Impact of IASI in HARMONIE forecasting system during convective storm events in Finland during summer 2010

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Abstract

HARMONIE (Hirlam Aladin Regional/Meso-scale Operational NWP in Europe) is a limited area non-hydrostatic NWP system for meso-scale weather events. At the Finnish Meteorological Institute it is used in its AROME (Applications of Research to Operations at MEsoscale) configuration with 2.5 km resolution. The data assimilation system in HARMONIE is 3D-Var. The first operational version of HARMONIE with 3D-Var was implemented in 2011. Work to assimilate hyperspectral observations is still going on. This study is part of the preparatory work before extensive case studies with several hyperspectral observation types.

IASI (Infrared Atmospheric Sounding Interferometer) has been shown to have a clear positive impact in global and regional models alike. In this work its impact was studied in a large Finnish domain during July and August 2010. During that period Finland was struck by several heavy convective storms causing considerable damage. The general impact of IASI is analyzed during a one month period. As a case study one of the storms is studied in detail.

The assimilated IASI channels were chosen by looking at bias time series for each channel separately. Variational bias correction scheme (VAR-BC) was applied and only channels showing reduced bias were selected. Efficiency of VAR-BC depends on the amount of observations on the model domain at the particular cycle. Since the satellite passage is almost the same every day at the same time it was possible to blacklist channels separately for each cycle. The passages with too little observations on certain channel were blacklisted. Most of the selected channels peak in stratosphere but some tropospheric channels are selected as well. The tropospheric channels are all peaking above 400 hPa to avoid contamination by surface.

The general impact of IASI in the forecasts during the one month experiment period was rather neutral. However, in the storm studied more closely IASI had a clear impact on the wind velocities. The strength and structure of the storm were forecast slightly better in the run with IASI than without IASI.

1. Introduction

Infrared Atmospheric Sounding Interferometer (IASI) on-board EUMETSAT Metop satellite is currently assimilated in most NWP centers and has been shown to have a clear positive impact in both global and limited-area models. In this work the impact of IASI is studied in the HARMONIE limited-area NWP system in a large Finnish domain.

The work consisted on three parts: 1) choosing the appropriate IASI channels for assimilation, 2) studying the general impact of IASI in the forecasts over a one month long impact study period and finally 3) looking at the impact more in detail during one storm picked as a case study.

2. HARMONIE forecasting and assimilation system

The HARMONIE data assimilation and forecasting system is a complete NWP system suitable for mesoscale forecasting at a target resolution of 2.5 km. Both the data assimilation and forecasting models are based on the ALADIN and AROME models developed at Meteo-France.

The forecasting model is a non-hydrostatic spectral model, using two-time level semi-implicit time integration and Semi-Lagrangian discretization (Benard et.al., 2010). Hydrostatic option is also available. In the horizontal direction Arakawa A-grid is used, while the vertical coordinate is the terrain following eta coordinate.

For physical parameterization the default option is to use the AROME physics (Seity et.al., 2011). The lateral boundary conditions are taken from a larger scale model, be default ECMWF forecasts are used.

The upper-air data assimilation is 3DVAR and is based on the AROME and ALADIN 3DVAR (Seity et.al., 2011). In addition to conventional observations (TEMP, SYNOP, AIREP, PILOT, SATOB, SHIP, DRIBU) the AMSU-A/ATOVS radiances over sea are used by default. Optionally, several satellite observations can be used. The background error statistics are based on ensemble method (Brousseau et al., 2008).

3. Preparation of the IASI observations

IASI observations were thinned before assimilation so that only one field of view out of four was used. The selection of assimilated IASI channels is based on the 366 channels used at ECMWF (Collard, 2007). For the sub-selection of channels a method introduced by Randriamampianina et. al (2011) was used.

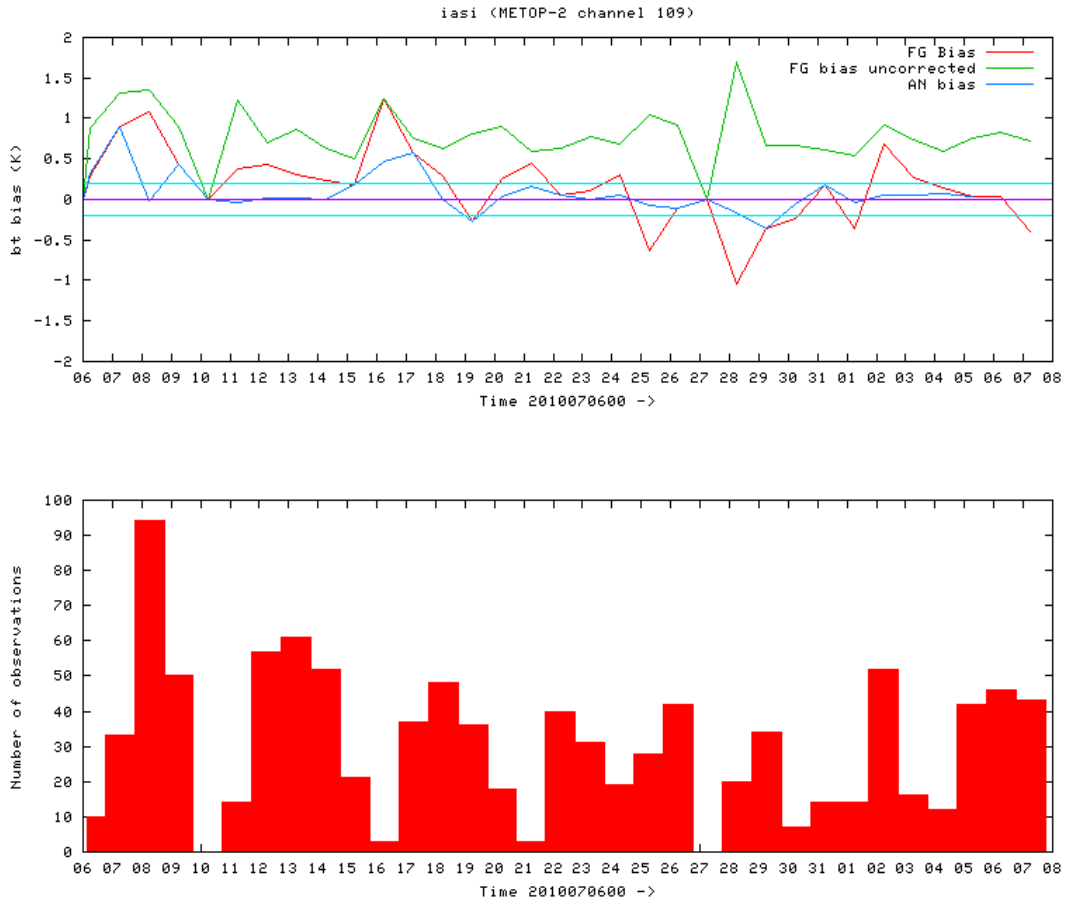

Figure 1. The evolution of bias for IASI channel 109 at cycle 06 UTC during the one month passive IASI run.

To select the channels a one month experiment with passive IASI observations was run before the actual impact study. The evolution of bias during the experiment was studied for each channel separately. Variational bias correction scheme (VAR-BC) was applied and only channels showing clear reduced bias were selected (Fig. 1). Efficiency of VAR-BC depends on the amount of observations on the model domain at the particular cycle. Since the satellite passage is almost the same every day at the same time it was possible to blacklist channels separately for all four cycles: 00, 06, 12 and 18 UTC. The passages with too little observations on certain channel were blacklisted. For example at 00 UTC cycles no IASI observations at all were assimilated since the amount of observations over the model domain at 21 – 03 UTC was so few.

The final channel selection is shown in Table 1. Average weighting functions of the chosen channels can be seen in Fig. 2.

Table 1: Assimilated IASI channels.

Surface	Selected channels
Land	38, 49, 55, 79, 109, 116, 122, 128, 135, 141, 148, 154, 159, 161, 167, 173, 179, 183, 185, 187, 193, 195, 199, 205, 207, 210, 212, 214, 217, 219, 222, 224, 226, 230, 232, 236, 239, 242, 246, 249, 252, 254, 260, 262, 265, 267, 269, 275, 294, 296, 299, 306
Sea	38, 49, 55, 79, 109, 116, 122, 128, 135, 141, 148, 154, 159, 161, 167, 173, 179, 183, 185, 187, 193, 195, 199, 205, 207, 210, 212, 214, 217, 219, 222, 224, 226, 230, 232, 236, 239, 242, 246, 249, 252, 254, 260, 262, 265, 267, 269, 275, 280, 282, 294, 296, 299, 306

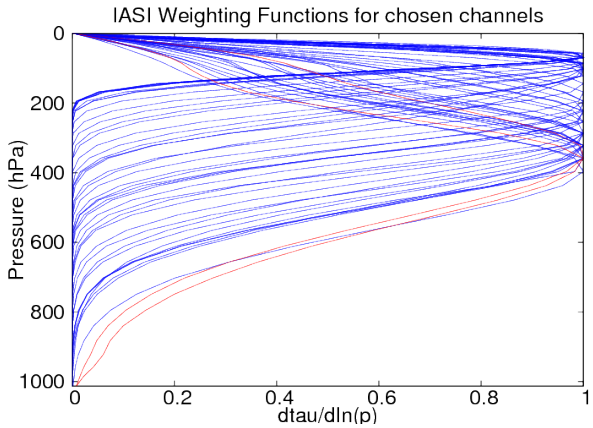

Figure 2: Weighting functions of the chosen IASI channels in a standard atmosphere. Channels marked with blue lines are assimilated everywhere, channels marked with red lines are only assimilated over sea.

4. Impact of IASI in the forecasts

4.1 General impact on the forecasts

To study the impact of IASI two experiments were run on HARMONIE. The assimilated observations in the two experiments differed only by the IASI observations assimilated in one experiment and not assimilated in another experiment (Table 2). The study period was from July 10th to August 10th 2010 during which several heavy thunderstorms occurred in Finland.

Table 2: Assimilated observation types in experiments noIASI and IASI.

Exp noIASI	Exp IASI
TEMP, SYNOP, AIREP, PILOT, SATOB, SHIP, DRIBU, AMSU-A	TEMP, SYNOP, AIREP, PILOT, SATOB, SHIP, DRIBU, AMSU-A, IASI

Verification against surface and temperature sounding observations showed mainly neutral impact from the IASI observations for the 36 hour forecasts launched at 00 UTC and 12 UTC. The general impact was slightly larger upper in the troposphere than on surface but mostly it wasn't statistically significant.

The rather neutral general impact of IASI on the HARMONIE forecasts is probably due to the assimilation of IASI into ECMWF model where the HARMONIE lateral boundary conditions are taken from. Therefore the impact of IASI is easier to see when looking at single weather systems developing inside the used HARMONIE domain. For that purpose a shorter case study was conducted, also during summer 2010.

4.2. Case study

On August 8th 2010 Finland was struck by a long lived bow echo thunderstorm as well as a few possible

supercells. Several intense downbursts and over 24000 ground flashes were observed during the storm period. The storm caused one fatality and dozens of people were injured. The insurance claims were worth around 15 million euros.

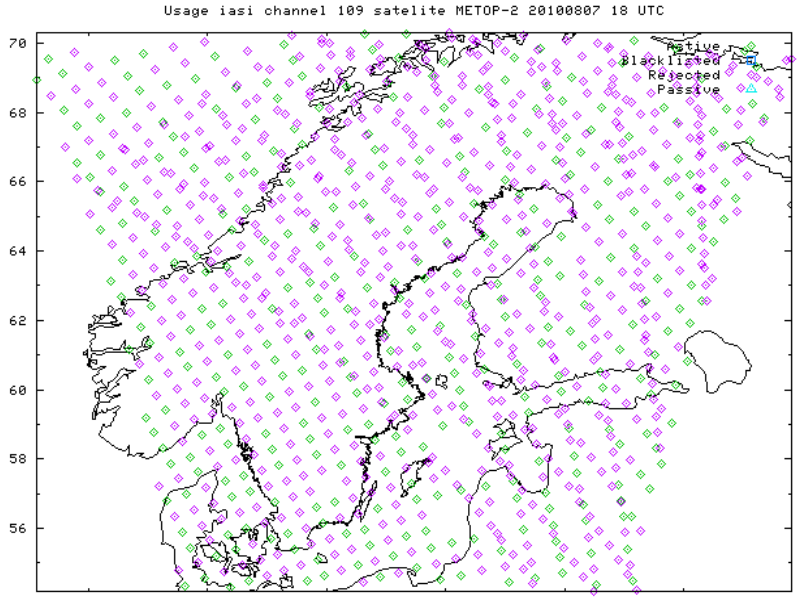

Figure 3: Assimilated IASI observations at the beginning of the case study forecast 7th August 2010 at 18 UTC. Active observations are marked with green. The observations marked purple are thinned out.

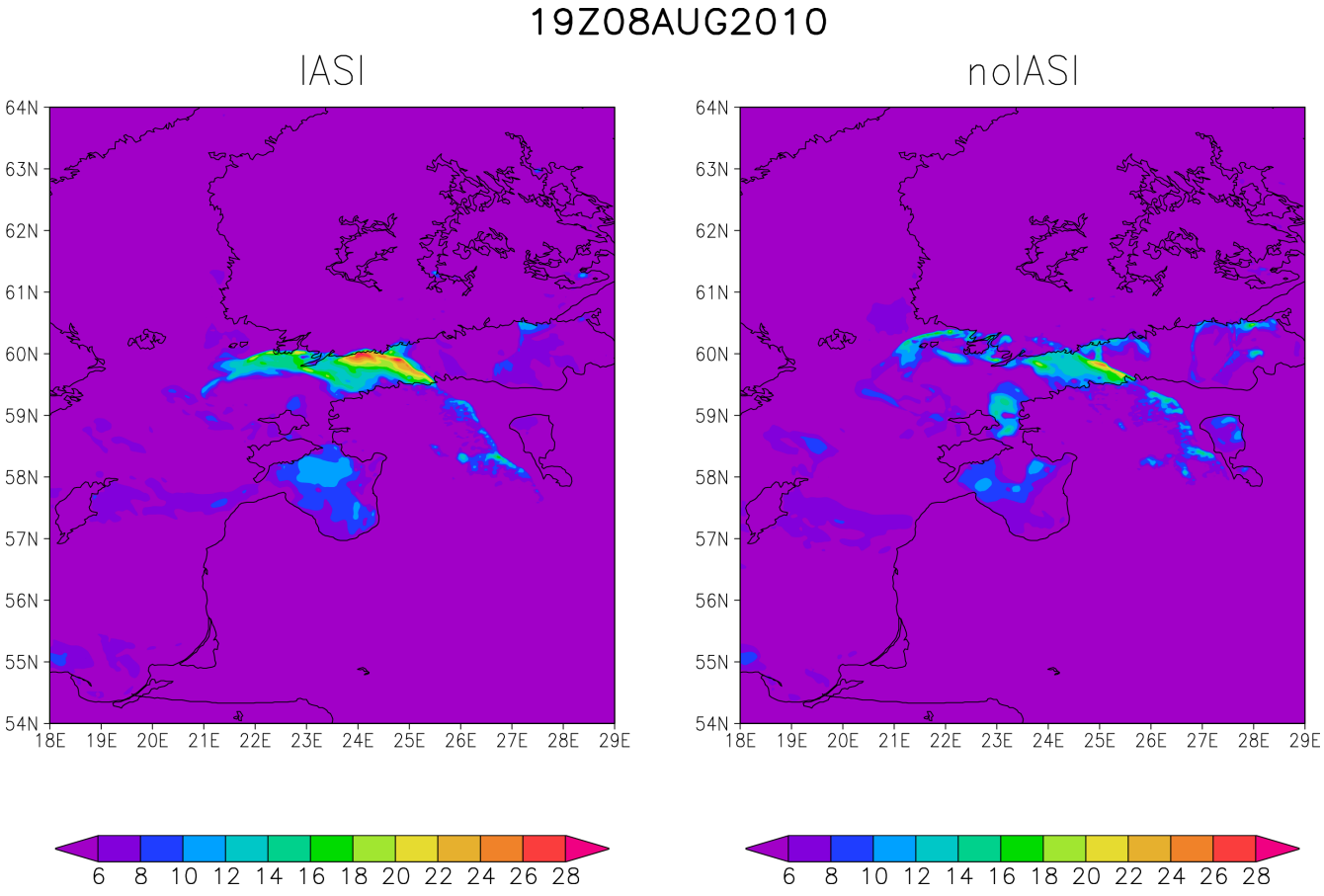

Figure 4: The maximum wind speed on August 8th 2010 at 19 UTC on the experiments with and without IASI.

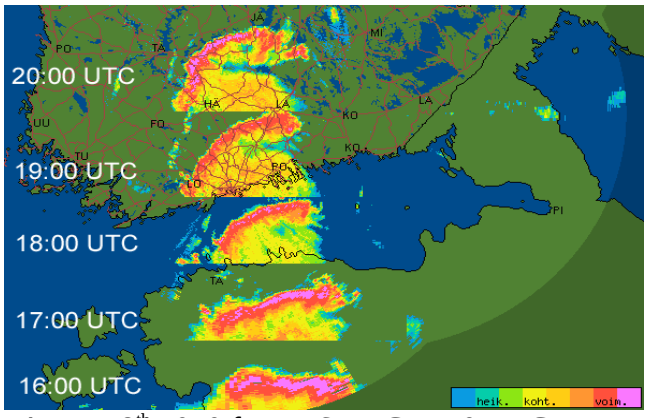

Figure 5: Radar echoes on August 8th 2010 from 16 UTC to 20 UTC.

For the case study 36 hour forecasts with and without IASI were launched August 7th at 18 UTC. The coverage of assimilated IASI observations can be seen in Fig. 3. IASI had a clear impact on the wind velocities (Fig. 4 and 5). The strength and structure of the storm were forecast slightly better in the run with IASI than without IASI. However, there were no significant changes to the thunderstorm tracks nor timing.

5. Conclusions

The rather neutral general impact of IASI in the forecasts was expected since IASI is already assimilated in the ECMWF global model, which is used to get the lateral boundary conditions for HARMONIE. However, in the case study IASI showed potential to improve forecasting of the heavy convective storms. More case studies will be conducted later on.

In the future the possibility of assimilation of the lower peaking IASI channels over land will be investigated. They have a possibility to bring more impact to the HARMONIE forecasts since they are not at the moment assimilated at ECMWF.

Acknowledgements

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