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Improve carbon flux predictions in ecosystem models using lidar and imaging spectroscopy

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The composition and structure of vegetation are key attributes of ecosystems, affecting their current and future carbon, water, and energy fluxes. Information on these attributes has traditionally come from ground-based inventories of the plant canopy within small sample plots. In this study, airborne and satellite lidar in conjunction with available hyperspectral imagery, are used to provide estimates of sub-pixel forest canopy composition and structure in New England. Hyperspectral imagery is used to determine forest plant functional types. Waveform lidar is used to determine the vertical structure of foliage, which in turn is used to derive stem density, basal area and biomass. This method of determining structure is compared against widely used lidar-derived regression methods with similar biomass uncertainty (RMSE $\sim$2.5 kgC/m2). Regional-scale applicability is investigated using satellite lidar to derive sub-pixel forest structure. This fine scale information is then integrated into a size-structured terrestrial biosphere model (Ecosystem Demography) to improve the accuracy of carbon flux predictions at the local to regional scales. These improvements are quantified against simulations initialized with ground measurements and from a potential vegetation simulation. These results suggest that terrestrial biosphere model simulations can utilize modern-remote sensing data on vegetation composition and structure to improve their predictions of the current and near-term future functioning of the terrestrial biosphere.