CICE
The Los Alamos Sea Ice Model
. . . a Community Ice CodE . . .

Elizabeth Hunke

Fluid Dynamics Group, Los Alamos National Laboratory
CICE (PIPS 3.0) Annual Ice Concentration

1999 - 2003 NOGAPS 3

Hourly wind and thermal forcing

Naval Research Laboratory
National Ice Center
Environment Canada
others...
Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects

Dave Bailey
National Center for Atmospheric Research
Figure 1: Sea ice topography. Throughout the melt season, the area of sea ice covered in ponds of meltwater increases. The UK National Scientific Diving Facility at SAMS conducted research in this area.

Daniela Flocco
University College London
Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects
Melt Pond Physics
Biogeochemistry

Framework is ready
Harvest data, guidance, assistance
Several groups have S and other results
Build 1st regional DMS ice model
Multielemental basis has to be strong

ON TO COLLABORATIONS
Offshore Barrow, Landfast
Water column Bering
All data courtesy Deal IARC

DMSP$_{\text{total}}$ (nmol/l)

Sea ice depth (cm)

DMSP$_{\text{total}}$ in sea ice, 2002

Clara Deal
International Arctic Research Center
Wiscombe, 1980, implying further ablation acceleration during the melt season. Fourth, spring and summer melting can... and density. We will work with Elizabeth Hunke and Bill Lipscomb to implement SNICAR into the developmental

Charlie Zender
University of California Irvine
Lars Smedsrud
Bjerknes Centre for Climate Research, Norway
Sliding Friction Rheology

The yield curve was originally adopted by Coon (1972), who considered the analogy of sea ice with a granular... the elliptic yield curve with an aspect ratio equal to 1/2 (dotted).
Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects
Biogeochemistry
Grease and Frazil Ice
Melt Pond Physics
Soot and Snow
Sliding Friction Rheology
EVP on the C-grid

\[ p = p_{\text{max}} \times \frac{\delta}{\max(\delta, \delta_{\text{min}})} \]

\[ p = p_{\text{max}} \]

Martin Losch
Alfred Wegener Institute
for MITgcm
Fig. 11. Model optimization, illustrated using one metric to gauge thickness, speed, and extent predictions, where $\alpha = 0.56$. Red lines: $h_{\text{mod}} - h_{\text{obs}}$ (m); contour interval: 0.2 m; green lines: $\nu_{\text{mod}} - \nu_{\text{obs}}$ (cm s$^{-1}$); contour interval: 0.2 cm s$^{-1}$; blue lines: RMSD $\text{sep}$ ($10^6$ km$^2$); contour interval: 0.02 $\times 10^6$ km$^2$. Optimal values are indicated with bold lines. The + symbol marks the optimized model run and the × symbol marks the standard model run. We also indicate parameter values used in previous studies that use the same air drag and ice strength parameterizations: ≃, Hibler (1979); ≅, Holland et al. (1993); !, Hibler and Walsh (1982); *, Harder and Fischer (1999). Note, however, that the albedo parameterizations and values used in these studies differ.
Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects
Biogeochemistry
Grease and Frazil Ice
Parameter Optimization
Inverse Modeling

Total hemispheric ice volume sensitivity

Jong Kim
Argonne National Laboratory
Operational Forecasting/Data Assimilation
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EVP on the C-grid
Computational Efficiency

March 16, 2007
Software Engineering Working Group Meeting

Small domains @ high latitudes
Large domains @ low latitudes

John Dennis
National Center for Atmospheric Research
CICE User Community

United States
Argonne National Laboratory
Colorado State University
Columbia University
Geophysical Fluid Dynamics Laboratory
Jet Propulsion Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Massachusetts Institute of Technology
National Center for Atmospheric Research
Naval Postgraduate School
Naval Research Lab, Stennis Space Center
NASA Goddard Institute for Space Studies
New York University
Old Dominion University
University of Alaska, Fairbanks
University of California, Los Angeles
University of California, San Diego
University of California, Santa Cruz
University of Colorado, Boulder
University of Illinois at Urbana-Champaign
University of Miami
U.S. Army Cold Reg. Res. and Engineer. Lab

International
Alfred Wegener Institute, Germany
Allahabad University/CSIR, India
Bjerknes Centre for Clim. Res., Norway
British Antarctic Survey
CRIEPI, Japan
CSIRO, Victoria, Australia
Dalhousie University, N. S., Canada
Danish Meteorological Institute
Environment Canada
Hadley Centre, UK Met Office
Institut Maurice-Lamontagne, Canada
Institute of Ocean Sciences, B. C., Canada
Inst. of Ocean., Polish Academy of Sciences
NERSC, Norway
Norwegian Meteorological Office
Proudman Oceanographic Laboratory, UK
Université Catholique de Louvain, Belgium
Southampton Oceanography Centre, UK
Swedish Meteorolog. and Hydrolog. Institute
Université Laval, Quebec, Canada
University College London, UK
University of Reading, UK
University of Tasmania, Australia
University of Tokyo, Japan
University of Victoria, B. C., Canada
CICE

version 3.14

- Energy conserving, multi-layer thermodynamics
- Ice thickness distribution with 5 categories and open water
- Variables/tracers (for each thickness category):
  - Ice area fraction
  - Ice/snow volume in each vertical layer
  - Ice/snow energy in each vertical layer
  - Surface temperature
- Elastic-viscous-plastic (EVP) dynamics
- Incremental remapping advection
- Energy-based, multi-category ridging and ice strength
- Nonuniform, curvilinear, logically rectangular grids
- Fortran 90
- Parallelization via the Message Passing Interface (MPI)
- NetCDF or binary input/output
- Users in 12 countries, dozens of institutions

version 4.0

- Multi-layer snow
- Multiple-scattering radiation
- Ice age
- Melt ponds
- Algal ecosystem
- Tripole grids
- Regional configuration
- Cache-based decomposition
- More coupling/forcing options
- Available to collaborators through subversion repository
CICE Plans

- New/improved parameterizations from users
- Improved snow physics aging, densification
- Accelerated melting/weakening biology, soot, etc.
temperature change ridge disintegration
- Alternative dynamics schemes e.g., elastic-decohesive model
- Geodesic infrastructure
- Hydrology prognostic salinity percolation flushing, flooding, etc.
- Biogeochemistry

Requests from Users

- Fast ice
- Univ. College London rheologies (directional leads)
- Air and ocean drag as $F(\text{ridges})$
- Updated frazil/new ice parameterization
- Tidal effects