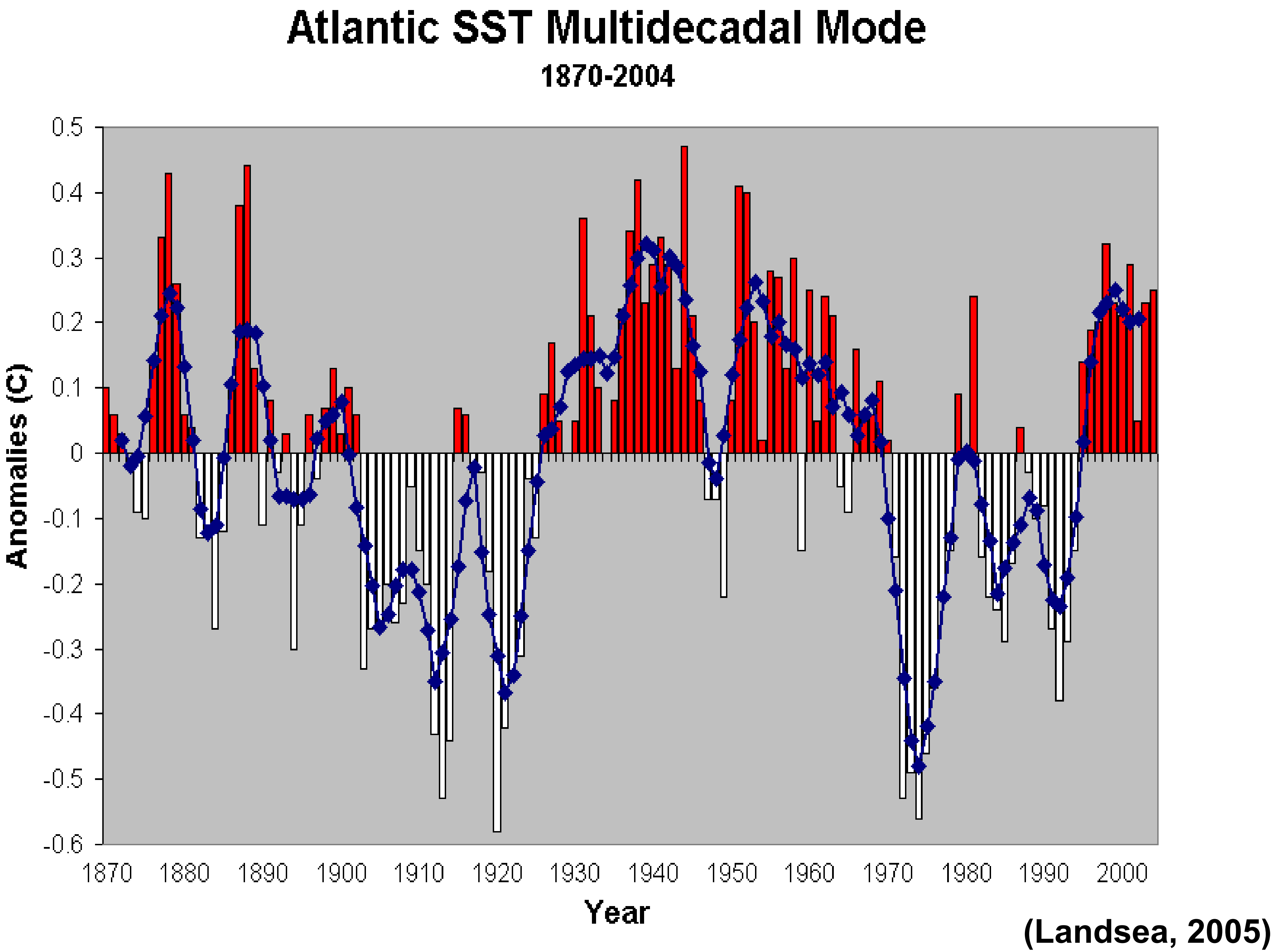
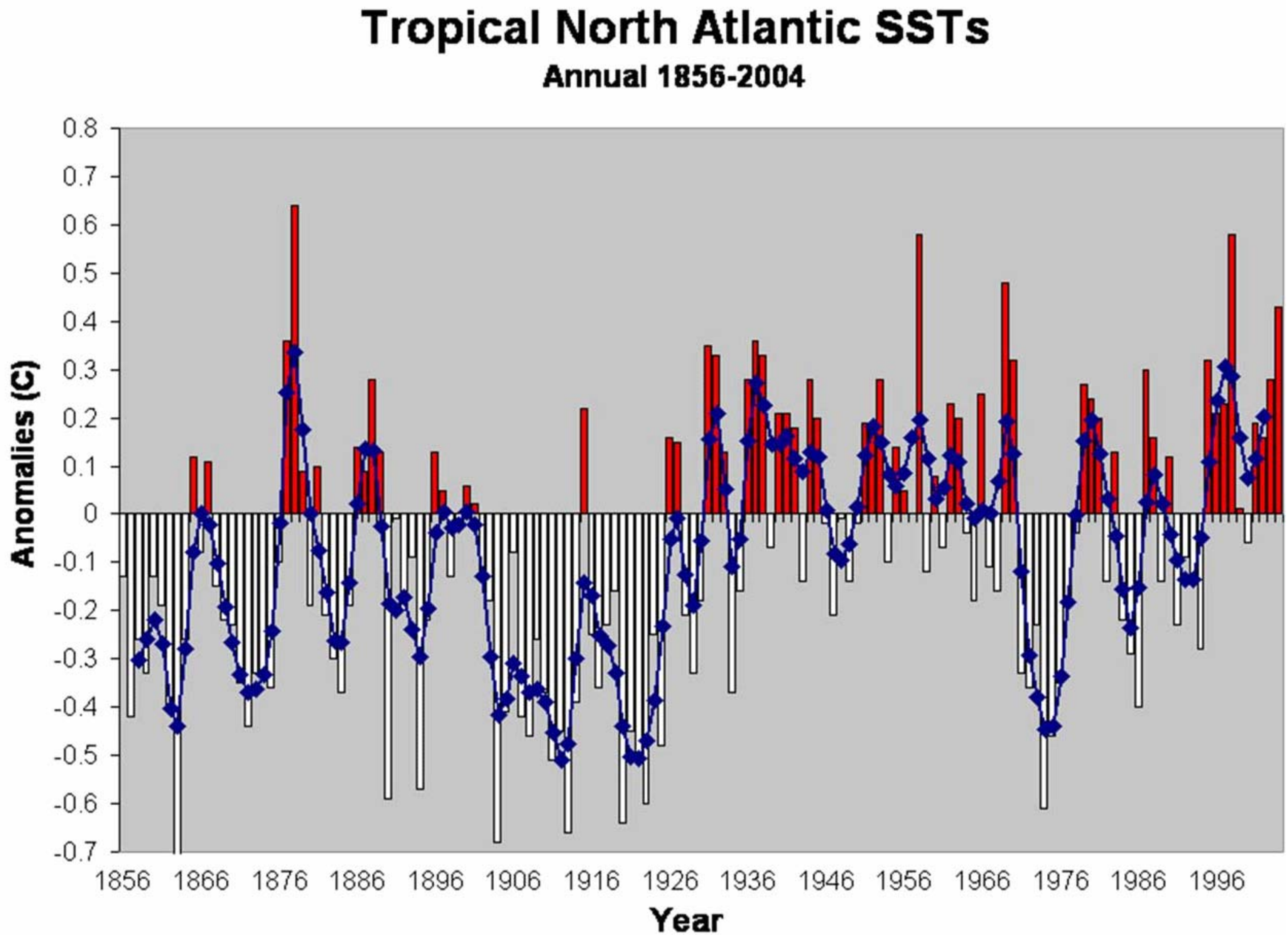
Variabilidad atmosférica y ciclones tropicales


2005
Dennis
10 July
Rita
23 September
Katrina
28 August
Wilma
21 October
Emily
17 July
NASA
NOAA
CIMSS

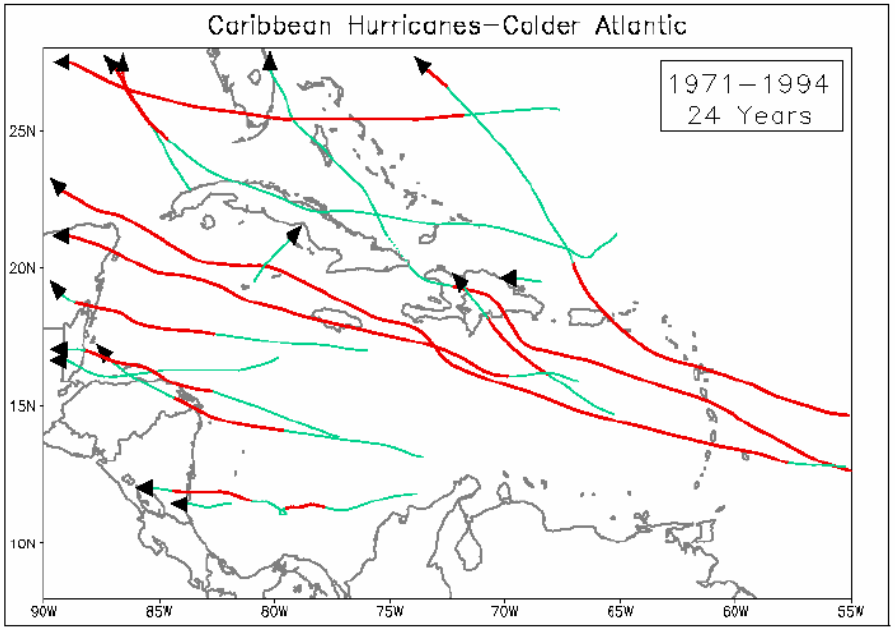


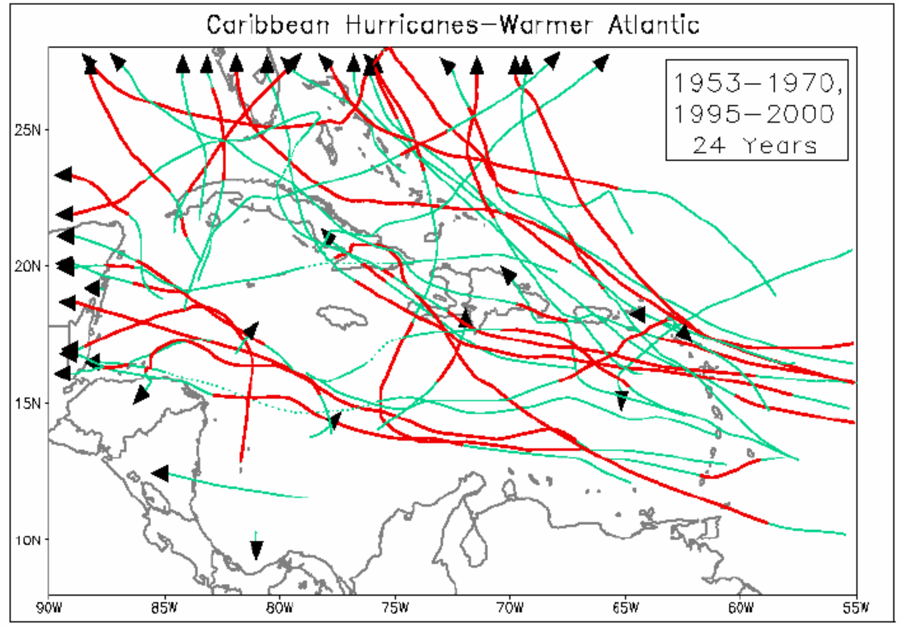
Atlantic SST Multidecadal Mode
1870-2004
Anomalies (C)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
(Landsea, 2005)



(Landsea, 2005)

Huracanes en el Caribe:
Oscilación Multi-decadal del Atlántico

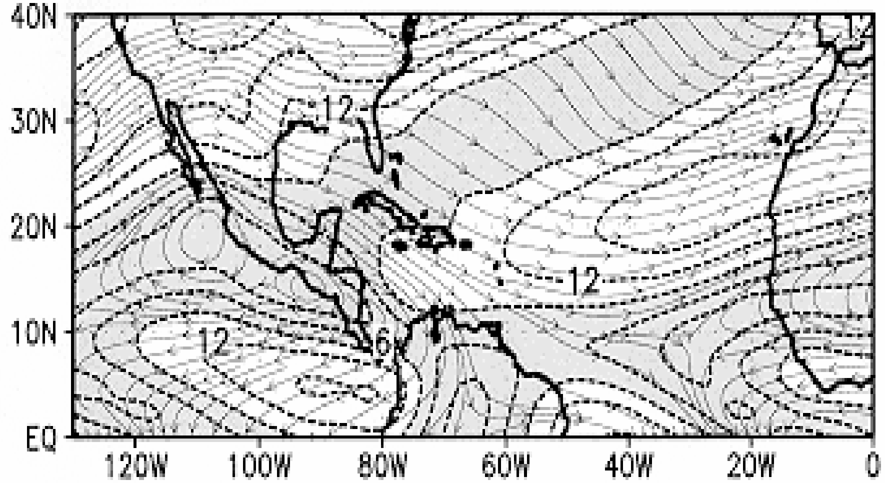




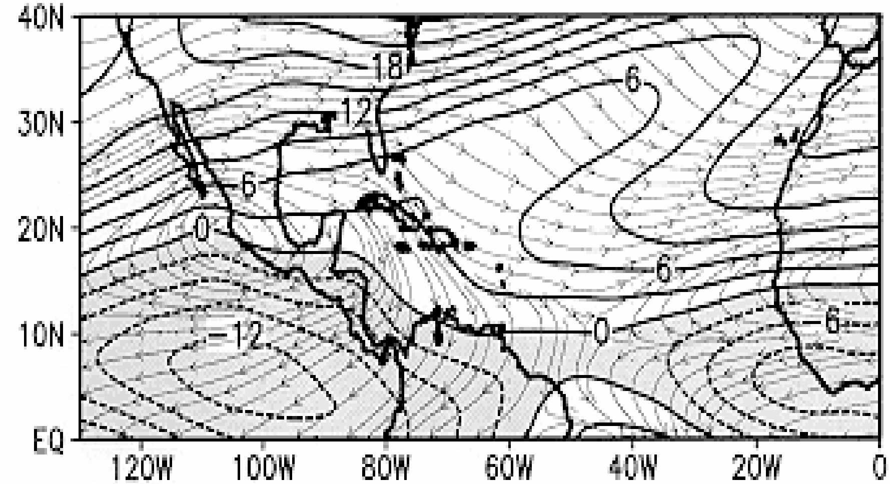
(Landsea, 2005)

August–October Climatology

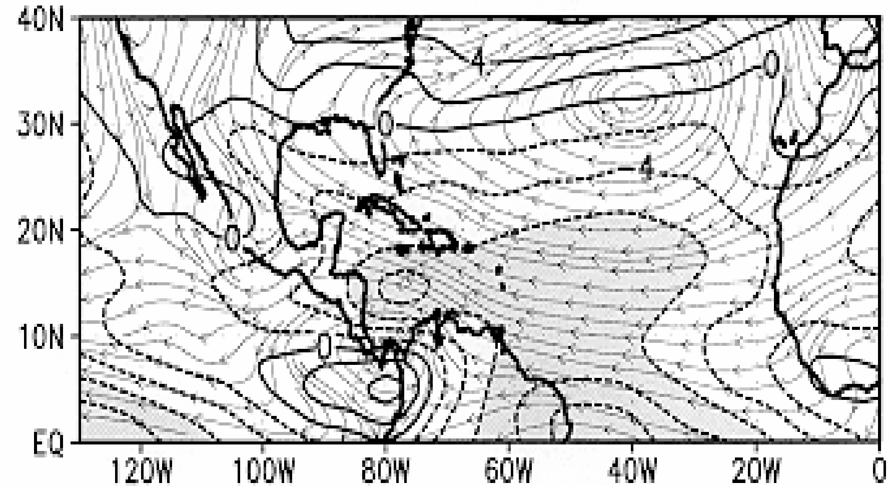
200–850 hPa Vertical Shear



200 hPa Streamlines Zonal Wind

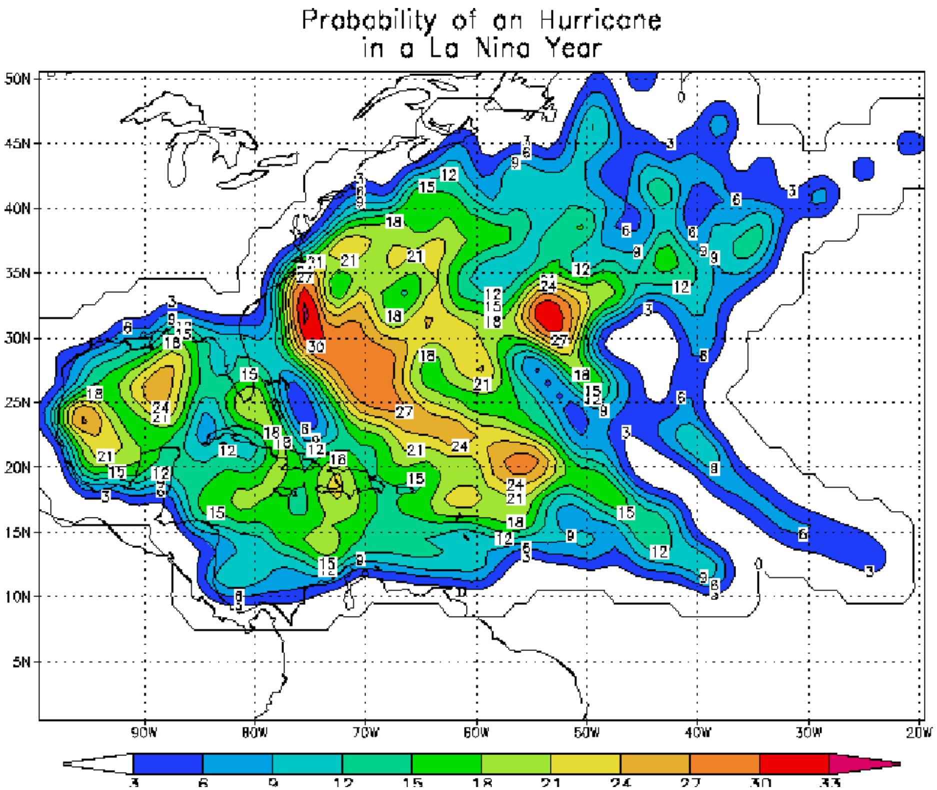


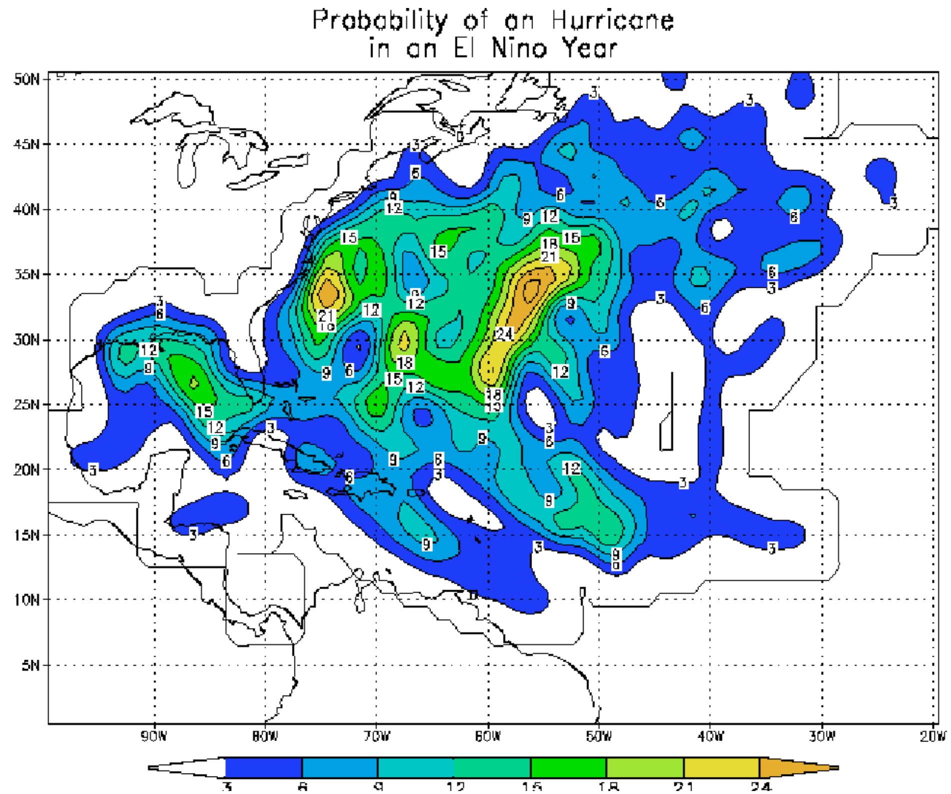
850 hPa Streamlines Zonal Wind



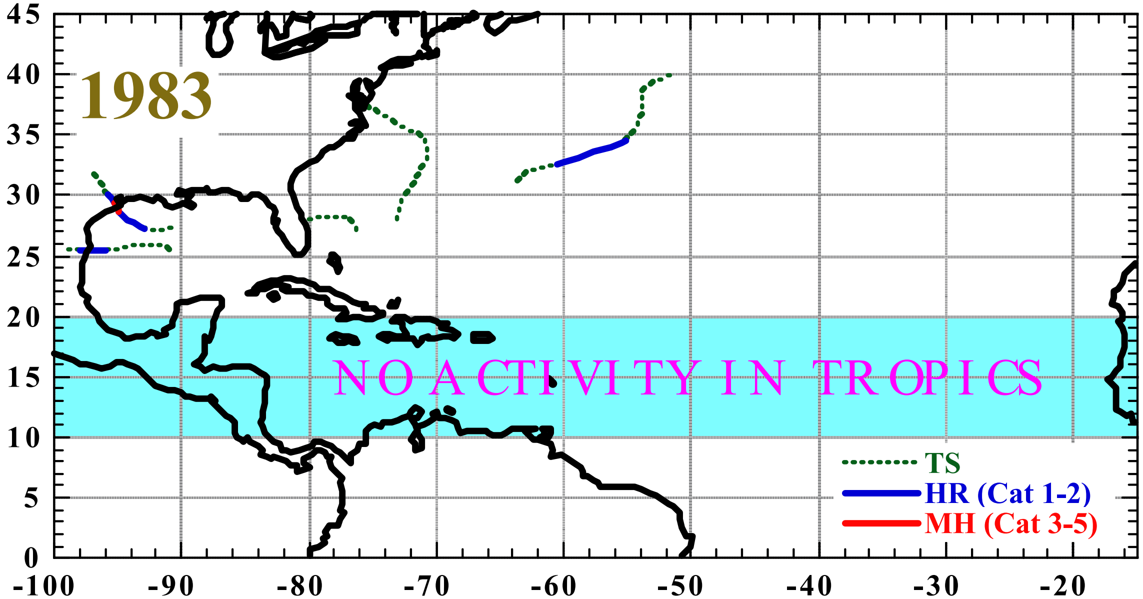
(Landsea, 2005)

La Niña versus El Niño: Probabilidad de formación de huracanes

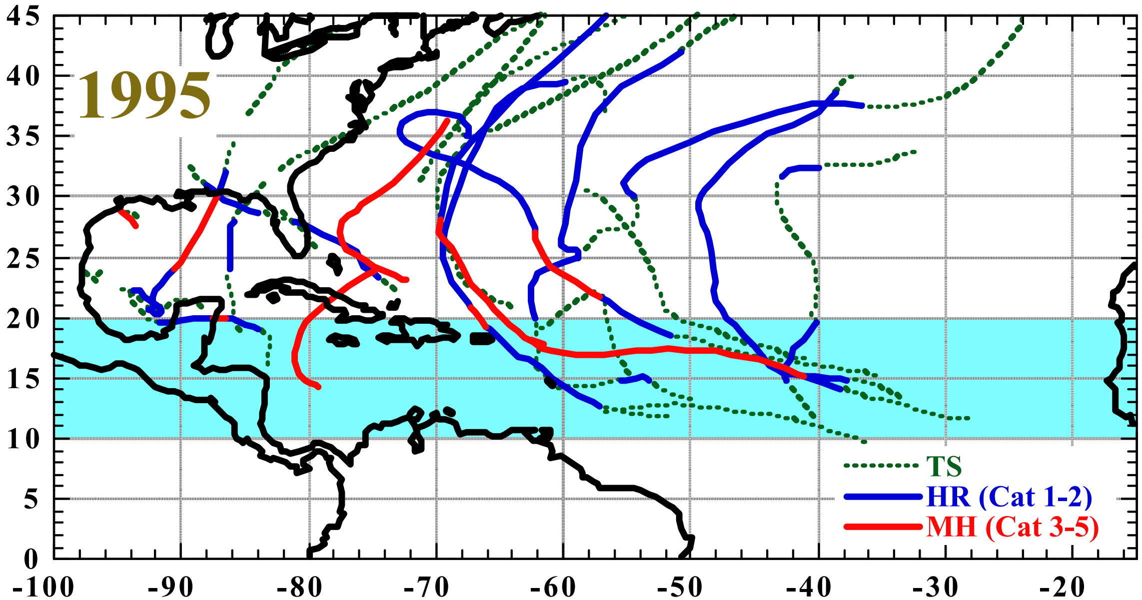




(Landsea, 2005)



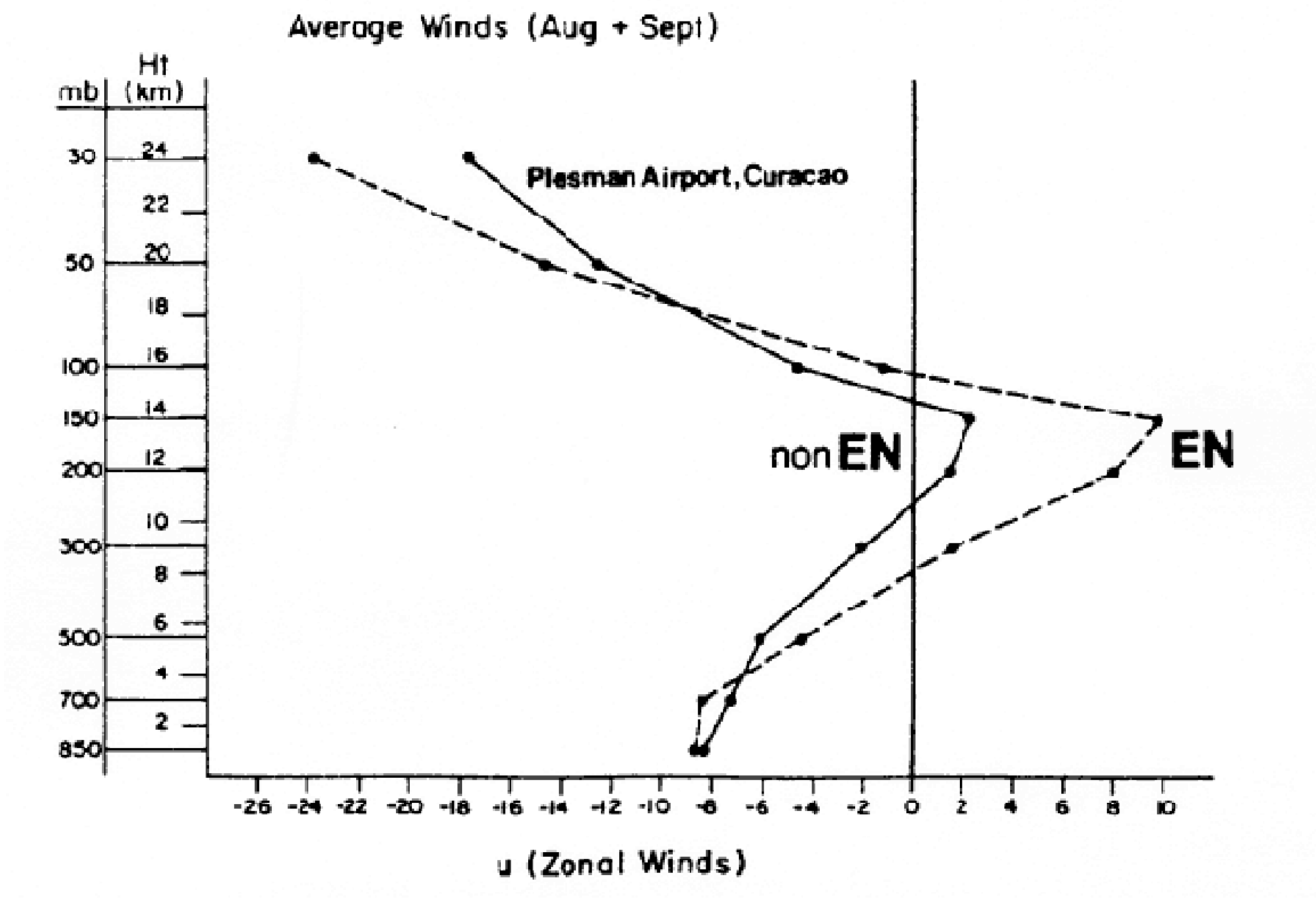
Influencia de El Niño en el Atlántico



STANLEY B. GOLDENBERG
Hurricane Research Division
AOML/NOAA (4/98)

Note: In 1983, Barry (southernmost track) starts east of Florida, then became a depression in the Gulf of Mexico before regaining TS strength and finally making landfall as a HR. (i.e., there are really *only 4 storms* on the plot.

Cizalla del viento: Niño versus no - Niño



(Landsea, 2005)

Variabilidad en el Pacifico Oriental: 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					
		Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5	Total
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)

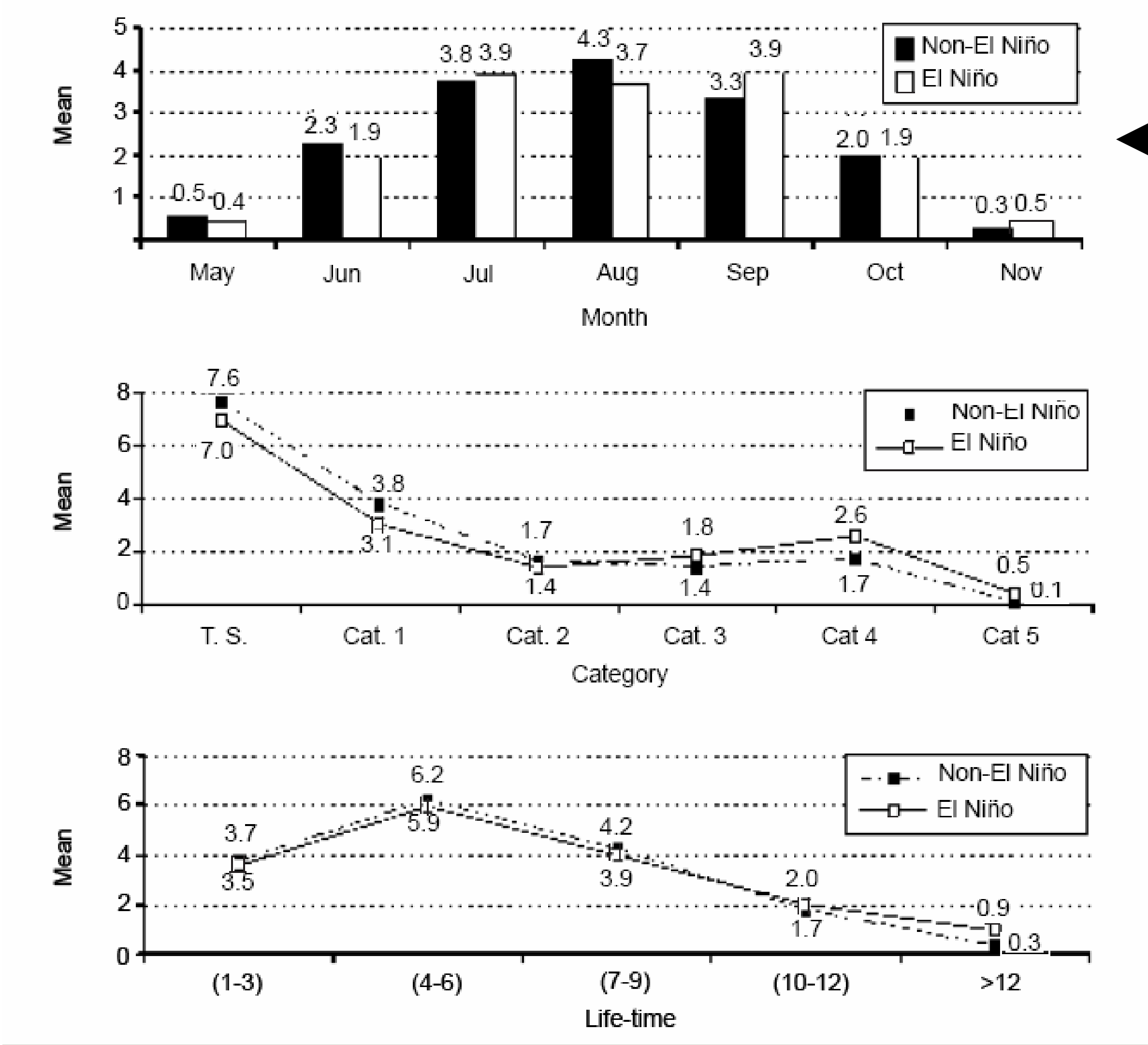
Variabilidad en el Pacifico Oriental : duración de los ciclones

Table II. Statistics of cyclone duration during the period 1966 to 2004 in the NE Pacific. The numbers in parentheses represent the mean number of storms in each category.

	Days					
	1 to 3	4 to 6	7 to 9	10 to 12	Longer than 12	Total
El Niño years	53 (3.5)	92 (6.1)	59 (3.9)	31 (2.1)	14 (0.9)	248 (16.5)
Non-El Niño years	85 (3.7)	143 (6.1)	96 (3.9)	40 (2.1)	7 (0.9)	371 (16.13)
Total	138 (3.6)	234 (6.2)	155 (4.1)	71 (1.9)	21 (0.6)	619 (16.3)

(Romero-Vadillo et al, 2007)

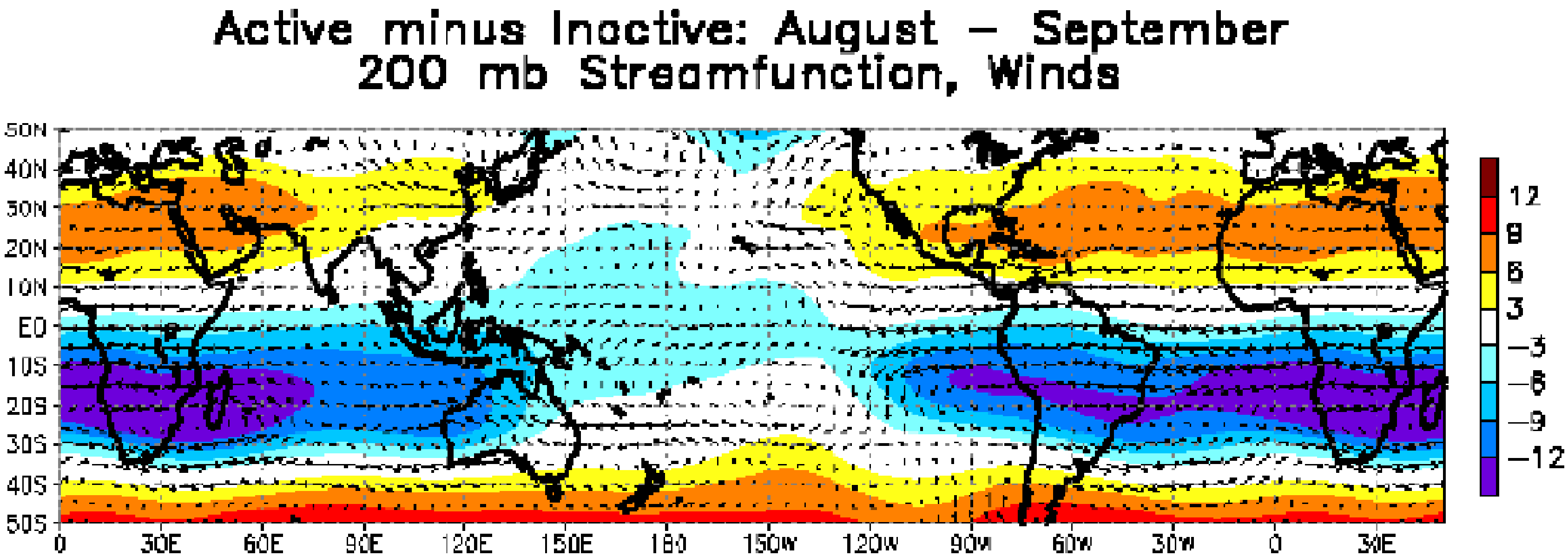
Variabilidad en el Pacifico Oriental



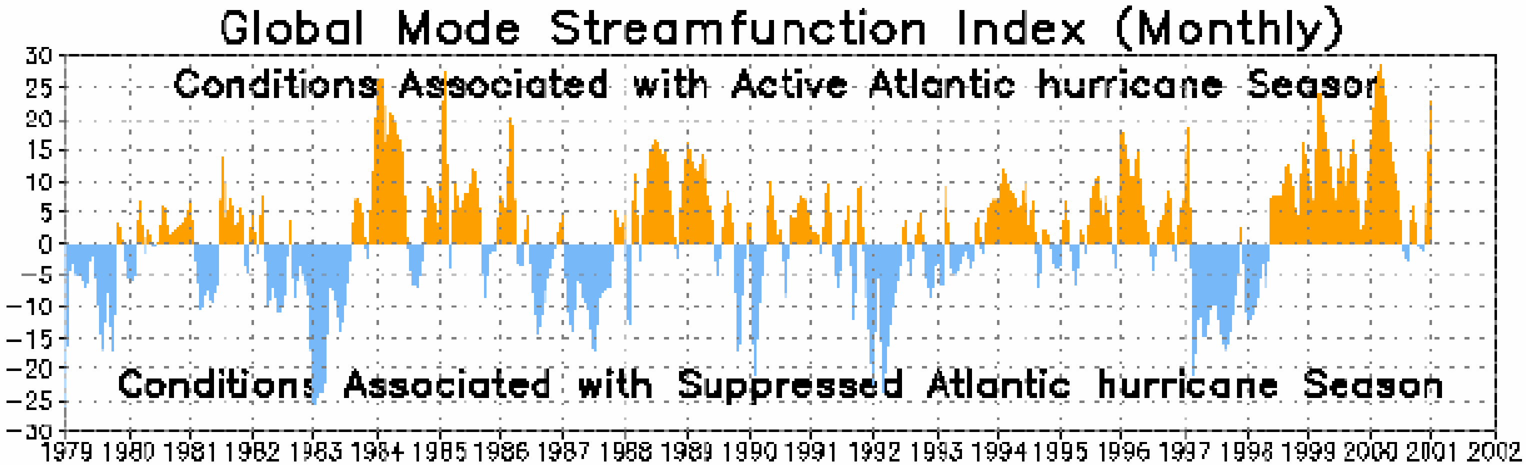
Ciclo anual

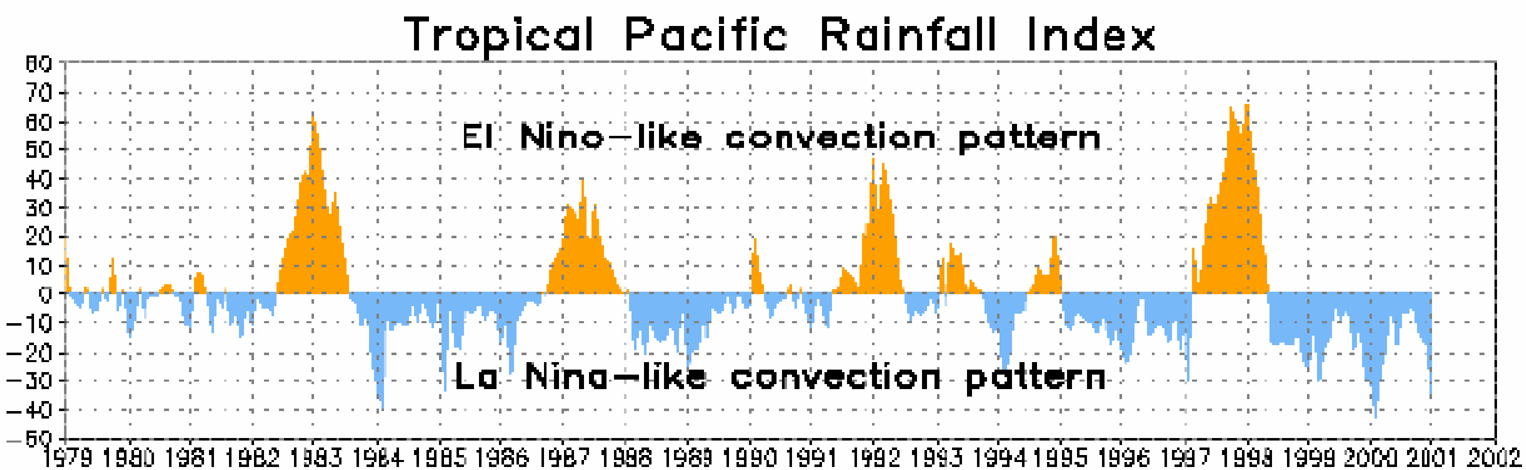
(Romero-Vadillo et al, 2007)

The “Global Mode”: Enhanced 200mb Subtropical Ridges

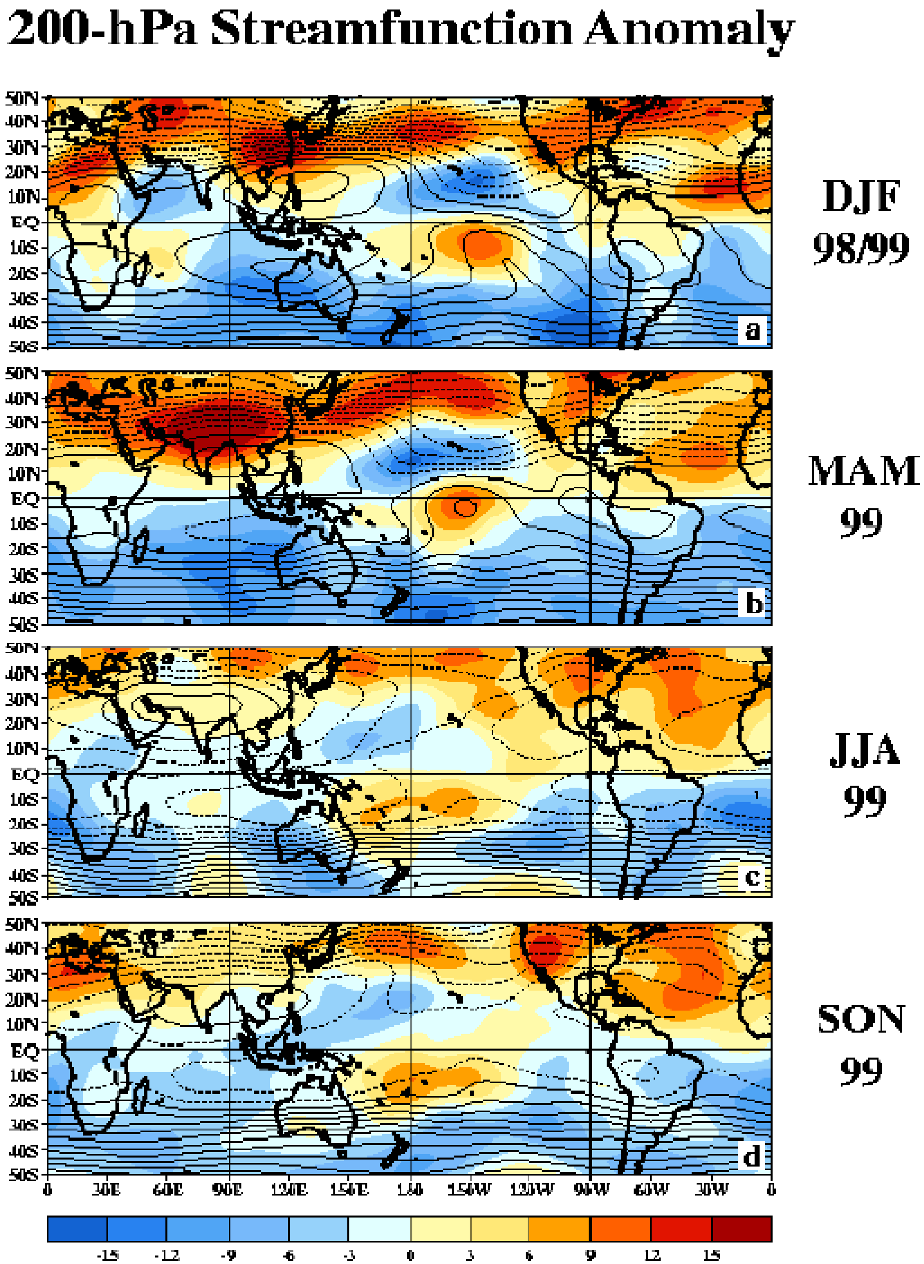


(Landsea, 2005)



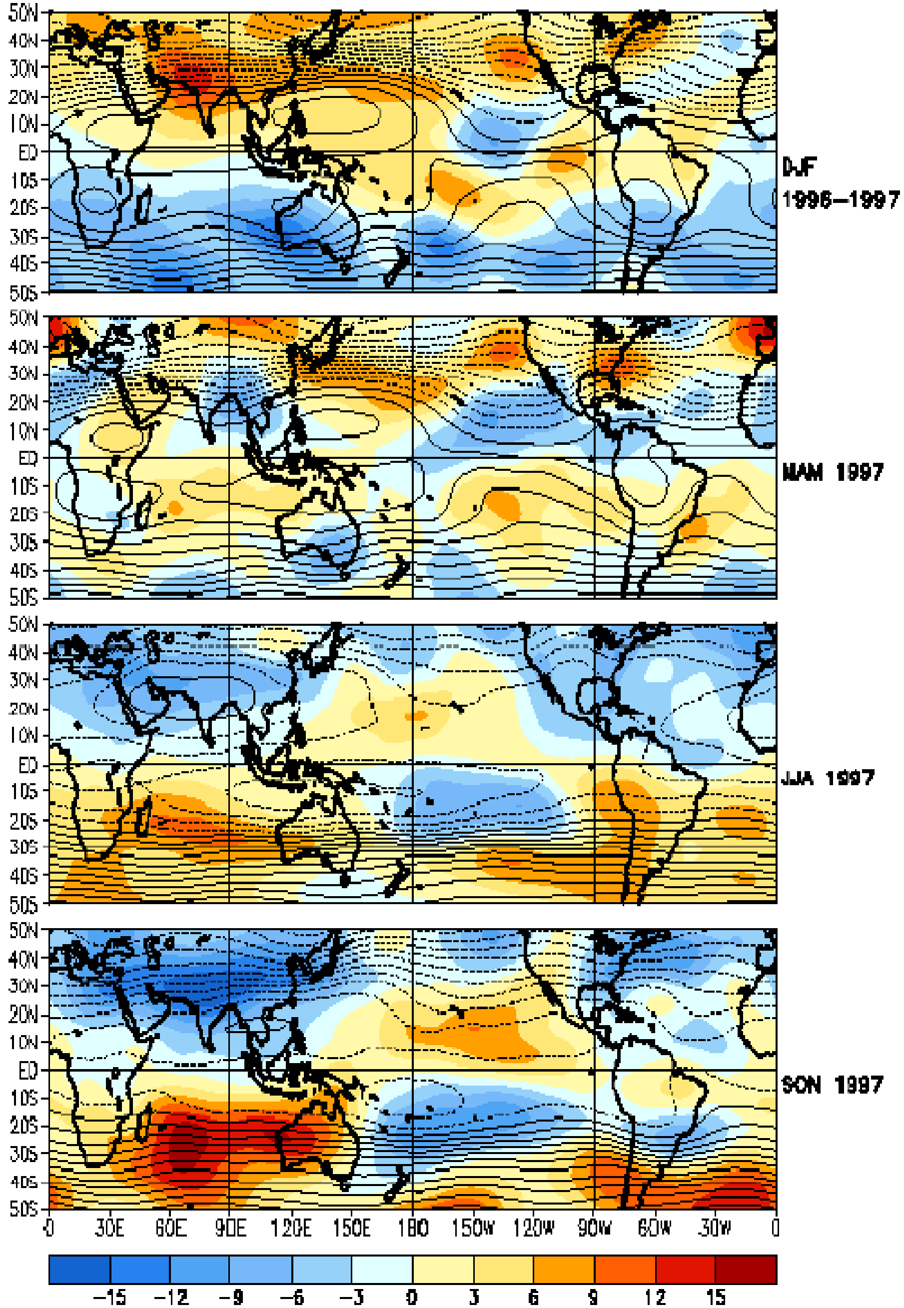


(Landsea, 2005)



"Global Mode": Winter '98-'99 To '99 Hurricane Season

(Landsea, 2005)



"Global Mode": Winter '96-'97 To '97 Hurricane Season

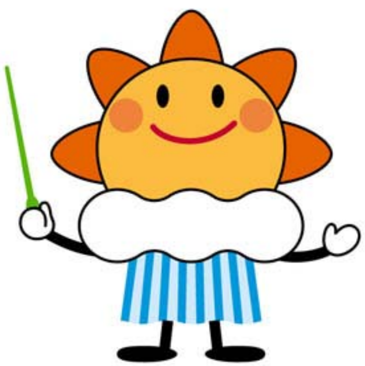
(Landsea, 2005)

A continuación se incluyen dos presentaciones de colegas en un congreso reciente sobre ciclones tropicales.

1st International Summit on Hurricanes and Climate Change
(27 May – 1 June 2007, Crete, Greece)

1st International Summit on Hurricanes and Climate Change
(27 May – 1 June 2007, Crete, Greece)

Global warming and tropical cyclone climatology as simulated in a 20-km-mesh global atmospheric model



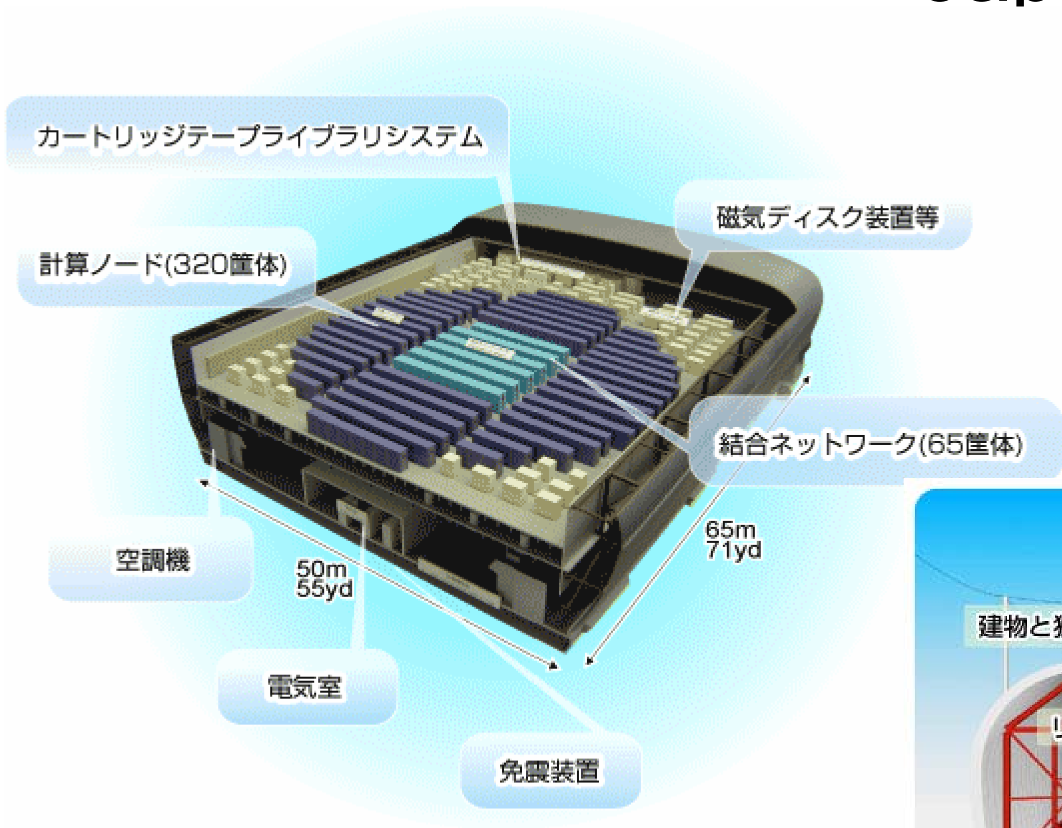
J. Yoshimura (MRI)
K. Oouchi (AESTO/MRI, FRCGC)
H. Yoshimura (MRI)
R. Mizuta (AESTO/MRI)
S. Kusunoki (MRI) and

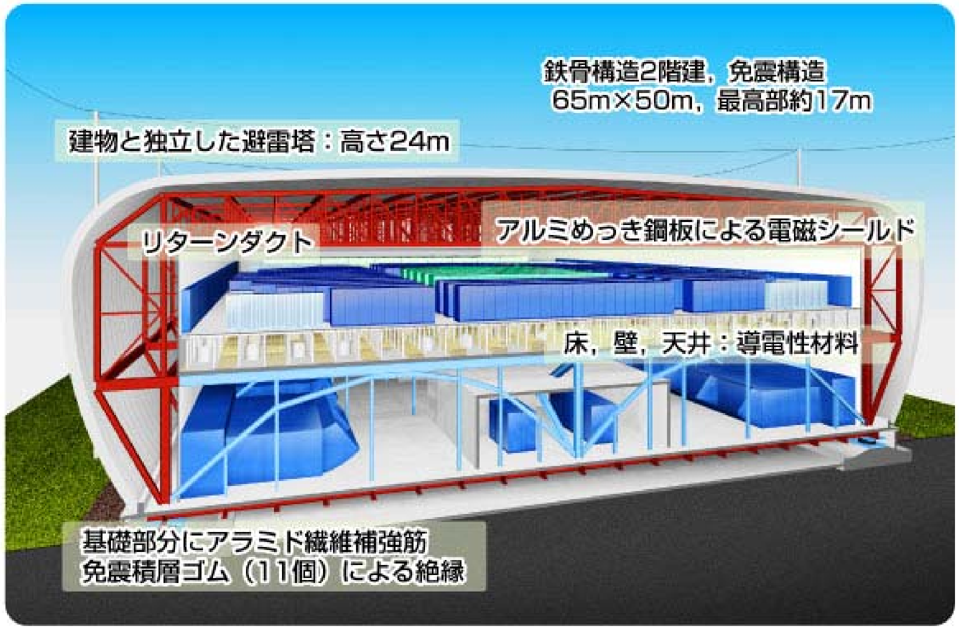
20-km-mesh atmospheric GCM simulation

- Unprecedented as a global climate simulation.
- The main focus is TC climatology under global warming condition in the end of 21st century.
- SST given as a boundary condition:
  - Excludes coupling with ocean subsurface,
  - Enables much-higher-resolution simulation.

Early results of this study have been published.

"Earth Simulator"
– A huge computing system in Yokohama, Japan –



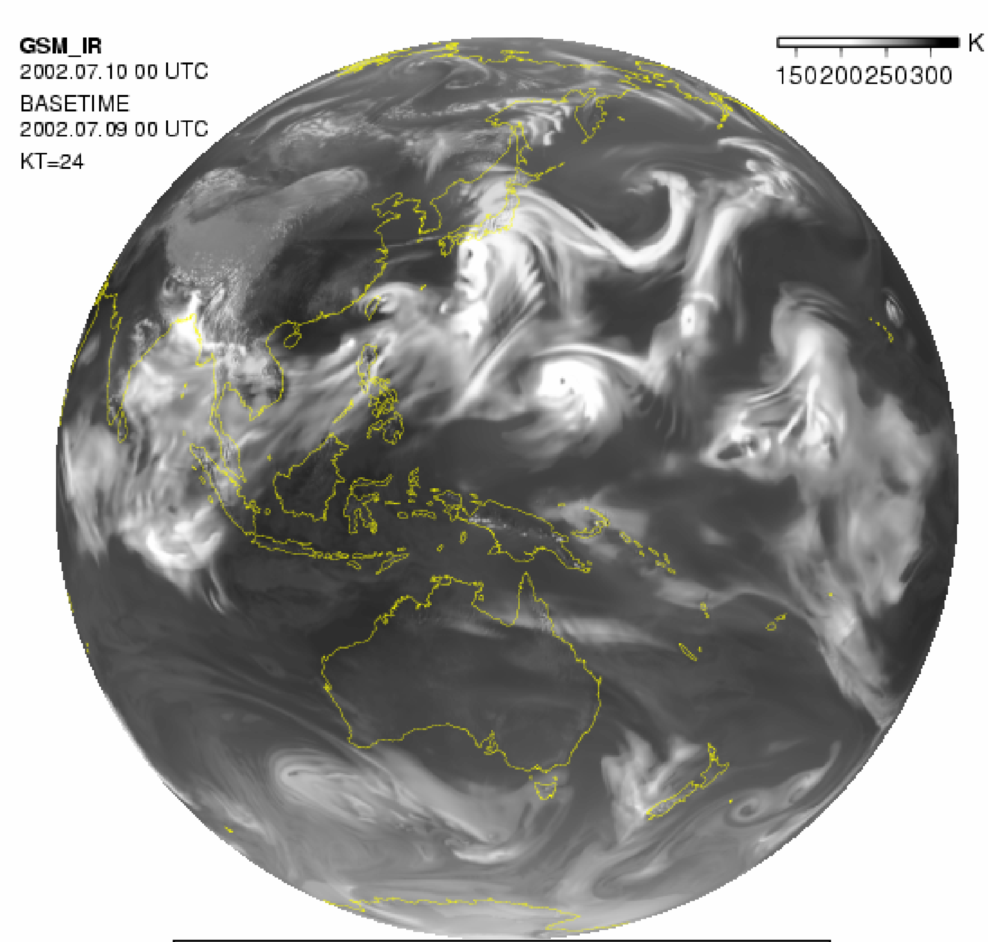


Super-high-resolution global atmospheric model

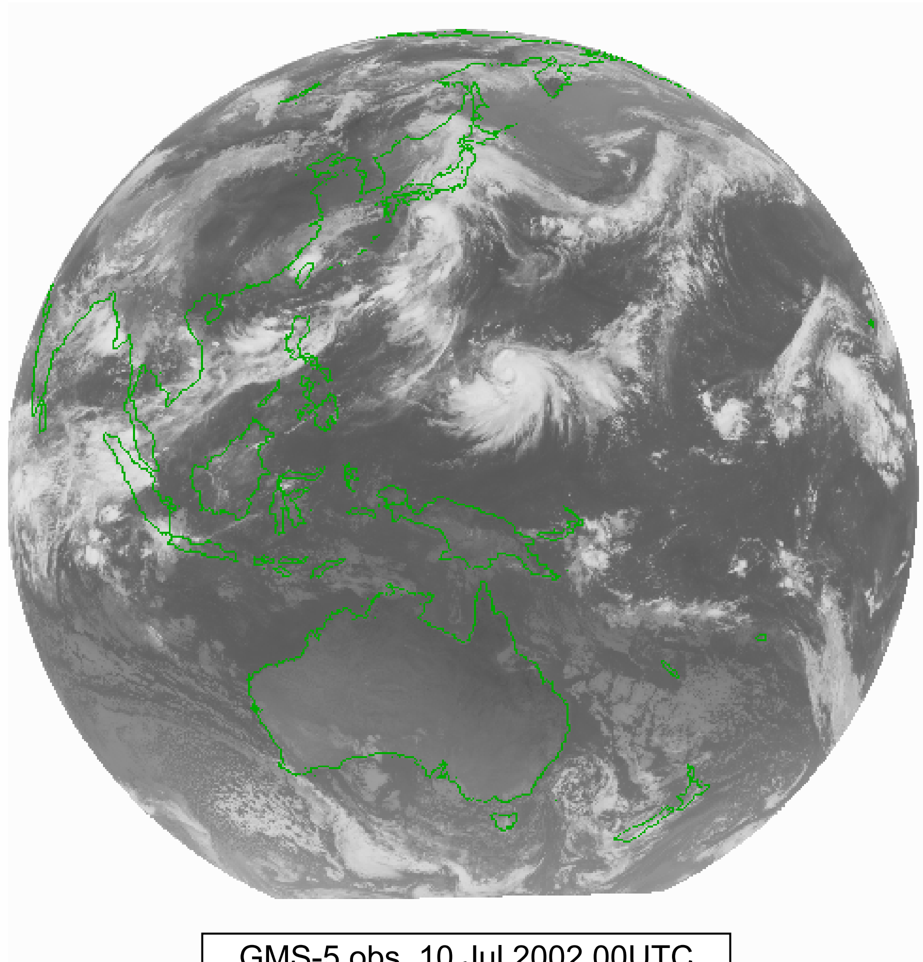
- Collaborative work
  - NPD/JMA
  - Climate Research Department of MRI
- JMA : Next operational global NWP model
- MRI : Next generation climate model
- Based on operational JMA-GSM
- Fortran90 coding style
  - Resolution:TL959(20km) with 60 layers
  - Time integration: Semi-Lagrangian Scheme (Yoshimura, 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

The same model used for NWP

(09 Jul 2002 00UTC, FT=24, GMS-IR forecast images)

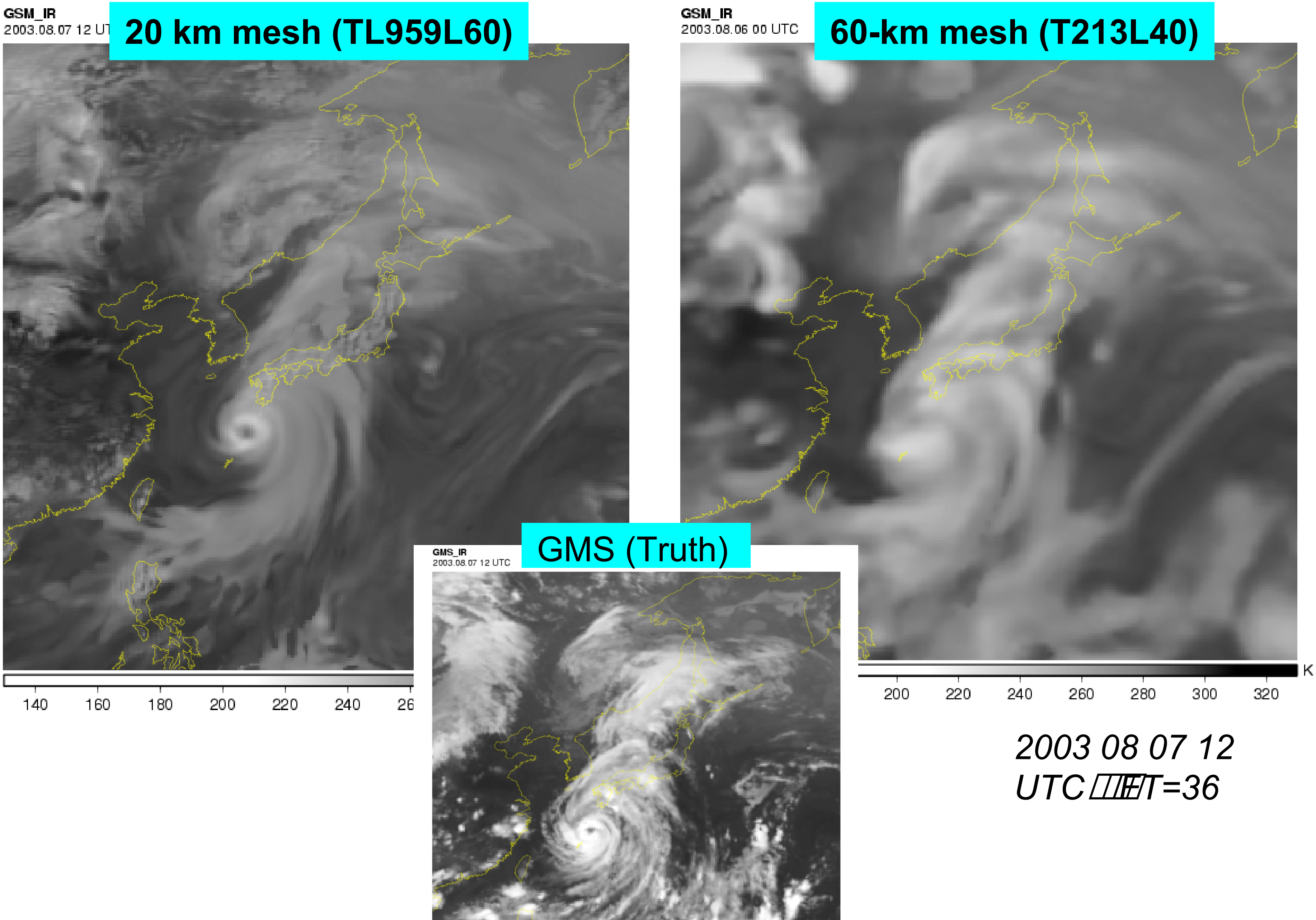


20km-GSM TL1023L40 2002.7.9.00Z FT=24



GMS-5 obs. 10 Jul 2002 00UTC

The same model used for NWP



2003 08 07 12
UTC□□FT=36

“Time-slice” simulations of future climate change based on the IPCC SRES A1B scenario.

SST data from two coupled AOGCMs

- **MRI**-CGCM2.3.2
  - AOGCM of MRI
  - Resolution: atmosphere T42L30, ocean 2.5°× 2°
  - With “flux adjustment”

- **MIROC** ver 3.2 high-resolution
  - AOGCM of CCSR, NIES and FRCGC
  - Resolution: atmosphere T106L56, ocean

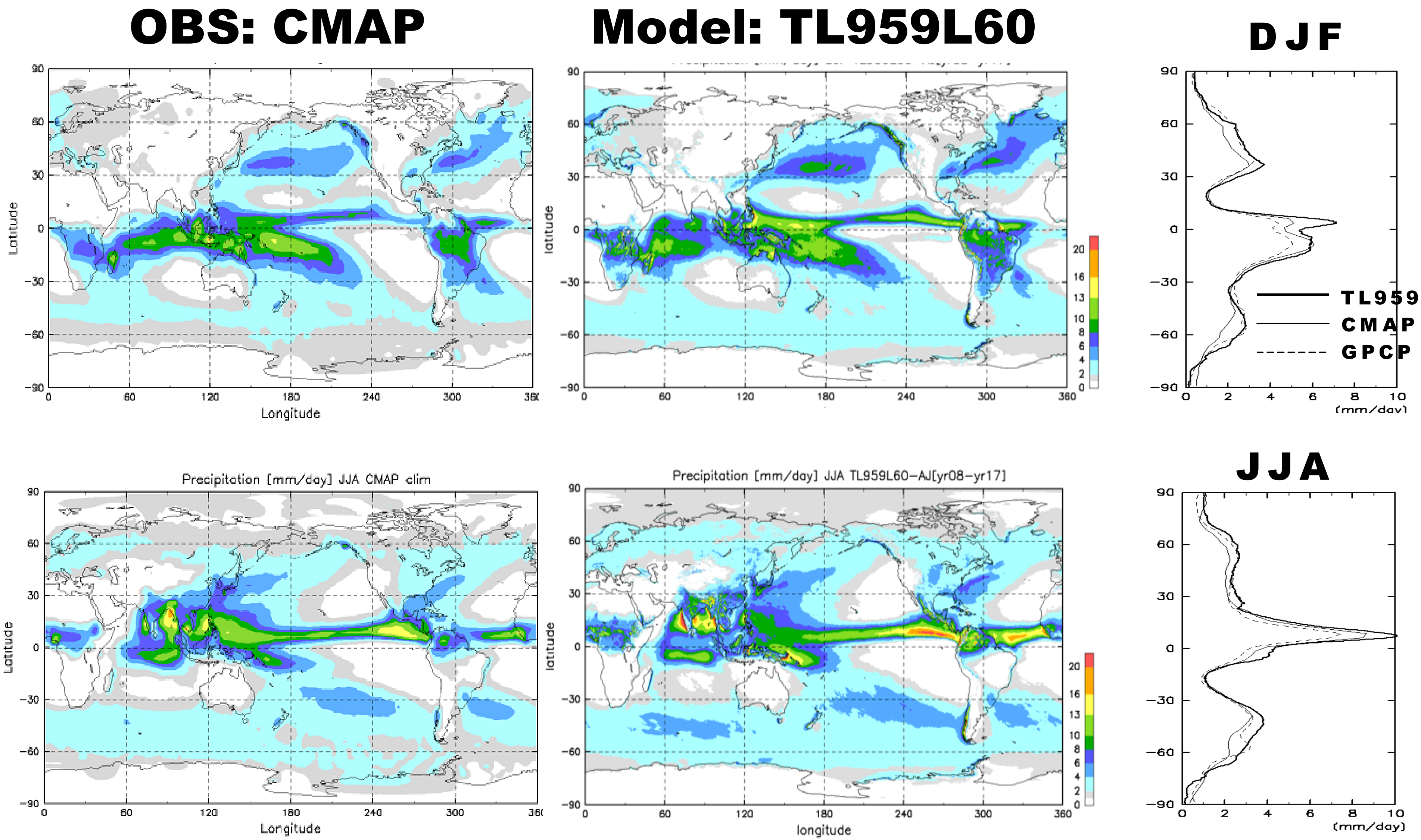
SST settings

“Present-day” End of 20^{th} century	“Future” End of 21^{st} century
Obs. SST 20 yrs	Obs. SST□MRI ΔSST 20 yrs
	Obs. SST□MIROC ΔSST 10 yrs
MRI SST 20 yrs with year-to-year variation	MRI SST 20 yrs with year-to-year variation
MIROC SST 5 yrs	MIROC SST 5 yrs

SST anomalies

“Raw” data of SSTs

Seasonal-mean precipitation

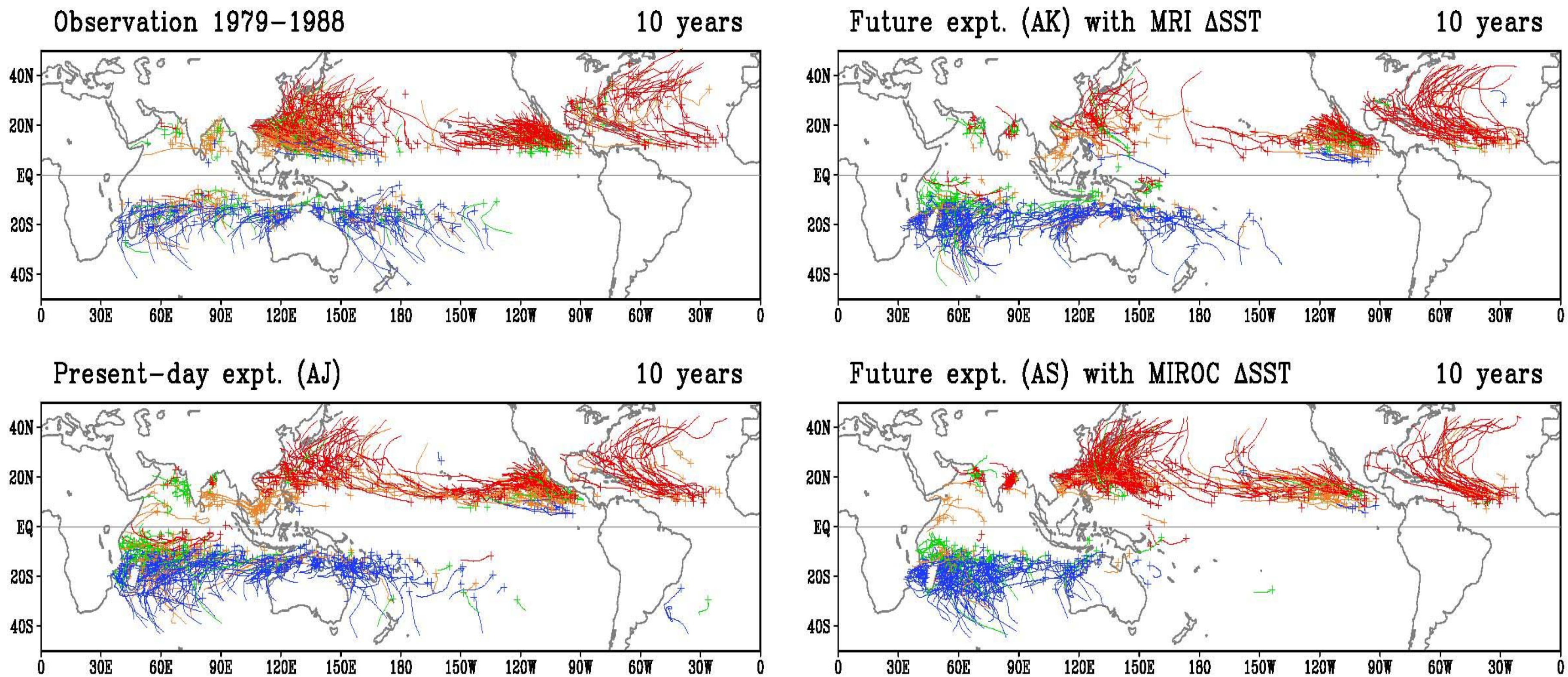


Criteria to define TCs in the model

Based on those of Sugi et al. (2002) and Bengtsson et al. (1996)

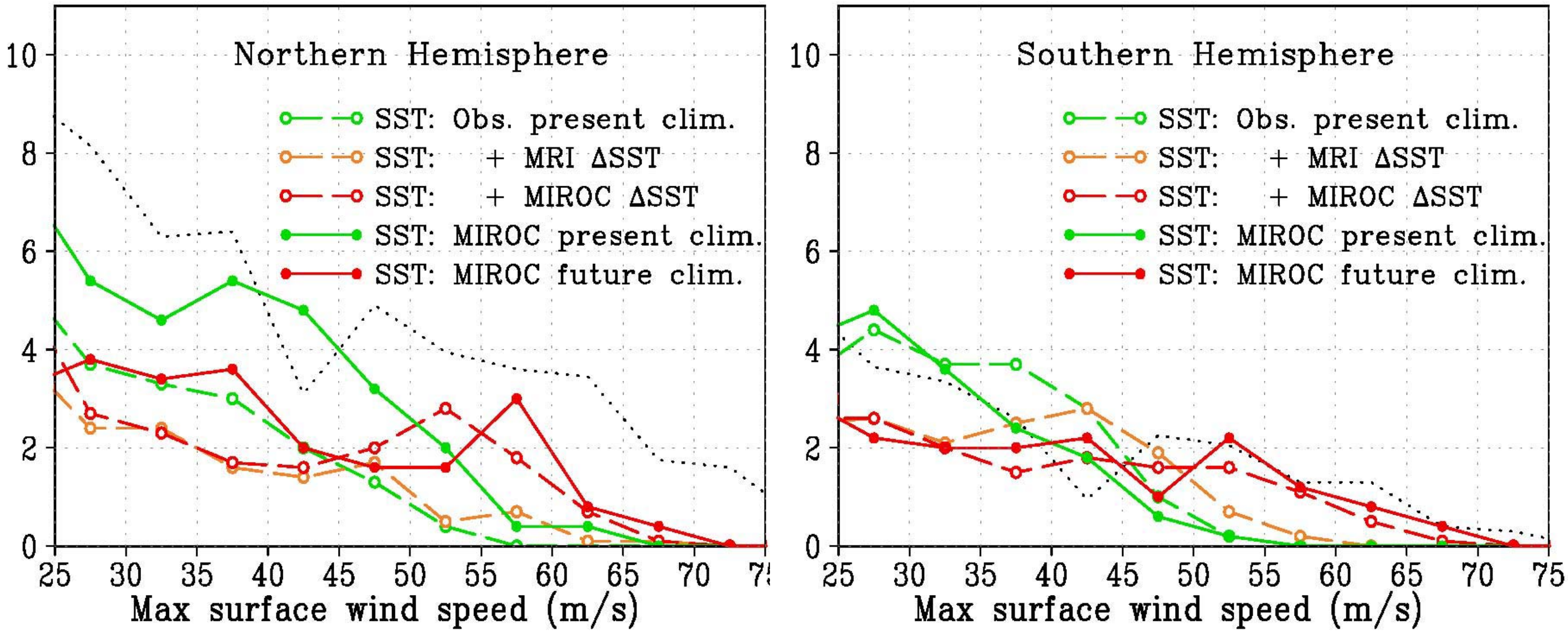
- [1] A grid point (45N-45S) with local-minimum surface pressure is selected as a TC-center candidate. The minimum surface pressure is at least 2 hPa lower than mean surface pressure of a $7^{o}\times 7^{o}$ grid box.
- [2] Maximum magnitude of relative vorticity at 850 hPa is above 3.5×10^{-5} s^{-1} near the point.
- [3] Maximum wind speed at 850 hPa is larger than 15 m s^{-1} near the point.
- [4] Temperature structure has a warm core above the point: Sum of temperature deviations at 300, 500 and 700 hPa exceeds 2.0 ^{o}C
- [5] Maximum wind speed at 850 hPa near the point is larger than that at 300 hPa. (This criterion is to remove extratropical cyclones.)

Tracks of tropical cyclones (TCs)



Blue for Jan-Feb-Mar,
green for Apr-May-Jun,
red for Jul-Aug-Sep,
orange for Oct-Nov-Dec.

TC frequency as a function of peak wind intensity

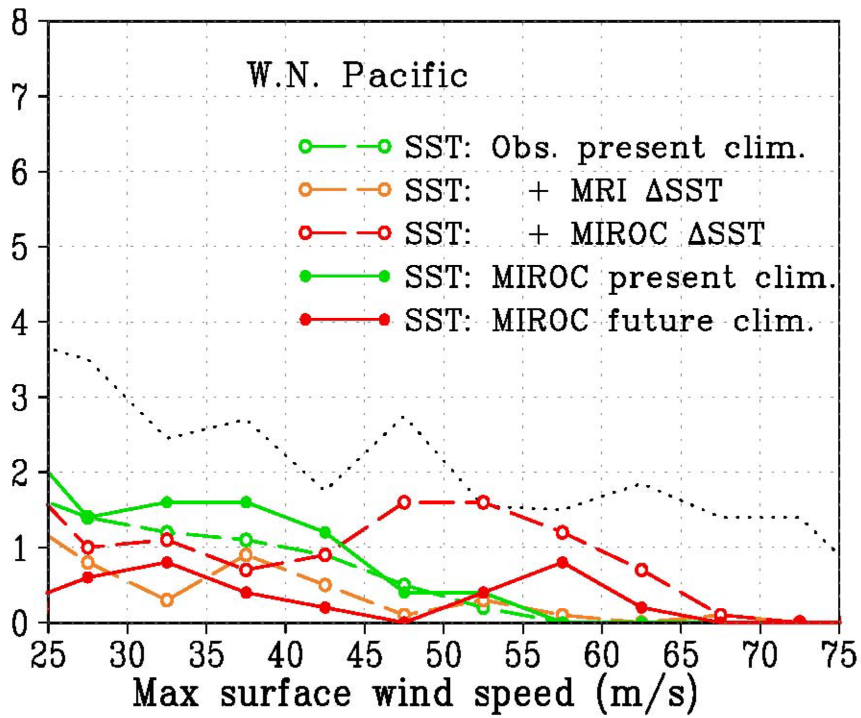


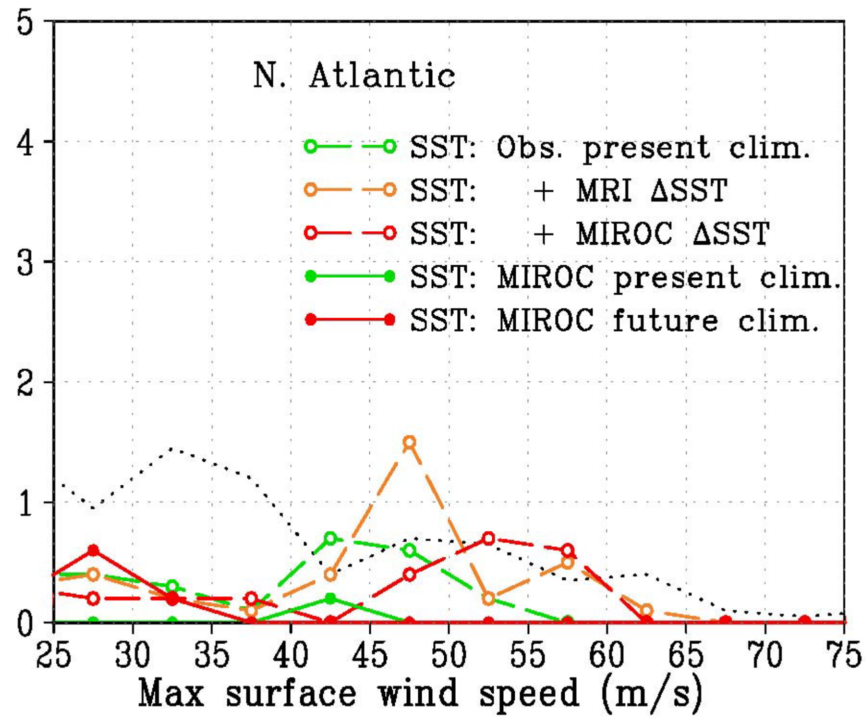
Global-mean SST warming

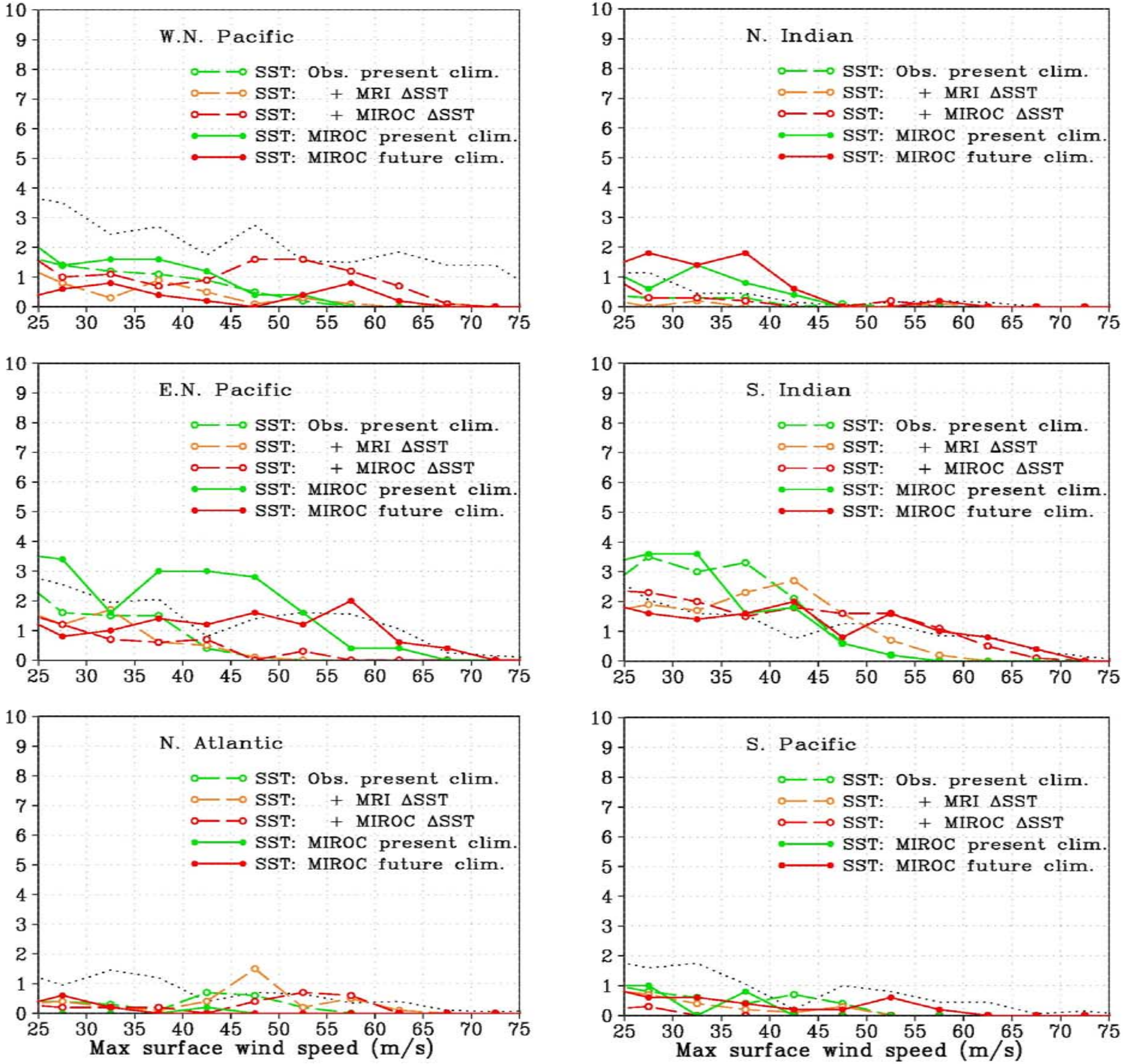
MRI ΔSST = 1.6□ vs. MIROC ΔSST = 3.2□

Increase of intense cases under global warming

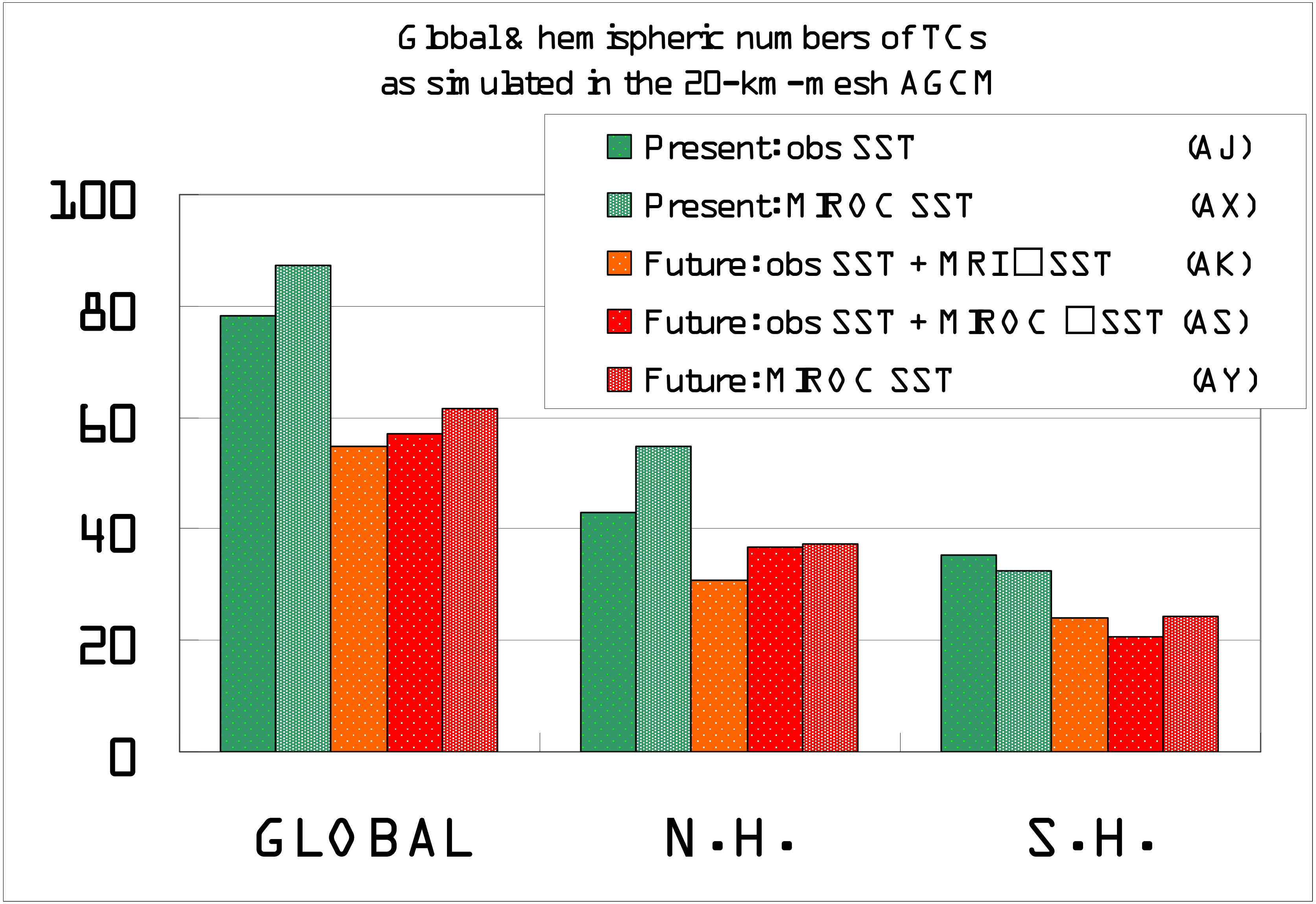
TC frequency as a function of peak wind intensity



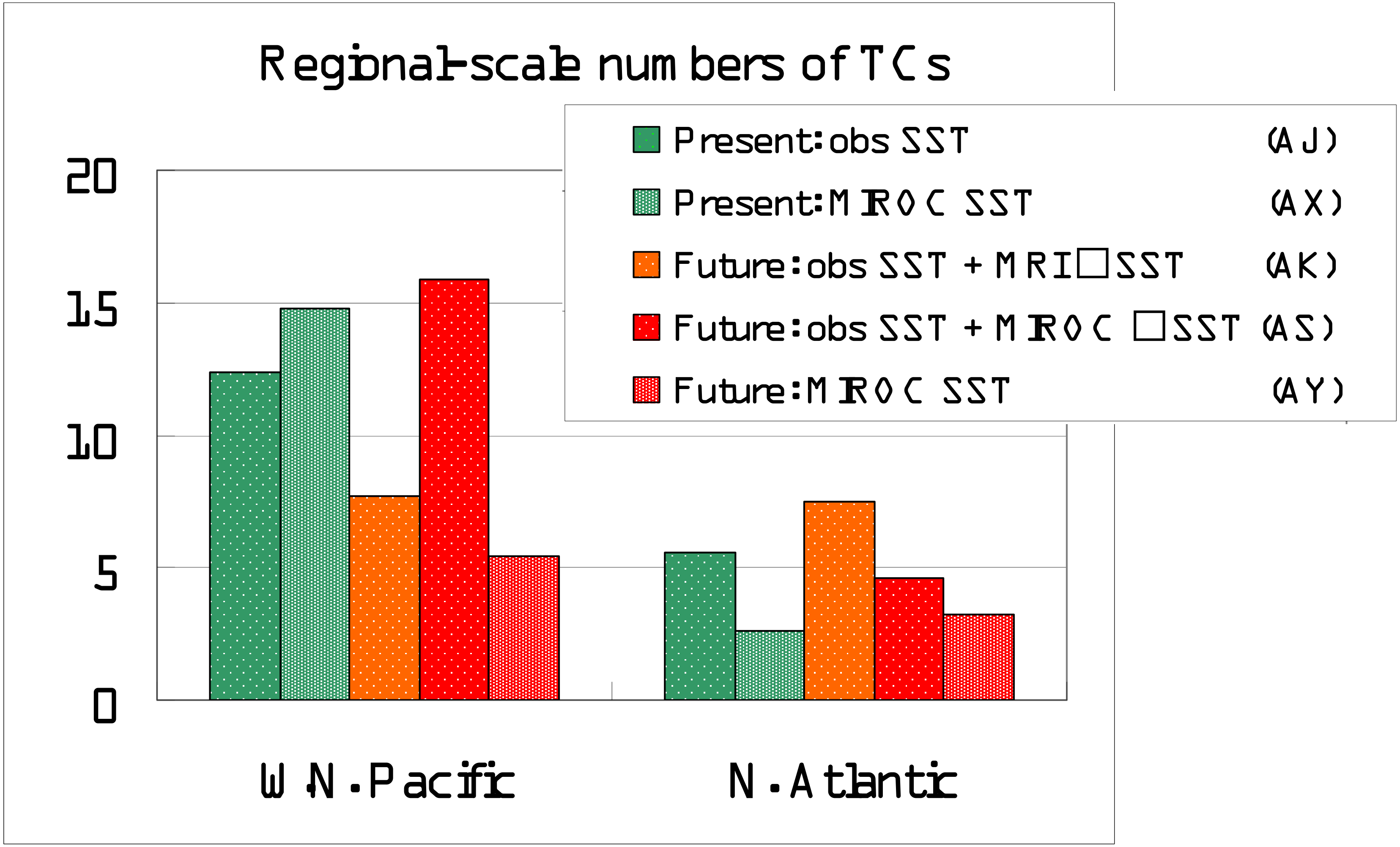



W.N. Pacific
N. Indian
E.N. Pacific
S. Indian
N. Atlantic
S. Pacific
SST: Obs. present clim.
SST: + MRI ΔSST
SST: + MIROC ΔSST
SST: MIROC present clim.
SST: MIROC future clim.
Max surface wind speed (m/s)

The number of TC formation



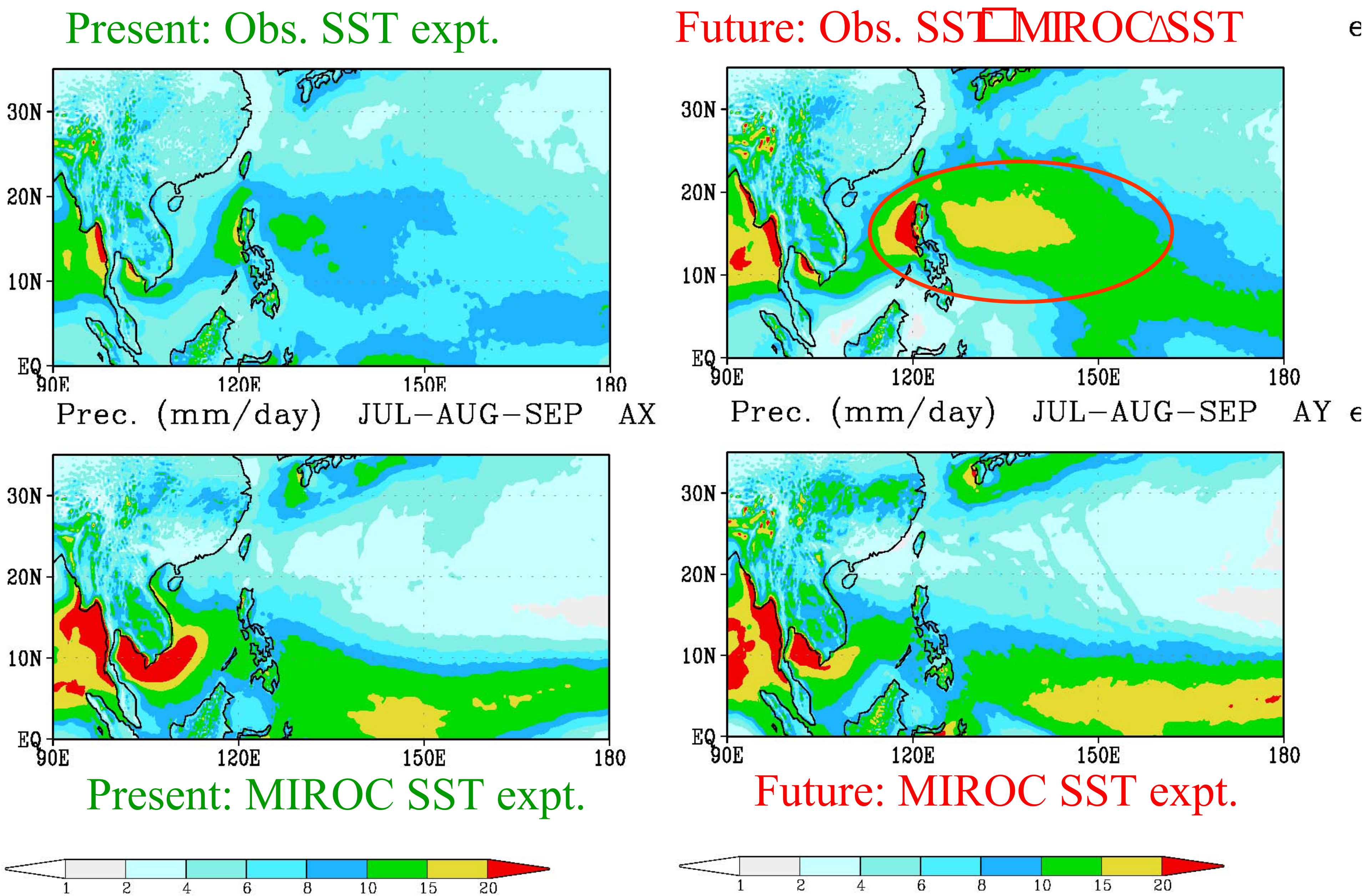
The number of TC formation



W.N. Pacific: the number of TC formation (0N□45N, 100E□180E□ # per year

	"Present-day" End of 20th century	"Future" End of 21st century	Change
SST anomalies used	【Obs. SST】 12.6	【Obs. SST□MRI ΔSST】 8.1	-4.5
		【Obs. SST□MIROC ΔSST】 15.9	+3.3
"Raw" data of SST used	【MRI SST】 20.9	【MRI SST】 14.9	-6.0
	【MIROC SST】 15.8	【MIROC SST】 5.8	-10.0

W. N. Pacific: climatological precipitation (mm/day) Jul-Aug-Sep



Summary

- Frequency of tropical cyclone formation decreased globally by ~30%.
- Frequency of intense tropical cyclones increased with a higher SST condition.
- Basin-scale tropical cyclone activity depends on regional SST variations.
    - Consistency of a constructed SST condition with its original AOGCM is discussed. Such consideration could enable more robust projection of regional TC activity.

RESPONSE OF TROPICAL CYCLOGENESIS TO GLOBAL WARMING IN IPCC AR-4 SCENARIOS ASSESSED BY A MODIFIED YEARLY GENESIS PARAMETER

Jean-François ROYER and Fabrice CHAUVIN

CNRM/GAME (Meteo France/CNRS)

Toulouse, France

Supported by ANR project « Cyclone & Climate »

The Yearly Genesis Parameter of W. Gray

The Yearly Genesis Parameter (YGP) represents cyclogenesis in an oceanic basin (Gray, 1975) as the sum of 4 the Seasonal Genesis Parameters (SGP) that are the product of a thermal and dynamical potential.

Thermal potential :
- ocean heat content
- vertical stability of the lower troposphere
- mid-tropospheric moisture

Dynamical potential :
- Coriolis effect
- low layer vorticity
- vertical shear of the horizontal wind

Simulated YGP and CYGP as compared to observations (Royer et al., 1998)

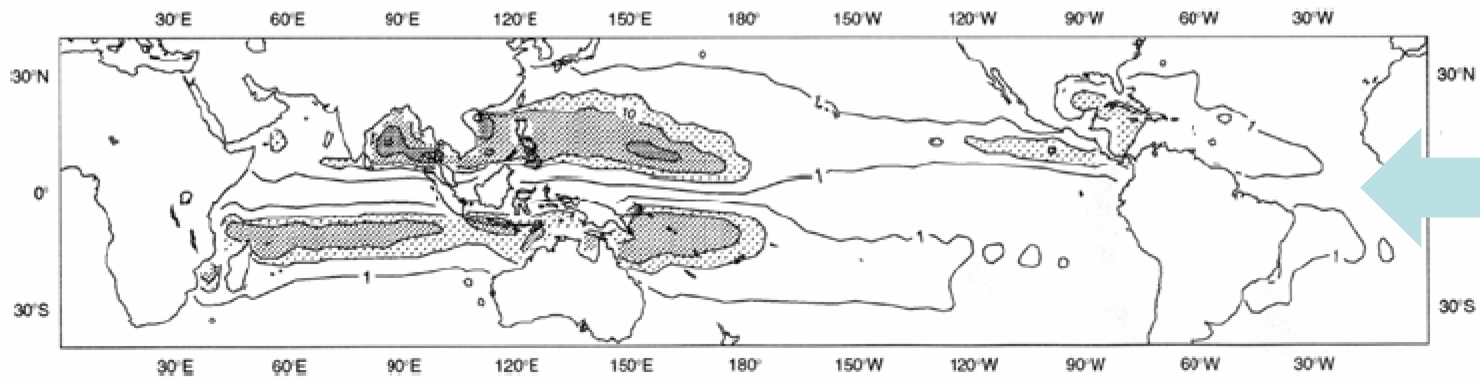


Figure 8. Geographical maps of the convective YGP calculated from ARPEGE-Climat control experiment CO1 (units: number of TC genesis in 20 years per 5° lat.-lon.). Isolines are drawn at 1, 5, 10, 20, 40, 50 and values above 5 are shaded.

Convective YGP

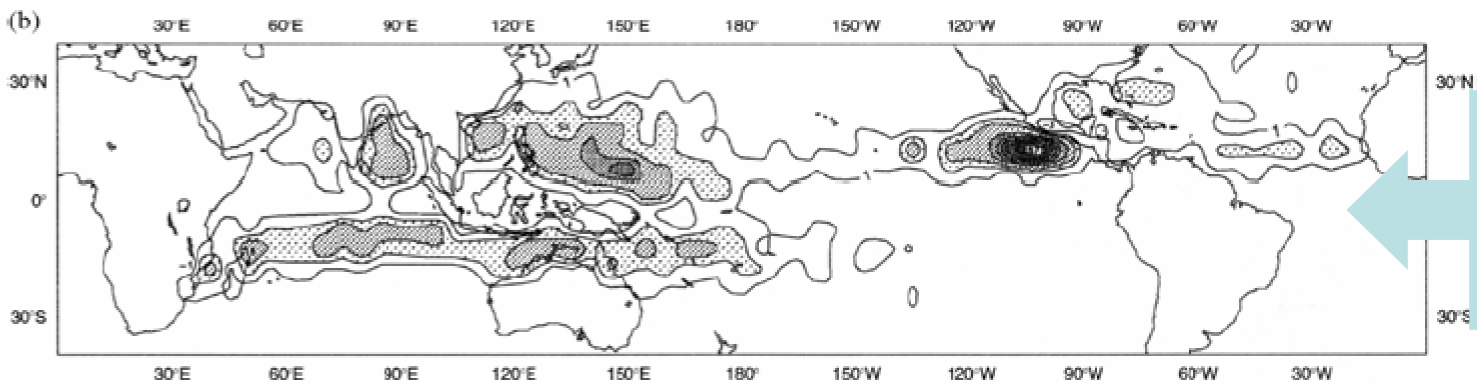
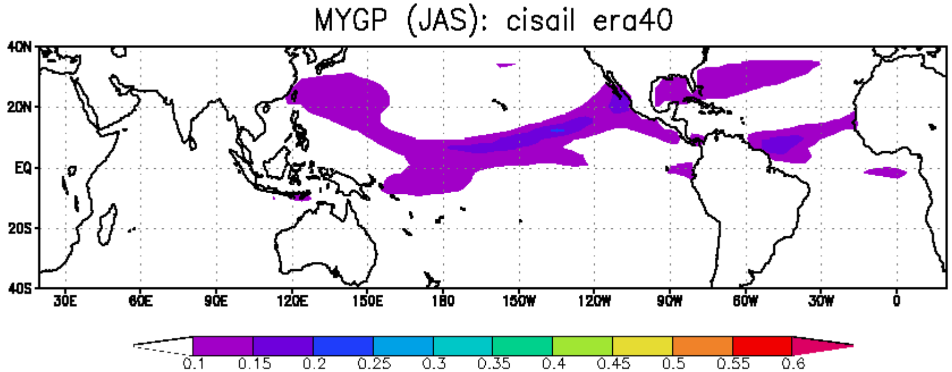


Figure 3. Geographical map of the YGP (a) calculated from ARPEGE-Climat control experiment (CO1), (b) as observed from 1973 to 1992 (Tsutsui and Kasahara, 1996) (units: number of TC genesis in 20 years per 5° lat.-lon.). Isolines are drawn at 1, 5, 10, 20, 40, 50 and values above 5 are shaded.

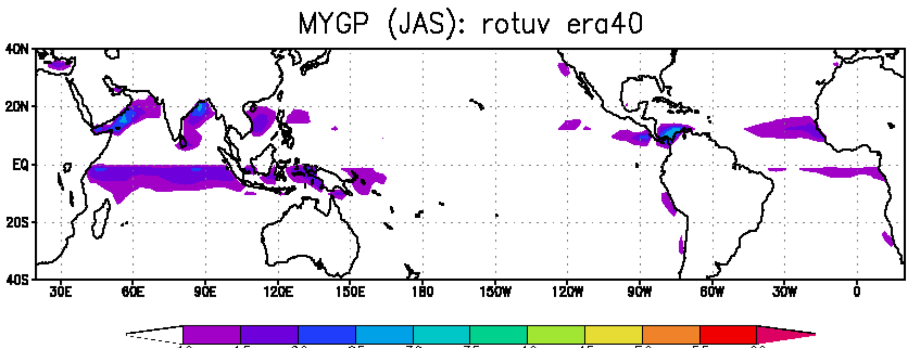
Observed

Components of the dynamical potential (JAS season)



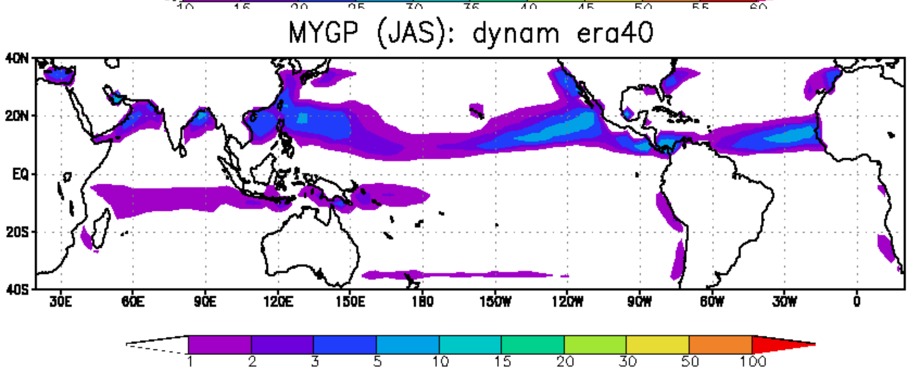
Shear:
(200 – 850 hPa horiz. wind shear in ms^{-1}/650 hPa)

$$I_s = 1/\left(|dv/dp| + 3\right)$$



Vorticity:
(850 hpa rel. vort ζ in $10^{-6}\,s^{-1}$)

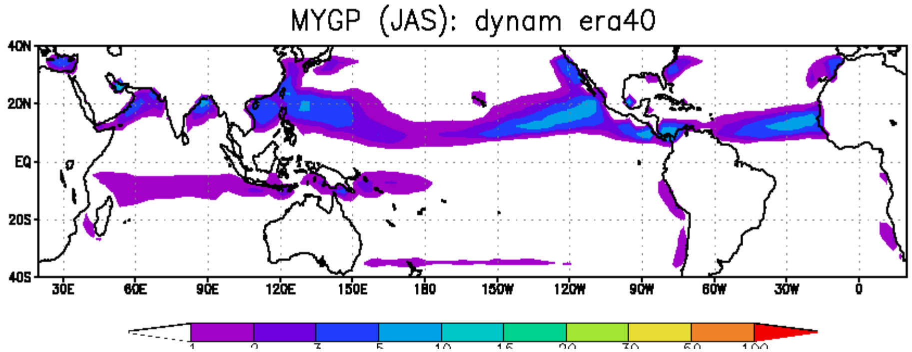
$$I_v = \max(0, \zeta\,(f/|f|) + 5)$$

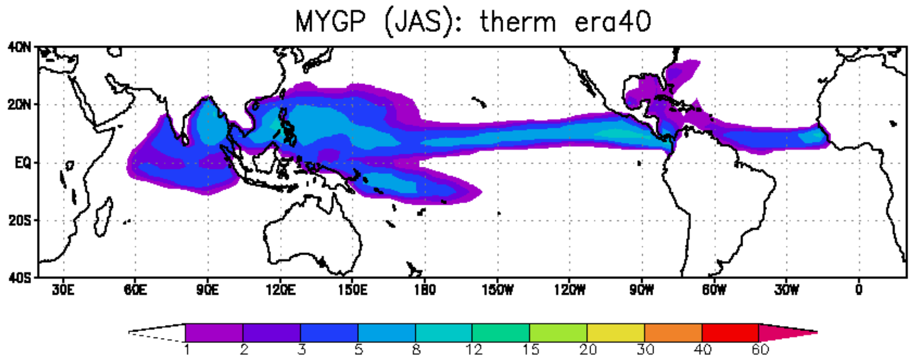


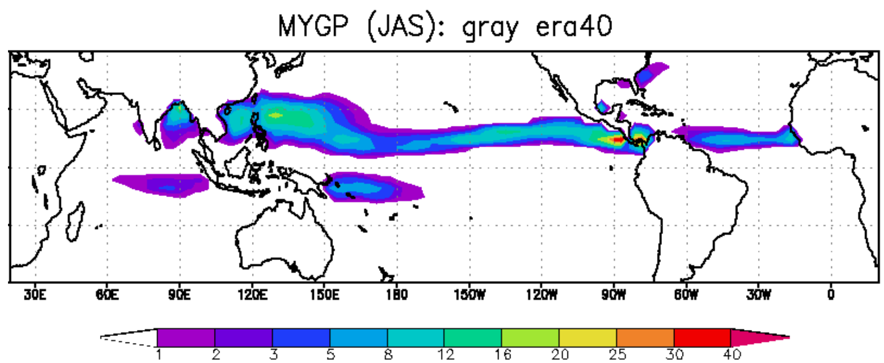
Dynamical potential:
($f=2\Omega \sin\phi$ in $10^{-5}\,s^{-1}$)

$$DP = I_s \,.\, I_v \,.\, f$$

Dynamical and convective components of the CYGP (JAS season)







Dynamical potential:

$$DP = I_s \,.\, I_v \,.\, f$$

Convective potential:
(conv. Precip. P_c above threshold P_0)

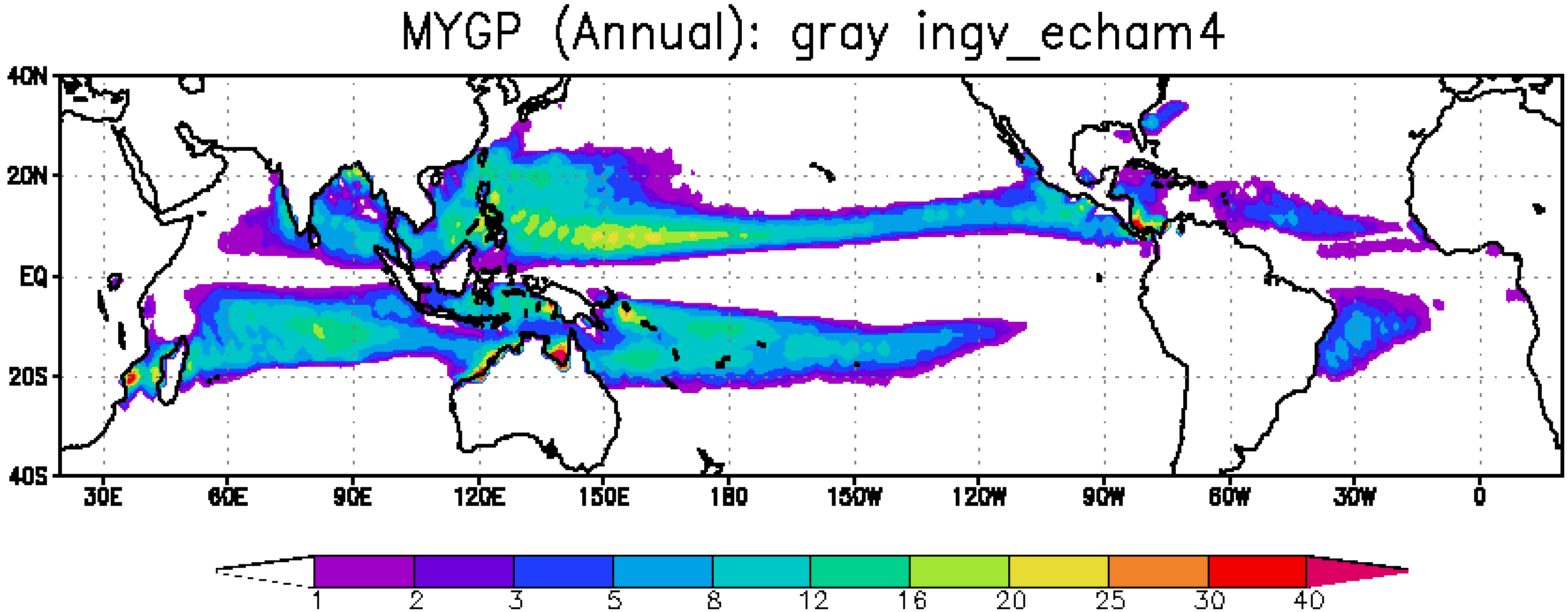
$$CP = k.\ \max(0, P_c - P_0)$$

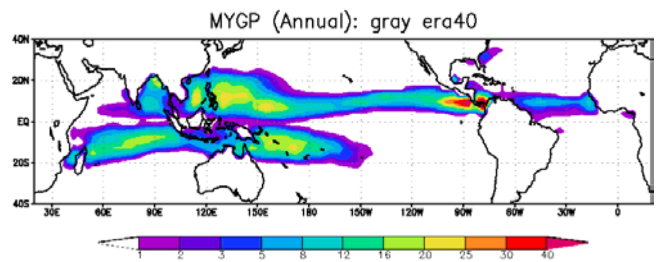
(k calibration factor -> 84 TC genesis annually on average)

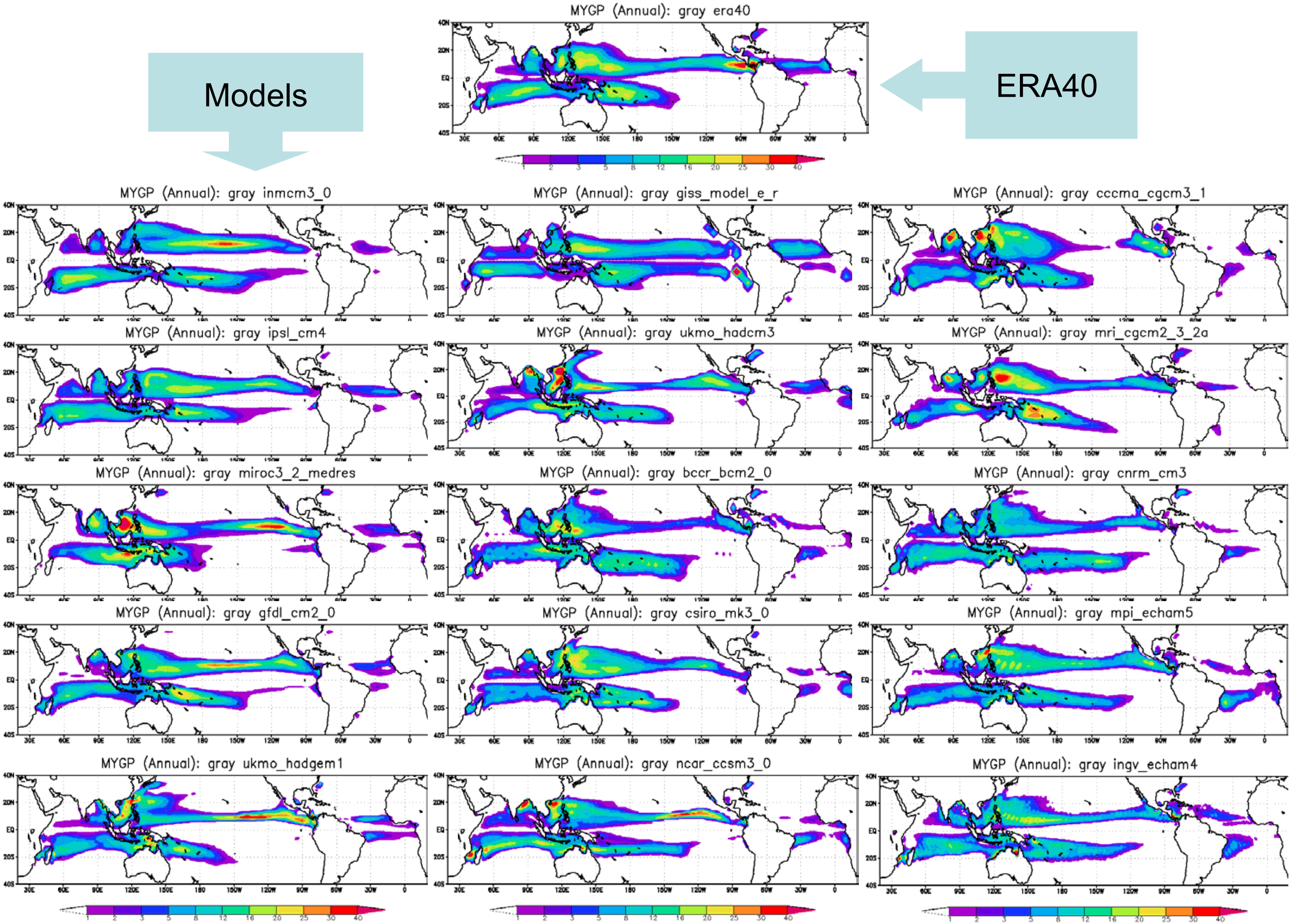
Genesis potential:

$$SGP = DP.\ CP$$

Model CYGP 1970-2000







Models
ERA40
MYGP (Annual): gray era40
MYGP (Annual): gray inmcm3_0
MYGP (Annual): gray giss_model_e_r
MYGP (Annual): gray cccma_cgcm3_1
MYGP (Annual): gray ipsl_cm4
MYGP (Annual): gray ukmo_hadcm3
MYGP (Annual): gray mri_cgcm2_3_2a
MYGP (Annual): gray miroc3_2_medres
MYGP (Annual): gray bccr_bcm2_0
MYGP (Annual): gray cnrm_cm3
MYGP (Annual): gray gfdl_cm2_0
MYGP (Annual): gray csiro_mk3_0
MYGP (Annual): gray mpi_echam5
MYGP (Annual): gray ukmo_hadgem1
MYGP (Annual): gray ncar_ccsm3_0
MYGP (Annual): gray ingv_echam4