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Evaluation of Baltic Sea transport properties using particle tracking

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Particle tracking model (PTM) is an effective tool for quantifying transport properties of large water bodies such as the Baltic Sea. We have applied PTM to our fully calibrated and validated Baltic Sea 3D hydrodynamic model for a 10-years period (2000-9). One hundred particles were released at a constant rate during an initial 10-days period from all the Baltic Sea sub-basins, the major rivers, and the open boundary in the Arkona Basin. In each basin, the particles were released at two different depths corresponding to the deep water and middle water layers. The objectives of the PTM simulations were to analyse the intra-exchange processes between the Baltic Sea basins and to estimate the arrival times and the paths of particles released from the rivers. The novel contribution of this study is determining the paths and arrival times of deeper water masses rather than the surface masses.

Advective and diffusive transport processes in the Bornholm and Arkona basins are both driven by the interacting flows of the northern basins of the Baltic Sea and the North Sea. Particles released from Arkona basin flows northwards along the Stople Channel.

The Gotland basins are the major contributors to the exchange process in the Baltic Sea. We find high values of the advection ratio, indicative of a forced advective transport process. The Bay of Gdansk is probably the most vulnerable region in the Baltic Sea. This is despite the fact that the main exchanging basins are the Bornholm Sea and the Easter Gotland Basin. The main reason is the intensive supply of the particles from the northern basins that normally take about 3000 days to reach the Bay of Gdansk. The process maintains a high level of particle concentration (90%) along its coastlines even after the 10-years period.

Comparing the particle paths in the Western and Eastern Gotland basins two interesting features were found. Particles travelled in all four directions in the former basin and the middle layer particles reached the surface flow in the eastern most part of the Gulf of Finland. This implies mixing of deeper waters of the Western Gotland Basin with the sub-surface waters of the Gulf of Finland. We believe strong density current and upwelling processes drive the process.

Surprisingly, the two rivers Narva and Venta have the highest spreading in comparison to other rivers. This is despite the relatively low flow discharge values that rules out a correlation between high moment flows and the extent of spreading. We found the flow discharge to be correlated with the advection lengths. The lack of any correlation for the other rivers, signifies different hydrodynamic characteristics among the basins.

The results of our PTM study may be used for a general environmental assessment in terms of sensitivity of the various coastlines and rick to the release of contaminants in the Baltic Sea.