Forests' use of water, energy, and carbon dioxide in a changing climate has profound implications for the global climate. To advance knowledge of how a forest uses these resources, it is critical to understand above- and below-canopy wind patterns. Turbulence can create a coupled wind regime that moves resources through the canopy, though below-canopy horizontal flows can also produce significant fluxes of resources. This study evaluates the energy budget and quantifies the horizontal fluxes of CO_2 and water vapor in the Hubbard Brook Experimental Forest (HBEF).

The HBEF is an 8,700-acre temperate mixed deciduous and conifer forest located in North Woodstock, New Hampshire, USA. The 20-m heterogeneous canopy has sparse undergrowth. From 25 May - 16 June 2022 and 18 May - 9 June 2023, an eddy covariance tower with two sets of flux instrumentation gathered measurements including 3-D wind speed and direction and H_2O and CO_2 concentrations at 30 m and at 6 m AGL.

The lower friction velocity (u*) coupling threshold for 2022, used to delineate coupled and decoupled regimes, suggests that less turbulence was required for the air masses to be considered coupled than in 2023, possibly a result of differing yearly canopy density. The energy budget was evaluated using a decoupled flux correction where below-canopy fluxes were added to above-canopy measurements. The 2022 dataset showed higher budget closure for the uncorrected model (67%) while 2023 showed higher closure for the corrected model (72%), implying that 2022 was more coupled than 2023 as above-canopy measurements more accurately detected below-canopy fluxes. Flux divergence between the sensors suggests horizontal advection that exports CO_2 and imports H_2O via katabatic flow at night. Larger overnight flux differences in 2023 imply more frequent horizontal advection and decoupling than in 2022. Further investigation with more data is needed to examine larger-scale temporal variability in wind and flux patterns.