Tropical Cyclone Activities in the Asia-Pacific Region: Past Variations and Future Predictions

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Atlantic 2005

- Rita: 23 September
- Dennis: 10 July
- Katrina: 28 August
- Wilma: 21 October
- Emily: 17 July
Atlantic 2005

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH ATLANTIC BASIN
Annual No. of TCs in the Atlantic

- Severe Hurricane (>127 knots)
- Hurricane (64-127 knots)
- Tropical Storm (34-63 knots)
- Tropical Depression (<34 knots)
Webster et al.’s (2005) Science paper
Outline

- Past variations of TC activity
  - Western North Pacific
  - North Indian Ocean
  - Southern Hemisphere
- Possible causes of such variations
- Future predictions/projections of TC activity
- Summary
Number of Tropical Cyclones Making Landfall in Japan

Year:
- 1960
- 1965
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000

Number:
- 0
- 2
- 4
- 6
- 8
- 10
- 12

The chart shows the number of tropical cyclones making landfall in Japan from 1960 to 2000. The highest number of landfalls occurred in 1990 and 2000.
No. of Tropical Cyclones Making Landfall in Japan and Korea Every 5-year period (1970-2004)

Year | Number
--- | ---
1970-74 | 15
1975-79 | 10
1980-84 | 5
1985-89 | 10
1990-94 | 25
1995-99 | 20
2000-04 | 22
No. of Typhoons Making Landfall in Zhejiang Province Every 5-year period (1960-2005)
No. of Tropical Cyclones Making Landfall in Southern China Every 5-year period (1960-2005)
Number of tropical cyclones in the western North Pacific
ACE vs. May-Nov SSTA (5-30°N, 120-180°E)
Webster et al.'s (2005) *Science* paper

**A** Number of intense hurricanes

- **maximum wind speed**
- cat: 1
- cats: 2+3
- cats: 4+5

**B** Percentage of intense hurricanes

- cats: 2+3
- cat: 1
- cats: 4+5
ACE vs. May-Nov SSTA (5-30°N, 120-180°E)
## No. of Category 4 and 5 Typhoons

<table>
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<th>1975-89</th>
<th>1990-2004</th>
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<tr>
<td>Number</td>
<td>75</td>
<td>115</td>
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<tr>
<td>Percentage</td>
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### No. of Category 4 and 5 Typhoons

<table>
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<tr>
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<th>1960-74</th>
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<tr>
<td>Percentage</td>
<td>37</td>
<td>32</td>
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Variations of Landfall in Different Regions in East Asia

South Asia

East China

Japan/Korea
Tropical Cyclone Activity in the North Indian Ocean

Annual anomaly of TCs

Anomaly of no. of intense TCs

- Entire basin
- Bay of Bengal
- Arabian Sea
Tropical Cyclone Activity in the Southern Hemisphere
Tropical Cyclone Activity in the Australian region

The graph shows the number of tropical cyclones from 1970 to 2005.

- EN: Red circles indicate El Niño years.
- LN: Blue squares indicate La Niña years.

The data points fluctuate over time, with higher peaks in some years and lower in others.
El Niño/Southern Oscillation (ENSO)
No. of TCs in the western North Pacific

Annual number of tropical storms and typhoons

- **El Niño**
- **La Niña**

Data points for years 1960 to 2005.
Anomalies in TC Activity During an El Niño year

Annual TC activity anomaly, EN year
Anomalies in TC Activity During an La Niña year
Western North Pacific TCs in 1997 – an El Niño year

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH-WEST PACIFIC BASIN
Western North Pacific TCs in 1998 – a La Niña year
Tropical Cyclone Activity in the Australian region
Typical Examples in El Niño and La Niña years

El Niño

La Niña
Indian Ocean Dipole

Positive Dipole Mode

green\textcolor{green}{positive mode}

Negative Dipole Mode

\textcolor{red}{negative mode}
Typical Tracks in IOD+ and IOD- years

Anomalous frequency of occurrence (2006/07) IOD+

Anomalous frequency of occurrence (1998/99) IOD-
Pacific Decadal Oscillation

warm phase

cold phase
PDO effects on tropical cyclone intensity
### Ratio (%) of number of tropical storms in global warming experiment to number without global warming

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Global</th>
<th>NH</th>
<th>SH</th>
<th>N Atl.</th>
<th>WN Pac.</th>
<th>NE Pac.</th>
<th>N Indian</th>
<th>S Indian</th>
<th>SW Pac.</th>
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<td>161</td>
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<td>10y 1xCO2 2xCO2 from 115y CO2 1% pa</td>
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<td>10y A1B 2080-2099</td>
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</table>
Distribution of Maximum Wind Speeds for 20th and 21st Century Simulations (Northern Hemisphere)
Distribution of Maximum Rotation for 20th and 21st Century Simulations

(c) W. Pacific

Total 20C – 44.0
Total 21C – 35.3

(a) Atlantic

Total 20C – 11.9
Total 21C – 11.0
Dynamical downscaling

Global Scale, $\sim 200$ km
Dynamical downscaling

Regional Scale
~ 20-60 km
Example of a tropical cyclone in the model
Model Climatology (1982-2001, May to Oct)

(a) Annual-mean TC genesis in 1982 to 2001 May to Oct (JTWC) 5° / 10yrs

(b) Mean TC genesis in 1982 to 2001 May to Oct (RegCM) 5° / 10yrs

Legend:
- JTWC
- RegCM

Map showing the distribution of tropical cyclone genesis.
Model Climatology (1982-2001, May to Oct)

\[ 450 \times 10^{-6}/s \]
\[ 1^\circ C \]
\[ \geq 2\text{days} \]

- RegCM3
- JTWC

\[ r=0.646 \]
Model vs. Observed (1997, May to Oct)
Model vs. Observed (1998, May to Oct)
Example of simulation of a 3-month forecast

red – simulated
blue - observed
Summary

- Tropical cyclone activity does not show any trend in any of the Asia-Pacific ocean basins. In other words, *global warming is not contributing to the observed variations in TC activity.*

- Instead, TC activity goes through large-amplitude variations on time scales from a few years to a few decades.
Summary

- The El Niño phenomenon is an important factor in contributing towards the variations in TC activity in each of the regions, as well as the variations in TC landfall locations.

- Other atmospheric and ocean conditions are also likely to affect such variations but more research is necessary to ascertain the physical processes involved.
Summary

- Future projections suggest the possibility of higher frequency of intense TCs although the percentage change is small.

- Improved predictions of TC activity on a seasonal scale may come through better regional model integrations.