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Spatial statistical analysis on glacier surface elevation change based on ALS data

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Monitoring the behaviour of glaciers has gained more significance with the increasing amount of studies on global change. Due to the sensitive reaction of glaciers to changes of regional climate, an increasing number of scientific studies are focusing on glacier mass balances. Glacier mass balance depends on climate, topography and surface albedo. It is assumed, that topographic characteristics, such as slope, curvature, aspect or surface elevation, as well as their changes, modify the local climate as well as radiation with a direct impact on the mass balance of a glacier.

The monitoring of surface elevation changes with methods of airborne remote sensing (e.g. airborne laser scanning (ALS)) is useful to derive topographic information with high accuracy and high resolution which are used within the presented workflow. The multi-temporal ALS dataset of the Hintereisferner (Ötztal, Tyrol, Austria) from the Institute of Geography, University of Innsbruck (acquired during the OMEGA, ALS-X and C4AUSTRIA projects), gives the opportunity to calculate spatial volume changes over the years 2001 to 2009. These volume changes are defined as the dependent variable for further regression analysis. Additionally, significant topographic explanatory variables for each year were calculated using the digital elevation models (DEM) with a resolution of five meters. Explanatory variables are used for a multiple statistical analysis, with the aim of spatial visualisation and quantification. The achieved results describe the influence of each explanatory variable, as well as all variables combined on the annual surface elevation change.

In order to yield results, the raster dataset has to be preprocessed due to computer-dependent limitations and the annual glacier boundary has to be taken into account. Subsequently, the autocorrelation structure (commonly present for correlated high resolution raster data sets)of the predictors has to be checked. Afterwards redundant input data can be identified and eliminated, which is important for multiple spatial regression with the consideration of interactions between the explanatory variables. As a first result of single linear regression modelling for each predictor, the corresponding residuals are plotted into one map applying the rule of best fitted value. In that case, the maps allow a visual impression of the influence of topographic parameters in the test site Hintereisferner. The second result quantifies the dependence of surface elevation changes from at least three explanatory variables (elevation, solar potential and slope). The according multiple regression model is well fitted with R^2= 0,67. For the interpretation of both results, it is important to keep in mind that surface elevation changes derived from remote sensing data integrate effects both due to mass accumulation/mass ablation and due to glacier dynamics.