2023-24 SOUTHWEST PACIFIC TROPICAL CYCLONE OUTLOOK

New Zealand's National Institute of Water & Atmospheric Research (NIWA) was the lead author of this tropical cyclone outlook, which was contributed to by the Meteorological Service of New Zealand (MetService), the University of Newcastle, the Australian Bureau of Meteorology, MétéoFrance, and meteorological services across the Pacific Islands

Pacific Islands | New Zealand | El Niño-Southern Oscillation | Consensus outlook | Background

Tropical cyclone outlook summary for the Pacific Islands

- The NIWA and MetService assessment of tropical cyclone[1] (TC) activity for the coming season indicates normal to above normal activity.
- 9 to 14 named TCs could occur in the Southwest Pacific from November 2023-April 2024.
- TCs have a significant impact across the Southwest Pacific, with the season starting in November and lasting through April. For the coming season, significant differences are expected between the western and eastern halves of the basin.
- The risk of impact from a TC is expected to be higher around and to the east of the International Date Line, as illustrated below, and in a band across the tropics associated with a more northward displaced South Pacific Convergence Zone.

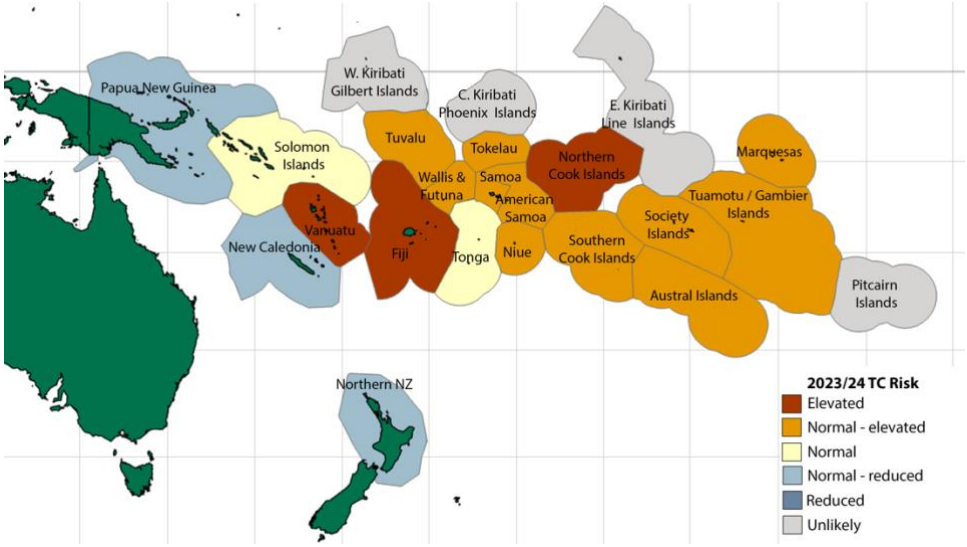

Figure 1: Tropical cyclone risk for the 2023-24 season

- Vanuatu and New Caledonia typically experience the greatest TC activity with an average of two or three named TCs passing nearby each year.
- **Elevated activity:** Vanuatu, Fiji and the Northern Cook Islands.
- **Normal or elevated activity**: Wallis & Futuna, Tuvalu, Tokelau, Niue, Samoa, American Samoa, Austral Islands, Southern Cook Islands, Society Islands, Tuamotu Archipelago and Marquesas.
- **Near normal activity**: Solomon Islands and Tonga.
- **Normal or reduced activity**: Papua New Guinea, New Caledonia and Northern New Zealand.

[1] Tropical cyclones are categorised in strength from 1 to 5, with 5 being most intense. Tropical cyclones that reach category 3 or higher are classified as severe, with mean (10 minute) wind speeds of at least 119 km/h.

- Between 4-8 severe TCs reaching category 3 or higher may occur anywhere across the region, so all communities should remain prepared.

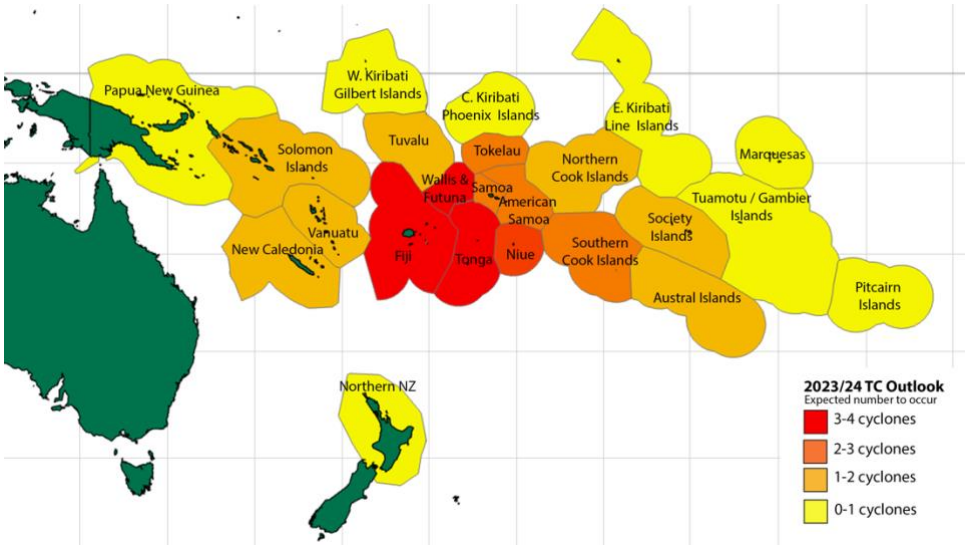

Figure 2: Number of predicted named tropical cyclones interacting with an island group for the 2023-24 season

- Past seasons with similar conditions to the present, called "analogue years", suggest multiple TCs could intensify to at least category 3 strength.
- Category 5 strength TCs[2], in which sustained winds exceed 199 km/h, are associated with a majority of the analogue years.
- Despite the official season running from November through April, TCs sometimes occur out-of-season.
- It does not take a direct hit or severe TC to cause considerable damage or life-threatening weather. When dangerous weather is forecast, please heed the advice of your local meteorological service, civil defence, or disaster management office.

Tropical cyclone outlook summary for New Zealand

- On average, at least one ex-TC passes within 550 km of New Zealand each year. This season, the risk is considered normal-reduced.
- If an ex-TC tracks close to the country, there is a near-equal probability of it tracking to the east or west of the North Island.
- Two out of five analogue years considered in this outlook had at least one ex-TC passing within 550 km of the country.
- Analogue years suggest that a decaying ex-TC entering the New Zealand region could affect maritime and coastal areas around the North Island, but an interaction with the South Island cannot be ruled out.
- Significant rainfall, extreme winds, hazardous marine conditions and coastal damage are all possible leading up to and during ex-TC events.
- The effects of ex-TCs can also be spread over a large area, particularly if the decaying ex-TC interacts with mid-to-high latitude weather systems.

[2] Since quality observations began in the early 1970s, there has been a trend toward fewer but stronger TCs.

El Niño-Southern Oscillation outlook

- The El Niño Southern Oscillation (ENSO), comprised of La Niña, neutral, and El Niño phases, plays an important role in year-to-year regional TC development and spatial coverage and is a key factor in this outlook.
- As of early October 2023, sea surface temperatures across the eastern and central equatorial Pacific Ocean are above average and exceed El Niño thresholds.
- Atmospheric circulation patterns related to ENSO over French Polynesia and northern Australia indicate well-coupled El Niño conditions at present.
- Oceanic and atmospheric forecasts for ENSO suggest El Niño, of moderate or strong intensity, has an 95% of continuing through December 2023 and that El Niño conditions are highly likely to persist (75% chance) through the back half of the TC season in February-April.
- The progress of ENSO and TC activity will continue to be tracked with an update to this guidance in January 2024 if needed.

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In the Pacific Islands, please contact your local national meteorological service for information about how this guidance should be interpreted. In Australia and the associated offshore islands, please contact the Australian Bureau of Meteorology. In French Polynesia, Wallis & Futuna, and New Caledonia please contact Météo-France.

For the latest issue of the tropical cyclone outlook and a video presentation discussing expected regional tropical cyclone activity, head to https://niwa.co.nz/climate/southwest-pacific-tropical-cyclone-outlook.

Island Climate Update consensus outlook

Table 1: Island Climate Update (ICU) consensus outlook for November 2023-April 2024 tropical cyclone activity based on combining NIWA analogue model, international dynamical climate model, and TCO-SP deterministic statistical model outlook results. Indications for seasonal TC activity based on these joint methods are stated in the "ICU consensus" column and are also shown in Figure 1. Expected TC numbers are based on the NIWA analogue method (see Table 2) and supported by the TCO-SP deterministic method.

TC activity 2023/24	NIWA Analogue	International Dynamical		TCO-SP Deterministic	ICU Consensus	Outlook Confidence
SP Basin	Normal-Elevated	Normal	*	Normal-elevated	**Normal-elevated**	Moderate
Solomon Is.	Normal	Elevated	1	Reduced	**Normal**	Low
Papua New Guinea	Normal	Normal		Reduced	**Normal-reduced**	Moderate-high
N. New Zealand	Normal-Reduced	Normal		Reduced	**Normal-reduced**	Moderate
Vanuatu	Reduced	Elevated		Elevated	**Elevated**	Moderate
New Caledonia	Reduced	Normal		Reduced	**Normal-reduced**	Moderate-high
Tonga	Elevated	Normal		Reduced	**Normal**	Low
Fiji	Elevated	Normal-Elevated		Elevated	**Elevated**	High
Wallis & Futuna	Elevated	Normal	2	Normal	**Normal-elevated**	Moderate-high
Tokelau	Elevated	Normal		Normal	**Normal-elevated**	Moderate-high
Tuvalu	Elevated	Normal		Normal	**Normal-elevated**	Moderate-high
Niue	Elevated	Normal	3	Reduced	**Normal-elevated**	Low
Samoa	Elevated	Elevated		Reduced	**Normal-elevated**	Moderate
American Samoa	Elevated	Elevated		Reduced	**Normal-elevated**	Moderate
Austral Is.	Normal-elevated	Normal	4	Elevated	**Normal-elevated**	Moderate
Society Is.	Elevated	Normal		Elevated	**Normal-elevated**	Moderate-high
S. Cooks	Elevated	Normal		Elevated	**Normal-elevated**	Moderate-high
N. Cooks	Elevated	Elevated	5	Elevated	**Elevated**	High
Tuamotu	Elevated	Normal		Elevated	**Normal-elevated**	Moderate-high
W. Kiribati	Unlikely	Unlikely		Unlikely	**Unlikely**	High
Marquesas	Elevated	Normal		Elevated	**Normal-elevated**	Moderate-high
Pitcairn	Unlikely	Unlikely		Elevated	**Unlikely**	Moderate-high
C. Kiribati	Unlikely	Unlikely		Unlikely	**Unlikely**	High
E. Kiribati	Unlikely	Unlikely		Unlikely	**Unlikely**	High

***TCO-SP model area of focus**

1. Island scale model
2. Northern SW Pacific region
3. Central SW Pacific region
4. Southeast SW Pacific region
5. Northeast SW Pacific region

Background information – summary of analogue, dynamical, and deterministic guidance for the ICU TC outlook

Analogue, dynamical and deterministic model guidance for the SW Pacific show good agreement for the coming season (Table 1). The ICU consensus column is based on the combined outcomes for the three types of seasonal outlook information. The consensus forms the basis for the full season (November-April) outlook for Southwest Pacific TC activity (and risk) for the 2023/24 season. It should be noted that there are only very minor differences in terms of the TC risk that are ascribed using the consensus method relative to previous years that used the analogue guidance supported by the dynamical guidance. Future work will evaluate (and validate) the outcome of each individual model vs the consensus-based approach.

Modern analogue guidance

TCs in the Southwest Pacific usually develop between November and April, occasionally develop in October and May, and very rarely develop in June – August. An analysis of past TC tracks in the SW Pacific indicate they are exceptionally unlikely in September, although systems in the past have formed during this time. Peak TC activity in the SW Pacific Basin is usually between January to March; however, severe TCs can occur at any time during the season.

Based on past seasons with similar background climate conditions to the present, TC activity in the coming season is expected to be elevated close to and to the east of the International Dateline. Elevated activity is expected for Fiji, Wallis and Futuna, Samoa, American Samoa, Tokelau, Niue, Tonga, the Southern Cook Islands and the Society Islands. On average, nearly half of the TCs that developed since the 1969/70 season have reached at least Category 3 cyclones with mean wind speeds of at least 64 knots (119 km/h).

To find past analogues that describe the climate state leading into the upcoming TC season, the conditions for May 2023 through to the beginning of October 2023 were examined for the tropical Pacific. Similar situations from 1969 to the present were then identified from the historical record. For late autumn through early austral winter (May-June) ENSO neutral conditions prevailed, but by mid-to-late winter (July-August) conditions for the Pacific had moved to an ocean-dominated El Niño state. During that time, southwest Pacific regional climate patterns also showed signs of reaching coupled ocean-atmosphere El Niño thresholds, which occurred during September. There is no evidence of the strength of the current El Niño event abating or retrograding to neutral conditions at the onset of austral spring.

NIWA's monitoring of the Niño3.4 region (central-western equatorial Pacific Ocean) shows monthly sea surface temperature anomalies of +1.58°C as of late September. Significant positive temperatures of +3°C to +6°C exist at depth in the same region. This indicates the current El Niño developing is one of the strongest in recent decades, with SST anomalies only being greater in 1997 and 2015 (since monitoring began in 1981).

The available information from international forecasting centres that issue global climate outlooks and ENSO diagnostics support this outlook, and they are integrated by NIWA's National Climate Atmosphere and Hazards Centre. The collective guidance summarised by NIWA suggests El Niño is established and will continue from the start of the TC season through 2023, with a 95% chance the event will persist through austral summer and a 75% chance it will persist through autumn. As such, an additional element used to hone the historic analogues for the upcoming TC season included years when ENSO conditions during November-April were reminiscent of either a strong or moderate El Niño in either the early or late season.

To help identify past ENSO conditions for the selection of analogue seasons, we used an ENSO index that combines the Southern Oscillation Index (SOI) with the most widely used oceanic index of sea surface temperature anomalies in the equatorial central-western Pacific (NINO3.4). This joint ENSO index is described in Gergis and Fowler (2005) as the "Coupled ENSO Index" (CEI) but employing a five-month average for NINO3.4 and a three-month average for the SOI when computing this ENSO index. Using the CEI, we selected analogue TC seasons for the 2023/24 outlook, highlighting seasons when the equatorial SSTs and the SOI were indicative of neutral conditions predominantly in late autumn and early/mid-winter, and either ocean-dominant El Niño or a well-coupled El Niño conditions ahead of the official TC season start in November. We also tempered our selection of analogues with knowledge that there will be a continuation of El Niño conditions during summer and into autumn.

NIWA selected five analogue TC seasons (1972/73; 1982/83; 2002/03; 2004/05; 2009/10) that typified the antecedent ENSO conditions during austral winter-early spring. Note that the selection of analogue seasons in this step of the outlook relates to the high-quality TC data period in the satellite era beginning in 1969/70 (54 seasons, for which TC track data are current only to the end of the 2021/22 season), and the limited number of similar analogues to this season (including rejected analogues, which may include some past seasons with similar antecedent conditions but not similar to what is forecast for ENSO). These selected analogues also encapsulate strong-to-moderate El Niño conditions during the full, early and late season that align with the expected ENSO outlook.

NIWA's SW Pacific TC outlook spans four areas of responsibility overseen by international monitoring and forecast agencies (RSMC Nadi, TCWC Brisbane, TCWC Port Moresby, TCWC Darwin and TCWC Wellington). We used a high-quality set of past TC tracks from the International Best Tracks Archive for Climate Stewardship (IBTrACS) which covers 135°E to 120°W longitude to draw on past TC track patterns for the seasonal outlook. The domain for the seasonal outlook encompasses a basin that is defined by climatological properties of TC occurrences rather than geopolitical or meteorological service administrative boundaries (Diamond et al., 2012). Based on the selection of analogues, there is an expectation of increased TC activity in the Southwest Pacific Basin for the 2023/24 season relative to normal. Elevated TC risk is expected for Pacific Islands located close to and to the east of the International Dateline. Higher than normal risk is expected for Fiji, Wallis and Futuna, Tokelau, Samoa, American Samoa, Niue, Tonga, the Southern Cook Islands, and the Society

Islands (See Table 1 and Table 4; Figure 1, 3 & 4). There is also elevated TC risk relative to normal for island groups that usually experience quiescent TC activity including the Marquesas, the Austral Islands and the Tuamotu Archipelago. The outlook for the region indicates reduced overall risk to the west of the International Date Line including Vanuatu and New Caledonia (Figure 1). Normal risk of TC activity exists for the Solomon Islands, Papua New Guinea and Tuvalu (See Table 1 and Table 4; Figure 1, 3 & 4).

The main TC genesis region for the coming season is expected to lie within the latitudinal band between 8 – 14°S near to and east of the International Date Line where a majority of the historic tracks associated with the analogue seasons showed storm formation. There is a clear signal for elevated risk of cyclones developing and tracking over waters located east of the International Date Line during both the early and late season. All analogue seasons had multiple Category 3 or greater strength, storms and most of the analogue seasons (4 of 5) experienced multiple Category 4 or greater storms with at least one of those systems reaching a Category 5 strength cyclone. Based on historic analogues, we suggest at least one third to two thirds of named storms that form during this season will transform into at least a Category 3 TC system, with strong possibilities that we will see multiple storms of Category 4 or greater strength. A total of 12 named cyclones are expected during this coming season (spread of 9-14 based on past analogues), which is normal or above normal activity relative to an average of nine named storms that have occurred each season in the southwest Pacific basin between 1991-2020. At least one of the selected analogues had out of season TCs that formed beyond the end of April, so all communities should remain vigilant even beyond the traditional end of the TC season.

A split of the analogue TC seasons into early (November – January) and late (February – April) periods suggests TC activity may be elevated along the western Coral Sea and to the northwest of and over Fiji as well as to the east of the International Dateline during the early TC season (Figure 3). In general, TC activity is expected to increase greatly during the late season, especially for areas east of the International Date Line in areas near Fiji, Tonga, Samoa, American Samoa, Niue, Tokelau, the Northern Cook Islands and the Southern Cook Islands. Risk will also be elevated more for the Society Islands, the Marquesas and the Tuamotu Archipelago during this time. The spatial anomalies shown by the analogue seasons in this TC outlook indicate a reduced late season risk of TCs for Vanuatu and New Caledonia.

Previous TC research has indicated cyclone track sinuosity increases during El Niño (Malsale, 2011). Many of the TC track trajectories in the analogues identified for the coming season suggest 'wandering' and long-lived storms are possible. TC intensity is partly related to how long developing cyclonic systems reside in the tropics and gain support for their growth from underlying warm waters. Nevertheless, lower strength TCs that have wandering tracks can still produce significant impacts on island communities and TCs of all strength should be monitored closely. In addition, the subtropical jet and South Pacific Convergence Zone (SPCZ[3]) interact and contribute to shear (which can disorganise cyclone systems) during

[3] The South Pacific convergence zone (SPCZ) is an extensive Southern Hemisphere atmospheric circulation feature that contains one of Earth's most expansive and persistent convective cloud bands.

extra-tropical transition (ETT). Hemispheric winds that help to steer storms exiting the tropical Pacific as well as the SPCZ are expected to be displaced north of normal, and the former may lead to increased shear and reduced retention of cyclone strength in the subtropics. The outcomes from the regional ocean-atmosphere patterns may also include weaker ex-TC impacts for northern New Zealand, however marine and coastal impacts from a decaying system could still be prominent.

The interplay of hemispheric-scale atmospheric circulation with the timing of short-term Madden-Julian Oscillation (MJO) activity on a 30 to 50-day cycle has significant bearing on regional TC activity. Increased frequency and more intense TC activity can be expected during the MJO 6-7 paired phase (Diamond and Renwick, 2015). Weekly statistical forecasts of TC genesis and TC activity for the SW Pacific basin are produced by MétéoFrance based on phasing of the MJO (Leroy and Wheeler, 2008). This guidance is useful for sub-seasonal regional TC guidance (see https://www.meteo.nc/nouvelle-caledonie/cyclone/coin-des-experts). Real-time MJO monitoring is also available from the Australian Bureau of Meteorology at http://www.bom.gov.au/climate/mjo/ and NOAA at https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml.

TC tracks that have previously undergone ETT at 25°S latitude (Diamond et al., 2013) cover a wide area spanning east and west of the International Date Line (~165°E – 165°W). For the historical TC tracks in the seasons we selected as analogues for this outlook, a vast majority underwent ETT to the east of the International Dateline. This presents a view of significantly elevated risk related to the presence of TCs and ex-TCs in the Southwest Pacific Ocean for the maritime region between 25°S - 35°S and 140°W to the International Dateline (south of Tonga, the Austral Islands and the Tuamotus/Gambier Islands). Extra caution for vessels navigating maritime waters in that remote area is warranted.

Previous work indicates New Zealand interacts with at least one ex-tropical cyclone passing within 550 km of the country every year on average (Lorrey et al., 2014). Some years there are none, while in other years there are more than one. For the coming TC season, the risk for New Zealand is normal to below normal. We identified two ex-tropical cyclones using five analogue seasons in this outlook that passed close to New Zealand, demonstrating interactions with an ex-TC during El Niño years have a low probability (and are not entirely absent). The historic TC tracks selected for this outlook that passed close to New Zealand indicate a near equal probability of decaying ex-tropical cyclones tracking offshore to either the east or west of the North Island (see Figure 3).

Dynamical climate model guidance summary

A synthesis of atmospheric and sea surface temperature (SST) guidance favours near or above average tropical cyclone (TC) activity for the 2023/24 SW Pacific TC season. Multi-model ensemble (MME) guidance is in good agreement and reflective of the presence of at least a strong El Niño event in the central and eastern Pacific that is likely to continue for much or all of the upcoming TC season (Figure 6 and Figure 7).

Through the austral summer, mean sea level pressure (MSLP) is forecast to be above normal for much of the western and southwest sections of the Southwest Pacific basin (Figure 7), with below normal MSLP forecast east of the Date Line and north of 20° south latitude. This is likely indicative of the South Pacific Convergence Zone being displaced northeast of normal, a typical impact of El Niño, and one that can cause above normal rainfall for many near-equator island groups. For island nations and territories that are located farther from the equator, particularly near and south of 10˚ S, drier than normal conditions are expected to elevate the risk of drought as a result of the SPCZ moving northeast of normal (Figure 6). However, the nearby passage of a single tropical storm could counter that situation.

MME guidance points to enhanced zonal mid-atmospheric wind shear across much of the Southwest Pacific between 10-25° south latitude. Below normal wind shear is forecast for most areas north 10°S and south of 25°S. An increase in wind shear results in a more unfavourable environment for TC genesis, intensity, and duration. If reduced atmospheric wind shear co-exists with other favourable environmental conditions, such as above average SSTs, then the odds for areas of increased TC activity (both occurrence and intensity) are elevated.

Deterministic statistical model summary

The Long-Range Tropical Cyclone Outlook for the Southwest Pacific (TCO-SP) product has been incorporated into the ICU outlook since the 2020/21 seasonal outlook to provide support for a consensus-based ensemble of TC risk. TCO-SP is based on a different method than the analogue and dynamical approaches. The TCO-SP method is calibrated using the IBTrACS data set and several key climate indices for the Southern Hemisphere (see Magee et al., 2020 and the supplementary material for more details). For the coming Southwest Pacific TC season, the deterministic TCO-SP outlook suggests 10 named TCs may form (probable range of 8-14), indicating near normal-to-above normal activity for the basin when compared with the 1991-2020 average of 8.7 TCs (Table 1, Table 4, and Figure 8). This TC count range agrees with the analogue guidance.

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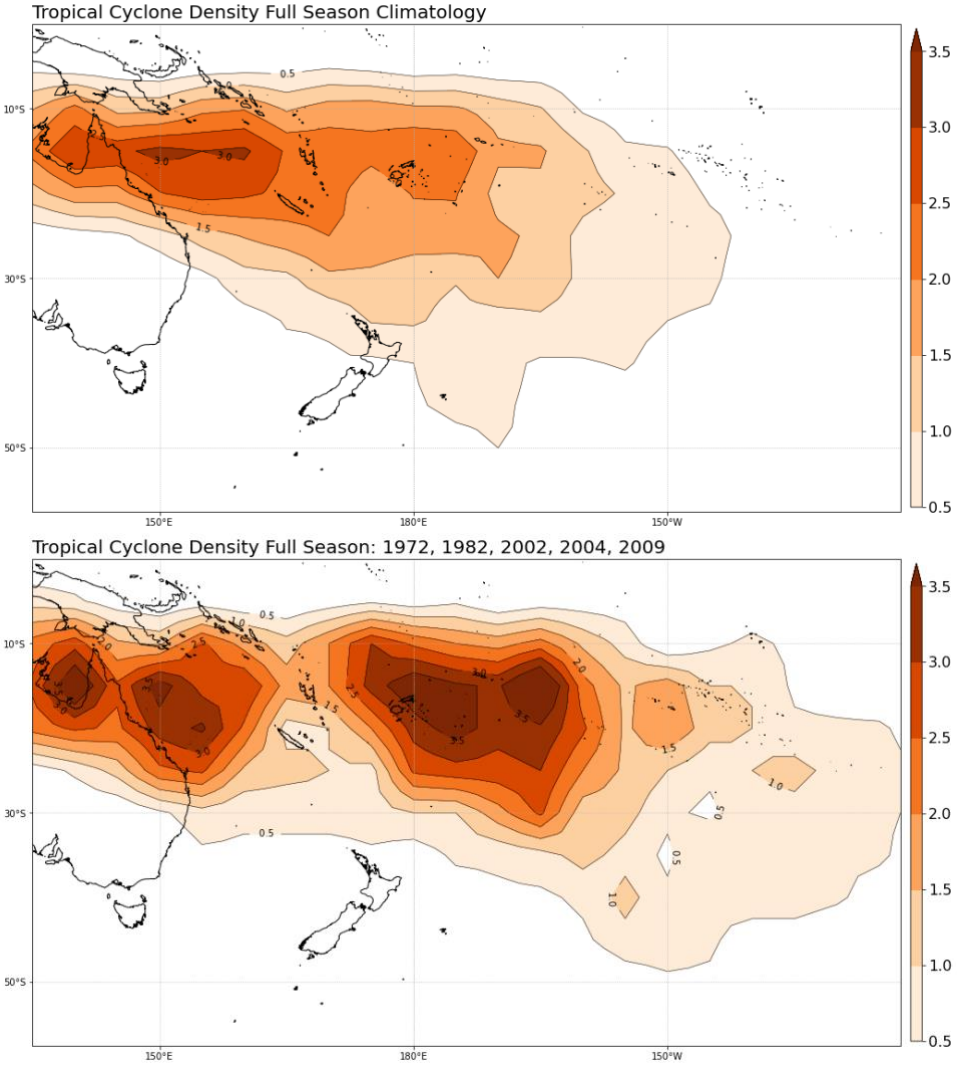


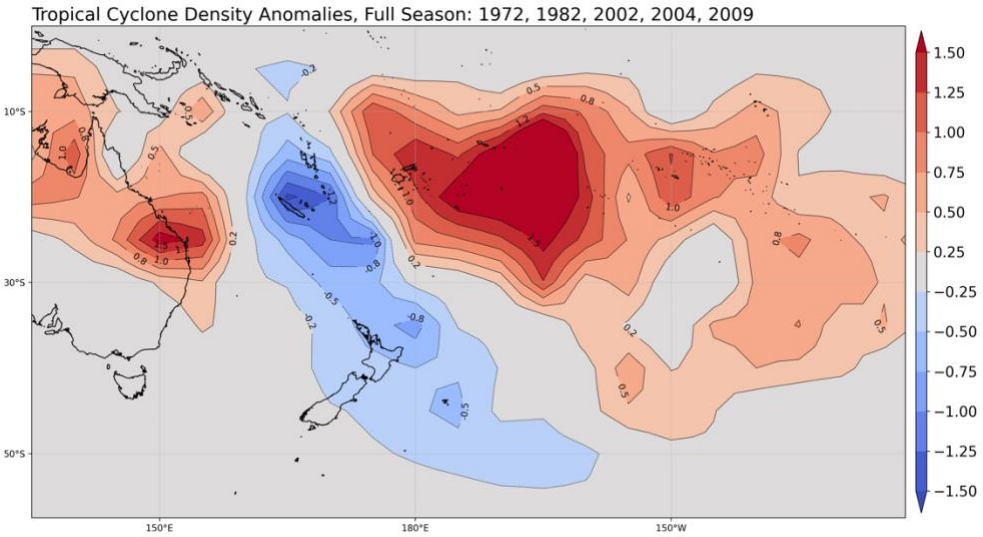


Figure 3: Number of TCs occurring for the main development season (November – April) in the Southwest Pacific (135°E to 120°W): (top panel) average number during 1991 to 2020 (normal); (centre panel) average number over selected five analogue seasons (Table 3); (bottom panel) departure from normal for the analogue seasons (difference between count in centre and top panels). For each year noted, that represents the start of the main development season (i.e. 1972 = November 1972-April 1973)

Table 2: The average number of TCs passing close to the main South Pacific Island groups between November and April based on analogue guidance but contains subjective assessments in some cases to be consistent with the wishes of the national meteorological services involved in generating this regional outlook. In addition, subjective qualification of activity (and associated risk) also recognises the small differences between the actual TC counts for the analogue composites and climatological values. The table is therefore only generally indicative of how many cyclones might be expected for any given island group for the coming season. This information feeds into the final outlook for the season as in Table 1.

Country / Territory	Climatology	Analogue seasons	Anomaly	% normal	Risk
Tonga	2.0	3.6	1.6	180	Elevated
Fiji	2.2	3.5	1.3	160	Elevated
Wallis & Futuna	2.1	3.3	1.2	155	Elevated
Niue	1.4	3.2	1.8	230	Elevated
American Samoa	1.6	2.9	1.3	180	Elevated
Samoa	1.7	2.8	1.1	165	Elevated
Tokelau	1.3	2.8	1.5	215	Elevated
Southern Cook Isl.	1.2	2.3	1.1	190	Elevated
Tuvalu	1.4	1.9	0.5	135	Elevated
Society Islands	0.7	1.8	1.1	260	Elevated
Solomon Islands	1.7	1.7	0.0	100	Normal
Vanuatu	2.3	1.5	-0.8	65	Reduced
Austral Islands	0.7	1.2	0.5	170	Normal-Elevated
New Caledonia	2.3	1.2	-1.1	50	Reduced
Northern Cook Isl.	0.4	1.0	0.6	250	Elevated
Tuamotu	0.1	0.9	0.8	900	Elevated
Papua New Guinea	0.8	0.8	0.0	100	Normal
Marquesas	0.1	0.6	0.5	600	Elevated
N. New Zealand	0.8	0.3	-0.5	40	Normal-Reduced

Pitcairn Isl.	0.0	0.2	0.2	N/A	Unlikely
W. Kiribati	0.1	0.1	0.0	N/A	Unlikely
E. Kiribati	0.0	0.1	0.1	N/A	Unlikely
C. Kiribati	0.0	0.0	0.0	N/A	Unlikely

Table 3: Previous analogue seasons and intensity of TCs that occurred in the Southwest Pacific during the November-April TC season. Categorisation of TCs aligns to the Australian Bureau of Meteorology (BoM) scale. Italicised figures for category totals are the mean of the count for that category instead of the rounded mean total.

Season	Number of storms Cat 1 or higher	Right: TC category (BOM scale)	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
1972/73	12		6	3	3	0	0
1982/83	16		3	3	3	5	2
2002/03	11		2	3	1	1	4
2004/05	12		5	0	2	1	4
2009/10	11		3	2	3	2	1
Cat total	12.4		3.6	2.2	2.4	1.8	2.2
Rounded	12		4	2	2	2	2

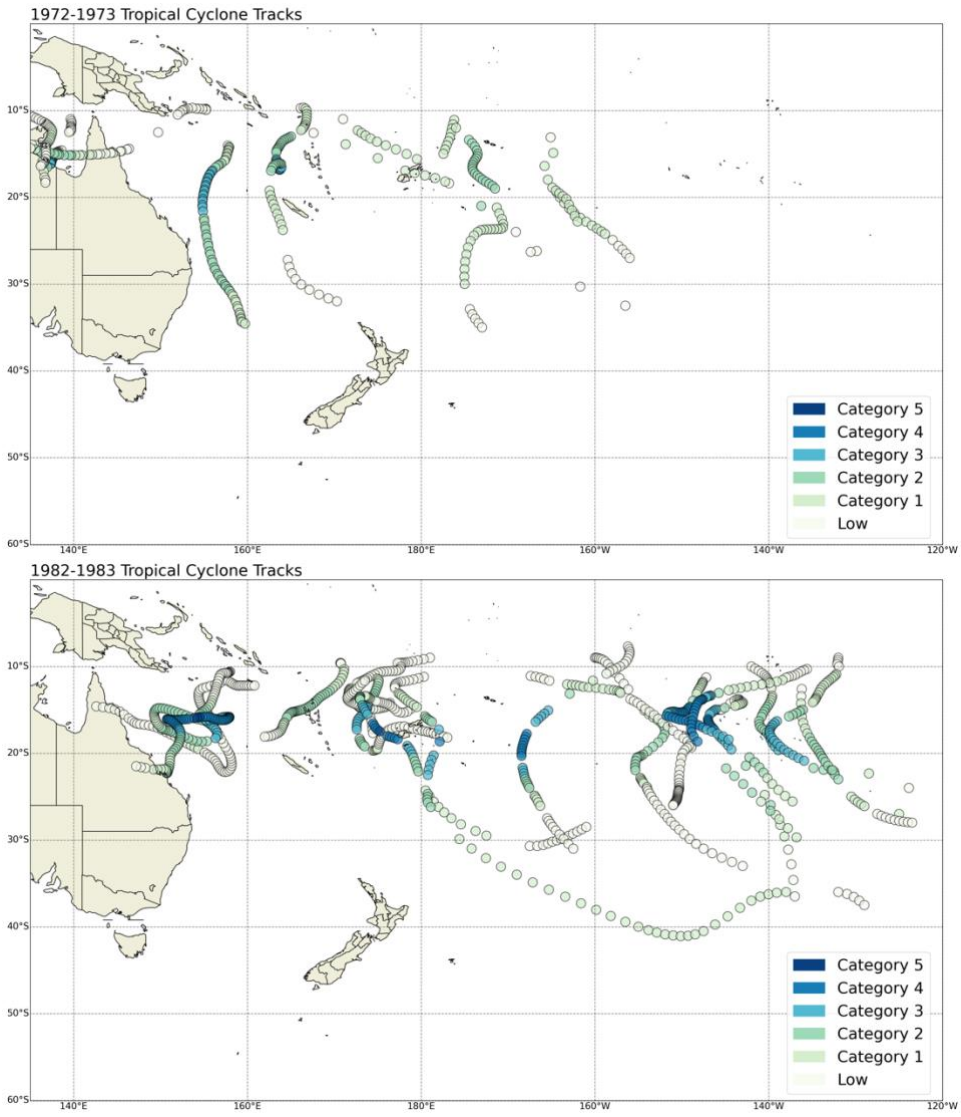
Analogue guidance summary

Based on the guidance from the NIWA analogue method, a conservative range of 9-14 named TCs could be expected during the 2023/24 season for the Southwest Pacific basin (135° E – 120° W). The spread for the estimated cyclone activity comes from the variation between five selected analogue seasons. The historic long-term seasonal average is just under 9 named TCs for the SW Pacific basin. All of the analogue seasons indicate a total number of cyclones that are above the long-term average. However, the long-term regional trend for TC occurrence in the SW Pacific has seen decreasing numbers of named storms. The spread for the coming season based on the analogues encapsulates that trend.

One third to two thirds of the named storms that are expected to form this coming season (e.g. between 3-8 named tropical cyclones out of 12 total) may reach severe Category 3 or higher status. All the historic analogues selected for the 2023/24 outlook have at least three severe TCs, indicating a strong likelihood of multiple named storm systems reaching Category 3 or higher in the SW Pacific. Four out of five of the historic analogue seasons also indicate multiple cyclones that reached at least Category 4 strength. This provides confidence in the statistical outlook for expected cyclone strengths and supports a conservative range of 4-8 severe tropical cyclones for the coming season. The seasons selected for NIWAs analogue outlook also contain multiple Category 5 cyclones (see Table 3). Despite a notable trend toward fewer named storms and stronger TCs in the SW Pacific over the past five decades, the agreement of the analogues raises the possibility that multiple severe storms expected for this season could transform into a Category 5 system.

For the selected analogues, two seasons show at least one ex-tropical cyclone came within 550 km of New Zealand. Some of the seasons had no ex-tropical cyclone interactions

(1982/83; 2002/03; 2004/05). Some past decaying ex-tropical cyclone systems have been associated with high rainfall, damaging winds and amplified coastal wave conditions. Because the analogues have identified multiple years with an ex-tropical cyclone system interacting with the New Zealand Exclusive Economic Zone (EEZ), the risk of an interaction for the country (where at least one cyclone approaches within 550 km of land) for the 2023/24 season is normal-reduced. A majority of ex tropical cyclones deteriorated or transited Pacific Ocean waters well to the east of New Zealand in the historical analogues. There is a near-equal probability of a decaying ex-tropical cyclone tracking to the east or west of the North Island based on historic track data (Figure 4).



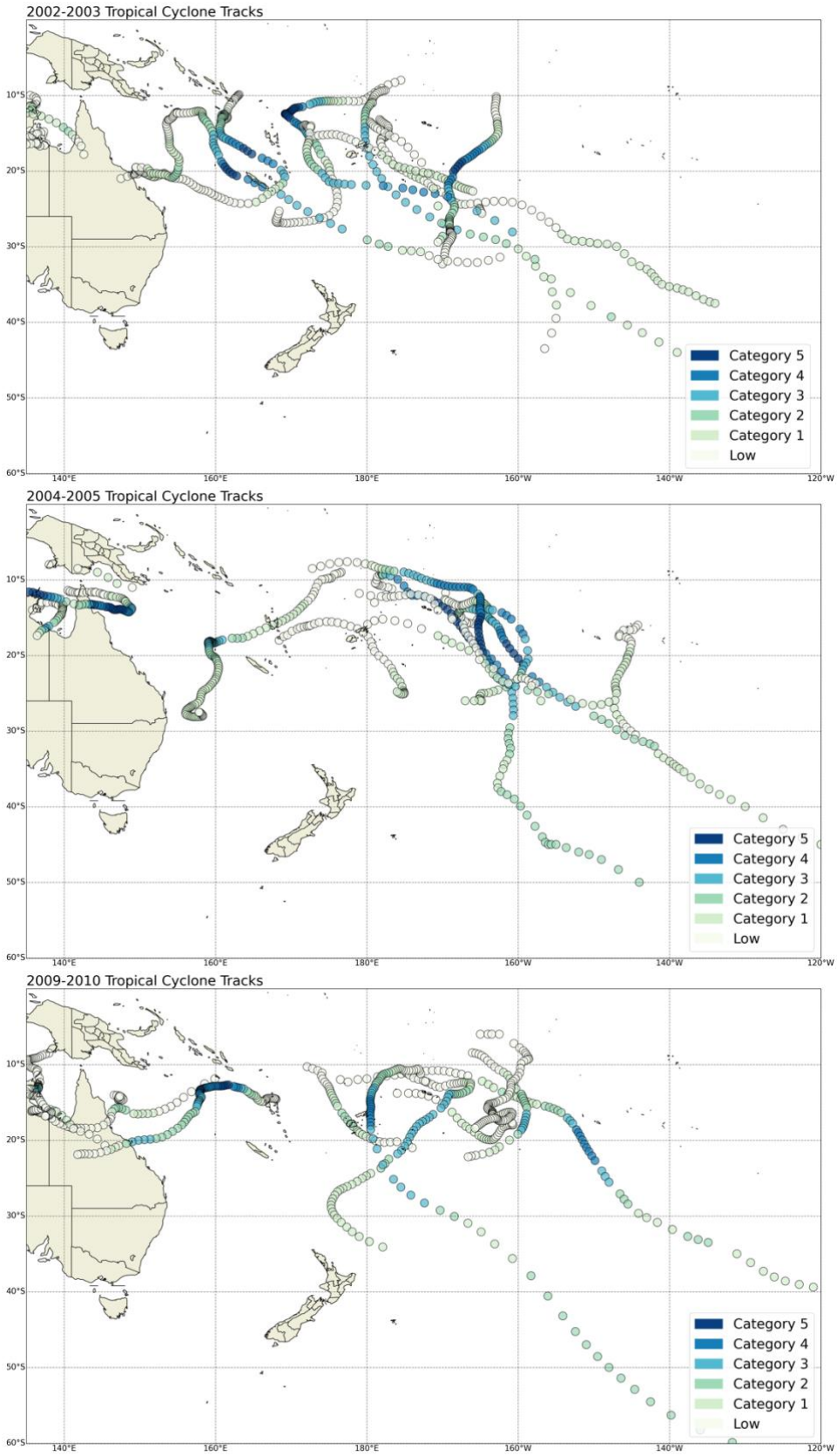


Figure 4: Plots of TC tracks and major tropical lows that were monitored for analogue seasons used in the 2023/24 seasonal forecast for the full season (November - April). Track data are courtesy of International Best Tracks Archive for Climate Stewardship (IBTRaCS)

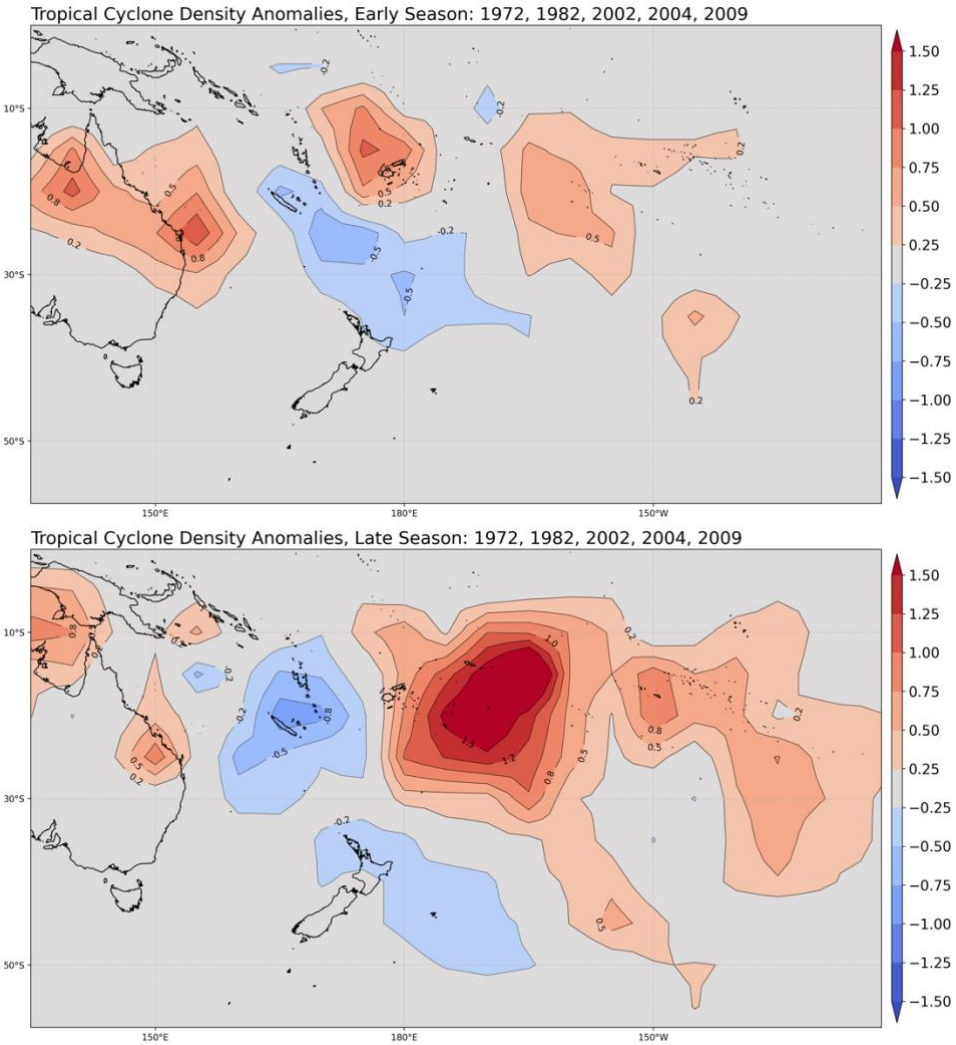


Figure 5: Early season (November to January; top panel) and late season (February to April; bottom panel) anomaly plots for selected TC analogue seasons (data courtesy of International Best Tracks Archive for Climate Stewardship (IBTrACS)). The year label notes the first month in the analogue year selection (i.e. for the early TC season "1972" = November 1972, December 1972, January 1973; and for the late TC season "1972" = February – April 1973).

Dynamical Guidance Summary

A synthesis of model atmospheric and SST guidance favour near average TC activity across the Southwest Pacific basin for the 2023/24 season. However, there is the potential for above normal storm occurrences near the Gulf of Carpentaria, in the northern Coral Sea, near the Solomon Islands and Vanuatu, to near Fiji.

ECMWF seasonal guidance, November 2023-April 2024

The Accumulated Cyclone Energy, or ACE forecast: October 2023 ECMWF seasonal guidance indicates that near normal seasonal ACE (90% of normal) is most likely for the Southwest Pacific region (160˚E-120˚W) and that near normal ACE (90% of normal) is most likely for the Australian region (90˚E-160˚E). ACE is a metric derived from tropical cyclone intensity and duration, averaged across the basin.

Tropical storm (cyclone) density anomaly is forecast to be near or above normal in the northern half of the region. More specifically, a zone of enhanced activity is forecast from the northern Coral Sea, eastward to the Solomon Islands and northern Vanuatu, to near Fiji. Pockets of reduced activity is signalled from the southern Coral Sea to near New Caledonia and eastward toward Tonga, Niue, the southern Cook Islands, and southern French Polynesia, as well as north of New Zealand.

Tropical storm (cyclone) and hurricane frequency (Category 3 or higher):
For the Southwest Pacific region, ECMWF seasonal guidance indicates that the number of tropical cyclones is most likely to be near normal (85% of normal). Guidance suggests that the frequency of severe TCs will also be near normal (85% of normal).

For the Australian region, ECMWF seasonal guidance indicates a below normal number of tropical cyclones (75% of normal) and a near normal number of severe TCs (85% of normal). For the region as a whole, this guidance supports a near normal number of TCs and severe TCs for the 2023/24 tropical cyclone season. However, the dynamical guidance indicates regional variability; western and northern areas of the basin are likely to be more active than southern and south-eastern parts of the basin.

The dynamical guidance agrees with the deterministic guidance for TC count being in the normal range for the SW Pacific basin as a whole but shows some areas of enhanced TC activity close to the International Dateline near Fiji and Samoa and reduced activity near New Caledonia. The dynamical guidance has clusters of enhanced activity in the Coral Sea and along coastal Queensland. Reduced activity is forecast for areas due east of Fiji, including around Niue, Samoa, American Samoa, and northern parts of French Polynesia. This spatial pattern is in contrast with the analogue guidance that is based on historical seasons with ENSO conditions similar to present.

The ECMWF Southwest Pacific forecast domain for ACE is from 160˚ E to 120˚ W. NIWA's outlook covers 135˚ E to 120˚ W, therefore the forecast generated by NIWA extends 25˚ westward relative to the ECMWF forecast domain.

Information about the dynamical models used: information on ECMWF model skill can be found here for: tropical cyclones, severe tropical cyclones, and ACE. An overview of the multi-model ensemble used to create the rainfall and air pressure plots can be found here.

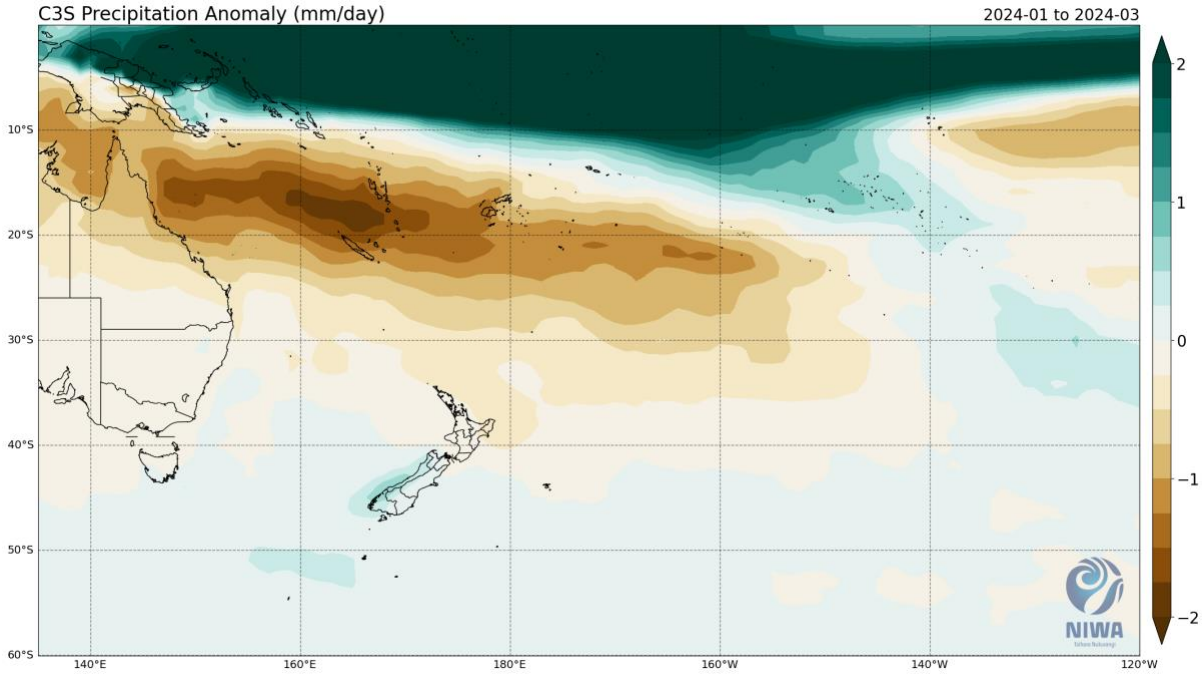


Figure 6: Multi-model ensemble forecast rainfall anomaly (mm/day), January-March 2024; green (brown) shades indicate above (below) normal forecast rainfall

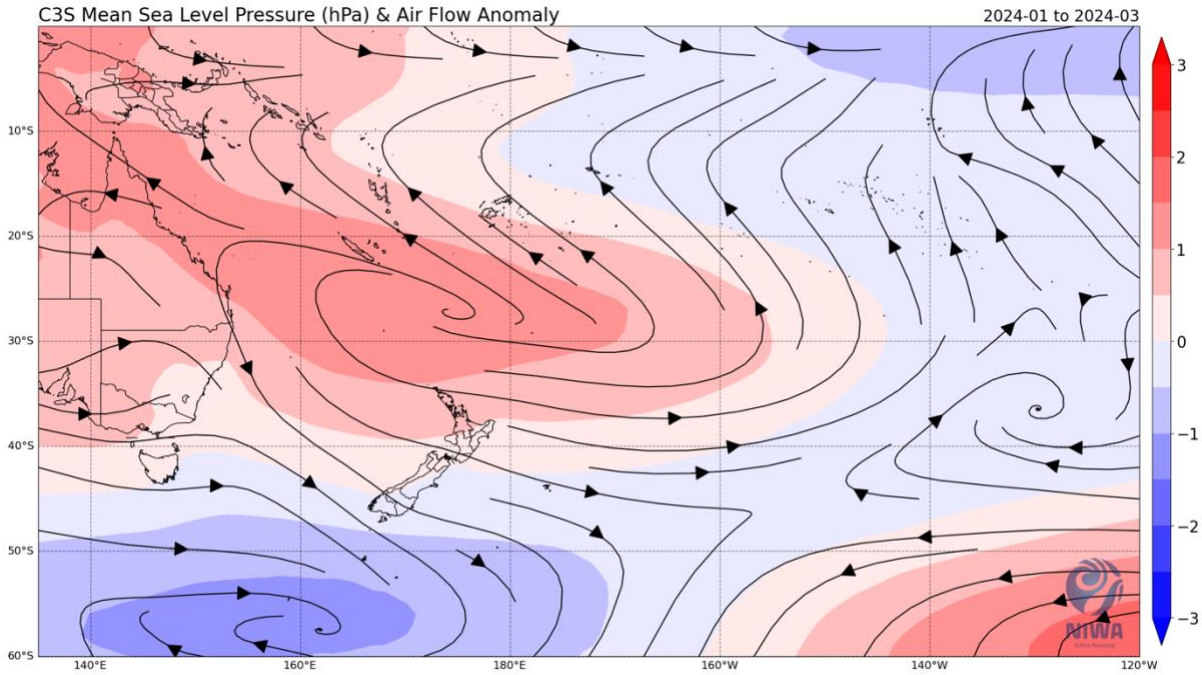


Figure 7: Multi-model ensemble forecast air pressure anomaly (hPa), January-March 2024; red (blue) shades indicate above (below) normal air pressure; areas of below normal pressure in the tropics can indicate an increased potential for tropical cyclone genesis

TCO-SP (University of Newcastle) deterministic model summary

TCO-SP is a long-range tropical cyclone outlook based on a multivariate statistical method generated using Poisson Regression (Magee et al., 2020) published in *Scientific Reports.* This is the fourth year the product is available, and we have continued to incorporate it into the ICU outlook because it provides a different view from analogue and dynamical approaches. For the coming 2023/24 season, the deterministic TCO-SP outlook for Southwest Pacific TC season suggests 10 named TCs may form (probable range of 8-14), indicating normal-above normal activity for the basin when compared with the 1991-2020 average of 8.7 TCs (Table 4 and Figure 8). See https://tcoutlook.com/swpacific/ for more details related to this part of the outlook.

For the SW Pacific basin, the multi-model average based on the 10 models used in TCO-SP indicates ~10 TCs are expected (see Figure 7). The majority of the models indicate normal or below normal activity for the basin. The skill score of the model for the basin-wide outlook (which has been selected using an objective convention) is the highest of the group of 10 models employed in the TCO-SP guidance. The expected TC count (10.1 TCs) for the SWP domain is similar to the average TC count (8.7 TCs). The near-normal risk profile for this region considers the percentage difference between the normal and forecast TC numbers (10.1 vs 8.7 = 16% increase). Overall, the spatial pattern for the TCO-SP outlook displays similarities to both the analogue and dynamical guidance, with more similarities to the analogues in the far eastern part of the basin and greater similarities to the dynamical guidance in the western and central part of the basin.

		Long-term average TC count (1991-2020[b])	**Expected TC Count** (Probable TC count range: 95% CI)	**Difference between expected and long-term average (TC)**
	Southwest Pacific	8.7	10.1 (8.1 – 14.0)	▲ +1.4
Island Scale Models	Fiji	2.5	3.3 (1.3 – 4.2)	▲ +0.7
	Solomon Islands	2.5	1.8 (0.9 – 3.4)	▼-0.7
	New Caledonia	2.3	1.8 (1.0 – 3.2)	▼-0.5
	Vanuatu	2.0	2.5 (1.8 – 3.4)	▲ +0.5
	Tonga	2.0	1.2 (0.7 – 2.0)	▼-0.8
	Papua New Guinea	1.6	1.2 (0.7 – 2.2)	▼-0.4
	Northern New Zealand	0.7	0.1 (0.0 – 0.6)	▼-0.6
Subregional models[a]	**N SWP** (Tuvalu, Wallis & Futuna, Tokelau)	1.8	2.0 (1.0 – 4.3)	▲ +0.2
	C SWP (Samoa, American Samoa, Niue)	1.5	1.0 (0.4 – 2.1)	▼ -0.5
	SE SWP (Southern Cook Islands, Society Islands, Austral Islands)	1.6	2.0 (0.8 – 4.6)	▲ +0.4
	NE SWP (Northern Cook Islands, E Kiribati: Line Islands, Marquesas, Tuamotu Archipelago, Gambier Islands, Pitcairn Islands)	1.1	1.7 (0.9 – 3.4)	▲ +0.6

Table 4: Expected TC counts including expected range (95% confidence intervals (CI)) for the 2023/24 Southwest Pacific tropical cyclone season (September 2023 update), difference from long term average TC count (1991-2020).

[a] Sub-regional models – where individual island TC climatology shows less than 1.5 TCs per season, geographically neighbouring EEZs have been merged to increase sample size (Click here for more information).
[b] Average TC counts calculated for November-April TC season.

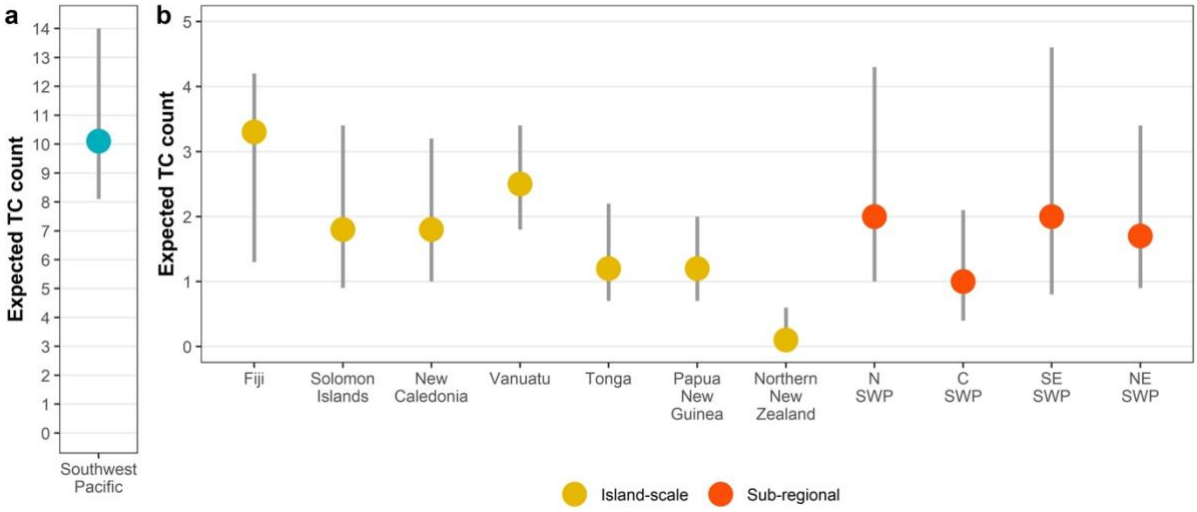


Figure 8: Expected TC count including probable range (95% confidence intervals) for the 2023/24 Southwest Pacific Tropical Cyclone Season based on TCO-SP (Magee et al., 2020). Expected TC counts are summarised for the Southwest Pacific (panel a) and island-scale and sub-regional locations (panel b)