Three-dimensional dispersion of neutral "plastic" particles in a global ocean model

Thierry Huck*[1], Raphaël Bajon , Nicolas Grima , Esther Portela , Jean-Marc Molines[2], and Thierry Penduff

[1]Laboratoire d'Océanographie Physique et Spatiale – Université de Bretagne Occidentale (UBO), Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), CNRS : UMR6523, Institut Universitaire Européen de la Mer (IUEM), LOPS, Université de Brest, CNRS, IFREMER, IRD – IUEM, rue Dumont d'Urville,Technopôle Brest Iroise, 29280 Plouzané, France

[2]Laboratoire de glaciologie et géophysique de l'environnement (LGGE) – CNRS : UMR5183, OSUG, INSU, Université Joseph Fourier - Grenoble I – Domaine Universitaire 54 Rue Molière - BP 96 38402 ST MARTIN D HERES CEDEX, France

Abstract

The fate of plastics entering the 3D ocean circulation from rivers discharge is examined through the Lagrangian analysis of neutrally buoyant particles. Particles are released continuously over 1991–2010 at the surface along the coasts according to monthly estimates of rivers plastic waste input. They are advected by daily currents from a state-of-the-art global ocean model at 1/12∘ resolution. At the end of the simulation (year 2010), particles remaining in the surface layer of 1 m thickness represent less than 2% of the total particles released. These are concentrated in the center of subtropical gyres, mostly in the South Indian Ocean, and the North Pacific, in relation with the large sources from Asia, and in good agreement with previous 2D numerical experiments in the surface layer. These patterns remain similar down to about 30 m depth, this upper layer strongly influenced by Ekman currents trapping about 20% of the total released particles. About 50% of the total released particles remain in the upper 100 m, and up to 90% are found in the upper 400 m at the end of the experiment. Below the mixed layer, they are more widely dispersed horizontally and follow the main global pathways of ocean ventilation of mode and deep water masses. Plastic particles, neutrally buoyant because of their small size or biofouling, are thus expected to be strongly dispersed in the global ocean thermocline following mode waters patterns, and reach the deeper layers following the North Atlantic Deep Water formation path. Two major source regions have a global impact. Particles from the western North Pacific spread over the whole Pacific Ocean poleward of 20∘S, whereas particles from Indonesia spread over the whole latitude band from 60∘S to 20∘S.

Keywords: marine debris, microplastics, nanoplastics, Lagrangian analysis, dispersion, global ocean

*Speaker