BLUE ACTION

Tipping points, extreme events and uncertainty

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How can studying the Arctic help us predict future European climate beyond the mean?

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About Blue-Action

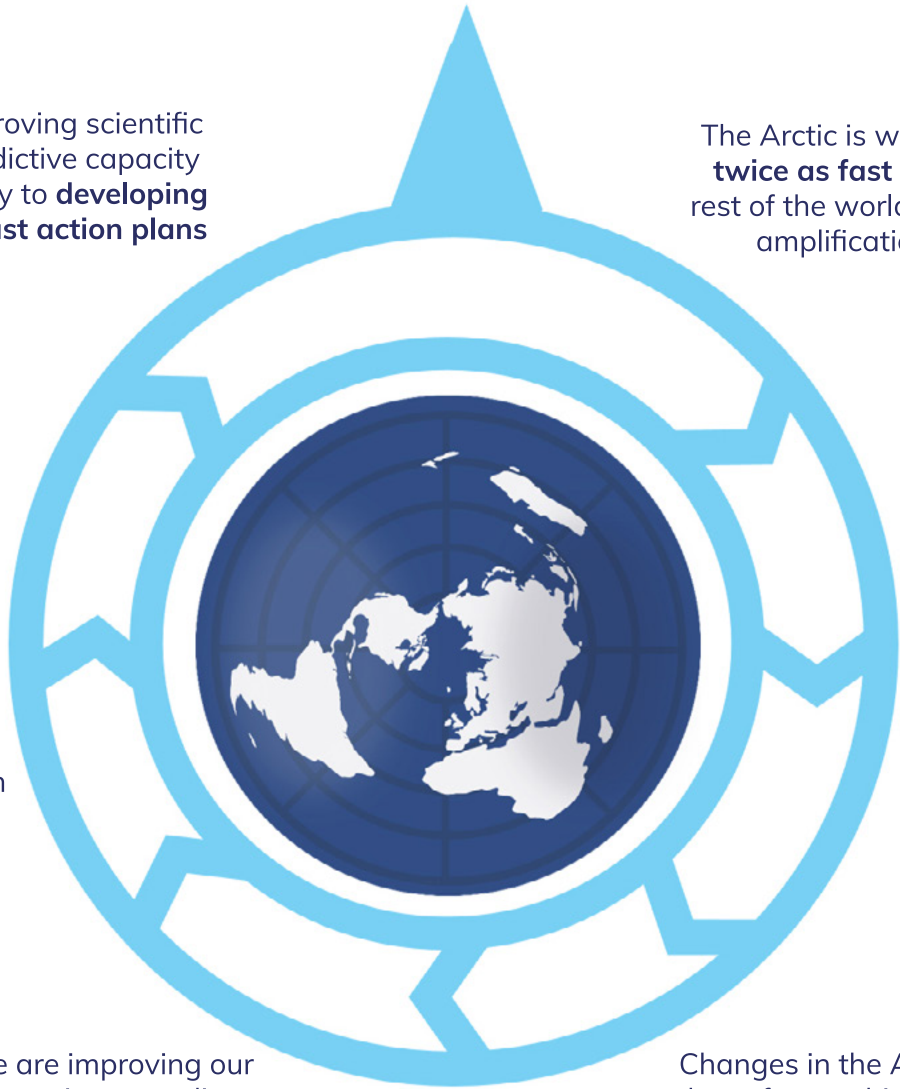
The changing climate is affecting all aspects of our environment and society, including weather, food production, biodiversity loss, energy generation and freshwater availability. Economic losses from weather and climate-related extremes across Europe are already on average EUR 12 billion per year. As many of the changes we are seeing are predicted to continue or accelerate, understanding future climate impacts are a policy priority.

There is therefore a need for robust and reliable climate predictions that can allow for longer-term planning on policy-relevant temporal and spatial scales. Climate adaptation requires not only planning for gradual changes over time, but also preparing for high impact consequences such as abrupt climate shifts and weather extremes. Understanding climate change in the Arctic is key to help us predict these high impact events, and develop early-warning systems.

Blue-Action is a Horizon2020 EU funded project that aims to evaluate the impact of Arctic warming on the Northern Hemisphere and develop new techniques to improve forecast accuracy at sub-seasonal to decadal scales. Blue-Action specifically works to understand and simulate the linkages between the Arctic and the global climate system, and the Arctic's role in generating weather patterns associated with climatic extremes.

In this booklet, we explore recent research on predicting high impact events, from large-scale abrupt climatic changes on decadal timescales to localised extreme weather on subseasonal timescales, and how we can develop early-warning systems of relevance to policy makers on international to regional levels.

Background



The Arctic is warming **twice as fast** as the rest of the world (Arctic amplification)

Through monitoring and observations of current changes we can **predict future climate changes** in the Arctic

These include identifying signals for **potential abrupt climatic changes (tipping points)**

Changes in the Arctic also have far reaching effects accross the Northern Hemisphere through **teleconnections**

We are improving our capacity to predict these effects through **modelling ocean and atmospheric processes**

These skilful models mean we can begin to **predict extreme weather events across Europe**

Abrupt climate changes and extreme weather events require **early warning systems on different timescales**

Improving scientific predictive capacity is key to **developing robust action plans**

Much success is achieved in using climate models to predict the ocean several years ahead in the North Atlantic, but we need to build and further enhance prediction skill in the Arctic region.

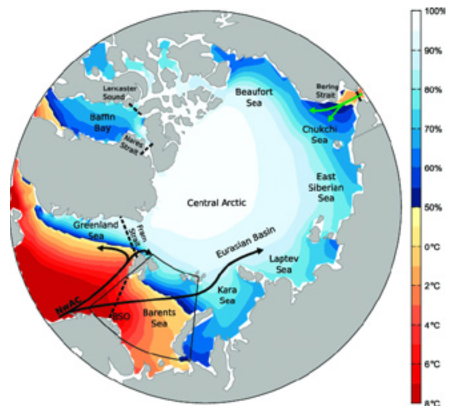
To build good climate predictions it is vital to expand the observational network and ways to use observations in climate models, reflecting key processes in the Arctic.

Greater awareness among stakeholders of the potential benefits of climate services is required to further accelerate the field of climate prediction

The ocean is key to predicting the Arctic

A key aspect of making skilful predictions of weather and climate is understanding where the main part of the predictability comes from. The ocean, slow to move and slow to change, is a great source of long-term predictability. By looking at evolving ocean temperatures in the North Atlantic it is therefore possible to make predictions about the climate in the Arctic region and over Western Europe years into the future.

Decadal climate predictions are now beginning to reach the stage where the outputs are sufficiently accurate to input into decision-making, and research indicates that there is great potential to further enhance this skill. In the Arctic region, it is yet challenging to predict several years ahead. More research on how to successfully transfer oceanic signals, in decadal climate predictions, from the North Atlantic and to the Arctic is needed. Furthermore, in decadal climate predictions, atmospheric skill is typically lower than for the ocean, but recent results show promising results for the atmospheric circulation over Northern Europe.



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Understanding how to increase atmospheric skill over Europe requires further research into the underlying mechanisms and interactions between ocean and atmosphere, and also research on teleconnections between Arctic and Europe . With better understanding of where predictability comes from, climate predictions are improving, and will continue to improve.

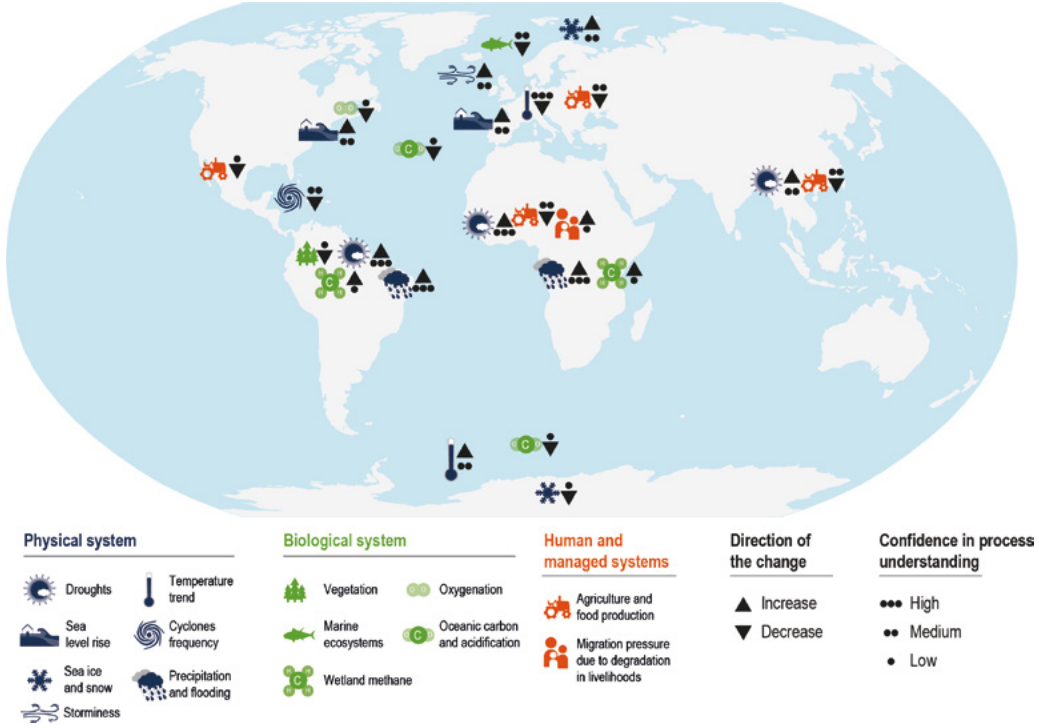
Abrupt changes in the Arctic

Lessons from ice cores show that, in both glacial and interglacial periods, the Earth's climate experienced abrupt changes.

As we continue to alter our current climate through anthropogenic emissions, it is possible that we will also reach "tipping points", thresholds beyond which the climate will stop changing gradually but instead change abruptly. These abrupt changes can trigger large-scale impacts across Europe, causing widespread disruption across physical, biological and societal spheres.

Theory from dynamical systems teaches us that approaching a tipping point, the system variability tends to increase. For example, over the past century, we have observed a cooling and freshening of the subpolar gyre, and some CMIP5 models show that this may be a sign of an approaching abrupt change.

Predicting the likelihood of these type of abrupt changes is necessary to prepare adaptation plans for potential associated crises. Decadal prediction systems with initialized ocean states including observations might be the most up to date tool to predict the risk for such a shift in the coming decades.



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Abrupt changes occurred in the past in the North Atlantic and are projected in some climate models.

The possible impact of such abrupt changes across Europe are widespread, from agricultural degradation to intense migration pressure.

Based on computer models and observations, it is possible to develop an early-warning system on a decadal timescale

Extreme weather events

Changes in the Arctic region can have global impacts, from weather events across the Northern hemisphere to feedback loops that influence European climate and beyond. For example in the Arctic, the reduced sea ice cover and therefore warmer ocean creates warmer and wetter air over the region and beyond.

The reduced temperature difference between the Arctic and the lower latitudes leads to a weaker jet stream, which can result in systems moving more slowly and a particular weather pattern becoming more persistent over a specific area and reaching lower latitudes. Persistent weather can itself be the basis of an extreme event, such as drought, flood or heat or cold waves.

At present, many observational studies suggest that a warming Arctic is related to extreme weather events at lower latitudes, but many models do not reproduce this connection.

Further work on representing earth system processes within models, supported by increased observations of long-term variability, are needed to reconcile these differences.

Case study: heatwaves in Spain

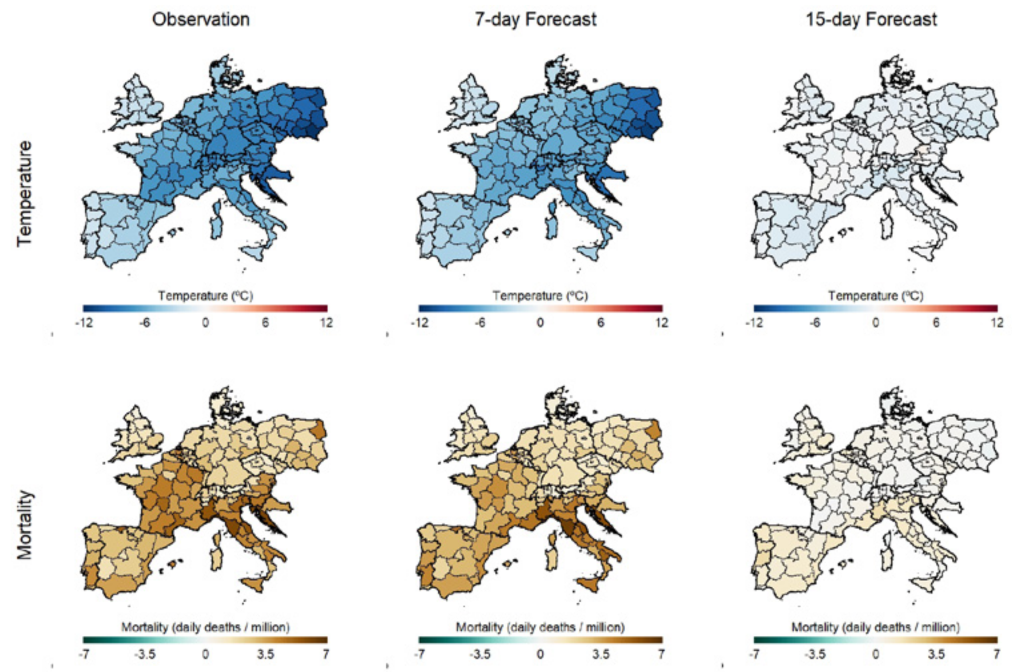
Thanks to improved understanding of linkages between atmosphere and oceans in the Arctic and beyond, our capacity to predict extreme events is improving.

Blue-Action has developed a case study on creating an early-warning system for heatwaves in Southern Europe to demonstrate the potential for predictions to be turned into a diverse range of policy-relevant climate services.

One of the major climate change challenges faced by southern Europe is the incidence of more frequent, longer and harsher summer heat waves. The increase in frequency and severity of heatwaves poses an threat to societies that are widely unused to the increasing risks of climate change. Overall, about 8% of deaths across Europe are associated with the short-term health effects of environmental temperatures.

Researchers can use epidemiological models to transform the output from operational weather and climate models into predicted impacts on health, such as temperature-attributable mortality.

These can form the basis of early-warning systems, to support adaptation planning for public health.



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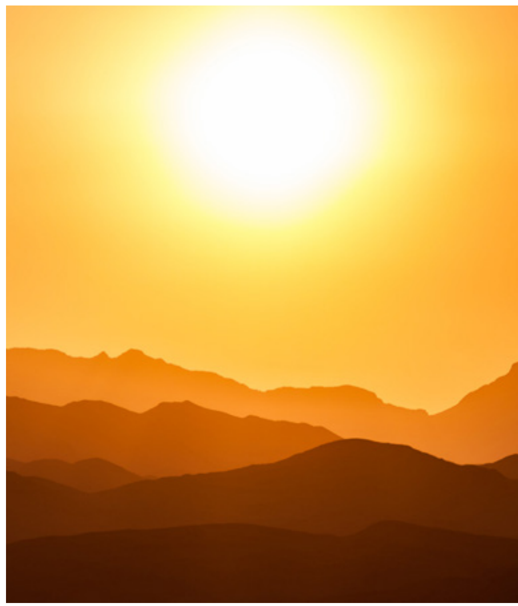

Improvements in climate predictions can also lead to improvements in health forecasting, as health is predictable.

Health early warnings need to include environmental and socioeconomic data. These early warning systems can reduce inequalities in the adaptation to climate change.

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This publication was authored by Blue-Action partners:

Steffen M. Olsen, Danish Meteorological Institute
Didier Swingedouw, University of Bordeaux
Helene R. Langehaug, Nansen Environmental and Remote Sensing Centre
Joan Ballester, Barcelona Institute for Global Health
Hannah Grist, SAMS Research Services Ltd

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Figure 3 - from: Quijal-Zamorano et al. (2020). Prediction of temperature-attributable mortality in Europe at regional scale using weather forecasts with lead times up to 15 days. Manuscript in preparation.

ISGlobal Barcelona Institute for Global Health NERSC université de BORDEAUX SAMS Research Services Ltd Danmarks Meteorologiske Institut

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