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Spreading of CFC-11 in the subpolar North Atlantic Ocean

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Chlorofluorocarbons (CFCs) enter the mid-depth layers of the North Atlantic Ocean from the atmosphere during the formation of dense mode water in the Labrador and Irminger Seas of the subpolar gyre. The CFC-bearing waters then spread from the convection regions through advection and diffusion of the water masses. Using recent estimates of the circulation at 1500 m depth from subsurface profiling floats the spreading of CFC-11 is simulated in the subpolar North Atlantic with an advective-diffusive model. Several numerical experiments are performed with different streamfunctions and variations in the CFC-11 sources and the diffusivity, and the results are compared to the observed CFC-11 field during 1996-1998. Poor fits are found for diffusivities less than about 500 m^2s^{-1}. Equally good fits are found for diffusivities ranging from 500–12000 m^2s^{-1}, although unrealistically smooth model solutions are produced if the diffusivity exceeds about 3000 m^2s^{-1}. Simulations that include both Labrador and Irminger Sea CFC-11 sources fit the data better than with Labrador sources alone. None of the model CFC solutions fit the data within the CFC uncertainty over the whole domain; the model performs well in the western part of the subpolar gyre, but CFC-11 concentrations are consistently too low in the West European Basin. It is possible that uncertainty in the float-based circulation can account for these misfits, and a more accurate circulation estimate might be able to fit the observed CFC-11 field. Alternatively, time variations in the flow or deep water formation processes, which clearly exist in the real ocean, may need to be included.