Environmental Audit Committee – National Oceanography Centre's response to committee inquiry into The UK and the Antarctic environment (supplemental)

The UK's National Oceanography Centre (NOC) is one of the world's leading ocean scientific research and technological institutions, with a remit to deliver research from the coast to the deep sea. We manage two of the UK's oceanographic Royal Research Ships, RRS *Discovery* and RRS *James Cook,* and serve the needs of the wider UK marine science community through the National Marine Equipment Pool and the British Oceanographic Data Centre.

We welcome the opportunity to provide additional evidence to the Environmental Audit Committee and we were pleased to submit evidence into the Environmental Audit Sub-Committee on Polar Research's inquiry into the UK and the Antarctic Environment in September 2023[1]. NOC would also be delighted to meet with members of the Committee to discuss in greater detail our understanding and scientific research of the Antarctic environment, including the impact of the changing climate, and the role that UK science can play in understanding and protecting the region. This evidence submission complements the submission we sent in 2023.

Scientific research has long established that what happens in the Antarctic has a substantial impact on the global climate.

The Sixth Assessment Report (AR6) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) suggests that the UK is expected to be impacted by global mean sea level (GMSL) rise over the 21st century, with obvious effects such as more frequent and more intense coastal flooding events.

A large part of the expected GMSL rise comes from melting of Antarctic ice sheets, but there is a broad range of uncertainty on the rate of melt, depending on the climate change pathway, but importantly also on the uncertain physical processes linked to marine ice shelf instability and marine ice cliff instability. These involve various factors, including ice dynamics, transport and mixing of warm ocean waters to enhance the melt rate near the base of these massive ice structures, and feedback mechanisms which may amplify the rate of collapse. For example, ice structures can act as buttresses. When these melt, the part of the ice sheet upstream and uphill may begin to move downhill, towards the ocean, being exposed to warm ocean waters and melting faster. If a large region of the West or East Antarctic Ice Sheets melted over, say, a few decades, there would be two main timescales of sea level response: a continually adjusting, fast response, associated with barotropic dynamics (like surface waves on a beach, or like the progression of a tsunami); but also a slower, baroclinic dynamical response, over weeks to decades, due to changes in the vertical structure of density of the ocean, which would be harder to model and to predict.

A starting point to improve the UK's capability to predict the associated sea level response could be to simulate a range of such scenarios, but importantly also to critically assess both the ability of Earth System Models (ESM) to include all the relevant processes, interactively

[1] committees.parliament.uk/writtenevidence/124688/html/

(including ice sheet instability processes, baroclinic dynamics such as the Atlantic Meridional Overturning Circulation (AMOC), tidal mixing of warm or fresh seawater near ice sheets, glacial isostatic adjustment and far-field response of sea level), and also the sea level and ocean bottom pressure (mass) observing networks currently available, so that we can verify the skill of ESMs against recent observations. Regional sea level prediction includes the uncertainties from the processes mentioned above and has been identified in IPCC AR6 as an area of remaining uncertainty. Currently, the UK, like all nations, faces the challenge of potentially reducing this uncertainty from ~1 metre spread across UK sea level estimates for the end of the 21st century, to hopefully something more certain. Even a reduction of uncertainty by a few centimetres can make all the difference for whether current or future coastal defences are breached. The implications for the UK policy and planning are evident.

In terms of challenges, it is worth adding that a recent study led by NOC showed that Antarctic Sea ice is in steady decline, with a record low in 2023. Progress has been made towards establishing the causes of ice loss, but uncertainty remains regarding its consequences for ocean-atmosphere interaction. Resolution of this uncertainty is important as ice decline can substantially alter surface heat loss, and thus the ocean and atmosphere. The study shows that the strongest winter 2023 ice retraction regions provide a major new source of turbulent ocean heat loss to the atmosphere in wintertime. Ice concentration in these regions (located primarily in the Weddell, Bellingshausen and Ross Seas) is reduced by up to 80% and is accompanied by an unprecedented doubling of mid-winter ocean heat loss. Our results reveal that the 2023 Antarctic Sea ice loss has substantially modified Southern Ocean-atmosphere interaction and motivate in depth analysis of the wider climate system impacts[2].

There is also an issue that the full Earth System Models we use to do climate predictions, such as those involving the UK model UKESM1 submitted to IPCC, are too coarse in spatial resolution to capture some of the processes known to be important. Firstly, the balance between wind, eddies and bottom friction, that sets the strength of the Antarctic Circumpolar Current (ACC) and the overturning circulation in the upper ocean, is poorly represented by coarse resolution models, such that models grossly over-estimate the sensitivity of the ACC strength and overturning to wind. Secondly, dense abyssal waters are formed in limited spatial areas offshore of the ice shelves, where wind pushes away ice as it forms, exposing more seawater to heat loss from the strong cold winds: the coarse resolution of present climate models cannot properly model this formation mechanism. This is a major model failing as the formation of dense waters around the Antarctic is thought to be very likely to decrease greatly over the next century. In addition to observational challenges, there is therefore a major modelling challenge to accurately capture Southern Ocean dynamics in Earth System Models, particularly as we know the Southern Ocean is also very important for heat and carbon uptake.

Additionally, an Antarctic ecosystem is also quite dependent on the availability of iron in seawater, and we do not currently have the capability to measure this using autonomous vehicles such as Argo floats or Autonomous Underwater Vehicles (AUV) because we

---

[2] Record-low Antarctic sea ice in 2023 increased ocean heat loss and storms | Nature

currently have no robust sensor that can measure iron in seawater. That means we remain dependent on research vessels to collect information on a major control of primary production in the Southern Ocean – the conversion of inorganic to organic carbon by phytoplankton – that supports almost all other marine life.

NOC hosts the National Marine Equipment Pool (NMEP), which are an important component of UK Antarctic science and enable world-class research with innovative technology capabilities. NOC's Marine Autonomous Robotic Systems (MARS) supports under-ice capable autonomy, with enhanced navigation capabilities to enable observations for a full seasonal cycle. Autonomous marine science technology, including long-range AUVs Boaty McBoatface, allows for expanded measurements of essential ocean variables beyond what is possible with a research vessel alone.

For more information, please contact UK Public Affairs Manager, Vita Zaporozcenko

December 2024