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Identification of characteristic model-observation deviations for coupled data assimilation

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Exchange fluxes of water and energy between the land surface and the atmosphere lead to the propagation of errors from one model component to the other. Data assimilation can correct such errors in two ways, either by correcting the observed state directly or by changing the state that caused the exchange fluxes. The land surface, for example, strongly determines the temperature in the atmospheric boundary layer. The assimilation of boundary layer temperature can then correct the model's temperature directly. Or the assimilation of boundary layer temperature can act on the model's land surface state. A coupled data assimilation system should exploit these links and enable the second type of correction across model components.

Data assimilation relies on instantaneous deviations between model forecasts and observations. Such instantaneous deviations are often hard to relate to errors in specific model components. Therefore, model verification builds on more sophisticated statistics such as long-term biases, gradients, phase shifts, or conditional differences that yield characteristic differences between model forecasts and observations. Compared to the instantaneous deviations in data assimilation, the characteristic deviations in model verification are more closely linked to errors in specific model components. Consequently, such characteristic deviations can potentially be used for data assimilation across model components where instantaneous deviations are not sufficiently informative.

As a first step towards data assimilation with characteristic deviations (here named fingerprints), we use ensembles of simulations with the Icosahedral Non-hydrostatic (ICON) model to identify applicable statistics of observable variables. We run ICON in a large eddy simulation configuration on a small, limited domain and systematically perturb soil and land-surface parameters and states to produce the ensembles. Subsequently, we test statistics of boundary layer observables to find fingerprints from which we can infer soil and land-surface variables. In this way, we identify potential fingerprints for coupled land-surface atmosphere data assimilation.