Regional aspects of a European upper-air network redesign study: results obtained with the ALADIN limited-area model at the Hungarian Meteorological Service

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Main objectives and background

- **<u>Main objective:</u>** assessment of the **European** upper-air observing systems with special attention to the **radiosonde and aircraft** measurements
  - What is the optimal coverage of radiosonde and aircraft profiles over Europe (is futher degradation possible)?
  - Can aircraft (AMDAR) data "substitute" some radiosondes in Europe from regional NWP point of view?
- Global and regional data assimilation centres were running Observing System Experiments (based on predefined scenarios)
  - The results obtained by the ALADIN regional model in Hungary is going to be presented

Operational LAM setup at OMSZ

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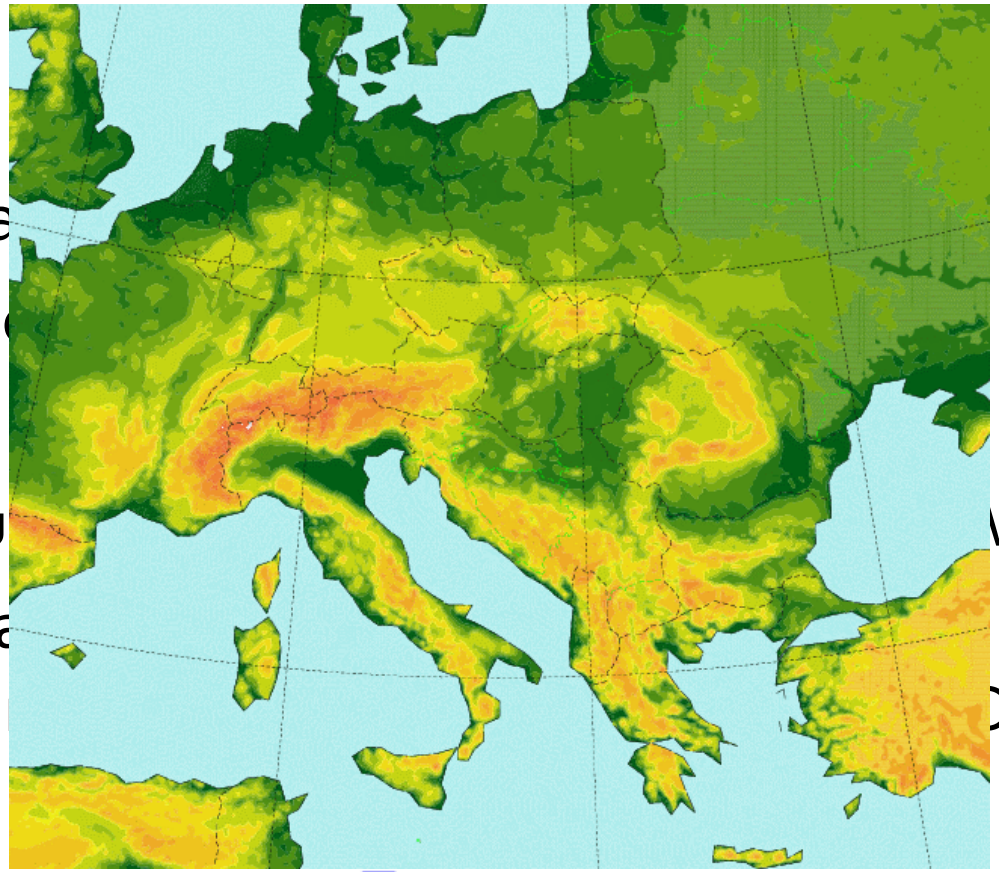
- LAM doma
- 8 km horiz
- 49 vertical
- lateral bou
- local data a
  - upper ai
  - surface:

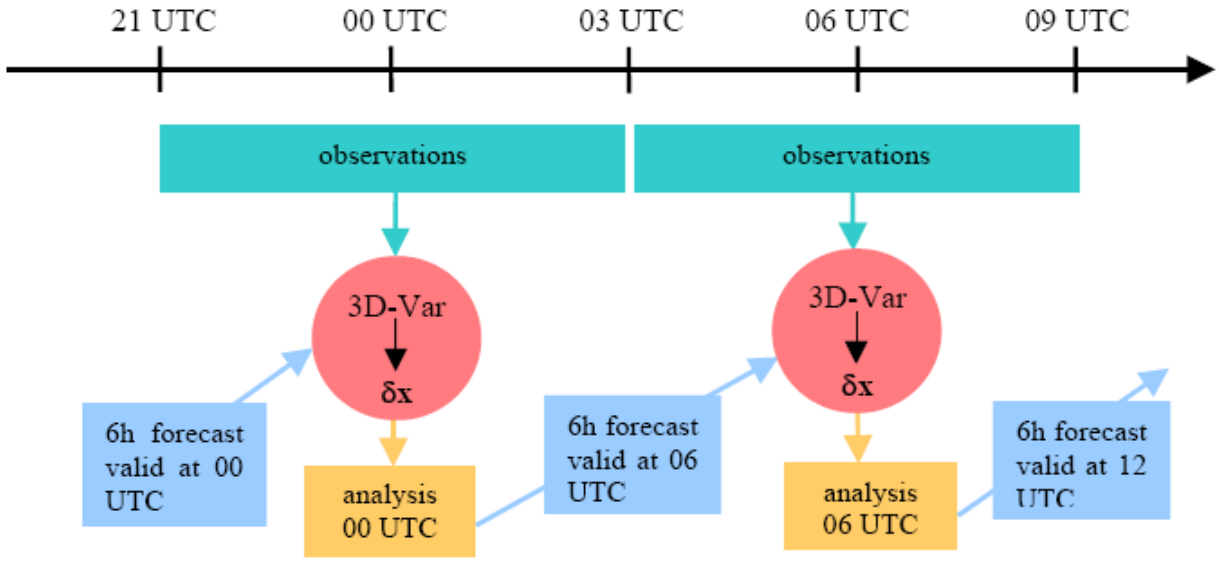


WF (IFS)

D-Var)

Local data assimilation in Hungary

- Analysis 6 hourly
- Observations:
  - Conventional (SYNOP, TEMP)
  - AMDAR
  - Wind Profiler
  - Satellite (MSG2/SATOB, ATOVS/AMSU-A, ATOVS/AMSU-B, ATOVS/MHS)



Experimental setup

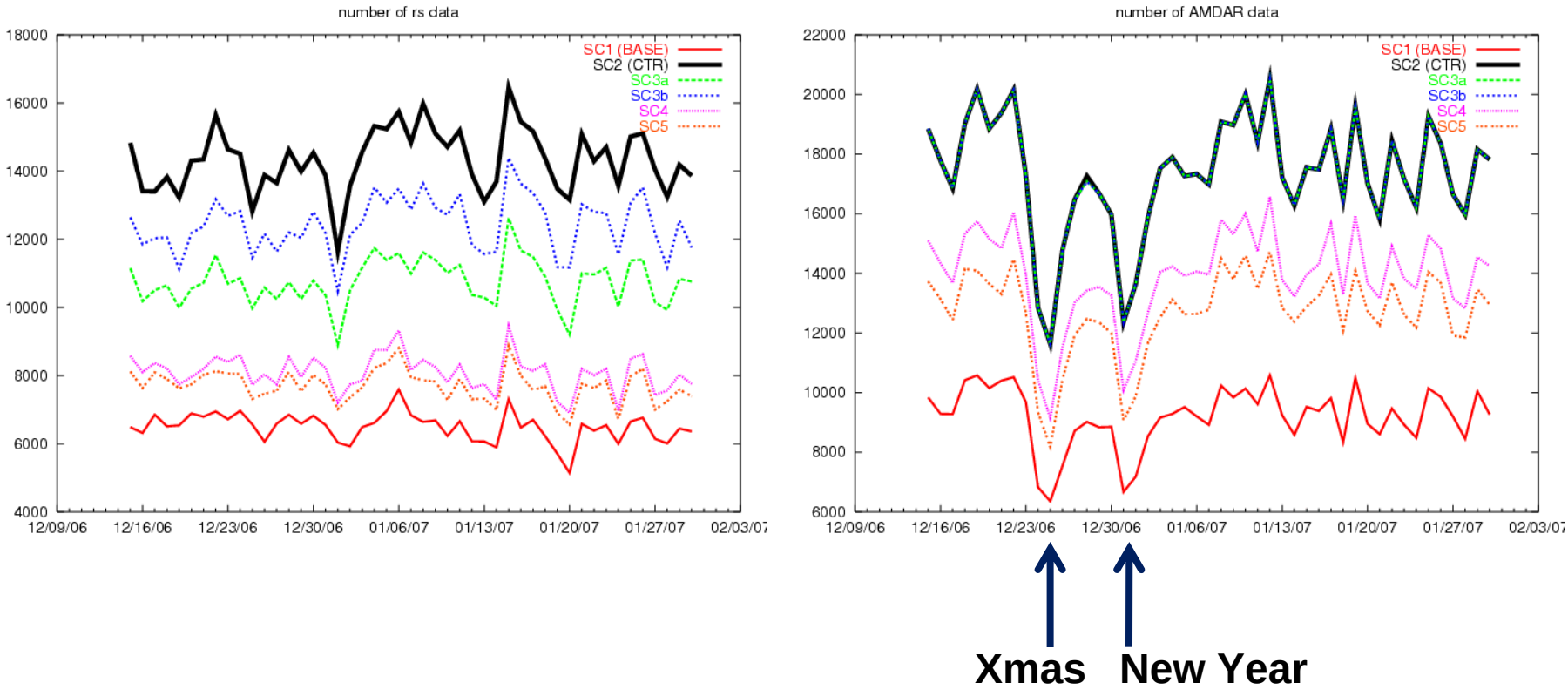
- Experimental periods: winter 2006/2007 and summer 2007 (6-6 weeks including 1 week warm-up)
- Forecast: 2 runs daily:
  - 00 UTC – 54 hours
  - 06 UTC – 48 hours
- Verification
  - against observations (SYNOP and TEMP)
  - winter and summer periods, 00 and 06 UTC runs, separately
  - **RMSE, significance test for RMSE differences (T850, T300, RH700, Z1000, Z500, wind speed 850, wind speed 300)**
  - (contingency tables for precipitation)

Overview of the predefined 6 scenarios (from the data rich to the data poorer)

- **Sc2:** control – full operational observation usage
- **Sc3b:** all radiosonde data at 00 UTC + 100 km thinning at 06, 12, 18 UTC + all aircraft data
- **Sc3a:** 100 km thinning of radiosondes + all aircraft data
- **Sc4:** 250 km thinning of both radiosondes & aircraft data
- **Sc5:** 500 km thinning of both radiosondes & aircraft data
- **Sc1:** baseline (basic network including GUAN radiosonde network, flight level aircraft data, aircraft profiles of less than 3 hourly visited airports and full remaining part of the observation network)

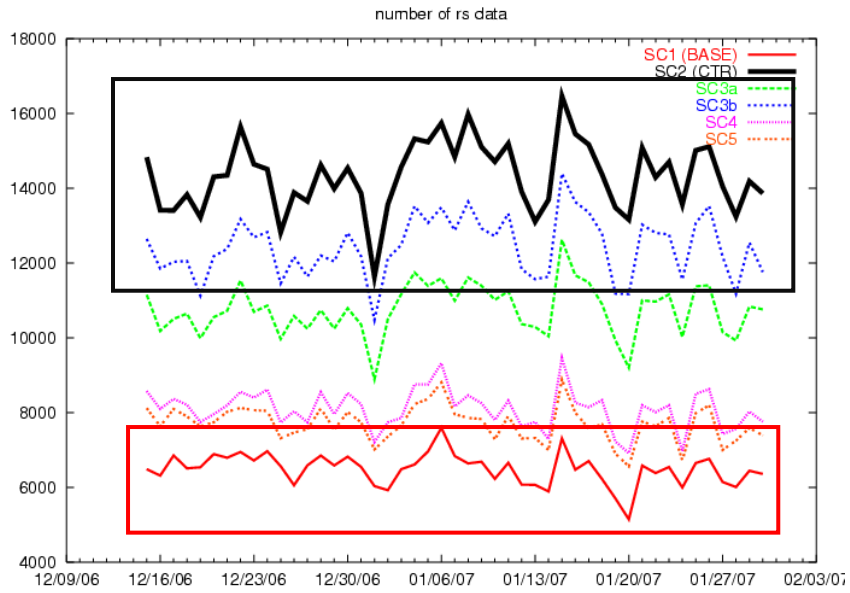
Observation usage

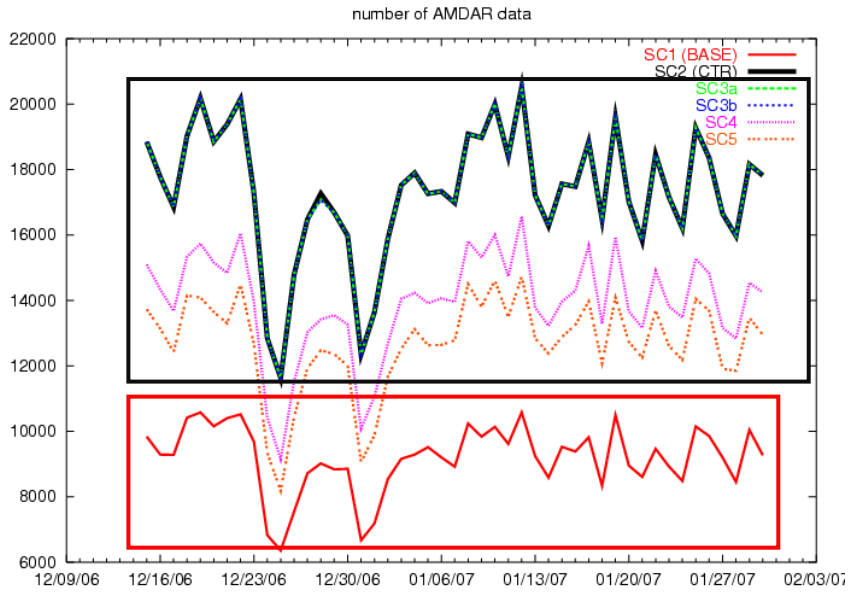
Daily assimilated **radiosonde (left)** and **AMDAR (right)** data over the LAM domain in winter



Baseline scenario (Sc1): (basic network including GUAN radiosonde network, flight level aircraft data, aircraft profiles of less than 3 hourly visited airports and full remaining part of the observation network)

Baseline scenario

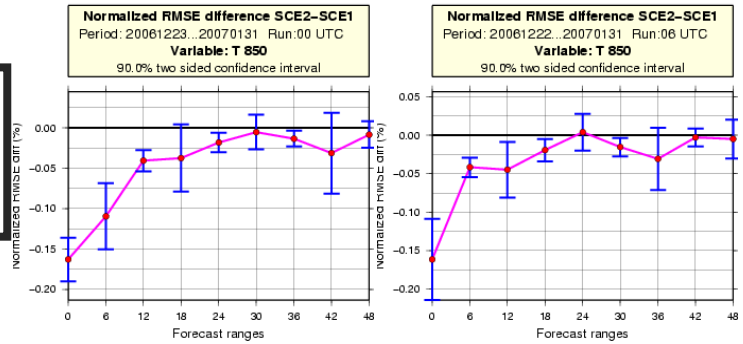


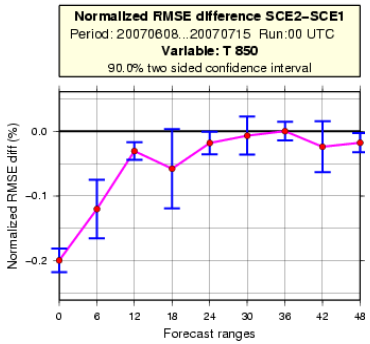


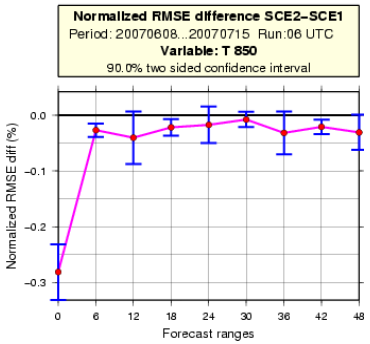
Control vs. Baseline

00 UTC | winter | 06 UTC | 00 UTC | summer | 06 UTC

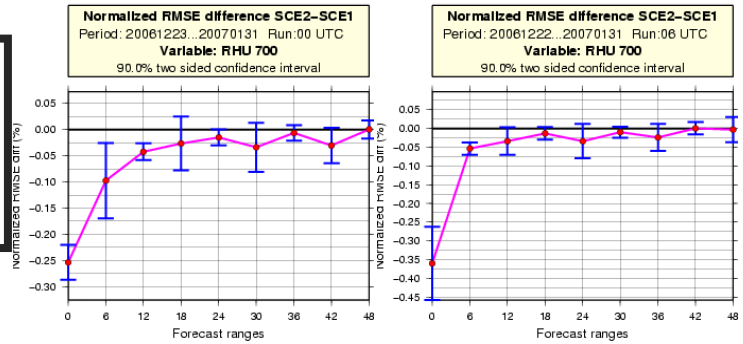
T 850

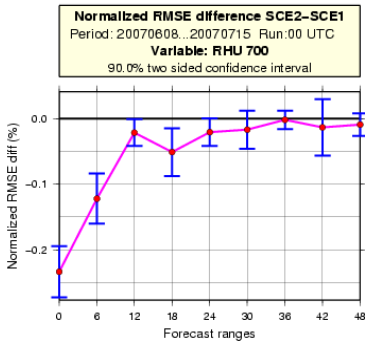


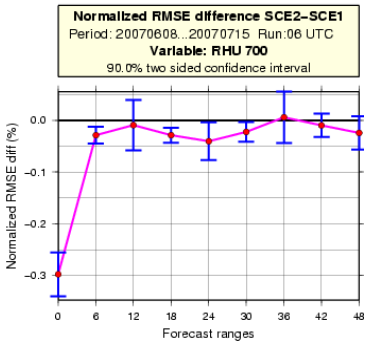




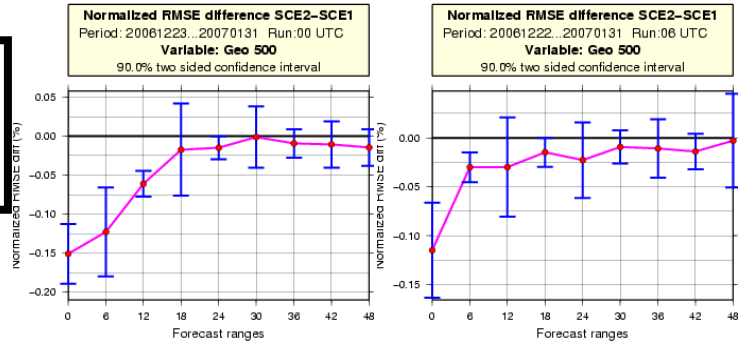
RH 700

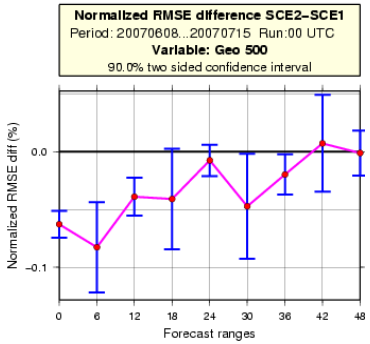


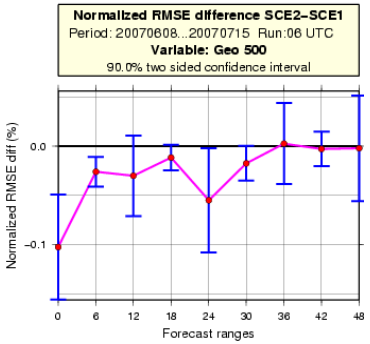




Z 500







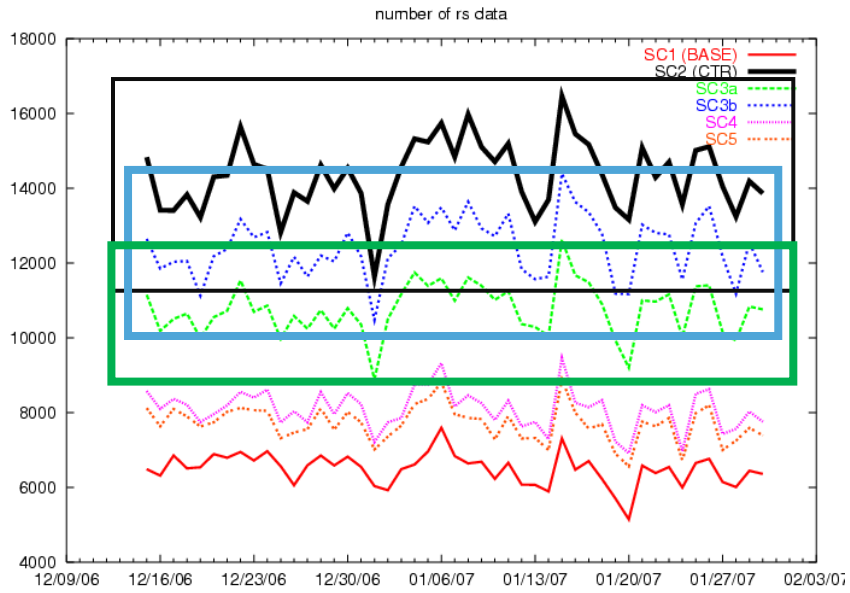
Control vs. Baseline

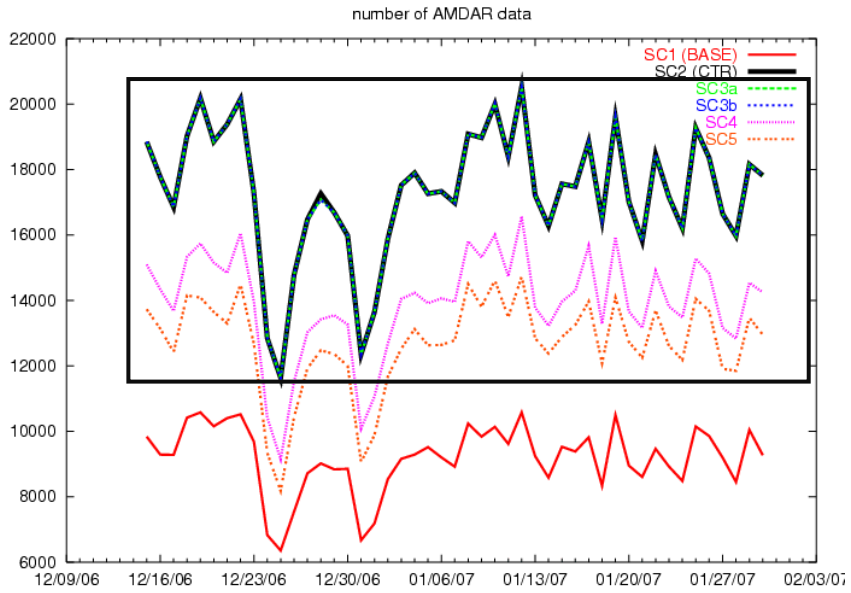
- The control scenario performs clearly better than the baseline, this is significant up to 24 hours
- No visible differences between the winter and summer periods (and 00 and 06 UTC runs)

Scenario 3b: all radiosonde data at 00 UTC + 100 km thinning at 06, 12, 18 UTC + all aircraft data

Scenario 3a: 100 km thinning of radiosondes (all network times) + all aircraft data

Scenario 3a and 3b

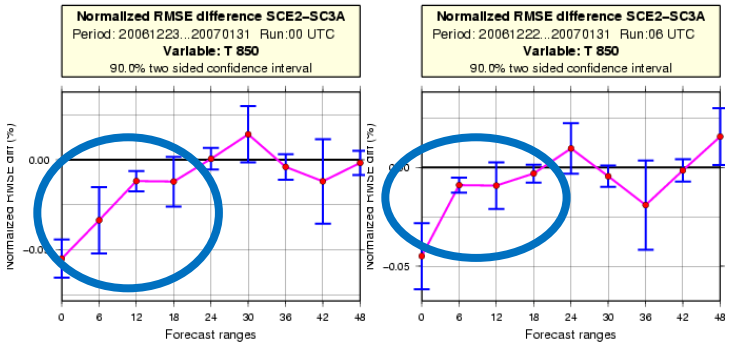


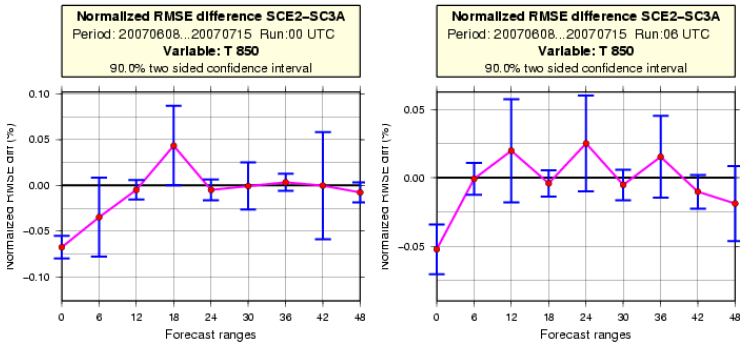


Control vs. Sc3a

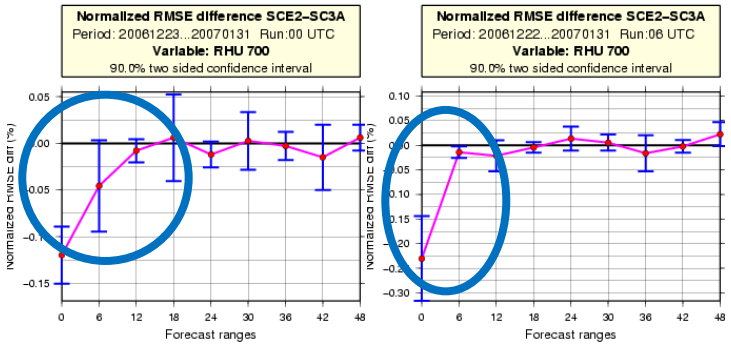
00 UTC | winter | 06 UTC | 00 UTC | summer | 06 UTC

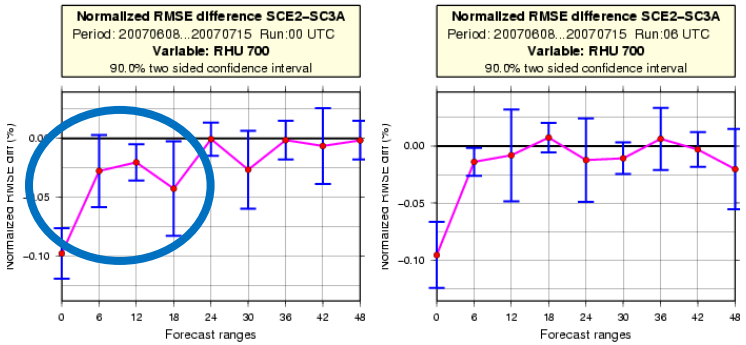
T 850





RH 700





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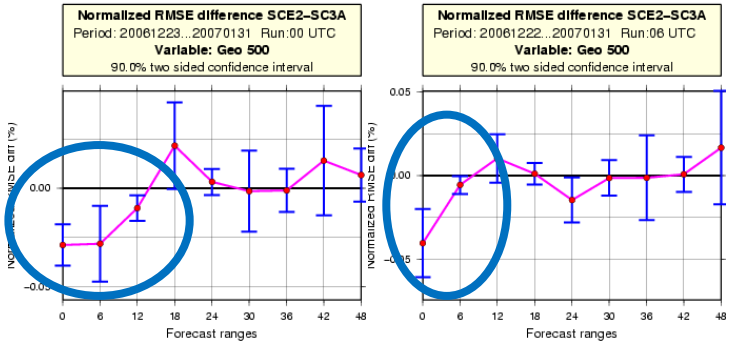
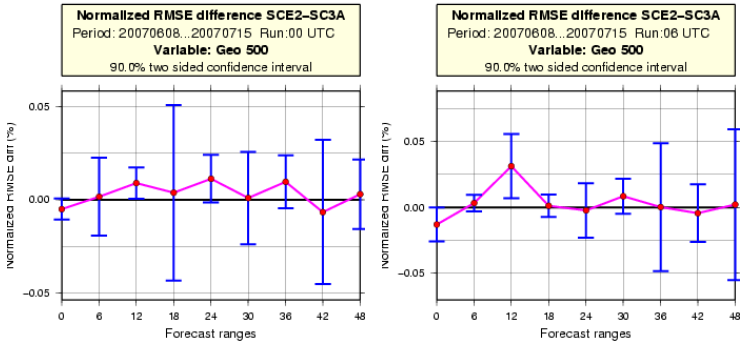




Control vs. Sc3a

- The impact is small, but there is still significantly negative impacts of the data denial for 6-12 hours for:
  - Temperature at 850 hPa in winter
  - Geopotential height at 500 hPa in winter
  - Relative humidity at 700 hPa

➔ **Thinning of radiosonde data for every time range has important negative impact for the forecasts of the LAM (ALADIN), therefore the European radiosonde network should not be further degraded**

Control vs. Sc3b

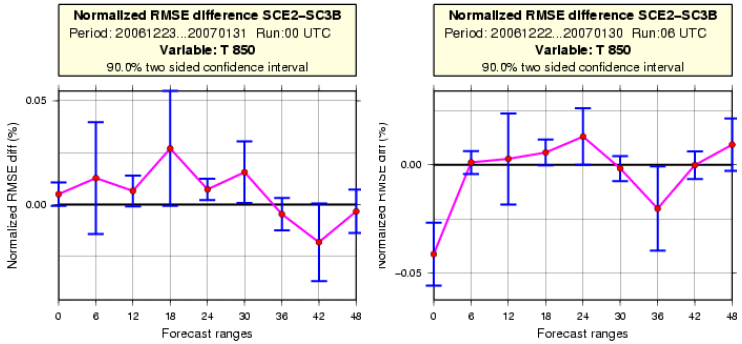
winter

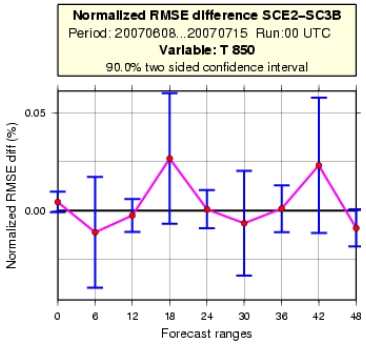
00 UTC | 06 UTC

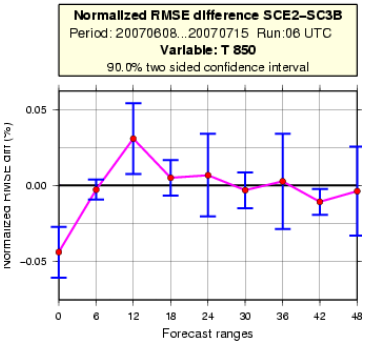
summer

00 UTC | 06 UTC

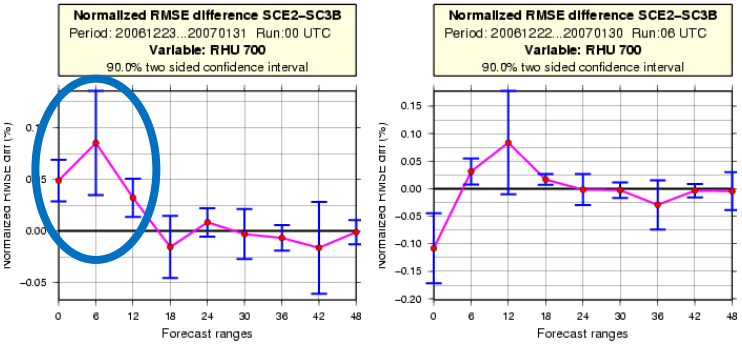
T 850

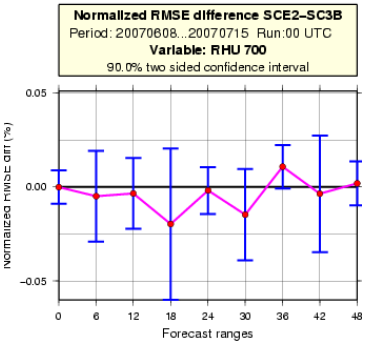


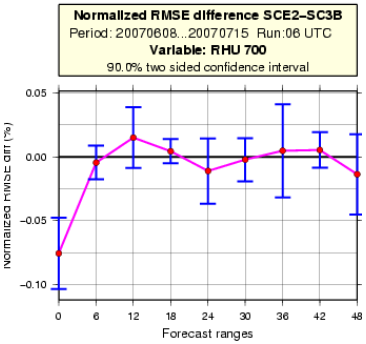




RH 700







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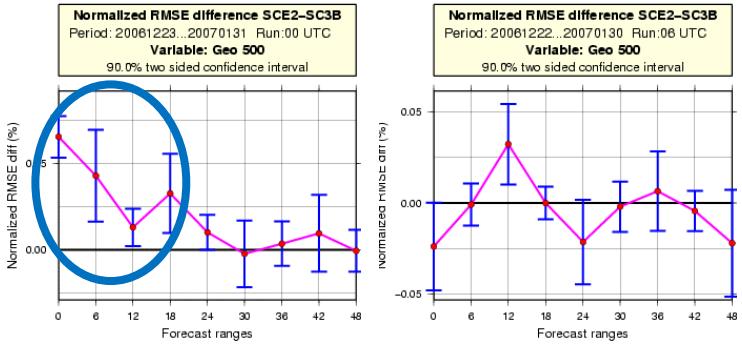
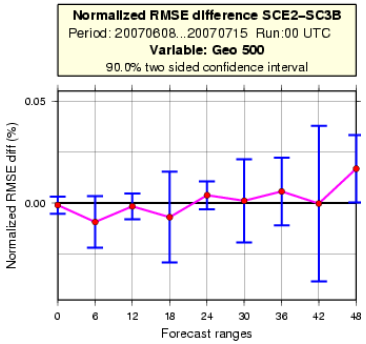
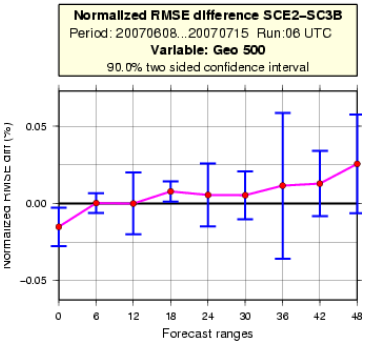






Control vs. Sc3b

- Sc3b is neutral compared to control in summer and for the 06 UTC runs

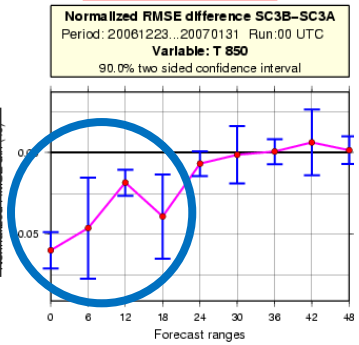
- In winter for the 00 UTC run, Sc3b performs better for:
  - Relative humidity at 700 hPa
  - Geopotential height at 500 hPa

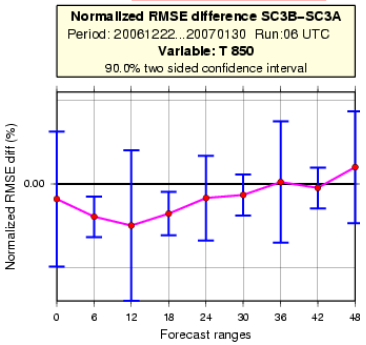
➔ **00 UTC radiosondes have an important role in the LAM model, while the thinning of radiosondes at 06, 12 and 18 UTC doesn't have significant negative effect on forecast skill (therefore some reduction of the 06, 12 and 18 UTC soundings might be possible)**

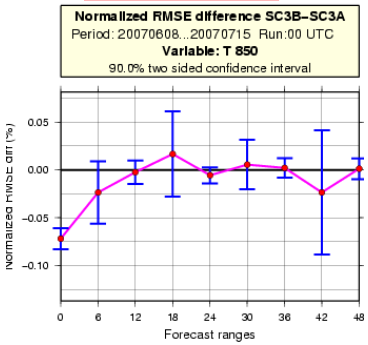
Sc3b vs. Sc3a

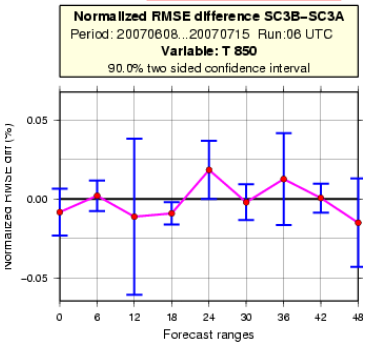
00 UTC | winter | 06 UTC | 00 UTC | summer | 06 UTC

T 850

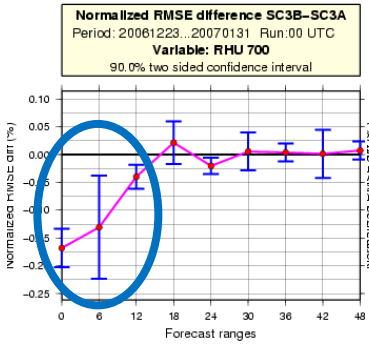


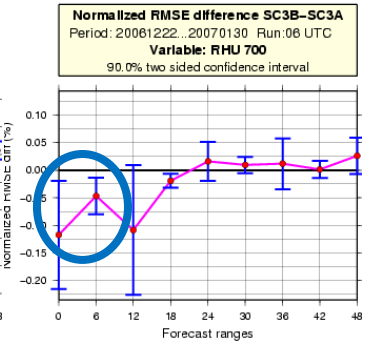


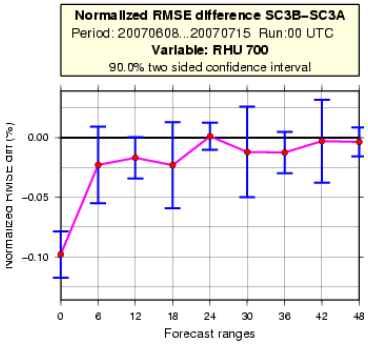


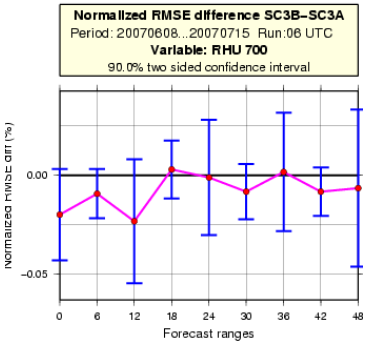


RH 700









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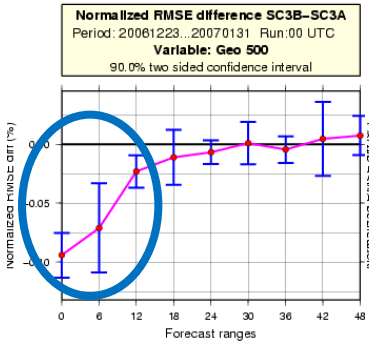
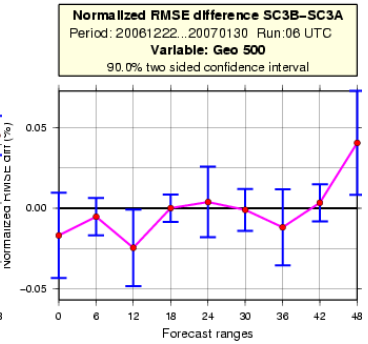
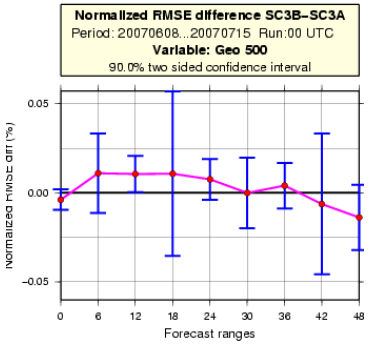
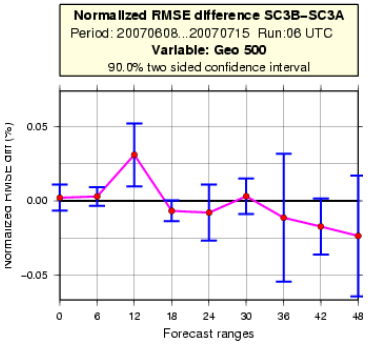








Sc3a vs. Sc3b

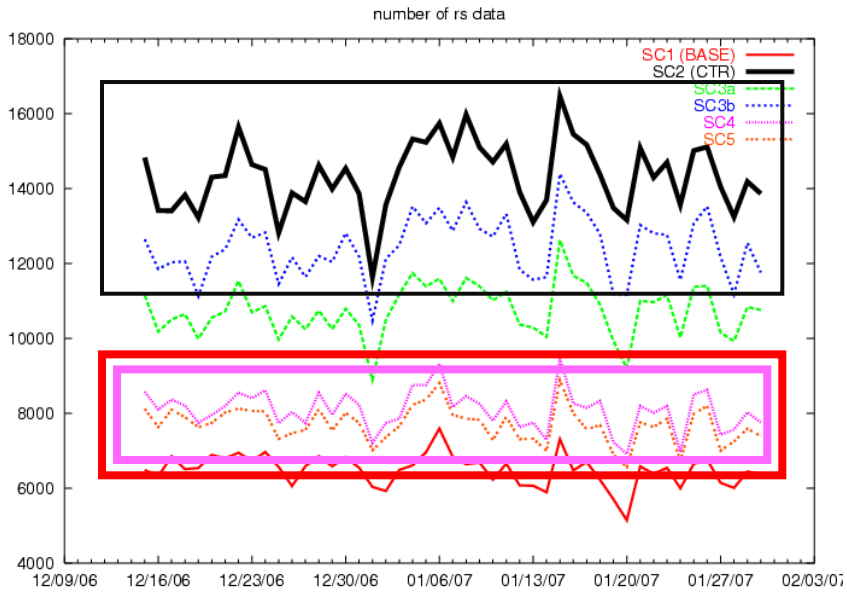
- Sc3b is slightly better than 3a.

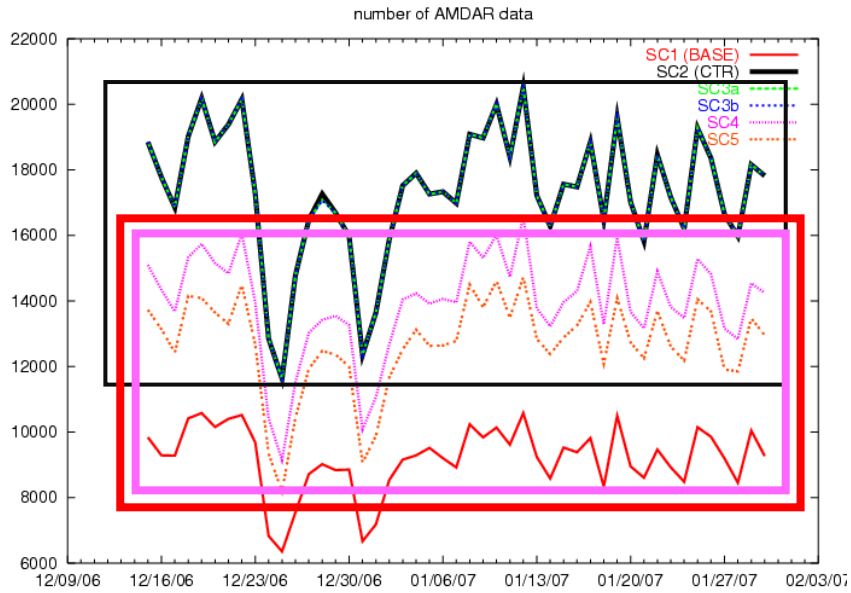
- In *winter* for 00 UTC runs Sc3b is better for:
  - Temperature at 850 hPa
  - Geopotential height at 500 hPa
  - Relative humidity at 700 hPa

- **On the contrary to the global results (as mentioned by Erik), THERE ARE forecast performance differences between scenarios 3a, 3b and control**

Scenario 4: 250 km thinning of both radiosondes & aircraft data
Scenario 5: 500 km thinning of both radiosondes & aircraft data

Scenario 4 and 5

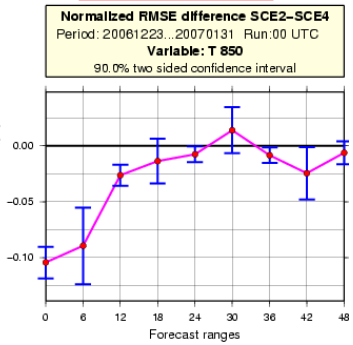


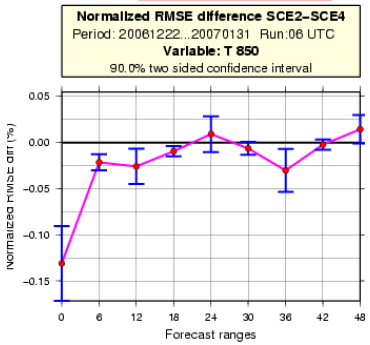


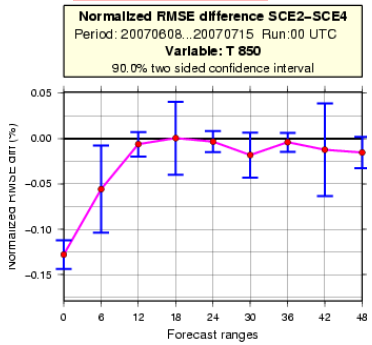
Control vs. Sc4

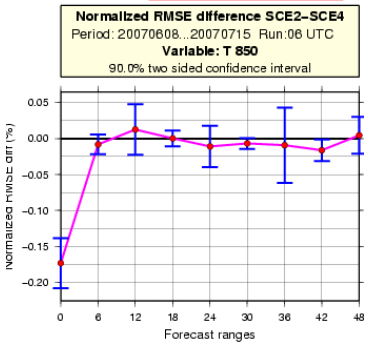
00 UTC | winter | 06 UTC | 00 UTC | summer | 06 UTC

T 850

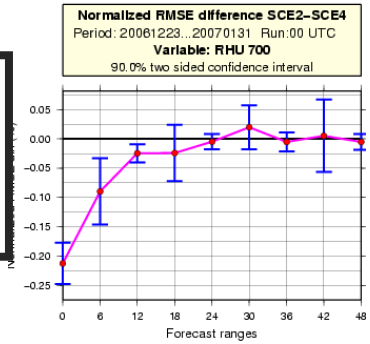


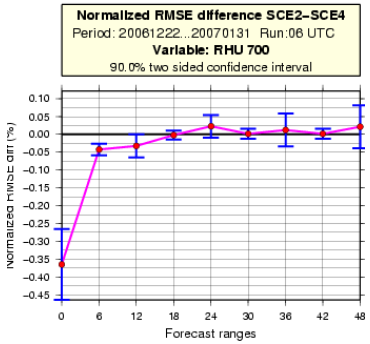


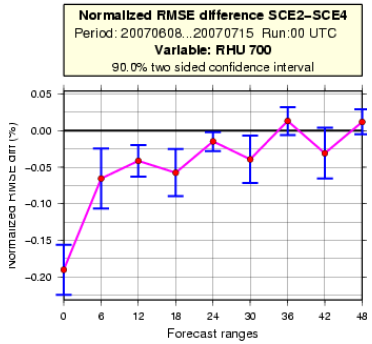


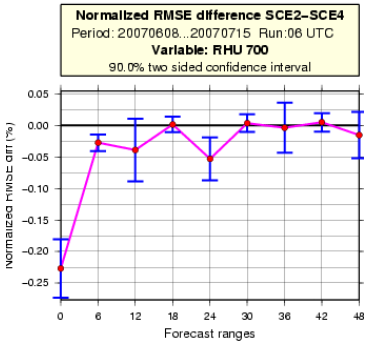


RH 700

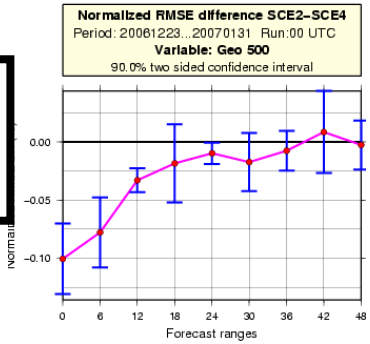


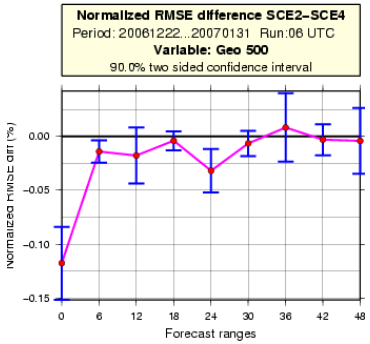


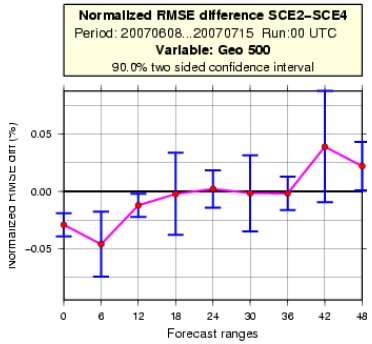


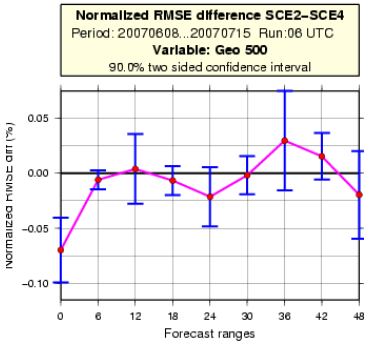


Z 500





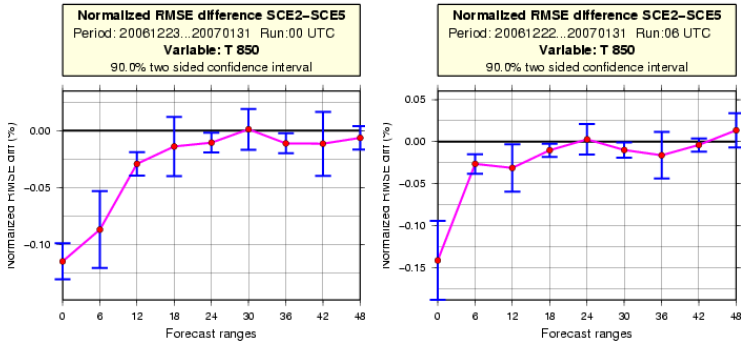


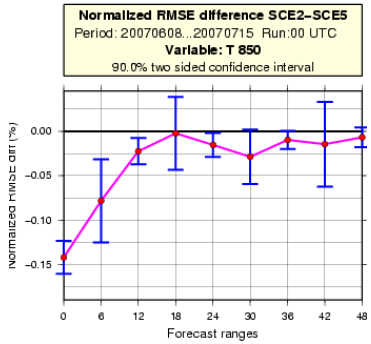


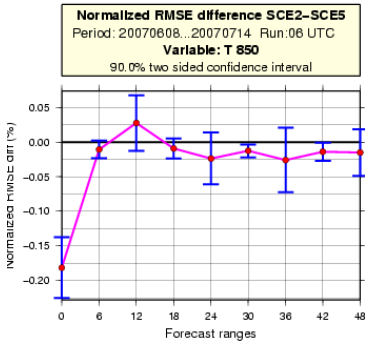
Control vs. Sc5

00 UTC | winter | 06 UTC | 00 UTC | summer | 06 UTC

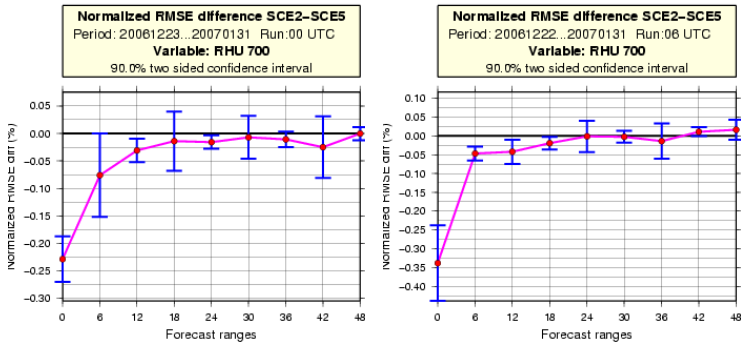
T 850

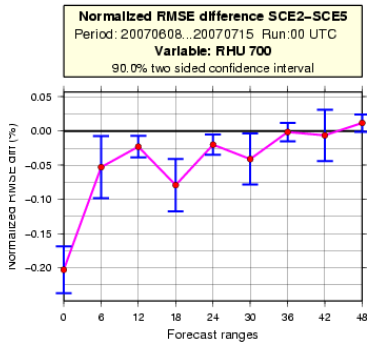


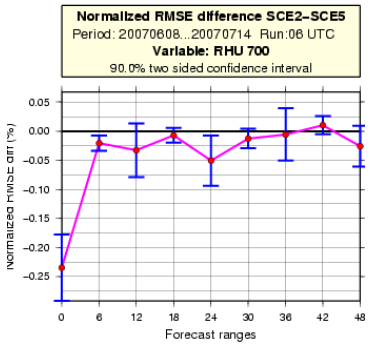




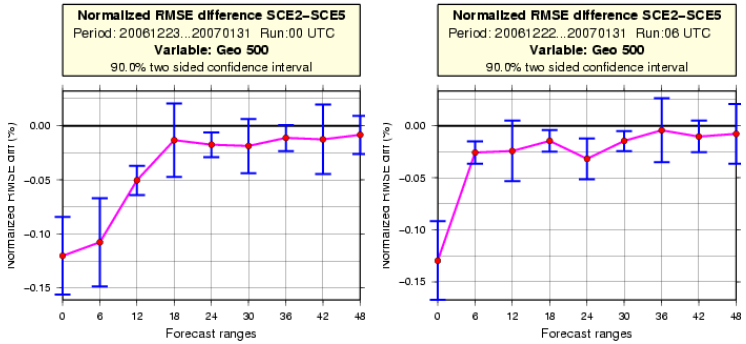
RH 700

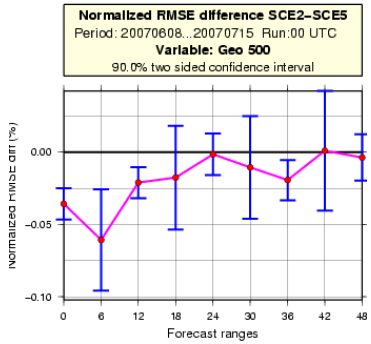


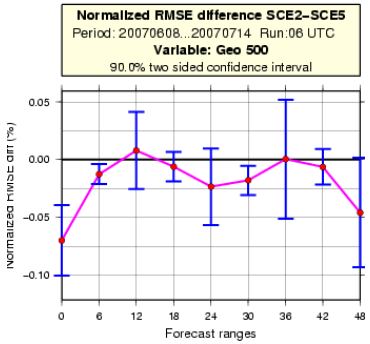




Z 500







Control vs. Sc4 // Sc5

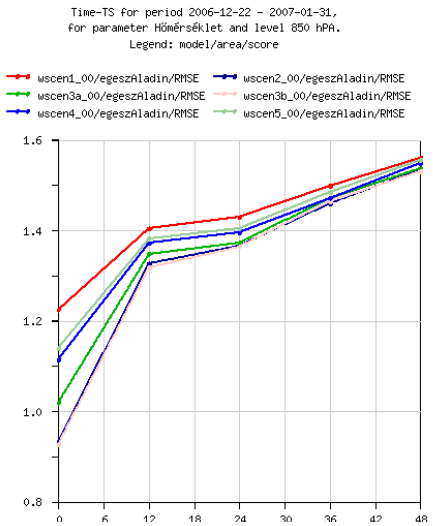
- The control scenario clearly performs better than scenario 4 and 5
- The impact is largest on: relative humidity at 700 hPa

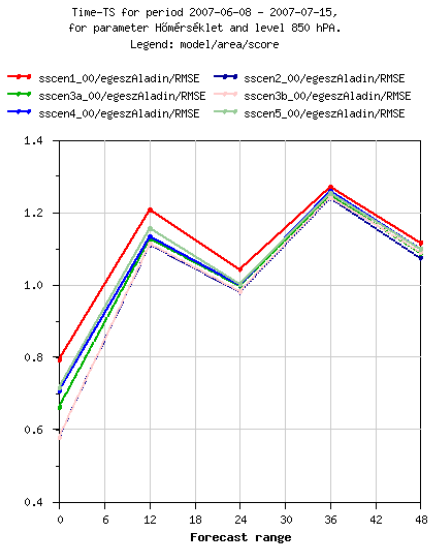
Overall comparison

Relative performance of the different scenarios (RMSE errors of the experiments)

winter **summer**

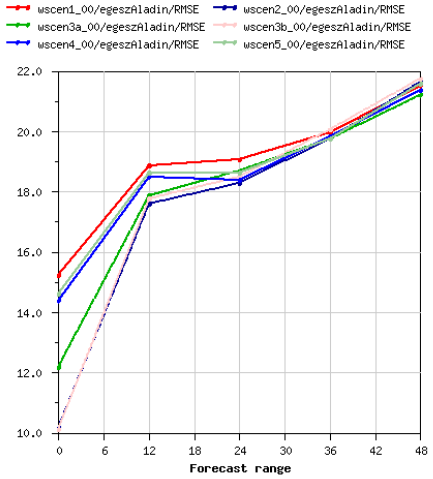
T850

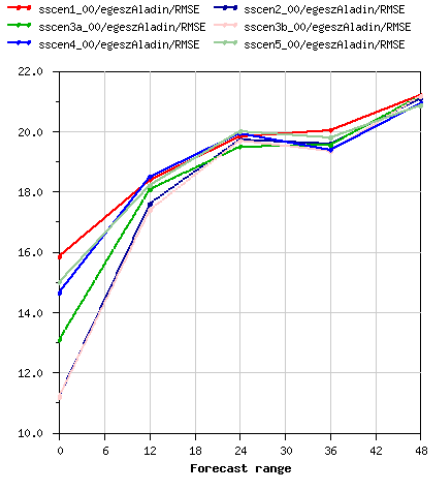




The scores of control, Sc3a and Sc3b are running together

RH700





Overall evaluation

The „length" of the significantly negative impact of the data denial

	Baseline		Sc3a		Sc3b		Sc4		Sc5	
winter	**00 UTC**	**06 UTC**	**00 UTC**	**06 UTC**	**00 UTC**	**06 UTC**	**00 UTC**	**06 UTC**	**00 UTC**	**06 UTC**
T850	12	18	12	6	0	0	12	18	12	18
RH700	12	6	0	6	-12	0	12	12	12	18
Geo500	12	6	12	6	-24	0	12	6	12	6
summer										
T850	12	6	0	0	0	0	6	0	12	6
RH700	6	6	0	6	0	0	30	6	30	6
Geo500	12	6	0	0	0	0	12	0	12	6

Final conclusions

- The most sensitive variables to the thinning of radiosonde and AMDAR data are the temperature at 850 hPa and the relative humidity at 700 hPa

- 00 UTC forecasts are more sensitive than the 06 UTC runs

- Winter is more sensitive than the summer

➔ **00 UTC radiosondes are really essential (basically no AMDAR data available at that time slot in Europe), WHILE the 06, 12 and 18 UTC radiosondes have less importance**

Thank you for your attention!

The final recommendation based on the Hungarian ALADIN results is that Sc3b (radiosonde thinning only at 00, 06 and 12 UTC) might be implemented without loss of quality of the regional NWP models, BUT Sc3a would have negative impact on the forecasts!

Special thanks to the EUCOS team (Stefan Klink) and Erik Andersson for the invitation to the workshop!