Fluxes of N_2O at an Intensively Grazed Dairy Farm in New Zealand

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New Zealand's greenhouse gas (GHG) inventory is dominated by methane and nitrous oxide which together account for ~54% of emissions, reflecting the important economic role of pastoral agriculture supporting dairying and meat production. To date, most research on agricultural N_2O emissions has been based on chamber methods. Our goal was to establish a long-term measurement capability using the eddy covariance method that can be used to determine annual N_2O emissions and their environmental and management controls, necessary for advances in GHG mitigation and inventory.

In November 2016, we established an eddy covariance system on a dairy farm with year-round dairy herd grazing that incorporates an Aerodyne quantum cascade laser configured for 10 Hz N_2O, CH_4 and H_2O concentration measurements. The key development criteria for this new EC system were: small system size; ultra-stable controlled temperature environment for the QCL; low maintenance and high reliability; and sensitivity suited to the full range of N_2O fluxes (F_{N2O}). We constructed a weatherproof and insulated instrument system enclosure with a 0.9 m × 1.2 m footprint, with additional 0.7 m × 0.7 m vacuum pumphouse, both of which are powered by mains power (240 VAC). The QCL enclosure maintains a stable setpoint temperature (30±0.2°C) by using a novel system of underground cooling pipes, fans and recirculating instrument heat, without artificial air conditioning. QCL (true 10 Hz digital) and CSAT3B sonic anemometer high frequency data are aligned using Network Time Protocol and EddyPro covariance maximisation during flux processing.

Initial results indicate relatively stable summertime baseline F_{N2O} around 0.5–1.0 nmol N_2O m^{-2} s^{-1}. Rain events typically cause short-lived (1–3 days) F_{N2O} pulses reaching peaks of 6–8 nmol N_2O m^{-2} s^{-1}. N_2O flux magnitudes were best explained using a log-log relationship of soil water filled pore space ($R^2 = 0.44$). During times of elevated N_2O emissions following rain, F_{N2O} displayed a significant diurnal signal, with peak fluxes mid-afternoon which was best explained by variation in shallow soil temperature. While F_{N2O} responded strongly to environmental factors, CH_4 fluxes were close to zero, except for when cows were grazing up-wind. The Aerodyne QCL spectral line includes a small peak for H_2O primarily for broadening correction of N_2O and CH_4. However, we achieved excellent agreement between latent heat fluxes

calculated from the Aerodyne data and a co-located LI-7200/CSAT3 EC system, giving additional confidence in the system.