Geophysical Research Abstracts
Vol. 21, EGU2019-15546-1, 2019
EGU General Assembly 2019

Modular sensor system for precise ground surface temperature measurements

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Temperature conditions in permafrost are typically monitored using deep boreholes that are complex to establish and maintain. In order to assess ground surface temperature (GST) simple single channel data loggers at the surface, e.g. Maxim i-button devices, or data loggers with one or at most a few (2-3) temperature sensors are placed into a shallow borehole, e.g. Geoprecision devices. Different products but also custom built solutions all exhibit different characteristics w.r.t. measurement depth, sensor types, sensor characteristics, resolution, measurement range, long-term stability, interchangeability, calibration capabilities, possible installation depth etc. A number of products are limited in configurations, e.g. only at pre-defined depth, limited in range, e.g. UMS TH3 bottoms out at -20C. Reports of problems with casing, water ingress, corrosion, power loss etc. are abundant. Costly replacements after short lifetimes or total loss of experiments are the norm and consequentially many measurement are unreliable and inaccurate. The plethora of solutions available make it difficult for cryospheric sciences to achieve reliable, repeatable, interchangeable and comparable temperature measurements.

In this presentation we provide a modular sensor rod solution that can be custom configured to the desired number of measurement channels each positioned at the required depth all sealed and encased in a glass fibre reinforced tubing. The design is inspired and based on the original PermaSense sensor rod designed by H. Gubler and A. Hasler (2007) and interchangeble to the UMS TH3 sensor rods but significant improvements have been made: The dimensions have been enlarged to 20 mm diameter to allow better handling, all thermistors are housed in metal contact rings for good thermal coupling to the ground. The rings are stacked with segments of glass fibre reinforced tubing that is configurable to the number of sensor channels and spacing desired. All cabling and electronics is routed inside the tubing that is finally filled with industrial potting resin compound. Built-in reference resistivities allow to cross check for cable breaks. We employ 44031 thermistors that are a good compromise between price and interchangeable accuracy of +/- 0.1C although other thermal sensors can also be used if required. The 20 mm diameter of the sensor rod requires a larger hole to be drilled but we have shown the feasibility of installation with a standard battery powered hammer drill, e.g. on the Matterhorn Hoernliridge site with 100 cm depth and 22 mm diameter in under 30 min installation time.

Furthermore a calibration bath for horizontal positioning of the while sensor rod in a dewar-like structure has been designed. Forced water circulation in a crushed ice/water mix contained in an insulated stainless steel container with additional temperature control allows a single point calibration of the fully assembled device up to the accuracy of the reference thermometer provided. Possible further improvements could be to pump the whole ice/water slush to avoid further layering effects during temperature calibration or to perform multi-point calibration using other liquids than water (alcohol, oil) but these have so far not been considered.