1. Motivation
The Hindu-Kush Himalaya stores more ice than anywhere on earth outside the Arctic and Antarctica, yet predictions of glacier mass loss in High Mountain Asia are severely limited by data availability. Surface ablation processes have received focused attention, but observations of englacial and subglacial properties and processes are severely lacking. In particular, few measurements exist of glacier thickness, ice temperature, englacial sediment concentration, basal water pressures, bed composition or 3D strain. The EverDrill project seeks to collect unique borehole observations of these properties and processes for the debris-covered Khumbu Glacier in order to better constrain current and future glacier dynamics.

2. Hot-water Drill Design
Basic operating requirements:
- Hot, pressurized water at 5200 m (52% sea level pressure)
- Can drill to 200 m
- No component over 200 kg

Balancing design needs we used an altitude-adapted Kärcher HDS 8018 pressure washer in a system similar to those described in Hubbard and Glasser (2005). On-site adjustments were needed. Starting the engine and burner was very challenging. Drilling was slow, but steady.

3. Observational Techniques
To assess englacial and subglacial conditions, we used two probes and installed several types of sensor:
- A CT probe: electrical conductivity & temperature
- An optical televiewer (OPTV): produces a high resolution 360° image of the borehole.
- Thermistors: temperature.
- Solid-state inclinometers: tilt and rotation.
- A multiprobe at the borehole bottom: pressure, electrical conductivity, and temperature.

Preparing to use the OPTV at Site 1.

4. Selecting Drill Sites

<table>
<thead>
<tr>
<th>Site Requirements</th>
<th>Rationale</th>
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<tbody>
<tr>
<td>Elevation &lt; 5300 m</td>
<td>Combustion engine and heater has reduced output with lower pO₂ and temperature</td>
</tr>
<tr>
<td>Pond or stream within 20 m laterally, 3 m vertically</td>
<td>Need liquid water to supply drill; limited by hose length and power of water pump</td>
</tr>
<tr>
<td>Heightened glacier velocity</td>
<td>Increased likelihood of basal hydrology</td>
</tr>
<tr>
<td>Glacier thickness &lt; 200 m</td>
<td>Drill hole length, heat dissipation</td>
</tr>
<tr>
<td>Debris-free patch ~ 5 m²</td>
<td>Sediment in borehole inhibits drilling</td>
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</tbody>
</table>

Combining field and satellite observations with the results of numerical modelling, we consider zones of research interest on Khumbu Glacier. Specifically, the possibility to reach the bed is limited by glacier thickness and our ability to heat water (A). Thick, continuous debris hampers hot-water drilling efforts, which require a liquid water supply (B). Heightened surface velocities indicate possible basal hydrology (C).

5. Target Zones and Initial Outcomes

Zone 3: Most likely basal hydrology, unable to reach bed due to depth >200m and cold temperatures. Easy access, lots of ice, limited surface water.

Zone 2: Possible basal hydrology, possibly able to reach bed. Lots of bare ice and surface water, but difficult access.

Zone 1: Stagnant and thin ice, likely to penetrate to bed. Easy access but thick debris cover, good water availability.


6. References and Acknowledgements


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