Summary of 2006/7 Australian-Region Tropical Storm Season and Verification of Authors' Seasonal Forecasts

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Summary

The 2006/7 season saw near-average Australian-basin tropical storm numbers and near-average Australian landfalling activity but a well below-average Australian-basin ACE index. This continues the run of average to below-average Australian tropical storm seasons since 1999. The TSR deterministic forecasts for the 2006/7 season showed good precision at all leads for total basin and landfalling activity. The TSR tercile probability forecasts showed good skill for the May to August forecasts but no skill for the September to December forecasts.

The Tropical Storm Risk (TSR) consortium presents a summary of the 2006/7 Australian-region tropical storm season and a validation of their seasonal probabilistic and deterministic forecasts for this activity. These forecasts were issued monthly from the 12th May 2006 to the 5th December 2006 and include separate predictions for numbers of basin tropical storms, numbers of basin severe tropical cyclones, the basin ACE (Accumulated Cyclone Energy) index and numbers of Australian landfalling tropical storms.

Features of the 2006/7 Australian-Region Season

- The 2006/7 Australian-region tropical cyclone season featured 10 tropical storms of which 5 made severe tropical cyclone strength (U.S. hurricane equivalent). These figures compare to 30-year climatology values of 10.6 and 5.7 respectively. This is the eighth consecutive year without an active season.
- The total ACE index for 2006/7 was 39. This is the lowest ACE index since 2001 and the ninth lowest since 1960.
- Cyclone George was the most destructive cyclone to affect Port Hedland since cyclone Joan in 1975. Estimated wind gusts were around 170 mph at landfall. Three people were killed and there were numerous injuries at mining camps south of Port Hedland.
- All four landfalling tropical cyclones struck along a 300 mile stretch of NW Australia.
- The ACE index of 39 is exceptionally low for a season featuring five severe tropical cyclones (U.S. hurricane equivalent) and three very severe tropical cyclones (U.S. intense hurricane equivalent). The only other season comparable to 2006/7 is the 2000/1 season which featured five severe tropical cyclones and one very severe tropical cyclone and an ACE index of 22.

Catalogue of Storm Events in 2006/7

Individual Storm Summary 2006/7					
No.	Name	Dates	Peak Wind (kts)	Storm Category	Category at Australian Landfall
1	Xavier	20-28 Oct	115	4	-
2	04P	29 Nov-04 Dec	35	TS	-
3	Isobel	31 Dec-03 Jan	40	TS	TS
4	Nelson	31 Jan-07 Feb	45	TS	TS
5	George	26 Feb-10 Mar	110	3	3
6	Odette	26 Feb-07 Mar	35	TS	-
7	Becky	25-31 Mar	70	1	-
8	Kara	24-28 Mar	105	3	-
9	Jacob	05-12 Mar	75	1	TS
10	Pierre	17-18 May	35	TS	-

Yani (November 2006) is not included because the Fiji Meteorological Service classified the system as a tropical depression east of 170°E (although JTWC listed the system as forming west of 170°E).

Storm categories are based on 1-minute sustained windspeeds and the Saffir-Simpson Hurricane Scale.

Verification of Forecasts for 2006/7

1. Australian Region Total Numbers and ACE Index

a) Deterministic forecasts

Australian Region (100°E to 170°E) Total Numbers and ACE Index				
		ACE Index ($x10^4$ knots^2)	Severe Tropical Cyclones	Tropical Storms
Average Number (±SD) (1975/6-2005/6)		83 (±42)	5.7 (±2.4)	10.6 (±3.6)
Actual Number 2006/7		39	5	10
TSR Forecasts (±FE)	5 Dec 2006	59 (±37)	4.6 (±2.0)	7.9 (±3.0)
	8 Nov 2006	59 (±37)	4.4 (±2.0)	8.3 (±3.0)
	4 Oct 2006	59 (±37)	4.6 (±2.1)	7.6 (±3.2)
	7 Sep 2006	59 (±37)	4.9 (±2.0)	8.1 (±3.0)
	4 Aug 2006	-	5.8 (±2.1)	9.3 (±3.0)
	5 Jul 2006	-	5.5 (±2.1)	9.0 (±3.2)
	7 Jun 2006	-	5.7 (±2.3)	9.9 (±3.3)
	12 May 2006	-	5.6 (±2.2)	10.0 (±3.4)

Total activity (ACE index) was over one standard deviation below the 1975/6-2005/6 climate norm, although tropical storm numbers were only slightly below average. This is the lowest

basin ACE index since 2001/2. TSR anticipated a well below average basin ACE index and slightly below average tropical storm numbers, although the ACE index was lower than forecast. Severe tropical cyclone numbers were also well predicted.

b) Tercile probabilistic forecasts

Australian Region Tropical Storm Numbers 2006/7					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2006/7		0	100	0	1
Climatology 1975/6-2005/6		35	36	29	0
TSR Forecasts	6 Dec 2005	52	44	4	-0.32
	7 Nov 2005	46	48	6	-0.04
	4 Oct 2005	55	41	4	-0.47
	8 Sep 2005	48	47	5	-0.13
	5 Aug 2005	33	56	11	0.41
	7 Jul 2005	38	51	11	0.24
	7 Jun 2005	29	54	17	0.45
	9 May 2005	28	53	19	0.45

The probabilistic forecasts showed skill for the May to August forecasts but no skill for the September to December forecasts. This is suprising since the deterministic forecasts were very good at all leads. The reason for the apparent zero skill in the September to Decemeber forecasts is because the forecasts slightly favoured below average activity whereas the actual tropical storm numbers only just fell into the middle tercile. If there had been one less observed tropical storm then the tropical storm numbers would have fallen in the lower tercile and the skill for the September to December forecasts would have been positive. As the observed and forecast tropical storm numbers both fell very close to the lower and middle tercile boundary this means that the rank probability skill score shows no skill even though the deterministic forecasts performed well.

2. Australian Landfall Numbers and ACE Index

a) Deterministic forecasts

Australian Landfalling Numbers 2006/7		
		Tropical Storms
Average Number (±SD) (1975/6-2005/6)		4.6 (±2.1)
Actual Number 2006/7		4
TSR Forecasts (±FE)	5 Dec 2006	3.6 (±2.0)
	8 Nov 2006	3.8 (±2.0)
	4 Oct 2006	3.5 (±2.0)
	7 Sep 2006	3.7 (±1.9)
	4 Aug 2006	4.1 (±2.0)
	5 Jul 2006	4.0 (±2.0)
	7 Jun 2006	4.3 (±2.0)
	12 May 2006	4.4 (±2.0)

b) Tercile probabilistic forecasts

Australian Landfalling Numbers 2006/7					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2005/6		0	100	0	1
Climatology 1975/6-2005/6		32	42	26	0
TSR Forecasts	5 Dec 2006	37	51	12	0.11
	8 Nov 2006	36	51	13	0.14
	4 Oct 2006	39	50	11	0.03
	7 Sep 2006	36	52	12	0.15
	4 Aug 2006	28	55	17	0.37
	5 Jul 2006	31	53	16	0.28
	7 Jun 2006	25	54	21	0.37
	12 May 2006	21	54	25	0.37

Four tropical storms made Australian landfall, which is comparable to the 1975/6-2005/6 climate norm. All TSR deterministic forecasts performed well, correctly predicting the number of landfalling events at all leads. All tercile probabilistic forecasts correctly predicted near-average landfalling activity and therefore showed positive skill at all leads.

Environmental Factors in 2006/7

Sound seasonal forecasts of Australian tropical storm activity are achieved by predicting key environmental conditions prior to the Australian cyclone season. We find that the most important contemporaneous factor influencing the overall activity of the Australian tropical cyclone season is the October-November (ON) Niño 4 sea surface temperature (SST) [region

150°W-160°E, 5°S-5°N]. Above-average (below-average) ON Niño 4 SSTs in this region lead to above-average (below-average) atmospheric vertical wind shear over the Australian region during Austral summer; a condition favouring below-average (above-average) tropical storm activity. The table below verifies our forecasts for this predictor.

Predictor Forecasts 2006		
		ON Niño 4 SST (°C)
Actual Value 2006 (1975-2005 Anomaly)		0.77
TSR Forecasts (±FE)	4 Oct 2006	0.79 (±0.21)
	7 Sep 2006	0.64 (±0.24)
	4 Aug 2006	0.32 (±0.32)
	5 Jul 2006	0.41 (±0.43)
	7 Jun 2006	0.16 (±0.49)
	12 May 2006	0.13 (±0.50)

The TSR forecasts for the ON Niño 4 predictor correctly predicted a warmer than normal Niño 4 SST at all leads. The October forecast performed best overall correctly predicting the observed Niño 4 SST to within 0.02°C.

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.

Severe Tropical Cyclone = 1 minute sustained winds > 63kts (73mph) = Hurricane category 1 to 5.

Tropical Storm	=	1 minute sustained winds > 33kts (38mph).
SD	=	Standard Deviation.
Terciles	=	Data groupings of probability corresponding to the upper, middle and lower one-third of values historically (1975/6-2004/5).
Australian Region	=	Southern Hemisphere 100°E to 170°E (Storm must form as a tropical depression within to count).
Australian Strike	=	Strike on Australian Coast from Perth around to Brisbane.

References

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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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