

Equilibrium line altitude

ELA - losses equal to gains



Equilibrium line altitude

where annual accumulation
exactly balances annual ablation



Equilibrium line altitude

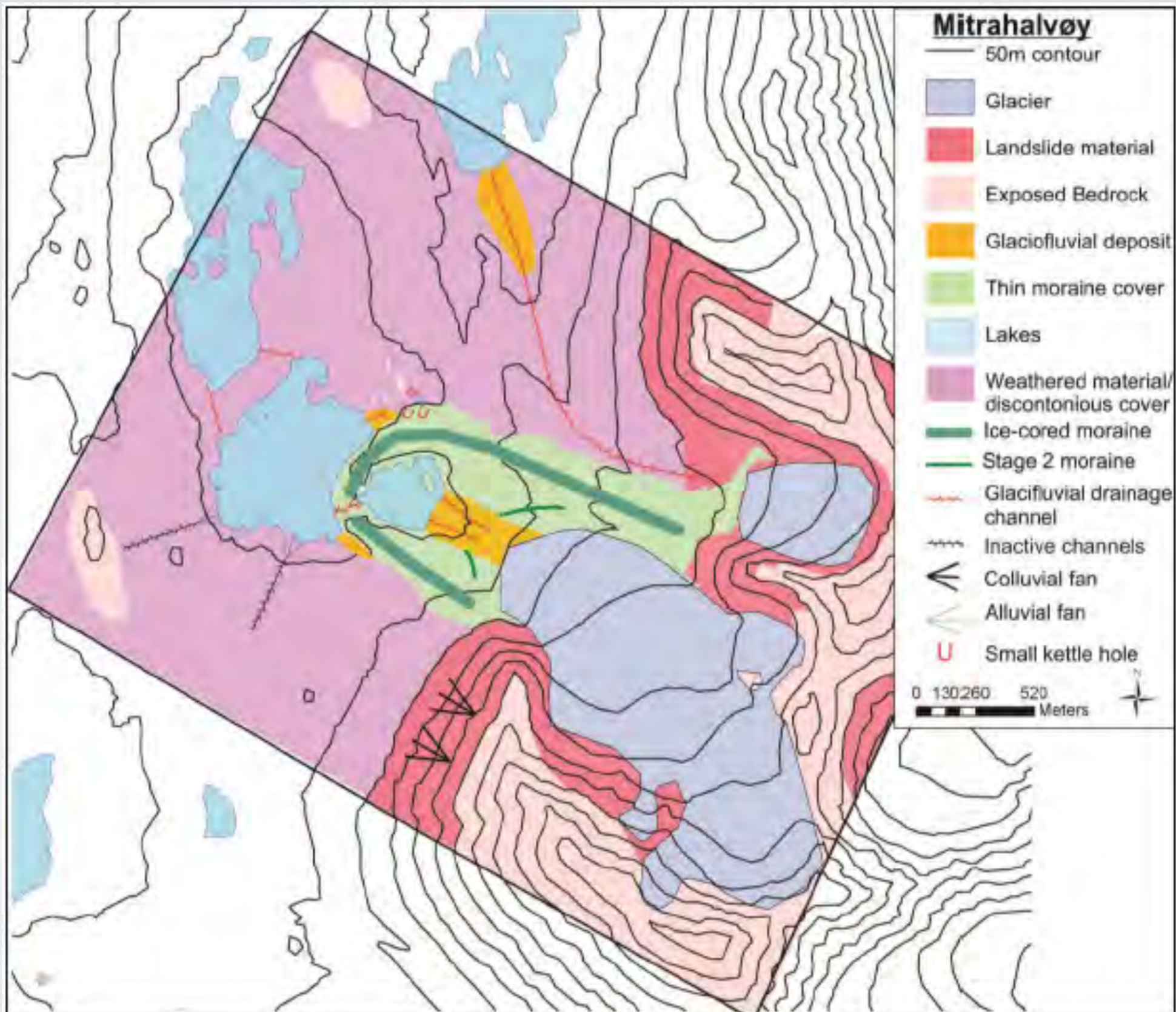
reflects transient climatic conditions and might never become steady-state, as glacier might still react on mass gain or loss of the previous year



Clear periglacial trimlines and moraines needed for Paleo-ELA reconstructions



Quaternary mapping need to map moraines

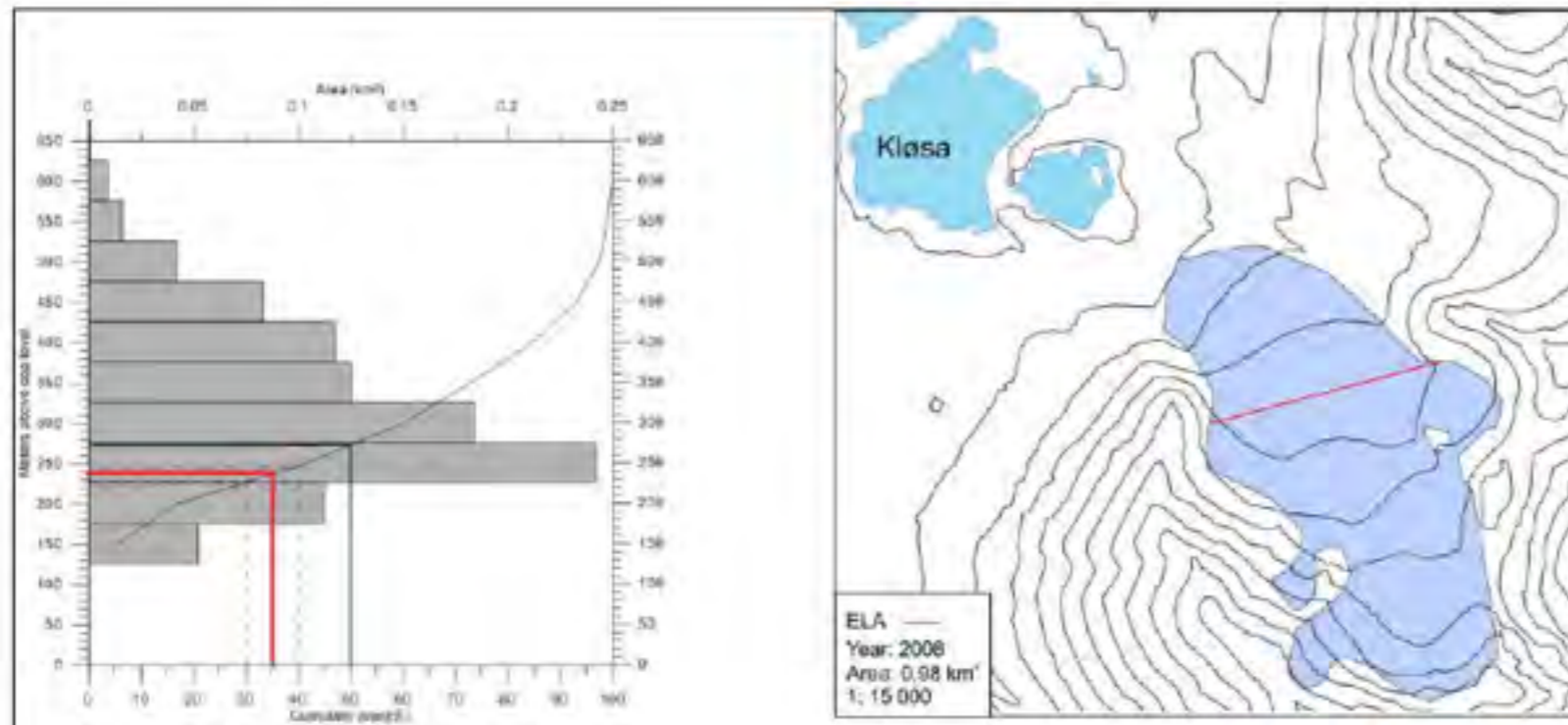


Quaternary dating method needed to assign age to moraines

- Radiocarbon dating
- Cosmogenic nuclide dating



Paleo-ELA



- Clear periglacial trimlines and clear moraines needed for reconstruction of past glacier extension
- Contours to be extrapolated from known ice surface elevations at the margins across the glacier surface

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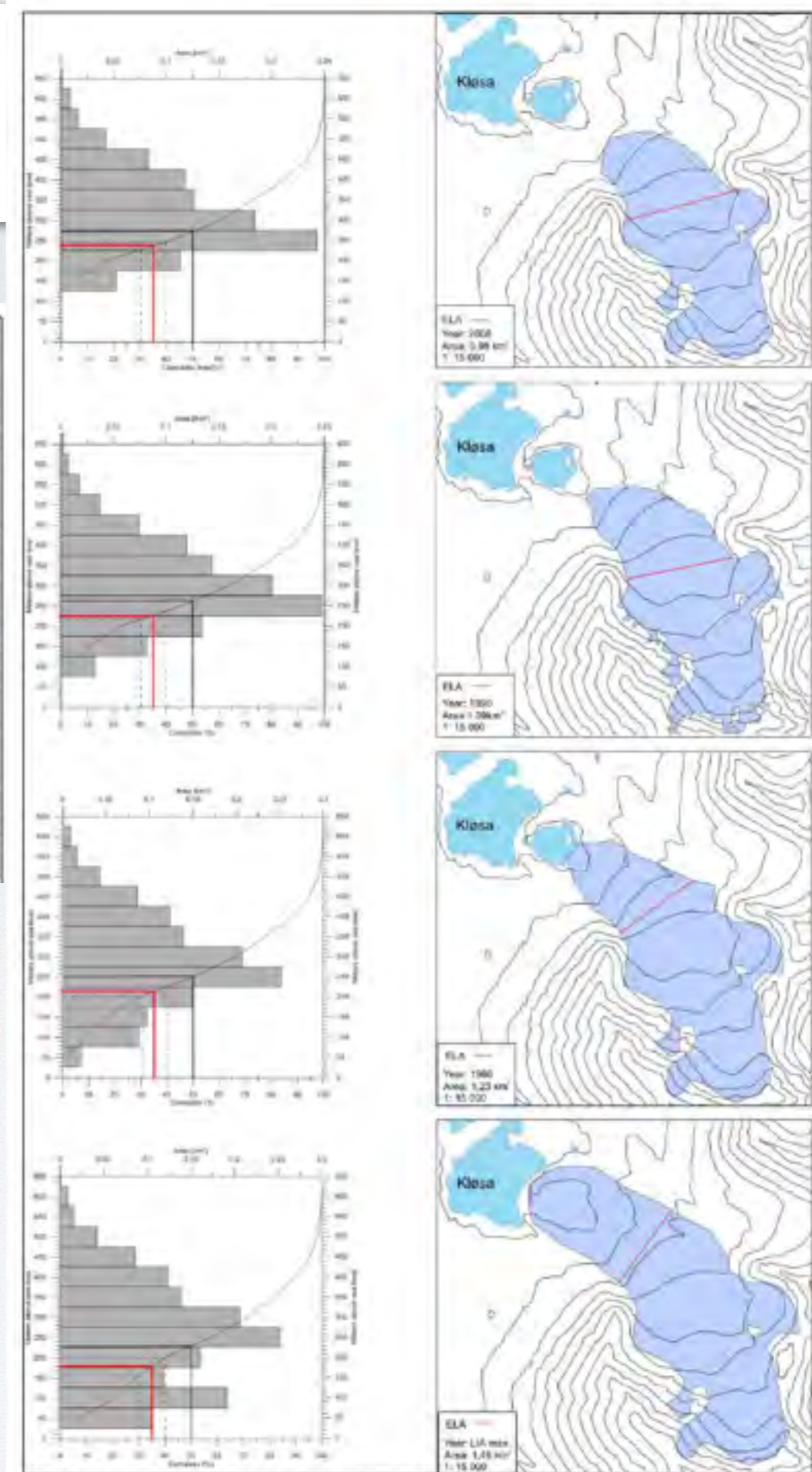
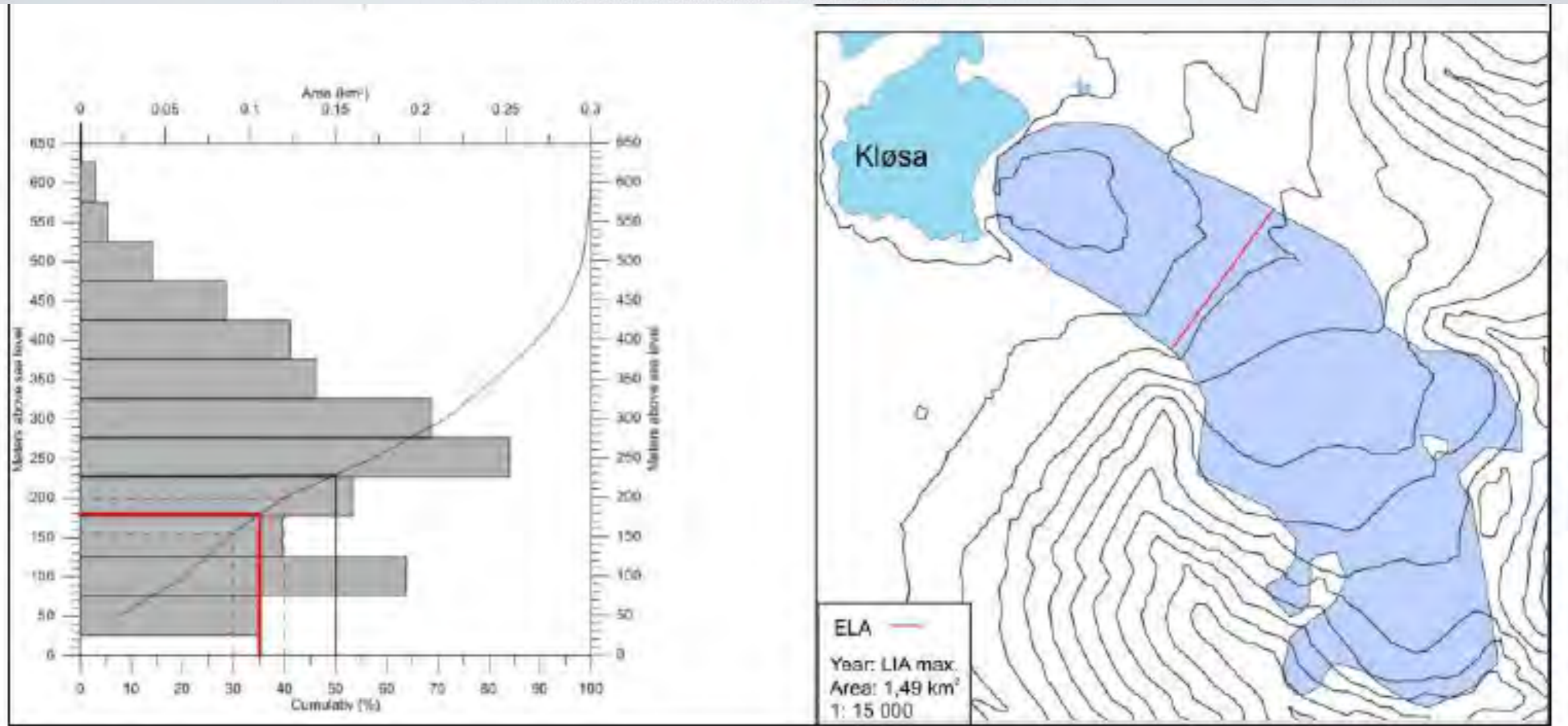


Figure 4-1: The extent of Karlbreen is shown on the right, obtained from the Norwegian Polar Institute (Svalbardkartet, 2013). Results from the AAR-method are presented to the left, red solid line represents an AAR of 0.65:1 with its uncertainty (± 0.05). Whereas the solid black line represents an AAR of 0.5:1.

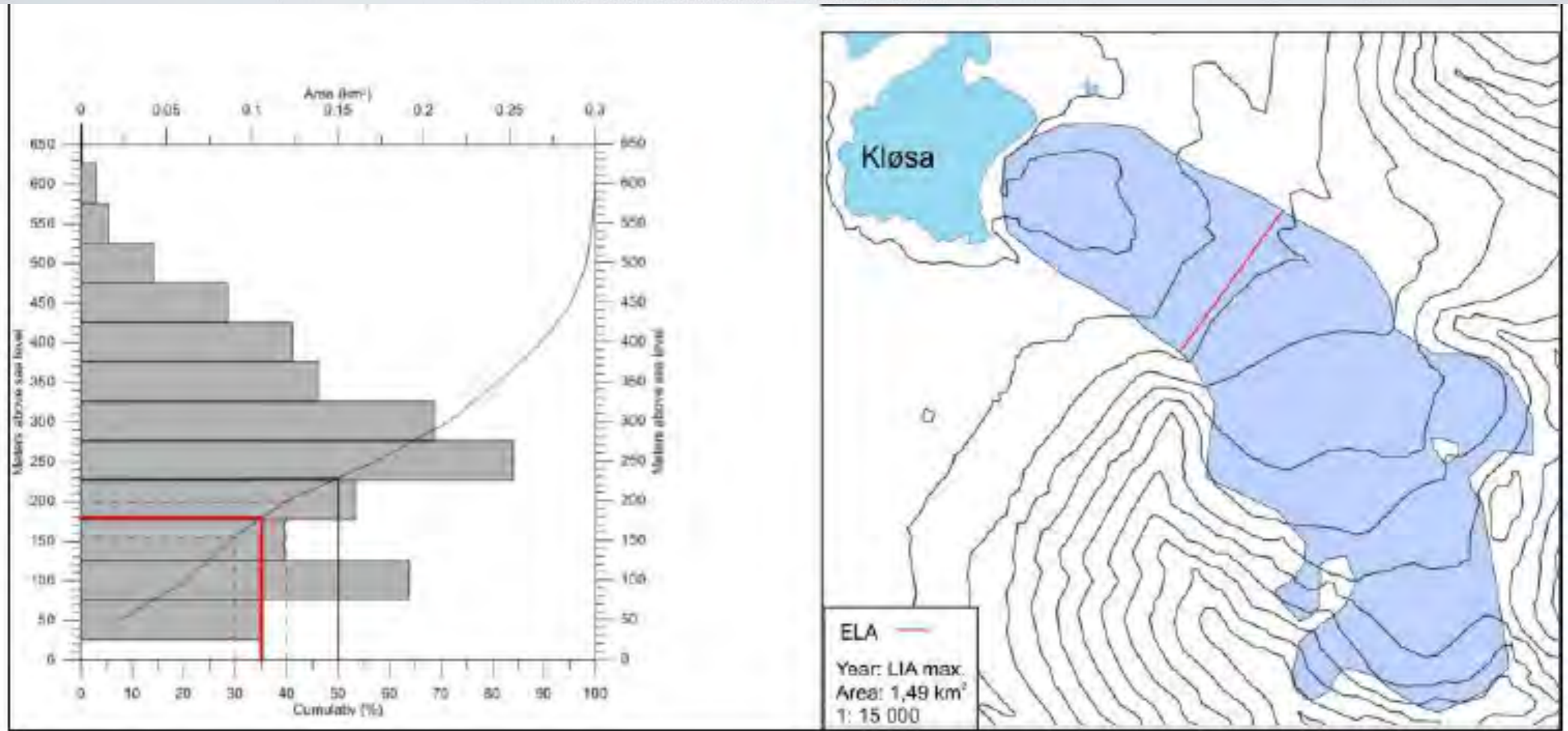
AAR - Accumulation area method



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Former steady-state ELAs can be determined from contour maps of reconstructed glaciers

AAR - Accumulation area method



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Former steady-state ELAs can be determined from contour maps of reconstructed glaciers = here $AAR = 0.65$ (surface area that lies below 35% of total area)

AAR - backdraws

Variations in glacier shape is not taken into account



Area Altitude Balance Ratio (AABR)

Hypsometry and shape of glacier taken into account

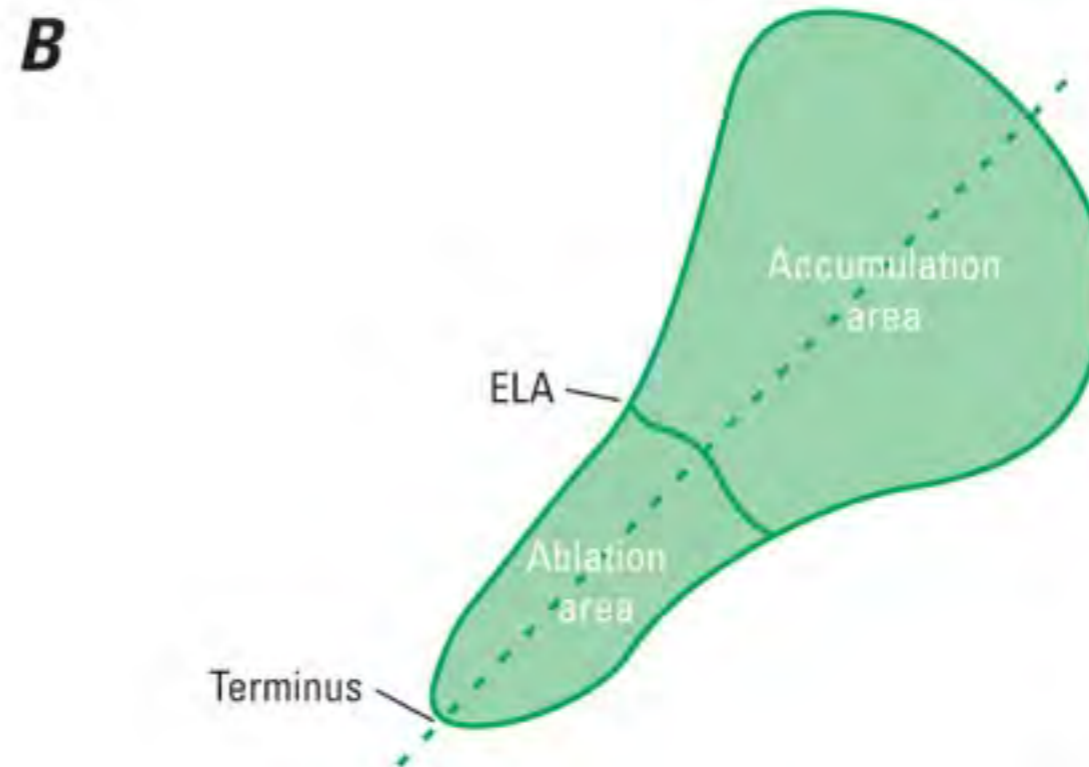
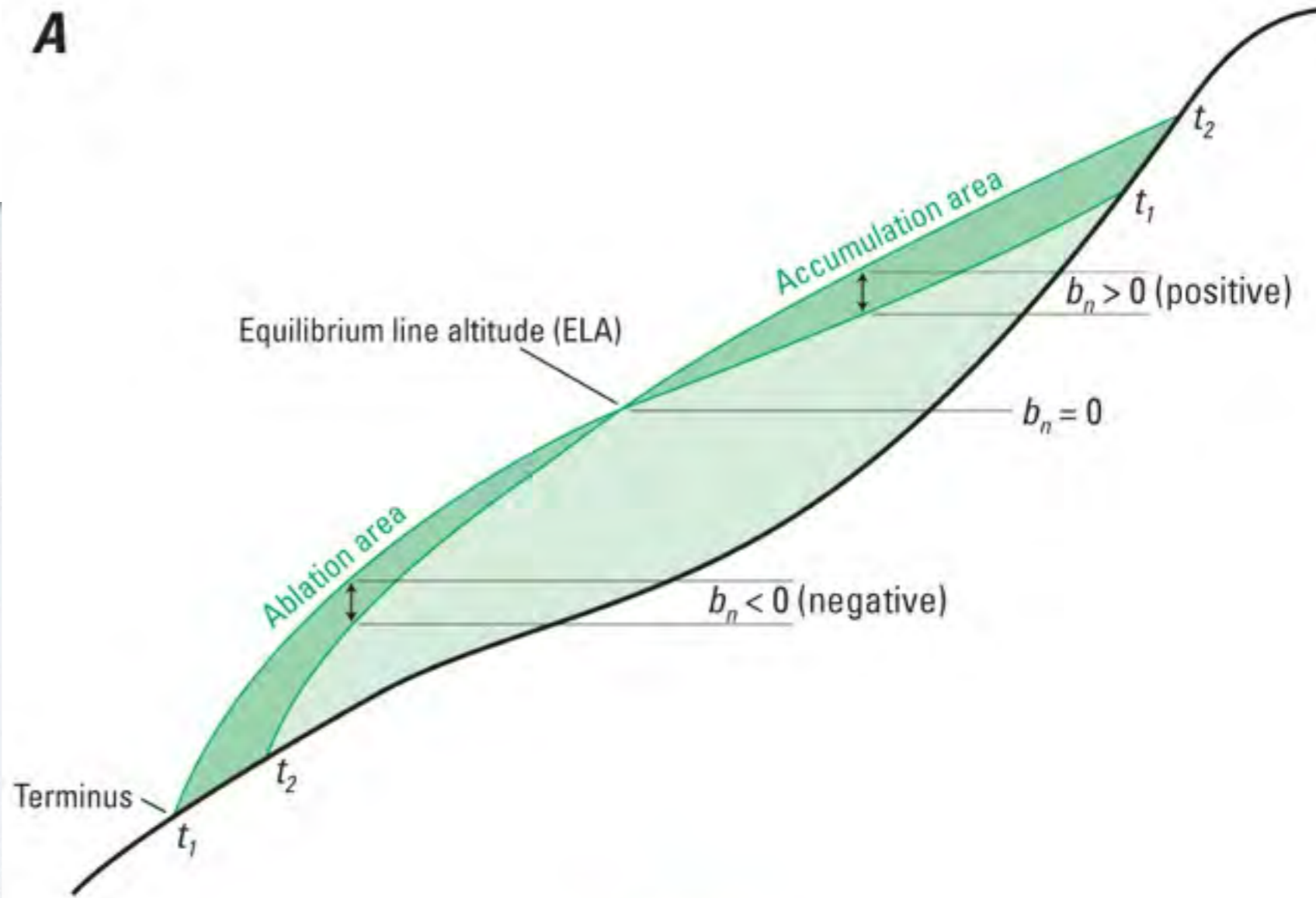
$$\bar{b}_{nb} A_b = \bar{b}_{nc} A_c$$

\bar{b}_{nb} and \bar{b}_{nc} = average net annual mass balance in ablation and accumulation area

A_b and A_c = respective ablation and accumulation areas

Area Altitude Balance Ratio

Balance ratio needs to be satisfactory for study region

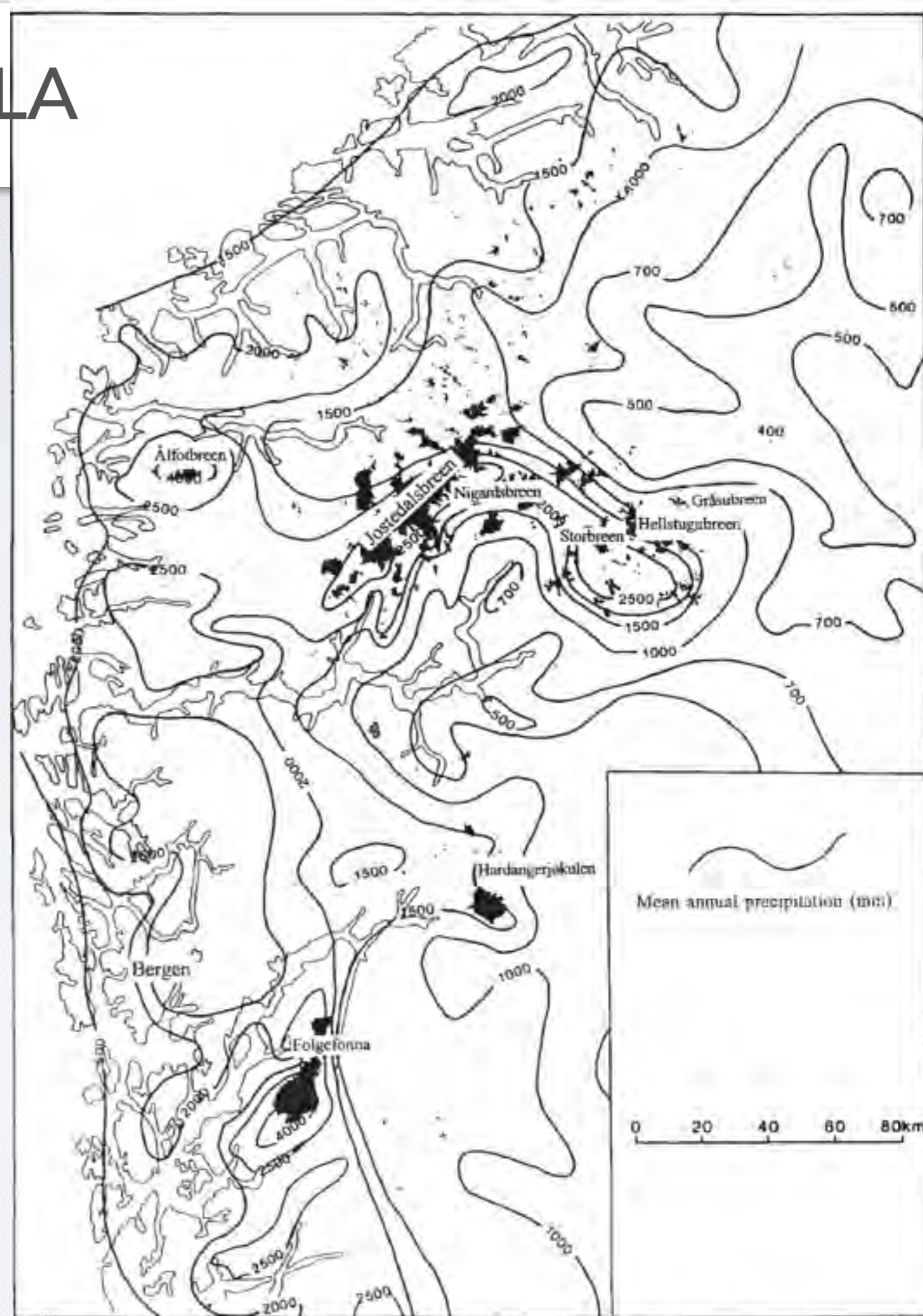


NOT TO SCALE

Climatic significance of ELA

Summer temperatures and annual precipitation are correlated at ELA

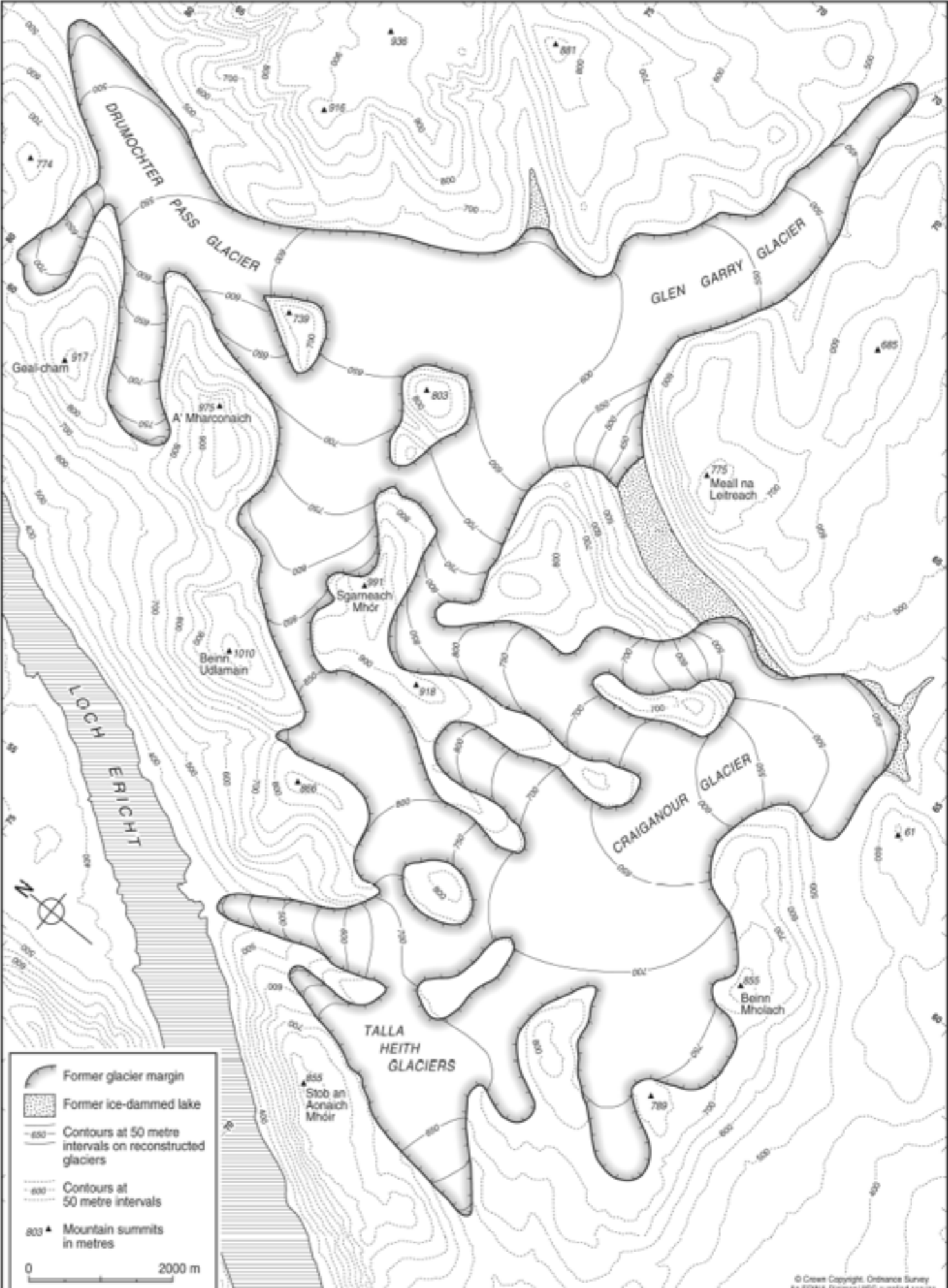
If one parameter is known, like summer temperature, precipitation can be reconstructed



Climatic significance of ELA

reconstructed glacier extension and ELA can be used to estimate paleo-precipitation, if temperature record from the same region is available

Drumochter Icefield during Younger Dryas
Ballantyne and Benn 2005



Climatic significance of ELA

Chironomid June temperature reconstruction from this area during Younger Dryas: 4.0 ± 0.7 °C

Data needed for empirical relationship between temp and prep at present day = 1976 ± 456 mm similar to present day data:

Drumochter Icefield during Younger Dryas
Ballantyne and Benn 2005

