New momentum, stress, and transport schemes for the CICE sea ice model on a C-grid

Science

- The C-grid implementation solves for velocity on cell edges rather than corners.

- The fundamental equations are susceptible to nonphysical solutions associated with a singularity in the continuous equations and a null space in their discrete form.

Approach

- Implement and test new discretizations of the momentum and stress equations

- Adjust edge fluxes, allowing the existing incremental remapping advection scheme to be used directly

Impact

- The C-grid offers several advantages over the B-grid:
  - It can represent transport along one-grid-cell-wide channels
  - It better represents inertial-plastic compressive waves in ice
  - It allows straightforward coupling of sea ice dynamics quantities with C-grid ocean and atmospheric models

Checkerboarding Challenge
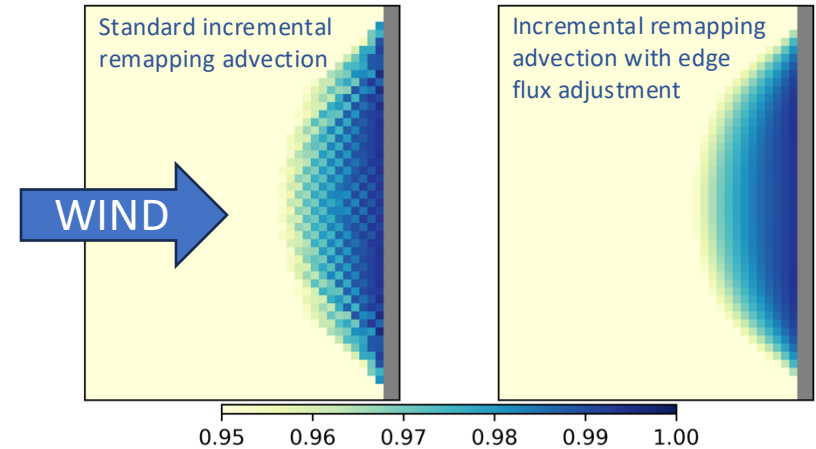
Simulated sea ice concentration field after 15 days using a C-grid illustrates the checkerboard null-space solution caused by discrete momentum-advection coupling, and the result when edge fluxes are adjusted in the incremental remapping advection scheme.

Lemieux, J.-F., Lipscomb, W. H., Craig, A., Bailey, D. A., Hunke, E. C., Blain, P., Rasmussen, T. A. S., Bentsen, M., Dupont, F., Hebert, D., and Allard, R.: CICE on a C-grid: new momentum, stress, and transport schemes for CICEv6.5, Geosci. Model Dev., 17, 6703–6724, https://doi.org/10.5194/gmd-17-6703-2024, 2024.

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