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Commission



Arctic research funded by the **European Union**

*Research and
Innovation*



EUROPEAN COMMISSION

Directorate-General for Research and Innovation
Directorate I — Climate Action and Resource Efficiency
Unit I.4 — Climate Action and Earth Observation Unit

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EUROPEAN COMMISSION

Arctic research funded by the European Union

edited by
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Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2014

ISBN 978-92-79-35262-1

doi 10.2777/60696

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Printed in Luxembourg

PRINTED ON ELEMENTAL CHLORINE-FREE BLEACHED PAPER (ECF)

INTRODUCTION

The record low in Arctic summer sea ice extent in 2012 is only one of the many indications of the rapid change observed in the Arctic, the ocean and land enveloped by the northern polar circle (66° 33' N). In fact, the northern high latitudes warm twice as fast as the rest of the world. The latest IPCC report states that “it is likely that there has been an anthropogenic contribution to the very substantial Arctic warming since the mid-20th century”¹. A virtually ice-free Arctic Ocean in autumn might well be seen within the next few decades. Greenland’s glaciers release hundreds of gigatons of ice into the ocean each year, adding to global sea level rise. Polar ecosystems back out, giving way to Atlantic species. Coasts are eroding and permanently frozen ground (permafrost) is thawing and emits methane into the atmosphere, a potent greenhouse gas, thus accelerating global warming.

None of these changes come as a surprise, since climate models predicted decades ago that the polar regions would warm more rapidly

than the lower latitudes. However, the speed at which some of these changes are currently being observed, in particular the sea ice melt, is breath-taking and was not expected. Moreover, we know little about the consequences of these changes for the Arctic environment, the people living in it and the global repercussions.

Melting ice-caps and sea-ice offer economic opportunities, like the extractions of minerals and fossil fuels in areas previously not accessible. Also, the opening of new shipping routes connecting Europe with Asia, thriving tourism and increasing fish stock in some areas are good news for local development as well as for the European and global economy. The loss of biodiversity, rising sea levels and unpredictable feedbacks of a tipping Arctic on the global climate system are the downsides. We need to better understand the Arctic environment and its changes, in order to profit from the opportunities and being able to manage the risks, as well as possible.

¹ IPCC, Working group 1, Assessment report 5, Summary for policy maker http://www.climatechange2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf

Europe has a longstanding tradition in Arctic polar research, which dates back to the pioneering explorers such as Fridtjof Nansen, Roald Amundsen, Umberto Nobile, Alfred Wegener and many others. While modern equipment allows for less riskier operations in the Arctic today, the harsh conditions and remoteness of the Arctic mean that research in this area still tends to be challenging and expensive. European countries sustain excellent infrastructure in both the Arctic and Antarctic, with permanent stations on land and in the ocean, icebreakers, aircrafts and satellites. International coordination is required in order to allow research operation in the Arctic to be effective and efficient. It helps to maximise the output and impact of national research efforts.

The European Union has supported polar research through a large number of collaborative projects, coordination activities, and support to infrastructures. Under the Seventh Framework Programme for Research and Technological Development (FP7, 2007-2013) about 200 Mio Euro were spent on research related to the Arctic.

This brochure highlights the ongoing activities supported by the Environment (including climate change) and the Infrastructure programmes of FP7.

The research adds to a number of already completed projects funded by FP7 which address all relevant aspects of Arctic environmental change like ocean and climate, sea ice, tipping points, glaciers, permafrost, marine and terrestrial ecosystems as well as the effects of Arctic change on humans including direct impacts on health, the economy and global sea level rise.

European research has contributed significantly to improve international cooperation and has provided valuable results for climate mitigation policies, adaptation, sustainable economic exploration and the local development.

The European Union and the Arctic region

Considering that three EU Member States have Arctic territory (Finland, Sweden, Denmark) the European Union plays an important role on the socio-economic

and environmental aspects of the Arctic region. The European Union is also a major destination for resources and goods from the Arctic region and many European companies operate in the Arctic. EU policies and regulations have implications for Arctic stakeholders. The European Union wants to engage more with Arctic partners in order to increase awareness of their concerns and to address common challenges in a collaborative manner focussing on three key components: knowledge, responsibility and engagement.

In the Joint Communication to the European Parliament and the Council (2012)²: “Developing a European Union Policy towards the Arctic Region”, the Commission and the High Representative of the Union for Foreign Affairs pointed out that “The EU will target its actions on knowledge: to further our understanding of the Arctic by investing in Arctic research, developing Arctic monitoring from space, supporting information and observation networks, while building

know-how and technical expertise”. Research is at the centre of European Commission engagement in the Arctic. The communication was welcomed by the Council of the European Union who supports an increased engagement of the EU research in the Arctic.

Over the last decade, the EU has become one of the largest funders of Arctic research, with contributions of about 20 million Euros per year through the Framework Programmes for Research and Innovation, to which two more Arctic States, Iceland and Norway are associated. Additionally, as part of its regional and cross-border funding, the European Union has put over one billion Euros into economic development from Greenland to Russia.

The new framework programme for Research and Innovation - Horizon 2020 (2014-2020) - will provide further opportunities to increase our shared knowledge on the Arctic and to promote innovation in and for the Arctic. Horizon 2020 is a globally open research

² *Joint Communication to the European Parliament and the Council, 2012*
(http://eeas.europa.eu/arctic_region/docs/join_2012_19.pdf)

programme and will foster international research co-operation with non-EU countries. Enhanced coordination of the Arctic research strategy has already started with the US and Canada within the Transatlantic Ocean Research Alliance³.

Polar research contributes to the EU blue growth strategy

which aims to harness the potential of Europe's oceans, seas and coasts for jobs and growth by supporting sustainable exploitation of marine resources whilst safeguarding biodiversity and protecting the marine environment, thus preserving the services that healthy and resilient marine and coastal ecosystems provide.

³ See: <http://ec.europa.eu/research/iscp/index.cfm?lg=en&pg=transatlantic-alliance>

Collaborative Research Projects - FP7 -Environment - 141 million euros

Project Name	Total Project Costs (€ mill)	Project Description (focusing on its relevance for the Arctic)
ACCESS	11,0	To assess and quantify climate change impacts on key economic sectors (maritime transport, fisheries, tourism and resource extraction) and on how the development of these sectors could affect the Arctic environment, including climate feedbacks. To produce scenarios that will help policy makers in their strategic choices. The project will also consider Arctic governance issues, including the United Nations Convention for the Law of the Sea framework.
ACOBAR	3,0	To develop an observation system for environmental monitoring of the Arctic Ocean using underwater acoustical methods.
ArcRisk	3,5	To understand a) the influence of climate change on the long-range transport of contaminants; b) the transfer of contaminants within the food web; c) and the impacts thereof on the health of human populations, including that of the Arctic. This project is coordinated by the Arctic Monitoring and Assessment Programme, a working group of the Arctic Council.
ATP	5,0	To identify and assess potential critical thresholds at which minor perturbations can irreversibly change the Arctic marine ecosystems as a result of climate change.
BACCHUS	8,8	BACCHUS will quantify key processes and feedbacks controlling Aerosol-Cloud-Interacton (ACI), by combining advanced measurements of cloud and aerosol properties with state-of-the-art numerical modelling. The analysis of contrasting environments will be the guiding strategy for BACCHUS. We will investigate the importance of biogenic versus anthropogenic emissions for ACI in regions that are key regulators of Earth's climate (Amazonian rain forest) or are regarded as tipping elements in the climate system (Arctic).
CLEAR	2,4	To investigate the links between climate change, environmental contaminants and reproductive health. Specifically, to investigate how climate change may alter the mobility, distribution and transfer of environmental contaminants, and impact on human exposure to them; and how contaminants impact on the occurrence of reproductive disorders.
COMBINE	11,4	The European integrating project COMBINE brings together research groups to advance Earth System Models (ESMs) for more accurate climate projections and for reduced uncertainty in the prediction of climate and climate change in the next decades. A work package assess climate change impacts on water availability and agriculture, globally and more specifically in three selected regions: The Arctic, the Eastern Mediterranean and the Amazon basin, where different feedbacks are important.

Project Name	Total Project Costs (€ mill)	Project Description (focusing on its relevance for the Arctic)
ECLIPSE	2,7	Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants (SLCF), perform case studies involving two major SLCF source regions as well as the Arctic as a receptor region and characterizing the uncertainties associated with impacts of SLCFs on air quality and climate and quantify the climate impacts of SLCFs beyond global-mean radiative forcing.
EPOCA	6,5	EPOCA improved our understanding of past and present spatio-temporal changes of ocean acidification; of the impacts of ocean acidification on marine biota; and of future changes in ocean chemistry and biogeochemical feedbacks in terms of hotspots, uncertainties, thresholds. It shed light on tipping points.
EUROBASIN	7,0	To understand the potential impacts and feedbacks of global change and anthropogenic forcing on the sea ecosystems of the North Atlantic, including the associated Arctic shelf. The ultimate goal of the program is to further our capacity to manage these systems (e.g. fisheries) in a sustainable manner. EURO-BASIN is part of a multidisciplinary international effort (BASIN) linked with similar activities in the US and Canada.
GREENSEAS	3,5	GreenSeas acquires historical plankton data from the Arctic, Atlantic and Southern Ocean, preparing them for rigorous statistical analysis.
HERMIONE	8,0	This project seeks to advance knowledge of the functioning of EU deep-sea ecosystems and their contribution to the production of goods and services. It considers the combined effects of climate change and human activities such as fishing, resource extraction, seabed installations and pollution. It comprises a component looking at the impact of global warming in the Arctic on deep sea ecosystems.
HYPOX	3,5	To monitor oxygen depletion and associated processes in aquatic systems due to global warming and eutrophication in open waters and land-locked systems. The Arctic is one of the focus regions. The project improves the capacity to monitor oxygen depletion globally by implementing reliable long-term sensors to different platforms for in situ monitoring. This project will use a state of the art data centre and comply with GEOSS standards.
ICE-ARC	8,8	The ICE-ARC project aims to understand and quantify the multiple stresses involved in the change in the Arctic marine environment. Particular focus is on the rapid retreat and collapse of the Arctic sea ice cover and to assess the climatic (ice, ocean, atmosphere and ecosystem), economic and social impacts of these stresses on regional and global scales.
ICE2SEA	10,0	To analyse the contribution of the loss of continental glaciers and ice sheets to sea-level rise; to reduce the uncertainties in the projections of sea-level rise due to global warming.

Project Name	Total Project Costs (€ mill)	Project Description (focusing on its relevance for the Arctic)
NACLIM	8,6	NACLIM investigates the predictability of the climate on seasonal to decadal time scales. The focus is on North Atlantic and Arctic Ocean sea surface temperatures and sea ice distributions. Both strongly affect the weather conditions in Europe.
PAGE21	6,9	To improve the understanding of the processes and dynamics affecting the size of the Arctic permafrost carbon and nitrogen pools and to assess their vulnerability to climate change. Will improve datasets and modelling, and further the understanding of uncertainties and of feedbacks involving permafrost and global change, as well as explore stabilisation scenarios.
PAST4FUTURE	9,2	Involves ice core drilling in the Arctic for understanding past climate change including sea ice and ocean circulation changes.
RECONCILE	3,5	To study the atmosphere in the Arctic and better quantify the effects of climate change on stratospheric ozone depletion and related feedback mechanisms for the Arctic region. In addition, to collect atmospheric data for accurate predictions of the future development of the ozone layer and to determine its impact on climate.
STRATOCLIM	8,5	Observation of Arctic ozone losses by means of Match campaign(s). Information of the public of increased UV radiation in case of severe ozone losses.
THOR	9,3	To forecast the development of the Atlantic Thermohaline Circulation (THC) and variability; to assess induced climate implications of changes in the THC; and to evaluate probability of extreme climate events, especially in the European/North Atlantic region.

Infrastructure - FP7 - 45 million euros

Project Name	Total Project Costs (€ mill)	Project Description
EMSO	3,9	European Multidisciplinary Seafloor and Water Column Observatory to shed light on complex earth-ocean system.
ERICON-AB	4,5	To generate strategic, legal, financial and organisational frameworks as a basis to develop, construct and run the European Polar Research icebreaker Aurora Borealis.
Eurofleets2	9,0	The WP NA2 "Polar Vision" will be the emblematic "Pioneering Group" of the EUROFLEETS2 project aiming at integrating the European Polar Research Vessel (PRV) fleet and establishing models for implementing a joint coordination of these vessels. It aims at optimizing the usage of the European Polar Research Fleet.
Fix03	7,0	The Fixed point Open Ocean Observatory network (Fix03) seeks to integrate European open ocean fixed point observatories and to improve access to these key installations for the broader community.
ICOS	4,3	To decipher the greenhouse gas balance of Europe and adjacent regions, to provide the long-term observations required to understand the present state and predict future behaviour of the global carbon cycle and greenhouse gas emissions and to monitor and assess the effectiveness of carbon sequestration and/or greenhouse gases emission reduction activities on global atmospheric composition levels.
INTERACT	7,0	To build a circum-arctic network of terrestrial field bases and thus build capacity for research and monitoring in the Arctic. Includes access to the field stations and data.
LAPBIAT	1,5	The Lapland Atmosphere-Biosphere Facility, LAPBIAT, consists of seven installations, which are spatially distributed in Finnish Lapland over 500 km range. LAPBIAT offers an access to study the interactions between the thermosphere, mesosphere, stratosphere, troposphere, biosphere and various types of ecosystems from Taiga to Tundra in the vicinity or north of the Arctic Circle.
MESOQUA	3,5	Network of leading MESOCosm facilities to advance the studies of future AQUATIC ecosystems from the Arctic to the Mediterranean, quantify the uncertainty of state-of-the-art climate forecasts by evaluating the ability to model the most important oceanic and atmospheric processes in the North Atlantic and Arctic Oceans, and by comparing key quantities with observations, quantify the impact on oceanic ecosystems and on European urban societies of predicted North Atlantic/Arctic Ocean variability.
SIOS	4,0	To assemble all existing research infrastructure in Svalbard under a common structure to integrate geophysical, chemical and biological research facilities and monitoring platforms (land-, sea-, ice/glacier- and atmosphere/space based) for improved monitoring of the global environmental change.

ACCESS

ARCTIC CLIMATE CHANGE, ECONOMY AND SOCIETY

Climate change is strongly impacting both marine ecosystems and human activities in the Arctic, which in turn has important socio-economic implications for Europe. ACCESS will make 30 years projections based on climate change scenarios for assessing the evolution of human activities such as marine transportation, fisheries, oil and gas extraction in the Arctic. Understanding the socio-economic impacts of these changes along with their influence on Arctic Governance, are key areas of research within ACCESS.

ACCESS dedicates effort to investigate new opportunities for exploiting Arctic resources due to sea ice retreat and their potential impact on the sensitive marine environment, including maritime transportation, air pollution and long range transport of pollutants by the atmospheric circulation, soot and black carbon deposition on sea-ice, oil spill and ballasting ship tanks in the Arctic Ocean.

ACCESS is also focusing on enhancing knowledge related to bio-economic and socio-economic aspects of fish resources and aquaculture in the context of climate change in the Arctic. It is the aim of ACCESS to assess the opportunities and multiple

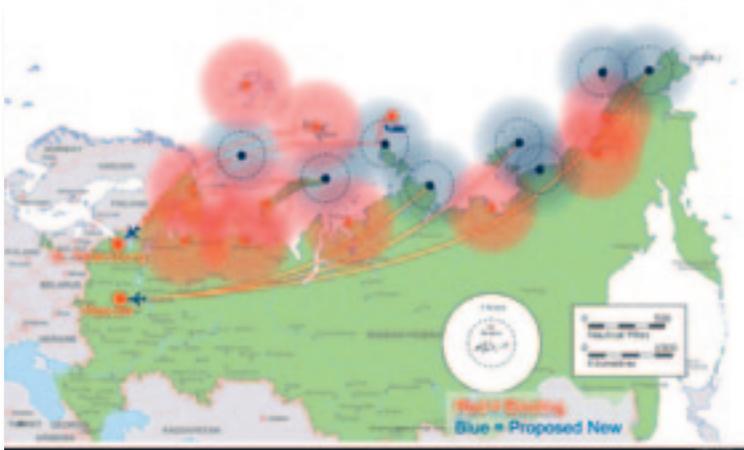
risks related to oil and gas extraction in the Arctic Ocean, to highlight potential environmental pressures, provide pathways for technological, legal and institutional solutions and to analyse the socio-economic impacts of resource extraction activity on European, world markets and societies.

A key objective of ACCESS is to point out governance options in the context of climate change and the envisioned human activities increase in the economic sectors mentioned above. The wide range of existing legislative instruments, conventions, agreements at national and international level, provide a complex system

of regulation in an area requiring special integrated overview. ACCESS is uniquely positioned to identify lacunae and to offer strategic policy options for the medium and long term future in the context of climate change and the integrated Maritime Policy.



For the first time ever, an ice class 1A bulk carrier "Nordic Orion" 225 m long from the Nordic Bulk Carriers A/S Danish company, is using the North West Passage in September 2013 as a transit trade lane when transporting 75000 tons of coal from Vancouver, Canada to the port of Pori in Finland



Assessment of existing and probably required Escape, Evacuation and Rescue stations (EER) along the Northern Sea Route (NSR)

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IMPACTS ON HEALTH

in the Arctic and Europe owing to climate-induced changes in contaminant cycling

To understand a) the influence of climate change on the long-range transport of contaminants; b) the transfer of contaminants within the food web; c) and the impacts thereof on the health of human populations, including that of the Arctic. This project is coordinated by the Arctic Monitoring and Assessment Programme, a working group of the Arctic Council.

ArcRisk used models to study transport of contaminants to the Arctic under current climate and future climate scenarios. Models compared influence of climate change on contaminant cycling in Arctic and European areas. A bioaccumulation model of organic contaminant transfer in an Arctic marine food web was developed, including the possible role of climate change.

Field/laboratory studies were: 1) contaminant deposition on snow and melt-runoff; 2) interaction of contaminants with snow/ice surfaces and particle contributions; 3) pesticides in a west Greenland fjord; 4) PCBs in coastal Arctic seas and input via major Arctic rivers; and 5) contaminant levels in seawater/ice/snow and fluxes from sea ice to water near Svalbard. Fish, reindeer and ptarmigan from

Svalbard and food samples from Greenland were analysed for organic contaminants to determine dietary levels for consumers.

Contaminant levels and health outcomes were studied in people, mainly mothers and children, in the Arctic and in Mediterranean areas and reviews prepared on health effects of various contaminants. Study of dietary sources of contaminants showed that fish/seafood are main sources of most environmental contaminants, but also contain important nutrients and omega-3 oils.

Case studies of PCBs and Hg from emission to potential health effects, a synthesis report and a web-based legacy overview of project results were also carried out.



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CLEAR

CLIMATE CHANGE, ENVIRONMENTAL CONTAMINANTS

and Reproductive Health

CLEAR - a study on the potential consequences of climate change on contaminant release to the environment and subsequent effects on human reproductive health.

The main aim of the CLEAR project is to evaluate how climate change may alter human exposure to environmental contaminants with the potential to disturb human reproductive health and development in a cohort including about 1400 pregnant women and 600 spouses from Greenland, Poland and Ukraine.

Male and female exposure to most of the measured persistent organic pollutants (POPs) and heavy metals were particularly high among Inuits from Greenland.

Only small changes in exposure to POPs are expected due to changes in temperature, precipitation, sea ice cover, primary productivity and resultant organic carbon

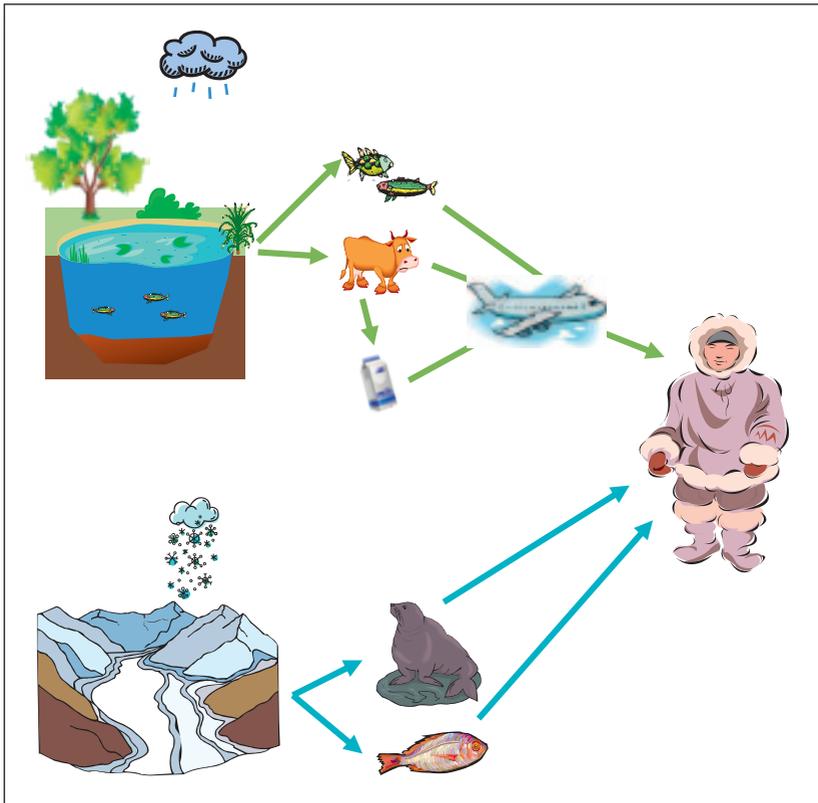
dynamics in the Arctic Ocean. However, dietary transitions which may partly be a consequence of changes in available local food items due to climate change induced habitat changes, are expected to play a major role in changes in exposures.

Studies of male reproductive toxicity indicated a relative strong inverse association between phthalate metabolites and male testosterone level. Female reproductive function measured as time to pregnancy and menstrual cycle characteristics was indicated to be adversely affected at higher level of exposure to perfluorinated compounds (PFCs). Finally organochlorine exposures were indicated to have minor if any effects on growth,

motor and behavioural development, but PFCs was indicated to be associated more ADHD like behaviour.

In conclusion, the study demonstrates that climate change will not directly cause major changes in environmental POP exposure

levels in the Arctic and environmental contaminants does not have marked influence on adult male and female fertility or child growth and development. However, the long-term effect of fetal exposure on adult reproductive health has not been addressed.



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EUROBASIN

BASIN-SCALE ANALYSIS, SYNTHESIS & INTEGRATION

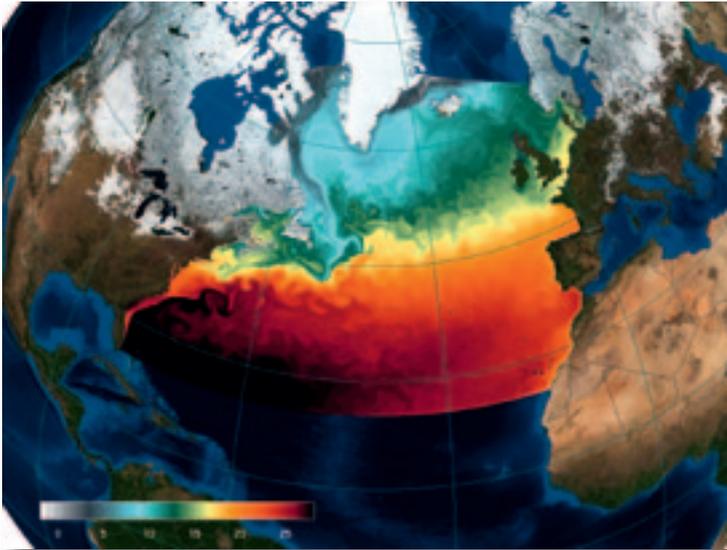
EURO-BASIN sheds light on the North Atlantic

The North Atlantic abundant fishing stocks have steered the course of Western civilization over the past 5 centuries, and the sustainability of its ecosystem services are a vital part to the economies of Europe and N. America.

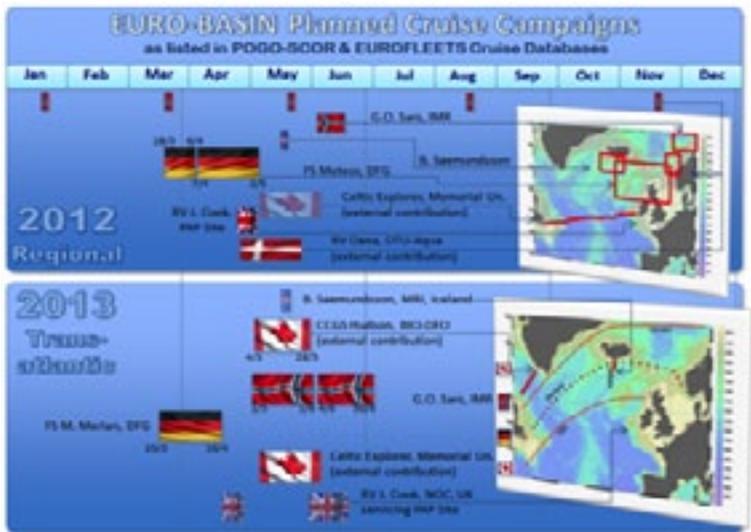
Human exploitation and a changing climate place immense pressures on the basin's ecosystems and threaten fisheries grounds. EURO-BASIN is part of an international initiative co-funded by the EU, that brings together leading marine institutes to study how a changing climate and ocean management scenarios may affect ecosystem services.

The North Atlantic not only regulates European climate, but also effortlessly recycles every second molecule of CO₂ that we expire in the atmosphere (even while reading these lines). The EURO-BASIN project aims to find management strategies, so that it will continue to do so effectively in the future.

The extensive 2012-2013 field campaigns at sea have gathered significant data throughout the food-web, extending to sub-Arctic waters. The final synthesis phase in 2014 will demonstrate the economic value of the basin in climate regulation, and economic loss of suboptimal fisheries management.



EURO-BASIN domain of activity as defined by sea surface temperature from NEMO-ERSEM model (courtesy of J.Harle, NOC; NASA Blue Marble).



International collaborations during the 2012-2013 ocean-going campaigns (www.euro-basin.eu).

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EUROFLEETS2

NEW OPERATIONAL STEPS TOWARDS AN ALLIANCE

of European research fleets

EUROFLEETS2 is promoting integration within research fleets. It is focusing on polar research fleets through a work package dedicated to a flagship initiative for polar access led by AWI. Its trans-national access activity makes 2 ice breakers and 5 polar and sub polar European research vessels available.

EUROFLEETS 2 is an Integrated Infrastructure Initiative European project as its predecessor EUROFLEETS 1. It aims to develop a new pan-European distributed infrastructure with common strategic vision and coordinated access to key European research vessels and marine equipment.

Launched in March 2013, EUROFLEETS2 undertakes specific actions to consolidate fleets' organization, methodology and tools through operational initiatives leading to more interoperable and cost effective European research fleets.

EUROFLEETS2 main objectives concerning polar research fleets are:

- Completion of strategic perspectives for the European fleets with a polar component focus;
- Trans National Access activity, to allow international scientific parties to get access to key polar research vessels as

Polarstern, Hesperides, OGS-Explora or G.O. Sars on condition of scientific excellence of their cruise proposals. Various calls for ship time will be opened in this respect in 2014;

- Launching of training actions including a pilot floating university on board Dana.

EUROFLEETS2 involves multi-disciplinary expertise split

among 31 marine organizations, universities and SMEs from 19 nations (including fourteen member states, four associated countries to EU and Greenland).



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EuRuCAS

EUROPEAN- RUSSIAN CENTRE

for cooperation in the Arctic and Sub-Arctic
environmental and climate research

EuRuCAS project uses the Nansen International Environmental and Remote Sensing Centre in St. Petersburg, Russia, as the joint research facility to extend and consolidate scientific cooperation between researchers from EU Member States and Associated Countries with those from Russia in the field of climate and environmental changes in the Arctic and Sub-Arctic in the 21st century and their socio-economic impact.

EuRuCAS project aims on extension, consolidation and strengthening scientific cooperation between researchers from EU Member States and Associated Countries and Russia on the base of the Nansen International Environmental and Remote Sensing Centre (NIERSC) in St. Petersburg through physical work of researchers from Partner's institutions at NIERSC and conducting joint studies with Russian scientists in the environmental and climate change research in the Arctic and Sub-Arctic including socioeconomic issues, submitting joint proposal for further scientific cooperation far beyond EuRuCAS completion and opening NIERSC institutional arrangements

for new partners from EU Member States and Associated Countries.

For the first half of the Project the following major results were obtained: NIERSC research facilities were enhanced; the Integrated Research Plan (IRP) was developed and several joint working groups within EuRuCAS Consortium were established according to IRP; Memorandum on the NIERSC's Associated Partnership was elaborated and two new Associated Partners –University of Helsinki from Finland and Nansen Scientific Society from Norway, joined NIERSC; several joint proposals were submitted, two from which got funded.

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FIXO³

FIXED POINT OPEN OCEAN

Observatory network

The FixO³ Project seeks to integrate the European open ocean fixed-point observatories. 29 partner institutions from 10 European countries participate in the 4-years programme.

The Fixed-point Open Ocean Observatory network (FixO³) is a 4-years programme started in September 2013 with a budget of 7 Million Euros that seeks to integrate European open ocean fixed point observatories and to improve access to these key installations for the broader community providing multidisciplinary observations of the oceans from the air-sea interface to the deep seafloor.

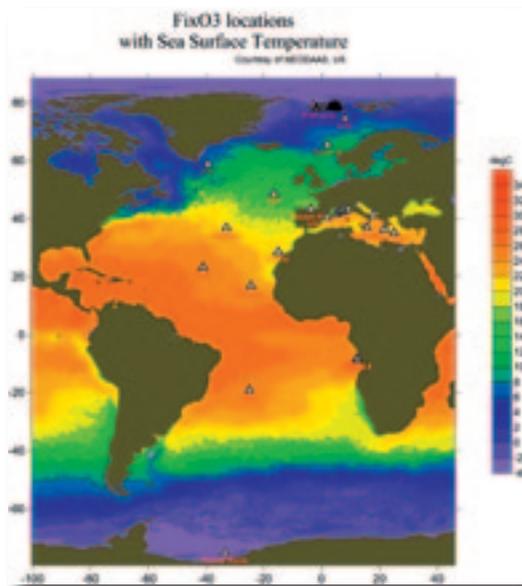
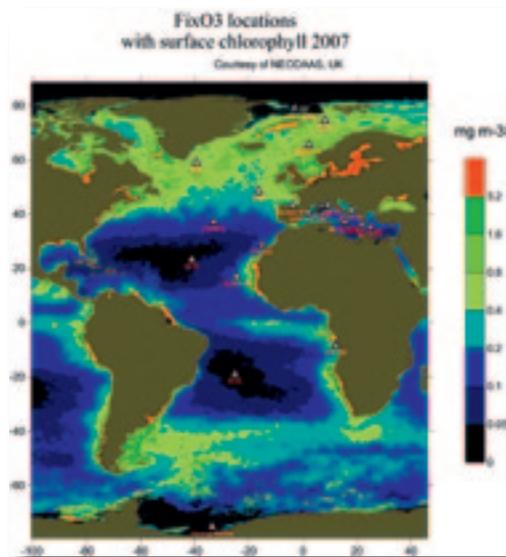
Coordinated by the National Oceanography Centre in the UK, the Network includes 29 partners from academia, research institutions and small and medium enterprises. In addition 12 international experts from a wide range of disciplines comprise an Advisory Board.

The programme includes: coordination activities to integrate and harmonise the

current procedures and processes; support actions to offer access to observatory infrastructures and open data services and products; joint research activities to innovate and enhance the current capability for multidisciplinary in situ ocean observation.

The FixO³ network will provide a strong integrated framework of open ocean facilities including the Arctic enabling an integrated, multidisciplinary approach to understand natural and anthropogenic change in the ocean.

Within few months since the start, the Project Management Office has been set up and delegates from all partners met in Rome to kick-start the programme. Further information can be found at <http://www.fixo3.eu/> and on Twitter, Facebook and Google+.



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ICE-ARC

ICE, CLIMATE AND ECONOMICS -

Arctic Research on Change

ICE-ARC (Ice, Climate and Economics - Arctic Research on Change) assesses the impact of change in the Arctic on regional and global scales. These include both economic, and social and climatic (sea-ice, ocean, atmosphere, and ecosystem) impacts.

Arctic change impacts the local, regional and global climate through complex coupling mechanisms within the Earth system. However these are not the only changes the Arctic is going through. It is predicted that commercial investment in the Arctic could reach \$100bn or more in the coming decade, with oil and gas, mining and the shipping industries being the biggest drivers. This 'industrialisation of the Arctic' seems to be driven by a combination of climate change and the ever-increasing demand, and price, for resources. The environmental, socio-economic and geopolitical consequences of Arctic change will be considerable.

Because of the seriousness of this situation we have to ensure that national and international politicians and

policy-makers, as well as industry and the public, have the most up-to-date and robust science available on Arctic change. Evidence based and not ideological based decision-making is fundamental to ensure that informed policy decisions can be reached.

With these substantial issues in mind the EU have funded a €12 million programme of research that aims to understand and quantify the multiple stresses involved in the change in the Arctic marine environment. Our programme ICE-ARC (Ice, Climate and Economics - Arctic Research on Change) assesses the climatic (sea-ice, ocean, atmosphere, and ecosystem), economic, and social impacts of these stresses on regional and global scales.

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Ice2Sea

ESTIMATING THE FUTURE CONTRIBUTION

of continental ice to sea-level rise

Ice2sea brings together the EU's scientific and operational expertise from 24 leading institutions across Europe and beyond, to improve understanding of ice-sheets. Ice2sea has provided improved projections of the contribution of ice to sea-level rise and informed the IPCC's 5th Assessment Report.

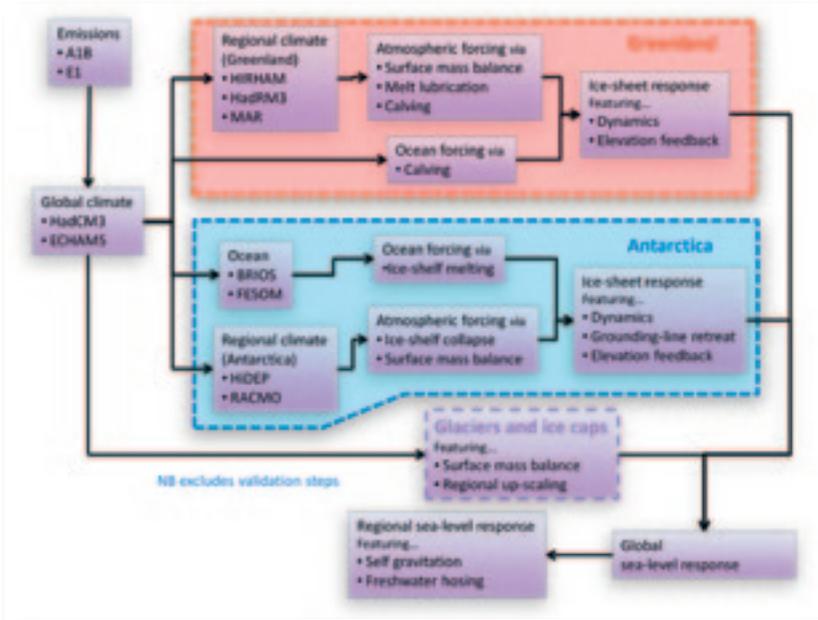
The future security and prosperity of European coastal cities and the survival of many unique European coastal habitats are threatened by rising sea-levels and increased risk of coastal flooding. Reliable projections of future sea-level change provide a basis for planning associated adaptation and risk-management strategies.

Ice2sea has focussed the efforts of researchers in 24 institutes from across Europe and beyond - in a coordinated programme of field-work, satellite observations, and computer simulations. The cooperation achieved by ice2sea between key institutes and scientific

disciplines has advanced the understanding of present and future sea-level change to a degree that would not otherwise have been possible. Ice2sea has made fundamental progress in measuring ongoing changes in ice sheets and glaciers, and in understanding the processes responsible for rapid ice-loss, and both global and regional sea-level rise.

Ice2sea has reduced uncertainty in the contribution of ice sheets and glaciers to sea-level projections by: making key measurements of current changes; improving understanding of their causes; and by developing new methods for projection. Ice2sea has established

a substantial European capability in sea-level projection, has identified where the remaining uncertainties exist, and which key processes are still not fully understood.



Ice2sea model approach

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INTERACT INTERNATIONAL NETWORK

for Terrestrial Research and Monitoring in the Arctic

INTERACT, a multi-disciplinary network of 58 land-based Arctic and northern research stations, is building capacity throughout the Arctic for environmental monitoring, research, education and outreach. It brings station managers together, operates transnational access, develops new monitoring technologies and interacts with regional and global initiatives.

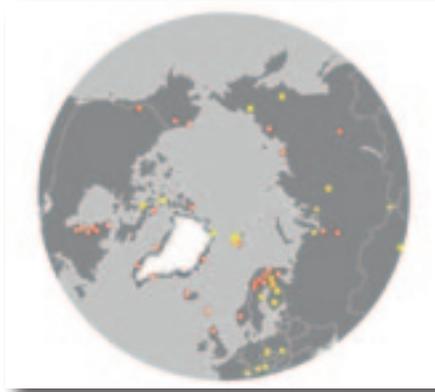
INTERACT networks land-based research stations from all Arctic countries and northern regions to build capacity for research, monitoring, education and outreach. INTERACT is multi-disciplinary. It networked 33 research stations in 2010 but by 2013, the network had grown to 58 in 19 countries. Together, these stations host thousands of researchers.

A Station Managers Forum has produced a highly successful Station Catalogue containing practical information to prospective researchers and a volume on Station Best Management. It is also producing a metadata base of monitoring and research activities. Over 20 Stations offer Transnational Access and for the first time, INTERACT offers access to Russian

and Canadian stations. By the end of 2014, INTERACT will have provided over 7600 person-days Transnational Access to over 500 researchers.

INTERACT networks regionally and globally and is implementing international research and monitoring agendas. These roles are enhanced by Joint Research activities that have designed virtual instrumentation, established equipment to measure biophysical feedbacks to climate, and have designed software to improve data management by stations. INTERACT works with educators and gives exceptional outreach at all levels, operates community science and is collecting Traditional Knowledge.

INTERACT is continuing to grow.



INTERACT is a comprehensive network of Arctic and northern research stations that together host thousands of scientists each year and have environmental monitoring programmes. There are currently 33 partner research stations (red dots) and 25 Observer Stations (yellow dots), in 19 countries but INTERACT is still growing.



International Summer School at the INTERACT Observer Station Aktru in the Altai Mountains where environmental change is particularly rapid.

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NACLIM

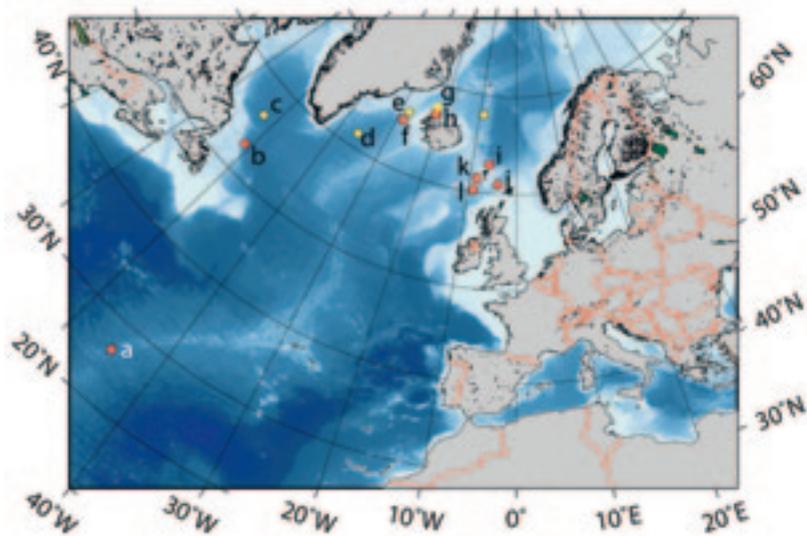
NORTH ATLANTIC CLIMATE

The project scientific focus is on the following core themes: Predictability of key oceanic and atmospheric quantities, monitoring of North Atlantic parameters, initialization of prediction systems with ocean observations, impact on the oceanic ecosystem and urban societies.

NACLIM investigates the predictability of the climate on seasonal to decadal time scales. The focus is on North Atlantic and Arctic Ocean sea surface temperatures and sea ice distributions. Both strongly affect the weather conditions in Europe. NACLIM goals include an improvement of multi-model decadal predictions and optimizing long-term observations in the North Atlantic.

Atmospheric model simulations show a clear linkage between the autumn Arctic sea ice retreat and winter snowfall in Europe. Sea ice anomaly patterns affect the atmospheric circulation over the continent and can be used to forecast the upcoming winter conditions by determining the large-scale air pressure distribution.

Coupled ocean-atmosphere forecast models, initialized with high quality observational data, were run using start conditions from the past. Here we are able to predict surface temperature and ice cover in the Nordic and Barents seas up to eight years ahead. For understanding climate variability on even longer time scales we have studied the Atlantic Ocean's response to increased freshwater input from the Arctic Ocean. We conclude that the ongoing freshening can still be explained by natural variability, but the expected increase associated with global warming and the gradual transition to an ice free Arctic Ocean in summer will reduce the stability of the Atlantic Meridional Overturning Circulation.



Red dots represent locations where data on fluxes are collected, yellow dots represent locations where hydrography data are collected: RAPID — transport of MOC components at 26.5° N (a), Labrador Sea western boundary current (b), Central Labrador Sea (c), Irminger Sea (d), Denmark Strait (e and f), Hornbanki section (g and h), Iceland Faroe Ridge (i), Faroe Shetland Channel (j), Faroe Bank Channel (k), Wyville Thomson Ridge (l).

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CHANGING PERMAFROST

in the Arctic and its Global Effects
in the 21st Century

To improve the understanding of the processes and dynamics affecting the size of the Arctic permafrost carbon and nitrogen pools and to assess their vulnerability to climate change. PAGE 21 will improve datasets and modelling, and further the understanding of uncertainties and of feedbacks involving permafrost and global change, as well as explore stabilisation scenarios.

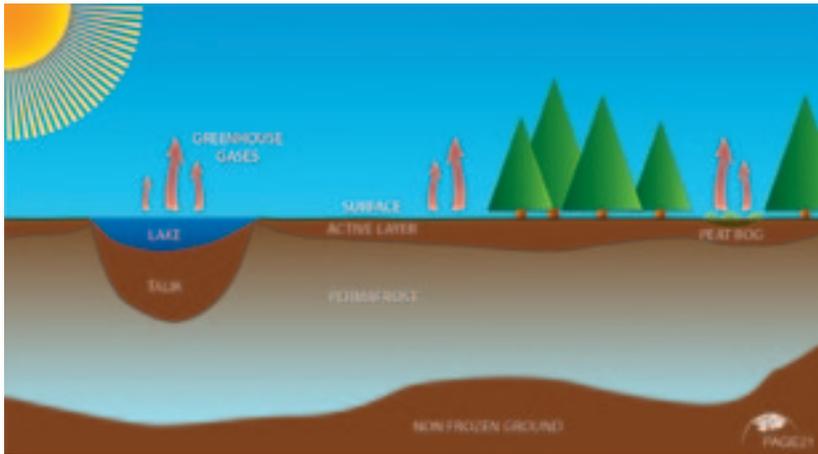
PAGE21 is a large scale integrated permafrost research project that will further our understanding on the interactions between the global climate system and the frozen ground.

The project is at midterm and moving from field research period to remote sensing data integration and Global Climate Model development. It has been actively establishing ties to international projects of a similar dimension, including Memorandums of Understanding with the Japanese GRENE-TEA and the Canadian AD-APT projects and a linkage with the North-American project NGEE, becoming a

part of a research network of coordinated investment in permafrost research close to 50 M€.

Several members of the IPCC 5th Assessment Working Group I participate in PAGE21, ensuring a strong impact of the results on global policy discussions on emission reduction targets.

PAGE21 has also close ties with the International Permafrost Association (IPA) and contributes to the creation of the first global database on permafrost temperatures within the framework of the Global Terrestrial Network for Permafrost (GTN-P).



Info graphic on permafrost



Svalbard, Norway

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SIOS

SVAlBARD

INTEGRATED EARTH

Observing System

*SIOS will set up new core **research services** providing coordinated open access to research facilities, better sharing of data, efficient logistics, scientific and observational integration, training programs, workshops and better knowledge management. SIOS will also optimize the **Observing system** within the Earth System Science domain by managing a joint research infrastructure development plan, developing new methods for designing and implementing observational capacities, and enhancing the use of remote and small foot-print observation methods.*

SIOS shall be a regional observational system for long term acquisition and proliferation of fundamental knowledge on global environmental change within an Earth System Science (ESS) perspective in and around Svalbard. SIOS aims to be the world's leading large-scale research infrastructure in the Arctic, and will provide state-of-the-art research services to the international polar research community by:

- improving collaboration and formalise scientific and observational integration between the extensive existing research infrastructures already in place in Svalbard
- providing a regional, world class, integrated observing system for long-term acquisition of fundamental data in

the ESS domain

- providing better coordinated services for the international research community; access to infrastructure, data and knowledge, sharing of data, logistics, training, education and outreach
- close coordination with other ESFRI and I3 projects with Arctic nodes, regional research networks in the European Arctic - significantly contribute to the realisation of a pan-Arctic Observing Network (SAON), endorsed by the Arctic Council.

SIOS will establish a joint Knowledge Centre (SIOS-KC) in Longyearbyen for coordination and services for access to world class research infrastructure and manage shared resources, data and joint activities.



Spitsbergen mountains and glaciers.



Polar bear at a weather station on Kvitøya, Svalbard.

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STRATOCLIM

STRATOSPHERIC AND UPPER TROPOSPHERIC

processes for better climate predictions

Understanding the role of the upper troposphere and the stratosphere in the climate system and improving its interactive representation in earth system models.

StratoClim will produce more reliable projections of climate change and stratospheric ozone by a better understanding and improved representation of key processes in the Upper Troposphere and Stratosphere (UTS).

The project will integrate observations from dedicated field activities, process modelling and global modelling.

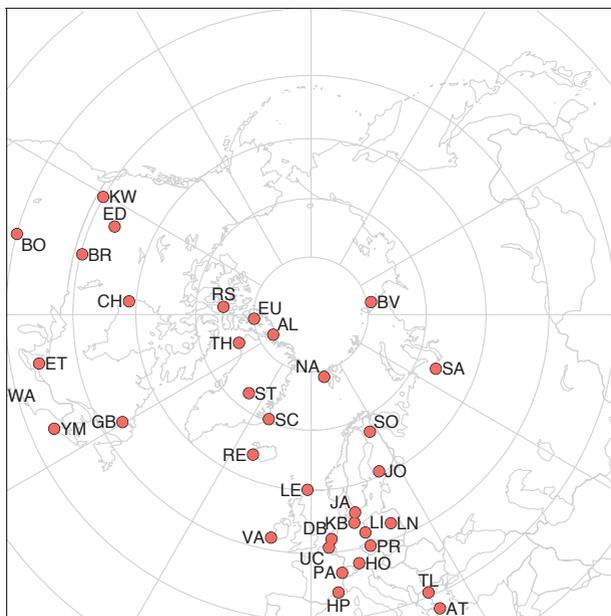
StratoClim will

- improve the understanding of the microphysical, chemical and dynamical processes that determine the composition of the UTS, such as the formation, loss and redistribution of aerosol, ozone and water vapour, and how these

processes will be affected by climate change;

- implement these processes and fully include the interactive feedback from UTS ozone and aerosol on surface climate in CCMs and ESMs. To better constrain the mutual interactions between climate change and polar ozone chemistry a highly coordinated ozonesonde campaign started in the Arctic stratosphere in January 2014. Based on the data from the campaign and real time model calculations the situation in the Arctic stratosphere will be monitored closely and upcoming severe ozone loss events will be communicated.

Match Winter 2013/14 : Participating Ozonesonde Stations



Stratoclim match stations

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European Commission

Arctic research funded by the European Union

Luxembourg: Publications Office of the European Union

2014 — 40 pp. — 14.8 x 21 cm

ISBN 978-92-79-35262-1

doi 10.2777/60696

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This publication offers a selection of key FP7 projects in the area of the Arctic research.

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Project information



Publications Office

ISBN 978-92-79-35262-1



doi:102777/60696