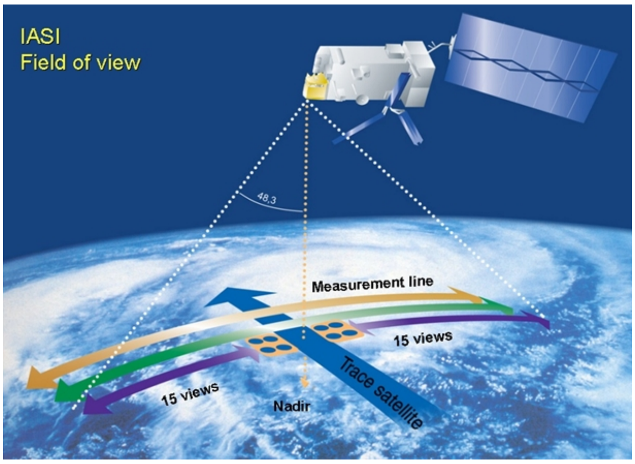
Assimilation of IASI data

report from LACE stay in Budapest, 3/10/11-17/11/11

Scientific supervisor:
Roger Randriamampianina



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Contents

1 Introduction

The Infrared Atmospheric Sounding Interferometer (IASI), is a key payload element of the Metop series of European meteorological polar satellites. It was developed by CNES in the framework of a cooperation agreement with EUMETSAT. The instrument has been designed for operational meteorological soundings with a very high level of accuracy, contributing to improved weather forecasting as well as climate monitoring and atmospheric chemistry (for more details see EUMETSAT web pages).

IASI radiances are being successfully assimilated in several NWP centers, see for example the overview by Hilton et al (2010), Collard and McNally (2009), Guidard et al (2010) or Randriamampianina et al (2011). The aim of this study was to gain experiences with hyper-spectral sounder data assimilation in ALADIN 3D-VAR system at Hungarian Meteorological Service (HMS). In following sections a monitoring of observation and an impact study are presented and the last section brings a summary.

2 Data monitoring

A set of 366 channels available through EUMETCAST (or from September 2011 also provided to LACE Members via OPLACE) was used for this study, more details of this selection can be found in Collard (2007) and Collard and McNally (2009). One field of view (FOV) of the four available from each field of regard collocated with the one corresponding to AMSU-A FOV was used. Note that IASI were assimilated also in the presence of cloud, the cloud detection scheme of McNally and Watts (2003) was used, where active channels having peak above the cloud top are assimilated.

The first part of this study was dedicated to the testing of IASI data treatment by ALADIN 3D-VAR system and validation of diagnostics tools for the data monitoring. Technical details (scripts, tools and source code modifications) are summarized in Appendix. Here follows the summary of the first experimental set-up of passive IASI data assimilation **EZ04**. The idea was to monitor the data quality with respect to current operational system used in HMS. New data (comprising IASI from METOP and also ATOVS from METOP and NOAA 19) were added to the system and observation statistics were evaluated. Here follows an overview of satellite treatment used in the passive IASI test:

- all IASI channels were assigned flag EXPERIMENTAL in mf_blacklist.b file (to become passive)
- almost all FOV were used for ATOVS (except 3 resp. 9 closest to the edges for AMSU-A and AMSU-B respectively) and one FOV of the four for IASI was used, this specification is illustrated on Figure 1
- to save CPU time only screening and minimization were computed starting always from operational analyses with all the data (operational and new ones) for period from 6 August 2011 till 30 August 2011
- variational bias correction (VARBC) started from zero (no input files provided for the first day) and 24H VARBC cycling was considered

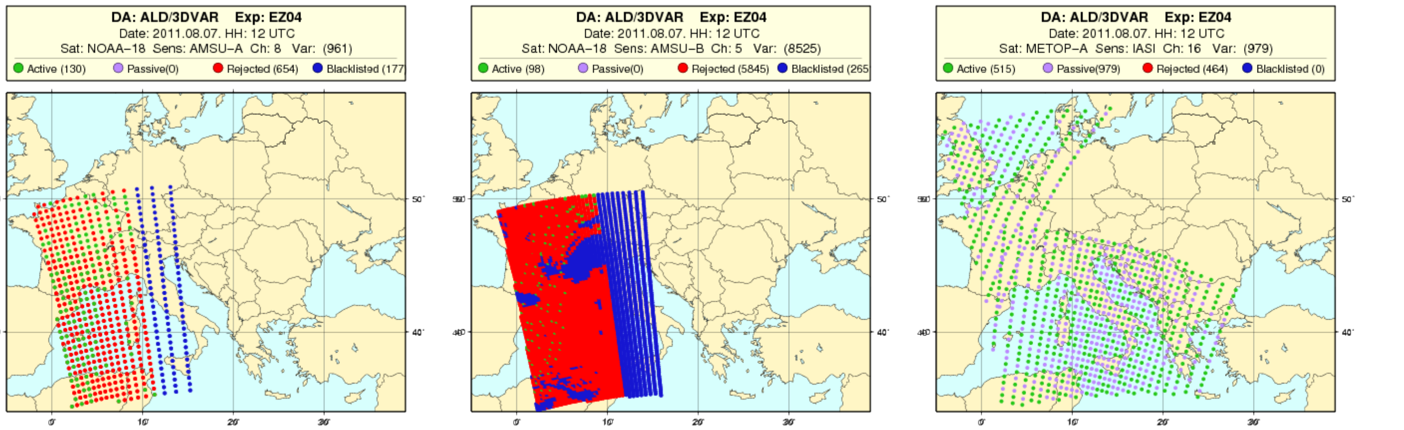


Fig. 1: Illustrative overview of data coverage for ATOVS for NOAA 18 and IASI from METOP.

The observation statistics comprises bias and standard deviation of observation departures (with respect to the first guess and analysis) and number of active observations. Vertical profile and time series of observation departures were monitored mostly. The following figures show the vertical profiles for AMSU-A and IASI and a selection of time series for randomly chosen channels.

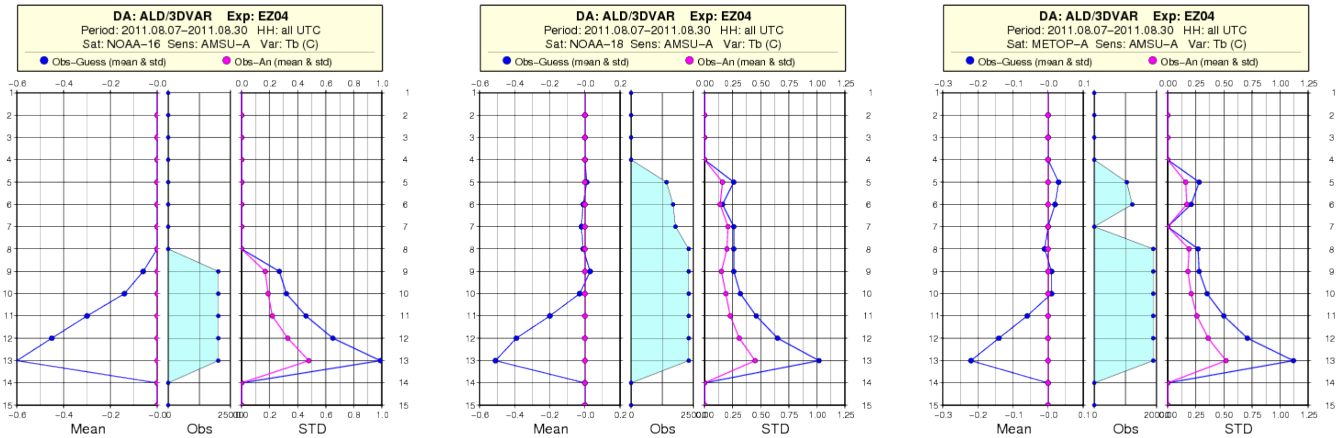


Fig. 2: Vertical profile of observation statistics for AMSU-A of NOAA-16, NOAA18 and METOP

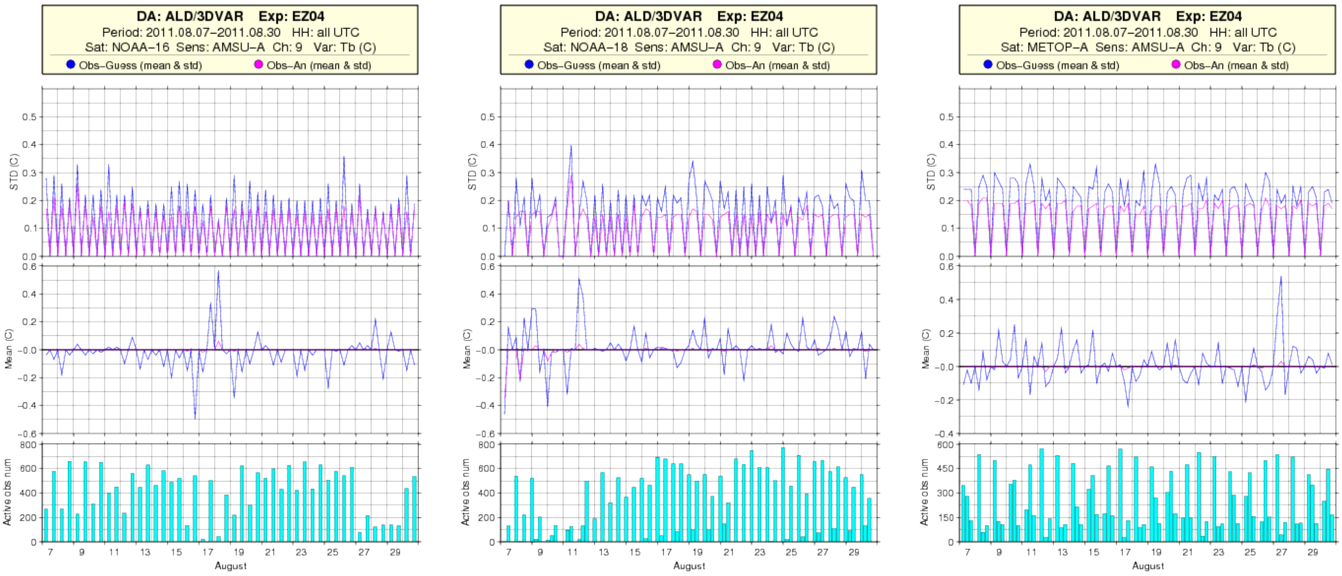


Fig. 3: Time series of observation statistics for AMSU-A **channel 9** of NOAA-16, NOAA18 and METOP

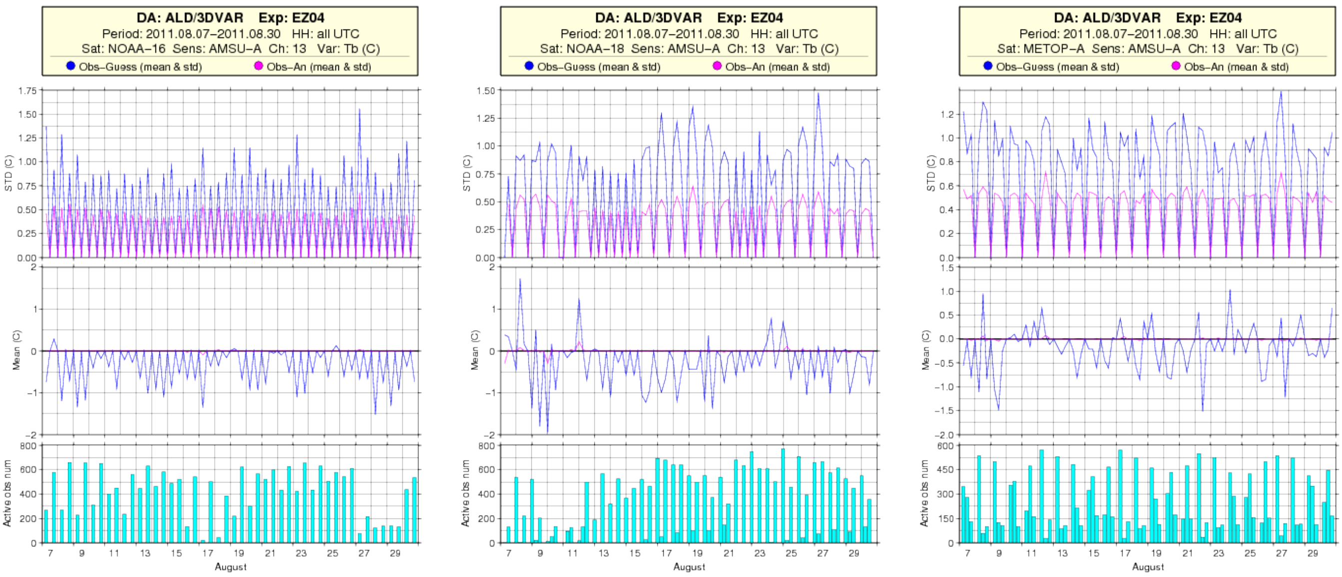


Fig. 4: Time series of observation statistics for AMSU-A **channel 13** of NOAA-16, NOAA18 and METOP

There is apparent an increase of bias and standard deviation for higher peaking channels 11, 12 and 13. The time series show very small bias for channel 9 of NOAA 16, after short spin-up period quite stable small bias for NOAA 18 and slightly bigger for METOP. There prevails considerable negative bias for channel 13 of all satellites.

The time series statistics especially are quite surprising. Taking into account that we attempted to perform coldstart for VARBC (we did not provided any VARBC.cycle file at the beginning of the experiment 20110806 and so no data passed screening and this first day was skipped from the monitoring figures), already second day of the cycling 20110807 we found quite good fit with respect to the provided background fields (operational guesses). It is an open question, if there is an error in the experiment or our expectations based on results of Randriamampianina et al (2011). Possible explanation could be that used first guess is very close to most of the radiances and/or VARBC is tuned to converge very fast. Unfortunately even further tests didn't bring any clear explanation of this behavior.

The observation statistics for IASI data, which were of our main interest, are presented on following Figures 5-7. As the first approximation we focused on temperature sounding CO2 channels (wave number interval from 648.75 to 744 cm^{-1}, which corresponds to channel numbers from 16 up to 400). The vertical profiles shows quite small bias and standard deviation except for a few channels. The time series exhibit similar behavior (close fit to the background after single analysis with VARBC starting from zero) as AMSU-A.

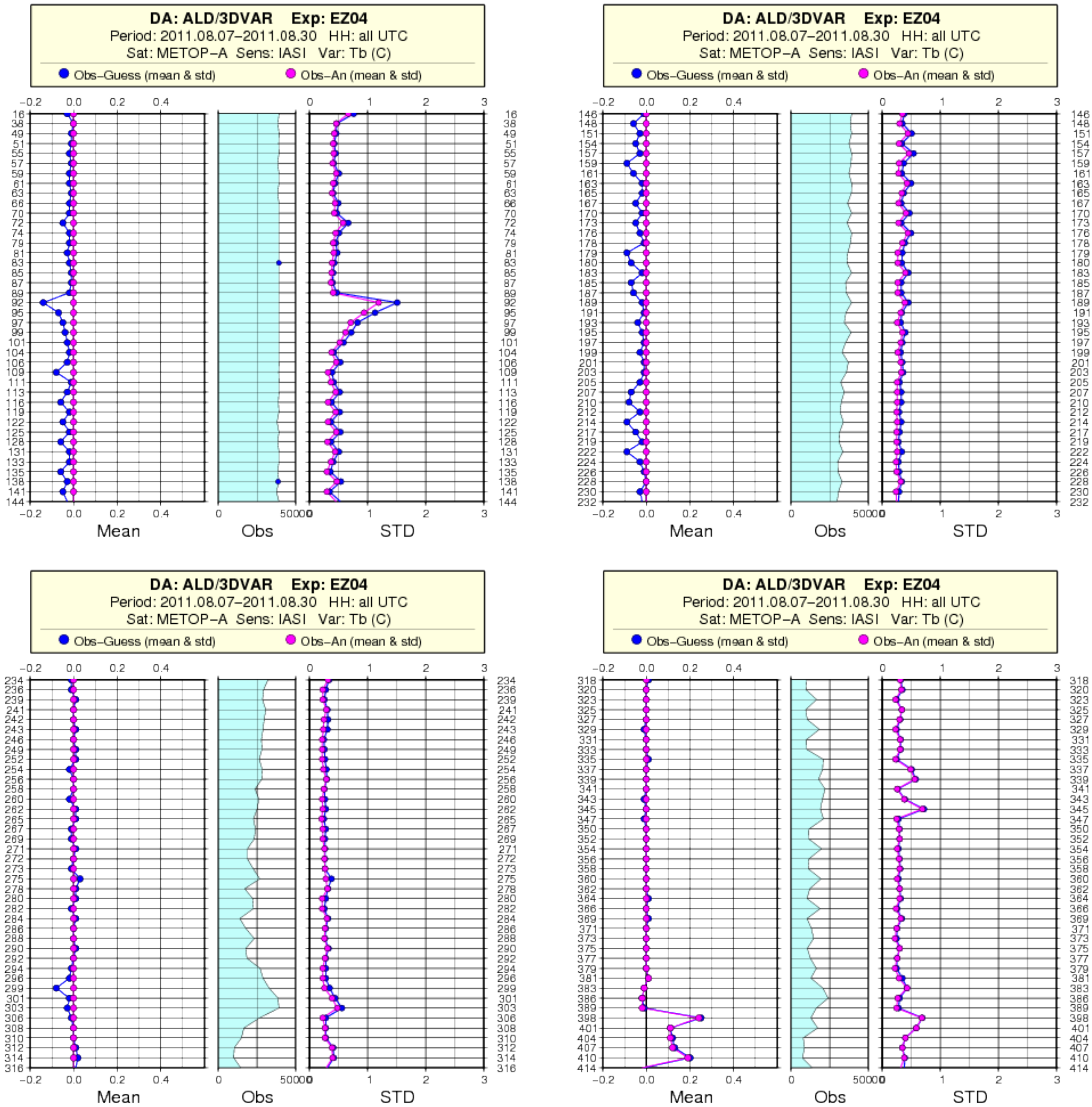
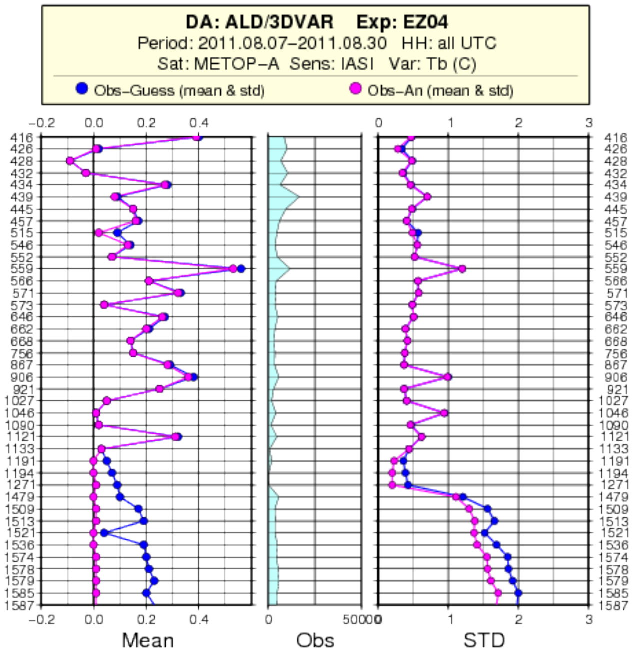
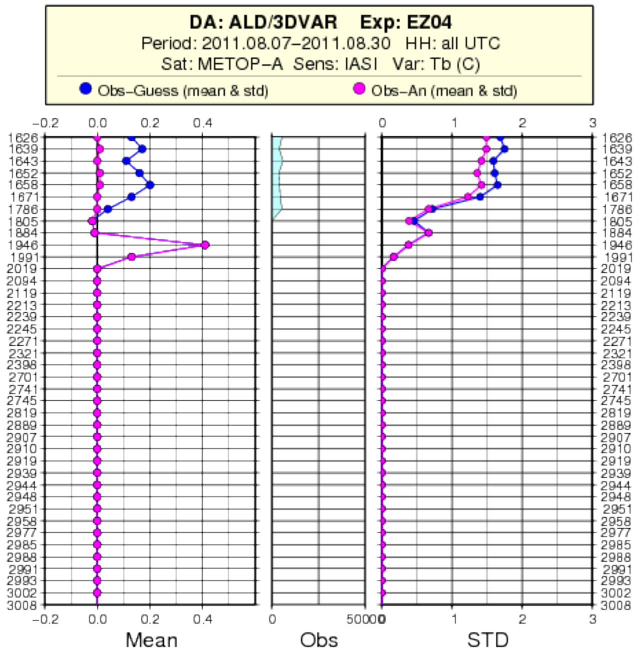


Fig. 5: Vertical profile of observation statistics for IASI on METOP


DA: ALD/3DVAR Exp: EZ04
Period: 2011.08.07–2011.08.30 HH: all UTC
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD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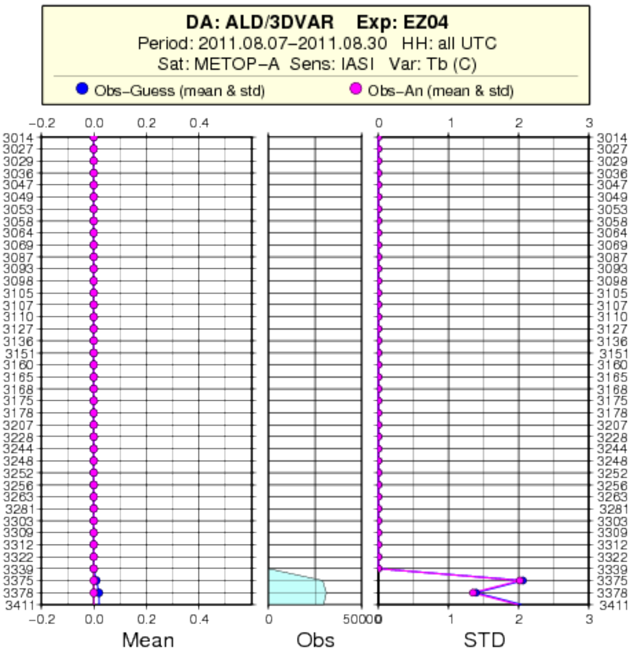
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD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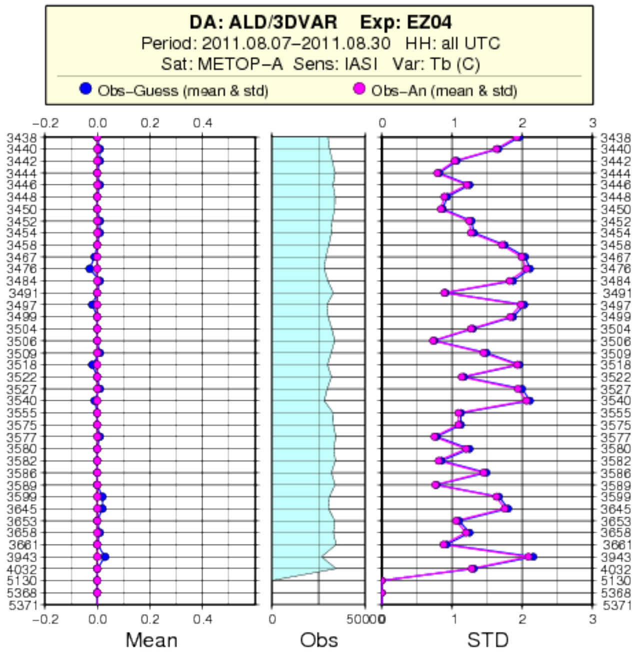
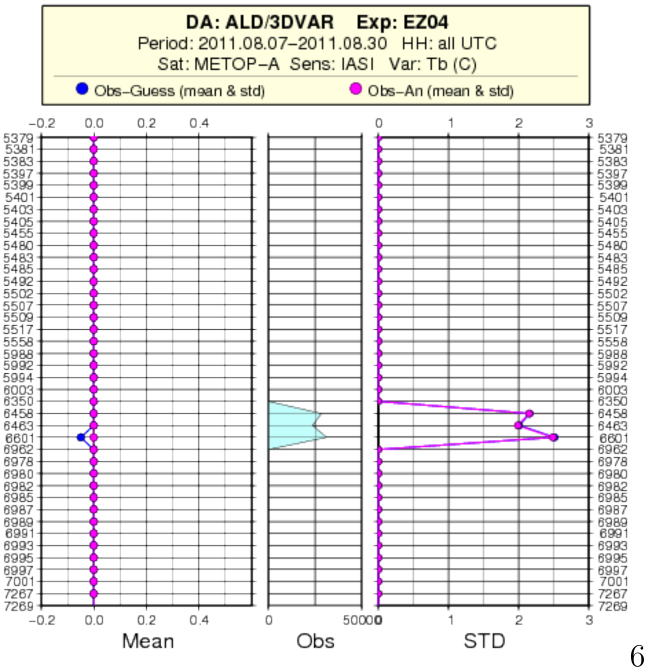
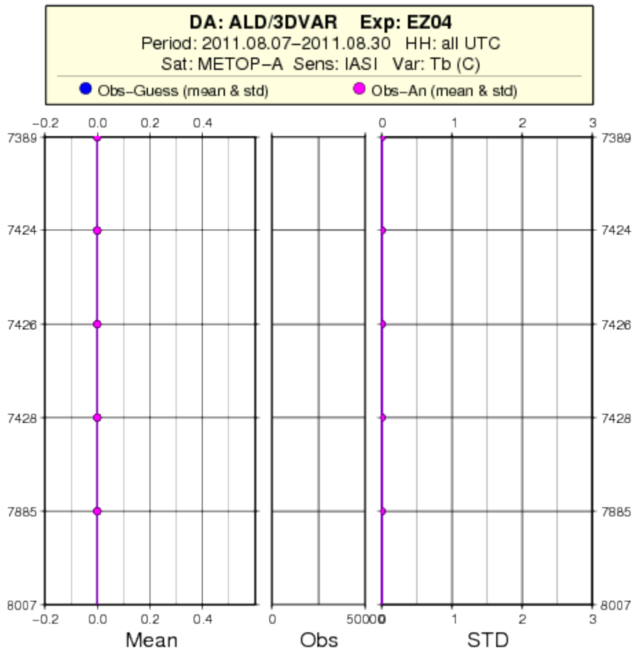
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD


DA: ALD/3DVAR Exp: EZ04
Period: 2011.08.07–2011.08.30 HH: all UTC
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD


DA: ALD/3DVAR Exp: EZ04
Period: 2011.08.07–2011.08.30 HH: all UTC
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD


DA: ALD/3DVAR Exp: EZ04
Period: 2011.08.07–2011.08.30 HH: all UTC
Sat: METOP–A Sens: IASI Var: Tb (C)
Obs–Guess (mean & std)
Obs–An (mean & std)
Mean
Obs
STD

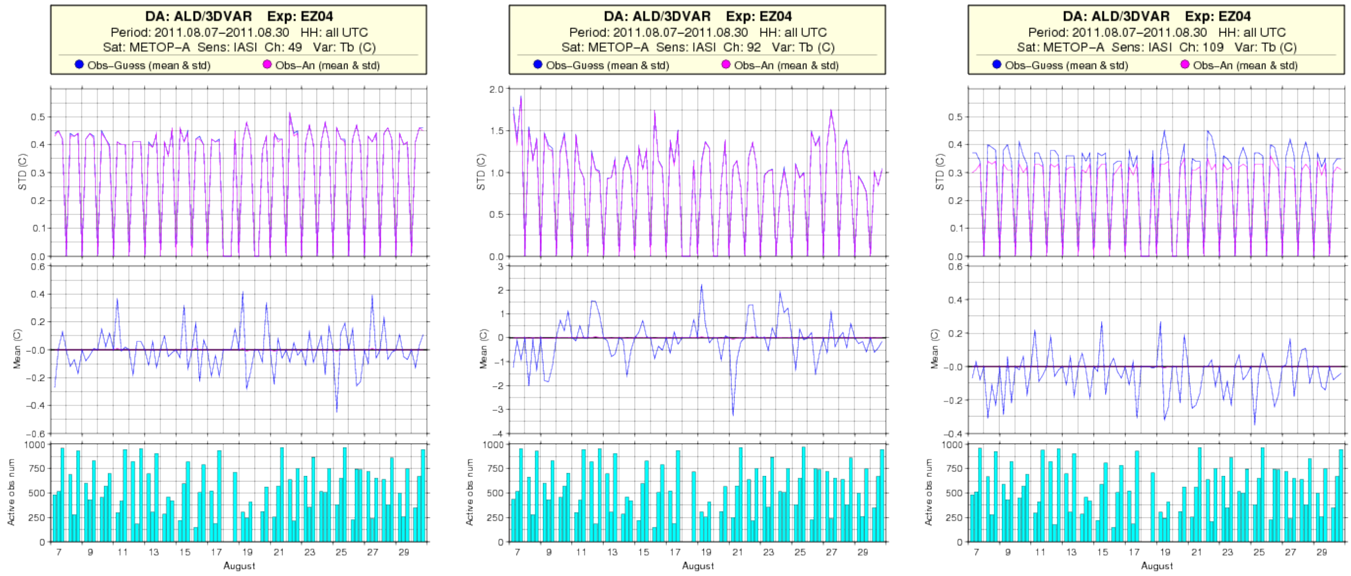


Fig. 6: Time series of observation statistics for IASI on METOP for channels **49, 92 and 109**

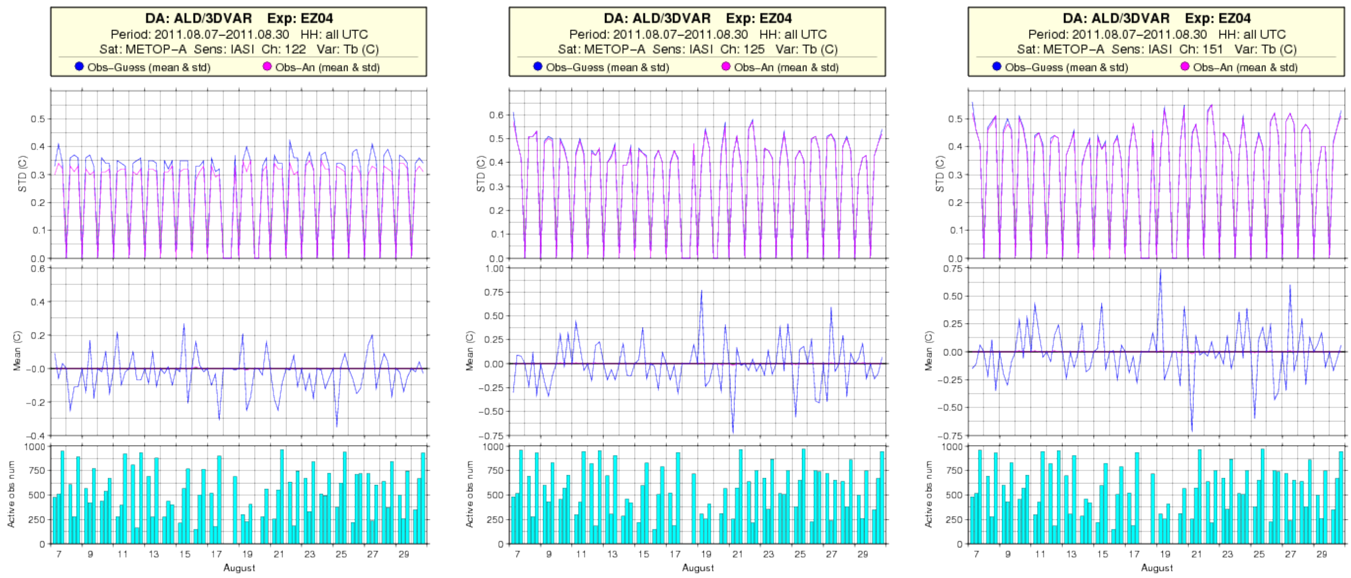


Fig. 7: as above but for channels **122, 125 and 151**

We have evaluated also statistics for land and sea pixels separately (using tools kindly provided by R. Randriamampianina). No particular signal for sea or land pixel was found, so just for illustration channel 16 and 49 are presented.

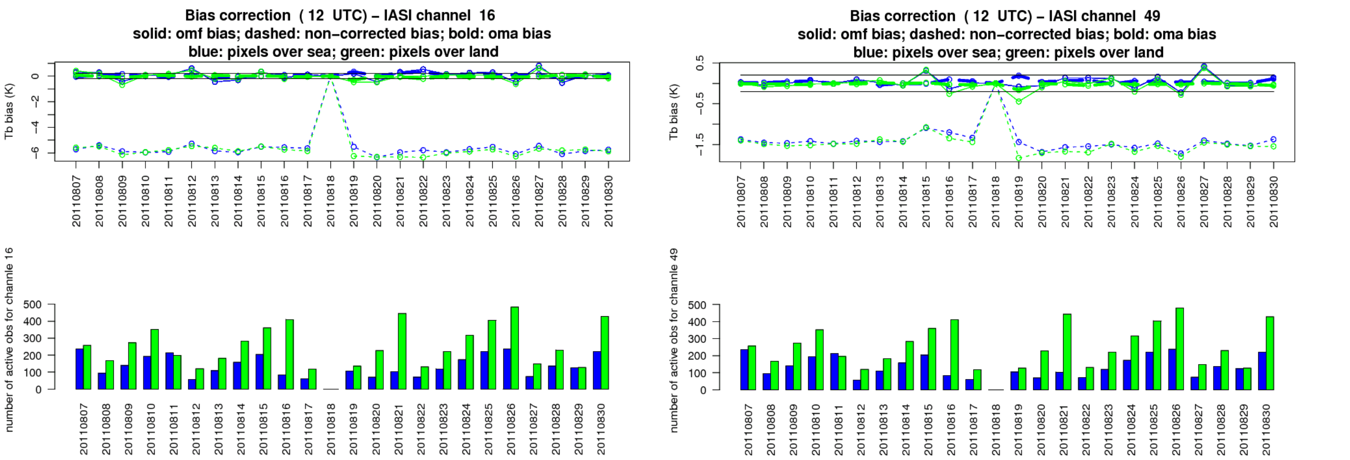


Fig. 8: Time series of corrected (solid) and non-corrected (dashed) departures [K] and number of active pixels for over land (green) and sea (blue) of channels **16** and **49** at 12 UTC analysis time.

3 Channel selection

The data monitoring showed quite close fit to the first guess, so no particular strategy for channel selection was considered. Also due to lack of time we rely on Randriamampianina et al (2011) selection, which can be summarized as follows:

- channels **70,133,154,180,214,217,219,301,303** used over land
- channels **49,51,66,70,83,109,122,125,128,131,133,135,141,144,148,151,154,159,161,165,167,180, 185,189,193,201,203,207,214,217,219,222,224,226,228,230,232,236,299,301,303** used over sea
- no channel used over sea ice

4 Impact studies

The impact of IASI data assimilation was evaluated for one month period of September 2011. The objective scores (BIAS,RMSE and STDE) with respect to SYNOP and TEMP observations were computed for +48H forecast starting from 00 UTC short cut-off analyses. Both short and long cut-off cycle were considered in the experiments. A reference experiment with a new ARPEGE/IFS cycle **Ref36New** as close as possible to operational setting was computed (as IASI development was available on CY36T1, more details can be found in Appendix). And following revision of ATOVS data usage (summarized in Table 1 and Table 2) was introduced in the experiments. Unfortunately due to a bug in blacklisting (LISTE_LOC files) HIRS sensor and SEVIRI channels 4,6, and 7 were active, while operationally they are blacklisted (so just for completeness Table 3 shows used HIRS channels selection). As the same error is in both reference and IASI run, we can still evaluate relative impact of IASI from those experiments.

	00 UTC	06 UTC	12 UTC	18 UTC
NOAA-16	–	9 to 12	–	9 to 11
NOAA-18	5 to 11	–	7,9 to 12	–

Table 1: AMSU-A channel numbers used for given analysis times and satellites, no ATOVS from NOAA-15, NOAA-17, NOAA-19 and METOP were considered in experiments.

	00 UTC	06 UTC	12 UTC	18 UTC
NOAA-16	–	3	–	3
NOAA-18	3,4	–	3,4	–

Table 2: AMSU-B/MHS channel numbers used for given analysis times and satellites, no ATOVS from NOAA-15, NOAA-17, NOAA-19 and METOP.

	00 UTC	06 UTC	12 UTC	18 UTC
NOAA-16	–	4 to 7,11,12,14,15	4 to 7,11,12,14,15	4 to 7,11,12,14,15
NOAA-18	4 to 7,11,12,14,15	4 to 6, 12,15	4 to 7,11,12,14,15	–

Table 3: HIRS channel numbers used for given analysis times and satellites, no data from NOAA-15, NOAA-17, NOAA-19 and METOP.

The IASI experiment **IASI36b** differs from the reference only in adding predefined IASI channels and in the variational bias correction starting file (VARBC.cycle from passive IASI run, detailed in previous section, it was used in order to have VarBC coefficients for IASI up to date).

Finally we have decided to perform new reference **Ref36NewBf** and IASI experiment **IASI36c** with HIRS and SEVIRI blacklisted. The **IASI36c** differs from the reference only in adding predefined IASI channels and in the variational bias correction starting file (VARBC.cycle from passive IASI run, detailed in previous section, it was used in order to have VarBC coefficients for IASI up to date).

List of the experiments is as follows:

- **Ref36New** reference experiment (labeled as E36N in VERAL scores and as EZ06 in monitoring statistics)
- **IASI36b** experiment (labeled as I36b in VERAL scores and as EZ07 in monitoring statistics)
- **Ref36NewBf** reference experiment with HIRS and SEVIRI blacklisted (labeled as E36B in VERAL scores)
- **IASI36c** experiment with HIRS and SEVIRI blacklisted (labeled as I36c in VERAL scores)

4.1 The impact on analyses

The observation monitoring statistics were checked to take control of analysis performance. Here only a sample of IASI statistics is presented. There is apparent almost no BIAS with respect to analysis and reduced values of analysis standard deviation.

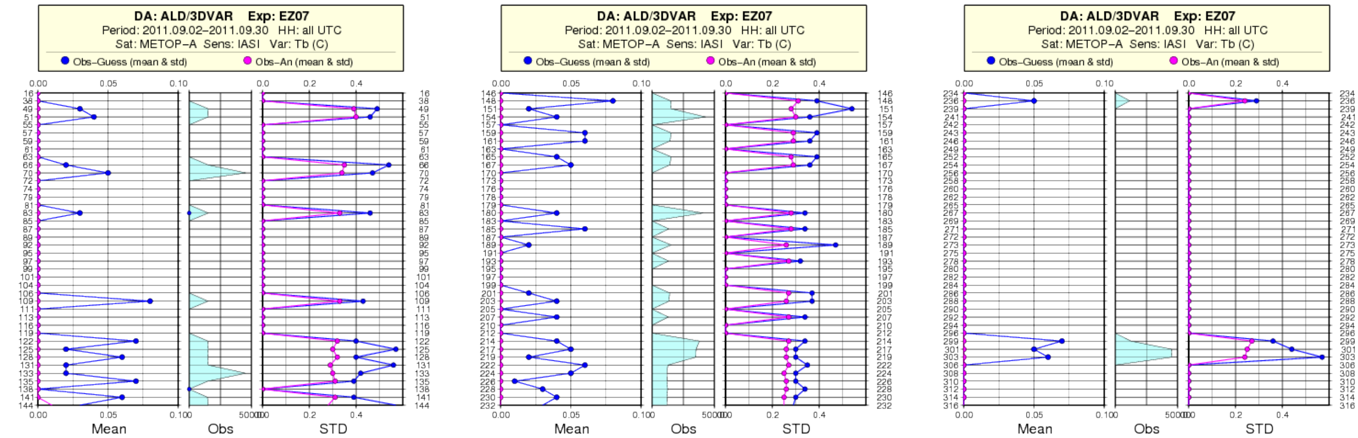


Fig. 9: Vertical profile of observation statistics for IASI on METOP

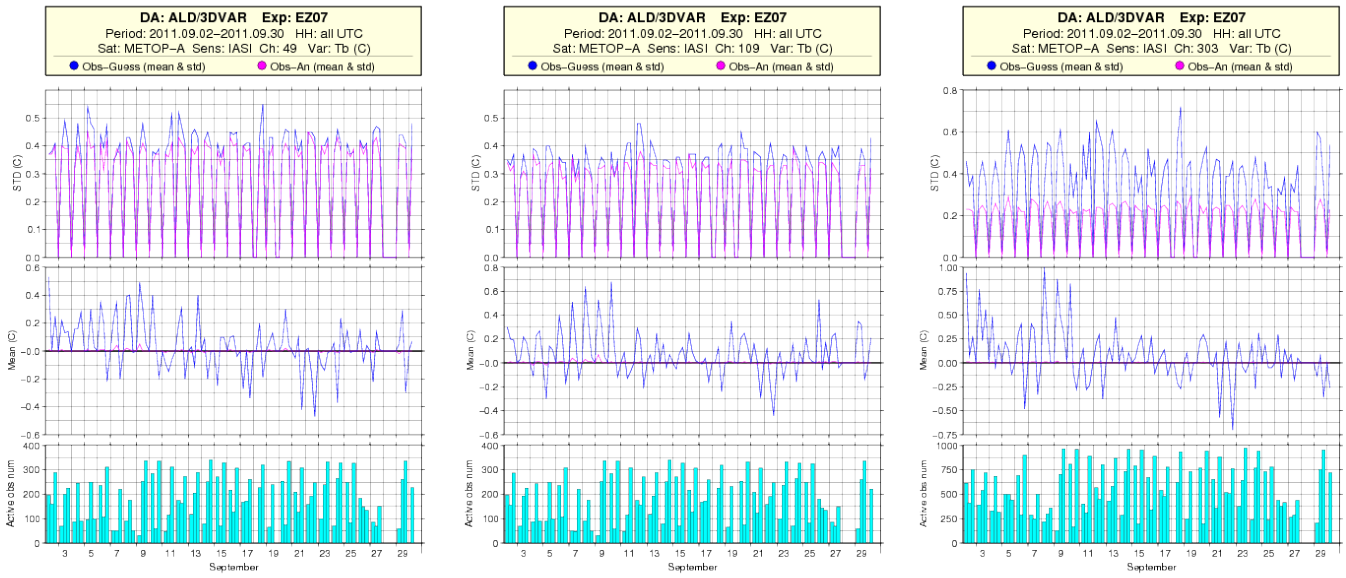


Fig. 10: Time series of observation statistics for IASI on METOP for channels **49, 109 and 303**

4.2 The impact on forecasts

The objective scores (BIAS,RMSE and STDE) with respect to SYNOP and TEMP observations were computed for +48H forecast starting from 00 UTC short cut-off analyses. On following figures the RMSE differences of the IASI36b experiment and corresponding reference scores are displayed. The impact of predefined IASI channels is quite small, more or less neutral, although for some parameters and forecast ranges both significantly positive and negative differences were found. The negative impact is in upper levels mostly for relative humidity during the first 12H of the forecast and the geopotential for various levels (500, 700, 50,30 hPa). No impact was found for the screen level parameters, see Fig 13.

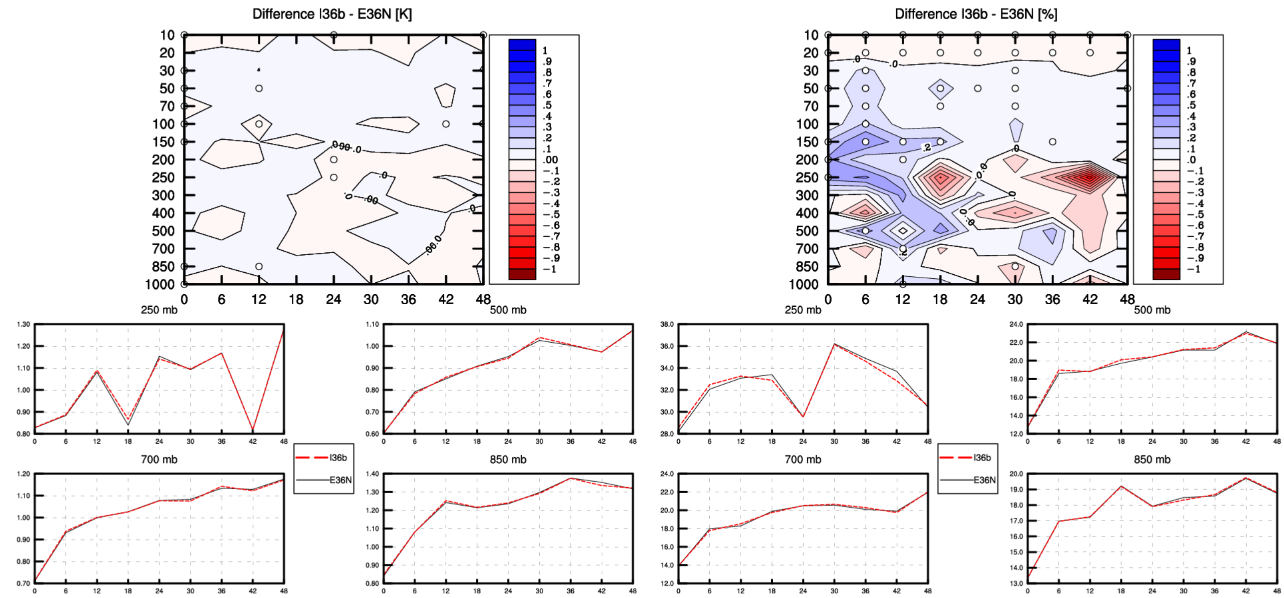


Fig. 11: RMSE differences against observation of T (left) and RH (right), red areas denote positive impact of IASI assimilation (**IASI36b**). The white circles point that RMSE difference is better/worse with significance 95% two-side confidence interval.

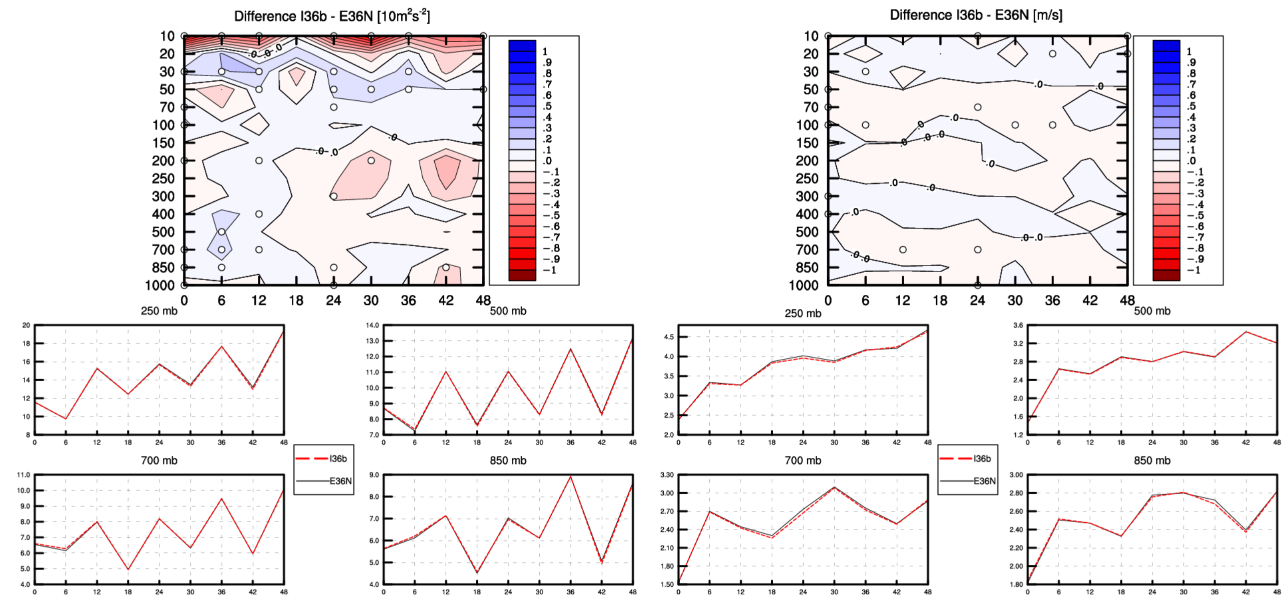


Fig. 12: RMSE differences against observation of ϕ (left) and wind speed (right), red areas denote positive impact of IASI assimilation (**IASI36b**). The white circles point that RMSE difference is better/worse with significance 95% two-side confidence interval.

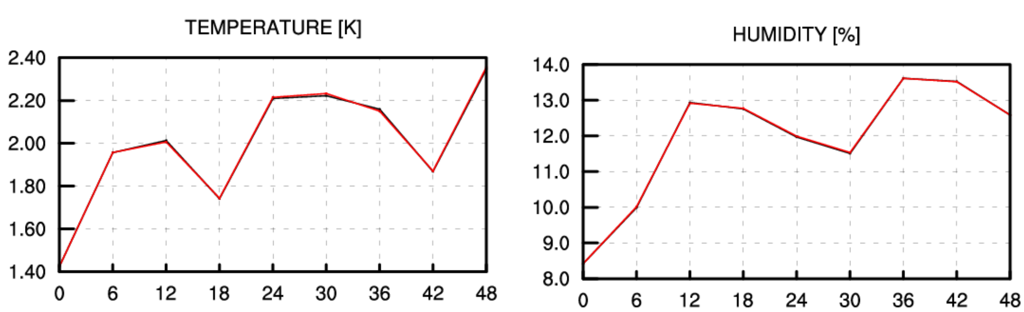


Fig. 13: RMSE against observation of $T2m$ (left) and $RH2m$ (right), reference **Ref36New** in black and IASI experiment (**IASI36b**) in red.

Qualitatively the same results were found also in corrected experiments (with HIRS and SEVIRI assimilation suppressed), see Fig 14.-15. The impact of IASI data in this setting seems slightly better for the relative humidity and the geopotential, but the overall impact is again rather small and more or less neutral.

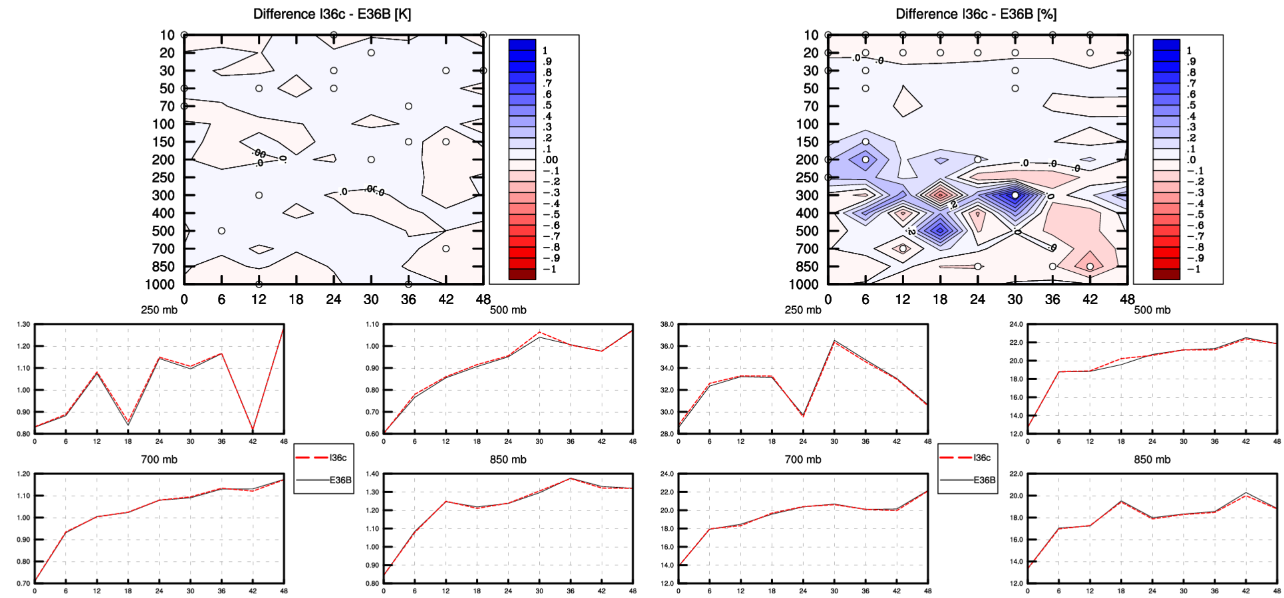


Fig. 14: RMSE differences against observation of T (left) and RH (right), red areas denote positive impact of IASI assimilation (**IASI36c**). The white circles point that RMSE difference is better/worse with significance 95% two-side confidence interval.

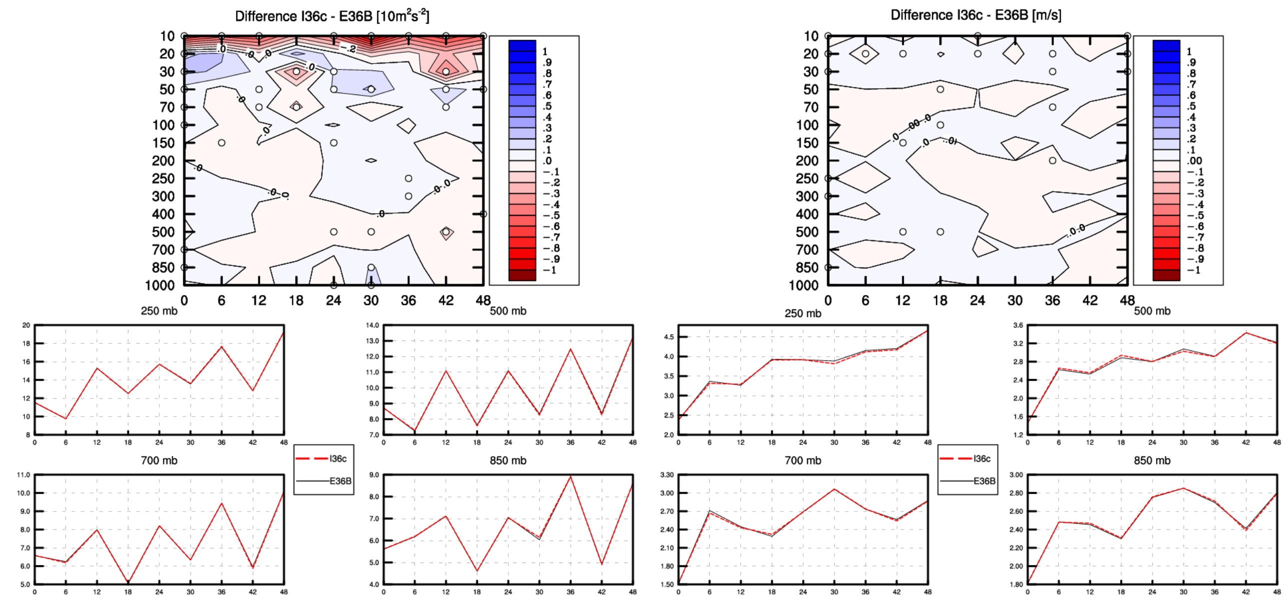


Fig. 15: RMSE differences against observation of ϕ (left) and wind speed (right), red areas denote positive impact of IASI assimilation (**IASI36c**). The white circles point that RMSE difference is better/worse with significance 95% two-side confidence interval.

5 Summary

The assimilation of IASI data was tested technically with the ALADIN 3D VAR data assimilation system installed at HMS. Available IASI data were monitored with respect to the operational first guesses. The monitoring showed that the corrected first guess departures are after single analysis update of VARBC ! quite close to zero and that the uncorrected first guess departures have much larger values than the similar monitoring results at Norwegian Meteorological Institute (Roger personal communication). The reason of such behavior is still not clear to us.

The impact study with IASI data was performed, no particular strategy for channel selection was considered and as starting point Randriamampianina et al (2011) channel selection was used. The impact was found to be more or less neutral, although for some parameters and forecast ranges both significantly positive and negative differences were found. We should keep in mind that the domain of our interest is covered mostly by mainland and the selection take in account only 9 channels over land. And also that we verified only 00 UTC forecasts, when no IASI data are available over our domain of interest and an influence is comming through the guess only.

We should consider the results as an encouraging starting point of potential development on the field of IASI data assimilation and further elaboration of full potential of the IASI data usage is essential.

Acknowledgment
The author wishes to thank Roger Randriamampianina for his kind supervising of this work and all NWP group for their warm welcome and hospitality. This work was made possible by the financial support of the LACE (Limited Area model for Central Europe) project.

References

EUMETSAT *http://www.eumetsat.int/Home/Main/News/Features/716376?l=en*
Guidard V., Brusseau P, Fouriee N, Rabier F, 2010: Impact of IASI assimilation in convective scale model AROME, *2nd International IASI Conference, Annecy, France. 25-29 January 201*
http://smsc.cnes.fr/IASI/PDF/conf2/session3/Guidard.pdf
F. Hilton, A. Collard, V. Guidard, R. Randriamampianina and M. Schwaerz 2010: Assimilation of IASI Radiances at European NWP Centers, *Proceedings of ECMWF/EUMETSAT NWP-SAF Workshop on the assimilation of IASI in NWP, 6-8 May 2009* http://www.ecmwf.int/publications/library/do/references/list/17784
Randriamampianina R., T. Iversen and A. Storto, 2011: Exploring the assimilation of IASI radiances in forecasting polar lows *Q.J.R. Meteorol. Soc.*: DOI: 10.1002/qj.838
AD. Collard, 2007: Selection of IASI channels for use in numerical weather prediction *Q.J.R. Meteorol. Soc.* **133**:1977-1991
Collard AD, McNally AP, 2009: The assimilation of Infrared Atmospheric Sounding Interferometer radiances at ECMWF *Q.J.R. Meteorol. Soc.* **135**:1044-1058
Storto A and Randriamampianina R, 2009: The relative impact of meteorological observations in the Norwegian regional model as determined using an energy norm-based approach *Atmos. Sci. Lett.* **11**:51-58

Appendix

A Adaptation of assimilation scripts

The scripts were adapted from SMS based experiment Alaro kindly provided by Gergely Bölöni, which includes both short and long cut-of assimilation and 48H production forecast at 00 UTC only. For validation of this environment experiment **Ref35** was created in order to reproduce current operational setting. Using operational namelist and executables and with following modifications:

- reorganization of SMS directory structure into one directory

```
trojakova@wfma: ~/SMS/$EXP1/bin
                           /include
                           /nam
                           /scr
```

- update of the paths in include/variables.h
- added task getoperdata/getdata.sms to get data from long-term archive
- change of climatological files (in all necessary tasks) from lin_mean to lin only.
- LBC treatment, following condition was suppressed

```
if [[ $fh = "06" ]] ; then
 fp_data=${d_LOCDATA}/obs/${n6_yy}/${n6_mm}/${n6_dd}/${n6_time}/ICMSHGLOB+000
fi
```

- special DFI treatment for Alaro was removed (alad001.sms)
- added new environment variable necessary from CY36 for prepobs, screening and minimization and slight update of namelist treatment and param files (param.cfg and iasichannels)

```
export ODB_FEBINPATH=
ODB_FEBINPATH=${d_BIN}
```

- increase of number of processors to 48
- manually inserted operational guess for the first long cutoff assimilation of 20110611 00 UTC, as default SMS suite uses as the very first guess 6H integration without any data assimilation

```
cd ~/workdir/SMS
mkdir -p work/Ref35/Aladin/assim/guessdir
cd work/Ref35/Aladin/assim/guessdir
cp ~/workdir/SMS/operdata/obs/2011/06/10/18/ICMSHALAD+0006 guess_2011061100
```

it was possible to reproduce operational results before the implementation of the lake temperature change (which was skipped due to technical difficulties to get archived observation). Listings of canari and minimization were checked for 3 subsequent analysis (both short and long cut-off) with respect to operational suite for 20110611. Listings have shown bit identical results and based on that the SMS environment was assumed to be ok.

As IASI development is supposed to be available from CY36 only, a new reference experiment named **Ref36New** was created. The Ref36New was based on Ref35 with following modifications:

- a coldstart option was suppressed and the very first guess is based on long cut-off operational analysis
- new executables based on CY36T1 were used
- some modification with respect to operational namelists were considered
  - new blocks were added for CY36 in blendsea.nml,blendsur.nml,e001.nml,namel_ee927 and namel_previ
  - more changes were done for canari,screening and minimization
    (for more details check trojakova@wfma: sms/Ref36New/nam/Aladin)
  - LISTE_LOC files were also updated (separately for each analysis time)

B Source code modification for IASI treatment

Changes in BATOR executable used in IASI experiment:

- default number of channels

```
diff inter.1/odb/pandor/module/bator_init_mod.F90 local/odb/pandor/module/bator_init_mod.F90
345c345
<     TS_IASI(xx)%t_select  =  SATOBSSEL(0,0,-9,-9,.TRUE.,314,-9,.TRUE.)
---
>     TS_IASI(xx)%t_select  =  SATOBSSEL(0,0,-9,-9,.TRUE.,366,-9,.TRUE.)
```

- fix to allow skip scan lines before Struct%SclStart given via namelist

```
  odb/pandor/module/bator_decodbufr_mod.F90 ../inter.1/odb/pandor/module/bator_decodbufr_mod.F
618,621d617
< ! atro skip scanlines before Struct%SclStart set via namelist
<  if ( Scanline < Struct%SclStart ) then
<   SelSclAndFov = .FALSE.
<  else
634d629
<  endif
```

Changes in MASTERODB executable used in IASI experiment:

- Fixes by Magnus Lindskog for Out of bounds in RTTOV preparation https://hirlam.org/trac/changeset/9527/branches/harmonie-36h1/src/arp/op_obs
- Updated VarBC coefficients, and bug-fixes by Roger Randriamampianina were used in IASI experiment https://hirlam.org/trac/changeset/8343/trunk/harmonie/src/arp/var/cvarbcin.F90
- modification of VARBC predictor number 5 due to low model top

```
  $ diff local/arp/module/varbc_pred.F90 main//arp/module/varbc_pred.F90
207,208c207
< !atro change of pred5 to 10-5hPa thickness due to low model top
< REAL(KIND=JPRB), PARAMETER   :: zplev(7)=(/5.0_JPRB,   5.0_JPRB,   10.0_JPRB,&
---
> REAL(KIND=JPRB), PARAMETER   :: zplev(7)=(/1.0_JPRB,   5.0_JPRB,   10.0_JPRB,&
277,287c276,278
< !atro based on KLMN modifs from cy35t1_top.01
<     IF(ilev<=1) THEN
<       !extrapolate
<       zw1 = (zlp(ilev)-zlplev(j))/(zlp(ilev+1)-zlp(ilev))
<       zzlev(j) = zw1*(pzpp5(ipf,ilev)-pzpp5(ipf,ilev+1))+pzpp5(ipf,ilev)
<     ELSE
<       !interpolate
<       zw1 = (zlplev(j)-zlp(ilev-1))/(zlp(ilev)-zlp(ilev-1))
<       zw2 = 1.0_JPRB-zw1
<       zzlev(j) = zw1*pzpp5(ipf,ilev) + zw2*pzpp5(ipf,ilev-1)
<     ENDIF
---
>     zw1 = (zlplev(j)-zlp(ilev-1))/(zlp(ilev)-zlp(ilev-1))
>     zw2 = 1.0_JPRB-zw1
>     zzlev(j) = zw1*pzpp5(ipf,ilev) + zw2*pzpp5(ipf,ilev-1)
```

C Bator namelist

Take care of BATOR namelist setting for desired data reading. Here follows some examples for IASI data settings.

- option 1 - default setting (no specification except the number of channels, which differs from Meteo France default due to different data source)

```
&NADIRS
TS_IASI(4)%t_select%NbChannels=366,
/
```

- option 2

```
&NADIRS
TS_IASI(4)%t_select%SclStart=1,
TS_IASI(4)%t_select%SclJump=0,
TS_IASI(4)%t_select%FovInterlace=.true.,
TS_IASI(4)%t_select%TabFov(1:30)=1,5,9,13,17,21,25,29,33,37,41,45,49,53,57,61,65,69,73,
                                 77,81,85,89,93,97,101,105,109,113,117,
TS_IASI(4)%t_select%NbChannels=366,
/
```

- option 3 - selection used in tests at HMS

```
&NADIRS
TS_IASI(4)%t_select%SclStart=1,
TS_IASI(4)%t_select%SclJump=0,
TS_IASI(4)%t_select%FovInterlace=.false.,
TS_IASI(4)%t_select%TabFov(1:30)=1,5,9,13,17,21,25,29,33,37,41,45,49,53,57,61,65,69,73,
                                 77,81,85,89,93,97,101,105,109,113,117,
TS_IASI(4)%t_select%NbChannels=366,
/
```

- option 4 - Meteo France AROME setting for 366 channels

```
&NADIRS
TS_IASI(4)%T_SELECT%TABFOV=1,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,37,39,41,43,45,
                           47,49,51,53,55,57,59,61,63,65,67,69,71,73,75,77,79,81,83,85,
                           87,89,91,93,95,97,99,101,103,105,107,109,111,113,115,117,119,
TS_IASI(4)%T_SELECT%TABFOVINTERLACE=1,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,37,39,
                           41,43,45,47,49,51,53,55,57,59,61,63,65,67,69,71,73,75,77,79,81,
                           83,85,87,89,91,93,95,97,99,101,103,105,107,109,111,113,115,117,119,
TS_IASI(4)%t_select%NbChannels=366,
/
```

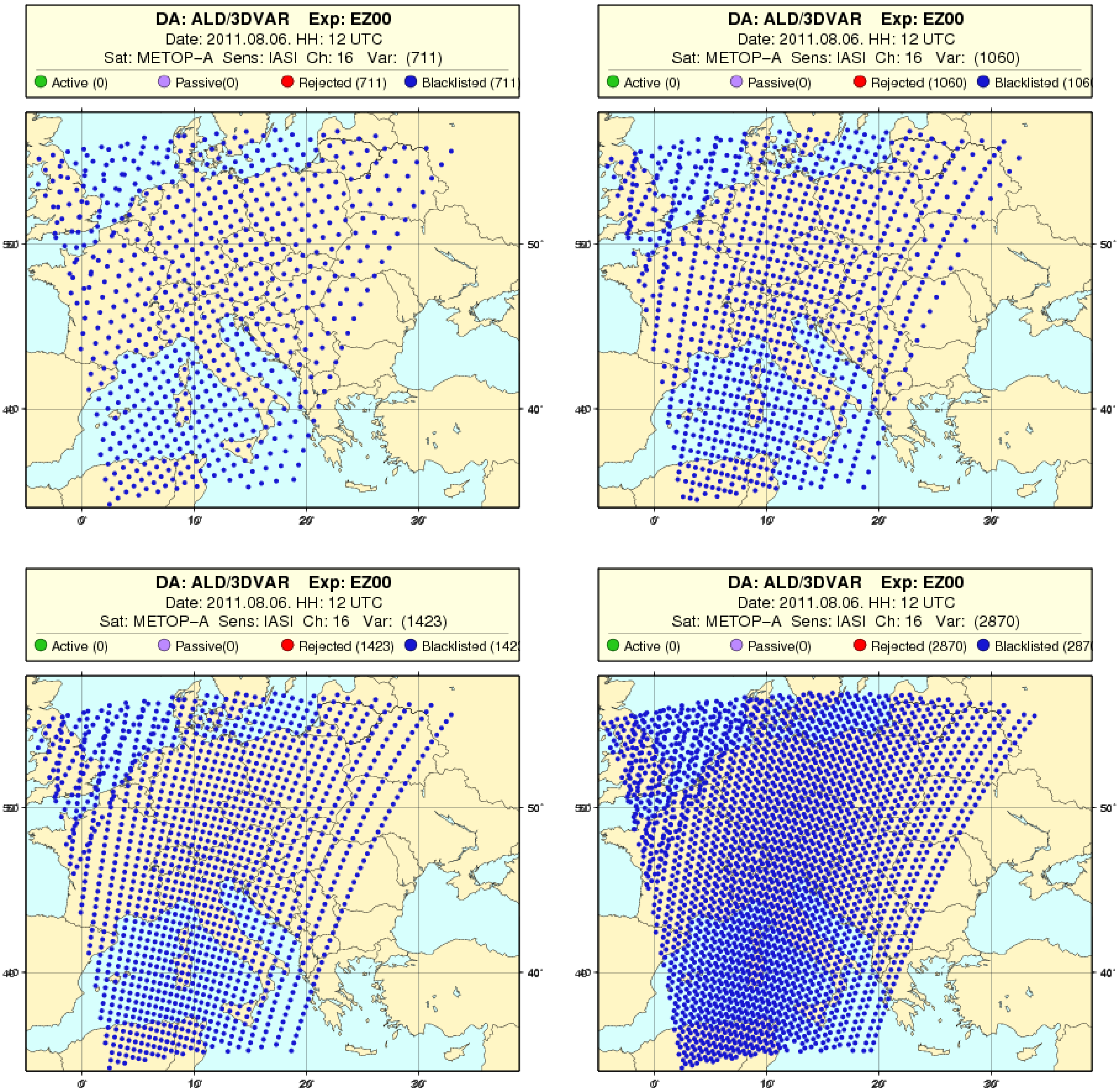


Fig. C1: IASI data selection for option 1 (top-left), option 2 (top-right), option 3 (bottom-left) and option 4 (bottom-right) as described above.

D Various tools

D.1 Monitoring tool

A tool for monitoring corrected and non-corrected observation departures separately for land and sea pixels was kindly provided by Roger Randriamampianina. The tool consists of

- an extraction of following data from CCMA database

```
  SELECT
obstype,statid, varno,press_rl,sensor,fov@atovs, an_depar, fg_depar, obsvalue,  biasctrl,
predictor[1]@atovs_pred FROM  hdr,desc,body,atovs,atovs_pred
WHERE ((varno /= 91 ) AND (an_depar is not NULL))
```

- a FORTRAN program to computing average and standard deviation of departures
- a plotting script using R software

Extraction and the statistics computation was installed on wfma in *trojakova@wfma : /home/trojakova/Monitor/*, where the extraction script **ExtractOdb_cc_landsea_separately_wkdir**, the script for statistics computations script **run.sh** and the sources **checkbias_iasi_land_sea** can be found.

The plotting scripts are available on **trojakova@blade12:/home/trojakova/bin**. where **R_ccma.sh** provide pictures for IASI data and **R_ccma_bias_amsua_lan/sea.sh** for ATOVS. Some input/output samples are available on *trojakova@blade12 : /home/trojakova/monitor/new*.

D.2 Moist total energy norm

A diagnostics of moist total energy norm based on Storto and Randriamampianina (2010) was installed. The tool consists of

- a program to compute moist total energy norm and/or its particular terms
- a program to compute total norm (NormExpVal.F90)
- a plotting script using R software

The sources were compiled using gmkpack on wfma
trojakova@wfma : /home/trojakova/pack/cy36t1_mten.01.INTEL111059.x.pack
and the sample of script to run the norm computation can be found on
trojakova@wfma : /home/trojakova/mten/comp_mten.sh.
The plotting scripts and data sample are available on
trojakova@blade12 : /home/trojakova/work/OLD_FULL_RESULTS, due to lack of time plotting was not fully tested.

D.3 Observation perturbation

A program for observation perturbation was compiled with following gmkpack *trojakova@wfma : /home/trojakova/pack/cy36t1_pertobs.01.INTEL111059.x.pack*, the executable was tested using a full assimilation script **trojakova@wfma:/home/trojakova/AladIasi/scr/iasi_006**. The result for single analysis were checked and differences of the two analyses (with and without perturbed observation) are on next Figure or in *trojakova@blade12 : /home/trojakova/pert*.

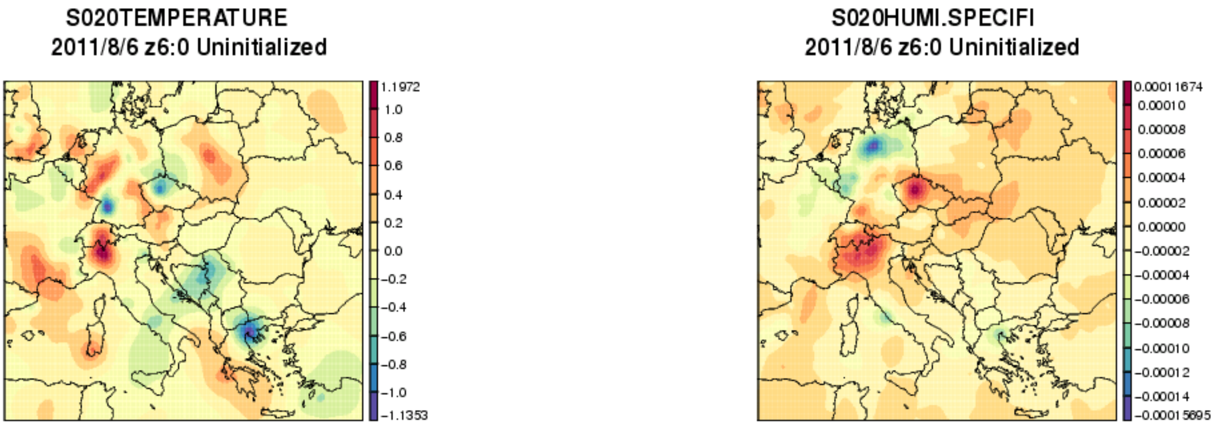


Fig. D3.1: The difference of temperature and specific humidity at level 20 for the analysis with and without perturbed observation.