# Late 20th century simulation of Arctic sea-ice and ocean properties in the CCSM4


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## Objective

**Evaluate the CCSM4 Arctic sea-ice simulation**

## Introduction

Previous studies have shown the importance of realistic sea-ice conditions in climate model simulations for studies of Arctic climate change in the 20th and 21st centuries (Stroeve et al., 2007; Holland et al., 2010). It is therefore important to evaluate the performance of climate models in the 20th century. We here show some selected results from the evaluation of the sea-ice simulation from the new, fully-coupled global Community Climate System Model version 4 (CCSM4), using six 20th century ensemble members. Unless otherwise noted, the period used for the comparisons is 1981-2005.

## Seasonal cycle of sea-ice extent

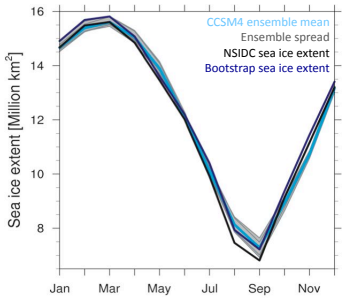


**Figure 2:** Seasonal cycle of the Arctic sea-ice extent from the CCSM4 and satellite data (NSIDC ice extent from Fetterer et al. (2002), which uses the NASA algorithm, and bootstrap ice extent calculated from the sea-ice concentration data of Comiso (1999), which uses the AMSR-E algorithm).

- The seasonal cycle of the Arctic sea–ice extent is well captured in the CCSM4 compared to the satellite-derived sea-ice extents

## September sea-ice extent

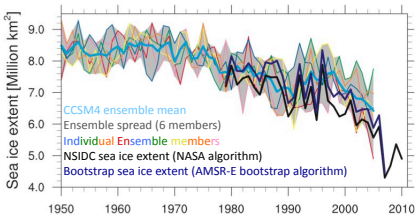


**Figure 3**: September sea-ice extent timeseries from the CCSM4 and satellite data

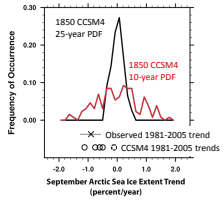


**Figure 4**: Probability density function of September sea-ice extent trends in the 1850 CCSM4 simulation, compared with observed and simulated 25-year

- The CCSM4 ensemble simulations suggest that the 1981-2005 sea-ice extent trend has a strong imprint of natural variability
- The observed sea-ice extent trend is bracketed by the trends in the six ensemble simulations, but is on the high end → this suggests that natural variability has enhanced the observed sea-ice loss

## Sea-ice thickness

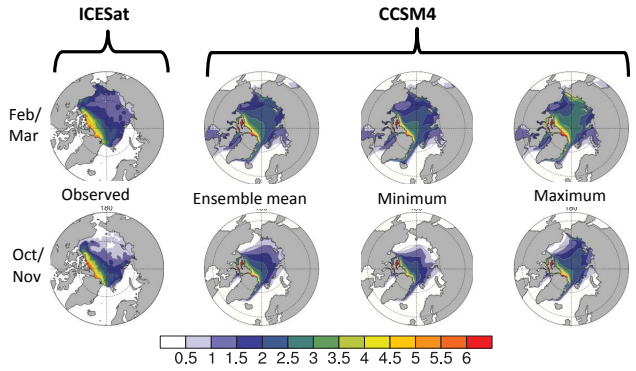


**Figure 2:** 5-year average sea ice thickness [m] in the early 21st century from ICESat (Kwok et al., 2009) and the CCSM4 (ensemble mean & ensemble member with minimum/maximum thickness) for Feb/Mar and Oct/Nov

- The sea-ice thickness is well simulated by the CCSM4 compared to ICESat-derived ice-thickness
- The variability between the six ensemble members is quite large
- The largest biases in the CCSM4 simulation are a too small area of very thick (>4 m) ice north of Greenland and the Canadian Arctic Archipelago and too thick winter sea ice over the Eurasian shelves

## Sea-ice motion

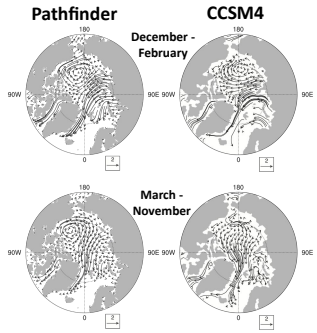


**Figure 5:** Climatological sea ice motion [cm/s] from pathfinder data (Fowler 2003) and the CCSM4

- Due to a strong sea level pressure bias in the CCSM4 simulation, the Beaufort Gyre is too weak and is displaced towards the East Siberian Sea
- A cyclonic sea-ice circulation in the Beaufort Sea is only simulated for December to February

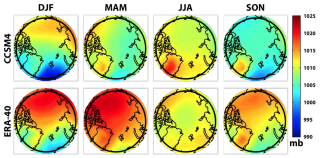


**Figure 6:** Climatological sea level pressure from CCSM4 and ERA-40

Figure courtesy of G. de Boer, de Boer et al. (2011)

## Conclusions

- **The CCSM4 simulates the sea-ice thickness and the seasonal and temporal evolution of the ice extent well compared to observations.**
- **The simulated sea-ice extent trend over 1981-2005 shows a strong imprint of natural variability, with one ensemble member showing a larger trend than observed and two ensemble member showing no significant trend for this period.**
- **The largest bias in the sea-ice simulation is found in the simulated sea-ice motion field between March and November, when the Beaufort Gyre is absent.**
- **More details and an evaluation of the multiyear ice fraction, the timing of melt onset and freeze-up, and of the oceanic simulation in the Arctic can be found in Jahn et al. (2011, Journal of Climate).**


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