Coastal Resilience Project:
The purpose of the Coastal Resilience project is to provide communities with easy access to information to assist in coastal planning, zoning, acquisition, and other management decisions regarding resources at risk from sea level rise (SLR) and coastal hazards. One of the principal products of the project is a spatially explicit web mapping tool that provides forecasts of inundation on the south shore of Long Island under different sea level rise and storm surge scenarios. This web mapping tool is intended to assist local participatory stakeholder processes in towns and villages on Long Island in order to garner awareness and guide decision makers on climate change issues. Specifically this application tries to identify explicit relationships between ecological, social and economic indicators and thereby provide a comprehensive platform for decision making.

Category: Flood Scenarios

General Description:
Sea level rise scenarios were generated for the Coastal Resilience project by faculty from the Columbia University Center for Climate Systems Research (CCSR) and NASA Goddard Institute for Space Studies based on the best available scientific information about greenhouse gas emissions and sea level rise. Sea level rise projections were then used in conjunction with elevation data to generate spatially-explicit inundation projections.

Sources:
- International Panel on Climate Change (IPCC)
- Program for Climate Model Diagnosis and Intercomparison
- Goddard Institute for Space Studies, New York, NY
- Tide gauge data, the Battery and Montauk - NOAA
- LiDAR data, Suffolk County Information Services

Sources of Global Circulation Models (GCMs)
- Goddard Institute for Space Studies, New York, NY – (GISS)
- NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ – (GFDL)
- United Kingdom Meteorological Office, UK – (UKMO)
- National Center for Atmospheric Research, Boulder, CO – (NCAR)
- Meteorological Institute of the Rheinische Friedrich-Wilhelms Universität, Bonn, Germany – (MIUB)
- Meteorological Research Institute, Japan – (MRI)
- National Frontier Research Center for Global Change, Japan The Model for Interdisciplinary Research on Climate - (MIROC)

Caveats and Limitations:
Sea level rise projections using the Global Circulation Models (GCMs) have a 'model-based probability'. This represents what is the most likely outcome based upon projections across the seven models. It does not taken into account the possibility that all of the GCM's could be wrong; instead it looks for consensus. For each decade CCSR and NASA produced GCM sea

level rise projections (3 IPCC emission scenarios x 7 GCMs). Two additional scenarios were calculated: an A2 IPCC scenario with 1-meter of ice sheet melting over the next century, and an A2 scenario with a 2-meter melting over the same time period. This allows us to show the mean value as well as the range (high/low) or some other measure of the distribution (Table 1). Since the sea level rise projections vary from model to model these scenarios are estimates and therefore no specific model output should be considered a prediction of future conditions. Instead, they should be considered as a range of most likely outcomes (as shown by the table below) based upon the present state of the art climate models.

Table 1. Example of Three Decades of Projected GCM Sea Level Rise for the South Shore, Long Island

Projection*	2020 (inches)	2050 (inches)	2080 (inches)
GFDL - A2	4.21	10.71	22.51
GISS - A2	4.17	11.25	20.62
UKMO - A2	5.40	11.48	21.43
MIROC - A2	3.94	12.02	24.49
MRI - A2	1.42	5.59	12.11
MIUB - A2	4.05	7.47	16.65
NCAR - A2	2.26	10.21	21.32
GFDL - A1b	4.98	12.64	22.71
GISS - A1b	4.97	10.09	18.28
UKMO - A1b	4.22	10.00	16.97
MIROC - A1b	3.59	13.48	25.55
MRI - A1b	1.59	6.03	11.97
MIUB - A1b	2.68	9.39	16.29
NCAR - A1b	3.19	10.43	17.88
GFDL - B1	3.76	10.05	16.03
GISS - B1	3.77	9.40	14.87
UKMO - B1	4.85	8.51	13.76
MIR - B1	5.52	13.63	21.95
MRIOC - B1	1.56	5.04	9.32
MIUB - B1	4.70	9.23	15.88
NCAR - B1	2.86	7.37	12.08
Mean	**3.70**	**9.72**	**17.75**
Low	**1.42**	**5.04**	**9.32**
16.7%	**2.40**	**7.40**	**12.66**
83.3%	**4.93**	**11.84**	**22.32**
High	**5.52**	**13.63**	**25.55**

*Projection – 7 GCMs x 3 emission scenarios (B1, A1b, A2)

The “bathtub” method of mapping water surfaces on the LiDAR digital elevation model (DEM) was used for this project. This method simply “raises the water surface” or delineates a contour on a DEM based on a value. A major drawback of this method is that it does not take into account or model the hydraulics of SLR. Further, low elevation values are inundated as the bathtub fills although some of these values are not necessarily connected with the main body of water moving landward. This has created discontinuous ponds that lie upland of a future Mean High Water tide line. Future mapping efforts will take those areas into account and will likely be deleted from the SLR mapping scenarios. Future efforts will also take into account the accuracy of the elevation data, with more consideration given to the relationship between the scale of the SLR projections and the geospatial information used to map those projections. Though very basic, in the absence of a more sophisticated modeled SLR surface, this method can be performed quickly and efficiently for many SLR scenarios.

Process:
Project personnel examined the range of GCMs reviewed by the International Panel on Climate Change (IPCC), and chose 7 of them to use in forecasting SLR. Calculations were then performed on the GCM data to downscale the models to include local variables such as historic information from tide gauges at Battery and Montauk stations, land subsidence, and local differences in mean ocean density, circulation changes, and thermal expansion of sea water, and global variables including components for thermal expansion of the oceans due to global temperature increases and changes in the ice mass (including Greenland, Antarctica, and glaciers) due to temperature increases.

Greenhouse gas emissions used in forecasting were chosen to represent a range of reasonable future emissions from the suite of IPCC scenarios (Special Report on Emissions Scenarios from 2000). For this project 3 emission scenarios were calculated: B1, A1b, and A2. In terms of mapping we chose the A1b and A2 IPCC scenarios for incorporation into the Future Scenarios Mapper. The A1B scenario assumes that the effects of economic growth are partially offset by the use of new technologies to address emissions and a decline in global population after 2050. The result is a relatively rapid increase in emissions for the first half of the 21^{st} century followed by a decrease in emissions after 2050. We considered this emission projection to be a “conservative” estimate. The A2 scenario assumes relatively rapid population growth and high and growing greenhouse gas emissions. We considered this to be a “medium” level estimate.

Many in the scientific community have expressed concerns that the IPCC data underestimate potential SLR. To address this concern, the Long Island projections made with these inputs were supplemented by a qualitatively determined, upper-bound scenario taking into account the low-probability, high-impact events associated with more rapid ice sheet melting in Greenland and the west Antarctic than is shown by the GCMs. CCSR and NASA added to additional scenarios that took this into account: an A2 scenario with one-meter of melting of the next century, and an A2 scenario with a two-meter melting over the same time period. We implemented the one-meter melting scenario into the Future Scenarios Mapper considered this to be a “high” level estimate.

Project staff used all of the above information to generate probability distributions of SLR for the individual and combined GCMs over 7 decades, from the 2020s to the 2080s. Projections for the 2020s, 2050s and 2080s are included as options in the mapping tool, labeled as “conservative,” “medium,” and “high” sea level rise projections that correspond respectively with A1b, A2, and A2 plus melting scenarios. Clicking on these options on the map will provide a visual depiction of inundation.

The “bathtub” method of mapping water surfaces on a digital elevation model (DEM) was used to delineate a contour on a DEM based on a value above present-day Mean High Water (MHW). SLR values were mapped to a future Mean High Water (MHW) tide line or vertical datum.

Vertical datum conversions were necessary to map the correct MHW plus SLR values on the DEM, which was based on the NAVD88 vertical datum.