The assimilation of AMSU-A radiances in the NWP model ALADIN

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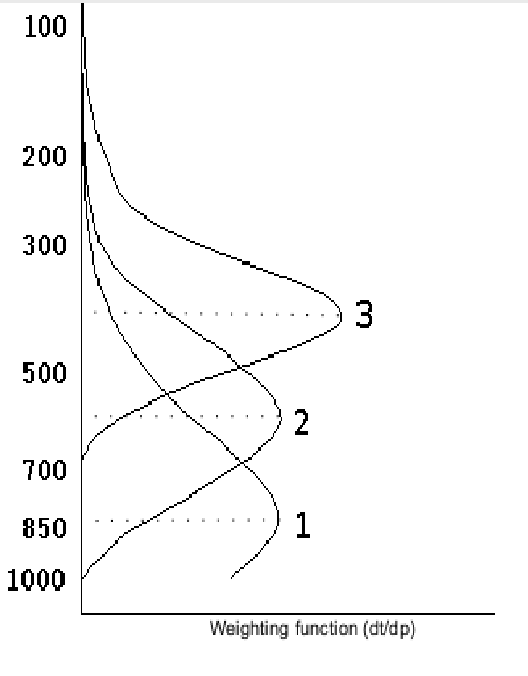
Outline

- Introduction
  - Sensor AMSU-A
- Set-up of model ALADIN
- Set-up of experiments
  - Channel blacklist
- Results of experiments
  - Impact of sensor AMSU-A
  - Single observation experiments
- Conclusion

Introduction

- Satellite instruments measure radiance (surface & atmosphere) that reaches the top of atmosphere at given frequency.
- Air parcel emits radiation to space (temperature) → absorption with higher atm. level – weighting function (figure).
- The weightening function specifies the layer of atmosphere from which the measured radiation originates.
- Sensing of radiation provide information on the vertical profile of the termodynamic state.
- Measured radiation ↔ geophysical variables = RTE (Radiative Transfer Equation)



AMSU-A instrument

- The Advanced Microwave Sounding Unit (AMSU).
- Passive instrument – sense natural radiation emitted by the earth's surface or the atmosphere in MW region.
- Situated on polar-orbiting satllites (f.e. NOAA, MetOp).
- Characteristics:
  - 15 channels between 23.8 and 89 Ghz
  - practically ch: 5-13 (T information from 50-60GHz O2 absorption)
  - ground resolution 48km at nadir
  - broad width of weightening function

AMSU-A instrument

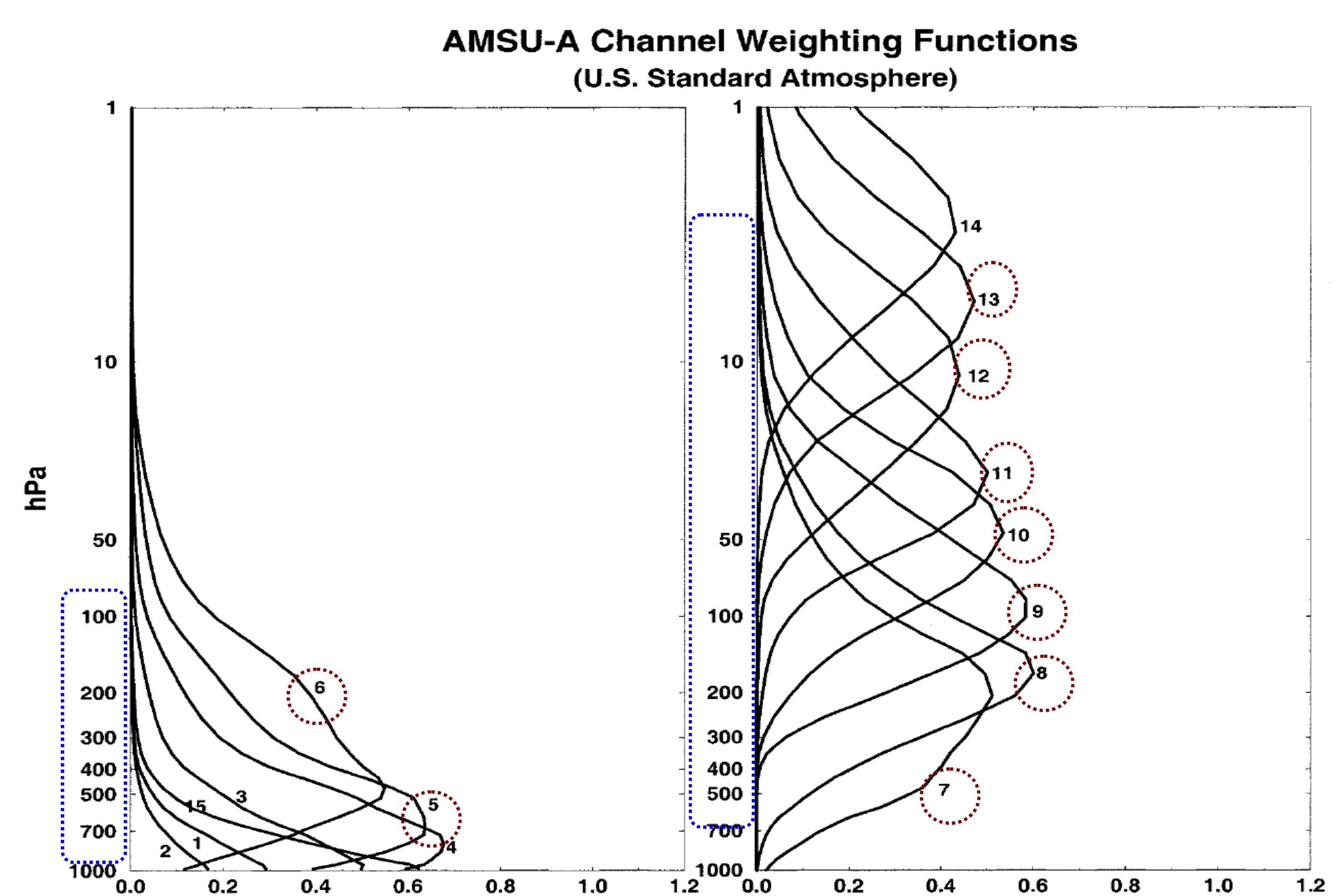


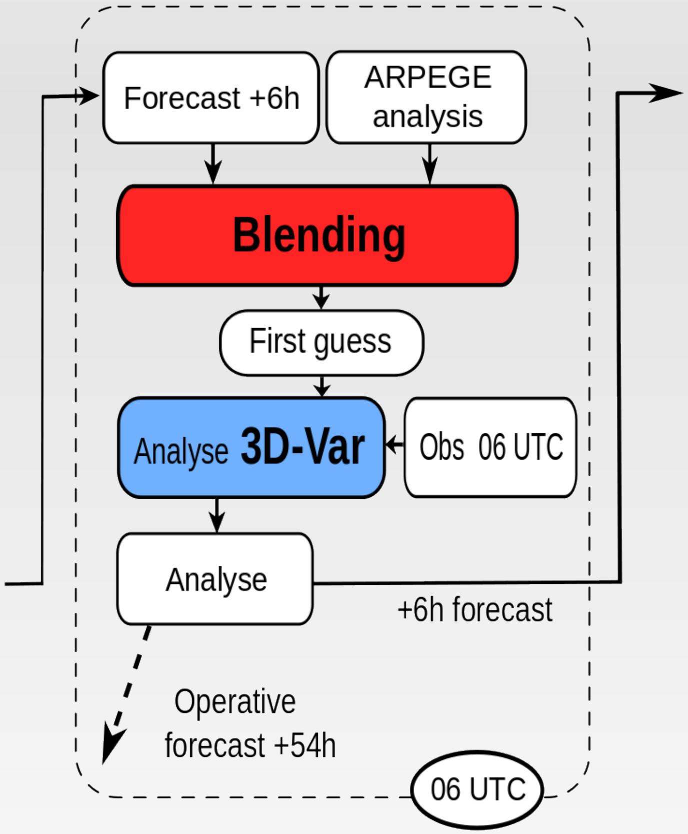
FIG. 1. AMSU-A sensitivity functions ($d\tau/d\ln p$).

The weightening function specifies the layer of atmosphere from which the measured radiation originates.

Model ALADIN set-up

- ALADIN cycle 35t1star (ALARO-0 with 3MT)
- LACE domain (309x277 grid points, linear truncation E159x143, Δx=9km)
- 43 vertical levels, mean orography
- time step 360 s, 3h coupling interval
- Analysis cycle 00, 06, 12 and 18 UTC forecast to +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*



Set-up of experiments

Model	3DVar cycle 36t1ope, ALADIN cycle 35t1star (ALARO-0 with 3MT)
Satellite	NOAA16, 18, 19, METOP 2
Sensors	AMSU-A
Thinning	90km
Bias correction	VarBC (8 active predictors) VARBC.cycle from ARPEGE (24h cycling) Warm-up: 29.-31.5.2010 (6h - cycling)
Experiment	Test period: 1.6.-14.6.2010

- **r01** … reference experiment
- **k04, r03** … AMSU-A data assimilation

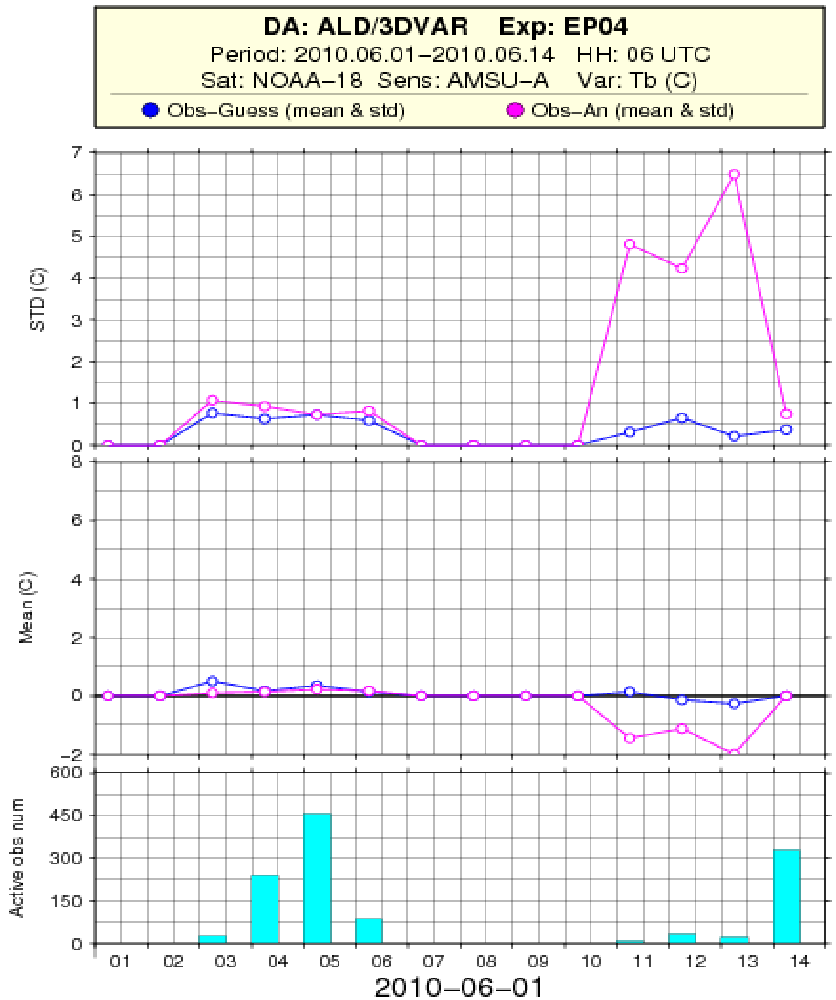
Experiment k03

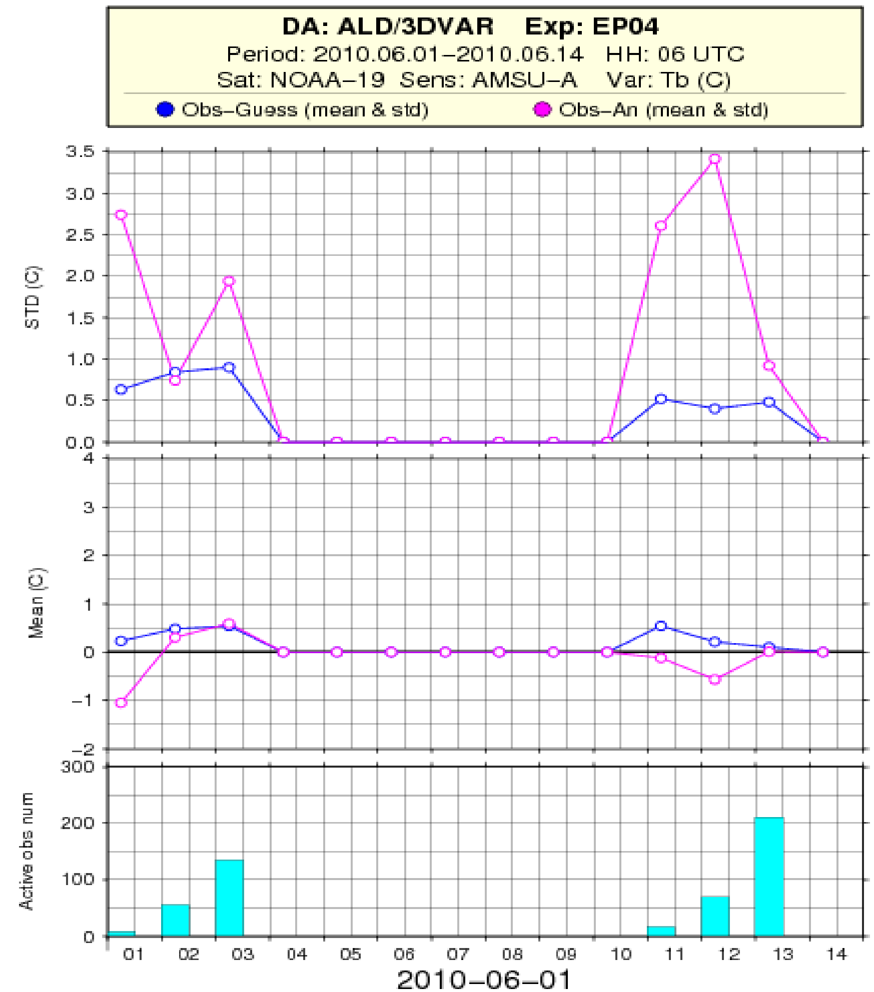
Satellite	Sensor	0 UTC	6 UTC	12 UTC	18 UTC
NOAA16	AMSUA	--	9-13	--	9-13
NOAA17	AMSUA	x	x	x	x
NOAA18	AMSUA	5-13	5-13	5-13	--
NOAA19	AMSUA	5-13	5-13	5-13	--
METOP	AMSUA	--	5,6,8-13	5,6,8-13	--

5-13 … active data
x … blacklisted data
-- … not available data

Monitoring of experiment k04

NOAA18 **06UTC** **NOAA19**

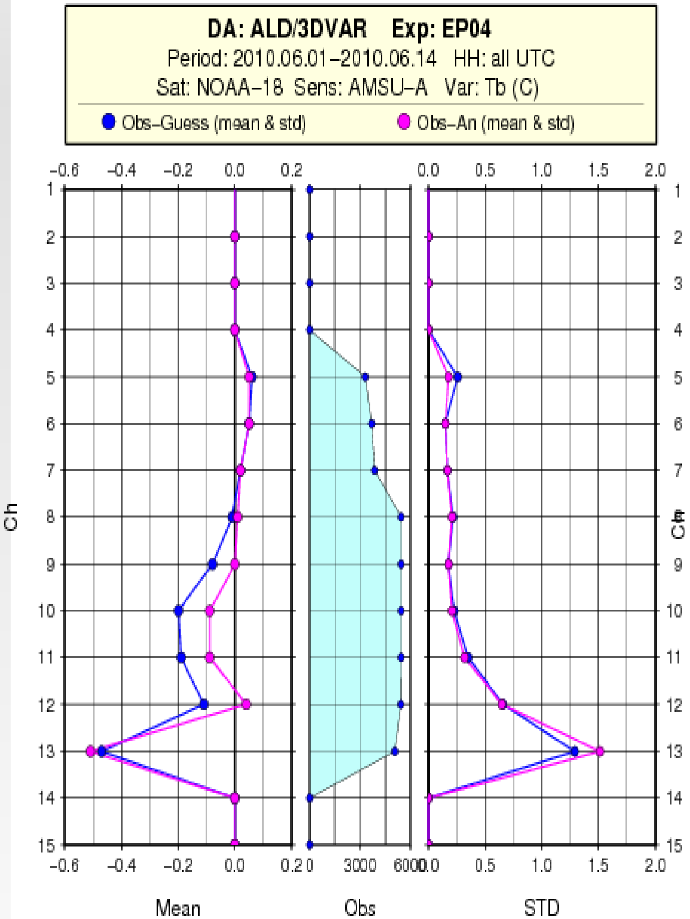




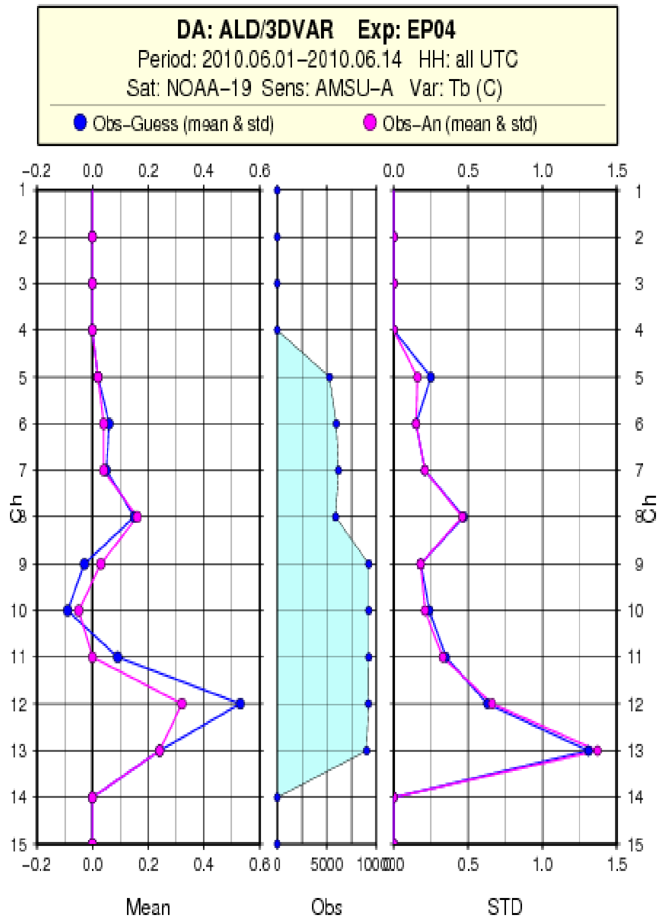
Time evolution of mean and STD of obs-guess (blue) and obs-analysis (red) for sensor AMSU-A. Figures show increasing BIAS for term 06UTC for satellite NOAA18 and 19.

Monitoring of experiment k04

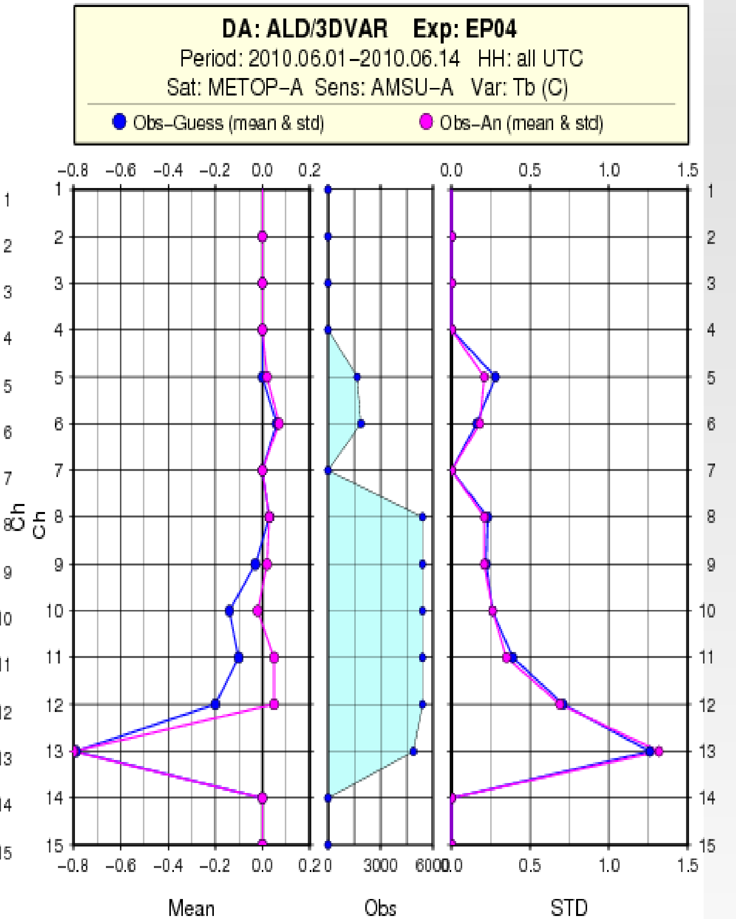
NOAA18



NOAA19



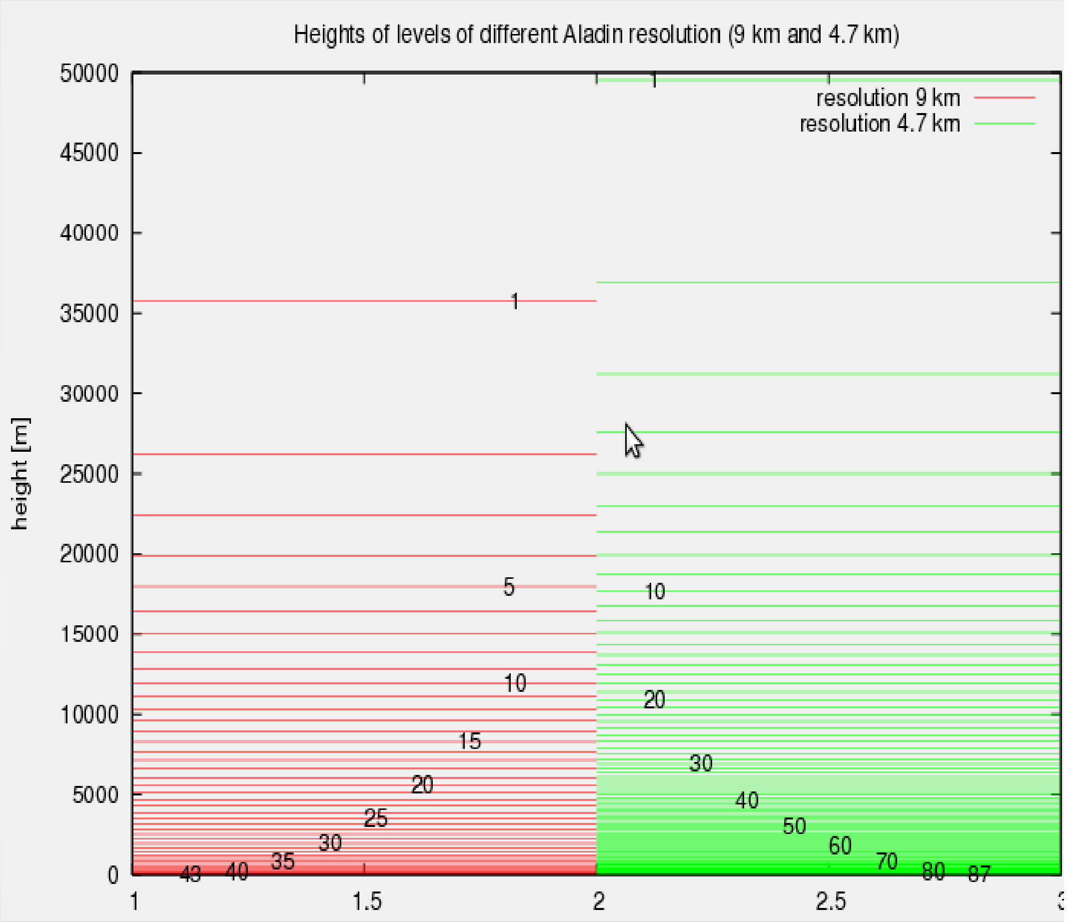
MetopA

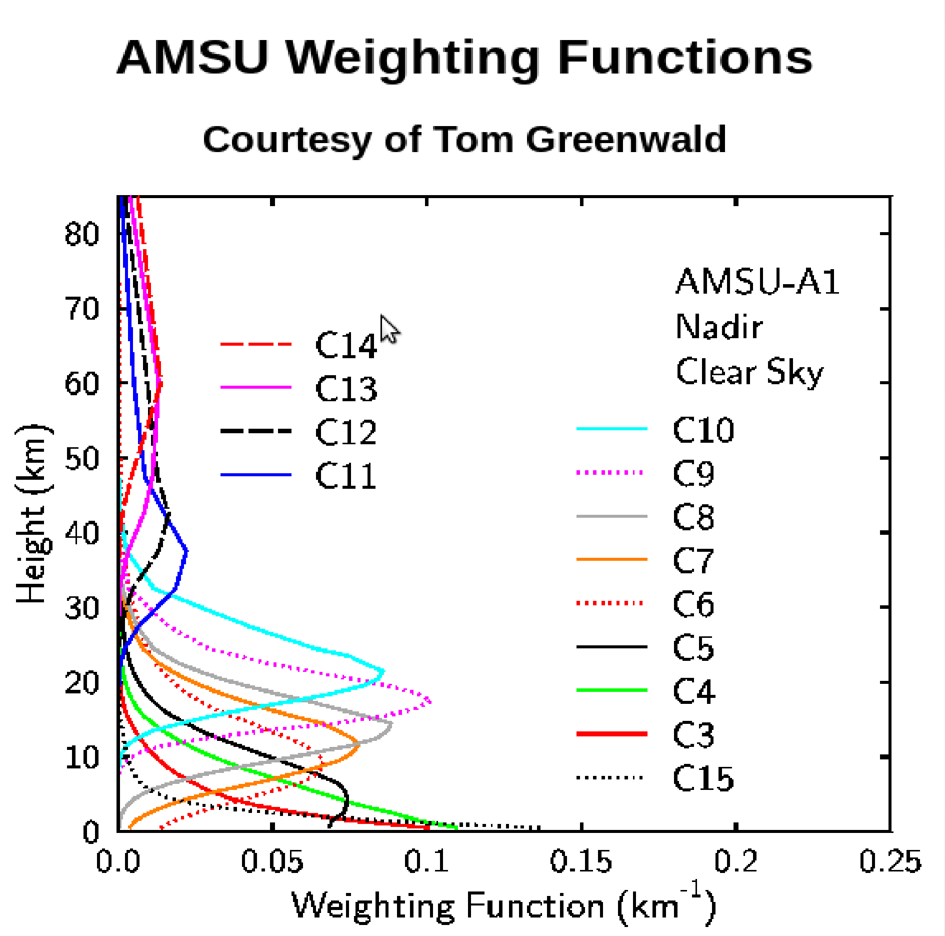


Mean and STD of obs-guess (blue) and obs-analysis (red) for each channels AMSU-A. Figures show increasing mean and STD for channels 13. NOAA16 (no depict) has similar value: RMSE ~1.5K

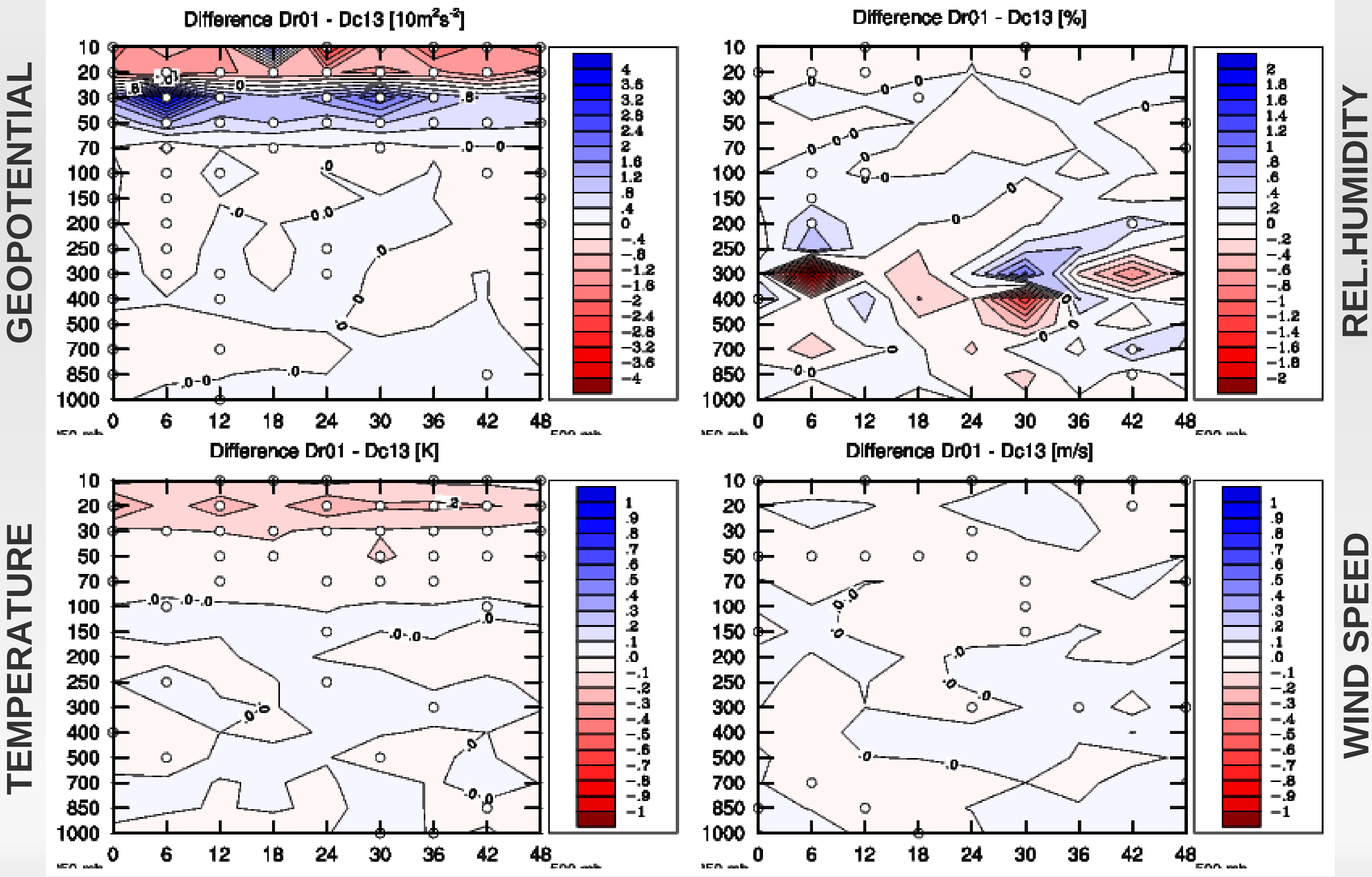
Weight function AMSU-A

- Channels 12 (~40km), 13 (~50km) are related to radiance measurement above the top of ALADIN vertical level (~35km)
- Potential improvement for new ALADIN set-up (Δx=4.7km, 87 vertical levels)



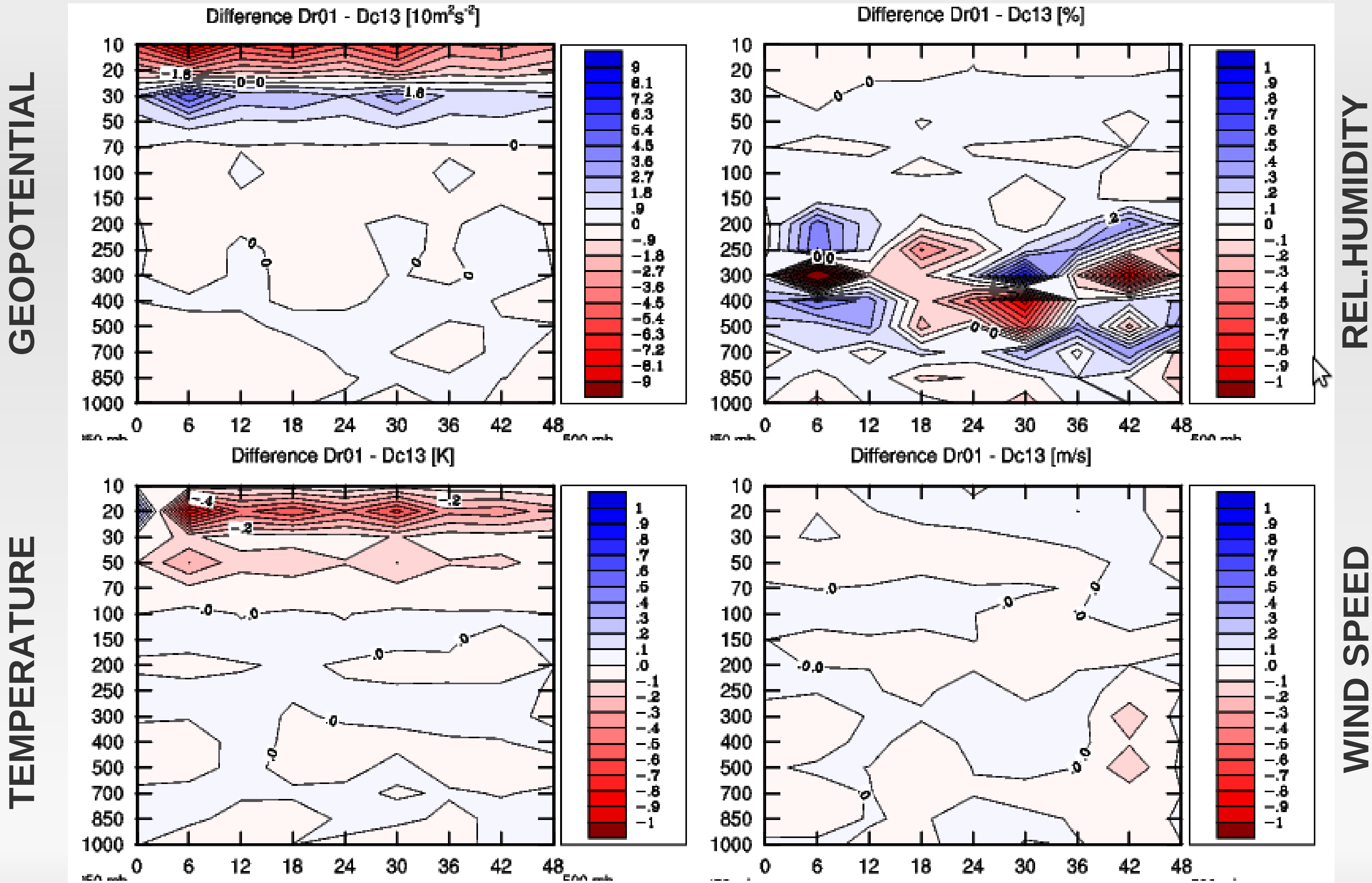


Impact of channel 13 (RMSE)



Experiment c13: Impact of channel 13 on RMSE for 12UTC.

Impact of channel 13 (BIAS)



Experiment c13: Impact of channel 13 on BIAS for 12UTC.

Set-up of experiment

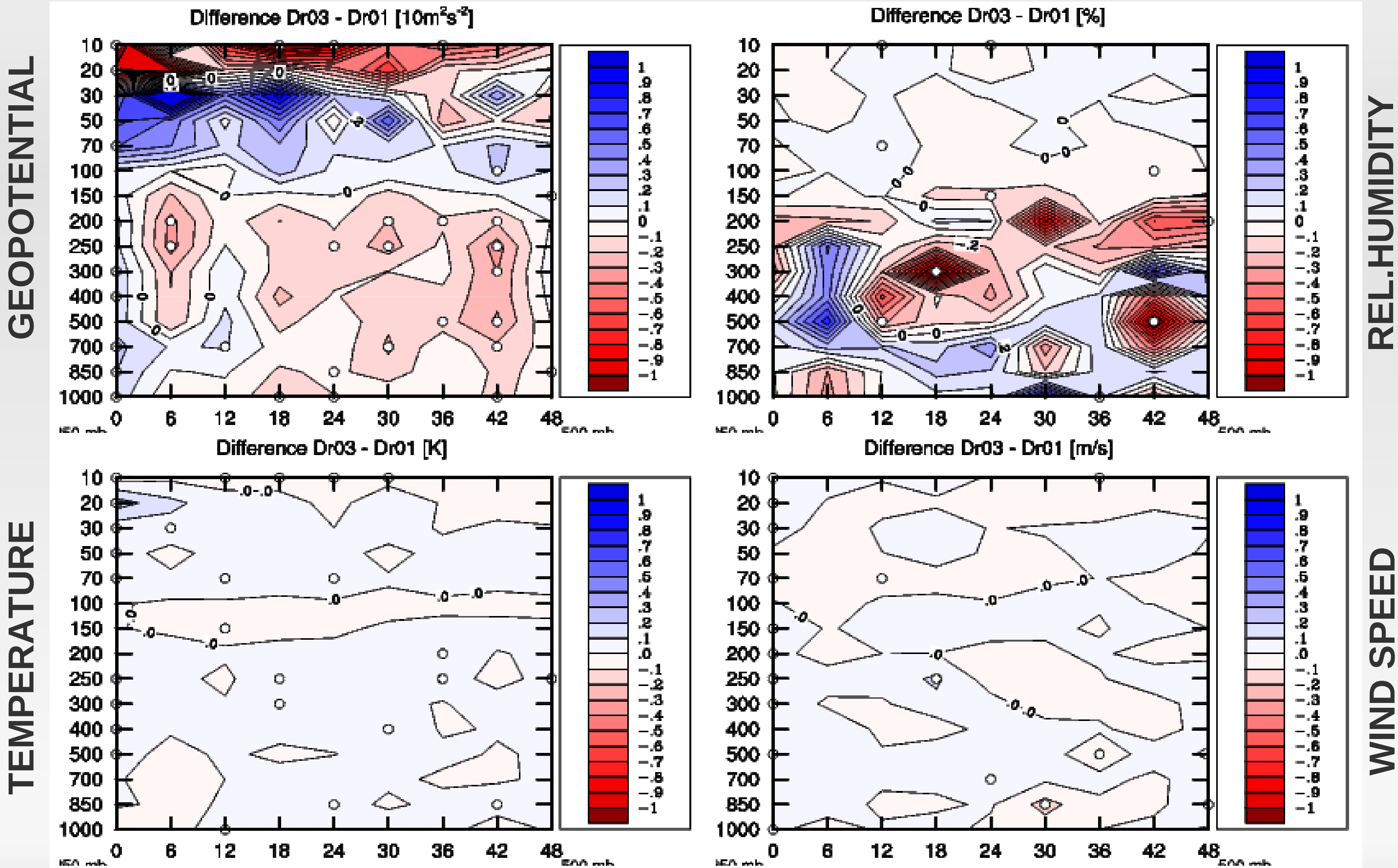
Experiment r03

Satellite	Sensor	0 UTC	6 UTC	12 UTC	18 UTC
NOAA16	AMSUA	--	9-11	--	9-11
NOAA17	AMSUA	x	x	x	x
NOAA18	AMSUA	5-11	B	5-11	--
NOAA19	AMSUA	5-7,9-11	B	5-7,9-11	--
METOP	AMSUA	--	5,6,8-11	5,6,8-11	--

5-13	… active data
x	… blacklisted data
--	… not available data
B	… new blacklisted data

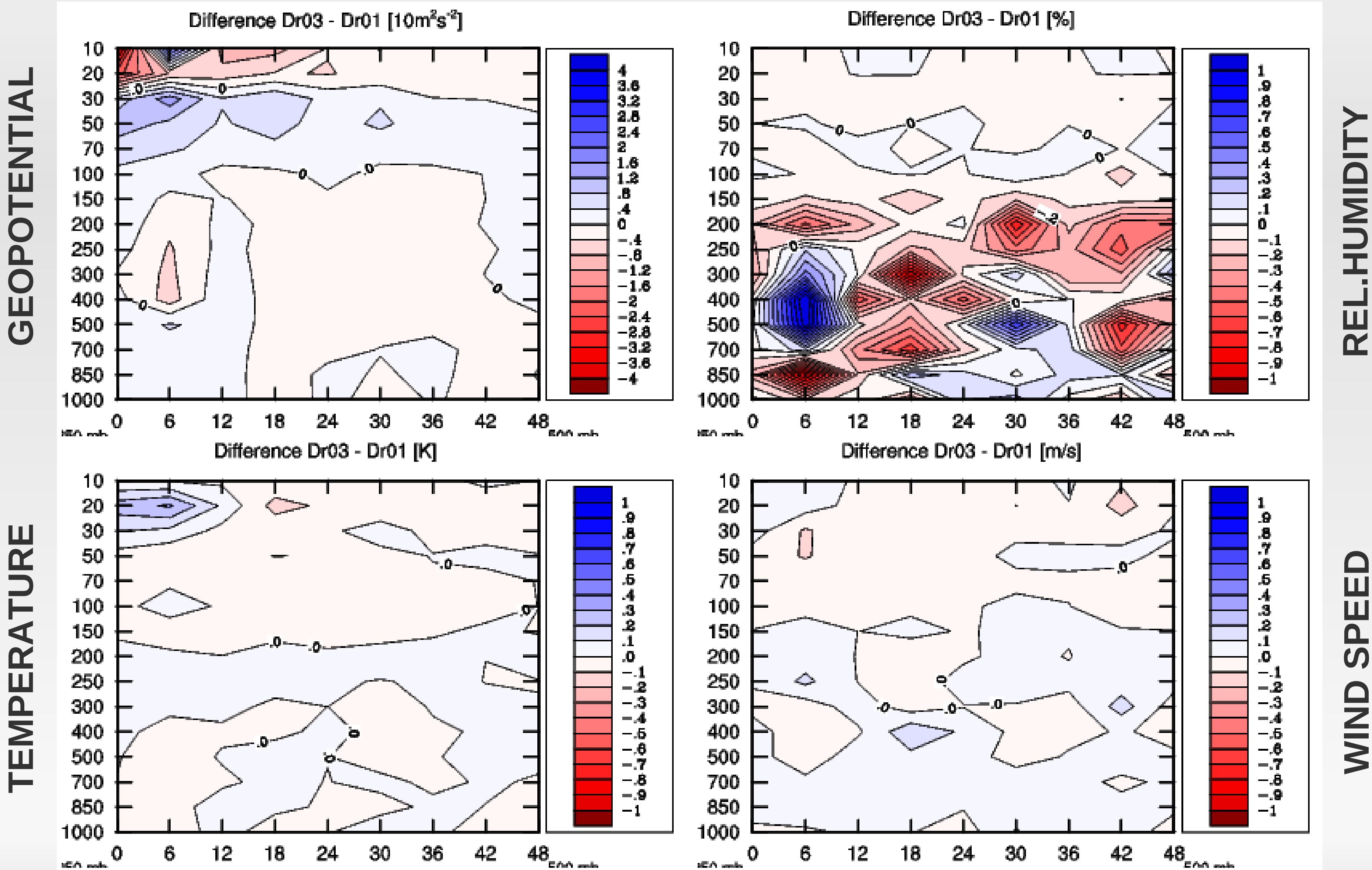
- Blacklist:
  - 06UTC (NOAA18, 19) – too big O-G departures and STD
  - Ch12, 13 - too big O-G departures (above last model vertical level)
  - Ch8 (NOAA19) - too big STD

Impact of AMSU-A (RMSE)



Experiment r03: Impact of AMSU-A on RMSE for 12UTC.

Impact of AMSU-A (BIAS)



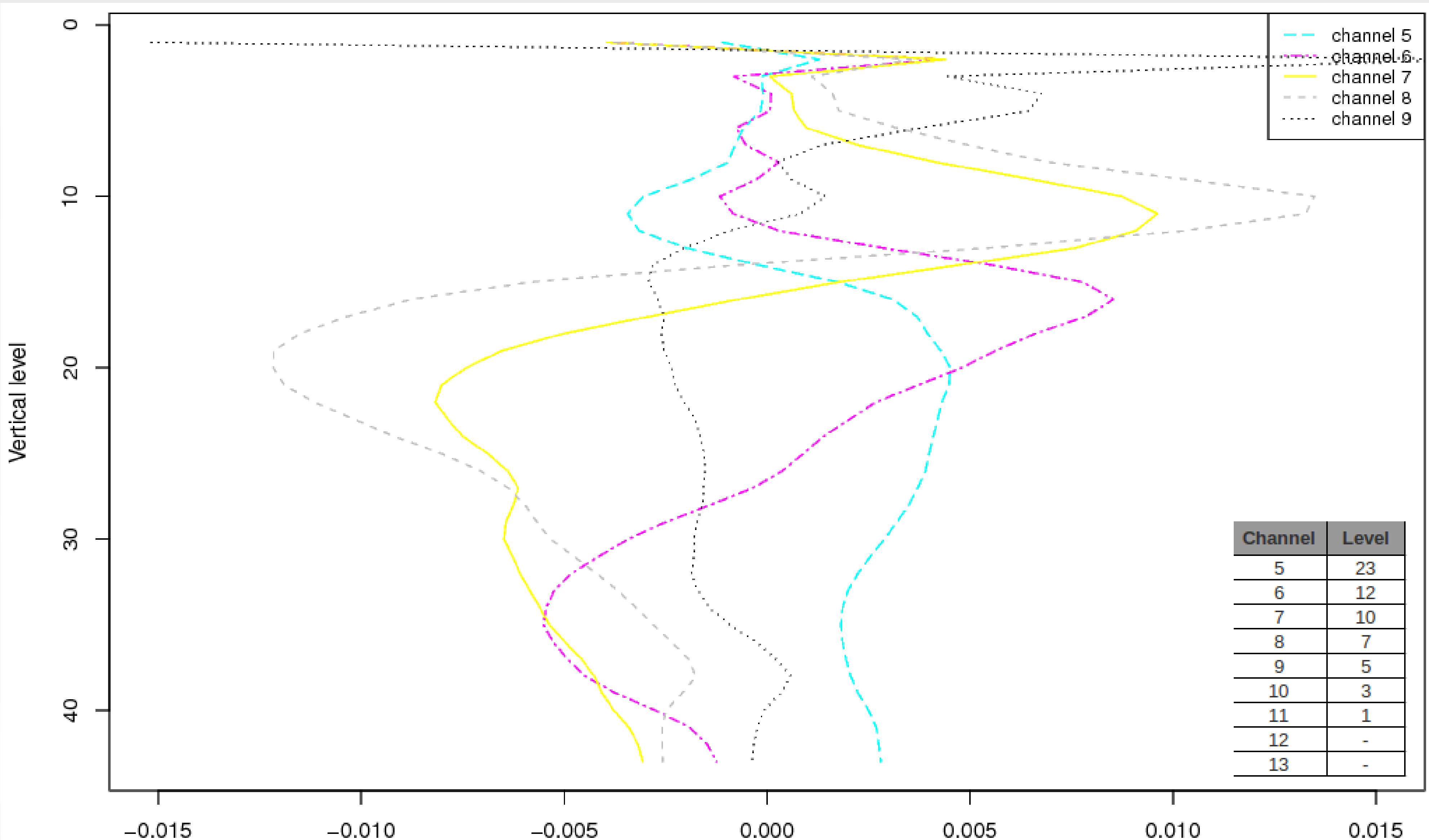
Experiment r03: Impact of AMSU-A on BIAS for 12UTC.

Single-observation experiments

- Assimilation of one observation for each channel 5-13 (of AMSU-A) to look contribution of increment for prognostic variable (T, RH).
- Increment of BT δ=0.1K for all channels
- Dependence between channel contribution of increment δ and vertical levels

For illustration: BT increment contribution of channel 6 (1 observation) for temperature.

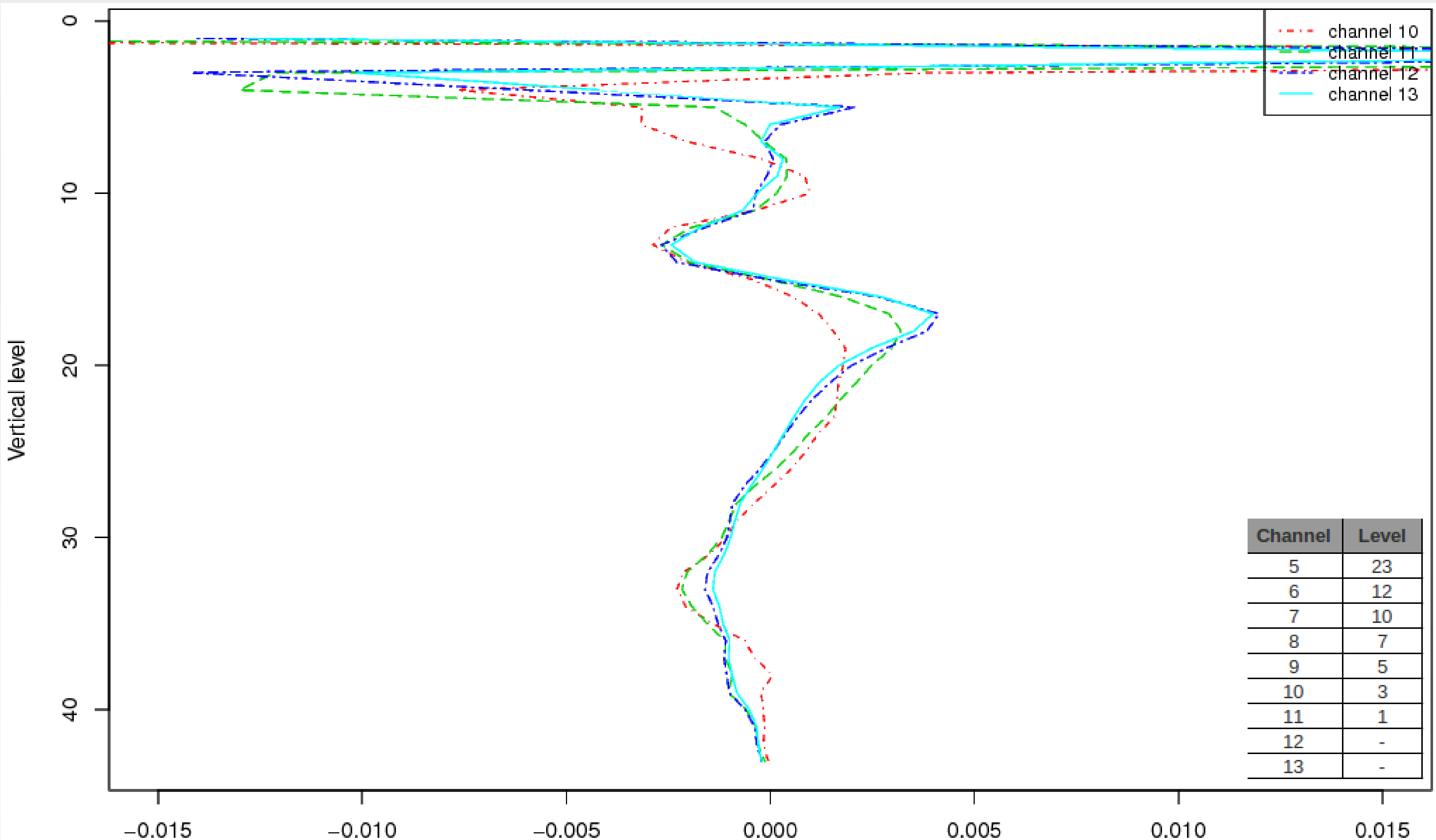
AMSU-A contribution for T



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 5-9 for temperature in each model levels.

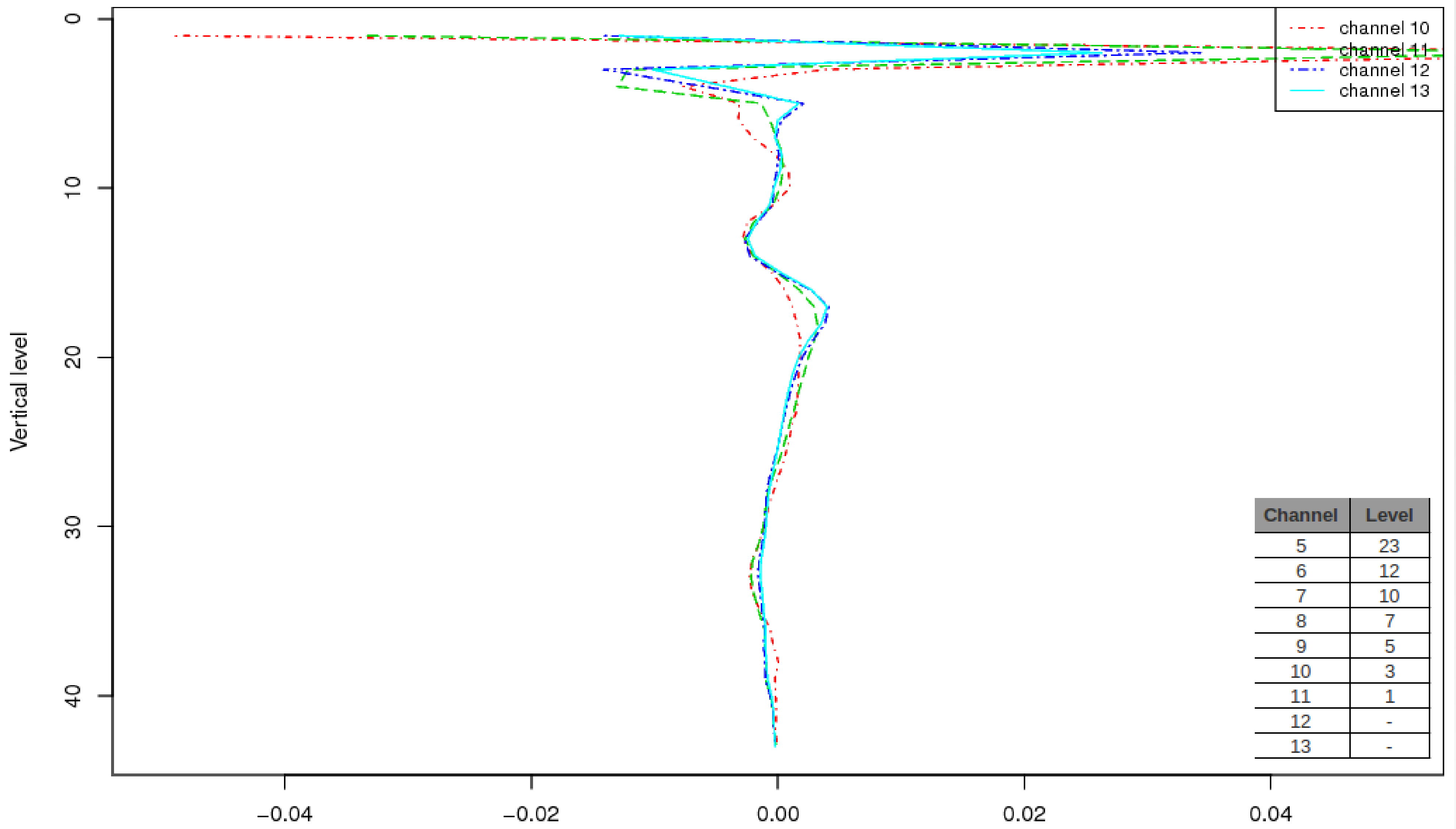
AMSU-A contribution for T



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 10-13 for temperature in each model levels. There is too big contribution (in temperature) of channels 10 and 11 for the first two model levels.

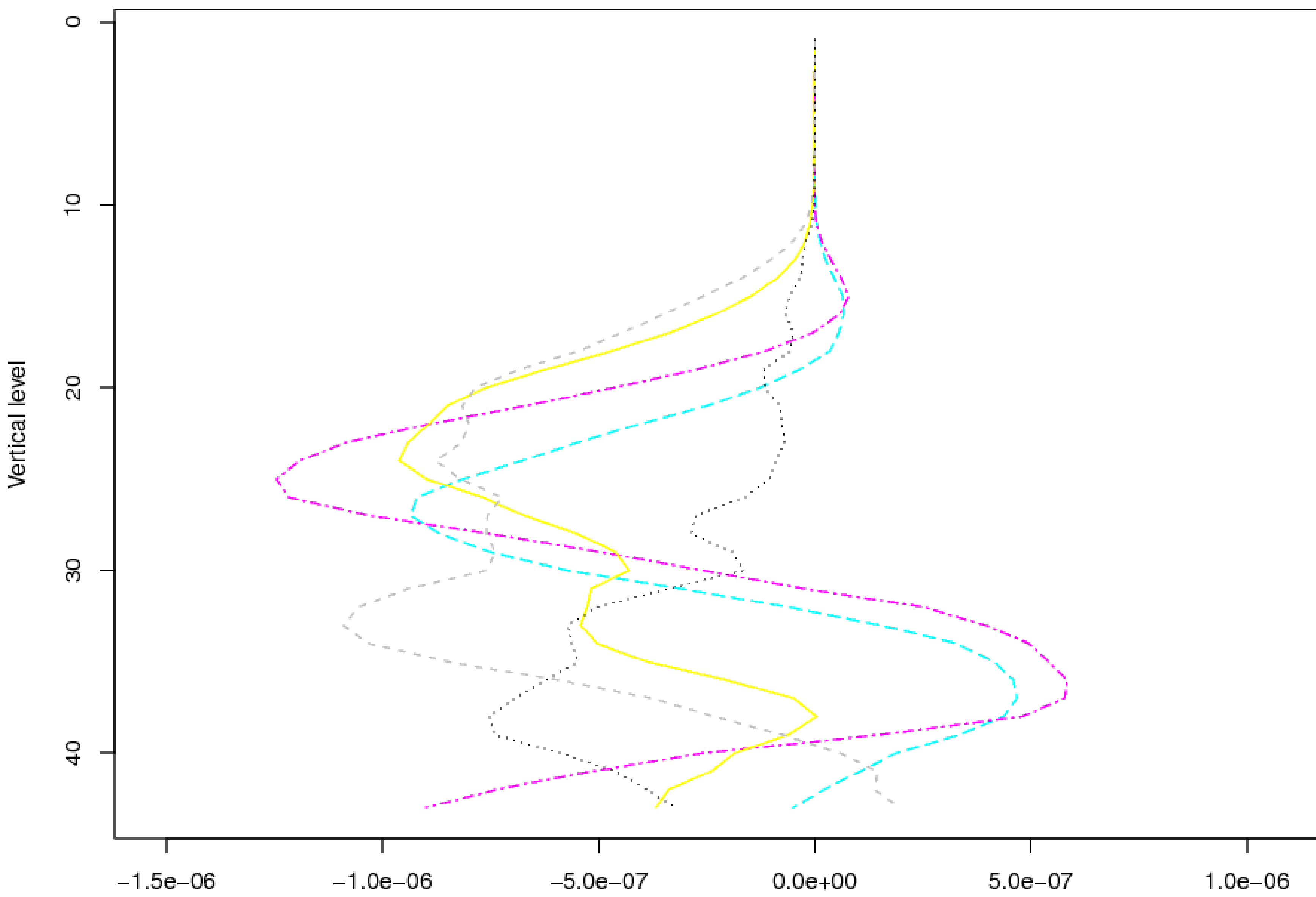
AMSU-A contribution for T



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 10-13 for temperature in each model levels. There is too big contribution (in temperature) of channels 10 and 11 for the first two model levels.

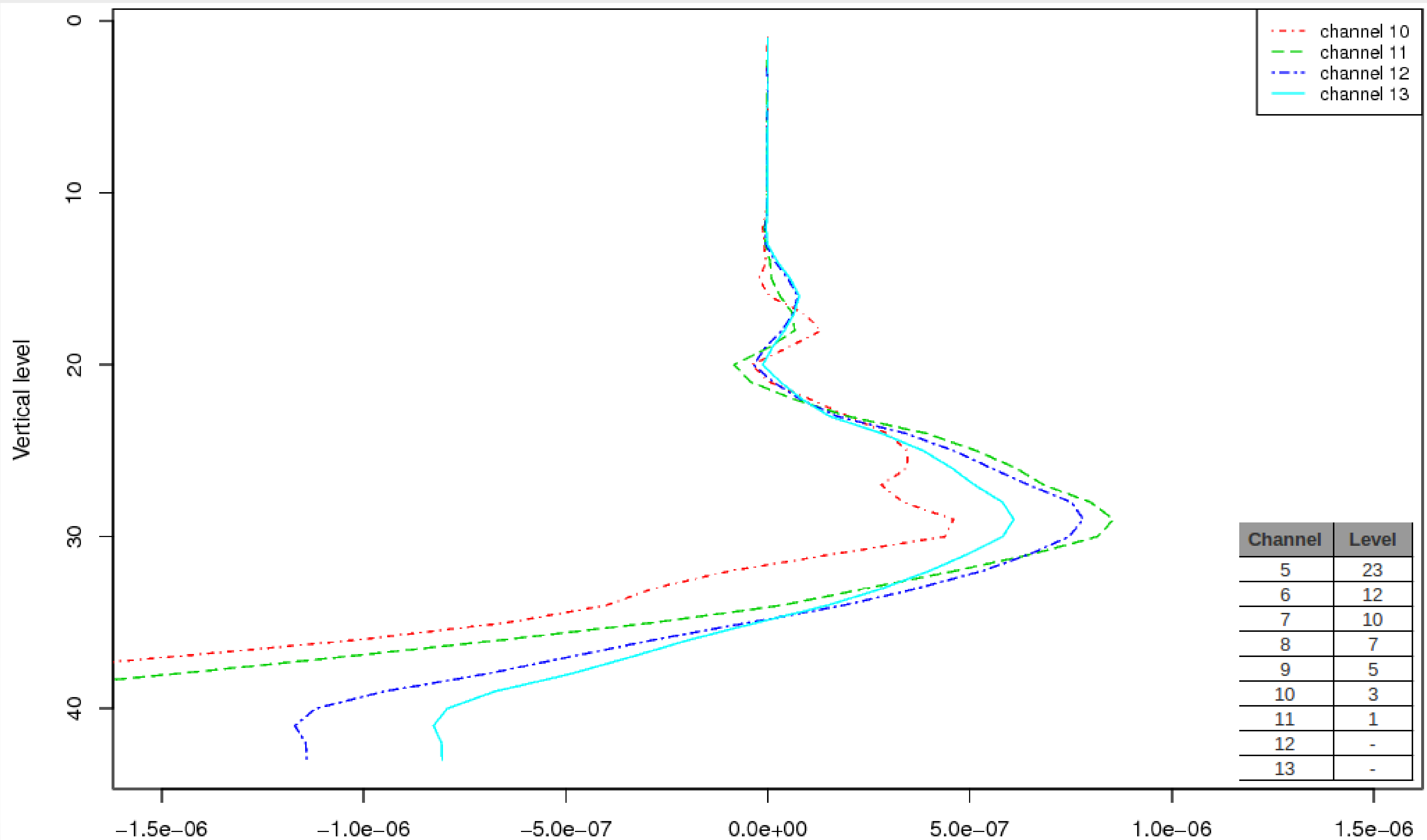
AMSU-A contribution for RH



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 5-9 for relative humidity in each model levels.

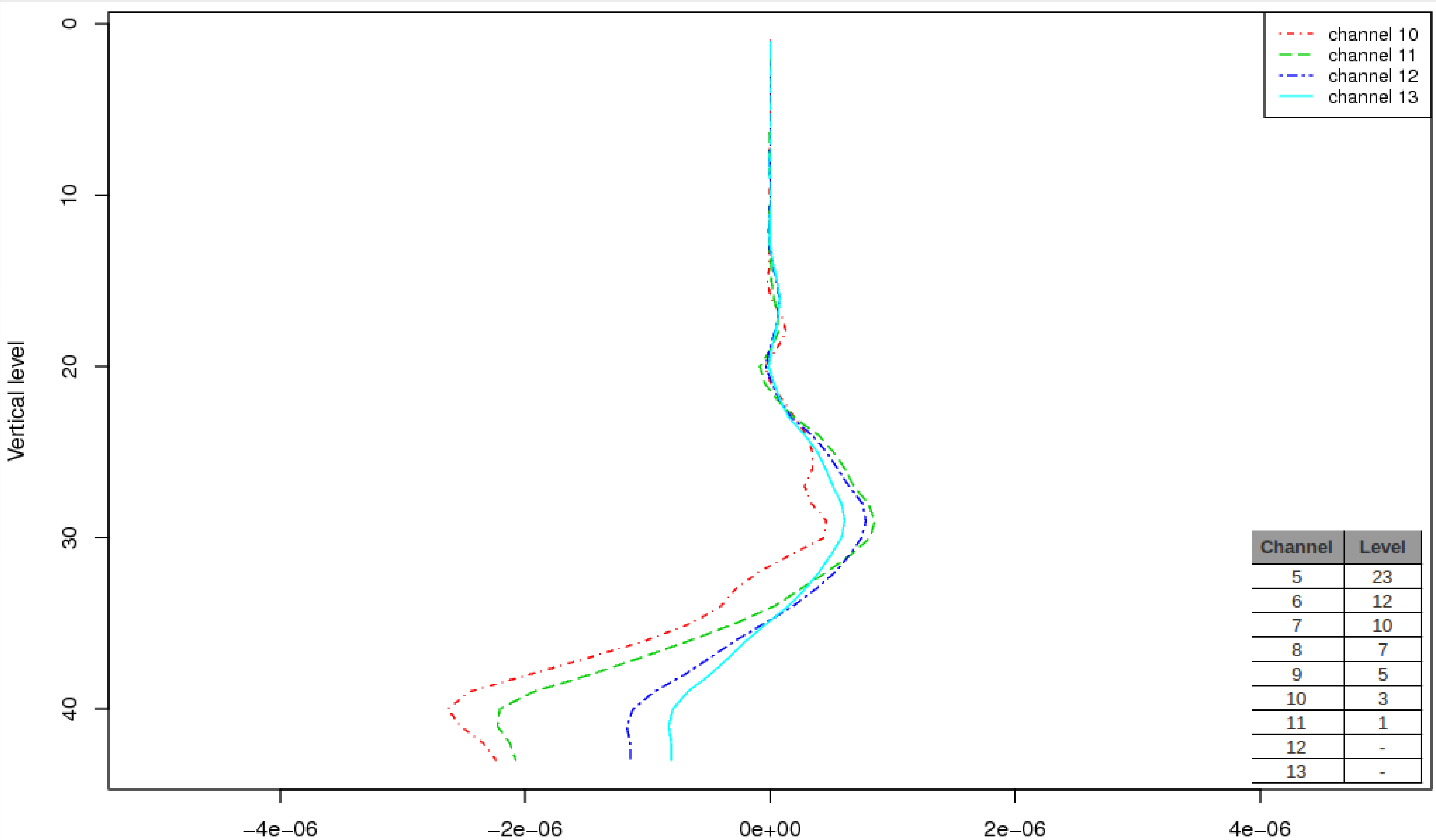
AMSU-A contribution for RH



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 10-13 for relative humidity in each model levels. There is too big contribution (in RH) of channels 10 and 11 near the surface.

AMSU-A contribution for RH



Channel	Level
5	23
6	12
7	10
8	7
9	5
10	3
11	1
12	-
13	-

Figure: Contribution of channels 10-13 for relative humidity in each model levels. There is too big contribution (in RH) of channels 10 and 11 near the surface.

Conclusion

- We tested blacklisting of some AMSU-A channels (with positive impact on the forecast):
  - channels 12, 13 for all satellites
  - NOAA18, 19 from 06UTC
  - channel 8 for NOAA19
- Overall scores of BlendVar with AMSU-A data are quite encouraging, but there is a lot of degradation, whose source is under investigation.

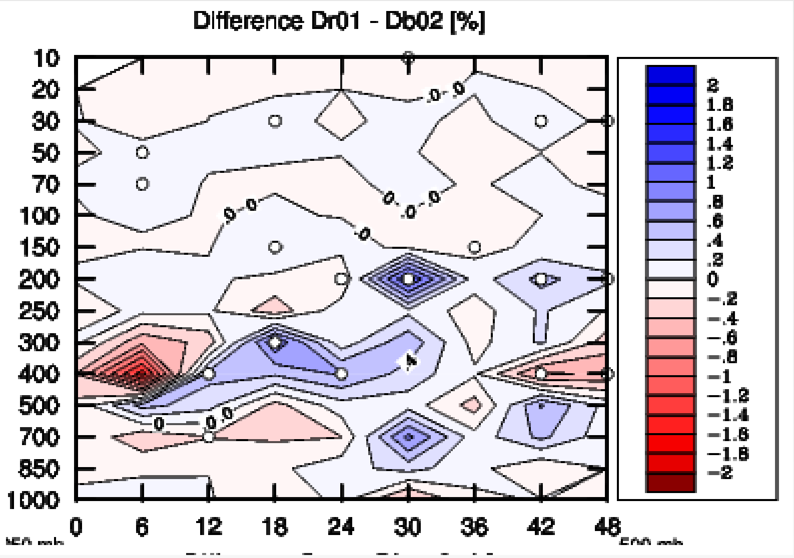
- <u>Regarding of future plans:</u>
  - AMSU-A: test impact of channels 10, 11 on the forecast and study the impact of AMSU-A with new ALADIN set-up (Δx=4.7km, 87 vertical levels).
  - Use of satellite data will be further exploited (AMSU-B, HIRS, MSG...).
  - A behaviour of BlendVar technique will be studied on increased resolution of 4.7 km.

Poster - Norrköping

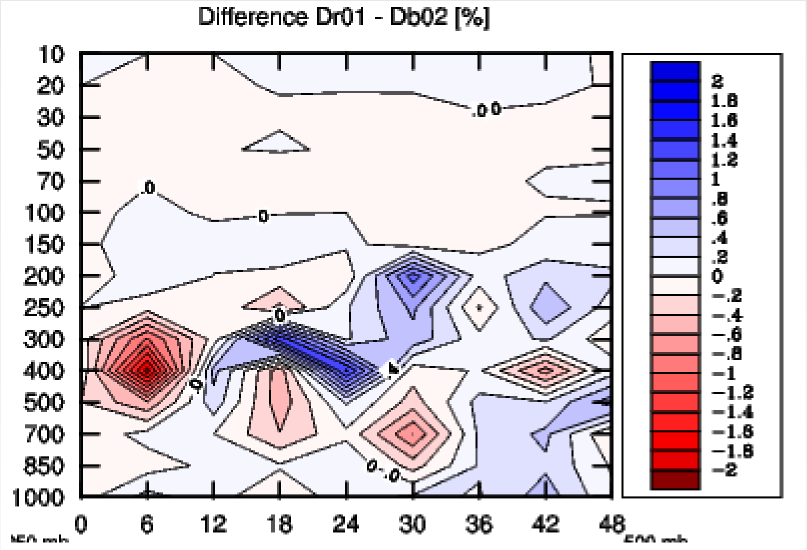
- Presentation results of AMSU-B data assimilation (strong positive impact for BIAS and RMSE in relative humidity) = incorrect impact
- Wrong reference were used!!

REL.HUMIDITY

RMSE



BIAS



Impact of AMSU-B data for relative humidity for 12UTC a thinning of data 80km.

New veral.visr

- Modification:
  - add significance T-test
  - new contour (statical or dynamical scale for RMSE, BIAS and STD)
  - upgrade of bias visualization

- Example:

veral.visr -pRELATIVE_HUMIDITY -t1 -m2 -b3 -iscores.tab

  - vertical cross sections of relative humidity will be produced with static scale for RMSE (-m2) from -2 to 2% and with static scale for BIAS (-b3) from -3 to 3%.

Thank you for attention

Appendix A

Desroziers diagnostic

Tuning of error statistics: On the basis of estimation theory Desroziers et al. (2005) proposed simple diagnostics which should be fulfilled in an optimal analysis. For any subset of observations *i* with p_i observations one can compute diagnosed value of observation and background error:

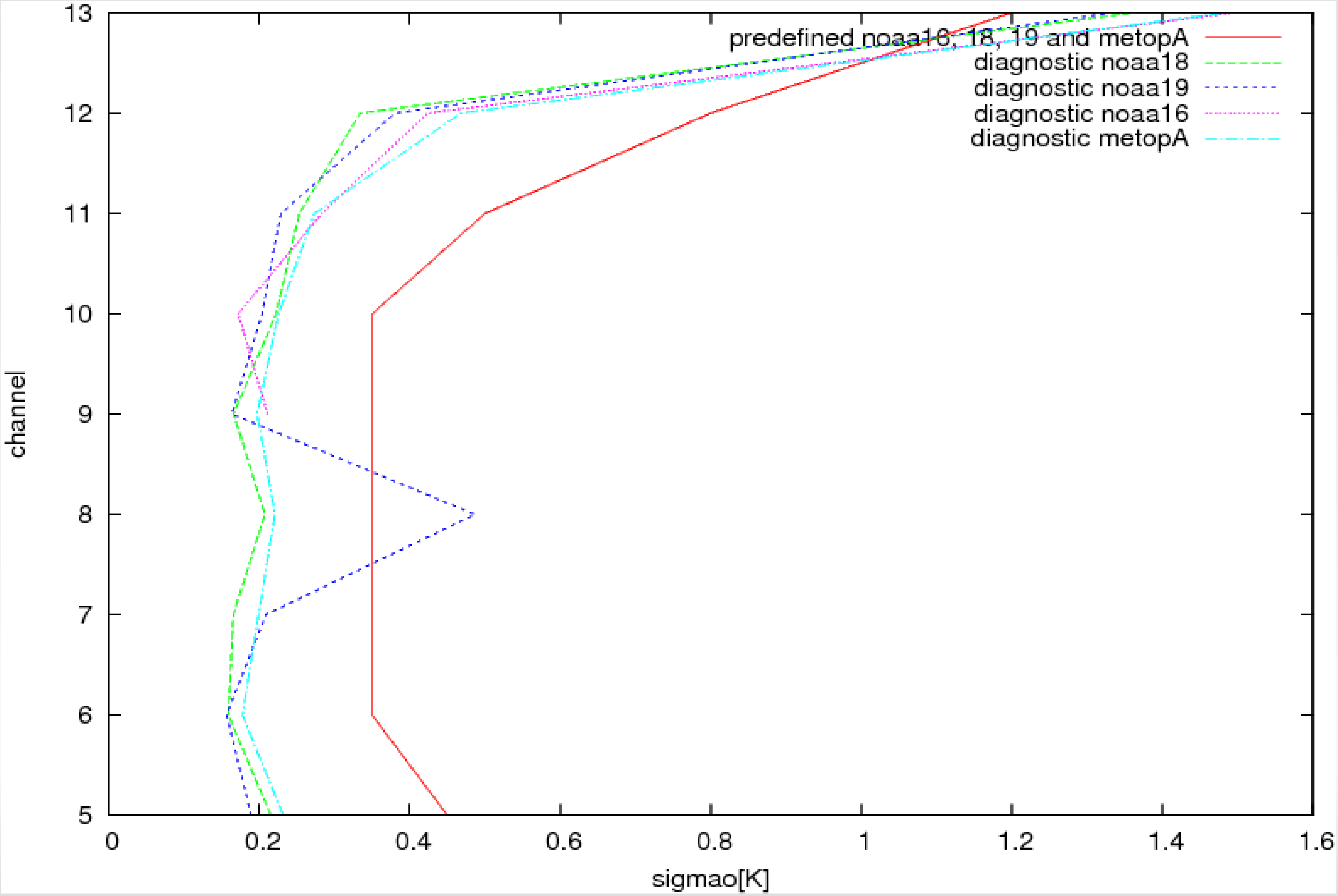
$$(\sigma_i^o)^2 = \sum_{j=1}^{p_i} \frac{(y_j^o - y_j^a)(y_j^o - y_j^b)}{p_i}$$

$$(\sigma_i^b)^2 = \sum_{j=1}^{p_i} \frac{(y_j^a - y_j^b)(y_j^o - y_j^b)}{p_i}$$

Diagnosed values of observation and background error were computed for analyzes of given experiment and compared with prescribed ones currently used in the model.

Diagnostic of observation errors

- Diagnostic (derived by Desroziers et al. [2005]) and predefined observation errors for satellites NOAA and MetopA



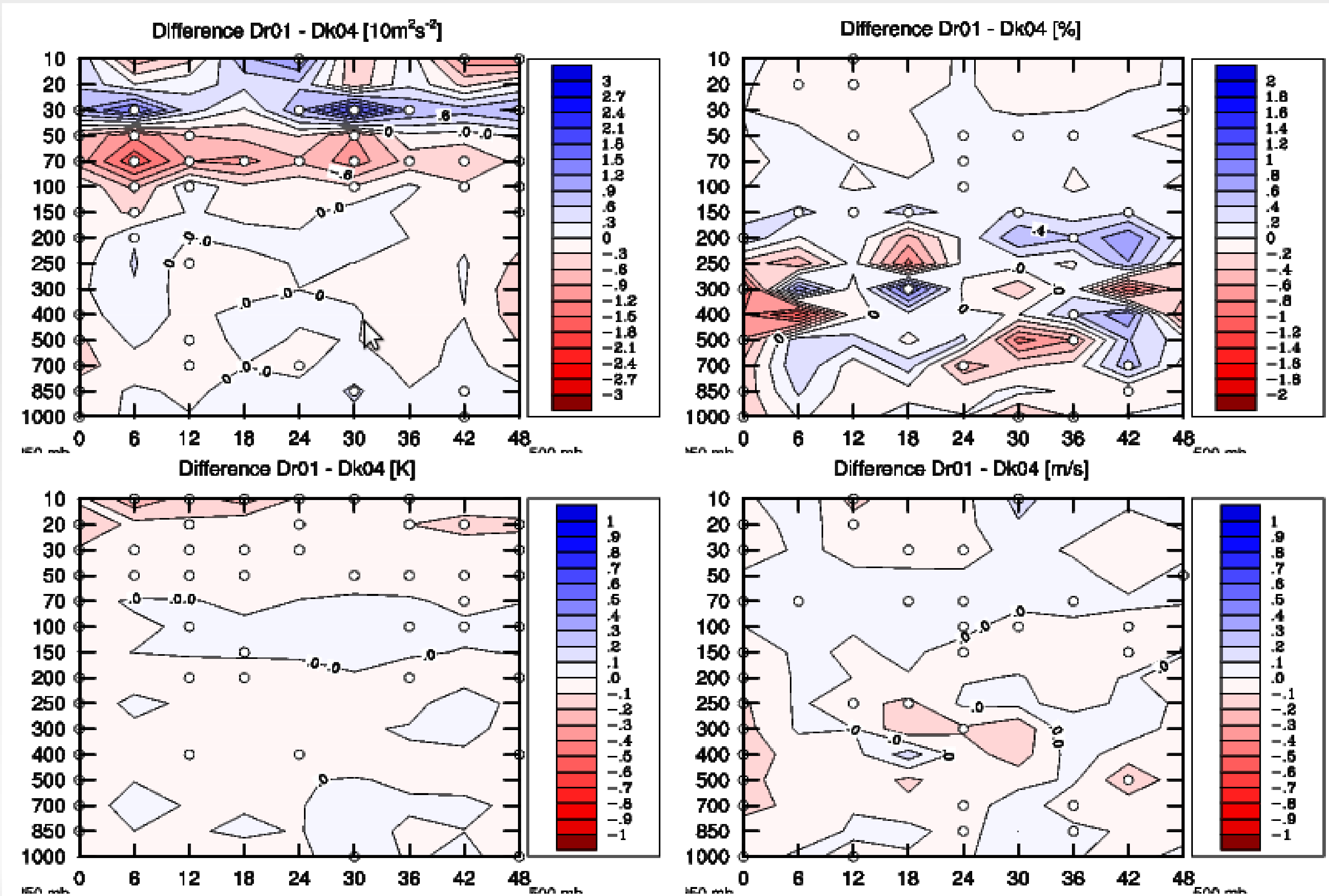
Impact of AMSU-A (RMSE)

GEOPOTENTIAL

REL.HUMIDITY

TEMPERATURE

WIND SPEED



Experiment k04: Impact of AMSU-A on BIAS for 12UTC.