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Rethinking large scale river routing by leveraging a field-scale resolving land surface model

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Over the past decade there has been important progress towards modeling the water, energy, and carbon cycles at field scales (10-100 meter) over continental extents. One such approach, named HydroBlocks, accomplishes this task while maintaining computational efficiency via sub-grid hydrologic response units (HRUs); these HRUs are defined via cluster analysis of available field-scale environmental datasets (e.g., elevation). However, until now, there has yet to be complementary advances in river routing schemes that are able to fully harness HydroBlocks' approach to sub-grid heterogeneity, thus limiting the added value of field-scale resolving land surface models (e.g., riparian zone dynamics, irrigation from surface water, and interactive floodplains). In this presentation, we will introduce a novel large scale river routing scheme that leverages the modeled field-scale heterogeneity in HydroBlocks through more realistic sub-grid stream network topologies, reach-based river routing, and the simulation of floodplain dynamics.

The primary features of the novel river routing scheme include: 1) each macroscale grid cell is assigned its own river network delineated from field-scale DEMs; 2) similar sub-grid reaches (e.g., Shreve order) are grouped/clustered to ensure computational tractability; 3) the fine-scale inlet/outlet reaches of the macroscale grid cells are linked to assemble the continental river networks; 4) river dynamics are solved at the reach-level via an implicit solution of the Kinematic wave with floodplain dynamics; 5) two way connectivity is established between each cell's sub-grid HRUs and the river network. The resulting routing scheme is able to effectively represent sub-100 meter-delineated stream networks within Earth system models with relatively minor increases in computation with respect to existing approaches. To illustrate the scheme's novelty when coupled to the HydroBlocks land surface model, we will present simulation results over the Yellowstone river in the United States between 2002 and 2018. We will show the added value of the scheme when compared to existing approaches with regards to floodplain dynamics, water management, and riparian corridors. Furthermore, we will present results regarding the scheme's computational tractability to ensure the feasibility of its use within Earth system models. Finally, we will discuss the potential of this approach to enhance flood and drought monitoring tools, numerical weather prediction, and climate models.