# DYNAMIC REGIONAL AND CITY SCALE SENSING OF GHG'S USING A DUAL-COMB SPECTROMETER

ELEANOR WAXMAN, KEVIN C COSSEL, FABRIZIO GIORGETTA, GAR-WING TRUONG[a], MICHEAL CERMAK, WILLIAM C SWANN, *Applied Physics Division, NIST, Boulder, CO, USA*; DANIEL HESSELIUS, *College of Engineering, University of Colorado Boulder, Boulder, CO, USA*; GREGORY B RIEKER, *Department of Mechanical Engineering, University of Colorado Boulder, Boulder, CO, USA*; NATHAN R. NEWBURY, IAN CODDINGTON, *Applied Physics Division, NIST, Boulder, CO, USA*.

The output of a laser frequency comb is composed of 100,000+ perfectly spaced, discrete wavelength elements or comb teeth, which act as a massively parallel set of single frequency (CW) lasers with highly stable, well-known frequencies. In dual-comb spectroscopy (DCS), two such frequency combs are interfered on a single detector yielding absorption information for each individual comb tooth. This approach combines the strengths of both CW laser spectroscopy and broadband spectroscopy providing high spectral resolution and broad optical bandwidths, all with a single-mode, high-brightness laser beam and a simple, single photodetector, detection scheme. Inter comparisons of DCS instruments in the 1.55-1.7um region have shown that atmoshpheric CO2 and CH4 concentrations can be retrieved with precisions of 0.14% and 0.35% respectively making this an attractive source for quantifying greenhouse gas emissions[b]. Here we show that DCS can be employed for dynamic regional monitoring using an unmanned aerial systems (UAS) to identify and quantify methane leaks[c]. Additionally, we will show that much larger scale (multi-kilometer) fixed path measurements can be used for continuous monitoring of city scale CO2 emissions. A preliminary demonstration of this technique in Boulder Colorado shows reasonable agreement with the city's own bottom up emission projections.

---

[a] currently at Crystalline Mirror Solutions

[b] E. M. Waxman, et al. "Intercomparison of open-path trace gas measurements with two dual-frequency-comb spectrometers." Atmos Meas Tech 1,3295–3311 (2017)

[c] K. C. Cossel, et al. "Open-path dual-comb spectroscopy to airborne retroreflector." Optica 4, 724–728 (2017)