In-Canopy Measurements of Ozone and Other Gases and Particles at Maine's Howland Research Forest

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In September 2011, the Clean Air Status and Trends Network (CASTNET) began a collaborative effort with Ameriflux to investigate atmospheric to vegetative exchanges of ozone and sulfur and nitrogen species at the Howland Research Forest Ameriflux site in Maine. The forest is comprised of mature, lowland evergreen trees aged 40 to 160 years with a local canopy height of 20 meters. Measurements taken at the site consist of hourly ambient ozone concentrations sampled at eight levels throughout and above the evergreen canopy and weekly integrated ambient concentrations of gases and particles from CASTNET filter packs located above and below the canopy. Design for the ozone system centered on the use of a single ozone analyzer and site transfer standard in conjunction with a solenoid system to allow for all eight levels to be measured with a residence time less than 20 seconds using the same analyzer. Quality assurance and analyzer performance is checked daily with calibration gas delivered through-the-probe at an inlet height of 23.5 meters. The checks show no evidence of line loss. Hourly ozone data collected thus far have shown evidence of episodic, nighttime negative concentration gradients with decreasing sampling height that may be indicative of potential deposition and scavenging mechanisms occurring within the canopy. These losses were compared with meteorological data to provide insight as to the degree of these phenomena as opposed to a gradient due to poor mixing within the canopy.

Weekly-integrated ambient concentrations measured with the filter pack support these observations having below canopy concentrations of approximately 60% and 64% of above-canopy concentrations for sulfur dioxide and total nitrate (including gaseous nitric acid), respectively. Above and below-canopy concentrations for concentrations of particulate matter components (i.e. total ammonium and sulfate) show much less difference, which may be indicative of slower deposition rates compared with those of the gaseous species. In addition, both hourly ozone and weekly filterpack data are collected at a nearby (5 kilometers) CASTNET site where measurements occur in a clearing at 10 meters. For the first quarter of 2012, concentrations of sulfur dioxide and total nitrate at this site were ~10% lower than those of the above-canopy filter pack (R^2= 0.96). Particulate sulfate and ammonium concentrations were 2% (R^2= 0.99) and 8% (R^2= 0.98) lower, respectively. Hourly ozone concentrations were ~9% lower than above-canopy measurements (R^2= 0.93), but more investigation is needed as there is evidence of a diminished episodic nighttime loss consistent with that described for the forest canopy. Future work will include comparison of CASTNET data with AmeriFlux carbon dioxide and flux data and the possibility the installation of similar equipment at other AmeriFlux sites.

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