Study of Air-Sea Interaction over Hudson Bay and its Effect on Regional Climate of Québec by using the MRCC coupled with MRO.

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Abstract

The MRCC (Modèle Régional Canadien du Climat), which is developed at UQAM, has been coupled with MRO (Modèle Régional d'Océan), which is developed at Institut Maurice-Lamontagne of the Department of Fishers and Oceans Canada. This coupled model will be used to study the regional climate change around Hudson Bay region. The results show that the regional climate in Quebec is very sensible to the Hudson Bay, especially in the north of Quebec. The atmospheric temperature near surface could change greatly due to the presence of sea ice. Since the coupled model is able to reproduce the coverage of sea ice reasonably, it seems to be a reliable model to study the regional climate over Quebec.

1. Introduction

One of the most important features of Hudson Bay is the highly variable sea ice coverage. The Hudson Bay is completely covered by ice in winter and becomes ice free in September. The actual amount of ice and its distribution show large year to year variability. Due to its high albedo and its isolation properties, sea ice impacts on the regional climate near the Hudson Bay, especially to the region of northern Quebec that is located downwind of the Hudson Bay. The purpose of this study is to understand how sensitive the surface air temperature over Quebec region is with respect to ice coverage.

2. The diagram of coupled model

The Pipe technique is applied to couple MRCC and MRO. This technique allows MRCC, MRO and the Coupler to run in parallel with communications among different CUPs (Figure 1).

In each 30 minutes, the MRCC transfers screen air temperature, wind, humidity, long wave and short radiations and precipitation to MRO. At the same time, the MRO transfers sensible, latent heat fluxes, albedo, sea surface temperature, ice concentration, ice movement and sea current to MRCC. In order to have all fluxes be conserved at the coupling interface, all fluxes mentioned above are calculated in one model and then transferred to the other.

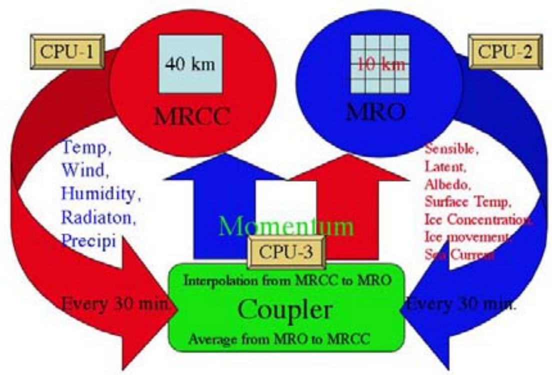

Figure 1. Diagram of coupled model

3. Results

The simulations of the coupled model begin on 1st of August 1996. In order to learn the sensitivity of ice to the regional climate in Quebec, two simulations are performed. The difference between the two simulations lies in the initialization of ocean temperature for Hudson Bay ocean model. One simulation starts with normal initialization of ocean temperature for Hudson Bay. Another starts with a warmer state of ocean temperature. The simulation starting with warmer temperature (around 3-5 C warmer) results in less ice and we might find some differences in atmosphere due to this ice difference.

Fig. 2 shows the simulated ice concentration (monthly average) for December 1996 with normal initialization of ocean temperature for Hudson Bay ocean model. Fig. 3 shows the same as Fig. 2 but with warmer initialization. Clearly in the normal simulation, the ice coverage is about 40 – 90 % in the most area of Hudson Bay, while in the warmer simulation, the ice appears only in the half of the Hudson Bay area.

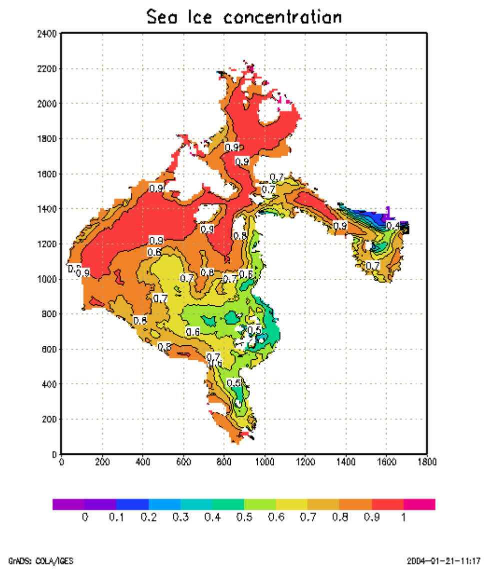

Figure 2. Simulated ice concentration in Dec. 1996 with normal initialization of ocean temperature for Hudson Bay ocean model

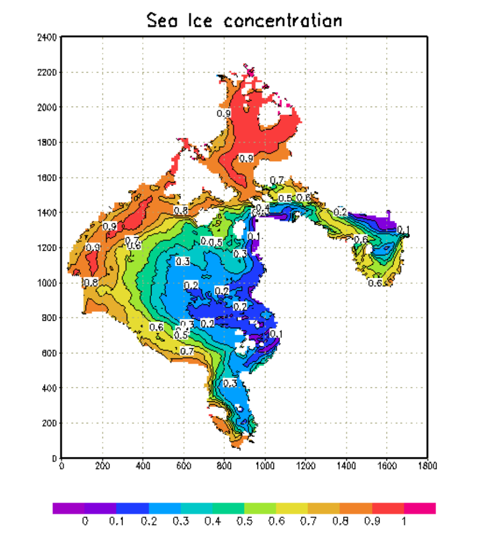

Figure 3. Simulated ice concentration in Dec. 1996 with warmer initialization of ocean temperature for Hudson Bay ocean model

This ice difference results in the difference of atmospheric temperature around Hudson Bay region. Fig. 4 represents the air temperature at 1000 mb in December 1996 from normal simulation (corresponding to Fig. 2). Fig. 5 represents the difference of air temperature between the warmer simulation and the normal simulation. The difference can reach 0.5 C to 2.0 C over the northern Quebec region.

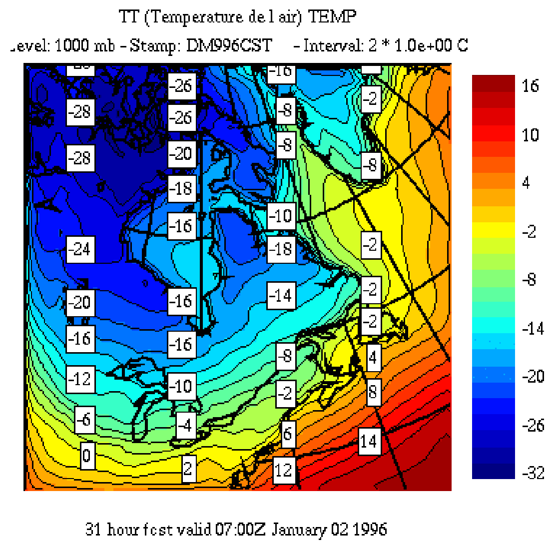

Figure 4. Simulated air temperature in Dec. 1996 (monthly mean) at 1000 mb corresponding to Fig. 2.

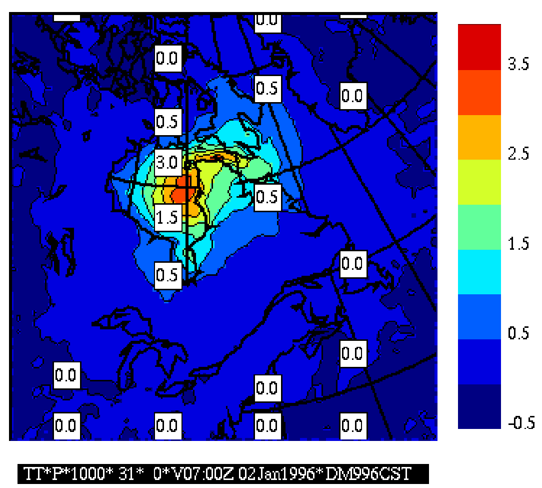

Figure 5. The difference of air temperature (monthly mean) at 1000 mb between the warmer simulation and the normal simulation (Warmer – Normal)

References

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