Overshootings and spurious oscillations caused by biharmonic mixing

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Biharmonic diffusion is often used in large scale numerical models of the ocean because of its scale selectivity. It effectively damps small scale noise and leaves the large scale dynamics rather unaffected. The biharmonic operator lacks however positiveness and monotonicity. Therefore, it can produce unphysical results exhibiting spurious overshootings and oscillations. This problematic behaviour cannot be avoided by the addition of some Laplacian diffusion. This problem appears in the solutions of both continuous and discrete equations, in bounded and unbounded domains of interest. The overshootings and oscillations are induced by the strong damping of the smaller scale modes and are, therefore, comparable to the Gibbs phenomenon. With appropriate boundary conditions, the variance of the field decreases monotonically and the oscillations are expected to remain small. However, it cannot be guaranteed that the solution will remain positive, which is a serious drawback for tracer studies.