Sensitivity of an ice-ocean coupled model to COREv2 atmospheric forcing over the Arctic Ocean

Su-Bong Lee, Joo-Hong Kim, Baek-Min Kim and Seong-Joong Kim

Division of Polar Climate Change, Korea Polar Research Institute, Incheon 21990, Korea

Atmospheric dynamic/thermodynamic forcing is an external driver for underlying ice and ocean variability in an ice-ocean coupled model. In this study, we examine the sensitivity of an ice-ocean coupled component set (compset) of the NCAR CESM v1.2.1 to different Coordinated Ocean-ice Reference Experiments version 2 (COREv2) atmospheric forcing data. In a control run, the model is forced with the normal year forcing from COREv2, which is the default setup of the G_Normal_Year_Forcing (G_NYF) compset. In G_NYF, the atmospheric forcing includes many years of the pre-satellite era. Thus, it may not represent the recent climate during which Arctic sea ice has been rapidly declined. To test the model response to the recent climate forcing, the climatological mean of interannually varying COREv2 forcing for the period from 1984 to 2009 is prescribed for the same model in the G_IAFmean experiment. Both G_NYF and G_IAFmean are integrated for 100 years enough to reach an equilibrium state for the sea ice.

The annual cycle of the Arctic sea ice extent (SIE) in G_NYF reasonably follows that from the SMMR and SSM/I satellite records, while the nearly ice-free Arctic is obtained during late summer in G_IAFmean due to the rapid ice disappearance during July. The sea ice volume is underestimated all-year-round ice, compared with PIOMAS, for the two simulations. The underestimation largely comes from the lower simulated ice thickness than expected. It is noted that the G_IAFmean simulation of Arctic sea ice has larger discrepancy with the recent Arctic state than the G_NYF simulation despite we applied the recent climate forcing in the experiment.

The excessive incoming total energy flux to sea ice seemed to play a critical role in leading to the ice-free Arctic in G_IAFmean. The dramatic acceleration of the retreat of SIE during July in G_IAFmean is natural because most of the accumulated energy is effectively used to melt the sea ice. In G_IAFmean, the ice surface becomes bare without snow earlier in July, so the melting goes faster over the ice top than that in G_NYF. Moreover, it seems that relatively less energy consumed to melt the snow in G_IAFmean because snow volume also underestimated. The increase of net shortwave radiative flux during early summer in G_IAFmean seems to make such differences in summer SIE between the two simulations, reflecting the importance of enhanced ice-albedo feedback in accelerating sea ice melting.

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