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A European vision for hydrological observations and experimentation

Can Earth System Models represent the spatial variability of land surface processes over complex terrain?

Enrico Zorzetto[1], Sergey Malyshev[2], Nathaniel Chaney[3], and Elena Shevliakova[2]
[1]Princeton University, Program in Atmospheric and Oceanic Sciences, Princeton, NJ, USA
[2]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA
[3]Duke University, Department of Civil and Environmental Engineering, Durham, NC, USA

The land components of Earth System Models (ESMs) are increasingly used to predict changes in surface climate and hydrological processes at the global scale. However, due to their coarse resolution, these models still struggle in representing the fine-scale spatial variability of key land variables important for hydrological applications, such as snow cover, land surface temperature, and soil moisture. To address this limitation, we test here a sub—grid model structure recently developed for the Geophysical Fluid Dynamics Laboratory (GFDL) ESM4.1 land model. This novel model structure employs a machine learning technique and high-resolution terrain data to partition each land surface model grid in a set of land 'tiles' with homogeneous physical properties, which are then used to learn land processes at scales finer than the nominal land model resolution. This technique is especially relevant over complex terrain, where we can use elevation information to refine model predictions of the local energy balance and hydrological processes. Over each topography-aware model tile, the land model can thus provide local estimates of relevant land variables which can be then combined to produce high resolution maps and learn their spatial variance. As a proof of concept, here we will compare this modelling approach with satellite observations of land surface temperature, evaluating the skill of the model in reproducing land heterogeneity over complex topography regions. This analysis can be extended to other variables of hydrological interest, in particular soil moisture. As land models of increasing spatial resolution are being developed, our analysis here underlines the importance of evaluating not only grid average model output, but also predicted spatial variability using observational datasets.