11.2 LANDFALLING CYCLONE FORECAST SENSITIVITY TO VARYING DATA ASSIMILATION METHODS IN A MESOSCALE MODEL.

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1. INTRODUCTION

During PACJET 2001, an intense extratropical cyclone rapidly developed off the Southern California coast and produced substantial rainfall as it interacted with coastal topography. Operational models tended to misplace the position and underforecast the intensity of the storm, which was due in part to a lack of observations over the cyclogenesis region off the coast of Southern California. PACJET made dropsonde and other insitu observations in the area, which were available for data assimilation tests using the Navy's COAMPS model.

Previous work has suggested that orographic rainfall predictions by a mesoscale model are sensitive to details in the specification of initial conditions. Nuss and Miller (2001) found significant differences in mesoscale precipitation for a landfalling front interacting with coastal topography that was rotated by 1 degree relative to the large scale wind direction. Their results suggest that in some situations the terrain forced precipitation can be sensitive to small differences in the synoptic-scale structure. In this study, the sensitivity of the cyclogenesis and subsequent orographic rainfall to the choice of data assimilation method is examined. The range of forecast errors and character of the forecast differences are examined to highlight crucial aspects in the initial state that must be faithfully represented by the assimilation system to accurately predict the cyclogenesis and orographic rainfall.

2. OVERVIEW OF CASE

On Feb. 12-13, 2001 an explosive cyclone developed off the coast of Southern California and produced heavy rainfall over the Southern California region. The evolution of the storm is depicted in Fig. 1, which shows a sequence of satellite images from 1200 UTC 12 February through 1200 UTC 13 February. The storm developed in the cold post-frontal airmass behind the cold front from an earlier system as depicted in Fig. 2. The development of the surface low, shown as multiple centers in Fig. 2, occurred as a strong jet aloft rounded the base of closed upper-level trough. Although poorly represented in the model fields shown in Fig. 3, satellite feature-tracked winds and NOAA P-3 aircraft observations (not shown) show that the left exit region of this jet occurred over the region of enhanced cold air convection where the surface low was developing.

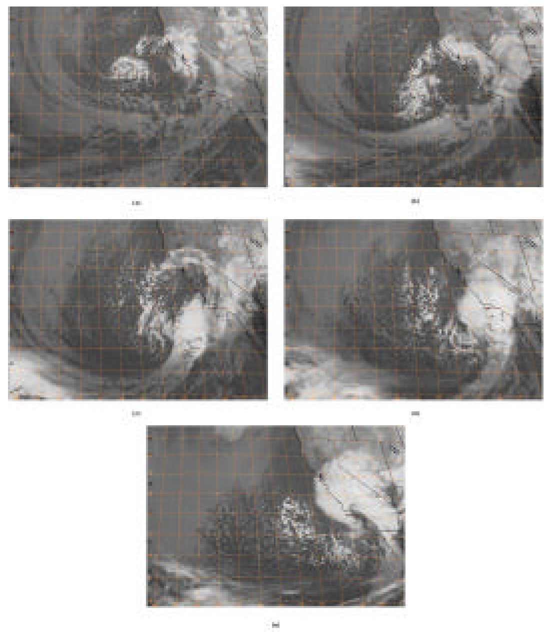

Figure 1. GOES-10 IR satellite imagery for (a) 12/12 February, (b) 12/18 February, (c) 13/00 February, (d) 13/06 February and (e) 13/12 February.

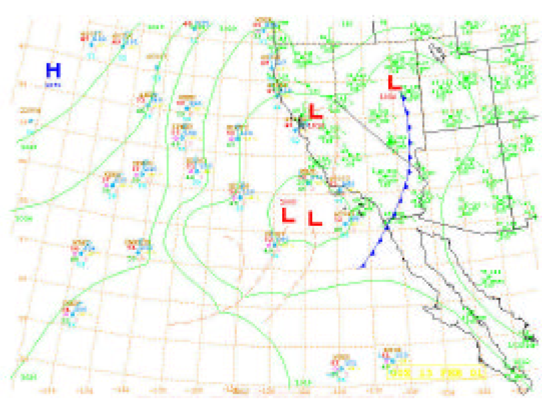

Figure 2. 13/00 February surface analysis with selected observations plotted.

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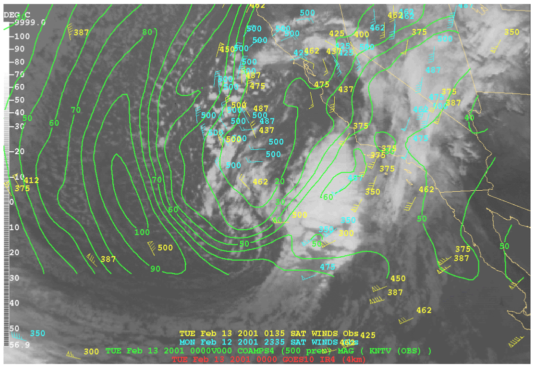

Figure 3. 13/00 IR satellite image with COAMPS 13/00 500 mb isotachs (kt) analysis and 300 to 500 mb SATWINDS for 12/23 (blue) and 13/01 (yellow).

During the next 12 hours, the cyclone underwent rapid intensification and propagated toward the Southern California coast just west of Los Angeles. The sea-level pressure analyses for 0600 UTC 13 February (Fig. 4) and 1200 UTC February (Fig. 5) depict the low-level evolution of this storm. It is during this time period as the low rapidly deepened and the cold front moved onshore that heavy precipitation occurred over the heavily populated Southern California region. Some rain gauges in mountainous regions reported storm totals of as much as 5 inches with this event, which resulted in regions of local flooding. The cyclone reached its greatest intensity at 1200 UTC 13 February and within 12 hours it decayed with little recognizable organized frontal cloud structure and only terrain-enhanced cold air convection over the southern portions of California.

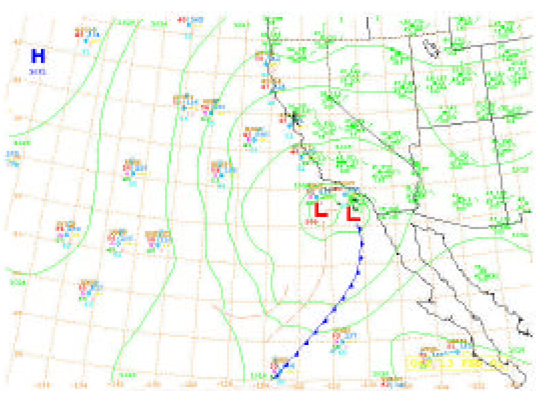

Figure 4. 13/06 February surface analysis with selected observations plotted.

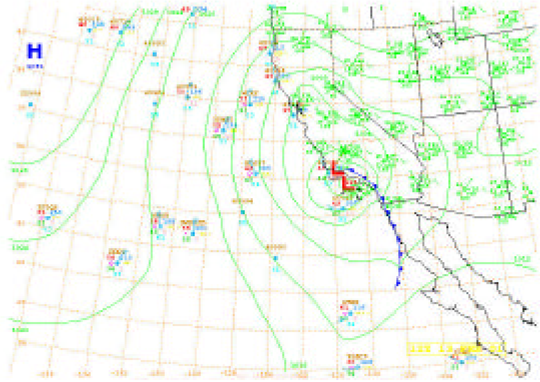

Figure 5. 13/12 February surface analysis with selected observations plotted.

Operational model forecasts of this event were rather poor at depicting the intensity and track of the cyclone. This is illustrated in Fig. 6, which compares the observed cyclone central pressure with that from 4 different operational forecasts initialized at 1200 UTC 12 February. The NCEP ETA and AVN models produced a cyclone of much weaker intensity and the track was too far south compared to the actual track (not shown). The Navy's NOGAPS and COAMPS models failed to develop any cyclone until 1200 UTC February 13 by which time the actual cyclone was 10 hPa lower in pressure and at its maximum intensity. All models were able to produce precipitation over the Southern California region, although the magnitude of the precipitation was generally underforecast.

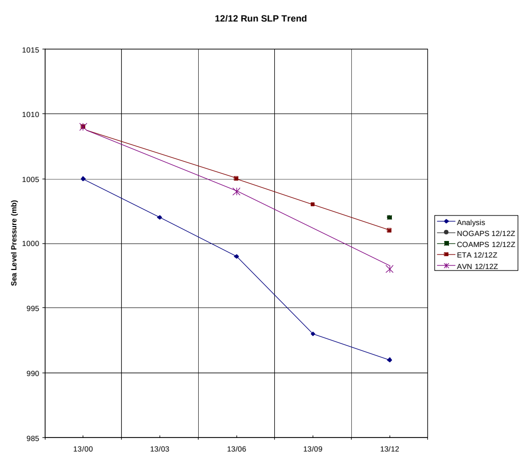

Figure 6. 12/12 NWP forecasts of the central pressure as compared to the analysis.

3. EXPERIMENT DESIGN

Given the difficulty that the operational models had in predicting the evolution of the cyclone, the potential sensitivity of coastal precipitation forecasts to errors in the synoptic-scale evolution was tested through several experiments using different data assimilation approaches. NPS has developed both two- and three- dimensional multiquadric-based (Nuss and Titley, 1994) data assimilation for COAMPS and other models and can run the multivariate optimum interpolation (MVOI) with COAMPS, as well. The analysis that results from these data assimilation systems will be different due to the relative weighting of the first guess, differing treatments of various observation types, and differing treatments of dynamic balance. These differences result in varied synoptic evolutions of the cyclone, which can impact on the timing, location, and intensity of terrain-enhanced precipitation. The goal of this study is to quantify the impact of the data assimilation on mesoscale forecast variance.

This study consisted of running the COAMPS model initialized at 1200 UTC 12 February using available observations and assimilating them into COAMPS using the MVOI, 2-D multiquadric, and 3-D multiquadric methods. The model was then run to generate forecasts through 36 h that were using in subsequent comparisons. Tests were made using observation plus first guess and first guess only (no observations).

4. PRELIMINARY RESULTS

Preliminary results are shown in Fig. 7 that compares the rainfall obtained using MVOI and 2-D multiquadric assimilations. The rainfall is a 21 hour forecast and represents 6 hour accumulations in the respective model runs. The two data assimilation systems result in different evolutions of the cyclone and the associated precipitation. The cyclone generally is more intense in the run using the MVOI assimilation than the multiquadric approach. This difference is probably related to stronger use of the first guess in MVOI than the multiquadric, which is advantageous in this data sparse region. The forecasts also show that the inclusion of observations in the MVOI had minimal impact on the forecast precipitation, whereas the stronger dependence of the multiquadric approach on observations exhibited a very strong variation due to the inclusion or exclusion of the observations. Further analysis is being done to better quantify the differences between these forecasts and the factors important for producing these differences. These results will be shown in the presentation.

5. REFERENCES

Nuss, W.A. and D.K. Miller, 2001: Mesoscale predictability under various synoptic regimes., *Nonlinear Proc. in Geophys*., in press.

Nuss, W.A. and D.W. Titley 1994: Use of Multiquadric interpolation for meteorological objective analysis*. Mon. Wea. Rev.*, **122**, 1612-1631.

a)

b)

c)

d)

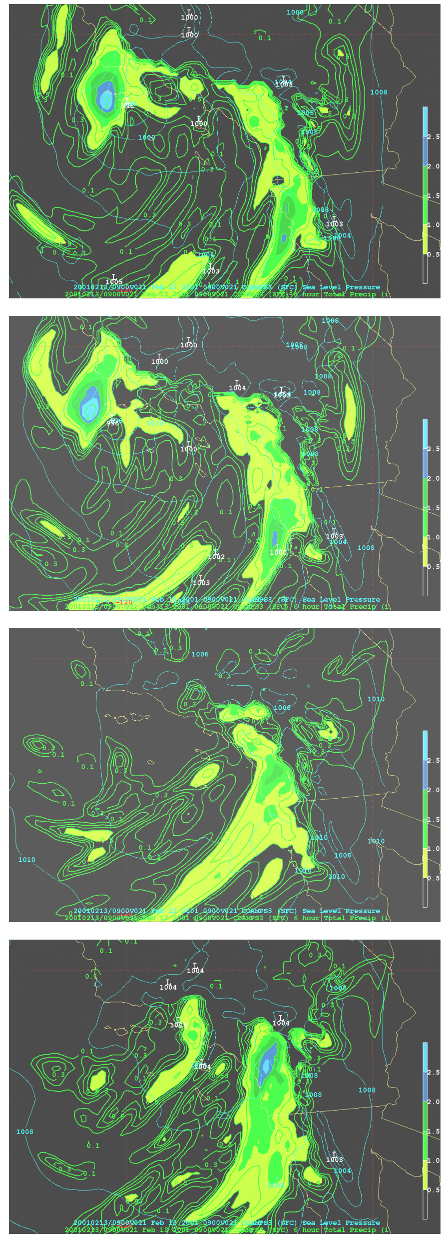

Figure 7. The 6 hour accumulated precipitation at 13/09 February (21 hour forecast) are shown for COAMPS forecasts using a) MVOI and observations, b) MVOI and no observations, c) 2DMQ and observations, and d) 2DMQ and no observations. Shaded regions are precipitation in excess of 0.5 inches.