Global Stocktake Goals in Light of Latest Cryosphere Science

Latest cryosphere science, building on IPCC AR6, increasingly finds that the 2°C upper limit of the Paris Agreement is too high to prevent dangerous and irreversible global impacts from a disintegrating cryosphere. For the GST process, this means a far more stringent focus on steps to decrease CO2 emissions to allow only marginal overshoot of the lower 1.5°C limit. This difficult but necessary conclusion comes from some of the latest research shown below.

GLOBAL SEA LEVEL RISE

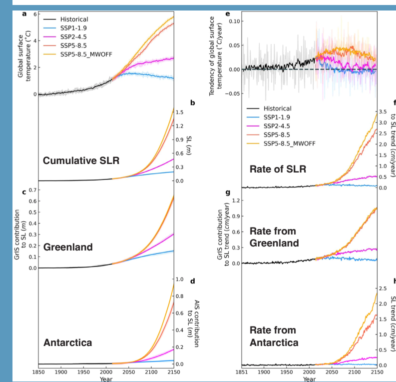
Earth's climate record makes clear that warming above even 1°C over pre-industrial levels has resulted in very different coastlines in Earth's past, due to extensive melting of the West Antarctic Ice Sheet (WAIS), Greenland and likely parts of East Antarctica (ref. 6,18).

Earlier studies show that **the WAIS may have already passed its threshold for collapse at around 0.8°C global warming** (10,14), which would lead to about 4 meters of sea-level rise; but this loss can be slowed to take place over many hundreds or thousands of years if temperatures remain close to 1.5°C, and return below as soon as possible (4,15).

Although once considered stable even at relatively high temperatures, several studies published since AR6 indicate **East Antarctica could substantially contribute to sea level rise if temperatures rise above 1.8°C** (1,13,18).

The rate of loss from Greenland is growing rapidly, and will soon be the largest single contributor to global sea-level rise; **growing observational evidence points to irreversible loss of Greenland's ice sheet well below 2°C** (2,3,9).

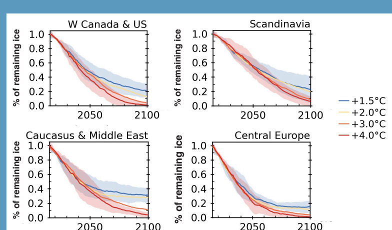
Global surface temperature and sea level projections



From Park et al. (2023), see reference 13 below

GLACIER AND SNOW LOSS

Most mid-latitude glaciers outside the Himalayas will completely disappear if temperatures reach 2°C. This includes the Alps, Andes, Patagonia, Iceland, Scandinavia, the North American Rockies and New Zealand (11,16). Even the Himalayas lose a great deal of their ice above low and very low emissions pathways (19).



From Rounce et al. (2023), see reference 16 below

But with very low emissions, most glaciers and snowpack can be preserved for reliable water resources. Losses would begin to slow slightly around 2040, though many glaciers are not expected to stabilize until the next century, between 2100–2200 (11).

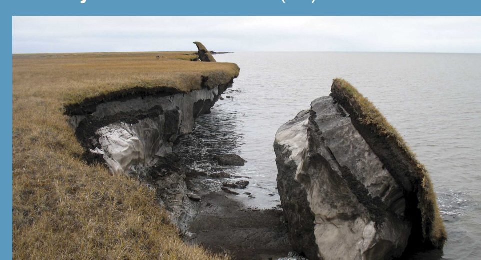
Snow is generally following the same downward trajectory as glaciers, increasing the risk of downstream drought conditions as well as landslides and floods with extreme rain events on snow (8).

PERMAFROST EMISSIONS

Rising temperatures cause permafrost to thaw, releasing CO2 and methane into the atmosphere. Permafrost thaw is projected to add as much greenhouse gas forcing as a large country, depending on just how much the planet warms.

Today, at about 1.2°C, permafrost already emits about as much as Japan, and the scale of emissions will grow with each tenth of a degree rise in temperature. **By 2°C, permafrost emissions may be larger than even the largest national emitter** (5,20).

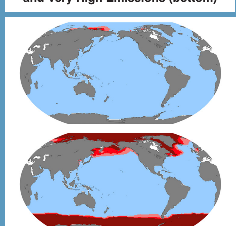
Permafrost thaw can result in large-scale erosion, ground collapse along hillsides and cliffs, and rapid formation of new lakes or wetland (17). **If temperatures exceed 1.5°C, these rapid thaw events could increase permafrost carbon emissions by as much as 50%** (20).



Credit: U.S. Geological Survey / Benjamin Jones, collapsed permafrost in Alaska

POLAR OCEAN ACIDIFICATION

Acidification with Low Emissions (top) and Very High Emissions (bottom)



IPCC SROCC (2019)

The Arctic and Southern Oceans serve as an important carbon sink, absorbing around 40% of all atmospheric CO2 taken up by the world's oceans; however, this comes at a cost. **Polar oceans are acidifying more rapidly than any of the world's other oceans**, as dissolved CO2 forms carbonic acid, harming shell-building species (7). Shell damage is already being observed today in the wild.

Both polar oceans already appear to be nearing a critical ocean acidification threshold, which has been determined to be around 450ppm (12). At current rates of CO2 rise (≈2.5ppm/year), we will reach that level in just 11 years. It will take 30–50,000 years for these increasingly acidic ocean conditions to reverse (7).

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For additional references, see the 2022 State of the Cryosphere Report: **www.iccinet.org/statecryo22**

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