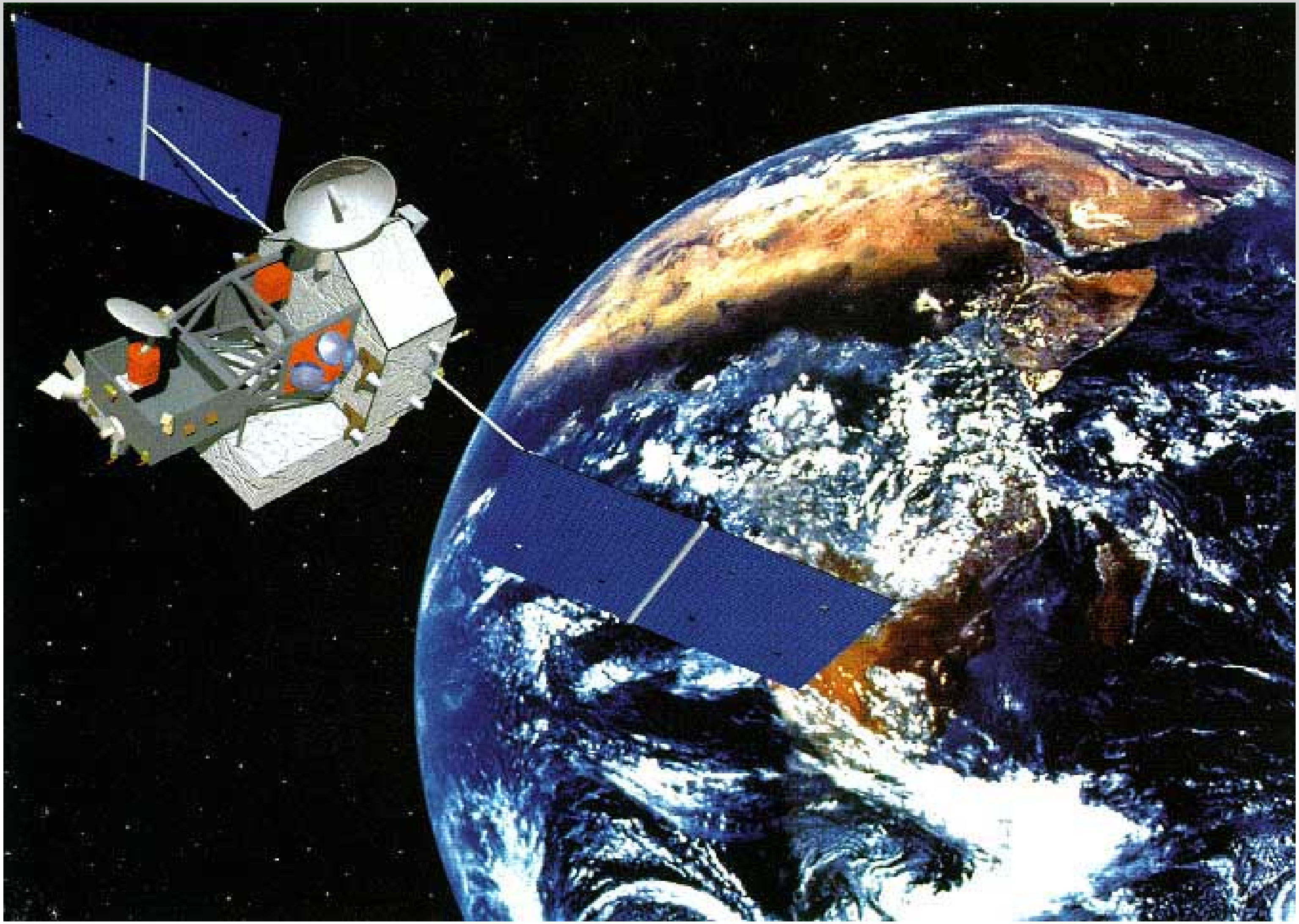


Satellite data assimilation in model ALADIN/CZ

P. Benáček, DA WD Prague, 2012

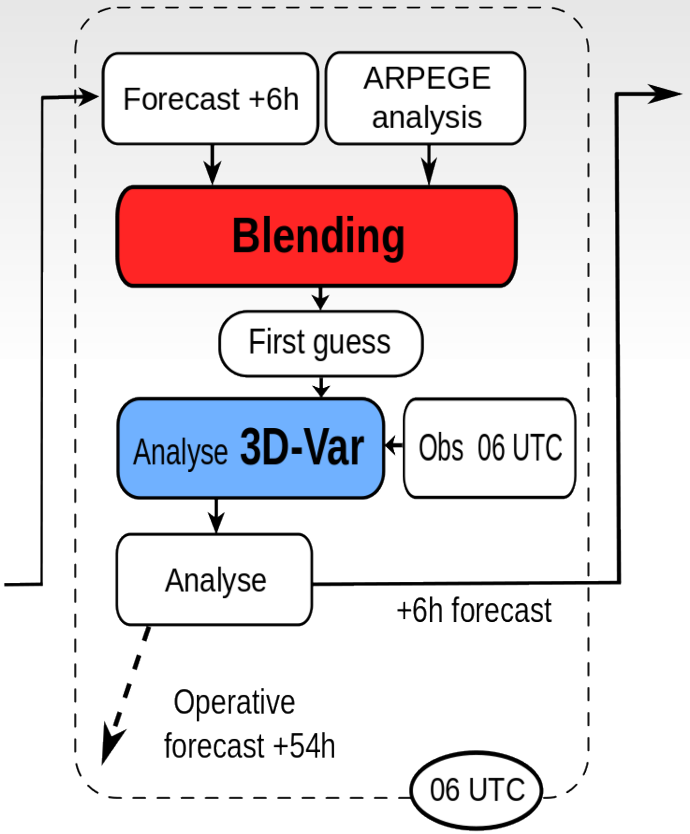
Outline

- New setup of model ALADIN
    - cycle 36t1 (innovations in VarBC)
    - VarBC stratospheric predictors
    - High peaking channels
- Experiments setup
    - Channel selection
    - Forecast impact verification (Temp, Ecmwf, Arpege)
    - Impact of AMSU-A, AMSU-B
- Case study

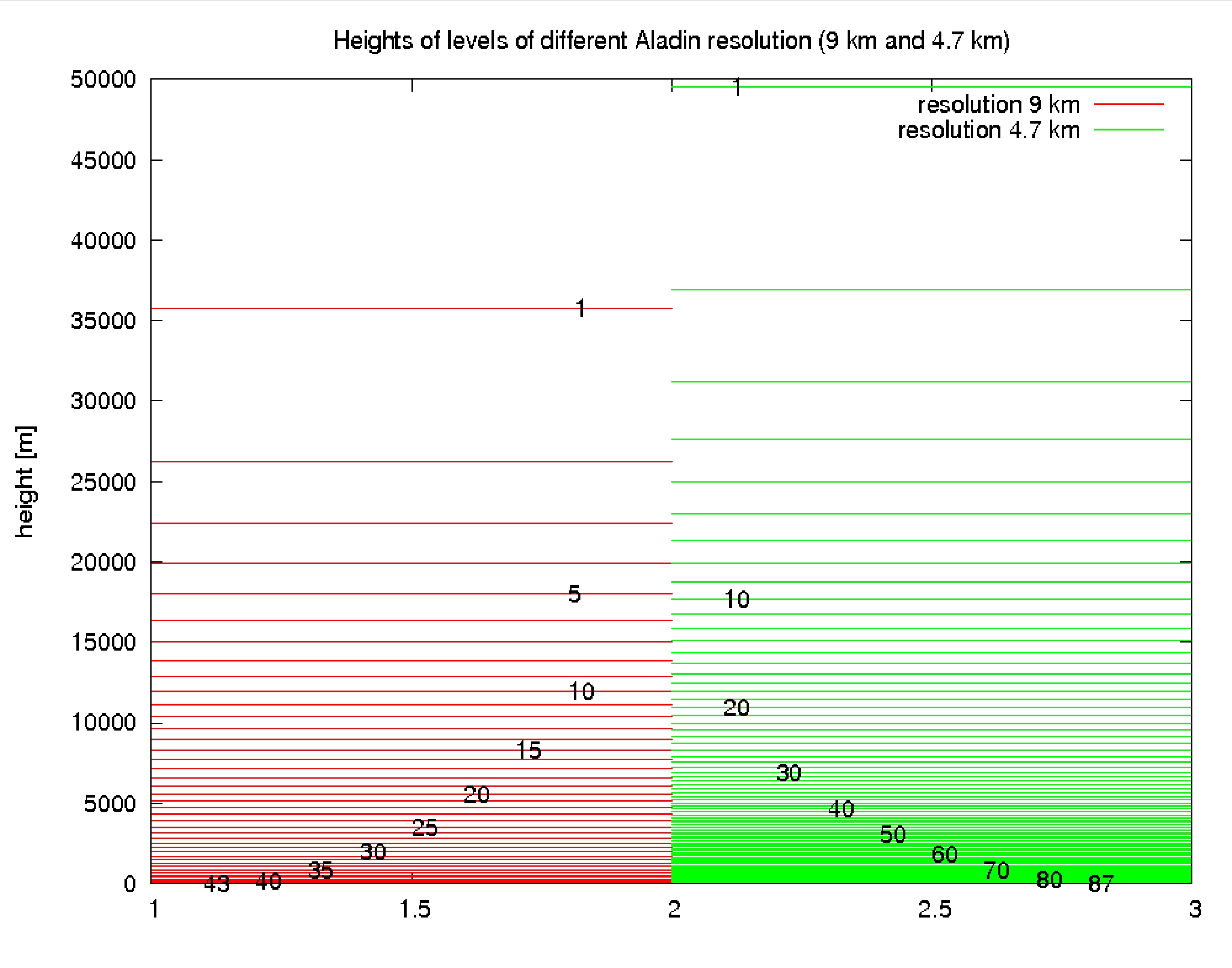
Model aladin set-up

- ALADIN new cycle *36t1ope.v01*
- *New domain* (529x421 grid points, *Δx=4.7km*)
- *87 vertical levels*, mean orography
- time step 180 s, 3h coupling from Arpege
- Analysis cycle 00, 06, 12,18 UTC; forecast +54h
- B matrix was computed by the lagged NMC method

- BlendVar scheme – consists of adding a 3D-VAR analysis on the top of digital filter blending. All analysis steps are sequential: *surface analysis – blending upper air – 3DVar*



Aladin set-up



New cycle 36t1

- Cycle 36t1 contains a lot of innovations for VarBC
  - Add new modules:
    - For allsky (*varbc_allsky.F90), ozone radiance data (varbc_to3.F90, ...*)
  - Add new namelist groups: (*&NAMVARBC_RAD, &NAMVARBC_TO3,* ...)
  - New logical keys: (*yconfig%ncstart, yconfig%npredcs, …)*

  → leads to problems mainly with coldstart settings → IASI presentation!!

- Satellite data assimilation improvements for new model setup:
  - Smaller domain: amount of satellite observations
  - 87 vertical levels:

    1) better use of VarBC predictor for high atmosphere
    2) Improve of bias correction for high-peaking channels

VarBC predictors

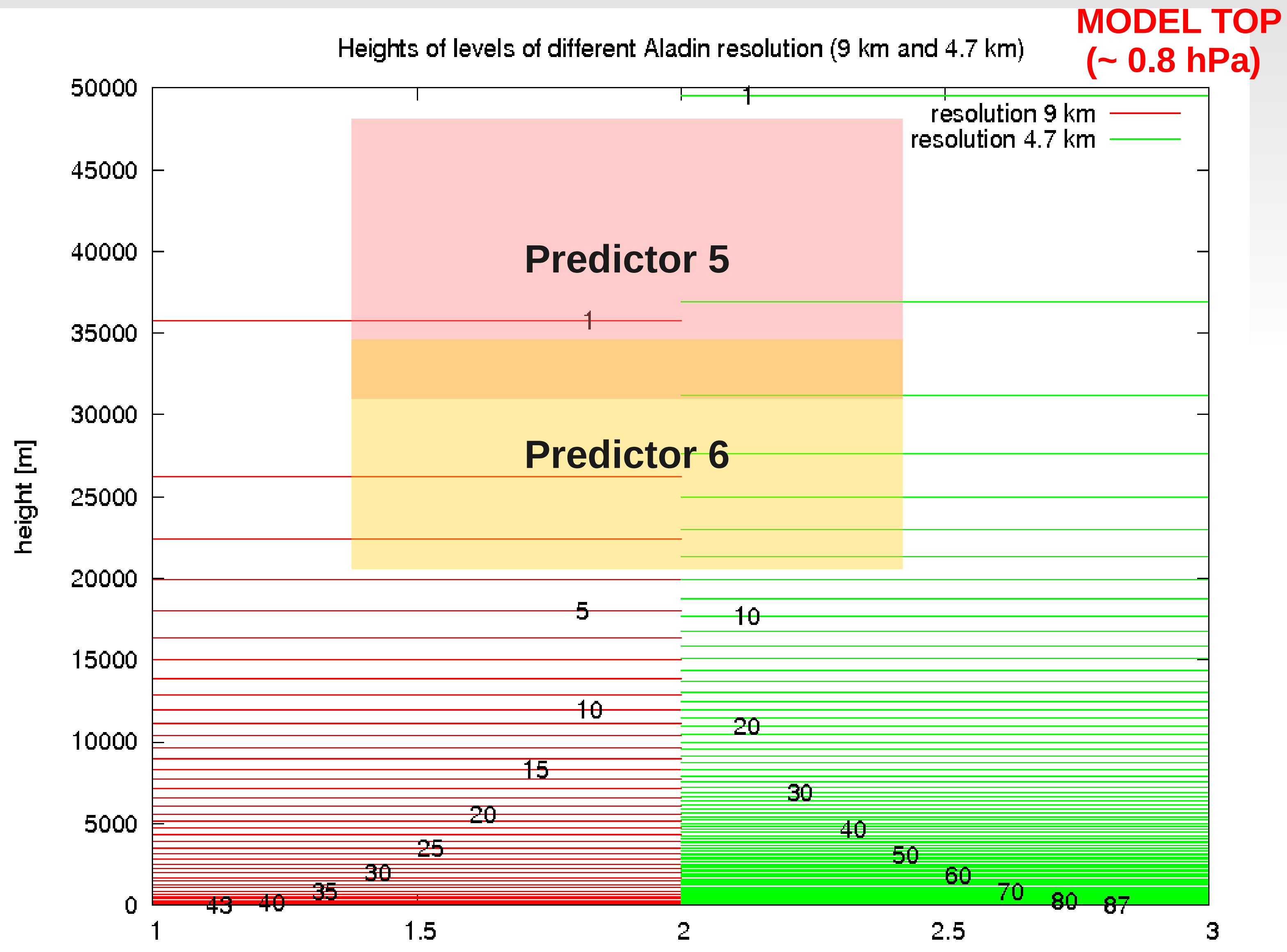
Bias correction B is obtained like linear combination of N state-dependent predictors p_i from the model first-guess, which are good correlated with bias:

$$B = \sum_{i=1}^{N} \beta_i p_i(x)$$

, where bias parameter β_i is a weight of N suitable predictors $p(i)$. Bias parameter is included in the control vector and updated every cycle in variational assimilation system 3DVAR. Overview of all predictors is in the table below. For IASI channels are used predictors 0,1,2,5,6,8,9,10.

$p_i(x)$	**Character**
1	Thicknesses of pressure level 1000-300 hPa
2	Thicknesses of pressure level 200-50 hPa
3	Skin temperature
4	Total column precipitable water
5	Thicknesses of pressure level 1-10 hPa
6	Thicknesses of pressure level 5-50 hPa
7	Surface wind speed
8	Satellite nadir viewing angle
9	Satellite nadir viewing angle**2
10	Satellite nadir viewing angle**3
11	Satellite nadir viewing angle**4
12	cosine solar zenith angle
14	TMI diurnal bias
15	0 over sea, 1 over land
16	0 over sea, nadir viewing angle over land
17	0 over sea, nadir viewing angle **2 over land
18	0 over sea, nadir viewing angle **3 over land

VarBC predictors



VarBC predictors

- New cycle: change thickness for predictor 5 (2-10hPa)
  (better coverage with model levels for new setup)
- Normalized predictors → not problematic p5,6
  (check possibly problematic predictors in screening listing)
- More info in IASI data assimilation presentation

```
Predictor definitions:

p0 : 1 (constant)
p1 : 1000-300hPa thickness minus     9207.0 divided by      446.0
p2 : 200-50hPa thickness   minus     8491.0 divided by      387.0
p3 : T_skin                minus      285.0 divided by       20.5
p4 : total column water    minus       25.0 divided by       17.8
p5 : 10-2hPa thickness     minus    11338.0 divided by      467.0
p6 : 50-5hPa thickness     minus    14975.0 divided by      570.0
p7 : surface wind speed    minus        6.0 divided by        3.6
p8 : nadir viewing angle   minus        5.5 divided by       28.7
p9 : nadir view angle **2  minus      853.0 divided by      744.0
p10: nadir view angle **3  minus     9300.0 divided by    46700.0
p11: nadir view angle **4  minus  1540000.0 divided by  2799000.0
p12: cos solar zen angle   minus        0.0 divided by        0.3
p13: solar elevation       minus      -12.0 divided by       40.0
p14: TMI diurnal bias      minus        0.0 divided by        1.0
p15: land or sea ice mask  minus        0.0 divided by        1.0
p16: view angle (land)     minus        5.5 divided by       28.7
p17: view angle **2 (land) minus      853.0 divided by      744.0
p18: view angle **3 (land) minus     9300.0 divided by    46700.0
```

setup

```
p5 : 10-1hPa thickness     minus    16622.0 divided by      374.0
p6 : 50-5hPa thickness     minus    14975.0 divided by      570.0
```

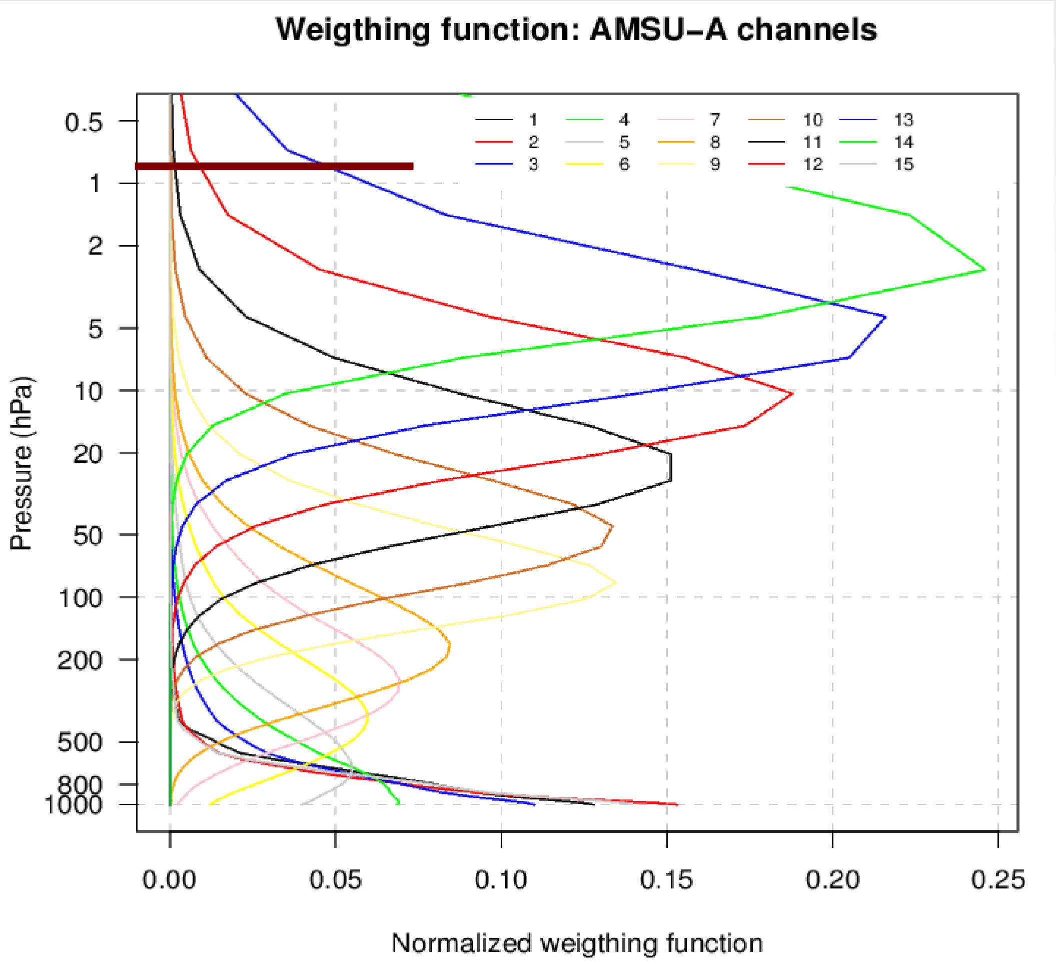
Cross-correlations:

	nsample	mean	stdv	p0	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	p16	p17	p18
p0	32678	1.000	0.000																			
p1	32678	-0.630	0.266		1.000	-0.956	0.403	0.417	0.882	0.762	-0.102	0.104	-0.246	0.038	-0.247	0.087		0.196	-0.256	0.094	-0.227	
p2	32678	0.657	0.212			1.000	-0.325	-0.296	-0.843	-0.747	0.149	-0.018	0.369	0.023	0.349	-0.072		-0.147	0.252	-0.028	0.350	
p3	32678	-0.446	0.270				1.000	0.443	0.609	0.499	0.536	0.235	-0.127	0.155	-0.149	0.026		0.190	-0.754	0.185	0.001	
p4	32678	-0.820	0.152					1.000	0.459	0.392	0.335	0.343	0.063	0.200	0.008	0.029		0.227	-0.273	0.160	-0.020	
p5	32678	-0.277	0.250						1.000	0.898	0.175	0.217	-0.348	0.107	-0.357	0.078		0.251	-0.439	0.182	-0.286	
p6	32678	0.149	0.090							1.000	0.090	0.065	-0.579	-0.010	-0.578	0.032		0.132	-0.271	0.067	-0.491	
p5	31914	-31.478	0.047						1.000	0.935	-0.248	0.045	-0.139	0.084	-0.133	-0.656		-0.049	0.596	-0.085	-0.163	
p6	31914	1.139	0.089							1.000	-0.210	0.045	-0.072	0.094	-0.064	-0.668		-0.005	0.535	-0.076	-0.119	

High peaking channels

- Maxima of weight function for AMSU-A heigh peaking channels are under the top of model (< 0.8 hPa)

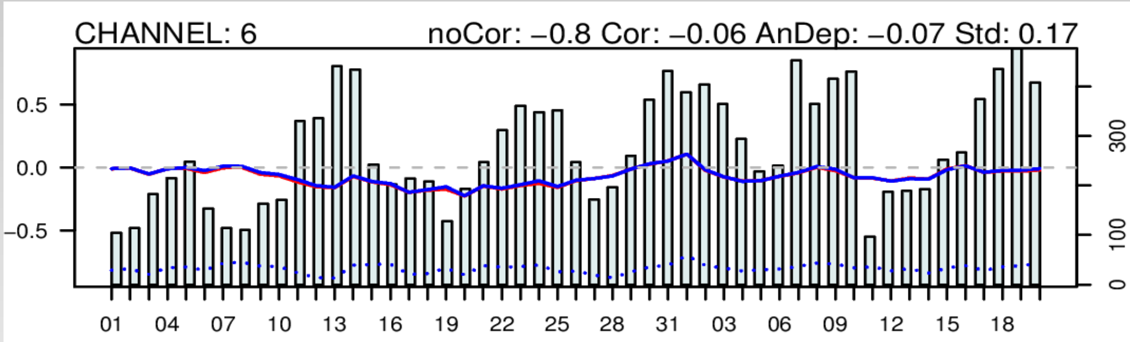
- Improvement of bias and std for ch11, 12 and 13 for new model setup

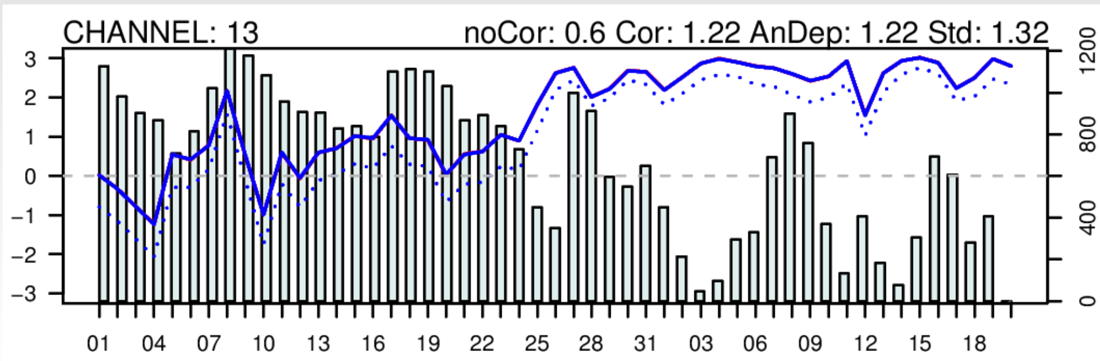


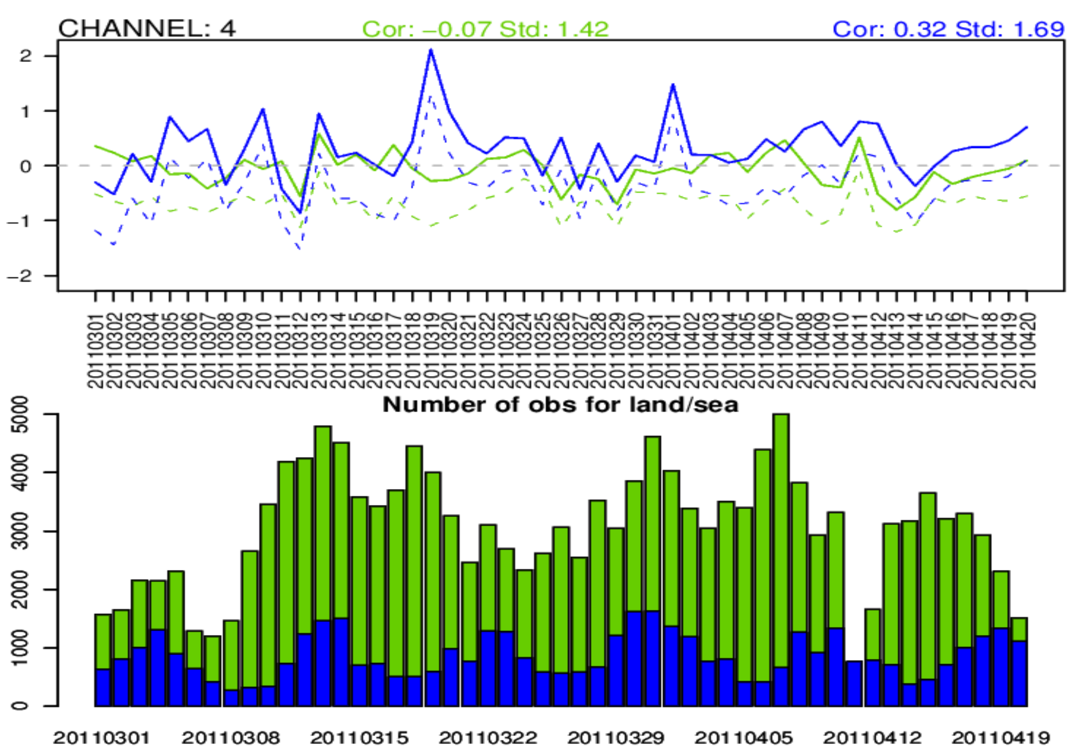
Channel selection

- *Observation monitoring statistics* → based on comparsion O-G departures; identify possibly-problematic channels (bias > 0.2 K)
  - All satellites passive assimilation 1.3.-20.4.2011
  - Warmstart from Arpege; 24-h cycling

Satellite	Sensor	0 UTC	6 UTC	12 UTC	18 UTC
NOAA16	AMSUA	--	9,10	--	9-11
	AMSUB	--	Big STD	--	Big STD
	HIRS	--	x	--	x
NOAA17 (corrupted)	AMSUA	--	--	--	--
	AMSUB	--	x	--	x
	HIRS	--	x	--	x
NOAA18	AMSUA	5-12	5-11	5-12	--
	AMSUB	3,4	little data	3,4	--
	HIRS	--	--	--	--
NOAA19	AMSUA	5-11 (no 8)	little data	5-11 (no 8)	--
	MHS	4	little data	3,4	--
	HIRS	x	x	x	--
METOP	AMSUA	--	6,8-11	5,6,8,9	little data
	MHS	--	Big BIAS	3,4	little data
	HIRS	--	x	x	x
MSG	29	2,4,6,7	2,3,4,6,7	2,3	2,4,6,7







- **AMSU-A: ch6-10**
- ~200-50hPa
- Good bias correction

- **AMSU-A: ch12,13**
- High peaking channels (~10-5hPa)
- Big bias → blacklisted

- **AMSU-B: ch3,4,5**
- Low peaking channels (~800-300hPa) depend on surface properties (surface emissivity, surface temperature...)

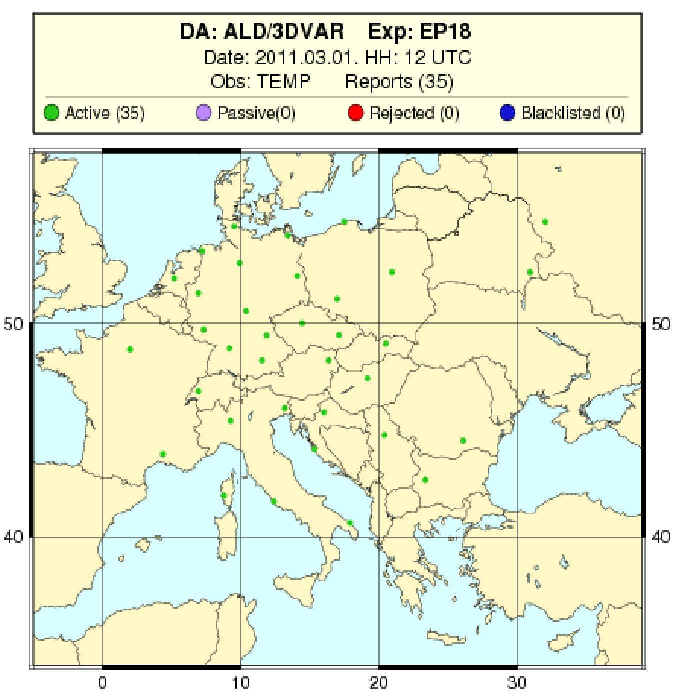
Experiments setup

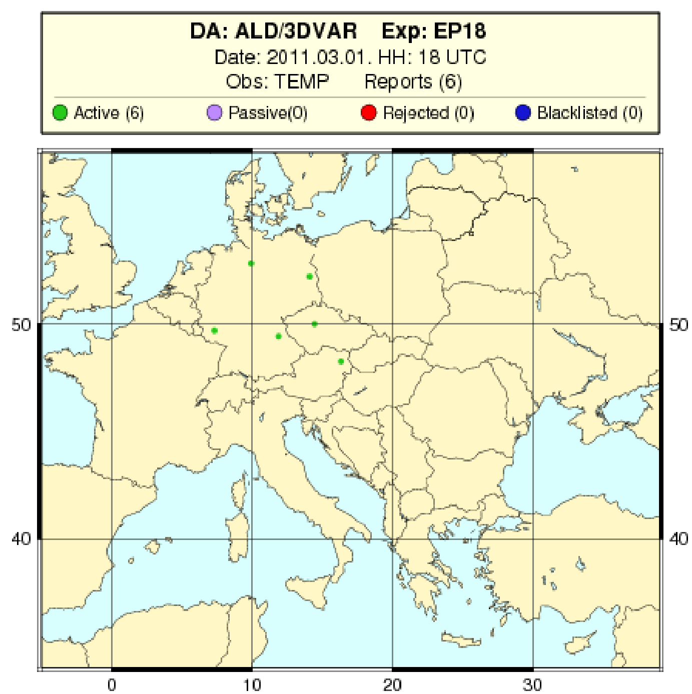
- previous channel selection, VarBC initialization from Arpege (24h-cycling)
- active assimilation for 1.-15.3.2011
- Thinning for all sensors 69.5km

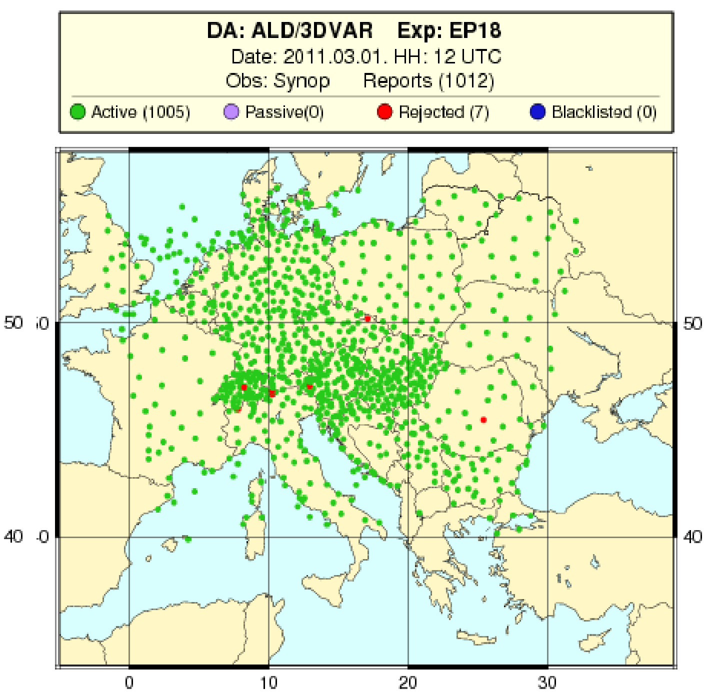
- **Ds03** – reference: conv
- **Ds02** – active assimilation: conv, AMSU-A
- **Ds03** – active assimilation: conv, AMSU-B, MHS

Verification of satellite impact

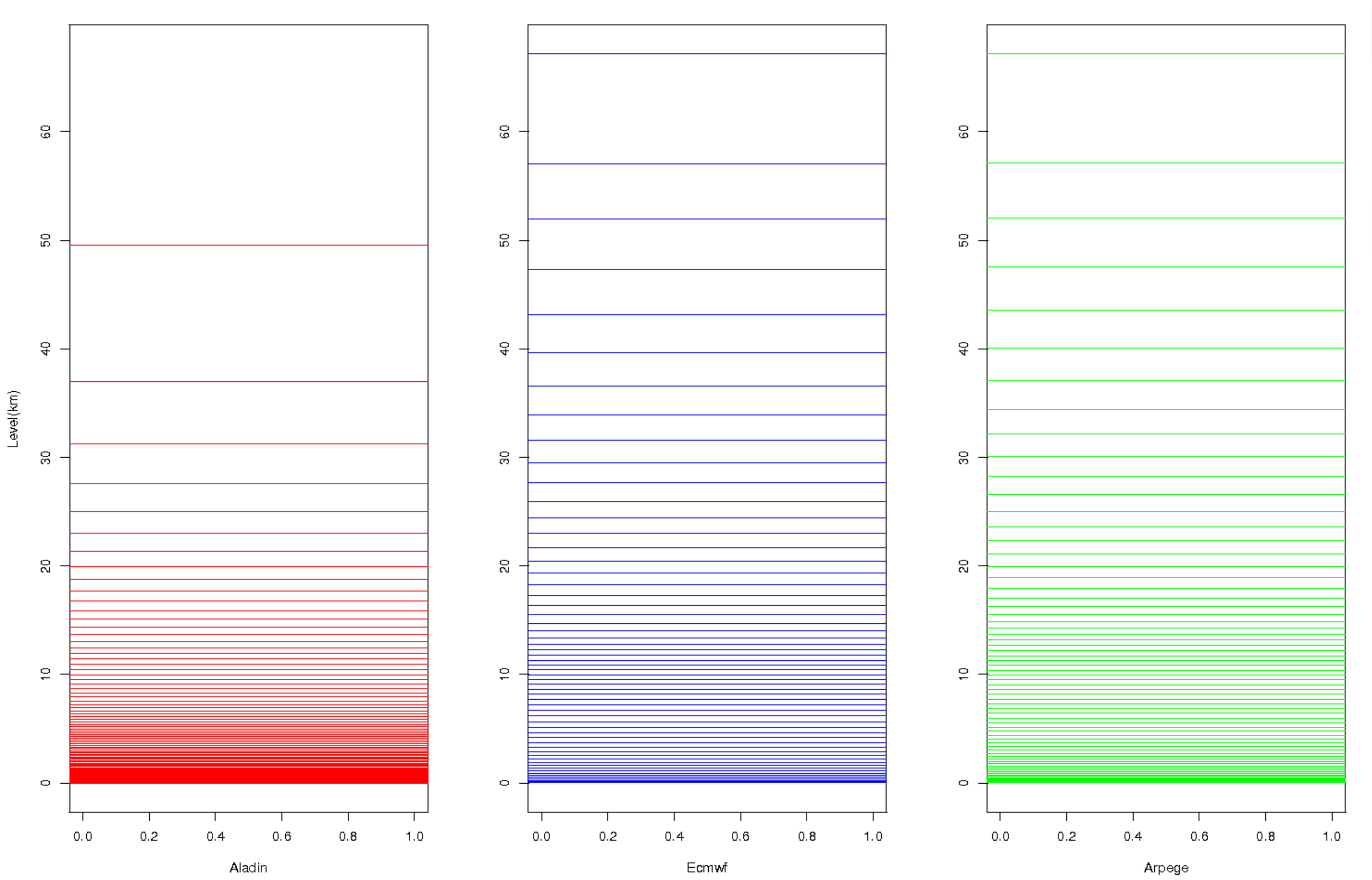
- **<u>Synop & temp</u>** suitable for:
  – surface verification (synop)
  – low and middle atmosphere (temp) at 00,12 UTC (more observation)







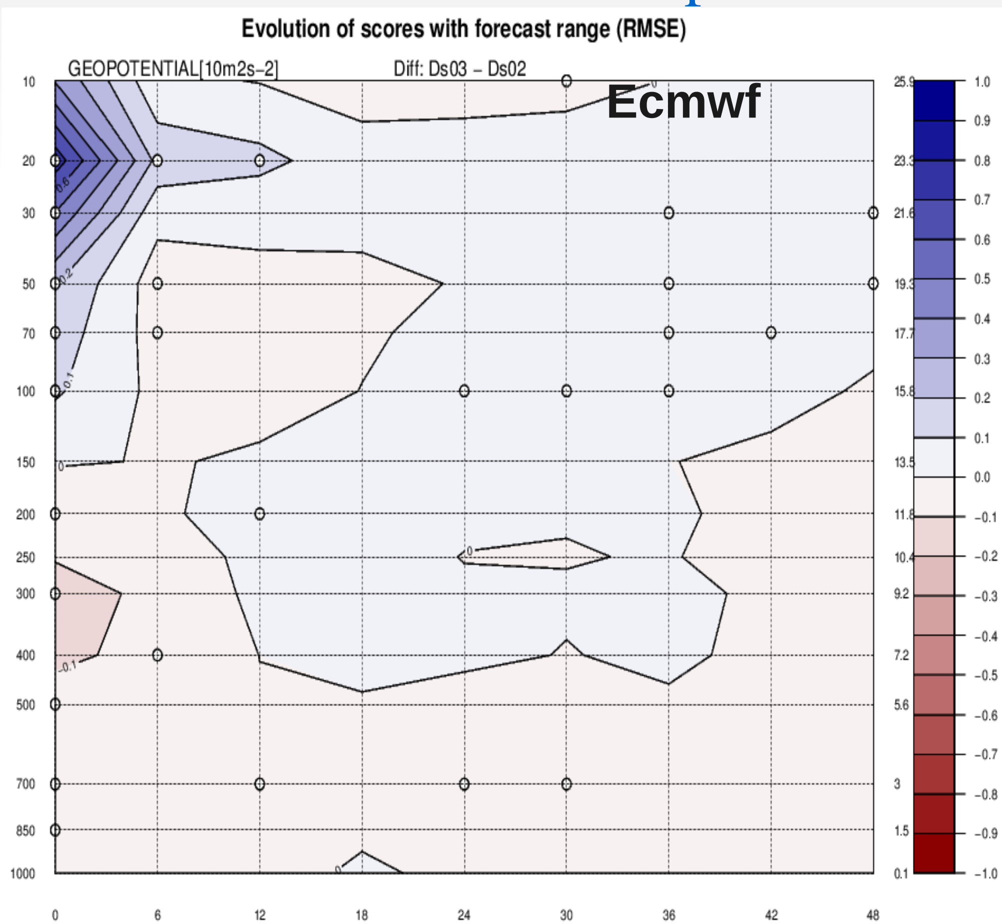
- **<u>Global analysis (ecmwf, arpege)</u>**:
  – better for verification of middle and high atmosphere (more data)
  – worse resolution, description and parametrization of (near) surface processes

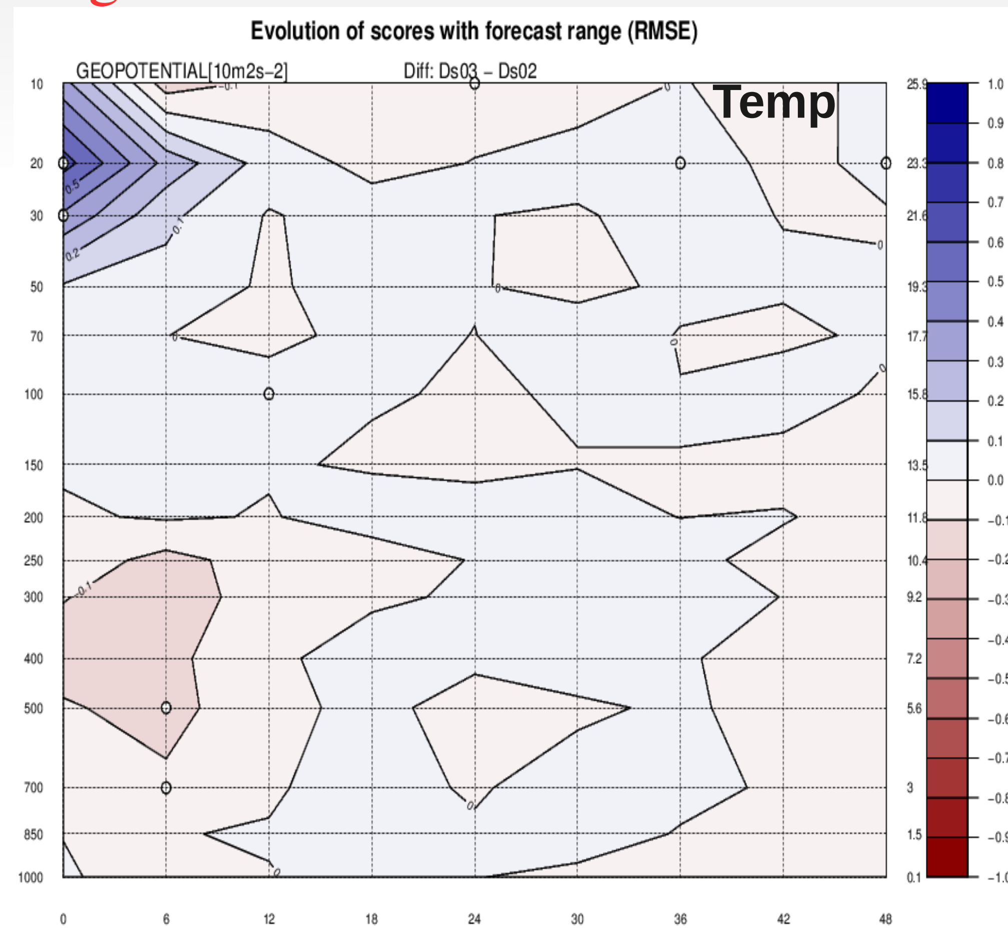


Impact for forecast AMSU-A

- **<u>ECMWF, TEMP:</u>** neutral impact, slightly improvement (for bias, rmse in analysis) for T, geop (10-50hPa)

improvement & degradation

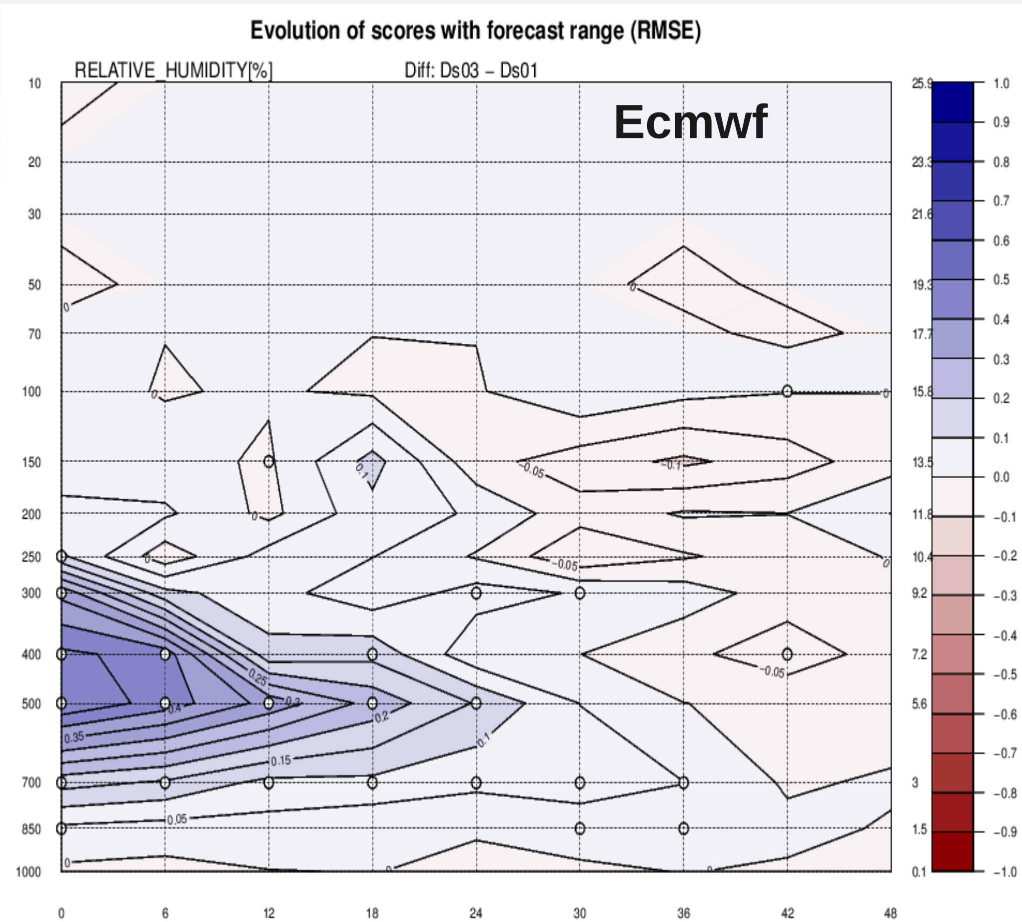


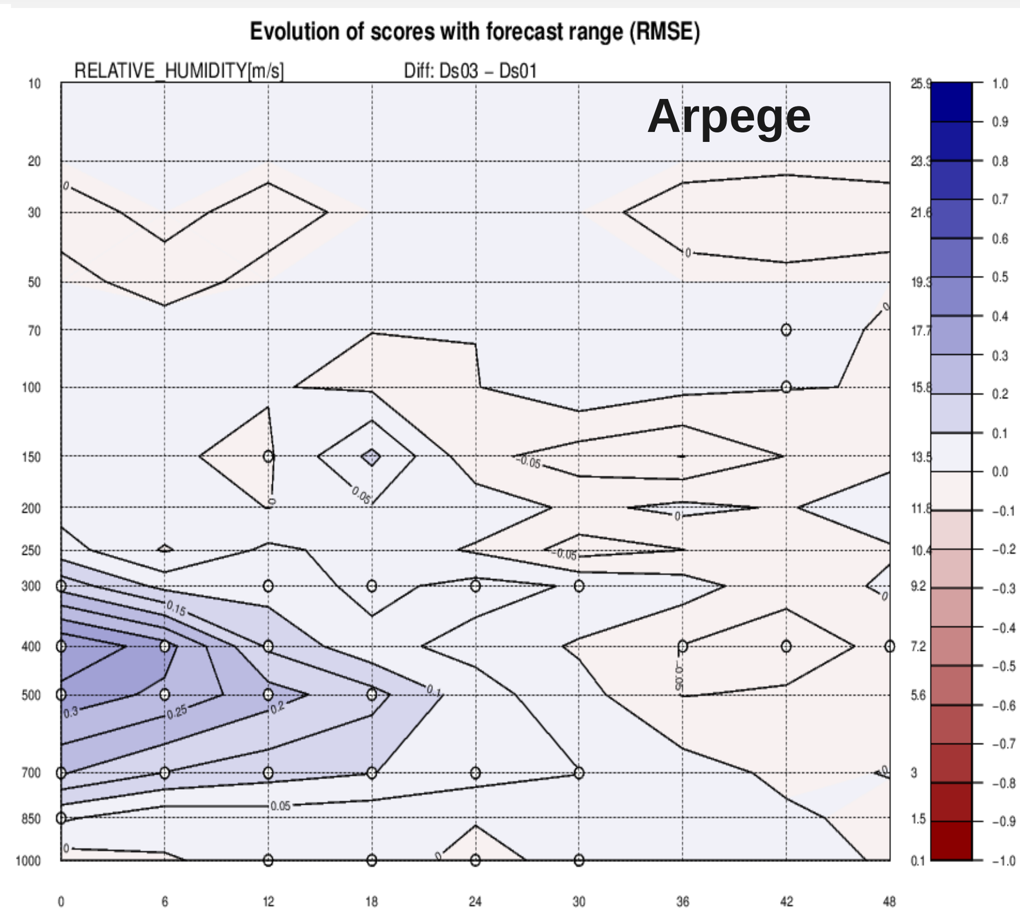


Impact for forecast AMSU-B

- **Global analysis**: positive impact for RH (200-700hPa) in bias and rmse

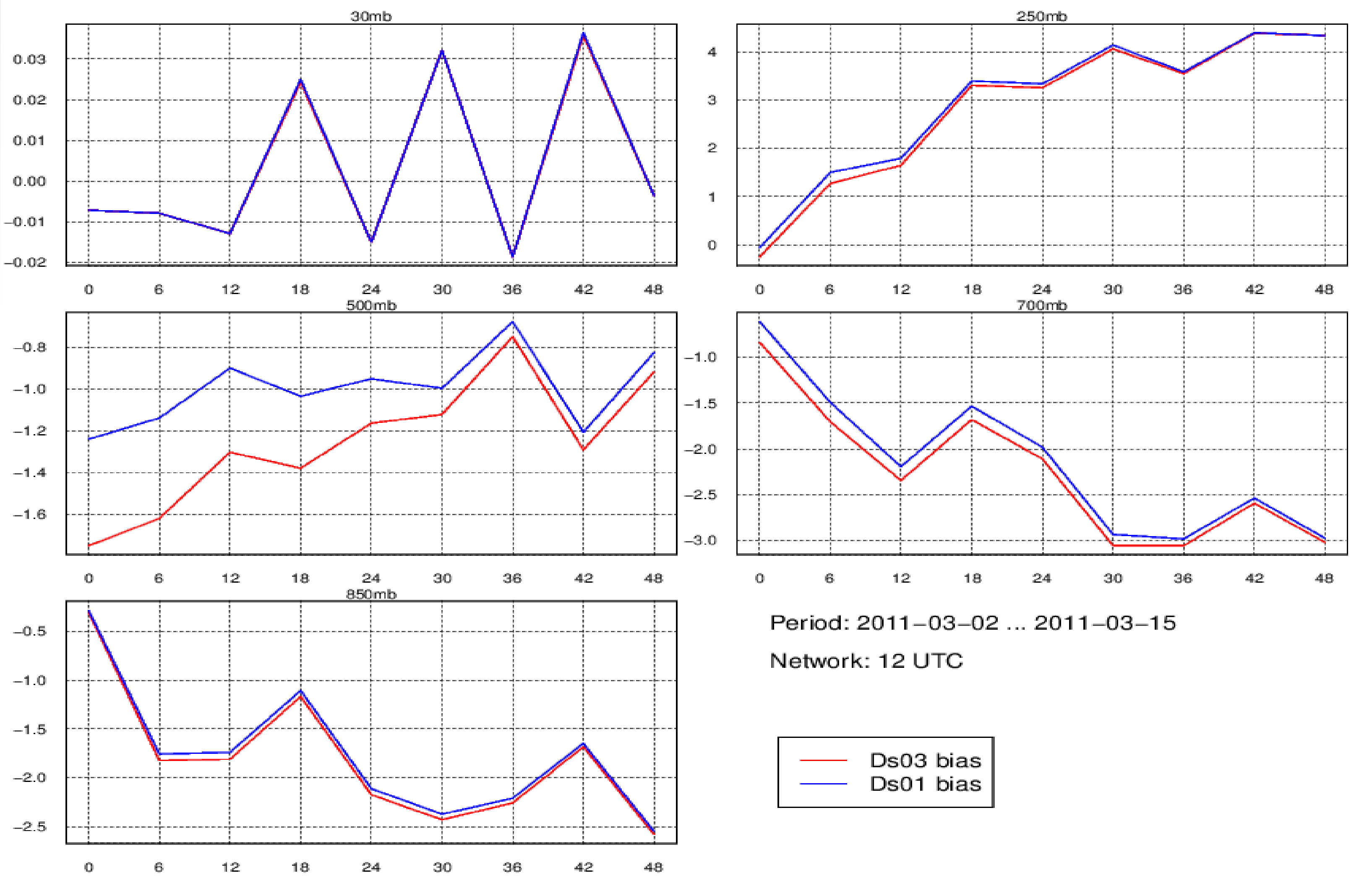
improvement & degradation





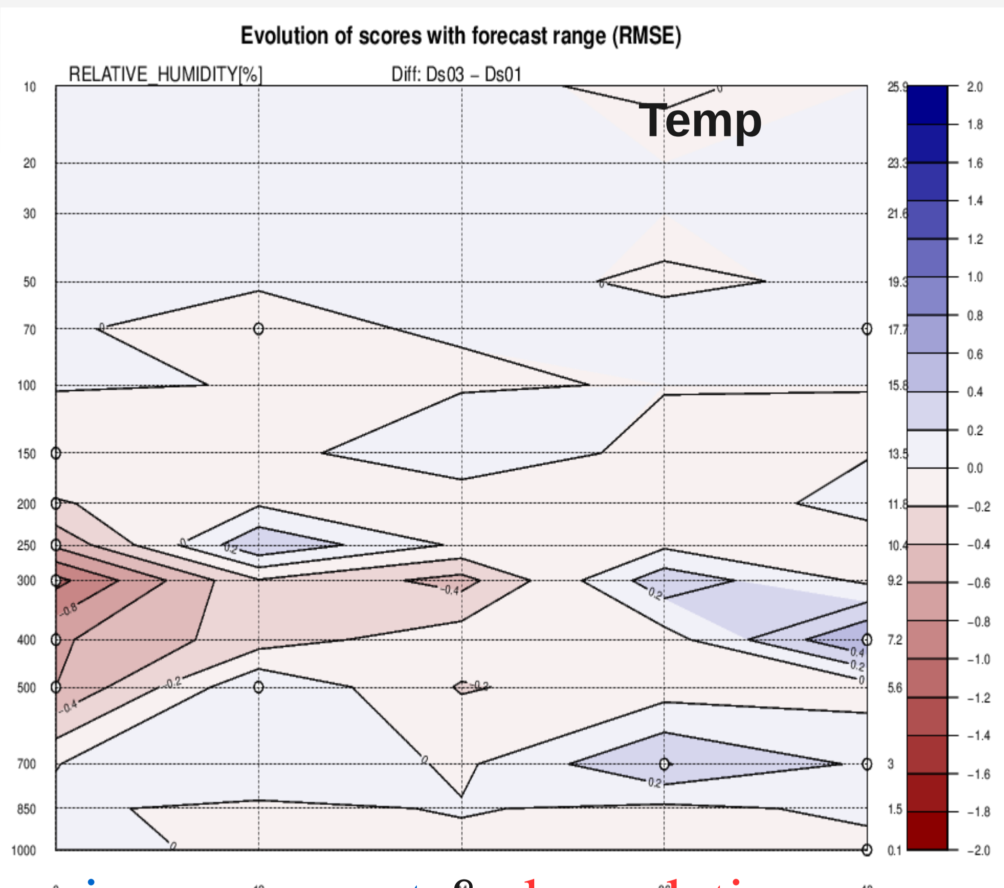
Impact for forecast AMSU-B

Arpege – **bias** range evolution for; similar for ECMWF

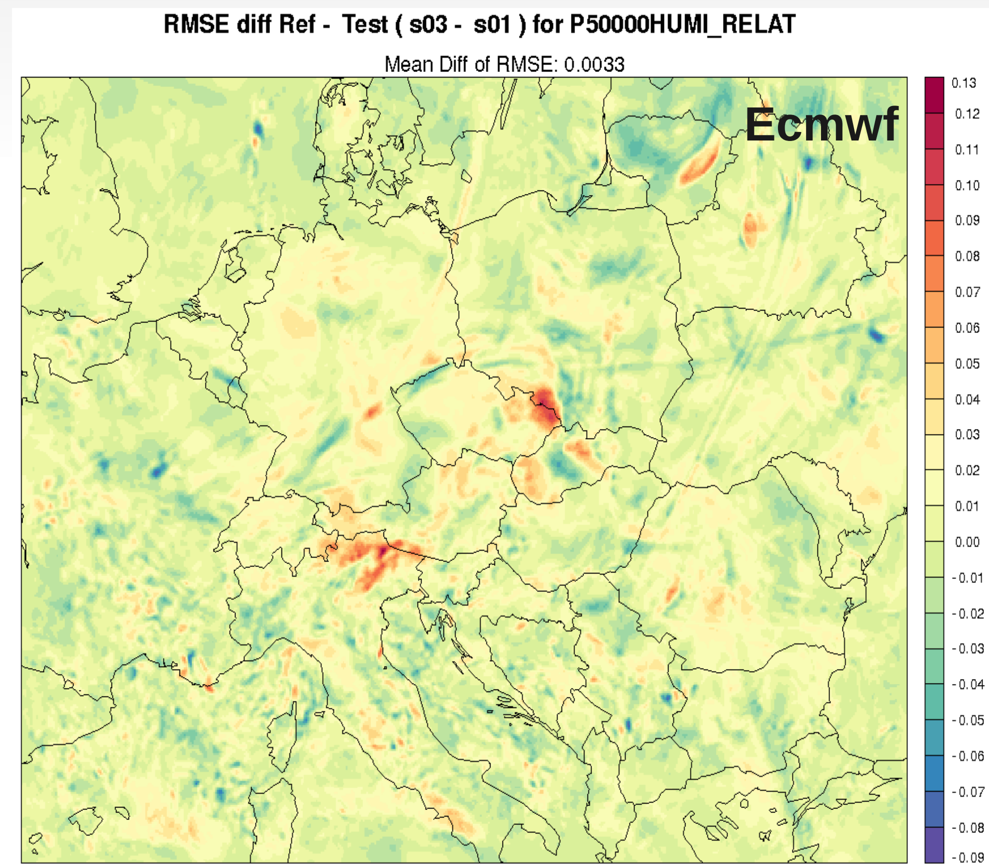


Impact for forecast AMSU-B

- **Temp**: significant degradation for RH (200-500hPa)
- Distribution of RMSE in domain for ECMWF
  → local improvement (35 temp observation in degradation fields)



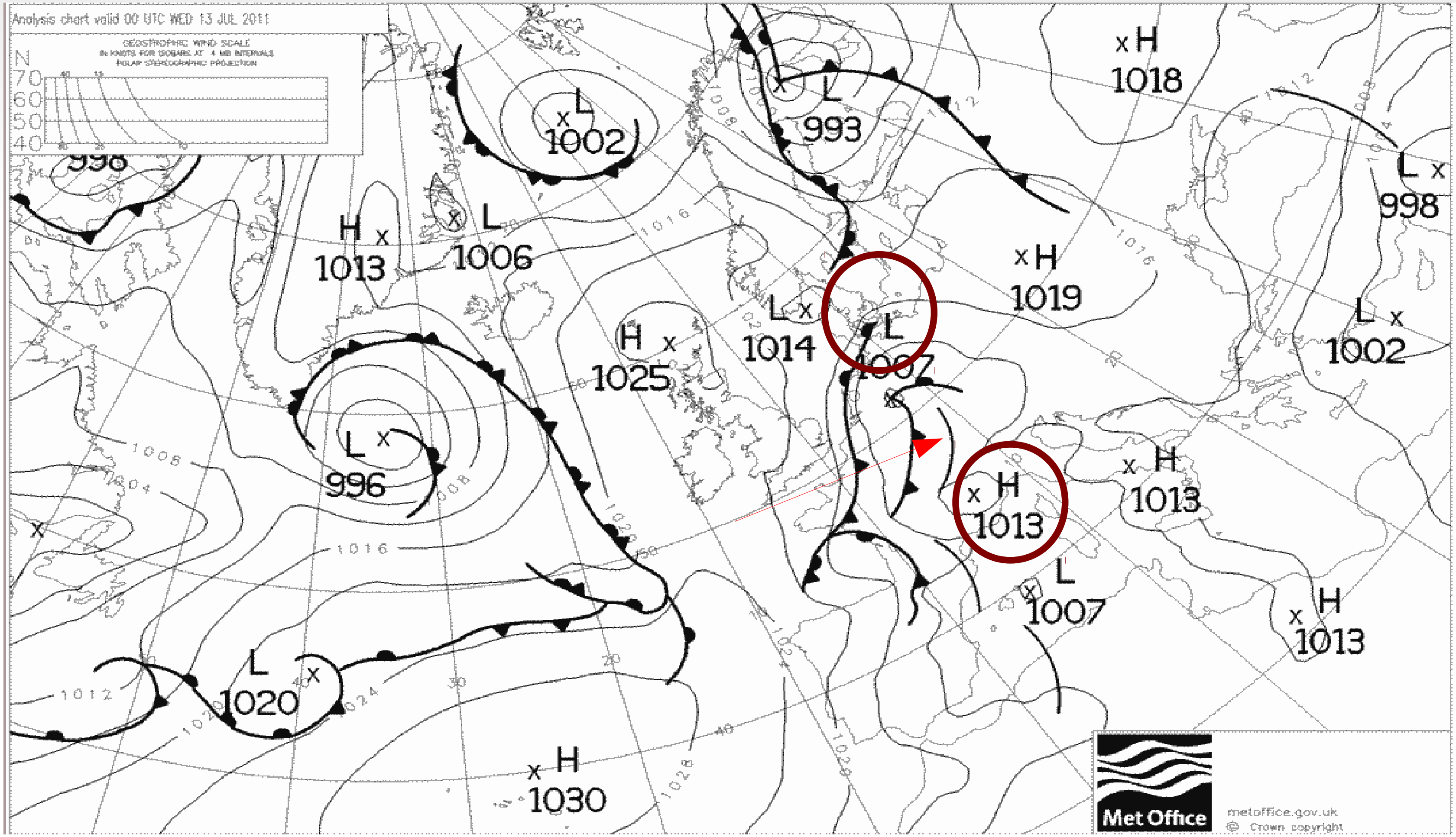
improvement & degradation



improvement & degradation

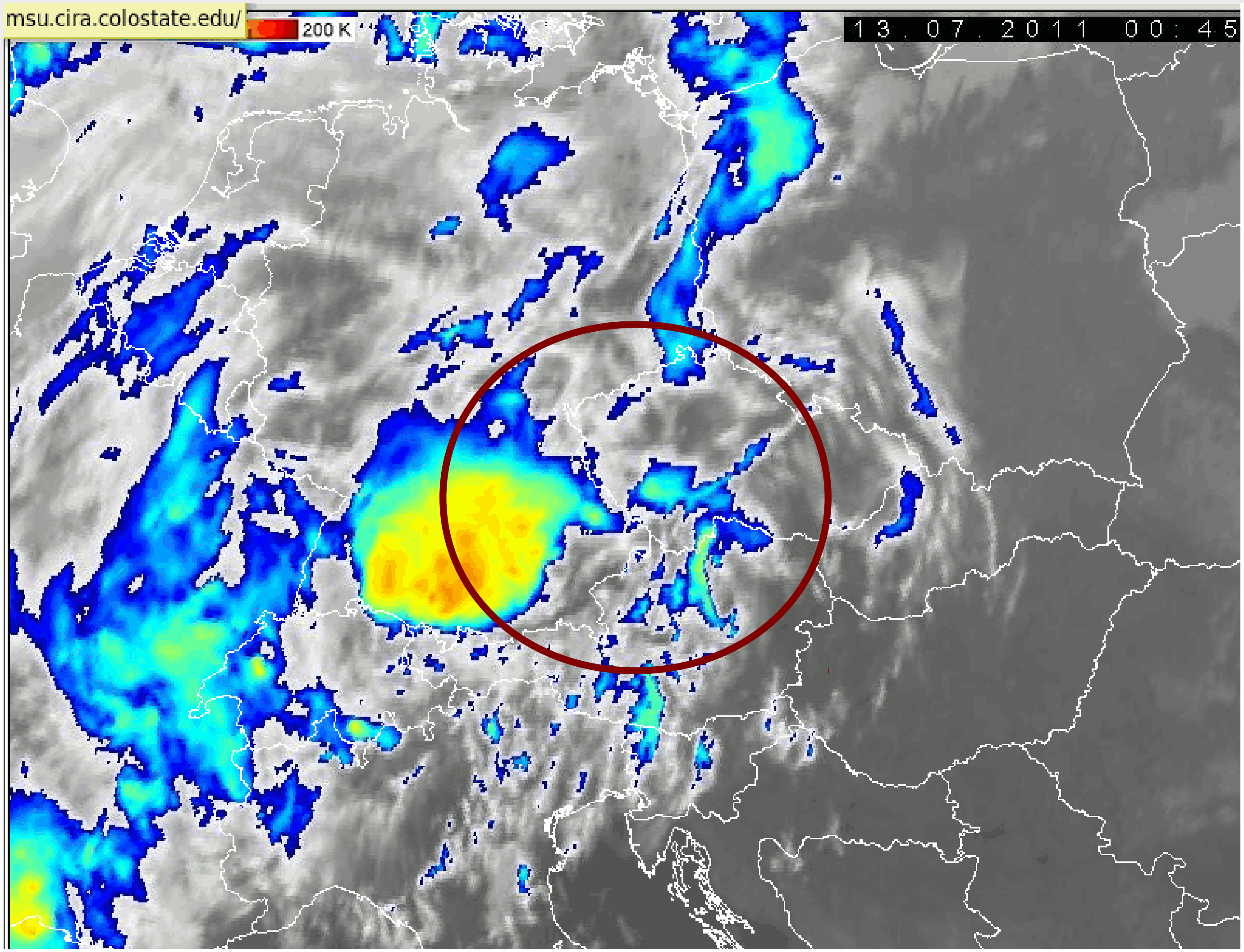
Case study

- 13.-14.7.2011; typical summer storm situation
- unstable atmosphere (temperature startification), humid air
- interesed in first instability line (red arrow)



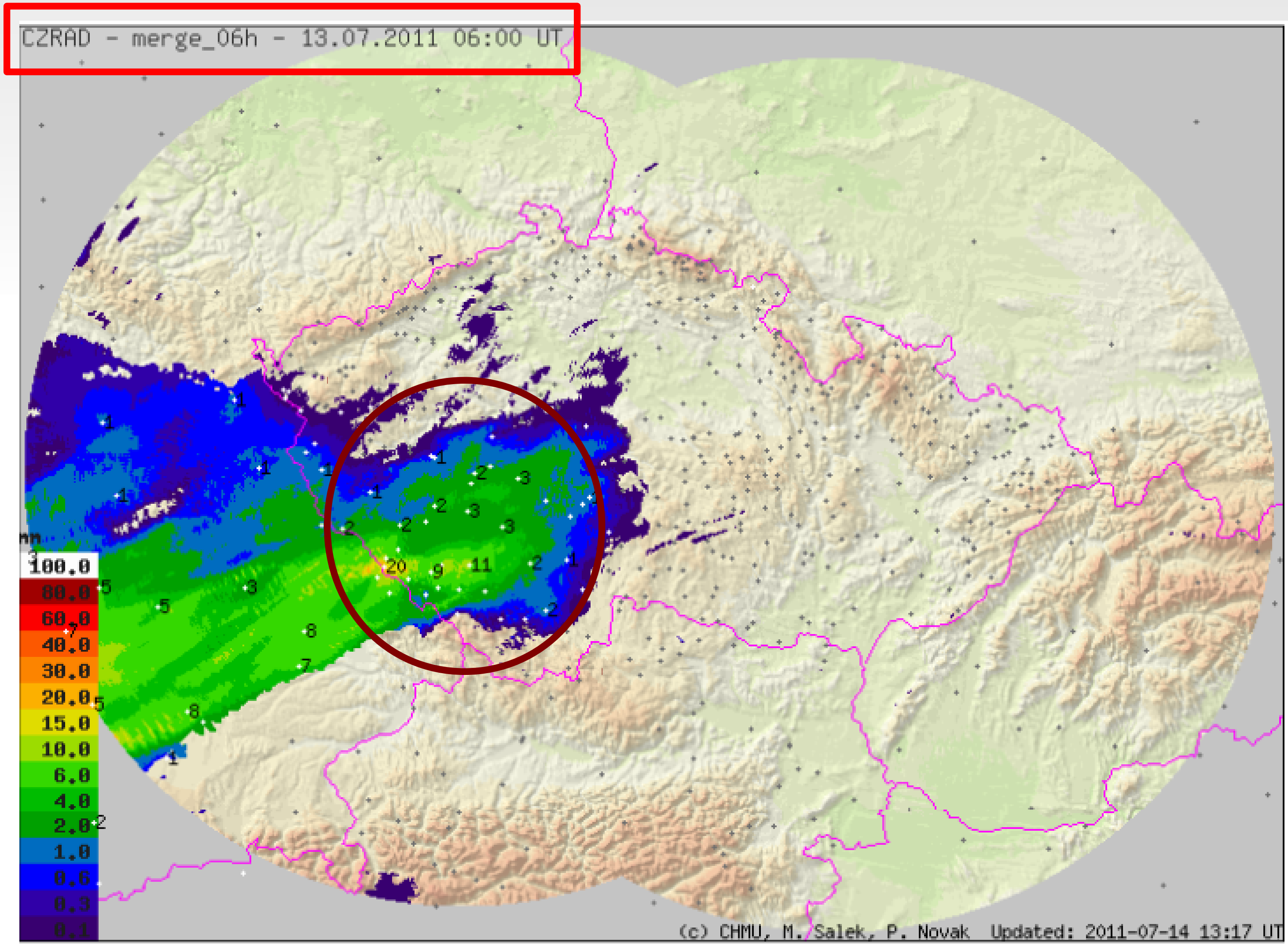
Case study

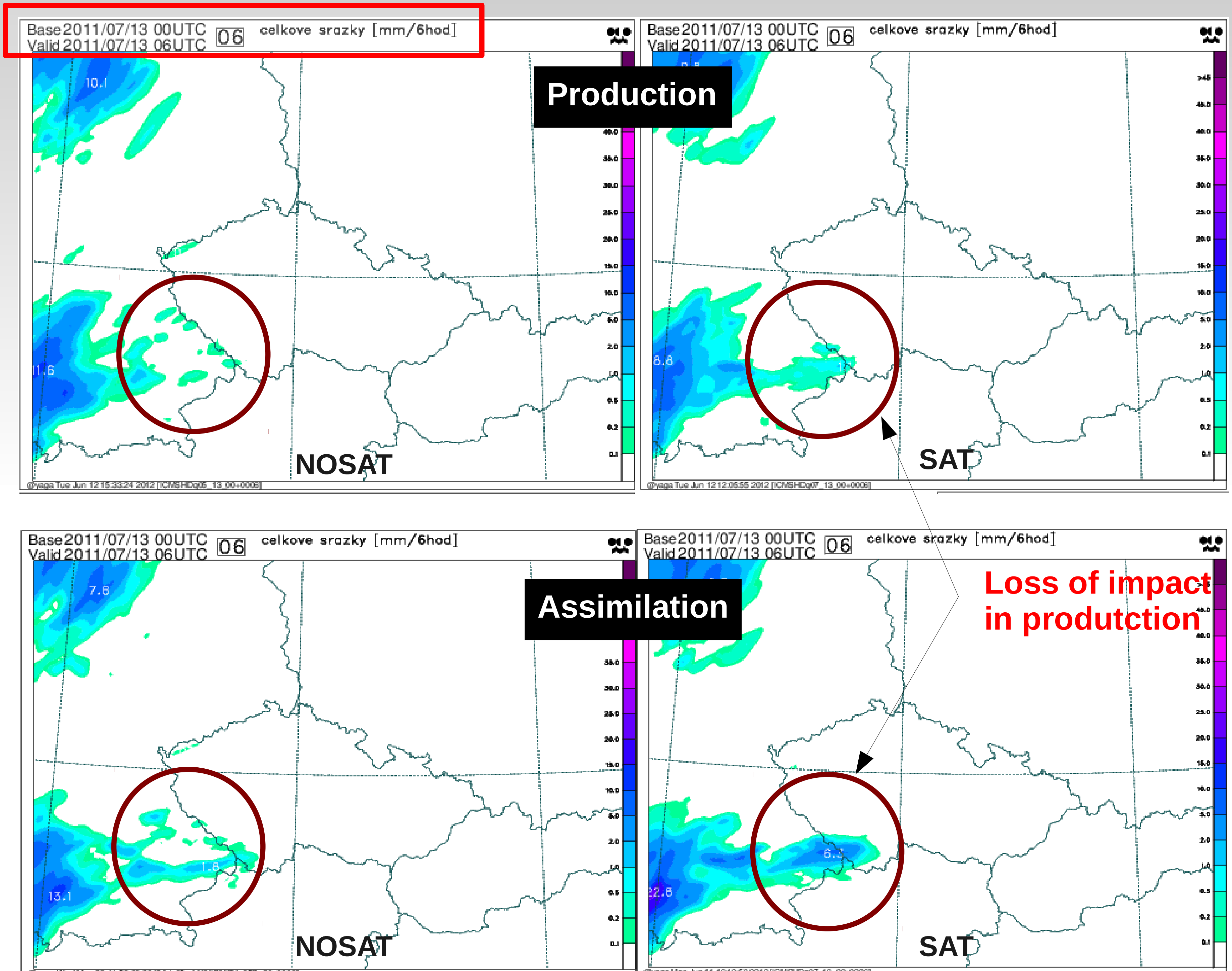
- Band of convective activity **13.7.2011 00-06UTC** (instability line)
- Weak storm in the south of Czech Republic



Case study

- Combination radar + measurements (total 6h precipitation)





Base 2011/07/13 00UTC
Valid 2011/07/13 06UTC
06
celkove srazky [mm/6hod]
Production
NOSAT
SAT
Base 2011/07/13 00UTC
Valid 2011/07/13 06UTC
06
celkove srazky [mm/6hod]
Assimilation
NOSAT
SAT
Loss of impact
in productction

Assimilation vs. production

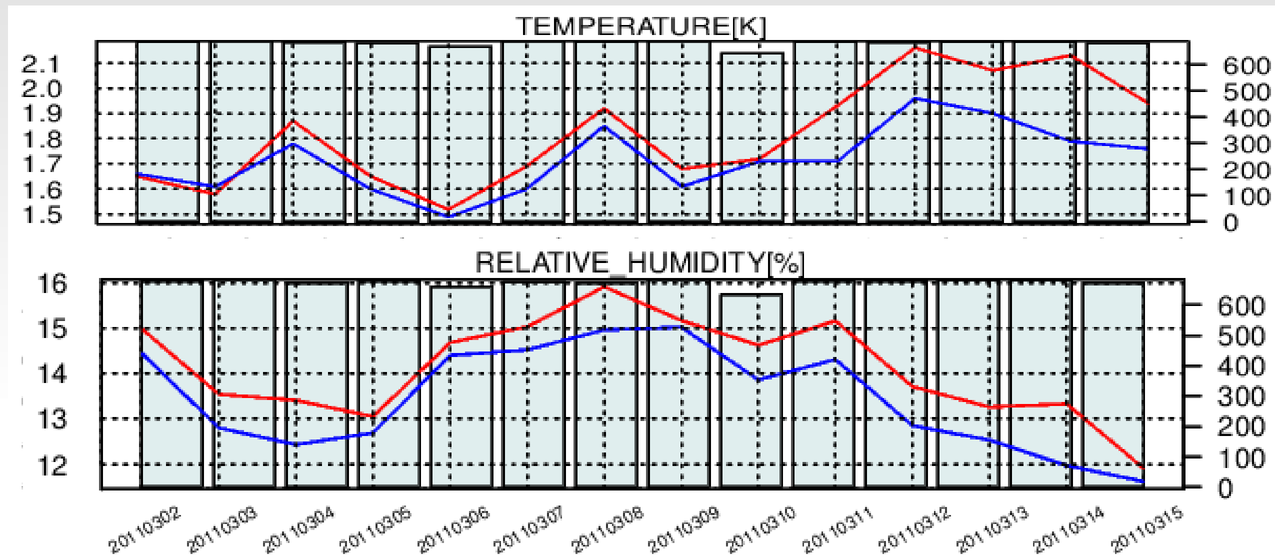
- The loss of information in production:
  - Short cut-off observations (smaller amount of conv observation; satellites the same amount)
  - Arpege short cut-off analysis (!)
  - IDFI (incremental DFI) on analysis (!)

- Long time experiment → assimilation vs. production
  - REF (conv), EXP (conv, amsub)
  - Production in 12UTC for 15 days (1.-15.3.2011)
  - Verification +6h forecast (vs. temp)

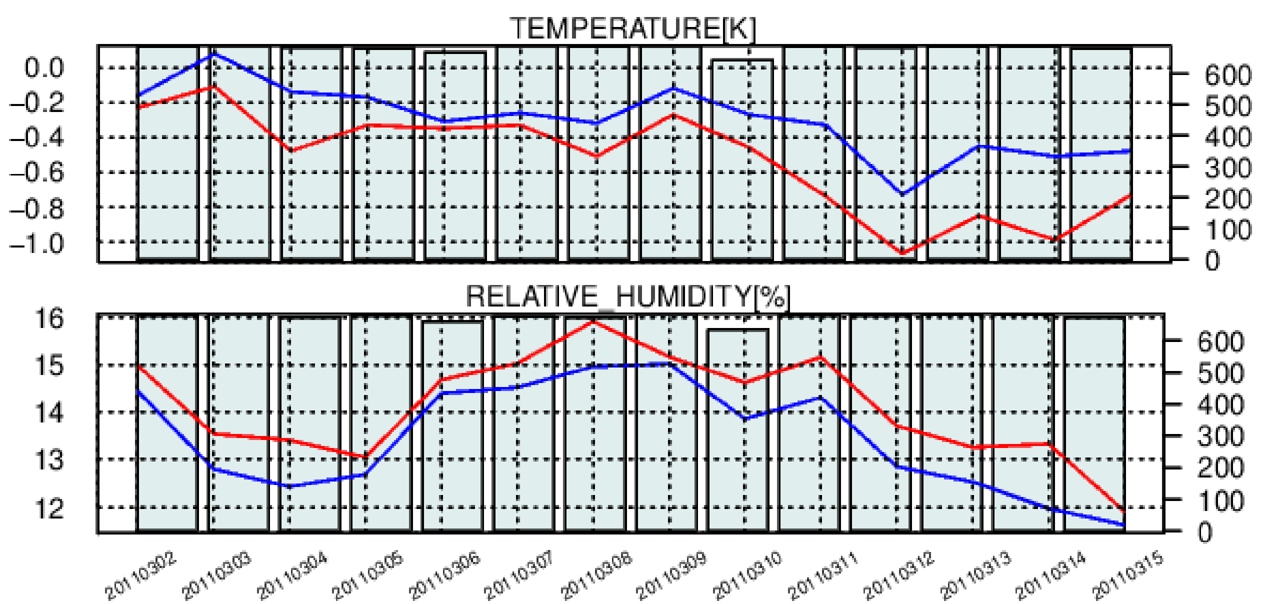
Assimilatoin vs. production

- Degradation for surface in production (T, geop, RH) → new tuning IDFI?

RMSE
Production
Assimilation



BIAS
Production
Assimilation



Conclusion

- Improve the use of sattelite data for new model setup (stratospheric predictors, high peaking channels)
- **Channel selection** (passive assimilation → plan to run longer 3 months period)
- **Impact for forecast:** AMSU-A (high atmosphere – slightly positive in temperature), AMSU-B (middle and low atmosphere – positive in RH)
- **Case study:** impact for summer storm situation in assimilation → the loss of new information (observations) for surface in production (T, RH, geop)

Future plans

- More channel-selection methods to get optimal channel selection for active assimilation
- Seviri and IASI data assimilation
- Investigation of IDFI tuning to get better impact in production

Thank you for your attention.