Late-glacial to Neoglacial evolution of glacier extent and surface mass balance in the Cordillera Blanca, Peruvian Andes

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- Overall project: **CASCADA: Toxin or Treat?**

  Principal investigator: Prof. Jemma L. Wadham

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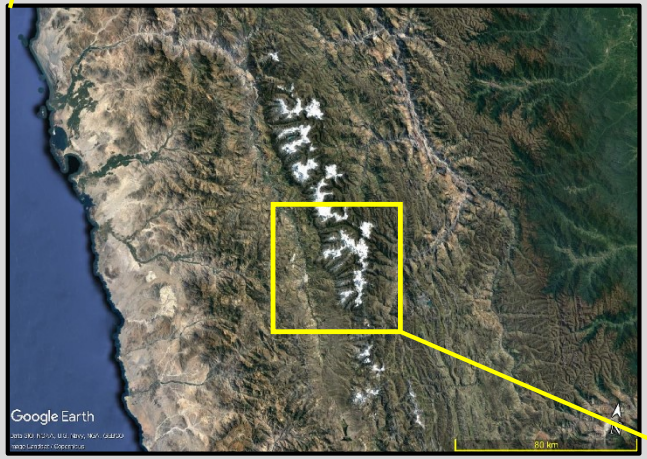
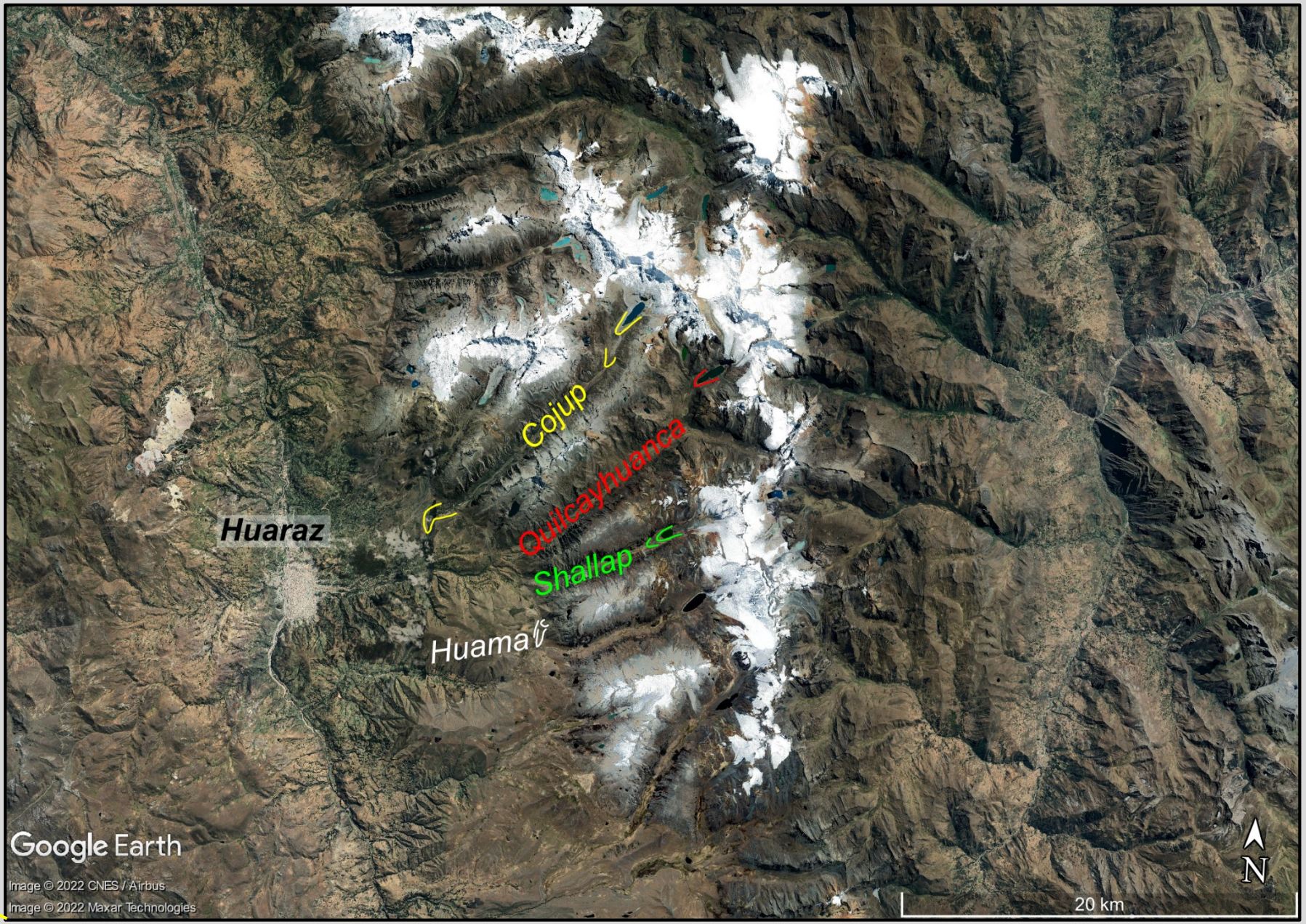
❖ Study area


Cordillera Blanca


Google Earth


Huaraz
Cojup
Quilcayhuanca
Shallap
Huama
Google Earth
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N
20 km

❖ Aims

- Establish a robust geomorphological and geochronological reconstruction of glacier advances in 4 target valleys of the Cordillera Blanca.

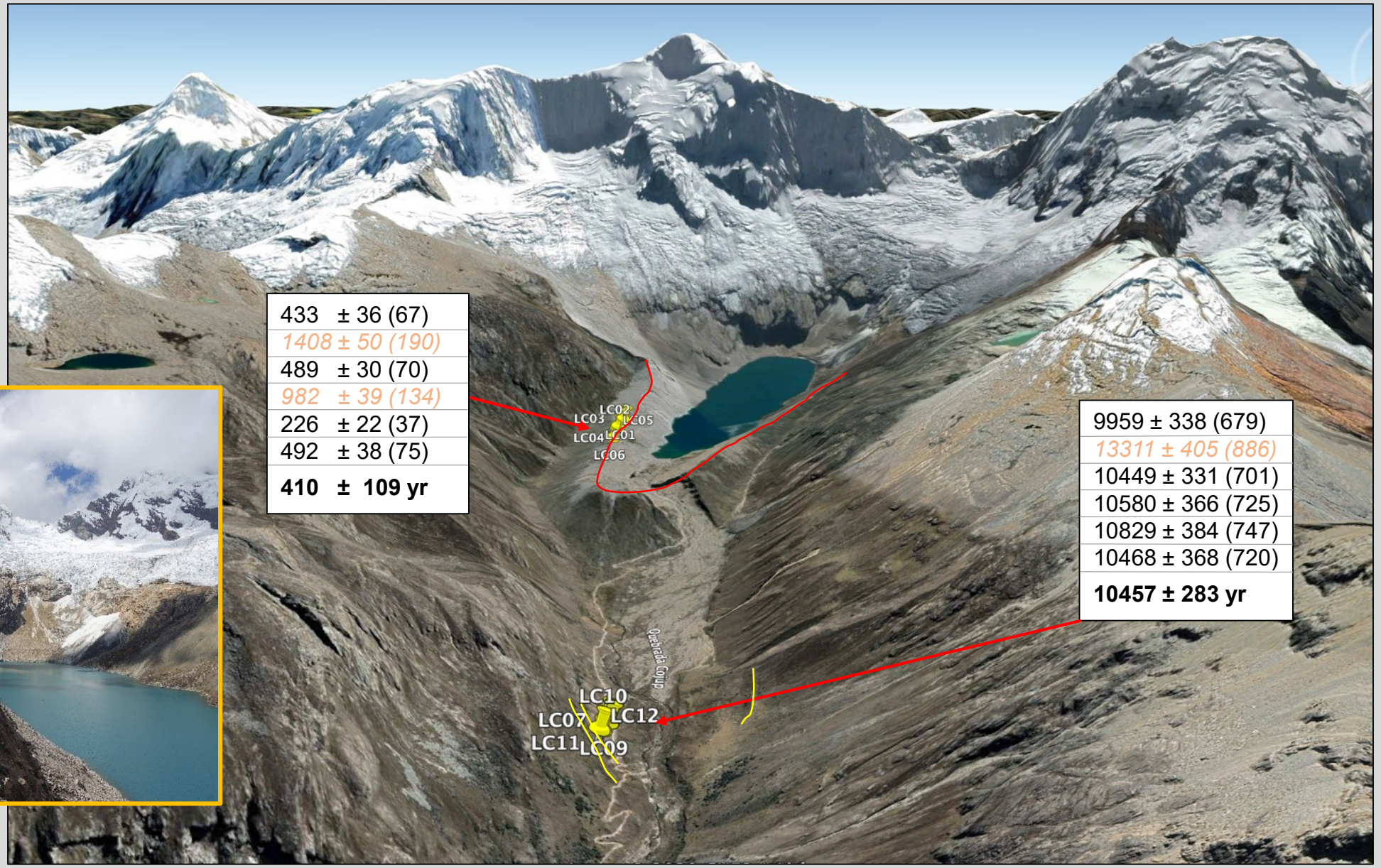
- Conduct a numerical glacier modelling experiment to reconstruct former glacier geometries, ice-mass fluctuations and surface mass balances for each studied glacier advance.

- Combine the cosmogenic nuclide-derived chronology and modelling to estimate palaeo-climate conditions in the region between the LGM and the LIA.

➢ Cojup valley

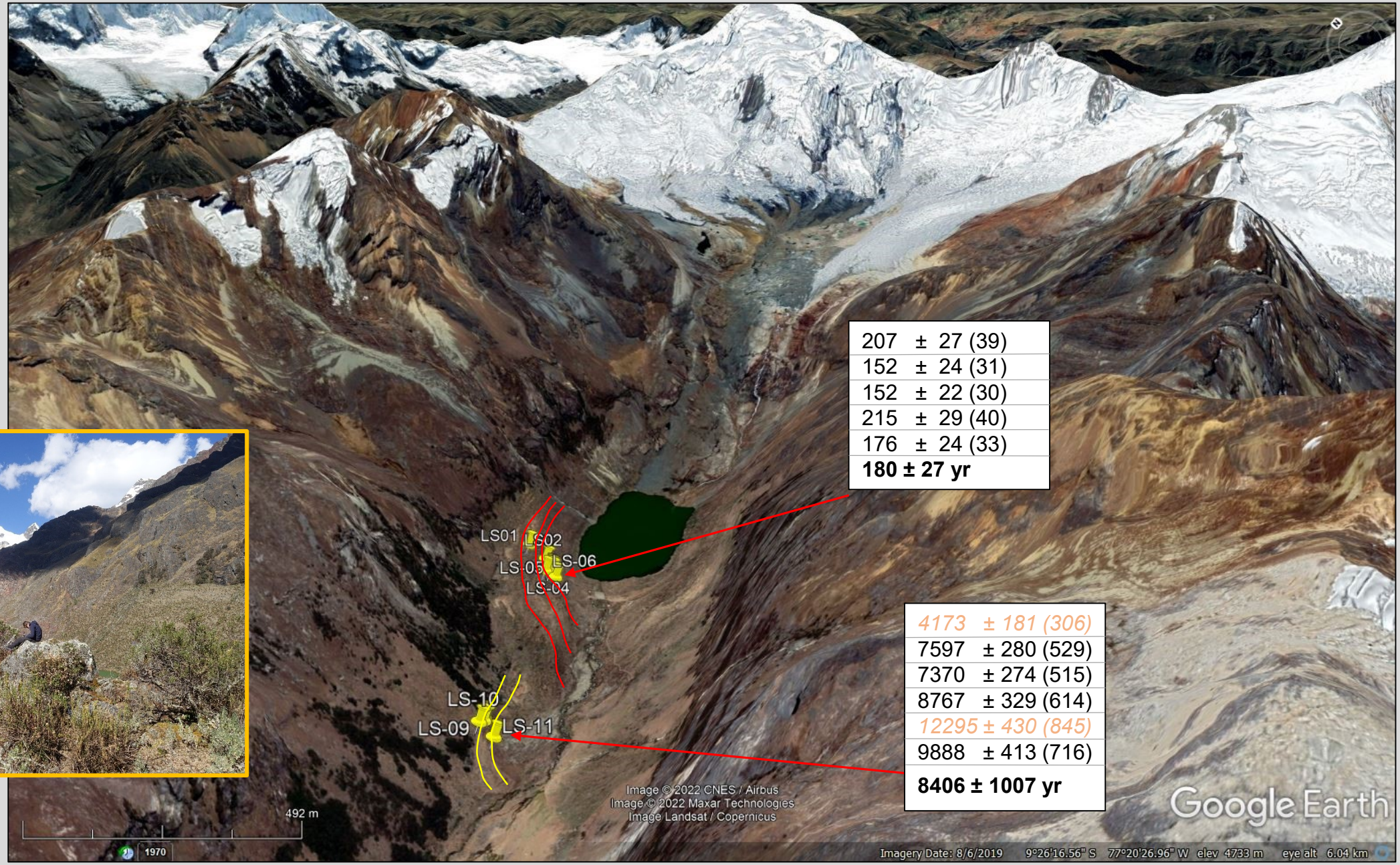
TCN exposure dating:

- 12 boulder samples (granite)
- Prominent LIA advance
- EH advance 1.6 km outboard



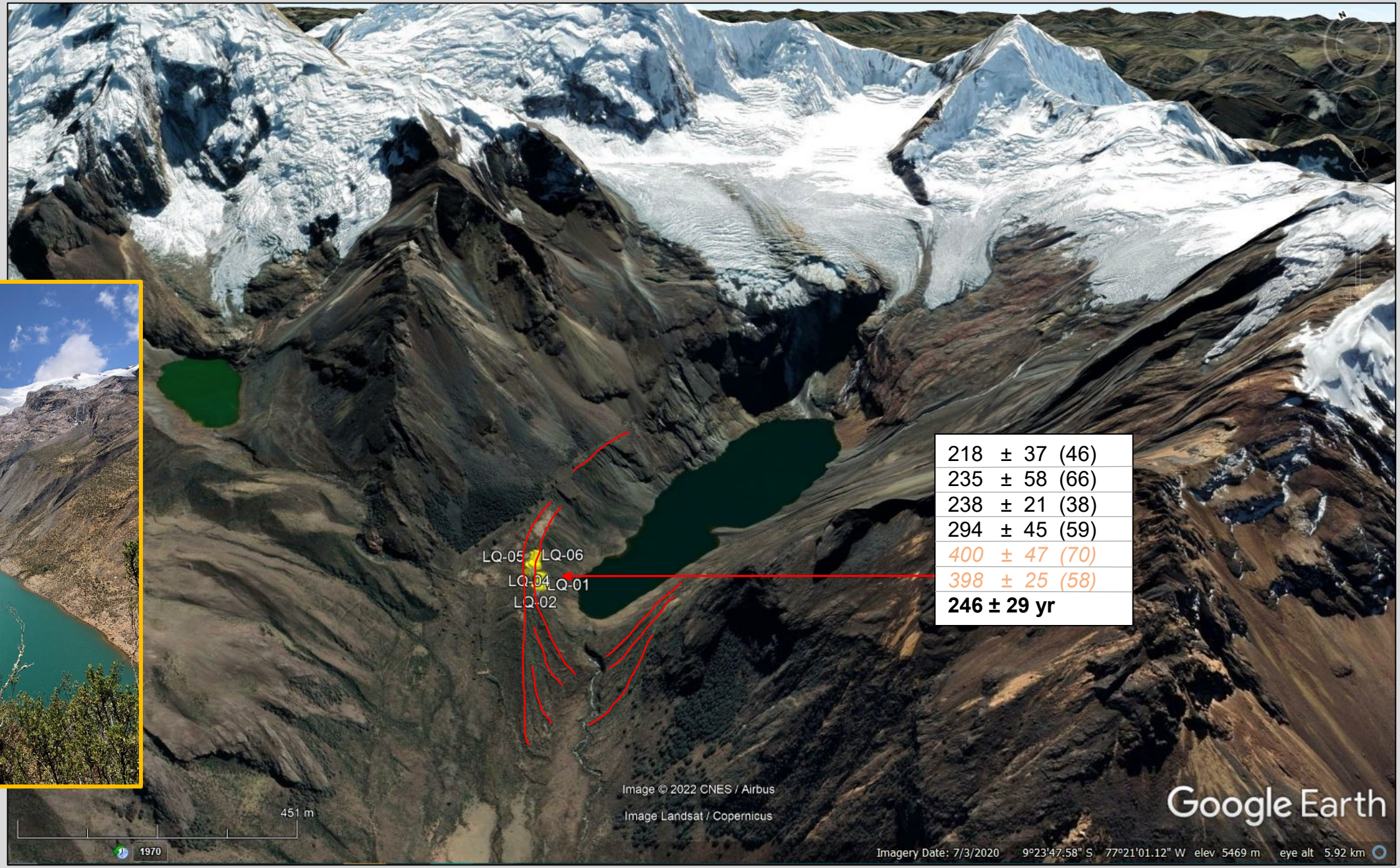
➢ Shallap valley

- 11 boulder samples
- Prominent LIA advances
- EH advance 0.6 km outboard: smaller moraine ridges



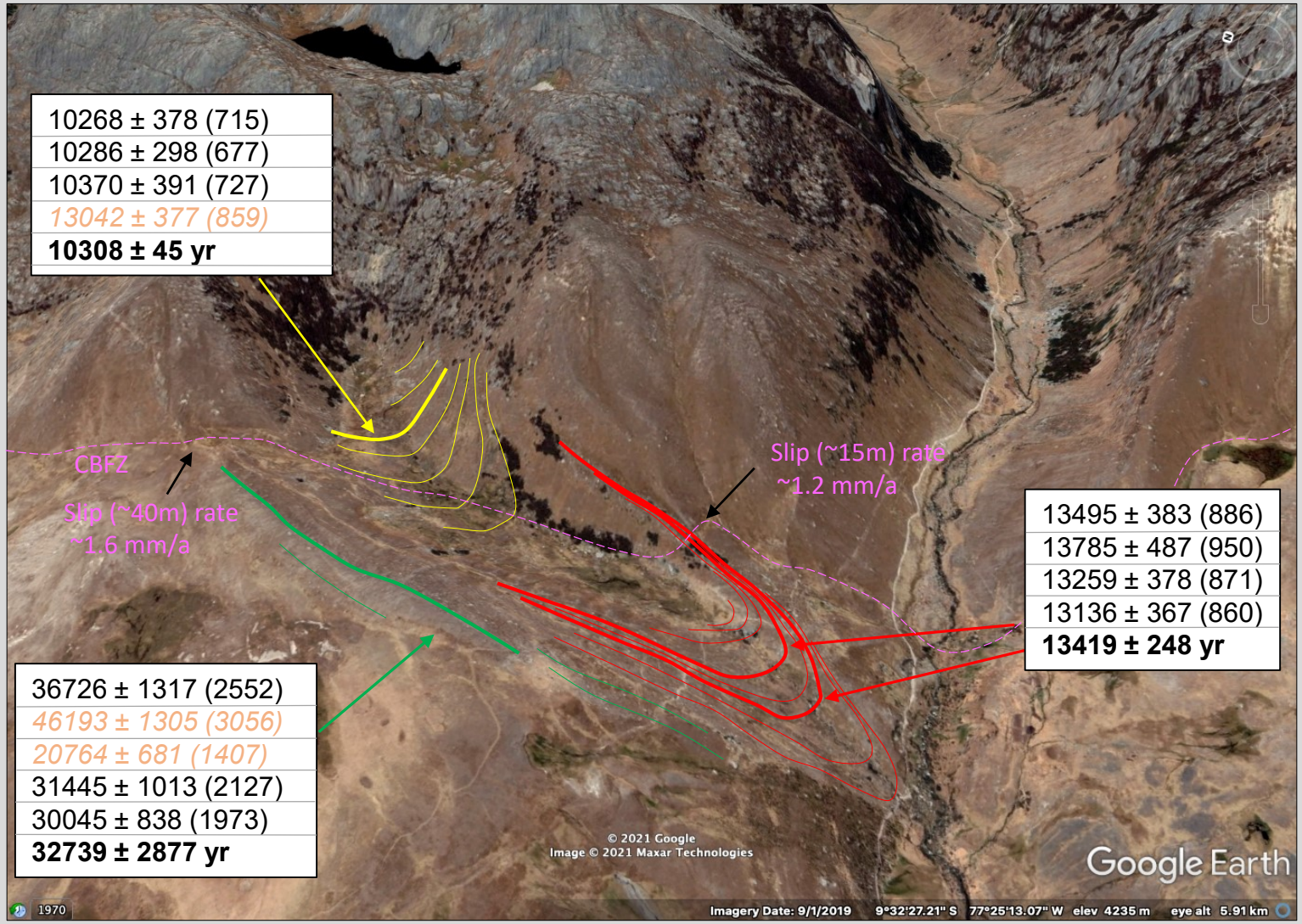
Quilcayhuanca Valley

- 6 boulder samples
- Prominent LIA advances



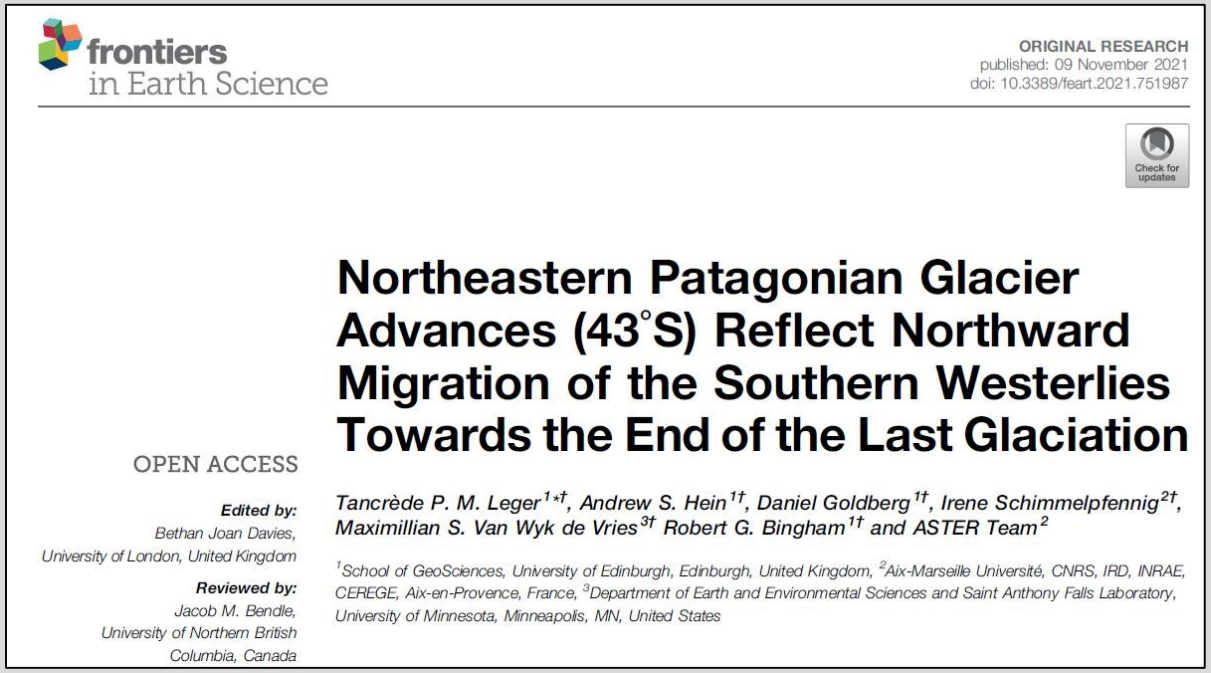
➢ Huamashraju valley

- 13 boulder samples
- 3 distinct glacier expansions preserved
- EH advance
- ACR advance
- Late MIS 3 / early MIS 2 advance



❖ Icecap model

- Spatially distributed ice-flow model
- 30 x 30 m resolution gridded DEM (AW3D30)
- Physics: Shallow Ice Approximation
- Ice-flux = internal deformation + basal sliding (sliding = Weertman's law)
- SMB parameterisation: Positive degree-day
- Modern glacier removal using Glabtop
- 1970-2000 mean climate data downscaled to catchment (WC2 data)
- Calibration of SMB using modern ice extent



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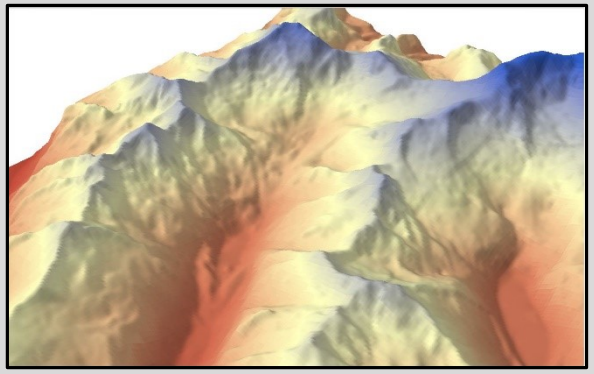
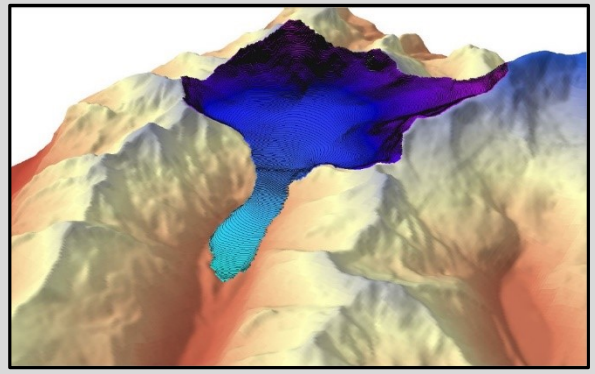
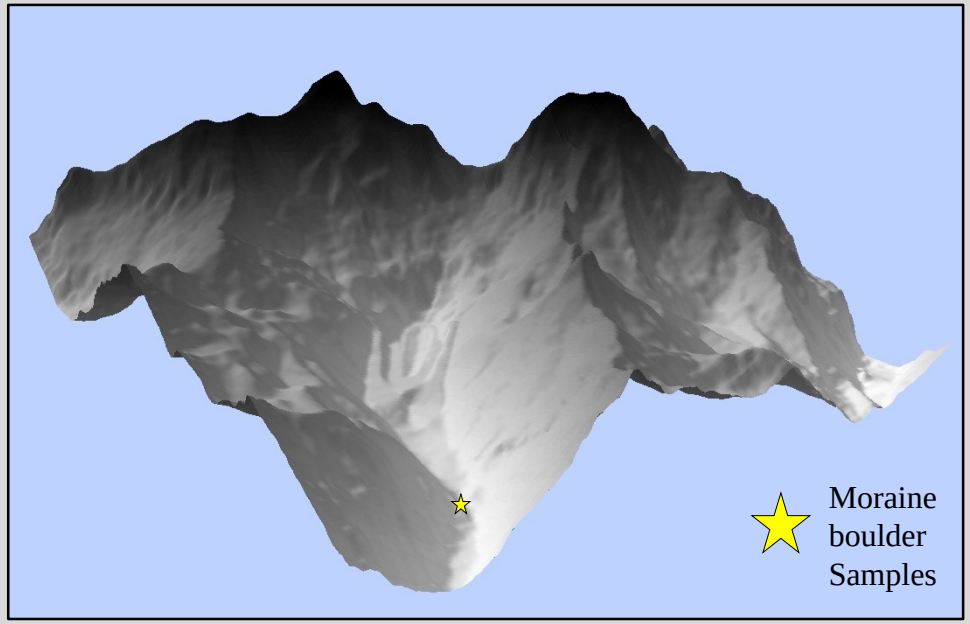
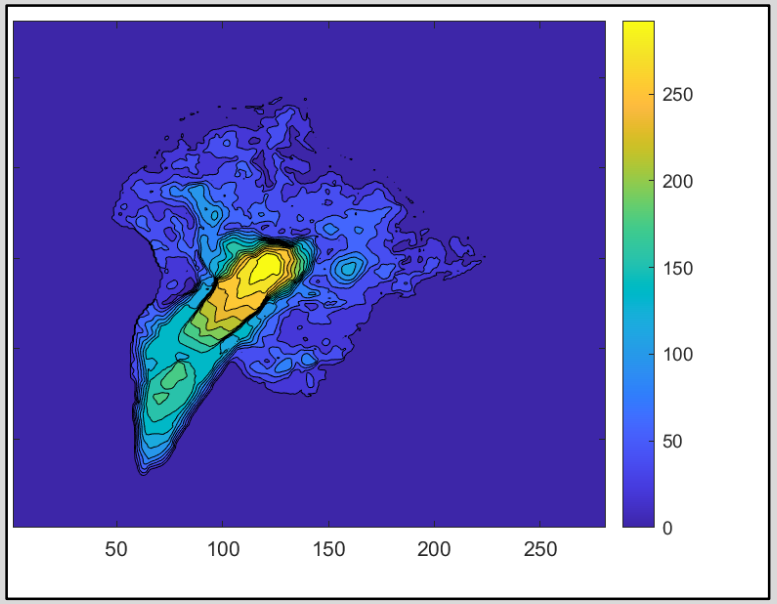


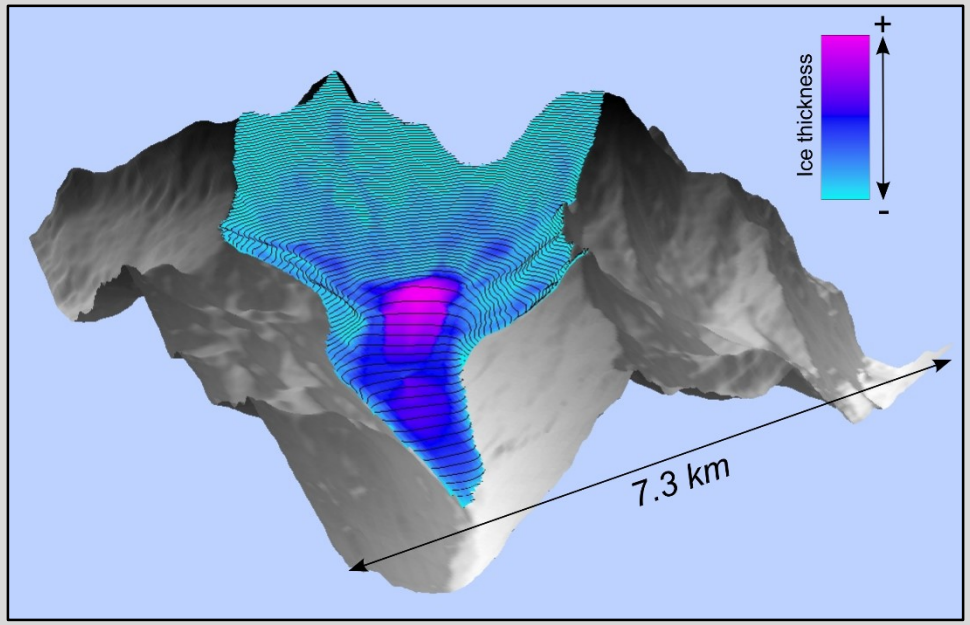


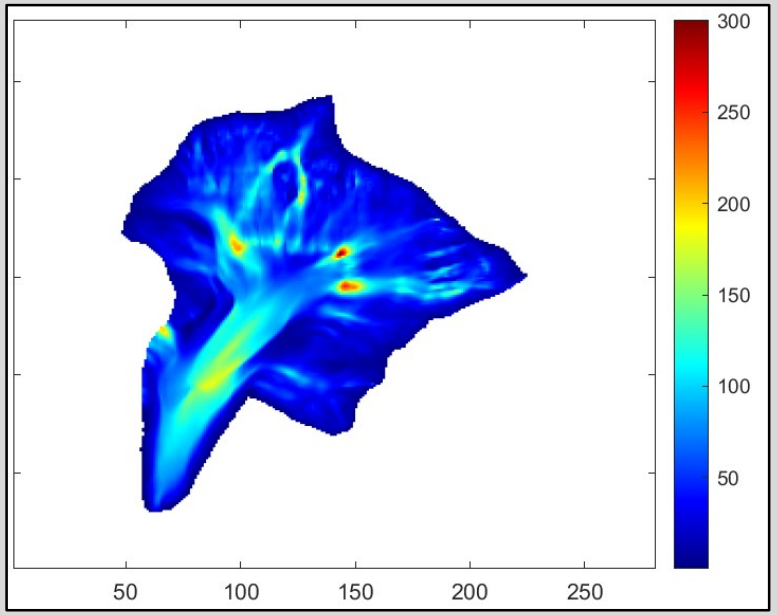
1- Cojup EH





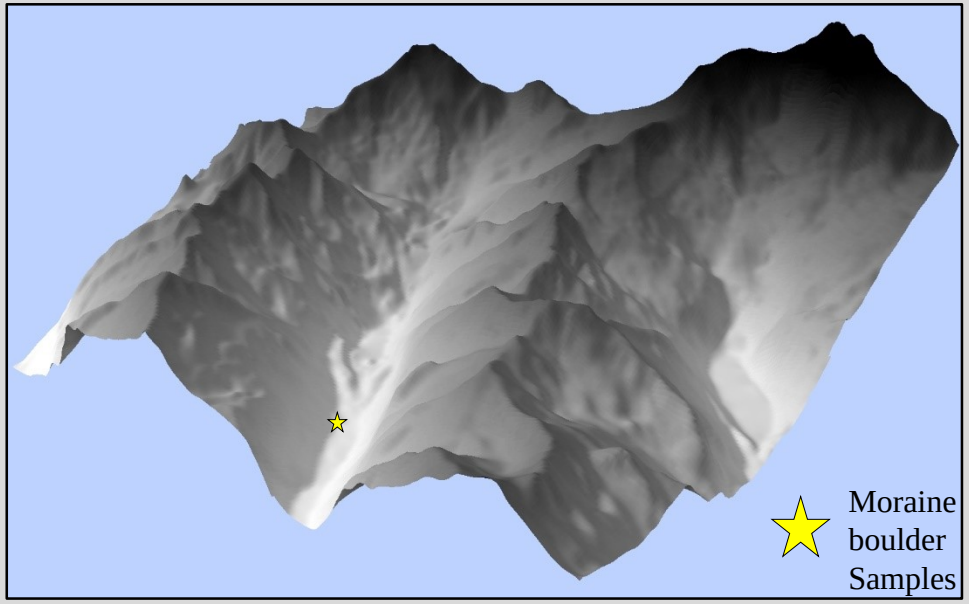
Ice thickness (m)

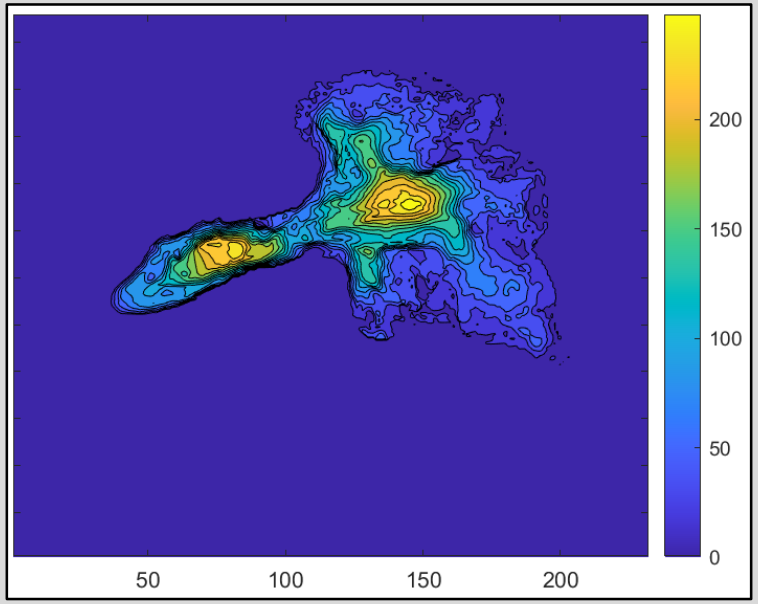




Ice surface velocity (m a^{-1})

2- Shallap EH





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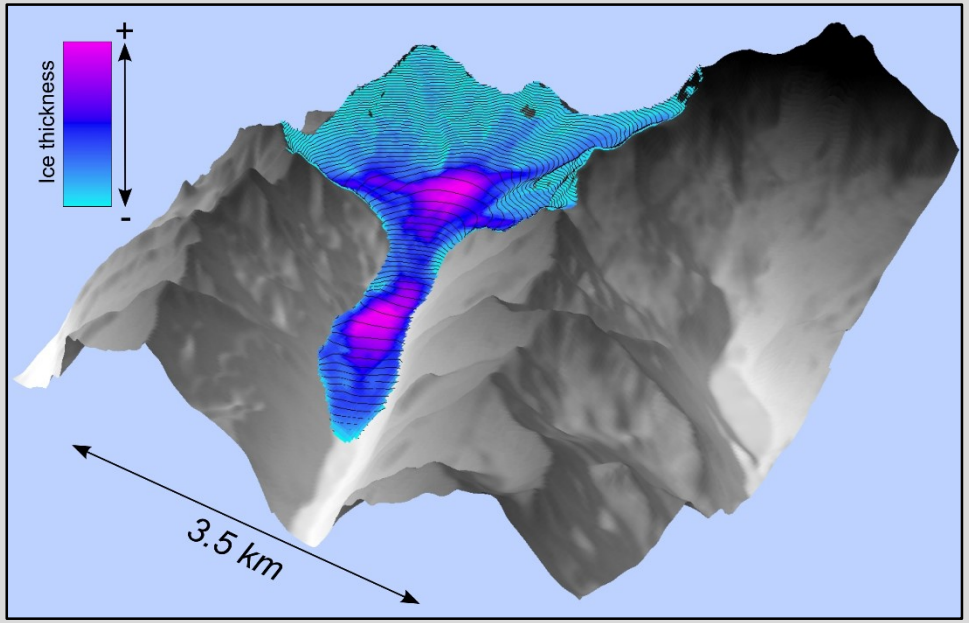
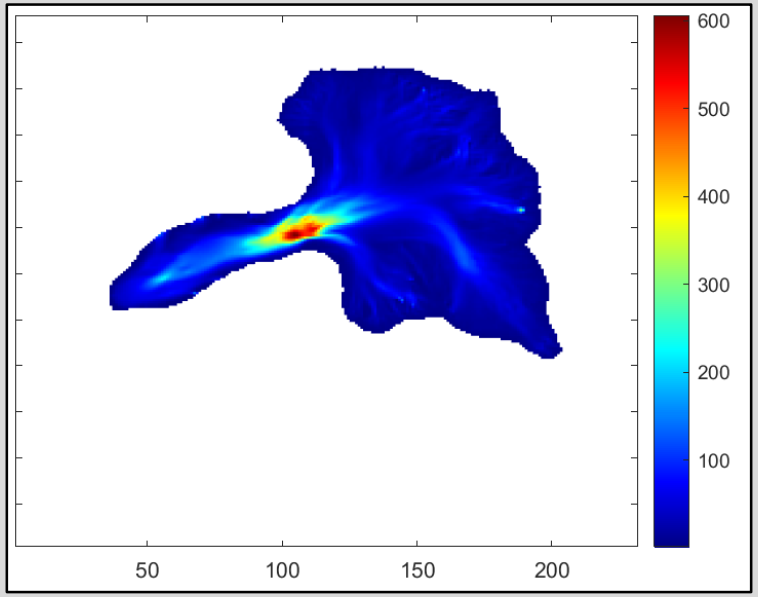
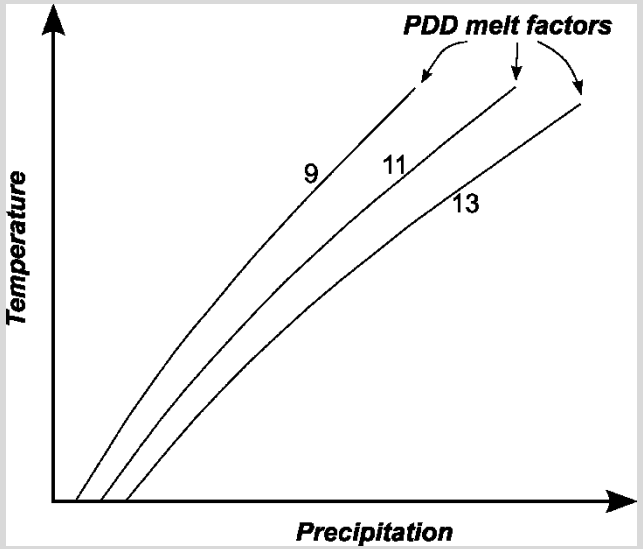
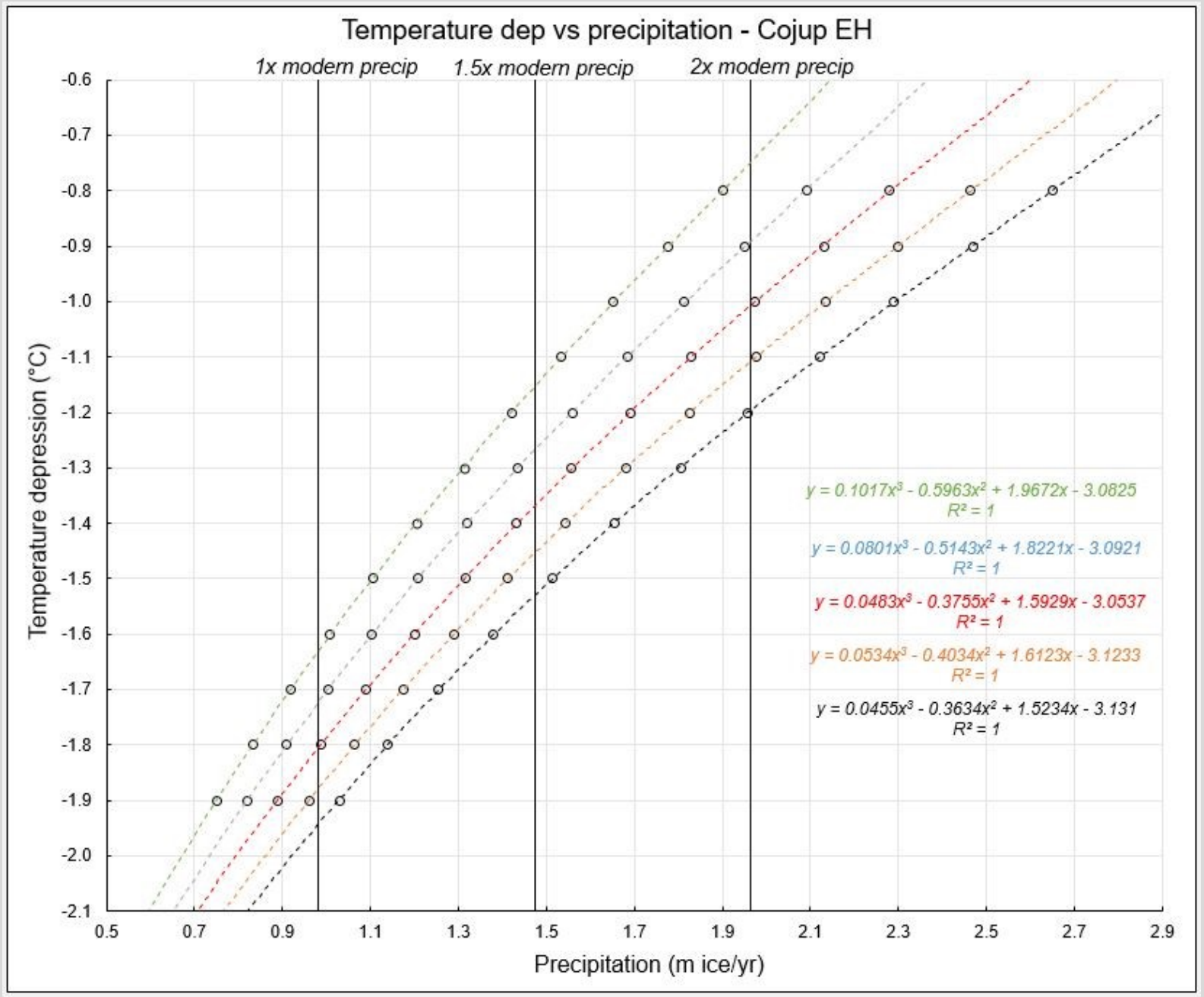




Ice surface velocity (m a^{-1})

- 60-100 simulations per advance (n = 8 advances reconstructed)

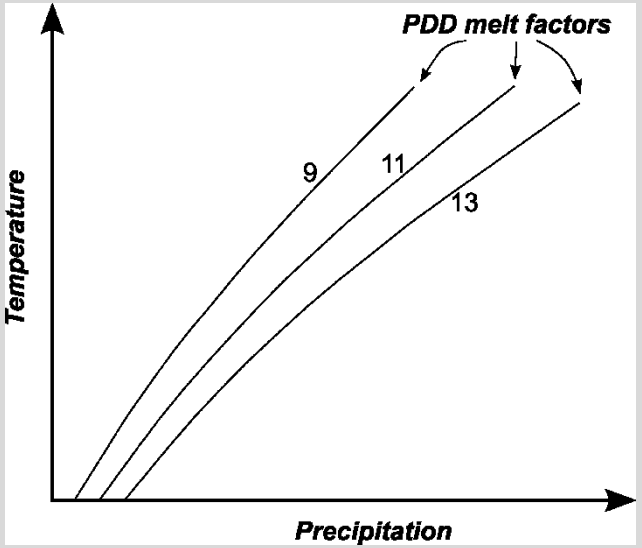


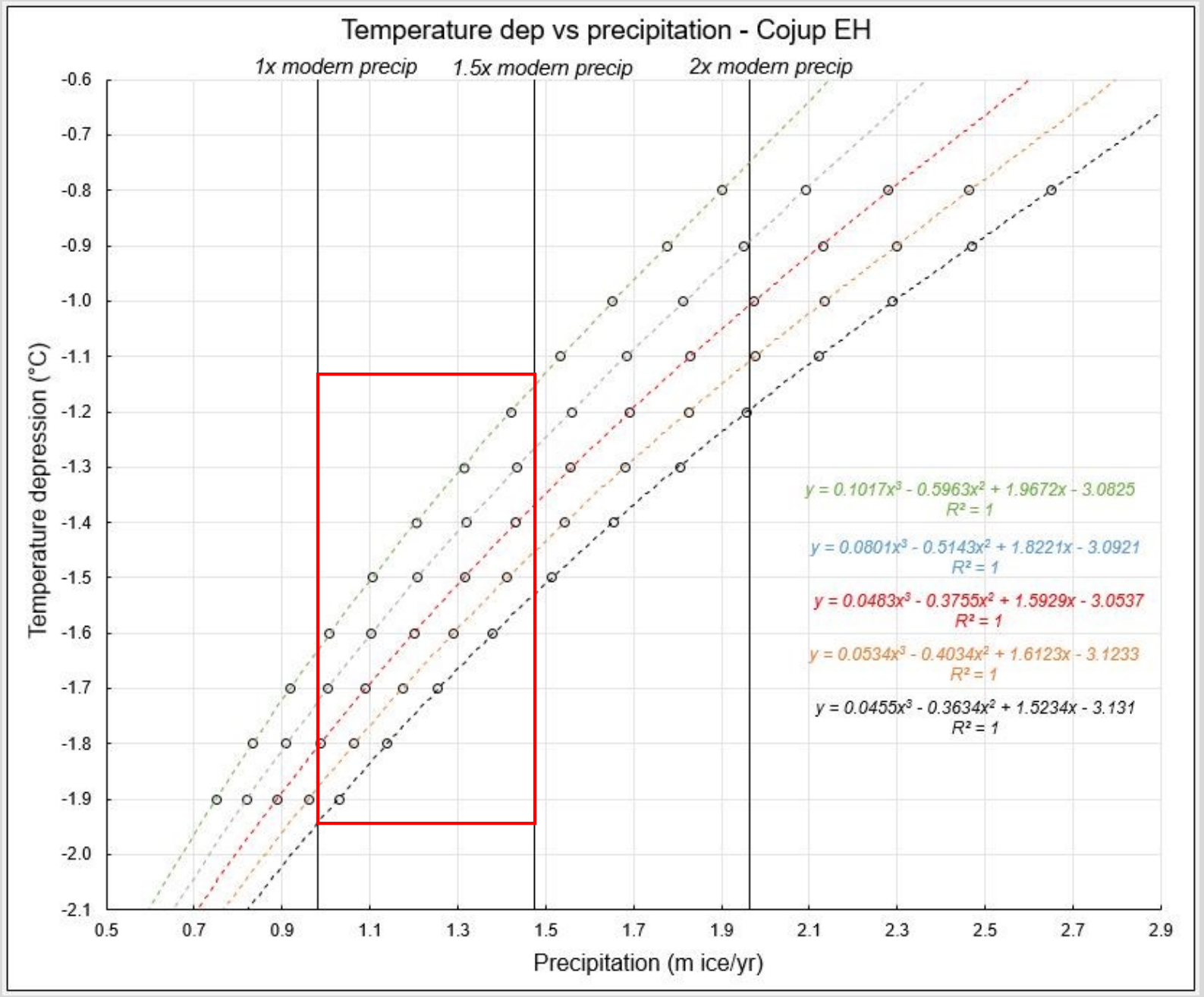


- 60-100 simulations per advance (n = 8 advances reconstructed)

Model output constraints:

- e.g. PDD melt factors of between 9 and 13 mm we d^{-1} $°C^{-1}$
- e.g. Precipitation values of between 100% and 150% modern precipitation (1970-2000 mean)

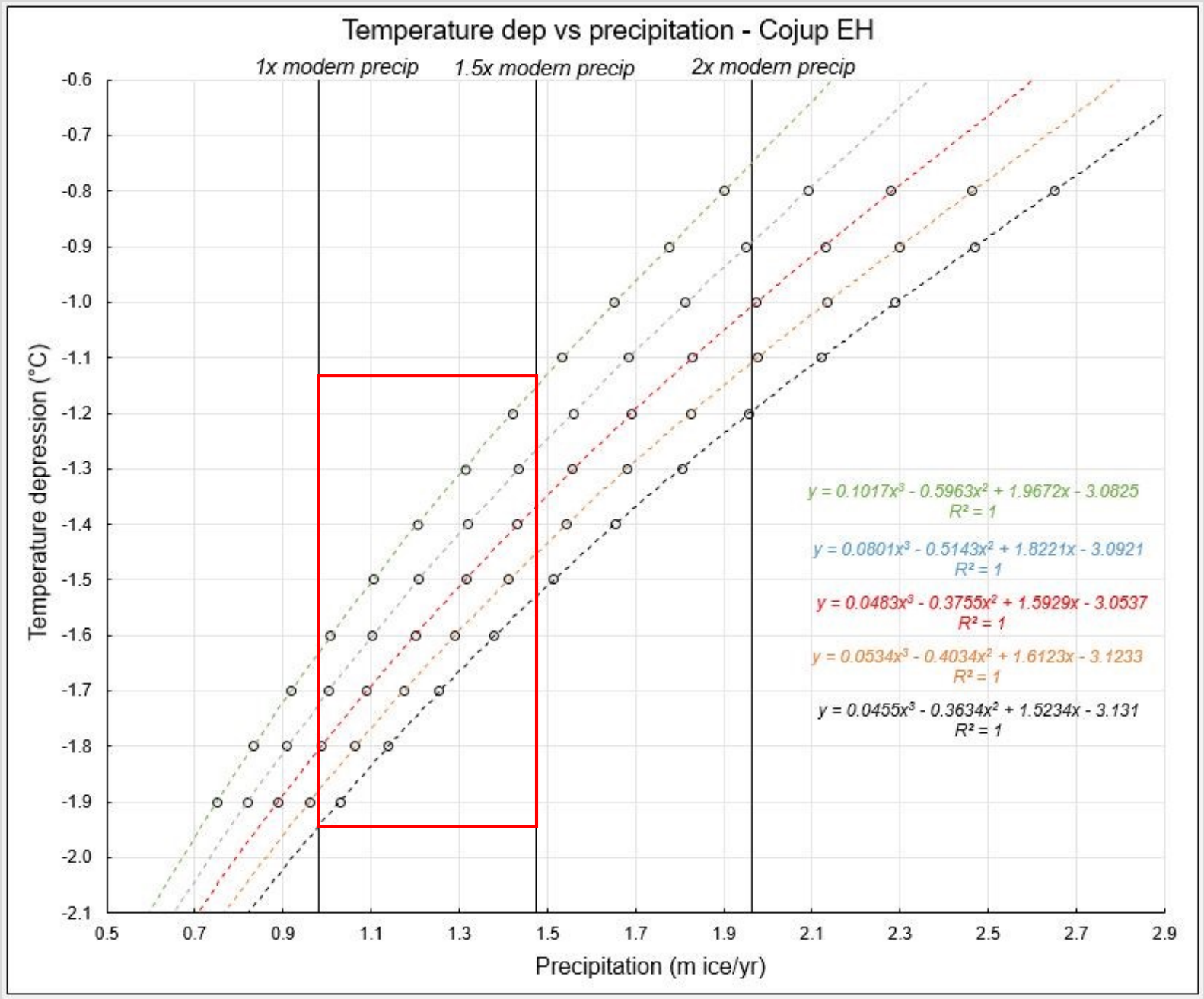




- Mean & stdev statistics on:

  - Glacier area & volume
  - ELA & AAR
  - Glacier thickness
  - Mean & max surface velocity

  - **Atmospheric temperature**



- Mean & stdev statistics on:

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  - **Atmospheric temperature**

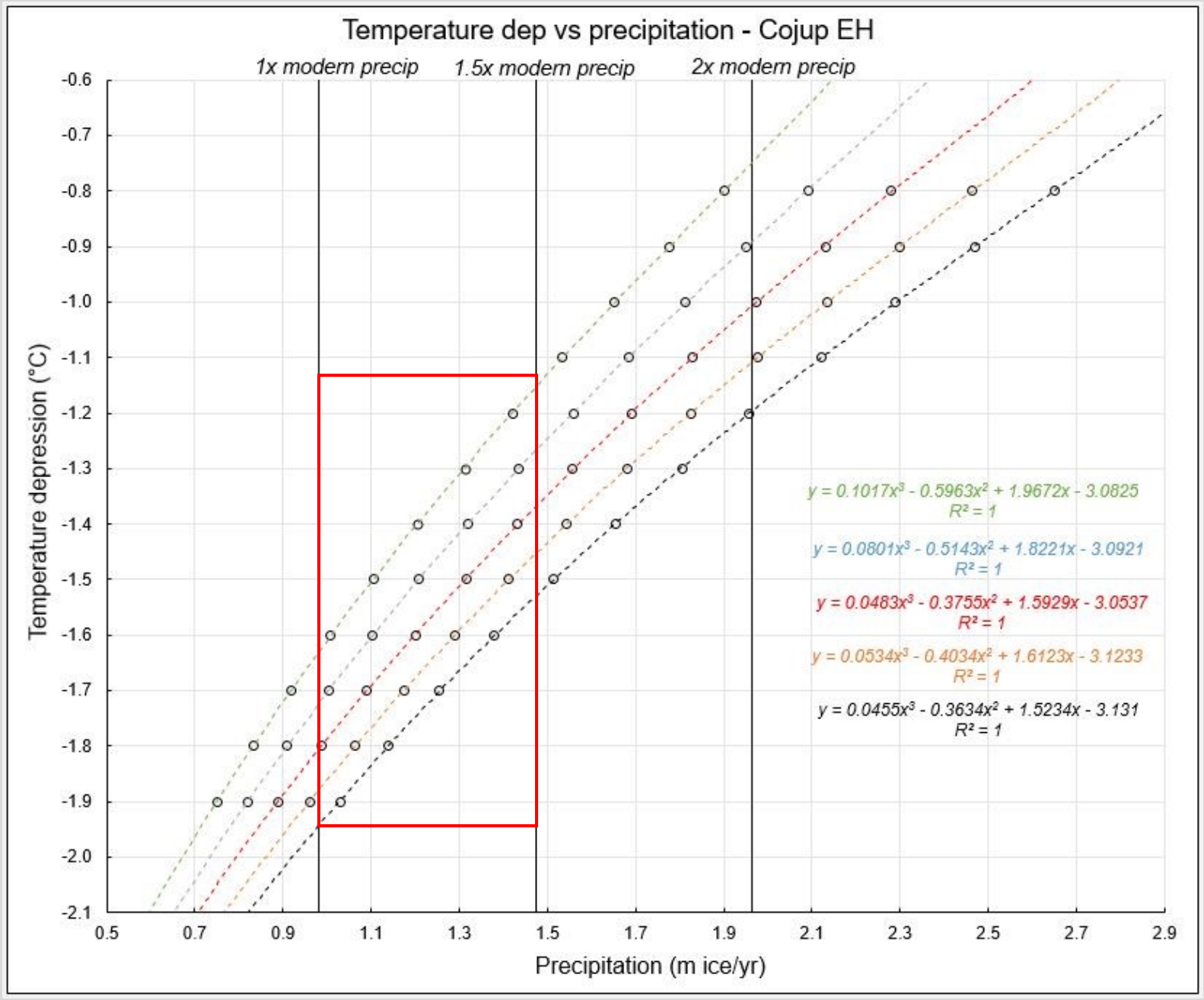
- e.g. Between the LIA advance and today: we estimate that:

-Cojup glacier lost 57 +/- 4 % of its volume and 20 % +/- 0.1 of its surface area.

-Its ELA rose by 153 +/- 43 m

-The glacier experienced a maximum thinning of 160 +/- 8 m

-Surface temperature has increased by 1.0 +/- 0.2 °C



❖ Palaeo-temperature

-Malone *et al*. (2015): modelling of the Quelccaya Ice Cap in Peru:

"*During the LIA, we reconstruct air temperature coolings at the ice cap of between ~0.7 °C and ~1.1 °C*"

"*During the YD, we reconstruct an upper bound on air temperature coolings at the ice cap of ~2.6 °C and a lower bound of ~0.9 °C*"

-Based on a regional study of ELA depression in the southern tropical Andes: maximum cooling during the LGM is estimated at 4.7 ± 0.8°C (Porter, 2001)

→ Our estimations are comparable