CICE Consortium 2020 User's Workshop

Welcome to NCAR!

CICE and Icepack Workshop and Tutorial

February 3-5, 2020

Welcome – CICE Consortium Code of Conduct
See https://github.com/CICE-Consortium/About-Us/

Our Pledge

- In the interest of fostering an open and welcoming environment, we as contributors and maintainers pledge to making participation in our project and our community a harassment- free experience for everyone, regardless of age, body size, disability, ethnicity, gender identity and expression, level of experience, nationality, political affiliation, veteran status, pregnancy, genetic information, personal appearance, choice of text editor or operating system, race, religion, or sexual identity and orientation, or any other characteristic protected under applicable US federal or state law.

Our Standards

Examples of behavior that contributes to creating a positive environment include:

- Using welcoming and inclusive language
- Being respectful of differing viewpoints and experiences
- Gracefully accepting constructive criticism
- Focusing on what is best for the community
- Showing empathy towards other community members

- ***If you have any concerns please contact Alice – duvivier@ucar.edu***

CICE Consortium

CICE Consortium Workshop

Goals

- To determine how the CICE Consortium can best help to advance the sea-ice science needs of the community for research and applications
  - Research directions
  - Operational directions
  - Time lines

The Plan for the Day

- CICE model background
- How the Consortium works
  - Structure/teams
  - Agency contributions, plans
  - Consortium plans
- Community activities
- Discussion
  - Community needs
  - Consortium activities
  - Future directions

CICE model and Consortium background

Elizabeth Hunke – LANL and CICE Consortium Lead Coordinator

Monday Feb 3, 8:40-8:55

CICE 1.0
1998

DYN.F	ICE.H	MAKEFILE
FLUX.F	ICE.INP	NCDF.H
FLUX_MP.F	ICEGRID.F	THERM.F
ICE.DOC	ICEINIT.F	TIMERS.H
ICE.F	ICEOUT.F	TRANSP.F

CICE Consortium

Los Alamos NATIONAL LABORATORY EST. 1943

25 years

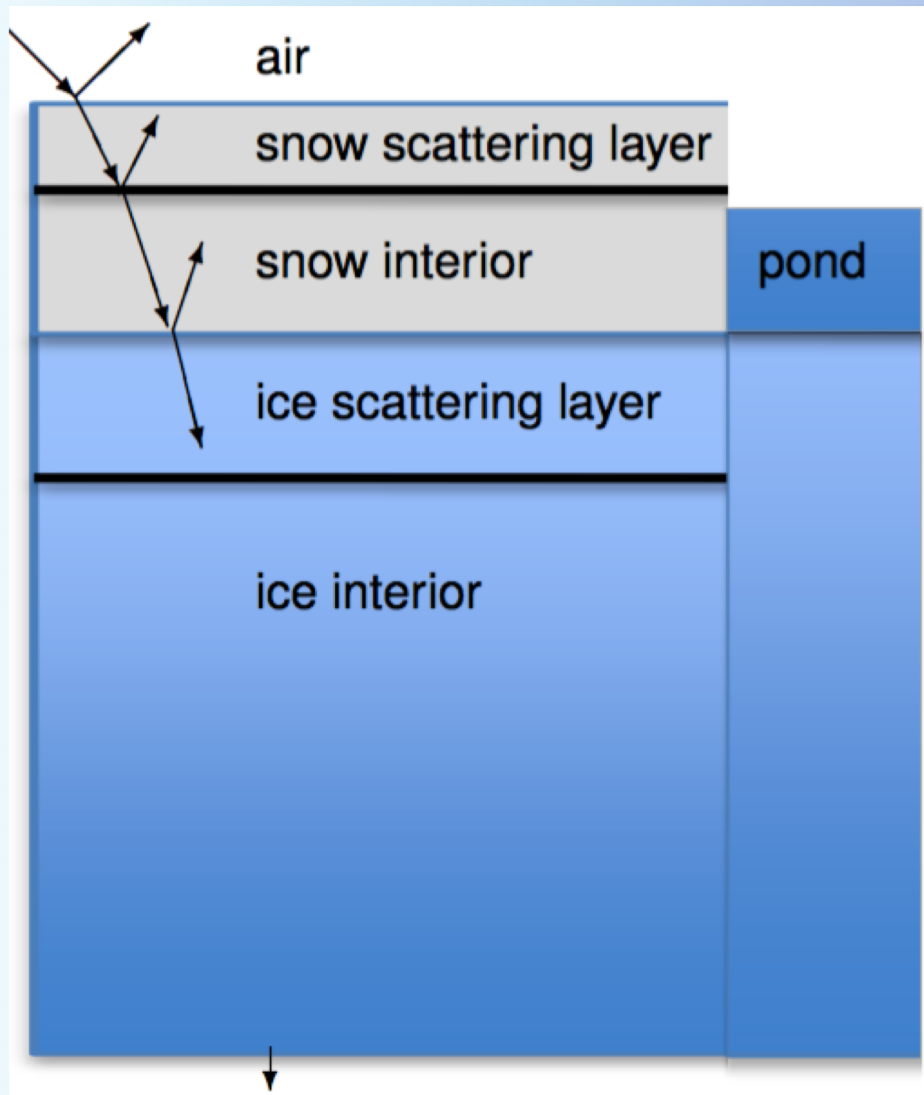
of sea ice model development

1994		
1995	Transcribed Semtner 3-layer model into Fortran 77	
1996		
1997	EVP released	
1998	CICE 1.0	
1999	CICE 2.0	NPS validation of EVP
2000		
2001	CICE 3.0	EVP in NCAR PCM (via NPS)
2002		
2003		
2004	CICE 3.1	NCAR CSIM v2
2005		
2006	CICE 3.14	GFDL CM2 (EVP only)
2007		UK HadGEM1
2008	CICE 4.0	
2009		Canadian sea ice workshops
2010	CICE 4.1	
2011		NRL ACNFS implementation
2012		NRL ACNFS validation
2013	CICE 5.0	NCEP CFSv2 (EVP only)
2014		NRL ACNFS becomes operational
2015	CICE 5.1.2	
2016	CICE Consortium	
and continuing		

CICE Consortium

Community Contributions
through the years

Delta-Eddington radiative transfer



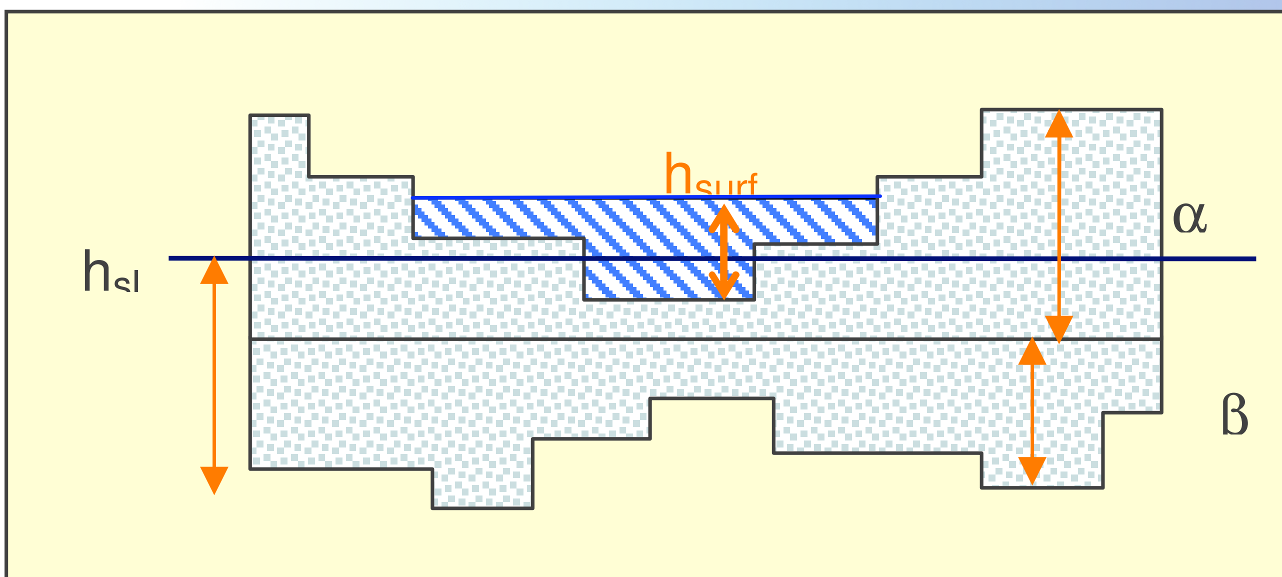
National Center for Atmospheric Research

CICE Consortium

Community Contributions
through the years

Delta-Eddington radiative transfer

Melt pond physics



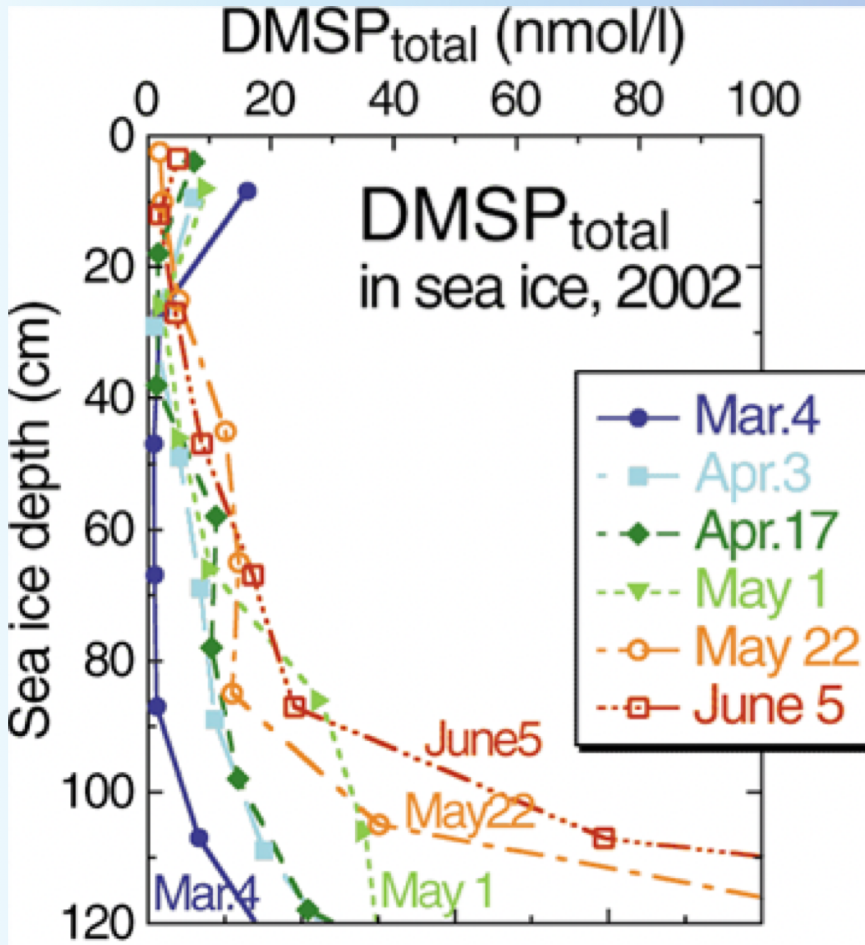
University College London

Community Contributions
through the years

Delta-Eddington radiative transfer

Melt pond physics

Biogeochemistry



University of Alaska Fairbanks

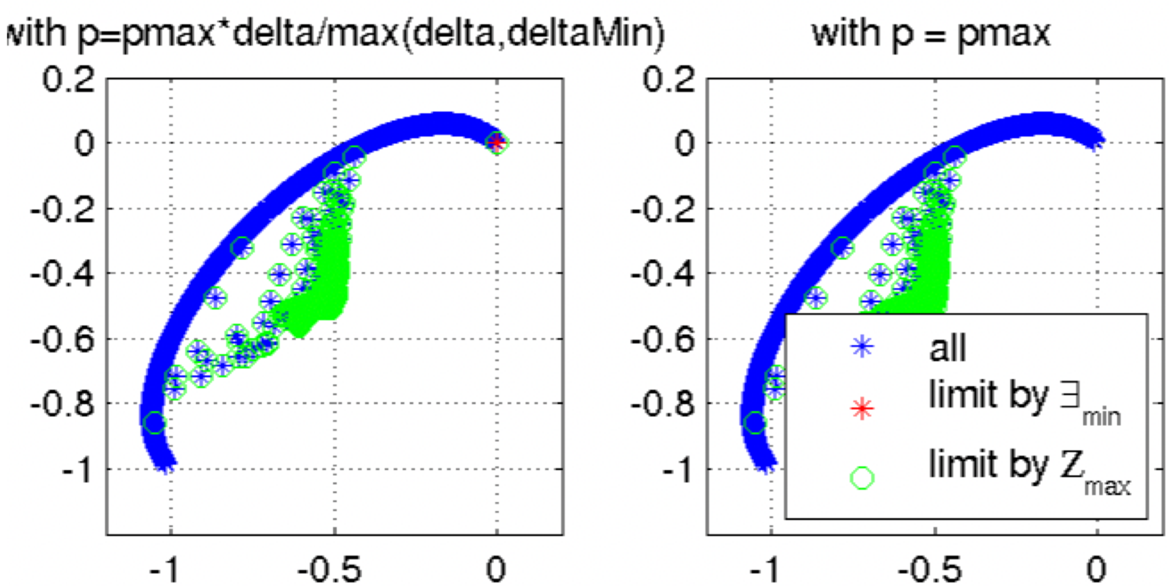
Community Contributions
through the years

Delta-Eddington radiative transfer

Melt pond physics

Biogeochemistry

EVP on the C-grid



Alfred Wegener Institute
for MITgcm

Community Contributions
through the years

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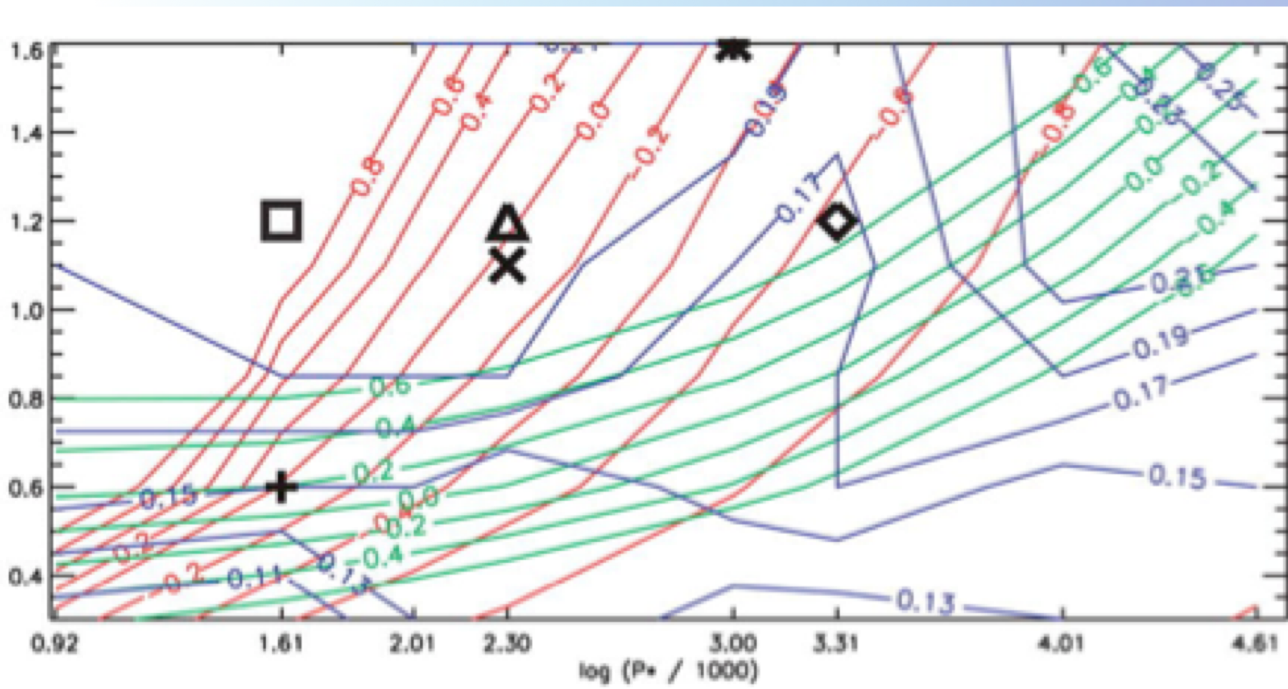
EVP on the C-grid

Parameter optimization



University College London

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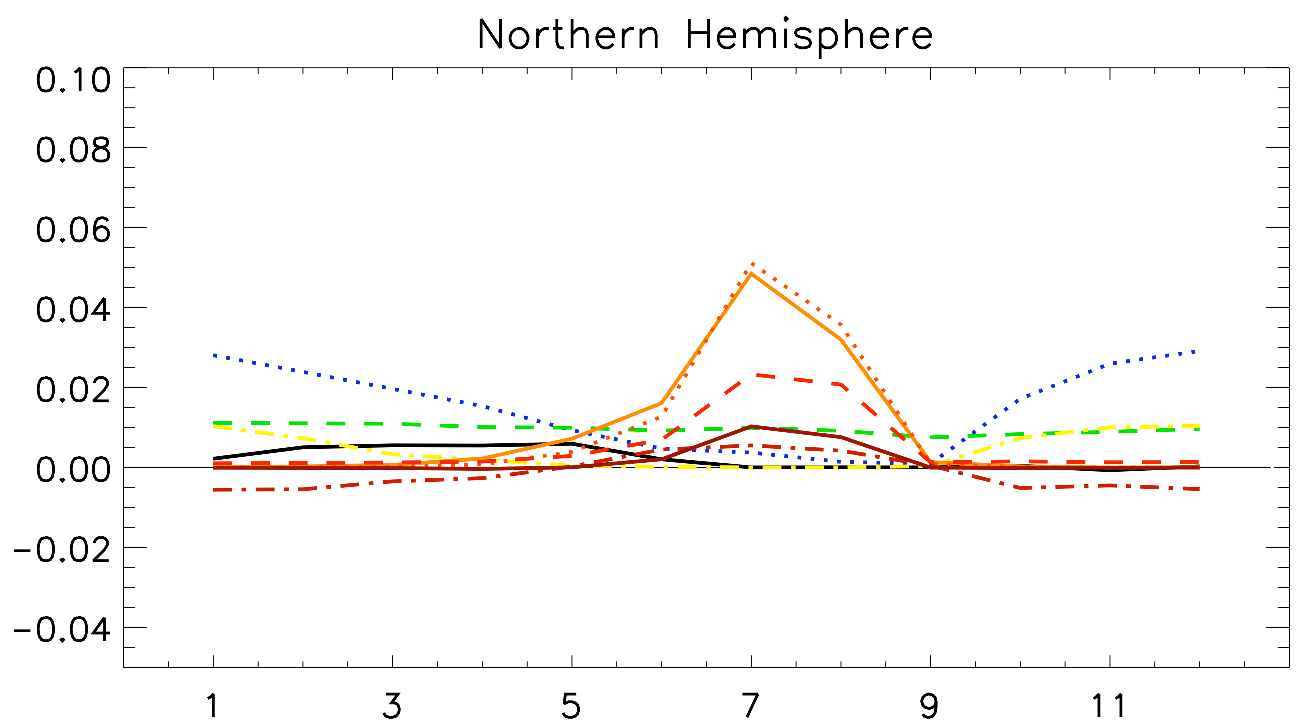
Parameter optimization

Inverse modeling



Argonne National Laboratory

Community Contributions
through the years

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Parameter optimization

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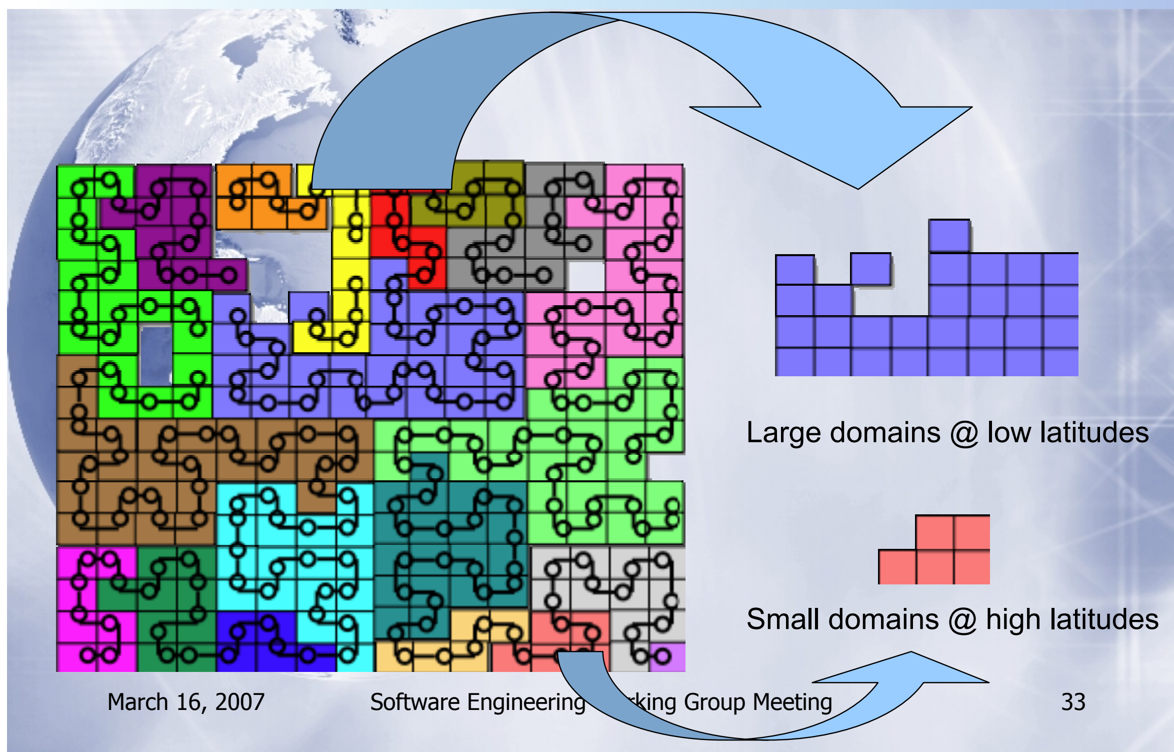
Computational efficiency



National Center for Atmospheric Research

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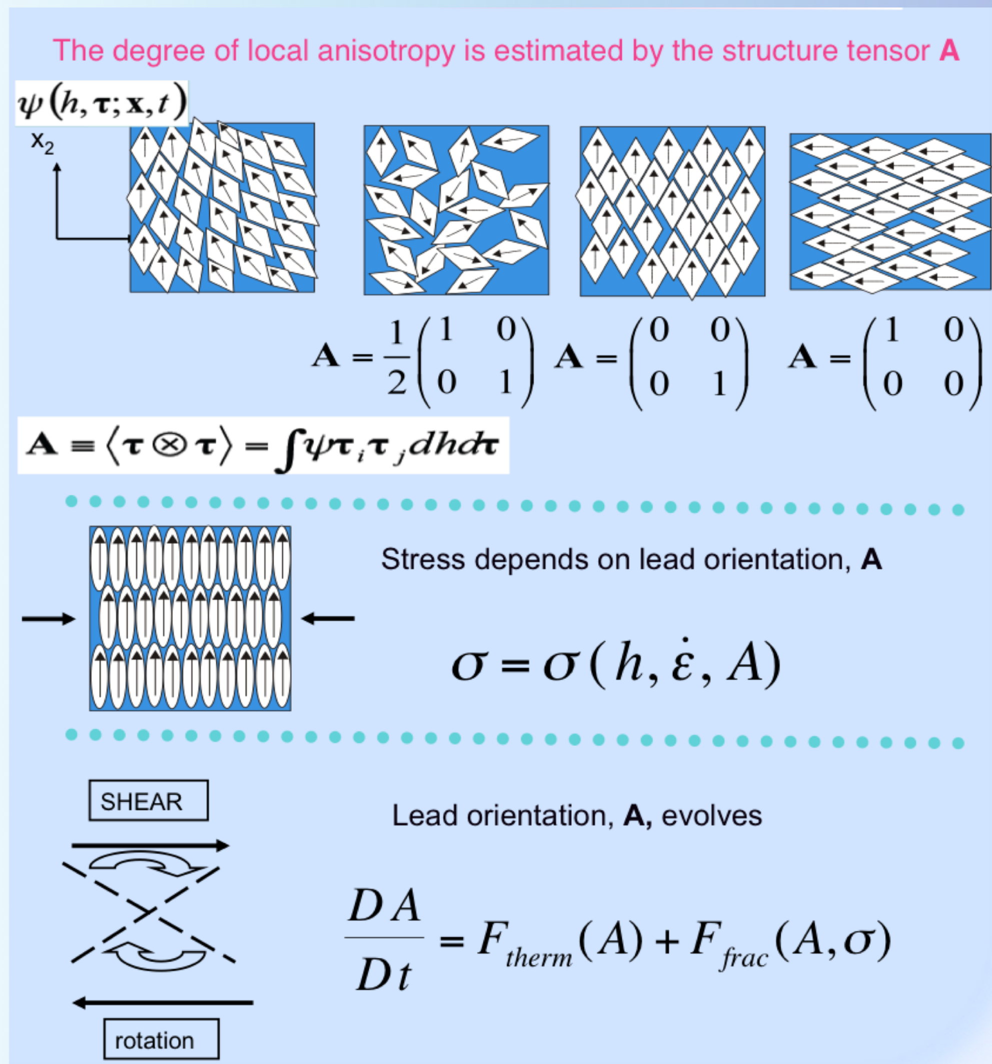
Computational efficiency

Elastic Anisotropic Plastic rheology



University of Reading, UK

Community Contributions
through the years

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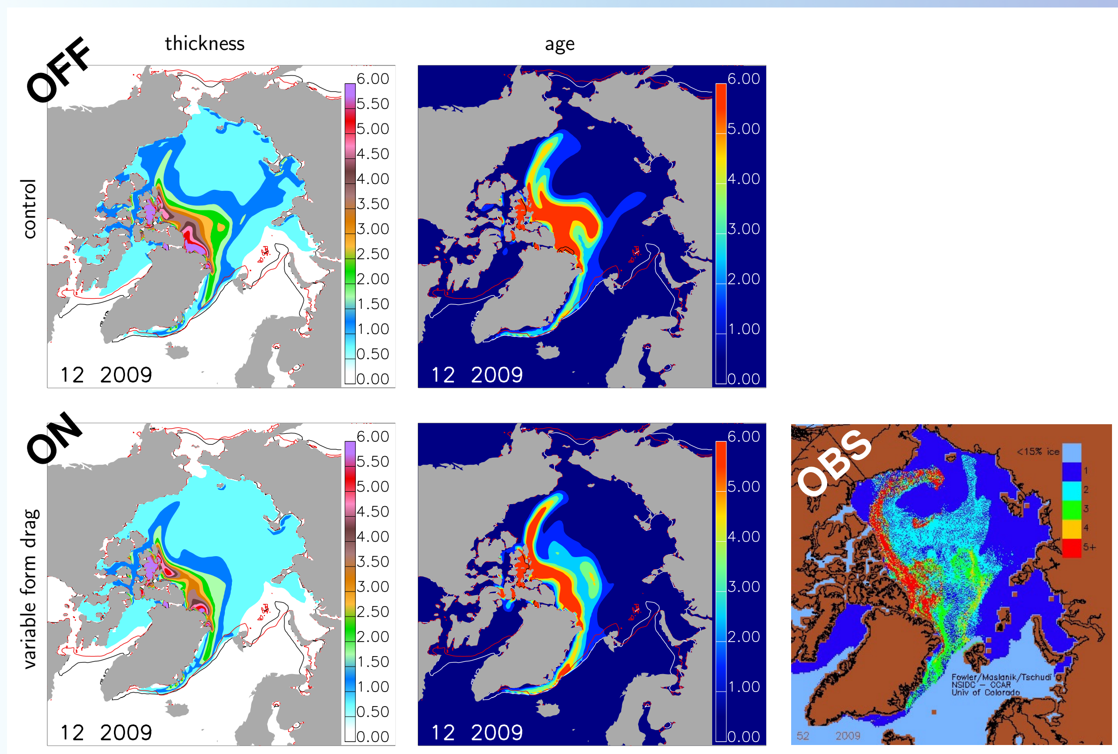
Variable form drag



University of Reading, UK

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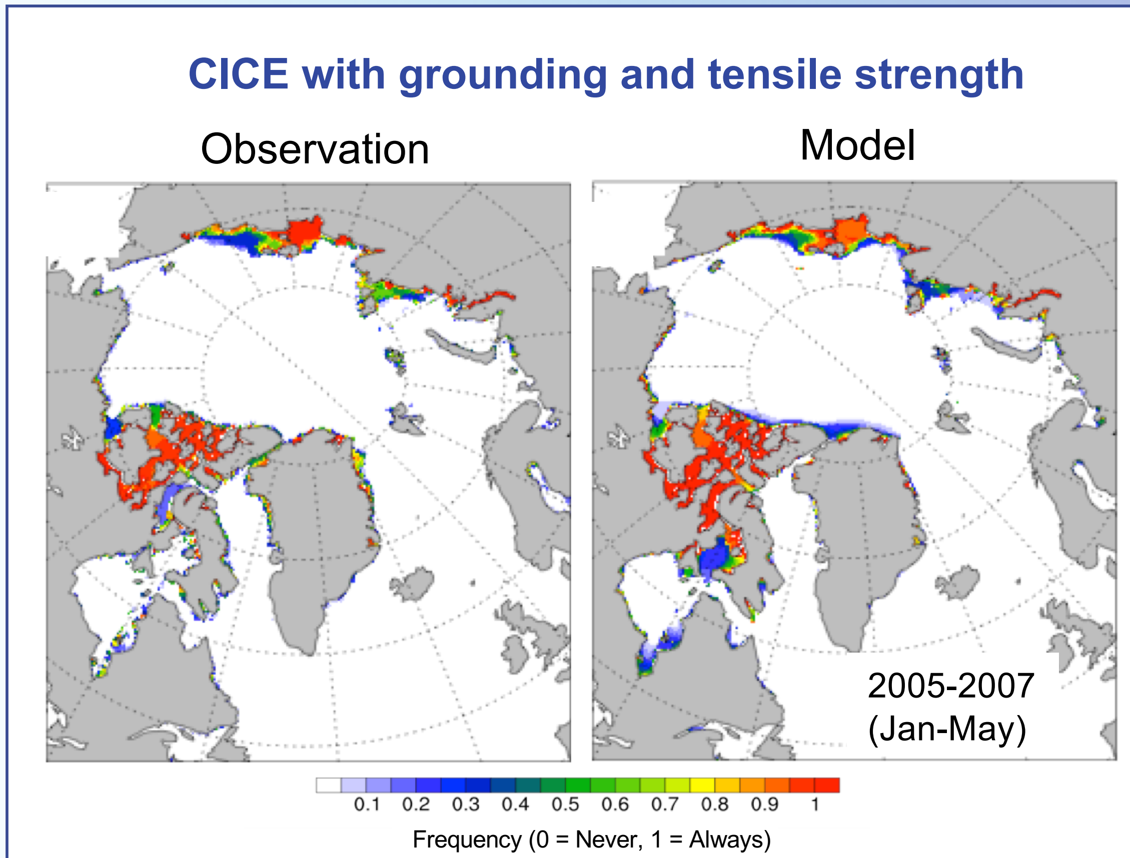
Variable form drag

Landfast ice



Environment and Climate Change Canada

Community Contributions
through the years

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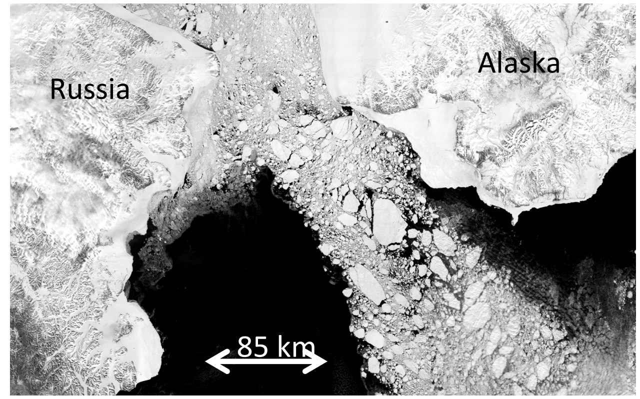
Landfast ice

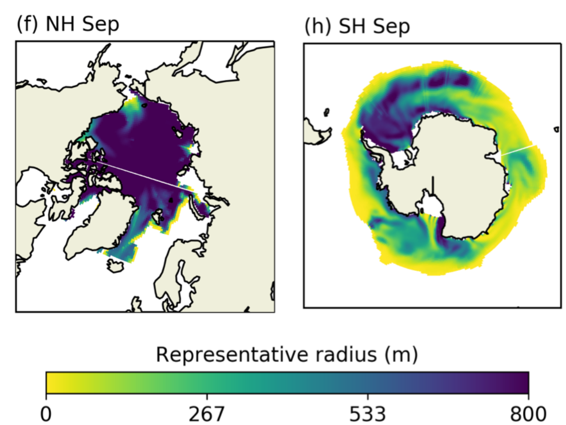
Floe size distribution

Floe sizes span a wide range of scales, described statistically by their floe size distribution (FSD).



Floes in the Bering Sea (MODIS)

https://royalsociety.org.nz/



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

Roach, L. A., Horvat, C., Dean, S. M., & Bitz, C. M. (2018). An emergent sea ice floe size distribution in a global coupled ocean--sea ice model. *J. Geophys. Res. Oceans.*

National Institute of Water and Atmospheric Research, NZ

Community Contributions
through the years

Delta-Eddington radiative transfer

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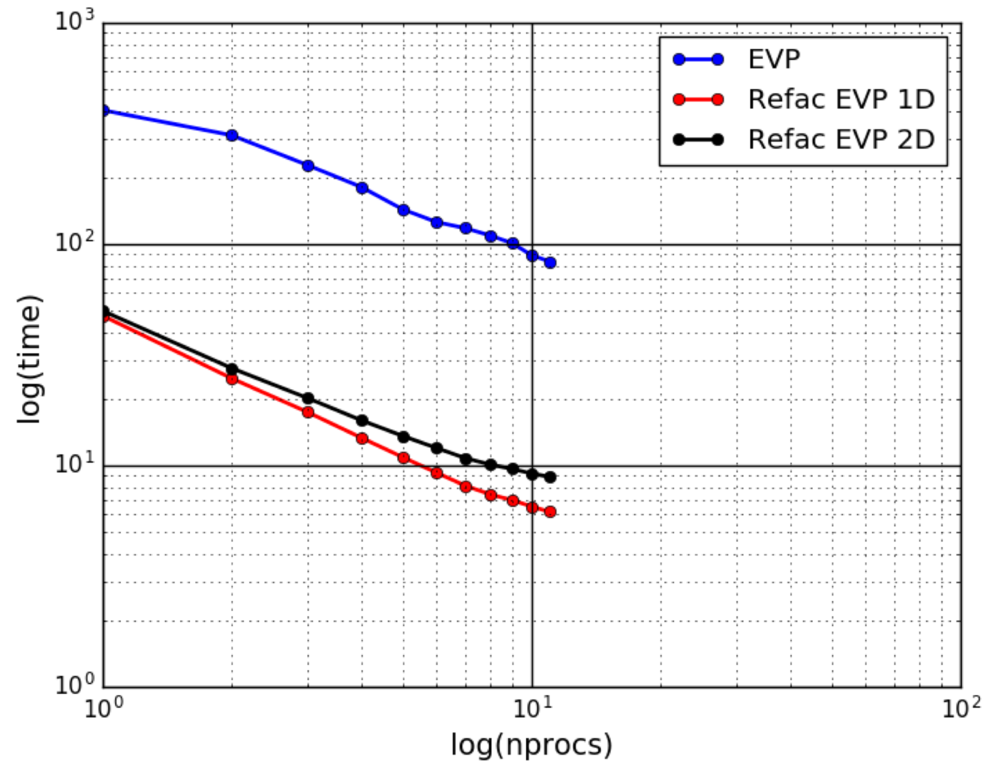
Variable form drag

Landfast ice

Floe size distribution

Refactored EVP dynamics

... and much more …



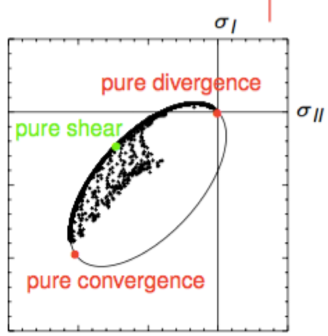
Danish Meteorological Institute

LANL Contributions
through the years

Elastic Viscous Plastic Rheology

$$m\frac{\partial u_i}{\partial t} = \frac{\partial \sigma_{ij}}{\partial x_j} + \tau_{ai} + \tau_{wi} + \epsilon_{ij3} m f u_j - mg\frac{\partial H_\circ}{\partial x_i}$$

momentum
internal stress
wind stress
ocean stress
Coriolis
sea surface tilting



$$\frac{1}{E}\frac{\partial \sigma_{ij}}{\partial t} + \frac{1}{2\eta}\sigma_{ij} + \frac{\eta - \zeta}{4\eta\zeta}\sigma_{kk}\delta_{ij} + \frac{P}{4\zeta}\delta_{ij} = \dot{\epsilon}_{ij}$$

timescale $\tau_e \sim \Delta x\sqrt{\frac{m}{E}}$

⋆ *EXPLICIT*

Los Alamos National Laboratory

LANL Contributions

through the years

Elastic Viscous Plastic Rheology

Incremental Remapping advection

$$\frac{\partial c}{\partial t} + \nabla \cdot c\vec{u} = 0 \qquad (1)$$

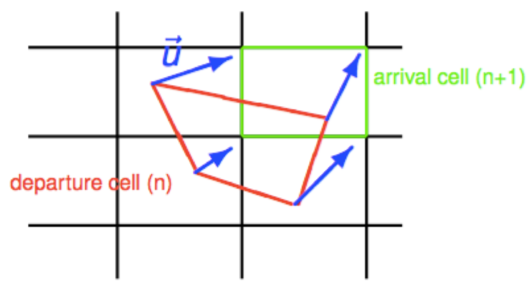
$$\frac{\partial ch}{\partial t} + \nabla \cdot ch\vec{u} = 0 \qquad \text{for tracer } h$$

(1) can be rewritten $\frac{d}{dt}\int_{V(t)} c\, dV = 0$

$$M_{n+1} = M_n = \int_V c\, dV$$

c constant $\Rightarrow$ 1st order

c linear $\Rightarrow$ 2nd order



conservative
monotone
tracers are cheap!

Los Alamos National Laboratory

Los Alamos NATIONAL LABORATORY EST. 1943

CICE Consortium

LANL Contributions
through the years

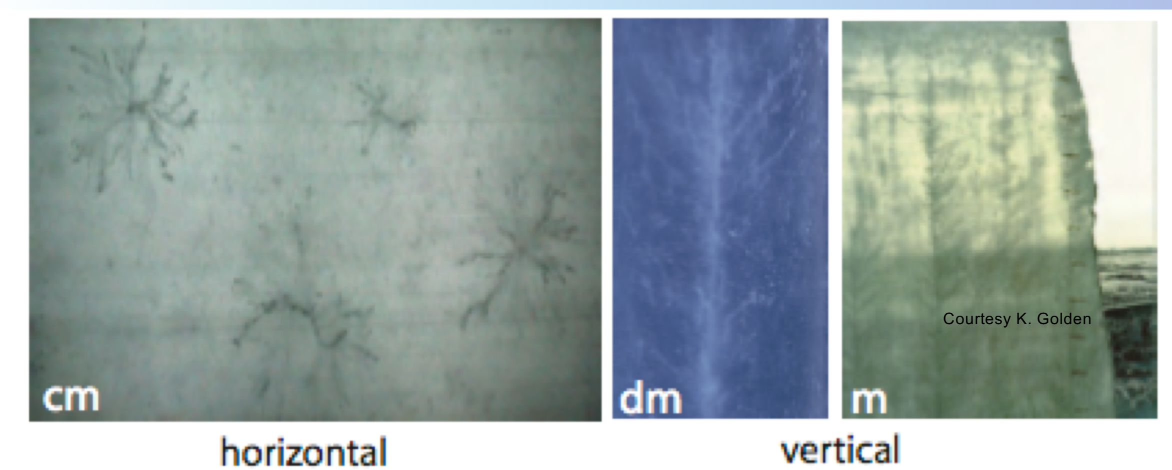
Elastic Viscous Plastic Rheology

Incremental Remapping advection

“Mushy” thermodynamics

Equations	Variables
Conservation of Energy	Enthalpy
Conservation of Salt	Salinity
Ice-brine liquidus relation	Liquid fraction
Darcy flow through a porous medium	Vertical velocity

Brine channels



LANL Contributions
through the years

Elastic Viscous Plastic Rheology

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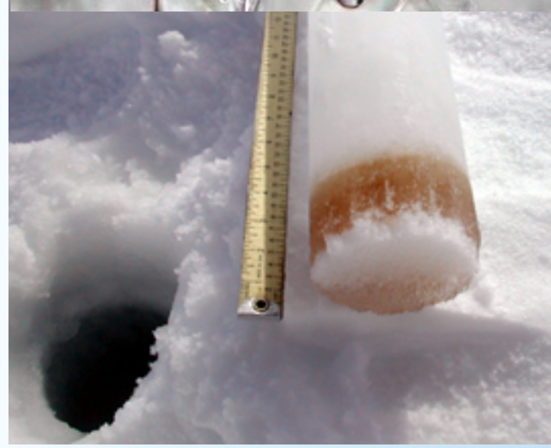
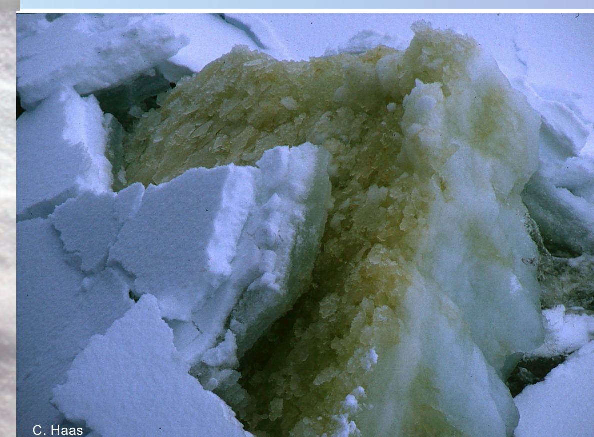
“Mushy” thermodynamics

Vertical biogeochemistry

Sea ice ecosystem

Algae live in the liquid (brine) within sea ice and thrive where there are nutrients





Los Alamos National Laboratory

LANL Contributions
through the years

Elastic Viscous Plastic Rheology

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“Mushy” thermodynamics

Vertical biogeochemistry

Icepack

Documentation

Community support

... and much more …

CICE: the Los Alamos Sea Ice Model
Documentation and Software User's Manual
Version 5.1
LA-CC-06-012

Elizabeth C. Hunke, William H. Lipscomb,
Adrian K. Turner, Nicole Jeffery, Scott Elliott
Los Alamos National Laboratory
Los Alamos NM 87545

March 17, 2015

Contents

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Los Alamos National Laboratory

CICE Consortium

to enhance sea ice model development for and by the community

- Acceleration of scientific development
- Acceleration of R&D transfer to operational use
- Vehicle for collaboration and sharing

U.S. NAVAL RESEARCH LABORATORY

NSF

NOAA

PAN

DMI Danish Meteorological Institute

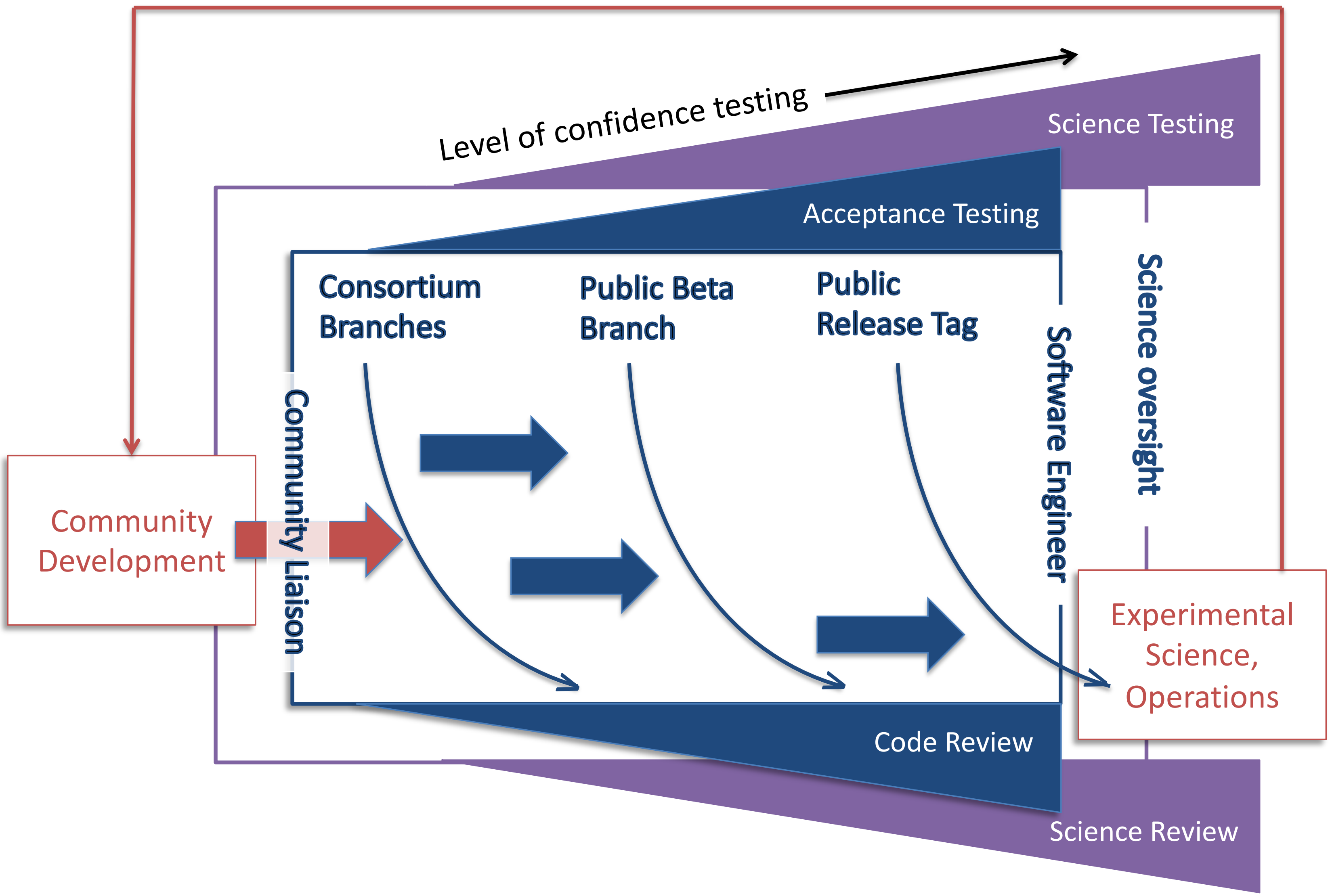
Environment Canada

CICE Consortium

- Executive Oversight Board
  - Lead Coordinator
    - Co-Lead
    - Software Engineer
      - CICEdyn
        - Dynamics
        - Transport
        - Documentation Contributor
      - Icepack
        - Thermo
        - Ridging/ Morphology
        - BGC
        - Documentation Contributor
      - Infrastructure
        - Drivers, Time-Stepping
        - Initialization
        - Data Assimilation
        - Output
        - Grids
        - Optimization, Parallelization
        - Documentation Contributor
      - Testing and Analysis
        - Regression testing
        - Testing in coupled models
        - Post-processing tools
        - New code Contributor
        - Documentation Contributor
      - Community Support
        - Code releases
          - CICE
          - icepack
        - Liaison
        - Bug tracking/ oversight
        - User workshops
      - Repository
        - Admin
        - Maintenance

CICE Consortium Org Chart. White boxes indicate task areas or responsibilities for each of the six Teams, including code elements, post-processing software, and community interfaces.

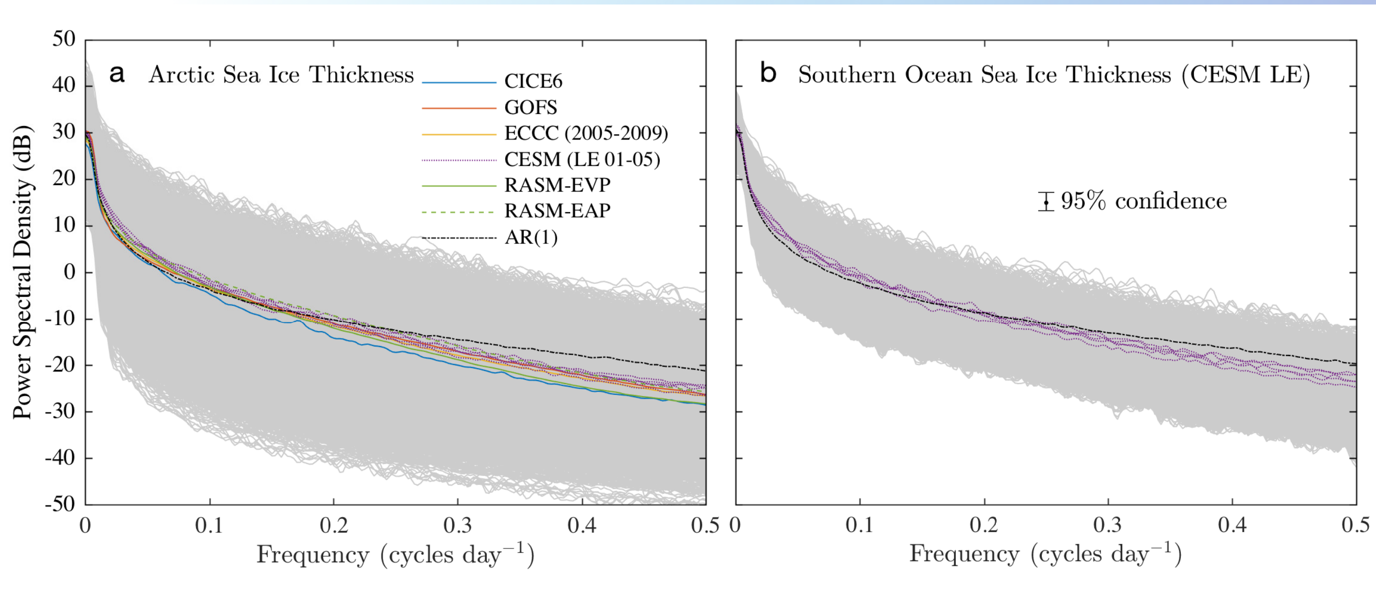
CICE Consortium Functional Design



CICE Quality Control

Categorize code modifications based on test simulations

1. Bit-For-Bit (BFB)
2. Non-BFB, but not climate changing
3. Non-BFB, climate changing, requires review and checking
4. A new model improvement or addition, requiring review and checking



Objective, statistical tests allow code modifications to be quickly evaluated for potential bugs etc.
Automated, standardized testing enables community participation in sea ice model development.
The metrics provide objective guidance for assessing new physics and code functionality.

Roberts, A. F., Hunke, E. C., Allard, R., Bailey, D. A., Craig, A. P., Lemieux, J., & Turner, M. D. (2018). Quality control for community-based sea-ice model development. *Philosophical Transactions of the Royal Society A*, *376*, 17. doi:10.1098/rsta.2017.0344

CICE Consortium

CICE version 6 code structure

github.com/CICE-Consortium/CICE

CICEcore (dynamical core)

- Momentum
- Stress
- Transport
- Grid/parallelization
- I/O
- Etc

github.com/CICE-Consortium/Icepack

Icepack (column physics)

- Ice thickness distribution
- Thermodynamics
- Ridging
- Biogeochemistry