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Soil temperature dynamics in eastern US salt marshes

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Salt marshes are vital coastal wetland ecosystems that provide essential services including carbon sequestration, nutrient cycling, biodiversity support, and coastal protection. The productivity of the marsh vegetation and biogeochemical processes in the marsh soil are influenced by soil temperature and salinity. Both vary with changes in marsh elevation along a transect from tidal creeks towards the upland and are sensitive to changes in inundation patterns.

To quantify the response of soil temperature and salinity to changes in relative marsh elevation, e.g. due to sea level rise, we integrate observational datasets into a 1D mechanistic model. The model incorporates physical drivers, including short- and long-wave radiation, tide, evapotranspiration and precipitation, using data collected at the Georgia Coastal Ecosystems LTER marsh flux tower site on Sapelo Island, GA (USA). Heat and salinity propagation through conduction, diffusion and advection were simulated from the sediment surface to a depth of 200 cm to capture the variations in soil temperature and salinity with depth. The model reproduces the soil temperature measured at a depth of 10 cm. It captures diurnal dynamics and shows substantial seasonal temperature variations in the surficial sediment, decreasing with depth in summer, while increasing in winter. The model was applied to assess marsh soil conditions under varying inundation patterns, and it was seen that soil temperature decreased with rising sea level, with a projected 1.1°C average soil temperature decrease in the top 25 cm when the sea level rises by 20 cm.

We also present a complimentary approach to simulating soil temperature using AI and open-source remote sensing and climate data. Using data from five eastern US marshes, we fit a spatially explicit model predicting hourly soil temperature (RMSE=1.5°C) at 10-m resolution and provide assessments for applicability to new locations.

Our mechanistic model framework offers critical insights into the controls of temperature in intertidal marshes and establishes the foundation for simulations of the subsurface biogeochemistry. Combined with our AI model, we can spatially monitor temperature dependent processes and provide tidal wetland specific inputs for earth system models.