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A neural network approach to estimate water-column nutrient concentrations and carbonate system parameters in the Mediterranean Sea: CANYON-MED

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The semi-enclosed nature of the Mediterranean Sea, together with its small inertia which is due to the relatively short residence time of its water masses, make it highly reactive to external forcings and anthropogenic pressure. In this context, several rapid changes have been observed in physical and biogeochemical processes in recent decades, partly masked by episodic events and high regional variability. To better understand the underlying processes driving the Mediterranean evolution and in order to anticipate changes, the measurement and integration of many climatic and biogeochemical variables are mandatory.

In the context of a critically undersampled ocean, the development and intensive use of instrumented in situ autonomous platforms will allow, in the medium term, to densify the measurements of some biogeochemical variables. However, the measurements carried out by in situ autonomous platforms (e.g. profiling floats, gliders, moorings) are not exhaustive.

Recently, deep learning techniques and in particular neural networks have been developed for the global ocean. The CANYON (for Carbonate system and Nutrients concentration from hYdrological properties and Oxygen using a Neural-network) neural network-based method provides estimations of nutrients (i.e. nitrates, phosphates and silicates) and carbonate system parameters (i.e. total alkalinity, dissolved inorganic carbon, pHT, pCO_2) from systematically measured oceanographic variables such as in situ measurements of pressure, temperature, salinity, and oxygen together with geolocation and date of sampling.

However, while providing satisfactory results for the global ocean, the CANYON approach produces limited results in the Mediterranean Sea stemming from the Mediterranean Sea's specific characteristics (such as its elevated salinity). The CANYON approach has therefore been adapted to this region considered as a "miniature ocean" and a "hot-spot" of climate change. In situ measurements from 33 cruises from 1976 to 2017 have been assembled to constitute a new quality-controlled database for the training of a regional neural network.

The updated method, CANYON-MED, constitutes an improvement of the CANYON method, and satisfactory results are obtained: accuracies of 0.73, 0.043, and 0.63 μmol.kg-1 for the nitrates, phosphates and silicates concentrations respectively, and 0.014, 17 μmol.kg-1 and 12 μmol.kg-1 for pHT, total alkalinity and dissolved organic carbon respectively.

CANYON-MED will generate "virtual" data of parameters not yet measured by autonomous platforms. Applied to the large and growing network of autonomous platforms, CANYON-MED could be used to increase the amount of biogeochemical data in the Mediterranean Sea and fill the gaps in time-series, dramatically improving our understanding of nutrients, pH and pCO_2 variability of the basin.