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Assessing groundwater availability in a folded carbonate aquifer through the development of a numerical model

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The study of aquifer systems from a quantitative point of view is fundamental for adopting water management plans aiming at preserving water resources and reducing environmental risks related to groundwater level and discharge changes. This is also what the European Union Water Framework Directive (WFD, 2000/60/EC) states, holding the development of numerical models as a key aspect for groundwater management.
The objective of this research is to i) define a methodology for modeling a complex hydrogeological structure in a structurally folded carbonate area and ii) estimate the concurrent effects of exploitation and climate changes on groundwater availability through the implementation of a 3D groundwater flow model.
This study concerns the Monte Coscerno karst aquifer located in the Apennine chain in Central Italy in the Nera River Valley.This aquifer, is planned to be exploited in the near future for water supply. Negative trends of precipitation in Central Italy have been reported in relation to global climate changes, which are expected to affect the availability of recharge to carbonate aquifers throughout the region . A great concern is the combined impact of climate change and groundwater exploitation, hence scenarios are needed taking into account the effect of possible temperature and precipitation trends on recharge rates. Following a previous experience with model conceptualization and long-term simulation of groundwater flow, an integrated three-dimensional groundwater model has been developed for the Monte Coscerno aquifer. In a previous paper (Preziosi et al 2014) the spatial distribution of recharge to this aquifer was estimated through the Thornthwaite Mather model at a daily time step using as inputs past precipitation and temperature values (1951-2013) as well as soil and landscape properties. In this paper the numerical model development is described. On the basis of well logs from private consulting companies and literature cross sections the multilayer aquifer was conceptualized as five folded hydrostratigraphic units: three main carbonate aquifers are separated by two aquitards, which can be locally discontinuous, leading to a complicated flow pattern. In general the vertical leakance is upward from the basal aquifer to the unconfined uppermost aquifer. As shown by the increasing discharge from north to south, the Nera river acts as the main sink of the study area, gaining groundwater as it cuts through the folded terrain.
The numerical model was implemented using the MODFLOW-2000 code and extends over an area of 235 km2 with a grid spacing of 100 meters in each of the 5 layers.
Model calibration was achieved by comparing the model results with observed streamflow of the Nera river (8-10 measures per year during 1991-1993 and 1996-2012) which on the basis of the river hydrograph at gaging locations is considered to be derived entirely from groundwater. The effects of climate variation on groundwater discharge to the river in the past 60 years are analyzed. Key issues related to the elaboration of a numerical model of a folded structure are also described.