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Closing the Energy Balance at an infinitesimal thin surface layer (SkIn) – A new approach for the land surface scheme JSBACH (MPI-ESM)

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Land surface-atmosphere interactions are one of the most important characteristics for understanding the terrestrial climate system consisting of the compartments soil, vegetation, and the atmospheric boundary layer as it determines the exchange fluxes of energy and water between the land and the overlaying air mass.

In most of the current climate models it is common practice to use a prognostic procedure to close the surface energy balance within a soil layer with a finite heat capacity. In this study, a different approach is investigated by closing the energy balance diagnostically at an infinitesimal thin surface layer (SkIn) including an iteration of the heat transfer coefficient to ensure the numerical stability of the system.

Therefore, results of the offline simulations of the land component JSBACH of the Max Planck Institute Earth system model (MPI-ESM) – constrained with atmospheric observations – are compared to energy- and water fluxes derived from eddy covariance measurements observed at the CASES-99 field experiment in Kansas. This comparison of energy and evapotranspiration fluxes with observations at the site-level provides an assessment of the model's capacity to correctly reproduce the coupling between the land and the atmosphere throughout the diurnal cycle. In a further step, a global coupled land-atmosphere experiment is performed using an AMIP type simulation over 30 years to evaluate the regional impact of the SkIn scheme on longer time scales.

The results of this study show distinct improvements of the modeled surface fluxes on diurnal time scales using the SkIn scheme: unrealistic nocturnal heat releases disappear, phase errors are removed and the amplitudes of heat fluxes and surface temperature agree with the observations. On global scale the scheme leads to marked improvements for serveral regions where shallow vegetation prevails but still oversimplifies the description of near surface energy fluxes in most forest regions. Thus, for these regions a more detailed approach to represent the canopy layer might be appropriate.