TERRA

Soil Vegetation Atmosphere Transfer across Models and Scales

DWD contribution

COSMO-SOILVEG Workshop 2014

TERRA – New features

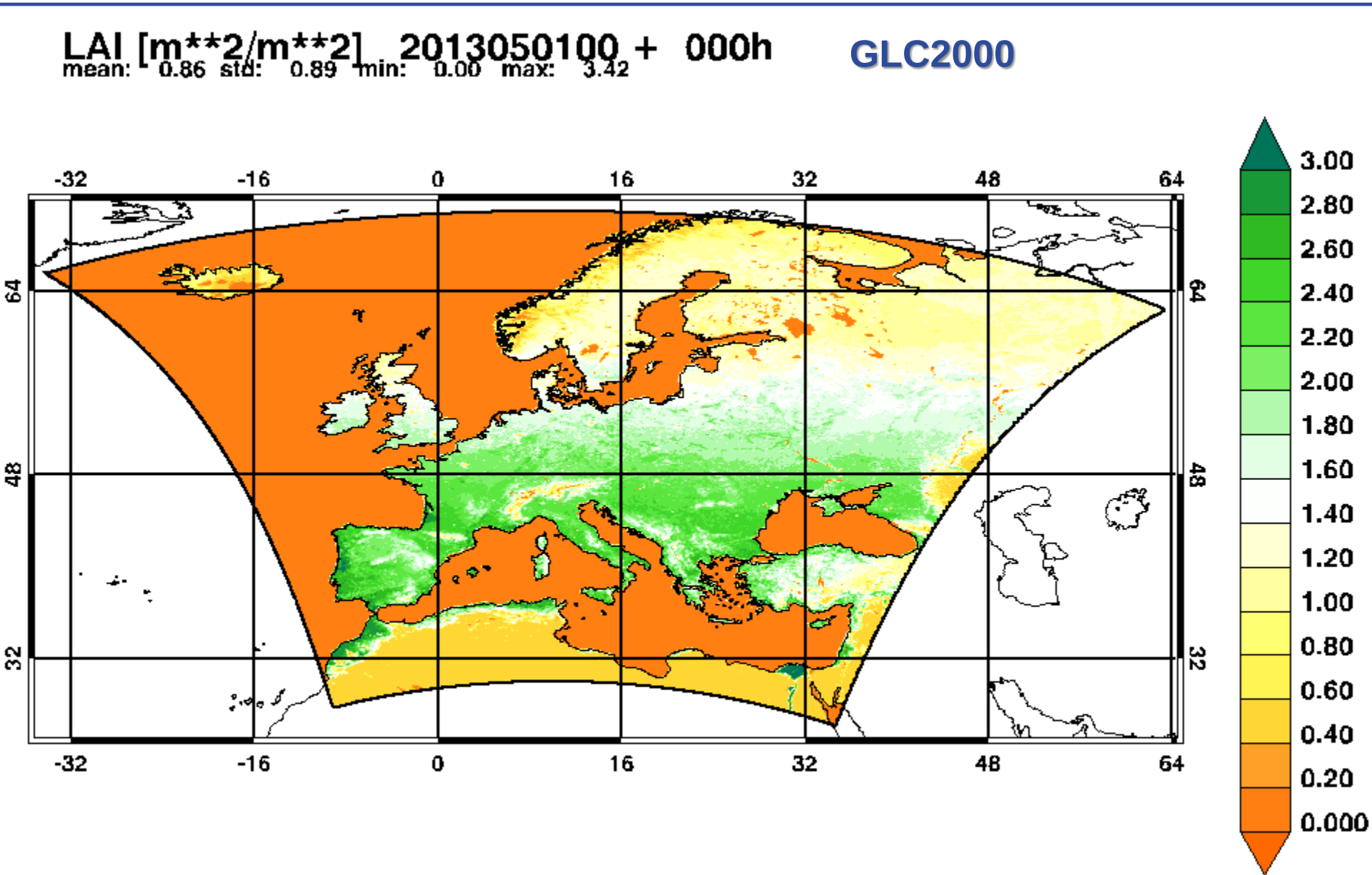
- COSMO-EU with GlobCOVER land-use data
- Revised infiltration
- COSMO-CLM study using TERRA with HWSD and new water transport
- Tuning of the ML-snow scheme and the snow albedo scheme in ICON

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
- Experiment start 2013040100 – one month verification

GlobCover in COSMO-EU

CONSORTIUM FOR SMALL SCALE MODELING
COSMO
Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD



GlobCover in COSMO-EU

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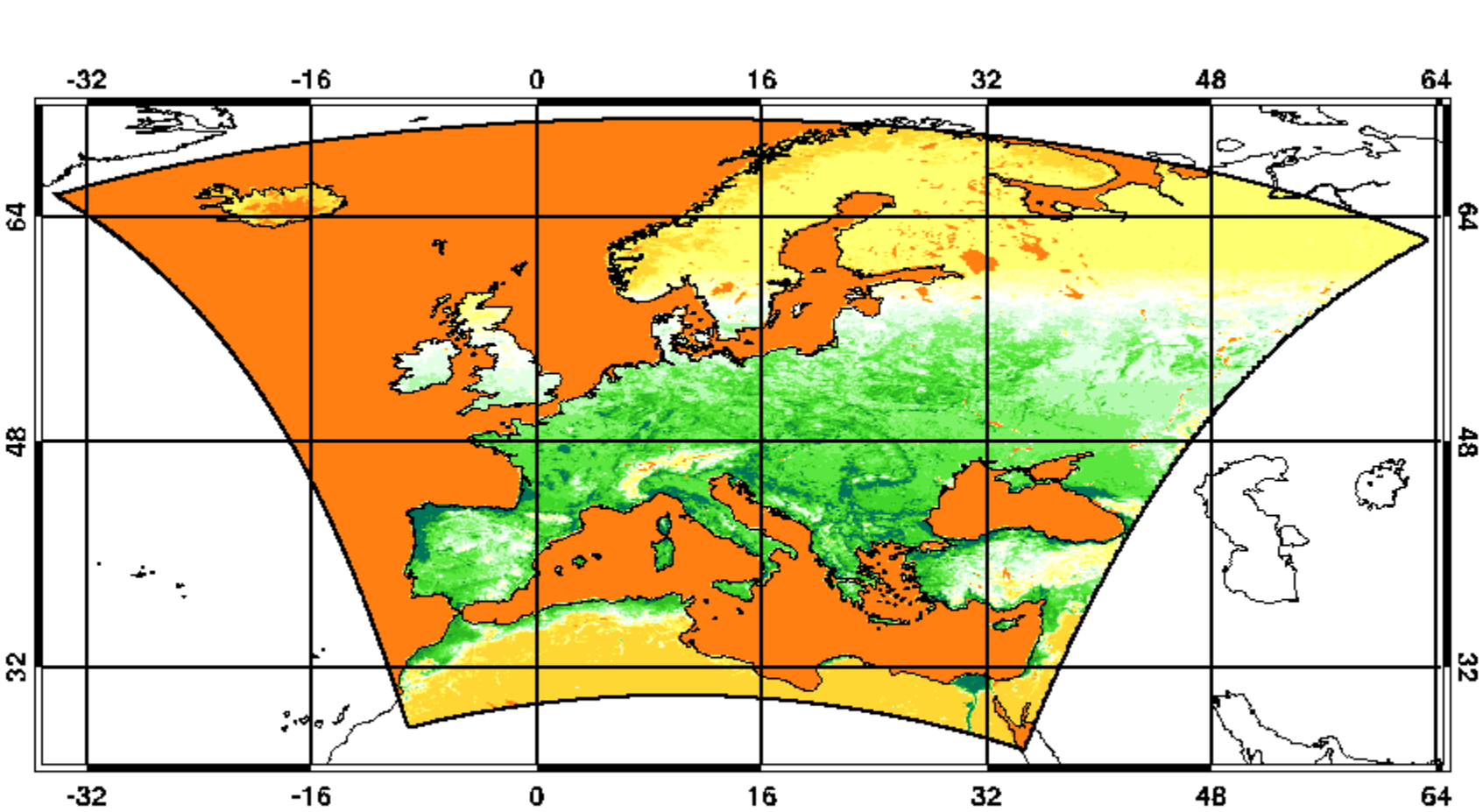
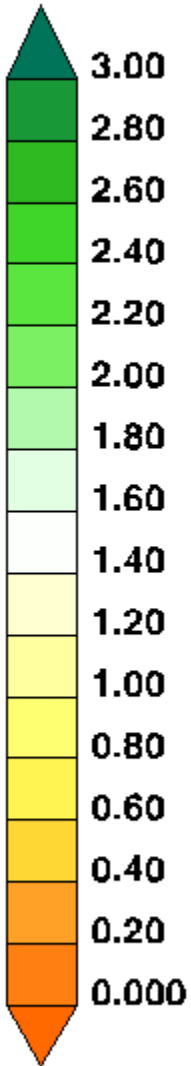
LAI [m**2/m**2] 2013050100 + 000h
mean: 0.93 std: 1.01 min: 0.00 max: 4.77

GlobCover





GlobCover in COSMO-EU

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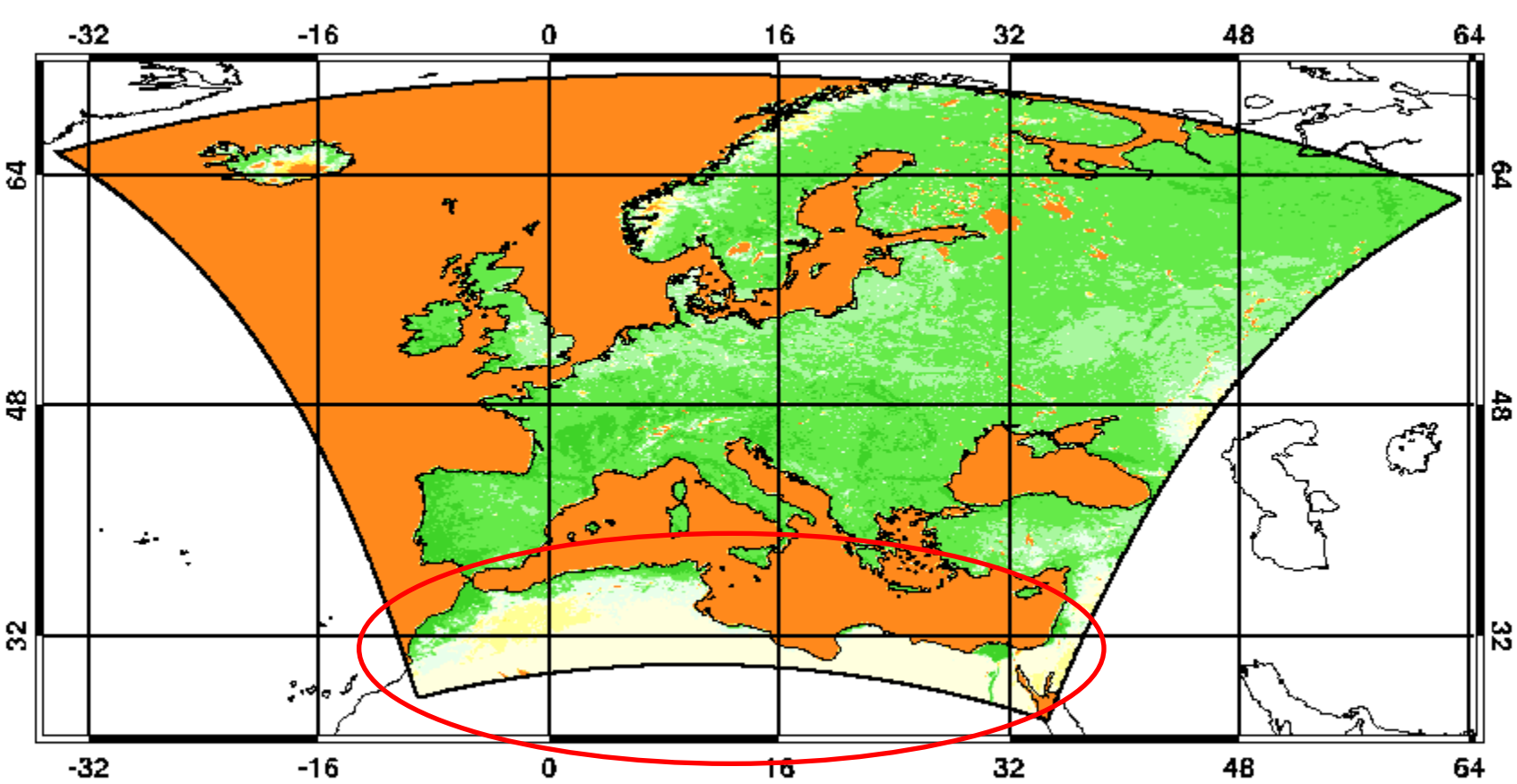
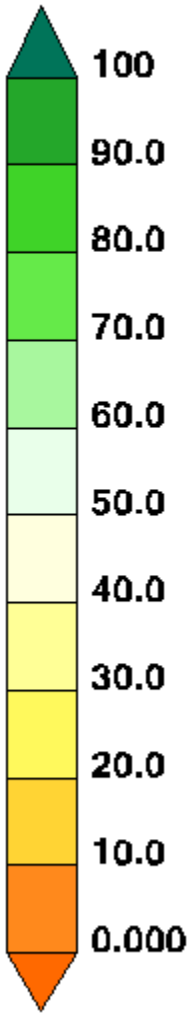
PLCOV [%] 2013050100 + 000h
mean: 39.09 std: 35.13 min: 0.00 max: 88.08

GLC2000





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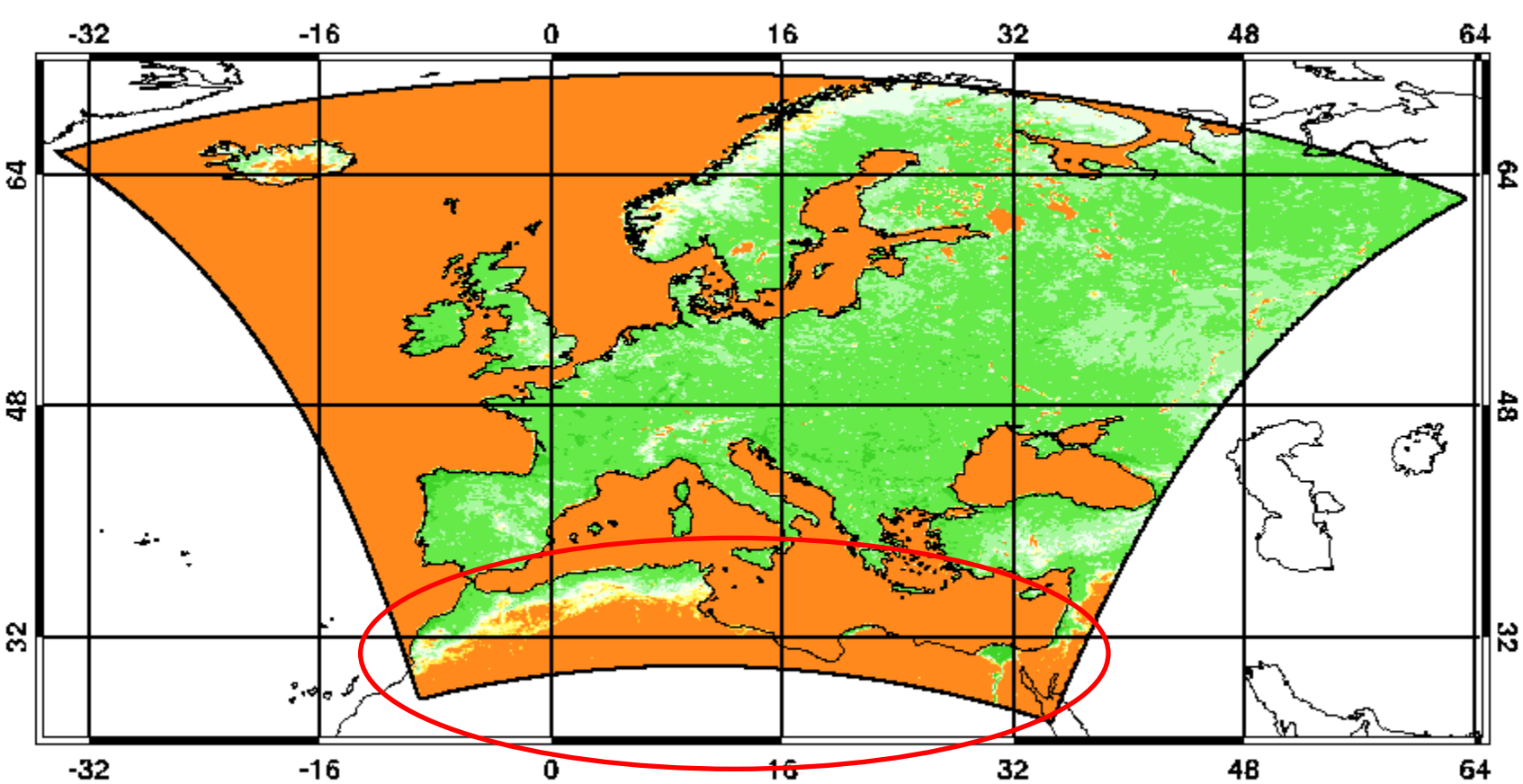
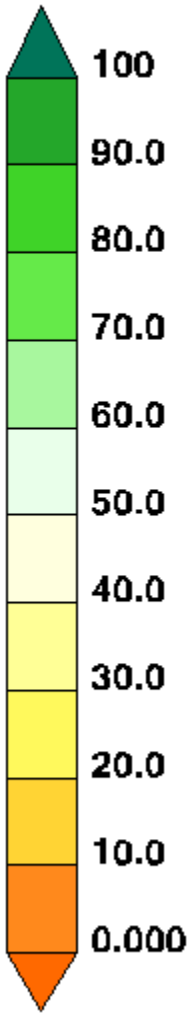
PLCOV [%] 2013050100 + 000h
mean: 34.68 std: 35.37 min: 0.00 max: 86.68

GlobCover





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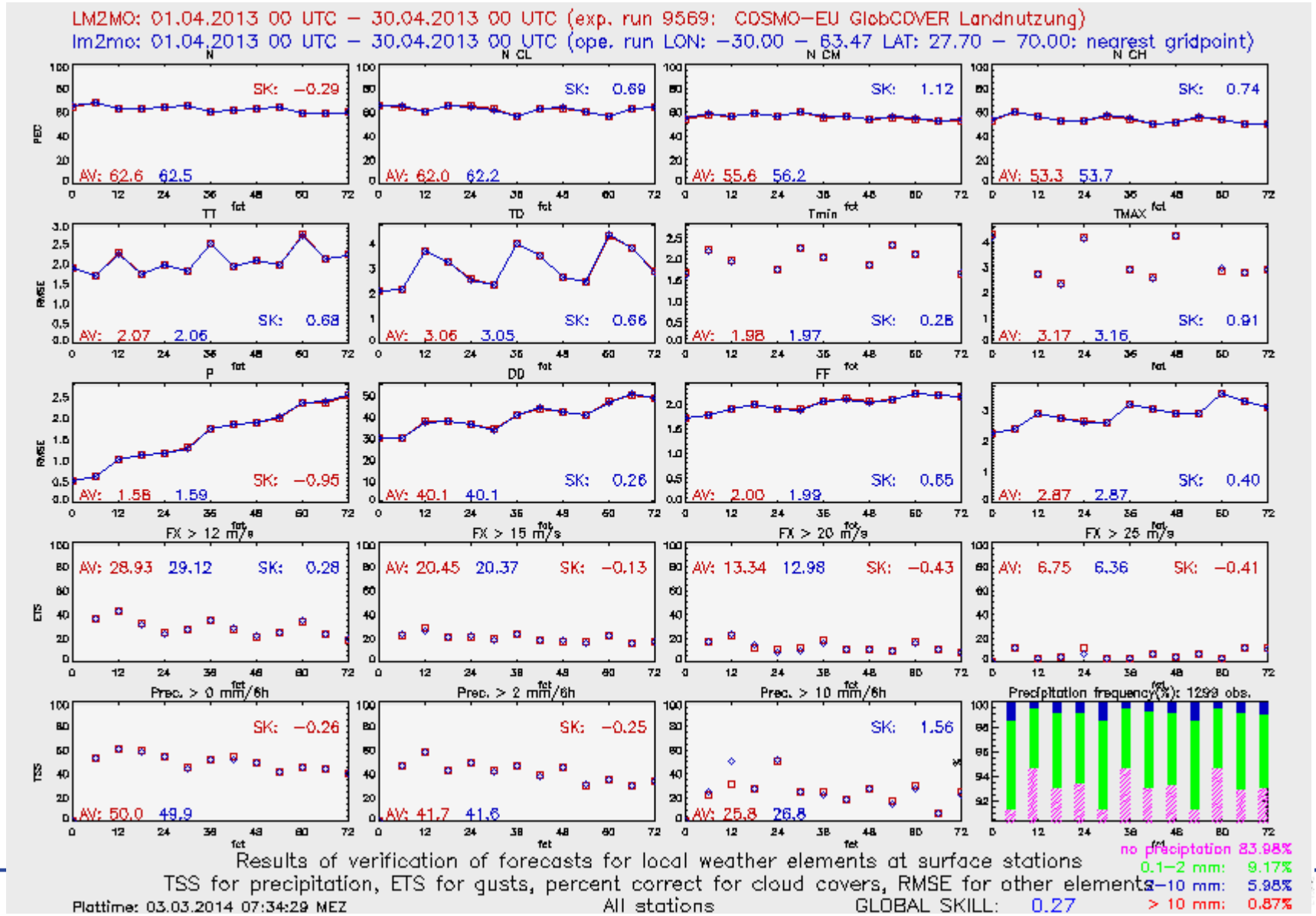
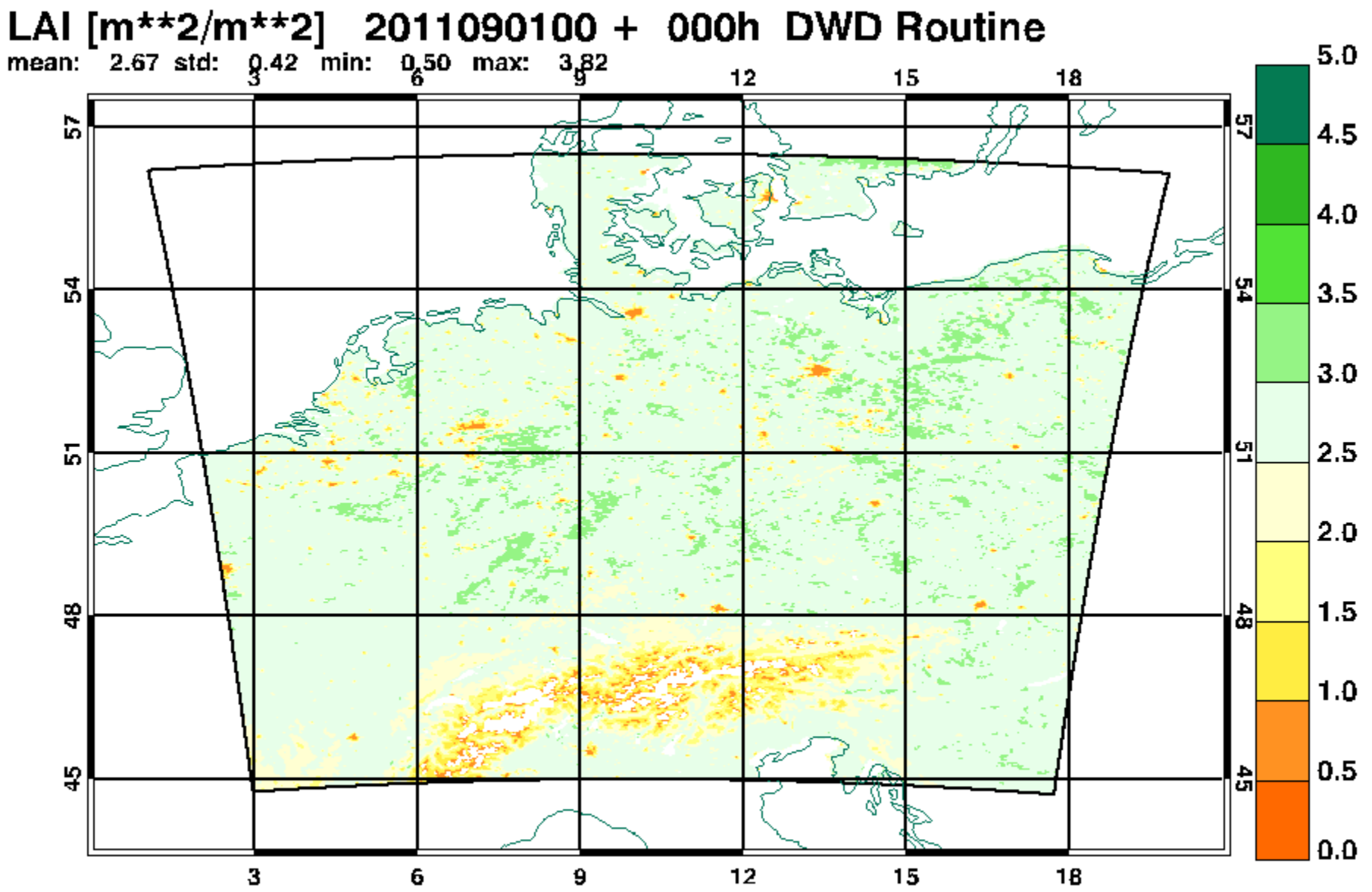


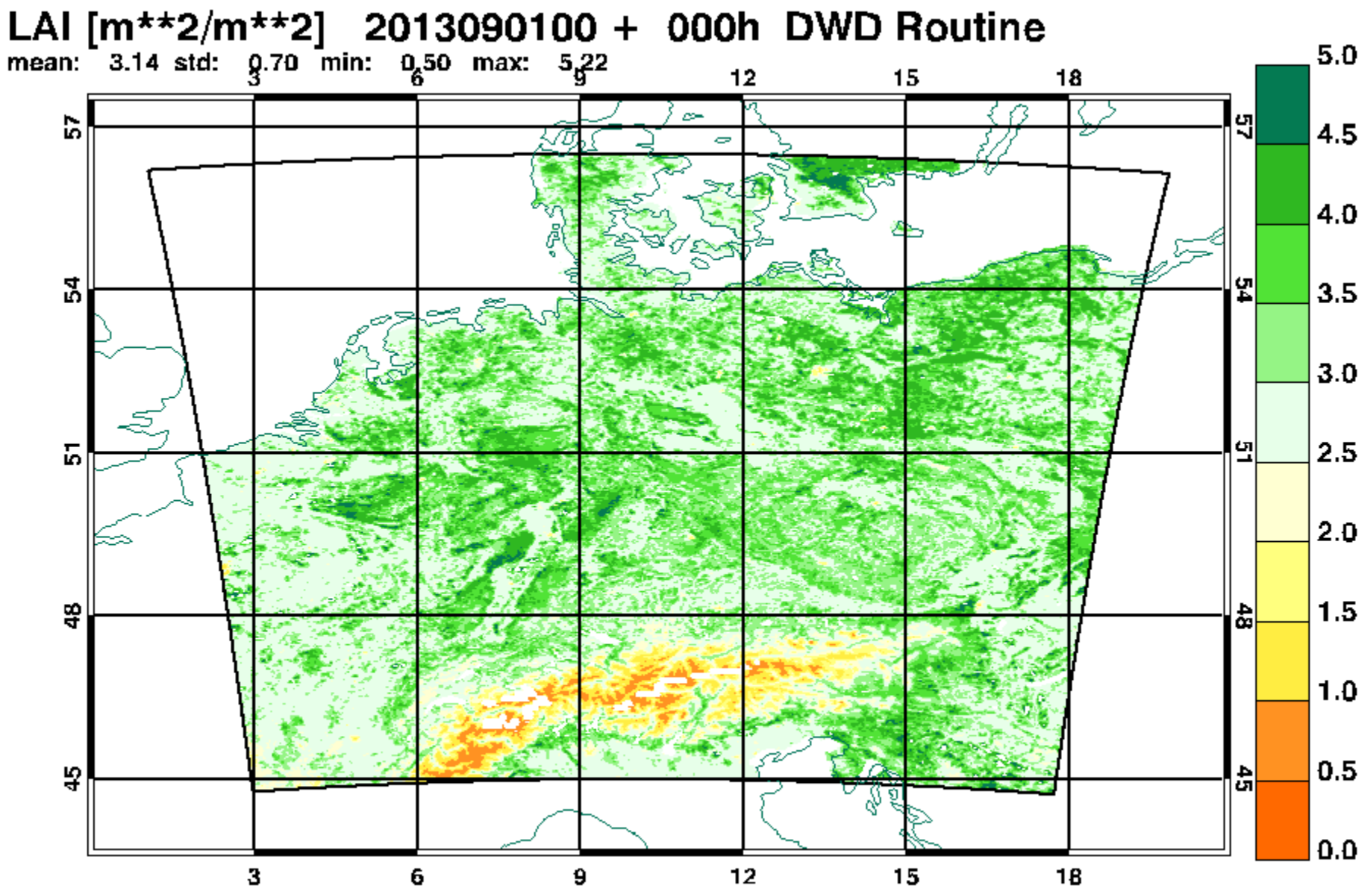
Revised Infiltration

- COSMO-DE changed land-use data set 20120418
- Enhanced LAI in GlobCover increased evapotranspiration
- Problem: dry out of root zone soil possible
- Shutdown of latent heat flux
- Solution: Enhanced infiltration parameterization
- Experiment start 2013040100 – 5 months assimilation

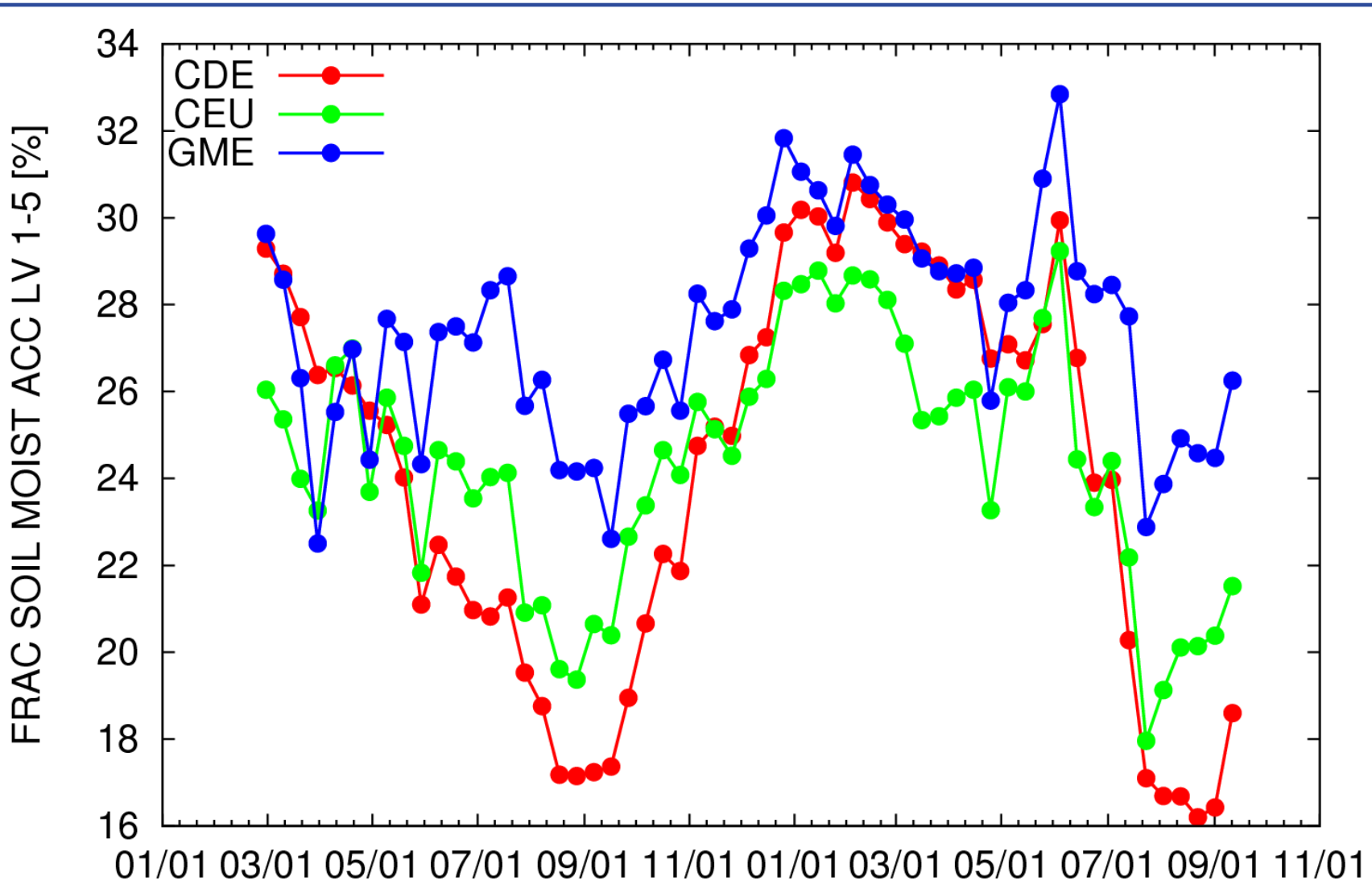
Revised infiltration



Revised infiltration



Revised infiltration



Revised infiltration

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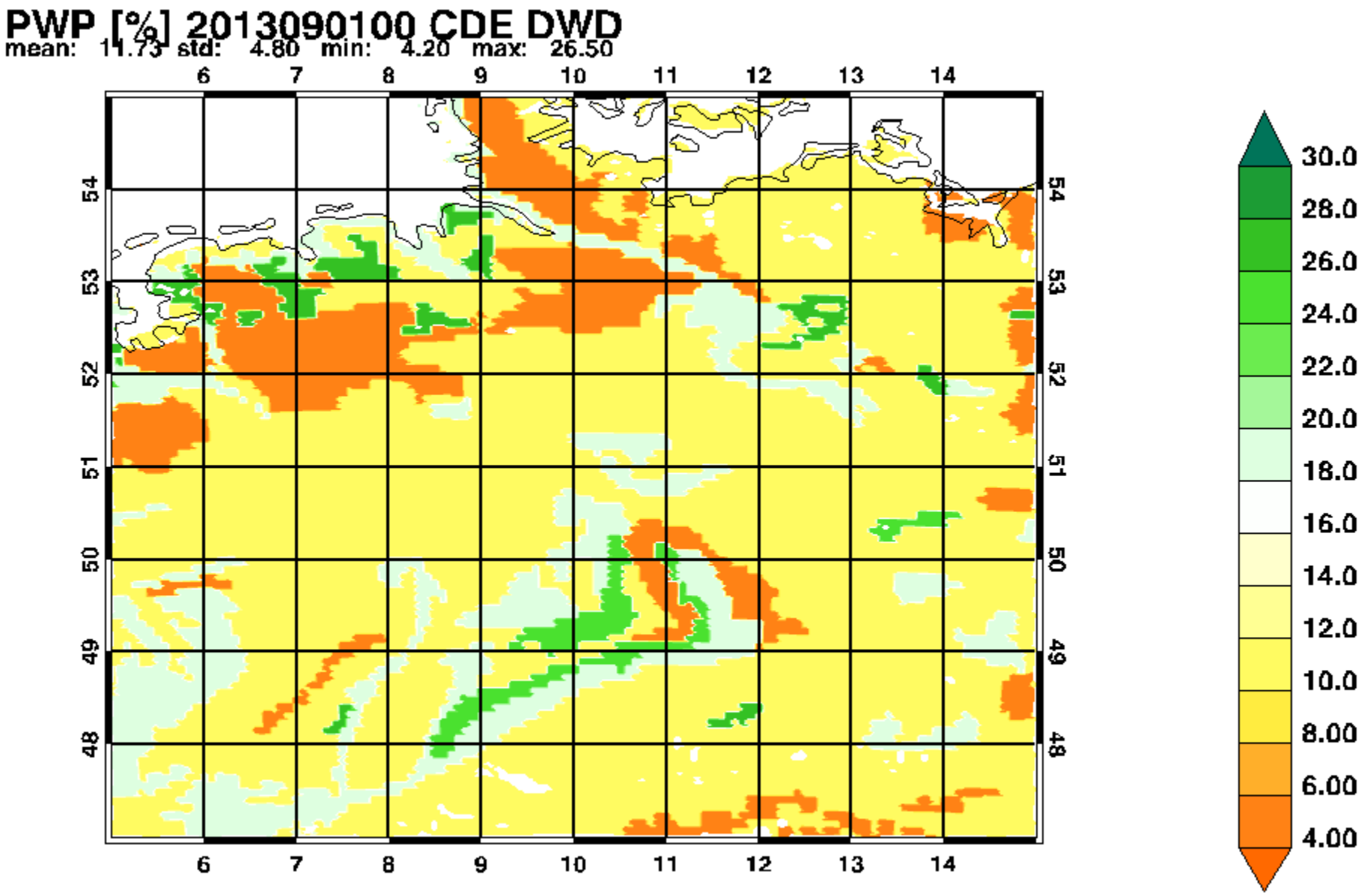
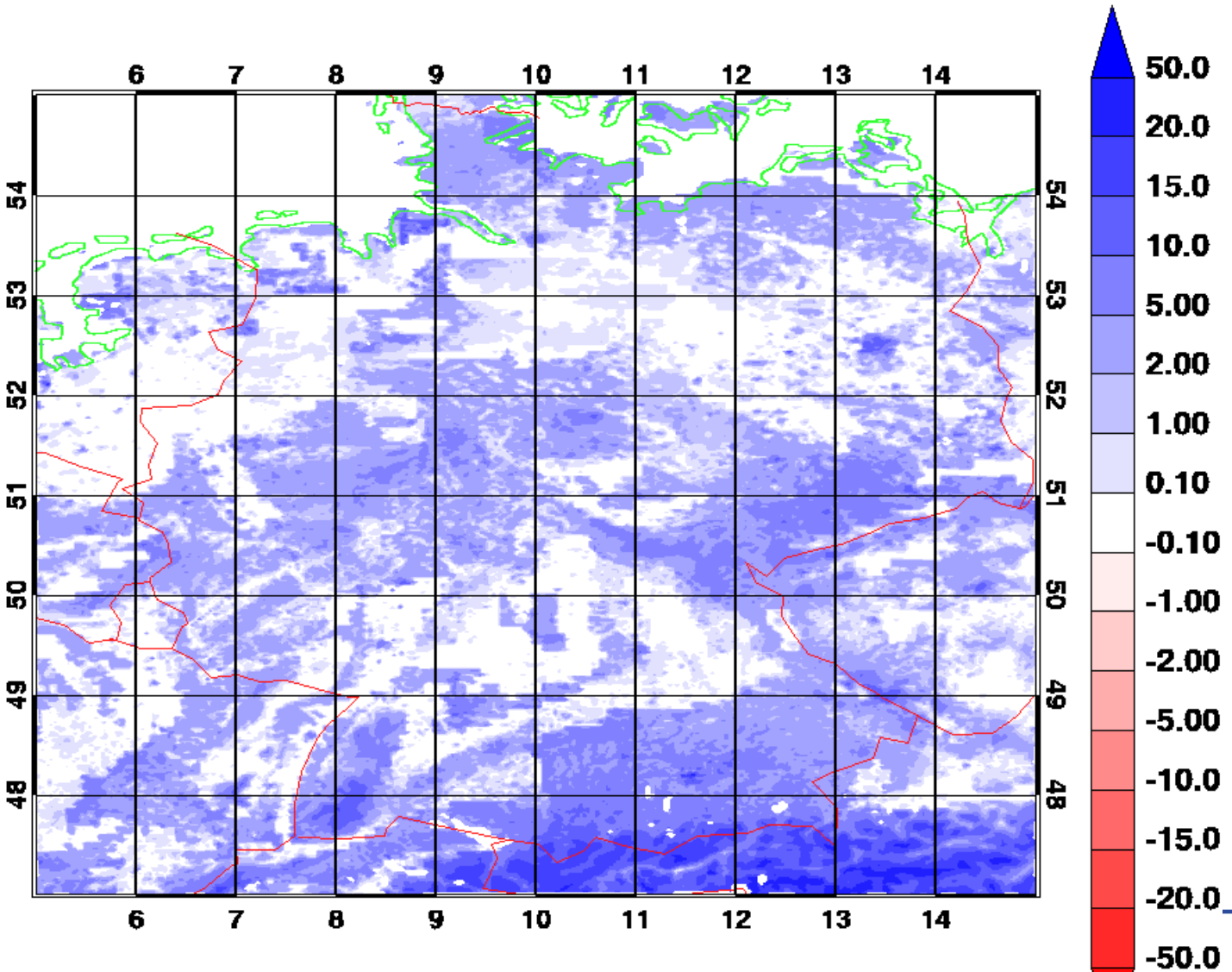


Revised infiltration



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)

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

soil water conductivity, Rijtema (1969)

Revised infiltration

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

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

```
 ! 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)):

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

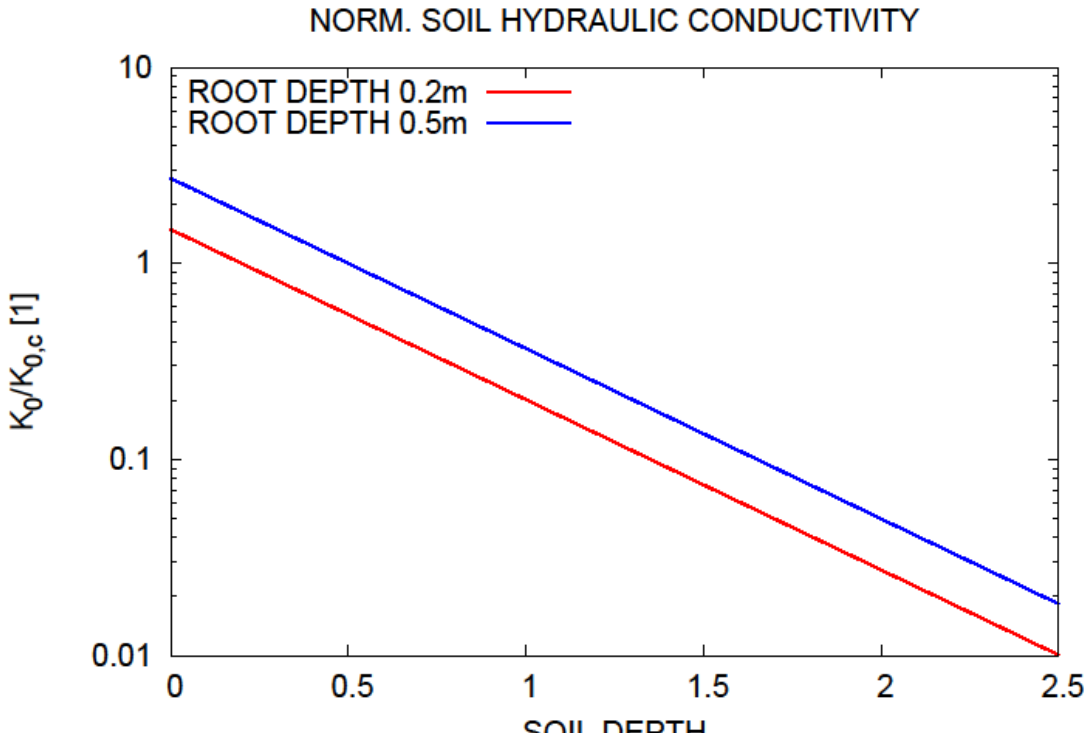
Revised infiltration

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

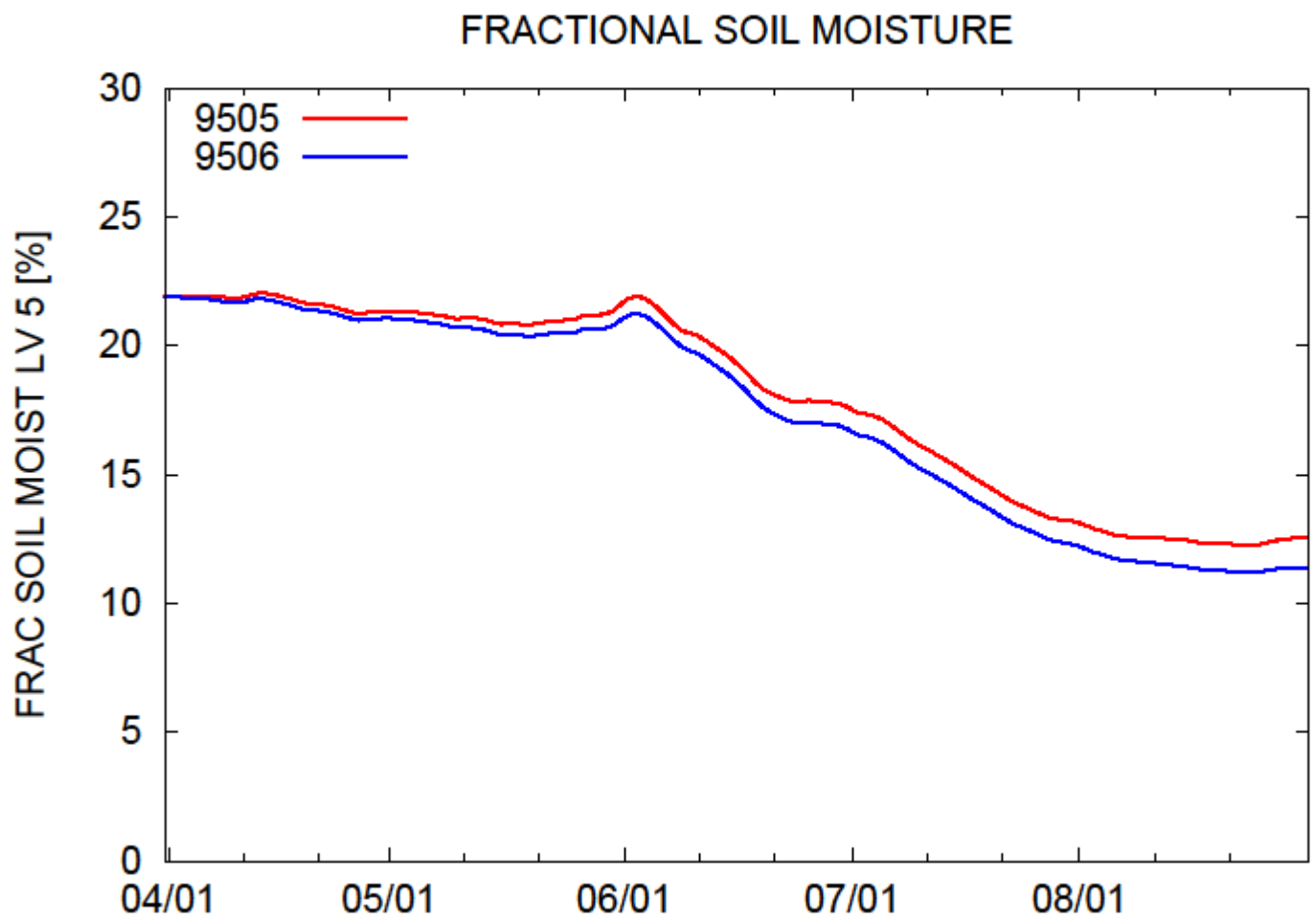
$$K_w(w_l) = K_0(z) \exp\left[K_1 (w_{PV} - \bar{w}_l)/(w_{PV} - w_{ADP}) \right]$$

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

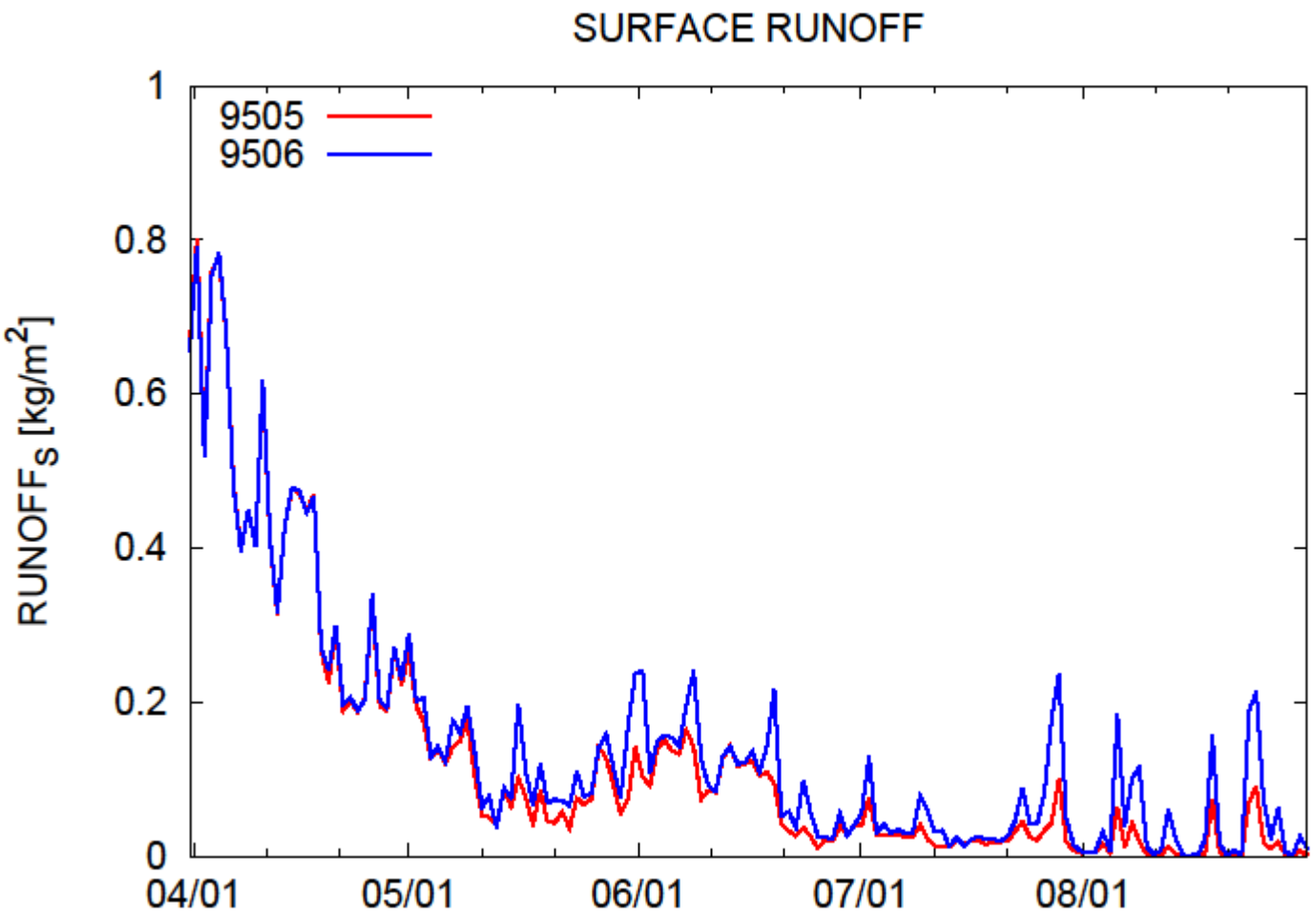
Profile of sat. hydr. conductivity, Decharme (2006)



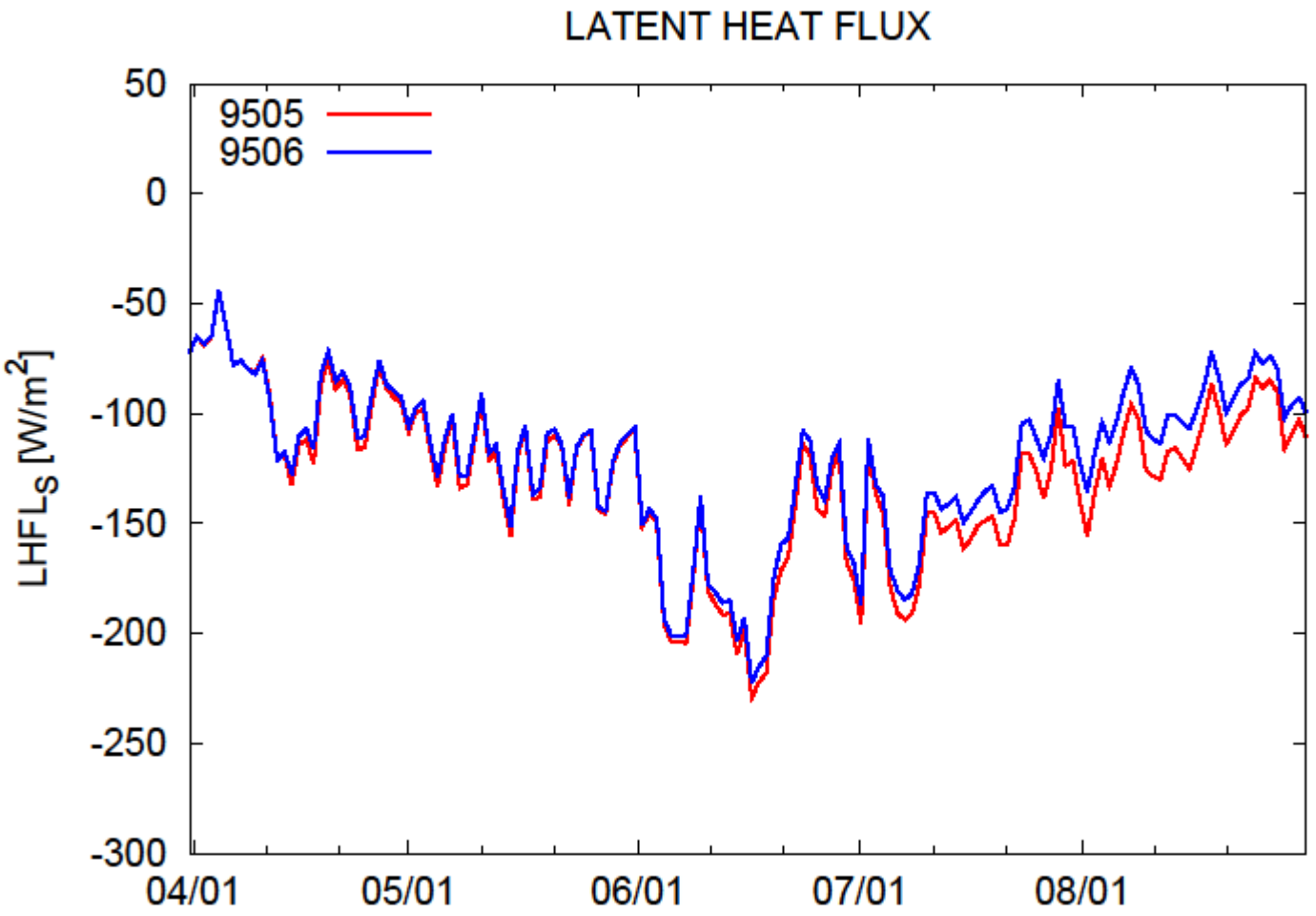
Revised infiltration
CDE- domain average



Revised infiltration
CDE- domain average



Revised infiltration
CDE- domain average



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, submitted

HWSD option in EXTPAR 2.0

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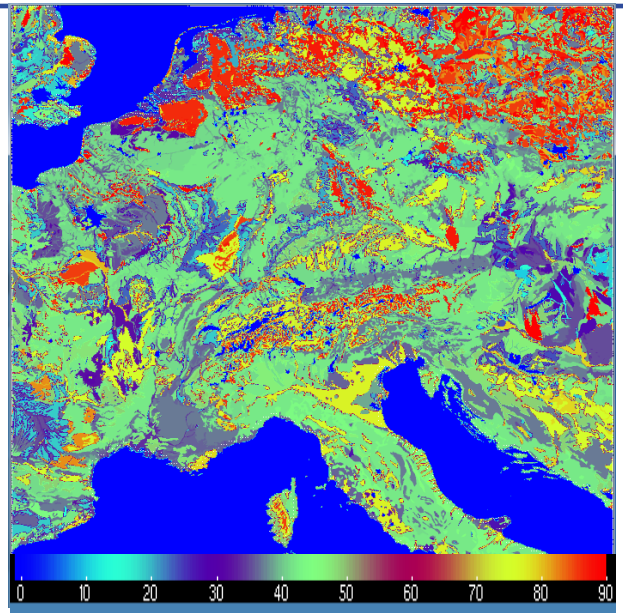
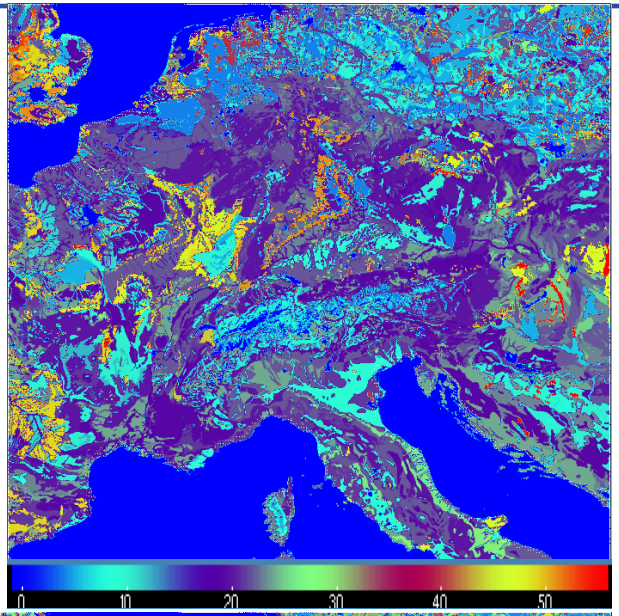
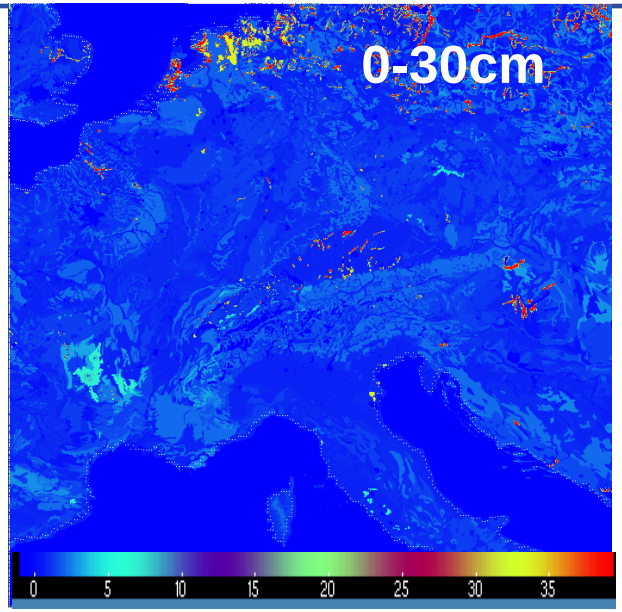
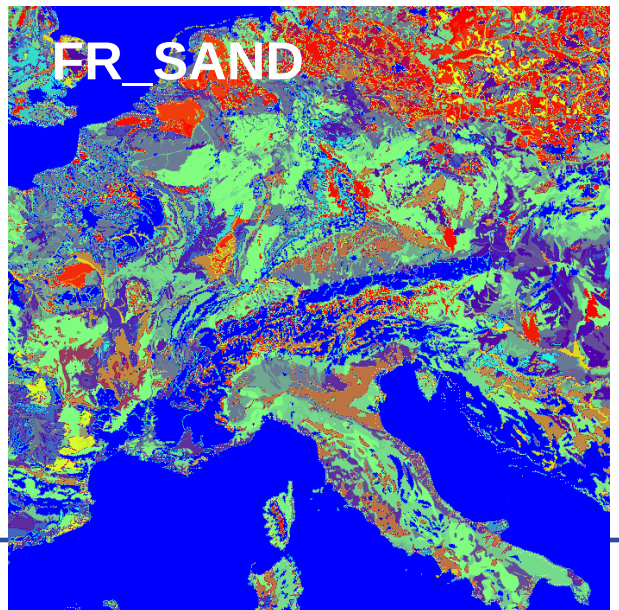
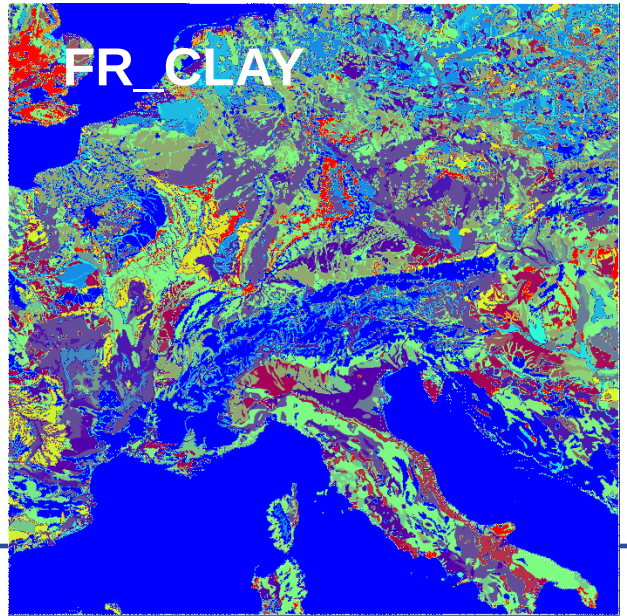
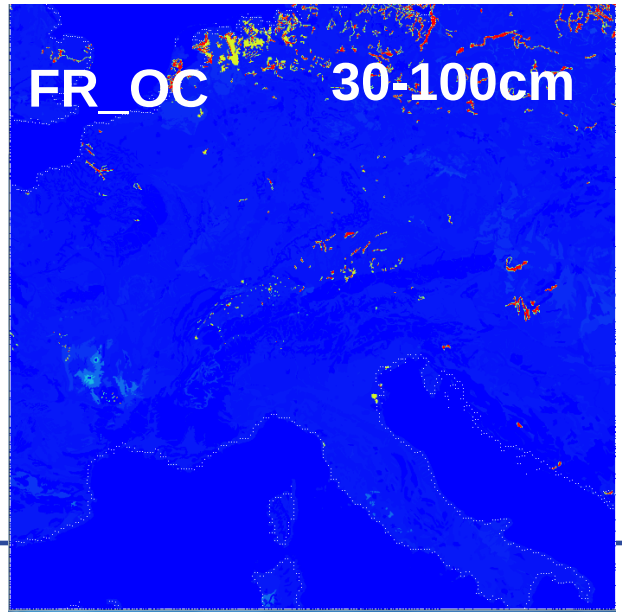












Soil water transport
Rijtema model in TERRA

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

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)

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

soil water conductivity, Rijtema (1969)

Soil water transport
Brooks and Corey model

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

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

$$\theta = \frac{\theta - \theta_r}{\theta_s - \theta_r}$$

$$\lambda = n - 1$$

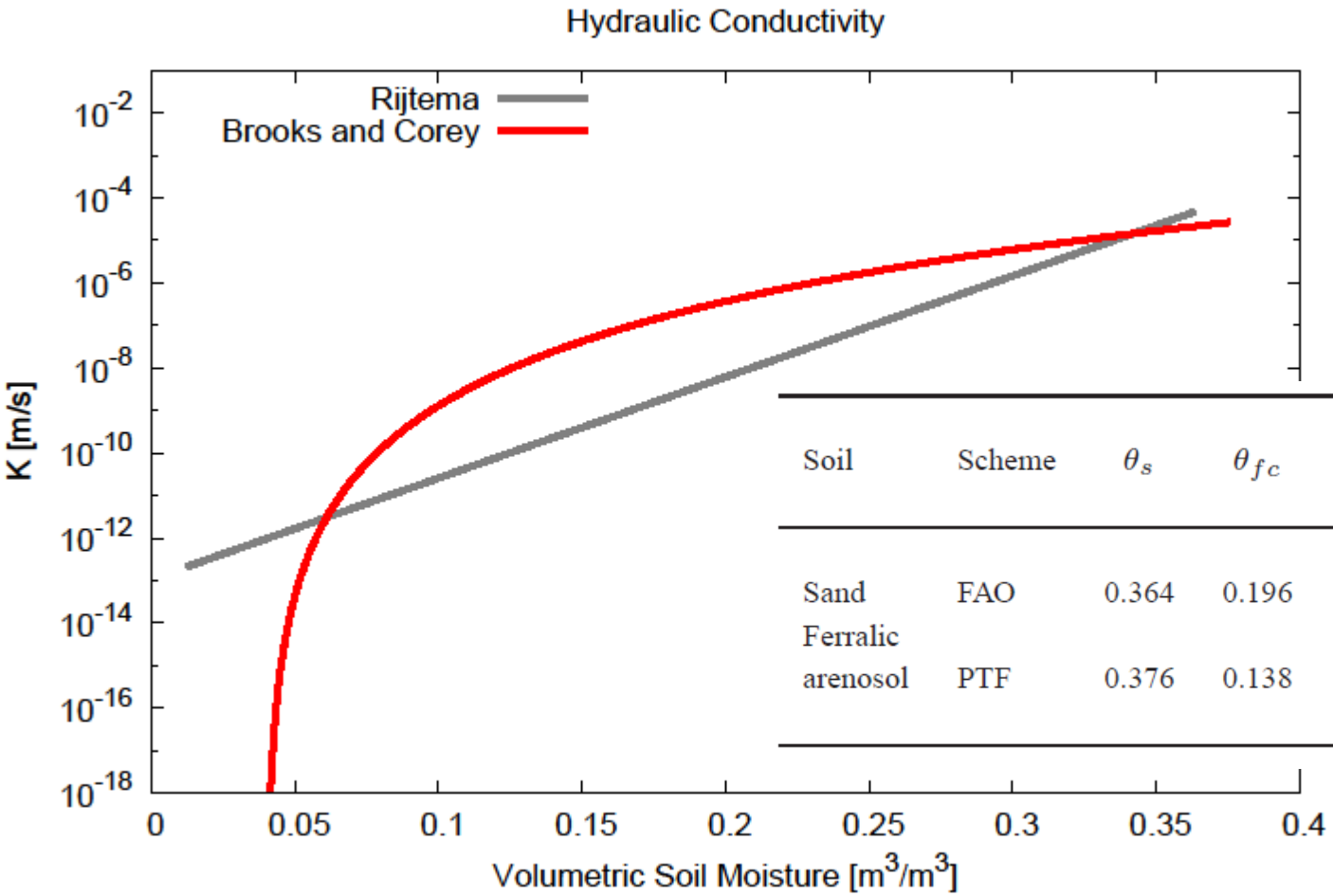
$$K(\Theta) = K_s \Theta^{5/2+2/\lambda}$$

$$D(\Theta) = \frac{K_s}{\alpha\lambda(\theta_s - \theta_r)} \Theta^{3/2+1/\lambda}$$

Determination of required soil parameters – PTF regression

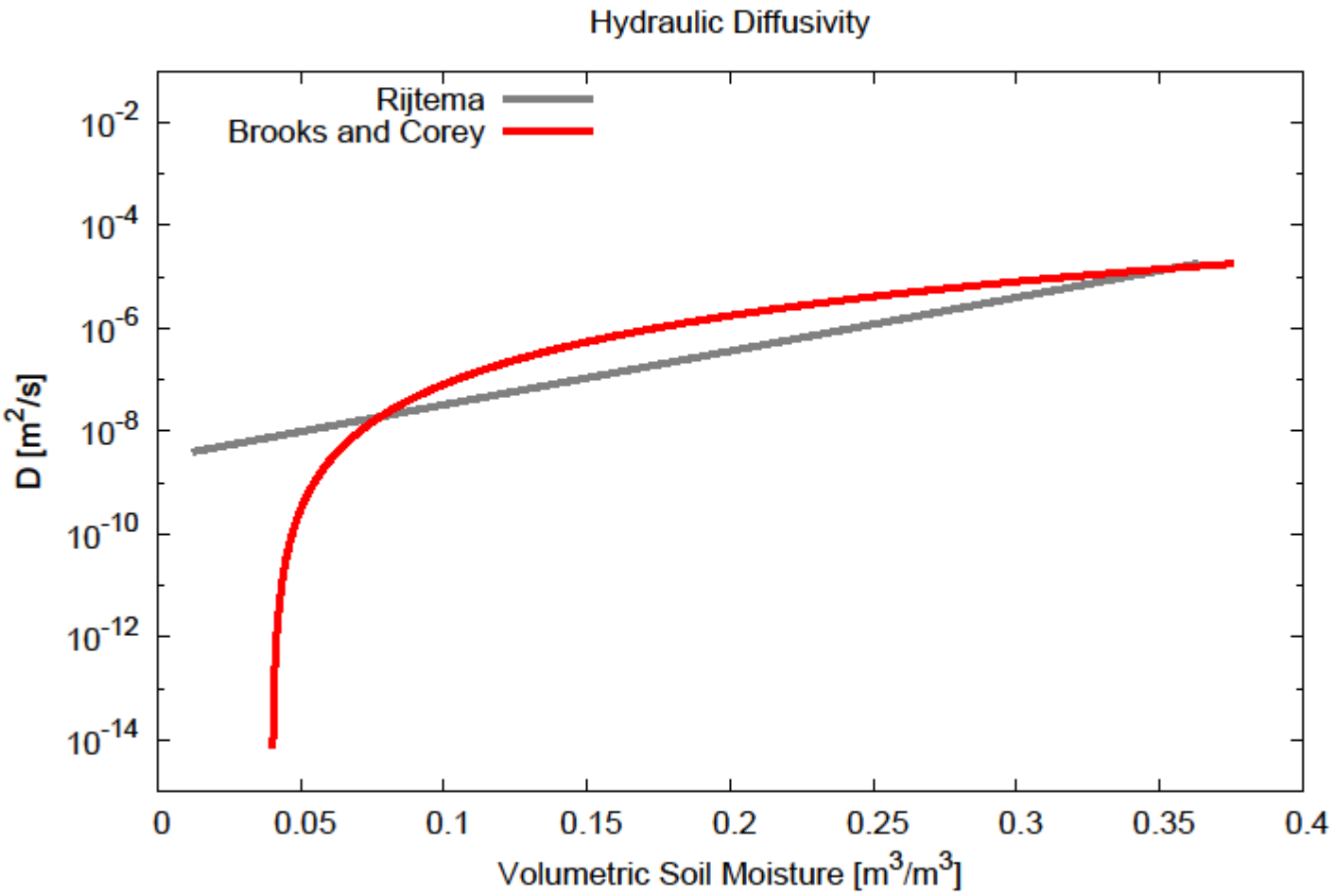
$$\theta_r \quad \theta_s \quad \alpha \quad n \quad K_s$$

HWSD soil in COSMO-CLM



Soil	Scheme	θ_s	θ_{fc}	θ_{pwp}	θ_r	K_s (m s^{-1})
Sand	FAO	0.364	0.196	0.042	0.012	4.79E-5
Ferralic arenosol	PTF	0.376	0.138	0.045	0.040	2.65E-5

HWSD soil in COSMO-CLM



Hydraulic properties

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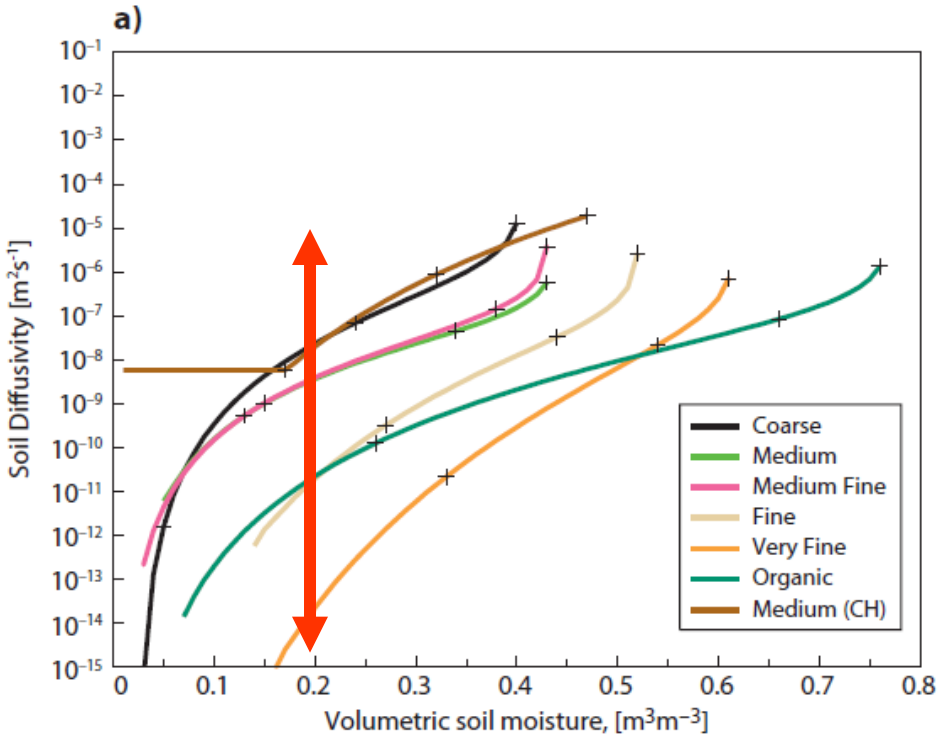
Diffusivity m^2/s



Conductivity m/s

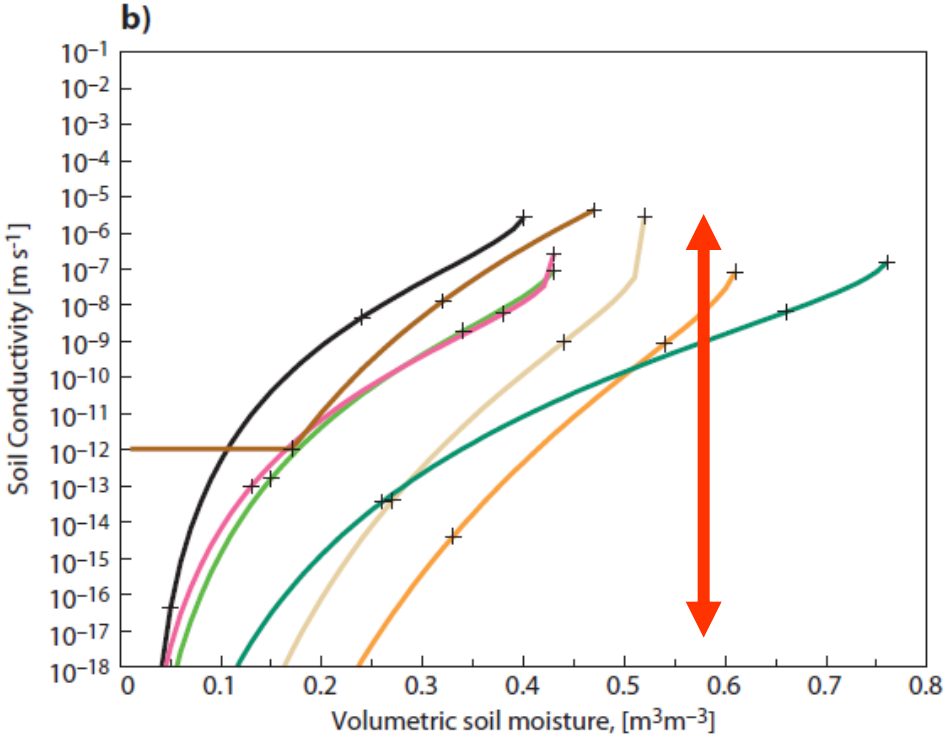


Figure 7.3 *Hydraulic properties of TESSEL and HTESSEL: (a) Diffusivity and (b) conductivity. The (+) symbols on the curves highlight (from high to low values) saturation, field capacity permanent wilting point.*

IFS documentation

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