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An efficient solution of the large aspect ratio pressure Poisson equation in unstructured global ocean models

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One of the most challenging aspects of global ocean modelling is the great variety of length scales that play a role; small scale features may have a significant impact on the global circulation. The required variability in grid resolution is made possible in unstructured grid models. The presence of various scales however has a seriously negative impact on the conditioning of the discretised system of equations, and thus on the model efficiency.

Already in structured ocean models, the large difference between horizontal and vertical length scales poses a similar problem, especially for those that take non-hydrostatic effects into account. Here the solution of a 3D pressure Poisson equation with a very large aspect ratio is a real challenge. The paper of Marshall et al. (1997) provides an efficient solution strategy that performs well across a whole range of scales, and is able to compete with the performance of shallow water models in the hydrostatic limit.

In our contribution we will demonstrate a similar strategy, developed for implementation in ICOM, the Imperial College Ocean Model, an adaptive, fully unstructured global ocean model. The approach of Marshall et al. is generalised to include more sophisticated preconditioning techniques such as hierarchical mesh methods and algebraic multigrid methods. This will enable us to achieve similar performance not only for layered (prismatic) meshes but also for fully unstructured 3D grids. Simulations with layered meshes will be presented that show very good results with the desired efficiency for nearly hydrostatic regions. Also the results for simulations with fully unstructured meshes look promising.

References

J. Marshall, C. Hill, L. Perelman, A. Adcroft, Journal of Geophysical Research vol.102, pp. 5733-5752, 1997