Increasing evidence of critical sea-level rise with emissions above 1.5°C Paris agreement limit

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**Information Paper submitted by ASOC**

***Summary***

Increasing published research on projected Antarctic ice sheet loss, using ever-more sophisticated methods, points to thresholds of irreversible sea-level rise at lower temperatures and emissions pathways than previously considered, even within the upper 2°C Paris Agreement limit. These studies forecast loss not only from smaller glaciers of the Peninsula and West Antarctic Ice Sheet (WAIS), but vulnerable sections of East Antarctica. Greater efforts are needed to support continued monitoring and modelling, as well as communicating this research, including at COP28 in Dubai, as one output from the ATCM’s first Climate Day.

***Introduction – Recent Developments***

Beginning with its AR6 Working Group I Report (Physical Science Basis, 2021), the IPCC raised the possibility of extreme sea-level (SLR) rise occurring sooner, and faster than previously considered. It found such projections sufficiently serious to include them in its Summary for Policy Makers (SPM), despite comprising only two very recent studies16, 44 as “high impact, low likelihood” projections -- with the latter phrase referring however not to their likelihood, but simply to the lack of similar studies at that time.

Since then, a growing number of these more sophisticated modelling studies have pointed to similar results, implicating a threshold for irreversible ice loss already around 1.8°C, with losses becoming far more rapid between 2-3°C and once 3°C is exceeded. Important research published just in the year since the Berlin ATCM includes:

* The East Antarctic Ice Sheet, once considered relatively stable, could contribute substantially to sea level rise should temperatures rise above 1.8°C1, 2.
* There is increasing evidence that warming Southern Ocean waters, and changes in ocean currents will bring warmer water to the edge of the ice sheet and increase the rate and extent of sea-level rise from Antarctica4,5,6,7,8,9.
* Heatwaves in Antarctica continue to break records, putting ice shelves at greater risk of collapse10.
* There is increasing evidence from the paleo-climatic record that ice sheets can collapse relatively quickly, with outlet glaciers retreating hundreds of meters per day.11, 12

***Background***

Antarctica holds enough ice to raise sea level by 58 meters. The Earth’s climate record makes clear that warming above even 1°C over pre-industrial has resulted in very different coastlines in Earth’s past, due to extensive melting of the West Antarctic Ice Sheet (WAIS); and by 1.5°C, possibly parts of East Antarctica1. While some of these changes occurred very slowly, over thousands of years, there have also been periods where extremely rapid sea level rise (around 4 meters per century) occurred due to rapid ice sheet collapse. Termed “melt-water pulses,” the last took place around 14,000 years ago, when global sea levels rose between 12-18 meters in just 350 years, with ice sheets retreating up to hundreds of meters per day11,12.

However, the observed human-induced global temperature increase over the past few decades is much faster than anything documented in Earth’s past. CO2 increases in the last 50 years are 200 times greater than during the end of the last Ice Age. This means that future rates of ice sheet loss and sea-level rise could increase even further beyond the acceleration observed over the past few decades, and potentially be more rapid than at any other time in the past 130,000 years13. Better understanding of ice sheet behavior, especially interactions between the ice and the warming oceans that surround them, informs us that ice sheet collapse and rapid sea-level rise cannot be ruled out,14, 15, 16, 17 especially if peak warming were to exceed 3°C.

At least parts of Antarctica have certain thresholds where irreversible melt becomes inevitable and, in the case of the WAIS, potentially rapid18, 19. Much of the WAIS actually rests over island archipelagoes separated by extremely deep (>2.5 km below sea level) and vast downward-sloping basins20, 21. As warm water melts the marine edges of the WAIS, this exposes more of the underside to warming waters. These processes may cause very rapid ice sheet loss and resulting sea-level rise over just a few centuries.

In Earth’s past, several of these thresholds have occurred somewhere between 1 and 2 degrees of warming: for the WAIS and Antarctic Peninsula (containing around 5 meters SLR), about 1-1.5°C. Some studies indicate that the WAIS threshold for inevitable loss already may have been passed at around 0.8°C above pre-industrial22, 23, although its loss might be slowed to take place over many centuries if temperatures remain close to the lower Paris Agreement goal of 1.5°, with an aim to return below that level as soon as possible.24

Similar conditions exist in parts of East Antarctica and have become far better documented on the continent through coordinated scientific efforts over the past five years, though much remains to be learned25. Recent work also suggests that although the East Antarctic Ice Sheet was once considered relatively stable, the ice sheet could contribute substantially to sea level rise if temperatures rise above 1.8°C 1, 2. Parts of East Antarctica, especially the Wilkes and Aurora Basins (~4 meters of SLR), may have a threshold around or just beyond 2°C1, 26.

Because of the existence of these thresholds, when temperatures reached 2°C above pre-industrial in the Earth’s past, sea levels peaked at around 12-20 meters higher than present-day.27 Such extensive sea-level rise would be catastrophic for today’s coastal communities, but we are currently on track for even higher temperatures than those that drove sea-level rise in the past.

Antarctic sea ice and ice shelves play an important role in ice-loss processes, as they hold back the ice sheets upstream. Loss of this buttressing effect through ice shelf thinning and break-up can accelerate the rate of ice flow from the land into the sea28. From 1997 to 2021, Antarctic ice shelves experienced a net area loss of over 36,000 km2, equal to the size of the country Guinea-Bissau29. Ice shelves have also become thinner, driven by intrusion of warmer ocean currents30 and water ponding on the surface31. Reduced ice-shelf buttressing could drive increasingly significant sea-level rise in the future32, 33, 34, 35.

Ice loss from Antarctica has doubled over the past 20 years 36, 37, 38, 39, 40. For a growing number of ice sheet experts, the true “guardrail” to prevent dangerous levels and rates of sea-level rise is actually 1°C above pre-industrial 2, 16, 17. We are currently 1.2°C above pre-industrial. A key argument therefore in favor of very low emissions, is that staying close to the 1.5°C limit will allow us to return more quickly to that 1°C level, drastically slowing global impacts from ice sheet loss, and WAIS collapse especially 41, 42. This will help provide low-lying nations and communities more time to adapt through sustainable development, though some level of managed retreat from coastlines in the long term is now inevitable.43

However, rates of SLR from Antarctica may reach as much as 5cm a year by 2150 should today’s emissions continue and cause temperatures to reach 4°C above pre-industrial in 2100.44 A key impetus for 1.5°C-consistent emissions reductions is that once ice sheet melt accelerates due to such higher temperatures, it cannot be stopped or reversed for many thousands of years, even once temperatures stabilize or decrease.2, 44 Ice core and sea level records clearly show that it takes tens of thousands of years to re-grow an ice sheet. Sea level lowering from these new highs will not occur until temperatures go well ***below*** pre-industrial, initiating a slow ice sheet re-growth.3, 45, 46, 47 Sea-level rise caused by overshoot of Paris Agreement goals is therefore an essentially permanent impact, one not reversible on human time scales.

The rate of future sea-level rise, and associated risks to security and development, now largely depends on human decisions on future emissions of greenhouse gases. To maintain the possibility of staying below 1.5°C, CO2 emissions must be at least halved by 2030, and reduced to zero by mid-century.41, 43 Otherwise, due to the long-term response of Antarctica, world leaders are *de facto* making a decision to erase all human settlement along many coastlines within the next few centuries, displacing hundreds of millions of people and erasing some nations from physical land existence.

***Outputs from ATCMXVL/CEPXXV Climate Day***

Given the widespread global impacts of climate change on Antarctica and growing evidence of irreversible sea-level rise at lower temperatures than previously projected, ASOC believes that the ATCM should raise this science to the attention of all governments in cooperation with ASOC, SCAR, the WMO, UNEP and other UN bodies.

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