7.8 OROGRAPHIC PRECIPITATION PROCESSES ASSOCIATED WITH 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. Participants include the University of Utah, National Severe Storms Laboratory, National Weather Service, Desert Research Institute, NOAA Air Operations Center, University of Oklahoma, Storm Prediction Center, and Hydrometeorological Prediction Center. The field phase of IPEX was held in February 2000, during which seven Intensive Observing Periods (IOPs) were conducted, several of which examined precipitation processes associated with the narrow, steeply sloped Wasatch Mountains of northern Utah. This paper presents preliminary results from IOP3, which examined a major 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 the closure of Little Cottonwood Canyon where more than 200 people were forced to stay overnight at Alta and Snowbird ski areas.

2. OBSERVATIONAL ANALYSIS

IOP3 was associated with the passage of a forward-tilting trough (i.e., the 700-hPa trough axis preceded that at the surface) and featured large-scale southwesterly crest-level flow that gradually veered to westerly, weak low-level warm advection, and a near-saturated upstream environment. The 700-hPa trough axis is evident over the Great Salt Lake (GSL) in the cross section presented in Fig. 1. Lapse rates were initially slightly more stable than moist adiabatic and gradually increased to moist adiabatic.

With crest-level winds oriented roughly normal to the Wasatch Mountains, substantial orographic precipitation enhancement was observed along the entire Wasatch Crest (Fig. 2). North of Salt Lake City (SLC) lowland precipitation increased as one moved across the Great Salt Lake towards the Wasatch Mountains (Figs. 2, 3a). Observations from the P-3 tail doppler radar showed a broad region of high reflectivity extending well upstream

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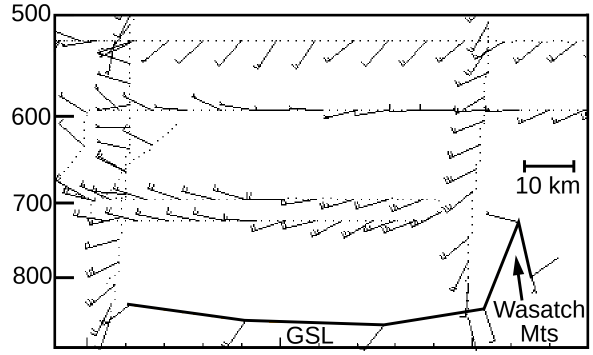

Figure 1. Cross section of flight-level winds, mobile sounding vertical profiles, and MesoWest surface observations from 1700–1900 UTC 12 Feb 2000. Cross section oriented roughly along line AB of Fig. 2. Full and half barbs denote 5 and 2.5 m s^{-1}, respectively.

of the Wasatch Mountains in this region (Fig. 4). This region of enhanced lowland precipitation appeared to be associated with a convergence zone that formed 20-30 km upstream of the initial Wasatch Slope (Figs 1 and 5). Several factors may have contributed to the formation of the convergence zone, including topographic blocking, as observed upstream of coastal mountain ranges (e.g., Overland and Bond 1995, Ralph et al. 1999), and frictional convergence associated with land–lake roughness contrasts.

In contrast, further to the south near Salt Lake City, such lowland precipitation enhancement was not observed (Figs. 2, 3b). This appeared to be due to the presence of upstream topography, which prevented the development of low-level convergence zone and, due to southwesterly flow at mid-mountain and crest levels (e.g., Fig. 1), resulted in direct rainshawdowing.

Precipitation decreased dramatically to the lee of the Wasatch, with accumulations decreasing by at least a factor of 3 just 15 km downstream of the crest (e.g., Fig. 2). As illustrated in Fig. 4, the region of maximum reflectivity during the event sloped strongly downward to the lee of the Wasatch, suggesting that a region of intense lee-side subsidence may have limited downstream hydrometeor transport.

Although several pronounced precipitation maxima were observed along the Wasatch Crest, by far the largest precipitation amounts (74 mm) were observed near the summit of Ben Lomond Peak (BLU, Fig. 2). This location frequently observes heavy snowfall during precipita-

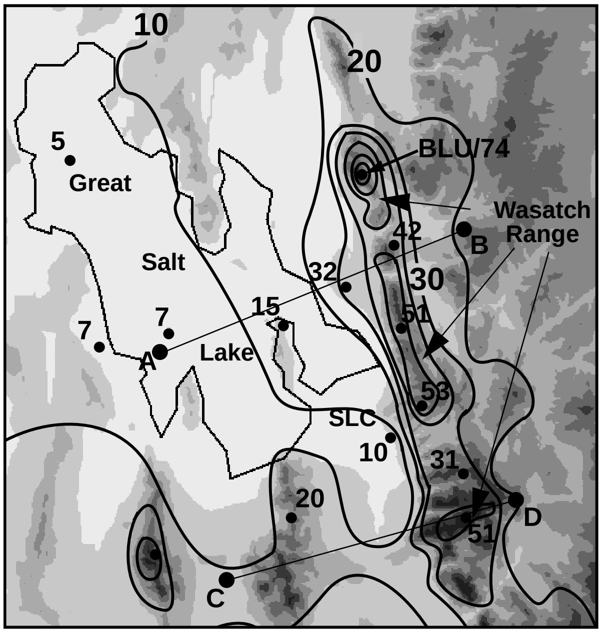

Figure 2. IOP3 Storm-total precipitation (liquid equivalent, contours every 10 mm) from 06 UTC 12 Feb – 06 UTC 13 Feb 2000. Accumulation at selected sites annotated (courtesy Linda Cheng, University of Utah).

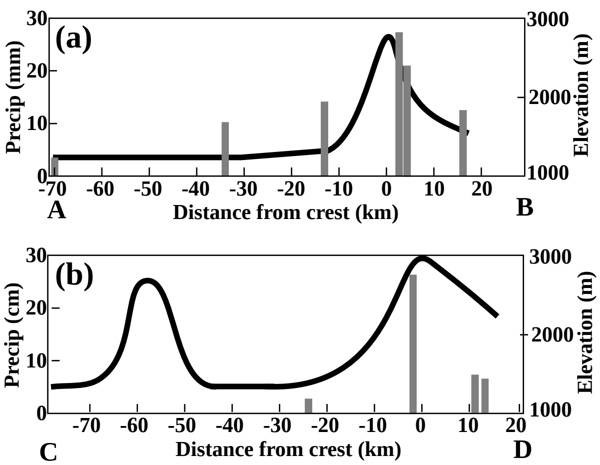

Figure 3. Terrain height (solid line) and observed precipitation (liquid equivalent, mm, vertical bars) along lines (a) AB and (b) CD of Fig. 2 from 1600 UTC 12 Feb – 0100 UTC 13 Feb 2000 (P-3 flight period).

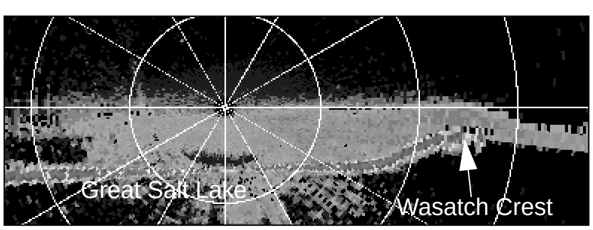

Figure4. P-3 tail radar reflectivity cross section (roughly along orientation of line AB of Fig. 2) showing windward enhancement and lee side spillover. Range rings every 5 km.

tion events with southwesterly large-scale flow. Although not immediately evident in Fig. 2, Ben Lomond peak protrudes several kilometers westward towards the Great Salt Lake. Doppler velocity analyses from the University of Oklahoma Doppler on Wheels (DOW) showed that the along-barrier flow near the Wasatch was blocked by Ben Lomond Peak, resulting in a westward deflection of the along-barrier flow and low-level convergence (not shown).

3. SUMMARY AND FUTURE WORK

Data collected during IPEX IOP3 illustrates the important role of local terrain-induced circulations in controlling the mesoscale 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 low-level flow impinging on Ben Lomond Peak produced heavy localized accumulations. Future work will further detail the kinematic and microphysical aspects of the event, as well as validate and improve high-resolution numerical simulations.

4. REFERENCES

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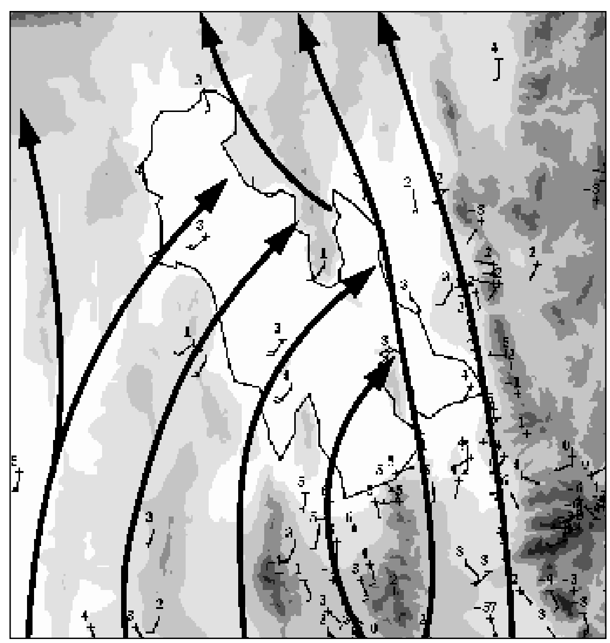

Figure 5. Surface winds and streamline analysis at 1800 UTC 12 February 2000.