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MODELACIÓN PARSIMONIOSA Y ESPACIALMENTE DISTRIBUIDA DE LOS PROCESOS DE ACUMULACIÓN Y FUSIÓN DE NIEVE

Autor:

ISMAEL OROZCO MEDINA

Director:

Dr. FÉLIX FRANCÉS GARCÍA

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Abstract

This thesis aims to investigate the variability effects of snowmelt factors used by the degree-day method in the hydrological modeling of run-off production and in the processes of accumulation and snowmelt in high mountain basins. This, in order to provide a parsimonious alternative to simulate the snowmelt in hydrological modeling of such basins, whose the main problem is not having enough information to apply models conceptually more complex as the energy balance model. To accomplish this, three mathematical conceptualizations of snowmelt hybrid models have been proposed, based on the degree-day classic method, but considering the variability of snowmelt factors. These conceptualizations have been implemented in the conceptual distributed hydrological model with parameters physically based, TETIS, that model the processes of hydrological cycle. The variability of snowmelt factors is introduced into the hybrid models, with a cell scale, by using maps of radiation indexes, which are built taking into account the global shortwave radiation with clear sky, the morphological characteristics of the basin, the shadow of the relief and the season of the year. Also, the maps of the snowmelt factors, determined from energy inputs to snowmelt, depending on land cover, are used. In addition, the automatic calibration of the parameters is implemented using the mathematical conceptualizations proposed, by using the optimization algorithm Shuffled Complex Evolution (SCE-UA) developed by the University of Arizona, USA.

To evaluating the hybrid models implemented, it has been proposed three case studies: the sub-basins of the Carson and American rivers of Sierra Nevada, USA, and the Mediterranean basin Contraix, located in the Aigüestortes National Park in the Catalan Pyrenees, Spain. These basins are geographically closed and have a completely different hydrological regime, due to its location and its average elevation. The evaluation process has involved the analysis of the results obtained both with the variability of snowmelt factors, as those obtained using homogeneous snowmelt factors through the classical degree-day conceptualization method. In the case of results of streamflow production at the control points located in the mouth and in the interior of the basins Sierra Nevada, it is observed that the effect of variability is minimal. In the same way, have demonstrated the high efficiencies achieved with all the models analyzed, including the degree-day model with homogeneous snowmelt factors. However, these high efficiencies achieved in the modeling of the streamflow, do not mean

the correct modeling of snow, specifically the processes of accumulation and melting of the implemented models. In relation to above, the effect of the variability of the snowmelt factors is evaluated through the spatial point and validation of the results obtained in the modeling of Sierra Nevada basin. To do this, information from SNOTEL meteorological stations, of poles and satellite images are used. In this case the results showed a completely different behavior in the modeling of snow by the models analyzed. It is also noted that the hybrid model which introduces variability, using the maps of radiation indexes, provides better results in the validations performed.

The evaluation of the models implemented also been performed by comparing the results with those obtained previously, analyzed for the same basins for other hydrologic models that have participated in the Distributed Hydrologic Model Intercomparison Project-Phase 2 (DMIP2). Some of these models use the energy balance modeling of snow. In general, the results of this comparison showed efficiencies of the models proposed in this thesis, very similar to those achieved by DMIP2 models and even, in the case of modeling snow efficiencies are overcome some of the models the DMIP2.

In the last part of this thesis are evaluated two of the models implemented using the Contraix basin, with a spatial scale of greater precision and a time scale of half an hour. These models have been selected according to the results of the Sierra Nevada basins and evaluated following the same procedure as above. This, in order to detect inconsistencies in the analyzed conceptualizations of the change of scale, and validate the results achieved in the basins of Sierra Nevada. The results showed a very similar behavior, with efficiencies in modeling the streamflow very similar between the models and results on the modeling of snow variability influenced by snowmelt factors. The same way, the best results in the Contraix basin were obtained with the hybrid model that uses radiation index maps.

Finally, in this thesis demonstrates that the results in modeling the processes of accumulation and melting snow in high mountain basins can be improved significantly when a parsimonious conceptualization to consider the variability factors used fusion. Also, the effect of the variability in modeling runoff production at the mouth of a basin, provides no greater advantages than the classic conceptualization degree-day model. For all these reasons, the selection of model to be used in these areas will depend on the available information, the objective of the model and the results to achieve.