Surface temperature retrievals from IASI and SEVIRI channels in the convective scale numerical prediction AROME-France model

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Introduction

Land surface temperature (LST) is one of the key surface parameters which indicates the energy balance at the Earth's surface and is particularly relevant for domains such as agriculture, climatology, hydrology and weather forecasts [Kerr et al., 2004]. The retrieval of LST from remote sensing is still a big challenge basically because of cloud cover and variation of land surface emissivity. By pursuing the approach developed by Vincensini [2013] to find the LST from a combination of IASI channels, a new selection of channels over land was built, to better analyse the lower layers of the atmosphere, in particular in terms of temperature. This work shows the results of the best surface-sensitive IASI channel selection for LST retrieval. For that, we first compared LST from IASI MetOp A & MetOp B. Then, we compared background (which is a short-range forecast of AROME model) LST with retrieved IASI channels LST. We also performed inter-channels IASI LST comparisons. Finally, we validate IASI surface-sensitive channel by comparing retrieved LST from IASI with retrieved LST from SEVIRI.

IASI and SEVIRI channel selection

To retrieve LST, we should have the best surface-sensitive channel. For that, we chose five surface IASI channels and three SEVIRI channels. The five IASI channels selected for retrieving LST are: 1027 (901.5 cm-1), 1191 (942.5 cm-1), 1194 (943.25 cm-1), 1271 (962.5 cm-1) and 1884 (1115.75 cm-1). For SEVIRI, we selected: channel 01 [IR3.9 (2564.10 cm-1)], channel 04 [IR8.7 (1149.43 cm-1)] and channel 07 [IR12.0 (833.33 cm-1)]. All these channels are sensitive to surface and clouds.

Methodology for LST retrieval

The same approach used in the Guedj et al [2011] study was chosen for the computation of LST using radiative transfer equation inversion (Equation (1)):

$$LST = L\left[\frac{R_v(\theta) - L_v^{\uparrow}(\theta) - \Gamma_v(\theta)\left(1-\varepsilon_v(\theta)\right)L_v^{\downarrow}(\theta)}{\Gamma_v(\theta)\,\varepsilon_v(\theta)}\right]^{-1}$$

(Eq.1) [Karbou et al., 2006]

Where ε_v, Γ_v, $L_v^{\uparrow}$ and $L_v^{\downarrow}$ represent the surface emissivity, the atmospheric transmission, and the atmospheric upwelling and downwelling radiances at channel v, respectively. The value of Γ_v, $L_v^{\uparrow}$ and $L_v^{\downarrow}$ can be computed using the RTTOV model v 11 [Saunders et al., 2012] given a priori knowledge of the atmosphere (short range forecasts of air temperature and humidity) [Borbas et Ruston, 2010]. For IASI LST retrievals, we compared two types of emissivity: constant emissivity (0.98) and emissivity atlas developed by the Space Science and Engineering Center at University of Wisconsin [Borbas et al., 2007]. In operational, retrieved LST from SEVIRI uses variable emissivity derived from EUMETSAT.

In this poster, we present only the results using emissivity atlas of 2013 (for IASI) for a study period from the 15th January 2015 till the 28th February 2015. All experiments was operated in the new configuration of AROME model with 1.3 km spatial resolution and 90 vertical levels. For the assimilation, AROME uses 3DVar data assimilation with long-range 36 h forecasts every 3h.

Results

I. Comparison of retrieved LST IASI MetOp A vs MetOp B

MetOp A & B satellites are on the same orbit with a 180° shift which induces a 50 minutes temporal shift. To be sure that we retrieved the similar LST, we compared retrieved LST from IASI MetOp A & B during the whole period. Given that IASI MetOp A & B have not the same coordinates, we calculated the mean of retrieved LST from IASI MetOp A & B per box of 0.5° squared. We present for example the result for IASI channel 1191 (Figure 1).

The result showed a very good correlation higher than 0.960 especially at night-time. This correlation was slightly decreased during the daytime (0.920 in this case) because of a large dispersion at cooling value between 256 K and 274 K. The same results were obtained for the five IASI channels (not shown).

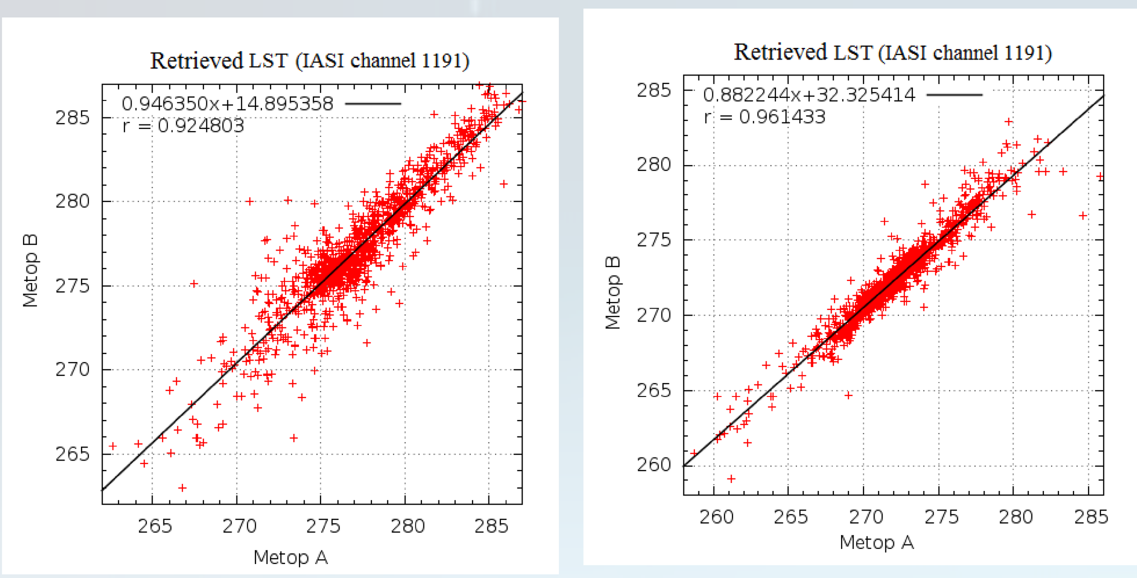

Figure 1: *Comparison of retrieved LST IASI MetOp A vs MetOp B (in Kelvin) for IASI channel 1191 at daytime (left) and night-time (right).*

In order to maximise the number of IASI observations, we combined data from MetOp A & B satellites to retrieve LST.

II. Comparison between background and retrieved LST IASI

In this part of study, we compared background and retrieved IASI LST at daytime and night-time (Figure 2). We observed that the largest difference between background and retrieved LST is located over the Alps and the Pyrénées mountains where background LST is colder than retrieved LST especially at night (more than 8-16K). Also, background and retrieved LSTs are warmer on the South-Western part of the domain (between 272K and 288K).

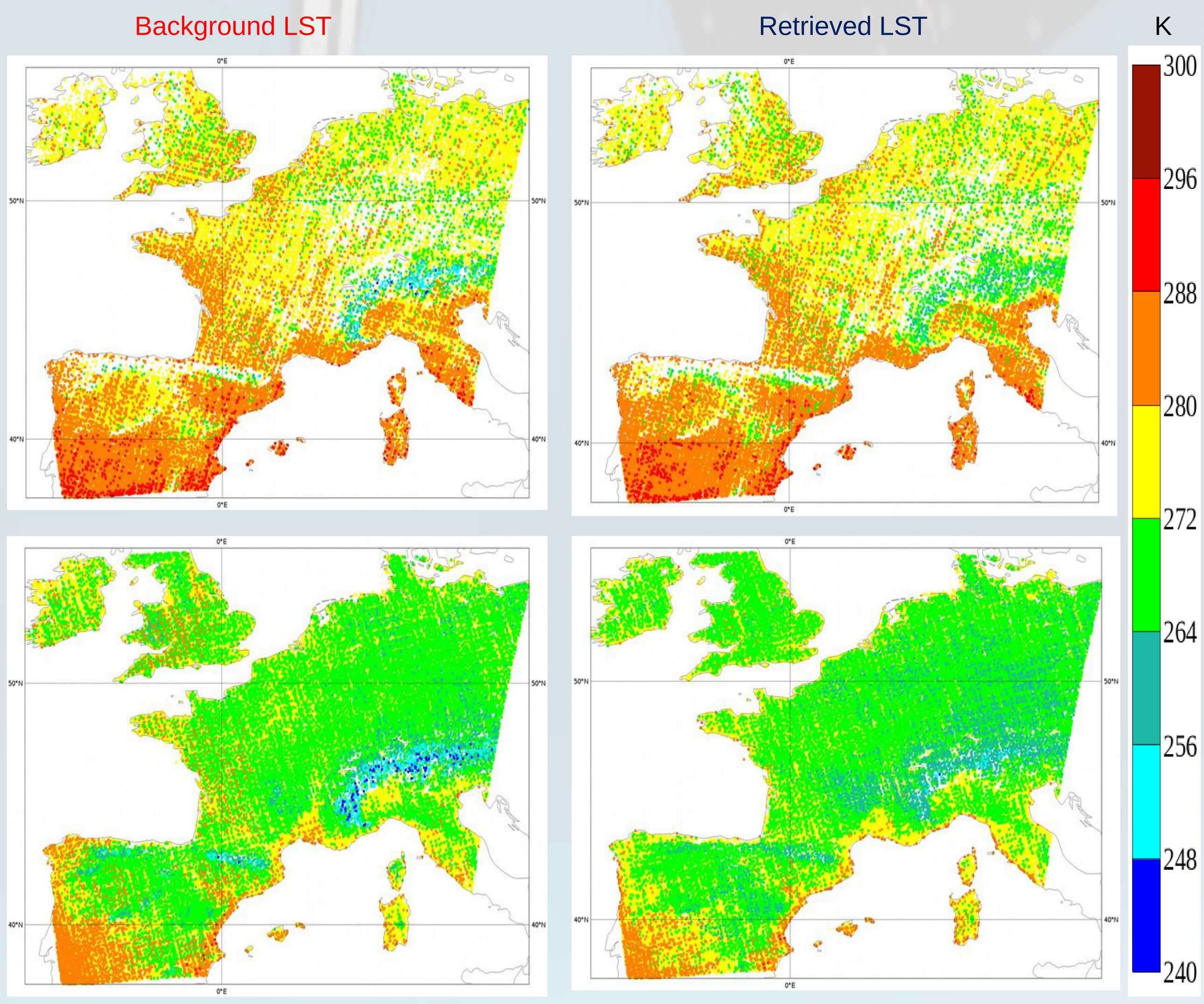

Figure 2: *Comparison between background (left panels) and retrieved (right panels) LST IASI channel 1191 at daytime (top) and night-time(bottom).*

The mean difference between background and retrieved LST for the five IASI channels (not shown) shows that we have less than 1K of difference at day and at night, except for IASI channel 1884 at night because this channel is in a spectral band different from the other IASI channels. The standard deviation is around 2K at daytime and 3K at night-time. Also, the correlation is much better at day (0.88 instead of 0.72) (not shown).

After that, we performed IASI inter-channel comparison of retrieved LST and we found a very good correlation, almost equal to 1. Figure 3 shows an example between IASI channel 1191 and channel 1027 with correlations higher than 0.997.

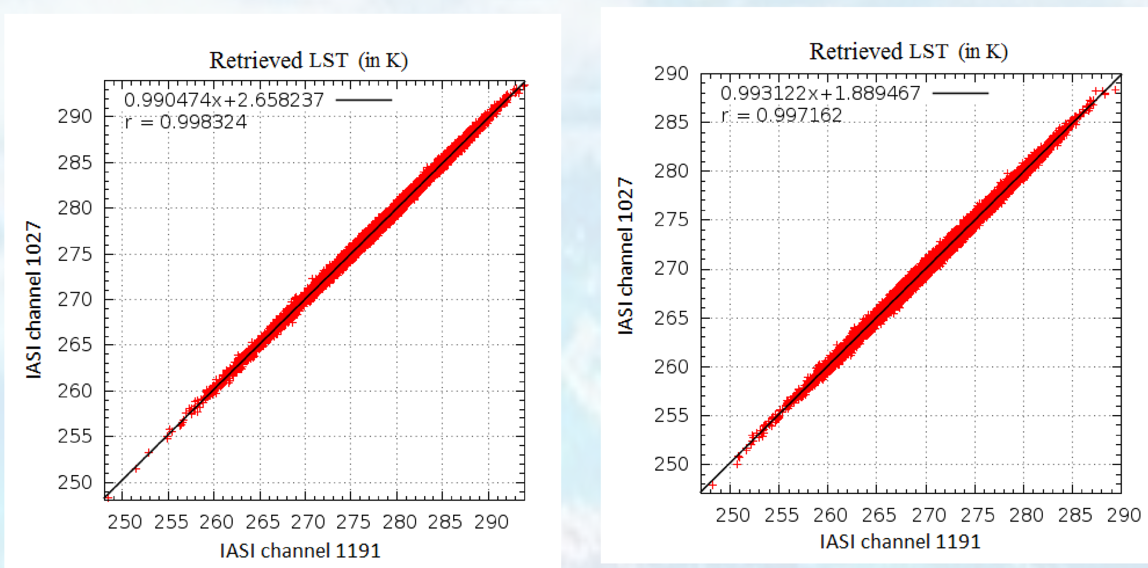

Figure 3: *Scatterplot of Retrieved LST from IASI channel 1191 and channel 1027 at daytime (left) and night-time (right).*

III. Retrieved LST from IASI vs Retrieved LST from SEVIRI

IASI and SEVIRI channels have different spectral and spatial resolutions, also different total observation numbers (e.g. 1,277,674 SEVIRI observations against 161,890 IASI observations from January 15th to February 28th 2015 over the AROME France domain). To be able to compare them to each other, we calculated the mean of LST in boxes of 0.5° squared (not shown). We chose this spatial resolution because it is the best one giving enough IASI and SEVIRI observation number per box.

In order to evaluate the quality of the IASI retrieved LST, we made a comparison with LST retrieved from SEVIRI channel 04 in a grid with in 0.5° squared boxes (Figure 4). We found a very good correlation higher than 0.9. This correlation was slightly better at night-time (because there is a higher dispersion during daytime).

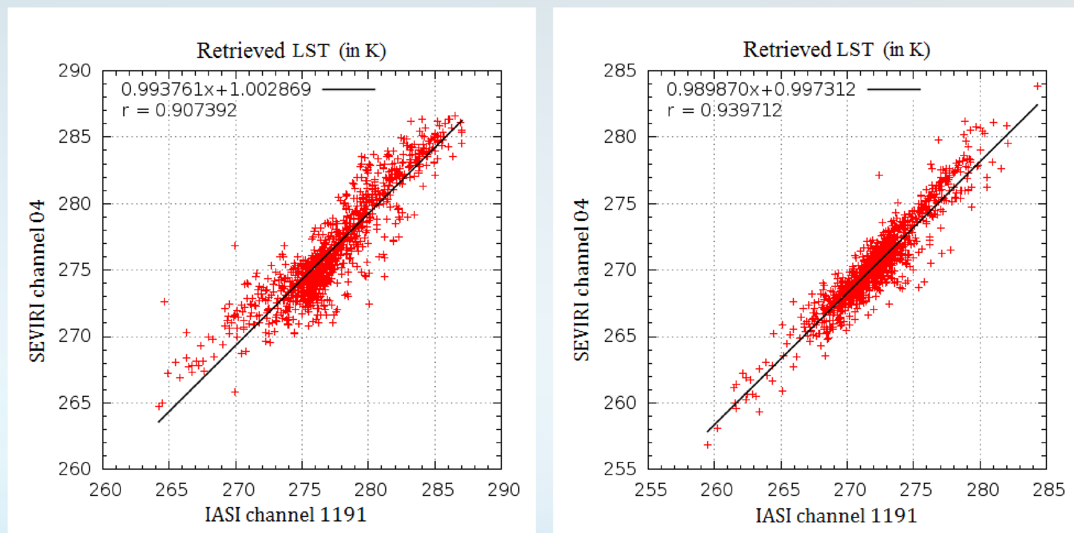

Figure 4: *Comparison between LST Retrieved from IASI channel 1191 and SEVIRI channel 04 (by box of 0.5° squared),at day (left) and night (right).*

After that, we looked at the LST spatial differences between both sounders (not shown). During day time, SEVIRI LST presented higher temperatures than IASI LST in the South East part of Europe: the difference was around 2K. At night we saw the opposite, SEVIRI LST was colder than IASI LST: the difference was included between 2K and 6K in the North East of AROME domain, also over UK and Ireland.

The mean difference (not shown) was lower than 0.8K at day and 2K at night. The Standard Deviation was around 2K with a very good correlation higher than 0.9, even for IASI channel 1884 which presented a very good correlation with 04 SEVIRI channel. Both channels are located in the same spectral band which differs from the one of the other chosen surface channels (IASI and SEVIRI).

Conclusions and future work

In order to prepare the assimilation of the new hyperspectral sensors such as IRS (which will be onboard Meteosat Third Generation and will supply for the first time measures in thousands of channels, at high-temporal frequency “every 30 minutes” over Europe) and IASI-NG (IASI-New Generation) over continents in AROME model, we performed a comparison between current sensors. For that, we chose to work with IASI and SEVIRI. We first compared LST retrieved from IASI MetOp A & MetOp B. Then, we compared background LST with retrieved IASI channels LST. We also performed inter-channels IASI LST comparisons. After that, we compared IASI LST vs SEVIRI LST.

The results of this study has shown that IASI from MetOp A & MetOp B produces similar LST retrievals. The use of an emissivity atlas has allowed to obtain a more realistic LST compared to the results using constant emissivity (not shown). The comparison between channels in regional AROME model has enabled to select one IASI channel for LST retrieval: channel number 1191, because it provided the best results in terms of lower difference between background and retrieved LST, correlation with other retrieved LST from IASI and SEVIRI channels (we found similar results in the global ARPEGE model, not shown). The comparison between IASI and SEVIRI retrievals presented good results allowing to study the complementarity between polar and geostationary satellites. The next step is to study the impact of this retrieved LST on the simulation and assimilation of IASI surface-sensitive infrared observations in the AROME model.

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