Lagrangian particle tracking for the assessment of the flushing efficiency of harbor structures: the case of the Port of the Bay of Algeciras, Strait of Gibraltar

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The Bay of Algeciras, an inlet of about 9 x 11 km located at the eastern margin of the Strait of Gibraltar, opens to the south, where the Atlantic jet leaves the Strait and starts spreading into the Alboran Sea. In its western side, the Bay hosts one of the main ports in Europe, neuralgic base of the major traffic load from Europe to Africa and from Europa to the rest of the oversea countries. The massive transport of liquid and solid bulk or bunkering activity, daily carried out in the Bay, combined with the harsh weather conditions that often lash the zone, give the ideal scenario for an incipient ecological disaster. This high environmental risk motivates the interest for a deeper understanding of the small scale dynamics of the Bay and the role played by the port structures in case of oil spill or other surface contaminations. A series of Lagrangian particles tracking (LPT) experiments were carried out to investigate the flushing patterns of the Bay and 8 different docks inside the local port, under a representative variety of external conditions, such as tide phase and strength, and winds. A 2D LPT algorithm has been adapted to fully exploit the outputs of a very high resolution (~30m) three-domain-nested hydrodynamic model, with the aim of resolving the complex circulation within the structures of the harbor. Winds are a clearly dominant factor, with westerlies featuring e-folding times one order of magnitude lower than easterlies. Fortnightly tidal modulation presents a counter-intuitive effect, with spring tides that, despite promoting higher ventilation in a first instance, end up providing higher accumulation of particles inside the docks and higher e-folding times than neap tides. Tide phase affects the current direction at the entrance of the docks during the first few hours of simulation and its effect is progressively masked throughout the experiment. In the 45% of the experiments, a significant quantity of particles flow out to the Alboran Sea (55% in the whole Bay experiment), confirming the importance of the Bay on the exportation of pollutant/properties to the nearby basin.