Deutscher Wetterdienst

Validation of Soil Moisture in GME

and COSMO-LME

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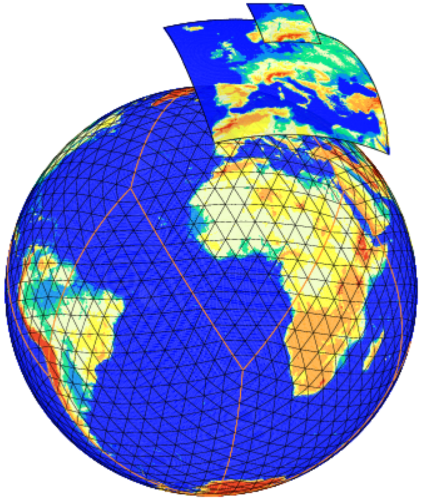


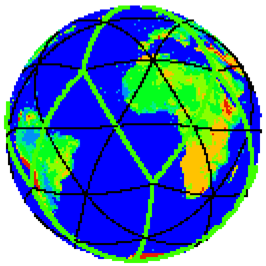
Overview of presentation

- Introduction
- Background
- Problem detection
- Sensitivity of simulated soil moisture to modelling assumptions
- Conclusion and outlook

Introduction

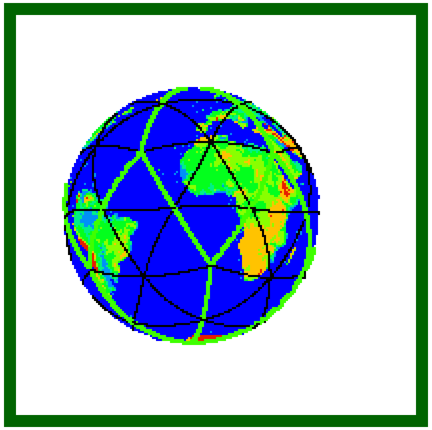
All results shown in this presentation refer to the GME!

So, why am I here?



The same soil model is used by GME, COSMO-LME and COSMO-LMK (and other COSMO versions and HRM)

Some aspects of the soil moisture evolution in GME may be of special relevance for the CLM!



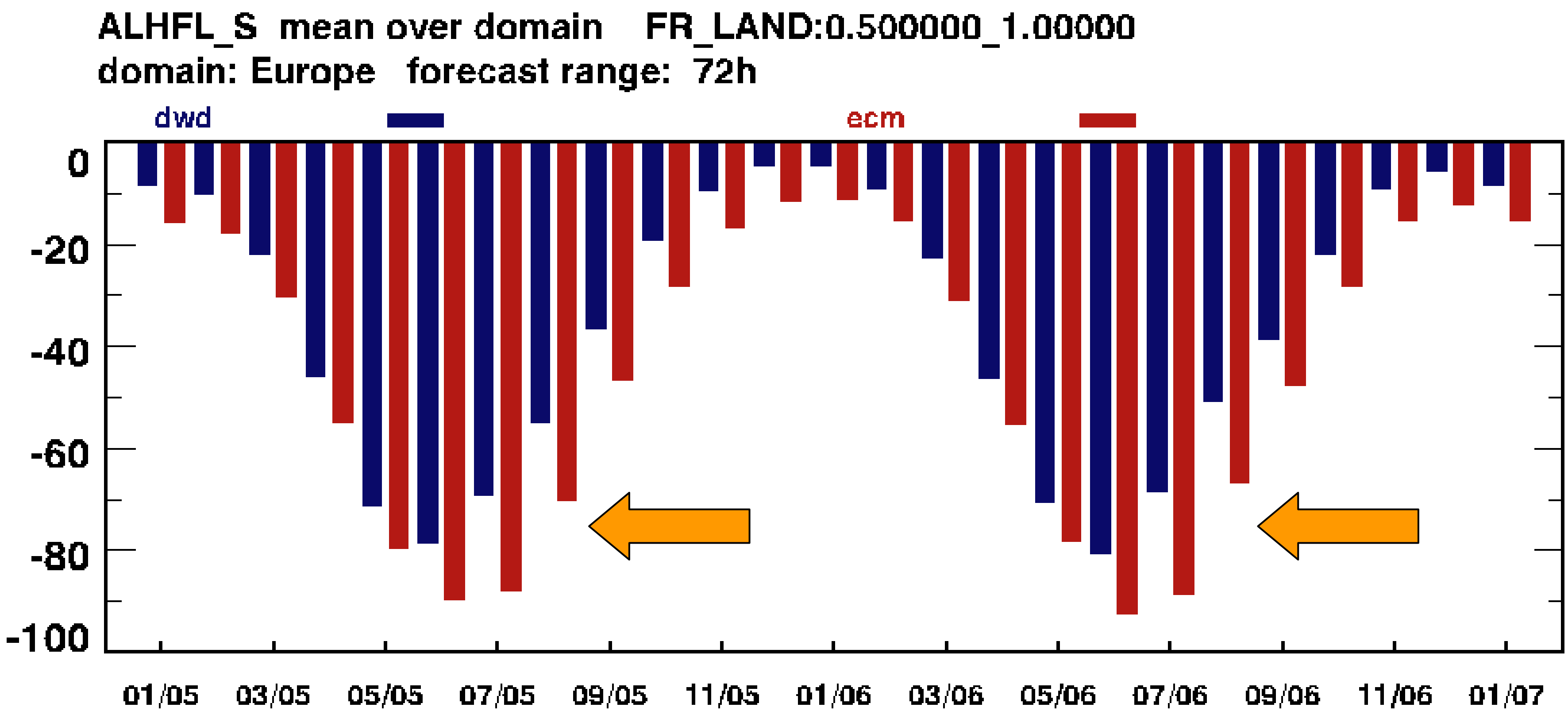
Background:
Basic structure of soil model

- 7 layer scheme (z_i: 1,3,9,27,81,243,729 cm)
- prognostic variables T_SO, W_SO, W_SO_ICE, W_Snow, Rho_Snow, W_i
- direct solution of heat conduction equation
- simulation of freezing/melting of soil water/ice
- 8 soil types and soil moisture determine thermal and hydrological properties of soil
- external parameters, e.g. plant cover, leaf area index and root depth effect strong control over evapo-transpiration process

Background: Main difference between GME&LME version of multi-layer soil model

- same basic model algorithms and soil parameters, but
- operational LME employs SMA to counteract systematic T2m errors through modifications in soil moisture content (see presentation by M.Lange)
- operational GME soil moisture state is controlled only by physical constraints (ADP & PV) and forecasted components of hydrological budget in data assimilation cycle forecasts, i.e.
  - precipitation
  - evapo-transpiration
  - run-off

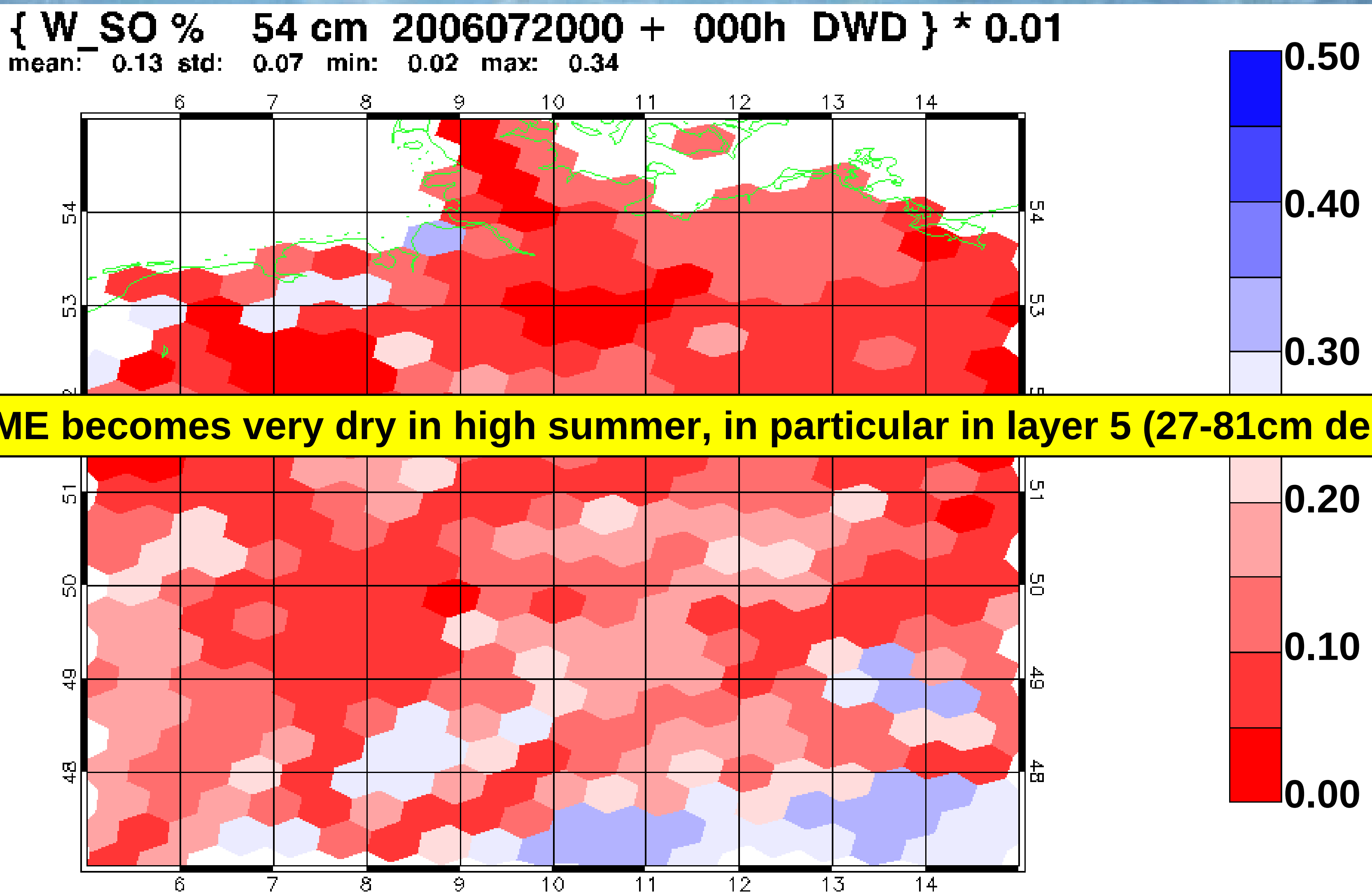
Problem detection
a) LHF comparison GME/ECMWF



Monthly mean latent heat flux averaged over land points in Europe, forecast range 72 h, dark blue: GME, red: ECMWF

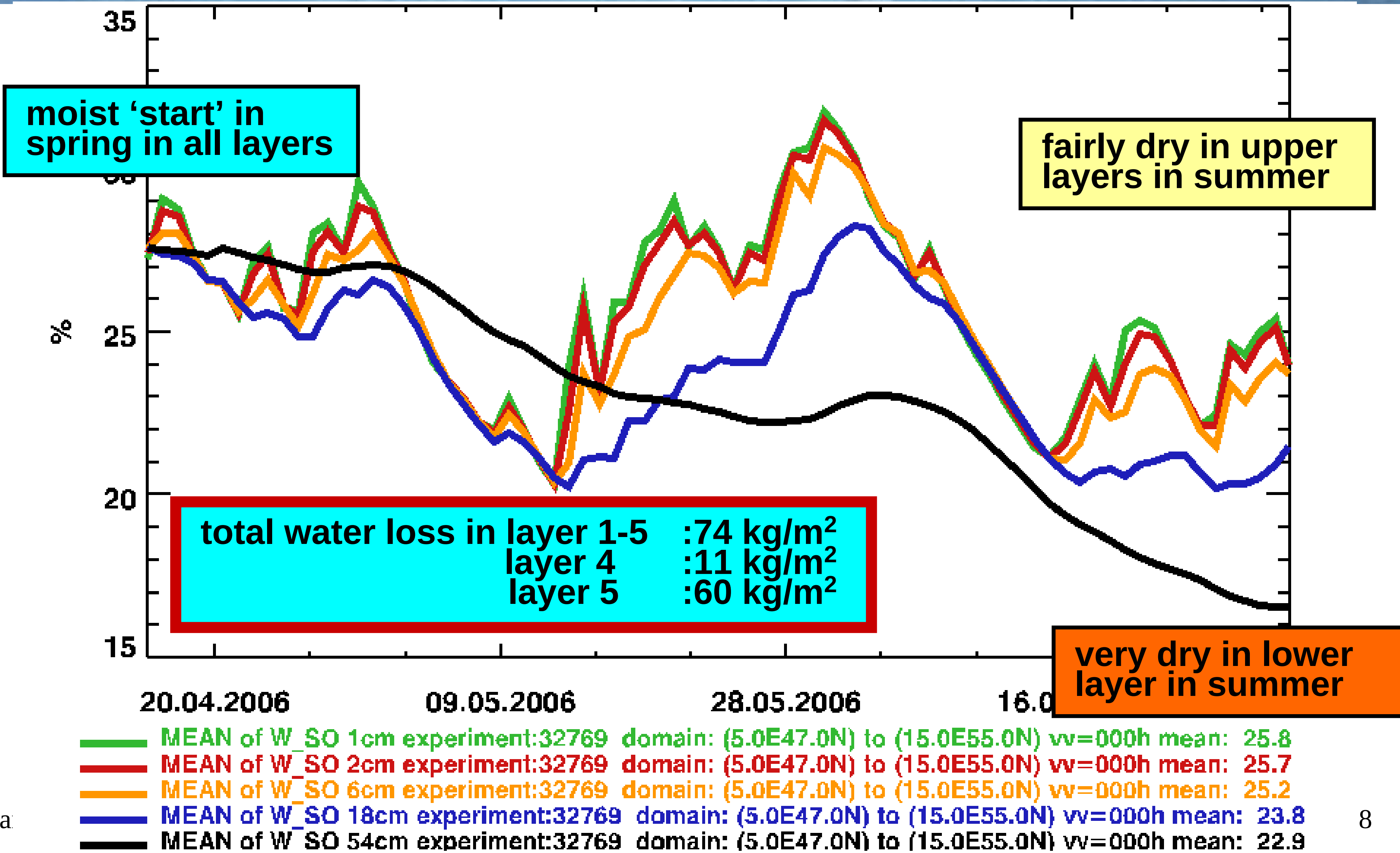
Problem detection
b) GME soil moisture inspection

(and comparison to other models, not shown)

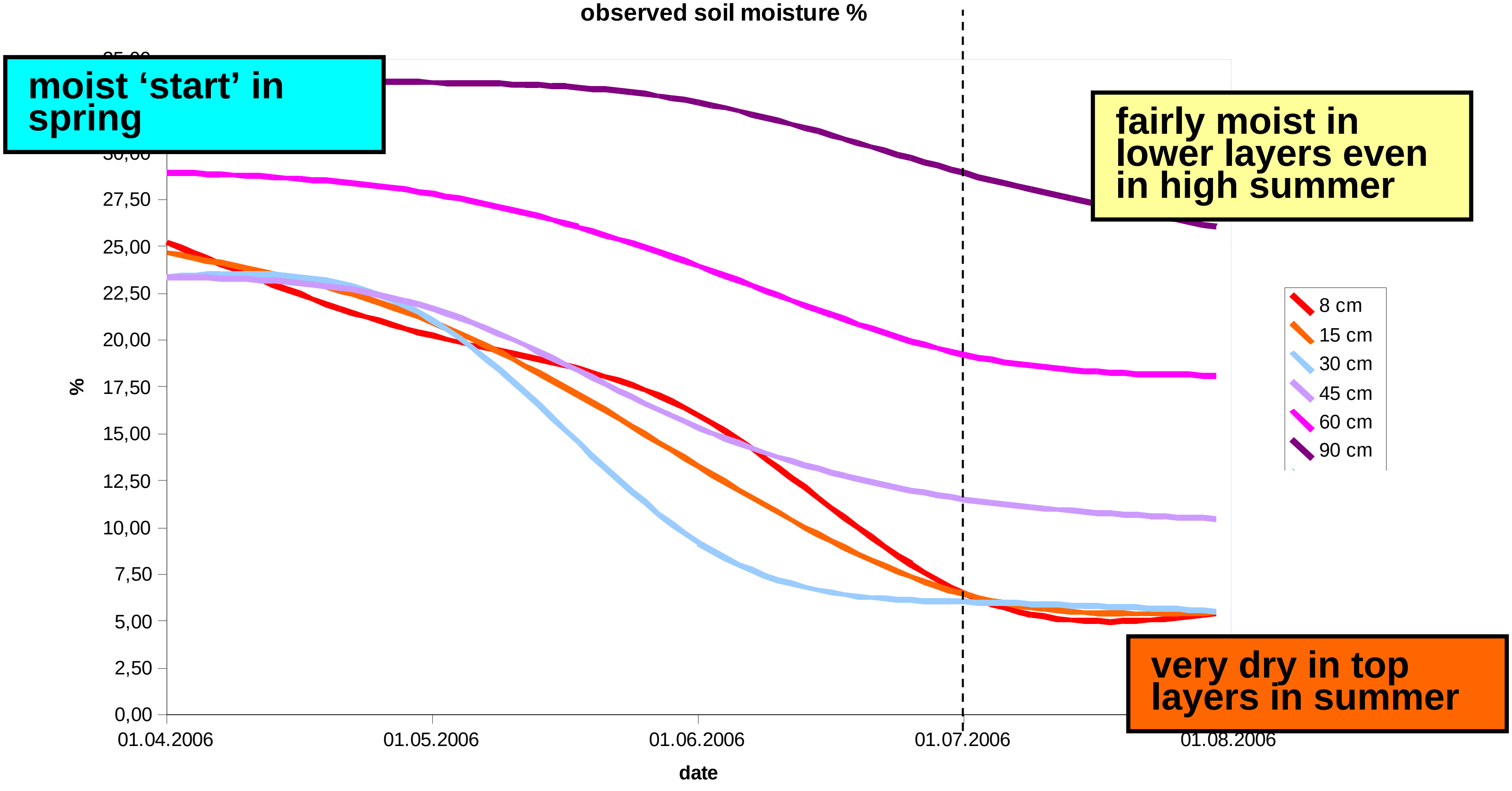


soil in GME becomes very dry in high summer, in particular in layer 5 (27-81cm depth)

Temporal evolution of soil moisture
Spatial mean over Germany April to June



Temporal evolution of observed soil moisture
Observatory Lindenberg/Germany



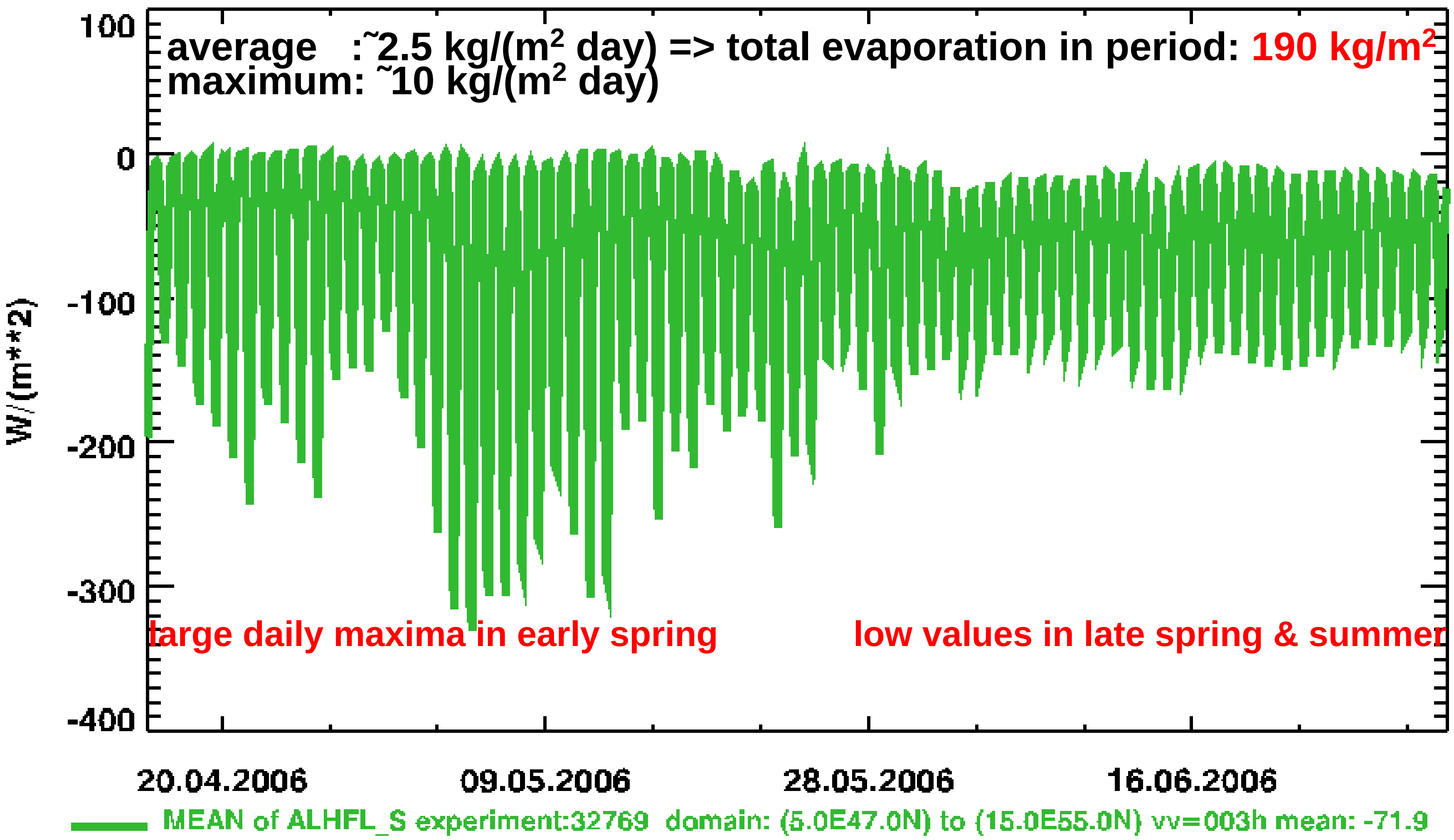
Inspection of the hydrological budget of GME soil layers

Without any form of SMA the soil moisture state in GME is controlled by physical limits and the components of the hydrological budget simulated in short term forecasts within the data assimilation cycle. So there is no guarantee for a realistic evolution of the soil state.

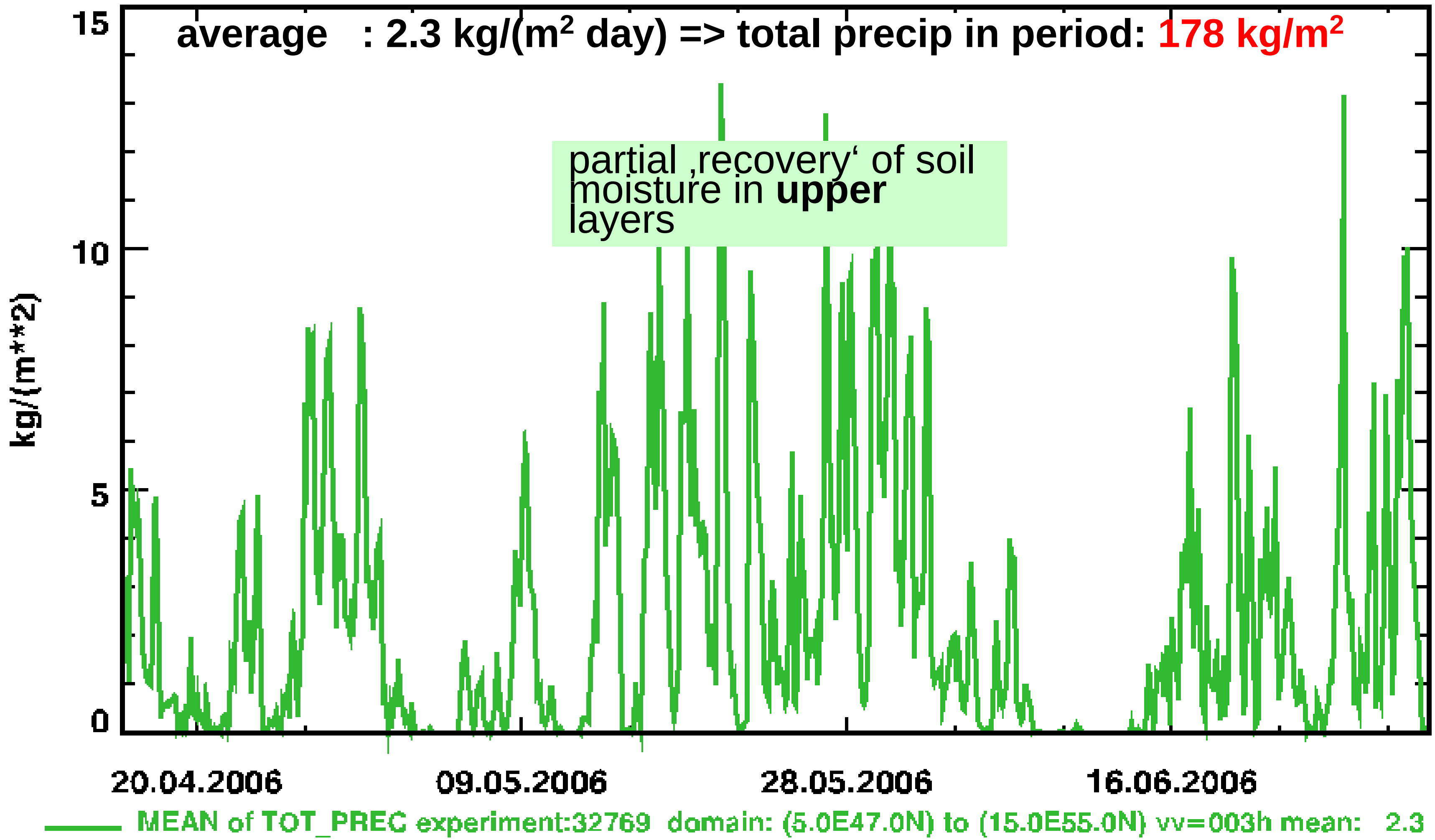
Questions:

- **Is the temporal evolution of evapo-transpiration, precipitation and run-off realistic/plausible?**
- **Do the individual components add up to the simulated loss in soil moisture?**
- **Are there any indications for the cause of problems detected in the soil state?**

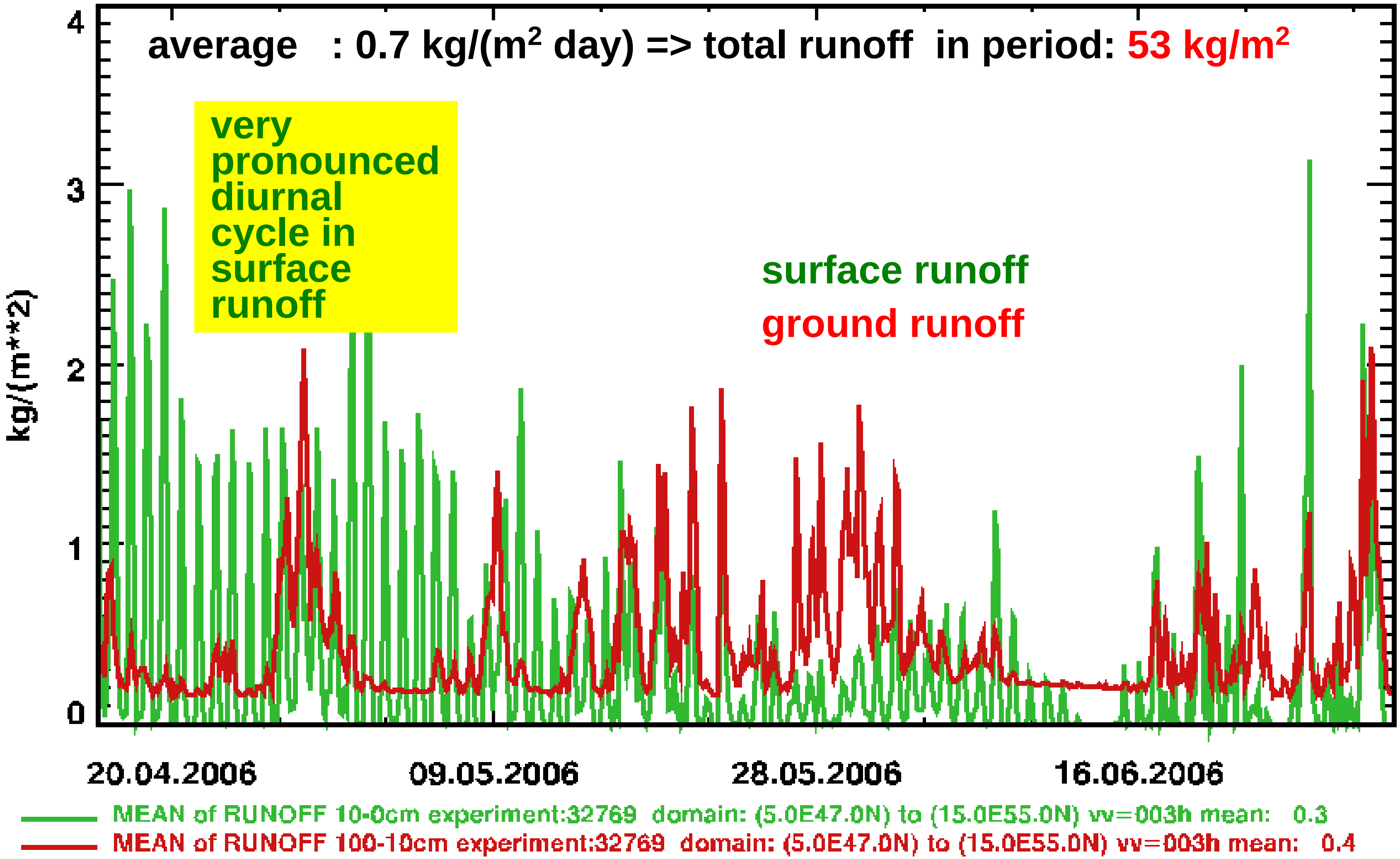
Temporal evolution of evapo-transpiration
Spatial mean over Germany April to June



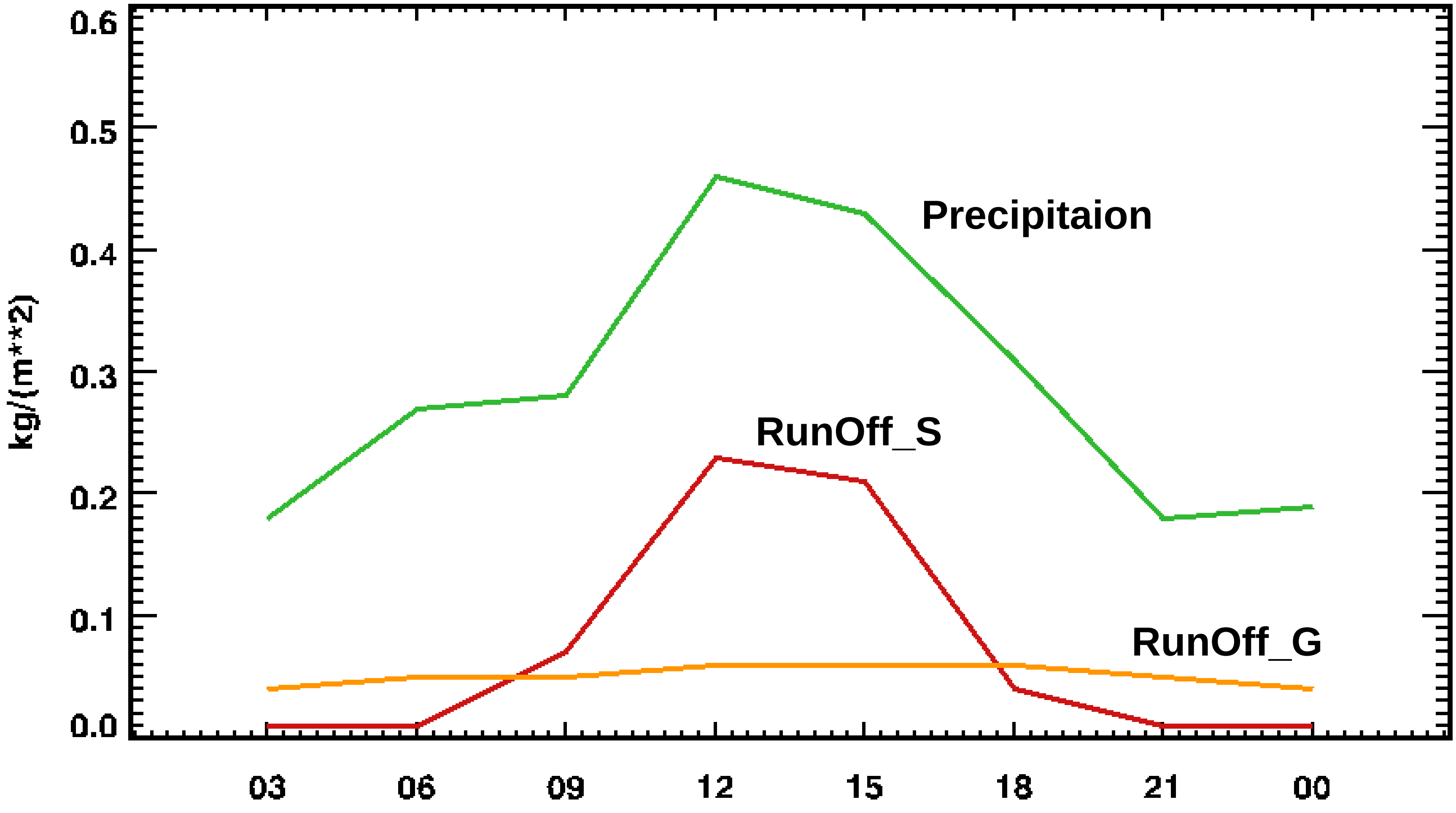
Temporal evolution of Precipitation
Spatial mean over Germany April to June



Temporal evolution of RunOff
Spatial mean over Germany April to June



Diurnal Cycle of RR and RunOff
Spatial mean over Germany in 2nd half of April 2006



Preliminary diagnosis

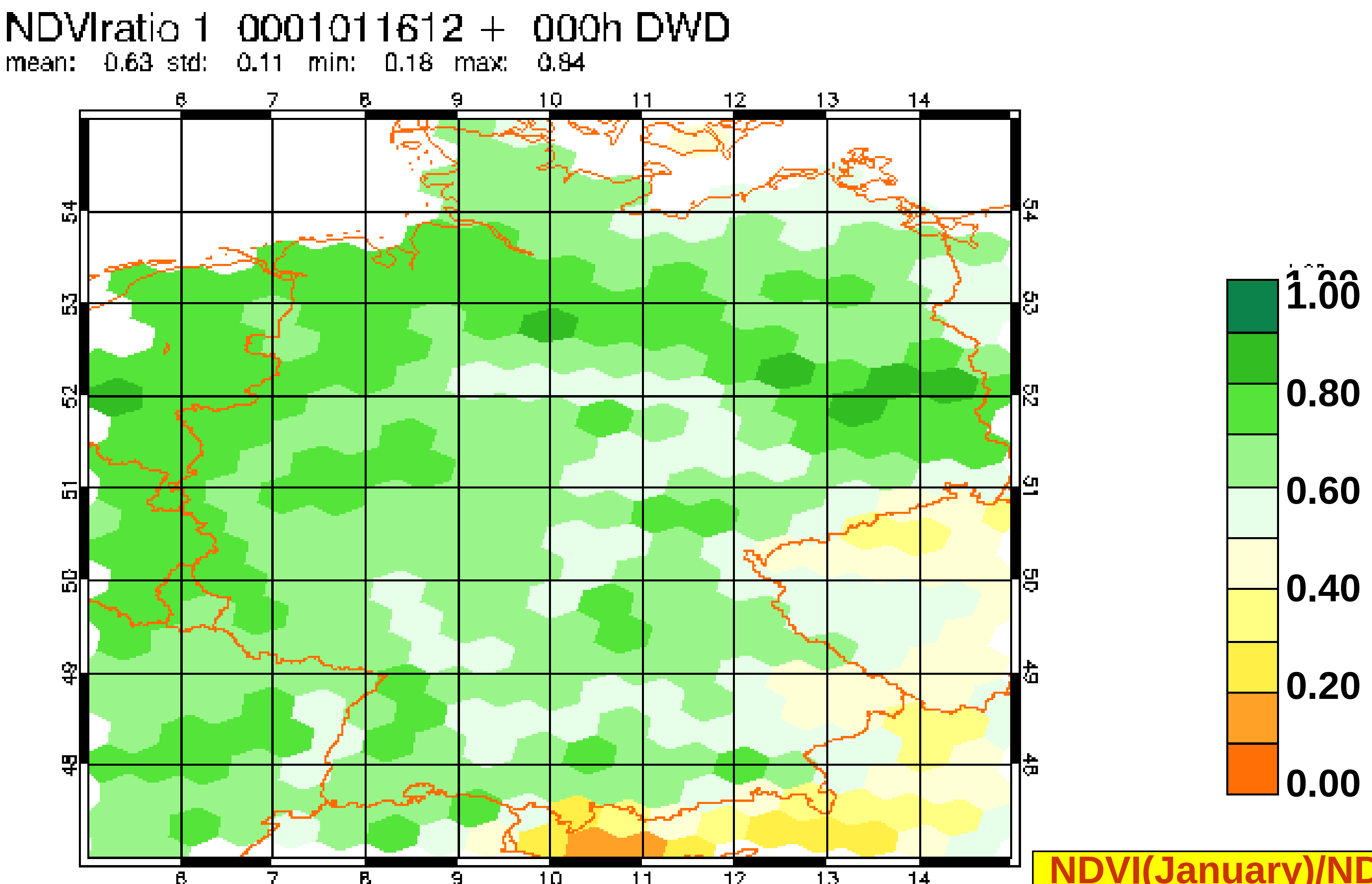
- GME seems to suffer from an excessively dry soil (compared to other models with SMA and observations) in lower soil layers in summer
- The strong loss of moisture in spring to evapo-transpiration is partly counterbalanced by precipitation for the upper layers but only in the upper 27 cm of soil
- Assumption: rapid evapo-transpirative moisture loss in layer 5 (i.e. 27-81cm depth) is most likely a direct effect via plant transpiration

  → investigate role of plant cover and root profile

Sensitivity experiments

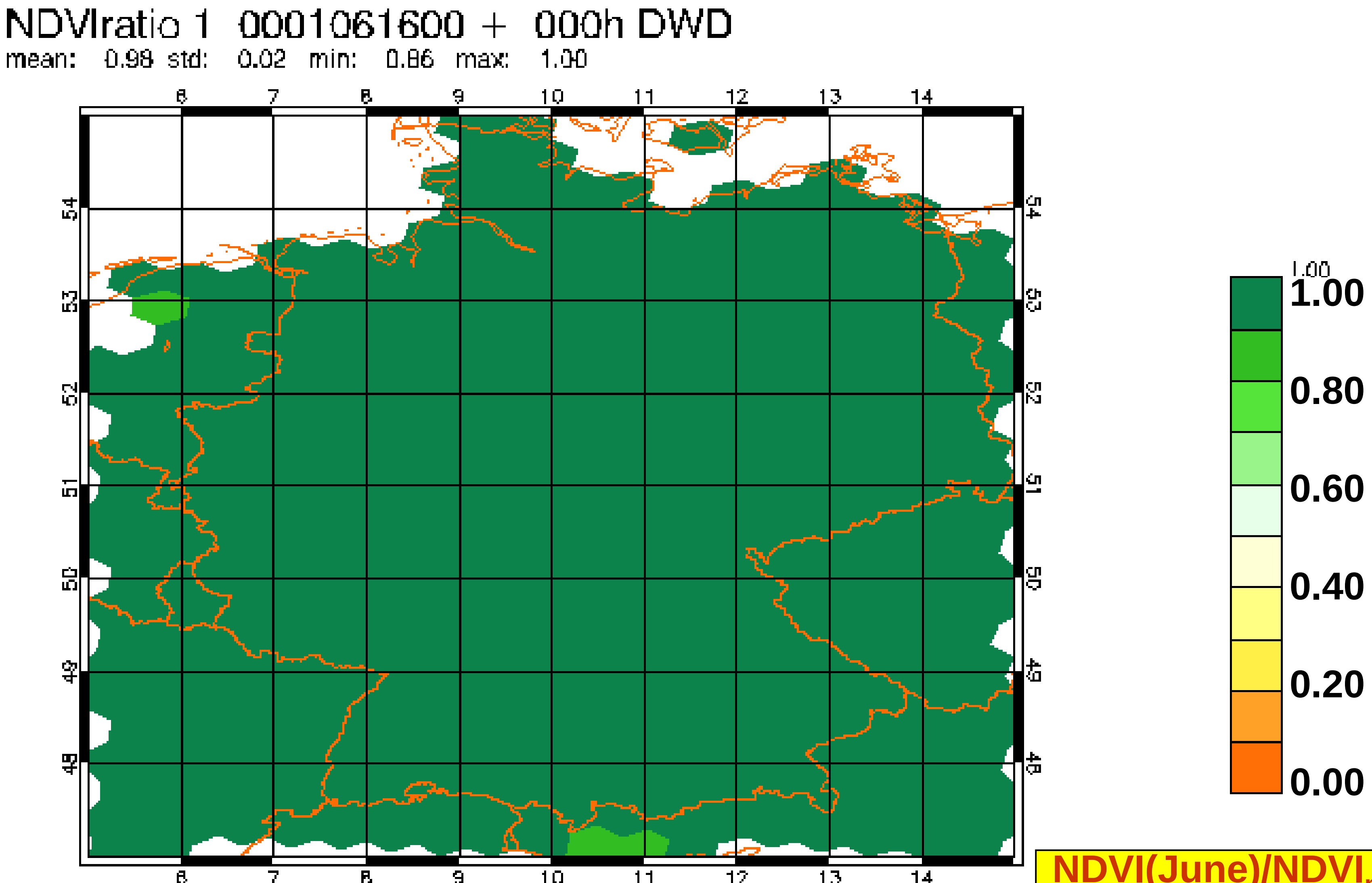
- forecast in data assimilation mode for the period 15th April to 30th June 2006
- Exp_5806: replace constant plant cover by a climatological variation (based on NDVI scaling approach)
- Exp_5803: as Exp_5806 but with additional modification of root density profile (exponential decrease with depth instead of constant root density)

Seasonal variation of NDVI over Germany



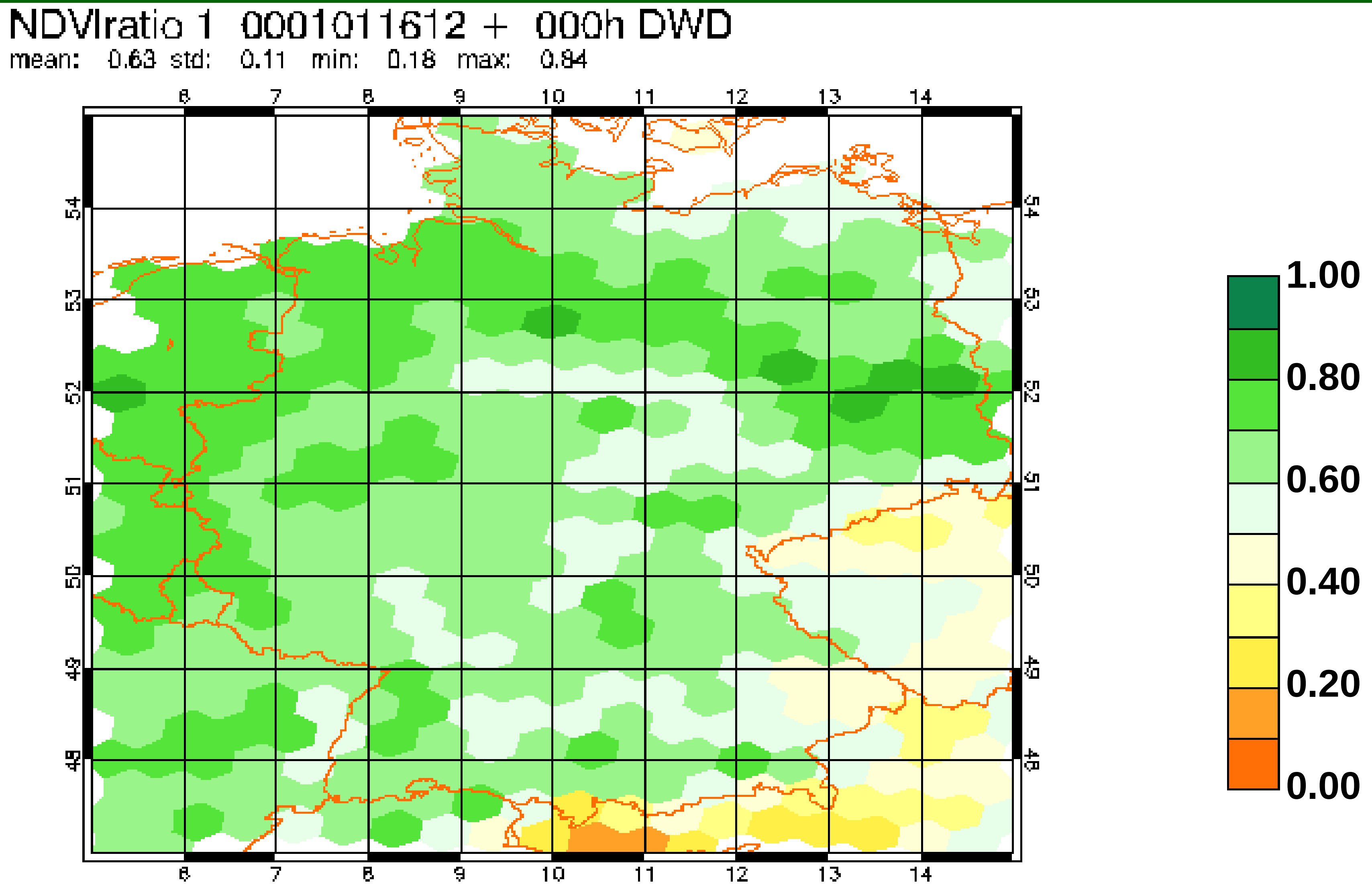
$NDVI(January)/NDVI_{max}$

Seasonal variation of NDVI over Germany



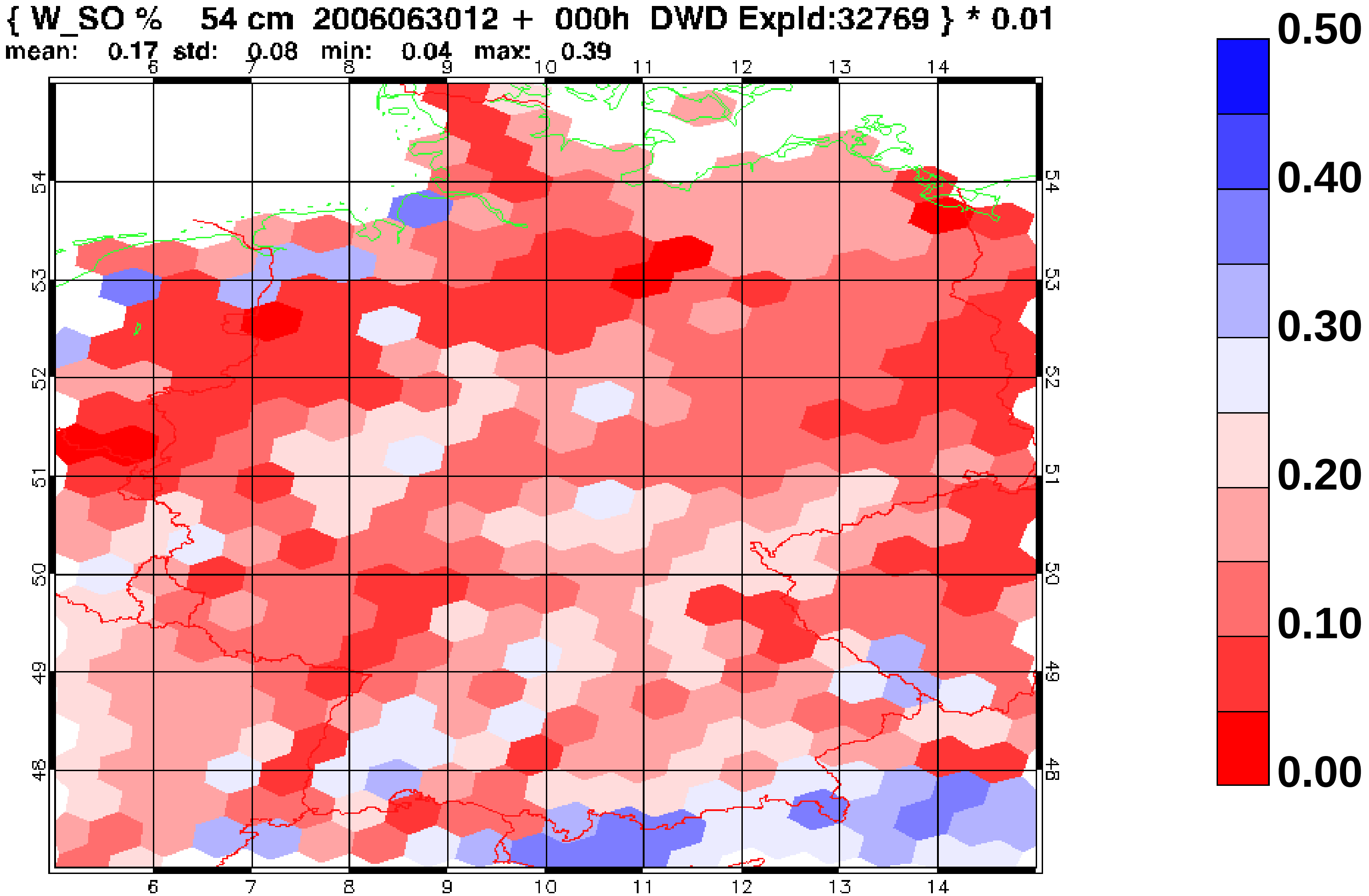
NDVI(June)/$NDVI_{max}$

Seasonal variation of NDVI over Germany



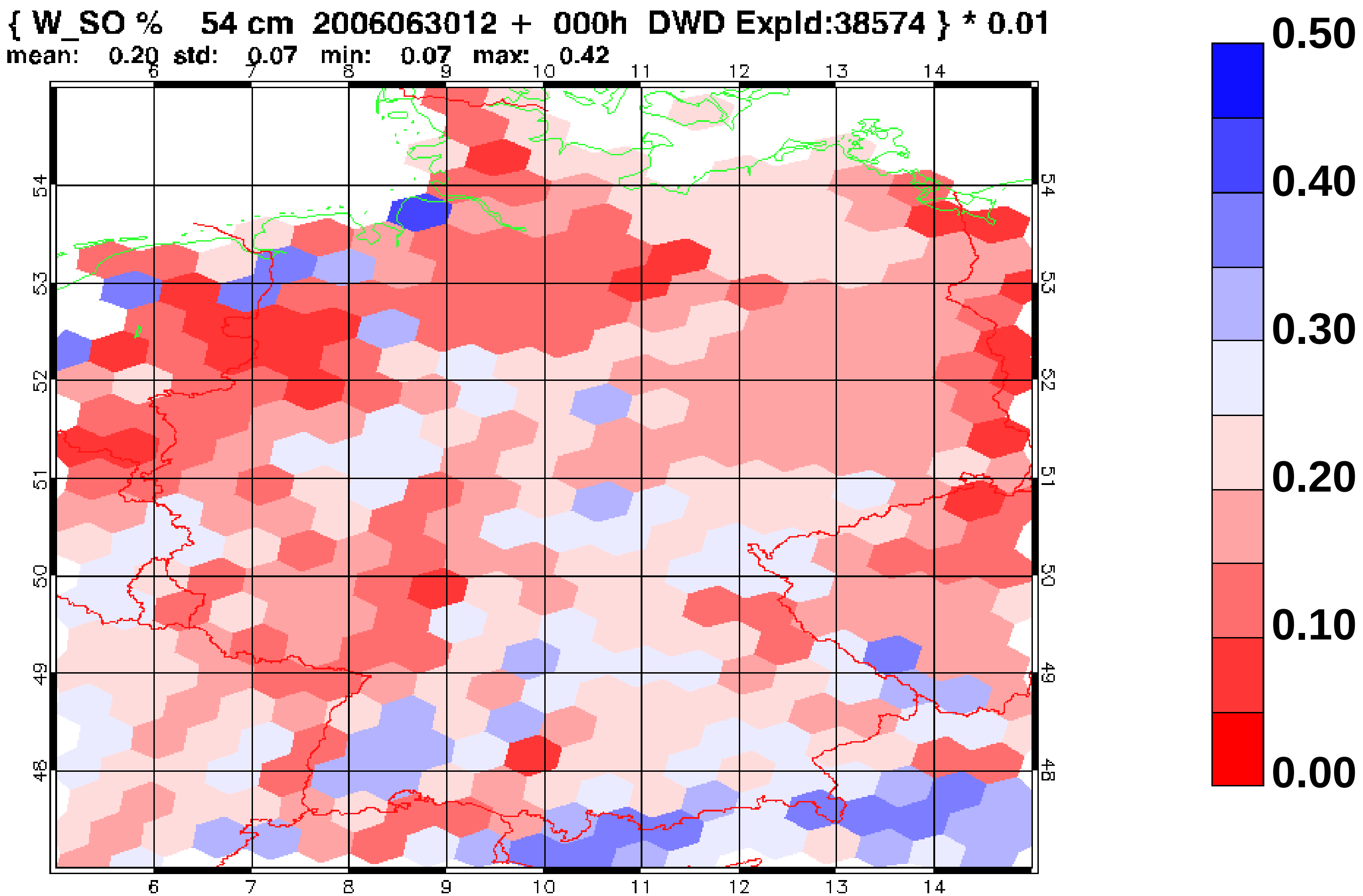
$NDVI(t)/NDVI_{max}$

Operational GME



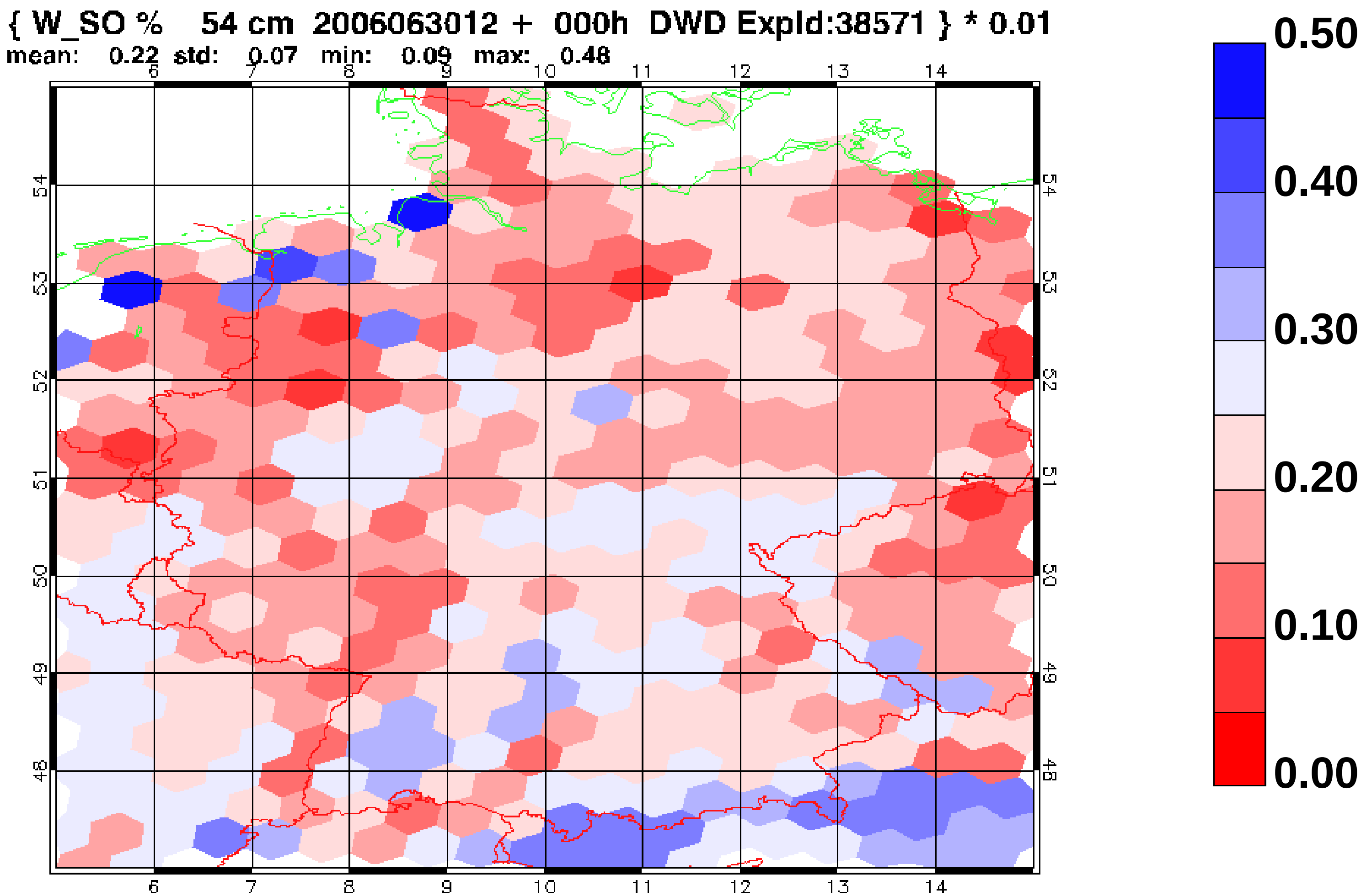
volumetric soil moisture in layer 5 on 30th of june 2006

Sensitivity experiment with seasonally variable plant properties (i.e. NDVI scaling)



volumetric soil moisture in layer 5 on 30th of june 2006

Sensitivity experiment with seasonally variable plant properties and variable root density



volumetric soil moisture in layer 5 on 30th of June 2006

Conclusions and Outlook

- current configuration of multi-layer soil model in GME exhibits ‘strange’ vertical moisture profile in dry period
- introduction of seasonal effects and variable root density profile alleviates problem
- precipitation runoff may be excessive and needs to be investigated in more detail
- soil hydrological properties may need to be revised (cf. ‘discharge’ presentation by R.Grasselt)
- soil model may have to be constrained via SMA in order to provide better soil moisture evolution (and evapo-transpiration, near surface temperatures, etc.)