Arctic Climate and Climate Change in the CCSM2.0
Evaluation and Comparison to Other Coupled Models

Marika Holland
National Center for Atmospheric Research

In Collaboration with
Cecilia Bitz, U. Washington
Introduction

* The Community Climate System Model (CCSM2.0) has just recently been released

  Control integration underway (at 600+ years)

  1% increasing CO2 run performed (out to 4XCO2 levels)

  Components of CCSM2 will take part in AOMIP and ARCMIP

* Brief Evaluation of CCSM2.0 Polar Simulation and Comparison to Observations

* Analysis of Climate Change Simulations

  Comparison to Coupled Model Intercomparison Project

  Indication of processes that modify simulated polar amplification
Model Description

Community Atmosphere Model
- Builds on CCM3
- 26 vertical levels, T42 resolution
- prognostic cloud water formulation
- generalized cloud overlap scheme
- new longwave absorption/emission by water vapor

Parallel Ocean Program
- anisotropic horizontal viscosity
- eddy mixing parameterization
- KPP vertical boundary layer mixing
- more accurate equation of state
- displace pole grid, <1 degree resolution
- open Bering Strait, CAA

Community Sea Ice Model (CSIM)
- subgridscale ITD
- multiple vertical layers
- EVP dynamics
- same resolution as ocean model

Community Land Model (CLM)
- sub–grid mosaic of land cover and plant types from satellite
- 10 layer soil model
- multi–layer snow model
- river routing scheme on 0.5 degree grid
CCSM2 Ice Conditions

Mean JFM Ice Conditions

White line = 10% SSMI Contour

Mean JAS Ice Conditions
Ice Velocity and SLP

ANN Mean Case b20.007

Ice velocity cm/s

180
150E
150W
120E
120W
90E
90W
60E
60W
30E
30W
0

2 4 6 8 10 12 14 16 18 20

Avg Simulated PSL (cint=2)

Avg NCEP PSL (cint=2)
Average River Runoff

Alaska+Northwest Canada

Northern Europe

Western Siberia

Eastern Siberia

Observations

Model
Global Average Temperature Change

Global Annual Temp Change

- ech3
- giss
- bmrc
- mri
- ccsr
- ccc
- ncar_csm
- ukmo
- gfdl
- csir
- ukmo3
- pcm
- ccs

CCSM

CO2 Doubling

Year

0 20 40 60 80
Influence of Ice Extent on Location of Warming

Models with larger ice extent in the control simulation generally obtain maximum warming further south

Correlation of ice extent and latitude of maximum warming = -0.79
CCSM2 has a number of substantial improvements in the Arctic simulations although deficiencies remain.

**Polar amplification**

* Ranges from < 2 to > 4 X the global average warming.

* Location of maximum warming varies considerably

* Magnitude of the polar amplification is related to the control climate sea ice conditions
  - larger amplified warming associated with thin ice
  - higher amplification with larger ice extent
  - more southerly warming with larger ice extent

* Some models do not agree with these conclusions, related to feedbacks associated with other model physics (ocn transport, clouds, etc)

Across model comparison generally agrees with Rind et al studies. This further indicates the need for realistic sea ice simulations in climate models.