ANALYSIS OF AN OROGRAPHICALLY MODIFIED CYCLONE OVER THE WESTERN UNITED STATES DURING IPEX IOP3

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1. INTRODUCTION

The Intermountain Precipitation Experiment (IPEX) is a field and research program designed to improve the understanding, analysis, and prediction of precipitation in complex terrain, with an emphasis on the Intermountain West of the United States. The field phase of IPEX was held Feb 2000, during which seven Intensive Observing Periods (IOPs) were conducted. This paper presents a synoptic and mesoscale observational analysis of IOP3, during which a major winter storm produced up to 90 cm of snow in the Wasatch Mountains from 0600 UTC 12 Feb - 0600 UTC 13 Feb 2000. The storm was associated with an upper-level shortwave trough and frontal cyclone. In this paper, these features are traced from landfall in Northern California, where a coherent, rearward-sloping trough axis below 600 hPa was observed, to northern Utah, where the trough axis at 700 hPa was decoupled from the surface trough. The synoptic pattern was important for providing conditions that were conducive for orographic precipitation in higher elevations, and precipitation enhancement in the lowlands upstream of the northern Wasatch, where terrain-driven circulations dominated the mesoscale distribution of precipitation.

2. DATA AND METHODS

The observational analysis of IOP3 presented in this paper is based on conventional synoptic data, high density surface data from the MesoWest cooperative networks, special three hourly radiosonde observations, NEXRAD radar data, including level-2 velocity azimuth display data, wind profiler observations, and flight-level data from the NOAA P-3 aircraft. Subjective analyses of surface potential temperature and 1500-m pressure were performed every one to three hours.

3. PRELIMINARY RESULTS

From 0000 to 1200 UTC 12 Feb, a fast-moving upper-level trough and associated frontal cyclone made landfall and moved across California and southern Oregon. As the upper-level trough and an associated 250-hPa jet streak moved over California, large-scale ascent developed over eastern California and Nevada. This ascent resulted in the development of a short-lived mesoscale cyclonic vortex over Nevada, while low-level downslope flow produced a trough to the lee of the Sierra Nevada (not shown).

Although strong upper-level dynamical support existed between 0000-1200 UTC, the frontal cyclone was relatively weak. Lowest mean sea level pressures were 1000 hPa, and temperature falls of 2-4°C, were observed across much of north and central California with cold frontal passage. As the low pressure center and attendant cold front moved inland, the front weakened and deformed (Fig. 1). It moved through the Sacramento and San Joaquin Valleys and was retarded by the Sierra Nevada. Wind profiler observations indicated that below 4000 m the front featured a rearward-sloping coherent structure along the California coast; however, as the front reached the western Sierra Nevada, it was oriented vertically.

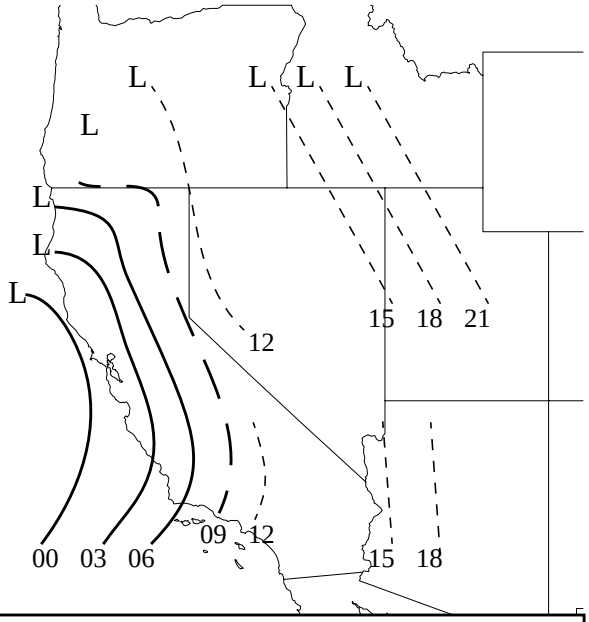

Figure 1. Surface low, front, and trough positions for 12 Feb 2000. All times UTC. Solid line cold front, long dash decaying front, short dash trough.

Downstream of the Sierra Nevada, the synoptic evolution of the system became increasingly complex. A continuous progression of the surface trough was not observed across northern Nevada (Fig. 1). Instead, the upper-level trough moved rapidly downstream with a new surface trough developing over northeast Nevada and southwest Idaho. This may have been related to retardation and lysis of the low-level front and accompanying trough as they traversed the Sierra Nevada and Great Basin ranges. Eventually, over northern Utah, decoupled

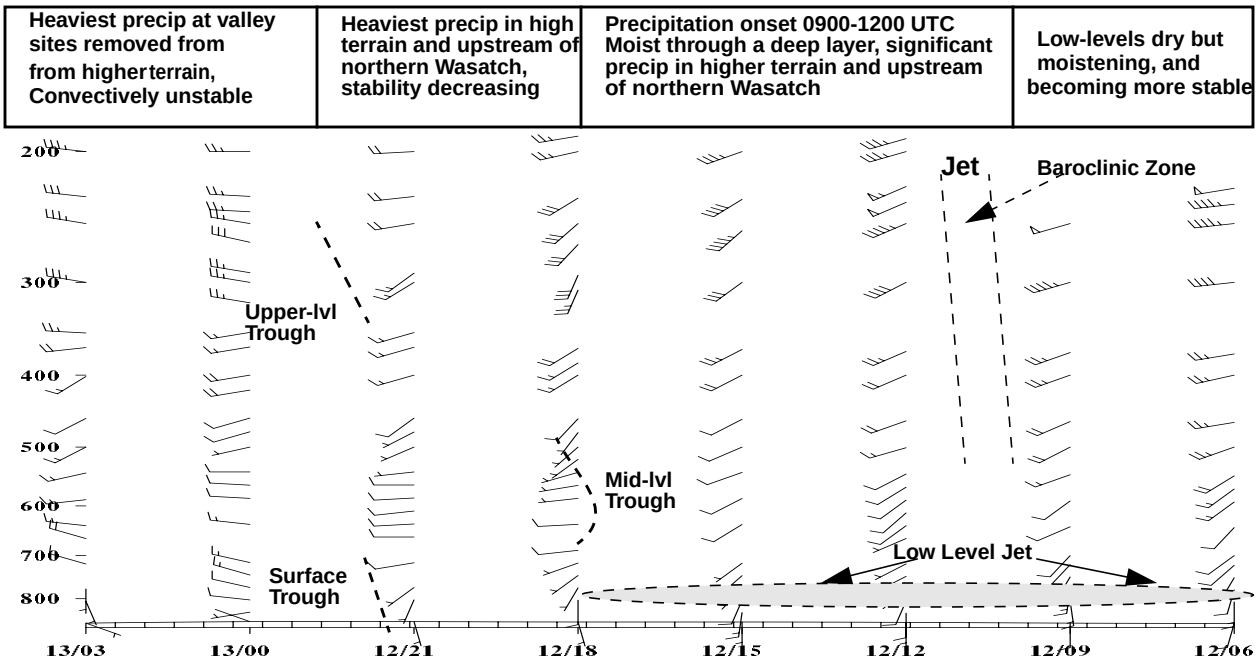

Figure 2. Salt Lake City time-height section from 0600 UTC 12 Feb – 0300 UTC 13 Feb 2000.

mid-level and surface troughs were observed, with the former preceding the latter by approximately 3 h (Fig. 2). During this period, conditions became increasingly unstable with warming at the surface and cooling aloft.

Figure 2 summarizes the relationship of these features to the observed precipitation over northern Utah. As the low pressure center moved across Oregon and Idaho (Fig. 1), clouds and precipitation spread over northern Utah, and by 1200 UTC 12 Feb, precipitation was falling at most mountain and valley sites. This precipitation region accompanied synoptic scale lifting associated with an upper-level baroclinic zone and approaching upper-level trough (Fig. 2). Southwesterly large-scale flow resulted in the development of a near surface convergence zone and precipitation enhancement 20-30 km upstream of the Wasatch Mountains and substantial orographic precipitation enhancement over the Wasatch Crest (Cox et al. 2002).

From 1800–0000 UTC the heaviest precipitation of the event was observed over and upstream of the Wasatch Mountains. During this period, the mid-level, surface, and upper-level trough axes moved through northern Utah, low to mid levels became increasingly unstable, and cross-barrier flow increased.

4. SUMMARY

The analysis presented above illustrates the complexities of cyclone and frontal evolution over the Sierra Nevada and Intermountain West. In particular, a rearward sloping, vertically continuous frontal trough developed an increasingly complex structure as it traversed the Sierra Nevada and Great Basin ranges so that over Northern Utah, the trough at mid-levels preceded the surface trough by about 3 h. Heavy precipitation was observed over and upstream of the Wasatch Mountains as these features moved through the region. This case also shows the need for improved observation and understanding of the evolution of fronts and cyclones across the western United States, including new conceptual models of frontal interaction with the Sierra Nevada and Great Basin ranges. Future work will further detail the evolution of this case and its impact on the mesoscale distribution of precipitation over northern Utah.

5. REFERENCES

Cox, J. A. W., W. J. Steenburgh, and D. E. Kingsmill, 2002: Dual-Doppler analysis of the kinematic structure of a Wasatch Mountain Winter Storm. *Preprints, 10th Conference on Mountain Meteorology* (this preprint volume).

Schultz, D. M., and Coauthors, 2002: Understanding Utah winter storms: The Intermountain Precipitation Experiment. *Bull. Amer. Meteor. Soc.*, **83**, 190-210.