Sea Level Rise and Hurricane Irma Storm Surge Research Methodology

Hurricane Irma storm surge analysis was conducted using a variety of input sources. In order to determine the maximum storm surge elevations, High Water Marks from the USGS event viewer were acquired and supplemented with peak data collected from the Virginia Key NOAA tide station. Only stations with reported water levels in NAVD88 were selected, and stations that recorded precipitation driven riverine flooding or with Very Poor (VP) quality indicators were removed. In total, 317 observations collected in Florida were used.

Combination of NOAA and USGS High Water Mark and Station Peak Data
HWM and gauge observations were then interpolated while taking account land barriers that would prevent free flow of water between water bodies (e.g. islands between open ocean and the intracoastal), and in southeast Florida this interpolation was checked against the NOAA SLOSH Category 3 Maximum of Maximum (MOM) output in order to take into account the topographic characteristics and water controls affecting storm surge in the region. This post-processed interpolation was then compared against elevation data collected from NOAA, USGS, and other local sources. Prior to this analysis elevation data had already been preprocessed and cleansed for tidal & hurricane risk data shown on floodiq.com. Areas with surge elevations higher than land elevation were identified as impacted.

These impacted areas were compared against parcel data acquired from various sources including the Florida Geographic Data Library (FGDL). Parcels with more than 25% of the dry land below surge elevations were counted as impacted, and the number of units within each residential parcel was summed. Parcel level housing unit information was sourced from county tax assessor offices and aggregated by a third party.
Impacts over parcels example:

In order to project the surge heights that would be expected had a Irma like storm hit in 1970 or in 2050, past sea level rise was first calculated from the Key West, FL tide station after fitting a local regression to yearly averages of verified monthly means.

Future sea level rise projections were accessed from the Army Corps of Engineers curve calculator, and USACE High values were used to adjust sea levels to 2050. The 2013 USACE High curve is now between NOAA’s 2017 Intermediate and NOAA 2017 Int-High curves.
Multiple academic papers were researched for the methodological assumptions used in this analysis, which utilized the sea level rise-storm surge relationships identified from CEST models simulations on Hurricane Andrew's surge heights. "Comparison of three methods for estimating the sea level rise effect on storm surge flooding". This research showed 0.6 meters of sea level rise leads to storm surge increases greater than 0.6 meters for most areas overland and the average increase on surge heights above SLR alone was 22-24%.

"Dynamics of sea level rise and coastal flooding on a changing landscape" was also referenced as it identifies using ADCRIC simulations that sea level rise from 1960 to 2005 had a non-linear impact for Hurricane Katrina on Mississippi and Alabama, and that although there were some exception areas "However, in most areas (e.g., Mobile Bay and western Mississippi Sound), the maximum water level increases an additional 80% of the applied SLR, resulting in amplification of storm surge greater than the amount of SLR." A graph of the Normalized Nonlinearity (NNL) index shows that for most of the region surge increases are higher than sea level rise alone.
Four numbers were ultimately used to adjust the surge heights mapped against parcels in the Florida: 1.26 feet of SLR from 2017 - 2050 from the USACE High, 1.55 feet in surge addition applied to Irma surge HWM interpolation surface due to the ~23% additional increase of surge over SLR identified in the Hurricane Andrew analysis, 0.57 feet of sea level rise from 1970 to 2017 identified with an analysis of the Key West, FL tide gauge, and 0.71 feet of surge reduction applied to Irma surge heights to estimate the surge impact of a similar storm in 1970.
Lastly, in order to quantify the impact of development on the number of residential units that have been developed in the region between 1970 and 2017 tax assessment data was combined with a census tract database. The proportion of housing units within each tract impacted by the storm surge in 2017 was applied to the 1970 housing census numbers (A Longitudinal Tract Database) in order to estimate the number of housing units that would be impacted with at 1970 development levels.

This analysis does not include additional flooding due to wave run-up, heavy precipitation and poor drainage, riverine flooding, or damage due to wind, so overall underestimates the full impact of Irma. Research consistently shows sea level rise has a non-linear impact on storm surge, and in most areas increases surge heights above the magnitude of sea level rise alone. For the purpose of the analysis the conservative additional increase of 23% was applied across the region, however topography and bathymetry would likely cause this increase to be 200-300% in many areas over land that would have had smaller surges (1 - 3 meters) but likely even decrease surge heights changes in a few areas below the magnitude of sea level changes.