

Ciclones tropicales en el Pacífico Oriental

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<http://www.iai.int>

Nuestro proyecto:

CRAII-048: *Landfalling tropical cyclones in the EPAC basin*

*Investigadores trabajando en
4 países, colaborando para consolidar
Vínculos entre universidades y centros
de investigación y crear una **RED***

*Cursos de capacitación para
estudiantes*



La Paz, BCS, sábado 16 de marzo 2013

Definiciones

Los **ciclones tropicales** son *sistemas de baja presión en la región tropical*, cuya circulación del viento es en sentido ciclónico y se observan nubes organizadas en bandas.

Se clasifican por la **intensidad del viento**

- depresiones tropicales (vientos $< 17\text{m/s}$, $< 62\text{ km/h}$)
- tormentas tropicales ($18\text{-}32\text{ m/s}$, $< 118\text{ km/h}$)
- huracanes ($> 33\text{ m/s}$), categoría por Saffir-Simpson

<i>Saffir-Simpson</i> <i>Categoría</i>	<i>Maxima velocidad del viento</i> <i>(m/s)</i>	<i>Minima presión en superficie</i> <i>(mb)</i>
1	33-42	>980
2	43-49	979-965
3	50-58	964-945
4	59-69	944-920
5	70+	<920

¿De dónde proviene la palabra “Huracán”?

Es derivada de “Hurican”, que corresponde al dios del mal entre los indios caribes → **connotación negativa**

También se sabe que fue derivado del nombre que utilizaban los Mayas para el dios *Hurakan*.

El dios *Hurakan* era uno de los creadores del universo, quien con su aliento sobre las aguas turbulentas dio origen a la tierra firme → **connotación positiva**

¿Por qué se le asignan nombres?

Simplemente para facilitar la comunicación entre los pronosticadores y el público, dado que porque tienen una vida de varios días puede haber más de un ciclón en la misma zona. Un australiano comenzó a darles un nombre a principios del siglo XX, utilizando los nombres de figuras políticas de la época.

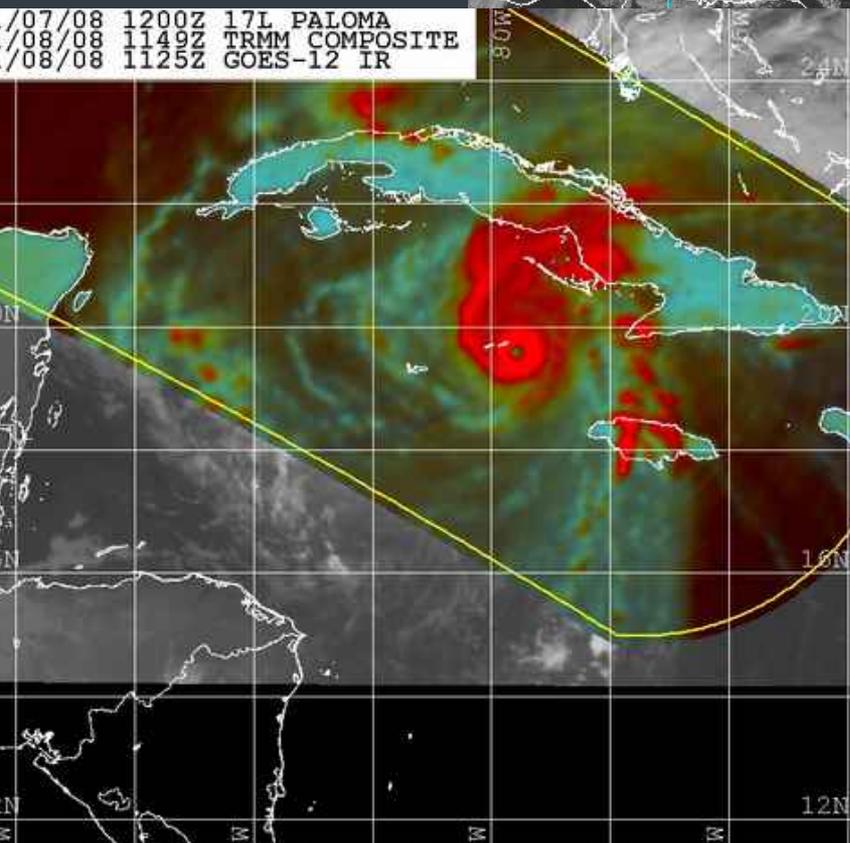
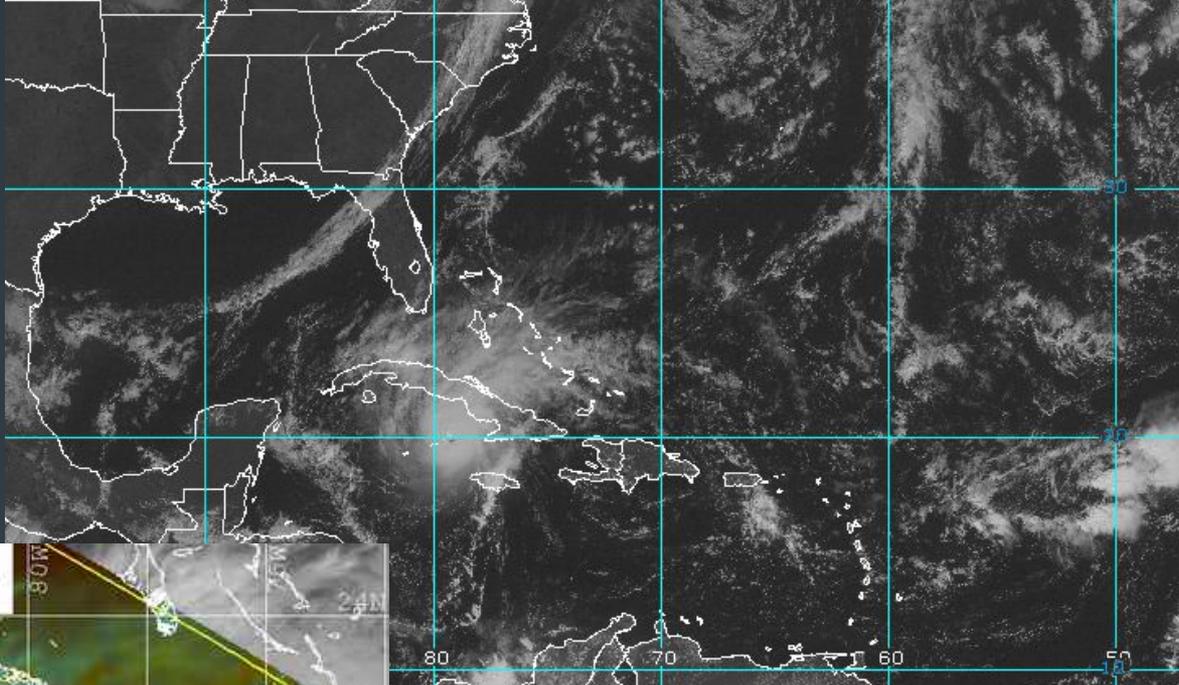
Durante la Segunda Guerra Mundial se empezó a utilizar nombres femeninos de las esposas o novias de los pronosticadores. Desde 1979 también se usan nombres masculinos. La OMM es quien fija los nombres (por orden alfabético).

PALOMA

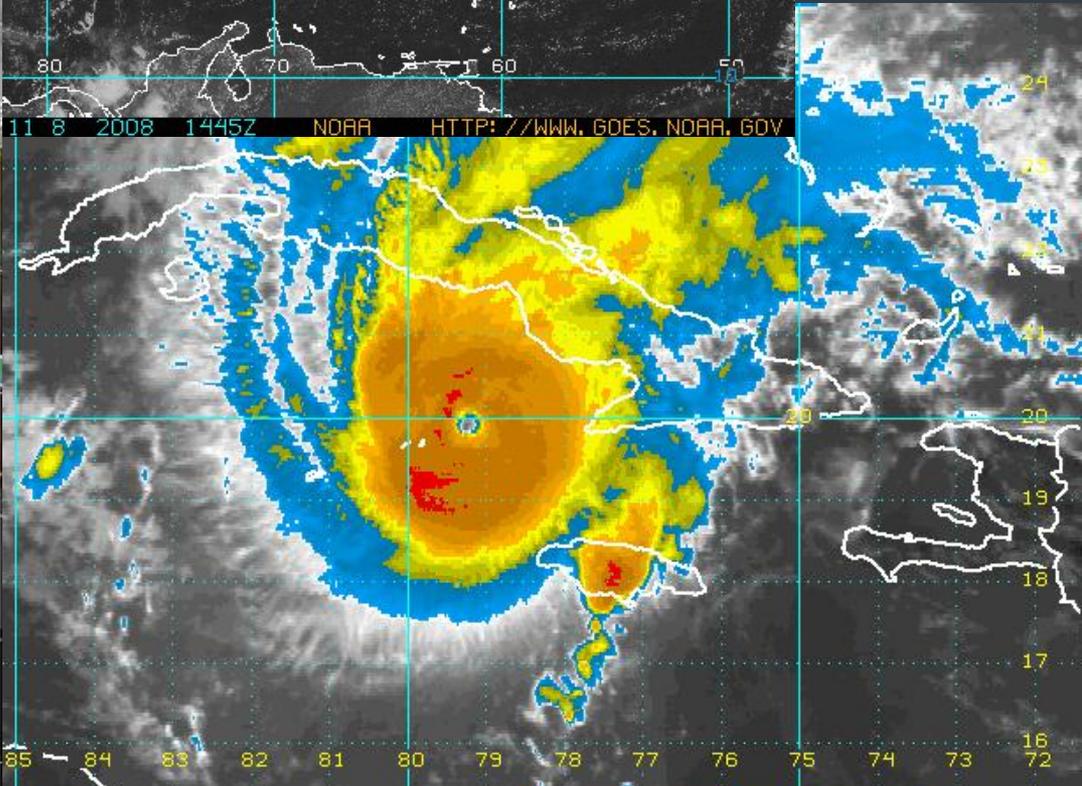
Agosto 2008



/07/08 1200Z 17L PALOMA
/08/08 1149Z TRMM COMPOSITE
/08/08 1125Z GOES-12 IR



11 8 2008 1445Z NDAA HTTP://WWW.GOES.NDAA.GOV



Naval Research Lab www.nrlmry.navy.mil/sat_products.html
Red=85PCT Green=85H Blue=85V

GOES-FLOATER AVNCOLOR IR CH. 4 - NOV 8 08 14:45 UTC

¿Cuándo se forman?

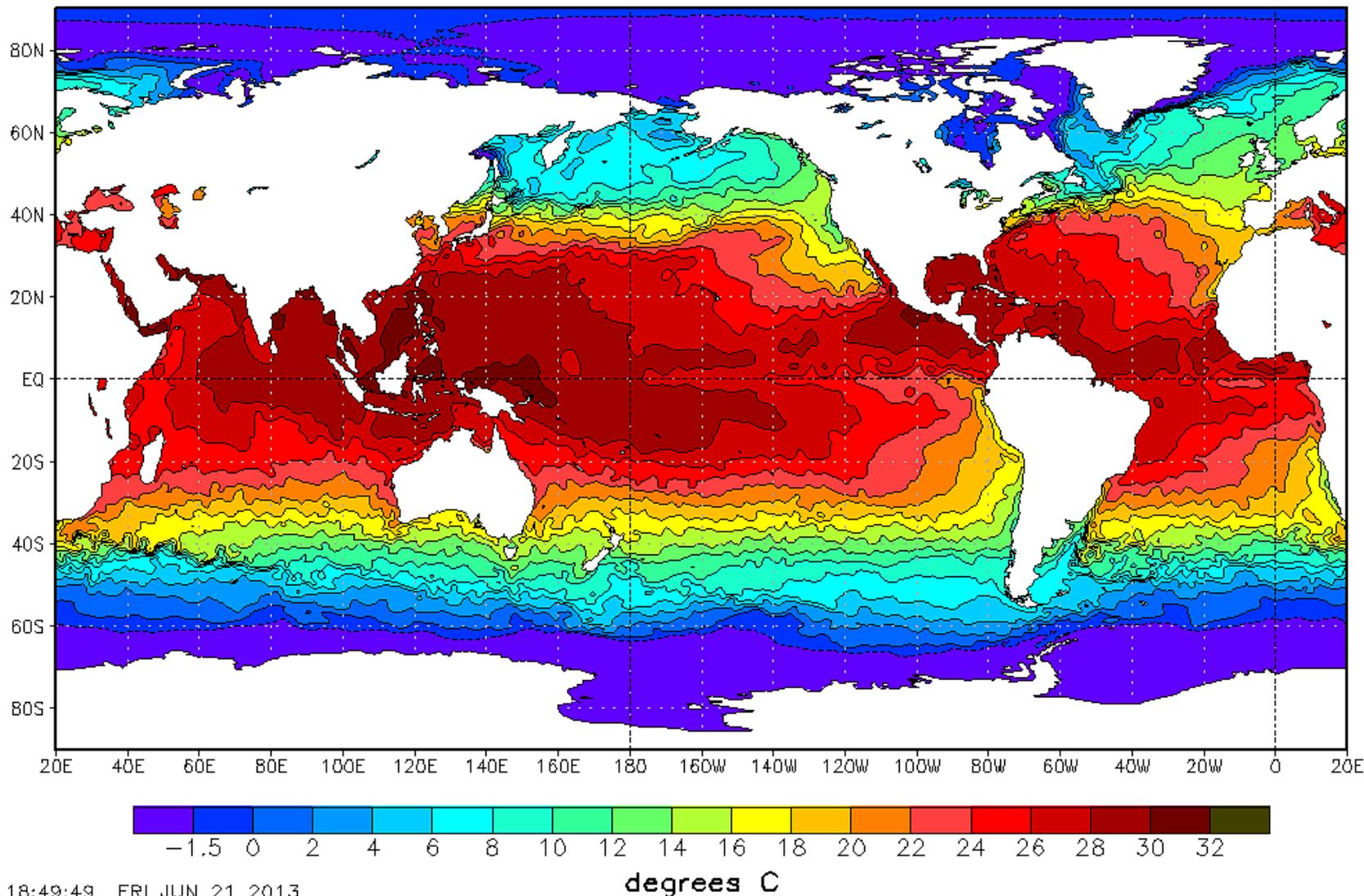
Existen ciertas **condiciones necesarias** para la formación de un ciclón tropical:

1. Aguas superficiales (hasta 50m) con $T > 27^{\circ}\text{C}$
2. Atmósfera condicionalmente inestable
3. Suficiente humedad hasta 500mb
4. Por lo menos una distancia de 500km del ecuador
5. Una perturbación pre-existente con convergencia y vorticidad
6. Muy poca variación del viento con la altura

Temperatura de la superficie del mar

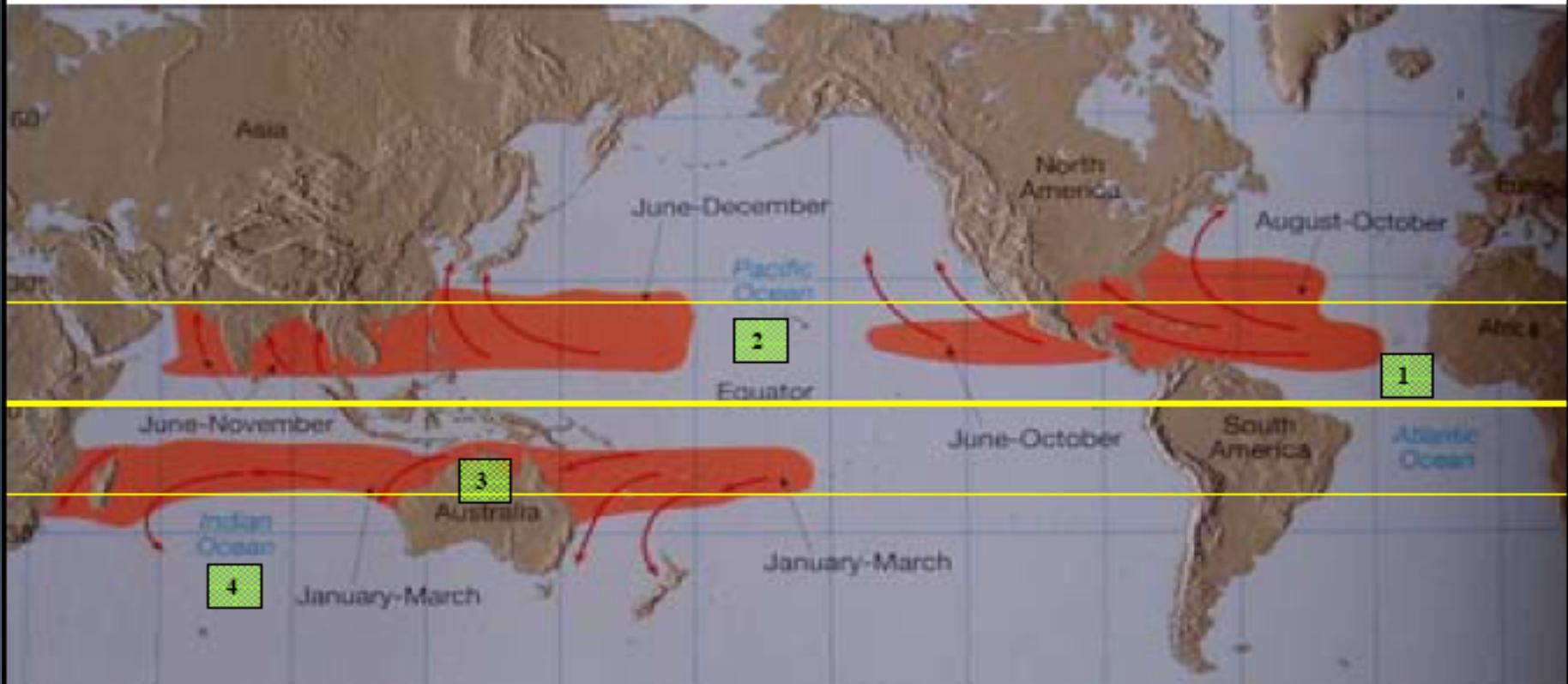
NOAA/NWS/NCEP/EMC Marine Modeling and Analysis Branch

RTG_SST Analysis (0.5 deg X 0.5 deg) for 21 Jun 2013



Climatología

Regiones de formación y movimiento de ciclones tropicales



1. Océano Atlántico: central y occidental
2. Océano Pacífico: oriental y occidental
3. Australia: oriental, norte y occidental
4. Océano Indico: sur de la India y este de Africa

Ciclones tropicales a nivel global :

Frecuencia por cuenca: 1985-2003

Year	AT	EP	IO	SH	WP
1985	11	23	6	35	27
1986	6	17	3	33	27
1987	7	20	8	28	26
1988	12	15	5	21	25
1989	11	17	2	28	35
1990	14	21	4	29	31
1991	8	14	4	22	31
1992	7	27	12	30	32
1993	8	15	2	27	37
1994	7	20	5	30	39
1995	19	10	4	22	34
1996	13	9	8	28	43
1997	8	19	4	38	33
1998	14	13	8	38	27
1999	12	9	5	33	33
2000	15	19	4	27	33
2001	15	15	4	21	33
2002	12	15	4	25	32
2003	16	16	3	29	27
Mean	11.32	16.53	5.00	28.63	31.84

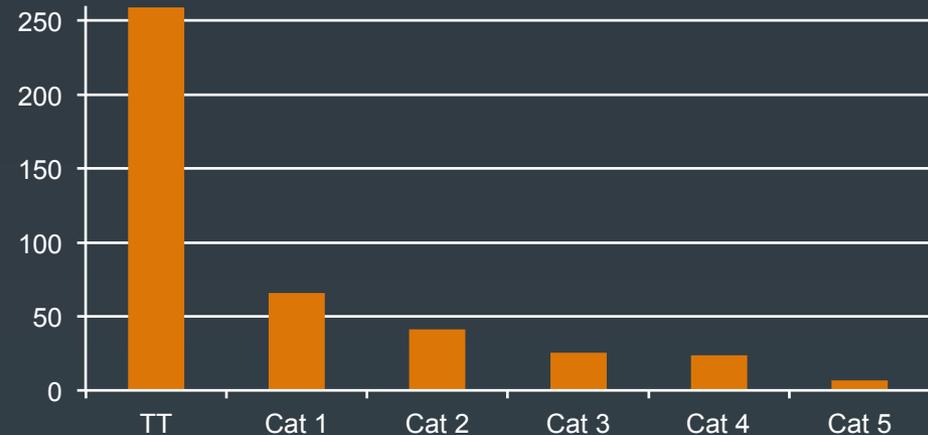
(Frank and Young, 2007)

Ciclones tropicales a nivel global : Duración e intensidad: 1985-2003

TABLE 2. Annual global number of storms for three intensity groups: the std dev of these means over the 19-yr sample, the std dev of the 1000 random draws for 19 yr, and the percentage of the random draws whose std dev exceeds the std dev of the observed totals.

	TS-Category 5	Category 1-5	Category 4-5
No.	87.1	49.4	16.0
Std dev—observations	8.3	6.7	5.4
Std dev—draw	8.6	6.1	4.3
% of draws over std dev of observations	55.3	26.6	6.0

Dias con ciclones tropicales



Numero promedio global

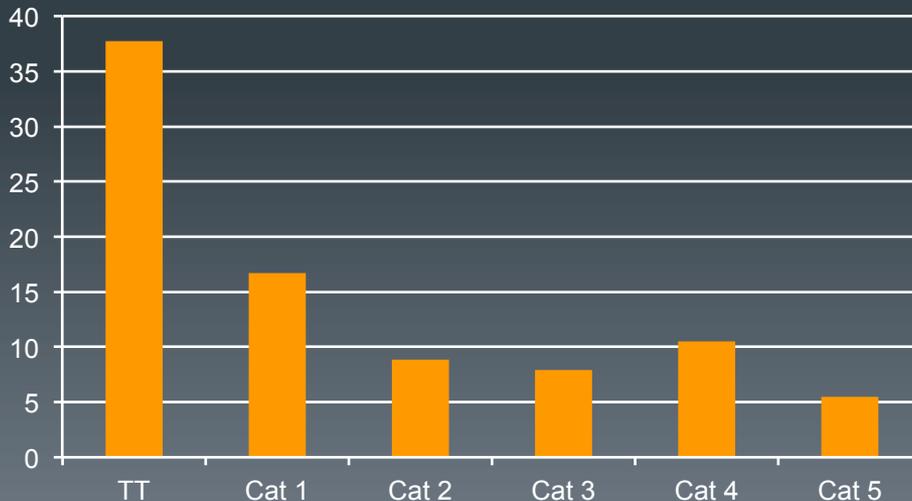


TABLE 3. As in Table 2, but for storm days.

	TS-Category 5	Category 1-5	Category 4-5
No.	441.7	182.8	41.8
Std dev—observations	76.6	35.3	14.5
Std dev—draw	65.4	33.6	10.7
% of draws over std dev of observations	15.3	36.2	3.0

(Frank and Young, 2007)

2005

Rita
23 September

Dennis
10 July

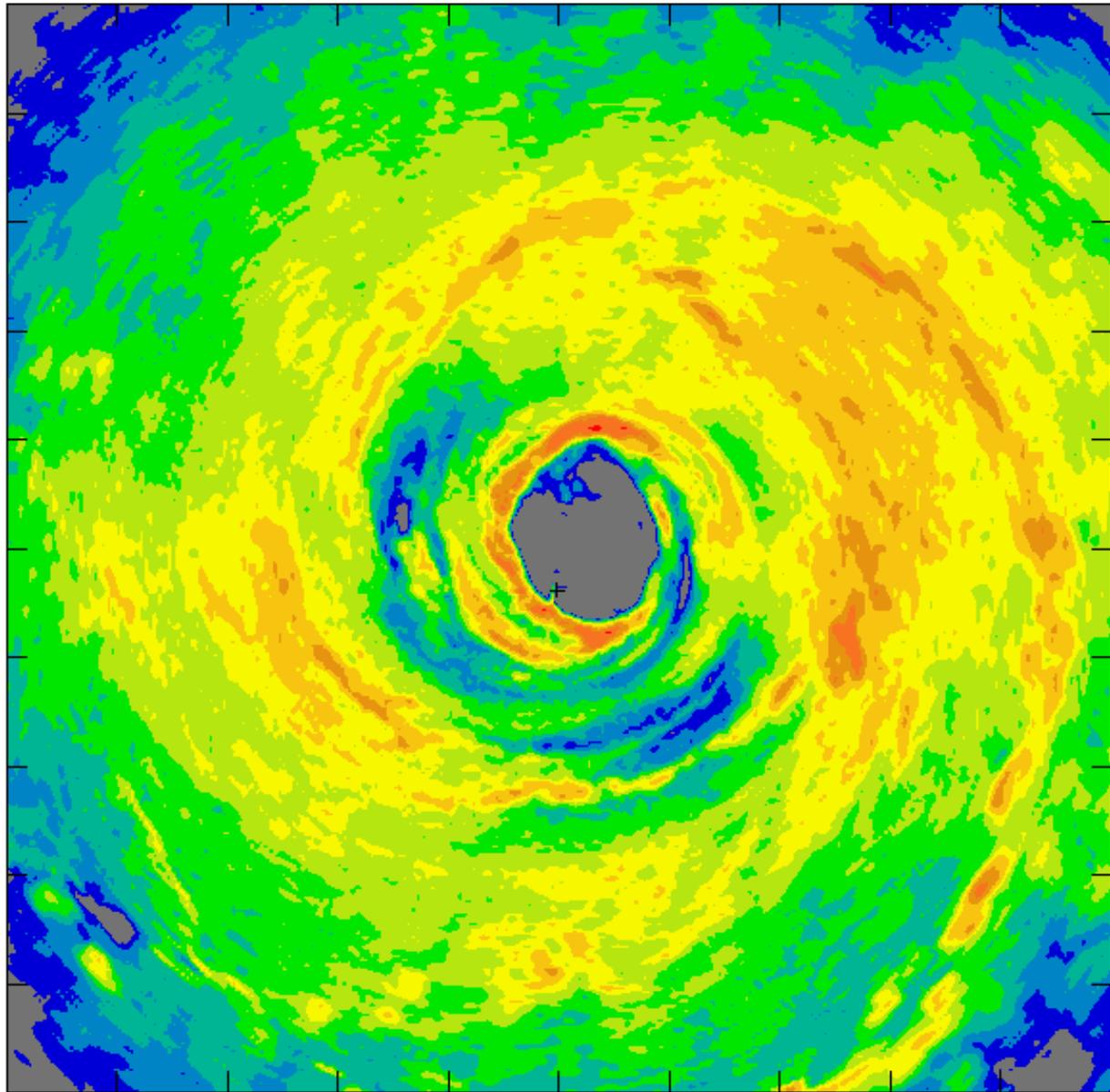
Katrina
28 August

Wilma
21 October

Emily
17 July

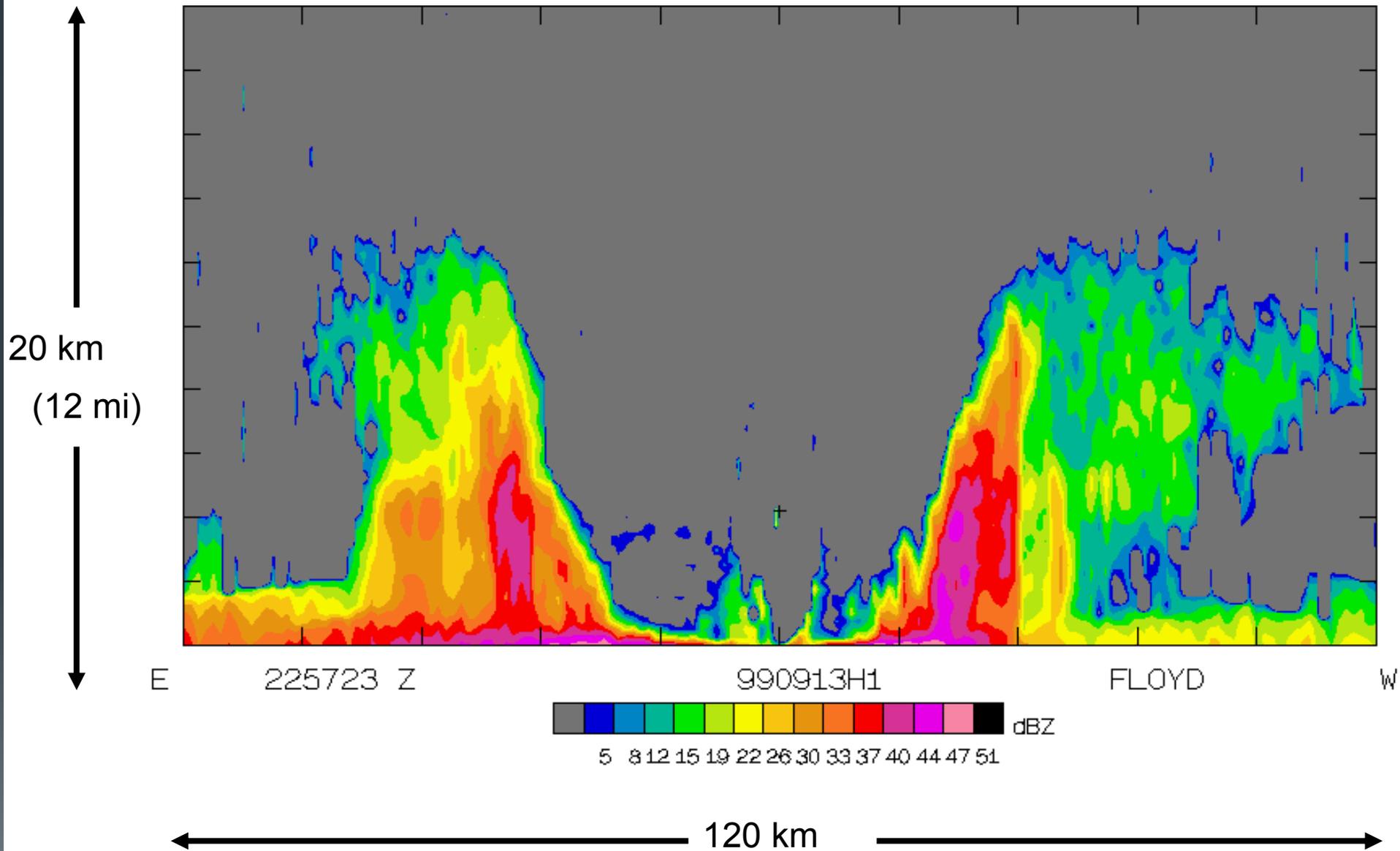


360 km
(220 mi)



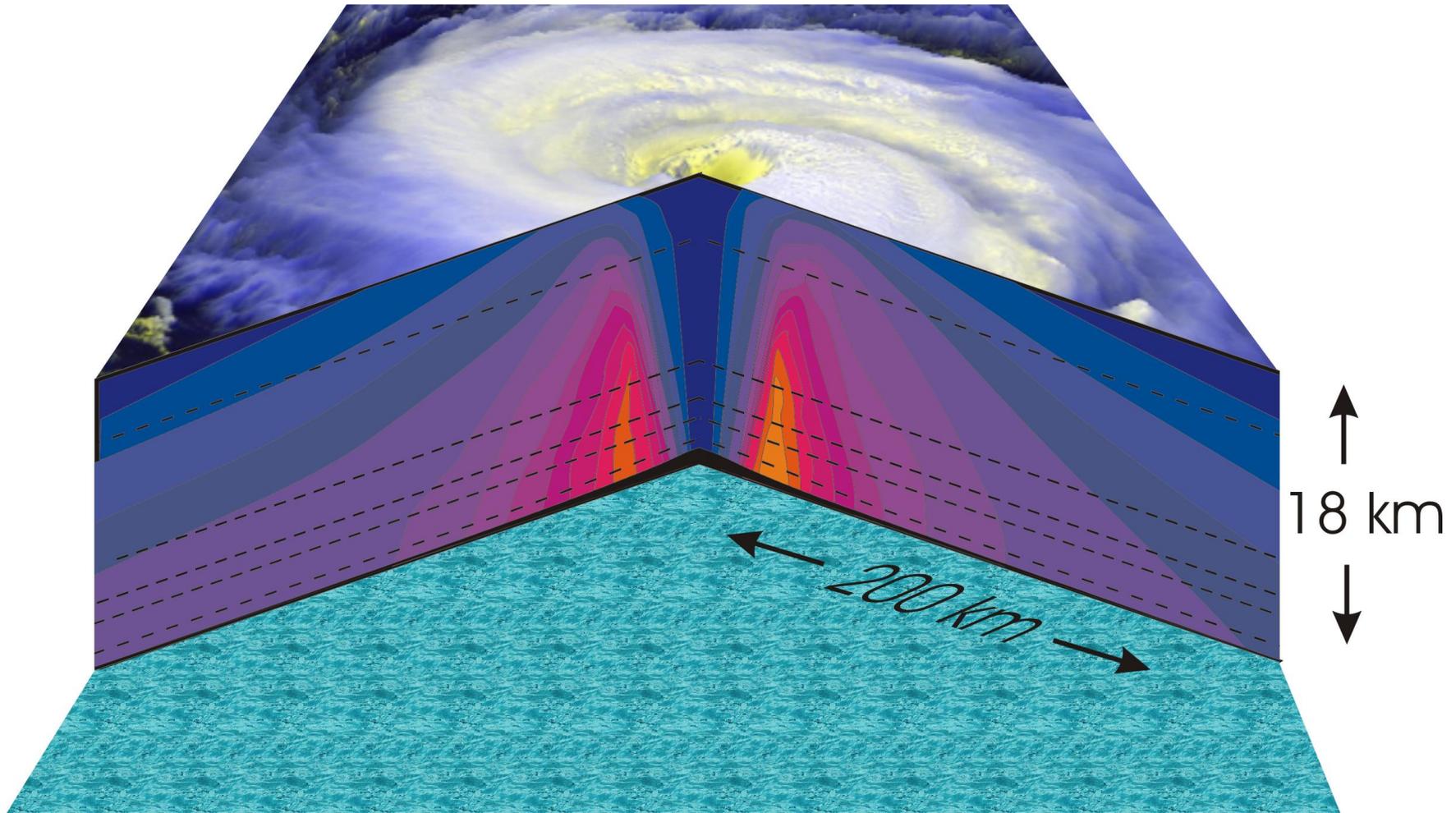
(Emanuel, 2010)

Airborne Radar: Vertical Slice



(Emanuel, 2010)

Hurricane Structure: Wind Speed

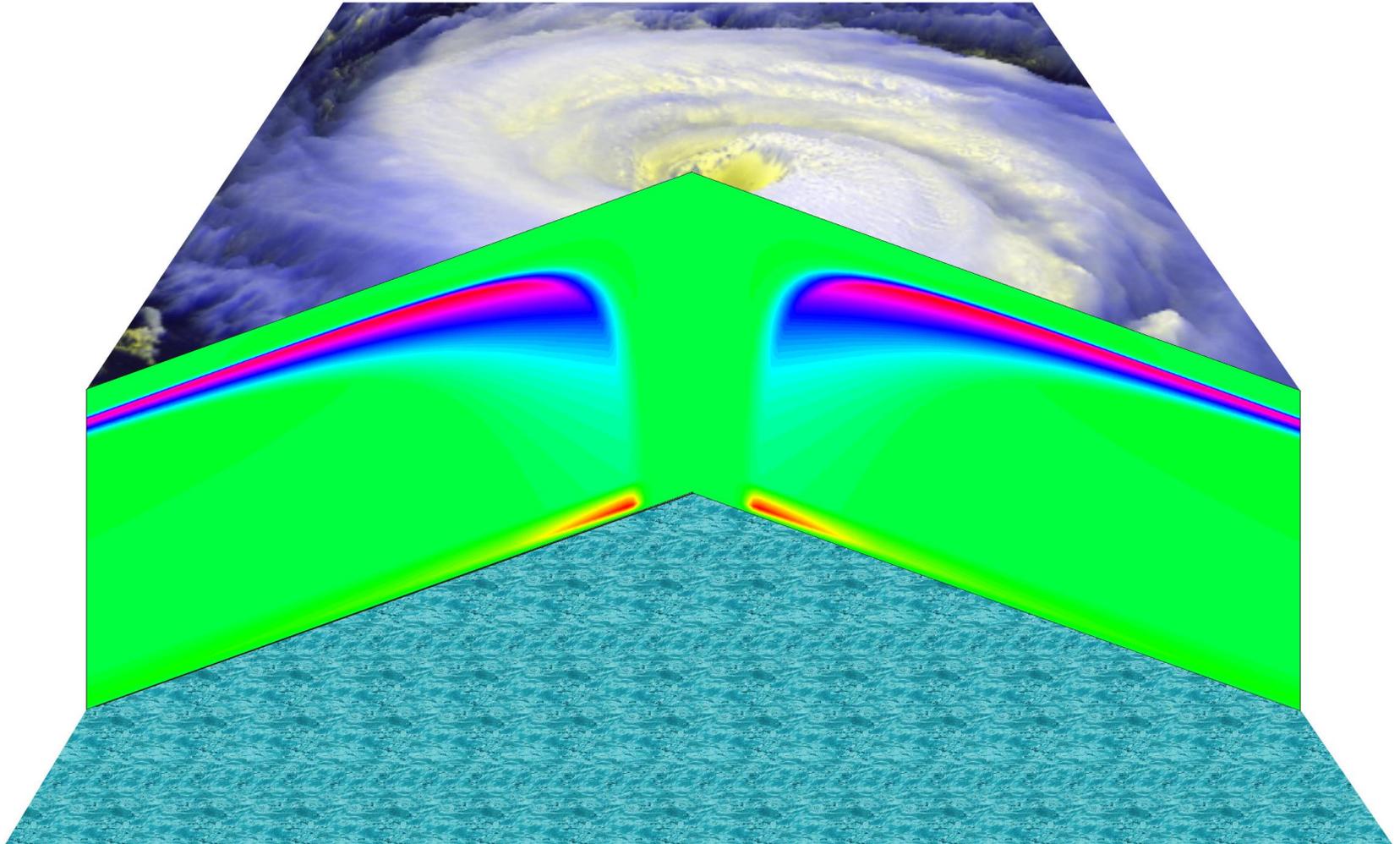


Azimuthal component of wind

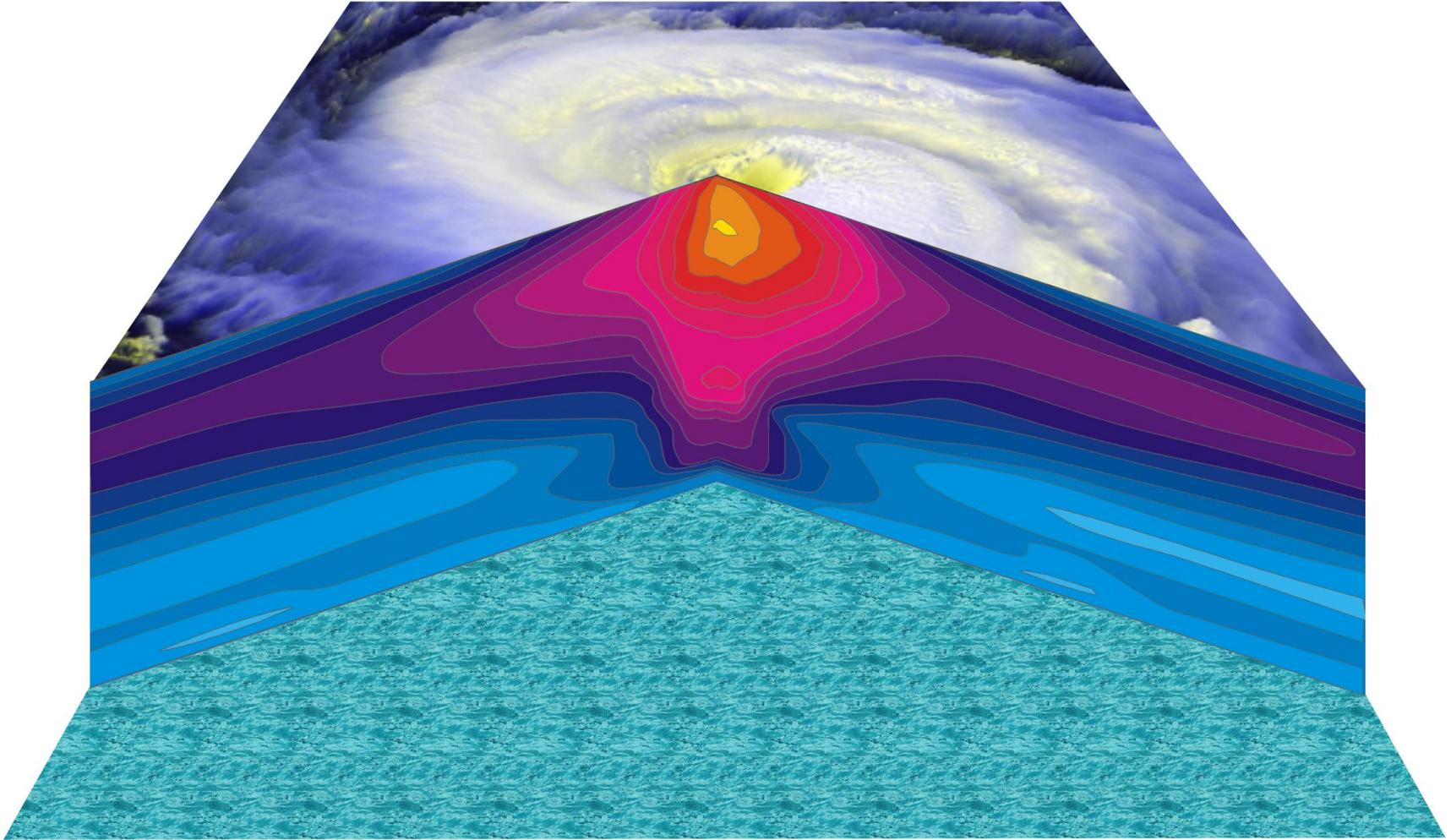
< 11 mph - > 145 mph

(Emanuel, 2010)

Radial wind



Hurricane Temperature Perturbations



No temperature difference - **> 16°C (29°F) warmer**

(Emanuel, 2010)

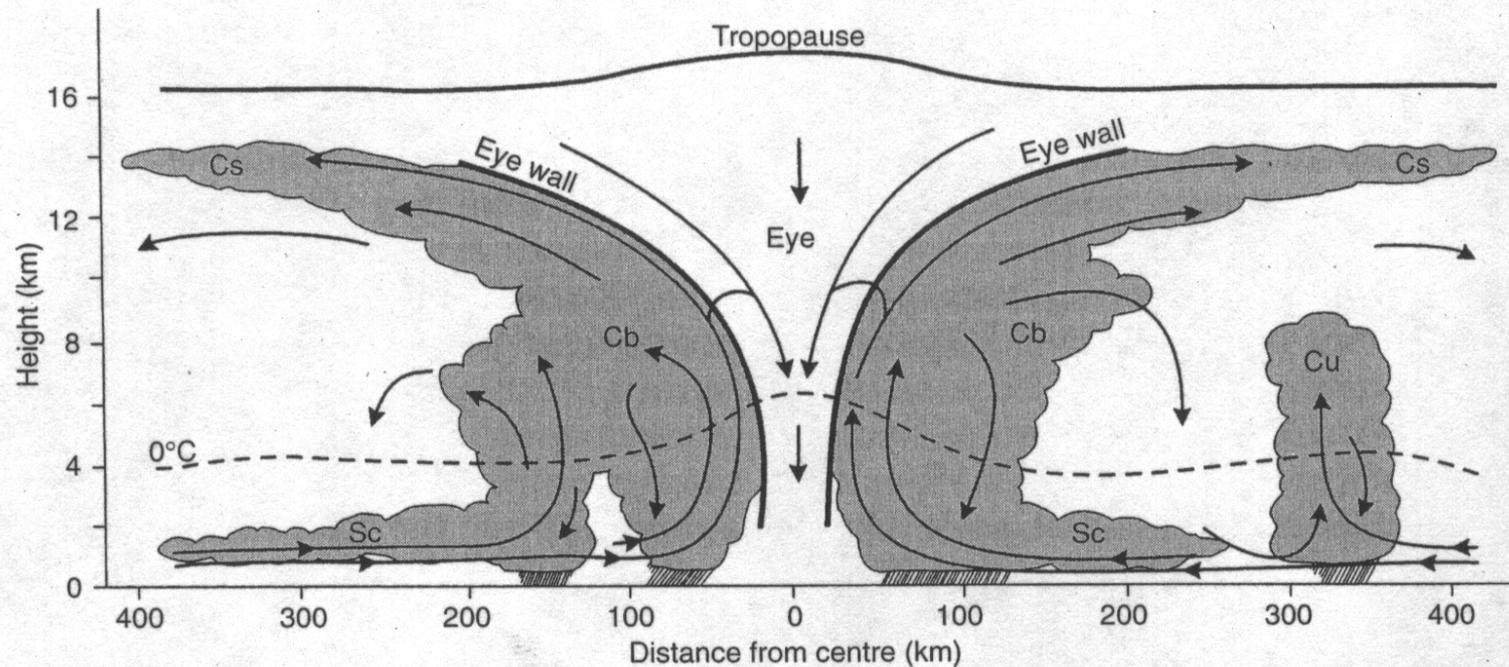


FIGURE 2.9 Schematic representation of the vertical structure of a mature hurricane, with arrows representing the air flows involved. (Reproduced from *Atmospheric Processes and Systems* by Russell D. Thompson, 1998 with permission from Routledge)

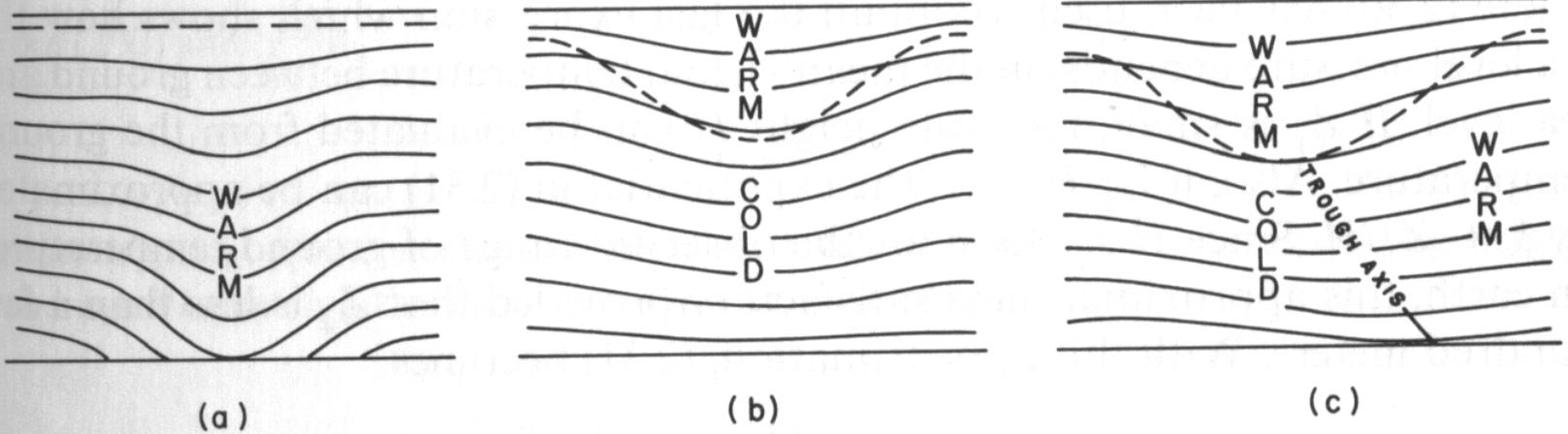
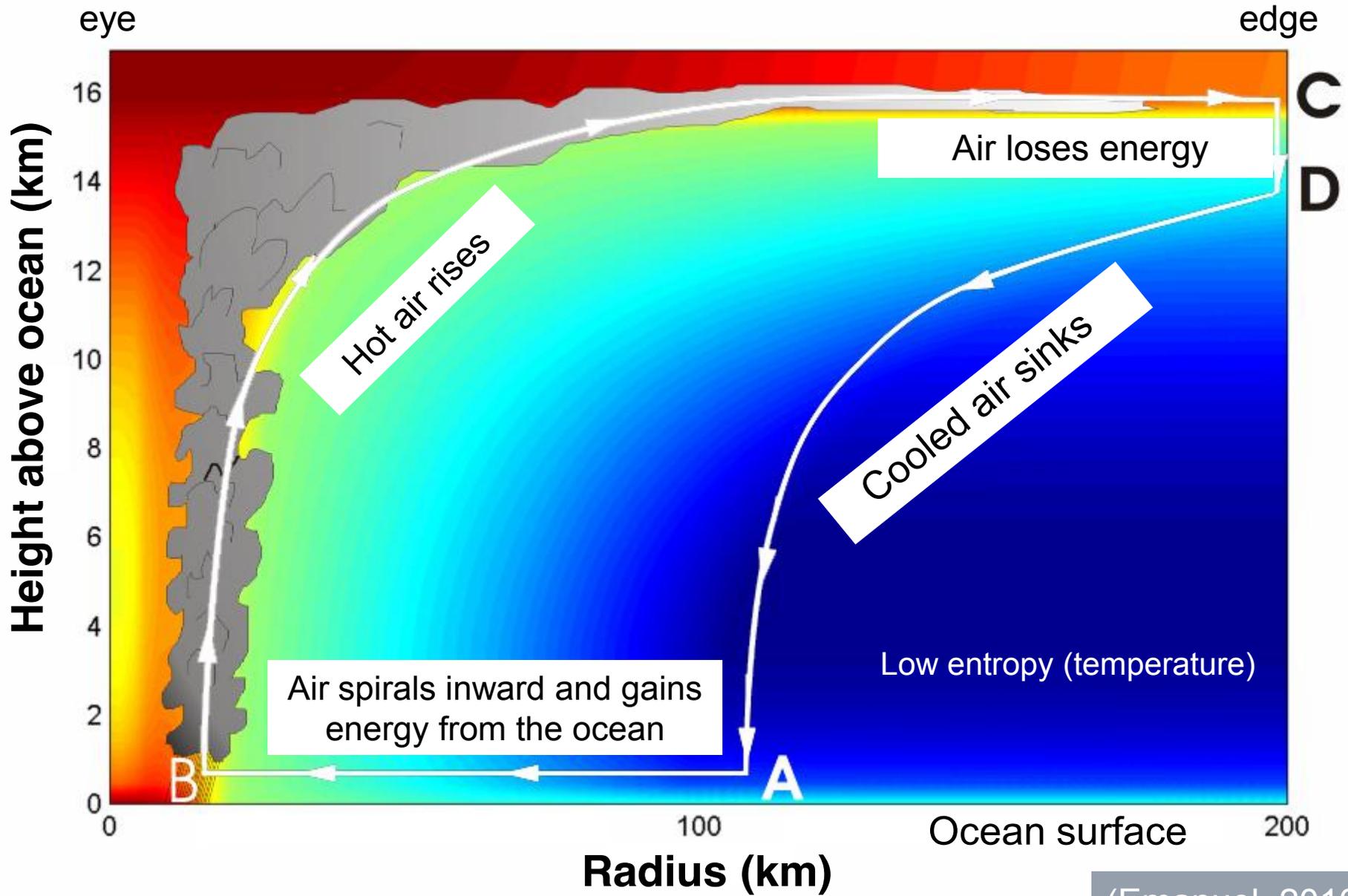
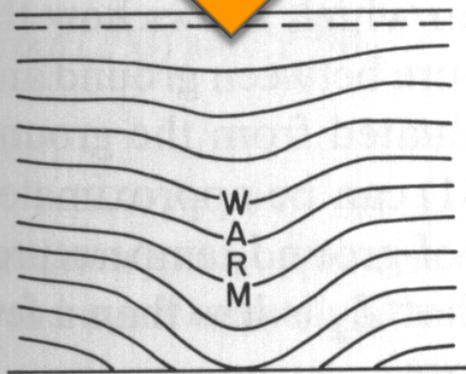


Fig. 2.3 Vertical cross sections through (a) a hurricane, (b) a “cold core” upper tropospheric low in middle latitudes, and (c) a middle-latitude disturbance which tilts westward with increasing height. The solid lines indicate various constant pressure surfaces and the dashed lines represent the tropopause. The sections are drawn such that the thickness between adjacent pressure surfaces is smaller in regions labeled *cold* and larger in regions labeled *warm*.

Cross-section through a Hurricane & Energy Production

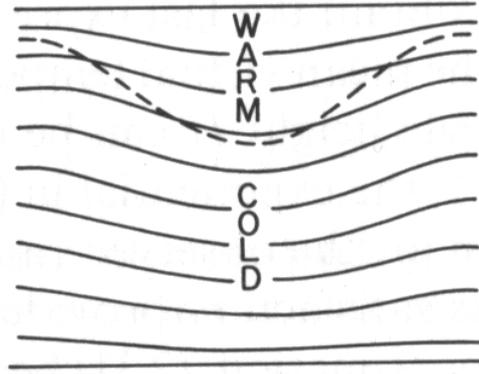


Ciclón tropical



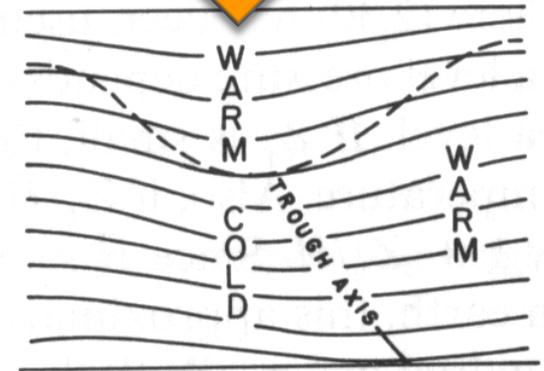
(a)

Baja en altura (latitud media)



(b)

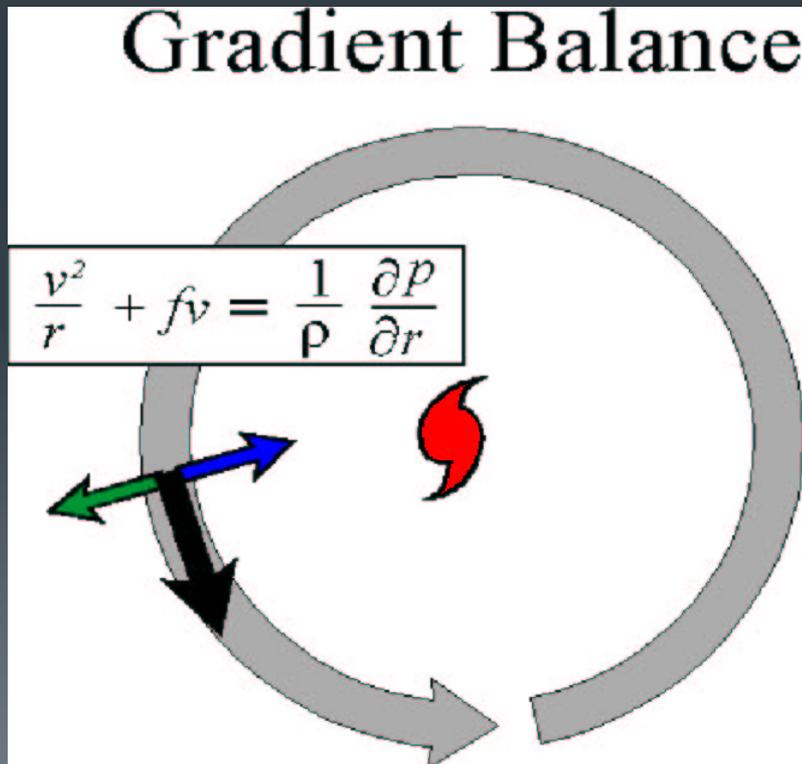
Ciclón extratropical



(c)

Fig. 2.3 Vertical cross sections through (a) a hurricane, (b) a “cold core” upper tropospheric low in middle latitudes, and (c) a middle-latitude disturbance which tilts westward with increasing height. The solid lines indicate various constant pressure surfaces and the dashed lines represent the tropopause. The sections are drawn such that the thickness between adjacent pressure surfaces is smaller in regions labeled *cold* and larger in regions labeled *warm*.

Los vientos en el “muro” que rodea al ojo se encuentran en un ***casi-balance*** de “viento gradiente”. Es el equilibrio entre las fuerzas centrípeta, de gradiente de presión y de Coriolis.

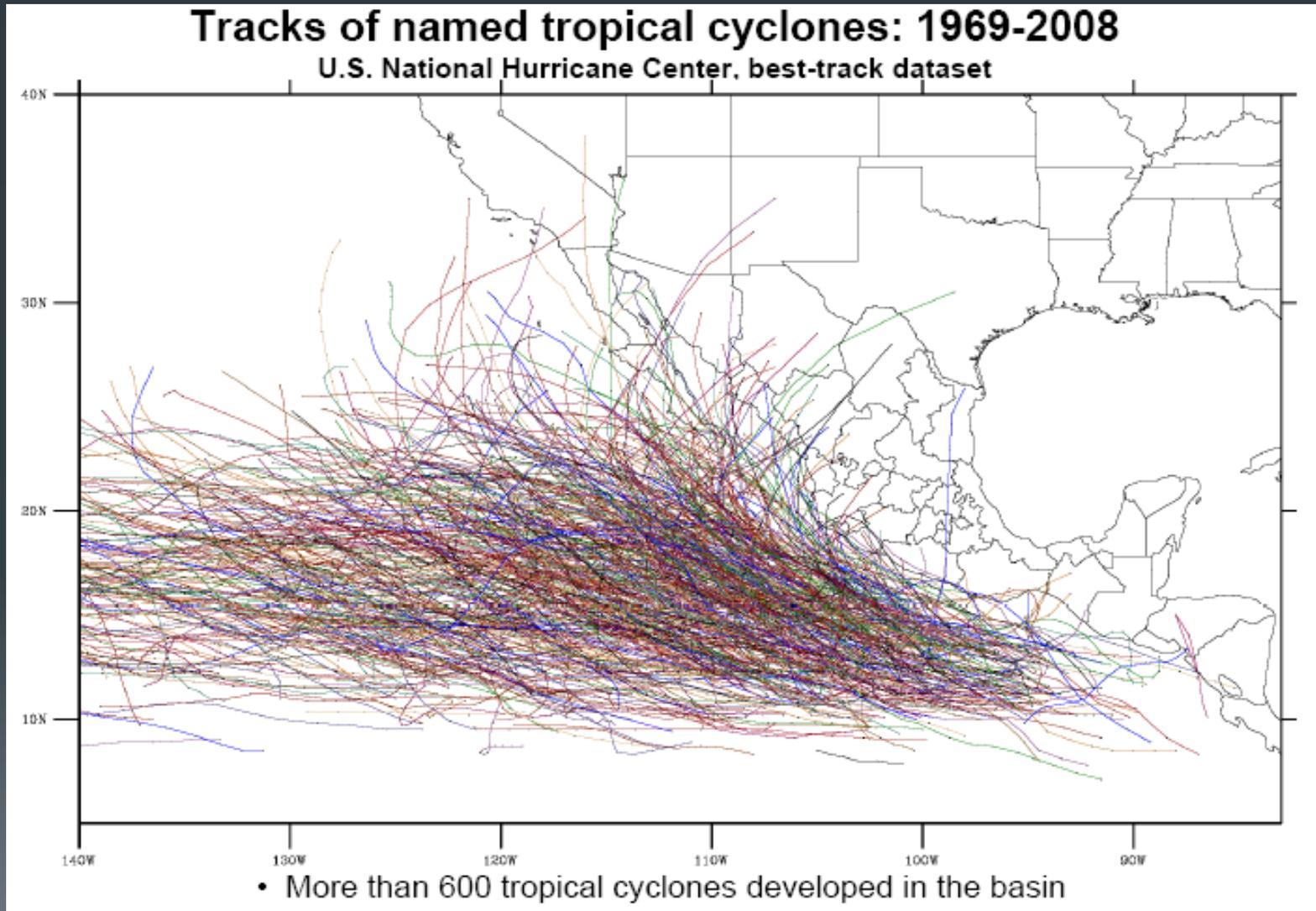


v: velocidad tangencial
f: factor de Coriolis
p: presión



Poster del Prof. Julio
presentado la semana
pasada sobre este tema

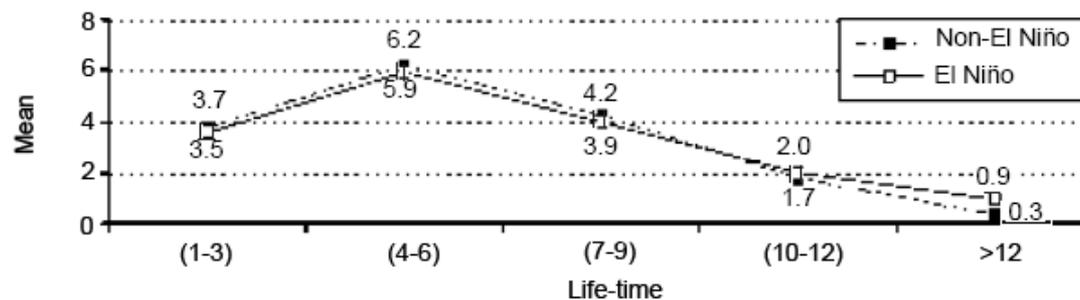
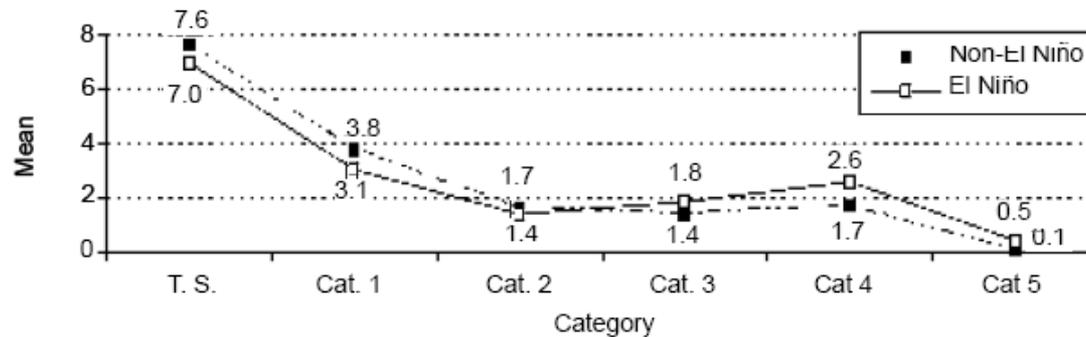
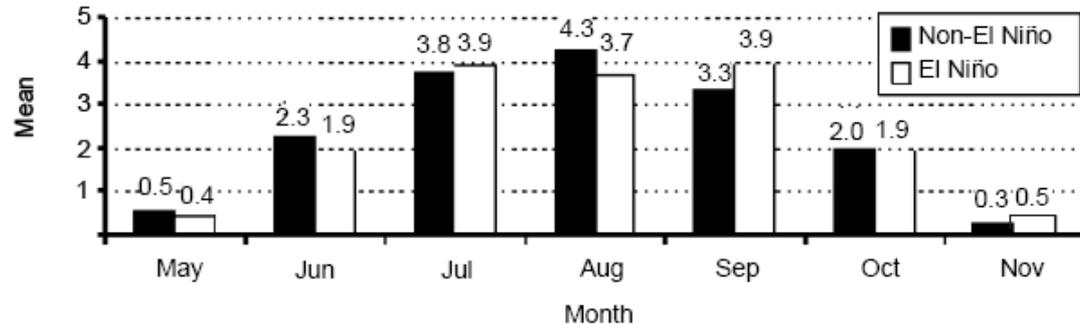
Variabilidad en el Pacífico Oriental



(Farfan, Romero-Centeno & Raga, 2012)

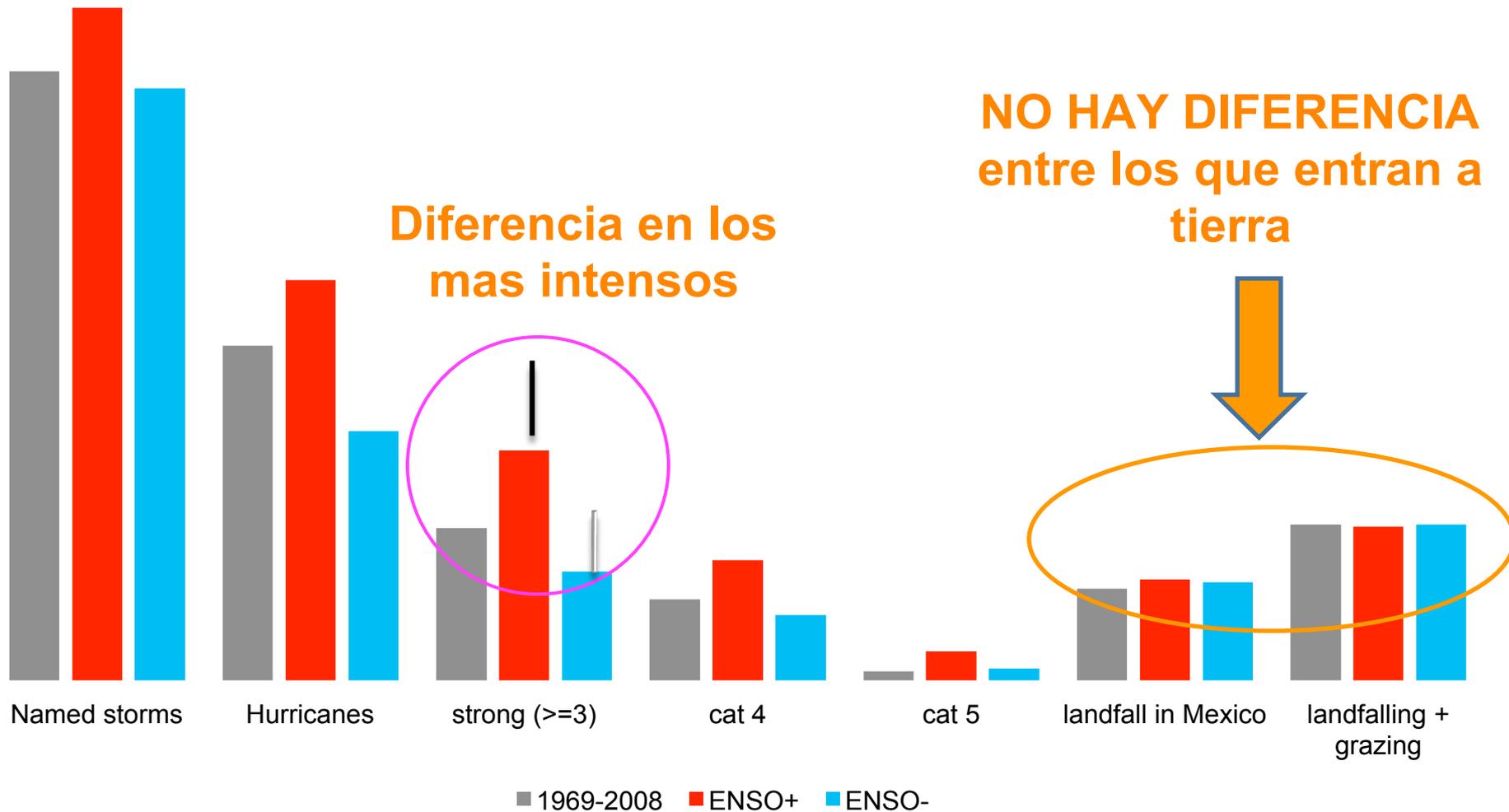
Variabilidad en el Pacifico Oriental

Ciclo anual

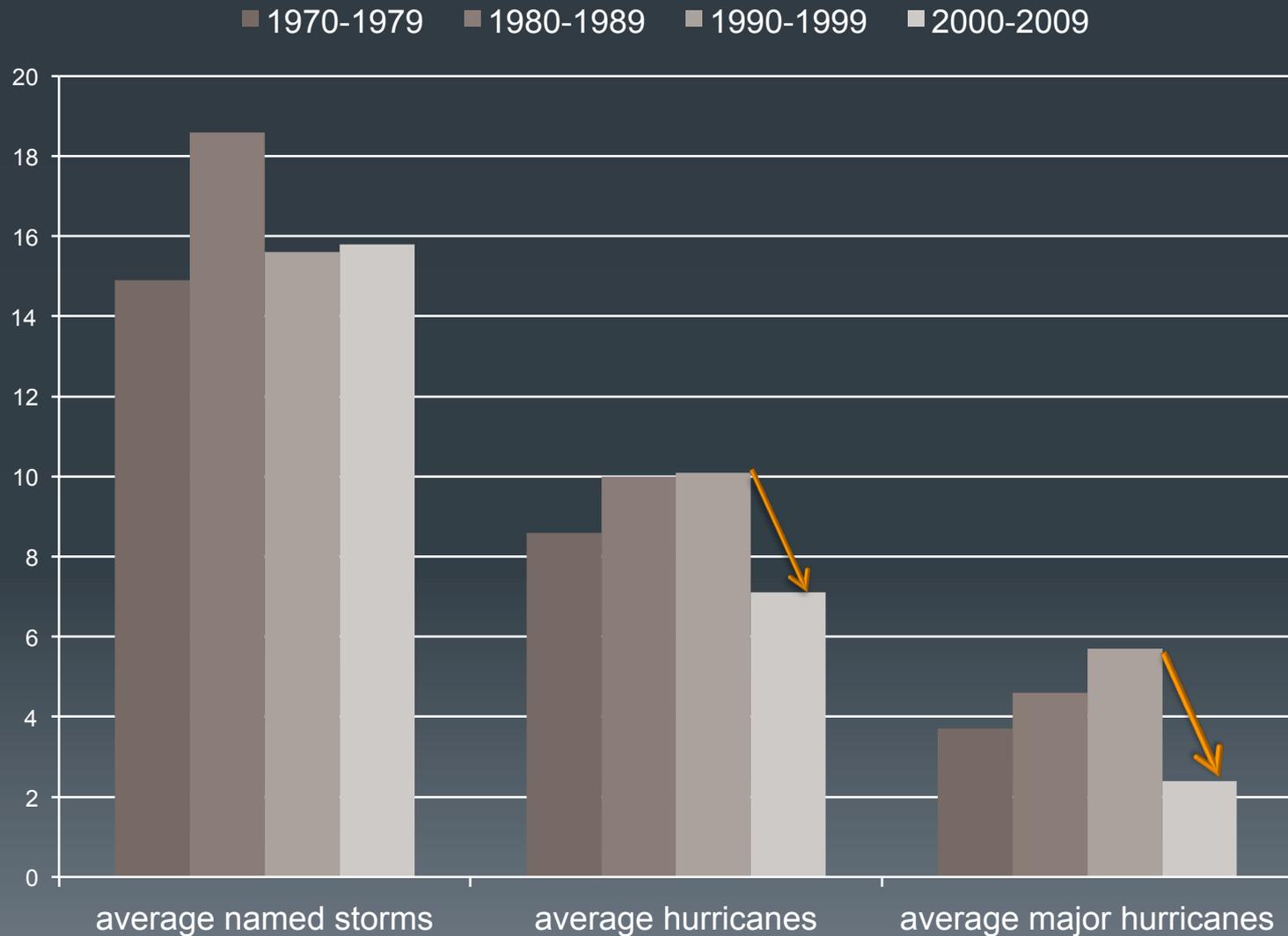


(Romero-Vadillo et al, 2007)

Variabilidad en el Pacifico Oriental : Influencia de ENSO en el numero *promedio*

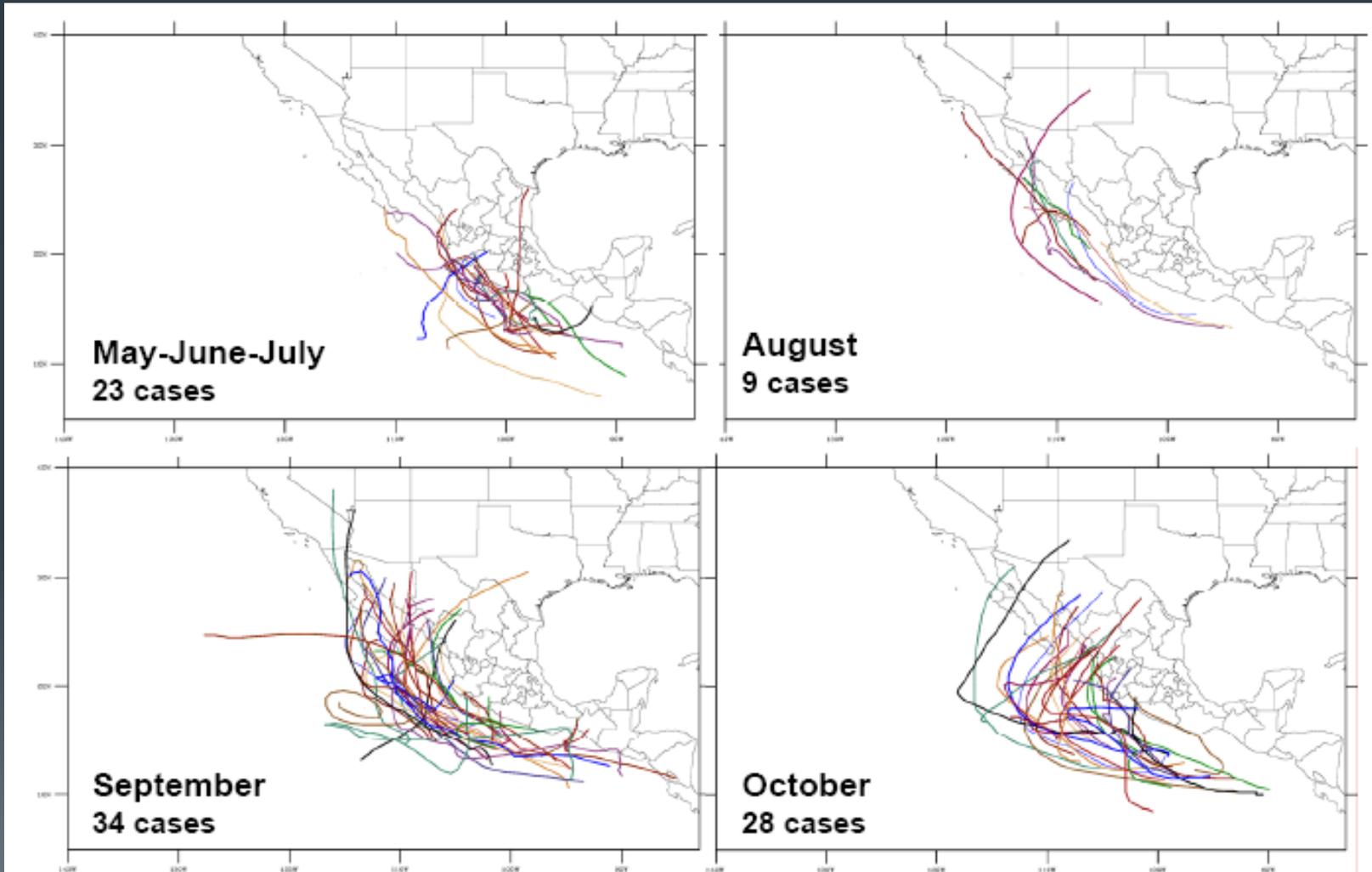


Ultimos 40 años en el Pacífico Oriental



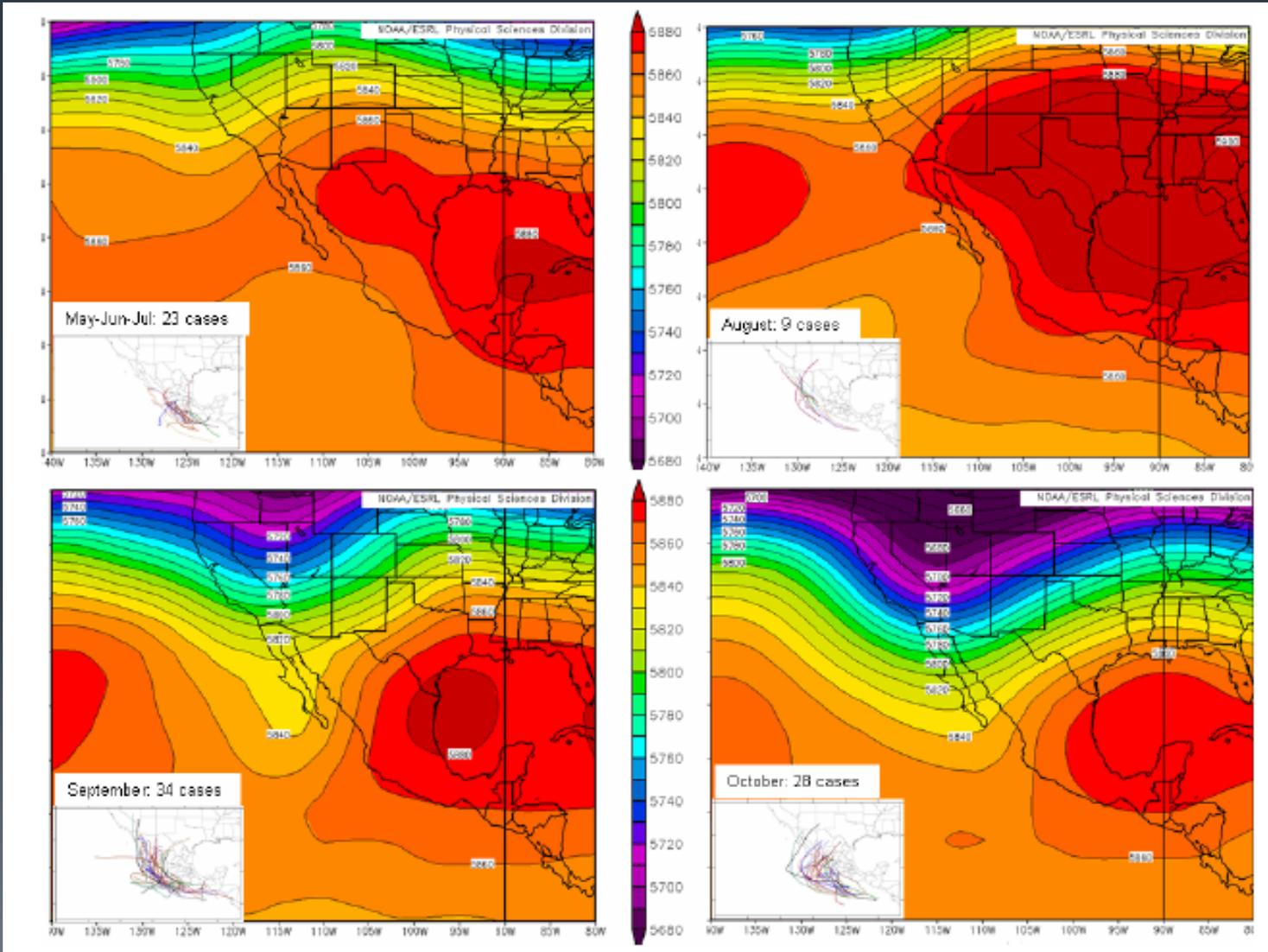
Entrada a tierra

1969-2008



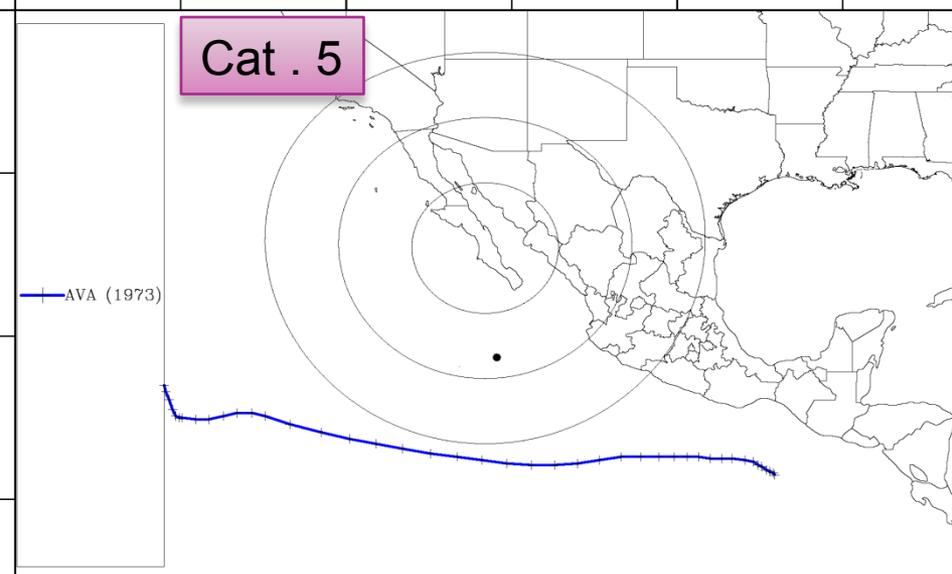
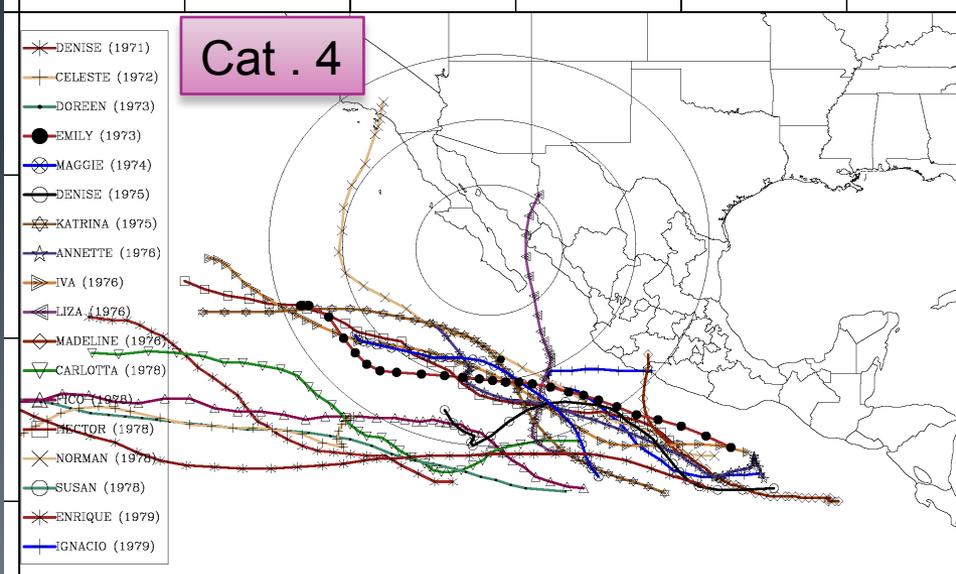
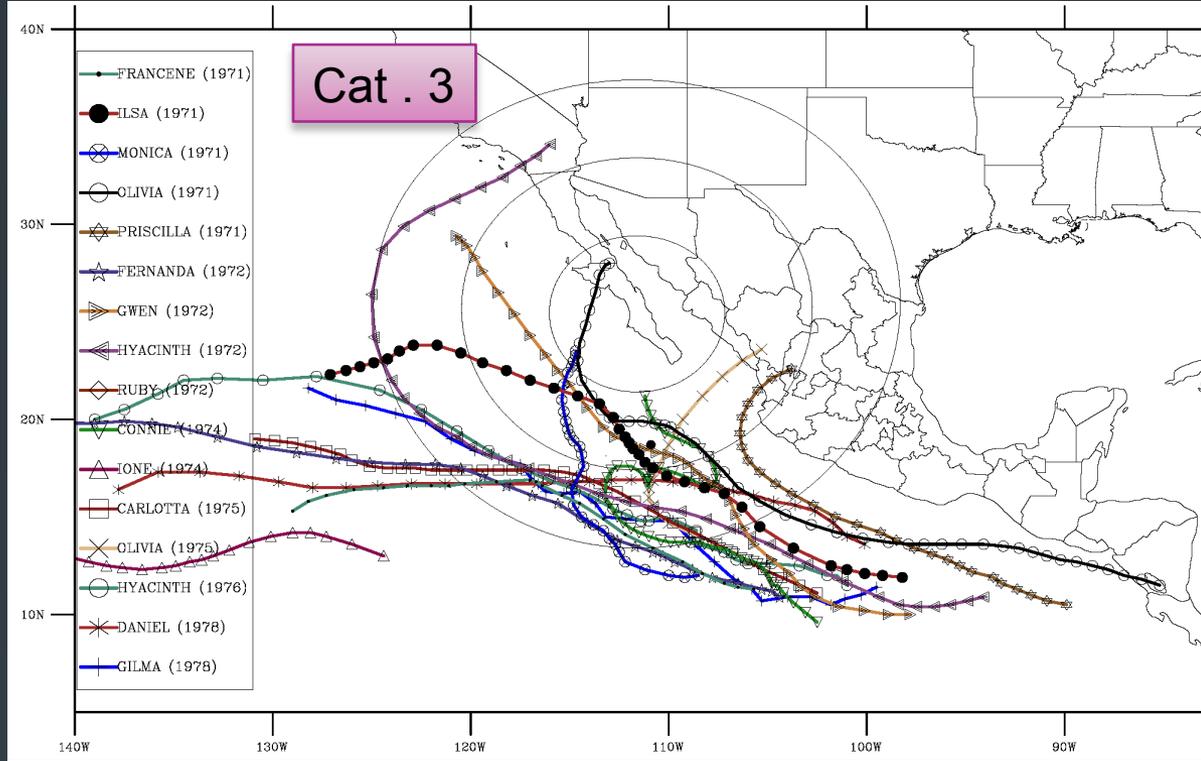
Entrada a tierra

1969-2008



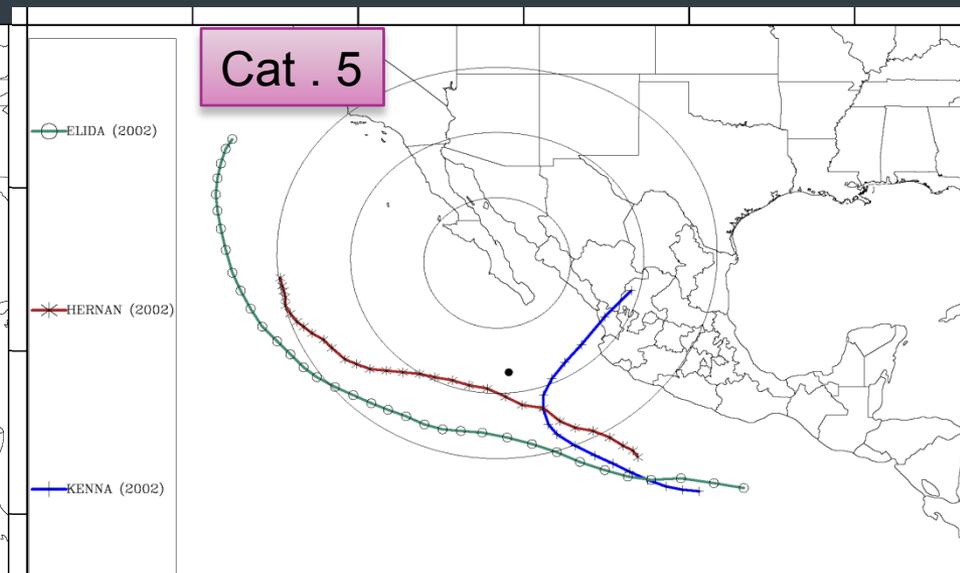
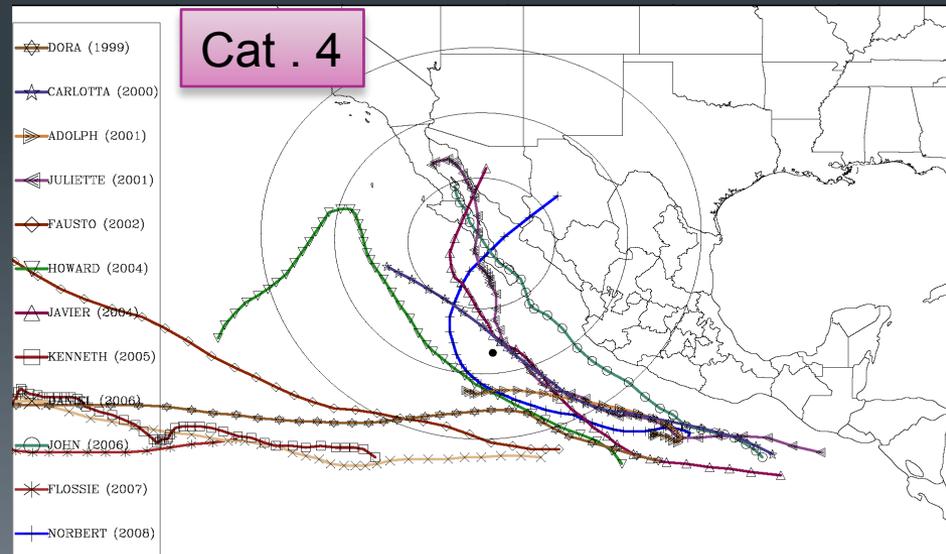
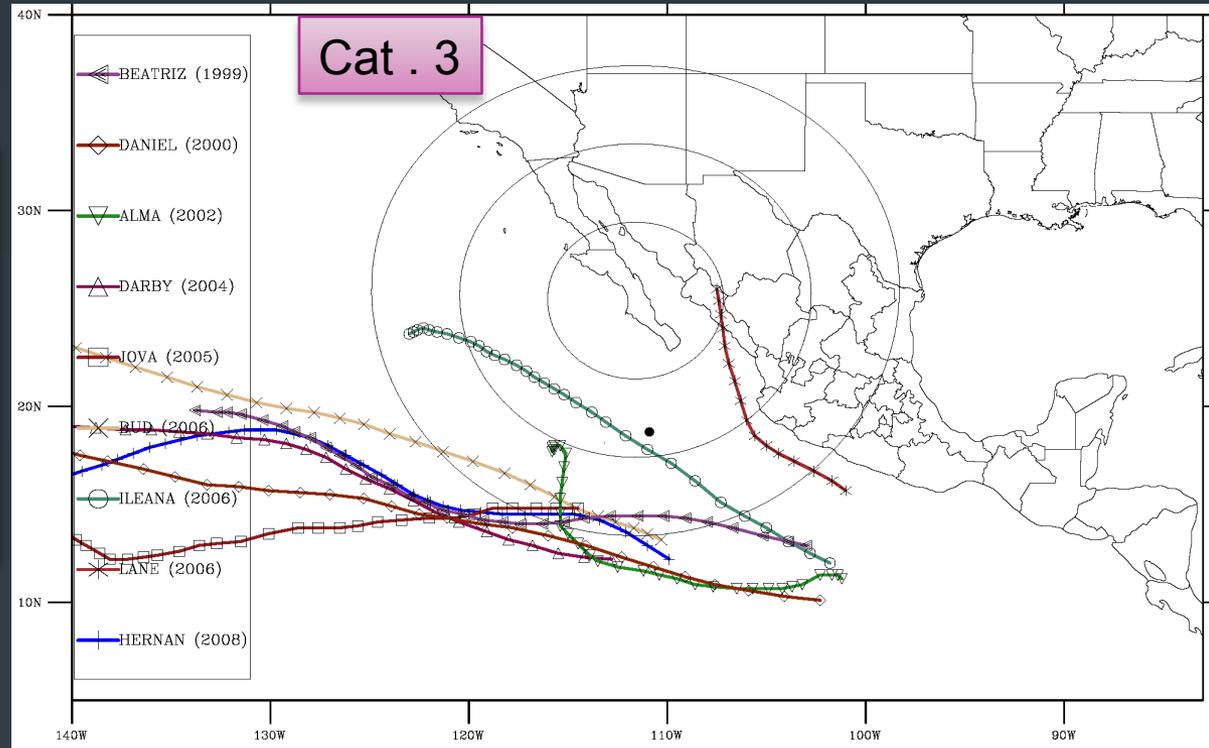
Variabilidad de las trayectorias en función de la intensidad y por década

1970-1979



Variabilidad de las trayectorias en función de la intensidad y por década

2000-2008





PASADO ...

**Landfalling tropical cyclones on the Pacific coast
of Mexico: 1850-2010**

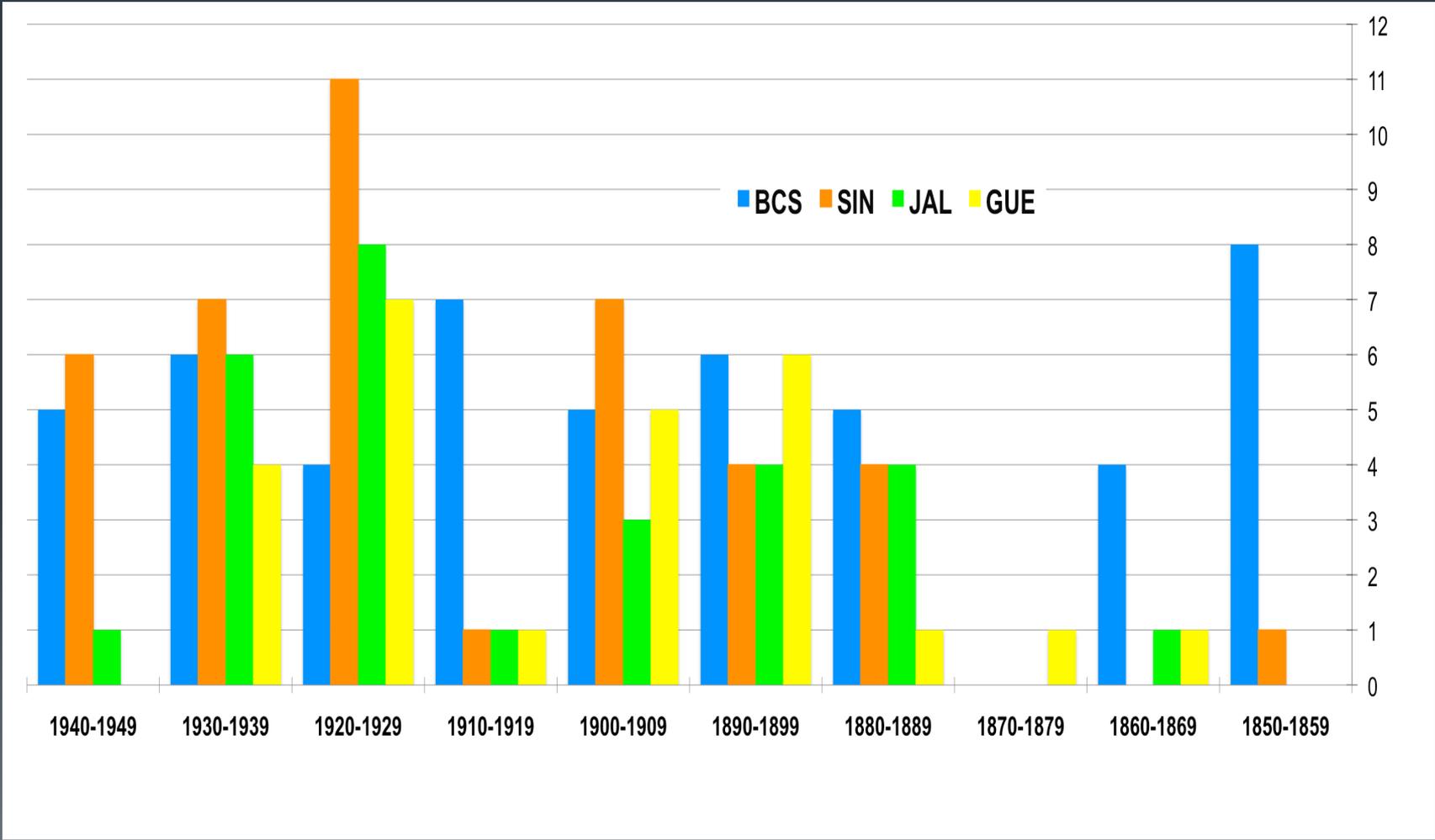
Raga, Bracamontes, Farfan, Romero-Centeno, 2013

Metodología: Archivos históricos en oficinas regionales de gobierno, periódicos y boletines oficiales



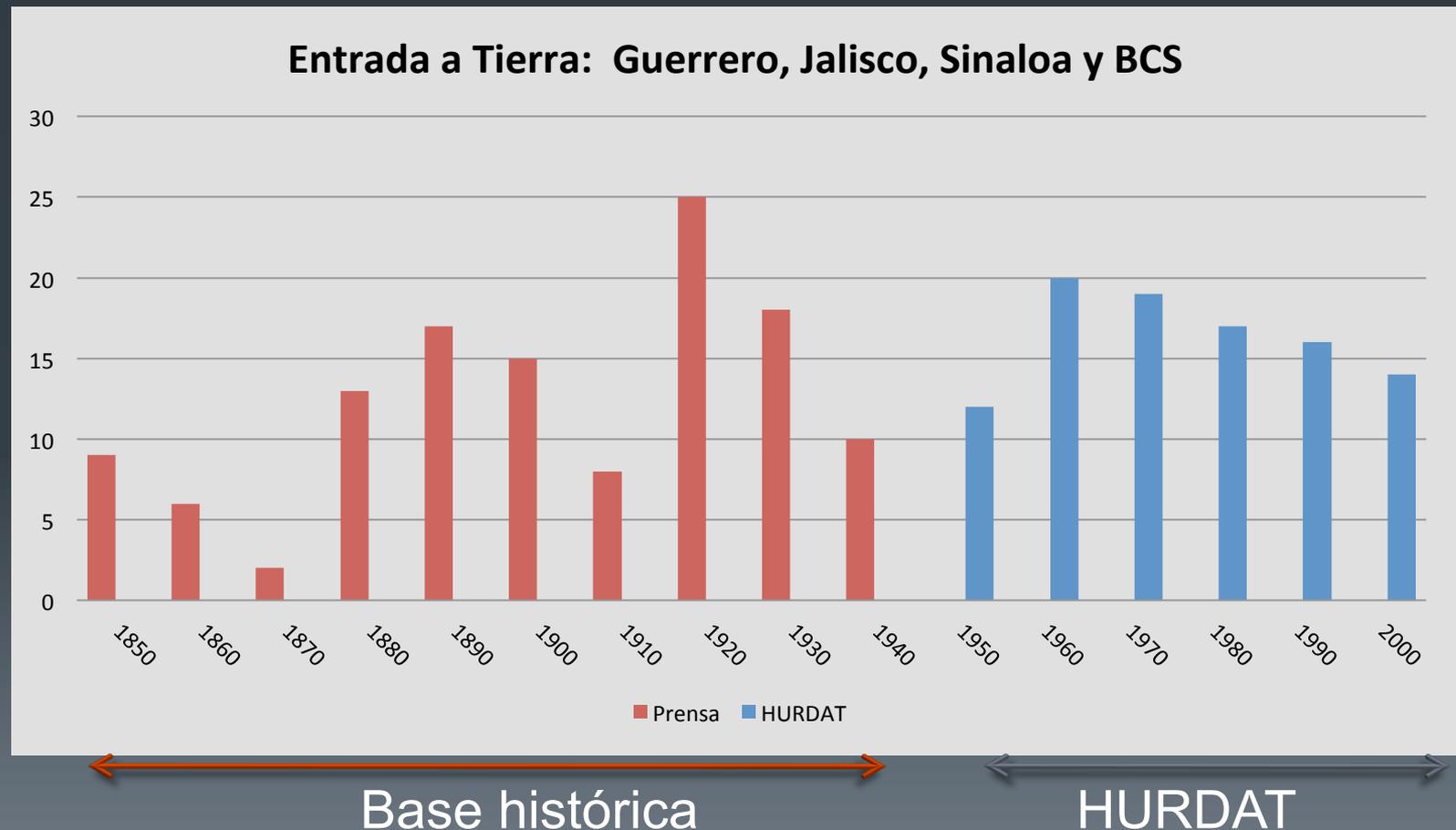
Los culiacanenses, desde el puente, observando la gran creciente del río Tamazula.

Ciclones Tropicales registrados en los 4 estados, por década



(Raga et al 2013)

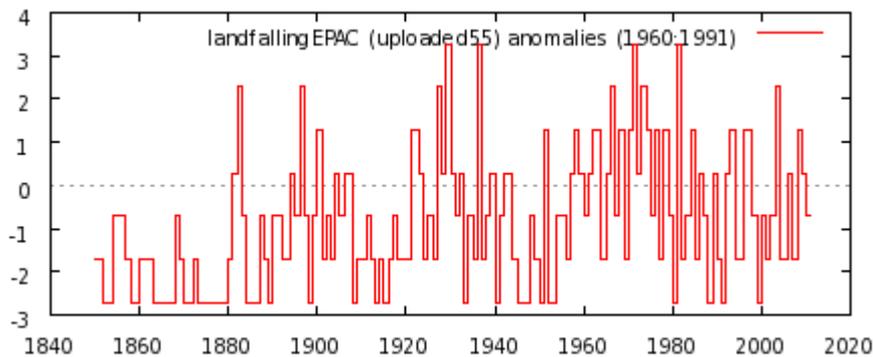
Registro histórico de entradas a tierra: Guerrero, Jalisco, Sinaloa y BCS (1850-2009)



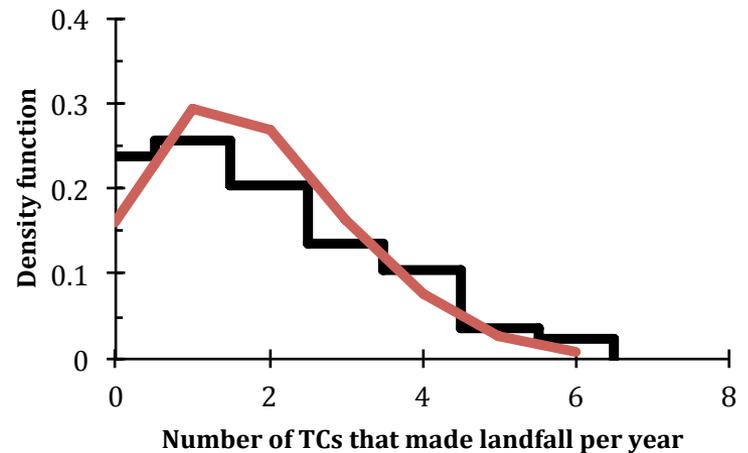
Entrada a tierra

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

Anomalias

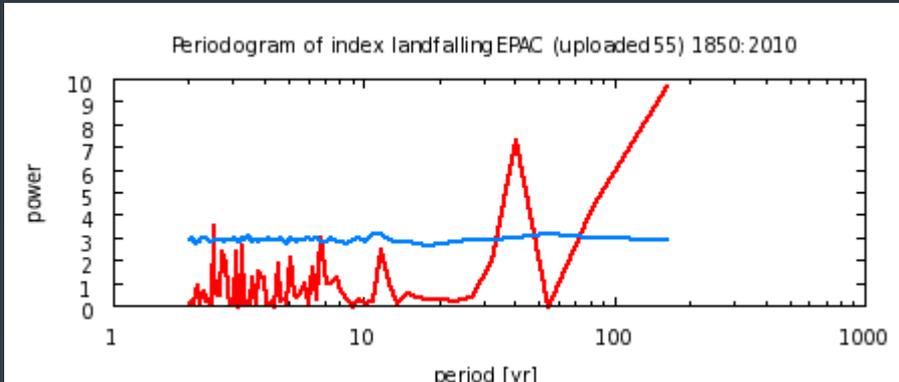


Landfalling TCs: 1850-2010



Distribución de Poisson

Periodograma (1850:2010)

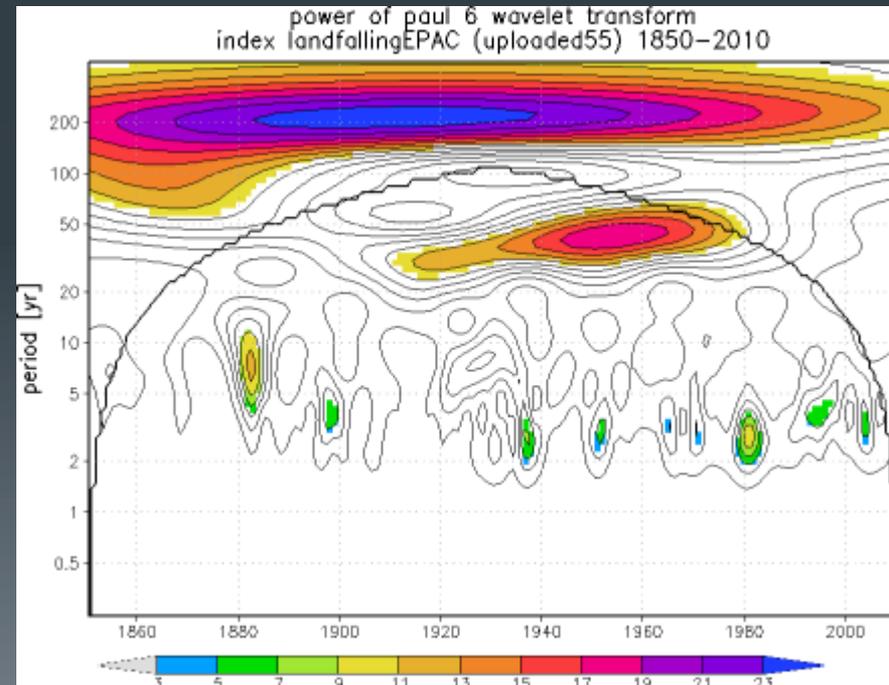


Coeficiente de correlacion

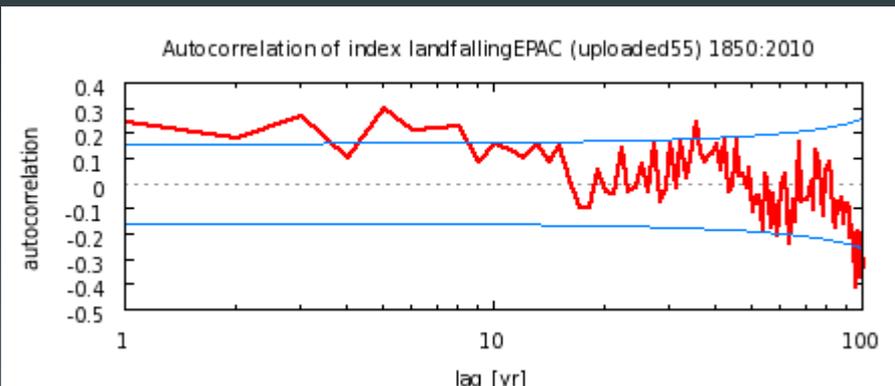
		Pearson	Spearman
1850-2010	NAO	0,01	0,22
1866-2009	SOI	-0,02	0,13
1900-2010	PDO	0,09	0,31
1856-2010	Niño3	0,01	0,22

Wavelet (1850:2010)

Linea negra: cono de influencia



Autocorrelacion (1850:2010)





FUTURO...

Super-high-resolution global atmospheric model

- Resolution: TL959(20km) with 60 layers
- Time integration: Semi-Lagrangian Scheme (Yoshimura, 2004)
- SW radiation: Shibata & Uchiyama (1992)
- LW radiation: Shibata & Aoki (1989)
- Cumulus convection: Prognostic Arakawa-Schubert (Randall and Pan, 1993)
- Land hydrology: Sib with 4 soil-layers and 3 snow-layers
- Clouds: large-scale condensation, Cumulus, stratocumulus
- PBL: Mellor & Yamada (1974,1982) level-2 closure model
- Gravity wave drag: Iwasaki et al. (1989) + Rayleigh friction

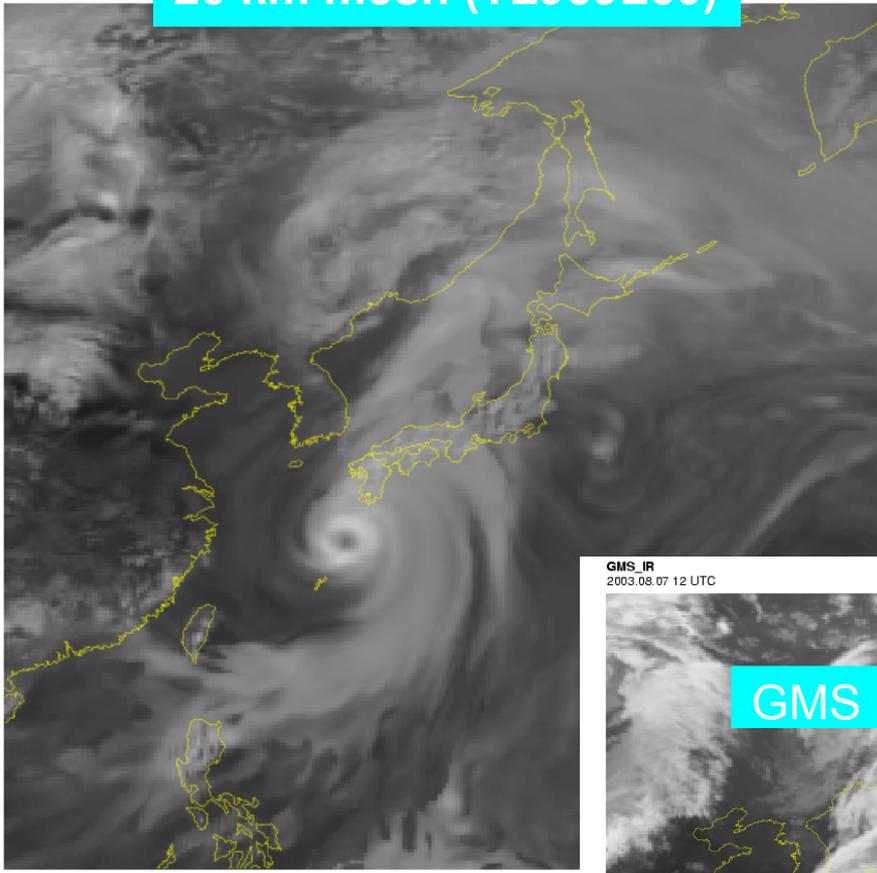
SST given as a boundary condition:

- Excludes coupling with ocean subsurface,
- Enables much-higher-resolution simulation.

(Oouchi et al. 2006, Yoshimura et al, 2007)

GSM_IR
2003.08.07 12 UTC

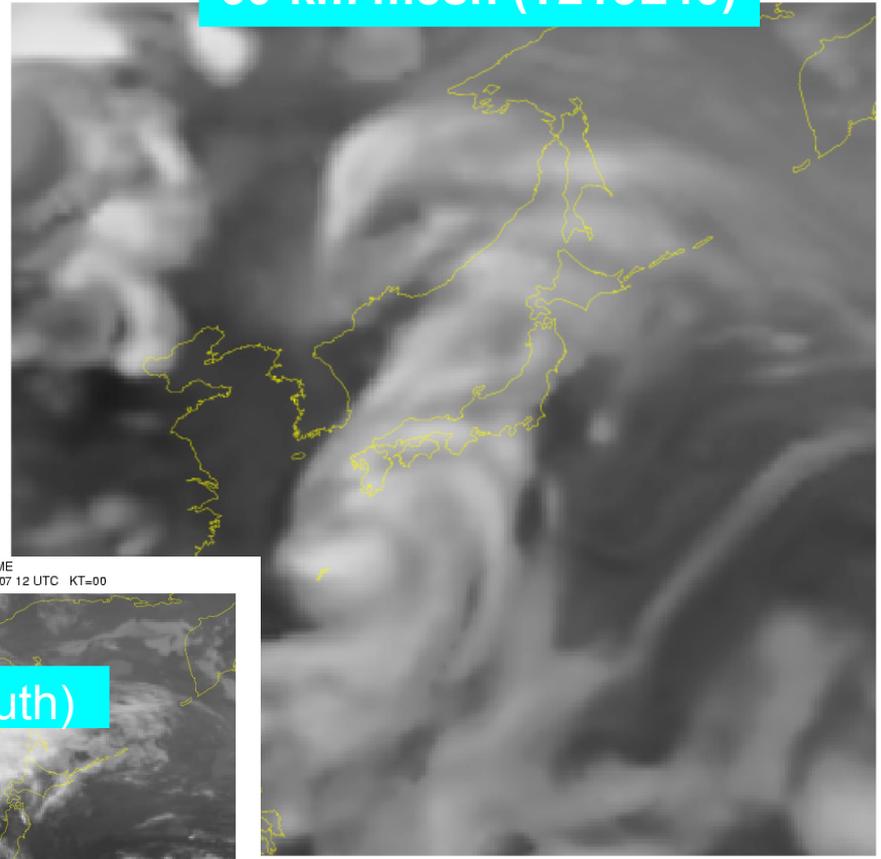
20 km mesh (TL959L60)



140 160 180 200 220 240 260

GSM_IR
2003.08.06 00 UTC

60-km mesh (T213L40)

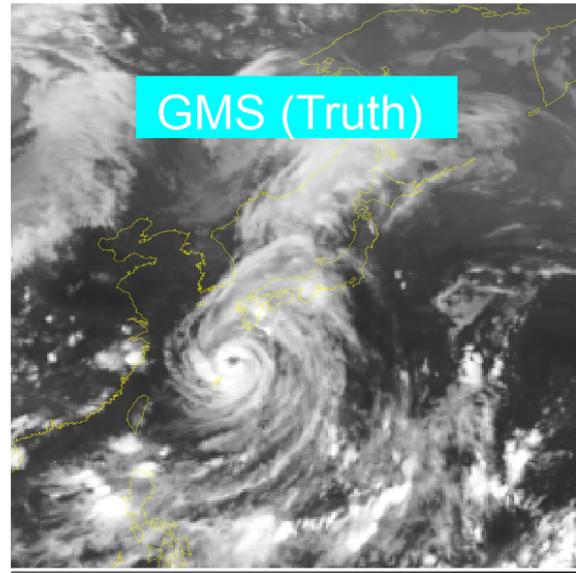


200 220 240 260 280 300 320 K

GMS_IR
2003.08.07 12 UTC

BASETIME
2003.08.07 12 UTC KT=00

GMS (Truth)



140 160 180 200 220 240 260 280 300 320 K

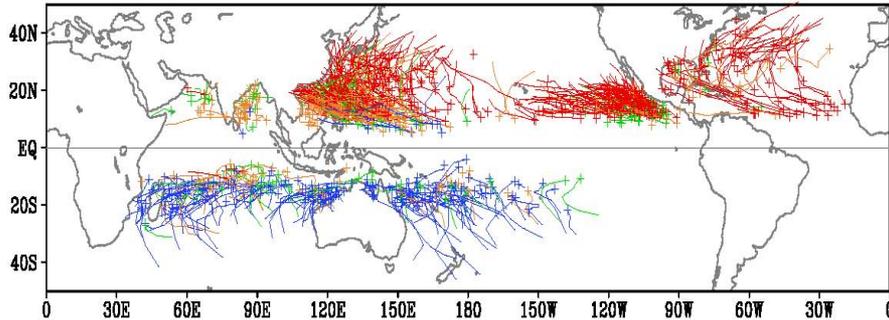
2003 08 07 12
UTC

(Oouchi et al. 2006,
Yoshimura et al, 2007)

Tracks of tropical cyclones (TCs)

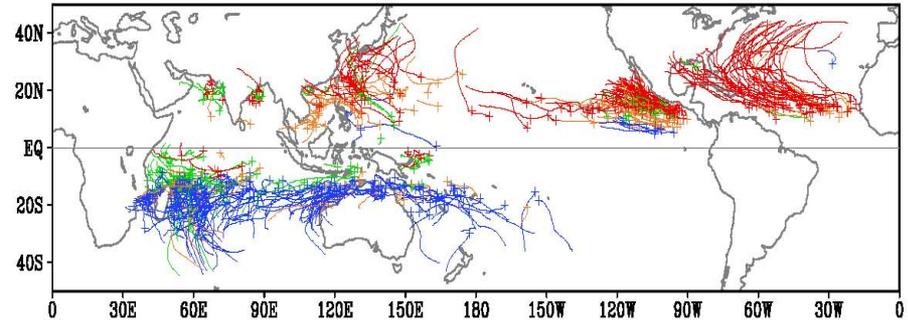
Observation 1979–1988

10 years



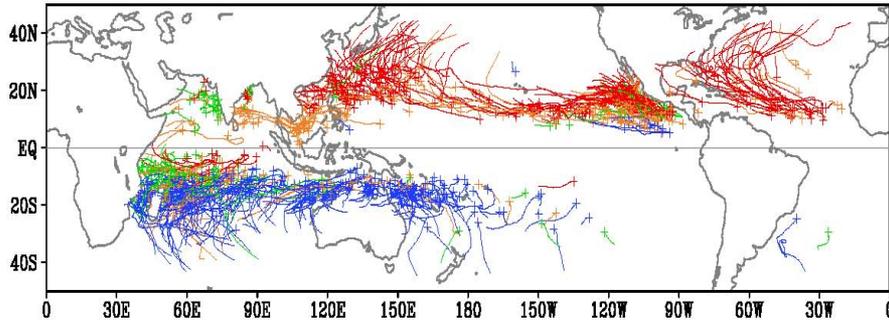
Future expt. (AK) with MRI Δ SST

10 years



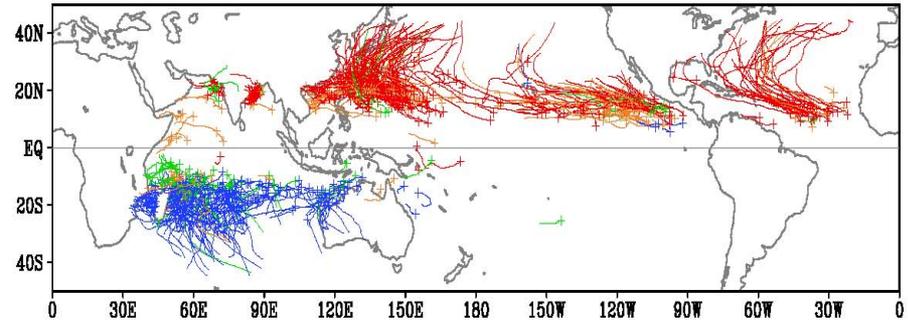
Present-day expt. (AJ)

10 years



Future expt. (AS) with MIROC Δ SST

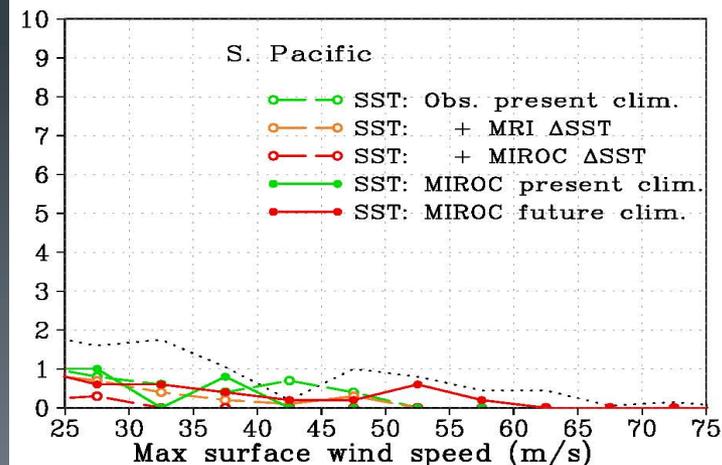
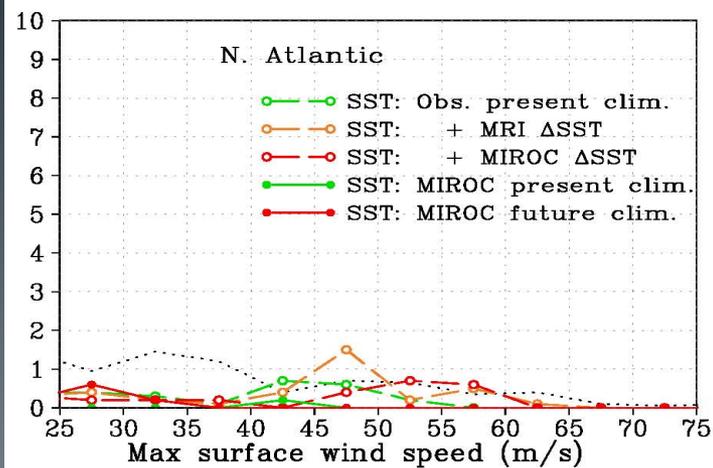
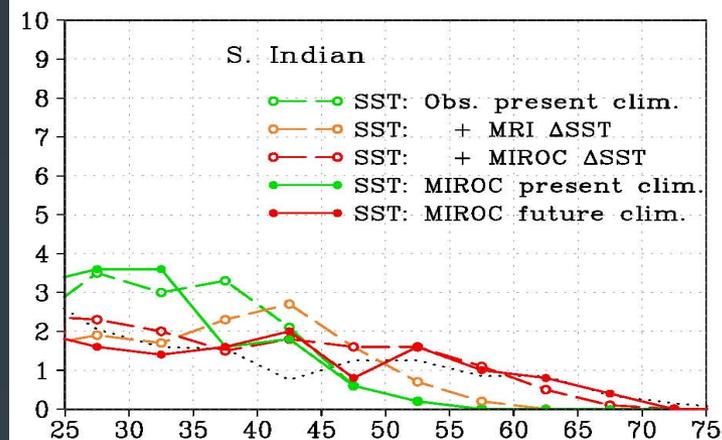
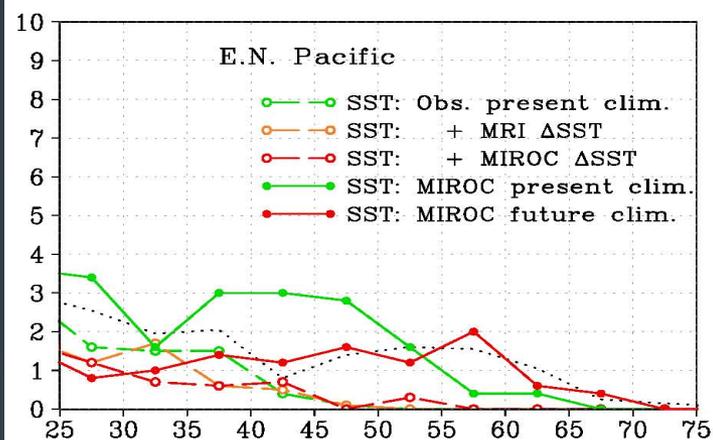
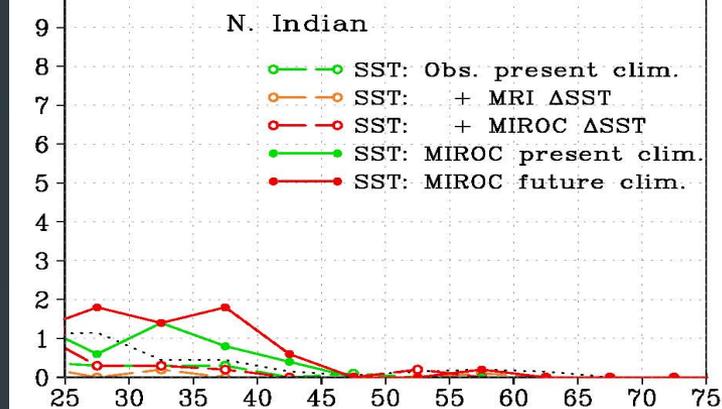
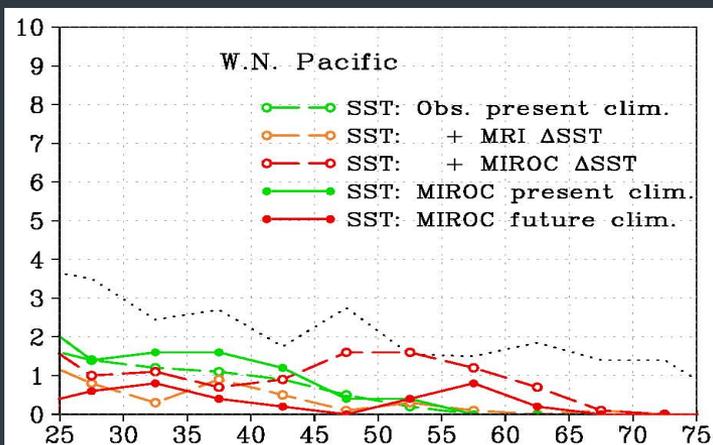
10 years



Blue
for Jan-Feb-Mar,
green
for Apr-May-Jun,

red
for Jul-Aug-Sep,
orange
for Oct-Nov-Dec.

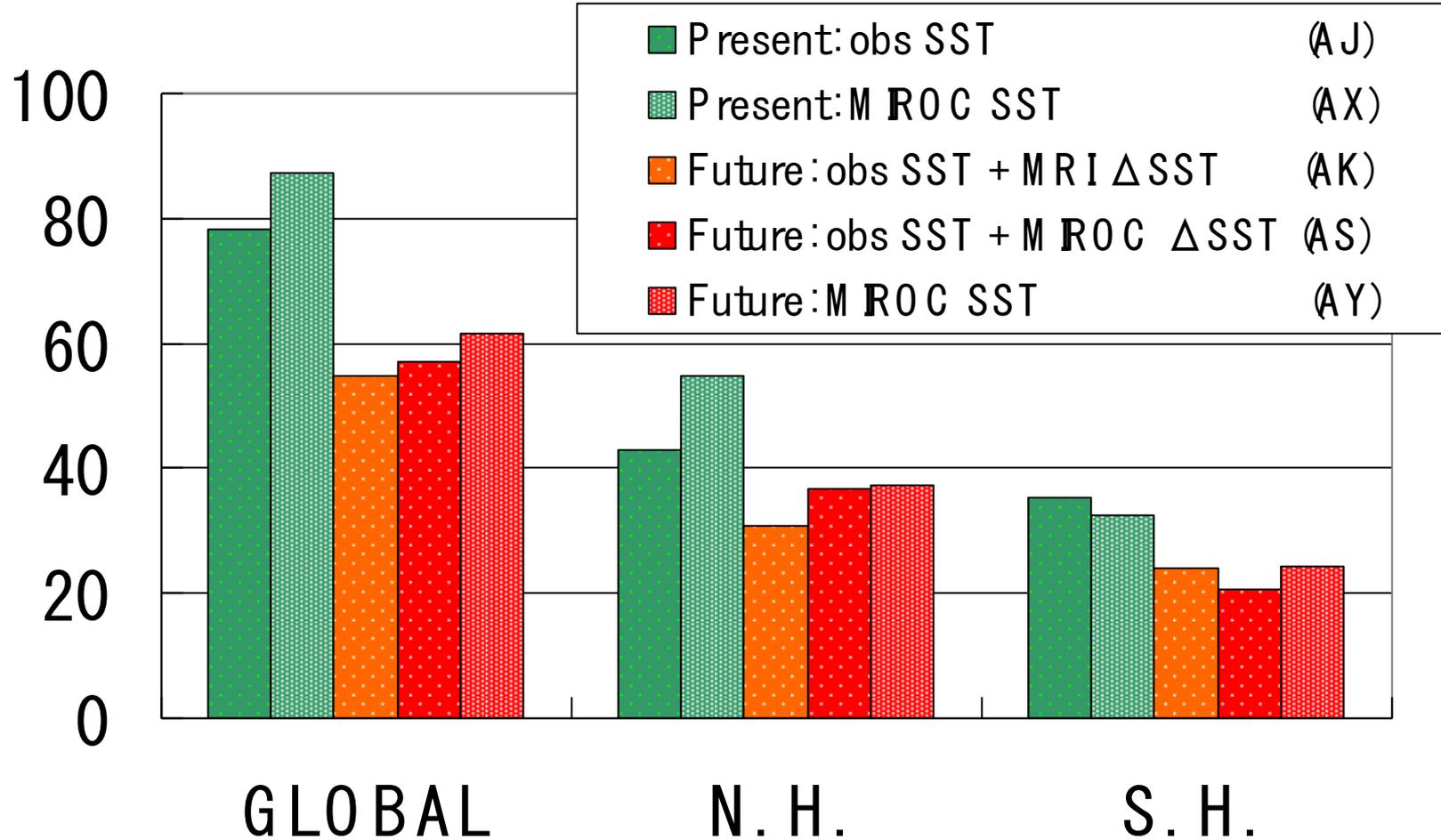
(Oouchi et al. 2006, Yoshimura et al, 2007)



(Oouchi et al. 2006, Yoshimura et al, 2007)

The number of TC formation

Global & hemispheric numbers of TCs
as simulated in the 20-km-mesh AGCM

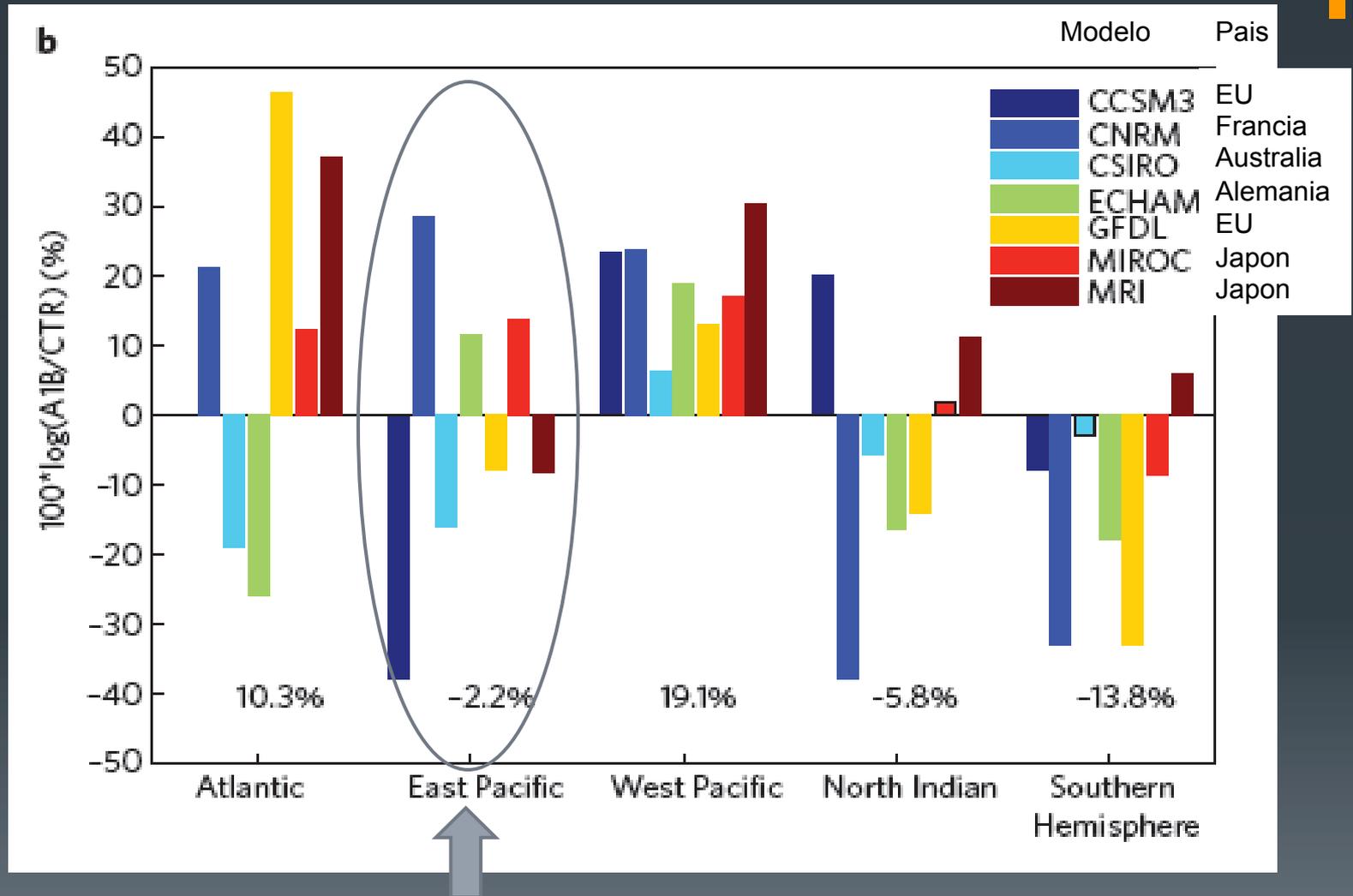


Conclusiones



- La frecuencia de formación de CT a nivel global **disminuye** en ~30%.
- La frecuencia de CT intensos (3-5) **aumenta** en condiciones de mayor SST.
- A nivel regional, la actividad de CCT **depende** de las variaciones de SST en cada cuenca

Cambio en la potencia de CT por cuenca (escenario A1B) para el 2100:



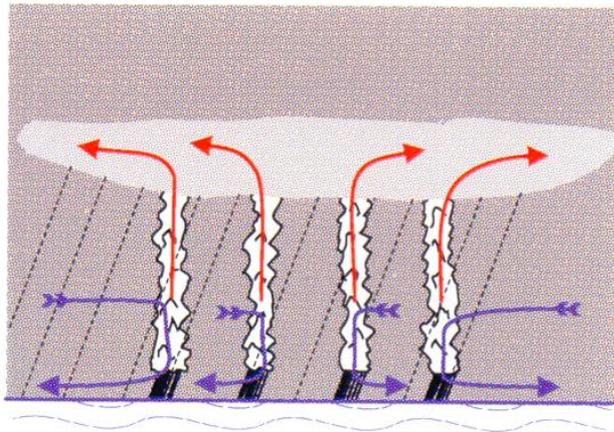
Muy poca concordancia entre los modelos en esta cuenca!!!

Resumen

- Características generales de Ciclones Tropicales
- Variabilidad observada en el Pacífico Oriental
- Reconstrucción histórica desde 1850 de los ciclones tropicales que entran a tierra
- Que pasará con los ciclones tropicales en el futuro?

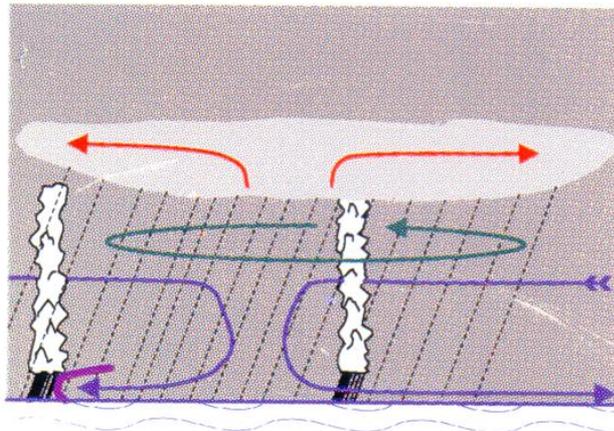
 No muy claro en el Pacífico Oriental!

1. TRIGGERING



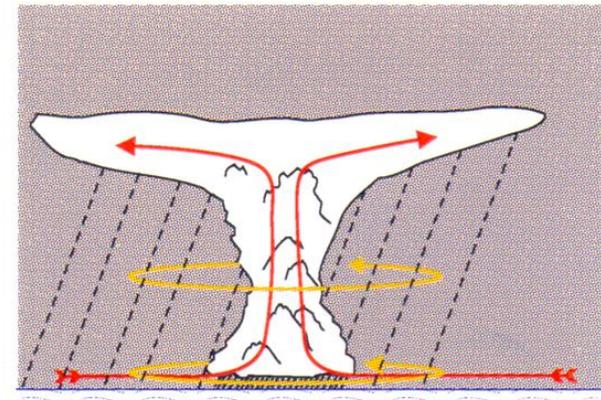
- Formation of long-lived mesoscale stratiform anvil
- Appears to require large-scale ascent in the upper troposphere
- Reduction of subcloud layer entropy by downdrafts

2. Gestation



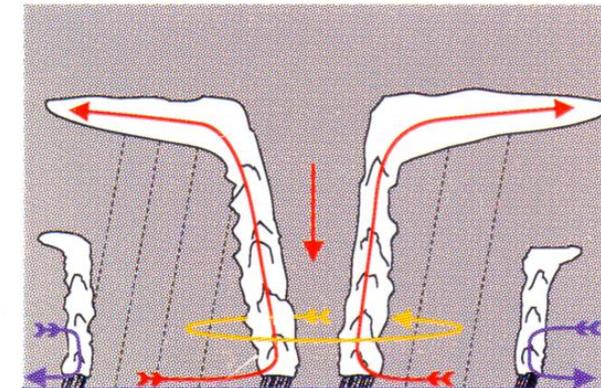
- Light to moderate stratiform rain; little deep convection, except at periphery
- Formation of middle tropospheric mesoscale cyclone cold core in the lower troposphere
- *High relative humidity* develops in core
- Subcloud layer entropy recovers

3. Ignition



- New episode of convection that is *free of downdraft* forms near core
- Strong surface *in*flow, strong surface heat fluxes
- Carnot engine switched on

4. Intensification



5. Maturity

6. Dissipation

Variabilidad en el Pacífico Oriental : Influencia de ENSO en el número de ciclones

Table I. Statistics of cyclone activity from 1966 to 2004 in the NE Pacific. The numbers in parentheses represent the mean number of storms per year.

	Tropical storms	Hurricanes					Total
		Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5	
El Niño years	98 (6.53)	45 (3.0)	19 (1.3)	27 (1.8)	37 (2.5)	5 (0.33)	231 (15.4)
Non-El Niño years	182 (7.9)	88 (3.8)	40 (1.7)	33 (1.4)	41 (1.8)	4 (0.17)	388 (16.9)
Total	280 (7.4)	133 (3.5)	59 (1.5)	60 (1.6)	78 (2)	9 (0.23)	618 (16.3)

(Romero-Vadillo et al, 2007)