On the causes of systematic biases in near surface weather parameters in the ECMWF forecasting system

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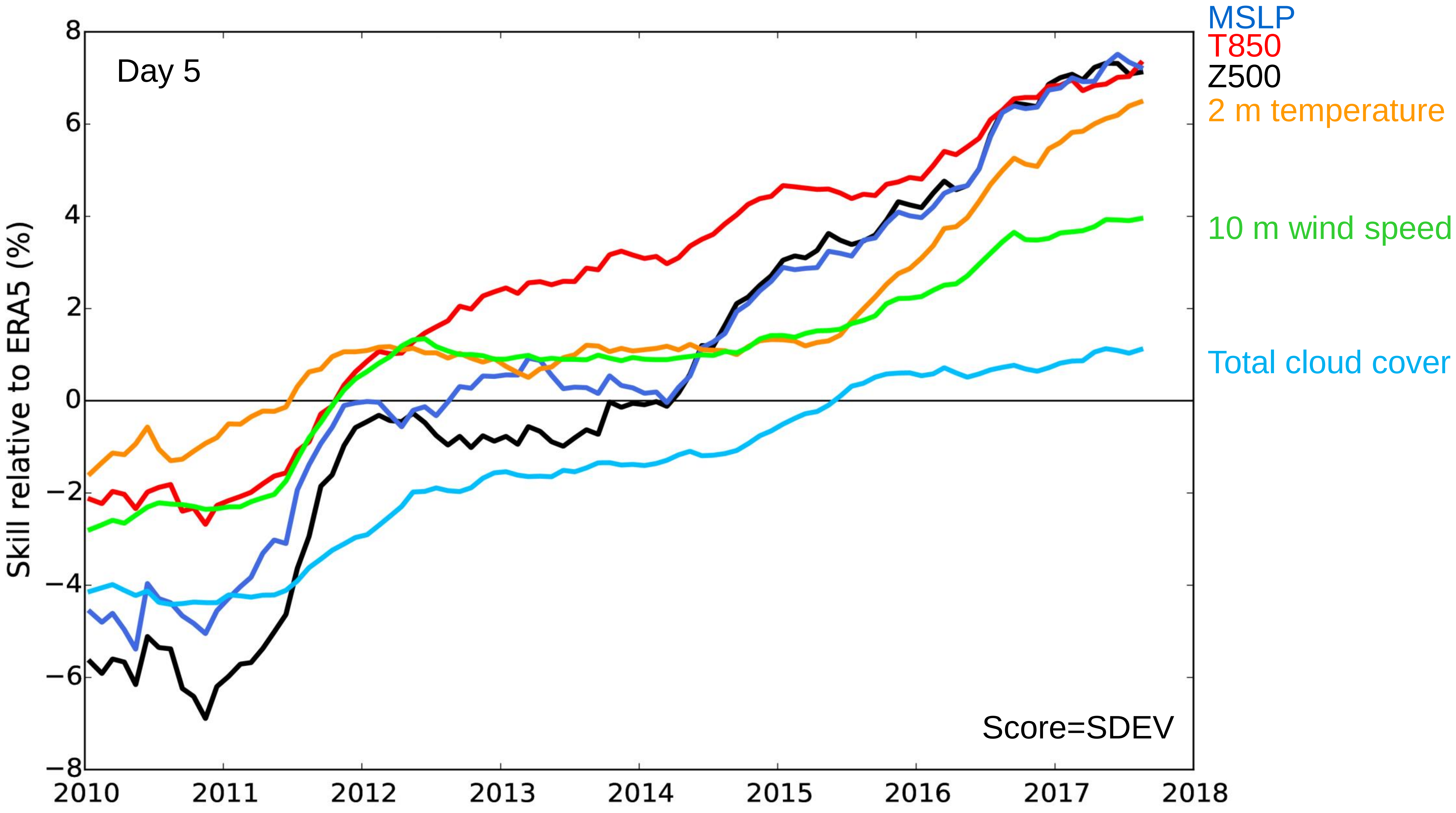
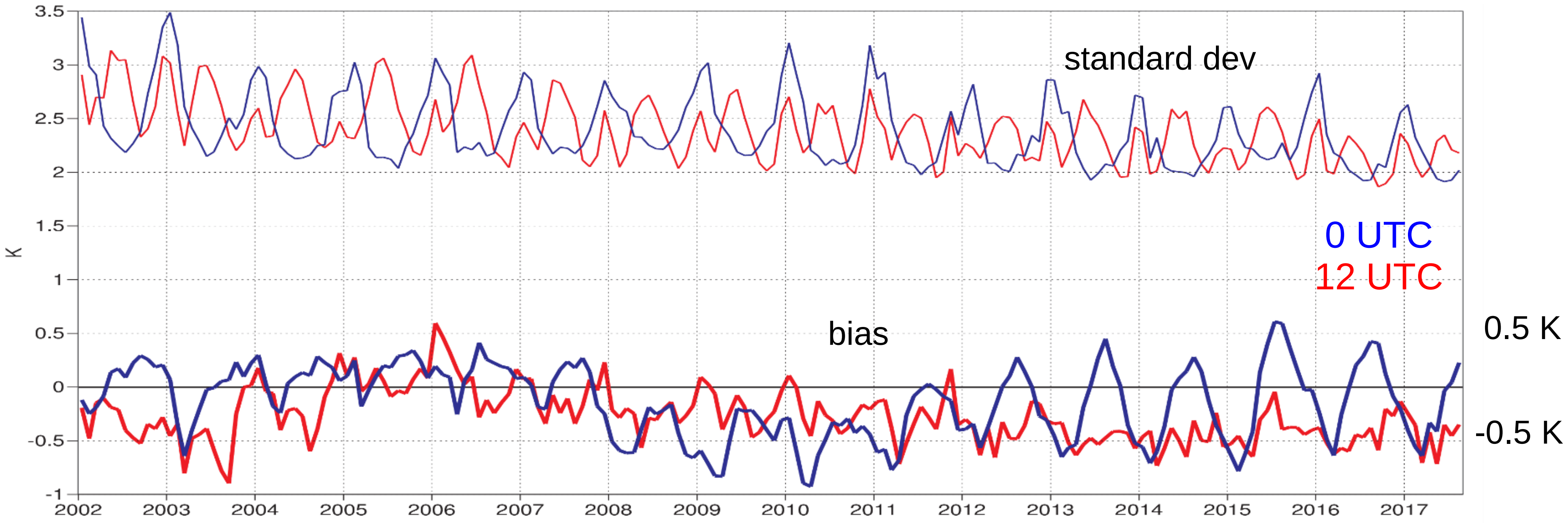
ECMWF

Continous improvements in predictions of near-surface weather parameters



However, systematic biases remain, i.e. underestimation of diurnal cycle of 2m temperature

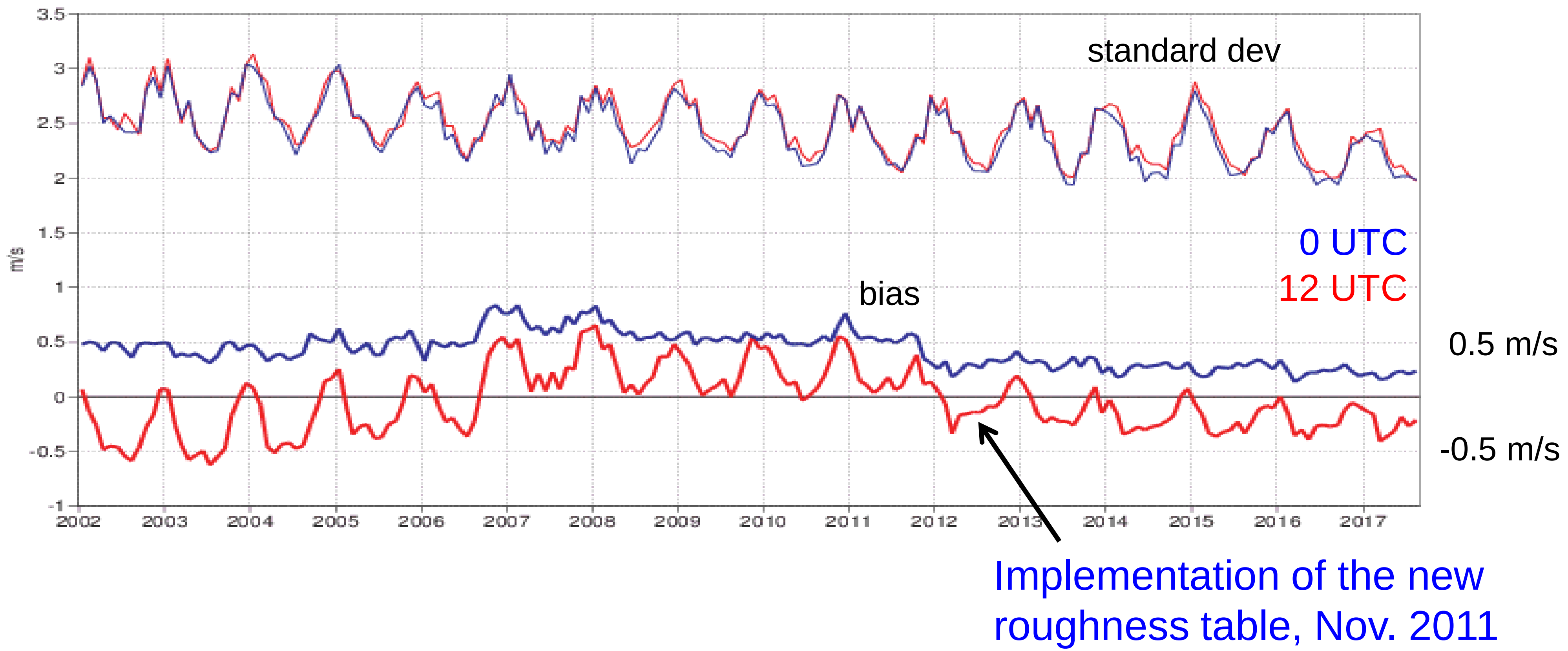
2 m temperature, day 3, Europe, all SYNOP stations



ECMWF

However, systematic biases remain, i.e. errors in wind speed

10m wind speed, day 3, Europe, all SYNOP stations



The roughness controls the magnitude of the 10m, but not the diurnal cycle

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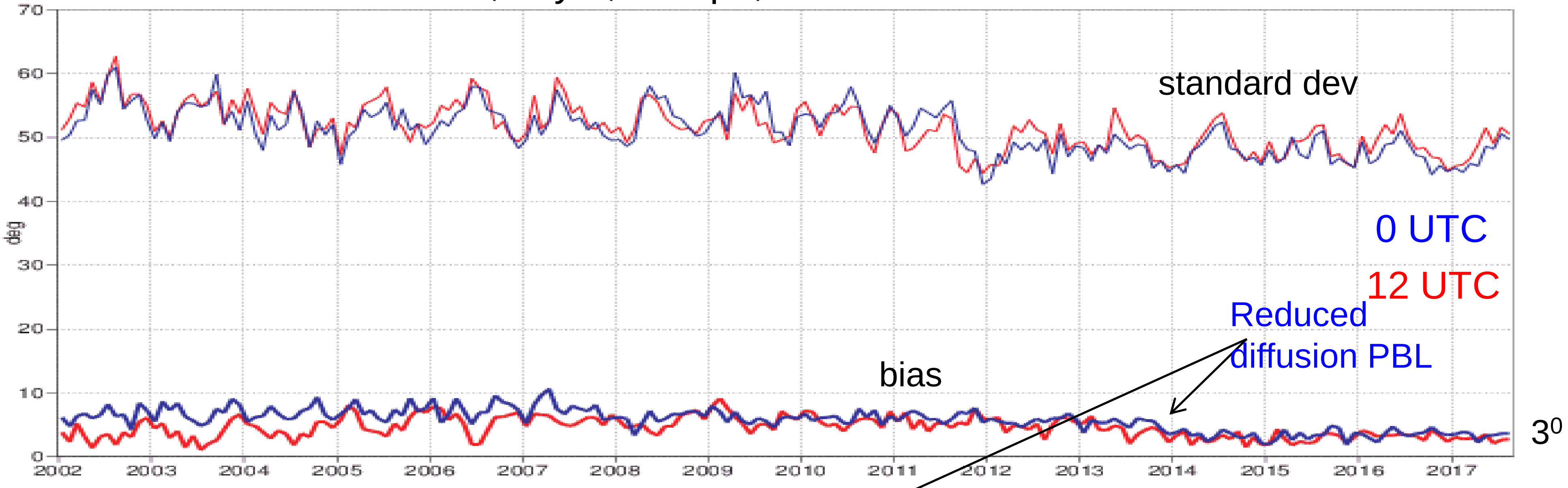
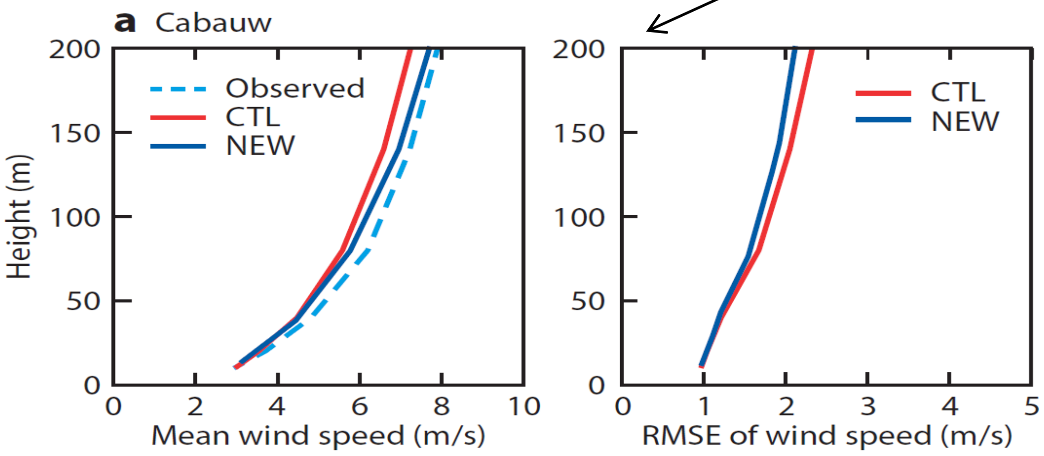
However, systematic biases remain, i.e. errors in wind direction



+ underestimation of wind turning in PBL

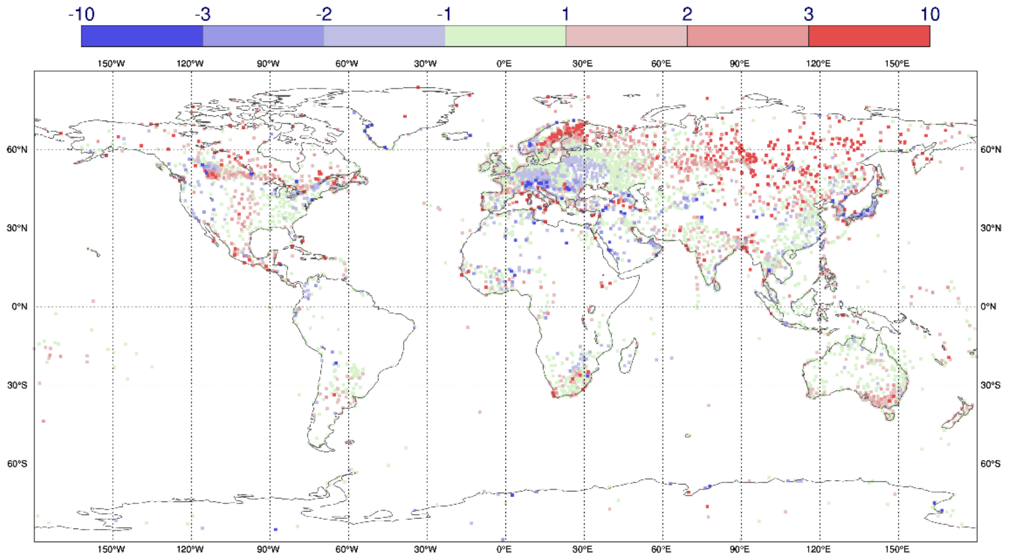


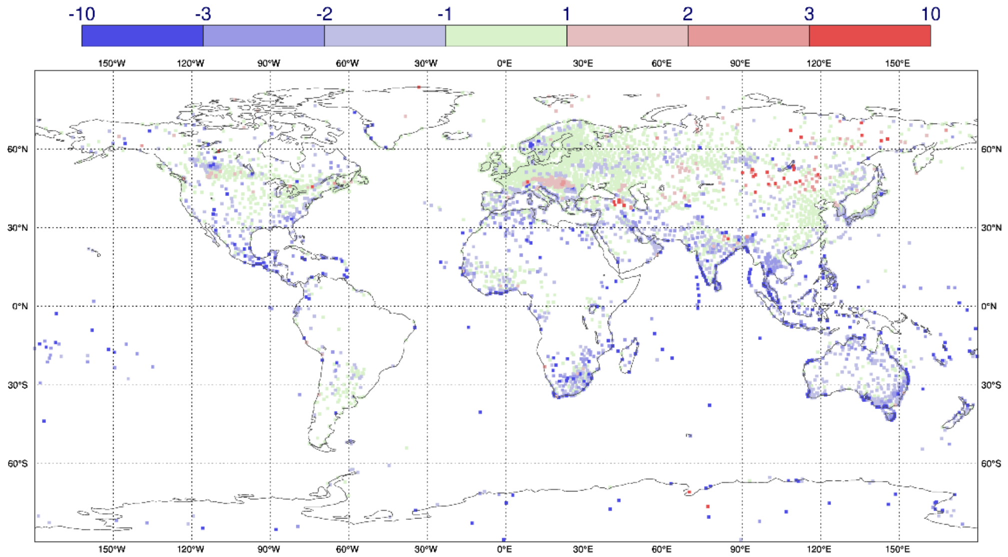
Sensitive to turbulent mixing

Less diffusion, more wind turning, stronger low level jets,etc

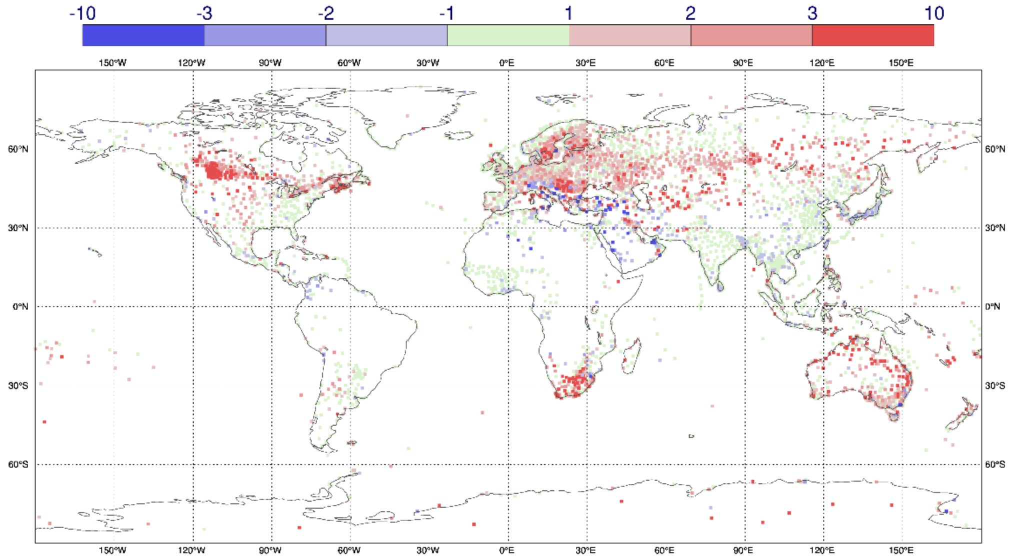
The patterns of these biases are often complex, and not straightforward to understand

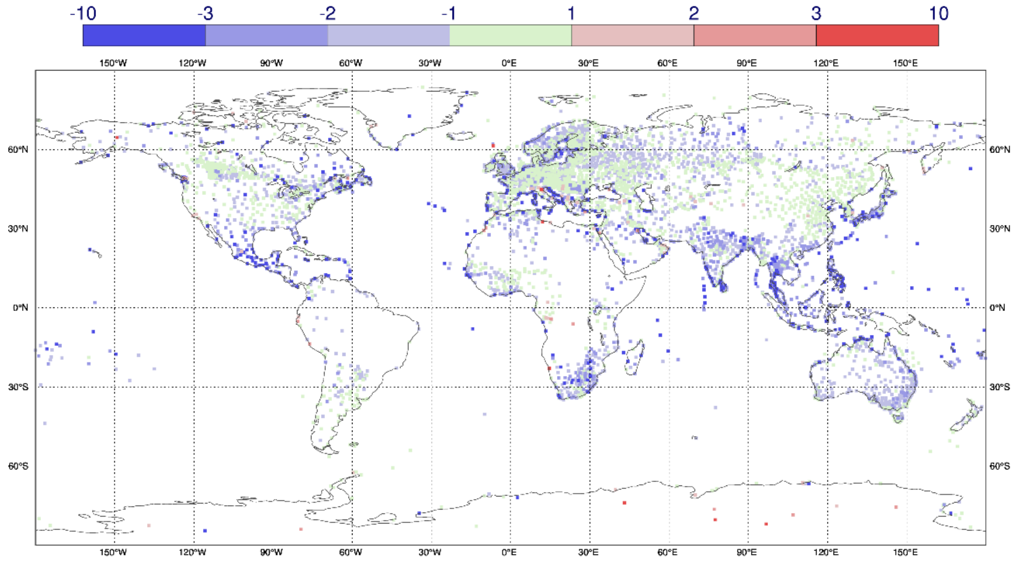
T2m MIN and T2m MAX bias – DJF 2016-17



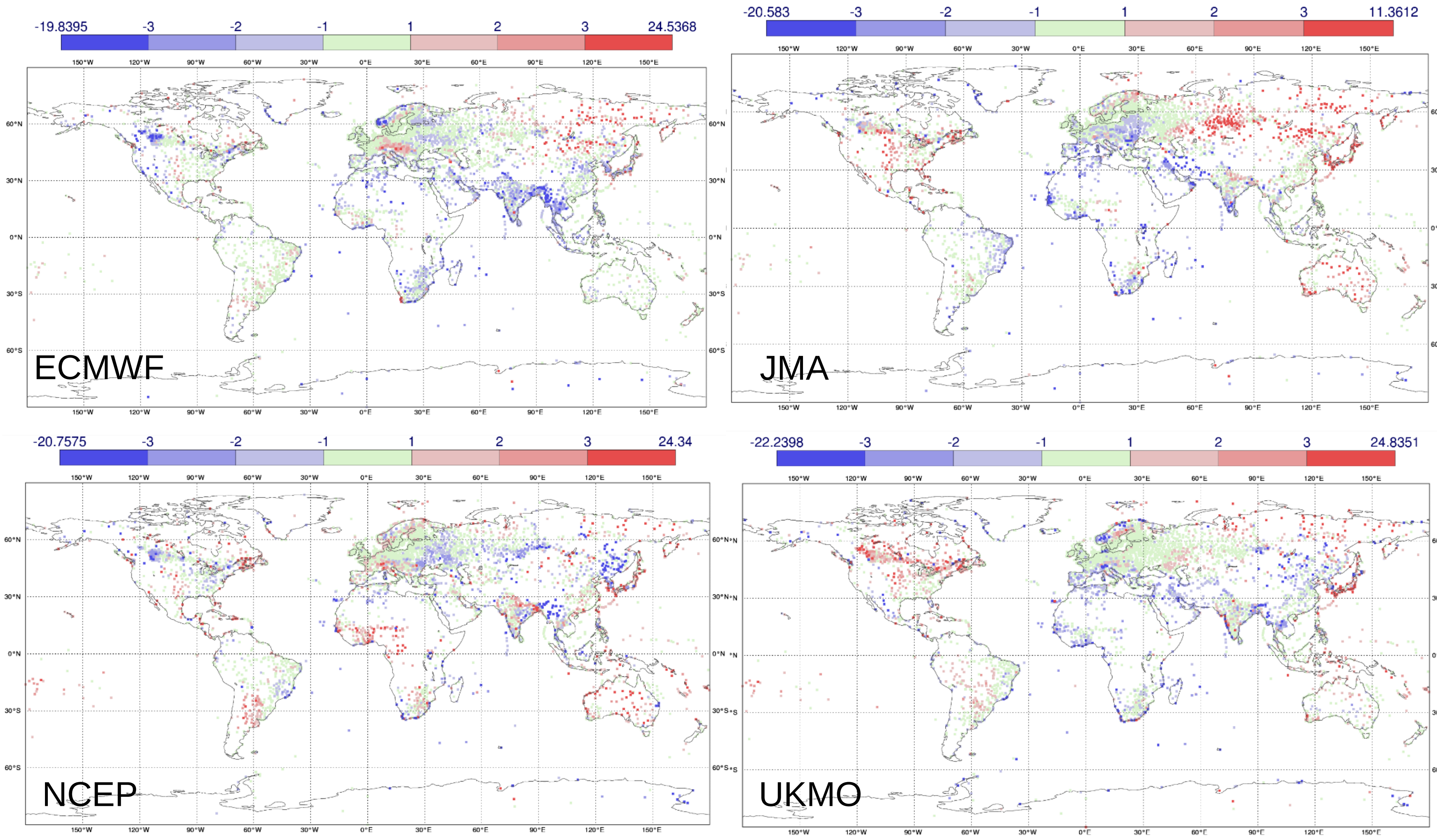


T2m MIN and T2m MAX bias – JJA 2016-17





This is not only the case for ECMWF forecasts: T2m forecasts from different centres (TIGGE)



Day 5
T2m bias
12 UTC
DJF 2016-17

An internal project focusing on ‘Understanding uncertainties in surface-atmosphere exchange’

- overview of current biases in 2m temperature and humidity and 10 wind speed and direction
- understand the main causes of these biases (multiple bias sources: clouds, surface, turbulence, radiation, etc)
- identify areas where research is needed to reduce these biases

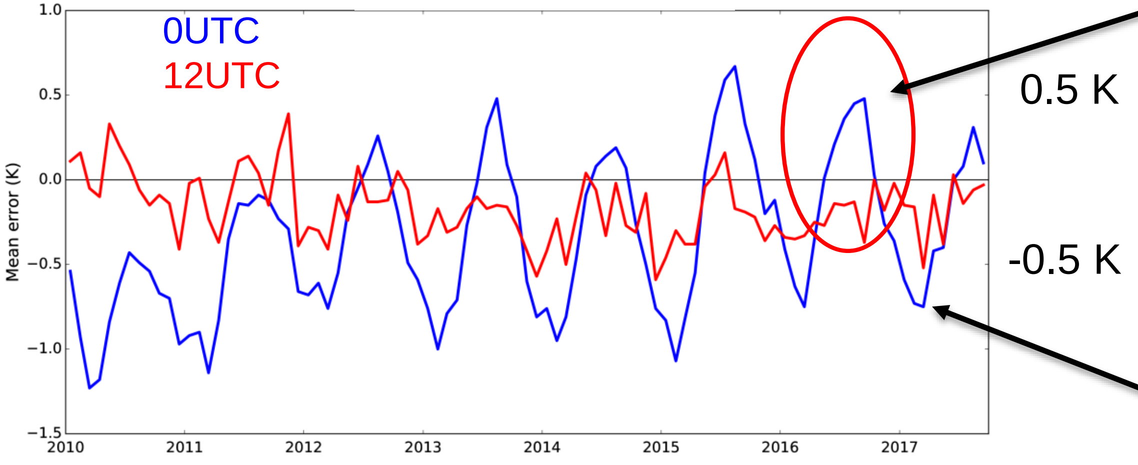
How?

- Focus on a ‘easy region’, relatively flat, no orography, away from coasts
- Do conditional verification (i.e. stratify by cloud/no cloud, etc)
- Use independent observations (radiation, meteorology from towers, etc)
- Explore the sensitivity of near-surface biases to the representation of atm/land processes (mixing, coupling, surface)

1. Biases are easier to understand when focusing on land only and no mountains

Europe, inland only, no mtns

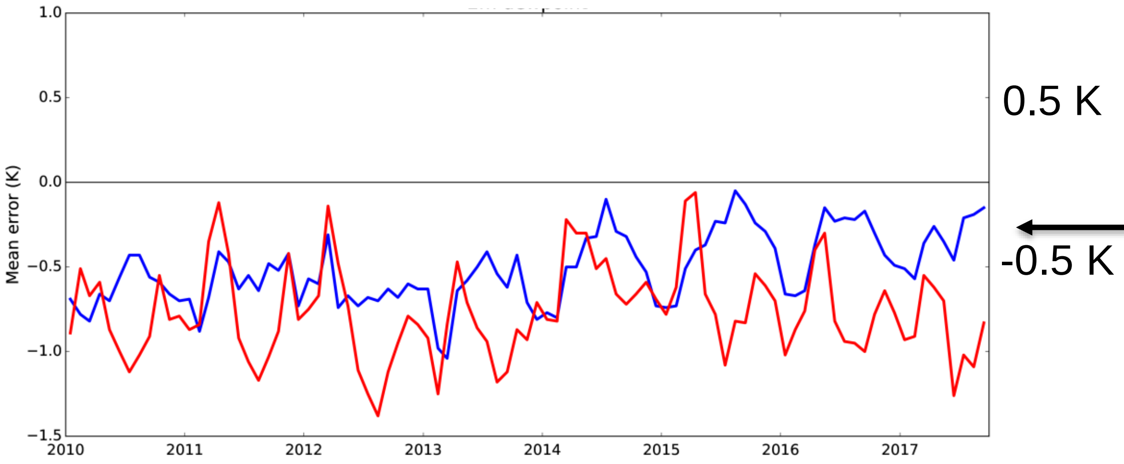
2m temperature



Diurnal cycle underestimated in summer

Too cold in winter

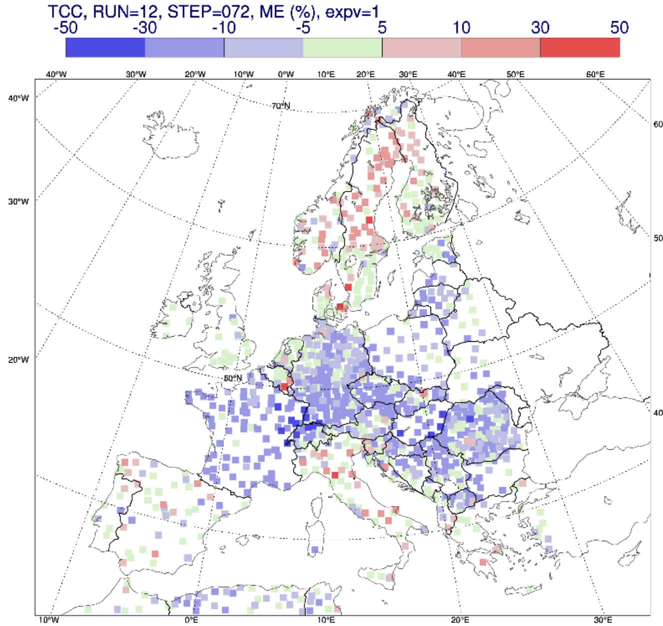
2m dew point



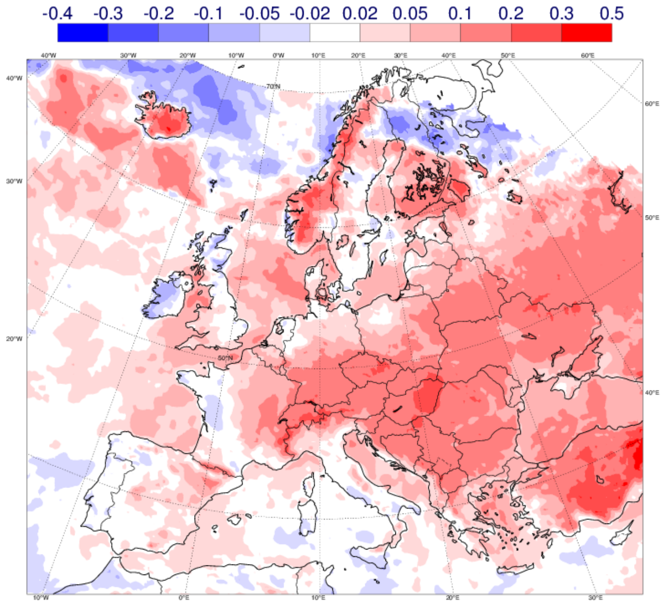
Too dry all the time

2. Cold biases in winter are primarily, though not only, due to cloud errors

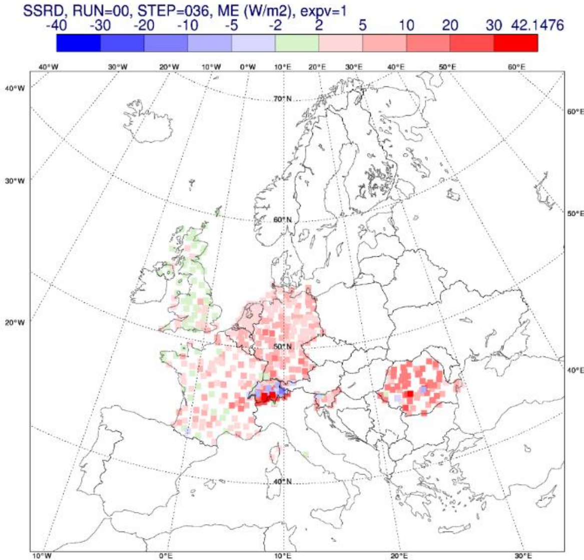
Cloudiness bias DJF 2016-17



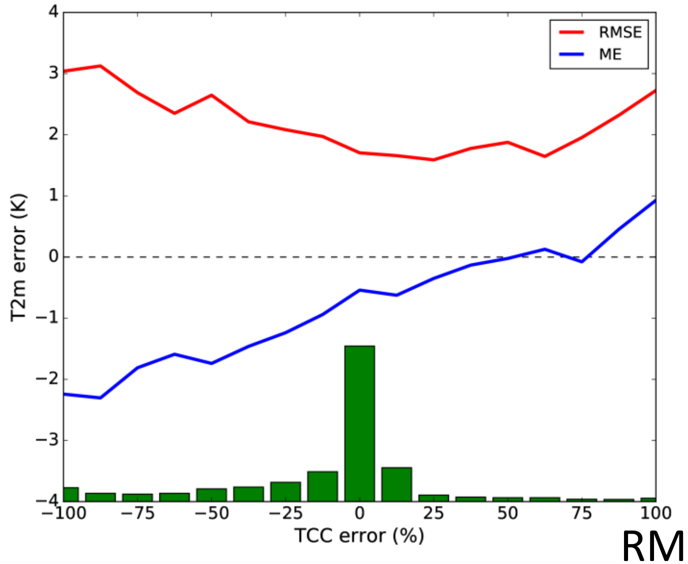
TCC error (SYNOP)



SSRD error (CM SAF)

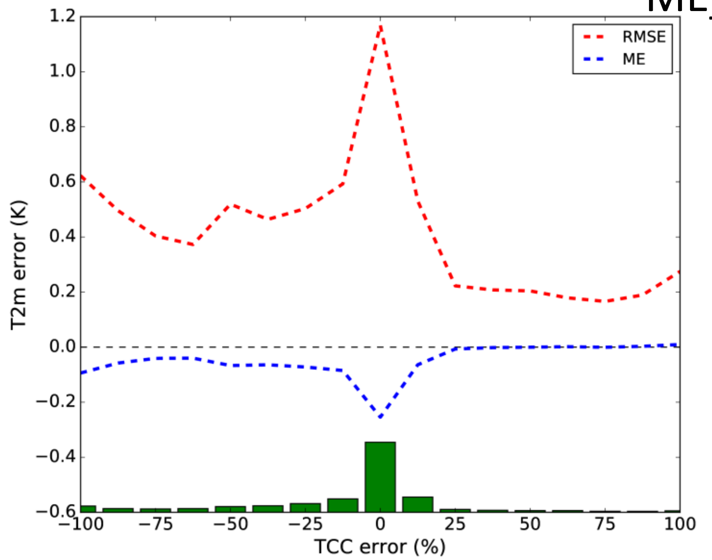


SSRD synops



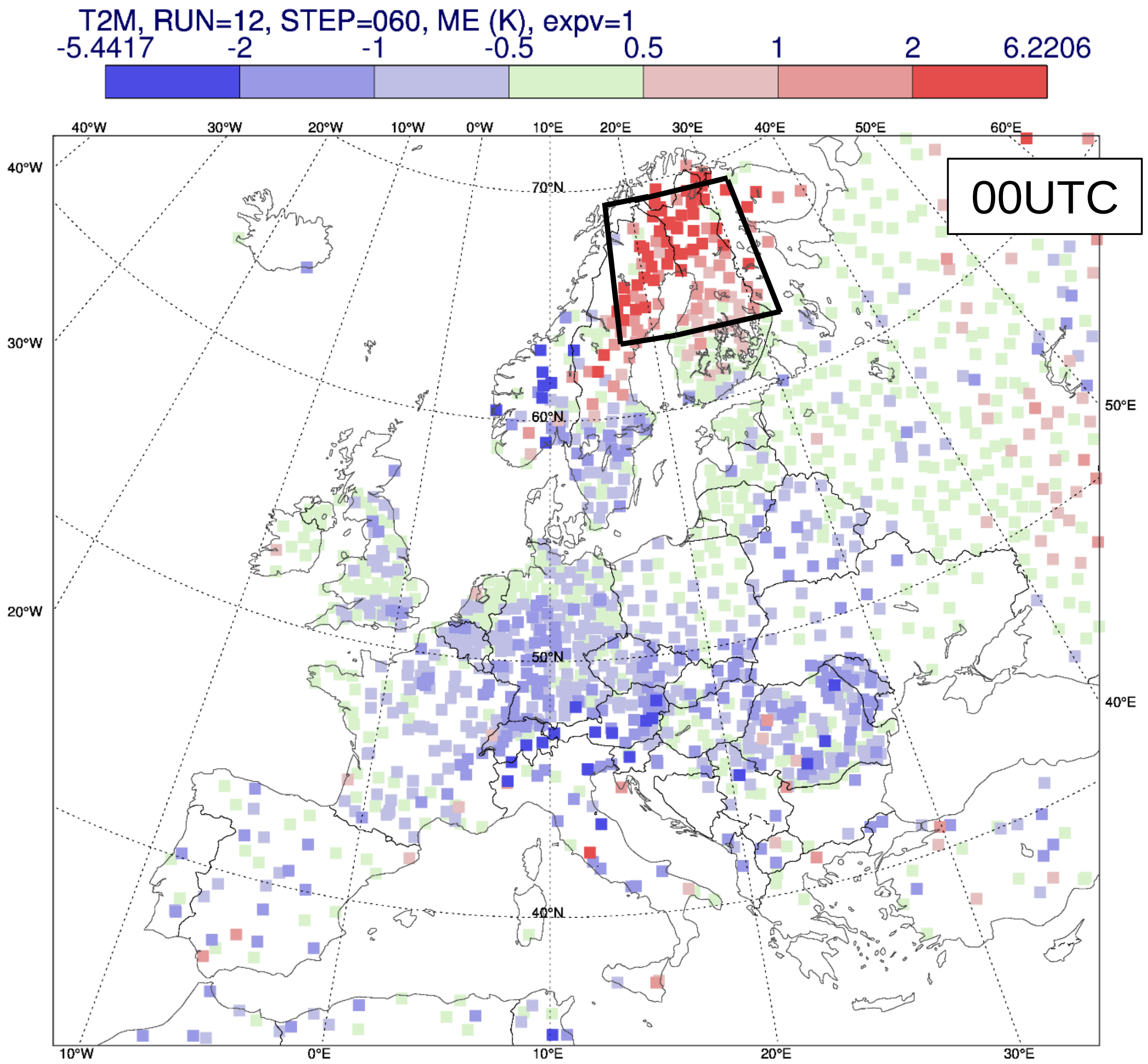
RMSE_tot = 1.99 K

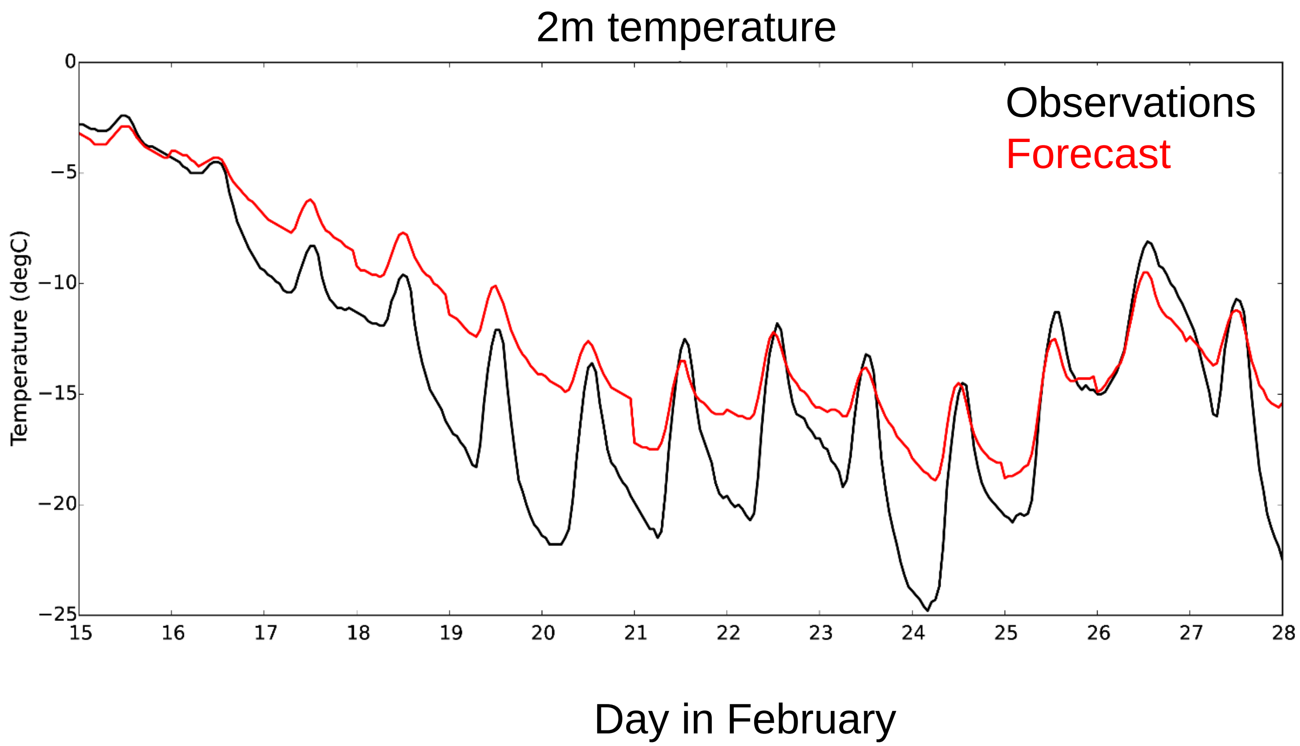
ME_tot = -0.84 K



T. Haiden

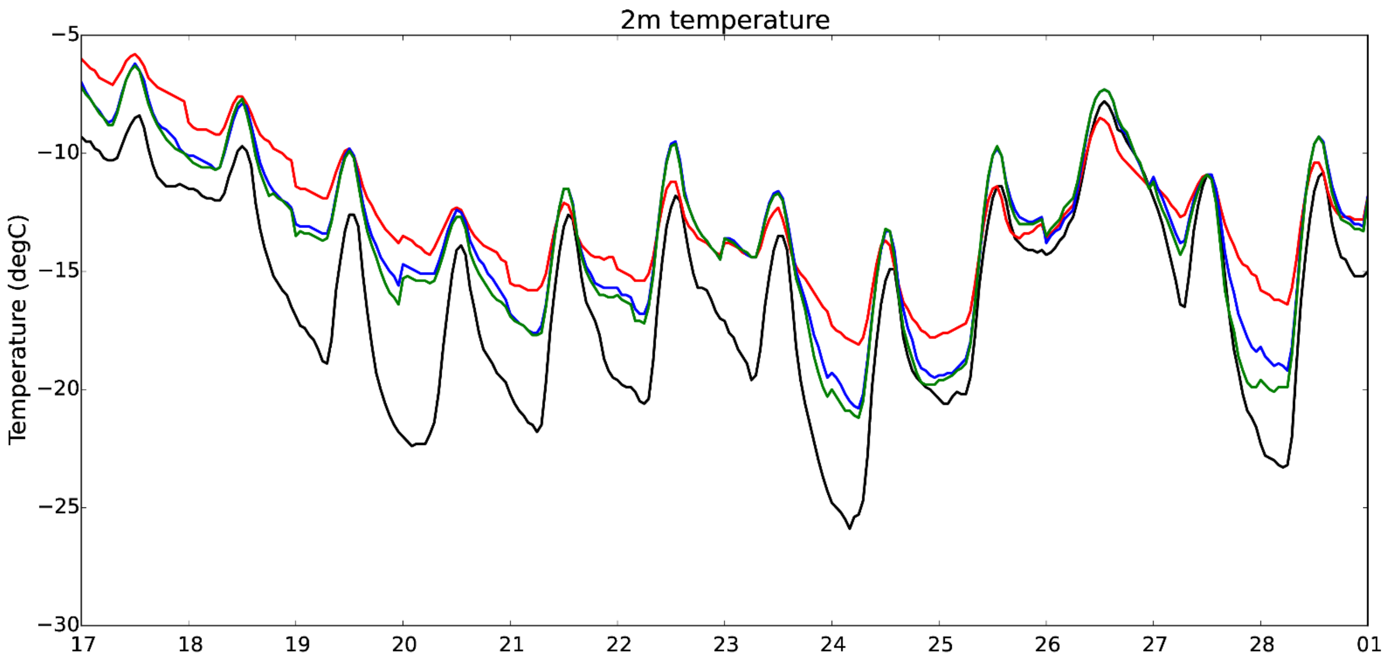
But, warm bias in winter over Scandinavia (DJF 2017/18)





T. Haiden

Warm bias in winter over Scandinavia (DJF 2017/18) – partly related to snow representation

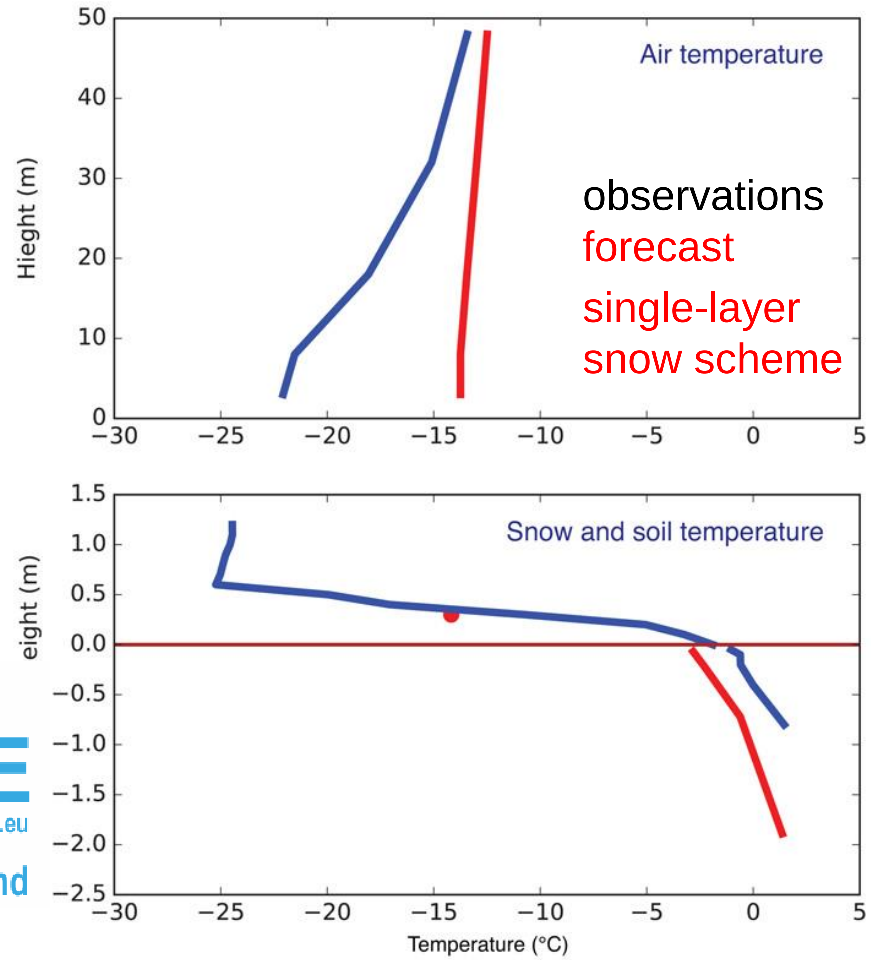


T2m Observations

T2m single-layer

T2m Multi-layer

Sodankyla, Finland



APPLICATE
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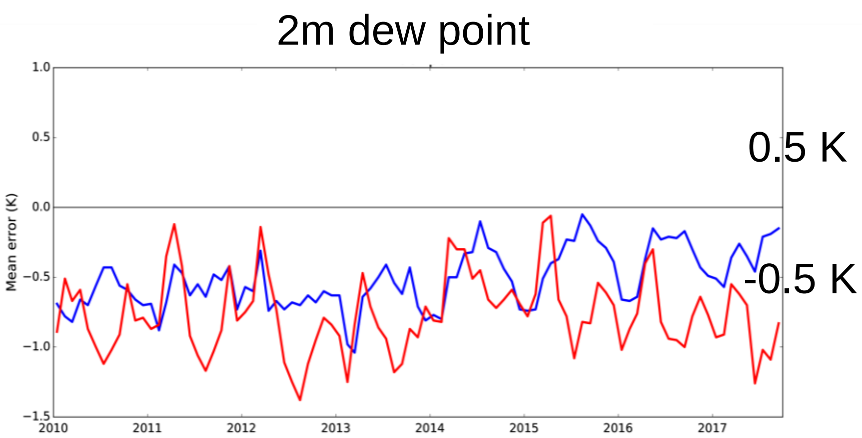
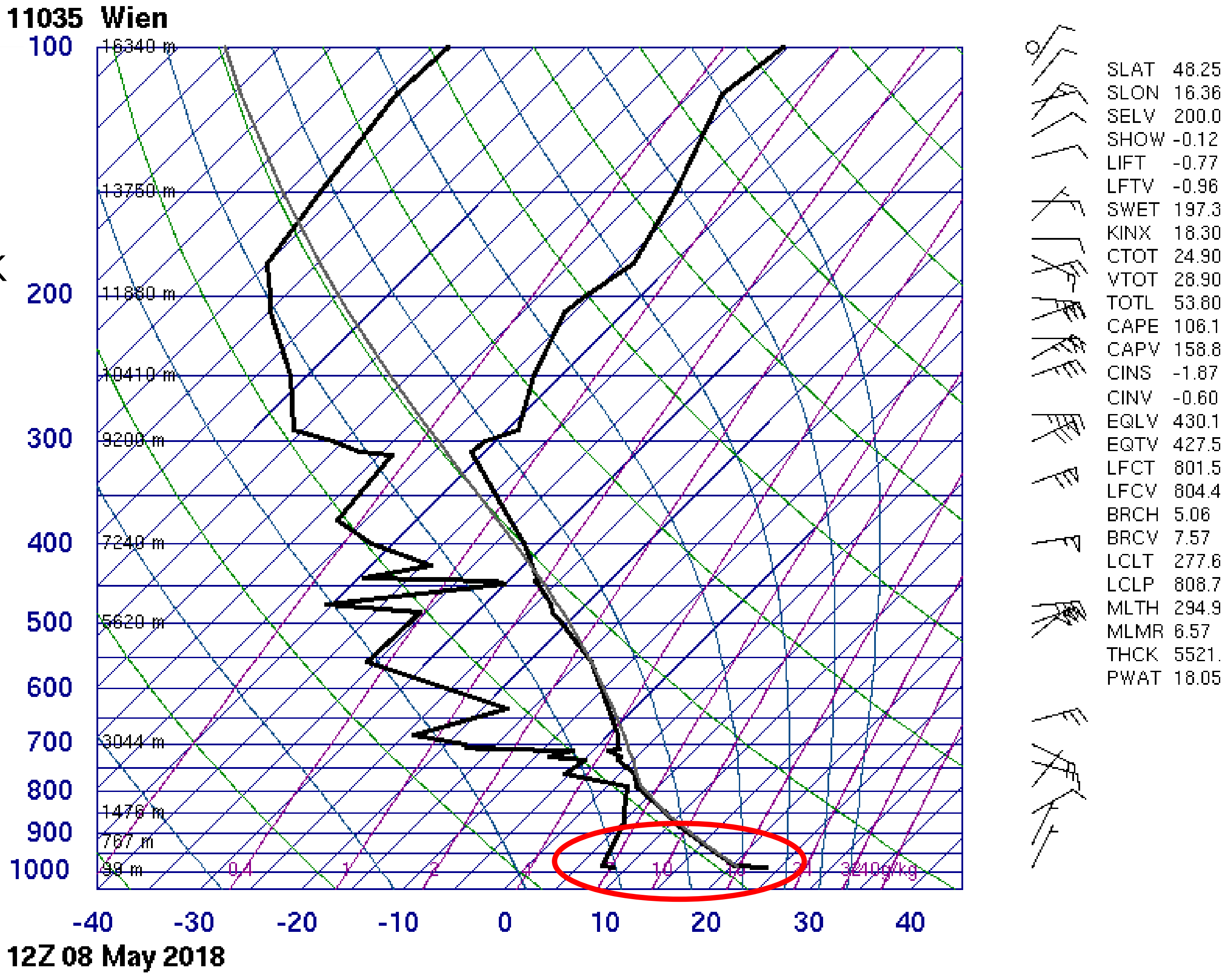
Advanced prediction in Polar regions and beyond

ECMWF

G. Arduini, J. Day, L. Magnusson

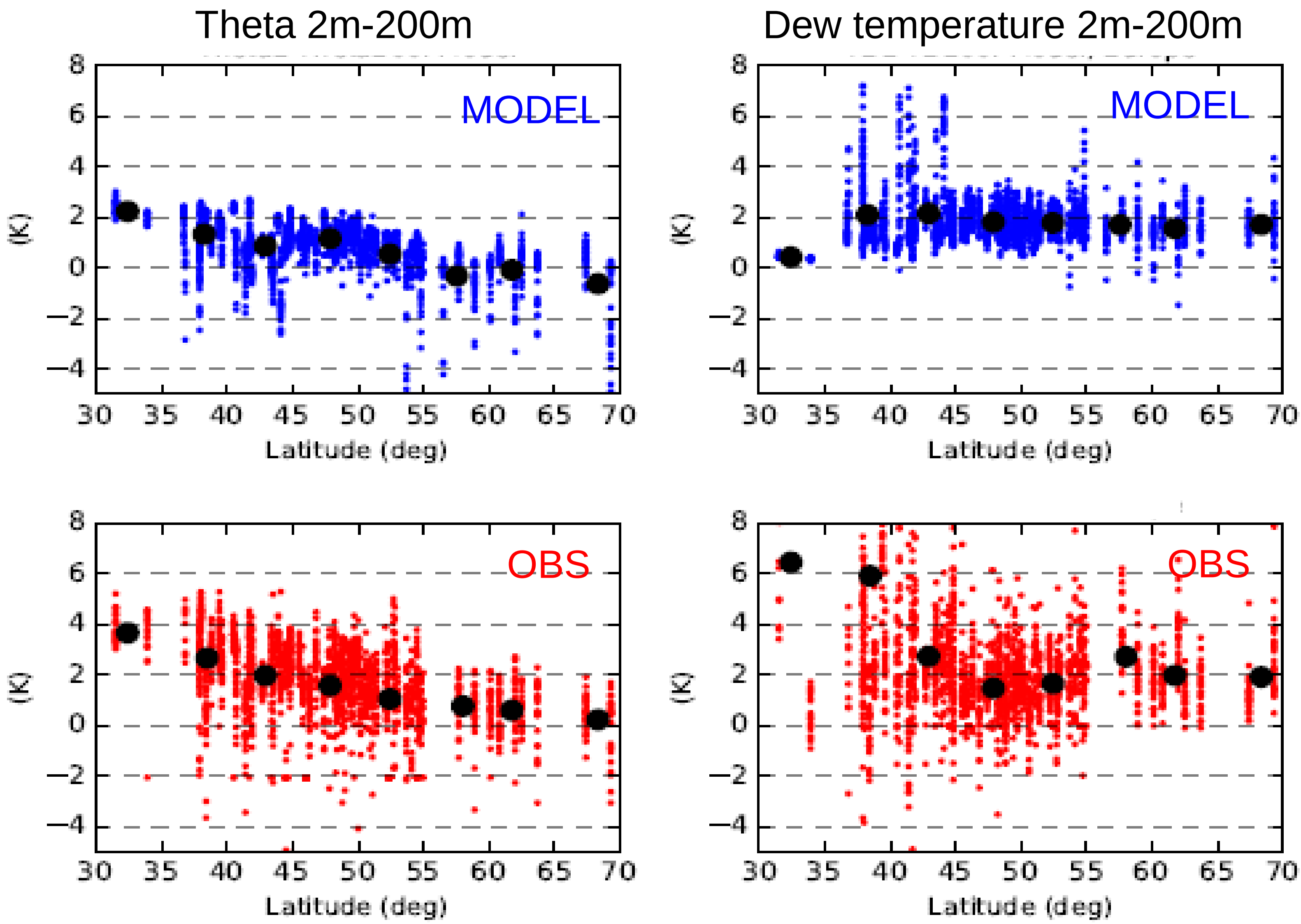
3. Dry/cold bias during summer daytime partially related to super-adiabats





ECMWF

3. Dry/cold bias during summer daytime, partially related to super-adiabats

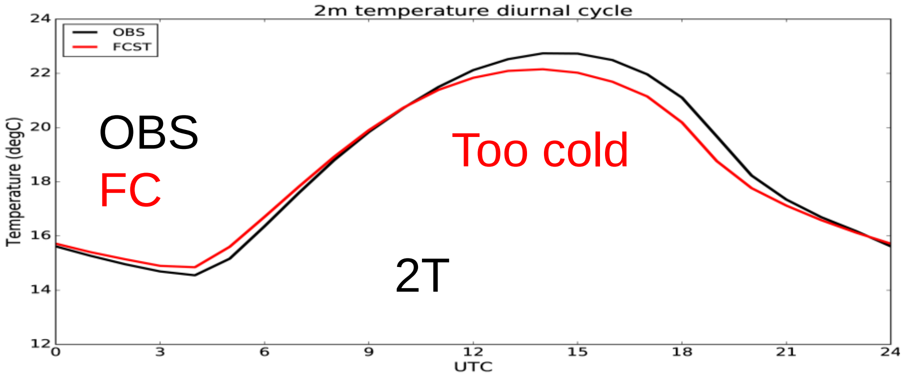


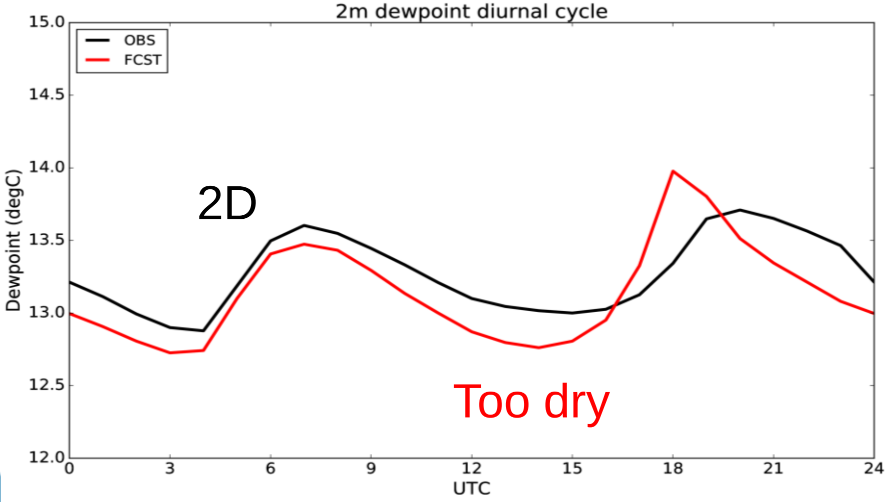
A. Beljaars

4. What controls the diurnal cycle of 2T/2D?

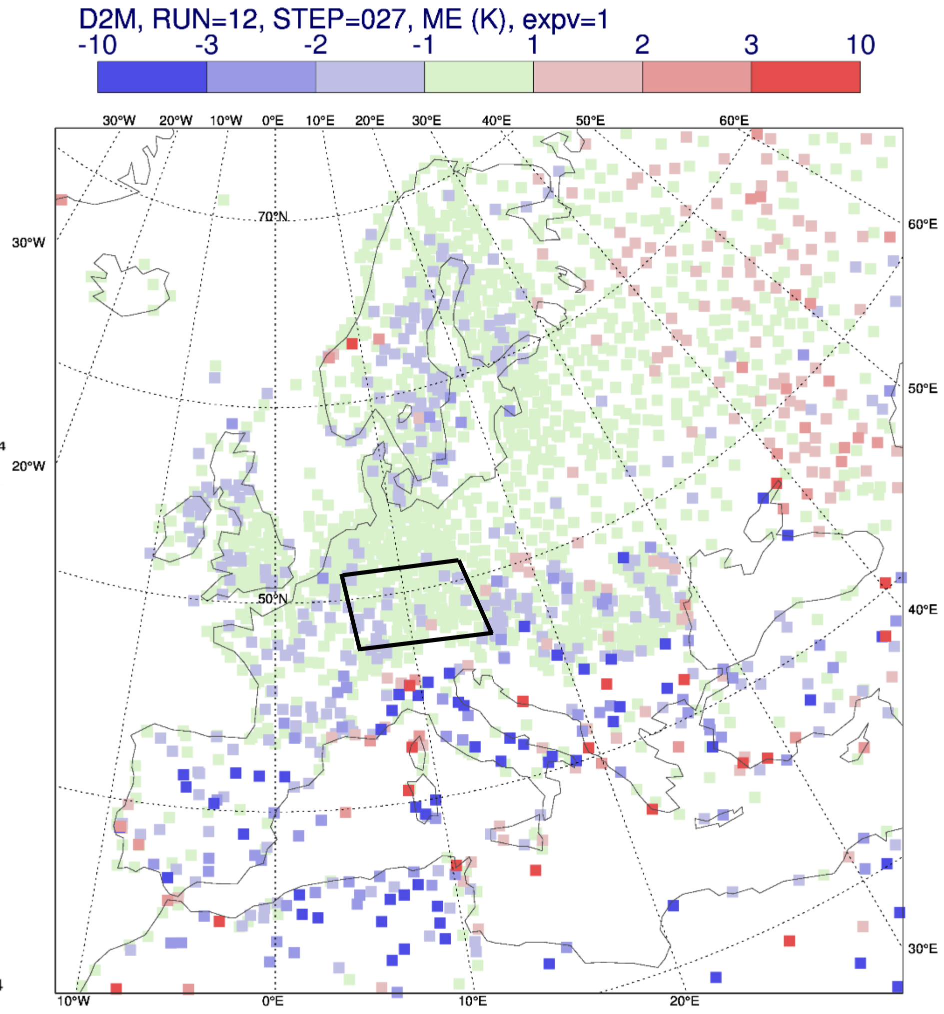
Focus on Germany (48-53N, 6-14E)

Summer june july 2017





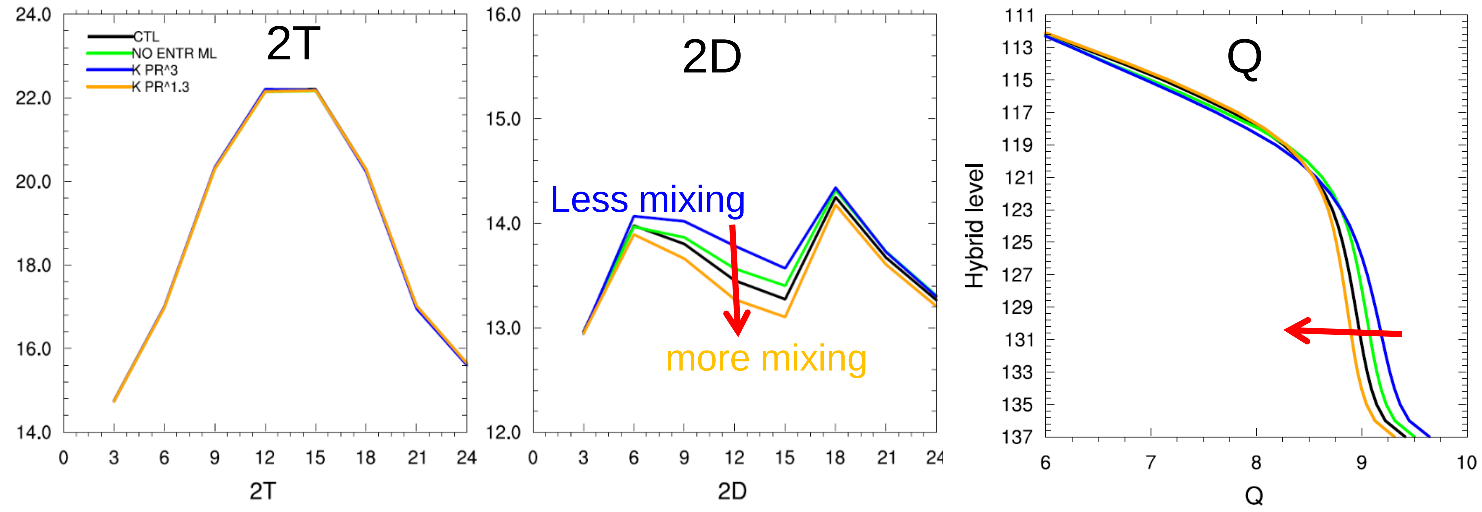
2D 15 UTC

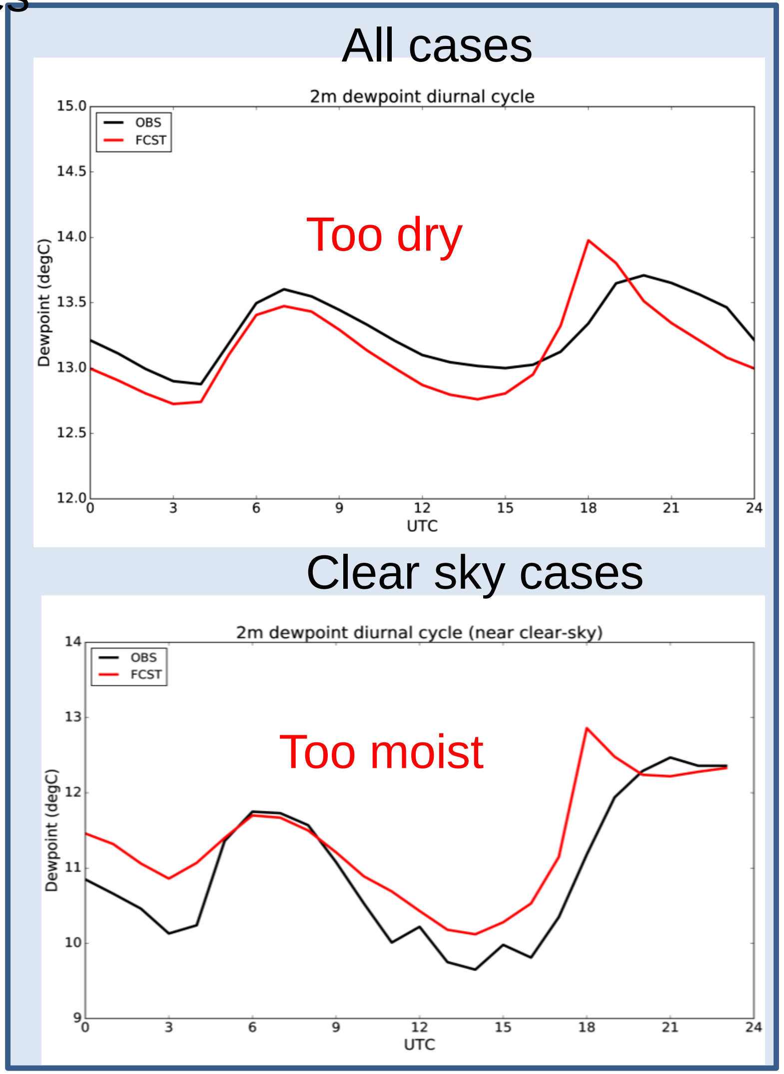


ECMWF

A comprehensive set of sensitivity experiments (TCO399 July 2016)

- 2T summer not very sensitive to mixing in PBL
- 2D/Q very sensitive to the mixing profile in the unstable PBL (also stable), mixing in cloudy PBL likely over done by the current BL/Convection schemes

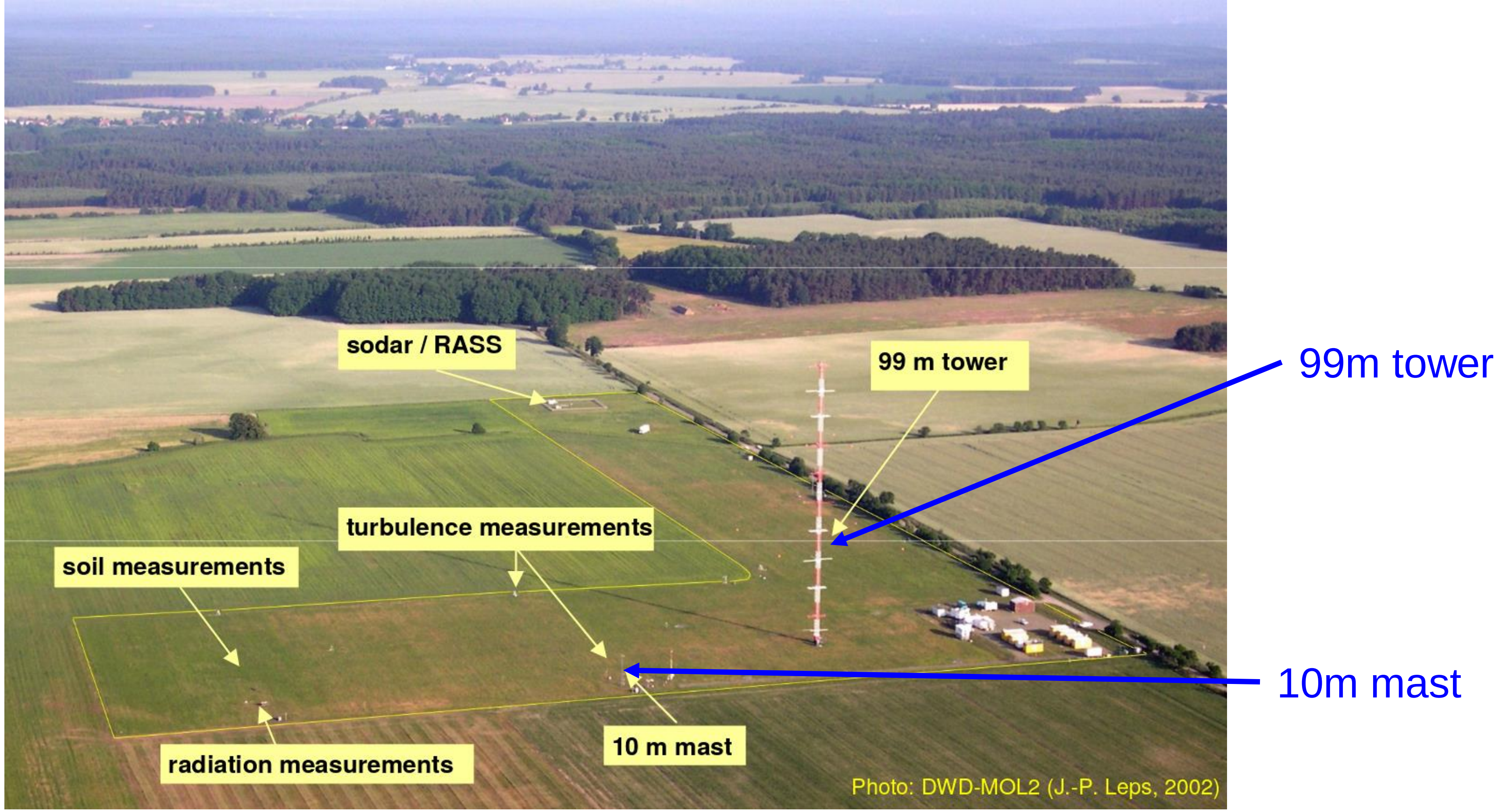




ECMWF

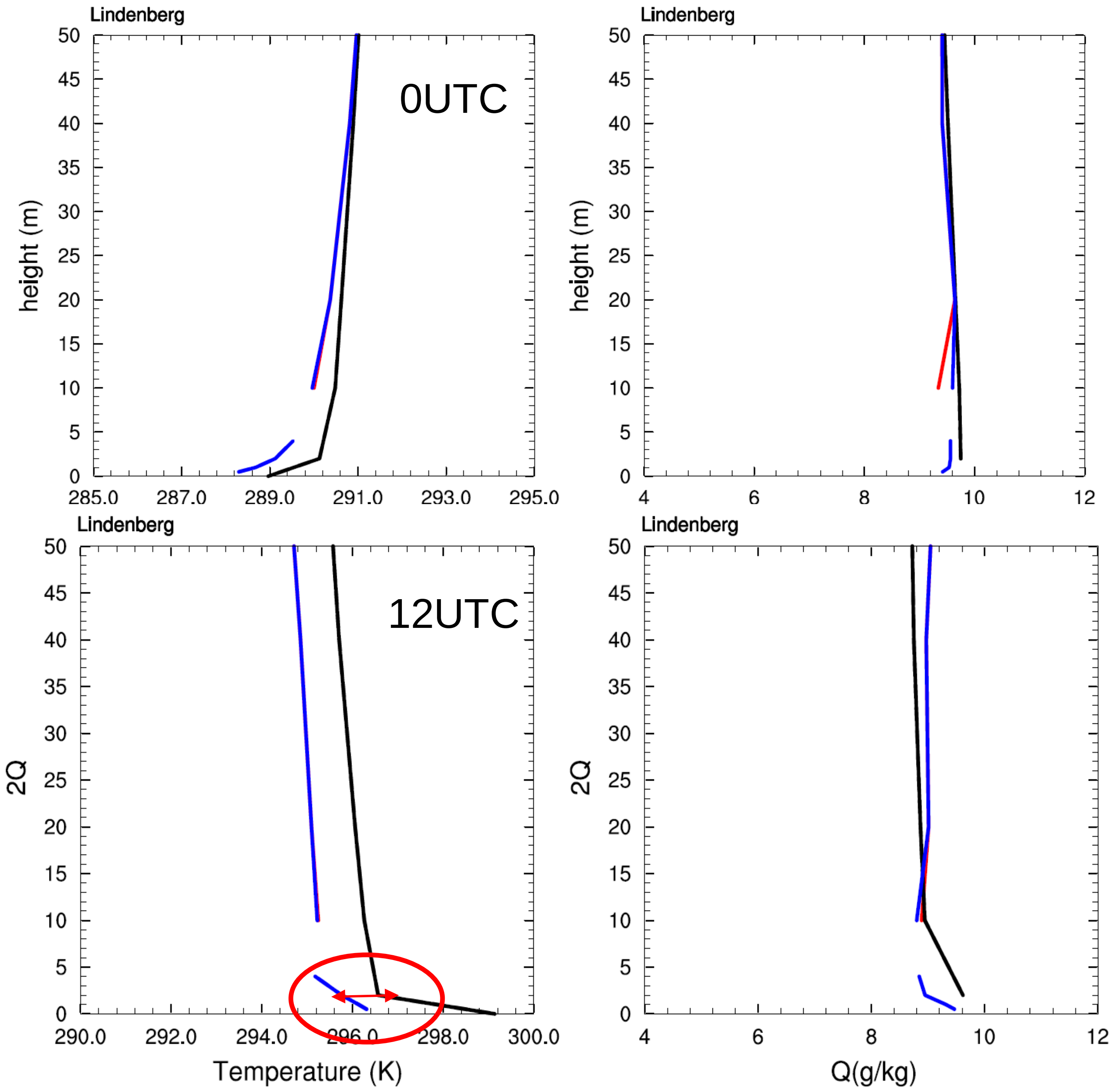
5. Tower verification to assess whether 2T/2D biases are representative of near surface biases

Comparison with Lindenberg observations (tower+mast) – July 2016



New dataset from colleagues at DWD (C. Becker and F. Beyrich)

July 2016



MODEL
OBS

Looking just at 2T/2D can be misleading, showing errors smaller than in rest of the PBL

Lessons learned so far

- T2m/D2m biases are easier to understand if focusing on inland stations and stations outside mountain areas

- Negative nighttime T2m bias in Europe in winter partly due to cloud effects; some negative bias present also if total cloud cover is ok

- Strongly positive T2m bias in Scandinavia in winter is partly due to use of single (deep) snow layer in the model (→ thermal inertia of snowpack too large → skin temperature too high);

- Underestimation of T2m/D2m during daytime in summer at least partly due to insufficient superadiabatic gradient in the surface layer

- Daytime T2m in the model resilient to changes in atmospheric mixing, while 2m humidity is sensitive to atmospheric mixing

- T2m/D2m biases not necessarily representative of biases in the lower atmosphere (being smaller than at the surface and at 50/100m). This highlights the importance of tower verification.