Climate Change in Siberia

What is happening and why should we care?

Thank you for visiting our slideshow, part of the *Siberia: At the Edge of the World* exhibition at the Manchester Museum. This information pack is designed to provide you with some more detailed information about climate change in Siberia, and the Arctic related research of the Organic Geochemistry research group at the University of Manchester and the Geosciences group at Newcastle University.

Here in Manchester and Newcastle we have been working with colleagues all around the world to try and understand what happens to the carbon trapped in Siberian permafrost as the climate changes. We now believe that rising temperatures will mean that carbon trapped deep in the permafrost for thousands of years will be washed out into the Arctic Ocean, where some of it will be released to the atmosphere as carbon dioxide (CO_2).

In this information pack we will introduce our NERC funded research project, our group members and collaborators and some of the academic papers that we have published looking at Arctic climate change.

If you would like to learn more about Arctic research, or to enquire about possible school visits in the Manchester or Newcastle area, please contact:

Researchers from Manchester and Newcastle universities who study Siberian permafrost

Dr. Bart van Dongen (Manchester; bart.vandongen@manchester.ac.uk)

or

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NERC SCIENCE OF THE ENVIRONMENT

Arctic Research Programme NATURAL ENVIRONMENT RESEARCH COUNCIL

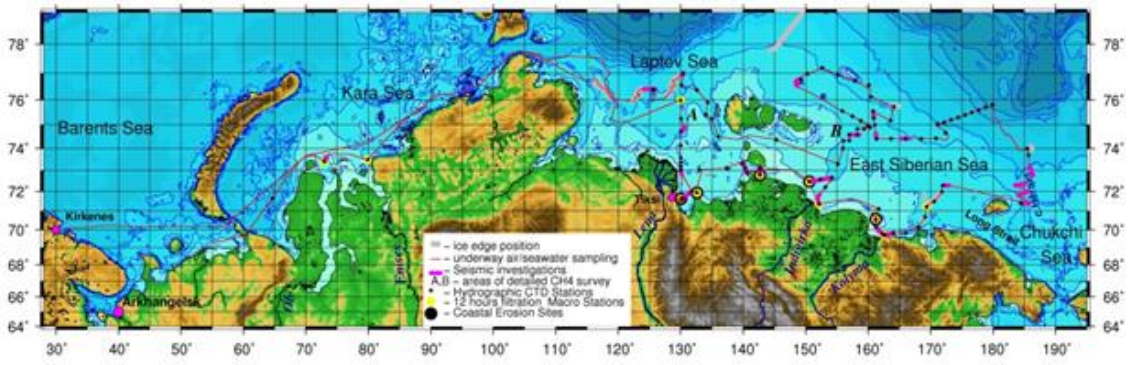
OUR RESEARCH IN THE ARCTIC

Funding: NERC (NE/I0247898/I) *Effects of a warming climate on the key organic carbon cycle processes in the Eurasian Arctic.*

Associated with the NERC Arctic Research Programme (http://arp.arctic.ac.uk/)

The fastest warming regions on the planet are close to the poles, especially the Siberian region. The Eurasian Arctic, where permafrost traps one of the largest carbon reservoirs on the globe, is at risk as warming leads to a general reduction of the total volume of permafrost. This could allow large amounts of trapped carbon to be released. It is presently unclear whether this is already happening and what will happen to this carbon after it is transported from the permafrost areas to the Arctic Shelf. Changes in the Arctic region have potential effects on the entire global carbon-climate system. Therefore if we want to understand the effects of climate warming on the global carbon cycle we must understand the processes occurring in the Arctic region.

In 2008 a ground breaking scientific mission took place. A research ship sailed from Norway all the way across the Arctic Ocean to eastern Siberia. In the middle of summer, with nothing but seagulls, polar bears and the ever-present sun for company, a group of scientists from all over the world collected water and sediment samples stretching across thousands of miles of ocean. These samples have allowed us to carry out the most detailed investigation ever into the processes affecting Siberian permafrost and the Arctic Ocean shelf.



Track of the ISSS-08 research cruise. The red line shows the path of the ship, black dots are sampling stations

The sediment samples were collected using a grab sampler – a big pair of metal jaws that scooped mud up from the sea floor. Once they were on the boat, they were frozen to preserve them, and transported back to Sweden and from there to Manchester. Here we dissolved them in organic solvents so that we could access very particular tracer molecules in the samples, which we are using to work out what is happening to the carbon that was locked in the permafrost.

Left to right: sampling sediments, sampling water, collected sediment samples, samples being analysed

WHO ARE WE?

Dr Bart E. van Dongen (Lead Investigator on the Project): Before joining the University of Manchester's School of Earth, Atmospheric and Environmental Sciences as Senior Lecturer in Organic Geochemistry, Dr van Dongen studied in the Netherlands and worked in Sweden as well as the UK. His research focuses on the application of organic geochemical techniques to the study of biogeochemical processes. He is an associate editor for Organic Geochemistry, board member of the European Association of Organic Geochemists and a member of the NERC Life Sciences Mass Spectrometry Facility Steering Committee and the UK Polar Partnership Steering Committee.

Dr. Helen Talbot (Co-Investigator on the project): Dr Talbot is a Reader in Organic Geochemistry in the School of Civil Engineering and Geosciences having previously worked as an Experimental Officer in Mass Spectrometry in the same school. She is also an associate editor for the journal Organic Geochemistry. Her research interests involve tracing signatures of biogeochemical processes, such as aerobic methane oxidation, using characteristic lipids which can be preserved in the geological record. These complex lipids, biosynthesised by specific groups of bacteria, can also be applied for tracing the origin, transport and fate of terrestrial organic carbon, at the land-ocean interface, including the Polar Regions.

Dr. Robert Sparkes (Post-Doctoral Researcher): Dr Sparkes completed his PhD at the University of Cambridge in 2012 before moving to the University of Manchester. His research concentrates on understanding and quantifying the transfer of organic matter from terrestrial to marine systems. He studied organic carbon transport and deposition processes in Taiwan, Spain and Italy before joining the Arctic Programme. He has experience with a wide range of analytical techniques including isotope and organic geochemistry, infra-red and Raman spectroscopy, and computational modelling and analysis.

Dr. Juliane Bischoff (Post-Doctoral Researcher): Dr Bischoff is an Environmental Researcher at Newcastle University, using organic geochemistry and microbiology tools to investigate carbon cycling and transport in the Russian Arctic. During her PhD in Germany, she also worked in the Russian Arctic, but focused on much deeper permafrost and lake sediments to reconstruct the changing paleo microbial communities as a response to climate changes in the Middle- to Late Pleistocene and Holocene in Siberia and Chukotka.

Dr. Ayça Doğrul Selver (Ph.D. student): Dr. Doğrul Selver obtained her M.Sci. in Geological Sciences from the Florida State University (2010). In 2010, she joined the University of Manchester to obtain a Ph.D. degree and worked on the effects of global climate change on the release of terrestrial organic carbon in the Arctic Region. She successfully defended her thesis in September 2014!

COLLABORATORS ASSOCIATED WITH ARCTIC RESEARCH IN MANCHESTER AND NEWCASTLE

Prof. Örjan Gustafsson, Stockholm University

Dr. Jorien Vonk, Utrecht University

Prof. Igor Semiletov, Russian Academy of Sciences

Prof. Tim Eglinton, ETH Zurich




LINKS TO ARCTIC SCIENCE RESOURCES

The NERC Arctic Research Programme has information about lots of UK Arctic science research projects:

http://arp.arctic.ac.uk/

The US Government's National Climate Assessment is a well-written report dealing with all aspects of climate research, and includes a section about Arctic ice cover:

http://nca2014.globalchange.gov/

Dr Robert Sparkes, part of this project, maintains a website highlighting advances in permafrost science, and information about our work here in Manchester:

http://www.defrostingthefreezer.co.uk/

SCIENTIFIC PUBLICATIONS FROM OUR RESEARCH GROUP

Unfortunately most of these papers are not "open access", and require a log-in to download. If you would like a copy of any of these, please email Bart van Dongen
bart.vandongen@manchester.ac.uk

Authors: M. P. Cooke, **B. E. van Dongen**, **H. M. Talbot**, I. Semiletov, N. Shakhova, L. Guo and Ö. Gustafsson
Year: 2009
Title: Bacteriohopanepolyol biomarker composition of organic matter exported to the Arctic Ocean by seven of the major Arctic rivers
Journal: Organic Geochemistry, 40, 1151-1159
http://www.sciencedirect.com/science/article/pii/S0146638009001648
Summary: This paper identifies bacteriohopanepolyols (BHPs), which are membrane lipids produced by a wide range of bacteria, in sediments from the Arctic Ocean. These were analysed for a series of rivers draining into the Arctic Ocean, and it was found that they can be used to identify the input of soil into the ocean sediments.

Authors: A. Doğrul Selver, **H. M. Talbot**, Ö. Gustafsson, S. Boult and **B. E. van Dongen**
Year: 2012
Title: Soil organic matter transport along an sub-Arctic river- sea transect
Journal: Organic Geochemistry 51, 63-72.
http://www.sciencedirect.com/science/article/pii/S014663801200157X
Summary: Two groups of biomarkers (molecular fingerprints for biological processes) were analysed from a river-sea transect in the northern Baltic Sea. Both sets of measurements (GDGTs and BHPs) were shown to be good methods of tracking terrestrial material in marine sediments. By comparing multiple methods of tracking the terrestrial-marine transition, we developed a new way of working out what made up a complex offshore sample.

Authors: X. Feng, J. E. Vonk, **B. E. van Dongen**, Ö. Gustafsson, I. P. Semiletov, O. V. Dudarev, Z. Wang, D. B. Montluçon, L. Wacker and T. I. Eglinton
Year: 2013
Title: Differential mobilization of terrestrial carbon pools in Eurasian Arctic river basins
Journal: PNAS, 110, 14168–14173
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3761604/
http://www.pnas.org/content/early/2013/08/09/1307031110.abstract
Summary: By measuring the radiocarbon content of lignin (plant stem material) in samples from large Siberian rivers we discovered new insights about the processes affecting Siberian permafrost. Rivers deliver young carbon from the top layers of the permafrost. Plant wax lipids trace ancient (permafrost) OC which has been mobilized from thawed permafrost regions, where water penetrates deeper into soils. Because river runoff has significantly increased across the Eurasian Arctic in recent decades, we estimate that the proportion of mobilized terrestrial OC accounted for by ancient carbon has increased by 3-6% between 1985 and 2004. These findings suggest that climate change-induced mobilization of old permafrost carbon is well underway in the Arctic.

Author: Ö. Gustafsson, **B. E. van Dongen**, J. E. Vonk, O. V. Dudarev and I. P. Semiletov
Year: 2011
Title: Widespread release of old carbon across the Siberian Arctic echoed by its large rivers
Journal: Biogeosciences 8, 1737-1743
http://www.biogeosciences.net/8/1737/2011/
Summary: Climate warming in the Eurasian Arctic and Alaska causes thaw-release of old permafrost carbon from local tundra sites. The dynamics of Siberian permafrost can be probed via the molecular-radiocarbon signal as carried by Arctic rivers. We measured radiocarbon concentrations for major Siberian rivers and found that in the western part of Siberia warmer conditions led to more permafrost thawing and more carbon degradation.

Author: B. E. van Dongen, I. Semiletov, J. W. H. Weijers and Ö. Gustafsson
Year: 2008
Title: Contrasting lipid biomarker composition of terrestrial organic matter exported from across the Eurasian Arctic by the five great Russian Arctic rivers
Journal: Global Biogeochemical Cycles, 22, GB1011
http://onlinelibrary.wiley.com/doi/10.1029/2007GB002974/abstract
Summary: Sediments outside Siberian rivers were investigated for their lipid biomarker composition. The biomarker composition is dominantly terrestrial with only minor marine contributions. There is a large contribution peat bogs to the samples. The organic matter exported by the eastern GRARs is less degraded, which is consistent with increasing permafrost and a shorter annual thaw period in eastern Siberia. If the climate in the eastern Russian Arctic region becomes more like the current state in the western part, these results would predict a greater degree of decomposition of the old terrestrial OM released by the eastern GRARs and greater release as CO_2 and methane.

Authors: B. E. van Dongen, Z. Zencak and Ö. Gustafsson
Year: 2008
Title: Differential transport and degradation of bulk organic carbon and specific terrestrial biomarkers in the surface waters of a sub-arctic brackish bay mixing zone
Journal: Marine Chemistry, 112, 203-214
http://www.sciencedirect.com/science/article/pii/S0304420308001382
Summary: Detailed organic geochemical analyses were performed on surface water particulate samples of the lower Kalix River and northern Bothnian Bay collected during the spring flood of 2005. Both bulk geochemical and molecular biomarker analyses indicated a predominance of terrestrially-derived particulate organic matter , both of higher plant and *Sphagnum* origin in the Kalix River estuary, with an increasing contribution of marine-derived material in the offshore Bothnian Bay basin.

Authors: J. E. Vonk, L. Sanchez-Garcia, **B. E. van Dongen**, V. Alling, D. Kosmach, A. Charkin, I. P. Semiletov, O. V. Dudarev, N. Shakhova, P. Roos, T. I. Eglinton, A. Andersson and Ö. Gustafsson
Year: 2012
Title: Activation of old carbon by erosion of coastal and subsea permafrost in Arctic Siberia
Journal: Nature, 489, 137-140
http://dx.doi.org/10.1038/nature11392
Summary: Ancient Ice Complex deposits outcropping along the 7,000-kilometre-long coastline of the East Siberian Arctic Shelf are a large pool of permafrost carbon, yet their vulnerabilities towards thawing and decomposition are largely unknown. Recent Arctic warming is stronger than has been predicted by several degrees. Here we show that extensive release of carbon from these Ice Complex deposits dominates the sedimentary carbon budget. Old carbon is activated annually from Ice Complex permafrost, about two-thirds of this escapes to the atmosphere as carbon dioxide, with the remainder being re-buried in shelf sediments.

Authors: J. E. Vonk, **B. E. van Dongen** and Ö. Gustafsson
Year: 2010
Title: Selective preservation of old organic carbon fluvially released from sub-Arctic soils
Journal: Geophysical Research Letters
Volume: 37, L11605
http://onlinelibrary.wiley.com/doi/10.1029/2010GL042909/abstract
Summary:
We assess the remobilization and preservation of old carbon using radiocarbon measurements of molecular markers released from northernmost Scandinavia. We inferred river export of two carbon pools; a young surface peat component, and an old deep mineral soil component. The young pool is easily degradable, while the old pool is protected from degradation settles quickly to the sea floor. Part of the thaw-released carbon may be relocated to sediments instead of being emitted to the atmosphere.