Geophysical Research Abstracts
Vol. 19, EGU2017-16840-2, 2017
EGU General Assembly 2017

Assessment of future impacts of potential climate change scenarios on aquifer recharge in continental Spain

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This research proposes and applies a method to assess potential impacts of future climatic scenarios on aquifer rainfall recharge in wide and varied regions. The continental Spain territory was selected to show the application. The method requires to generate future series of climatic variables (precipitation, temperature) in the system to simulate them within a previously calibrated hydrological model for the historical data. In a previous work, Alcalá and Custodio (2014) used the atmospheric chloride mass balance (CMB) method for the spatial evaluation of average aquifer recharge by rainfall over the whole of continental Spain, by assuming long-term steady conditions of the balance variables. The distributed average CMB variables necessary to calculate recharge were estimated from available variable-length data series of variable quality and spatial coverage. The CMB variables were regionalized by ordinary kriging at the same 4976 nodes of a 10 km x 10 km grid. Two main sources of uncertainty affecting recharge estimates (given by the coefficient of variation, CV), induced by the inherent natural variability of the variables and from mapping were segregated. Based on these stationary results we define a simple empirical rainfall-recharge model. We consider that spatiotemporal variability of rainfall and temperature are the most important climatic feature and variables influencing potential aquifer recharge in natural regime. Changes in these variables can be important in the assessment of future potential impacts of climatic scenarios over spatiotemporal renewable groundwater resource. For instance, if temperature increases, actual evapotranspitration (EA) will increases reducing the available water for others groundwater balance components, including the recharge. For this reason, instead of defining an infiltration rate coefficient that relates precipitation (P) and recharge we propose to define a transformation function that allows estimating the spatial distribution of recharge (both average value and its uncertainty) from the difference in P and EA in each area. A complete analysis of potential short-term (2016-2045) future climate scenarios in continental Spain has been performed by considering different sources of uncertainty. It is based on the historical climatic data for the period 1976-2005 and the climatic models simulations (for the control [1976-2005] and future scenarios [2016-2045]) performed in the frame of the CORDEX EU project. The most pessimistic emission scenario (RCP8.5) has been considered. For the RCP8.5 scenario we have analyzed the time series generated by simulating with 5 Regional Climatic models (CCLM4-8-17, RCA4, HIRHAM5, RACMO$_2$2E, and WRF331F) nested to 4 different General Circulation Models (GCMs). Two different conceptual approaches (bias correction and delta change techniques) have been applied to generate potential future climate scenarios from these data. Different ensembles of obtained time series have been proposed to obtain more representative scenarios by considering all the simulations or only those providing better approximations to the historical statistics based on a multicriteria analysis. This was a step to analyze future potential impacts on the aquifer recharge by simulating them within a rainfall-recharge model.

This research has been supported by the CGL2013-48424-C2-2-R (MINECO) and the PMAFI/06/14 (UCAM) projects.