September 2023 Long-Range Outlook for the 2023-24 Southwest Pacific Tropical Cyclone Season

Long-Range Tropical Cyclone Outlook for the Southwest Pacific (TCO-SP)

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TCO-SP
Long-Range
Tropical Cyclone Outlook
for the Southwest Pacific
www.tcoutlook.com

TCO-SP is a long-range tropical cyclone outlook based on a method published in Scientific Reports and the Bulletin of the American Meteorological Society. Please see the disclaimer about the use of TCO-SP outlooks in the "Interpreting TCO-SP" section.

Outlook Summary

The September 2023 Long-Range Tropical Cyclone Outlook for the Southwest Pacific (TCO-SP) suggests **near-normal** TC activity for the coming 2023-24 Southwest Pacific TC season (1st November 2023 to 30th April 2024). In total, **10 TCs** are expected for the Southwest Pacific region[1], however, the probable range of TC could lie between **8 and 14 TCs**. There is a **55% chance that the season will see average or below-average TC counts (9 TCs or less)** and a 45% chance the season will see above-average TC counts (10 TCs or more). An El Niño and Positive Indian Ocean Dipole event are underway, driving elevated risk of TC activity towards the eastern Southwest Pacific.

Expected average TC counts for island-scale and sub-regional outlooks are summarised in Figure 1 (see Table 1 for detailed deterministic guidance):

- **Above-normal[2]** TC activity is expected for Fiji (3 TCs), Vanuatu (3 TCs), SE SWP (2 TCs) and the NE SWP (2 TCs).
- **Near-normal[3]** TC activity is expected for the entire Southwest Pacific (10 TCs) and the N SWP (2 TCs).
- **Below-normal[4]** TC activity is expected for the Solomon Islands (2 TCs), New Caledonia (2 TCs), Tonga (1 TC), Papua New Guinea (1 TC), Northern New Zealand (<1 TC), and the C SWP (1 TC).

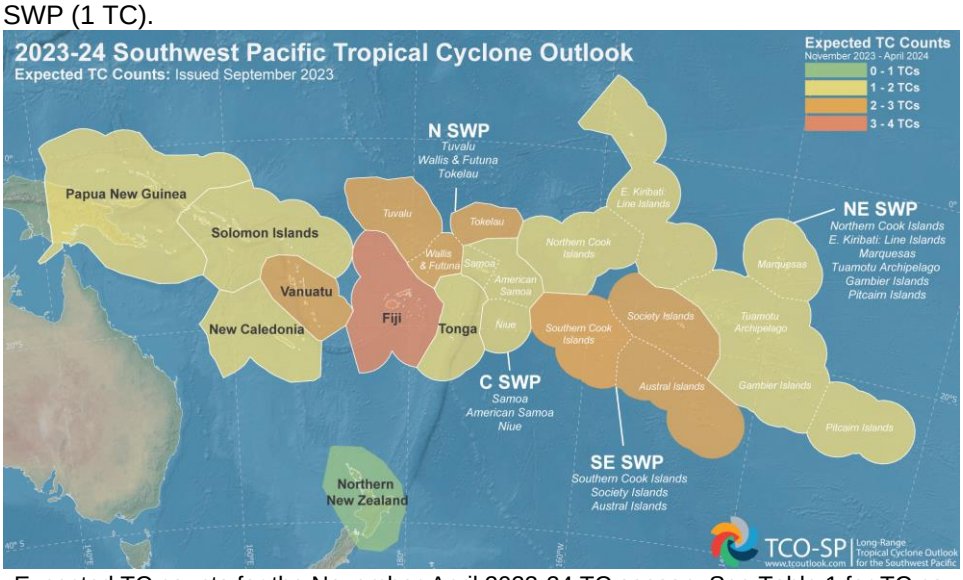

Figure 1. Expected TC counts for the November-April 2023-24 TC season. See Table 1 for TC counts, including probable TC range.

[1] Southwest Pacific region: 135°E-120°W.
[2] Above-normal activity is defined as when the difference between expected TC counts and the long-term average (1991-2020) exceeds +20%.
[3] Near-normal is defined as when the difference between expected TC counts and the long-term (1991-2020) average is between -20% and +20%.
[4] Below-normal activity is defined as when the difference between expected TC counts and the long-term average (1991-2020) exceeds -20%.

Deterministic guidance

For the coming 2023-24 Southwest Pacific TC season, 10 TCs are expected (probable range of 8-14 TCs), suggesting near-normal activity when compared with the 1991-2020 average of 8.7 TCs (Table 1).

Table 1: Summary of deterministic guidance. Average TC count (1991-2020), expected TC count including expected range (95% confidence intervals (CI)) for the 2023-24 Southwest Pacific tropical cyclone season (September 2023 update) and difference between expected and average TC count.

		Average TC count (1991-2020[b])	**Expected TC count** (Probable TC count range: 95% CI)	**Difference between expected and average TC count**
	Southwest Pacific	8.7	10.1 (8.1-14.0)	▲ +1.4
Island Scale Models	Fiji	2.5	3.3 (1.3-4.2)	▲ +0.8
	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 (0.7-2.2)	▼ -0.8
	Papua New Guinea	1.6	1.2 (0.7-2.0)	▼ -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

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

Probabilistic guidance

Figure 2 summarises the probabilistic outlook for the 2023-24 Southwest Pacific Tropical Cyclone Season.

- **Above-normal**[5] TC activity is expected for Fiji (42% chance of 4 or more TCs), Vanuatu (46% chance of 3 or more TCs), SE SWP (32% chance of 3 or more TCs) and the NE SWP (51% chance of 2 or more TCs).
- **Near-normal**[6] TC activity is expected for the entire Southwest Pacific (45% chance of 10 or more TCs), and the N SWP (32% chance of 3 or more TCs).
- **Below-normal**[7] TC activity is expected for the Solomon Islands (11% chance of 4 or more TCs), New Caledonia (27% chance of 3 or more TCs), Tonga (12% chance of 3 or more TCs), Papua New Guinea (12% chance of 3 or more TCs), Northern New Zealand (3% chance of 2 or more TCs) and the C SWP (8% chance of 3 or more TCs).

[5] Above-normal activity is defined as when the difference between expected TC counts and the long-term average (1991-2020) exceeds +20%.
[6] Near-normal is defined as when the difference between expected TC counts and the long-term (1991-2020) average is between -20% and +20%.
[7] Below-normal activity is defined as when the difference between expected TC counts and the long-term average (1991-2020) exceeds -20%.

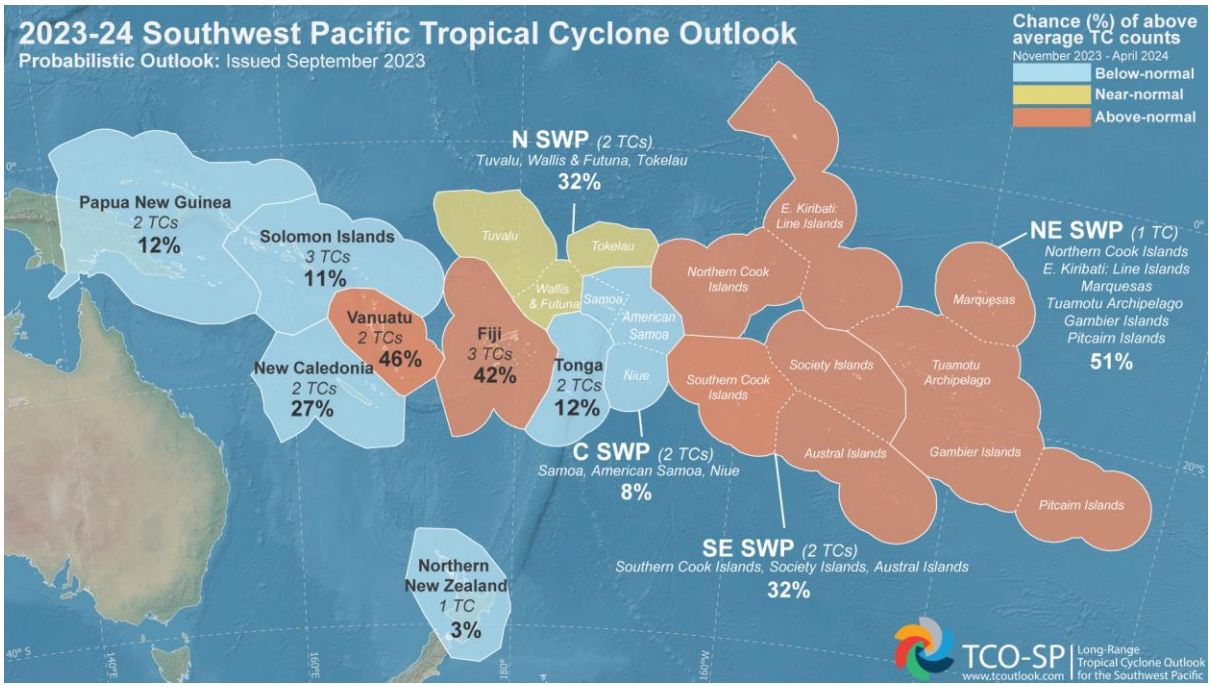

Figure 2. Probabilistic TC outlook for the November-April 2023-24 Southwest Pacific tropical cyclone season. TC counts (italics) refer to the 1991-2020 climatology (average TC counts). The chance (%) of above-average TC counts are summarised. See Table 2 for tabular probabilities of above-average and below-average TC counts.

Table 2. Summary of probabilistic guidance. Calculation of difference between the long-term average and expected TC count (%), TC risk and chance of near-normal, below-normal or above-normal TC activity for the 2023-24 Southwest Pacific tropical cyclone season.

		Long-term average TC count (1991-2020)	**Expected TC count**	**Difference between long-term average and expected TC count (%)**	**TC risk[a]**	**Chance of average or below-average TC activity (%)[b]**	**Chance of above-average TC activity (%)[b]**
	Southwest Pacific	8.7	10.1	+16	Near-normal	45	55
Island Scale Models	Fiji	2.5	3.3	+32	Above-normal	58	42
	Solomon Islands	2.5	1.8	-28	Below-normal	89	11
	New Caledonia	2.3	1.8	-22	Below-normal	73	27
	Vanuatu	2.0	2.5	+25	Above-normal	54	46
	Tonga	2.0	1.2	-40	Below-normal	88	12
	Papua New Guinea	1.6	1.2	-25	Below-normal	88	12
	Northern New Zealand	0.7	0.1	-86	Below-normal	97	3
Subregional models	**N SWP** (Tuvalu, Wallis & Futuna, Tokelau)	1.8	2.0	+11	Near-normal	68	32
	C SWP (Samoa, American Samoa, Niue)	1.5	1.0	-33	Below-normal	92	8
	SE SWP (Southern Cook Islands, Society Islands, Austral Islands)	1.6	2.0	+25	Above-normal	68	32
	NE SWP (Northern Cook Islands, E Kiribati: Line Islands, Marquesas, Tuamotu Archipelago, Gambier Islands, Pitcairn Islands)	1.1	1.7	+55	Above-normal	49	51

[a] TC risk is calculated using the percentage difference between expected TC counts and the 1991-2020 climatology. Near-normal risk is defined as when the difference between expected TC counts and the long-term (1991-2020) average is between -20% and +20%. Below-normal (above-normal) risk is defined as when the difference between expected TC counts and the long-term average (1991-2020) exceeds -20% (+20%).
[b] Chance of average or below-average TC activity and chance of above-average TC activity calculated using the Poisson distributional process.

Predictors and climate influences relevant to 2023-24 TC season

El Niño-Southern Oscillation: An El Niño is currently underway in the tropical Pacific Ocean[8]. Multiple agencies indicate a 100% chance of El Niño conditions for the first three months (November-January) of the Southwest Pacific TC season, including the Australian Bureau of Meteorology[9] and the CPC/IRI[10]. El Niño conditions typically results in increased TC activity towards the east/northeast of the Southwest Pacific basin, and reduced activity towards the west (Magee et al., 2017). However, every El Niño event is different. TCO-SP is updated monthly, so any changes in ocean temperatures or atmospheric variability related to ENSO will be considered in the TCO-SP updates to follow.

Indian Ocean Sea Surface Temperatures: The Indian Ocean Dipole (IOD) is currently positive. Statistical and dynamical guidance collected from five international climate models indicate that all five models (BOM, CanSIPS, ECMWF, METEO, UKMO) exceed IOD positive SST thresholds by

[8] Bureau of Meteorology ENSO Outlook (Published September 19 2023) http://www.bom.gov.au/climate/enso/outlook/
[9] IRI ENSO forecast (Published September 20 2023) https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table
[10] CPC/IRI ENSO Forecast (Published September 14 2023) https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-cpc_update

November 2023, and continue to do so until January 2024.[11] According to ACCESS-S,[12] there is a 100% chance of IOD positive conditions until December 2023, with a 67% chance of IOD positive conditions by February 2024. TCO-SP is updated monthly, so any changes in Indian Ocean SST variability will be considered in the TCO-SP updates to follow.

Model Validation

Model validation statistics compare key model performance metrics for (i) the modelled TC time series when trained on the entire 1970-2023 training period, and (ii) the TC time series derived from the Leave-One-Out Cross-Validation (LOOCV)[13] step. The model with the highest LOOCV skill score (1970-2023) is selected as the superior model and is used to derive the island-scale and sub-regional seasonal outlooks. The statistics for the same model when trained on the entire 1970-2023 period are also summarised in Table 3. Model validation statistics (Table 3) offer important insights when considering outputs from TCO-SP.

Table 3. Summary statistics comparing model performance (predicted TCs compared with observed TCs) for the 1970-2023 training period (top values) and the Leave-One-Out Cross-Validation (LOOCV) time-series (bottom values in parentheses) for the September long-range outlook for the 2023-24 Southwest Pacific tropical cyclone season.

		Correlation	R^2	RMSE	Skill Score (%)[a]	Strike Rate (exact) (%)[b]	Strike Rate (±1) (%)[c]
	Southwest Pacific	0.66 (0.54)	0.44 (0.29)	2.50 (1.77)	44.1 (28.2)	15 (13)	54 (43)
Island Scale Models	Fiji	0.70 (0.44)	0.49 (0.19)	1.11 (0.97)	48.6 (11.8)	30 (22)	89 (81)
	Solomon Islands	0.76 (0.62)	0.57 (0.38)	1.21 (1.10)	57.4 (36.0)	35 (24)	78 (74)
	New Caledonia	0.74 (0.60)	0.54 (0.36)	0.98 (0.92)	54.1 (31.4)	43 (37)	91 (78)
	Vanuatu	0.58 (0.51)	0.34 (0.26)	1.19 (0.73)	34.0 (25.1)	31 (30)	78 (74)
	Tonga	0.48 (0.15)	0.23 (0.02)	1.3 (1.69)	22.0 (10.1)	37 (30)	85 (74)
	Papua New Guinea	0.56 (0.39)	0.31 (0.15)	1.01 (0.65)	31.5 (11.1)	44 (41)	85 (80)
	Northern New Zealand	0.73 (0.29)	0.54 (0.08)	0.60 (0.97)	53.5 (29.7)	61 (50)	98 (81)
Subregional models	**N SWP** (Tuvalu, Wallis & Futuna, Tokelau)	0.56 (0.38)	0.32 (0.15)	1.29 (1.07)	31.5 (22.4)	37 (33)	80 (72)
	C SWP (Samoa, American Samoa, Niue)	0.72 (0.48)	0.52 (0.23)	1.08 (1.05)	51.5 (13.8)	31 (31)	85 (78)
	SE SWP (Southern Cook Islands, Society Islands, Austral Islands)	0.80 (0.51)	0.65 (0.26)	1.13 (1.27)	64.5 (18.2)	50 (44)	80 (70)
	NE SWP (Northern Cook Islands, E Kiribati: Line Islands, Marquesas, Tuamotu Archipelago, Gambier Islands, Pitcairn Islands)	0.92 (0.84)	0.84 (0.70)	0.78 (1.02)	84.0 (67.7)	54 (50)	94 (85)

[a] Skill score evaluates model performance over the specified training period. 100% represents a perfect outlook. 0% represents outlooks as accurate as the climatology. See Roebber and Bosart, (1996).
[b] Strike Rate exact is the % of seasons throughout the training period (1970-2023) where the prediction matched the observation.
[c] Strike Rate ±1 is the % of seasons throughout the training period (1970-2023) where the prediction matched the observation ±1 TCs.

[11] BOM Indian Ocean Dipole Outlook (Issued September 19 2023) http://www.bom.gov.au/climate/model-summary/#tabs=Indian-Ocean.
[12] Australian Community Climate Earth-System Simulator-Seasonal (ACCESS-S) IOD outlooks (Issued September 16 2023) http://www.bom.gov.au/climate/model-summary/#tabs=Bureau-model&region=IOD.
[13] The Leave-One-Out Cross-Validation (LOOCV) is a method of model cross-validation. Using this approach, the model is trained using n – 1 seasons to produce a hindcast number of events and is iteratively applied in a jackknife fashion to hindcast every historical season in the record. The subsequent time series provides a view of hindcast model skill.

Model consensus

Evaluating model consensus provides an understanding of how well predictor models agree on the expected TC count and range. In total, 10 predictor models are trained per location. An automated variable selection algorithm selects the best combination of predictors for each of the 10 predictor models. In an update to the methodology published by Magee et al., (2020), a LOOCV time series is derived for each of the 10 predictor models (using the same indices identified by the automated variable selection algorithm). The model with the highest LOOCV skill score (Table 3) over the 1970-2023 training period is selected as the superior model and is used to derive the location-specific seasonal outlooks. Figure 3 summarises the expected TC count and probable range for the 10 predictor models (TC count and confidence intervals) for the September 2023 outlook and the red dot indicates the model with the highest LOOCV skill score which is the prediction selected to generate the outlook. The multi-model average (AV) is also included in Figure 3.

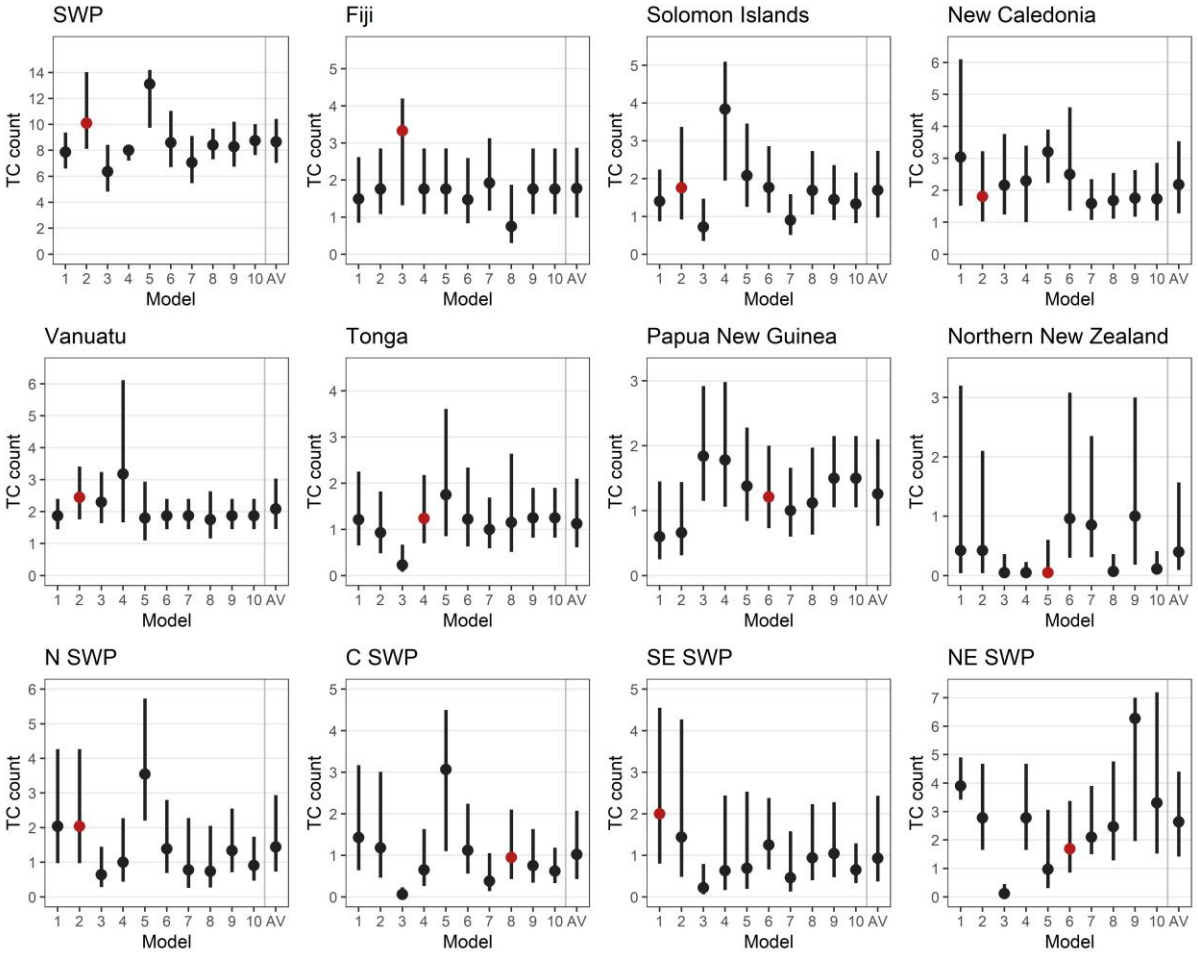

Figure 3. Comparison of predictor model consensus for expected TC counts (dot) and probable range (95% confidence intervals). Red dot indicates model selected due to superior model performance (highest skill score from the LOOCV time series). Models 1-10 refer to each unique predictor model. AV (average) refer to multi-model average (average of expected TC counts and range (95% confidence intervals)). A StepAIC function is applied to each set of predictor models to calculate the optimum combination of covariates (see Magee et al. (2020) for more information).

2023-24 TCO-SP update schedule

Pre-season TCO-SP outlooks will be generated every month between July and October, while in-season outlooks will be generated between November and January. Table 4 outlines the TCO-SP outlook schedule for the 2023-24 Southwest Pacific Tropical Cyclone Season. Guidance from the October TCO-SP outlook will be included in the NIWA-led Southwest Pacific Tropical Cyclone Outlook that is produced through the Island Climate Update (ICU).

Table 4. TCO-SP update schedule for the 2023-24 Southwest Pacific Tropical Cyclone Season

	Outlook	Date
Pre-season outlook	July TC Outlook	W/C 17th July 2023
	August TC Outlook	W/C 21st August 2023
	September TC Outlook	W/C 18th September 2023
	October TC Outlook	W/C 16th October 2023
In-season outlook	In-season guidance may be released if conditions materially change.	

Interpreting TCO-SP

TCO-SP is a statistically driven, island and regional scale TC outlook for the Southwest Pacific region. Rolling monthly updates will be provided between July and October so predictive models used in TCO-SP can consider the latest changes in ocean temperature and atmospheric variability. The following details should be considered when using TCO-SP:

- **Guidance from TCO-SP does not and should not replace the advice provided by your local Pacific Island National Meteorological Service.**
- TCO-SP considers an updated climatological baseline of 1991-2020. This means that average TC counts may differ from TCO-SP outputs generated for previous TC seasons (previously averaged between 1981-2010) and from other agencies.
- Timescales associated with outlooks (months) are different to shorter-term weather forecasts (hours to days). In the case of outlooks, particularly long-range outlooks such as those presented here, TCO-SP provides guidance up to four months before the start of the Southwest Pacific TC season. As such, it is possible for daily or weekly changes in predictors (i.e. ocean temperatures and atmospheric variability) to influence TC numbers and result in discrepancies with the long-range TC outlooks.
- Monthly TCO-SP guidance will track any changes in ocean temperature/atmosphere variability, which may result in changes in guidance from one monthly outlook to another. Subscribing to TCO-SP is the best way for end-users (e.g. Pacific Island Meteorological Services) to stay up to date with the latest TCO-SP updates.
- Users should evaluate model skill (Table 3) and the predictor model comparison (Figure 4) to inform decision-making.
- TCO-SP is an experimental platform and should be used in combination with other guidance for decision-making. TCO-SP does not accept any liability associated with decisions that are made using this guidance.
- It does not take a landfalling TC to cause significant and life-threatening impacts. TCs that pass neighbouring Pacific Island nations can also cause significant damage. Always be alert. Listen to the advice of your local meteorological office and/or disaster management office.

Questions? Contact:

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