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Effects of climate change on groundwater: observed and forecasted trends on Italian systems

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Groundwater represents the main source of water supply at global level. In Italy, as well as in most European countries, water needs are mainly covered by groundwater exploitation. The reliance on this resource is continuously growing, given the key role that groundwater plays for mitigating the climate change/variability and for addressing the significant increase in the global water demand. Despite this, and unlike surface waters, groundwater bodies have not been widely studied, and there is a general paucity of quantitative information, especially in relation to climate change. Although groundwater systems are more resilient to climate change than surface waters, they are affected both directly and indirectly. The estimation of the entity of these effects is mandatory for a reliable management of this crucial resource.

The analysis of hydro-meteorological data over a few decades highlights that also the Italian territory is experiencing a change of the climate regime. Besides the increase of mean annual temperature, observed in particular since the early 1980s, longer and more frequent drought periods have been registered, as well as an increase of extreme events characterized by heavy rainfall. It is also noticeable a decrease in total rainfall, that is much more evident in the period from January to June. In addition to the reduced yearly inputs from precipitation, such trends determine also a lower snow accumulation and earlier snow melt in mountain areas, a general increase of evapotranspiration rates and an increased runoff fraction of the effective rainfall amount.

As flood hydrographs of several major Italian rivers (e.g., Po, Brenta and Arno rivers) confirm, evident effects concern surface water resources. The main observed phenomena consist in the decline of mean annual discharge, the increase of extreme events with high discharge concentrated in short periods, and longer and earlier periods of low base flow.

Impacts on groundwater recharge are not well understood. However, data analysis at specific Italian sites indicate that they are actually occurring. Here we discuss the results of the analysis of the data provided by a set of groundwater monitoring sites, not affected by artificial water extraction. Data refer to flowrates in spring and water levels from piezometers, and they are representative of different typologies of aquifers, such as karst, fractured and unconsolidated, located in mountain and foothills areas of central and northern Italy. Both flowrates and water levels indicate a decline of groundwater yields in these systems over the last two decades. This trend is much more evident when focusing on the periods of high level conditions (i.e. maximum effect of infiltrated water), thus demonstrating the reduction of recharge. The more attenuated trend observed by analyzing low level periods (i.e. at the end of dry periods) testifies the buffer role of aquifers, which partially compensate the general reduction by releasing water from storage reserves. A tendency to consume more recharge water through sudden and short flow rate peaks is also observed for karst systems, as a consequence of the increased occurrence of storm events.

Furthermore, data were elaborated in order to study possible empirical relationships between meteorological parameters and groundwater quantity indices, in the wider framework of a research concerning the estimation of the performance of groundwater systems under specific climate scenarios.