Geophysical Research Abstracts
Vol. 19, EGU2017-15927, 2017
EGU General Assembly 2017

A novel precipitation mapping approach based on identifying the scale of topographic control and direction of the dominant weather circulation

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Accurate precipitation maps are essential for ecological, environmental, element cycle and hydrological models that have a spatial output component. It is well known that topography has a major influence on the spatial distribution of precipitation and that increasing topographical complexity is associated with increased spatial heterogeneity in precipitation. This means that when mapping precipitation using classical interpolation techniques, a climate measuring network with higher spatial density is needed in mountainous areas in order to obtain the same level of accuracy as compared to flatter regions. In this study, we present a novel mean total annual precipitation mapping technique that combines topographical information (i.e. elevation and slope orientation) with average total annual rain gauge data in order to overcome this problem. A unique feature of this paper is the identification of the scale at which topography influences the precipitation pattern as well as the direction of the dominant weather circulation. This method was applied for Belgium and surroundings and shows that the identification of the appropriate scale at which topographical obstacles impact precipitation is crucial in order to obtain reliable mean total annual precipitation maps. One of the main outcomes is that annual precipitation can be modelled as a function of smoothed altitude (H) and deviation of the slope orientation to the dominant weather circulation (S) maps, considering a first order interaction term between both topographical variables. Best results were obtained using smoothed altitude maps at aggregation resolutions of 8.1 km and 90 km for the H maps (i.e. outside and within the interaction term) and 30.6 km for the S map. In addition, the dominant weather circulation is determined at an aspect of 260°. Hence, this approach allows accurate mapping of mean annual precipitation patterns in regions characterized by rather high topographical complexity using a climate data network with a relatively low density and/or when more advanced precipitation measurement techniques, such as radar, aren't available, for example in the case of historical data.