Geophysical Research Abstracts, Vol. 7, 00376, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00376

Particle Trajectories of Arctic Shelf Waters: the Effects of Time-dependence and Diffusion

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We have applied a time-dependent variant of a fast and accurate particle tracking technique (Döös 1995) to calculate pathways of dense Arctic shelf waters, and to asses their influence on the Arctic Ocean circulation. This technique uses stored 10-daily velocity fields from a high-resolution simulation of the OCCAM global ocean model. An expression for the random motions due to diffusive effects is derived using the theory of Brownian motion, and is chosen to match the Laplacian eddy viscosity terms in the momentum equations of the OCCAM model. The prescribed air-sea fluxes on the continental shelves help to form a large amount of dense water, which is important in driving the Arctic Ocean circulation. The formation region of the circumpolar boundary current is found in the Barents Sea, which coincides with a high pressure region due to the convergence of dense Barents Sea Water (BSW) at the St Anna Trough. The BSW is found to mainly follow topographic contours, however the trajectories are severely affected by the wind-driven Beaufort Gyre and the Trans-Polar drift. It takes approximately 30 years for the bulk of dense Barents Sea Water to reach the North Atlantic Ocean. The transport of the BSW through the Arctic can be accurately modelled using a one-dimensional advection-diffusion model, with a diffusion coefficient of 1.3 10ˆ9 cmˆ2/s and an advection coefficient of 2.9 cm/s. This suggests that the diffusion of particles is caused by basin-scale features rather than meso-scale eddies. We also compare the diffusive time-dependent technique to the original time-independent technique, which shows the latter produces unrealistic trajectories.

References:

K. Döös. Interocean exchange of water masses. Journal of Geophysical Research, 100:13499-13514. 1995.