CICE Consortium Progress and Plans

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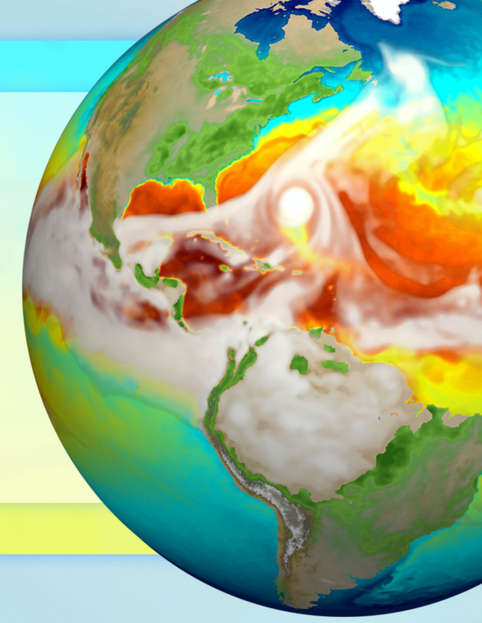


The CICE Consortium

What we do:

The CICE Consortium is a group of stakeholders and primary developers of the Los Alamos sea ice model (CICE) formed

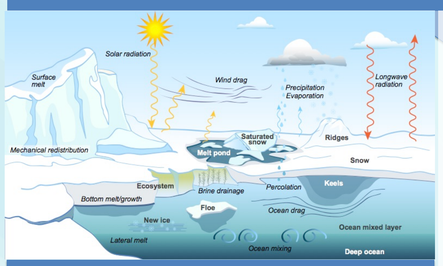
- to maintain the current CICE model for existing and new users,
- to incorporate and maintain new research and development, and
- to accelerate scientific sea ice model development and its transfer into operational use.

The CICE model was originally developed and maintained by the Department of Energy as a computationally efficient sea ice component for use in fully coupled, atmosphere-ice-ocean-land global circulation models. Over the past two decades, a broad community of climate and weather forecasting groups have adopted and enhanced the code. The CICE Consortium is recognized[10] as a vehicle for collaboration in sea ice model support and development as the community continues to use and improve sea ice models.

What we do for DOE:

Since DOE moved to the MPAS framework for the sea ice component in E3SM and is also supporting development of a new, discrete element sea ice model, the Consortium provides the sea ice column physics, now referred to as Icepack, for these DOE models. Here we provide an update of new sea ice modeling capabilities incorporated into the Consortium's CICE and Icepack repositories with particular relevance to DOE, and outline expected future developments.

Icepack, a sea-ice column-physics package



Icepack is the column physics code extracted from CICE for use in other sea ice models.

Major improvements to Icepack

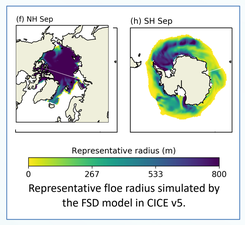
Floe size distribution with wave-ice interactions
Water isotopes
Mushy thermodynamics improvements
Improved interfaces between Icepack and host sea ice models

Coming:

- Snow model, radiation upgrades from E3SM
- Satellite emulator
- Machine learning for wave-ice interactions
- Improved radiation using MOSAiC data
- Stochastic and variational [12] mechanical redistribution schemes

Floe size distribution and wave-ice interactions [11]

For DOE's new focus on coastal regions, waves and tides are important for determining the size distribution of sea ice floes, which affects the behavior of the ice pack.



Representative floe radius simulated by the FSD model in CICE v5.

User workshop and tutorial

February 3-5, 2020, NCAR

Major recommendations:

- Develop a set of observations and metrics (international benchmarking project)
- Set up short-term, topical working groups

Areas of common interest:

- Snow, waves in sea ice, radiation effects, data assimilation, freshwater ice (lake ice, icebergs)

Longer-term physics priorities:

- Dependence of rheology on model resolution
- Validate/improve sea ice hydrology including ocean coupling
- Snow

CICE Consortium

Major community contributions

Major additions to Icepack

Floe size distribution with wave forcing [11]
Water isotopes [13]
Mushy thermodynamics improvements
Improved Icepack-host model interfaces

Major additions to CICE

Basal stress / landfast ice [14]
Vectorized EVP kernel
Implicit solver for viscous-plastic (VP) dynamics [15]
NUOPC drivers

Coming:

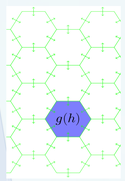
Mohr-Coulomb rheology
Landfast ice: probability based grounding, iceberg interactions
C-grid dynamical core
Debugging and improvements for OpenMP
New time manager
Metrics and scripts for comparison with obs
JRA-55 forcing data

Both Icepack and CICE

Automated testing of code [16] and documentation
CMIP6 history support [17]

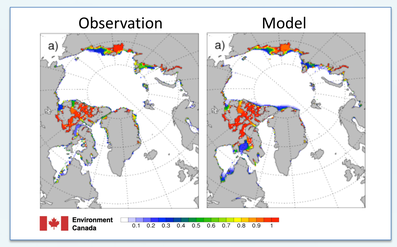
C-grid dynamical core

A C-grid option for momentum, stress and transport equations will be added to the CICE repository for NOAA/NCAR grids. LANL is considering how to do this more generally, to include MPAS meshes.



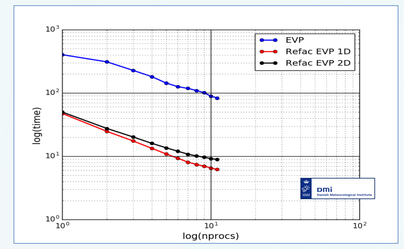
Improved landfast-ice representation [15]

Coastal research in the Arctic must account for fast ice, a new capability implemented in CICE. The parameterization causes the ice to stop moving when keels reach the sea floor.



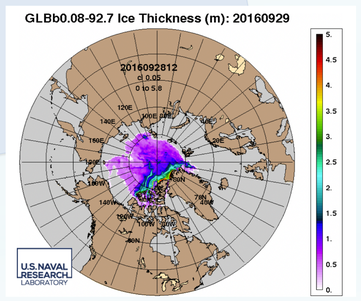
Vectorized EVP kernel

The elastic-viscous-plastic dynamics module was vectorized, enabling the entire stress calculation to be put onto a single processor (or GPU), while keeping the rest of the code parallelized using a domain decomposition. Performance improved 10X.

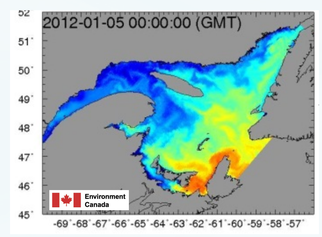


Scientific Research and Operational Applications

U.S. and international operational forecasting



U.S. Navy forecasts of ice concentration, thickness and drift are pushed daily to the U.S. National Ice Center and NOAA. NOAA uses the data for weather forecasting and to produce experimental sea ice forecasts.



Surface temperature in the Gulf of St. Lawrence. Environment and Climate Change Canada provides forecasts for North American and Arctic regions in a variety of domains and resolutions.

DMI provides in-situ observations, ice charts and remotely sensed data for users and model validation, including CICE model products (ice thickness, concentration, convergence, drift, temperature)

Should sea-ice modeling tools designed for climate research be used for short-term forecasting? [18]

Yes. Develop a community modeling framework for staged improvements:
Status quo Continue using existing models
Evolution Continue improving existing models, porting new advancements into operational modeling systems
Revolution Develop new modeling strategies such as Discrete Element Models

Acknowledgments and References

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[1] Los Alamos National Laboratory
[2] Naval Research Laboratory Stennis Space Center
[3] National Center for Atmospheric Research
[4] Environment and Climate Change Canada
[5] National Oceanic and Atmospheric Administration
[6] Institute of Oceanology, Polish Academy of Sciences
[7] Danish Meteorological Institute
[8] University of Washington
[9] NOAA Geophysical Fluid Dynamics Laboratory

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E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY