The influence of atmospheric rivers-related precipitation on Antarctic sea ice

Melanie Lauer*[1], Christopher Horvat[1], and Michelle Mccrystall[2]

[1]Brown University – United States
[2]Maynooth University – Ireland

Abstract

In 2016, following years of modest increases in annual sea ice extent, Antarctica experienced a rapid decline in sea ice extent. Rapidly changing sea ice conditions across Antarctica have consequences on its climate system, yet much is still unknown about the coupled process of atmosphere-ocean-ice interactions and how they affect the decline in Antarctic sea ice. Precipitation is an important atmospheric variable that affects the surface mass balance of the Antarctic ice sheet and the formation and sustainability of Antarctic sea ice. Two major moisture sources for precipitation in the polar regions are local evaporation due to the missing insulation effect of sea ice and poleward moisture transport which is often associated with atmospheric rivers (ARs). Despite their rarity, ARs are responsible for surface melting on the West Antarctic Ice Sheet and extreme precipitation events across East Antarctica. However, the role of ARs and AR-related precipitation – in particular, the different effects of snow and rain – on Antarctic sea ice has been less explored. It is expected that the surface warming effect of ARs and the AR-related rainfall alters the ice surface albedo and may lead to thinning and melting of Antarctic sea ice and snow cover. Subsequently, it is expected that the loss of Antarctic sea ice will increase local evaporation and, therefore, the atmospheric water vapor content, leading to a potential increase in precipitation over the Antarctic ice sheet. These assumptions give rise to the following research question:
How does AR-related precipitation affect the Antarctic sea ice?
To answer these question, we investigate the complex interplay between the poleward moisture transport by ARs, precipitation, and sea ice in the Antarctic with ERA5 reanalysis data. We distinguish between different surface characteristics (open ocean, marginal sea ice zone (MIZ), and sea ice) and types of precipitation (rain or snow) over specific regions in Antarctica. For all regions, unsurprisingly, we find that snow is the dominant type of precipitation. The highest precipitation amounts are concentrated in Amundsen-Bellingshausen and the Ross Sea over open ocean and in the Weddell Sea over sea ice. For most regions, snow follows the seasonal cycle of sea ice, with higher snowfall amounts over sea ice in fall and winter and over the open ocean in spring and summer. Generally, there have been anomalous high precipitation rates over Antarctica since 2008 relative to the climatological mean (1980 – 2010), with a shift from anomalous high precipitation rates over sea ice (2008 – 2015) to anomalous high precipitation rates over open ocean (2016 – 2023) – for both rain and snow and AR-related precipitation.

*Speaker