Assimilation of satellite derived surface temperature over land in AROME-France model

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The surface temperature is a key parameter in Earth radiative balance simulation and numerical weather prediction. However, its high spatial and temporal variability makes its observation and simulation complex over land. Nowadays, the meteorological satellites observe the Earth with high coverage and several algorithms enable the retrieval of the surface temperature from satellite observations (Li et al, 2013). Although it is used for the assimilation of satellite radiances in AROME model (Seity et al, 2011), the satellite derived land surface temperature (LST) itself is not currently assimilated. The aim of this work is to evaluate the benefit of assimilating the SEVIRI (Aminou, 2002) LST in AROME and to study its impact on the assimilation of different observations and also on the forecasts.

Since this project represents the first work of LST assimilation in AROME, the first step consisted in implementing the assimilation of SEVIRI LST in the surface analysis system as described on figure 1. AROME model is coupled to SURFEX platform (Masson et al, 2013) for surface modelisation. The operational version of the surface analysis system uses a 2D Optimal Interpolation to assimilate as a first step the 2 meter temperature and relative humidity observations, then a 1D Optimal Interpolation based on 2 meter temperature and relative humidity increments is used to analyze the soil temperature and water content in the first and second soil layers. As described in figure 1, the assimilation of SEVIRI LST has been implemented and is used in addition to the 2 meter temperature to analyze the soil temperature.

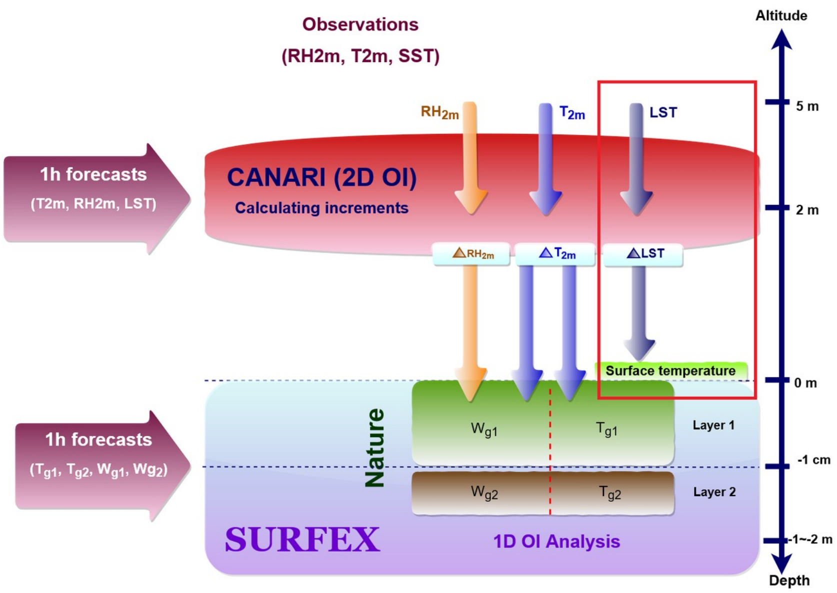

Figure 1: Implementation of the LST assimilation in the surface analysis of AROME model

Based on the results of previous work showing a better synergy between infrared sensors derived LST during nighttime (Sassi et al, 2020) and on the diagnostics of LST observations and model errors showing lower uncertainties by nighttime, the assimilation of SEVIRI LST has been first implemented at nighttime analysis times (00 and 03 h). The results obtained in this experiment were compared to the ones from a reference experiment without the assimilation of SEVIRI LST.

The second step of this work consisted in evaluating the impact of SEVIRI LST assimilation over a two-month period on the assimilation of surface and atmospheric observations. A slight decrease of the difference between the 2 meter temperature observation and the model first guess has been observed during the first assimilation analysis times of the day (00-06 h) as shown in figure 2. A consistent decrease in difference between the first guess and the 2 meter relative humidity has been also observed during nighttime assimilation.

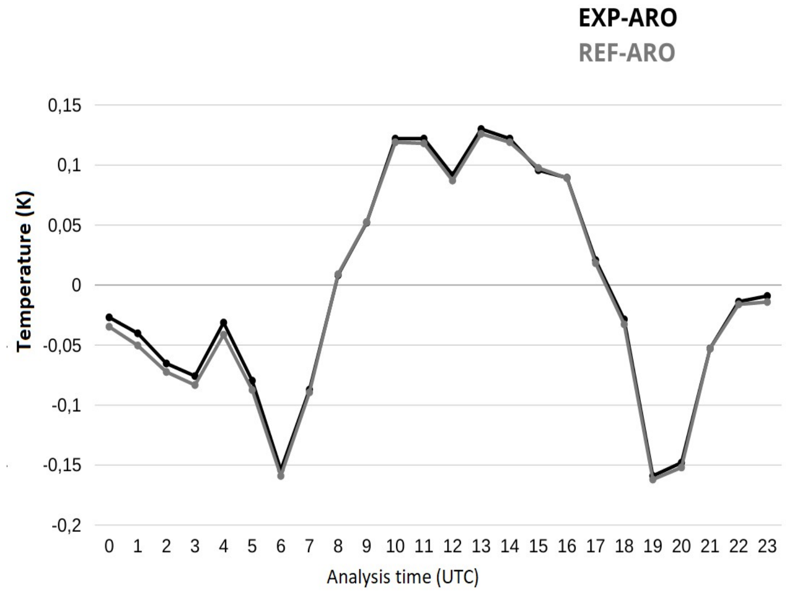

Figure 2: Mean differences between 2 m temperature (K) observations and first guess for July and August 2019. Black line represents the first guess departure in the experiment assimilating LST and grey line the results for the reference.

Moreover, the evaluation of satellite channels in the atmospheric assimilation has shown a decrease of difference between first guess and observation for microwave sensors and an improvement of the background for most analysis times.

Concerning the impact on forecasts, when compared to surface stations, a slight but significant and consistent improvement has been observed on the temperature and relative humidity at 2 meters during nighttime forecast ranges. Compared to radiosondes observations, a decrease of the RMSE of the temperature and relative humidity parameters has been observed, mainly between 1000 and 700~hPa levels, for the first forecast ranges in most cases, up to 24h.

To further evaluate the benefit of the satellite derived LST assimilation, initially implemented for nighttime assimilation, it would be interesting to evaluate the impact of the LST assimilation at all analysis times, including the daytime assimilation times. Further steps will also include the extension of the methodology to other instruments and the use of LST for soil moisture analysis.

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