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Ultra High Precision Laser Monitor for Oxygen Eddy Flux Measurements

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Atmospheric oxygen provides one of the most powerful tracers to study the carbon cycle through its close interaction with carbon dioxide. Keeling and co-workers demonstrated this at the global scale by using small variations in atmospheric oxygen content to disentangle oceanic and terrestrial carbon sinks. It would be very exciting to apply similar ideas at the ecosystem level to improve our understanding of biosphere-atmosphere exchange and our ability to predict the response of the biosphere and atmosphere to climate change. The eddy covariance technique is perhaps the most effective approach available to quantify the exchange of gases between these spheres. Therefore, eddy covariance flux measurements of oxygen would be extremely valuable. However, this requires a fast response (0.1 seconds), high relative precision (0.001% or 10 per meg) oxygen sensor.

We report recent progress in developing such a sensor using a high resolution visible laser to probe the oxygen A-band electronic transition. We have demonstrated precision of 1 ppmv or 5 per meg for a 100 second measurement duration. This sensor will enable oxygen flux measurements using eddy covariance. In addition, we will incorporate a second laser in this instrument to simultaneously determine the fluxes of oxygen, carbon dioxide and water vapor within the same sampling cell. This will provide a direct, real time measurement of the ratio of the flux of oxygen to that of carbon dioxide. This ratio is expected to vary on short time scales and small spatial scales due to the differing stoichiometry of processes producing and consuming carbon dioxide. Thus measuring the variations in the ratio of oxygen and carbon dioxide fluxes will provide mechanistic information to improve our understanding of the crucial exchange of carbon between the atmosphere and biosphere.