**Los Alamos**
NATIONAL LABORATORY

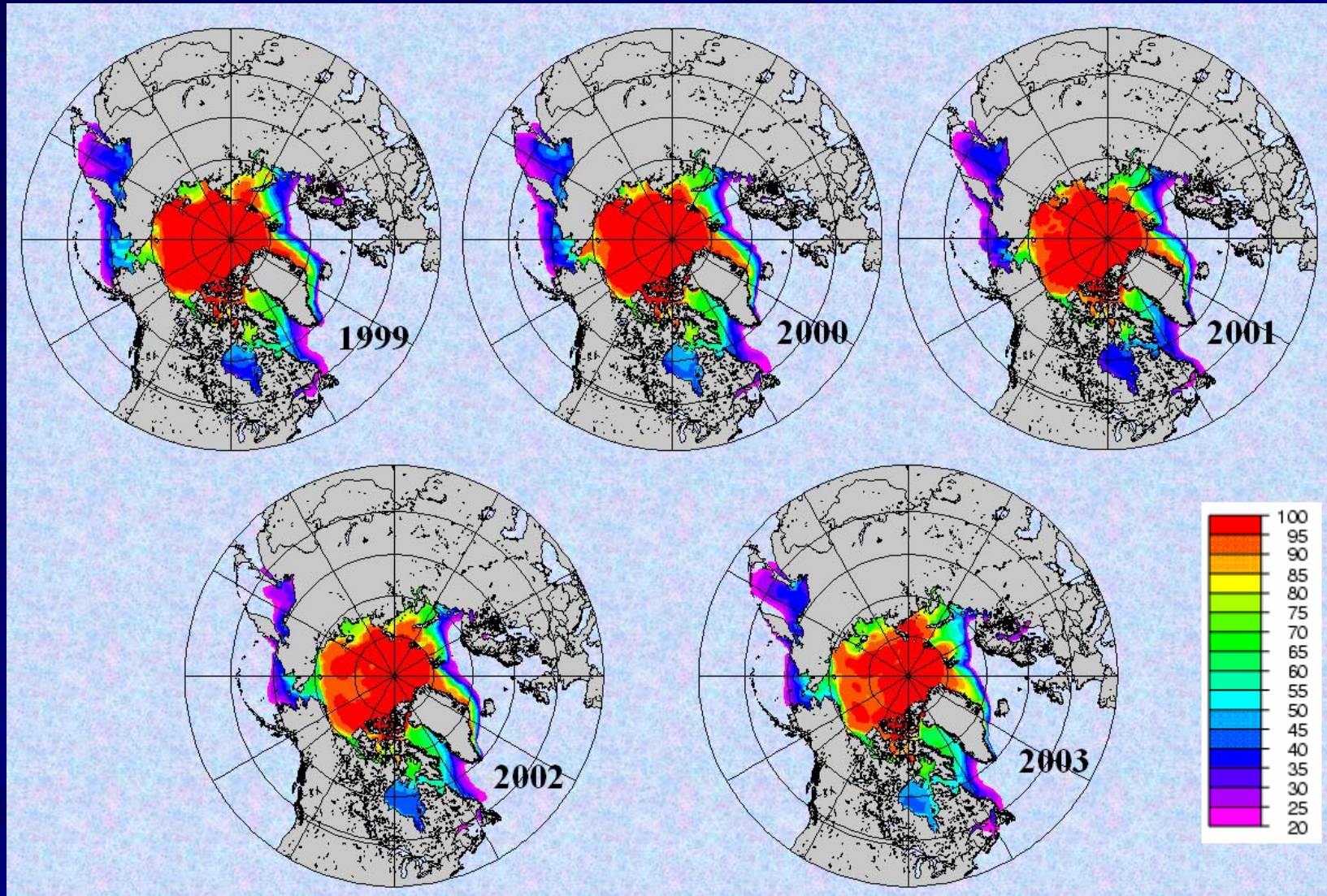CLIMATE, OCEAN AND SEA ICE MODELING PROGRAM

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

Elizabeth Hunke

Fluid Dynamics Group, Los Alamos National Laboratory

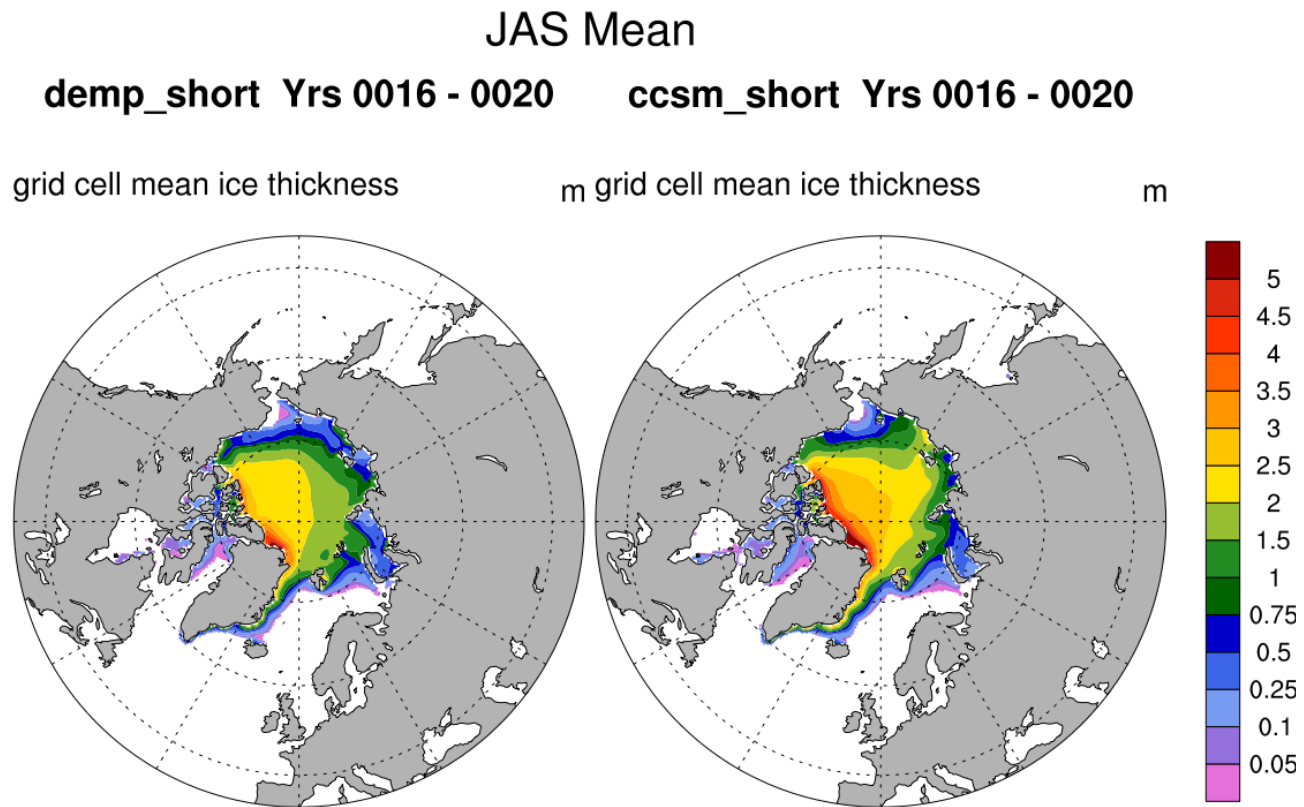# CICE (PIPS 3.0) Annual Ice Concentration



Naval Research Laboratory
National Ice Center
Environment Canada
others...

# Operational Forecasting/Data Assimilation
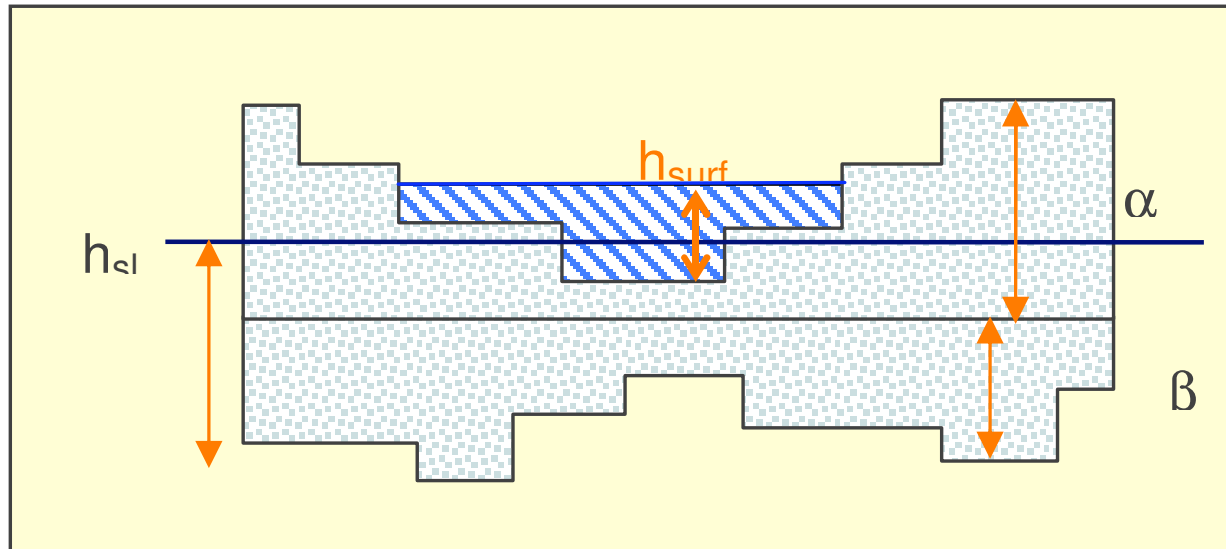## Delta-Eddington Radiative Transfer
## Melt Pond Albedo Effects



JAS Mean

**demp_short  Yrs 0016 - 0020**     **ccsm_short  Yrs 0016 - 0020**

grid cell mean ice thickness          grid cell mean ice thickness

Dave Bailey
National Center for Atmospheric Research

# Melt Pond Physics

Daniela Flocco
University College London

Clara Deal
International Arctic Research Center

Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects          Melt Pond Physics
Biogeochemistry                    Soot and Snow



1998−2001_JJA_cnt2 BC Snow Forcing.

W/m2

1.2
1.0
0.7
0.4
0.1
−0.1
−0.4
−0.7
−1.0
−1.2

Charlie Zender
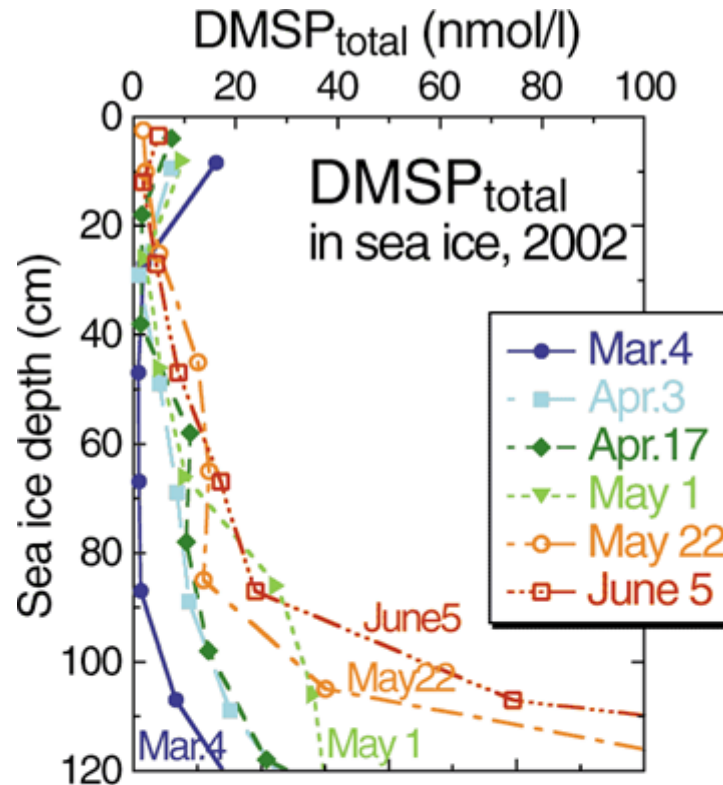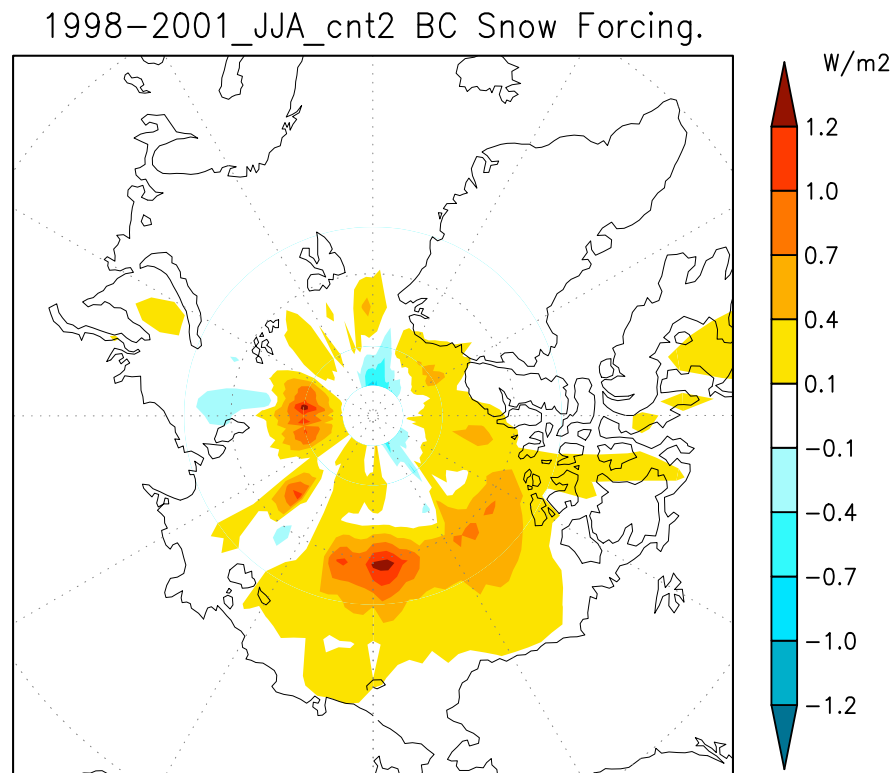University of California Irvine

Operational Forecasting/Data Assimilation
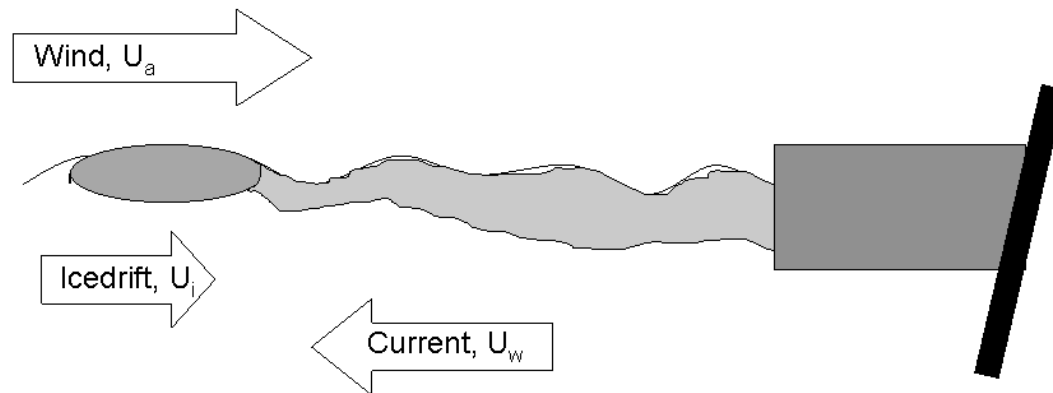Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects            Melt Pond Physics
Biogeochemistry                         Soot and Snow
Grease and Frazil Ice



Lars Smedsrud
Bjerknes Centre for Climate Research, Norway

Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
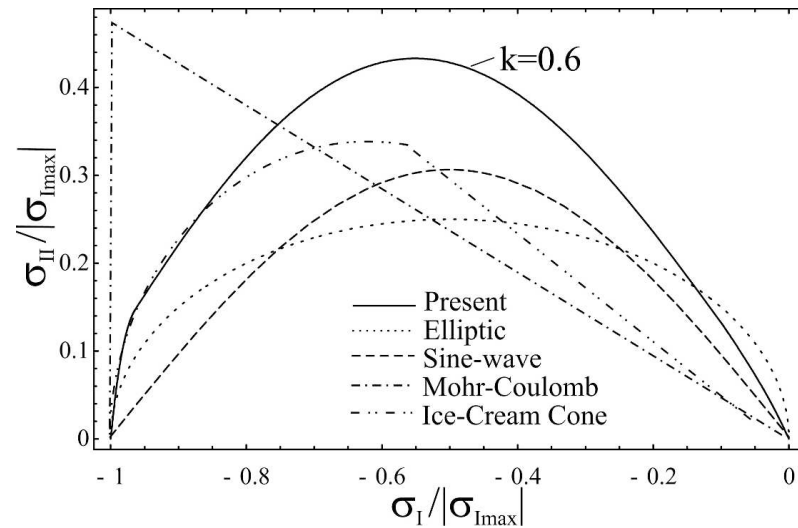Melt Pond Albedo Effects                    Melt Pond Physics
Biogeochemistry                                    Soot and Snow
Grease and Frazil Ice       Sliding Friction Rheology
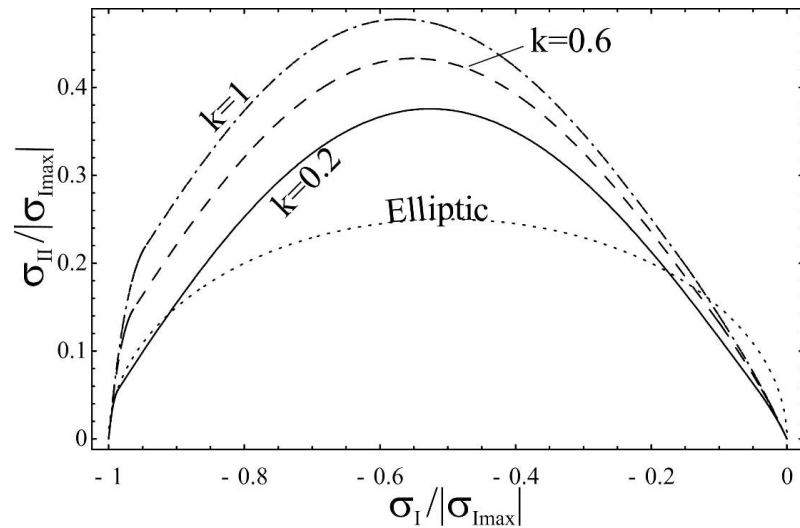


Alexander Wilchinsky
University College London

Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects                Melt Pond Physics
Biogeochemistry                                    Soot and Snow
Grease and Frazil Ice            Sliding Friction Rheology
                                                EVP on the C-grid



Martin Losch
Alfred Wegener Institute
for MITgcm

Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects          Melt Pond Physics
Biogeochemistry                          Soot and Snow
Grease and Frazil Ice          Sliding Friction Rheology
Parameter Optimization          EVP on the C-grid
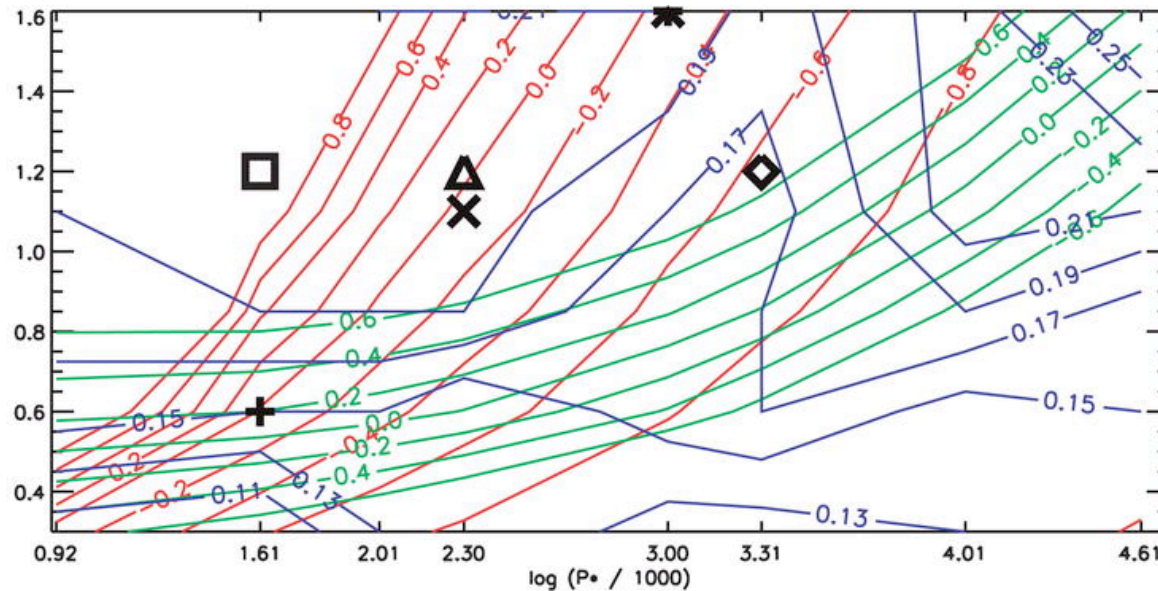


Paul Miller
University College London

Operational Forecasting/Data Assimilation
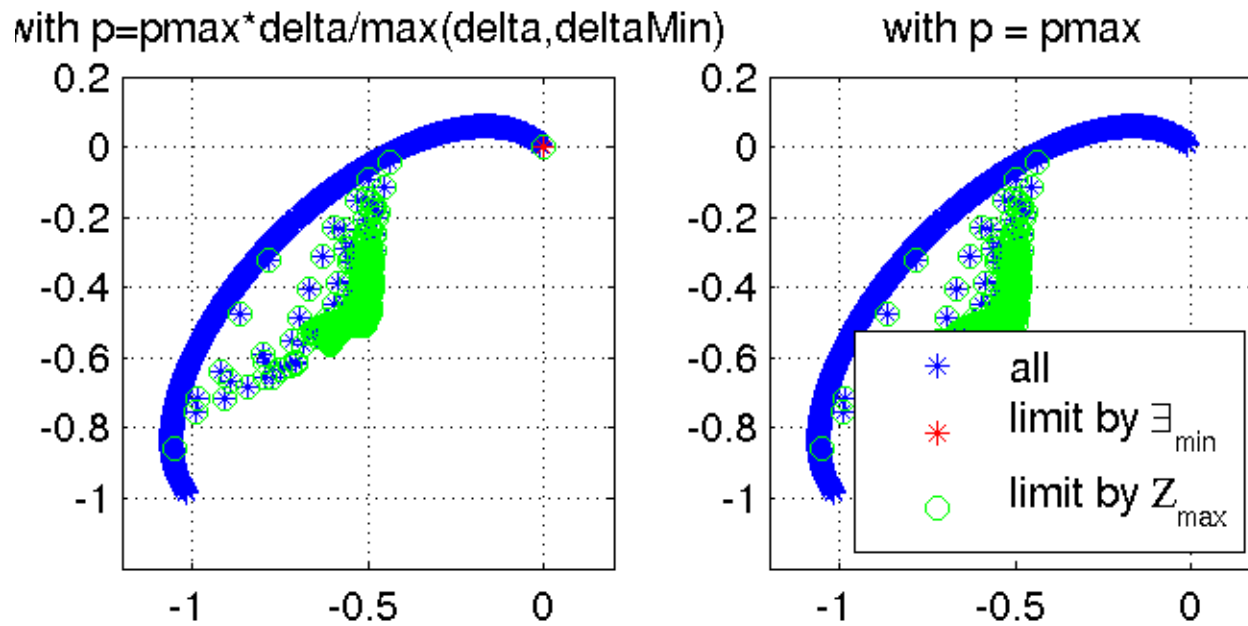Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects          Melt Pond Physics
Biogeochemistry                          Soot and Snow
Grease and Frazil Ice          Sliding Friction Rheology
Parameter Optimization            EVP on the C-grid
Inverse Modeling



Northern Hemisphere

Jong Kim
Argonne National Laboratory

Operational Forecasting/Data Assimilation
Delta-Eddington Radiative Transfer
Melt Pond Albedo Effects          Melt Pond Physics
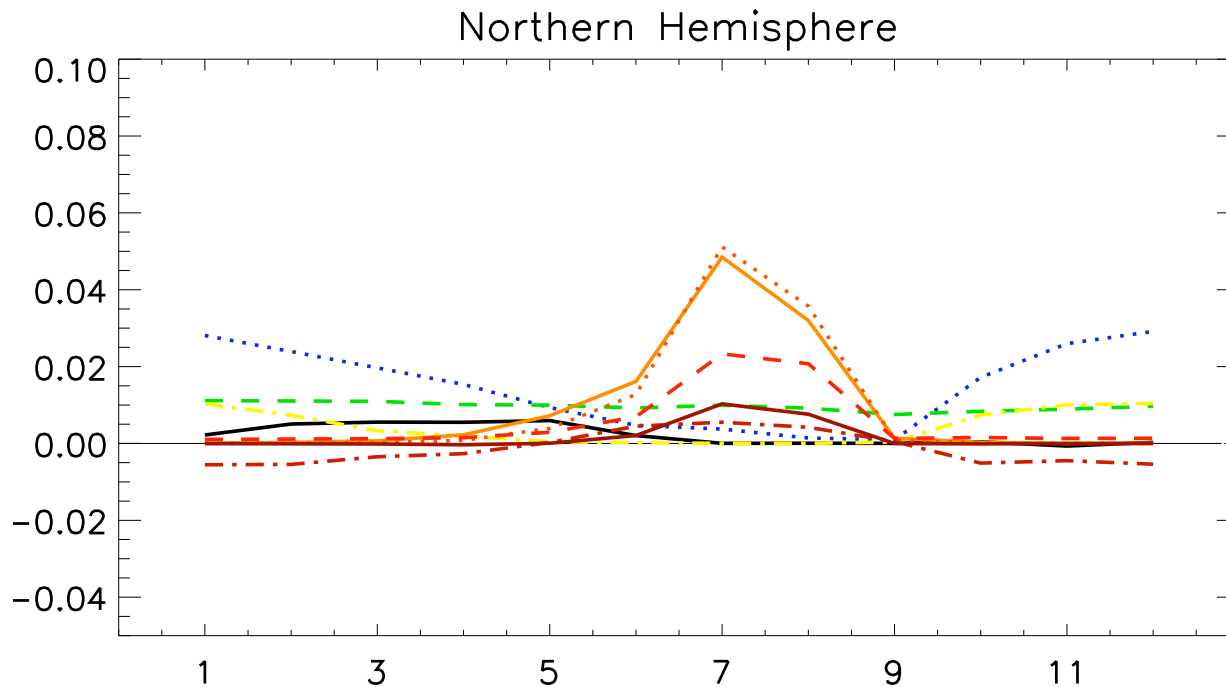Biogeochemistry                            Soot and Snow
Grease and Frazil Ice          Sliding Friction Rheology
Parameter Optimization              EVP on the C-grid
Inverse Modeling          **Computational Efficiency**



Large domains @ low latitudes

Small domains @ high latitudes

March 16, 2007          Software Engineering          king Group Meeting          33
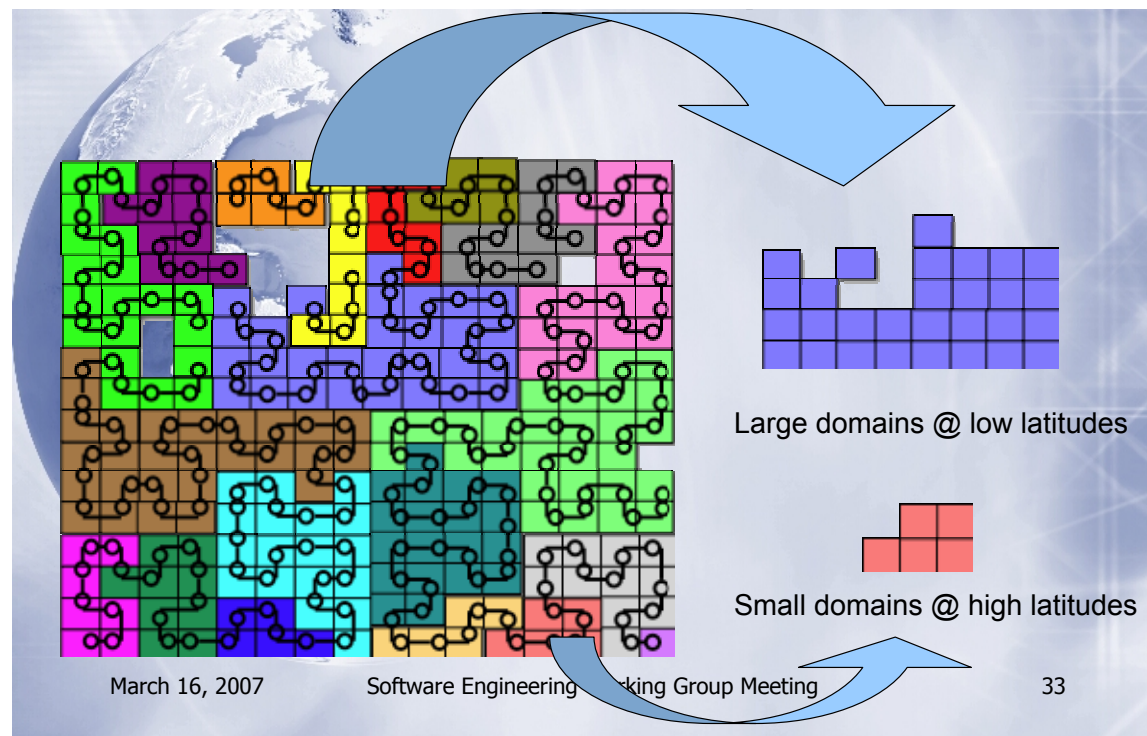
John Dennis
National Center for Atmospheric Research

# CICE User Community

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 | version 4.0 |
| --- | --- |
| energy conserving, multi-layer thermodynamics | multi-layer snow |
| ice thickness distribution with 5 categories and open water | multiple-scattering radiation |
| variables/tracers (for each thickness category): | |
|      ice area fraction | ice age |
|      ice/snow volume in each vertical layer | melt ponds |
|      ice/snow energy in each vertical layer | algal ecosystem |
|      surface temperature | |
| elastic-viscous-plastic (EVP) dynamics | |
| incremental remapping advection | |
| energy-based, multi-category ridging and ice strength | |
| nonuniform, curvilinear, logically rectangular grids | tripole grids |
| Fortran 90 | regional configuration |
| parallelization via the Message Passing Interface (MPI) | cache-based decomposition |
| netCDF or binary input/output | more coupling/forcing options |
| users in 12 countries, dozens of institutions | 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 $F$(ridges)
- Updated frazil/new ice parameterization
- Tidal effects

# Questions?