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How to Represent 100-meter Spatial Heterogeneity in Earth System Models

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Terrestrial ecosystems play a pivotal role in the Earth system; they have a profound impact on the global climate, food and energy production, freshwater resources, and biodiversity. One of the most fascinating yet challenging aspects of characterizing terrestrial ecosystems is their field-scale (∼100 m) spatial heterogeneity. It has been observed repeatedly that the water, energy, and biogeochemical cycles at multiple temporal and spatial scales have deep ties to an ecosystem's spatial structure. Current Earth system models largely disregard this important relationship leading to an inadequate representation of ecosystem dynamics. In this presentation, we will show how existing hyperresolution environmental datasets can be harnessed to explicitly represent field-scale spatial heterogeneity in Earth system models. For each macroscale grid cell, these environmental data are clustered according to their field-scale soil and topographic attributes to define unique sub-grid tiles or hydrologic response units (HRUs). The novel Geophysical Fluid Dynamics Laboratory (GFDL) LM3-TiHy-PPA land model is then used to simulate these HRUs and their spatial interactions via the exchange of water, energy, and nutrients along explicit topographic gradients. Using historical simulations over the contiguous United States, we will show how a robust representation of field-scale spatial heterogeneity impacts modeled ecosystem dynamics including the water, energy, and biogeochemical cycles as well as vegetation composition and distribution.