Improvement of land surface emissivity and surface temperature estimates for the assimilation of IASI data over land.

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PhD supervised by Nadia Fourrié, Florence Rabier and Vincent Guidard.

3rd IASI Conference
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cnrs dépasser les frontières

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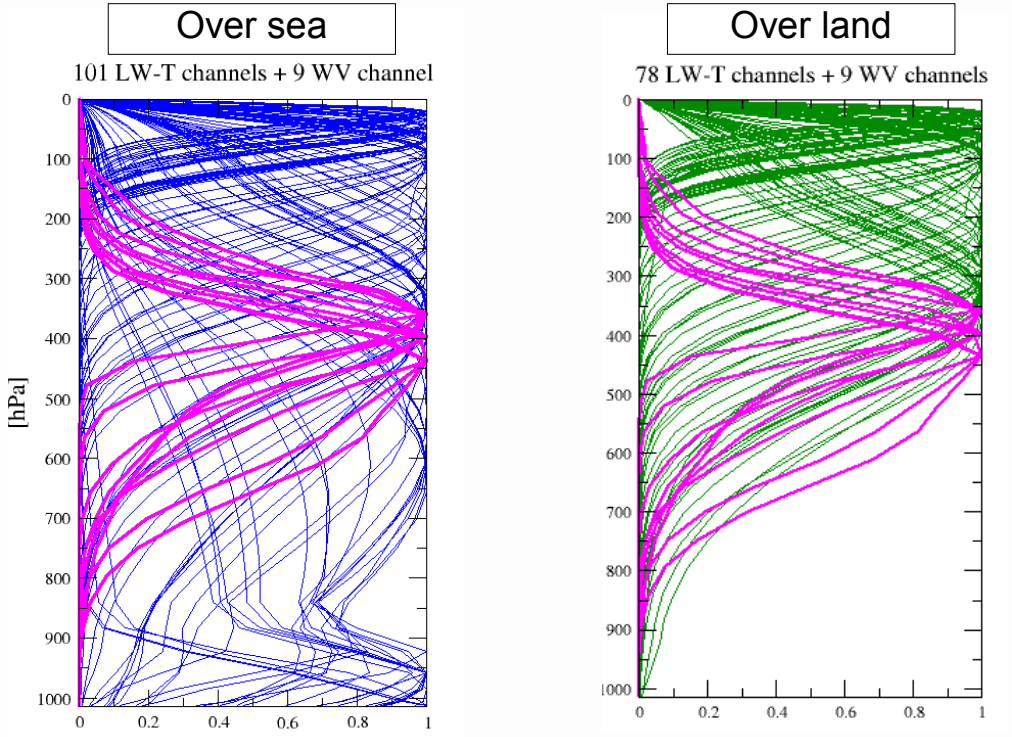
Plan

1. IASI data assimilation over land at Météo-France.
2. Importance of surface parameters over land.
3. Retrievals of land surface temperature and impact on brightness temperature simulations.
4. Emissivity atlases over land and impact on brightness temperature simulations.
5. Conclusion.

IASI data assimilation over land at Météo-France

The limits of the use of IASI data over land

- Important radiative impact of clouds on infrared radiances that limits the information from advanced sounders => use of radiances in clear sky conditions for the retrievals.
- Uncertainty on emissivity and surface temperature.
- Good use of these data over sea but limited over land => less IASI data used in NWP over land.



Figures : Weighting functions of IASI channels assimilated over sea (left) and over land (right) for temperature and water vapour channels.

- Study on the subset of 314 IASI channels.

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IASI data assimilation over land at Météo-France.

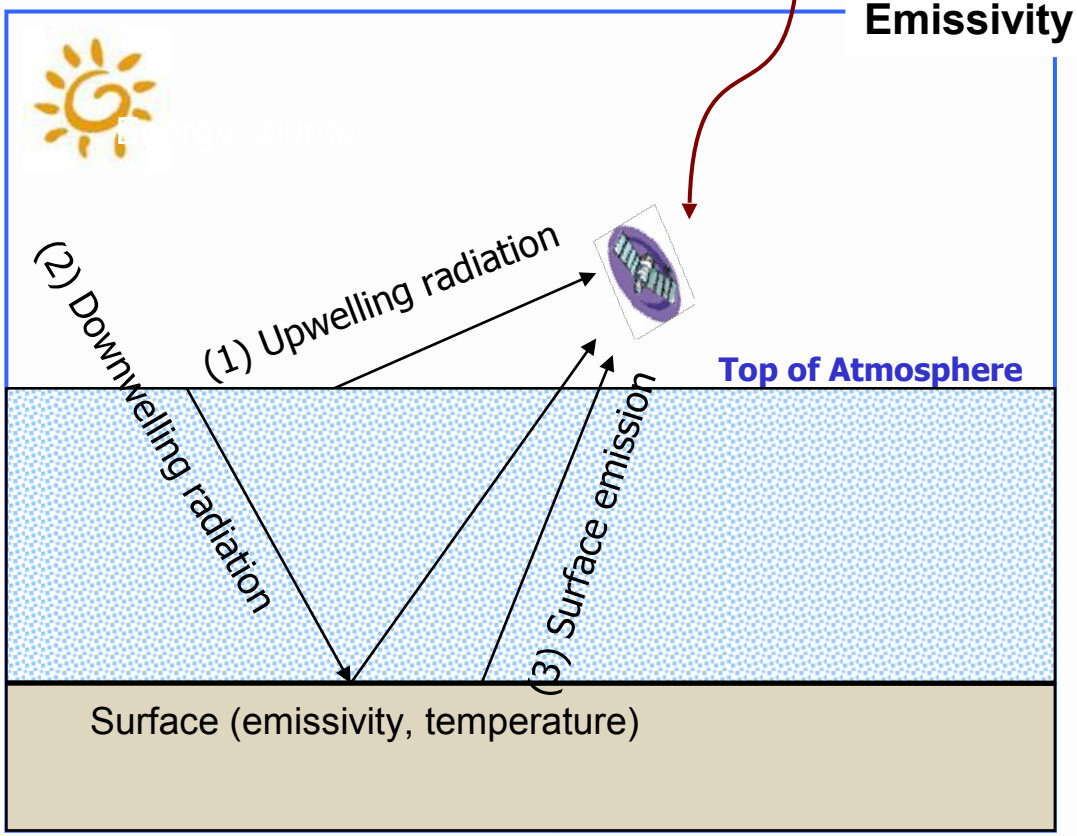
Importance of surface parameters over land

Measurements at infrared frequency: Instruments receive an electromagnetic signal.

Observed brightness temperature (υ):

$$T(\upsilon) = \overbrace{\varepsilon(\upsilon).Ts.\tau}^{(3)} + \overbrace{(1-\varepsilon(\upsilon)).\tau.T(\upsilon\downarrow)}^{(2)} + \overbrace{T(\upsilon\uparrow)}^{(1)}$$

Emissivity **Surface temperature**



- In operations : constant ε and Ts bad estimated
- Over land, emissivity varies in time and space, with wavenumbers, surface types, roughness and moisture content.
- With RTTOV, Ts can be calculated :

$$Ts = \frac{T(\upsilon) - (1) - (2)}{\varepsilon(\upsilon).\tau}$$

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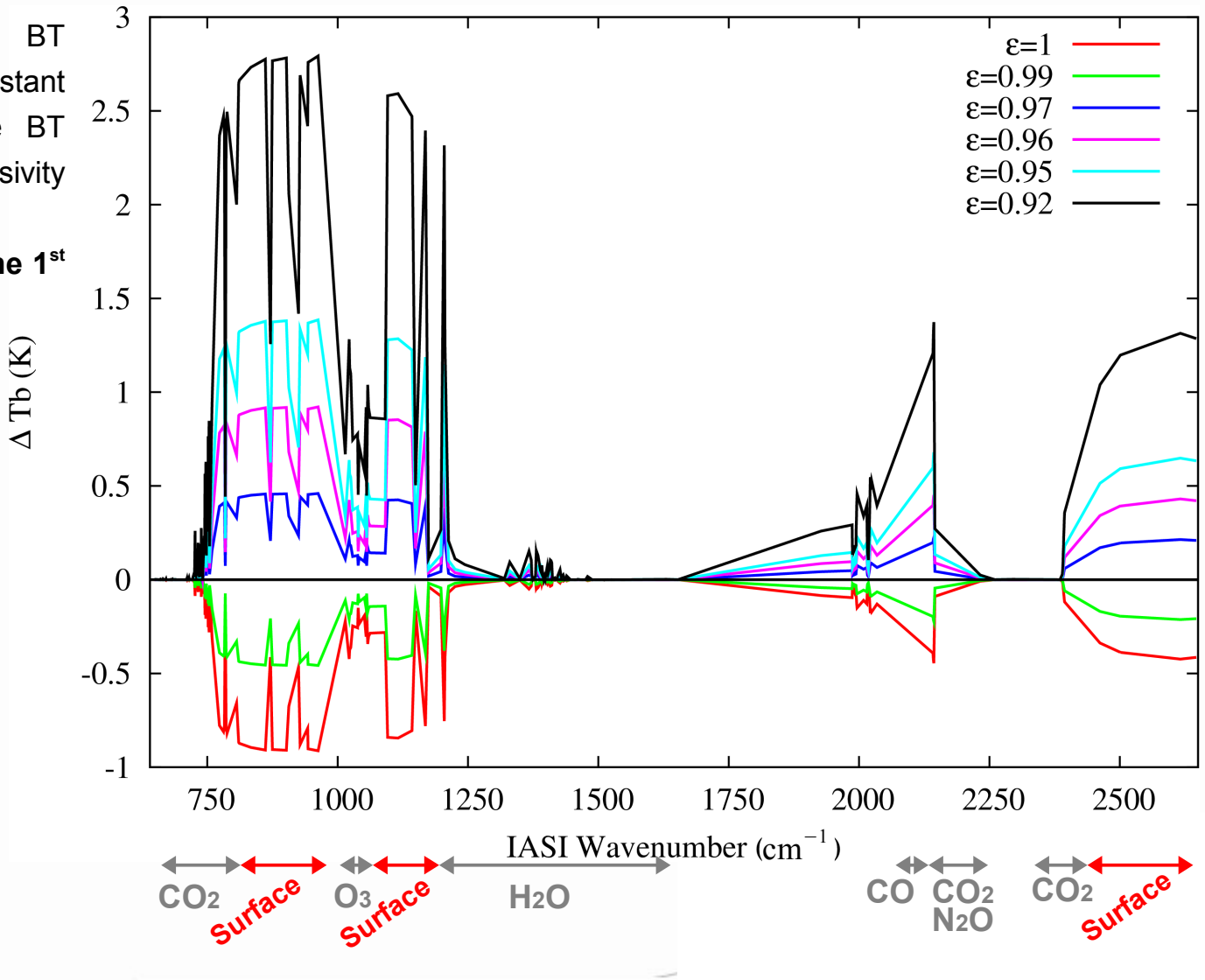
The importance of surface parameters over land.

Impact of emissivity on brightness temperature simulations

Differences between BT simulated with the constant emissivity 0.98 and the BT simulated with other emissivity values.

Average on the globe, the 1st July 2011 at 0 UTC.

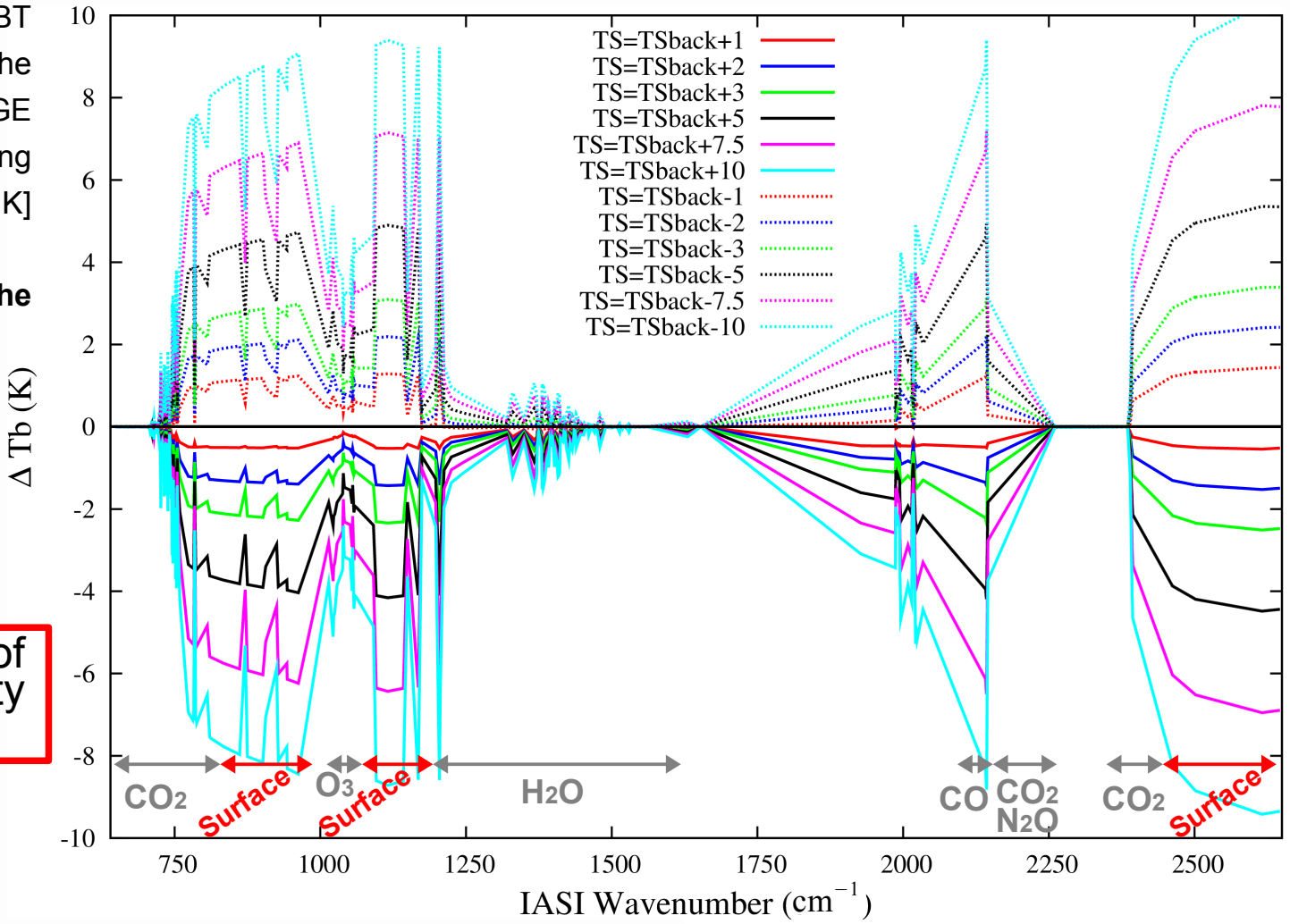


The importance of surface parameters over land.

Impact of surface temperature on brightness temperature simulations

Differences between the BT simulated with the background LST of ARPEGE and the BT simulated adding a factor between [-10 K,10 K] to the background LST.

Average on the globe, the 1st July 2011 at 0 UTC.



=> Larger impact of LST than emissivity on simulated BT.

The importance of surface parameters over land.

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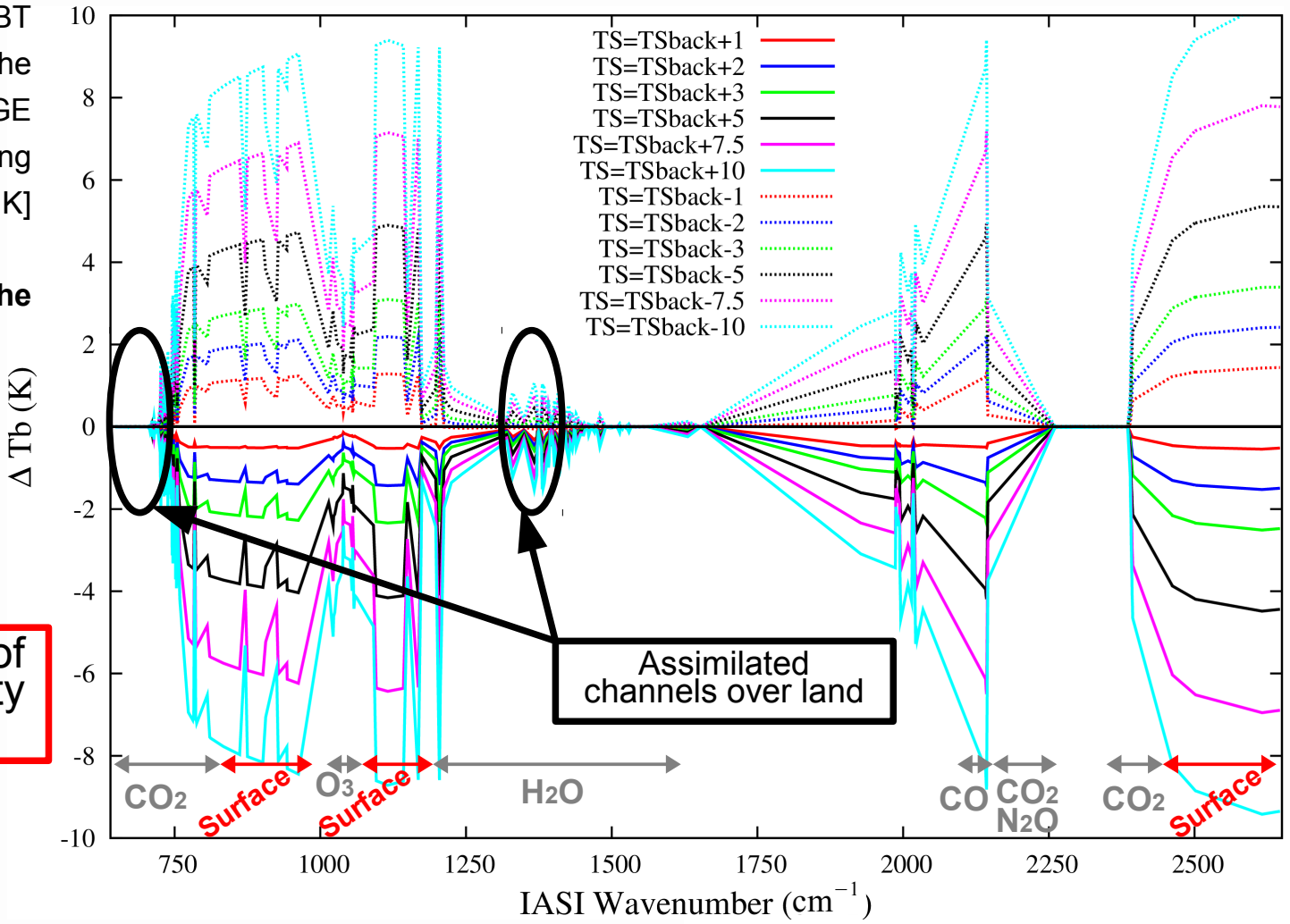


=> Larger impact of LST than emissivity on simulated BT.

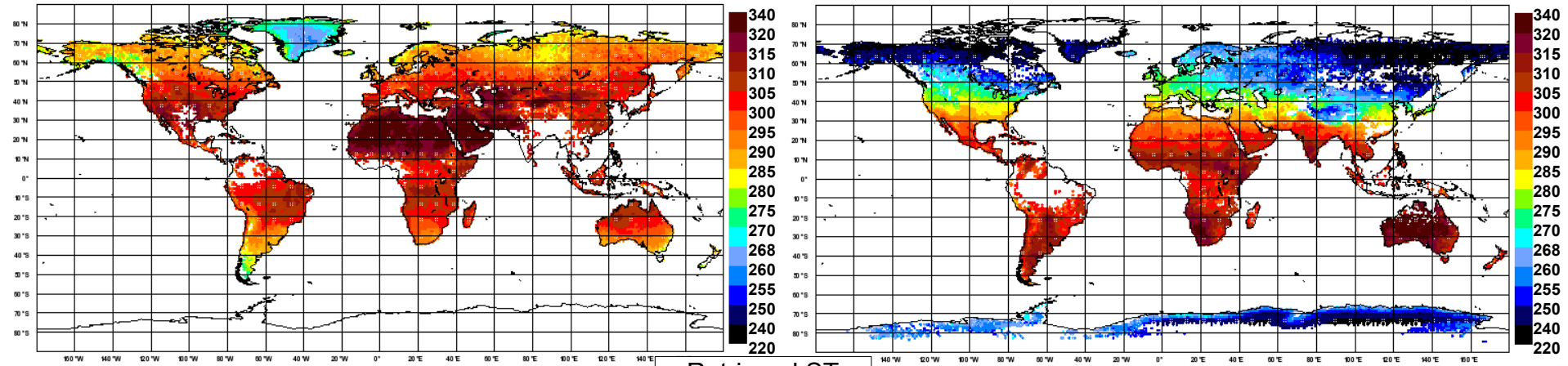
Retrievals of land surface temperature and impact on brightness temperature simulations.

The inversion method

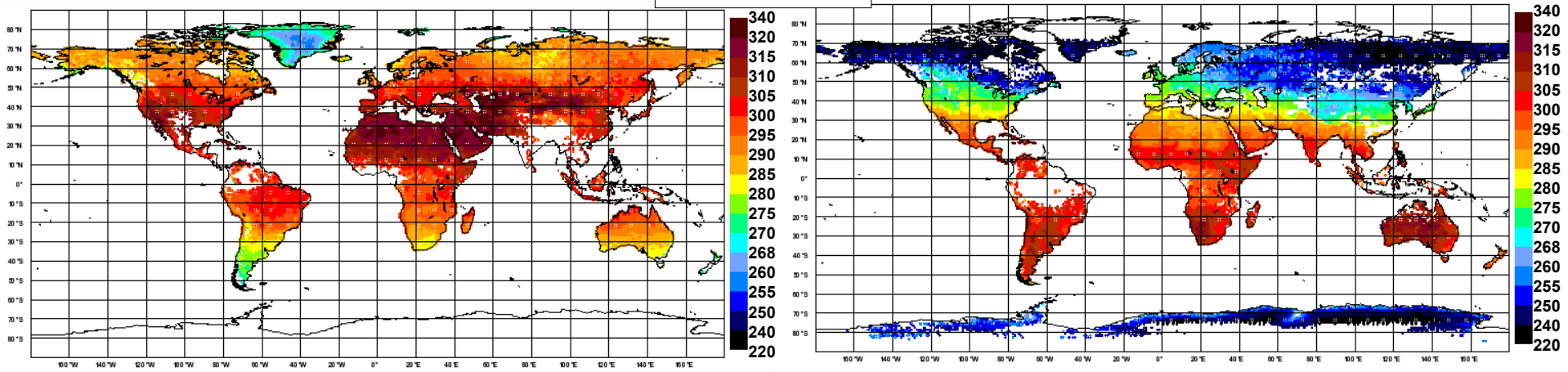
- Dynamical calculation of LST inverting the equation of the RTTOV radiative transfer model from a single IASI channel and from a combination of several channels.
- In a first time, LST is retrieved using a **constant emissivity equal to 0.98**.

Surface Channel 1191 (942.5 cm^{-1}) Day

JULY 2011 | Background ST | JANUARY 2012



Retrieved ST



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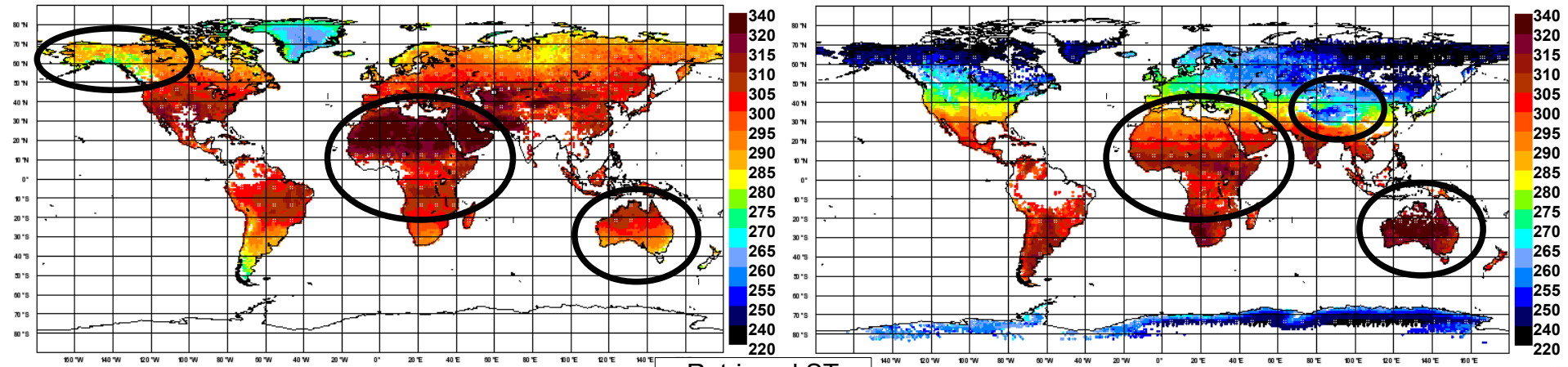
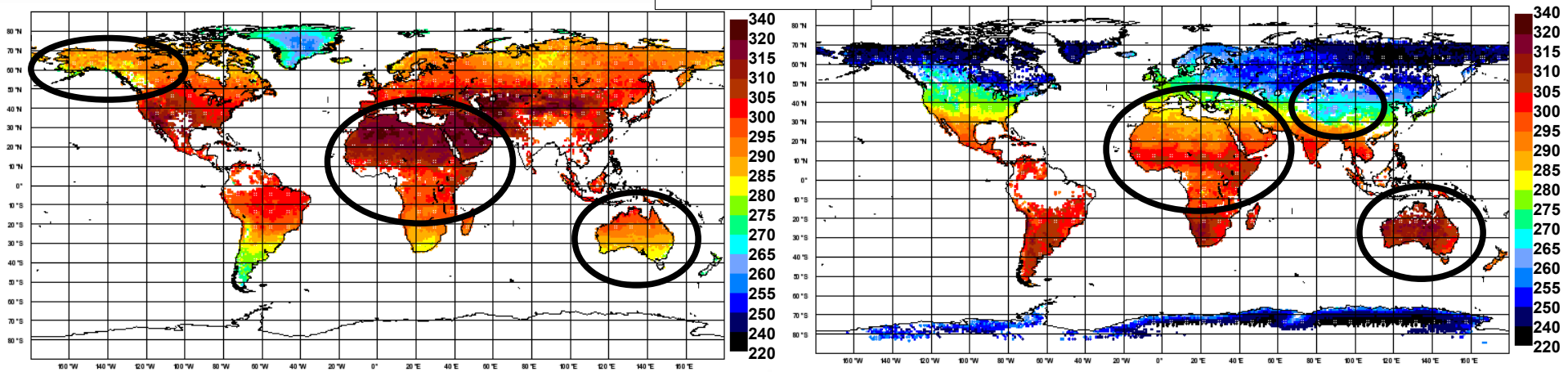


Retrieved ST



Retrievals of land surface temperature and impact on brightness temperature simulations.

Evaluation of the retrievals

- Evaluation for **5 days** from **1st to 5 July 2011** of the retrieved LST with 2 products :
  - the **IASI Level 2 (L2) products** of LST from EUMETSAT (August et al, 2012 ; Zhou et al, 2011)
  - the **MODIS LST products** for the Terra platform from the Nasa (Wan, 2008 ; Hulley & Hook, 2009 ; Wan & Dozier, 1996).

- Evaluation for **clear sky cases** according to the AVHRR imager and according to cloud detect method (Mc Nally and Watts 2003).

Channels used for the retrievals

- Retrievals calculated for each surface channel in the wavebands between **773 and 962 cm^{-1}** and between **1091 and 1168 cm^{-1}**.

- Retrievals also calculated using **combination of 2 or 3 channels**. Calculation of the LST averaging the estimated LST for each channel in the combination.

- Combination with channels selected for :
  - their almost constant emissivity with respect to soil type
  - the good correlations between the IASI observations and the products
  - the high transmittance of channels and high number of observations for comparison with products.

- Combination **1191+1271** is chosen (942.50 and 962.50 cm^{-1}).

Clear cases according to AVHRR

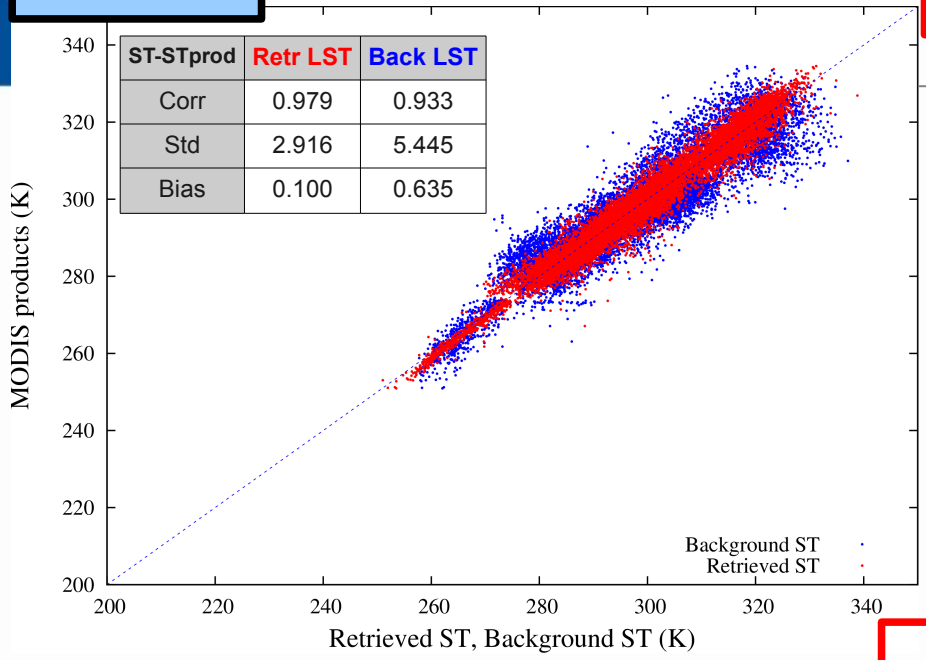
MODIS products

Channels 1191 + 1271

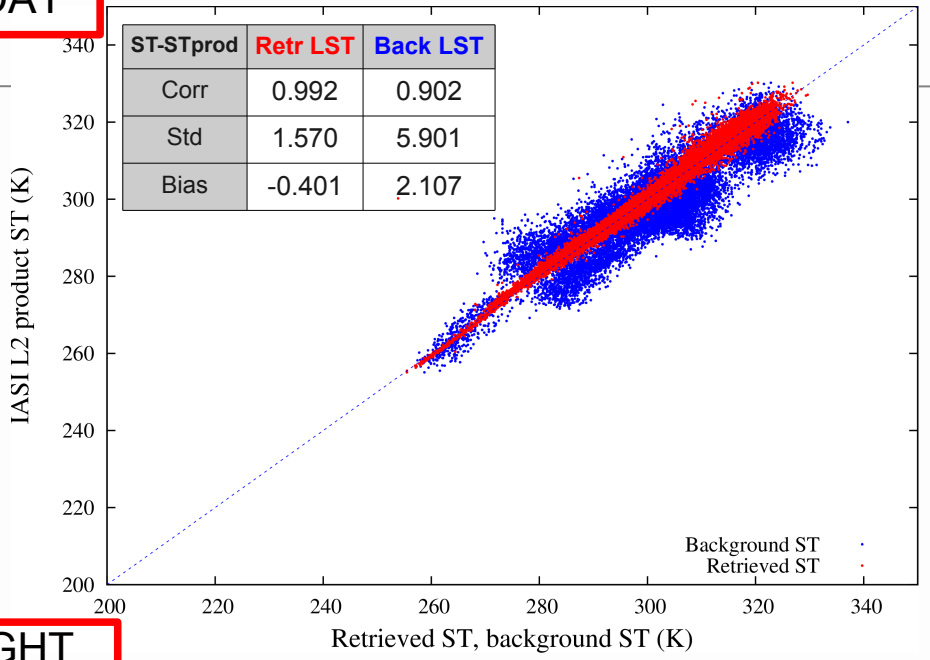
IASI L2 products

DAY

ST-STprod	Retr LST	Back LST
Corr	0.979	0.933
Std	2.916	5.445
Bias	0.100	0.635

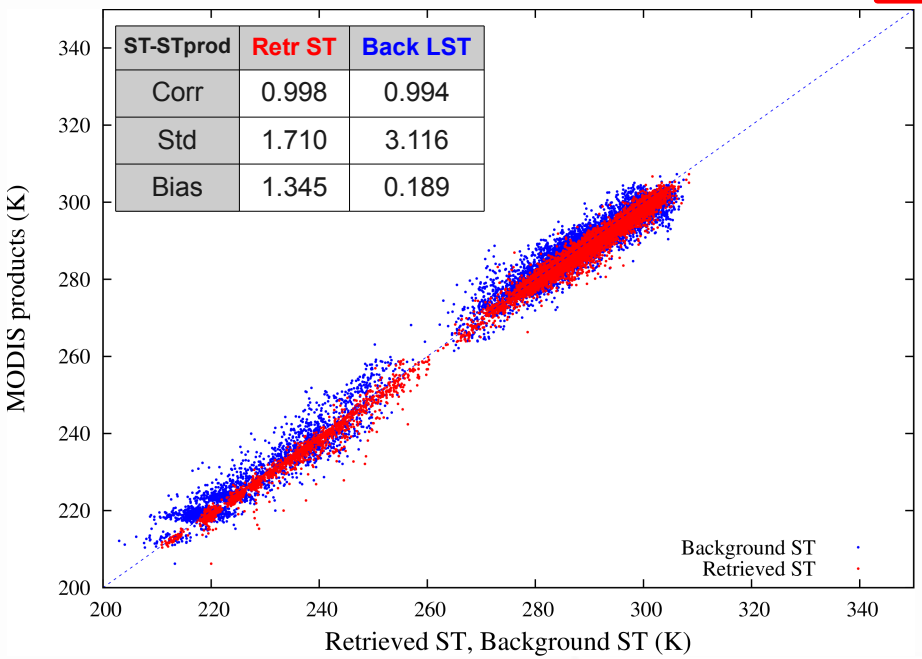


ST-STprod	Retr LST	Back LST
Corr	0.992	0.902
Std	1.570	5.901
Bias	-0.401	2.107

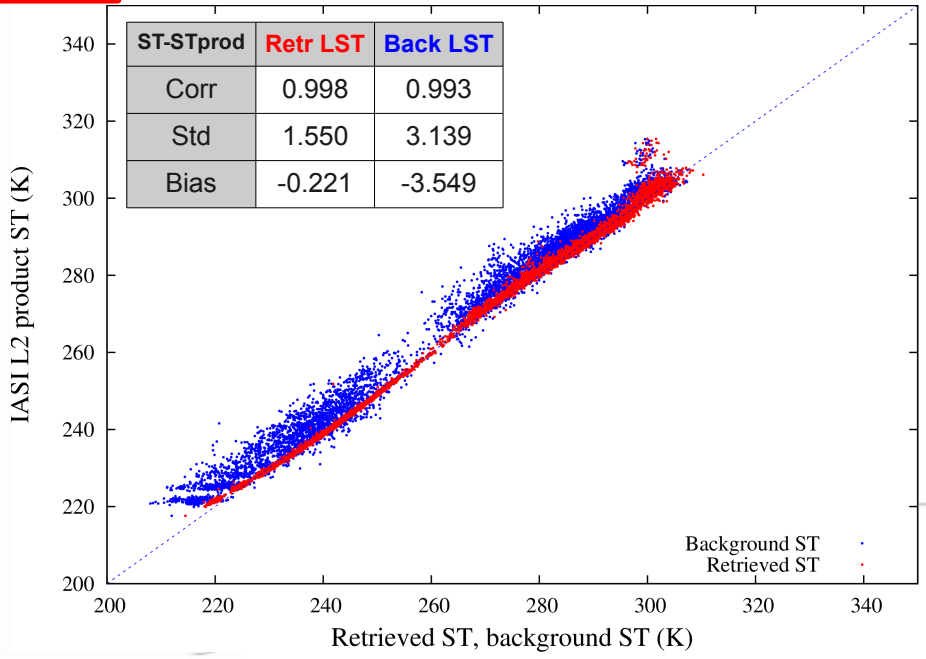


NIGHT

ST-STprod	Retr ST	Back LST
Corr	0.998	0.994
Std	1.710	3.116
Bias	1.345	0.189



ST-STprod	Retr LST	Back LST
Corr	0.998	0.993
Std	1.550	3.139
Bias	-0.221	-3.549



Retrievals of land surface temperature and impact on brightness temperature simulation.

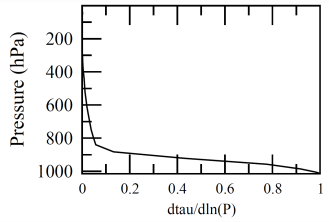
Impact on simulated brightness temperature

- Study period : July 2011 and January 2012.

- Clear cases determined according to the AVHRR imager and the cloud detect method.

DAY

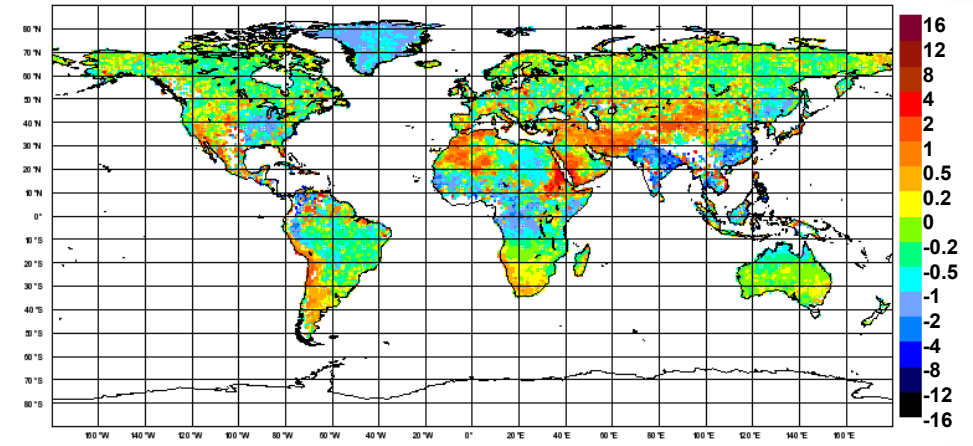
Clear cases : AVHRR Channel 515 (773.50 cm^{-1})



JULY 2011

Obs-guess with the **retrieved LST**

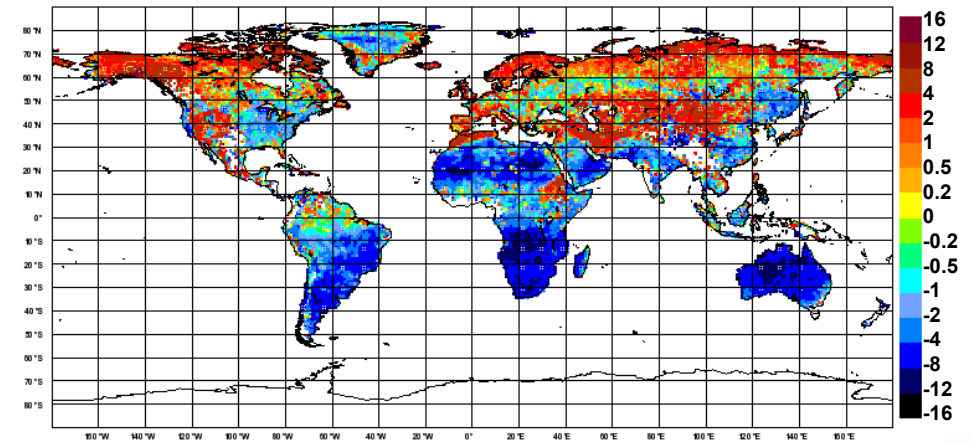
Min= -2 K, max= 2 K



Mean bias= -0.25 K

Obs-guess with the **background LST**

Min= -12 K, max= 12 K



Mean bias= -2.18 K

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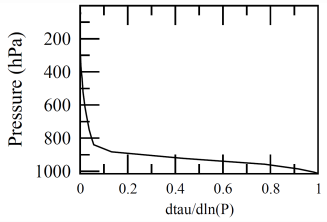
DAY

Clear cases : AVHRR Channel 515 (773.50 cm^{-1})

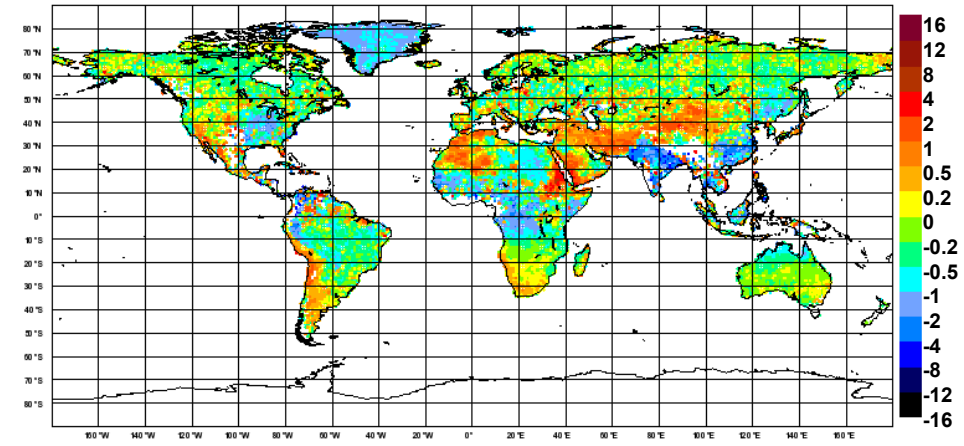


JULY 2011

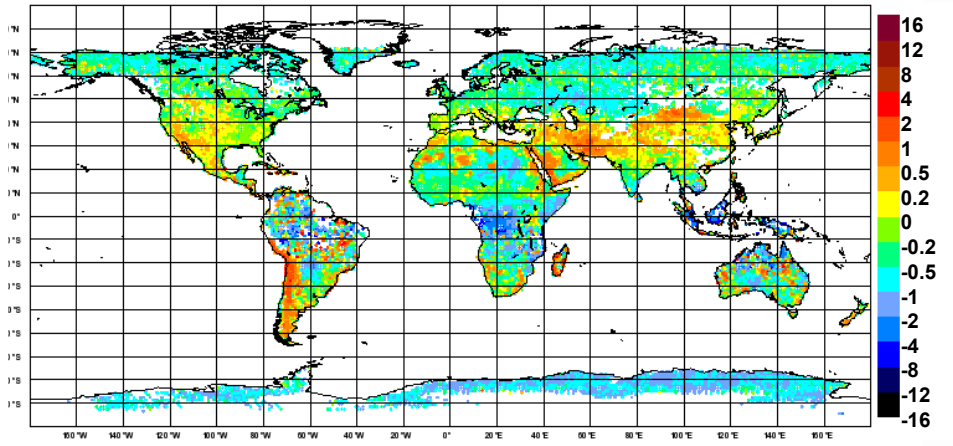
JANUARY 2012

Obs-guess with the **retrieved LST**

Min= -2 K, max= 2 K



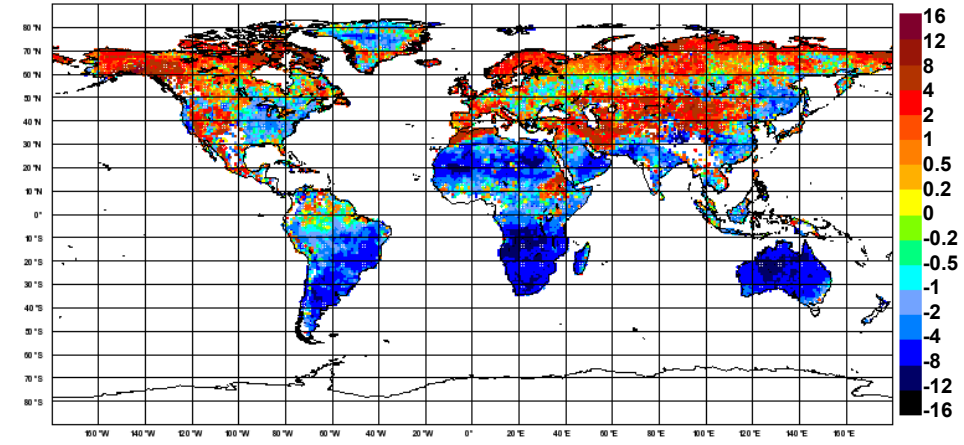
Mean bias= -0.25 K



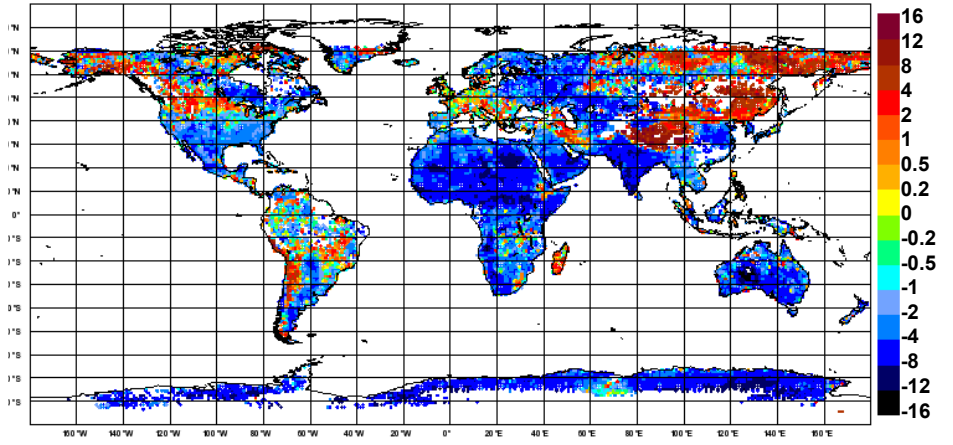
Mean bias= -0.36 K

Obs-guess with the **background LST**

Min= -12 K, max= 12 K



Mean bias= -2.18 K



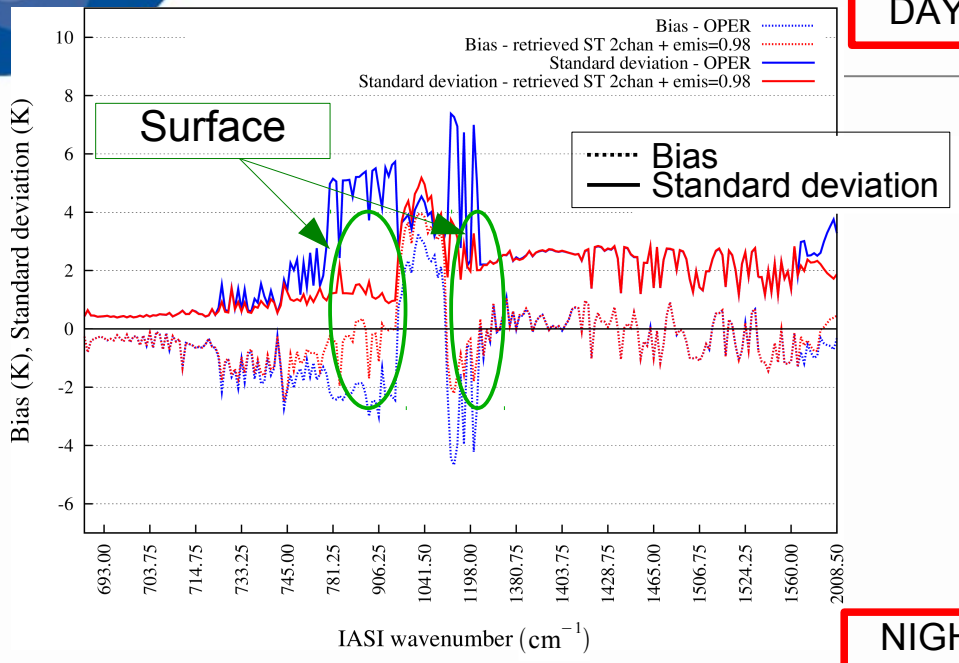
Mean bias= -3.74 K

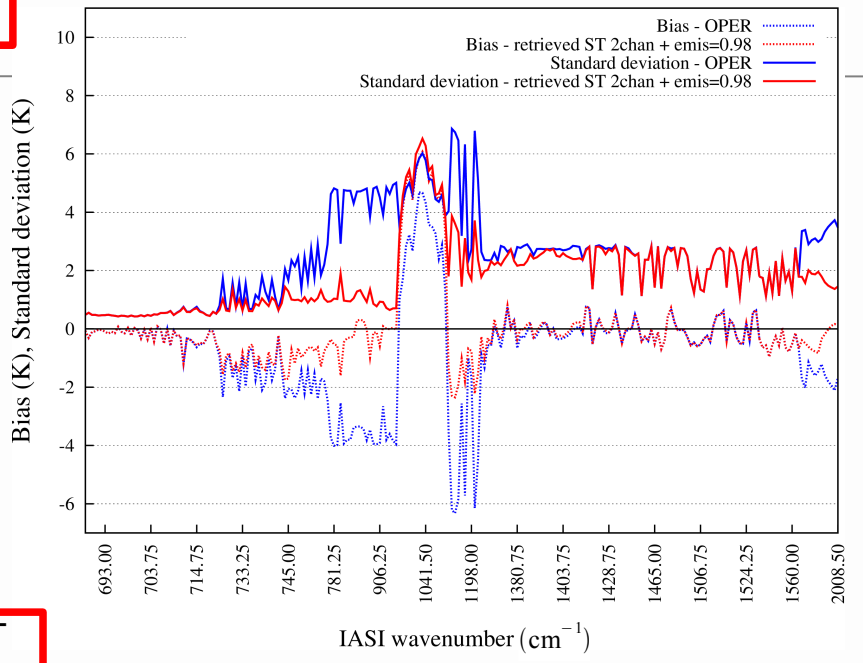
JULY 2011

Clear cases : AVHRR

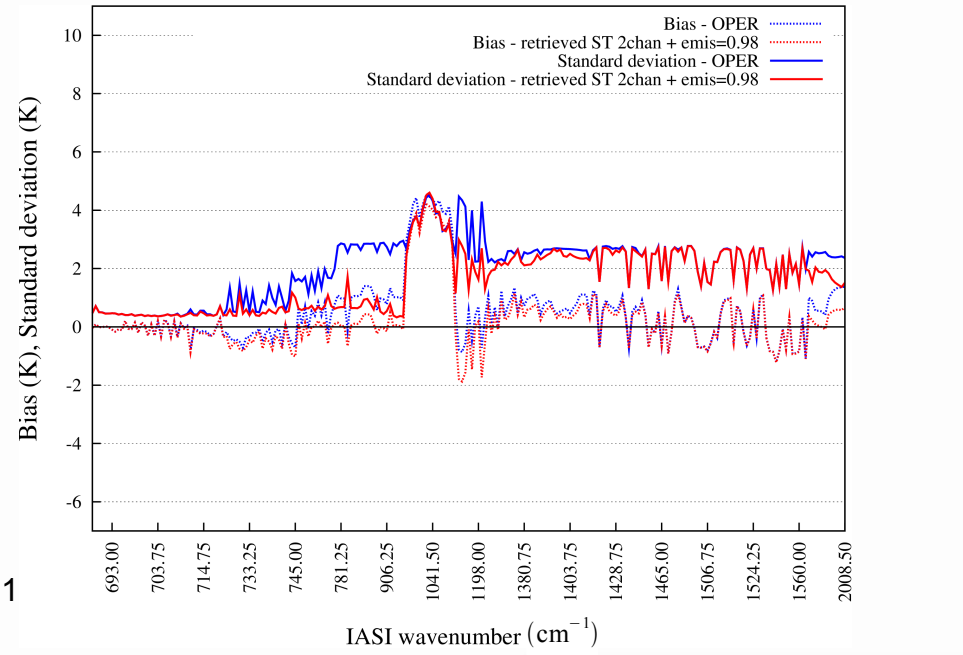
JANUARY 2012

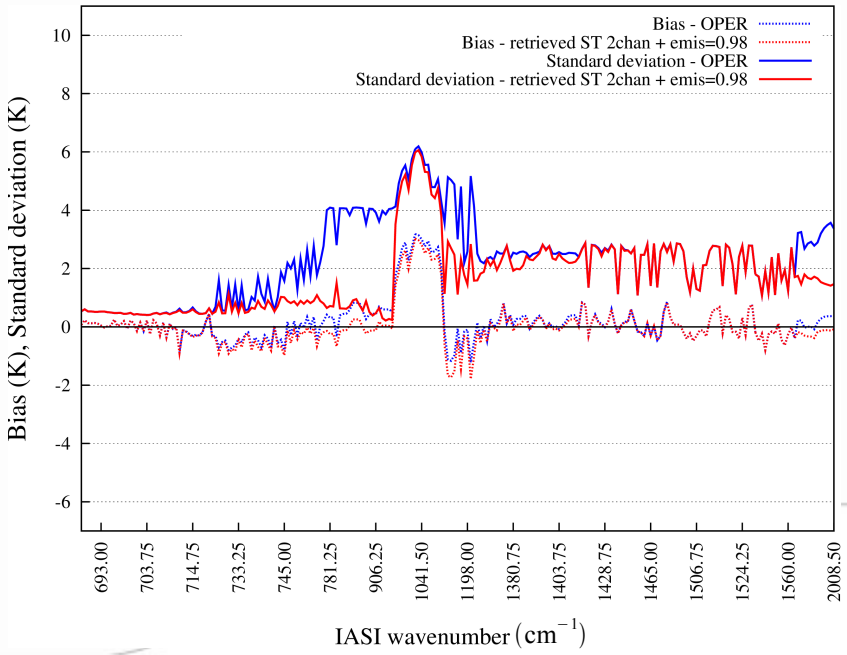
DAY





NIGHT



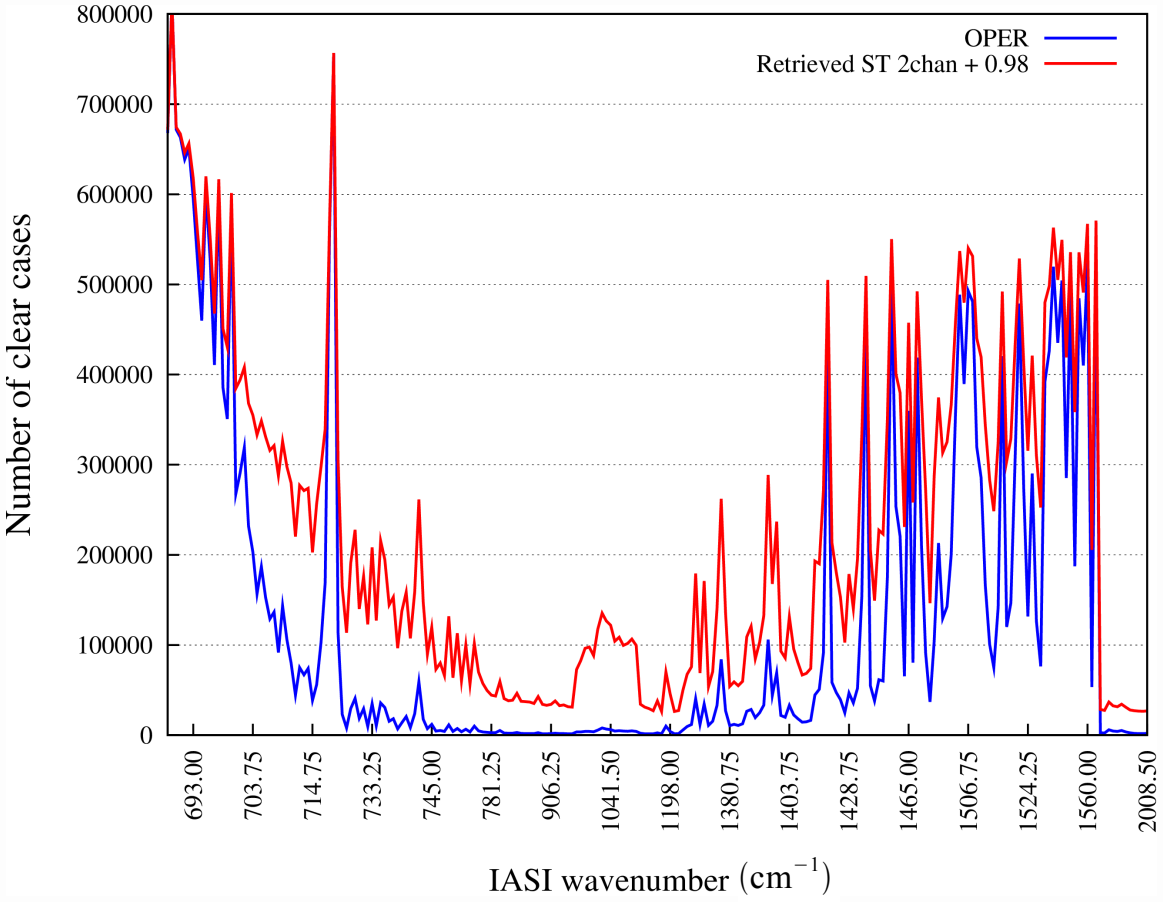


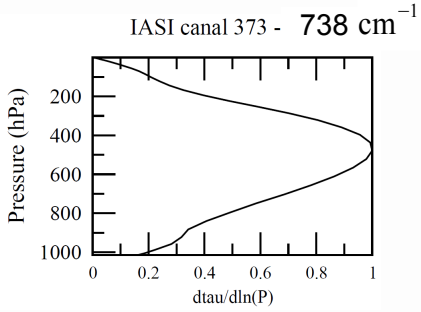
JANUARY 2012

Impact on cloud detection

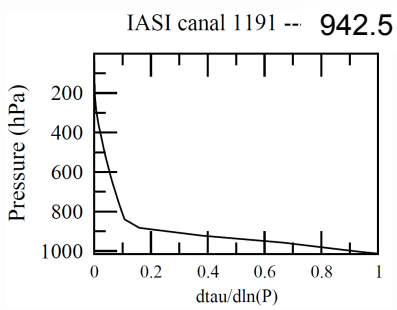
DAY

Number of clear channels with cloud detect method (McNally and Watts 2003)





=> x 8.4



=> x 18.4

=> larger number of potential observations for assimilation

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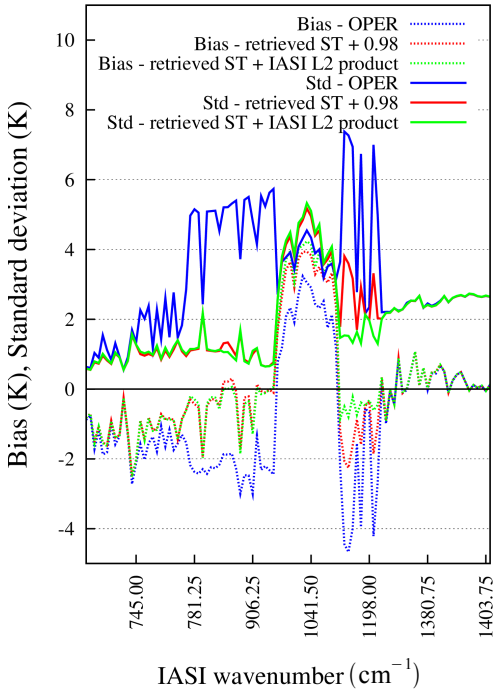
Emissivity atlases over land and impact on brightness temperature simulations.

The atlases

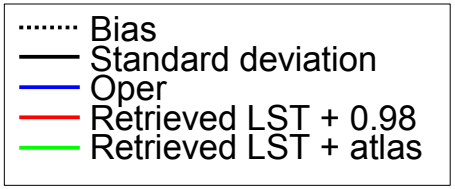
- Impact of the combination of LST retrievals with atlas emissivity. Two atlases are used :
  - the **IASI L2 products** of emissivity from EUMETSAT (August et al, 2012)
  - the global high spectral resolution infrared land surface emissivity database (called **UWIREMIS atlas**) developed by the UW/CIMSS (Seeman et al, 2008 ; Borbas and Ruston 2010)

Impact on brightness temperature simulations

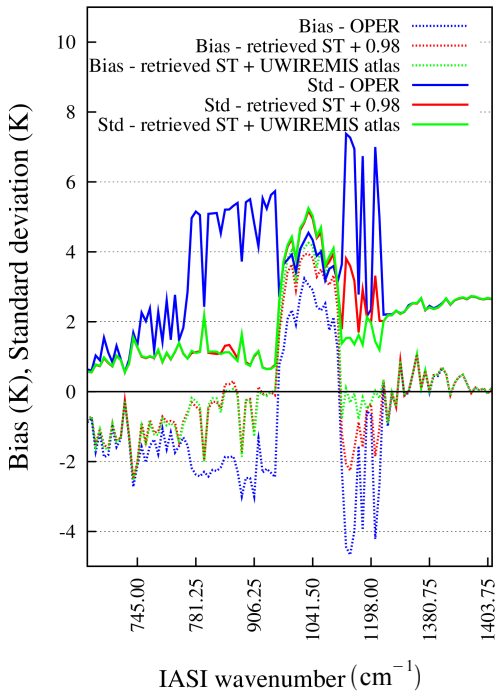
IASI LSE L2 products



July 2011
AVHRR
Day



UWIREMIS atlas



- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm^{-1}.

Emissivity atlases over land and impact on brightness temperature simulations.

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Impact on brightness temperature simulations

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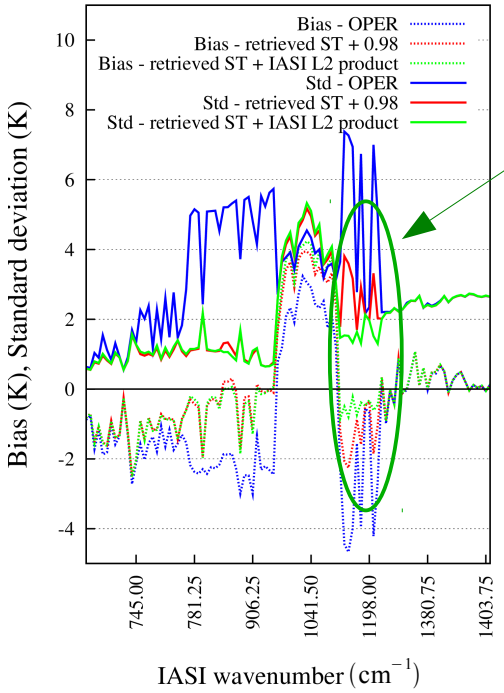
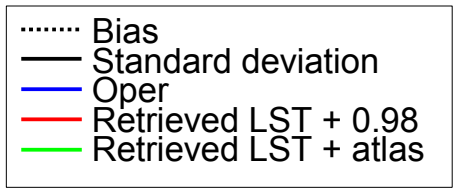
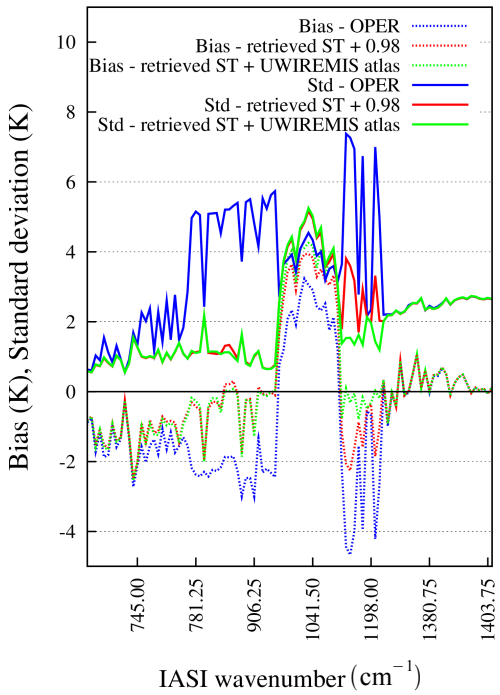


July 2011
AVHRR
Day

Surface



UWIREMIS atlas



- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm^{-1}.

Conclusion

Conclusion of this study

- Realistic estimate of the retrieved LST compared with MODIS products and IASI L2 products.
- Importance of accurate land surface temperature and emissivity in the brightness temperature simulations.
- Good impact of the LST retrievals on cloud detection. More clear cases detected and so more potential channels per observation could be used in the assimilation.
- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm^{-1}.

Future work

- Assimilation experiments using LST retrievals and emissivity atlases into the ARPEGE NWP of Météo-France with channel selection.