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Influence of waves on the three-dimensional distribution of plastic in the ocean

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The world's oceans are confronted with plastic pollution, 80% of which is of terrestrial origin, flowing mainly from the mismanaged waste of coastal populations and to a less extent, from river discharge. To study the fate of this pollution, we follow the trajectories of neutral plastic particles released continuously in numerical ocean simulations with two realistic source scenarios defined according to poorly managed waste from coastal populations and river discharge. The trajectories are three-dimensional and calculated for a period of 24 years by the Ariane Lagrangian tool from ocean currents simulated by a ¼° global ocean general circulation model (NEMO). The important particularity of the present model is that it is coupled with the WaveWatch III (WW3) wave model and consequently represents the Stokes drift in a consistent manner. The results are compared to trajectories calculated with an uncoupled NEMO simulation in which the Stokes drift is simply not considered. The results show that microplastics (as neutral particles) accumulate at the surface in the subtropical convergence zones of the Ekman transport before penetrating to depth and being strongly dispersed around 200 to 300 m depth over 40 degrees of latitude. At the end of the simulation, about 5.3% of the microplastics remains at the surface in these convergence zones and near the emission regions for the wave-coupled model, whereas only 2% remains for the uncoupled model. Our results indicate that waves may increase the retention of neutral plastic particles at the surface by a factor of two to three because of the upward vertical velocities induced by the divergence of Stokes transport in the surface layers. Plastic surface concentrations are maximal in the North Pacific and Indian Ocean basins. This result is due to the large discharge fluxes surrounding these basins of the northern hemisphere. The Mediterranean Sea exhibits also highly concentrations in microplastics due to high coastal population densities. This work shows the strong influence of waves (and Stokes drift) on the transport of plastic particles in the oceans, both on the retention of particles at the surface, the importance and location of convergence zones, and on the dispersion of neutral plastics at depth.