SEASONAL PREDICTION OF TYPHOON ACTIVITY IN THE NORTHWEST PACIFIC BASIN

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INTRODUCTION

Typhoons are amongst the most damaging and deadly natural disasters affecting much of southeast Asia. Seasonal predictions of typhoon activity will help benefit industry and society by reducing risk and uncertainty.

The TSR (Tropical Storm Risk) seasonal prediction model for Northwest (NW) Pacific typhoon activity uses Niño sea surface temperatures (SSTs) to forecast the NOAA Accumulated Cyclone Energy (ACE) index. This index is defined as the sum of the squares of six hourly wind speeds along all the storm tracks whilst the systems are at least tropical storm strength. The motivation for this approach is that the strong and long lived storms contribute most to the ACE index so the magnitude of the ACE index should give a better indication of the overall activity of a season than tropical cyclone or typhoon numbers alone.

In this study we examine the physical mechanism which links Niño SSTs to the NW Pacific ACE index. We then use this link to compute the cross-validated hindcast skill for the NW Pacific ACE index as a function of monthly lead out to 10 months for the 1965-2005 period of reliable typhoon data.

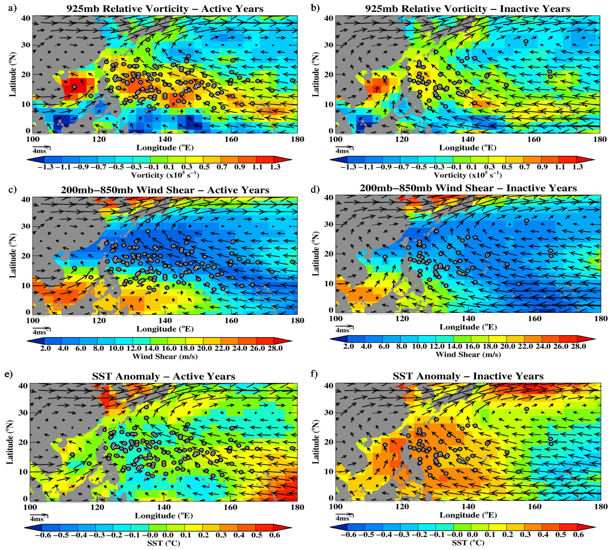

Figure 1. Environmental parameters linked to active (left column) and inactive (right column) typhoon seasons. August/September 925mb relative vorticity, 200 mb - 850 mb wind shear and SST anomaly over the NW Pacific basin averaged over the ten years with the highest ACE index during the period 1965-2005 [(a), (c) and (e)] and the ten years with the lowest ACE index over the period 1965-2005 [(b), (d) and (f)]. Also shown are the 925 mb - 400 mb height averaged wind vectors and the location of where the intense typhoons during the active and inactive years first reached 100 kts (dotted circles).

Figure 1 shows that the strongest typhoons tend to form in regions of high vorticity and low wind shear. Interestingly the active seasons correspond to cooler SSTs, suggesting that local SST anomalies in the NW Pacific basin have little influence on the number of intense typhoons that form.

PHYSICAL MECHANISM LINKING NINO SSTS TO ACE INDEX

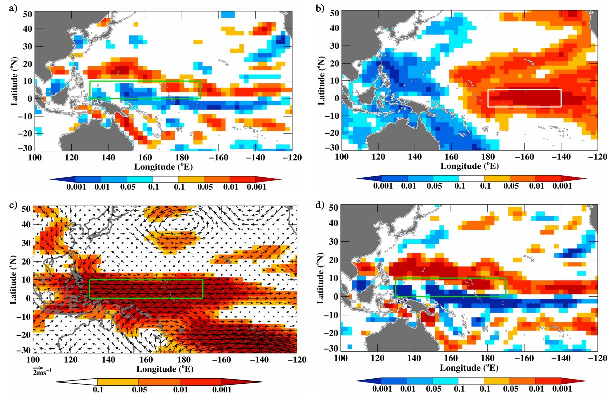

Figure 2. Physical link between Niño SSTs, wind and vorticity anomalies expressed using composite plots. (a) Significance of August/September 925mb vorticity anomalies composited by ACE index. (b) Significance of August/September sea surface temperature composited by ACE index. Also shown is the Nino 3.75 region (5°S-5°N, 180°-140°W) (white box) (c) Significance of August/September 925 mb wind composited by August/September SST in Niño 3.75 region, and (d) August/September 925 mb vorticity composited by 925mb U wind in region defined by green box shown in (c) . Composites are defined by taking the difference between the ten most active and ten least active years over the period 1965-2005 for ACE index (a) and (b), Niño 3.75 SST (c) and 925 mb U wind (d) within the green box.

Figure 2(a) shows that years with a high ACE index correspond to positive 925 mb vorticity anomalies in the region 10°-20°N, 130°E-160°E, which is where the majority of the NW Pacific typhoons form. Figure 2(b) shows that years with high ACE correspond to warm SSTs in the central and east Pacific and cooler SSTs in the NW Pacific, consistent with figure 1 (e) and (f). Figure 2(c) shows that anomalous westerly winds are present in the west Pacific between 0° and 10°N. Figure 2(d) shows that years with anomalous westerly winds in the region 0°-10°N, 130°E-170°W correspond to enhanced vorticity anomalies in the NW Pacific basin where the typhoons form. In summary, warm SST anomalies in the central Pacific lead to enhanced cyclonic vorticity which favours enhanced intense typhoon activity.

HINDCAST SKILL 1965-2005

The TSR seasonal prediction model for the NW Pacific ACE index uses forecast August/September SSTs in the Niño 3.75 region. The Niño 3.75 region was chosen because this Niño region is the most significantly linked to the NW Pacific ACE index (figure 2(b)). The August/September Niño 3.75 SSTs are predicted using the consolidated ENSO-CLIPER model described in Lloyd-Hughes et al (2004).

To assess the skill in predicting NW Pacific ACE and August/September Niño 3.75 SSTs we employ the percentage improvement in mean square error over a climatological forecast, which is the skill score recommended by the World Meteorological Organisation for seasonal forecasts (WMO, 2002). This is a robust and tough skill measure which is immune to the bias problems associated with other skill measures such as the percentage of variance explained. For climatology we employ a 1965-2005 average. Positive skill indicates the model does better than a climatology forecast, negative skill indicates that it does worse than climatology. Confidence intervals are computed around this value using the standard bootstrap method (Effron and Gong, 1983) with replacement. The skill plot for the Niño 3.75 SSTs also includes persistence skill and its associated 95% confidence interval.

Forecast skill is assessed by cross-validated hindcast testing over the period 1965-2005. For each year a new model is formulated trained on all data excluding a five year block centred on the year of interest. This block is tapered at the time series ends. Block elimination is employed to minimise potential skill inflation which may result from multi-annual persistence of Niño SSTs.

Positive skill to 95% confidence is obtained for the Niño 3.75 SST from early February (figure 3a). The SST hindcasts outperform persistence at all leads. The NW Pacific ACE index is forecast to 95% confidence from early May (figure 3b).

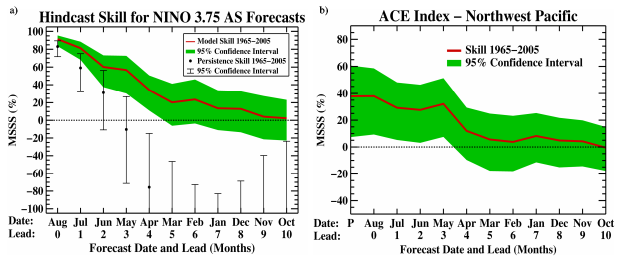

Figure 3. Deterministic seasonal prediction skill for (a) NW Pacific ACE index 1965-2005 and (b) August/September Niño 3.75 SSTs 1965-2005. Skill is shown by the mean square skill score (MSSS) and is displayed out to 10 months lead. The Niño SSTs are predicted from a cross-validated ENSO-CLIPER model (Lloyd-Hughes et al. 2004).

CONCLUSIONS

- The NW Pacific ACE index and numbers of intense typhoons are linked more strongly to Niño 3.75 SSTs than to either local SSTs or to local vertical wind shear.
- Above average (below average) Niño 3.75 SSTs are associated with weaker (stronger) trade winds over the region 0°-10°N, 130°E-170°W. These in turn lead to enhanced (reduced) cyclonic vorticity over the NW Pacific region where most intense typhoons form.
- Having established a sound physical mechanism for the interannual variability in the NW Pacific ACE index we show this index is predictable with useful skill from early May for the period 1965-2005 (95% of typhoons historically occur after 1st May).

ACKNOWLEDGEMENTS

We thank David Simmons (Benfield), Alan Fowler (Royal & Sun Alliance) and Jonathan Clark (Crawford Company) for industrial liasion, NCEP/NCAR for environmental data and the Joint Typhoon Warning Center for best track data.

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