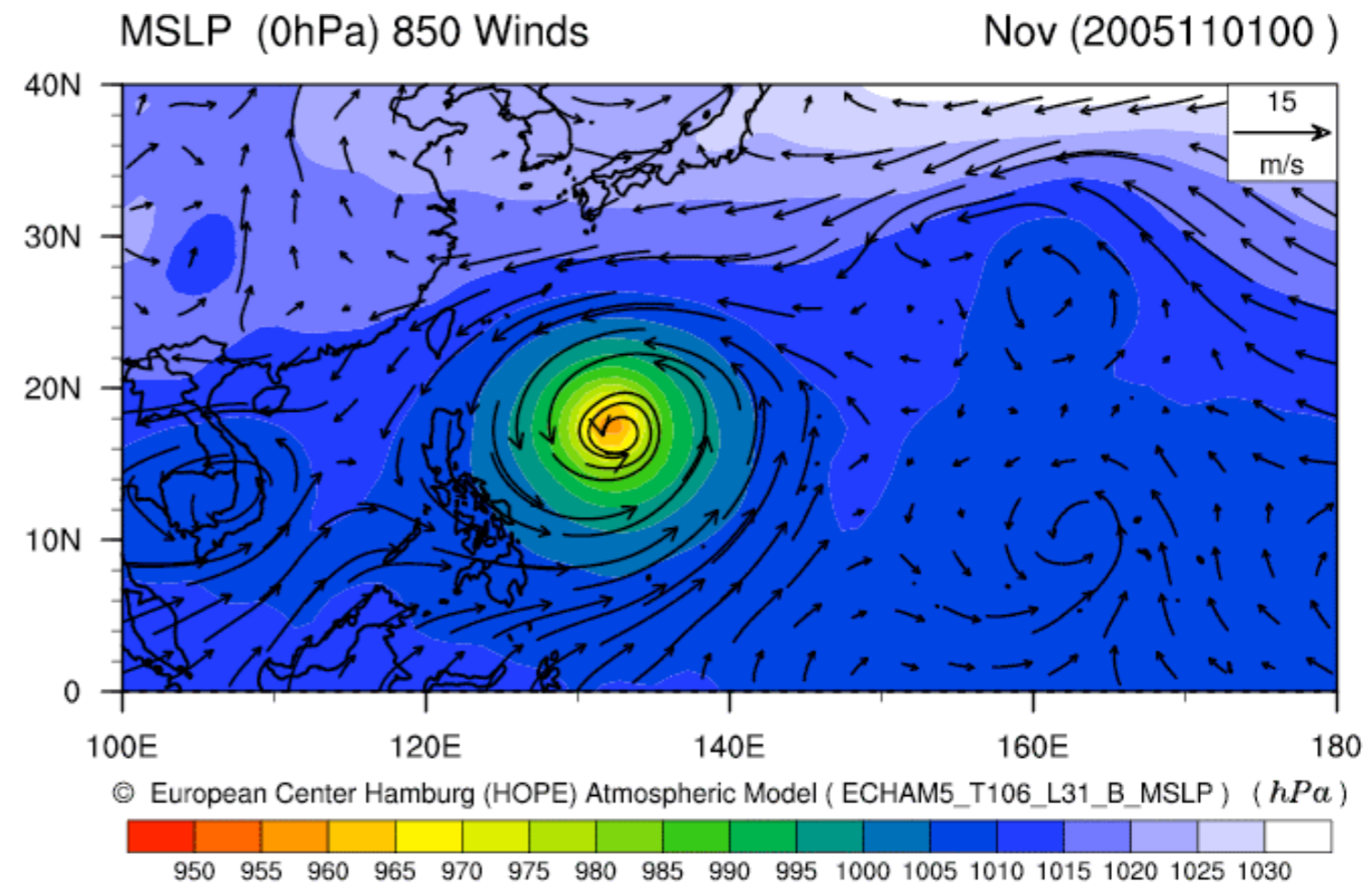
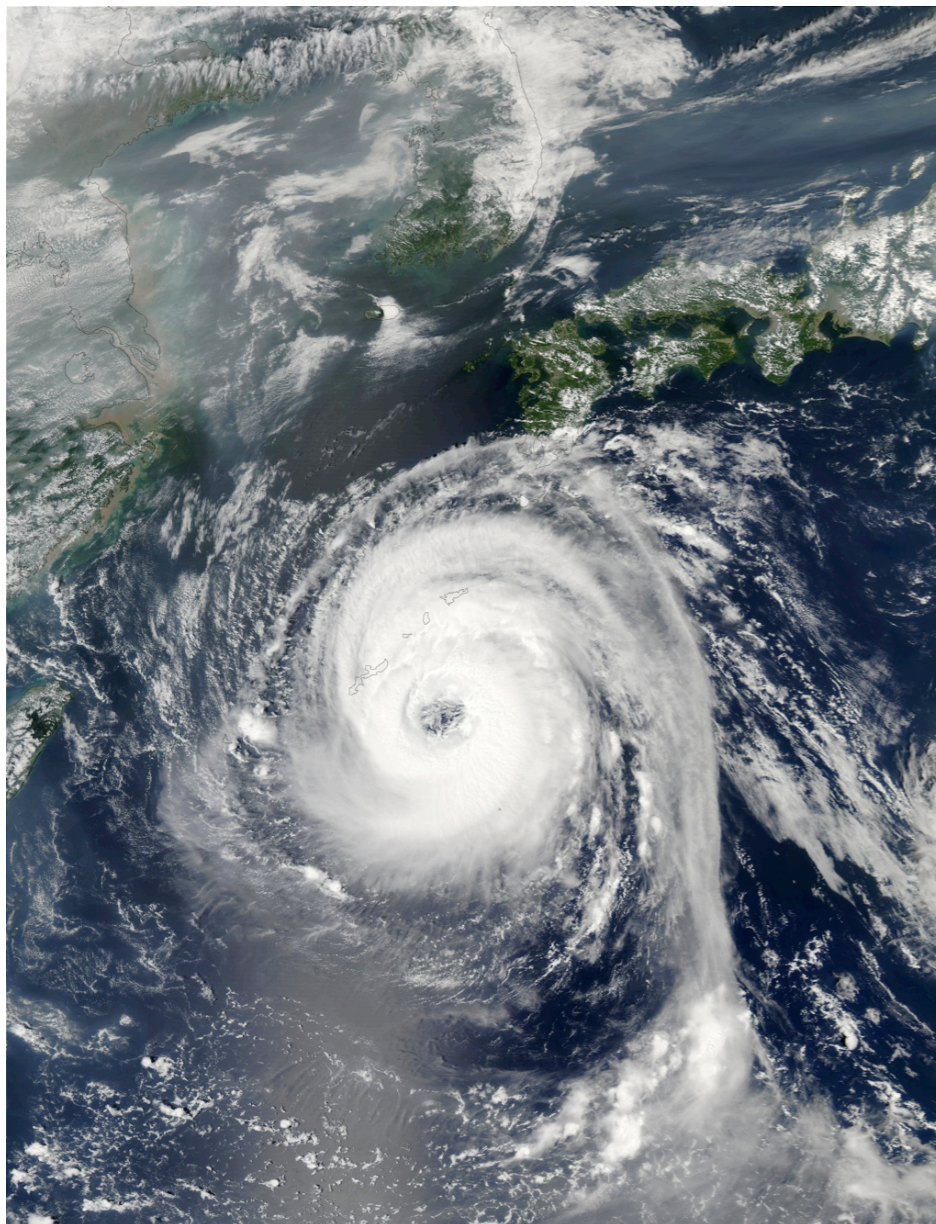


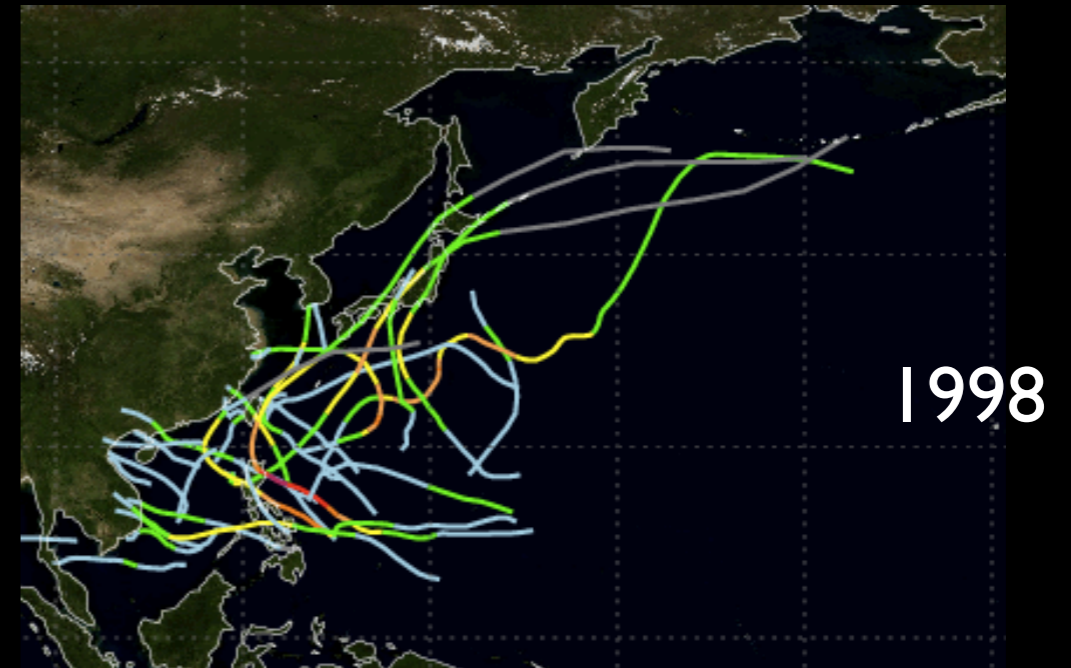
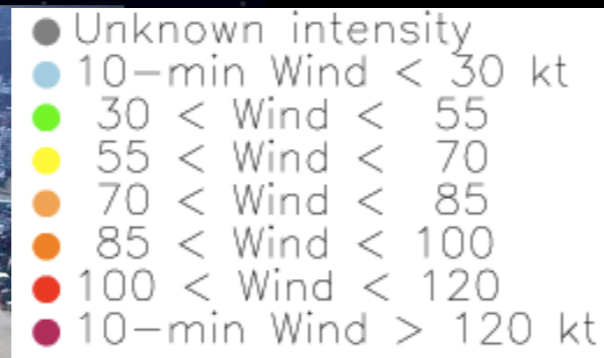
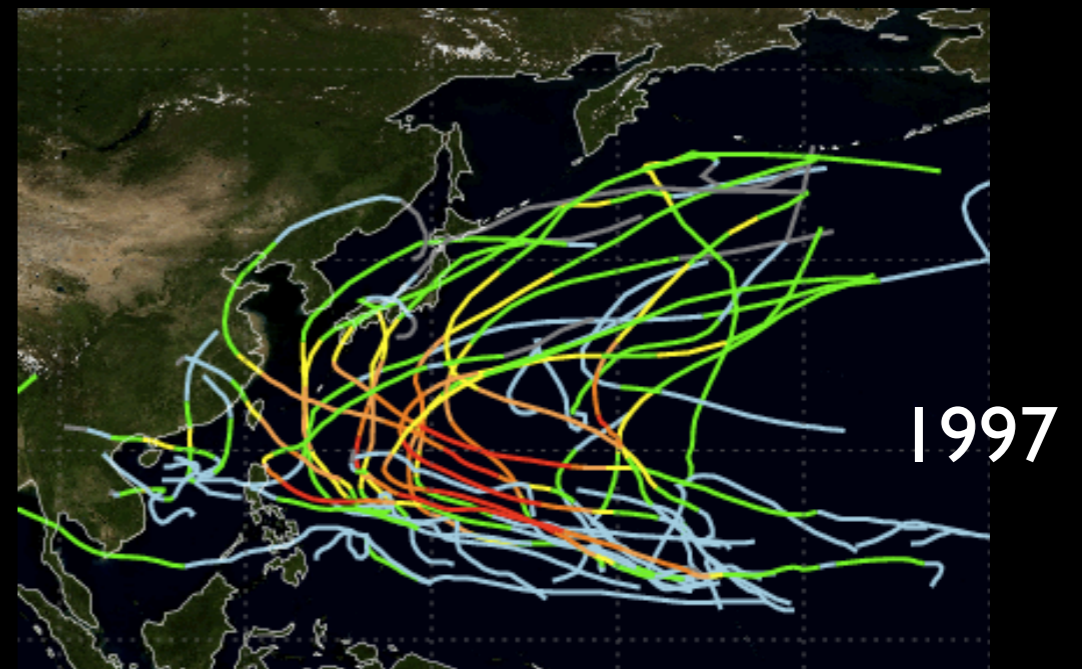
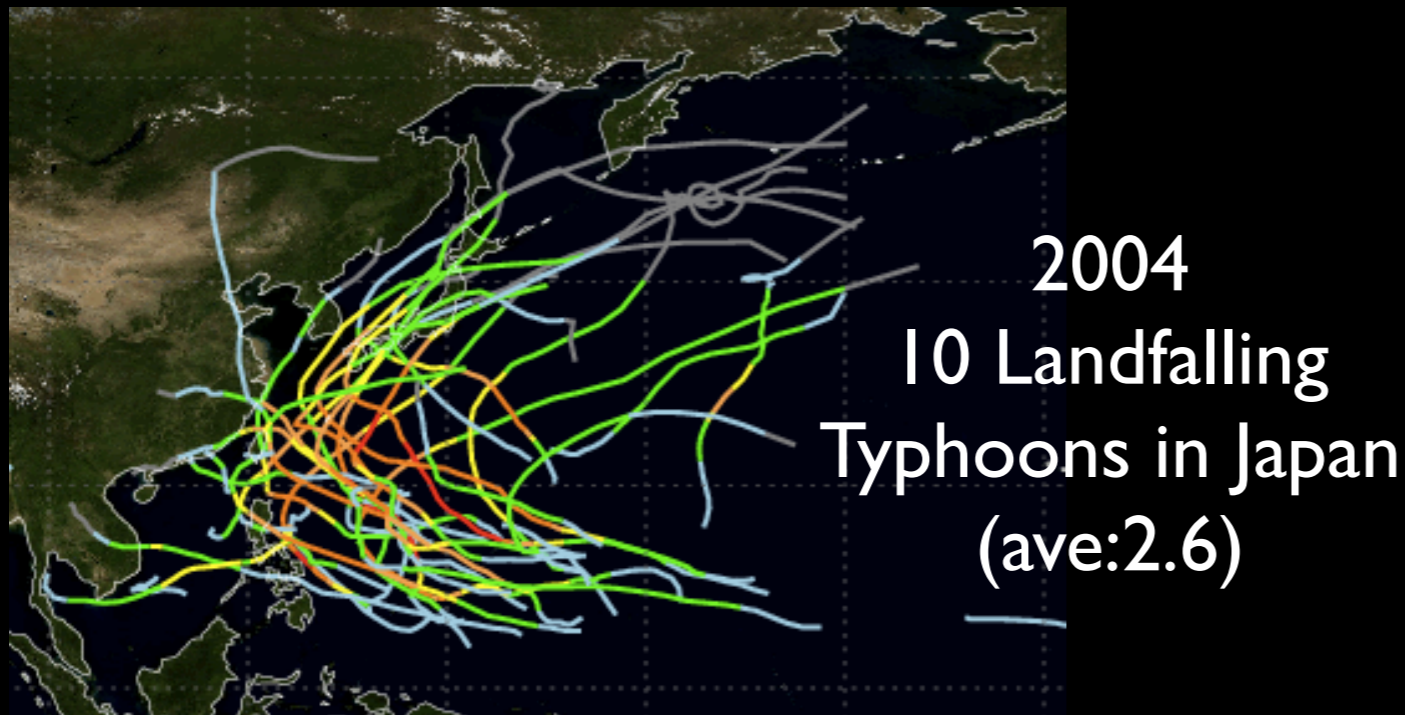
# Dynamical Seasonal Typhoon Ensemble Simulation over Northwest Pacific Basin

Cheng-Ta Chen, Hsin-Chien Liang, and Teng-Ping Tzeng

National Taiwan Normal University, Department of Earth Sciences

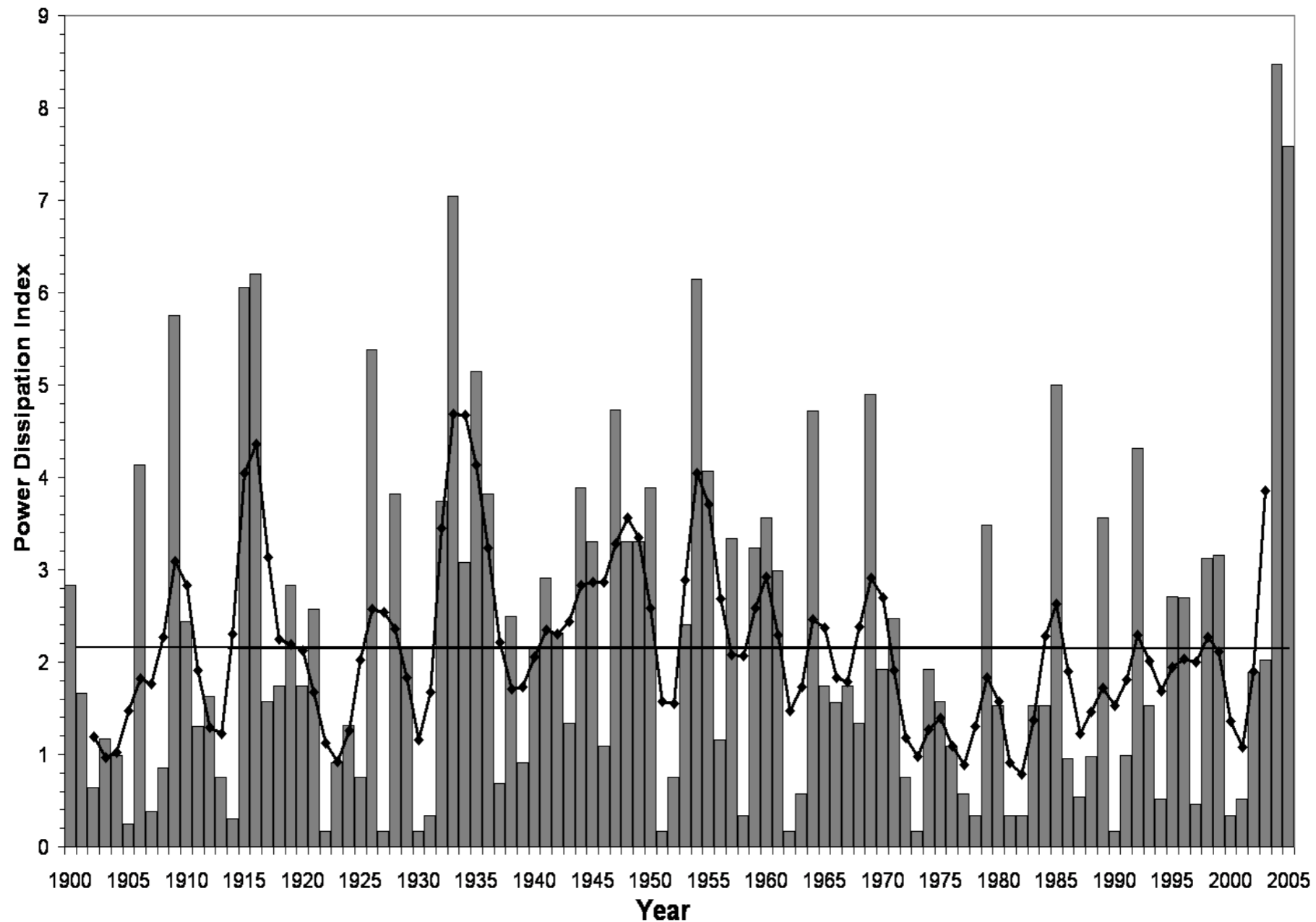


# Increasing Interests in the Seasonal Prediction on Typhoon (Hurricane) Activities due to their catastrophic damage on the environment, society, lives, property and economy



# Large interannual variability in annual U.S. landfalling hurricane activity

United States Power Dissipation Index  
1900 to 2005

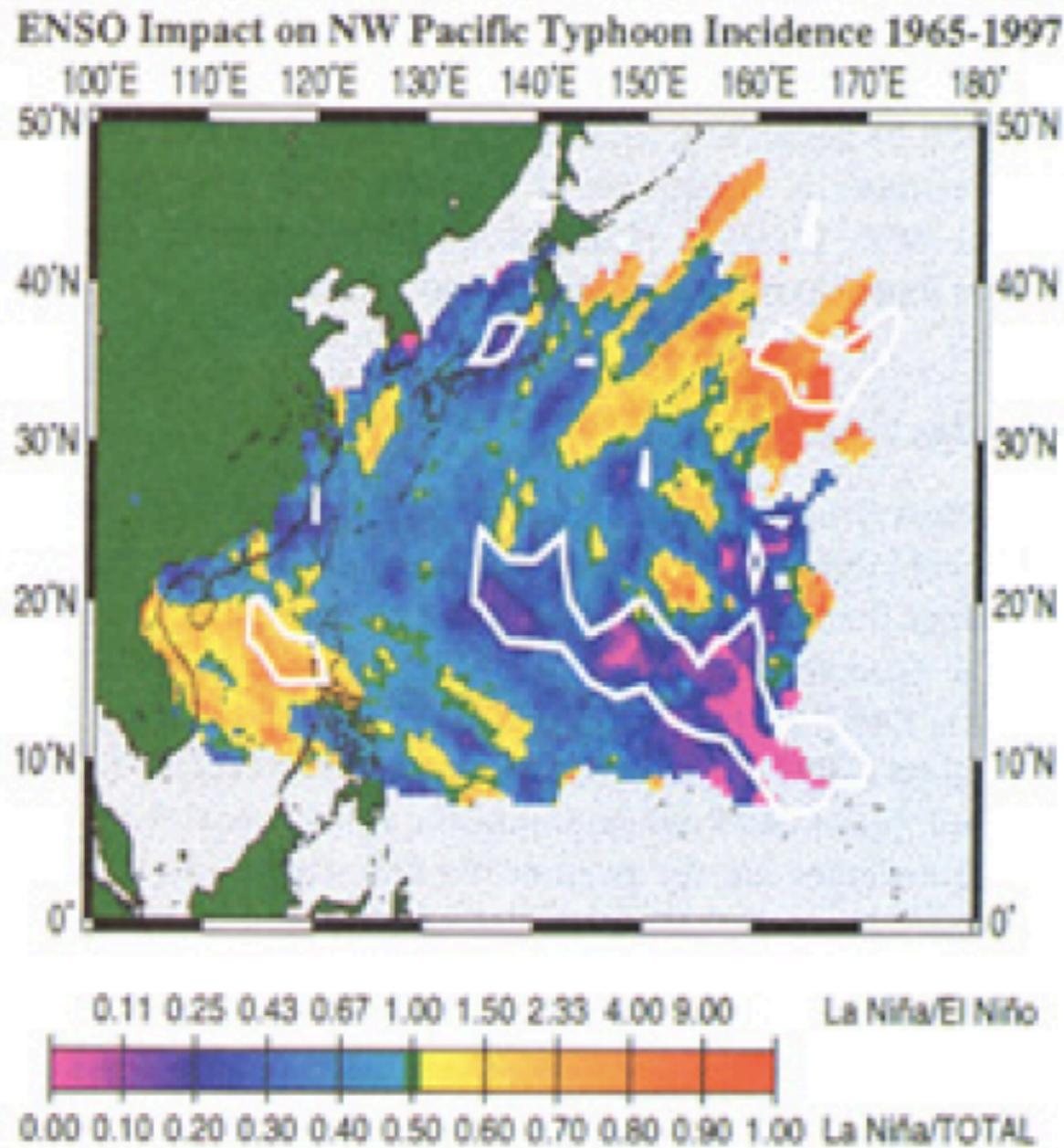


Source: Chris Landsea, NOAA/NHC

- Ratio of landfalling typhoons in La Nina and El Nino years are quite different among the NW Pacific regions:

=> Much higher than 1 for Philippine.

=> Smaller than 1 for Taiwan and Japan.

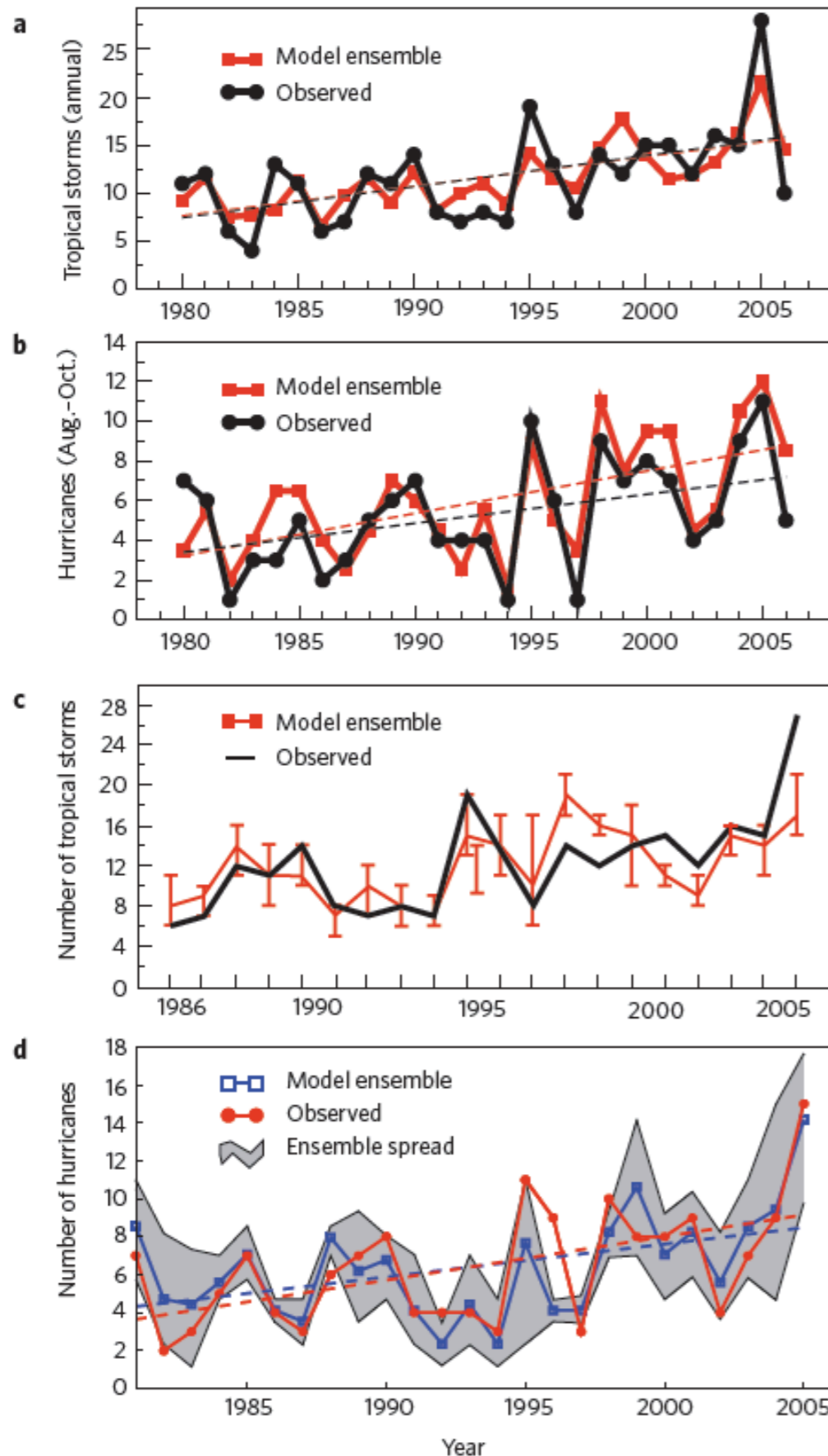


Saunders et al. (2000)

Coastal Region	All Events ASO Nino 3.4 No SST Threshold			JASO Events JASO Nino 3.4 No SST Threshold		
	EN IR (18 yrs)	LN IR (15 yrs)	IRR (LN/EN)	EN IR (19 yrs)	LN IR (14 yrs)	IRR (LN/EN)
Japan	4.50	3.67	0.82	4.16	3.29	0.79
South Korea	0.44	0.53	1.20	0.42	0.57	1.35
Taiwan	2.11	1.60	0.76	1.84	1.21	0.66
Philippines	1.56	2.13	1.37	0.53	1.21	2.28
Vietnam	1.00	1.40	1.40	0.89	1.00	1.12

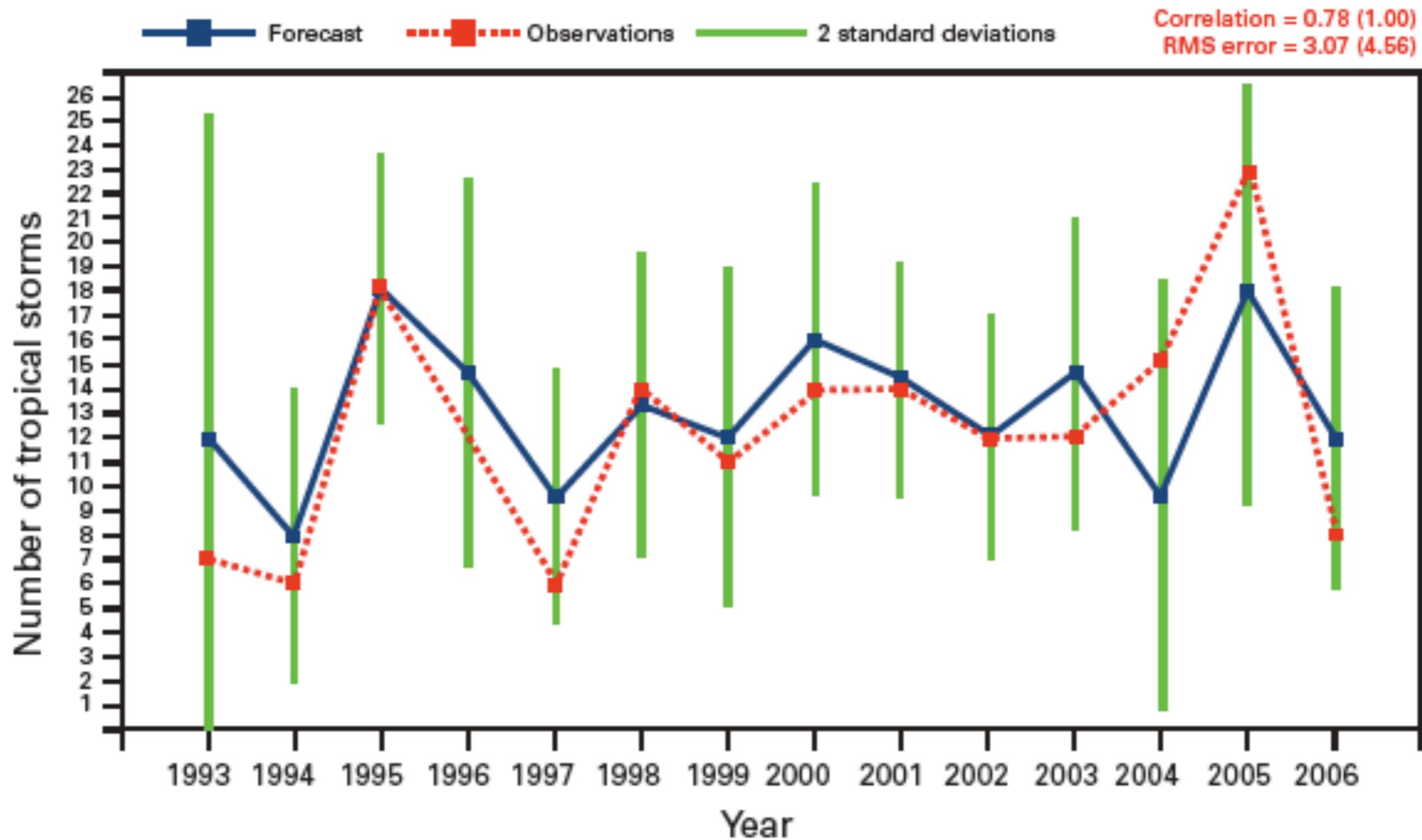
# Reasonable model simulation of past Hurricane variability over Atlantic

Knutson et al. (2010)



**Figure 3 | Simulated versus observed Atlantic tropical cyclone interannual variability (approximately 1980-2006) using several methods.** **a**, Tropical storm counts using a statistical/dynamical downscaling method and atmospheric reanalyses and observed SSTs as input. Reproduced with permission from ref. 11 (© 2008 AMS). **b**, Hurricane counts (August-October) using a regional climate-model downscaling method and data from observed SSTs and interior spectral nudging to atmospheric reanalyses. Reproduced from ref. 12 (© 2008 NPG). **c**, Tropical storm counts using an ~100-km grid global model and only observed SSTs. Reproduced with permission from ref. 30 (© 2008 AMS). **d**, Hurricane counts using a 50-km grid global model and only observed SSTs. Reproduced with permission from ref. 29 (© 2009 AMS). Dashed lines (**a,b,d**) are linear trends (colour-matched to time series). Future projections of tropical storm frequency using methods **a**, **b** and **d** are included in Supplementary Table S1.

# ECMWF EUROSIP (from Vitart et al., 2007)



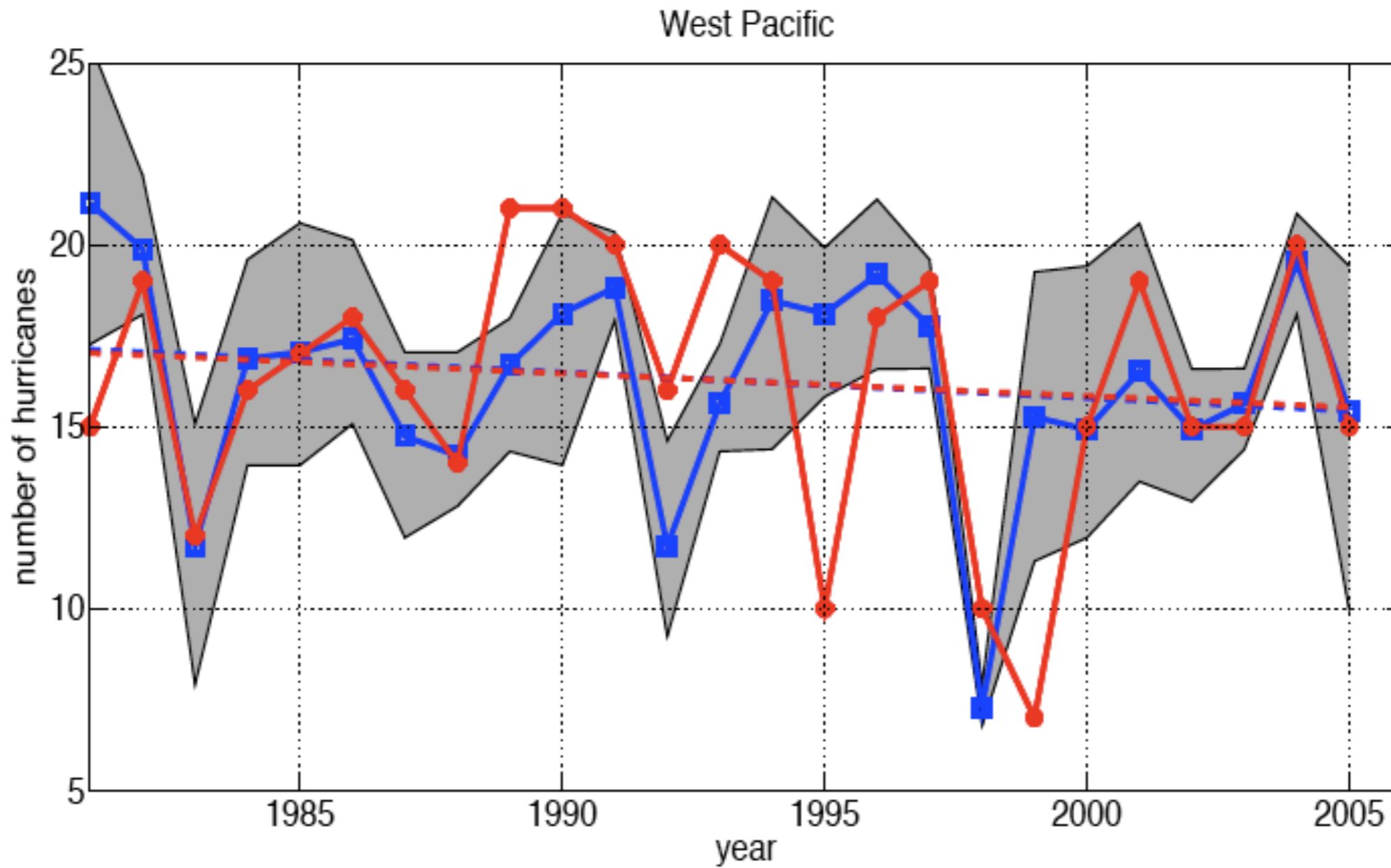
	Model 1	Model 2	Model 3
Correlation	0.67 (0.01)	0.78 (0.002)	0.59 (0.027)
RMS error	3.35	3.65	4.4
	EUROSIP	TSR	CSU
	0.81 (0.00036) 3.26	0.65 (0.004) 4.70	0.39 (0.16) 4.76

1993-2006

# Inter-annual variability and trend (1981-2005)

## Number of West Pacific Typhoons

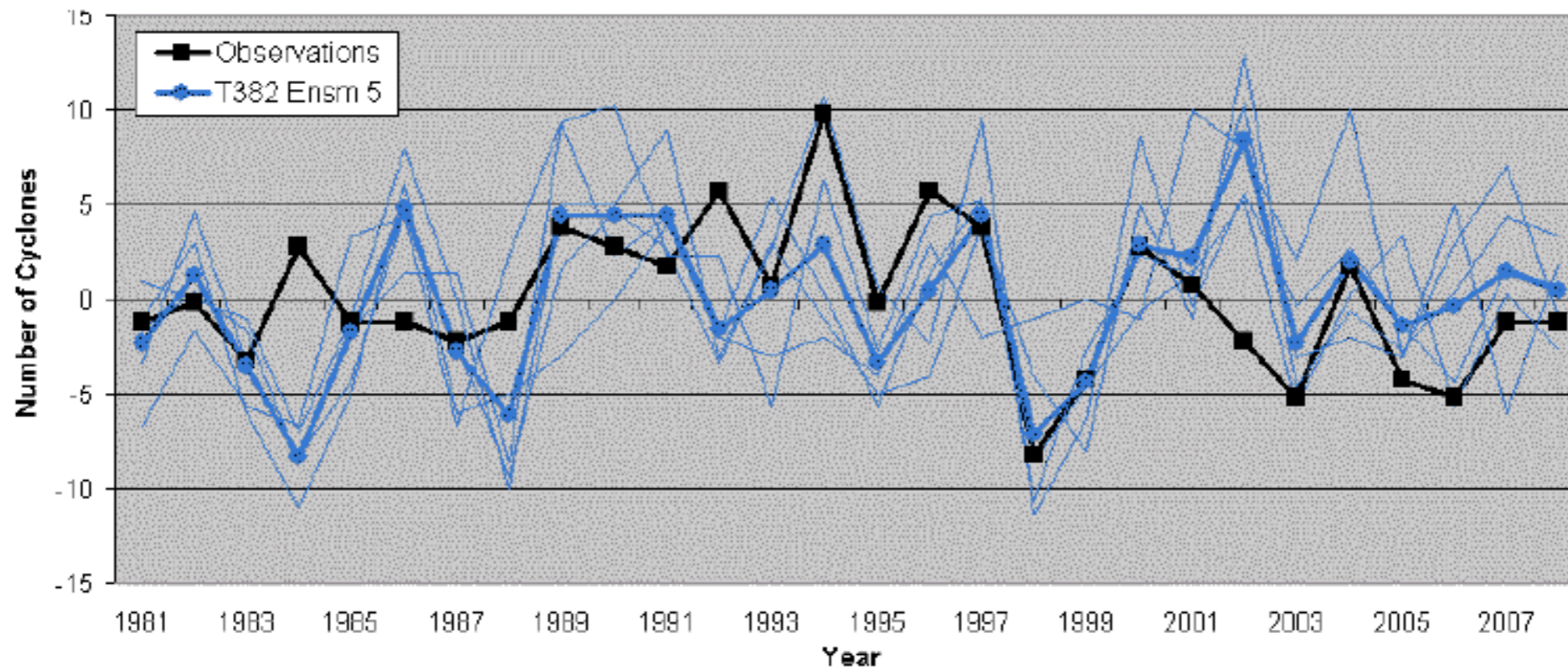
correlation: 0.52



Zhao et al. (2009)

# Dynamic Hurricane Season Prediction Experiment with the NCEP CFS CGCM

## Anomalous Number of TC: Western N. Pacific

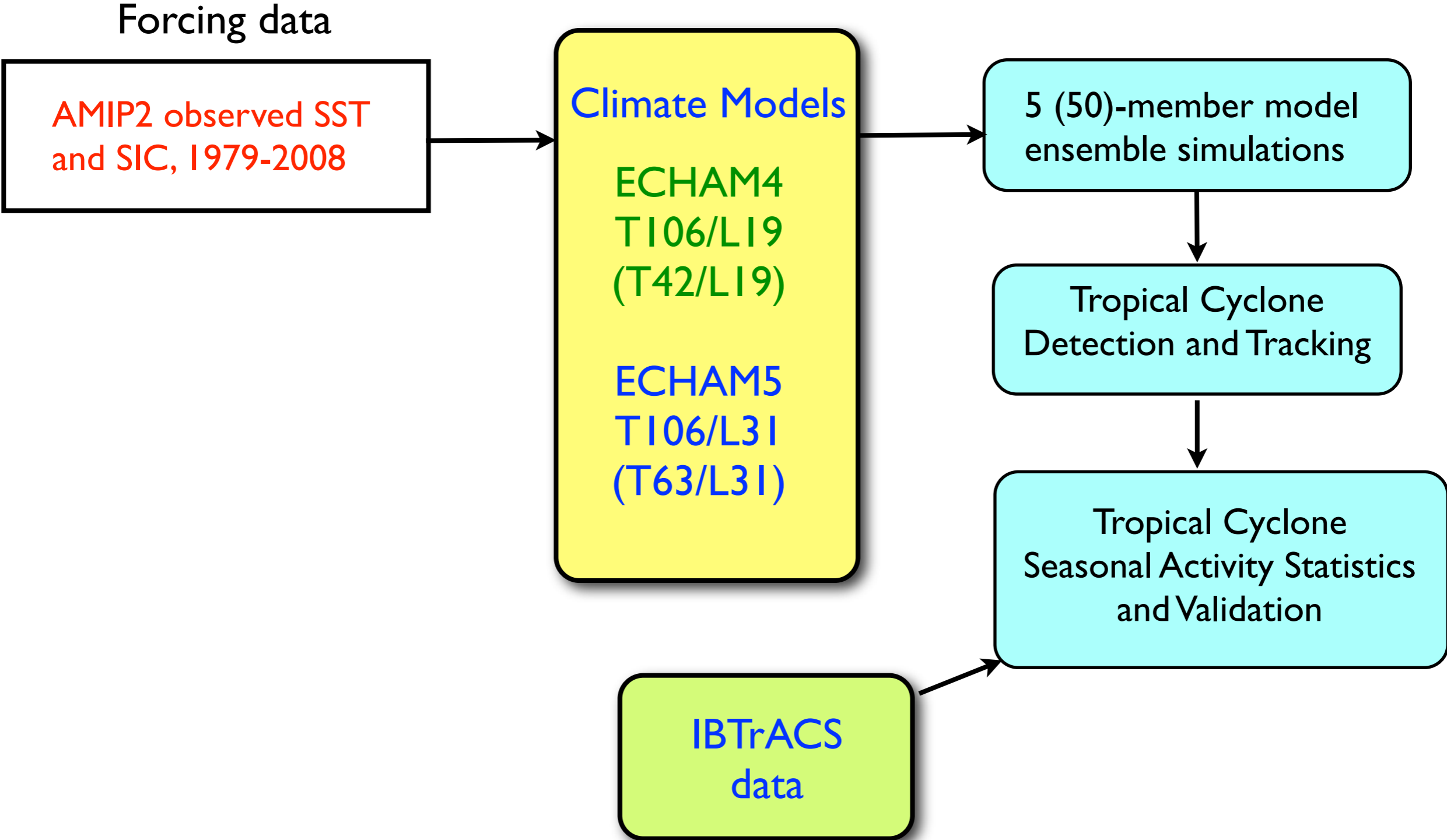


Correlations	Total
IC=0419	0.40
IC=0420	0.47
IC=0421	0.01
IC=0422	0.53
IC=0423	0.14
April Ensm 5	0.46

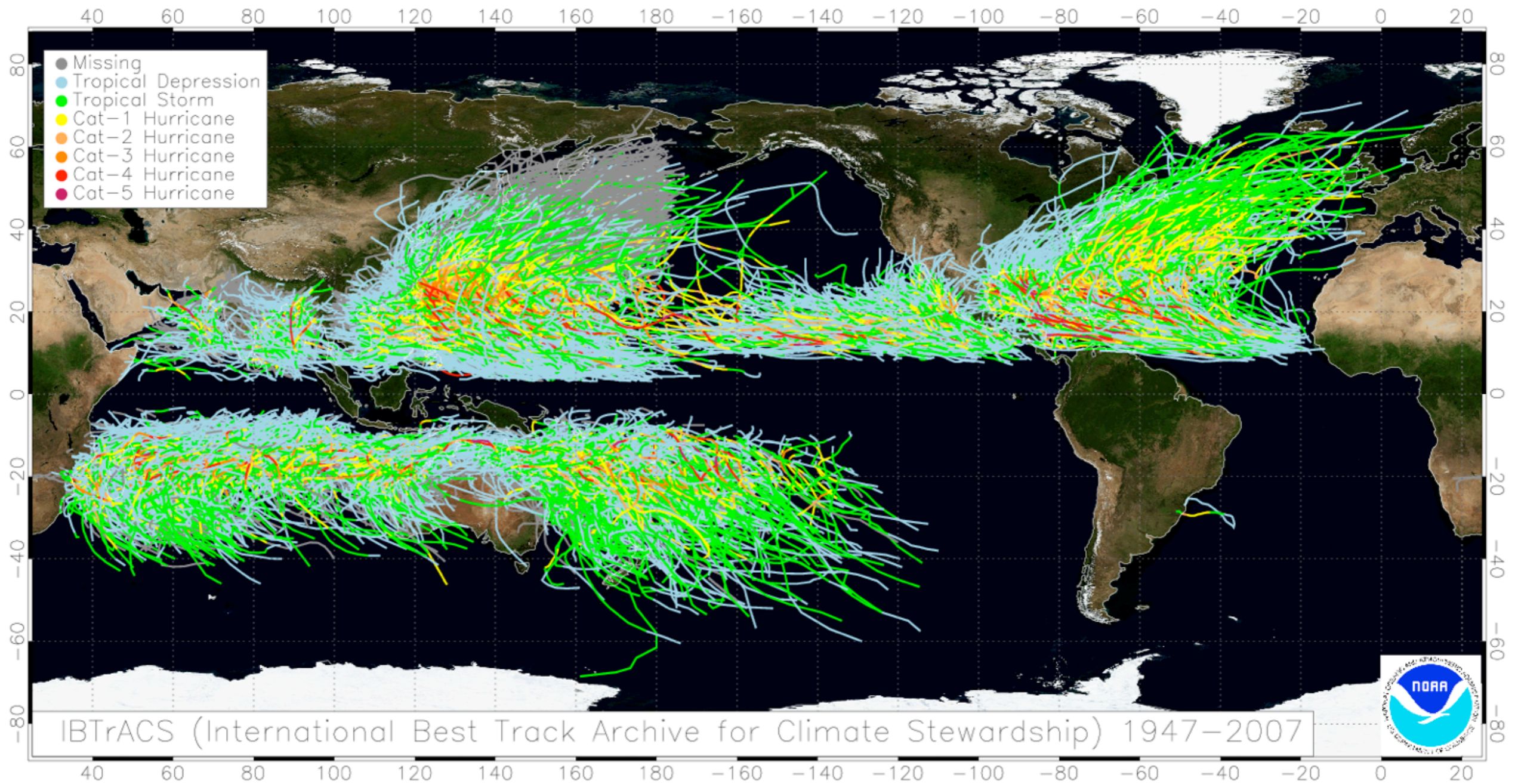
Red = Statistically  
Significant at 0.95

Courtesy of  
Dr. J.-K. Schemm

# Dynamical Typhoon Seasonal Simulation Experiment for NW Pacific

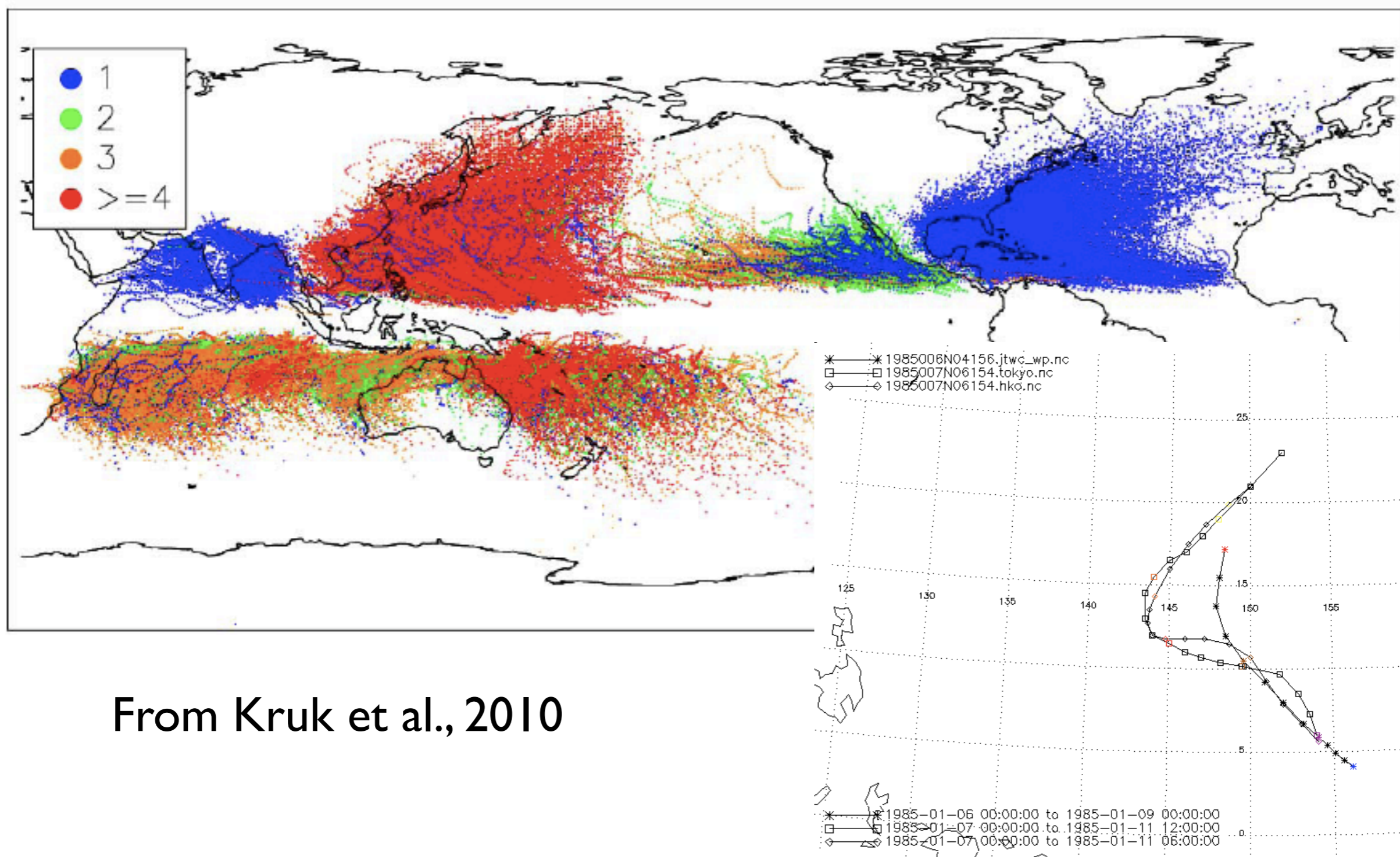


# International Best Track Archive for Climate Stewardship, IBTrACS



Kruk et al., 2010

# International Best Track Archive for Climate Stewardship, IBTrACS



# ECHAM4 Model Characteristics (Roeckner et al., 1996)

- ECMWF dynamical core with semi-Lagrangian scheme for the transport of water vapor and cloud water.
- The radiation code was from ECMWF (Morcrette et al., 1986) with a few modifications (additional greenhouse gases, aerosols, single scattering properties of cloud droplets)
- Cumulus convection (shallow, mid-level, and deep) parameterization is based on the bulk mass flux concept of Tiedtke (1989) with Nordeng (1994) modification.
- Turbulent surface fluxes are calculated from Monin-Obukhov similarity theory (Louis, 1979). Within and above the atmospheric boundary layer, a higher-order closure scheme is used to compute the turbulent transfer of momentum, heat, moisture, and cloud water.
- Gravity wave drag associated with orographic gravity waves is simulated after Miller et al. (1989), using directionally dependent subgrid-scale orographic variances
- Detailed land surface parameterization with soil and vegetation model and their impacts on water and energy flux.
- T106 grid; 19 vertical levels
- Boundary forcing: AMIP2 SSTs (1979-2007)
- 5 ensemble members

# ECHAM5 Model Characteristics (Roeckner et al., 2003)

- Finite volume dynamical core for positive definite variables (water vapour, cloud variables and chemical tracers) a mass- conserving and shape-preserving advection scheme is applied (Lin and Rood, 1996).
- ECMWF new longwave radiation code (RRTM) developed by Mlawer et al. (1997) has been adopted. Based on 2-stream approximation and higher spectral resolution. The solar spectral band is increased from 2 to 4.
- A new scheme for stratiform clouds has been developed. It includes prognostic equations for cloud liquid water, cloud ice and for the higher order moments of the total water content (Lohmann and Roeckner, 1996). Fractional cloudiness is calculated from a statistical model (Tompkins, 2002) using a probability density function (PDF) for total water as suggested from simulations with a cloud-resolving model. Variance and skewness of the PDF are related to the intensity of subgrid-scale processes such as turbulence and convection.
- An implicit scheme is used for coupling the land surface and the atmosphere (Schulz et al., 2001). A prognostic equation for the amount of snow on the canopy has been introduced. Interactions between snow, soil, vegetation and surface albedo are parameterized (Roesch et al., 2001). A new scheme for the representation of subgrid-scale orographic effect is used (Lott, 1999; Lott and Miller, 1997). A new set of land surface data (vegetation ratio, leaf area index, forest ratio, background albedo) has been derived from a global 1 km-resolution dataset (Hagemann, 2002).
- T106 grid; 31 vertical levels
- Boundary forcing: AMIP2 SSTs (1979-2007)
- currently only 4 ensemble members (5th member to be finished)

## Tropical Storm **Detection** and **Tracking** Scheme (following Vitart et al. 1997)

- Local relative vorticity maximum exceed threshold,

$$\xi_{\max} \text{ at } 850 \text{ hPa} > 8 \times 10^{-5} \text{ s}^{-1}$$

- Local sea level pressure minimum nearby and defined as storm center,

$$\text{SLP}_{\text{environment}} - \text{SLP}_{\min} > 5 \text{ hPa} \quad (\text{SLP}_{\min} \text{ within } 2^\circ \text{ radius of } \xi_{\max})$$

- Local upper level warm core near storm center:

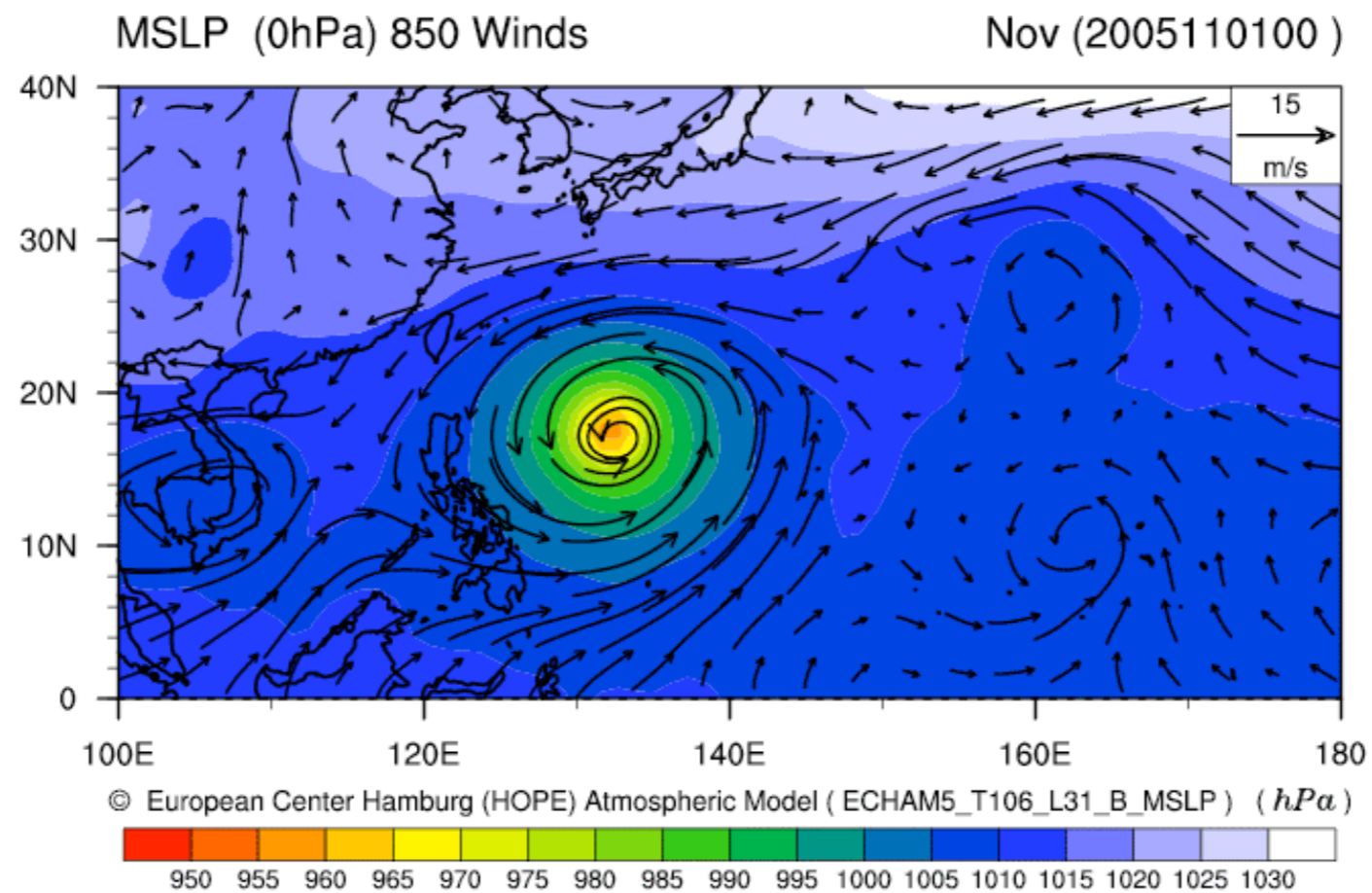
$$T_{200-500\text{hPa}} - T_{\text{environment}} > 0.4 \text{ K} \quad (\text{and within } 2^\circ \text{ radius of center})$$

- Local maximum thickness near storm center:

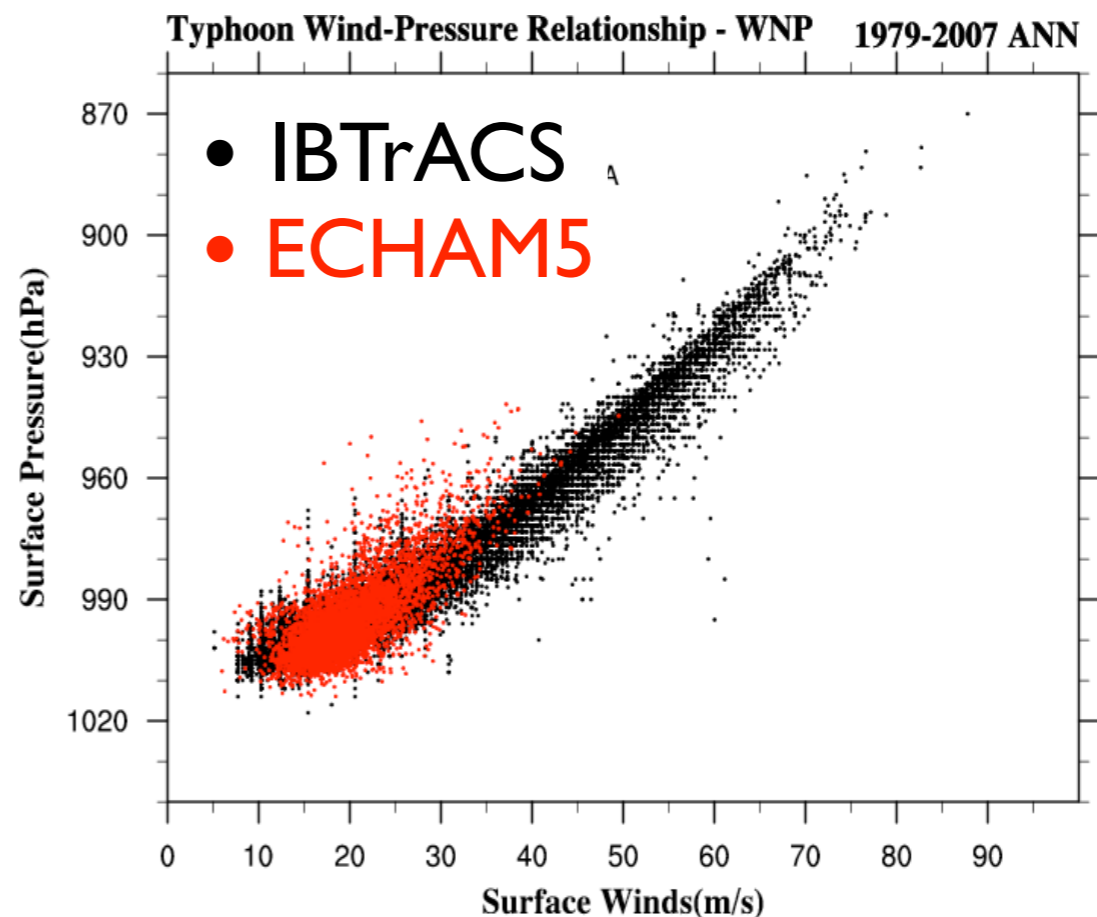
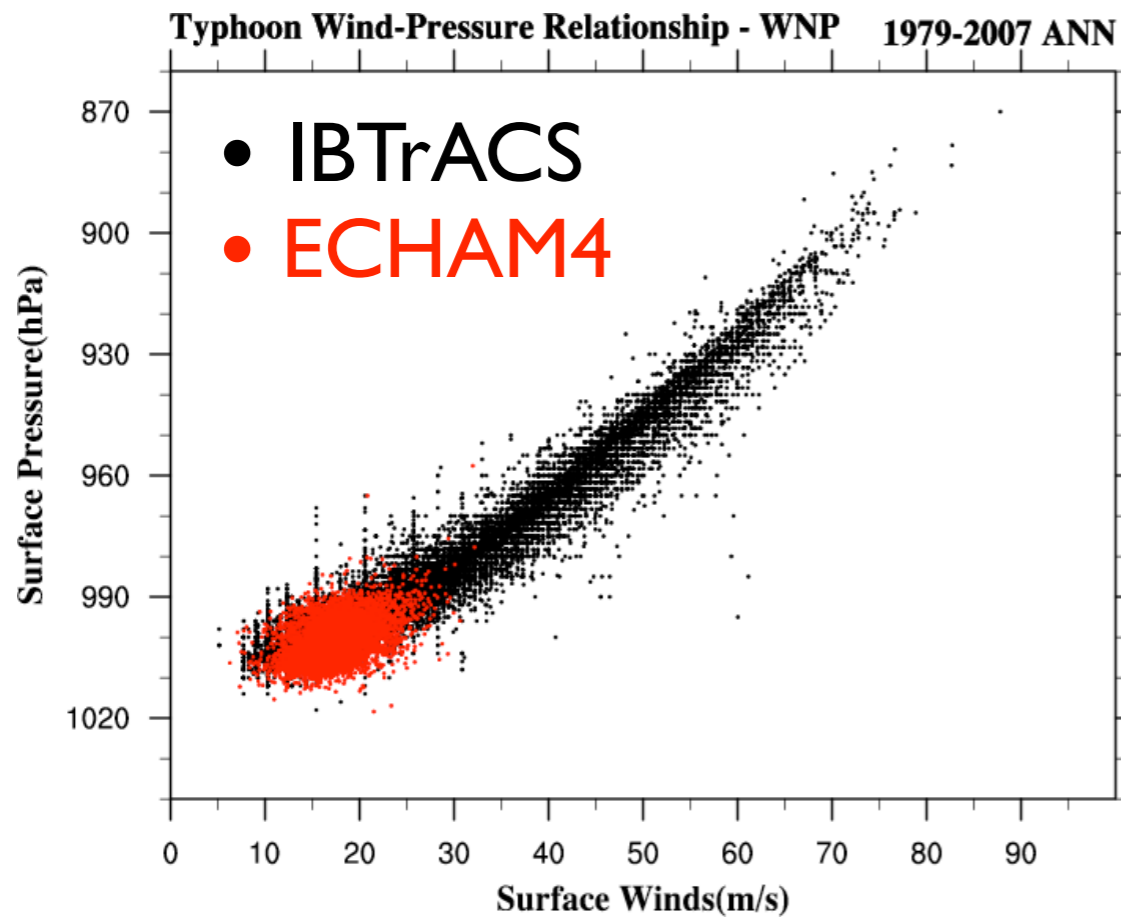
$$Z_{200-1000\text{hPa}} - Z_{\text{environment}} > 50 \text{ m} \quad (\text{and within } 2^\circ \text{ radius of center})$$

- Trajectory stopped if there is no storm on the next time step (6hr) within 400 km.

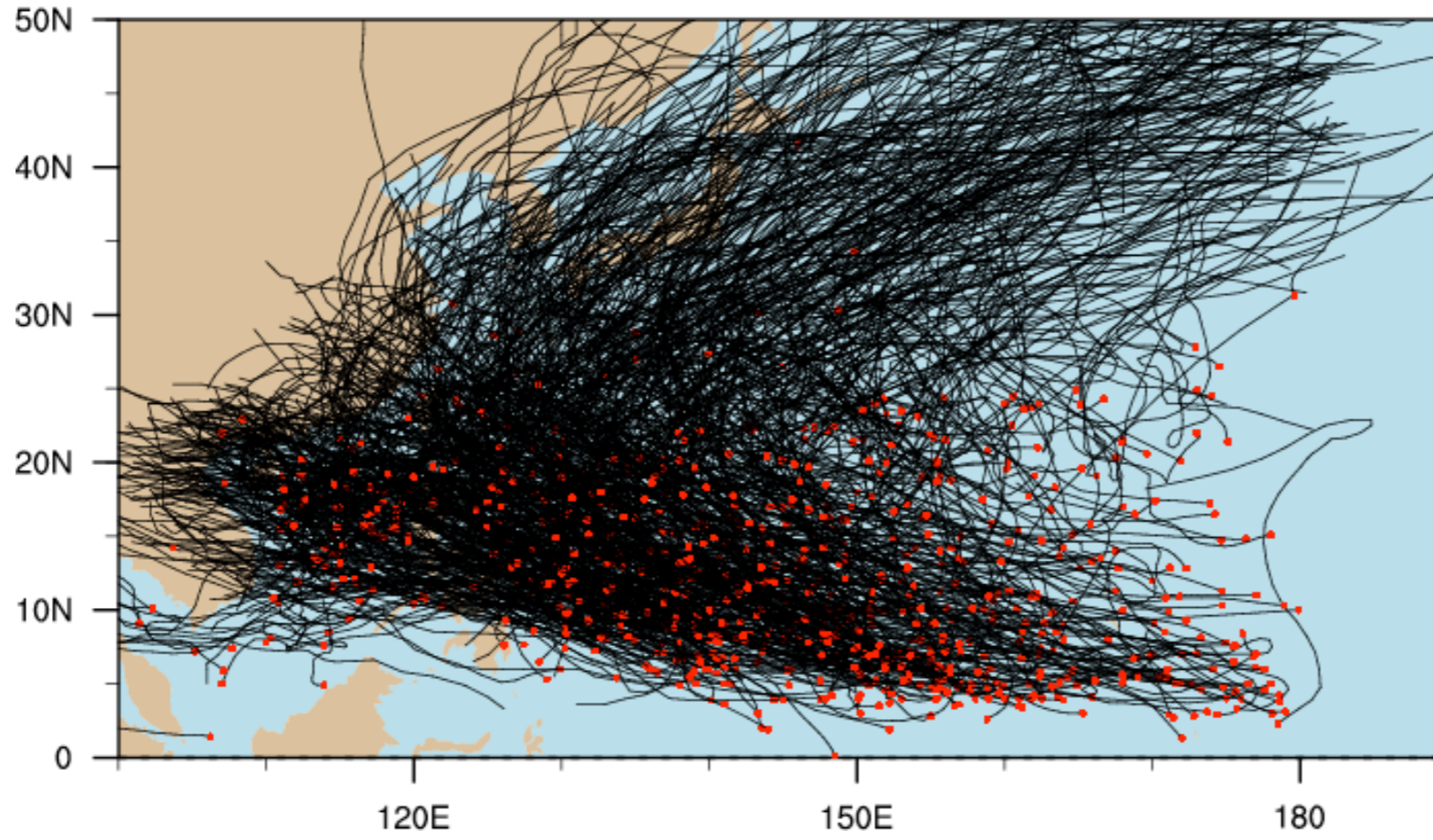
- Trajectory must last at least 1.5 days and have lowest model level wind velocity  $> 15 \text{ m/s}$  during at least 1.5 days (not necessarily consecutive)



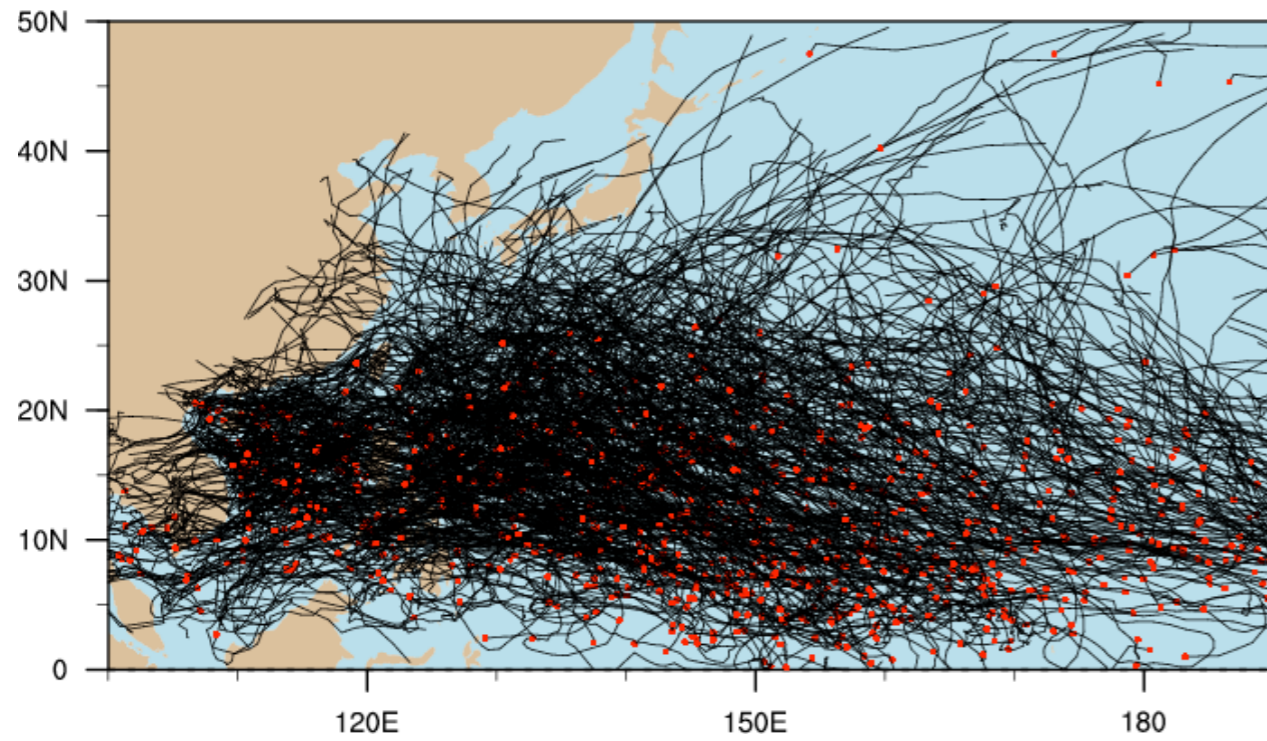
## Maximum Wind vs. Minimum Pressure



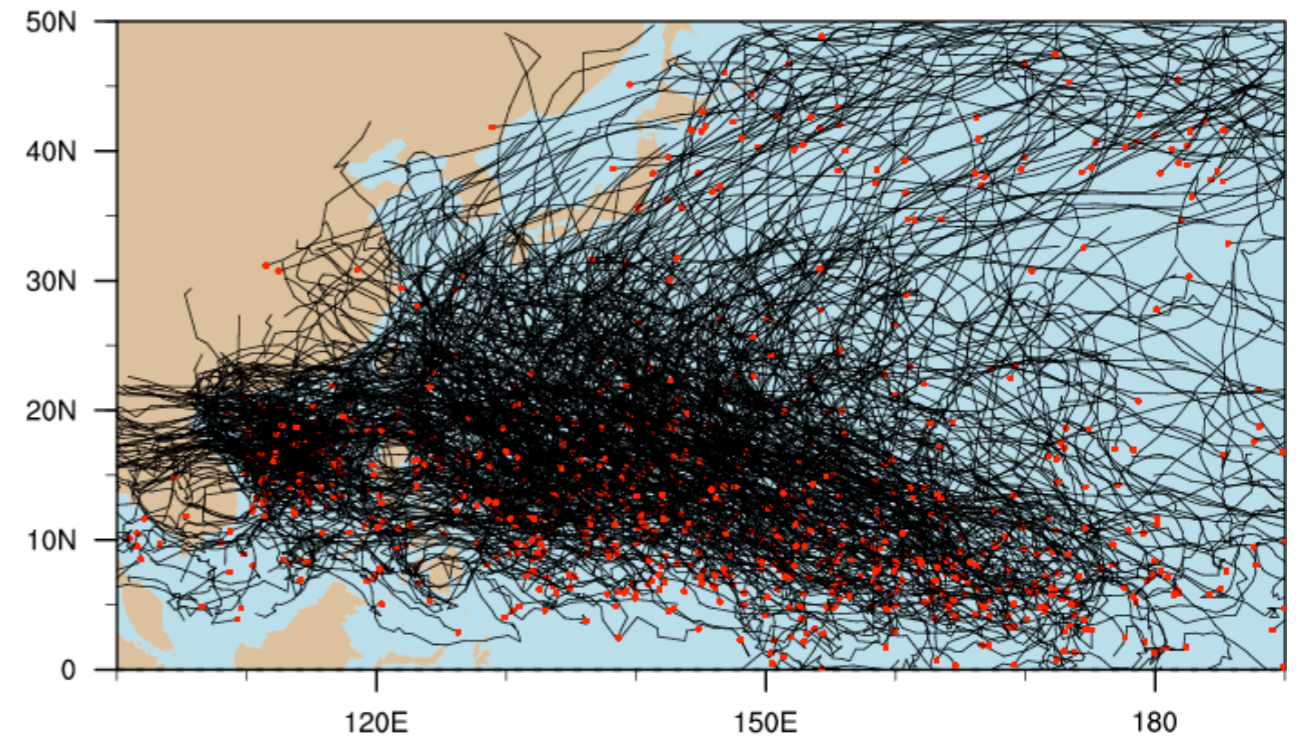
# 1979-2007 IBTrACS Tracking



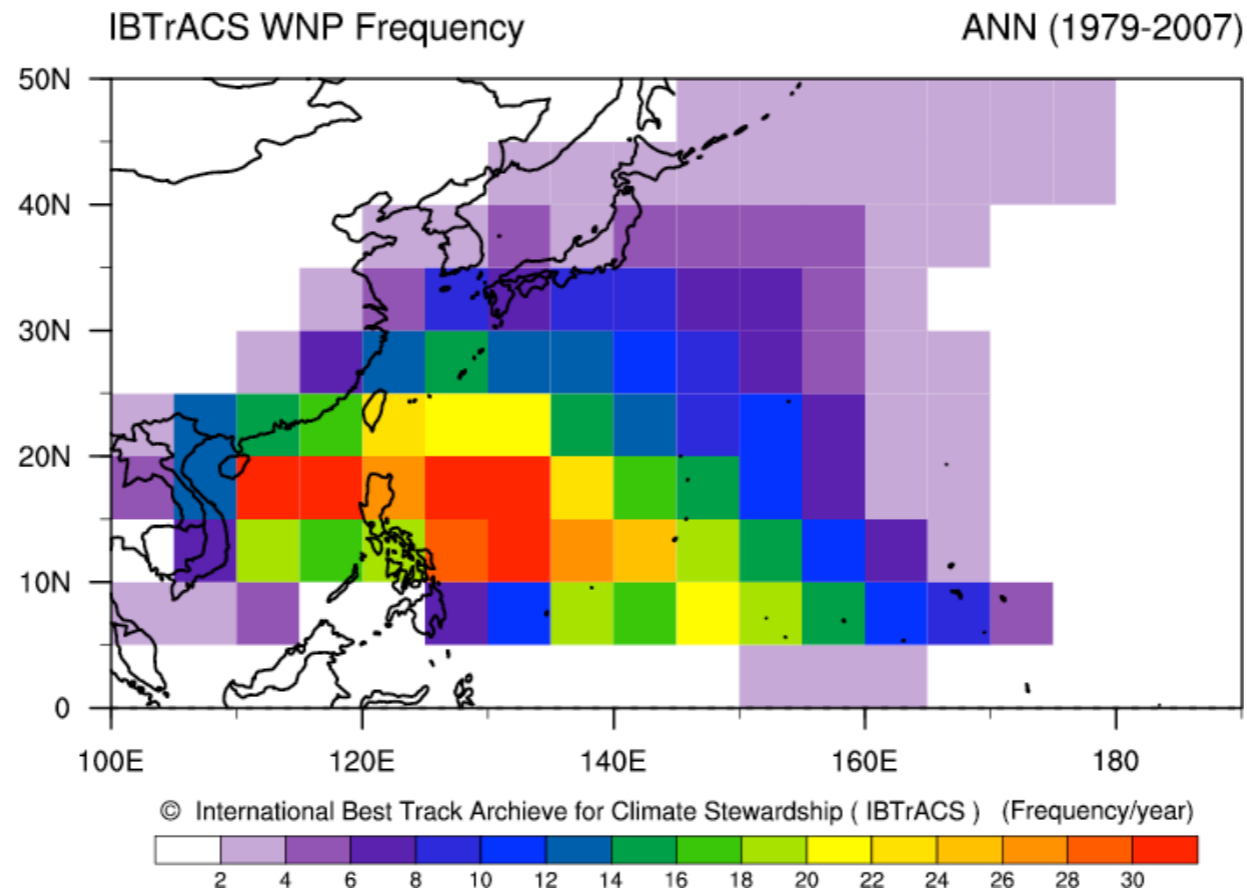
## 1979-2007 ECHAM4\_T106\_A Tracking



## 1979-2007 ECHAM5\_T106\_L31\_D Tracking

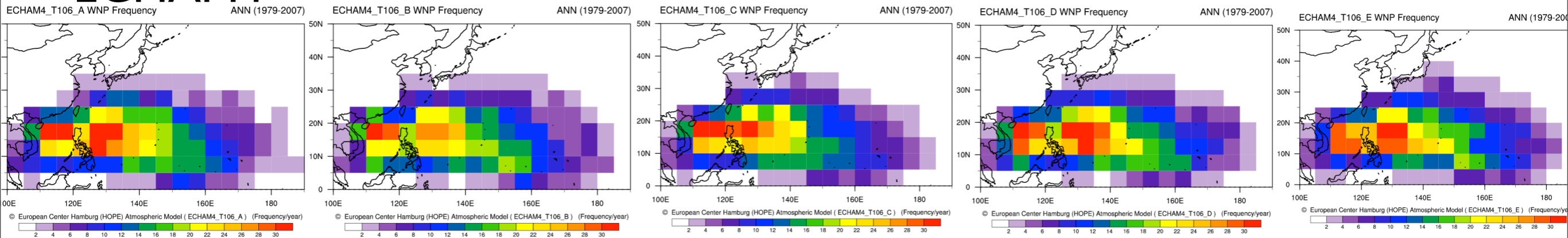


# IBTrACS

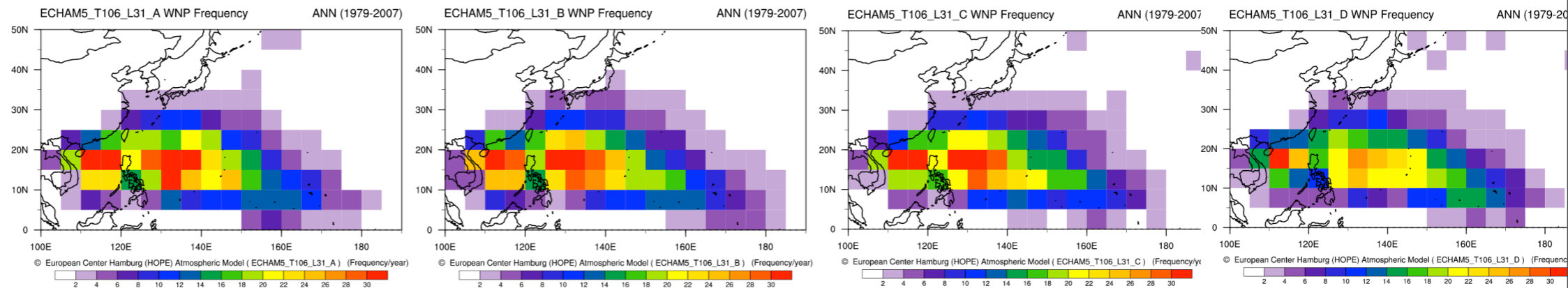


Ocurrence/year  
(6 hourly tracks)  
5°x5° box

# ECHAM4

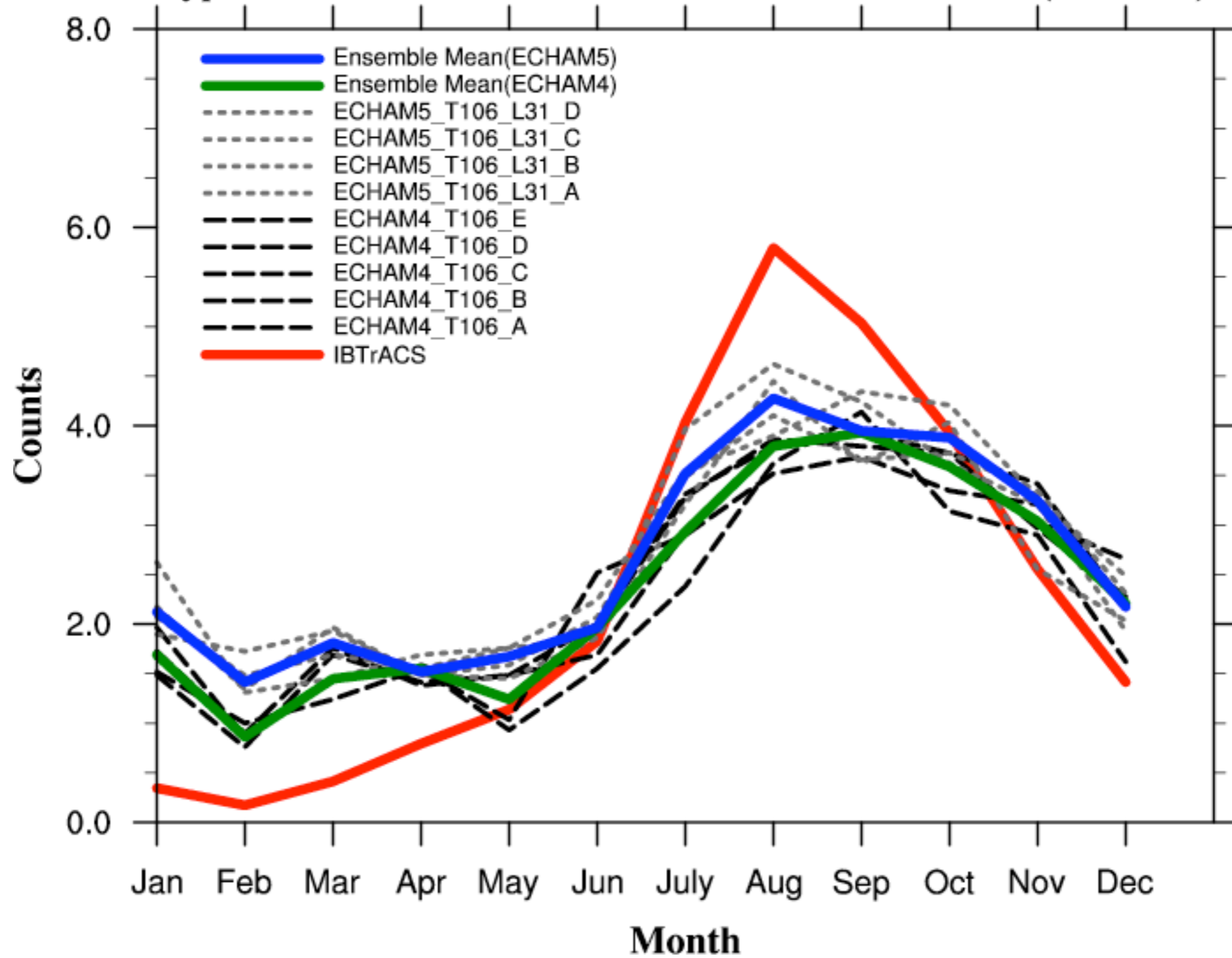


# ECHAM5



# Typhoon Counts - WNP

1979-2007 ANN (Seasonal)

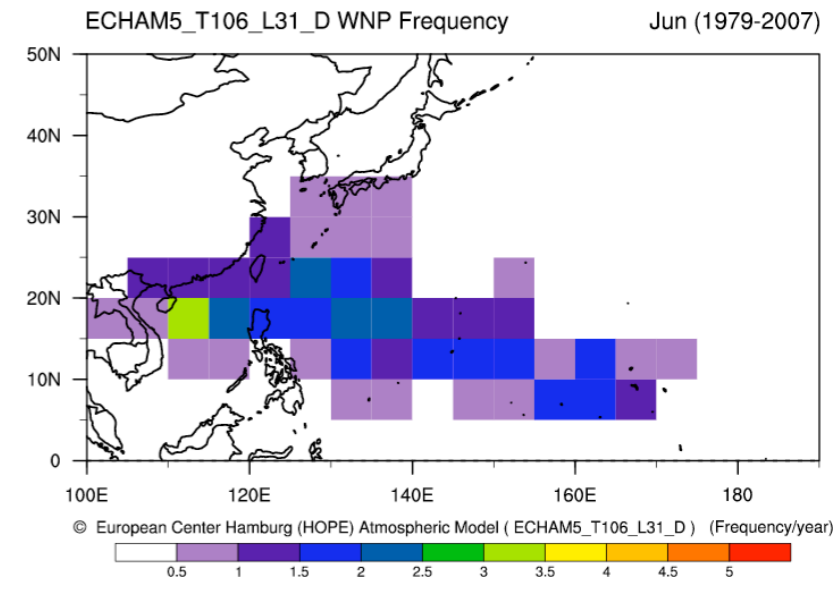
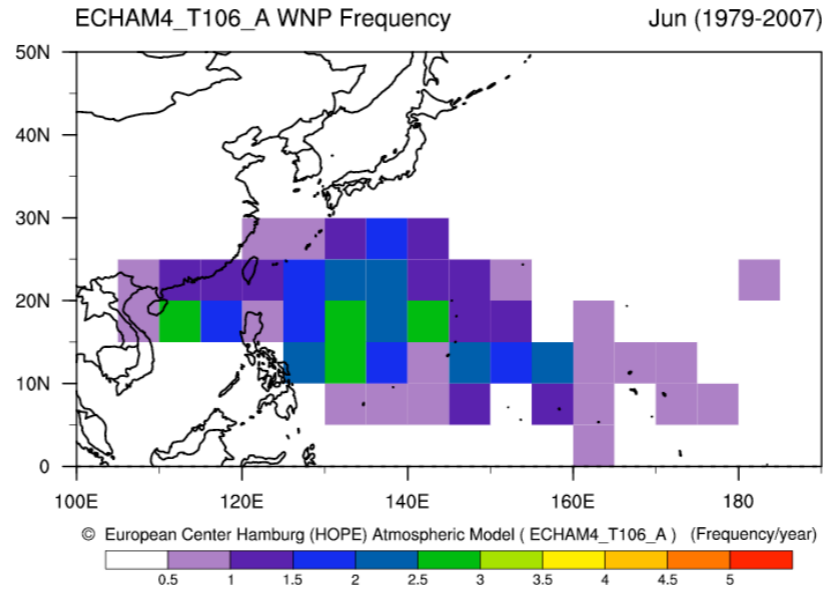
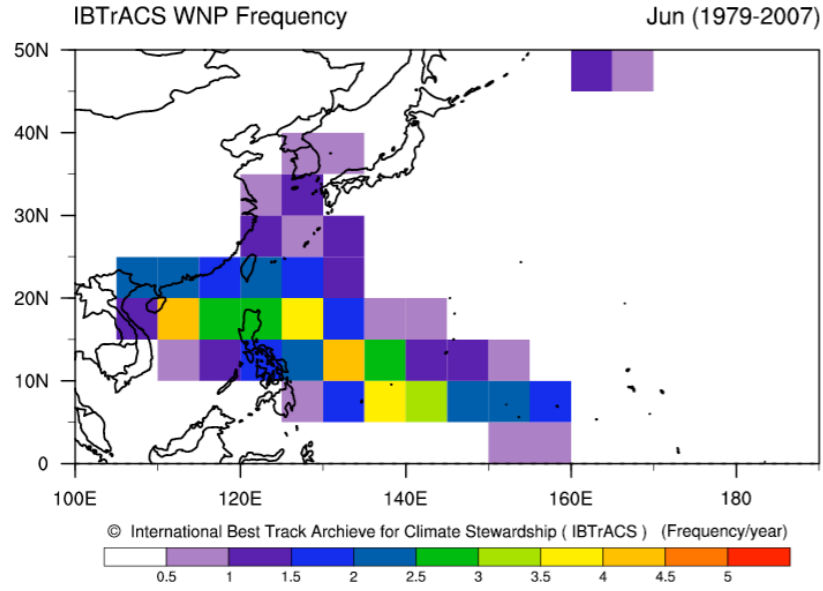


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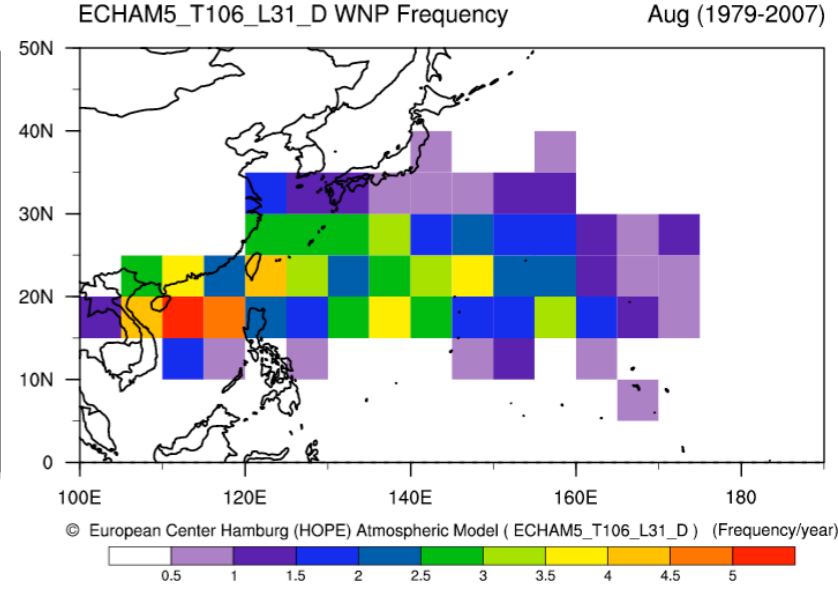
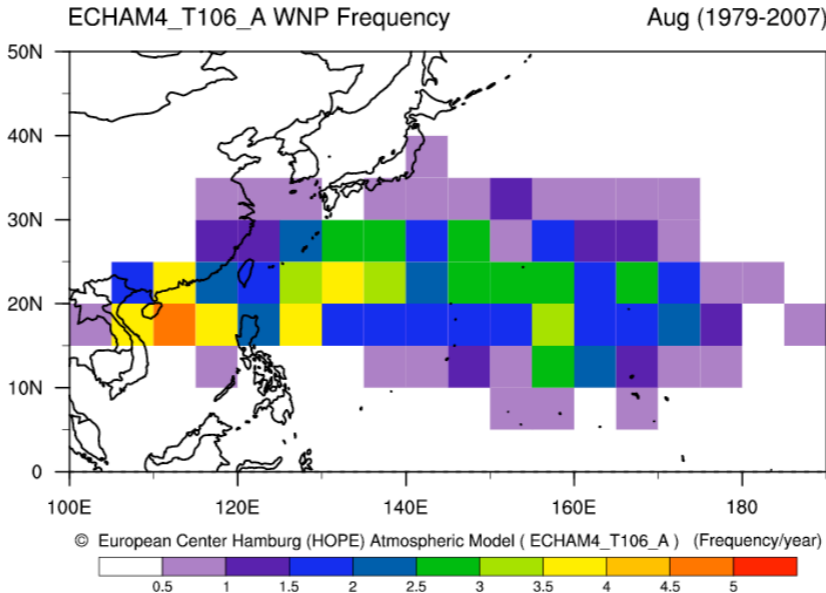
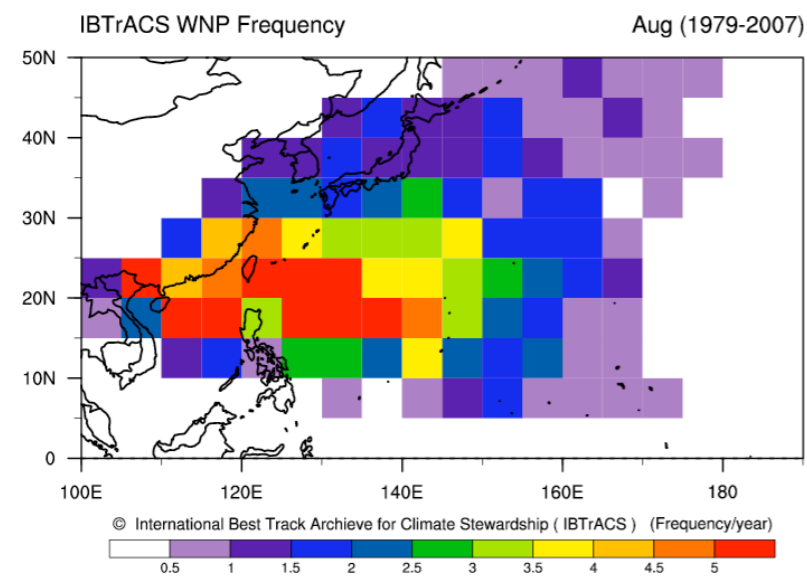
# ECHAM4

# ECHAM5

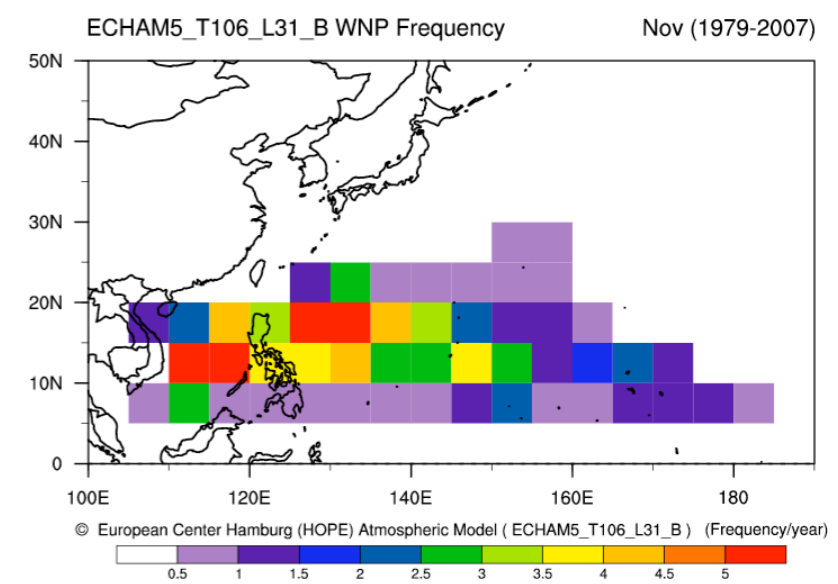
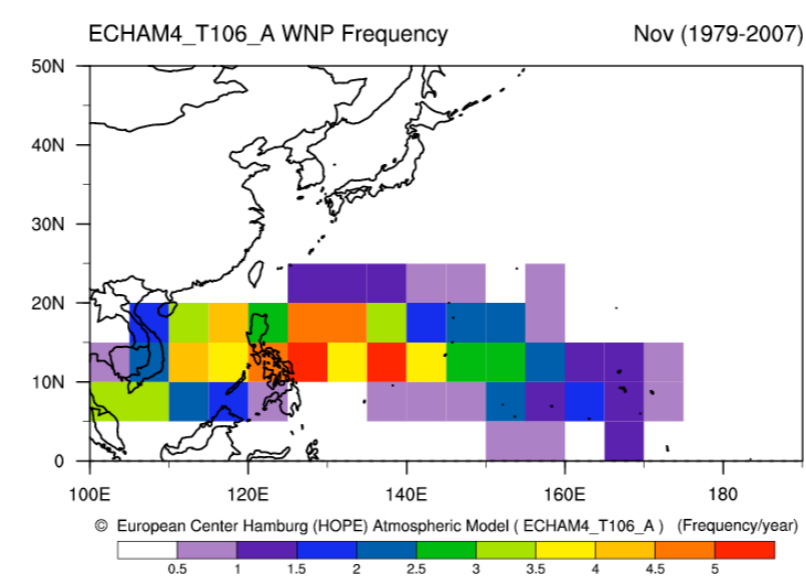
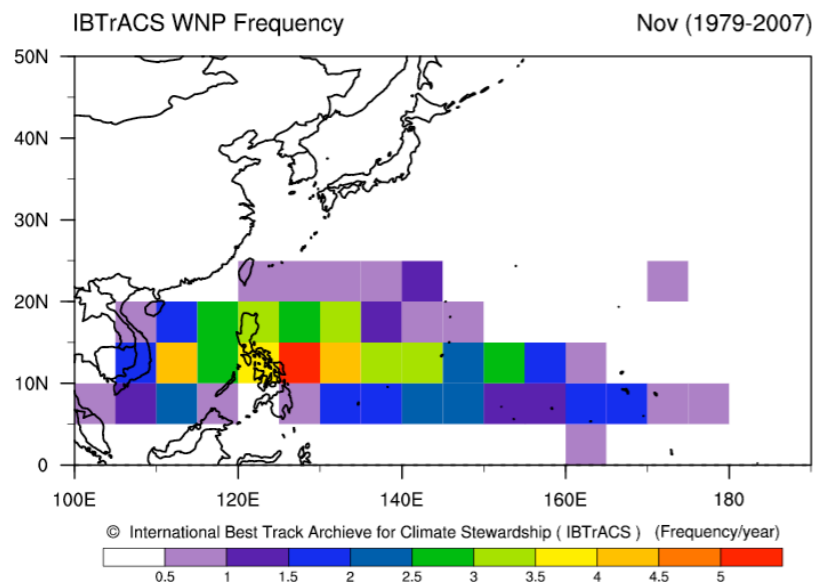
## Jun



## Aug

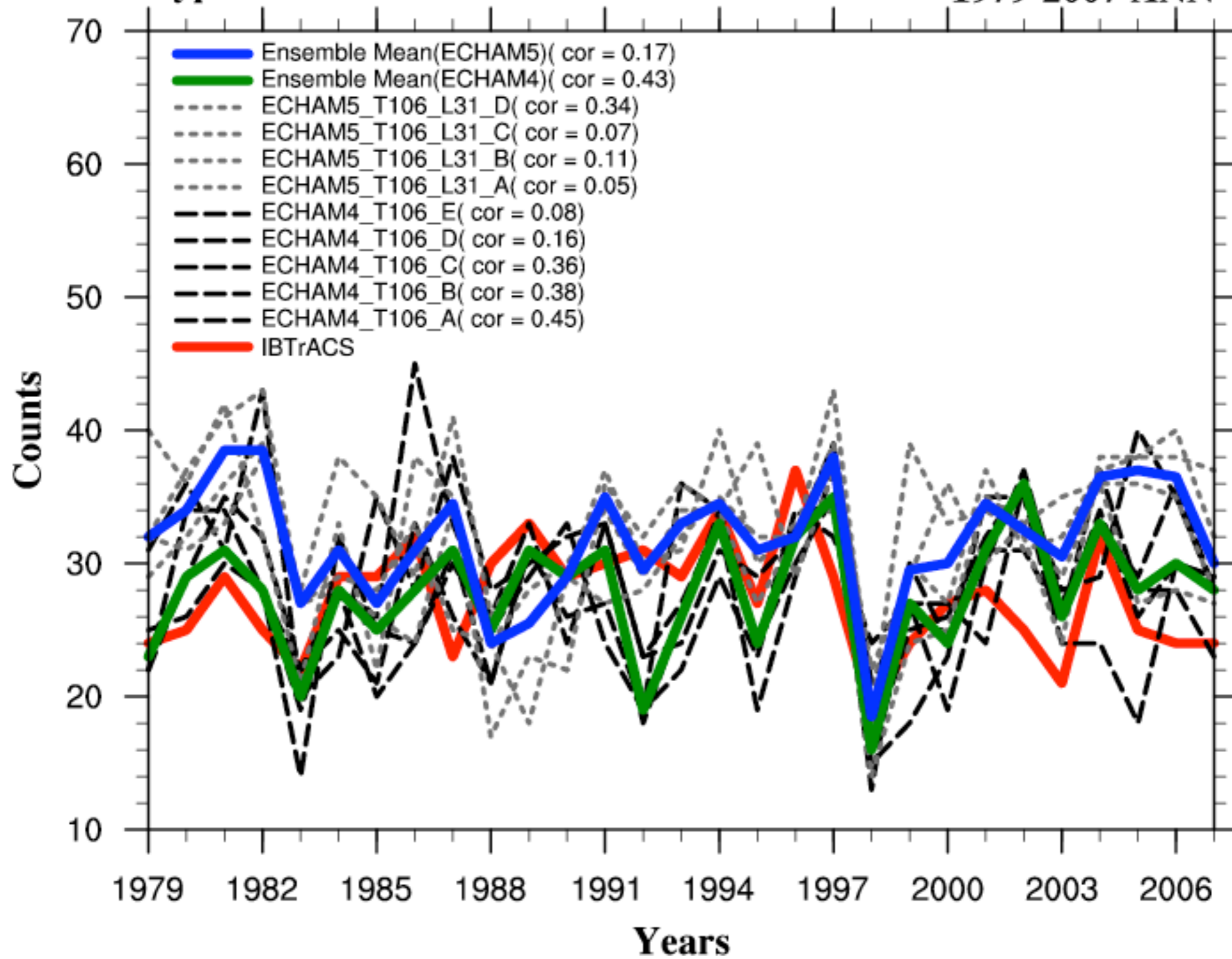


## Nov



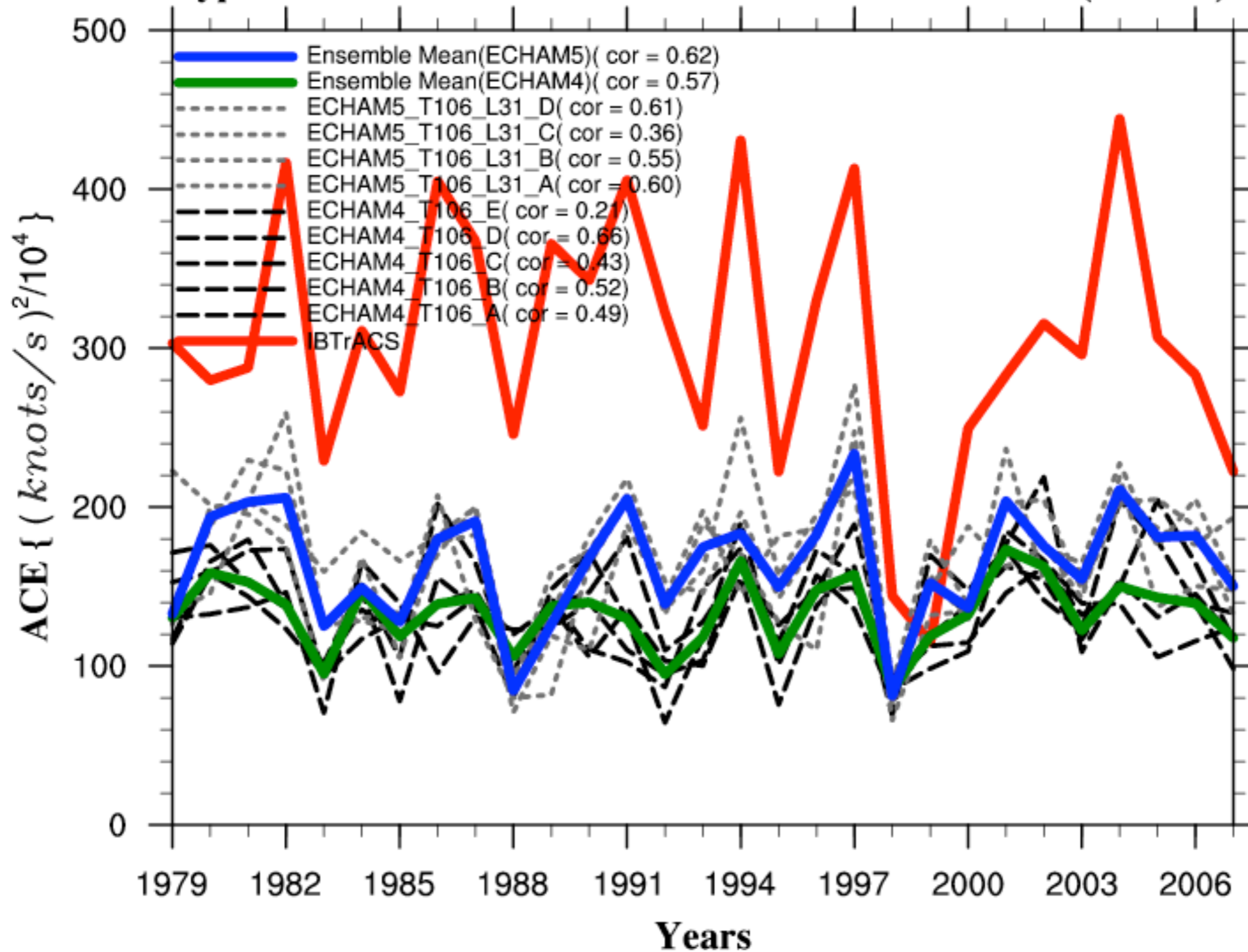
# Typhoon Counts - WNP

1979-2007 ANN



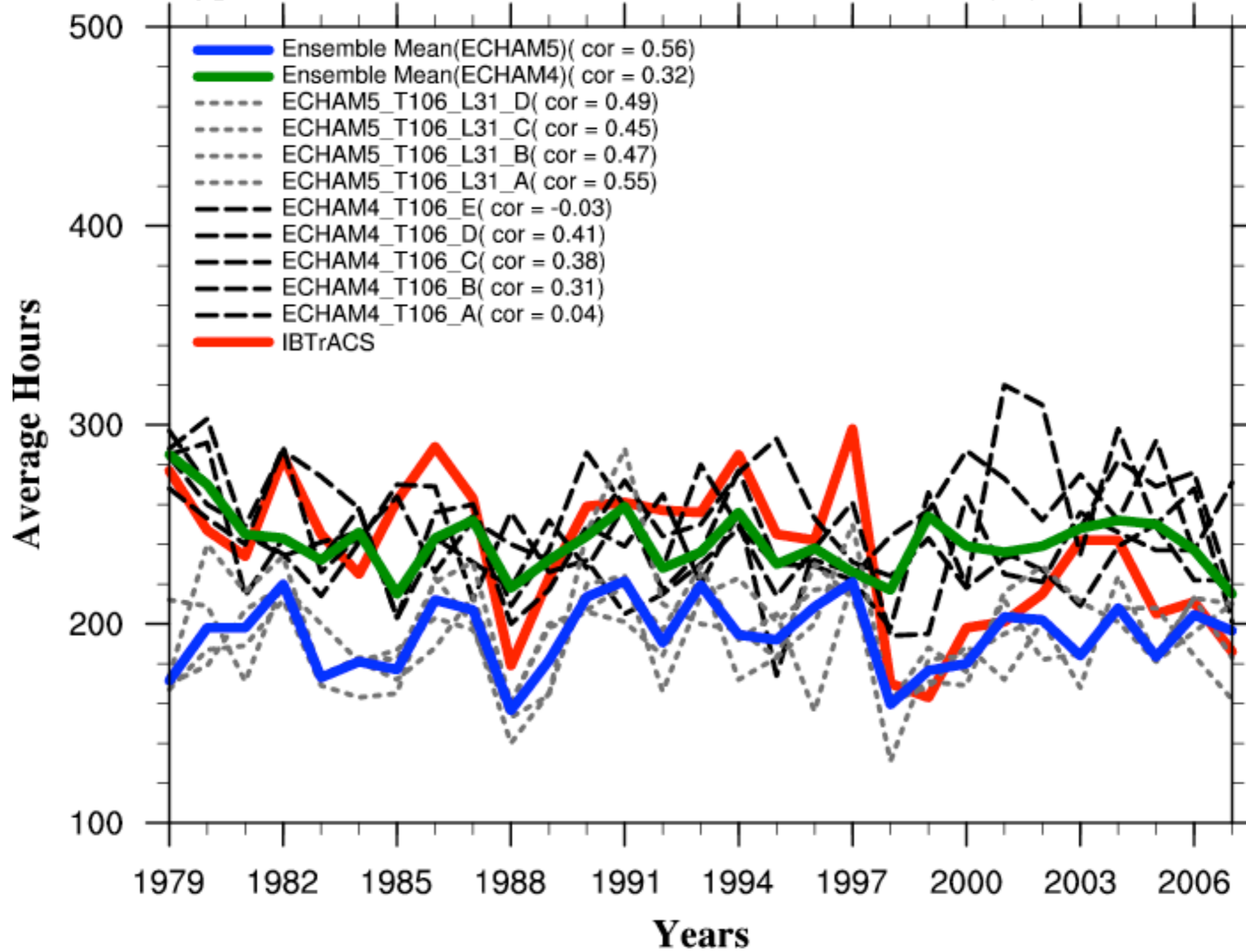
# Typhoon ACE - WNP

1979-2007 ANN (Annual)



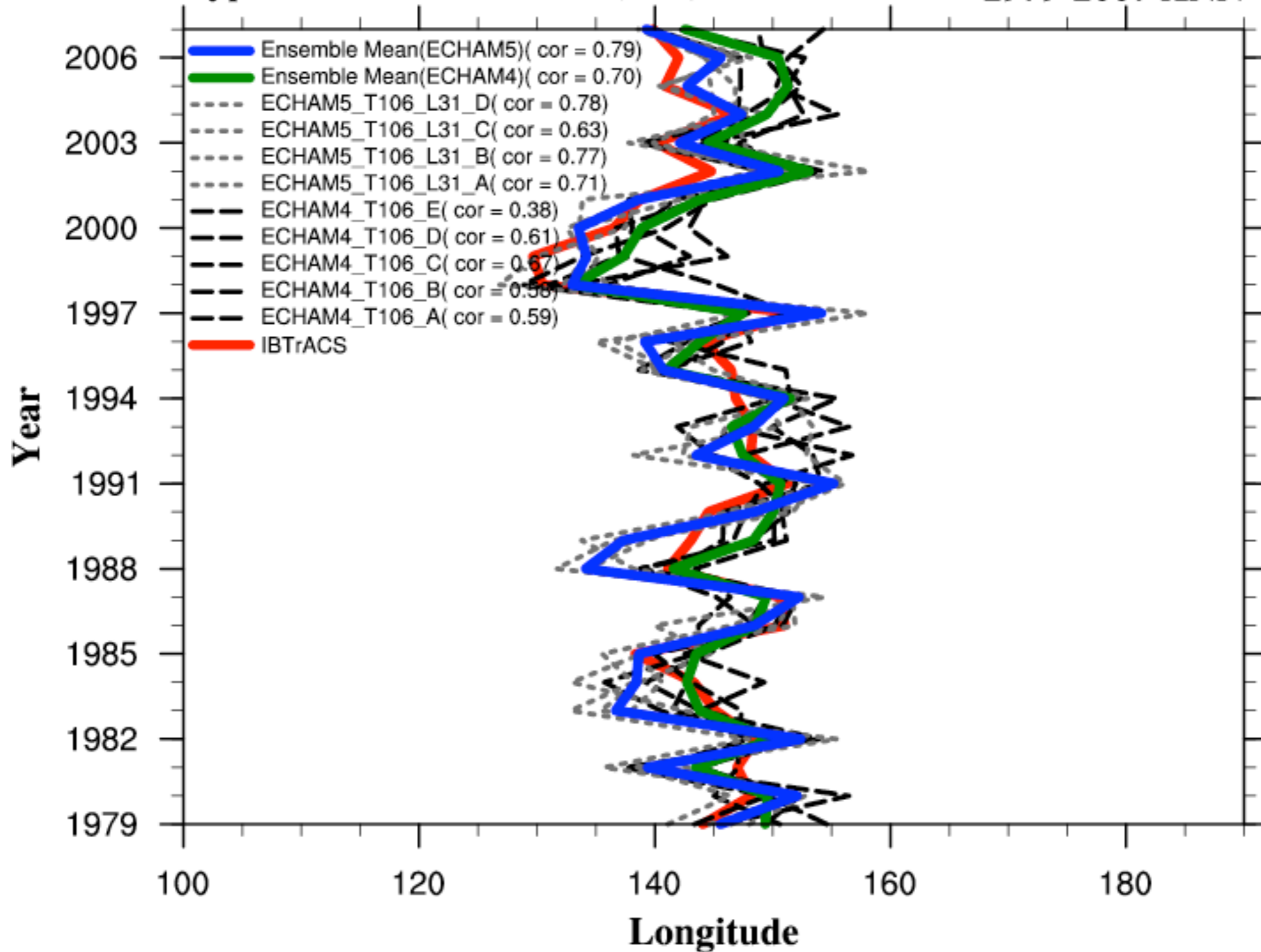
# Typhoon Lifetime - WNP

1979-2007 ANN



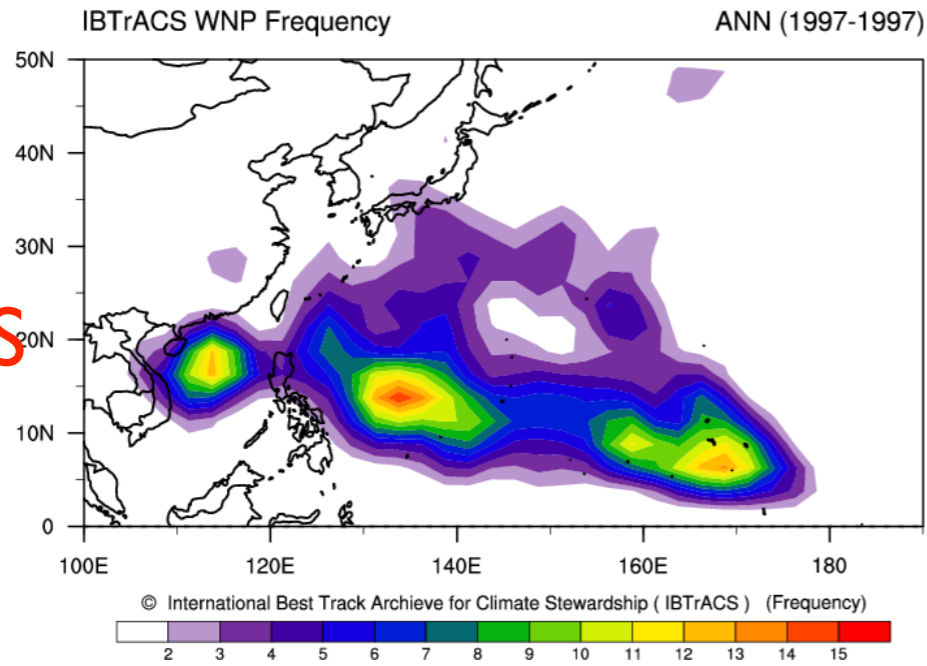
# Typhoon Genesis location(Lon) - WNP

1979-2007 ANN



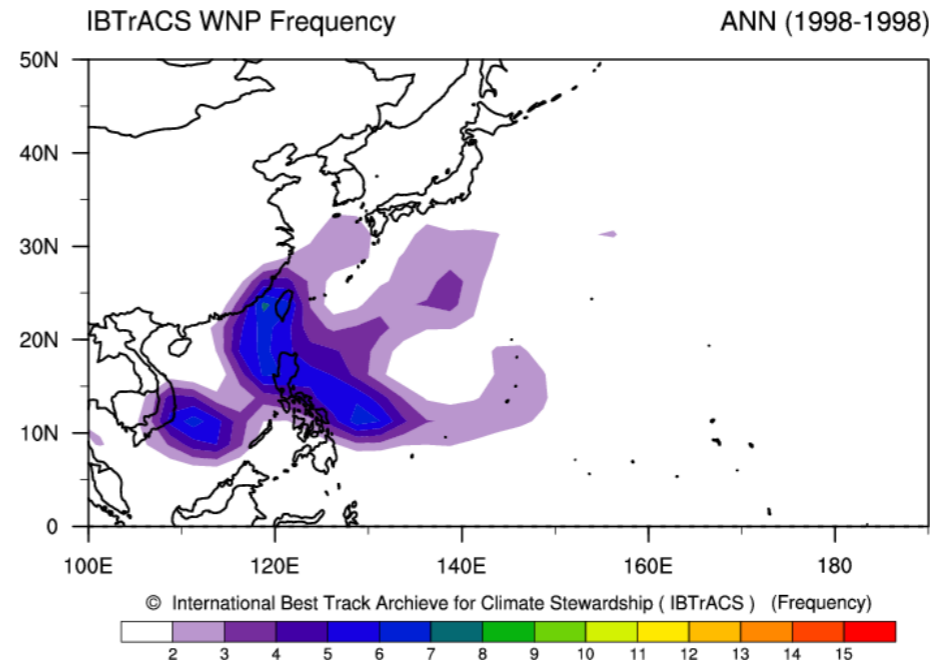
1997

IBTrACS

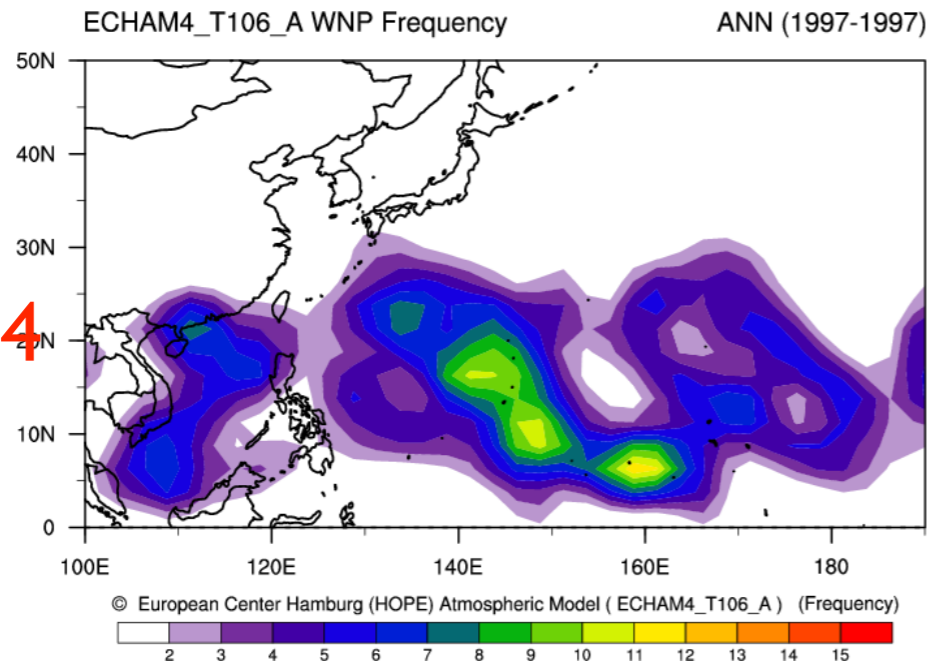


1998

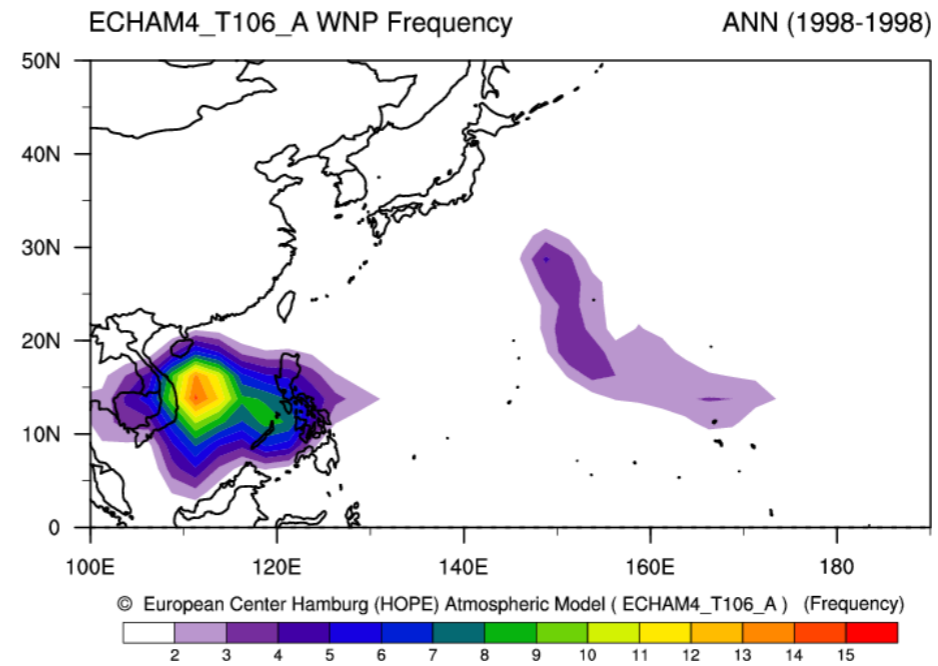
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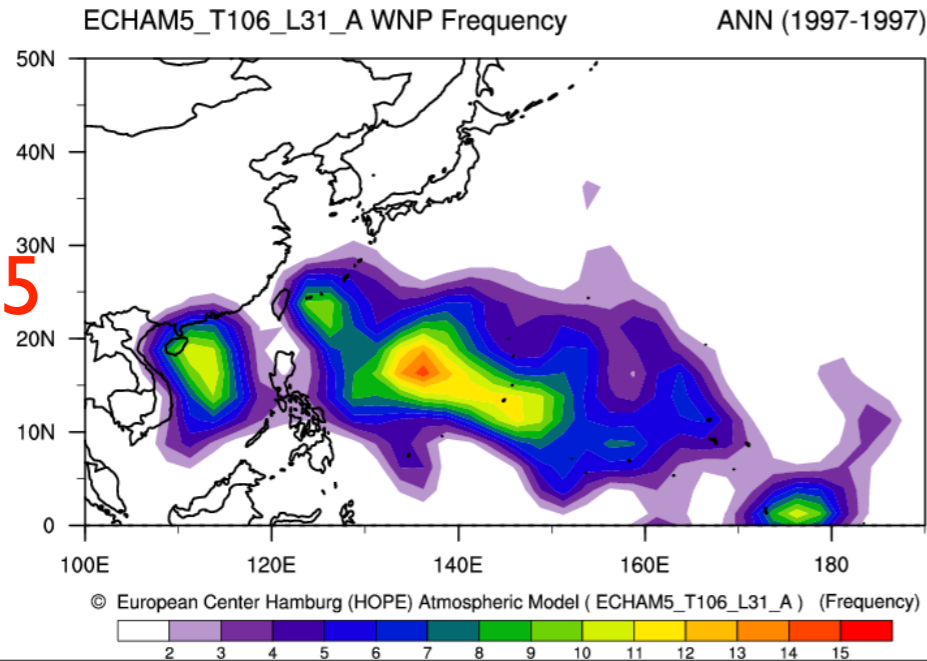
ECHAM4



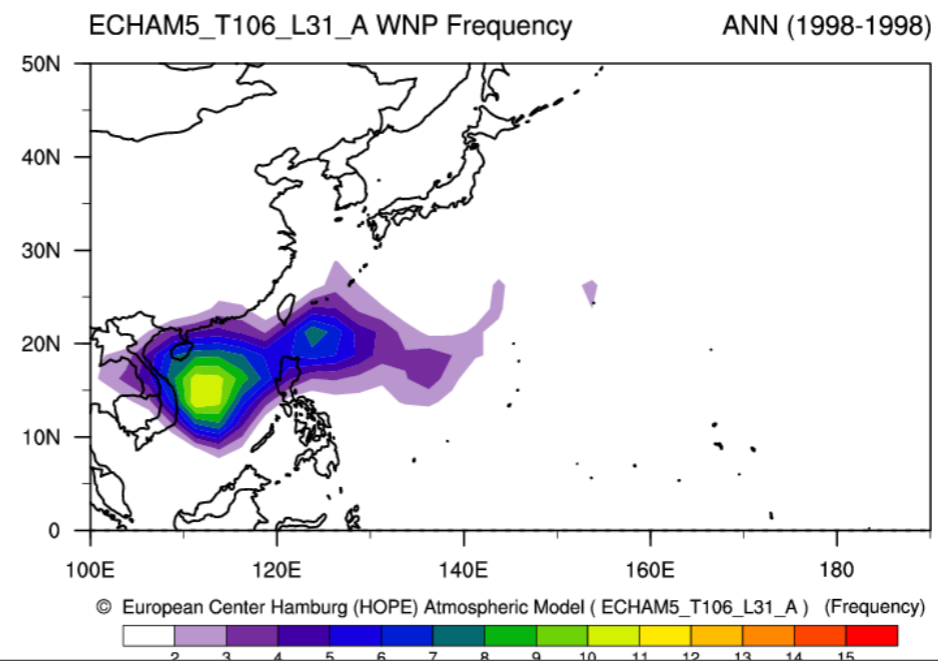
ECHAM4



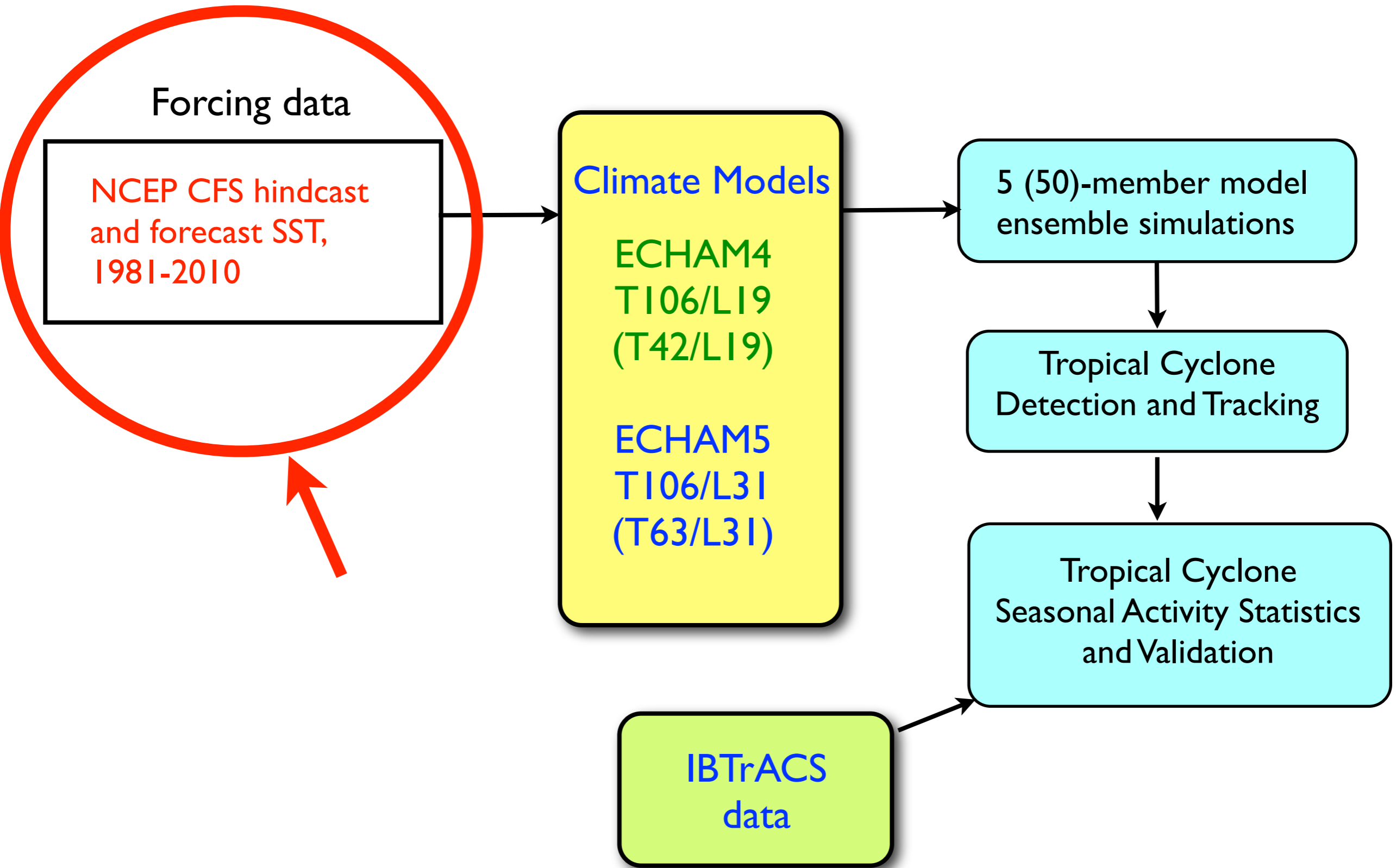
ECHAM5



ECHAM5



# Dynamical Typhoon Seasonal Prediction Experiment for NW Pacific



# Summary

- Although the tropical cyclone (TC) like vortices are generally too weak in medium resolution (T106) global climate models (ECHAM4 and ECHAM5), they exhibit reasonable skill in simulating the seasonal cycle and interannual variability of TC activities for NW Pacific basin.
- The reproducibility of the contrast in TC number and track distribution between El Nino and La Nina years demonstrate the feasibility of using dynamical model to predict TC activity over NW Pacific basin. However, the landfalling statistics still represents a major challenge for dynamical model and real usefulness of TC seasonal forecast.
- Further dynamical downscaling with regional model is possible and can provide better typhoon intensity simulation.