Title: Impact of climatic variations on groundwater recharge processes of carbonate aquifers of the southern Apennines and on availability of groundwater resources

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Research program

The peculiar geo-structural, hydrogeological, geomorphological and climatic features of southern Italy determine the existence of numerous carbonate aquifers, which are characterized by a huge groundwater circulation, feed the main regional aqueduct systems and nourish groundwater-dependent river ecosystems. The wide availability of groundwater resources can be considered among the factors that favored the socio-economic development of the southern regions of Italy. In such a framework, the strong dependence of the current socio-economic structure on the availability of groundwater resources has been, so far, largely underestimated, as the latter are commonly considered as being renewable with a steady periodicity. However, the ever-increasing direct awareness, as well as indirect by media, of climate change makes urgent to focus research activities on effects climatic variations at different temporal scales, from interannual to decadal, can have on recharge processes of carbonate aquifers and therefore on the availability of groundwater resources. In fact, the analysis of medium to long term scenarios appears to be crucial for the resilient management of low-flow periods at a regional scale.

In this regard, by a normative point of view, the management of groundwater resources has made significant progresses due to the application of the EU regulations (2000/60 / EC and 2006/118 / EC) and the consequent issue and application of the D. Legislative Decree 152/2006, Legislative Decree 30/2009 and Ministerial Decree 260/2010, which defined criteria for the identification and characterization of groundwater bodies, as well as the definition of new methods for the classification of their chemical and exploitation status. Nevertheless, differently from what has been implemented in the landslide and flood risk management system, issued for Civil Protection purposes through the Regional Alert System (D.P.G.R. N. 299 of 30 June 2005), current regulations and policies regarding the management of groundwater resources in Italy are lacking about the risk management of low-flow periods, caused by the inter-annual to decadal rainfall fluctuations. To highlight the relevance of such type of research, it is useful to remember that the winter rainfall of 2015-2016 and 2016-2017 hydrological years, has been considerably lower than the average values, determining a strong reduction in spring discharge flow rates and the lowering of the water table levels, which caused concern in the water network management bodies (e.g. public announcement of CONSAC - Gestioni Idriche S.p.A. of May 2017 - http://www.consac.it/crisi-idrica-2017/).

Starting from a sound basis of studies produced by the proponents in the last decade, which has been focused on the regional hydrogeology characterization (Allocca et al., 2007; De Vita et al.; 2018), characterization of groundwater recharge of carbonate aquifers (Allocca et al., 2014; 2015) and effects of long-term climatic variations on the recharge of carbonate aquifers (De Vita et al., 2012; Manna et al., 2013), the PhD project aims to analyze the effects of climate change on the recharge of the principal carbonate aquifers of southern Italy, at different spatial and temporal scales, and the impacts on groundwater circulation as well as on the availability of groundwater

resources, which are currently used by the regional aqueduct systems, not excluding the inherent quality.

The phases of study and methodologies applied in the PhD program will include: 1) implementation in a GIS platform of the fundamental regional hydrogeological data, comprehending also the exploitation state of aquifers as well as quality of their groundwater; among these data, data remotely-sensed from satellite platforms surveys (MODIS and SENTINEL) should also be included; 2) gathering of historical series data concerning the monitoring of groundwater levels, spring discharge and pumping rates, to be implemented in a georeferenced relational database; 3) acquisition on a wide regional range of historical data of precipitation and air temperatures, measured and collected by the meteorological network of the former National Hydrographic and Mareographic Service, and by the current Meteorological Service of Civil Protection, and its implementation in a georeferenced relational database; 4) statistical-probabilistic analysis of the precipitation regime aimed at identifying scenarios of extraordinary, or extreme, low rainfall, occurring under a given probability of occurrence; 5) analysis of the effects, on a large spatial and temporal scale, of the effects of continental atmospheric phenomena such as the North-Atlantic Oscillation (NAO); 6) development of empirical models aimed at the correlation between rainfall, spring discharge and groundwater levels, to be implemented in sample carbonate aquifers; 7) definition of climate scenarios based on General Atmospheric Circulation Models (GCMs) to be adapted at the local scale by different dynamic or statistical downscaling techniques. These techniques are aimed at providing predictive scenarios representative of local conditions through statistical relationships which link climatic parameters (especially temperatures and rainfall) on a large scale with the regional ones, with spatial resolutions between 20 and 50 km, and assuming that the atmospheric circulation phenomena remain constant at local scale (Trzaska and Schnarr, 2014). With this approach, Regional Climate Models (RCMs) are set up, which can provide predictive scenarios for future extreme climate variations (daily temperatures and precipitation) to be used for quantitative analyzes projected until the end of the 21st century.

Proposal for a PhD position

Starting from the aforementioned scientific background, a PhD position is proposed, for the development of which collaborations with the Berlin Polytechnic (Germany) and other European research centers at the forefront on the topic of aquifer recharge and/or formulation of climate change scenarios will be activated, considering these collaborations as fundamental for the scientific development of the PhD student, as well as for the achievement of scientific results in a way that should be widely shared and validated within the scientific community.

It is therefore believed that the research can be articulated, during the three years of the PhD program, as described following: first year) attendance at PhD institutional courses provided by the PhD program as well as at other courses regarding the specific research topic; collection and analysis of the specific bibliography; data collection and implementation of the GIS platform, including mapping of the main aqueduct networks; second year) hydrogeological characterization of sample areas and physical modeling of selected sample basins, through specific hydrogeological surveys; development of rainfall-groundwater discharge empirical and physical models to be carried out on sample aquifers; third year) development of Regional Climate Models (RCMs) and simulation of the effects of climatic variations, namely comprehending the decrease in precipitation

and/or increase in the average air temperature, on the recharge of carbonate aquifers and availability of groundwater resources.