MESOSCALE SIMULATIONS OF HEAVY PRECIPITATION EVENTS IN SOUTHERN CALIFORNIA DURING THE 1997-98 EL NIÑO

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1. INTRODUCTION

The terrain of southern and central California is one of extremes. For example, Los Angeles County alone is arguably the most terrain diverse county in the Nation. It encompasses the islands of Santa Catalina and San Clemente–20 to 50 miles offshore in the Pacific Ocean, the broad expanses of the L.A. Basin and the San Fernando Valley, the Santa Monica Mountains that reach over 3000 feet, the San Gabriel Mountains that exceed 10,000 feet, and the dry and sparsely populated Antelope Valley of the Mojave Desert.

Like the terrain, the weather of central and southern California is one of extremes. The complex coastal topography, for example, can induce mesoscale circulations responsible for heavy precipitation. For instance, some of the heaviest 24-hour precipitation totals ever reported in the entire state of California were recorded in southern California. Goodridge (1992) reports 26.12" of rain fell in just 24 hours in the San Gabriel Mountains of Los Angeles County in 1943. In fact, the U.S. Department of Commerce (1998) estimates the maximum probable 24-hour precipitation is 38" for the mountains in Santa Barbara County, 42" for Ventura County and over 48" for the mountain ranges of Los Angeles and San Bernardino Counties. Current operational models from the National Centers for Environmental Prediction (NCEP) are of insufficient resolution (30 to 40 km or greater) to accurately capture both the complex weather/terrain interactions and the intense gradients of temperature and humidity which are so important for providing daily, critical forecasts for the millions of central and southern Californians.

In a collaborative project between the University of California Santa Barbara (UCSB) and the National Weather Service Los Angeles/Oxnard Office, high-resolution daily real-time forecasts are produced with the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model 5 Version 3 (MM5-V3). The objective of this presentation is to investigate the skill of MM5 forecasts during heavy precipitation situations in southern California during El Nino of 1997-1998 (ENSO97).

2. MESOSCALE MODEL EXPERIMENTS

The ENSO97 was the strongest El Nino/Southern Oscillation (ENSO) event in the instrumental record. It caused significant climatic anomalies worldwide especially over North America. Four major storms during that winter season produced individually over 10 inches of rain in Southern California–along with extensive flooding. We specifically analyze the events of 5-6 December, 2-3 February, 6-7 February and 23-24 February 1998.

The MM5-V3 model is a non-hydrostatic mesoscale model in sigma vertical coordinates. The model configuration includes three nested grids of 36 km, 12 km and 4 km and 23 sigma vertical levels. Figure 1 shows the nested domain configuration, while Fig. 2 shows the topography resolution for the finest nested grid. The open circles denote the locations of weather stations used to assess the skill of the MM5-V3 precipitation forecasts.

The current UCSB real-time model configuration uses Schultz (1995) cloud microphysics scheme, which account for ice and graupel/hail processes. Additionally, Kain-Fritsch cumulus parameterization in the outermost two grids (36 km and 12 km) and simple radiational cooling in the atmosphere are used. The planetary boundary layer scheme from the Medium Range Forecast (MRF) global model from NCEP is used for all three grids. The model configuration also includes a five-layer soil model. Additional details on model physics and parameterizations are discussed in Grell et al (1993).

For these experiments, initial and boundary conditions were created by interpolation from global fields from National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis. For each of the four extreme precipitation cases (5-6 Dec, 2-3 Feb, 6-7 Feb and 23-24 Feb), the model was initialized at 00Z and integrated for 48 hours. Model outputs for the finest grid (4 km) were saved every hour.

3. DISCUSSION

This presentation will discuss the skill of the high resolution MM5-V3 mesoscale model in producing

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quantitative precipitation estimates during the extreme events during the El Niño of 1997-98. Hourly precipitation totals from weather stations distributed throughout southern California were used for comparison with MM5-V3 estimates of precipitation. Mean biases, root-mean square errors and correlation coefficients were computed between observed and simulated precipitation estimates.

Figure 3 shows an example of hourly precipitation from 2 February 00Z through 3 February 23Z 1998 derived from station data and MM5-V3 forecasts. The time series were averaged in the station locations over the three key regions shown in Fig. 2. The MM5-V3 forecasts show an obvious overestimation of the actual precipitation in some circumstances as well as a time lag of about 2-4 hours with the highest precipitation.

Further comparison with local radar reflectivity indicates that the high-resolution real-time MM5 forecasts provide an extremely important tool for local forecasters in Southern California. The MM5 forecasts in general successfully capture the mesoscale structure of precipitation in southern California. The inland movement of weather systems in the MM5 forecasts is in general delayed by about 1-4 hours.

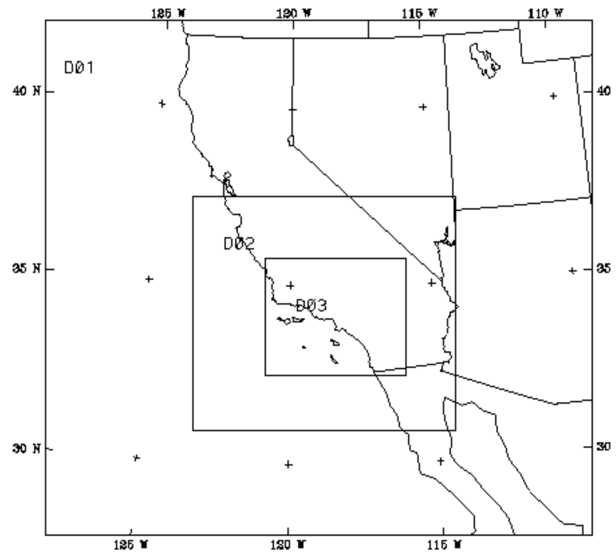

Figure 1. Nested configuration used by the Model (MM5-V3). The grid resolutions for the domains are: 36, 12 and 4 km.

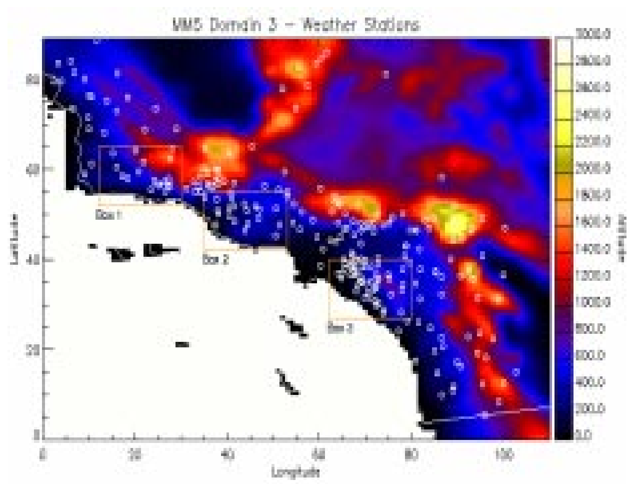

Figure 2. MM5-V3 Domain 3 (4 km) and terrain height (m). Open circles denote locations of weather stations used to assess the skill of precipitation forecasts. Boxes 1, 2 and 3 are key regions used to determine the time evolution forecast of synoptic systems moving over Southern California.

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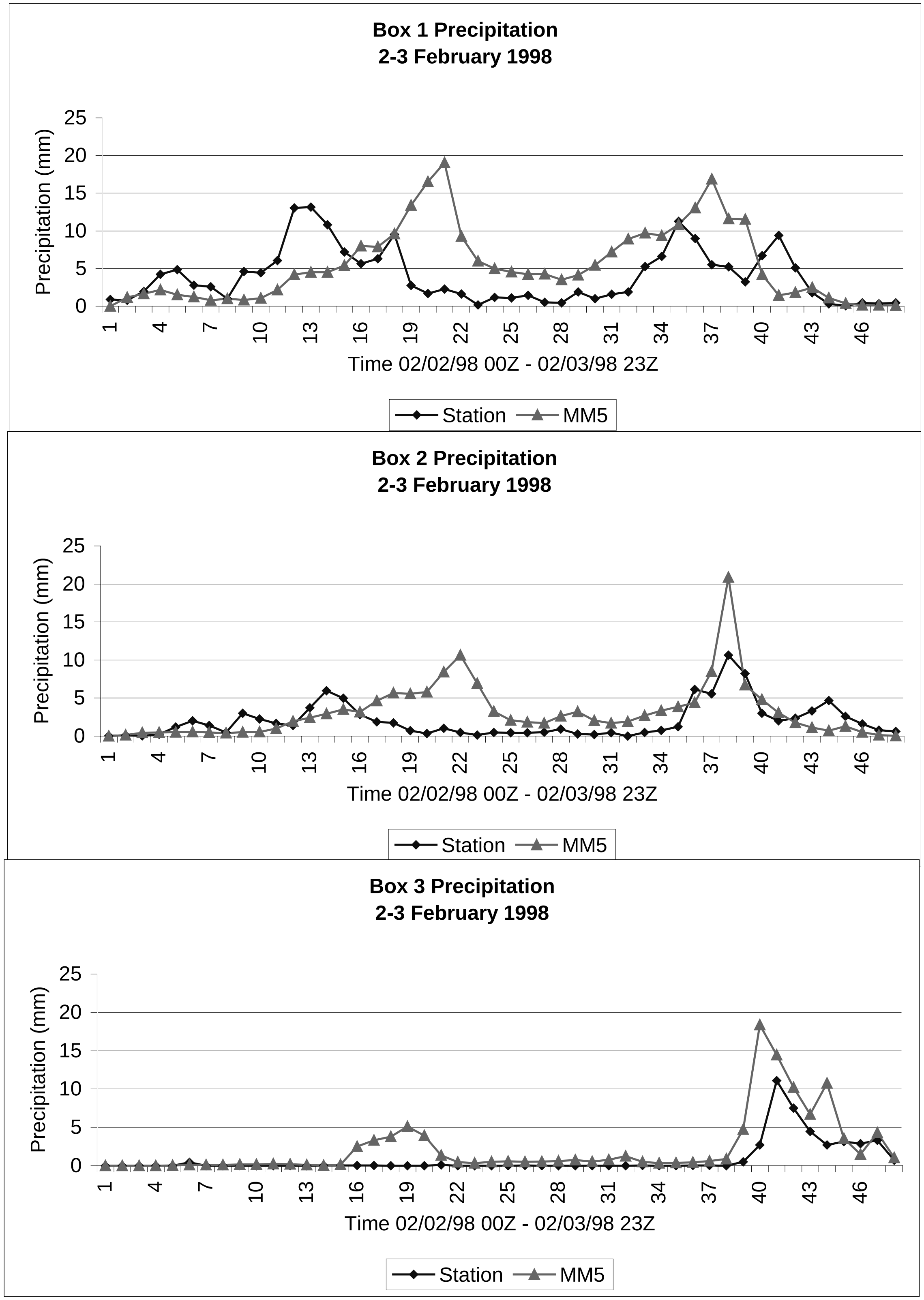

Figure 3. Comparison of Station (blue and small triangles) and MM5 hourly Precipitation (pink and triangles) during 3 February 1998. Hourly precipitation is averaged over station locations contained in the three boxes shown in Fig. 2. Units are in mm.