FACTSHEET

Climate Change in the Arctic

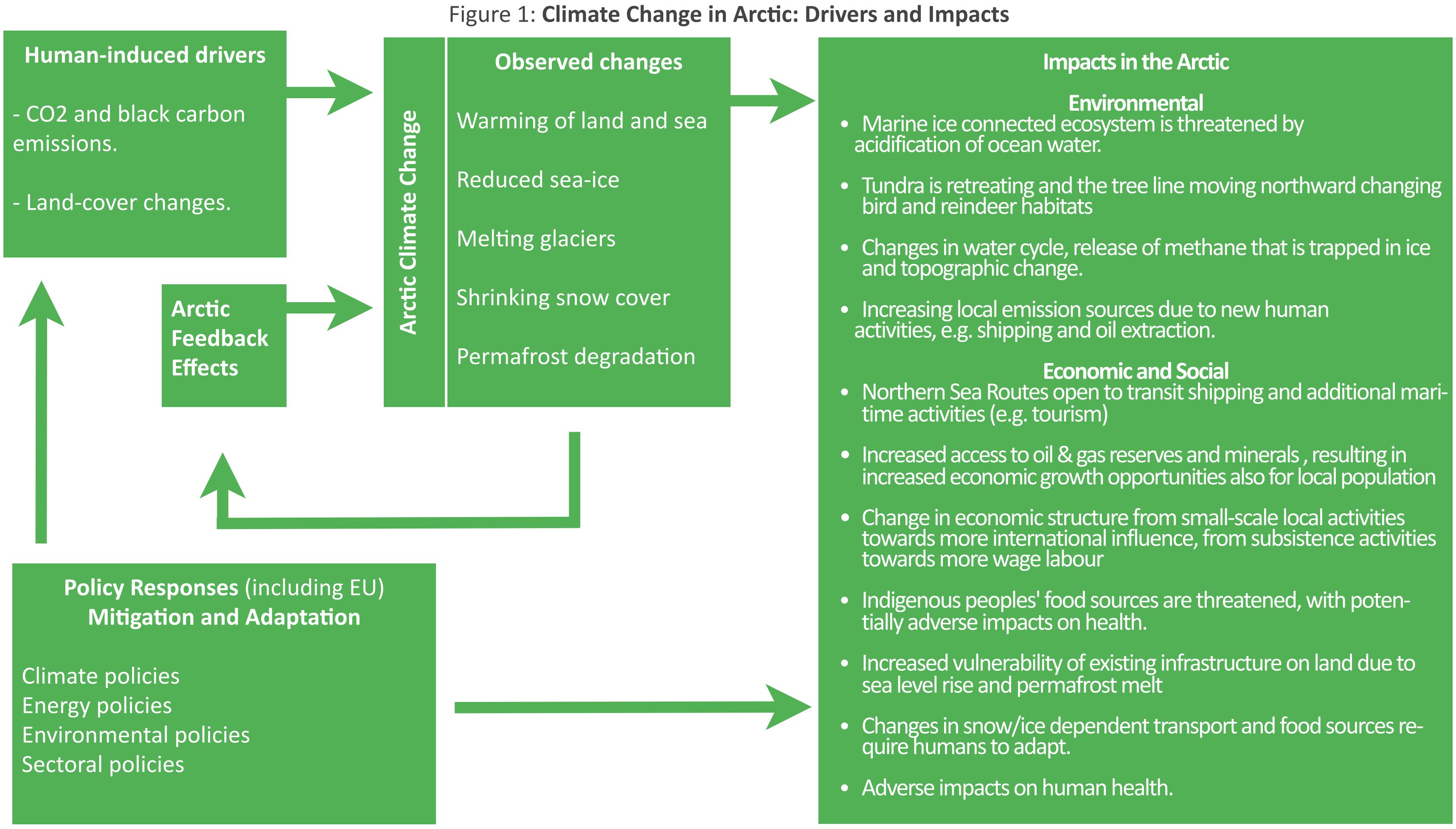
Overview

The Arctic is the most rapidly changing climate region on Earth. There is clear evidence of change that has already occurred due to emissions of greenhouse gases and aerosols from human activities. These affect the fundamentals of Arctic ecosystems and the lives of its inhabitants. The Arctic is a particularly fragile region where strong ecosystem feedbacks accelerate changes compared with other regions - an effect called “Arctic amplification”. Changes in the Arctic ecosystem dynamics have global consequences

Today we see clear evidence of significant changes in Arctic landscapes and marine environments. Climatic changes are affecting the Arctic cryosphere (areas where water is in solid form, e.g. sea-ice, glaciers, snow cover and permafrost), hydrology, habitats and species. Examples of impacts include the formation of new wetlands and lakes due to melt water and the rapid draining of lakes and loss of freshwater resources due to permafrost degradation.

Changes in temperature, sea-ice cover, snow cover and water regimes are linked to the loss of important habitats for Arctic species, as well as shifts in the species composition due to landscape transformations, which in turn impact on people’s livelihoods (Figure 1).

Figure 1: **Climate Change in Arctic: Drivers and Impacts**



Website: www.arcticinfo.eu

Strategic Environmental Impact Assessment of Development of the Arctic

This factsheet is to stimulate dialogue between stakeholders, Arctic experts and EU policymakers. Stakeholder input informs the analysis of trends and the role of the European Union in shaping Arctic developments. It will lead to recommendations to EU policymakers and be published as the Strategic Assessment of Development of the Arctic Report in spring 2014. The European Commission-funded project is implemented by a network of 19 institutions lead by the Arctic Centre in Rovaniemi and is linked to the EU Arctic Information Centre initiative.

Research shows unquestionably that the effects of climate change are strong in the Arctic. Yet there remains uncertainty on its drivers, evolution and ultimate impacts. More long-term observations are needed to improve analysis of climate-related predictions in the Arctic.

The European Climate Research Alliance (ECRA) – an association of institutions focused on climate research - has initiated an Arctic programme to improve understanding and analysis. The European Union has raised the profile of the Arctic for its Member States.

> "Research shows unquestionably that the effects of climate change are strong in the Arctic. Yet there remains uncertainty on its drivers, evolution and ultimate impacts."

This factsheet considers climate change in the Arctic with a European perspective. It looks at potential impacts in the Arctic based on a long-term outlook that assumes a 4 degrees Celsius (°C) global warming by 2100, a "most likely scenario" in the World Bank's 2012 *Turn Down the Heat* report. It also relies on region-specific information from the Arctic Monitoring and Assessment is informed of the preliminary fifth Intergovernmental Panel on Climate Change (IPCC) assessment report information.

The IPCC reviews and assesses the most recent available scientific, technical and socio-economic information relevant for the understanding of human-induced climate change and issues its reviews every four to six years. It does not conduct research nor monitor climate-related data. Its assessment is influential in global consideration of climate change and its impacts.

IPCC´s most recent assessments are due to be released in the period September 2013 to October 2014 in its Fifth Assessment Report. The IPCC Physical Science Basis report is due to be released and this fact sheet is aligned with its findings.

A Hunting Polar Bear Searches for the Next Prey

Photo: GettyImages

Trends from a rapidly warming Arctic

The most straightforward change is globally strongest increase of temperatures in the Arctic. The region is predicted to experience almost three-times the warming compared to the European average. Climate prediction models agree that the most pronounced warming (between 4 °C and 10 °C) would likely occur over land surfaces, particularly during the boreal winter.

Why Does the Arctic Warm Faster than Lower Latitudes?

- As snow and ice melt, darker land and ocean surfaces absorb more solar energy and the extra trapped energy goes directly into increased warming of the atmosphere.
- The Arctic atmosphere is shallower than in lower latitudes (thus, the same amount of absorbed energy warms the atmosphere more) and less effective to transport energy away.
- Black carbon (soot) has a feedback effect on both the atmosphere and on snow and ice cover.

The Arctic amplification effect results in projected temperature anomalies of more than 10 °C in the Arctic region. Winters are predicted to warm more than summers.

Today's climate prediction models need to be improved to more accurately reflect potential changes in snow, ice and permafrost in the Arctic.

> "The region is predicted to experience almost three-times the warming compared to the global average. "

Because of limitations in representing the cryosphere, climate model predictions for the Arctic have a lower confidence level than for other regions. Nevertheless, the outlook for changes in the Arctic is significant and must be fully taken into account despite this uncertainty.

Arctic Sea-Ice Cover is Rapidly Shrinking

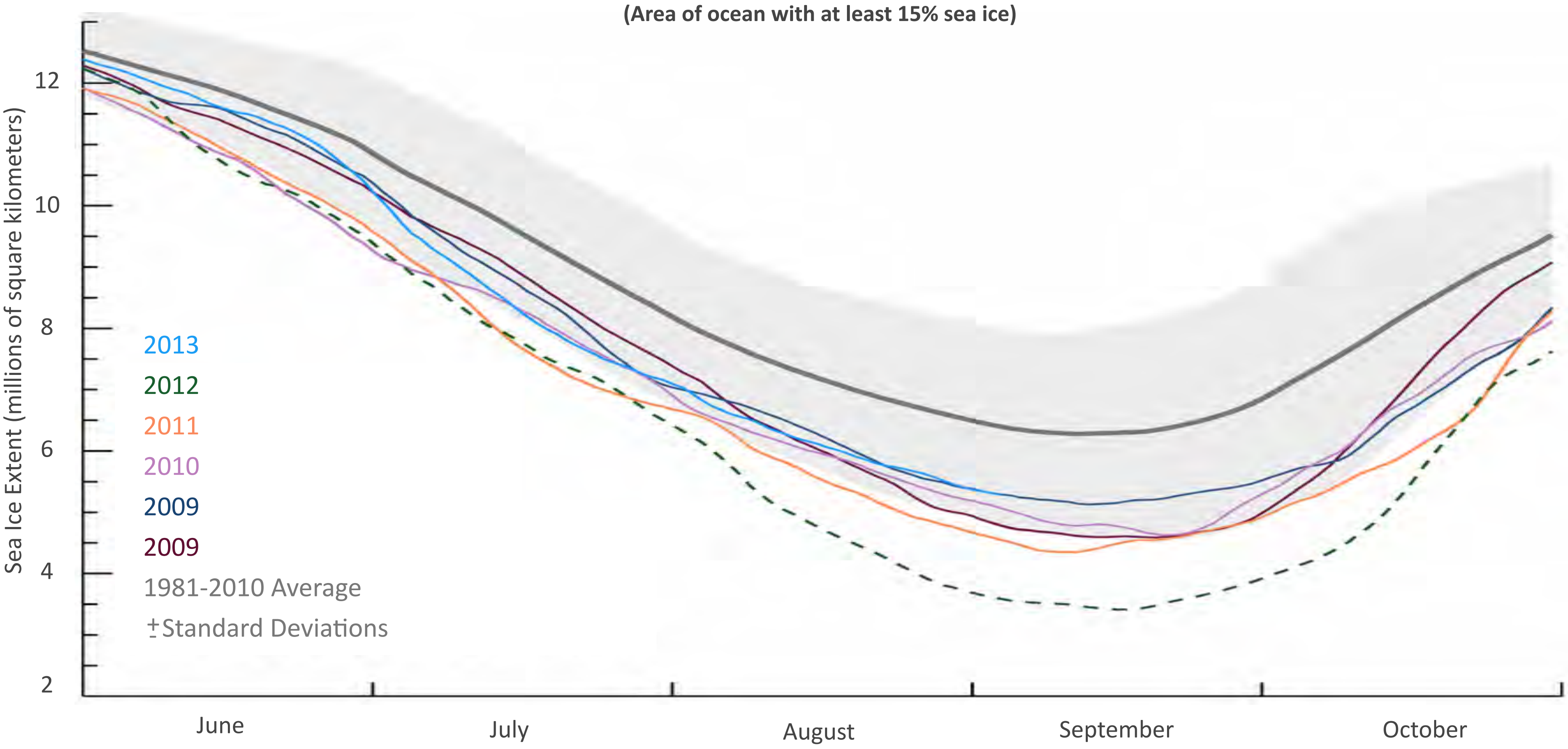
The summer extent of sea-ice has notably declined in recent years, as illustrated for 2008-2013 in Figure 2. The difference in the extent of sea-ice in September 2012 compared with the median over the last three decades is striking (Figure 3, page 3).

In addition, the ice that remains has less multi-year ice, which means the ice is weaker and thinner. The outlook is for continued decline of sea-ice extent and less multi-year ice. By the 2030s, the Arctic could be ice-free in late summer.

Melting Ice Is Raising Sea Levels

Since 1993, world average sea level has been rising 3.2 millimetres (mm) per year, compared to the 1901-2010 average of 1,7 mm per year. In the Western North Pacific sea level rise is over 10 mm per year Melting of glaciers in the Arctic amount to almost 80% of total ice loss in the last decade.

Figure 2: **Arctic Sea-Ice Extent, 2008 - 2013**
(Area of ocean with at least 15% sea ice)

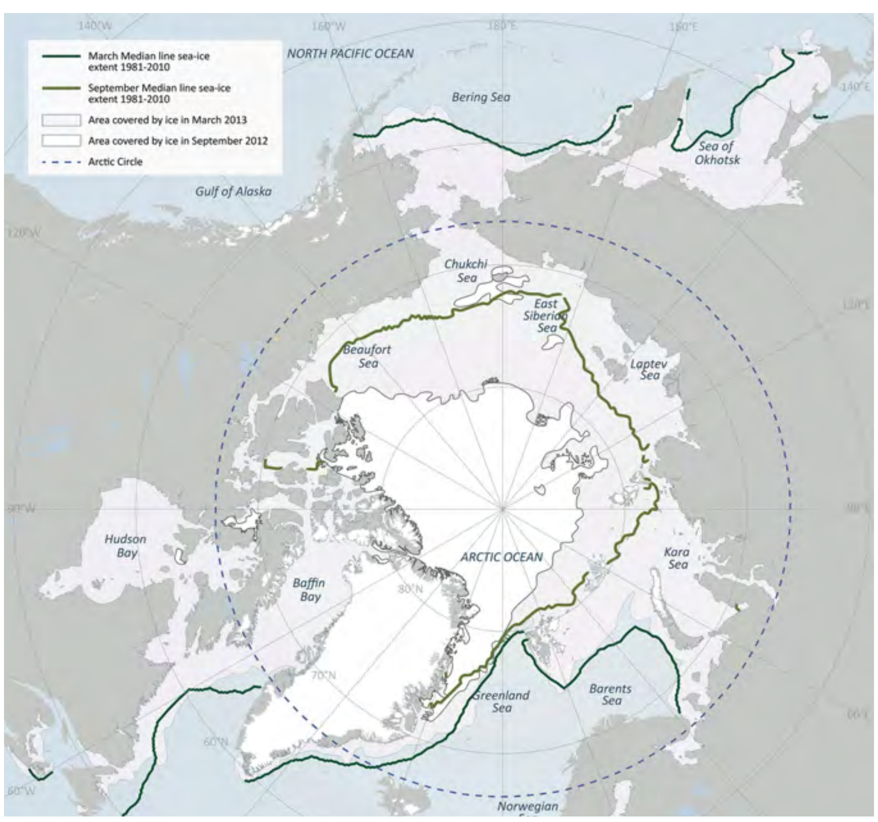


Note: The dark grey shows the average for 1979 – 2000; light grey shading represents standard deviations. Source: US National Sea and Ice Data Centre, 2013, at nsidc.org

Glaciers in Greenland are losing ice mass at a pace over six-times that of the previous decade.

Plus, the speed at which it is melting is accelerated. Figure 4 depicts the extent of melting in 2012 and 2013 compared with the 1981-2010 average.

Figure 3: **Arctic Sea-Ice Extent, September 2012 and**



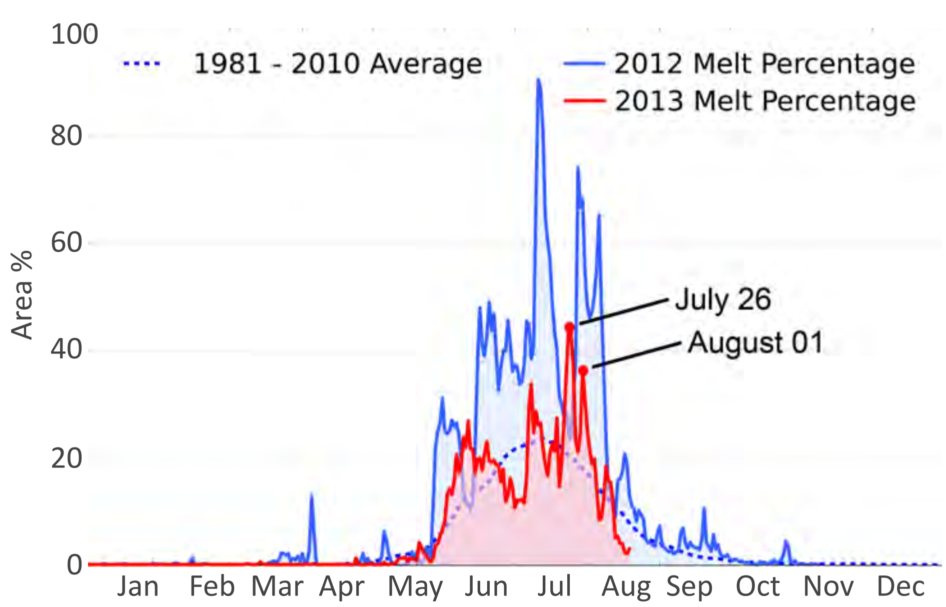
Note: Sea-Ice extent on 16 September 2012 in blue (the smallest sea-ice extent occurs annually in mid September); median extent 1981-2010 in orange contour. Source: Arctic Portal, based on data from US National Snow and Ice Data Center, 2012.

Snow Cover Is Shrinking Faster than Sea-Ice

Duration and extent of snow cover have significant impacts on life in the Arctic. Both length of time and spring/summer extent of snow-cover area are diminishing. Snow observations in recent years show a more rapid change than in sea-ice. Over the period 1967–2012, northern hemisphere snow cover extent decreased most in June by 53%. Models are indicating a future where winters will likely have more precipitation in the European Arctic, while summers show only modest increases.

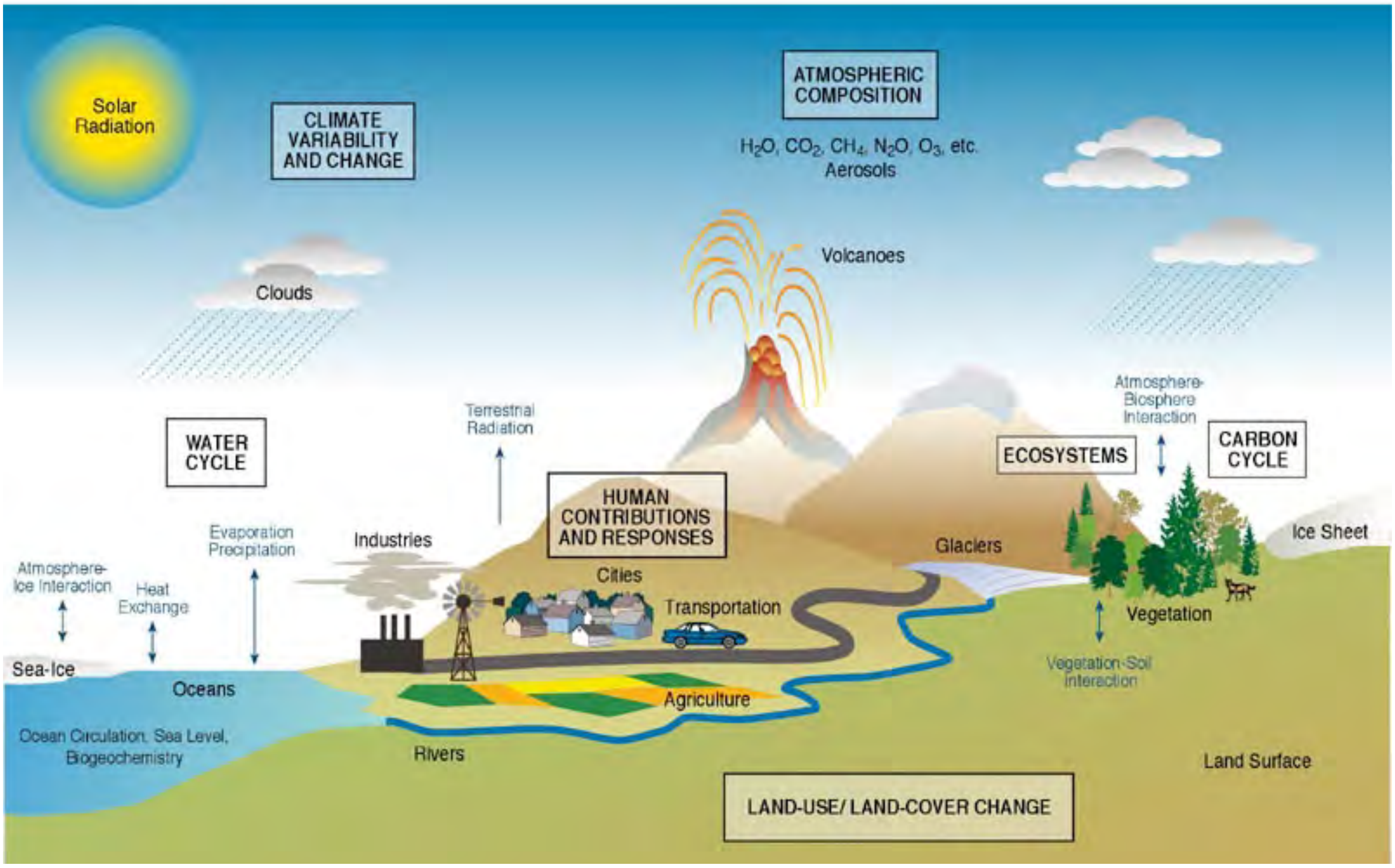
The Arctic could see a shorter period of snow cover, while having more snow during winter. If this occurs, snow cover in the summer will continue to shrink.

Figure 4: **Greenland ice sheet melting in 2012 and 2013**



Source: US National Snow and Ice Data Center, 2013.

Figure 5: **Earth Climate System and Main Forcing Mechanisms on Our Atmosphere**



Source: Intergovernmental Panel on Climate Change, Third Assessment Report, 2002.

Drivers

The main drivers of Arctic climate change are the same as the drivers of global climate change. The complex interactions governing our atmosphere are simplified in Figure 5.

Human activities create emissions of greenhouse gases and aerosols. Greenhouse gases increase the natural greenhouse effect of the atmosphere forcing the atmosphere to warm and change many other conditions on Earth.

Aerosols and other gases have more complicated processes that impact the climate, for example by changing the location and properties of clouds or by darkening snow surfaces.

Soot (black carbon particles) and co-emitted short-lived climate forcing particles may be contributing to Arctic amplification. Black carbon on snow/ice absorbs more sunlight than clean snow. Soot in the air warms the atmosphere directly.

The Arctic has a specific amplification mechanism associated with the changing Arctic sea-ice extent. Atmospheric warming and warmer waters enhance the melting of Arctic sea-ice in summer. Ice would reflect most sunlight back. The open ocean absorbs the sunlight energy, which results in additional warming.

Impacts

Today's global-scale climate prediction models lack the precision and complexity for detailed regional and local impact analysis. Nonetheless, predicted changes can be related to concrete challenges for life in the Arctic.

Oceans absorb some CO2 from the atmosphere in natural processes. Additional CO2 in the atmosphere caused by human activity results in additional acid uptake by the ocean. This uptake causes a chemical change in the ocean CO2 system so that pH has decreased, resulting in ocean acidification. In the Arctic and high latitudes, this mechanism is stronger than in regions closer to the equator. In addition, melting of the cryosphere adds freshwater to the Arctic Ocean, which has the potential to alter ocean circulation patterns.

Reduced sea-ice, ocean acidification and changes in landscape increase the vulnerability of Arctic indigenous peoples. Traditional food sources may decline which would lead to disruption in hunting and food sharing cultures.

The loss of ice and snow cover and the thawing of permafrost can make traditional transport and hunting routes more dangerous or inaccessible. Changing landscape can disrupt forage availability, migration routes of reindeer, as well as community infrastructure, water supply and connectivity with population centres. Traditional harvesting and other nature-based activities as well as landscape endowed with cultural and spiritual values are intimately connected with Arctic cultures and identities, both indigenous and non-indigenous, with implications for well-being and health.

Additional impacts of Arctic climate change are increases in both atmospheric and ocean pollution. Reduced sea-ice is opening access for harvesting natural resources from changes in fish stocks to minerals that are in demand worldwide, and especially large reserves of oil and natural gas. All of which present the potential for new pollution sources. Transit shipping is increasing in the sea-ice free season. This results in new emissions of soot and other pollution that may negatively impact Arctic air and water quality.

Consequences of environmental changes have both positive and negative impacts in the Arctic. Melting ice and snow make access to the Arctic easier and enable new economic activities. Positive impacts may include increased onshore mining and offshore exploitation of oil and gas resources, less ice-constrained shipping routes and increased tourism and fisheries activities.

Negative impacts include the increased vulnerability of infrastructure due to sea level rise and permafrost melt, or investments required for new infrastructure to compensate for ice-based transport routes. The increase in activities of large international companies, potentially displacing small-scale enterprises can be seen both as an opportunity or threat – the large companies may provide more stable jobs and may generate more wage labour as opposed to subsistence activities; on the other hand, they can contribute to the loss of jobs in small-scale activities, at least in the short term. (More information is available in the other EUAIA Factsheets: *Social and Cultural Changes in the European Arctic; Changing Nature of Arctic Fisheries; Increasing Land-Use Pressures in the European Arctic; Mining in the European Arctic, Changes in Arctic Maritime Transport* and *Developing Oil and Gas in Arctic Waters.*)

Governance and Stakeholders

As a global problem, it is clear that climate change needs to be tackled by the world community. In 1992, nations adopted the United Nations Framework Convention on Climate Change (UNFCCC), which lays down general obligations to reduce greenhouse-gas emissions (mitigation) and to adapt to consequences of climate change. It entered into force in 1994 with 195 parties.

> "UNFCCC lays down general obligations to reduce greenhouse-gas emissions (mitigation) and to adapt to consequences of climate change"

The treaty itself provides only general greenhouse-gas emissions commitments for industrial countries and contains no enforcement mechanisms. Yet, the treaty provides a framework for negotiating specific international treaties (called "protocols") that may set binding limits on greenhouse gases.While UNFCCC is a convention adopted by countries, other stakeholders influence how climate change is tackled (Figure 6).

The parties to the convention have met annually from 1995 in the Conferences of the Parties (COP) to assess progress in dealing with climate change. In 1997, the Kyoto Protocol was concluded and it established legally binding obligations for developed countries to reduce their greenhouse-gas emissions.

A new phase in international climate change negotiations resulted from the COP-18 in 2012. The focus is on the negotiation of "a protocol, another legal instrument or an agreed outcome with legal force under the UNFCCC applicable to all Parties," to be negotiated

Valuating Climate Change Impacts: A Difficult Exercise

In the context of the impact of Arctic changes on global warming, it may be important to quantify the worldwide economic impact of climate change feedback effects happening in the Arctic. An attempt made by the Pew Environment Group identifies three main feedback effects where global warming leads to changes in the Arctic, and these changes again lead to increased global warming.

Pew concludes the resulting costs of "lost climate services from a warming Arctic" to range between $2.4 trillion and $24.1 trillion in the period between 2010 and 2050. One order of magnitude range of the estimates shows how difficult such economic valuation is. However, even the mid-range estimate of $7.4 trillion is equivalent to the combined GDP of Germany, Russia and the United Kingdom. Worldwide costs (or GDP losses) of this scale can certainly be expected to affect the European economy even beyond the direct effects of Arctic warming on European weather.

Such estimates need to be specified geographically and thematically. From an EU perspective, how do changes to Arctic ecosystems affect economic activities? And what impact do changes have to ecosystem services that the EU benefits from? So far, efforts have been made to assess the value of the threatened services of ecosystems, such as biodiversity and the loss of cultural services for indigenous peoples. Direct estimates link economic income generated from certain ecosystem services, such as water quality in river systems and hunting, which generally have a local impact. For example, the fisheries sector around the Barents Sea contributes to 8.2% of GDP in the Murmansk region.

Indirect approaches use surveys on the "willingness to pay" for the existence today and availability for future generations of a species or a culture. For example, in a study related to the Exxon Valdez oil spill off the Alaskan coast, a typical US household showed a willingness to pay for the ecosystems of $48, which if multiplied by the number of relevant households gave a non-use value of these ecosystems of $2.8 billion. Similar estimates for actual climate impacts on the Arctic are not available. However, such valuations are very contested among economists and can come up with very different figures depending on the background of the people asked. Moreover, the notion of "ecosystem services" is problematic especially in the context of Arctic indigenous peoples, who tend to view themselves more as part of a complex web of natural interactions than as the ultimate beneficiary of ecosystem services. Thus, further valuation of EU relevance, as envisaged in several upcoming research projects, is needed.

Ice Road and Skiing Trails on Kemijoki River in Rovaniemi, Finland. Ice and winter roads are an element of the transport network. Due to mild winters and changes in hydropower systems, it has not been possible to establish ice roads in some locations in Lapland during the past decade.

Photo: Ilona Mettiäinen, Arctic Centre, University of Lapland.

by 2015 and to enter into force by 2020. If such an agreement is achieved, it would be the first global climate agreement to extend to all countries, both developed and emerging economies.

COP-18 also delivered an extension of the Kyoto Protocol to 2020, with 38 countries, representing 13% of global greenhouse-gas emissions, taking on binding targets. Major greenhouse-gas emitters do not either have binding emission reduction targets, such as China, or are outside of the Kyoto Protocol, such as the United States, the second-largest emitter. Canada has also withdrawn from the Protocol, while Russia, Japan and New Zealand have refused a post-2012 Kyoto target.

As part of the Cancun Agreements, 91 countries representing nearly 80% of global greenhouse-gas emissions, have adopted and submitted targets for international registration or pledged actions. These pledges, however, are not legally binding (although may be considered politically binding) and fall well short of what is necessary to deliver the 2 degree Celsius goal (UNEP, 2012).

Governments Agree a Target of 2 degrees Celsius and 450 ppm CO2

Governments agreed at the UNFCCC Conference of the Parties in 2010 (Cancun Agreements) that the average global temperature increase, compared with pre-industrial levels, must be held below 2 degrees Celsius, meaning that greenhouse-gas emissions must be reduced. (Average global temperatures have already increased by 0.8 degrees C from pre-industrial levels.)

There is broad international acceptance that stabilising the atmospheric concentration of greenhouse gases at below 450 parts per million (ppm) of carbon-dioxide equivalent gives a 50% chance of curbing warming below 2 degree Celsius. This threshold is drawing close. Carbon-dioxide levels reached 400 ppm in May 2013, having jumped by 2.7 ppm in 2012 – the second-highest rise since record keeping began.

Figure 6: **Stakeholders in Climate Change Arena**

States	Non-governmental based on the Agenda 21 groups:
Intergovernmental organisations	• indigenous people • business and industry • environmental NGOs • local government and municipal authorities • research and independent NGOs • workers and trade unions • farmers • women and gender NGOs • children and youth.

Climate change is being addressed also regionally. As the Arctic Council-sponsored Arctic Climate Impact Assessment demonstrated, the Arctic is an early warning region of climate change. The Inuit Circumpolar Council took, without legal success, the United States into legal proceedings on the basis of climate change having adverse effect on human rights of the Inuit.

Since countries in the region can influence Arctic warming by reducing the sources of short-lived climate forcers, like soot, they agreed recently to pursue actions to establish national black carbon emission inventories.

The Arctic has potential as a model to demonstrate adaptation measures. Vulnerability and Adaptation to Climate Change in the Arctic has been the main climate change adaptation programme under the auspices of the Arctic Council. On-going work takes place via the Adaptation Actions for a Changing Arctic project. The aim is to enhance the capacity of decision makers to manage climate risks via an information portal and through improved predictions of combined impacts.

How Climate Change in the Arctic May Affect the European Union

Climate change is clearly visible in the Arctic areas of European Union (EU) Member States. Many impacts of the warming Arctic have effect all over the world. Sea-level rise partly has its origin in the melting of the Greenland ice sheet. The impact will hit coastal areas in central and southern Europe. The Netherlands is already planning adaptation measures.

> "Decreased winter sea-ice coverage, accompanied with increased surface temperature over Arctic Ocean results in less maritime and more continental climate in Europe."

Arctic amplification has strong implications for the weather and climate of Europe. Increased temperature in the Arctic has directly led to an increasing loss of snow cover in spring and summer over much of the last century. In contrast, the snow cover in boreal autumn and winter increased over the 20th century, since a warmer atmosphere is able to hold more moisture and hence produces greater snowfall in autumn. This trend is especially obvious in October and it seems this trend is accelerating.

Arctic sea-ice change was also linked to changes in mid-latitude weather patterns that increase the probability of persistent extreme weather events, such as droughts, floods, heat waves in summer and cold snaps in winter. Very low sea-ice extent in summer and autumn enhances probability of cold temperatures in Europe in the following winter.

Decreased winter sea-ice coverage, accompanied with increased surface temperature over Arctic Ocean results in less maritime and more continental climate in Europe. Anomalously low sea-ice coverage in the Barents and Kara Seas in winter increases variability in European winter temperatures.

The Arctic environment will be under heavy stress from the rapid changes. This will also affect EU territory and through this potentially exert pressure on EU regulatory frameworks. The most imminent area is biodiversity related action as many Arctic species are threatened for extinction in Europe.

Arctic sea routes will also affect traffic on the global seas. The Northeast Passage has already seen an increasing number of ships (more than 500 ships in 2013) during autumn and more traffic is anticipated. Still this is very light traffic compared to the overall maritime traffic landscape. It is also difficult to predict if this will affect European ports or the location of main shipping hubs.

Policy areas likely affected include transport, energy, fisheries, climate change and environment. It would be useful to prepare the next Multiannual Financial Framework of the EU (2021-2027) with the relevant predicted climate impacts in mind.

EU Policies Relevant for Arctic Climate Change

The EU has the most significant influence on Arctic climate change via its climate change, transport and energy policies, and particularly in its role in helping to shape a global climate regime. The EU accounts for about 11% of global greenhouse-gas (GHG) emissions.

> "The EU accounts for about 11% of global greenhouse-gas (GHG) emissions."

Its share of global emissions has been declining reflecting results from mitigation and efficiency measures, economic slowdown and shifts in economic structure such as relocation of manufacturing industry, as well as significant growth in GHG emissions from emerging economies such as China and India, where, however, still significant part of production supplies European markets. Notably, a significant part of the black carbon reaching the Arctic is of European origin.

The most visible components of the EU's climate change related policies are its 20-20-20 targets for 2020. These include:

- 20% reduction in GHG emissions.
- 20% increase in energy efficiency.
- 20% share of renewable sources in energy consumption by 2020.

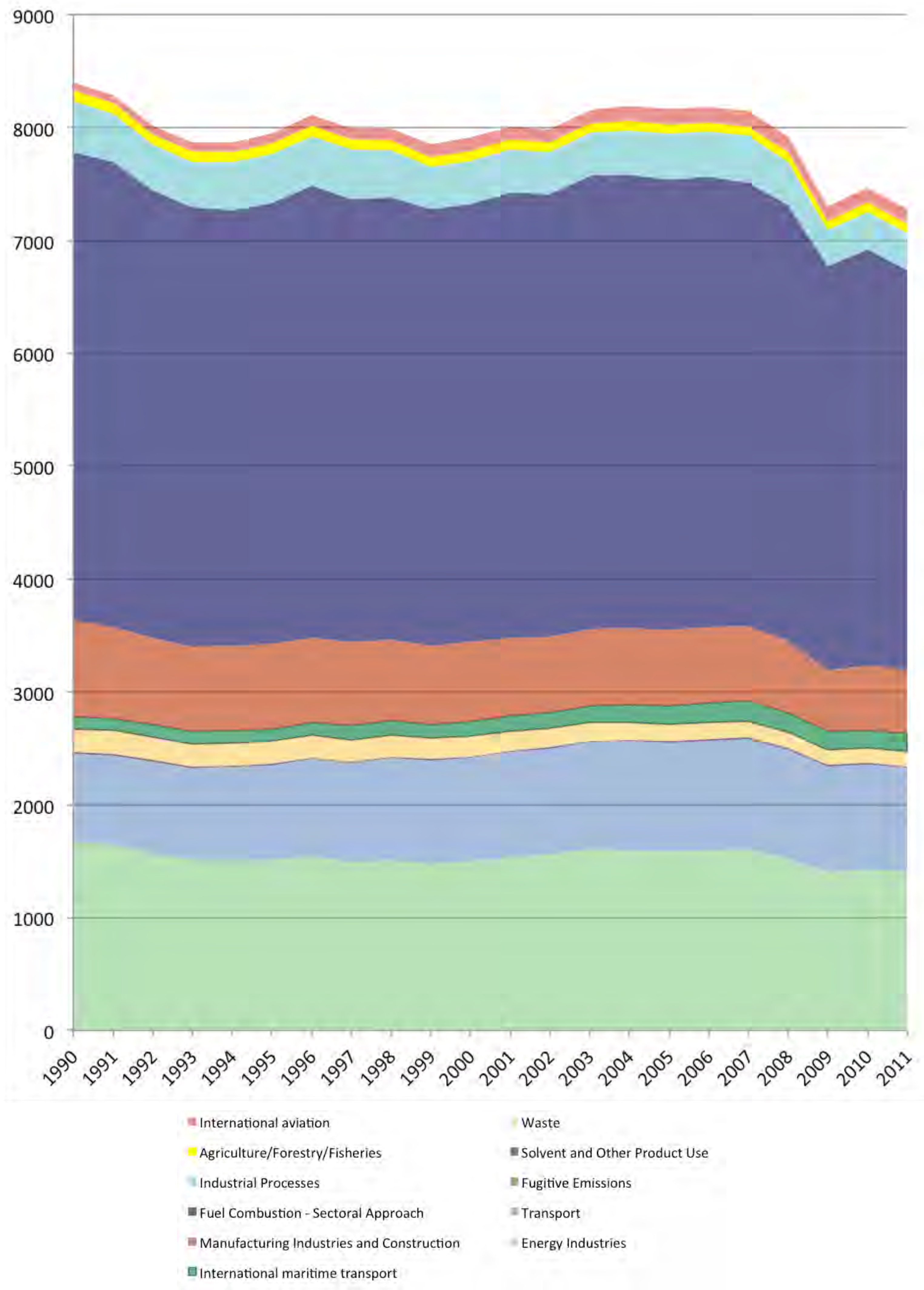
The EU is well on the way to meet its 20% GHG reduction goal, currently expecting a 27% reduction by 2020. In the UNFCCC arena, the EU has been allowed to take a reduction target (EU bubble), which is then internally shared between Member States. The EU is one of the most active players in the UNFCCC and in the establishment of the post-Kyoto climate regime.

EU policies in many areas affect energy, the largest contributor to GHG emissions, and climate change mitigation and adaptation. For example, in transport, where curbing emissions has been slow, the EU has fuel-economy standards, supports public and rail transport and has made attempts to introduce a carbon tax for international aviation.

The EU has the most long-standing emissions trading market (EU ETS). It covers about 45% of EU GHG emissions and is a key instrument to deliver the 20% reduction of GHG emissions in 2020. Due to, inter alia, economic slowdown, carbon price within EU ETS declined by more than 80% from 2008 to mid-2013, a level that is insufficient to attract investment needed in low-carbon technologies.

> "The EU is one of the most active players in the UNFCCC and in the establishment of the post-Kyoto climate regime."

Figure 7: **EU-27 Greenhouse Gas Emissions by Sector, 1990 – 2011**



Note: in million tonnes of CO2 equivalent. EU-27 does not include Croatia (data before 2013). Sources: European Environment Agency; Arctic Portal.

> “EU policies are also relevant for developments in the Arctic where climate change is a key driver, such as Arctic maritime transport, minerals and oil and gas exploitation”

Moreover, EU policies have relevance for short-lived climate forcers, climate adaptation and monitoring of Arctic change:

• Based on a review that is underway, EU air pollution policies are to take into account reducing short-lived climate forcers that contribute to Arctic amplification. The EU is also active in negotiations to address Arctic black carbon emissions from ships within the International Maritime Organization.

• The EU is increasingly active in climate adaptation within Europe, including its northernmost regions. In 2013, the European Commission adopted the Climate Adaptation Strategy package. Adaptation is to be taken into account, with Arctic regions perceived as among particularly vulnerable, across various EU policies including: transport; health; migration; cohesion; agriculture; disaster insurance; fisheries; maritime and coastal issues. The EU climate adaptation platform, CLIMATE-Adapt, is to support informed decision-making at all governance levels and includes, inter alia, a toolset for adaptation planning and database of projects. The strategy also encourages Member States to prepare national adaptation strategies. Swedish and Finnish strategies have already been adopted.

• New earth observation programs funded by the EU, such as GMES/Copernicus, can contribute to better monitoring of many parameters relevant for the understanding of climate change in the Arctic.

EU policies are also relevant for developments in the Arctic where climate change is a key driver, such as Arctic maritime transport, minerals and oil and gas exploitation (see relevant factsheets in this series).

Waterfall at the Glacier Front of the Greenland Ice Sheet, near Olrik Fjord, North-West Greenland

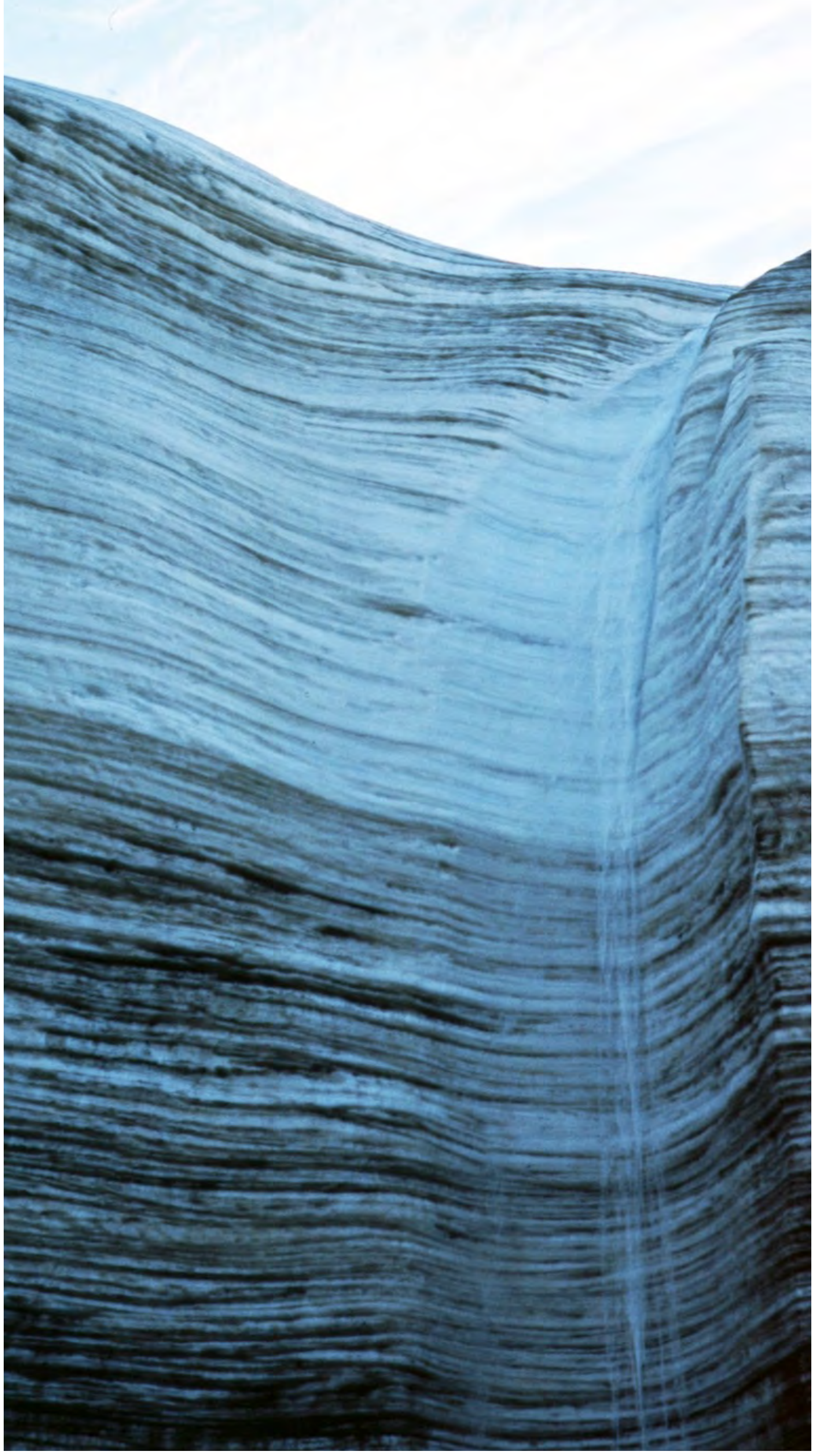


Photo: Peter Prokosch, GRID-Arendal.

What is the Role of the European Union in the Arctic?

The European Union is a complex international actor. It has acquired a number of decision-making powers from its Member States and hence influences the content of their national legislation. Based on the European Economic Area Agreement, the EU also influences relevant legislation in Iceland and Norway. The EU also influences outcomes of international negotiations – including those of importance for the Arctic.

Only a small part of the territory of EU Member States - in northern Sweden and Finland – is located in the Arctic and the EU has no Arctic coastline. Nevertheless, EU regulations and actions, including research funding and regional policies, influence Arctic developments. Moreover, the EU is a major environmental and economic actor in the Arctic and has established a special relationship with Greenland.

Since 2008, relevant EU activities have been brought under a common umbrella of “Arctic policy”. A communication in 2012 stresses three key aspects: knowledge – support for scientific research; responsibility – promoting the sustainable use of natural resources; and engagement – enhancing co-operation with Arctic partners.

Key Questions to Stakeholders Regarding Climate Change in the Arctic

1. How have you experienced environmental change in the Arctic? Specifically, have you experienced changes in wildlife; nutrition; flora; landscape; in snow and ice?
2. What are the main threats, challenges and opportunities related to Arctic climate change, from the perspective of your organisation, industry or community?
3. What local adaptation measures are you investing in (or would be willing to in the near future)?
4. What EU climate change-related legislation affects you and how?
5. Are you satisfied with EU support to climate change mitigation and adaptation in the Arctic? What could the EU do to support climate change adaptation in the Arctic region?

Selected References

ACIA (2005). Arctic Climate Impact Assessment. Cambridge University Press; AMAP (Arctic Monitoring and Assessment Program), (2005), Arctic Climate Impact Assessment, www.amap.no; AMAP (2011), Snow, Water, Ice and Permafrost in the Arctic www.amap.no/documents/download/1448; AMAP (2011), The Impact of Black Carbon on Arctic Climate, www.amap.no/documents/download/977; IPCC (Intergovernmental Panel on Climate Change) (1997), An Introduction to Simple Climate Models Used in the IPCC Second Assessment Report, ww.ipcc.ch/publications_and_data; IPCC (2007), "Polar Regions (Arctic and Antarctic)", Climate Change 2007: Impacts, Adaptation and Vulnerability (WG2 Fourth Assessment Report), ww.ipcc.ch/publications_and_data/ar4/wg1; IPCC (2007), Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ww.ipcc.ch/publications_and_data/ar4/wg1; European Topic Centre on Air and Climate Change (ETC/ACC) (February 2011), Impacts of Climate Change on Snow, Ice and Permafrost in Europe: Observed Trends, Future Projections and Socio-economic Relevance, available http://acm.eionet.europa.eu/reports/ETCACC_TP_2010_13_Cryosphere_CC_Impacts; Goodstein, E. et al. (2010), "An Initial Estimate of the Cost of Lost Climate Regulation Services Due to Changes in the Arctic Cryosphere", Pew Environment Group; Hasselström, L. et al. (2012), "The Value of Ecosystem Services at Risk from Oil Spills in the Barents Sea", paper for the ISEE conference in Rio de Janeiro 16-19 June 2012; Huntington, H. et al. (2013), "Provisioning and Cultural Services", Arctic Biodiversity Assessment, Status and Trends in Arctic Biodiversity, Conservation of Arctic Flora and Fauna, Akureyri, pp. 485-519; Kettunen, M. et al. (2012), "Socio-economic Importance of Ecosystem Services in the Nordic Countries: Synthesis", The Economics of Ecosystems and Biodiversity (TEEB); TEEB (The Economics of Ecosystems and Biodiversity) (2010), The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB; UNEP (United Nations Environment Programme) (2012), The Emissions Gap Report 2012, UNEP, Nairobi; World Bank (2012), Turn Down the Heat: Why a 4°C World Must Be Avoided, World Bank, Washington, D.C.

The content of this factsheet does not reflect the official opinion of the European Union. Responsibility for the information and views expressed herein lies entirely with the authors.

The chapter "Climate Change in the Arctic" in the final assessment report (see www.arcticinfo.eu) builds on this factsheet and on the stakeholder consultations conducted between October 2013 and February 2014.

Published in September 2013, Revised in May 2014

*Recommended citation: Strategic Assessment of Development of the Arctic (2014), 'Climate Change in the Arctic' [factsheet], -
URL: www.arcticinfo.eu.*

Image on page 1 by GettyImages

Contact: astepien@ulapland.fi