Summary of 2005/6 Australian-Region Tropical Storm Season and Verification of Authors' Seasonal Forecasts

Issued: 15th May 2006

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Summary

The 2005/6 season saw near-average Australian-basin tropical storm activity and near-average Australian landfalling activity. This contrasts with the four previous Australian tropical storm seasons which all had below-average activity. The TSR tercile probability forecasts for the 2005/6 season showed excellent skill, predicting from May 2005 that Australian basin and landfalling activity would be close to average. The TSR deterministic forecasts showed good skill for basin activity and for landfalling tropical storm numbers from May 2005.

The Tropical Storm Risk (TSR) consortium presents a summary of the 2005/6 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 9th May 2005 to the 6th December 2005 and include separate predictions for numbers of tropical storms, numbers of severe tropical cyclones and the ACE (Accumulated Cyclone Energy) index. The latter is given for the whole Australian-region.

Features of the 2005/6 Australian-Region Season

- The 2005/6 Australian-region tropical storm season featured 11 storms of which 7 made severe tropical cyclone strength (U.S. hurricane equivalent). These figures compare to 30-year climatology values of 10.6 and 5.7 respectively.
- In contrast to the period 2001/2 to 2004/5, the 2005/6 season was close to average in terms of both basin and landfalling activity. This is the most active season since 1998/9.
- Cyclone Monica was the most powerful cyclone ever observed in the Australian basin with maximum 1-minute sustained winds of 155kts (180mph) at peak intensity. Fortunately its landfall as a Cat 5 storm occurred in a sparsely populated area to the east of Darwin so damage was minor.
- As well as Monica two other very severe tropical cyclones struck Australia in 2005/6. Cyclone Glenda lashed the Pilbara region in northwest Australia with winds gusting to 145mph and causing US$ 405m in damage. Cyclone Larry struck the east Queensland coast with wind gusts as high as 180mph leaving 50,000 homes without power and destroying 90% of the region's banana crop.
- Cyclone Clare, the first tropical cyclone of the season, struck north-western Australia near the town of Dampier with winds gusting to 115mph. Fortunately damage was minor.

Catalogue of Storm Events in 2005/6

Individual Storm Summary 2005/6					
No.	Name	Dates	Peak Wind (kts)	Storm Category	Category at Australian Landfall
1	Clare	08-10 Jan	60	TS	TS
2	Daryl	19-22 Jan	65	1	-
3	Jim	28 Jan-01 Feb	80	1	-
4	Kate	22-24 Feb	50	TS	-
5	Emma	27-28 Feb	35	TS	-
6	Larry	18-20 Mar	100	3	3
7	Wati	19-24 Mar	80	1	-
8	Floyd	21-26 Mar	115	4	-
9	Glenda	27-30 Mar	140	5	3
10	Hubert	01-05 Apr	55	TS	TS
11	Monica	17-24 Apr	155	5	5

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

Verification of Forecasts for 2005/6

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) (1975/6-2004/5)		83 (±43)	5.7 (±2.4)	10.6 (±3.7)
Actual Number 2005/6		83	7	11
TSR Forecasts (±FE)	6 Dec 2005	90 (±38)	5.8 (±2.1)	10.2 (±3.0)
	7 Nov 2005	90 (±38)	5.7 (±2.0)	9.9 (±3.0)
	4 Oct 2005	90 (±38)	5.5 (±2.1)	9.8 (±3.2)
	8 Sep 2005	90 (±38)	5.3 (±2.1)	9.8 (±3.0)
	5 Aug 2005	-	5.2 (±2.2)	9.6 (±3.0)
	7 Jul 2005	-	5.4 (±2.3)	10.0 (±3.3)
	7 Jun 2005	-	5.3 (±2.3)	9.8 (±3.4)
	9 May 2005	-	5.6 (±2.3)	10.4 (±3.5)

b) Tercile probabilistic forecasts

Australian Region Tropical Storm Numbers 2005/6					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2005/6		0	100	0	1
Climatology 1975/6-2004/5		37	33	30	0
TSR Forecasts	6 Dec 2005	14	68	18	0.78
	7 Nov 2005	17	68	15	0.77
	4 Oct 2005	19	65	16	0.73
	8 Sep 2005	18	68	14	0.77
	5 Aug 2005	20	67	13	0.75
	7 Jul 2005	18	64	18	0.71
	7 Jun 2005	20	62	17	0.68
	9 May 2005	25	53	22	0.51

Total activity (ACE index) was equal to the 30-year climate norm. This is the most active season for seven years TSR correctly anticipated a near-average season at all leads. All forecasts were similar from month to month in predicting about 10 tropical storms and 5-6 severe tropical cyclones. All forecasts were correct to within one standard error. The May forecast performed best for tropical storm numbers; the December forecast performed best for severe tropical cyclone numbers. The tercile probabilistic forecasts showed excellent skill at all leads, with the December forecast having the highest skill.

2. Australian Landfall Numbers and ACE Index

a) Deterministic forecasts

Australian Strike Numbers		
		Tropical Storms
Average Number (±SD) (1975/6-2004/5)		4.6 (±2.2)
Actual Number 2005/6		5
TSR Forecasts (±FE)	6 Dec 2005	4.4 (±2.0)
	7 Nov 2005	4.3 (±2.0)
	4 Oct 2005	4.3 (±2.0)
	8 Sep 2005	4.2 (±2.0)
	5 Aug 2005	4.2 (±2.0)
	7 Jul 2005	4.3 (±2.0)
	7 Jun 2005	4.3 (±2.0)
	9 May 2005	4.5 (±1.9)

b) Tercile probabilistic forecasts

Australian Strike Numbers					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2005/6		0	100	0	1
Climatology 1975/6-2004/5		33	40	27	0
TSR Forecasts	6 Dec 2005	25	54	21	0.41
	7 Nov 2005	26	54	20	0.41
	4 Oct 2005	27	54	19	0.41
	8 Sep 2005	26	55	19	0.43
	5 Aug 2005	28	54	18	0.40
	7 July 2005	26	54	20	0.41
	7 June 2005	27	53	20	0.38
	9 May 2005	24	53	23	0.39

Five tropical storms made Australian landfall, which is comparable to the 30-year climate norm. The Australian landfalling ACE index was also close to average. All TSR forecasts correctly predicted the number of landfalling events to within one standard error for all leads. All tercile probabilistic forecasts correctly predicted near-average landfalling activity and therefore showed good skill.

Environmental Factors in 2005/6

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

Predictor Forecasts 2005		
		ON Niño 4 SST (^{o}C)
Actual Value 2005 (1975-2004 Anomaly)		0.14
TSR Forecasts (±FE)	4 Oct 2005	0.19 (±0.21)
	8 Sep 2005	0.20 (±0.25)
	5 Aug 2005	0.25 (±0.33)
	7 Jul 2005	0.14 (±0.43)
	7 Jun 2005	0.20 (±0.50)
	9 May 2005	0.04 (±0.51)

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^{o}W-160^{o}E, 5^{o}S-5^{o}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 verifies our forecasts for this predictor.

The TSR ON Niño 4 predictor forecasts performed very well predicting the actual Niño 4 SST anomaly to within 0.11^{o}C at all leads from May 2005. The July forecast performed best predicting the Niño 4 SST anomaly perfectly.

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.
Australian ACE Index	=	Sum of the squares of hourly maximum sustained wind speeds (in units of knots) for all systems while they are at least tropical storm strength and over the Australian mainland (reduced by a factor of 6). ACE unit = 10^4 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^{o}E to 170^{o}E (Storm must form as a tropical depression within to count).
Australian Strike	=	Strike on Australian Coast from Perth around to Brisbane.

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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 the *Benfield Group*, 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 based at the *UCL* (University College London) Benfield Hazard Research Centre. TSR forecasts are available from *http://tropicalstormrisk.com*.

Acknowledgements

We thank David Simmons (Benfield Group), Alan Fowler (Royal & SunAlliance) and Jonathan Clark (Crawford & Company) for industrial liaison. We acknowledge web-site assistance by Peter Yuen (UCL).