Early July Forecast for Northwest Pacific Typhoon Activity in 2022

Issued: 6th July 2022

by Adam Lea and Frank Roberts
EuroTempest Ltd, London, UK

TSR predicts that Northwest Pacific typhoon activity in 2022 will be 20-25% below the 1991-2020 30-year norm. This forecast has more confidence than is usual at this range.

Summary: The TSR (Tropical Storm Risk) early July forecast for Northwest Pacific typhoon activity in 2022 continues to anticipate another season with below-norm activity albeit at levels slightly higher than in 2020 and 2021. TSR uses the strong link (R^2 = 0.82; 1997-2021) between the annual Northwest Pacific ACE index and August-September-October (ASO) ENSO combined with the increasing expectation that the current La Niña state will persist through ASO 2022. Although some uncertainties remain, TSR anticipates there is a 97% likelihood that Northwest Pacific ACE in 2022 will be below the 1991-2020 30-year norm and anticipates there is a 82% chance Northwest Pacific ACE in 2022 will be in the lower tercile of years 1991-2020.

Contents:

1. TSR July 2022 Northwest Pacific Seasonal Typhoon Activity Forecast

1.1 Forecast Northwest Pacific ACE Index and System Numbers in 2022:

		ACE Index	Intense Typhoons	Typhoons	Tropical Storms
TSR Forecast	2022	217	7	13	23
72-yr Climate Norm	1965-2021	293	8.8	16.2	25.9
30-yr Climate Norm	1991-2020	301	9.3	16.0	25.5
10-yr Climate Norm	2012-2021	275	9.2	14.9	25.7
Forecast Skill at this Lead	2012-2021	43%	8%	0%	22%

Key:
- ACE Index = Accumulated Cyclone Energy Index = Sum of the squares of 6-hourly maximum sustained wind speeds (in units of knots) for all systems while they are at least tropical storm strength. ACE unit = x10^4 knots^2.
- Intense Typhoon = 1 minute sustained wind > 95 kts = Hurricane category 3 to 5.
- Typhoon = 1 minute sustained wind > 63 kts = Hurricane category 1 to 5.
- Tropical Storm = 1 minute sustained wind > 33 kts.
- Forecast Skill = Percentage improvement in mean square error over running 10-year prior climate norm for the TSR publicly-released seasonal outlooks for the 10-years 2012-2021.
- Northwest Pacific = Northern hemisphere region west of 180°W including the South China Sea. Any tropical cyclone (irrespective of where it forms) which reaches tropical storm strength within this region counts as an event.

The forecast tercile probabilities (1991-2020 data) for the 2022 Northwest Pacific typhoon season ACE index are as follows: only a 1% probability of being upper tercile, a 17% likelihood of being middle tercile and an 82% chance of being lower tercile.

Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values for the current 30-year climate norm (1991-2020). Upper tercile = ACE value greater than 328. Middle tercile = ACE value between 258 and 328. Lower tercile = ACE value less than 258.

1.2 Forecast Probability of Exceedance Plot for the Northwest Pacific ACE index in 2022:

Seasonal outlooks for Northwest Pacific typhoon activity contribute to the anticipation of risk for insurance companies, other weather-sensitive businesses, and local and national governments. However, the uncertainty associated with such forecasts is often unclear. This reduces their benefit and contributes to the perception of forecast 'busts'. The robust assessment of risk requires a full and clear probabilistic quantification of forecast uncertainty with the forecast issued in terms of probability of exceedance (PoE). In this way the chance of each typhoon number/activity outcome occurring is clear for the benefit of users.

Figure 1 displays our current forecast for the 2022 Northwest Pacific ACE index in terms of PoE. The forecast PoE curve is computed using the robust method described in section 3 of Saunders et al. (2020) while the climatology PoE curve is computed directly from observations. The figure specifies the current chance that a given ACE index will be reached in 2022 and how this chance compares to climatology.

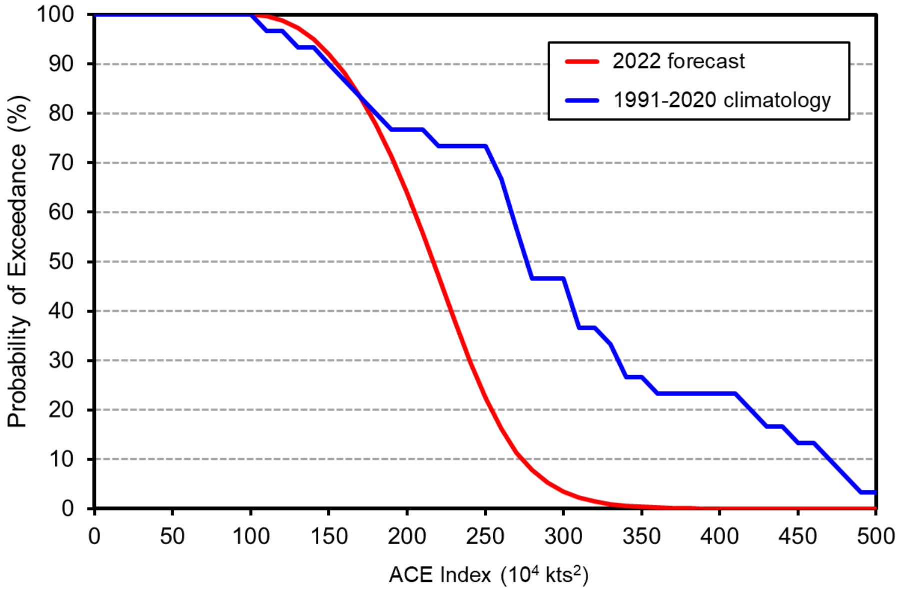

Figure 1. Forecast probability of exceedance (PoE) plot for the Northwest Pacific ACE index in 2022. The plot displays two sets of PoE data comprising the TSR forecast PoE curve issued in early July and the 1991-2020 climatology PoE curve.

2. TSR Forecast Methodology

2.1 Primary Models:

The TSR forecast model is statistical in nature and employs predictors that have sound physical links to contemporaneous tropical cyclone activity. The TSR primary models are underpinned by the expected state of El Niño Southern Oscillation (ENSO) in August-September-October (ASO). Figure 2 shows the strong linear link that exists between the magnitude of the annual Northwest Pacific ACE index and the sign and magnitude of the ASO ENSO (see also, for example, Saunders et al. (2000) and Maue (2011)). ENSO is represented in Figure 2 by the Oceanic Niño Index (ONI) defined as the 3-month average surface temperature anomaly for the Nino 3.4 region. When the ASO ENSO ONI value is ≤ -1 the ACE index is 200 or less. In contrast, when the ASO ENSO ONI is ≥ 1 the ACE index is 400 or more.

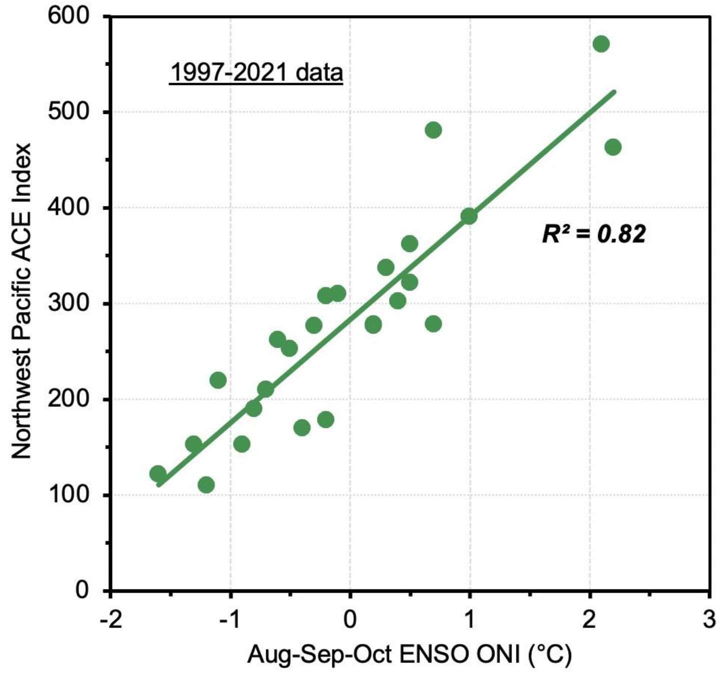

Figure 2. Nature of the TSR primary model for forecasting Northwest Pacific seasonal typhoon activity. The figure shows the strong linear link (R^2 = 0.82; 1997-2021) between the annual Northwest Pacific ACE index and the sign and magnitude of ENSO in August-September-October.

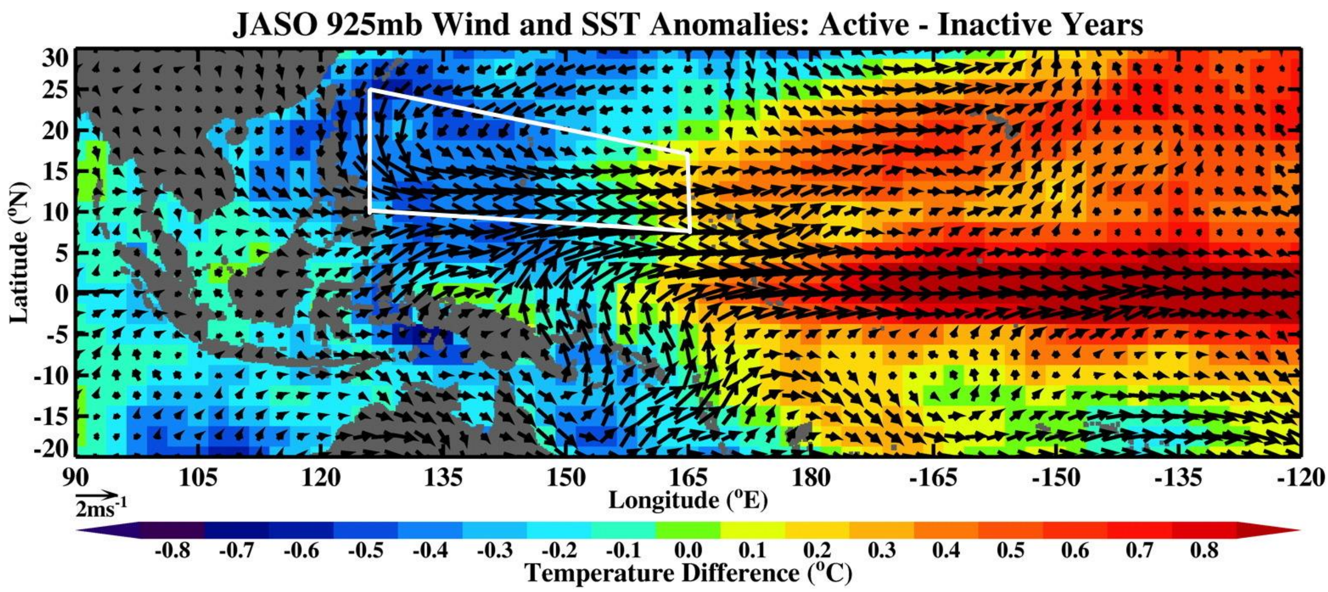

Figure 3. Nature of the physical mechanism behind the TSR primary model in Figure 2. The composite difference figure shows the dominant July-August-September-October (JASO) environmental fields associated with active Northwest Pacific intense typhoon years. Active typhoon seasons occur due to the effects of the anomalous Walker circulation and the resulting weakened easterly trade winds that occur over the tropical Northwest Pacific due to El Niño (warm ENSO) conditions. Inactive typhoon seasons occur due to the effects of the anomalous Walker circulation and the resulting strengthened easterly trade winds that occur over the tropical Northwest Pacific due to La Niña (cold ENSO)

conditions. The white quadrilateral denotes where Northwest Pacific tropical cyclones become intense typhoons.

The physical mechanism behind the strong ASO ENSO link to Northwest Pacific seasonal ACE and seasonal intense typhoon numbers is described in Lea and Saunders (2006) and is illustrated in Figure 3. When ASO ENSO is El Niño (ONI value > 0.5°C) the anomalous Walker circulation leads to anomalously weak trade winds in the Northwest Pacific between 2.5°N and 12.5°N. These in turn increase the cyclonic vorticity and decrease the vertical wind shear where intense typhoons form and track, leading to greater intense typhoon numbers and to an enhanced seasonal ACE index. In contrast when ASO ENSO is La Niña (ONI value < -0.5°C) the anomalous Walker circulation leads to anomalously strong trade winds in the Northwest Pacific between 2.5°N and 12.5°N. These in turn weaken the cyclonic vorticity and increase the vertical wind shear where intense typhoons form and track, leading to fewer intense typhoon numbers and to a reduced seasonal ACE index.

The predictor(s) used for each TSR seasonal forecast primary model are as follows:

Early May: ACE is forecast from our expectation for the value for ASO ENSO ONI and the regression in Figure 2. Intense typhoon numbers are forecast by using their observed regression with ACE for 1998-2021. Typhoon numbers are forecast by using their observed regression with intense typhoon numbers for 1998-2021. Tropical storm numbers are forecast by using their observed regression with typhoon numbers for 1991-2021.

Early July: ACE is forecast from our expectation for the value for ASO ENSO ONI, using the June 925 hPa trade wind speed for the region 2.5°N-12.5°N, 120°E-180°E and by using the observed ACE activity up to the date of the forecast issue. Storm numbers are forecast by applying the methods used in the early May forecast.

Early August: ACE and intense typhoon numbers are forecast by using the June-July 925 hPa trade wind speed for the region 2.5°N-12.5°N, 120°E-180°E and by using the observed ACE activity up to the date of the forecast issue. Typhoon numbers and tropical storm numbers are forecast by using their observed regression with intense typhoon numbers.

The ASO ENSO is predicted by using the statistical consolidated CLIPER model (Lloyd-Hughes, Saunders and Rockett, 2004) and by the methods described in §2.2. All regressions are performed using normalized data for all variables to ensure that the requirements of linear regression modeling are met. Normality is assessed using the Anderson-Darling statistical test.

2.2 Procedures, Checks and Adjustments to Finalise Forecast:

Each TSR seasonal typhoon forecast is initiated by running the TSR primary seasonal forecast model with NCEP/NCAR reanalysis data updated to within a few days of the seasonal forecast issue date. These outputs are then assessed in combination with other sources of information before the final values for the seasonal forecast are decided. The other sources of information often lead either to the TSR forecast model bring rerun with different values for its predictor(s) or to the outputs of the forecast models being manually adjusted.

The sources of other information that are referred to when finalising the TSR Northwest Pacific seasonal typhoon activity forecasts include the following:

- ENSO consensus forecasts compiled and provided by IRI (International Research Institute for Climate and Society).
- NCEP CFSv2 seasonal forecast data (updated daily).
- ECMWF seasonal forecast data (updated monthly).
- NOAA 'ENSO: recent evolution, current status and predictions' weekly report.
- UCL unpublished 'statistical composite prediction of ENSO outcomes' data.
- Tropical Tidbits data and forecast data (updated daily).

The following procedures and adjustments to the outputs from the TSR primary forecast models are made in order to enhance forecast precision:

a) The additional information sources are used to give a consensus value for TSR's main primary predictor – the ASO ENSO ONI. In determining this consensus value more weight is given to the seasonal ENSO forecasts from the *NCEP CFSv2* and *ECMWF* models and from the *UCL "Statistical composite prediction of ENSO outcomes".*
b) If the consensus value obtained from (a) differs by more than 0.1°C from the value output by the statistical consolidated CLIPER model (Lloyd-Hughes, Saunders and Rockett, 2004) the consensus value is used as the TSR primary model forecast value for ASO ENSO ONI.
c) If forecasts anticipate the intensification of either a La Niña or an El Niño event during the second half of the typhoon season (namely during the period from mid September to the end of November) the TSR seasonal typhoon forecasts (especially the early May and early July forecasts) are adjusted slightly to reflect this ENSO intensification.

3. Factors Influencing the July 2022 TSR Forecast

The TSR early July forecast for Northwest Pacific typhoon activity in 2022 calls for ACE-activity 20-25% below the 1991-2020 30-year climate norm because TSR's primary predictors at this range – the strength of the June trade wind anomaly in the region 2.5°-12.5°N, 120°E-180°, and the observed ACE index up to the 5^{th} of July, are both indicative of a below average season. The June trade wind anomaly is currently -1.78 ms^{-1} which is the fifth most negative anomaly since 1965. A negative (stronger easterly) trade wind anomaly in early summer is associated with reduced cyclonic vorticity over the NW Pacific basin when it persists through the season, resulting in below average typhoon activity. When the June trade wind anomaly is in the lowest quartile (< -1.12 ms^{-1}), the mean NW Pacific ACE index is 216. The ACE index to date in the NW Pacific basin is 23 which is in the lower tercile of years back to 1965. The mean ACE index for years where the ACE index to date was in the lowest tercile is 233. A third factor is the expectation that La Niña to persist through ASO 2022 with some forecast models predicting a slight strengthening through the autumn. La Niña conditions are linked to stronger than average trade winds over the NW Pacific basin, which results in reduced cyclonic vorticity and less favourable conditions for storms to develop and intensity.

Historically the skill from early July forecasts for Northwest Pacific typhoon activity is low to moderate (§1.1 and Figure 4). This is due to moderate uncertainty in the ASO ENSO ONI value at this two-month lead, and whether the stronger than average trade wind anomaly will persist through summer, because even if the ASO ONI value is anticipated correctly a spread in ACE levels can still ensue (Figure 2), and conditions can change through the season. However, because the current likelihood for ASO 2022 ENSO being La Niña is high, and all other factors mentioned above point to a below average typhoon season, we believe that the uncertainty in our early July 2022 forecast is less than is typical at this range.

4. Precision of TSR Seasonal Typhoon Forecasts 2003-2021 Issued Publicly

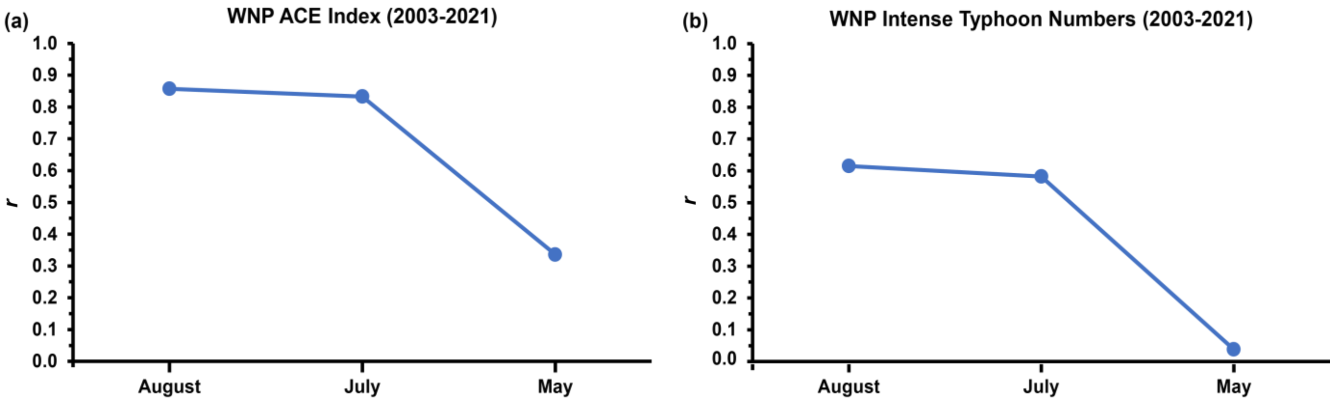

Figure 4. Real-time skill of the TSR seasonal outlooks for northwest Pacific (a) ACE and (b) intense typhoon numbers assessed for the 19-year period 2003-2021. Skill is shown as the Pearson correlation, *r*, between the forecast values (issued separately in early May, early July and early August) and the observed values.

The skill of the TSR seasonal forecasts for Northwest Pacific typhoon activity issued publicly in real-time for the 16-year period 2003-2018 were assessed by Klotzbach et al (2019) (see their Figure 4). Figure 4 extends the Klotzbach et al. skill assessment to span the period between 2003 and 2021. Skill is displayed as a function of forecast lead-time for two measures of seasonal typhoon activity – the basin ACE index and basin intense typhoon numbers. Figure 4 shows that the TSR seasonal forecast skill from early July is moderate to good. The correlation skill for typhoon numbers (not shown) is lower, reaching 0.35 by early August.

5. Forecast Archive, Next Forecast, Acknowledgements and References

5.1 Forecast Archive and Date of Next Forecast:

The archive of all the TSR publicly released Northwest Pacific seasonal typhoon forecasts (from 2000 to 2022) may be viewed at *https://www.tropicalstormrisk.com/for_typh.html*. The final TSR forecast update for the 2022 Northwest Pacific typhoon season will be an early August update issued on Tuesday 9th August, 2022.

5.2 Acknowledgements:

The TSR (Tropical Storm Risk) Northwest Pacific seasonal typhoon forecasts were instigated in 2000 by Professor Mark Saunders at UCL with funding from the UK insurance industry. Saunders led these predictions until his retirement in April 2022. Notable contributions to the development and operation of the TSR seasonal typhoon forecasts were also made by Dr Paul Rockett, Frank Roberts and Dr Adam Lea (all former UCL research assistants of Saunders).

5.3. References:

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Appendix: List of Predictions Issued for the 2022 NW Pacific Typhoon Season

NW Pacific ACE Index and Numbers 2022						
		ACE Index	Named Tropical Storms	Typhoons	Intense Typhoons
Average Number (1965-2021)		293	25.9	16.2	8.8
Average Number (1991-2020)		301	25.5	16.0	9.3
Average Number (2012-2021)		275	25.7	14.9	9.2
TSR Forecasts	5 July 2022	217	23	13	7
	5 May 2022	230	23	13	7