CLIMATE, OCEAN AND SEA ICE MODELING PROGRAM

Update on CICE activities

Elizabeth Hunke

October 30, 2009

Outline

Outline

CICE 3.14
August 2006

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

Fortran 90
nonuniform, curvilinear, logically rectangular grids
parallelization via the Message Passing Interface (MPI)

netCDF or binary input/output

users in many countries, dozens of institutions

CICE 4.0
August 2008

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	
surface temperature	
elastic-viscous-plastic (EVP) dynamics	
incremental remapping advection	
energy-based, multi-category ridging and ice strength	
Fortran 90	tripole grids
nonuniform, curvilinear, logically rectangular grids	regional configuration
parallelization via the Message Passing Interface (MPI)	cache-based decomposition
netCDF or binary input/output	more coupling/forcing options
users in many countries, dozens of institutions	available to collaborators through subversion repository

CICE
October 2009

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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	icebergs
	3D salinity
elastic-viscous-plastic (EVP) dynamics	
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Fortran 90	tripole grids
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parallelization via the Message Passing Interface (MPI)	cache-based decomposition
netCDF or binary input/output	more coupling/forcing options
	multi-frequency history output
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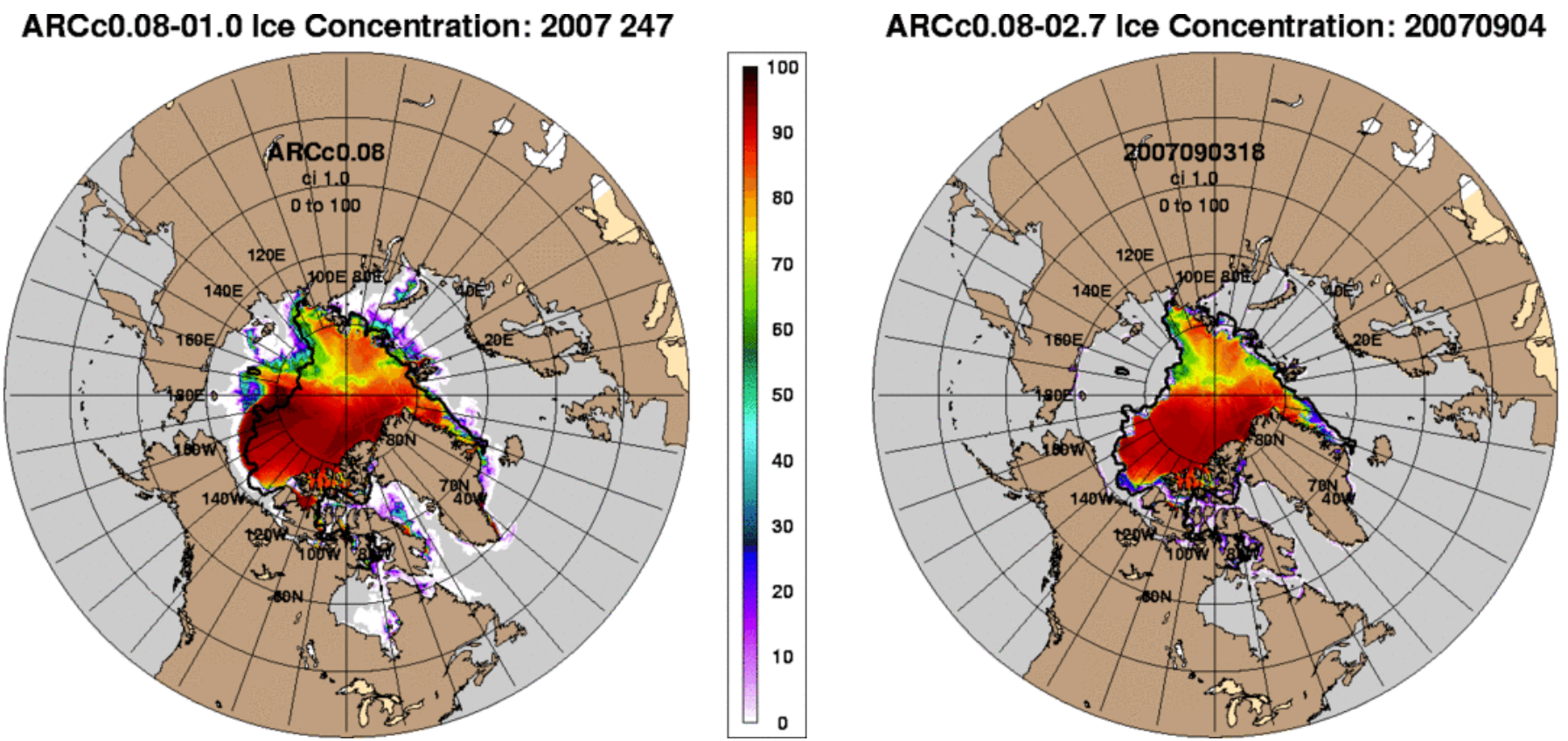
CICE wiki: http://oceans11.lanl.gov/trac/CICE

Outline

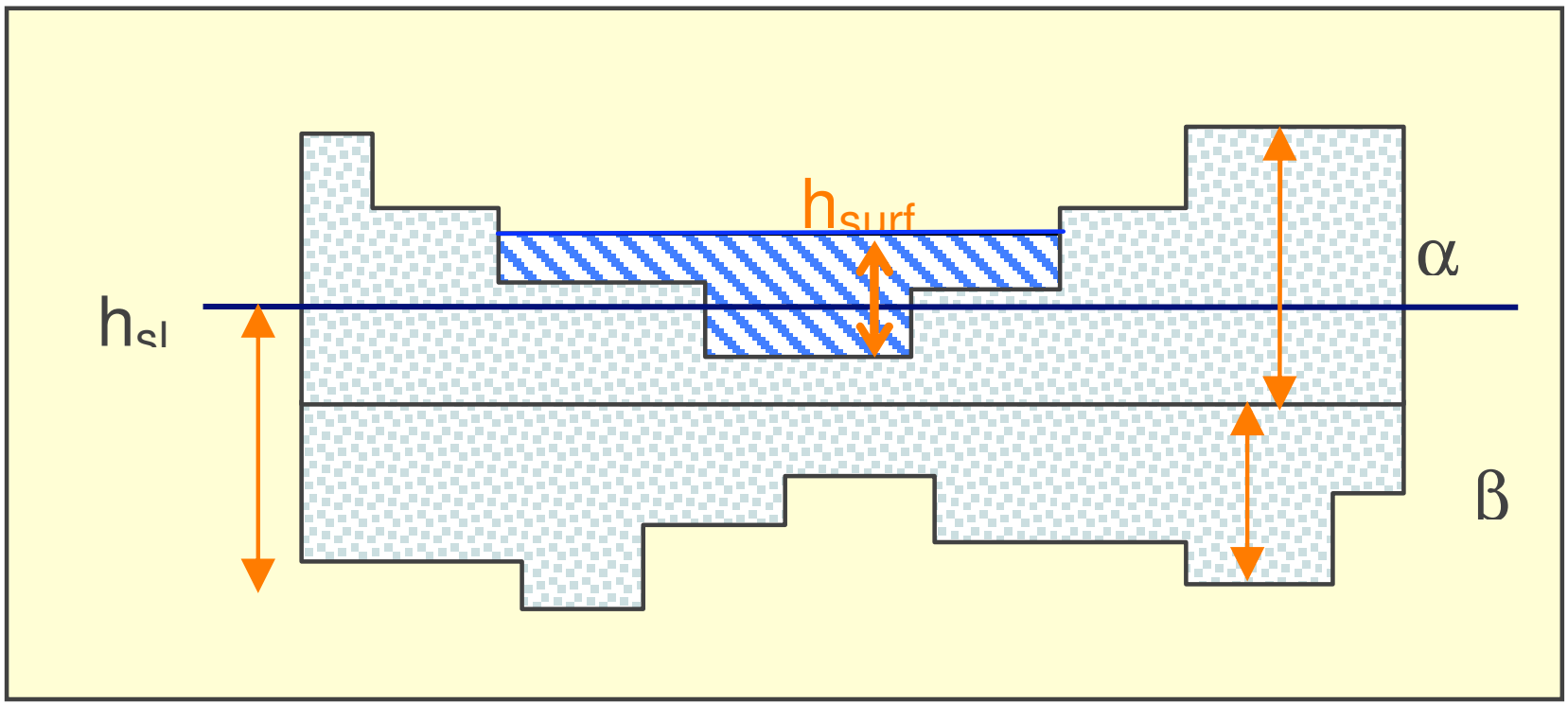
Operational Forecasting/Data Assimilation

Naval Research Laboratory



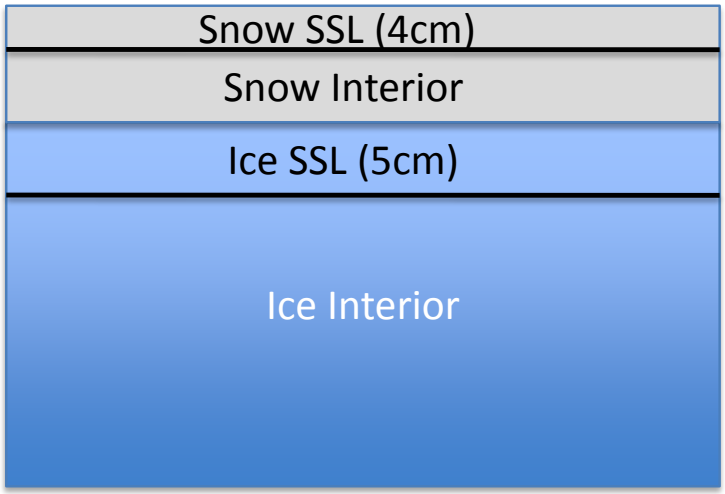
Melt Pond Physics

University College London



Aerosol Deposition and Cycling

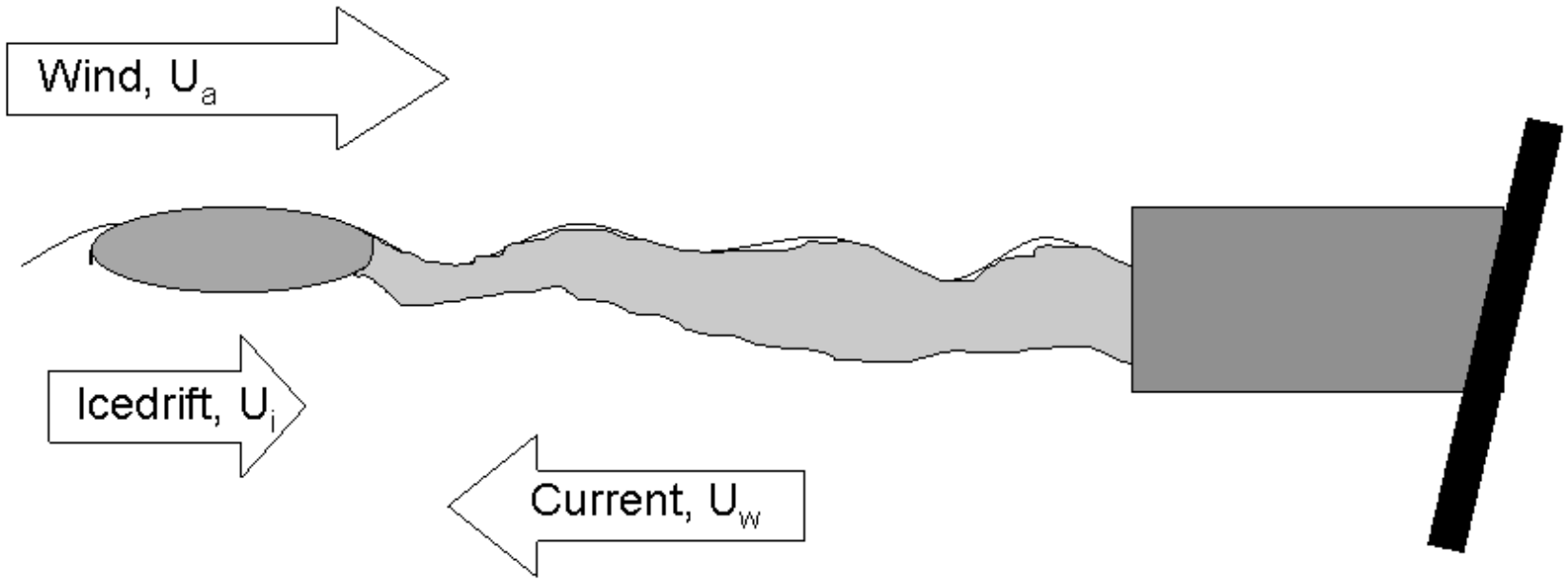
National Center for Atmospheric Research



- Four aerosol reservoirs in the vertical
- Aerosol cycling due to ice transport, vertical melt/growth
- Melt water scavenging
- Six aerosols – 2 black carbon (hydrophilic/phobic), 4 dust
- Currently affects radiative transfer

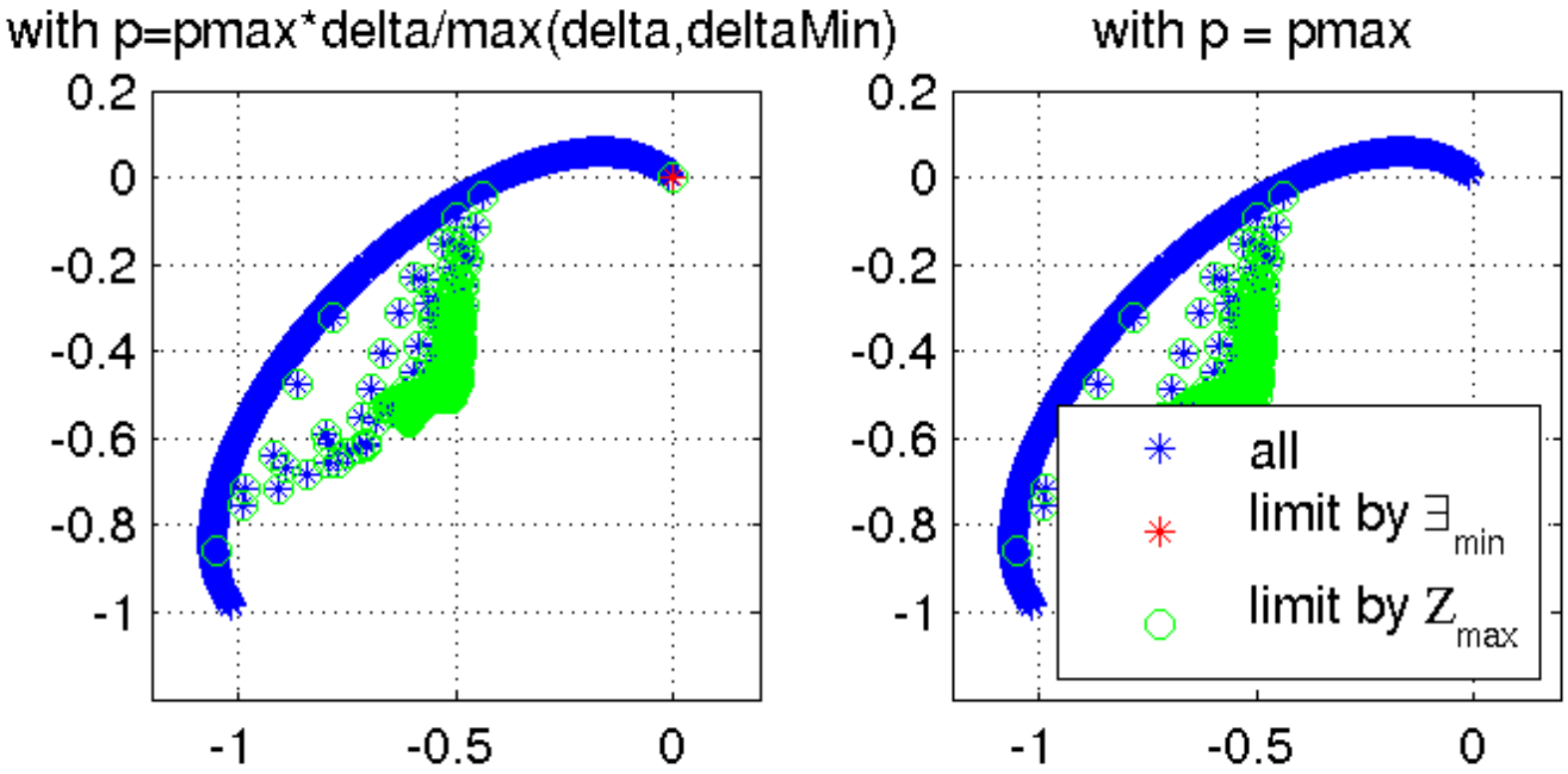
Grease and Frazil Ice

Bjerknes Centre for Climate Research, Norway



EVP on the C-grid

Alfred Wegener Institute for MITgcm

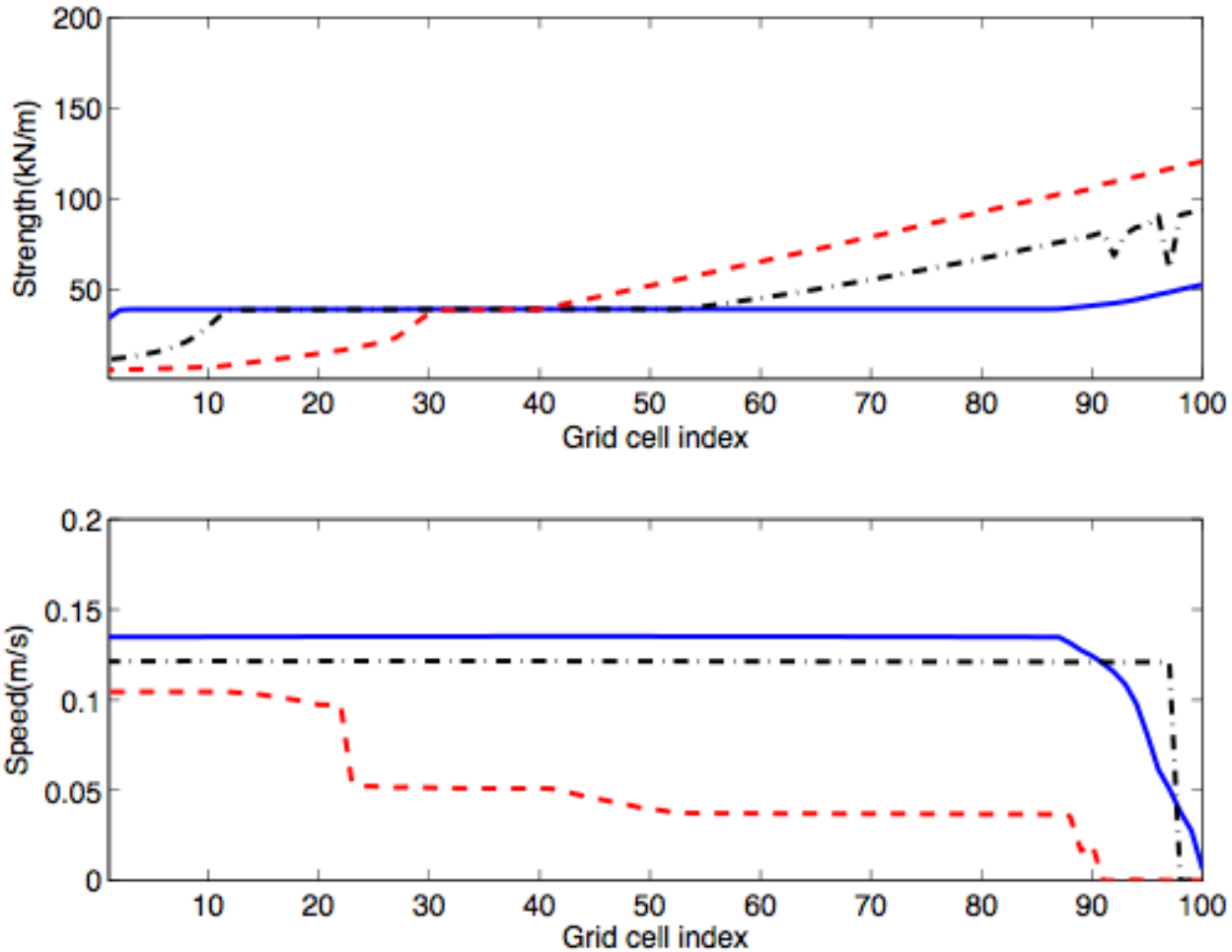


Tripole T-fold Option

U.K. Hadley Centre/University of Reading

CICE on an Unstructured Grid

University of Massachusetts



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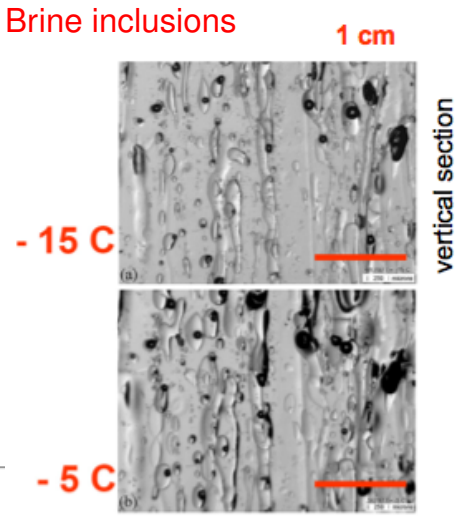
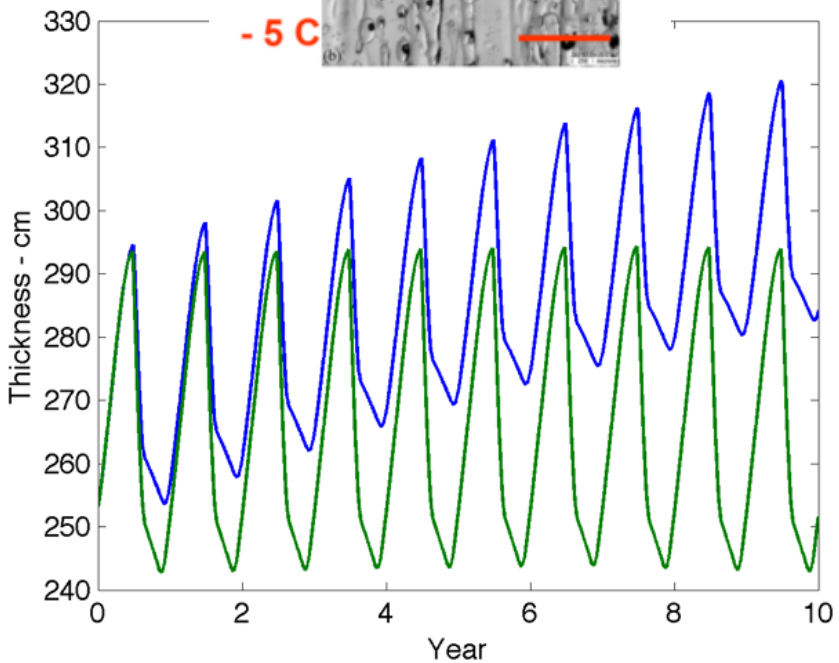
Prognostic salinity



Green:
Well flushed
Ice bulk salinity
Currently
in CCSM

Blue:
Late spring
C-shaped
Bulk Salinity



- Cecilia Bitz

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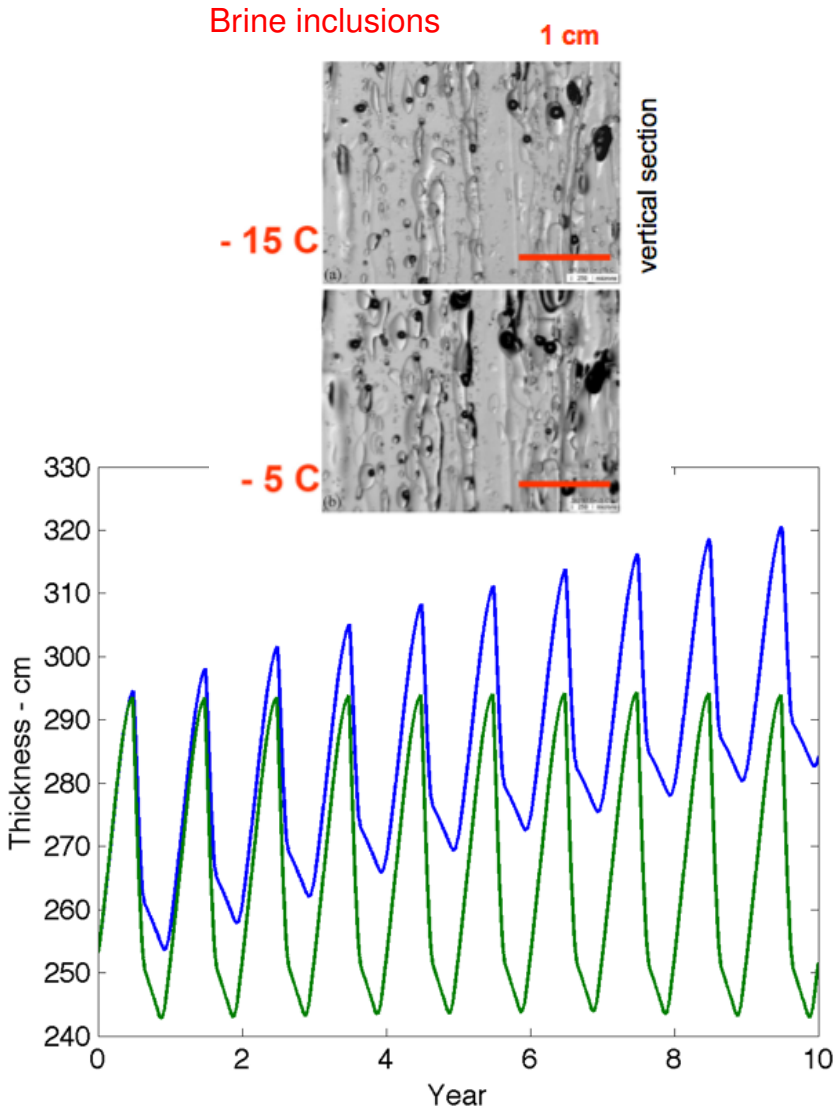

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  University of Washington

- Adrian Turner

  University College London (now)

  LANL (Jan 2010)

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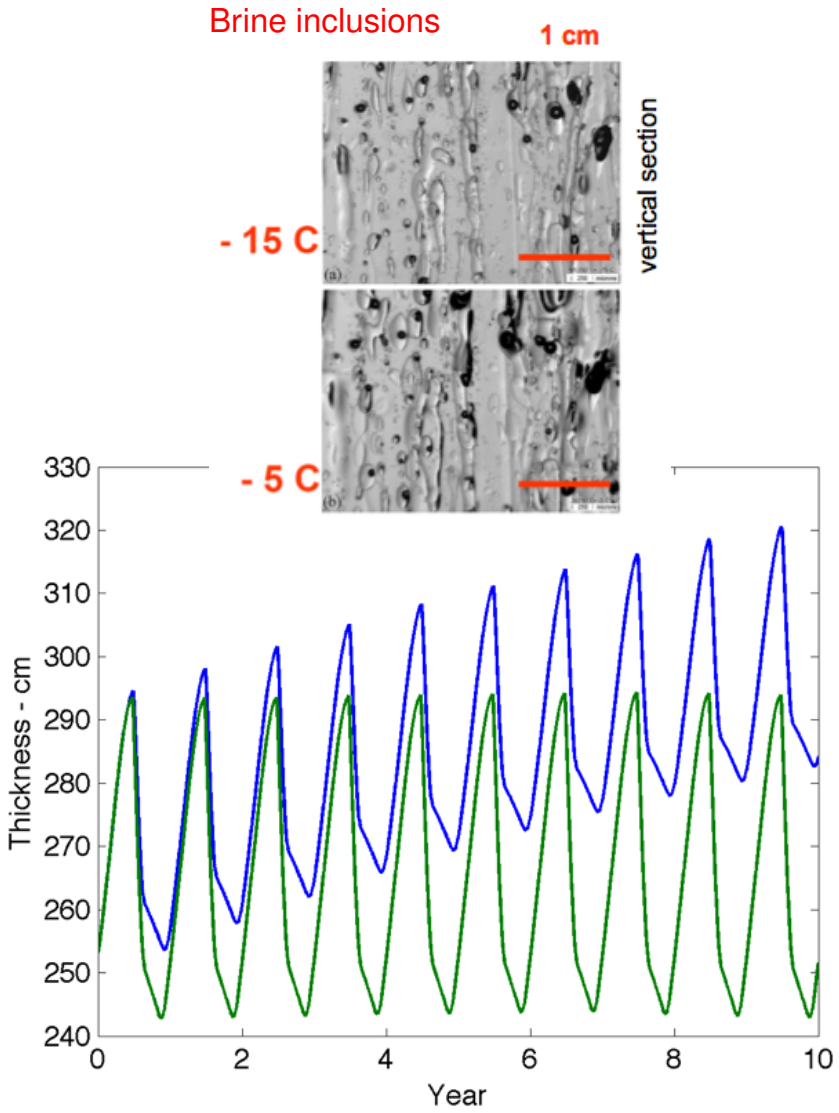


- Cecilia Bitz

  University of Washington
- Adrian Turner

  University College London (now)

  LANL (Jan 2010)
- Wang Xiucheng

  Chinese Academy of Sciences

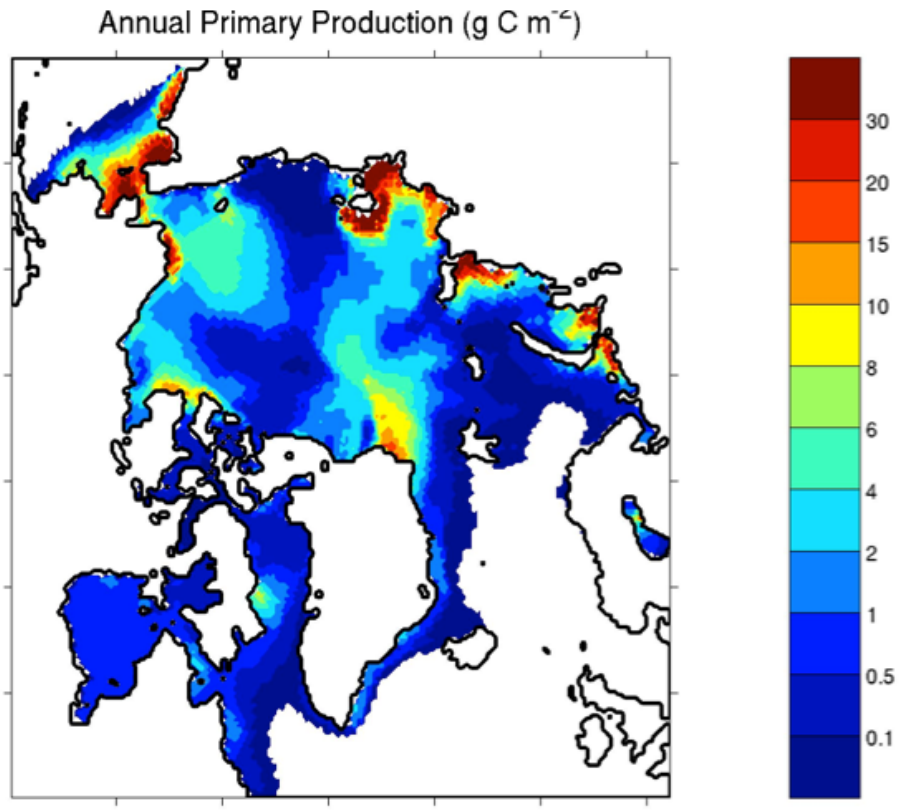
Sea Ice Ecosystem

- Scott Elliott
  Nicole Jeffery
  Mat Maltrud
  Elizabeth Hunke

  Los Alamos National Laboratory
- Clara Deal
  Meibing Jin

  IARC, U. of Alaska, Fairbanks

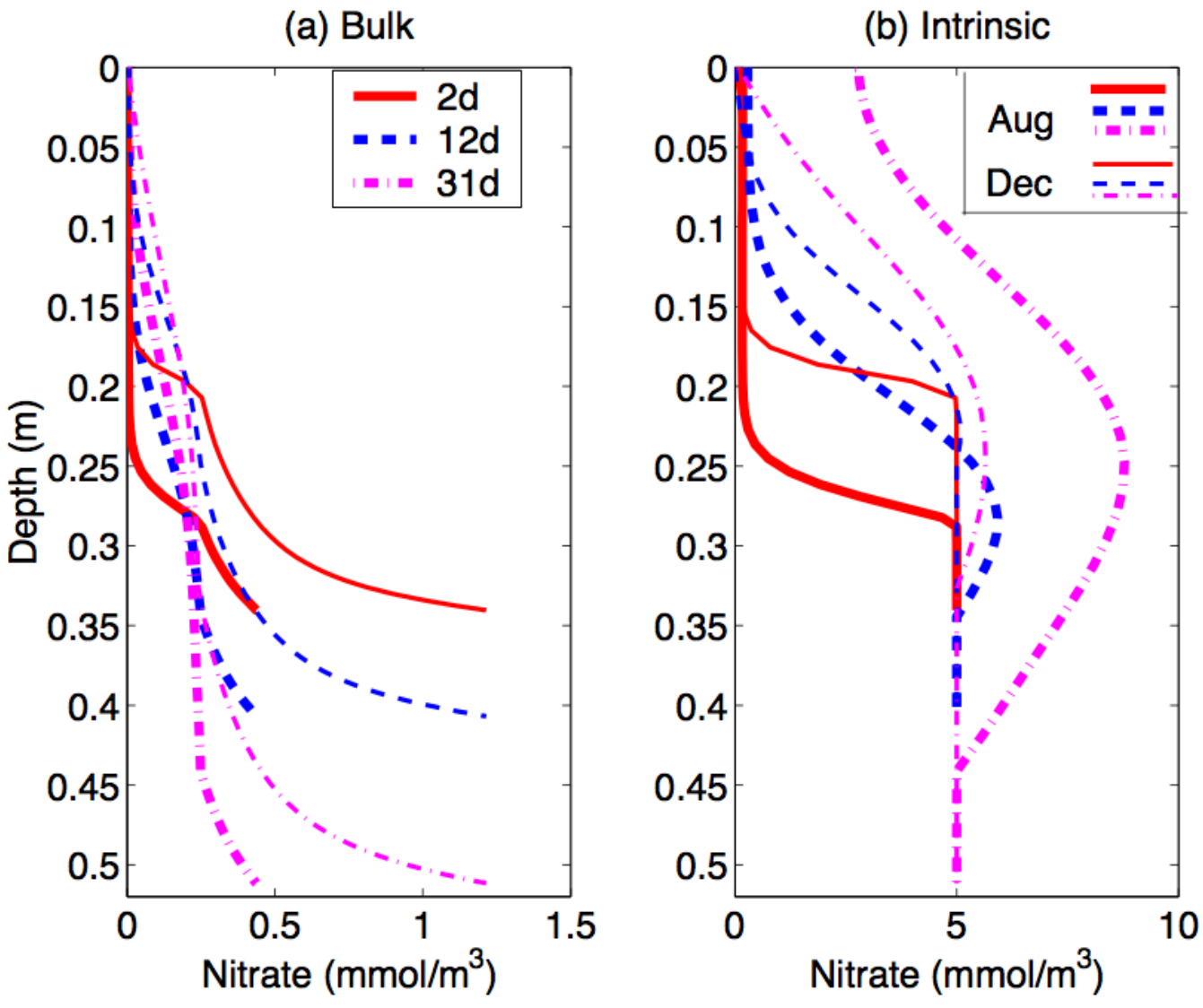
Sea Ice Ecosystem



- stand-alone CICE
- WOA nutrient climatology
- nitrate, silicate, ammonium, DMS(P)
- limiting by light, nutrients, melting
- coupled POP-CICE ecosystem in progress

Vertical Transport

Nicole Jeffery



Ice-ocean dynamic coupling approaches

ocean-ice stress τ_w = drag coef $\times$ quadratic $f(U_o - U_i)$

1. ice-ocean stress = – (ocean-ice stress)
2. ice-ocean stress = div(ice internal stress) + wind stress
3. various levels of "embedding"
4. variable drag coef
5. resolution of ocean boundary layer

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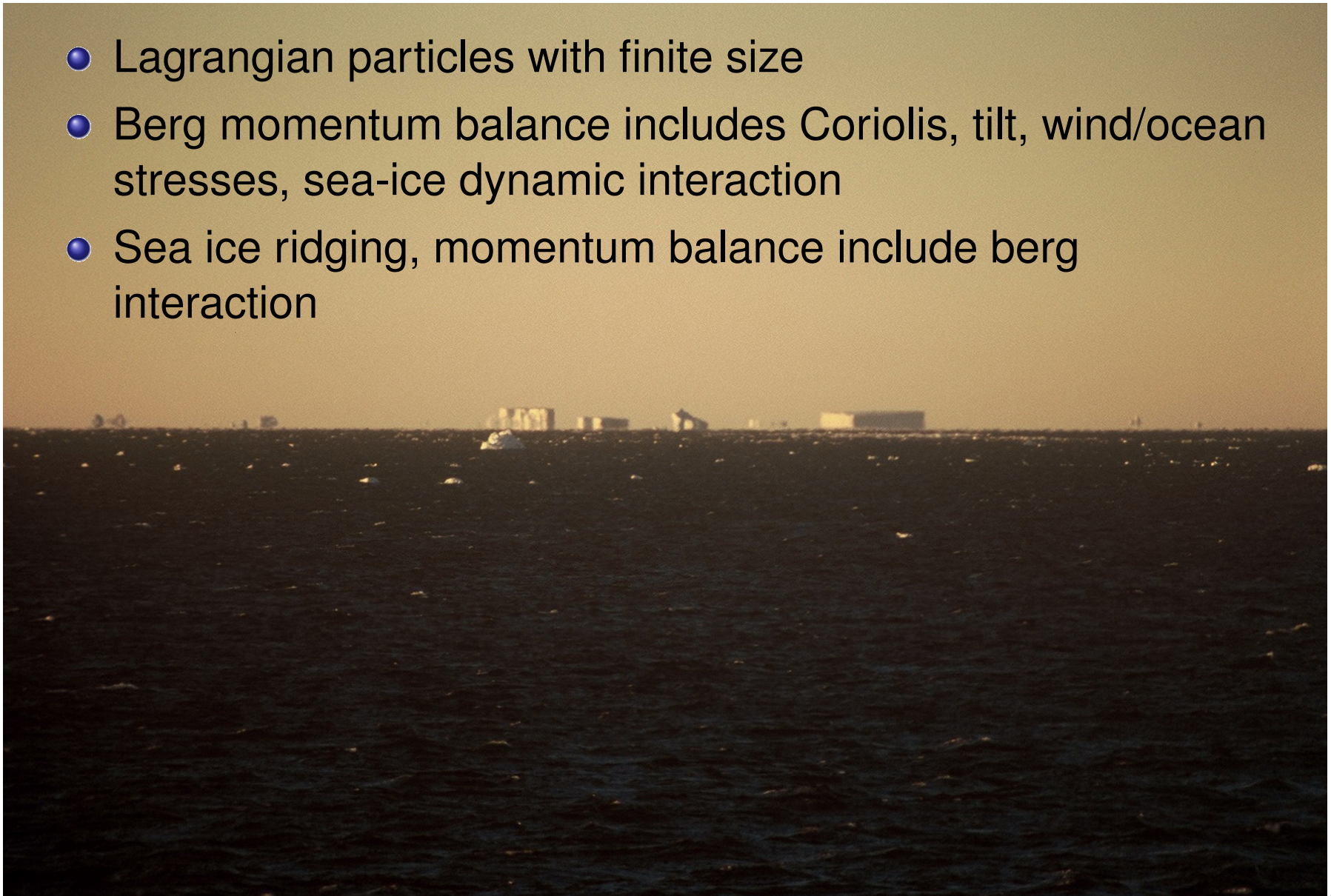
How much is necessary for climate modeling?

Icebergs in CICE



- Lagrangian particles with finite size
- Berg momentum balance includes Coriolis, tilt, wind/ocean stresses, sea-ice dynamic interaction
- Sea ice ridging, momentum balance include berg interaction

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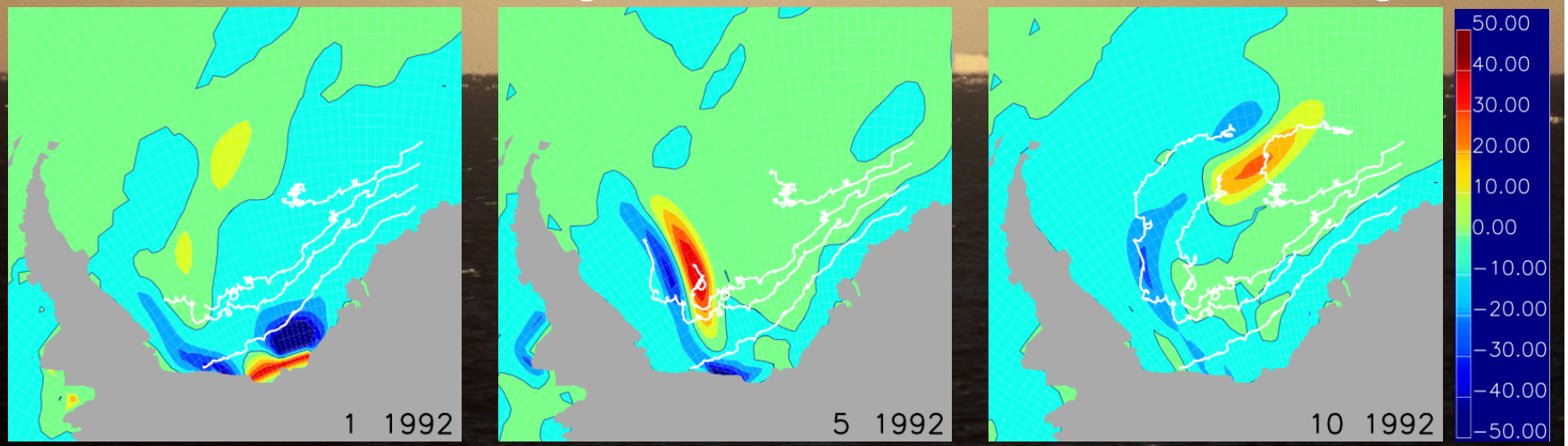
Change in sea ice thickness due to bergs, cm



E. Hunke

Snow

- compaction and densification
- granularization
- moisture transport
- wind redistribution
- slush and snow-ice...

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Help needed!

Sea Ice Constitutive Modeling

Now: Elastic-viscous-plastic (EVP)

Compare: Newton-Krylov solver for viscous-plastic

Future: Elastic-decohesive implementation ?

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Summary: CICE 4.0 Development

Community Efforts

- data assimilation
- physical parameterizations
- numerical implementations

LANL Efforts

- prognostic salinity, ice hydrology
- ecosystem
- icebergs
- ice-ocean coupling
- constitutive modeling
- snow