

Assimilation of land surface skin temperature observations derived from GOES imagery

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Introduction

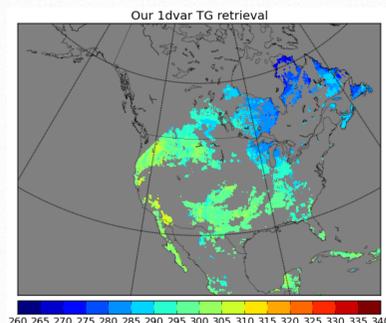
In this poster, we present results of data assimilation experiments performed in the CALDAS (Canadian Land Data Assimilation System). The positive impact of assimilating Soil Moisture Active Passive (SMAP) satellite observations in CALDAS on soil moisture, near surface temperature and humidity and precipitations was recently demonstrated in CALDAS (Belair et al. 2017). Here, we will describe experiments where skin surface temperature retrievals from infrared imagers onboard the two GOES geostationary satellites are assimilated on top of SMAP brightness temperatures.

Description of the assimilation system

CALDAS is based on an Ensemble Kalman Filter (EnKF) with 24 members. The surface analysis is performed on a 10 km grid every 3 hours. The surface model using the Soil, Vegetation and Snow (SVS) scheme is run on the same grid used by the analysis.

Description of the assimilated observations

The observations (brightness temperatures) received at the Canadian Meteorological Center (CMC) are subjected to a cloud analysis and projected onto a 0.1x0.1 degree regular grid. One data file of each GOES satellite is received every 30 minutes. Two skin surface retrievals are performed for the clear pixels according to the cloud analysis. The first one is based on the direct inversion of the radiative transfer equation assuming perfect thermodynamic profiles and emissivity. It will be referred later to as the direct retrieval. The second one is performed using a 1DVAR approach. The trial fields come from the regional model. Temperature and water vapour profiles, surface pressure and skin surface temperature increments are generated but only the skin surface temperature is kept and used for the retrieval. 3 channels at day time and 4 channels at night time are assimilated. The observation errors standard deviations and the constant bias correction used for brightness temperature are summarized in table 1 below. These were estimated from observation departure statistics above sea. The background error covariance matrix used in the 1DVAR is a static matrix based on the NMC approach from the operational assimilation system. The observation operator used is RTTOV-10 using the land surface emissivity atlas from University of Wisconsin. The retrievals from the two satellites are combined so that the lowest zenith angle is used and nearest-neighbour projected onto the 10 km assimilation grid. Every 3 hour, between 20000 and 80000 retrievals are typically available for assimilation depending on cloud conditions.



A sample retrieval from GOES-13

	Channel 1 (3.9 μm night only)	Channel 2 (6.5 μm water vapour)	Channel 3 (10.7 μm : window)	Channel 4 (13.3 μm)
GOES 13 (east)	1.4 (-0.13)	1.15 (0.18)	0.9 (-0.5)	0.75 (-0.52)
GOES 15 (west)	1.7 (-0.36)	1.3 (2.00)	0.9 (-0.25)	0.60 (0.16)

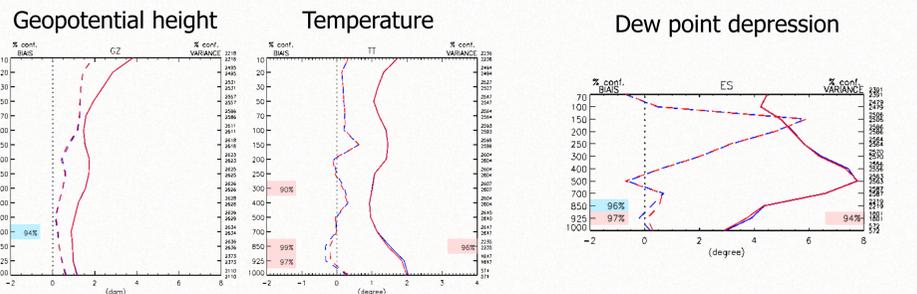
Table 1: Observation error standard deviation and constant bias correction (all in K) used in this study

The SMAP brightness temperatures received at CMC are subjected to a quality control and projected onto the 10km assimilation grid.

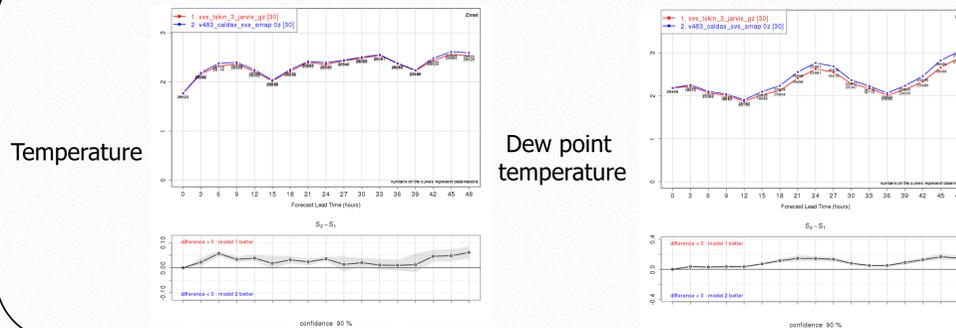
Impact of the assimilation of skin surface temperature 1Dvar retrievals on surface analysis

Two surface data assimilation experiments using CALDAS will be presented. The **control** (blue line in the scores below) assimilates only SMAP brightness temperatures whereas the **experiment** (red line) assimilates SMAP observations and GOES skin surface temperature retrievals. The observation error standard deviation was set to 1.0 K for GOES tskin retrievals and to 4.0 K for SMAP brightness temperatures. Large increments of soil temperature were limited to 3.0K. The two assimilation experiments were ran for three months from 20150601 to 20150830. The first month is used to spin-up the system. It is important to note that no bias correction was applied to the observation assimilated. GEM regional atmospheric forecasts were launched using each surface analysis to specify the lower boundary and initial conditions every 48 hours from 2050701 to 20150830. Significant positive impact on forecasts signal is noticed on near surface air temperature and humidity.

48 hour forecast scores against radiosondes. North America

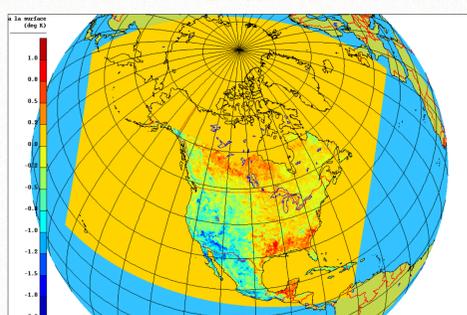


Surface stations RMS error scores. North America

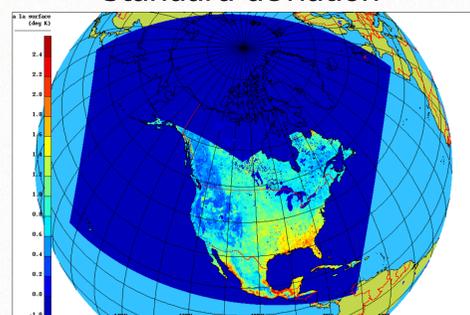


Comparison between direct and 1DVAR skin surface temperature retrievals

Bias



Standard deviation



Maps of bias and standard deviation of the difference $T_{\text{skin}}(1\text{Dvar}) - T_{\text{skin}}(\text{direct})$.

Assimilation experiments performed using the direct skin temperature retrieval instead of the 1Dvar one demonstrated very little difference in terms of impact on forecast scores except a slight advantage (expected) for the 1dvar retrieval.

Conclusion and final remarks

Results of the assimilation experiments presented in this poster show that there is a significant potential to use infrared geostationary imagery to improve the CALDAS surface analysis. There is still room for improvements for example by adjusting the observation error. Preliminary results from experiments performed with an improved SVS model including photosynthetic modelling of stomatal resistance show even better results. We also plan to replace RTTOV-10 with RTTOV-12 in order to be able to use the latest CAMEL land surface emissivity atlas. We hope to introduce the presented approach in our operational assimilation system probably using observations from the GOES-R satellite. Another project linked to the work presented in this poster that we want to pursue is the assimilation of surface sensitive channels of hyperspectral infrared sounders above land.