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# Glacier variation in the Massif des Ecrins during the 20th century : spatial and temporal patterns

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Glacier variation is one of the best indicator of climate change in the mountainous environment. In French Alps, many temporal data are acquired by glaciologists at glaciers scale : geometrical parameters (surface area, thickness, length and front altitude) are surveyed since the end of the 19th century, such as glaciers of the Massif du Mont Blanc area (Argentière, Mer de Glace, etc.). Those parameters are necessary to estimate mass-balance of glaciers and, then, an accurate temporal signal of glacier variation. However, the time-response of the glaciers can be highly variable through topoclimate, and more generally the local settings of the glaciers. Moreover, climatologists and hydrologists are requiring estimation of glacier variations at regional scale and not at local scale.
In this presentation, we highlight that the Equilibrium Line Altitude (ELA) is a parameter prone to spatio-temporal reconstructions at regional scale, as suggested by S.C. Porter since 1975. ELA can indeed be interpolated at a region scale from local data: for instance, many geographers have reconstructed spatial trends during 1980s. Here, we try to interpolate ELA from multi-dimensionnal regression analysis : ELA is explained by many local parameters (Incoming solar radiation, topographic indexes, snow-redistribution by wind, etc.). Regression model was adjusted from a spatio-temporal database of 60 glaciers, located in the Massif des Ecrins. ELA was estimated for each glacier thanks to the Accumulation Area Ratio (ratio = 0,65) at two stages. For the LIA maximum, glacier extents was already reconstructed through moraine identification and mapping. Present extents of glacier were reconstructed thanks to 2003 aerial photographs and field observations.
Results first show that the multiple regression analysis is efficient to interpolate ELA through space: the adjusted $r^2$ is about 0,49 for the reconstruction during the LIA, and 0,47 at present. Moreover, the RMSE error is about 50 meters for the LIA period, 55 meters at present. Finally, a high spatial variability (standard deviation of about 150 meters) is highlighted: incoming solar radiation and snow redistribution mostly explain the differences observed. Secondly, we can assess a rise of the ELA of about 250 meters through the 20th century.