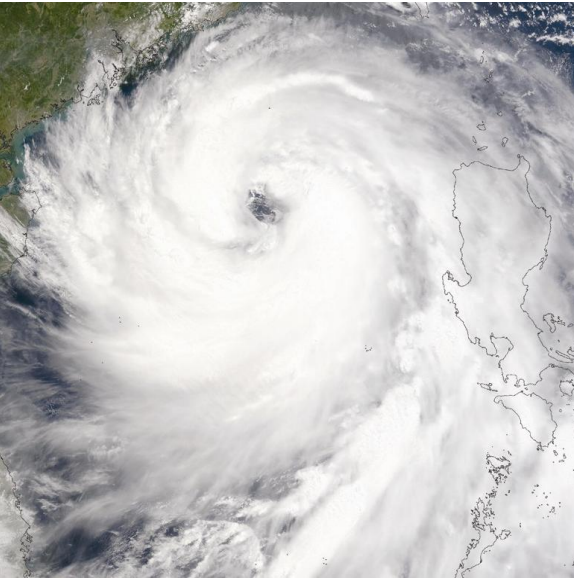




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Seasonal Tropical Cyclone Activity Prediction: Where We Stand & the Way Forward

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Outline

- **Statistical methods – where we stand**
- **Statistical dynamical method**
- **Dynamical methods**
- **Summary**

Statistical Method: Where We Stand

Statistical method

- **Identify a list of variables relating to the atmospheric and oceanographic conditions prior to the season that significantly correlate with seasonal tropical cyclone activity**
- **Perform regressions to derive prediction equations**

Examples of Predictors used in the CityU Forecasts

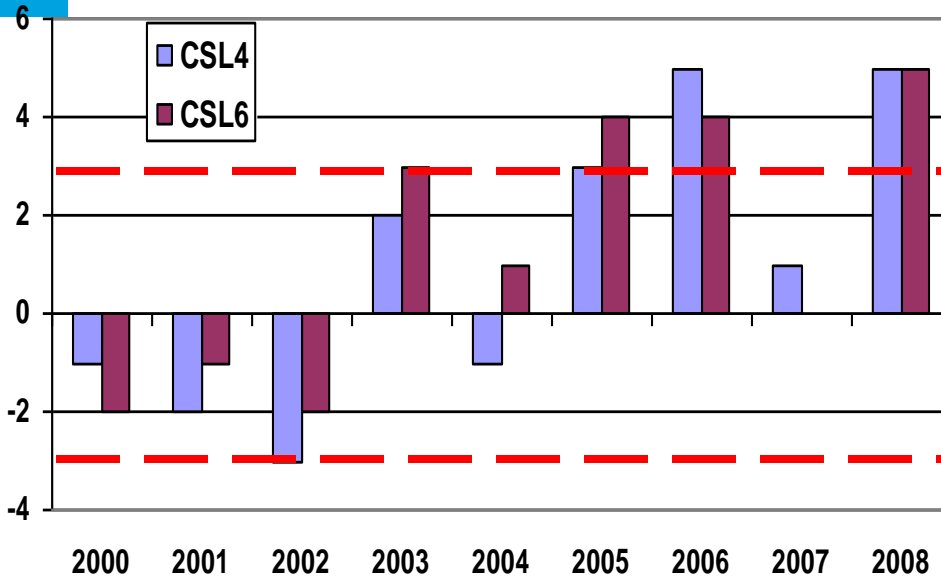
large-scale atmospheric conditions

- **Index of the westward extent of the subtropical high over the western North Pacific**
- **Index of the strength of the India-Burma trough (15-20°N, 80-120°E)**
- **West Pacific index**

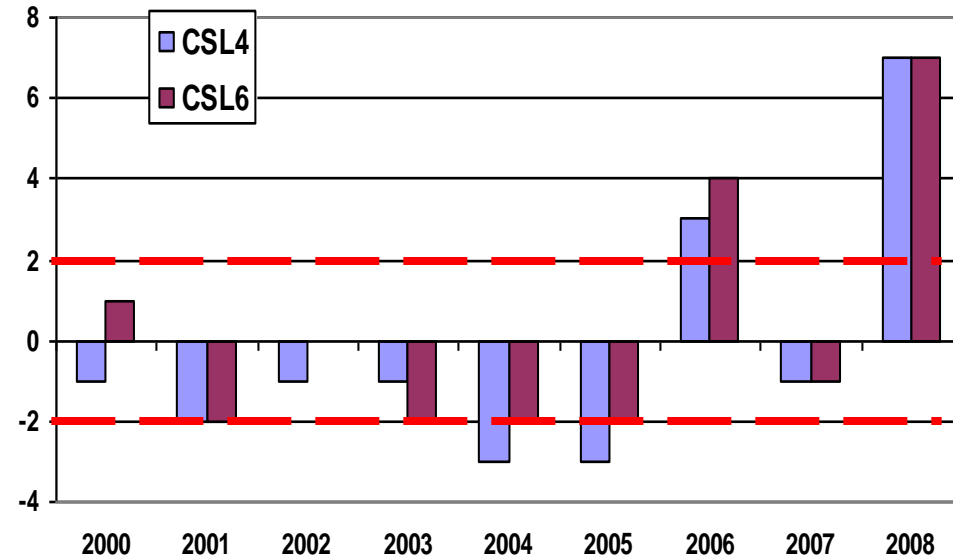
- **Sea surface temperature (SST) anomalies in the NINO3.4 region (5°S-5°N, 170-120°W)**
- **Sea surface temperature (SST) anomalies in the NINO4 region (5°S-5°N, 160°E-150°W)**
- **Equatorial Southern Oscillation Index (Equatorial SOI)**
- **Equatorial Eastern Pacific SLP - Indonesia SLP (standardized anomalies)**

ENSO conditions

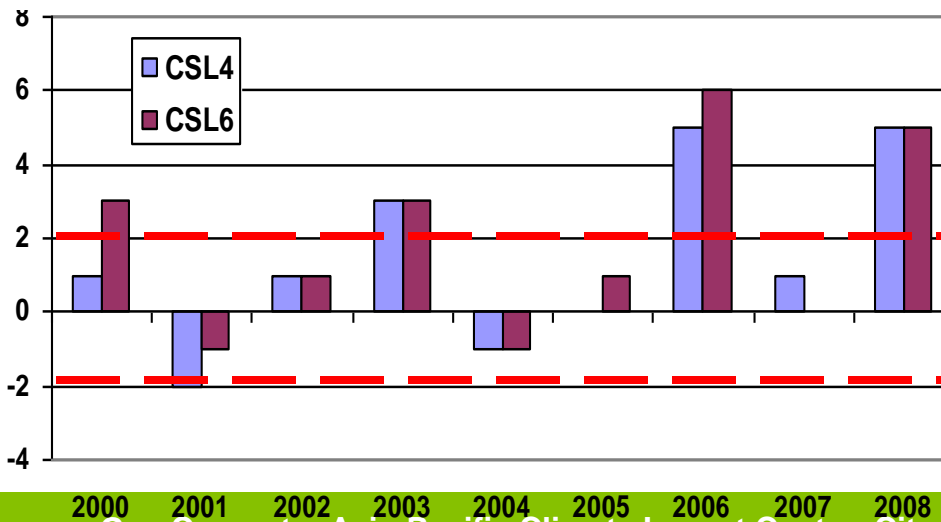
All tropical cyclones



Typhoons



Tropical storms and typhoons



Forecasts of Annual Tropical Cyclone Activity over the western North Pacific (Deviations from Observations)

Predictors used in the Tropical Storm Risk Forecasts

- **Tropical storm and typhoon (before May): Nino3 SST from prior September**
- **Tropical storm and typhoon (from May): April MSLP within (17.5-35°N, 160°E-175°W); forecast number of intense typhoons for that year**
- **Intense typhoons (before May): Mar and Apr MSLP within (10-20°N, 145-165°W);**
- **Intense typhoons (from May): Predicted SST for Aug and Sep within (5°S-5°N, 140-180°W)**

Forecasts from Tropical Storm Risk

NW Pacific ACE Index and System Numbers 2009

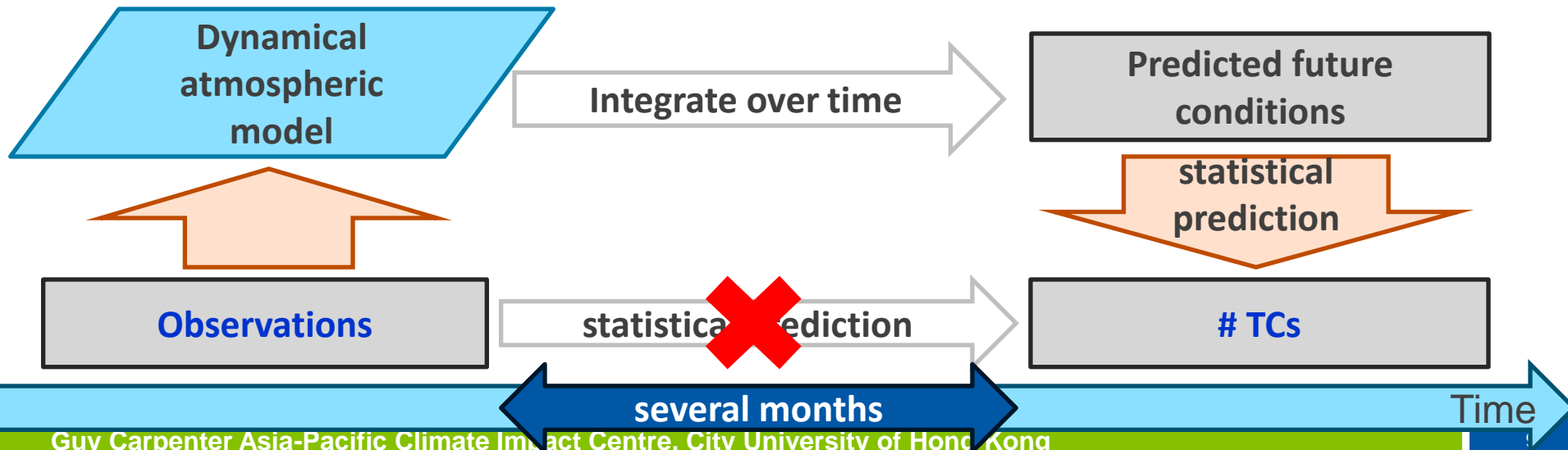
		ACE Index ($\times 10^4$ knots ²)	Intense Typhoons	Typhoons	Tropical Storms
Average Number (\pm SD) (1965-2008)		300 (\pm 98)	8.6 (\pm 3.0)	16.7 (\pm 3.6)	26.6 (\pm 4.3)
TSR Forecasts (\pm FE)	6th Jul 2009	359 (\pm 83)	10.3 (\pm 2.4)	18.1 (\pm 3.0)	28.0 (\pm 3.9)
	7th May 2009	319 (\pm 80)	9.1 (\pm 2.5)	17.6 (\pm 3.0)	27.5 (\pm 3.8)
	16th Mar 2009	247 (\pm 89)	6.7 (\pm 2.6)	16.0 (\pm 3.4)	25.6 (\pm 3.9)
Chan Forecasts	24th Jun 2009	-	-	19	27
	18th Apr 2009	-	-	18	27

An aerial photograph of a tropical cyclone, showing a well-defined eye and spiral cloud bands over a dark ocean. The image is in grayscale and serves as the background for the slide.

Statistical Dynamical Method

Statistical vs. Statistical-dynamical Methods

- **Problem with the statistical method**
 - **Relate the past events and future conditions by statistics**
 - **Inherent problem**
 - **assumes the future would behave the same as the past, which may not be correct**
- **Statistical-dynamical method partly solves the inherent problem by**
 - relating dynamical model predictions with future conditions



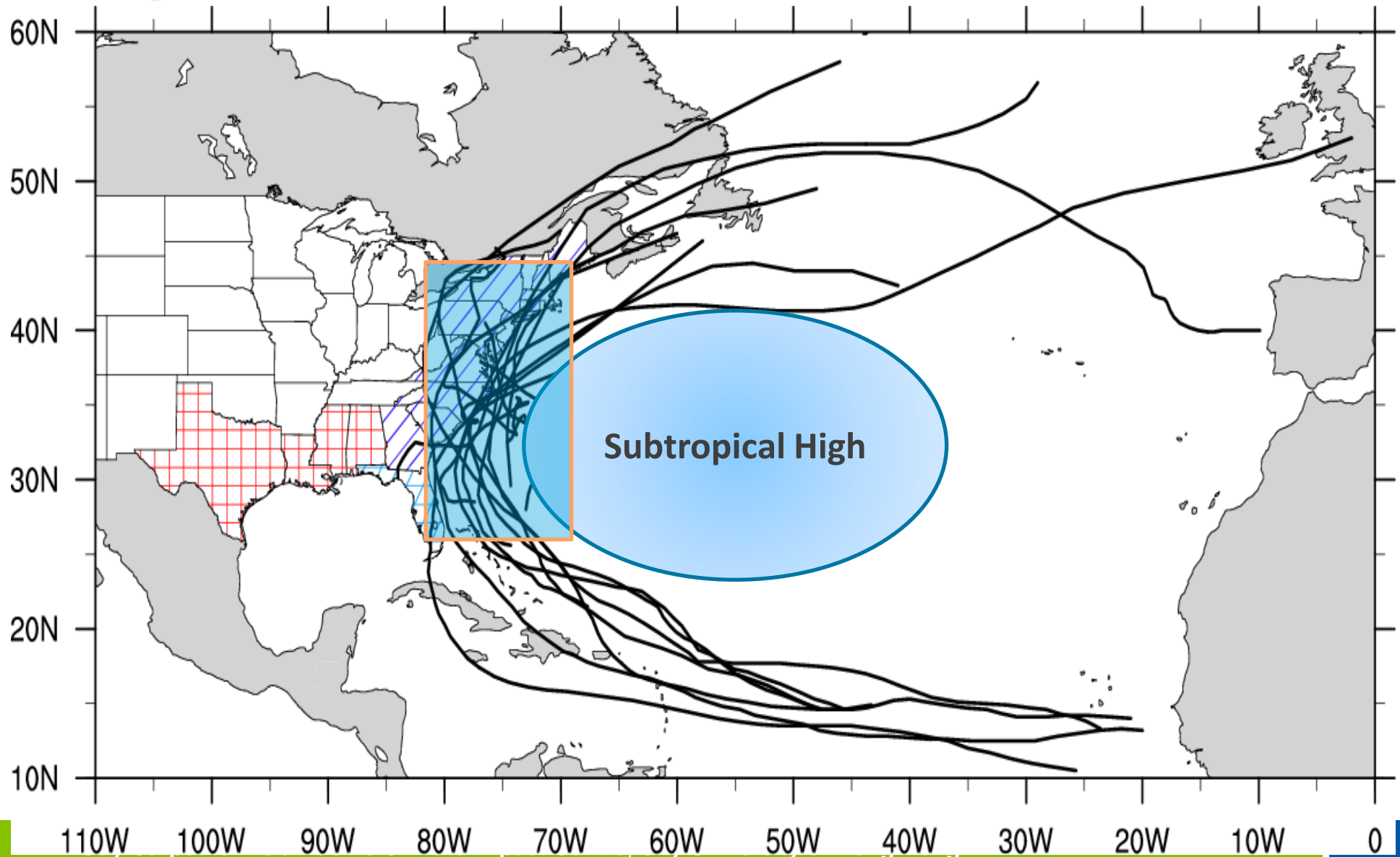
Dynamical model data – DEMETER

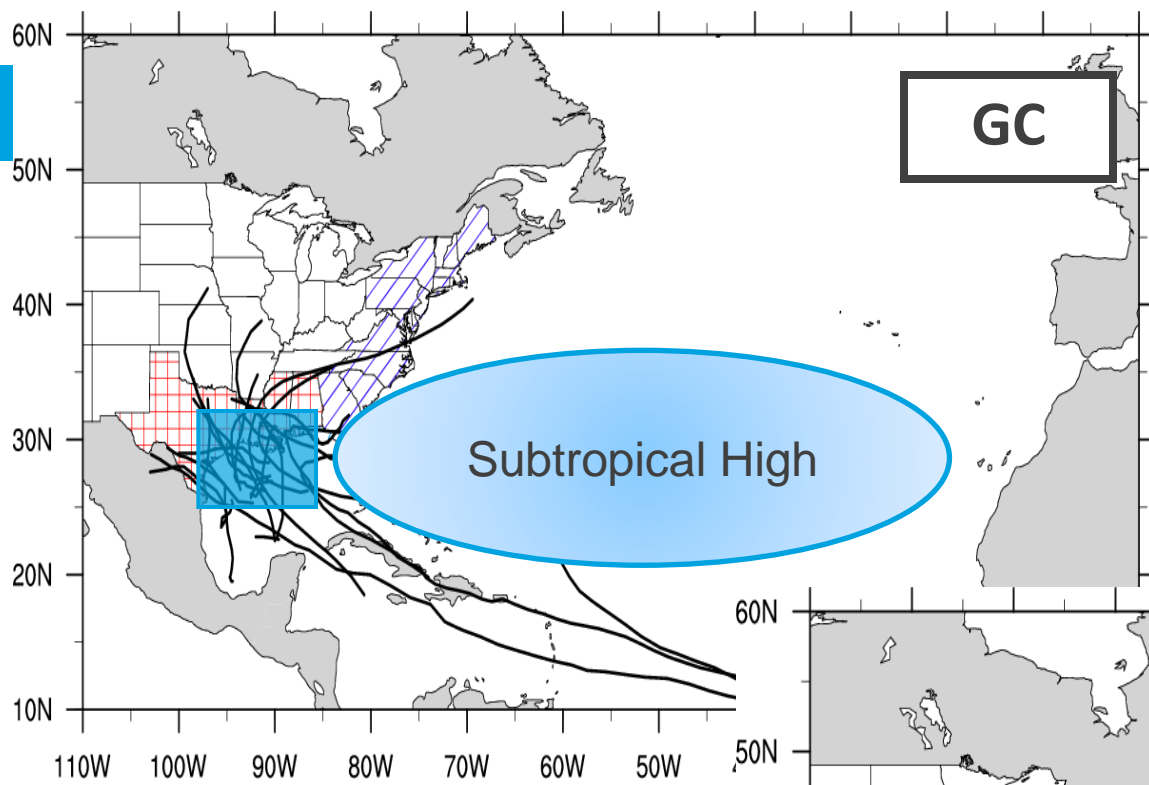
- **Development of a European multimodel ensemble system for seasonal to interannual prediction (from European Union)**
 - **7 models (CERFACS, ECMWF, INGV, LODYC, Météo-France, MPI and UKMO)**
 - **9 ensemble members each**
 - **6 months forecasts available**
 - **Base time @ 1 Feb, May, Aug, Nov**
 - **1980-2001 (22 years hindcast)**
 - **2.5 x 2.5 degree resolution**

Dynamical model data – DEMETER

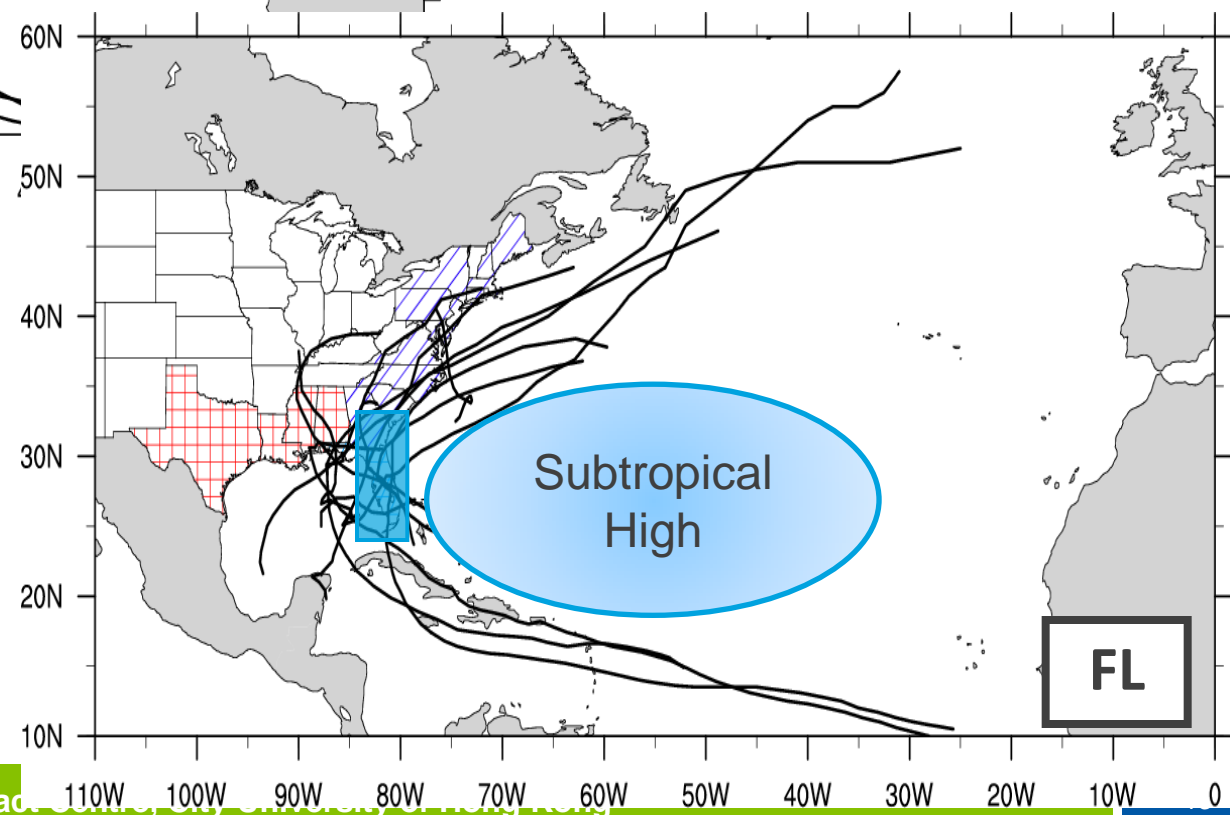
Parameter	Physics
Geopotential (200-, 500-, 850-hPa)	subtropical high
Wind fields (200-, 500-, 850-hPa)	steering flow
SST	TC genesis
Sea-level pressure (SLP)	subtropical high, low for TC genesis

Tracks of EC landfalling TCs 1980 – 2001, Aug – Sept





**Tracks of FL/GC
landfalling TCs
1980 – 2001,
Aug – Sept**



Methodology

- **Compute the 9-member ensemble mean of each model-predicted atmospheric fields (Aug-Sept)**
 - **geopotential, zonal and meridional winds (850, 500 and 200 hPa)**
 - **SST, SLP**
- **Extract the first 4 EOF modes of each predictor fields**
 - **11 fields x 4 modes = 44 potential predictors from each DEMETER model**
- **Test the statistical significance of the relationship between the coefficient of each mode and the number of landfalling TCs**

Methodology

- **Fit a forecast equation for the number of landfalling TCs in each region**
 - **Poisson regression**
 - **Cross-validation (Jackknife method)**
- **7 forecast equations, each from an individual model**
- **Multimodel equation derived from the 7 equations**
 - **Simple average**
 - **Agreement coefficient weighted-average**

Regression

- **Linear regression is used in most previous studies**
 - **Normality assumption of predictors and predictand**
 - **Fails in # landfalling TCs (Discrete non-negative integers)**
- **Poisson regression**
 - **Discrete probability distribution**
 - **Zero probability for negative numbers**
- **Stepwise regression**

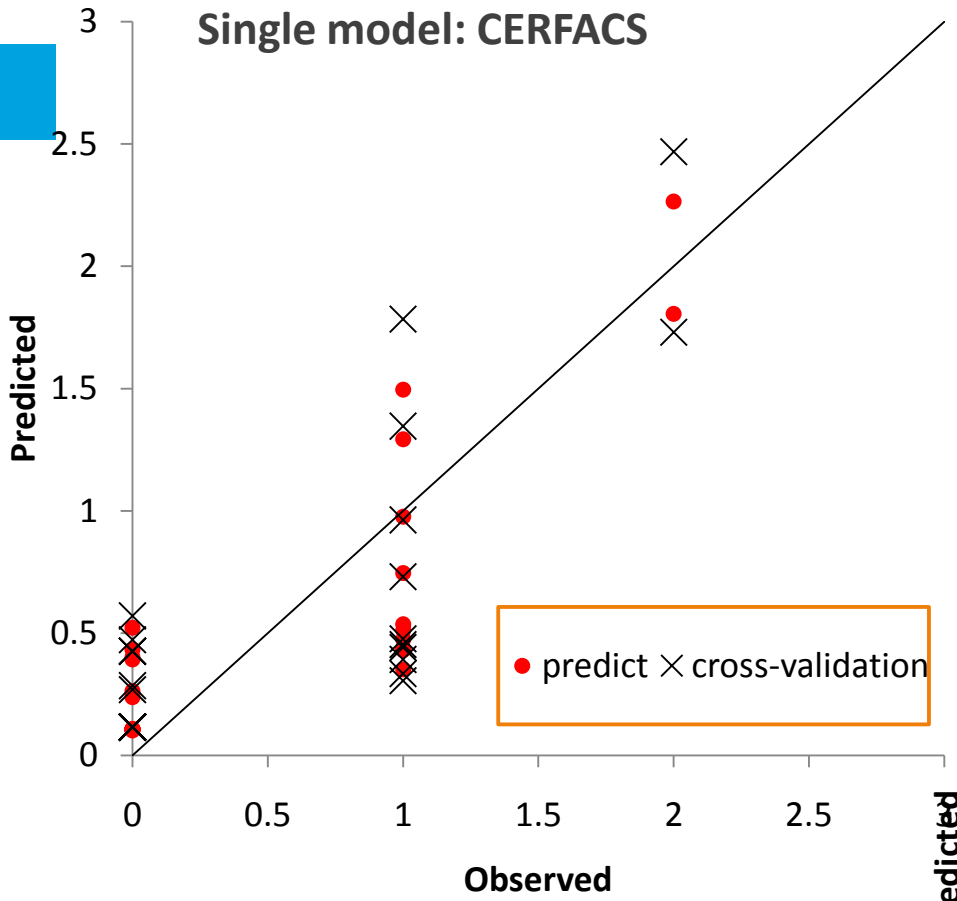
Factors affecting EC landfalling TCs

Model CERFACS

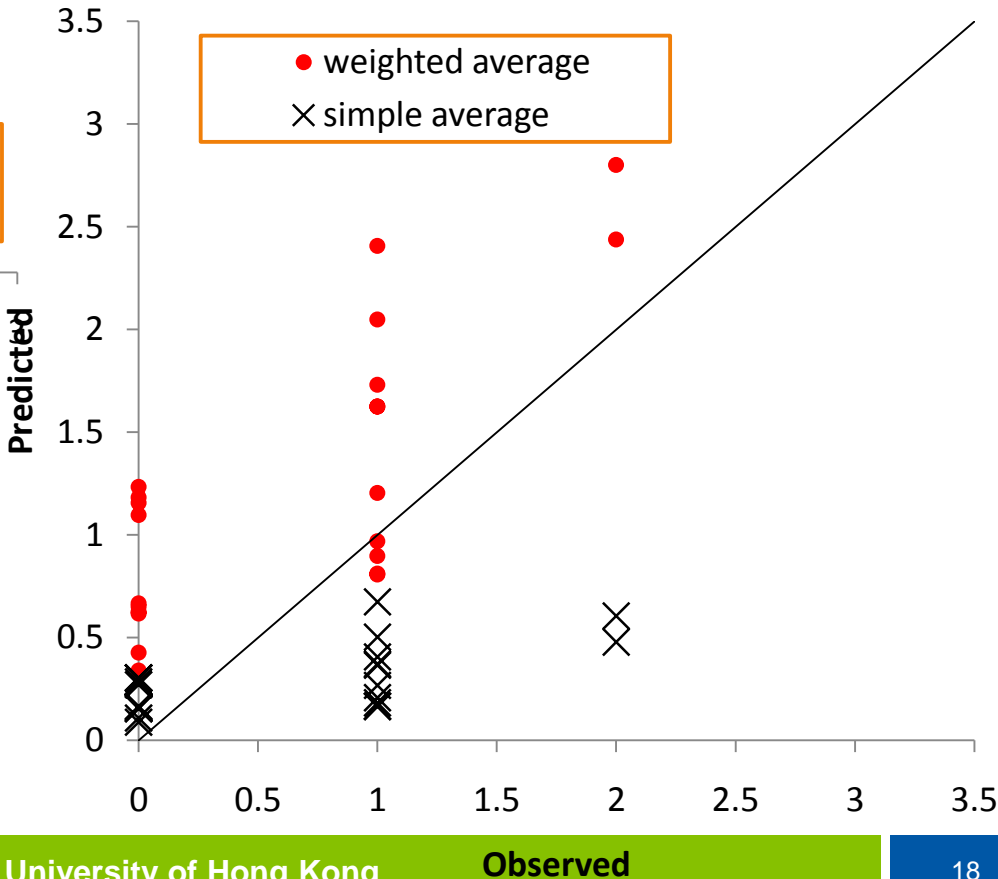
Level	Parameter	EOF mode
200 hPa	zonal wind	1
	zonal wind	3
	geopotential	1
500 hPa	zonal wind	1
	geopotential	1
	geopotential	4
850 hPa	meridional wind	1
surface	SST	1
	MSLP	1

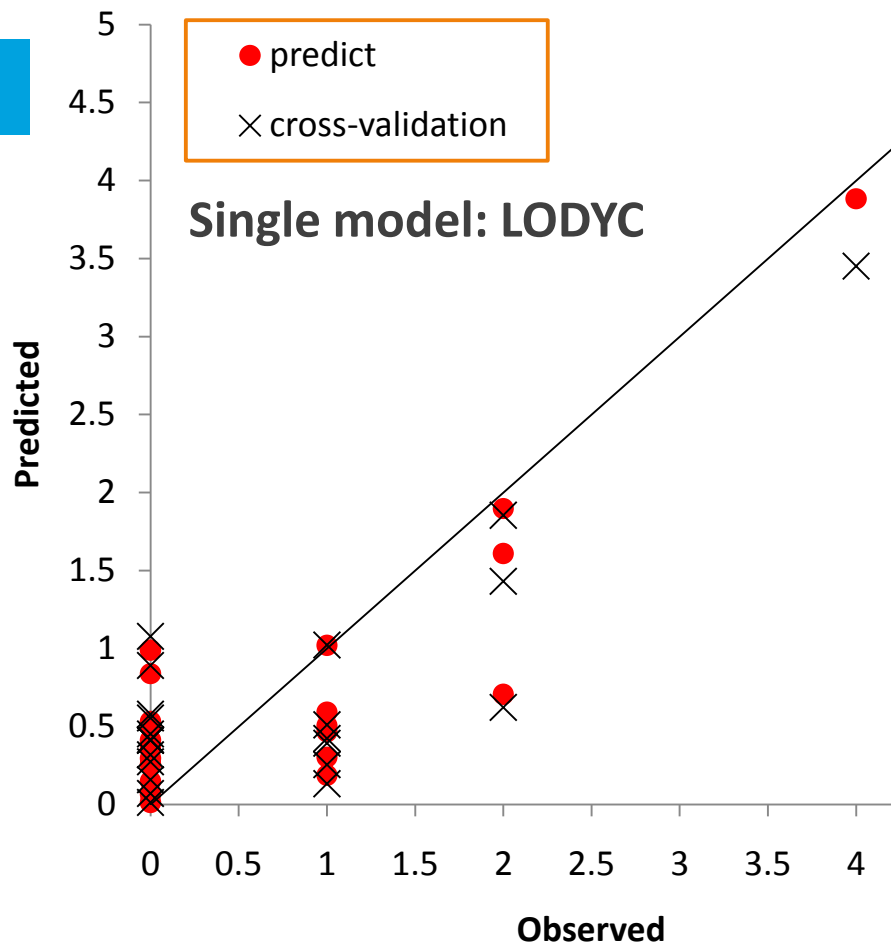
Observed vs. Predicted East Coast

Single model: CERFACS

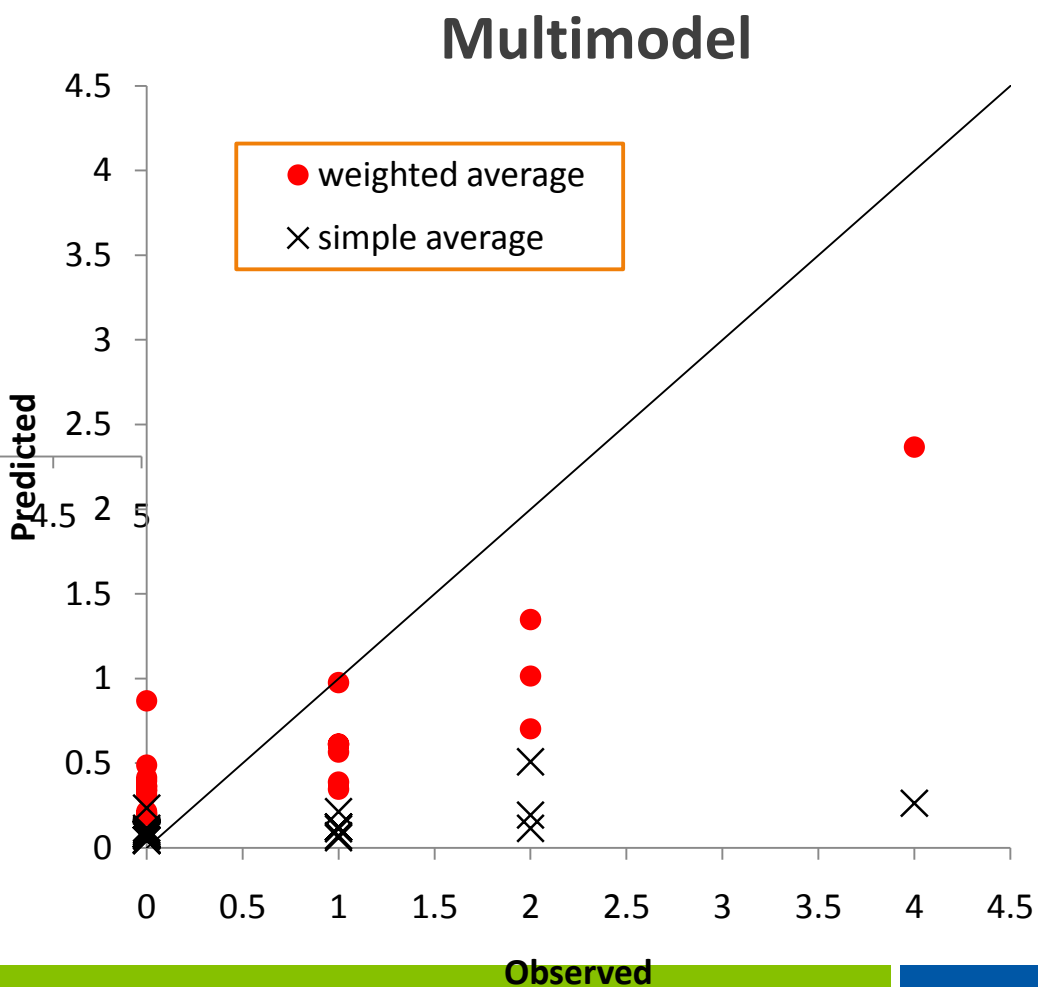


Multimodel

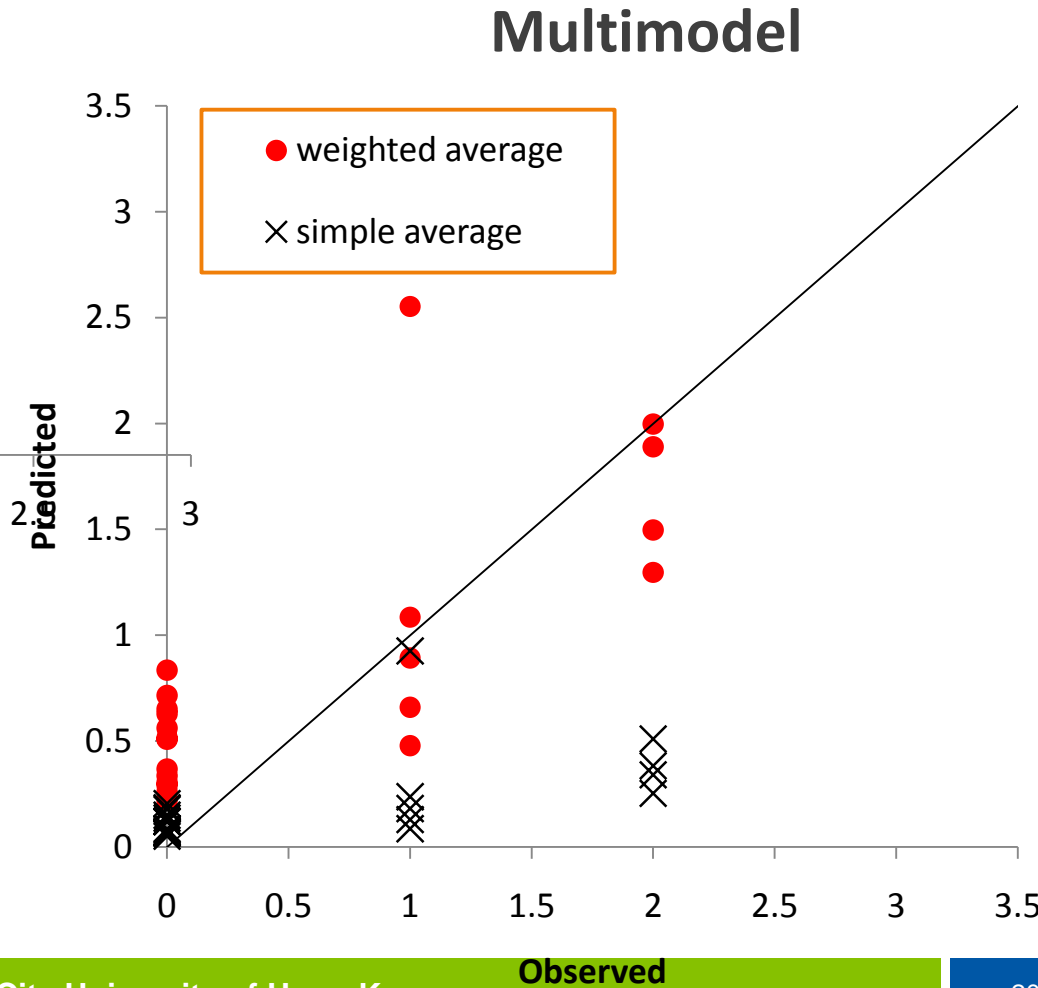
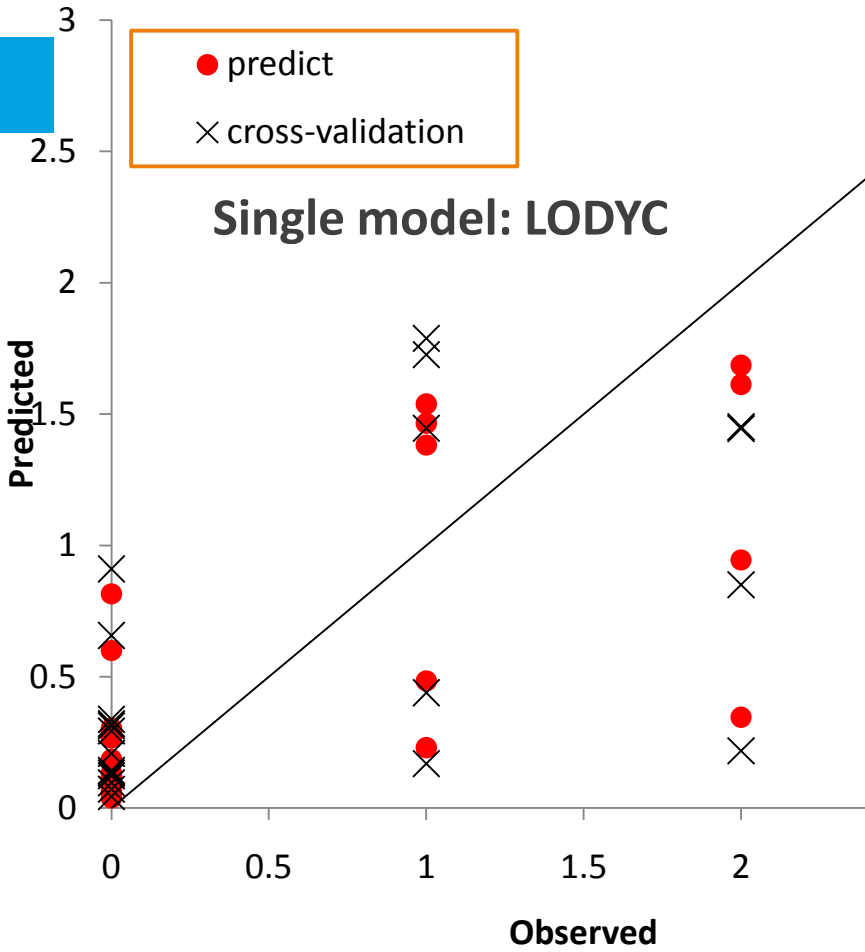




Observed vs. Predicted Gulf Coast



Observed vs. Predicted Florida



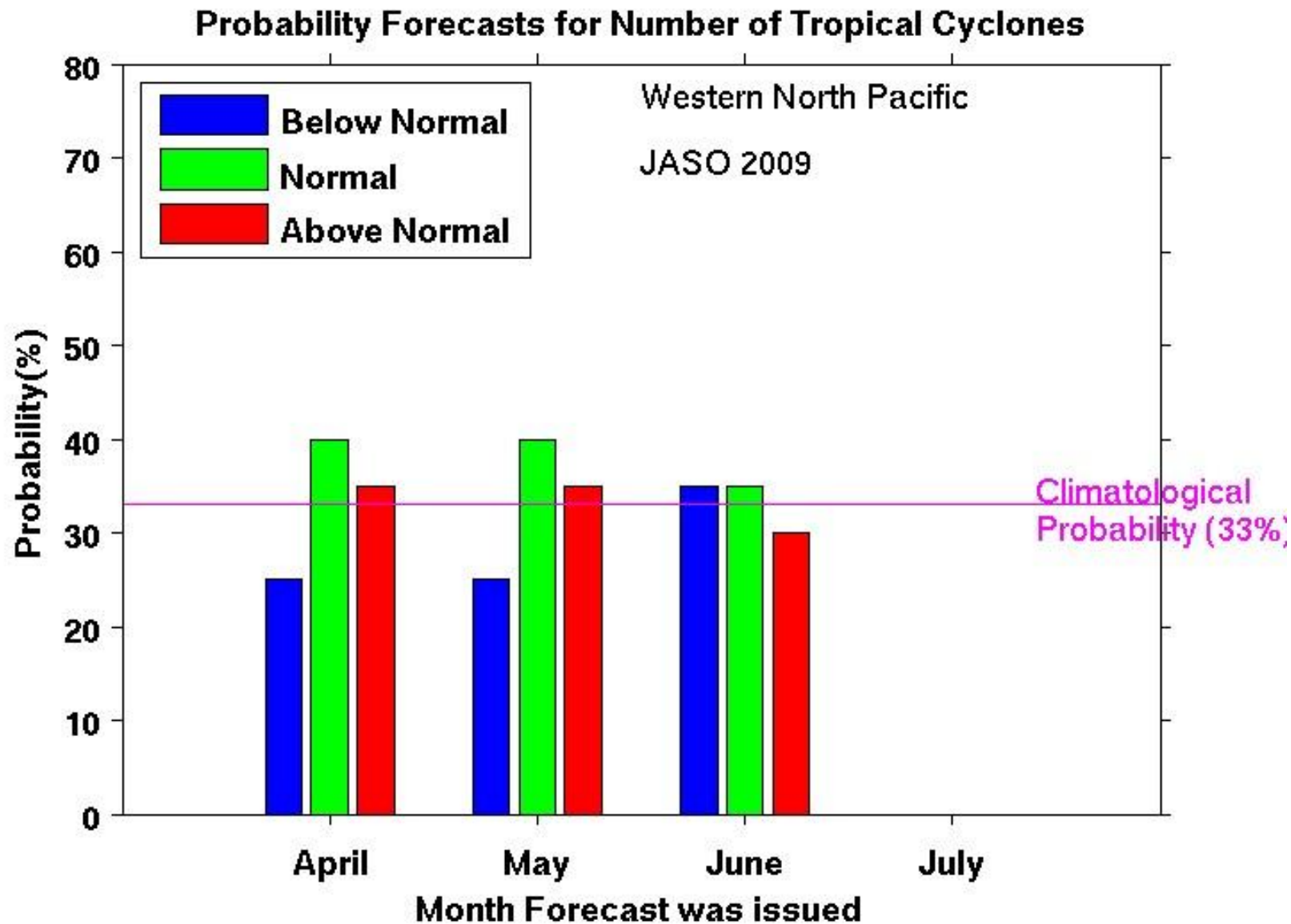
An aerial photograph of a river delta, showing a central vortex or whirlpool in the water. The water is a light grey color, and the surrounding land is a darker grey. The text "Dynamical Methods" is overlaid in white, bold, sans-serif font.

Dynamical Methods

Dynamical method (1)

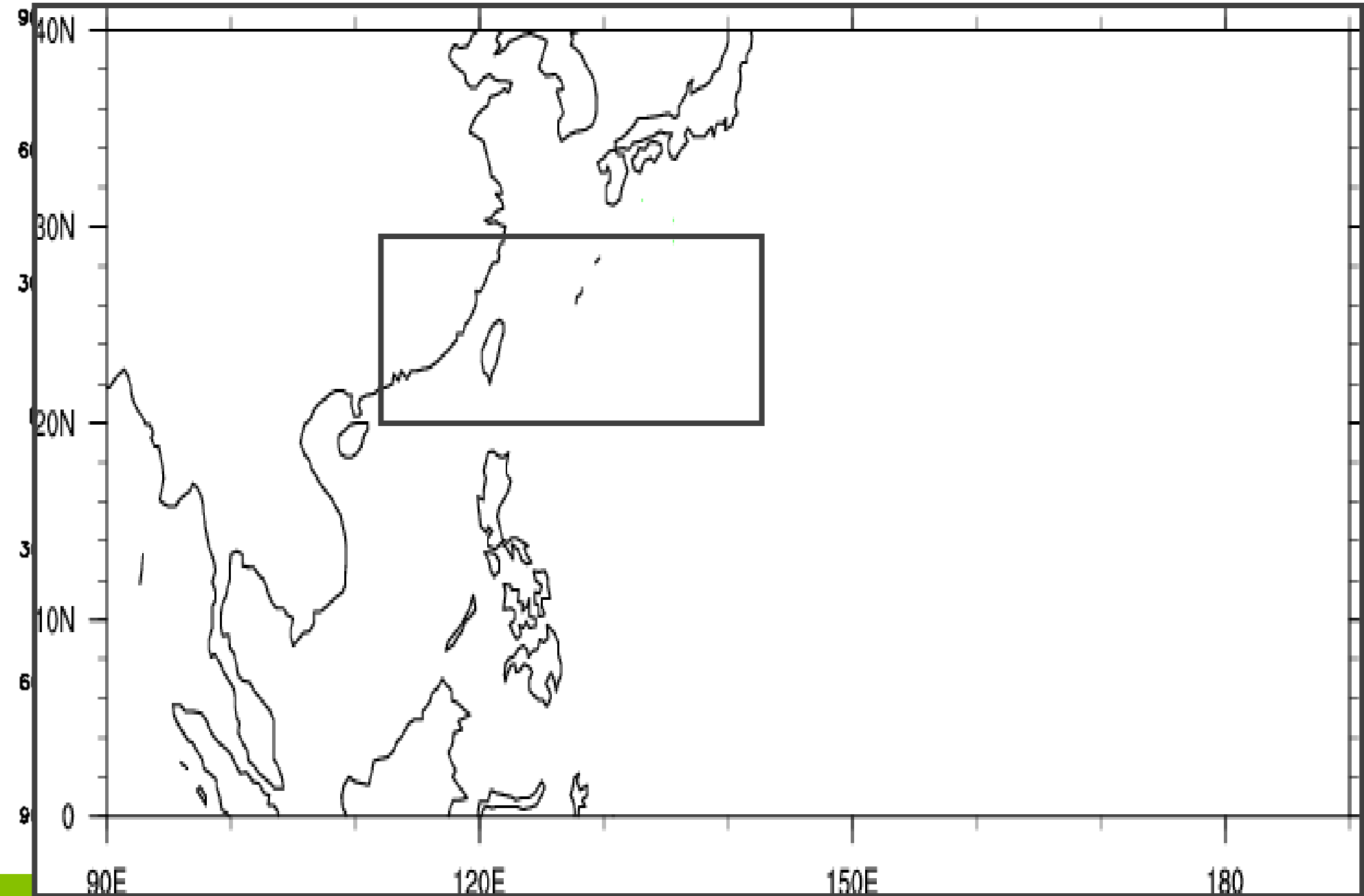
- **Run a global circulation model (GCM)**
- **Identify and count the number of vortices from the model integrations**

IRI forecasts

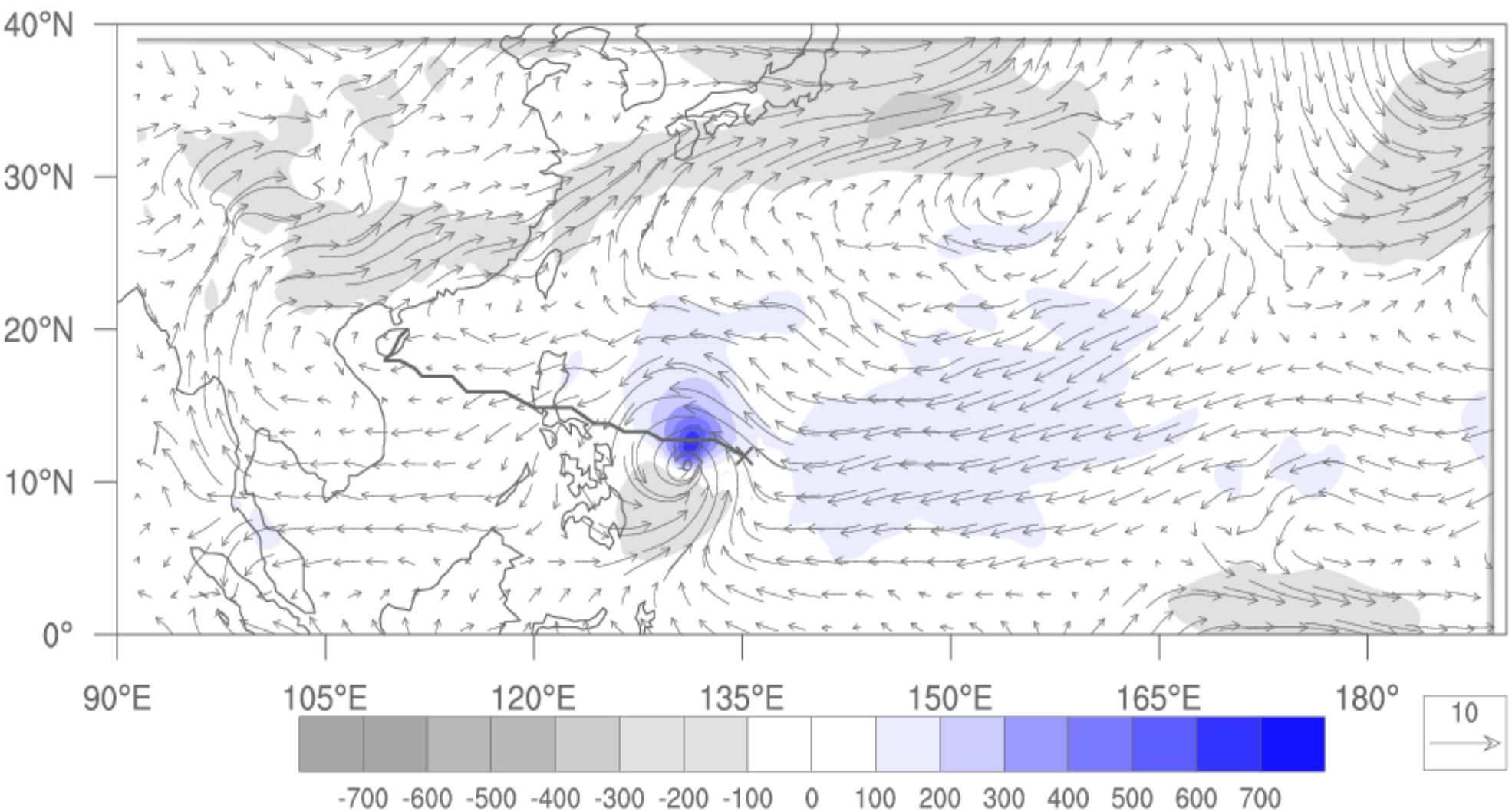


Dynamical method (2)

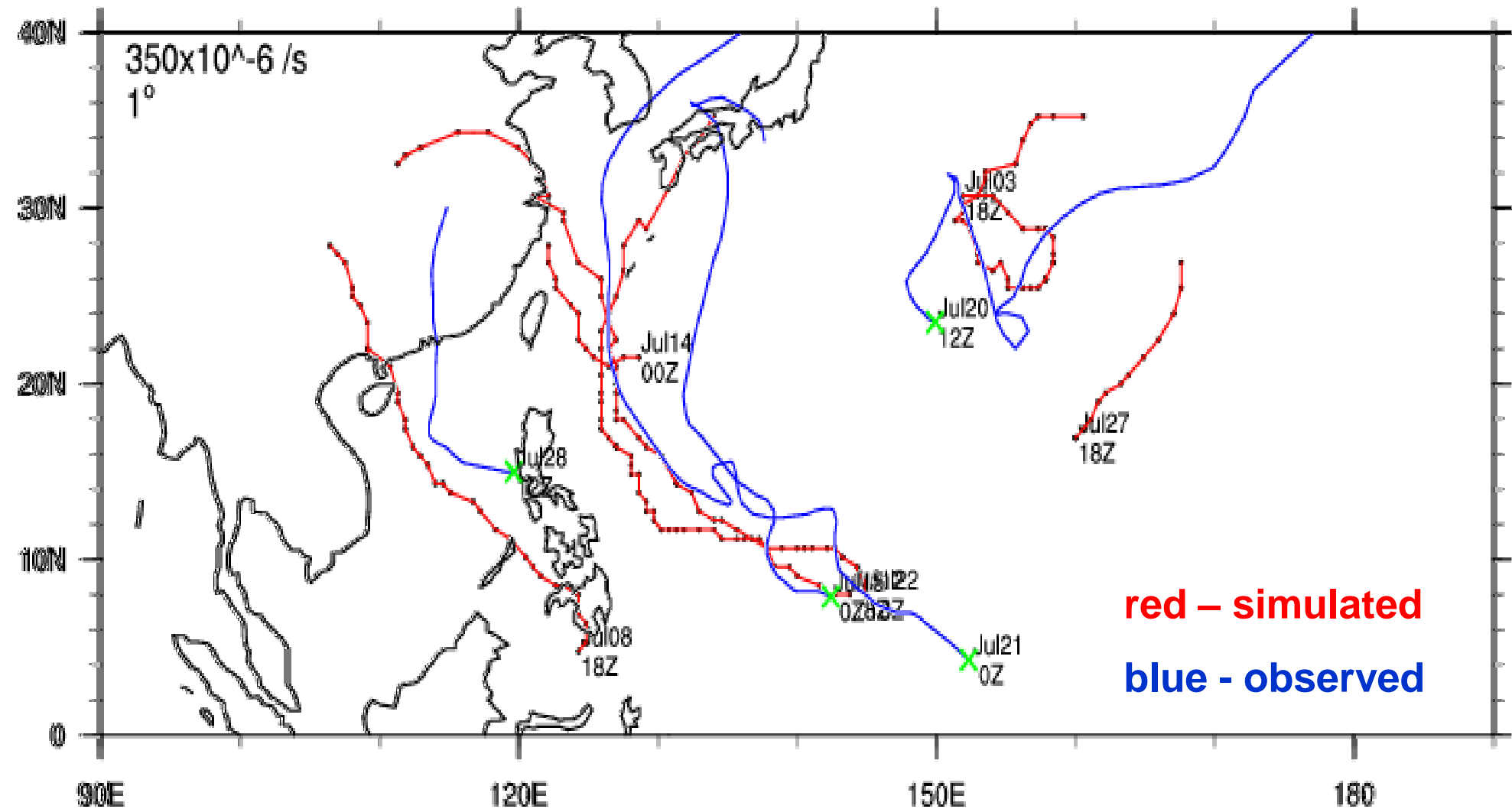
- **Run a global circulation model (GCM) with a relatively coarse resolution**
- **Solutions from the GCM are used as boundary conditions for a regional model with a higher resolution that can “resolve” a tropical cyclone**
- **Integrate the regional model to predict seasonal activity.**



Example of 850-hPa flow and relative vorticity

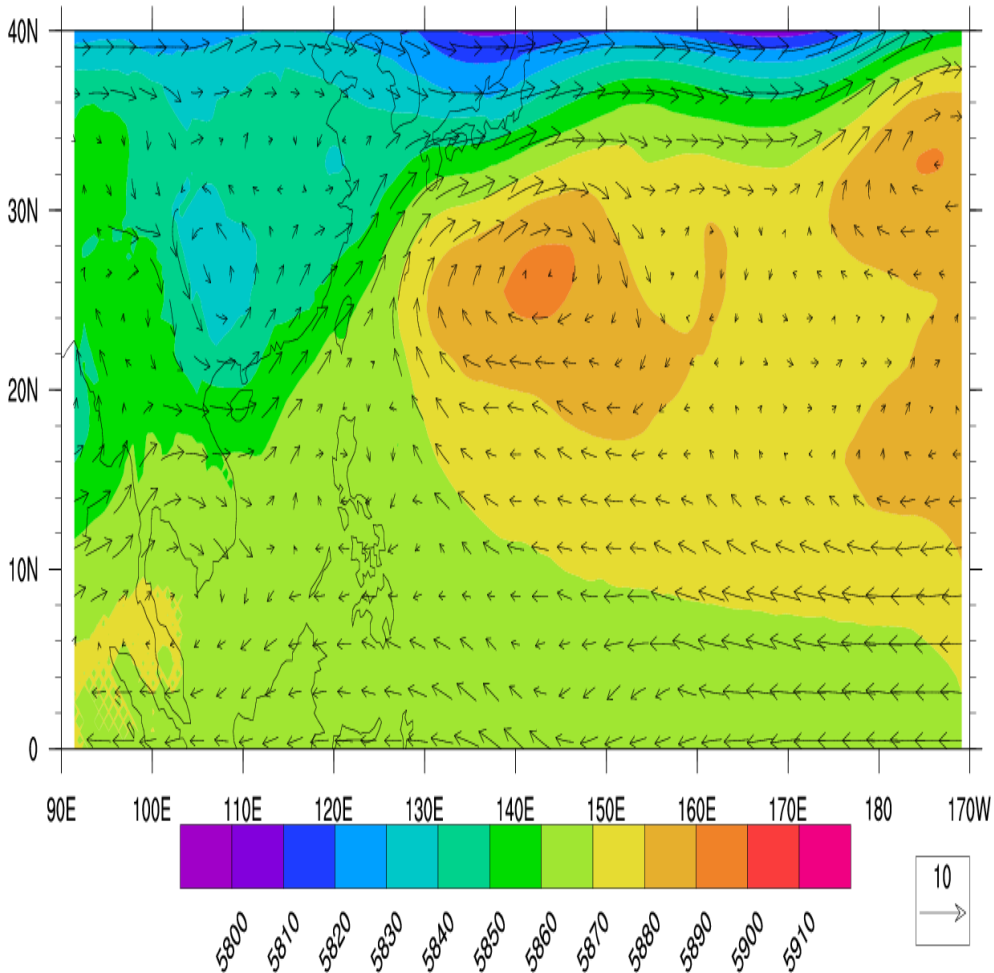


Example of simulation of a 3-month forecast

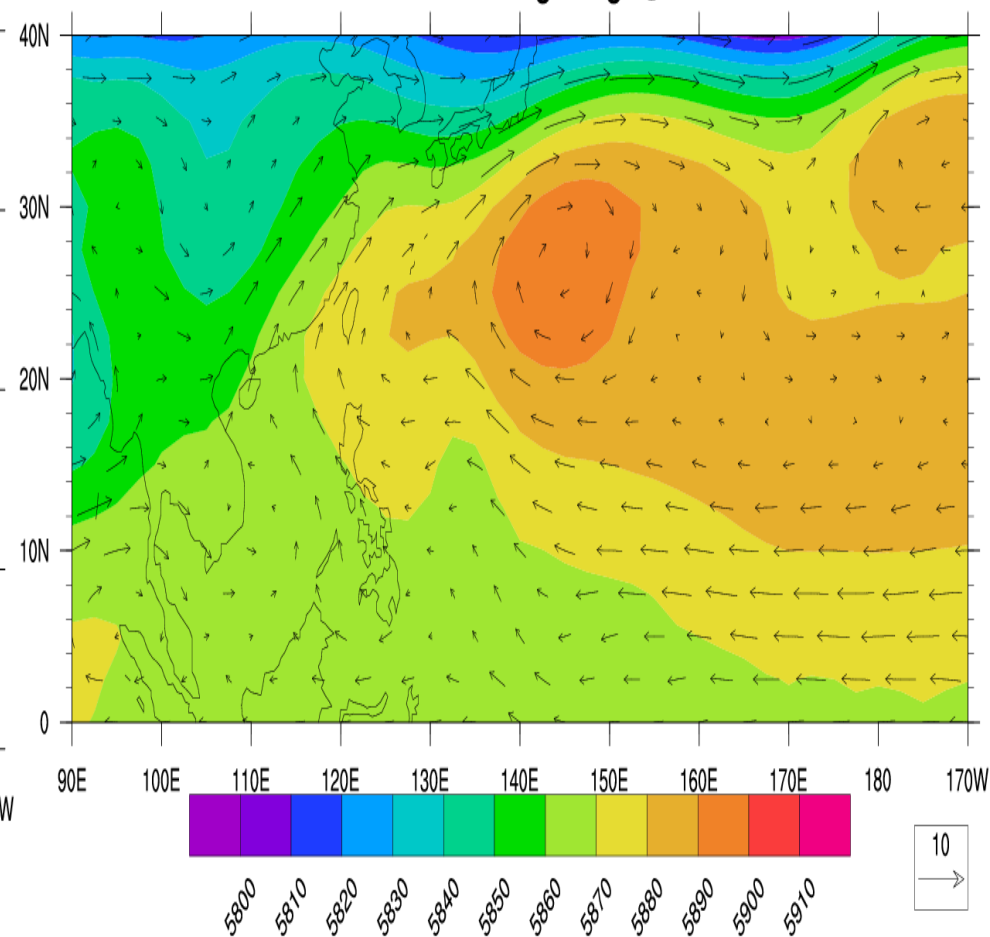


500-hPa simulated flow pattern

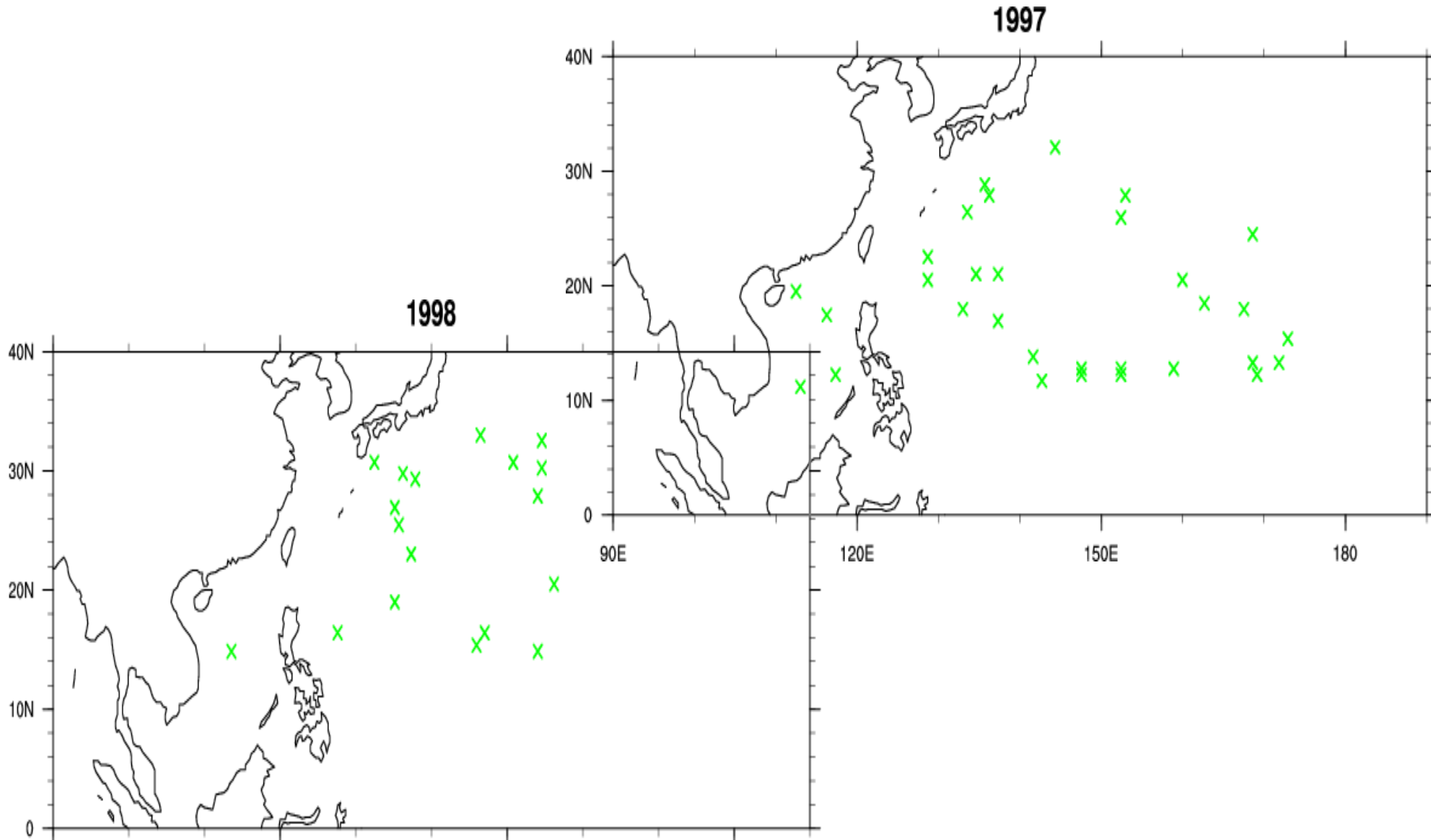
Run_090616 1997Jul1500Z@500hPa



ERA40 1997JUL ave geo hgt @ 500hPa



Regional Model Simulations of 1997 and 1998 TCs



Summary

- **Statistical methods can provide some clues on tropical cyclone activity but suffers from an inherent problem of predicting future events based only on past conditions**
- **Statistical-dynamical methods can provide predictive information and therefore should give better results, but still suffers from the statistical nature of the method.**
- **Dynamical model forecasts should be the way forward to predict tropical cyclone risks although more research is still necessary on fine-tuning the regional model.**