RELATIONSHIPS BETWEEN TROPICAL CYCLONES AND RAINFALL IN BAJA CALIFORNIA, MEXICO

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1. Introduction

The weather of the Baja California peninsula, in northwestern Mexico, is mild and dry most of the year. The peninsula's geographical position places it in the path of humid air masses associated with tropical cyclones moving northward in the eastern Pacific Ocean from July through September. Added features that create a unique meteorological situation include mountain ranges, warm water in the Gulf of California, and the cold California Current in the Pacific Ocean. These features interact with the flow of humid air masses inducing conditions that play a role in localized, convective systems during the passing of tropical cyclones.

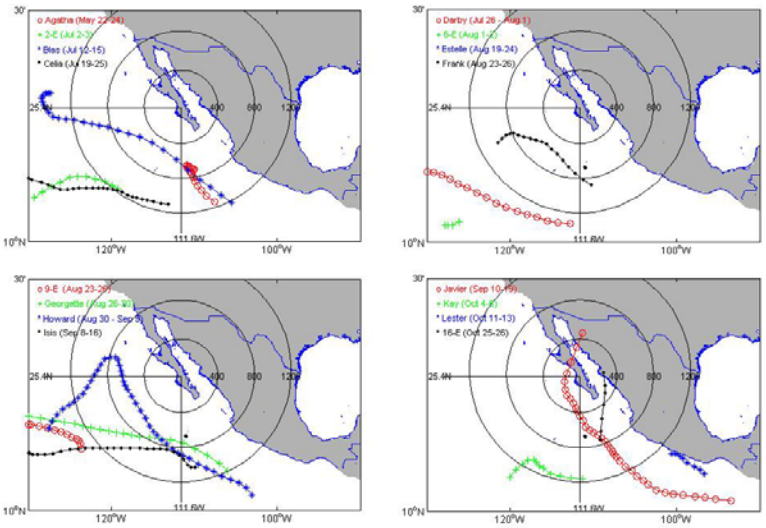

Fig. 1. Best-track of tropical cyclones from the season of 2004. Positions are at 6-h intervals and labels next to the name are life-cycle dates. Concentric circles, centered at 25.4°N and 111.6°W, are shown at 400-, 800- and 1200-km radii.

2. Geography and data

Our study area is the peninsula which is surrounded by the Pacific Ocean and Gulf of California. Since the main impact of tropical cyclones occurs over the southern peninsula, we concentrate our attention to the state of Baja California Sur (BCS, 22.9°N to 28.0°N).

For the 92-day period 1 July - 30 September 2004, data are extracted from a variety operational sources that include:

- Best-track data compiled by the U.S. National Hurricane Center (NHC). Figure 1 shows tracks of 12 named systems plus 4 tropical depressions that developed from late May through October of 2004.
- Upper-air soundings from La Paz (24.1°N,110°W) from the University of Wyoming historic archive. Figure 2 shows a time series of humidity parameters derived from the dataset.
- Daily rainfall from a network of 128 rain-gauge stations in BCS. The network is managed by Comisión Nacional del Agua (CNA) and the data are used to determine the distribution and intensity of rainfall.

3. Methodology

The following sequence of steps is applied:

1. Tropical cyclones that passed less than 800 km (for at least 24 hours) are selected. This make use of the NHC best-track (Fig. 1).
2. Changes in humidity at the La Paz (Fig. 2) are identified. Note above-average values of precipitable water and peaks on surface dewpoint during the approach of Tropical Cyclones Blas, Frank, Howard and Javier.
3. Rainfall accumulation during storm passage are estimated (Fig. 3). This is based in daily reports from the CNA rain-gauge network and is limited to the period in which the tropical cyclones developed inside the 800-km circle.
4. We also use an estimate of monthly and seasonal rainfall (Fig 4). This is based in daily reports from the CNA network and is limited to the period from July through September 2004.
5. Finally, we examine the distribution of rainfall anomalies on BCS determined from the difference of accumulated seasonal average minus the annual mean (Fig. 5).

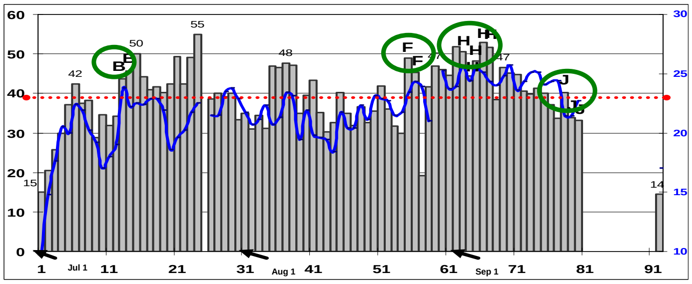

Fig. 2. Precipitable water (mm, shaded columns) and dewpoint (ºC, blue line) derived from the 1200 UTC upper-air soundings at La Paz. The red, dotted line represents average precipitable water (39 mm) for the period. Upper-case letters (B, F, H and J) identify tropical cyclones that penetrated the 800-km circle for more than 24 hours.

4. Results from the season of 2004

4.1. Significant Case Studies

We identified tropical cyclones that made landfall or that passed close to the peninsula (Fig. 3). These systems are assumed to provide some contribution of rainfall to the study area. In 2004, Tropical Cyclones Blas (13-14 July), Frank (23-26 August) and Howard (2-6 September) were classified under the group of close approximation (400-800 km) while Javier (16-20 September) was the only case making landfall. Among this group, Howard provided the largest amounts of accumulated rainfall (100-200 mm) near the southern tip while moving at about 600 km away from the coast. In contrast, with the exception of a well-defined area around landfall, Javier resulted in minimum accumulations (5-50 mm) through most of the southern peninsula. This fact is associated with the presence of dry air in the mid- to upper-troposphere (Fig. 2).

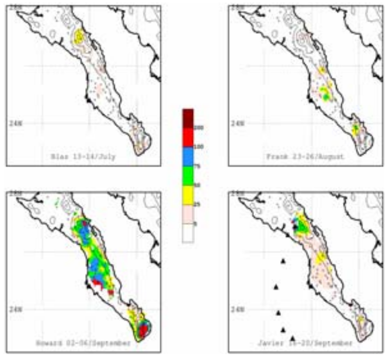

Fig. 3. Distribution of accumulated (mm) rainfall during the approach and landfall of tropical cyclones in 2004.

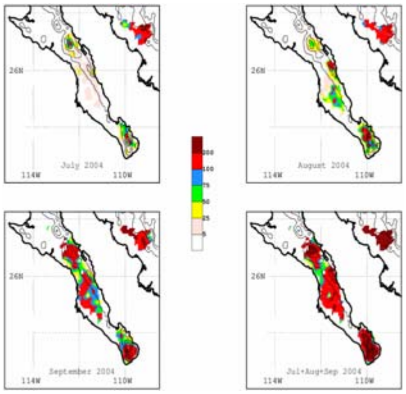

Fig. 4. Accumulated rainfall during monthly periods and total accumulation from July through September 2004.

4.2. Monthly and seasonal rainfall

Figure 3 shows rainfall accumulations and contours of terrain elevations. In general, there is a tendency for higher accumulations over the southern mountains (23°N-24°N) and a second maximum over the central range (25°N- 27°N). September provided an important contribution to the summer budget and tropical cyclone Howard (Fig. 3c) played a significant role by providing values above 100 mm in a period of 5 days. As previously documented by Latorre and Penilla (1988 in Atmósfera)[1], the southern part of Baja California receives most rainfall during the passage of tropical cyclones from the eastern Pacific Ocean.

4.3. Rainfall anomalies

In order to compare the seasonal accumulations from 2004, with those from a long-term average, we performed an analysis of rainfall anomalies for the summer season. This subtracts the (1991-2004) average from the season of interest (2004). Figure 5 shows these anomalies, where below normal rainfall (50-200 mm) occurred over the southern peninsula (22°-24°N) and above normal accumulations were detected over the central and northern portions of the state. This is due, in part, to the approach and landfall of Hurricane Javier in mid (16-19) September.

While all storms are detected before landfall and their motion known to some degree, predictions of storm intensity and structure still contain great uncertainty. Although there have been substantial increases in the accuracy of hurricane track prediction over the past decade, seasonal predictions have shown little skill (*Eos 2006*)[2].

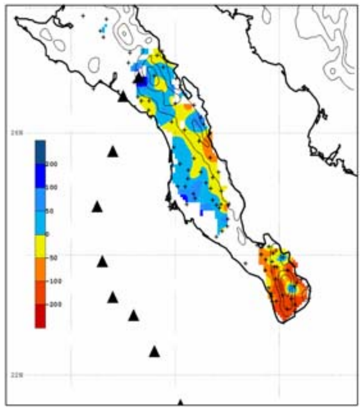

Fig. 5. Rainfall anomaly of July-September (2004) with respect to average accumulations in the base period July-September 1991-2004. Units are in mm; positive values indicate more rainfall in 2004.

5. Conclusions

Our analysis shows evidence of the tropical cyclone influence on patterns of rainfall in the southern peninsula. During the summer of 2004, several systems (Blas, Frank and Howard) moved close to the area while one case (Javier) resulted in landfall. The combination of these events provided above normal rainfall to some areas in the central and northern portions of the state.

1 Latorre D., Carlos and Penilla, Luis,1988. Influencia de los Ciclones en la Precipitación en Baja California Sur, Atmósfera, Vol. 1, pp 99-112.

2 Hurricanes and the U.S. Gulf Coast: Science and Sustainable Rebuilding, 20 June 2006. EOS, Volume 87, Number 25 p 245 and 250.