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Diurnal variation in soil nitrous oxide emissions (DIVINE): drivers and mechanisms

James Benjamin Keane[1], Niall P. McNamara[2], Jeanette Whitaker[2], James Moir[3], Pete E. Levy[4], Sam Robinson[2], Stella Linnekogel[2], Hanna Walker[3], Kate Storer[5], Pete Berry[5], Sylvia Toet[1], and Sarah Lee
[1]Department of Environment and Geography, University of York, Wentworth Way, YO10 5NG, UK
[2]UK Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster, LA1 4AP, UK
[3]Department of Biology, University of York, Wentworth Way, YO10 4DD. UK
[4]UK Centre for Ecology & Hydrology, Bush Estate, Penicuik, Midlothian, EH26 0QB, UK
[5]ADAS, High Mowthorpe, Duggleby, Malton, North Yorkshire YO17 8BP, UK

Nitrous oxide (N_2O) is a potent greenhouse gas (GHG) with a global warming potential 298 times that of carbon dioxide (CO_2). Measurements of soil N_2O emissions typically use manual chambers, with samples taken at low temporal resolution over long durations (months), or at higher temporal resolution (multiple samples per day) over short durations. Automated GHG flux systems have allowed the measurement of high frequency (sub-daily) N_2O fluxes over longer periods (weeks to months), revealing that emissions can vary diurnally by up to 400% in agricultural soils.

Contributing approximately 70% of global anthropogenic N_2O emissions, agriculture represents the largest area of uncertainty for GHG reporting and the most challenging sector for emissions reduction: global N_2O emissions are increasing at double the rate estimated by the Intergovernmental Panel on Climate Change (IPCC). Improvements to agricultural GHG emission estimates have increased the accuracy of GHG reporting, but N_2O emissions from agricultural soils still contribute 25% of the uncertainty of total GHG emissions across all sectors. Our project, diurnal variation in soil nitrous oxide emissions (DIVINE), combines field and laboratory experiments that exploit high-resolution, robotic and continuous N_2O measurement technology, to investigate the drivers and mechanisms underpinning diurnal variation in N_2O.

We will present work from a field study investigating the effect of soil properties and nitrogen (N) fertiliser management on diurnal variation in N_2O emissions from a wheat crop. We assess how N fertiliser application (rate and frequency) and soil gas diffusivity (determined by bulk density and rain events), affect the depth of N_2O production and N_2O transport in the soil, and resultant impacts on the peak timing and amplitude of diurnal N_2O emissions across the crop life cycle and seasons.

N_2O emissions will be compared in paired transects with contrasting bulk density but similar soil texture and history, with three ammonium nitrate fertiliser scenarios. N_2O is being measured continuously using SkyLine2D automated flux chamber technology. To resolve depth/gas transfer coefficients after N fertiliser and rain events, we will measure soil N_2O concentration profiles

across the rooting zone in discrete campaigns during the crop life cycle.

Further, we will discuss how our data will be used to improve the accuracy of N_2O emission factors by accounting for environmental and diurnal variation. Bayesian statistical modelling will be used to represent the spatial and temporal distribution of emissions following fertilisation, and the effects of known environmental factors (e.g. temperature, soil moisture, light intensity), as well as the residual effect explicable by the diurnal cycle.