ABSTRACT

In this modeling study, NASA GISS ModelE atmospheric general circulation model was employed to investigate the atmospheric response to winter (DEC-FEB) sea ice anomalies. Two sensitive cases were simulated, one used 10-yr linear trend of winter sea ice concentration in the high latitude of northern hemisphere from 40°N to 90°N (Atrend) as the imposed boundary forcing and the other used 10-yr linear trend of winter sea ice concentration in north Pacific sector (Ptrend, 60-80°N,30°W-45°E). The responses were obtained from the mean difference between the sensitive experiments and the control. The effects of sea ice anomalies on China winter temperature were discussed, especially, the way of China winter response to the sea ice anomalies were further revealed.

KEY WORDS: winter sea ice; anomalies; numerical simulation; response

INTRODUCTION

The global is warming now with the largest amplitude in the higher latitude of northern hemisphere. The largest warming occurs in Arctic region (60°-90°N), and a series of climate changes are taking place there, more severely compared with those in the other regions. As one of the most important climate factors in polar region, sea ice is undergoing unprecedented change. It goes in two ways: firstly, Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I Passive Microwave Data showed that the extent of the Arctic sea ice as a whole has decreased 14% from 1978 to 1996, about 35,000 km² every year (Parkinson et al., 1999). Secondly, Data from submarine observations showed that the average thickness of sea ice in the 1990s is 1.3m thinner than that in the period from 1958 to 1970, i.e. a decrease of about 40% (Rothrock et al., 1999). The more recent observation facts have showed that all these trends are getting more and more rapidly.

The sea ice in Arctic significantly affects the interaction between atmosphere and ocean. Firstly, the high albedo of sea ice creates greatly the absorption of short wave radiation, making polar region the source of cold air in the global climate system. Secondly, the low thermal conductivity of sea ice greatly decreases the exchange of heat, moisture and momentum between the atmosphere and ocean. Thirdly, the forming and melting of sea ice change the perpendicular structure of upper sea water. Studies have showed that Sea ice change can influence the local climate. The decrease of Greenland sea ice in winter goes with the decrease of surface pressure and 500hPa height and the increase of surface temperature (Deser, 2000). Through complex feedback, the sea ice change can affect the large-scale atmospheric, further the global climate. Several Chinese scholars had pointed out that the Arctic sea ice can affect the temperature and precipitation patterns in China through changing storm tracks and subtropical high pressure in northwest Pacific (Fang and Wallace, 1994; Wu et al., 1999, 2001, 2004; Liu et al., 2007).

The effect of sea ice change on the general circulation has received more and more attention. But most earlier studies used idealized sea ice perturbations, such as removing all the sea ice or changing of the extent or concentration of sea ice by means of latitudinal symmetry (Huang, 1992; Murry and Simmonds, 1995). Some recent studies have begun using sea ice anomalies derived from observed data to force atmosphere. Honda et al. (1996) examined the atmospheric response to maximum and minimum sea ice extent in the Sea of Okhotsk, where the difference between the two extreme states of the ice was specified to be approximately twice as large as what had been ever observed. Alexander et al. (2004) carried out a modeling study of the influence of realistic Arctic sea ice anomalies on the atmosphere during the winter with CCM3.6. Model experiments were performed for the winters with the most (1982/83) and least (1995/96) Arctic ice coverage during 1979–99. They indicate that the remote or large-scale response to changes in sea ice depends on the interaction between the anomalous surface fluxes and the large-scale circulation. The local response to ice anomalies over the subpolar seas of both the Atlantic and Pacific is robust and generally shallow. The large-scale response to reduced (enhanced) ice extent to the east (west) of Greenland during 1982/83 resembles the negative phase of the Arctic Oscillation/North Atlantic Oscillation (AO/NAO). The large-scale response was distinctly different in the Pacific.

In this Study, the responses of winter general circulation and temperature to sea ice anomalies are mainly discussed. What sets our experiments apart from many other AGCM studies is the realistic spatial structure of the boundary forcing. Real sea ice change per