Geophysical Research Abstracts
Vol. 20, EGU2018-15045, 2018
EGU General Assembly 2018

The role of groundwater modelling for the sustainable management of water resources in a context of climatic change: an experience on a carbonate aquifer in Tuscany (Italy)

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In a growing number of countries, safeguarding drinking water supplies is strictly linked with the sustainable usage of groundwater resources. In the European Union, about 70% of the water destined to the supply network is groundwater, and almost 75% of this source comes from carbonate aquifers. Although groundwater systems can be considered as more resilient to climate change than surface waters, climate change affects them both directly and indirectly. For carbonate aquifers the impact can be very significant, given the high sensitivity of these reservoirs.caused by their karst features. The analysis of hydro-meteorological data over a few decades highlights that also Italy is experiencing a change in the climate regime, with impacts on groundwater yield that are not yet well understood. In this work, we discuss the results of the analysis of data provided by the Tuscan Water Authority (AIT) and GAIA SpA (Integrated Water Service). Data refer to flowrate at springs of the karst aquifer system of the Apuan Alps (northwestern Tuscany). Flowrates trend indicates a slight decline of groundwater yields in this system over the last two decades. A tendency to consume more recharge water through sudden and short flow rate peaks seems also to occur, as a consequence of the increased occurrence of storm events.
Data were elaborated in order to study possible empirical relationships between meteorological parameters and groundwater quantity indices, in the wider framework of a research for the development of support tools for the management of the resource under specific climate scenarios. In particular, this work describes the different data-driven approaches experimented with the collected time series, essentially based on multi-variate analysis techniques and on a simplified machine learning scheme based on neural networks.
The collected time series were first analyzed by classical statistical and advanced spectral analysis techniques, in order to extract the embedded significant periodicities and trends. Forecasting was thus applied on clean signals only, to reduce the background noise propagation; both empirical models applied to the whole cleaned dataset, and single components projection methodologies were taken into account.
Also, a preliminary test of a data-driven approach based on Multi Layer Perceptron Neural Networks (MLP-NN) is described in this work. In particular, dedicated techniques for data pre-processing, training and validation have been experimented. A further activity regarded the assessment of a performance metric for the evaluation of multiple MLP-NNs with respect to independent test sets, based on either historical or synthetic data.