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New insights into nutrients dynamics and the carbonate system using a neural network approach in the Mediterranean Sea

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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, anticipate changes, the measurement, and integration of many biogeochemical variables are mandatory.

The development of new BGC sensors implemented on *in situ* autonomous platforms allows to increase the acquisition of essential 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. The CANYON-MED (for Carbonate system and Nutrients concentration from hYdrological properties and Oxygen using a Neural-network in the MEDiterranean Sea) neural network-based method provides estimations of nutrients (i.e. nitrates, phosphates, and silicates) and carbonate system variables (i.e. total alkalinity, dissolved inorganic carbon, pH_T) from systematically measured oceanographic variables such as in situ measurements of pressure, temperature, salinity, and oxygen together with geolocation and date of sampling.

This regional approach, therefore, using quality-controlled in situ measurements from more than 35 cruises. CANYON-MED obtains satisfactory results: accuracies of 0.73, 0.045, and 0.70 $\mu mol.kg^{-1}$ for the nitrates, phosphates and silicates concentrations respectively, and 0.016, 11 $\mu mol.kg^{-1}$ and 10 $\mu mol.kg^{-1}$ for pH_T, total alkalinity and dissolved organic carbon respectively. CANYON-MED thus generates "virtual" data of parameters not yet measured by autonomous platforms, while ably reproducing the data already sampled, emphasizing its ability to fill the gaps in time-series.

Hence, by applying it to the large and growing network of autonomous platforms in the Mediterranean Sea, this method allows us to gain new insights into nutrients and carbonate system dynamics in targeted areas. In particular, in the northwestern Mediterranean Sea, the impact of deep convection on biogeochemistry (e.g., nutrient replenishment and pH_T variability) is highly variable over time and poorly covered by observing networks. In this case, CANYON-MED would improve our observations and understanding of the dynamic and coupled system.

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