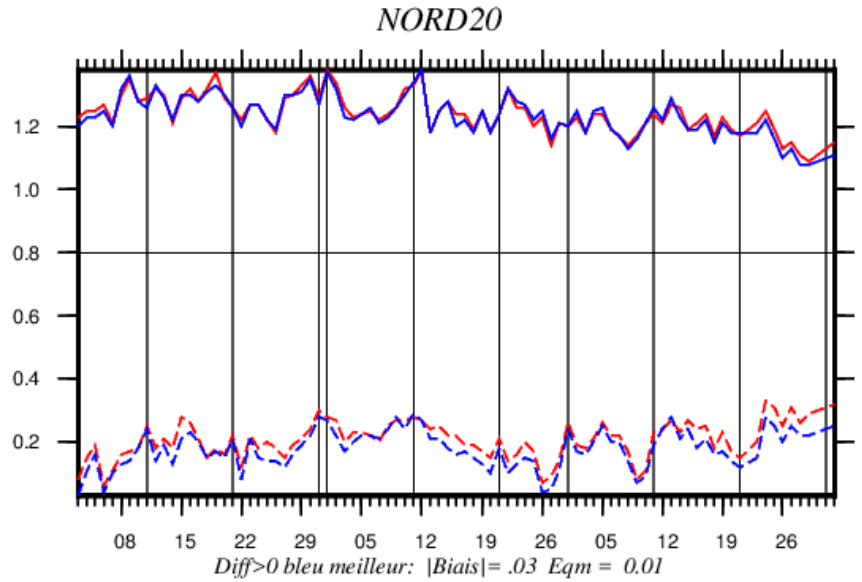






Impact of the forecast scores : evolution of the 24h forecast error wrt ECMWF analyses.

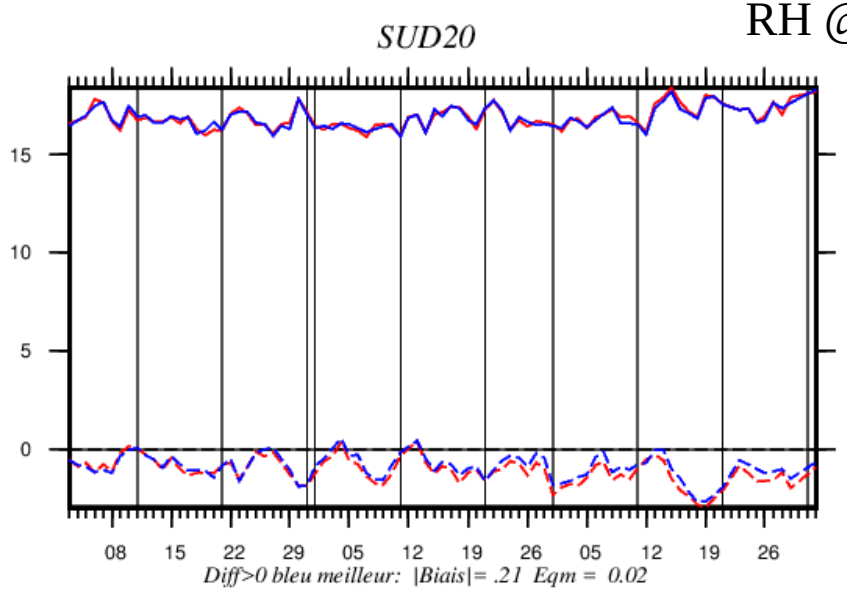
T @ 850hPa

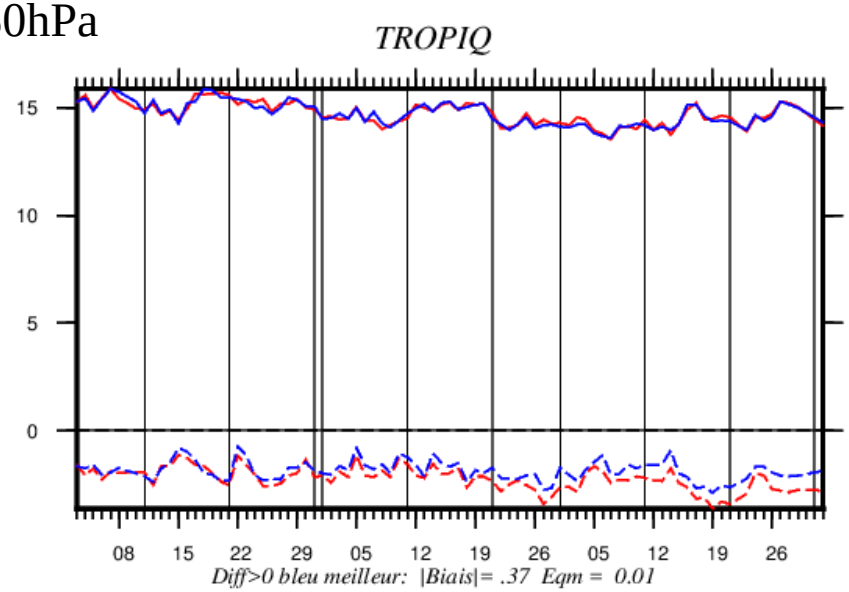


Small impact in the forecast skill below 850 hPa. Neutral elsewhere.

REF
NEW

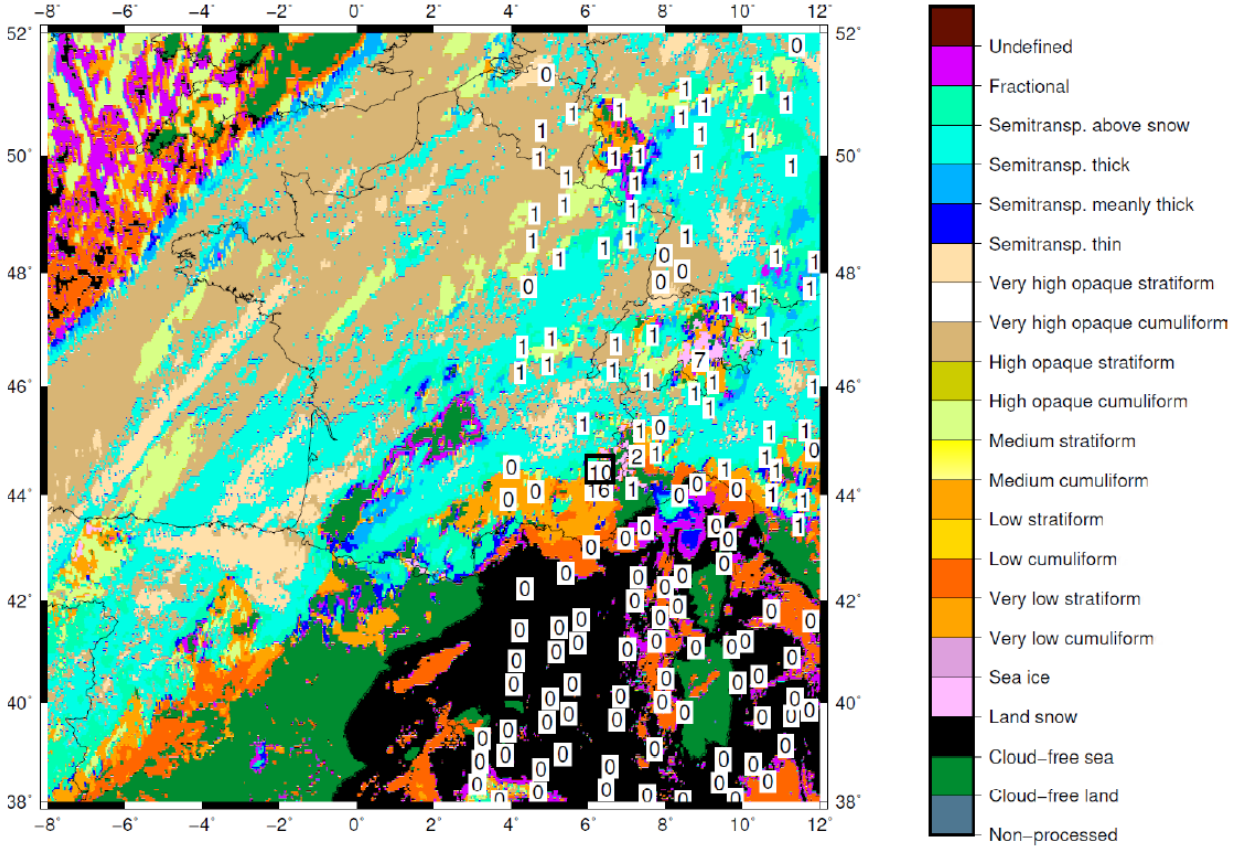
RH @ 850hPa





3. Assimilate surface-sensitive channels over land

Case in mesoscale model AROME 15 Jan 2015 @ 09UTC



SEVIRI cloud type +
number of additional IASI channels assimilated

Boukachaba et al., submitted to Tellus

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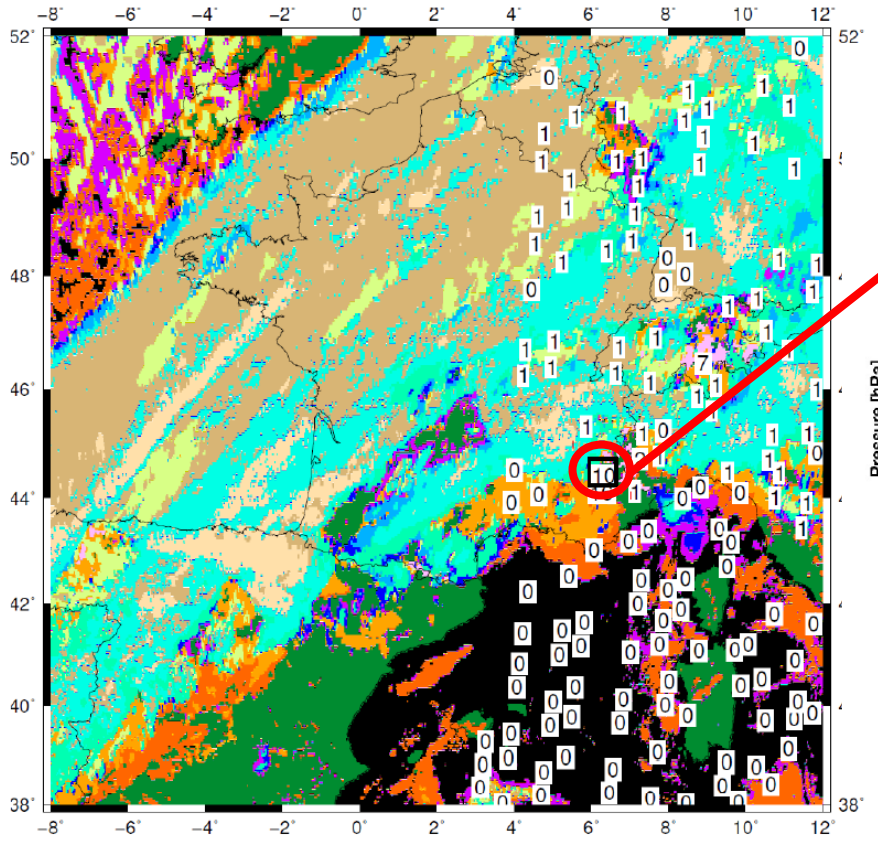
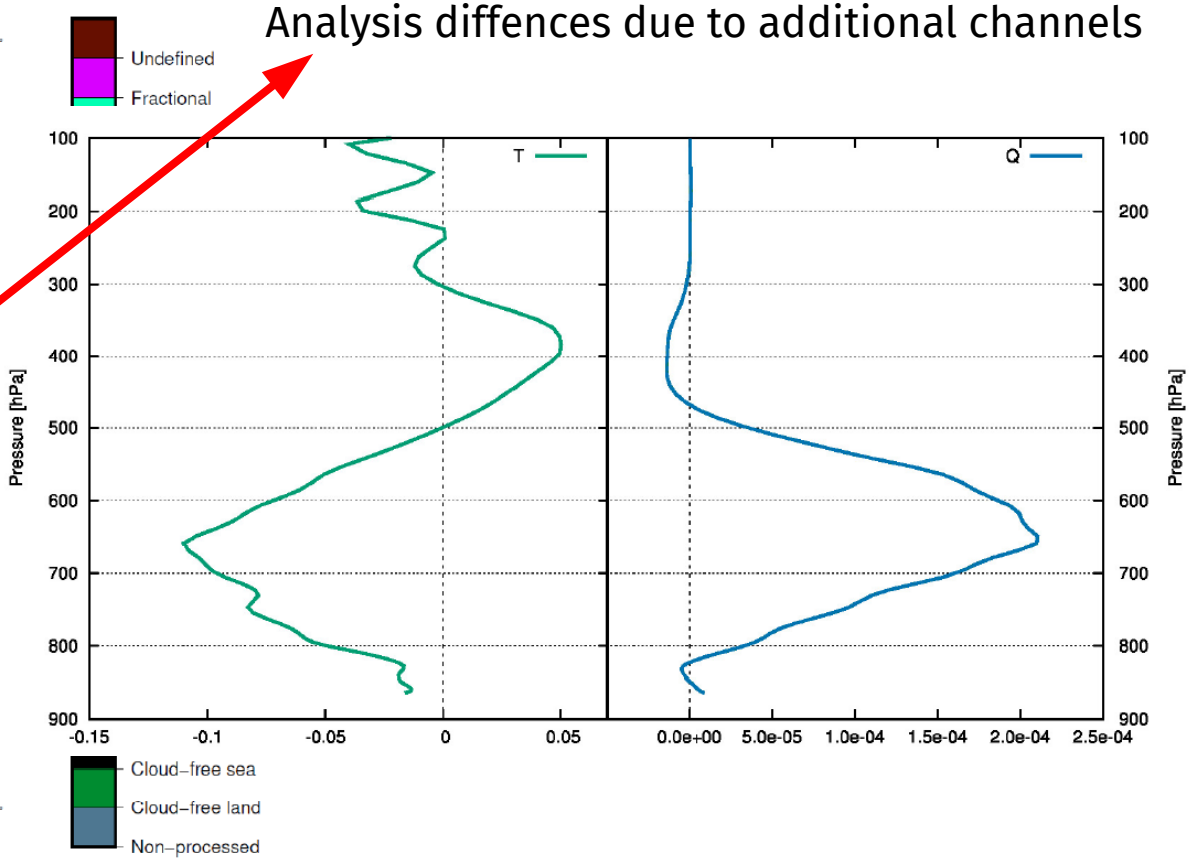


Analysis diffences due to additional channels



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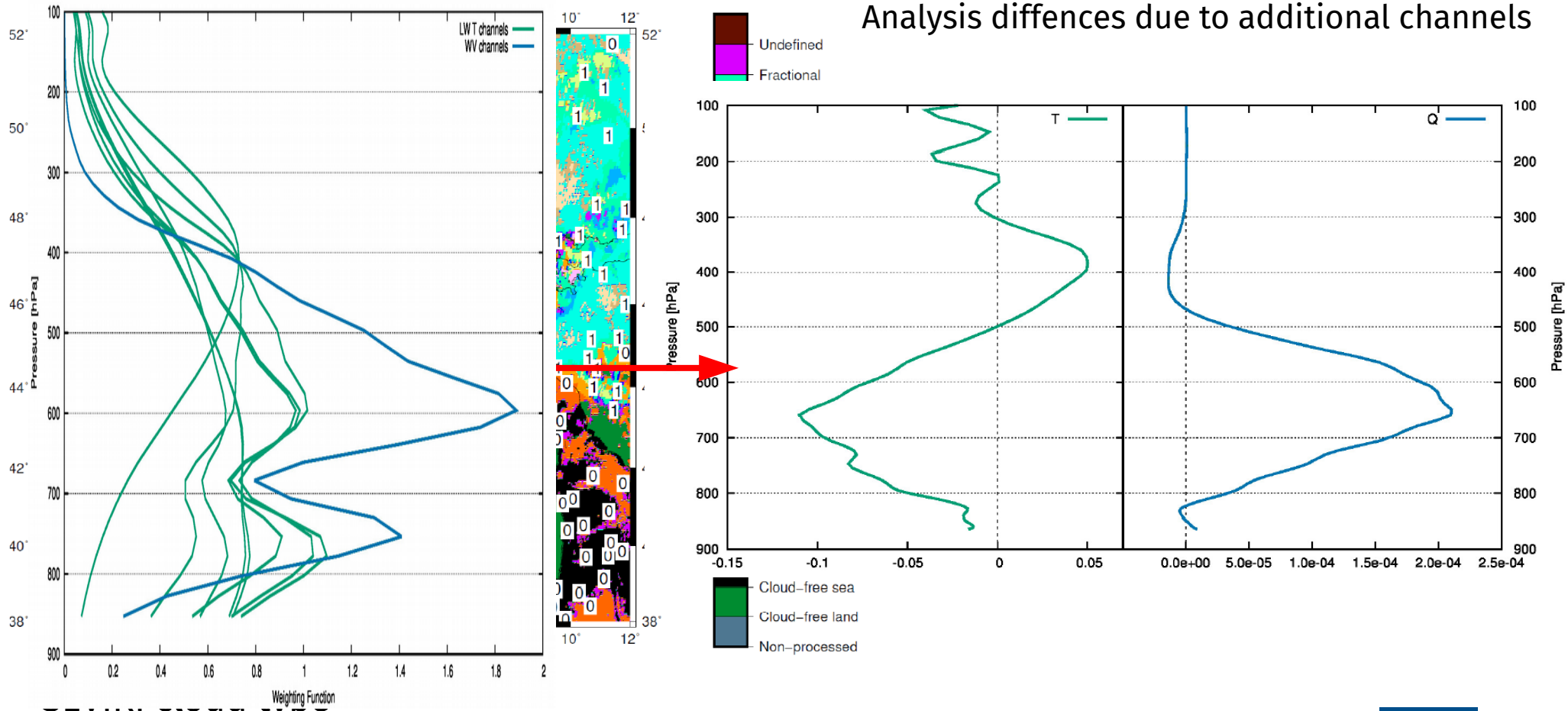

Analysis diffences due to additional channels

number of additional IASI channels assimilated

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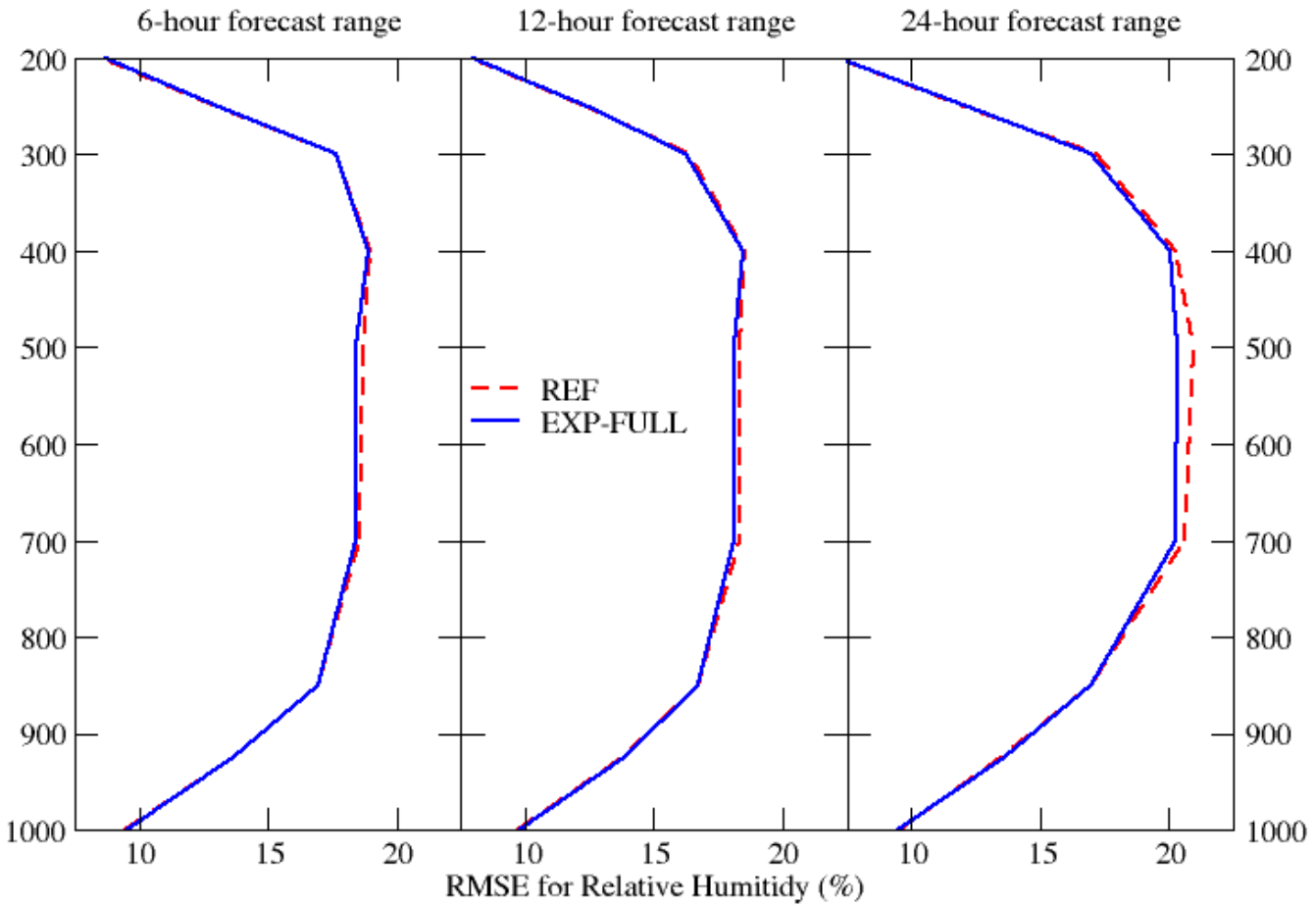
3.Forecast scores wrt ECMWF analyses

Root Mean Square error for relative humidity wrt ECMWF analyses
15 January 2015-28 February 2015



Improvement of the relative humidity forecast between the 6 and 24 h forecast range.

Summary and future work

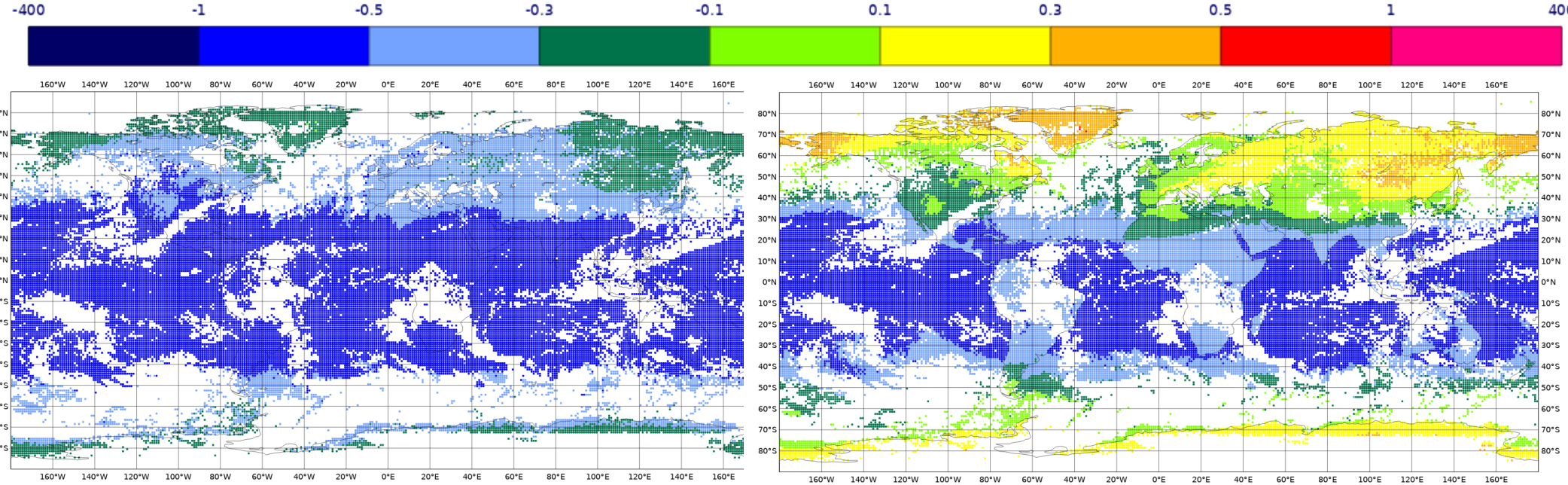
- **A realistic land surface description (emissivity atlases+ retrieved land surface temperature)** enables the assimilation of IASI down to the surface over land.
- This methodology can be extended to the other infrared hyperpspectral sounders (CrIS, IASI-NG, IRS…)
- However the surface temperature of the model is not directly modified.

- **<u>Towards land atmosphere coupled data assimilation</u>**

- PhD on the synergy of satellite observations for the definition of surface temperature
- Comparison between surface temperature from various sensors (micro-wave, infrared) onboard different platform (geostationary vs polar-orbiting satellites).
- Assimilation of LST retrieved from satellite observations (preliminary studies with IR observations) in the land surface model.

Bias correction :

Mean Bias correction for channel 1191 (642.5 cm-1)
17-18 January 2017



predictors computed only over sea

predictors computed over sea and over land

Increase of the number of assimilated channels over mid-latitude (tropical regions are cloudy).