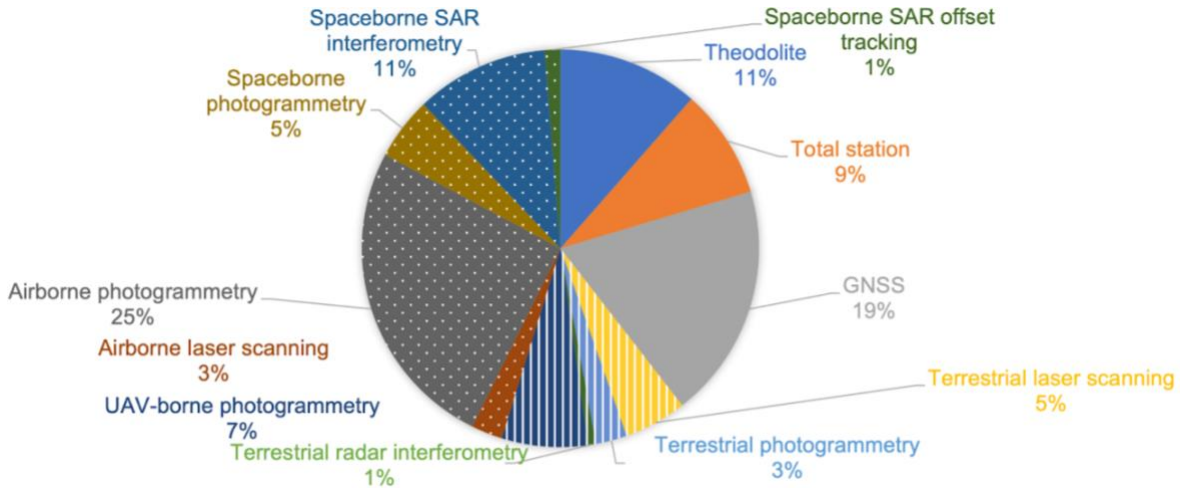
Geodesy for Essential Climate Variable products associated with Permafrost

Lin Liu[1,2] and Yan Hu[1,2]

1. Earth and Environmental Sciences Programme, Faculty of Science, The Chinese University of Hong Kong, Hong Kong SAR, China
2. Institute of Environment, Energy and Sustainability, The Chinese University of Hong Kong, Hong Kong SAR, China

Permafrost has long been listed as a terrestrial Essential Climate Variable (ECV) by the Global Climate Observing System (GSOS). Since permafrost is purely defined by the subsurface temperature, many of its changes occurring underground are mainly observed by borehole measurements but with limited spatial coverage.

This paper reviews the applications and potential of geodetic methods to generate two ECV products: active layer thickness and rock glacier velocity. Leveling, InSAR, and GNSS Interferometric Reflectometry measure seasonal, cyclic thaw subsidence and frost heave. A few retrieval algorithms have been developed to take the geodetic measurements of elevation changes as the input to indirectly estimate active layer thickness and have achieved moderate success in a few case studies. Substantial improvements, especially incorporation with frozen ground hydro-thermal models and remote sensing products of soil moisture and ground surface temperature, are warranted to improve the accuracy and generalizability of geodetic methods for generating reliable active layer thickness. Despite being just added by GSOS in 2022 as a new ECV product, rock glacier velocity has been routinely measured using various geodetic methods including theodolites, total stations, GNSS, laser scanning, and InSAR for years to decades. The geodesy community should be actively involved to provide inputs to the International Permafrost Association to standardize the measurement protocols towards monitoring changes of rock glacier velocities around the globe.



Percentages of the different techniques adopted for measuring or computing rock glacier velocities in the literature. The solid, striped, and dotted areas represent in-situ, close-range remote sensing, and remote sensing techniques, respectively.