Assimilation of IASI retrieved LST in the surface analysis system of ARPEGE NWP global model

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RÉPUBLIQUE FRANÇAISE
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Acknowlegment

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Summary

Summary

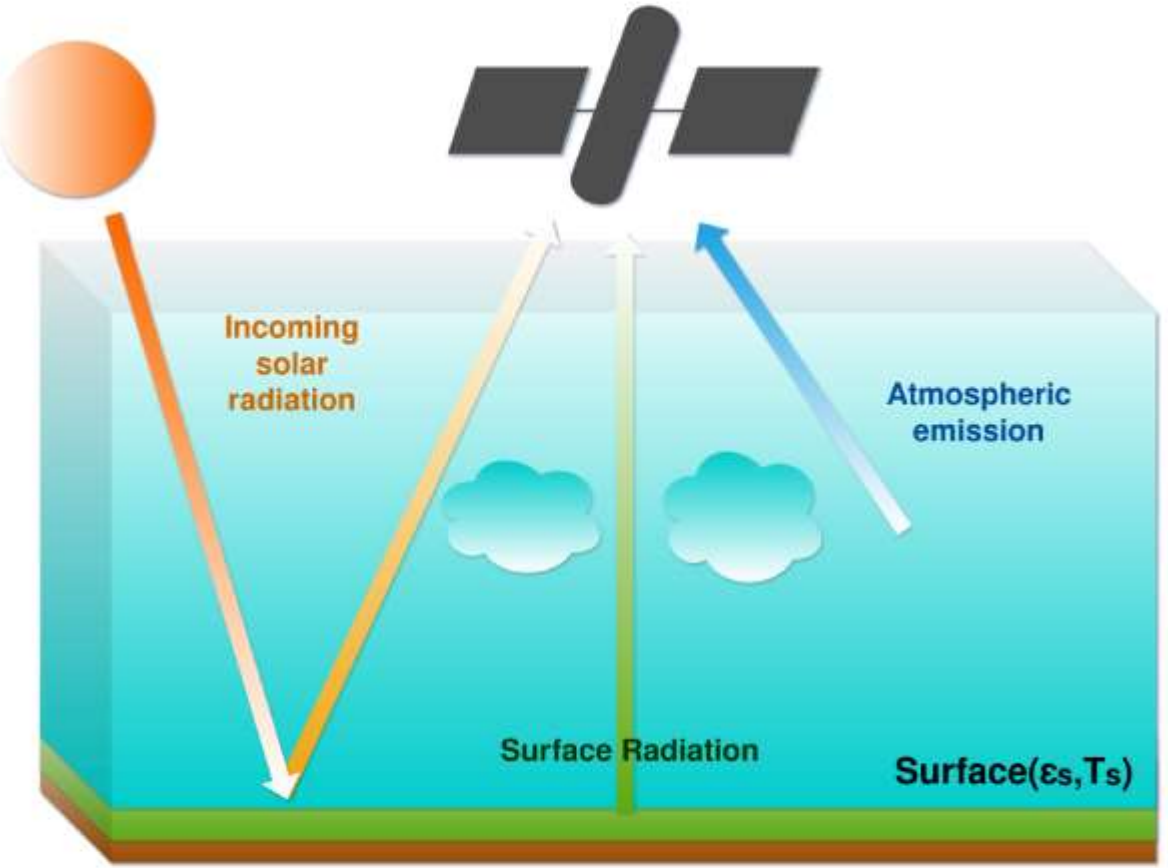
Introduction

Land surface temperature in NWP

- Importance of land surface temperature in a context of land-atmosphere coupled system.
- Need of a realistic description of land surface temperature for a better modelization of the radiative budget.
- High variability of the land surface parameters due to land surface temperature dependance to soil occupation and use of approximations
- Use of 2 m temperature in order to update soil temperatures in first and second soil layers.

Introduction

- Realistic observations used for satellite radiances assimilation instead of model forecast : retrieval of the LST (IR) or the surface Emissivity (MW) in ARPEGE (Karbou et al., 2006)
- Use of window channels for surface parameters retrieval for every instrument : Clear sky retrieval of IASI LST with mono-channel method (use of emissivity atlas (Guedj et al., 2011 ; Boukachaba, 2017))



Introduction

Land surface temperature in NWP

- IASI provides the most assimilated satellite observations in ARPEGE global model
- Retrieval of IASI LST in ARPEGE global model, retrieval of IASI and SEVIRI LST in AROME limited area model
- **Operationally retrieved LST is only used in satellite radiances simulation but is not assimilated in surface analysis at Météo-France**
- Previous study evaluated IR instruments LST : Sassi, Z ; Fourrié, N ; Guidard, V ; Birman, C : "Use of infrared satellite observations for the surface temperature retrieval over land in a NWP context". ***Remote sensing***, 2019 (DOI : 10.3390/rs11202371)
- Contribution of satellite derived LST in surface analysis ?

Introduction

Land surface temperature in NWP

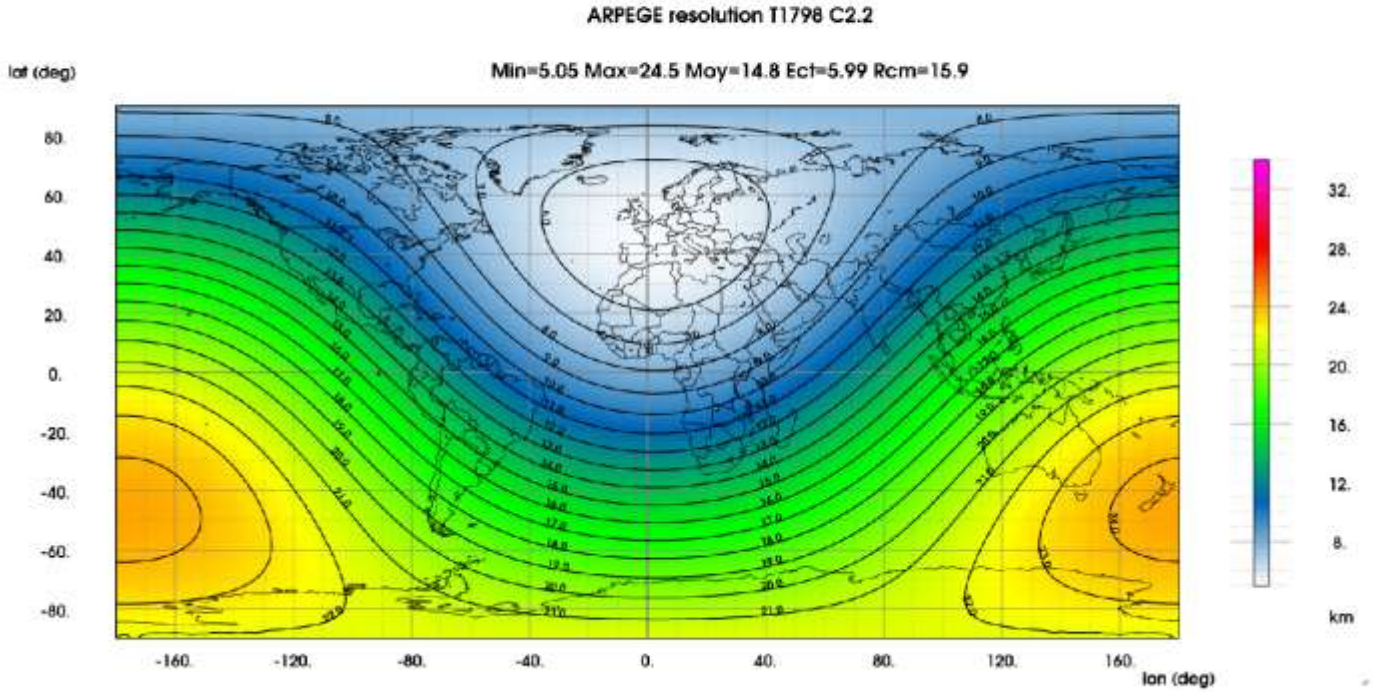
- First work of SEVIRI LST assimilation in AROME LAM model
- Encouraging results : Sassi, MZ, Fourrié, N, Guidard, V and Birman, C : "Preliminary Assimilation of Satellite Derived Land Surface Temperature from SEVIRI in the Surface Scheme of the AROME-France Model". ***Tellus A : Dynamic Meteorology and Oceanography***, 2023 (DOI : 10.16993/tellusa.48)
- **Assimilation of LST at a global scale ?**

Introduction

The ARPEGE model

- ARPEGE (Action de Recherche Petite Echelle Grande Echelle) is a global NWP atmospheric model developed by Météo-France and operational since more than 30 years.
- Coupled to surface plateforme SURFEX (Surface Externalisée)
- Most of assimilated observations are taken from IASI IR sensor

- Horizontal resolution from 5 km to 24 km
- 105 vertical levels
- Assimilation window of 6 h
- 4D-VAR atmospheric assimilation

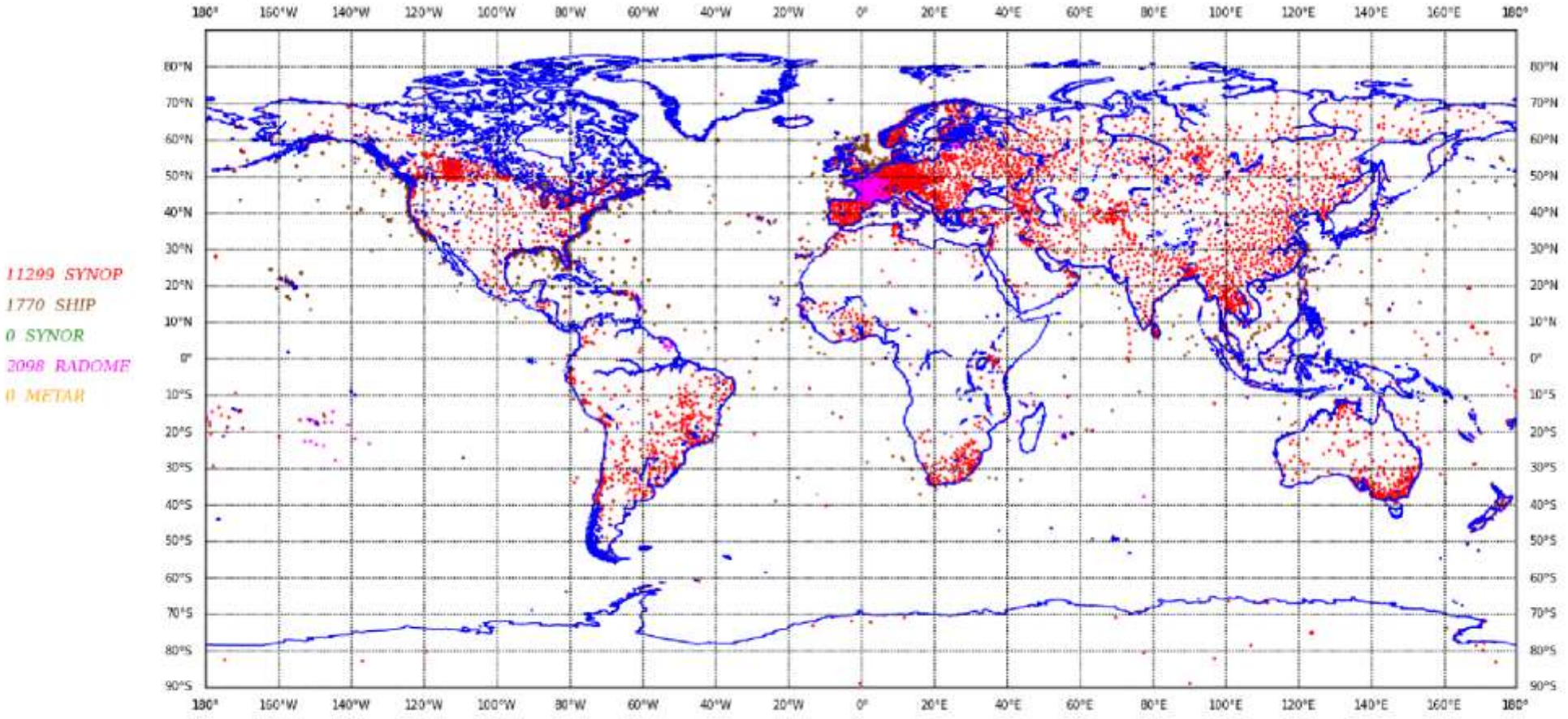


Introduction

2 m temperature observations

Available data for ARPEGE oper - SYNOP/SHIP - 2024/04/29 00H UTC

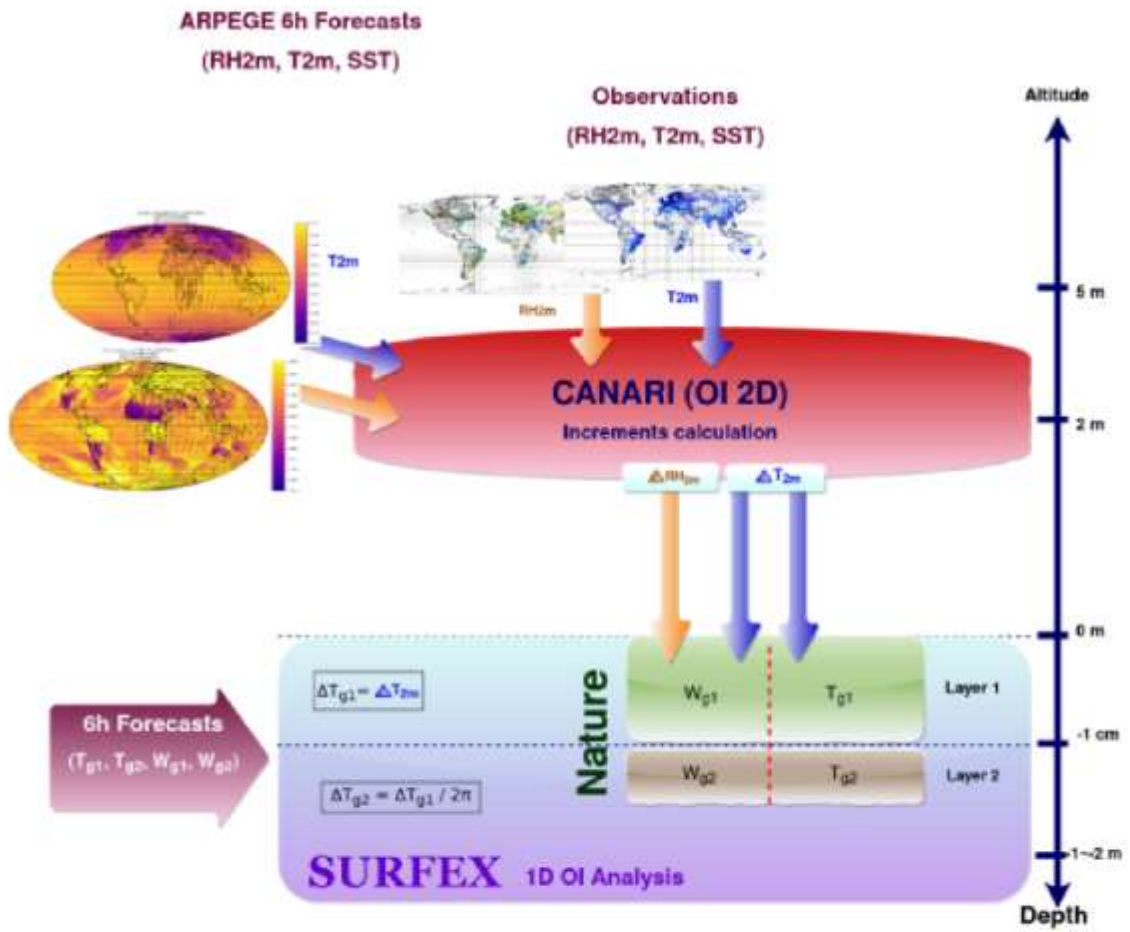
Total number of observations before screening: 15167



Introduction

Surface Analysis System in ARPEGE model

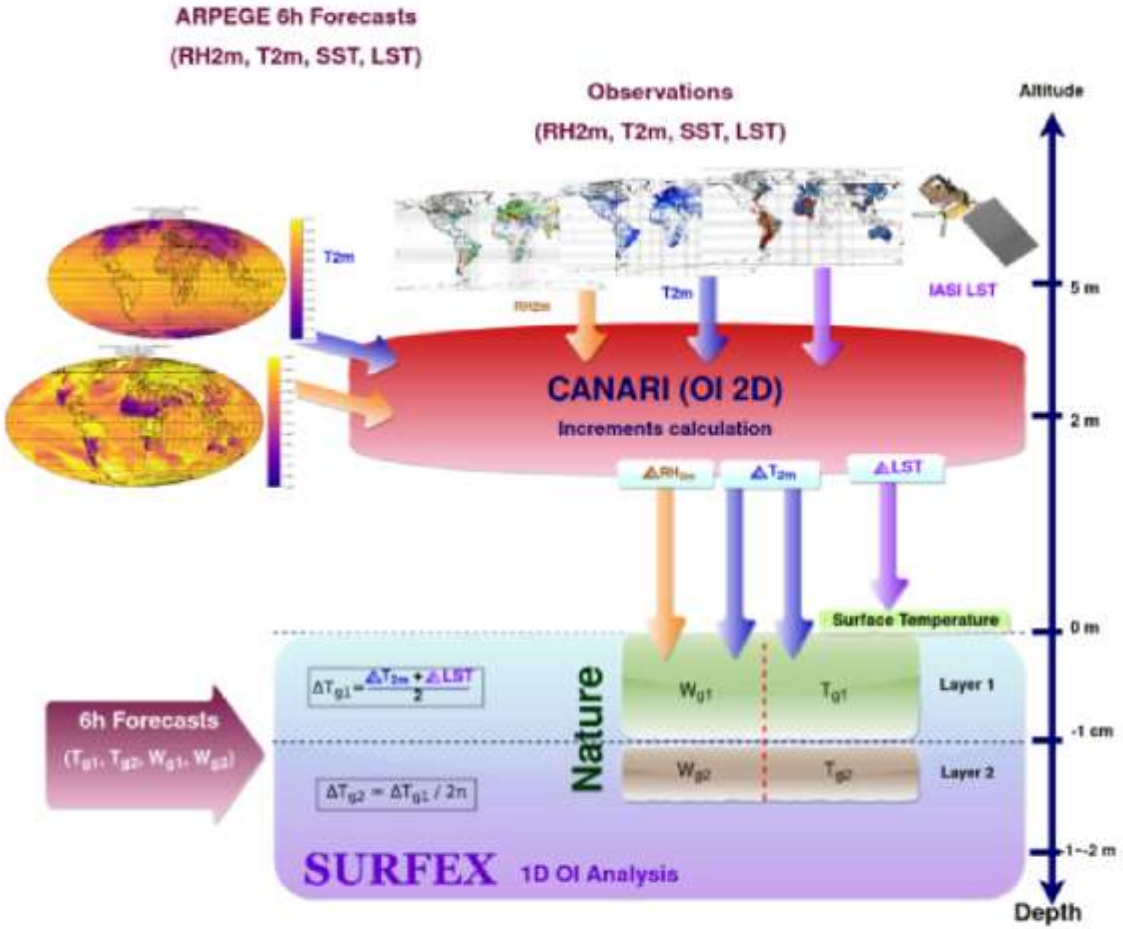
- Surface assimilation system in ARPEGE model
- Analysis every 6 hours
- Use of 2 m variables for soil analysis
- Analysis in 2 steps : 2D OI for T2m, Hu2m and snow then 1D OI for soil variables



Summary

Assimilation of IASI LST - Implementation

- Assimilation of IASI LST in addition to T2m and Hu2m in the 2D OI step
- Analysis of soil temperature (Tg1 and Tg2)



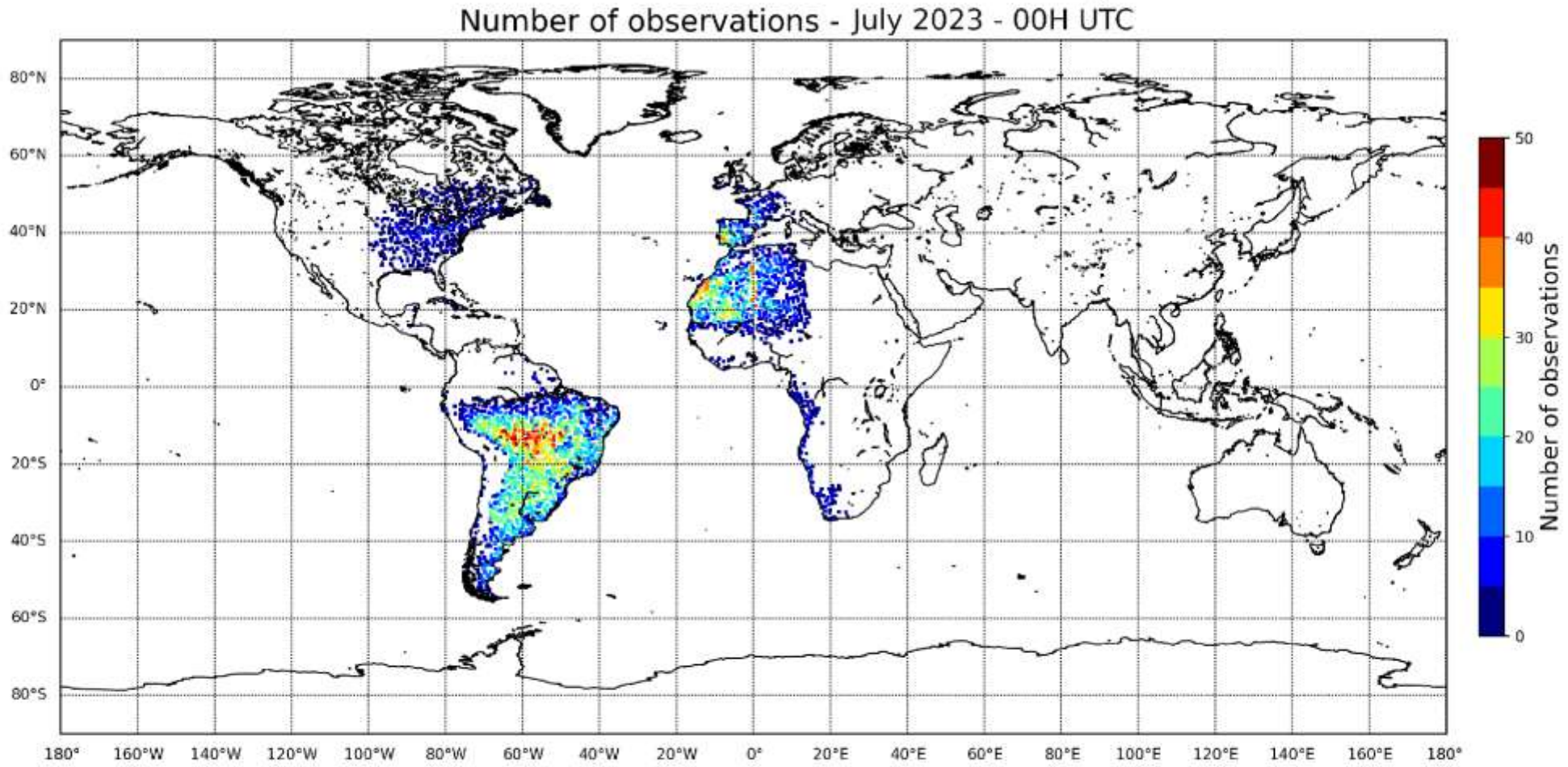
Assimilation of IASI LST - Implementation

Configuration of IASI LST assimilation

- IASI IR sensor on board polar orbiting METOP-B/C satellites
  $\Longrightarrow$ Discontionuity in time and space availability of clear sky observations
- Diagnostics of model and observation errors at a global scale
- Assimilation of IASI LST by nighttime only, in clear sky conditions
- Application of orography threshhold for height (1000 m) and standard deviation (100 m)
- 2 m temperature assimilated as in the operational suite
- IASI LST assimilation in addition to T2m

Assimilation of IASI LST - Implementation

Number of IASI filtered LST observations for July 2023 - 00H UTC



Assimilation of IASI LST - Implementation

Configuration of IASI LST assimilation

- Experimentation of IASI LST assimilation in ARPEGE :
  - Reference : Use of T2m only for soil temperature analysis (as operational)
  - Experiment : Use of IASI LST in addition to T2m for soil temperature analysis (by nighttime only)
- Sensitivity study for assimilation parameters
- Applied a thinning of IASI LST observations (50 km)

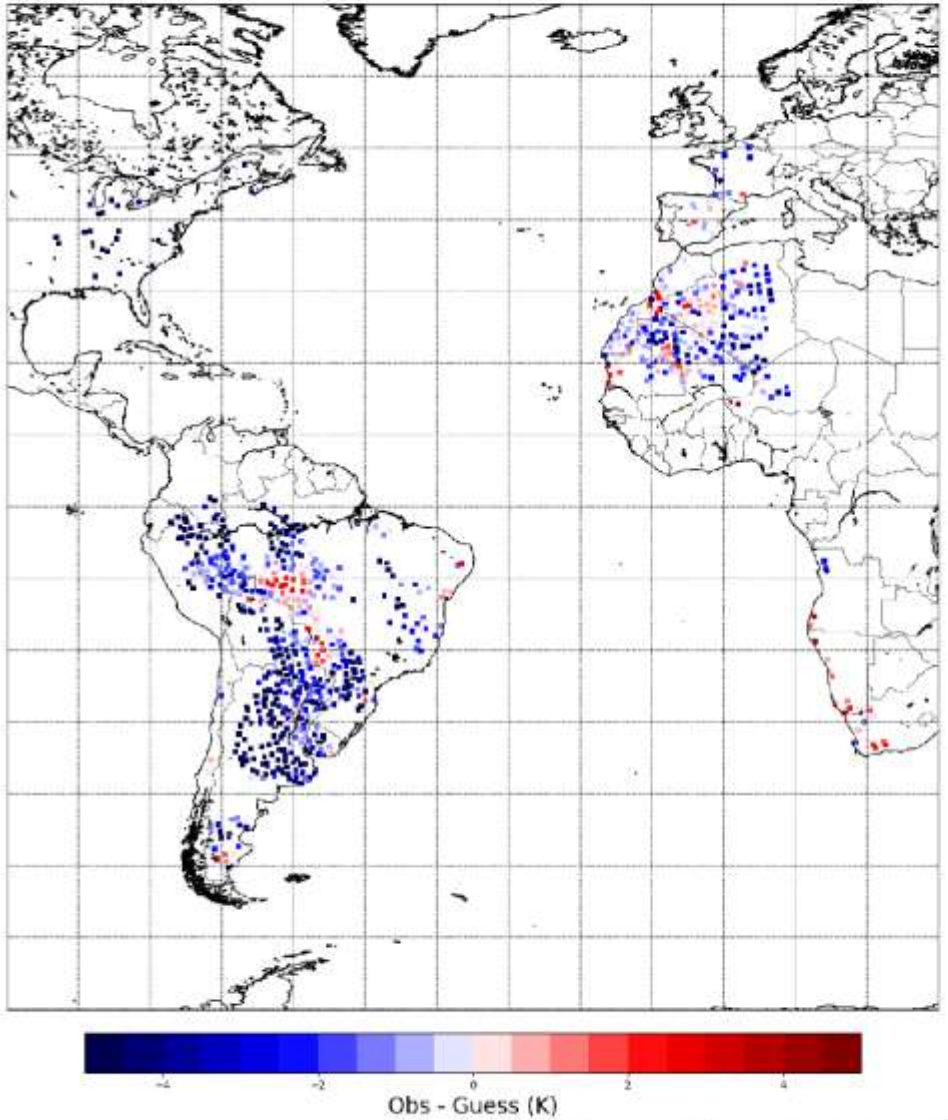
Configuration of assimilation parameters

	T2m				IASI LST			
	Assimilated	σ_o	σ_b	Corr. length	Assimilated	σ_o	σ_b	Corr. length
REF	Yes	1.4 K	1.6 K	100 km	No	-	-	-
EXP1	Yes	1.4 K	1.6 K	100 km	Yes	5 K	1.5 K	100 km
EXP2	Yes	1.4 K	1.6 K	100 km	Yes	3 K	1.5 K	100 km

Summary

Assimilation of IASI LST - Validation

- First guess departures of LST - 2023/06/16 - 00H UTC
- $\sim$ 800 considered observations ($\sim$ 600 assimilated, mean=-1 K, std=1.7 K)
- Globally a colder IASI LST compared to model guess over the study period



Assimilation of IASI LST - Validation

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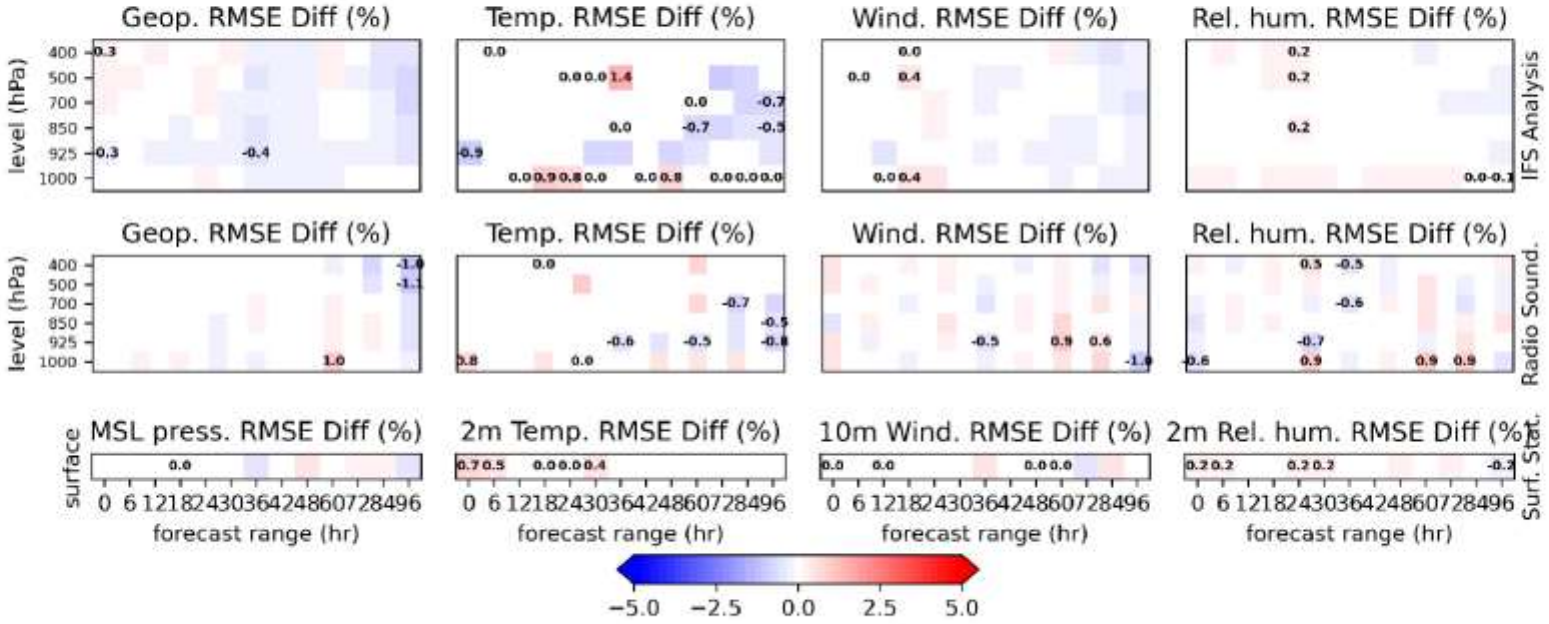
Assimilation of IASI LST - Validation

Validation period : Summer

- Summer period validation : June 15^{th} to September 15^{th} 2023
- Global improvement of the LST assimilation in the surface analysis (Blue=improvement, **Bold**=Significant with 95% confidence level)

Evaluation of IASI LST assimilation impact on ARPEGE forecasts (NORD20 big domain)



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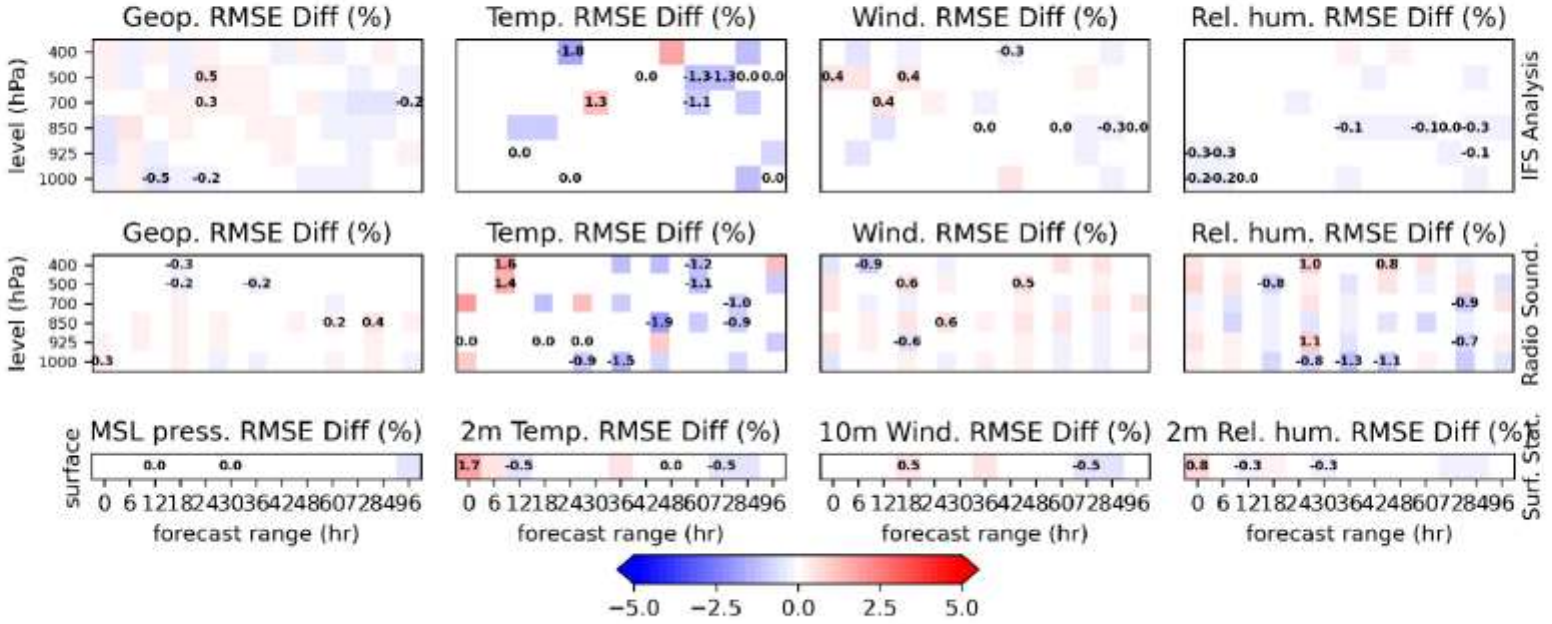

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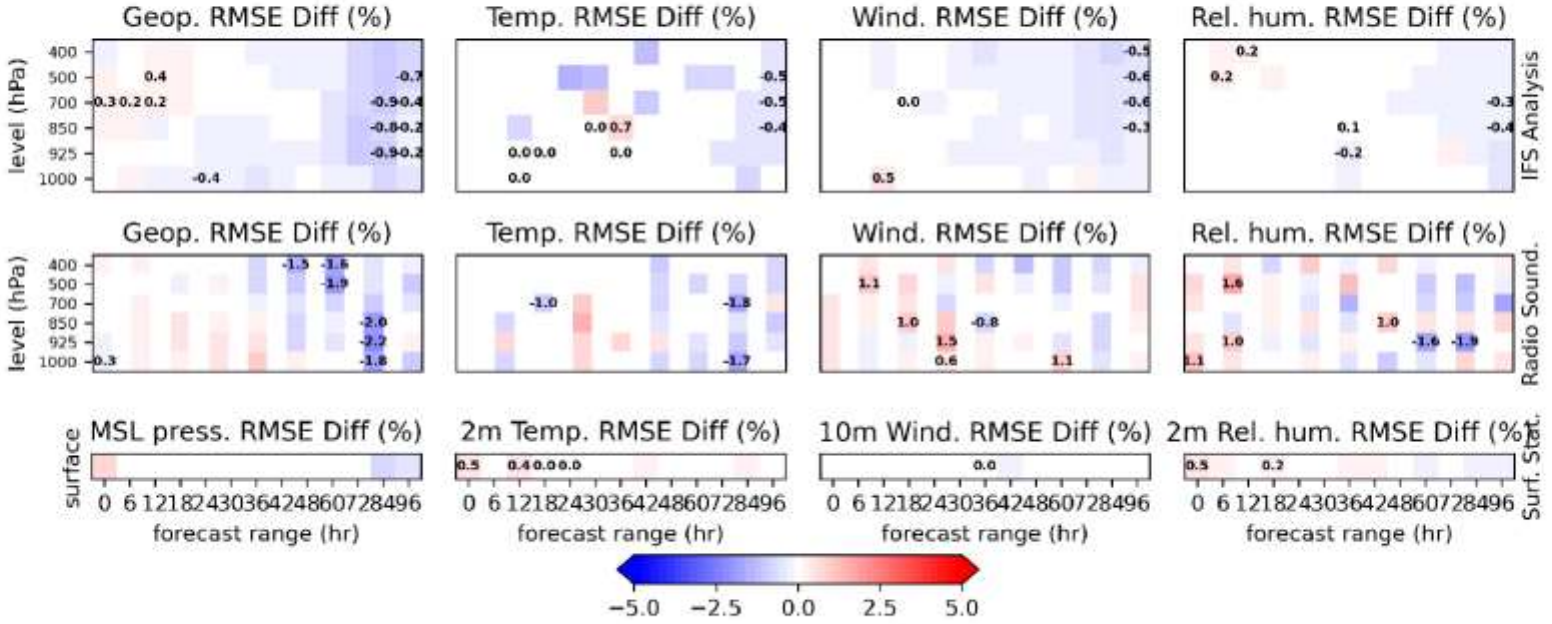

Assimilation of IASI LST - Validation

Validation period : Winter (in progress)

- Winter period validation : January 1^{st} to February 29^{th} 2024
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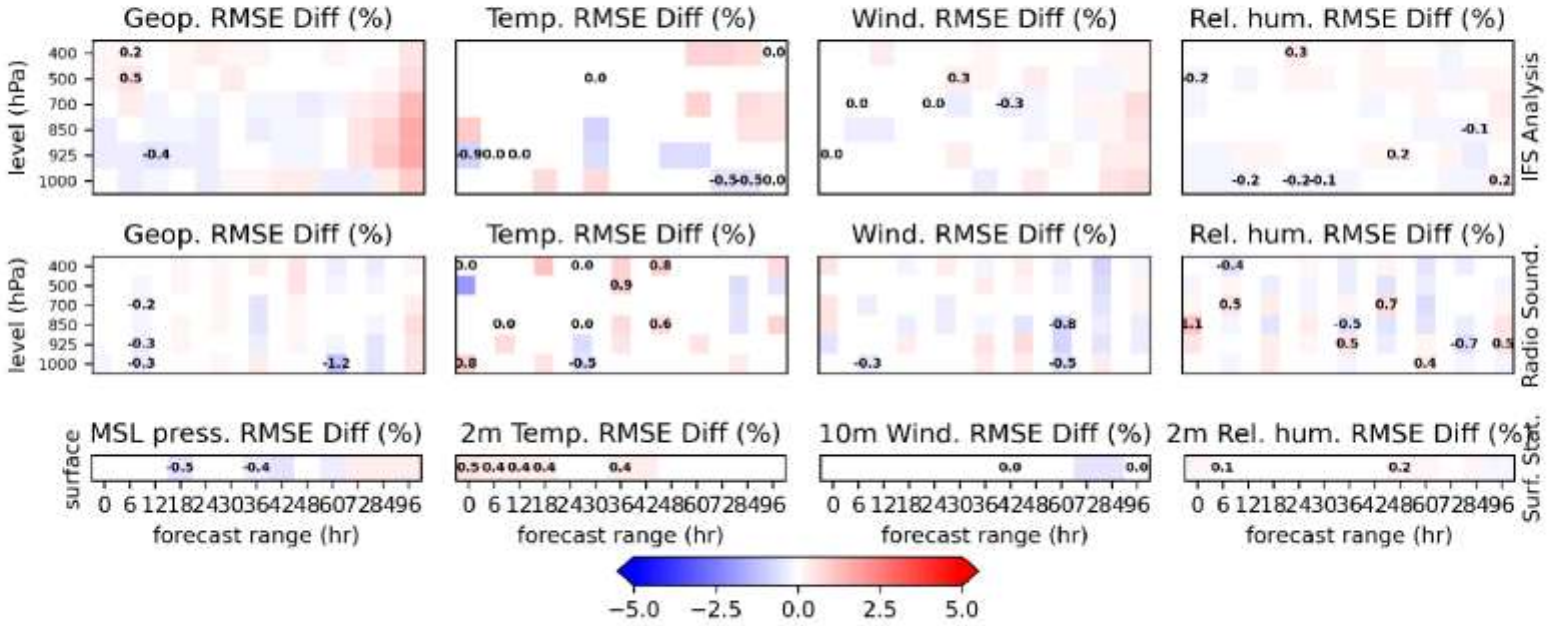

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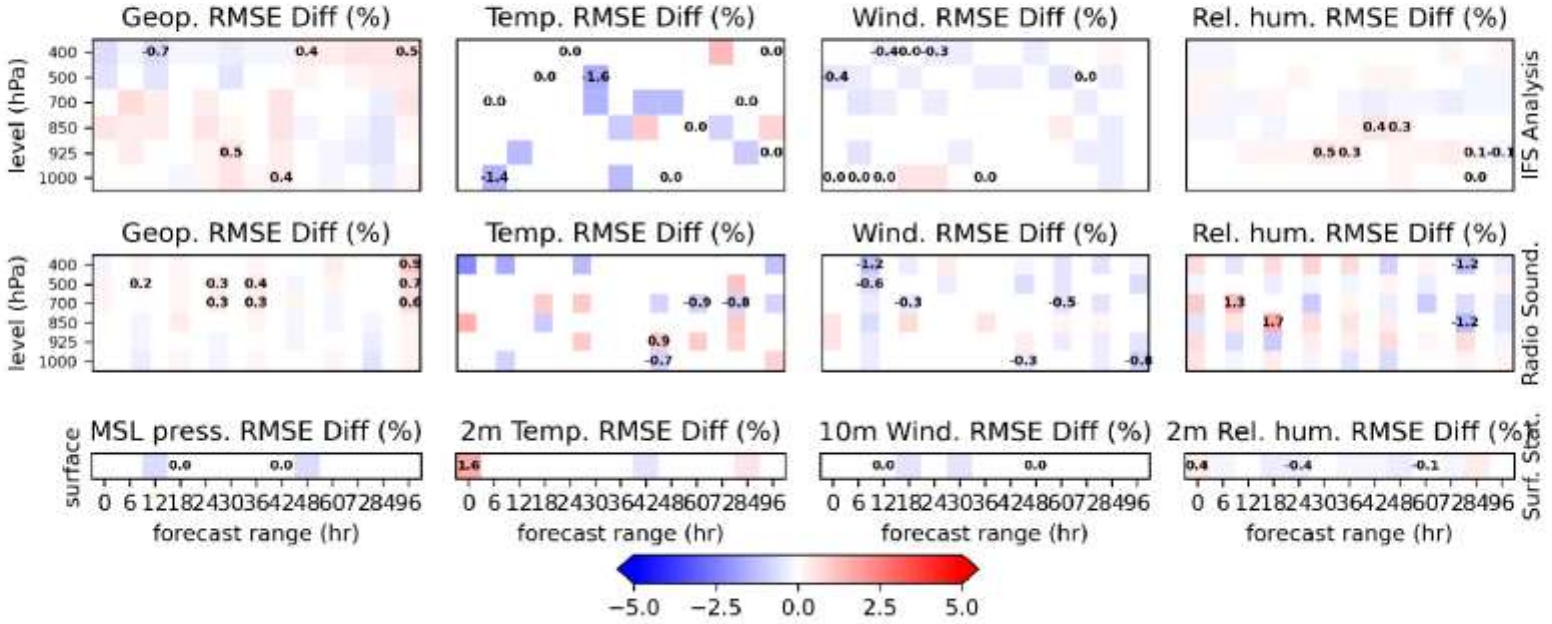

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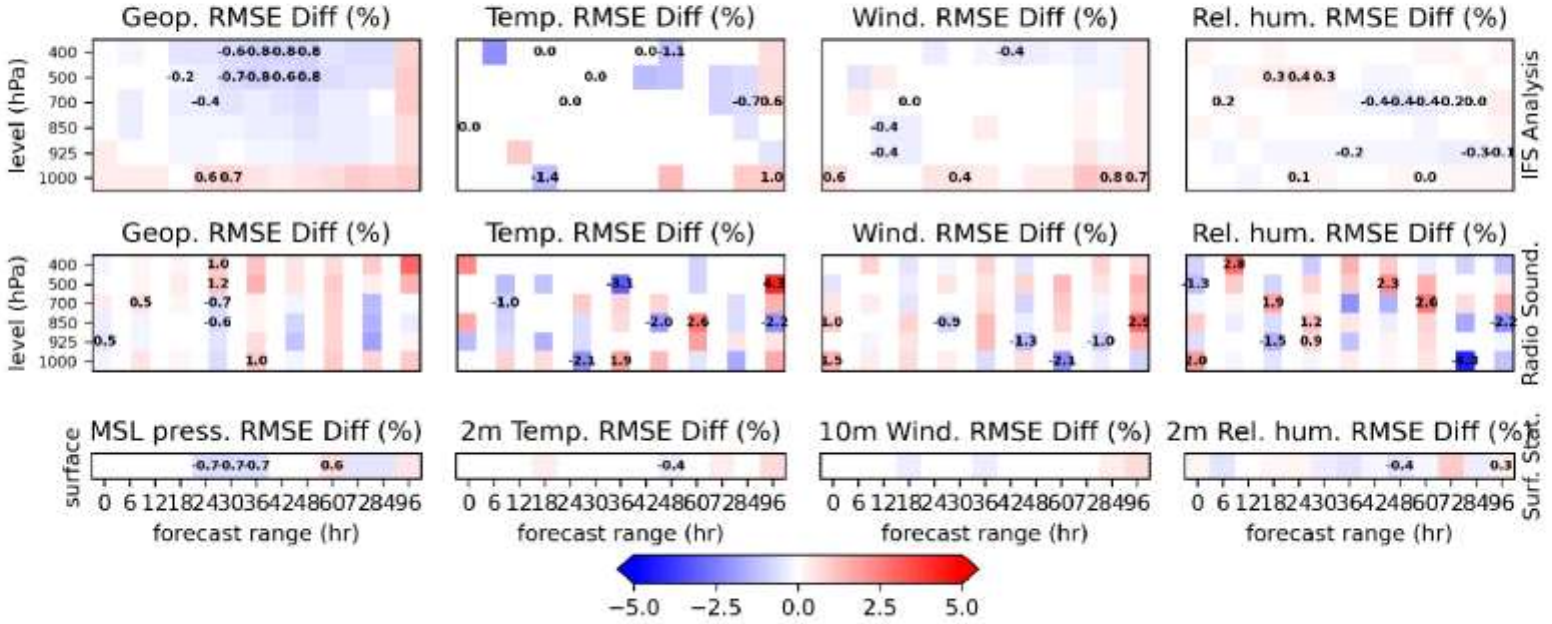

Summary

Conclusions and perspectives

Conclusions

- Assimilation of IASI LST by nighttime only
- Mainly negative bias for obs - guess departures especially for summer period
- Impact seen on analysis and forecasts
- Forecasts comparison to radiosondes and ECMWF analysis show impact on several parameters especially temperature and wind
- Encouraging results especially for summer period

Conclusions and perspectives

Perspectives

- Generalization of the validation over different seasons
- Application of a bias correction method
- Use of dynamic instead of static observation errors
- Use of IR sensors synergy for a larger time/zone cover
- More details submitted soon (paper in process)

Conclusions and perspectives

Thank you for your attention