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Global snowline and mountain topography: a contrasted view

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The examination of the relationship between Earth's topography and present and past climate (i.e. long-term elevation of glaciers Equilibrium Line Altitude) reveals that the elevation of mountain ranges may be limited or controlled by glaciations (e.g. Porter, 1989). This is of prime importance, because glacial condition would lead to a limit the mountain development, hence the accumulation of gravitational energy and prevent the development of further glacial conditions as well as setting the erosion in (peri)glacial environments.
In this study, we examine the relationships between topography and the global Equilibrium Line Altitude of alpine glaciers around the world ($\sim$ long term snowline, i.e. the altitude where the ice mass balance is null). This analysis reinforce a global study previously published (Champagnac et al., 2012), and provide a much finer view of the climate-topography-tectonics relationships. Specifically, two main observations can be drawn:
1) The distance between the (averaged and maximum) topography, and the ELA decreases pole ward the poles, and even become reversed (mean elevation above to ELA) at high latitude. Correlatively, the elevation of very large portion of land at mid-latitude cannot be related to glaciations, simply because it was never glaciated (large distance between topography and long-term mean ELA). The maximum distance between the ELA and the topography is greater close to the equator and decreases poleward. In absence of glacial and periglacial erosion, this trend cannot have its origin in glacial and periglacial processes. Moreover, the ELA elevation shows a significant (1000$\sim$1500m) depression in the intertropical zone. This depression of the ELA is not reflected at all in the topography
2) The distribution of relief on Earth, if normalized by the mean elevation of mountain ranges (as a proxy for available space to create relief, see Champagnac et al., 2012 for details) shows a latitudinal band of greater relief between $\sim$40 and $\sim$60° (or between ELA of $\sim$500m to $\sim$2500m a.s.l.). This mid-latitude relatively greater relief challenges the straightforward relationship between glaciations, erosion and topography. Oppositely, it suggests that glacier may be more efficient agent in temperate area, with an important amplitude between glacial and interglacial climate. This is consistent with the view of a very variable glacier erodibility that can erode and protect the landscape, as well as with studies documenting a bimodal location of the preferred glacial erosion, at relatively high elevation (around the long-term ELA), and at much lower elevation (close to the glacial maximum lower reaches), thanks to efficient water lubrication of the glacier bases that greatly enhance the sliding velocity (Herman et al., 2011).
These findings show that the relation between the mountain topography and the long term snowline is not as straightforward as previously proposed (e.g. Egholm et al., 2009) . Beside the role of tectonic forcing highlighted by several authors (e.g. Pedersen et al., 2010;Spotila and Berger, 2010),, the importance of the glacial erosion appears to be crucial at mid latitude, but more complex at both high and low latitude. Moreover, the relief at mid latitude appears to be higher, hence suggesting a positive correlation between relief and topographic control of glacier on the landscape

Champagnac, J.-D., Molnar, P., Sue, C., and Herman, F.: Tectonics, Climate, and Mountain Topography, Journal of Geophysical Research B: Solid Earth, 117, doi:10.1029/2011JB008348, 2012.
Egholm, D. L., Nielsen, S. B., Pedersen, V. K., and Lesemann, J. E.: Glacial effects limiting mountain height, Nature, 460, 884-888, 2009.
Herman, F., Beaud, F., Champagnac, J.-D., Lemieux, J.-M., and Sternai, P.: Glacial hydrology and erosion patterns: A mechanism for carving glacial valleys, Earth and Planetary Science Letters, 310, 498-508, 2011.
Pedersen, V. K., Egholm, D. L., and Nielsen, S. B.: Alpine glacial topography and the rate of rock column uplift: a global perspective, Geomorphology, 122, 129–139, 10.1016/j.geomorph.2010.06.005, 2010.
Porter, S. C.: Some geological implications of average Quaternary glacial conditions., Quaternary Research, 32, 245-261, 1989.
Spotila, J. A., and Berger, A. L.: Exhumation at orogenic indentor corners under long-term glacial conditions: Example of the St. Elias orogen, Southern Alaska, Tectonophysics, 490, 241–256, doi:10.1016/j.tecto.2010.05.015, 2010.