OSEs with HIRLAM and HARMONIE for EUCOS

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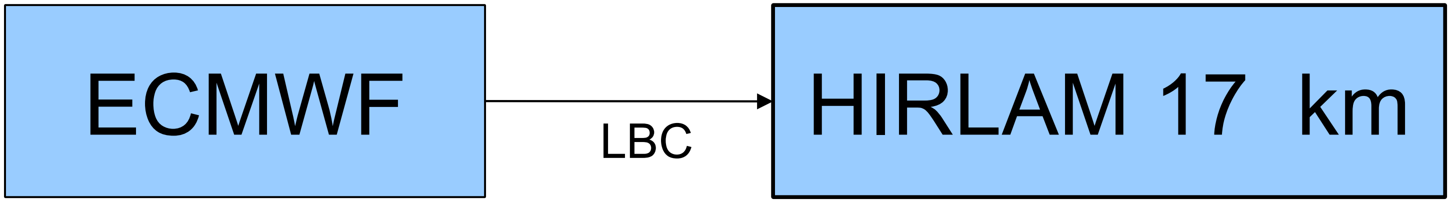
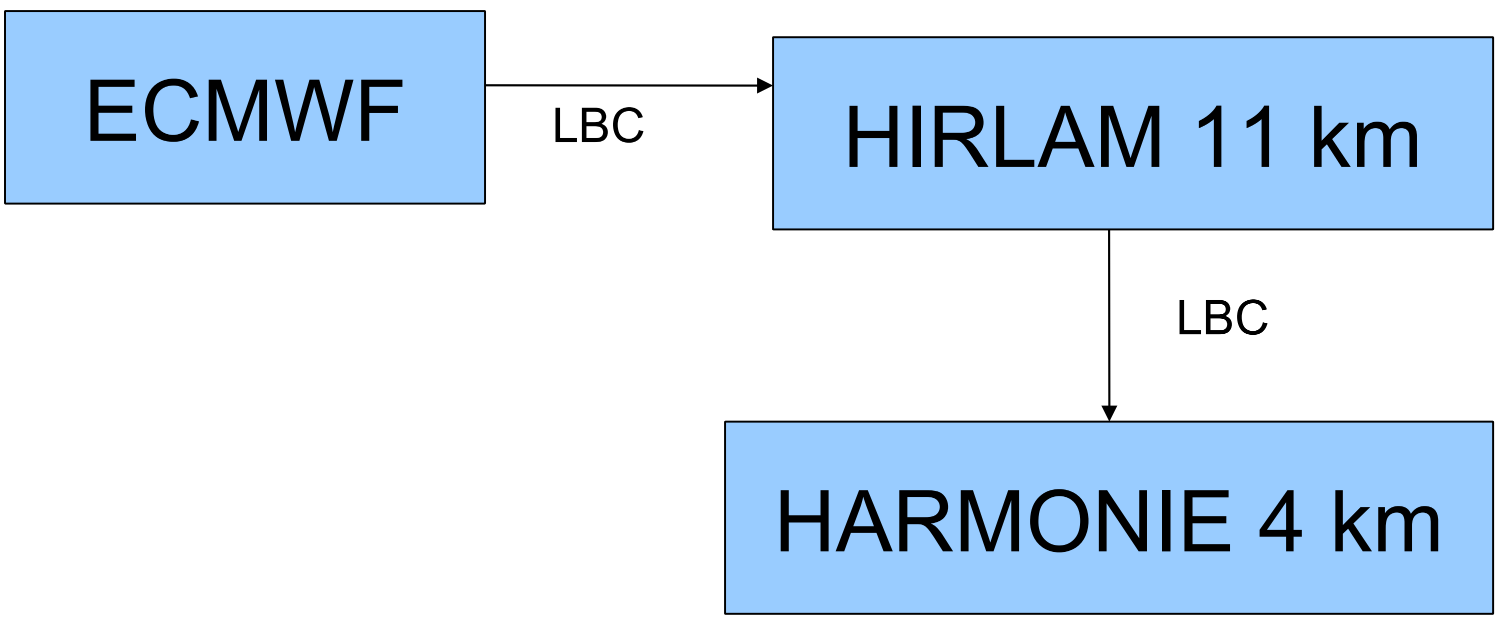
EUCOS network scenarios

- **Sc1, Baseline: a minimal radiosonde network (GUAN + GSM) and also a reduced set of aircraft data.**
- **Sc2, Control: the present operational network.**
- **Sc3a: the radiosonde network thinned to a 100 km resolution.**
- **Sc3b: as Sc3a but thinning only at 12 UTC.**
- **Sc4: radiosonde and aircraft profiles at a horizontal spacing of 250 km over Europe.**
- **Sc5: similar to Sc4 but with a thinning to 500 km.**

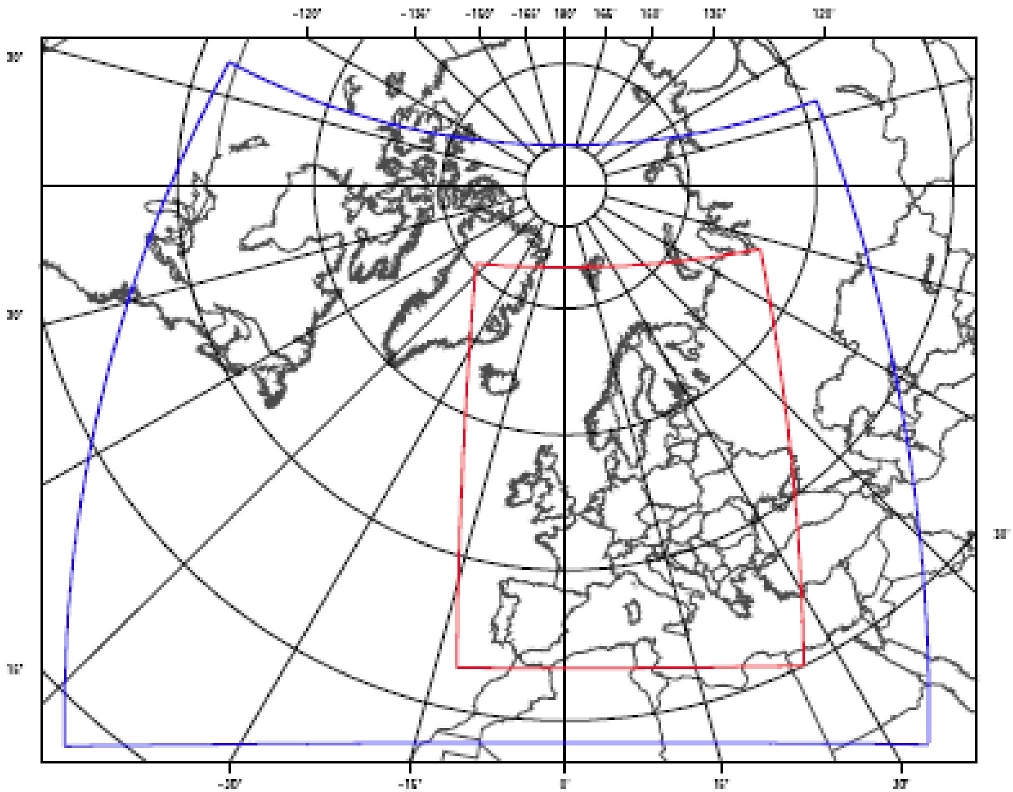
Winter period: 15 Dec 2006 – 31 Jan 2007:



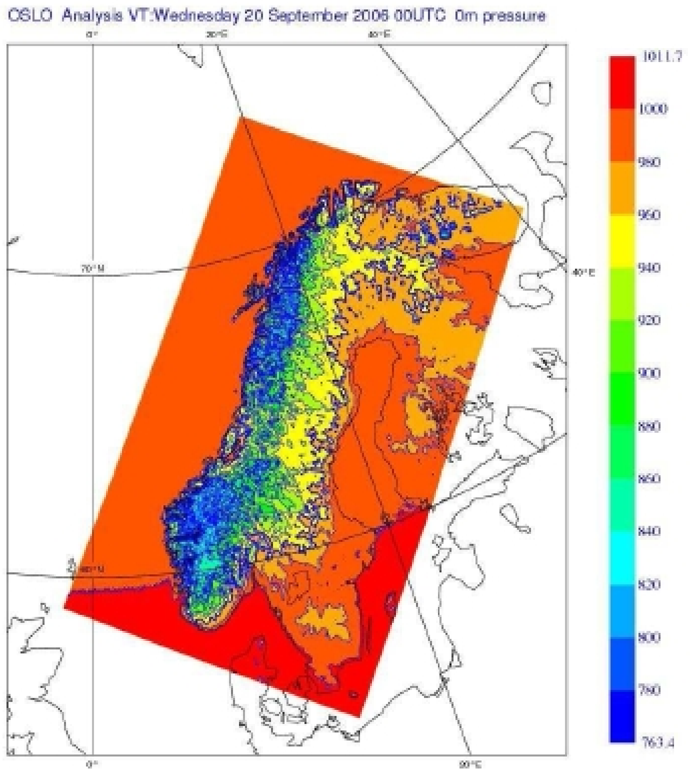
Summer period: 1 June – 16 July 2007:



Model domains:



HIRLAM 17 km and 11 km



HARMONIE 4 km

Operational HIRLAM model:

- Hydrostatic, gridpoint model, C-grid
- 60 vertical levels
- 2 time level Semi-Implicit Semi-Lagrangian
- Davies-Kållberg LBC relaxation
- CBR turbulence, Rasch-Kristjansson cond. and clouds, Kain.Fritch convection, Savijärvi radiation, ISBA surface and soil, 5 surface tiles
- No explicit initialization

Operational HIRLAM 4D-Var

- 6 hr assimilation window (and cycle)
- TL and AD models based on spectral SI SL (SETTLS) version of HIRLAM
- Only vertical diffusion in simplified 4D-Var physics
- 2 outer loop iterations
  - Winter case: 102 km and 51 km increments
  - Summer case: 66 km and 33 km increments
- Weak digital filter constraint
- Statistical balance background constraint

Experimental mesoscale HARMONIE forecasting system

- **Non-hydrostatic spectral SI SL model (ALADIN)**
- **Meteo-France Aladin PHYSICS**
- **ALADIN 3D-Var**
- **Digital Filter Initialization**

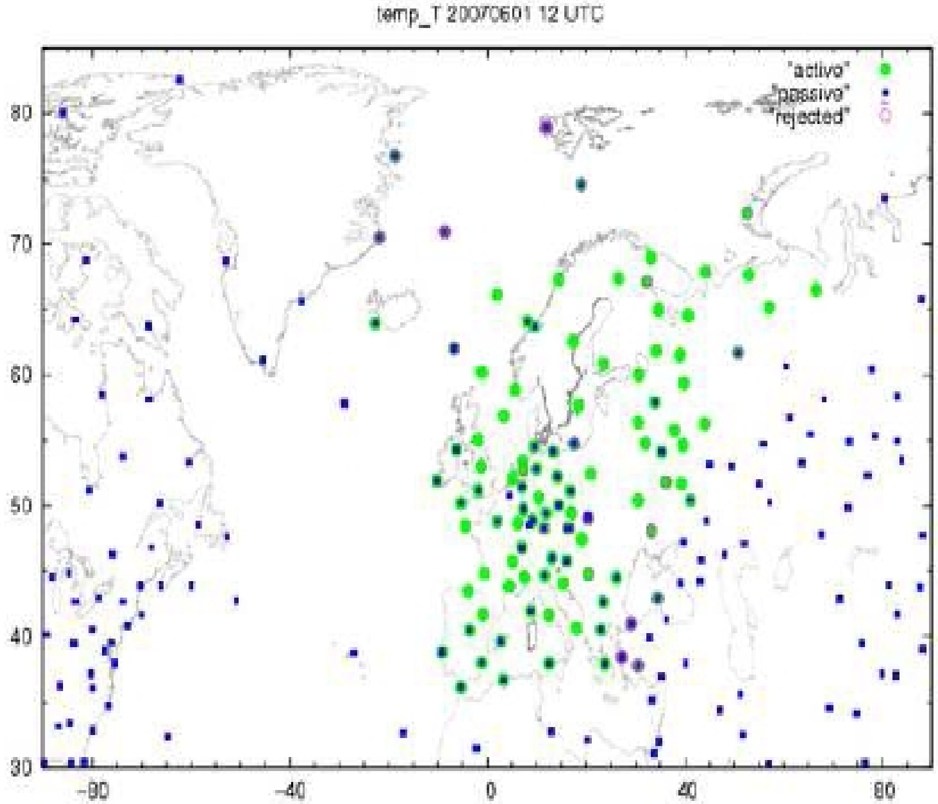
Utilized observations:

Observation types	Winter period HIRLAM	Summer period HIRLAM	Summer period HARMONIE
TEMP	u,v,T,q Blacklisting following EUCOS lists	u,v,T,q Blacklisting following EUCOS lists	u,v,T,q,z Blacklisting following EUCOS lists
Aircraft reports	u,v,T Thinning following EUCOS	u,v,T Thinning following EUCOS	u,v,T Thinning following EUCOS
SYNOP	P_s	P_s	P_s
SHIP (not used in Sc1)	P_s	P_s	P_s, u_{10}, v_{10}
DRIBU	P_s	P_s	P_s
AMSU-A radiances	Channels 5-10 sea and sea ice	Channels 5-10 sea and sea ice	Channels 8-10 sea and land
AMSU-B radiances	Channels 3-5 sea	Channels 3-5 sea	Channels 3-4 sea and land
GEO AMV	u, v	u, v	not used
MODIS AMV	not used	not used	u, v
Seawinds, scatt. winds	u_{10}, v_{10}	u_{10}, v_{10}	Not used

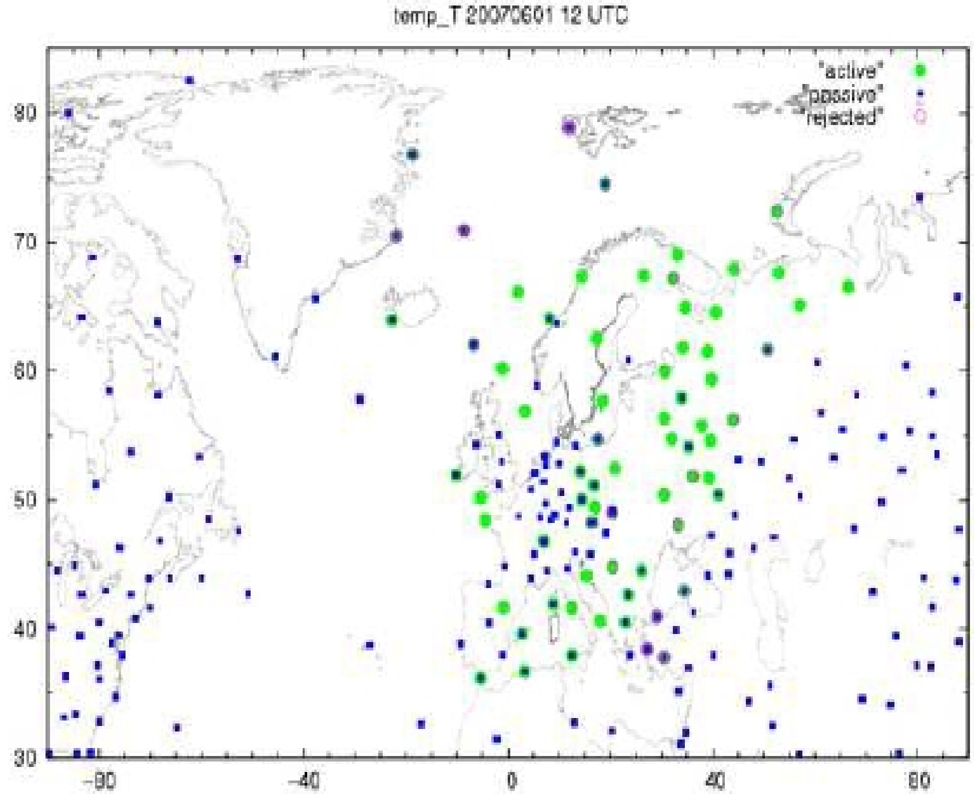
Verification of analyses and forecasts

- Verification against radiosonde and SYNOP observations (no analysis verifications)
- Bias (mean) and Root Mean Square verification scores.
- Significancy student t test for normalized mean RMS verification score differences (ECMWF algorithm)

Validation of scenario simulations
Observation distribution maps

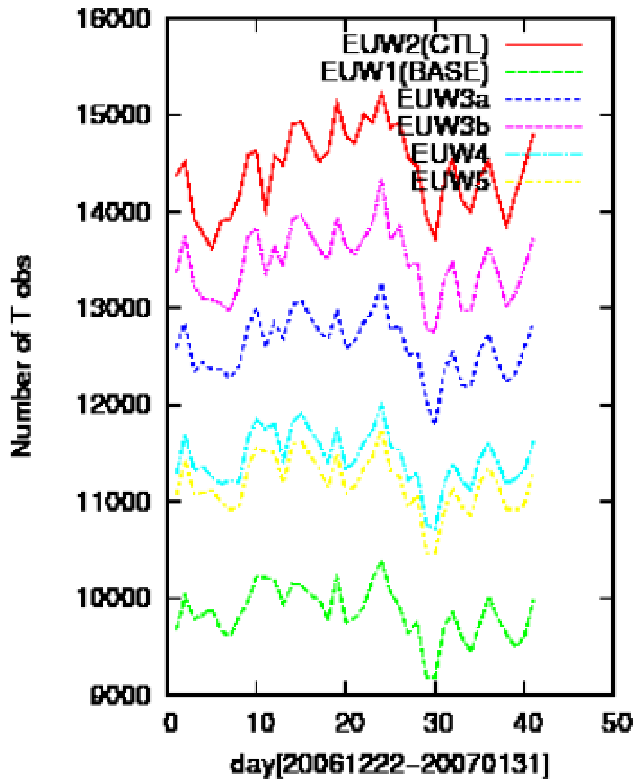


Radiosonde data, summer, Sc2, 12 UTC

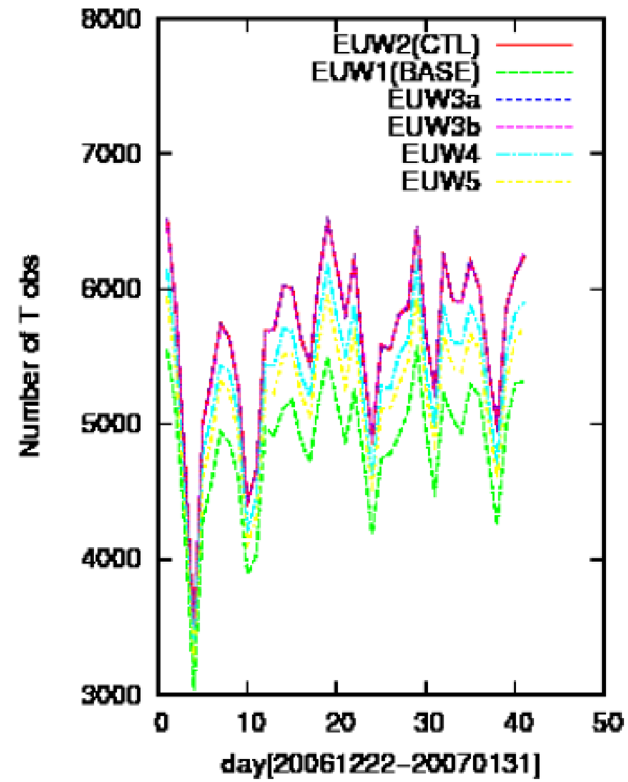


Radiosonde data, summer, Sc5, 12 UTC

Validation of scenario simulations
Observation counts, winter



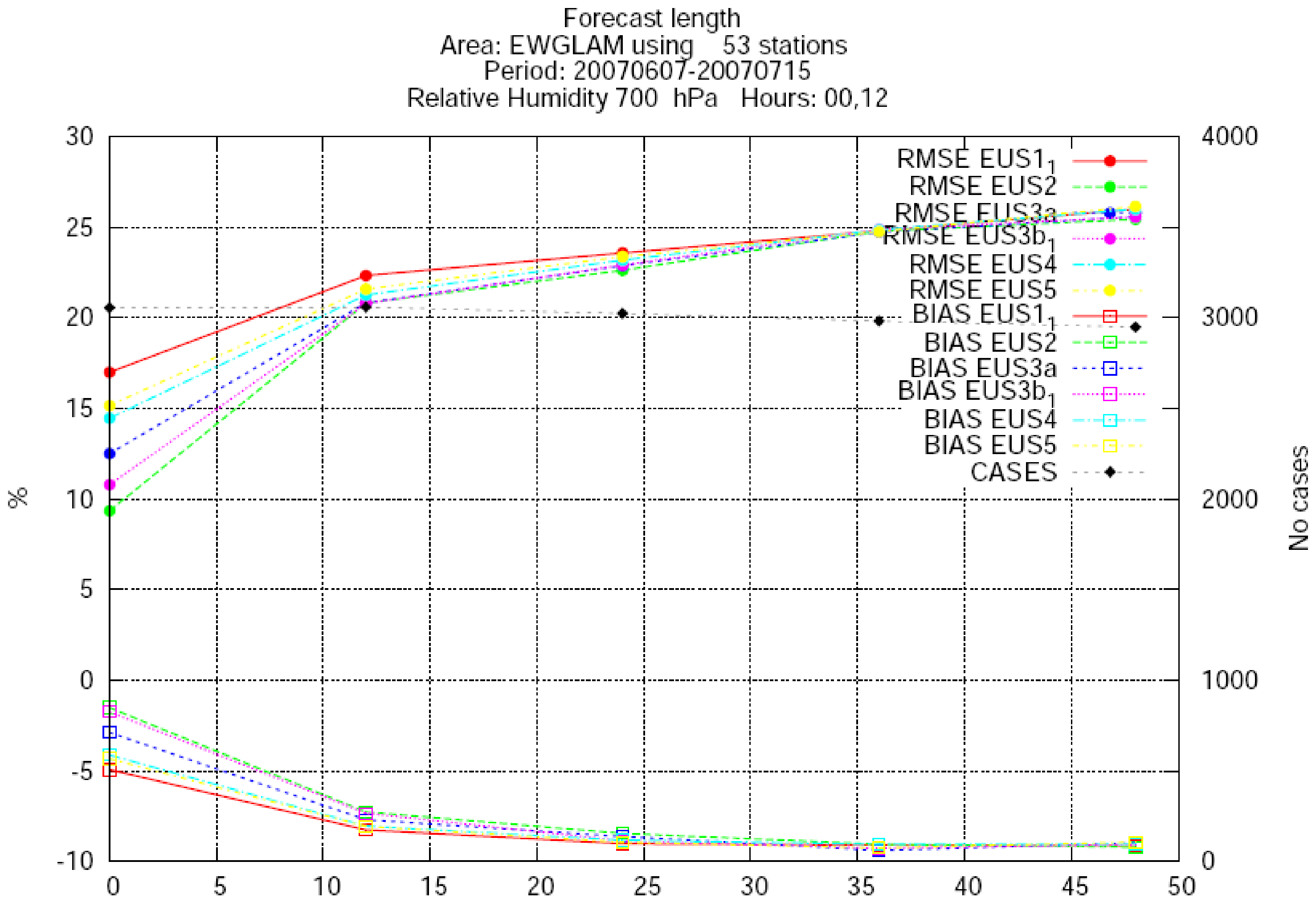
Radiosonde



Aircraft

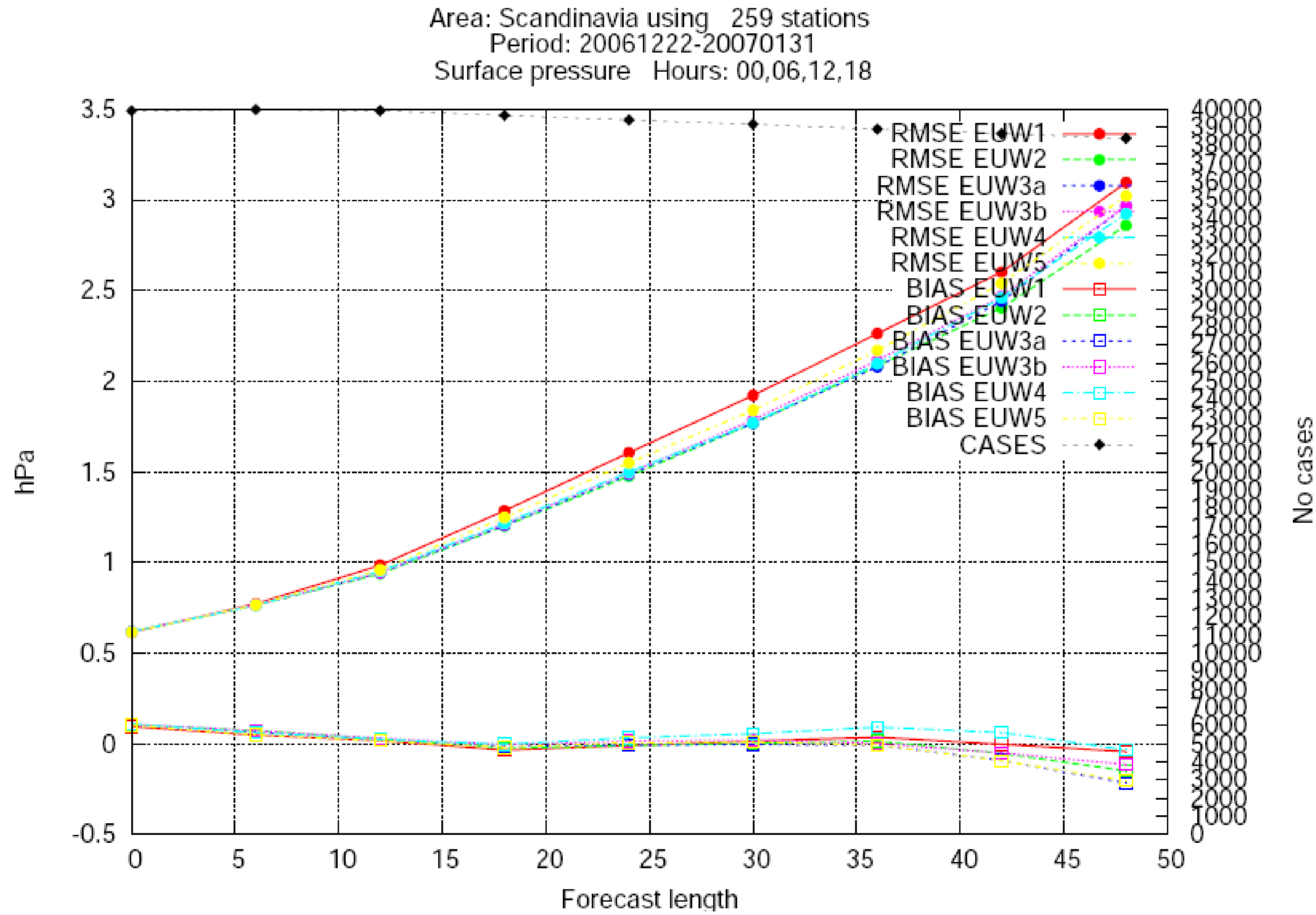
Number of temperature observations per day

On the timescale of the observation impact of forecast scores - 1



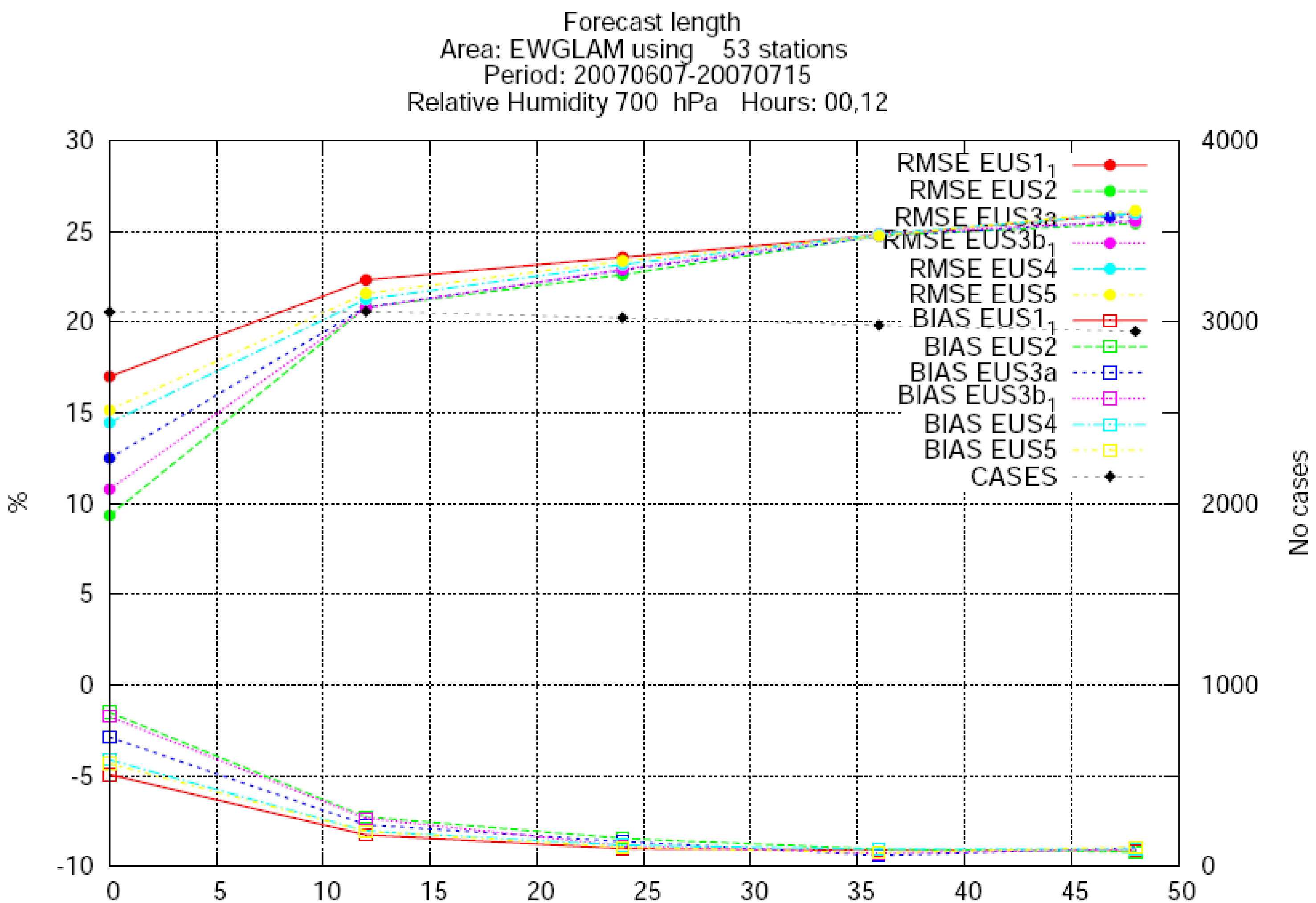
Local impact on model state variables (moisture, temperature, ...), diminshes quickly in time

On the timescale of the observation impact on forecast scores - 2

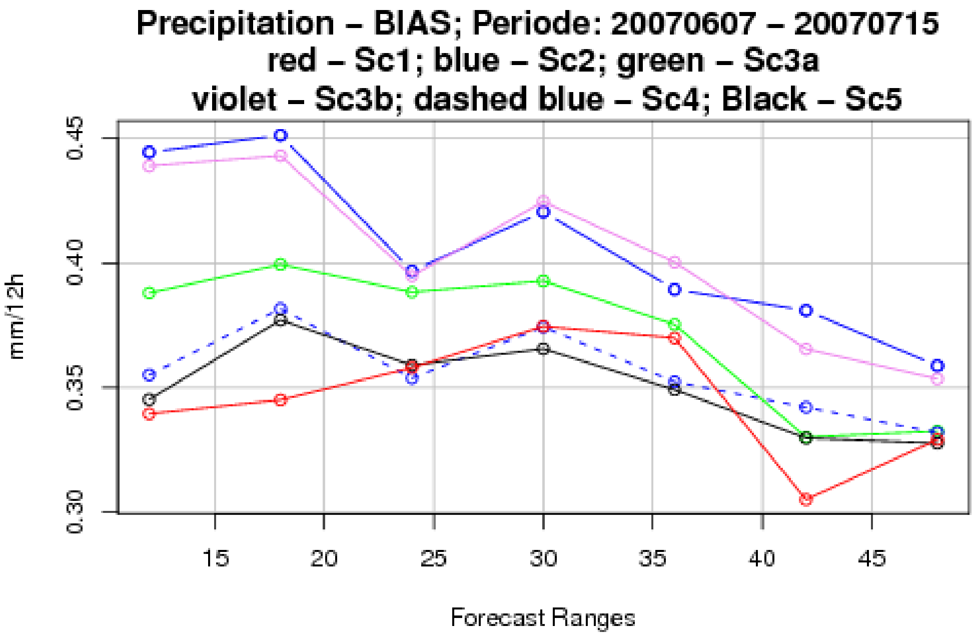


“Downstream” impact on synoptic scales, increases with forecast length

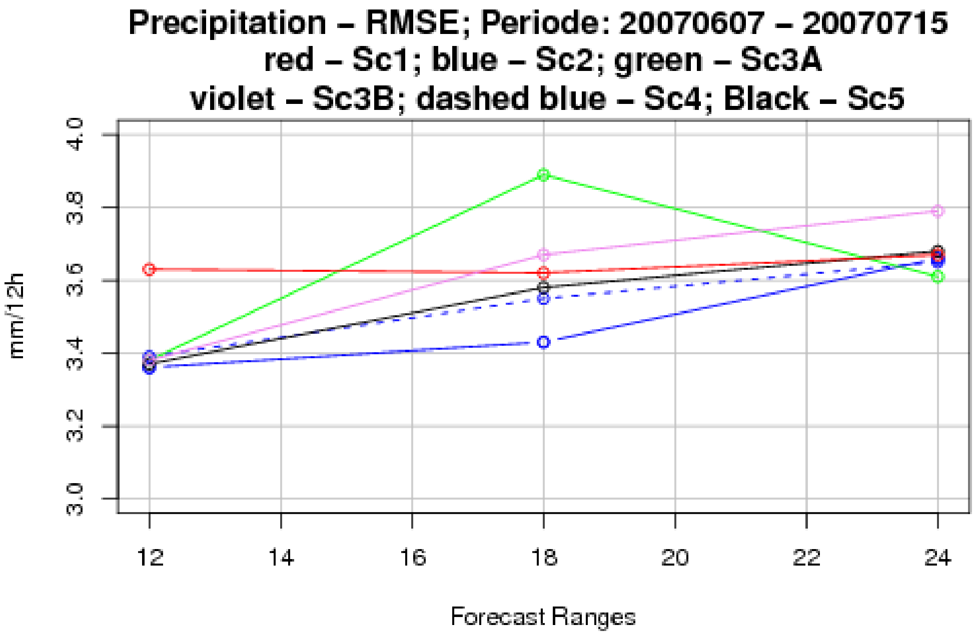
A warm and dry bias of the HIRLAM forecast model



Effects on precipitation forecasts - summer



HIRLAM



Mesoscale HARMONIE

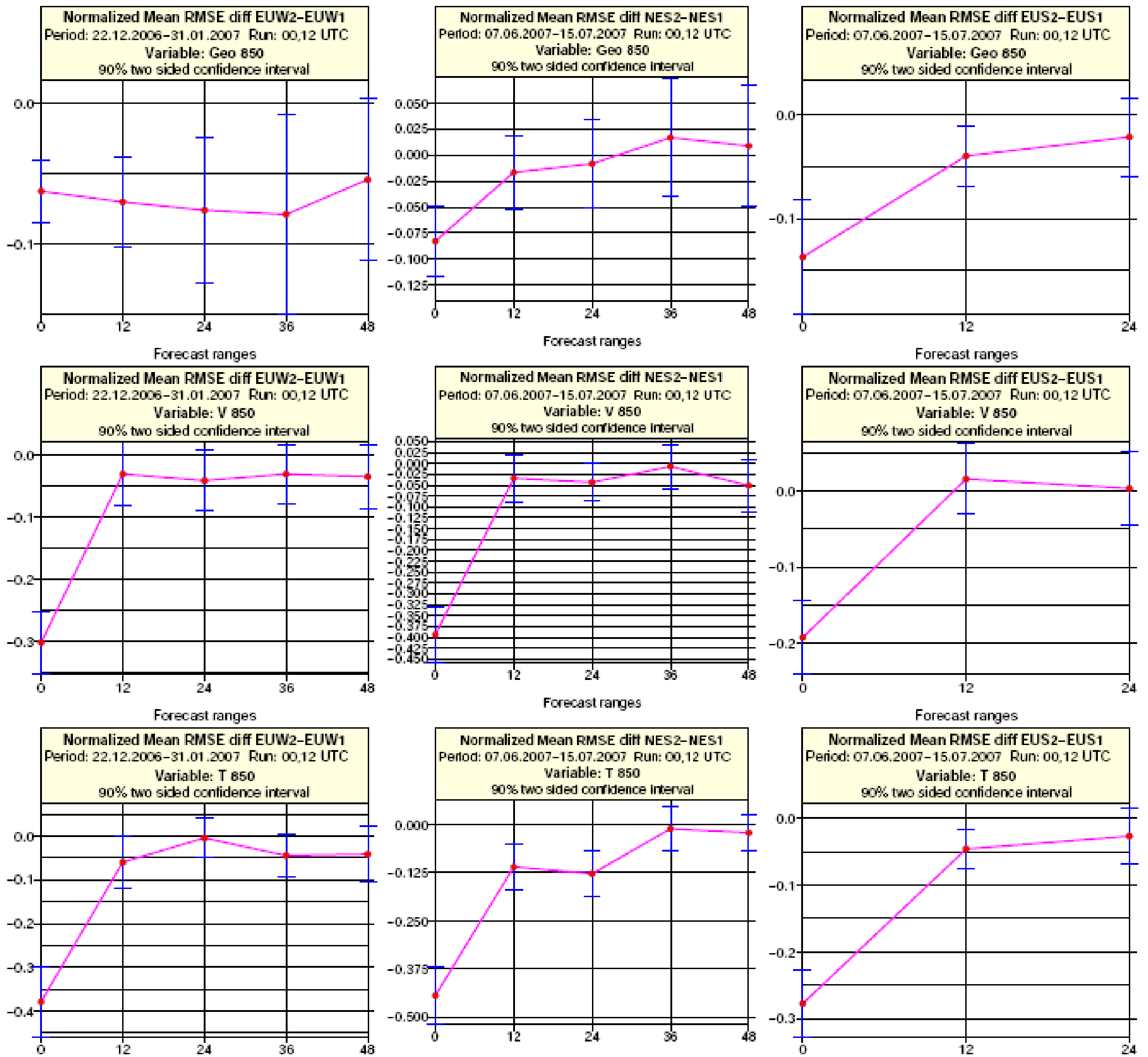
Significance test of RMS differences – Baseline scenario versus control scenario

Winter Summer Summer mesoscale

850 hPa height

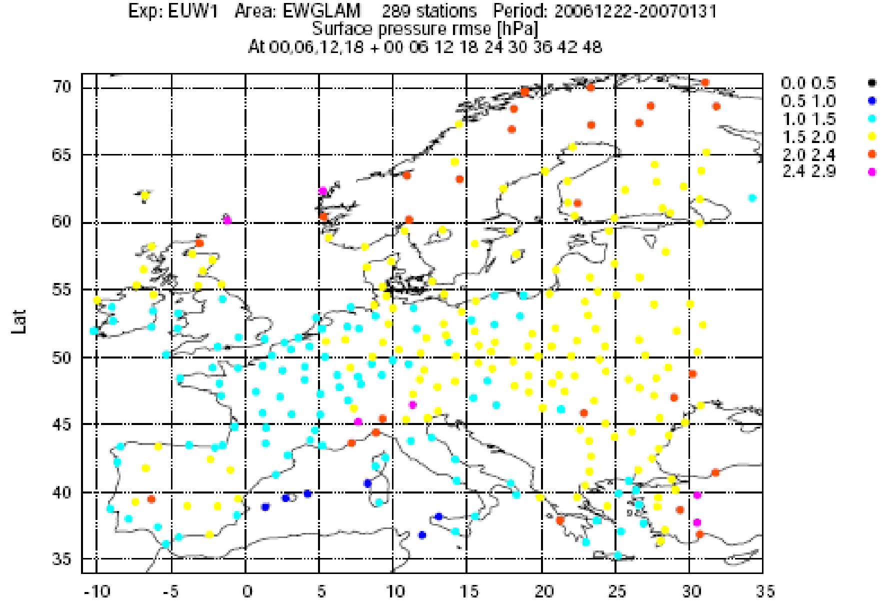
850 hPa wind

850 hPa Temp.

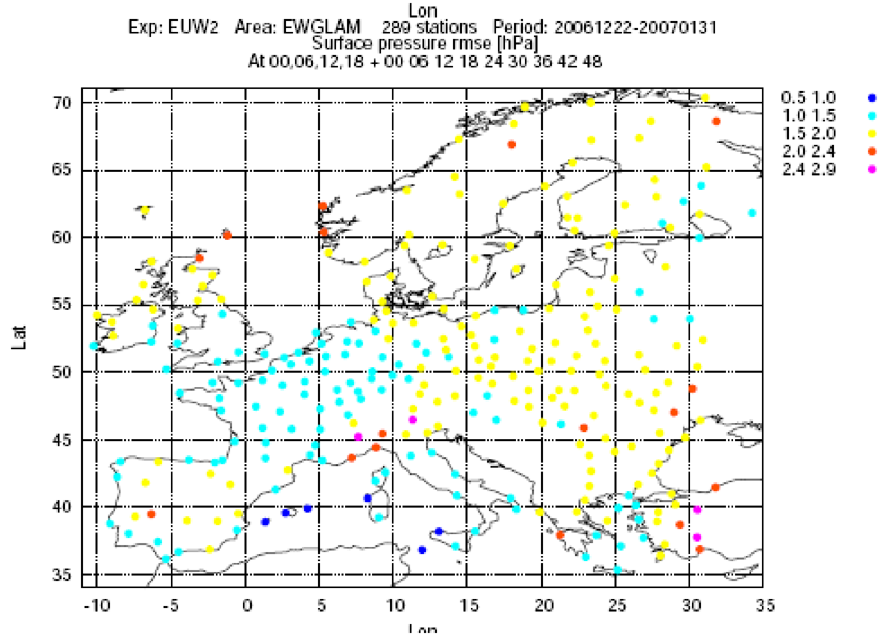


Geographical distribution of RMS scores – PMSL winter +48h

Baseline

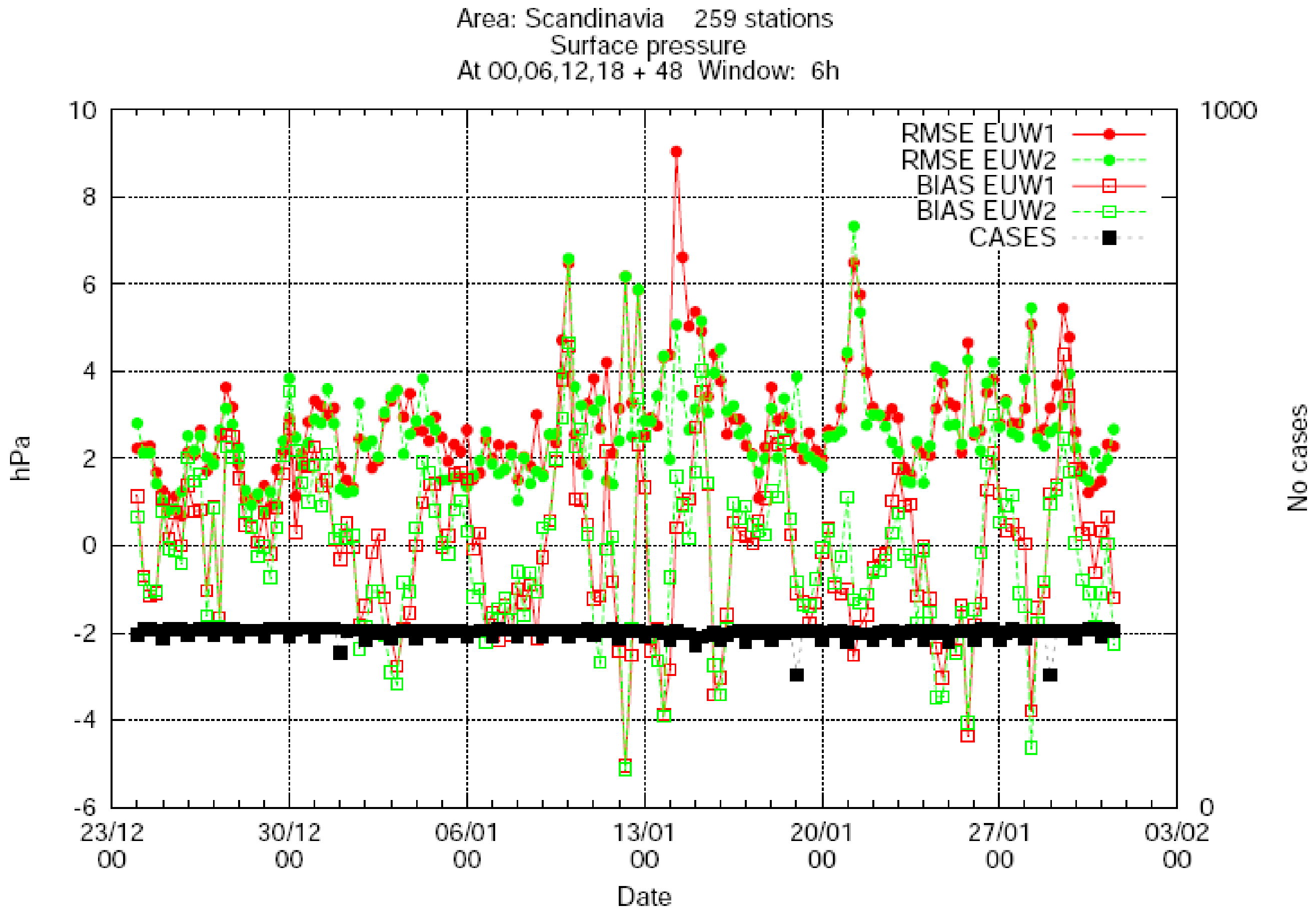


Control



Time series of RMS scores for +48 h PMSL forecasts over Scandinavia –

Control versus Baseline

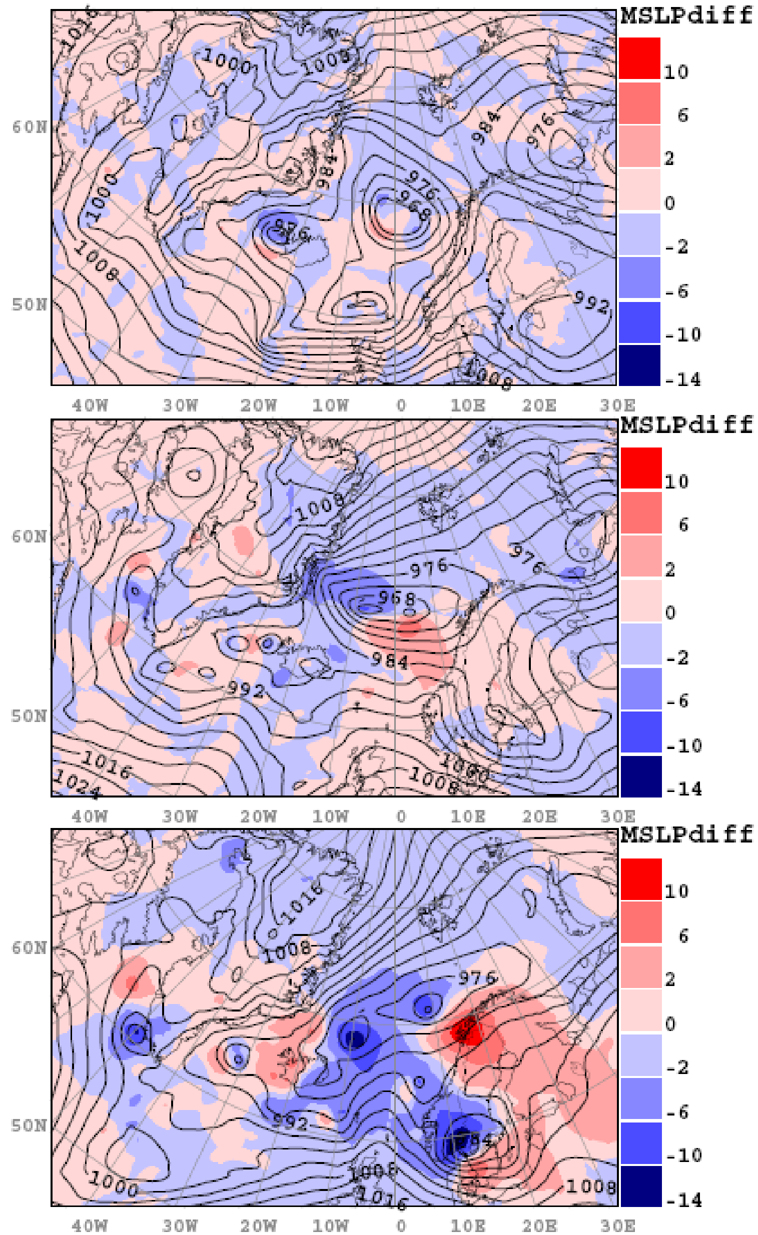


MSLP – 12 Jan 2007 06 UTC Control forecast and Control–Baseline differences

+6 h

+24 h

+48 h



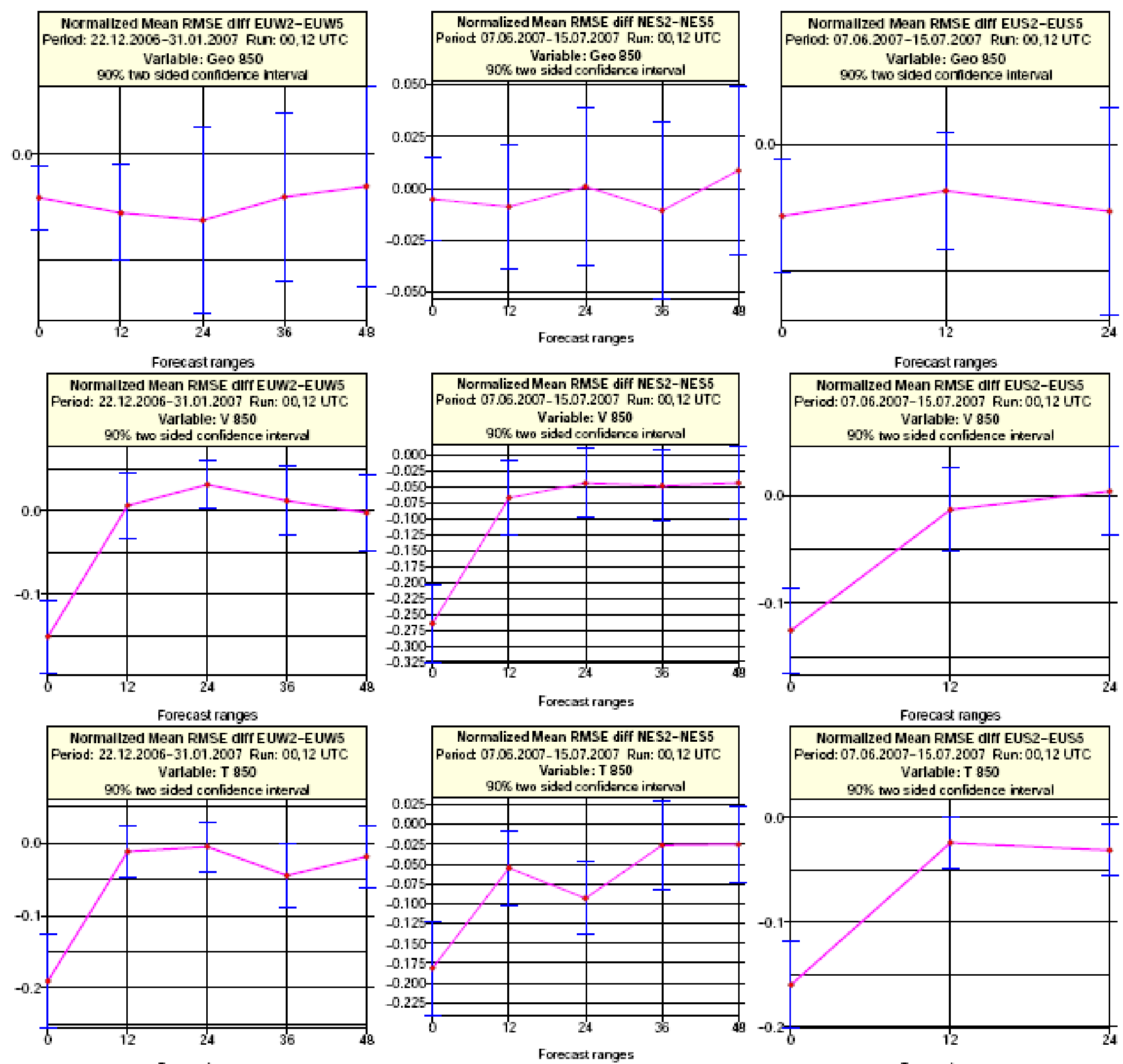
Significance test of of RMS differences Sc5 versus Control

Winter | **Summer** | **Mesoscale**

850 hPa height

850 hPa wind

850 hPa temp.



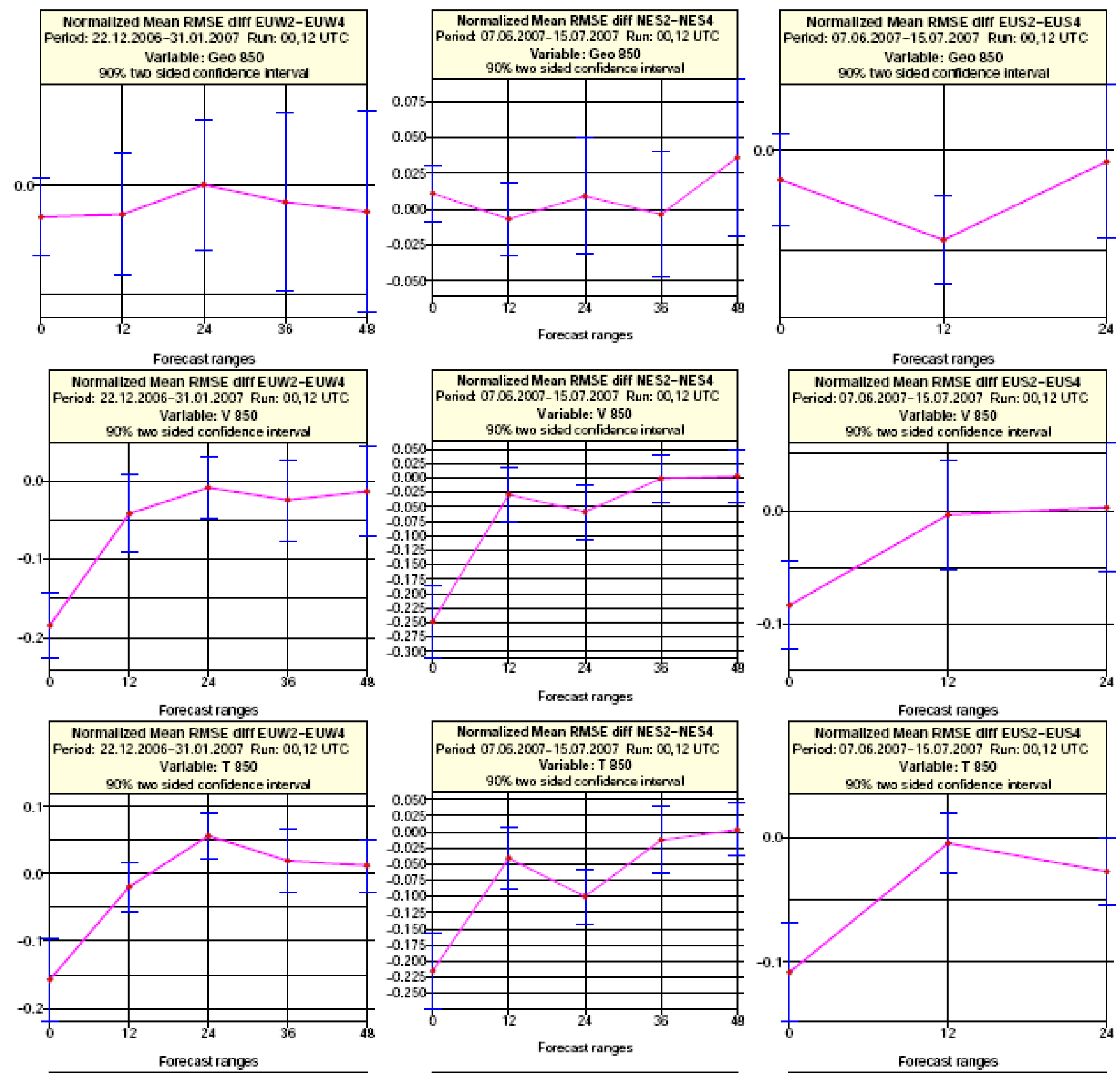
Significance test of of RMS differences Sc4 versus Control

Winter Summer Mesoscale

850 hPa height

850 hPa wind

850 hPa temp.



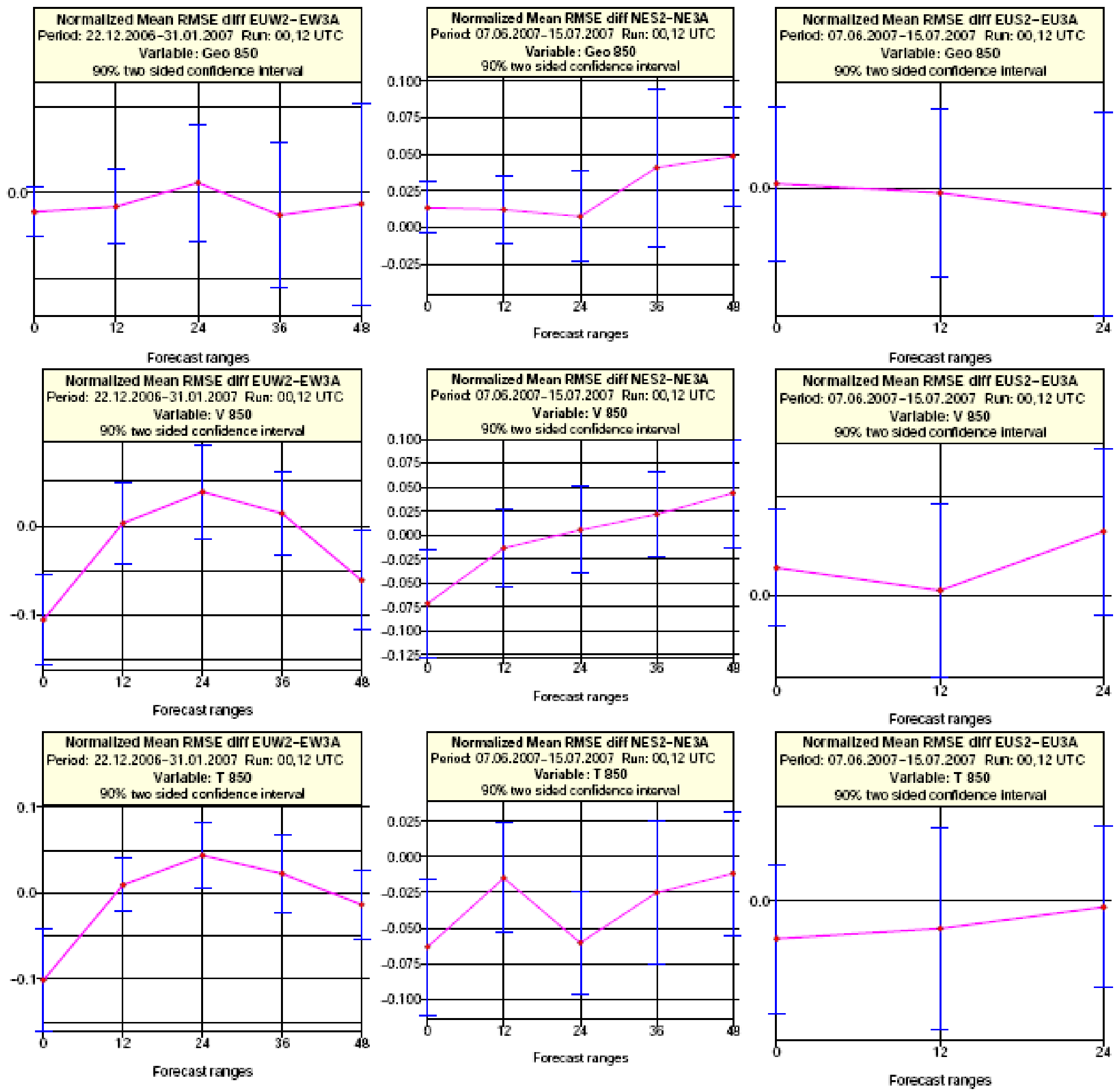
Significance test of of RMS differences Sc3a versus Control

Winter Summer Mesoscale

850 hPa height

850 hPa wind

850 hPa temp.



Significance testof of RMS differences Sc3b versus Control

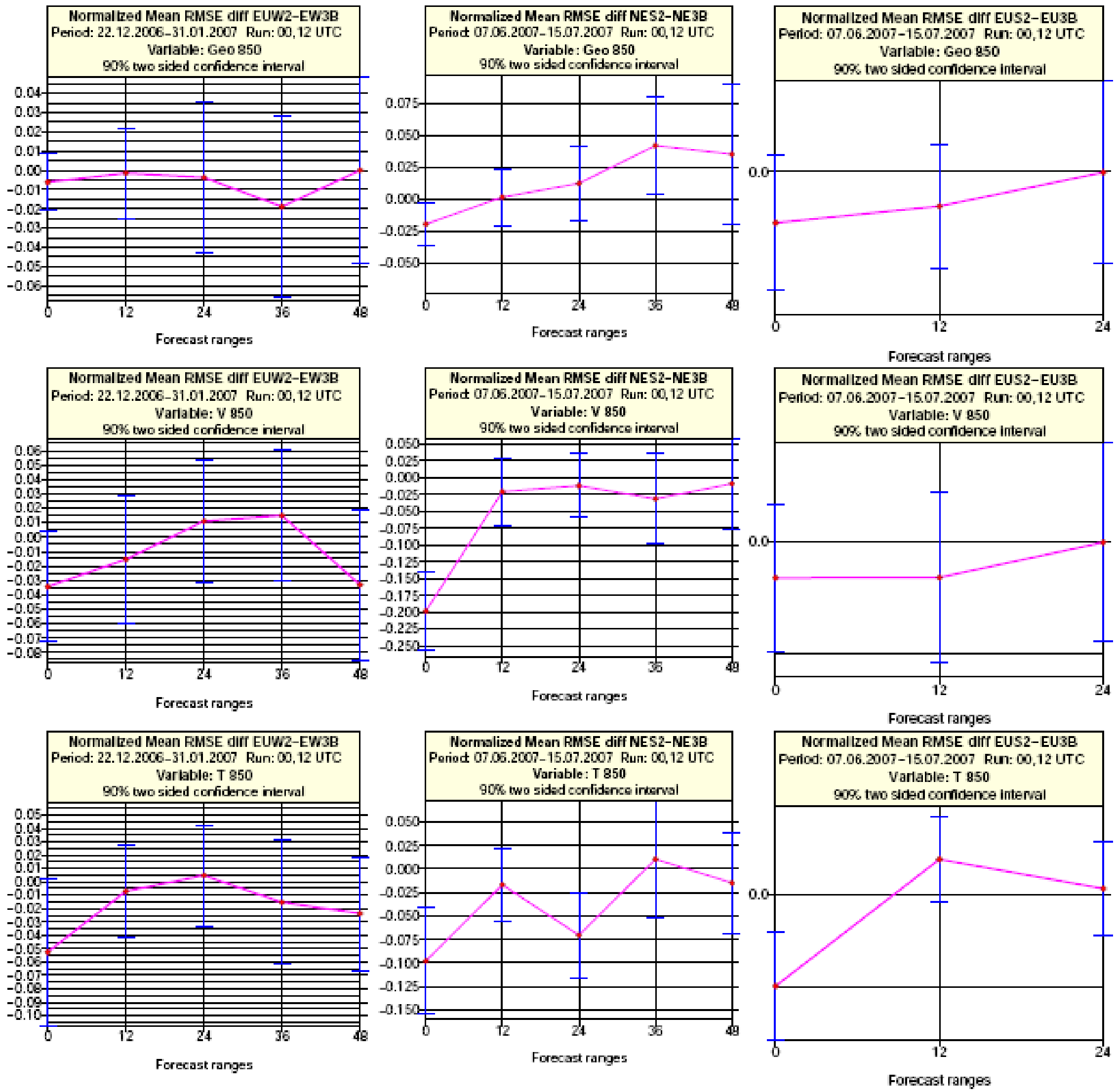
Winter Summer

Mesoscale

850 hPa height

850 hPa wind

850 hPa temp.



Summary of RMS score differences - % degradation in comparison with control

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	+2	+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

Conclusions and recommendations - 1

- **From significance test:**

→ Scenario 3a will have a small and not significant impact on the

- forecast skill scores of the current HIRLAM model in summer and winter
- → for a forecast model, which is less affected by a dry bias, we cannot exclude the advantage of a higher density of humidity measurements as provided by the scenario 2 compared with the sc3a and sc3b.

→ The degradation of forecasts quality in the Baseline scenario is unacceptable

→ The thinning of the radiosonde network and aircraft profile data to 250 km (sc4) and 500 km (sc5) causes deterioration in the forecast scores.

Conclusions and recommendations - 2

From the perspective of short range weather forecasting with regional (Limited Area) NWP models for the European area, taking known limitations of present regional model forecasting system into account, ***we do not recommend a further thinning of the upper air observation density below the 100 km density simulated in scenarios Sc3a and Sc3b of this study***.

Differences in ECMWF and Hungarian results:

- Stronger sensitivity to humidity observations in summer
- Stronger sensitivity to the thinning to 100 km (Sc3a and Sc3b) in the Hungarian results

PB-OBS recommendation:

- Scenario 3B: Thinning of radiosonde data to 100 km at 12UTC