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Assessing the snowmelt submodel of TETIS within the DMIP2 project

Ismael Orozco and Félix Francés
Research Institute of Water Engineering and Environment, Polytechnic University of Valencia, Spain

Melt modelling is a crucial element in any attempt to predict runoff from snow-covered or glacierised areas, as well as to assess changes in the cryosphere associated with clime change. In mountainous regions, snow and ice significantly affect catchment hydrology by temporarily storing and releasing water on various time scales (Jansson et al., 2003). Hence, success of runoff modelling in such areas largely depends on accurate quantification of the melt process (Hock, 2003). Snowmelt modelling is complex and dependent on elevation, slope, vegetation type, surface roughness, radiation load, and energy exchange at the snow-air interface (Baron, 1992; Barros and Lettenmaier, 1993; Becker et al., 1994; Cline, 1995; Elder et al., 1991). This paper describes the application of the degree-day method for snowmelt-runoff at hourly time discretization, which is implemented in the distributed and conceptually based hydrological model TETIS, as well as the evaluation of results.

In the TETIS model the natural basins are discretizated in grid cells according to drainage network. This conceptualization permits all parameters do not lose its physical meaning (Francés et al., 2007). At each cell the main soil properties need to be estimated previously using topographical, environmental, land use, geological and soil maps. The model has been applied to the Sierra Nevada basins, in USA: the American River (886 km2) and the Carson River (922 km2), as a part of the Distributed Model Intercomparison Project, second phase (DMIP2), of the National Oceanic and Atmospheric Administration's National Weather Service (NOAA/NWS), in which we are participating. These basins are geographically close, but their hidrological regimes are quite different: the Carson River is a high altitude basin with a snow dominated regime; while the American River drains an area that is lower in elevation with precipitation falling as rain and mixed snow and rain (Jeton et al., 1996). Details on the basins features are available in Smith et al. (2006).

The degree-day method in the TETIS model, assuming an empirical relationship between air temperatures and melt rates, applied and refined (e.g. Clyde, 1931; Collins, 1934; Corps of Engineers, 1956; Hoinkes and Steinacker, 1975; Braithwaite, 1995). The snow (initial values) and temperature are interpolated at each cell with inverse distance squared algorithm with a linear correction with altitude. The degree-day method was implemented with a simple and parsimonious parameterization using one melting coefficient for rainy and another for not-rainy time.

The evaluation of the modeling results was performed using the observed snow water equivalent (SWE) at daily scale, hourly discharges at the basin outlet and some snow-covered images provided by NOAA/NWS. As expected, the model does not reproduce the fluctuations observed in the outflow hydrograph, caused by diurnal melting. The results obtained are acceptable according to the Nash-Sutcliffe coefficient, but excellent at daily scale. Concerning the SWE, the results are very good, taking into account we are dealing with point observations in space. Also, it must be underline that such results are better at higher altitude stations than in lower altitude ones.

In conclusion, the results are acceptable, but indicate the need to add information of radiation to the snowmelt model in order to improve the energy-balance and the sensitivity of the model against spatial-temporal changes in the energy fluxes and assess what degree of complexity is recommended for snowmelt model, based on the results and the principle of parsimony.