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Estimation of snow water equivalent in a mountain range by using a dynamic regression approach

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The snow dynamics in alpine systems governs the hydrological cycle in these regions. However, snow data are usually limited due to poor accessibility and limited funds. On the other hand, the majority of scientific studies about snow resources are carried out at mountain slope or basin scale. The main goal of this work is to propose a parsimonious methodology to estimate snow water equivalent (SWE) at mountain range scale. A regression model that includes non-steady explanatory variables is proposed to assess snow depth dynamic based on the information coming from snow depth point observations, a digital elevation model, snow cover area from satellite and a precipitation index representative of the area. The main advantages of the method are its applicability in cases with limited information and in mountain ranges scales. In the proposed methodology different regression model structures with different degrees of complexity are calibrated combining steady and non-steady explanatory variables (elevation, slope, longitude, latitude, eastness, northness, maximum upwind slope, radiation, curvature, accumulated snow cover area and precipitation in a temporal window) and four basic mathematical transformations of these variables (square, root square, inverse and logarithm). In the case of the temporal variables different time windows to define the accumulated values of the explanatory indices have been tested too. We have applied the methodology in a case study, the Sierra Nevada mountain range (Southern Spain), where the calibration has been performed by using the snow depth data observation provided by the ERHIN program which have a very low temporal frequency (2 or 3 measurement per year). When only non-steady explanatory variables are considered, the coefficient of determination of the global spatial estimation model is 0.55. When we also include non-steady variables we obtain an approach with a coefficient of determination of 0.62. We have also calibrated a new regression approach by using, in addition to the ERHIN program information, data coming from a detailed temporal series of snow depth in a new specific location, which has allow to obtain models with R^2 of 0.59 (for steady explanatory variables) and 0.64 (including also non-steady explanatory variables). The dynamic of the snow density in the mountain range has been estimated by means of a physically based simulation driven by WRF data. Combining the snow depth and the density approaches we have estimated the final SWE in Sierra Nevada.

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