Regime Behaviour in the Upper Stratosphere as a Precursor of Stratosphere-Troposphere Coupling of the Northern Hemisphere

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A flow regime index is constructed based on the November-December standard deviation of the Ertel's potential vorticity (EPV) in the northern upper stratosphere at 1500 K (~40 km). The index reveals two flow regimes in both the stratosphere and the troposphere. In the stratosphere, the two flow regimes involve zonally asymmetric variability that is manifested by a modulation of the Aleutian High and distinct early-to-late winter development of the polar vortex. During the wide-jet regime, an anomalously strengthened, upright polar vortex is found in middle winter, which involves an equatorward shift of the surf zone in the middle to upper stratosphere, a poleward movement of the polar vortex axis, and a sharpening of the polar vortex edge, suggesting a dominant effect of Rossby wave breaking. During the narrow-jet regime, the vortex weakens at least a month earlier in association with enhanced large-scale PV mixing.

The upper stratospheric flow regimes also have detectable signal in the vicinity of the tropospheric westerly jets in middle winter. The tropospheric responses are also zonally asymmetric. During the wide-jet regime, the largest response is found over the North Pacific with a weakened, poleward shifted westerly jet over north America. The circulation anomalies during the narrow-jet regime are most strong over the North Atlantic with a weakened, and equatorward shifted westerly jet there. The flow regimes also differ distinctively in their impacts on high-frequency variability downstream of the westerly jets and associated temperature variability. Given the flow regimes in the upper stratosphere leads the tropospheric response by one to two months, improved representation of upper stratospheric variability in climate models may offer more skillful prediction of long-range surface weather forecasts.