EGU24-13878, updated on 29 Jul 2024
https://doi.org/10.5194/egusphere-egu24-13878
EGU General Assembly 2024

Hyperspectral imaging system for ice core studies

Andrei Kurbatov[1], Edward Brook[2], Christo Buizert[2], Theodore Carr[3], John Fegyveresi[4], Tyler Fudge[5], Geoffrey Hargreaves[6], Todd Hoefen[7], Liam Kirkpatrick[5], Curtis Labombard[3], Richard Nunn[3], Lindsay Powers[3], Kevin Rock[8], and Mikhail Zhizhin

[1]Climate Change Institute, University of Maine, Orono, USA (akurbatov@maine.edu)
[2]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[3]National Science Foundation Ice Core Facility, U.S. Geological Survey, Denver, CO, USA
[4]School of Earth & Sustainability, Northern Arizona University, Flagstaff, AZ, USA
[5]Department of Earth and Space Sciences, University of Washington, Seattle, WA, USA
[6]National Science Foundation Ice Core Facility, U.S. Geological Survey, Denver, CO, USA (retired)
[7]U.S. Geological Survey, Denver, CO, USA
[8]SPECIM, Spectral Imaging Ltd., Oulu Finland

Hyperspectral imaging (HSI) technology has been increasingly used in Earth and planetary sciences. This imaging technique has been successfully tested on ice cores using VNIR (visible and near-infrared, 380-1000 nm) (Garzonio et al., 2018) and near-infrared (900 - 1700 nm) (McDowell et al, 2023) line-scan cameras. Results show that HSI data greatly expand ice core line-scan imaging capabilities, previously used with gray or RGB cameras (see summary in Dey et al., 2023). Combinations of selected HSI bands from the hyperspectral data cube improve feature detection in ice core stratigraphy, and map distribution of volcanic material, dust, air bubbles, fractures, and ice crystals in ice cores. Captured spectral information provides unique fingerprints for specific materials present in ice cores. This method helps to guide ice core sampling because it provides non-destructive, rapid visualization of microstructural properties, layering, bubble contents, increases in dust, or presence of tephra material. Precise identification of these atmospheric components is important for understanding past climate drivers reconstructed from ice cores.

As part of the COLDEX project (Brook et al., this meeting) we adapted the SPECIM SisuSCS HSI system for ice core imaging. The ice core scanning system is housed inside the ca. -20°C main NSF ICF freezer, and externally computer-controlled. The operator monitors scanning operations and communicates with personnel inside of the freezer via radio. The system is equipped with a SPECIM FX10 camera that measures up to 224 bands in the VNIR range. We modified the ice core holder tray and installed a heated enclosure for the camera. The system uses SCHOTT DCR III Fiber Optic light sources with an OSL2BIR bulb from Thorlabs. IR filters are removed to extend the light spectral range beyond the 700 nm limit without heating the ice core surface during rapid (<5 minutes) scanning of an entire meter-long section. Emitted light enters ice at a 45° angle from two top and two bottom light sources. To calibrate absolute reflectance we use three Spectralon panels with 100, 50 and 20% reflectance values with every scan as well as several secondary reflective standards and USAF targets for geometric corrections. We are developing Python-based

open source data processing routines and currently comparing HSI data with existing ice core physical and chemical measurements. The goal is to fully integrate the ice core HSI system with ice core processing at the NSF ICF.

Dey et al., 2023. Application of Visual Stratigraphy from Line-Scan Images to Constrain Chronology and Melt Features of a Firn Core from Coastal Antarctica. Journal of Glaciology 69(273): 179–90. https://doi.org/10.1017/jog.2022.59.

Garzonio et al., 2018. A Novel Hyperspectral System for High Resolution Imaging of Ice Cores: Application to Light-Absorbing Impurities and Ice Structure. Cold Regions Science and Technology 155: 47–57. https://doi.org/10.1016/j.coldregions.2018.07.005.

McDowell et al., 2023. A Cold Laboratory Hyperspectral Imaging System to Map Grain Size and Ice Layer Distributions in Firn Cores. Preprint. Ice sheets/Instrumentation. https://doi.org/10.5194/egusphere-2023-2351.