

Holocene Summer Temperature Increase in West Antarctica

Sarah B. Das

Geology and Geophysics Department

Woods Hole Oceanographic Institution

sdas@whoi.edu

Richard B. Alley

Department of Geosciences and the Earth System Science Center

Penn State University

Summer climate conditions in West Antarctica changed significantly during the Holocene, as recorded by the frequency of occurrence of rare melt layers in the Siple Dome deep ice core. Surface melting began around 11.7 ka at the end of the glacial/ interglacial transition. This was followed by an extended period of no melt layers from 8.8 - 6.6 ka. There has since been an increase in melt frequency starting at 6.6 ka, with the most rapid increase from 4 ka to the present. The millennially-averaged melt frequency increased from 0% at 7.5 ka to a maximum of 2% observed during the most recent 1000 years. We have calibrated this change in melt frequency using a statistical relationship between mean summer temperature and the melt-layer threshold temperature. We estimate this change represents an increase in mean summer temperature of $\sim 2^{\circ}\text{C}$. The broad millennial-scale trend of increasing melt-frequency matches other available Holocene West Antarctic climate records, such as $\delta^{18}\text{O}$ and sea-salt Na from Siple Dome as well as $\delta^{18}\text{O}$ from Byrd Station, which all also show increasing trends from the early Holocene to the present. We interpret these records together as indicating an increase in both mean-annual and mean-summer temperature, as well as indicating an increase in temperature variability and storm (or cyclonic activity) frequency in West Antarctica. This is in contrast to other East Antarctic climate records, which show an early Holocene climatic optimum followed by stable or decreasing temperatures through the mid- to late-Holocene. We interpret the regional mid- to late-Holocene rise as evidence of an increasing marine influence on the Ross Sea sector of West Antarctica, where Siple Dome is located. We believe this is due to the continued lateral retreat through the mid- to late-Holocene of the West Antarctic ice sheet from its furthest LGM configuration resulting in more coastal climate conditions. The delayed draw-down in ice thickness from the Marie Byrd Land area may have also allowed more frequent and stronger cyclonic activity to more easily reach interior West Antarctica beginning in the mid-Holocene. The more rapid increase in melt-frequency seen from 4 ka to the present could also be reflecting a change in Pacific Ocean climatology, such as a southward movement of the Amundsen Sea Low, or an increase in ENSO variability, bringing more climate variability to the Ross Sea sector of West Antarctica.