6.2 OROGRAPHIC PRECIPITATION PROCESSES OVER THE WASATCH MOUNTAINS 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 (Schultz et al. 2002). This paper presents an analysis of the third intensive observing period (IOP3), which examined a winter storm that produced up to 90 cm of snow in the Wasatch Mountains from 0600 UTC 12 Feb - 0600 UTC 13 Feb 2000. During the event, heavy snow accumulations resulted in an avalanche that briefly dammed the Provo River, and avalanche hazard prompted the closure of Little Cottonwood Canyon, where more than 200 day visitors were forced to stay overnight at Alta and Snowbird ski areas.

## 2. OBSERVATIONAL ANALYSIS

IOP3 featured the passage of a mid-level (700–500 hPa) trough followed 3 h later by a surface trough (not shown). Crest-level winds prior to and during passage of the mid-level trough were southwesterly to westerly and oriented roughly normal to the Wasatch Mountains where substantial orographic precipitation enhancement was observed (Fig. 1). Although precipitation generally increased with elevation, there were some important exceptions. First, near Ogden (OGD), precipitation was enhanced in the lowlands upstream of the Wasatch Mountains. Second, over the Salt Lake Valley, precipitation shadowing by the Oquirrh Mountains resulted in lower precipitation amounts. Finally, although several precipitation maxima were observed along the Wasatch crest, by far the largest precipitation amounts (74 mm liquid equivalent) were observed near the summit of Ben Lomond Peak (BLP).

Figures 2 and 3 summarize the mesoscale and radar structure of IOP3 at ~1800 UTC 12 Feb 2000. At this time, the mid-level trough was located over the Great Salt Lake and southwesterly large-scale flow with a Froude number of ~0.75 impinged on the Wasatch Mountains. Low-level confluence was observed between this southwesterly flow and terrain-parallel southerly flow within about 30 km of the Wasatch Mountains (Fig. 2). Analysis of gridded surface analyses of this event revealed that the conflu-

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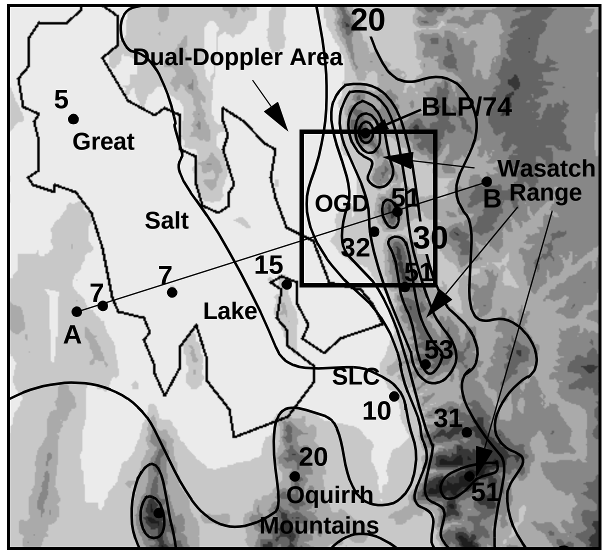


Figure 1. IOP3 Storm-total precipitation (liquid equivalent, contours every 10 mm) from 06 UTC 12 Feb – 06 UTC 13 Feb 2000. Accumulation at selected sites annotated. Reprinted with permission from Cheng (2001).

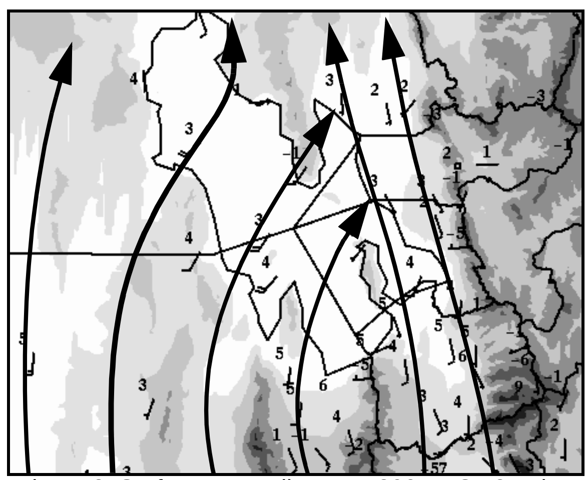

Figure 2. Surface streamlines at 1800 UTC 12 Feb.

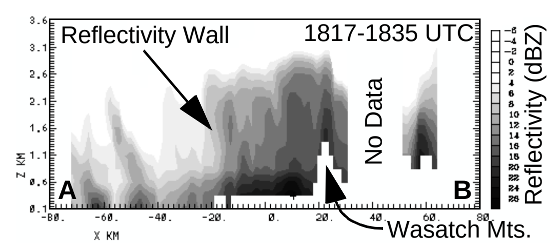


Figure 3. Radar cross-section along line AB of Fig. 1.

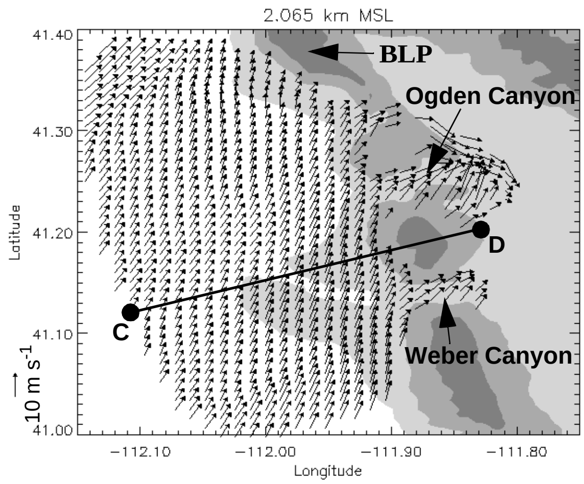


Figure 4. Mid-mountain level (2.07 km MSL) dual-Doppler wind vectors at 1832 UTC 12 Feb.

ence zone was also convergent and thus is termed a convergence zone. Radar imagery from the NOAA P-3 tail-Doppler radar, collected from 1817–1835 UTC, showed an impressive "reflectivity wall" just east of the convergence zone, roughly 20 km upstream of the Wasatch, with higher reflectivities to the east (Fig. 3). A narrow reflectivity maximum was also observed directly over the Wasatch Mountains where the greatest precipitation rates were observed. High reflectivities near the surface upwind of the Wasatch represent the bright band.

Figures 4 and 5 illustrate the near-barrier kinematic structure at 1832 UTC 12 Feb based on data collected by two University of Oklahoma Doppler on Wheels (DOW) X-band radars (Wurman et al. 1997). At mid-mountain level, southwesterly flow was observed (Fig. 4). Analysis of the upslope component of the horizontal wind at this level suggests that upward motion reached ~2 m $s^{-1}$ near the Wasatch Mountains (not shown). In addition, the southwesterly flow was oriented nearly perpendicular to the Ben Lomond ridge line, which observed the greatest precipitation during this event. Strong up-canyon flow was found in Ogden and Weber canyons, suggesting that the Wasatch act as a "leaky barrier" during this event. Fig. 5a reveals that a shallow terrain-parallel wind maximum was located at or just above the surface near the Wasatch Mountains (Fig. 5a). Above this maximum, the terrain-parallel wind component decreased to near zero just above crest level. In contrast, the cross-barrier wind component increased with height, reaching a maximum of 12 m $s^{-1}$ just above crest level (Fig. 5b).

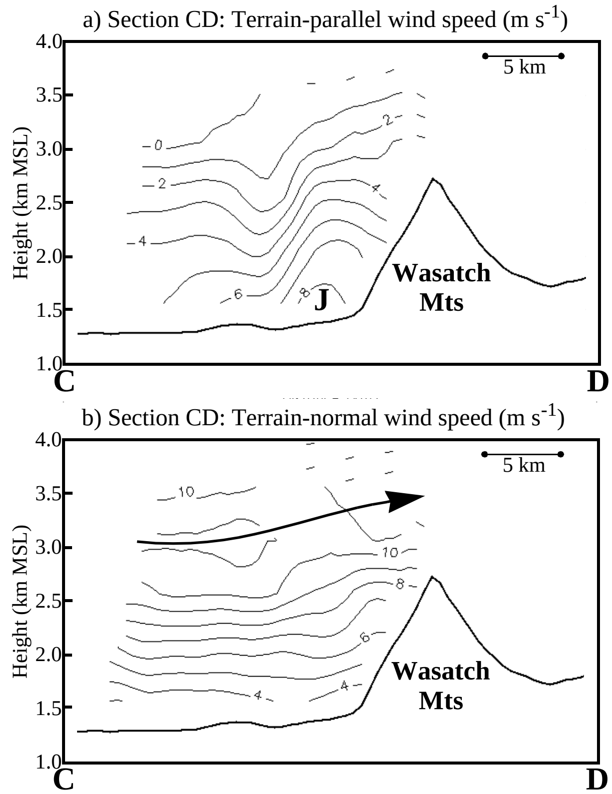


Figure 5. Cross sections of (a) terrain-parallel and (b) terrain-normal wind components along line CD of Fig. 4.

## 3. SUMMARY

Data collected during IPEX IOP3 illustrates the important role of terrain-induced circulations in determining the distribution of precipitation over northern Utah. The development of a low-level convergence zone upwind of the initial Wasatch slope resulted in precipitation enhancement over lowland regions, while mid-mountain southwesterly flow impinging on the Wasatch Mountains contributed to a narrow region of enhanced precipitation directly over the barrier. The heaviest accumulations were observed on Ben Lomond Peak, where the local ridgeline was oriented normal to the mid-mountain flow. Ongoing work is examining the precipitation microphysics of the event, and using numerical simulations to determine the processes responsible for producing the windward convergence zone.

## 4. ACKNOWLEDGEMENTS

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