Arctic Academy Programme (ARKTIKO) 2014 – 2018

Project Descriptions

ACADEMY OF FINLAND

Academy Programme on Arctic research (ARKTIKO) supports transdisciplinary problem based Arctic research

The Academy of Finland's Arctic Academy Programme (ARKTIKO, 2014-2018) was launched to strengthen high-quality, transdisciplinary and problem-based Arctic research in Finland in the long term. The aim is to study the change factors affecting the development of the Arctic region, the transformation process, and the dynamics of change. Another aim is to produce new research knowledge and actively disseminate it to policy-makers and stakeholders and for public discussion.

ARKTIKO includes twenty projects eight of which are individual projects and twelve larger consortia; altogether there are 39 sub-projects. In addition, two international Network Projects (Joint Programme Initiative JPI-Climate) are included under ARKTIKO umbrella. More projects will be included later through international joint calls.

The projects cover widely disciplines under the four thematic areas of the programme: Good-quality life in the north, Economic activity and infrastructure in Arctic circumstances, The northern climate and environment, Cross-border Arctic policy.

More information

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ACADEMY OF FINLAND

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Understanding the Cultural Impacts and Issues of Lapland Mining: A Long-Term Perspective on Sustainable Mining Policies in the North. *Vesa-Pekka Herva, University of Oulu*

Mining in northern Fennoscandia (Lapland/Sápmi) is subject to controversies and entangled with diverse broader issues, such as nature preservation and indigenous rights. The debates over mining largely reflect differing contemporary interests in northern environments, but underlying those immediate concerns are also more fundamental issues of conflicting worldviews and modes of perceiving and engaging with the environment. These deeper tensions date back to at least the 17th century and are intertwined with the colonial past and modernisation of Lapland/Sápmi.

Historical and contemporary mining is often considered in narrow technological, economic or political terms, whereas this project studies northern mining as a sociocultural phenomenon. The research analyses the emergence and development of Lapland mining in conjunction with a series of wider reforms imposed in northern regions since the early modern period. Historical mining in the northern region and its manifold cultural impacts, as well as continuing cultural heritage, will be analysed and interpreted against that broader background and in terms of interactions between people, material cultures, infrastructures and environments. The research employs diverse datasets and approaches from history, archaeology, anthropology, geography, material culture studies and heritage studies.

The research seeks to understand the historical foundations of the current issues around Lapland mining and the complex cultural impacts of mining in a long-term perspective. This has important implications for the development of socially sustainable and culturally and socially sensitive policies of natural resources utilisation. The results of the research will be disseminated so as to benefit both academia and various stakeholders and decision-makers involved in contemporary mining and resources management in northern regions.

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Kara-Arctic Monitoring and Operation Planning Platform (KAMON). *Mikko Lensu, Finnish Meteorological Institute and Jukka Tuhkuri, Aalto University*

The KAMON project (Kara-Arctic Monitoring and Operation Planning Platform) aims to develop new generation services for ice-covered Arctic sea areas. The platform links an ice information system with the use of the system by different kinds of actors: shipping, offshore activities, environmental monitoring and operation optimising, and international policy-makers. This is done so that the feedback from the use helps improve the ice information.

The platform will be set up in the Kara Sea, the next frontier of Arctic offshore. This serves as a stepping stone for Pan-Arctic services. The main innovative feature is that all Arctic ship traffic is included and coupled in near real-time fashion with ice information consisting of ice model forecasts and satellite data analyses. The ice model is set up for the whole Arctic with a high-resolution submodel for the Kara Sea. The ship traffic information is obtained through satellite-received AIS (Automatic Identification System) data. AIS is mandatory for all commercial vessels, and the data messages include, among other things, the position, speed and navigational status of the vessel. AIS data is used to compare how ice conditions are mirrored by ship speed and other ship ice performance. Moreover, the project aims to better understand how ship speed depends on the variable thickness of Arctic ice, especially if there are ice ridges, which are among the main obstacles to Arctic navigation and may stop even the strongest icebreakers. This will be addressed by numerical methods and by model scale tests conducted in an ice tank. Combined with ice information, the formulas for ship ice resistance will enable route optimisation. Vice versa, the resistance formulas make possible the estimation of ice cover thickness from ship speed data. This provides a new source of initialisation and validation data for ice forecast models, which have suffered from a lack of thickness data, because the thickness cannot yet be reliably sensed remotely.

The main application of the platform during the project will be the calculation of ship emissions in the Arctic. The calculations are based on the estimated fuel consumption of the ships, obtained from ship particulars data and AIS retrieved speed. The lacking component has been the ice resistance, which increases fuel consumption in ice-covered seas. The ship-specific resistance formulas implemented for the platform will facilitate emission modelling in the Arctic. Several other applications related to ship traffic will also be demonstrated, especially concerning the optimising of oil combat strategies.

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Towards Efficient and Sustainable Arctic Oil-Spill Response: Green Dispersing and Herding Agents Derived from Northern Bioresources (ARCRESPO). *Jouko Niinimäki, University of Oulu and Mika Sillanpää, Lappeenranta University of Technology*

The Arctic region has long possessed a low general appeal for industrial activities and sea transport due to its harsh climate conditions. However, climate change is opening the region from permanent ice coverage, making it more attractive for several industrial activities including oil production and transport. The risks of accidental oil spills have therefore increased significantly in the Arctic region.

The cold and windy climate, ice-affected waters and logistic challenges make oil-spill response demanding in Arctic regions. In the case of large spills, mechanical methods are too slow to respond in the cold ice-affected waters, especially when the spills start to spread in severe weather conditions. Chemical surfactants, which can rapidly be applied from aircrafts, may therefore be the most feasible response option. However, the potential drawbacks of chemical oil response are the harmful environmental effects caused by the chemicals used.

The aim of the present research is to investigate aspects of production and use of new efficient and sustainable chemical oil-spill response techniques in Arctic conditions. Within the project, green, nontoxic surfactants from renewable biopolymers, cellulose and chitosan, will be fabricated using sustainable chemical modifications. The toxicity and biodegradability of the sustainable surfactants will also be investigated, and their performance will be demonstrated in Arctic conditions.

It is likely that the results of this research project will possess a high practical significance for the sustainable use and refining of Arctic natural resources. The project is conducted in cooperation between the University of Oulu, Fibre and Particle Engineering Laboratory, and Lappeenranta University of Technology, Laboratory of Green Chemistry. The project will be a multidisciplinary collaborative effort, encompassing knowledge and facilities from the whole value chain from biomaterial modification and refining to its characterisation and evaluation, and application demonstration in Arctic oil-spill response conditions.

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Governing Change in Adaptive Fashion towards Sustainable Economy in the Arctic (GovAda). *Jukka Similä, University of Lapland; Pasi Eilu, Geological Survey of Finland and Artti Juutinen, Natural Resources Institute Finland*

GovAda, coordinated by the University of Lapland, is a joint project of the University of Lapland, the Geological Survey of Finland and Natural Resources Institute Finland. The project's multidisciplinary research team started its work in September 2014 and the project will run for four years.

A key driver of economic transition in the Arctic is the growing importance of extractive industries such as mining. Mineral extraction in the Arctic may, however, adversely affect other livelihoods, especially tourism and forestry. Competing land-use interests related to mining, other livelihoods and environmental protection are likely to increase in the future. The potential conflicts may threaten the sustainable growth of the economy. Achieving a balanced development between different land uses and economic branches supporting the needs of both society and business will require stronger reconciliatory capabilities from enterprises as well as from governmental and community organisations.

The challenge of a sustainable economy in the Arctic calls for a better knowledge base to inform infrastructure-related decisions and improve social institutions to enable adaptive governance of land resources on which different livelihoods depend. As a response to this challenge, we aim in an iterative and integrated way to:

1) develop and test scenario methodology for predicting the quantitative and qualitative development of the mining industry in the Arctic; develop methods for assessing economic, social and environmental impacts of associated scenarios
2) develop and test a GIS-based method for the adaptive management of mining environments that gives full consideration to socioeconomic and ecological values of competing land uses
3) assess how law supports or suppresses adaptive governance towards sustainable economy; develop law's adaptive capacity
4) examine the role of various kinds of knowledge; develop mediation structures through action research approaches
5) provide new insights into improving, in an integrated way, both the knowledge base and the processes of decision-making.

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Towards Better Tailored Weather and Marine Forecasts in the Arctic to Serve Sustainable Economic Activities and Infrastructure (TWASE). *Timo Vihma, Finnish Meteorological Institute*

In the Arctic, economic activities such as navigation, aviation and energy production are extremely sensitive to weather. Increasing human activities in the Arctic will induce many new needs for operational weather and marine services (WMS). To address these needs, the TWASE project will build a close, interactive collaboration between meteorologists, oceanographers and economists.

The main objectives of TWASE are to:

1) identify, classify, prioritise and conceptualise the user needs of WMS for developing sustainable economic activities in the Arctic
2) improve the predictability of Arctic weather, marine and sea ice conditions and their consequences on navigation, aviation and wind energy production
3) evaluate and optimise, together with end-users, the benefits of improved WMS to enhance the development of sustainable economy and infrastructure in the Arctic.

To meet Objective A, we will:

- create a set of combined climate change-socioeconomic scenarios for the Arctic
- engage stakeholders in the development process of WMS and in the assessment of their benefits.

To meet Objective B, we will:

- further improve numerical weather prediction (NWP) models in presentation of physical processes specific for the Arctic
- analyse how much NWP models will benefit from new in-situ and satellite observations and improved coupling with sea ice models
- improve methods for post-processing NWP model output to meet concrete user needs, related, for instance, to the icing risk of ships, aircraft and wind farms.

To meet Objective C, we will:

- analyse the differential effects that the information contained in WMS has on economic decisions of end-users, related, for instance, to a choice between alternative navigation routes
- use experimental economics to explore likely shapes of response functions reflecting the improved information and the critical threshold levels related to the quality of the information.

The work will be carried out in extensive international collaboration, applying Arctic field observations, satellite data, user surveys, new scenarios serving the IPCC 5th Assessment Report cycle, as well as meteorological, sea ice and economic models.

Arctic targeted call 2013: Sustainable economy and infrastructure in Arctic conditions

Strap-Down Sensing for Safe Material Handling and High-Performance Motion Control. *Ari Visa, Tampere University of Technology*

Articulated heavy-duty hydraulic cranes are widely used for various tasks ranging from traditional cargo loading/unloading tasks to sub-sea infrastructure installations and oil recovery operations thanks to their high power-to-weight ratio. Driven by the perceived cost savings in reducing the human element, a major challenge is to push towards safety-prioritised and potentially teleoperated technologies in the Arctic region. We believe that the recently introduced cost-effective motion sensing and radio-based positioning technologies, together with advanced stability-guaranteed robotic motion control theories, can overcome the main open problems of current offshore crane controllers and of those fixed on land. In this way, the coupled dynamics of platform-crane-payload systems are addressed using sensor fusion and virtual decomposition control theory, which is expected to elevate the current state of hydraulic material handling to the level required by complex and often safety-critical tasks.

The work is carried out in collaboration with the TUT Department of Intelligent Hydraulics and Automation.

Arctic Academy Programme call 2014

Geomorphic Sensitivity of the Arctic Region: Geohazards and Infrastructure (INFRAHAZARD). *Jan Hjort, University of Oulu and Miska Luoto, University of Helsinki*

A deeper understanding of the impacts of current and future climate on Earth surface systems (ESS) is fundamental for science and society. This is highly relevant in the Arctic region, where geomorphic ESS processes control landscape dynamics and ecosystem processes. In addition to the nature, the Arctic is undergoing significant changes regarding urbanisation, settlement patterns and economic activities, creating challenges for planners, decision-makers and engineers. Infrastructure forms the basis for regional economic growth and sustainable development in the Arctic. The increase in Arctic soil moisture and temperature may change physical properties of soil, which can have drastic negative effects on infrastructure and land use.

The INFRAHAZARD consortium focuses on the modelling of the Arctic ESSs in a changing climate and on the production of GIS-based infrastructure risk maps for decision-making and land use planning. For the first time ever, the sensitivities of ESSs and their relation to human activity is explored across the Arctic region. More precisely, the objectives are to:

1) investigate the environmental drivers of Arctic geomorphic processes across scales
2) forecast the geomorphic sensitivity of the Arctic throughout the 21st Century
3) identify threat spots of Arctic infrastructures in the face of climate warming.

Our groundbreaking approach is to apply complementary research data and approaches to assess the impact of climate change on the Arctic ESSs and infrastructure. The research is based on comprehensive GIS- and remote-sensing-based data at global, regional and local scales, and on innovative modelling methodology. The research will provide science-based new knowledge and insights regarding the environmental drivers of Arctic ESSs and the relations between ESS changes and infrastructure. The results have both theoretical and applied implications with considerable societal significance. In addition to scientific publications, the results will be disseminated using existing spatial data infrastructures.

Arctic Ark – Human-Animal Adaptations to the Arctic Environment: Natural and Folk Selection Practices (ARC-ARK). *Juha Kantanen, Natural Resources Institute Finland and Florian Stammler, University of Lapland*

The Arctic region is often seen as a biodiversity-poor area where animal husbandry is solely based on the herding of reindeer (*Rangifer tarandus*). However, in northern Europe and Siberia, also breeding of special autochthonous cattle (*Bos taurus*) and horse (*Equus caballus*) breeds has a long tradition (e.g. Northern Finncattle, Yakutian cattle, Mezen horse and Yakutian horse). The Arctic Ark project studies animals' adaptation to the Arctic as a complex human-environmental process. Old traditions of 'folk selection' rather than those implemented by institutions have been shaping Arctic animals' valuable traits. Each of the ethnic groups studied in this project (Finns, Sámi, Nenets, Pomors, Russians, Sakha and Eveny) have myths and legends connected to orally transmitted narratives of domestication and selection animals. This kind of cultural adaptation assistance is mostly due to symbiotic domesticity, an intimate human-animal partnership. As a result of natural and folk selection, reindeer and Arctic cattle and horse breeds show metabolic, morphological and reproductive adjustments.

Using methods of genetics, ecology and anthropology, we investigate how indigenous and nonindigenous societies raise reindeer, cattle and horse breeds in Finnish Lapland, Archangelsk and Eveno-Bytantaj, Russia. In the animal genomics analyses, we focus on animals' metabolic adaptation and structural and functional genome variations. We use modern genomic analysis approaches: whole-genome sequencing of animals and gene expression analyses of host animals and their rumen microbiota. In the socio-anthropological studies and across several regions, we compare animal farmers' knowledge of the environment and desired animal characteristics that facilitate a sustainable Arctic livelihood. The data of these two disciplines are integrated through approaches of ecological anthropology. The close association between animals and humans over many centuries in the Arctic allows us to identify the human and natural footprints in animal adaptations as well as the importance of different animal species for the resilience of Arctic cultures and economies.

Arctic Academy Programme call 2014

Keeping the Arctic White: Regulatory Options for Reducing Short-Lived Climate Pollutants in the Arctic (WHITE). *Kati Kulovesi, University of Eastern Finland; Kaarle Kupiainen, Finnish Environment Institute and Kari Lehtinen, University of Eastern Finland*

The WHITE project brings together a combination of law, atmospheric physics and environmental science to identify ways to strengthen the regulatory framework for reducing emissions of short-lived climate pollutants (SLCP) in the Arctic region. Strengthening action on SLCPs is a new, promising area of climate policy that could slow down climate change in the short-term while simultaneously improving local air quality.

SLCPs are pollutants with a significant short-term warming influence on the climate, especially in sensitive regions like the Arctic. They include black carbon, methane, tropospheric ozone and some hydrofluorocarbons (HFC). According to estimates by the United Nations Environment Programme, reducing SLCP emissions, especially methane and black carbon, could slow the rate of global climate change by 0.5°C by 2040. Rapid action on SLCP emissions holds important potential to complement efforts to reduce the emissions of the main greenhouse gas carbon dioxide, leaving more time for transitioning to a low-carbon economy.

The Arctic region is warming faster than the global average and the extent of Arctic sea ice has been declining dramatically. Recent research indicates that SLCPs contribute to Arctic warming. Without new controls, there is a risk that the emissions may increase, driven, for example, by expanding economic activities in the Arctic region. In addition to their warming impact, SLCPs are, in many cases, harmful air pollutants. Reducing pollution from black carbon and methane could therefore have important co-benefits.

The WHITE project builds on the idea that prompt action to reduce emissions of SLCPs in the Arctic could improve local air quality and limit climate change and glacial melting, resulting in a multitude of benefits for the region. The project will produce a comprehensive analysis of regulatory options for reducing SLCP emissions in the Arctic region on the basis of latest research on SLCP emission models and climate change impacts of the various regulatory options.

The project includes four interlinked subprojects. Subproject 1 will study the multi-level legal and regulatory framework for regulating SLCPs in the Arctic, with a special focus on the relevant national, regional and transnational initiatives. Subproject 2 will study and develop emissions scenarios for the different regulatory options to reduce SLCPs in the Arctic. Subproject 3 will improve understanding of climate impacts of SLCPs and measures to mitigate them in the Arctic region through short- and mid-term climate simulations. Subproject 4 will collect outcomes from all other subprojects and produce an interdisciplinary synthesis of the key outcomes.

Arctic Academy Programme call 2014

Domestication of Indigenous Discourses and Processes of Constructing Political Subjects in Sápmi. *Veli-Pekka Lehtola, University of Oulu*

The project Domestication of Indigenous Discourses? Processes of Constructing Political Subjects in Sápmi is a joint project of two northern universities, the University of Oulu and the University of Lapland. The project will benefit from the concept of domestication, launched by Alasuutari & Qadir (2014), which refers to the taming and adopting of global trends to national and local contexts. Worldwide models are seldom just "copied", but rather instituted at the own will and desire of indigenous and national leaders and decision-makers.

The project analyses the processes of constructing the Sámi as political subjects at the crossroads of local, national and transnational contexts. In political terms, the Sámi are citizens of their respective home countries, but culturally they belong to Sápmi, a cross-national symbolic and cultural entity, which has not been officially recognised by the nation states or international organisations. Tensions caused by this discrepancy are present at different levels of Sámi society and in state-Sámi and minority-majority relations. To compensate the lack of power at local and national levels, Sámi politicians have already for decades invoked international norms especially by United Nations and the discourses of (other) indigenous peoples to support their claims.

Taking a bottom-up perspective, we scrutinise local, national and transnational political processes when identifying the ways in which the Sámi political subjects implement global trends, conventions and regulations to the local context. We recognise the strong influence of international discourses on Sámi policies, but also emphasise the choices of Sámi subjects, arising from special contexts and special terms of agency.

Our project challenges the straightforward perceptions about unidirectional processes between international trends and local implementations, but it also tests the applicability of the concept of domestication with concrete and detailed case studies. The project grasps the concrete activities and possible frictions and tensions in constructing the Sámi political subjects. Many crucial layers of modern Sámi society are represented in the project, from recent ethno-political history and the role of women in Sámi policies to Sámi participation at many levels of local, national and international politics. Sámi reindeer herding and repatriation processes are introduced as examples of controversies between Sámi and Finnish institutions.

Wastewater Treatment by Natural Freeze Crystallization and Ice Separation (WINICE). *Marjatta Louhi-Kultanen, Lappeenranta University of Technology; Pentti Kujala, Aalto University and Aki Mikkola, Lappeenranta University of Technology*

The Arctic region is a potential area for natural resources exploration. To be sustainable, this exploration should be carried out with minimal disruption to the Arctic environment. As such, the proper handling and treatment of wastewater is critical. The WINICE project investigates an energy-efficient variation of freeze wastewater treatment, which uses available cold Arctic air to cool the wastewaters to their freezing points.

When wastewater begins to freeze, more pure layer of ice forms on its surface. This upper layer of ice is separated from the unfrozen liquid below, now with a higher contaminant concentration, and subsequently melted to obtain pure water. Because the method relies on natural cold climate freezing, energy needs only be consumed to break, separate and transport the purified ice from the wastewater pond area to melting ponds.

The research project involves interdisciplinary research in chemical technology, mechanical engineering and mathematical modelling. The freezing equipment includes a winter simulator, which makes it possible to study how the temperature and flow velocity of cooling air affects freezing. The simulator is used to study the growth rate of the layer of ice that emerges, and the degree of purity when various wastewater solutions of different concentrations are investigated. Furthermore, the ice purities of various wastewater bonds during natural winter conditions will be investigated. The project focuses on freezing fundamentals and develops technology for ice breaking and collection in Arctic environments.

Arctic Academy Programme call 2014

Cooperative Heavy-Duty Hydraulic Manipulators for Sustainable Subsea Infrastructure Installation and Dismantling. *Jouni Mattila, Tampere University of Technology and Ville Kyrki, Aalto University*

To sustainably exploit natural resources in the Arctic region, new subsea technologies are needed for infrastructure installation and dismantling. Currently, subsea operations are carried out with surface-operated platforms supported by small, submarine-like remotely operated vehicles (ROVs) whose safety and payload capacity are not adequate for harsh Arctic conditions. New subsea technologies are needed for sustainable Arctic development, comprising seabed crawlers with on-board heavy-duty hydraulic manipulators. In the proposed concept, multiple crawler-mounted manipulators are used for precise and safe infrastructure installation and dismantling. The aim of the project is to develop a science-based foundation for an underwater robotic control system, enabling sustainable exploitation of natural resources.

Controlling the multiple cooperative manipulators performing installation and dismantling includes many challenges, where the most significant are as follows:

1) the nature of the task (e.g. coordinated motion control of manipulators, control of the contact force on the environment and control of the internal force in the object)
2) positioning of the manipulator base on top of a slowly moving crawler vehicle on an uneven seabed
3) commercial robot force/moment sensors do not exist on the market for robots with high-contact forces
4) the subsea environment places strong practical limitations on real-time information flow among different vehicles.

The main hypothesis of the research project is that, despite the design challenges mentioned above, it is possible to establish a stability-guaranteed comprehensive control framework for underwater assembly tasks using two decentralised hydraulic robot arms.

The research project is divided into three work packages (WP). WP 1 includes the development of a stability-guaranteed decentralised model-based controller for two crawler-mounted manipulators performing installation and dismantling tasks. The developed control system considers a complex system dynamics model (incl. manipulators' nonlinear dynamic behaviour, complex environmental contact, water drag, and model parameter uncertainties). WP 2 addresses the estimation of unmodellable factors in interaction dynamics as a learning problem and the use of multi-sensor feedback. WP 3 integrates results from WP 1 and WP 2 to demonstrate the viability of Arctic underwater collaborative manipulation in the experimental setup.

Arctic Academy Programme call 2014

Oil Production Networks in the Russian Arctic: Societal Impacts and Potential for Partnerships. *Soili Nystén-Haarala, University of Lapland*

Extractive industries are the most rapidly developing economic activity in the Arctic today. Transnational corporations (TNC) are increasingly attracted to the remote regions of the Russian Arctic to drill vast oil reserves. Russia is one of the most important oil and gas suppliers to the EU and Finland. But little is known about what is happening in Russia's local communities where oil extraction occurs.

The Russian economy is dependent on oil and the Russian state plays the primary role governing the Russian oil industry and is a significant shareholder. However, the Russian government has not prioritised the effective regulation of the oil industry's social and environmental impact (Stammler and Wilson 2006, Yakovleva 2011). To ensure the sustainability of oil production and the protection of indigenous peoples' rights, global standards are developed at the transnational level. Despite TNCs' claims to adhere to global standards, the relationships between TNCs and indigenous people have in practice been marked by damage to indigenous lands, forced displacement, violations of rights to resources, cultural destruction, and increased poverty. This research aims to analyse the extent to which such problems have been replicated in the Russian Arctic.

We hypothesise that, in the absence of appropriate national regulation in Russia, global standards regulating oil production networks can assist in protecting the rights of local inhabitants and in developing democratic decision-making processes in natural resources management. The project will investigate how national legislation and the local/national context influence the adoption and implementation of global standards and financial flows towards indigenous communities.

The project focuses on the global production networks (GPNs) that shape the interaction among indigenous peoples, oil companies and other actors in the Russian Arctic. It will determine how these networks could be constructed to ensure the coexistence of profitable industries and sustainable indigenous communities.

Three ideal types of oil GPNs have been identified: the partnership mode, the CSR mode, and the paternalistic mode. Each mode captures a distinct pattern of interaction between the company and indigenous communities. Using methods of sociology and legal studies, the project will identify the best benefit sharing practices, coming from the oil companies towards indigenous communities, and will communicate the results to Arctic policy-makers.

Arctic Academy Programme call 2014

Towards More Efficient Arctic Research Using Dominant Betula Species, Spectromics and Genomics (BETUMICS). *Elina Oksanen, University of Eastern Finland; Juha Mikola, University of Helsinki and Kaisa Nieminen, Natural Resources Institute Finland*

The impact of climate change on northern ecosystems, and particularly on forests growing in their northern extreme limits, is one of the most demanding challenges faced by Finnish society, northern nations and environmental scientists today. The climate change scenarios for Finland predict longer growing seasons, increased effective heat sums and increased precipitation. As northern ecosystems, particularly in Arctic conditions, are already probably operating near their ecological limits, they may be vulnerable to such unprecedented extreme events and chronic climate change. Predicting their responses has, however, so far been hampered by a scarcity of experiments and observations.

The BETUMICS project studies the acclimation and adaptation capacity of four ecologically and economically important Betula species, Betula pendula, B. pubescens, B. pubescens subsp. czerepanovii and B. nana. All four species are likely to be among the key species that will determine the responses of Arctic ecosystems to climate change. We combine common garden and translocation experiments, growth chamber tests, spectromics for in situ monitoring and genetic methods to achieve a novel perspective on the effects of climate change on the performance of woody species in Arctic ecosystems. The novel hyperspectral imaging techniques, which are available in our spectromics laboratory (www.spectromics.com), will produce nondestructively spectral data that can be correlated with various leaf traits, such as chemical quality, nutrient deficiency, water content, incipient pest damage, vitality and phenotyping.

We will also perform genome sequencing and genetic association analyses for genetic relationships of birch genotypes within and between populations. We will select the most diverse phenotypes inside the species for pedigree-based mapping approaches, identify the genetic loci behind the adaptive traits and study the importance of hybridisation and introgression among the species. Finally, using heated field plots, we can investigate how the four species respond to climate warming in Arctic conditions, whether pests can weaken their acclimatisation capacity and whether changes in their performance can affect the functioning of Arctic ecosystems.

The consortium brings together researchers, methods and knowledge from ecophysiology, ecology, forestry, genetics and photonics. The project will produce new knowledge on the hybridisation of northern birches, their acclimatisation capacity to drastic climatic changes, and the potential of spectromics in environmental and genetic research. The project and results have high socio-economic value through improved risk assessment, support for decision-making and EU policies, climate change mitigation, sustainability of silviculture in the Arctic, gene reserve protection, and research training.

Arctic Academy Programme call 2014

Integrative Science for Adaptive Co-Management in the Arctic: Teno Atlantic Salmon as a Model System (ISAMA). *Craig Primmer, University of Turku; Jaakko Erkinaro, Natural Resources Institute Finland and Timo P. Karjalainen, University of Oulu*

Atlantic salmon are a cornerstone of culture and livelihoods in many regions, especially the Arctic, but wild salmon numbers have declined considerably over the past 40 years. Key challenges in the sustainable management of salmon and other harvested species include determining the relative importance of different human-mediated and environmental effects, identifying the significance of interactions between them, and predicting the evolutionary response of populations. Further, governance of Arctic natural resources such as wild salmon stocks is a complex task that often involves cross-boundary interests between nations, regions and communities. The Atlantic salmon stock of the River Teno (Tana in Norwegian, Deatnu in Northern Sami) in northernmost Finland/Norway is an ideal study system to show how an integrative scientific approach can promote the sustainable use of such Arctic natural resources.

The ISAMA project brings together three research groups that have each been investigating different aspects of natural resource management (population dynamics, evolutionary genetics, fisheries science and environmental sociology) with a view to integrating these research approaches.

The Teno salmon monitoring programme, which has been running for 45 years and involves close cooperation between the Natural Resource Institute Finland and local fishers, provides multiple sources of data for this project. The programme includes an archive of more than 100,000 scale samples, each of which has associated data on fish length, weight, sex and capture date and location. Additionally, information on a fish's life history strategy and growth rate can be obtained from reading growth rings on the scales. The archived scales are also a good source of DNA for genetic analyses. Research in ISAMA will focus on six Teno sub-populations that have been particularly intensively monitored. The specific aims of the project are to:

1) characterise the ecological and genetic changes in the Teno salmon stock over the past 40 years
2) identify the key human-mediated/climatic factors that have contributed to these changes
3) determine the relationships between these changes and the co-occurring societal and political changes
4) better understand the genetic basis of life-history traits important for maintaining stock diversity and stability (and thus salmon-related livelihoods)
5) use local knowledge and management of Teno salmon as a case study to examine links between scientific research, local resource users, and adaptive co-management and policy.

Arctic Academy Programme call 2014

Carbon Balance under Changing Processes of Arctic and Subarctic Cryosphere (CARB-ARC). *Jouni Pulliainen, Finnish Meteorological Institute and Timo Vesala, University of Helsinki*

Higher northern latitudes are especially sensitive to climate change, as indicated by above-average rising temperatures. A considerable positive feedback on global warming is likely once additional carbon is liberated from thawing ground. However, the prediction of the overall response of the system is uncertain. Thus, the quantification and monitoring of physical processes of the circumpolar terrestrial cryosphere are highly important for the understanding of climate system feedbacks, especially concerning linkages between the atmosphere and soil/biosphere. Space-borne derived global long-term datasets of high temporal resolution are the only means to obtain information on some of the relevant processes. Currently, such proper datasets are available for the spatial distribution of polar sea ice, whereas in the case of land areas, information on snow and soil freezing characteristics is limited or inadequate. On the other hand, investigations performed by applying detailed on-site measurement data have shown that changes in the seasonal cycle of soil-snow-vegetation processes have a major impact on the annual carbon balance.

The CARB-ARC project is concerned with using novel space-borne earth observation (EO) instruments, in situ CO2 and CH4 flux measurements and Earth System Models to synergistically retrieve information on the seasonal cycle of the high-latitude land surface carbon exchange processes. The scope is to develop and demonstrate continental-scale mapping of CO2 and CH4 sources and sinks in the boreal forest, subarctic and Arctic zones based on the developed techniques.

The goals are achieved by using EO data products as proxy indicators of selected key variables that are directly linked to greenhouse gas (GHG) exchange. The development work is carried out with the aid of in situ flux measurement data and inverse modelling of CO2 and CH4 processes, applying new methods to constrain model simulations with remote-sensing-data-based estimates on atmospheric GHG concentrations. We develop proxies to map the annual carbon balance, derive products indicating seasonal phase changes relevant to carbon balance in boreal and Arctic land areas, and combine the newly developed EO products with established observations of the carbon cycle into a novel data assimilation system for tracking both CO2 and CH4 emissions in the Arctic/boreal region. Research materials include satellite datasets, flux observations from different continents and model predictions.

The consortium consists of leading teams in Finland concerning the topic. Their complementary expertise covers all relevant scientific and technical issues, including specialists in the necessary fields of remote sensing of soil, vegetation and snow processes using diverse optical and passive microwave satellite data (Finnish Meteorological Institute). The team furthermore consists of experts in GHG flux measurements (University of Helsinki and FMI), extrapolation of measurements to a larger scale (UH), inverse methods for GHG monitoring (FMI) and data assimilation (FMI).

Arctic Academy Programme call 2014

Long-Term Effects of Fire on Carbon and Nitrogen Pools and Fluxes in the Arctic Permafrost and Subarctic Forests (ARCTICFIRE). *Jukka Pumpanen, University of Helsinki*

The ARCTICFIRE project addresses important questions of the response of Arctic forest soils to rising temperature and increased fire frequency as well as the present and future role of Arctic forests in the global carbon (C) cycle. Boreal forests are a crucial part of the climate system since they contain about 60 per cent of the C bound in global forest biomes. About 24 per cent, or 23 million square kilometres, of the land in the Northern Hemisphere, including most of the boreal forests, is underlain by permafrost. However, the effects of forest fires on soil have not been studied extensively in the Arctic and permafrost areas.

Permafrost melting threatens to release vast amounts of C into the atmosphere, but the exact interactions between ecosystem disturbances, permafrost melting, soil organic matter (SOM) decomposition and vegetation productivity are not known. The acceleration of biological processes such as decomposition and below ground C input and C allocation of trees and associated priming effects following forest fires in the Arctic region may lead to large changes in CO2, CH4 and N2O fluxes. These processes evidently alter the C and nitrogen (N) turnover rate of the remaining SOM, which may ultimately affect the net primary production (NPP) of the forest ecosystem causing feedback mechanisms to C uptake and eventually atmospheric CO2 concentration.

The aim of the project is to study the long-term effects of fire on the decomposition of SOM in the northern Arctic and subarctic forests. We will study the changes in size and quality of soil C and N pools and fluxes after forest fires and their underlying processes in the Arctic and subarctic zone, especially the interactions of permafrost and post fire C balances. We will use state-of-the-art analysis techniques, field measurements and process modelling to reveal the interactions and mechanisms behind C and N cycles in Arctic forests in Finland, Canada and Russia.

The multidisciplinary project combines detailed soil process studies with remote sensing and ecosystem modelling, and produces new research knowledge on the multidimensional change processes in the Arctic region and on the factors affecting them.

Arctic Academy Programme call 2014

Long-Term Effects of Fire on Carbon and Nitrogen Pools and Fluxes in the Arctic Permafrost and Subarctic Forests (ARCTICFIRE) (cont.)

The project will be based on intensive field measurement campaigns that will be carried out in Arctic forests in Northern Yukon, Canada, in Tura in Central Siberia and at the Värriö research station in Lapland, Finland. The campaigns will be carried out in forests at different times since the last fire. We will study how forest fires affect the biologically active layer on top of the permafrost by measuring biogeochemical properties of the soil, such as soil carbon and nitrogen content, microbial species composition as well as greenhouse gas fluxes. We will also measure the changes in soil surface reflectance (albedo) from satellite images and the depth of the melted permafrost layer during the summer by using temperature sensors and soil dielectricity measurements. Finally, we will combine the measured data for developing and parameterising process-based ecosystem models to predict the effect of forest fires on forest carbon and nitrogen dynamics in the Arctic.

The international partners in ARCTICFIRE are the University of Saskatchewan, the Russian Academy of Sciences (Sukachev Institute of Forests), the Memorial University of Newfoundland and the Austrian Academy of Sciences (Commission for Interdisciplinary Studies). We will carry out our measurements in Canada in the areas of the indigenous people living in the study areas in the Arctic, such as the Gwich'in tribe, one of the northernmost aboriginal people in the American continent living in the communities of Fort McPherson, Tsiigehtchic, Aklavik and Inuvik in Northern Yukon and the Northwest territories of Canada. We will share our results with the local people living in the areas.

Arctic Academy Programme call 2014

Exposing the Long-Term Change of Arctic Ecosystems Using Novel and Multidisciplinary Techniques. *Tomas Roslin, University of Helsinki*

The Arctic is changing rapidly: it is one of the fastest-warming regions on the planet. Yet, we still know little about how environmental change affects interactions among species – what species are present in communities, and how they function together. Now, we will target this question with the help of a unique Arctic time series.

Until now, research into change in Arctic communities has been hampered by the fact that, among Arctic organisms, we know the least about the ones that make up the largest part. The Arctic, like most of the planet, is dominated by arthropods: insects, spiders and their relatives. These organisms sustain Arctic ecological functions, like plant pollination – and also plant consumption. At the same time, they feed millions of migratory birds flying north every year.

What complicates the detection of Arctic ecosystem change is the fact that long-term monitoring of Arctic arthropods has hardly been done anywhere. For this reason, our objective is to first refine, then model, possibly the longest continuous time series of arthropods from the Arctic: the arthropod samples from Zackenberg, Northeast Greenland, collected over 18 years.

The size of the Zackenberg material is both its advantage and its curse. This much material will probably never be identified to the species level by traditional means. Yet, species-level information is what we need to understand the system – to describe changes in overall biodiversity, in the relative abundances of different organisms, and in their annual rhythms.

To convert this set of just under a million specimens into straightforward numbers, we have brought together a multidisciplinary team of scientists. Using new techniques in genetics and statistical inference, we will convert the samples into a record of Arctic community composition. We intend to probe the resulting new resource to find out what determines a species' response to climate, and how communities change in time, while also seeking evidence of structural and functional tipping points. Finally, we intend to develop new protocols for the extension and continued use of the time series into the future. In this way, we aim to build a model system for exploring the biological consequences of Arctic change.

Arctic Academy Programme call 2014

Assessing Intermediary Expertise in Cross-Border Arctic Energy Development.
Veli-Pekka Tynkkynen, University of Helsinki

The Assessing Intermediary Expertise in Cross-Border Arctic Energy Development project establishes partnerships with private enterprises and North American universities to improve our understanding of how consultant experts drive the location and content of pivotal conversations on Arctic oil and natural gas development. We aim to provide a learning platform in science-industry relationships that offers public access to future Arctic developments.

Consultants and the firms they work for significantly affect the way in which government and industry leaders visualise perspectives on Arctic energy proposals. Creating Arctic energy futures brings together various types of knowledge not limited to geology, regulation and market dynamics but also new forms of visualisation and ritual-like learning environments. On-site visitations at firms will offer opportunities for identifying new aligned interests at the intersections of proprietary practice and multidisciplinary analysis.

We will undertake research assessing the role of intermediaries (consultants) in creating Arctic energy futures and utilise multidisciplinary knowledge transfers in order to transition into globally recognised leaders of cultures of expertise frameworks for scholars involved in the geographies of finance, futurity and expertise, linked to anthropology and genealogies related to science and technology studies. We want to improve the state of theory and knowledge in relation to how intermediaries engage in valuation practices that drive the location and content of pivotal conversations on Arctic oil and gas extraction.

Two patterns of development will be addressed: the increasing visibility of Arctic energy futures as detailed expectations that represent strategic resources for attracting attention from (financial) sponsors to stimulate agenda-setting processes; and the rise of intermediaries suggesting a trend towards greater control over access and production of Arctic knowledge that is privatised via commodification.

The research objectives include building a conceptual terminology and typology of the kinds of assessments that consultants produce, and further developing alignments at the intersection of proprietary practice and multidisciplinary analysis. We will combine data collection at two consulting firms and at key networking events with training secondments at Rice University and the Regional Council of Lapland in order to pilot industry and policy relevance. Utilising the results of US National Science Foundation research, we will create EU knowledge transfers for the systematised study of intermediary experts and Arctic energy futures. Supervised training on science management, raising the profile of research team members through high h-index journal publications and advisory responsibilities will increase prospects among team participants for securing tenured professorships while establishing the PI as an international science research leader.

Arctic Academy Programme call 2014

Ice Clouds and Ice Nucleation in Arctic (ICINA). *Hanna Vehkamäki, University of Helsinki; Annele Virtanen, University of Eastern Finland; Sami Romakkaniemi, Finnish Meteorological Institute and Jorma Keskinen, Tampere University of Technology*

Interest in Arctic regions has increased considerably during recent years due to the warming climate. Climate change will have a pronounced influence in the Arctic areas, where the rise in the average temperature is predicted to be twice as high as the global average. As a global average, clouds tend to cool the climate, but Arctic clouds have an opposite effect: they block more infrared radiation from escaping the Earth's surface than reflect solar radiation back into space, and contribute significantly to the melting of Arctic ice. A realistic representation of the impact of Arctic clouds is a key for proper simulation of the present-day and future climate. An accurate description of clouds in climate models requires solid knowledge about their occurrence and properties, including their phase: the amount and distribution of both liquid water and ice in the clouds need to be known. Both ice crystal formation and liquid drop formation require a seed particle to be present, and the properties of available seeds are crucial in dictating the phase of a cloud. The ice nucleation activity and concentrations of particles in the Arctic are poorly known.

The main objective of the ICINA project is to build up a framework for a realistic representation of Arctic clouds in global models. We are studying which aerosol particles can act as seeds for ice particle formation in Arctic clouds and how their abundance changes with a changing Arctic climate. The work will rely both on atmospheric observations, laboratory work and theoretical models. State-of-the-art molecular-level modelling tools will be applied to gain a fundamental understanding of ice nucleation and to construct a molecular-level theoretical framework describing the ice nucleation processes. The approach will be validated by performing experiments for ice nucleation seeds.

We will determine the ice nucleus concentrations and types and their ice nuclei activity as well as properties of clouds in Arctic areas. This will be done both by targeted laboratory experiments and by atmospheric measurements utilising direct aerosol measurement and remote sensing techniques. The project also involves development of novel measurement methods for classification of ice nucleation active particles in the atmosphere, and leads to the construction of a realistic representation of Arctic clouds in global models.

Combining expertise on ice nucleation theory, measurement method development and global modelling will help predict how the formation and properties of Arctic clouds will change in the future, improve our understanding of how these changes are feeding back to the Arctic climate and what effect increasing human activity has on the area, and improve climate models.

International Network Projects: EU Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate Call 2013)

Constraining Uncertainties in the Permafrost-Climate Feedback. *Christina Biasi, University of Eastern Finland and Tarmo A. Virtanen, University of Helsinki*

As the global climate warms, thawing permafrost may lead to increased greenhouse gas release from Arctic and Boreal ecosystems. Scientists agree that the permafrost-climate feedback is important to the global climate system, but its magnitude and timing remains poorly understood. Better predictions of how permafrost areas will respond to a warming climate can help us understand and plan for future global change. The overall aim of the COUP project is to use detailed understanding of landscape-scale processes to improve global-scale climate models. Our work is part of the European JPI Climate Transnational Collaborative Research Project (www.jpi-climate.eu/projects). COUP will provide fully coupled, quantitative estimates of the permafrost-climate feedback and its impact on global warming. To achieve this, the work in COUP follows a logical progression of (a) empirical field studies, (b) landscape-scale modelling, (c) climate model development, (d) permafrost-climate feedback quantification, and (e) parameterisation and characterisation of earth system models.

COUP builds on knowledge gained through several EU-funded and other research projects. It focuses on key remaining sources of uncertainty in the permafrost-climate feedback. Several key sites across the Russian Boreal and Arctic domains have been selected to cover the full range of environmental conditions needed to understand the permafrost-climate feedback. For these sites, data are synergistically available through other projects. In addition, some new data will be gathered to complete existing datasets.

COUP includes world-leading experts within relevant scientific disciplines with an understanding of high-latitude ecosystem climate feedbacks. Furthermore, many international external experts participate in the project's work. The research covers the whole range of studies from the molecular and microbial level to the landscape level, and from field measurements to climate model development. This gives full scientific competence needed to go from field-based knowledge to climate model projection.

As an integral part of the COUP project, the University of Eastern Finland (UEF), Kuopio, and the University of Helsinki (UH) have joined forces in making Finland an active partner of COUP. UEF's work will focus on assessing the vulnerability of Arctic soil organic C to decomposition under changing climate and landscape-level biogeochemical modelling of greenhouse gas exchange from key sites in different Arctic regions. UH will produce detailed land cover classifications and vegetation property descriptions based on satellite image and field data for the study sites, and analyse regional patterns in these datasets. Carbon and permafrost dynamics are known to vary greatly between different land cover types. Thus, detailed land cover mapping is important when the dynamics are predicted using different climate change scenarios. The information produced by the joint work in Finland will serve as a crucial input to better characterise the earth system models that presently have large uncertainties in Arctic C balance predictions. The project will also produce climate-policy-relevant information about C budgets.

International Network Projects: EU Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate Call 2013)

Social-Ecological Transformations: HUMan-ANimal Relations Under Climate Change in NORthern Eurasia (HUMANOR). *Bruce Forbes, University of Lapland*

The Arctic has undergone profound climatic variation in past centuries, when indigenous Saami, Nenets and Evenki shifted from hunters to herders. Some socio-ecological systems (SES) have proven resilient in space and time, yet most are considered at risk. An ancient Northern Eurasian livelihood, reindeer herding is a nexus for feedbacks between humans, animals and the environment. Modern management benefits from comparative analyses of complex SESs experiencing multiple stresses. Even at low human population densities, large herds affect ecosystem structure and function. Projecting future transformations requires retrospective partitioning of (1) the socio-economic and the political from climate drivers over decadal scales; and (2) human-animal agency from climate drivers over centennial scales. Robust analyses must be made in contrasting SESs across diverse geographic scales and account for heterogeneous perceptions of risk concerning the future viability of herding in the European Research Area.

HUMANOR's innovative approach includes stakeholders, in this case indigenous herders and scholars from different cultures, regions and countries, in participatory action research aimed at more flexible and collaborative governance. Grounded in the social sciences, in particular social anthropology, interdisciplinary collaboration encompasses environmental history and political ecology. We apply lessons learned from past transformations in contrasting nomadic pastoralist societies in Northern Europe, Russia and Mongolia. Through these comparisons, we aim to better understand resilience in persistent SESs within the European Research Area. Our two major research questions are as follows:

1. Based on past decadal to centennial social-ecological transformations in Northern Eurasia, to what extent is RCC likely be a factor in anticipated SES changes?
2. If patterns of real or perceived risk are identified within and among contrasting SESs, are the existing governance regimes able to facilitate resilience to sustain nomadic pastoralist SESs?

Social-Ecological Transformations: HUMan-ANimal Relations Under Climate Change in NORthern Eurasia (HUMANOR). (cont.)

The methodology encompasses several complementary aspects, including:

1) extensive participant observation in the field with active herders, semi-directed interviews with sedentary or retired herders, and phased content analysis of the resulting interviews and field notes
2) PGIS mapping of cultural heritage sites as well as contemporary human-animal agency and landscape use; knowledge held by people who have been involved in intimate and direct engagement with their land is valuable for understanding past and contemporary land use
3) reconstruction of past human-animal relationships and environmental histories on and in the vicinity of cultural heritage sites through various proxies, such as terrestrial and lacustrine pollen records, coprophilous fungi and other soil-based signatures (e.g. lipids and carbon and nitrogen isotopes)
4) visual anthropology, such as audio-visual documentation of oral histories (myths, legends, etc.) among different age cohorts, both male and female.

These methods cover different time scales, from decadal to centennial (perhaps even millennial), and various spatial scales from individual dwellings, households and corrals to landscapes and regional SESs (e.g. Sápmi). All methods share the potential to shed new light on socio-ecological transformations regardless of their nature (e.g. climate- or non-climate-related), as manifest through human-animal relationships (i.e. domestication) and landscape agency.

Notes:

