



On Θ -peaks and wild updrafts

Ulrich Blahak

DWD

with warm thanks to Oliver Fuhrer,
Matthias Raschendorfer and Bodo
Ritter!

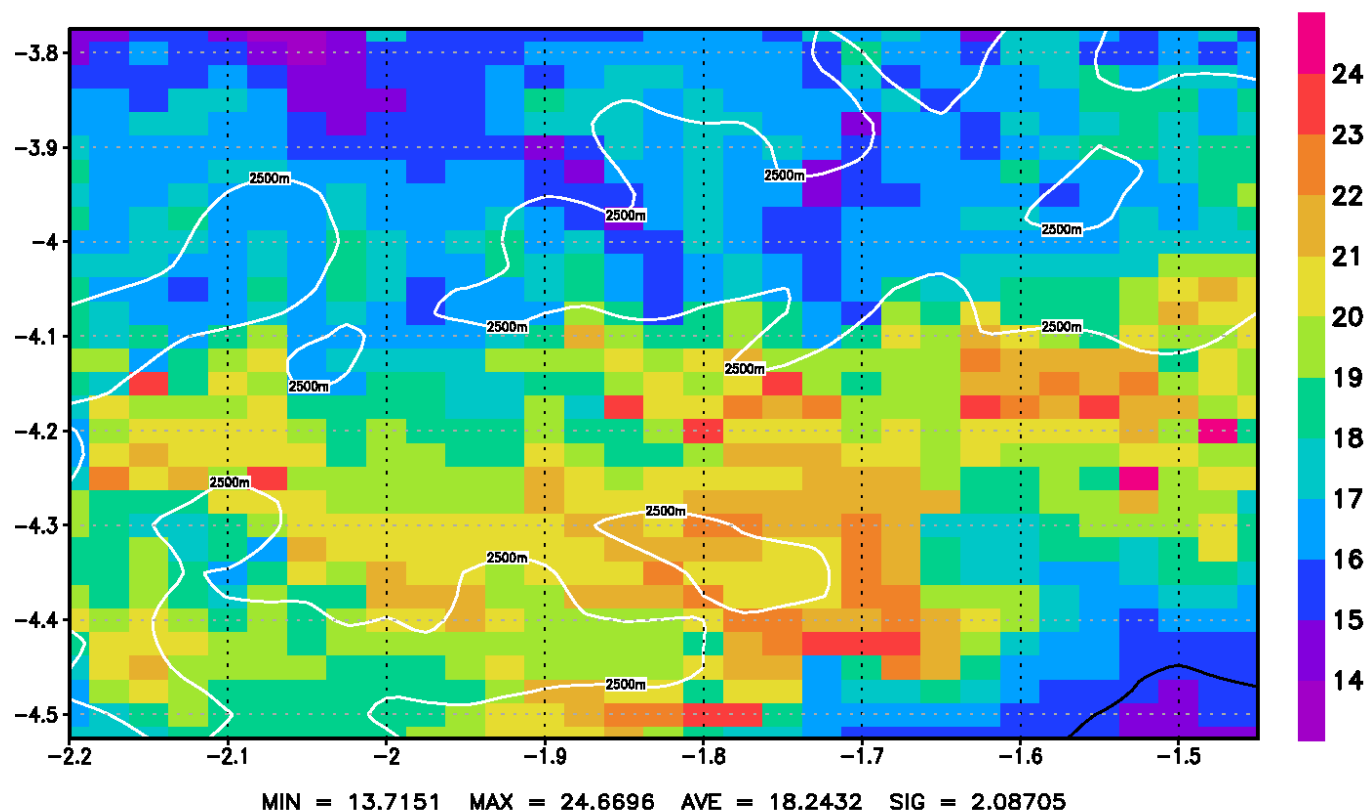


Problem

- The COSMO-model generates, in conjunction with small-scale thermally driven circulations, „strange“ effects such as isolated „ Θ -peaks“ in alpine valleys, or as „grid point storms“ in mountaineous regions or at coasts (visible as isolated surface pixels with very high precipitation).

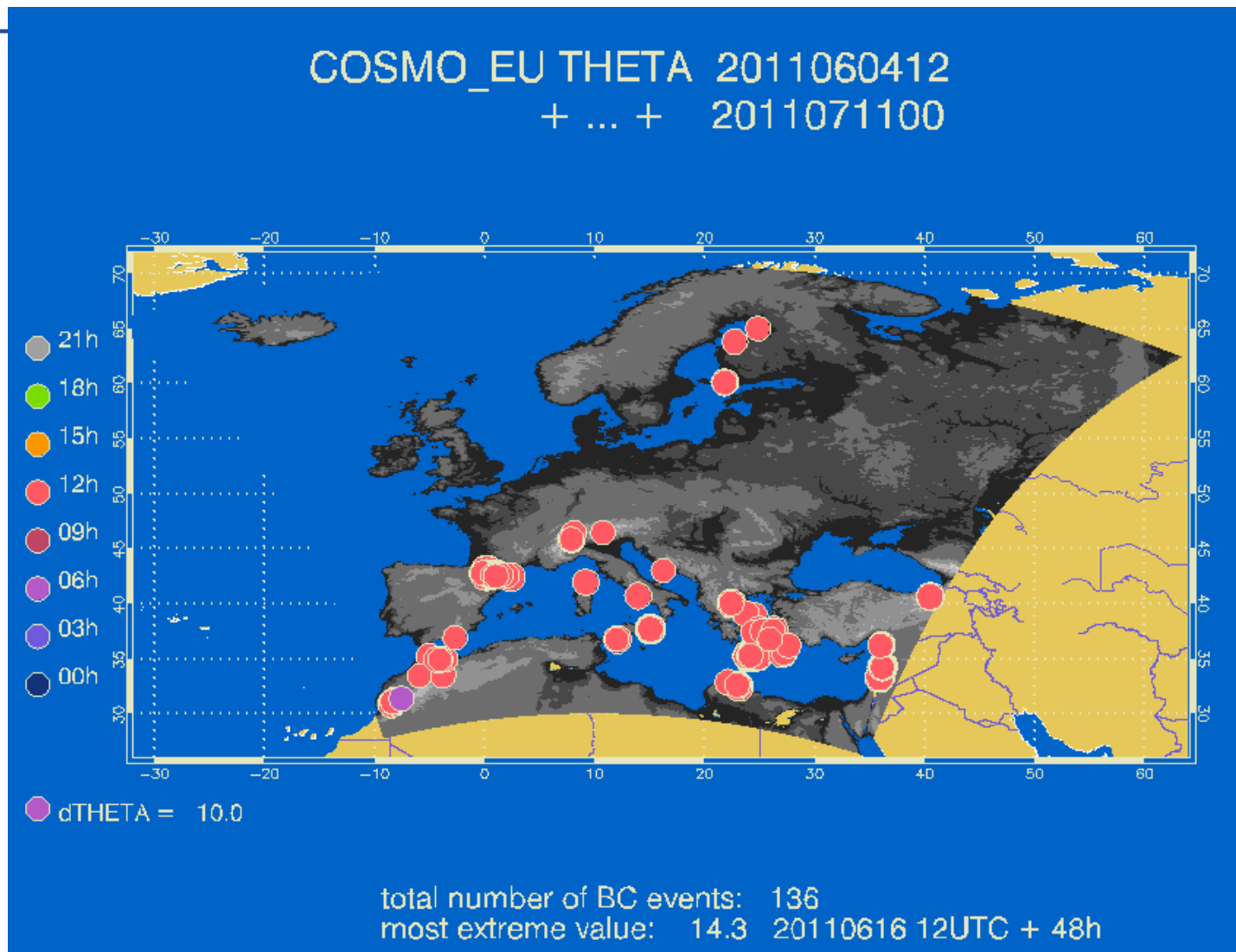
Potential temperature [C]

out_lm3_4.14.3_rlmk (Lev 50)



COSMO-DE 13.04.2011, 00 UTC + 11 h © M. Raschendorfer

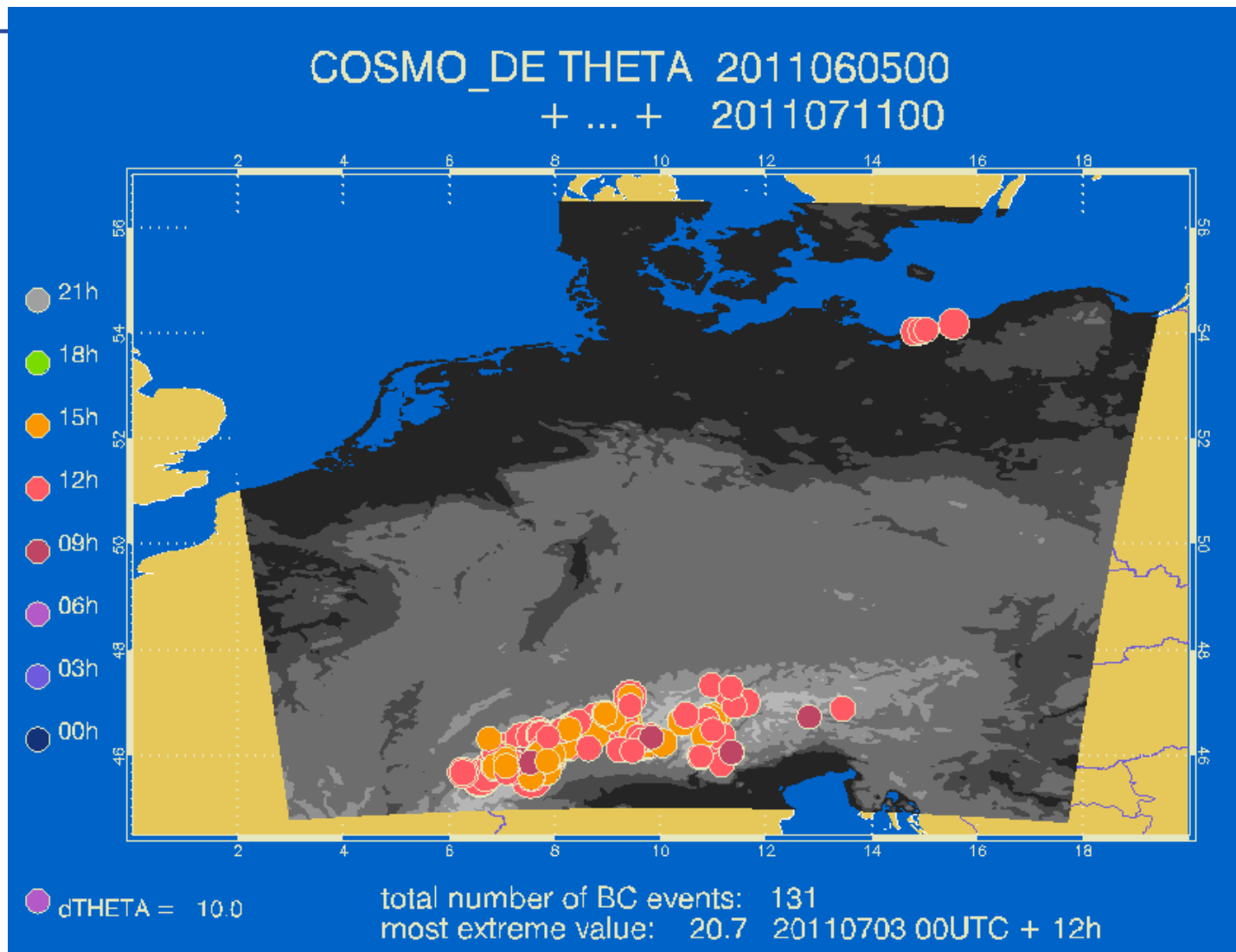
Problem



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Problem

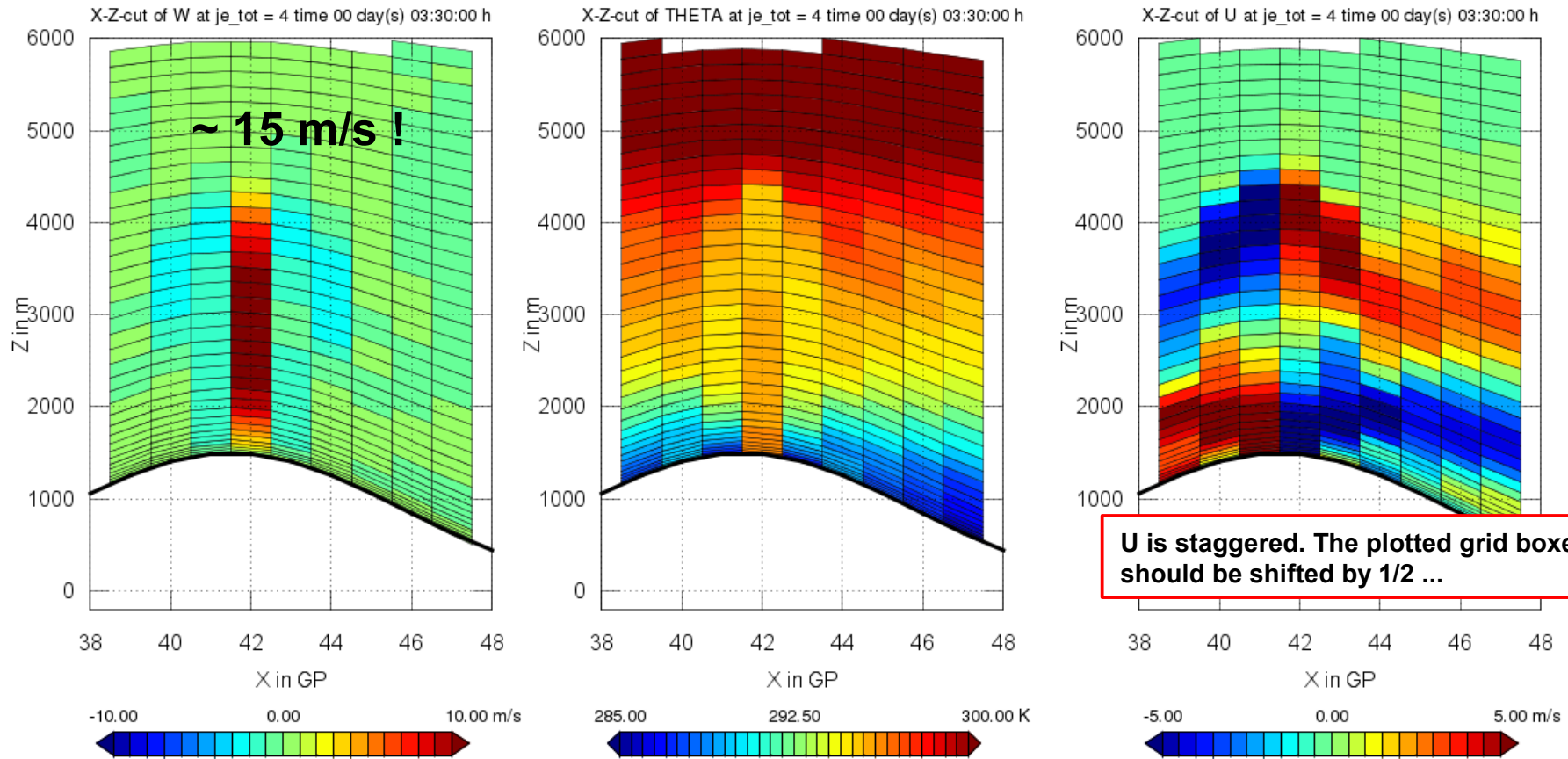


© Routine-Wachhund (B. Ritter)

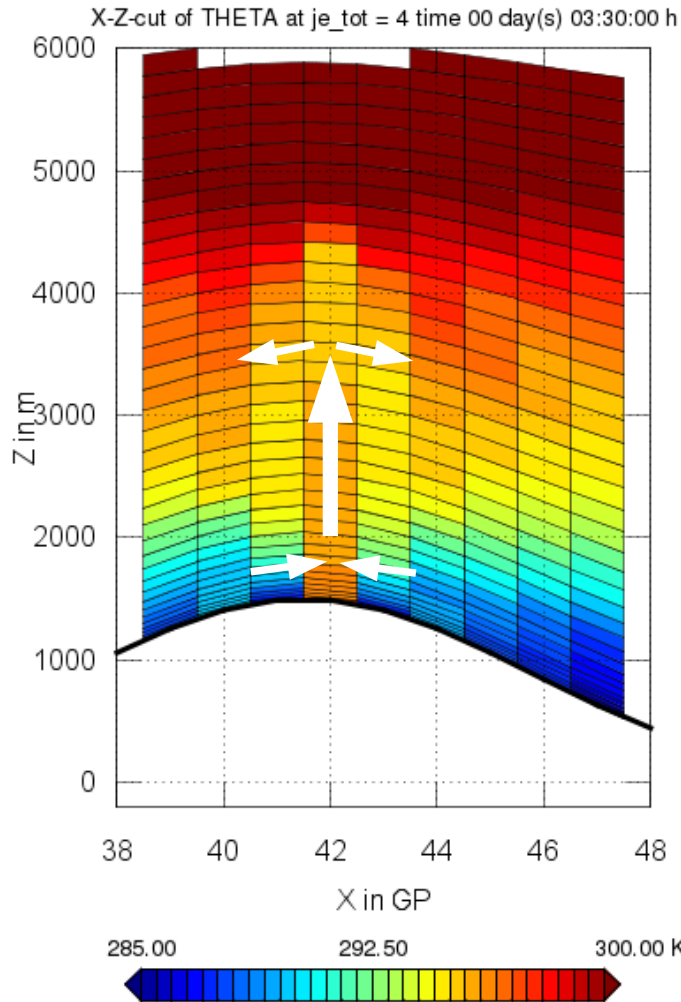


Explanation by means of idealized study

2D-simulation (dry), 2 hills, at start time: $V = 0$, $N = 0.01 \text{ s}^{-1}$, surface overheated



Explanation by means of idealized study



Smallscale circulation with rising warm air within 1 grid column and lateral advection of cooler air ...

Here: Fatal effect caused by the advection discretization of T (and p) ...

Explanation by means of idealized study

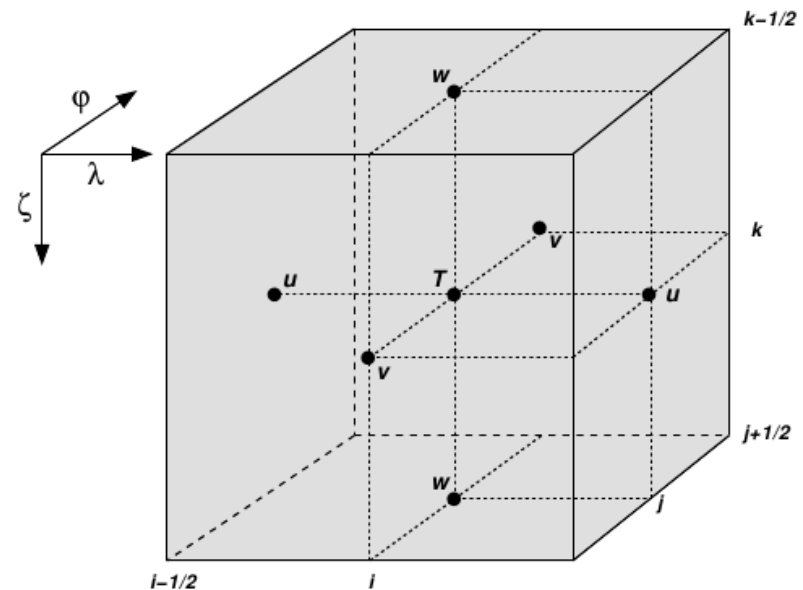
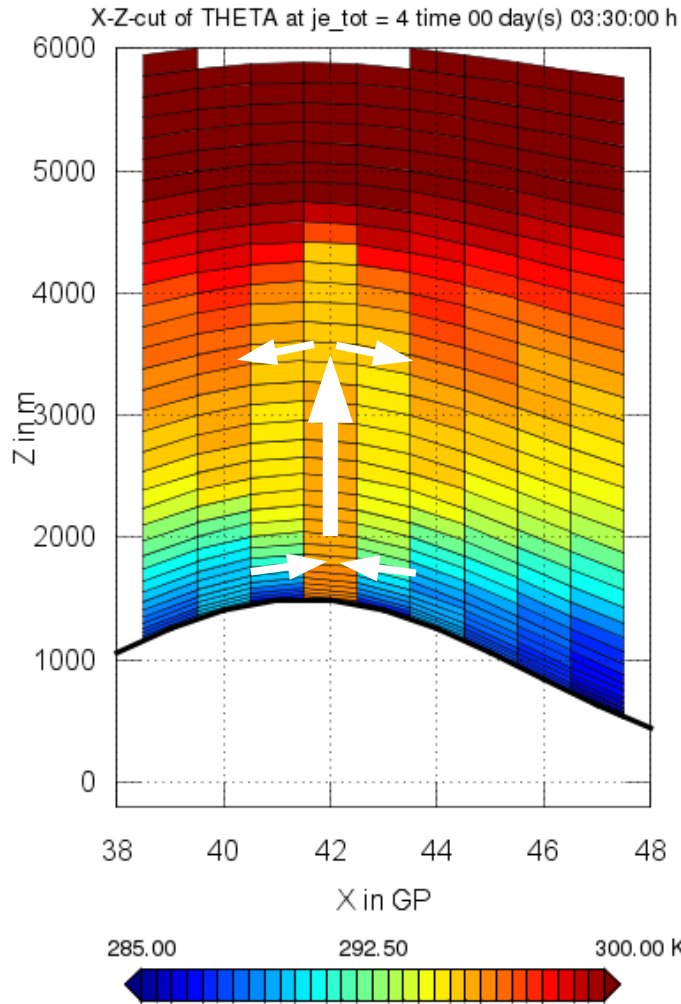
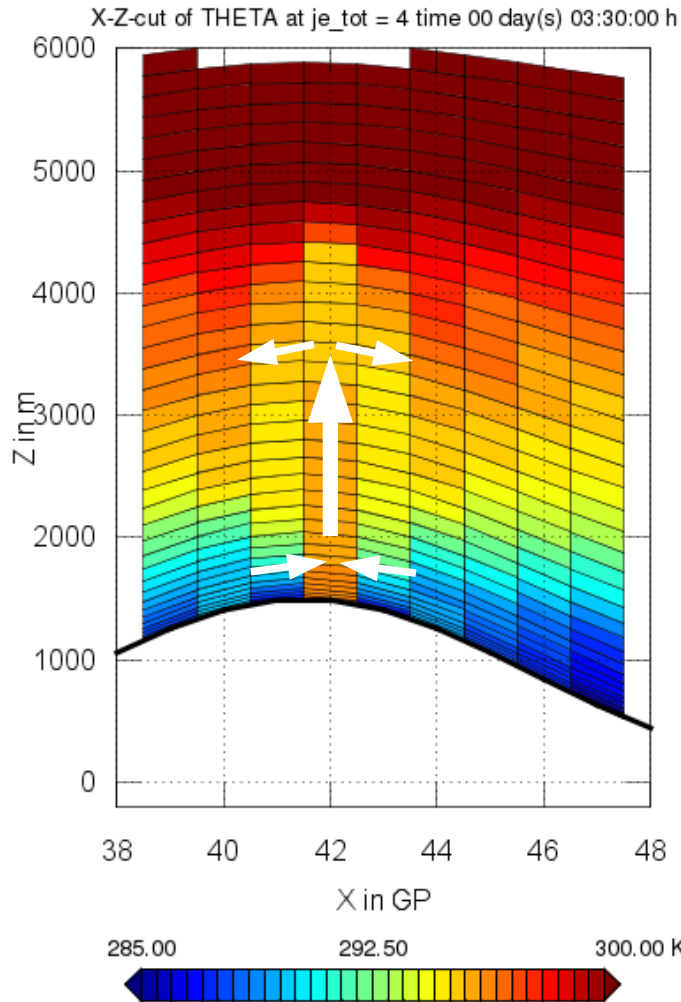


Figure 3.1: A grid box volume $\Delta V = \Delta\zeta\Delta\lambda\Delta\varphi$ showing the Arakawa-C/Lorenz staggering of the dependent model variables.

Explanation by means of idealized study



$$Adv_{X,T} = -U \frac{dT}{dx} \approx - \underbrace{\left(\frac{U_{i-1/2} + U_{i+1/2}}{2} \right)}_{\bar{U}} \Delta_{upwind}(T_i, \text{sign}(\bar{U}))$$

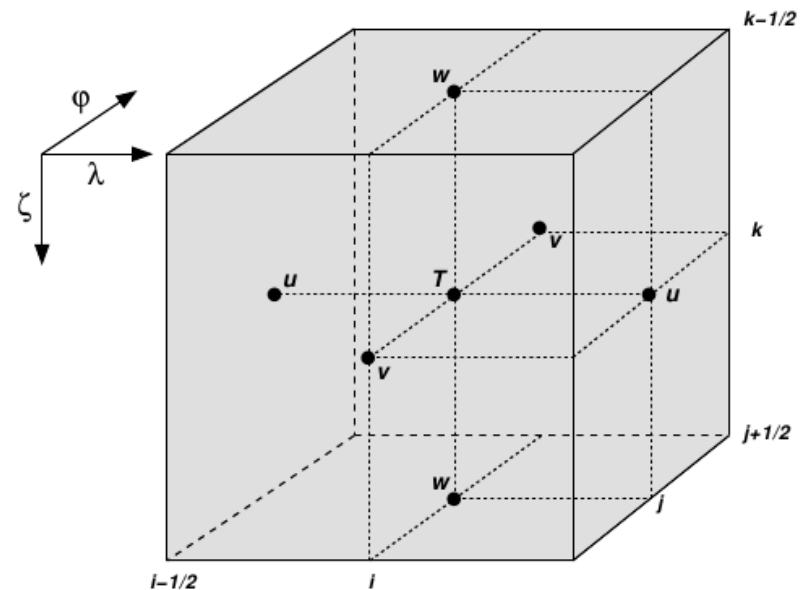
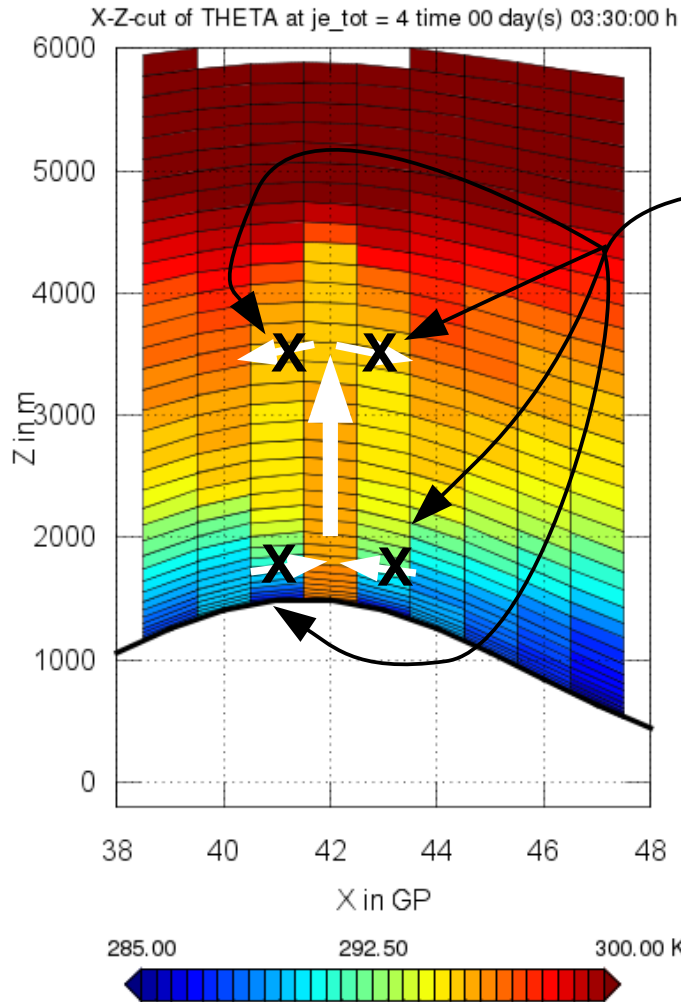


Figure 3.1: A grid box volume $\Delta V = \Delta\zeta\Delta\lambda\Delta\varphi$ showing the Arakawa-C/Lorenz staggering of the dependent model variables.

Explanation by means of idealized study



$$Adv_{X,T} = -U \frac{dT}{dx} \approx - \underbrace{\left(\frac{U_{i-1/2} + U_{i+1/2}}{2} \right)}_{\bar{U} \sim 0!!} \Delta_{upwind}(T_i, sign(\bar{U}))$$

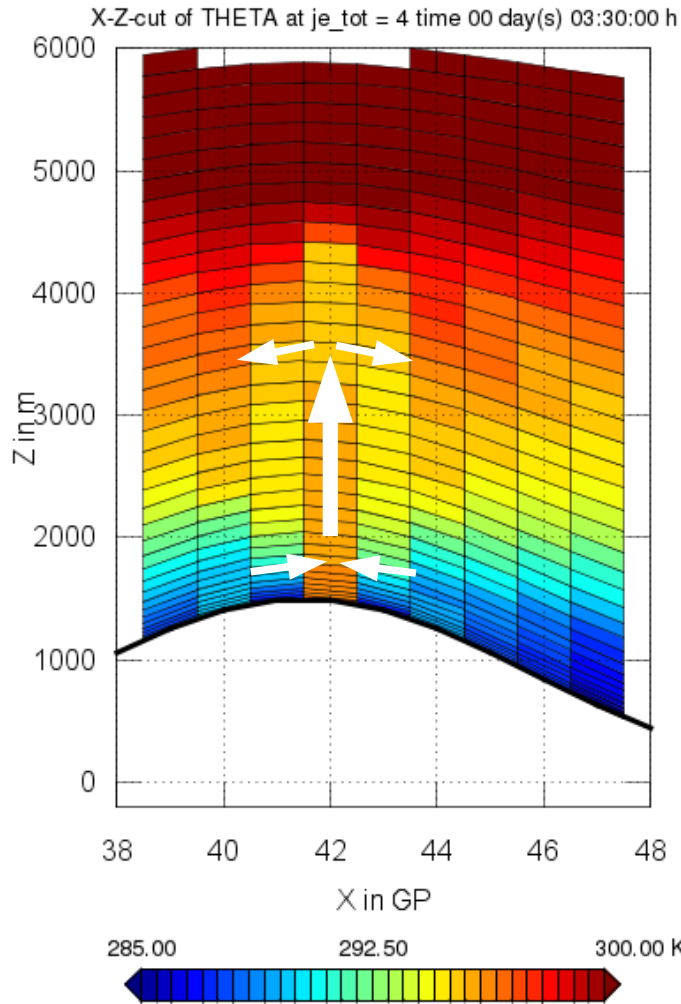
Correct exactly at the center of the box (extremum), but not representative for the grid box averaged horizontal advektion von T (und p') !

At the same time, vertical adv. and Divergence terms are estimated/discretized more grid-box-average-consistent !

This incompatibility leads to too low lateral inflow of cooler air into the grid column

→ **artificial heat source !!!**

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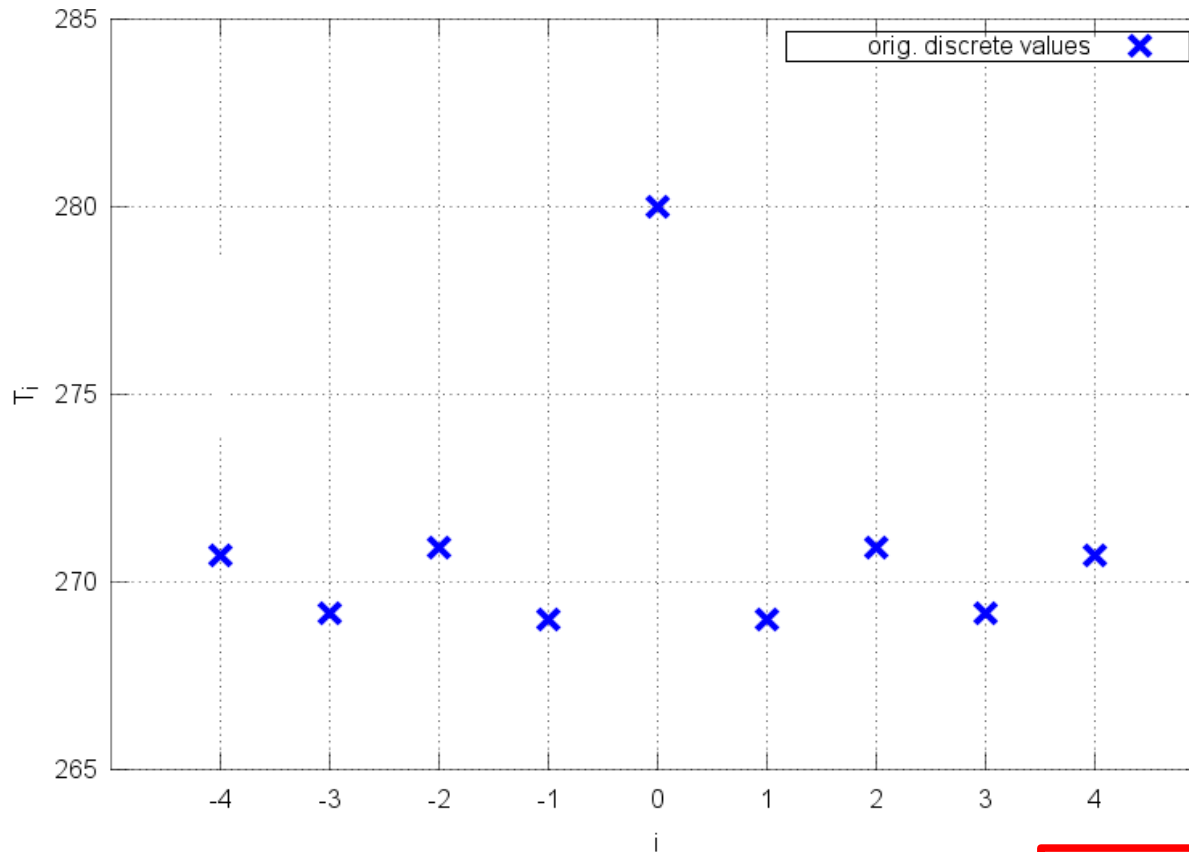
→ **artificial heat source !!!**

Ad-hoc correction:

$$Adv_{X,T} \approx - \frac{1}{2} \left\{ U_{i-1/2} \Delta_{upwind}(T_i, sign(U_{i-1/2})) + U_{i+1/2} \Delta_{upwind}(T_i, sign(U_{i+1/2})) \right\}$$

Schematic explanation of ad-hoc correction

$$\Delta_{upwind}^{(5)}(T_0, \text{sign}(U_{xxx}))$$



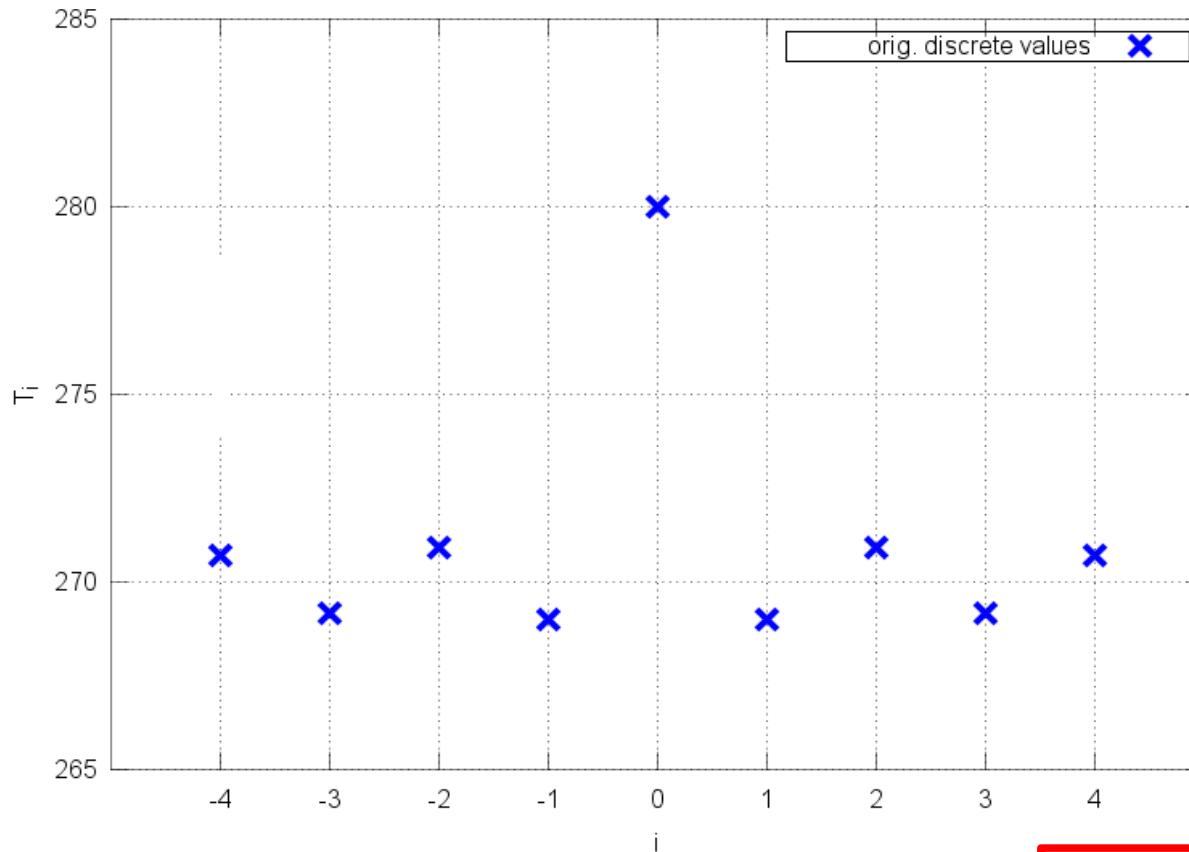
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Schematic explanation of ad-hoc correction

Assump.: $U_{xxx} > 0$ 

$$\Delta_{upwind}^{(5)}(T_0, \text{sign}(U_{xxx}))$$



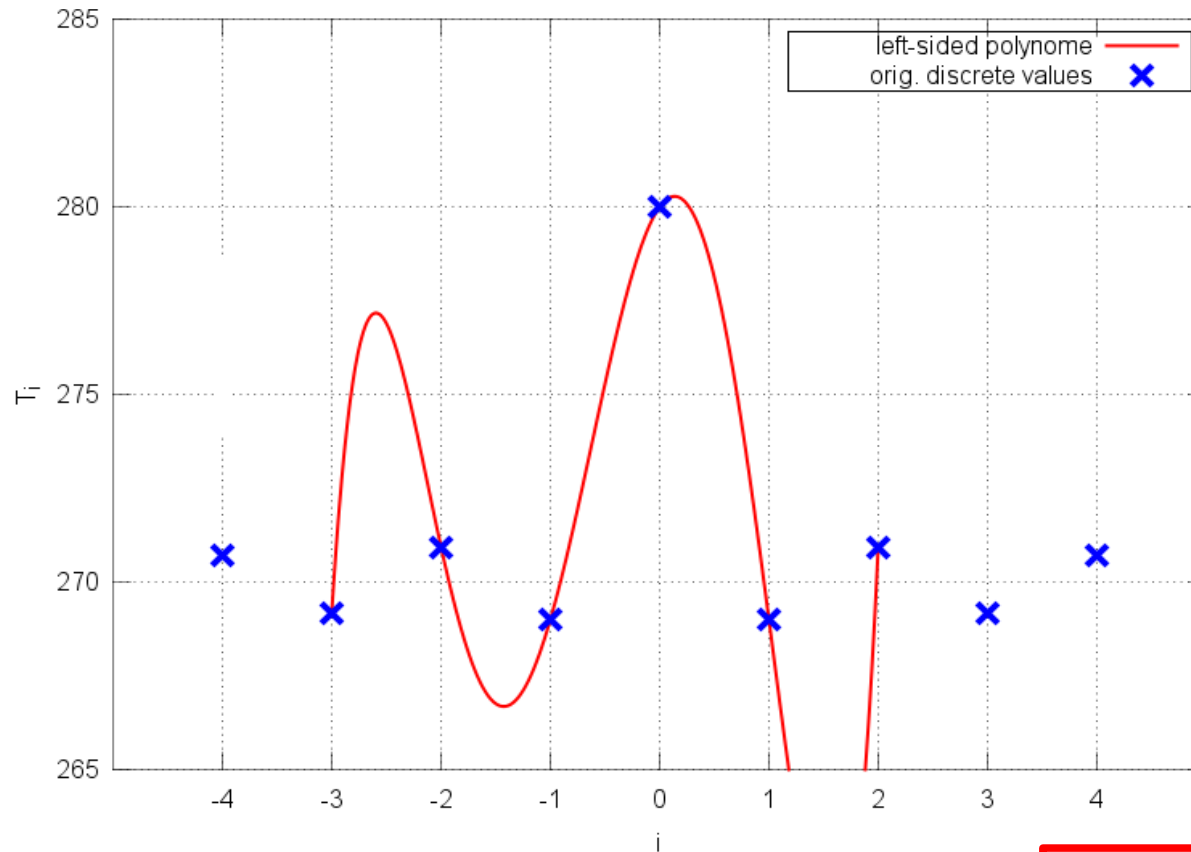
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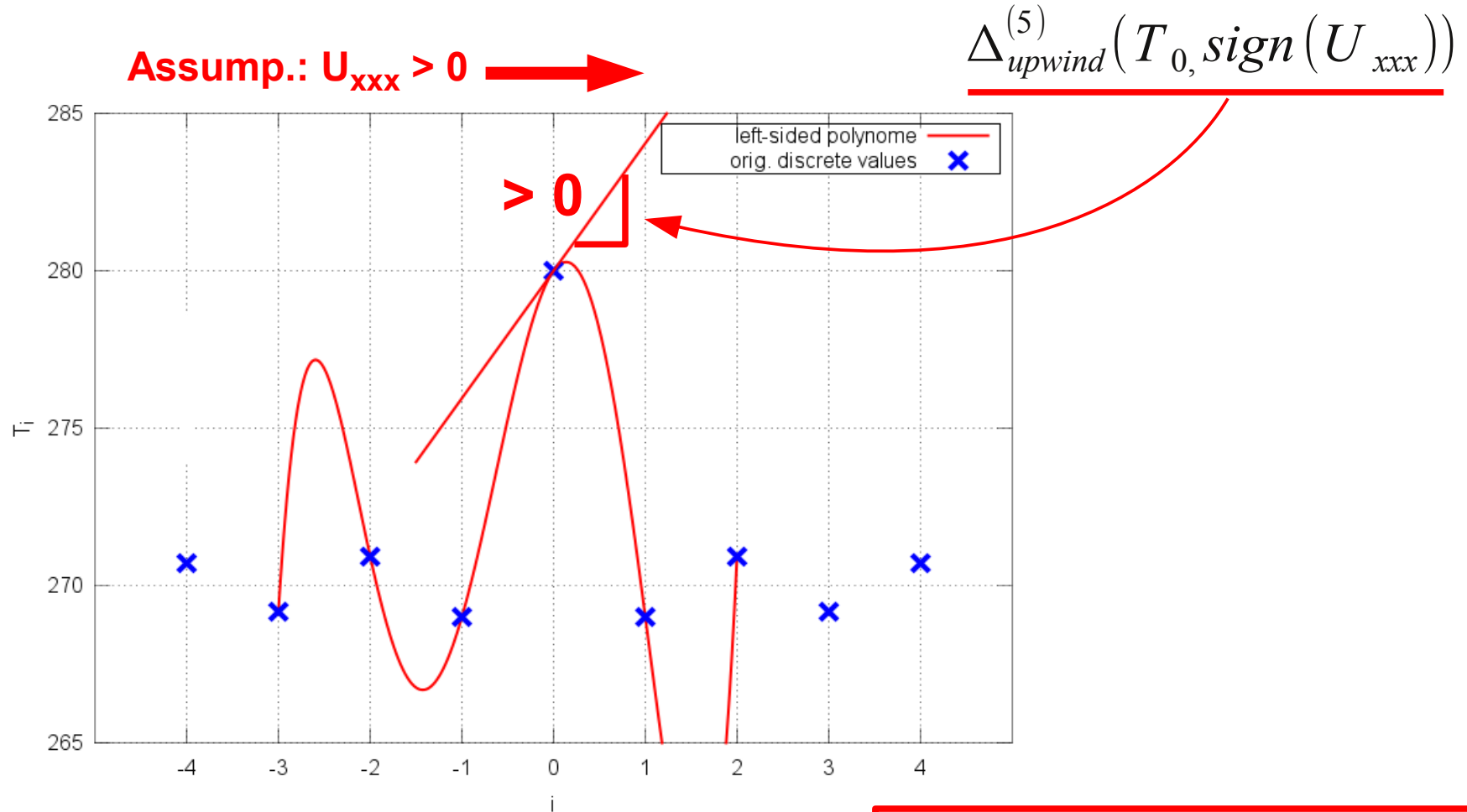
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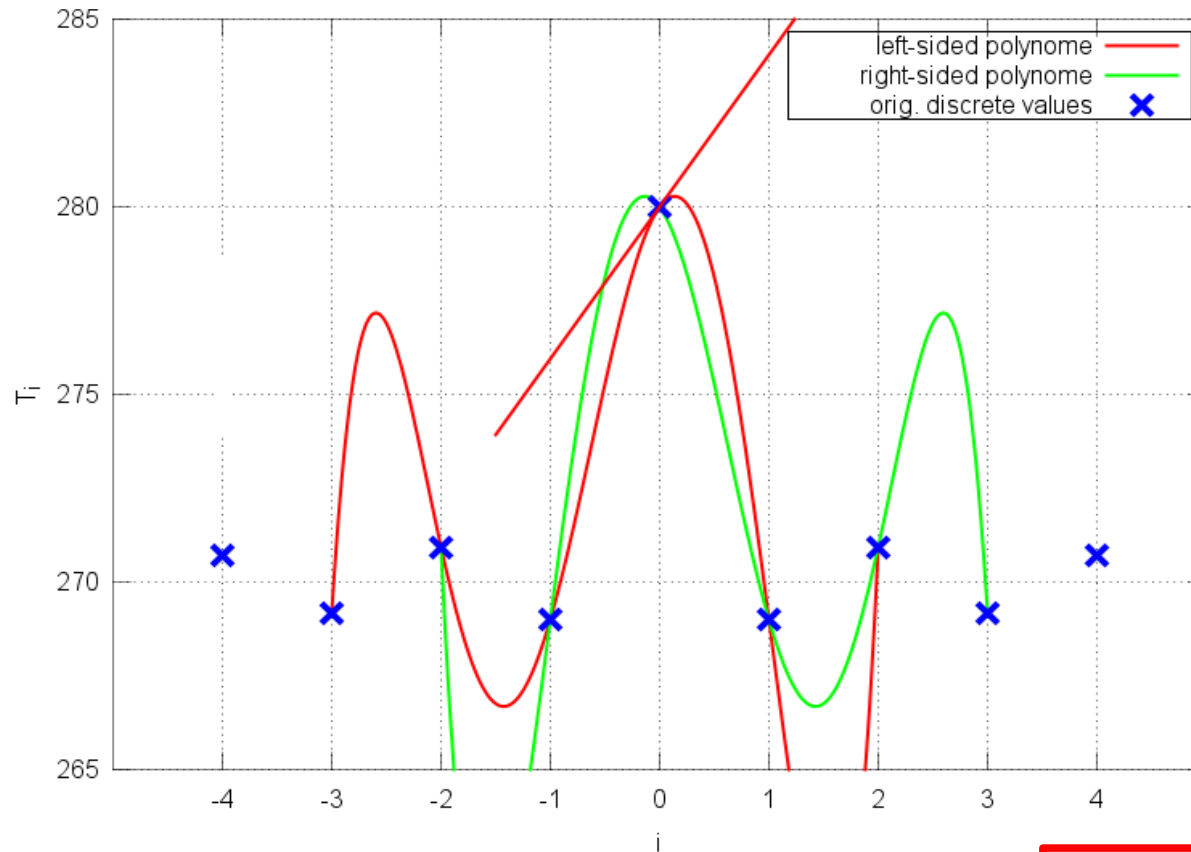
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Schematic explanation of ad-hoc correction

Assump.: $U_{xxx} < 0$ 

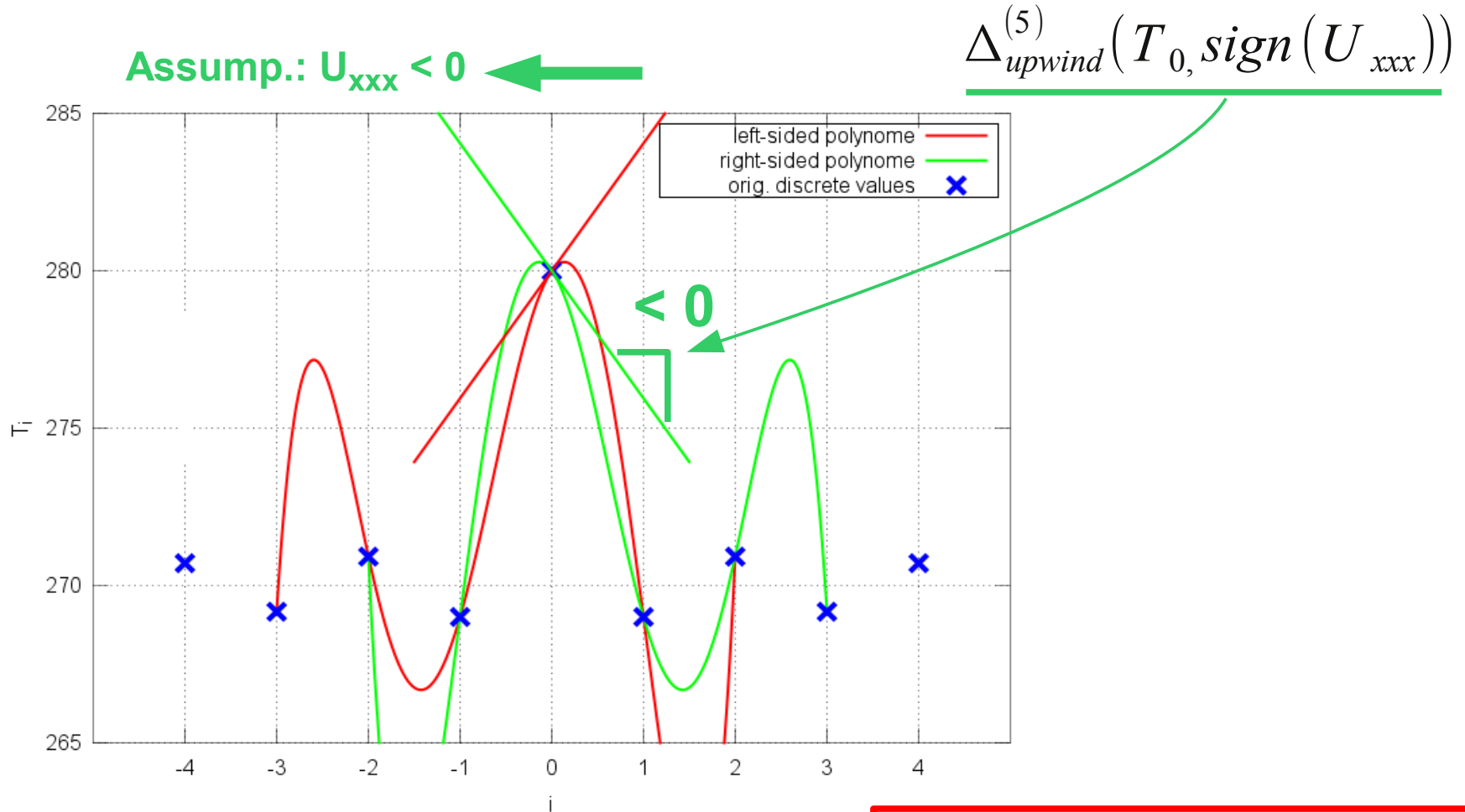
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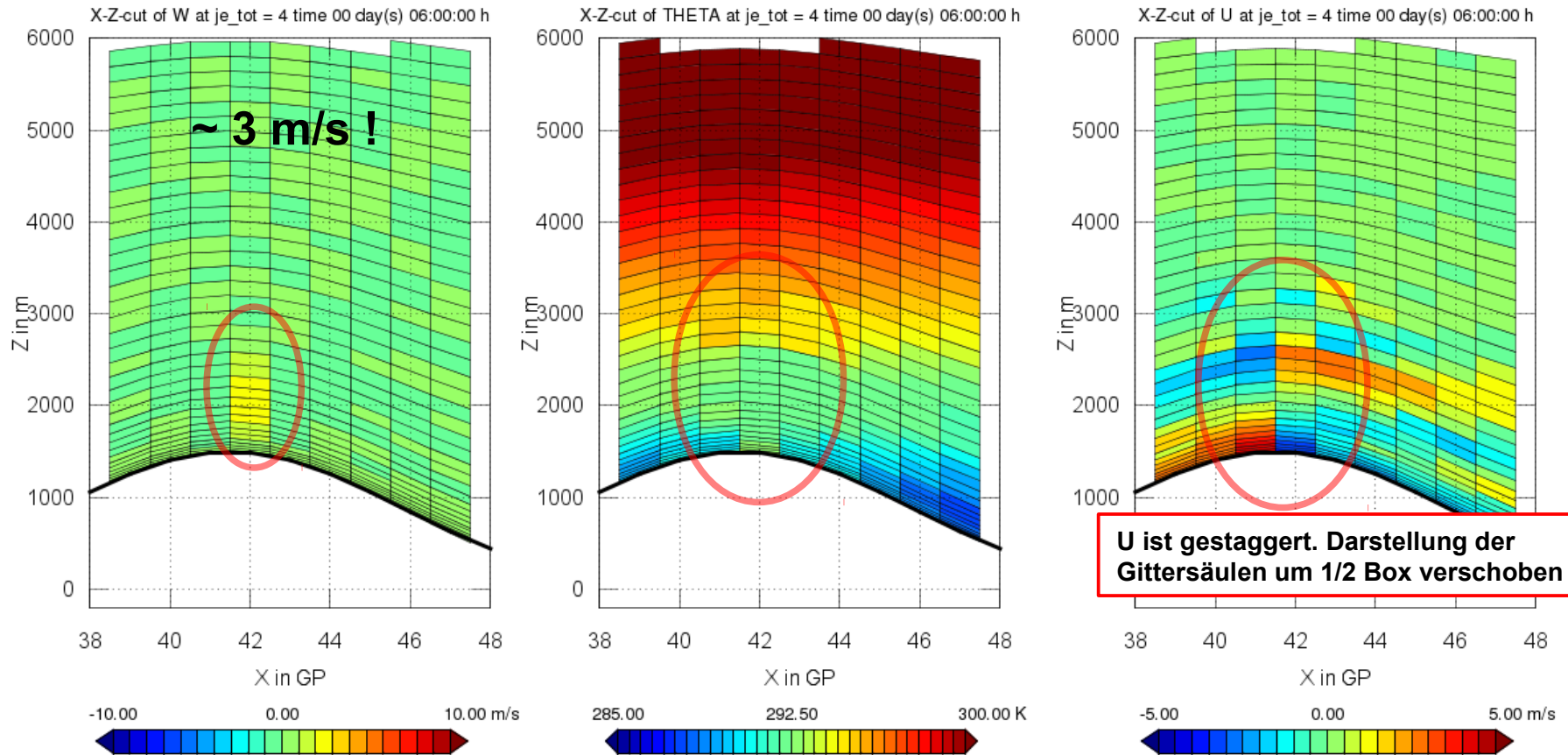


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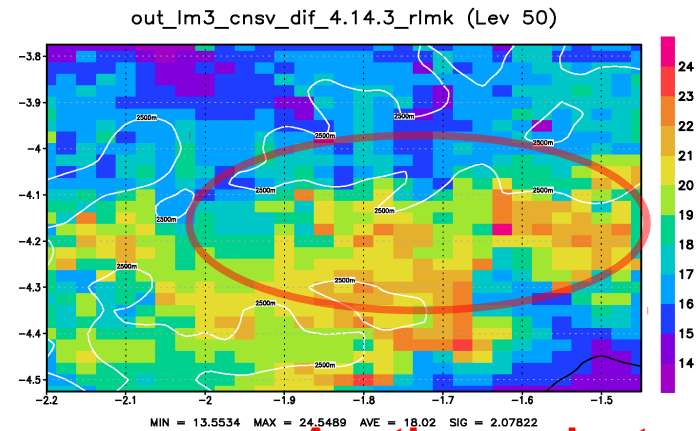
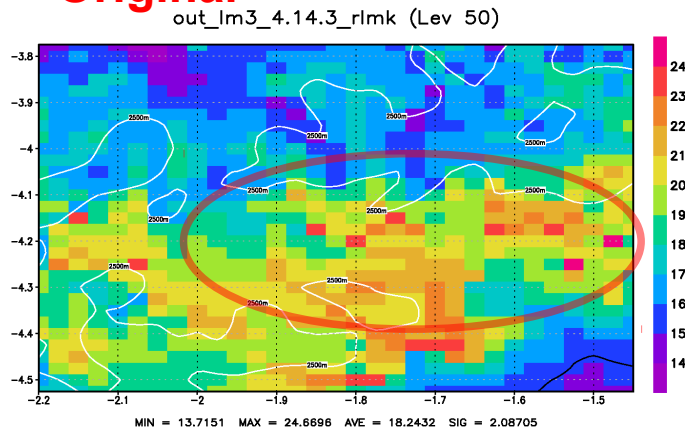
Effect on the idealized study

2D-simulation (dry), 2 hills, at start time: $V = 0$, $N = 0.01 \text{ s}^{-1}$, surface overheated

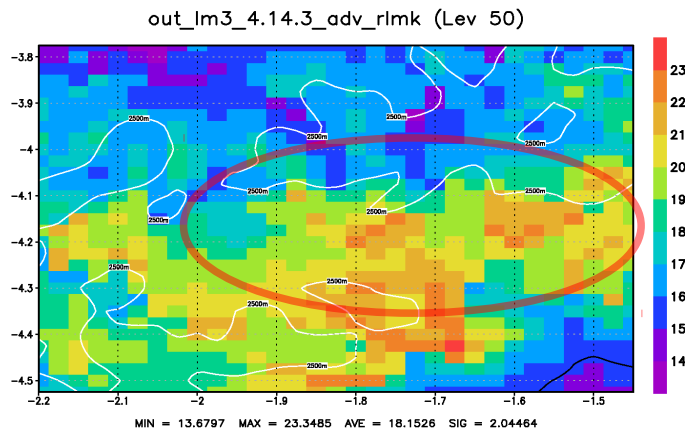


Potential temperature [C]

Original



Another variant with diffusion of conserved quantities (M. Raschendorfer)



Adv-patch

© M. Raschendorfer

pr_time=11Z13APR2011 pr_hour=11hr

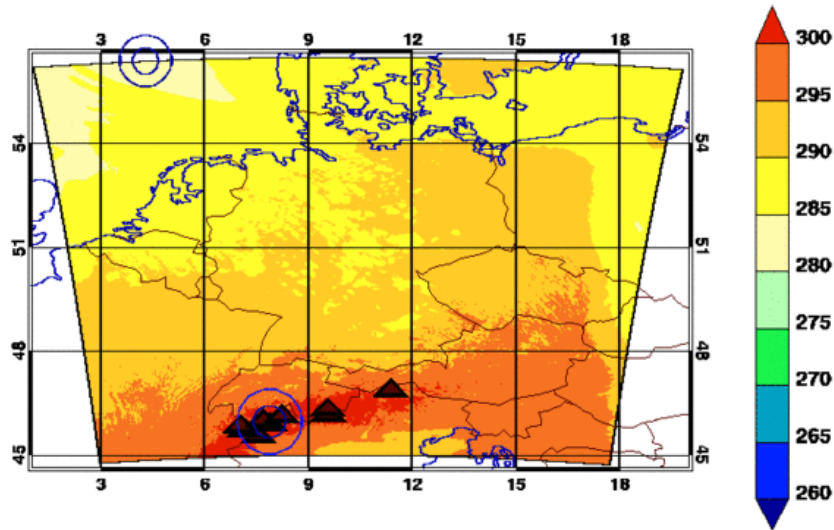
Experiment: 1.6. - ~20.7.2011



Reduction of „Theta-peaks“ in July 2011 (COSMO-DE)

THETA [K] COSMO_DE 20110701 00UTC + 12h LV=51

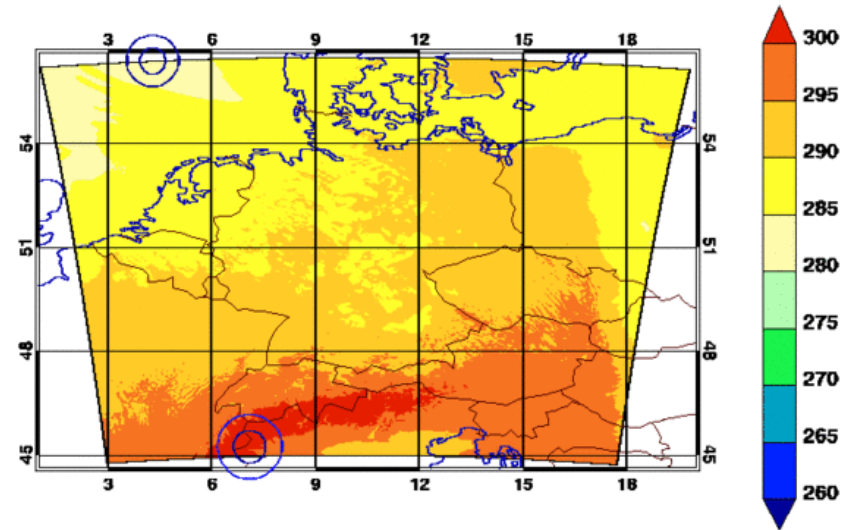
mean: 291.50 std: 4.30 min: 284.41 max: 318.10



pos. difference to average of neighbours threshold value: 10.000 maximum discrepancy: 1.507E+01

THETA [K] COSMO_DE_08291 20110701 00UTC + 12h LV=51

mean: 291.49 std: 4.31 min: 284.41 max: 312.07



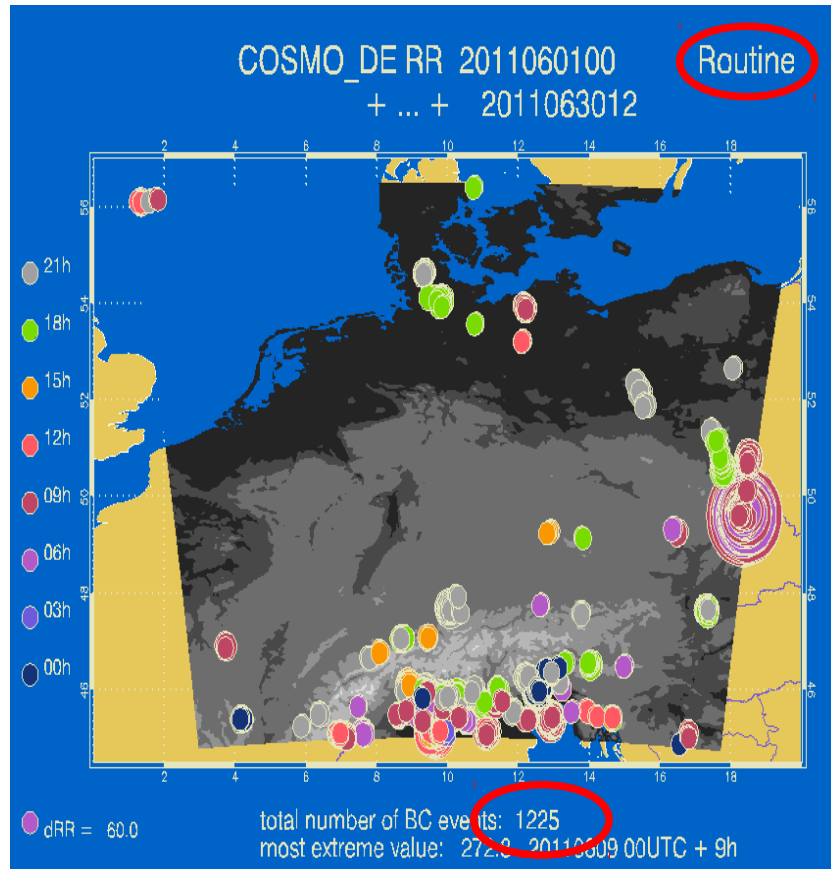
pos. difference to average of neighbours threshold value: 10.000

© B. Ritter



Experiment: 1.6. - ???.7.2011

Reduction of „grid point storms“ in June 2011



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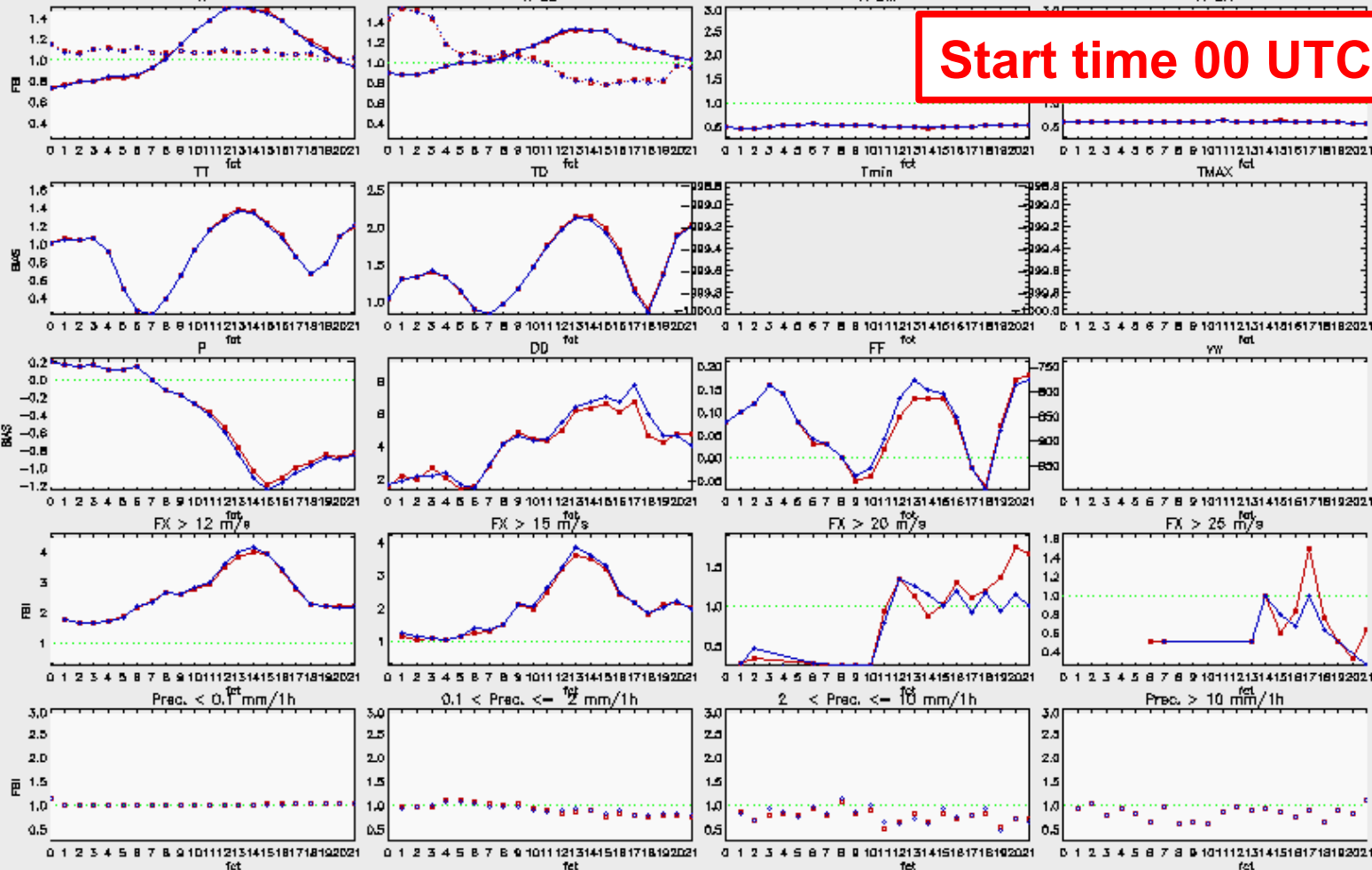
- The COSMO-model generates, in conjunction with small-scale thermally driven circulations, „strange“ effects such as isolated „ Θ -peaks“ in alpine valleys, or as „grid point storms“ in mountaineous regions or at coasts (visible as isolated surface pixels with very high precipitation).
- Result: The reason is the special discretization of the T- and p'-advection terms on the staggered grid in situations with locally strong horizontal con- and diffluent flow structures (thermally driven updrafts covering only 1 grid column)
- Ad-hoc correction developed
- Case studies (Förstner, Raschendorfer) relating to „ Θ -peaks“
- June/July 2011 – Experiment
- Verification results: Neutral to slightly positive regarding p
- Not shown: COSMO 7 km reduction of w_{\max}

Experiment Verifikation: 1.6. - 15.7.2011

LM3MO: 01.06.2011 00 UTC - 15.07.2011 00 UTC (exp. run 8291_national: nearest gridpoint)

lm3mo: 01.06.2011 00 UTC - 15.07.2011 00 UTC (ope. run LON: 02.98 - 19.84 LAT: 44.77 - 56.14: nearest gridpoint)

Start time 00 UTC



Results of verification of forecasts for local weather elements at surface stations

FBI for cloud covers gusts and precipitation, BIAS for other elements

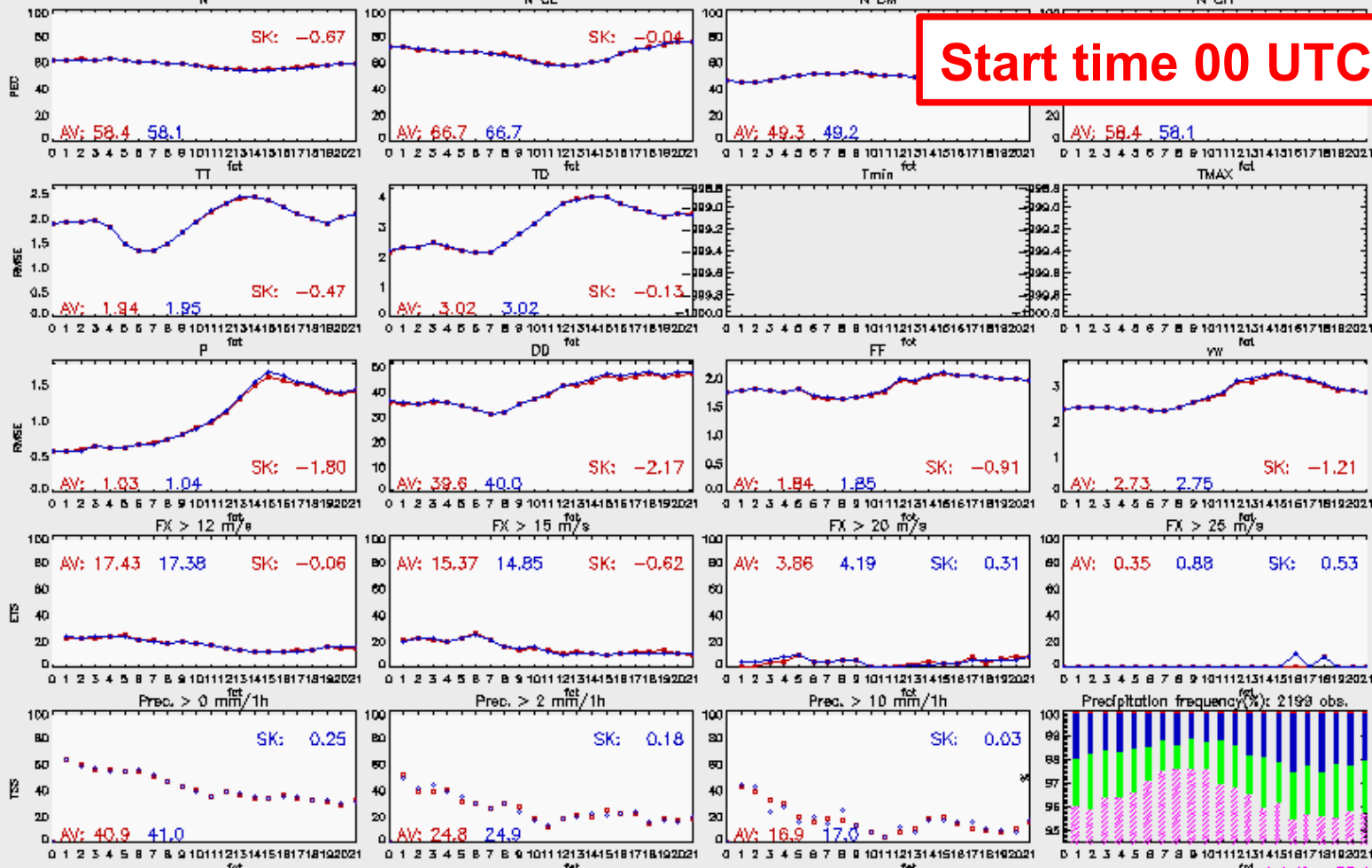
All stations

Plottime: 18.07.2011 12:32:49 MESZ

Experiment Verifikation: 1.6. - 15.7.2011

LM3MO: 01.06.2011 00 UTC - 15.07.2011 00 UTC (exp. run 8291_national: nearest gridpoint)
 lm3mo: 01.06.2011 00 UTC - 15.07.2011 00 UTC (ope. run LON: 02.98 - 19.84 LAT: 44.77 - 56.14: nearest gridpoint)

Start time 00 UTC



Results of verification of forecasts for local weather elements at surface stations
 TSS for precipitation, ETS for gusts, percent correct for cloud covers, RMSE for other elements
 Plattime: 18.07.2011 12:32:49 MESZ All stations

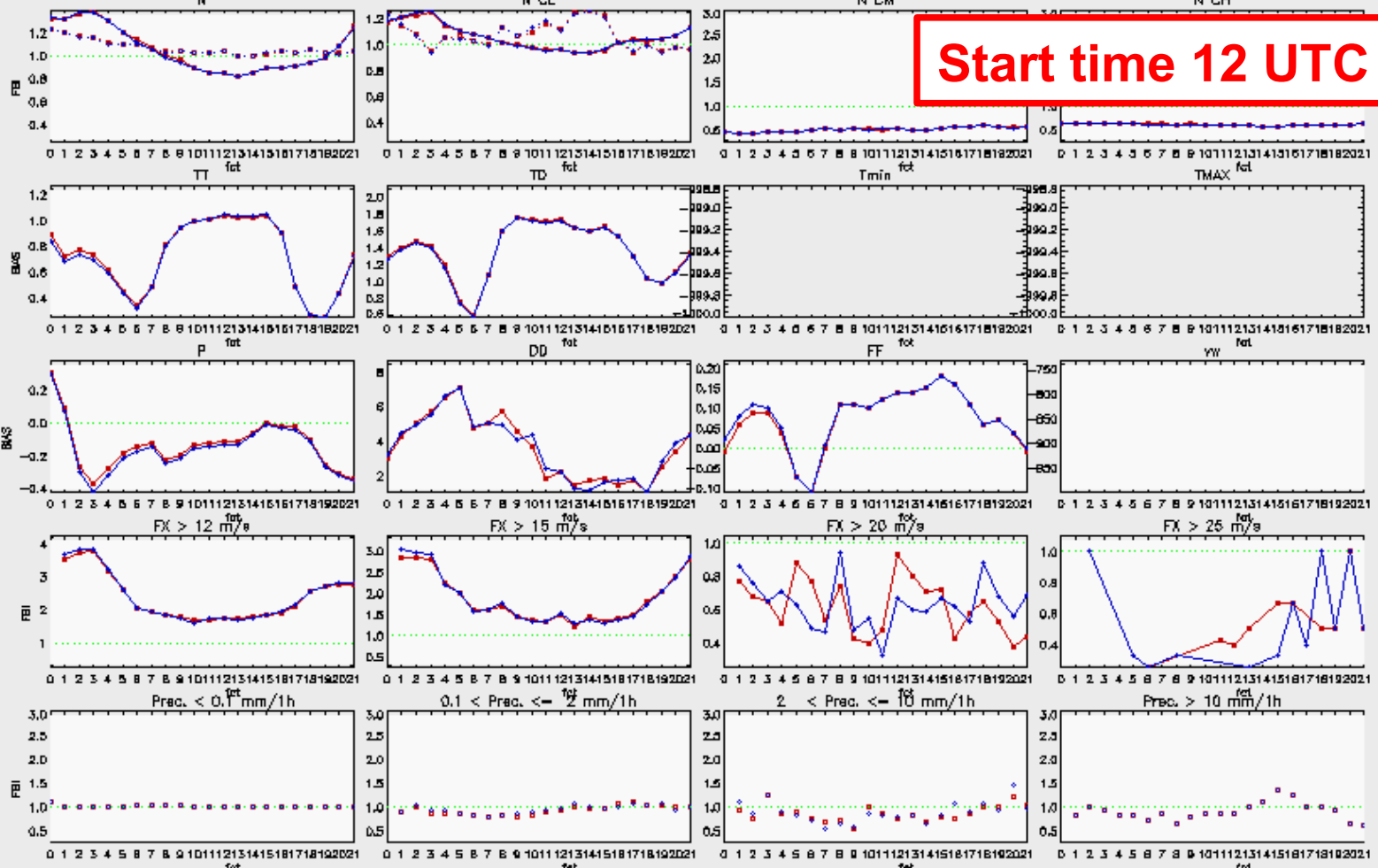
Category	Percentage
no precipitation	88.49%
0.1-2 mm	7.95%
3-10 mm	1.80%
> 10 mm	1.76%

Experiment Verifikation: 1.6. - 15.7.2011

LM3MO: 01.06.2011 12 UTC - 15.07.2011 12 UTC (exp. run 8291_national: nearest gridpoint)

lm3mo: 01.06.2011 12 UTC - 15.07.2011 12 UTC (ope. run LON: 02.98 - 19.84 LAT: 44.77 - 56.14: nearest gridpoint)

Start time 12 UTC



Results of verification of forecasts for local weather elements at surface stations

FBI for cloud covers gusts and precipitation, BIAS for other elements

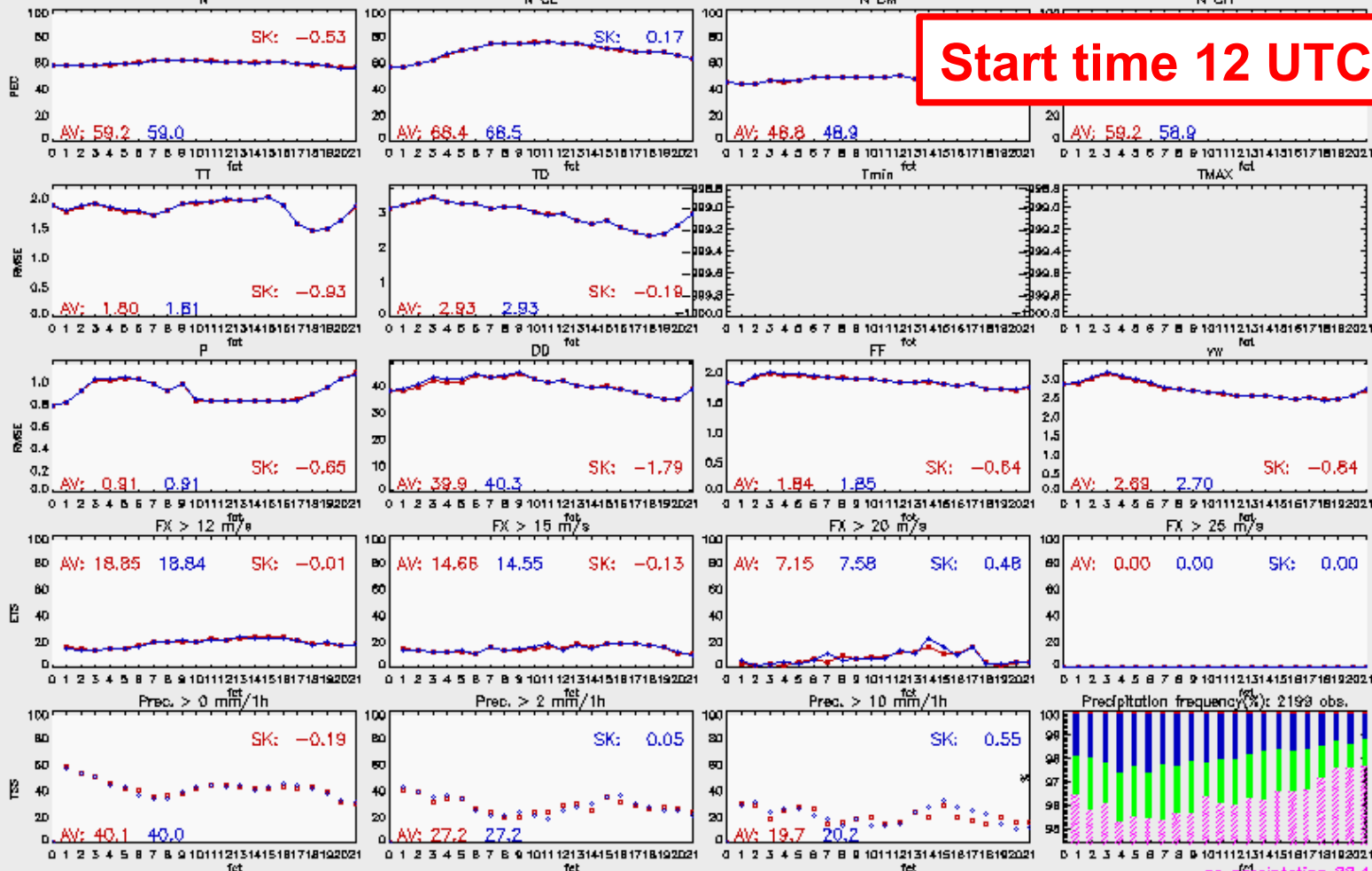
All stations

Plottime: 18.07.2011 13:07:35 MESZ

Experiment Verifikation: 1.6. - 15.7.2011

LM3MO: 01.06.2011 12 UTC - 15.07.2011 12 UTC (exp. run 8291_national: nearest gridpoint)
 lm3mo: 01.06.2011 12 UTC - 15.07.2011 12 UTC (ope. run LON: 02.98 - 19.84 LAT: 44.77 - 56.14: nearest gridpoint)

Start time 12 UTC



Results of verification of forecasts for local weather elements at surface stations
 TSS for precipitation, ETS for gusts, percent correct for cloud covers, RMSE for other elements
 Plattime: 18.07.2011 13:07:34 MESZ All stations

Category	Percentage
no precipitation	88.41%
0.1-2 mm	7.97%
3-10 mm	1.78%
> 10 mm	1.84%