An Analysis of Snowpack Temperature, Density, and Cold Content across the US West from the Repurposed USGS RMS Dataset

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ABSTRACT

Snowpit records provide insight into snowpack conditions and changes, but many existing records are still in paper format, making analysis difficult. Undergraduate students digitized 1,818 historical, hand-written snowpit records from the Western U.S. Rocky Mountains. These unique vertical temperatures and density profiles enable analysis and physical understanding of snowpack cold content (CC) and other snowpack variables. CC represents the energy required to raise the snowpack's temperature to its melting point (related to the snowmelt onset date). It can be an indicator of large-scale climate change and is valuable for assessing the performance of numerical models of the internal snowpack energy and mass flux system. Digging snowpits and recording vertical temperature and density profiles from which temperature, density, and CC can be calculated is laborious and time-consuming. Few campaigns collect snowpit data and even fewer open-source, large geographic scale, high-quality datasets. For 29 years, the USGS Rocky Mountain Regional Snowpack Chemistry Monitoring Study (USGS RMS) has collected snowpit records at a network of 192 sites. At present, the record is updated annually at 60 snowpits. This thesis describes the compilation of the USGS RMS snowpit records into a quality-controlled dataset of temperature and density profiles followed by a detailed analysis of snowpack CC, temperature, density, and their variability across Rocky Mountain West.

This thesis demonstrates several important aspects of the dataset. First, the manual measurements are high quality and provide useful information to study the Rocky Mountain West snowpack and water resources. Snow water equivalent (SWE) contributes to the CC magnitude, but largely, temperature determines CC variability. CC is useful because it combines temperature and SWE into a single variable. CC reduces the internal snowpack physical system down to MJ m^{-2}, a basic energy term.

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