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Assimilation of the IASI data in the HARMONIE data assimilation system

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Acknowledgement: Andrea Storto (met.no), Andrew Collard (ECMWF), Fiona Hilton (MetOffice) and Vincent Guidard (Météo France)

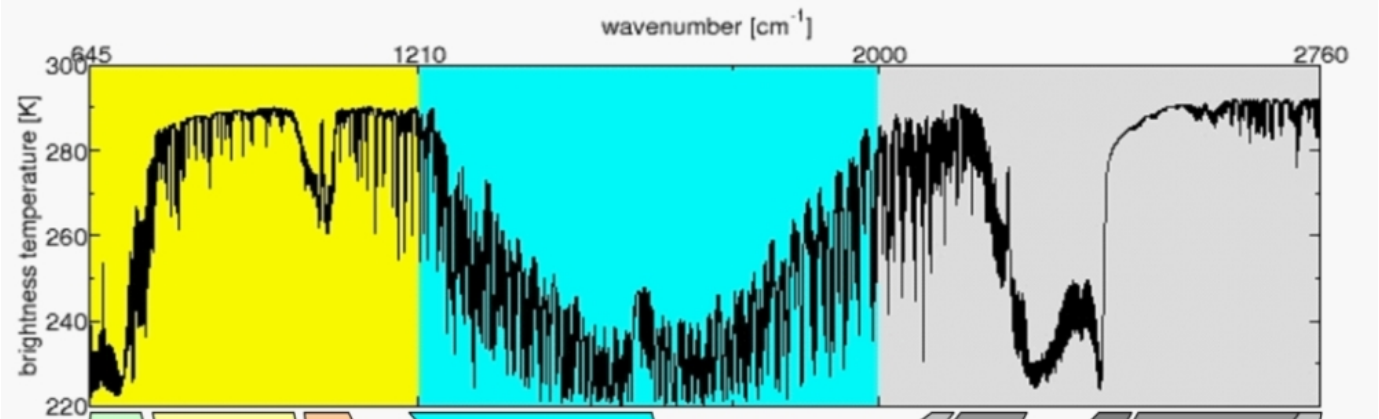
Outline of the talk

- IASI data (pre-)processing
  → channel selection
- Specific assimilation problem over high latitude in winter
- IASI assimilation
  → Use of channels with respect to cloud condition/properties
- Impact study trial
  → case study
- Conclusions and future plans

IASI instrument

→ IASI is a new instrument onboard METOP satellite

- multi-spectral instrument **with 8461 channels**
- **we extract 366** channels, as proposed by Andrew Collard (ECMWF)



650-770	790-980	1000-1070	1080-1150	1210-1650	2100-2150	2150-2250	2350-2420	2420-2700	2700-2760
CO_2	Atm. window	O_3	Atm. window	H_2O	CO	N_20 & CO_2	CO_2	Atm. window	CH_4
Temp. profile	Surface & cloud properties	O_3 sounding	Surface, cloud properties	Humidity profile, CH_4, N_20 colume amount	CO column amount	Temp. profile, N_20 column amount	Temp. profile	Surface & cloud properties	CH_4 column amount

The assimilation system (3D-VAR)

The analysis is obtained by minimizing the cost function

Variational cost function

$$J(\mathbf{x}) = J_b(\mathbf{x}) + J_o(\mathbf{x})$$

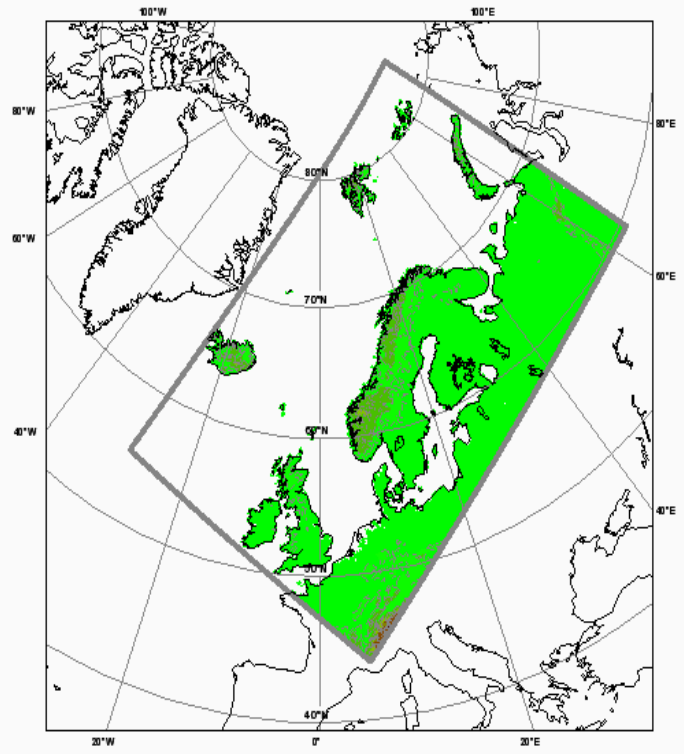
$$J(\mathbf{x}) = \tfrac{1}{2} (\mathbf{x} - \mathbf{x}^b)^T \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x}^b) + \tfrac{1}{2}(\mathbf{y} - H(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - H(\mathbf{x}))$$

x is the control variables vector
y is the observation vector
H is the observation operator

B is the background error covariance matrix
R is the observation error covariance matrix

HARMONIE and its assimilation system

(Hirlam Aladin Regional/Meso-scale Operational NWP In Europe)



Model domain:

Small domain: rotated Lambert pr.
Dx=dy= 11 km, 60 vertical levels
up to 0.2 hPa

HARMONIE analysis and forecast system

Upper-air analysis

→ Three-dimentional variational (3DVAR) assimilation system

- Use of conventional and satellite data
- Operator for radiance data: RTTOVS-8.7

Surface analysis

→ Optimum interpolation

- Univariate analysis of 2m T and 2m Hu
- Diagnosis parameters are skin T and water content

Forecast system

→ Hydrostatic (IFS/ARPEGE/ALADIN/HARMONIE) CY33T1

→ Initialisation technique: Digital filter

→ Radiation scheme: ECMWF FMR

→ Advection: using semi-lagrangian interpolation

→ Lateral boundary files: IFS analyses and forecasts

Type of observations actually in use

Conventional Observations

→ Surface data:
- Synop, Ship
- Bathy, Tesac
- Buoy

→ Upper-air data:
- Airep, Amdar, Acar
- Temp, Temp-ship, Temp-mobil, Temp-drop **(New)**
- Pilot, Pilot-ship, Europrofil, Profiler

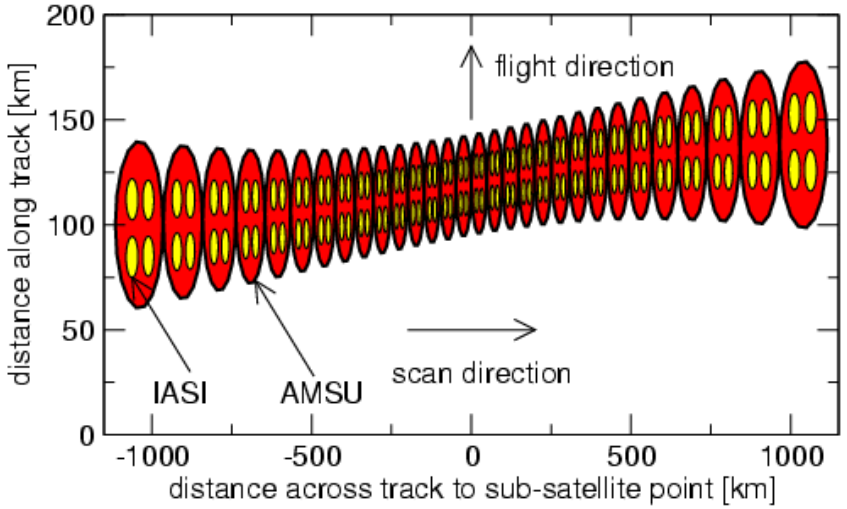
Satellite Observations

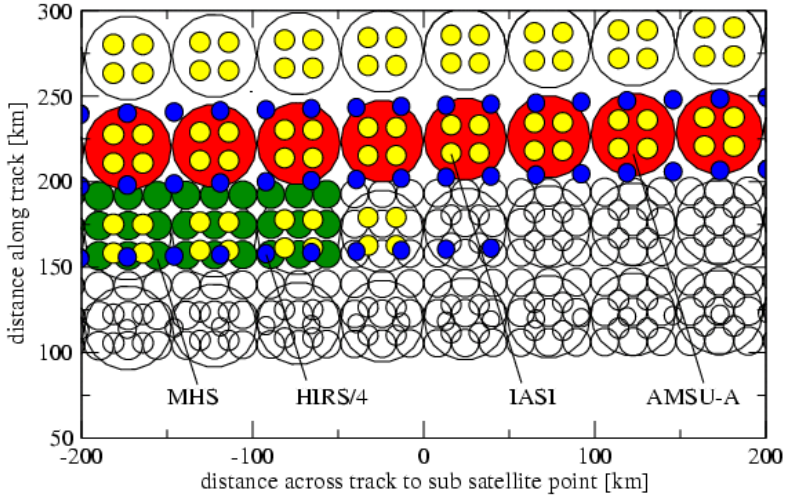
→ NOAA Atovs:
- Amsua, Amsub

→ METOP:
- Amsua, Mhs, Iasi

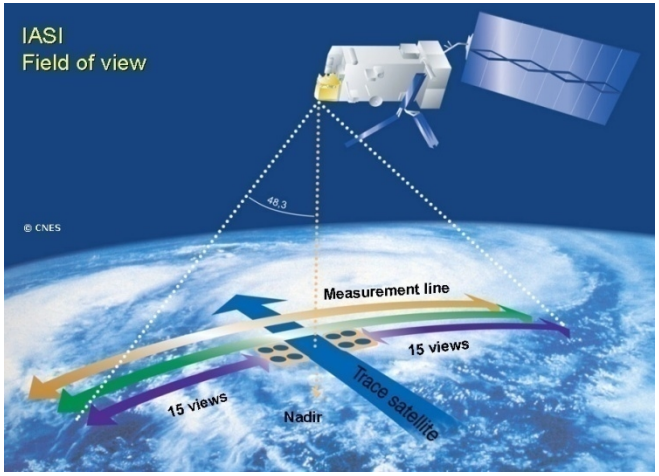
→ METEOSAT and MODIS
- Satob, Satgeo, geowind

IASI data and its pre-processing





The pre-processing of the data is almost ready
- -- Reads a restricted number of channels
- -- Uses 1 of the 4 FOV´s (field of view) in FOR (field of regard)



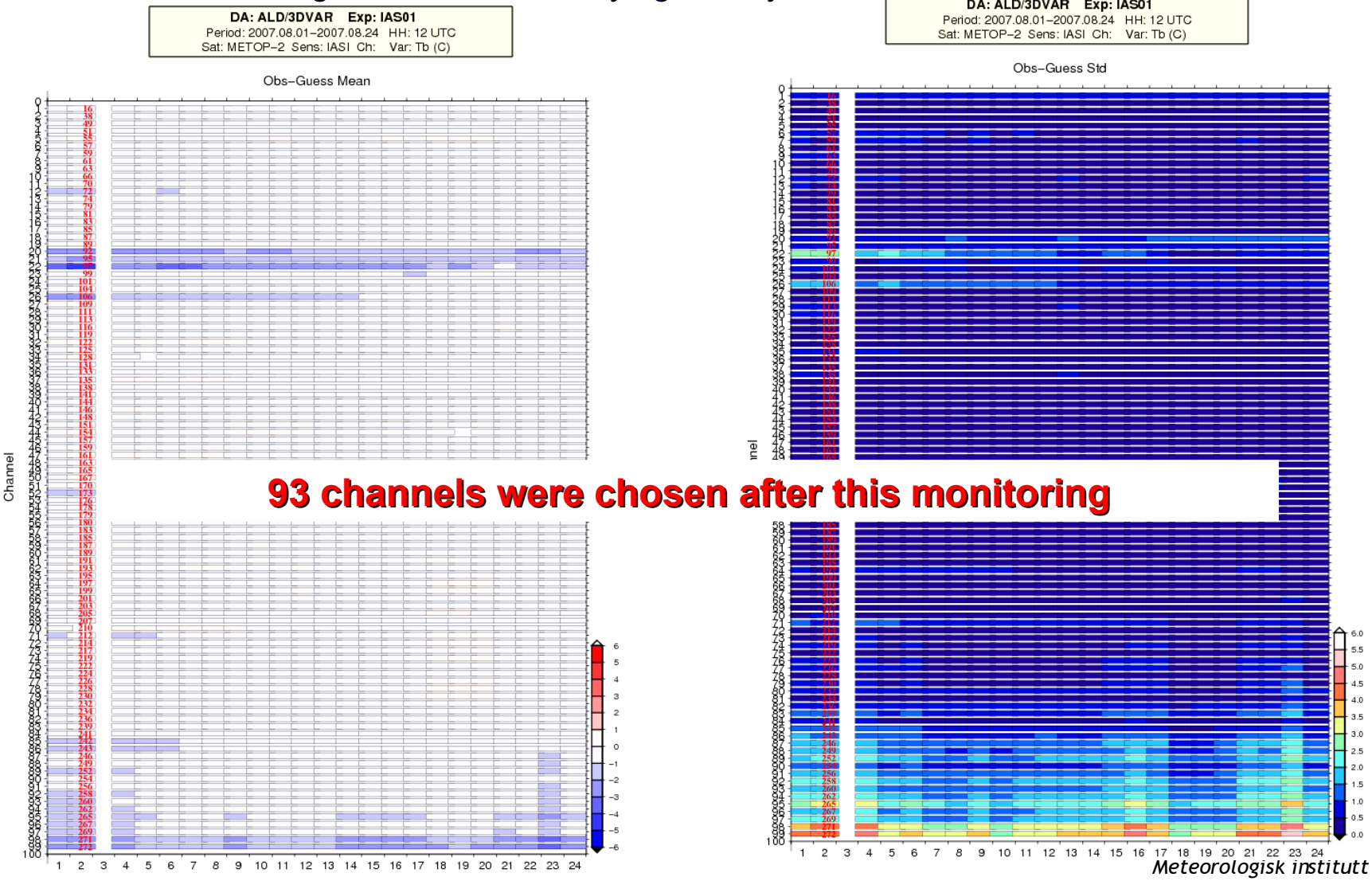
Radiance data assimilation monitoring

Multistep channel selection method – first step

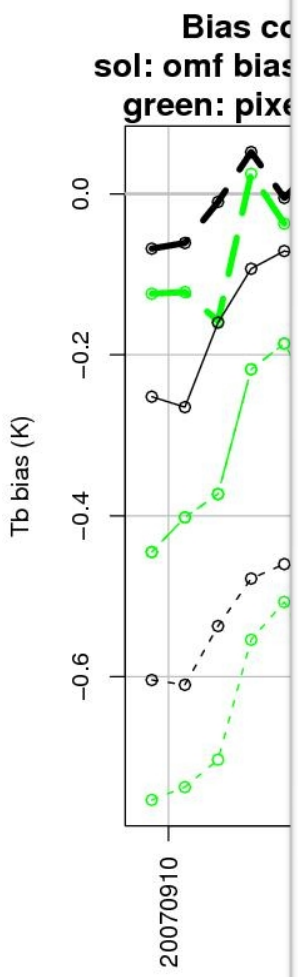
Monitoring the extracted IASI channels (100 ch/page)

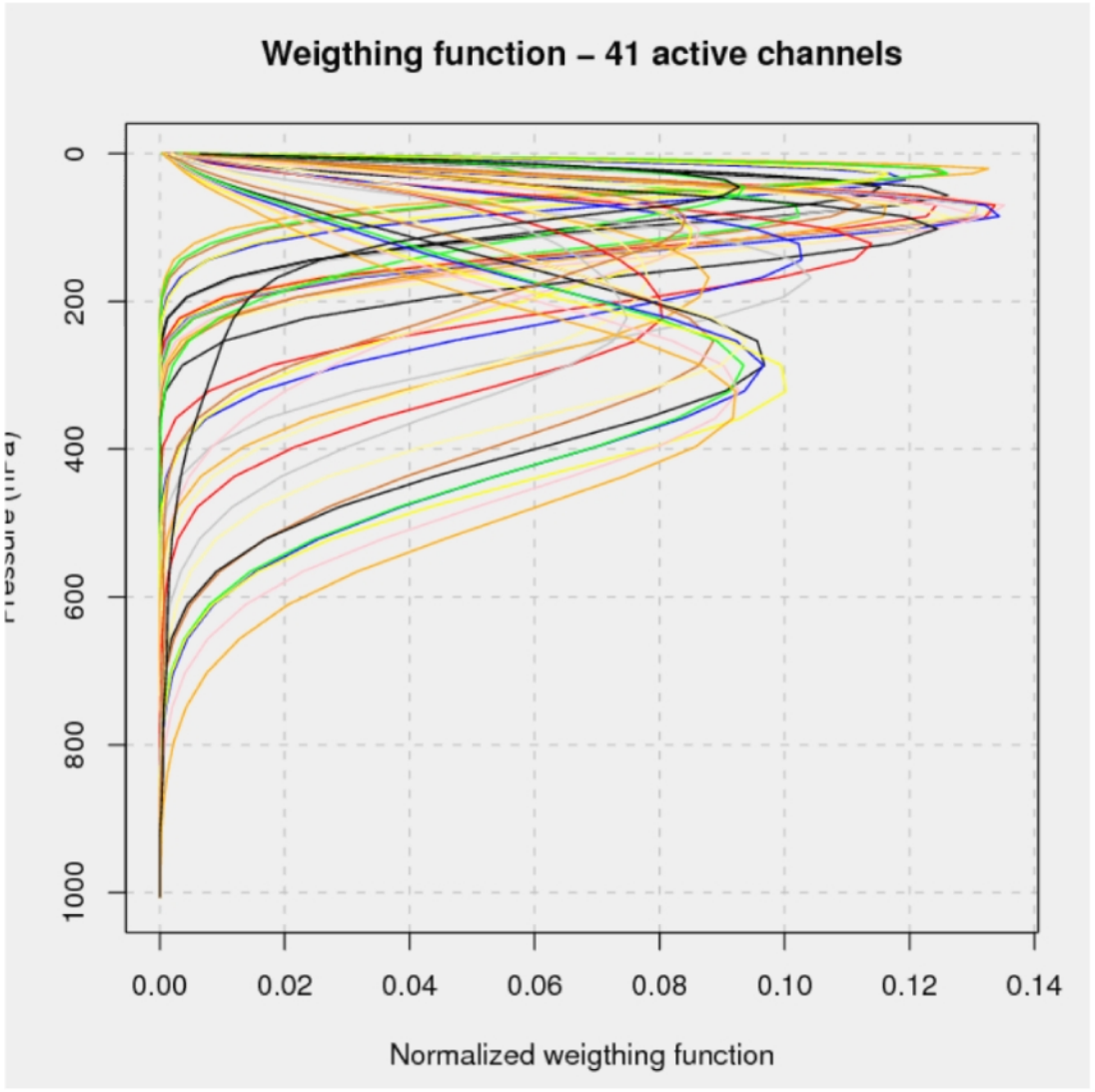
Time series of bias and STDV for obs-guess in observation space

→ Choosing the channels “obeying” the system



Radiance data assimilation monitoring
multistep channel selection method – second step





selected first
ea statistics

selected
sea statistics

the vertical
atmospheric
ed channel

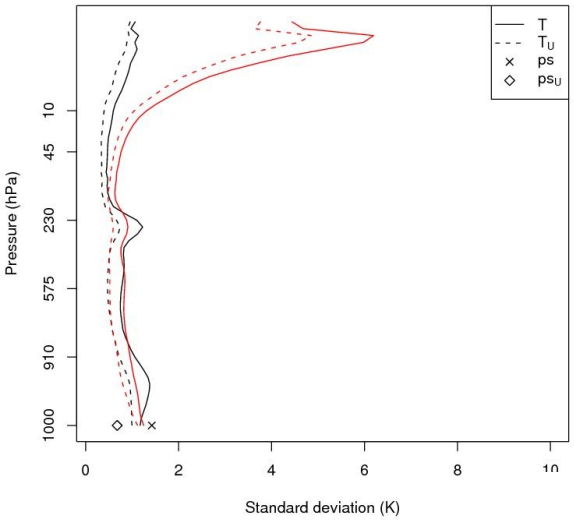
The problems we had to face and channels usage

- We observed large stratospheric model error, resulting in large observation increments in winter
  → Any disbalance at any model level can produce large model error in the troposphere after 2-3 days.

- **IASI channels are used in the following way:**
- Over sea: 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
- Over Land: 70, 133, 154, 180, 214, 217, 219, 301, 303
- Over ice: None

- Channels having peak above the cloud top are assimilated

Assimilation in polar region seasonality of the background statistics

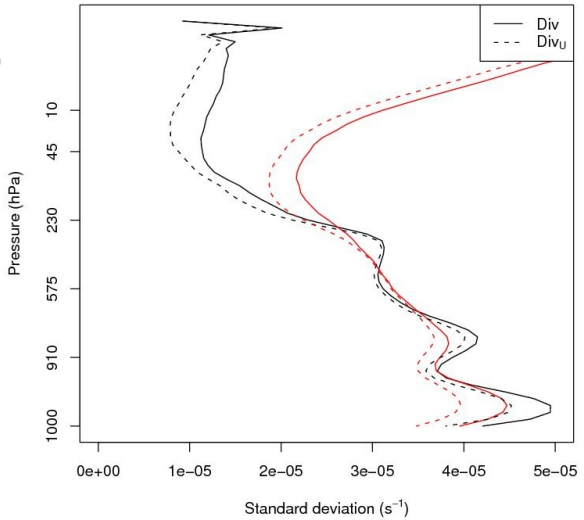


Black- summer stats

Red - winter stats

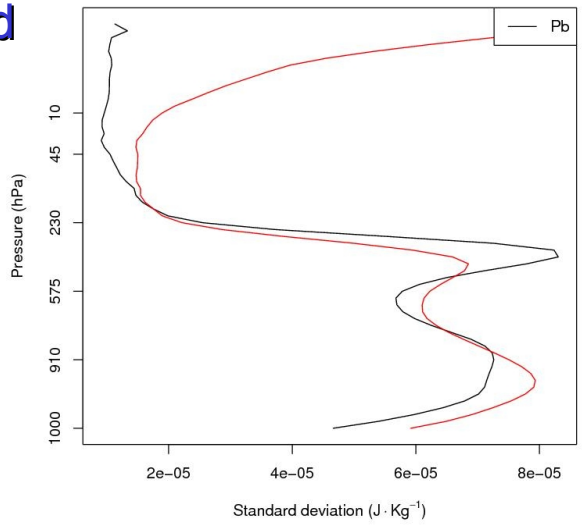
using

„NMC" technique



Statistics for balanced and unbalanced T

Statistics for balanced and unbalanced Divergence



Statistics for Vorticity

Assimilation in polar region estimation of ensemble based statistics

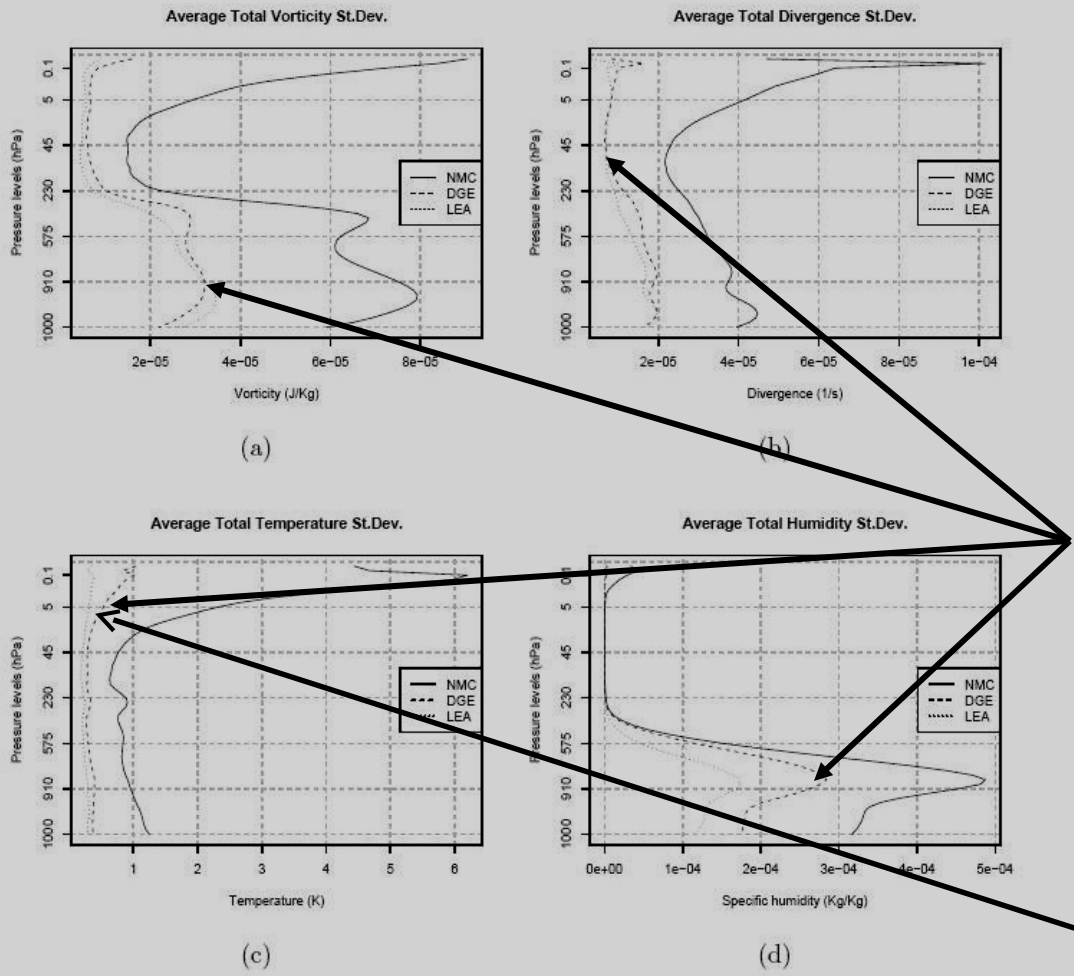


Figure 7: Vertical profiles of total standard deviations of vorticity (a), divergence (b), temperature (c) and specific humidity (d) for the three statistics (NMC: NMC-derived background-error standard deviations; DGE: background-error standard deviations from downscaled global ensemble analysis; LEA: background-error standard deviations from limited area ensemble variational assimilation).

- Statistics used in the assimilation trial
  → Computed using downscaled ensemble fields

! This small increase in background error can produce a very large observation increment

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 – 2008031512
(Warming period 5 days)

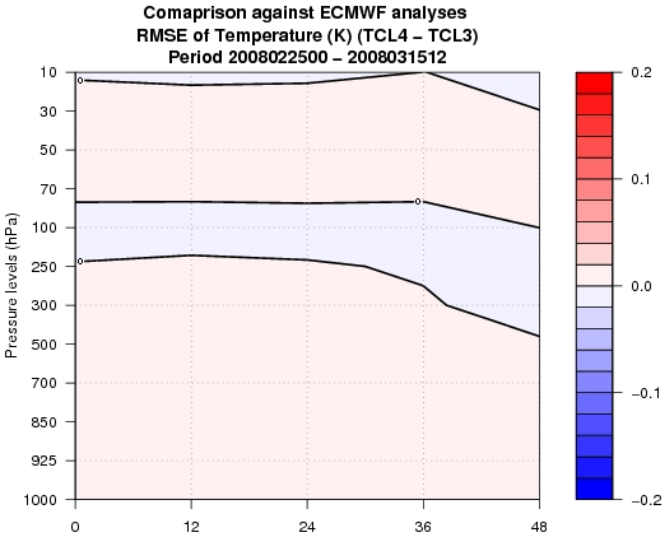
	Run with IASI data	Run without IASI
Run with campaign data	THCL1	THCL2
Run without campaign data	THCL3	THCL4

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

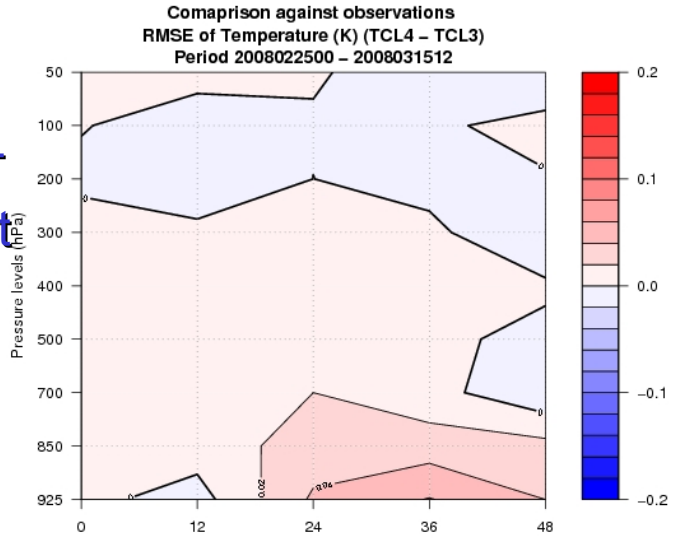
THCL1 vs THCL3 and THCL2 vs THCL4 will show the impact of the campaign observations with and without presence of IASI data in the assimilation system, respectively

Impact of IASI data

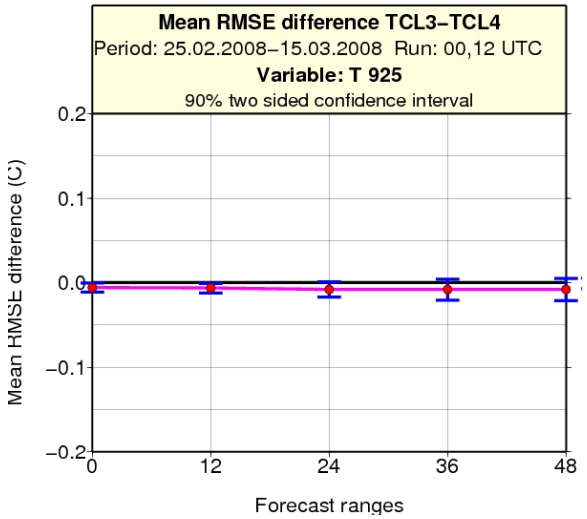
Comparison against analyses

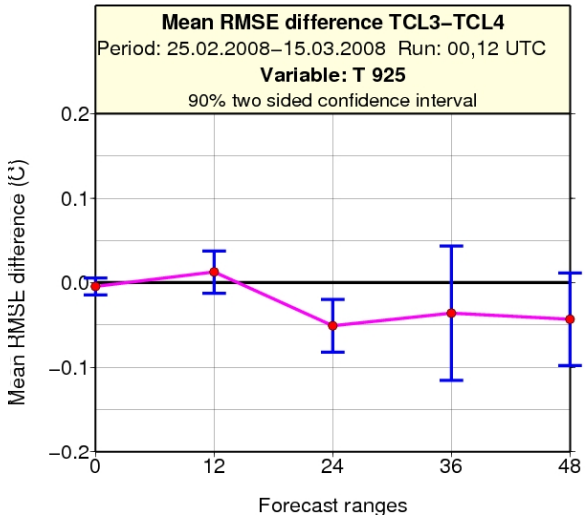


Comparison against observations



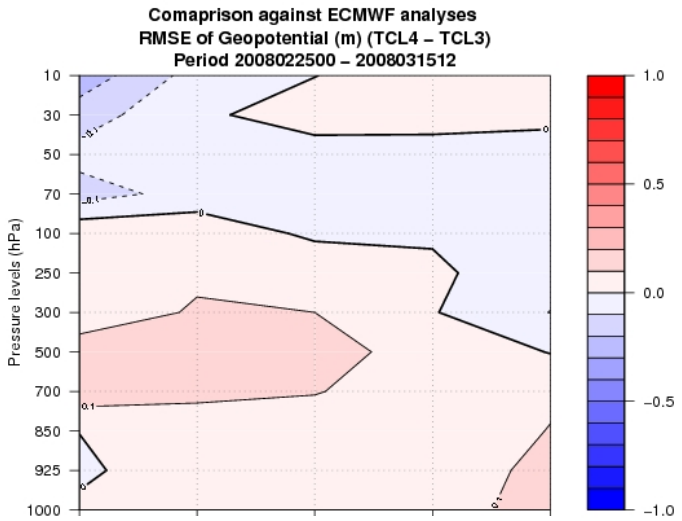
Impact on T exps without campaign data



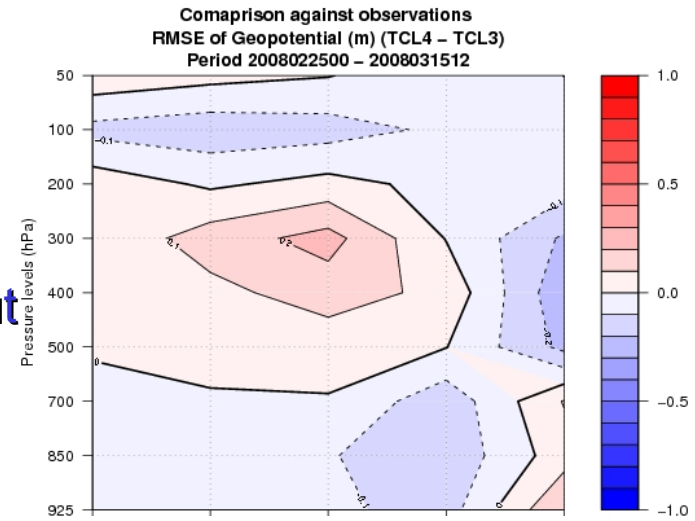


Impact of IASI data

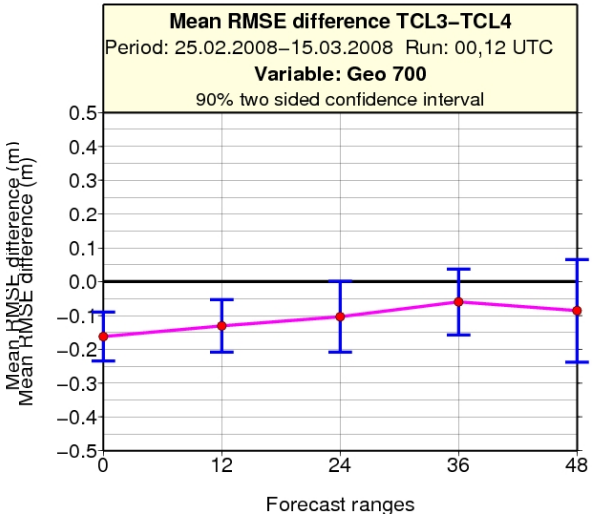
Comparison against analyses

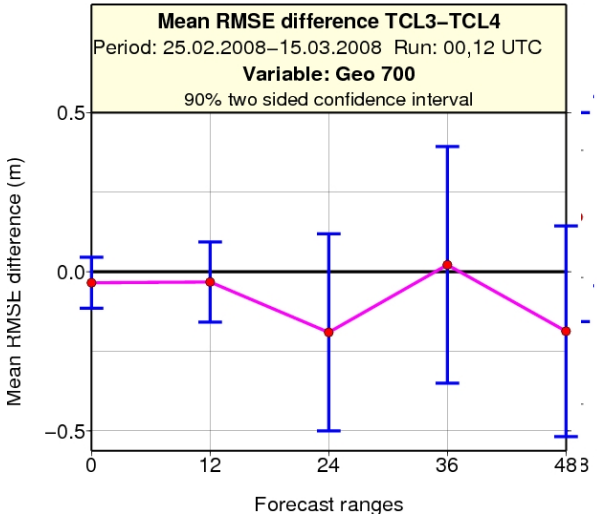


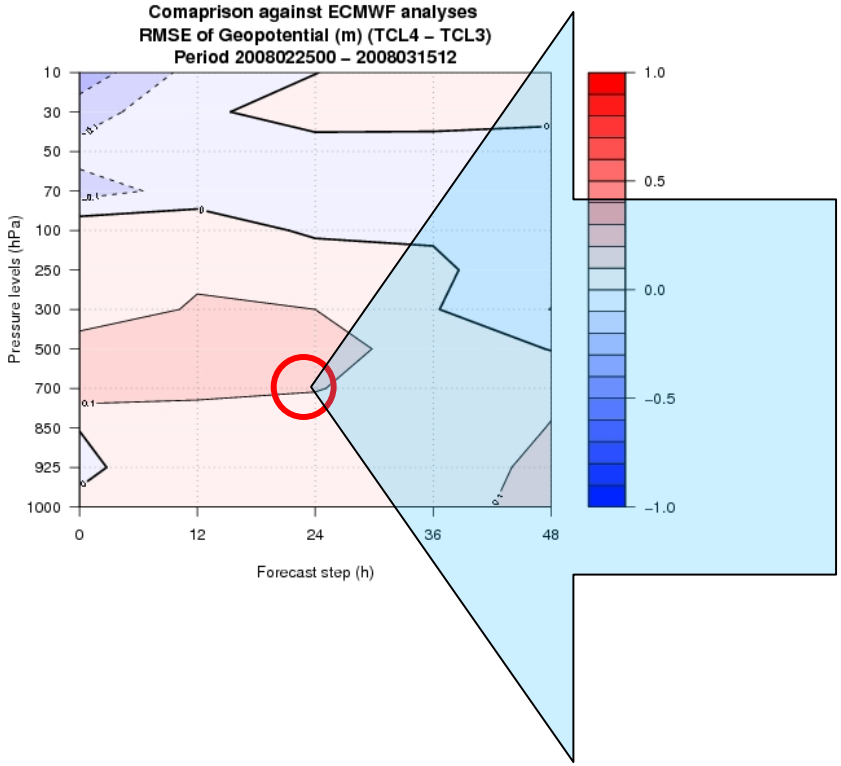
Comparison against observations

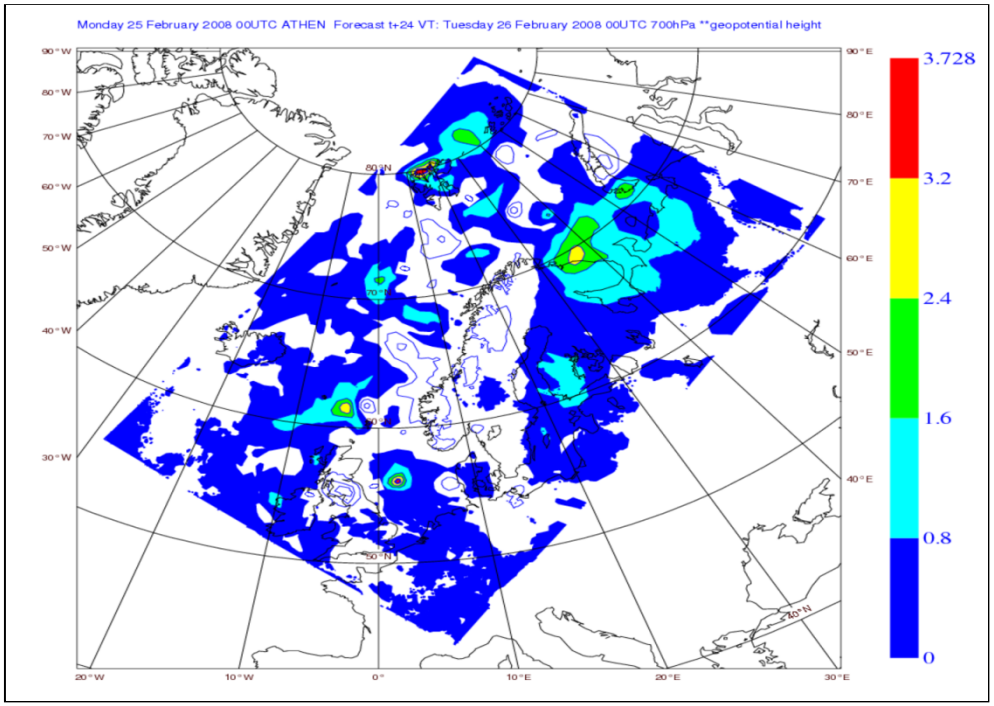


Impact on Geo exps without campaign data





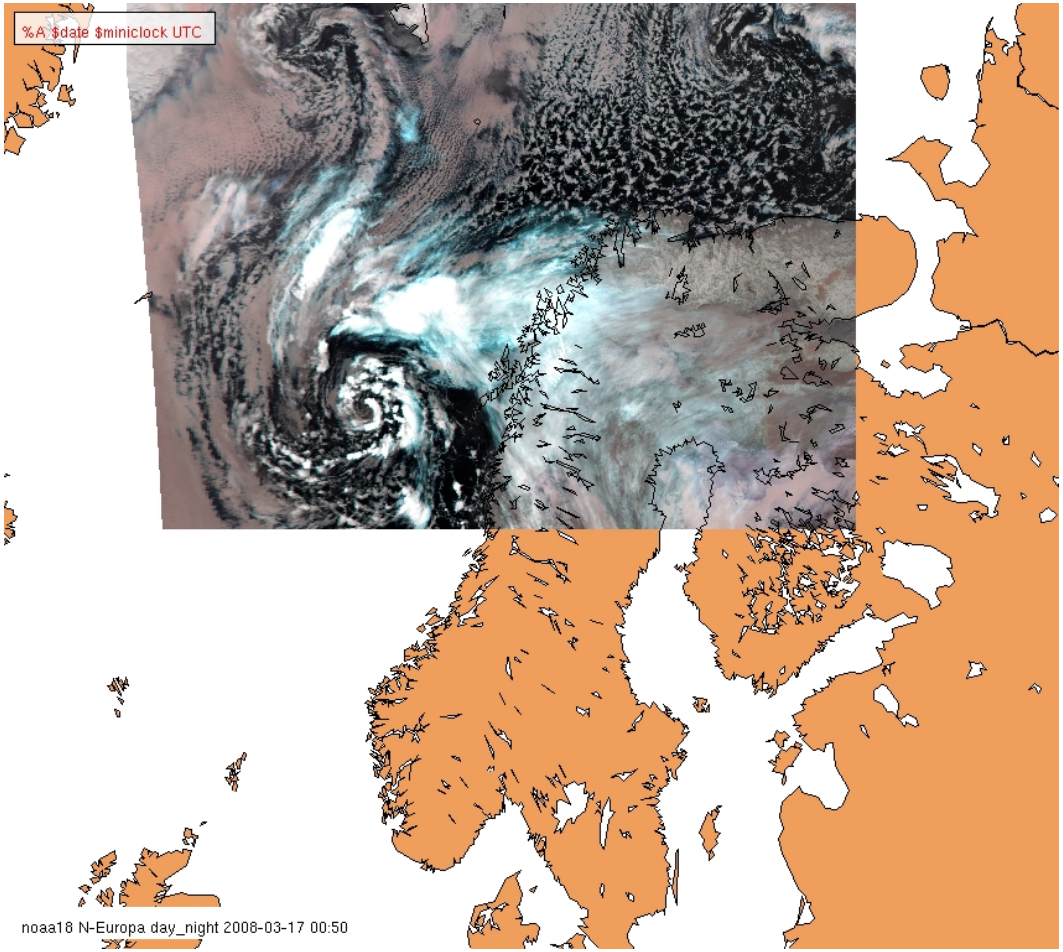




The impact on geopotential at 700 hPa for 24-hour forecast – coloured patterns show positive impact

Case study

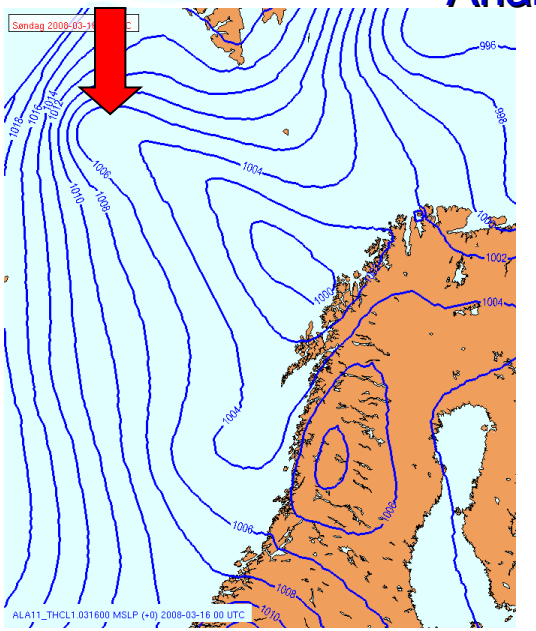
Very fast developing polar low from 16-17 March 2008



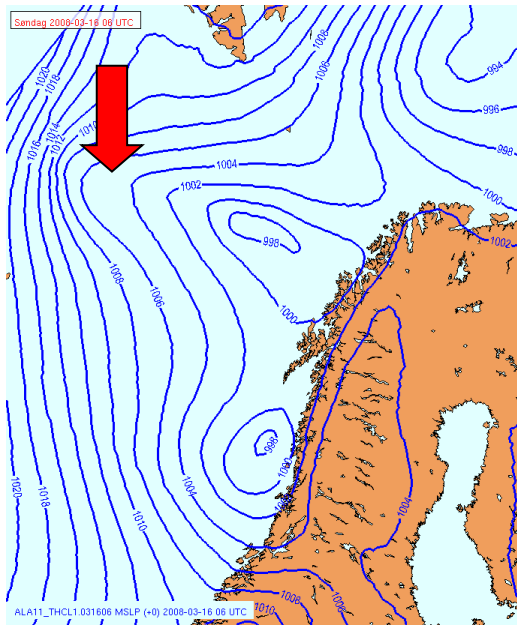
Position and intensity
at 00:50 UTC
17 March 2008

Analyses with IASI and campaign data

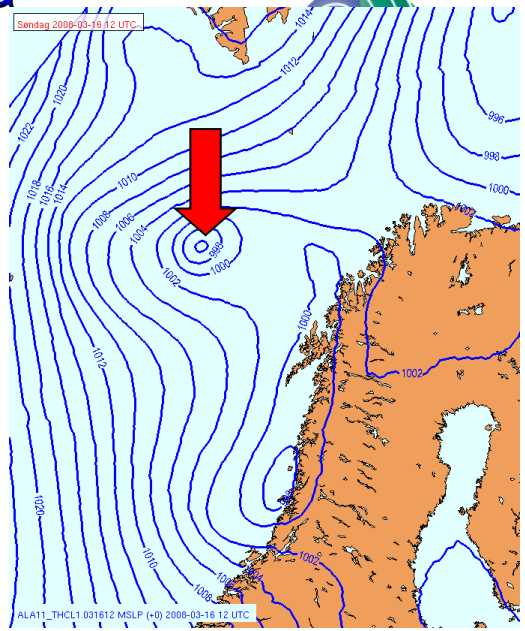
20080316 00 UTC



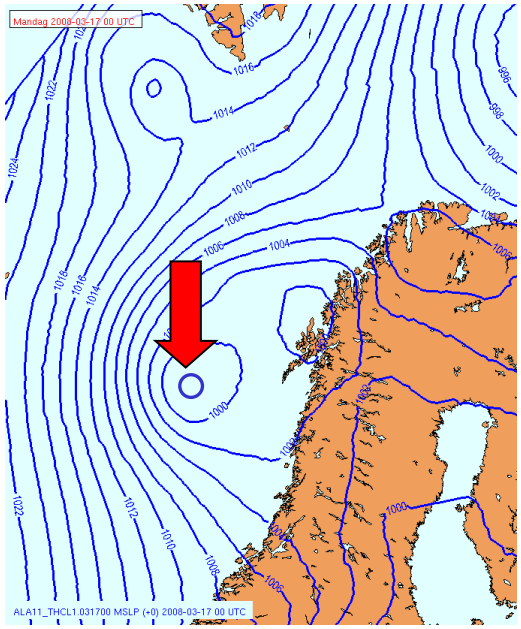
20080316 06 UTC



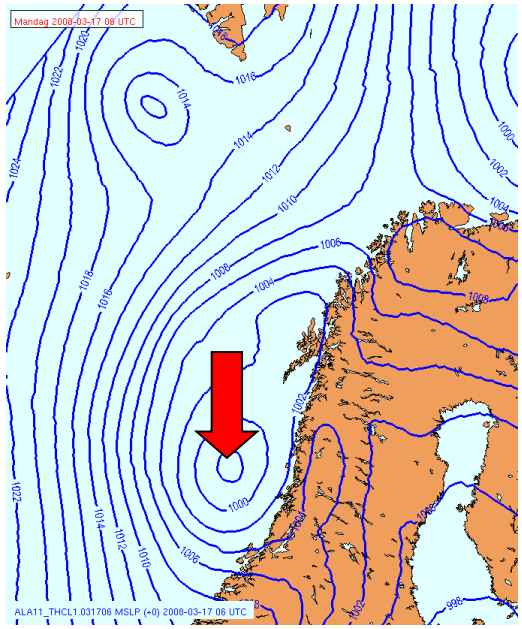
20080316 12 UTC



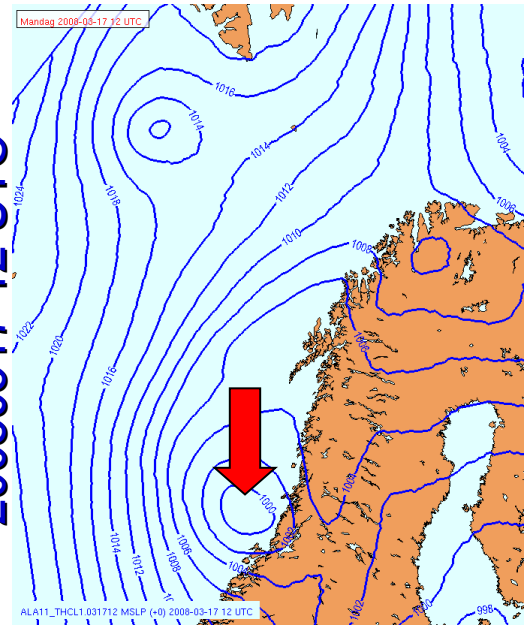
20080317 00 UTC



20080317 06 UTC

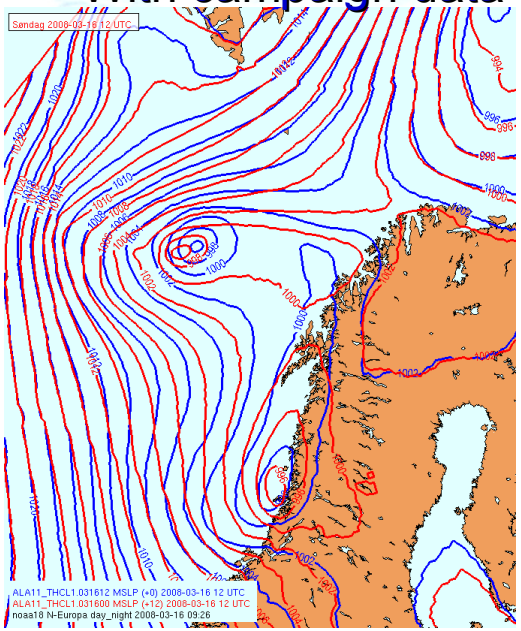


20080317 12 UTC



With campaign data

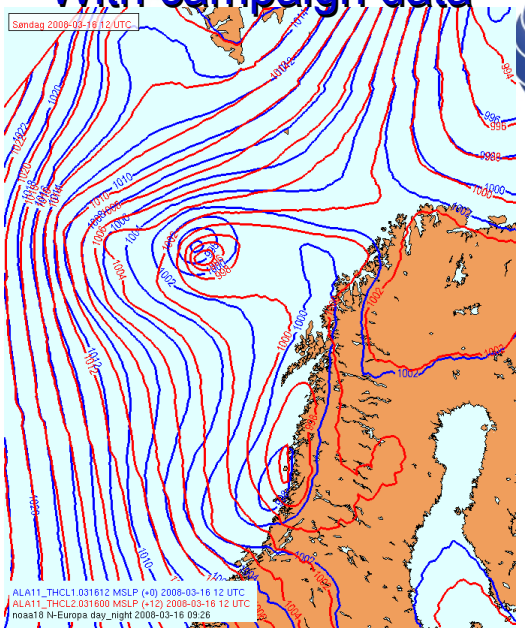
With IASI data



12-hour forecasts valid for 20080316 12UTC

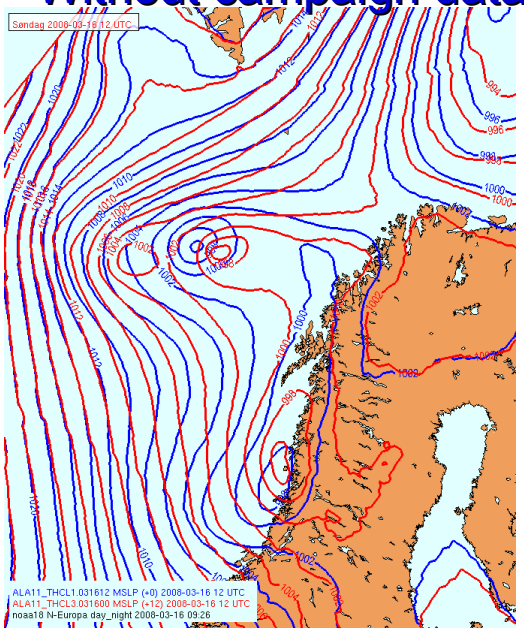
With campaign data

Without IASI data



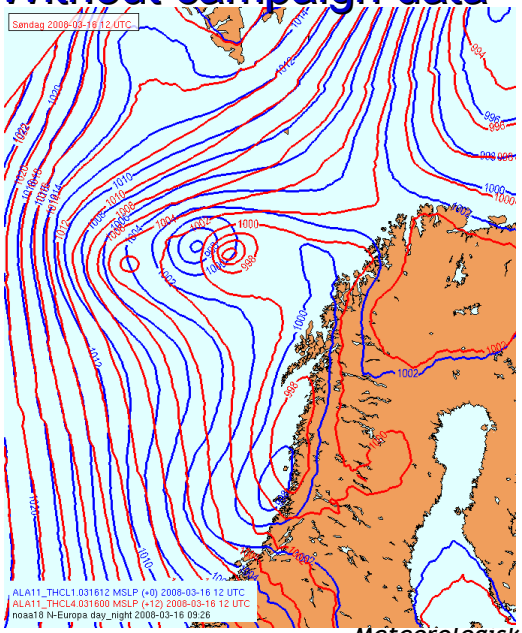
Without campaign data

With IASI data



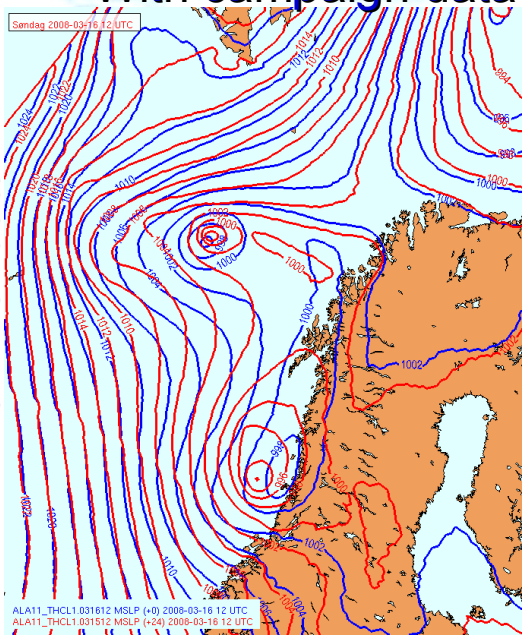
Without campaign data

Without IASI data



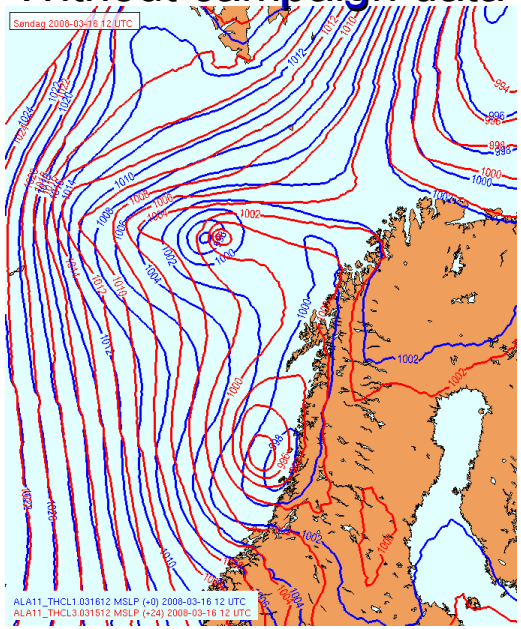
With campaign data

With IASI data



Without campaign data

With IASI data



24-hour

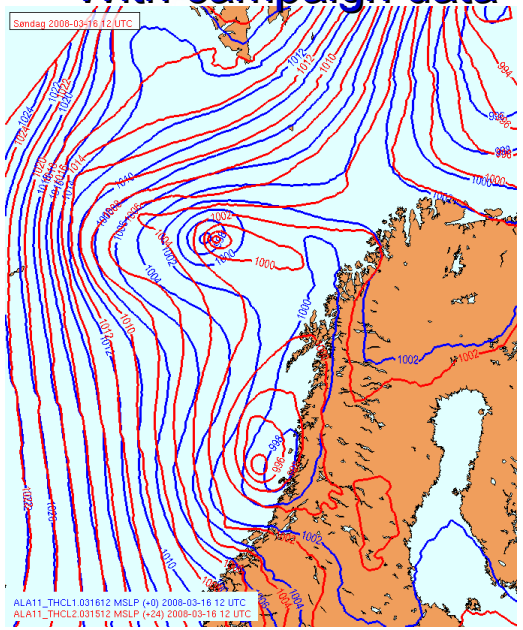
forecasts valid for

20080316

12UTC

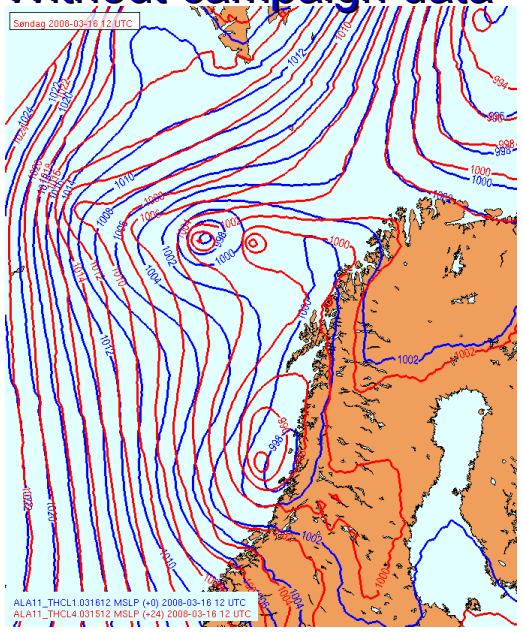
With campaign data

Without IASI data



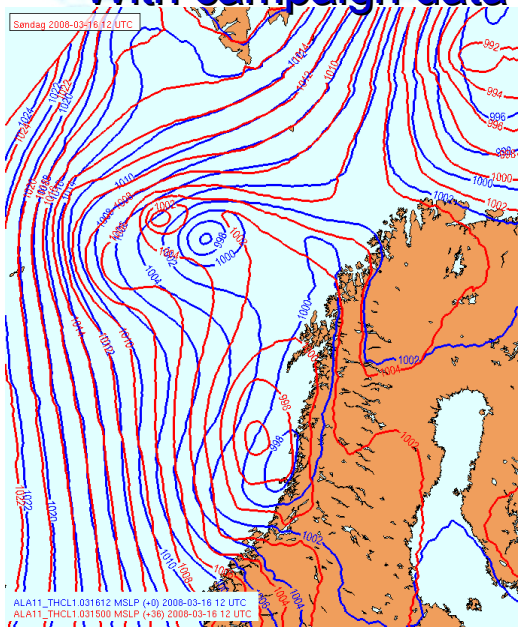
Without campaign data

Without IASI data



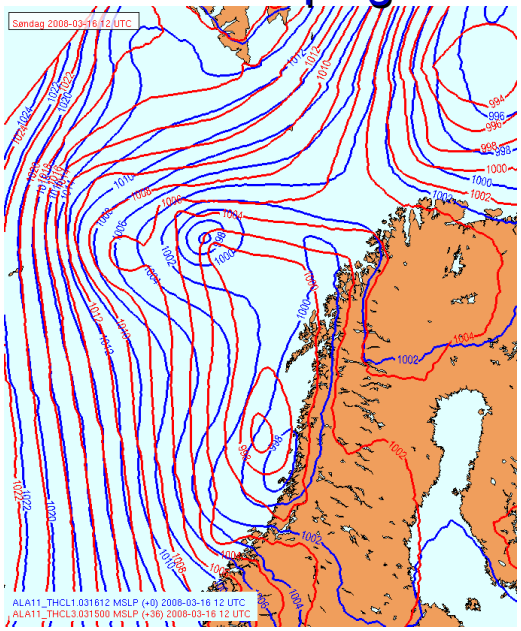
With campaign data

With IASI data



Without campaign data

With IASI data



36-hour

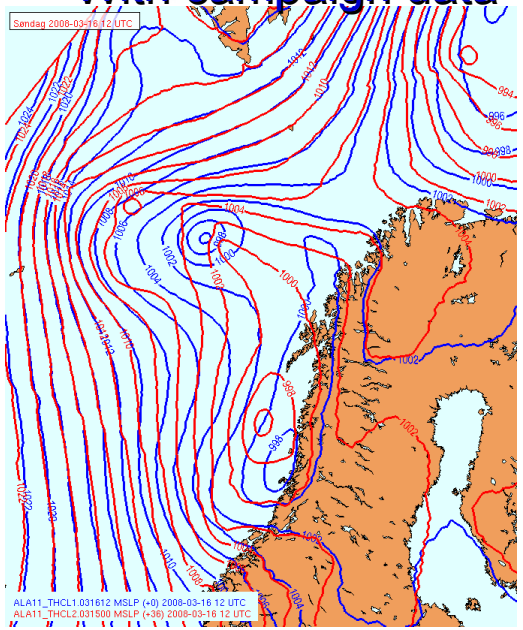
forecasts valid for

20080316

12UTC

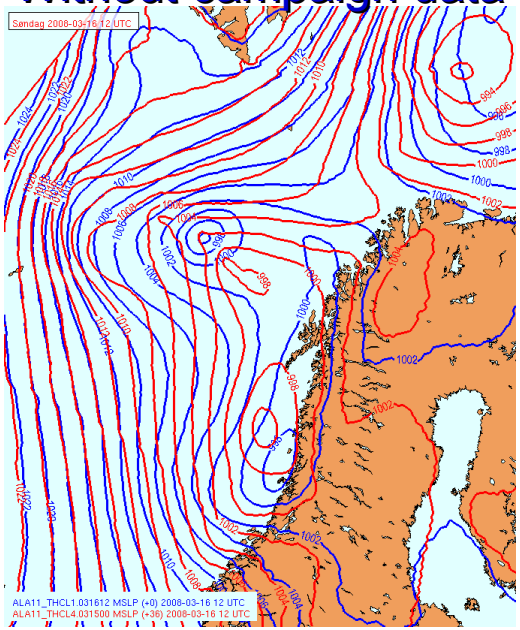
With campaign data

Without IASI data



Without campaign data

Without IASI data



Conclusions and *future plans*

→ We found the optimal way to assimilate the IASI data in the HARMONIE assimilation system:

-- *Tropospheric peaking channels are under test now;*

-- *To improve the system, a better analyses of skin temperature is needed;*

-- *Using the current analysis system, but with restriction over high altitude terrain can be an alternative solution.*

→ We showed that IASI data improved the analyses and forecasts in the conditions with and without campaign observations:

-- the relative impact is slightly reduced with additional campaign data.

→ The impact of the IASI data on temperature (in the lower troposphere) and geopotential (in the middle troposphere) is significatly positive;

→ Significant impact on the humidity was observed around 700-850 hPa;

→ An overall neutral impact (comparison against analyses) on wind speed was observed, but comparison against radiosonde showed positive impact in lower troposphere.

→ Case study showed positive impact of IASI data on the analysis and forecasts of polar lows

-- with campaign data, the positive impact is up to 36-hour forecast;

-- without campaign data, the positive impact is up to 24-hour forecast “only”.

→ *Please visit our poster to see more case studies and other developments related to the assimilation of satellite observations, including the use of IASI data in high resolution*

Thank you for your attention!