Forest and Ice Tipping Points in the Earth System

AMAZON FORESTS

For 65 million years, Amazon forests have withstood large variations in climate, but today are exposed to **unprecedented stressors from climate change including drought, heat, fire and deforestation.** This has already brought the region close to a potential tipping point, especially as the forest produces less rain, turning it from a carbon sink into a carbon source.

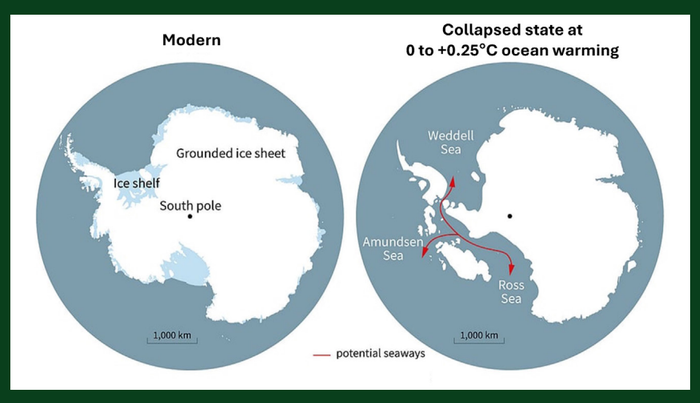
This is because the Amazon rainforest gets up to half of its rain from moisture recycling, as warm surface waters of the Atlantic Ocean form clouds that carry rain to the eastern Amazon. The forest absorbs the rain, and then releases it back into the atmosphere through transpiration. Such water vapor from the eastern forests is then carried as “flying rivers” and rains down into the west, in what is likely a far more important water source than Andean glaciers and snow.

The Amazon Rainforest, Credit: Ivars Utināns, Unsplash

Deforestation in the eastern third of the Amazon may cause the entire system to “tip” into a much drier savannah ecosystem, with critical thresholds that could trigger local, regional or even Amazon-wide forest collapse. Recent studies indicate that a safe boundary would be to keep deforestation to 10% of the Amazon region, with global warming limited to 1.5°C; but about 15% has already been cleared and another 17% degraded by human activity, making protection and reforestation efforts critical.

ICE SHEETS AND SEA-LEVEL RISE

The West Antarctic Ice Sheet’s sensitivity to ocean warming means that the threshold or “tipping point” for irreversible ice loss is **likely close to today’s temperatures** or may have already been passed. West Antarctica holds enough ice to raise sea levels by 4 meters.



The Antarctic Ice Sheet: Chandler et al. (2025)

New research finds that **the ice sheet has consistently collapsed in the past when ocean temperatures cross a tipping point of 0 to +0.25 °C warmer than present.** Current ocean conditions are already warm enough to trigger collapse if these temperatures are maintained for long enough.

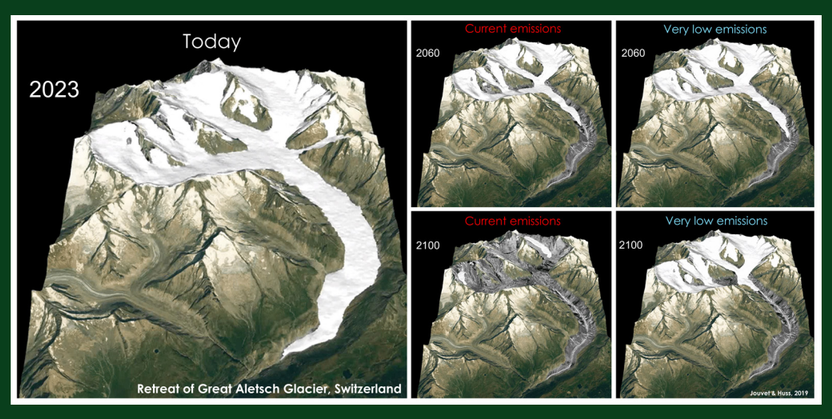
The much larger East Antarctic Ice Sheet is thought to be vulnerable to just 2–3°C of global warming, especially areas that are marine-based.

Greenland will pass a threshold when surface melting lowers the ice sheet’s height to such an extent that above-freezing temperatures occur for much of the year, accelerating melting.

MOUNTAIN GLACIERS

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. Even the Himalayas lose a great deal of their ice above low and very low emissions pathways.

Glaciers begin to lose ice very rapidly when above-freezing temperatures occur for much of the year at high elevations on the glacier, especially as snow begins to fall as rain so that the glacier is not “replenished” each winter. Evidence points to such losses not being reversible, perhaps not even until temperatures fall back to pre-industrial levels or below.



The Future of Great Aletsch Glacier, Credit: Matthias Huss

With low emissions consistent with 1.5°C, losses would begin to slow slightly around 2040, though many glaciers are not expected to stabilize for centuries. Snow is generally following the same downward trajectory as glaciers, increasing the risk of downstream drought conditions, but is seen as more reversible with lowering temperatures should greenhouse gas concentrations in the atmosphere decrease.

POLAR OCEAN ACIDIFICATION

Shell Damage from Corrosive Waters: Niemi et al. (2021)

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 other ocean** as dissolved CO2 forms carbonic acid, harming shell-building species. Shell damage is already being observed today in the wild.

Both polar oceans are nearing a critical acidification threshold as we approach **450 ppm.** At current rates of CO2 rise (~3.5 ppm per year), **we may reach that threshold in about 10 years. It will take 30–50,000 years for these increasingly acidic ocean conditions to reverse**, making this perhaps the most long-term “tipping point” of all.

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For additional references, see the 2024 State of the Cryosphere Report: **www.iccinet.org/statecryo24**

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