Investigation of the Dynamical Mechanisms Facilitating Jet Superpositions over North America

by

A. C. Winters 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

Narrow, rapidly flowing currents of air located near the tropopause are known as jet streams, or jets. These jets, often found nearly girdling the globe while exhibiting large meridional meanders, are among the most ubiquitous structural characteristics of the earth's atmosphere and known to play a substantial role in the production of sensible weather in the mid-latitudes. Observational work by Defant and Taba (1957) demonstrated that jets are associated with steep gradients in tropopause height, with the so-called polar jet typically located poleward of its subtropical counterpart. They further recognized that, occasionally, the polar and subtropical jets became vertically superposed, incorporating the upper tropospheric/lower stratospheric baroclinicity associated with each jet into a single, more intense zone of contrast. Attendant with this increased baroclinicity is a steeper tropopause, a more potent jet, and a more vigorous ageostrophic circulation.

Recent analysis of the May 2010 Nashville Flood has shown that such features can play a considerable role in the evolution of high-impact weather events. Preliminary investigation of a number of other high impact events associated with superposed jet structures suggests that these structures may be produced in a variety of different ways. The present study investigates the dynamical mechanisms underlying the jet superpositions observed in association with a December 2009 blizzard across the Mid-Atlantic States and the aforementioned Nashville Flood. The analysis will consider the life cycles of the jet structures in these cases from both piecewise PV and semi-geostrophic perspectives. In both cases, characterized by jets in southwesterly synoptic-scale flow, the interaction between internal jet-front dynamics and latent heat release associated with lower tropospheric convection appears to encourage the development of jet superpositions via restructuring of the tropopause. The resultant ageostrophic circulations associated with this restructuring are isolated and shown to have a considerable impact upon the development of these particular high-impact weather events.