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Near-Simultaneous Measurement of Ground Level Carbon Dioxide and Methane Concentrations with an Open-Path Tunable Diode Laser Sensor at the Bonanza Creek Long Term Ecological Research site near Fairbanks, Alaska

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Beyond anthropogenic carbon emissions, the increase in atmospheric carbon from natural feedbacks such as thawing permafrost poses a risk to the global climate as global temperatures continue to increase. Permafrost is formally defined as soil that is continuously frozen for 24 consecutive months. These soils comprise nearly twenty-five percent of the Earth's terrestrial surface and possess twice the amount of carbon currently in the atmosphere. Continuous collection of carbon dioxide (CO_2) and methane (CH_4) concentrations is imperative in understanding seasonal and inter-annual variability of carbon feedbacks above thawing permafrost. A multi-year collaborative effort with the University of Alaska – Fairbanks, NASA Goddard Space Flight Center, and our group at George Washington University was undertaken to monitor these feedbacks near Fairbanks, Alaska.

In June 2017, we deployed two open-path tunable diode laser sensors at the Bonanza Long Term Ecological Research Site for measurement of CO_2 and CH_4 concentrations. The open-path instrument (OPI) is an inexpensive, low-power sensor that collects spatially-integrated measurements of target molecules approximately 1.5 meters above ground level. With a total power burden of 18 W, the sensors ran exclusively on solar power for 15 days in a young thermokarst bog and 3.5 days at a rich fen site. Here we report on initial retrieval of diurnal cycles from each field site and compare our spatially-integrated measurements of $CO_2$and CH_4. For CO_2, the magnitude of the diurnal cycles show a strong dependence on daily weather at both field sites. These laser measurements are complemented by point measurements of CO_2, temperature, pressure, and humidity made along the laser's optical path by non-dispersive infrared (NDIR) sensors.

Instrument up-time during field campaigns was limited by ground-surface instability resulting in misalignment and loss of laser-return signal. To mitigate against this performance degradation, we also present an auto-alignment scheme for the OPI. By implementing a simplex optimization approach via a custom Python script, the instrument can adjust the alt-azi position of the laser *launch box* in order to maximize return signal without human intervention. We have demonstrated this alignment protocol over short and long pathlengths and found that the utility of auto-alignment is limited by the pointing accuracy of our motorized mount.