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NATURAL ENVIRONMENT RESEARCH COUNCIL

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Sea-level rise

Why is sea-level rise important?

Sea-level rise increases the frequency and severity of storm surges and coastal flooding, causing serious damage to critical infrastructure and leading to the displacement of coastal communities around the world. Globally, more than 100 million people live in coastal regions vulnerable to sea-level rise, and many of the world's largest cities are situated less than 10 metres above current sea level. In the UK, current annual damages from coastal flooding are estimated at over £500 million per year, and costs of damage are likely to increase under projections of future sea-level rise. As such, sea-level rise presents one of the biggest adaptation challenges to climate change.

How much and how fast is sea level rising?

Since 1900, global mean sea level (GMSL) has risen by approximately 20cm. The rate of sea-level rise has increased throughout the 20th and early 21st centuries, and it is currently rising at about 3.2cm per decade.

What causes sea level to rise?

Increasing global surface temperatures, resulting from human emissions of greenhouse gases (GHGs), cause the sea level to rise through two main processes. Firstly, more than 90% of the excess heat in the atmosphere is absorbed by the oceans, causing the ocean to increase in volume as it warms. Secondly, water that is currently stored on land in the form of ice is added to the oceans as glaciers and ice sheets melt, further increasing ocean volume.

How do the ice sheets contribute to sea-level rise?

Together, the ice sheets in Greenland and Antarctica hold over 99% of all ice on Earth. Observations show that the sea-level contribution due to ice loss from these ice sheets has tripled in the past two decades, and now accounts for a third of total GMSL rise. Enhanced ice loss from the ice sheets can occur either through increased melting of ice at their surfaces, with the resulting meltwater running off into the ocean, or from an acceleration of the rate of ice flow into the ocean. In Greenland, surface melting during summer months is the dominant driver of this ice loss, while in Antarctica the majority of ice loss is caused by a speed-up of ice-sheet flow in certain regions.

The flow of the Antarctic Ice Sheet towards the ocean is to a large extent controlled by the floating ice shelves that fringe its coastline, which act as buttresses to stem the flow. Observations show that these ice shelves are experiencing widespread thinning, driven by melting both from above due to warmer temperatures and from below by warm ocean waters. This is particularly the case for ice shelves along the coast of the West Antarctic Ice Sheet (WAIS), where the largest accelerations in ice-sheet flow are also observed, especially for the Pine Island and Thwaites Glaciers.

There are also concerns that parts of the WAIS that rest on bedrock below sea level could be unstable. Thinning in coastal regions may cause acceleration of the ice sheet and further thinning upstream, making sections of the WAIS vulnerable to collapse. In contrast, the East Antarctic Ice Sheet, which rests largely on bedrock above sea level, appears to be more stable, although some parts of East Antarctica may also be vulnerable to oceanic melting.

How has sea level changed in the past?

There is evidence that during extended warm periods in the past (125,000 and 400,000 years ago) a large fraction of Greenland was ice-free and sea levels rose slowly over centuries to be more than 6m higher than today. Local conditions influence the ice sheets, but during these periods the global average temperature was perhaps only slightly warmer than today.

How much will sea level rise in future?

The recent Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C projects that GMSL rise by 2100 is likely to lie within the ranges of 22-77cm or 35-93cm for warming of 1.5°C or 2°C above preindustrial levels respectively. The largest source of uncertainty in these projections is currently associated with quantifying the potential additional sea-level rise contribution due to instability of the WAIS, which remains the subject of ongoing research. The recently launched International Thwaites Glacier Collaboration, a research program involving US and UK scientists including from BAS, aims to improve understanding of ice-sheet stability in this region and reduce these uncertainties in future sea-level projections.

Beyond 2100, sea level will continue to rise for many centuries, even if GHG emissions are reduced to net-zero in line with the 2016 Paris Agreement targets to limit global warming to 1.5°C or 2°C. However, the magnitude and the rate of this committed long-term sea-level rise depends strongly on near-term emissions reductions in coming decades. The sooner net-zero or net-negative GHG emissions are achieved, the more the amount of long-term sea-level rise can be limited. If GHG emissions are left unchecked, the rate of sea-level rise will further accelerate. The IPCC 1.5°C report stated that instabilities of the Greenland and West Antarctic Ice Sheets could be triggered between 1.5°C and 2°C of warming, which would eventually result in several metres of sea-level rise over hundreds or thousands of years. Some glaciologists consider such instabilities could be triggered even below this level, but there is little doubt that the greater the warming, the greater the likelihood of such events occurring.

How does sea-level rise vary locally?

Sea-level rise is not uniform globally, as it is affected by multiple local and non-local factors including gravitational effects, ocean circulation patterns, and vertical land movement. Projections of GMSL rise, including BAS estimates of the future Antarctic sea-level contribution, therefore feed into locally-specific sea-level rise projections, which are crucial for informing local adaptation planning. The Met Office recently published its updated UK sea-level projections as part of the UK Climate Projections 2018, which show how the amount of sea-level rise by 2100 will vary for different UK coastal locations and different GHG emission scenarios (Table 1).

	RCP2.6		RCP4.5		RCP8.5	
	5th	95th	5th	95th	5th	95th
London	0.29	0.70	0.37	0.83	0.53	1.15
Cardiff	0.27	0.69	0.35	0.81	0.51	1.13
Edinburgh	0.08	0.49	0.15	0.61	0.30	0.90
Belfast	0.11	0.52	0.18	0.64	0.33	0.94

0.3 0.4 0.5 0.6 0.7
Sea-level change (m)

Table 1: *Range of sea-level change (m) at UK capital cities in 2100 relative to 1981-2000 average for a low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenario (Figure from: Palmer M, et al., 2018. UKCP18 Marine Report. Met Office).*