Project 3

In the project description we sketch the analysis of the problem we expect you to do. (Obviously you are welcome to do more.) To pass the project a short report should be written and handed in to the project supervisor. In addition the group should present their results in class. The presentation should take about 15 minutes. Please include a short introduction which will facilitate for other students to understand the results of the project. (Do not assume that the audience knows the subject.)

1 Introduction - Has the intensity of hurricanes changed?

Discussions on climate change are intense. Broadly speaking, one aspect is whether certain events, for instance storms or hurricanes, have been more common recently; another if such events (possibly in addition) have become more severe and violent. A difficult problem related to the later issue is the relation to climate change: are changes to occur statistically speaking, as a part of the inherent variability of nature, or are these an effect from human activity.
In this project you will investigate possible trend change by means of deviance in Poisson regression model for the trends.
Focusing on hurricanes in the Atlantic, the season 2005 resulted in many broken records: 27 named storms, 14 hurricanes, 7 major hurricanes, 4 hurricanes of Category 5. Moreover, the hurricane Katrina implied very large and severe losses. Researchers agree that a change in intensity has occurred in recent years. When investigating a possible trend over time for the yearly number of hurricanes, analyses are often based on regression models where the number of hurricanes is supposed to be a random variable dependent on covariates like North Atlantic oscillation index. Some researcher found that only weak linear trends can be ascribed to hurricane activity and that multidecal variability is more characteristic of the region.
Hurricanes can be divided into 5 categories according to the Saffir-Simpson scale which is a 1-5 rating based on the present intensity of the hurricane. The scale is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale. Major hurricanes are usually defined as those in Category 3 or higher.
The region of the Atlantic basin will be studied. The data can be found on the Tropical Prediction Center homepage of Unisys Weather,http://weather.unisys.com/hurricane/atlantic/. The data is called `hurri.dat`. It contains 6 columns; the year is given in the first column; the columns 2 to 6 contain number of hurricanes of Saffir-Simpson scale 1-5, respectively (for the year given in column 1). Load the data and employ the Poisson regression model, you practised in computer exercise 5, to check for trends in the data.

2 Poisson Regression

Poisson regression is used to estimate models of the number of currencies, that is, counts, of an event N. Denote by m the expected value for a Poisson variate N. Further, let x be an explanatory variable. Traditionally, one uses a Poisson loglinear model of the form

$$\ln m = \alpha + \beta x. \tag{1}$$

Intuitively, we can think of the explanatory variable x in Eq. (1) as an index, here year, related to a certain Poisson process.
For the model in Eq. (1), the mean satisfies the exponential relationship

$$m = \exp(\alpha + \beta x) = \mathrm{e}^{\alpha}(\mathrm{e}^{\beta})^{x}$$

From this formula, one notes that a one-unit increase in x has a multiplicative impact of e^{β} on μ. If $\beta = 0$, then $\mathrm{e}^{\beta} = \mathrm{e}^{0} = 1$ and the multiplicative factor is 1; that is, the mean of N does not change as x changes (no significant trend is present). If $\beta > 0$, then $\exp(\beta) > 1$, and the mean of N increases as x increases. Deviance can be used to test whether a model with $\beta \neq 0$ explains better the variability observed in the data then the simpler model with $\beta = 0$ does.

3 The analysis

Assume first that we study the total yearly number of major hurricanes. Clearly, we model a discrete response variable, N say, assumed to have a Poisson distribution. Suppose that the mean of N is m. For the hurricane data let

$$m_i = exp(\alpha + \beta \cdot x_i),$$

x_i is year. This explanatory variable is introduced since the purpose is to test for a possible trend over time: is the number of hurricanes increasing over the time period studied? The statistical test for testing if $\beta = 0$ can be made by using the deviance. Check the residual. Conclusions.
Try other models. For example

$$m_i = exp(\alpha + \beta_1 \cdot x_i + \beta_2 \cdot x_i^2).$$

Plot residuals, repeat the tests if $\beta_2 = 0$ or $\beta_1 = 0$ etc. Conclusions.