CLIMATE CHANGE: WHAT ICE SAYS ABOUT PAST, PRESENT, AND FUTURE

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Human activities are warming the planet and are adversely impacting the health and economic and social well-being of people, communities, and nations, worldwide. The polar and high mountain regions heating twice as fast as the global average. As well as posing an existential threat to high latitude and elevation ecosystems, environmental changes there have immediate effects at lower latitudes, including modifying weather, rising sea levels and changing the distributions of plant and animals. The ocean is storing an estimated about 90% of the excess heat energy trapped in the Earth's climate system by excess anthropogenic greenhouse gases. Crucially, environmental change in the cryosphere can have a multiplying effect on global temperature changes, making human-induced warming a self-accelerating process. Moreover, polar ice provides a cornucopia of climatic proxies, greater than any other natural climate archive and it is a cold-store for information about Earth's deep history. Studying it allows us to learn from the past, be receptive to warning signs in the present and use this knowledge to predict change into the future. Direct measurements of the concentration of CO_2 in the atmosphere were systematically collected since 1958. Samples of ancient air can be extracted and analysed from bubbles preserved in Antarctic ice and providing information about the concentration of greenhouse gases of the past 800,000 yrs. Anthropogenic CO_2 emissions have driven an increase in the global atmospheric CO_2 concentration from 280 ppm before industrialization to an annual average of 427 ppm in June 2024. The ice core records point out that during the last 800,000 yr the value of 300 ppm of CO_2 is the highest value measured to date. The 2023 and 2024 El Nino year has taken global temperatures close to the 1.5°C mark above the 1850-1900 pre-industrial levels and are the hottest year since records began. Moreover, we have seen extraordinary extrema in high sea surface temperature in the North Atlantic and in low sea ice extent in the Southern Ocean, significant outside the envelope of the 1982–2011 daily time series. Scientists have long warned that 1.5°C is a physical limit, not a political target. Tipping points are critical thresholds beyond which a system reorganises, often abruptly and/or irreversibly, according to the Intergovernmental Panel on Climate Change (2023). Breaching 1.5°C has a domino effect – triggering critical changes in Earth systems that reinforce rather than reduce warming – with cascading consequences for economies and societies. Moreover, of the 16 climate tipping points identified, six are likely to be triggered below 2°C of warming, while also unleashing a cascading effect on other tipping points. We are already starting to see these realities play out. Five of six tipping points between 1.5 and 2°C degree are linked to cryosphere. The sea ice cover is one of the key components of the polar climate and Earth system. It has been a focus of attention in recent years, largely because of a strong decrease in the summer Arctic sea ice extent is shrinking by 13% per decade due to warmer temperatures. Modelling results indicate that global warming is amplified in the Arctic on account of ice-albedo feedback. Rapid declines in Arctic sea ice coverage over the past four decades have increased the commercial feasibility of trans-Arctic routes. Summertime sea ice will likely cease to exist sometime during the 21st century. Glaciers around the globe saw a new record annual mass loss of 1.1 m ice thickness during 2023, with regional ice thickness losses of 0.5–3.0 m. In European Alp, glaciers lost 10% of their ice volume during 2022 and 2023, which was a record for ice loss in the Alps as a whole. Between 1970s and 2022, the Greenland and Antarctica Ice Sheets lost on average 216 Gt of ice per year, contributing a total of 28.5 mm to Global mean sea level (GMSL) rise. GMSL will likely rise by 280-550 mm under a very low emissions scenario (SSP1-1.9) and 630-1020 mm under a very high emissions scenario (SSP5-8.5) by 2100, relative to the 1995-2014 average. GMSL simulations that include the possibility of fast disintegration of the polar ice sheets project a rise of up to 5 meters by 2150.