Exclusive Interview

ENHANCED NITROUS OXIDE EMISSIONS FOUND IN FIELD WARMING EXPERIMENT IN THE ARCTIC

As anthropogenic climate change continues seemingly unabated, research continues into the impact of our warming climate on a variety of habitats. IET Editor Rachael Simpson recently spoke to Carolina Voigt, lead author of the paper "Warming of subarctic tundra increases emissions of all three important greenhouse gases - carbon dioxide, methane and nitrous oxide", about her work monitoring greenhouse emissions on the Russian tundra, and the interesting results she has seen.

Rachael Simpson

1. So Carolina, could you give us a bit on your background – your qualifications, where your interest on this subject stems from for example.

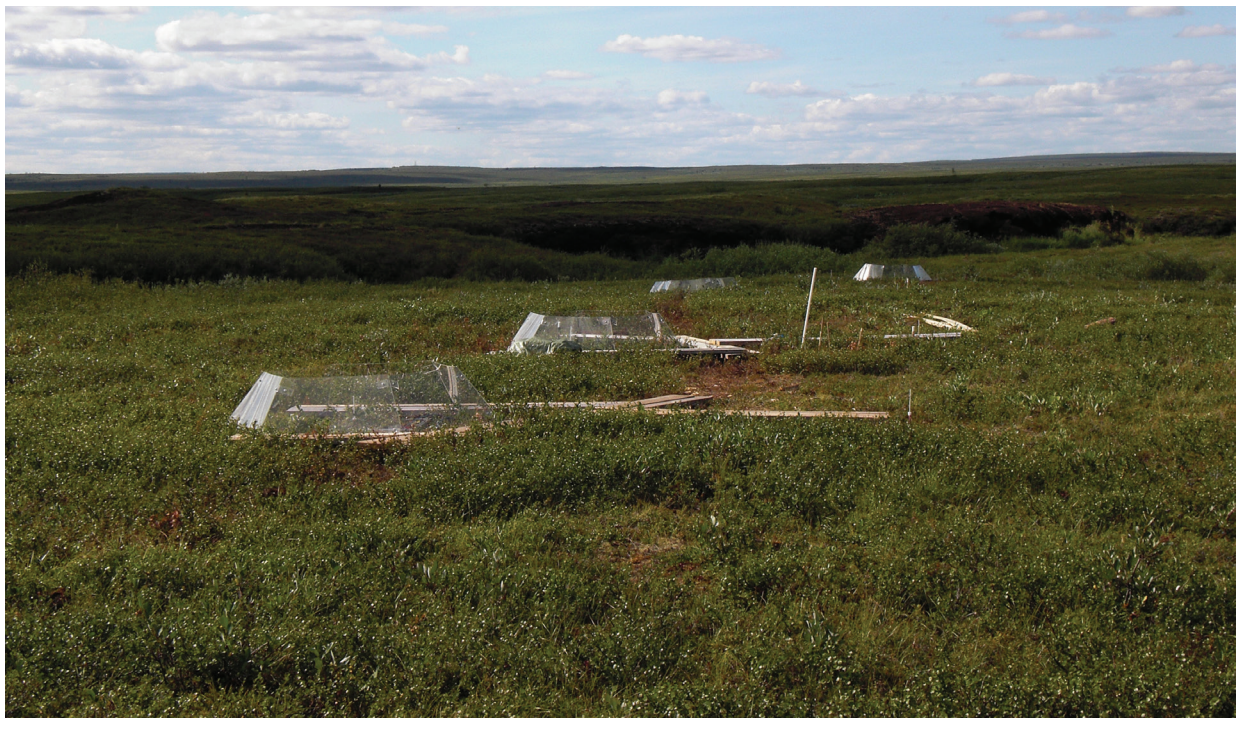
I am a PhD student and I'm writing my doctoral thesis at the moment at the University of Eastern Finland with the Biogeochemistry research group. I did my masters in Germany on a similar topic, studying greenhouse gas cycling from peatlands which is where I became interested in this topic. I then applied for a PhD position here in Finland, with the opportunity of studying greenhouse gas fluxes from permafrost soils in the Arctic. I've been here in Finland for the past 5 years.

2. You mention similar research you'd undertaken in Germany – was this study in the Arctic a follow-on from your previous work?

Fluxes of carbon dioxide, methane, and nitrous oxide from Arctic soils is generally a topic that interests me, and in particular the fieldwork connected to it. Taking measurements during Arctic field expeditions and living in remote conditions with an international research team for several months in a row – that's what interested me in the first place. And then of course in terms of the topic itself, there is huge potential for new findings and some very interesting subjects for a PhD thesis work in this field.

3. Can you give an explanation of the methods, research techniques and equipment used in this study?

What we are using is a quite basic method called the chamber method that is used to measure fluxes of greenhouse gases produced (or consumed) in the soil. We just place a chamber, any kind of chamber from simple to very sophisticated, on pre-installed collars in the soil and then leave the chamber in place for a certain period of time. Within this time frame there is an accumulation of gases within the chamber headspace and that is what we actually measure. From that concentration change in the chamber headspace we can calculate the flux of greenhouse gases that are emitted or taken up by the soil and vegetation.



Source: University of Eastern Finland

> ***"Taking measurements during Arctic field expeditions and living in remote conditions with an international research team for several months in a row – that's what interested me in the first place."***

We also have a warming experiment going on alongside, where we are measuring fluxes from control surfaces next to surfaces that are artificially warmed. We use Plexiglass chambers (so-called open-top chambers, OTCs) which are open on top so they don't limit air exchange much but are still warming the soil surface and the air close to it by a few degrees, which is what is predicted for the near future in climate change scenarios.

These are the core measurement methods that we are using. Of course, we are also using all kinds of surrounding supportive

Source: University of Eastern Finland

measurements, for example a weather station logging the meteorological conditions at the site. We are collecting water samples to determine the concentration of nutrients and carbon in the soil pore water, and we are also measuring soil temperature, moisture and other surrounding parameters that help us to put the flux data into context later on and help us to explain the patterns we are observing.

> *"to our knowledge this is the first study that has found this warming-induced increase in nitrous oxide emissions from Arctic tundra"*

4. Do you face any challenges whilst working in the Arctic conditions that make this research difficult?

In the field we are living without running water or electricity so the conditions are very basic. I have to say, I was worried when I was first going out there to be living under these conditions, but I was really surprised by how quickly one can adapt to living like that, even within just a couple of days. I can't say that I missed much other than certain kinds of food! Otherwise it was fairly easy to adapt.

You do have to be physically fit, the work involves lots of walking. The tundra landscape has no roads or paths so there is a lot of walking with quite heavy backpacks. Other than that I found living out there quite easy.

It's quite amazing to be living in nature with the feeling of freedom that you get from being so far away from everything. On top of that we were working in the North of Russia, which I think was an additional factor in the feeling of being in the wild, even feeling like an outlaw in a way!

5. What where the results of this study?

We have measured over two years, two summer growing seasons that we have been in the Arctic, mainly during July and August as this is the main growing period. We measured fluxes of carbon dioxide, methane and nitrous oxide.

What we saw was that warming of only a few degrees centigrade increased fluxes of all three greenhouse gases, not just carbon dioxide and methane but also nitrous oxide which was quite surprising - to our knowledge this is the first study that has found this warming-induced increase in nitrous oxide emissions from Arctic tundra.

6. You say this was surprising, so can we assume these results weren't completely what you were expecting?

It's surprising because nitrous oxide isn't measured much in tundra. It's quite a recent finding that Arctic soils might emit nitrous oxide – usually there are lots of monitoring stations in the Arctic that only focus on carbon dioxide and methane emissions, and nitrous oxide is generally not included in those measurements. Therefore there are only a few studies that have observed nitrous oxide emissions from tundra and now we showed that warming might increase those emissions. It was also surprising that just gentle surface warming increased the emissions of all three gases. For carbon dioxide and methane in particular, we observed increased concentrations of those gases even in the deeper soil profile, where the warming treatment did not reach.

> *"In terms of nitrous oxide, there is still a lack of knowledge about where throughout the Arctic nitrous oxide emissions occur, and under what particular current and future conditions."*

7. What do the results of this research mean for the way we try to study and limit climate change?

Even gentle warming, as is predicted for the short-term, can obviously promote emissions of all three greenhouse gases from tundra, including nitrous oxide. The response of vegetation to temperature played a large role in the changes in emissions that we observed. In terms of nitrous oxide, there is still a lack of knowledge about where throughout the Arctic nitrous oxide emissions occur, and under what particular current and future conditions. There are very few sites where nitrous oxide emissions have been measured. With this study we are hoping to encourage other research teams to include nitrous oxide fluxes in their greenhouse gas budgets. It's quite clear that arctic soils can be a source of nitrous oxide, but we need to identify those nitrous oxide emitting surfaces. In our study the main source of nitrous oxide were peatlands, uplifted permafrost peat soils, which store large amounts of nitrogen in the peat or in the organic soil layer. That is why, under favourable environmental conditions, these surfaces are sources of nitrous oxide.

It would be helpful to establish an extended network of measurement sites that measure nitrous oxide emissions from various surfaces in the Arctic, to generate further knowledge on Arctic nitrous oxide emissions.

8. As global temperatures continue to increase, is there anything that can be done in these arctic regions to mitigate the effect of GHG emissions?

I am not sure which human activities in the Arctic could mitigate GHG emissions. Temperatures in the Arctic are predicted to increase, and together with local moisture and vegetation changes, this will affect greenhouse gas exchange. It's comparably easy to predict changes in temperature, but to determine changes in soil moisture is connected to large uncertainties. Yet, soil moisture and local hydrological conditions play a huge role in regulating greenhouse gas exchange. Greenhouse gas exchange is also connected to vegetation. I would say that, besides temperature, moisture and vegetation are the key factors regulating future Arctic greenhouse gas emissions. Future research should focus on improving projections of moisture and vegetation changes.

> *"nitrous oxide emissions are an unknown in Arctic biogeochemical cycling, and require further investigation."*

9. What is next for this research/your department? Have you any plans for expanding upon this study?

We have studies going on alongside this one – we have, for example, conducted detailed process studies, and are investigating the microbial communities at the site and how they are affected by warming. This will provide a valuable insight into soil processes that govern the changes we have observed above ground. We are also conducting lab studies focussing not only on what happens when the soil column is warming, but also what happens when the permafrost is starting to thaw, and how that, in turn, is affecting greenhouse gas production, consumption, or release.

10. And why do you think that up till now no-one has looked at nitrous oxide? A lack of technology, too much focus on carbon dioxide?

It's not the technology as it's fairly easy to measure, and measurements could easily be integrated into studies from existing measurement sites. But nitrous oxide emissions from tundra were only first observed in 2009/2010. Not all surfaces emit nitrous oxide, so you do have to recognize the potential sources. The basis for nitrous oxide production in soils is a sufficient supply of mineral nitrogen. Often Arctic soils are nitrogen limited. Organic soils and peatlands, however, store large amounts of nitrogen.

11. It mentions in your recent press release that nitrous oxide emissions are not incorporated in Arctic biogeochemical climate models, so in terms of modelling I assume you feel it should be taken into account.

Yes, it should be, because in our studies we found a high potential of Arctic soils to emit nitrous oxide. Surely carbon dioxide and methane are the dominant greenhouse gases emitted in tundra, as nitrous oxide emissions might be small on a mass basis. But nitrous oxide is a strong greenhouse gas, about 300 times stronger than carbon dioxide on a 100-year time horizon, so even a small Arctic nitrous oxide source could be of importance. In any case, nitrous oxide emissions are an unknown in Arctic biogeochemical cycling, and require further investigation.

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Research article:
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