Predicting reservoir water volumes in the Mediterranean area by combining a data-driven approach with seasonal forecasts data

Antonio Francipane[1], Elisa Arnone[2] and Leonardo Valerio Noto[1]

(1) Dipartimento di Ingegneria, Università degli Studi di Palermo, Palermo, Italy
(2) Dipartimento Politecnico di Ingegneria e Architettura, Università degli Studi di Udine, Udine, Italy

Water resources management in Mediterranean areas is still today a critical issue (Markantonis et al., 2019, Zribi et al., 2020), with an ever growing water demand (Sanchez et al., 2020) that contrasts with an increasing trend of extreme events, such as droughts, heat waves, etc., due to the alteration in climate (Fowler et al., 2021). In this context, a sustainable management of the water supply cannot be separated by the capability to predict the future water availability, on one hand, and to adapt promptly and efficiently to the modifications in water resources, on the other.

In the case of the Mediterranean area, one of the main multi-purpose water resources is provided by artificial reservoirs.

On one hand, predicting well in advance future reservoir volumes is one of the critical engineering problems to guarantee an efficient water supply planning for water utilities (Awchi, 2014; Hassan et al., 2015). Common methods to do this rely on statistical approaches based on condition of stationarity of the climate variables involved. Recently, methodologies based on machine learning approaches, such as data-driven models, are more commonly used (Yu et al., 2017; Rozos, 2019; Niu and Feng, 2021). Among these, Nonlinear AutoRegressive networks with eXogenous input (NARXs) are widely used for time series forecasting, since their capability in learning long-time dependences among time series and a better ability to generalize (Hadiyan et al., 2020).

On the other end, alterations in climate have further stressed the problem of water scarcity in Mediterranean area, more frequently hit by prolonged droughts and short-duration extreme precipitation (Forestieri et al., 2018; Arnone et al., 2020; Treppiedi et al., 2021), thus making even more complex the management of water resources. In a context of probabilistic assessment of the possible climate anomalies, the use of the seasonal forecasts (SFs) data may offer a powerful tool for guiding a strategic planning of the resources across several climate-sensitive sectors (De Felice et al., 2015; Essenfelder et al., 2020; Viel et al., 2016).

This study proposes a methodology which combines a NARX model with climate SF data, with the aim to predict the water volumes stored in reservoirs at a mid-term scale (up to six months ahead in time).

The methodology is applied to four Sicilian reservoirs that experienced water scarcity in the recent past. SFs produced at the European Centre for Medium-Range Weather Forecasting are used, after a bias correction procedure, to force the NARX models. The results showed that the NARXs, when forced with bias corrected SFs, are capable to successfully predict water volumes within the reservoirs up to four months in advance. The performance of the modelling system strictly depends on: (i) the goodness of climate forecasts, which in turn depends on the month of release and the timeframe of the prediction, and (ii) the strength of the autocorrelation for the water volumes.

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