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Intensification of the Ferrel circulation and an abrupt warming in the late 1980s over the Northern Hemisphere

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In this study, we analyze the winter temperature regime shift (WTRS) over the Northern Hemisphere in the late 1980s using observation data and reanalysis data, and examine the possible cause of the WTRS with a focus on mean meridional circulation, especially, Ferrel cell. To identify the time when there was a regime shift in the winter temperature at the surface and in the troposphere over the Northern Hemisphere, we apply a regime shift index, which is based on determining the significance of differences between the mean values of two subsequent regimes. We detect a WTRS over the Northern Hemisphere during the period from 1986 to 1989 (regime shift period), both at the surface and in the troposphere of mid-latitudes. The WTRS shows latitudinal movement from 30ºN to 60ºN with time and vertical movement from the surface to the upper troposphere over time. Compared to the reference period of 1976-1985 before the regime shift, the temperature at the surface and in the troposphere during the regime shift period increase significantly in the mid-latitudes from 30ºN to 50ºN, especially in maximum warming over 40ºN. Interestingly the latitudinal belts of the maximum warming coincide with an anomalous boundary between the Hadley and Ferrel cell during the regime shift period, indicating that an abrupt warming during the regime shift is strongly associated with the intensification of the Ferrel cell. In fact, the vertical structure of the zonal-mean temperature anomaly during the regime shift period is similar to the correlation pattern between the maximum of the Ferrel cell intensity and the zonal-mean temperature, which indicates that intensification of the Ferrel cell during the regime shift period induced adiabatic warming over the 30°-50°N latitude band and northwards transport of warm air.