IDENTIFICATION OF CHARACTERISTIC MODEL-OBSERVATION DEVIATIONS FOR COUPLED DATA ASSIMILATION

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INTRODUCTION

- Coupled data assimilation should exploit links between model components, such as the impact of soil moisture on near-surface air temperature.
- Instantaneous deviations commonly used in data assimilation are related to many different sources and often fluctuate on short time scales.
  $\Rightarrow$ Instantaneous deviations are not well suited to relate innovations $(\mathbf{y} - \mathbf{H}\mathbf{x}_i^f)$ to analysis increments $(\mathbf{x}_i^a - \mathbf{x}_i^f)$.
- Characteristic patterns in model-observation deviations are better suited to update, eg., soil moisture from near-surface air temperature: Too wet soils lead to a slower temperature increase in the morning and a lower mean daytime temperature (Fig. 1).

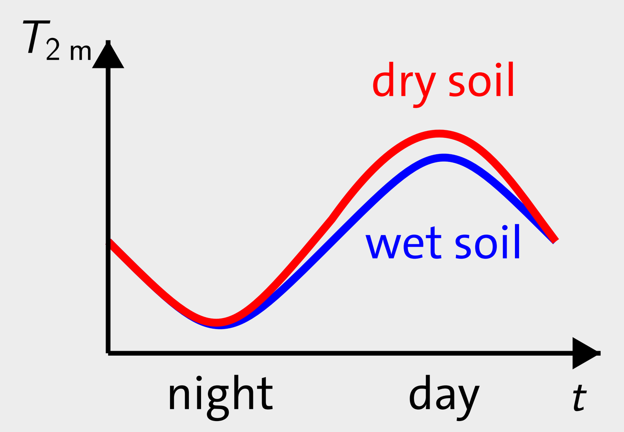


Figure 1: Idealised diurnal cycle of 2 m-temperature for wet soil and dry soil conditions.

ICON-LES MODEL SETUP

- We use ensemble simulations of a small, limited domain with ICON-LES (Dipankar et al., 2015) with a horizontal resolution of $\approx$ 620 m (Fig. 2).
- Initial conditions and boundary forcing are derived from a high-resolution "virtual truth" simulation within the DFG Research Unit FOR2131:
  - COSMO coupled to CLM with 1 km horizontal resolution (TerrSysMP, Shresta et al., 2014)
  - 15 min output time step
  - $\Rightarrow$ capture the system as realistically as possible

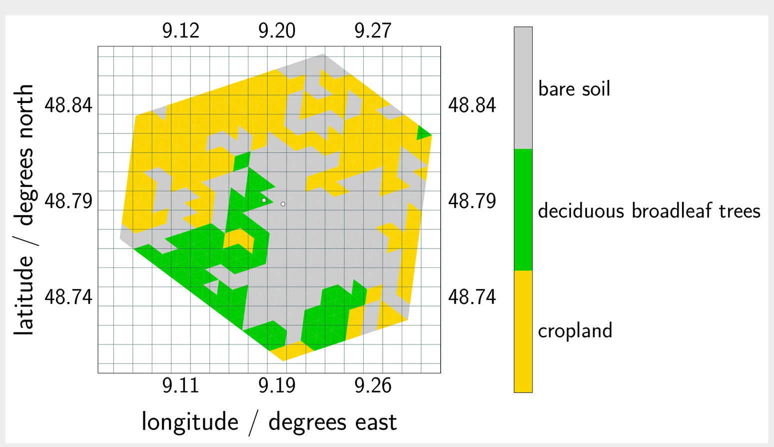


Figure 2: Land cover in ICON-LES ensemble simulations. Gridlines show resolution of the virtual truth. White dots show the location of the bare soil and forest cells referred to in the figures.

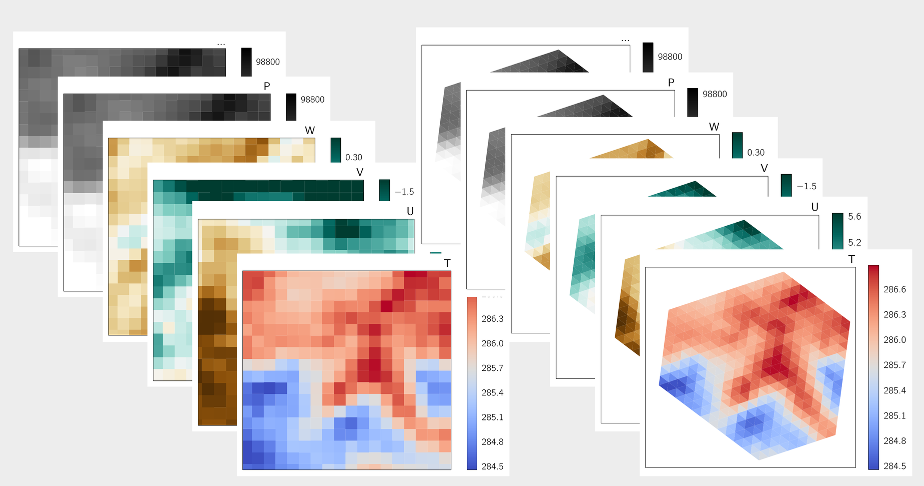
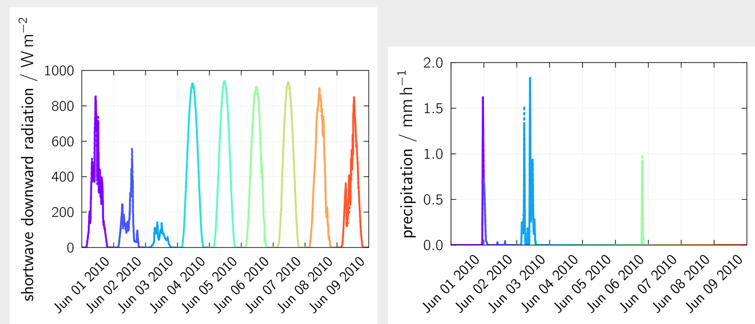


Figure 3: Virtual truth and remapped ICON-LES fields for boundary and initial data. Boundary data are available every 15 min.

Dipankar, A., B. Stevens, R. Heinze, C. Moseley, G. Zängl, M. Giorgetta, and S. Brdar (2015), Large eddy simulation using the general circulation model ICON, J. Adv. Model. Earth Syst., 7, 963–986.
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. Weather Rev., 142(9), 3466-3483

ENSEMBLE SIMULATIONS WITH PERTURBED INITIAL SOIL MOISTURE

- We simulated 200 ensemble members for 9 days in June 2010.
- The ensemble spans dry to wet soil conditions (permanent wilting point to field capacity at initial date).
- We analyse 5 min-output at two points close to the centre of the domain (see Fig. 2).



(a) Incoming shortwave radiation. (b) Precipitation

Figure 4: Incoming shortwave radiation and precipitation for bare soil (solid) and deciduous forest (dashed) cell. Colors represent simulation days.

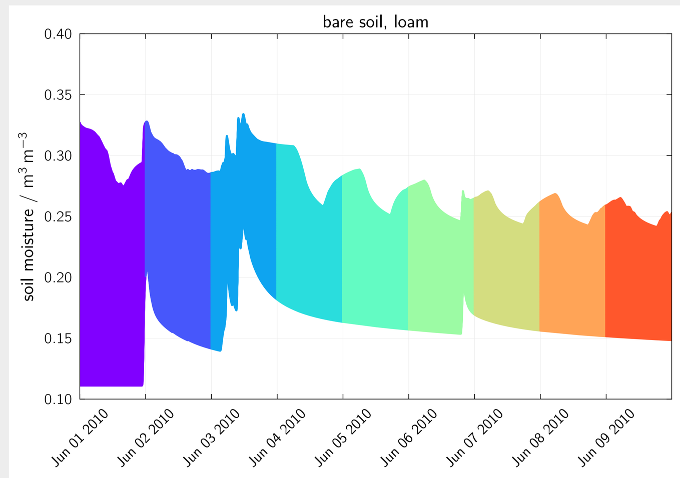


Figure 5: Volumetric soil moisture at bare soil cell (upper two layers = 3 cm).

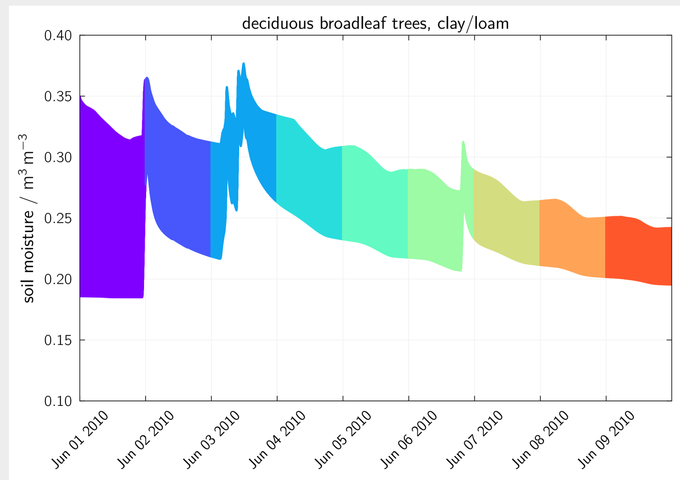


Figure 6: Volumetric soil moisture at deciduous forest cell (upper two layers = 3 cm).

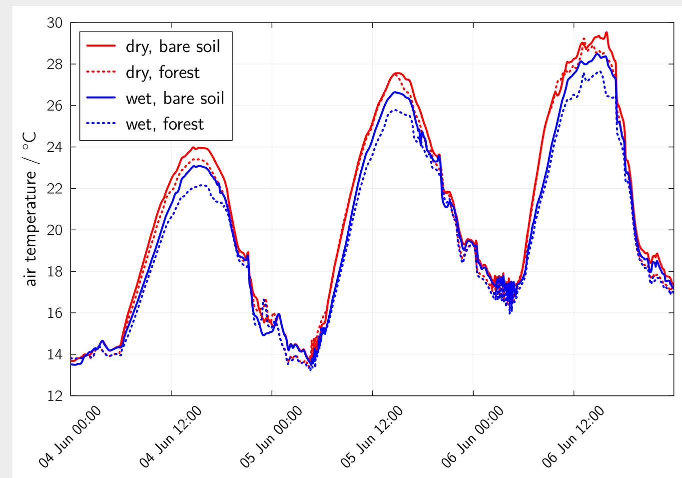


Figure 7: Air temperature at lowest model level ($\approx$ 10 m) for dry and wet soil.

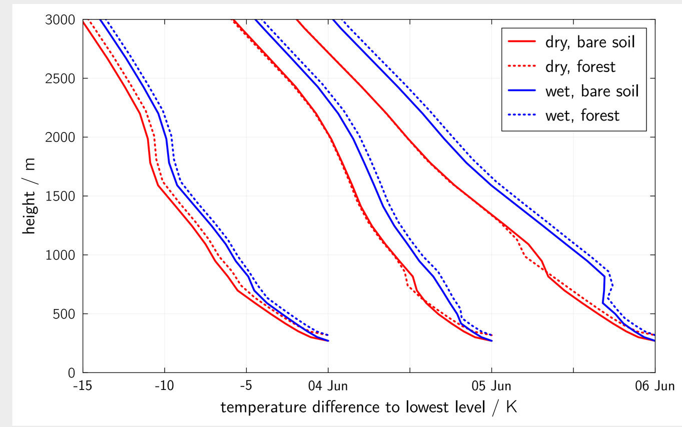
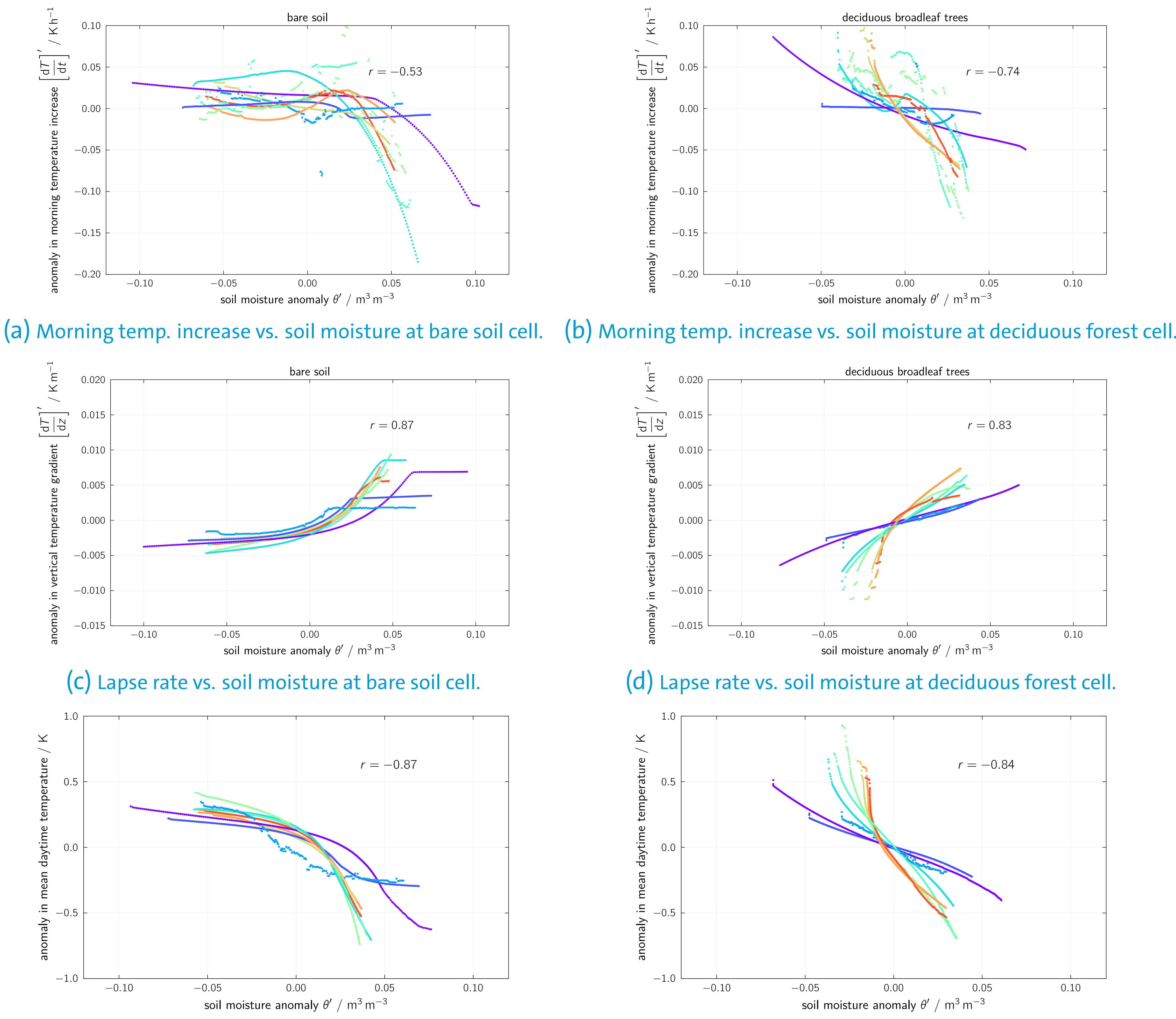


Figure 8: Differences between air temperature and air temperature at the lowest model level for three days at 9:00 UTC, respectively.

CHARACTERISTIC DEVIATIONS IN BOUNDARY LAYER TEMPERATURES

- Potential characteristic quantities are
  - the temperature increase in the morning (07:00 to 12:00 local time),
  - the mean daytime temperature (07:00 to 19:00 local time),
  - and the lapse rate (at 09:00 local time).
- They show high correlation coefficients with near-surface soil moisture.
- The characterics of the relationships change depending on meteorological conditions.



(a) Morning temp. increase vs. soil moisture at bare soil cell. (b) Morning temp. increase vs. soil moisture at deciduous forest cell.

(c) Lapse rate vs. soil moisture at bare soil cell. (d) Lapse rate vs. soil moisture at deciduous forest cell.

(e) Mean daytime temp. vs. soil moisture at bare soil cell. (f) Mean daytime temp. vs. soil moisture at deciduous forest cell.

Figure 9: Relationships between characteristic quantities derived from boundary layer temperatures and soil moisture (colors correspond to simulation days, see above).

POTENTIAL AND OUTLOOK

- Characteristic deviations in boundary layer temperature can be useful to constrain soil moisture.
- The quality of the relationship depends on meteorological conditions.
- $\Rightarrow$ Include conditional sampling.
- $\Rightarrow$ Constrain land surface parameters with characteristic deviations.

FOR 2131

Work in progress:

- We are preparing longer ensemble simulations (1 year) including mixed perturbations to verify the robustness of the characteristic deviations and to identify conditions in which they apply.
- We plan to perturb the atmospheric forcing on the land surface.