Improvements and Scientific Validation of CLM in the framework of the Terrestrial Systems Modeling Platform (TerrSysMP)

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Transregional Collaborative Research Centre 32 (TR32)

To improve our knowledge about the mechanisms leading to spatial and temporal patterns in energy and matter fluxes of the soil-vegetation-atmosphere system, using modeling, monitoring and data-assimilation

Cluster D
Spatiotemporal variability in land surface-atmosphere exchange processes
e.g., D6 LES with TerrSysMP

Cluster C
Analyzing and modeling spatiotemporal variability of water and solute fluxes from micro- to meso-scale catchments
e.g., C4 CO2 coupling in SVA
C6 Data Assimilation with CLM

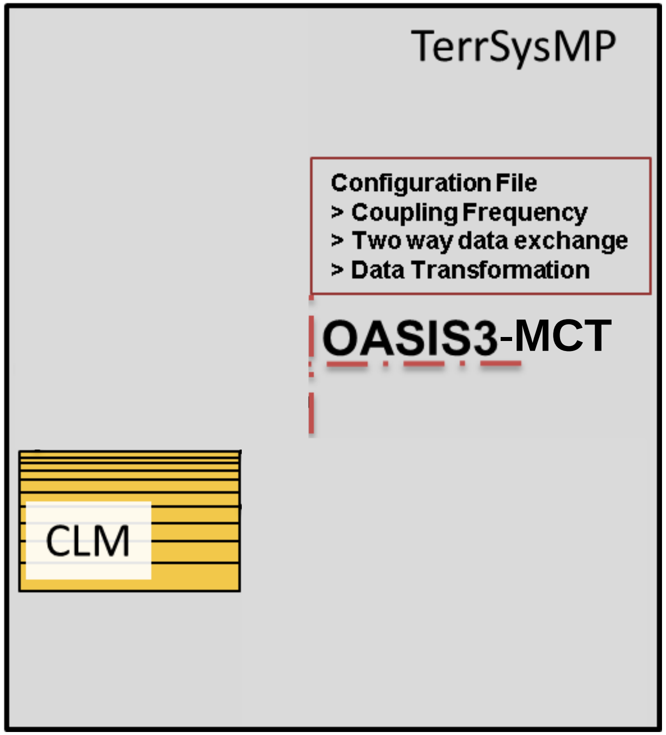
Cluster B
Combining non-invasive measurements and modeling to analyze spatiotemporal variability of water and matter fluxes at the field scale
e.g., B1 Net ecosystem carbon fluxes at field scale
B4 Root water uptake at field scale
B5 Crop Ecology

Cluster A
Characterization of flow, transport and structure of unsaturated soils at the pore to meter scale

Cluster Z
Central Service Project
e.g., **Z4** Model Development and Maintenance Services

Terrestrial Systems Modeling Platform

Primary Objective:
Develop a tool to study patterns from subsurface to atmospheric boundary layer
Integrate improved understanding of physical processes into the component models



TerrSysMP schematic
(Shrestha et al. 2014) Gasper et al. 2014)

TerrSysMP
(Shrestha et al. 2014)

COSMO
Convection permitting configuration (COSMO-DE)
(Baldauf et al. 2011)

CLM
CLM3.5 (Oleson et al. 2008)

ParFlow
Integrated surface-groundwater flow model with terrain following co-ordinates
(Kollet and Maxwell 2006; Maxwell 2012)

OASIS3
External coupler with multiple executable approach
(Valcke 2013)

Shrestha P., M. Sulis, M. Masbou, S. Kollet, and C. Simmer, 2014: A Scale-Consistent Terrestrial Systems Modeling Platform Based on COSMO, CLM, and ParFlow. Mon. Wea. Rev., 142, 3466–3483

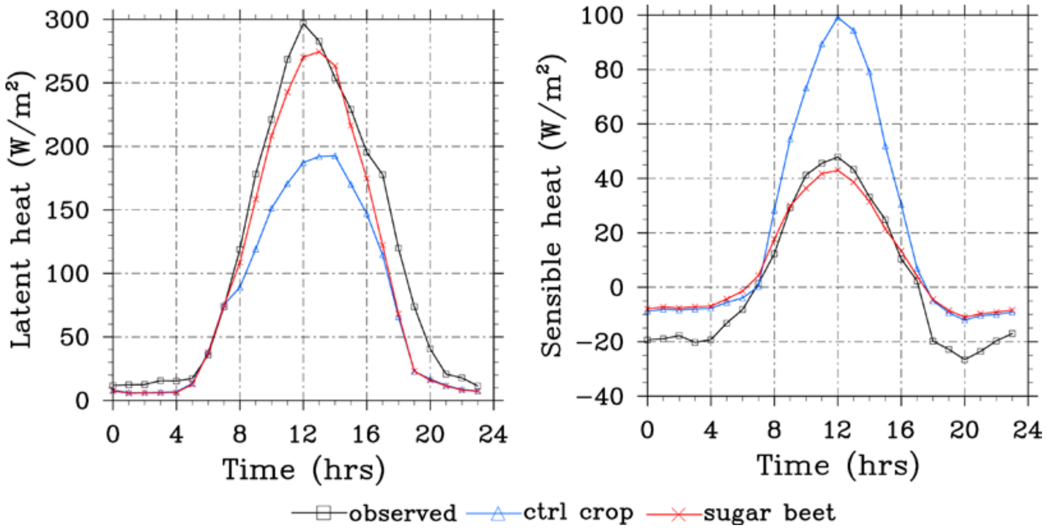
Parameters for sugar beet and winter wheat

- sugar beet and winter wheat included in generic crops for CLM3.5[1].
- Measurements of optical properties, photosynthesis characteristics, transpiration, and nutrient balances.

Key parameters:	CTRL	sugar beet	winter wheat
Slope of conductance-to-photosynthesis [/]:	9.0	6.7	7.0
Leaf nitrogen content [gC/gN]:	25.0	10.0	14.0

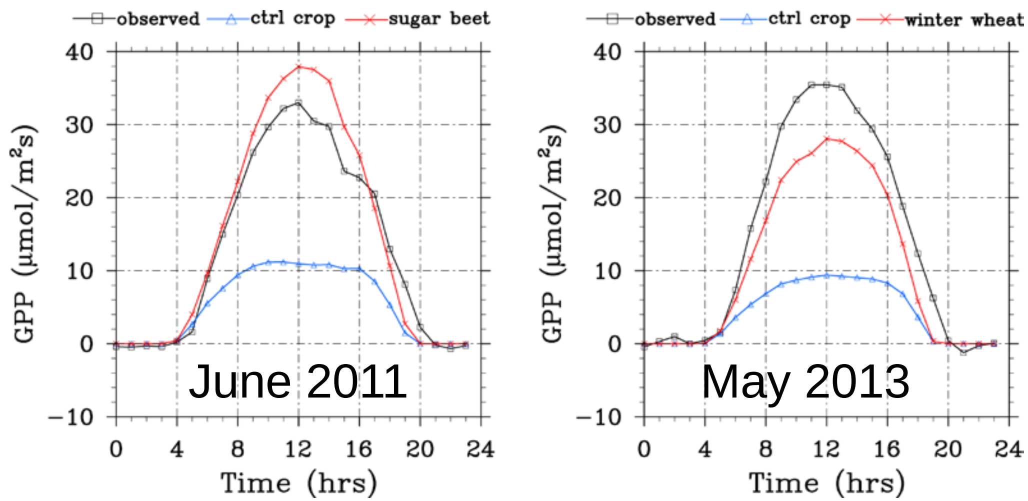
Sulis, M., M. Langensiepen, P. Shrestha, A. Schickling, C. Simmer, and S. J. Kollet, 2015: Evaluating the Influence of Plant-Specific Physiological Parameterizations on the Partitioning of Land Surface Energy Fluxes. J. Hydrometeor, 16, 517–533.

Comparison of simulated energy and carbon fluxes



Monthly averaged diurnal cycle of the LH and SH flux at Selhausen, Germany (TR32 site, June 2011).

Monthly averaged diurnal cycle of GPP at Selhausen, Germany (TR32 site)



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Compensatory Root Water Uptake (RWU) in clm 3.5

Standard Implementation

$$e_i = E_{vt} * r_e$$

$$r_e = \frac{r_i * w_i}{\beta_t}$$

$$\beta_t = \sum_i w_i r_i$$

$$w_i = \frac{\psi_{close} - \psi_i}{\psi_{close} - \psi_{open,i}}$$

3 parameter Macroscopic RWU model based on hydraulic architecture: Couvreur et al. 2012

$$RWU = T_{act} * SSF_i + K_{comp} * (\psi_i - \psi_{i,eq}) * SSF_i$$

K_{comp} (compensatory RWU conductance) ->depends on root axial and radial resistance to water flow.
K_{rs} – (equivalent conductance of root system)
SSF_i – (standard sink fraction) ->depends on root system architecture and hydraulic properties

T_{act} – Actual Evapotranspiration(L^3T^{-1})

SSF_i – Standard Sink Fraction$(-)$

K_{comp} – Compensatory RWU conductance$(L^3P^{-1}T^{-1})$

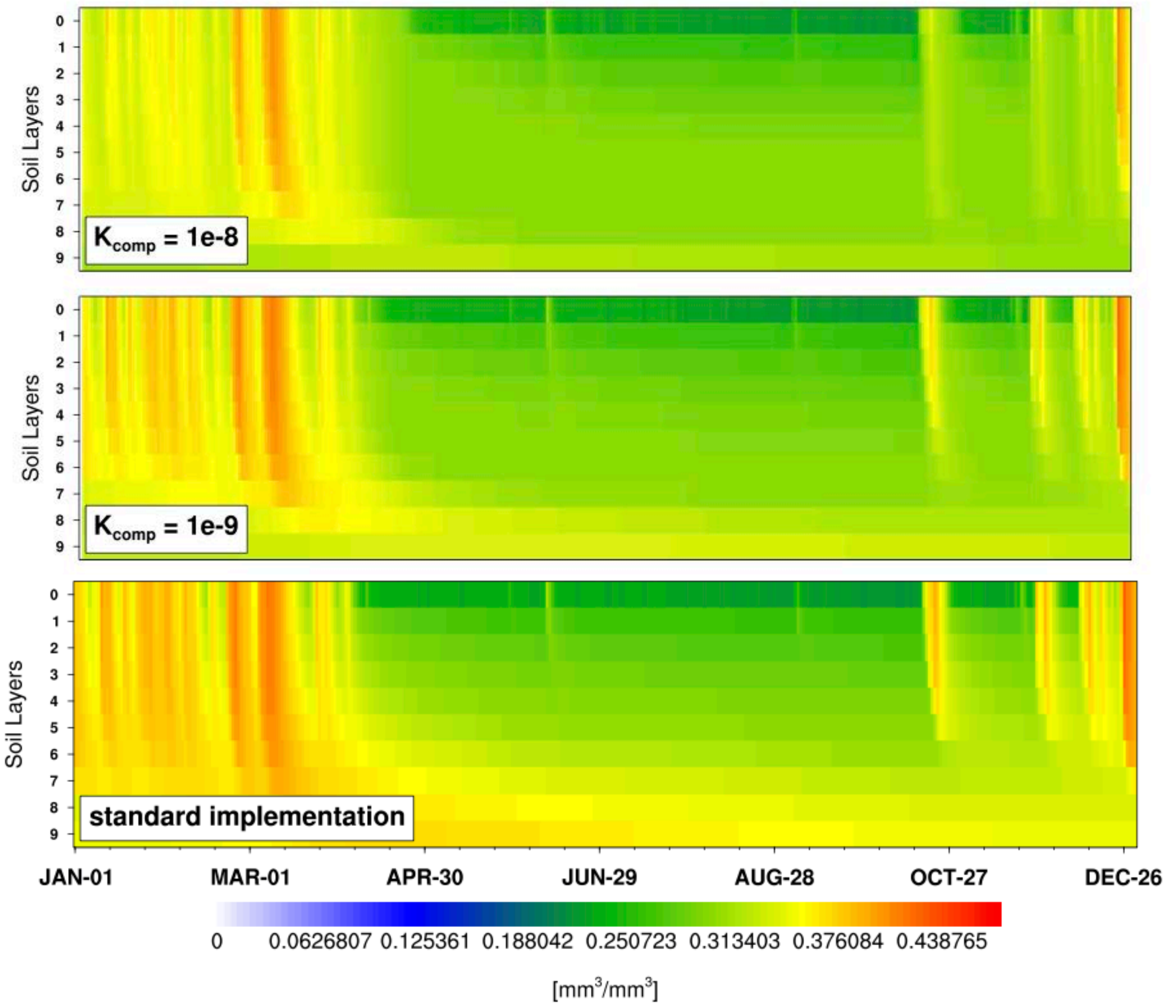
ψ_i – Soil water potential(P)

$\psi_{i,eq}$ – Equivalent ψ_i sensed by plant(P)

Couvreur, V., J. Vanderborght, and M. Javaux (2012). A simple three-dimensional macroscopic root water uptake model based on the hydraulic architecture approach. Hydrology and earth system sciences, 16(8), 2957-2971.

Compensatory Root Water Uptake in clm 3.5

$$\theta_v (mm^3 / mm^3)$$



Semi-idealized simulation for a semi-arid climate

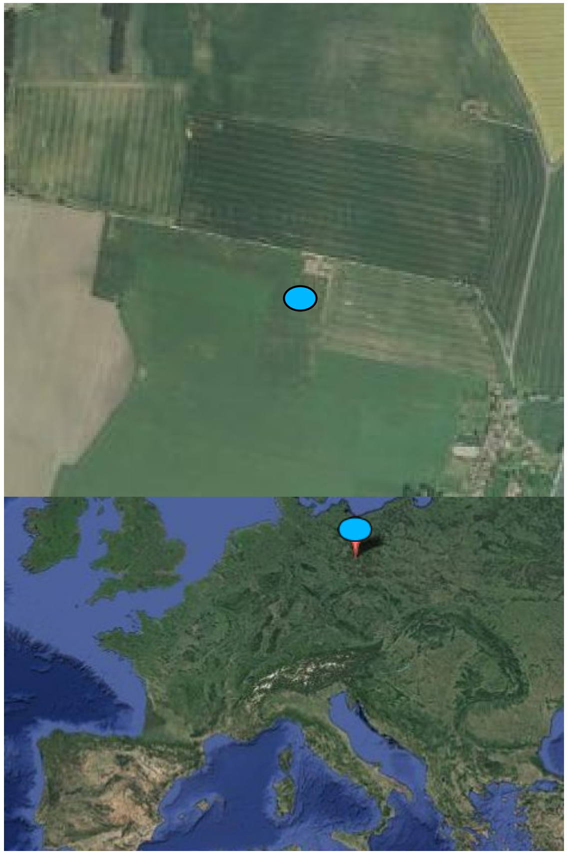
– PFT (crop)

-- clay soil (sand15%; clay 70%))

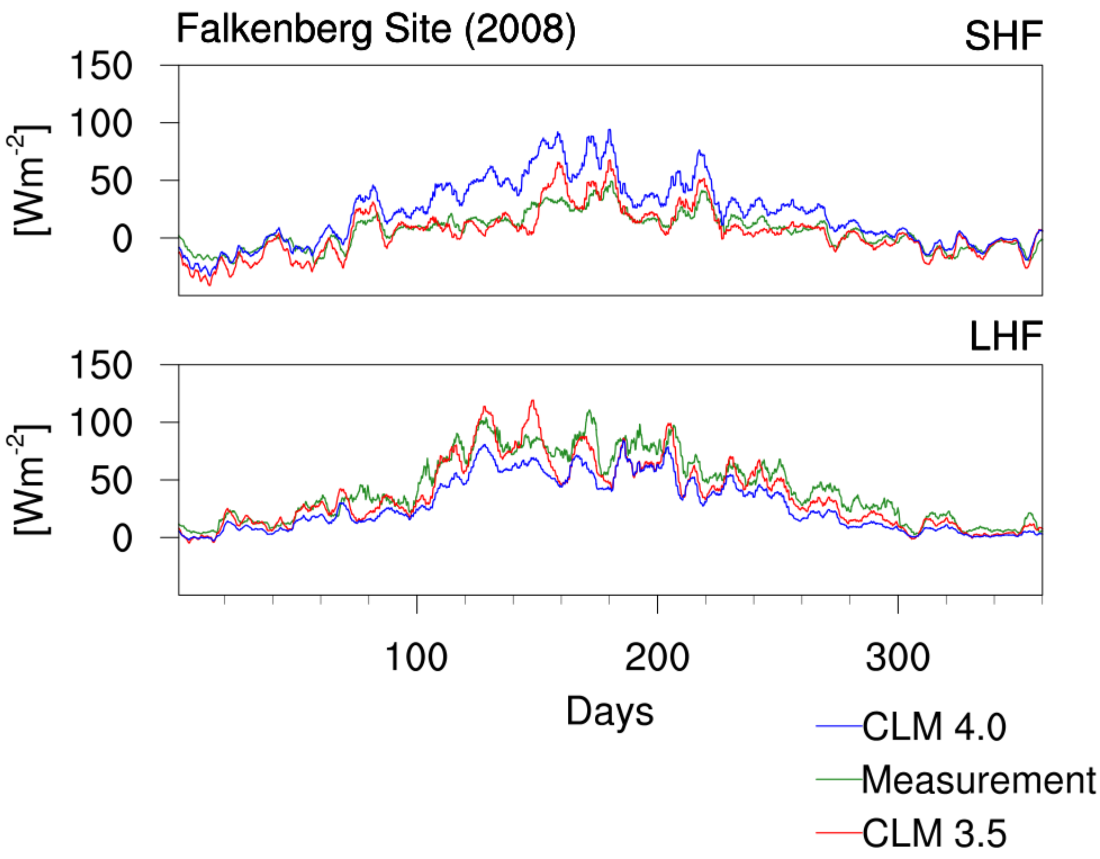
– Krs =10^{-9}

Marschollek, S., 2015. Implementation and testing of an improved root water uptake parameterization in CLM3.5, Bachelor Thesis, Meteorological Institute, University of Bonn

CLM validation runs over Falkenberg, Germany

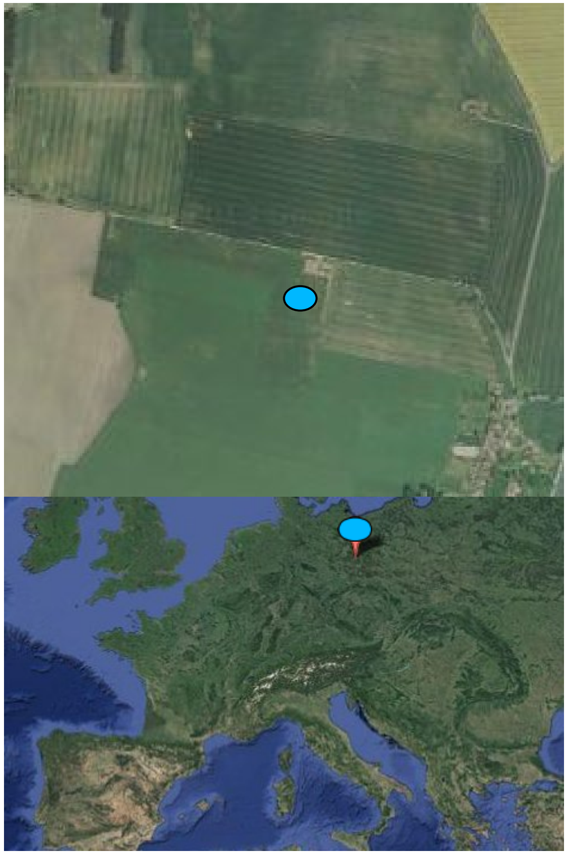


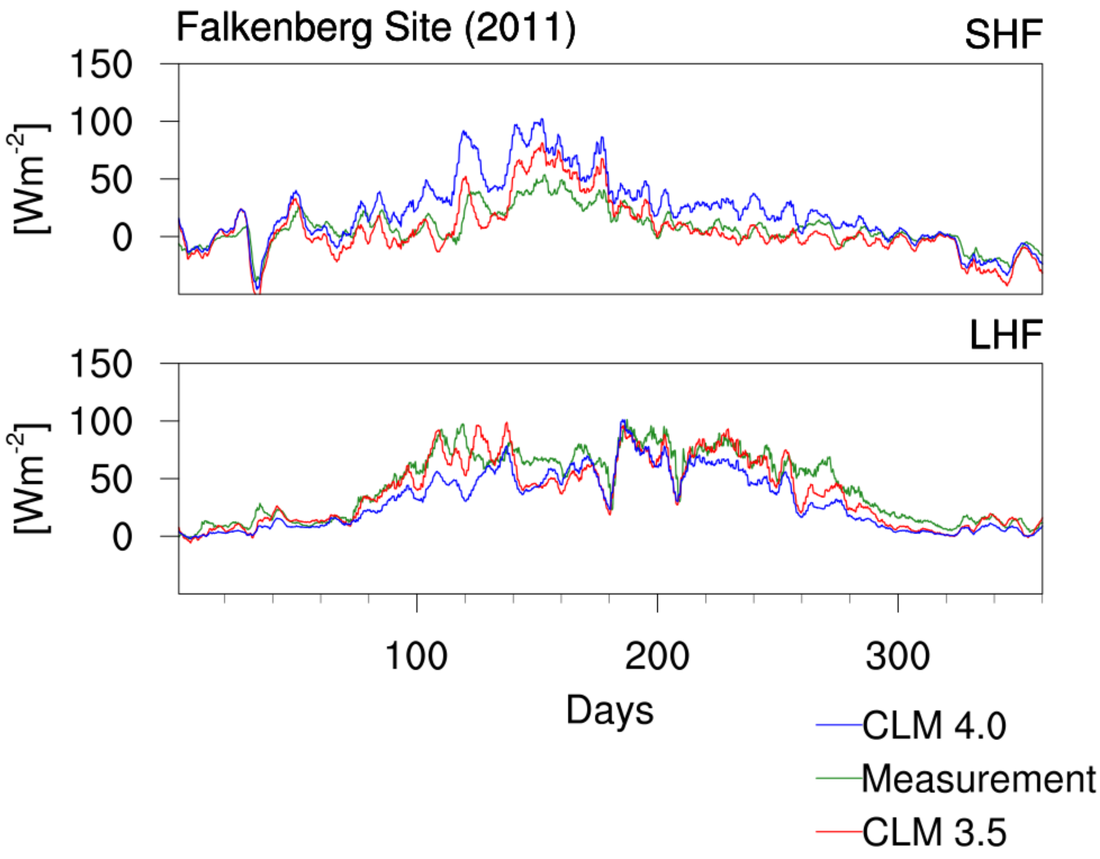
Grassland site (Falkenberg) of the Lindenberg Meteorological Observatory – Richard Aßmann Observatory (DWD).



Work done in collaboration with Gerd Vogel, DWD.

CLM validation runs over Lindenberg, Germany





Grassland site (Falkenberg) of the Lindenberg Meteorological Observatory – Richard Aßmann Observatory (DWD).

Outlook

Work is under progress to use the I-compset (clm4.0, clm4.5, clm5.0) of CESM as the land surface model in TerrSysMP

- TerrSysMP interface added as a new utility library in cesm
- Component model dependent TerrSysMP interface added in component models
- New entry id in xml files and pre-processor flags added to compile CESM with TerrSysMP
- Framework for data exchange has been established

Generic crop parameters for sugar-beet and winter wheat ingested into post clm4_5 in crop model, and work under progress in the update of additional parameters.

Develop a systematic approach to scientifically validate RWU parameterization in clm

We are also allocating resources to generate seasonal LAI and plant height data measurements over the TR32 sites (for the next 3 years), which will be used for systematic evaluation of CLM.

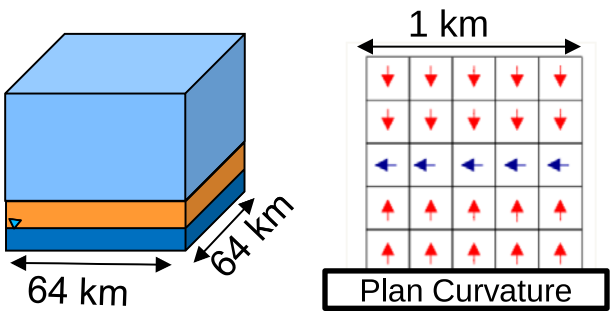
Thank you.

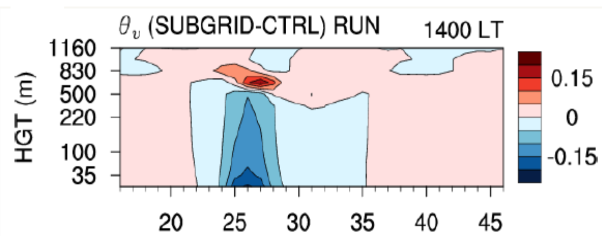
For more updates, visit us at: www.tr32.de

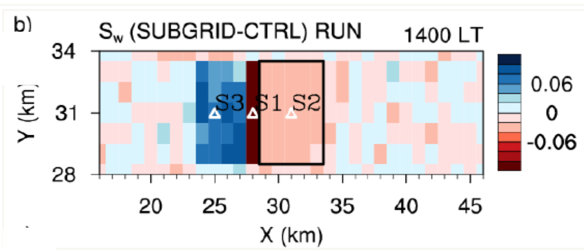
Integrated Surface and Groundwater Flow

Lateral Flow Effect on ABL

Excess rainfall and saturation
(0.015 mm/s, 0100 - 0200 UTC)
CTRL : Sx = 0.03 (DX=1 km)
SUBGRID : Mosaic (DX = 250 m)

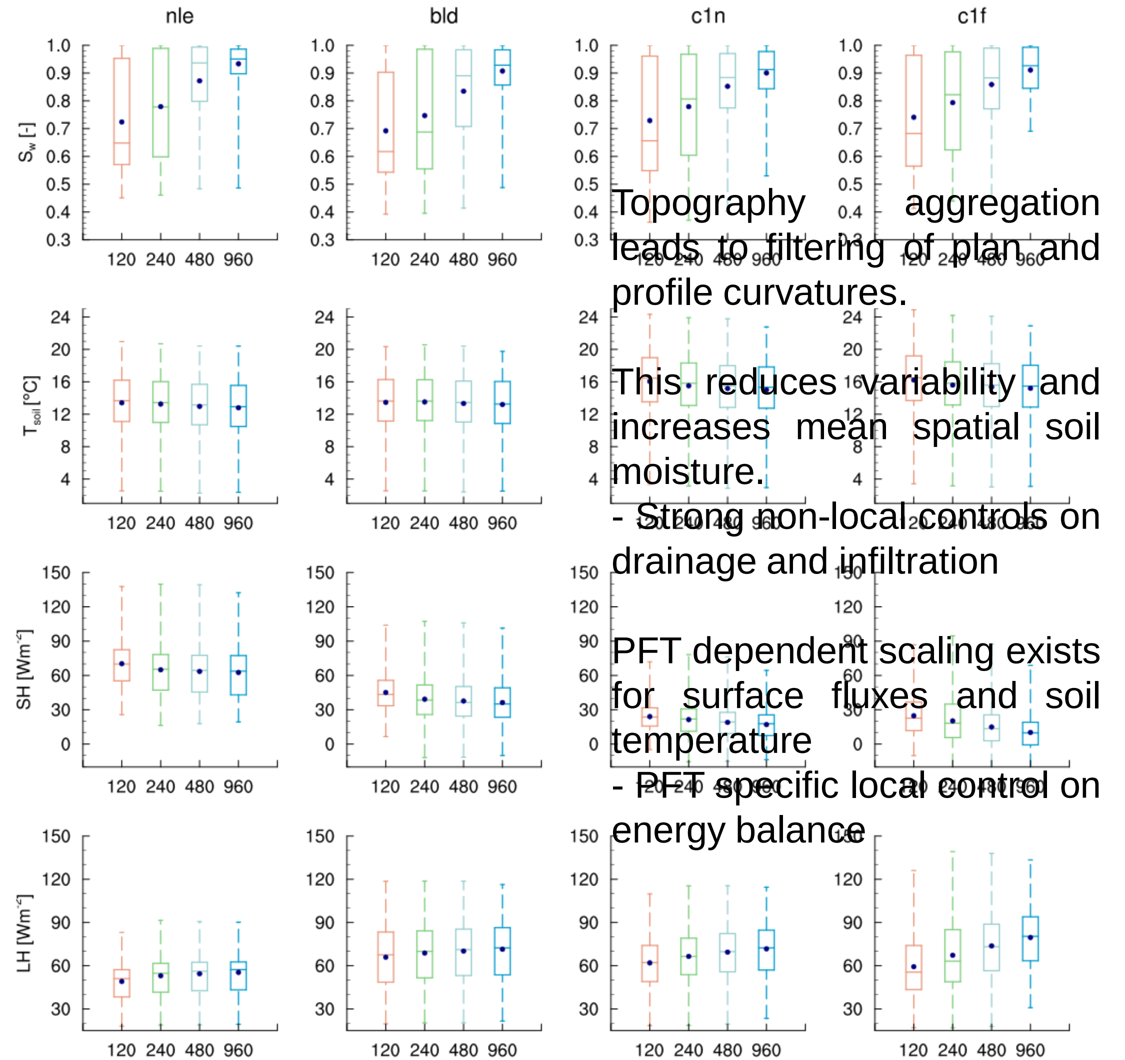






(Shrestha et al. 2014)

Real Data Study with Offline Hydrological Component



Topography aggregation leads to filtering of plan and profile curvatures.

This reduces variability and increases mean spatial soil moisture.
- Strong non-local controls on drainage and infiltration

PFT dependent scaling exists for surface fluxes and soil temperature
- PFT specific local control on energy balance

Shrestha, P., M. Sulis, C. Simmer and S. Kollet : Impacts of grid resolution on surface energy fluxes simulated with an integrated surface-groundwater flow model, Hydrol. Earth Syst. Sci., 19, 4317-4326, doi:10.5194/hess-19-4317-2015, 2015.