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The Hercules Dome Ice core project

Content

Hercules Dome, East Antarctica, has been identified as the next priority ice core in the US Antarctic research program. Hercules Dome is 150 km upstream from "the Bottleneck," through which ice flows from the East Antarctic Ice Sheet to the West Antarctic Ice Sheet (WAIS). An ice core from Hercules Dome is motivated by the potential to obtain records through the Eemian interglacial from a site that is sensitive to changes in the WAIS. The high snowfall (~14 cm ice/year) and cold temperature (−40℃) should also allow us to extend the high-resolution gas records from the WAIS Divide ice core, which reached only 68,000 years.

We conducted geophysical surveys at Hercules Dome to determine the best location for drilling (Fudge et al., in review). Hercules Dome comprises three distinct topographic features. The location indicated by the earlier work of Jacobel et al. (2005) (86.5°S, 107.99°W) has large subglacial relief and complex ice flow. Further to the grid west is a more promising site ("West Dome", ~85.8 °S, ~102.9°W), ~1800 m in depth, characterized by a simple ice divide anchored by a bedrock ridge, with bed-conformal radar reflectors observable within tens of meters of the bed. Vertical velocity profiles obtained from repeat phase-sensitive radar acquisitions, combined with independent estimates of geothermal flux, indicate that the bed is frozen. Ice older than 132 ka should be preserved >50 m above the bed, with an annual layer thickness of ~1 mm.

Storms reaching Hercules Dome originate in the south Pacific and cross over the WAIS (Nicolas and Bromwich, 2011). Climate-model simulations show that changes in WAIS topography would influence atmospheric circulation, affecting climate not only over the WAIS but also over adjacent areas, including Hercules Dome (Steig et al., 2015; Goursaud et al. 2021), though such simulations do not resolve small-scale topographic features, which could affect the results. New high-resolution (15 km) simulations with an isotope-enabled version of the Weather Research and Forecasting Model (Dütsch et al., in review) confirm that WAIS lowering would cause statistically significant and detectable snow accumulation and isotopic change. The most robust signals from a lowered WAIS include elevated deuterium excess at Hercules Dome, as well as elevated $\delta^{18}O$ at SkyTrain Ice Rise in West Antarctica. A combination of records from multiple sites would constrain the magnitude and timing of past WAIS changes – in particular, the possibility that WAIS collapsed during the Eemian, as inferred from sea level records.

Drilling at Hercules Dome is scheduled to commence in early 2025, following additional site-selection radar surveys in 2022/2023. Drilling to bedrock will be completed in two to three seasons using the FORO3000 drill. An additional season may be used for replicate coring to obtain larger volumes of ice and for borehole logging experiments.

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