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FUTURE POLAR CLIMATE CHANGE SIMULATIONS WITH THE CCSM3

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1. INTRODUCTION

The new Community Climate System Model version 3 (CCSM3) has been developed and has recently been released. We will show the simulations of Arctic sea ice in two aspects: climatology in the past two decades and future trends in IPCC scenarios.

The model has significant advances in all major climate components: atmosphere, ocean, land, and sea ice. In particular, the sea ice component of the CCSM3 features an energy conserving thermodynamics from Bitz and Lipscomb (1999), four layers of ice and single layer for snow. The sea ice has five thickness categories and sea ice ridging formulation comes from Thorndike et al. (1975). The sea ice model makes use of the elastic-viscous-plastic ice dynamics of Hunke and Dukowicz (1997, 2002) and incremental remapping scheme of Lipscomb and Hunke (2004). A more complete description can be found at www.ccsm.ucar.edu/models/ccsm3.0/csim/.

We have performed the following ensemble simulations: a historical ensemble from 1870 to 2000 and all the IPCC future scenarios (A1B, B1, A2, 20th century freeze at year 2000 values). In Figure 1 we show the CO_2 concentrations for various IPCC scenarios. Note that other forcing factors causing climate changes such other greenhouse gases and aerosols are not shown in the figure.

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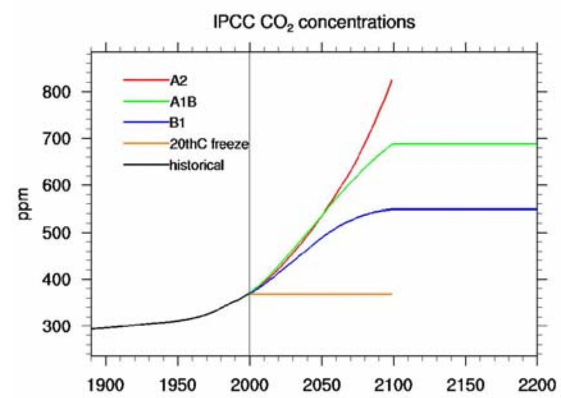

Figure 1. IPCC CO_2 concentrations: In addition to CO_2, the simulations are run with solar, volcanic aerosols, sulfate aerosols, ozone and other greenhouse gases for the period 1870-2000. A spread of CO_2 concentrations for future forcing scenarios is used from years 2000-2200 that also include sulfates aerosols and ozone.

2. DATA SOURCES

The observed 1979-2002 sea ice extent (threshold 15% area) came from Parkinson et al. (1999) and the 1979-1999 sea ice concentrations came from SMMR/SMMI-derived HadIsst data (Rayner et al. 2003).

3. RESULTS

We first show in Figure 2 the sea ice concentrations averaged over 1979 to 1999 and compared the historical sea ice concentrations from the CCSM3. The general patterns of modeled sea ice concentrations are quite similar in the winter months of January, February, and March. There is more sea ice in the Labrador Sea in the model but less in the Barents Sea. Also we have more sea ice in the Sea of Okhotsk. The differences are larger in the summer months of July, August, and September. Generally the sea ice has retreated in the Arctic Ocean but the concentrations are less than the observed.

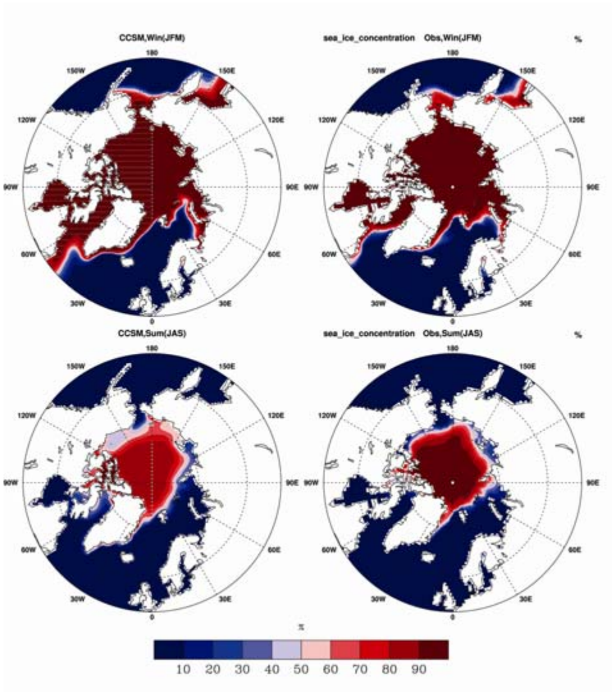

Figure 2. Northern Hemisphere seasonal (JFM and JAS) sea ice concentrations over the years 1979-1999. The model outputs (left panels) are 4-member ensemble means from CCSM3 historical runs. The observations (right panels) are derived from HadISST.

The summer sea ice extent (15% area) from the CCSM3 historical runs agrees well with the observation regarding both the exact values and the decreasing trends (Figure 3). The A2 and B1 scenarios suggest the Arctic sea ice extent will keep decreasing in the 21st century. Note in Figure 1 that the A2 scenario has an increasing positive trend and exceeds the other two emission curves after the 2050's. Eventually Arctic sea ice almost disappears in the A2 scenario at the end of the 21st century.

We will be showing results of the trends in sea ice concentration and sea ice thickness compared to the observed along with ocean circulations changes and North Atlantic ocean thermohaline circulation changes from present to future. By the use of a higher horizontal resolution atmospheric model (T85) we can show a better sea ice distribution than a simulation with lower resolution. However, resolution alone does not explain model deficiencies.

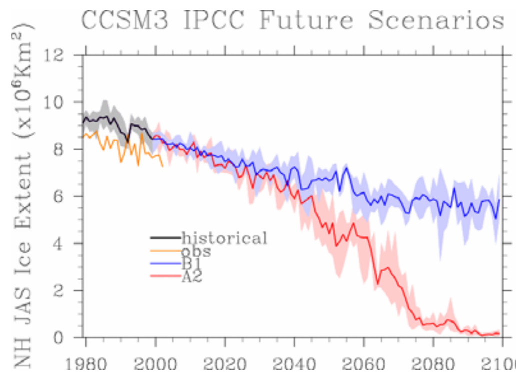

Figure 3. Northern Hemisphere summer mean (JAS) sea ice extents from observation (Parkinson et al. 1999) and CCSM3 simulations, which include the historical runs during 1979-2000, A2 and B1 runs during 2000-2099. The shading indicates the spread within the ensemble members.

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