Greenhouse Gas Sources Polar Regions

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<u>Is this a CASE studentship?</u> NO – However CEH may contribute to T&S for visits.

Introduction:

Nitrous oxide (N2O) is a natural greenhouse gas (GHG) more potent than CO2 and CH4. Increases of N2O in the atmosphere since the beginning of the industrial revolution, over 20%, has contributed significantly to climate change (IPCC, 2007) and may affect many natural ecosystems particularly in polar regions. N2O has a significant atmospheric lifetime (>100 years) and a global warming potential (GWP) 300 times that of CO2 contributing 6% of the global total radiative forcing from long-lived greenhouse gases. Whilst the seasonal cycle of N2O in polar-regions has been well documented and attributed to seasonal cycles in surface N2O sources, actual fluxes of N2O, particularly from natural sources, are difficult to measure, particularly in climate sensitive remote polar regions. As such there are still large gaps in our knowledge of the actual N2O sources and how these might respond to climate warming in these regions. As such sources and sinks of N2O are poorly quantified in climate models. For example it has been suggested recently that emissions from supersaturated brines in arctic sea-ice may be an important atmospheric seasonal source of N2O. Another concern is the potential for enhanced releases of N2O in polar regions due to melting permafrost in tundra regions as well as changing snow and ice covered surfaces. N2O, is a by-product of nitrification, and studies show that N2O production can occur in ice surfaces. Recent observations also support the existence of significant nitrification in Antarctic sea ice also supplying up to 70% of nitrate assimilated within Antarctic spring sea ice. The conclusions from these studies is that a better understanding of N2O sources is needed for polar regions so that the impacts of warming on release rates can be better predicted.

In this project the student will investigate surface-atmosphere fluxes of N2O over key surfaces using direct flux measurement techniques (Neftel, A., et al. 2007, Famulari et al. 2010) incorporating a high precision quantum cascade laser absorption spectrometer. The student will initially receive training and test and characterise the flux system both at an urban site (Manchester) and at an rural agricultural site (in Scotland with partners at CEH, Edinburgh, Dr. Ute Skiba) to investigate agricultural and farm emissions before deploying it to tundra and wetland sites in northern Scotland and Scandinavia to assess seasonal changes in N2O emissions as a function of the surface freeze-thaw cycle. Additional fluxes of CH4 and methane isotope concentrations (using a new ICL real-time isotope analyser) will also be measured for comparison. Pending funding there may also be opportunity to take part in a field experiments on research ships to either the Arctic or Antarctic to determine N2O emissions over sea-ice which are current areas of interest.

Image 1 – Arctic research station (photo courtesy CEH).

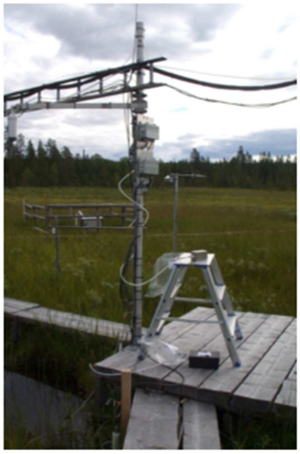

Image 2 - Measurements of greenhouse gas emissions and isotopes over artic wetlands using eddy covariance and chamber systems

References

Famulari, D., et al. (2010). Eddy-covariance measurements of nitrous oxide fluxes above a city, Agricultural and Forest Meteorology, Volume 150, Issue 6, 2010, Pages 786-793, ISSN 0168-1923, http://dx.doi.org/10.1016/j.agrformet.2009.08.003.

Neftel , A., et al (2007), Experimental assessment of N2O background fluxes in grassland systems. Tellus B, 59: 470–482. doi:10.1111/j.1600-0889.2007.00273.x

O'Shea S.J.; Allen G.; Gallagher M.W.; Bower K.; Illingworth S.M.; Muller J.B.A.; Jones B.T.; Percival C.J.; Bauguitte S.J.-B.; Cain M.; Warwick N.; Quiquet A.; Skiba U.; Drewer J.; Dinsmore K.; Nisbet E.G.; Lowry D.; Fisher R.E.; France J.L.; Aurela M.; Lohila A.; Hayman G.; George C.; Clark D.B.; Manning A.J.; Friend A.D.; Pyle J.; , 2014, Methane and carbon dioxide fluxes and their regional scalability for the European Arctic wetlands during the MAMM project in summer 2012. , 14, 13159-13174.

Fowler, David; Coyle, Mhairi; Skiba, Ute; Sutton, Mark A.; Cape, J. Neil; Reis, Stefan; Sheppard, Lucy J.; Jenkins, Alan; Grizzetti, Bruna; Galloway, James N.; Vitousek, Peter; Leach, Allison; Bouwman, Alexander F.; Butterbach-Bahl, Klaus; Dentener, Frank; Stevenson, David; Amann, Marcus; Voss, Maren, 2013, The global nitrogen cycle in the twenty-first century. Philosophical Transactions of the Royal Society (B), 368