Polar Climate Working Group Update

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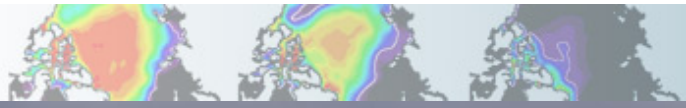
http://www.cesm.ucar.edu/working_groups/Polar/

NSF

NCAR Earth System Laboratory

U.S. DEPARTMENT OF ENERGY

Los Alamos NATIONAL LABORATORY EST. 1943

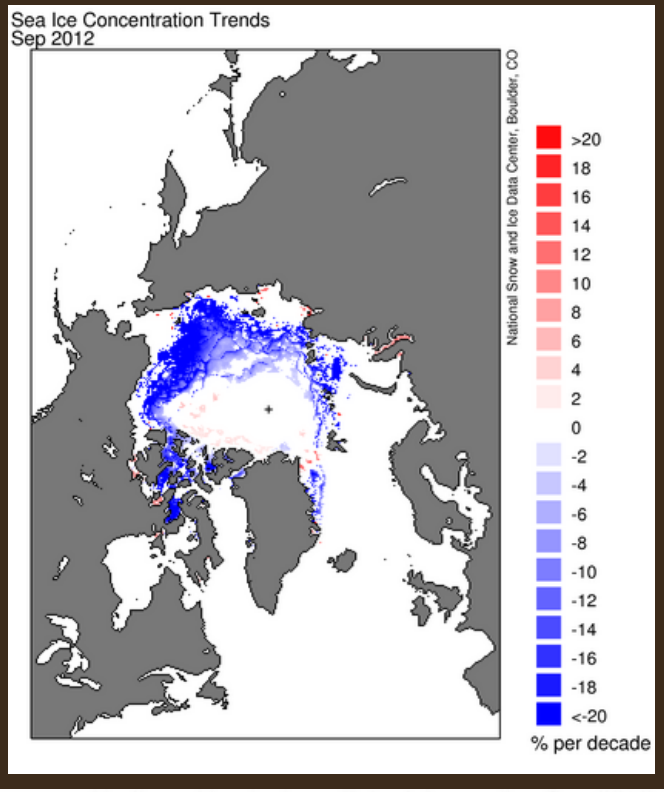


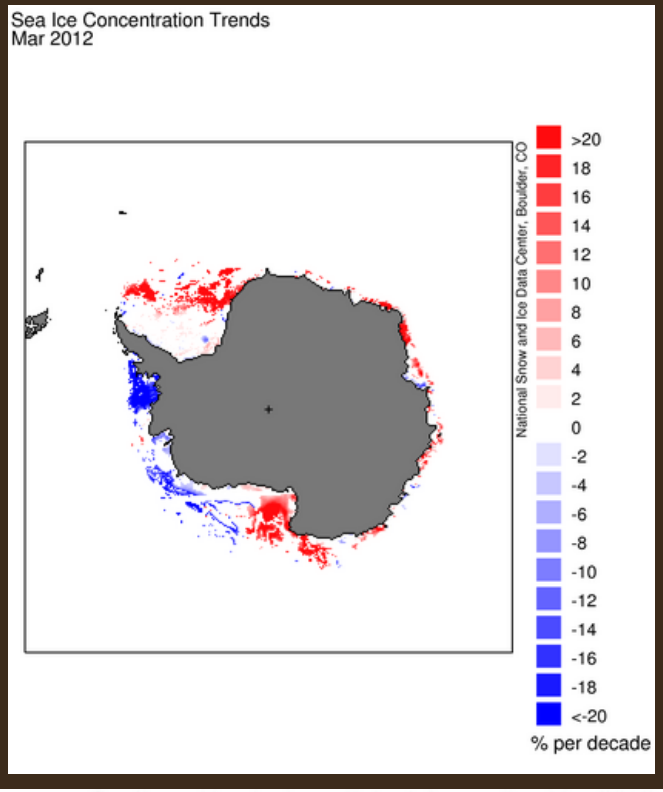
PCWG 2-year Priorities (March 2012):

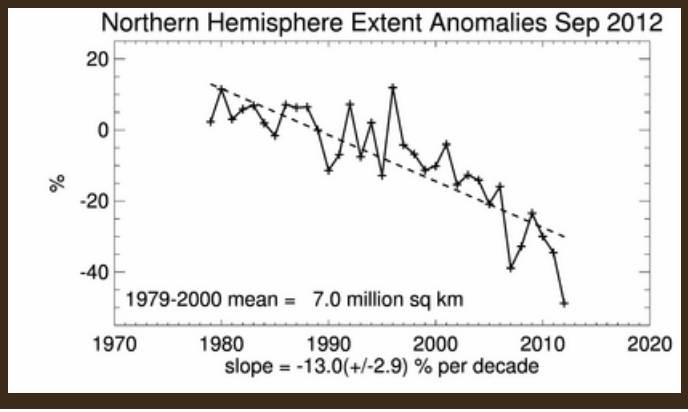
1. Polar climate research
2. Observational needs/uses
3. High resolution runs
4. Modeling issues/strategies
5. Merge CICE/CESM, CICE development

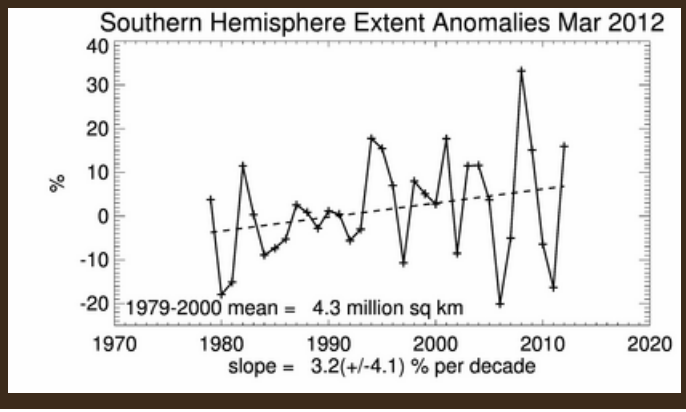
Photo courtesy National Geographic

Polar Research: Sea Ice Trends



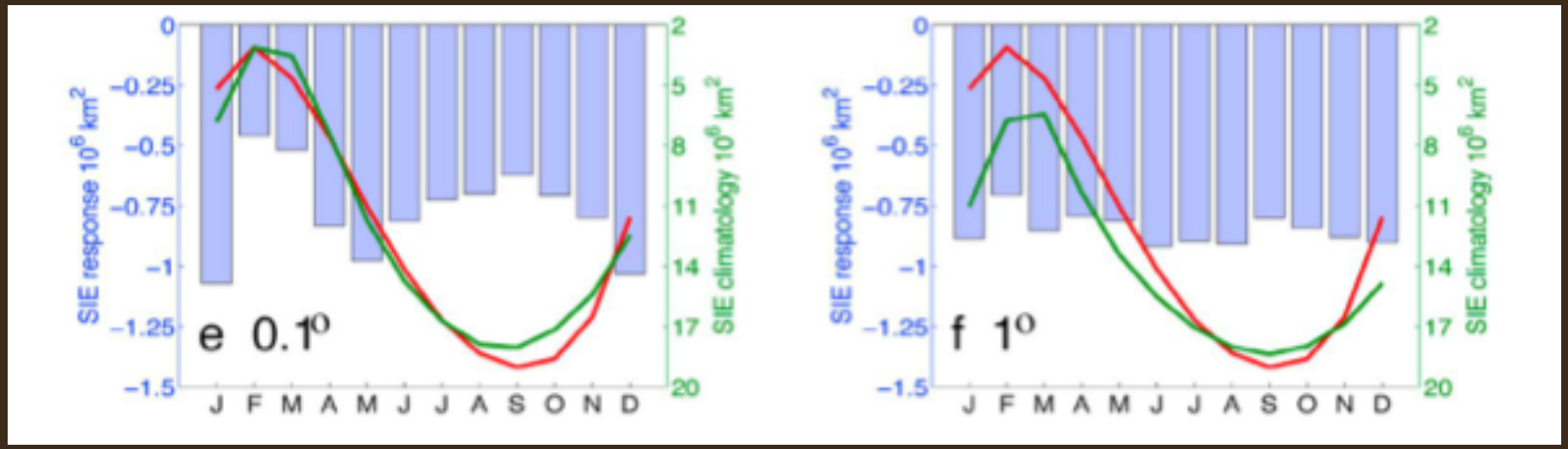






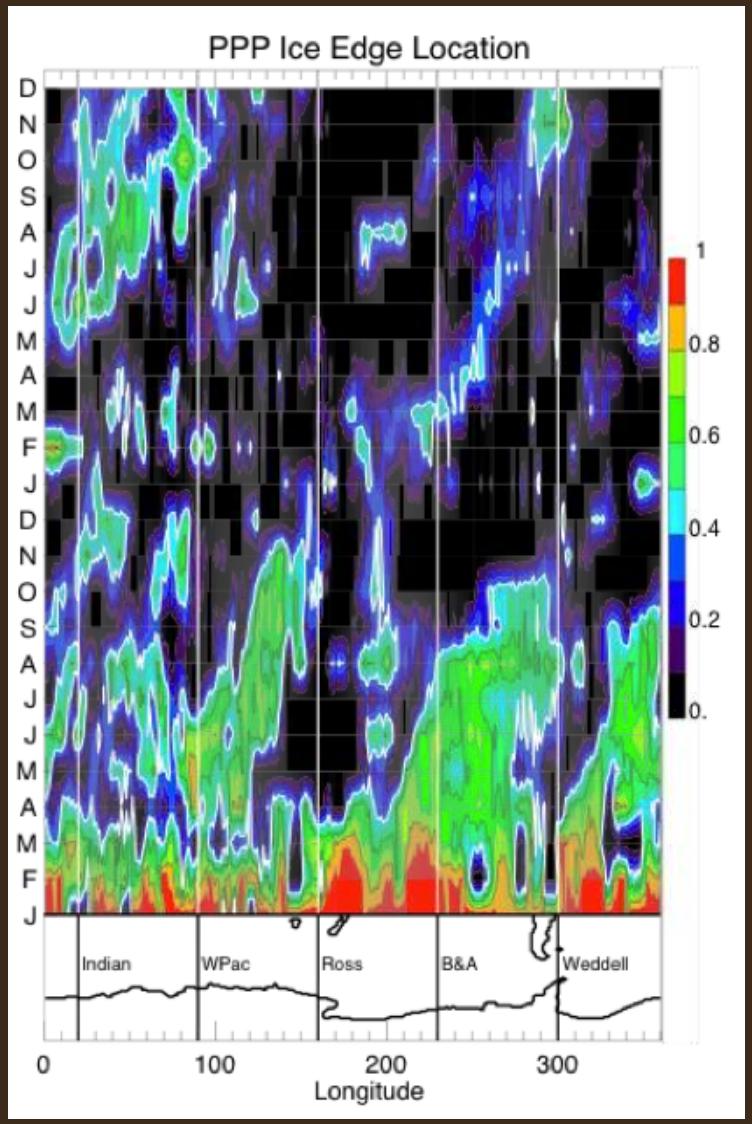
Polar Research: Antarctic Sea Ice Trends

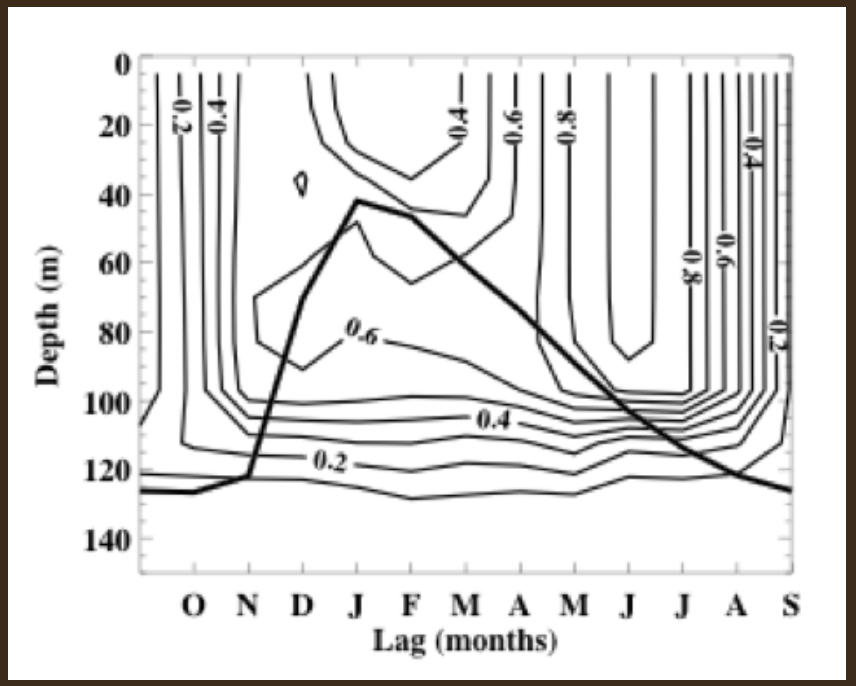
"The effect of ozone depletion is to warm the surface and the ocean to a depth of 1000 m and to significantly reduce sea ice extent…. The total loss of sea ice area is roughly the same in the fine and coarse resolution cases"



Bitz and Polvani 2012

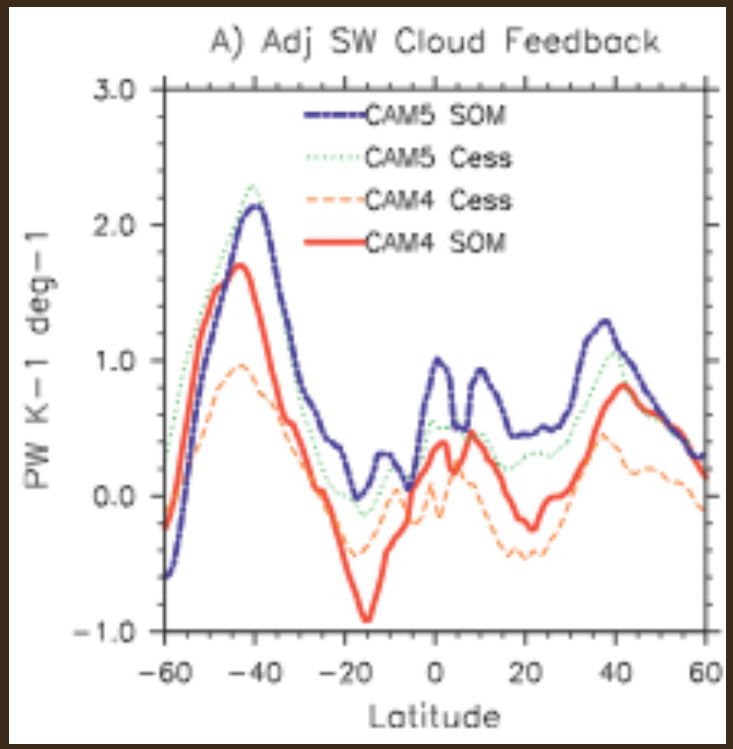
Polar Research: Sea Ice Predictability



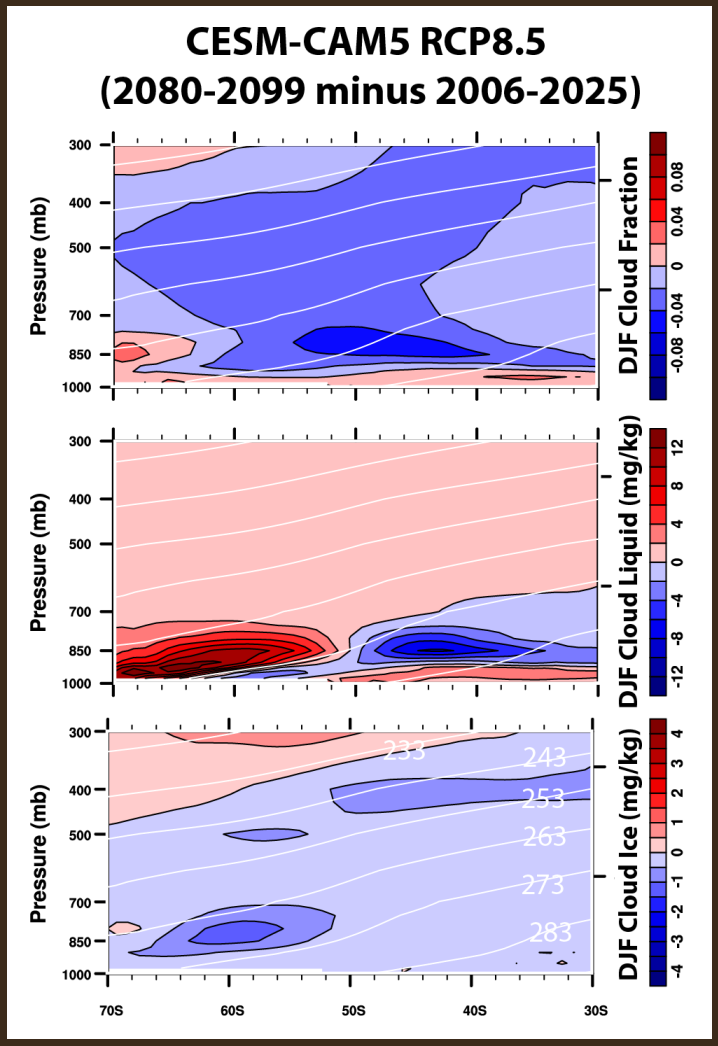


Holland et al. submitted

Polar Research: Cloud Feedbacks

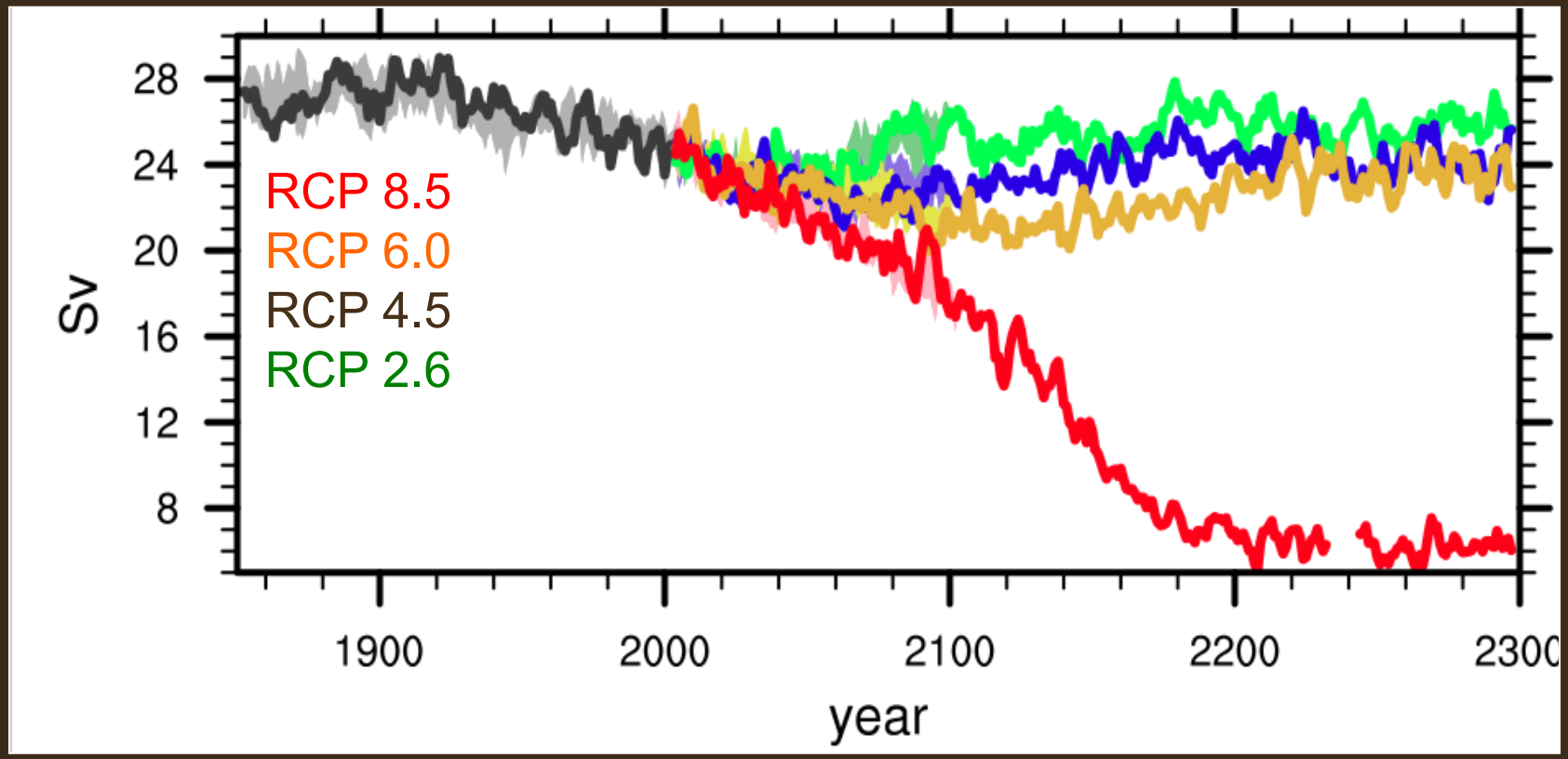


Gettelman et al. 2012



Kay, Medeiros (in progress)

Arctic Research: AMOC and Sea ice Loss



Jahn and Holland 2013

CESM-CAM5 Large Ensemble

coordinated by Clara Deser and Jen Kay

1850 control run (1000 years)

Large ensemble (30+) from 1900-2080 using historical/RCP8.5 forcing. Ensemble spread from round-off error in CAM initial condition.

Using released version of CESM-CAM5 1 degree FV with Yellowstone support (CESM1_1_1)

Community process to establish output variables: monthly throughout, daily throughout, timeslice 6-hourly

PCWG observational needs/uses

"living" document to increase transparency and facilitate communication with observational community, updated annually.

Input very welcome.

Document available through the PCWG website.

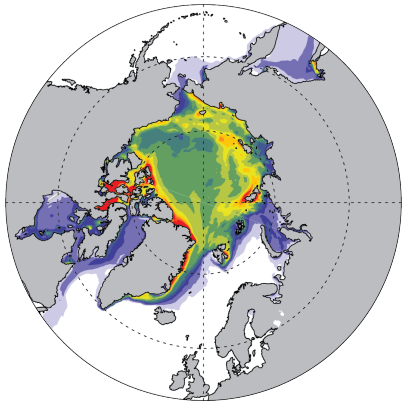
http://www.cesm.ucar.edu/working_groups/Polar/PCWG_workingdoc_obs4models_July22012.docx.pdf

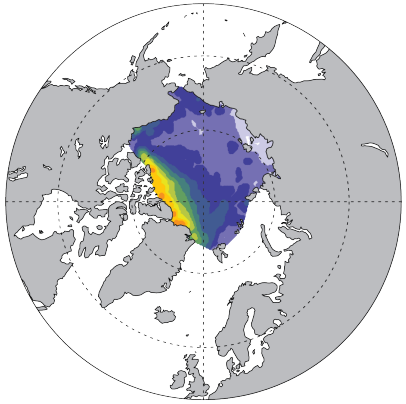
High resolution runs

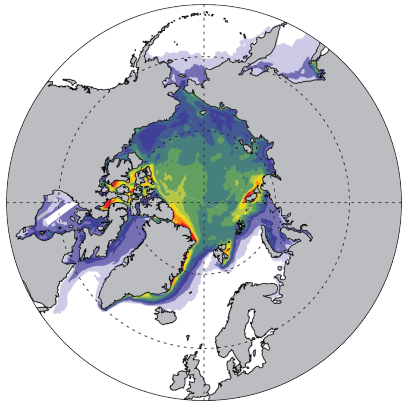
Modeling issues/strategies

CAM-SE
CAM4
physics

Both use
D-Edd
standard
settings







T341
CAM4
physics

Both
initialized
from 0.1°
POP/
CICE

various atmo models/versions/resolutions

ocean & ice 1/10°, 1/12°

inertial oscillations

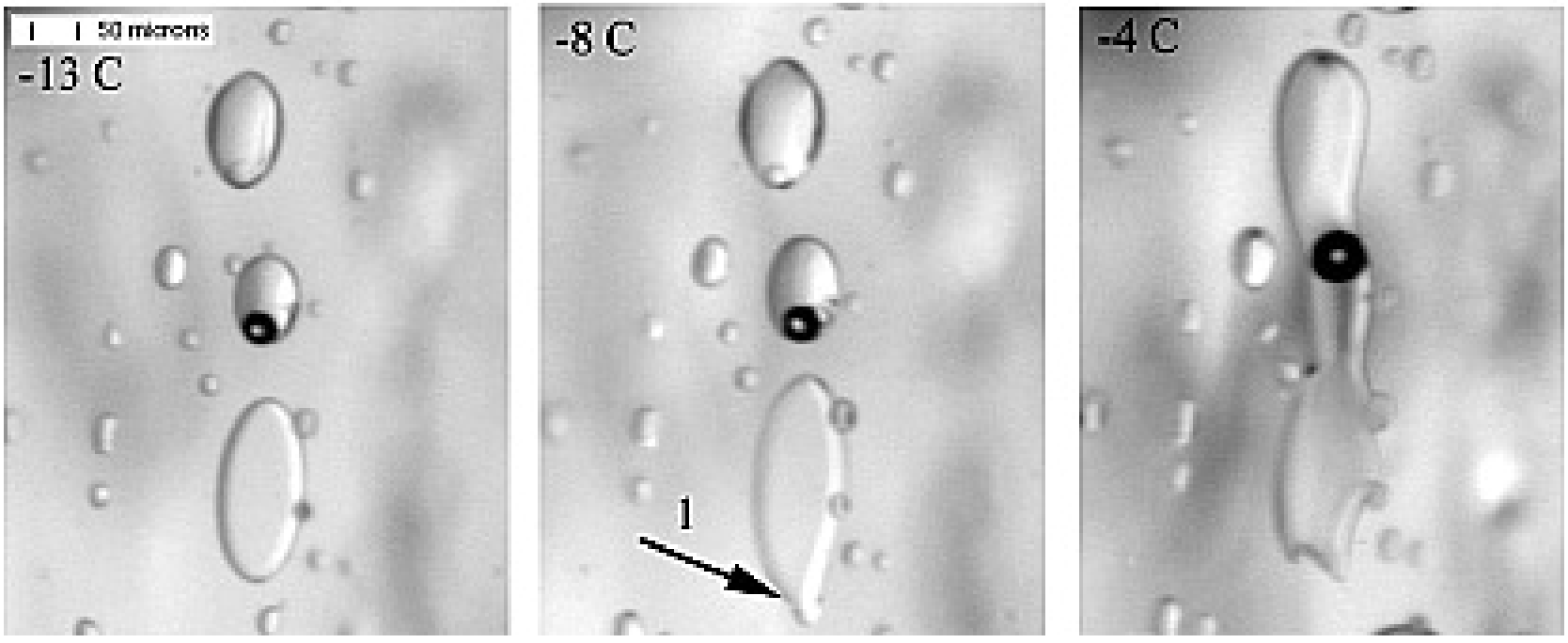
apparent instabilities in some configs

CICE Infrastructure & efficiency improvements

e.g., from CESM:

- Tony Craig's grid decompositions, ice halos
- OpenMP threads
- Parallel I/O (PIO/pnetcdf)
- miscellaneous parameters, etc.

Multiphase Physics 2 Approaches

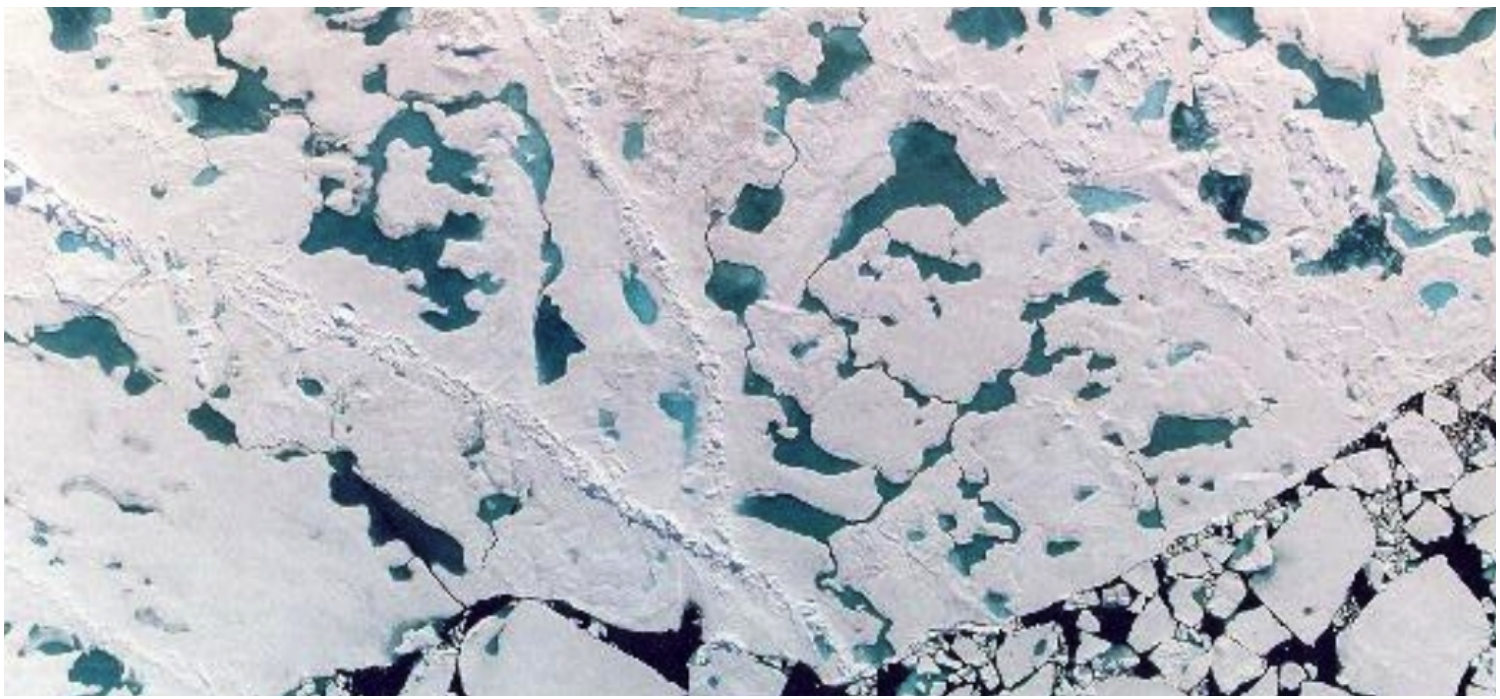


courtesy B. Light, JGR 2003

1. Mushy Layer thermodynamics from the ground up
2. Bitz & Lipscomb 1999 thermodynamics
   + coupled vertical salinity transport model

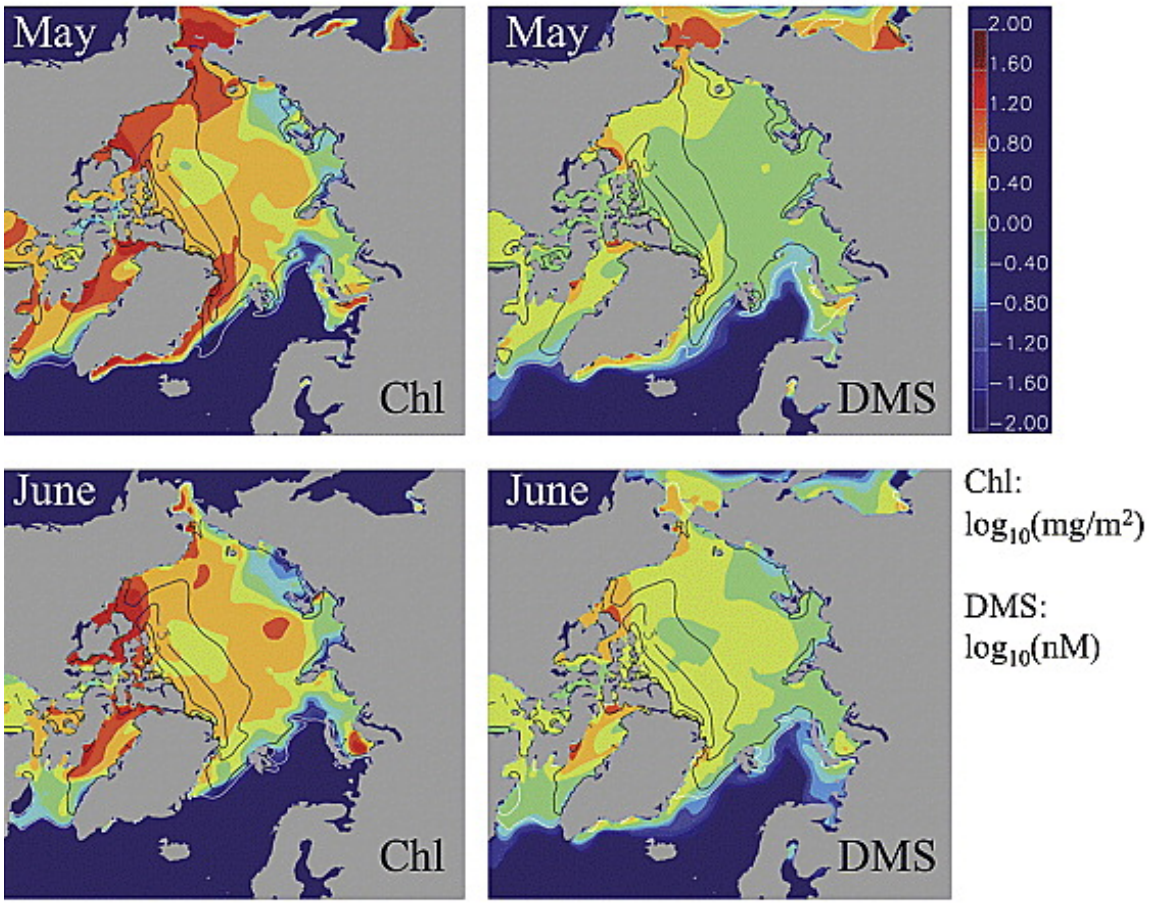
Melt Ponds in CICE

1. implicit: old shortwave parameterization reduces albedo
2. explicit, empirical: CCSM4/CESM1 pond scheme “cesm"
3. University College London’s approach “topo"
4. fusion of 3 and 4 “lvl"



Biogeochemistry

Chlorophyll, DMS produced by CICE algae: Pigments in ice, trace gas below and in margins



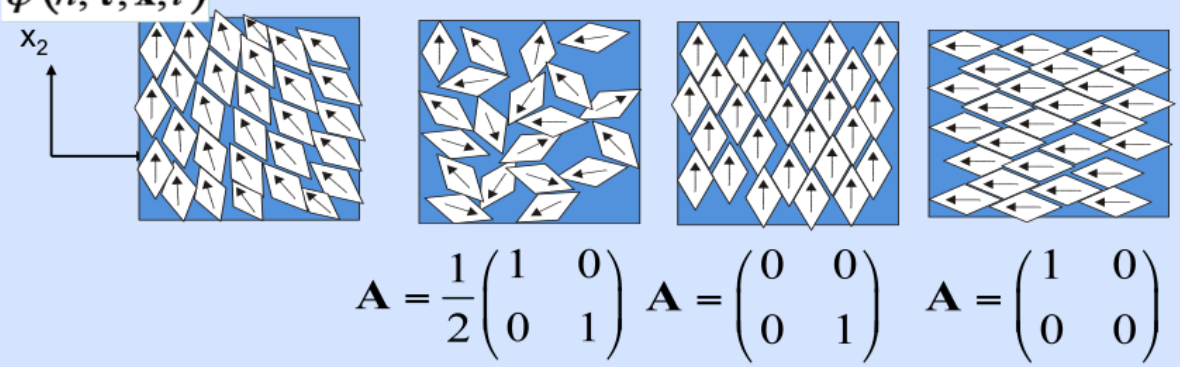
Elliott et al., “Pan-Arctic simulation of coupled nutrient-sulfur cycling due to sea ice biology,” J. Geophys. Res., 2012.

Anisotropic Rheology

EAP

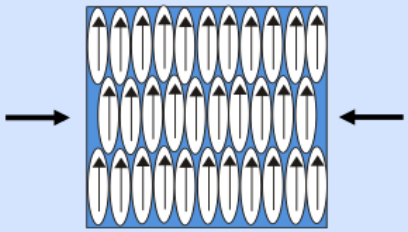
The degree of local anisotropy is estimated by the structure tensor **A**

$\psi(h, \boldsymbol{\tau}; \mathbf{x}, t)$



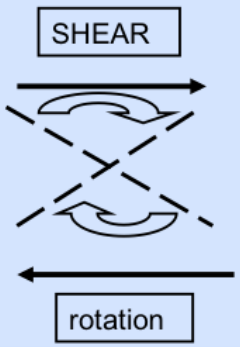
$$\mathbf{A} = \frac{1}{2}\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad \mathbf{A} = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \quad \mathbf{A} = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$$

$$\mathbf{A} \equiv \langle \boldsymbol{\tau} \otimes \boldsymbol{\tau} \rangle = \int \psi \tau_i \tau_j \, dh d\boldsymbol{\tau}$$



Stress depends on lead orientation, **A**

$$\sigma = \sigma(h, \dot{\varepsilon}, A)$$



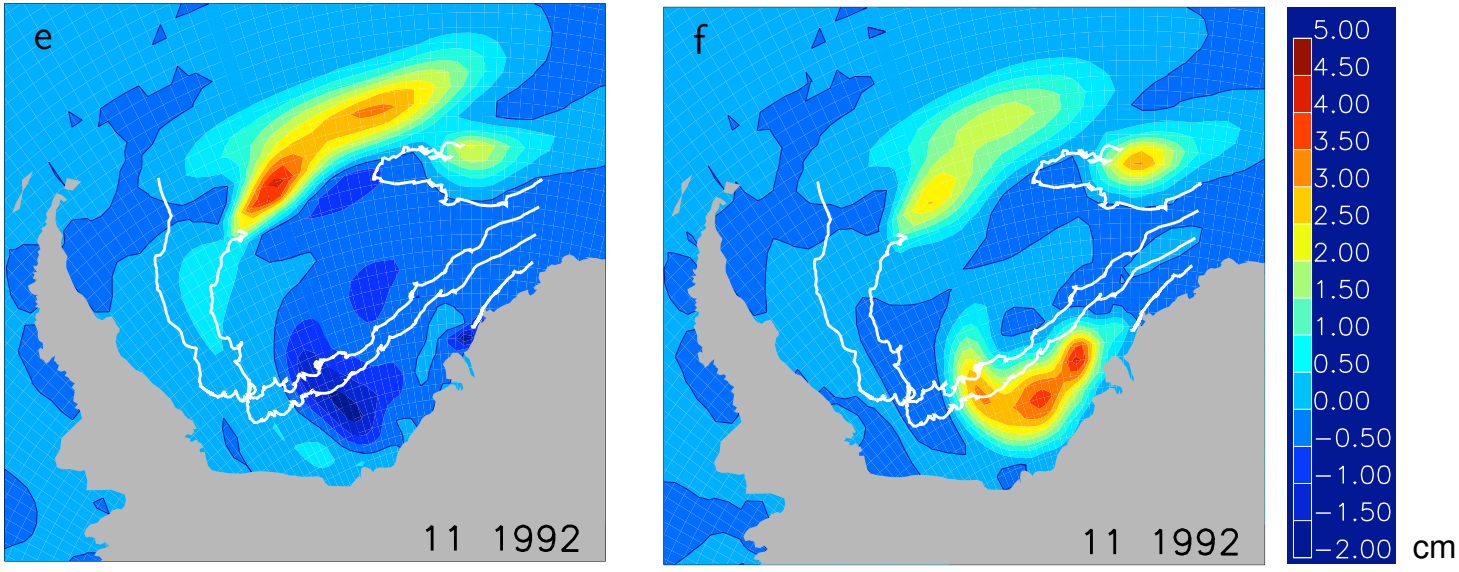
Lead orientation, **A,** evolves

$$\frac{DA}{Dt} = F_{therm}(A) + F_{frac}(A, \sigma)$$

elastic
anisotropic
plastic

M. Tsamados et al.
CPOM
U. Reading, UK

Icebergs in CICE



Δ deformed ice h Δ level ice h

$\Delta =$ with bergs - without bergs

Evaluating: Thermodynamics
Size distribution
CESM coupling

Future: Berg mass flux from CISM

E. Hunke and D. Comeau, Sea ice and iceberg dynamic interaction. *J. Geophys. Res.* **116**, 2011.