Geophysical Research Abstracts
Vol. 19, EGU2017-10324-1, 2017
EGU General Assembly 2017

Development of a High Precision Oxygen, Carbon Dioxide, and Water Monitor for Fast Plume and Eddy Flux Measurements

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A central concept of the carbon cycle is the inverted relationship between CO_2 and O_2, which provides detailed information about CO_2 sources and sinks. For example, Keeling was able to use very precise O_2 and CO_2 measurements to understand oceanic vs terrestrial carbon sinks. It has been a long-standing challenge to measure both species with enough precision and response time to understand the CO_2/O_2 exchange on a local scale. Such a capability would allow for detailed measurements of ecosystem exchange, fossil fuel burning processes, and emissions from carbon sequestration sites.

Here we report on recent advances using near-infrared direct absorption spectroscopy to measure CO_2, O_2, and H_2O on timescales of 0.1 to 1 second and at high precision, for eddy flux quantification of ecosystem exchange. O_2 is quantified using the A-band electronic absorption at 763 nm, yielding a 1 s precision of 6 ppm and 100 s precision of 1 ppm (30 and 5 per meg fractional precision, respectively). CO_2 and H_2O are quantified using overtone transitions at 2 micron, providing 1 s precisions of <0.02 ppm and <0.2 ppm, respectively. The monitor uses a compact multipass cell with a time response is <0.3 s at 3 SLPM flow rate. We present long-term O_2 and CO_2 rooftop measurements, revealing multiple combustion sources contributing to the local CO_2 enhancement.