Modeling narrative

We made use of a wide range of models, from a simple building flood damage estimate to high-resolution climate simulations, in the pursuit of an answer to the following question:

What is the flood risk of the MIT campus in 2050, and what type of intervention offers the highest the cost-benefit ratio?

We devised a strategy with three steps to answer the question from a scientific perspective:

1. **Climate modeling:** *What will Boston's strongest storms look like in 2050?*

   The campus is at risk from two types of storms: Nor'easters, which are most intense during the middle of winter, and hurricanes, which are most intense at the beginning of fall. This seasonality allows us to evaluate the risk for the different types storms independently, without considering the case where two descend on Boston simultaneously. To characterize how Nor'easters change with climate, we used data from a high-resolution numerical model of New-England weather embedded within a global model of the future climate. We estimated the precipitation and storm surge from Nor'easters in 2050 with this data by projecting the Boston observational historical record (data from 1936-2017) forward in time.
   To estimate the precipitation and storm surge from hurricanes, we analyzed output from a high-resolution hydrology model of the Boston region that was embedded within a tropical cyclone simulator. The tropical cyclone simulator was set up according to a global climate model's projection of the future climate. Our results from these data is the first estimate of the combined precipitation and storm surge risks from both Nor'easters and hurricanes in 2050.

2. **Flood modeling:** *How will the campus flood during the strongest storms in 2050?*

   We extracted bi-hourly records of the precipitation and storm surge from the top 1% strongest storms provided by our statistical analysis. From the storm surge data, projections of sea level rise in the Boston area, and data from a simulation of the Charles River Dam, we estimated the height of the Charles River during a storm. Using the Charles River basin height and additional precipitation from a storm, we ran a state-of-the-art hydrological model of the MIT campus pipe infrastructure to find the height of flooding at each building on campus.

3. **Cost-benefit analysis:** *How expensive will the storm be, and how much will different solutions cost?*

   We obtained a flood damage cost estimate by adapting a widely used flood risk assessment framework to the MIT campus. This framework estimates the anticipated economic loss in two categories, content value and structural damage. We combined these two costs with the estimated productivity loss based on analysis from the City of Cambridge to construct a fiscal model of each intervention's return-on-investment. The utility of an intervention is a function of the amount of floodwater the strategy can keep off campus, since the height of the floodwater is directly correlated with the cost flooding.