Summary of 2009 NW Pacific Typhoon Season and Verification of Authors' Seasonal Forecasts

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Summary

The 2009 NW Pacific typhoon season had activity 10-20% below the long term (1965-2008) climate norm. The year had two halves with January to August having typhoon activity 54% below norm, and September to December having typhoon activity 28% above norm. The TSR deterministic and probabilistic forecasts overpredicted overall activity except for the March forecast and the May probabilistic forecast.

The Tropical Storm Risk (TSR) consortium presents a validation of their seasonal probabilistic and deterministic forecasts for the NW Pacific basin ACE index, and of their deterministic forecasts for the numbers of NW Pacific intense typhoons, typhoons and tropical storms in 2009. These forecasts were issued on the 16th March, 7th May, 6th July and the 4th August. The 2009 NW Pacific typhoon season ran from 1st January to 31st December 2009.

Features of the 2009 NW Pacific Season

- The 2009 NW Pacific season featured 25 tropical storms, 14 typhoons, 7 intense typhoons and an ACE index of 266 x10^4 knots^2. This is the third consecutive year that the ACE index has been below the 1965-2008 climate norm of 300 x10^4 knots^2.

- The first half of the 2009 NW Pacific typhoon season was very quiet compared to the second half. The ACE index from January to August (67) was 54% below the 1965-2008 climate norm. In contrast, the ACE index from September to December (199) was 28% above the 1950-2008 climate norm.

- The 2009 NW Pacific typhoon season was the most destructive for the Philippines for several decades. Five tropical storms, including three at typhoon strength struck the country. The most damaging and deadly storms were tropical storm Ketsana and typhoon Parma which struck in late September and early October respectively. These two storms caused serious flooding, killed over 600 people, and left a damage bill of over US$ 300m.

- Typhoon Melor struck Japan on October 8th with 1-min sustained winds of 75 mph causing US$ 1.5bn in damage. Melor was the only tropical cyclone to strike the Japanese mainland in 2009.

- Typhoon Morakot struck Taiwan with 1-minute sustained winds of 90 mph; the large size and slow movement of the storm brought severe flooding to the island. Rainfall in southern Taiwan was 2.9 m in three days, with a record 1.4 m falling on August 8th. These totals broke all tropical cyclone rainfall records for a single place in Taiwan.

- Vietnam was struck by two typhoons in 2009. Typhoon Ketsana made landfall with 1-min

sustained winds of 104 mph killing 163 people and causing an estimated US$ 785m in damage, mainly due to flooding. Ketsana also killed 43 in Cambodia, 26 people in Laos and 2 people in Thailand. Typhoon Mirinae was less destructive, making landfall with 75 mph sustained winds and killing 20 people.

- Typhoon Nida had peak winds of 160 kts (185 mph) on the 25th November making it the most intense tropical cyclone anywhere in the world in 2009.Nida was also the most intense typhoon in the NW Pacific since typhoon Paka in December 1997. Fortunately the storm did not impact land and eventually dissipated at sea.

Tropical Storm Catalogue 2009

NW Pacific Individual Storm Summary 2009					
No.	Name	Dates	Peak wind (kts)^x	Typhoon category	Landfall country and storm category at landfall*
1	Kujira	2-7 May	115	4	-
2	Chan-Hom	3-11 May	85	2	Philippines (1)
3	Linfa	17-22 Jun	75	1	China (TS)
4	Nangka	22-26 Jun	45	-	Philippines (TS)
5	Soudelor	9-12 Jul	35	-	China (TS)
6	Molave	15-19 Jul	65	1	China (1)
7	Goni	2-8 Aug	45	-	China (TS)
8	Morakot	3-9 Aug	85	2	Taiwan (2), China (TS)
9	Etau	8-12 Aug	35	-	-
10	Maka	14-18 Aug	45	-	-
11	Vamco	17-25 Aug	115	4	-
12	Krovanh	28-31 Aug	60	-	-
13	Dujaun	3-4 Sep	35	-	-
14	Choi-Wan	12-20 Sep	140	5	-
15	Koppu	13-15 Sep	70	1	China (1)
16	Ketsana	25-29 Sep	90	2	Philippines (TS), Vietnam (2), Laos (TS)
17	18W	27-30 Sep	35	-	-
18	Parma	27 Sep-14 Oct	130	4	Philippines (2), China (TS)
19	Melor	29 Sep-8 Oct	145	5	Japan$^+$ (1)
20	Nepartak	8-13 Oct	55	-	-
21	Lupit	14-26 Oct	135	4	-
22	Mirinae	26 Oct-2 Nov	90	2	Philippines (2), Vietnam (1)
23	25W	7-9 Nov	45	-	-
24	Nida	22 Nov-3 Dec	160	5	-
25	28W	5-5 Dec	35	-	-

^{x} 1-min sustained winds.

* Landfall is defined as the intersection of the surface centre of a tropical storm with a coastline.

$^+$ Mainland only.

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.hk/*).

Verification of Forecasts

NW Pacific ACE Index and System Numbers

a) Deterministic forecasts

NW Pacific ACE Index and System Numbers in 2009		ACE Index ($\times 10^4$ knots^2)	Intense Typhoons	Typhoons	Tropical Storms
Average Number (±SD) (1965-2008)		300 (±98)	8.6 (±3.0)	16.7 (±3.6)	26.6 (±4.3)
Actual Number 2009		266	7	14	25
TSR Forecasts (±FE)	4 Aug 2009	367 (±77)	10.6 (±2.4)	18.2 (±2.9)	28.1 (±3.8)
	6 Jul 2009	359 (±83)	10.3 (±2.4)	18.1 (±3.0)	28.0 (±3.9)
	7 May 2009	319 (±80)	9.1 (±2.5)	17.6 (±3.0)	27.5 (±3.8)
	16 Mar 2009	247 (±89)	6.7 (±2.6)	16.0 (±3.4)	25.6 (±3.9)
Chan Forecasts	24 Jun 2009	-	-	19	27
	18 Apr 2009	-	-	18	27

b) Probabilistic forecasts

NW Pacific ACE Index 2009		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2009		0	100	0	1
Climatology 1965-2008		33.3	33.3	33.3	0
TSR Forecasts	4 Aug 2009	5	33	62	-0.74
	6 Jul 2009	7	35	58	-0.52
	7 May 2009	16	46	38	0.32
	16 Mar 2009	46	40	14	-0.04

All TSR forecasts with the exception of the March forecast overpredicted the NW Pacific activity this year. The March forecast performed best overall for deterministic forecasts and was the only forecast to predict slightly below-average NW Pacific typhoon activity. Despite this, the March probabilistic forecast was not skilful. This is because the deterministic forecast for the NW Pacific ACE index was very close to the lower tercile boundary. The best probabilistic forecast was the May forecast. This is because it was the only forecast that predicted a near-

average season as the most likely outcome.

The Chan forecasts also overpredicted NW Pacific typhoon activity in 2009. The TSR forecasts were slightly better than Chan for typhoon numbers and slightly worse for tropical storm numbers. Further details on the Chan forecasts and their verification may be obtained from *http://weather.cityu.edu.hk/tc_forecast*

Environmental Factors in 2009

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 2009 for this predictor.

Predictor Forecasts 2009		
		AS Niño 3.75 SST (^{o}C)
Actual Value 2009 (1965-2008 Anomaly)		0.61
TSR Forecasts (±FE)	4 Aug 2009	0.67 (±0.21)
	6 Jul 2009	0.59 (±0.29)
	7 May 2009	0.16 (±0.44)

The July and August TSR forecasts performed well in 2009 correctly predicting the magnitude of the August/September Niño 3.75 SST anomaly to within 0.1^{o}C. Despite this accurate prediction, the NW Pacific ACE index and intense typhoon numbers were overpredicted. The March forecast underpredicted the Niño 3.75 SST anomaly yet performed best at predicting the ACE index and intense typhoon numbers. This is because NW Pacific typhoon was unusually low this year given the observed August/September Niño 3.75 SST anomaly. 2009 is the only year with an observed August-September Niño 3.75 SST anomaly above 0.5^{o}C and an ACE index below 300. One reason for the lower than expected activity was the first half of the season being very quiet with an ACE index of only 67 through to the end of August. This lack of activity was not factored into our forecasts. It is not clear why NW Pacific typhoon activity was so low during the first half of the season. The July forecast for AS Niño 3.75 SST performed best and was just 0.02^{o}C away from the observed value.

Definitions

Rank Probability Skill Score
The probabilistic skill measure employed is the rank probability skill score (*RPSS*) (Epstein 1969; Wilks 2006; 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 = <u>A</u>ccumulated <u>C</u>yclone <u>E</u>nergy 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 2010

The TSR extended range forecast for the 2010 NW Pacific typhoon season will be issued in early March 2010 followed by bi-monthly forecast updates through to early August. Forecasts will be deterministic and probabilistic.

References

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Tropical Storm Risk.com (TSR)

Tropical Storm Risk (TSR) offers a leading resource for predicting and mapping tropical storm activity worldwide. The public TSR website provides forecasts and information to benefit basic risk awareness and decision making from tropical storms. The new TSR Business service and web site offers real-time products of unrivalled accuracy for the detailed mapping and prediction of tropical storm windfields worldwide. The TSR consortium is co-sponsored by Aon Benfield, the leading reinsurance intermediary and capital advisor, RSA Insurance Group, the global

insurance group, and Crawford & Company, a global claims management solutions company.

Tropical Storm Risk has won two major insurance industry awards. 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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