

Diagnosics of Climate Variability and Trend Using Potential Vorticity Maps

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Abstract

Daily pressure fields on a constant potential vorticity (PV) surface ($PV = 2.5$ unit) are analyzed using NCEP/NCAR reanalysis II (1979-2000) dataset. Potential vorticity intrusion (PVI) indices are developed to measure the mean latitudinal position, area, and intensity of the subtropical and polar front zones, as well as the equatorial convection zones. It is found that the polar front indices are closely related to the interannual and decadal variability of the cold air temperature anomalies over the high latitudes. In general, these indices are negatively correlated with the cold air temperature anomalies near the surface. The interannual variability of these indexes has a strong QBO signal. These indices also exhibit strong interdecadal variability. Between early 80s and early 90s, these indices all exhibit a negative trend, accompanied with which is a warming trend in both cold/warm surface air temperature anomalies. During last 5 years of 90s, these indices have a positive trend superimposed on a QBO-like interannual variability. Interestingly, the surface air temperature anomalies continuously exhibit a warm trend while their interannual variability follows the interannual variability of PVI indices.

The composite anomaly surface air temperature maps of high versus low PVI indices exhibit a pattern resembling to the familiar regression map against the AO index found in Thomson and Wallace, 1998. However, the composite maps of surface pressure anomaly show a very different pattern in which the pattern over the north Atlantic basin is very like NAO but the pattern over the Pacific shows a dipole like structure in the zonal direction rather than in meridional direction. The spatial probability distribution function of daily PV frontogenesis activities clearly shows a shift of storm track activities from oceans to continents from a low PVI index phase to a high PVI index phase, explaining that more and more extreme cold events and much cold temperature anomaly are observed over the northern Eurasian continent and western Northern America continent.