The impact of different observation types in the HIRLAM/ALADIN-LACE regional weather forecasting models

Roger Randriamampianina, Magnus Linskog, Nils Gustafson, Florian Meier, Benedikt Strajnar *and many others* ...

HIRLAM – High Resolution Limited Area Model

ALADIN

LACE nwp central europe

Outline of the talk

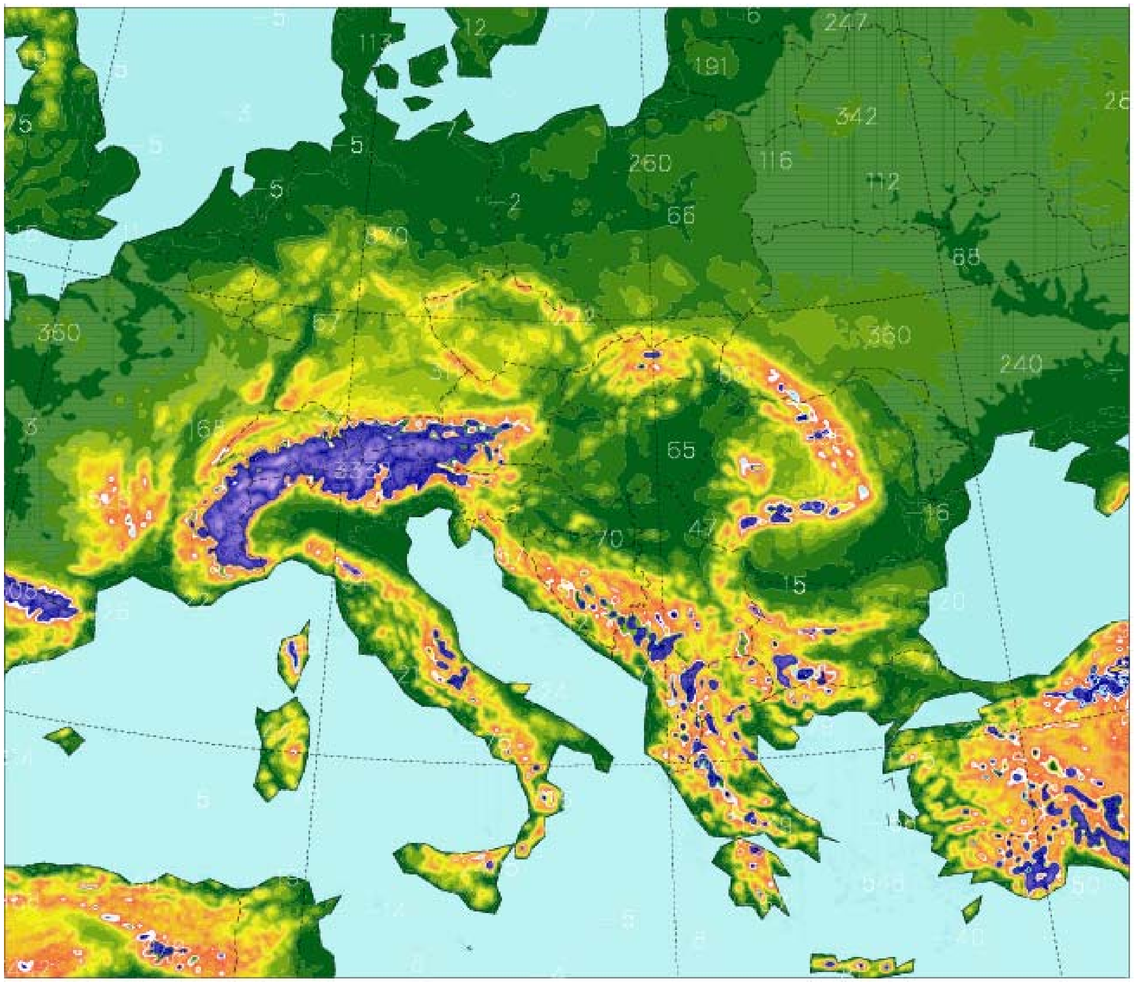
➔ Introduction

➔ The impact of different observations on the ALADIN analyses
– *Degrees of Freedom for Signals (DFS)*

➔ The impact of different observations on the HIRLAM and HARMONIE/ALADIN models forecasts
– *Moist Total Energy Norms (MTEN)*
– *Verification scores*
→ *EUCOS coordinated upper-air network redesign exp.*
→ *IPY-THORPEX/Norway*
→ *Radar impact study*
→ *Impact of geowinds (work done in collaboration with NWCSAF)*

➔ Concluding remarks

ALADIN-LACE assimilation and forecast system (1)
(ALADIN - Air Limitee Adaptation Dynamique development InterNational)



Model domain:

Domain: Lambert projection
Hungary: Dx=dy= 8 km, L49

Slovenia: Dx=Dy=4.9km, L43

Austria: Dx=Dy= 4.8 km, L60

Similar physics : ALARO

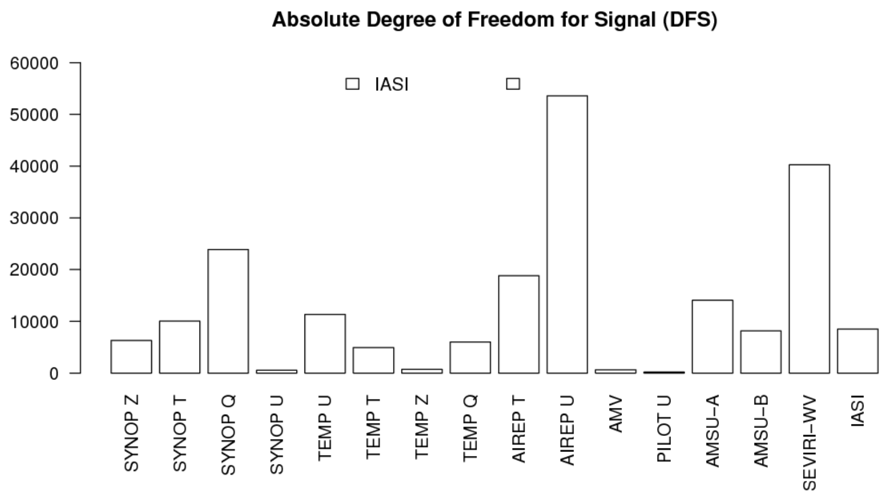
Assimilation system:
3D-VAR for upper-air
OI for surface analysis

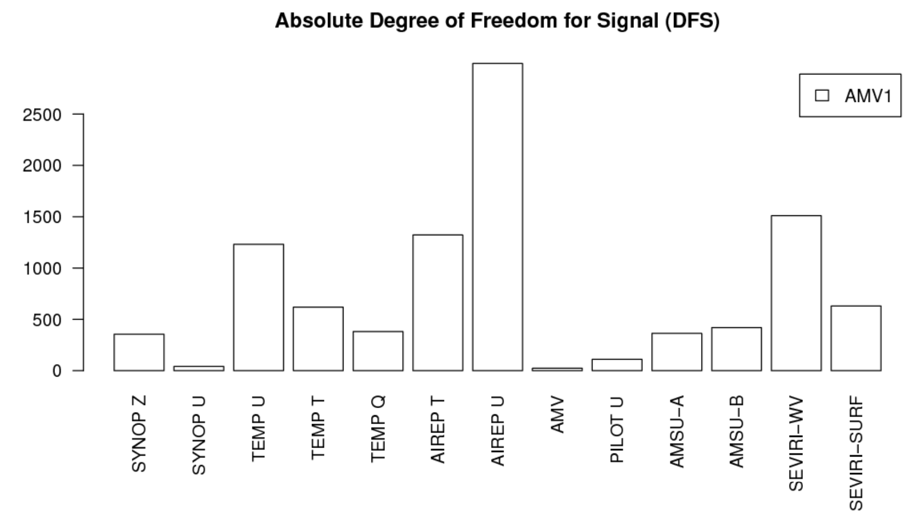
Impact of the different observations on the ALADIN 3D-VAR analysis system – using DFS computation

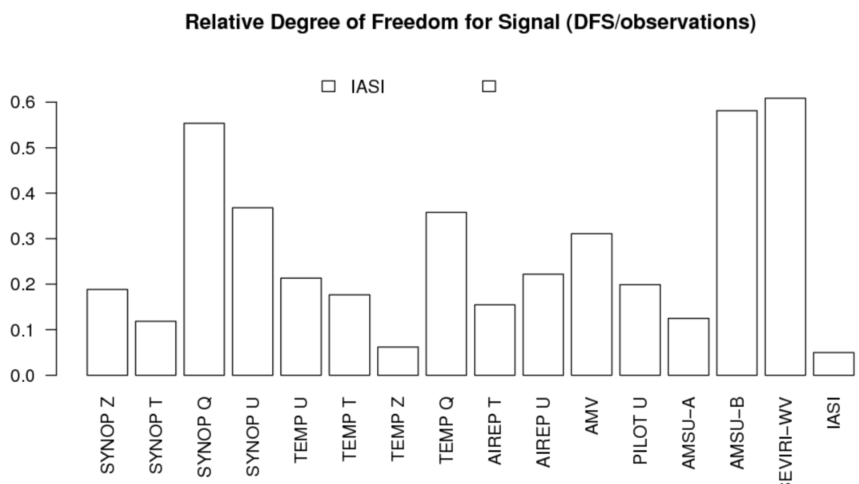
ALADIN/Slovenia

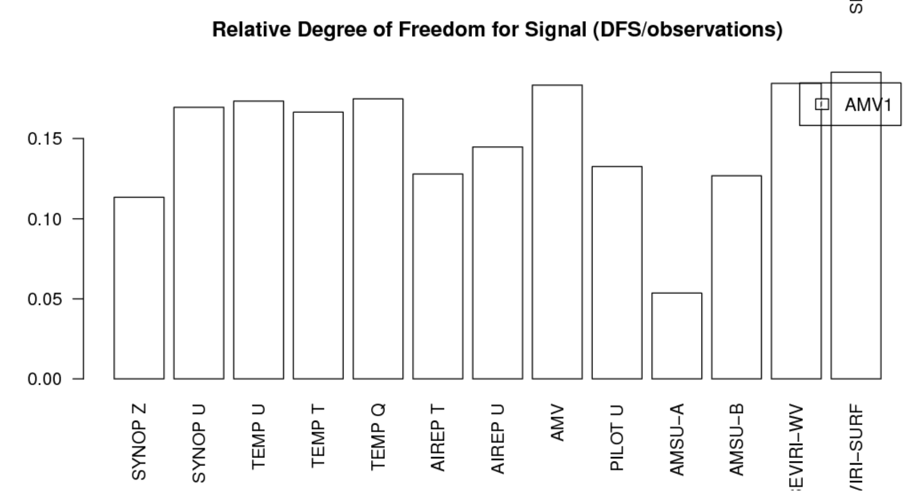
ALADIN/Hungary

3D-VAR







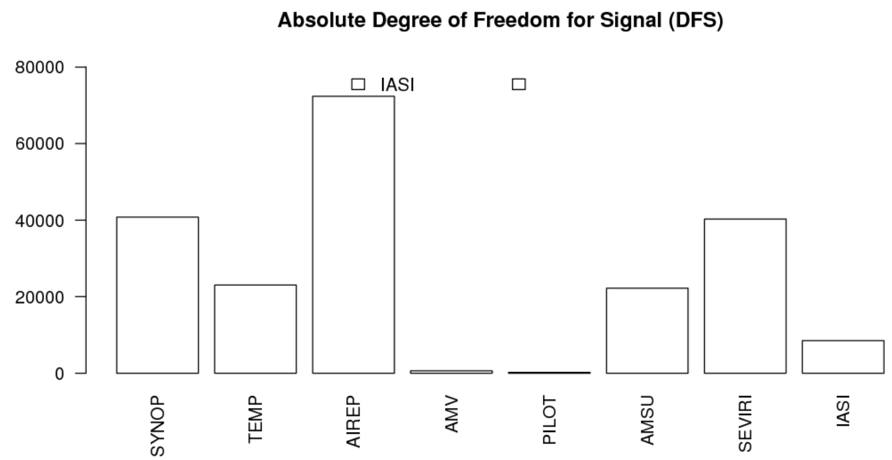


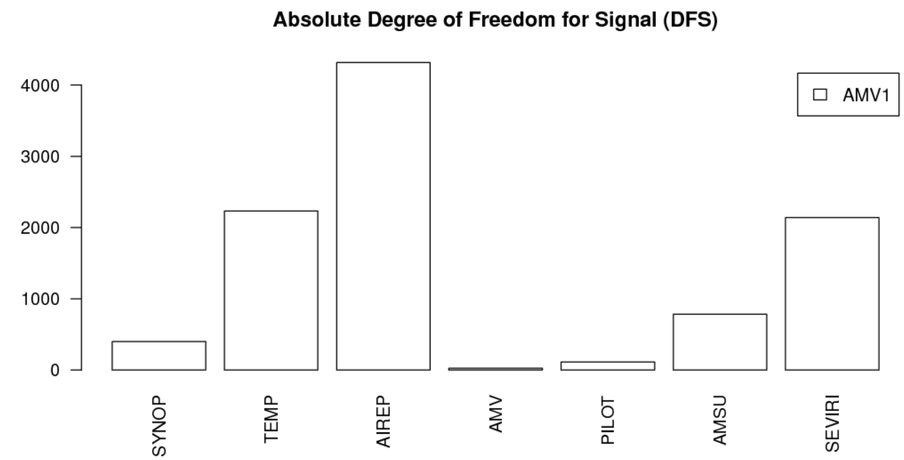
Impact of the different observations on the ALADIN 3D-VAR analysis system – using DFS computation

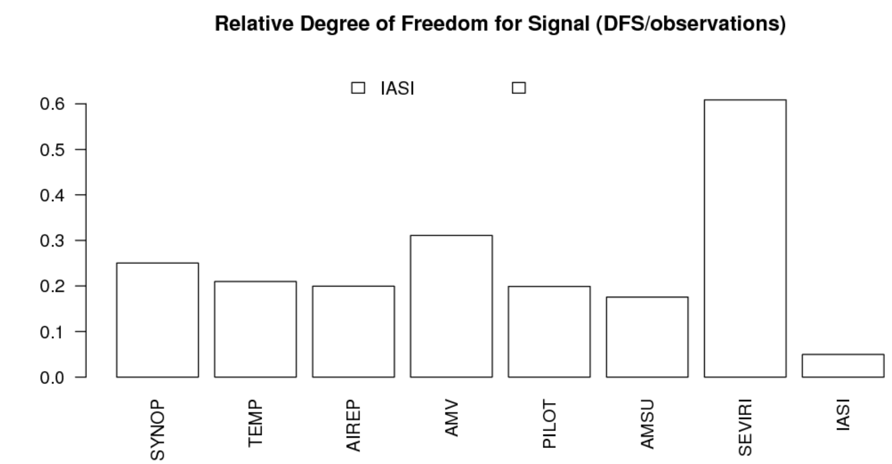
ALADIN/Slovenia

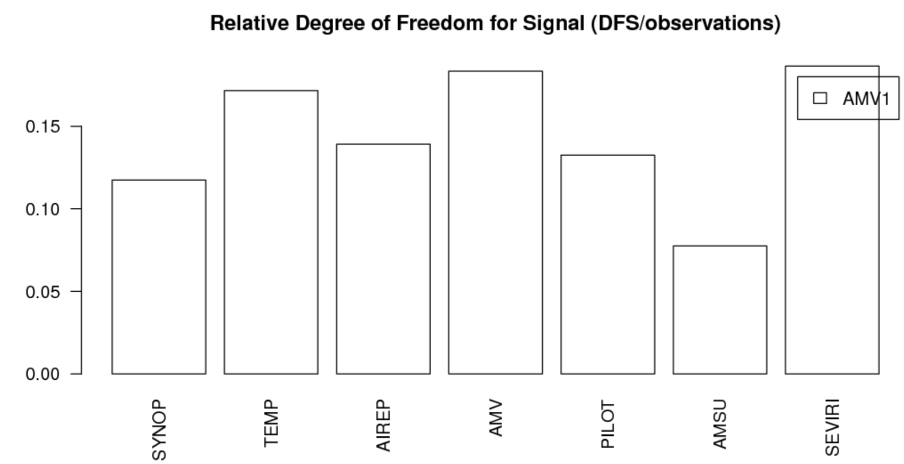
ALADIN/Hungary

3D-VAR









Forecasts sensitivity study - Definitions

The energy loss based on moist total energy norm

Computation can be based on …

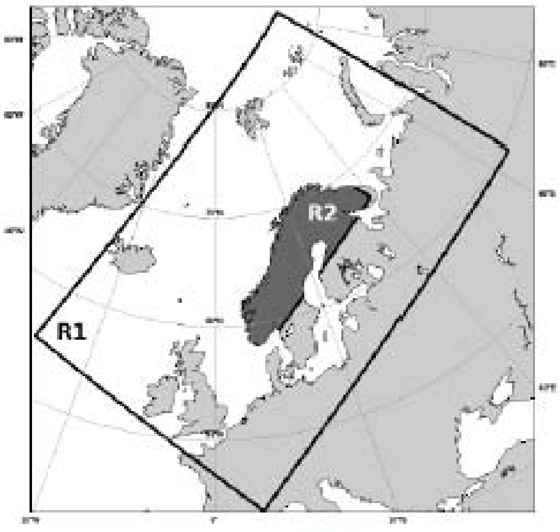


Table I. Definition of vertical sub-regions of the atmosphere for use with the localisation operator.

Vertical region	Region Bottom	Region Top
Low-troposphere	850 hPa	600 hPa
Middle-troposphere	600 hPa	350 hPa
High-troposphere	350 hPa	150 hPa
Stratosphere	150 hPa	20 hPa

Horizontal/domain extension definition

Atmospheric/vertical layers extension definition

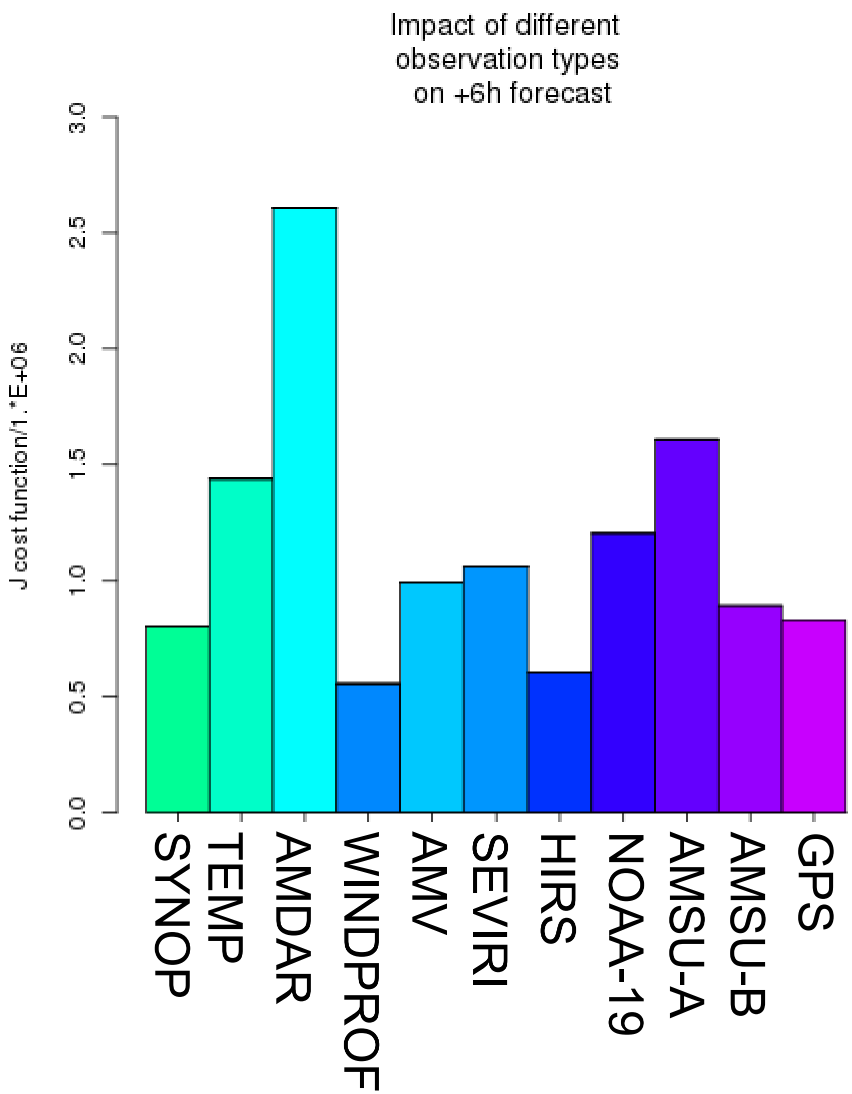
Impact of the different observations on the ALADIN 3D-VAR forecast system (MTEN)

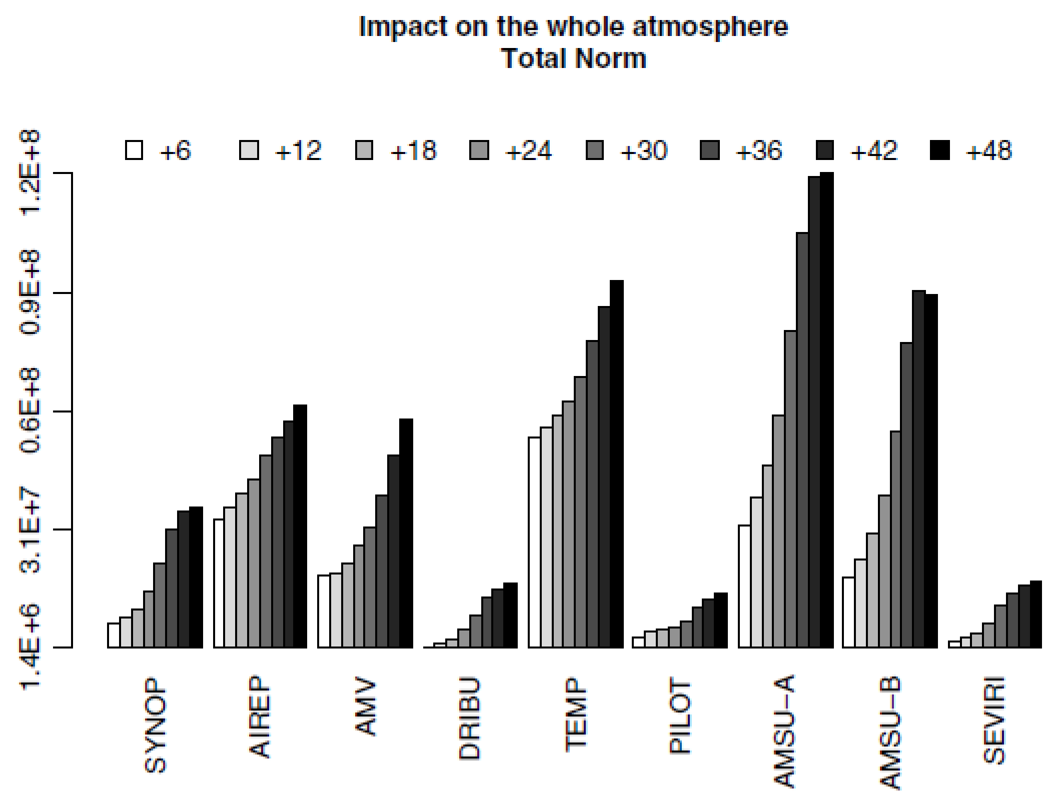
(Storto A, Randriamampianina R., 2010. The relative impact of meteorological observations in the Norwegian regional model as determined using an energy norm-based approach. Atmos. Sci. Lett.11: 51–58.)

ALADIN/Austria

HARMONIE/Norway

3D-VAR

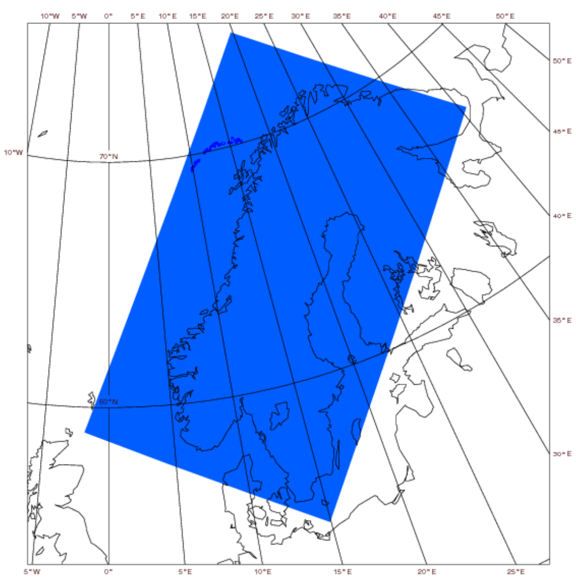




Impact of the different observations on the HIRLAM&ALADIN forecast systems (Verification scores)

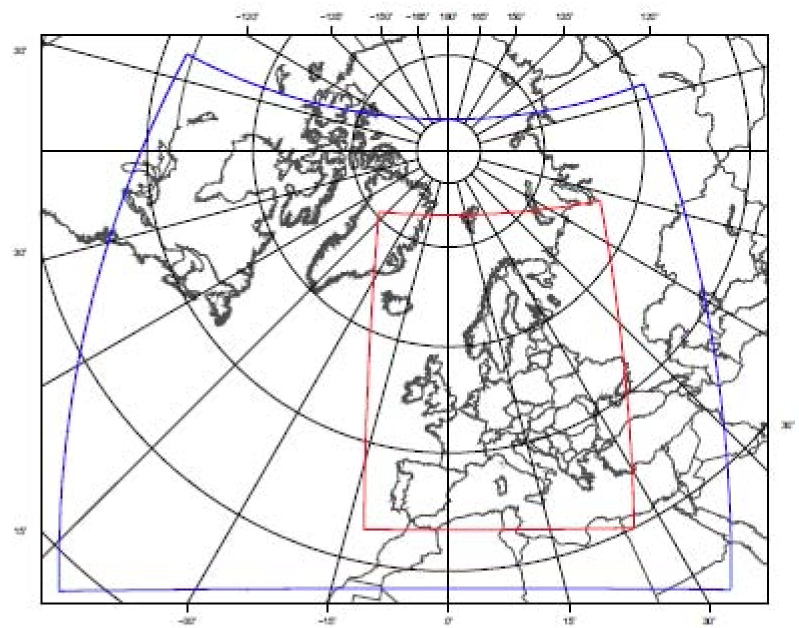
EUCOS coordinated upper-air network redesign study

3D-VAR
4km horizontal resolution
non-hydrostatic



HARMONIE/met.no domain
for the EUCOS study
(only for summer period)

4D-VAR
Two outerloop min. iter. 0.90deg/0.45deg - winter
0.60deg/0.30deg – summer
hydrostatic



HIRLAM domain for the EUCOS study for winter (blue), and summer (red) period

The scenarios

Baseline – minimal network GUAN and GSM radiosonde and reduced aircraft observations

Sc3a- profile from radiosonde thinned to 100km

Sc3b- the "sc3a" was done only for 12 UTC

Sc4- radiosonde and aircraft thinned at 250km

Sc5- similar with "sc4", but with thinning at 500km over European area

Table 2: 850 hPa temperature, 700 hPa relative humidity and 500 hPa geopotential height RMS error increase (in %) for selected denial experiments

Forecast length	Baseline	Sc3a	Sc3b	Sc4	SC5
Winter HIRLAM:					
T850+12h	+5	-1	0	+2	+2
T850+24h	+1	-4	0	-5	+1
T850+48h	+5	+2	+2	-1	+2
RH700+12h	+1	+5	+1	+2	+1
RH700+24h	+2	0	0	-1	+2
RH700+48h	+5	+3	+2	0	+2
Z500+12h	+6	+1	0	+2	+2
Z500+24h	+7	-1	+1	+1	+4
Z500+48h	+5	0	+1	+3	+2
Summer HIRLAM:					
T850+12h	+12	+2	+2	+4	+5
T850+24h	+12	+6	+7	+10	+10
T850+48h	+2	+1	0	+1	+3
RH700+12h	+6	+4	+4	+1	+4
RH700+24h	+5	0	-2	0	+5
RH700+48h	+3	0	0	+3	+1
Z500+12h	+1	-1	-2	0	-3
Z500+24h	+6	-2	+1	+3	+3
Z500+48h	+3	0	-1	+6	+5
Summer HARMONIE:					
T850+12h	+5	+1	-2	0	+3
T850+24h	+3	0	0	+2	+4
RH700+12h	+6	0	-2	0	+1
RH700+24h	+2	-6	-3	-1	-4
Z500+12h	+4	-6	-1	+3	-1
Z500+24h	+5	-1	0	+4	+2

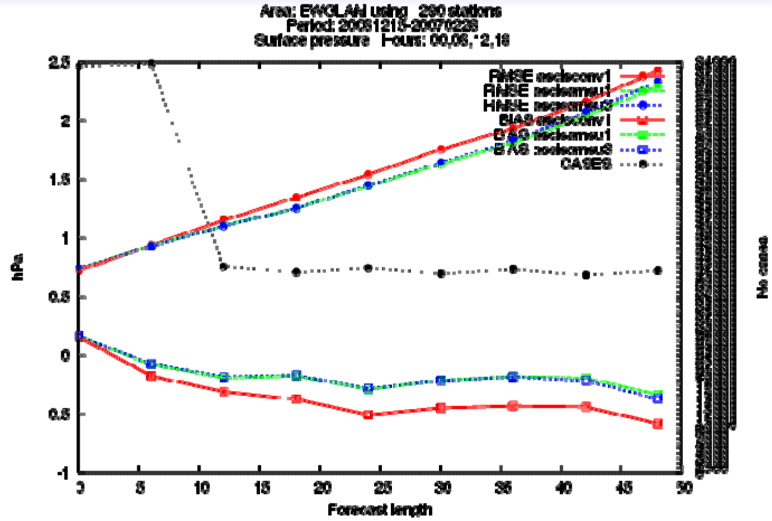
ATOVS impact study

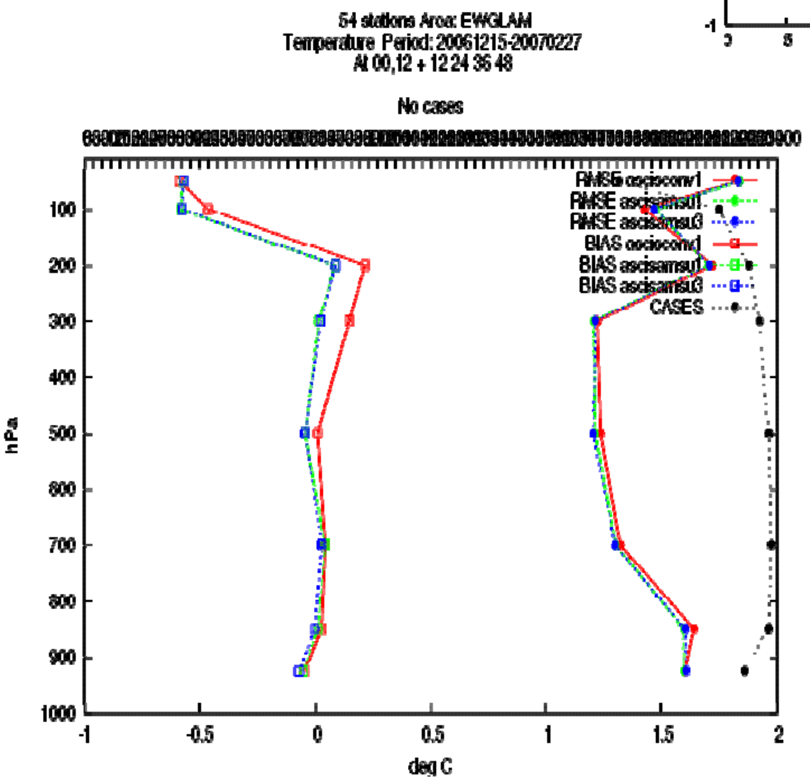
- HIRLAM 4D-Var, 15 km resolution, 60 levels
- All satellites NOAA-15, 16, 18, METOP 2
- AMSU-A over sea and sea ice, AMSU-B over sea
- Bias corrections
- 15 Dec 2006 – 28 Feb 2007
- Parallel experiments
  - No ATOVS
  - AMSU A channel 5-10 + AMSU B
  - AMSU A channel 4-10 + AMSU B

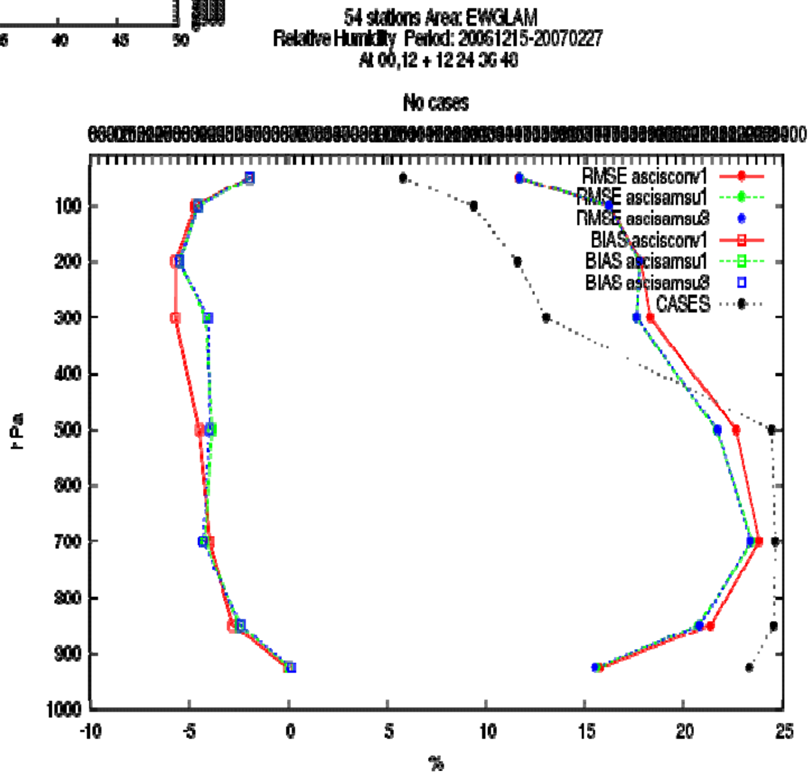
ATOVS impact study (cont'd)

Verification of surface pressure, temperature, and humidity

HIRLAM 4D-VAR +ATOVS







Exploring the impact of IASI data during the campaign period

A winter assimilation test

Four experiments have been performed using 41 active channels
Period: 2008022000 – 2008031712
(Warming period 5 days)

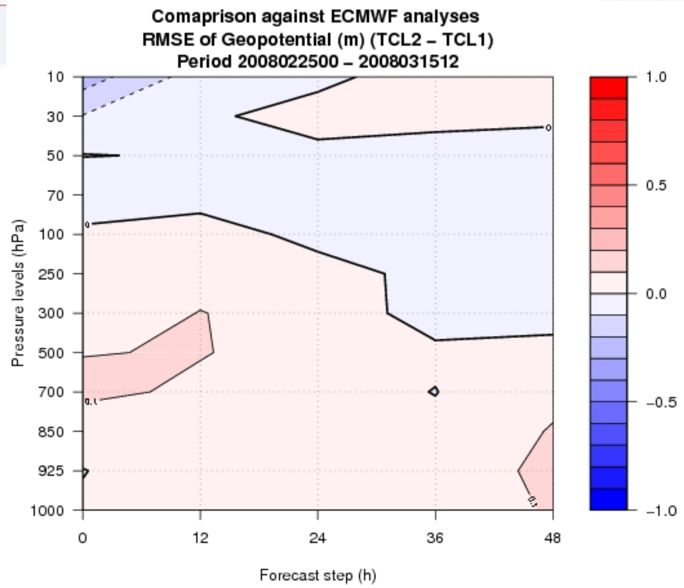
	Run with IASI data	Run without IASI
Run with campaign data	THCL1	THCL2
Run without campaign data	THCL3	THCL4

THCL1 vs THCL2 and THCL3 vs THCL4 will show the impact of IASI data with and without aide of campaign observations, respectively

THCL1 vs THCL3 and THCL2 vs THCL4 will show the impact of the campaign observations with and without presence of IASI data in the assimilation system, respectively

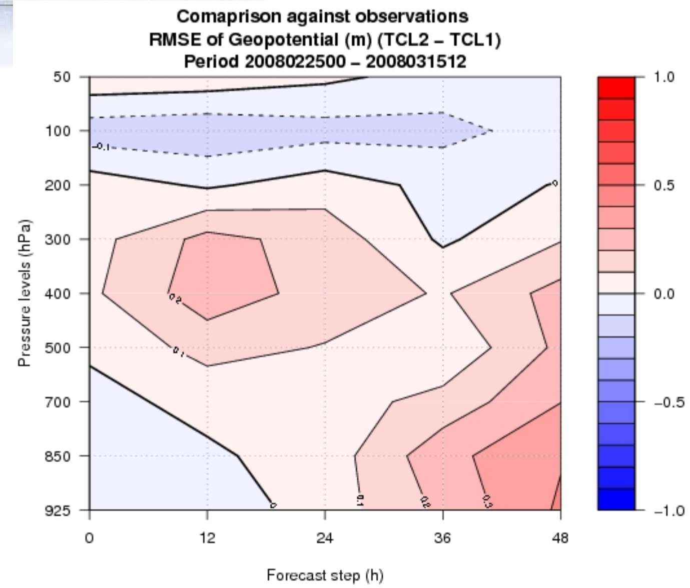
Impact of IASI data

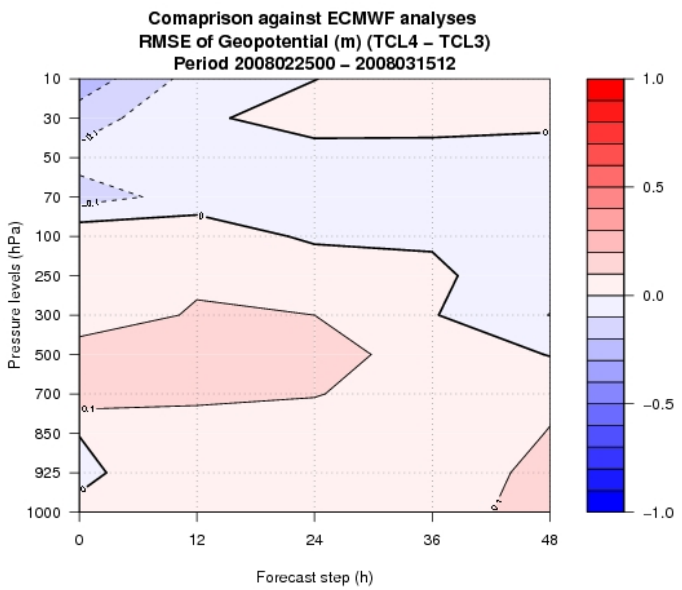
Comparison against analyses | Comparison against observations



Impact on geopotential:

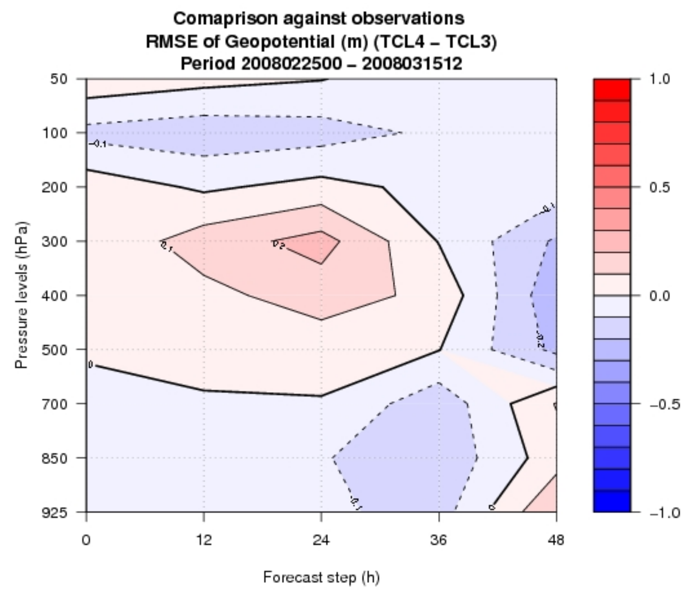
experiments with campaign data



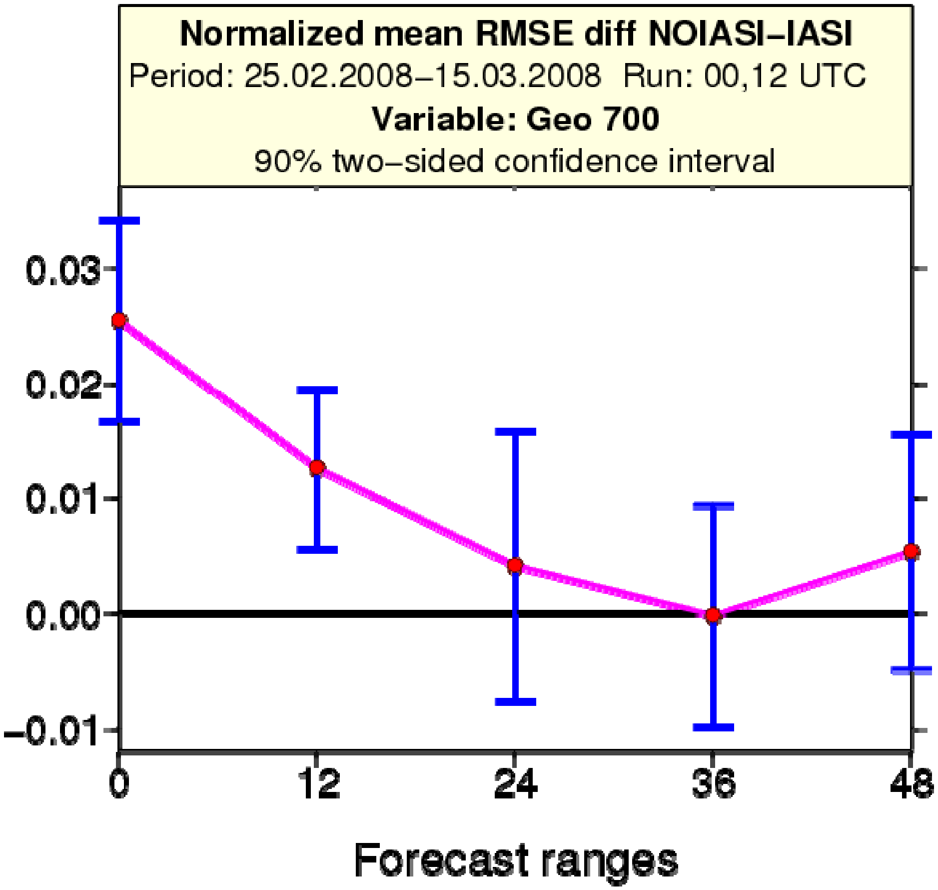


Impact on geopotential:

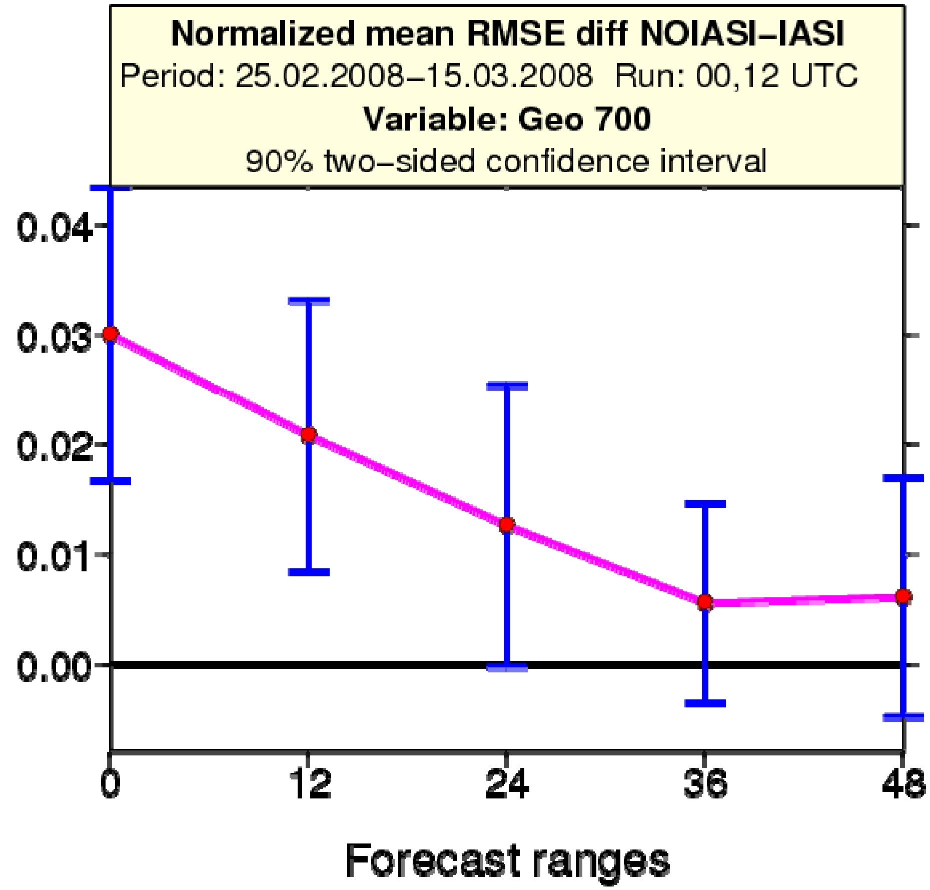
experiments without campaign data



experiments with campaign data



experiments without campaign data

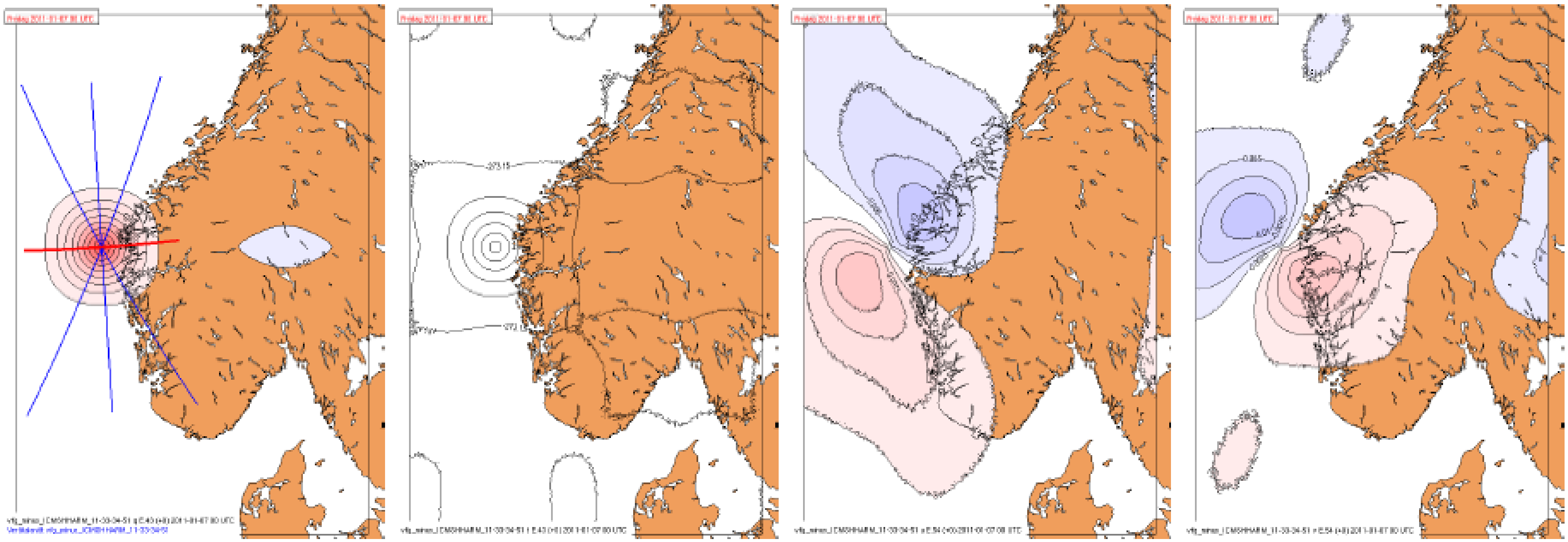


BUT! The case study showed that the warning the polar lows would be efficient only 12 hours ahead, while with IASI radiances it could be improved up to 24 hours, and up to 36 hours when the IASI radiances were assimilated together with the additional campaign observations

Radar data impact study

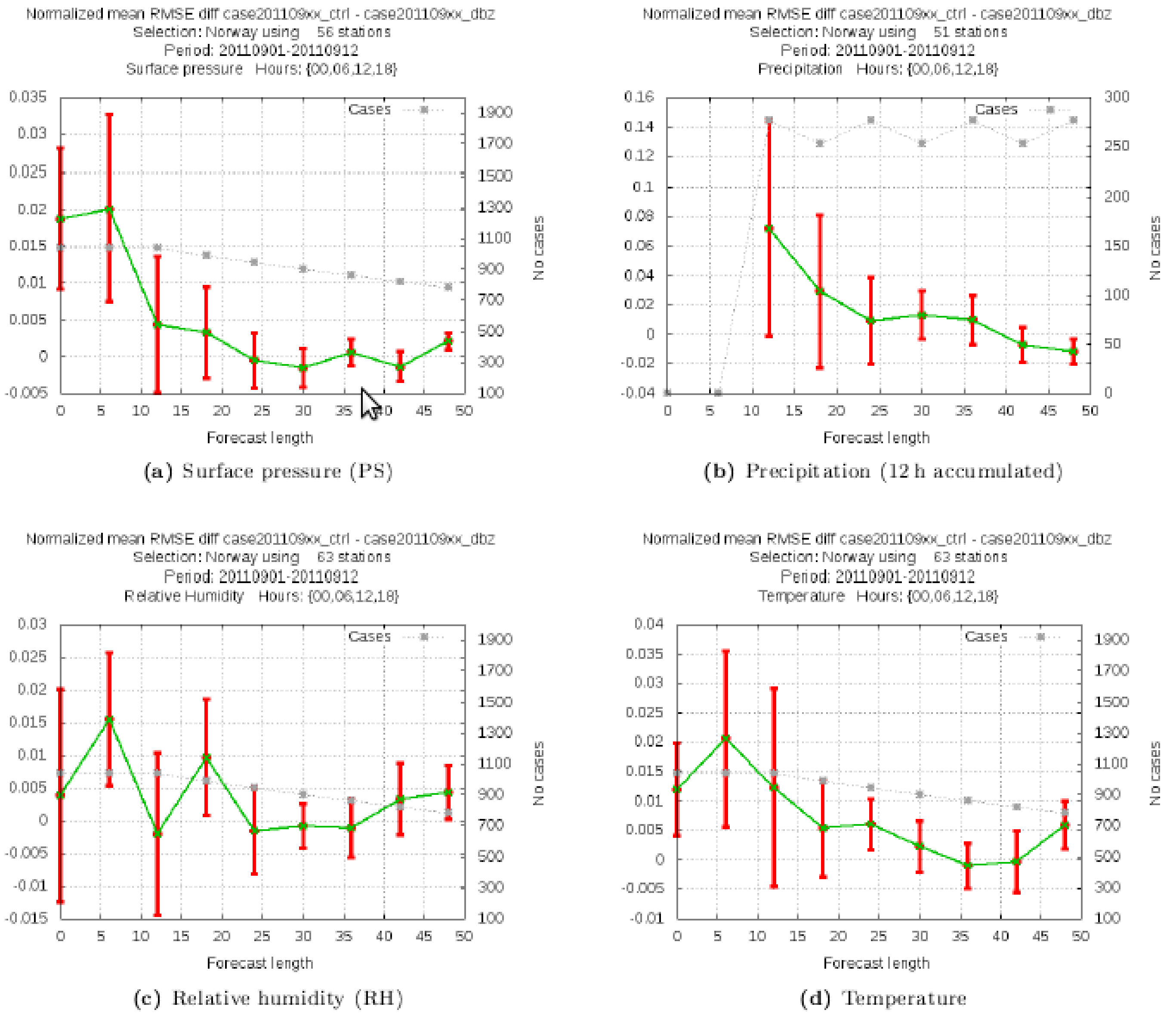
- Domain: HARMONIE/Norway-South
- Forecast system: AROME physics (2,5 km horizontal resolution)
- Assimilation scheme: 3D-VAR
- Radar reflectivity assimilation (Meteo France solution): 1D Bayesian + 3D-VAR (Montmerle et al., 2008; Wattrelot et al., 2008; Caumont et al., 2006)
- Assimilation with conventional observations

3.3 Single reflectivity observation experiment



(a) Specific humidity, Q. Equidistance: $1 \cdot 10^{-5}$. (b) Temperature, T. Level 43. Equidistance: $1 \cdot 10^{-2}$. (c) Wind U component. Level 54. Equidist.: $2.5 \cdot 10^{-3}$. (d) Wind V component. Level 54. Equidist.: $2.5 \cdot 10^{-3}$.

Radar data impact study (cont'd)



(a) Surface pressure (PS) (b) Precipitation (12 h accumulated)

(c) Relative humidity (RH) (d) Temperature

Figure 3.21: Normalized difference in RMSE in given parameters. Note that this is CTRL minus RADAR, so positive numbers are in favor of radar assimilation. Period 2011-09-01–2011-09-12, forecast length +48 h. Significance level 90 %.

Impact of atmospheric motion vectors (AMV- Geowind) on ALADIN/Hungary

Assimilation time	Oper AMV (EUMETCast AMV)	HRW data
00 UTC	IR3, WVCL1, WVCL2	IR3
06 UTC	IR3, VIS2, VIS3, WVCL1, WVCL2	VIS2
12 UTC	IR3, VIS2, VIS3, WVCL1, WVCL2	VIS2
18 UTC	IR3, VIS3, WVCL1, WVCL2	VIS2

➔The following observations were used in the assimilation system:

Type	Parameter (Channel)	Bias correction	Thinning
TEMP	U, V, T, Q, Z	Only T using ECMWF tables	No
SYNOP	Z	No	Temporal and spatial
PILOT (Europrof.)	U, V	No	Redundancy check against TEMP
DRIBU	Z	No	Temporal and spatial
AIREP	U, V, T	No	25 km horizontal
AMV	U, V	No-Use of quality flags	25 km horizontal
MSG/SEVIRI	2 wv channels	Variational	70 km horizontal
AMSU-A	5 to 10	Variational	80 km horizontal
AMSU-B, MHS	3, 4, 5	Variational	80 km horizontal

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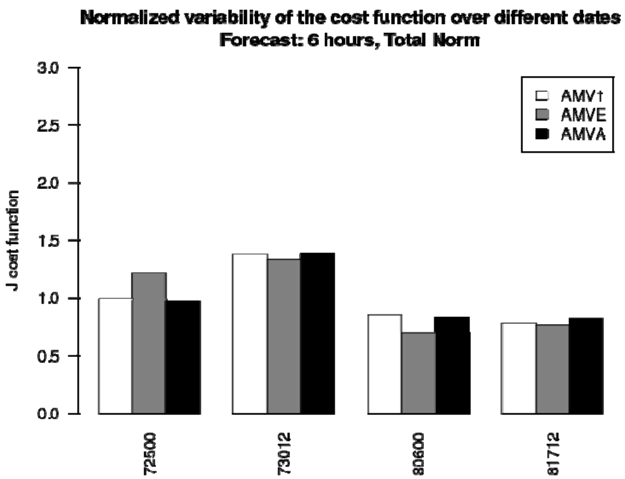
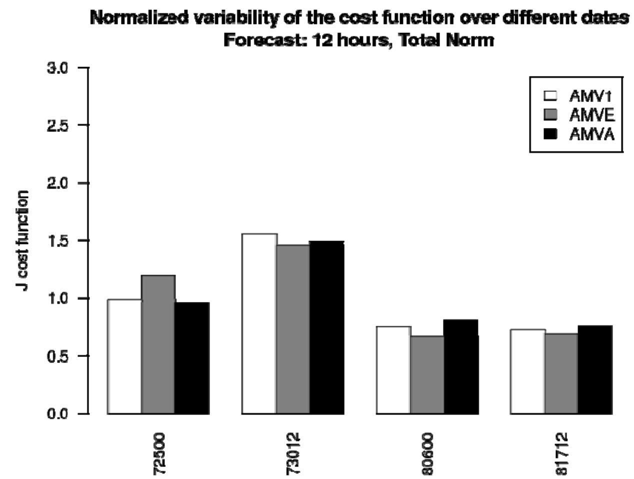
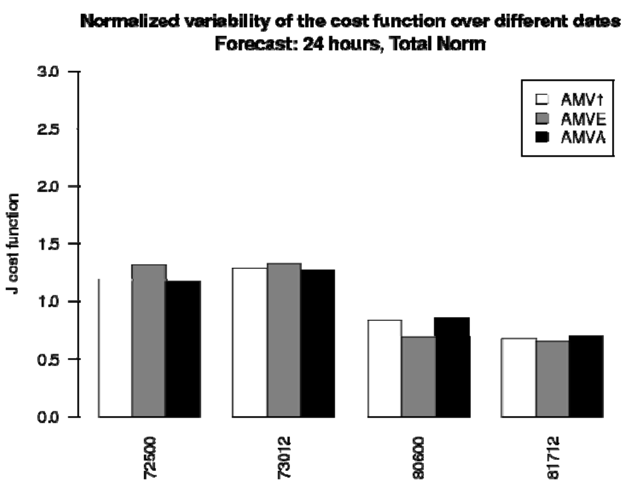
Impact of the HRW/Geowind data on the forecasts – Moist total energy norm



The runs used for the computation were:

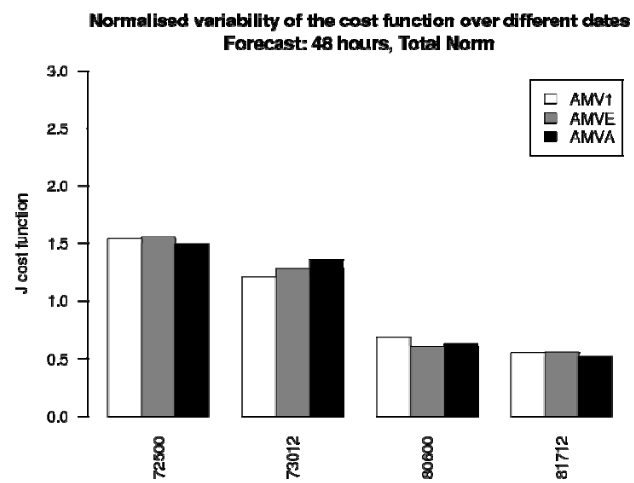
25.07.2011 (00UTC) (72500);
30.07.2011 (12UTC) (73012);
06.08.2011 (00UTC) (80600);
17.08.2011 (12UTC) (81712)





The sensitivity to:

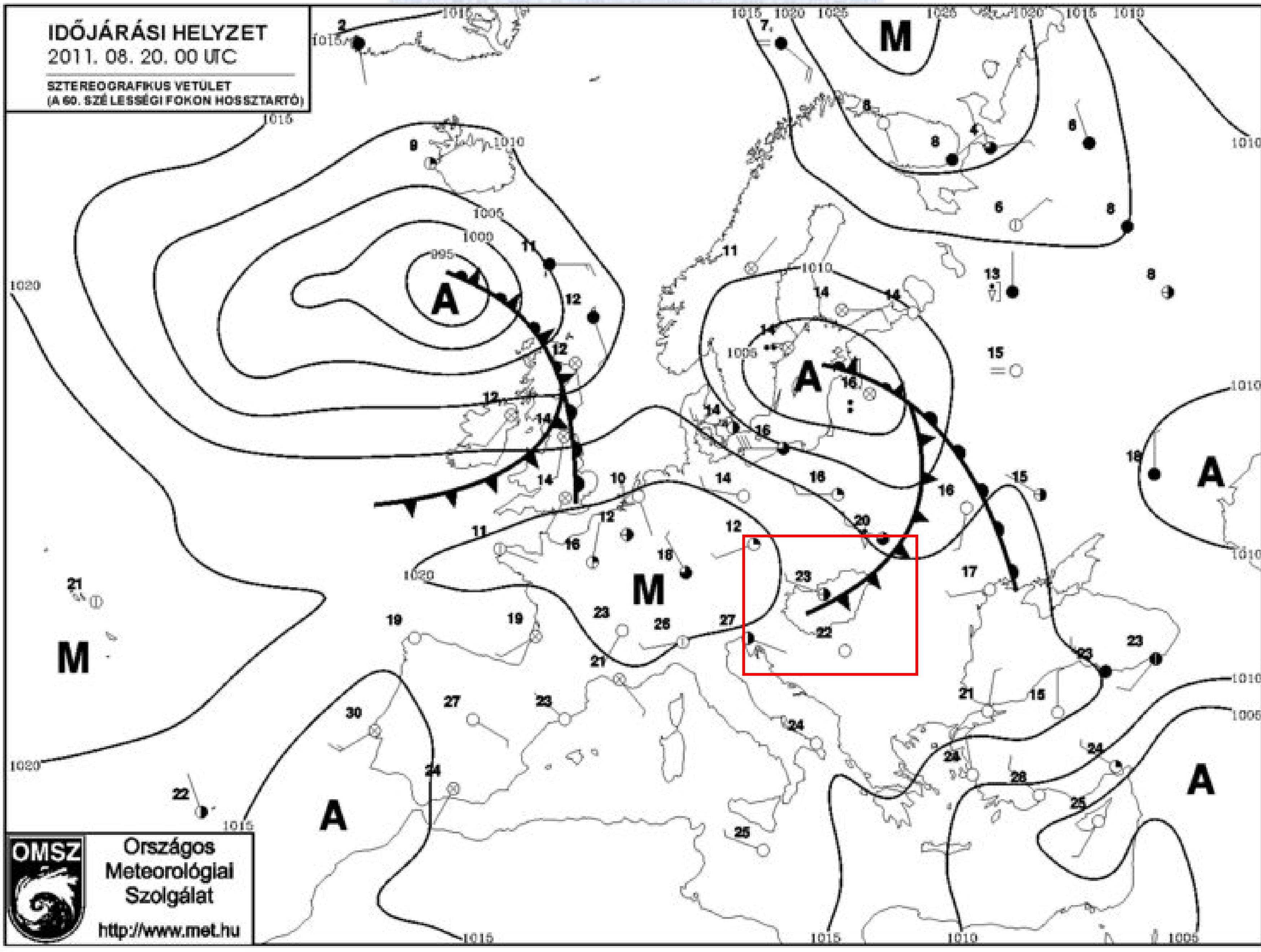
- EUMETSAT geowind
- NWC SAF geowind
- both the geowinds



Impact of the HRW data on the forecasts –

Case studies – forecast of the same event

The weather chart for the verifying time (20.08.2011 00UTC)



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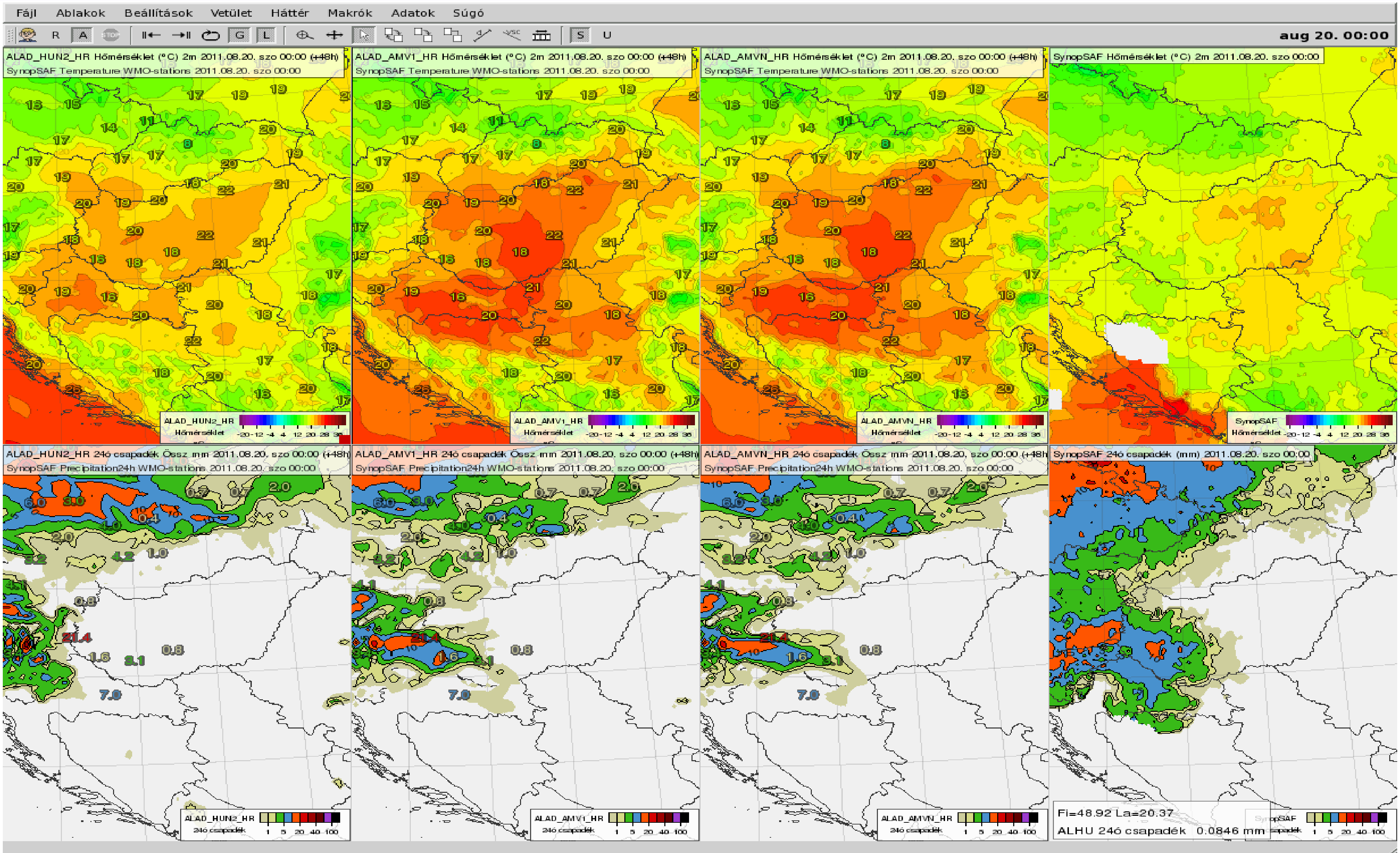
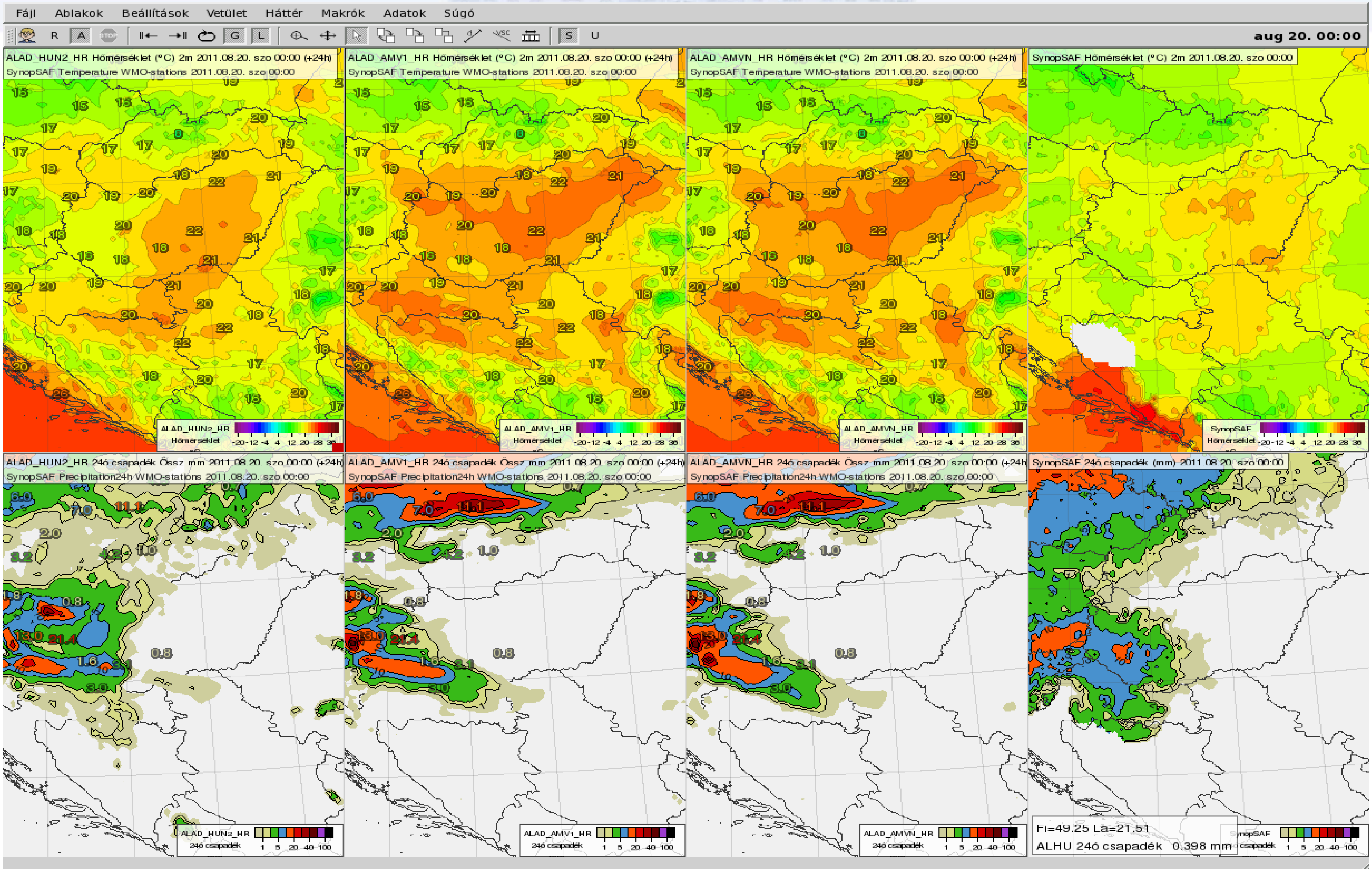
Impact of the HRW data on the forecasts –
Case studies – forecast of the same event (20.08.2011 00UTC) – 48h before

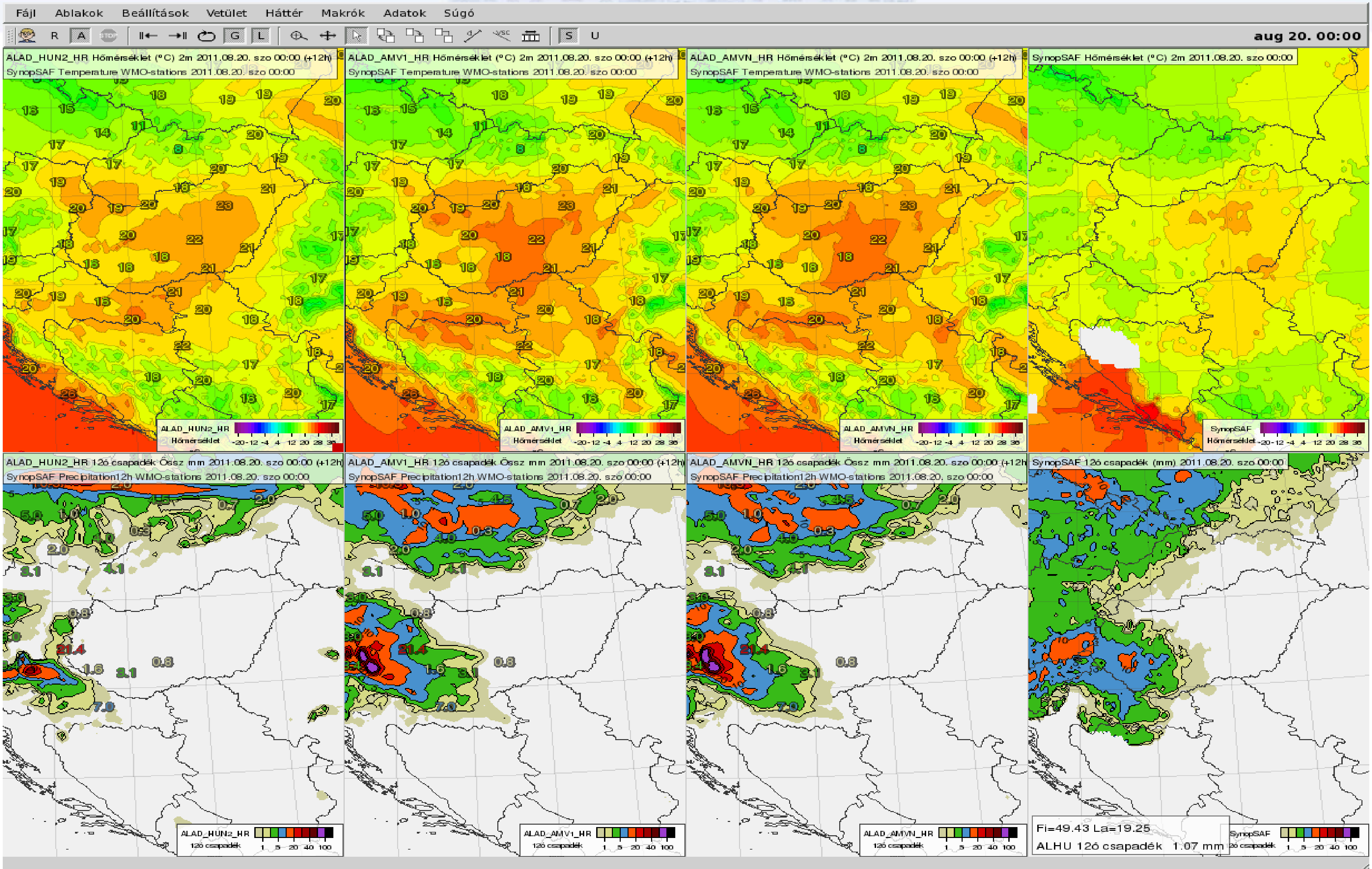


Impact of the HRW data on the forecasts –

Case studies – forecast of the same event (20.08.2011 00UTC) – 24h before



Impact of the HRW data on the forecasts – Case studies – forecast of the same event (20.08.2011 00UTC) – 12h before emplacement: the same as before



The availability of the AMV data

Assimilation time	Oper AMV (EUMETCast AMV)	HRW data
00 UTC	IR3, WVCL1, WVCL2	IR3
06 UTC	IR3, VIS2, VIS3, WVCL1, WVCL2	VIS2
12 UTC	IR3, VIS2, VIS3, WVCL1, WVCL2	VIS2
18 UTC	IR3, VIS3, WVCL1, WVCL2	VIS2

ORSZÁGOS METEOROLÓGIAI SZOLGÁLAT

Concluding remarks

➔The DFS results showed that the ALADIN 3D-VAR over the central Europe is more sensitive to the wind and the humidity observations than the other observed parameters → Aircraft, radiosonde and Seviri radiances have the largest impact in the analysis;

➔The EUCOS conducted study on upper-air network redesign showed that strong reduction of radiosonde and aircraft observation over Europe lead to drastic model deterioration;

➔We have seen the importance of the satellite radiances (ATOVS and IASI) for high-latitude regional models;

→ The warning of polar lows would be efficient only 12 hours ahead. With IASI radiances it could be improved up to 24 hours. Furthermore, the impact could be improved up to 36 hours when the IASI radiances would be assimilated together with the additional campaign observations;

➔Very promising results were shown regarding the use of radar data in very high-resolution data assimilation and forecast systems;

➔The case study on assimilation of geowind data showed that the use all retrieved winds conducts to a deterioration of precipitation forecasts, suggesting that some retrieval techniques result to inefficient forecasts.

ORSZÁGOS METEOROLÓGIAI SZOLGÁLAT

Storto A, Randriamampianina R. 2010c. 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.

Randriamampianina R, Iversen T, Storto A., 2011. Exploring the assimilation of IASI radiances in forecasting polar lows. *Q. J. R. Meteorol. Soc.* DOI:10.1002/qj.838

Thank you for your attention