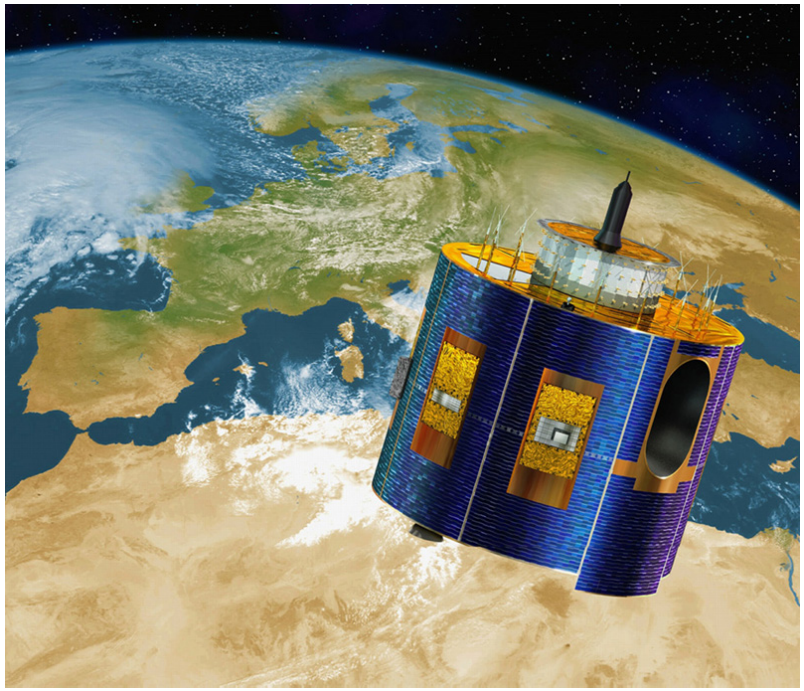
Satellite bias correction for MSG

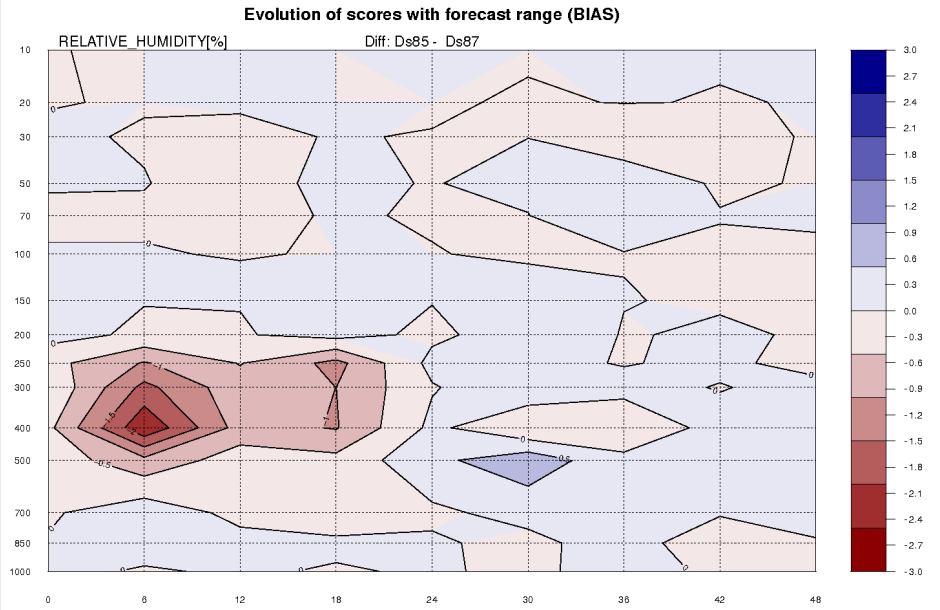


Patrik Benáček

Czech Hydrometeorological Institute
Department of Meteorology and Environment Protection

Motivation

Impact of MSG-WV channels (RH BIAS)



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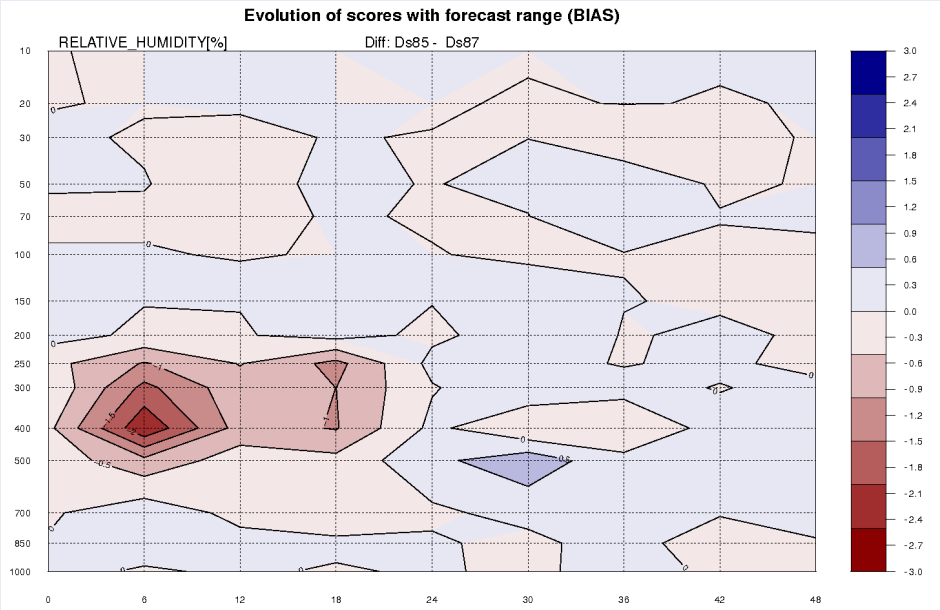

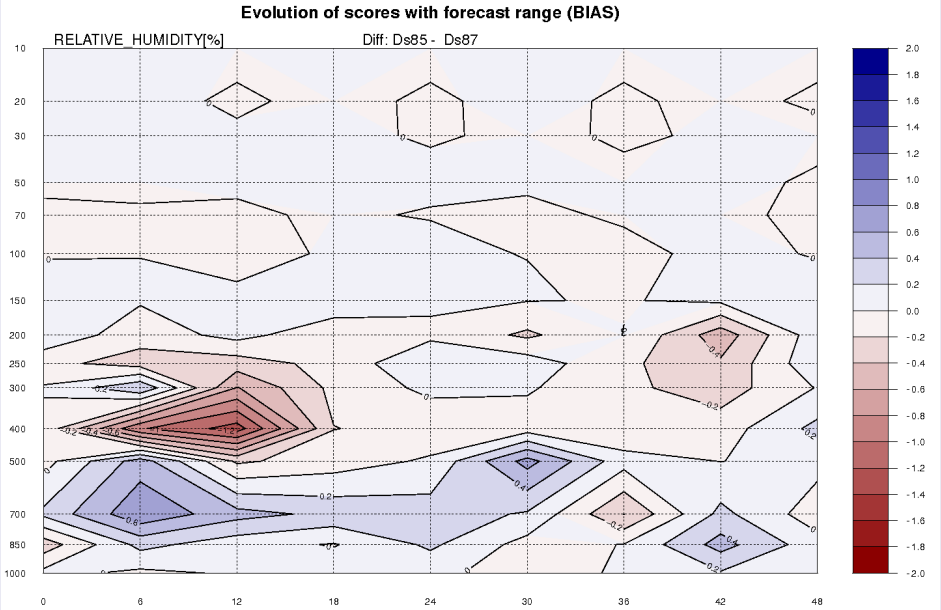

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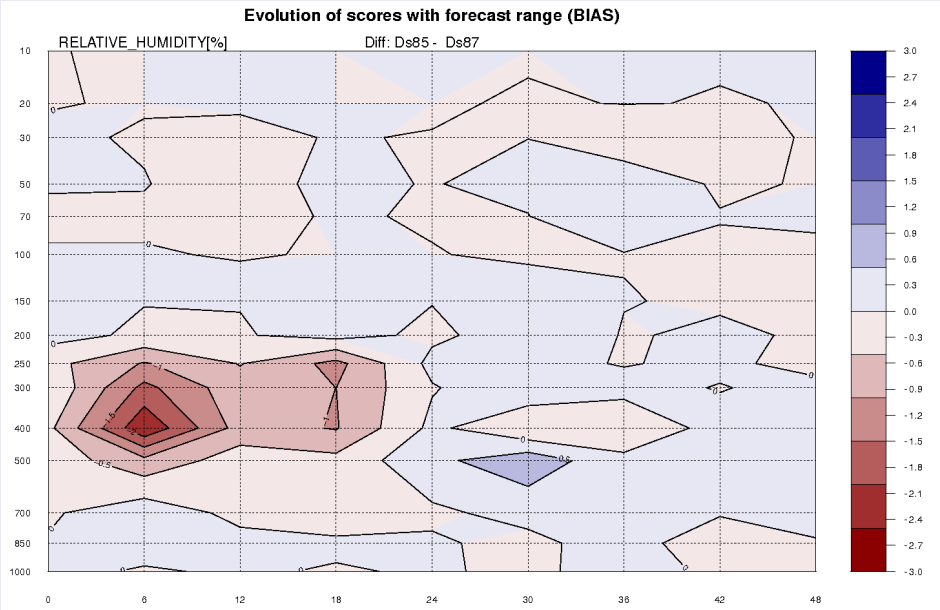

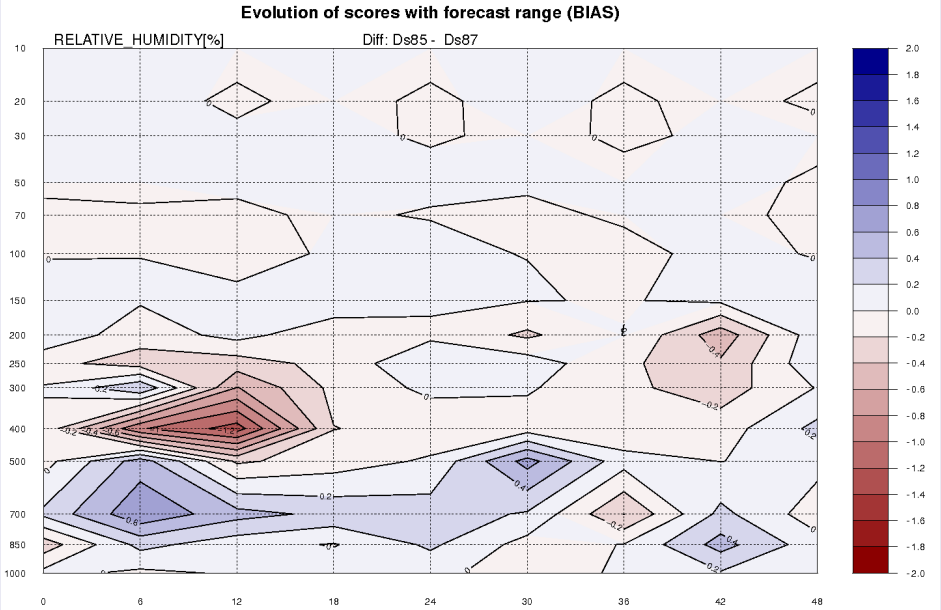

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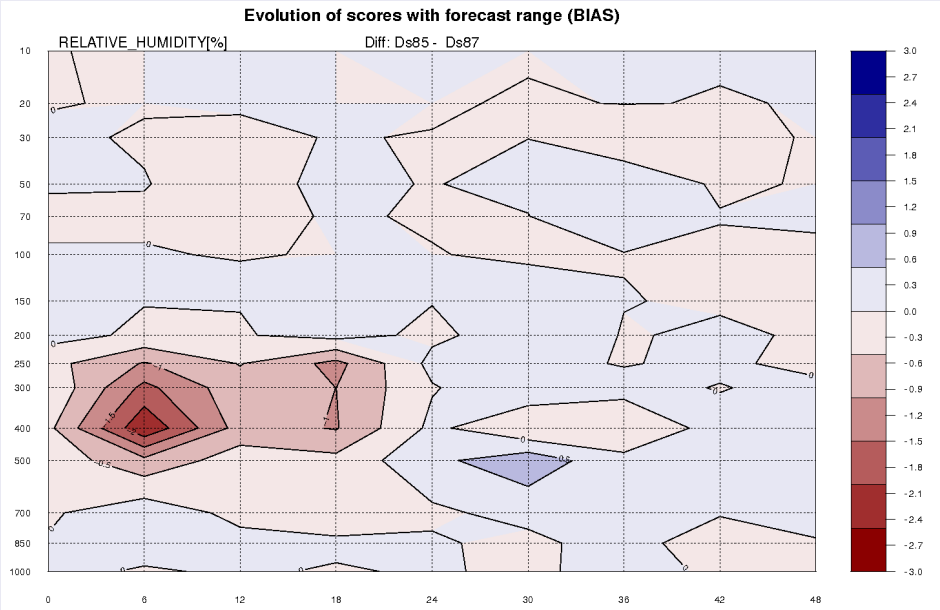

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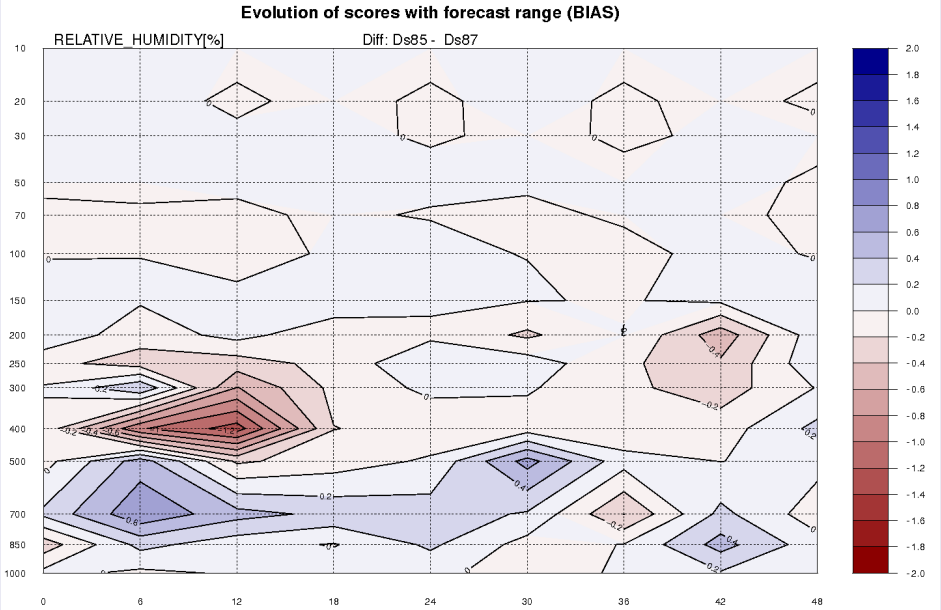

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Why we get the negative impact for WV-channels?
Why the impact depends on the period?

What are biases?

- biases = systematic errors inside of NWP assimilation systems
- NOT constant – vary with time, geographical position, scan position of the instrument or air-mass dependent
- using correction scheme (VarBC, Harris&Kelly, . . .)

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Mixture of model and satellite bias

$$BIAS = BIAS_{sat} + BIAS_{model}$$

Identifing/separating sources of bias

- NOT to separate leads to:
  - re-enforce the model bias
  - degrade the analysis fit to other observation
- to understand the origin of the bias and ideally correct instrument/NWP/RT model at source

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Outline/main goals:

- study model and satellite bias separatelly
- examine new parameters for satellite bias correction
- application of the improve bias correction in the assimilation system (3DVar)

Outline

How to separate model/satellite bias?

- cross validation method against radiosonde (RS) data

Model bias

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Radiosonde bias & data selection

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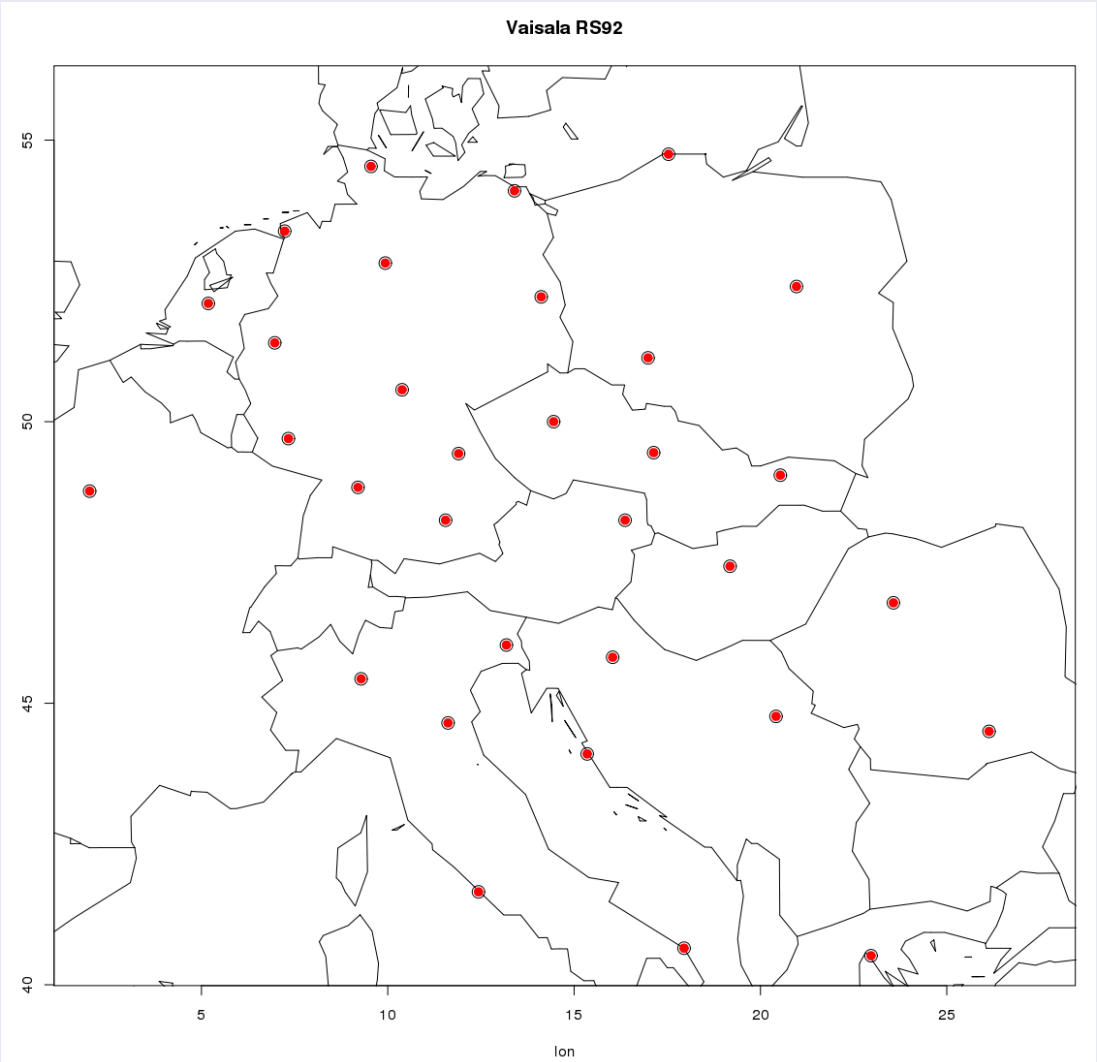

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Atmosphere	**Nighttime**	**Daytime**
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- data up to 200hPa (time-lag error avoiding)

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Detection using selected RS data:

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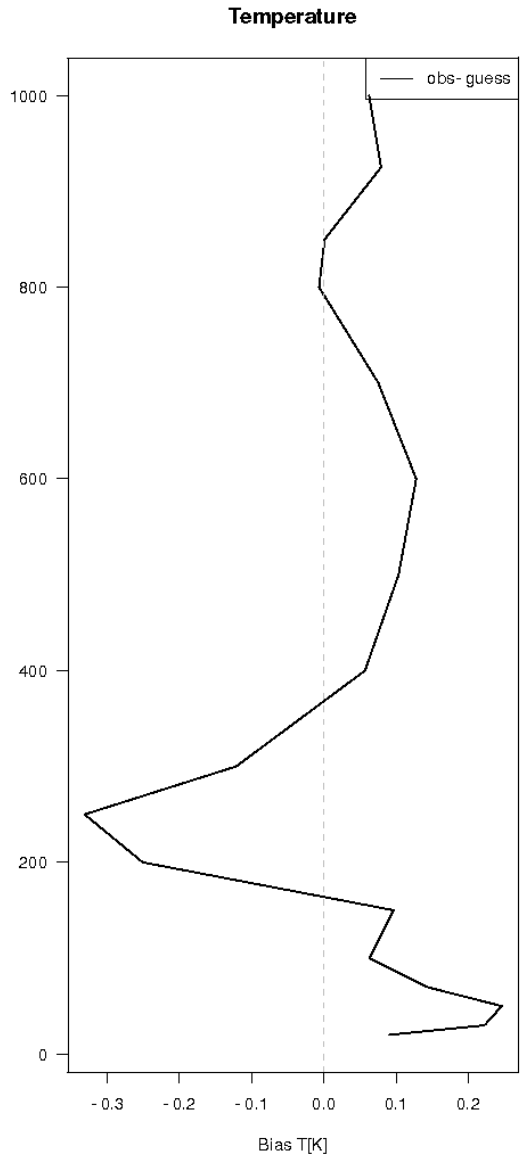

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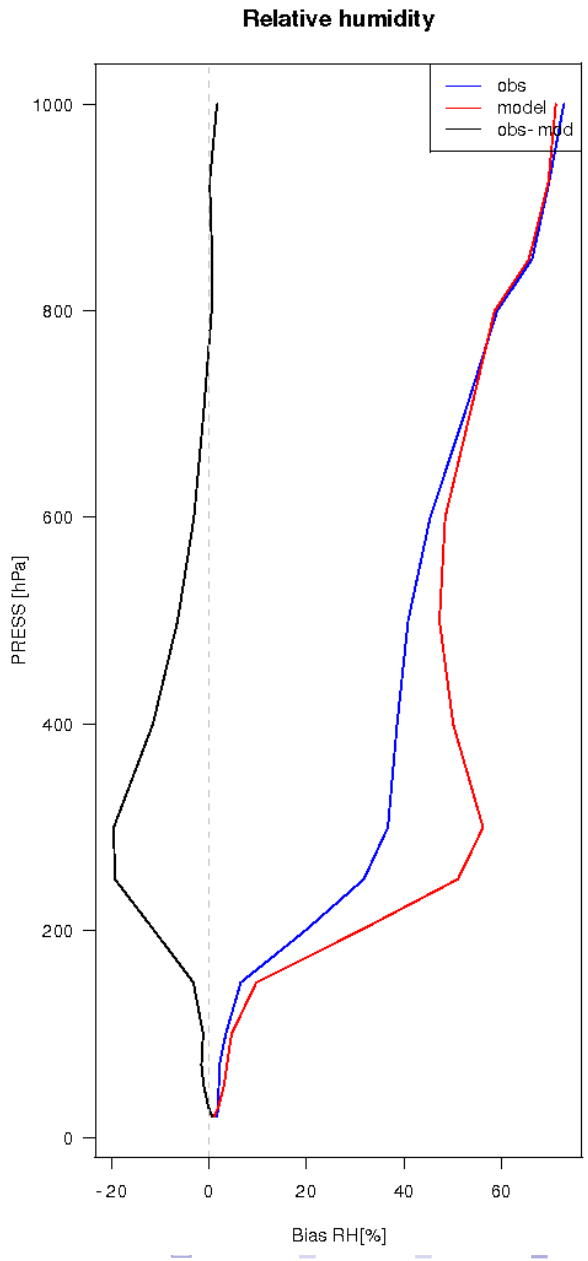

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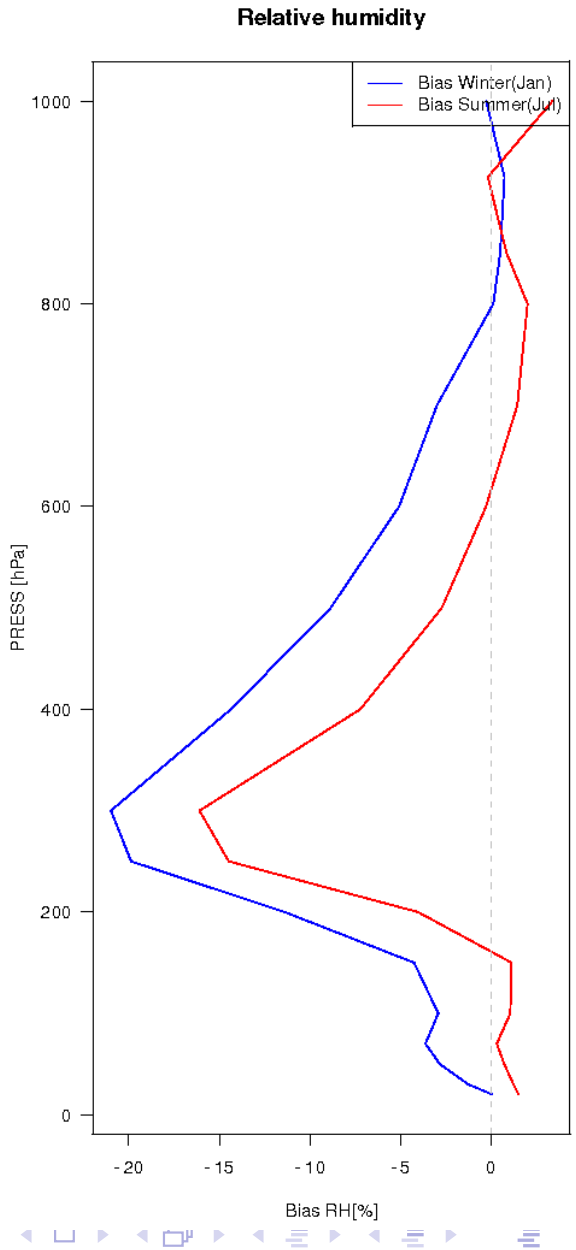

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NWP model bias

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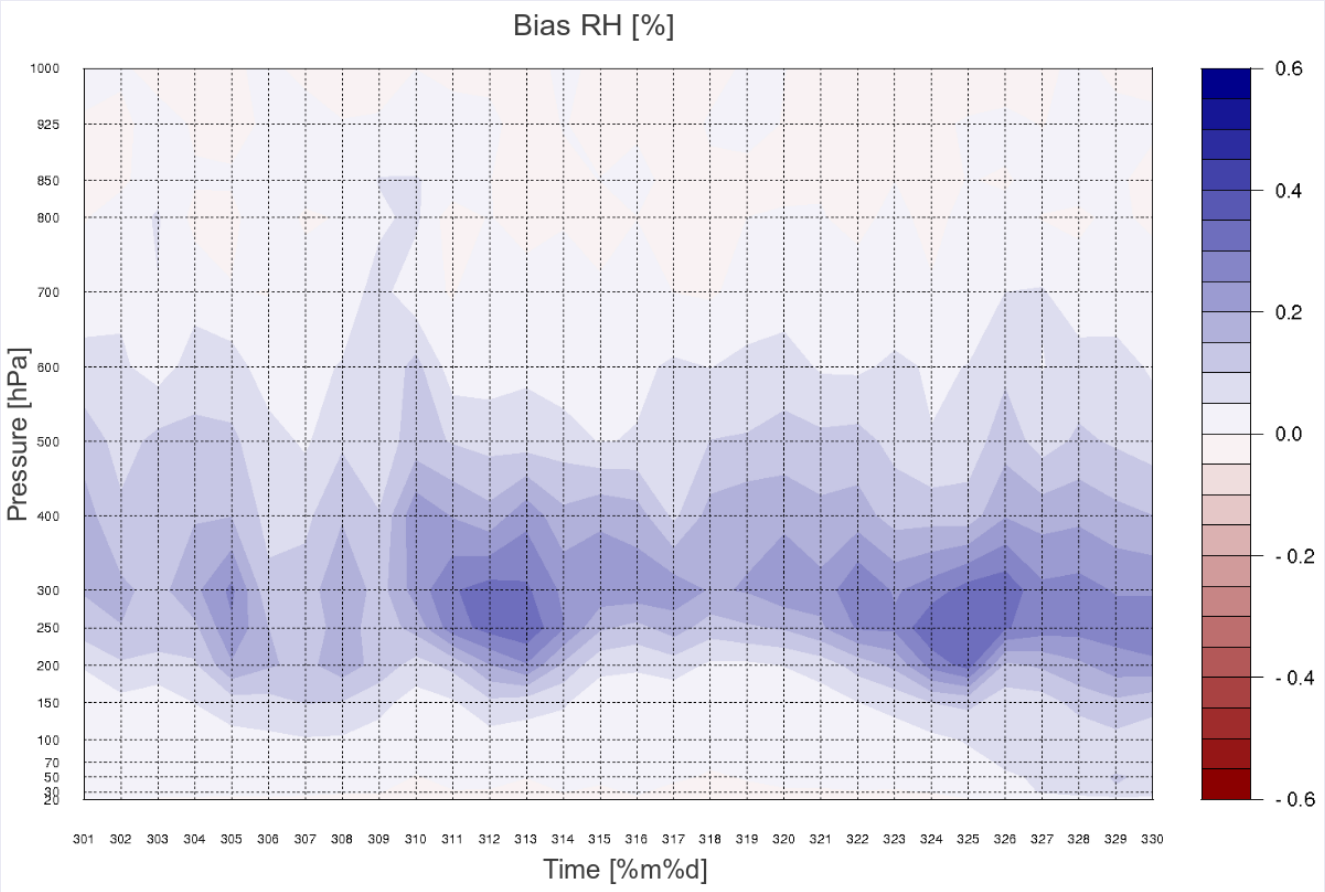

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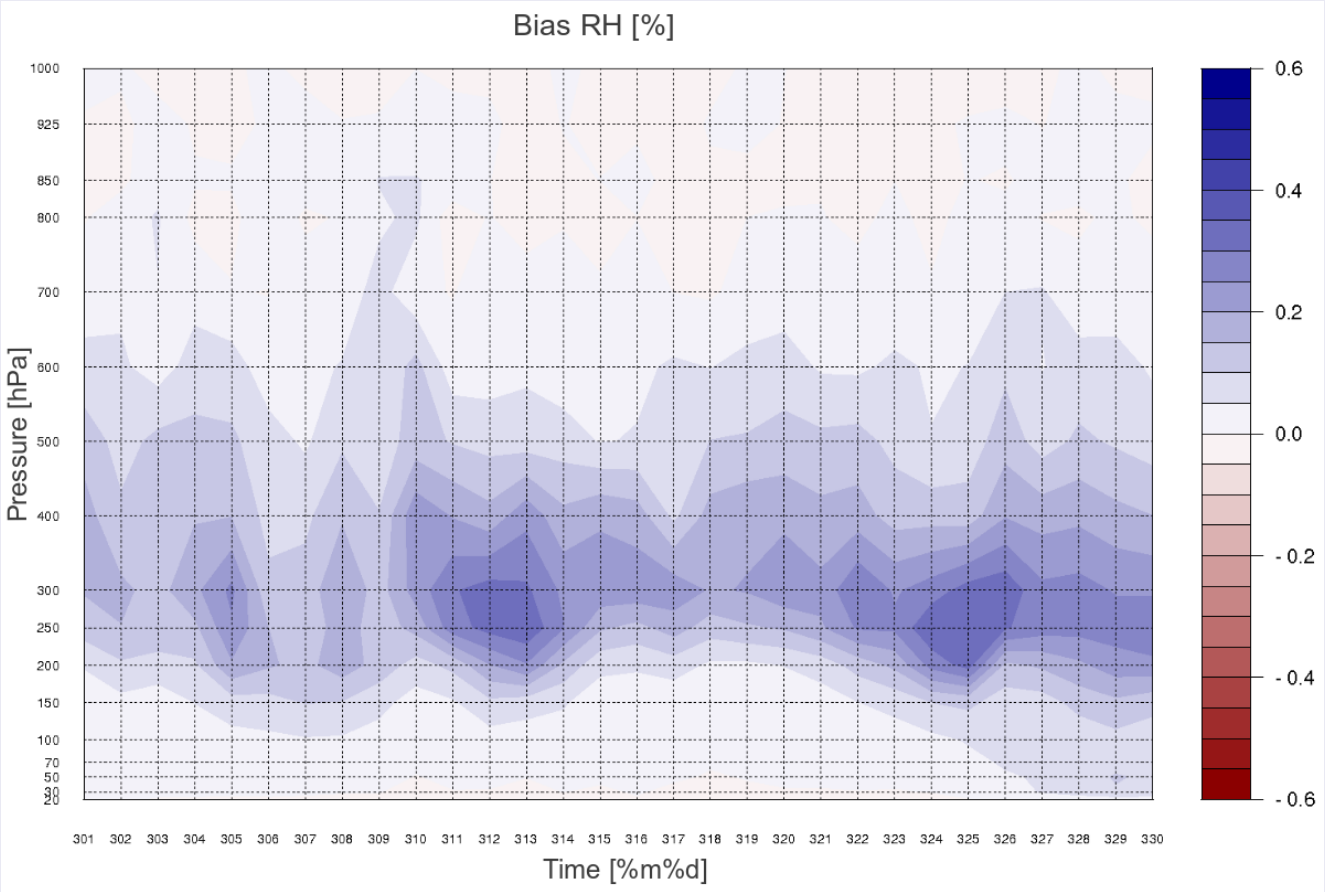
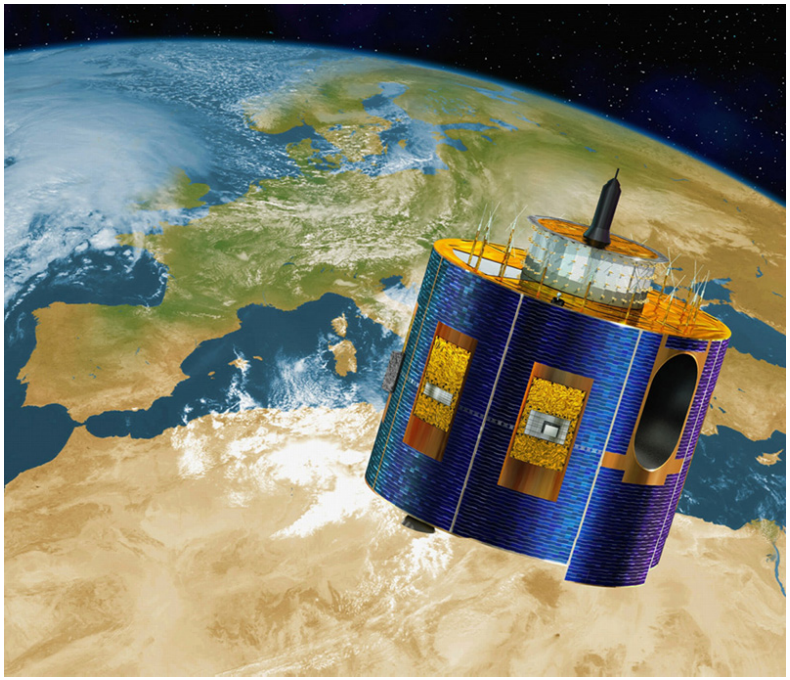


- increasing model RH bias in MT/UT (up to 20%)
- seasonal/daily/local RH bias variation

Satellite data

- the channels WV6.2 and WV7.3 from SEVIRI on board MSG
- every 15 min, horiz. resolutoin 4-6km (Central Europe)



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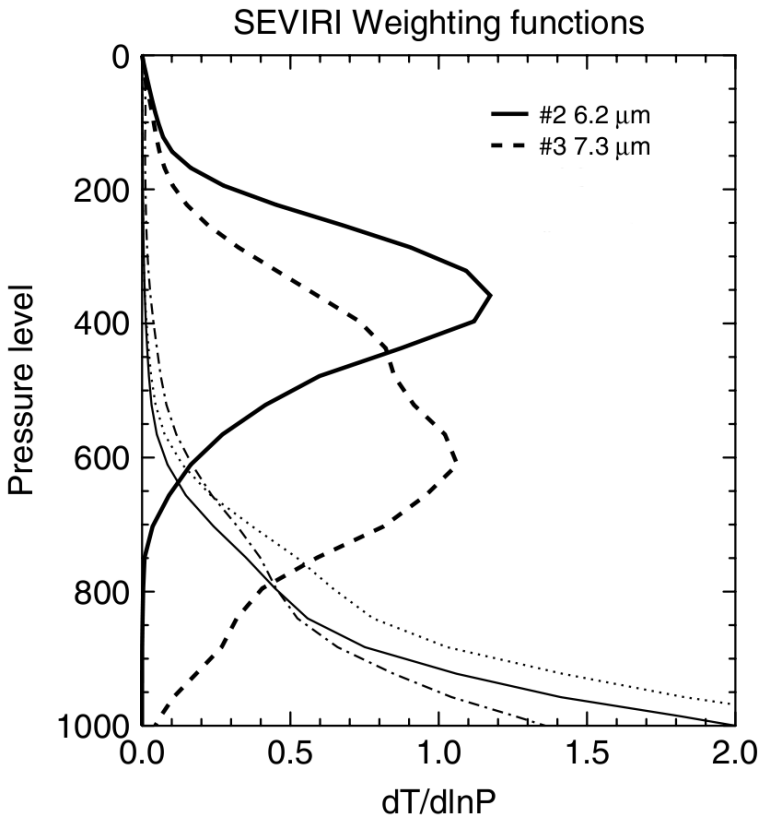

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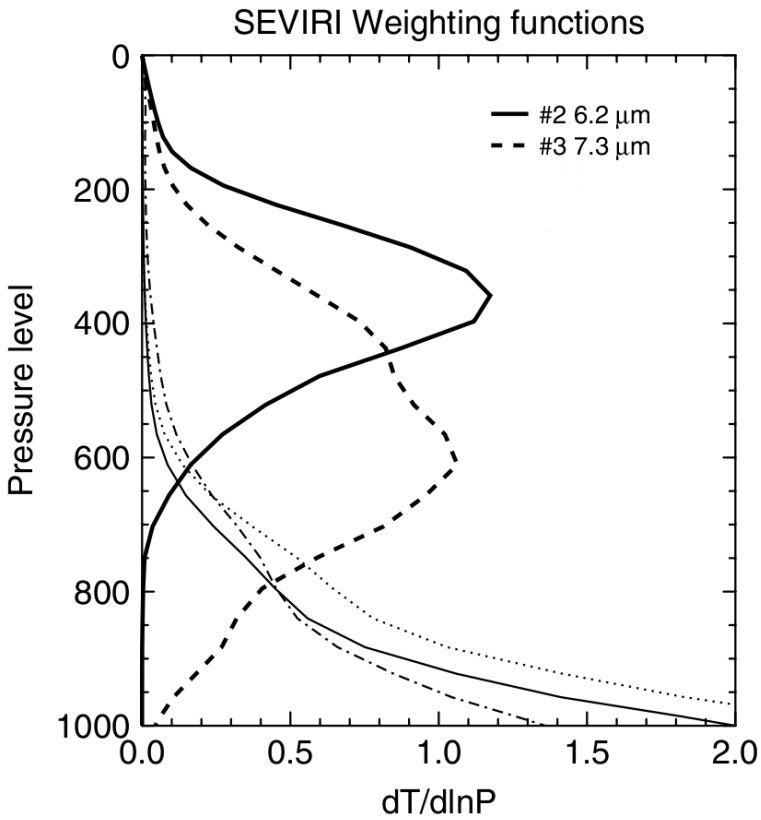


Satellite bias

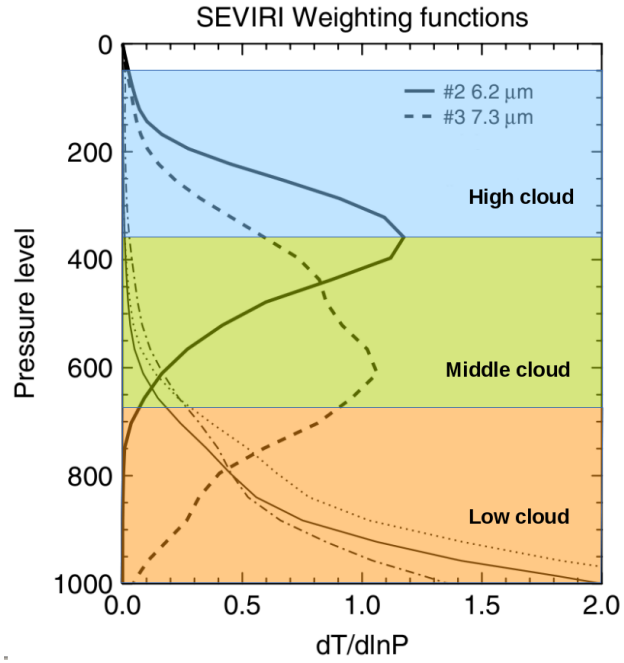
Bias sources:

$$BIAS_{sat} = \sigma_{instr} + \sigma_{rttov} + \sigma_{cloud} + \sigma_{airmass}$$

- σ_{instr} - satellite instrument error (calibration, environmental effects, etc.)
- σ_{rttov} - radiative transfer model error (spectroscopy, non-modelled proceses)
- σ_{cloud} – data pre-processing error (cloud/precipitation detection)
- $\sigma_{airmass}$ – air-mass characteristics dependency (T, Q, etc.)

Cloud contamination of radiation

- absorbing of radiation by high clouds (above the weighting functions)



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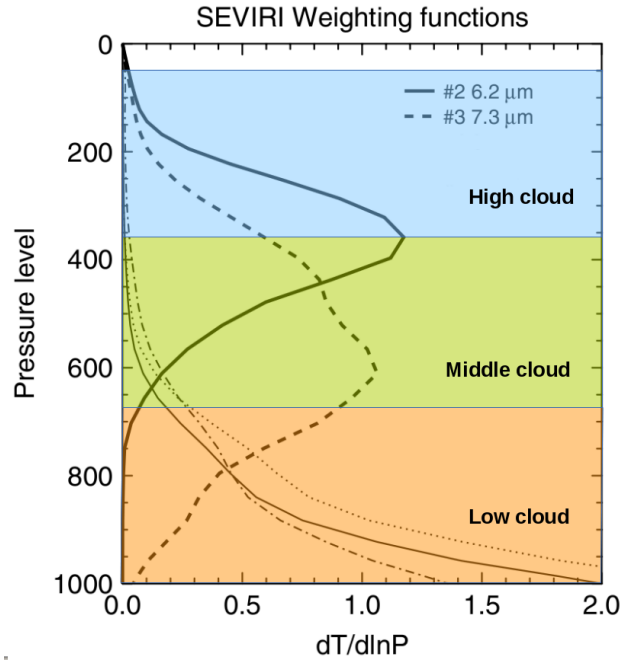

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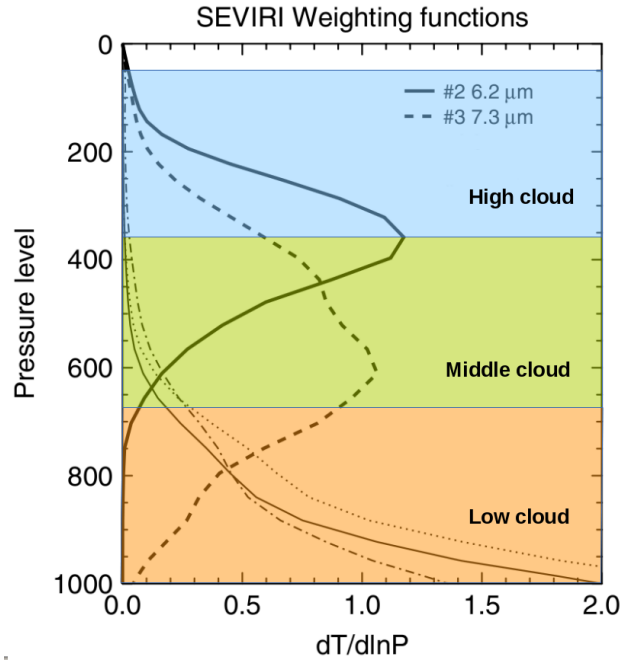

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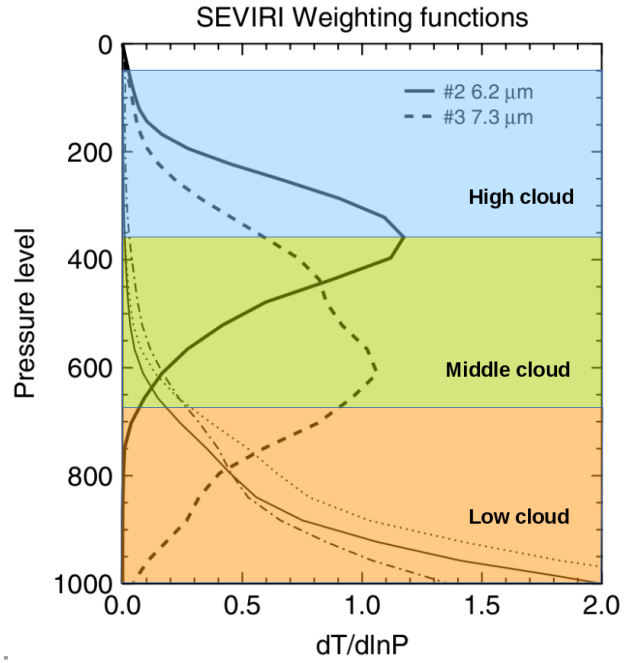

Bias contamination by clouds (mean per 4 months)

Chan/CT	**Cloud free 1**	**Very low 6**	**Low 8**	**Middle 10**	**High 12**	**Very high 14**
WV6.2	-3.1 ± 1.5	-2.7 ± 1.7	-2.8 ± 1.7	-2.5 ± 1.7	-6 ± 3	-14 ± 3
WV7.3	-1.1 ± 1.2	-1.2 ± 1.3	-1.9 ± 1.4	-4.3 ± 2.4	-15 ± 5	-30 ± 4

CT selection: used(green), rejected(yellow/red), investigated(yellow)

Bias identification

Satellite/model bias summary (in WV radiation spectra)

Chan/Bias[K]	$\mathbf{BIAS_{sat+model}}$	$\mathbf{BIAS_{sat}}$	$\mathbf{BIAS_{model}}$
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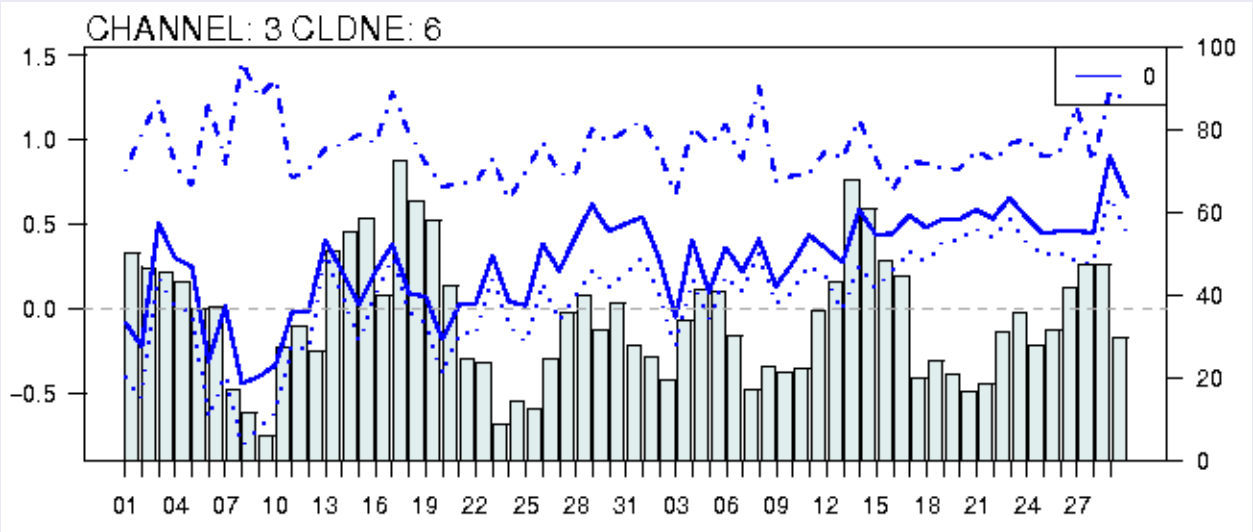
- monitoring of $BIAS_{sat+model}$ for 03/2011



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Detecting method

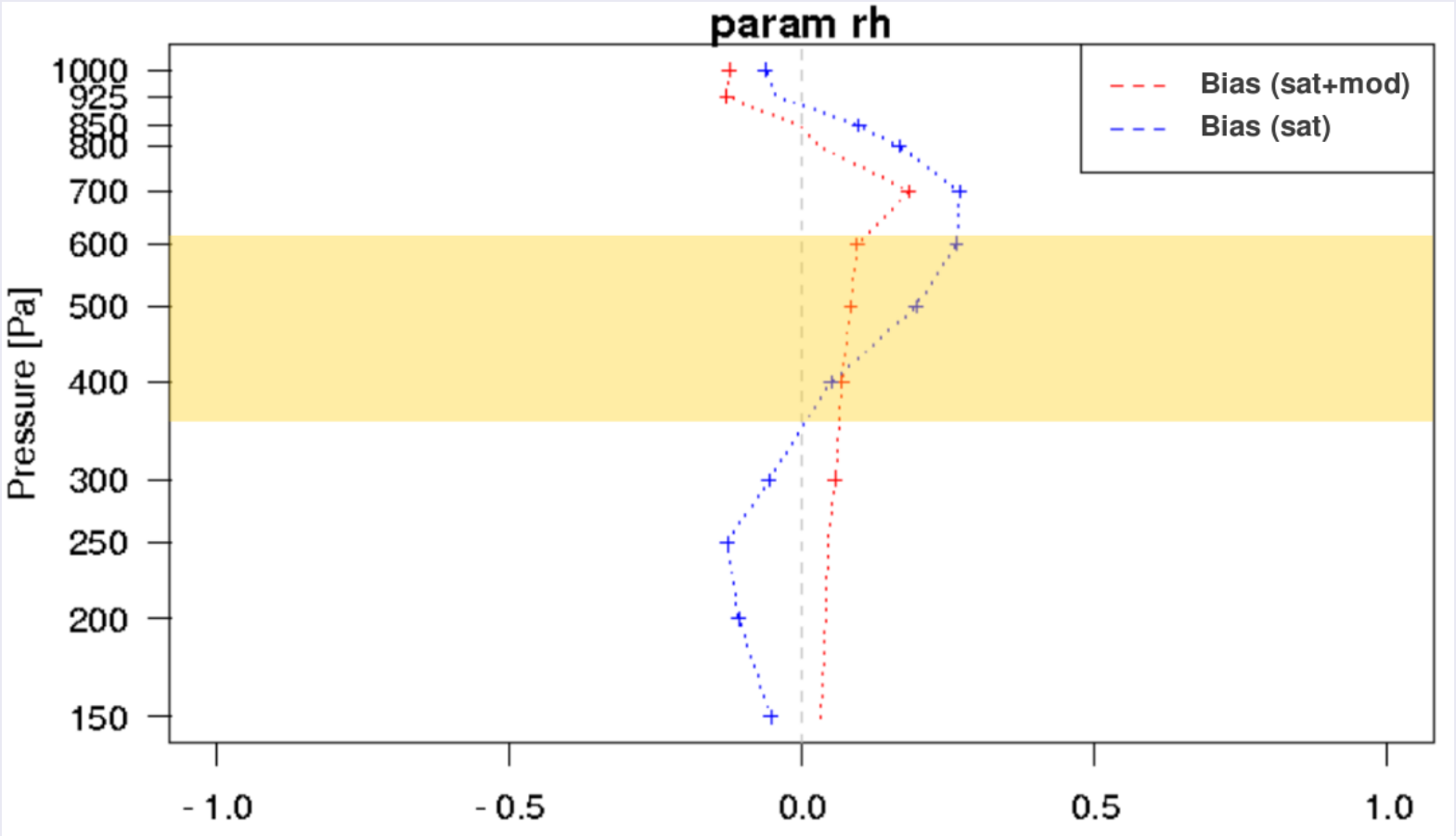
- using Spearman correlation method (not sensitive to outliers/non-normality):

$$BIAS_{sat} \sim (G, T, q, RH, u, v, \ldots)$$

$$BIAS_{sat+model} \sim (G, T, q, RH, u, v, \ldots)$$

Air-mass dependency

Relative humidity ∼ WV7.3



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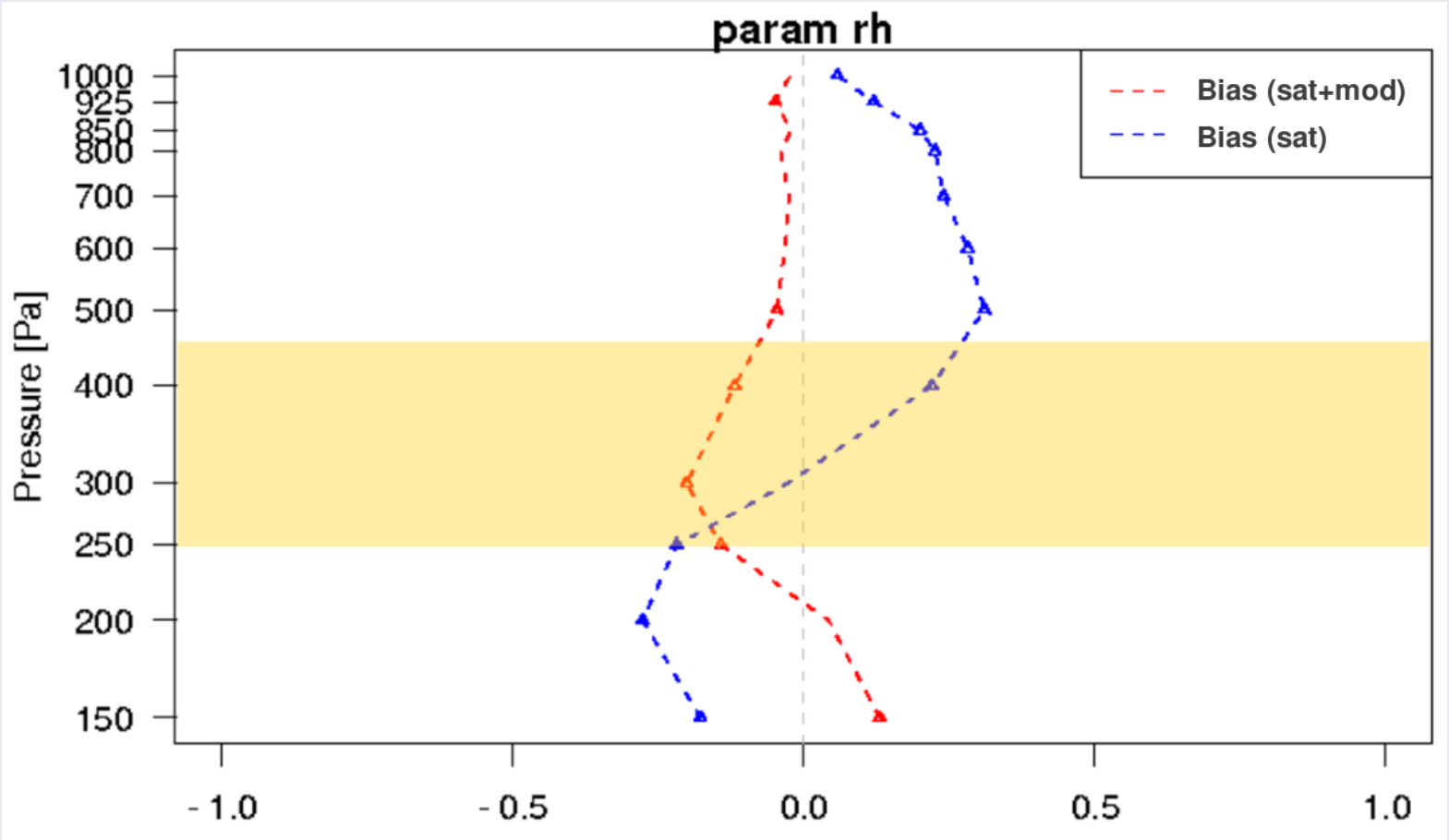
Relative humidity ∼ WV6.2



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Correction method

$$BIAS = \beta_0 P_0 + \beta_1 P_1 + \beta_2 P_2 + \beta_3 P_3$$

- P_0 – constant
- P_1 – thickness of layer 1000-300hPa
- P_2 – thickness of layer 200-50hPa
- P_3 – the total column water vapor

Air-mass correction results

Set of bias parameters for WV channels:

Exp	Chan	β_0	β_1	β_2	β_3
BIAS$_{sat}$	WV6.2	-2.90	-1.53	0.23	1.56
(new set)	WV7.3	-0.83	-0.42	0.19	0.98
BIAS$_{sat+model}$	WV6.2	-0.34	-0.15	-0.29	0.07
(old set)	WV7.3	0.33	0.39	0.16	0.15

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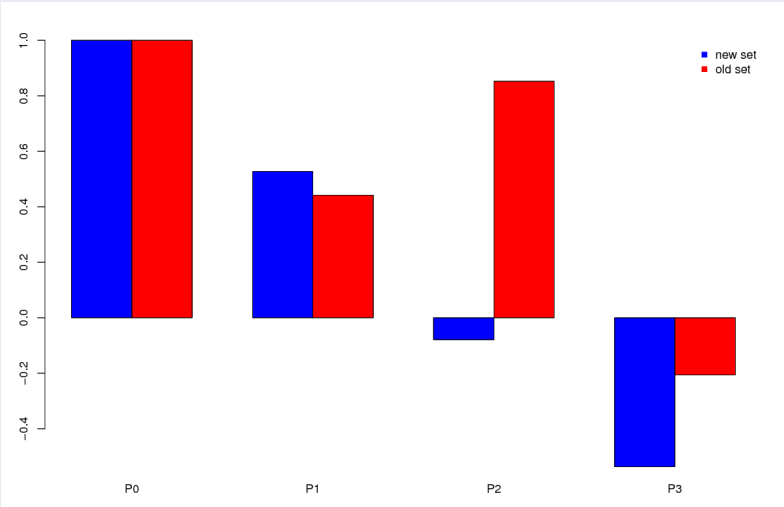
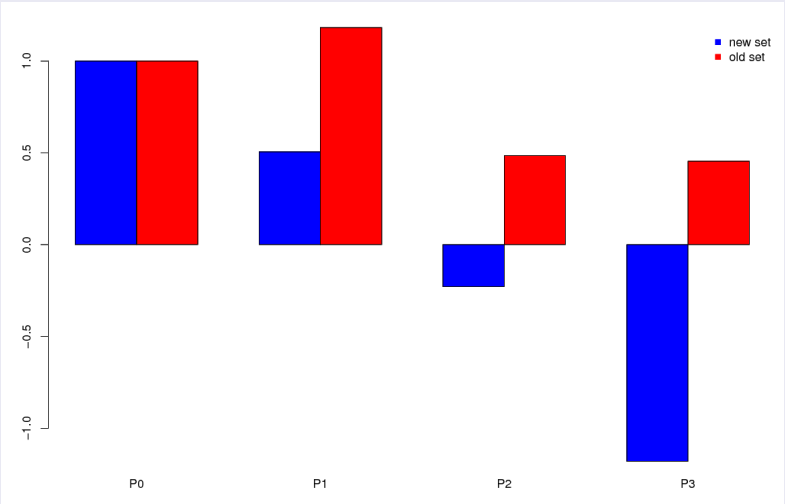
Normalize β for WV6.2



Normalize β for WV7.3



Impact of old/new set on analysis

Testing for 20/03/2011:

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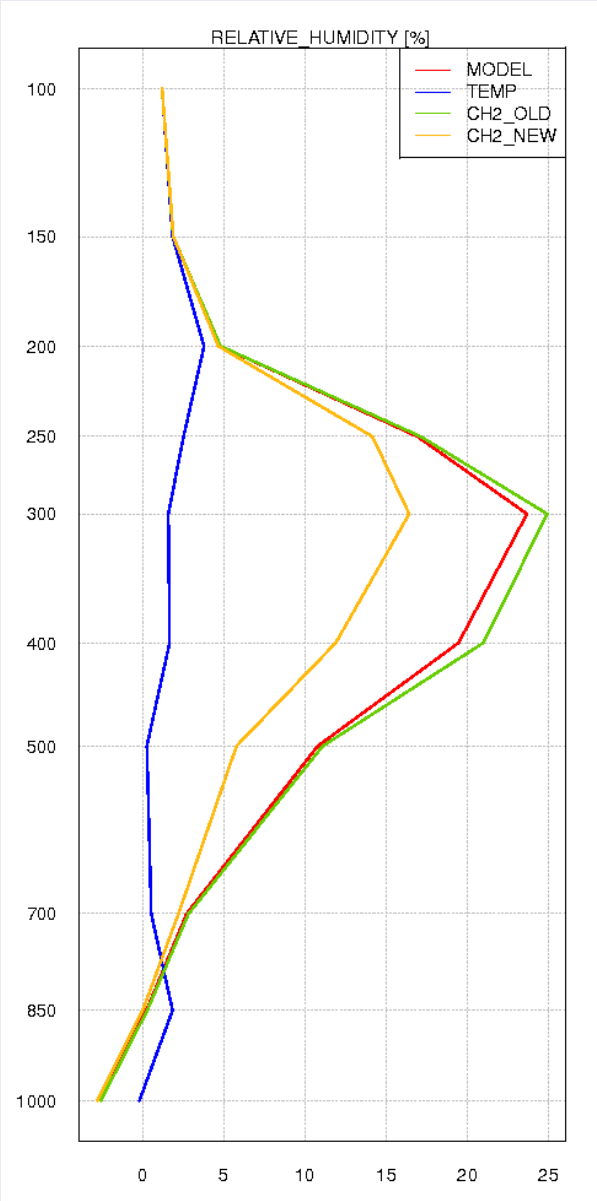

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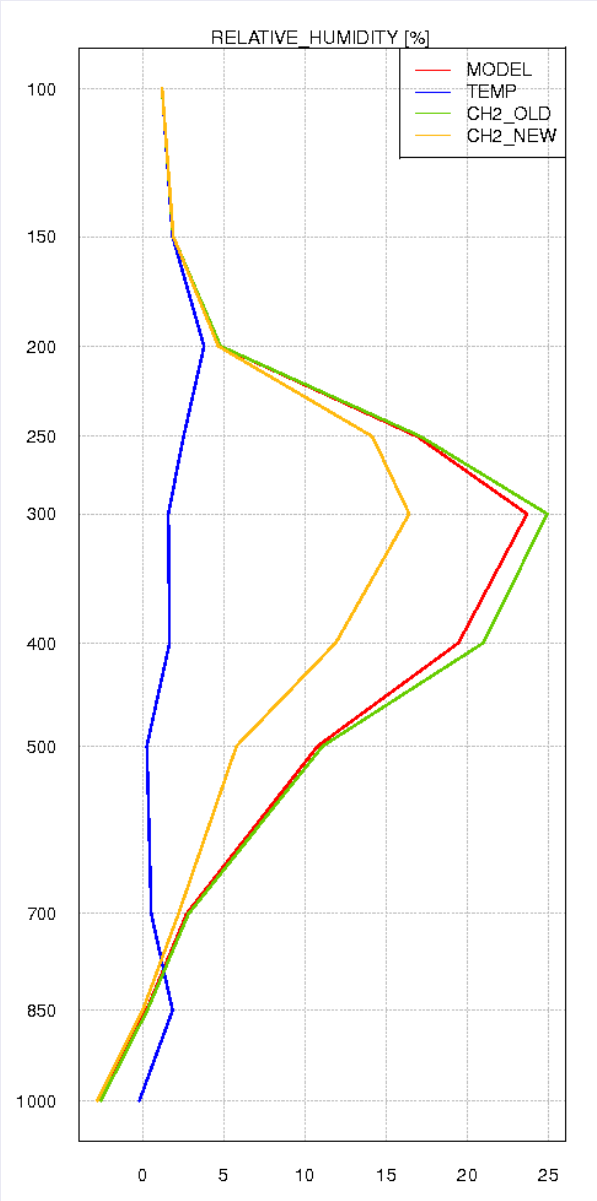

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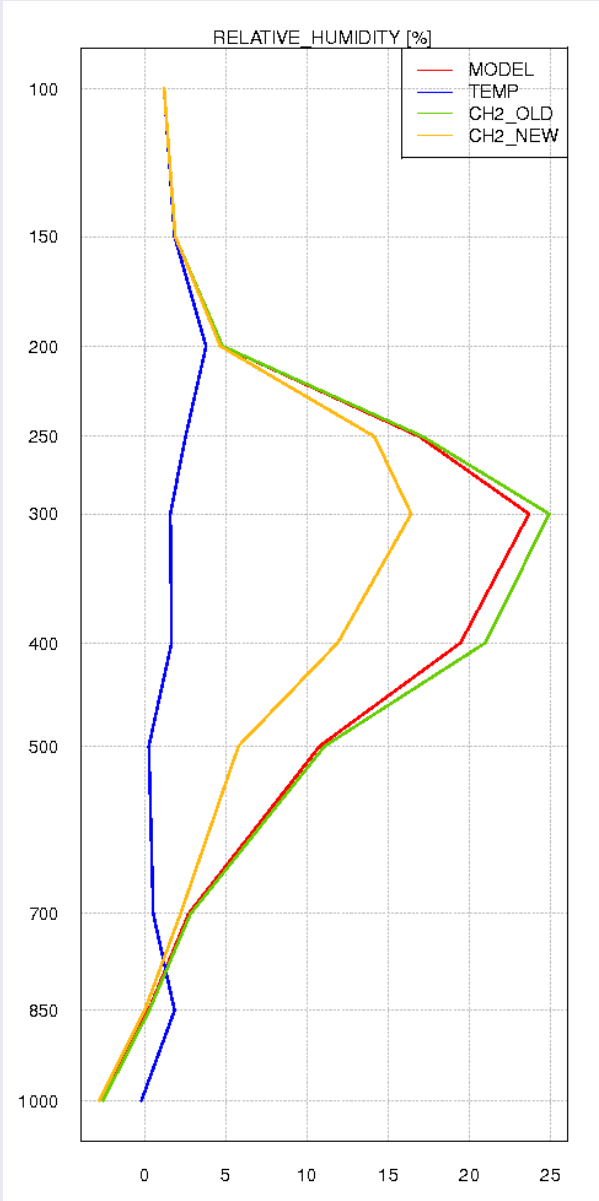


Imapct on forecast

Experiment settings:

- testing periods 1.3.-30.3.2011 at 00UTC
- VarBC: 24-h bias parameters cycling
- 60km thinning, cloud types 1-8
- ensemble B-matrix; REDNMC=2.
- verification against RS92

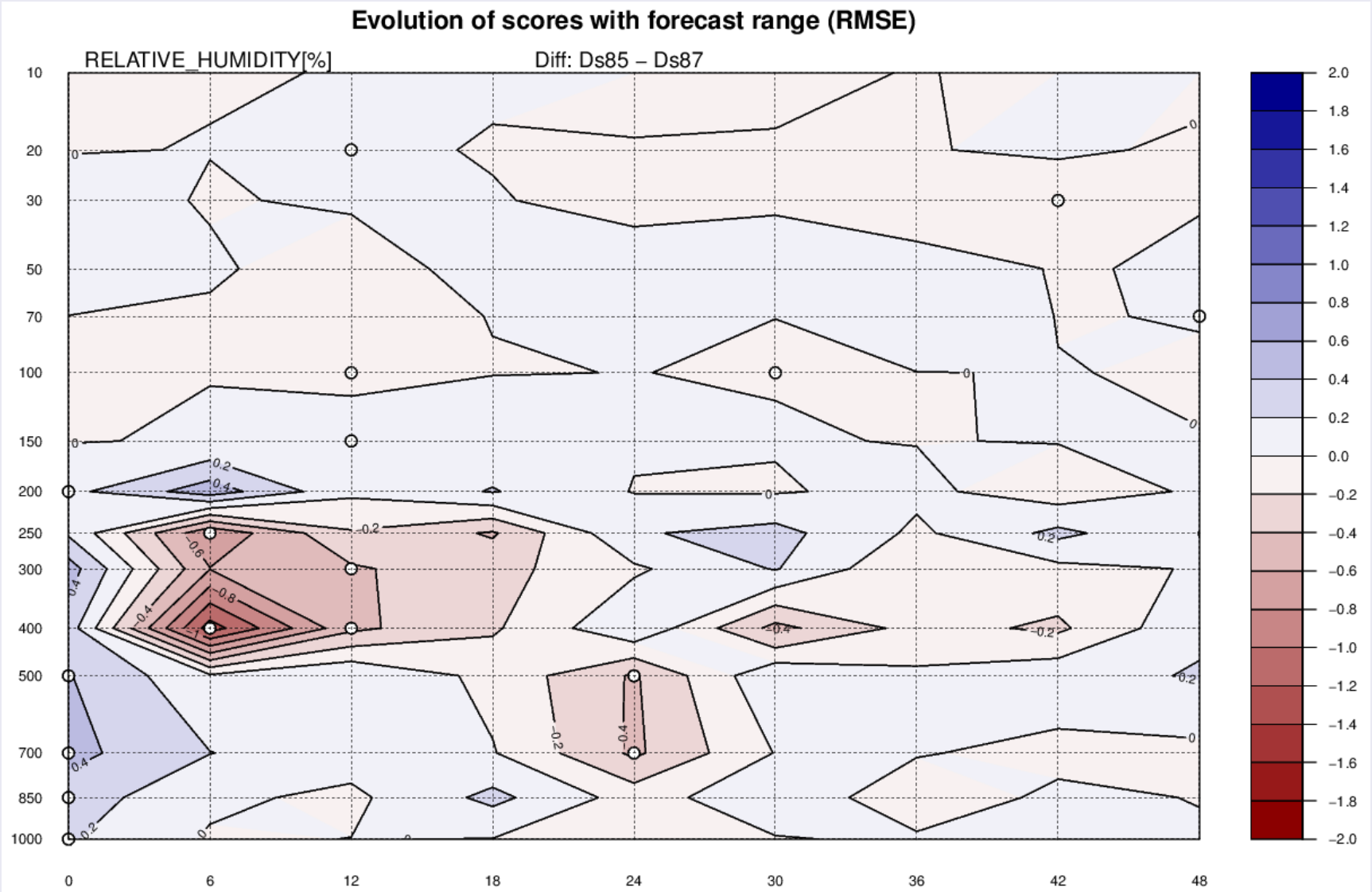
Imapct on forecast

Experiment settings:

- testing periods 1.3.-30.3.2011 at 00UTC
- VarBC: 24-h bias parameters cycling
- 60km thinning, cloud types 1-8
- ensemble B-matrix; REDNMC=2.
- verification against RS92
  - **TEMP** (s85) – reference
  - **TEMP+MSG(2,3)_new** (s86) – new set of β for WV6.2/WV7.3
  - **TEMP+MSG(2,3)_old** (s87) – old set of β for WV6.2/WV7.3

Impact of new/old scheme on forecast

Old schema



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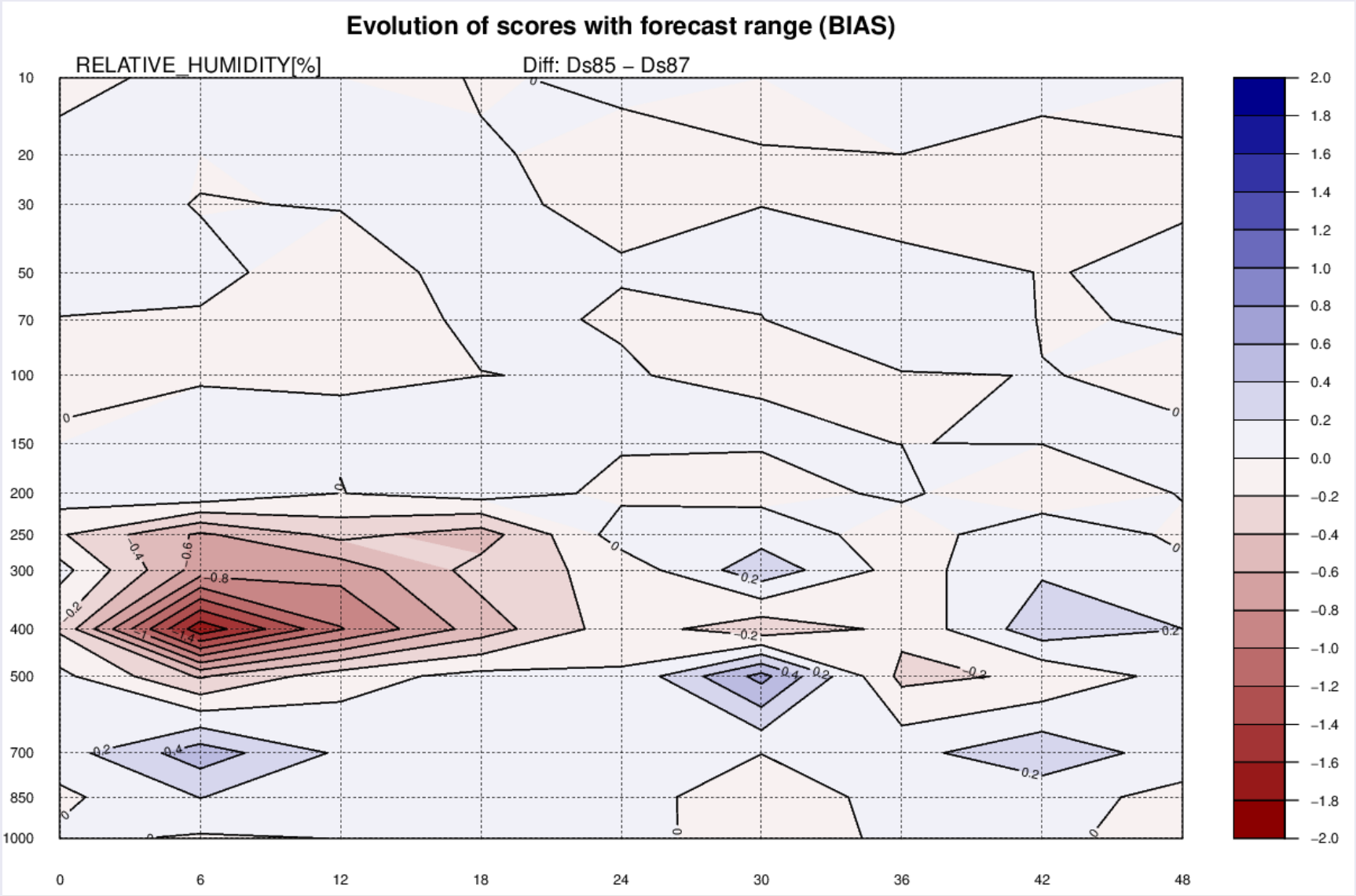

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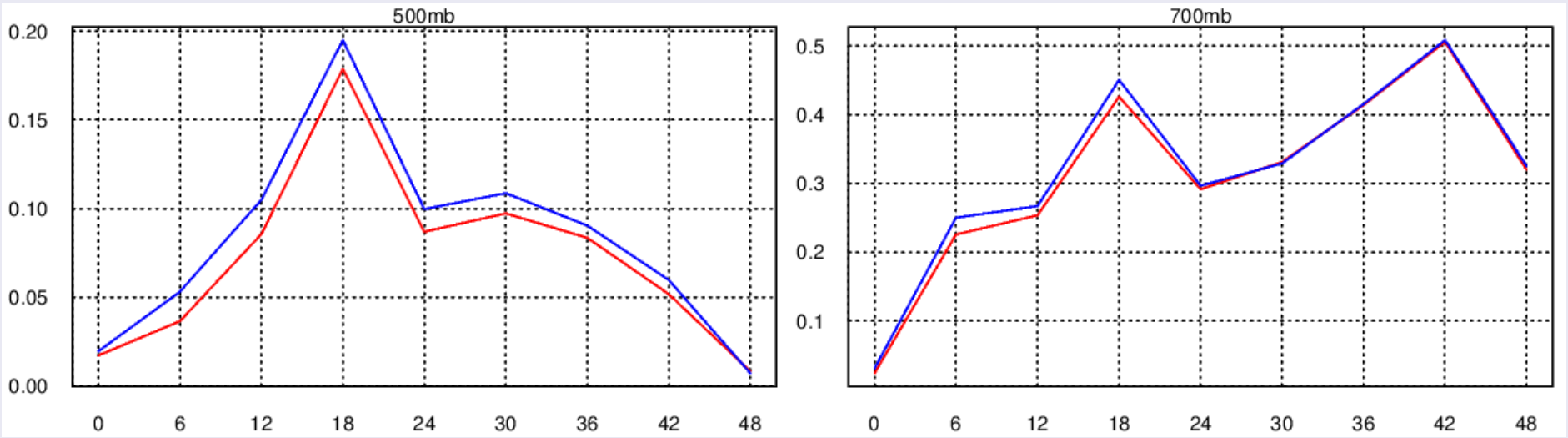

- Temperature bias [K]

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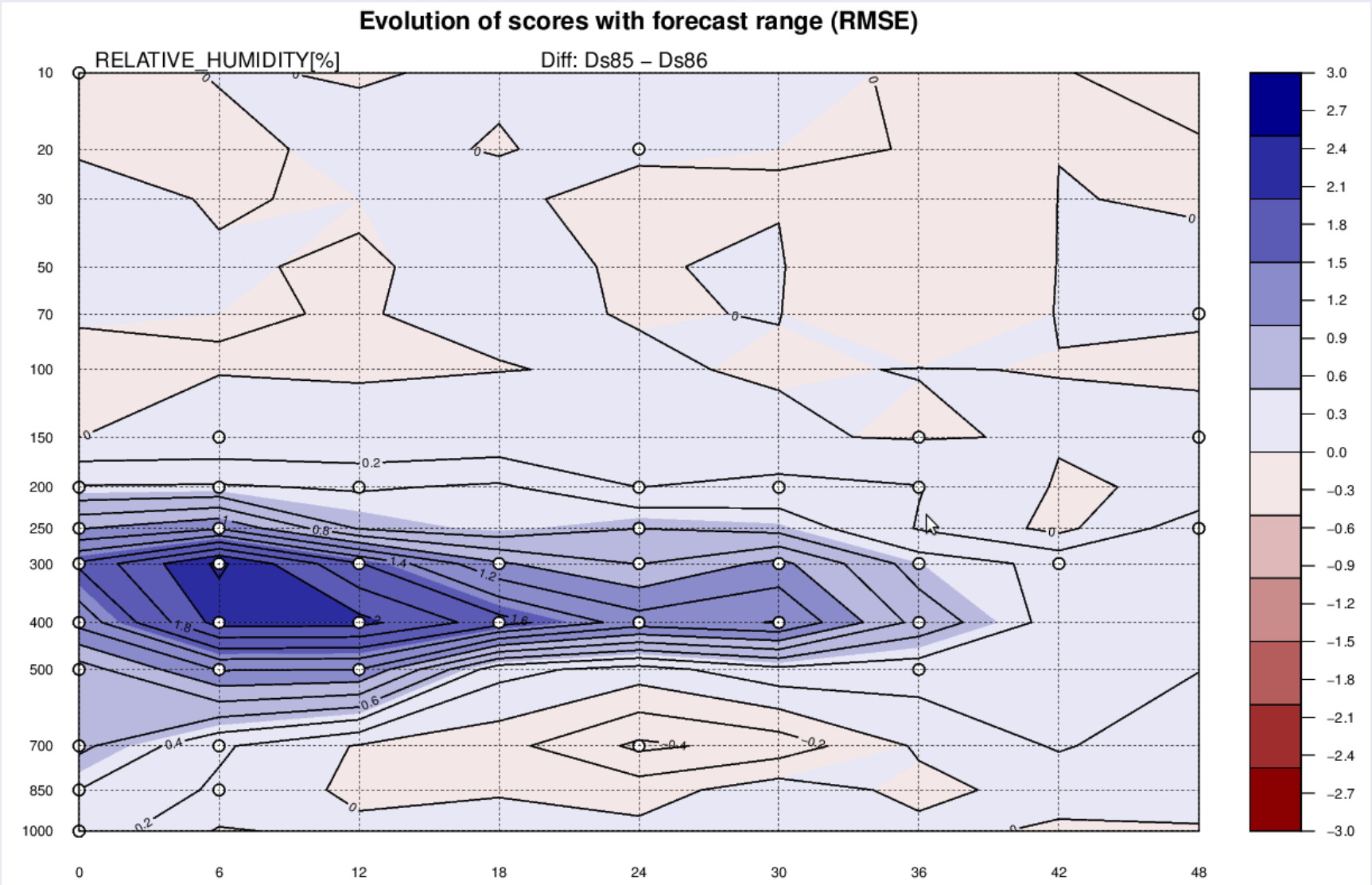
New schema



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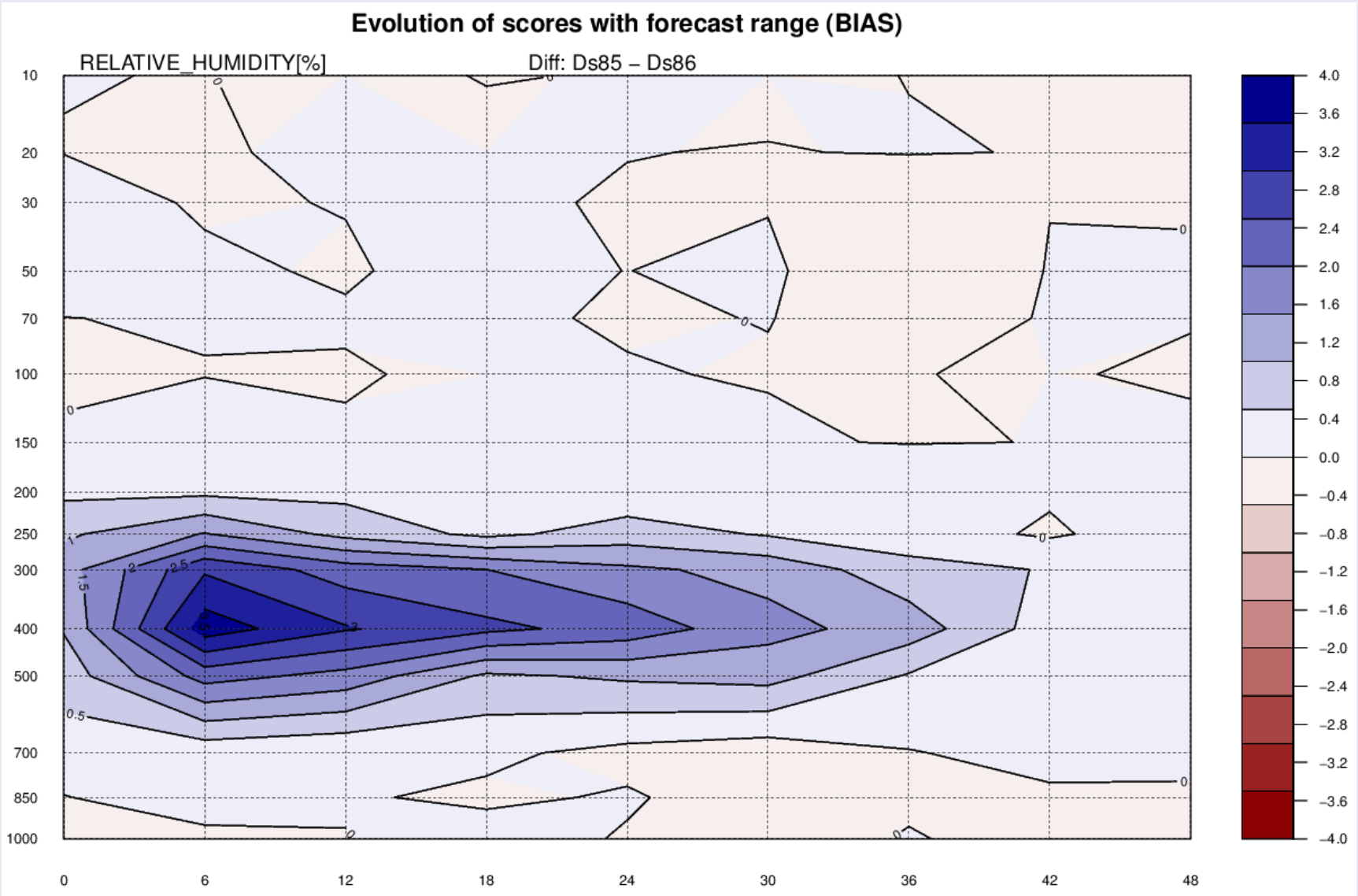

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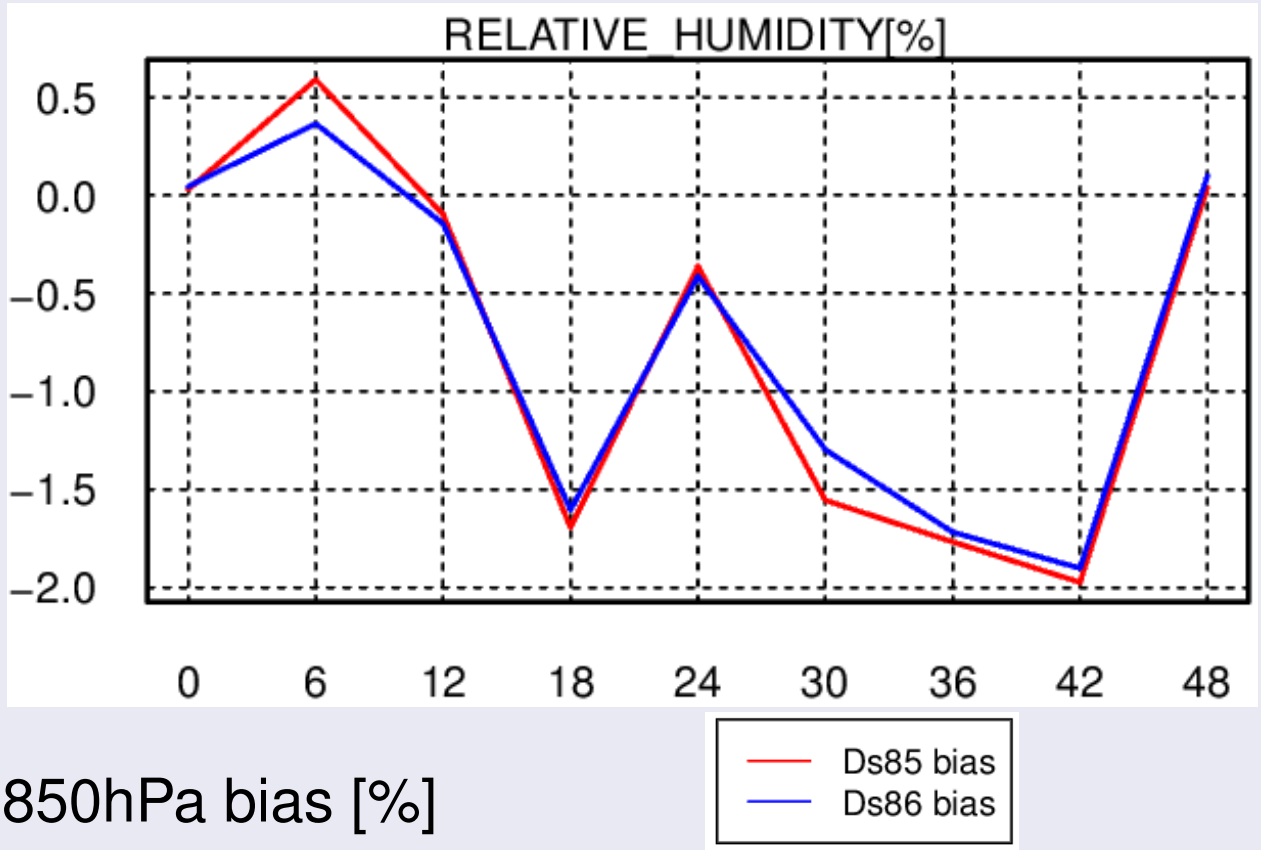

- RH 850hPa bias [%]

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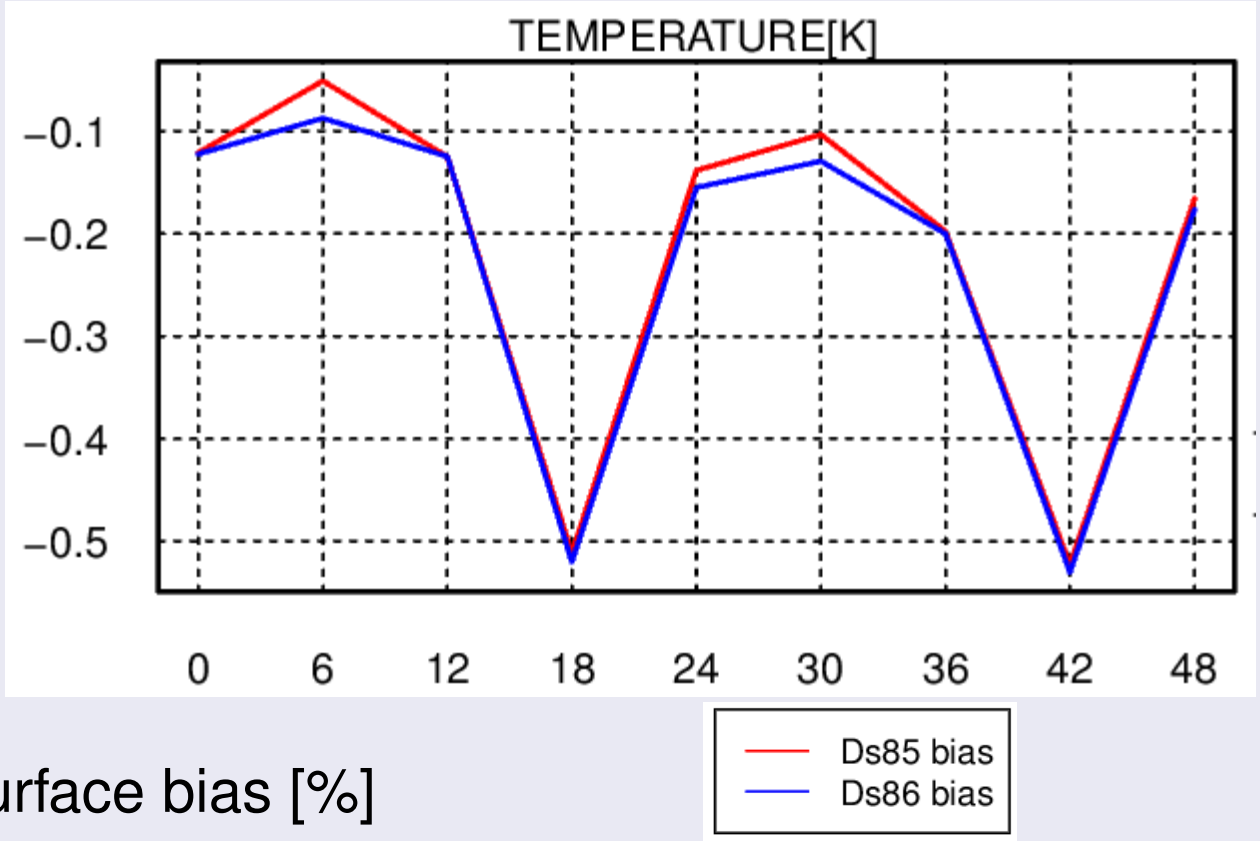

- T surface bias [%]

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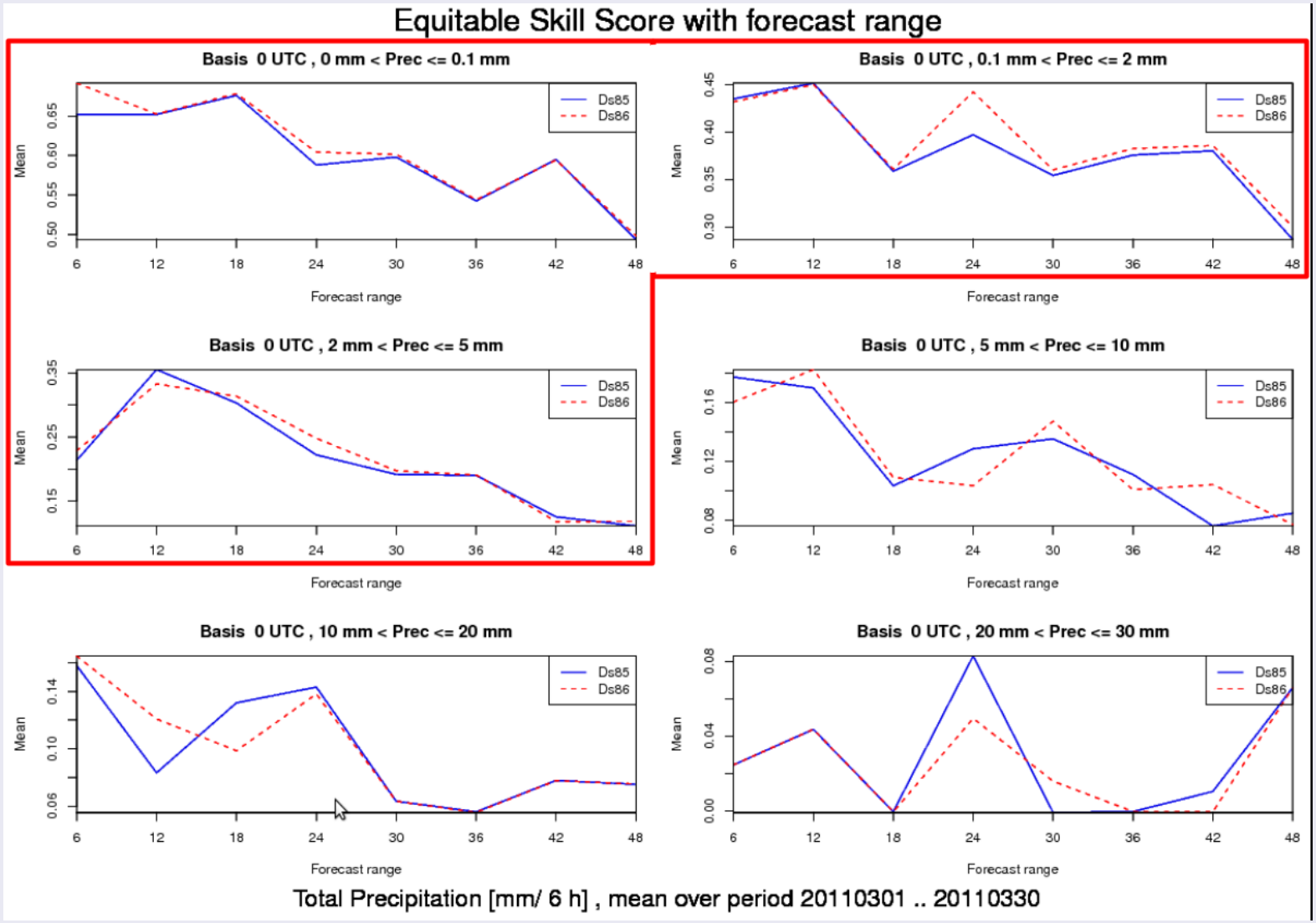
New schema



Conclusion

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- separate/identify model and satellite bias using RS measurements

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- application in assimilation system

Future plans

Model bias correction [2]

1. used the observed departures to tune NWP model parameters (physics)

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   - 3DVar is not designed to do
   - more investigation of J_b statistics/undesirable oscillation/spin-up)
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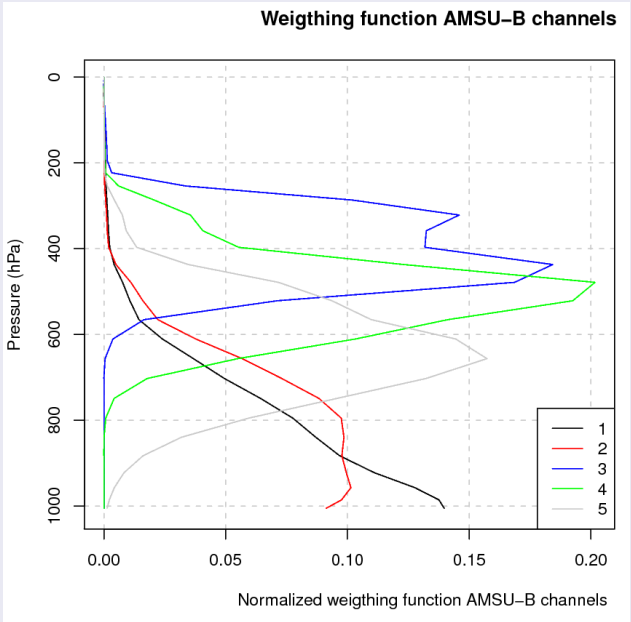
- more ideas??

Conclusion

Consequences:

- pontential problem with the high peaking H_2O absorbtion bands channels (sensor AMSU-B, MHS, IASI)



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Thank you for your attention.