Geophysical Research Abstracts
Vol. 19, EGU2017-10514, 2017
EGU General Assembly 2017
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Climatic and topographic controls on the extent of major Alpine ice sheets: implications from modeling and stratigraphy

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Climate exerts the primary control on glaciers' mass balance, in turn affecting the topographic evolution of mountain ranges 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. The importance of interacting factors, climate and landscape hypsometry, on the glacial history and 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 more than 260 km wide and the highest peaks are 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). 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, while there is no evidence for such an early extent on the eastern side. Later ice advances (i.e. after the mid-Pleistocene transition) show similar trends. These new observations conflict with older stratigraphic models and no explanations have been found yet. We present an investigation addressing the first-order factor affecting the growth and extent of Alpine glaciers by taking advantage of the comprehensive records of glacial history available from the European Alps and numerical models of ice dynamics.