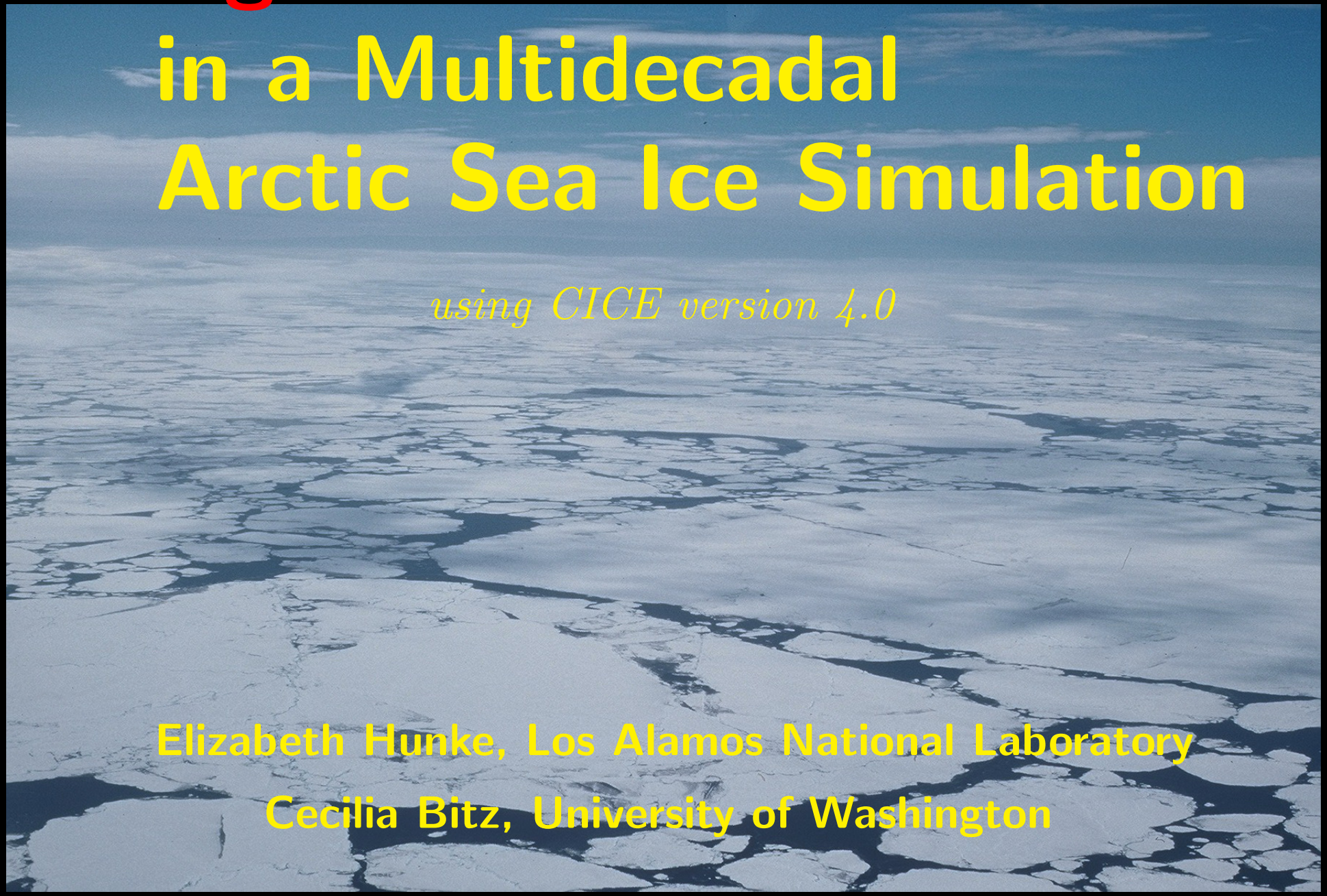
Age Characteristics in a Multidecadal Arctic Sea Ice Simulation



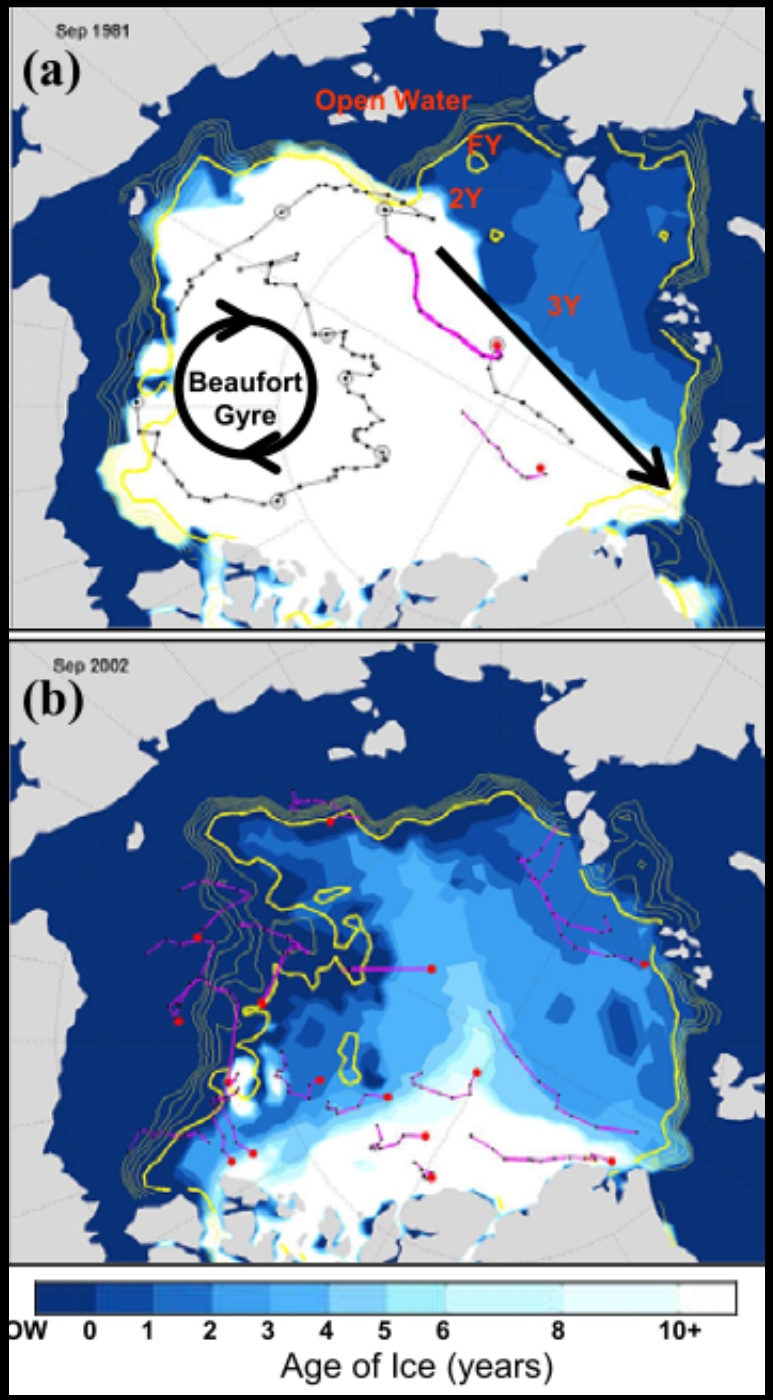
using CICE version 4.0

Elizabeth Hunke, Los Alamos National Laboratory

Cecilia Bitz, University of Washington

Ice age: So What?

- Can be deduced from satellite observations
- Related to ice physical properties (albedo, salinity, thickness)
- Might be useful for prediction of near-future ice pack
- Seasonal ice pack implies simpler logistics/shipping
- Ecosystem ramifications

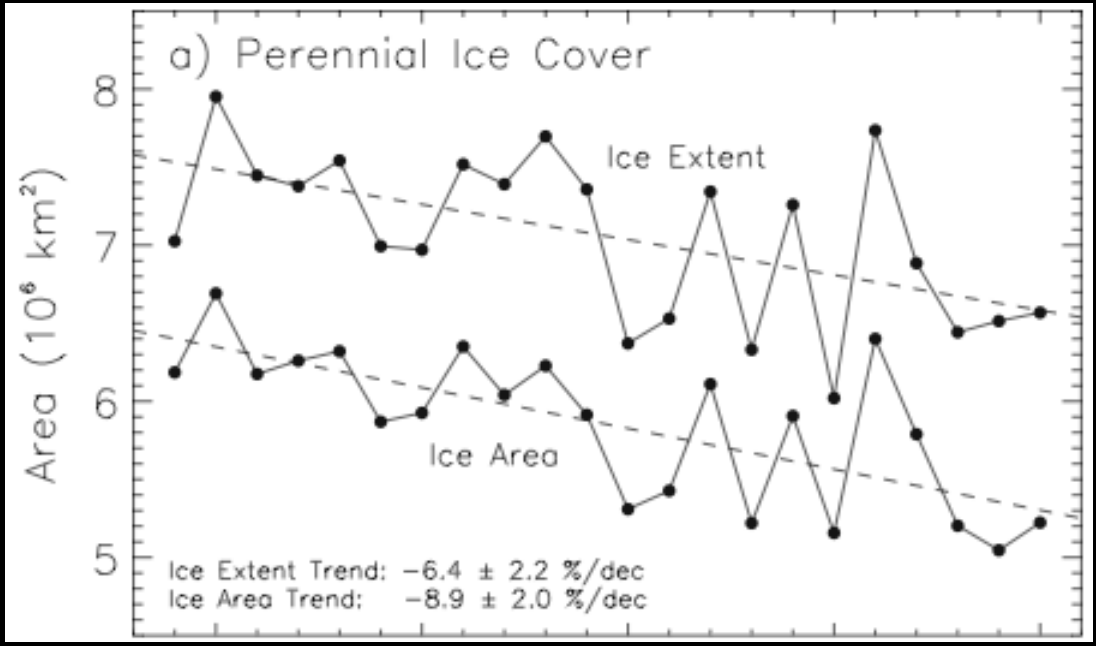


I. G. Rigor and J. M. Wallace, Geophys. Res. Lett. **31**, 2004

September 1981

September 2002

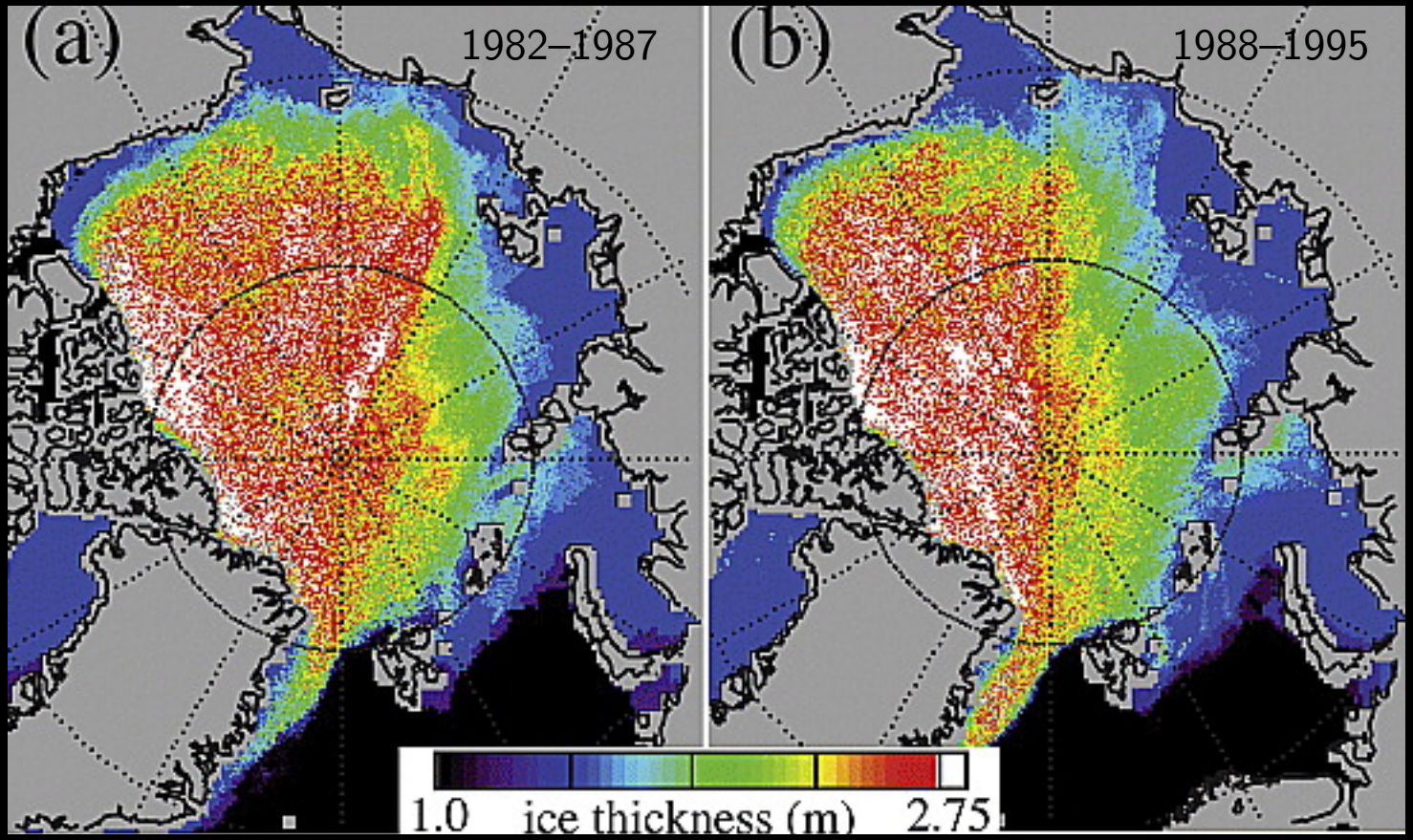
Observations



J. C. Comiso, Geophys. Res. Lett. **29**, 2002

- All use satellite-derived ice concentration
- Most use ice velocity (buoy, AVHRR, etc.)
- Some use ice thickness (elastic-gravity waves, laser altimeter)

Thickness proxy



Maslanik et al., Geophys. Res. Lett. **34**, 2007

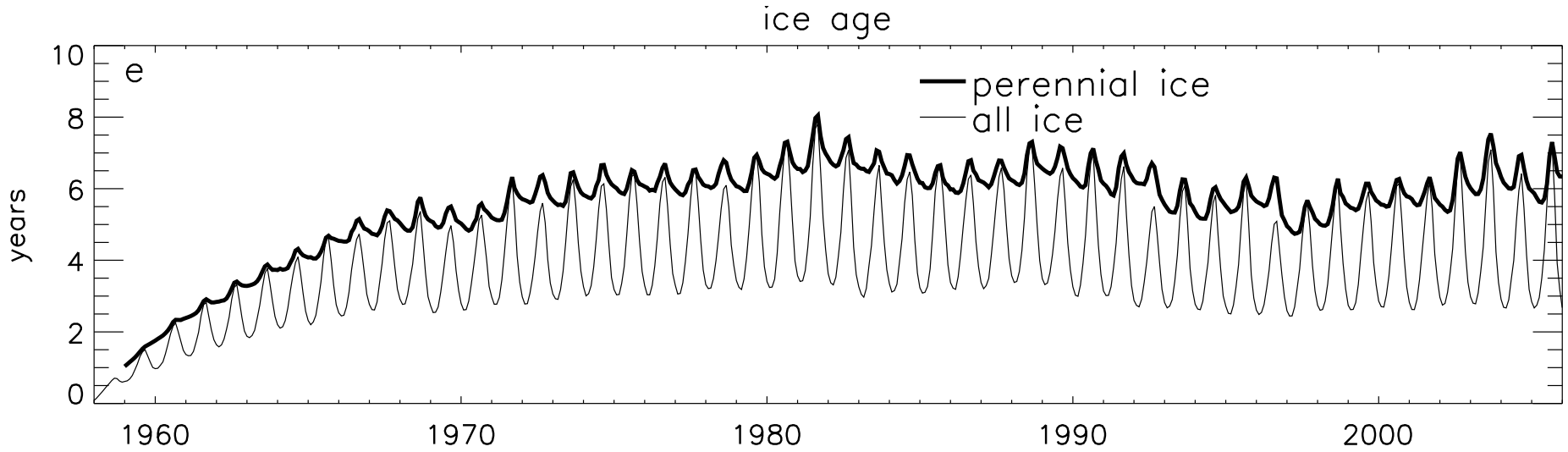
CICE

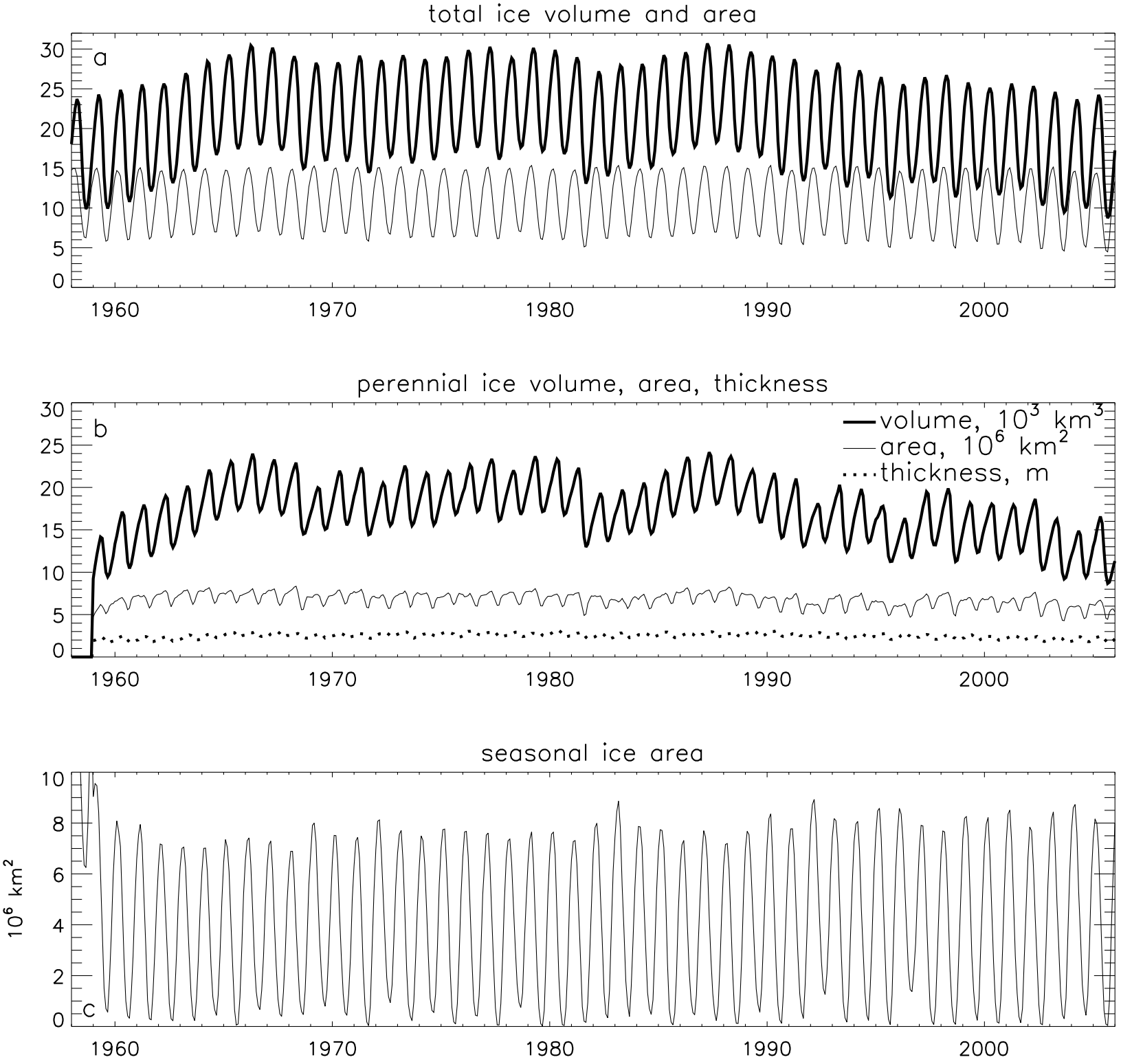
version 3.14	**version 4.0**
energy conserving, multi-layer thermodynamics	multi-layer snow
ice thickness distribution with 5 categories and open water	multiple-scattering radiation
variables/tracers (for each thickness category):	
ice area fraction	ice age
ice/snow volume in each vertical layer	melt 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:* web, subversion repository

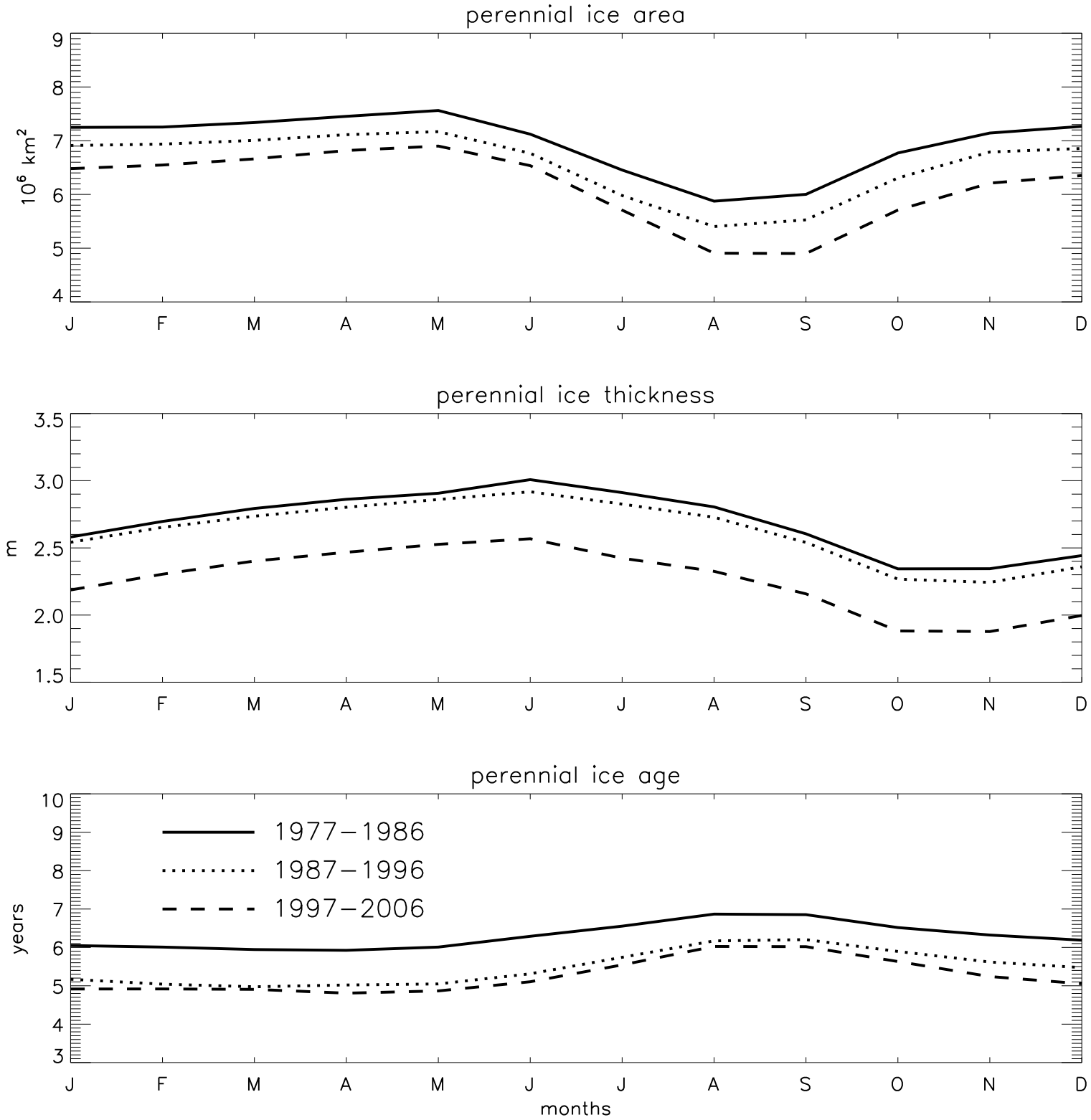
Configuration and Forcing

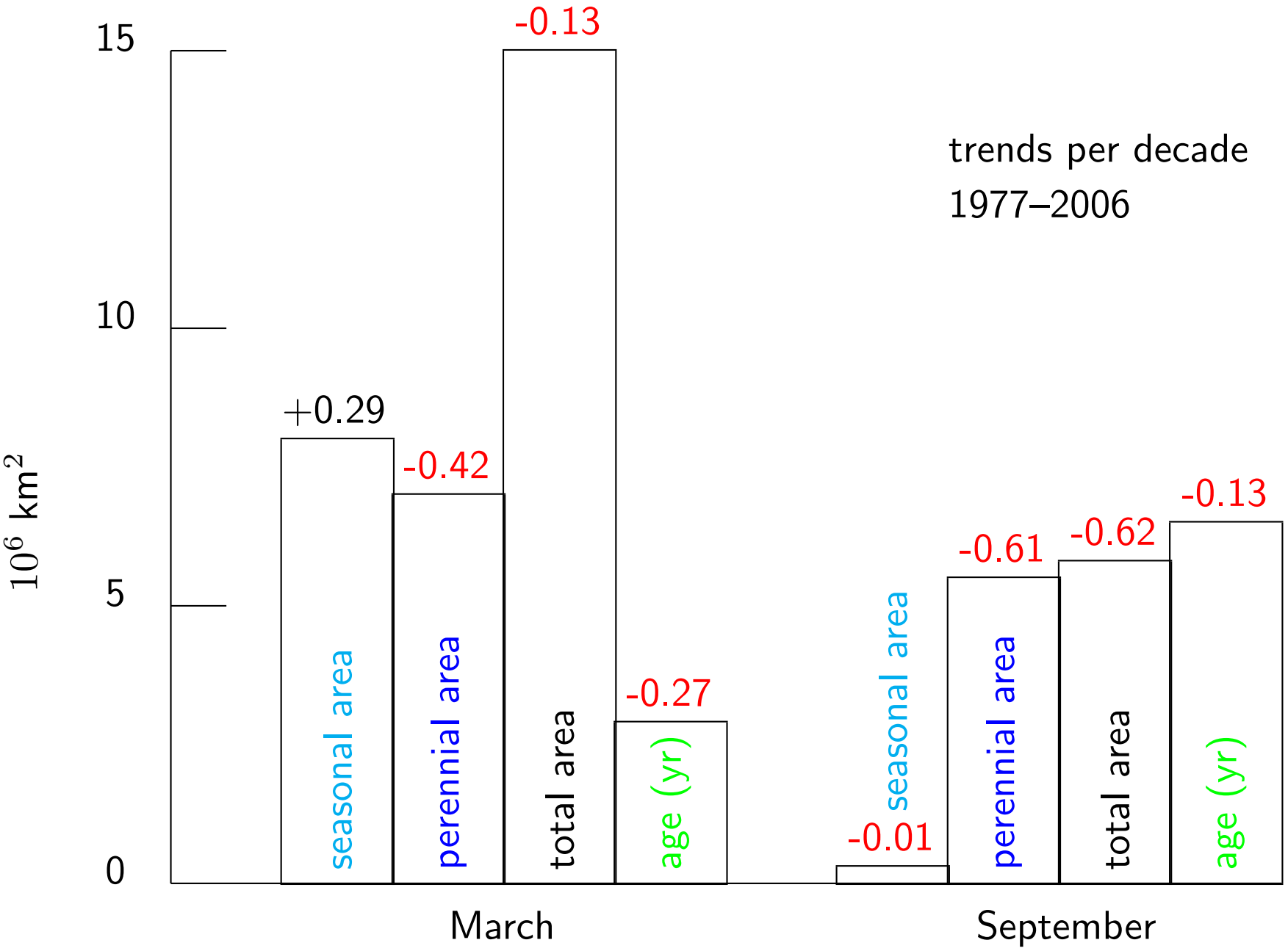
320×384 (1°) displaced-pole grid

air temperature humidity wind precipitation	modified CORE atmo forcing $1958 - 2006$
SST salinity deep ocean heat flux	CCSM/POP ocean output monthly climatology
radiation	AOMIP

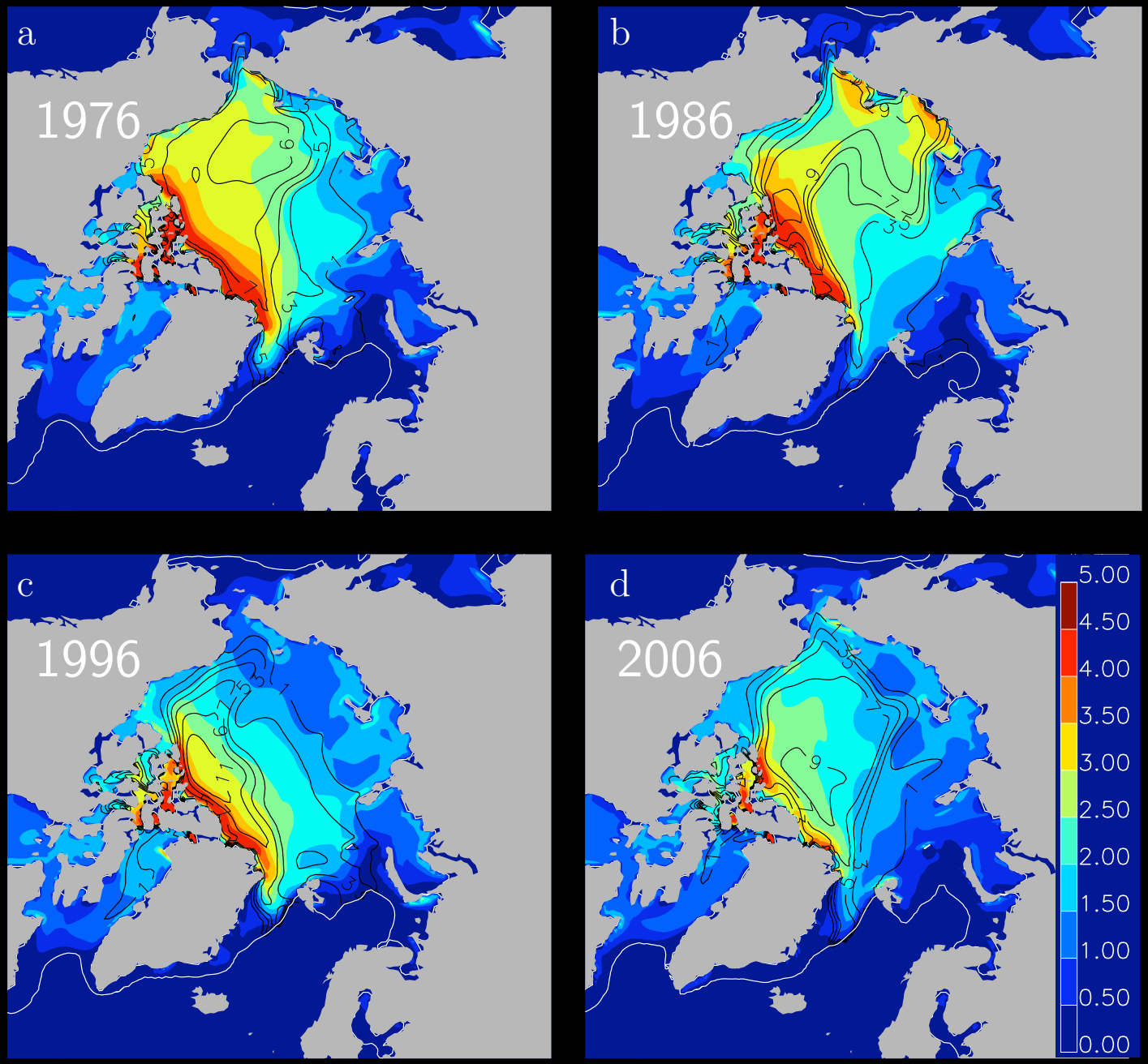

ice age
e
perennial ice
all ice
years
10
8
6
4
2
0
1960
1970
1980
1990
2000

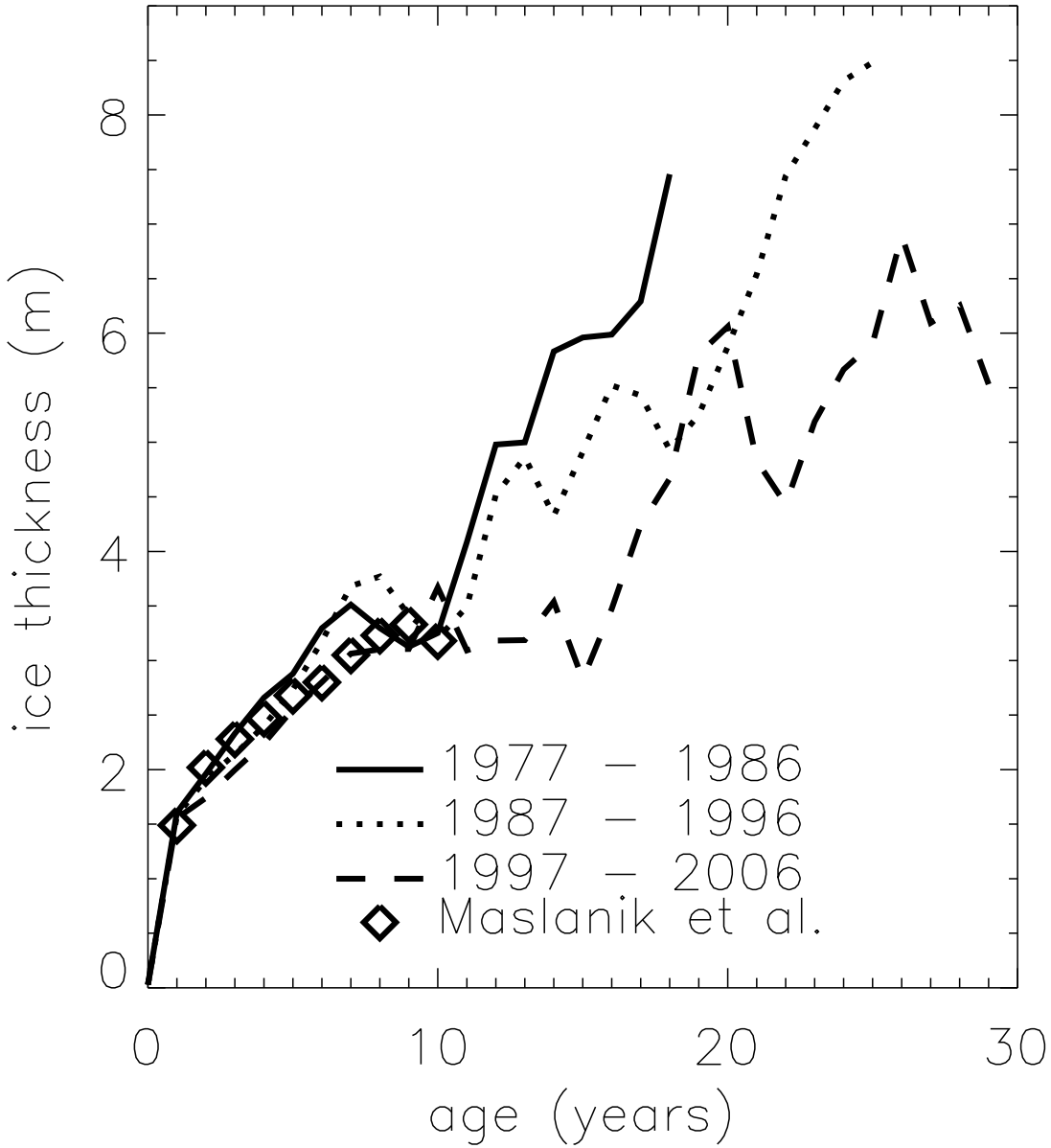

total ice volume and area
a
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
perennial ice volume, area, thickness
b
volume, 10^3 km^3
area, 10^6 km^2
thickness, m
seasonal ice area
10^6 km^2
c
10
8
6
4
2
0

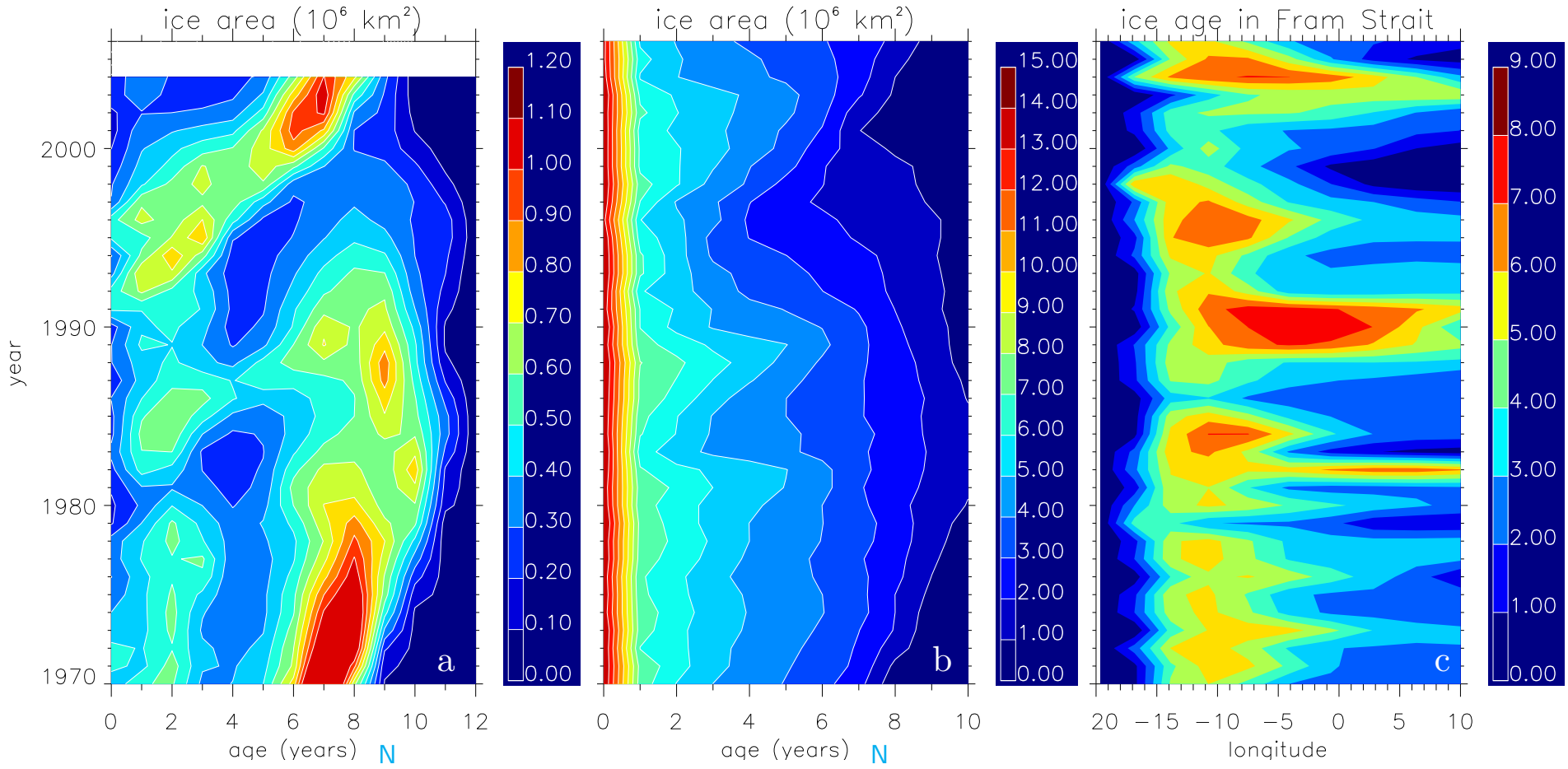

perennial ice area
10^6 km^2
9
8
7
6
5
4
J F M A M J J A S O N D
perennial ice thickness
m
3.5
3.0
2.5
2.0
1.5
J F M A M J J A S O N D
perennial ice age
years
10
9
8
7
6
5
4
3
1977–1986
1987–1996
1997–2006
J F M A M J J A S O N D
months


15
10
5
0
10^6 km^2
+0.29
-0.42
-0.13
-0.27
-0.01
-0.61
-0.62
-0.13
seasonal area
perennial area
total area
age (yr)
seasonal area
perennial area
total area
age (yr)
March
September
trends per decade
1977–2006

March ice thickness and age




ice thickness (m)
0
2
4
6
8
0
10
20
30
age (years)
1977 – 1986
1987 – 1996
1997 – 2006
Maslanik et al.



September
total area of age N
4-year running mean

March
cumulative area
$\geq$ age N

March
age in Fram Strait

Summary

— a consistent simulation of sea ice age, dynamics, and thermodynamics —

In agreement with observations:

- accelerating loss of perennial ice over last 3 decades
- a large spatial-scale, multi-year, average sea ice thickness–age relation holds
- anomalously high flushing of older ice through Fram Strait in high-index AO years led to declining average ice age

In addition:

- age is not a good proxy for sea ice thickness at smaller scales
- during more neutral AO years, age recovers but area, thickness and volume do not
- younger ice classes have again declined since 2000

In coming decades, it is possible that the age of the Arctic ice pack will fluctuate between younger and older ice types, sometimes exhibiting bimodal age distributions, before becoming completely dominated by seasonal ice.

AOMIP

Ice age: a diagnostic

- reasonably simple to implement
- comparable with observations
- additional insight for model comparisons?