Plinius Conference Abstracts
Vol. 13, Plinius13-82, 2011
13th Plinius Conference on Mediterranean Storms

Satellite and ground data assimilation in a surface hydrology model with snow dynamics

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The estimation of the different components of the energy balance at the land surface is recognized to be a crucial research field in many hydrological and meteorological problems. And above all this aspect plays a crucial role in snow covered areas, where water dynamics are governed by melting processes in snowpack.

The present study has the aim to evaluate energy and mass balance in snow covered areas by using a variational method of assimilation. It consists in an objective function constrained by the equations of a mathematical model that explains physics of the processes through Lagrange multiplier.

Snow dynamics are described through a 4-layer model: the model considers two layers of snow, to discriminate between fresh and old snow behavior, and two layers of soil. Four state variables are related to energy balance: they are temperatures in each layer. Four state variables are related to water balance in snow: they are snow water equivalent and snow density for each layer of snow.

These eight equations represent the constrains for the adjoined function, in which assimilated variables are surface temperature and snow height. Surface temperature is a variable observed from geostationary satellite MSG, and in the variational scheme is compared with surface temperature obtained from the 4-layer model. Surface temperature is a good parameter to improve the estimate of energy budget because it gives implicit information on available energy. Spatial resolution of satellite data is around three kilometers, and time resolution is 15 minutes, but data are assimilated each hour, and it is considered the average value for the hour. To keep into account problems associated with application of satellite data in a mountain area, such as georeferencing, changing in viewing angle and shadowing, it was applied a geometric correction to satellite data in order to consider orography complexity. Correction was made using a digital elevation model at spatial resolution of 400 meters, which is the final resolution of the model. The other assimilated variable is snow height: it is obtained by the interpolation of nivometer observations available. In assimilation process this observation in used to improve the estimate of snowfall. As formulated the model is able to manage the change between snow and soil cover.

Considered study area is Valle d'Aosta region in which several stations are available for the observation of snow height, and in which meteorological data necessary for 4-layer model, such as air temperature, relative humidity, air pressure, wind speed and precipitation, are available.

Final objective of the work is to show that using results of the assimilation model in hydrological simulations can improve the estimate of river discharge in mountain environment.