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Climatic versus topographic forcing on the extend of major Alpine ice-caps

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Climate exerts the primary control on glaciers' mass balance, in turn affecting the topographic evolution of mountain ranges worldwide by driving glacial erosion. The hypsometry (i.e. the distribution of elevations) of a mountain range, however, is also known to influence the evolution of glaciers and ice-caps, thereby affecting the patterns and magnitudes of glacial erosion (Pedersen and Egholm, 2013). The importance of these interacting factors, climate and landscape hypsometry, on the glacial history and associated erosion is commonly derived from the geomorphic and the stratigraphic records. However, first-order questions are still unanswered and a better understanding of this double forcing is clearly needed. In this presentation, we explore climate vs. hypsometric forcing on glacial dynamics through numerical landscape evolution modeling. We focus on the European Alps, a mountain range that was repeatedly affected by major glaciations throughout the Quaternary. The European Alps show clear east-west topographic variations in spite of relatively uniform climate forcing. While the width across the Western and Central Alps does not exceed 150 km and the highest peaks rise up to more than 4500 m, the Eastern Alps are up to 260 km wide and the highest peaks are clearly lower than 4000 m. This topographic gradient may be critical during major Quaternary climatic transitions (i.e. at 2.5 Ma, 1.4 Ma or at the mid-Pleistocene transition): Did the related ELA (equilibrium line altitude) variations really lead to strong variations in ice extend in the western and eastern Alps? What is the role of the hypsometry, including effects of landscapes very differently preconditioned by glaciers? In fact, stratigraphic records in the foreland of the western Alps suggest the arrival of glaciers at the mountain front probably long before 1 Ma (Akçar et al. 2014), while there is no evidence of such an early extent on the eastern side (e.g. Preusser, 2004). Later ice advances (i.e. after the mid-Pleistocene transition) show similar extensions. These new observations conflict with older stratigraphic models and no profound explanations have been found yet. Our aim is to explore these first-order feedback mechanisms impacting the growth and extend of Alpine ice shields through time and evolving topography by taking advantage of the comprehensive records and time constraints of glacial history available from the European Alps.

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