Analysis of Flood Risk in New York City, by Matt Koller

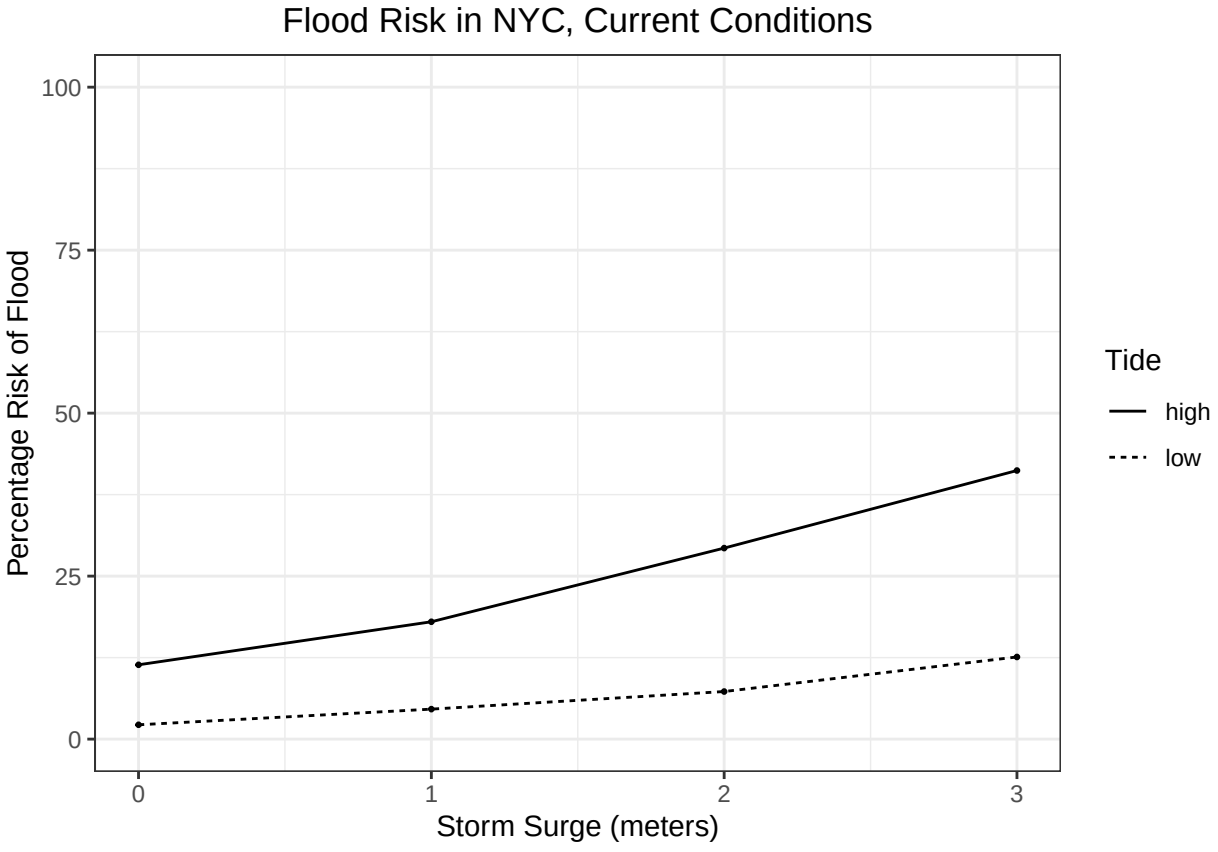
1. Introduction. New York City is increasingly at risk for major flooding events as a result of sea level rise. In 2012, Hurricane Sandy inflicted $19 billion worth of damages, so for planning purposes, it is extremely important to know how frequently these storms are expected to strike.

This memo assesses estimates of future flood risk based on IPCC estimates of future changes in sea level due to climate change, and will assume these projected changes are relative to 2020 mean sea levels.

2. Background. Sea level is affected by several different processes. First, tidal variations generate two low tides and two high tides every day. Second, storm surges during storm events can increase sea level up to 3 meters and beyond. This memo assumes that background variations in climate variability are normally distributed with a standard deviation of 3 meters and that tidal range for NYC is 2.5 meters.

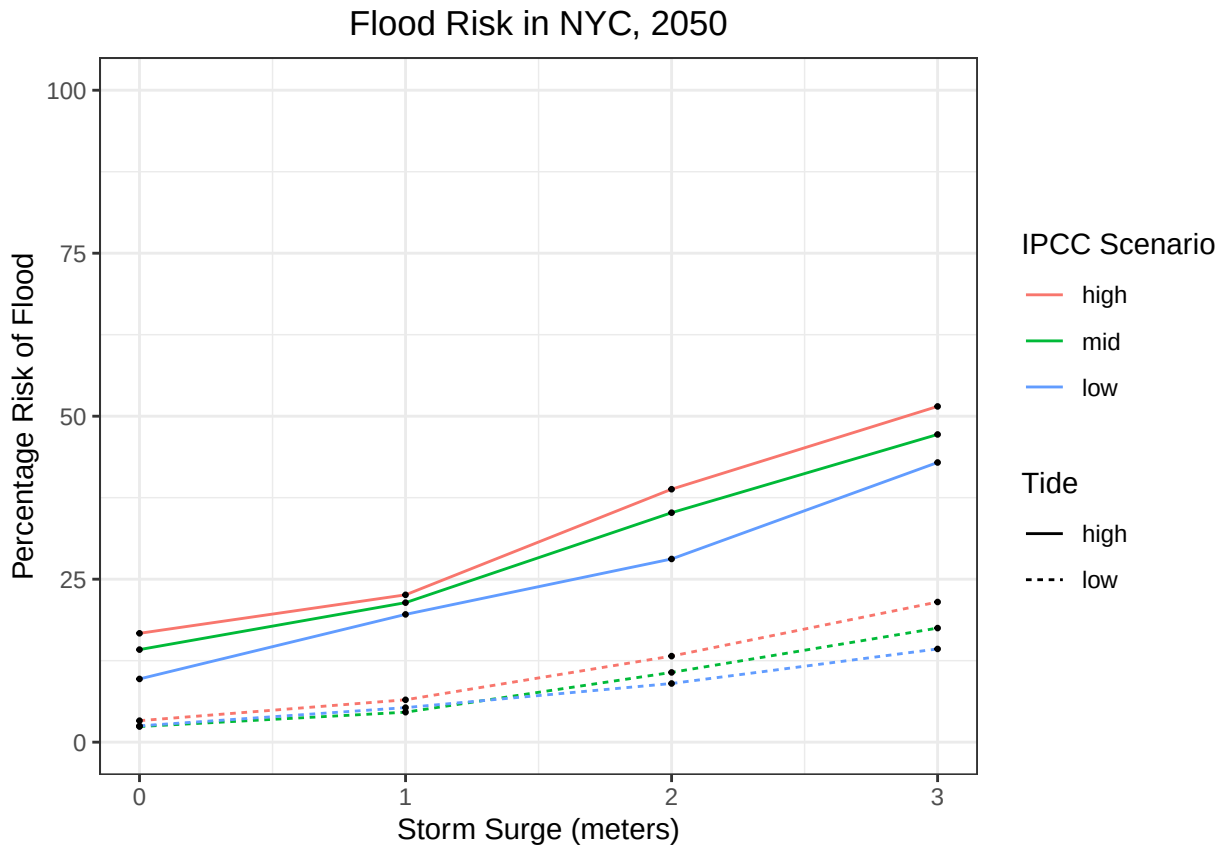
"Flood risk" is when mean sea level, tidal flux, and storm surge combine to produce a sea level that is 5 meters above average sea levels.

3. Analysis of Flood Risk in NYC, Current Conditions. At the low end of the spectrum is low-tide conditions with no storm surge. In this scenario, there is a 2.2% chance of a flood occurring. However, at the high end of the spectrum is high-tide conditions with a 3-meter storm surge. In this scenario, there is a 41.2% chance of a flood occurring, meaning there is *considerable* risk of significant flooding if a heavy storm hits NYC at high tide. For reference, Hurricane Sandy produced storm surges of 2.9 meters. Detailed figures relating to flood risk under current conditions can be found in the Appendix.



4. Analysis of Flood Risk in NYC, 2050. Climate change is causing sea levels to rise, however, no one can predict exactly how much the mean sea level will increase in 2050. The Intergovernmental Panel on Climate Change, however, has released three estimates: a low scenario, a middle scenario, and a high scenario.

The graph below charts NYC's flood risk in 2050, based on these three IPCC scenarios.



If mean sea level only rises to the lowest estimate, then at low tide with no storm surge the flood risk is minimal—only 2.5%. However, should mean sea level rise to the highest estimate, a storm with a 3 meter surge striking at high tide would produce a flood risk of 51.5%, presenting considerable risk to those living in flood-prone areas. Detailed flood risk figures under current conditions can be found in the Appendix.

5. Recommendations. There is considerable risk of flooding in New York City: under current conditions, a storm surge of 3 meters at high tide carries a 11.4% chance of flooding. As such, the City should halt development in low-lying coastal areas, fortify beachfronts with dunes to protect against storm surges, and construct seawalls to guard real estate from storm surges.

Worst-case scenario? There is a 51.5% chance of flood risk under the high IPCC scenario should a storm generate a surge of 3 meters at high tide. This is the worst-case scenario based on the assumptions in this memo.

Uncertainty. However, the figures cited in this report are based on the best available estimates and assume a normal distribution of risk. Sea levels and storm surges can significantly exceed the upper boundaries of these estimates, meaning that decision-makers should be prepared for flood risks higher than those outlined here.

Flood risk. Climate change will increase New York City's flood risk, however, storm surge and tidal levels have the greatest effect on flood risk. High tide occurs twice a day, meaning that when a hurricane strikes the city, it will almost inevitably hit during at least one high tide. Storm surges present considerable flood risk, regardless of the influence of climate change.

Final recommendation. While climate change and sea level rise increase flood risk in New York City, the threat posed by a storm striking at high tide is high enough to warrant immediate action, regardless of much sea levels will rise by 2050.

Appendix

Table 1: Flood Risk in NYC, Current Conditions

Sea Level Estimate	Tide	Storm surge (m)	Risk Percentage
normal	high	0	11.4
normal	high	1	18.0
normal	high	2	29.3
normal	high	3	41.2
normal	low	0	2.2
normal	low	1	4.6
normal	low	2	7.3
normal	low	3	12.6

Table 2: Flood Risk in NYC in 2050 based on IPCC Projection of Sea Level Rise: Low Estimate

Sea Level Estimate	Tide	Storm surge (m)	Risk Percentage
low	high	0	9.7
low	high	1	19.6
low	high	2	28.1
low	high	3	42.9
low	low	0	2.5
low	low	1	5.3
low	low	2	9.0
low	low	3	14.3

Table 3: Flood Risk in NYC in 2050 based on IPCC Projection of Sea Level Rise: Middle Estimate

Sea Level Estimate	Tide	Storm surge (m)	Risk Percentage
mid	high	0	14.2
mid	high	1	21.4
mid	high	2	35.2
mid	high	3	47.2
mid	low	0	2.4
mid	low	1	4.6
mid	low	2	10.7
mid	low	3	17.5

Table 4: Flood Risk in NYC in 2050 based on IPCC Projection of Sea Level Rise: High Estimate

Sea Level Estimate	Tide	Storm surge (m)	Risk Percentage
high	high	0	16.7
high	high	1	22.6
high	high	2	38.8
high	high	3	51.5
high	low	0	3.3
high	low	1	6.5
high	low	2	13.2
high	low	3	21.5

Data Citation

Intergovernmental Panel on Climate Change. "Climate Change 2013: The Physical Science Basis." 2013. http://www.ipcc.ch/report/ar5/wg1/

New York City Panel on Climate Change. "Climate Risk Information, 2013." 2013. http://www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf