



Multidecadal modulation and seasonal dependence of dominant variability in the wintertime Northern Hemisphere geopotential height fields

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Multidecadal modulation and significant seasonal dependence in the dominant mode of interannual variability for the wintertime tropospheric circulation over the extratropical Northern Hemisphere for recent 50 years are investigated based on a reanalysis data set. The Aleutian-Icelandic low seesaw (AL-IL seesaw), a mixed signature of the North Atlantic Oscillation (NAO) and Pacific-North American (PNA) pattern, which is apparent during late winter in the recent 30 years, significantly modify dominant spatial patterns obtained as the leading EOF in the troposphere. These modulation and seasonal dependence are more evident in the upper troposphere. The center of action in the North Pacific in the leading mode of the SLP is largely reduced in 1950s-60s, suggestive of weakening the linkage between the PNA and NAO teleconnection patterns. This period corresponds to an inactive phase of the AL-IL seesaw. The tropospheric leading mode during early winter is characterized by a polar-midlatitude dipole over the Euro-Atlantic sector through the recent 50 years, which may be an upper tropospheric manifestation of the Northern Hemisphere annular mode or the Arctic Oscillation, with a high degree of the annularity. A significant seasonal dependence during the cold season is not identified in the spatial pattern of the leading mode in the preceding 20 years of the recent 50 years. In the recent 30 years, however, the formation of the AL-IL seesaw in late winter significantly modifies the annularity of the leading mode of the tropospheric variability, particularly at the upper levels. This is consistent with that the AL-IL seesaw is identified as the most dominant mode of interannual variability in the upper troposphere for late winter. It is noted that the wintertime tropospheric leading mode does not always completely reflect the annular mode.