An open-path quantum cascade laser based ammonia analyzer for eddy covariance flux measurement

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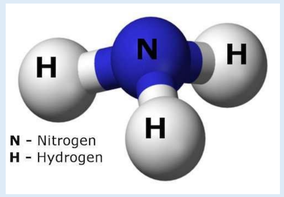
HT-8700E deployed in the field powered with solar cells

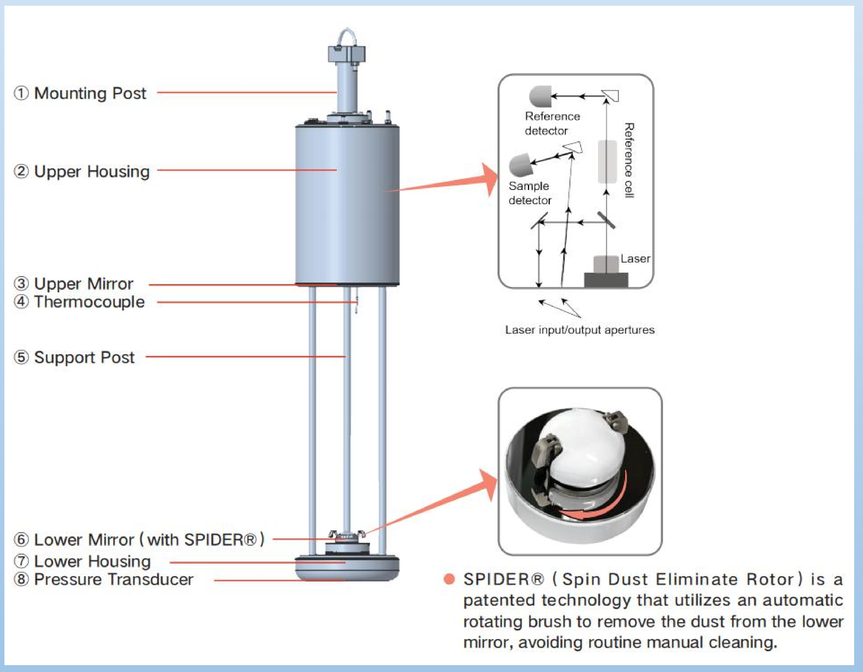
Introduction



- **Ammonia (NH_3)**
  - Fertilization and livestock are the main anthropogenic sources
  - Concentration in the atmosphere varies widely
  - Strong adsorption and viscosity
- Conventional analyzers suffer from 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 NH_3 analyzer (model HT-8700E) which has **high sensitivity, fast response, and low power consumption**. It is an ideal tool for NH_3 flux measurements based on the eddy covariance (EC) technique.

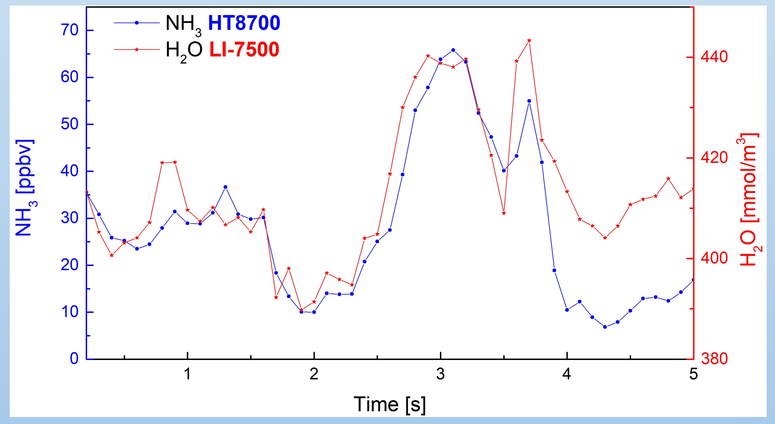
Quantum Cascade Laser Absorption Spectroscopy (QCLAS)

- Strong mid-infrared absorber --> ultra-high (sub-ppbv) sensitivity
- Distinct absorption lines --> high selectivity
- No consumables and auto cleaning --> unattended continuous monitoring
- Open-path --> fast response (10Hz) and no high frequency loss
- No sampling pump and pretreatment --> low power (50W) and small footprint (~10 kg, 84 * Φ20 cm)



Field Deployment of an NH_3 EC Flux System

- Location: A fallow paddy field at Ningbo, China
- Time: 2020.5.9 - 2020.5.15
- Eddy covariance system
  ① HT-8700E open-path NH_3 analyzer
  ② Campbell Scientific® CSAT3B+CR6
  ③ LICOR® LI-7500
- Synchronous monitoring with the LI-7500 verifies the response speed of the HT-8700E NH_3 analyzer



References
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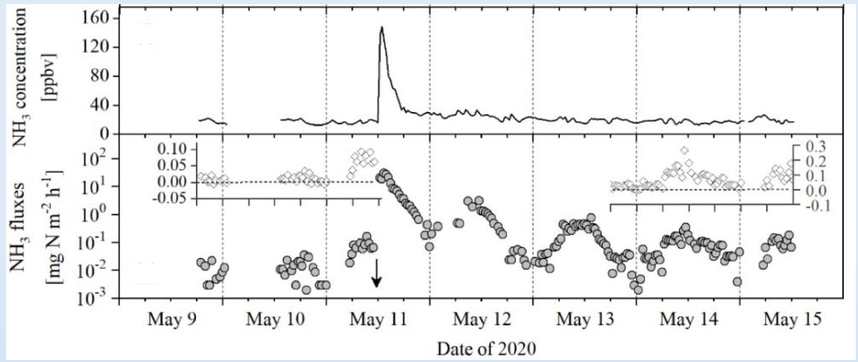
Field Experiment Result

- Continuous measurement without failure from 18:30 May 9 to 13:00 May 15.
- Ammonium bicarbonate fertilizer was applied on May 11, and the largest peak was observed directly following fertilizer application.
- Significantly enhanced NH_3 fluxes were observed following the fertilizer application. A typical flux diurnal variation pattern was also measured. The diurnal peak usually appeared at noon, agreed with the peaks of air temperature.
- On May 15, the diurnal maximum flux was reduced by nearly two orders of magnitude as compared to that of the fertilization day.



Conclusions

- We introduce a portable, low-power, and quantum cascade laser-based open-path NH_3 analyzer suitable for EC measurement of NH_3 fluxes particularly at sites without grid power.
- Its performance was investigated through laboratory experiments and one-week EC measurements at a subtropical rice paddy.
- The instrumental noise was estimated to be 0.286 nmol mol^{-1} (ppbv) at a sampling rate of 10 Hz, and the flux detection limit of the EC system (Fdet) was 6.7 μg N m^{-2} h^{-1} for half-hourly NH_3 flux measurement.
- During the entire EC measurement period, nearly 90% of the half-hourly fluxes were larger than the Fdet, while the remaining almost fell in the range of ± Fdet.

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