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Downscaling Ocean Conditions: Initial Results using a Quasigeostrophic and Realistic Ocean Model

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Previous theoretical work (Henshaw et al, 2003) has shown that the small-scale modes of variability of solutions of the unforced, incompressible Navier-Stokes equation, and Burgers' equation, can be reconstructed with surprisingly high accuracy from the time history of a few of the large-scale modes. Motivated by this theoretical work we first describe a straightforward method for assimilating information on the large scales in order to recover the small scale oceanic variability. The method is based on nudging in specific wavebands and frequencies and is similar to the so-called spectral nudging method that has been used successfully for atmospheric downscaling with limited area models (e.g. von Storch et al., 2000). The validity of the method is tested using a quasigestrophic model configured to simulate a double ocean gyre separated by an unstable mid-ocean jet. It is shown that important features of the ocean circulation including the position of the meandering mid-ocean jet and associated pinch-off eddies can indeed be recovered from the time history of a small number of large-scales modes. The benefit of assimilating additional time series of observations from a limited number of locations, that alone are too sparse to significantly improve the recovery of the small scales using traditional assimilation techniques, is also demonstrated using several twin experiments. The final part of the study outlines the application of the approach using a realistic high resolution (1/36 degree) model, based on the NEMO (Nucleus for European Modelling of the Ocean) modeling framework, configured for the Scotian Shelf of the east coast of Canada. The large scale conditions used in this application are obtained from the HYCOM (HYbrid Coordinate Ocean Model) + NCODA (Navy Coupled Ocean Data Assimilation) global 1/12 degree analysis product.

Henshaw, W., Kreiss, H.-O., Ystrom, J., 2003. Numerical experiments on the interaction between the larger- and the small-scale motion of the Navier–Stokes equations. Multiscale Modeling and Simulation 1, 119–149.

von Storch, H., Langenberg, H., Feser, F., 2000. A spectral nudging technique for dynamical downscaling purposes. Monthly Weather Review 128, 3664–3673.