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The Structure, Evolution, and Dynamics of Lower Stratospheric Frontal Zones

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The structure, evolution, and dynamics of two lower stratospheric frontal zones, observed in association with upper level jet-front systems, are examined from a basic state variables perspective. Results from the case study analyses illustrate that the baroclinicity associated with these frontal zones is confined to the cyclonic shear side of the jet. The case studies also highlight some substantial differences in lower stratospheric frontal development that occur in southwesterly and northwesterly flow. In the southwesterly flow case, the lower stratospheric front was aligned with an active surface cold front. A deep column of upward vertical motion resulted from the superposition of the lower tropospheric ascent associated with convection along the surface front and upper tropospheric-lower stratospheric (UTLS) ascent through the jet core forced by geostrophic warm air advection along the jet. The UTLS ascent, located on the cold edge of the lower stratospheric baroclinicity, served to intensify the lower stratospheric frontal zone via tilting.

In the northwesterly flow case, the lower stratospheric frontal intensity reached its peak prior to that of its upper tropospheric counterpart, which was the precursor to a surface cyclogenesis event. At the time of peak intensity, geostrophic cold air advection in cyclonic shear characterized the lower stratosphere, supporting a thermally indirect circulation and lower stratospheric frontal intensification via tilting. As the upper level jet-front system evolved, the lower stratospheric geostrophic cold air advection shifted toward the anticyclonic shear side of the jet, placing subsidence through the jet core within the upper troposphere, weakening the lower stratospheric front during upper tropospheric frontal development. The implications of these lower stratospheric frontal circulations on tropopause dynamics, stratosphere-troposphere exchange, and downstream sensible weather, are discussed.