Center for OLDest Ice EXploration (COLDEX)

Proposal to NSF Science and Technology Center (STC) Competition

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Co-PIs: Erin Pettit (Oregon State University), Michelle Koutnick (University of Washington), John Higgins (Princeton University), Jeff Severinghaus (Scripps Institution of Oceanography)

STC Program: 4-5 awards across all NSF Directorates, 5 years, $25M. Renewal for additional 5 years and $25M.

Current status: Pre-proposal accepted, full proposal submitted on Jan. 27 2020. Proposals that go to site visit stage announced in June 2020, site visits in Fall 2020, final decisions Feb. 2021.

COLDEX Vision and Mission

- **Vision:** Advance our understanding of the controls on Earth's climate by extending the ice core record of climate and atmospheric composition beyond the ice age cycles of the Pleistocene into the Pliocene, and possibly beyond.
- **Mission**
  - Use geophysical imaging, modeling, and novel exploration tools to identify a site for a deep ice core in the Antarctic interior that extends to at least 1.5 million years.
  - Use cores from blue ice areas to extend the record of Antarctic climate and atmospheric composition through and beyond the Plio-Pleistocene.
  - Create a national sample archive, recruit and mentor the next generation of polar researchers, increase participation of underrepresented groups in polar science.
  - Provide education, professional development and field experiences for early career scientists, undergraduates, graduate students and teachers, and knowledge transfer within the scientific community, and to external stakeholders.

Partner Personnel

Last Name	First Name	Institution/Organization
Aarons	Sarah	University of California, San Diego, Scripps Institution of Oceanography
Abshire	Wendy	American Meteorological Society, Education Program
Albert	Mary	Ice Drilling Program, Dartmouth College, Thayer School of Engineering
Arnold	Emily	University of Kansas, Center for Remote Sensing of Ice Sheets
Aydin	Murat	University of California, Irvine, Department of Earth System Science
Bay	Ryan	University of California, Berkeley, Department of Physics
Bender	Michael	Princeton University, Department of Geosciences
Blankenship	Don	University of Texas, Institute of Geophysics
Bouma-Gearhart	Jana	Oregon State University, College of Education
Brook	Edward	Oregon State University, College of Earth, Ocean, and Atmospheric Sciences
Buizert	Christo	Oregon State University, College of Earth, Ocean, and Atmospheric Sciences
Christianson	Knut	University of Washington, Department of Earth and Space Sciences
Conway	Howard	University of Washington, Department of Earth and Space Sciences
Fudge	TJ	University of Washington, Department of Earth and Space Sciences
Goodge	John	University of Minnesota, Duluth, Department of Geological Sciences
Greenbaum	Jamin	University of Texas, Institute of Geophysics
Hale	Richard	University of Kansas, Center for Remote Sensing of Ice Sheets
Hastings	Meredith	Brown University Department of Earth, Environmental, and Planetary Sciences; Earth Science Women's Network
Higgins	John	Princeton University, Department of Geosciences
Holschuh	Nick	Amherst College, Department of Geology
Huffman	Louise	Ice Drilling Program, Dartmouth College, Thayer School of Engineering
Koutnik	Michelle	University of Washington, Department of Earth and Space Sciences
Kurbatov	Andrei	University of Maine, Climate Change Research Institute
Mayewski	Paul	University of Maine, Climate Change Research Institute
Mills	Beth	American Meteorological Society, Education Program
Paden	John	University of Kansas, Center for Remote Sensing of Ice Sheets
Pettit	Erin	Oregon State University, College of Earth, Ocean, and Atmospheric Sciences; Inspiring Girls Expeditions
Rodriguez-Morales	Francisco	University of Kansas, Center for Remote Sensing of Ice Sheets
Roop	Heidi	University of Minnesota, Department of Soil, Water and Climate
Saltzman	Eric	University of California, Irvine, Department of Earth System Science
Severinghaus	Jeff	University of California, San Diego, Scripps Institution of Oceanography
Steig	Eric	University of Washington, Department of Earth and Space Sciences
Waddington	Ed	University of Washington, Department of Earth and Space Sciences
Winebrenner	Dale	University of Washington, Applied Physics Laboratory
Young	Duncan	University of Texas, Institute of Geophysics

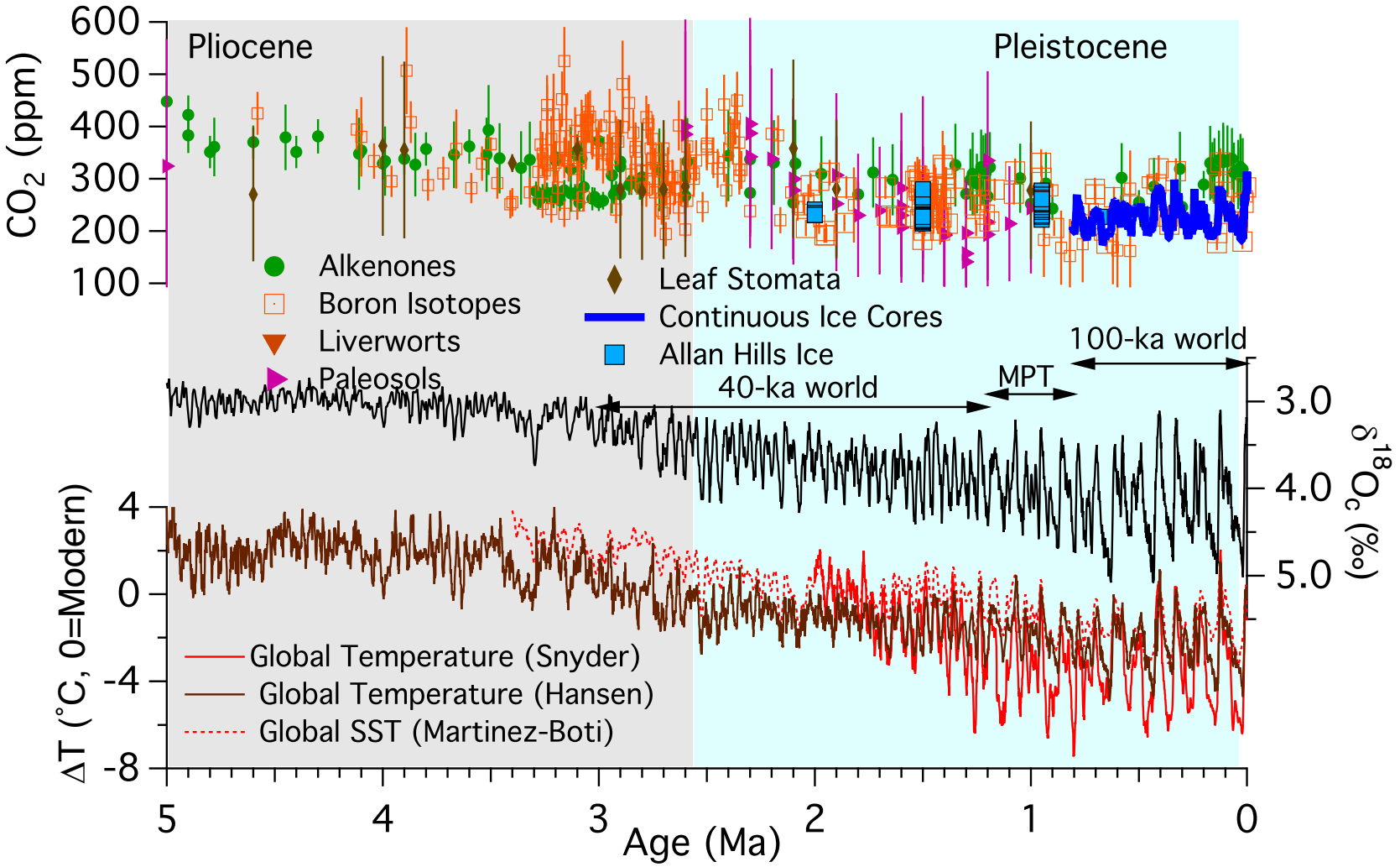
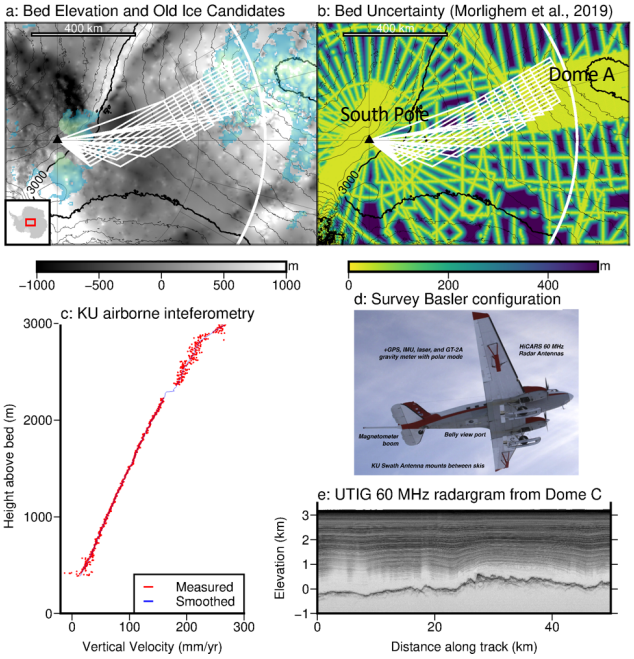


Figure 2. Climate records for the last 5 million years and reconstructions of atmospheric CO_2. Top: Estimates of CO_2 from indirect geological proxies and ice cores. Ice core data from Yan et al. (2019) and Bereiter et al. (2012); proxy data from the compilation of Foster et al. (2017) and Hönisch et al. (2009) and, Dyez et al. (2018). Error bars for the ice data are smaller than the plot symbols. Middle: the global average (stack) oxygen isotope ratio of bottom dwelling foraminifera in the ocean, a mixed indicator of changes in global ice volume and ocean temperature (Lisiecki and Raymo, 2005). Smaller values indicate warmer climates with less continental ice. Bottom: Estimates of global and sea surface temperature change reconstructed from a variety of sedimentary proxies from Snyder (2016); Martínez-Boti et al. (2015); Hansen et al., (2013). Change is relative to modern.

Key Elements of COLDEX 2021-2026

- Exploration for Old Ice Sites in the Antarctic Interior
  - Airborne and ground based geophysics
  - RAID boreholes
  - Thermal probe/dust logger
- Glaciological Modelling



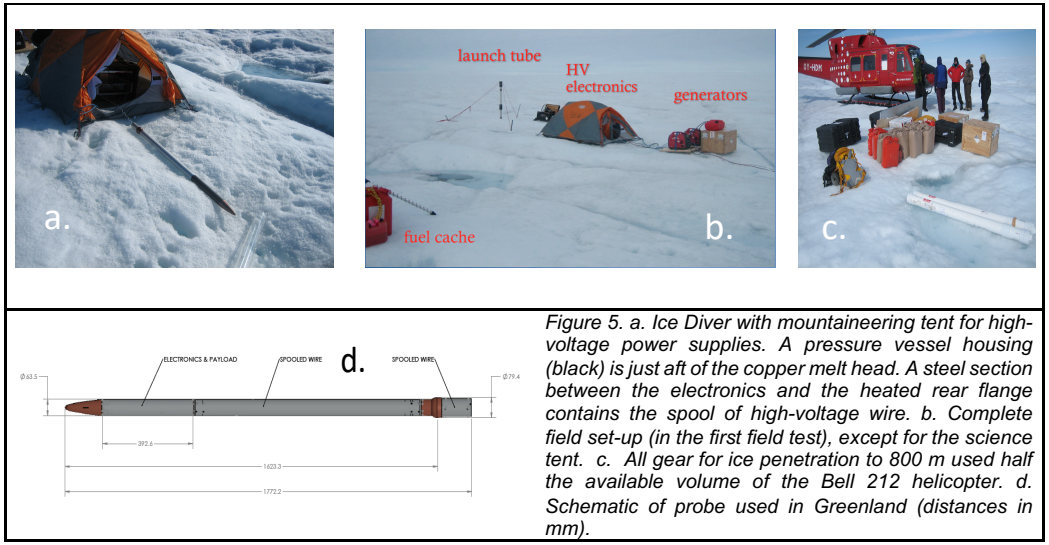
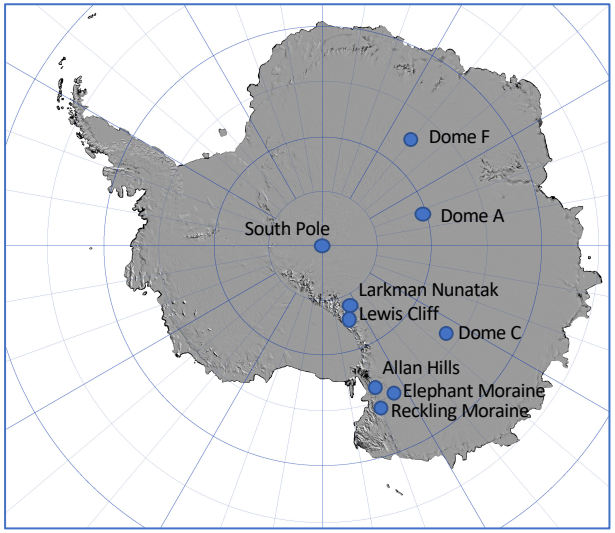


Figure 5. a. Ice Diver with mountaineering tent for high-voltage power supplies. A pressure vessel housing (black) is just aft of the copper melt head. A steel section between the electronics and the heated rear flange contains the spool of high-voltage wire. b. Complete field set-up (in the first field test), except for the science tent. c. All gear for ice penetration to 800 m used half the available volume of the Bell 212 helicopter. d. Schematic of probe used in Greenland (distances in mm).

Key Elements of COLDEX 2021-2026

- Coring on the Antarctic Ice Sheet Margin
  - Shallow coring in BIAs for very old ice
  - Intermediate depth core at Allan Hills
- Ice Core Analysis
- Integration and Synthesis
- Education and Human Resource Development
- Broadening Participation
- Knowledge Transfer
- International Collaboration



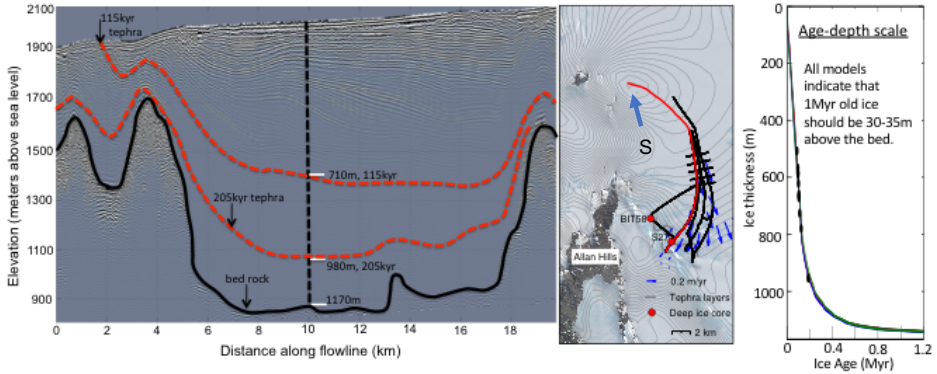


Figure 7. Radar-detected englacial layers along a flowline tracked two dated tephra layers (115 ka B.P. and 205 ka B.P.) that were used to constrain an ice-flow model. Results suggest the site preserves a continuous record through Marine Isotope stage 11, with the possibility that the record extends back 1 Ma (Kehrl et al., 2018). See Fig. 6 for Alan Hills location.

COLDEX Phase 2 2026-2031

- Drill and analyze a deep ice core for 1.5 Ma climate record
- Continue analytical improvements, modelling, melt probe technology, collaboration with RAID
- Continue education and broader impacts activities