Summary of 2004 NW Pacific Typhoon Season and Verification of Authors' Seasonal Forecasts

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Summary

An exceptionally active year with the third highest total ACE index since 1965 and four typhoon strikes on mainland Japan. The TSR probabilistic forecasts successfully predicted the above-average activity from June, the August update giving a 70% probability for the total ACE index in 2004 being in the upper tercile historically. The deterministic forecasts underpredicted the ACE index and intense typhoon numbers at all leads, but tropical storm and typhoon numbers were correctly forecast to within one standard error.

The Tropical Storm Risk (TSR) consortium presents a validation of their seasonal probabilistic and deterministic forecasts for NW Pacific total ACE index, tropical storm, typhoon and intense typhoon numbers in 2004. These forecasts were issued monthly from 5th March 2004 to 5th August 2004, spanning the official NW Pacific typhoon season from 1st January to 31st December. The TSR forecasts were correct to within one standard error for tropical storm and typhoon numbers, but, with the exception of the August forecast, underpredicted intense typhoon numbers and the ACE index. This was due to unusually warm sea surface temperatures in the Niño 4 region which the model did not anticipate until early July.

Features of the 2004 NW Pacific Season

- The 2004 NW Pacific season featured 31 tropical storms, 21 typhoons, 13 intense typhoons and an ACE index of 464 $x10^4$ $knots^2$. This is the third highest total ACE index (after 1992 and 1997) since reliable records began in 1965. It is unusual to have such a high ACE index during a non El-Niño year.
- A very active year for landfalling storms. Mainland Japan was struck by seven tropical storms in 2004, of which four were typhoons (the most typhoon strikes since 1982). Typhoon Songda caused total economic losses of US$ 6.2bn, property claims of US$ 2.5bn and 41 deaths. The figures for typhoon Tokage were US$ 1.4bn, 0.8 bn and 80 deaths respectively; and for typhoon Chaba, US$ 1.8bn, 0.7bn and 16 deaths respectively.
- Rananin was the most powerful typhoon to hit eastern China in 50 years destroying 42,400 homes and wiping out large tracts of farmland.

- Typhoon Nanmadol caused 775 deaths in Quezon province, Phillippines, striking with 120mph winds and up to 23 cm of rain in just 12 hours. A week earlier typhoon Muifa also struck the Phillippines killing 600 people and displacing thousands from their homes.

Tropical Storm Catalogue 2004

Individual Storm Summary 2004					
No.	Name	Dates	Peak wind (kts)	Typhoon category	Landfall country, storm and category at landfall*
1	01W	11-16 Feb	35	-	-
2	02W	16-22 Mar	45	-	-
3	Sudal	04-15 Apr	130	4	-
4	Nida	13-21 May	140	5	-
5	05W	15-17 May	35	-	-
6	Omais	17-22 May	65	1	-
7	Conson	04-11 Jun	95	2	-
8	Chanthu	09-13 Jun	75	1	Phillippines (TS), Vietnam (1)
9	Dianmu	13-21 Jun	155	5	Japan^{+} (TS)
10	Mindulle	23 Jun-04 Jul	125	4	Taiwan (1), China (TS)
11	Tingting	25 Jun-03 Jul	80	1	-
12	Kompasu	13-16 Jul	45	-	China, Hong Kong (TS)
13	Namtheun	25 Jul-01 Aug	115	4	Japan^{+} (TS)
14	Meranti	04-08 Aug	90	2	-
15	Rananim	07-13 Aug	90	2	China (2)
16	Malakas	10-12 Aug	35	-	-
17	Megi	14-19 Aug	65	1	South Korea (TS)
18	Chaba	18-31 Aug	155	5	Japan^{+} (2)
19	Aere	19-26 Aug	85	2	China (1)
20	21W	26-28 Aug	35	-	-
21	Songda	27 Aug-07 Sep	130	4	Japan^{+} (2)
22	Sarika	04-07 Sep	60	-	-
23	Haima	12-13 Sep	35	-	-
24	Meari	20-29 Sep	120	4	Japan^{+} (1)
25	Ma_on	04-09 Oct	140	5	Japan^{+} (2)
26	Tokage	12-20 Oct	125	4	Japan^{+} (TS)
27	Nock_Ten	14-26 Oct	110	3	Taiwan (2)
28	Muifa	14-26 Nov	115	4	Phillippines (2)
29	Nanmadol	29 Nov-03 Dec	130	4	Phillippines (4)
30	Talas	10-16 Dec	45	-	-
31	Noru	17-18 Dec	55	-	-

* Landfall is defined as the intersection of the surface centre of a tropical storm with a coastline.
$^{+}$ Mainland only
TS = Tropical storm.

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* and Julian Heming's Met Office Tropical Cyclone Website (*http://www.met-office.gov.uk/sec2/sec2cyclone/tcver.html*).

Verification of Forecasts

NW Pacific Total Numbers and ACE Index

a) Deterministic forecasts

NW Pacific ACE Index and Total Numbers in 2004					
		ACE Index ($x10^4$ knots^2)	Tropical Storms	Typhoons	Intense Typhoons
Average Number (±SD) (1970-2003)		292 (±95)	26.9 (±4.4)	16.9 (±3.9)	8.4 (±3.1)
Actual Number 2004		464	31	21	13
TSR Forecasts (±SD)	4 Aug 2004	373 (±84)	27.7 (±4.8)	18.5 (±3.6)	11.0 (±1.7)
	5 July 2004	336 (±85)	27.0 (±5.0)	17.6 (±4.0)	9.8 (±2.2)
	4 June 2004	317 (±81)	26.6 (±4.9)	17.1 (±3.9)	9.2 (±2.3)
	11 May 2004	296 (±71)	26.1 (±4.8)	16.6 (±3.6)	8.6 (±2.1)
	6 Apr 2004	286 (±92)	25.9 (±5.1)	16.3 (±4.0)	8.2 (±2.6)
	9 Mar 2004	309 (±91)	26.4 (±5.1)	16.9 (±4.1)	9.0 (±2.6)
Chan Forecasts	18 June 2004	-	29	18	-
	1 May 2004	-	29	18	-

b) Probabilistic forecasts

NW Pacific Total ACE Index 2004					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2004		0	0	100	1
Climatology 1970-2003		33.3	33.3	33.3	0
TSR Forecasts	4 Aug 2004	5	25	70	0.77
	5 July 2004	12	35	52	0.45
	4 June 2004	16	40	44	0.25
	11 May 2004	20	48	31	-0.12
	6 Apr 2004	30	39	31	-0.08
	9 Mar 2004	21	38	41	0.20

In 2004, the NW Pacific accumulated tropical cyclone wind energy (ACE Index) was 60% higher than the 34-year climate norm. This is the third highest since reliable records began in 1965. The TSR forecasts underpredicted the total activity at all leads but anticipated above average activity from June onwards. All probabilistic forecasts except April and May showed

positive skill.

With the exception of the August typhoon forecast, Chan's predictions for tropical storm and typhoon numbers were better than TSR's. The reason for TSR's underprediction of the overall activity was the underprediction of the Niño 4 SST, which was the second highest since 1987. If August-September Niño 4 SST had been predicted perfectly TSR would only have underpredicted the total ACE index by 16%. Further details on the Chan forecasts and their verification may be obtained from *http://aposf02.cityu.edu.hk/~mcg/tc_forecast/2003_Verification.htm*.

Environmental Factors in 2004

The principle of sound seasonal typhoon prediction work is to forecast the key environmental conditions at the height of the NW Pacific typhoon season. We find that the most important contemporaneous factor influencing the overall activity of the NW Pacific typhoon season is the August-September (AS) Niño 4 SST [region 150°W-160°E, 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 for this predictor.

Predictor Forecasts 2004		
		AS Niño 4 SST (°C)
Actual Value 2004 (1974-2003 Anomaly)		0.78
TSR Forecasts (±FE)	4 Aug 2004	0.63 (±0.14)
	5 July 2004	0.32 (±0.23)
	4 June 2004	0.16 (±0.28)
	11 May 2004	-0.02 (±0.33)
	6 Apr 2004	-0.11 (±0.31)
	9 Mar 2004	0.09 (±0.29)

With the exception of April and May, all the TSR AS Niño 4 predictor forecasts were skillful compared to climatology with accuracy increasing at shorter leads. However, all forecasts underpredicted the actual value by more than one standard forecast error.

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 (1970-2003).

Forecasts and New Developments for 2005

1. The TSR extended range forecast for the 2005 NW Pacific typhoon season will be issued in early March 2005 followed by monthly forecast updates through to early August. Forecasts will be deterministic and probabilistic.

2. For the 2005 NW Pacific typhoon season TSR will be: (a) Introducing improved models for predicting the total ACE index, intense typhoon, typhoon and tropical storm numbers; (b) Introducing storm forecast strike probabilities out to 5 days lead and automatic storm alert e-mails to the features of the TSR Tropical Storm Tracker.

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Tropical Storm Risk.com (TSR)

Tropical Storm Risk.com (TSR) is a venture which has developed from the UK government-supported TSUNAMI initiative project on seasonal tropical cyclone prediction. The TSR consortium comprises experts on insurance, risk management and seasonal climate forecasting. The TSR industry expertise is drawn from *Benfield*, the leading independent reinsurance intermediary, *Royal & SunAlliance*, the global insurance group, and from *Crawford & Company*, a global claims management solutions company. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians at *UCL* (University College

London) and the *Met Office*. TSR forecasts are available from http://tropicalstormrisk.com.

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