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Finding better numerical solutions for circulation along piecewise-constant coastlines in ocean models

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Using a 1/4° shallow water model, Adcroft & Marshall (1998) show that the solution obtained on a rotated mesh depends on the angle between the numerical grid and the physical coastline. They conclude that piecewise constant coastline exert a spurious form stress on the model boundary current.

Here, we reproduce these results and test the combination of free-slip and no-slip boundary conditions with the stress tensors' vorticity-divergence and symmetric forms. We show that, for all angles of rotation, the equilibrium solutions actually remain similar, provided that the system has numerically converged (i.e. higher resolution with physics unchanged). It appears that having at least 4 grid-points by internal radius of deformation is necessary to accurately represent flows along coastlines. Surprisingly, the symmetric tensor combined with the free-slip condition leads to dynamics that are insensitive to resolution and akin to no-slip. We argue that the way the free-slip condition is implemented with the symmetric tensor is not suitable. We propose an alternative implementation and discuss its advantages and limitations.