Assimilation of satellite retrieved land surface temperature in AROME

Zied Sassi, Camille Birman, Nadia Fourrié, Vincent Guidard

ASW ACCORD, 13 April 2021
Outline

• Introduction
• Land surface temperature assimilation: implementation
• Land surface temperature assimilation: results
• Conclusions and future work
**Introduction**

- Near surface atmospheric layers are crucial in NWP to modelize heat and water fluxes between surface and atmosphere.

- Satellite radiances are informative on surface and near surface atmosphere, but are not assimilated in surface model.

- The assimilation of satellite radiance needs realistic surface conditions:
  - Surface temperature retrieval for infrared sensors (surface emissivity for microwave sensors)
  - Retrieval at each assimilation time

\[
T(p, \nu) = \varepsilon(p, \nu) \cdot T_s \cdot \tau + (1 - \varepsilon(p, \nu)) \cdot \tau \cdot T(\nu, \downarrow) + T(\nu, \uparrow)
\]

\(T(p, \nu)\): brightness temperature  
\(\varepsilon(p, \nu)\): surface emissivity  
\(T_s\): surface temperature  
\(\tau\): atmospheric transmittance  
\(T(\nu, \downarrow)\): downward radiation  
\(T(\nu, \uparrow)\): upward radiation
Introduction

- Use of screen level observations of T2m and Hu2m to compute gidded analysed fields using 2D Optimal Interpolation
- 1D OI using the increments of T2m and Hu2m to analyse soil variables (T_s, T_2, w_g, w_2)
- Use of satellite retrieved Land Surface Temperature in surface analysis
  - Better consistency between model surface temperature and surface temperature used for the assimilation of satellite radiances
  - Improvement of coupling between surface and upper air assimilation
Land surface temperature assimilation: implementation

- Assimilation of SEVIRI retrieved land surface temperature in AROME model
- Assimilation of LST at 0h and 3h assimilation times
- Diagnostics of observation and background errors using Desroziers diagnostics
  - $\sigma_o = 3$ K, $\sigma_b = 1.8$ K, correlation length = 30 km

Observation standard deviations  
Background standard deviations
Land surface temperature assimilation: implementation

- Case studies
  - Threshold on innovation: obs – guess lower than -4.5 K removed to avoid undetected clouds

Obs LST – guess LST distribution
Land surface temperature assimilation: results

- Assimilation of SEVIRI LST at 0h and 3h in an AROME experiment over 2 months in 2019 (July and August)
- Evaluation of land surface temperature assimilation on assimilation

Mean differences between observations of T2m (left) and Hu2m (right) and background for each analysis time, for EXP-ARO and EXP-REF experiments

Smaller differences between observations and background for the first assimilation times (up to 6h)
Land surface temperature assimilation: results

- Evaluation of land surface temperature assimilation on assimilation

Impact on emissivity retrieval for MW sensors

Average decrease of RMSE: 0.29 %

Differences of RMSE for MHS channel 5 between observed and simulated radiances for EXP-ARO and EXP-REF
Land surface temperature assimilation: results

- Evaluation of land surface temperature assimilation on AROME forecasts against Synops

<table>
<thead>
<tr>
<th>Forecast ranges</th>
<th>0h</th>
<th>6h</th>
<th>12h</th>
<th>18h</th>
<th>24h</th>
<th>30h</th>
<th>36h</th>
<th>42h</th>
<th>48h</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2m (K)</td>
<td>-0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.01</td>
<td>0.01</td>
<td>0</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Hu2m (%)</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.04</td>
<td>0.08</td>
<td>0.06</td>
<td>0.06</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Relative difference of mean quadratic errors for T2m and Hu2m with respect to observations for forecast ranges up to 48h

-0.01: significant with 99.5% confidence
0.01: significant with 95% confidence

- Improvement of forecasts of T2m and Hu2m up to 48h, with significant impact by nighttime
- Improvement of forecasts of temperature and specific humidity below 400 hPa up to 24h
Conclusions and future work

- First experiments of assimilation of satellite land surface temperature in AROME model
- The assimilation of SEVIRI land surface temperature improves the assimilation of 2 metre and satellite observations
- Improvement in temperature and humidity forecasts up to 36h in low atmospheric layers
- **Sassi et al., 2021**: Assimilation of satellite retrieved land surface temperature in AROME NWP model, *in preparation*
- Experiments of assimilation of land surface temperature at all analysis times, and over different periods in AROME
- Future work: contribution of coupled surface and atmosphere assimilations for the representation of fluxes between surface and atmosphere in AROME model
  - Use of ensembles of data assimilation for T2m and Hu2m analyses
  - Evaluation on other kinds of observations: precipitation, land surface temperatures retrieved from SEVIRI
Conclusions and future work

- Application of the methodology to IASI observations: land surface temperature retrieval and assimilation in ARPEGE for land surface analysis

Land surface temperatures retrieved from IASI instrument (canal 10.8 µm)