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Modeling the drift of plastics in the Adriatic Basin

Svitlana Liubartseva (1), Giovanni Coppini (2), Rita Lecci (2), and Sergio Creti (2)

(1) Centro EuroMediterraneo sui Cambiamenti Climatici, Bologna, Italy (svitlana.liubartseva@cmcc.it), (2) Centro EuroMediterraneo sui Cambiamenti Climatici, Lecce, Italy

Recently, plastic pollution at sea has become widely recognized as an acute environmental problem. Distribution of plastics in the marine environment is controlled by (1) locations and time-varying intensity of inputs; (2) the dynamics of the upper mixed layer of the ocean, where the majority of plastics float; and (3) the sinks of plastics.

In the present work, we calculate the plastic concentrations at the sea surface and fluxes onto the coastline (2009-2015) that originated from terrestrial and maritime inputs. We construct a Markov chain model based on coupling the MEDSLIK-II model (De Dominicis et al., 2013) with the daily Adriatic Forecasting System (AFS) ocean currents simulations (1/45˚ horizontal resolution) (Guarneri et al., 2010) and ECMWF surface wind analyses (0.25˚ horizontal and 6-h temporal resolutions). We assume that the coastline is the main sink of plastics in the Adriatic Sea (Liubartseva et al., 2015).

Our calculations have shown that the mean particle half-life in the basin approximately equals 43.7 days, which allows us to define the Adriatic Sea as a highly dissipative system with respect to floating plastics.

On long-term time-mean scales, the most polluted sea surface area (more than 10 g/km^2 floating plastics) is represented by an elongated band shifted to the Italian coastline and narrowed from northwest to southeast. That corresponds to the spatial distributions of plastic inputs, and indicates a tight connection with patterns of the general Adriatic circulation, including the Western Adriatic Coastal Current and the South Adriatic gyre. On seasonal time-mean scales, we indicate the winter plastics' expansion into the basin's interior, spring trapping in the northern Adriatic, summer cleansing the middle and southern Adriatic and autumn spreading into the southeastern Adriatic.

Distinctive coastal "hot spot" is found on the Po Delta coastline that receives a plastic flux of 70 kg/(km·day).

Complex source-receptor relationships among the Adriatic subregions are quantified in terms of impact matrices.

The results obtained can be used to monitor the floating debris, plan cleanups, and make policy-relevant decisions. The methodology could be further improved by including consideration of plastic particles sinking, breaking into microplastics, and being ingested by biota. Furthermore, we believe that in the future, higher resolution current data will enhance the Lagrangian representation of floating plastic transport.

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