Characteristics of Arctic middle level cloud and Its Correlation with Extreme Sea Ice Anomalies

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Abstract

The Arctic region is a sensitive and critical area for global climate and environmental changes. Arctic sea ice anomaly is an indicator of climate change. Clouds, especially low clouds, are one of the most important variables that affect sea ice variability. Given the scarcity and uneven distribution of in-site observation in the Arctic, satellites are an important means of observation.

Mid-level clouds play a crucial role in the Arctic. Due to observational limitations, there is scarce research on the long-term evolution of Arctic mid-level clouds. From a satellite perspective, this study attempts to analyze the seasonal variations in Arctic mid-level clouds and explore the possible relationships with sea ice changes using observations from the hyperspectral Atmospheric Infrared Sounder (AIRS) over the past two decades.

Here, the satellite observations are primarily from AIRS, which is a hyperspectral infrared atmospheric sounder with 2378 spectral channels ranging from 3.75 to 15.4 µm. It obtains the atmospheric parameters corresponding to a range of heights through the sensitivity of channels to different atmospheric constituents. Benefiting from the AIRS's ability to make vertical observations, mid-level clouds and the related trends could be obtained and analyzed. For mid-level clouds of three layers (648, 548, and 447 hPa) involved in AIRS, high values of effective cloud fraction (ECF) occur in summer, and low values primarily occur in early spring, while the seasonal variations are different. The ECF anomalies are notably larger at 648 hPa than those at 548 and 447 hPa. Meanwhile, the ECF values at 648 hPa show a clear reduced seasonal variability for the regions north of 80◦N, which has its minimum coefficient of variation (CV) during 2019 to 2020. The seasonal CV is relatively lower in the regions dominated by Greenland and sea areas with less sea ice coverage. Analysis indicates that the decline in mid-level ECF's seasonal mean CV is closely correlated to the retreat of Arctic sea ice during September. Singular value decomposition (SVD) analysis reveals a reverse spatial pattern in the seasonal CV anomaly of mid-level clouds and leads anomaly. However, it is worth noting that this pattern varies by region. In the Greenland Sea and areas near the Canadian Arctic Archipelago, both CV and leads demonstrate negative (positive) anomalies, probably attributed to the stronger influence of atmospheric and oceanic circulations or the presence of land on the sea ice in these areas.