

Hurricanes and Climate Change - Is there a trend in tropical cyclone intensity?

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In this exercise, you will have the opportunity to explore the trend in the intensity of tropical cyclone intensity since 1950. In particular, you will be asked to think about how global warming might impact the strength of tropical cyclones as well as how confident you are in the trends you calculate. You will be responsible for including your answers and the figures you create in your write-up for this assignment.

- 1) In class, we discussed the ingredients necessary for tropical cyclone development. What do you think the effect of global warming will be on the intensity of tropical cyclones?
- 2) Using the provided data (collected from the HURDAT dataset), plot the annual number of storms for the Atlantic Ocean for all named tropical cyclones (including tropical storms and hurricanes) using Excel or some other plotting program. Then, plot the number of major hurricanes (Categories 3-5 of the Saffir-Simpson scale).
- 3) Calculate the linear slope for each plot from step 2. This represents the trend in the number of storms since 1970. To do this:
 - a. You need to click on the plotted data and then under the chart menu, select add trendline.
 - b. You should make sure that you print the equation on the graph, since you'll need the value of the slope of the line to complete the next couple of steps.
 - c. Based only on the trends that you just calculated, what can you conclude about the changes in tropical cyclone intensity in the Atlantic basin?
 - d. How confident are you in this trend based on how well the data appears to follow the trend line?

4) We will now calculate a confidence interval for in the trends from steps 2 and 3. and determine the range of possible trend values for each of them. To do this, we can use what's known as a Student's t-distribution which is a way of accounting for the natural variability of an observation. We will then calculate a range of trends so that we can say that we would expect the trends to be somewhere in that range 95% of the time. To do this, follow these steps:

- a. First, calculate the standard deviation of the total number of storms (from Step 2) - You can do this using Excel's built in formulas. We will call this value "STDDEV".
- b. Then, calculate the mean of the total number of storms over the past 40 years using the Average formula from Excel.
- c. Next, make a column of data which contains the value of each year's number of storms minus the mean number of storms from step 4b.
- d. Now, make another column which contains the values of this new column from step 4c squared.
- e. Now, total up that last column from step 4d. We will call this total "S_{xx}".
- f. Finally, we can use the following formula and the numbers you've calculated:

$$\left(trend - \left(\frac{2.042 * STDDEV}{\sqrt{S_{xx}}} \right), trend + \left(\frac{2.042 * STDDEV}{\sqrt{S_{xx}}} \right) \right)$$

- g. This range of trends provides an estimate of the likely values of trends that could possibly fit this data. If the range you calculated in 4f includes zero, then you can not say with certainty that the trend is non-zero, but if the range of possible trends is completely above zero, then we can be satisfied that there is a significant non-zero trend in the data. Does this change your opinion about whether the trends from Steps 2 and 3 are potentially positive, negative, or zero?
- 5) The ACE, or Accumulated Cyclone Energy, index is essentially a measure of the wind energy for all of the tropical cyclones in a year. It is calculated as the sum of the maximum wind speeds for every storm squared, and it was used by the IPCC in their report. Plot the ACE index for the North Atlantic since 1970. Calculate trends and uncertainty? Does this support or refute your previous observations? Which do you think is a better measure for determining if hurricane have become more intense since 1970? Explain your reasoning.
 - 6) Prior to 1970, there were no meteorological satellites available for monitoring the weather. What effect might this have had on calculating trends in hurricane intensity prior to 1970?
 - 7) Plot the trends and uncertainty in ACE for the Atlantic for the period 1950-present. When you include these additional data, how does that change your previous conclusions? How confident are you in these results that include data from prior to 1970?

8) Thinking back over the entire experiment, how did this analysis compare with your predictions in step 1? Did anything surprise you? If you had an opportunity to do further research, what questions does this analysis raise that might be worth further analysis?