Improved assimilation of IASI land surface temperature data over continents in the convective scale AROME France model

Niama Boukachaba

PhD supervised by Vincent Guidard and Nadia Fourrié

Météo-France and CNRS / CNRM-GAME

niama.boukachaba@meteo.fr

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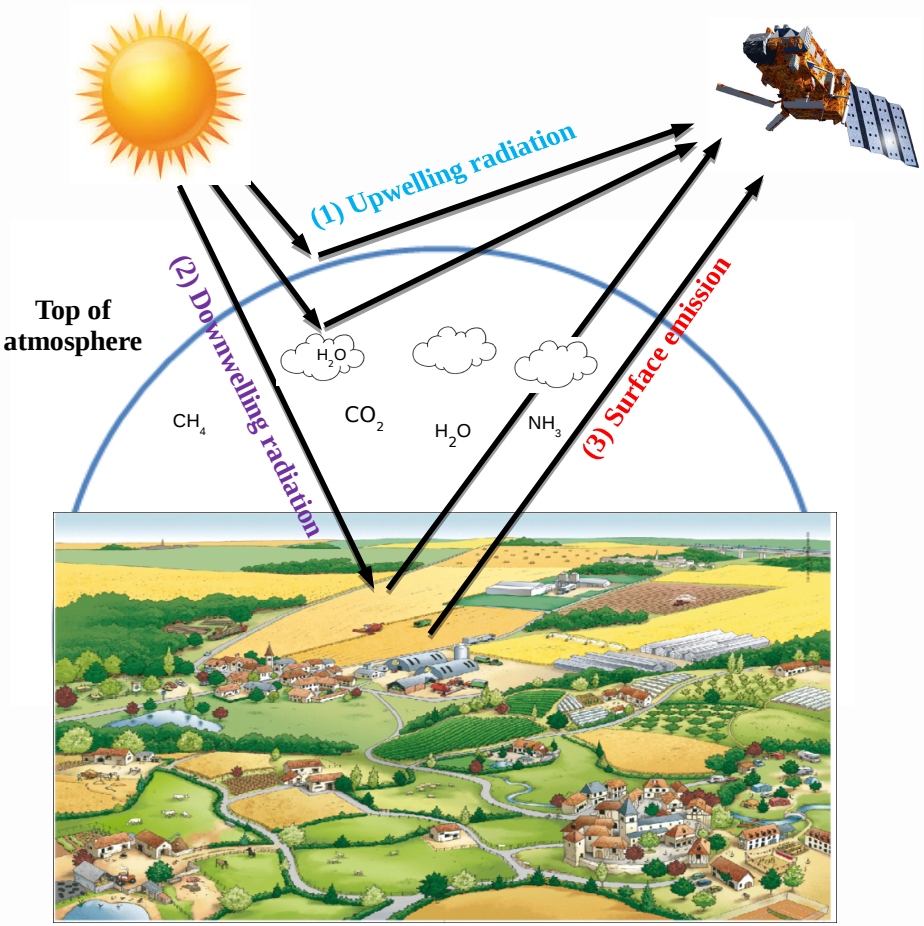
OUTLINE

- Assimilation of IR observation over continents
- IASI vs SEVIRI channels for land surface temperature (LST) retrieval and comparison method
- IASI channel selected for LST retrieval and its impact on the assimilation
- Conclusions and prospects

Assimilation of IR observation over continents

- IASI (Infrared Atmospheric Sounding Interferometer) has 8461 spectral samples but just 314 channels are used in NWP.
- The forecast of continental surface temperature is not realistic enough to use the infrared information in the lower troposphere and close to the surface over continents.



Assimilation of IR observation over continents

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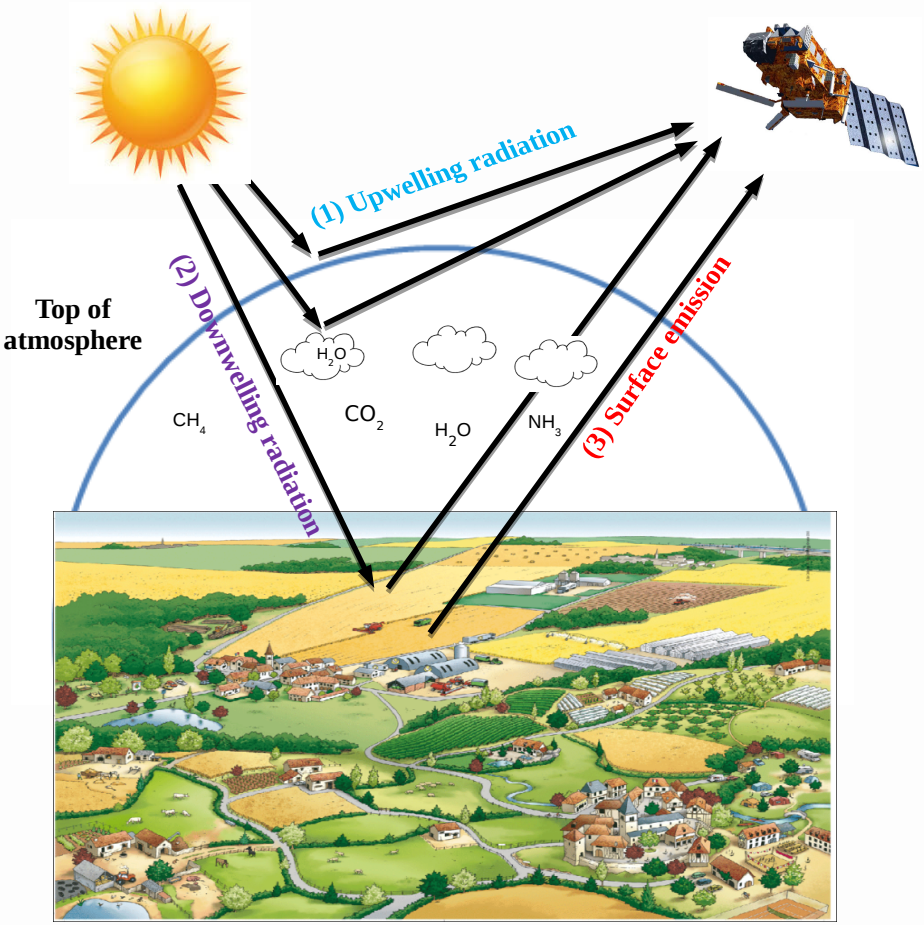
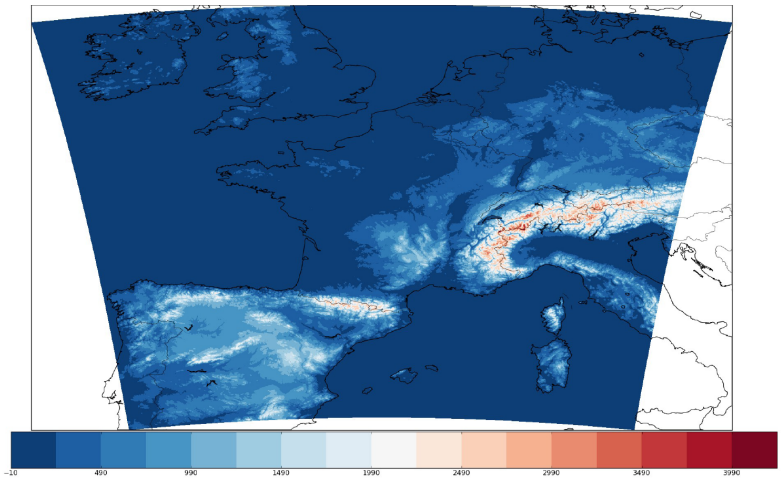


Radiative transfer equation inversion:

$$LST = L\left[\frac{R_\nu(\theta) - L_\nu^{\uparrow}(\theta) - \Gamma_\nu(\theta)(1-\varepsilon_\nu(\theta))L_\nu^{\downarrow}(\theta)}{\Gamma_\nu(\theta)\varepsilon_\nu(\theta)}\right]^{-1}$$

[Karbou et al., 2006]

εν: surface emissivity, Γν: atmospheric transmission , Lν and Lν: atmospheric upwelling and downwelling radiances at channel ν.



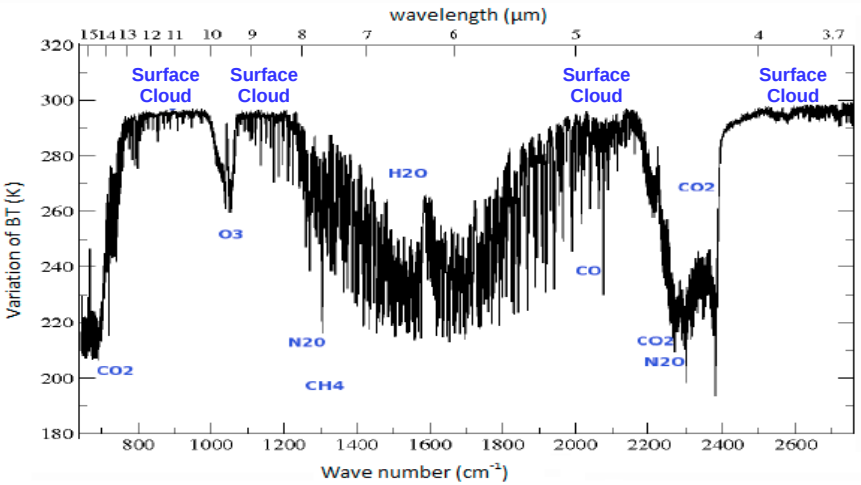
The geographical domain of AROME model

Challenges

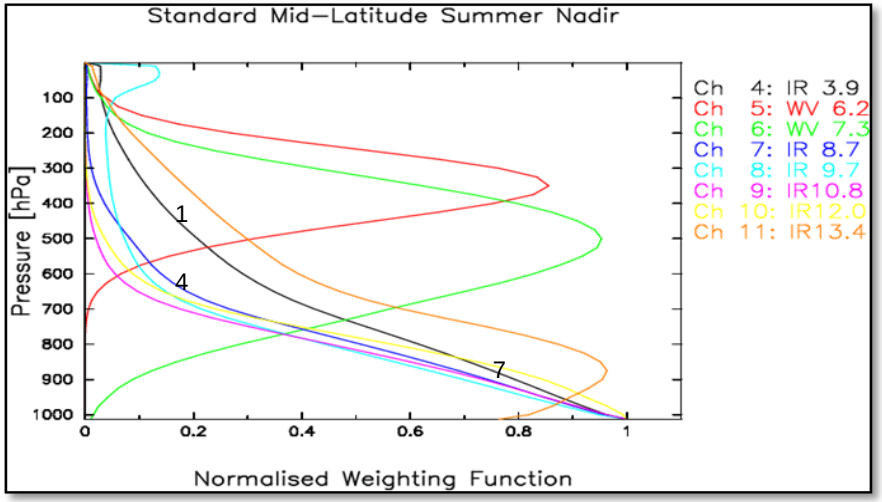
- What is the best IASI surface-sensitive channel for LST retrieval?
- What is the impact of this retrieved LST on the assimilation of IASI in AROME model?

IASI and SEVIRI channels for LST retrieval and comparison method

IASI		
Channels	**Wave number (cm^{-1})**	**Wavelenght (µm)**
1027	901.50	11.09
1271	942.50	10.61
1191	943.25	10.60
1194	962.50	10.39
1884	1115.75	8.96



Exemple of IASI profiles in clear sky conditions
[Fourrié, 2010]



Weighting function of SEVIRI channels
[Schmetz et al., 2002]

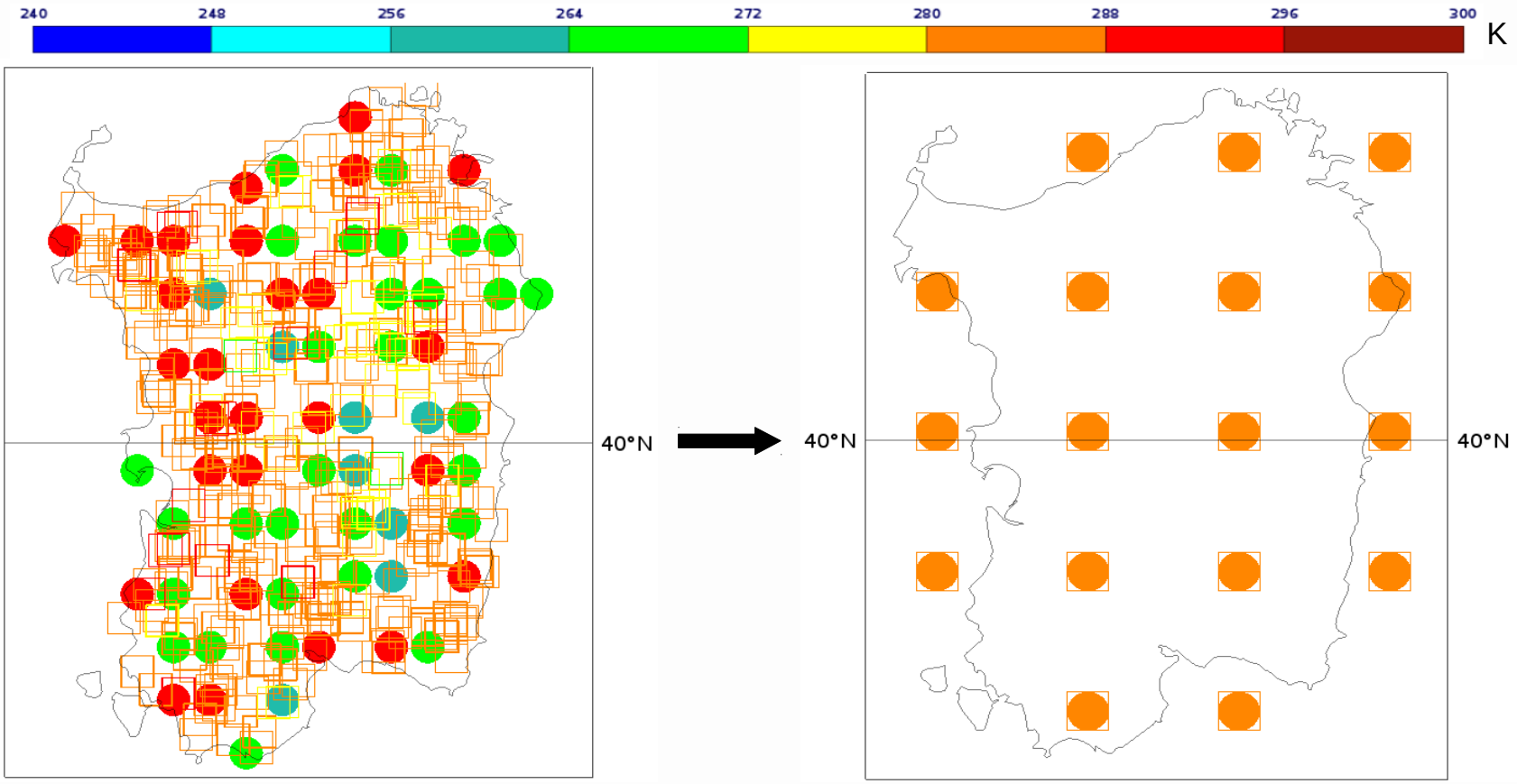
SEVIRI*	
Channels	**Wavelenght (µm)**
01	3.9
04	8.7
07	12.0

* Spinning Enhanced Visible and Infrared Image

Study period from 20150115 to 20150228

IASI and SEVIRI channels for LST retrieval and comparison method

- Comparison method between IASI and SEVIRI data

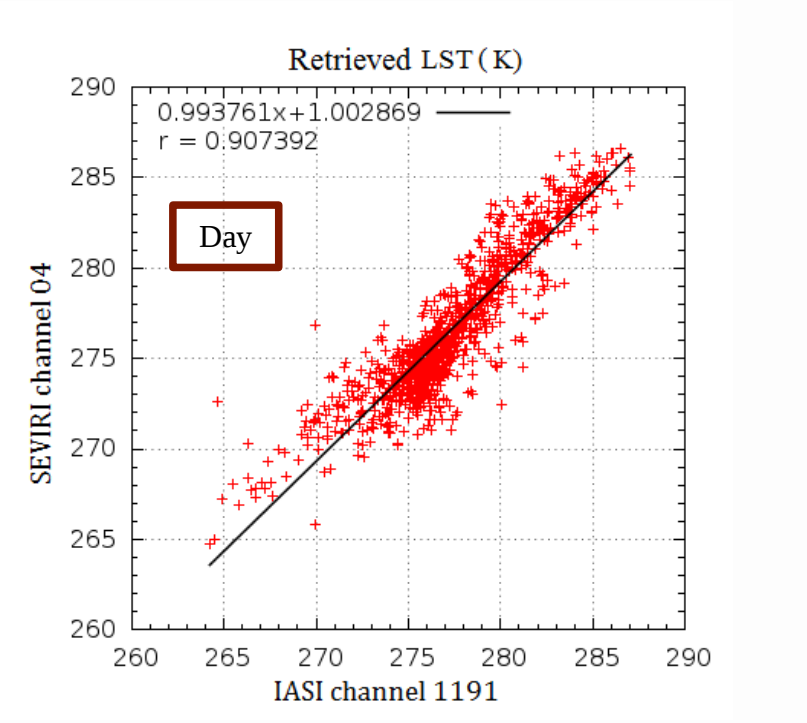


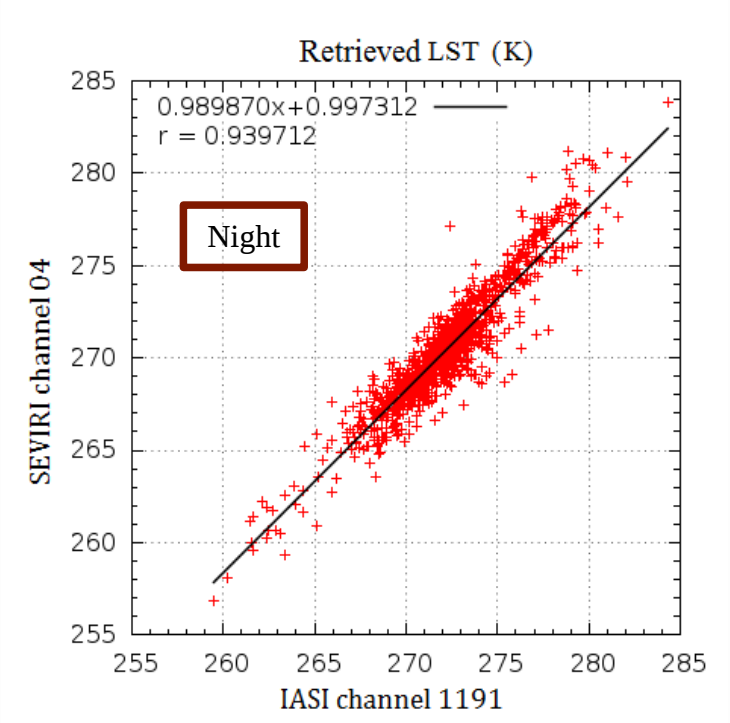
Retrieval LST IASI channel 1191 (in squares) and SEVIRI channel 04 (in circles) over Sardinia at day

Mean retrieval LST IASI channel 1191 (in squares) and SEVIRI channel 04 (in circles) over Sardinia by box of 0.5° * 0.5° at day

Comparison between retrieved LST: IASI vs SEVIRI

- Retrieved LST: IASI channel 1191and SEVIRI channel 04 (by box of 0.5° * 0.5°)





The correlation between LST from IASI channel 1191 and LST from SEVIRI channel 04 is even better at night.

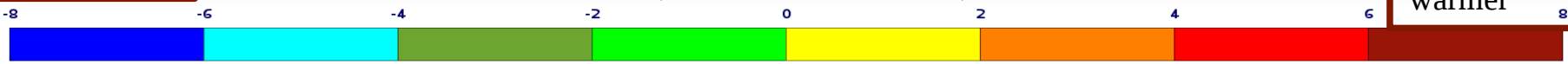
Comparison between retrieved LST: IASI vs SEVIRI

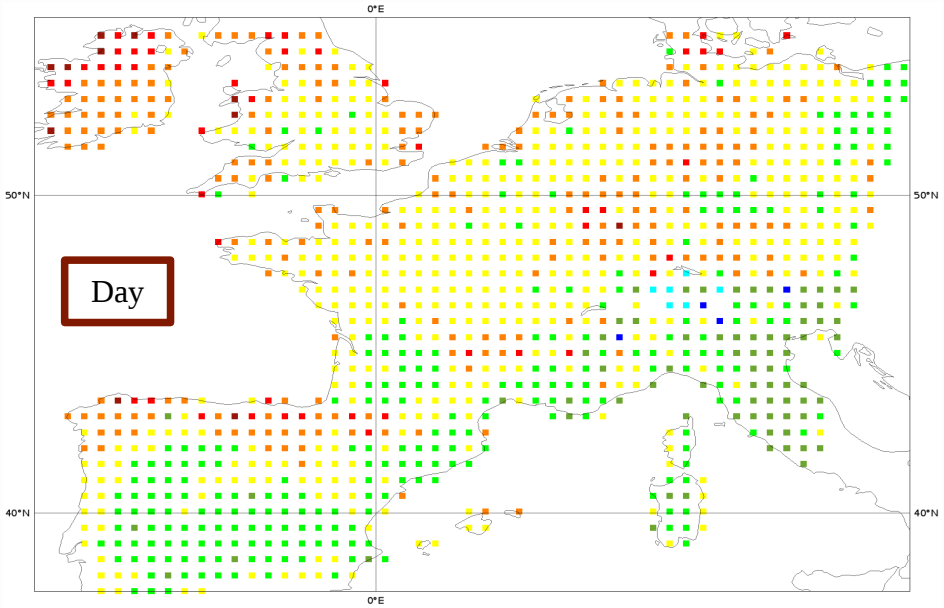
- Difference between retrieved LST (IASI channel 1191 and SEVIRI channel 04) (by box of 0.5° * 0.5°)

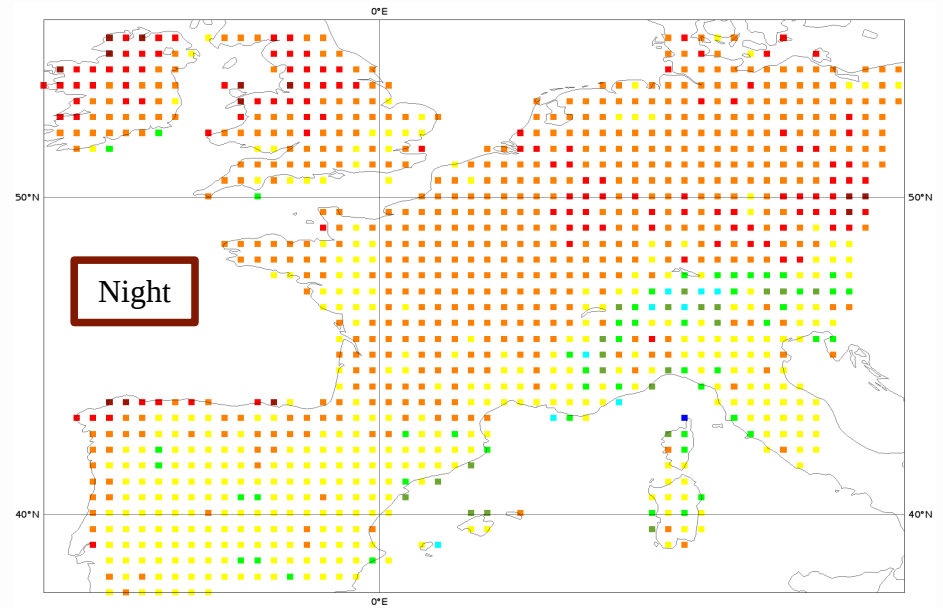
(IASI channel – SEVIRI channel)

IASI colder

IASI warmer







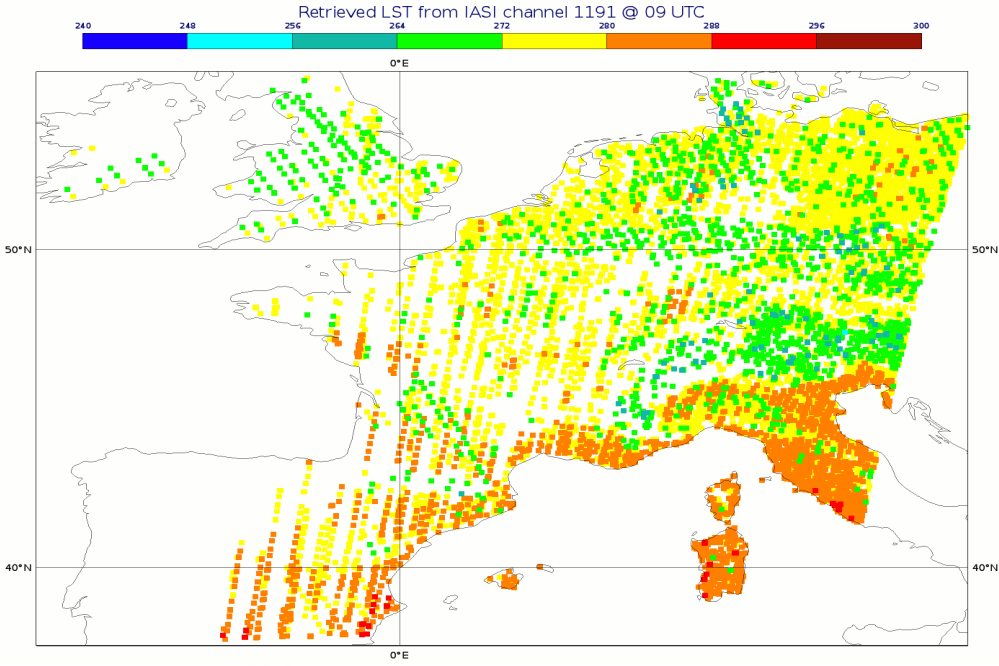
- Mean difference between retrieved LST (IASI channel 1191 and SEVIRI channel 04) (by box of 0.5° * 0.5°)

SEVIRI channel	IASI channels	Day			Night		
		Mean	Std	Correlation	Mean	Std	Correlation
04	1027	0.711	1.682	0.906	1.736	1.153	0.939
	1271	0.897	1.663	0.908	1.910	1.154	0.939
	1191	0.724	1.666	0.907	1.757	1.150	0.940
	1194	0.775	1.671	0.907	1.818	1.160	0.939
	1884	0.268	1.604	0.914	1.127	1.110	0.940
Total observation		1089			1090		

The mean difference between IASI and SEVIRI is around 0.8K at day and less than 2K at night. The correlation is much better at night.

Conclusions of this part

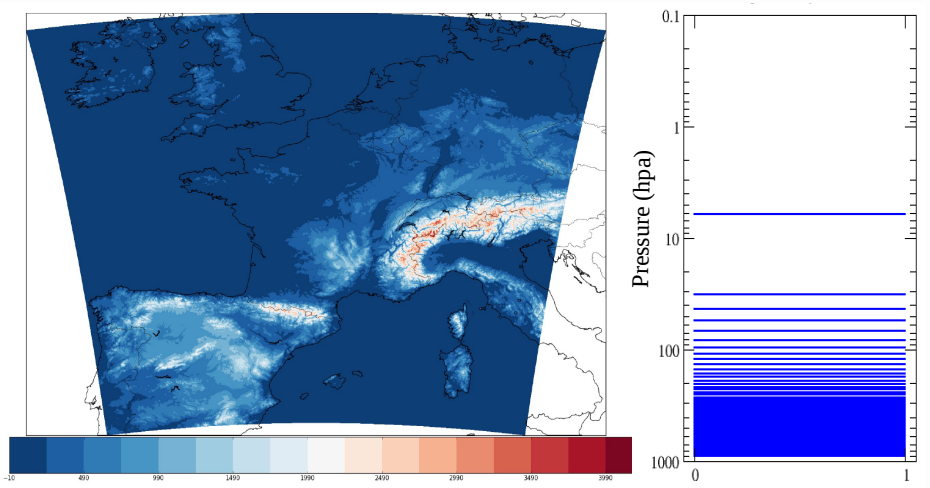
- IASI MetOp A & MetOp B produce similar LST retrievals.
- The use of variable emissivity provides a more realistic LST.
- The comparison between IASI and SEVIRI channels present good results allowing to study the complementarity between polar and geostationnary satellite.
- The comparison between channels in AROME model enable us to keep only the relevant IASI channels for temperature retrieval (the same resultats in the global ARPEGE model): we chose channel 1191.



Boukachaba, N., Fourrié, N., and Guidard, V., (2015) Land surface temperature retrieval from IASI for assimilation over the AROME-France domain. EUMETSAT Meteorological Satellite Conference, 21-25 September 2015, Toulouse, France.

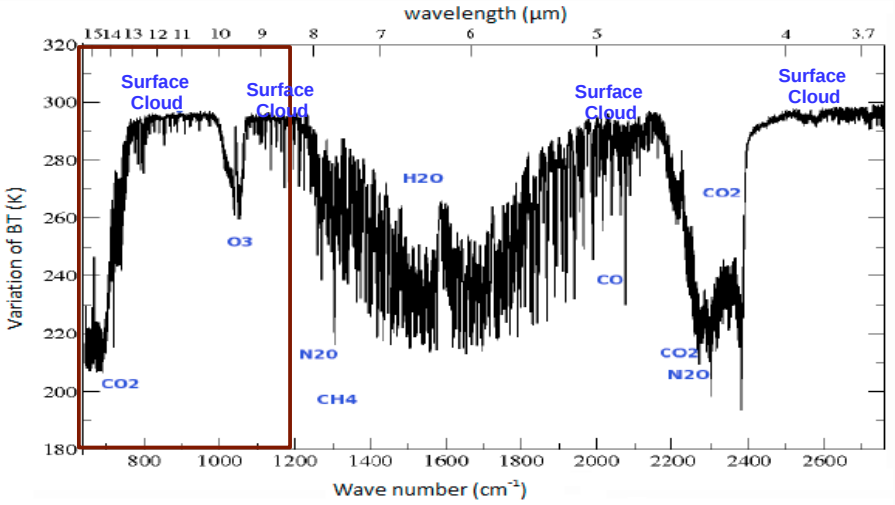
Using retrieved LST in the AROME assimilation

EXP	LST retrieved from IASI channel 1191 used for IASI BTs simulation
REF	LST from AROME forecast (= operations) used for IASI BTs simulation



The geographical domain of AROME model: horizontal resolution: 1.3 km, 90 vertical levels, 36 h forecasts every 3h, hourly 3DVar Data Assimilation.

- IASI channels used for cloud detection (McNally & Watts) in LW temperature band



Exemple of IASI profiles in clear sky conditions [Fourrié, 2010]

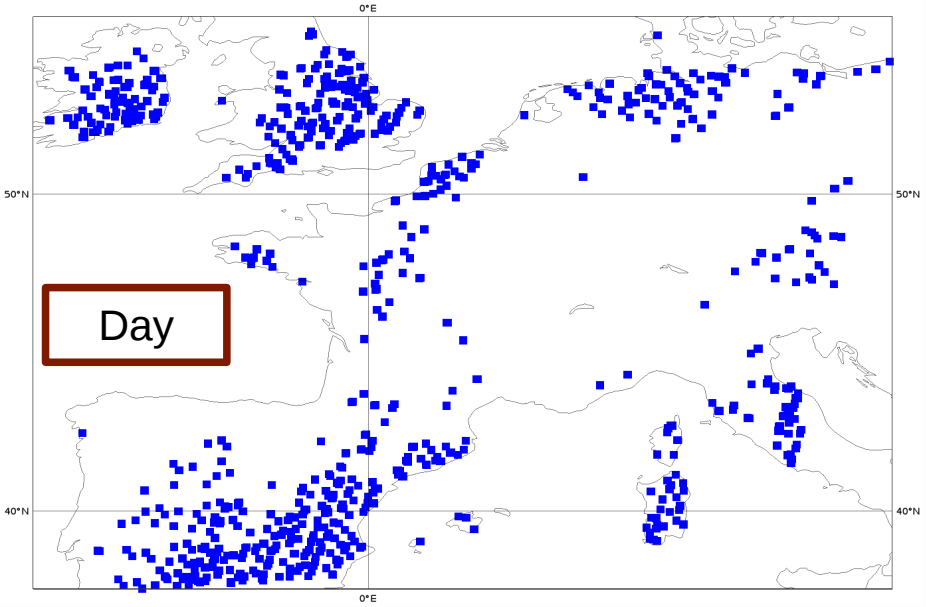
Study period from 20150115 to 20150228 using clear observations according to AVHRR

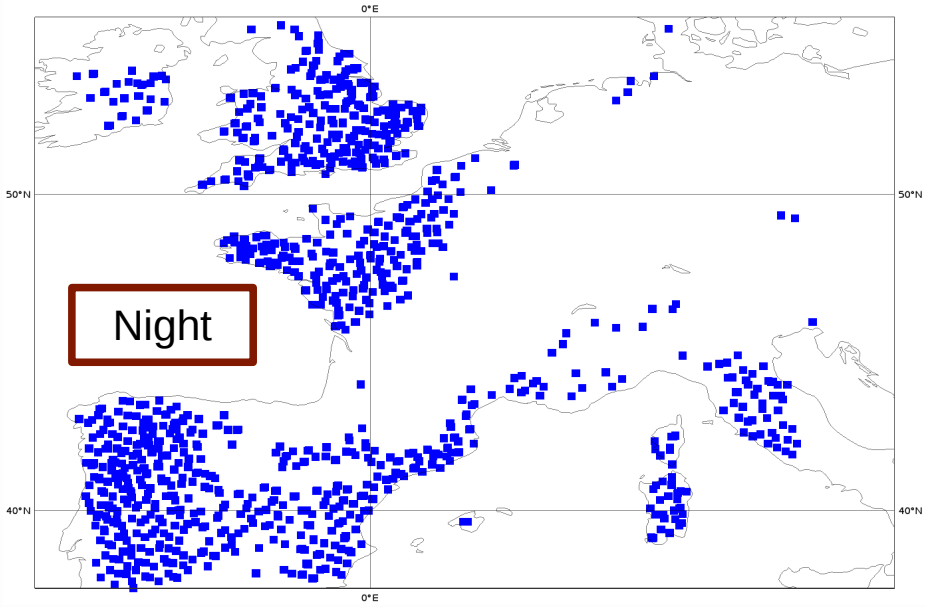
↓

Results from 20150115 to 20150116

Using retrieved LST in the AROME assimilation

- Location of IASI observations





The total clear observations is 988 at day and 1215 at night
for each IASI channel (according to AVHRR)

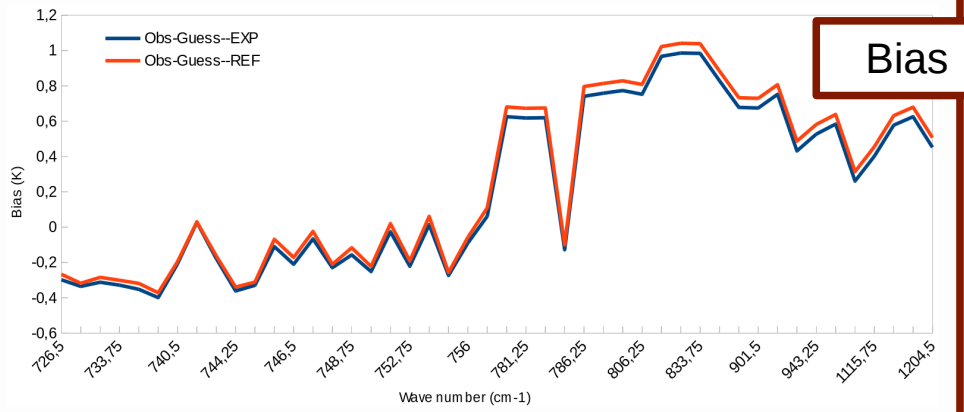
Using retrieved LST in the AROME assimilation

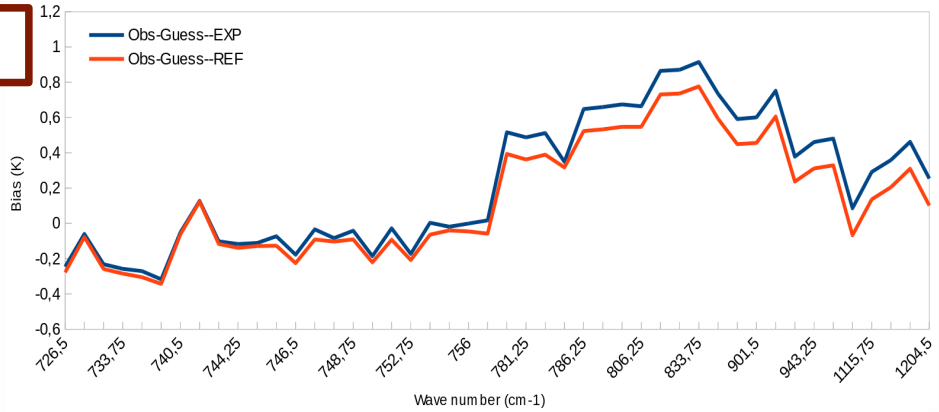
Day

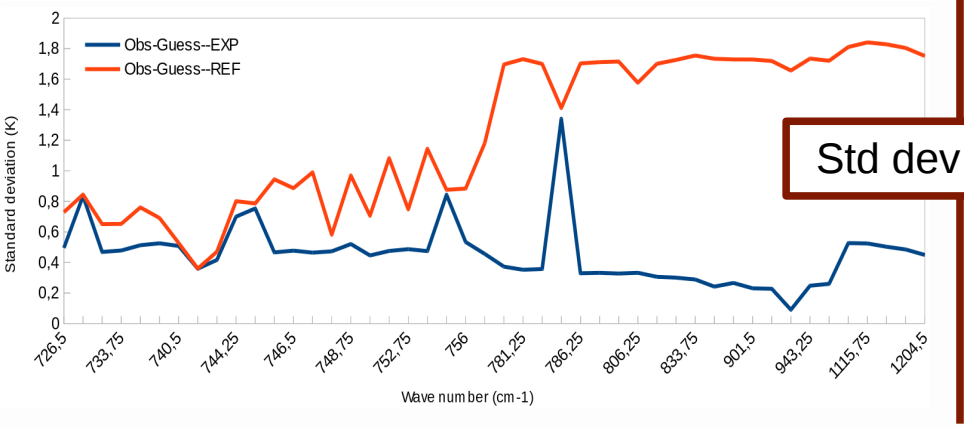
Night

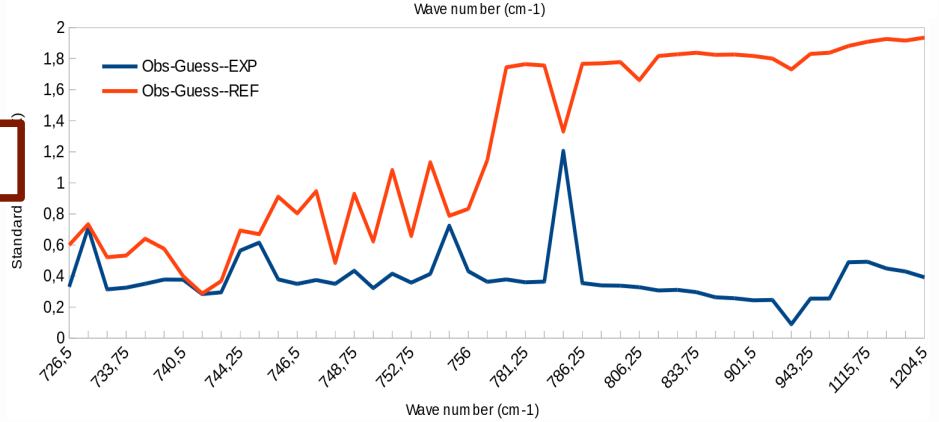
Bias

Std dev







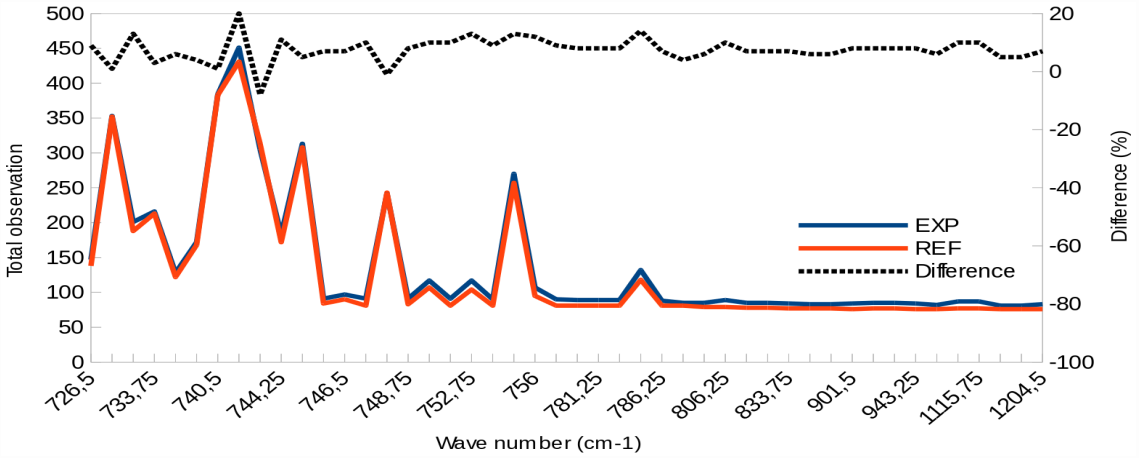


The Obs-Guess of EXP and REF (combined IASI data from MetOp A & B) is very similar at day and night. A small difference is observed for surface-sensitive channels. The Std is much better in EXP for both cases.

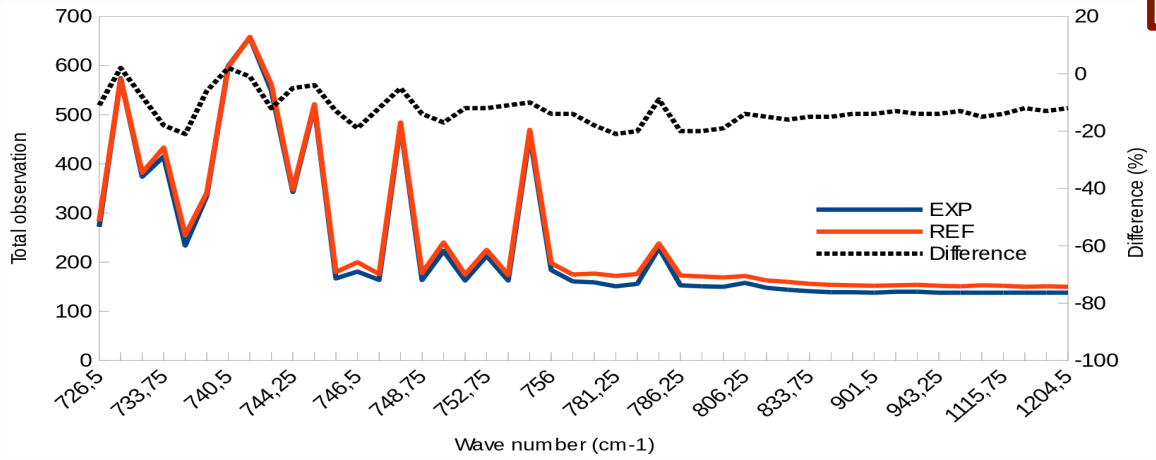
Using retrieved LST in the AROME assimilation

- Total clear observation according to AVHRR and McNally & Watts algorithms

Day



Night



At day, the impact on cloud detection is slightly improved. At night, a small degradation is observed.

Conclusions and prospects

Conclusions

- The comparison between channels in AROME model enable us to keep only the relevant IASI channels for temperature retrieval (the same resultats over global ARPEGE model): we chose channel 1191.
- The first results of assimilation are encouraging and present a slightly positive impact on some other observation such as temperature from radiosoundings.

Future work

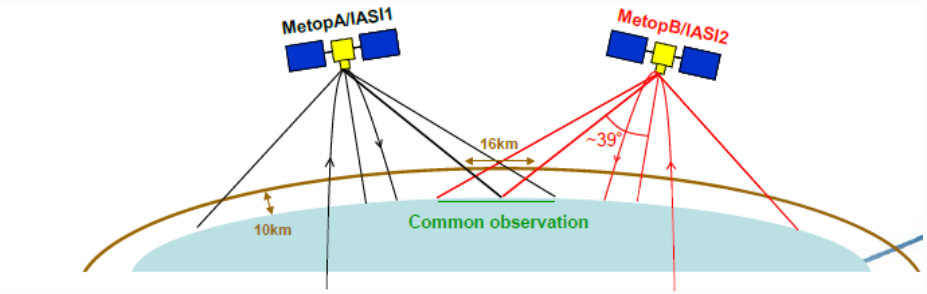
- Select IASI surface-sensitive channels to be assimilated over land and evaluate the improvement of assimilation and forecasts in the AROME-France domain.
- Assimilate the recent sensors like CrIs and prepare the assimilation of the new hyperspectral sensors such as IRS and IASI-NG over continents.

Thank you for your attention

Comparison between IASI MetOp A and MetOp B

- IASI MetOp A and MetOp B characteristics

  - IASI-A and B are on the same orbit with a 180° shift.
  - ~50 min temporal shift.
  - off-nadir: from 0° to 39°, opposite angles .
  - Regional averaging of the soundings (area 300 × 300km or less). [Jouglet et al., 2013]



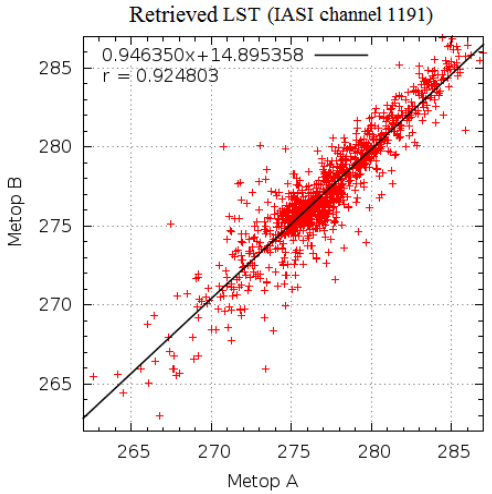
- Comparison between cloud cover IASI MetOp A vs MetOp B from 20150201 to 20150221 (according to AVHRR)

	Metop A		Metop B	
	Clear	Cloudy	Clear	Cloudy
Day	20%	80%	21%	79%
Night	43%	57%	33%	67%

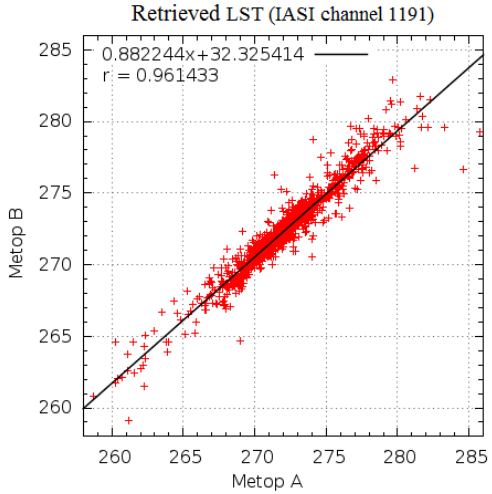
Around 80% of IASI MetOp A & MetOp B are affected by clouds at day and more than 50% at night

- Comparison of retrieved LST IASI MetOp A vs MetOp B from 20150115 to 20150228

Day



Night



Very good correlation between retrieved LST IASI MetOp A vs MetOp B (a little better at night)

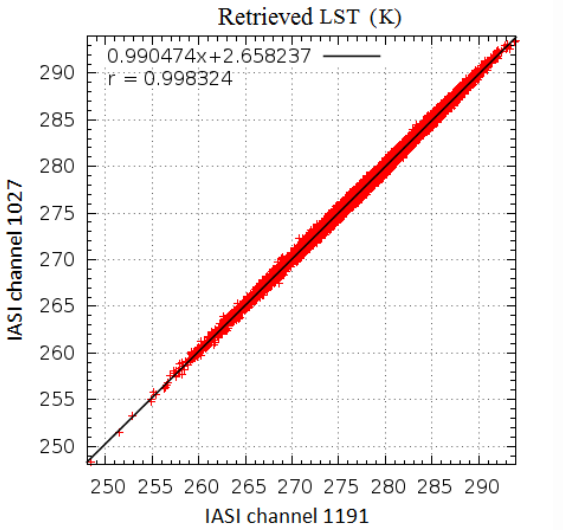
Comparison between background and retrieved LST

- Difference between background and retrieved LST IASI channels

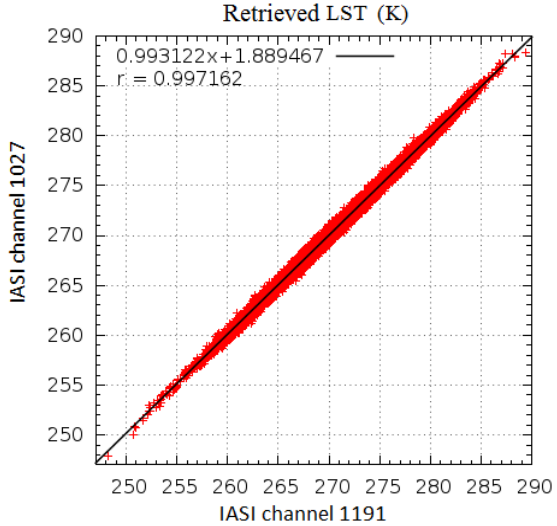
Channel number	Day			Night		
	Mean	Std	Correlation	Mean	Std	Correlation
1027	0.161	2.238	0.876	-0.695	2.936	0.718
1271	0.337	2.177	0.881	-0.524	2.902	0.722
1191	0.165	2.217	0.877	-0.678	2.938	0.716
1194	0.212	2.194	0.879	-0.615	2.901	0.722
1884	-0.324	2.191	0.879	-1.327	3.108	0.690
Total observation	66191			96070		

- Mean difference between background and retrieved LST is less than 0.4K at day and 0.7K at night for all IASI channels.
- Standard deviation is around 2K at day and 3K at night.
- Better correlation at day.

- Comparison between retrieved LST IASI 1191 and 1027 channels



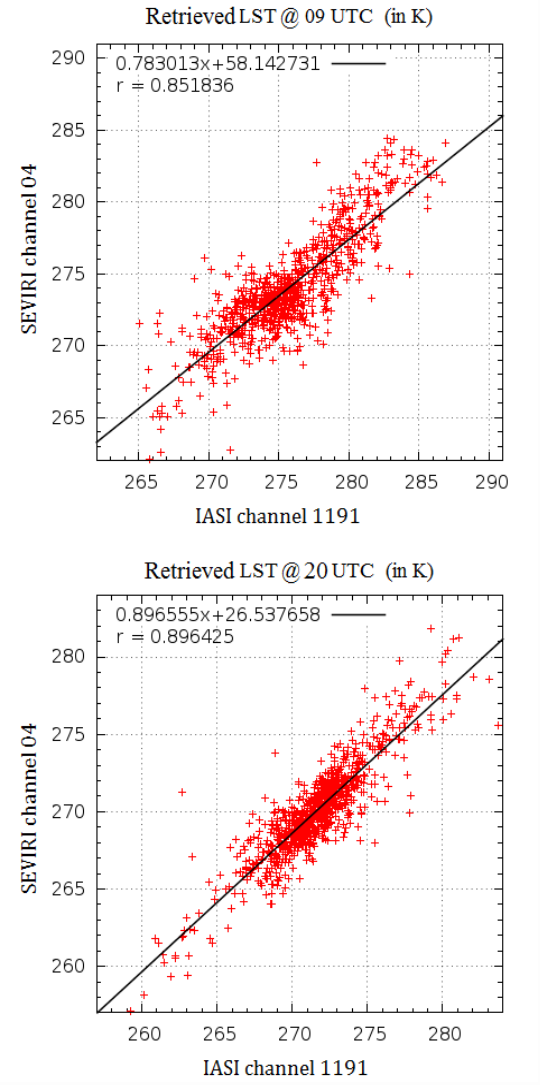
Day

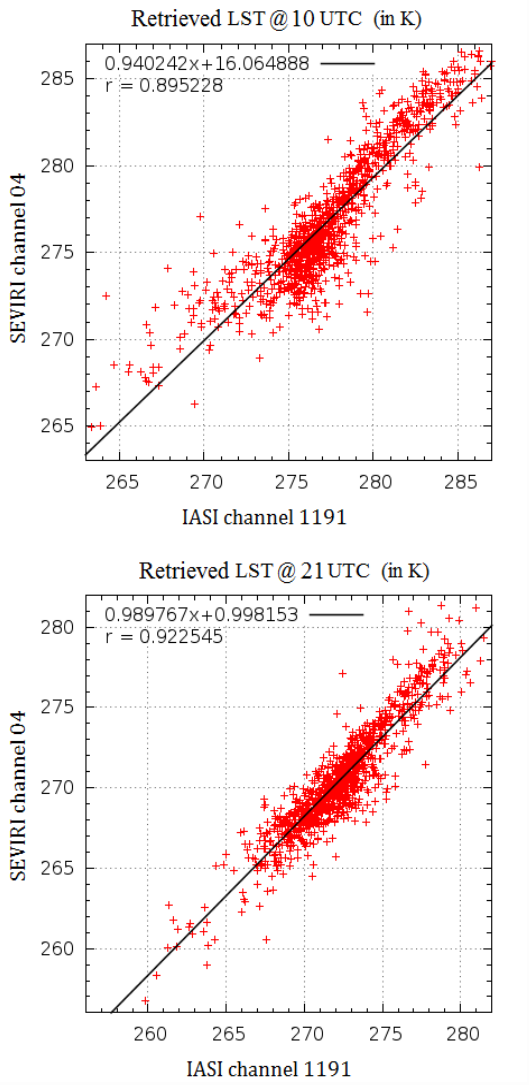


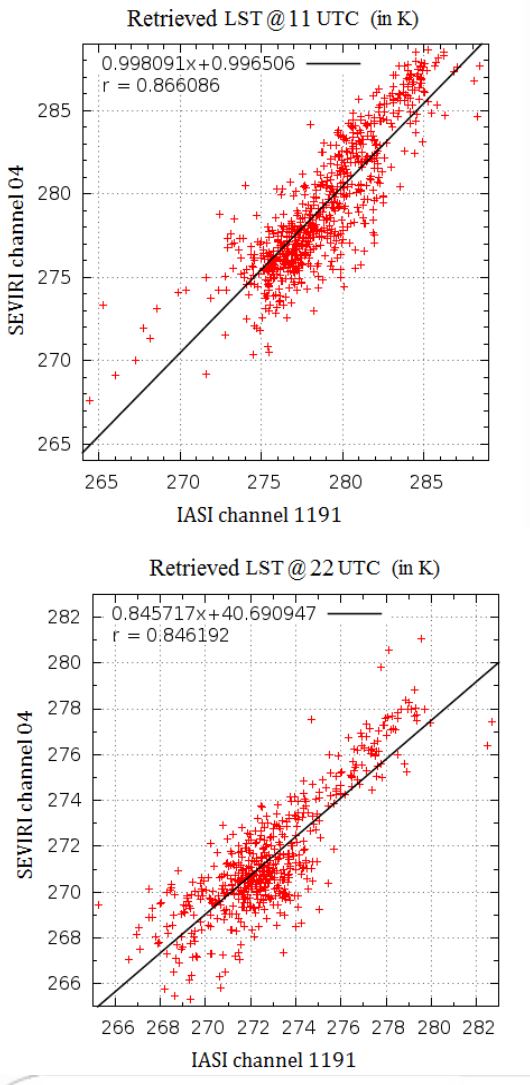
Night

- The comparison between retrieved LST IASI channels present a very good result with a correlation higher than 0.9.

Comparison between retrieved LST IASI vs SEVIRI channels per hour







Difference between retrieved LST using constant vs variable emissivity over ARPEGE model For October 2014