Deutscher Wetterdienst
Wetter und Klima aus einer Hand

TERRA

Soil Vegetation Atmosphere Transfer across Models and Scales

DWD contribution

COSMO-GM 2014

TERRA – Status

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- COSMO-EU with GlobCOVER land-use data
- Revised infiltration – Numerical experiments
- COSMO-CLM study using TERRA with HWSD and new water transport
- Tuning of the ML-snow scheme and the snow albedo scheme in ICON
- Treatment of permafrost in TERRA

GlobCover in COSMO-EU

- Land-use data set comparable to ICON and COSMO-DE
- Improved representation of land-use in deserts
- Enhanced variability in leaf-area index
- Changed roughness length due to land-use changes
- Experiment start 2013040100 – two months verification
- Operational since 2014050512

GlobCover in COSMO-EU

CONSORTIUM FOR SMALL SCALE MODELING COSMO
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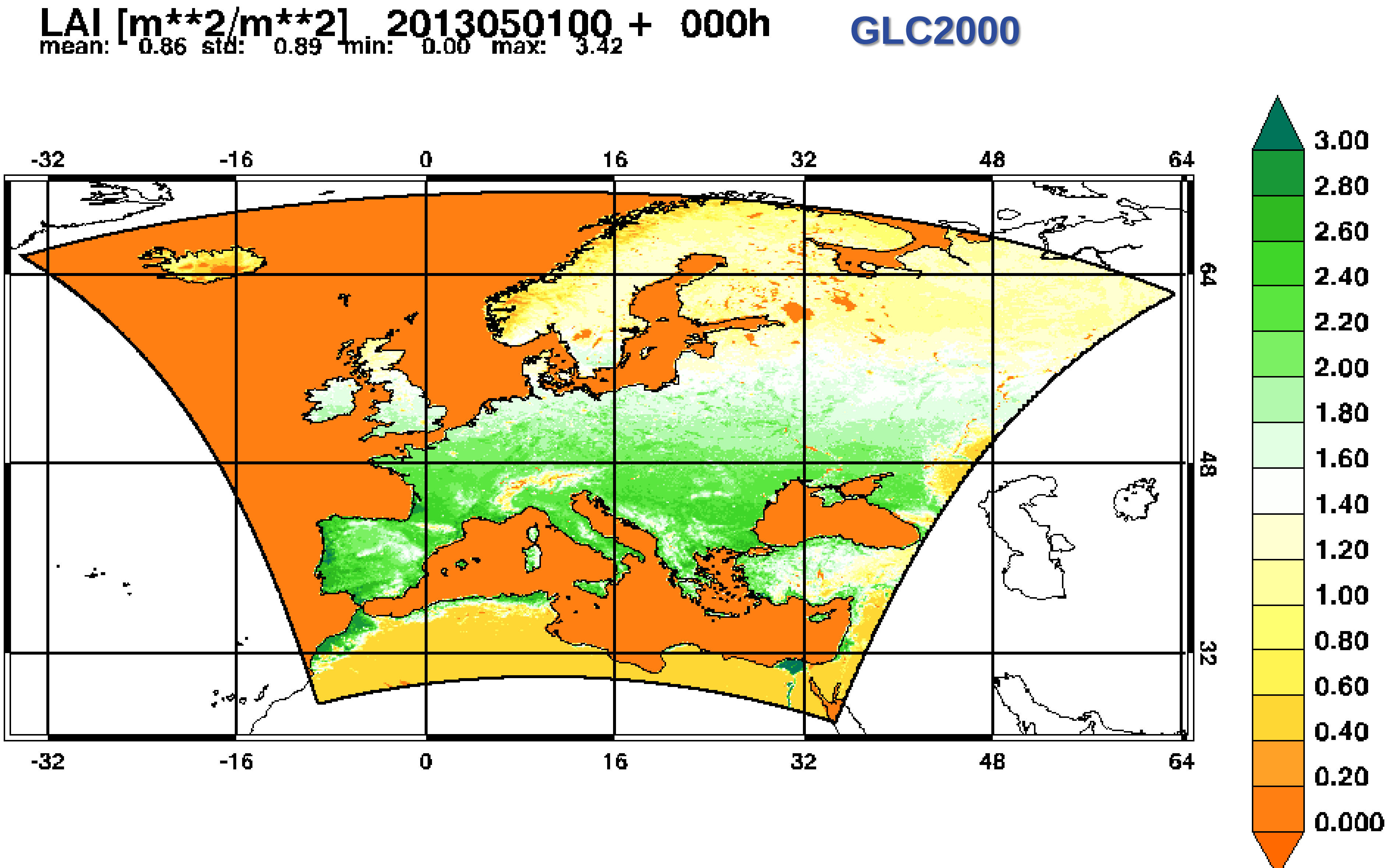
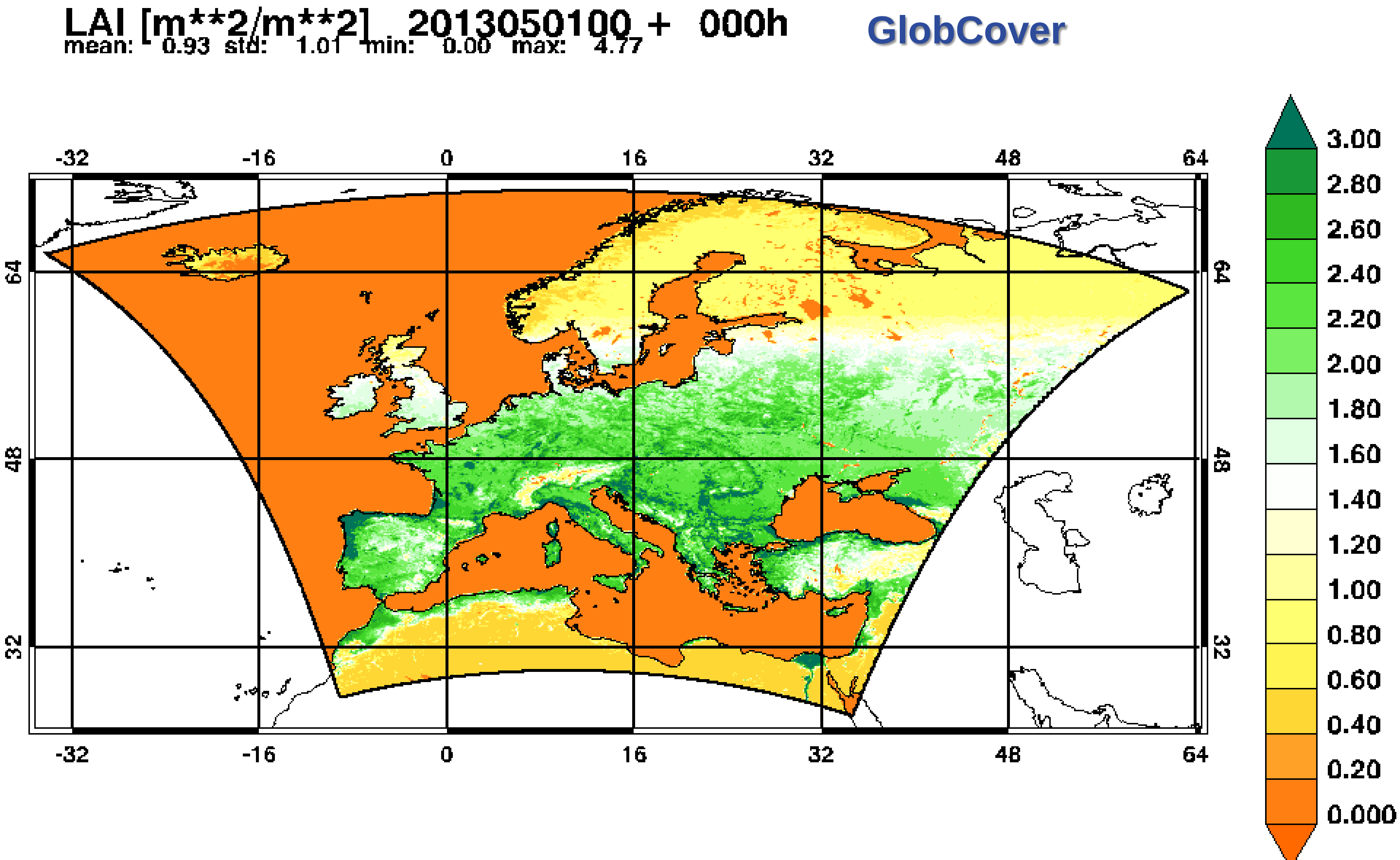
GLC2000



GlobCover in COSMO-EU



GlobCover in COSMO-EU

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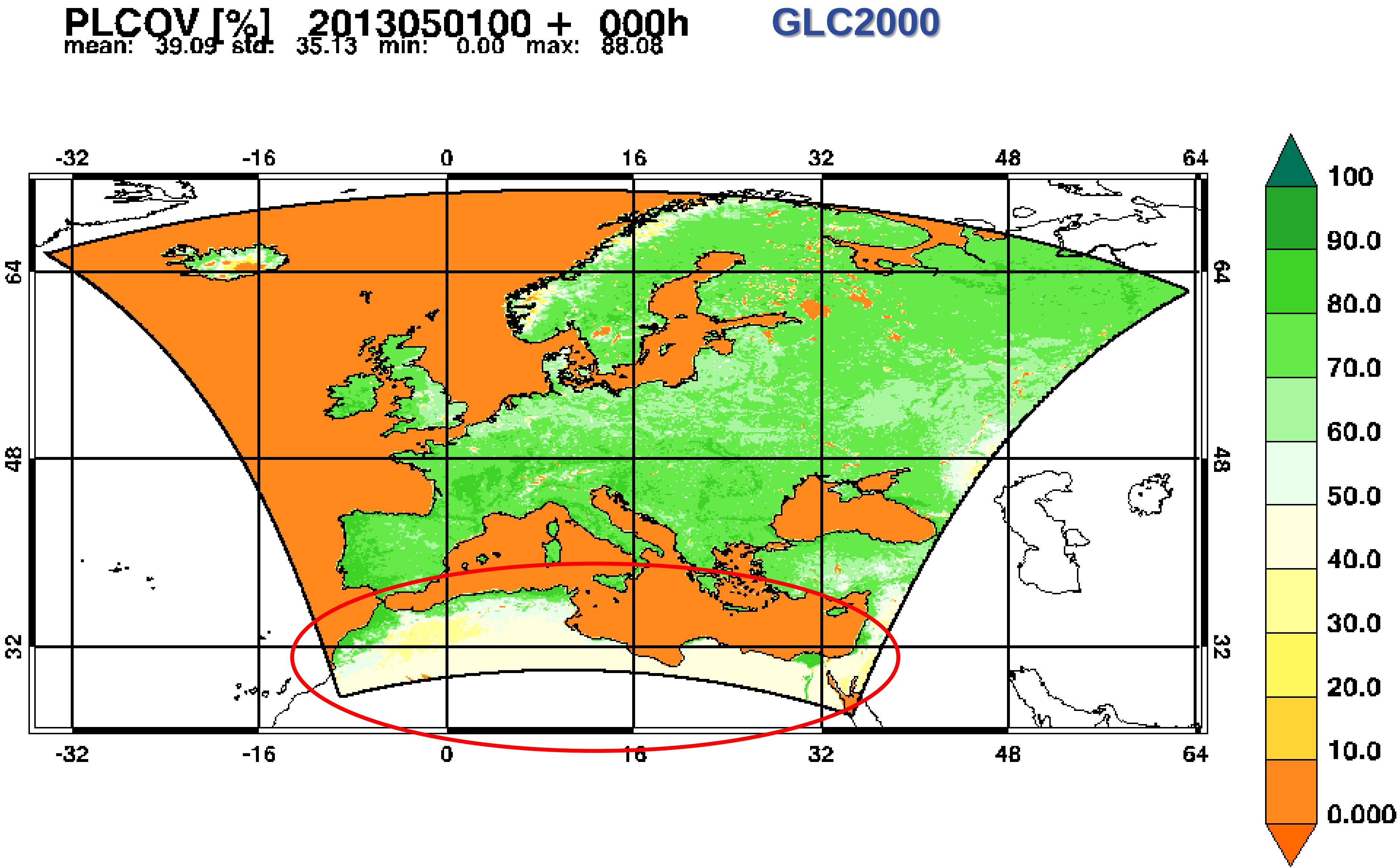
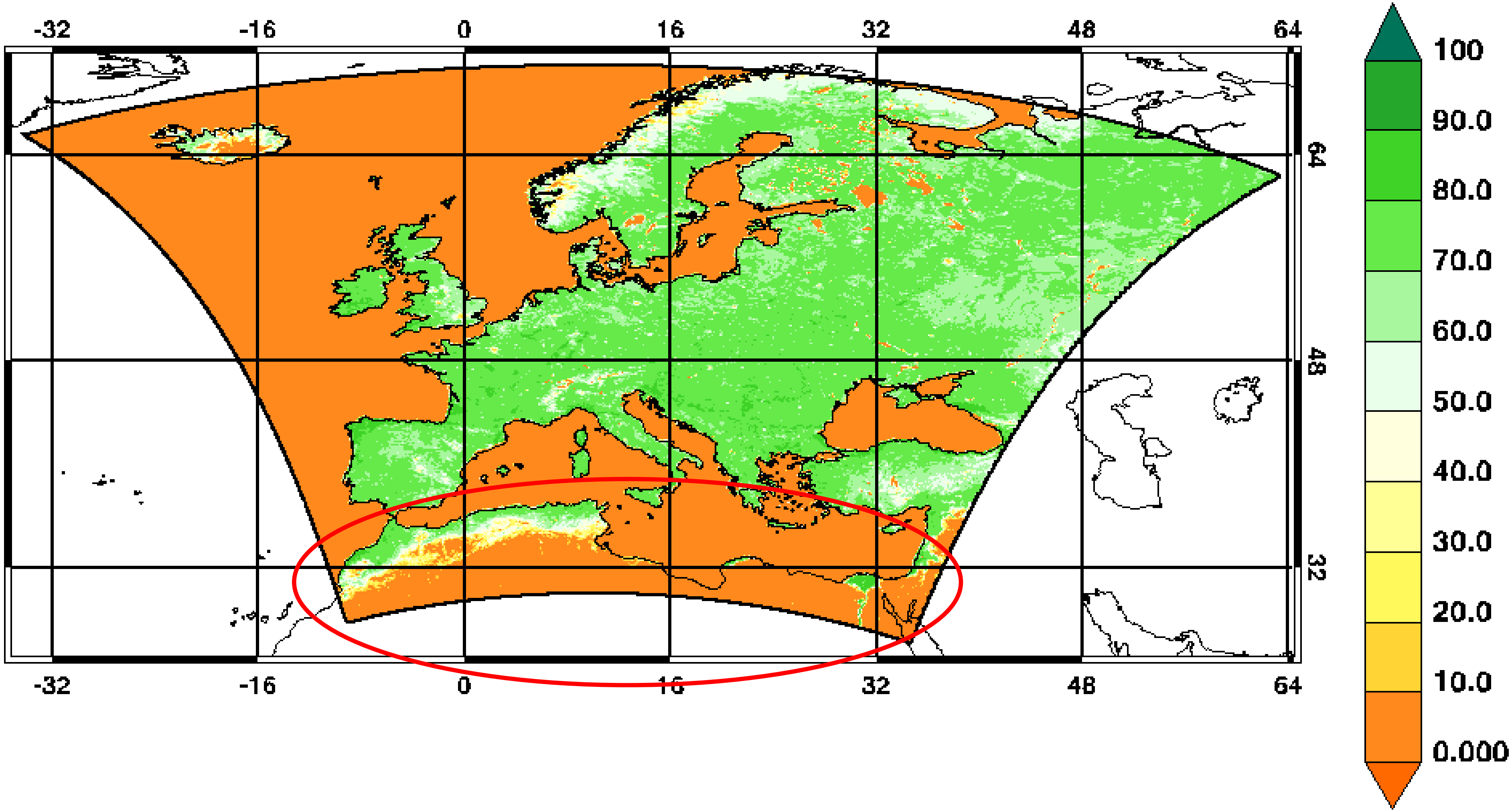


GlobCover in COSMO-EU

PLCOV [%] 2013050100 + 000h

mean: 34.68 std: 35.37 min: 0.00 max: 86.68

GlobCover



GlobCover in COSMO-EU

Results from preoperational runs

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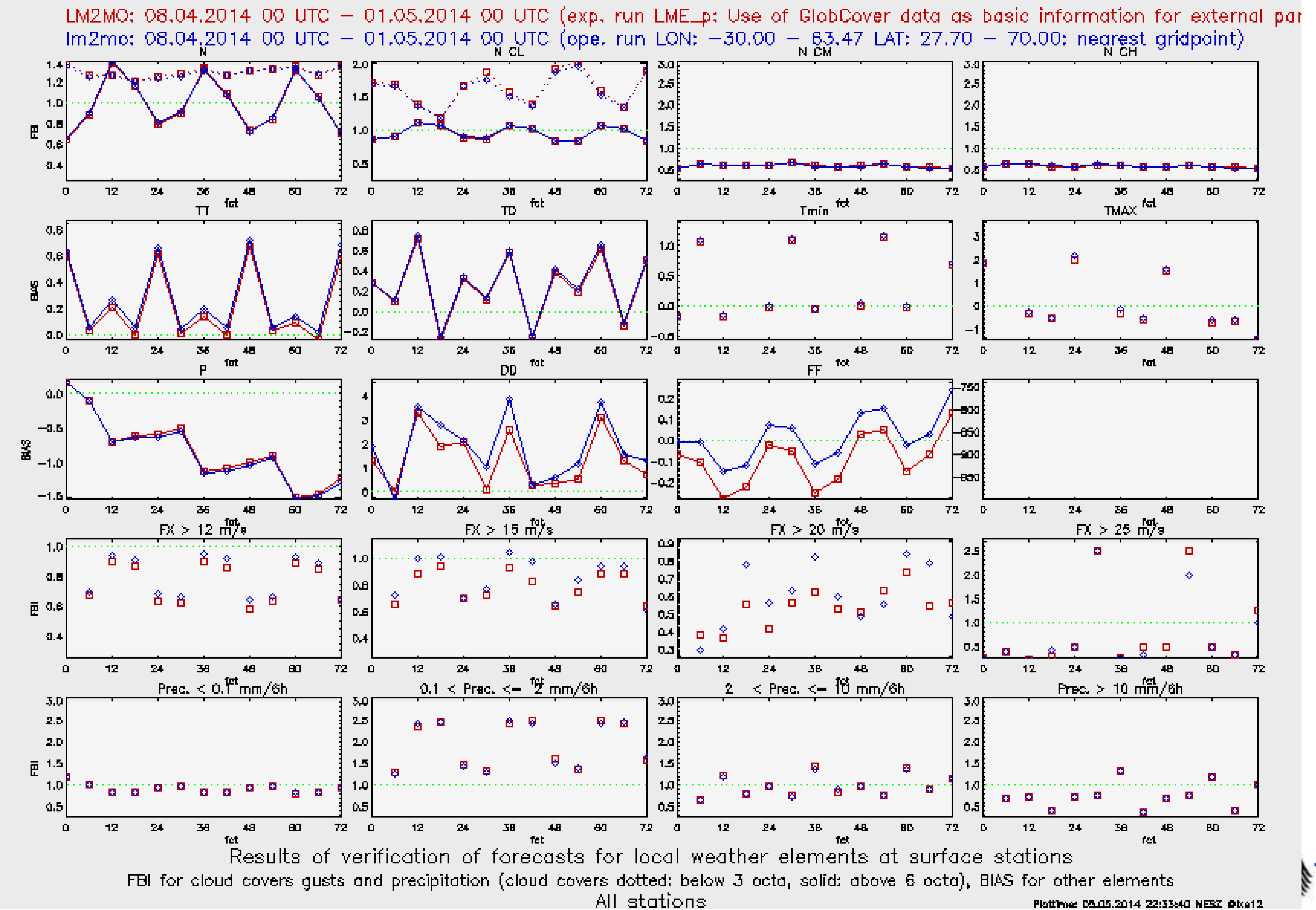
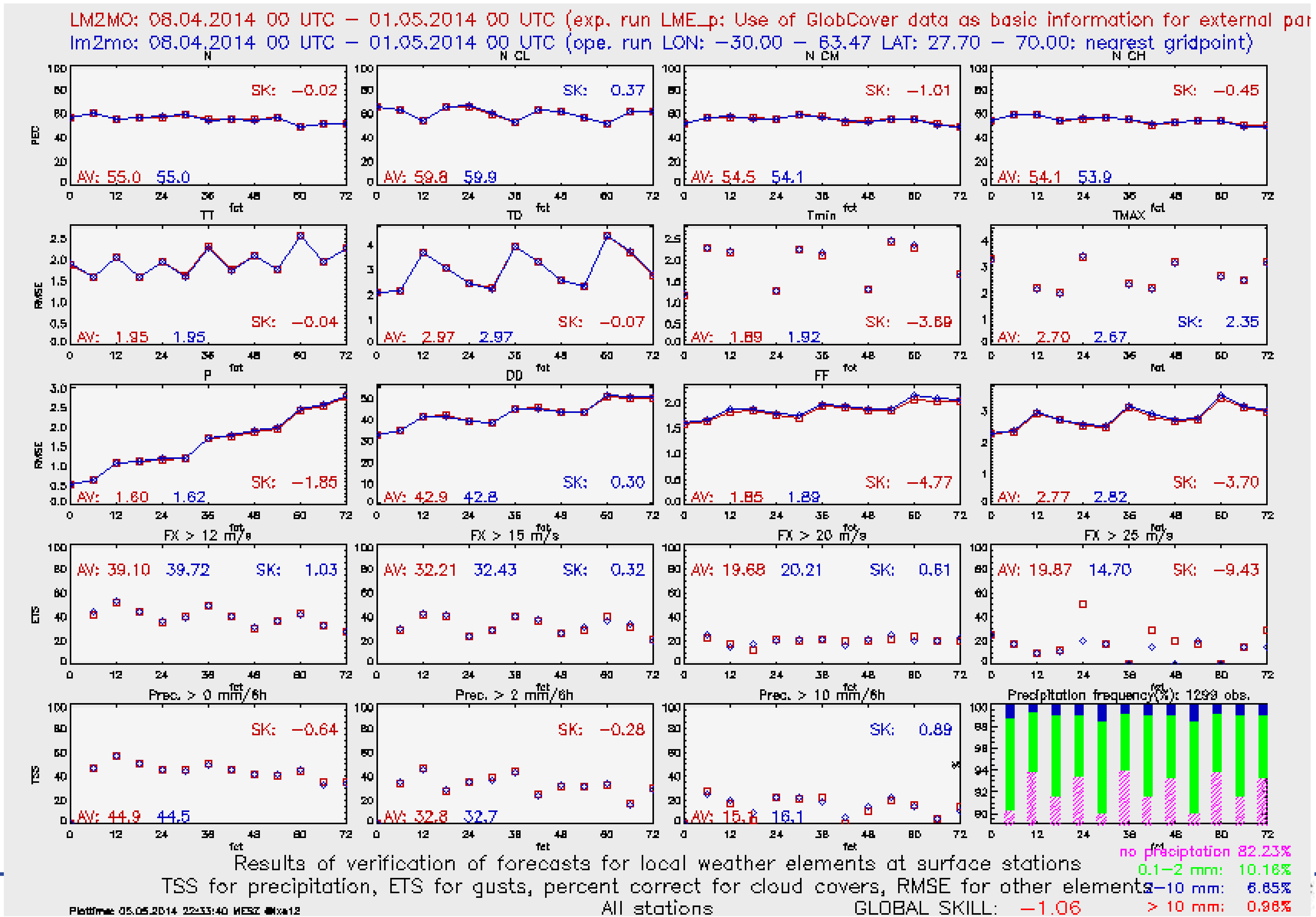


GlobCover in COSMO-EU

Results from preoperational runs



Revised Infiltration

- Problem: In late summer dry out of CDE root zone soil possible
- Implications: shutdown of latent heat flux
- Possible solution: Enhanced infiltration parameterization
- Faster infiltration reduces surface runoff
- CDE experiment (assimilation and forecasts) since 2014051000
- CEU experiment (assimilation and forecasts) since 2014051000

Revised infiltration

$$\frac{\partial w_l}{\partial t} = \frac{1}{\rho_w}\frac{\partial F}{\partial z}$$

soil water change

$$F = -\rho_w\left[-D_w(w_l)\frac{\partial w_l}{\partial z} + K_w(w_l)\right]$$

soil water flux, Richards equation

$$D_w(w_l) = D_0 \ \ exp \ \left[D_1(w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP})\right]$$

soil water diffusivity, Rijtema (1969)

$$K_w(w_l) = \boxed{K_0} \ \ exp \ \left[K_1(w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP})\right]$$

soil water conductivity, Rijtema (1969)

Revised infiltration

$$D_w(w_l) = D_0 \;\; exp \;\; \left[D_1(w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP}) \right]$$

$$K_w(w_l) = \boxed{K_0} \;\; exp \;\; \left[K_1(w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP}) \right]$$

```
  ! soil type     sand     sandy    loam    clay        clay    peat
  ! (by index)             loam             loam
DATA   cik2   / 0.0035, 0.0023, 0.0010, 0.0006, 0.0001, 0.0002, /
DATA   ckw0   / 479E-7, 943E-8, 531E-8, 764E-9,  17E-9,  58E-9, /
DATA   ckw1   / -19.27, -20.86, -19.66, -18.52, -16.32, -16.48, /
DATA   cdw0   / 184E-7, 346E-8, 357E-8, 118E-8, 442E-9, 106E-9, /
DATA   cdw1   / -8.45 ,  -9.47, -7.44 , -7.76 , -6.74 , -5.97   /
```

COSMO Docu:

The maximum infiltration rate is given by a simplified Holtan-equation (e. g. Hillel (1980)):

$$I'_{max} = \begin{cases} 0 & : \quad T_{sfc} \leq T_0 \\ f_r \; S_{oro}[Max(0.5 \; ; \; f_{plnt})I_{k1}(w_{PV} - w_1)/w_{PV} + I_{k2}] & : \quad T_{sfc} > T_0 \end{cases} \qquad (10.37)$$

Revised infiltration
New approach

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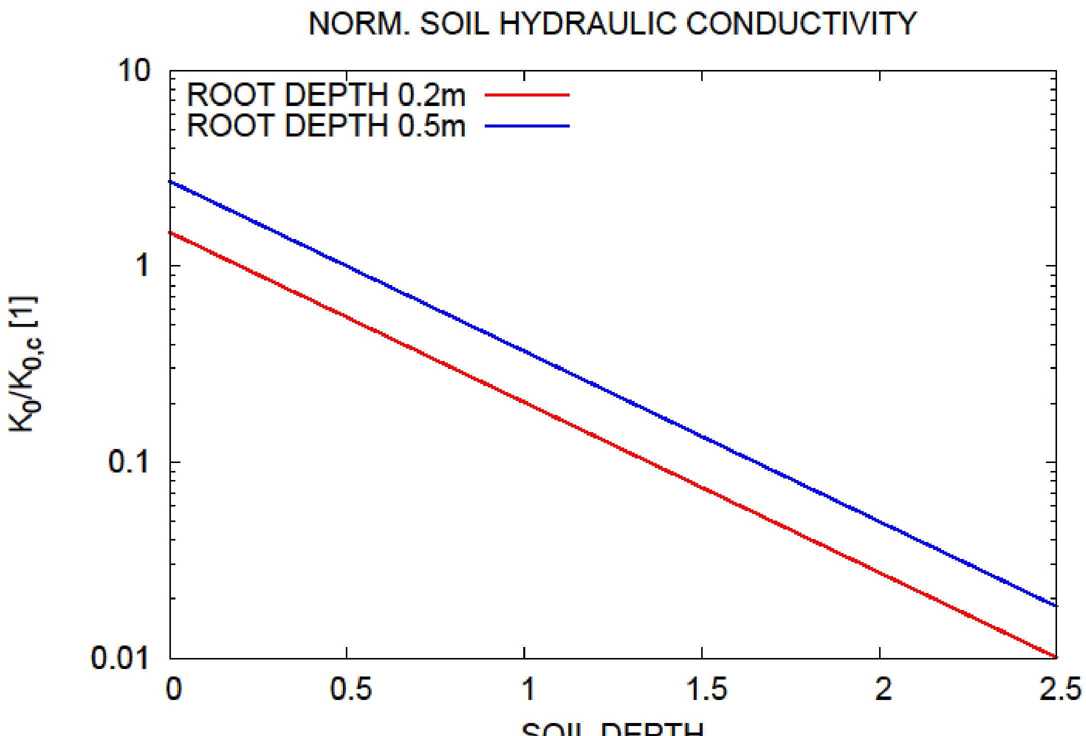
$$I'_{max} = \begin{cases} 0 & : T_{sfc} \leq T_0 \\ f_r\, S_{orc}\, \rho_w K_0(z) & : T_{sfc} > T_0 \end{cases} \quad (10.3$$

$$K_w(w_l) = K_0(z)\, exp \left[K_1 (w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP}) \right]$$

$$K_0(z) = K_{0,c} e^{-f(z-d_c)}$$

Profile of sat. hydr. conductivity, Decharme (2006)



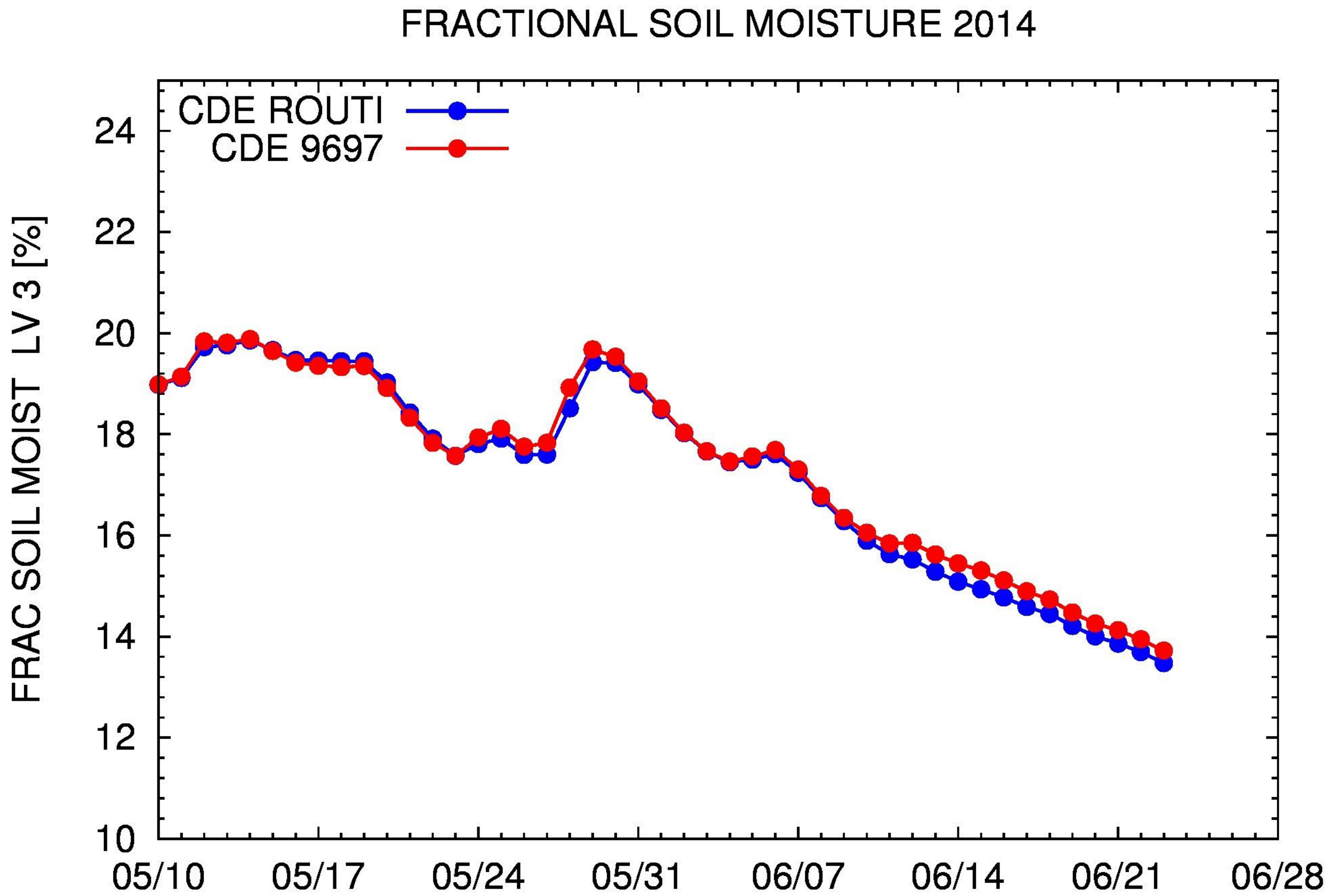
Higher hydr. conductivity near surface due to root macro pores

Compaction in deep soil decreases *K*

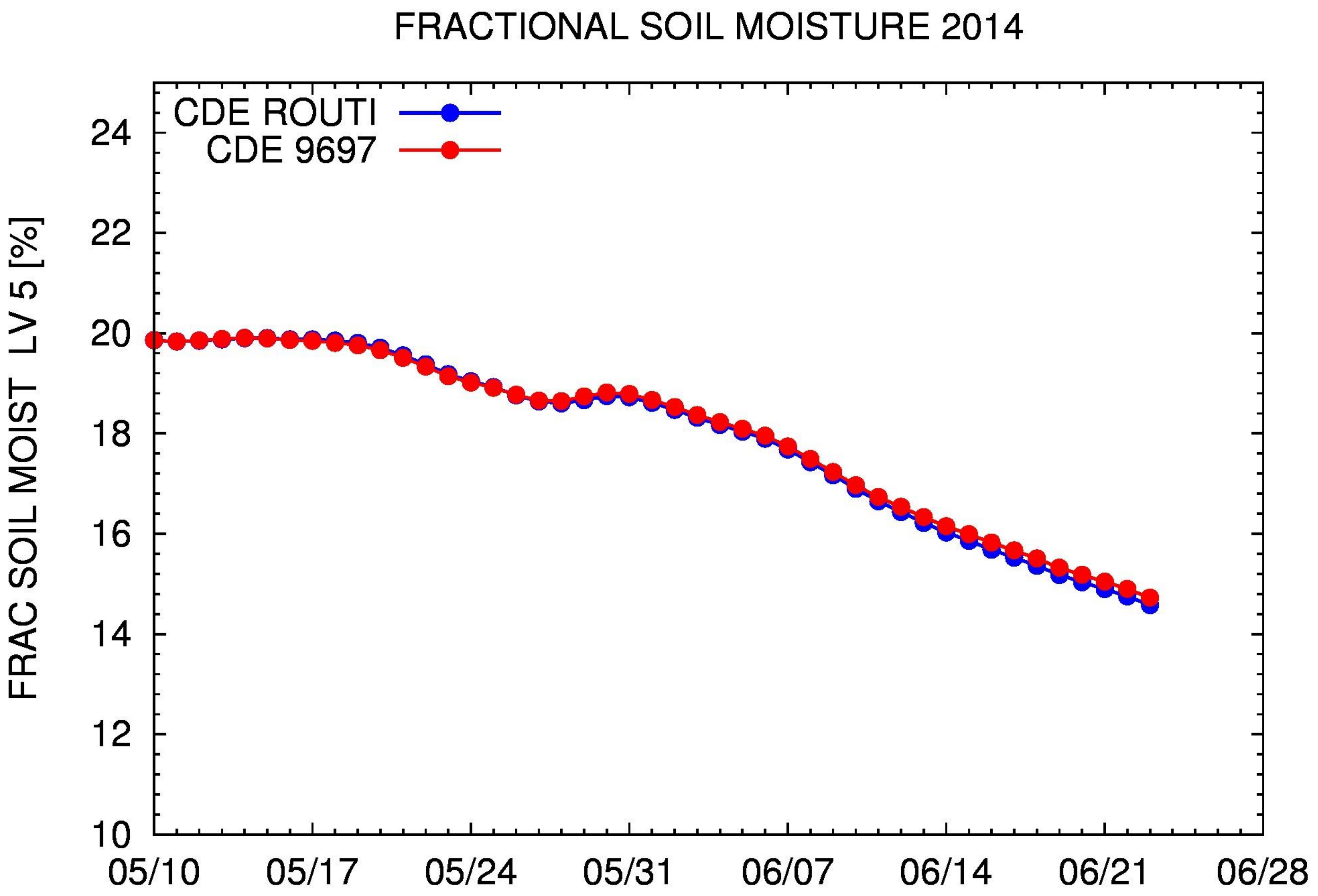
CDE experiment

2014051000-2014062300

Revised infiltration
CDE- domain average



Revised infiltration CDE- domain average



Revised infiltration
CDE- domain average

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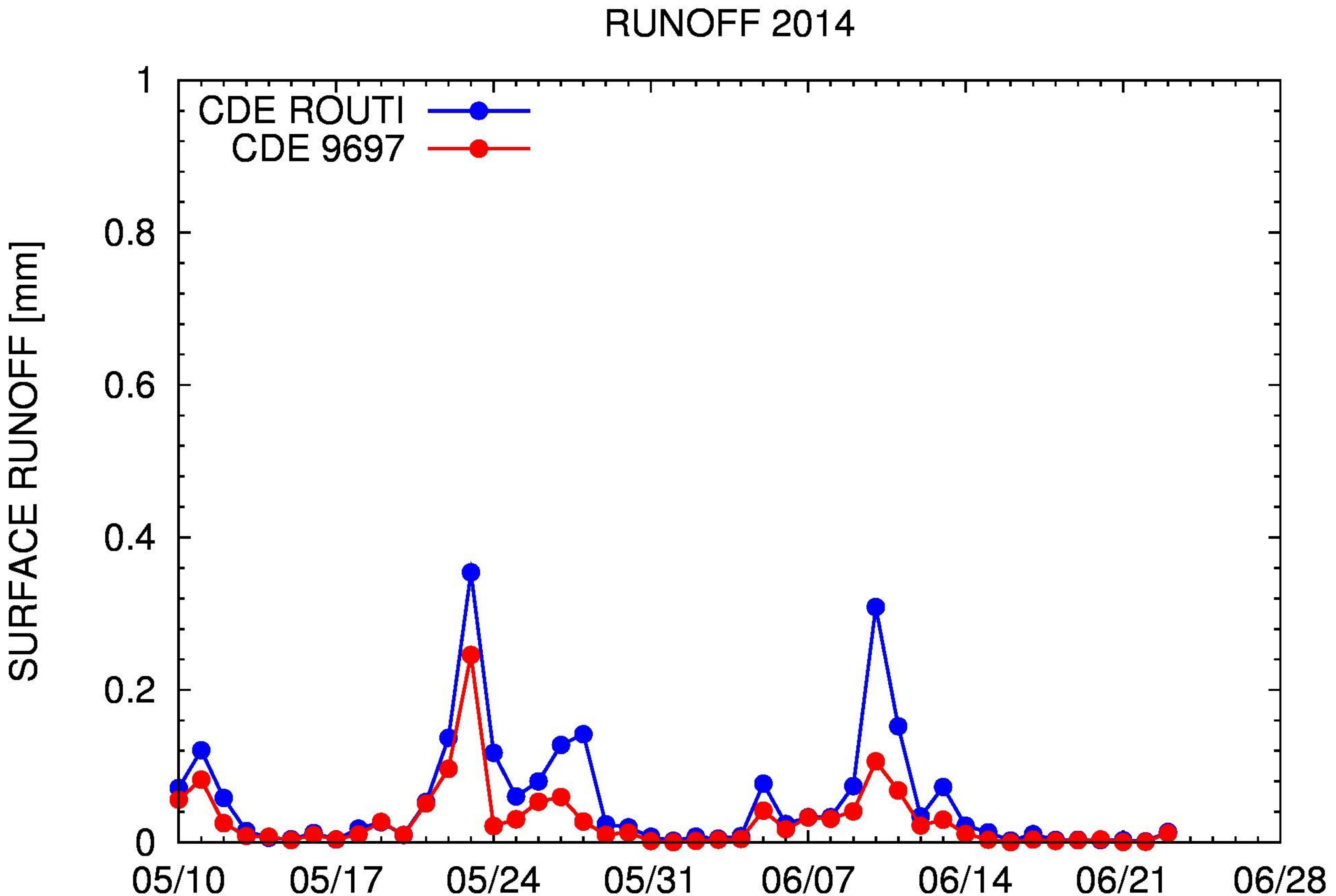

Revised infiltration
CDE- EXP one month - BIAS

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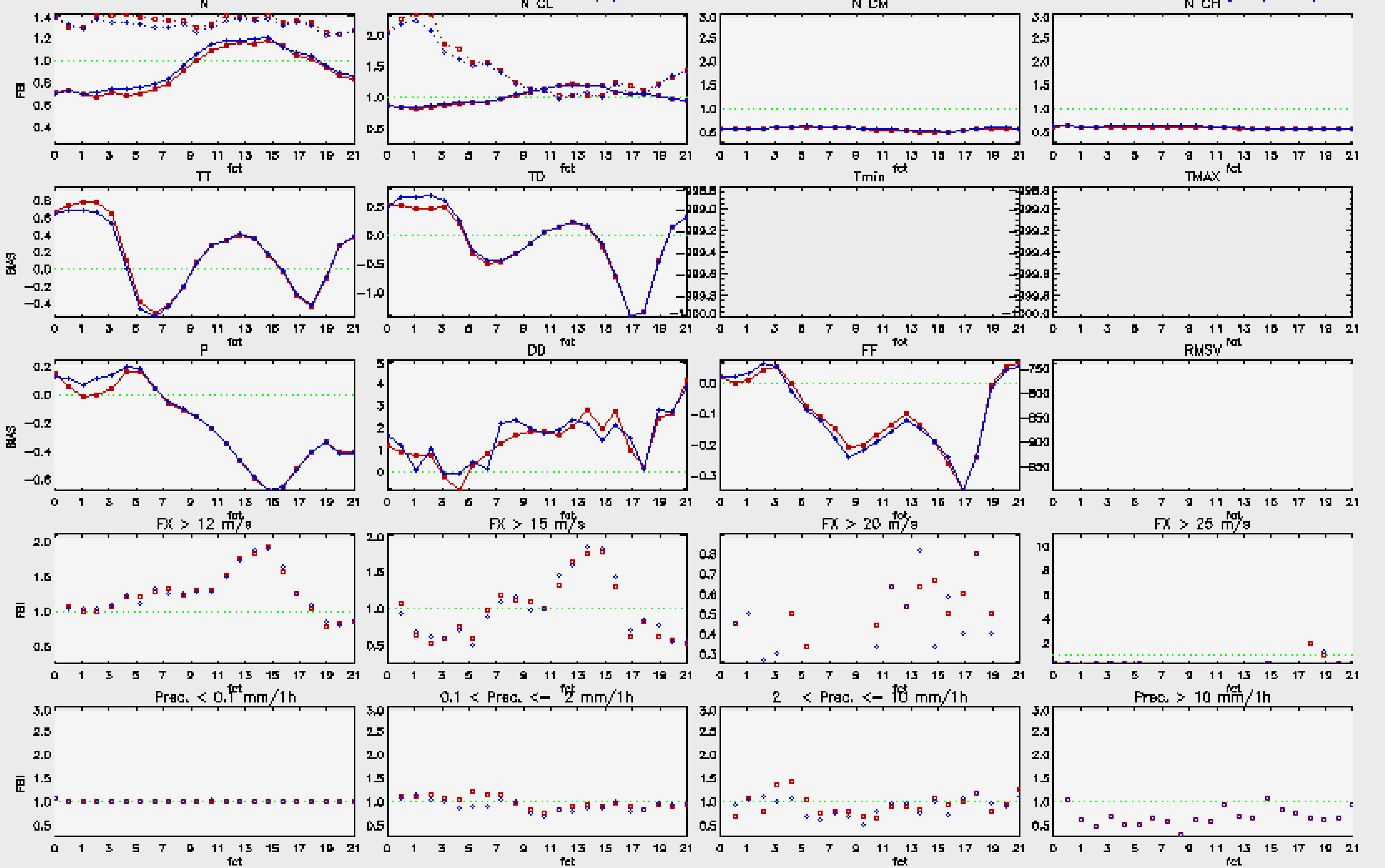


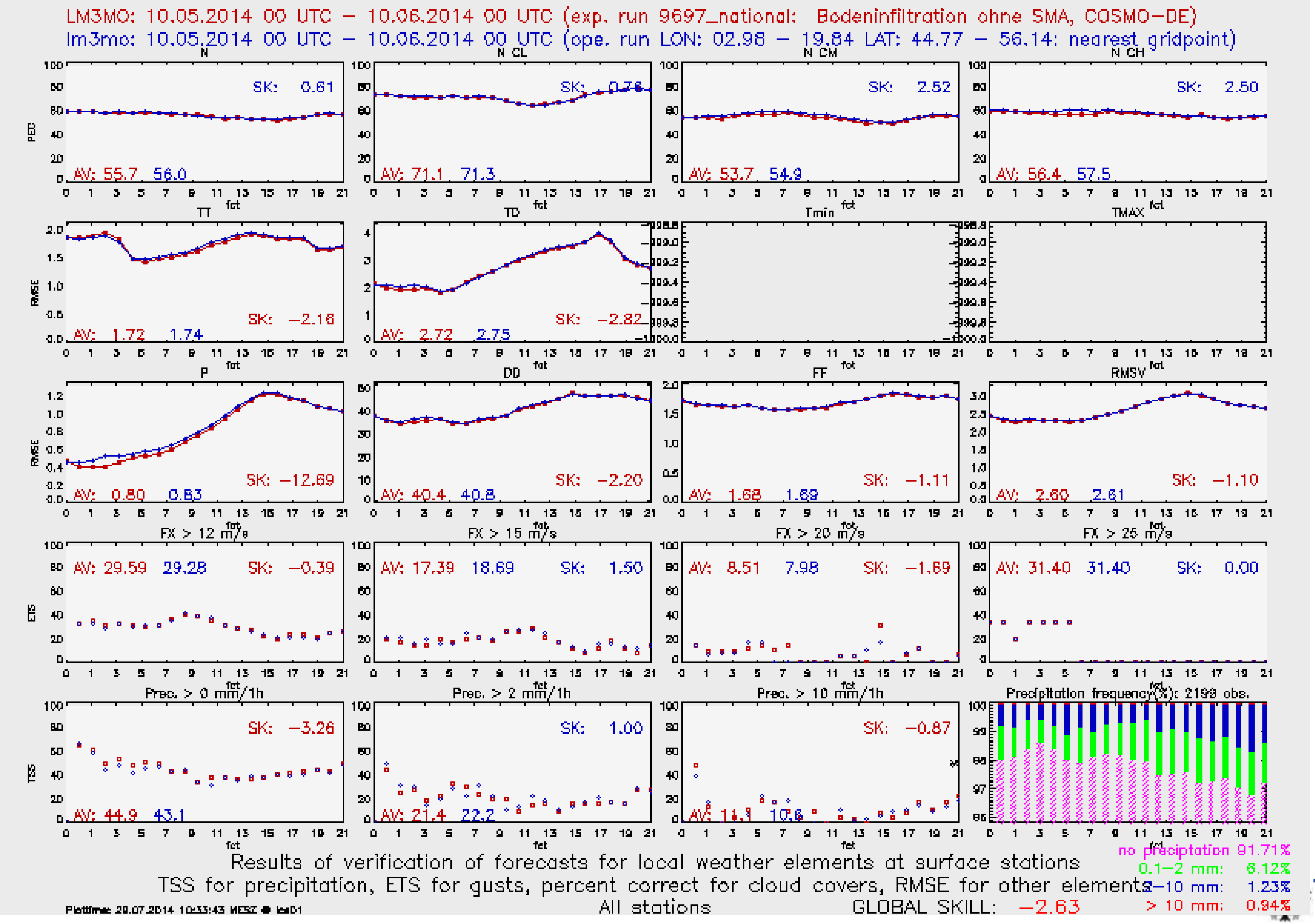
Results of verification of forecasts for local weather elements at surface stations

FBI for cloud covers gusts and precipitation (cloud covers dotted: below 3 octa, solid: above 6 octa), BIAS for other elements

All stations

Plottime: 29.07.2014 10:33:43 MESZ @ lce01

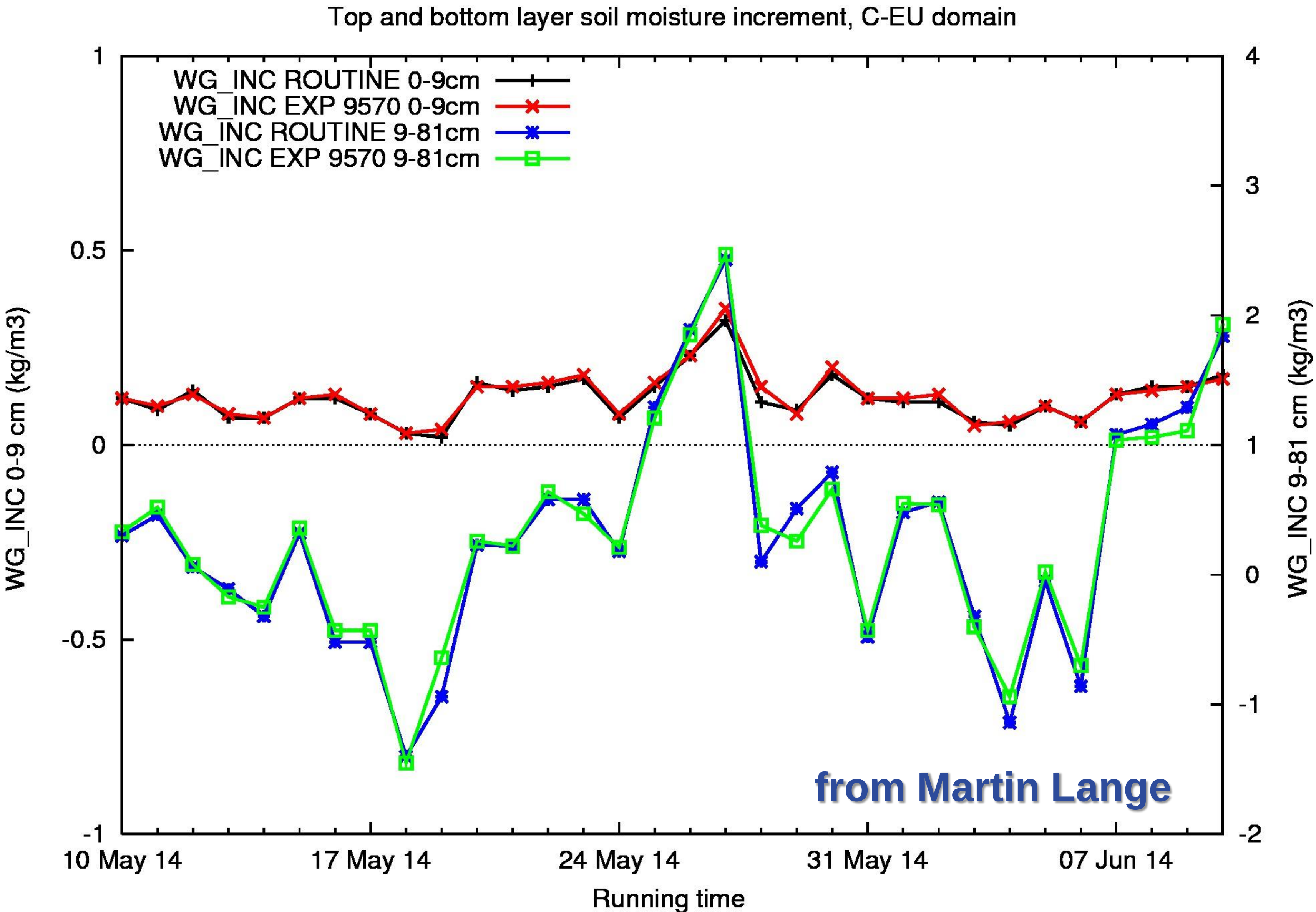
Revised infiltration
CDE- EXP one month - RMSE



CEU experiment

2014051000-2014061000

Revised infiltration CEU- domain average



from Martin Lange

Revised infiltration
CEU- domain average

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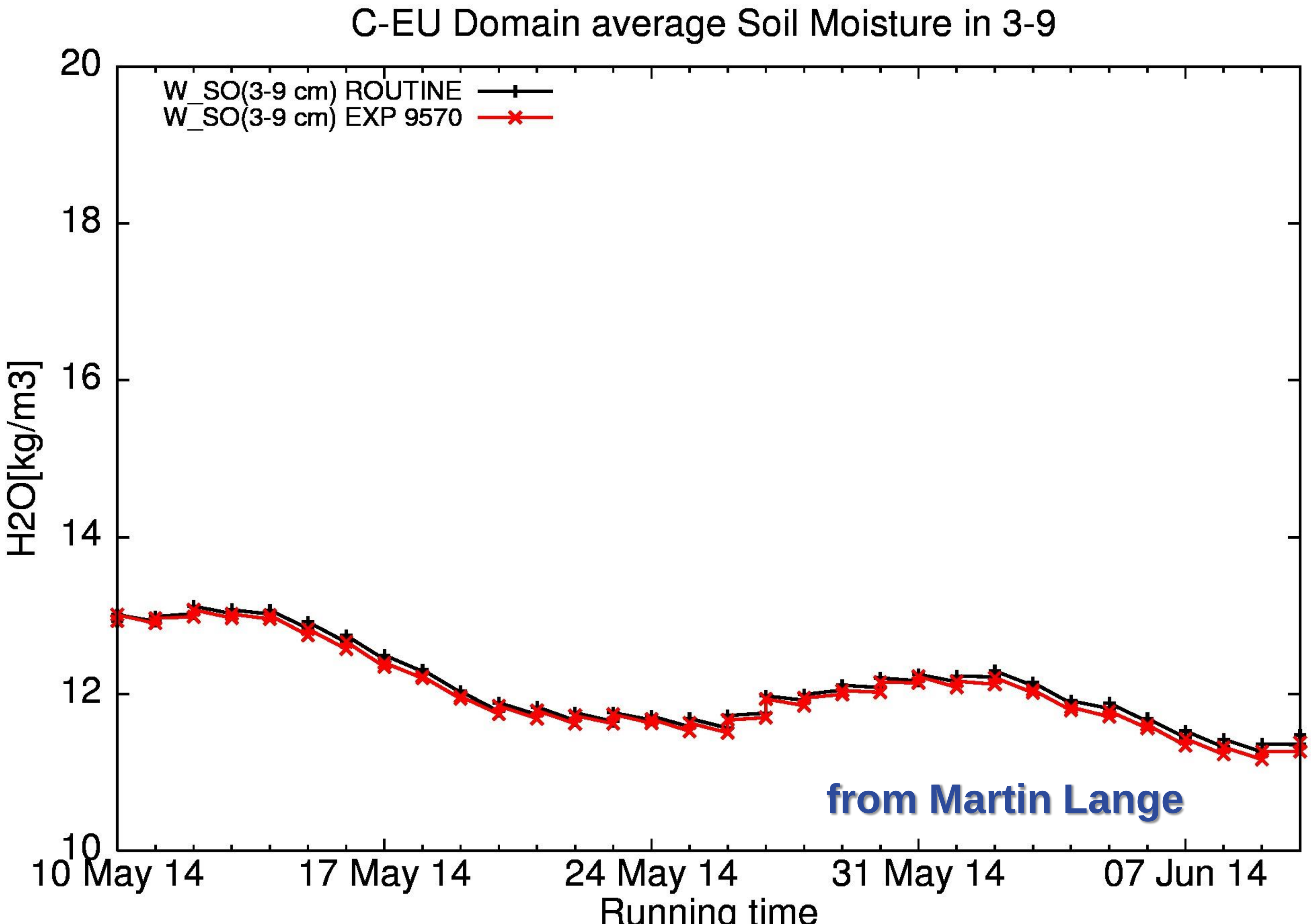
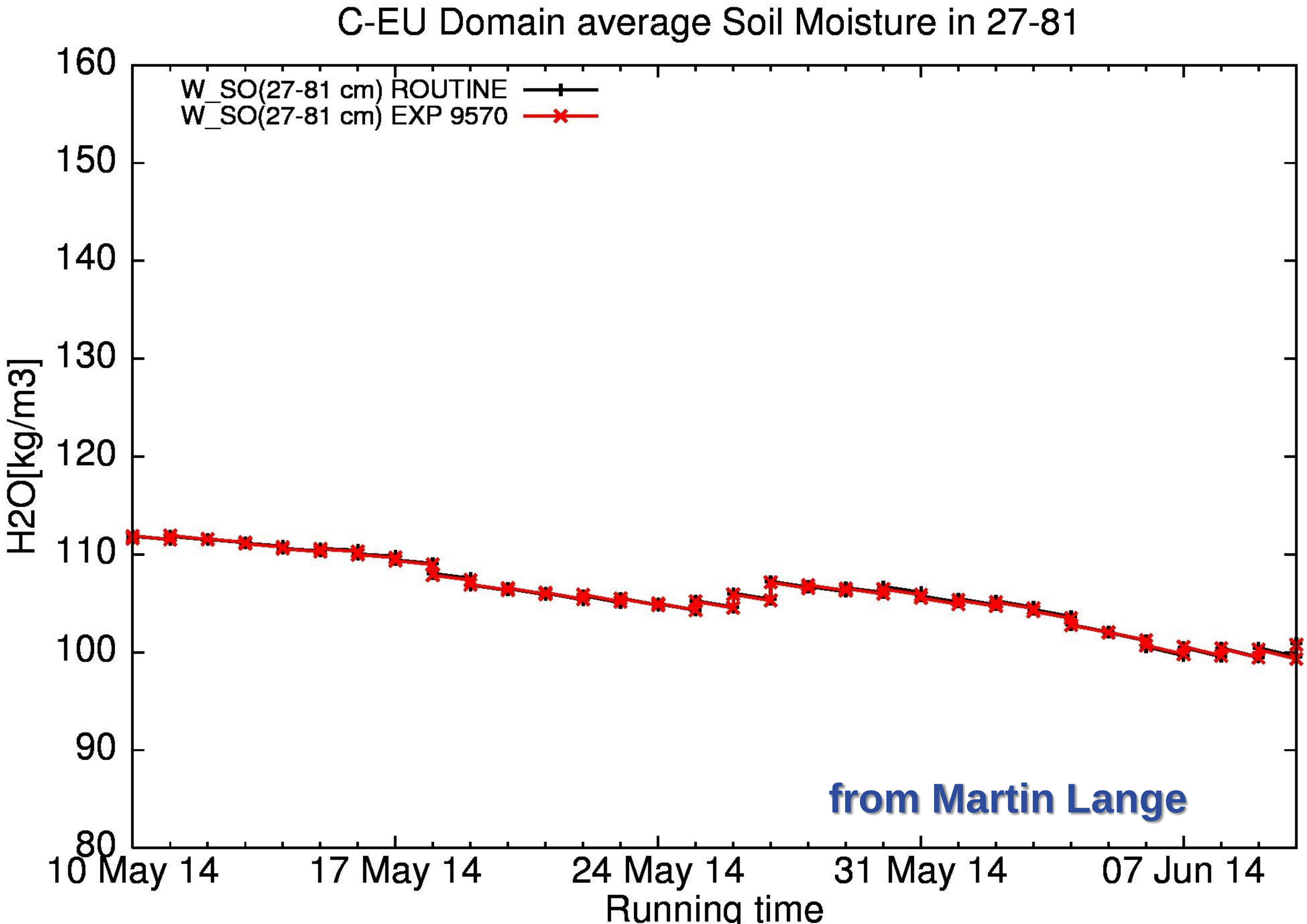
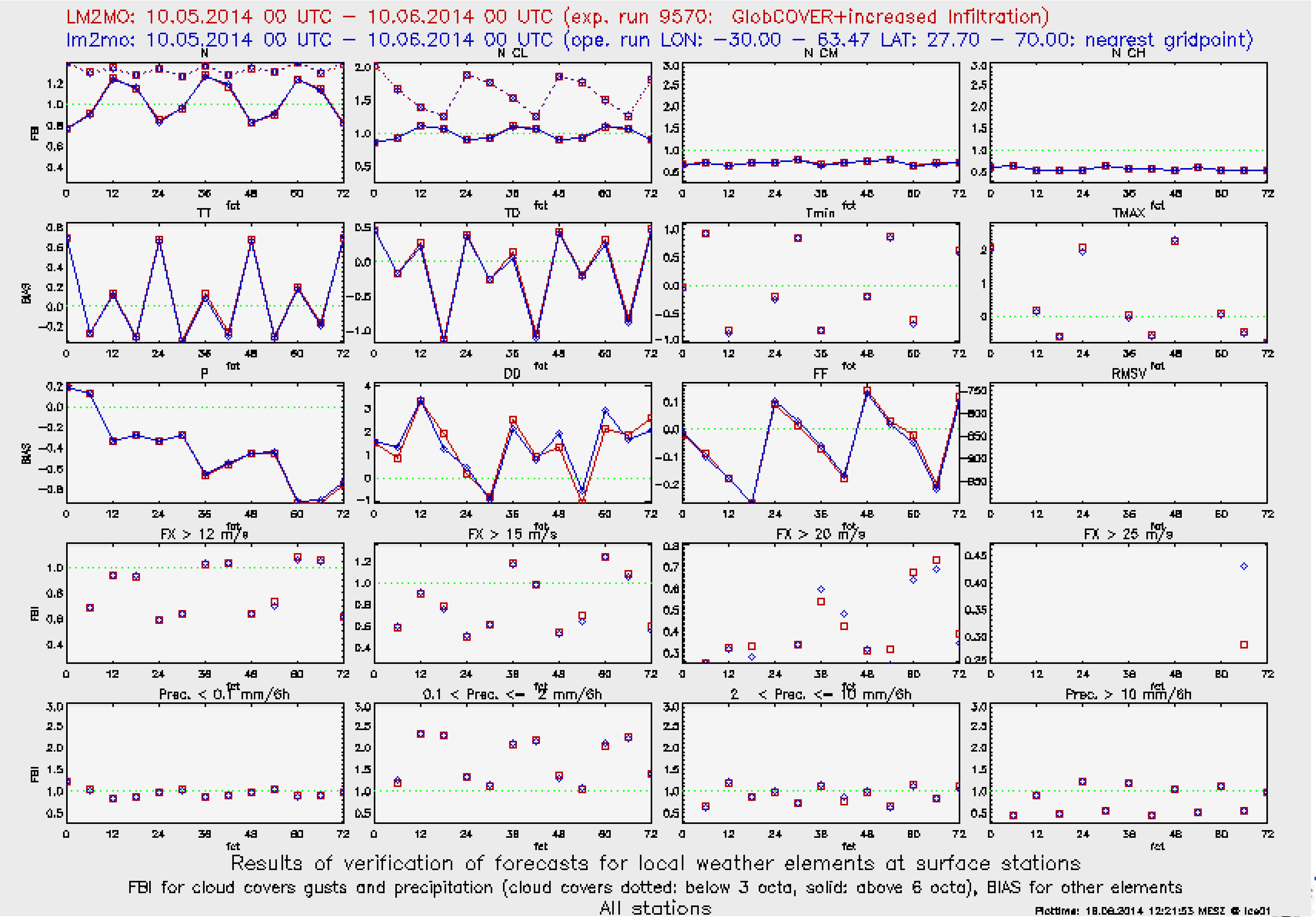


Revised infiltration CEU- domain average



Revised infiltration
CEU- EXP one month - BIAS



Revised infiltration
CEU- EXP one month - RMSE

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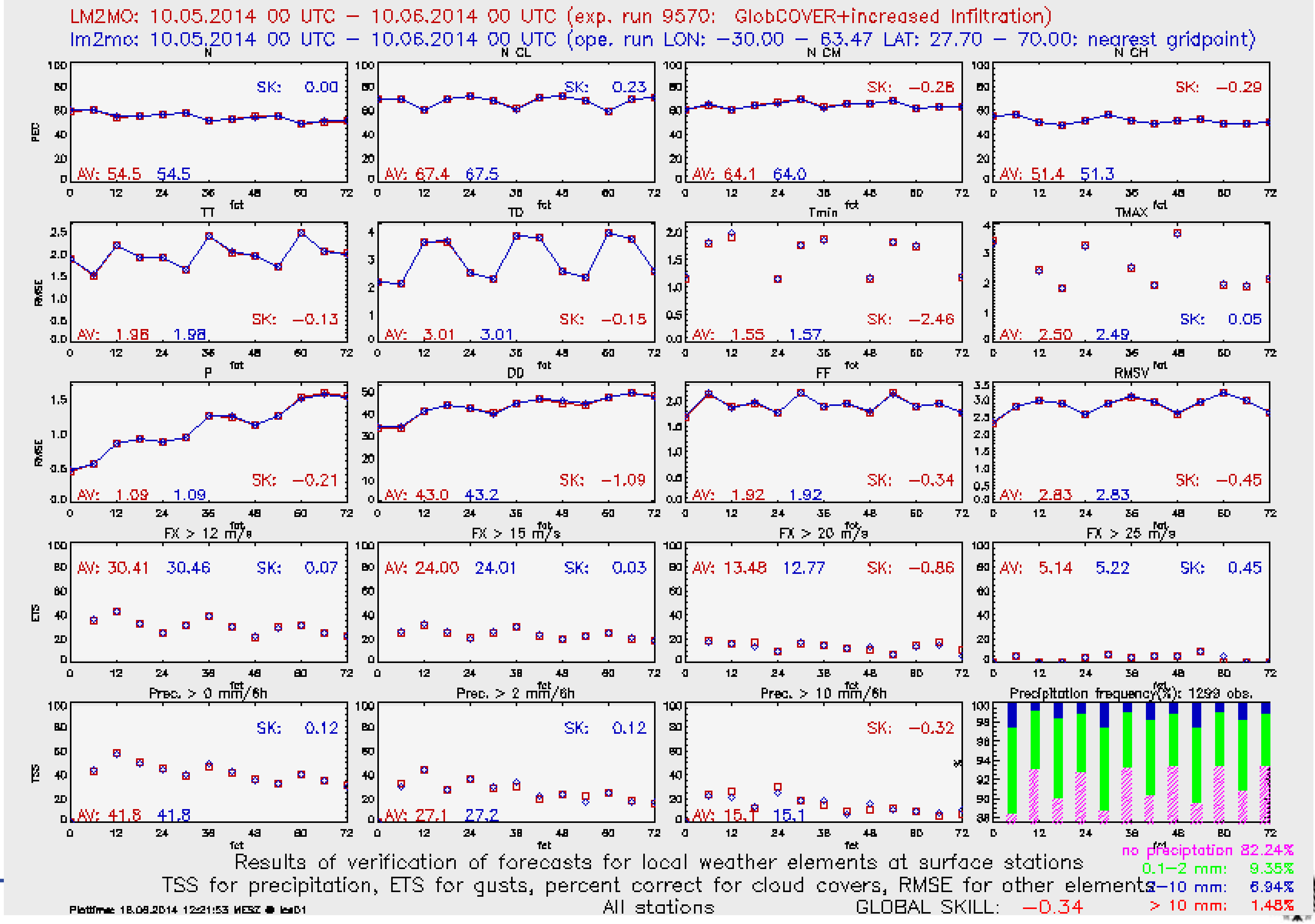


HWSD soil in COSMO-CLM

- New water transport scheme in TERRA (Brooks and Corey, 1964)
- CLM experiment over 15 years forced by ERA40
- Results in Smiatek et al., Impact of land use and soil data specifications on COSMO-CLM simulations in the CORDEX-MED area, Meteorologische Zeitschrift, in review

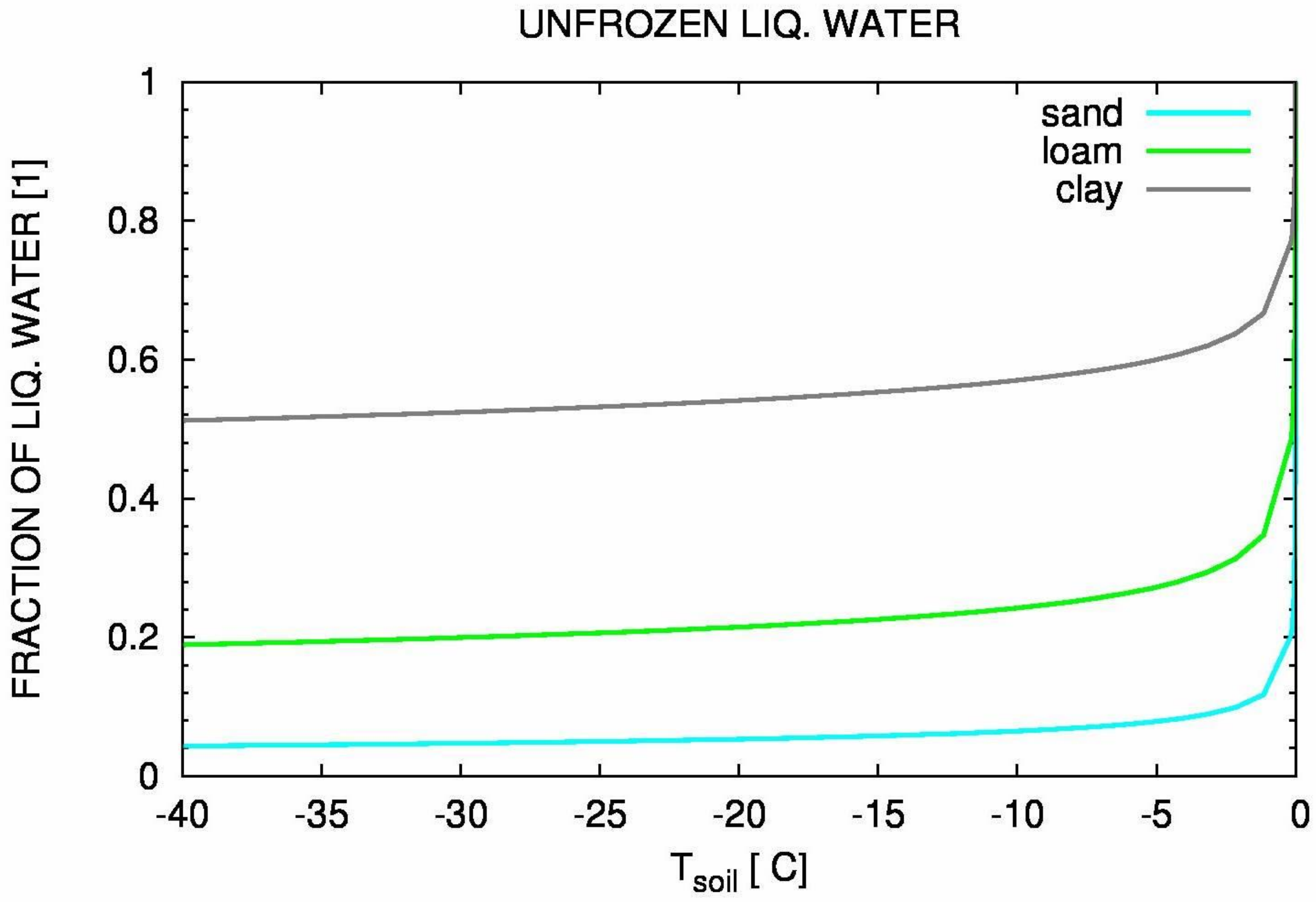
Snow scheme in ICON-TERRA

- Using 3 layer with snow depth limitations
- Limit snow depth of upper snow layers for improved daily cycle in Antarctica
- Experiments on snow albedo development – modifications of time constants

Treatment of permafrost in TERRA

- Unfrozen water depends on soil type
- Large fraction of soil liquid water for clay at -40°C
- Realistic?
- Do we need a revision of the parameterization?

Permafrost in TERRA



Permafrost in TERRA

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, D17116, doi:10.1029/2007JD009343, 2008

Evaluation of the algorithms and parameterizations for ground thawing and freezing simulation in permafrost regions

Yinsuo Zhang,[1] Sean K. Carey,[1] and William L. Quinton[2]

Unfrozen water parameterization

$$\theta_u = a|T|^c$$

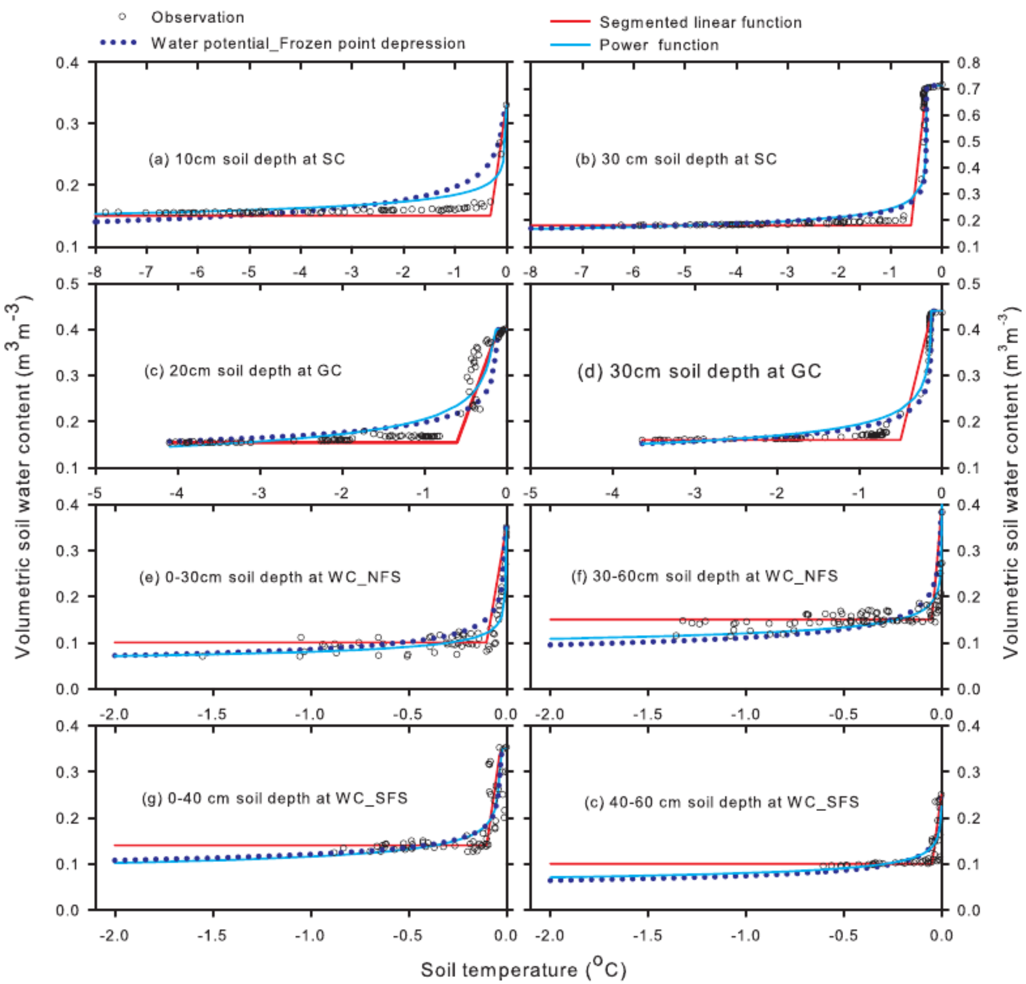
$$\theta_u = a|T - T_f|^c$$

$$\theta_u = \begin{cases} \theta_w - (\theta_w - \theta_{u,l})(T - T_f)/(T_{u,l} - T_f) & T > T_{u,l} \\ \theta_{u,l} & T \leq T_{u,l} \end{cases}$$

$$\theta_u = \theta_0(\psi/\psi_0)^{-1/b} = \theta_0\left[L(T - T_f)/[g(T + 273.15)\psi_0]\right]^{-1/b}$$

in TERRA

Permafrost in TERRA



re 1. Comparisons of observed and simulated unfrozen water content under subfreezing soil erature using three unfrozen water parameterizations at two soil layers for the four model testing

Table 2. Soil Profiles and Properties of the Four Sites

Site Name (Coordinates)	Depth of Soil Layers (m)
Scotty Creek (SC, 61°18'N; 121°18'W, 280 m)	0.0–0.10
	0.1–0.2
	0.2–0.3
	0.3–0.4
	0.4–0.5
	0.5–3.0
	>3.0
Granger Creek (GC, 60°33'N; 135°11'W, 1338 m)	0–0.03
	0.03–0.07
	0.07–0.15
	0.15–0.25
	0.25–0.35
	>0.35
Wolf Creek north-facing slope (WC_NFC, 60°31'N; 135°31'W, 1175 m)	0.0–0.11
	0.11–0.23
	0.23–0.60
	>0.6
Wolf Creek south-facing slope (WC_SFC, 60°31'N; 135°31'W, 1175 m)	0–0.4
	>0.4