# Summary of 2006 NW Pacific Typhoon Season and Verification of Authors' Seasonal Forecasts

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## Summary

**A year with near-average activity as defined by the basin ACE (Accumulated Cyclone Energy) index but where the numbers of intense typhoons were in the upper tercile and the number of tropical storms were in the lower tercile. The TSR probabilistic forecasts with the exception of the early July forecast all correctly predicted the near-average ACE index activity. The TSR deterministic forecasts performed well for the ACE index but over-predicted the number of tropical storms and typhoons.**

The Tropical Storm Risk (TSR) consortium presents a validation of their seasonal probabilistic and deterministic forecasts for the NW Pacific basin ACE index, and deterministic forecasts for the numbers of intense typhoons, typhoons and tropical storms in 2006. These forecasts were issued monthly from 7th March 2006 to the 4th August 2006 for the 2006 NW Pacific typhoon season which ran from 1st January to 31st December 2006.

## Features of the 2006 NW Pacific Season

- The 2006 NW Pacific season featured 24 tropical storms, 15 typhoons, 11 intense typhoons and an ACE index of 317 x$10^4$ knots$^2$.
- Damage from typhoons was higher in 2006 than in 2005. The total economic and insured losses are estimated to be US$ 15bn and US$ 1.5bn respectively (Munich Re, 2006).
- The most costly storm was typhoon Shanshan which struck west Japan in mid September causing total and insured losses of US$ 2.5bn and US$ 1.2bn respectively.
- Typhoon Saomai was the most powerful typhoon to make landfall in mainland China for over 50 years with 1 minute sustained winds of 115kts. Saomai was responsible for over 400 deaths and a total damage bill of US $1.4 bn.
- The Phillippines were struck by six typhoons - Chanchu, Xangsane, Cimaron, Chebi, Durian and Utor. This is the highest number of typhoon strikes on the Phillippines since 1974. Together they killed over a thousand people, with Durian responsible for at least 800 deaths.
- After striking the Phillippines typhoon Durian crossed the South China Sea and made landfall in Vietnam killing at least 80 people.
- Hurricane/typhoon Ioke's ACE index was 82. This broke the record (set by hurricane Ivan in 2004) for the highest recorded ACE index by an individual storm anywhere in the world.
- The ratio of numbers of intense typhoons to numbers of typhoons in 2006 - at 0.73 - was the highest since 1970.

# Tropical Storm Catalogue 2006

| NW Pacific Individual Storm Summary 2006 | | | | | |
|---|---|---|---|---|---|
| No. | Name | Dates | Peak wind (kts)[x] | Typhoon category | Landfall country and storm category at landfall* |
| 1 | 01W | 04-07 Mar | 35 | - | - |
| 2 | Chanchu | 08-18 May | 135 | 4 | Phillippines (2), China (1) |
| 3 | Jelawat | 26-29 Jun | 45 | - | - |
| 4 | Ewiniar | 29 Jun-10 Jul | 130 | 4 | South Korea (TS) |
| 5 | Bilis | 09-14 Jul | 55 | - | Taiwan (TS), China (TS) |
| 6 | 06W | 18-19 Jul | 35 | - | - |
| 7 | Kaemi | 22-25 Jul | 85 | 2 | Taiwan (1) |
| 8 | Prapiroon | 31 Jul-03 Aug | 70 | 1 | China (1) |
| 9 | Saomai | 04-10 Aug | 140 | 5 | China (4) |
| 10 | Maria | 05-09 Aug | 65 | 1 | - |
| 11 | Bopha | 06-10 Aug | 50 | - | Taiwan (TS) |
| 12 | Wukong | 12-19 Aug | 50 | - | Japan[+] (TS) |
| 13 | Sonamu | 13-16 Aug | 45 | - | - |
| 14 | Ioke | 19 Aug-05 Sep | 140 | 5 | - |
| 15 | Shanshan | 10-17 Sep | 120 | 4 | Japan[+] (1) |
| 16 | Yagi | 17-24 Sep | 140 | 5 | - |
| 17 | Xangsane | 25-30 Sep | 125 | 4 | Phillippines (4) |
| 18 | Bebinca | 01-06 Oct | 45 | - | - |
| 19 | Rumbia | 04-06 Oct | 45 | - | - |
| 20 | Soulik | 09-15 Oct | 90 | 2 | - |
| 21 | Cimaron | 27 Oct-04 Nov | 140 | 5 | Phillippines (5) |
| 22 | Chebi | 09-14 Nov | 115 | 4 | Phillippines (3) |
| 23 | Durian | 26 Nov-05 Dec | 135 | 4 | Phillippines (4), Vietnam (1) |
| 24 | Utor | 07-14 Dec | 100 | 3 | Phillippines (3) |

* Landfall is defined as the intersection of the surface centre of a tropical storm with a coastline.
[+] Mainland only.
[x] 1-min sustained winds.
TS = Tropical storm, 1-5 = Saffir-Simpson hurricane scale.

The tropical storm names and peak 1-minute sustained windspeeds are obtained from the following sources: Joint Typhoon Warning Center best track data, Gary Padgett's monthly global tropical cyclone summaries issued through the tropical storms mailing list at *tropical-storms@tstorms.org*, Julian Heming's Met Office Tropical Cyclone Website (*http://www.metoffice.gov.uk/weather/tropicalcyclone/observations.html*) and the City University of Hong Kong (*http://weather.cityu.edu.uk/*).

# Verification of Forecasts

## NW Pacific ACE Index and System Numbers

### a) Deterministic forecasts

| NW Pacific ACE Index and System Numbers in 2006 | | | | | |
|---|---|---|---|---|---|
| | | ACE Index ($x10^4$ knots$^2$) | Intense Typhoons | Typhoons | Tropical Storms |
| Average Number (±SD) (1965-2005) | | 305 (±98) | 8.6 (±3.0) | 16.9 (±3.6) | 26.7 (±4.4) |
| Actual Number 2006 | | 317 | 11 | 15 | 24 |
| TSR Forecasts (±SD) | 4 Aug 2006 | 325 (±77) | 9.3 (±2.5) | 18.6 (±2.9) | 29.0 (±3.7) |
| | 5 July 2006 | 349 (±82) | 10.0 (±2.4) | 18.6 (±2.9) | 29.0 (±3.7) |
| | 7 June 2006 | 315 (±84) | 9.0 (±2.6) | 18.6 (±2.9) | 29.0 (±3.7) |
| | 5 May 2006 | 326 (±80) | 9.3 (±2.6) | 18.6 (±2.9) | 29.0 (±3.7) |
| | 7 Mar 2006 | 298 (±92) | 8.4 (±2.7) | 17.1 (±3.3) | 27.1 (±4.0) |
| Chan Forecasts | 23 June 2006 | - | - | 18 | 28 |
| | 24 April 2006 | - | - | 17 | 27 |

### b) Probabilistic forecasts

| NW Pacific ACE Index 2006 | | | | | |
|---|---|---|---|---|---|
| | | Tercile Probabilities | | | RPSS |
| | | below normal | normal | above normal | |
| Actual 2006 | | 0 | 100 | 0 | 1 |
| Climatology 1965-2005 | | 33.3 | 33.3 | 33.3 | 0 |
| TSR Forecasts | 4 Aug 2006 | 14 | 52 | 34 | 0.452 |
| | 5 July 2006 | 10 | 44 | 46 | 0.077 |
| | 7 June 2006 | 19 | 50 | 31 | 0.427 |
| | 5 May 2006 | 15 | 50 | 35 | 0.408 |
| | 7 Mar 2006 | 26 | 47 | 27 | 0.368 |

For the second consecutive year the NW Pacific ACE Index was close to the long term climate norm (1965-2005 climatology). All the TSR forecasts except early July accuratly predicted the ACE index. Tropical storm and typhoon numbers were overpredicted, however, these numbers were unusually low this year given that the ACE index was near-average. Intense typhoon numbers were underpredicted at all leads. The June forecast performed best for the ACE index while the July forecast performed best for intense typhoon numbers. All the probabilistic forecasts showed skill with the August forecast having the highest skill.

Chan's predictions for tropical storm and typhoon numbers in 2006 were slightly better than TSR's, although Chan also overpredicted. Further details on the Chan forecasts and their verification may be obtained from *http://weather.cityu.edu.hk/tc_forecast/*

## Environmental Factors in 2006

The principle underlying sound seasonal typhoon predictions is to forecast the key environmental conditions at the height of the NW Pacific typhoon season. TSR finds that the most important contemporaneous factor influencing the overall activity of the NW Pacific typhoon season is the August-September (AS) Niño 3.75 SST [region 180°-140°W, 5°S-5°N]. This predictor influences cyclonic vorticity (the spinning up of storms) in the main typhoon formation region. The Table below verifies our forecasts in 2006 for this predictor.

| Predictor Forecasts 2006 | | |
|---|---|---|
| | | AS Niño 3.75 SST (°C) |
| Actual Value 2006 (1965-2005 Anomaly) | | 0.58 |
| TSR Forecasts (±FE) | 4 Aug 2006 | 0.24 (±0.20) |
| | 5 July 2006 | 0.50 (±0.30) |
| | 7 June 2006 | 0.13 (±0.43) |
| | 5 May 2006 | 0.25 (±0.46) |

All the TSR forecasts underpredicted the magnitude of the AS Niño 3.75 anomaly. The NW Pacific ACE index, however, was unusually low for such a high Niño 3.75 anomaly and thus the NW Pacific ACE index forecasts performed well overall. The July forecast proved best overall.

## Definitions

### Rank Probability Skill Score

The probabilistic skill measure employed is the rank probability skill score (*RPSS*) (Epstein 1969; Wilks 1995; Goddard et al 2003). Computation of *RPSS* begins with the rank probability score (RPS) which is defined as:

$$\sum_{m=1}^{N_{cat}} (CP_{Fm} - CP_{Om})^2$$

where $N_{cat} = 3$ for tercile forecasts. The vector $CP_{Fm}$ represents the cumulative probability of the forecast up to category $m$, and $CP_{Om}$ is the cumulative observed probability up to category $m$. The probability distribution of the observation is 100% for the category that was observed and is zero for the other two categories. For a perfect forecast $RPS = 0$. The *RPS* is referenced to climatology to give the *RPSS* which is defined as:

$$RPSS = 1 - \frac{RPS_{fcst}}{RPS_{ref}}$$

where $RPS_{fcst}$ is the *RPS* of the forecast and $RPS_{ref}$ ($=RPS_{cl}$) is the *RPS* of the climatology forecast. The maximum *RPSS* is 1; a negative *RPSS* indicates skill worse than climatology.

**Total ACE Index** = Accumulated Cyclone Energy Index = Sum of the squares of 6-hourly

maximum sustained wind speeds (in units of knots) for all systems while they are at least tropical storm strength. ACE Unit = $x10^4$ $knots^2$.

**Intense Typhoon** = 1 minute sustained winds > 95kts (110mph).
**Typhoon** = 1 minute sustained winds > 63kts (73mph).
**Tropical Storm** = 1 minute sustained winds > 33kts (38mph).
**SD** = Standard Deviation.
**Terciles** = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values historically (1965-2005).

## Forecasts for 2007

The TSR extended range forecast for the 2007 NW Pacific typhoon season will be issued in early March 2007 followed by monthly forecast updates through to early August. Forecasts will be deterministic and probabilistic.

## References


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Wilks, D., 1995: *Statistical Methods in the Atmospheric Sciences*. Academic Press, 467pp.


## Tropical Storm Risk.com (TSR)

Founded in 2000, *Tropical Storm Risk* (TSR) offers a leading resource for forecasting the risk from tropical storms worldwide. The venture provides innovative forecast products to increase risk awareness and to help decision making within the (re)insurance industry, other business sectors, government and society. The TSR consortium is co-sponsored by Benfield, the world's leading independent reinsurance and risk intermediary, Royal & Sun Alliance, the global insurance group, and Crawford & Company, a global claims management solutions company. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians at University College London and the Met Office.

Tropical Storm Risk has won two major insurance industry awards during the past three years. In 2006 TSR was awarded the prestigious Risk Management Award at the British Insurance Awards, and in 2004 won the British Insurance Award for London Market Innovation of the Year.

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