Geophysical Research Abstracts
Vol. 15, EGU2013-11824, 2013
EGU General Assembly 2013

High-Resolution Free-GIS operations to assist hydropower potential assessment

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Even in regions with mature hydropower development, needs for renewable energy suggest to revise plans of exploitation of water resources, according to EU and national environmental regulations. High resolution hydrological analysis is then needed to comply with the effects of existing hydropower plants and of other water withdrawals.
Flow duration curves (FDC) are the tool usually adopted to represent water availability and variability for hydropower purposes. For this study, developed within the RENERFOR-ALCOTRA Project, a regional "spatially smooth" model has been developed for FDC estimation: the procedure adopted relates the L-moments of the FDC to several geomorphoclimatic parameters (more than 100), with the purpose to directly reconstruct a "naturalized" FDC. The proposed procedure is systematically extended to all the gauged basins located in Northwestern Italy, which is an area characterized by the presence of a large number of dams. For each basin, the annual average FDC is computed, its L-moments are calculated and corrected using a simplified model that takes into account the effect of upstream reservoirs and power plants. Then, each corrected L-moment is regionalized using multiple regressions techniques, allowing one to reconstruct the L-moments at any ungauged basin. Finally, the "naturalized" FDC is reconstructed at the ungauged site on the basis of the predicted L-moments. Due to necessity of obtaining high-resolution estimates, the method has been designed to keep the estimates of mean annual runoff congruent in the confluences. This feature is obtained considering only raster-summable explanatory variables, which are only a subset of the available descriptors.
The residual hydropower potential is evaluated by mapping the mean naturalized flow estimated for each pixel of a DEM-derived river network raster model in two mountain basins used as case studies. Applying extensively the proposed methodology, the mean annual flow is reconstructed not only in some significant sections, but in all the about 25000 sections defined by each network pixel. We used a 50 m DEM to compute, for each network pixel, the upstream watershed and all the morpho-climatic characteristics needed in the regional model.
Maps obtained can return flow-altitude relations for each pixel along a drainage path assuming different possible headrace length (1, 2.5 and 5 km). Spatial algorithms and data management are developed by the use of the Free&OpenSource software GRASS GIS and PostgreSQL as database manager, integrated with PostGIS elaboration to create the outputs. The large number of data and the complexity of the information derived required some thinking about the best way to access and represent the data, that has to be easy-to-use also for no-expert GIS users.