Results From a New Permafrost Detection System, iFROST

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# Abstract

Permafrost is soil that has been frozen for two years or more and covers approximately 25% of the Northern Hemisphere. It plays a critical role in global water cycles by influencing the flow of rivers and streams, critical for modeling global climate because it acts as a large carbon sink, and supports unique ecosystems in the Arctic, including humans and their communities. Effective and efficient mapping of permafrost at scales relevant to the design and maintenance of horizontal and vertical infrastructure has been a long-standing challenge due to its variable distribution across the landscape, variable depth in the subsurface, and prevalence in extreme and remote environments. One impact of climate change is the accelerated thawing of permafrost. Data indicates that regions north of the Arctic Circle are warming three times faster than the rest of the globe. This phenomenon known as Arctic amplification has led to a more pressing need to constantly monitor permafrost status in sensitive areas such as cities, villages, and roads.

Several subsurface sensing techniques have been developed to address this mapping challenge, but these methods, such as Time Domain Reflectometry and GPR are either costly to deploy or overly sensitive to environmental conditions. The In-Flight Rapid Observation and Survey Tool (iFROST) is a prototype, remote, non-contact, frequency-domain electromagnetic (FDEMI) sensor that is light enough to be carried on a UAS and has been designed for the detection of permafrost.

Previous work on the iFROST system suggested that varying the sensor's elevation would provide higher resolution of the subsurface stratigraphy than employing multiple frequencies. Using this approach, we designed an electromagnetic induction system that operates at two frequencies. The system was tested over a freshwater pond in Hanover, NH, using various receiver coil combinations to demonstrate the system's stability. The data were compared to a forward model, suggesting that the results are also predictable. Finally, the system was deployed in Fox, Alaska, using a non-conductive rig over two sites with different permafrost depths. The commercially available GEM2® system from Geophex was used as the industry standard to compare the iFROST results.

This presentation demonstrates that the iFROST system is orders of magnitude more accurate per sample over permafrost locations and that the sensitivity of the iFROST system is high enough to detect the boundary between the active layer and permafrost within the top two meters.

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