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Improving weather predictability by including land-surface model parameter uncertainty

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The land surface forms an important component of Earth system models and interacts nonlinearly with other parts such as ocean and atmosphere. To capture the complex and heterogenous hydrology of the land surface, land surface models include a large number of parameters impacting the coupling to other components of the Earth system model.
Focusing on ECMWF's land-surface model HTESSEL we present in this study a comprehensive parameter sensitivity evaluation using multiple observational datasets in Europe. We select 6 poorly constrained effective parameters (surface runoff effective depth, skin conductivity, minimum stomatal resistance, maximum interception, soil moisture stress function shape, total soil depth) and explore their sensitivity to model outputs such as soil moisture, evapotranspiration and runoff using uncoupled simulations and coupled seasonal forecasts. Additionally we investigate the possibility to construct ensembles from the multiple land surface parameters.
In the uncoupled runs we find that minimum stomatal resistance and total soil depth have the most influence on model performance. Forecast skill scores are moreover sensitive to the same parameters as HTESSEL performance in the uncoupled analysis. We demonstrate the robustness of our findings by comparing multiple best performing parameter sets and multiple randomly chosen parameter sets. We find better temperature and precipitation forecast skill with the best-performing parameter perturbations demonstrating representativeness of model performance across uncoupled (and hence less computationally demanding) and coupled settings.
Finally, we construct ensemble forecasts from ensemble members derived with different best-performing parameterizations of HTESSEL. This incorporation of parameter uncertainty in the ensemble generation yields an increase in forecast skill, even beyond the skill of the default system.

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