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Snow cover retrieval over Rhone and Po river basins from MODIS optical satellite data (2000-2009).

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Estimation of the Snow Covered Area (SCA) is an important issue for meteorological application and hydrological modeling of runoff. With spectral bands in the visible, near and middle infrared, the MODIS optical satellite sensor can be used to detect snow cover because of large differences between reflectance from snow covered and snow free surfaces. At the same time, it allows separation between snow and clouds. Moreover, the sensor provides a daily coverage of large areas (2,500 km range).
However, as the pixel size is 500m x 500m, a MODIS pixel may be partially covered by snow, particularly in Alpine areas, where snow may not be present in valleys lying at lower altitudes. Also, variation of reflectance due to differential sunlit effects as a function of slope and aspect, as well as bidirectional effects may be present in images. Nevertheless, it is possible to estimate snow cover at the Sub-Pixel level with a relatively good accuracy and with very good results if the sub-pixel estimations are integrated for a few pixels relative to an entire watershed.

Integrated into the EU-FP7 ACQWA Project (www.acqwa.ch), this approach was first applied over Alpine area of Rhone river basin upper Geneva Lake: Canton du Valais, Switzerland (5 375 km^2). In a second step over Alps, rolling hills and plain areas in Po catchment for Val d'Aosta and Piemonte regions, Italy (37 190 km^2). Watershed boundaries were provided respectively by GRID (Ch) and ARPA (It) partners. The complete satellite images database was extracted from the U.S. MODIS/NASA website (http://modis.gsfc.nasa.gov/) for MOD09_B1 Reflectance images, and from the MODIS/NSIDC website (http://nsidc.org/index.html) for MOD10_A2 snow cover images. Only the Terra platform was used because images are acquired in the morning and are therefore better correlated with dry snow surface, avoiding cloud coverage of the afternoon (Aqua Platform).
The MOD9 Image reflectance and MOD10_A2 products were respectively analyzed to retrieve (i) Fractional Snow cover at sub-pixel scale, and (ii) maximum snow cover. All products were retrieved at 8-days over a complete time period of 10 years (2000-2009), giving 500 images for each river basin.
Digital Model Elevation was given by NASA/SRTM database at 90-m resolution and used (i) for illumination versus topography correction on snow cover, (ii) geometric rectification of images. Geographic projection is WGS84, UTM 32. Fractional Snow cover mapping was derived from the NDSI linear regression method (Salomonson et al., 2004). Cloud mask was given by MODIS-NASA library (radiometric threshold) and completed by inverse slope regression to avoid lowlands fog confusing with thin snow cover (Po river basin). Maximum Snow Cover mapping was retrieved from the NSIDC database classification (Hall et al., 2001).

Validation step was processed using comparison between MODIS Snow maps outputs and meteorological data provided by network of 87 meteorological stations: temperature, precipitation, snow depth measurement. A 0.92 correlation was observed for snow/non snow cover and can be considered as quite satisfactory, given the radiometric problems encountered in mountainous areas, particularly in snowmelt season.
The 10-years time period results indicates a main difference between (i) regular snow accumulation and depletion in Rhone and (ii) the high temporal and spatial variability of snow cover for Po. Then, a high sensitivity to low variation of air temperature, often close to 1° C was observed. This is the case in particular for the beginning and the end of the winter season. The regional snow cover depletion is both influenced by thermal positives anomalies (e.g. 2000 and 2006), and the general trend of rising atmospheric temperatures since the late 1980s, particularly for Po river basin.
Results will be combined with two hydrological models: Topkapi and Fest.