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Hydrostatic ma non troppo. Leptic expansion and Poisson solvers in thin domains[1]

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The hydrostatic approximation of internal waves fails when the horizontal scale is comparable to the local depth. The resulting dispersion opposes nonlinear steepening. Theoretical models rely on approximations to achieve physically reasonable dispersion while ocean models rely on fully nonhydrostatic equations, whose solution involves expensive Poisson solvers. We show that even within numerical models there exists a continuum between hydrostatic and fully nonhydrostatic behavior. A formal expansion of the solution of the Poisson problem can be used to explore the grey area separating hydrostatic from nonhydrostatic scales. We show that an asymptotically correct amount of dispersion can be added to internal waves without incurring the full cost of a nonhydrostatic solution. We also show that if the full nonhydostatic equations are needed, the expansion can be used in lieu of a preconditioner. Since the expansion is derived analytically for an arbitrary elliptic operator, it is independent on the particular choice of spatial discretization. It can thus be readily adapted to structured, unstructured or coordinate mapping based models.

[1]In collaboration with E. Santilli and J. Wilson, University of North Carolia-Chapel Hill.