Polar Climates and our Connected World

To develop reliable predictive capabilities, Europe must sustain comprehensive environmental research and monitoring of the Polar Regions

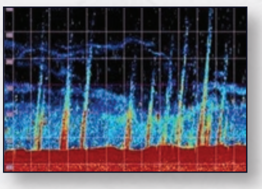
As part of the Earth System and as components of a connected world, the Polar Regions influence weather and climate conditions at lower latitudes and are influenced in their turn by tropical and mid latitude processes.

Despite the scale of change being observed at high latitudes and the important teleconnections with lower latitudes, the intricate climate processes of the Polar Regions and their components remain largely unknown. Essential requirements are therefore **comprehensive data capture and management**, and the development of **reliable regional models** that effectively represent the rate of change in polar environments and project its future consequences. A number of challenges are recognised as especially urgent where European research is well positioned to contribute. **These challenges could be addressed on a rolling basis throughout the duration of Horizon 2020**, giving focus to one group of topics at a time.

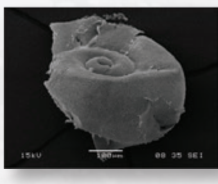
KEY ISSUES

1. **Regions with a polar climate represent a substantial 20% of the Earth's surface** and the extensive highly reflective areas of ice and snow contribute substantially to restraining the Earth's temperature regime. However, albedo changes due to loss of sea-ice cover and greater exposure of soils and vegetation **generates a significant feedback mechanism that amplifies the scale of warming**. Other relevant polar feedback mechanisms also contribute to create a complex interaction of climate related processes that are as yet to be fully deciphered.

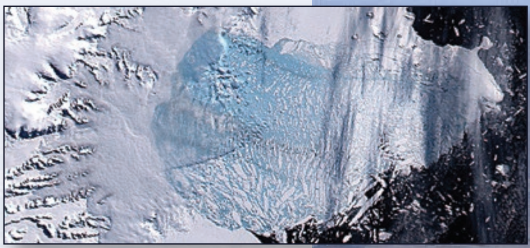
2. The Arctic has extensive stores of organic carbon in permafrost soils and it is feasible that **increased emissions of greenhouse gases (CO_2 and methane) from thawing permafrost** could lead to **positive climate feedbacks and increased warming on a global scale**. Similarly the methane hydrates and organic carbon present in the Arctic coastal marine environment could contribute substantial amounts of greenhouse gases if the ocean warms sufficiently to release **subsurface methane**.



3. In contrast **the Southern Ocean has been a significant carbon sink** drawing down very large amounts of carbon dioxide each year, and increasing open water conditions of the Arctic Ocean could also contribute to this sequestration of carbon. However warming seas and increased wind activity are **reducing the carbon sink potential of both polar oceans**. The increasing amounts of carbon dioxide dissolved in these waters are also **leading to ocean acidification**, threatening the viability of important marine plankton and thus the entire food chain, as well as further reducing the ocean ability to absorb carbon dioxide in coming decades.



4. Polar climate involves an **interaction of atmosphere, ocean, sea-ice and land-based ice** and **global warming is influencing the balance** of these components. The **loss of summer sea ice**, which is currently observed in the Arctic and certain areas of the Antarctic, will likely change the moisture supply to ice sheets and glaciers and will impact on the **calving rates of glaciers** that are now protected by sea ice for much of the year. Sea-ice loss could also lead to increases in wind-driven transport and mixing of ocean waters.



5. **Increased melting of glaciers and ice sheets is generating vast amounts of fresh water** which contributes to **global sea level rise**, and influences ocean currents and ocean mixing processes. The vast Antarctic ice sheets are retreating at a high rate, significantly contributing to global sea level rise. There is also concern that the 5000 km^3 of fresh water that has accumulated in the Canada Basin of the Arctic Ocean over the past decade could move south into sub-Arctic seas and **impact ocean currents** responsible for the relatively mild weather conditions experienced in western Europe.

6. Cold air is normally trapped in the Arctic in winter by strong Polar Vortex winds, which circle the North Pole from west to east. This process has broken down in recent years with a weak vortex and north-south winds increasing, allowing **cold Arctic air to spill southwards**, into Europe whilst bringing warm conditions to western North America. However there is still too little data to establish if this represents a **paradigm shift** for the region, reflecting the impact of increased areas of open water in summer, or is part of a cycle that will eventually revert.

7. There are links through high pressure systems over Siberia that **influence the monsoon** over the Indian subcontinent and similarly interactions between the monsoon region and Antarctica. Mid latitude and tropical regions also contribute **aerosols (notably black carbon)** to the Arctic which influence the reflectivity of snow and ice surfaces whilst tropical phenomena such as **El Niño** interact with areas of **both Polar Regions**. The integration of all these processes within global scale climate models is still at an early stage and so there is an important role for **regional polar climate models**.

8. There is also **vertical coupling between the various layers of the atmosphere** that influences climate processes in the Polar Regions. These include both downward transfer of energetic particles and stratospheric ozone chemistry that can **affect weather patterns** at the Earth surface and upward transport of chemical entities that **influence the ozone layer**. Furthermore, aerosols from the ocean and sea-ice can influence **cloud formation** and interact with atmospheric chemistry. Aerosols and clouds have substantial impact on radiative forcing but are amongst the least well represented components of current regional models.

9. **The atmospheric processes in the Arctic and in Antarctica are complex, showing significant interannual variability** and are also influenced by ocean, sea-ice and solar variability. So there is much observational and modelling work required to gain the necessary understanding and to develop reliable predictive capability.

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