"Seeing the wood for the trees? Strategies for managing the complexity of ecological process representation in Earth system models."

The land surface components of Earth System Model were originally envisaged as simple energy balance models, designed to return boundary conditions for atmospheric simulations. In the following decades, they have expanded in scope to include the simulation of carbon-climate feedbacks, complex surface hydrology (snow, permafrost, lakes, aquifers), nutrient cycling, urban areas, crop systems (including management, irrigation and fertilizer), fire and demographic representations of ecosystem processes, reflecting the needs of society to understand the climate system itself, and also the magnitude of impacts of climate at the continental surface, which is, or course, the location of all human civilization.

To robustly answer the questions currently asked of land surface models, we must find approaches that can tackle the interactive nature of these systems and the complexity which arises therein. In this talk, I will discuss the potential of “modular complexity” as a strategy to ‘divide and conquer’ interdependent aspects of a land surface model. In this system, the model can be run in different ‘modes’, each of which replaces a strategic feature of the model (leaf area index, vegetation distribution, growth rates, stand structure) with observations, allowing the testing and calibration of different model elements in isolation.

I will illustrate this using results from the FATES (Functionally Assembled Terrestrial Ecosystem Model). FATES (https://github.com/NGEET/fates) is an open-source, community effort to represent vegetation processes in Earth System Models, which is currently coupled to the Community, (CESM) the Norwegian (NorESM), and the Energy Exascale (E3SM) Earth System Model;s as well and the AFS 3D hydrology model. We hope that by our ongoing implementation of ‘modular complexity; within FATES, we can accelerate progress towards robust global calibrations of ecosystem dynamics, as well as allow a wider range of model applications.