Plate 3.4 Spatio-Temporal Variation in the Water Equivalent of the Snow Cover

Introduction

The water equivalent of the snow cover is defined as the liquid water column which would be created by the complete melting of the snow cover without any runoff or evaporation. This quantity is normally measured in mm, 1 mm water equivalent corresponding to 1 kg/m^2. The water equivalent of the snow cover describes the amount of water stored in the snow cover over days, weeks or months. The significance of the water equivalent is described in detail in map 3.3.

Sources of data

The database comprises: measurements of the water equivalent (taken every 14 days and sometimes every 7 days) supplied by 53 stations run by the Swiss Federal Institute of Technology in Zurich and/or the FISAR; snow-depth (HS) measurements and depth of new snow (HN) measurements (both taken twice a day) supplied by 72 stations run by the Swiss Meteorological Institute; daily HS and HN measurements supplied by 35 FISAR stations (FISAR: Federal Institute for Snow and Avalanche Research). Map 3.1 provides a comprehensive overview of the station network. For stations supplying only snow depth measurements, the water equivalent has to be calculated from the new and total snow depths according to [5], using the model adapted by [6].

Water equivalent maps

The maps of the water equivalent of the snow cover provide an overview of the long-term mean water equivalent of the snow cover on 1st January, 1st March, 1st April and 1st May. Basically these values refer to the period 1961 to 1985. Data from additional stations has also been taken into account if the series cover at least twenty years. The maps are made up of 2 km • 2 km pixels. For purposes of representation the water equivalent values were divided into classes. The highest class, which is open-ended above values > 1250 mm, covers areas in high altitude where the snow cover is in general largely redistributed by wind and avalanches. The locations of stations used in the interpolation are shown by symbols. A distinction has been made between measured water equivalent values and those which were calculated from measurements of the snow depth and the depth of new snow. Map 3.3 shows the long-term mean, minimum and maximum water equivalent patterns for the measurement stations.

It is evident from the maps that the highest values are to be found towards the end of the winter in high alpine regions in the eastern and central parts of the northern slope of the Alps. The areas with maximum values are situated within the headwater areas of the main alpine rivers, the Rhône, the Ticino, the Reuss and the Aare. Comparatively lower values at equal altitude are seen in the western part of the northern slope of the Alps, in the southern Valais and in the Engadine.

Methodology

The three-dimensional Kriging method with intrinsic random functions of the first order and generalised covariant functions was used for spatial interpolation of the water equivalent of the snow cover [3]. The 160 stations mentioned above served as supporting positions. Basing on the digital elevation model RIMINI, interpolations were done with a resolution of 2 km • 2 km in all three spatial dimensions. For each case nine stations were used to calculate the pixel values. The varying lengths of the series were taken into account in using different weights in the Kriging procedure. Data supplied by special measurement networks with spatially high resolution, such as the Wägital valley (900 m to 1800 m altitude, [2]), the Alptal valley (1140 m to 1450 m, [4]), the Linth-Limmern area (1800 m to 2900 m) and the Dischmatal valley (1600 m to 2100 m), was used as additional information for the interpolations in the z dimension (altitude above sea level).

Time-series of the water equivalent

For a selection of stations, figure 1 shows time-series of the water equivalent taken at the snow stake on 1st January, 1st March, 1st April and 1st May. The line shows the term values smoothed over five years, using a Gaussian low-pass filter. The near-periodic variations of approximately ten years, which can also be seen in the snow depth (cf. 3.1), are especially noticeable. In the following winters, for example, the equivalent values were high: 1944/45, 1950/51, 1965/66, 1974/75, 1981/82, and 1987/88. At the end of the 1980's and the beginning of the 1990's there seemed to be a tendency towards less snow in the winter, at least as far as the lower stations were concerned. Nevertheless, above-average water equivalent values were once more recorded at most stations during winter 1991/92. The high altitude station of Weissfluhjoch has observed no trend at all.

Water reserves in various catchments

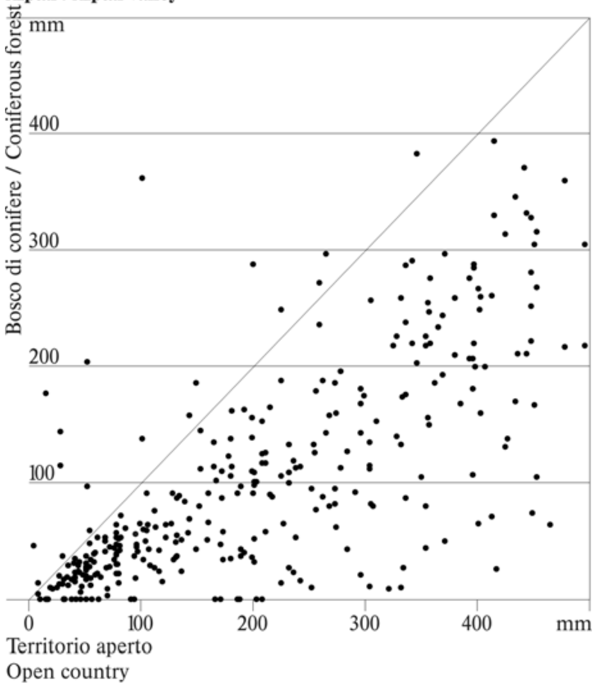
Figure 2 shows the mean water reserves of the Rhine, Aare and Limmat river basins on 1st January and 1st April, depending on altitude. Water storage is indeed strongly influenced by hypsography, whereas water equivalent values at similar altitude vary according to the river basin and tend to be less important in this representation. Since a generalised version of the RIMINI elevation model was used (2 km • 2 km raster), there may be minor deviations in the altitude data concerning the river basins compared with other Atlas maps.

Influence of forest on the water equivalent of snow cover

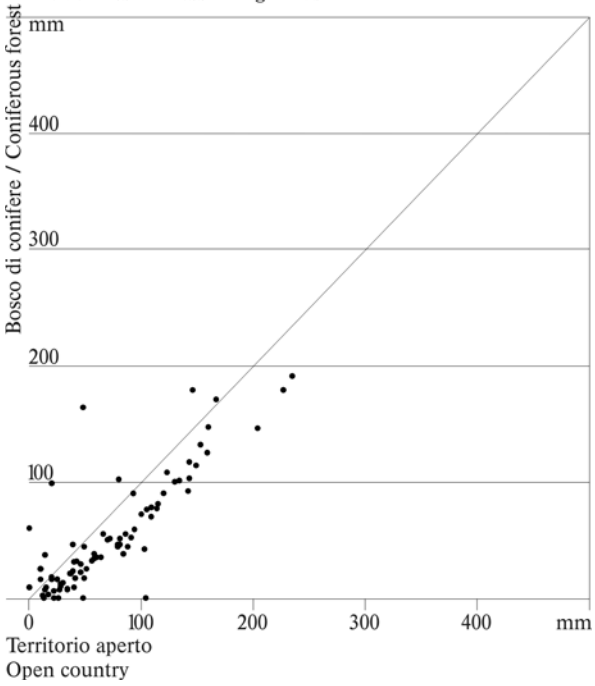
The question of water equivalents in forests has not yet been sufficiently answered, since almost all measurement stations are in open country. Generally speaking, it can be said that the water equivalent value in a forest tends to be lower than in open country mainly because of interception losses. However, there are exceptions in areas where water equivalent values tend to be lower. Figure 3 shows values from comparative measurements. This data originates from four pairs of measurement locations in the Alptal valley (between 1140 m and 1450 m altitude, 1984–1994) and 15 pairs of measurement locations from the Hessian highlands (between 100 m and 800 m altitude, 1971–1981 [1]). In each case the comparison is made between a measurement location in a coniferous forest and one in open country which is as similar as possible as regards altitude and aspect. The information presented in figure 3 should not be randomly applied to other areas or deciduous forests.

Fig. 3
Confronto tra le misurazioni dell'equivalente in acqua nei territori aperti e nei boschi di conifere
Comparison of measurements of the water equivalent in open country and in coniferous forests

Alptal / Alptal valley



Alture dell'Assia / Hessian highlands



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