Tropical Cyclone Season Summary 1999-2000

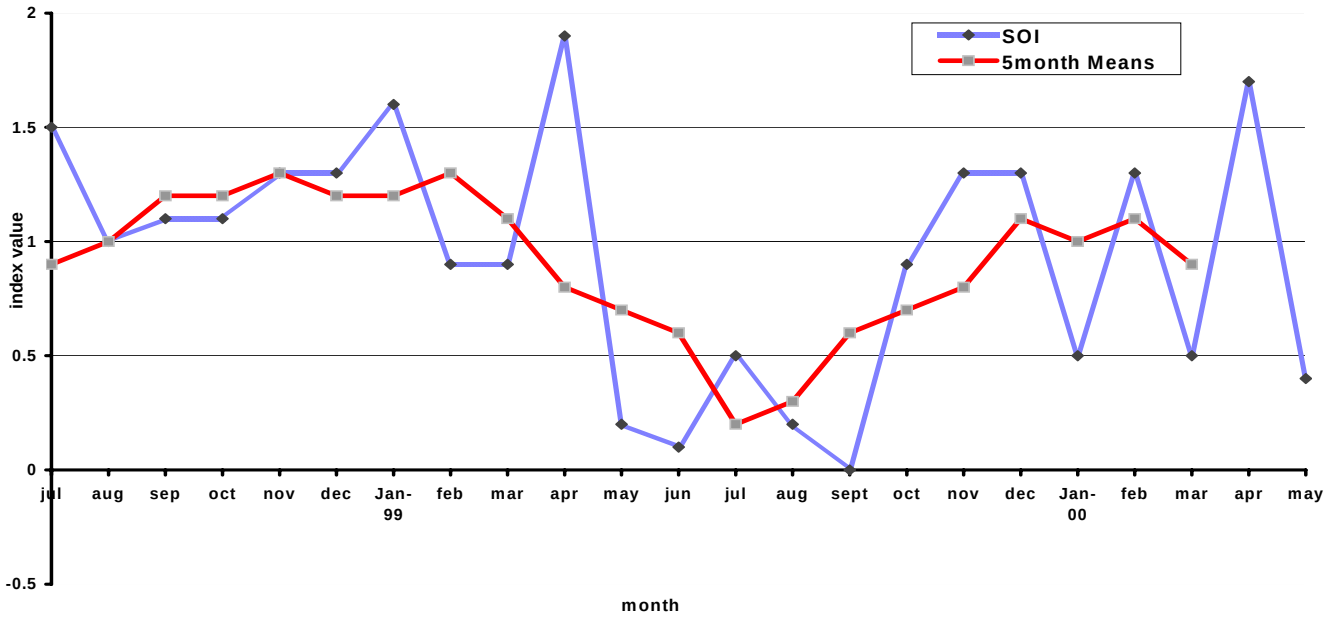
Introduction

A summary is presented of tropical cyclone activity during the 1999-2000 Cyclone Season for the Regional Specialised Meteorological Centre Nadi - Tropical Cyclone Centre (RSMC Nadi-TCC) area of responsibility (AOR) (Equator to 25°South, between 160°East and 120°West).

Since the 1997-98 season, arguably the most active for the region in the last 20 years, there was a marked decrease in tropical cyclone activity in Nadi's Area of Responsibility (AOR), as we entered the new millenium. In 1997-98, there were fifteen tropical cyclones; 1998-99, seven (eighth became a cyclone in New Zealand's AOR) and 1999-2000, down to six. This season then, was just a little below average, as far as the number was concerned. Of the six, four cyclones attained hurricane force intensity.

A rather moderately warm ENSO episode prevailed through the 1999-2000 season, following a period of five to six months near neutral conditions. Monthly values of the Southern Oscillation Index (SOI) (refer to **Figure 1** below) were +13 in November, +13 in December, +5 in January, +13 in February, +5 in March and +17 in April. This sinusoidal pattern was reflected in the constant shifts in the genesis trough, throughout the season, which may have influenced, to a greater degree, the seasonal total. Two of the six tropical cyclones originated west of 180°, in the Coral Sea area (refer **Table 1**). Two of the other four formed closer to the 180° meridian while the other pair, further to the east.

Figure 1 **Southern Oscillation Index values vs 5-Month Running Means for the period July 1998 to May 2000.**



The presence of the cold SST anomaly, near the equator, especially east of the 180° longitude, throughout the season, forced the cyclone trough further south than normal. Four of the six cyclones were named on or south of 20° South, two of which near our common boundary with New Zealand. At the same time, a persistent and extensive warm sea surface temperature (SST) anomaly south of Nadi's boundary throughout the season, helped sustain some cyclones, well into New Zealand's AOR, even after extra-tropical transition.

Another notable feature of the season, was that most of the cyclones displayed midget characteristics, while in Nadi's AOR. This has effectively become a more common occurrence, especially in the last three to four seasons.

Table 1. Tropical Cyclones in the RSMC Nadi area of responsibility, for the 1999-2000 Season. All dates and times are in UTC.

	Low first identified			Initial tropical cyclone phase			
Name	Date	Lat.	Long.	Date	Time	Lat.	Long.
Iris	06 Jan	15.0°S	164.0°E	07 Jan	0600	16.0°S	164.5°E
Jo	23 Jan	14.5°S	171.7°E	24 Jan	0000	17.9°S	173.1°E
Kim	23 Feb	23.0°S	132.8°W	24 Feb	1800	23.2°S	135.6°W
Leo	04 Mar	18.0°S	150.0°W	06 Mar	1200	24.7°S	163.4°W
Mona	06 Mar	15.1°S	171.3°W	08 Mar	1200	20.0°S	175.5°W
Neil	13 Apr	18.0°S	179.1°W	15 Apr	1800	20.2°S	178.8°E

	Maximum Intensity (knots)					End of Tropical Cyclone Phase			
Name	Date	Time	Lat.	Long.	Int.	Date	Time	Lat.	Long.
Iris	08 Jan	0000	16.6°S	166.5°E	70	10 Jan	0600	19.4°S	177.7°E
Jo	26 Jan	0000	23.2°S	176.8°E	65	27 Jan	1200	30.0°S	174.5°W
Kim	26 Feb	1200	25.7°S	139.9°E	95	29 Feb	0600	34.0°S	150.5°W
Leo	07 Mar	0600	29.5°S	166.0°W	50	08 Mar	0000	36.0°S	166.0°W
Mona	10 Mar	1200	25.6°S	172.2°W	75	11 Mar	1200	29.5°S	171.8°W
Neil	16 Apr	0000	21.8S	178.9°E	40	16 Apr	1200	22.8°S	179.3°E

Verification Statistics

Position forecast verification statistics for each cyclone (**Table 2**) were 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, which is used by RSMC Nadi, is sensitive to insufficient data. Consequently, we could not verify, beyond the initial positions, tropical cyclones *Leo* and *Neil.* These systems were named very close to our common boundary with RSMC Wellington, with *Neil* only surviving a mere 18 hours, as a cyclone.

However, overall, initial position errors were similar to previous seasons, except for a relatively large error contributed by *Leo*. This error was due to difficulty in tracking the low-level circulation centre, while being subjected to strong vertical shear.

At 12 hours, the aggregate revealed persistence slightly better than forecasts, similar to the 98/99 season, but showing improvement compared to the 96/97 and 97/98 seasons. This was despite relatively large errors associated with *Iris* and *Mona*; attributed to difficulties in forecasting their re-curvature, exacerbated by their small and compact nature.

At 24-hours, forecasts showed skill over persistence. Compared with the previous three seasons, the former showed significant improvement, despite the relatively large errors by *Iris* and *Mona.*

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. *Leo* and *Neil* could not be verified beyond 0 hours due insufficient data.

Lead-time	0 hours		12 hours		24 hours	
Name	Mean error (km)	Number	Mean error (km)	Number	Mean error (km)	Number
Iris	15	17	119(92)	9	236(267)	7
Jo	35	19	118(120)	12	185(226)	10
Kim	9	16	55(63)	11	116(196)	9
Leo	70	14	-	-	-	-
Mona	39	18	130(139)	11	216(293)	9
Neil	14	8	-	-	-	-
Aggregate	31	92	115(112)	48	190(245)	34

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, except for *Leo*. Therefore the warning positions could have been given as "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 example *Iris* and *Jo*, consistently ran east of the expected track, so the centroids are biased to the west. *Mona's* large westerly bias, at 24 hours, was due to the difficulty in forecasting its turn towards the southeast when it was steadily moving southwest.

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. *Leo* and *Neil* could not be verified beyond 0 hours due 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
Iris	-7, 1	15	-82, -13	85	-227, 16	86
Jo	-18, 5	33	-67, 17	92	-108, 62	117
Kim	2, 1	9	27, 27	39	59, 79	69
Leo	22, 27	72	-	-	-	-
Mona	11, -4	39	-52, -12	107	-141, 69	149
Neil	-5, 0	12	-	-	-	-
Aggregate	1, 5	40	-42, 13	106	-95, 51	151

Figure 2: Tracks of Iris, Jo, Kim, Leo, Mona and Neil.

Tropical Cyclones in the RSMC Nadi area of responsibility, 1999-2000.

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

Iris (05F) : 7 - 10 January 2000

Tropical Cyclone Iris was the first tropical cyclone of the new millenium, during the 1999/2000 season, in RSMC Nadi's area of responsibility (AOR). It was a small and compact system (midget), attaining peak intensity of hurricane force. Iris was a well-behaved cyclone, having a general southeasterly track. The system moved across Vanuatu, but weakened considerably as it slipped just south of Fiji, where it finally dissipated. Damage to Vanuatu was minimal, even though the centre came to within 60 miles (extent of gales) of the island of Epi.

Iris developed from a quasi-stationary monsoon trough, in a moderately sheared environment, just northwest of Espiritu Santo, in Vanuatu, on the 3rd of January. Three days later, after surviving shear and diurnal influence, overall organisation began to improve significantly. The system continued to intensify, and by 07/0000 [1]UTC, the low level circulation centre (LLCC) began to move under the deep convection. In retrospect, the system should have probably been named by 07/0600 UTC, after Quickscat data indicated 1-minute average winds of 35 to 40 knots surrounding the centre. Overnight, with weakening shear and adiabatic cooling, the depression intensified further consequently forming a compact central dense overcast (CDO).

Iris then rapidly intensified to storm category by 07/1200 UTC and reaching hurricane intensity by 08/0000 UTC. It peaked around 08/0600 UTC, while located about 130 miles northwest of Port Vila and tracking east-southeastward at 8 knots. The cyclone moved close to or over the island of Epi overnight, but its compactness was quite evident as recorded winds over Vila, about 60 miles due south, were only 15 to 20 knots. By 08/1200 UTC, the cyclone began to weaken rapidly to storm force, the intensity it maintained for the next 24 hours.

Under strengthening steering field and vertical shear, Iris gradually accelerated eastward as it left Vanuatu, tracking more and more south of east and also becoming more and more asymmetric as it moved closer towards Fiji. By 09/1800 UTC, Iris had weakened to a gale while located about 210 miles west-southwest of Nadi and moving east-southeastward at 13 knots. Under extreme shear and hostile environment, the cyclone was downgraded to a depression after 10/0000 UTC, finally dissipating about 150 miles southeast of Fiji, 12 hours later.

Damage, in Vanuatu and/or Fiji, was either minimal or negligible, apart from heavy swells.

JO (09F) : 23 - 27 January 2000

Jo, the second cyclone in RSMC Nadi's AOR this season, developed off a similar environment as Iris. It was a "normal" system, which steadily tracked south-southeast

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

before exiting Nadi's AOR, on a southeast course. The cyclone attained a peak intensity of hurricane force winds, but, fortunately, did not directly affect any inhabited land area.

A weak disturbance was first identified over the northern parts of Vanuatu on the 19th, embedded in an active and slow-moving monsoon trough. For the next 24 hours, it was subjected to very strong northwest shear and diurnal variations, which arrested development. This was despite pressure falls in a fairly extensive area, at the surface. At 21/2100 UTC, the llcc was located by visible imagery about 300 miles northeast of Port Vila and about 340 miles northwest of Nadi. Till 24/1800 UTC, the system's overall organisation displayed a marked increase, with convective tops cooling further, outflow improving significantly and spiral bands wrapping more tightly around the llcc. Consequently, it was named Tropical Cyclone Jo at 24/0000 UTC, while about 240 miles west of Nadi and moving southeast at 10 knots.

At a normal rate of intensification, Jo reached storm category at 24/1800 UTC, with gales fanning out to within 80 miles of the centre. However, Jo's peak intensity was somewhat controlled by a persistent warm air intrusion, which relentlessly stayed with the cyclone for most of its life inside Nadi's AOR. Locating the llcc was also made the more difficult by this environmental entrainment. Jo briefly peaked around 26/0000 UTC, while situated about 350 miles south of Nadi and beginning to trek southeast. It finally moved out of Nadi's AOR around 26/1200 UTC.

Jo's closest approach to Fiji was late on the 24th. Till the 26th, near-gale force winds (10-minute average winds of 32 knots with gusts to 50 knots), enhanced by squally rainbands associated with the cyclone, lashed the western parts of Viti Levu and nearby smaller islands to the south, inducing flash flooding. Fortunately, there was no major river flooding. Damage to Fiji, was minimal.

Kim (11F) : 23 - 29 February 2000

Kim was an aseasonal hybrid, which gradually gained a warm-core structure as it trekked westwards through the French Polynesia. The cyclone followed a general west-southwest track during its entire life in Nadi's AOR. Kim attained cyclone status, farther south than usual, closer to the Nadi/Wellington border. It had a peak intensity of hurricane force, but fortunately, the French territory was spared any direct effects of the destructive storm and/or very destructive hurricane force winds.

RSMC Nadi began monitoring a cold-cored tropical depression, located about 60 miles east-southeast of Rikitea or about 270 miles northwest of Pitcairn Island around 23/0000 UTC and moving slowly westwards. At 23/1800 UTC, the llcc was clearly exposed and displaced slightly northwest of the deep convection. For the next 24 hours, development was somehow halted. However, after 24/0000 UTC, surface convergence and upper divergence over the system significantly increased and by 24/1200 UTC, convection virtually had erupted over the llcc with spiral bands better organised and wrapping with more curvature. At 24/1800 UTC, it was named Tropical Cyclone Kim while located about 40 miles west of Rikitea or about 200 miles southeast of Mururoa and moving westwards about 05 knots.

Kim attained storm force at 25/0000 UTC and reached hurricane intensity 12 hours later. Kim intensified further overnight with deep convection cooling further and the rather broad eye becoming well-defined and contracting. After 26/0000 UTC, the cyclone gradually accelerated under the strengthening mid-level north-easterly steering regime towards New Zealand's AOR. Primary responsibility for warnings on Tropical Cyclone

Kim was handed over to RSMC Wellington after 26/0600 UTC. Kim reached its peak around 26/1200 UTC, while in New Zealand's AOR and on a steady southwest course.

According to Meteo France in French Polynesia, the only visible damage was some uprooted trees and a few less substantial homes, which lost their corrugated iron roofing.

Leo (14F) : 5 - 9 March 2000

Like Kim, which developed farther east and south than usual, Leo attained cyclone status near the Nadi/Wellington border, after tracking steadily southwest, since its inception in the vicinity of the French Polynesia. Maximum intensity reached was storm category. Leo did not directly affect or move near any populated land area.

14F was first identified by RSMC Nadi as a tropical disturbance around 04/0600 UTC, while quasi-stationary about 60 miles west-northwest of French Polynesia under a tropical upper tropospheric trough (TUTT). For the next 48 hours, overall convective activity increased steadily as the system moved southwest through the Southern Cook Islands, which registered significant falls in atmospheric pressure. After 06/0000 UTC, some weakening was apparent, under increasing shear. However, 6 hours later, the system went through a very remarkable, almost explosive development. Consequently, it was named at 06/1200 UTC, some 320 miles west-southwest of Mangaia, moving steadily southwest. Once named, Leo accelerated out of Nadi's AOR.

Leo peaked around 07/0000 UTC with 50 knots close to the centre, becoming extra-tropical, a day later. While still a depression Leo passed over the small island of Mangaia (southwest of Rarotonga) between 1200 and 1800 UTC on 5 March, where damage incurred, if any would be very minor.

Mona (15F) : 7 - 13 March 2000

Tropical Cyclone Mona developed closer to the 180-degree longitude, over Tonga. It initially assumed a southwesterly track, intensifying as it moved through the Kingdom, before eventually turning southeast, just to the west of Tongatapu, towards Wellington's AOR. Mona attained a peak intensity of hurricane category. Mona did not satisfy the wind/pressure relationship typical of "normal" cyclones - well corroborated by reports received from Vavau, Haapai, Fuamotu and Nukualofa. Also, the existence of strong gradients outward from the centre was quite evident. This basically qualifies Mona as a small (or even midget) cyclone.

While activity associated with Leo erupted, around 06/0900 UTC, another tropical disturbance was identified about 70 miles south of Apia, Western Samoa, along the SPCZ and drifting slowly southwestward. The system was lying under the 250-hPa outflow centre with good divergence. By 07/0600 UTC, it had developed into a tropical depression, prompting issuance of gale warnings, in certain sectors only. The depression was then located about 120 miles southeast of Niuatoputapu, in Northern Tonga, and moving southward at about 5 knots.

At 07/1800 UTC the system was located near Vavau, now better organised, and moving slowly southwestward. Special Weather Bulletins (SWB) for Tonga were then issued, updated every 3 hours, especially for damaging gales for Vavau, Haapai, and Tongatapu groups and nearby smaller islands. Amidst shear and diurnal effects, the depression continued to develop through the 8th. After 08/0600 UTC, the llcc began moving under the dense overcast, which had apparently erupted, aided by good outflow channels in all

quadrants. Hence, at 08/1200 UTC, it was named Tropical Cyclone Mona with gale force intensity while slow-moving about 40 miles west of Haapai. With the anticipation of the cyclone moving south-southwest, under the northeast steering regime, the whole Tongatapu Group was subsequently put on Storm Warning in the 7th SWB for Tonga, which was issued around 08/1500 UTC. Mona attained storm intensity by 08/1800 UTC while located about 110 miles west-southwest of Haapai, or 30 miles northwest of Tongatapu, and moving south-southwestward at 5 knots. The cyclone intensified further after 09/0000 UTC, with an eye gradually forming, as it turned more towards the south. Caught under a northwest steering field, Mona then accelerated towards the southeast, into Wellington's AOR.

Damage, especially in Vavau and Haapai groups, was mainly to crops, primarily banana, breadfruit and coconut plantations. In Tongatapu moderate damage was sustained by houses (mainly those of poorer construction) and by some school buildings. The unofficial damage assessment, according to the Tongan National Disaster Management Office, totaled Tongan $6 million. Of this amount T$4.7 million was to agriculture alone. A police patrol boat also sank off Eua Island in the Tongatapu Group. Surge/swell also affected Tongatapu.

Strongest winds/lowest pressures experienced are given below: Vavau: 07/1900 UTC, 10-min winds 34 knots/Gust 54 knots, Pressure 999 hPa Haapai: 08/1100 UTC, 10-min winds 30 knots/Gust 45 knots, Pressure 1003 hPa Fua'motu Airport (Tongatapu): 08/1500 & 09/1500 UTC, 10-min winds 50 knots/Gust 75 knots, Pressure 999 hPa Nuku'alofa (Capital of Tonga, on Tongatapu): 08/1500 & 09/1500 UTC, 10-min winds 44 knots/Gust 65 knots, Pressure 998 hPa.

Neil (19F) : 15 - 16 April 2000

Tropical Cyclone Neil was the sixth cyclone to form in RSMC Nadi's AOR this season. It was a small and short-lived system, which only lasted 18 hours as a cyclone. Neil maintained a southwest track, as a depression, diagonally across Fiji, but began turning southwards south of Kadavu, about 12 hours before it was named. As a cyclone, Neil did not directly affect any populated land area. The cyclone reached a peak intensity of gale force.

19F was first identified while embedded in a slow-moving trough of low pressure just northeast of Fiji, around 12/1200 UTC, and drifting slowly southwest. After 13/0600 UTC, it developed into a tropical depression, about 60 miles northeast of Vanuabalavu island, with convection immediately around the centre, increasing. Though it was then located just south of the 250-hPa ridge, shear was still minimal. Through till the 15th, overall organisation gradually improved and convective tops cooled further as the systems slipped under the 250-hPa outflow. A warm SST sustained development, subsequently enhancing its potential to attaining cyclone status within the next 12 to 24 hours.

Overnight, further cooling took place, and at 15/1800 UTC, it was eventually named, while about 80 miles southeast of Kadavu and moving slowly southwards. Shear gained prominence through the 16th, effectively displacing the deep convection some 30 to 40 miles to the southeast of the llcc. This was exacerbated by the approach of a sharp 250-hPa trough, upstream. After 16/0600 UTC, it was quite apparent that shear was not going to relent. Steering was also pushing the cyclone into cooler SSTs. Finally succumbing, Neil was downgraded to a depression at 16/1200 UTC, about 220 miles south-southeast of Kadavu while moving southeast.

Damage attributable to Neil was minimal, though marginal gales affected Kadavu and Ono-i-Lau islands. During the passage of Neil, torrential rain was experienced over some parts of Fiji while strong winds affected most places. There was one fatality, due to drowning, but not directly associated with the cyclone.