July Forecast Update for Northwest Pacific Typhoon Activity in 2021

Issued: 7th July 2021

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Forecast Summary

TSR maintains its extended-range forecast and predicts Northwest Pacific typhoon activity in 2021 will be 10% below the long-term norm and close to the 2011-2020 norm. This outlook is predicated on our expectation that a weak La Niña will develop during autumn 2021.

The TSR (Tropical Storm Risk) early July forecast update for Northwest Pacific typhoon activity in 2021 anticipates a season with activity ~10% below the long-term norm and close to the 2011-2020 10-year norm. The forecast spans the period from 1st January to 31st December 2021 (95% of typhoons occur historically after 1st May) and employs data through to the end of June 2021. The forecast includes deterministic and probabilistic projections for overall basin activity, and deterministic projections for the ACE index and numbers of intense typhoons, typhoons and tropical storms. Our forecast is predicated on the development of a weak La Niña during August-September-October 2021. This in turn would lead to decreased cyclonic vorticity over the Northwest Pacific region where intense typhoons form and to overall activity that is slightly below the long-term norm. However, there remains moderate uncertainty concerning the strength of La Niña by September-October 2021 and thus in the level of typhoon activity during autumn 2021. We include forecast probability of exceedance information for our forecast ACE index to quantify the historical forecast uncertainty from early July. The precision of TSR's outlooks for upcoming Northwest Pacific typhoon activity issued publicly in early July between 2003 and 2020 is moderate. A final updated seasonal outlook for 2021 will be issued in early August 2021.

NW Pacific ACE Index and System Numbers in 2021

		ACE Index	Intense Typhoons	Typhoons	Tropical Storms
TSR Forecast	2021	265	9	15	25
56-yr Climate Norm (±SD)	1965-2020	294 (±103)	9 (±3)	16 (±4)	26 (±4)
10-yr Climate Norm	2011-2020	272	9	15	25
Forecast Skill at this Lead	2011-2020	33%	16%	0%	0%

Key: ACE Index = Accumulated Cyclone Energy Index = Sum of the squares of 6-hourly maximum sustained wind speeds (in units of knots) for all eystems 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.
SD = Standard deviation.
Forecast Skill = Percentage improvement in mean square error over running 10-year prior climate norm for the TSR publicly-released seasonal outlooks for 2011-2020.
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.

There is a 19% probability that the 2021 NW Pacific typhoon season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>326)), a 49% likelihood it will be near-

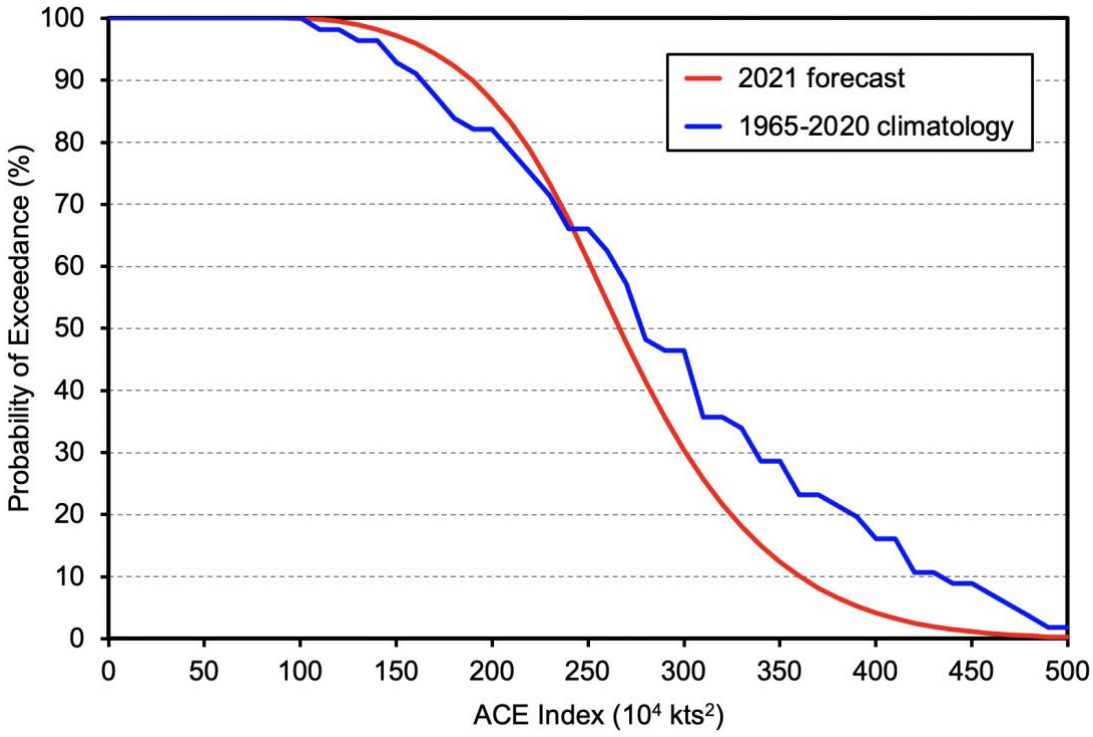
normal (defined as an ACE index value in the middle tercile historically (238 to 326) and a 32% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<238)). The 56-year period 1965-2020 is used for climatology.

Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values historically (1965-2020).

Forecast Probability of Exceedance Plot for the 2021 Northwest Pacific Typhoon Season

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 activity outcome occurring is clear for the benefit of users. Going forward TSR will be including robust forecast probability of exceedance (PoE) information based on the recommendation and methodology described in Saunders et al. (2020).

The figure below displays our current outlook for the Northwest Pacific ACE index in terms of PoE. The plot displays two PoE curves comprising the forecast PoE curve and the 1950-2020 climatology PoE curve. The forecast PoE curve is computed using a method similar to that described in section 3.3 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 2021 and how this chance compares to climatology.



Reference: Saunders, M. A., Klotzbach, P. J., Lea, A. S. R., Schreck, C. J., & Bell, M. M. (2020). Quantifying the probability and causes of the surprisingly active 2018 North Atlantic hurricane season. *Earth and Space Science*, *7*, e2019EA000852. https://doi.org/10.1029/2019EA000852

Predictors for 2021

TSR uses two predictors in its July forecast update for the Northwest Pacific ACE index in 2021. These are: (1) The June 925 hPa trade wind speed for the region 2.5°N-12.5°N, 120°E-180°E; (2) Our expectation for the state of El Niño Southern Oscillation (ENSO) in August-September-October (ASO) 2021. Intense typhoon numbers, typhoon numbers and tropical storm numbers are forecast by using linear regression based on either 1991-2020 or 1998-2020 data and the forecast ACE index value. For 2021 our

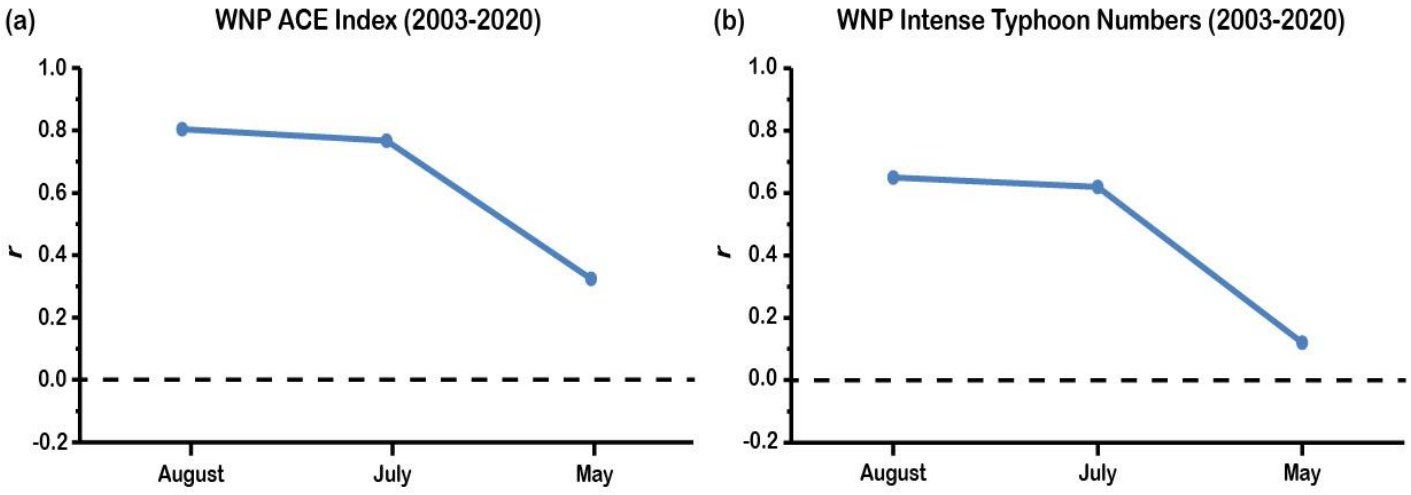
expectation for the state of ENSO in ASO is based on the statistical result that 'first-year' La Niña events in November-December-January (NDJ) persist as a weak La Niña in the following northern hemisphere autumn. Since 1970 there have been 10 'first-year' La Niña events in NDJ. Nine of these 10 events have persisted as a weak La Niña through to ASO with a mean ASO ENSO ONI value (all 10 events) of -0.41°C. With a moderate-to-strong La Niña event occurring in NDJ 2020-2021 we anticipate that a slightly cold ENSO or weak La Niña will occur in ASO 2021. Furthermore the current (18th June 2021) consensus ENSO outlook issued by the International Research Institute for Climate and Society also calls for slightly cold ENSO in ASO 2021 although there is a range in ASO ENSO outlooks from individual models.

Both TSR predictors point to Northwest Pacific typhoon activity in 2021 being below the long-term norm and close to the 2011-2020 norm. A slightly cold ENSO in ASO 2021 would likely point to the trade wind speed over the region 2.5°N-12.5°N, 120°E-180°E being slightly stronger than normal during ASO 2021. This in turn would lead to decreased cyclonic vorticity over the Northwest Pacific region where intense typhoons form and thus to fewer intense typhoons and to a slightly below-normal ACE.

It should be stressed that uncertainties in the forecast for Northwest Pacific typhoon activity in 2021 remain sizeable. These uncertainties surround in particular the strength of La Niña by September-October 2021 and the strength of the accompanying trade winds for the region 2.5°N-12.5°N, 120°E-180°E.

The Precision of TSR Seasonal Forecasts 2003-2020

The figure below shows the skill of the TSR-publicly-released seasonal outlooks for Northwest Pacific ACE (left panel) and intense typhoon numbers (right panel) assessed for the 18-year period 2003-2020. 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 figure shows low prediction skill from early May but good prediction skill (r = 0.6 to 0.8) by early July. The correlation skill for typhoon numbers for the 2003-2020 period (not shown) is lower than that for intense typhoon numbers at all forecast lead times.



Further Information

For more information about the TSR forecasts and their verifications for Northwest Pacific typhoon activity please see *https://www.tropicalstormrisk.com/for_typh.html*. The final TSR forecast update for the 2021 Northwest Pacific typhoon season will be issued on Monday 9th August 2021.

Appendix – Predictions from Previous Months

a) Deterministic forecast

NW Pacific ACE Index and System Numbers 2021					
		ACE Index ($x10^4$ knots^2)	Intense Typhoons	Typhoons	Tropical Storms
Average Number (±SD) (1965-2020)		294 (±103)	9 (±3)	16 (±4)	26 (±4)
TSR Forecasts	7 July 2021	265	9	15	25
	11 May 2021	270	9	15	24

b) Tercile probabilistic forecast

NW Pacific ACE Index 2021				
		Tercile Probabilities (%)		
		below normal	normal	above normal
Climatology 1965-2020		33.3	33.3	33.3
TSR Forecasts	7 July 2021	32	49	19
	11 May 2021	42	40	18