11.7 SIMULATIONS OF EXTREME PRECIPITATION EVENTS IN THE COLORADO ROCKY MOUNTAINS

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1. INTRODUCTION

Extreme precipitation events in mountainous terrain can lead to devastating flash floods in mountain drainages and canyons. A thorough knowledge of the frequency and magnitudes of such events is necessary in order to develop reliable estimates of probable maximum precipitation (PMP) and probabilities of events of various magnitudes (e.g., 100 or 500-year storms). Such probabilistic measures of extreme precipitation occurrence are important in developing design standards for structures such as dams in mountainous terrain.

Unfortunately, the knowledge base of extreme precipitation events in the Rocky Mountains of Colorado is limited, primarily because of a historical sparse population and general lack of observations over much of the region (particularly in higher elevations), combined with a relatively short period of record (<~100 years) for the precipitation observations that do exist. To overcome these observational deficiencies, various assumptions have to be made about extreme storm characteristics to estimate high elevation PMP, and these assumptions rely heavily on a more robust observational record of extreme precipitation events at lower elevations in and adjacent to the Rocky Mountains (Hansen,1987).

However, Jarrett (1993) and Jarrett and Costa (1982) concluded that there is little paleo-hydrologic evidence of extreme rainfall and flash-flooding above 7500 ft elevation in Colorado. Their findings suggest that current estimates of PMP and extreme rainfall potential may be significantly over-estimated at higher elevations. Thus, there is a need for developing alternate methods to assess extreme rainfall potential at high elevations in order to improve PMP estimates.

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In an effort to better understand extreme precipitation potential and its variability in Colorado's mountainous terrain, the Colorado Department of Natural Resources (DNR) supported an extensive, multi-phased program that may eventually lead to improved estimates of PMP. The first phase of this program was conducted by McKee and Doesken (1997), who compiled an extensive database of precipitation and streamflow observations and identified over 300 extreme precipitation events in and near the region of interest dating back to the late 1800s. We summarize the final results of the second phase of this Colorado DNR program, in which the development of new methodologies for estimating extreme precipitation at higher elevations in Colorado are explored. The methodology involves the use of a cloud resolving mesoscale model to simulate observed cases of extreme precipitation in Colorado and an examination of regional and elevational dependencies on the significant simulated precipitation events.

2. METHODOLOGY

The simulations are performed with the non-hydrostatic cloud-resolving version of RAMS (Cotton et al., 2002). The simulations are initialized from large-scale historical synoptic data and surface data. The coarse grid covers the western U.S. and using interactive nested grids, the grids are refined to permit cloud-resolving simulations of the respective storm events with grid spacing of 1.67 to 3 km depending on the scale of the particular extreme precipitation event. Following a baseline simulation, sensitivity runs are performed with various estimates of initial soil moisture, enhanced low-level atmospheric moisture, and translation of the synoptic patterns relative to the underlying terrain.

The following storms have been simulated (the number after the event is the number of simulations performed):

1) July 28, 1997 Fort Collins Storm (6)

2) Aug. 31, 1976 Big Thompson Storm (6)

3) July 31, 1999 Dallas Divide Storm (5)

4) Sept. 18-22, 1997 Park Range Storm (2 so far)

5) Sept. 4-6, 1970 Southern San Juans Storm (3)

6) July 26, 1999 Saguache Creek Storm (1)

3. SUMMARY

- The most accurate control simulations occur with the least convective, large-scale forced storms like the San Juan and Park Range storms. The least successful simulations occur with the older convective events like the Big Thompson storm. This is likely due to the coarse resolution of the initial NCEP reanalysis data used for the older events.

- Simulations of heavy convective events are highly sensitive to the specification of initial soil moisture fields.

- Precipitation maxima occurring at higher elevations generally have significant contributions from hail, which may diminish surface runoff rates due to prolonged melting.

- The simulated convective events produce extreme rainfall with typical spatial and timing errors of 10 to 50 km and one to several hours, respectively.

- The correlation between maximum accumulated liquid precipitation and elevation may be used to refine spatially interpolated estimates of maximum liquid rainfall through the use of a special interpolation technique called Kriging (Wackernagel 1998; Isaacs and Srivastava, 1989).

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