

ABSTRACT

The response of the Indian monsoon to polar sea ice melt has been a topic of growing interest in climate research. In this thesis, the effects of the Arctic and Antarctic sea ice melts on the Indian summer and winter monsoons have been examined. Coupled and uncoupled climate model simulations are performed to unravel the response of the climate system to the polar sea ice melt. The findings reveal that the combined melting of sea ice in the Arctic and Antarctic exerts a stronger influence on the Indian summer monsoon compared to the melting at a single pole. Specifically, the Indian summer monsoon exhibits a relatively weak sensitivity to the Arctic sea ice melt, while showing a stronger response to sea ice melt over the Antarctic and the combined melt over both poles. The response of summer monsoon is characterized by a weakening of the circulation and a decrease in the continental precipitation, indicating an overall weakening of the monsoon system as a result of the polar sea ice melt. Also, Indian winter monsoon precipitation weakens in response to the polar sea ice melt. The subtropical jet in the northern hemisphere also weakens during the winter months in the sea ice melt experiments. The intertropical convergence zone and associated precipitation pattern shift equatorward in the sea ice melt experiments.

In the subsequent chapters, the response to transient weather systems over Indian region to the polar sea ice melt has been examined using high-resolution atmospheric general circulation model forced with the boundary conditions from the coupled model experiments. To understand the response of the Indian summer monsoon synoptic activity to the sea ice melt, a suite of coupled and uncoupled climate model simulations is performed. A high-resolution (50 km) community atmospheric model (CAM5) is forced with the climatological annual cycles of sea surface temperature (SST) and sea ice concentrations (SIC) from the coupled model outputs to better resolve synoptic scale variability. In the CAM5 simulations forced with SST and SIC from the sea ice melt experiments, the Indian summer monsoon circulation weakened substantially, and the monsoon low-pressure systems (LPS) activity experienced an overall decline of 23%, with a widespread weakening in the south and a moderate strengthening over the north, in response to a decline of 78% (24%) in SIC over the Arctic (Antarctic) in June - September season. The changes in the LPS activity in response to polar sea ice melt are found to be mostly driven by the changes in low-level absolute vorticity and vertical shear over the Bay of Bengal.

In the last working chapter, a study on the impact of polar sea ice melt on the Indian winter monsoon is presented, with an emphasis on the western disturbance (WDs). In this study, the trajectories of WDs are extracted from the high-resolution CAM5 simulations using a Lagrangian tracking algorithm. The analyses presented in this chapter reveal that the WD activity is reduced in the CAM5 simulations forced with the SST and SIC from the sea ice melt experiment. It is shown that this weakening in WDs is linked to the weakening and equatorward shift in the subtropical jet as a result of the weakened tropics to pole temperature gradient in response to the polar sea ice melt. The weakening and widening of the subtropical jet is consistent with the predicted changes to thermal wind and upper-tropospheric meridional temperature gradient in response to the polar sea ice melt.