



# Assimilation of satellite retrieved land surface temperature in AROME

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# Outline

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- Introduction
- Land surface temperature assimilation: implementation
- Land surface temperature assimilation: evaluation on assimilation and forecasts
- 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 in the upper air assimilation needs realistic surface conditions:
  - Surface temperature retrieval for infrared sensors; surface emissivity retrieval for microwave sensors) 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

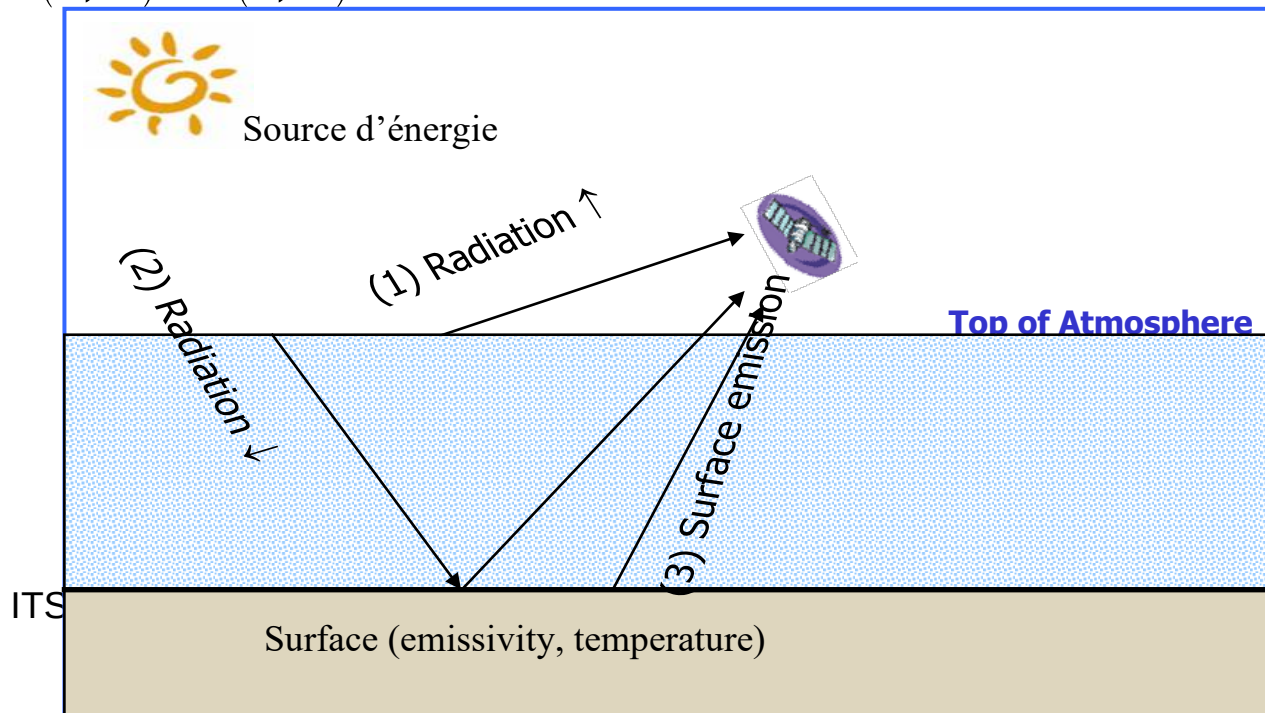
$\varepsilon(p, \nu)$ : surface emissivity

$T_s$ : surface temperature

$\tau$ : atmospheric transmittance

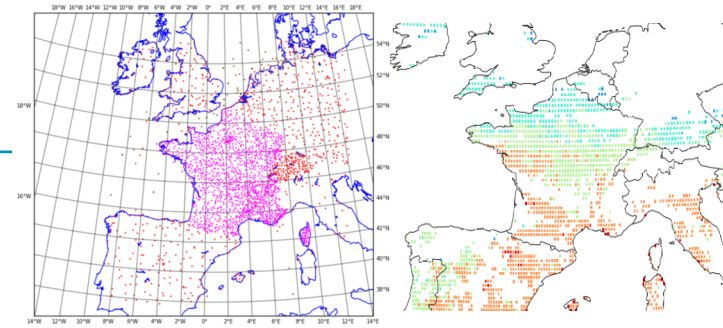
$T(\nu, \downarrow)$ : downward radiation

$T(\nu, \uparrow)$ : upward radiation



# Introduction

- **Surface assimilation in AROME limited-area model** in two steps
- Assimilation of T2m and Hu2m observations in a 2D Optimal interpolation → analysed fields of T2m and Hu2m
- Analysis of soil variables ( $T_s$ ,  $T_2$ ,  $w_g$ ,  $w_2$ ) with a 1D Optimal Interpolation assimilating the increments of T2m and Hu2m
- **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 assimilations



**1h forecast**  
 $T_{2m}$ ,  $RH_{2m}$

**Observations**  
 $T_{2m}$ ,  $RH_{2m}$ , snow depth, **LST**

Screen level  
parameters analysis  
2D OI (CANARI)

Analysis increments  
 $\Delta T_{2m}$ ,  $\Delta RH_{2m}$ ,  $\Delta LST$

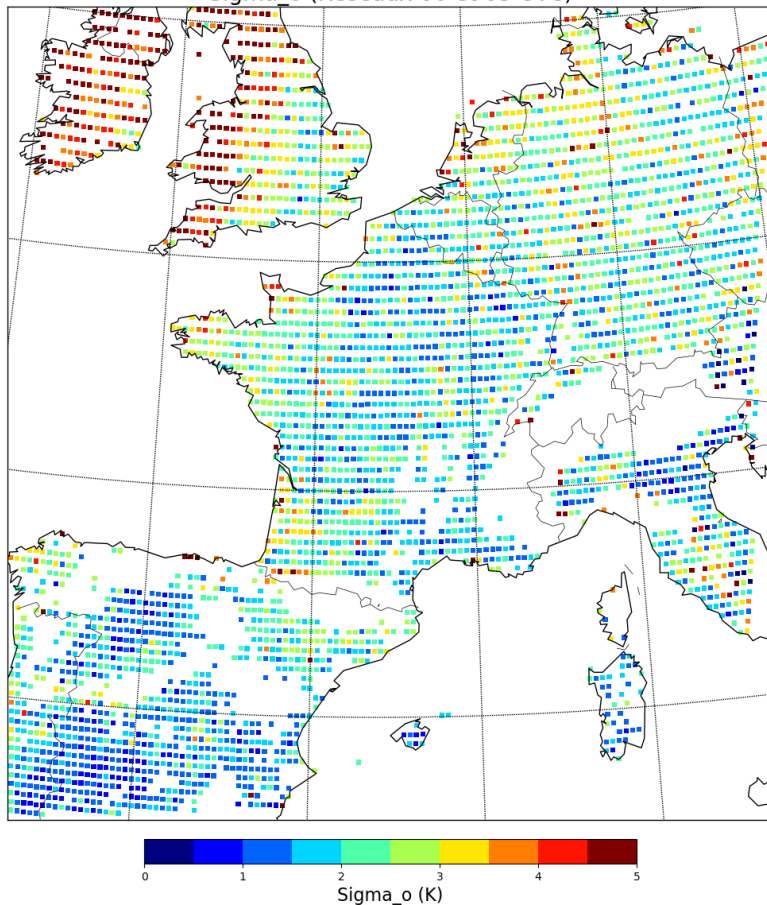
**1h forecast**  
 $T_s$ ,  $T_2$ ,  $w_g$ ,  $w_2$

Soil analysis  
1D OI

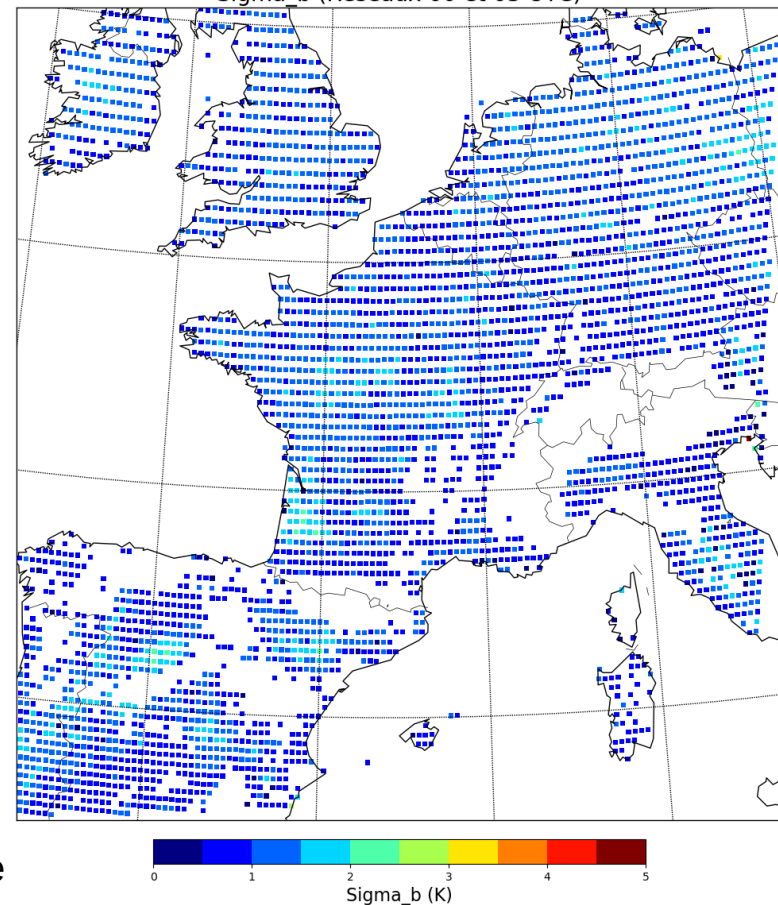
**Analysis**  
 $T_s$ ,  $T_2$ ,  $w_g$ ,  $w_2$

# Land surface temperature assimilation: implementation

- Assimilation of SEVIRI retrieved land surface temperature in AROME model
- Assimilation of LST by night-time only (0h and 3h)
- Diagnostics of observation and background errors using Desroziers diagnostics
  - $\sigma_o = 3$  K,  $\sigma_b = 1.8$  K, background correlation length = 30 km



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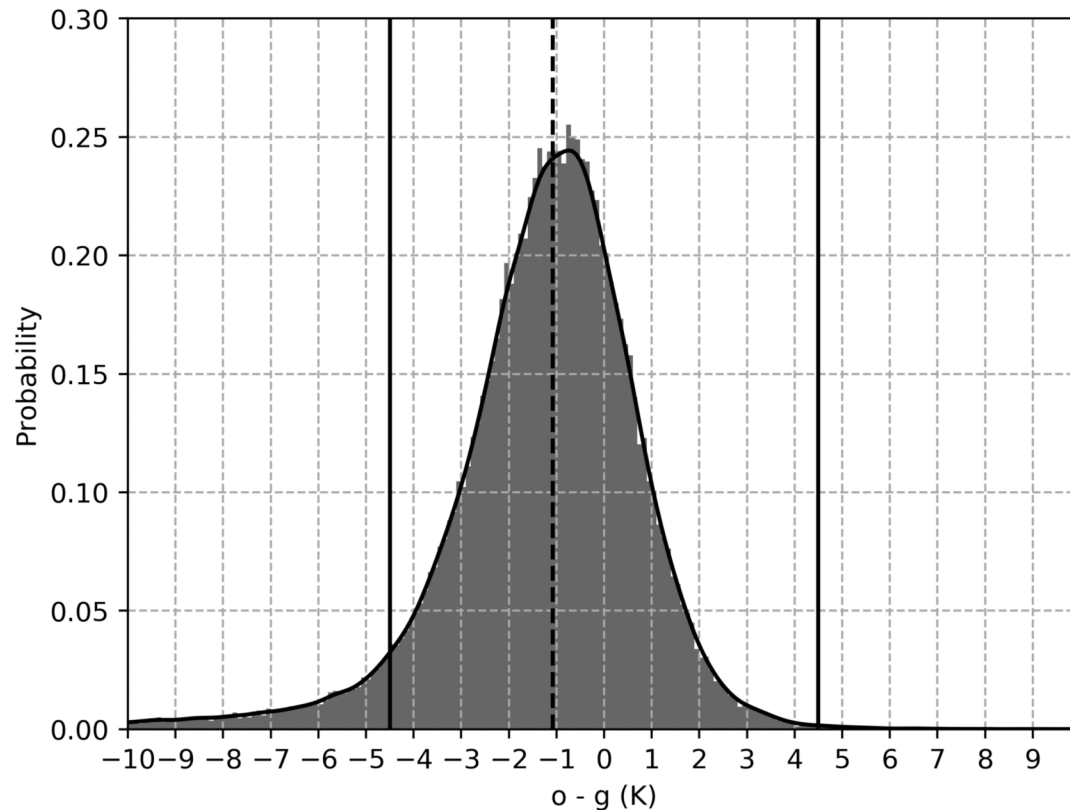


Observation error standard deviations

Background error standard deviations

# Land surface temperature assimilation: implementation

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

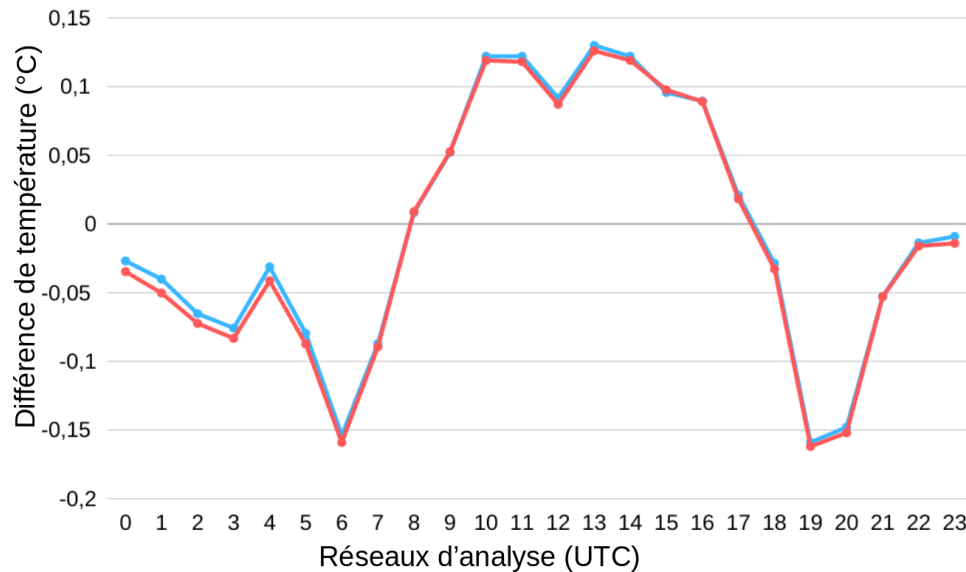


Obs LST – guess LST distribution

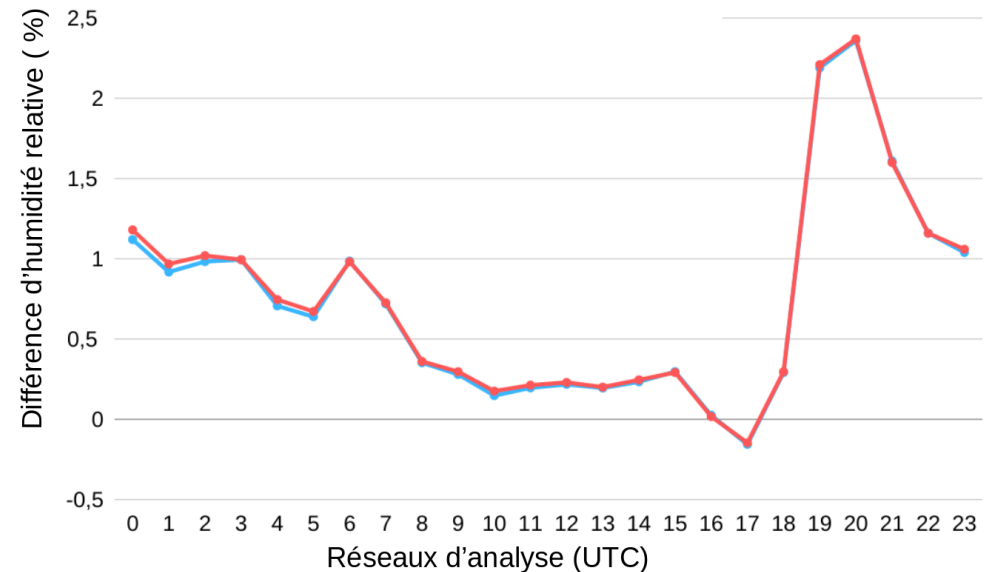
# Land surface temperature assimilation: results

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

**Obs T2m – Guess T2m**      EXP-ARO  
REF-ARO



**Obs Hu2m – Guess Hu2m**      EXP-ARO  
REF-ARO



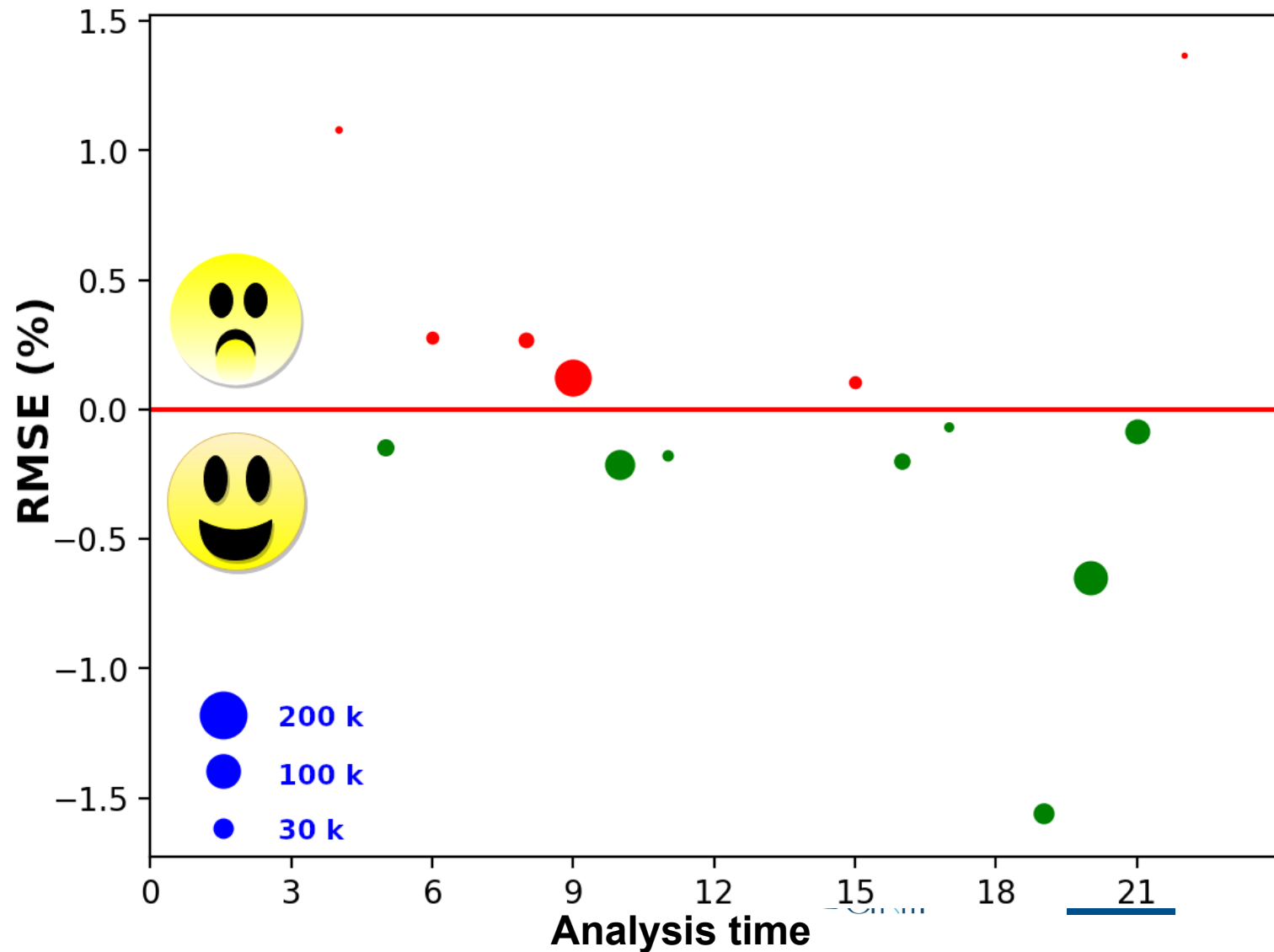
Mean differences between observations of T2m (left) and Hu2m (right) and background for each analysis time, for EXP-ARO and EXP-REF experiments

**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 the assimilation of satellite radiances

Differences of RMSE for MHS channel 5 between observed and simulated radiances for EXP-ARO and EXP-REF



Impact on emissivity  
retrieval for MW sensors

Average decrease of  
RMSE: 0.29 %



# Land surface temperature assimilation: results

- Evaluation of land surface temperature assimilation on AROME forecasts: impact on Synops

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

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 humidity below 400 hPa up to 24h

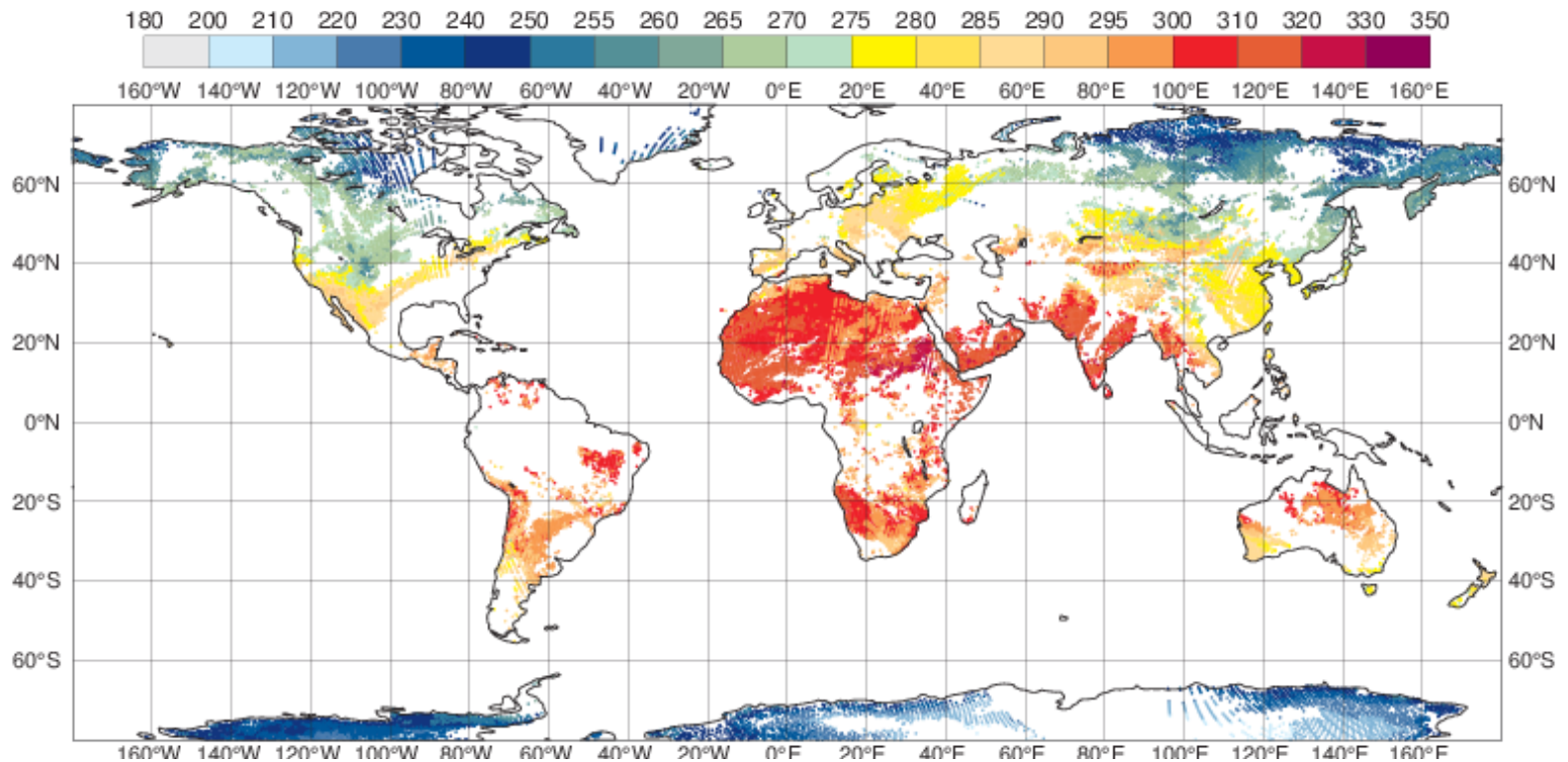
# Conclusions and future work

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- 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*
- 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
- Experiments of assimilation of land surface temperature at all analysis times, and over different periods in AROME

# 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  $\mu\text{m}$ )