Study of satellite observations synergy in order to improve surface temperature in NWP

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Introduction

This poster summarizes the main results of a preliminary study with as objective to assimilate land surface temperature (LST) in the surface analysis in Météo-France. More detailed results are available in **[Sassi et al., 2019]**. The LST is a key parameter in Numerical weather prediction (NWP) particularly in surface-atmosphere energy balance modelization. Surface schemes use 2 m temperatures to estimate LSTs. The upper air analysis uses realistic LSTs retrieved from satellite observations to improve the assimilation of surface sensitive channels [Boukachaba, 2017][Guedj et al., 2011]. The objective of this research is to investigate the opportunity of using the retrieved LSTs from different sensors in the surface assimilation to improve the current surface analysis and the upper air assimilation. In this poster, we focus on IASI and SEVIRI infrared sensors.

Methodology

We used the LST retrieval files of AROME-France model (Applications de la Recherche à l'Opérationnel à Méso-Echelle) which is the operational limited area non hydrostatic model of Météo-France since December 2008. Figure 1 and Table 1 describe the domain, the assimilated data and the main characteristics of AROME-France model.

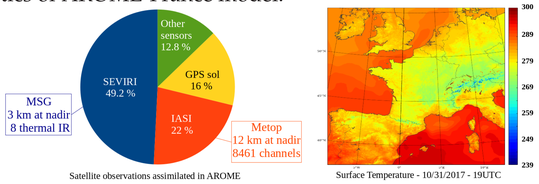


Figure 1 – AROME-France model domain and assimilated data

Parameter	Value
Horizontal resolution	1.3 km
Vertical levels (Hybrid coord.)	90 (5m above the surface - 10hPa)
Time-step	50s
Surface scheme	SURFEX-ISBA
Surface Initialization	CANARI + 1D OI for T2m & R2m
Upper air Initialization	3D-Var

Table 1 – Main AROME-France model characteristics

The retrieval of LST from satellite observation in AROME-France model uses the mono-channel with known emissivity method [Karbou et al., 2006]. This method inverts the radiative transfer equation to calculate the surface temperature.

For IASI we used the channel $10.6\mu m$ and the emissivity atlas of the University of Wisconsin and for SEVIRI the channel $10.8\mu m$ and the emissivity atlas based on LAND-SAF data.

Comparison to in-situ observations

We compared SEVIRI LST to LST observations taken in two stations: Toulouse station situated in the suburb areas of Toulouse (France) and Evora station located 12 km south-west of Evora (Portugal) and which is one of the four KIT (Karlsruhe Institute of Technology) LST validation stations. Figures 2 and 3 show good agreement between SEVIRI and in-situ LST diurnal cycles. SEVIRI LSTs represent in-situ LSTs better than the model especially for the extremes of the day. A higher standard deviations of SEVIRI LSTs (not shown) might be due to the different soil occupation properties between the used SEVIRI pixels.

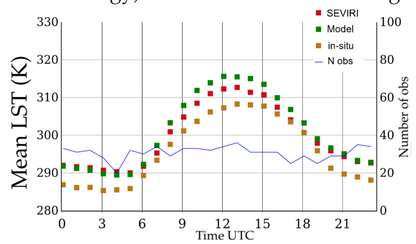


Figure 2 – Diurnal cycle of SEVIRI LSTs, model LST and in-situ LST during summer period for Toulouse station

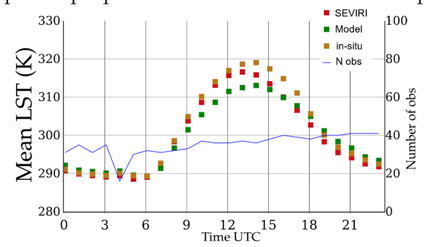


Figure 3 – Diurnal cycle of SEVIRI LSTs, model LST and in-situ LST during summer period for Evora station

Inter-comparison of retrieved LSTs

The IASI LSTs and SEVIRI LSTs diurnal variability during Winter (Figure 4) period shows a good agreement especially during nighttime with a larger amplitude of SEVIRI LSTs diurnal cycle.

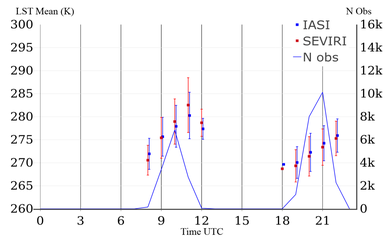


Figure 4 – Diurnal variability of IASI and SEVIRI mean LSTs during Winter period. The blue line describes the number of available observations.

To better understand the differences between the two sensors LSTs, we plotted the RMSE of differences (Figure 5) for each season. Figure 5 shows higher values of RMSE during daytime. This might be due to higher impact of shadow/sunlit effect that can increase the differences between both sensors LSTs known their different angles of view.

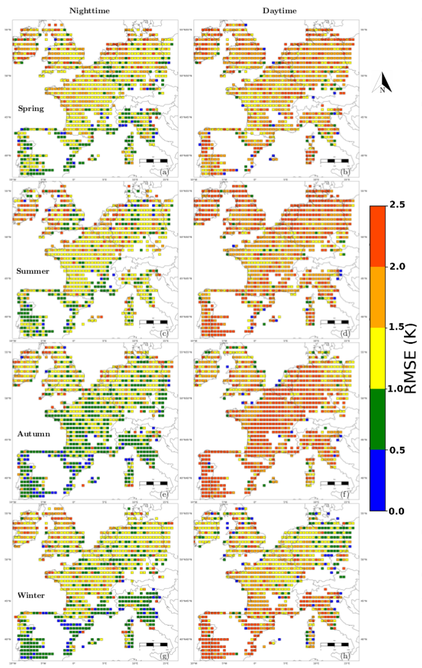


Figure 5 – RMSE of difference between IASI and SEVIRI LSTs (in K) averaged on a 0.5° × 0.5° resolution grid.

The comparisons of the four periods (Figure 6) show a better agreement during nighttime in all cases with high positive correlations (R > 0.96).

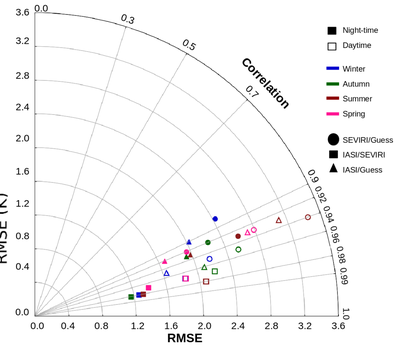
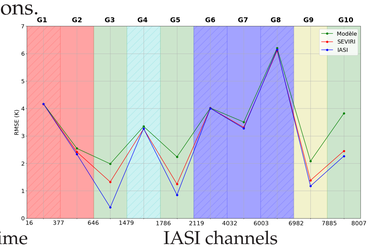


Figure 6 – Correlation coefficients and RMSE of difference of IASI and SEVIRI LSTs compared to each other and to model LSTs during daytime and nighttime (in K)

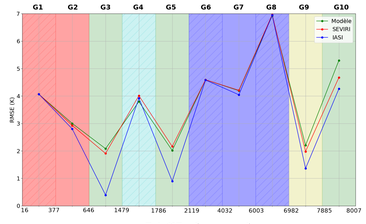
Figure 6 shows also that a better agreement is found between the two sensors LSTs than between every sensor LSTs and the model LSTs except for daytime comparisons during Winter and Autumn periods where we find a better agreement of IASI LSTs with the model LSTs than with SEVIRI LSTs.

Radiance simulation with RTTOV

To evaluate the impact of using one sensor's LST to simulate the other sensor's observed radiation, we have simulated the radiances of the 314 channels of IASI monitored at Météo-France using RTTOV model and compared them to the observed radiations.



(a) Nighttime IASI channels



(b) Daytime IASI channels

Figure 7 – Nighttime (a) and daytime (b) RMSE (K) related to simulations of IASI brightess temperatures using IASI LSTs (blue), SEVIRI LSTs (red) and model LSTs (green). Shaded areas correspond to channels which present very small sensitivity to LST.

During nighttime (Figure 7-a), SEVIRI LSTs gave better simulations and reduced the RMSE values with up to 1 K compared to model LSTs. During daytime (Figure 7-b), the use of SEVIRI LSTs has less impact. This might be due to the higher differences between IASI LSTs and SEVIRI LSTs during daytime.

Conclusions & perspectives

This preliminary study showed a good agreement between SEVIRI LSTs and in-situ LSTs in **Toulouse and Evora** stations. The comparison of SEVIRI LSTs to IASI LSTs for **clear co-localized data** showed **global agreement especially during nighttime**. Finally, the comparison of IASI observed radiances to simulated ones using different values of LST showed **better simulations with SEVIRI LSTs** than with model LSTs especially during nighttime. These results are encouraging to **use retrieved LSTs for further applications. The next step** will consist in **using LSTs to initialize the soil temperature** in the current **surface analysis system** by updating the surface and deep soil temperatures using satellite retrieved LSTs in order to propagate the impact from an assimilation cycle to the next. Then, we will **evaluate the impact** of using the LSTs in surface analysis on forecasts and upper air assimilation.

Acknowledgment

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References

[Sassi et al., 2019] Sassi, M.Z., Fourrié, N., Guidard, V., Birman, C. (2019). Use of Infrared Satellite Observations for the Surface Temperature Retrieval over Land in a NWP Context. Remote Sensing: 11(20), 2371. [Boukachaba, 2017] Boukachaba, N. (2017). Apport des observations satellitaires hyperspectrales infrarouges IASI au-dessus des continents dans le modèle météorologique à échelle convective AROME. Thèse Université de Toulouse. [Guedj et al., 2011] Guedj, S., Karbou, F., and Rabier, F. (2011). Land surface temperature estimation to improve the assimilation of SEVIRI radiances over land. Journal of Geophysical Research : Atmospheres, 116(D14). [Karbou et al., 2006] Karbou, F., Gérard, E., Rabier, F. (2006). Microwave land emissivity and skin temperature for AMSU-A and AMSU-B assimilation over land. Q. J. R. Meteorol. Soc. 2006, 132, 2333–2355.

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