Summary of 2004/5 Australian Region Tropical Storm Season and Verification of Authors' Seasonal Forecasts

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Summary

The 2004/5 season was the fourth consecutive year with below-average Australian-basin tropical storm activity. Australian landfalling activity in 2004/5 was either below-average or above-average depending upon the measure used. The TSR tercile probability forecasts successfully predicted below-average basin activity from early August (lead of 3 months) but showed no skill for landfalling activity. The TSR deterministic forecasts showed skill from early June (lead of 5 months) for basin activity and for landfalling tropical storm numbers. The skill of all forecasts increased as lead time decreased.

The Tropical Storm Risk (TSR) consortium presents a summary of the 2004/5 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 6th April 2004 to the 8th December 2004 and include separate predictions for tropical storms, severe tropical cyclones and the ACE (Accumulated Cyclone Energy) index. The latter is given for the whole Australian-region and for Australian landfall activity.

Features of the 2004/5 Australian Region Season

- The 2004/5 Australian-region tropical storm season featured 8 storms of which 3 made severe tropical cyclone strength (U.S. hurricane equivalent). These figures compare to 30-year climatology values of 10.7 and 5.8 respectively.
- A fourth consecutive inactive season. Only 6 years in the last 30 have seen less tropical storms. The period 2001/2 to 2004/5 has seen the lowest activity of any four-year period in the last 30 years. We believe this is due to the persistent warm anomaly in the ENSO Niño 4 region sea surface temperatures during this period.
- Cyclone Ingrid is the first category 4 cyclone to impact all three northern regions of Australia. Ingrid first crossed the Cape York Peninsula, then passed over Croker Island, North Goulborn Island and over the Coubourg Peninsula, causing widespread damage. Ingrids final landfall was at the remote resort of Faraway Bay, northeast of Kalumburu, where most of the buildings were destroyed.
- Severe tropical cyclone Ingrid contributed 48 ACE units which is equivalent to 73% of the total for the whole 2004/5 season (66). Ingrid also contributed an Australian landfalling ACE index of 5.9×10^4 kts^2, which is 86% of the total landfalling ACE index of 6.9×10^4 kts^2.

Catalogue of Storm Events in 2004/5

Individual Storm Summary 2004/5					
No.	Name	Dates	Peak Wind (kts)	Storm Category	Category at Australian Landfall
1	Raymond	31 Dec-03 Mar	50	TS	TS
2	Sally	07-10 Jan	45	TS	-
3	Tim	23-26 Jan	45	TS	-
4	Lola	26 Jan-02 Feb	40	TS	-
5	Vivienne	05-10 Feb	45	TS	-
6	Harvey	05-08 Feb	85	STC	STC
7	Ingrid	05-19 Mar	135	STC	STC
8	Willy	09-17 Mar	90	STC	-

Verification of Forecasts for 2004/5

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)	Tropical Storms	Severe Tropical Cyclones
Average Number (±SD) (1975/6-2003/4)		84 (±41)	10.7 (±3.7)	5.8 (±2.4)
Actual Number 2004/5		66	8	3
TSR Forecasts (±FE)	8 Dec 2004	53 (±38)	7.7 (±3.2)	4.1 (±1.5)
	5 Nov 2004	55 (±38)	7.9 (±3.0)	4.2 (±1.6)
	5 Oct 2004	-	7.0 (±2.9)	3.9 (±1.5)
	6 Sep 2004	-	8.0 (±3.0)	4.3 (±1.5)
	4 Aug 2004	-	8.6 (±3.1)	4.5 (±1.5)
	5 Jul 2004	-	9.7 (±2.7)	4.8 (±1.5)
	4 Jun 2004	-	10.6 (±3.0)	5.2 (±1.6)
	11 May 2004	-	11.0 (±3.4)	5.3 (±1.6)
	6 Apr 2004	-	11.4 (±2.4)	5.5 (±1.5)

b) Tercile Probabilistic forecasts

Australian Region Tropical Storm Numbers 2004/5					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2004/5		100	0	0	1
Climatology 1975/6-2003/4		34.5	34.5	31	0
TSR Forecasts	8 Dec 2004	63	27	10	0.66
	5 Nov 2004	63	28	9	0.65
	5 Oct 2004	75	20	5	0.84
	6 Sep 2004	63	28	9	0.65
	4 Aug 2004	50	33	17	0.40
	5 Jul 2004	35	42	23	-0.01
	4 Jun 2004	26	37	37	-0.28
	11 May 2004	28	34	38	-0.21
	6 Apr 2004	15	44	41	-0.68

Total activity (ACE index) was ~78% of the 29-year climate norm. TSR correctly anticipated a below-average season from early August. Forecasts correctly predicted the number of tropical storms to within one standard error from early May and severe tropical cyclones to within one standard error from early August. The September forecast performed best for tropical storm numbers which were predicted exactly at this lead; the October forecast performed best for severe tropical cyclone numbers which were overpredicted slightly at all leads. The tercile probabilistic forecasts showed positive skill from August onwards, with the October forecast having the highest skill.

2. Australian Landfall Numbers and ACE Index

a) Deterministic forecasts

Australian Strike Numbers and ACE Index			
		Australian ACE Index ($x10^4$ $knots^2$)	Tropical Storms
Average Number (±SD) (1975/6-2003/4)		3.0 (±2.2)	4.7 (±2.2)
Actual Number 2004/5		6.9	3
TSR Forecasts (±FE)	8 Dec 2004	2.7 (±2.7)	4.1 (±1.8)
	5 Nov 2004	2.6 (±2.7)	4.1 (±1.8)
	5 Oct 2004	-	4.0 (±1.8)
	6 Sep 2004	-	4.0 (±1.9)
	4 Aug 2004	-	4.2 (±1.9)
	5 Jul 2004	-	4.4 (±1.9)
	4 Jun 2004	-	4.4 (±1.8)
	11 May 2004	-	4.5 (±1.8)
	6 Apr 2004	-	5.0 (±1.9)

b) Tercile Probabilistic forecasts

Australian Strike Numbers					
		Tercile Probabilities			RPSS
		below normal	normal	above normal	
Actual 2004/5		100	0	0	1
Climatology 1975/6-2003/4		31	41	28	0
TSR Forecasts	8 Dec 2004	28	59	13	-0.22
	5 Nov 2004	29	58	13	-0.19
	5 Oct 2004	29	57	14	-0.17
	6 Sep 2004	30	56	14	-0.14
	4 Aug 2004	30	55	15	-0.13
	5 July 2004	30	55	15	-0.13
	4 June 2004	29	58	13	-0.19
	11 May 2004	29	57	14	-0.17
	6 Apr 2004	14	56	30	-0.54

Three tropical storms made Australian landfall, which is approximatly one standard deviation below the 29-year climate norm. However the Australian landfalling ACE index was 1.5 standard deviations above normal. This was due to the exceptional track of severe tropical cyclone Ingrid which made landfall in three different Australian regions and contributed a landfalling ACE index of 5.9×10^4 kts^2, which is almost double the 1975/6-2003/4 climatology. All TSR forecasts overpredicted the number of landfalling events and underpredicted the landfalling ACE index. All tercile probabilistic forecasts predicted near-average landfalling activity which resulted in negative skill scores at all leads.

Environmental Factors in 2004/5

The principle of sound seasonal forecasts of Australian tropical storm activity is to predict the key environmental conditions prior to the Australian cyclone season. We find that the most

Predictor Forecasts 2004		
		ON Niño 4 SST (^{o}C)
Actual Value 2004 (1974-2003 Anomaly)		0.90
TSR Forecasts (±FE)	5 Nov 2004	0.85 (±0.08)
	5 Oct 2004	1.09 (±0.16)
	6 Sep 2004	0.81 (±0.15)
	4 Aug 2004	0.64 (±0.25)
	5 Jul 2004	0.35 (±0.33)
	4 Jun 2004	0.09 (±0.40)
	11 May 2004	-0.01 (±0.45)
	6 Apr 2004	-0.14 (±0.40)

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 ON Niño 4 SSTs in this region lead to above average atmospheric vertical wind shear over the Australian region during Austral summer; a condition favouring below average tropical storm activity. The table verifies our forecasts for this predictor.

The TSR ON Niño 4 predictor forecasts were skillful compared to climatology from early June with accuracy increasing at shorter leads. The September and November forecasts performed best overall both having an error of less than 0.1^{o}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}.
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 (1975/6-2003/4).
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*.

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