CPT: Ocean mixing processes associated with high spatial heterogeneity in sea ice and the implications for climate models
(summary of NCAR activities)

Bruce Briegleb, Marika Holland, Gokhan Danabasoglu (NCAR)

and other PIs from UAF and GFDL

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SUMMARY

- CESM uses a multi-category sea ice model which calculates multiple ice-ocean fluxes per grid cell (e.g., ice growth, melt rates, tracer fluxes)

- Currently these exchanges are aggregated across ice categories and a single flux (per field) is provided to the ocean model

- This CPT will examine how resolving the sub-grid scale heterogeneity in ice-ocean fluxes can influence tracer exchanges, ocean mixing, sea ice mass budgets, and ultimately climate

PLAN

- Implement Multi-Category Ocean Grid (MCOG) scheme in both 3D and 1D frameworks, starting with the former.

- Validate MCOG in the 1D framework using field observations.

- Conduct long runs of the 3D climate model implementation and determine influence on climate and biogeochemical feedbacks.

PRESENT STATUS

Implementation of MCOG scheme in CESM has begun. Sea-ice and ocean models as well as the flux coupler are all being modified.

- We now send all the sea ice category fractions and fluxes to POP2, in addition to the standard aggregate fluxes.

- Additionally, open ocean fluxes (i.e. absorbed shortwave flux and air-ocean stresses) are sent as well.

PRESENT STATUS

We have considered two MCOG approaches for the ocean vertical mixing:

1. Apply category bouyancy forcing column by column to KPP to determine diffusivities and viscosities. Then aggregate these over category fraction and finally evaluate tracer changes due to vertical diffusion.

1. Apply category bouyancy forcing column by column to KPP to determine tracer changes due to vertical diffusion. Finally, aggregate tracer columns over category ice fractions.

We will implement the first approach (initially), and hope to have this working by early next year.

Some initial thoughts on simplification of 3D MCOG involve experimenting on reducing the number of categories by distinguishing only open ocean and sea ice covered regions, and also thin and thick sea ice categories. MCOG effects of these reduced category numbers may be almost the same as with all categories but be more computationally efficient.

* Present Status (NCAR)

   * In CICE, following ice/ocean fluxes
     are first evaluated on a category by category basis:

       - penetrating shortwave flux
       - ice/ocean basal heat flux
       - fresh water flux from melting
       - salt flux from sea ice formation
       - ice/ocean momentum stress

   * Before exchange with ocean, these fluxes are
     aggregated over the sea ice category distribution
     weighted by the category ice fraction.

   * Additionally, the aggregate fluxes are then averaged
     with open ocean contributions (where appropriate)
     before exchange with the ocean.

   * In POP2, the averaged and aggregated fluxes are then
     applied to the boundary layer scheme (KPP) to evaluate
     column diffusivities and viscosities for vertical mixing.