An open-path QCL-based instrument with sub-ppbv sensitivity for NH₃ eddy covariance measurement

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Ammonia (NH₃) emissions from farmlands and livestock are attracting more and more attention. There is an urgent need for ground-based instruments that can acquire the spatial and temporal variability in NH₃ concentrations and emissions, particularly in field environments where power and shelter are not readily available. However, accurate measurements of atmospheric NH₃ is of great challenges due to its reactive nature. Conventional NH₃ instruments are subject to drawbacks, such as slow response time, limited precision, intensive maintenance, or high power consumption due to the use of the closed-path tube, optics, and vacuum pump.

We have developed an open-path instrument for fast (10 Hz) and sub-ppbv sensitivity measurements of atmospheric NH₃ concentration. The instrument is based on second-harmonic (2f) wavelength modulated laser absorption spectroscopy technique (WM-LAS), which employs a distributed-feedback semiconductor quantum cascade laser (DFB-QCL) and a HgCdTe (MCT) photodetector. An open-path Herriott cell configuration with a 0.5 m physical path and 46 m optical path-length is used for selective and sensitive detection of the mid-infrared absorption transition of NH₃ at 9.06 μm [1]. There is no delay due to sample adsorption. The instrument has a precision (1σ noise level) of 0.53 ppbv and 0.15 ppbv at a sampling frequency of 10 Hz and 1 Hz, respectively. The entire NH₃ instrument has a weight of ~7 kg and dimensions of 84 cm (length) and 20 cm (diameter). It can be powered by rechargeable lithium batteries, with a total power consumption of as low as 50 W. The instrument has strong environmental adaptability and is suitable for field deployment in various environments. It can be used in ground-based or vehicle-based measurements of atmospheric NH₃ concentration.

With the good performance in terms of response time and precision, this instrument is an ideal tool for NH₃ flux measurements based on the eddy covariance (EC) technique [2]. An EC flux system was built based on the open-path ammonia instrument, which also included a CSAT3 sonic anemometer (Campbell Scientific®) and LI-7500 (LICOR®) for water vapor (H₂O) and carbon dioxide (CO₂) measurements. The system was installed at a rice paddy field with a typical Chinese-style rice-duck symbiosis system in Jiangsu province, China. Experiments showed that the lower
detection limit of the EC system for NH$_3$ flux was around 17ng m$^{-2}$ s$^{-1}$.
References:
