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Thèse de doctorat

Remote sensing methods for the investigation of the evolution and dynamics of Alpine landscapes

Résumé en anglais

Whilst the effects of present-day climate change are apparent in many environmental systems, much less is known about its impact upon the geomorphic systems characteristic of Alpine environments. This is an important knowledge gap because of the potential vulnerability of Alpine landscapes. The gap exists for two primary reasons: (1) observing climate forcing is challenging because it is manifest over timescales of decades to centuries, over which timescale geomorphic data are commonly scarce; and (2) the geomorphic response of landscapes to climate change can be complex, reflecting both spatially differential sensitivities to climate forcing and the effects of landscape heritage associated with historical glacial activity. Nonetheless, there is a consensus in the scientific community about the potentially high sensitivity of Alpine regions to climate change, because of the vulnerability of permafrost, glacial and nival processes to changes in atmospheric temperature and precipitation and the large amount of sediment stored on the associated hillsides.

One approach to addressing this knowledge gap is to harness the power of remote sensing. A number of active and passive remote sensing methods could be employed for the reconstruction and monitoring of both whole landscapes and individual landforms. This Thesis aims to use such approaches to quantify the geomorphic dynamics of high mountain areas at the timescale of decades and so in the context of recent and rapid climate warming. It does so recognizing that both endogenous (landscape legacy) and exogenous (climatic forcing) processes may matter. To support this primary aim, a secondary aim arises: the evaluation of the potential of a number of remote sensing techniques for landscape and landform monitoring at multiple temporal and spatial scales. Thus this Thesis also tests in an Alpine setting the geomorphological potential of photogrammetric methods, using both aerial and hand-held sensors and both traditional and the innovative Structure-from-Motion processing approaches, and Terrestrial Laser Scanner techniques.

The Thesis shows that remote sensing approaches prove to be an advantageous approach for a number of scales of application. In particular, over large spatial extents and in the case of decadal scale climate forcing of Alpine landscapes, photogrammetry was found to be capable of quantifying process rates within the limits of detection determined by the resolution of historical imagery. The information unlocked from aerial archives reveals distinct geomorphic responses to cold and warm periods and to changes in rates of precipitation and snow cover, favoring the hypothesis that some elements of the landscape are more sensitive to climate warming than others. Nonetheless, whilst enhanced sediment production is observed locally, evidence suggest a weak propagation of climate change signals through the landscape due to impeded connection to the river system and/or sediment transport capacity limitation.

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