RSMC NADI – TROPICAL CYCLONE CENTRE

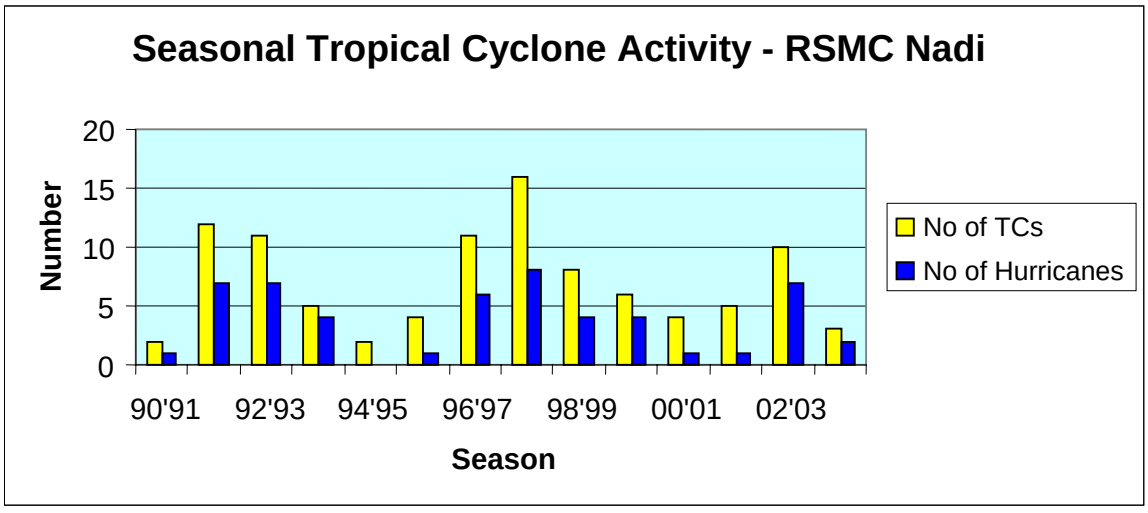
TROPICAL CYCLONE SUMMARY
2003-2004 Season

Introduction

A summary is presented of tropical cyclone activity during the 2003/2004 Tropical Cyclone Season for the Regional Specialised Meteorological Centre Nadi - Tropical Cyclone Centre (RSMC Nadi-TCC) Area of Responsibility (AOR) covering from Equator to 25°South Latitude and 160°East to 120°West Longitude.

Tropical Cyclone activity in the 2003/2004 Tropical Cyclone Season, in the RSMC Nadi AOR was well below average. Only three tropical cyclones occurred in the region**,** out of the expected average of around nine. Two of these cyclones attained hurricane intensity whilst the third, storm category.

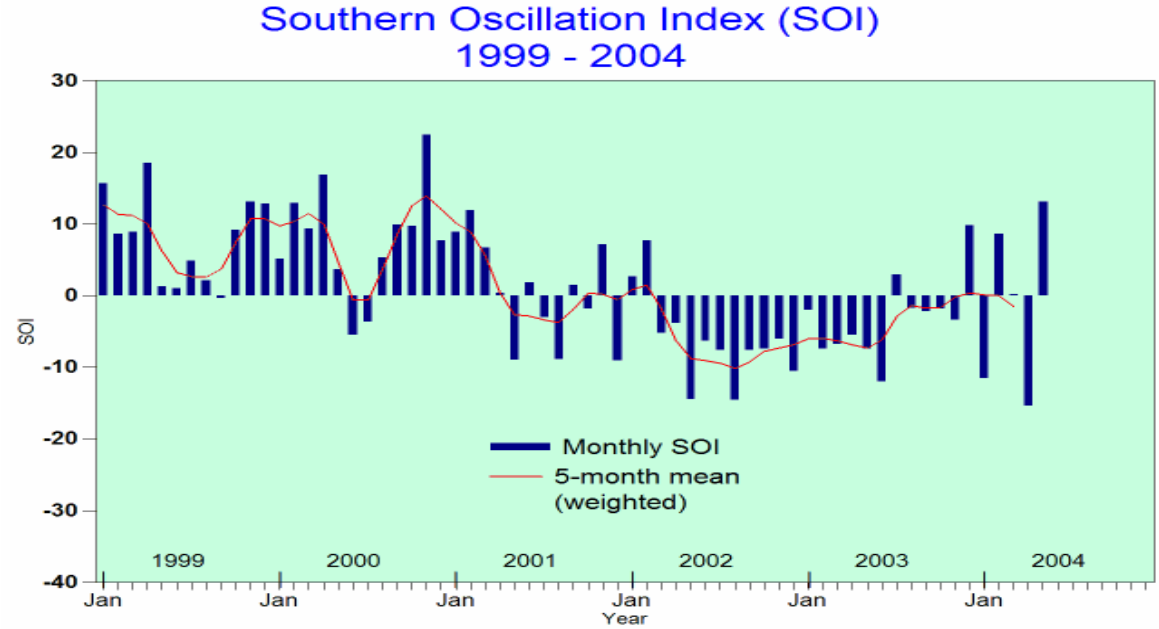
Figure 1 Tropical Cyclone Activity in RSMC Nadi AOR by Season



Climatic Indices

2003/4 Season was characterised by a neutral ENSO (refer **Figure 2**), where the monthly SOI values remained mostly negative. Sea Surface Temperature (SST) warmest anomalies dominated the tropical Pacific Ocean throughout the Season but receded to the west of the Dateline around March and April. Low-level wind anomalies portrayed that the easterly trades were near average in the beginning of the Season. Small anomalies appeared towards the end of the Season, and in April, westerly anomalies were observed in the far west near-equatorial Pacific and weak anomalies further east.

Figure 2 **Southern Oscillation Index values vs 5-Month Running Means for the period 1999 to mid 2004.**



A large cyclonic wind anomaly in the northwest Pacific deprived the South Pacific region of convective activity in the beginning of the Season. However, from late December to early January, a very active phase of the MJO moved across the Southwest Pacific basin, sparking an intense Topical Cyclone *Heta* just east of the Dateline. The second (February) and third (March) episodes coincided with Tropical Cyclones *Ivy* and *Grace* respectively.

Occurrence

In all, fifteen significant tropical disturbances were monitored and assigned numbers of the series (01F, 02F,…..etc) in the 2003/4 Tropical Cyclone Season by RSMC Nadi. Of this total, only 3 attained tropical cyclone status, one of which was a category one, another a category four, and the third, category two cyclone. Against an average of nine tropical cyclones per Season, 2003/4 Season activity was well below the expected.

With a predominantly neutral ENSO background, all three tropical cyclones originated west of the Dateline. *Heta* and *Ivy* were both first identified between Vanuatu and Fiji, while *Grace* formed in the Coral Sea. Both cyclones assumed initial equatorward tracks (*Heta* towards northeast; *Ivy* towards northwest) before turning poleward. Assisted by a very active MJO phase, *Heta* attained tropical cyclone status east of the Dateline after a week of subdued convective activity. It affected five countries (Tokelau, Wallis and Futuna, Samoa, American Samoa, Tonga) before eventually devastating Niue causing $NZ50 million worth of destruction and damage. Incredibly though, only one life was lost as a direct result of the cyclone.

Ivy's track was in some ways a mirror image of *Heta's*, when seen from the Dateline. As it moved south over Vanuatu, it caused moderate to severe damage. Only one life was lost as a direct consequence. After becoming extra-tropical, the remnants of *Ivy* was later caught up in the westerlies and shuttled southeast, passing just east of New Zealand. Subsequently, *Ivy* was one of the longest surviving systems, after transition, to be sustained well into the deep southern latitudes.

Table 1 Tropical Cyclones in the RSMC Nadi area of responsibility, for the 2003-2004 Season. All dates and times are in UTC[1]. (* - named by Brisbane TCWC).

	Low first identified			Initial tropical cyclone phase			
Name	Date	Lat.	Long.	Date	Time	Lat.	Long.
Heta	25 Dec	15.0°S	176.5°E	02 Jan	0000	08.0°S	174.2°W
Ivy	21 Feb	16.5°S	173.5°E	23 Feb	0300	15.0°S	172.5°E
Grace*	18 Mar	14.5°S	145.5°E	21 Mar	1800	20.0°S	155.0°E

	Maximum Intensity (knots)					End of Tropical Cyclone Phase			
Name	Date	Time	Lat.	Long.	Int.	Date	Time	Lat.	Long.
Heta	05 Jan	0600	14.7°S	173.5°W	115	08 Jan	0000	30.0°S	160.0°W
Ivy	26 Feb	0600	17.7°S	168.3°E	90	28 Feb	1200	30.0°S	174.0°E
Grace*	22 Mar	1200	22.3°S	158.2°E	50	23 Mar	1800	22.9°S	161.8°E

Verification Statistics

Position forecast verification statistics for each cyclone (**Table 2**) was derived by comparing the initial and forecast positions (given in warnings issued by RSMC Nadi-TCC) with post analysis 'best track' positions. It must be noted here that the Australian Tropical Cyclone Workstation (ATCW) verification programme used by RSMC Nadi-TCC is sensitive to temporal amount of data. Consequently, *Grace* could not be verified at all.

Overall, initial position errors for individual tropical cyclones were similar to previous Seasons, with the aggregate registering a marked improvement.

At 12 and 24 hours, errors for individual cyclones showed forecast skills. This was despite both *Heta* and *Ivy* doing u-turns towards the poles after initially moving equatorward. For the first time ever, errors at 24 hours have been slashed to below the 150km-mark.

Figure 3 RSMC Nadi Forecast Errors since TC Season 1994/95.

[1] UTC - Universal Co-ordinated Time (same as Greenwich Mean Time)

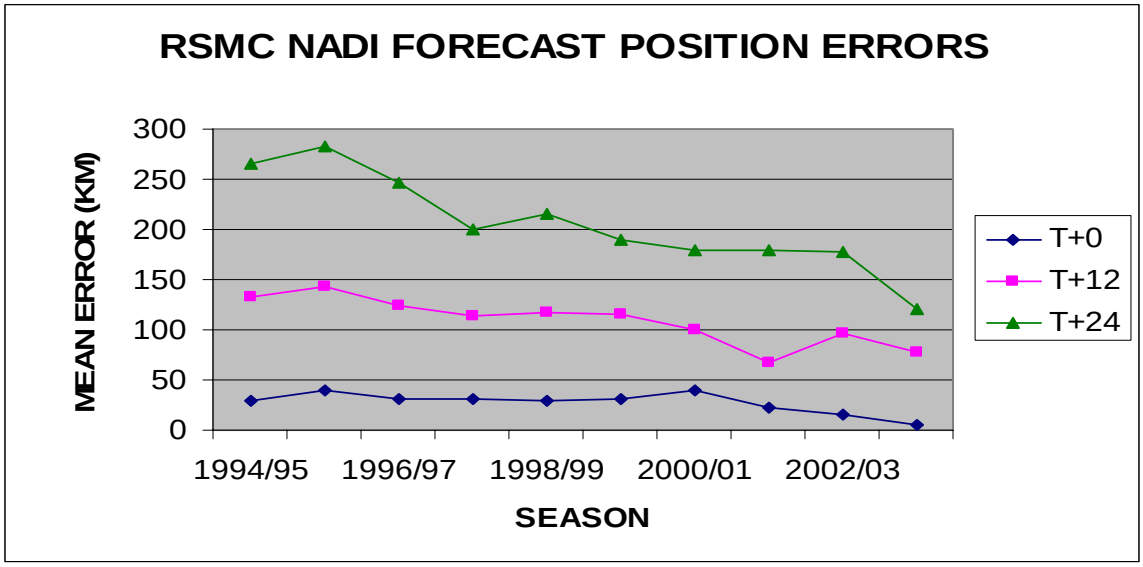


Table 2 **Position forecast verification statistics for official warnings issued by RSMC Nadi. Forecast positions are verified against the official best track. Persistence errors (in brackets) are included for comparison. *Grace* could not be verified at all due to insufficient data.**

Lead-time	0 hours		12 hours		24 hours	
Name	Mean error (km)	Number	Mean error (km)	Number	Mean error (km)	Number
Heta	3	21	63(104)	18	112(262)	16
Ivy	7	20	89(105)	18	129(231)	14
Grace	-	-	-	-	-	-
Aggregate	6	44	**78(106)**	39	**120**(248)	30

In **Table 3**, the radius of the circles (centred on the centroid of the errors) containing 50% of the operational initial positions, is smaller than 0.5 degree of latitude (55.5 km) for all cases. Therefore the location of systems could be summed up as falling within the category of "Position Good" most of the time.

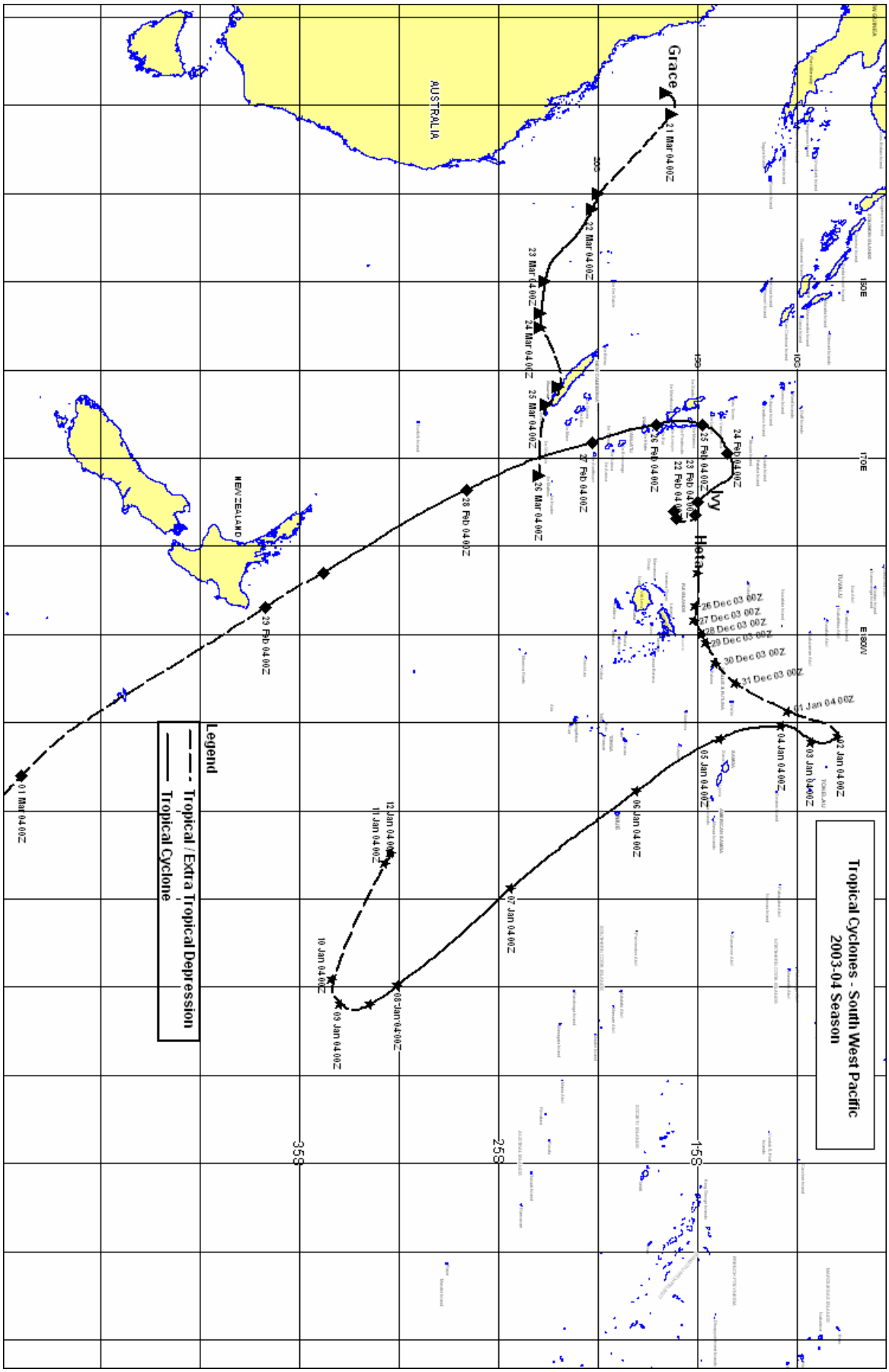
The forecast error centroids and size of the radius of the 50% circle (centred on the centroid of the errors) indicate bias and consistency of bias in the forecast positions. For instance, *Heta* consistently ran east of the expected track, forcing a westerly bias of the centroids. The southwest bias with *Ivy* was attributed to difficulty in forecasting the southward turn when the system was heading northwest.

Table 3 **Centroid of errors for initial (0-hour lead time), 12-hour and 24-hour forecast positions given in warnings issued by RSMC Nadi with the radius of the circle enclosing 50% of the positions. All distances are in kilometres. *Grace* could not be verified at all due to insufficient data.**

Lead-time	0 hours		12 hours		24 hours	
Name	Centroid E-wd, N-wd	Radius of 50% circle	Centroid E-wd, N-wd	Radius of 50% circle	Centroid E-wd, N-wd	Radius of 50% circle
Heta	1,0	0	-7,9	60	-30,23	103

Ivy Grace	1,-3 -	11 -	-27,-41 -	69 -	-74,-75 -	88 -
Aggregate	1,-2	9	-16,-22	69	-46,-35	107

Figure 4 Tracks of *Heta, Ivy* and *Grace.*



Tropical Cyclones in the RSMC Nadi Area of Responsibility (AOR), 2003/2004 Season.

In the discussion that follows, distances are in nautical miles and wind speeds are 10-minute averages.

Heta (03F) : 1 – 8 January 2004

Heta was the first tropical cyclone to form in RSMC Nadi's area of responsibility during the 2003/2004 South Pacific tropical cyclone season. It was a very intense category 5 tropical cyclone with maximum (10-minute) average winds estimated at about 115 knots and momentary gusts of up to 160 knots at its peak intensity. The cyclone caused destructive storm force winds and associated sea flooding over northern and western parts of Samoa with one death reported and destructive storm force winds over Niuatoputapu, in Tonga. But, it was Niue which was to bear the brunt of the very destructive hurricane force winds and associated extremely very high sea waves. These caused extensive and severe damage that was reported to be the worst seen in Niue in living memory. Amazingly enough, only one death, directly attributed to the cyclone was reported there.

The system which eventually developed into TC *Heta* originated in the area midway between Rotuma and Fiji on the 25th of December 2003 and was identified as Tropical Disturbance 03F. It moved slowly eastwards in the area just north of Fiji gradually developing into a tropical depression on the 28th of December. This depression continued to move northeastwards to just west of Atufu, the northernmost island of Tokelau, on the 2nd of January 2004. Under minimal shear and favourable divergence aloft, it was named TC Heta at 02/0300 UTC. Once named, *Heta* intensified rapidly while turning slowly southwards, under a weak steering regime, reaching storm intensity around 02/1200 UTC and hurricane intensity around 03/0600 UTC. Peak intensity was reached around 05/0600 UTC when the centre was passing about 80 miles to the southwest of Savai'i, in Samoa, with maximum (10-minute) average winds of about 115 knots close to its centre and momentary gusts estimated around 160 knots. This intensity was maintained over the next 24 hours or so as the cyclone turned onto a southeastward track, its speed of movement accelerating to about 15 knots, and later 20 knots. This track took the cyclone centre to within about 50 miles to the northeast of Niuatoputu in the northern Tonga Group around 05/1200 UTC, and very close to, but slightly west of Niue around 06/0300 UTC. *Heta* moved out of RSMC Nadi's area of responsibility soon after 07/0000 UTC, maintaining its southeastward movement at about 20 knots, but gradually weakening as RSMC Wellington took over primary responsibility for future warnings.

The first Gale Warning was issued at 01/0148 UTC for the tropical depression (TD 03F) about 230 miles southwest of the Tokelau Islands from which *Heta* developed about 24 hours later. The first Storm Warning was issued at 02/0719 UTC when *Heta* was some 120 miles west-northwest of Nukunono. The second Storm Warning was issued six hours later with the cyclone showing little signs of significant movement. However, the warning was upgraded to Hurricane at 03/0102 UTC as *Heta* showed signs of rapid intensification. Subsequent Hurricane Warnings were issued at six hourly intervals with *Heta* expected to peak in intensity at around 115 knots in the warning issued at 05/0102 UTC as the cyclone moved southwards and later southeastwards. This intensity was maintained in the warnings for 24 hours by which time the cyclone was near Niue. The intensity was then gradually decreased in the warnings before primary responsibility was handed over to Wellington for the issue of further warnings south of latitude 25 South.

The first Special Weather Bulletin (SWB) for the Tokelaus was issued at 01/0232 UTC as a Tropical Cyclone Alert when TD 03F was located about 230 miles southwest of Nukunono. Damaging gale force winds were expected to develop in the Tokelau Islands in the next 24 to 36 hours. The warning strategy was upgraded to a Tropical Cyclone Warning at 01/2026 UTC. Winds averaging 45 knots with momentary gusts to 65 knots were predicted in the SWB issued at 02/2326 UTC when the cyclone was about 120 miles west of Nukunono. The final warning for the Group was issued at 03/2032 UTC as the cyclone drifted slowly southwards away from Tokelau.

The first SWB for Wallis and Futuna was issued at 02/0841 UTC in the form of a Tropical
Cyclone Alert when *Heta* was just west of the Tokelaus. The SWB alerted the Group to the possibility of *Heta* bringing damaging gales to Wallis and Futtuna in the next 36 to 48 hours. The first Tropical Cyclone Warning was issued at 03/0305 UTC when *Heta* was still near the Tokelaus moving slowly southwards. At 03/2052 UTC a Storm Warning was issued for Wallis and a Gale Warning for Futuna when the cyclone centre was about 170 miles northeast of Wallis. The last warning for Wallis and Futuna was issued at 05/0832 UTC as *Heta* accelerated southeastwards away from the French Territory.

For Samoa, the first Special Advisory was issued at 01/0326 UTC when TD 03F was centred about 250 miles northwest of Samoa. This stated that gale force winds of 35 knots might develop within the next 24 to 48 hours, affecting areas to the north of Samoa with a moderate to heavy northwest swell developing. The Special Advisory issued at 01/1432 UTC warned that damaging gale to destructive storm force winds might develop in the next 24-48 hours affecting northern and western parts of Samoa, with a moderate to heavy swell developing and possible sea flooding. At 04/1401 UTC, when the cyclone was about 90 miles north of Savai'i, the Special Advisory stated that the centre of *Heta* should lie about 60 miles west of Savai'i by 05/0000 UTC. Gale to possible storm force winds were expected with very high seas, heavy swells and flooding including sea flooding.

For Tonga, The first SWB was a Tropical Cyclone Alert for Niuafo'ou, Niuatoputapu and the Vavau Group and nearby smaller islands. This was issued at 03/0243 UTC when *Heta* was near the Tokelaus moving slowly southwards. This alert warned of the possibility of damaging gales developing in the next 24 to 36 hours. At 03/1423 UTC a Gale Warning was issued for Niuafo'ou and Niuatoputapu. This was later upgraded to a Storm Warning for Niuatoputapu at 05/0823 UTC. All warnings and alerts were cancelled at 06/0240 UTC as *Heta*, accelerated southeastwards away from Tonga, towardsNiue.

The first SWB for Niue was issued as a Tropical Cyclone Alert at 04/0848 UTC. This was 40 hours before the cyclone started to affect Niue. *Heta* was then close to Samoa or about 520 miles northwest of Niue. The first Gale Warning was issued at 05/0246 UTC, about 24 hours before the cyclone centre passed close to Niue, on its way poleward. At that time *Heta* was about 380 miles northwest of Niue. The first Storm Warning was issued at 05/1420 UTC when *Heta* was about 250 miles northwest of Niue. The first Hurricane Warning was issued at 05/1734 UTC when the centre of *Heta* was about 200 miles northwest of Niue. The cyclone was forecast to pass over or very close to Niue between 0300 UTC and 0500 UTC on the 6th. Very destructive hurricane force winds with average speeds to 100 knots and momentary gusts to 140 knots or stronger were predicted to hit the island from that afternoon, or earlier, with very high to phenomenal seas and heavy swells. In the warning issued at 05/2329 UTC the forecast winds were increased to 110 knots with momentary gusts to 150 knots, and in the warning issued at 06/0244 UTC to 115 knots with momentary gusts to 160 knots. Damaging heavy swells were included.

The final SWB for Niue was issued at 06/1800 UTC whilst *Heta* was located about 270 miles to the southeast of the island and moving further away rapidly.

At the time of this report, no information on damage was available from Tokelau, Wallis or Futuna. In Samoa, there was extensive damage to houses, power lines and crops due to heavy swells and sea flooding as much as from wind. One person was swept out to sea and presumed dead. Airline schedules were disrupted.

From media reports, it appeared that at least as much damage was caused by the extremely high sea waves as by the wind. These reports described how the capital, Alofi, bore the brunt of the cyclone with half of the commercial area wiped out. Even houses built atop 30-metre cliffs and other houses thought to be safe up to 100 metres inland were destroyed. According to these reports, worst hit was the southern area of Aliluki where the terrifying monstrous waves, rather than the wind, appear to have been the main cause of the devastation. A woman was killed when a large wave smashed into the house where she and her 19-month-old son were sheltering. The boy received serious injuries and was evacuated to Auckland Hospital. Sadly, he died some days later from skull injuries and lacerations (media reports), surrounded by family and Hospital staff.

Communication to and from Niue was completely severed and the only means available was satellite phone, a few days after the passage of *Heta*. Much of the infrastructure on the island was destroyed. Buildings and houses were either demolished or severely damaged, subsequently releasing poisonous asbestos gas. Before meteorological instruments at the Niue Meteorological Station failed, the minimum atmospheric pressure recorded was 945hPa at 06/0411 UTC, maximum sustained 10-minute average winds of 80 knots and maximum gust of 107 knots at 06/0400 UTC. Media reports have put an estimate on the damage at 50 million New Zealand dollars (NZ$50 million).

In the aftermath of the tropical cyclone, some island leaders are calling for a return to New Zealand governance, and expect the population to fall from about 1200 native Niueans to an unsustainable 500 people. Such a drop would likely render the nation unviable. Niueans had been adamant they wanted to retain the status quo, i.e., financial and administrative support from New Zealand while retaining their own sovereignty. But, as the smallest independent state in the world, its constitutional status remained "under review". Niue has been self-governing in free association with New Zealand since 1974, and New Zealand has an ongoing responsibility to provide necessary economic and administrative assistance.

Ivy (05F) : 23 – 27 February 2004

Ivy was the second tropical cyclone to form in Regional Specialised Meteorological Centre (RSMC) Nadi's area of responsibility during the 2003/2004 South Pacific tropical cyclone season. A tropical disturbance was first identified about midway between Nadi, Fiji and Port Vila, Vanuatu, along an active monsoon trough on February 21st. On the 22nd, it had developed into a depression, with the low-level circulation centre (llcc) clearly exposed and displaced just southeast of the deepest convection. At this time, the depression began to move slowly west-northwestwards but still significantly influenced by shear and diurnal variation. On the 23rd, convection about the llcc, as well as overall organisation, increased further. Outflow was good to the north but still developing in the other quadrants. By 23/0000 UTC, the llcc had slipped under the cooling deep convection. Situated under an upper outflow region with minimal shear, TD 05F was then named TC *Ivy* at 23/0300 UTC as primary convective bands increasingly wrapped tightly around the

central feature. The cyclone was then located about 300 miles northeast of Port Vila and moving slowly northwest.

Ivy intensified steadily after being named attaining storm intensity 15 hours later, some 270nm north-northeast of Port Vila and still moving northwest. By 24/0000 UTC, the cyclone commenced its southwest track, generally towards the central parts of Vanuatu. Hurricane intensity was reached 6 hours later by 24/0600 UTC, while the centre was located 230 miles north-northeast of Port Vila and heading southwest. Some warm air entrainment, together with frictional interference by the rugged terrain of the Vanuatu islands influenced further intensification. *Ivy* peaked around 26/0600 UTC at 90 knots while located overhead or very close to Port Vila. By this time, the cyclone had begun to gather speed under a strengthening northwest steering field, gradually accelerating towards the south-southeast and keeping just west of the islands to the south. Primary responsibility for further warnings was handed over to TCWC Wellington after 27/1800 UTC. *Ivy* became extra-tropical by 28/1200 UTC but held itself together to pass close to the east of East Cape, New Zealand on the 29th on its way further south.

Ivy was an intense category 4 tropical cyclone with maximum (10-minute) average winds of about 90 knots. In Vanuatu, Ivy caused moderate to severe damage with one fatality. Areas worst affected were islands of Paama, Epi, Ambrym, the eastern coast of Malekula and the northern tips of Ambae (Aoba) and Maewo. More than 2,000 people had to be evacuated from their homes in the Port Vila area as the eye of *Ivy* passed directly over or close by. Many of the 24,000 residents of Vanuatu's central islands lost their homes. Most if not the whole mango and banana trees were damaged, and around 75% of the coconut and cocoa crops were affected.

Grace (07F) : 21 – 24 March 2004

A multi-centred tropical low formed adjacent to the north Queensland tropical coast near Cooktown as early as 20 March within a very active monsoon trough that stretched across the northern Coral Sea and Cape York Peninsula in an exaggerated northwest to southeast band across the Coral Sea toward New Caledonia. Over the ensuing days, the northernmost circulation became dominant and initially commenced a path toward the east and then southeast of the equator-ward ridge. The tropical low struggled to develop an upper-level structure under a relatively unfavorable upper-level wind environment. With hindsight the storm may well have been a hybrid system rather than a classic tropical cyclone. Gales were forecast well away to the north and south of the centre, until 21/1820 UTC when the Brisbane Tropical Cyclone Warning Centre deemed that the central circulation had consolidated sufficiently enough and subsequently named it *Grace*.

Tropical Cyclone *Grace* formed in the open ocean near 20.0S/155.0E (or approximately 330 nautical miles east-northeast of Mackay). At this time Grace had a central pressure of 988 hPa and was moving toward the southeast at 15 to 20 knots. This general motion was to continue for the remainder of the cyclone's life. Grace attained peak intensity of 50 knots around 22/1200 UTC. Twenty-four hours later, *Grace* began to undergo extra-tropical transition with an increasingly asymmetric wind field, enhanced by a surface ridge to the south. A vertical circulation remained in the lower levels but was sheared away above 500 hPa by a 30- to 50-knot northwesterly flow.

Grace rapidly lost its entire upper-level structure and was downgraded to a tropical depression (ex-Grace) at 23/1800 UTC, whilst located approximately about 240 nautical miles southwest of New Caledonia. The remnant surface wind field of the system

meandered to the east and then to the east-northeast over the following days, producing a very broad area of gales to its south through the Tasman Sea. RSMC Nadi continued to issue warnings on ex-tropical cyclone *Grace* for the next 24 hours, during which time gales were observed to increasingly withdraw further away from the centre.

References:

1. ***Australian Bureau of Meteorology web site***, http://www.bom.gov.au/, for Monthly SOI values and 5-month running mean, from 1999 to 2004.