Comparison of Arctic Simulations in Large-Scale Climate Models: Results from the Community Arctic Modeling Project (CAMP) Workshop

held in Madison, WI

May 20-22, 2002

Sponsored by International Arctic Research Center (IARC)

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Climate models have traditionally shown considerable inaccuracy in their simulations of the Arctic. This shortcoming is particularly troubling nowadays, because the Arctic is the region expected to undergo the most extreme climate changes in the future. Difficulties in simulating this region stem from a combination of numerical and physical conditions unique to high latitudes. To assess the current status of Arctic simulations in GCMs, the International Arctic Research Center (IARC) recently sponsored a workshop through its Community Arctic Modeling Project, the results of which will be presented here. The goals of the workshop were to (1) identify the most common systematic errors in simulations of the Arctic atmosphere, (2) explore reasons for differences in the Arctic fields simulated by different models, and (3) pursue strategies for reducing model errors in the Arctic. The climatic variables in the Arctic found to be the most challenging to simulate include clouds, surface pressure and winds, sea ice motion, and precipitation. Because most of these variables are atmospheric and show similar biases in both atmosphere-only and coupled atmosphere-ocean models, the key to improving coupled GCM simulations of the Arctic may lie in improving the representation of the atmospheric component.

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Workshop Themes

I. Arctic Climate Variables Needing Improvement
- clouds
- precipitation
- sea ice
- sea level pressure and winds

II. Simulated Arctic Climate Variability
- large inter-model variability

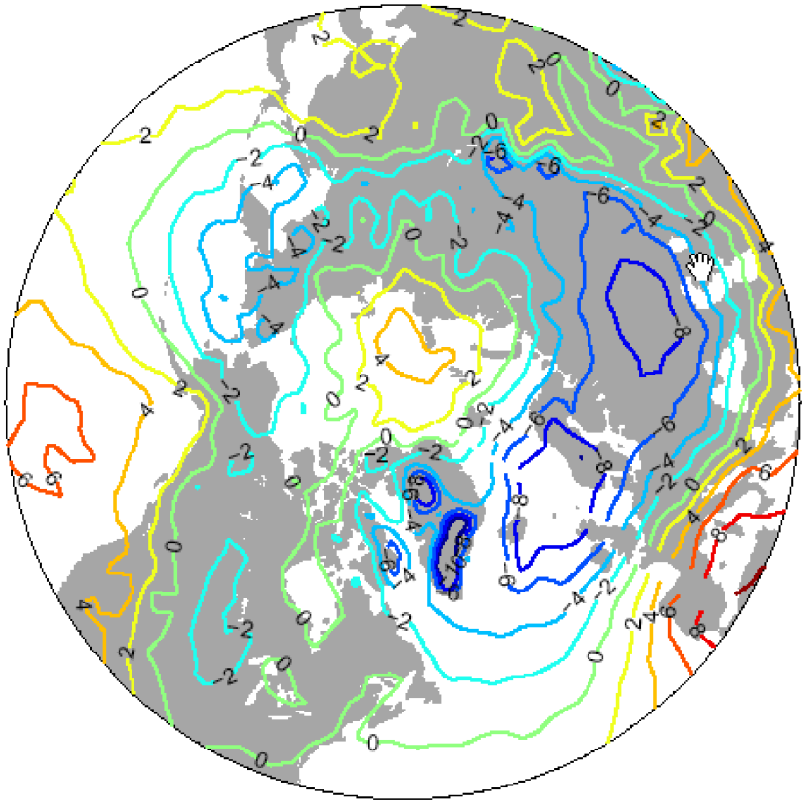
III. Simulated Arctic Climate Sensitivity
- greenhouse gas forcing
- warm paleoclimate simulation of Last Interglacial

IV. Numerical Issues
- importance of model resolution
- role of Regional Climate Models

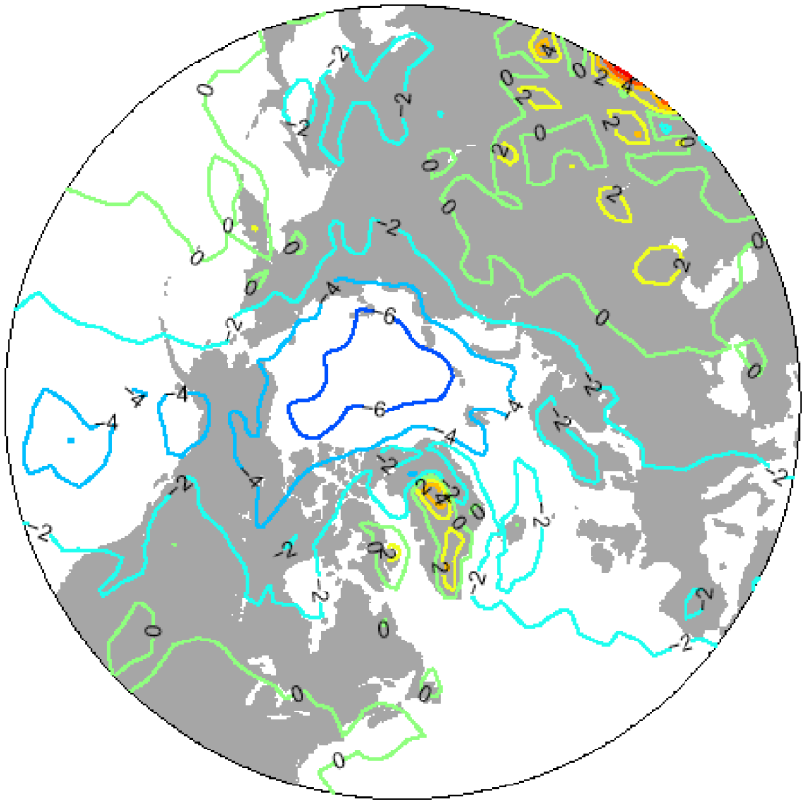
V. Consequences of Coupled, Global Models
- impact of remote processes affecting Arctic

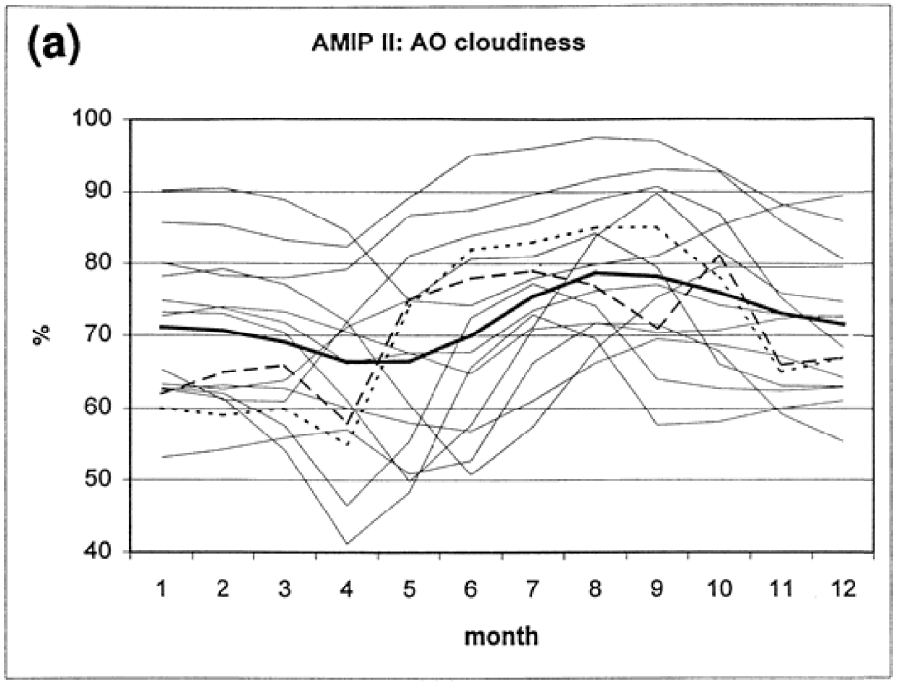
DJF Sea Level Pressure Bias

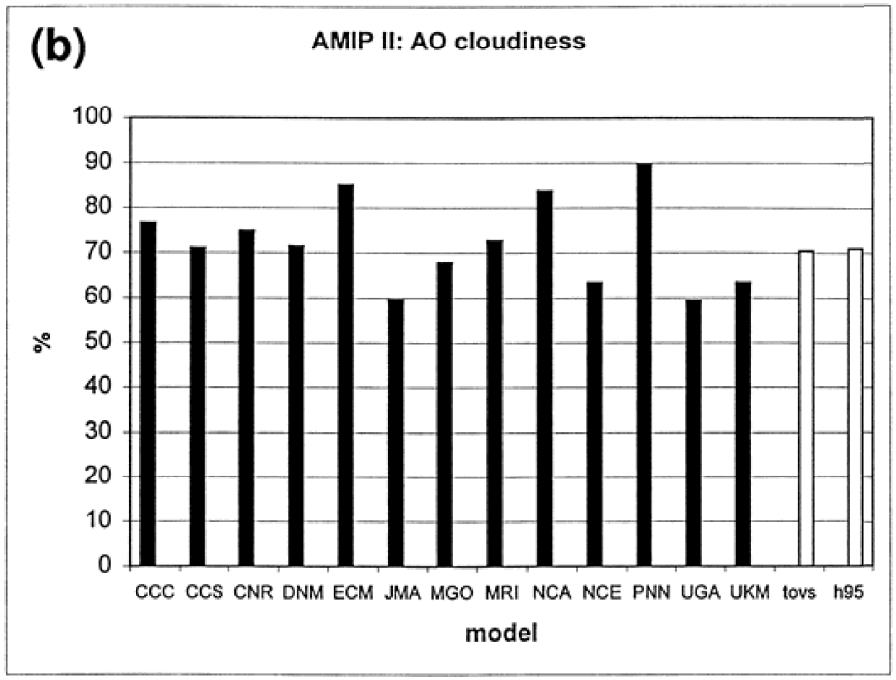
T42 minus NCEP

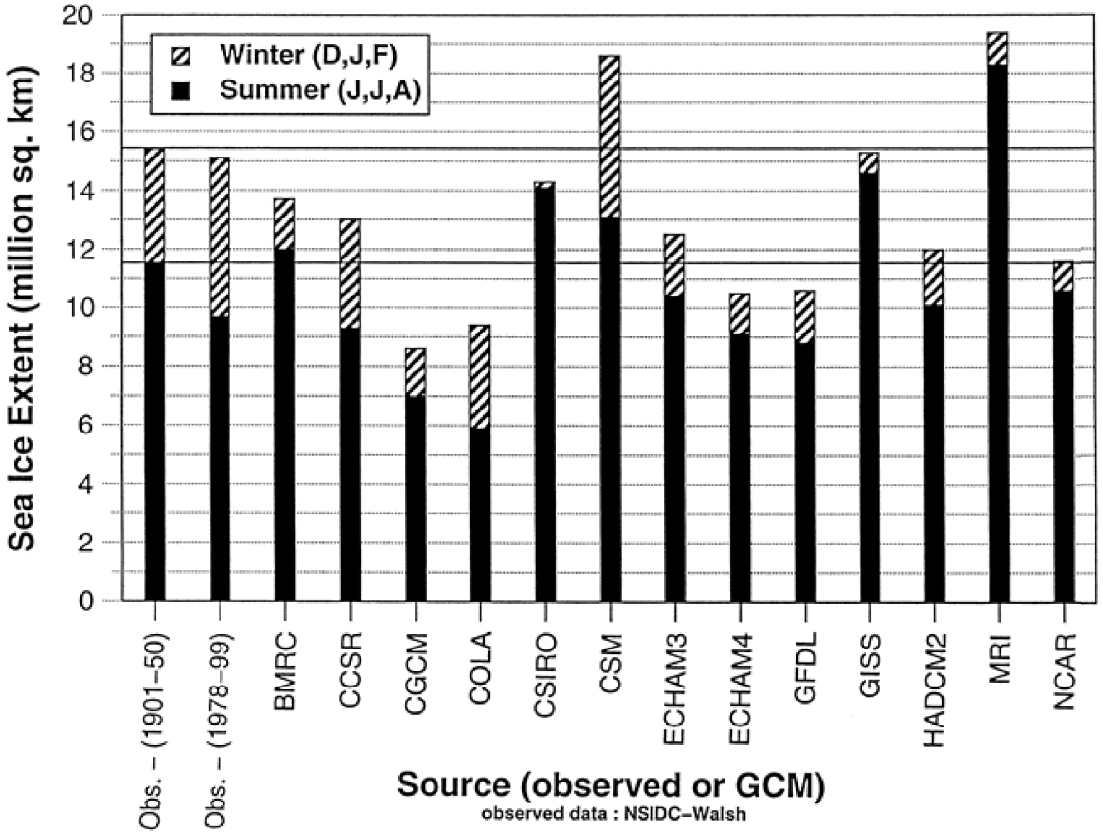


T85 minus T42




(a)
AMIP II: AO cloudiness
100
90
80
70
60
50
40
%
1
2
3
4
5
6
7
8
9
10
11
12
month


(b)
AMIP II: AO cloudiness
100
90
80
70
60
50
40
30
20
10
0
%
CCC
CCS
CNR
DNM
ECM
JMA
MGO
MRI
NCA
NCE
PNN
UGA
UKM
tovs
h95
model


Winter (D,J,F)
Summer (J,J,A)
Sea Ice Extent (million sq. km)
0
2
4
6
8
10
12
14
16
18
20
Obs. – (1901–50)
Obs. – (1978–99)
BMRC
CCSR
CGCM
COLA
CSIRO
CSM
ECHAM3
ECHAM4
GFDL
GISS
HADCM2
MRI
NCAR
Source (observed or GCM)
observed data : NSIDC–Walsh

CMIP Arctic Climate Sensitivity

19 Models
1%/year CO_2 increase

Control Simulations

	Mean	Bias	Range
Air Temperature	-11.4°	+1.5°	-4.3° – (-21.8°)
Precipitation	1.21 mm/d	+25%	0.91-1.57 mm/d

2 x CO_2 (Year 60-80 Mean)

	Mean	Range
Arctic Air Temperature Change	+3.4°	1.4°-7.6°
Global Air Temperature Change	+1.75°	1.1°-3.1°
Arctic Precipitation Change	+11%	4%-24%
Global Precipitation Change	+2.5%	-0.2%-5.6%

Conclusions

- Many climate models show similar errors whether coupled or uncoupled (SLP, clouds, precipitation)
- There is a large scatter of simulated Arctic variables among models, both for modern and future climates
- Higher atmospheric resolution may be necessary to simulate accurate Arctic SLP (and surface winds, ice drift)
- Models with a prognostic cloud water parameterization seem to more accurately reproduce Arctic cloud cover
- Approaches to improve simulated Arctic climate must carefully account for the remote impacts from lower latitudes