UAV N_2O Sensor for Agricultural Flux Measurements

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A quantum cascade, laser-based sensor for atmospheric nitrous oxide (N_2O) was developed for an unmanned aerial vehicle (UAV). Because atmospheric nitrous oxide is a long-lived greenhouse gas, its atmospheric concentrations show relatively little variation (~ 1 ppbv) on top of a large background of ~ 335 ppbv. Therefore, for relevant measurements in a field environment, any N_2O sensor must have high precision and stability throughout the duration of any flight. The drone-based sensor uses a quantum cascade laser at a wavelength 4.54 µm that minimizes temperature corrections (<1% per 1 K) arising from density (ideal gas law) and spectroscopic (linestrength) effects, factors that also are relevant to achieve high-precision and accuracy measurements. The laser is coupled to an open-path Herriott optical cell consisting of 2.54 cm radius mirrors separated by 50 cm (22.4 m optical pathlength). Custom microprocessor, data acquisition, laser control, and detector control boards are housed in a 2.5 x 3.5 x 8 cm enclosure. Power consumption of the sensor is 15 W, and the total mass is 1600 g. The sensor demonstrates detection of 0.3 ppb N_2O at 1 Hz against a calibrated standard of N_2O near atmospheric concentrations, and stability less than this amount for a typical drone flight of ~ 20 minutes. Preliminary flight tests have been conducted locally, and ongoing research efforts include measurements near dairy farms, croplands, and wastewater treatment plants, which are the largest anthropogenic sectors of emission for this rapidly-rising, yet poorly-constrained, greenhouse gas.