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Estimating the uncertainty of the impact of climate change on alluvial aquifers. Case study in central Italy

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There is evidence that the precipitation pattern in Europe is trending towards more humid conditions in the northern region and drier conditions in the southern and central-eastern regions. However, a great deal of uncertainty concerns how the changes in precipitations will have an impact on water resources, particularly on groundwater, and this uncertainty should be evaluated on the basis of that coming from 1) future climate scenarios of Global Circulation Models (GCMs) and 2) modeling chains including the downscaling technique, the infiltration model and the calibration/validation procedure used to develop the groundwater flow model. With the aim of quantifying the uncertainty of these components, the Valle Umbra porous aquifer (Central Italy) has been considered as a case study. This aquifer, that is exploited for human consumption and irrigation, is mainly fed by the effective infiltration from the ground surface and partly by the inflow from the carbonate aquifers bordering the valley. A numerical groundwater flow model has been developed through the finite difference MODFLOW2005 code and it has been calibrated and validated considering the recharge regime computed through a Thornthwaite-Mather infiltration model under the climate conditions observed in the period 1956-2012. Future scenarios (2010-2070) of temperature and precipitation have been obtained from three different GMCs: ECHAM-5 (Max Planck Institute, Germany), PCM (National Centre Atmospheric Research) and CCSM3 (National Centre Atmospheric Research). Each scenario has been downscaled (DSC) to the data of temperature and precipitation collected in the baseline period 1960-1990 at the stations located in the study area through two different statistical techniques (linear rescaling and quantile mapping). Then, stochastic rainfall and temperature time series are generated through the Neyman-Scott Rectangular Pulses model (NSRP) for precipitation and the Fractionally Differenced ARIMA model (FARIMA) for temperature. Such a procedure has allowed to estimate, through the Thornthwaite-Mather model, the uncertainty related to the future scenarios of recharge to the aquifer. Finally, all the scenarios of recharge have been used as input to the groundwater flow model and the results have been evaluated in terms of the uncertainty on the computed aquifer heads and total budget. The main results have indicated that most of the uncertainty on the impact to the aquifer arise from the uncertainty on the first part of the processing chain GCM-DSC.