6.1 DUAL-DOPPLER ANALYSIS OF THE KINEMATIC STRUCTURE OF A WASATCH MOUNTAIN WINTER STORM

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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 meso-γ scale (2-20 km) kinematic features from the third intensive observing period (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. 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 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. Dual-Doppler measurements were made with two University of Oklahoma Doppler on Wheels (DOW) radars from 1832 to 2134 UTC 12 February 2000. The 700-hPa trough axis was over the Great Salt Lake (GSL) during this time, while the surface trough axis lagged behind. Lapse rates were initially slightly more stable than moist adiabatic and gradually increased to moist adiabatic. The Froude number was slightly less than 1 (~0.75), so conditions were favorable for partial terrain-induced flow blockage.

With crest-level winds oriented roughly normal to the Wasatch Mountains, substantial orographic precipitation enhancement was observed along the entire Wasatch Crest. In general, precipitation increased with elevation, but there were some important exceptions. North of Salt Lake City (SLC), near Ogden (OGD), lowland precipitation increased as one moved across the Great Salt Lake towards the Wasatch Mountains (Fig. 1). This region of enhanced lowland precipitation appeared to be associated with a convergence zone that was observed 20-30 km upstream of the initial Wasatch slope (Fig. 2). Over the GSL, winds were strong and southwesterly throughout the period, while near the Wasatch barrier, winds were near terrain-parallel (southerly), as shown in Fig. 2. In contrast, precipitation shadowing by the Oquirrh mountains resulted in lower precipitation amounts in the Salt Lake Valley (e.g., SLC, Fig. 1).

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 (BLP, Fig. 1). This location frequently observes heavy snowfall during precipitation events with southwesterly large-scale flow. BLP protrudes several kilometers westward towards the Great Salt Lake, resulting in enhanced vertical motion since mid-mountain level southwesterlies were oriented perpendicular to the BLP ridgeline (Fig. 3). Also evident in this figure is significant channeling in Weber and Ogden Canyons.

The along-barrier component of the wind west of Ogden Peak featured a low-level maximum upstream of the initial mountain slope and decreased with height to zero near crest level (Fig. 4a, cross section along A-B of Fig. 3). The cross-barrier wind component along A-B, on the other hand, increased with height and reached a maximum near crest level (Fig. 4b). Local maxima and minima in the along-barrier wind were observed upstream and downstream, respectively, of Weber and Ogden canyons at this time (not shown). In addition to topographic blocking as observed upstream of mountain ranges (e.g., Parish 1982, Overland and Bond 1995), frictional convergence associated with land–lake roughness contrasts (e.g., Roeloffzen et al. 1986) also could have played a role in the formation of the along-barrier flow and windward convergence zone.

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 mid-mountain southwesterly flow impinging on Ben Lomond Peak produced heavy localized accumulations. Future work will analyze the structure of the near-mountain flow field in greater depth, detail the microphysical aspects of the event, and validate and improve high-resolution numerical simulations.

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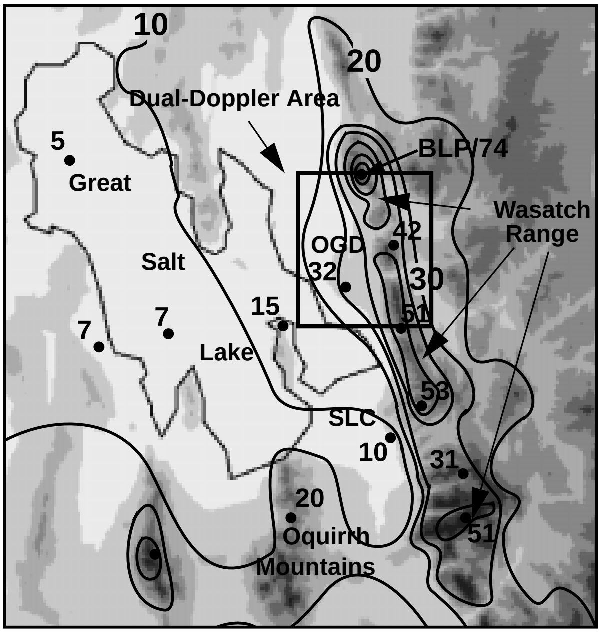

Figure 1. IOP3 Storm-total precipitation (liquid equivalent, contours every 10 mm) from 06 UTC 12 Feb – 06 UTC 13 Feb 2000. Accumulation at selected sites annotated. Reprinted with permission from Cheng (2001).

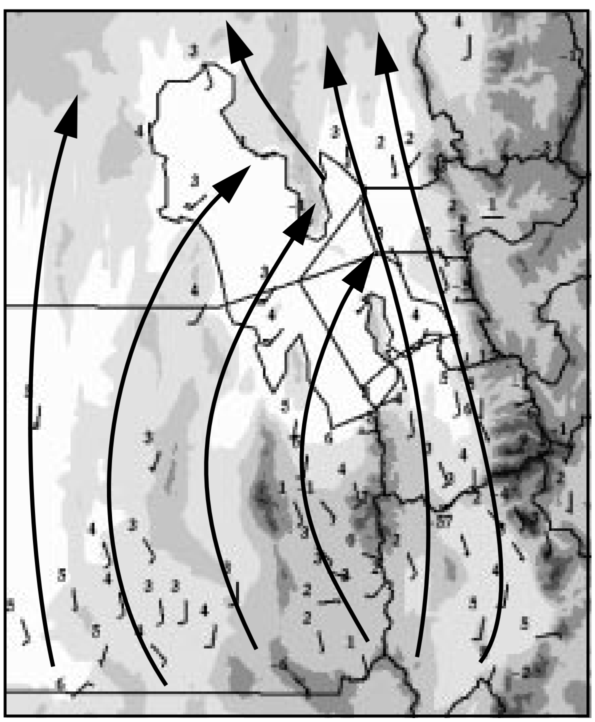

Figure 2. Surface winds and streamline analysis in northern Utah at 1800 UTC 12 February 2000.

4. REFERENCES

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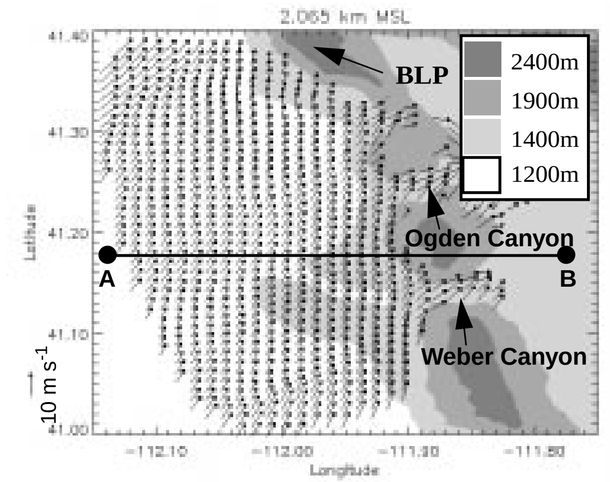

Figure 3. Dual-Doppler wind vectors at 1832 UTC 12 Feb., 2.065 km MSL, around mid-mountain level. Terrain shading as in scale at upper right.

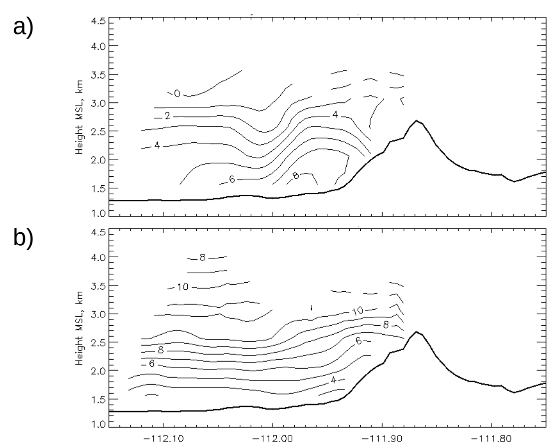

Figure 4. Dual-Doppler cross sections of (a) the along-barrier component and (b) the cross-barrier component of the wind (m s^{-1}), along A-B.