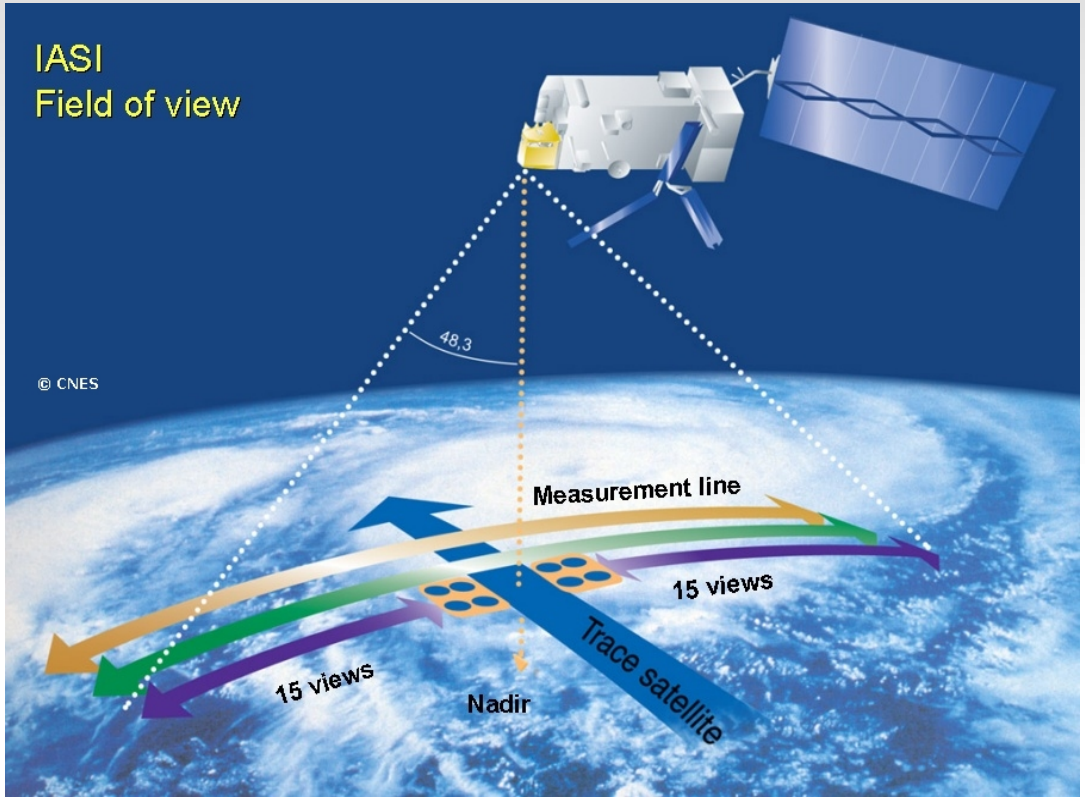
IASI data assimilation within RC LACE



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Based on the results from LACE stay in Budapest, 9.4.-18.5.2012

Outline

- Introduction
- Variational bias correction (VarBC)
  - Changes in the new cycle 36t1
  - Coldstart settings
  - Coldstart experiments
- VarBC stratospheric predictors and top of model
  - Impact of predictors 5, 6 to the analysis
- IASI channel selection and forecast impact

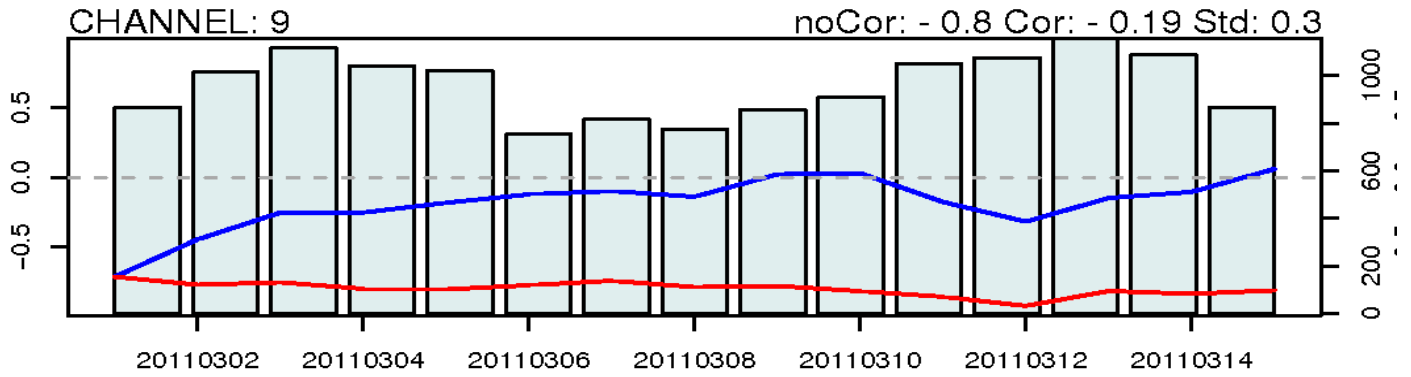
Introduction

- IASI data assimilation was technically prepared for new cycle 36t1 with ALADIN 3DVAR data assimilation system at HMS by A. Trojakova
  - Pre-processing, observation monitoring and first results with forecast impact.
- Open questions:
  - Problems within VarBC correction in observation monitoring.
  - Problems with analysis impact during passive assimilation.
- 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, ...)
  - Logical keys (yconfig%ncstart, yconfig%npredcs, ...)

    → changes with VarBC settings (mainly coldstart)

VarBC

- VarBC – observation bias correction implemented into the variational assimilation system 3DVAR. Initialization:
  - *warmstart* (from available varbc file)
    - include bias information (group tables & bias parameters)
    - FG departures are close to zero from beginning
  - *coldstart* (not available input varbc file)
    - new group table (from available observations)
    - bias parameters updated every analysis and FG departures converge to zero



VarBC settings

- **Coldstart settings** in screening namelist (&NAMVARBC_RAD):

  1) *YCONFIG(sensor,channel)%NCSTART = 0*

  – set the bias parameters to zero for $sensor, $channel

  2) *YCONFIG(sensor,channel)%NCSTART = 1*

  – use available bias information (from varbc file otherwise default value)

  3) *YCONFIG(sensor,channel)%NCSTART = 2*

  – use mode of FG departures as the first information

  – *default but NOT WORK CORRECTLY!!* (change)

- **Switch-off VarBC** for channels:

  YCONFIG(sensor,channel)%NPARAM = 0

- **Selection of predictors** (default settings in Arp/module/varbc_rad.F90)

  YCONFIG(sensor,channel)%NPARAM = 8
  YCONFIG(sensor,channel)%PREDCS(1:8) = 0,1,2,5,6,8,9,10

Coldstart settings (namelist)

```
&NAMVAR
  NITER=1,
  NSIMU=1,
  NGRATS(0)=1,
  NGRATS(1)=1,
  NFRANA=10000,
  NUPTRA=-1,
  LJCNMTL=.FALSE.,
  RCVGE=1.E-3,
  L_CHECK_CONVERGENCE=.FALSE.,
  LTOVSCV=.TRUE.,
  LVARBC=.TRUE.,
  LCLDSINK=.FALSE.,
/
&NAMVARBC
/
&NAMVARBC_ALLSKY
  LBC_ALLSKY=.FALSE.,
/
&NAMVARBC_RAD
  LBC_RAD=.TRUE.,
  YCONFIG(3,1:15)%NCSTART=0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
  YCONFIG(4,1:5)%NCSTART=0,0,0,0,0,
  YCONFIG(15,1:5)%NCSTART=0,0,0,0,0,
  YCONFIG(29,1:8)%NCSTART=0,0,0,0,0,0,0,0,
/
&NAMVARBC_TCWV
  LBC_TCWV=.FALSE.,
/
&NAMVARBC_TO3
  LBC_TO3=.FALSE.,
```

Switch on VarBC

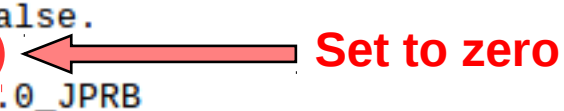
Coldstart settings

New module for allsky radiance data, ozone data, total column water vapour

Coldstart settings (2 option)

2) Modification in Arp/module/varbc_rad.F90

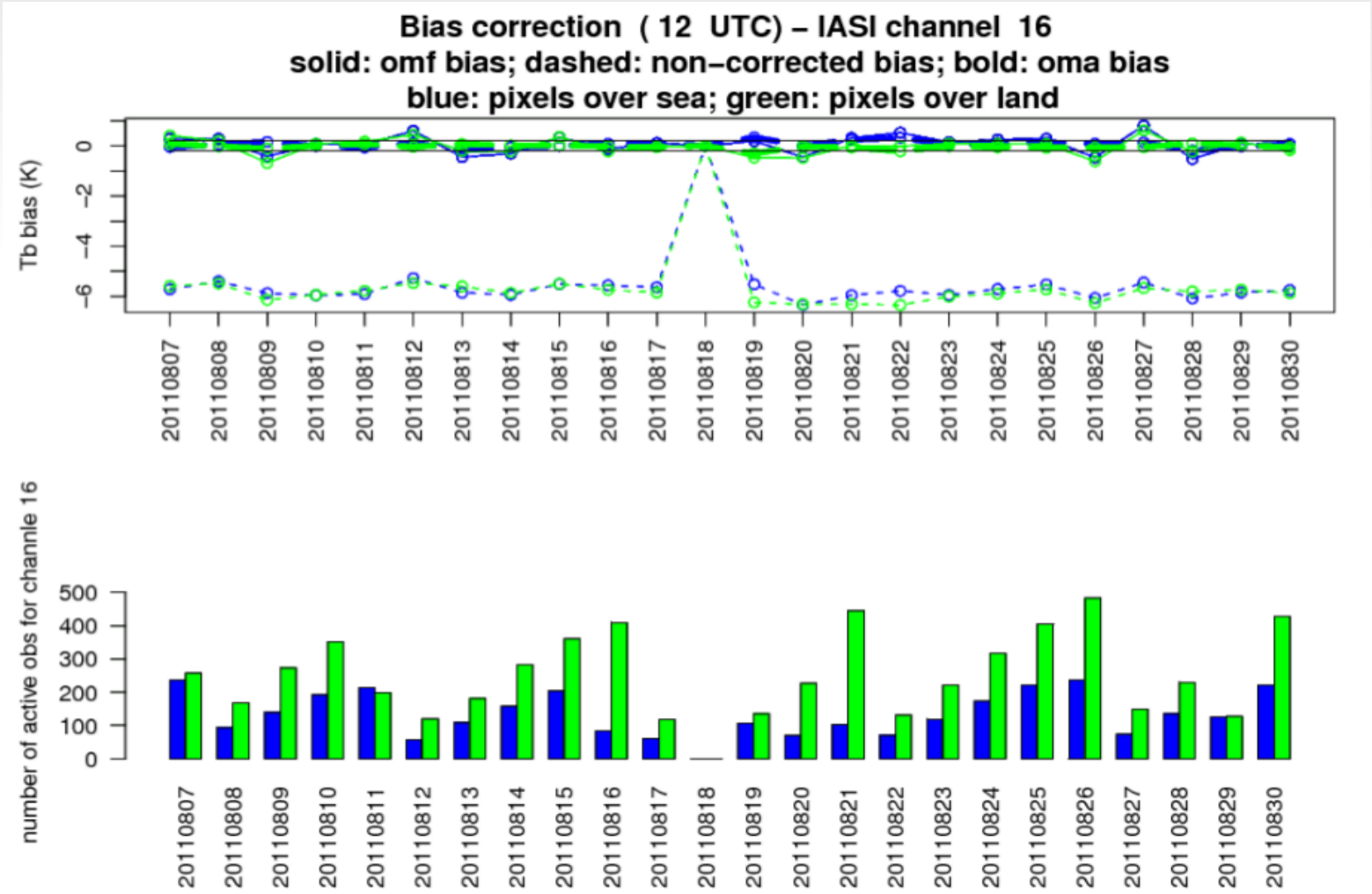
```
175 |
176 | ! default settings:
177 | ! ----------------
178 | DO is = 0, MXSENSOR
179 |   DO ic = 1, JPMXTOCH
180 |     yconfig(is,ic)%nparam      = 0
181 |     yconfig(is,ic)%npredcs(:)  = 0
182 |     yconfig(is,ic)%zparams(:)  = RMDI
183 |     yconfig(is,ic)%llconst(:)  = .false.
184 |     yconfig(is,ic)%ncstart     = 2
185 |     yconfig(is,ic)%dfgdep      = 20.0_JPRB
186 |     yconfig(is,ic)%nbgstdv     = 0
187 |     yconfig(is,ic)%llmode      = .false.
188 |     yconfig(is,ic)%llmaskrs    = .false.
189 |     yconfig(is,ic)%llmaskcld   = .false.
190 |   ENDDO
191 | ENDDO
192 |
```



- Available input varbc file → bias information from varbc file
- Not available input varbc file → ncstart (set to zero) → coldstart

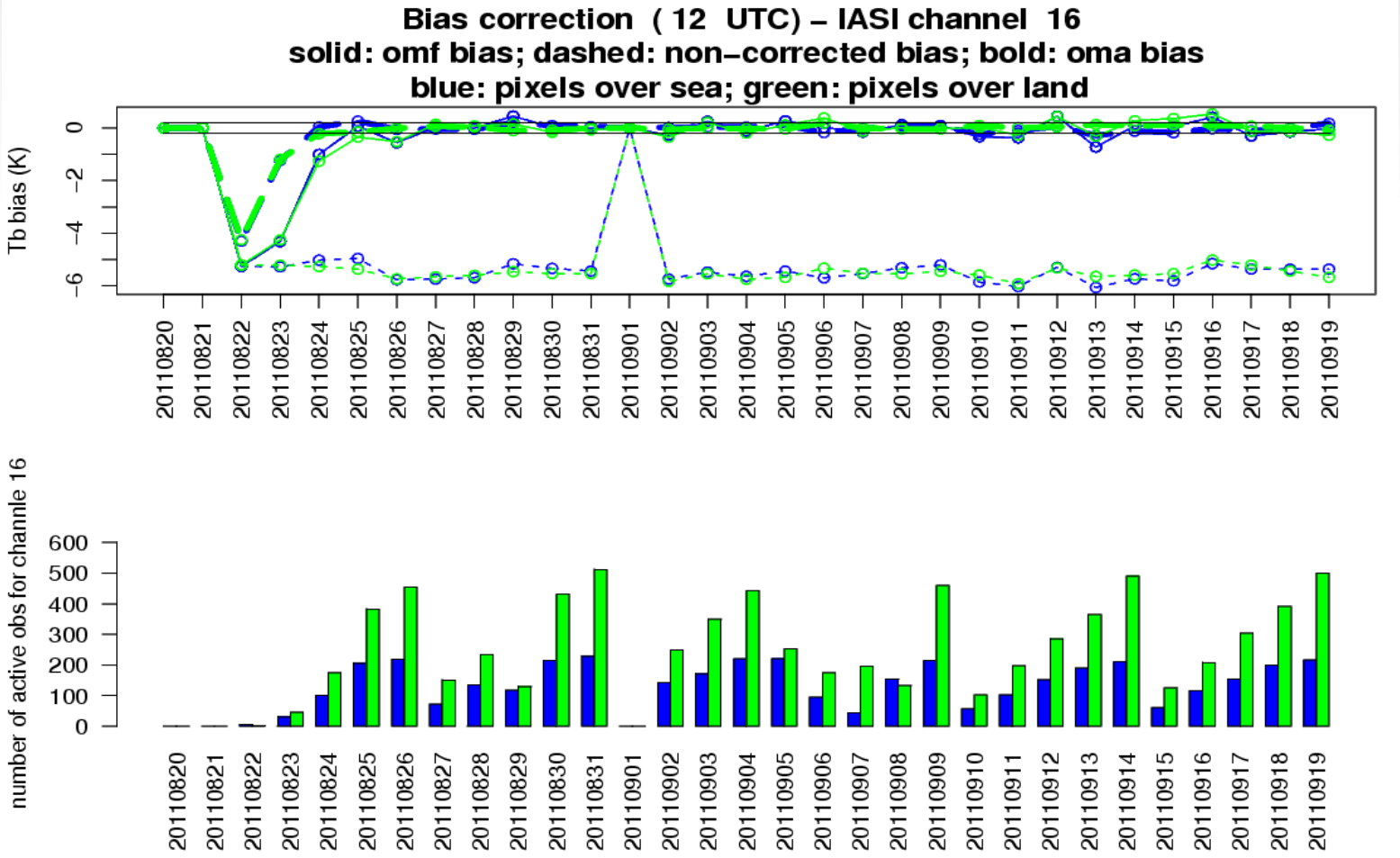
Coldstart experiments

- No modification for coldstart (not set ncstart to zero value)
- Not convergence period, no data passed screening first day



Coldstart experiments

- After namelist modification (ncstart = 0 for IASI channels)
- 4-5 days warmup period, impact to analysis ?? (passive assimilation)
  →problem only for channels where are used stratospheric predictor 5, 6



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:

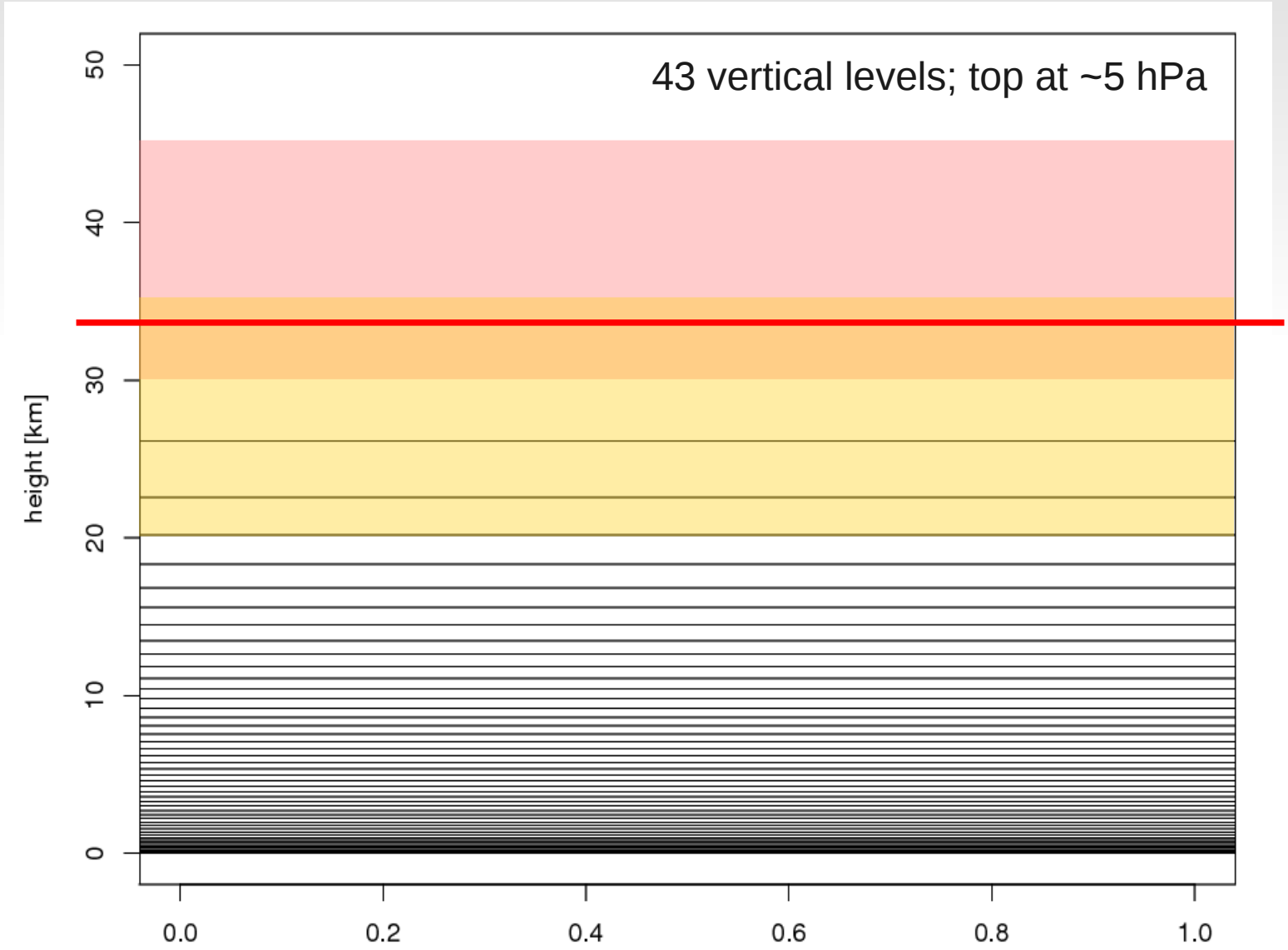
$$B = \sum_{i=1}^{N} \beta_i p_i(x)$$

, 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

Predictors used for IASI channels

Top of model at HMS



Top of model at HMS

- Check possibly-problematic predictors in screening namelist

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	40583	1.000	0.000																			
p1	40583	0.356	0.336		1.000	-0.980	0.739	0.450	-0.409	-0.654	-0.323	0.050	-0.118	0.041	-0.090	0.343		-0.181	-0.536	0.066	-0.154	
p2	40583	0.344	0.387			1.000	-0.713	-0.395	0.298	0.566	0.392	-0.041	0.137	-0.044	0.118	-0.402		0.125	0.475	-0.074	0.152	
p3	40583	0.327	0.292				1.000	0.153	-0.301	-0.567	-0.030	0.032	-0.046	0.024	-0.035	0.276		-0.094	-0.768	0.014	-0.042	
p4	40583	0.027	0.305					1.000	-0.530	-0.506	-0.244	-0.101	-0.203	-0.148	-0.160	-0.009		-0.151	-0.139	0.011	-0.233	
p5	40583	-11.848	0.033						1.000	0.906	0.107	0.007	0.264	0.065	0.211	-0.019		0.168	0.492	-0.005	0.278	
p6	40583	3.964	0.058							1.000	0.21											
p7	40583		0.573								1.00											
p8	26113	0.092	1.058																			
p9	26113	0.181	1.014																			
p10	26113	0.059	1.098																			
p11	26113	0.002	0.615																			
p12	40583	1.916	0.490																			
p13	0																					
p14	40583	-0.520	0.304																			
p15	26113	0.608	0.481																			
p16	26113	0.060	0.823																			
p17	26113	0.115	0.774																			
p18	26113	0.047	0.842																			

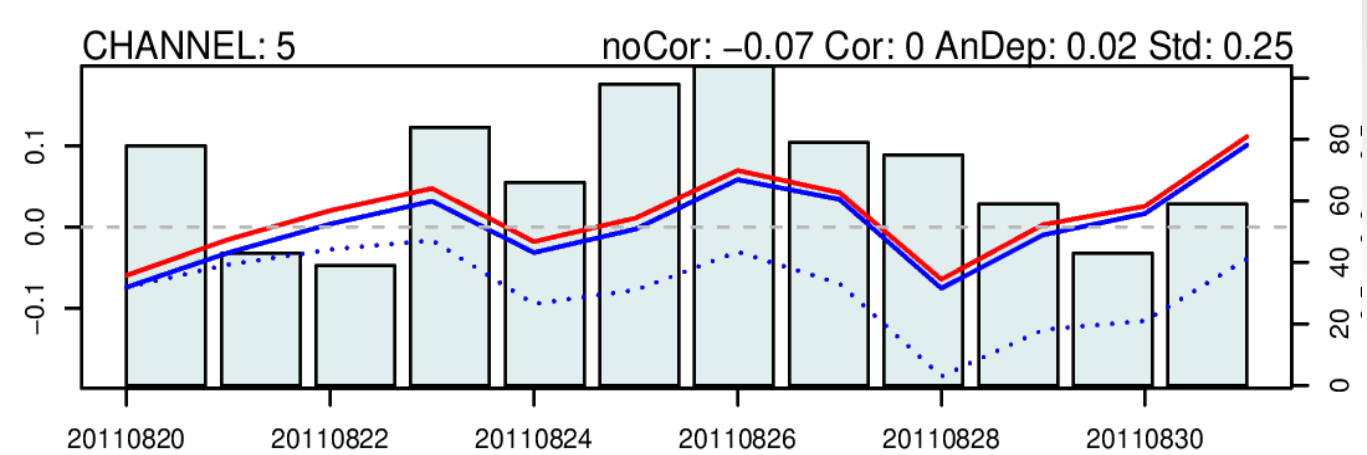
Predictor definitions:

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	

Normalize the predictors → $p_i < 1$
(see predictor definition)

Predictors experiments

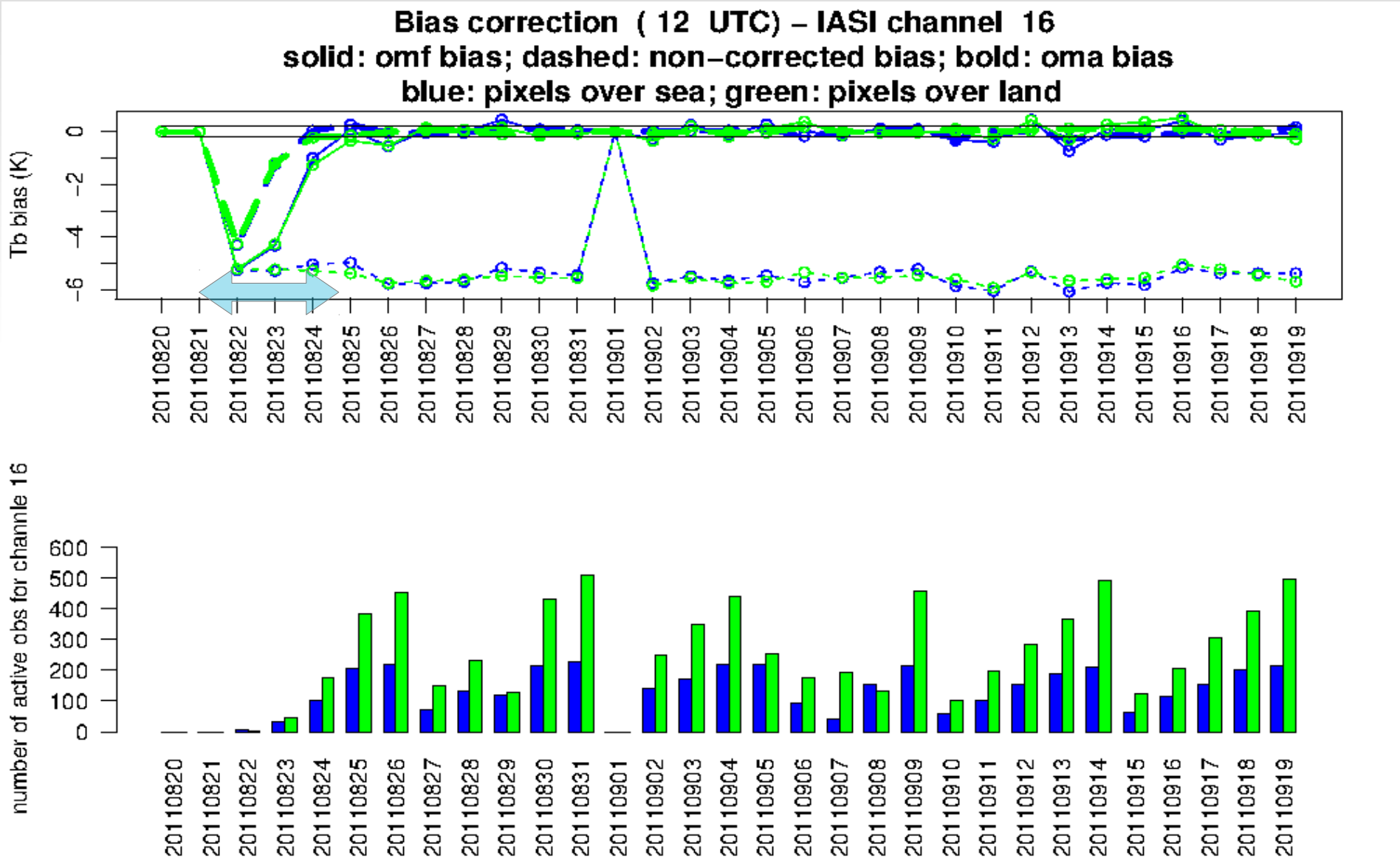
- ALADIN/CZ (previous presentation) → no problem with predictors 5,6



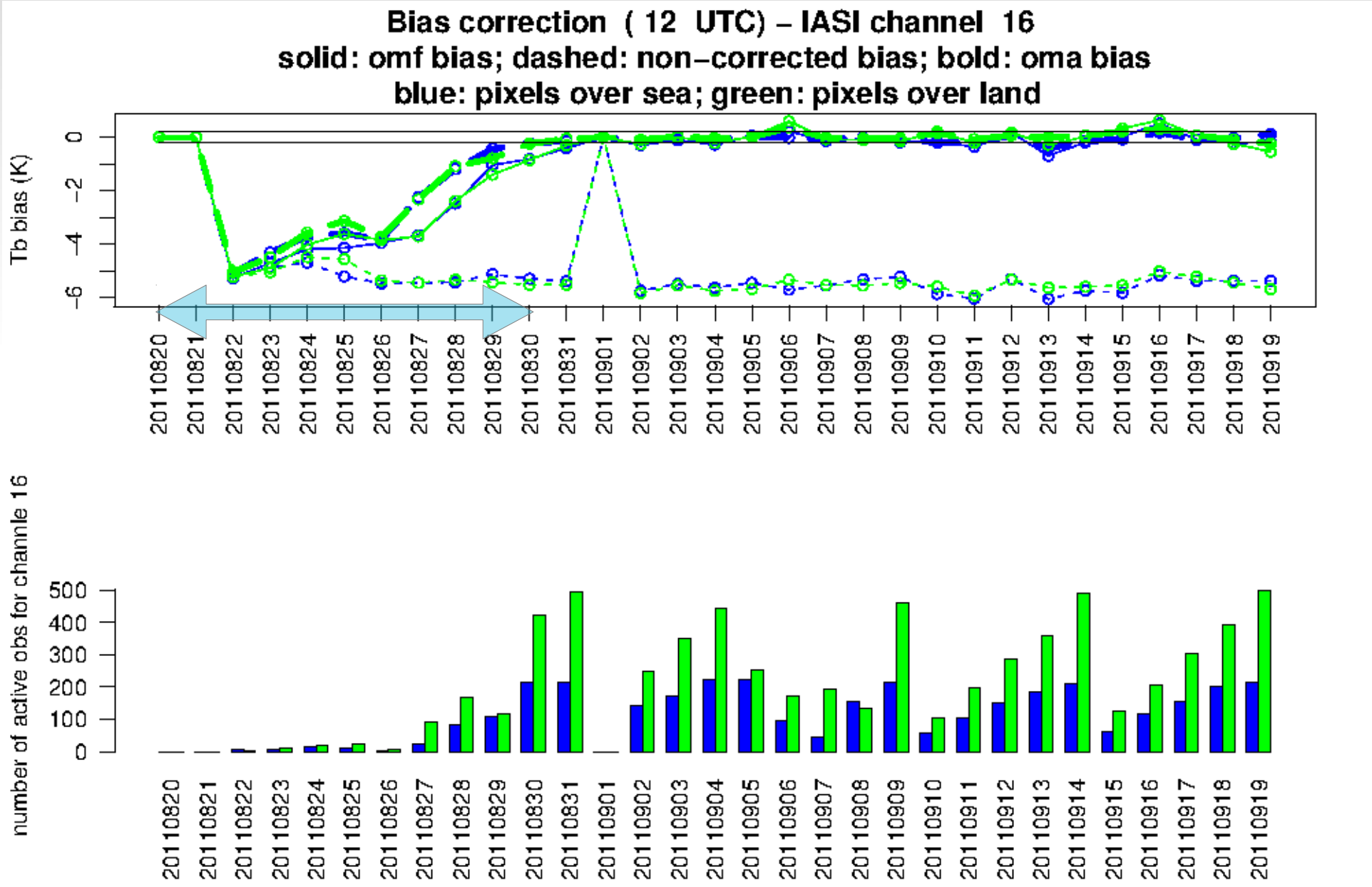
- ALADIN/HU (iasi, mhs, amsu-a,b, seviri)
- One month used for bias correction spinup

EXP1 – all predictors
EXP2 – no predictor 5
EXP3 – no predictors 5,6

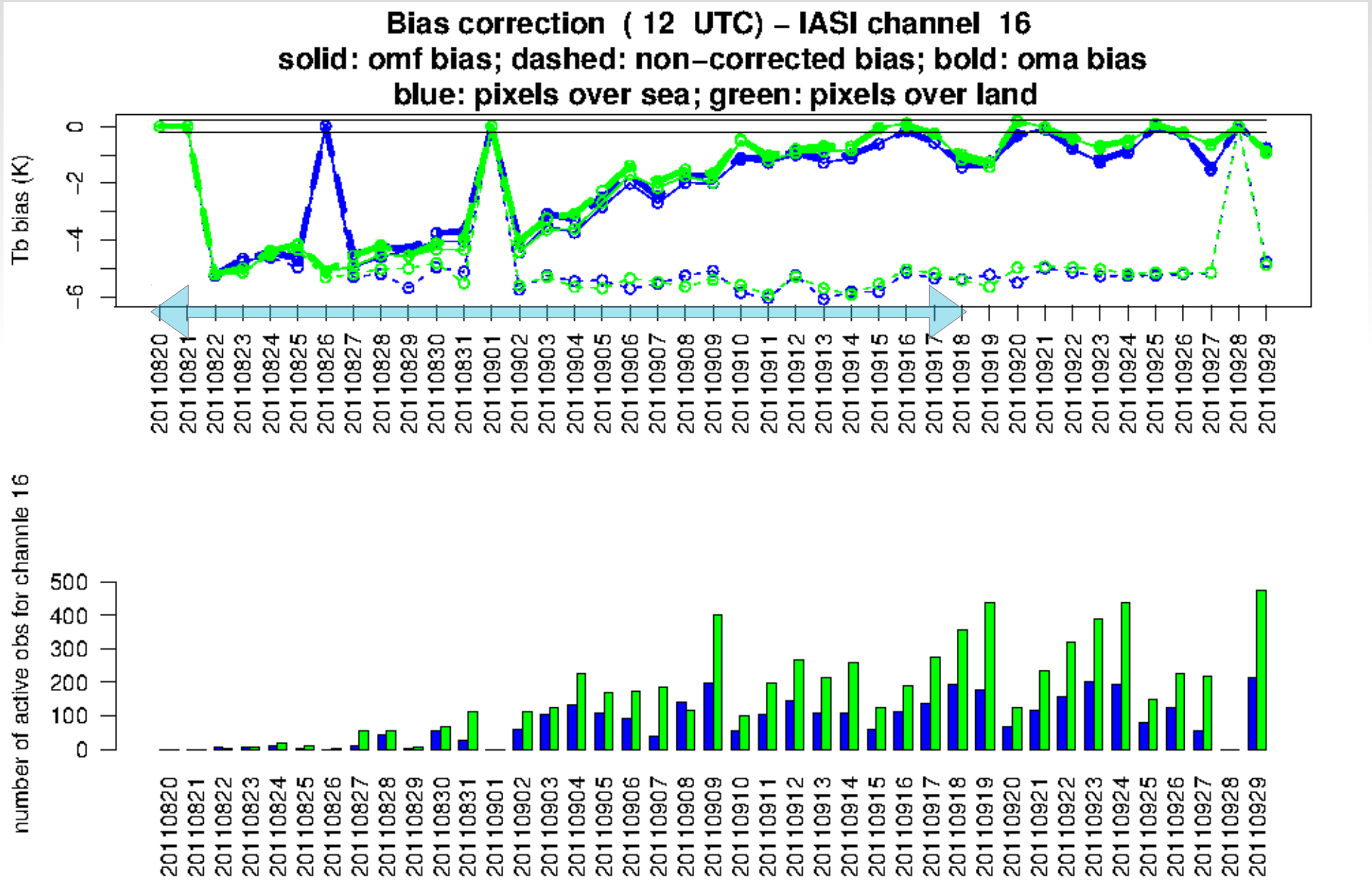
All predictor experiment



Not p5 experiment



Not p5,6 experiment



Forecast impact of p5,6

- Question: positive or negative impact of preditors 5,6?
- Initialization varbc file from experiment EXP3 (not used predictors 5 and 6) and EXP1 (used all predictors)
- Active assimilation of IASI, AMSU-A,B, MHS, SEVIRI for 15 days

- Experiments:
  - IASI36a2 – no predictors 5 and 6 for all sats
  - IASI36a3 – all predictors

Forecast impact of p5,6

- **<u>Not used predictors:</u>** slightly *improvement* analysis **50-20hPa** (temp[b], geop[b]), **500-300hPa** (rh[b,rms], geop[b])

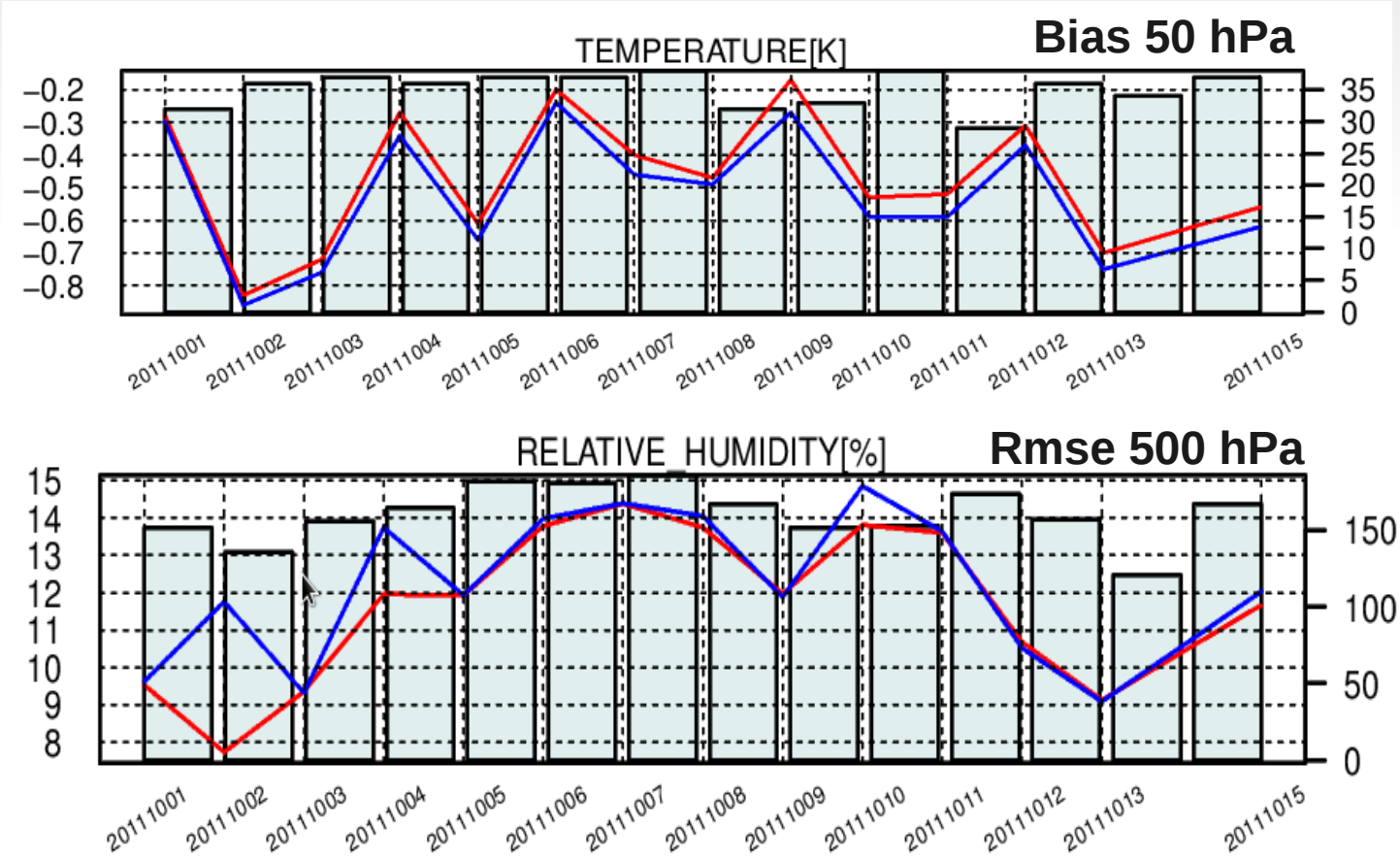


Figure – red line (not used p5,6), blue line (used all predictors)

Forecast impact of p5,6

- *Degradation* in analysis above **10-20hPa**: temp (rmse, bias)

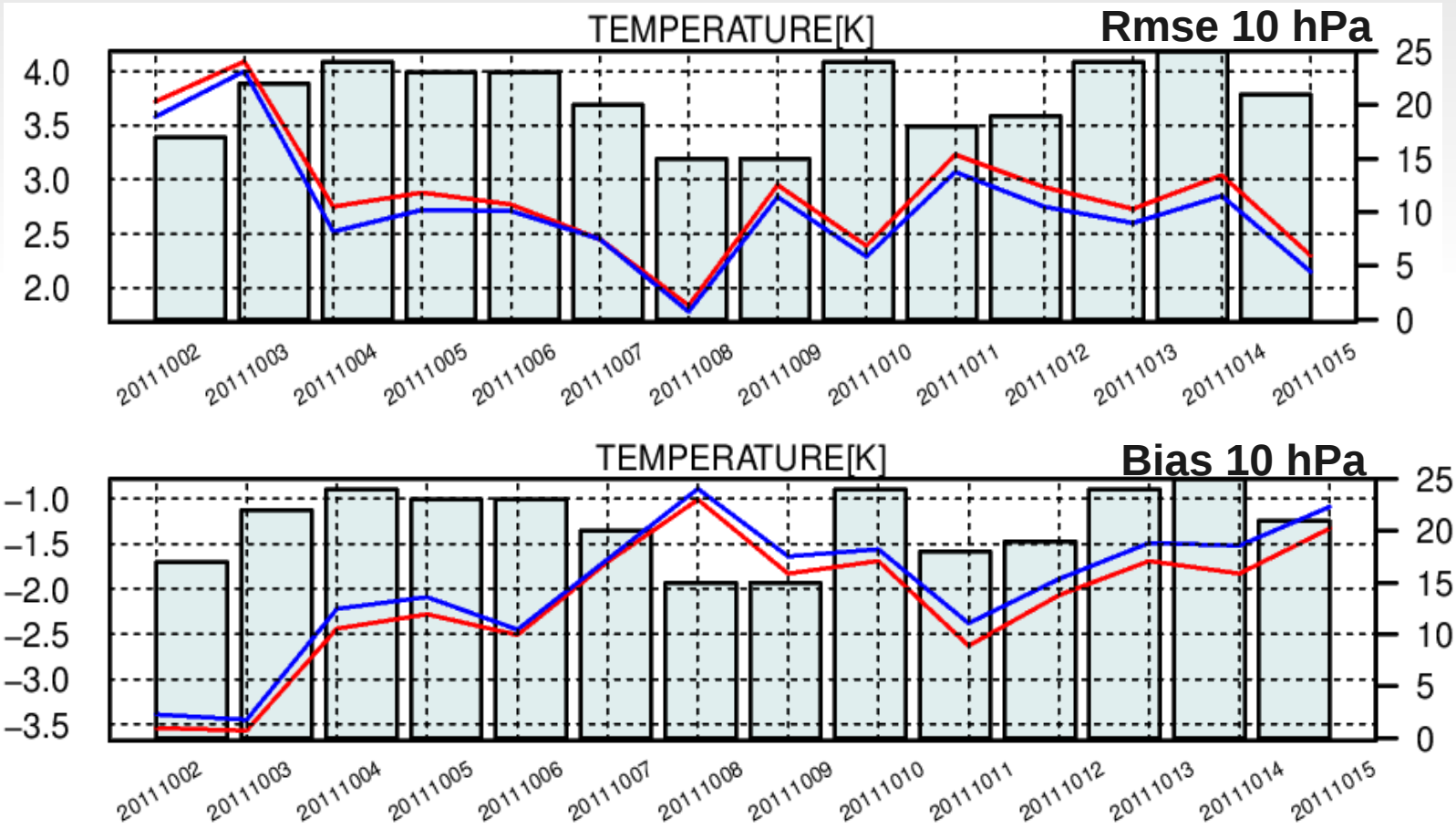


Figure – red line (not used p5,6), blue line (used all predictors)

Forecast impact of IASI

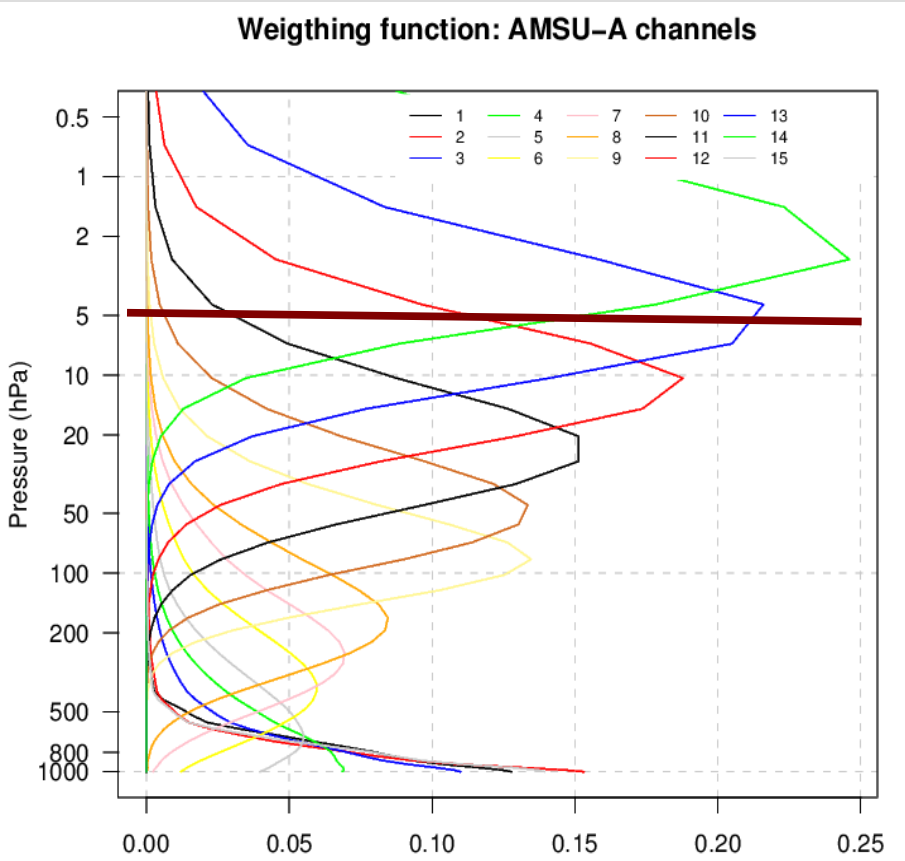
Experiments settings:

- Pre-processing (A. Trojakova)
- assimilation system in the table
- active assimilation (1.-15.10.2011)
- VarBC (24h-cycling)
- verification against TEMP

- IASI channel selection:

1) NWP monitoring statistics separately for land and sea (< 0.2K) – identify possibly-problematic channels (comparsion O-G)

2) Rejected channels with peak of weight function above the top of model (< 5hPa; ie 11-15 on figure) and on the surface (ie 1-4 on figure)



Sensor	Thinning [km]
IASI	80
AMSU-A	60
AMSU-B	40
MHS	60
SEVIRI	70

Channel selection

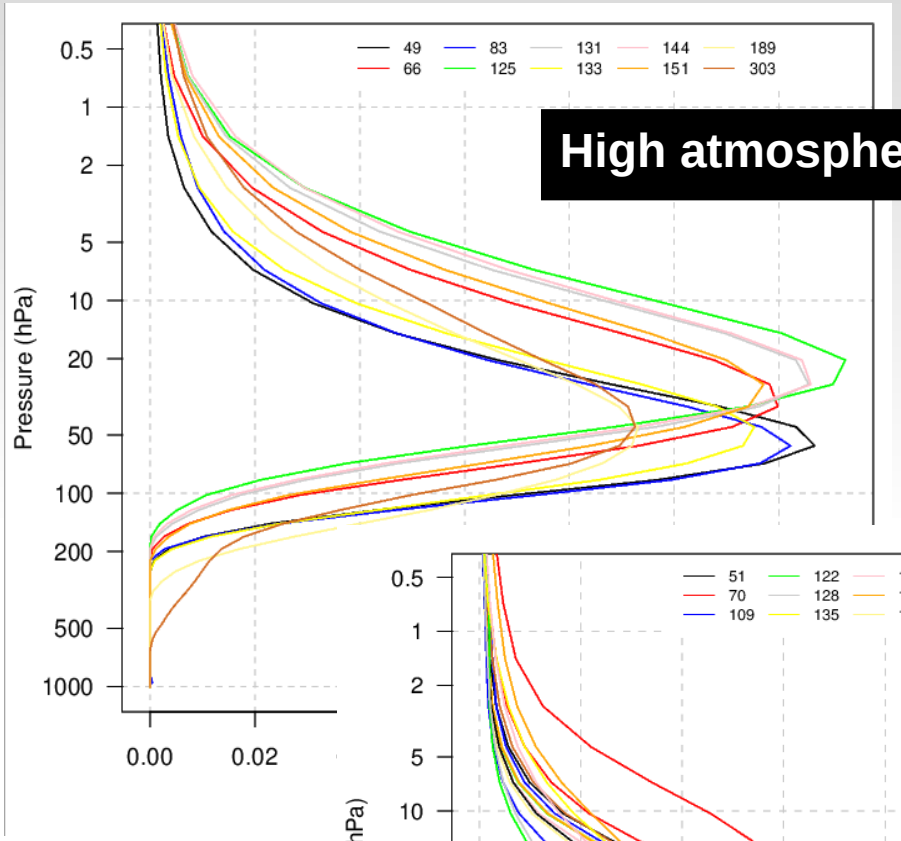
- Separately land and sea
  - **CO_2** channels: impact to temperature profile (high middle atmosphere)

```
 38  49  51  55  57  61  63  70  83  85  87 104 109 116 122 128 135 141 146
148 154 159 161 165 167 173 178 179 180 185 187 191 193 195 197 199 201 203
205 207 210 212 214 217 219 222 224 226 228 230 232 234 236 241 242 243 249
254 256 262 299 301 303
```

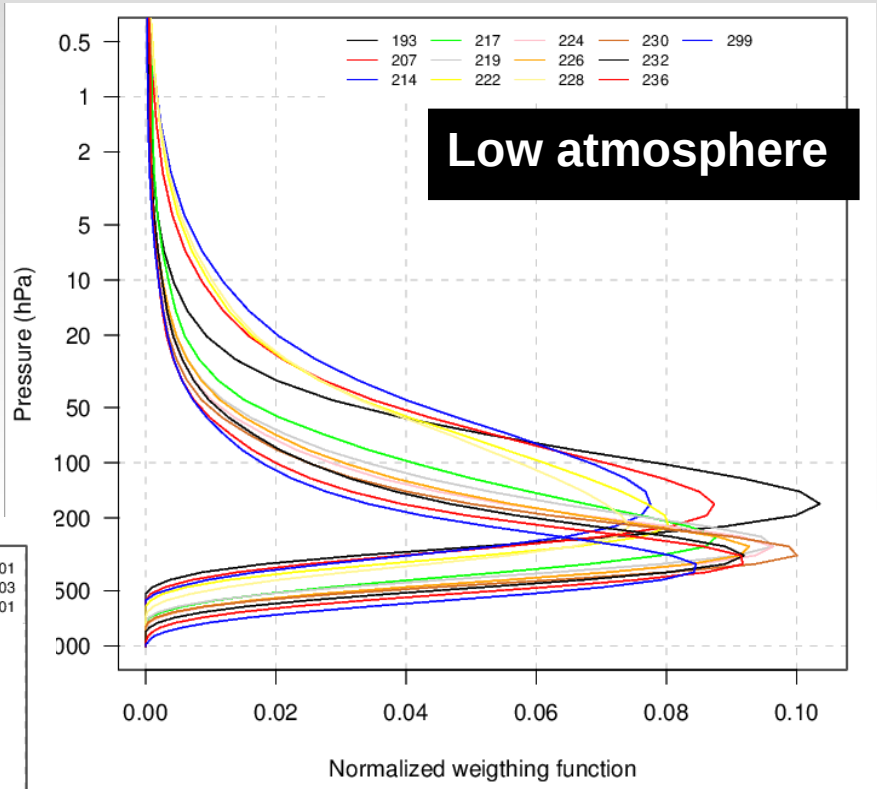
  - **H_2O** channels: humidity profile; weighting function ~ 500 hPa

```
3098 3168 3248 3252 3256 3312 3378 3440 3577 3586 3281 3309 3442 3444 3446
3448 3450 3452 3454 3491 3504 3506 3509 3522 3555 3575 3580 3582 3589 3599
3653 3658 3661 4032 3105 3136 3175 3207 3263
```

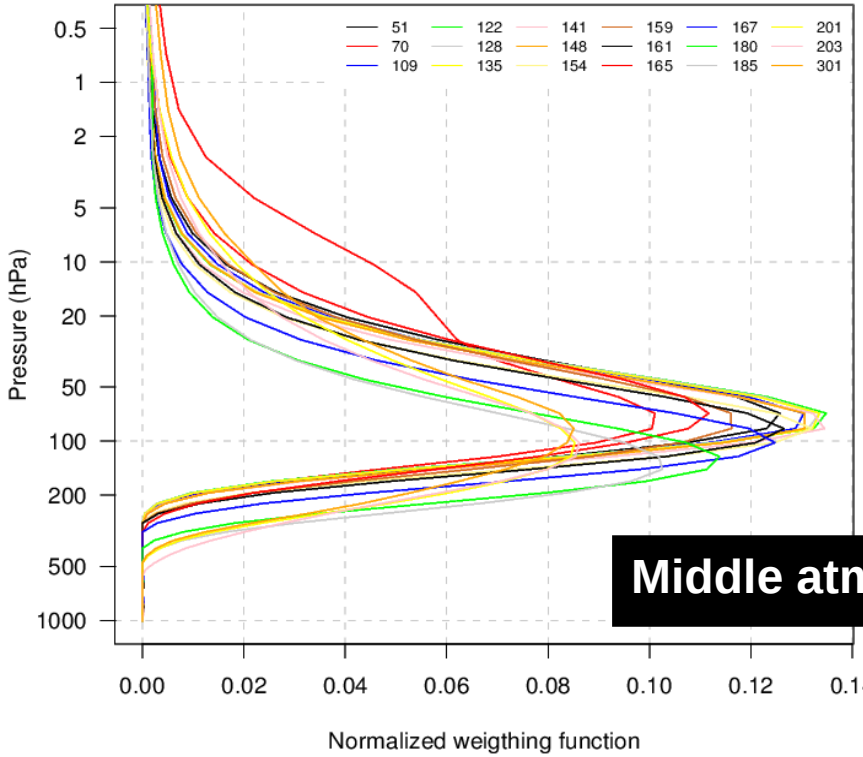
Weighting function



High atmosphere



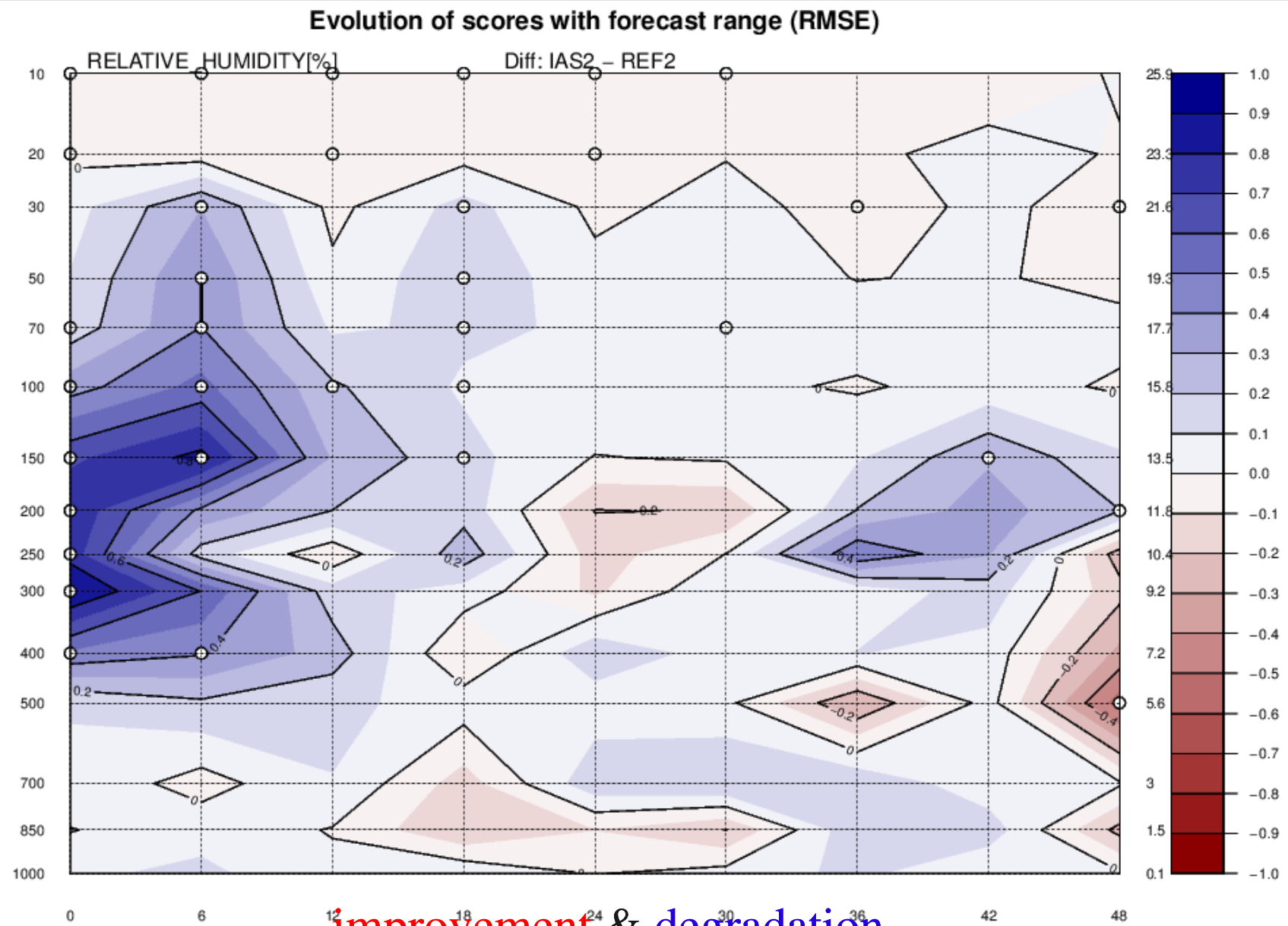
Low atmosphere



Middle atmosphere

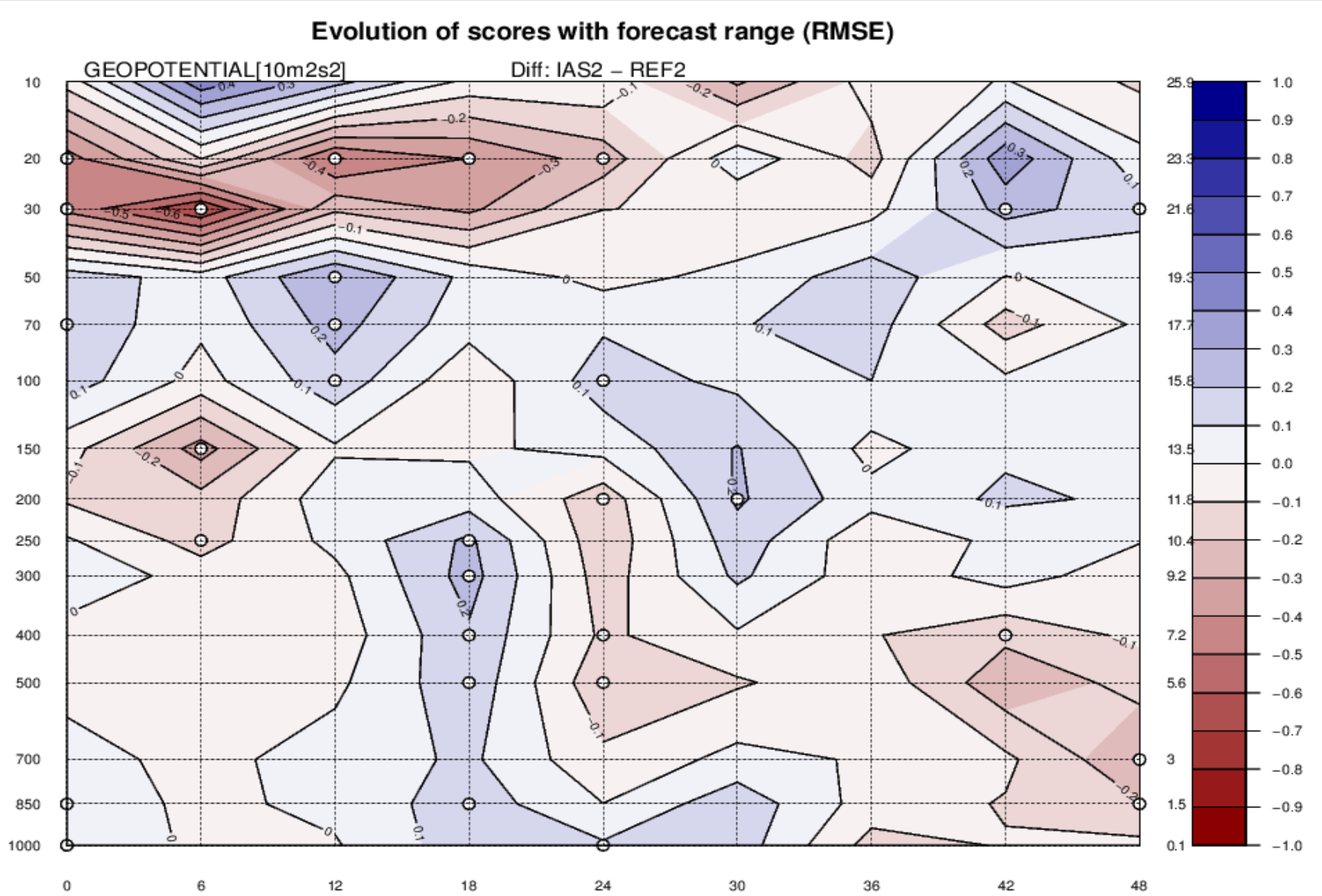
CO_2 channels

Forecast impact of IASI



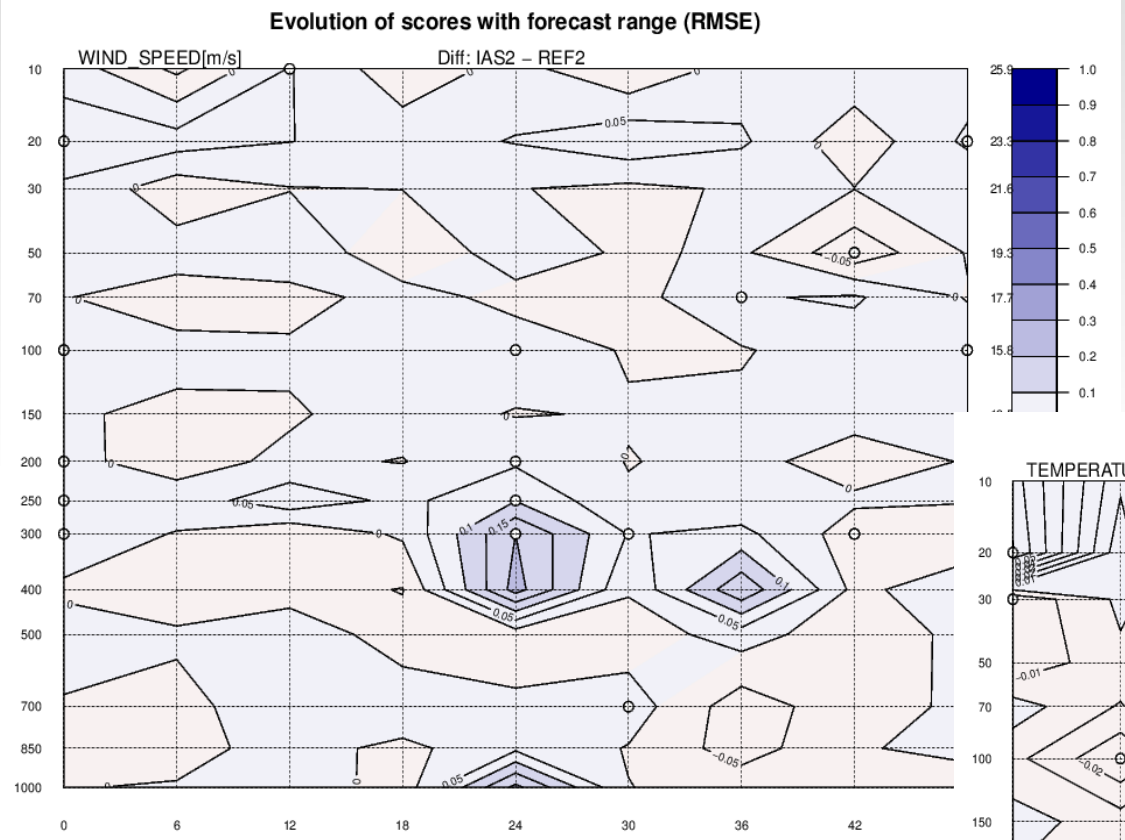
improvement & degradation

Forecast impact of IASI



improvement & degradation

Forecast impact of IASI

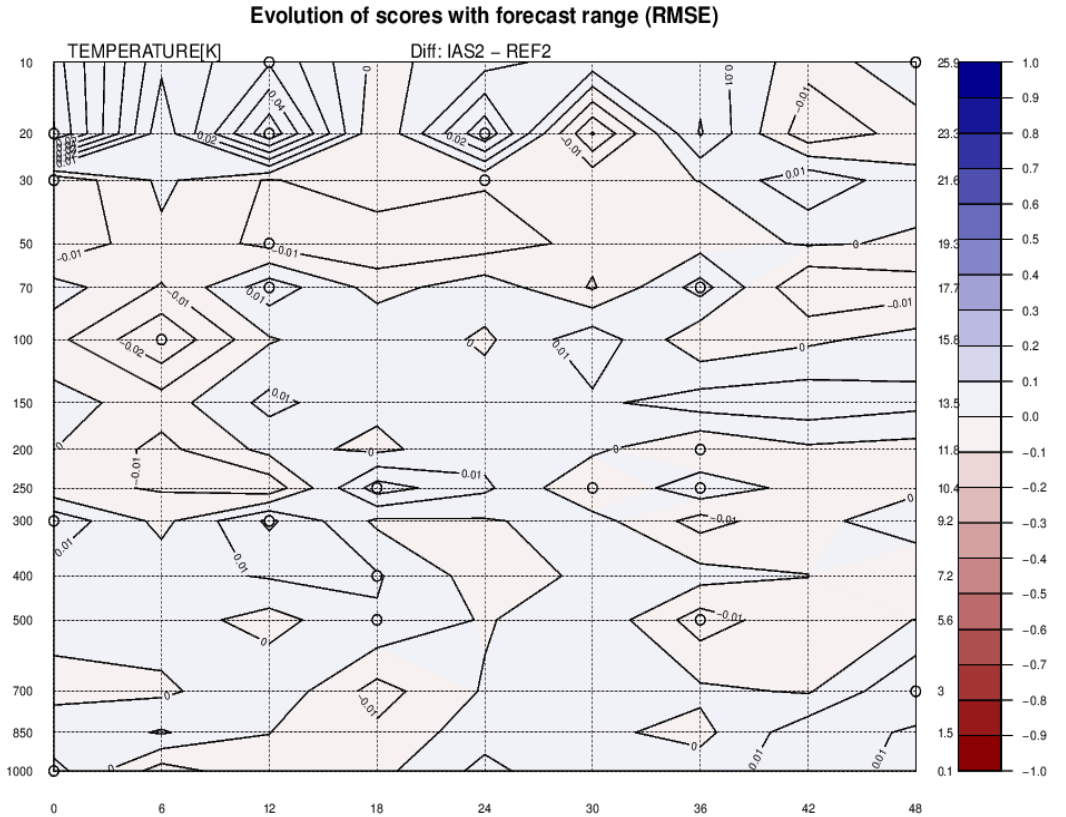


Improvement:

– temp(30-50hPa) rmse, bias

– slightly geop(20-30hPa) bias

improvement & degradation



Degradation:

– RH(high, middle) rmse, bias

Conclusion

- Fix the problems in VarBC (coldstart settings and use of stratospheric predictors 5 and 6)
  - *coldstart settings* – ensure set ncstart = 0 for all channels and sensors (via namelist or modification in routine varbc_rad.F90)
  - check top of model and possibly-problematic predictors in screening namelist
  - consider the application of predictor 5 and 6 in VarBC (slightly negative impact for forecast at HMS for middle and high atmosphere → top of model 5hPa)
- Channel selection (based on observation monitoring)
- Neutral, slightly negative impact for RH (middle, high), slightly positive T,geop (very high) for forecast

Future plans

- Channel selection:
  - more channel selection methods
  - MTEN (Moist Total Energy Norm) – sensitivity of forecast to different observation groups (e.g. groups of channels)

- Progressive active assimilation for groups of channels (H2O, CO2, CO, atm. window ...)

Thank you for your attention.