A reconstruction of landfalling tropical cyclones on the Pacific coast of Mexico from 1850 to 1949

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Tropical cyclones: Current characteristics and potential changes under a warmer climate (IAI-CRNII-048 )
http://cabernet.atmosfcu.unam.mx/IAI
Introduction

- Official NHC database in Eastern Pacific basin starts in 1949, compared to 1850 in the North Atlantic basin
- The time series is too short to evaluate natural variability of frequency and trajectories
- Landfalling cyclones cause most of the impact to society

Our OBJECTIVE is to try to extend the time series of landfalling cyclones backwards in time
TC climatology: Landfalls in Mexico hide Baja California and Yucatan

From official NHC database
Previous studies:
Reconstructed trajectories 1921-1969

Figure 1.—Trajectories of hurricanes and tropical storms during August 1921–1969; the 21 near the trajectory represents the year 1921, the 23 represents 1923, etc.

14 landfalls

(Serra, 1971)
Previous studies:
Total Landfalling TCs in (1951-2000)

- **BAJA CALIFORNIA SUR**
  - HUR = 19
  - TS = 30

- **SINALOA**
  - HUR = 18
  - TS = 8

- **OAXACA**
  - HUR = 2
  - TS = 11

Fig. 1. Number of landfalling hurricanes (all categories) by states in México. 1951-2000 period.

(Jauregui, 2003)
What has happened in the last 60 years?

EPAC statistics 1950-2009

From official NHC database
EPAC satellite era

**Landfalling dates**

- **10-30 May** when rains start in most of Mexico
  - **DRY SOIL**

- **10-30 September** when rains are present in most of Mexico
  - **WET SOIL**

**Formation dates of landfalling TC**

- **Minimum Activity**

For 1921-1969 Serra (1971) reported

[Graph showing the distribution of landfalling dates for TCs with annotations and labeled axes]
Large intra-seasonal land-fall variability (satellite era)

(Farfan, et al, 2012)
**Historical Reconstruction**

**Methodology:**
Visits to repositories in different cities: Mexico City, Chilpancingo, Acapulco, Guadalajara, Mazatlan, Culiacan, La Paz

**Repositories:**
Federal, State and local libraries
Regional government offices

**Sources:**
Newspapers
Official bulletins
Diaries

Source: Archivo Historico Municipal de Mazatlan
“New catastrophe by a cyclone in Puerto Vallarta”, reported in the newspaper El Sol, Guadalajara, 24 October 1925

Information about damages:

“Mr. State Governor: On the 24th at 22:00 a strong cyclone affected the city. Two hundred and seventy palapa houses were destroyed, leaving 200 homeless families, 3 dead and numerous injured... Roads were damaged and telegraph lines were down...”

Official municipal report
“Numerous houses destroyed by the cyclone”, Newspaper El Democrata Sinaloense, Mazatlan, 22 September 1928

Meteorological information:

“...On the 20th, a warning was issued to all ports that a cyclone was affecting the city, with heavy rains starting at 5 am.... By 4pm, the rain was light but constant... At 6:30pm the winds from the SE rotated to the East and lasted for 24 hours, reaching 159 km/hr. By the next morning winds were light and from the South...”
DATABASE
A special fiche was designed to transfer all the information found for each record.

Source information and digital files with photos of the original newspaper

Immediate effects: rains, winds, storm surge, landslide,…

The impacts were carefully classified: number of casualties, injured, missing, evacuated; damages to property (houses, cattle, crops), industry; city infrastructure such as schools, hospitals, roads, ports, communications, etc.
Historical records of landfalling TCs in 4 Mexican States:

Baja California Sur (BCS), Sinaloa (Sin), Jalisco (Jal), Guerrero (Gue)

![Bar chart showing historical records of landfalling TCs in 4 Mexican States: Baja California Sur (BCS), Sinaloa (Sin), Jalisco (Jal), Guerrero (Gue).]
Record of landfalling TCs in EPAC: Guerrero, Jalisco, Sinaloa and BCS (1850-2010)
Reconstructed landfalling timeseries

Parameter | Value | 95% CI
---|---|---
N: | 155 | 
mean: | 1.8 ± 0.2 | 1.6 ... 2.1 |
s.d.(n): | 1.6 ± 0.2 | 1.4 ... 1.7 |
skew: | 0.7 ± 0.3 | 0.4 ... 0.9 |
Wavelet (1850 - 2010)
Black curve: cone of influence

<table>
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<th>period</th>
<th>Index</th>
<th>Spearman</th>
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<tr>
<td>1850-2010</td>
<td>NAO</td>
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<tr>
<td>1866-2009</td>
<td>SOI</td>
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<td>1900-2010</td>
<td>PDO</td>
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<td>1856-2010</td>
<td>Niño3</td>
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- Large scale decadal variability in the Pacific

(Mantua et al, 1997)
Large scale decadal variability in the Pacific

1948-1976 Negative PDO index

1977-2006 Positive PDO index
Summary

- From NHC database, hurricanes and major hurricanes in the EPAC basin have *decreased* in last decade, while number of landfalling TCs remains fairly constant.
- Large *intraseasonal* variability of land-falling cyclones.
- Landfalling time-series were *reconstructed* from historical records and newspapers *back to* 1850, for 4 Mexican States in the Pacific.
- Variability *comparable* to that observed in NHC database.
Summary

→ Average of $1.8 \pm 1.6$ landfalls per year
→ Largest correlation with PDO index
→ A very rich database with thousands of records has been generated, not only about physical but social-economic aspects

Future work:
1. Funds from IAI already available to continue the reconstruction to 1500 AD with historians and social anthropologists, led by V. Garcia-Acosta
2. Collaboration with Kam-biu Liu already initiated, with several cores obtained in Guerrero, Jalisco and BCS, currently being analyzed
Landfalling TCs:
Where they start, when they start, where they land?

On average about 15% of the total named cyclones make landfall

Genesis location of landfalling TC

Genesis location of non-landfalling TC

(Romero-Centeno et al, 2011)
Variability associated to large-scale patterns

(Farfan, et al, 2012)
Variability associated to large-scale patterns: 1949-2010

Baja peninsula landfall

Mainland landfall
Historical records of landfalling TCs in 4 Mexican States

- Baja California Sur (BCS), Sinaloa (Sin), Jalisco (Jal), Guerrero (Gue)

No records found
Periodogram (1850 - 2010)

Autocorrelation (1850 - 2010)