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Lagrangian Model of a Surface Advected River Plume in Marginal and Enclosed Seas

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Freshwater discharges represent an important constituent in the mass, momentum, and vorticity budgets of the inland and enclosed seas. They are also a major pathway for nutrients and pollutants into the seas. Therefore, it is important to elaborate means for predicting the behavior of the plume under specific forcing conditions. We developed a Lagrangian particle tracking model that simulates a distribution of a surface advected river plume. The model combines deterministic and stochastic approaches for representing convection-diffusion and turbulent processes and is computationally unpretentious. Further, we applied the model to simulate the plumes at different spatial scales. The simulation results under idealized external forcing were verified against the findings from previous studies. The model runs with realistic shore lines, winds and discharge configurations for the Mzymta River plume at the eastern part of the Black Sea coast, with the area smaller than 50 km^2, as well as the extensive Ob-Yenisey plume in the Kara Sea, whose area is of order 10000 km^2. The simulated variability of the both plumes at the scales from synoptic to seasonal showed good agreement with the in-situ measurements and satellite images. Using the model, we also studied the general aspects of the plume dynamics. The dependence of the spatial extent of a plume of small size river on the wind stress and Coriollis parameter was investigated. We identified three distinctive regimes of the plume evolution depending on the wind direction with respect to the shoreline and the river mouth geometry. The dependence on the Coriollis parameter exhibited a characteristic “M-shaped” pattern indicating that under otherwise equal conditions, the plumes are best developed in the tropical regions. This dependence, however, is largely offset by a much stronger dependence on the wind stress.