**Title**: Machine learning upscaling of land-atmosphere exchanges across North America to capture extreme impacts

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**BER Program**: ESS – EESM

**Project**: DOE Early Career: Drought, heat and wildfire impacts on coastal water relations

**Project Website**: https://www.keenangroup.info/currentProjects.html

**Project Abstract**:

Eddy covariance networks have served as a primary tool to understand the dynamics of land-atmosphere interactions, in particular ecosystem-level photosynthesis (or gross primary production, GPP), ecosystem respiration, and water use. However, the eddy covariance technique provides only spatially sparse observations with limited representativeness. Thus, spatial upscaling of site-level measurements is often required to achieve regional and global synthesis. Here we explore novel machine learning frameworks informed by physical and physiological knowledge to upscale GPP from AmeriFlux eddy covariance network towards wall-to-wall maps over North America at 16-day and monthly temporal scales. Input datasets include remote sensing products from the Moderate Resolution Imaging Spectrometer (MODIS), satellite-based evapotranspiration, solar-induced chlorophyll fluorescence, and ERA5 atmospheric data. Models are trained with data from 2001 to 2017 and evaluated with spatiotemporal cross-validation as well as independent eddy covariance measurements after 2017 from National Ecological Observatory Network (NEON) sites. We find that incorporating physiological constraints improves machine learning models' ability to reconstruct interannual variability of land-atmosphere interactions by emphasizing extreme events which are often overlooked by standard learning algorithms due to their rarity. These improved estimates provide important insights into ecosystem-atmosphere feedbacks under a changing climate.