Union of Concerned Scientists

TECHNICAL BACKGROUNDER

Underwater

Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate

Methodology and Key Caveats

The Union of Concerned Scientists' report *Underwater: Rising Seas and the Implications for US Coastal Real Estate* assesses the risks of chronic, disruptive flooding to the coastal real estate sector in the continental United States. The analysis intersects two existing datasets: 1) zones of chronic inundation along the coast, previously published by Dahl et al. 2017 and Spanger-Siegfried et al. 2017; and 2) the Zillow Transaction and Assessment Database (ZTRAX), published by the online real estate company Zillow (Zillow 2017).

This document outlines the methods, tools, and data used, as well as key caveats for readers to bear in mind.[1]

The statistics reported here are intended to be a starting point for community- and national-level discussions about the risks of sea level rise to coastal property. Where possible, communities should undertake more detailed mapping in order to better assess their unique risk of chronic flooding.

Methodology

DEFINITION OF CHRONIC INUNDATION

Flood risk tolerance varies from community to community. In order to conduct a nationally consistent spatial and temporal analysis, we defined the zone of chronic inundation as the area flooded at least 26 times per year, or, on average, every other week. We derived this threshold by reviewing the literature on tipping points in the flood frequencies that communities can cope with (Sweet and Park 2014), and conducting interviews with community experts in east coast and Gulf coast communities including Annapolis, Maryland; Charleston, South Carolina; and Broad Channel, New York. We also consulted publicly available sources such as National Weather Service alerts. The interviews are summarized in Table S1 of Dahl et al. 2017.

We determined the water level that currently is exceeded 26 times per year at each of 93 tide gauges located along the east, Gulf, and west coasts by using 20 years (1996–2015) of hourly, verified water-level data for each gauge. We call this the chronic inundation water level, and it was determined with respect to the mean higher high water (MHHW) level for each gauge. For future time steps, we added gauge-specific sea level rise projections to today's chronic inundation water level to develop a future chronic inundation water level for each time step and scenario.

ELEVATION DATA

Determining the spatial extent of chronic flooding requires a digital elevation model (DEM). We obtained DEMs for the continental United States from the National Oceanic and Atmospheric Administration (NOAA; Marcy et al. 2011). The resolution of the DEMs varies between ⅓ arc second (~10 meters) and 1/9 arc second (~3 m). The DEMs, which were used in the creation of NOAA's Sea Level Rise Viewer, are lidar-based and were conditioned and created specifically for sea level rise mapping (NOAA 2017; Marcy et al. 2011). In order to ensure that the inundation zones for each future time interval were statistically different from one another, we used the vertical accuracy of the DEMs along with other sources of uncertainty to determine a minimum sea level rise interval of 11.3 inches (28.6 cm) for spatial analysis.

SEA-LEVEL-RISE SCENARIOS

We used three scenarios developed for the 2014 National Climate Assessment and localized for this analysis (Walsh et al. 2014; Parris et al. 2012), our high, intermediate, and low scenarios. The high scenario assumes rapid ice sheet loss and projects a global average rise of 6.6 feet (2.0 m) above 1992 levels by the end of this century. The intermediate scenario assumes a moderate rate of ice sheet loss that increases over time for a rise of 4.0 feet (1.2 m) globally by the end of this century. The low scenario assumes curtailed warming and sea level rise that is driven primarily by ocean warming with very little contribution of ice loss, and projects a rise of 1.6 feet (0.5m) by the end of this century. Because the total 21st-century warming in this scenario is in line with the Paris Agreement's goal of holding warming to less than 3.6°F (2°C) above preindustrial temperature levels, we use this scenario as a proxy for sea level rise under the Paris Agreement.

The National Climate Assessment scenarios represent globally averaged sea level rise. Because sea level is not expected to rise uniformly, we calculated local sea level rise projections at each tide gauge and at each future time step using the method described by the US Army Corps of Engineers (Huber and White 2015). This method incorporates the local vertical land movement rate into gauge-specific projections (Zervas, Gill, and Sweet 2013).

MAPPING OF CHRONIC INUNDATION

Our spatial analysis largely follows the methods outlined by NOAA (Office for Coastal Management 2012). An interpolated chronic inundation water surface for each time step and scenario was added to a MHHW surface developed by NOAA (NOAA 2016). We then subtracted the DEMs from the total water level surface to create an inundation surface for each time step and scenario. To ensure that the areas considered inundated were hydrologically connected to the ocean, and not just low-lying areas disconnected from the ocean by higher-elevation barriers, we performed a region grouping and extracted only hydrologically connected areas. Areas protected by federal levees were excluded from the analysis, as were zones in the San Francisco Bay Area that are categorized by the Federal Emergency Management Agency as having reduced flood risk due to levees (USACE 2017).

THE ZTRAX DATASET

The online real estate company Zillow has compiled records on real estate transactions from thousands of county assessors' offices. Zillow provided the resulting dataset, known as the Zillow Transaction and Assessment Database (ZTRAX) to UCS for the purposes of this analysis. The dataset contains addresses, assessed and market values, property taxes paid, and many other fields associated with commercial and residential properties. UCS used this information to identify properties that fall within chronically inundated areas today or in the future.

Because the ZTRAX dataset is a compilation of data many different offices, with varying data standards and coverage, issues such as duplicated properties and missing values are common. We applied three broad corrections to the ZTRAX data. First, we removed duplicate properties. Second, we re-geocoded each property using an external service (geocod.io) to ensure its positional accuracy. Finally, for properties missing a market value or a property tax value, we calculated the missing value based on the reported assessed value and county-specific information about the ratio between assessed and market values and/or effective tax rates. Missing market and property tax values were only calculated for residential properties. For California, where there is no simple ratio between assessed value, market value, and property tax value, we used assessed value in place of market value.

Each property in the ZTRAX database has a property land-use specification, and these were used to define residential and commercial properties for the purposes of this analysis. Residential properties include both owner-occupied and rental properties. Commercial properties include commercial office properties (general, professional, industrial, medical, etc.) as well as commercial retail properties (general, stores, restaurants, shopping plazas, etc.). Properties falling into agricultural, industrial, recreational, government, or transportation categories were not included.

Multi-unit buildings such as apartment complexes were treated such that each unit that can be sold independently was counted as a home. This means that in high-rise apartment buildings, upper story units would be counted as at-risk of chronic inundation even if only the ground floor was flooding. Conversely, many commercial properties contain multiple businesses (e.g., those in the Boston Seaport District), but may be counted in the database as a single property depending on how they are owned and divided.

DEFINITION OF A PROPERTY AS "AT-RISK"

Each property was defined not by its boundaries but by a single geographic latitude/longitude point determined via geocoding by the company geocod.io. When that point fell within a zone of chronic inundation, the property was determined to be at risk. Where possible, the geographic coordinates correspond to the center of a property's rooftop. However, the accuracy of the geocoding depends, in part, on the completeness of the recorded address of a property within the ZTRAX dataset. Where property addresses are incomplete, geocoded coordinates used in this analysis likely do not reflect rooftop position. As a result, properties with incomplete addresses may be incorrectly placed within or outside of chronic inundation zones.

POPULATION AND DEMOGRAPHIC STATISTICS

Estimates of the number of residents living in homes at risk of chronic inundation were derived using the housing unit method (Smith 1986) and 2010 census data on occupancy rate and number of people per household (US Census Bureau 2010). Population totals as well as racial demographics were also taken from the 2010 census. Community-level poverty rates were derived from the 2011-2015 American Community Survey.

Key Caveats

Each community has a distinct profile, defined by its unique location, topography, population, financial resources, and coastal development patterns, to name a few. Communities may find that their risks differ from those outlined here, particularly communities with important relevant features, such as locally controlled coastal defenses, geographic areas with complex tidal dynamics, and rapidly changing population numbers. Therefore, there are a few important caveats to bear in mind when considering or using these data:

1. In this analysis, population, demographics, number of properties, and associated property data are assumed to remain constant at present-day levels. Studies incorporating future population growth into analyses of sea level rise tend to show greater population impacts, which suggests that our results may be conservative (Hauer, Evans, and Mishra 2016).

2. The extent of chronic inundation in this analysis is dependent upon the quality of the underlying elevation data, which were provided by NOAA (NOAA 2017; Marcy et al. 2011). These data vary in horizontal resolution and accuracy, and communities are encouraged to work with the highest-resolution elevation data available to do more detailed mapping. In addition, any changes to the land that were made after the elevation data were collected—such as the installation of levees or bulkheads—will not be reflected.

3. Even the highest-resolution elevation data used here do not adequately capture most local coastal defenses such as sea walls. Areas with such structures in place may not experience as much flooding as suggested by our analysis.

4. Tidal dynamics vary greatly depending on local coastal morphology. Features such as bays, inlets, barrier islands, and wetlands can attenuate or amplify the tide relative to its level at the open ocean–facing tide gauges that were used to determine chronic-inundation water levels. As a result, some areas may experience more or less tidal flooding than suggested by this analysis.

5. This analysis makes no assumptions about adaptation measures communities may implement in the future, such as building flood-control structures or restoring wetlands. Several factors affect the range of adaptation options available to any given community including its geography and financial resources. Implementing and maintaining adaptation measures can be costly, but they can reduce flood risk in the near-term and may provide critical protection long over the long term.

Disclaimer

Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX). More information on accessing the data can be found at http://www.zillow.com/ztrax. The results and opinions presented in this report are those of the author(s) and do not reflect the position of Zillow Group.

This research is intended to help individuals and communities appreciate when sea level rise may place existing coastal properties (aggregated by community) at risk of tidal flooding. It captures the current value and tax base contribution of those properties (also aggregated by community) and is not intended to project changes in those values, nor in the value of any specific property. The projections herein are made to the best of our scientific knowledge and comport with our scientific and peer review standards. They are limited by a range of factors, including but not limited to the quality of property-level data, the resolution of coastal elevation models, the potential installment of defensive measures not captured by those models, and uncertainty around the future pace of sea level rise. More information on caveats and limitations can be found at http://www.ucsusa.org/underwater. Neither the authors nor the Union of Concerned Scientists are responsible or liable for financial or reputational implications or damages to homeowners, insurers, investors, mortgage holders, municipalities, or other any entities. The content of this analysis should not be relied on to make business, real estate or other real-world decisions without independent consultation with professional experts with relevant experience. The views expressed by individuals in the quoted text of this report do not represent an endorsement of the analysis or its results.

ENDNOTES

1 Language for this document is adapted from Dahl et al. 2017.

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