TROPICAL CYCLONES: CURRENT CHARACTERISTICS AND POTENTIAL CHANGES UNDER A WARMER CLIMATE

CRN II-048

G.B. Raga
Centro de Ciencias de la Atmosfera, UNAM
Participants

David Raymond, New Mexico Tech, USA

Omar Lizano, San Jose, Costa Rica

Luis Farfan, Cicese, La Paz, Mexico

Jorge Zavala & GB Raga, CCA, Mexico

IMTA (?) Mexico

Orzo Sanchez CICATA Mexico

D Martinez & I Mitrani, Cuba
Project workshop: 15-16 Feb

- All PIs from USA, Costa Rica and Mexico
- D. Pozo (post-doc) and B. Martinez (visiting scientist, oceanographer)
- R. Romero-Centeno and Julio Marin, PhD students (under GB Raga)
- 2 undergraduate students working with R. Prieto
Objectives

• To better understand the factors and processes that influence the intensification of tropical cyclones, through observations and model simulations

• To evaluate which of those factors could be more important under global warming scenarios

• To evaluate the impact of coastal waves induced by tropical cyclones under global warming scenarios
Methodology

- Climatology from gridded global data (NCEP & ERA40)
- Climatology from satellite data for ocean heat content (Topex/Poseidon)
- Analysis of high-rate in situ data:
  - Lightning
  - Aircraft during TSCP/IFEX (2005)
SLP anomaly with respect to (June-September average)

(Romero-Centeno, 2007)
Average SLP during summer

(Romero-Centeno, 2007)
Sea level pressure (ECMWF)

January

March

May

July

September

November

(Romero Centeno, 2007)
Could this in any way be related to changes in tropical cyclone trajectories and intensities?

(Vulnerabilidad y Adaptación Regional Ante El Cambio Climático y sus Impactos Ambiental, Social y Económicos. Magaña y Gay, Reporte Instituto Nacional de Ecología de Mexico)
Methodology (future)

- Modeling activities:
  - Mesoscale model in forecast mode
  - Mesoscale model in hindsight mode
  - Use of coastal models

- Climatology from global climate model output from IPCC-4AR

- PI-Workshop and spring school (Los Cabos, March 2008)
Lightning from WWLLN

Hurricane Lane
13-17 Sept 2006
Lightning from WWLLN

Hurricane Paul
21-26 Oct 2006
Hurricane Paul
21-26 Oct 2006 (Category 2)
Lightning from WWLLN

Hurricane John 2006
Hurricane John
28-Aug-4 Sept 2006
Category 4
Typhoon Maemi, 2003

(Lin et al, 2005)
\( g' = g \frac{\rho_{\text{lower}} - \rho_{\text{upper}}}{\rho_{\text{lower}}} \)

~500km

(Lin et al, 2005)
Spatial scales are typical of Atmospheric Numerical Weather Prediction.

Temporal sampling is much worse than in Atmospheric NWP, but that is ok for many open ocean applications.

(Courtesy J. Zavala-Hidalgo)
SSHA “wake” of hurricanes in EPAC

(Courtesy O. Sanchez-Montante)
CAMPOS MENSUALES MEDIOS DE MSLA EN EL PERIODO 1993-2006

(Courtesy O. Sanchez-Montante)
Altimetry observations can be used to estimate SSH and dynamic height (analogous to the height of a pressure level).


(Courtesy J. Zavala-Hidalgo)
Monthly Sea Surface Temperature

SST important but also depth of the oceanic mixed layer

Ocean heat content available for cyclone intensification
October

Relevant for intense precipitation in NW Mexico
Mapa 6d. Trayectorias del mes de agosto de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000

Mapa 6e. Trayectorias del mes de septiembre de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000
Mapa 6b. Trayectorias del mes de junio de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000

Mapa 6c. Trayectorias del mes de julio de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000
Positions of Tropical Cyclogenesis


Number of events
51 Tropical Storm  32 Hurricanes

Tropical Storm  Hurricane

Number of events
52 Tropical  32 Hurricanes

of Tropical Cyclogenesis

Diagnóstico de Peligros e Identificación de Riesgos de Desastres en México
When and where are the tropical cyclones formed in the East Pacific that significantly affect Mexico?

Can we determine why?
Low level zonal transport over the East Pacific and precipitation over S-Mexico and CA

(Romero-Centeno, 2007)
Low-level vorticity

January

April

June

July

September

November

(Romero-Centeno, 2007)
End of summer (September)

Low-level winds

Low-level divergence

(Romero-Centeno, 2007)
Mid-summer (July)

Low-level winds

Low-level divergence

(Romero-Centeno, 2007)
Beginning of rainy season (June)

Low-level winds

Low-level divergence

(Romero-Centeno, 2007)
Annual variation of low-level winds (Quickscat)
Annual variation of low-level winds (Quickscat)
Fig. 4. Climatological distribution of biweekly precipitation rates [mm (2 weeks)^{-1}] for contiguous 5° × 5° areas.

(Magaña et al, 1999)
Fig. 2. Precipitation (black solid line), maximum temperature (gray solid line), and minimum temperature (dotted line) biweekly climatologies for Oaxaca, Mexico (17°N, 97°W).

Fig. 3. Climatological precipitation (mm) (1979–93) for Jun–Sep.