6.058 Open-Path Laser Based Sensors for Measurements of Ammonia in the Atmosphere.

Early Career Scientist

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Abstract:

Ammonia is the third most abundant nitrogen containing species in the atmosphere. Its reaction with sulfuric acid (H_2SO_4) forms ammonium sulfate $(NH_4)_2SO_4$ or ammonium bisulfate $(NH_4)HSO_4$ aerosols, two important types of particulate matter ($PM_{2.5}$) which can have harmful effects on human health and the environment. Measurements of atmospheric ammonia are challenging because it is a trace species present with widely varying concentration, and because it is a sticky gas, such that there are significant inlet challenges for sampling techniques that involve direct contact between the sample gas and inlet or flow cell materials. An open-path absorption spectrometer can eliminate sampling issues since the ambient air flows freely across the probe laser beam. Removing the inlet can also be enabling for compact and low power designs, for example for use on unmanned aerial systems (UAS). This contribution presents research on two open-path ammonia laser sensors both of which target the strongest absorption features of ammonia in the 9-10 µm region using mid-infrared quantum cascade lasers (QCLs). First, we detail an open-path cavity ring-down spectroscopy (CRDS) instrument. This sensor shows a detection limit of 0.8 ppb (in 2 seconds) and good agreement with a commercial closed-path CRDS sensor in a side-by-side comparison at a feedlot. Second, we detail a follow-on instrument based on wavelength modulation spectroscopy (WMS) which seeks to achieve smaller mass and power. A multi-pass cell (30 cm base path with 20 m path length) is used to enhance sensitivity. All electronics are miniaturized such that the whole sensor size is compact (~3 kg) for UAS deployment. The contribution will discuss upcoming UAS measurements with the WMS sensor along with a CRDS methane sensor for agricultural emissions. Methane will be used as a conservative tracer and spatial variations in the ammonia-methane ratios will be used to study bi-directional ammonia fluxes.