A Synoptic-Climatology of Northern Hemisphere Jet Superposition Events

by

W. A. Perkins, C. E. Christenson and J. E. Martin
Department of Atmospheric and Oceanic Sciences
University of Wisconsin-Madison
1225 W. Dayton St.
Madison, WI 53706
jemarti1@wisc.edu
608-262-9845

Among the most ubiquitous structural characteristics of the Earth's atmosphere are the narrow, tropopause-level wind speed maxima known as jet streams or jets. Two varieties of these jets, distinguished by their underlying dynamical origins, can be observed on any given day. The polar jet (PJ) is tied, via the thermal wind relationship, to the troposphere-deep baroclinicity of the middle latitudes while the subtropical jet (STJ) is tied, by angular momentum constraints, to the poleward edge of the tropical Hadley Cell. As a consequence of their different origins, the PJ and STJ are separated by latitude and elevation. However, there are times when these two features coalesce and become vertically superposed. This results in anomalous upper tropospheric/lower stratospheric baroclinicity, as well as anomalous wind speeds along a deep, nearly vertical tropopause boundary. It is hypothesized that the attendant increases in wind speed and tropopause slope intensify the divergent circulations of the jet/front environment, encouraging the development of high impact mid-latitude weather in association with jet superposition.

Current jet climatologies often fail to distinguish between the PJ and STJ. Consequently, little is known regarding the spatial and temporal distributions of these two jet types. By employing the National Center for Environmental Prediction – National Center for Atmospheric Research (NCEP-NCAR) reanalysis data, and an analysis scheme that separately identifies the PJ and STJ, a 51-yr synoptic-climatology of jet superposition is created. The analysis demonstrates that while superposition events are relatively rare, there are clear geographical and seasonal maxima. Superpositions are most frequent in the western Pacific from December through February, abruptly decreasing in late winter (March/April), then increasing substantially again in late autumn (October/November). Consistent with expectations, the spatiotemporal maxima in jet superpositions appear to be coincident with maxima in rapid cyclogenesis events. Possible tropical/extratropical interaction mechanisms underlying jet superposition are considered.