SAMPLING SUPRAGLACIAL DEBRIS THICKNESS USING TERRESTRIAL PHOTOGRAMMETRY

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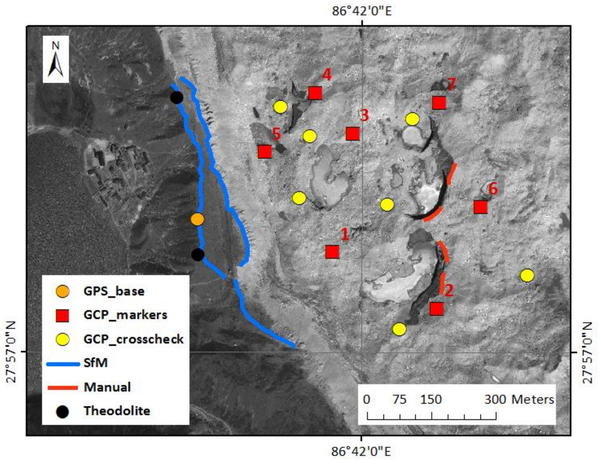
BACKGROUND:

- Thickness of debris cover (h_d) is most important parameter influencing surface ablation rate
- Its a really problematic variable to measure
- Many debris covered glaciers are studded with ice cliffs, topped with steep debris exposures
- Previous study approximated h_d using theodolite survey (Nicholson & Benn, 2010) of debris exposures
- Can we make similar measurements on a digital surface model (DSM) derived from photogrammetry and a structure from motion (SfM) workflow?

DATA COLLECTION:

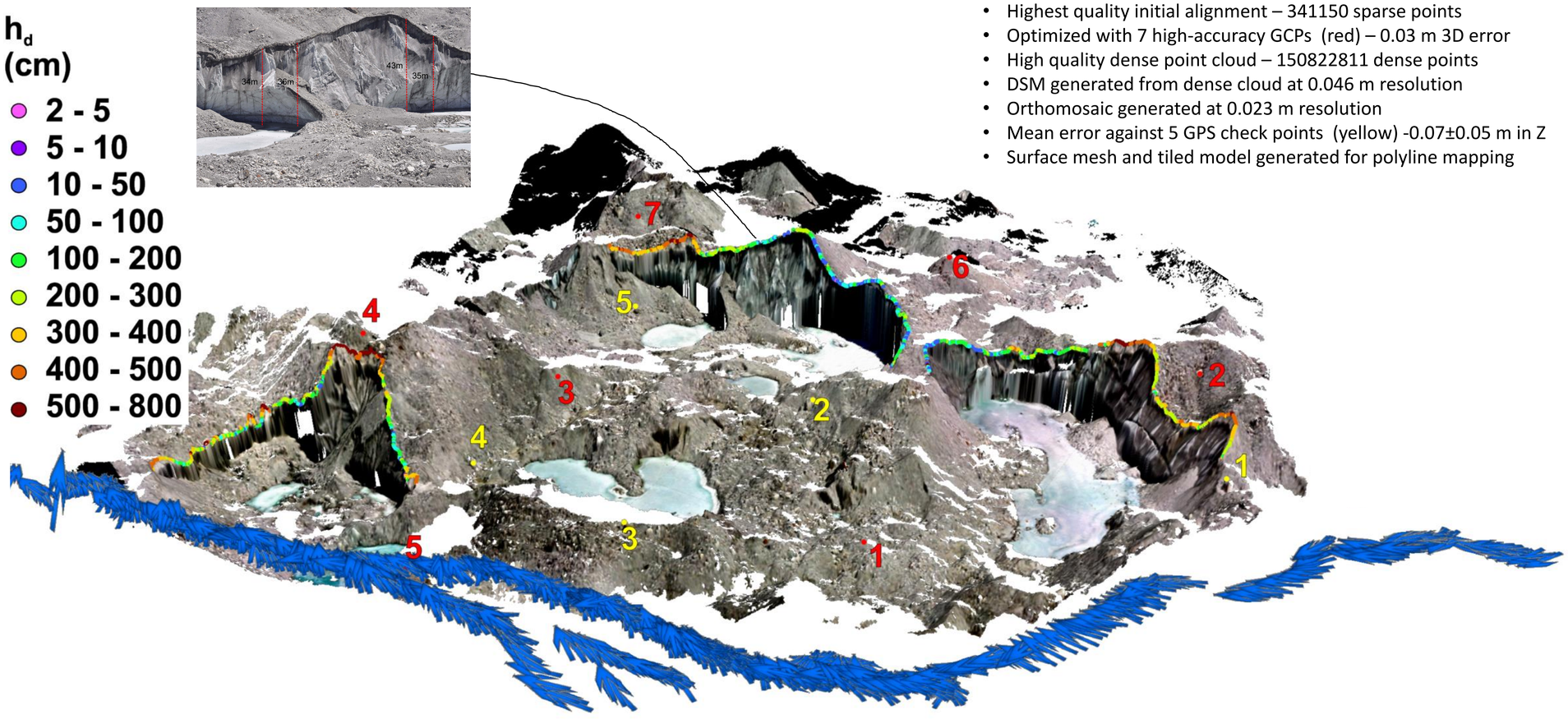
- Ngozumpa Glacier, Nepal
- Nikon D5000, 100mm Tamron lenses
- ISO 200, RAW and high resolution JPEG
- >2000 images taken from lateral moraine overlooking lake basin and cliffs
- 7 GCPs (red) and 5 cross check GCPs (yellow) measured with centimeter precision
- Trimble Geo 7X, dGPS, Zephyr antenna, local base
- Manual measurements along accessible cliff sections Theodolite survey from 2001



METHOD OF EXTRACTING DEBRIS THICKNESS:

- Polylines for debris crest and debris-ice interface mapped in Photoscan
- Polyline pairs imported into ArcMap and draped over digital surface model and Orthoimage
- Points extracted every 1 m along debris crest
- Corresponding debris-ice interface points calculated using 'Near' tool in ArcMap
- X,Y,Z coordinates extracted for each point pair
- Debris thickness estimated by differencing Z values between pairs

STRUCTURE FROM MOTION DIGITAL SURFACE MODEL WITH DERIVED DEBRIS THICKNESS (h_d) OVERLAIN:

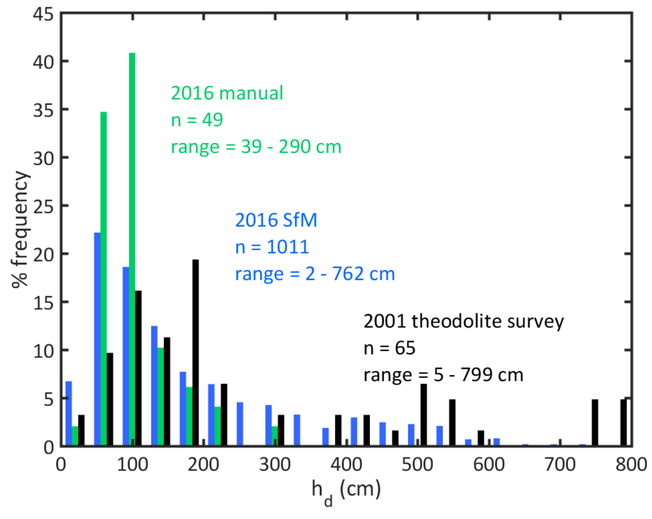


1160 camera positions along upper and lower western lateral moraine ridges

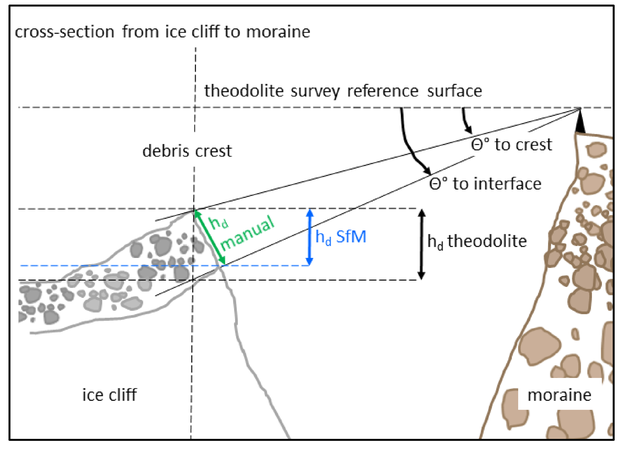
TECHNICAL DETAILS OF DIGITAL SURFACE MODEL:

- Highest quality initial alignment – 341150 sparse points
- Optimized with 7 high-accuracy GCPs (red) – 0.03 m 3D error
- High quality dense point cloud – 150822811 dense points
- DSM generated from dense cloud at 0.046 m resolution
- Orthomosaic generated at 0.023 m resolution
- Mean error against 5 GPS check points (yellow) -0.07±0.05 m in Z
- Surface mesh and tiled model generated for polyline mapping

"EVALUATION" OF DEBRIS THICKNESS:



COMPARING WHAT IS BEING MEASURED:



CONCLUSIONS:

- High resolution imagery provides a sufficiently high quality digital surface model
- Practical method to estimate h_d
- Allows a large number of sample points
- Sideways looking UAV imagery could be used to better capture debris exposures over whole glacier and all cliff orientations

- Samples restricted to debris exposures
  …. but these occur
  - all over glacier
  - all aspects
  - cut through terrain
- Uncertainty around appropriate representation of debris ice interface projected beneath debris crest