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A Survey of the Atmospheric Physical and Dynamical Processes Key to the Onset of Arctic Sea Ice Melt in Spring

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September sea ice concentration (SIC) is found to be most sensitive to the early melt onset over the East Siberian Sea and Laptev Sea (73°-84°N, 90°-155°) in the Arctic, a region defined here as the area of focus (AOF). The areal initial melt date for a given year is marked when sea ice melting extends beyond 10% of the AOF size. With this definition, four early melting years (1990, 2012, 2003, 1991) and four late melting years (1996, 1984, 1983, 1982) were selected. The impacts and feedbacks of atmospheric physical and dynamical variables on the Arctic SIC variations were investigated for the selected early and late melting years based on the NASA MERRA-2 reanalysis. The sea ice melting tends to happen in a shorter period of time with larger magnitude in late melting years, while the melting lasts longer and tends to be more temporally smooth in early melting years. The first major melting event in each year has been further investigated and compared. In the early melting years, the positive Arctic Oscillation (AO) phase is dominant during springtime, which is coupled with a poleward shift of storm tracks, intensified storm activity in the AOF and consequently enhanced northward transport of moist and warm air. As a result, positive anomalies of precipitable water vapor (PWV) and/or cloud fraction and cloud water path were found over the AOF, increasing downward longwave radiative flux at the surface. The associated warming effect further contributes to the initial melt of sea ice. In contrast, the late melt onset is linked to the negative AO phase in spring accompanied with negative anomalies of PWV and downward longwave flux at the surface. The increased downward shortwave radiation during middle to late June plays a more important role in triggering the melting, aided further by the stronger cloud warming effects than normal.