A statistical estimation of snow water equivalent using ground data and MODIS images

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The evaluation of Snow Water Equivalent (SWE) is necessary to exploit the hydrology of mountainous snow fed areas in Italian Alpine Range. Its use ranges from assessing water resource availability and distribution to evaluating snowmelt and its impact on spring and summer stream flows. The contribution presents a statistical methodology to estimate the Snow Water Equivalent (SWE) into a mesoscale mountain watershed (Mallero river basin, Northern Italy, approximately 323 Km2 in area). Attention is focused on the SWE cumulated on April 1st, henceforth SWE1. According to recent findings, the SWE on April 1st well approximates the yearly accumulation and therefore provide the water volume amount at snowmelt. The statistical procedure is applied for the year 2003. The available ground dataset is made up by 11 snow gauges. A two step procedure is set forward. First, the SWE in gauged sites is evaluated from local measurements of snow depth and mass density. Then, the spatial distribution of SWE is obtained through averaging of the standardized point SWE estimates. The latter is carried out conditioned on snow covered area (SCA), as evaluated by MODIS images. Snow depth measurements are taken at manual and automatic stations. Point measurements of snow depth are converted into SWE estimates. Because no systematic snow density measurements are available at the snow gauging stations, data from 200 sparse snow surveys are used to find a relation between the observed snow density and the main geo-morphologic features. Average and standard deviation of SWE1 at ungauged sites are estimated by using regression analysis against geomorphic and climatic attributes. A simple statistical spatialization technique is used to obtain information on a grid (cells 20 by 20 m). Standardized SWE is evaluated at the measured sites and averaged to obtain a mean areal standardized value. Then, the SWE in each grid cell is estimated by back-transformation according to its estimated average and

standard deviation. A map of SWE is so obtained for the whole basin. The MODIS derived SCA is used to constrain SWE estimation on actually snowed ground. The average area snow water equivalent at April 1st (SWE1S) is then calculated. Then, an estimation of SCA and respective total SWE is tentatively carried out by casting a snow line via snow depth regression against altitude. The results are good, with some discrepancies on the snow area edges at lowest altitude. The use of snow line aids the identification of snow areas affected by shadowing in MODIS images.