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SCHOOL OF ENERGY AND ENVIRONMENT

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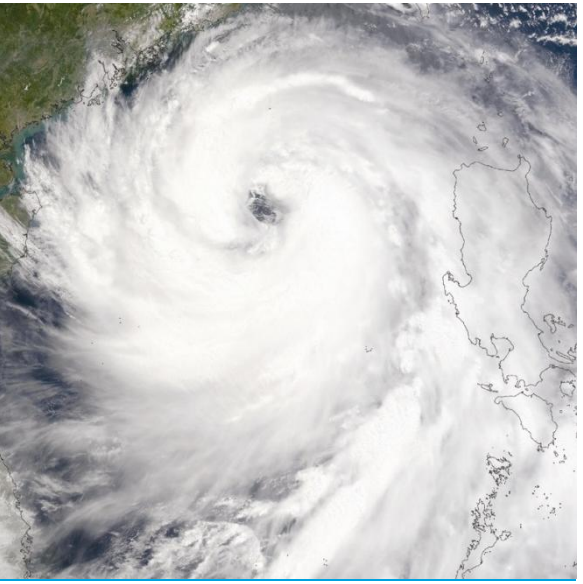

Tropical Cyclone Prediction on Seasonal or Longer Time Scales

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Outline

- Statistical method
- Statistical dynamical method
- Dynamical methods
- Summary

Statistical Method

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

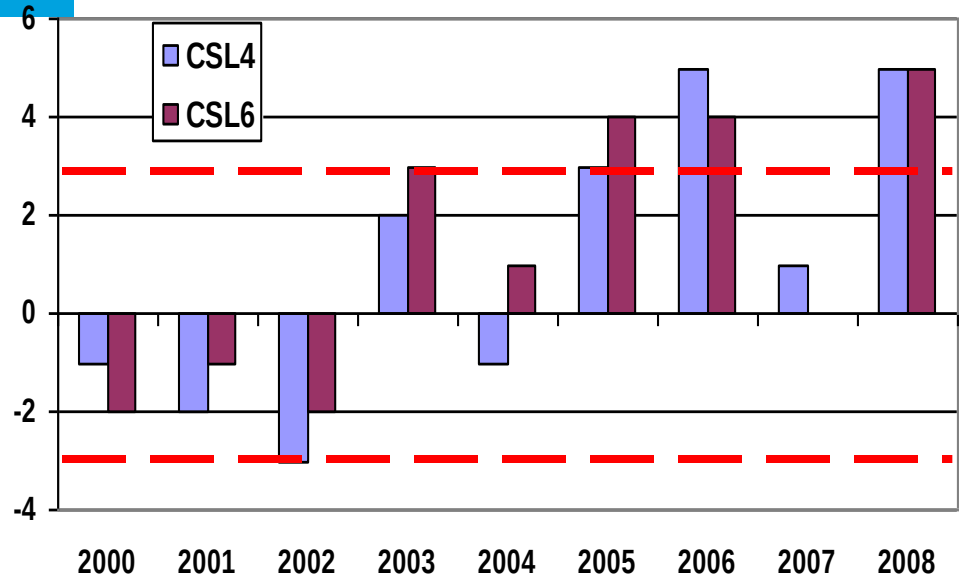
large-scale atmospheric conditions

- 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

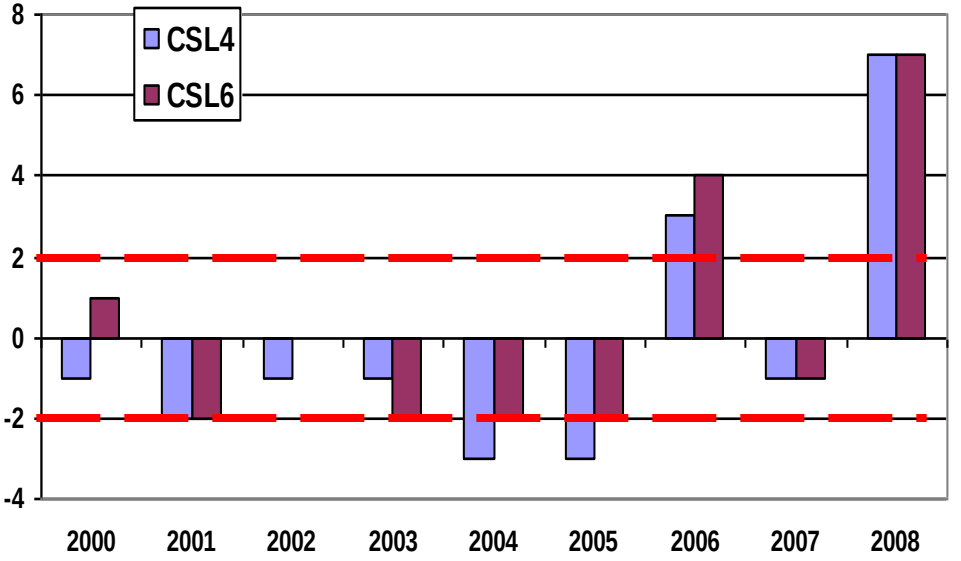
- Sea surface temperature (SST) anomalies in the NINO3.4 region (5°S-5°N,170-120°W)
- Sea surface temperature (SST) anomalies in the NINO4 region (5°S-5°N, 160°E-150°W)
- Equatorial Southern Oscillation Index (Equatorial SOI)
- Equatorial Eastern Pacific SLP - Indonesia SLP (standardized anomalies)

ENSO conditions

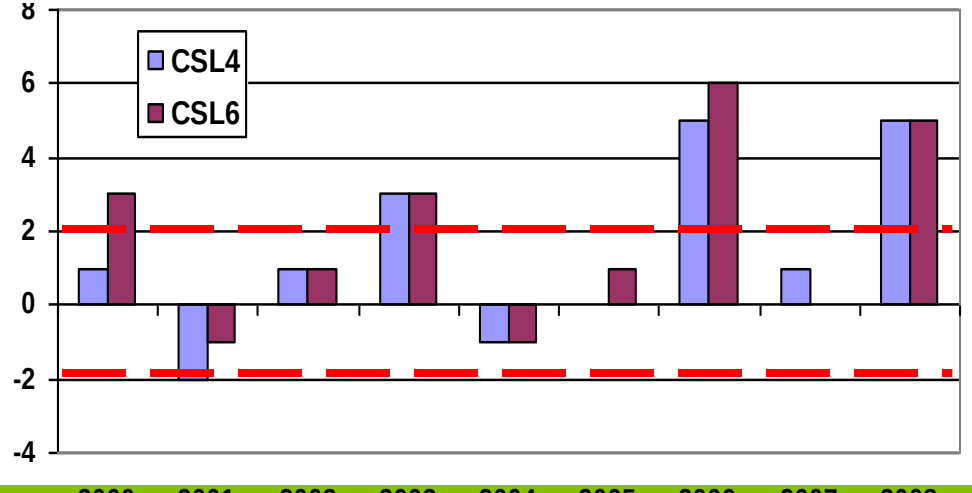
All tropical cyclones



Typhoons



Tropical storms and typhoons



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

Forecasts from Tropical Storm Risk

NW Pacific ACE Index and System Numbers 2010					
		ACE Index ($\times 10^4$ knots^2)	Intense Typhoons	Typhoons	Tropical Storms
Average Number (±SD) (1965-2009)		299 (±97)	8.6 (±3.0)	16.6 (±3.6)	26.6 (±4.3)
TSR Forecasts (±FE)	5th May 2010	321 (±80)	9.2 (±2.5)	14.6 (±3.0)	24.1 (±3.8)
	8th Mar 2010	284 (±88)	8.1 (±2.6)	14.8 (±3.3)	24.2 (±3.8)
Chan Forecast	26th Apr 2010	-	-	16	24

Predictors used in the Tropical Storm Risk Forecasts

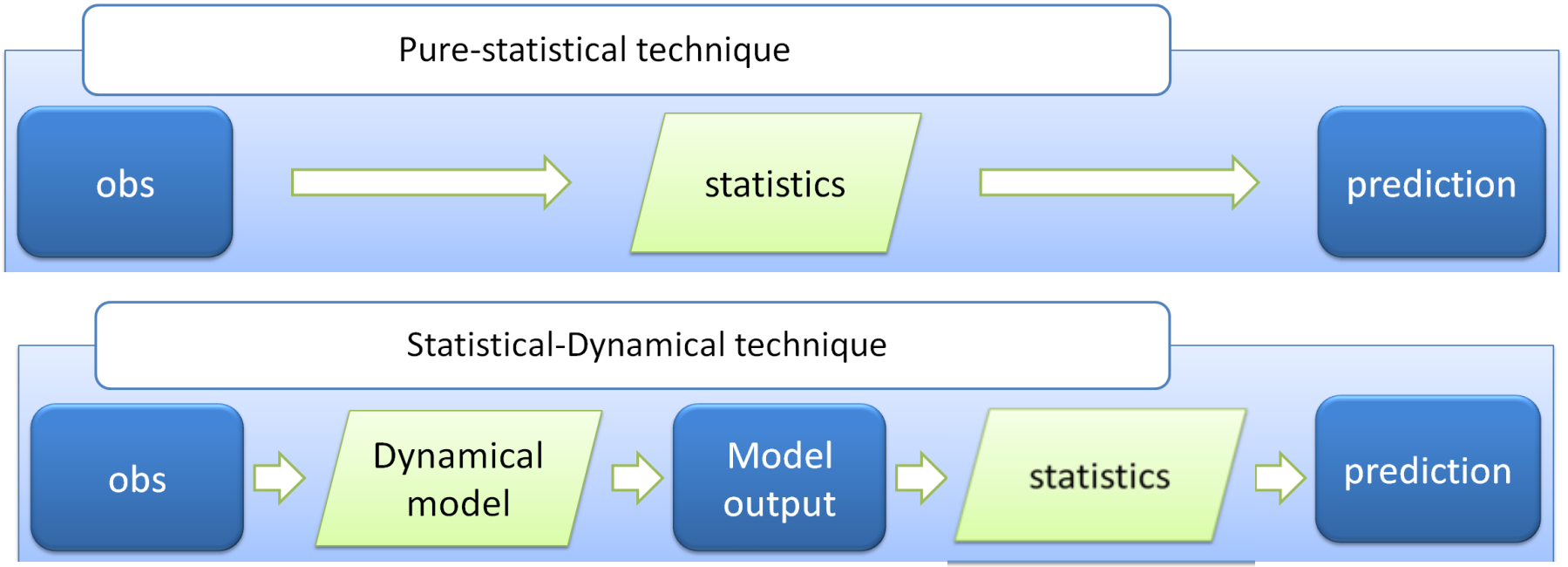
predictors from past observations

- 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) from a global model

predictors from the future

Statistical-Dynamical Method

Statistical vs. Statistical-dynamical Method



Statistical vs. Statistical-dynamical Method

- **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**

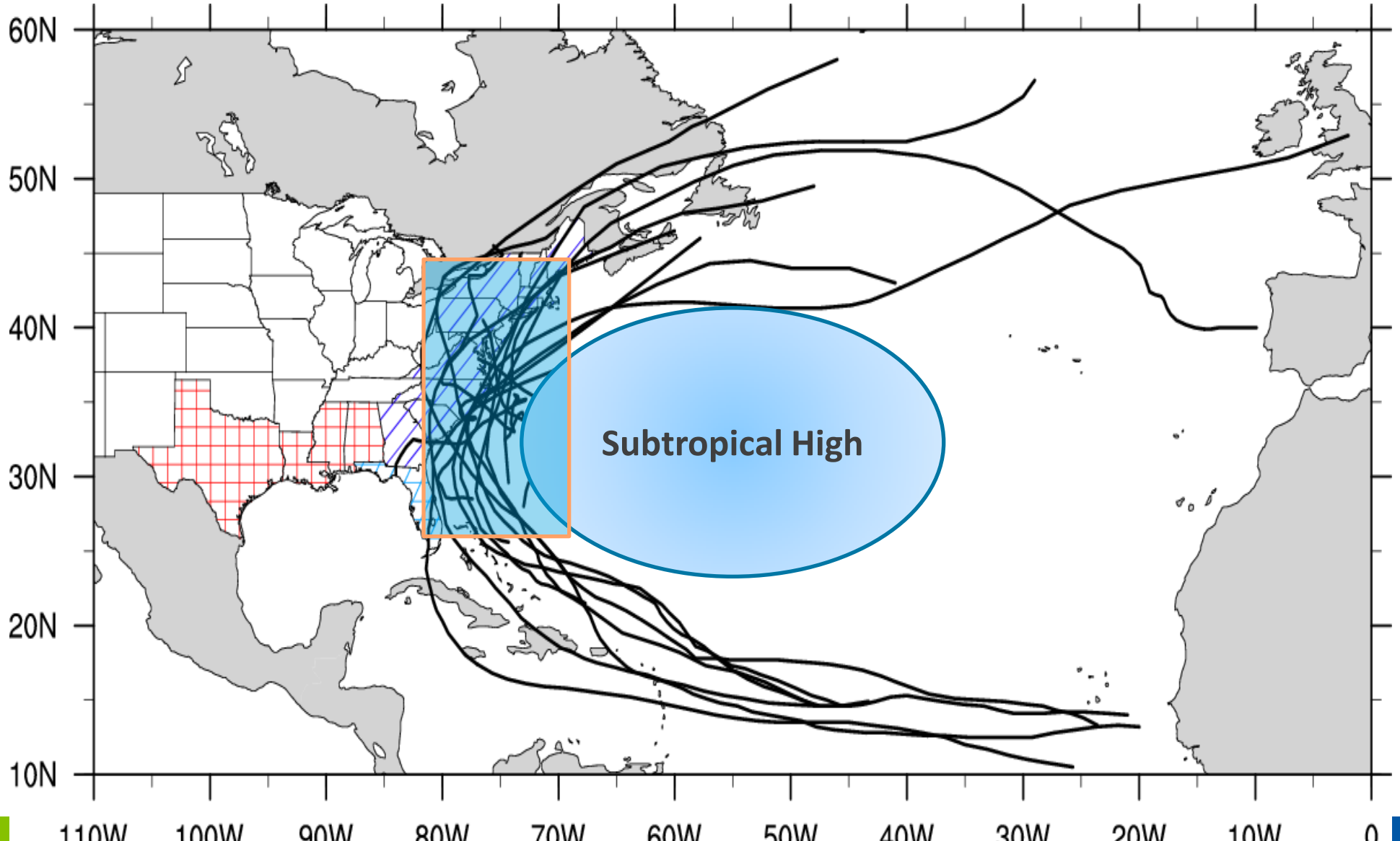
Dynamical model data – DEMETER

- **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**

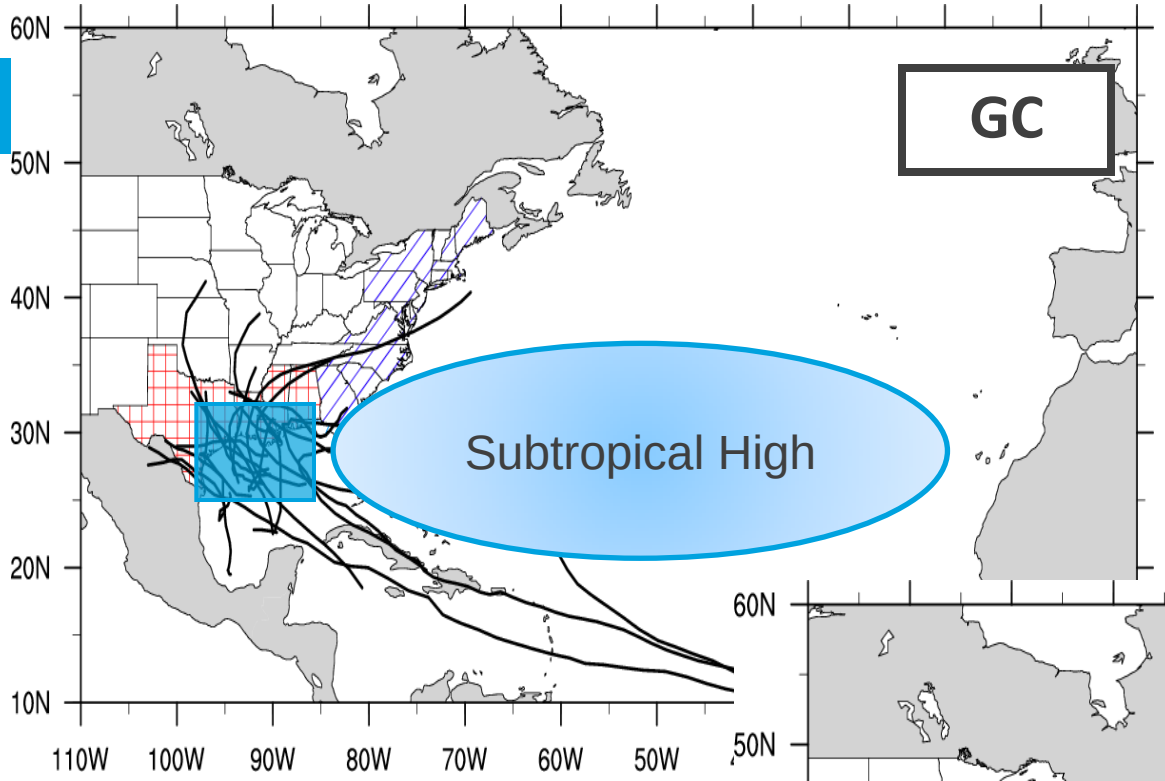
Dynamical model data – DEMETER

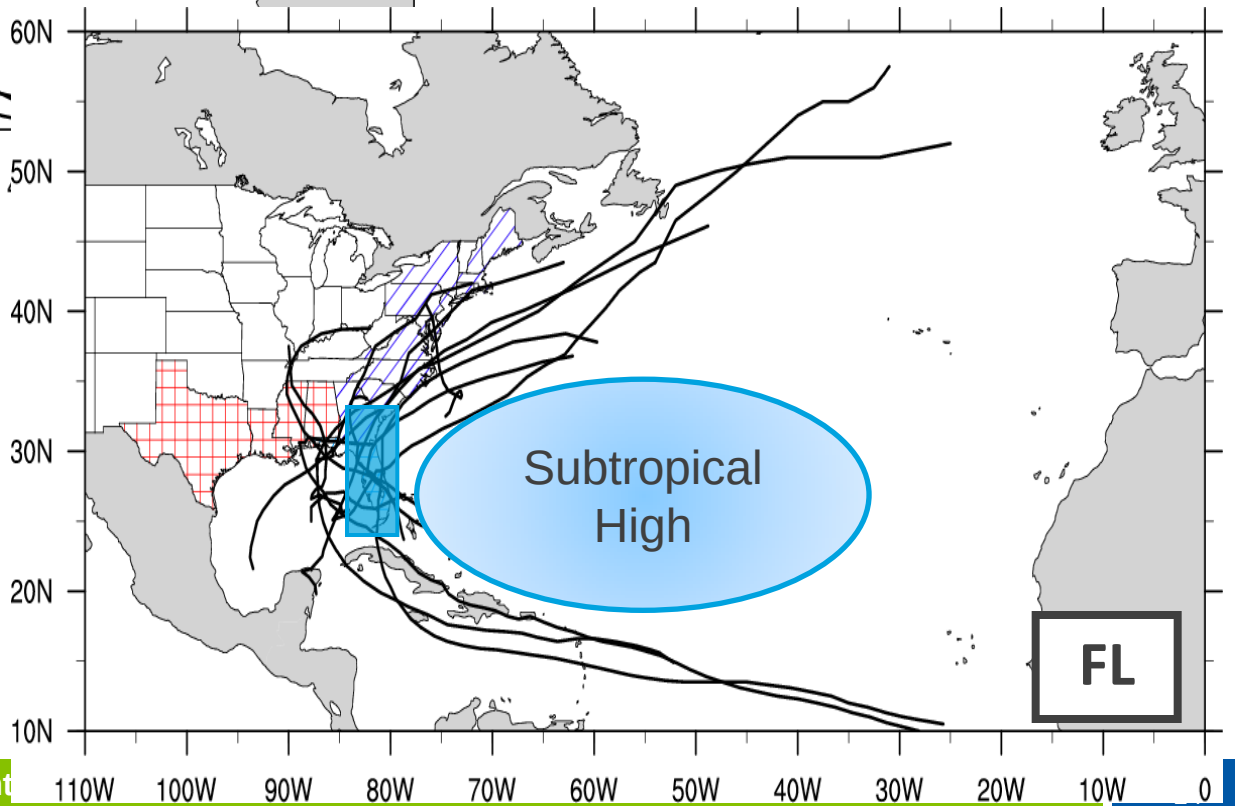
Parameter	Physics
Geopotential (200-, 500-, 850-hPa)	subtropical high
Wind fields (200-, 500-, 850-hPa)	steering flow
SST	TC genesis
Sea-level pressure (SLP)	subtropical high, low for TC genesis

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

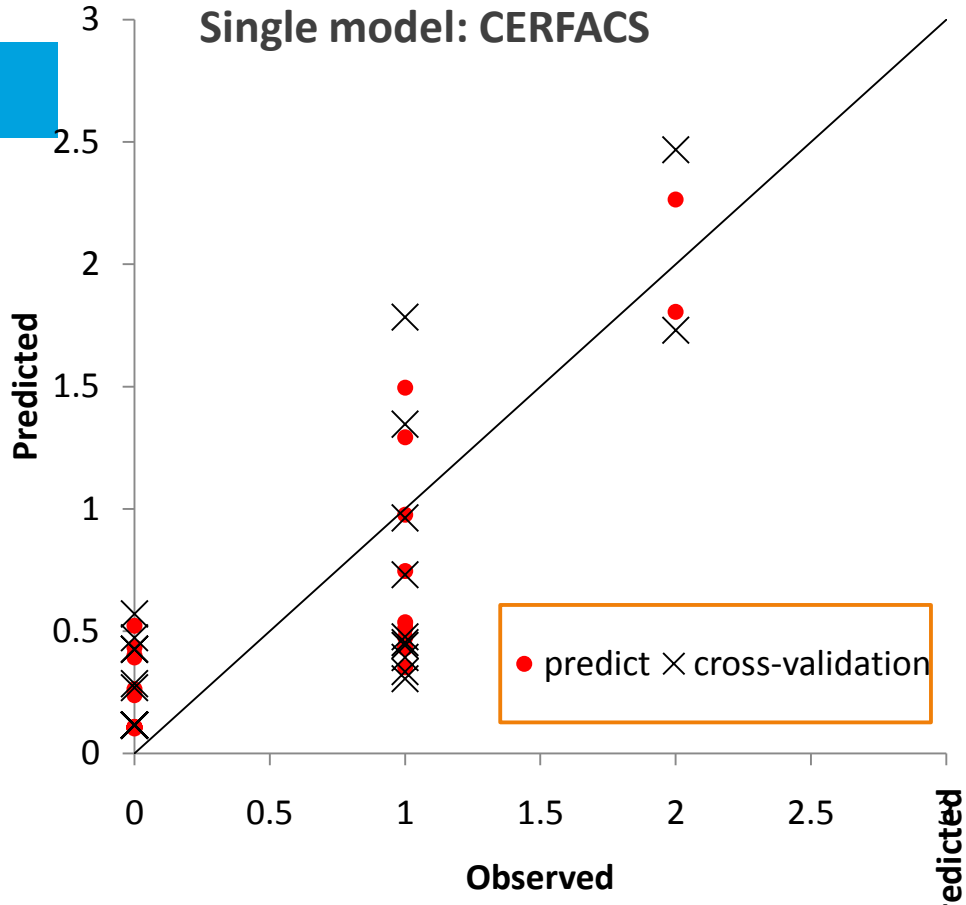
- **Fit a forecast equation for the number of landfalling TCs in each region**
  - **Poisson regression**
  - **Cross-validation (Jackknife method)**
- **7 forecast equations, each from an individual model**
- **Multimodel equation derived from the 7 equations**
  - **Simple average**
  - **Agreement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

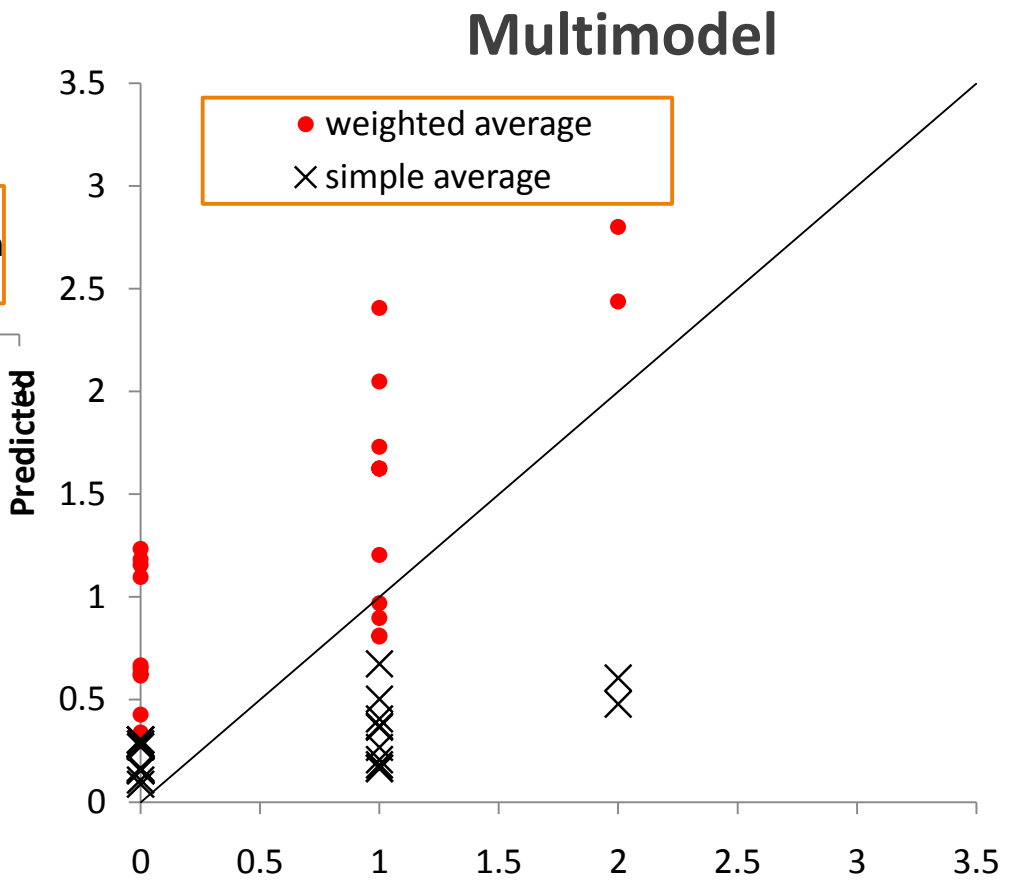
Factors affecting EC landfalling TCs

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



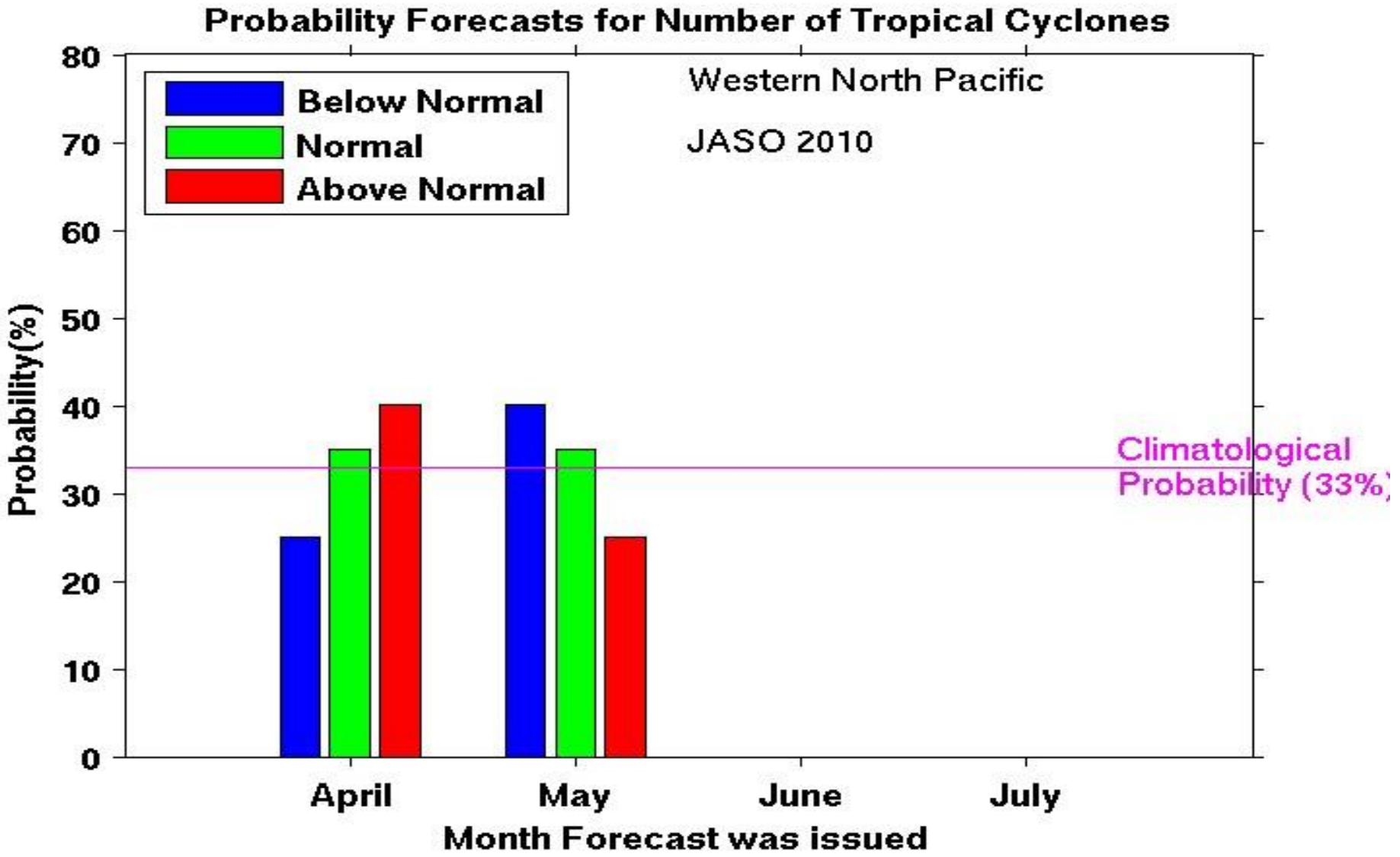


Dynamical Method

Dynamical method (1)

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

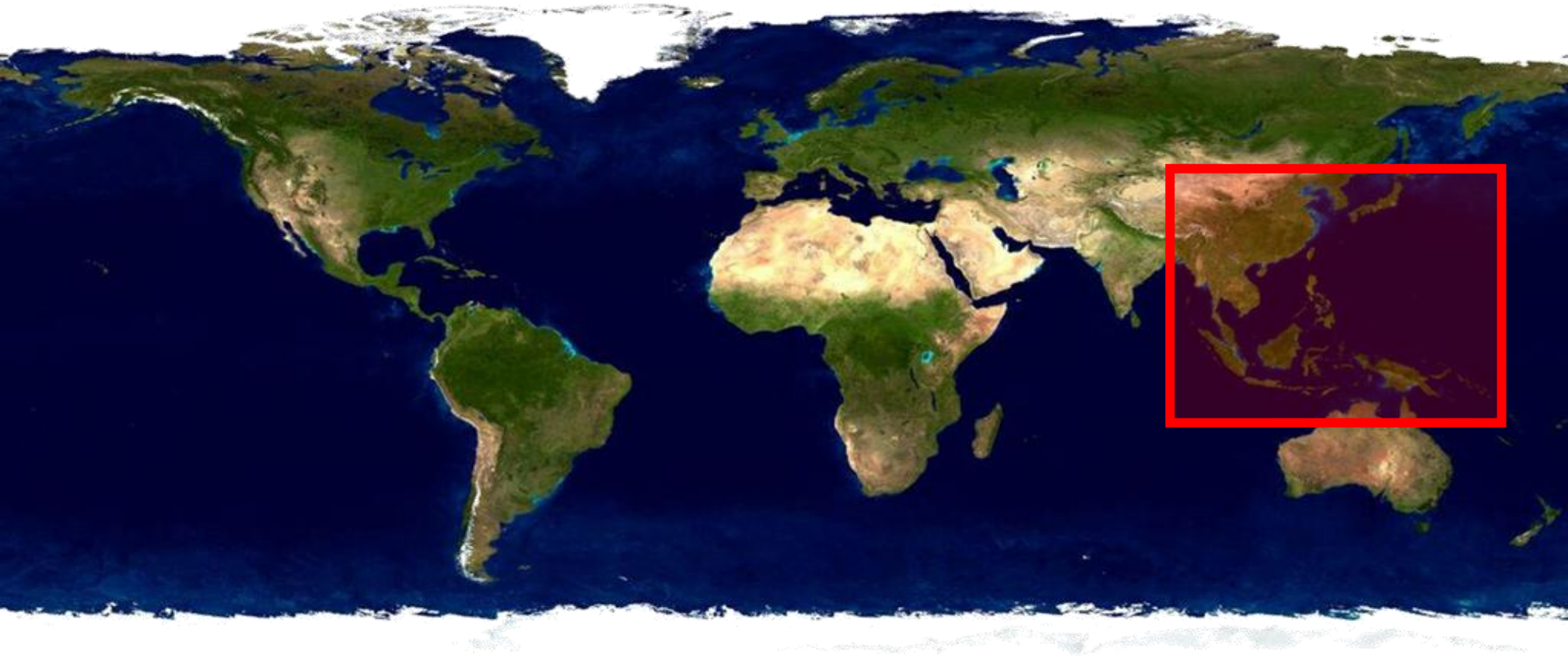
IRI forecasts



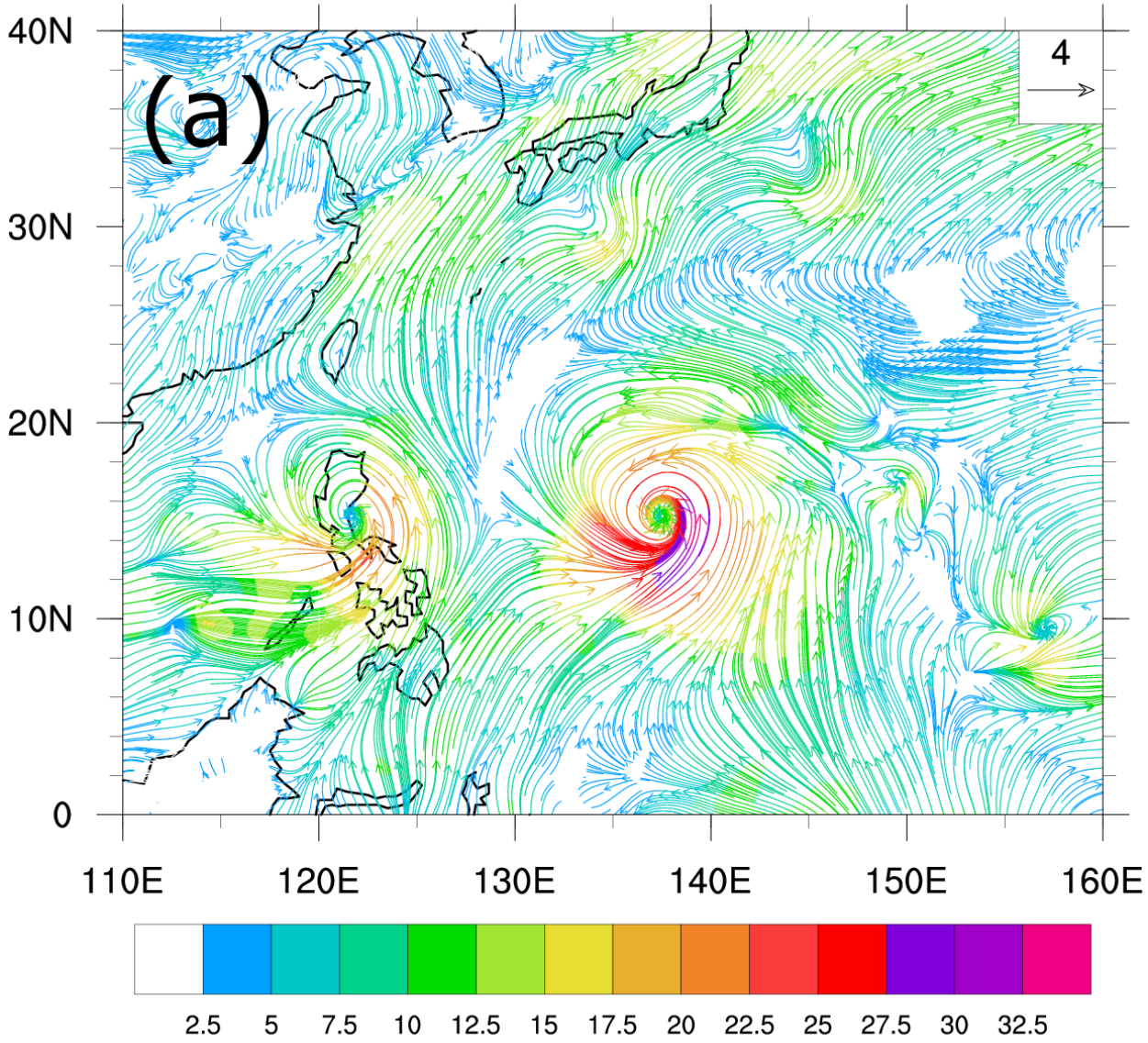
Dynamical method (2)

- 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.

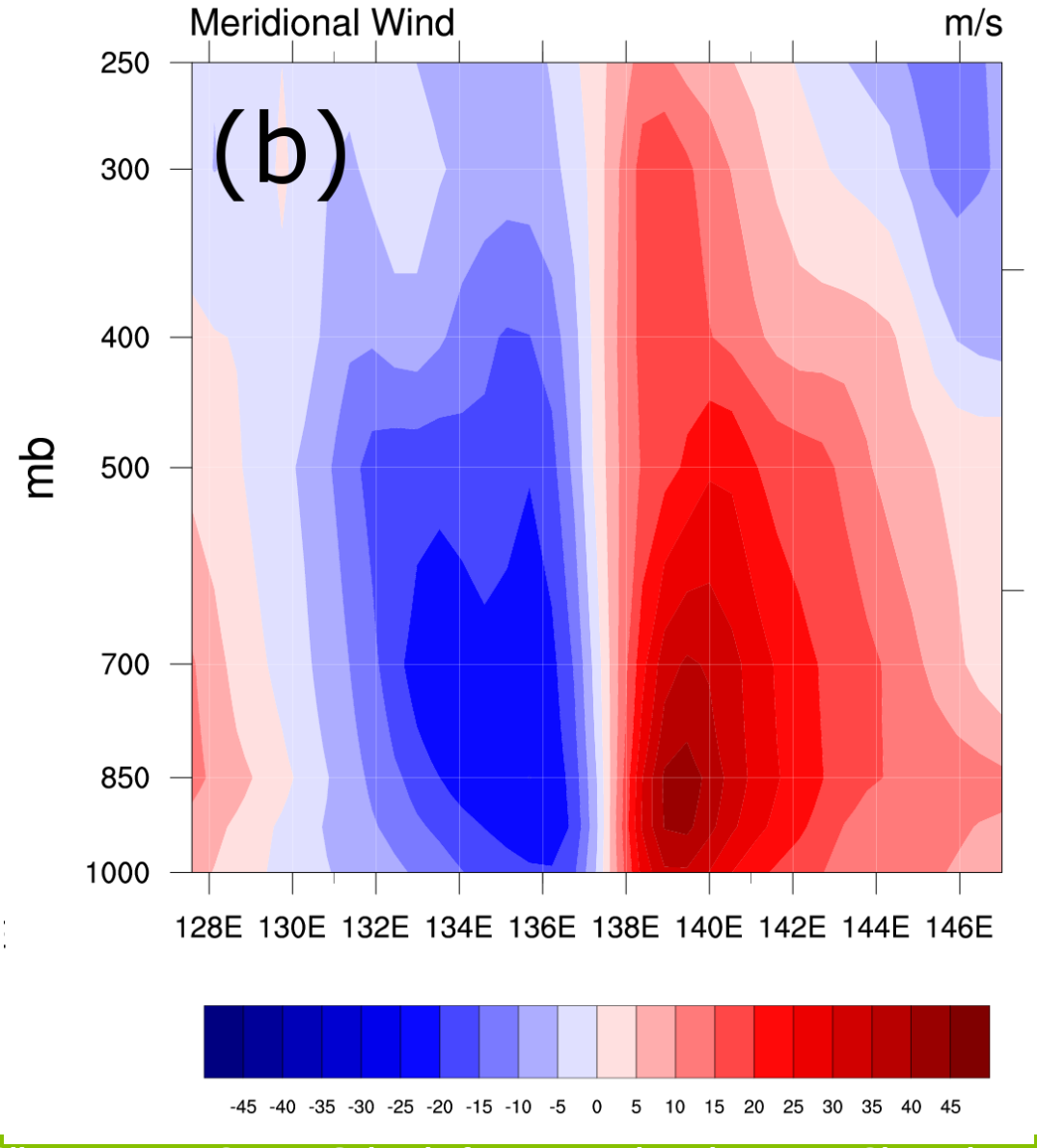
Dynamical method (2)



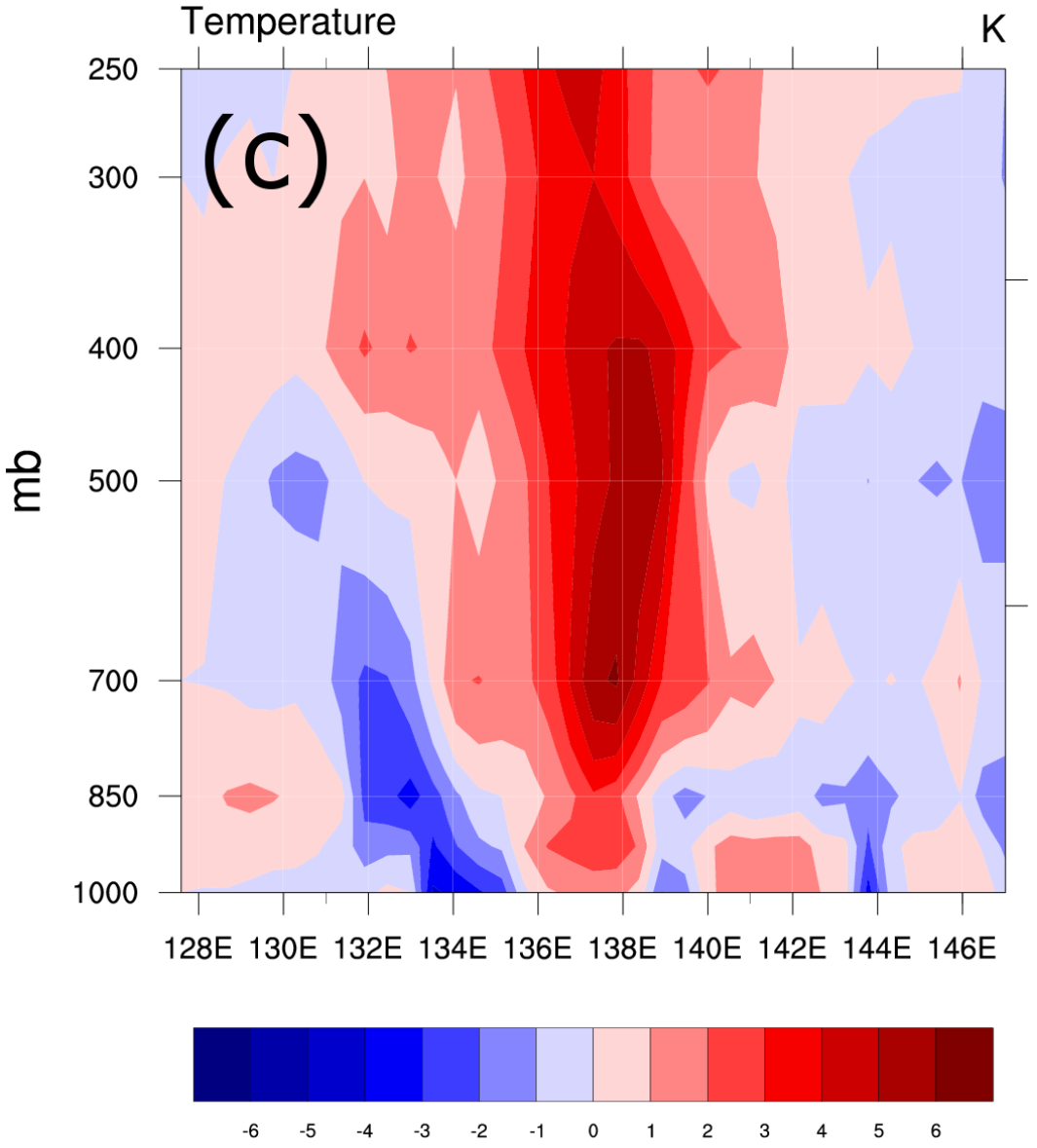
Example of a tropical cyclone in the Regional Model



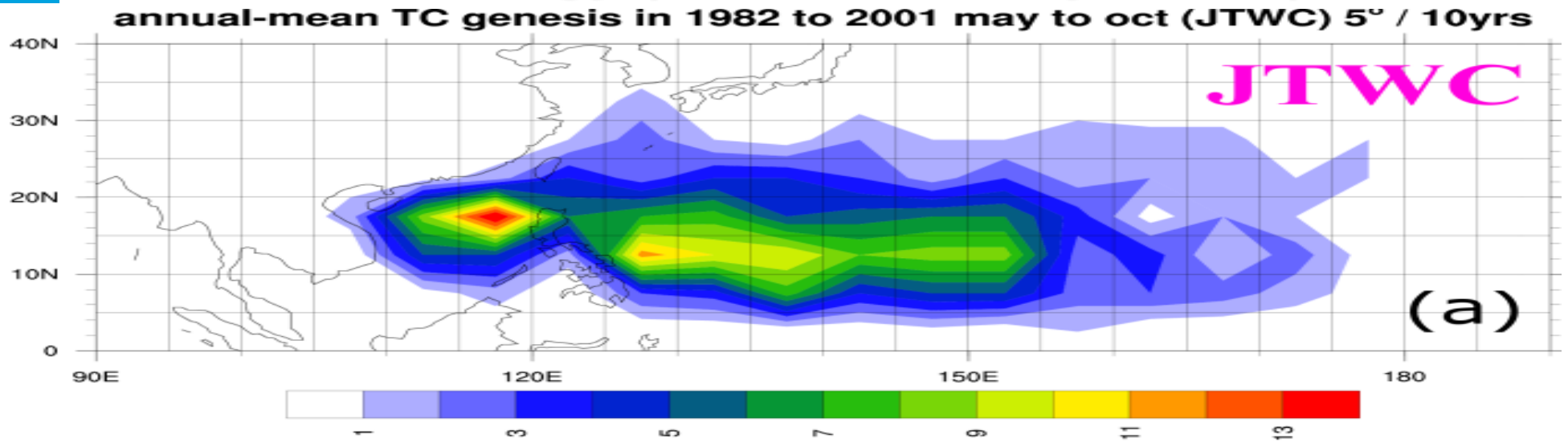
Simulated Tropical Cyclone Structure – North-South Wind

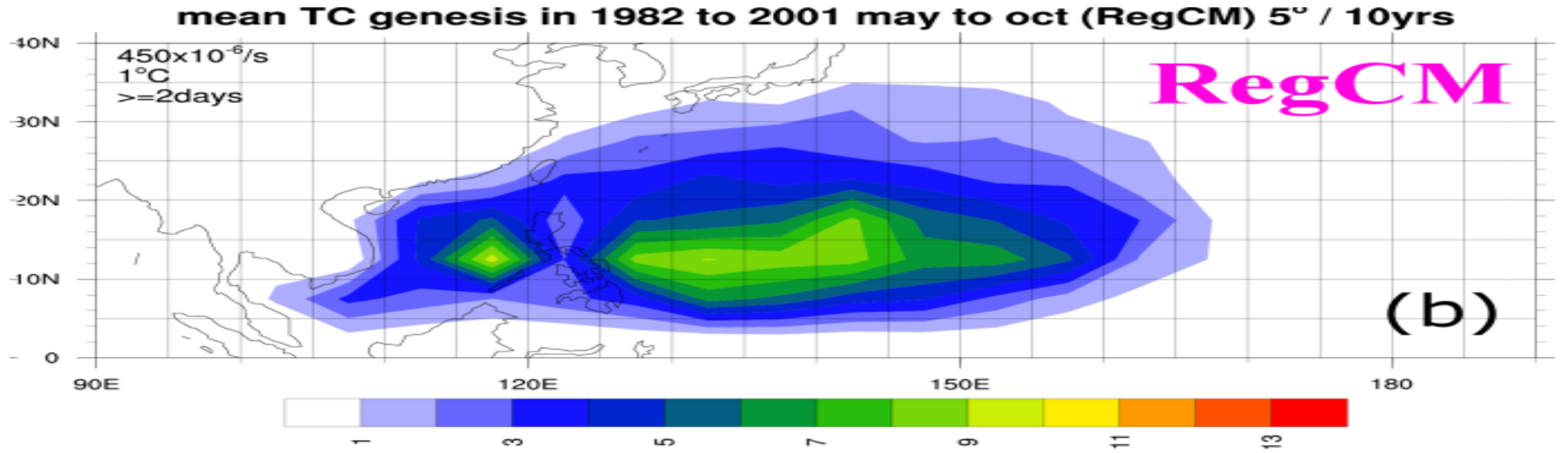


Simulated Tropical Cyclone Structure – Temperature

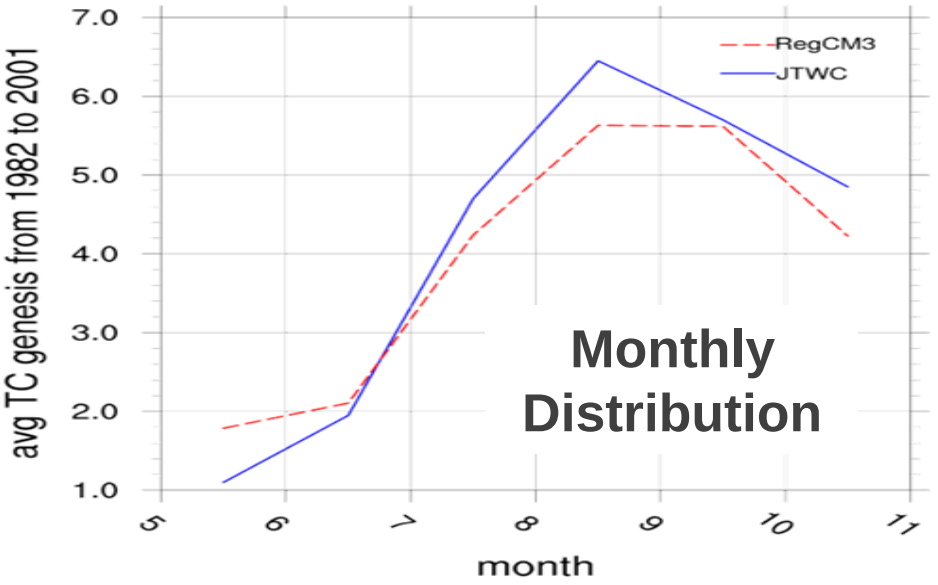


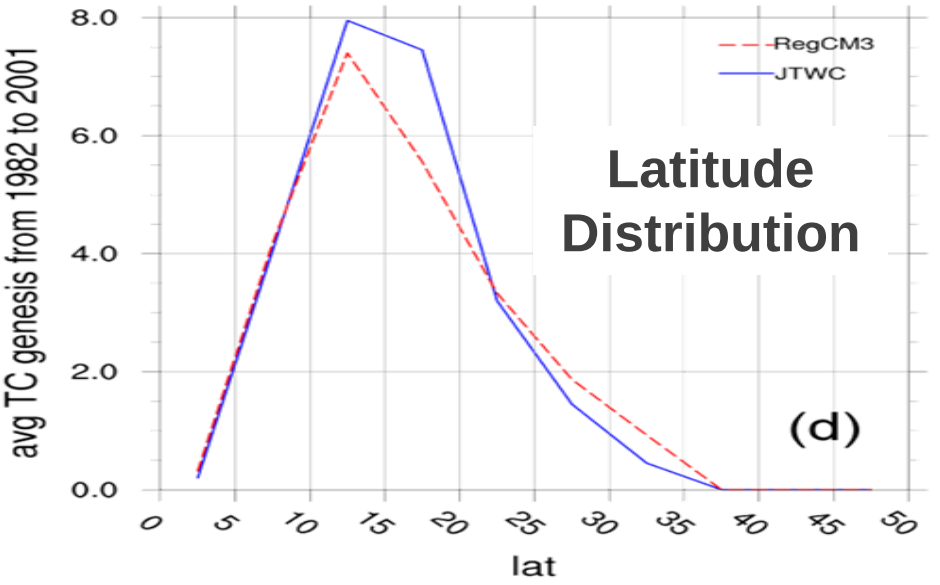
Model Climatology (1982-2001, May to Oct)

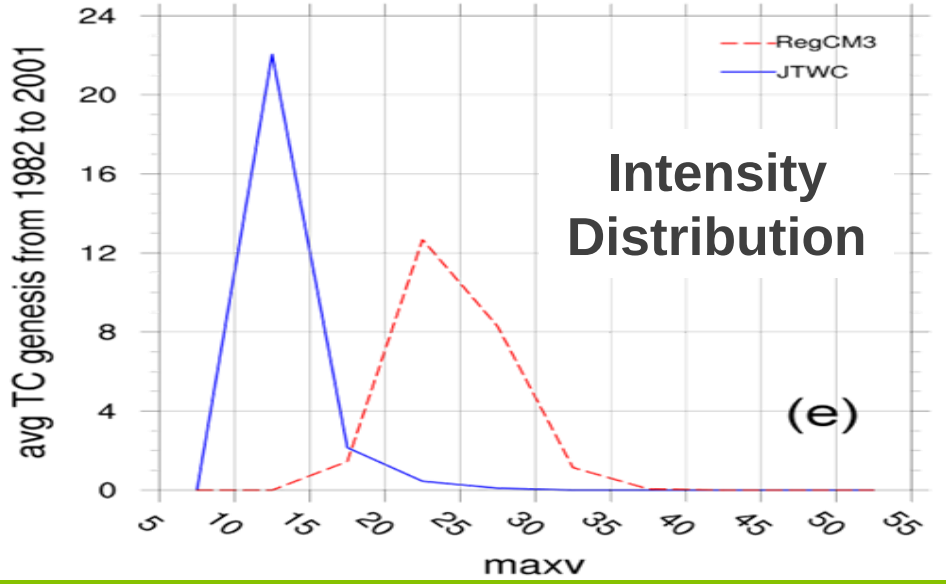


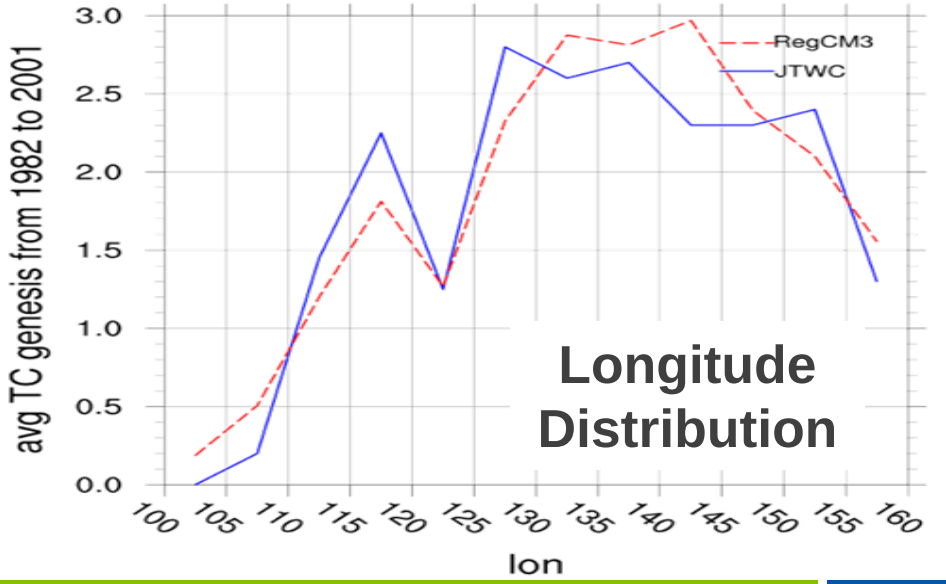


Model Climatology (1982-2001, May to Oct)

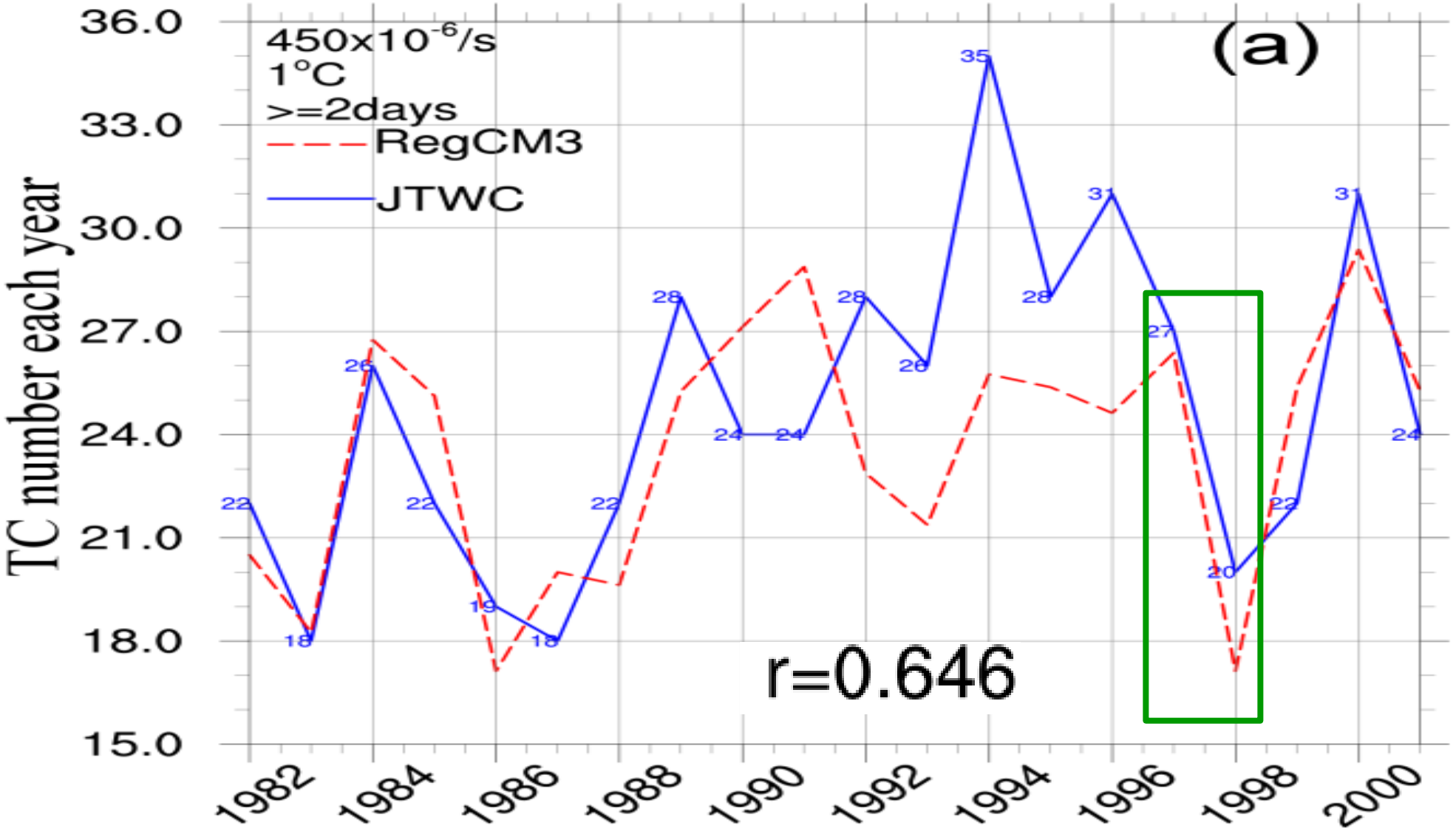




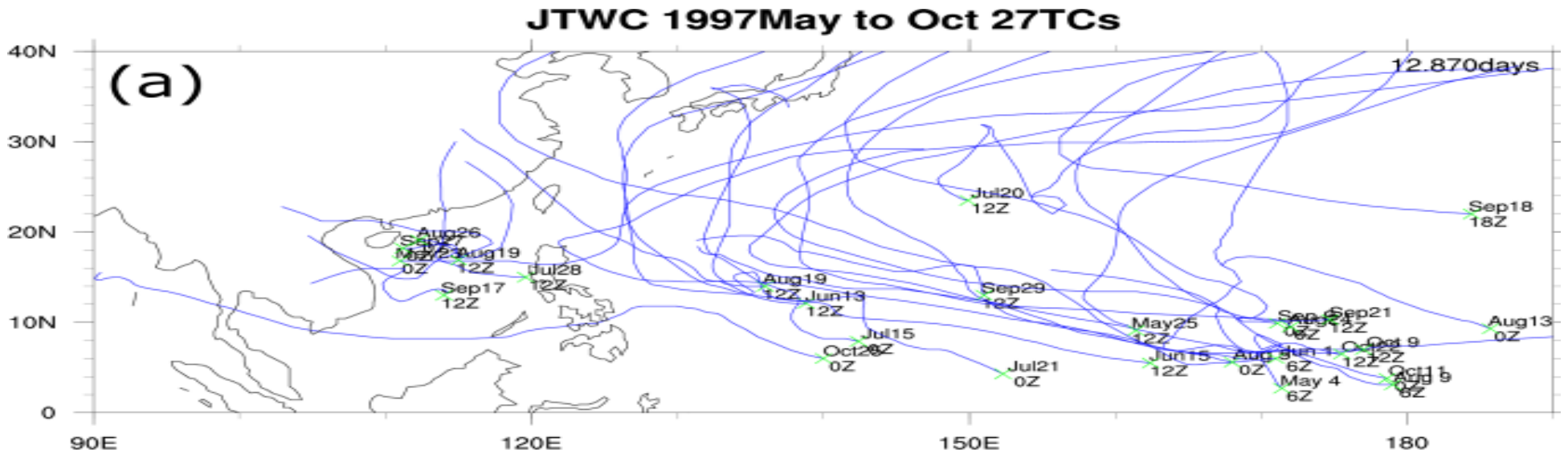


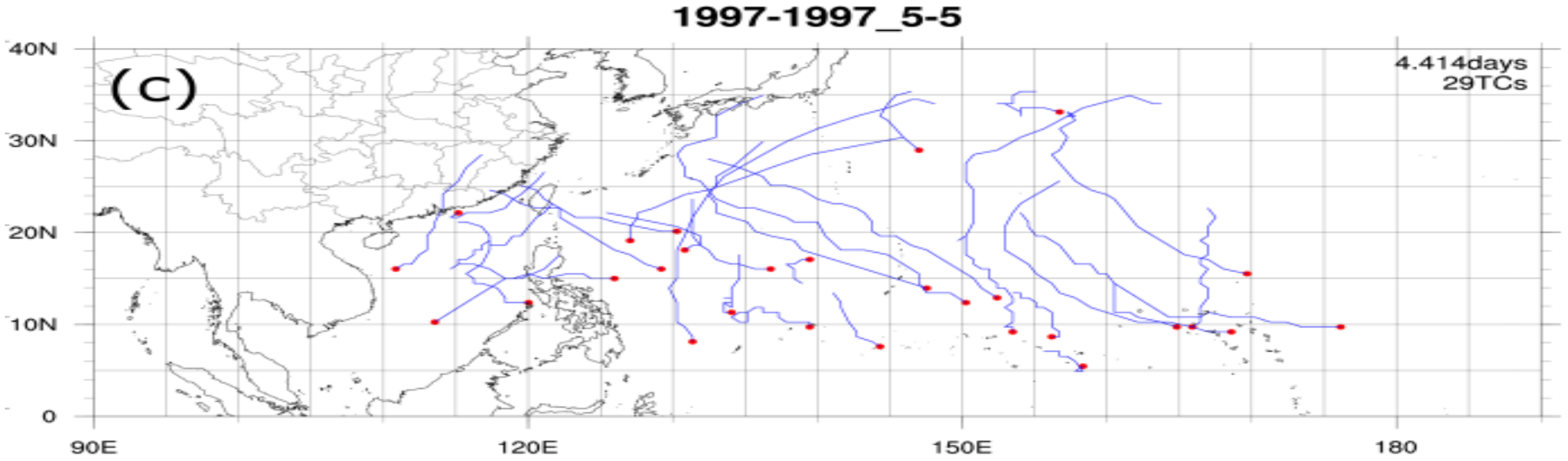


Model Climatology (1982-2001, May to Oct)

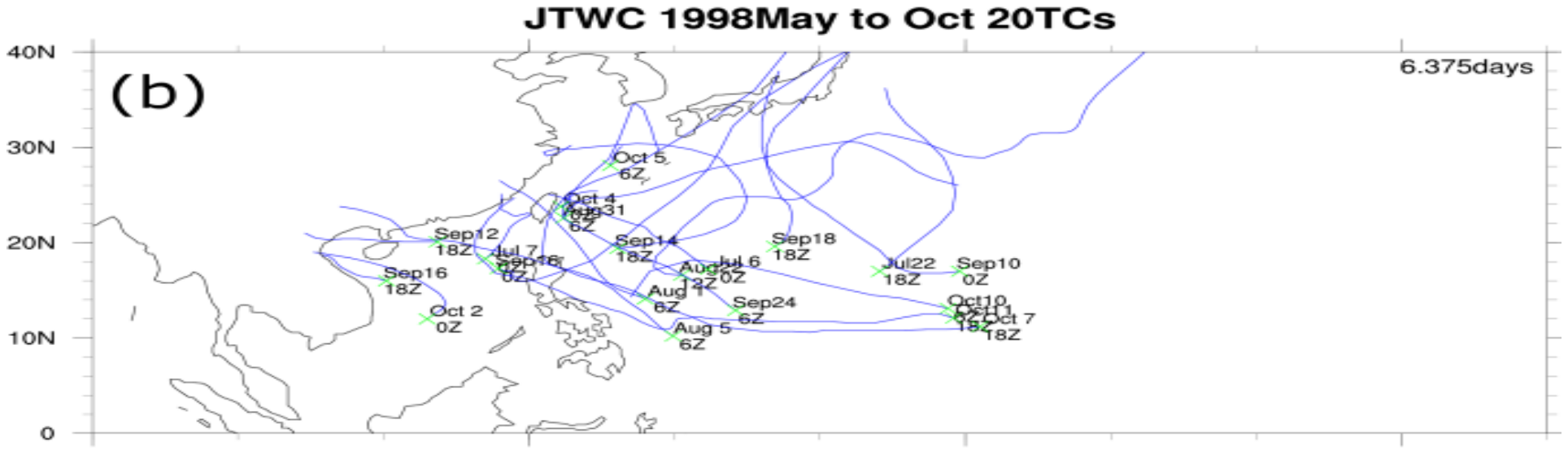


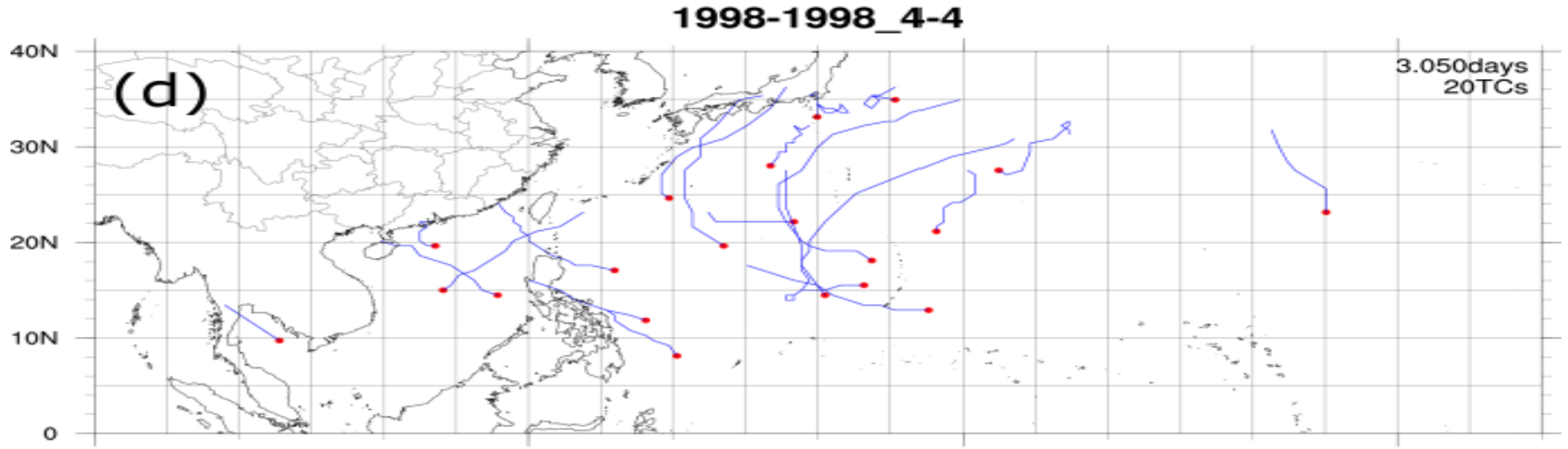
Model vs. Observed (1997, May to Oct)



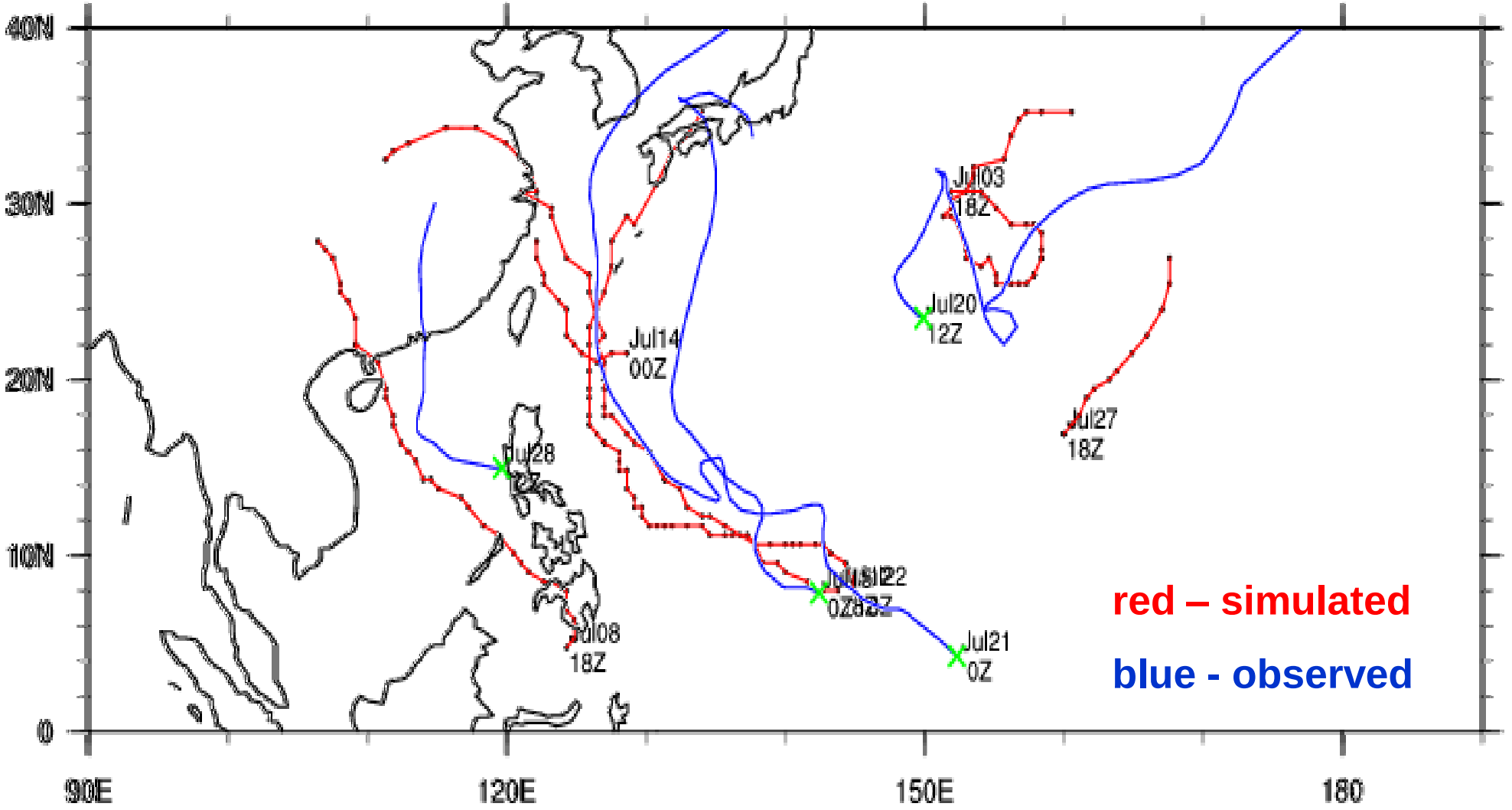


Model vs. Observed (1998, May to Oct)





Example of simulation of a 3-month forecast



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.**