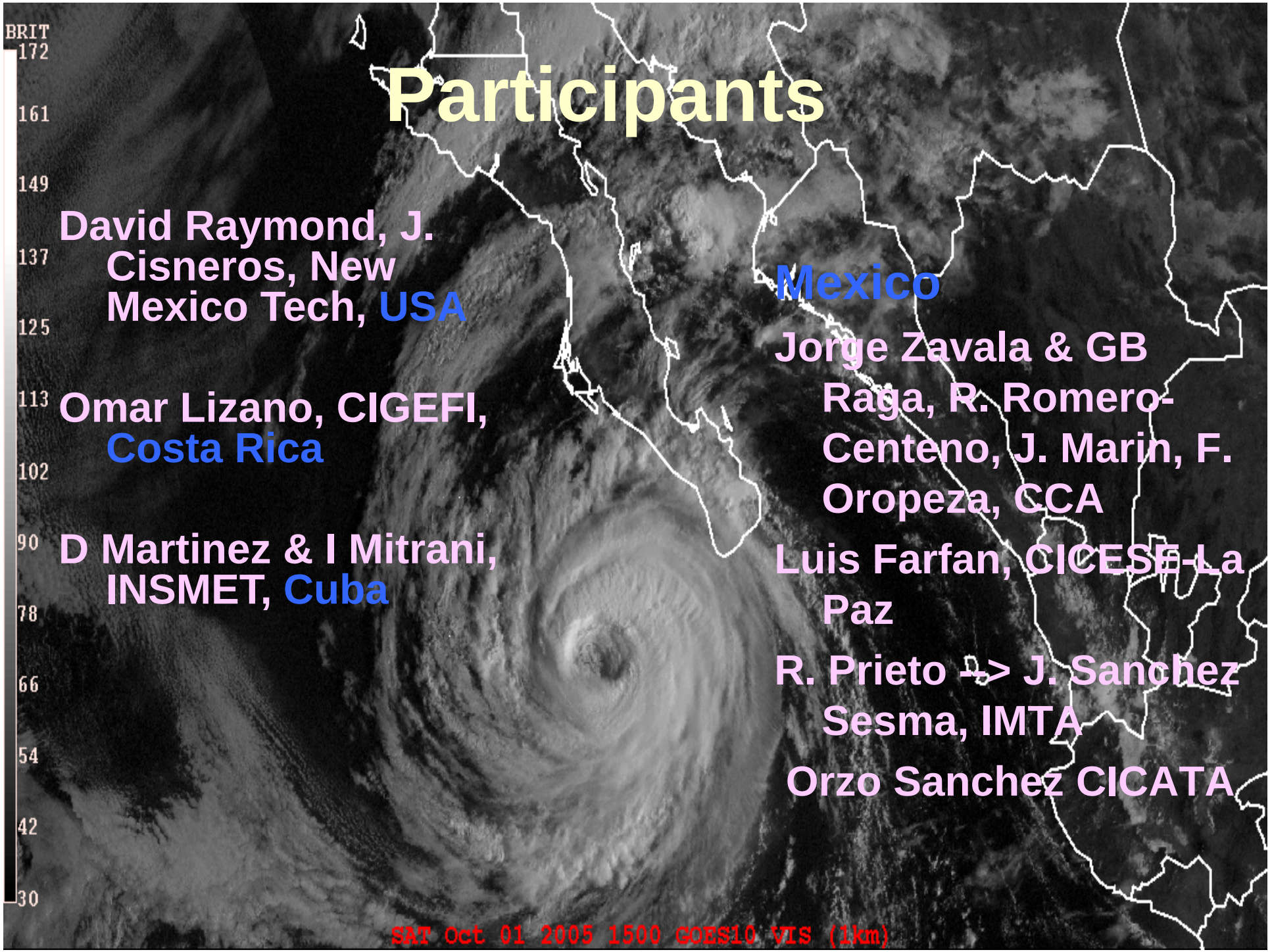
TROPICAL CYCLONES: CURRENT CHARACTERISTICS AND POTENTIAL CHANGES UNDER A WARMER CLIMATE

CRN II-048

G.B. Raga

Centro de Ciencias de la Atmosfera, UNAM



Participants

David Raymond, J. Cisneros, New Mexico Tech, USA

Omar Lizano, CIGEFI, Costa Rica

D Martinez & I Mitrani, INSMET, Cuba

Mexico

Jorge Zavala & GB Raga, R. Romero-Centeno, J. Marin, F. Oropeza, CCA

Luis Farfan, CICESE-La Paz

R. Prieto -> J. Sanchez Sesma, IMTA

Orzo Sanchez CICATA

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)

***When* and *where* are the tropical cyclones formed in the East Pacific that significantly affect precipitation in Mexico?**

Can we determine *why*?

Figura 73. Probabilidad de paso de un huracan en el periodo de 1960 a 1995 y trayectoria de los huracanes mas destructivos que han afectado al pais

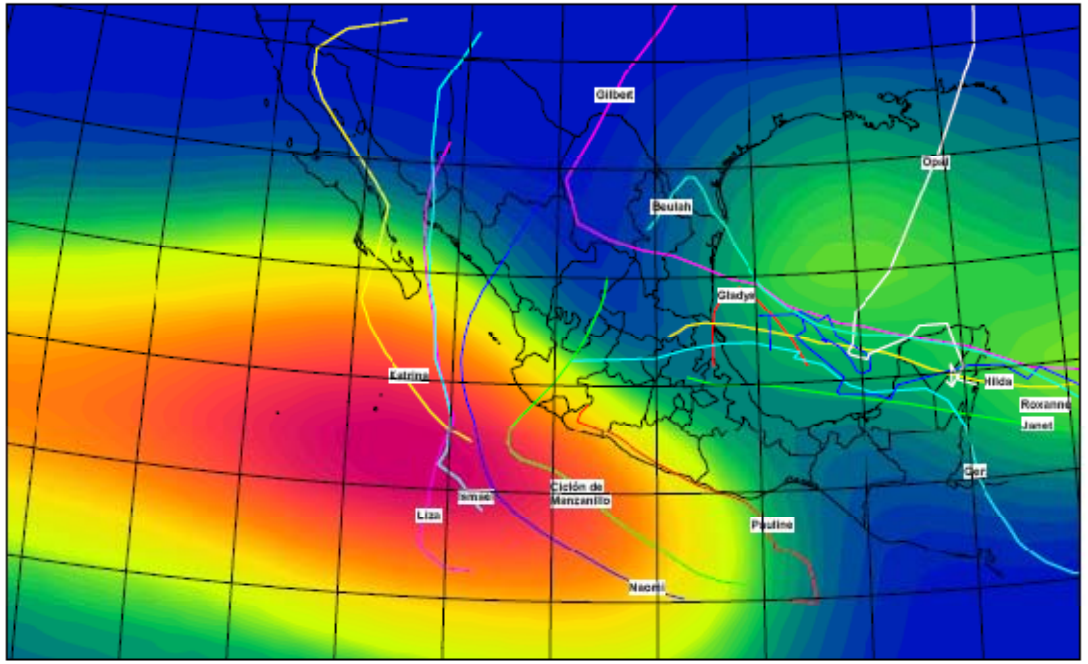
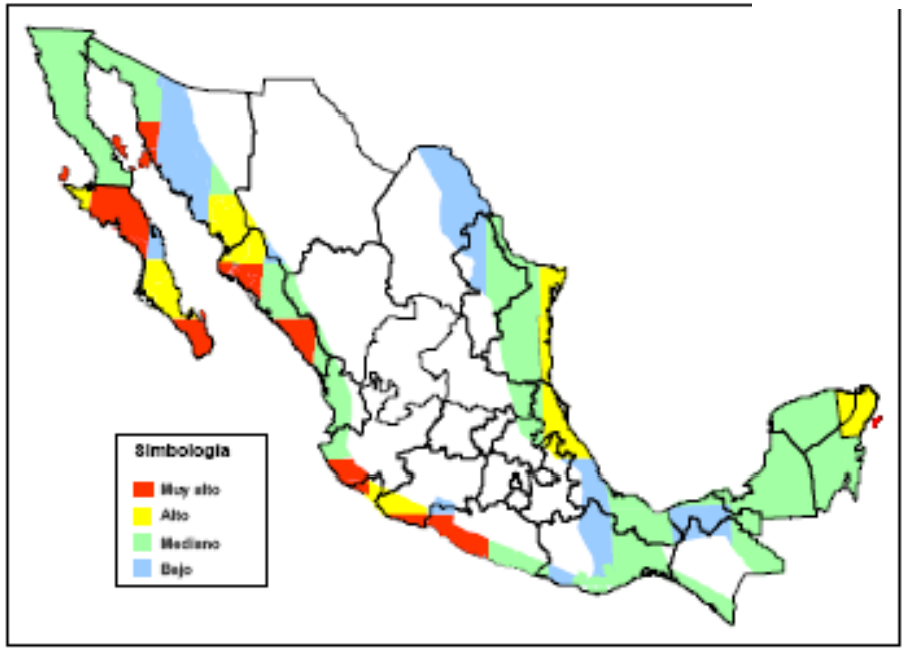
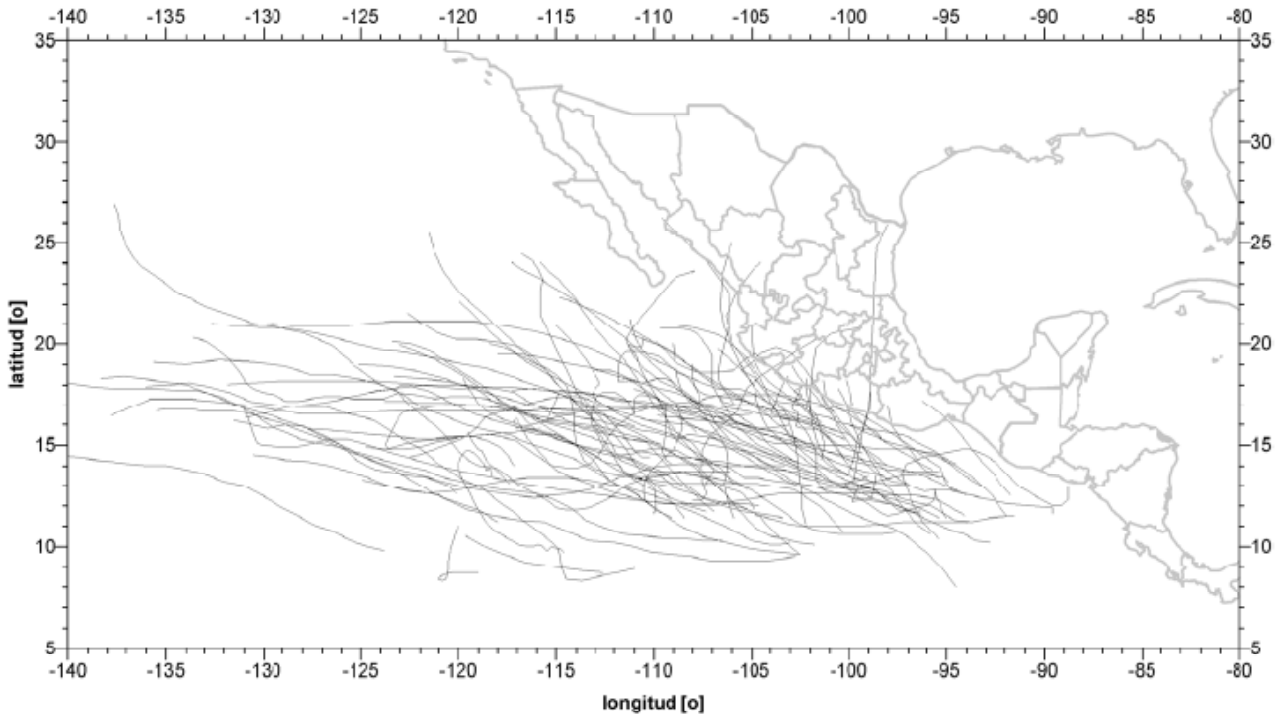


Figura 72. Mapa de peligros por inci



Diagnóstico de Peligros e Identificación de Riesgos de Desastres en México

CENAPRED

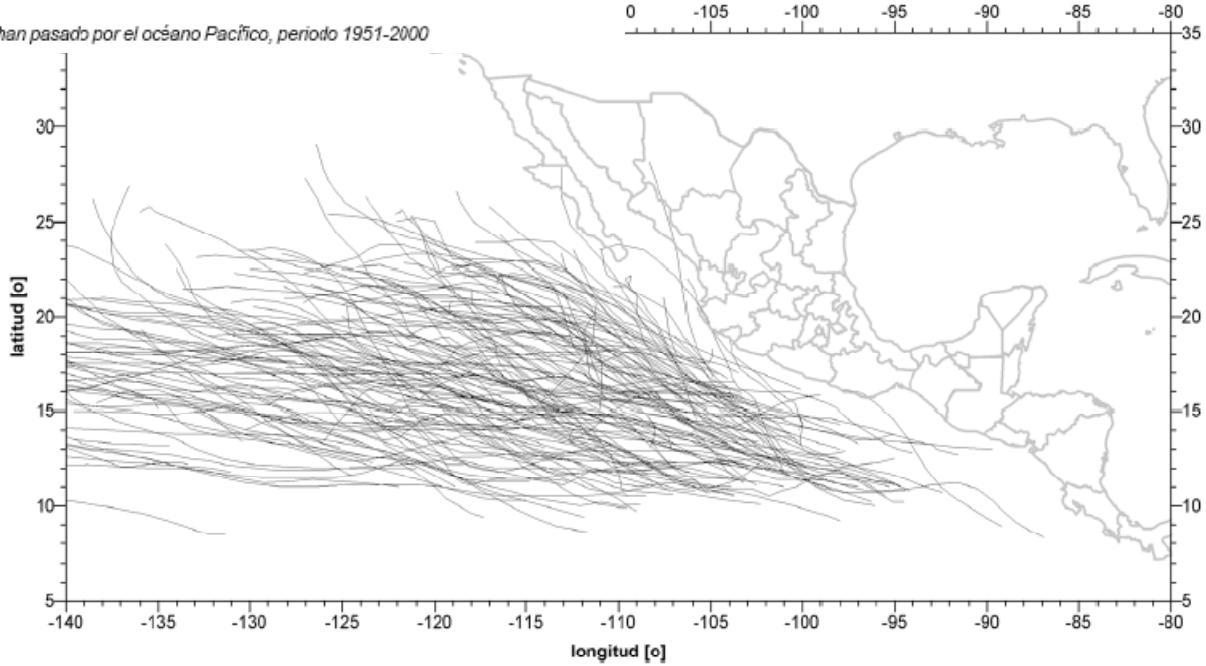


June

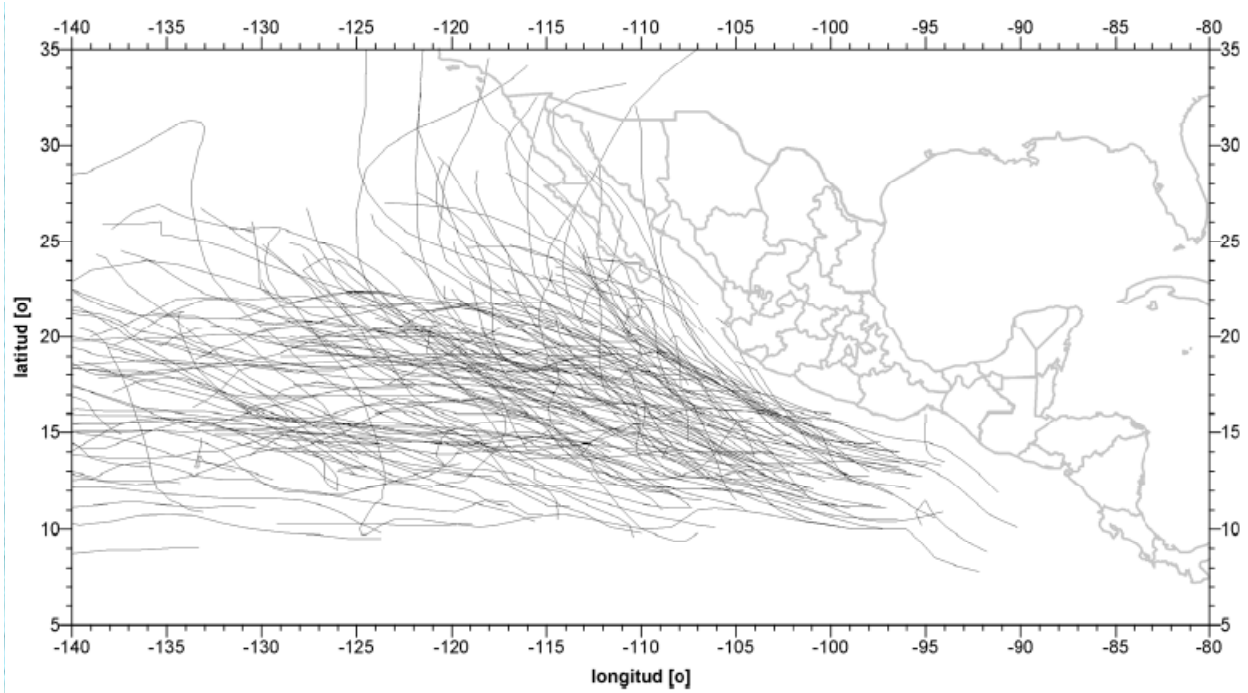
Mapa 6b. Trayectorias del mes de junio de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000

July

(Rosengaus et al., 2002)



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

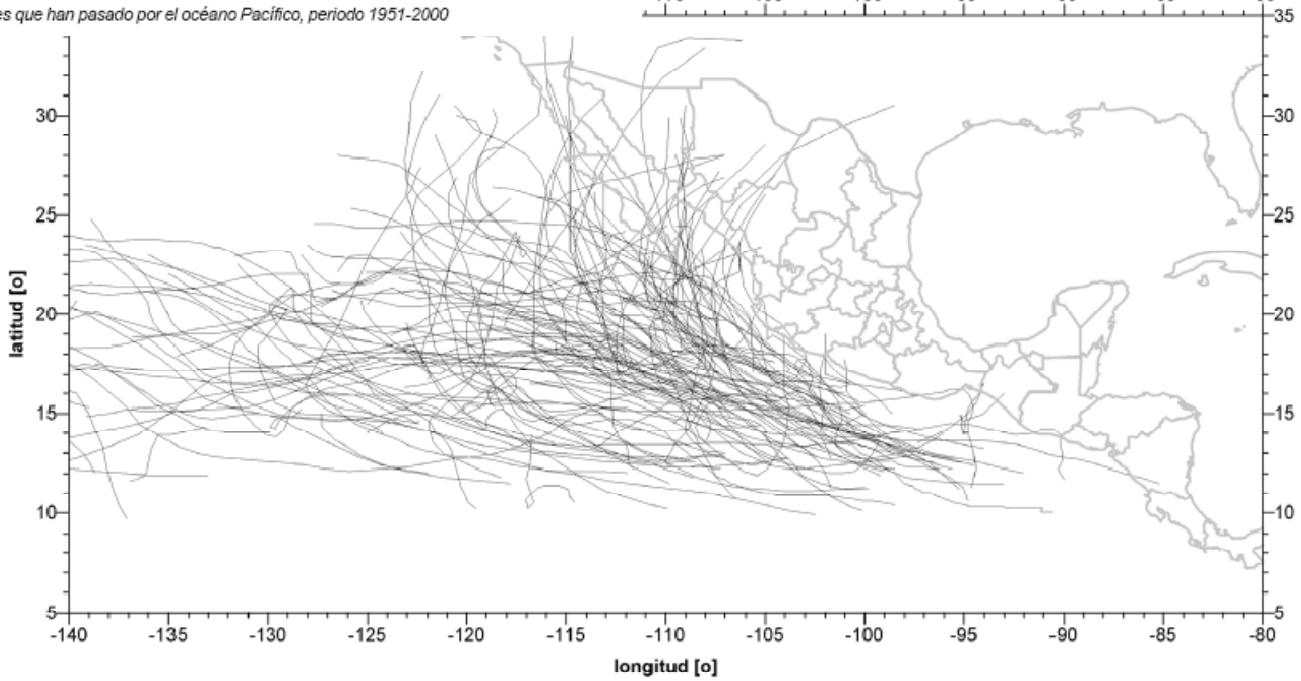


Mapa 6d. Trayectorias del mes de agosto de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000

August

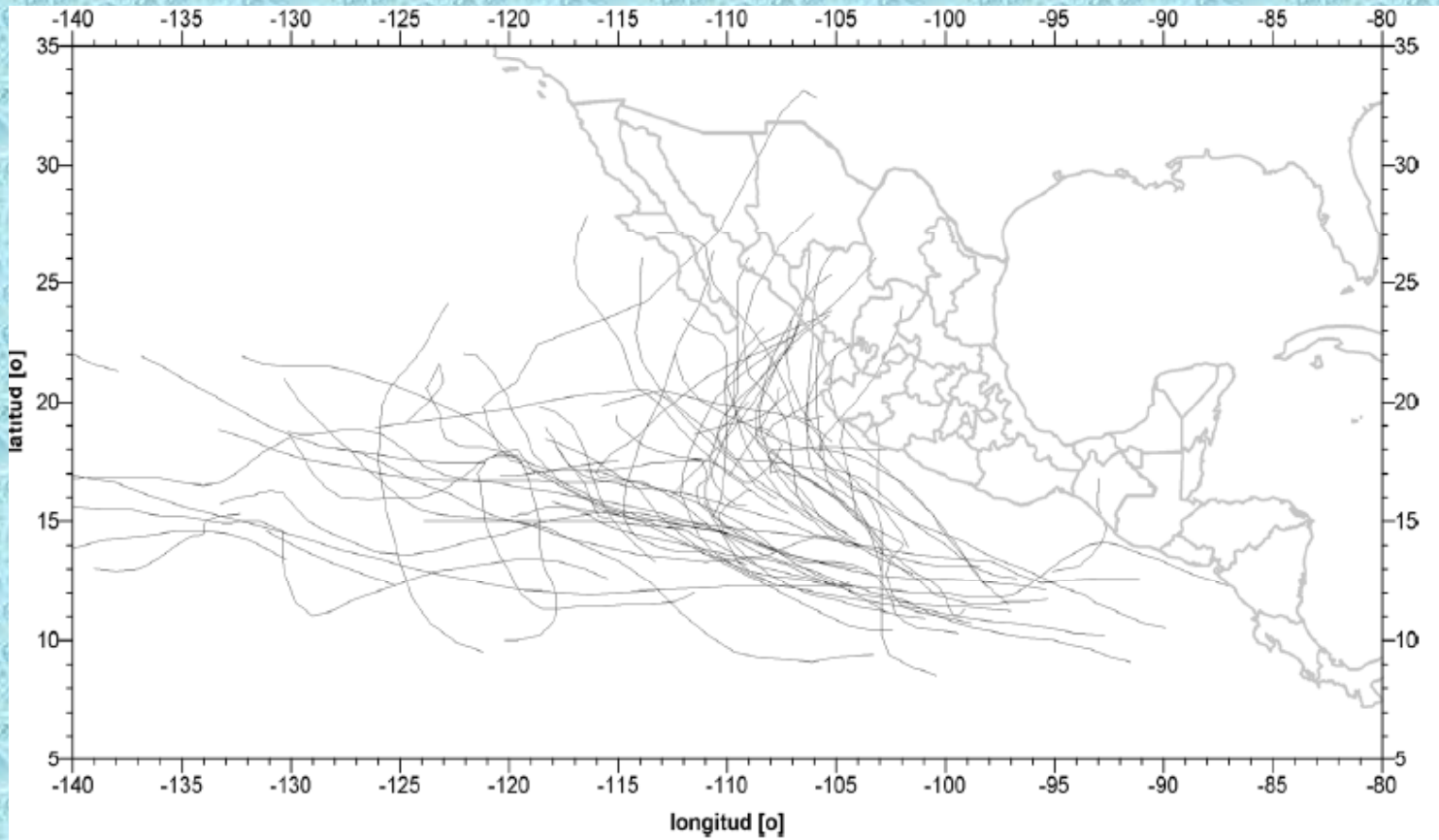
September

(Rosengaus et al., 2002)



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

October



Mapa 6f. Trayectorias del mes de octubre de los ciclones tropicales que han pasado por el océano Pacífico, periodo 1951-2000

(Rosengaus et al., 2002)

Relevant for intense precipitation in NW Mexico

(Magaña et al, 1999)

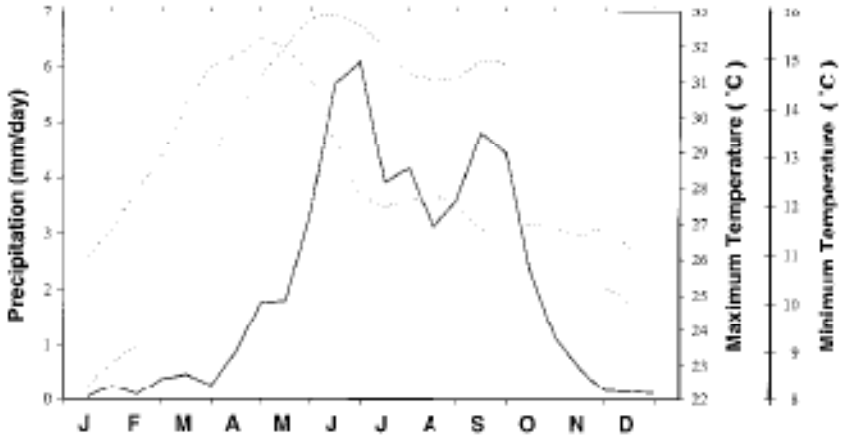


FIG. 2. Precipitation (black solid line), maximum temperature (gray solid line), and minimum temperature (dotted line) biweekly climatologies for Oaxaca, Mexico (17°N, 97°W).

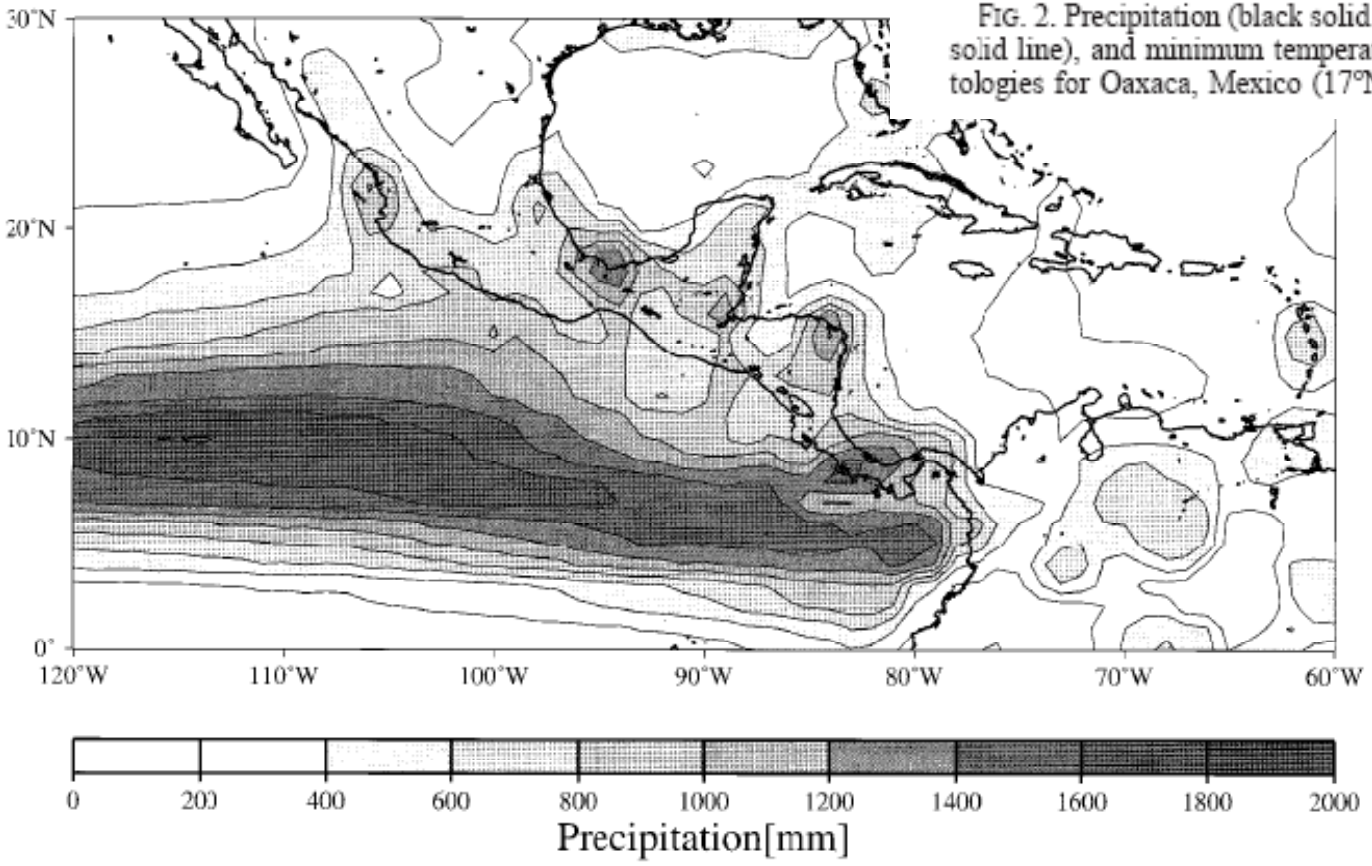


FIG. 3. Climatological precipitation (mm) (1979–95) for Jun–Sep.

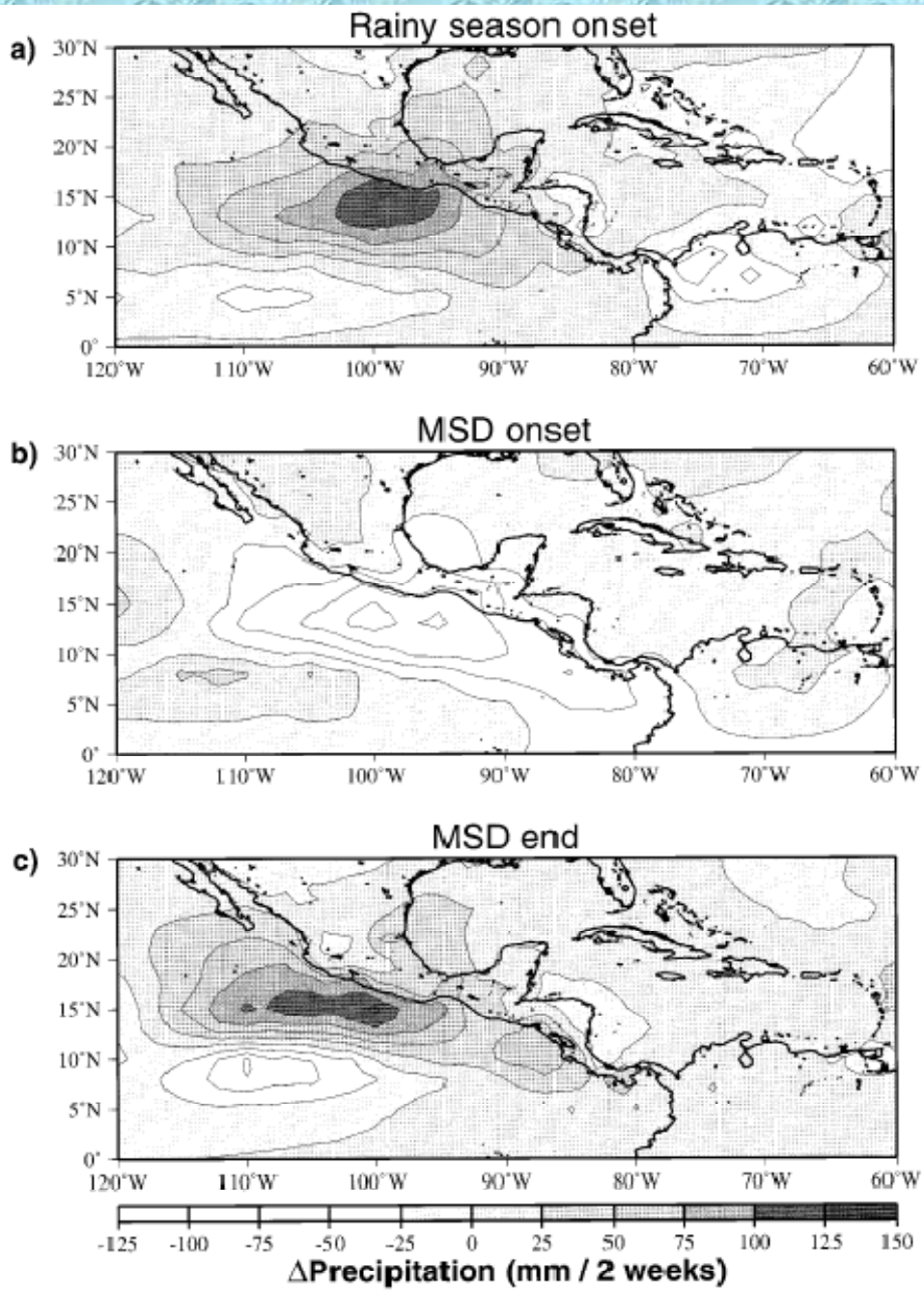


Fig. 6. Composite patterns for precipitation changes between two biweekly periods during (a) the onset of the rainy season, (b) the onset of the MSD, and (c) the end of the MSD.

June

July-August

September

(Magaña et al, 1999)

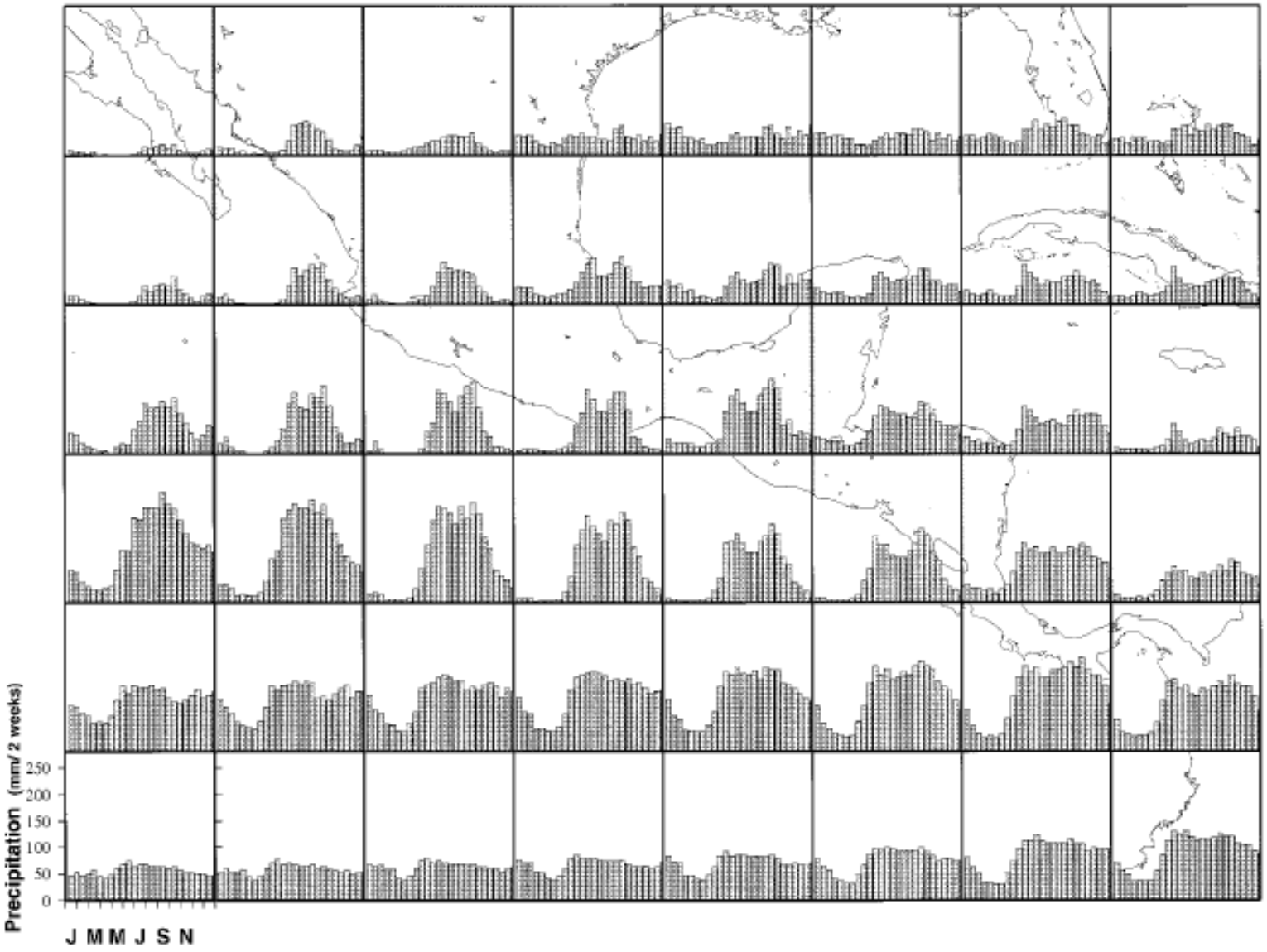
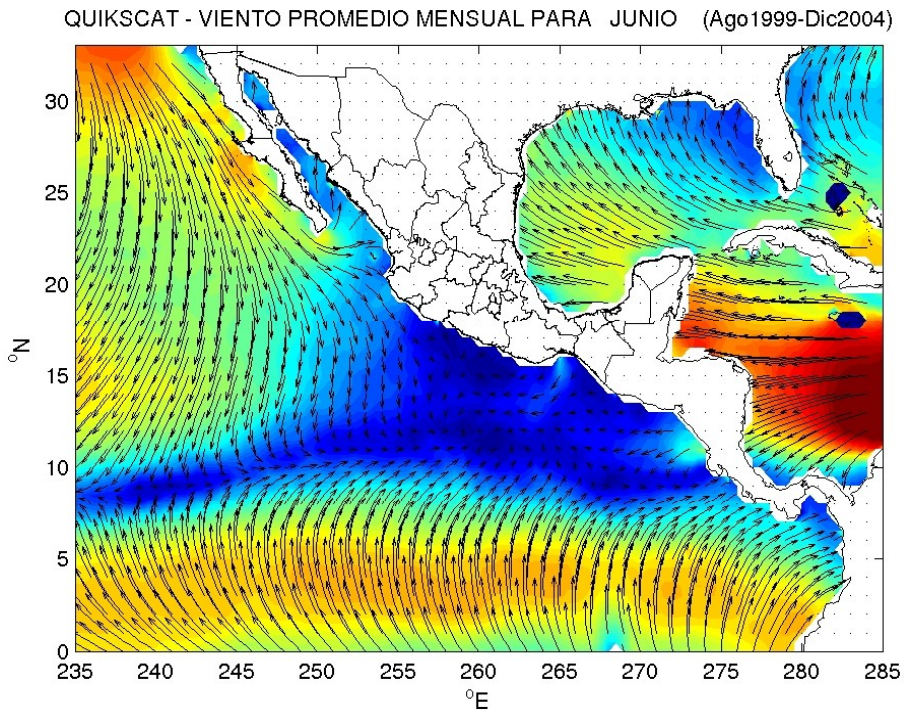
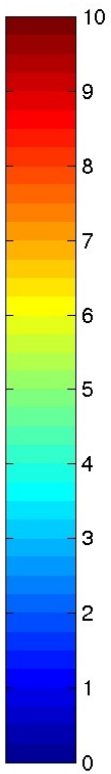


FIG. 4. Climatological distribution of biweekly precipitation rates [mm (2 weeks)$^{-1}$] for contiguous 5° × 5° areas.

(Magaña et al, 1999)

What is responsible for these observations?



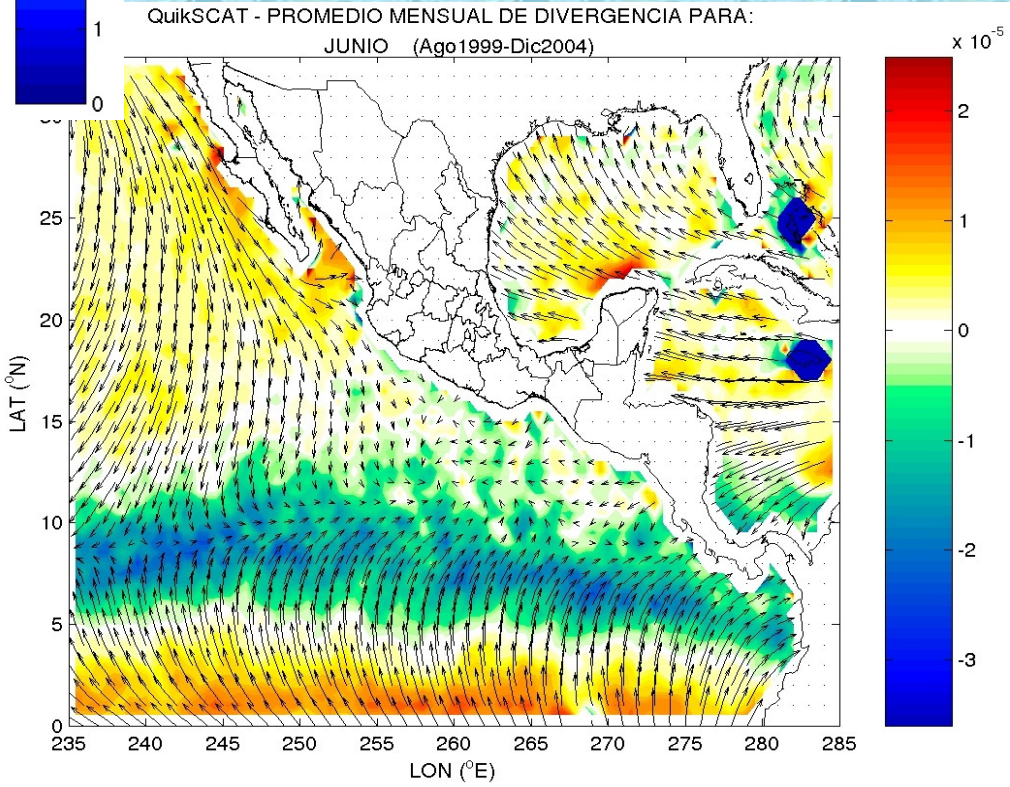


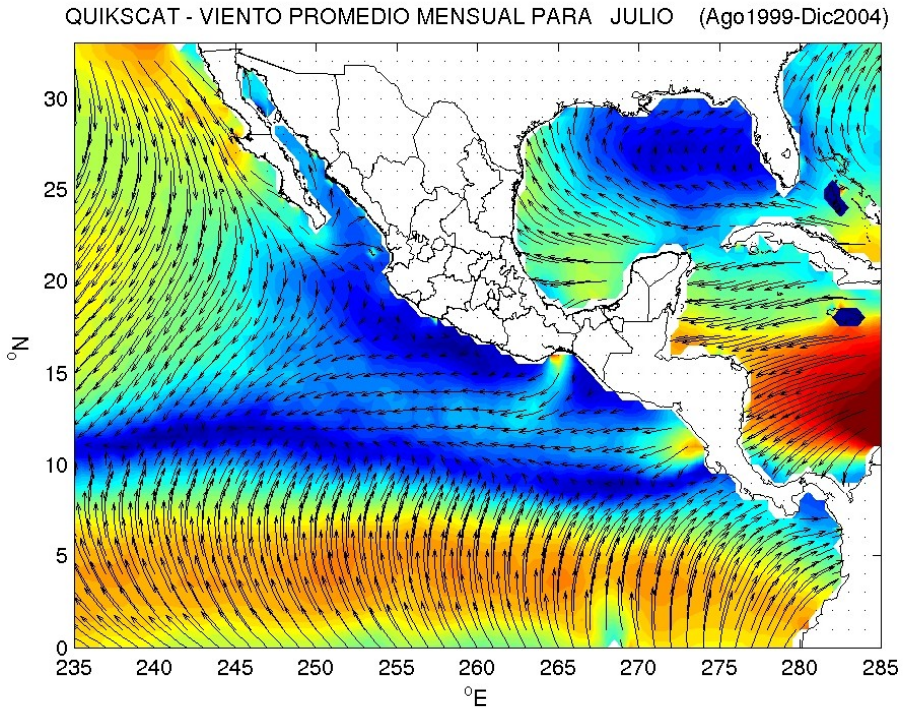
Beginning of rainy season (June)

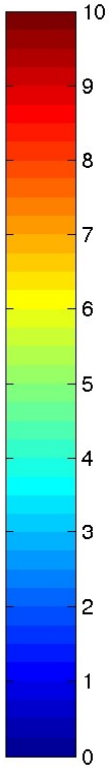
Low-level winds

Low-level divergence

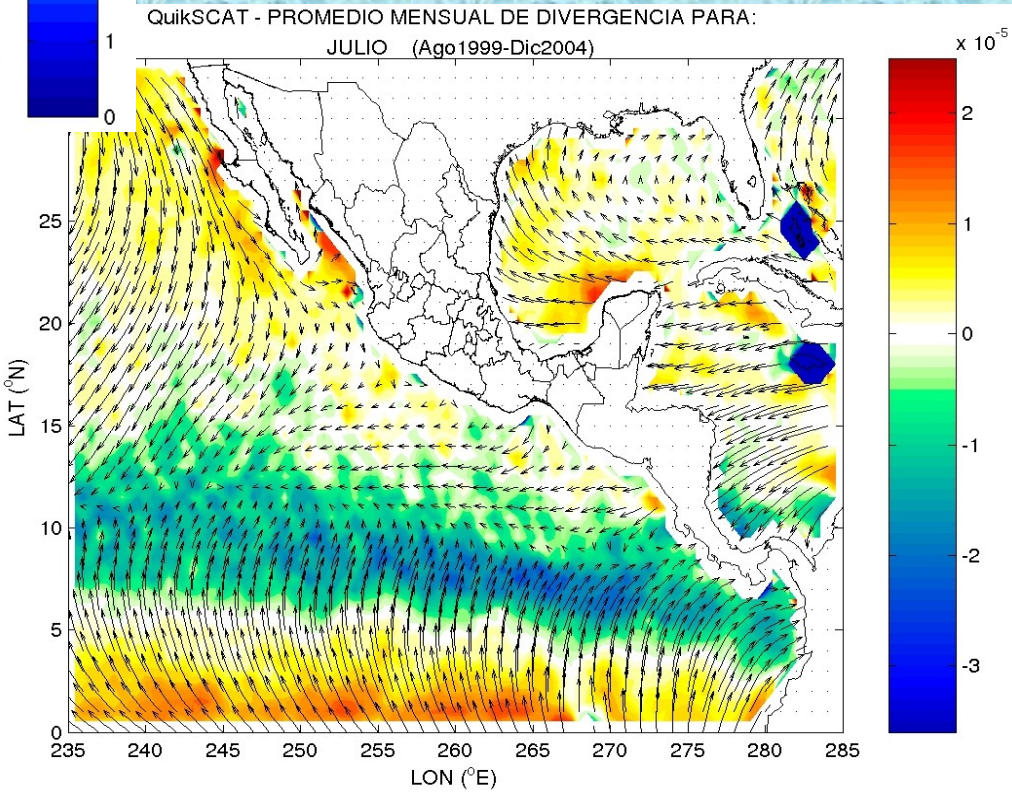
(Romero-Centeno, 2007)







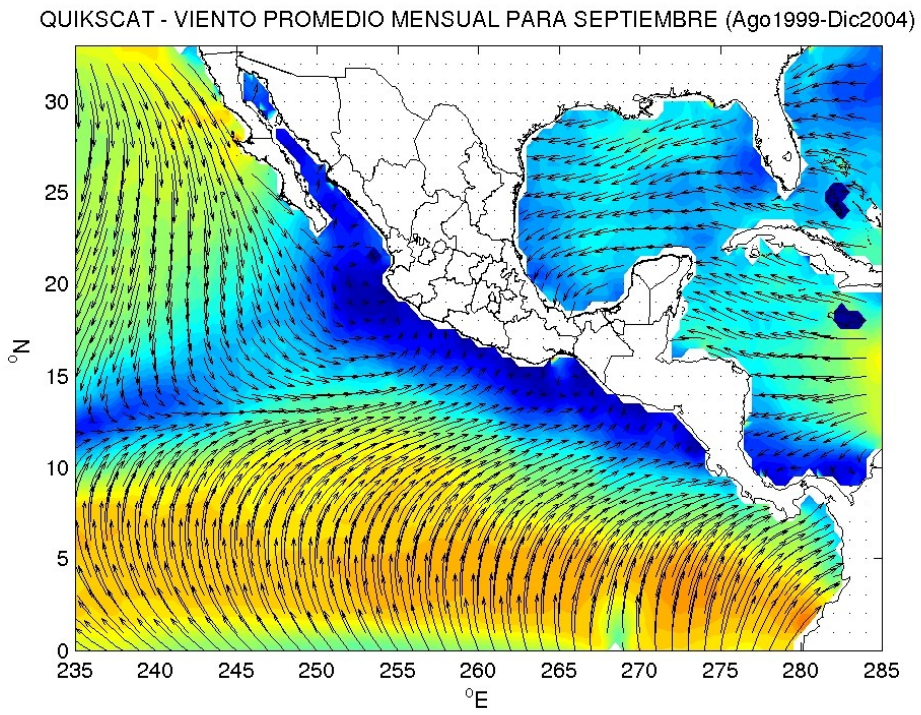
Mid-summer (July)



Low-level winds

Low-level divergence

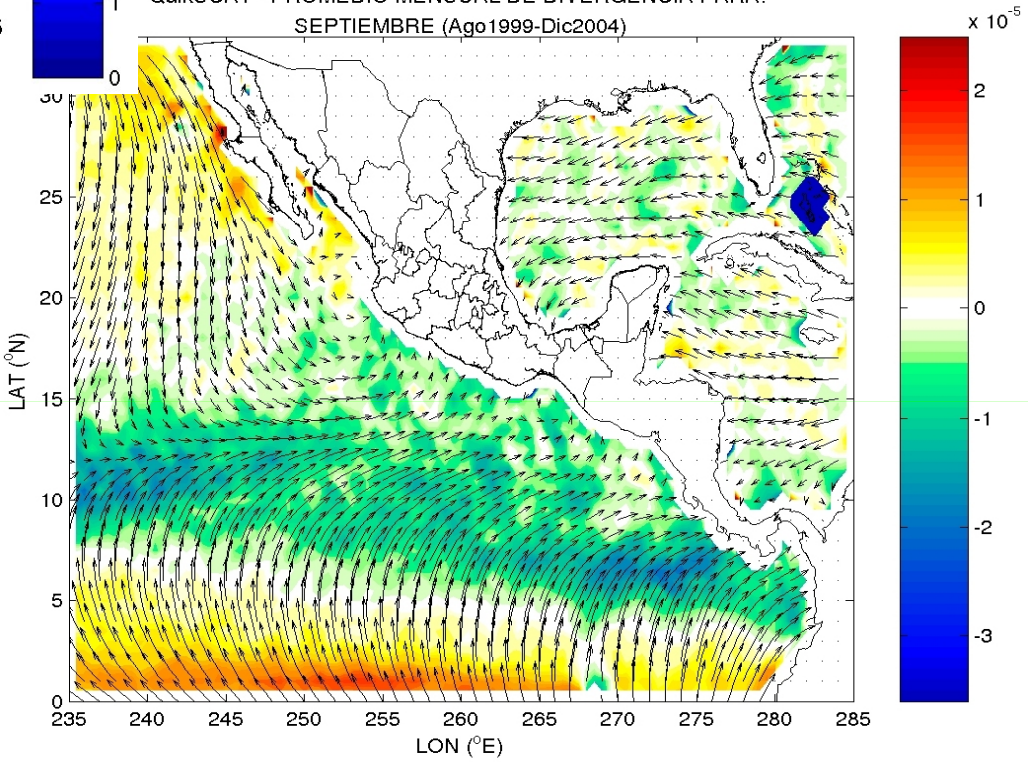
(Romero-Centeno, 2007)



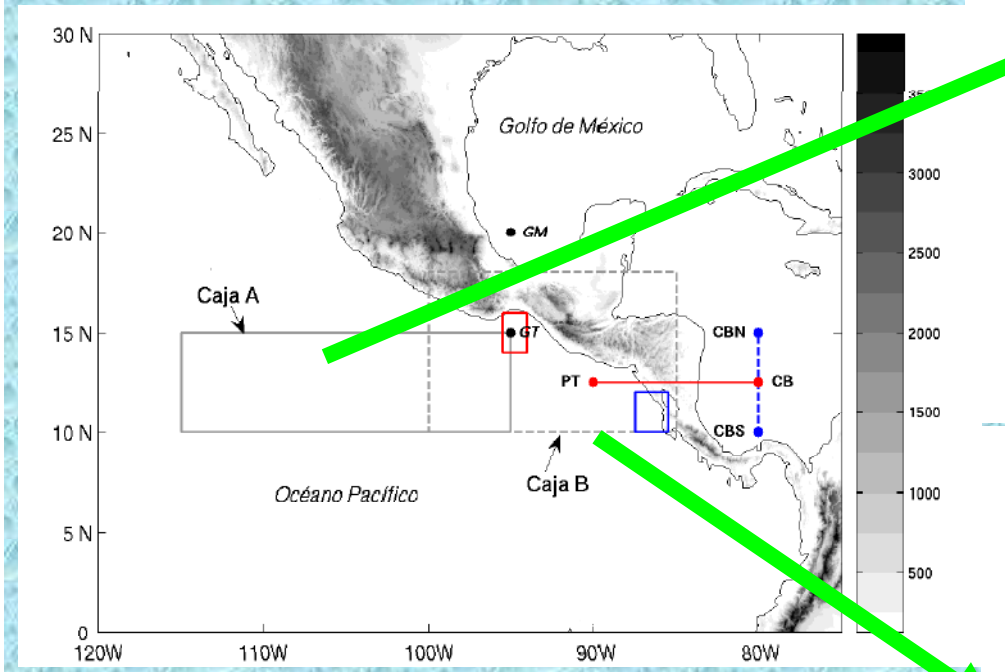
Low-level winds

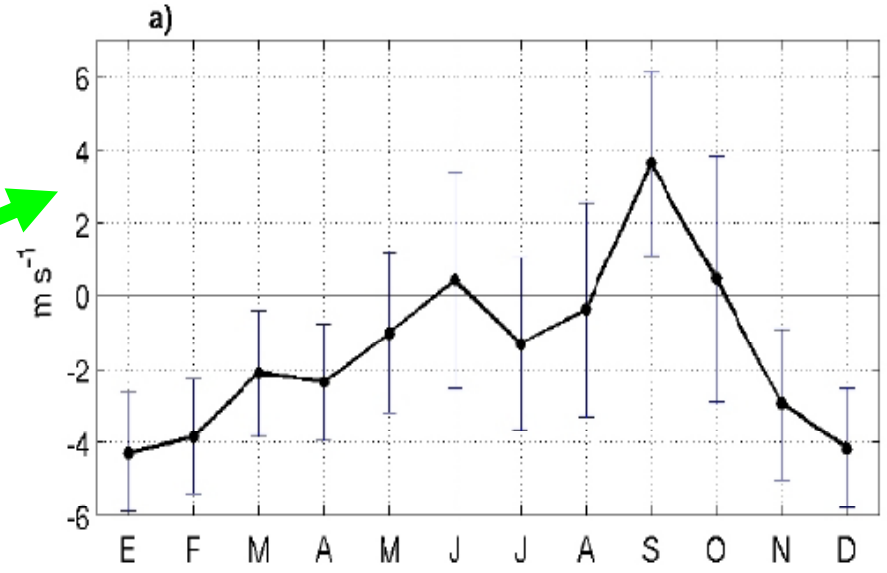
Low-level divergence

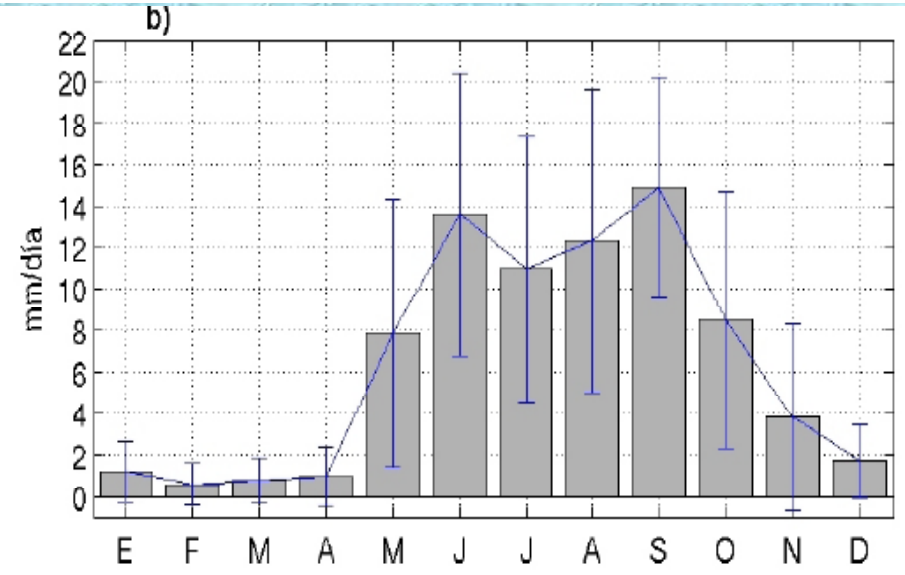
(Romero-Centeno, 2007)



Low level zonal transport over the East Pacific and precipitation over S-Mexico and CA







(Romero-Centeno, 2007)

Future work on this topic in collaboration with Rosario Romero

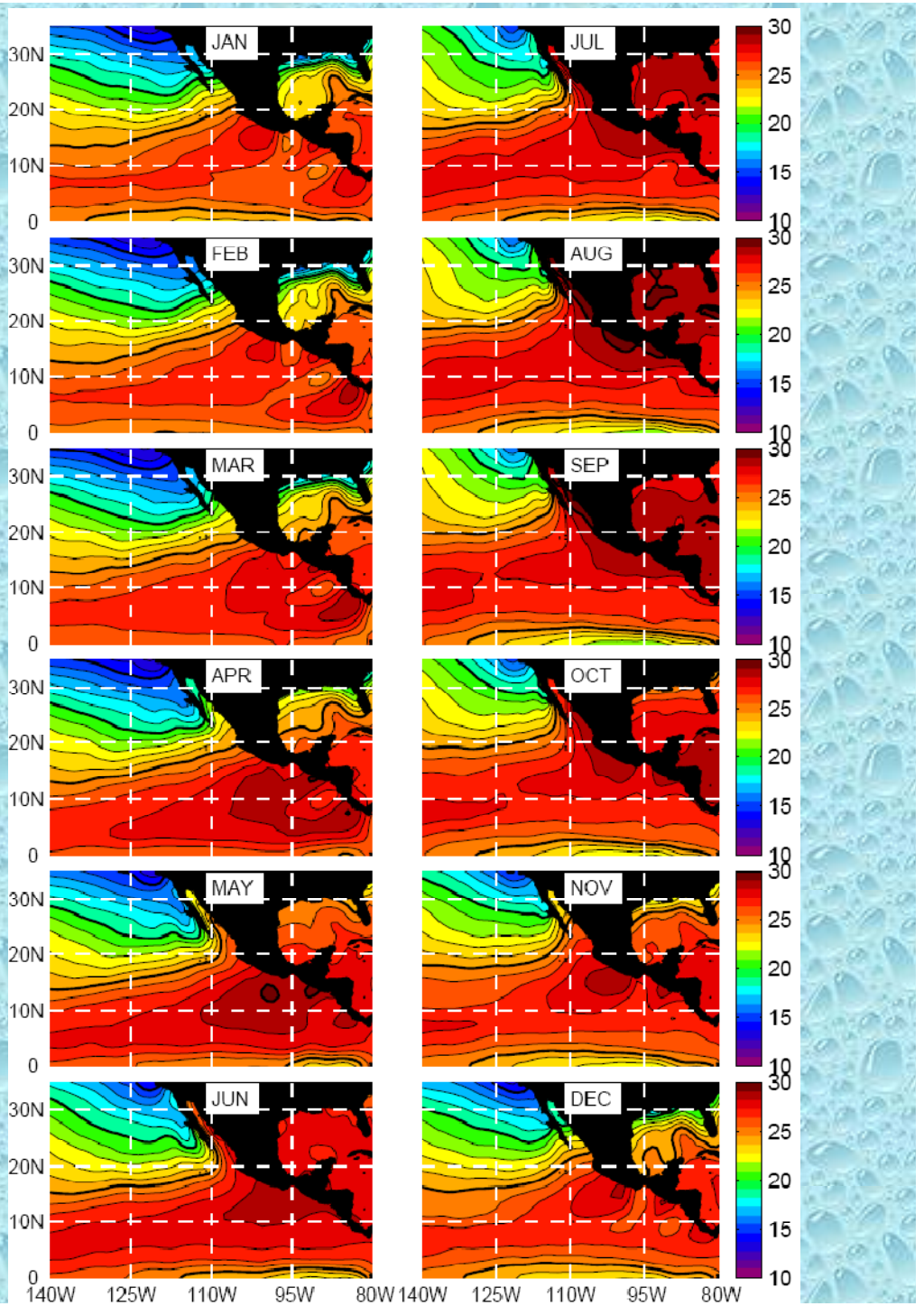
- Using the gridded global data (NCEP & ERA40), obtain sub-sets with and without tropical cyclones to determine main atmospheric patterns month by month
- Validate (?) results from ICCP-AR4 coupled climate models, obtaining equivalent patterns for cyclone season in EPAC

Monthly Sea Surface Temperature

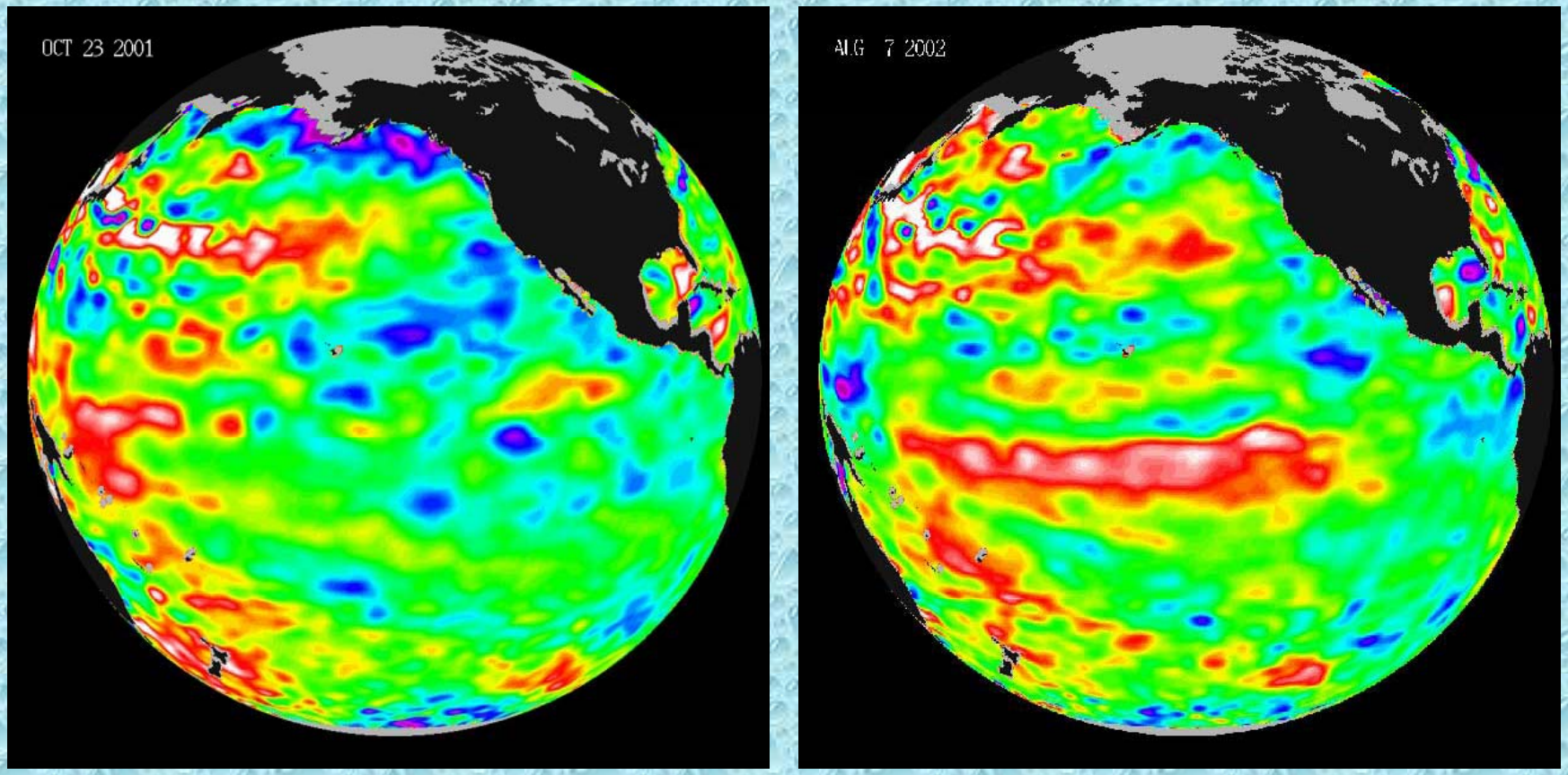
SST important but also depth of the oceanic mixed layer

Ocean heat content available for cyclone intensification

(Romero-Centeno, 2007)

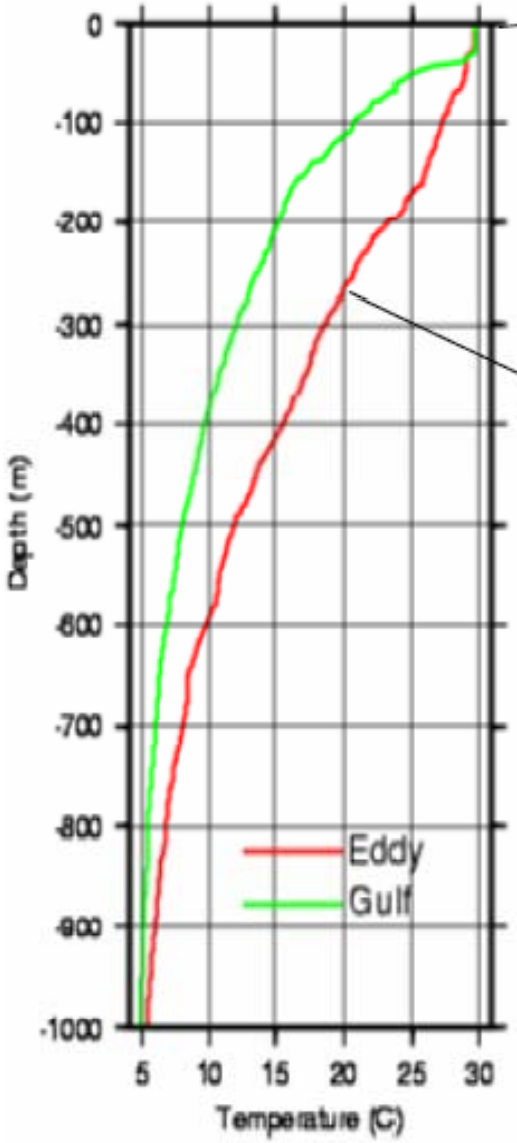


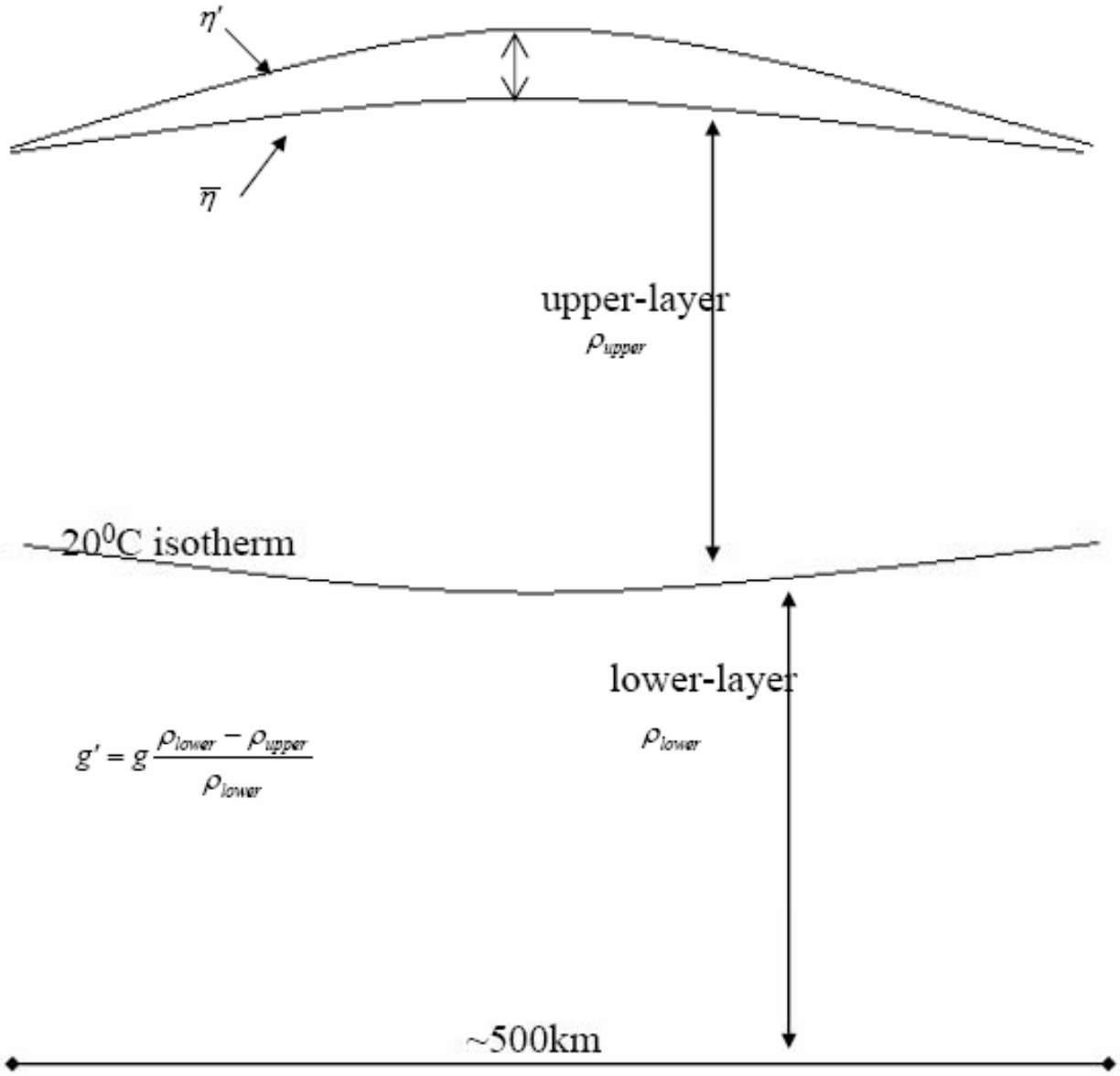
Altimetry: TOPEX/Poseidon & JASON



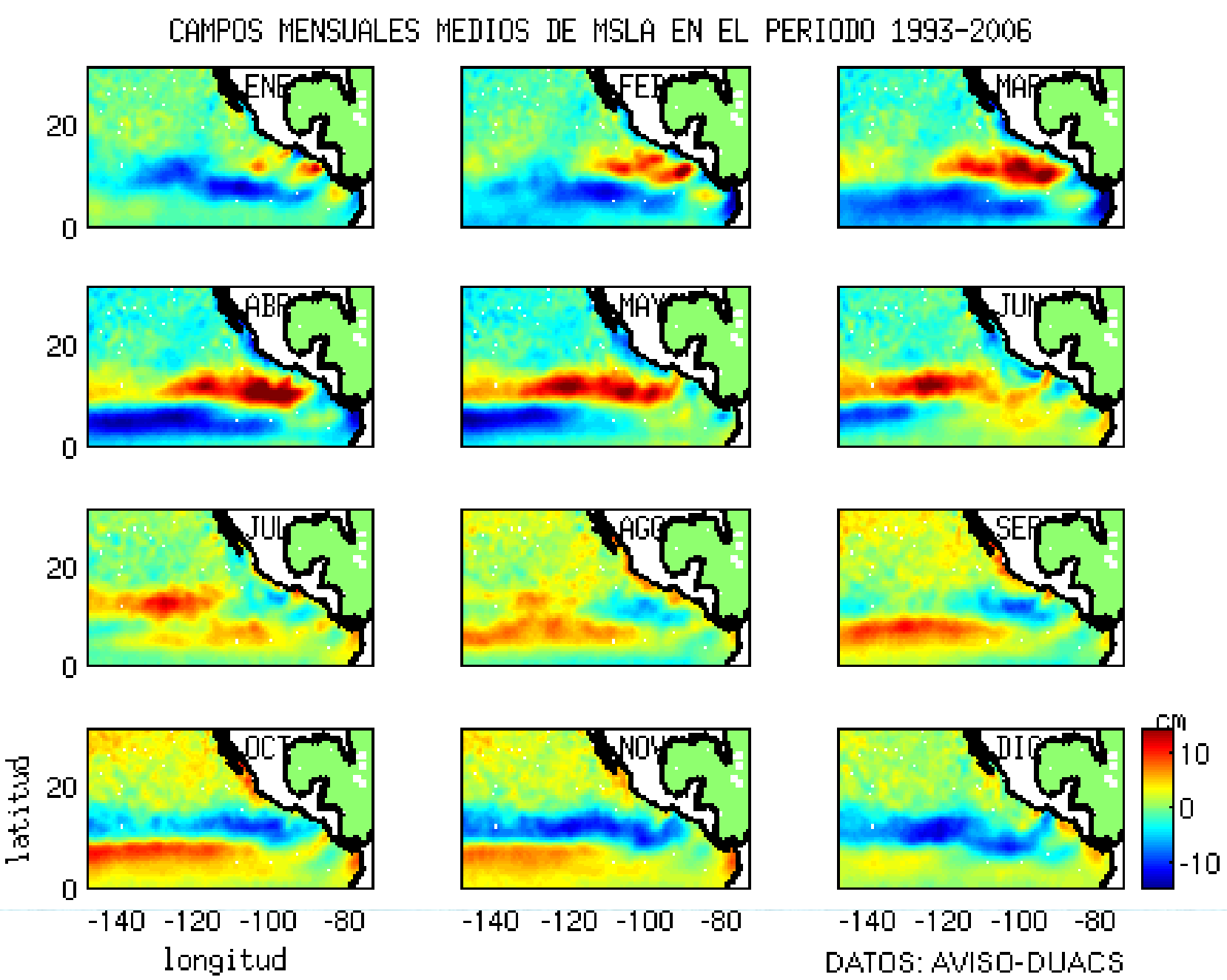
- Altimetry observations can be used to estimate SSH and dynamic height (analogous to the height of a pressure level).
- Pictures (from http://topex-www.jpl.nasa.gov/elnino/index.html) show an neutral winter (left) follow in August by a growing El Nino (right).

(Courtesy J. Zavala-Hidalgo)



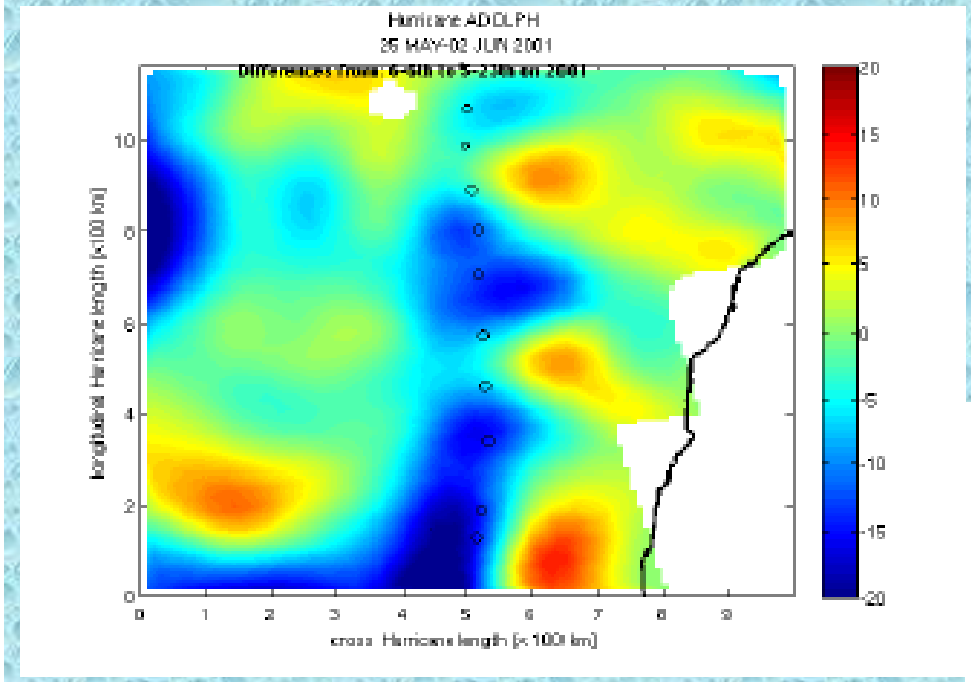


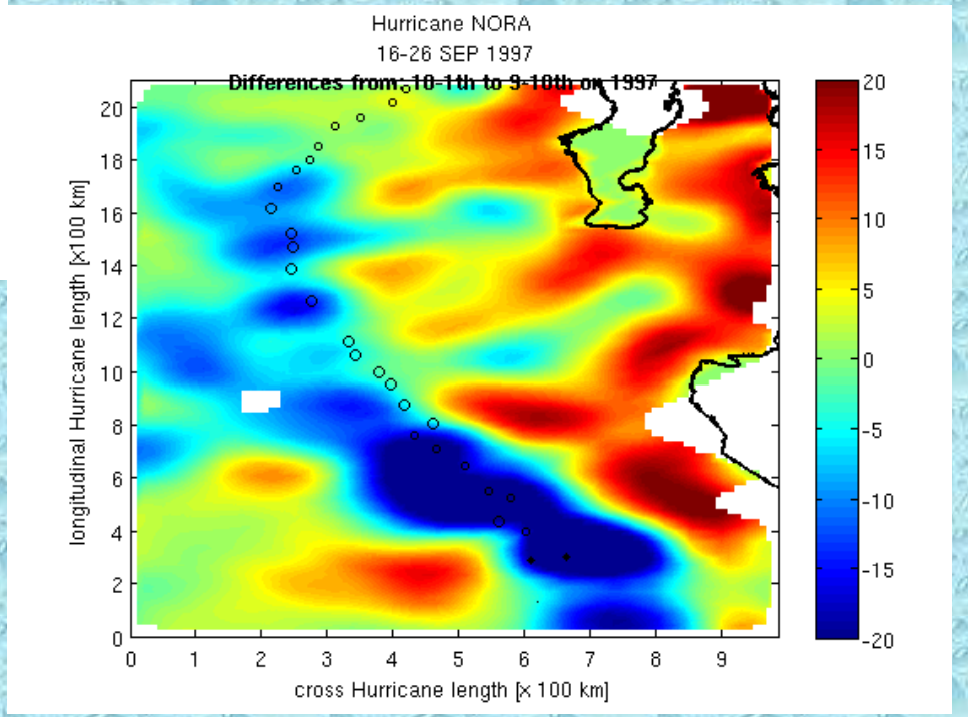
(Lin et al, 2005)



(O. Sanchez-Montante)

SSHA “wake” of hurricanes in EPAC





(O. Sanchez-Montante)

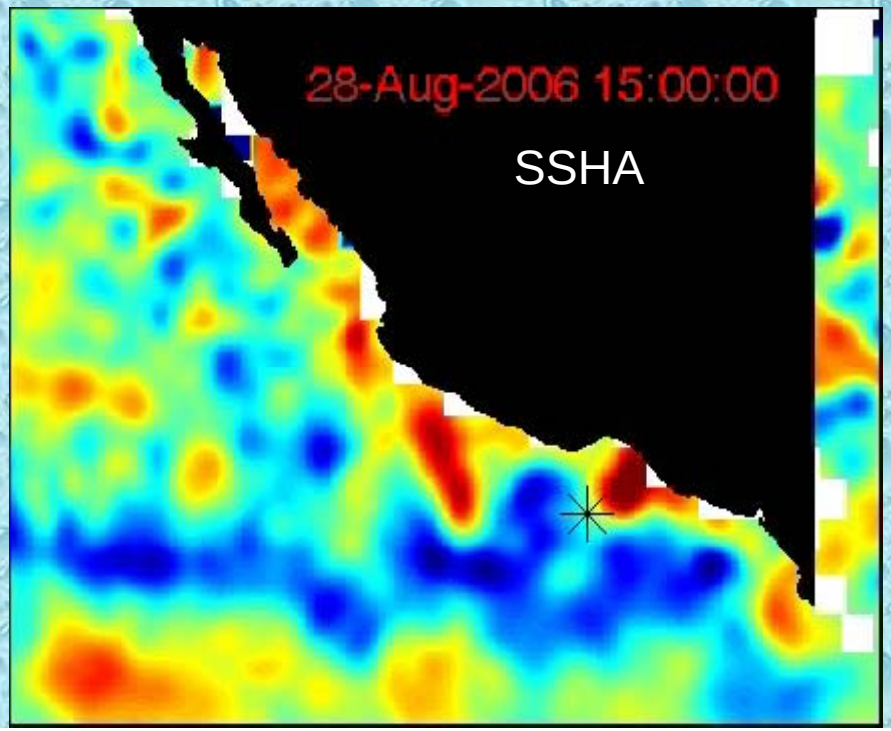
Current and future work on this topic in collaboration with Orzo Sanchez

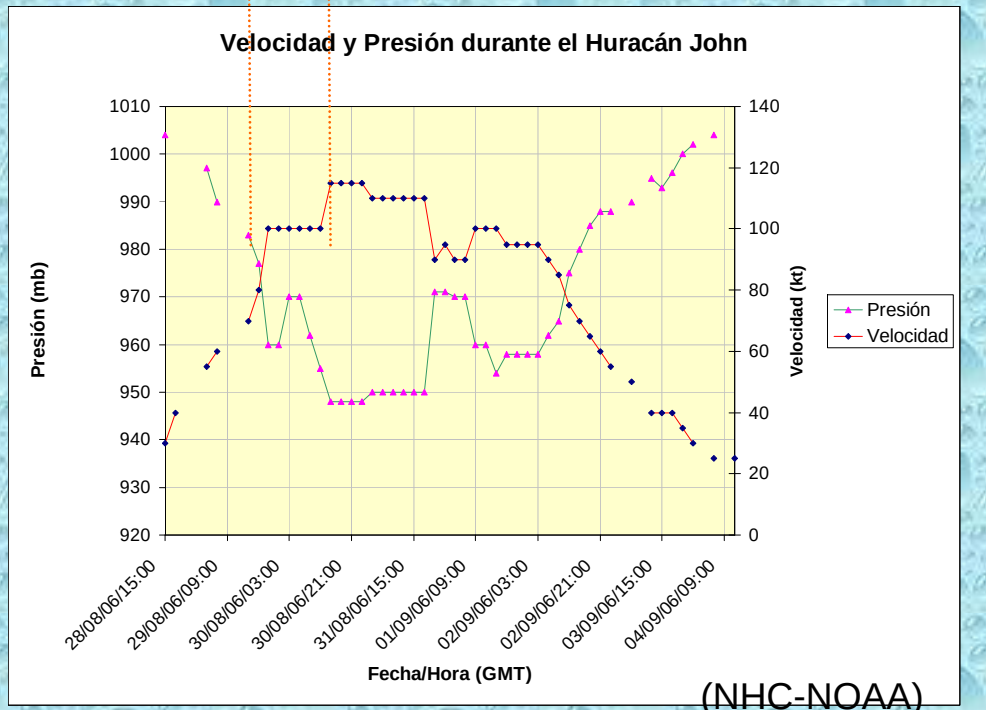
- Manuscript in preparation describing the climatological conditions of SSHA anomaly in EPAC
- Extend the analysis of the “wake” signal to all the database (1993-2006), look for correlations with SSTA

Hurricane John
28-Aug-4 Sept 2006
Category 4

(Track from NHC-NOAA)

4 hrs





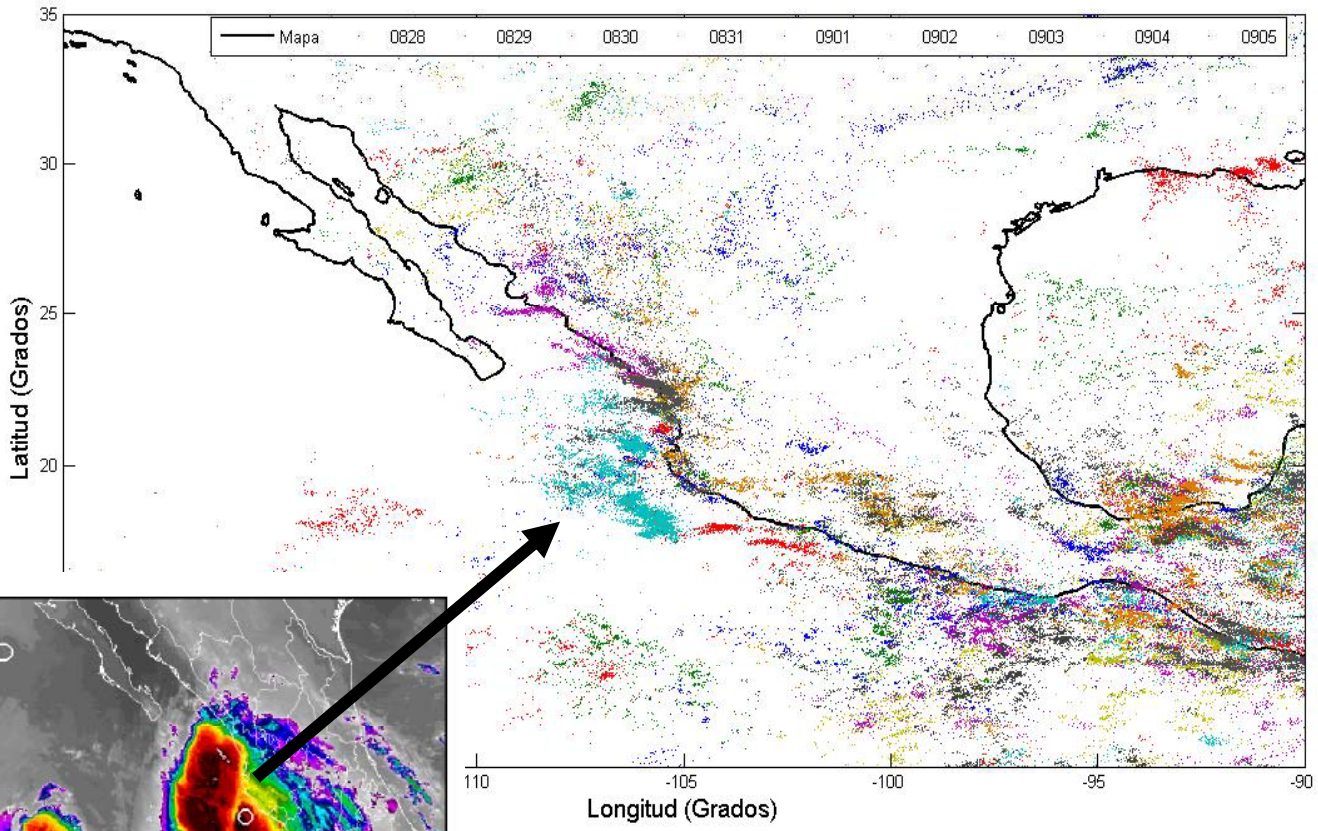
(NHC-NOAA)

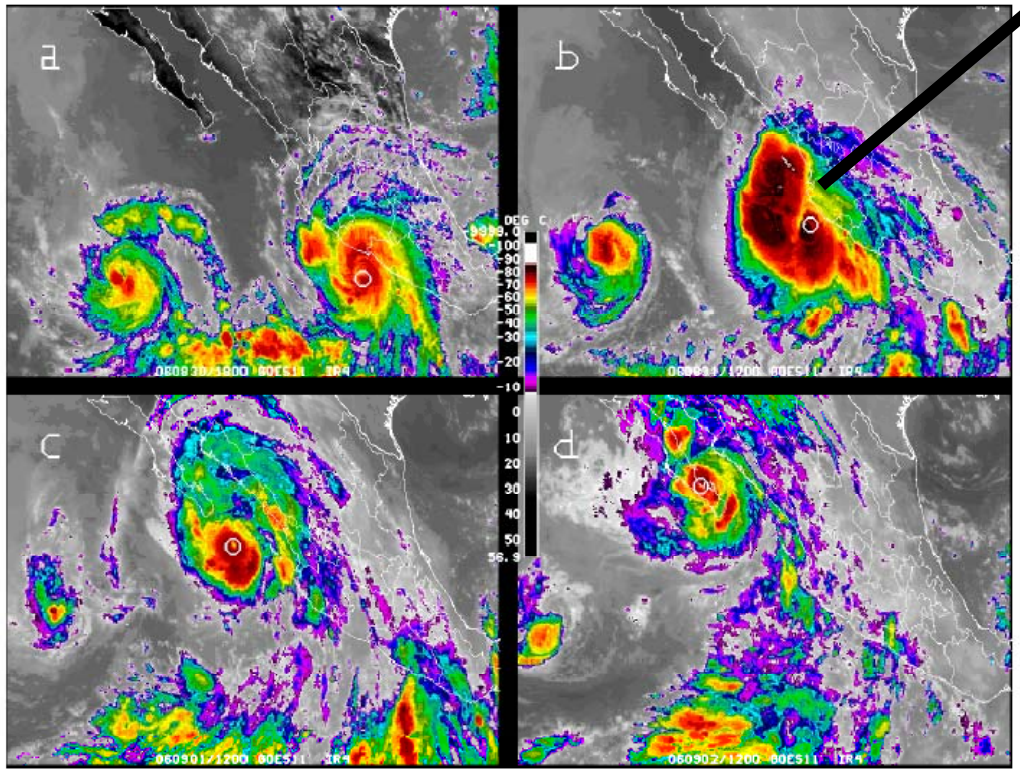
Current and future work on this topic in collaboration with Fernando Oropeza

- Implementation of regional ocean model (Rutgers Univ.) to study the evolution of SSH in the EPAC
- Comparison of model results with AXBT observations during EPIC (in collaboration with Dr. Shay, RSMS)
- Modeling results will provide insight into the role of ocean dynamics vs. thermodynamics

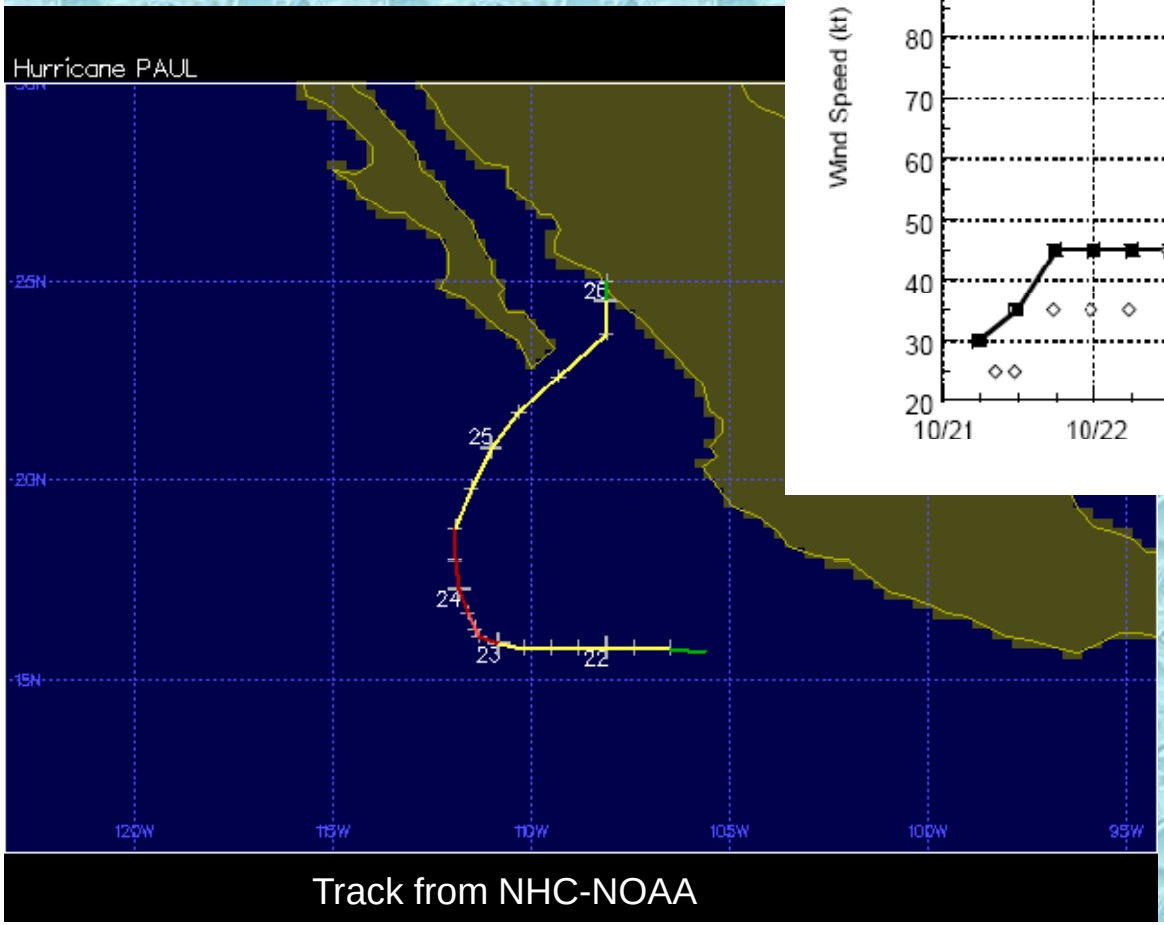
Hurricane John 2006

Lightning from WWLLN

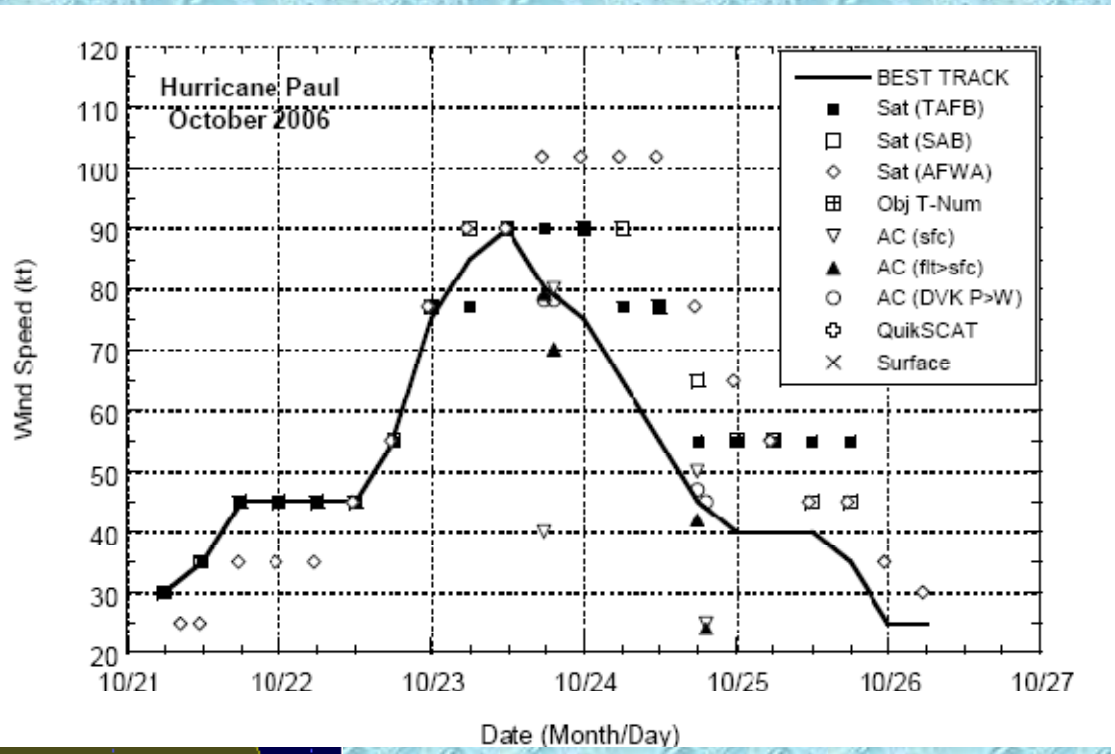




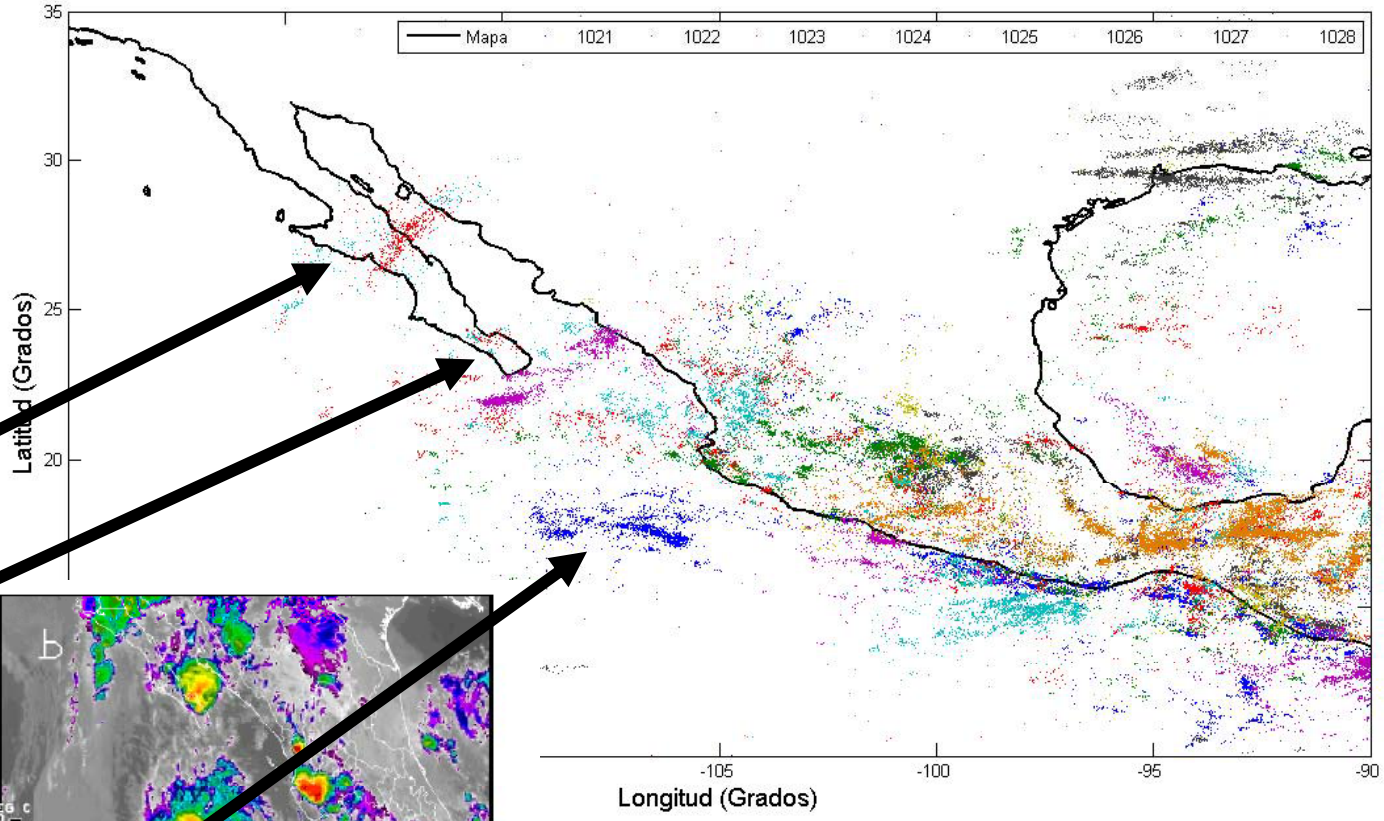
Hurricane Paul
21-26 Oct 2006 (Category 2)

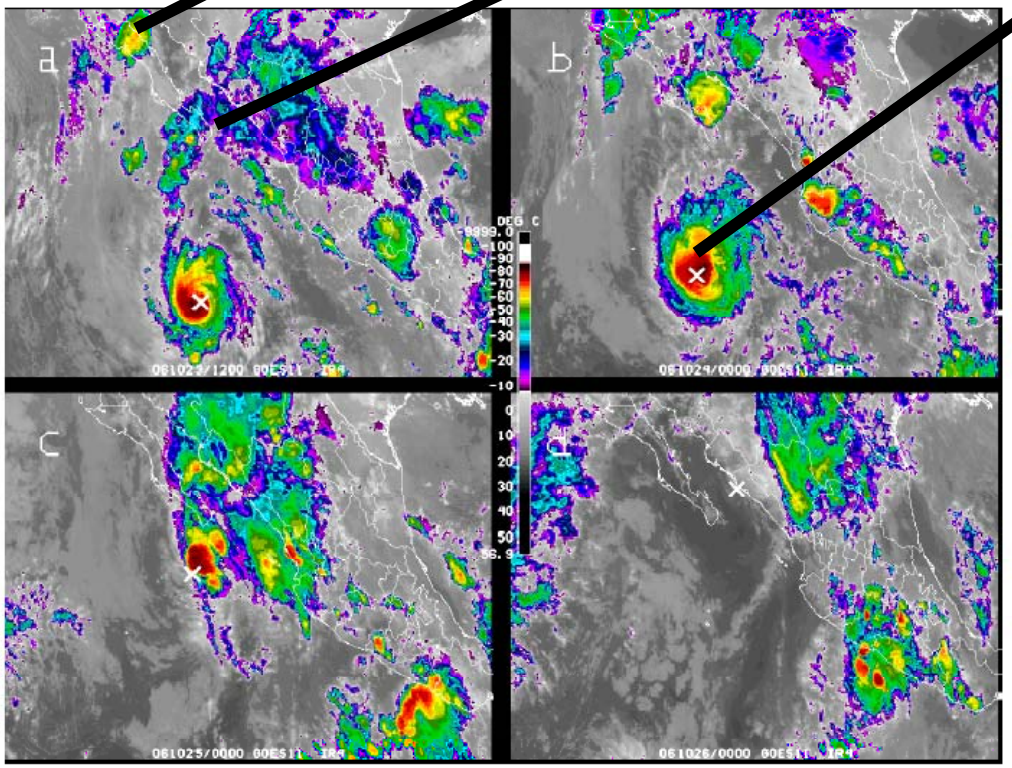


Track from NHC-NOAA



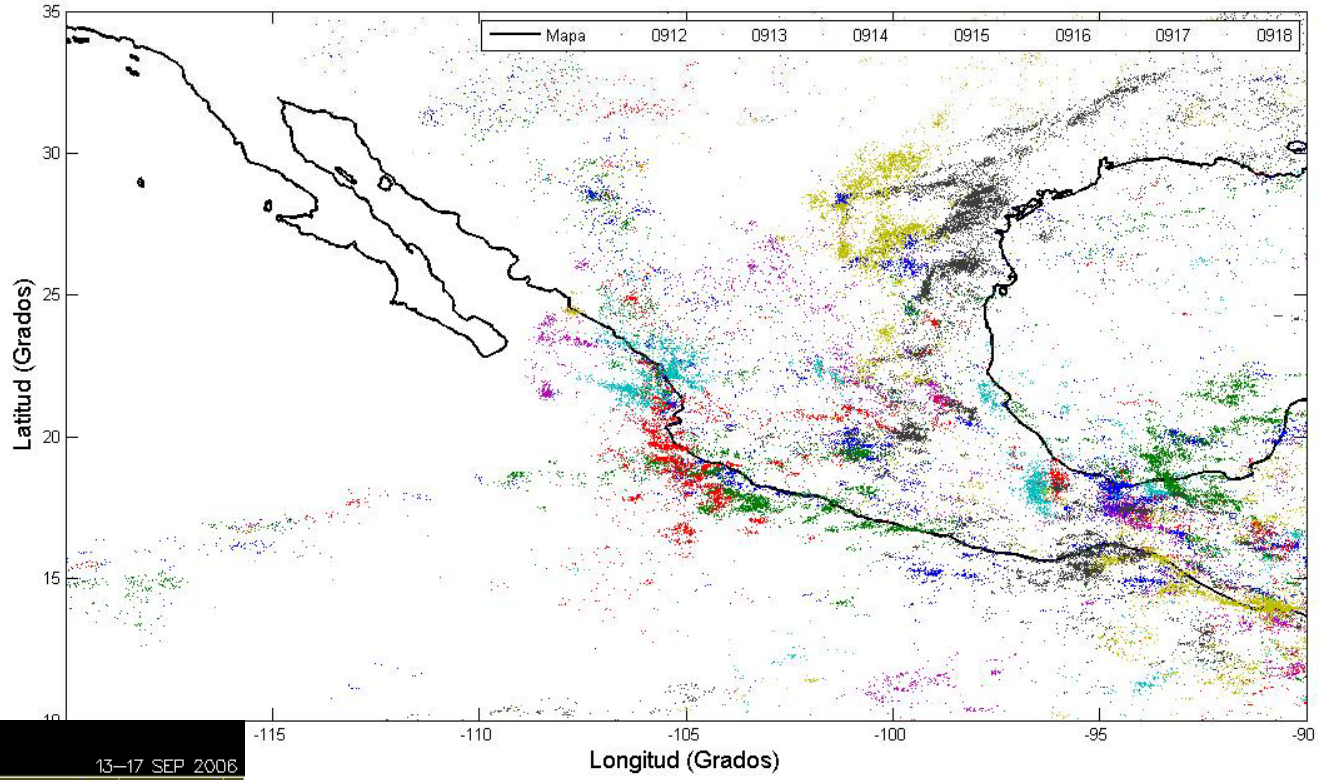
Lightning from WWLLN





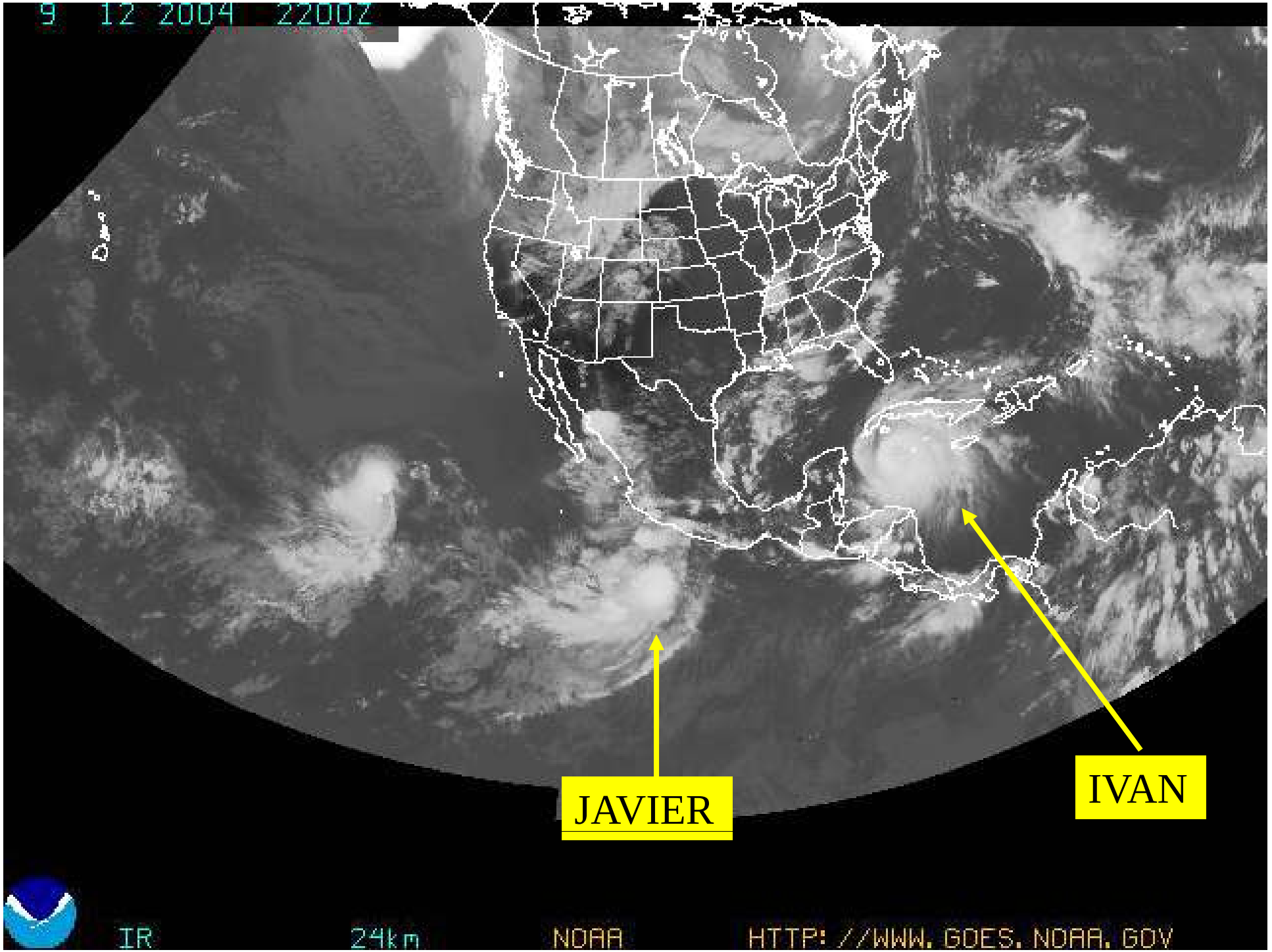
Hurricane Paul
21-26 Oct 2006

Lightning from WWLLN

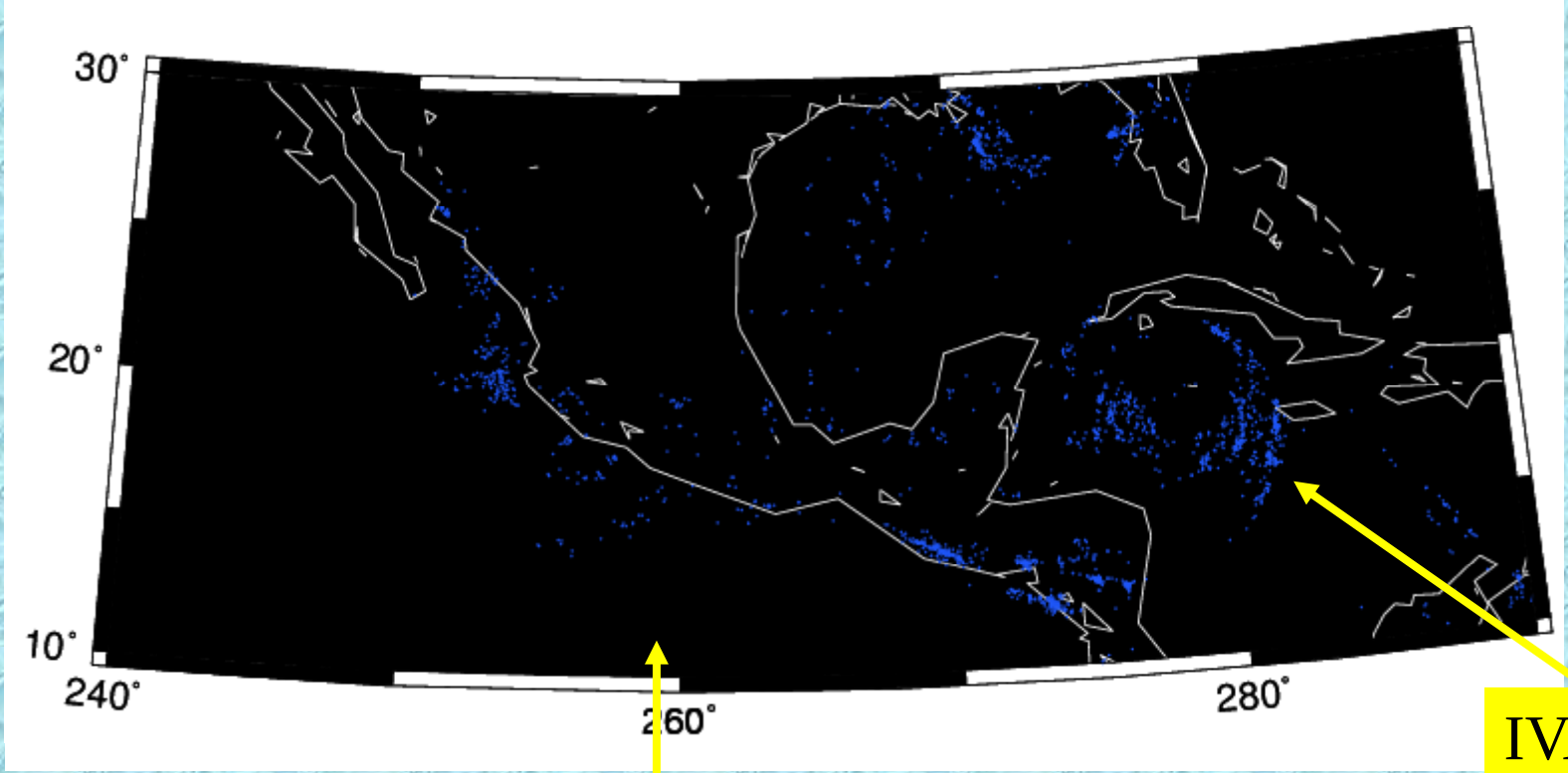


Track from NHC-NOAA

Hurricane Lane
13-17 Sept 2006


9 12 2004 2200Z
JAVIER
IVAN
IR
24km
NOAA
HTTP://WWW.GOES.NOAA.GOV

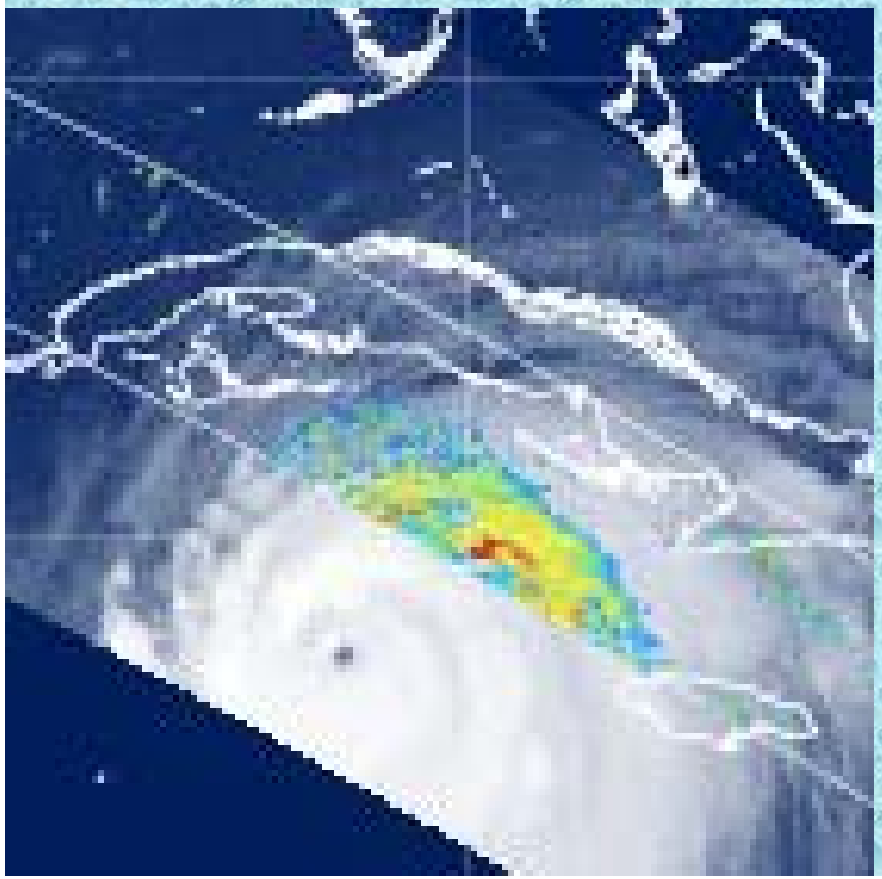
Descargas a tierra durante 12 horas (día)



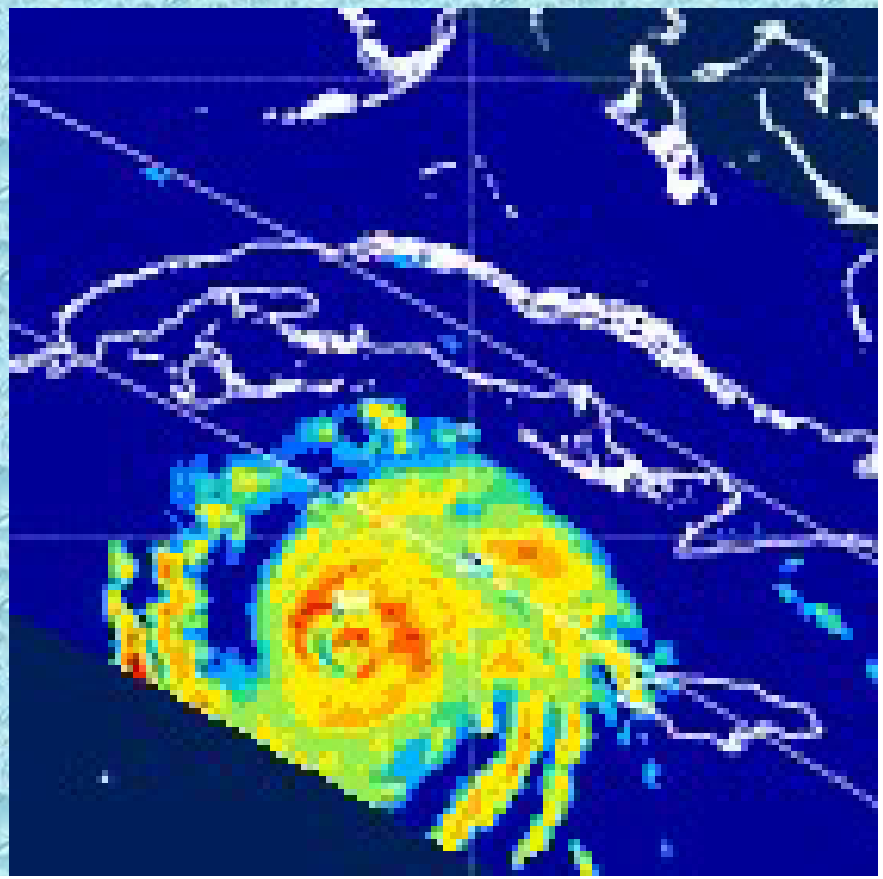
Huracan IVAN (Septiembre 2004)

(Data from http://www.eorc.nasda.go.jp/TRMM/index_e.htm)

PR



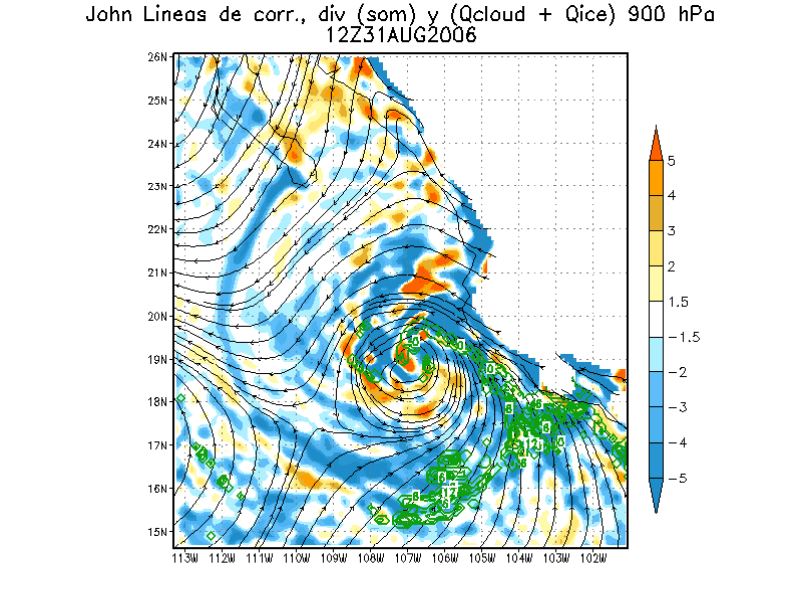
TMI

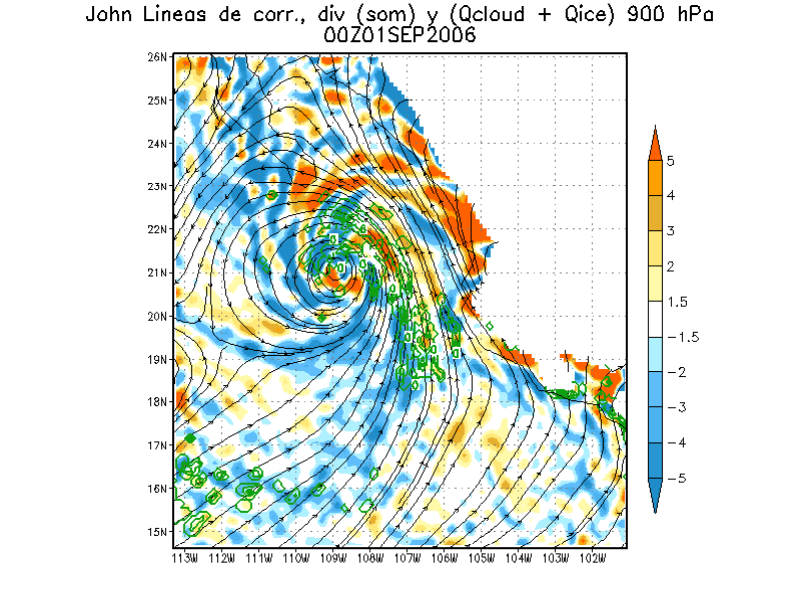


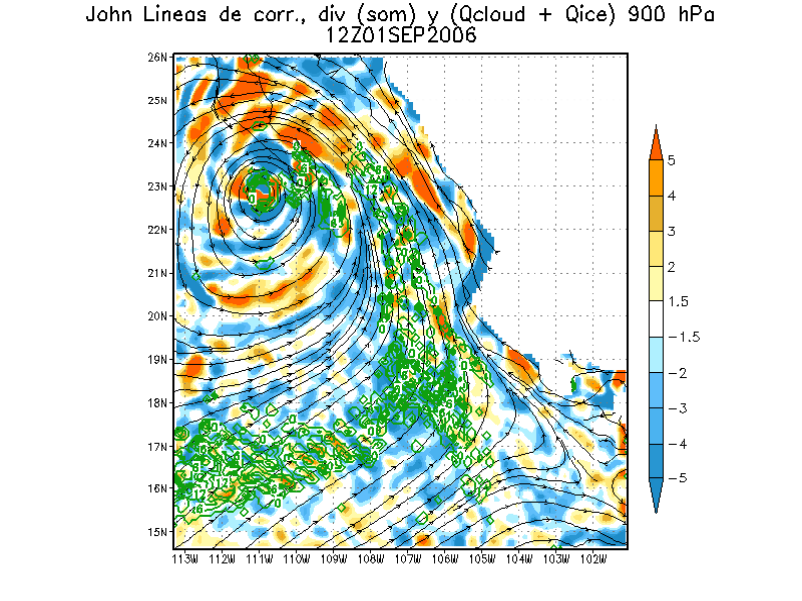
Current and future work on this topic (GBR and possibly an undergraduate)

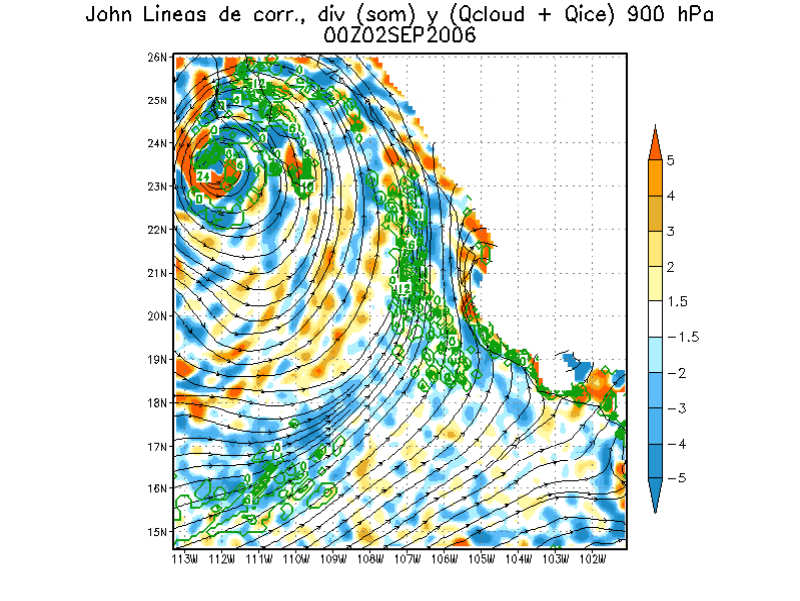
- Correlations between precipitation over land and lightning in cyclones
- Time evolution of lightning in cyclones and possible correlation with changes in intensity
- Spatial distribution of lightning in cyclone, as indicator of different microphysical processes in the clouds in bands vs. eyewall

Modeling results using WRF model: Hurricane John (2006)

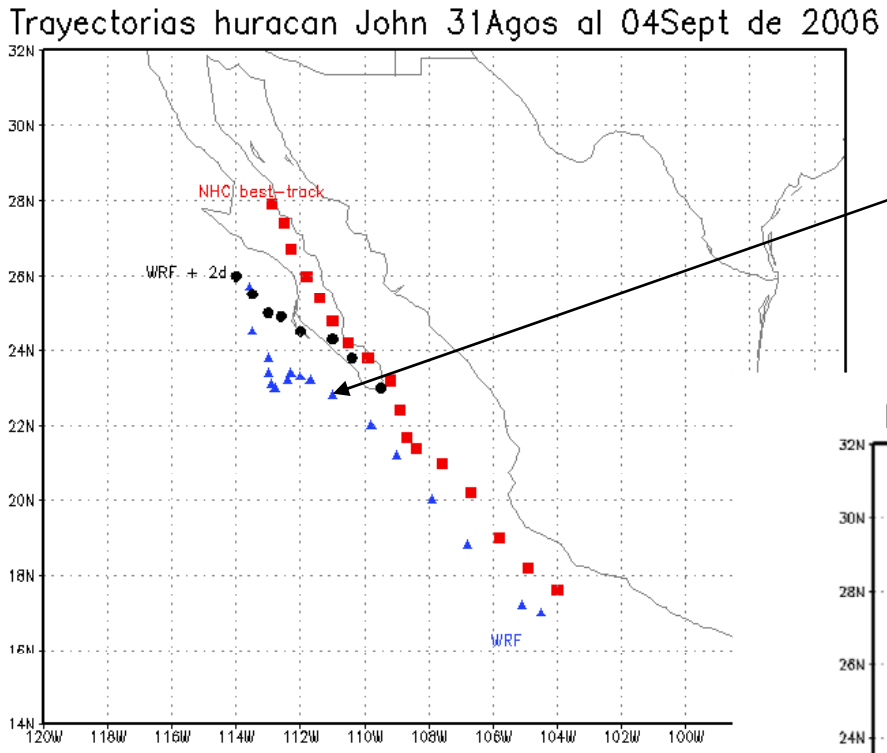




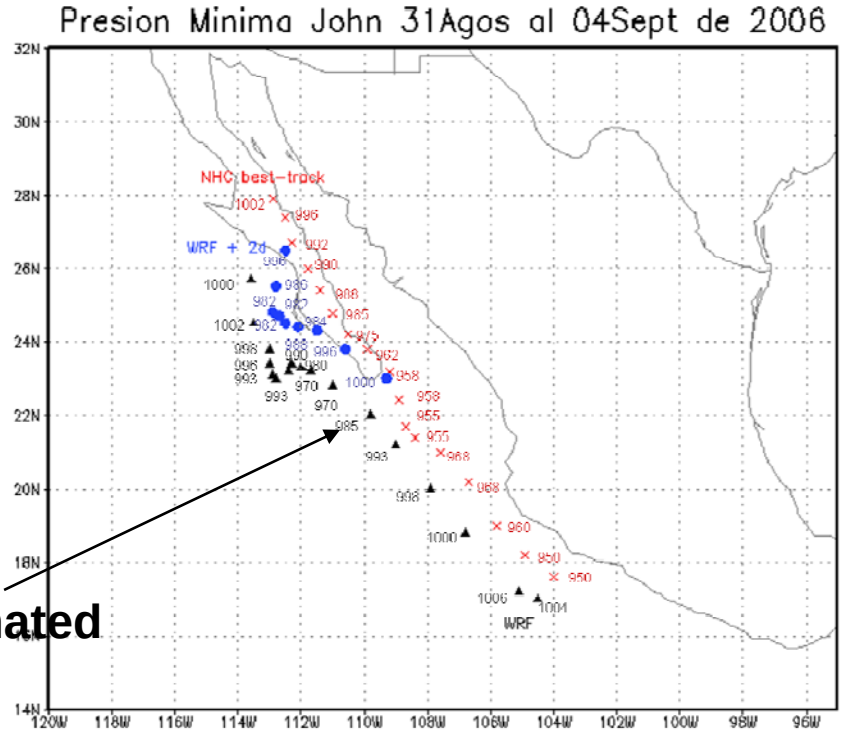




Modeling results using WRF model: Hurricane John (2006)



Track does not make landfall



Minimum pressure is overestimated

Current and future work on this topic (L Farfan, GBR, D. Pozo, D Martinez)

- Simulations with WRF of past cyclones, mainly 2006-2007 seasons, landfalling
- Operational runs during cyclone season
- Sensitivity to changes in parameterizations of surface fluxes of heat and momentum

Participation of Co-PIs in Spring AGU (21-24 May 2007)

- Drs. Raymond, Shay, Zavala-Hidalgo and Binimelis de Raga organized the special session: “The Tropical East Pacific: A natural laboratory for coupled ocean-atmosphere research”, held on 21 and 22 May with a total of 22 papers on the topic.
- Another related special session was organized by R. Romero-Centeno and S. Curtis: “Mid-summer drought: Causes and implications”, held on 24 May, in which 13 presentations were scheduled.
- Another special session named “Earth and Space Science Informatics” was organized by Drs. Luis Farfan (CICESE/Mexico) Tom Yoksas (UCAR) Elen Cutrim (Western Michigan Univ.), Glen Rutledge (NOAA) and Waldenio de Almeida (CPTEC/Brazil). It consisted of 22 oral presentations and 22 posters.
- An informal meeting was held in Acapulco during the AGU Spring meeting, where Co-PIs and PhD students from the project discussed results and planed following research activities.

Three poster presentations at the Spring Meeting of the AGU relate to the topics of this project:

- **Marin, J., D. Raymond and G.B. Raga: Vorticity balance in East Pacific tropical cyclones. (MarinEtAl_AGU2007.pdf)**
- **Romero-Centeno, Rosario, Jorge Zavala-Hidalgo, and G. B. Raga: Midsummer Drought in Mexico and Central America and its Relationship with the Eastern Pacific Gap Winds. (RomeroEtAl_AGU2007.pdf)**
- **Farfan, L. and M. Cosio: Relationships between Eastern Pacific tropical cyclones and convective rainfall in Baja California. (Farfan&Cosio_AGU2007.pdf)**

Other activities: Course at UBA

Date: 31 July - 30 August (3 times a week, 5 hours per day)
Title: Meteorología Tropical (ciclones tropicales)
Instructors: GBRaga, L Farfan, R Romero-Centeno, J Zavala-Hidalgo, D Pozo
24 undergraduate students (Lic. en Ciencias Atmosféricas)
11 graduate students (Programa de Doctorado de la UBA)

Link to SGP-HD, CO-PIs: Varady & Scott

Information Flows and Policy:
Use of Climate Diagnostics and Cyclone Prediction for Adaptive Water-Resources Management Under Climatic Uncertainty in Western North America

- **Meeting in Tucson: 29 October**
- **Participants:**

Martín Montero, IMTA
Nicolás Pineda, COLSON
Graciela de Raga, UNAM
Andrea Ray, NOAA
Barbara Morehouse, Institute for UA
Gregg Garfin, ISPE/UA
Margaret Wilder, Latin American Studies, UA
Robert Varady, Udall Center for Studies in Public Policy, UA
Ashley Coles, Geography & Regional Development, UA
Christopher Scott, Udall Center and Geography & Regional Development, UA

- **Concrete future steps:**
  - **8 May workshop: L Farfan will attend**
  - **Collaboration on case study of hurricane Henriette (2007) that affected Sinaloa and Sonora**

Plan for 2008

- New post-doc and PhD student start work at UNAM (January), web page
- Dave Raymond to visit CCA-UNAM, 7-11 January
- CRN-II all PI-Workshop, February, Panama (Luis Farfan)
- PI Workshop, 7-8 March, Los Cabos, BCS
- Spring Course on Tropical Cyclones, 10-15 March, Los Cabos, BCS

Financial requirements: Scholarships, per diem for DR, funds for all co-PIs to attend workshop and spring course, funds for 12-15 students to attend course, funds for office supplies and admin support

- **Presentations at 28H&TM Conference:**
  - **Landfalling Tropical Cyclones in the Eastern Pacific. Part I: Case studies from 2006 and 2007. Luis M. Farfán, Rosario Romero-Centeno, G. B. Raga and Jorge Zavala-Hidalgo**
  - **Land-falling Tropical Cyclones in the Eastern Pacific hurricanes. Part II: WRF simulations of John and Paul (2006) Diana Pozo, G.B. Raga, and Luis M. Farfán, Rosario Romero-Centeno, Jorge Zavala-Hidalgo**
  - **Evaluating the intensification of tropical cyclones with the GFS model. Julio C. Marin, David J. Raymond and G. B. Raga**
  - **Characteristic patterns associated with atmospheric circulation changes over the Northeastern Tropical Pacific in summer. Rosario Romero-Centeno, Jorge Zavala-Hidalgo, and G. B. Raga**
  - **Environmental Influences on the spin-up of Tropical Cyclones. David J. Raymond, Jorge Cisneros, Sharon Sessions, Julio Marin, G. B. Raga and Zeljka Fuchs**

Financial requirements: **L. Farfan and R. Romero-Centeno and J. Zavala-Hidalgo will attend conference (tickets, per diem and registration fees)**

- **Publications in preparation:**
  - **Landfalling Tropical Cyclones in the Eastern Pacific. Part I: Case studies from 2006 and 2007. Luis M. Farfán, Rosario Romero-Centeno, G. B. Raga and Jorge Zavala-Hidalgo**
  - **Land-falling Tropical Cyclones in the Eastern Pacific hurricanes. Part II: WRF simulations of John and Paul (2006) Diana Pozo, G.B. Raga, Luis M. Farfán, Rosario Romero-Centeno, and Jorge Zavala-Hidalgo**
  - **Intensification of tropical cyclones in the GFS model. Julio C. Marin, David J. Raymond and G. B. Raga**
  - **Assessment of global numerical models in the East Pacific as evidenced from EPIC2001 project. Julio C. Marin, G. B. Raga and David J. Raymond**
  - **Variability of sea surface height anomaly in the East Pacific. Orzo Sanchez Montante, G.B. Raga and Jorge Zavala-Hidalgo**

Financial requirements: **Publication charges**