Towards Fieldable Dual-Comb Spectroscopy For Greenhouse Gas Monitoring in Outdoor Air

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Dual Frequency-Comb Spectroscopy (DCS) is a technique akin to Fourier Transform Spectroscopy but offers faster acquisition times and simultaneous sampling over a broad band of wavelengths with negligible instrumental linewidth contribution. The coherent output of the comb permits the technique to be used for point-sensing applications with cavity enhancement to provide high sensitivity, or over open-air paths to provide column-averaged measurements over long distances. In a recent demonstration of DCS, two mutually coherent optical frequency combs centered at 1.6 μm with slightly differing repetition rates were transmitted through outdoor air over a 2 km open path[1]. CO_2 concentrations were retrieved with a precision of <1 ppm and an accuracy of ~7 ppm, whilst CH_4 concentrations were measured to <3 ppb precision with comparable absolute accuracy. In this talk, we will discuss our efforts to develop a fieldable DCS system, without compromising the performance demonstrated from the laboratory system. This will enable a range of high-precision, low-systematic error atmospheric carbon measurements. The main challenges towards a robust and fieldable dual-comb spectrometer are to reduce the overall system size, reduce its sensitivity to environmental perturbations, maintain mutual coherence between the two combs in the field (for coherent signal averaging), and maintain the absolute frequency calibration of the system (for low systematics). The planned fieldable system will cover CO_2 bands at 1.6 μm and 2.1 μm coinciding with the OCO-2 and ASCENDS missions. In addition, this broadband source will also cover H_2O, CH_4 in the 1.65μm band. We will present the current prototype dual-comb spectrometer, which has been significantly reconfigured from the laboratory design to support field operation.

References
[1] G. Rieker, et. al., Frequency-comb-based remote sensing of greenhouse gases over kilometer air paths, Optica 1, 290-298 (2014).