Geophysical Research Abstracts
Vol. 12, EGU2010-7053, 2010
EGU General Assembly 2010

Regionalization analysis of low flow for drought risk assessment in Tuscany (Italy)

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The estimates of river low flow characteristics play an important role in engineering practice for water resources design and management and their definition is necessary for several purposes, including water supply planning, river basin management, hydropower development and environmental flow characterization. Another important field and thorny task in which they are utilized is in identifying the occurrence, the extent and the magnitude of a drought,. The beginning and the persistency of droughts can be recognized with meteorological indices. With indices derived from low flow it is possible to recognize the hydrological droughts that affect mainly the water supply systems.
Low flow characteristics are estimated from observed streamflow data, identifying some duration curves, percentiles characteristics and some indices. Nevertheless the lack of observed streamflow data is a diffuse problem in the real world. For sites where data are not available, alternative techniques are necessary to infer this information. The regional regression approach is one of the more used. It consists in inferring data in ungauged stations using hydrological and statistical regionalization methods. The methods are based on catchment and climatic variables and data from other catchments where stream flow data are recorded.
The analysis of low flow indices is carried out on the discharge data from 1st January 1949 to 31st December 2008 of 65 consistent hydrometric stations located in Tuscany Region, in Central Italy. The area is subdivided into different regions using the L-moments method applied to the 7-day annual minimum and to the Q70 annual series. The division into subregions is tested using discordancy and heterogeneity statistics. Different subdivision are tested: a unique region, a subdivision into three different subregions and a subdivision in five subregions. The second subdivision is based on previous studies on rainfall extreme values. The last starts from the previous subdivisions and introduces some hydrological features.
Once the catchment area is identified for every river cross-section where a gauge station is installed, a suitable set of catchment physiographic and climatic characteristics is defined and a physiographical space-based method is used to relate the duration and percentile indices of low flow to the investigated territory characteristics. The new space is built as a linear combination of the catchment physiographic and climatic characteristics. Different interpolation techniques, either deterministic or geostatistical, such as Inverse Distance, Thiessen polygon methods and Kriging, are applied. Uncertainties measurements are implemented using jack-knife and bootstrap methods. Different error measurement (mean square error, mean relative error...) are also assessed to compare the results, to quantify the accuracy of the different techniques and to define the most suitable procedure for drought risk assessment.