Assimilation of Land Surface Temperature (LST) retrieved from IASI in ARPEGE surface analysis

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Introduction

Retrieval of the LST (Land Surface Temperature)

Assimilation of satellite radiances

- Importance of a realistic description of land surface in the radiative budget modelization ;
- High variability of the LST for IR sensors and of Emissivity for the MW sensors and retrieval of the LST or the surface Emissivity (Karbou et al., 2006) ;
- **Retrieved LST is only used in satellite radiances simulation but is not assimilated in surface analysis at Météo-France;**
- Contribution of LST assimilation (Radakovich et al., 2001), (Bosilovitch et al., 2007), (Reichle et al., 2010), (Candy et al., 2017)

Introduction

Conclusions of previous work

- First LST assimilation work in AROME limited area model ;
- SEVIRI LST assimilation : Positive impact on the assimilation in AROME (T2m, Hu2m, MW sensors, …) ;
- Positive impact on temperature and relative humidity forecast near the surface.

Encouraging results for AROME (Sassi et al., 2023)

Introduction

Extension of the previous work towards the assimilation of the IASI LST in surface analysis of ARPEGE NWP global model

- Implement and evaluate the impact of the IASI LST assimilation in ARPEGE, in particular in regions of the globe poor in T2m observations for soil temperature initialization

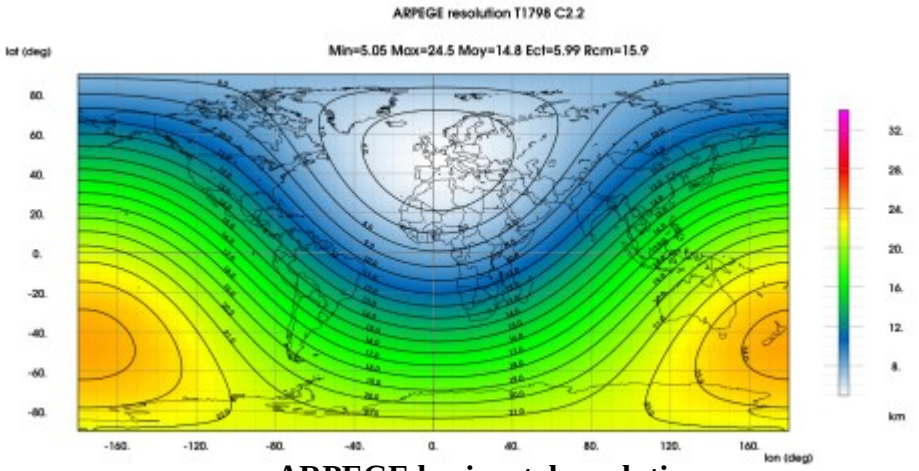
- Several challenges are added, such as the heterogeneity of surface cover at a global scale or the spatio-temporal availability of IASI observations

Evaluation of IASI LST at a global scale compared to ARPEGE

Introduction

ARPEGE NWP model

- ARPEGE is the global NWP model developed by Météo-France;
- Stretched grid with horizontal resolution from 5km over France to 25km;

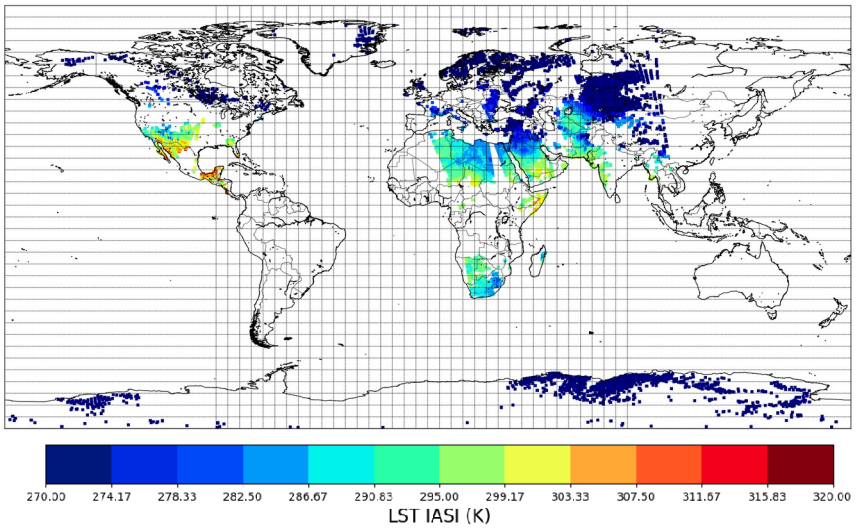


ARPEGE horizontal resolution

- Parameterized deep convection;
- 4D-VAR atmospheric assimilation with 6h of assimilation window;
- OI for Surface analysis;
- Forecast range up to 4 days;

IASI retrieved LST

- Infrared Atmospheric Sounding Interferometer
- Polar orbit (817km)
- 12km of resolution at nadir
- 8461 channels, 314 monitored at Météo-France



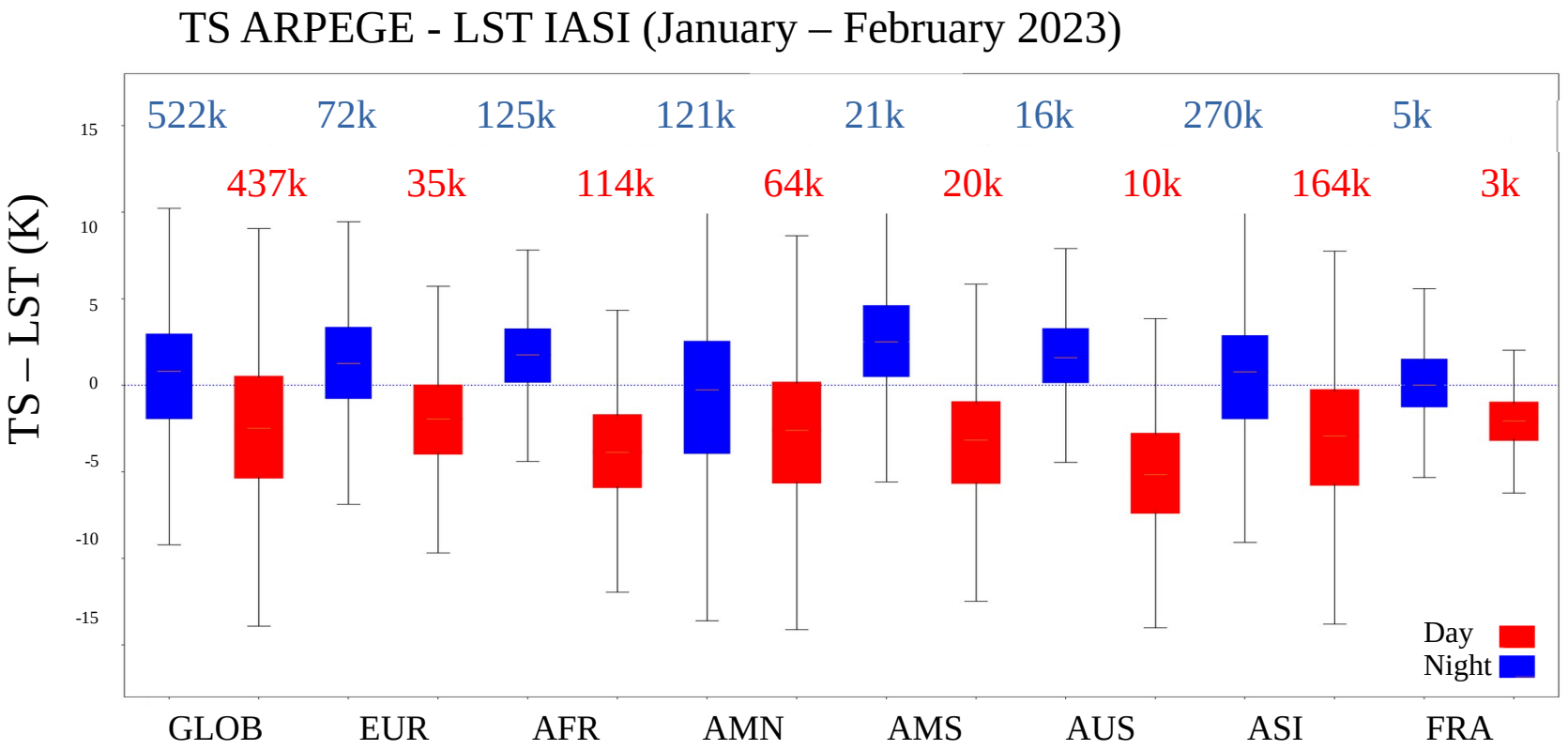
IASI clear sky LST 31/03/2023

- LST retrieved with channel 1194 (943.25 cm^{-1} /10.6 µm)
- Emissivity atlas of University of Wisconsin

Summary

- Introduction
- Evaluation of IASI LST
- Assimilation of IASI LST
- Conclusions and perspectives

Evaluation of IASI LST compared to ARPEGE surface temperature

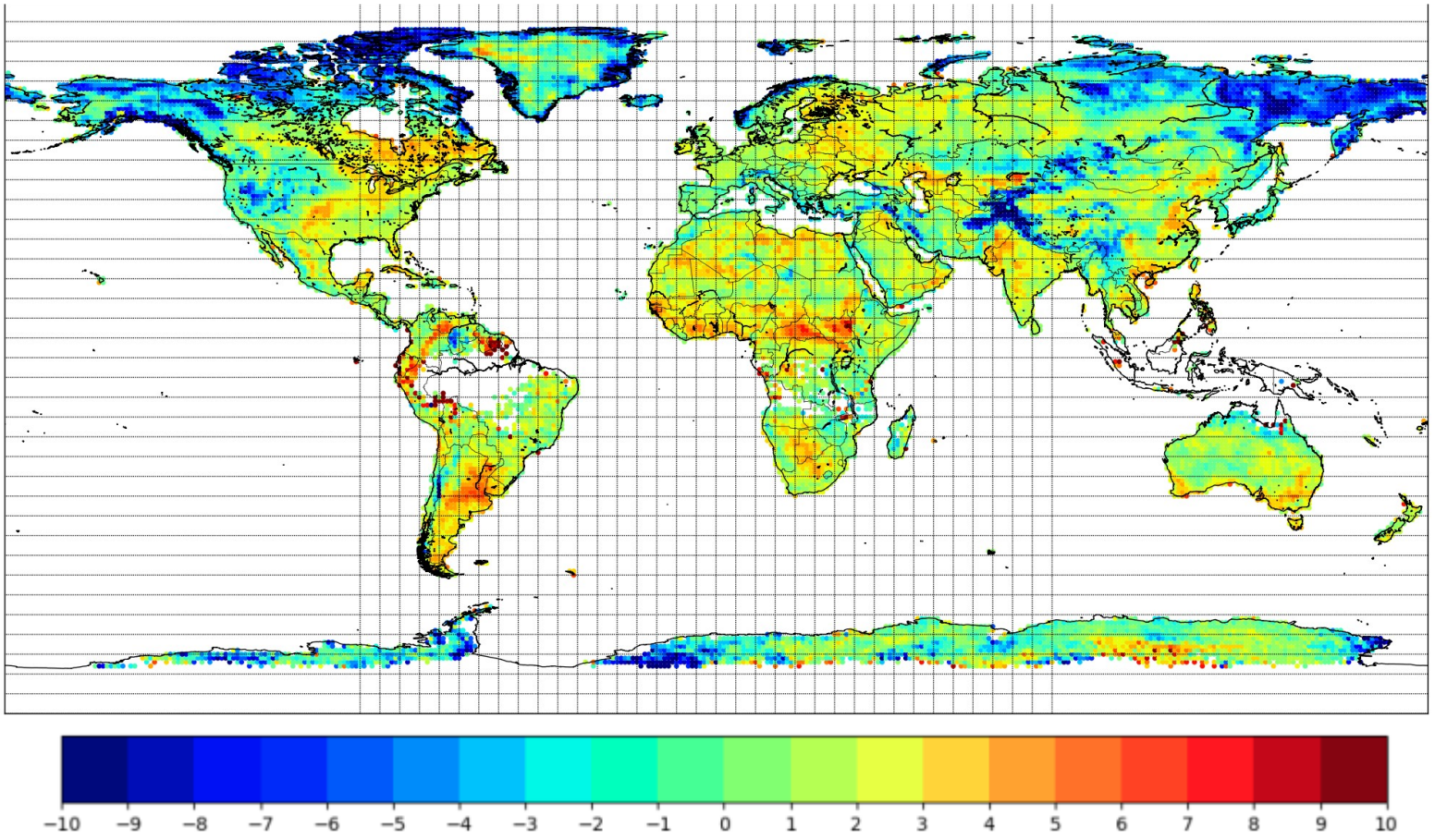


- Smaller differences during nighttime than daytime
- Spatial variability

Evaluation of IASI LST compared to ARPEGE surface temperature

Mean differences (0.5° x 0.5°) - Nighttime January - March 2023

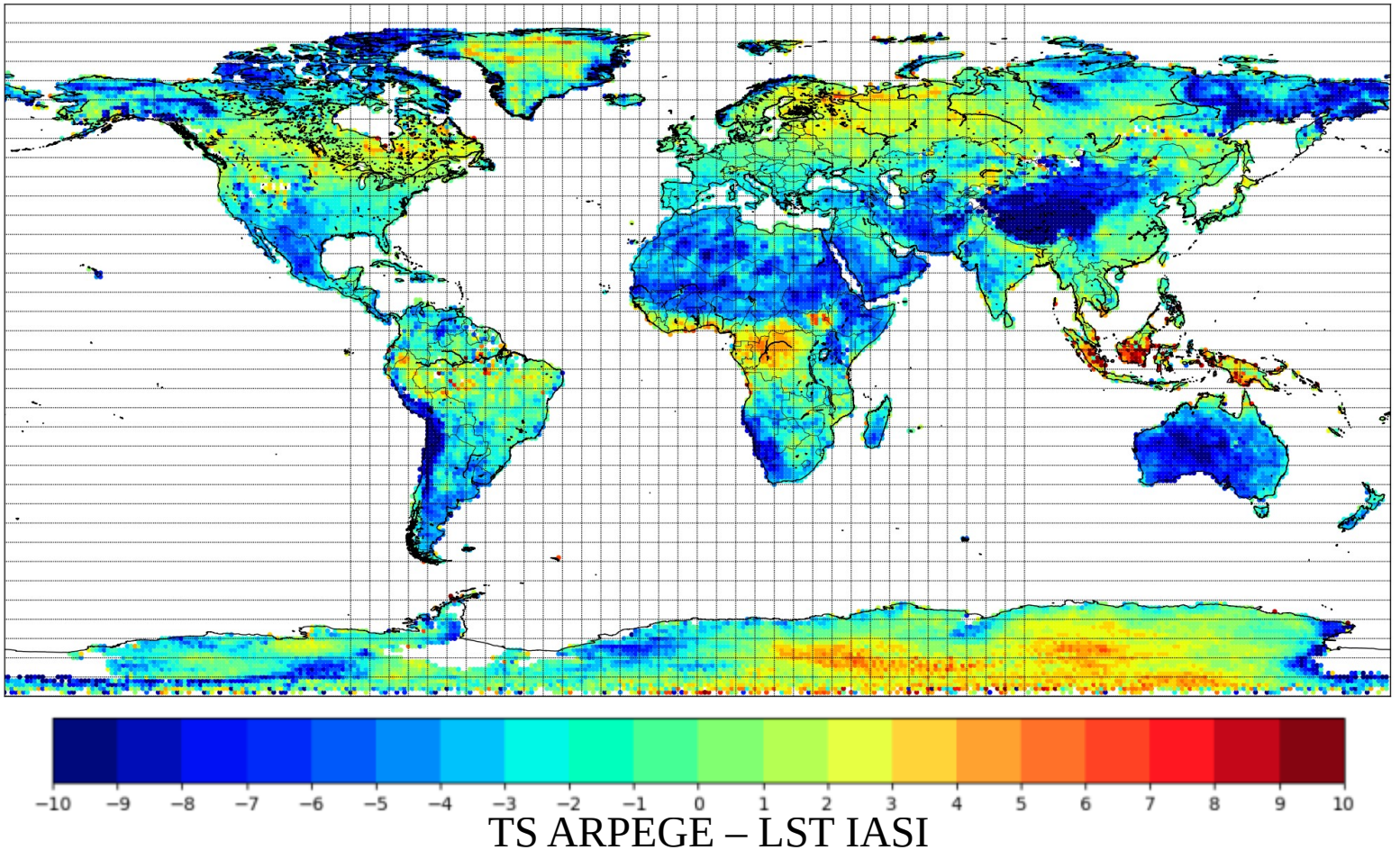
Geographical disparities :
Emissivity ?
Orography ?
Modelization ?



TS ARPEGE – LST IASI

Evaluation of IASI LST compared to ARPEGE surface temperature

Mean differences (0.5° x 0.5°) - Daytime January - March 2023



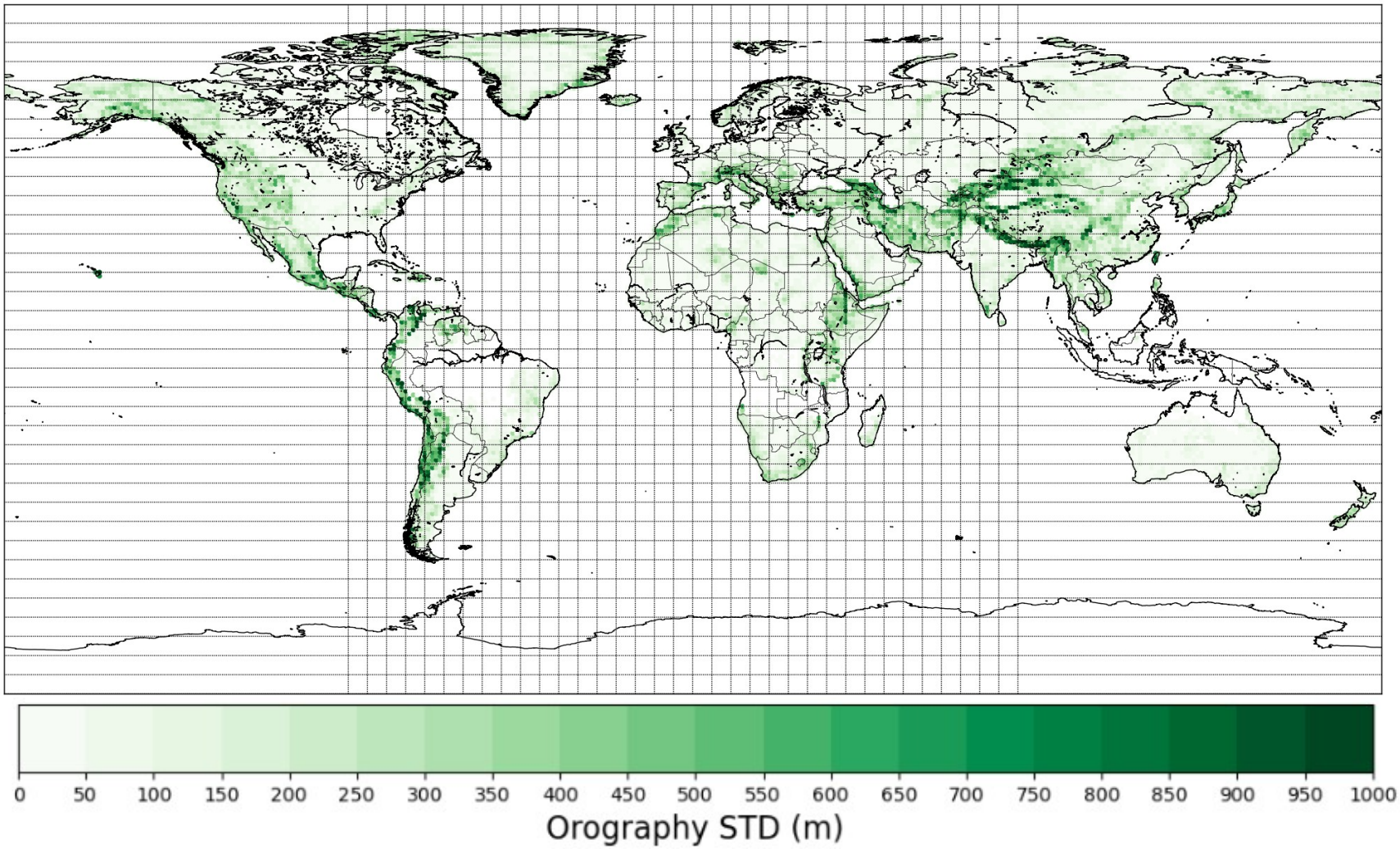
TS ARPEGE – LST IASI

Geographical disparities :
Emissivity ?
Orography ?
Modelization ?

Diurnal variability

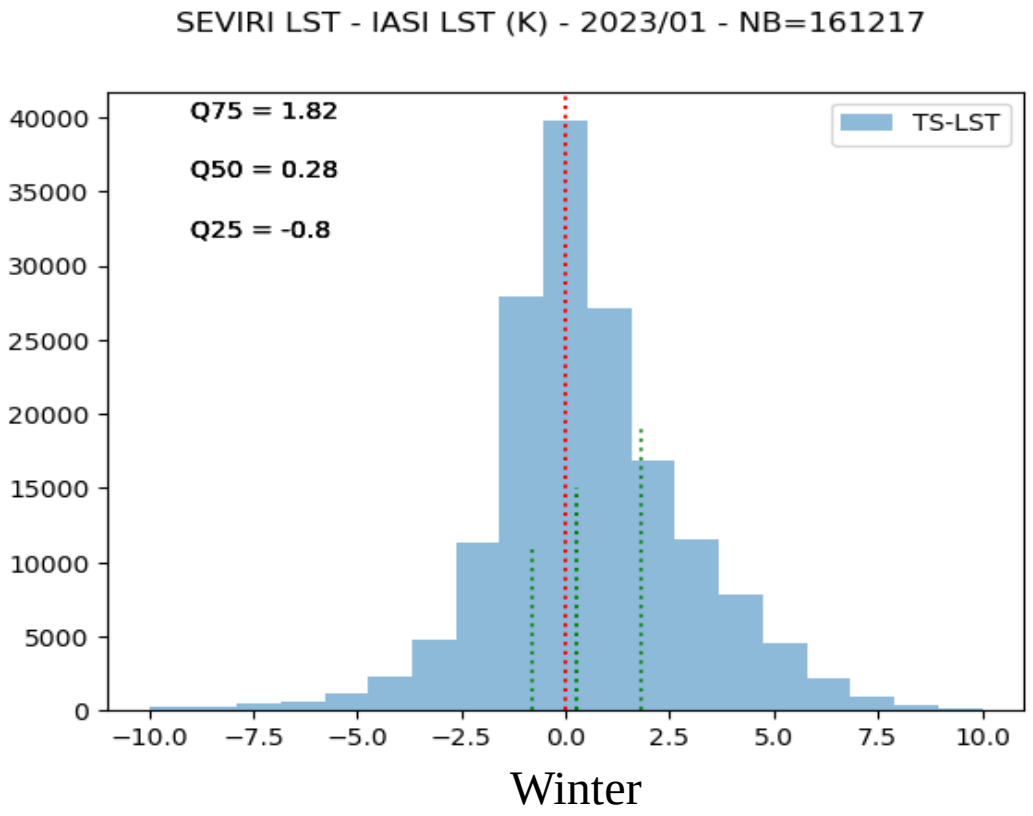
Evaluation of IASI LST compared to ARPEGE surface temperature

Orography standard deviation calculated within a radius of 50km



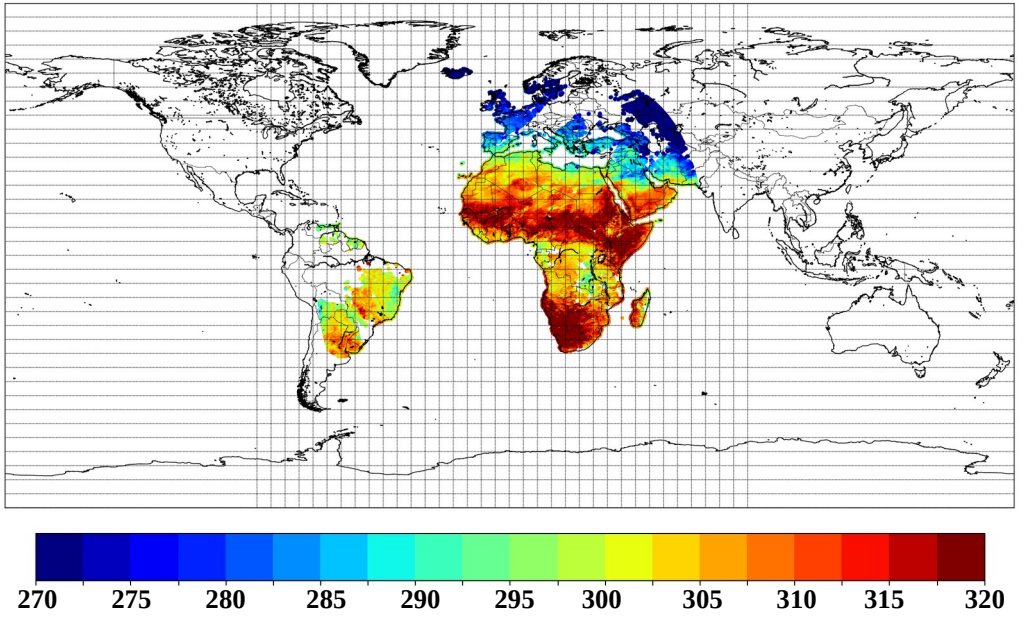
Evaluation of IASI LST compared to SEVIRI LST

Different pixel size between IASI and SEVIRI ➡ Colocalized LST within a 10km circle



Winter

Bias = 0.52 / Std = 2.58 / RMSE = 2.64



SEVIRI LST 15-01-2023 12h00
(LSA-SAF product)

Smaller differences during nighttime

Conclusions

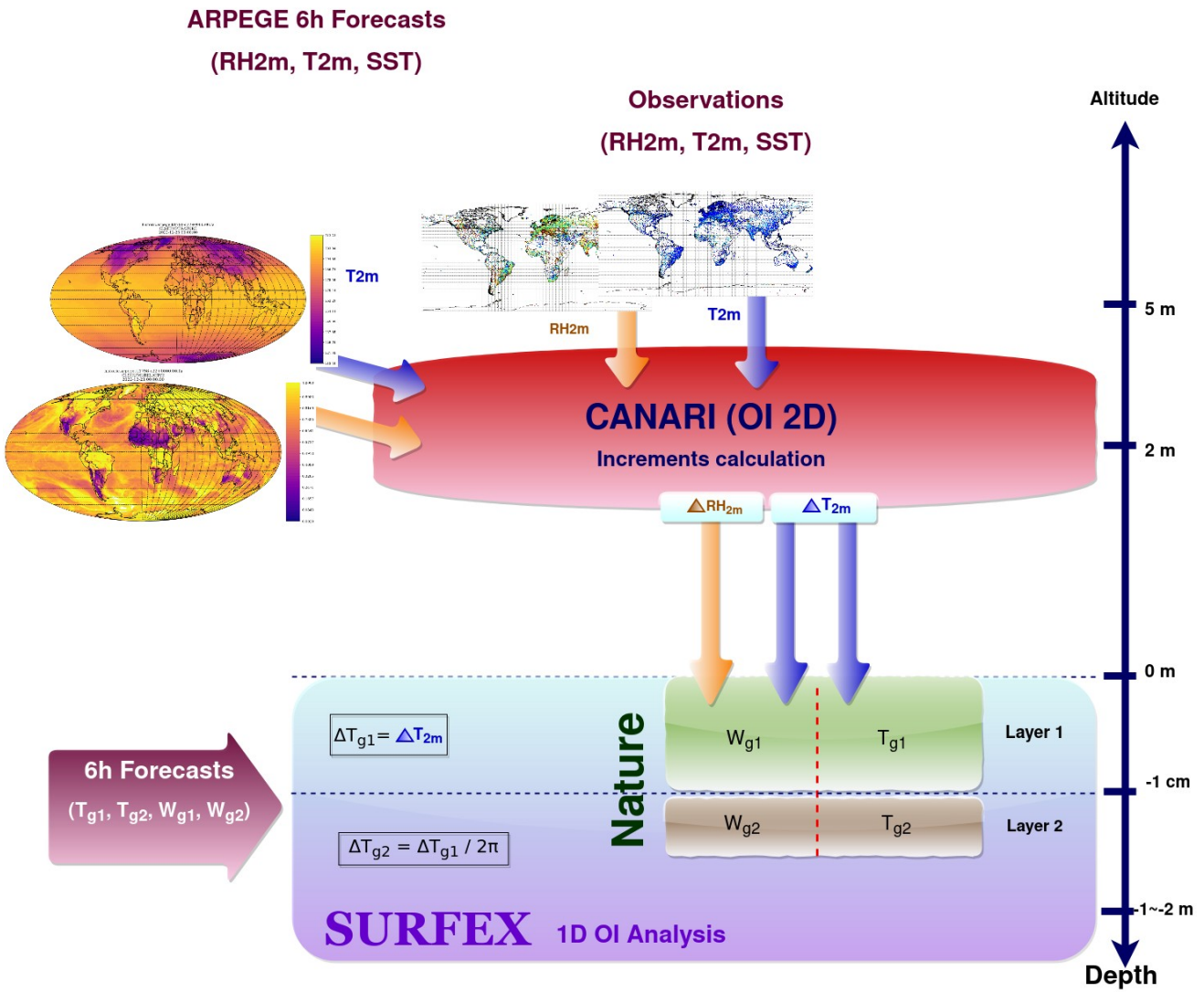
Compared to ARPEGE :

- Geographical disparities (equator, high latitudes, desert,…)
- Need for a better consideration of orography
- Smaller differences during nighttime

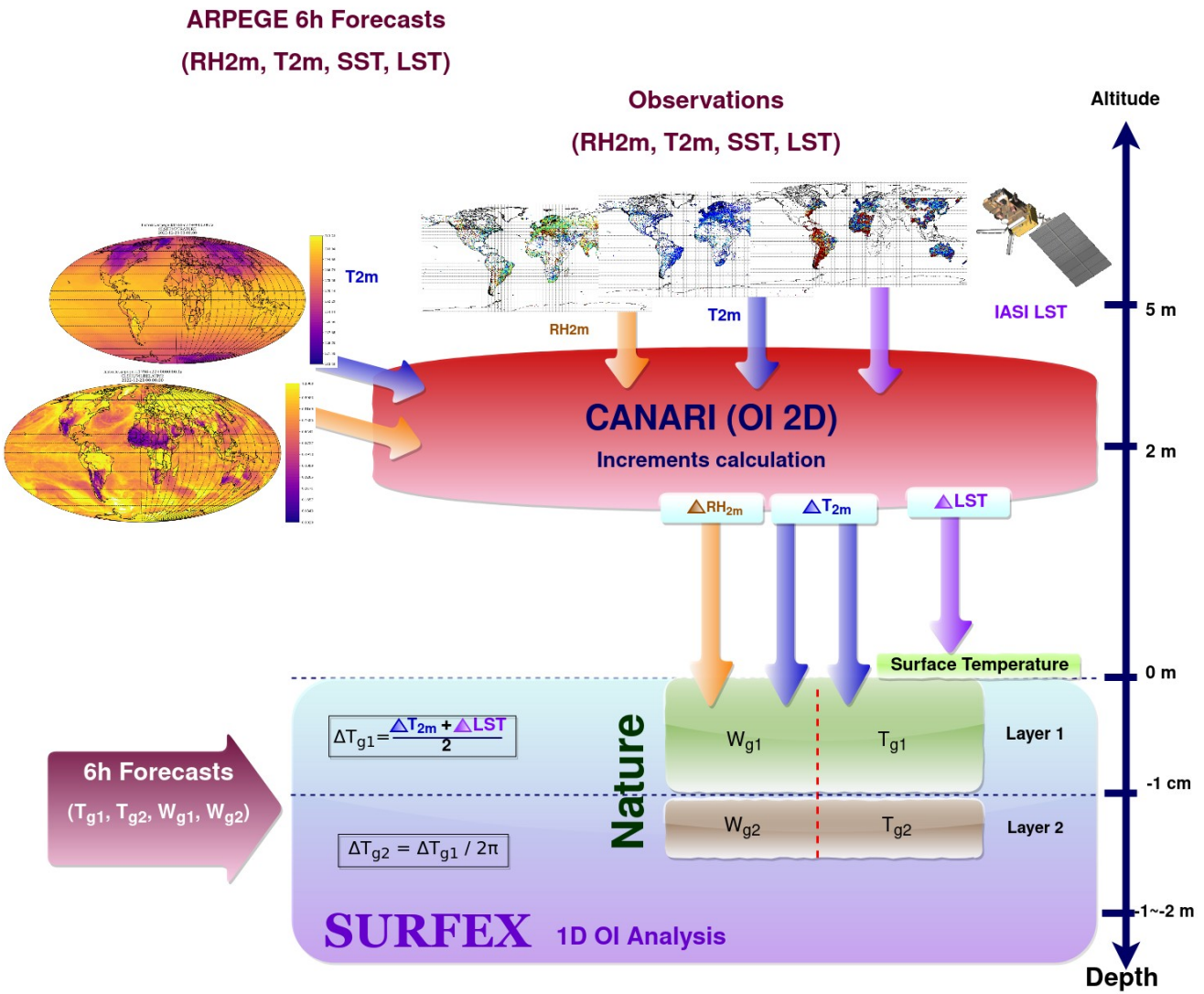
Compared to SEVIRI:

- Smaller differences during nighttime

Surface analysis in ARPEGE



IASI LST assimilation



Production of observation input files

- IASI LST retrieved for atmospheric assimilation
- Extraction of IASI LST from the screening outputs
- Use of nighttime observations only
- Use of clear sky observations only (AVHRR cloud mask)
- Use of orography threshold (< 1000m)

→ Production of observation files for several months (August 2022 to April 2023)

Configuration of the IASI LST assimilation

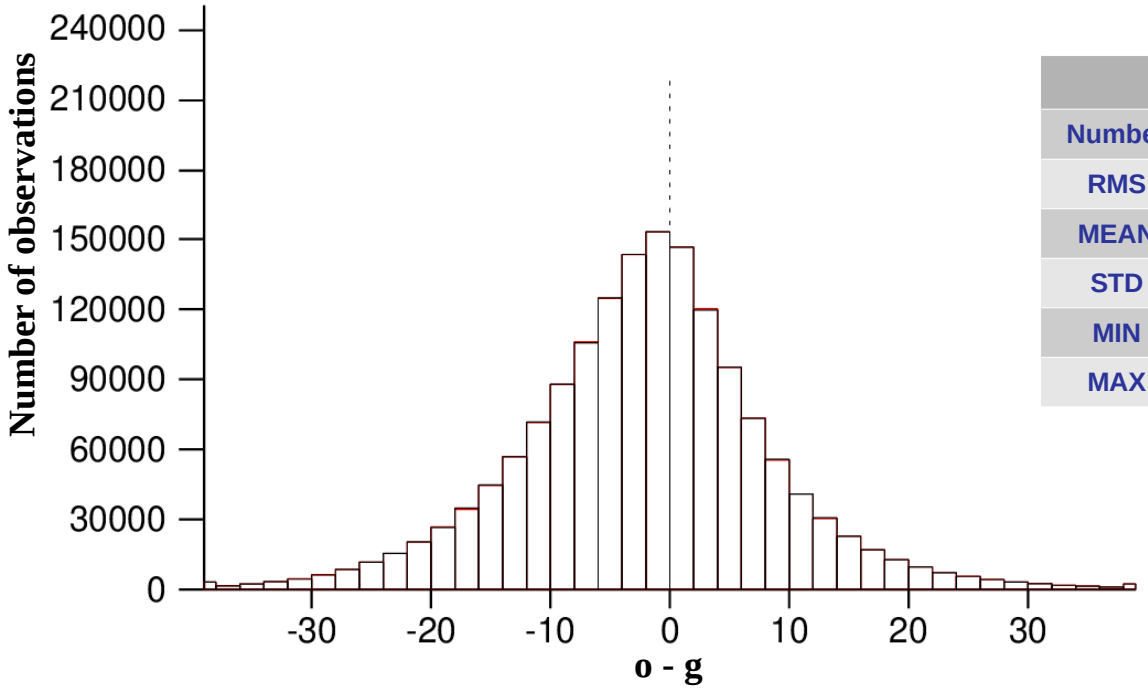
First settings based on the previous work of SEVIRI LST assimilation in AROME Limited Area Model :

- Observation and model errors found consistent with first Desroziers diagnosis (Consideration of 3K as observation error, 1.5K as model error and 30km of horizontal correlation length)
- Assimilation experiments over winter period (30/11/2022 - 31/03/2023)
- Evaluation of the LST assimilation impact (assimilation, forecast)

Use of IASI LST – Impact on assimilation

30/11/2022 to 04/02/2023

2m Relative Humidity

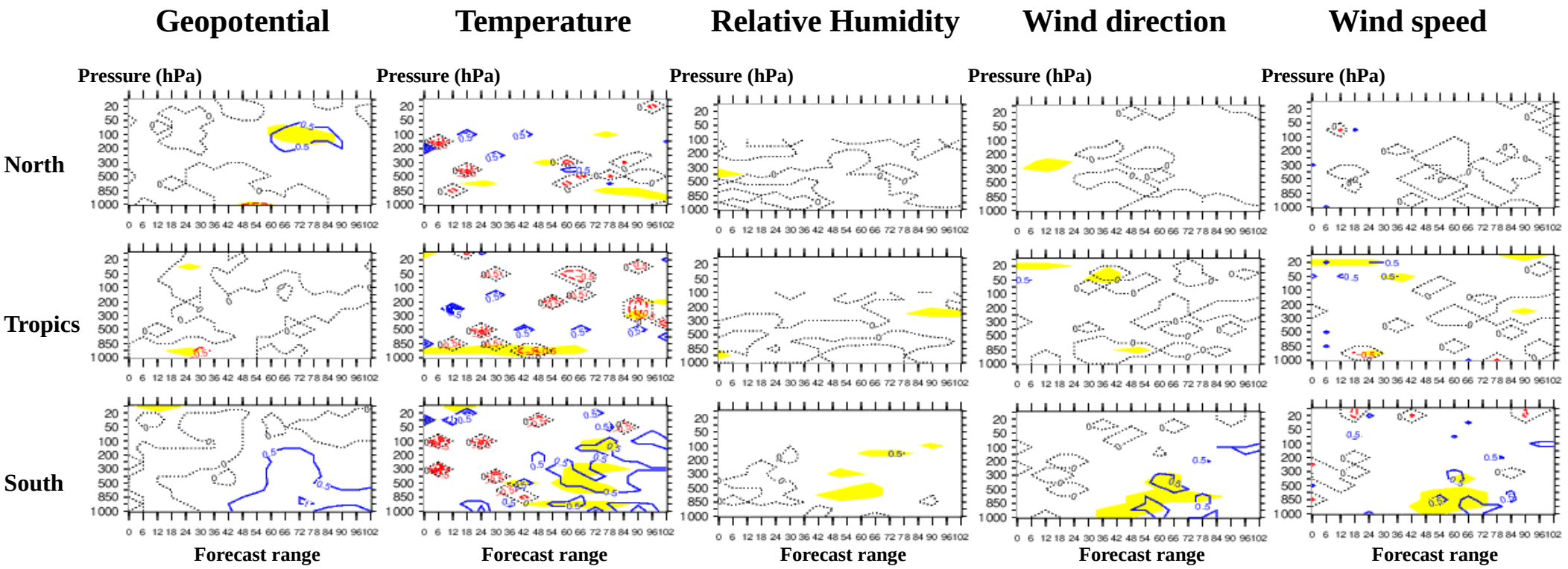


	EXP	REF
Number	1581219	1581277
RMS	10.4	10.4
MEAN	-2.07	-2.08
STD	10.2	10.2
MIN	-76.8	-74.4
MAX	70.7	72.3

Comparison of IASI LST assimilation experiment (black line) with no LST assimilation reference (red line)

Assimilation of IASI LST – Impact on ARPEGE forecasts

30/11/2022 - 20/03/2023



Relative difference of RMSE of ARPEGE forecasts vs ECMWF analysis for large domains

- An overall positive impact (Blue color) over the large domains, to be confirmed over longer periods (and different seasons).
- Yellow color indicates significant results (according to the Bootstrap test).

Blue : 😊

Red : ☹

Assimilation of IASI LST – Tunings

Initial parameters based on previous work with AROME LAM:

- Observation error: 3K

- Correlation distance: 30km

Should the assimilation parameters be revised with ARPEGE global model?

More diagnosis iterations?

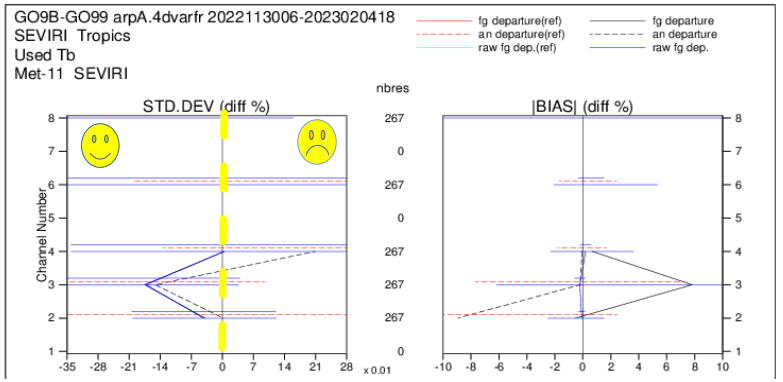
Larger correlation distance?

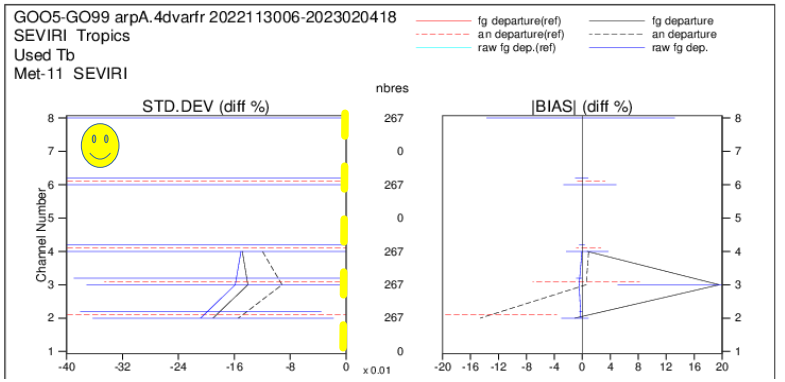
Interest of studying the sensitivity to assimilation parameters.

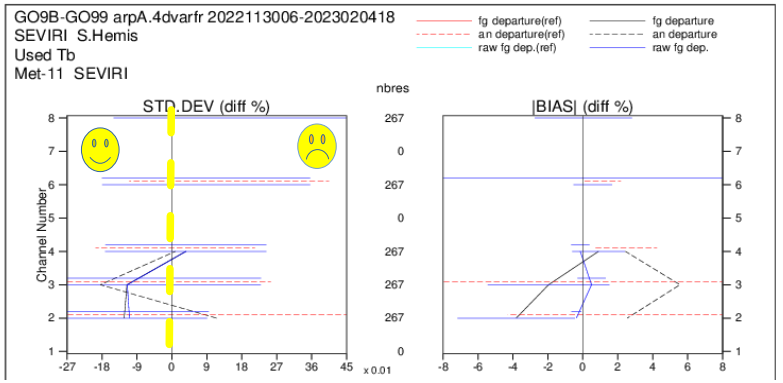
Use of IASI LST – Impact on assimilation

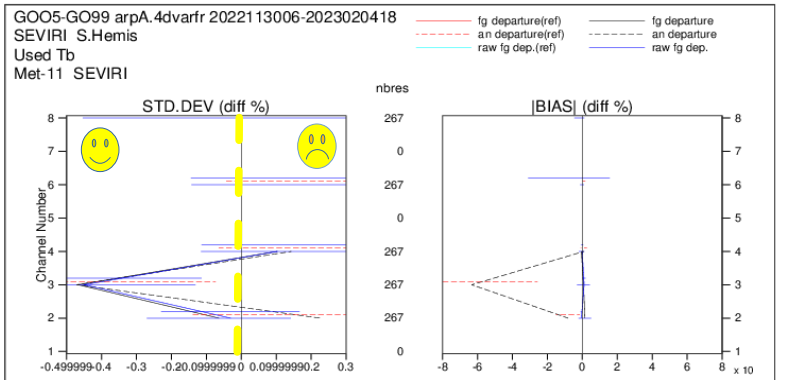
SEVIRI sensor

30/11/2022 to 04/02/2023









30km **60km**

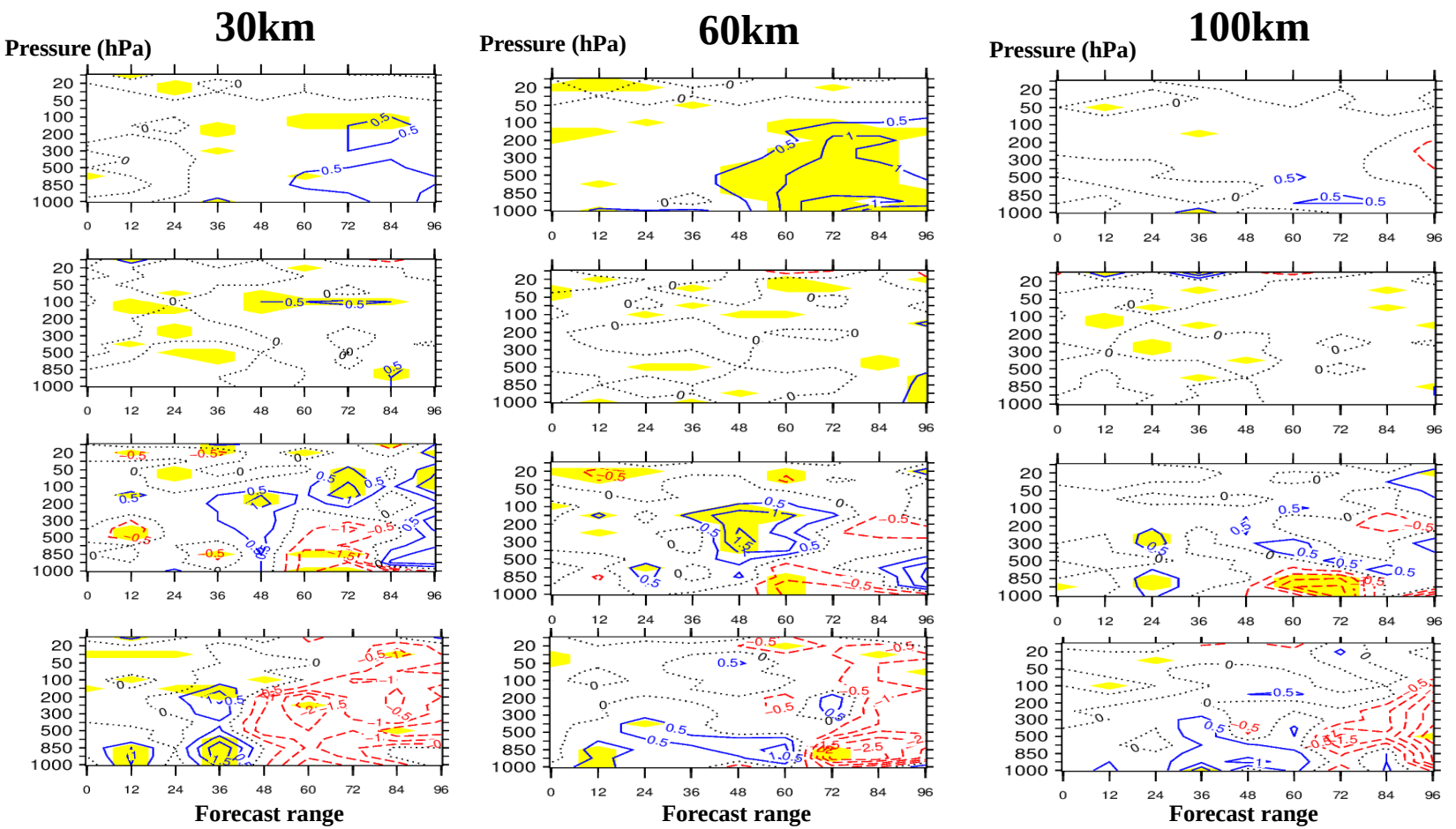
Channel	Wave length (µm)	Sensitivity
2	6.2	Mid/high troposphere
3	7.3	Mid/high troposphere
4	8.7	Surface/low troposphere
6	10.8	Surface/low troposphere
8	13.4	Troposphere

Smaller o-g error with 60km for Tropics and southern domain, especially for channels 2 and 3

Assimilation of IASI LST – Tunings

Geopotential

30/11/2022 to 08/02/2023



Blue :

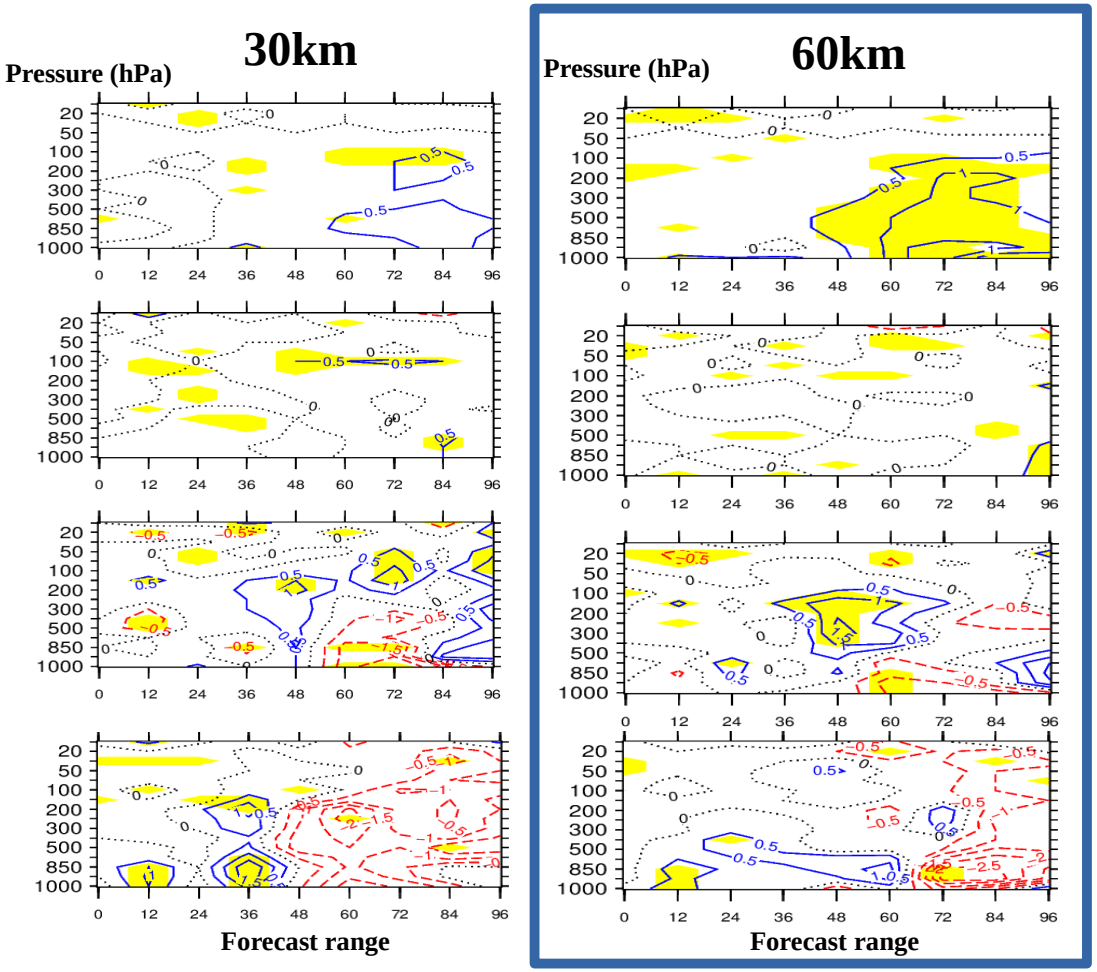
Red :

Relative difference of RMSE of ARPEGE forecasts vs radiosondes for large domains

Assimilation of IASI LST – Tunings

30/11/2022 to 08/02/2023

Geopotential



Blue :

Red :

Relative difference of RMSE of ARPEGE forecasts vs radiosondes for large domains

Conclusions

- Evaluation of the agreement between IASI LST and ARPEGE surface temperature with smaller differences by nighttime
- Implementation of IASI LST assimilation in ARPEGE global model
- Impact of the LST assimilation by nighttime positive over several time ranges
- Initial configuration gives encouraging results
- Sensitivity study to assimilation parameters: Further tunings of the configuration parameters (observation errors, horizontal correlation length, ...)

Perspectives

- **Improve the input observations :**
  - Taking into account the standard deviation of orography in the production of input files;
  - Evaluation of a Thinning of LST input data;
  - Update of the emissivity atlas for IASI (Talk of Camille Birman)
- **Improve assimilation parameters :**
  - Consideration of the geographical disparities with spatially variable observation errors to assimilate IASI LST over the 24h;
- **Improve soil analysis :**
  - Implementation of surface analysis diagnosis and improvement of the 1D soil analysis coefficients;
  - Consideration of LST increments in soil water content analysis;

Thank you for your attention