# RELATIONSHIPS BETWEEN EASTERN PACIFIC TROPICAL CYCLONES AND CONVECTIVE RAINFALL IN BAJA CALIFORNIA, MEXICO

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## 1. Introduction

The weather of the Baja California Peninsula is mild and dry most of the year. However, the geographical position palces it in the path of humid air masses associated with tropical cyclones from the eastern Pacific Ocean.

During the season of 2004, from late May through October, there were 12 named tropical cyclones in the basin. Most of them remained at sea. However, late in the summer one system made landfall as a tropical depression, moved across the Baja California Peninsula, and reached mainland Mexico.

This study analyzes humidity and rainfall patterns associated with the closest approach of Tropical Cyclones Blas, Frank, and Howard to the peninsula as well as during the landfall of Hurricane Javier. Figure 1 shows the tracks of these systems. Our analysis covers the storm events observed from 1 July to 21 September 2004.

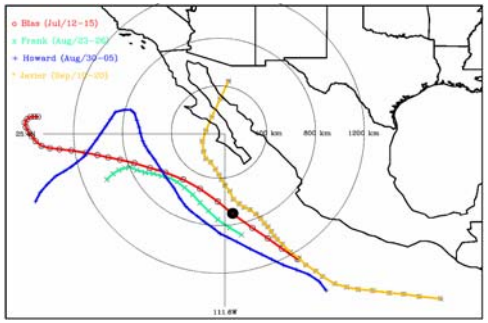

**Figure. 1.** Tracks of tropical cyclones from the season of 2004. Positions are given at 6-hour intervals and labels indicate formation-dissipation dates. Concentric circles are shown at 400-, 800- and 1200-km radii.

## 2. Observational datasets

The archived dataset of tropical cyclones, compiled by the National Hurricane Center (NHC), in the eastern Pacific basin provided position of the storm center and intensity as well as an estimate of the circulation size (radius of the 17 m $s^{-1}$ isotach).

Upper-air soundings were examined to identify characteristics of the large-scale environment over northwestern Mexico. These data included regular and special soundings taken for the North American Monsoon Experiment (NAME), which is intended to improve predictions of warm season precipitation over North America. Soundings were taken twice daily and, during Intensive Observing Periods (IOPs), releases were taken at intervals of 4-6 hours over several consecutive days.

Patterns of significant rainfall events were derived from a network of rain gauges managed by Comisión Nacional del Agua (CNA). These records are available as 24-h totals ending at 1500 UTC (local time is -6 hours). In southern Baja California, most of the stations are located at elevations below 500 m.

## 3. Results

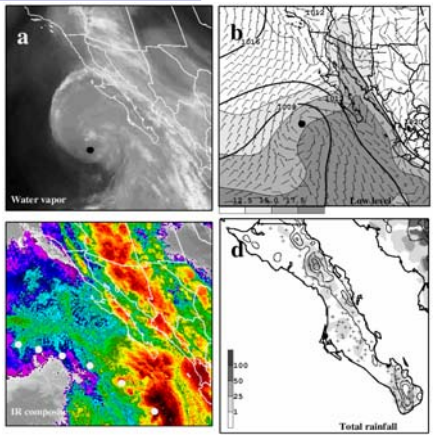


**Figure 2.** (a) GOES-10 water vapor image at 1200 UTC 14 July 2004. (b) Winds (m $s^{-1}$) at 10 m, 2-m mixing ratio (shaded, g kg -1), and sea-level pressure (thick line, mb) from corresponding GFS analysis. (c) GOES-10 infrared imagery composite (°C). (d) Total rainfall (shaded, mm) from 13-15 July and terrain elevation lines at 300, 600, and 900 m.

Figure 2a shows water vapor imagery at 1200 UTC 14 July. The storm center is about 700 km west of Cabo San Lucas and humid conditions (precipitable water > 45 mm) were present over the peninsula, gulf, and as far north as Arizona.

Low-level fields from the GFS analysis (Figure 2b) were used to identify the structure of cyclonic circulation extending across the southern part of the peninsula. The circulation is associated with a horizontal gradient of mixing ratio, which has a maximum (> 17.5 g kg-1) occurring southeast of the storm center. Note that southeasterly flow is present along the gulf and this fact provides advection of moist air.

In a composite image of deep convection, the pattern of cloud top temperatures is shown in Figure 2c. This image displays minimum temperature (maximum cloud tops) derived from hourly, infrared GOES-10 imagery for 1200 UTC 13 July to 0000 UTC 16 July. During this period, Blas was located within the 800-km circle and, as part of NAME, the second IOP was in progress.

Precipitation collected by the rain gauge network (Figure 2d) shows that scattered areas of light rain occurred along the mountain ranges. The largest amounts where in the range of 30-50 mm.

Of the four selected storms, Frank had the smallest horizontal circulation and produced a moderate impact in humidity fluctuations, along with limited areas of deep convection (not shown) and accumulated precipitation (Figure 3a).

Howard's was associated with prominent convective activity and the largest circulation. Moist air was advected into the southern part of the peninsula and Gulf of California, conditions that led to deep convection and high precipitation recorded by the regional network of rain gauges (Figure 3b). About 50% of the network received daily accumulations above 50 mm.

Javier made landfall in the central part of the peninsula, but had practically no impact on the population. A few rain-gage stations around the landfall area reported total accumulations above 50 mm (Figure 3c), but most of the stations outside this area had limited (< 25 mm) accumulations.

There was a set of storms (Celia, Darby, and Isis) that developed within the study period, but their movement was too far from the peninsula and had negligible impact. Thir small size and had a weak circulation resulted in very limited advection of moist air and rainfall.

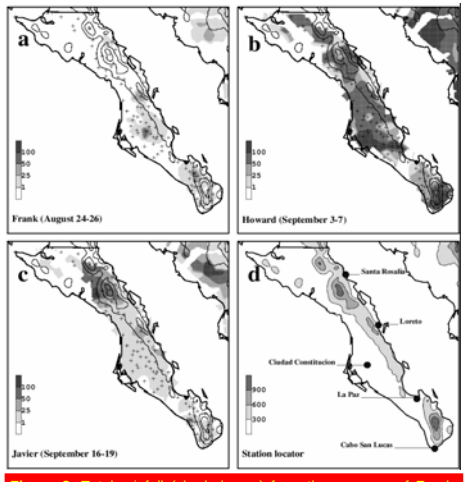


**Figure 3.** Total rainfall (shaded, mm) from the passage of Frank, Howard, and Javier. Terrain elevation lines at 300, 600, and 900 m and rain-gauge stations are indicated by plus symbols.

| Station | Blas | Frank | Howard | Javier | All |
|---|---|---|---|---|---|
| Santa Rosalía | 0 | 0 | 44.4 | 14.0 | 58.4 |
| Loreto | 4.3 | 0 | 4.8 | 3.8 | 12.9 |
| Ciudad Constitución | 2.8 | 5.5 | 37.1 | 9.9 | 55.3 |
| La Paz | 1.2 | 1.0 | 12.3 | 0.1 | 15.0 |
| Cabo San Lucas | 1.4 | 1.2 | 19.4 | 0.1 | 22.1 |

**Table 1**. Percentage of accumulated rainfall, associated with tropical cyclones, with respect to accumulations in the year 2004. Last column represents the contribution from all individual storms and station location is shown in Figure 3d.

Table 1 shows that Howard provided a leading contribution with respect to the rainfall received from other approaching storms during the season. In addition, all systems combined were able to provide between 10% and 60% of the total accumulations in 2004. This fact demonstrates that the approach of tropical cyclones played an essential role in the occurrence of rainfall during the warm season, which is consistent with the documentation from other studies.

In conclusion, this study documented the infuence of tropical cyclones on rainfall patterns over the Baja California Peninsula and additional information on the derived results is provided by Farfán and Fogel (2007, Monthly Weather Review, pp. 1208-1224).

## 4. Final remarks

A similar methodology to the one used in the above study is being applied to the tropical cyclone seasons 1991- 2003. This extension will increase knowledge of how regional environments affect approaching systems and provide a more general set of results to better understand impacts of storms in the southern part of Baja California.

As part of the extended study, we have the following findings:

- 6% of the storms made landfall in the peninsula while 29% of them passed within the 800-km circle from 26.4ºN and 111.6ºW.
- Mean fields of long-term precipitation have a well defined maximum (in the range of 300-500 mm) over the southern mountains.
- Wet summers are associated with the close approach (or landfall) of storms while lack of them is correlated with dry seasons.
- The slow forward motion and landfall of Hurricane Juliette (2001) has provided the largest rainfalli during the period of interest.
- When compared with long-term records, the southern peninsula received below normal precipitation during the summer of 2004.

## Acknowledgments

This work was carried out with the aid of a grant from the Inter-American Institute for Global Change Research (IAI) CRN II # 2048 which is supported by the U.S. National Science Foundation (Grant GEO-0452325).