RECENT ARCTIC AND ANTARCTIC CLIMATE CHANGE: A BRIEF REVIEW

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During the preindustrial period, the atmospheric carbon dioxide and methane concentration were about 280 ppm and 700 ppb, while now they are more than 380 ppm and 1700 ppb, respectively. This rate of greenhouse gas increase is unprecedented for the past million years (Brook, 2008). In response to the marked increase in greenhouses gases, polar regions are known to be more sensitive than other areas due to the 'polar amplification' associated with the presence of snow and ice. In the Arctic, a rapid increase in surface temperature and marked reduction in sea ice extent has been observed in recent years. For example, in 2007 the September sea ice extent was observed to be 4.28×10^6 km^2, which is about 23% lower than previous record minimum of 2005 (Fig. 1), and ice thickness decreased to 2.0 meters from 2.6 meters from March 1987 (Stroeve et al., 2008). The reduction of sea ice extent and thickness is associated with the increase in surface air temperatures which were greater than 6°C in 2007 relative to the 1958-1998 average and sea surface temperature which increased to 3.5°C in parts of the Arctic Ocean.

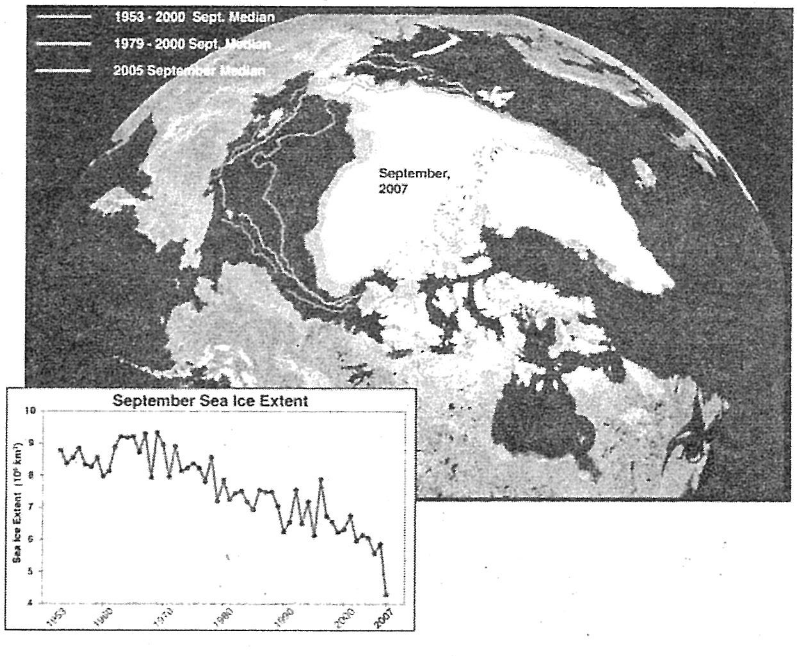

Fig. 1 Sea ice concentration for September 2007, with sea ice extent from 1953 to 2000 (red), 1979 to 2000 (orange), September 2005 (green). Sea ice extent time series is also shown. From Stroeve et al. (2008).

Several factors are responsible for the surface temperature increase in the Arctic in recent years such as the increase in greenhouse gas, change in atmospheric circulation, and ice albedo feedback. Due to the large natural variability, it is hard to distinguish the role of greenhouse gas on the recent warming. Nevertheless, a series of numerical model simulations showed that the increase in the greenhouse gases was needed to realistically represent the observed Arctic temperature in recent years (IPCC, 2007). The Arctic climate is mainly governed by the Arctic Oscillation (AO), which was in a positive phase from 1989 to 1995, which leads to the sea ice advection out of the Arctic Ocean through the Fram Strait. From the model results with the remarkable sea ice reduction in 2007 it is expected that seasonally ice free Arctic Ocean might be happened as early as year 2030 (Stroeve et al., 2008).

In contrast to the Arctic, the sea ice extent and temperatures in the Antarctic have not been changed in recent years (Monaghan et al., 2008), except for the Antarctic Peninsula where surface temperature increased by about 2°C since 1980 (Vaughan et al., 2001). The marked increase in surface temperature in the Antarctic Peninsula led to the breakup of e.g., the Larsen B ice shelf in 2003 (Scambos et al., 2004). In the Antarctic, the main climate driver is the Antarctic Oscillation (AAO). When the AAO is in positive phase, the southern hemisphere polar vortex tends to be stronger, circumpolar westerly is strengthened, sea ice production increases, and temperatures are colder over Antarctica but warmer over the Antarctic Peninsula due to enhanced temperature advection from the strong westerly winds as shown by Thompson and Wallace (2002). Marshall et al. (2003) showed that the AAO is in an increasing trend in recent decades, primarily due to the seasonal stratospheric ozone depletion and secondarily due to the increase in greenhouse gases.

In conclusion, the Arctic climate change is faster than predicted from model simulations (Stroeve et al., 2007) and from the degree of sea ice loss and greenhouse gas increase it might pass the 'tipping point'. In the Antarctic, the future recovery of stratospheric ozone will eventually lead to an Antarctic warming as predicted by model studies (e.g., Arblaster and Meehl, 2006).

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