Impacts of climate change on sub-surface water temperature

Fisheries and Oceans Canada Pêches et Océans Canada

Zhenxia Long and Will Perrie
Fisheries & Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS, Canada

Canada

1. Introduction

A coupled ice-ocean model (CIOM) is implemented in the Arctic Ocean (Fig.1) to investigate the impacts of Arctic warming on the sub-surface temperature. CIOM simulations are performed for 1979-2069, using the surface driving fields provided by the simulations with Canadian Regional Climate Model (CRCM), driven by the third-generation Canadian global climate model (CGCM3) output fields. The CRCM simulations were performed at a horizontal resolution of 45 km, with 29 levels in the vertical direction. The coupled ice-ocean model (CIOM) consists of two components, the Princeton ocean model and a multi-category Hibler ice model. It has 23 vertical sigma levels, and the horizontal resolution is 0.29°x0.25°.

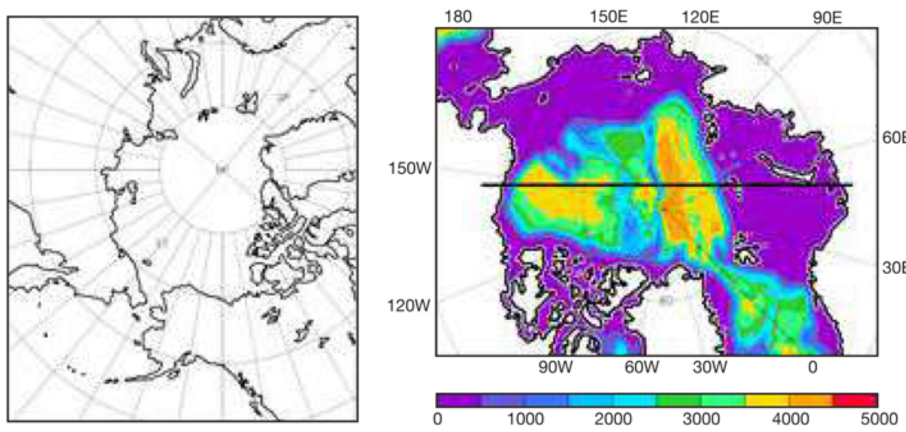

Figure 1 Model domains for CRCM (left) and CIOM (right).

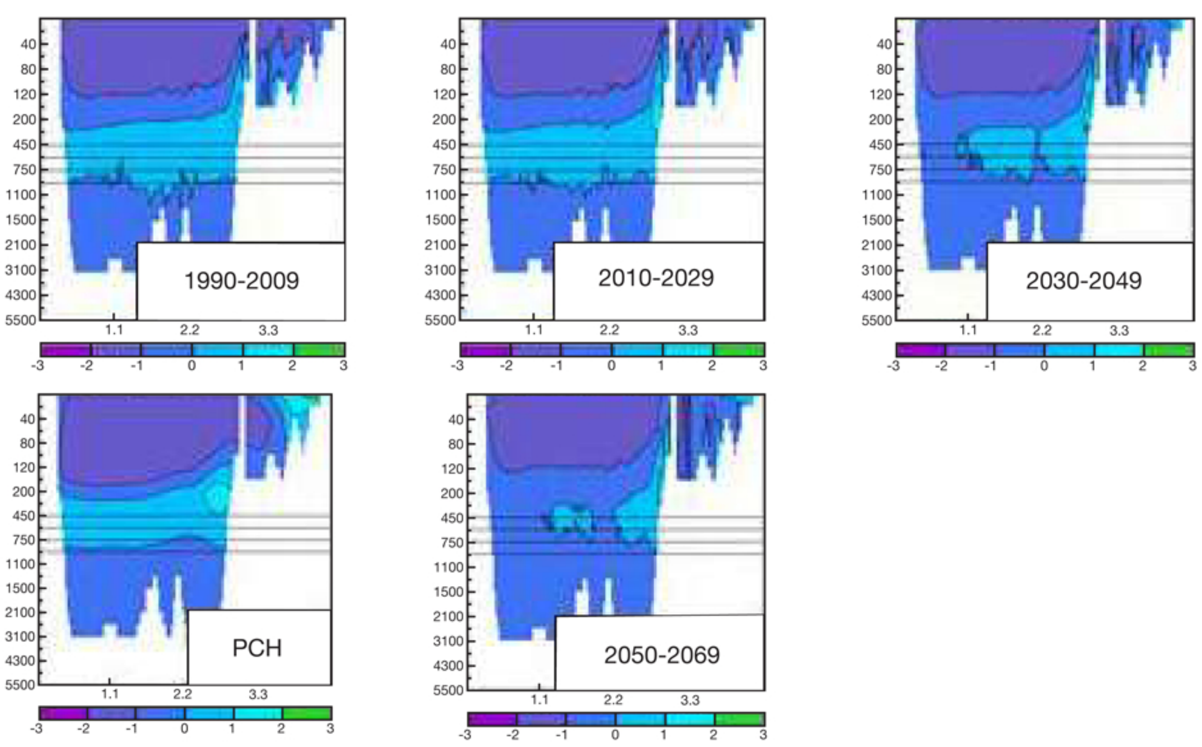

Fig2. Cross section for annual water temperature (°C) as a function of depth (m) along the transect indicated in Figure 1.

2. Results

Compared to PHC data, the warm temperature located between 200-900m has been reasonably simulated by CIOM. In addition, the sub-surface temperature shows a decreasing trend under climate change conditions, particularly in Canada Basin where the warm layer disappears after 2050 (Figs 2 and 4). The water temperature averaged between 200m and 900m decreases by 0.2°C (Fig.3). The decreases in water temperature at 450m gradually extend from Canadian Archipelago to the whole Canada Basin (Fig.4).

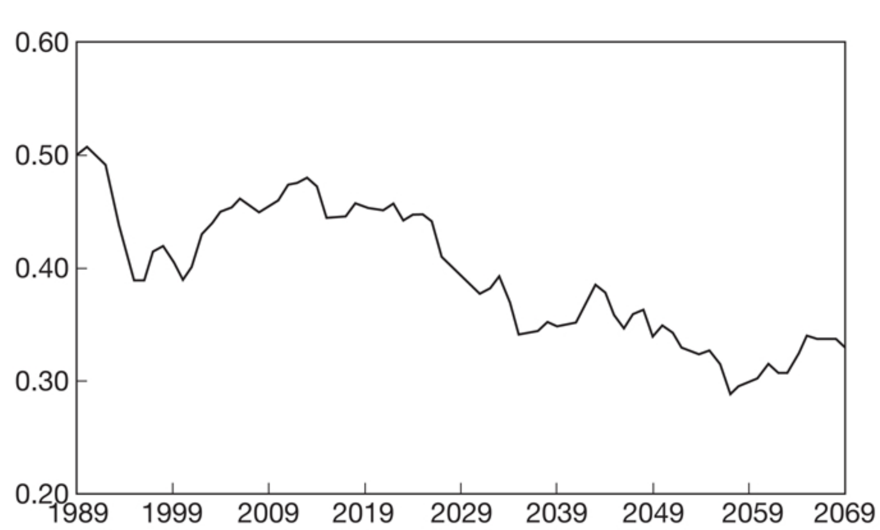

Figure 3 Simulated water temperature (°C) averaged between 200m and 900m.

Observations show that weak vertical mixing is crucial to main Atlantic Water Layer (AWL) in the Arctic Ocean. The Presence of sea ice prevents heat, moisture and momentum exchanges between atmosphere and ocean. The CIOM simulations show a steady decrease of the ice cover in the Arctic Ocean due to the surface warming (Fig.5). Moreover, our results show that the loss of sea ice significantly enhances the surface mixing (Fig.6).

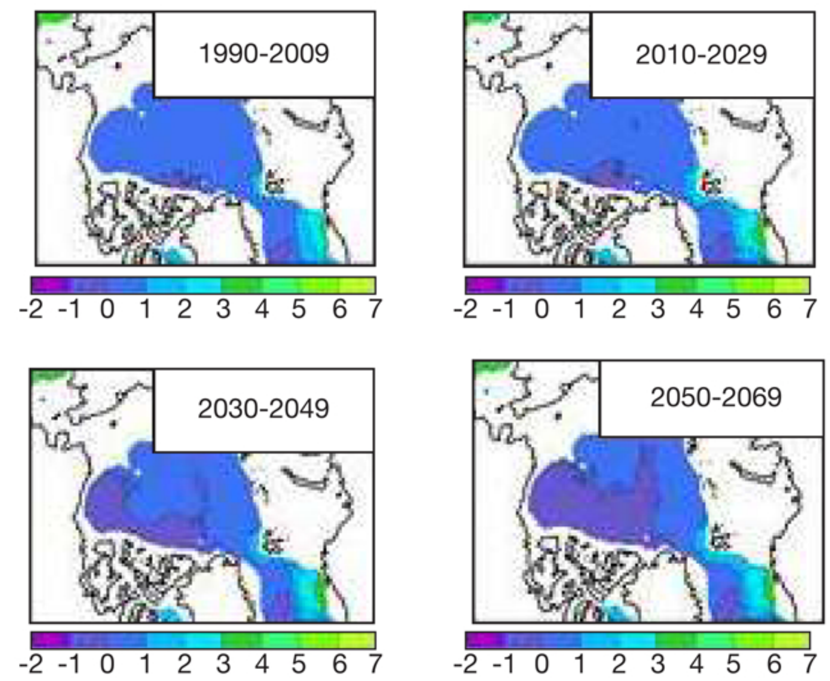

Figure 4 Annual water temperature (°C) at 450m.

In addition, our simulations show a significant increase of sea surface height in the Beaufort Sea (Fig.7), suggesting an enhanced the Beaufort Gyre, which could weaken the AWL.

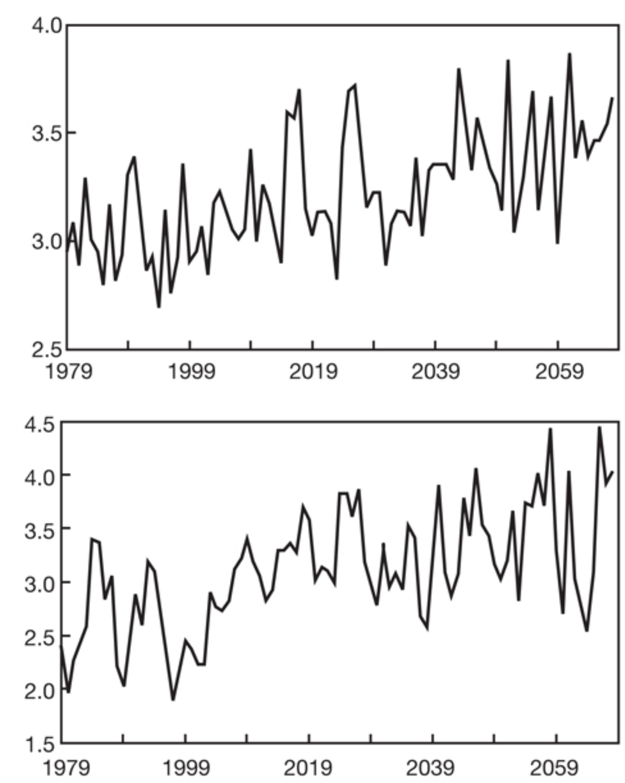

Figure 6 Time series of TKE at surface (left) and 150m (right). Units: $10^4 m^2/s^2$ and $10^6 m^2/s^2$ in (top) and (bottom) respectively.

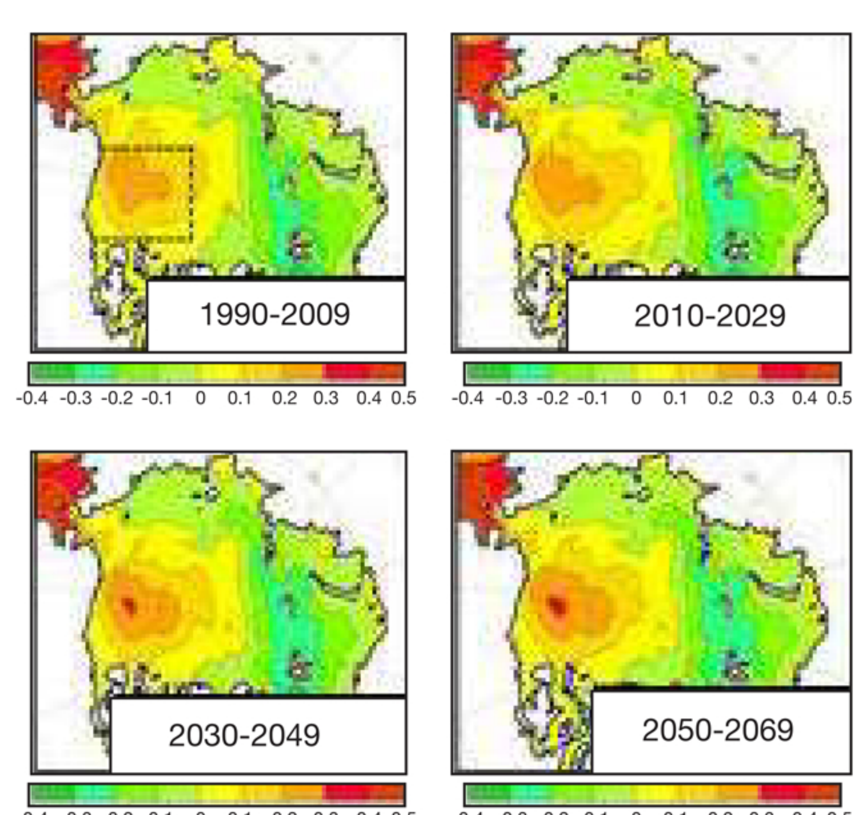

Figure 7 Annual sea surface height (m).

3. Conclusion

CIOM simulations show a significant weak AWL in the future climate.

(b) Weak AWL could be related to the increased surface mixing due to the loss of sea ice.

(c) The enhanced Beaufort Gyre could also play an important in the weakening AWL.