Understanding the current state and predictable future changes in the state of permafrost distribution in North-Western Himalayas, India

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ABSTRACT

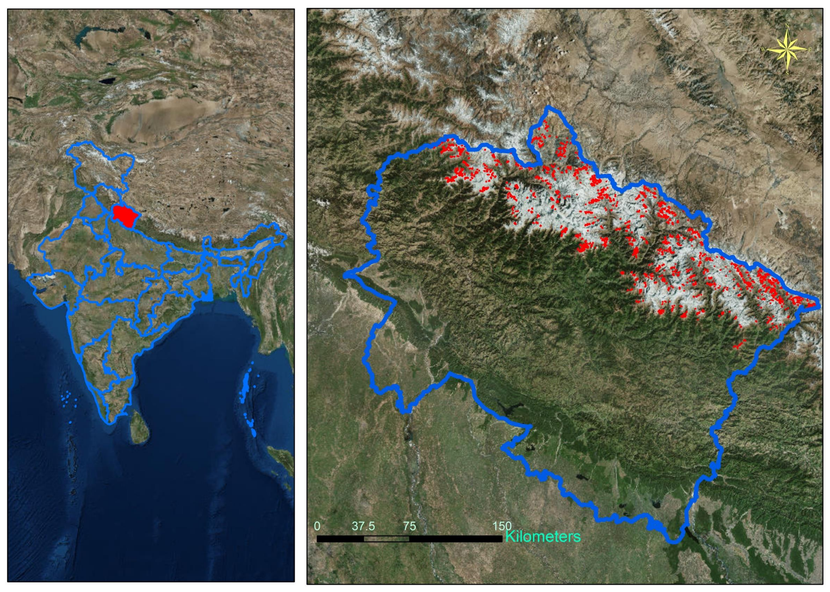
The impacts of climate change on extent of permafrost degradation in the Himalayas are not well understood due to lack of historical ground-based observations. The area of permafrost exceeds that of glaciers in almost all Hindu Kush Himalayan (HKH) countries. However, very little is known about permafrost in the region as only a few local measurements have been conducted which is not sufficient to produce the fundamental level of knowledge of the spatial existence of permafrost. We intend to simulate permafrost conditions in Western Himalayas in India using Hyperspectral and Microwave remote sensing methods and computational models for the quantitative assessment of the current state of permafrost and the predictions of the extent and impacts of future changes. We also aim to identify the strength and limitations of remotely sensed data sets when they are applied together with data from other sources for permafrost modelling. We look forward to modelling ground temperatures using remote sensing data and reanalysis products as input data on a regional scale and support our analysis with measured in situ data of ground temperatures. Overall, we approach to model the current state and predictable future changes in the state of permafrost in Western Himalayas and also couple our results with similar research outcomes in atmospheric sciences, glaciology, and hydrology in the region.

BACKGROUND

- HKH Region: 15.95° to 39.31° N latitude; 60.85° to 105.04° E longitude
- Permafrost studies mostly in the Qinghai-Tibet region
- Himalayas: studies are sporadic and intermittent
- Himachal Pradesh (Allen et al., 2016)
- Jammu and Kashmir Himalaya (Mayewski et al., 1981)
- Karakoram Mountains and Lahul and Garhwal Himalayas (Owen and England, 1998)
- Ladakh (Wünnemann et al., 2008; Wünnemann et al., 2010)
- Nanga Parbat Himalayas (Shroder et al., 2000)
- HKH region (Schmid et al., 2015)

WE HAVE STARTED WITH

- Creating an inventory of rock glaciers in Uttarakhand
- Polygons digitized as rock glaciers and embryonic rock glaciers in Google Earth
- Classification
  - Landform (Rock Glacier, Embryonic Rock Glacier)
  - Embryonic Rock Glaciers: Protalus ramparts, Pronival ramparts, Protalus lobes, Debris Covered Glacier in the process of transition into to a rock glacier
  - Activity (Intact, Relict, Could not be determined)
  - Source of sedimentary material transported (Debris, Talus)
  - Shape (Tongue shaped, Lobate shaped)

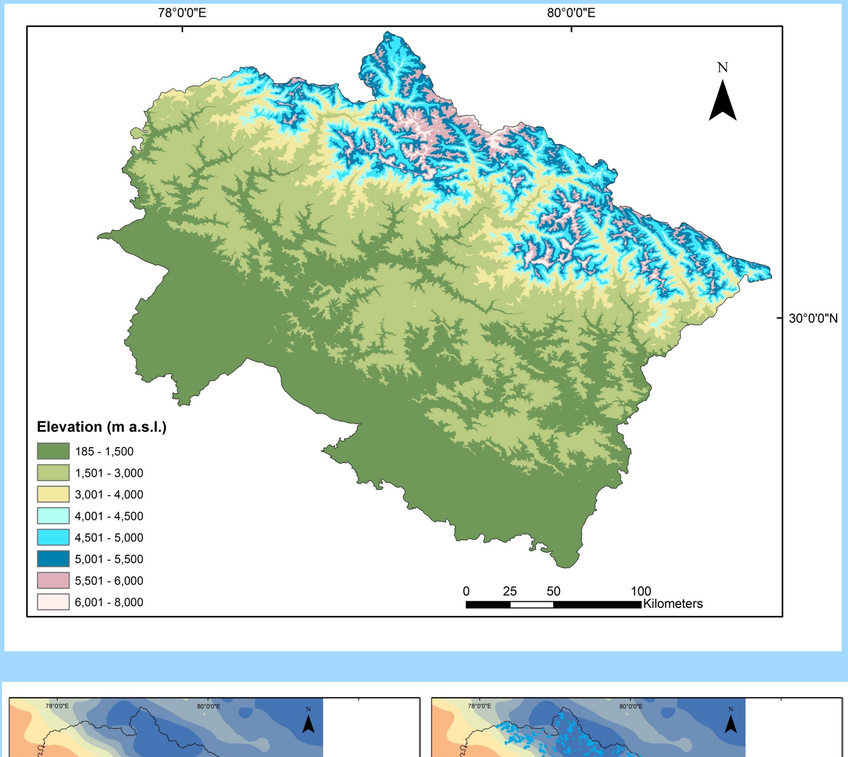


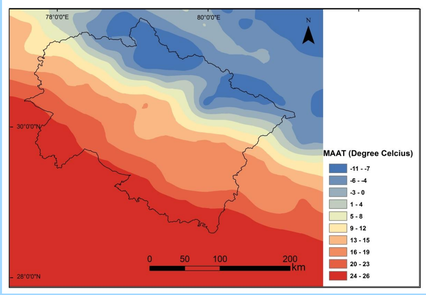
Classification on the basis of:

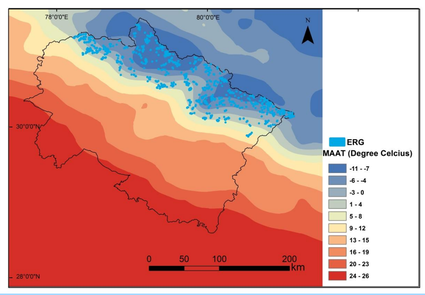
- Literature review [Scotti et al., 2013; Martin and Whalley (1987)]
- Study of the geomorphology (Elevation, Contributing area, Vegetation, Frontal Slope, Parallel or Curved Ridges, Visibility of front, Appearance of materials exposed, Convex shape)

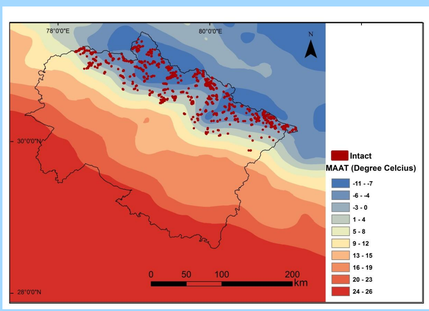
PRELIMINARY RESULTS

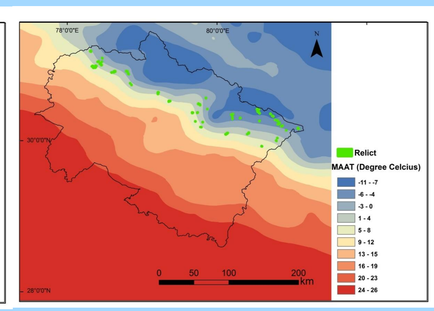
Mapped Landforms			
Embryonic Rock Glaciers	981		
Rock Glaciers	Intact	Relict	Activity Could not be determined
Talus — lobate	39	2	2
Talus — tongue shaped	84	18	5
Debris — lobate	107	9	3
Debris — tongue shaped	431	71	13
Total rock glaciers	661	100	23

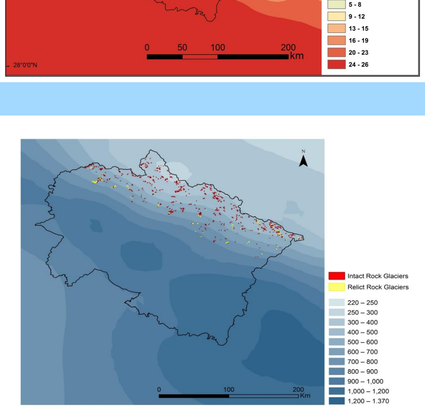


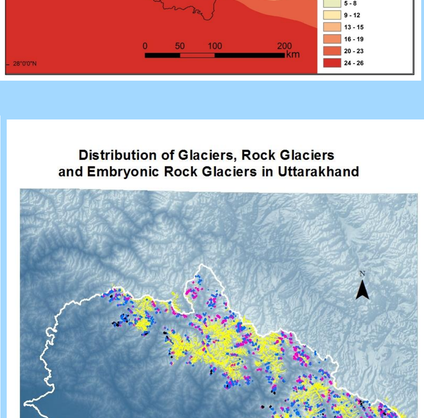


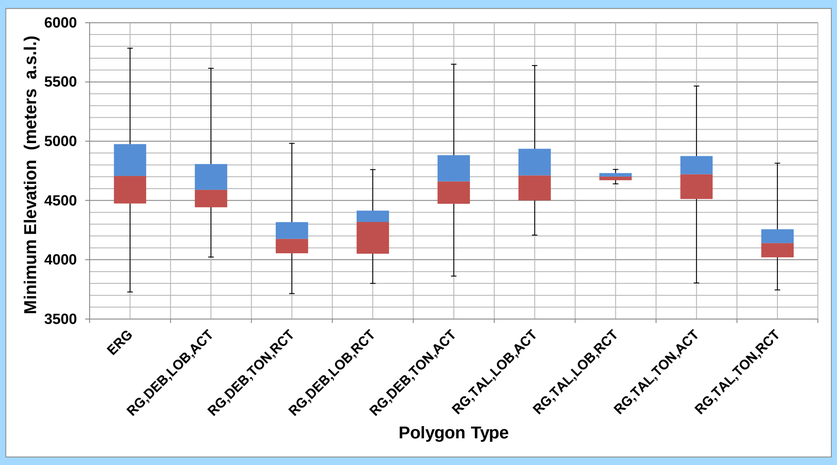


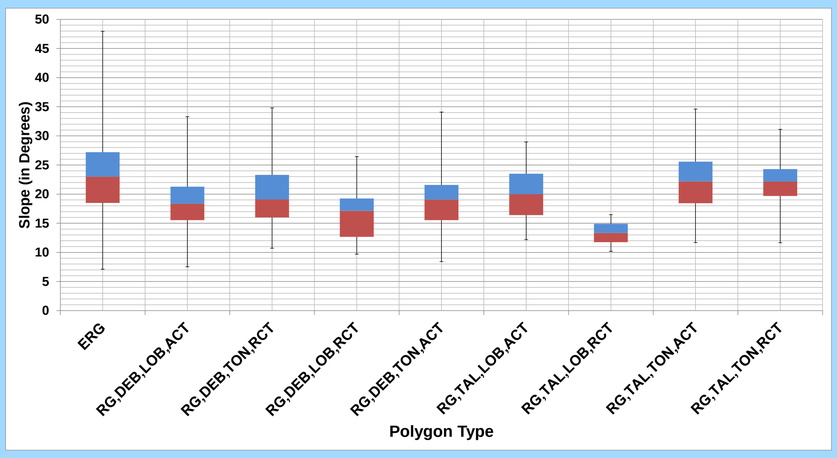


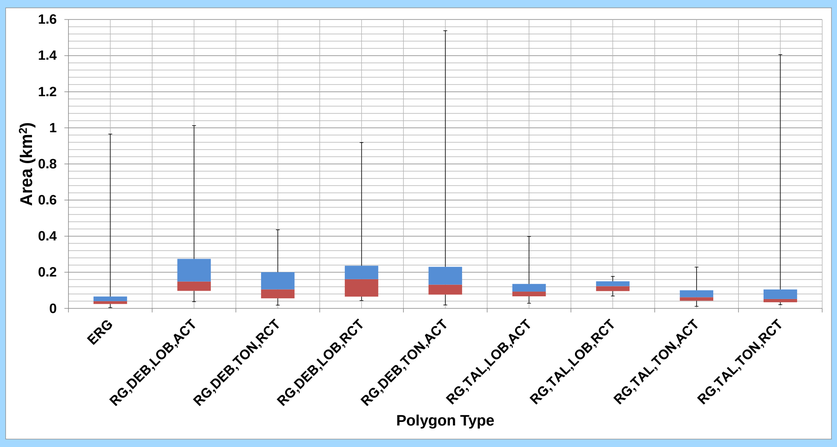


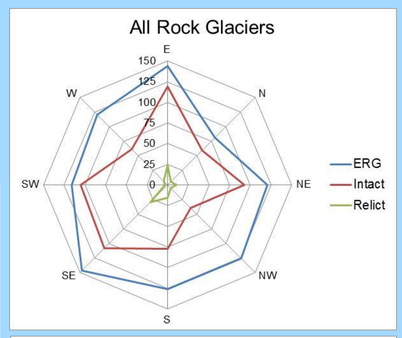


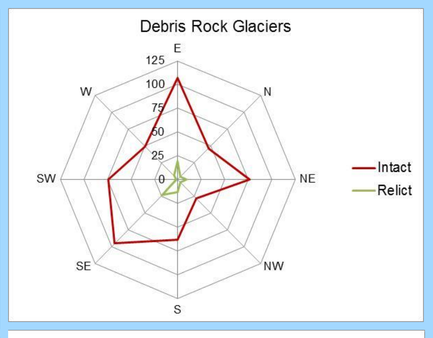


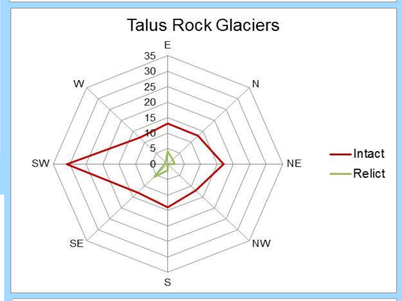


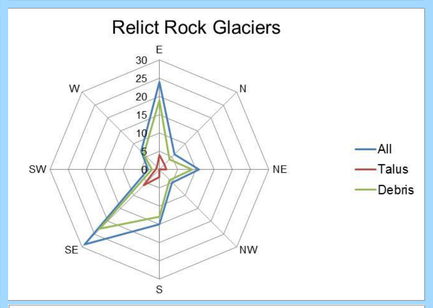


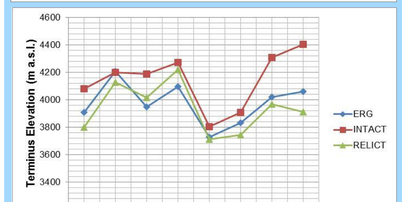


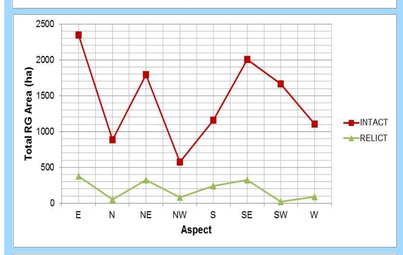


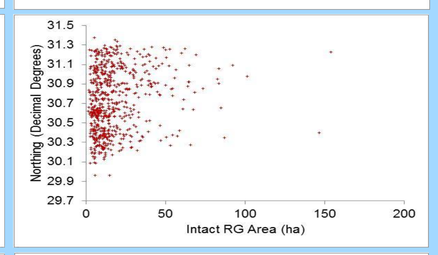


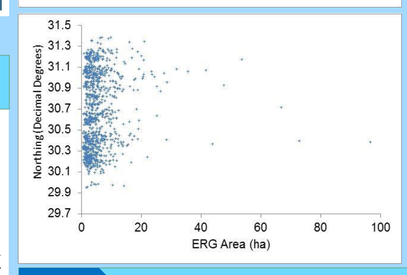


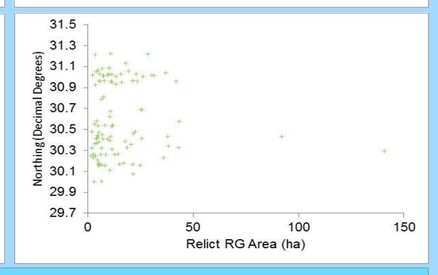












WHAT REMAINS?

- Field validation of digitized polygons (August - September 2017)
- Temperature measurement in the field using data loggers
- Application of microwave remote sensing to detect changes in rock glacier motion
- Delineating Accumulation area of Rock Glaciers and observe possible relationship
- Logistic Regression modelling to calculate spatially-distributed probability of permafrost occurrence using topoclimatic factors

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