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Measuring Atmospheric Carbon Dioxide from Space: Early Results from the NASA Orbiting Carbon Observatory-2 (OCO-2)

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Fossil fuel combustion, deforestation, and other human activities are now adding about 40 billion tons of carbon dioxide (CO_2) to the atmosphere each year, enough to increase the CO_2 concentration by 1% per year. Interesting, ground based measurements show that, on decadal time scales, less than half of this CO_2 remains in the atmosphere. The rest is apparently being absorbed by natural *sinks* in the land biosphere and ocean, whose location and identity are poorly understood. The ground based greenhouse gas monitoring network has grown steadily over the past 50 years and now has the capability to accurately track the rapid buildup of CO_2. However, this network still does not have the resolution or coverage needed to identify or quantify CO_2 emission sources or natural sinks on regional scales.

One way to improve the resolution and coverage is to collect high resolution global measurements of the column-averaged CO_2 dry air mole fraction (X_{CO2}) from space. The Japanese Greenhouse gases Observing Satellite (GOSAT, nicknamed *Ibuki*) has been collecting these measurements since 2009. Last summer, GOSAT was joined by NASA's Orbiting Carbon Observatory-2 (OCO-2), which was successfully launched from Vandenberg Air Force Base in California on 2 July 2014. After completing a series of spacecraft check-out activities and orbit raising maneuvers, OCO-2 joined the 705 km Afternoon Constellation (also known as the A-Train) on August 6, 2014. Its 3-channel imaging grating spectrometer was then cooled to its operating temperatures and a series of calibration and validation activities was initiated. This instrument's rapid sampling, small (<3 km^2) sounding footprint, and high sensitivity, combined with the observing strategy, are expected to provide improved coverage of the ocean, partially cloudy regions, and high latitude continents than earlier missions.

In early October, OCO-2 started routinely collecting almost one million soundings over the sunlit hemisphere each day. As expected, over 10% of these soundings (100,000/day) are sufficiently cloud free to yield full column estimates of X_{CO2}. For routine science operations, the instrument's bore sight is pointed to the local nadir or at the *glint spot*, where sunlight is specularly reflected from the Earth's surface. Nadir observations provide the best spatial resolution and yield more cloud-free X_{CO2} soundings over land. Glint observations have much more signal over dark, ocean surfaces, yielding much more complete coverage of the globe. The initial observation sequence alternates between glint and nadir observations on consecutive 16-day ground-track repeat cycles, so that the entire sunlit hemisphere is sampled in both modes at 32-day intervals. OCO-2 can also target selected surface calibration and validation sites to collect thousands of soundings as the spacecraft flies overhead. The primary surface targets include well calibrated surface sites, such as Railroad Valley, Nevada, and Total Carbon Column Observing Network (TCCON) stations, which make precise measurements of CO_2 and other trace gases from the ground. Both OCO-2 and GOSAT use these sites as critical elements of their calibration and validation programs. Observations of these sites are now being used to cross calibrate the GOSAT and OCO-2 instruments and to cross validate their products, so that they can be combined in CO_2 flux inversion experiments. The OCO-2 team started delivering calibrated, geo-located, spectra to the NASA Goddard Earth Sciences Data and Information Services Center (GES-DISC) on 30 December, 2014. They will start delivering estimates of X_{CO2} and other products derived from these spectra before March 30, 2015. This presentation will describe these early products and near-term plans for a continuing close collaboration with the GOSAT team.

Keywords: Orbiting Carbon Observatory-2, OCO-2, Carbon Dioxide, CO2, Remote Sensing