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Inverse modelling of microplastics sources and sinks in the Mediterranean by combining observational data and high-resolution simulations

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Plastics entering the aquatic environment face a fate which is still relatively unknown: how much of it will stay afloat, how quickly will it degrade, and how much of it will end up on the beach again? Estimates of plastic inputs are orders of magnitude larger than the quantities found in the surface waters (van Sebille et al., 2015), meaning that a more thorough understanding of the fate of plastics in the oceans is of importance. In order to get a better understanding of the fate of these plastics, an inverse modelling methodology is presented here for a Lagrangian ocean model, in order to predict floating microplastic quantities in the Mediterranean. While measurements of microplastic quantities match relatively well to larger scale patterns predicted by numerical models for the oceans on a global scale, no extensive validation of a numerical model with actual measurements has been found for a smaller scale basin such as the Mediterranean. In global scale Lagrangian models, the distribution of microplastics is relatively insensitive to the initial conditions, since Ekman transport leads to particles concentrating in the ocean gyres. Modelling transient processes which likely influence microplastic concentrations, such as beaching, biofouling, degradation, and varying plastic inputs due to for example seasonal changes in river run-off, is not strictly necessary in this case to have a reasonable agreement between model and measurements. However, these processes might play a larger role in a basin such as the Mediterranean, since no persisting microplastic patches have been found here, and numerical models predict the microplastic concentrations to be highly dynamic. In this research, measurements of plastic concentrations in the Mediterranean from literature are used in an attempt to infer the behavior of these transient processes. Rudimentary models are implemented in the Lagrangian framework for beaching, fragmentation, and sinking of microplastics, defining the chances particles are removed. The parameters of the models are then found using inverse modelling techniques in accordance to the available measurements for floating microplastic concentrations. It is shown that the most optimal choice of model parameters results in a much smaller mismatch of the numerical model with respect to the measurements compared to the baseline simulation where the given processes are not taken in account.