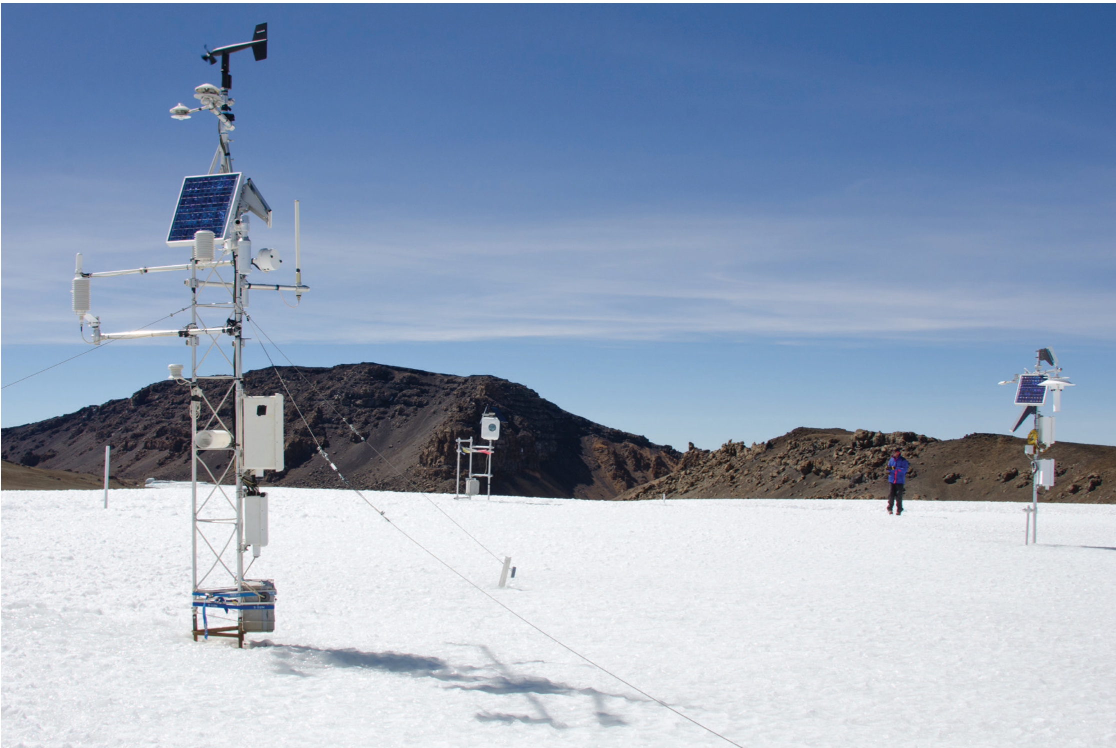
Global Network for Observations and Information in Mountain Environments

GEO MOUNTAINS
Observing Mountain Environments



UNIFORM HIGH-ELEVATION OBSERVING PLATFORM (UHOP)

For Detecting and Understanding Climate Change Phenomena Across the World's Mountains

MOUNTAIN RESEARCH INITIATIVE

ADAPTATION AT ALTITUDE
Taking Action in the Mountains

Fig. 1. Decreasing glacier extent at Chacaltaya, Bolivia – formerly the world's highest ski resort.

From rapidly retreating alpine glaciers to increasingly frequent landslides and rockfalls, there are indications that climate warming is proceeding more rapidly at higher elevations (Pepin et al. 2015, 2022). Elevation dependent warming (EDW) is similar to the recognized phenomenon of accelerated Arctic warming and may lead to similar environmental changes (e.g. reduced snow cover and increased glacier melt, stresses on mountain biodiversity, and changes in mountain water resources). As mountains and their downstream environments are often densely populated, however, the human consequences of accelerated warming in mountains are particularly important.

Unfortunately, our current climate data networks are often biased towards lower elevations (e.g. Thornton et al., 2022), where data are easier to collect and topographies less complex. In order to gain critical information on climate change in mountains, we need to expand our capabilities in mountain regions by establishing data-rich observing sites.

Since 2016, the Group on Earth Observations (GEO) has endorsed the Global Network for Observations and Information in Mountain Environments (GEO Mountains), which seeks to increase the discoverability, accessibility, and use of a wide range of data and information pertaining to the world's mountains to detect, understand, and predict future global change in mountains and consequences.

One key task of GEO Mountains is the creation of a so-called Unified High Elevation Observing Platform (UHOP). This platform will consist of observational elevational transects in mountain ranges representative of the global variation in latitude, elevational extent, continentality, and orientation. On some mountain ranges, it may be important for the transects to extend over the whole range to include both windward/lee slope effects. The exact number and location of sites will be established in consultation with national agencies and research organisations. GEO Mountains' ongoing work to develop inventories of in situ monitoring infrastructure will assist this effort (Fig. 5).

Each transect will ideally consist of :

1. At least two (on-grid/powered) weather stations ("Anchor stations") in a tower configuration with automatic data-logging, full energy balance instrumentation and standardised radiation shields for temperature and humidity measurements. At a minimum, measured variables will include Essential Mountain Climate Variables (Thornton et al., 2021) like air temperature, relative humidity, upward and downward shortwave and longwave energy fluxes, wind speed and direction, and pressure, but may also include others (e.g. full flux and air quality measurements). Stations will be equipped to measure precipitation in both solid and liquid form, as well as snow pack/depth where climate conditions are appropriate. Corroborating data can be supplied by a webcam/time-lapse camera for verification of snow presence/absence for quality control purposes.

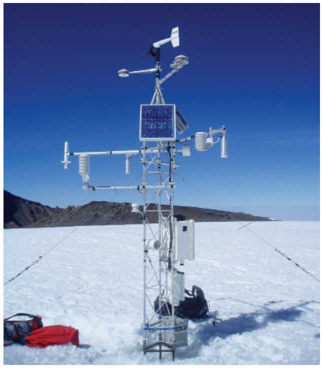


Fig. 2. Anchor station providing high quality data at Kilimanjaro Northern Ice Field (5,803 m a.s.l.). The anchor station is equipped to measure energy balance components and snow depth as well as well as standard variables.

2. Multiple sites (at least five, and maybe as many as 20) located between the two anchor sites along a mesoscale transect. Using inexpensive battery-powered sensors, these "Float stations" will measure limited variables (near surface air temperature, relative humidity and if possible land surface temperature/upward and downward short wave radiation or proxy) with hourly data logging to enable detailed characterisation of the diurnal cycle.

Fig. 3. Float station along a transect on Kilimanjaro. Sensors for temperature and humidity are shielded from radiation inside a section of PVC pipe. Use of local materials and methods is often more cost-effective in remote environments.

Located at or near the extremities of the observational transects, the two Anchor stations are essential for the calibration of Float sensors along the transect. Wherever possible, additional Anchor stations will be located at intermediate points along the transect, filling essential information gaps about high elevation climate changes in these complex topographies. In order to reduce costs, facilitate site selection, and encourage the participation of relevant meteorological agencies, elevational transects will be anchored by existing, well-established mountain weather stations.

These transects will provide the data needed to identify, track, and better understand elevation-dependent climate changes, as well as to validate remotely sensed land surface temperature and precipitation products. Finally, they will provide much needed data to assess the performance of climate simulation models, which currently perform rather poorly in complex mountain terrain.

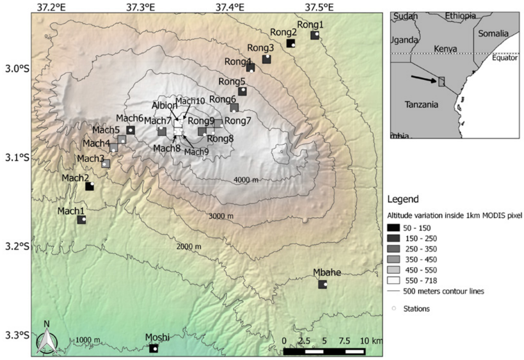


Fig. 4. A single elevational transect within UHOP with observing sites along elevational gradients on two different aspects of Kilimanjaro. Circles show the location of sensors. The ANCHOR station (see Fig. 2) is located at Mach10 at Kilimanjaro Northern Ice Field.

The first stage of development of the global UHOP will be to collate systematic information on current and potential new transects. Where possible, UHOPs will be embedded in within sites belonging to a more general Global Network of Mountain Observatories that is also being developed via the MRI and GEO Mountains (Shahgedanova et al., 2021).

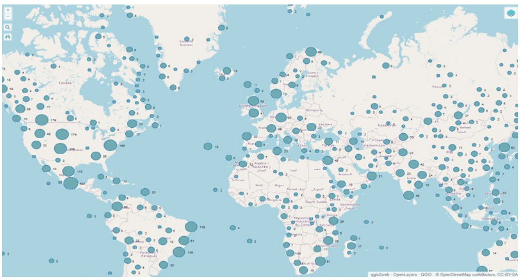


Fig. 5. GEO Mountains' In Situ Inventory, from which existing or potential future UHOP sites could be identified.

Next steps will focus on protocols concerning data quality, calibration, upgrading/maintenance of current instruments etc. These will be balanced such that the UHOP is composed of enough stations to build a representative overview of climate changes at high elevations on a global scale.

Please contact Dr. Nick Pepin (nicholas.pepin@port.ac.uk) or Dr. James Thornton (james.thornton@unibe.ch) to express interest in becoming part of UHOP or to obtain further information

https://www.mountainresearchinitiative.org/activities/community-led-activities/working-groups/2098-elevation-dependent-warming

www.geomountains.org