Chapter 13
Modelling the Frequency of Tropical Cyclones in the Lower Caribbean Region

Reynold J. Stone
The University of the West Indies – St. Augustine, Trinidad and Tobago

ABSTRACT

Modelling the frequency of occurrence of tropical cyclones is an important step in assessing risk with a view toward mitigating their adverse impacts. The Poisson model was evaluated for modelling the frequency of tropical cyclones over and around Trinidad and Tobago’s area of influence by statistically analysing a data series extracted from the Atlantic HURDAT2 count time series data for the period 1851 to 2014. This was tested for serial correlation and the residuals of a Poisson regression analysis. Both tests failed to detect the presence of trends or cycles thereby indicating that the data series is random. The Poisson model was subsequently fitted to the data. It was concluded that there has been no increasing trend in the frequency of tropical cyclones. Therefore, widespread claims of an increasing trend in the frequency of tropical cyclones in Trinidad and Tobago’s area of influence have no valid empirical basis. The Poisson model is recommended for estimating the probabilities of occurrence of tropical cyclones.

INTRODUCTION

Tropical cyclones (hurricanes and tropical storms) are among the most devastating natural disasters in the Caribbean region causing the loss of lives and huge infrastructural damage that adversely affect many sectors of these small island economies such as:

- Agriculture,
- Forestry,
- Tourism and
- Water resources.

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Consequently, these extreme weather events pose a serious threat to economic growth and development within the region. Modelling the frequency of occurrence of tropical cyclones is an important step in assessing risk with a view toward mitigating their adverse impacts. Stein and Stein (2014) underlined the importance of this step by pointing out that the assessment of natural hazards depends significantly on the probability density functions used to describe the occurrence of events.

Despite its importance, however, very little work has been done to quantify the frequency of occurrence of tropical cyclones over and around the islands of the lower Caribbean such as Trinidad and Tobago. For example, in a recent TTD $2.3 million report funded and published by the Inter-American Development Bank (IDB, 2014), the authors stressed the importance of analysing tropical cyclones due to their destructive potential and high economic and societal impacts. Disappointingly, they neglected to undertake an analysis of the frequency of occurrence of tropical cyclones and, instead, simply assumed higher tropical storm frequency in light of anticipated catastrophic anthropogenic climate change arising from human-produced greenhouse gases. This assumption was made despite substantial contrary evidence in the peer-reviewed scientific literature (Field et al., 2012; Hartmann et al., 2013; Kim et al., 2014; Knutson et al., 2010; Kossin et al., 2014; Murakami et al., 2013; Tory et al., 2013).

This study was undertaken with two major objectives in mind. The first was to determine whether there has been an increasing trend in the frequency of tropical cyclones over and around Trinidad and Tobago’s area of influence (9°N to 13°N latitude; 59°W to 63°W longitude). The second was to evaluate the well-known Poisson statistical model for modelling the frequency of occurrence of tropical cyclones in Trinidad and Tobago’s area of influence. Data sourced from the Atlantic HURDAT2 database for the period 1851 to 2014 were used in the analyses.

**Statistical Methods**

The statistical methods used in the analysis such as detection of serial correlation and regression analysis of count data are described by Cameron and Trivedi (2013). The statistical analyses were carried out in the R statistical computing environment (R Development Core Team, 2014).

The first step in the analysis was to test the data series for serial correlation. The data series was standardised by subtracting each observation from the mean and dividing by the standard deviation. The autocorrelation function of the standardised annual counts was computed to test for serial correlation in the data series. The Poisson regression model was used to test for trend in the data series. This regression model is given by:

\[
\log_e(\mu) = \alpha + \beta X
\]

or

\[
\mu = \exp(\alpha + \beta X)
\]

Where,

\[
\mu = \text{Mean number of cyclones per year}
\]

\[
\alpha = \text{intercept}
\]

\[
\beta = \text{Slope parameter}
\]