Implementation and testing of new observation in DA system

IASI data assimilation

report from LACE stay in Ljubljana, 17 September – 14 October 2017

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Outline

1. Introduction

With a high spatial and temporal density, Infrared Atmospheric Sounding Interferometer (IASI) is considered as a valuable observation data set and therefore is more and more assimilated in NWP systems.

The aim of this stay is to implement and test IASI in ALARO 3DVar Data Assimilation system in ARSO.
To study IASI channels behavior, two variationnal bias correction (VarBC) initialization approaches (a coldstart and a warmstart experiments) were tested.
After the data-monitoring, impact studies were made to investigate IASI assimilation effect on forecasts.

2. Data monitoring and Satellite bias correction

2.1 Methodology: variationnal bias correction and channel selection

As the first goal of this stay is the implementation of IASI in the DA system, we didn't make a specific channel selection and we rather chose to start with the default IASI channel selection used in operational in other LACE DA systems.

Data monitoring was based on checking, for each channel, during two months August-September 2017:
- the evolution of bias and standard deviation of observation departure from guess and analysis
- the evolution of the bias correction for IASI channels
- the evolution of bias of the predictors

Regarding the variationnal bias correction, we started with a VarBC coldstart initialization experiment over August 2017. When we noticed a slow convergence of the bias correction, we launched:
- a warmstart initialization experiment (starting from Meteo-France VarBC files)
- a passive experiment to have more observations to accelerate the bias correction convergence

For warmstart and coldstart experiments, all the channels were actively assimilated. For the passive experiment, all channels were passively assimilated during August 2017 and after monitoring and bias checking, we selected some channels that showed a bias correction stabilization to pass to active and we continued the monitoring for September 2017.

In order to compare VarBC initialization approaches for the three experiments (warm, cold and passive), we chose to focus on two channels:
- channel 327 : a CO2 channel (impact on temperature) actively assimilated for both warm and cold start and passed to active after one month in the passive experiment
- channel 3008: a HO2 channel (impact on humidity) actively assimilated for both warm and cold start and passively assimilated for the passive experiment

Table1: experiments summary

experiments	*Warm*	*Cold*	*Passive*
Varbc initialization	Warm start from Meteo-France varbc	Cold start	Cold start
Monitoring Period	August – September 2017	August – September 2017	August – September 2017
Channel active/passive	Active	Active	Passive except for some channels passed to active in September channels active after 1 month : 327 , 345, 350,356 , 375 , 398,2701,2910,3049,3058 ,5397

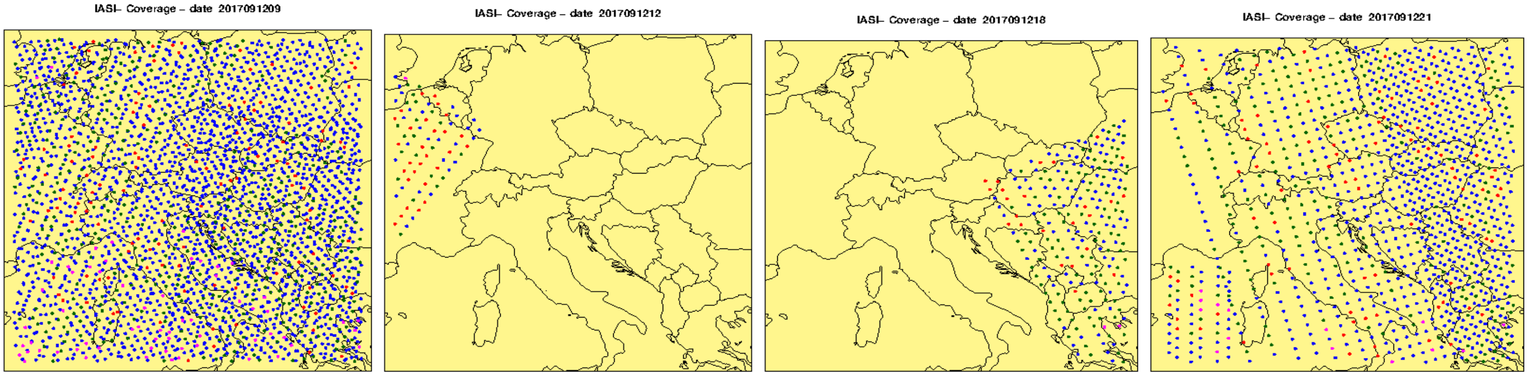

Figure 1: IASI data coverage for 12/09/2017 on,respectively from left to right , 09H 12H 18H and 21H for ecma (blue), ccma (red), channel 3008 (green) and channel 327 (magenta)

2.2 Results

Figures 2 & 3 show the bias evolution for the different predictors for warmstart, coldstart and passive experiments for channels 327 and 3008. As expected, when we compare active cold experiment (2.a b c) and passive cold experiment (3.a b c), we notice that due to larger number of observations, bias corrections converge faster in the passive mode.
Nevertheless, even after 2 month in passive mode, the bias corrections for some channels, as 3008, didn't seem to be stabilized yet. Besides, for the same channel, we have different behaviors between predictors. Predictor 1 for channel 3008 is around 0.6 in the warmstart , 0.8 in the passive and -0.5 in the coldstart after 2 month of VarBC cycling (See figure 3). Some predictors need a larger observation sample to stabilize which could be a constraint in the choice of VarBC initialization approach especially for an operational use.

Table2: Predictor table

Predictor	***Description***
1	Thicknesses of pressure level 1000-300 hPa
2	Thicknesses of pressure level 200-50 hPa
3	Skin temperature
4	Total column precipitable water
5	Thicknesses of pressure level 1-10 hPa
6	Thicknesses of pressure level 5-50 hPa
7	Surface wind speed
8	Satellite nadir viewing angle
8	Satellite nadir viewing angle**2
10	Satellite nadir viewing angle**3

After examining time series statistics of observation departure (OMG and OMA) and bias corrections over August-September 2017 in Figure 4, it is worth noticing that when starting cold (2.a and 2.b) , we have larger observation departure bias.
Regarding passive experiment, channel 327 bias corrections started to fit those of the warm experiment after 3 weeks (which was the motive to select this channel to pass active) (3.a). However channel 3008 bias correction were not there yet (3.b) which could be explained by a larger standard deviation of observation departure for channel 3008 compared to 327. This is more visible when we see the standard deviation difference between CO2 channel and HO2 channel in Figure 5 for both warm and active experiments. In fact, HO2 channels have bigger observation sample and present larger standard deviation than CO2 channels.

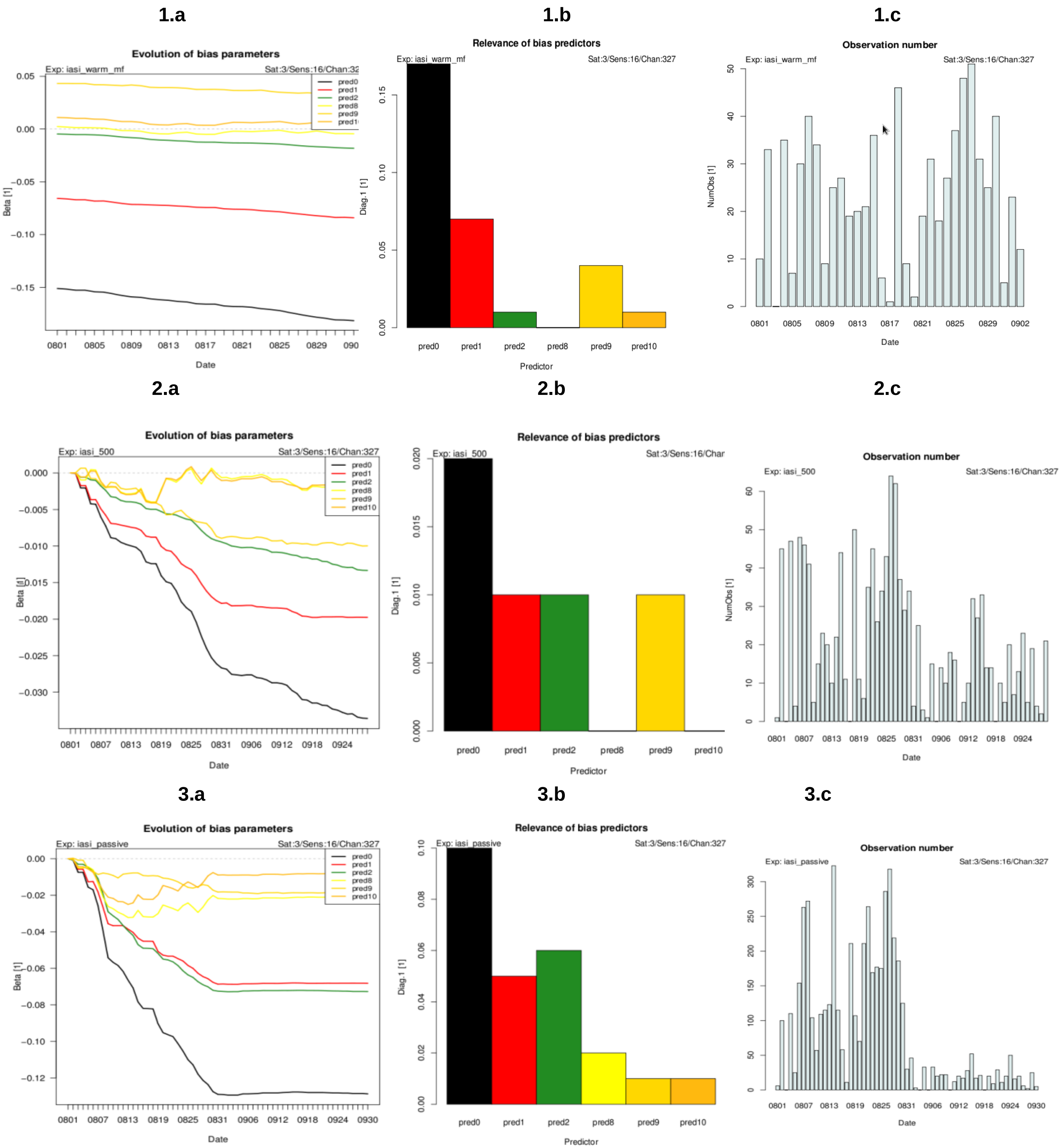

Figure 2: IASI Channel 327 METOP-A at 21H Monitoring (bias evolution (a), predictors relevance (b) and observation number (c)) for warm start (1), cold start (2) and passive (3) experiments

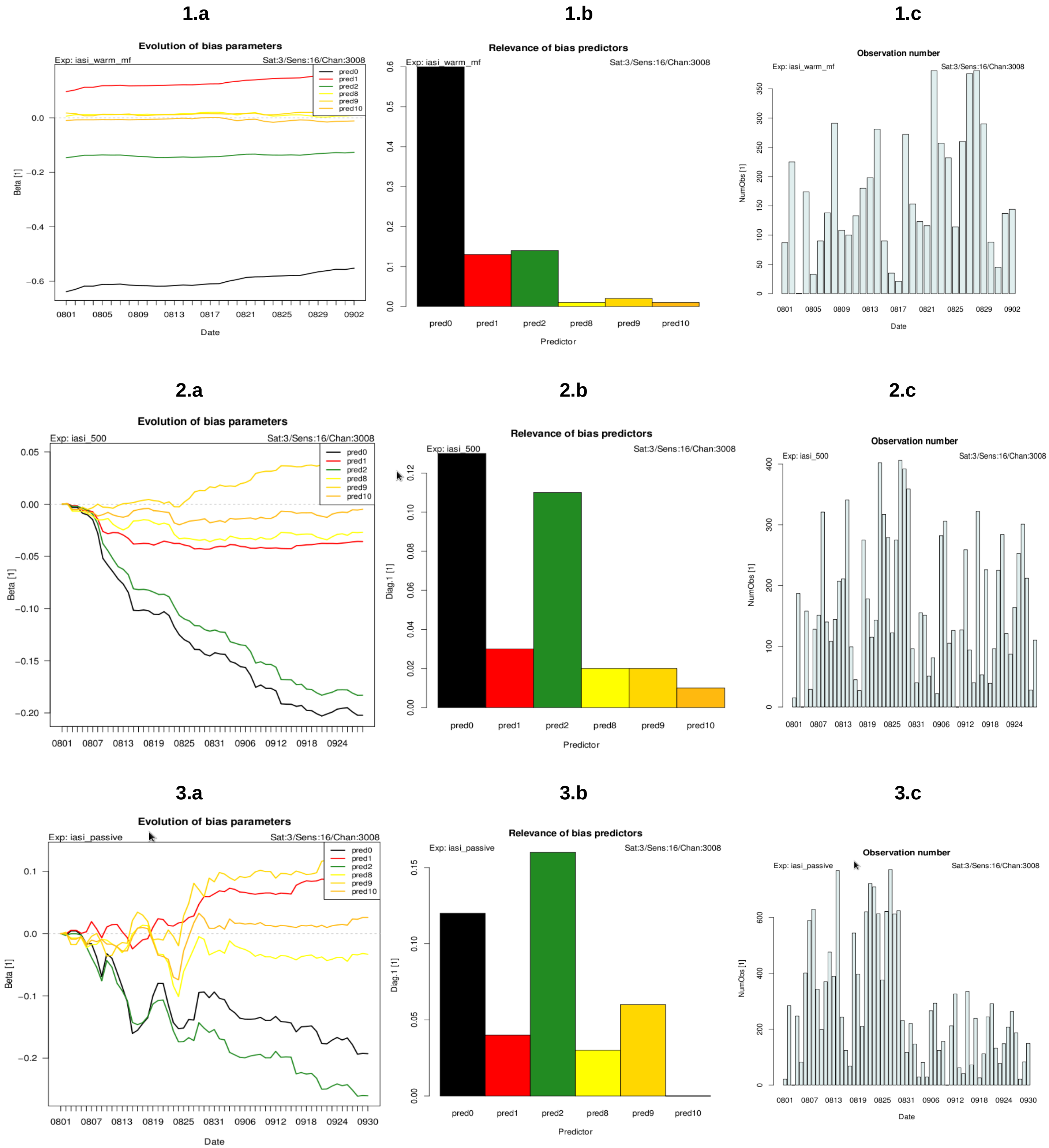

Figure 3: IASI Channel 3008 METOP-A at 21H Monitoring (bias evolution (a), predictors relevance (b) and observation number (c)) for warm start (1), cold start (2) and passive (3) experiments

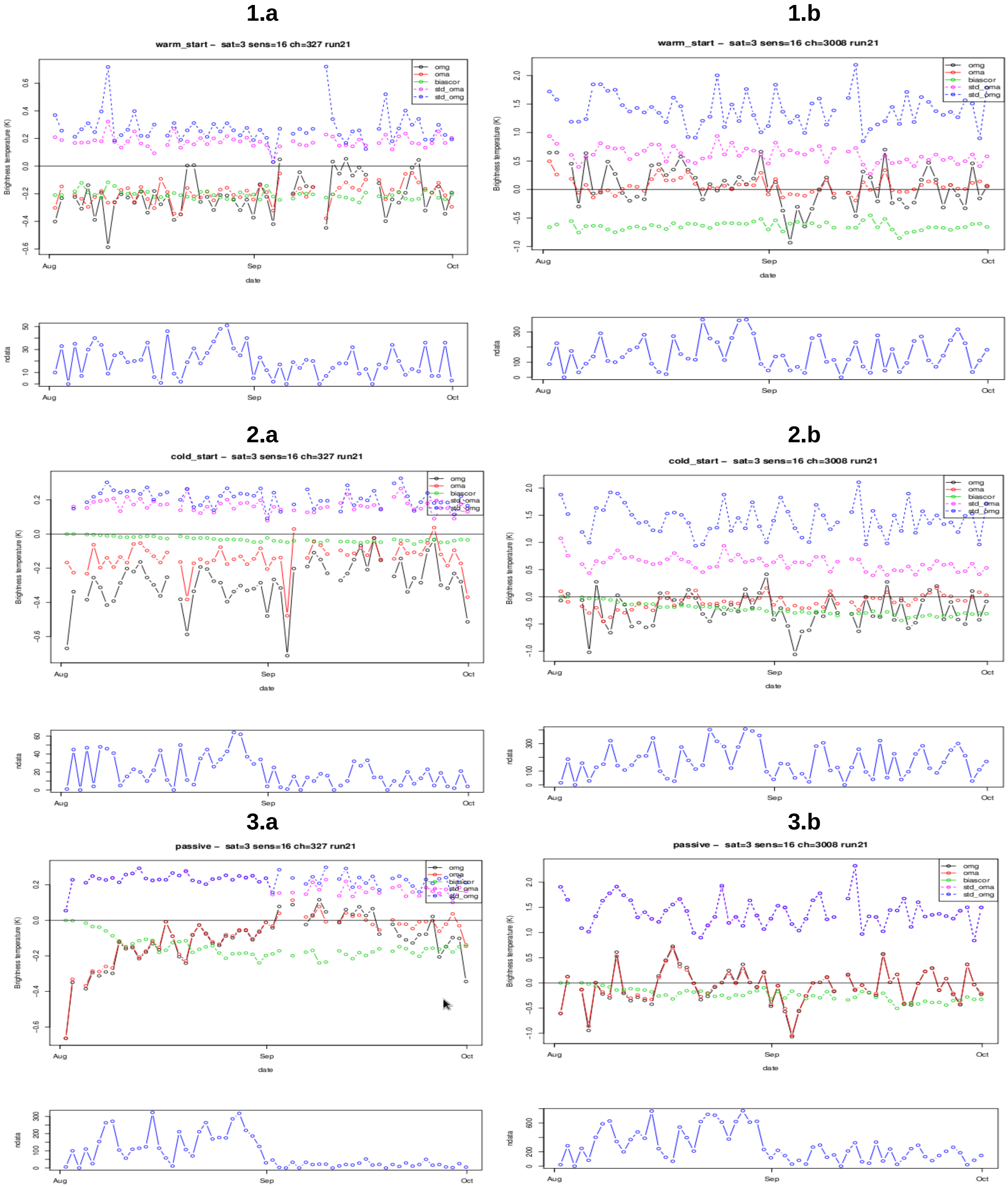

Figure 4: IASI Channels 327 (a) & 3008 (b) on METOP-A at 21H OMG, OMA and bias correction evolution for warm start (1), cold start (2) and passive mode (3) experiments

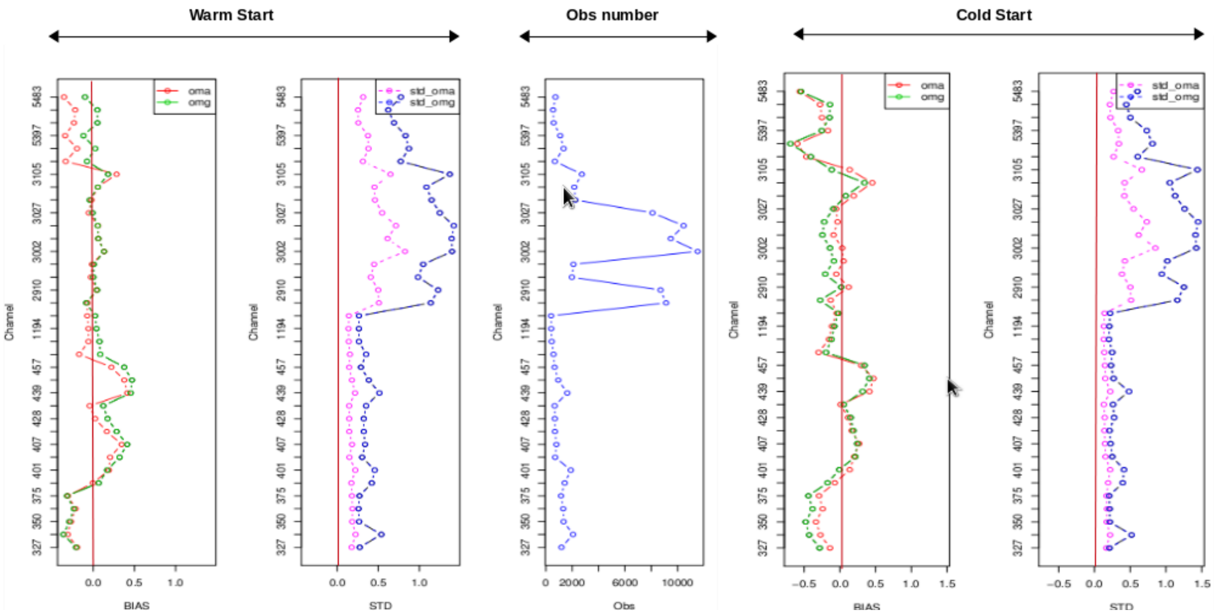

Figure 5: IASI METOP-A Channels OMG and OMA bias and standard deviation during August-September 2017 for warm start and cold start experiments

3. Impact Studies

To investigate the impact of IASI on the forecast, we run verification scores against observations during September 2017 after one month of VarBC “warm up” for IASI and we compared a reference experiment (operational suite), a “warm” experiment with IASI warmstart VarBC and a Passive experiment with coldstart VarBC (experiments described in section 2).

Over the hole domain and with all the cutoff, we obtained rather a neutral impact and we were not able to distinguish a clear signal or tendency between the three experiments (Figure 6) with both positive and negative differences found for some parameters and forecast ranges. Thus we tried to see clearer by comparing two rainy events: one in Slovenia on 19/09/2017 (Figure 7) and one in Albania 12/09/2017 (Figures 8 & 9).

First case study 19/09/2017 (Figure 7):
All experiments were able to predict the localization of the main cell and over estimated the 24H accumulated precipitation in the extreme north-east in Slovenia. The main difference between them was in the center of Slovenia (see the circle Figure 7):
“passive” experiment (c) over estimated the rain in the center however “reference” (a) and “warm” (b) experiments predicted less rain and were more close to rain gauges observations (d).

Second case study 12/09/2017 (Figures 8 & 9):
This event was characterized by a front over the south-east of the domain with precipitation in the north of Albania. The three experiments predicted the rain cell over Albania (Figure 7): “passive” (3.a and 3.b) and “warm” (2.a and 2.b) experiments predicted slightly more rain and presented bigger relative humidity increments compared to the “reference” experiment (1.a and 1.b) which is in concordance with the analysis of the cross section of the front (Figure 8) where we can notice a less decrease of the moisture when assimilating IASI with more pronounced relative humidity increments with the “warm” experiment (b) compared to the “passive” one (d).

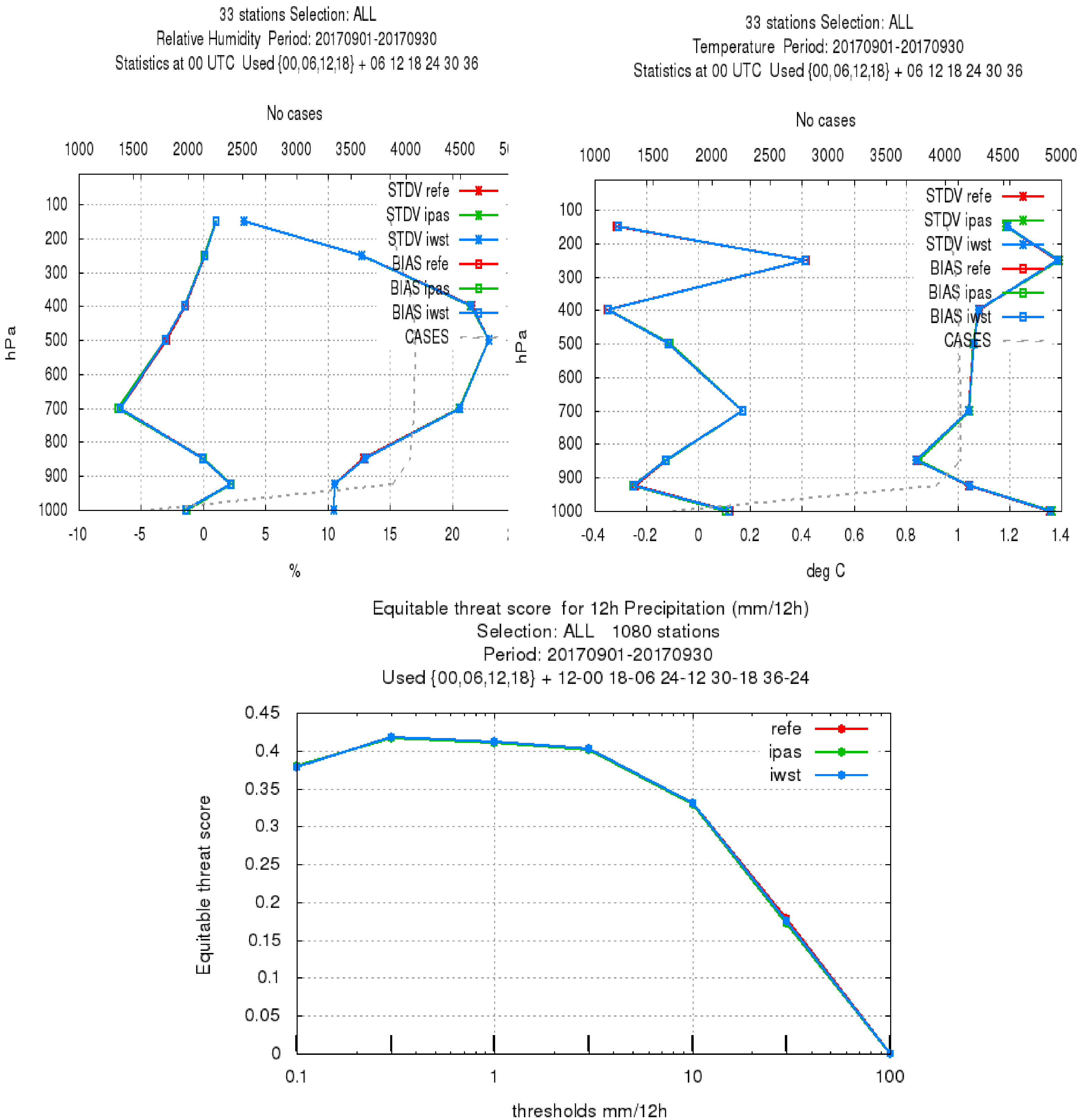

Figure 6: Verification scores for warm, passive and reference experiments against observations for relative humidity vertical profile (top left), temperature vertical profile (top right) and equitable threat score for 12H accumulated precipitation (bottom) in all the domain for all runs 00H , 06H, 12H and 18H.

(a) (b)

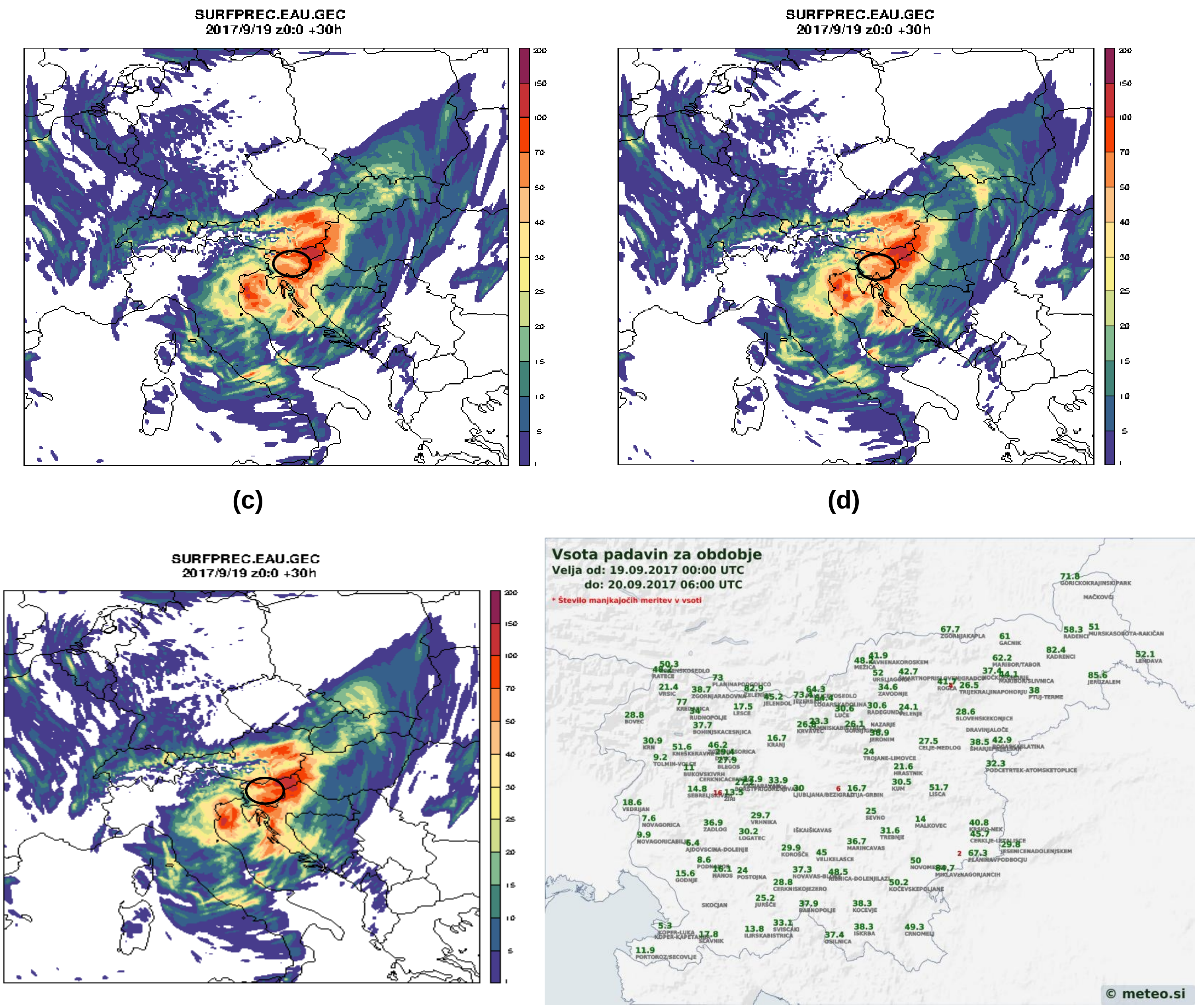

Figure 7: Case Study 19/09/2017 over Slovenia , 30 H accumulated rain for , respectively from upper left to lower right , the reference, warm start experiment, passive experiment and rain gauge observation.

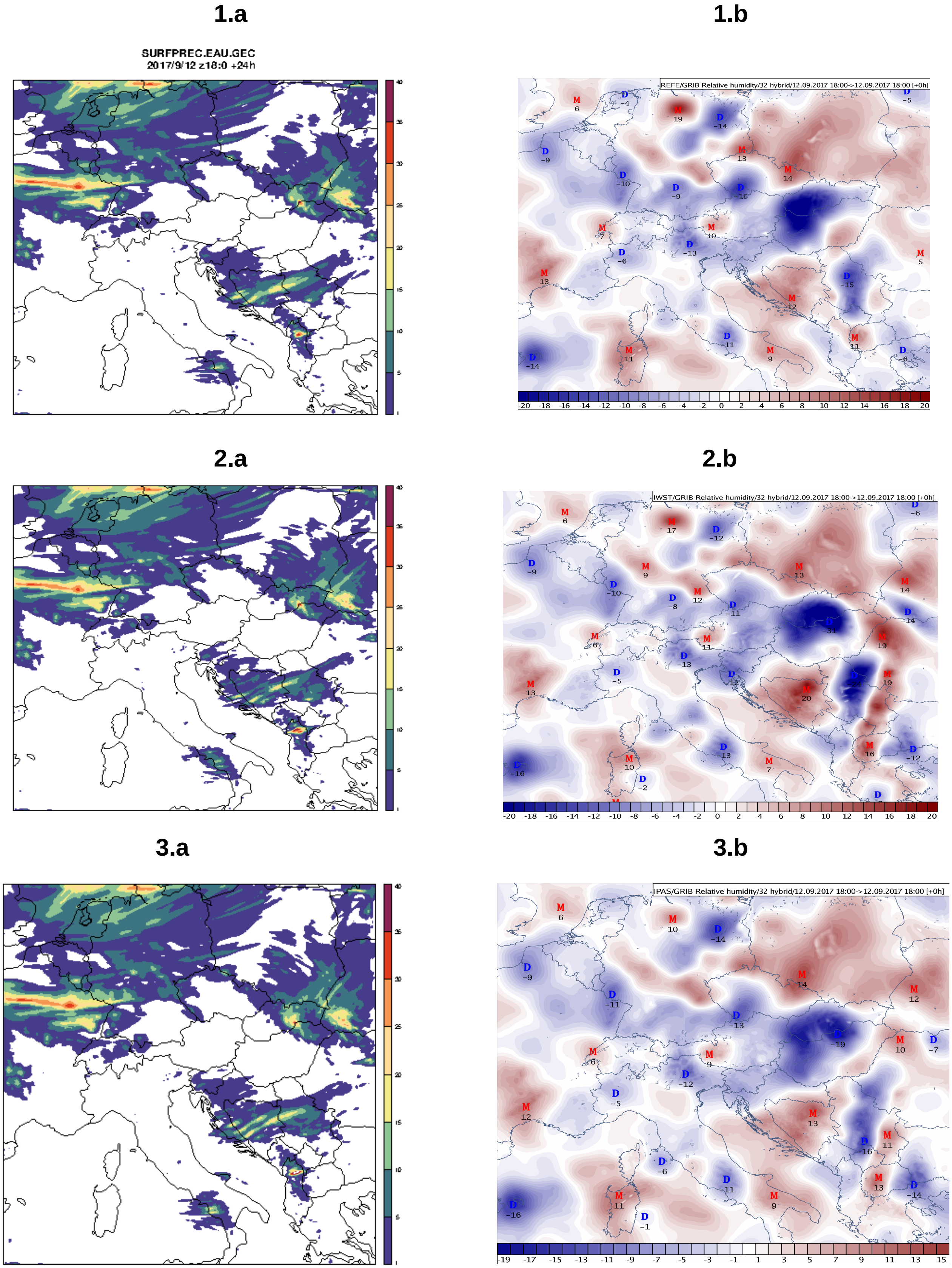

Figure 8: Case study 12/09/2017 - 24H Accumulated rain for the reference (1.a), Warm start experiment (2.a) and Passive experiment (3.a) and their humidity increment at run 18H (respectively 1.b , 2.b and 3.b)

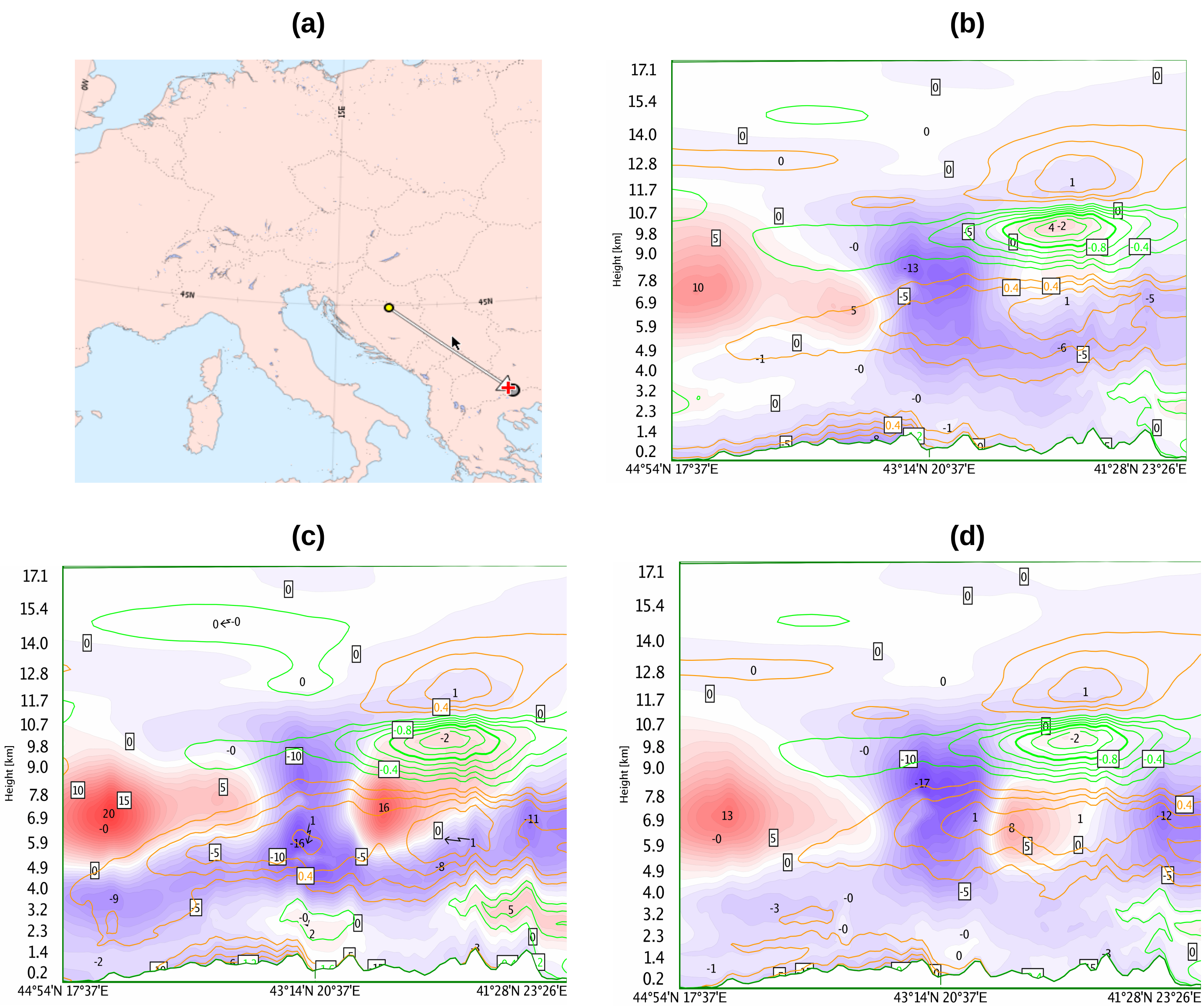

Figure 9: Case study 12/09/2017 - Relative humidity increment cross section (a) for the reference (b), Warm start experiment (c) and Passive experiment (d) at run 18H

4. Summary

During this stay, IASI assimilation was implemented and tested with ALARO 3DVar Data Assimilation System in ARSO.

Regarding VarBC “warm-up”, coldstart initialization approach for the variationnal bias correction (with both active and passive mode) requires more than 2 months to get the bias corrections stabilized. However the warmstart experiment with VarBC cycling, converged faster and presented stabilized bias corrections after 1 month of “spin-up”.

Even though there was no significant difference or clear tendency with the verification scores when comparing operational, warmstart and passive experiments, we can notice an impact of IASI on moisture but this behavior need to be confirmed with studying bigger sample.

In this preliminary work, we started by the default IASI channel selection already assimilated in other LACE NWP systems. Further investigations with focus on channel selection, especially for the HO2 band, can bring more insight in IASI impact.

Acknowledgments:

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References:

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