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Circulation patterns in northwest mediterranean harbours based on their geometric characteristics.

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This paper analyses the summer water circulation in Barcelona, Tarragona and Castellón harbours (east and north-east of Spain), based on field data acquired between April and September 2019. These data include information of wind, waves, 1DV currents, temperature and salinity parameters. The research characterizes the hydrodynamics at the mouth of each harbour and allows to estimate circulation patterns according to its physical characteristics. The availability of simultaneous data on the three harbours allows to analyse and study possible differences. The results show a two-layer circulation in all the harbours. In the cases of Tarragona and Castellón, both with a single mouth, the surface layer flows out of the harbour and the bottom currents circulate inwards. This pattern is reversed in the Barcelona harbour, which has two mouths and is more influenced by the local winds, affecting the distribution of currents in the water column. The bottom water temperature reveals significative differences between the three harbours, especially during the first half of the summer. The results suggest that sea level effects and the water exchange between the harbour and open-sea strongly determine the bottom water temperature. Nevertheless, the sea level series are different in the three harbours. In Barcelona and Tarragona, the meteorological tides are more affected by the atmospheric pressure changes; however, in the case of Castellón, which is smaller, the main influence is associated with the wind, which displaces water and causes a convergence when finding land that results in an increase in sea level. Therefore, the results reveal the importance of knowing the dimensions and morphology of each harbour to describe correctly its hydrodynamics because, despite being under comparable climatic conditions due to their geographical proximity, different hydrodynamic responses are observed to similar atmospheric forcings. The low intensities of the currents and the geometric complexity of the harbour domains, compared to open waters, imply that operational forecasting in these domains can present considerable uncertainties if they are not combined with field data.