기후 분과 [P-029]

Influence of the Madden-Julian Oscillation on Antarctic Atmospheric Rivers

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Atmospheric rivers (AR) are globally occurring phenomena in which water vapor generated in tropical oceans flows towards continents through jet streams, spanning hundreds to thousands of kilometers. When AR events occur, they transport substantial amounts of water vapor, leading to heavy rainfall and snowfall in inland areas. In the Antarctic, the occurrence of atmospheric rivers results in the melting of ice shelves, the formation of polynyas in the Antarctic sea ice, and localized accumulation of snow on glaciers. Previous studies have indicated that atmospheric rivers frequently occur in association with extratropical cyclones and are linked to climate modes on various timescales, such as the Southern Annular Mode and Pacific-South American pattern 2 on interannual timescales, and the Pacific Decadal Oscillation on decadal timescales. However, studies on the intraseasonal variability of this phenomenon are rare. This study investigates the relationship between the Madden-Julian Oscillation (MJO) and AR events in the Antarctic, along with their impacts on the Antarctic cryosphere. The MJO is a dominant mode of intraseasonal variability in the tropics, accounting for 20-30% of seasonal variability, with a temporal period of 30-70 days and an eastward propagation speed of about 5 m/s. In this study, the MJO phases were classified into four groups (phases 2-3, phases 4-5, phases 6-7, and phases 8-1). The vertically integrated water vapor transport is most pronounced during MJO phases 4-5, where surface temperatures over the eastern Peninsula rise due to Foehn effects, potentially accelerating glacial melt. Recent expansion of the Indo-Pacific warm pool has led to a decline in the frequency of phases 1-3 and an increase in the occurrence of phases 4-6. This study assesses the implications of these changes in MJO characteristics on AR activity in the Antarctic.

Key words: Antarctica, Atmopsheric Rivers, Cryosphere, Madden-Julian Oscillation

※ This research was supported by Korea Institute of Marine Science & Technology Promotion(KIMST) funded by the Ministry of Oceans and Fisheries(RS-2023-00256677; PM23020)