Lagrangian Model of a Surface Advected River Plume
Alexander Osadchiev (osadchiev@ocean.ru) and Peter Zavialov
Shirshov Oceanology Institute, Moscow, Russia

(1) STRiPE model: Description

Equations applied to an individual particle of the plume

\[
\frac{d\mathbf{r}}{dt} = \mathbf{u} + \mathbf{F} + \mathbf{v} + \mathbf{V} + \mathbf{w}
\]

Schematic of the forces applied to an individual particle of the plume

We developed a Lagrangian model of a surface-advected river plume, and tentatively identified it as STRiPE (Surface-Trapped River Plume Evolution). The model is designed specifically for simulating river plumes under various configurations of external forcing conditions and is computationally efficient. River plume is represented as a set of particles. Every particle corresponds to a vertical column of water, and the continuous spatial-temporal distribution of the plume can be obtained by interpolation between the particles. Hence the temporal evolution of the plume structure is obtained. The particles are released from the river mouth, separated by regular time intervals, and assigned with the initial velocity depending on the discharge rate. The acceleration of a particle at every time step is computed from the momentum budget determined by the forces mentioned above, and the trajectory is simulated by the interpolation equation.

More detailed description of STRiPE, as well as some results of its application to the river plumes in selected regions, are given in [A. Osadchiev and P. Zavialov, 2013].

(2) Validation and Real-time Predictions

We applied STRiPE to simulate river plumes at different geographic settings and spatial scales. The main advantage of STRiPE is its ability to produce realistic results with very high performance computing-to-widescale usage factor. The main drawback of the model lies in the fact that it presumes negligible influence of local bathymetry on river plume dynamics (which is acceptable for surface-advected plumes spreading over steep shelf areas) and ignores any feedback from the plume onto the ambient ocean (which is acceptable for plumes of small to medium rivers). Having wind, shell circulation and river discharge as input data STRiPE can be used for real-time predictions of river plume dynamics and distribution. As an example we present the simulations results for the Mzymta River plume at the eastern part of the Russian Black Sea coast. Low computational cost of STRiPE enabled us to perform the total of more than 3000 model runs. As a result we obtained the structure of Mzymta river plume during a period of one year with 3 hour temporal resolution. The results agreed well with the in situ data and high resolution satellite imagery.

(3) Diagnostic experiments: plume area vs wind forcing

Further, using the STRiPE model, we investigated the dependence of the spatial extent of a plume of small size river on the wind forcing. Due to low computational cost of STRiPE we performed the total of 720 simulation runs, changing the wind speed (10 different wind speed values, from 0 up to 10 m/s with the increment 1 m/s) for the modeled plume area as a function of wind velocity.

(4) Conclusions

A Lagrangian particle tracking model of a surface-advected river plume (STRIPE) is developed. STRiPE is capable for realistically simulating synoptic variability of small and medium river plumes under various configurations of external forcing conditions with low computational cost. STRiPE appears to be a useful and convenient tool for investigating the general aspects of the plume dynamics. Using the model, 3 regimes of the plume evolution depending on wind direction were identified. STRiPE can be used for providing real-time predictions of river plume behavior. It can have practical applications in the context of marine pollution, as well as sediment transport and nutrient cycling in the coastal zone.