Assignment #4: Climate Change and Urban Planning
ESM 203
Fall 2019

Background

You have just landed a job doing environmental planning for New York City. The city is concerned about the risks climate change poses to the city, and has hired you to help quantify the local impacts. The city government is particularly concerned about the potential for future increases to flood damage due to sea level rise: damages during Hurricane Sandy in 2012 were estimated at $19 billion, so for planning purposes it is important to know how frequently to expect these types of events.

Your task is to generate estimates of the range of flood risk expected under different climate change scenarios, and make recommendations based on the results.

Statistical Model

We will build a simple statistical model for flood risk, assuming that the local sea level is affected only by tidal variations, storm surge, and changes to the long-term mean. For simplicity, we will construct this model for several different (fixed) values of the tide level and storm surge, and assume that all other sea level variations follow a normal (Gaussian) distribution.

NOTE To do this portion of the assignment, you will need to use a random-number generator. In R, to create a sample of random, normally distributed values with a given mean and standard deviation, you can simply use the 'rnorm' function. For instance, an array of 1000 normally distributed values with a zero mean and standard deviation of 1 could be generated with:

x = rnorm(1000, mean = 0, sd = 1)

For your modeling, use the following approximations:
- Background variations in sea level due to climate variability are normally distributed, with a standard deviation of 3 meters.
- The tidal range for New York City is 2.3 meters. Further assume that the zero point is halfway between the high and low tide levels, such that the tide level ranges from -1.25 to 1.25m.
- A flood occurs when the TOTAL sea level anomaly (tide plus storm surge plus climate variability) is greater than 5 meters; this value indicates a water level sufficient to flood a significant area of the city.

Define risk as the proportion of time when the sea level anomaly exceeds the specified threshold, and answer the following questions for both low tide and high tide:
1. What is the risk of flooding under normal conditions?
2. What is the risk of flooding when the storm surge is 1m? 2m? 3m? (For reference, the storm surge during Hurricane Sandy was roughly 2.9 m).

Climate Scenarios

Now we will include estimates of the role of sea level rise in altering the background flood risk. The Intergovernmental Panel on Climate Change Fifth Assessment Report contains useful background information[1]. Even more relevant is the New York City Panel on Climate Change (NPCC), which commissioned a report on this topic in 2013[2].

Estimate plausible ranges of mean sea level change near New York from the New York City Panel report for the RCP4.5 and 8.5 climate change scenarios for the 2050s, and rerun your statistical model after adding these changes to the long-term average. Relevant data may be found in NPCC Table 3 ("Baseline Climate and Mean Annual Changes".

NOTE: adding the background effects of climate change will mean that your long-term average will no longer be zero!

Then think of answers to the following questions:
• *How does climate change affect the risk of flooding associated with future storm events occurring at low and high tide?*
• *Which future scenarios do you think are more plausible?*
• *How do the answers to the first two questions affect your recommendations on appropriate management actions?*

Providing Context

Summarize your results in a 1-page technical report, designed to be digestible to stakeholders. The same guidelines apply here as in the previous assignment; include 1-2 figures summarizing the results from your statistical analysis, and be as concise and professional as you can. Be sure to include a discussion of uncertainty, and your recommendations for dealing with those uncertainties.

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[1] http://www.ipcc.ch/report/ar5/wg1/

[2] http://www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf