A statistical analysis of Tropical Cyclone genesis

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Introduction

The genesis of tropical cyclones refers to the initialisation of a tropical cyclone in the atmosphere. Understanding the atmospheric and oceanic factors that contribute or inhibit the development of a tropical cyclone will help improve models to predict genesis both in the current climate and in future climates.

In this study we look at the cyclone-prone area of the western-North Pacific (WNP) as show in Figure 1. The aim is to predict the seasonal variation of tropical cyclone count, that is to predict the correct number of tropical cyclones not only each year but for each month of that year and to quantify our uncertainty.

Data

JTWC The Joint Typhoon Warning Centre is a joint US Navy - Air Force agency. It provides data on tropical cyclones from 1945 to the present. For the purpose of this study we examine the period from 1991 - 2010 in the western-North Pacific.

ERA Interim ERA Interim is a global atmospheric reanalysis product developed by European Centre for Medium Range Weather Forecasting (ECMWF). It provides reanalysis from 1979 on many physical variables at various spatial resolutions and pressure levels.

Source: NASA

Conclusion

Using generalised linear modelling we can predict with some skill the seasonal variation of tropical cyclones. We note that there is a peak in tropical cyclone activity in August that the model does not yet capture. We may need to include other physical factors not yet included in the model or look at interactions between current covariates.

Future Work

We would next like to investigate the spatial distribution of tropical cyclone genesis. Predicting the correct spatial distribution of tropical cyclone genesis is vital for land falling cyclones and hence risk assessment.

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Statistical Methodology & Analysis

Generalised Linear Models (GLM) provides a flexible statistical framework in which to analyse the environmental factors that affect tropical cyclone genesis. Since we are looking counts or the number of occurrences we use a *logit* link function resulting in a *logistic regression* model.

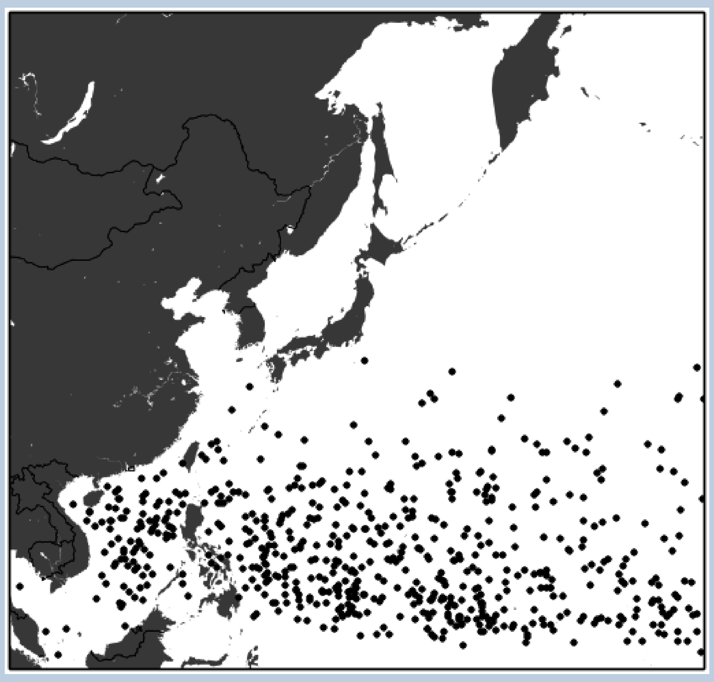

Figure 1: Genesis locations in WNP, 1991 - 2010.

We looked at several models combining a some or all the environmental factors listed above. To check the models predictive power we used Leave-one-out cross-validation on each of the 20 years and then averaged the values for each month. We also report the Mean Squared error (MSE) for each of the models,

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(\hat{Y}_i - Y_i)^2,$$

where Y_i is the vector of observations.
The atmospheric and oceanic factors that we consider are the following:

SST	Sea Surface Temperature ($°C$)
Lat	Latitude
Land	the percentage of land in a $1° \times 1°$ box around the genesis point
WindShear	vertical Wind Shear
CAPE	Convective Available Potential Energy
Relvor	Relative Vorticity

Results

Model	**MSE**
SST + Lat †	2.459
SSTmin3 + Lat	1.879
SSTmin3 +Lat+Land	1.751
SSTmin3 +Lat + WindShear	1.604
SSTmin3 +Lat + WindShear +CAPE	1.335
SSTmin3 +Lat + WindShear +CAPE+Relvor+Land ††	1.120

Table 1: Models and their corresponding MSE.

Note. SSTmin3 refers to the SST at the same location 3 days earlier. It was found that the SST at the time and location of the tropical cyclone is affected by the presence of the cyclone itself. Using the SST at the same location 3 days previous circumvents this problem.

	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
Null		2618	2864.33	
SSTmin3	1322.01	2611	1542.32	<2.2e-16
Lat	162.21	2602	1380.11	<2.2e-16
WindShear	322.66	2595	1057.44	<2.2e-16
CAPE	231.87	2588	825.58	<2.2e-16
Relvor	138.44	2587	687.14	<2.2e-16
Land	11.49	2584	675.65	0.009371

Table 2: ANOVA of Model ††.

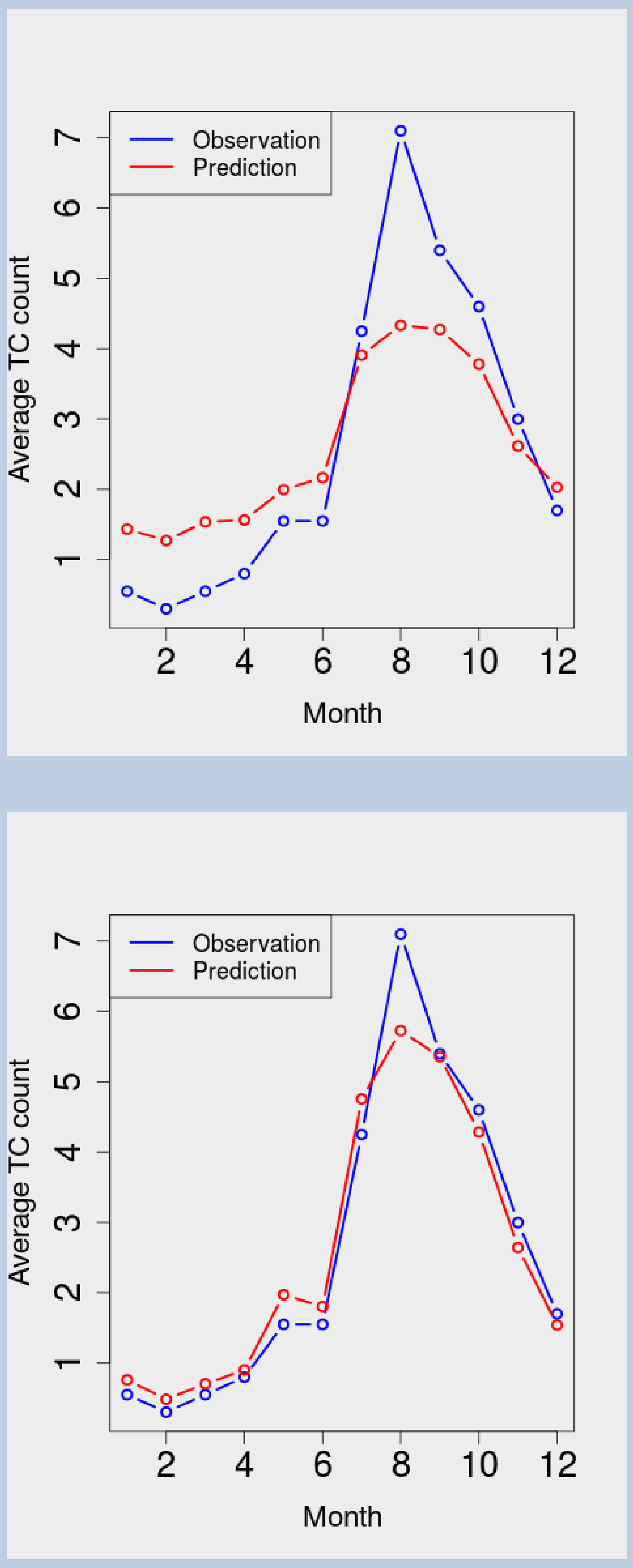

Figure 2: Model † (top); Model †† (bottom)

Figure 2 shows the improvement in the models to capture the seasonal variation of tropical cyclone count. The prediction somewhat follows the observations, however we note that the peak tropical cyclone activity in August is not captured.

Table 2 shows the analysis of variance for model ††. The deviance and residual deviance demonstrates the quality-of-fit of the model. The residual deviance of 675.65 is the amount of the uncertainty that is unexplained by the model. By improving our model , we aim to reduce the residual deviance which may aid in obtaining a better prediction of the peak tropical cyclone season.