1. How climate change may affect the composition of Dissolved And Volatile Organic Carbon Compounds generated by Arctic Peatlands: the DAVOCCAP project.

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Sites: Mukhrino Field Station (MFS) and (if available) Nymto Park Station (NPS).
Duration: 45 man days during Summer 2013, 1 visit.
Call: TA call for summer 2013 and winter 2013/2014, 31st October 2012 call deadline.

2. Background

Peatlands cover approximately 3% of the Earth's land surface and around 15% of that in the northern high latitudes [1], where low temperatures, high soil moisture and low fire frequency have led to the sequestration of globally significant stores of soil organic carbon (SOC) since the onset of the Holocene. In peatlands, carbon accumulates as a result of the imbalance between the uptake of atmospheric CO_2 through net primary production (NPP) and the lesser cumulative loss as CO_2 and CH_4 to the atmosphere and as dissolved organic carbon (DOC), which are driven by decomposition by microorganisms, combustion due to wildfires, and emissions and degradation of biogenic volatile organic compounds (BVOC) by living organisms. However, the prevailing conditions allowing this imbalance are currently changing (with climate change), and this is expected to continue in northern high latitudes [2] where small climatic changes could trigger disproportionally large consequences. For instance, in peatlands, climate driven alterations to permafrost layers caused by higher temperature and/or linked changes in dominant vegetation communities are anticipated to generate positive feedback loops [3] that could then have a profound impact on the fate of SOC [4]. This could in turn push existing peatlands beyond their envelope of self-regulation and compromise their global net cooling role by shifting them from a sink to a significant source of atmospheric carbon [5]. Thus, it is critical to assess how climate change will affect carbon biogeochemical processes in peatlands, as the weakening of terrestrial sinks has important implications for international climate policy that aims to manage the global carbon cycle [6].

So far, a number of studies in the subarctic and arctic regions have focussed on the impact of climate change on atmospheric losses of CO_2 and CH_4 from high-latitude peatlands; nevertheless, impacts on DOC and BVOC (other than methane) production and export are still poorly understood. DOC concentration, quality and exports are controlled by various mechanisms which integrate hydrological, physical and biological processes that interact in a complex way; a lack of consensus rather than a lack of research impedes us from appreciating the role of DOC in the carbon budget of peatlands under a changing climate [7]. On the other hand, non-methane BVOCs – the "*organic atmospheric trace gases other than CO_2 and CO*" [8] – are largely understudied. However, once in the atmosphere, these influence the global oxidizing capacity of the atmosphere [9], and generate secondary organic aerosols (SOAs) which cause negative radiative forcing on the climate [10]. Recent studies show that BVOCs also display a complex response to changes in hydrology, vegetation, and temperature in various high latitude ecosystems [11, 12]. We therefore propose a simple research project that aims to begin to disentangle the effect of vegetation type and prevailing temperature on DOC and BVOC emissions and chemistry in peatlands, as we believe this is an important step towards a better understanding of the consequences of climate change on the global carbon cycle.

The proposed project leader (Dr. Roxane Andersen) is currently involved in two large multi-disciplinary peatland-related projects, with sites in Northern Alberta (56°43'N) and another in Northern Scotland (58°36'N) where she is evaluating microbial communities and carbon biogeochemical processes in pristine, restored and disturbed peatland systems. The research leader is also collaborating with partners from the University of Eastern Finland on a research project that will study the impact of spruce-swamp forest rewetting on BVOC emissions and microbial dynamics. Through her graduate studies, post-doc fellowship and career debut, she has accumulated 10 years of field work experience in peatlands in remote areas. Her work in Northern Scotland is supported (in part) by a DOC/BVOC based PhD project being undertaken by Paul Gaffney (group member on this proposal) which is also co-supervised by Dr Mark Taggart (also a group member on this proposal). Dr Taggart is an environmental biogeochemist with extensive appropriate experience in the use of advanced analytical techniques (such as Gas Chromatography-Mass Spectrometry; GC-MS) which will be employed during the post-sampling phase of this project for BVOC characterisation. Therefore, the researchers have complementary skills, and the equipment, capacity and expertise are fully in place to enable the diligent completion of this small project. Furthermore, the data generated by the proposed research in Russia will complement data taken in the aforementioned Scottish and Canadian sites in similar peatland ecosystems out-with the InterAct network (at a similar time) and thus increase potential scientific impact by adding a biogeographical component. Finally, our aim would also be to consider a future application for a second InterAct (or comparable) call in 2013, to undertake a parallel study at higher latitudes in Alaska in 2014. This would allow us to collate complementary data from peatlands in at least four distinct biogeographic zones ranging in latitudes from ~56°N (in Canada), ~58°N (in Scotland), ~60 to 63°N in Russia and ~68 to 71°N in Alaska.

3. Objective

The objective of the proposed research is to determine the impact of contrasting vegetation types, prevailing temperature and latitude (as a proxy for climate change) on the quality, quantity and chemical composition of DOC and BVOC emissions in peatland ecosystems. More precisely, the research will be based on a nested replicated design in different locations, using site pairs of peatlands at different latitudes where plots dominated by different vegetation functional groups (mosses and shrubs) will be sampled. We will aim to compare 1) DOC quality and concentration and 2) BVOC composition and emissions within and between the vegetation types, latitudes and locations. Our hypotheses are that A) Climate exerts a greater control over DOC quantity/quality than vegetation type; B) the same is true for BVOC composition and emission; and C) the effect of regional climate and vegetation types will be greater than that of biogeography for DOC and BVOC compositions from peatlands.

We believe the proposed research fits extremely well with the current call as it has at its core an aim to improve our understanding of (and therefore our ability to predict and respond to) environmental change through the use of research undertaken in multiple Arctic/sub-Arctic biogeographic regions. Also, the proposed group has not previously used the infrastructure, is led by an early career scientist, and one of our key aims is to utilise data from multiple locations (InterAct and non-InterAct sites) to generate a comprehensive comparative study. The proposed Russian stations are ideal for this research as the stations act as a latitudinal transect (and therefore climate proxy) and Mukhrino (especially) provides a diverse and extensive peatland system. Given the current research undertaken at this station, the project provides an excellent opportunity for synergy (i.e., the station currently undertakes research regarding "*measurements of greenhouse gas fluxes to and from the pristine peatland complex*" and "*is the base for analyses of climate change effects in peatland ecosystems and on carbon balance*").

4. Research methods and material, ethical issues, permits

Our methodology will be simple and employ both field measurements and post-field laboratory analysis of samples returned back to the UK. In the field, we will undertake a range of in-situ measurements using portable equipment, these will include:

a) UV/Vis spectrophotometer measurements for DOC quality/quantity on filtered open water and peat pore waters. In addition we will take linked measurements of pH, temperature, dissolved oxygen, and conductivity. A limited number of water samples will be brought back to the UK for direct DOC measurement to calibrate against our UV/Vis observations.
b) Novel activated charcoal BVOC passive sampling units will be deployed over the study period (provisionally for up to 14 days) which will collect BVOC samples for the duration. These will be returned to the UK and chemically desorbed before analysis by GC-MS.
c) In parallel, traditional chamber measurements for BVOCs (after [13]) will be undertaken at matched locations using automatic thermal desorption tubes (packed with TenaxTA/Carbo-pack B) and will be returned to the UK for GC-MS analysis.
d) At all sampling sites, we will record % cover of vegetation functional types in 1 m^2 quadrats (using Braun-Blanquet scale) and the water table depth.

We do not envisage any ethical considerations would be relevant as we will not be working with fauna/people. We have already liaised with, and will communicate well in advance with the station manager regarding the need for any local permits (beyond VISAs), but again, we do not envisage the need for import or export permits since we will not be exporting any biological samples from the site (beyond volatile compounds captured on samplers and a limited number of filtered water samples) or importing/exporting any dangerous goods. We will also liaise closely with the station manager prior to the field visits to ensure that the need to export equipment is minimised where possible (i.e., where items needed are already available on station or through the associated University), whilst ensuring all required items are shipped in good time for the field exercises. Risk assessments will be undertaken in full coordination and with the guidance of the station manager. In terms of alternative stations, our longer term plan would be to undertake parallel work at the Alaskan stations within the network (Barrow and Toolik) and these would be appropriate alternatives if the selected Russian stations were unavailable in 2013.

5. Implementation: timetable, budget, distribution of work, specific logistic needs

Provisional Timetable (Roxane Andersen (RA); Mark Taggart (MT); Paul Gaffney (PG)):

Up to June 2013	Prepare for trip; acquire consumables, trial/prepare/pack/ship equipment, obtain VISAs/permits, book travel, liaise closely with the Station Manager, (RA, MT, PG).		
Mid-late June 2013	*Undertake trip RA+MT+PG*	*45 man days, 15 per person*	*16th June to 30th June on station (provisional)*
On return – up to late December 2013	Undertake sample analysis for BVOCs (passive samplers) on GC-MS from trip (MT, PG). Data analysis and preparation of results for conference/publication submission (RA, MT, PG).		
Post December 2013	Attend conference to present results (RA, PG), publish findings (RA, PG, MT).		

Provisional Budget table (Summer 2013):

Flights x 3	**UK LONDON - Khanty-Mansiysk RTN**	**6000€**
VISAs x 3	**Russia Business**	**900€**
Car Hire x 1	**Khanty-Mansiysk – 15 days**	**700€**
Train x 3	**Thurso (UK Base) – UK LONDON RTN**	**900€**
Equip/sample freight	**UK - Khanty-Mansiysk RTN**	**1500€**
In transit accomm x 3	**UK - Khanty-Mansiysk RTN**	**900€**

Total costs: 10900€.
Travel: estimated 7600€ total for flights, train travel and vehicle hire.
Logistics: estimated 3300€ total for in-transit accommodation, VISAs and equipment/sample freight.

Logistical needs: we have budgeted for the provision of VISAs and will consult with the station manager regarding the requirement for any local permits. We have no plans to import large/valuable/new equipment and all imported equipment will return to the UK; we have no plans to export dangerous/hazardous goods or any biological samples. Again, we will consult with the station manager regarding local rules, but we do not believe import/export licenses will be required at this stage. We will also consult with the station manager over equipment provision, i.e., certain basic equipment may be available on station or at the associated University, which may reduce our need to ship equipment (i.e., UV/Vis spectrometer, filtering equipment, chambers, etc).

6. Expected results and possible risks

We expect that the proposed research will provide new data on BVOCs that will complement the limited number of studies that have looked at this component of the carbon budget in high latitude peatlands. The work will also contribute to existing knowledge regarding the impact of climate change on DOC. As little work has been done on BVOCs, and as we have integrated a novel field technique into our proposal, we believe this project has the potential to generate new hypotheses and questions which may then be addressed in future research. We expect the research to generate sufficient data for one or more (combined site) scientific publications that would fit within the scope of high IF journals such as Global Change Biology. The results will also be presented to scientific colleagues at one conference. Once published in peer-reviewed journals, our data will be made freely available and added to any appropriate databases held at the research stations visited. We believe that our research will add to the current knowledge base on peatlands and their potential response to climate change, and thus, results could contribute to the development of policies on the protection of these habitats in the subarctic and arctic zones. To minimise complications associated with the transport of (for example) soil samples or plant material to the UK, the research proposed is based on non-destructive field and sampling techniques that are robust and reliable, and these will be fully trialled in similar field conditions by the research team in the UK before the work is undertaken. Research in remote conditions obviously holds an element of risk (in terms of access to logistics/equipment, etc) but we believe these risks are mitigated by keeping our methodology simple and liaising with the station manager well in advance.

7. Key literature

[1] Rydin H, Jeglum J, 2006. The Biology of Peatlands, New York, Oxford Univ. Press **[2]** McGuire AD, Chapin FS, et al., 2007. Responses of high latitude ecosystems to global change: Potential consequences for the climate system. In:Terrestrial Ecosystems in a Changing World. Eds. Canadell JG, Pataki DE, Pitelka LF, p297-310. Berlin Heidelberg, Springer-Verlag **[3]** Heimann M, Reichstein M, 2008. Terrestrial ecosystem carbon dynamics and climate feedbacks. Nature 451, 289–292 **[4]** Grosse G, Harden J, et al., 2011. Vulnerability of high-latitude soil organic carbon in North America to disturbance. J. Geophys. Res. 116, G00K06 **[5]** Zhaosheng F, McGuire AD, et al., 2012. The response of soil organic carbon of a rich fen peatland in interior Alaska to projected climate change. IN PRESS. doi: 10.1111/gcb.12041 **[6]** Canadell JG, Ciais P, et al., 2011. An international effort to quantify regional carbon fluxes. Eos 92, 81-82 **[7]** Freeman C, Fenner N, et al., 2004. Export of Dissolved Organic Carbon from peatlands under elevated CO_2 levels. Nature 430, 195-198 **[8]** Kesselmeier J, Staudt M, 1999. Biogenic volatile organic compounds (VOC): an overview on emission, physiology and ecology. J. Atmos. Chem. 33, 23–88 **[9]** Crutzen PJ, Zimmermann PH,1991. The changing photochemistry of the troposphere. Tellus A 43, 136–151 **[10]** IPCC, 2007. Climate Change 2007: The scientific Basis. New York, Cambridge Univ. Press **[11]** Faubert P, Tiiva P, et al., 2012. The shift in plant species composition in a subarctic mountain birch forest floor due to climate change would modify the biogenic volatile organic compound emission profile. Plant Soil 352, 199–215 **[12]** Potosnak MJ, Baker BM, et al., 2012. Isoprene emissions from a tundra ecosystem. Biogeosciences Discussions 9, 13351–13396. **[13]** Faubert P, Tiiva P. et al., 2010. Non-methane biogenic volatile organic compound emissions from a subarctic peatland under enhanced UV-B radiation. Ecosystems 13, 860-873.