

RESEARCH ARTICLE

Sea level rise drives increased tidal flooding frequency at tide gauges along the U.S. East and Gulf Coasts: Projections for 2030 and 2045

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Abstract

Tidal flooding is among the most tangible present-day effects of global sea level rise. Here, we utilize a set of NOAA tide gauges along the U.S. East and Gulf Coasts to evaluate the potential impact of future sea level rise on the frequency and severity of tidal flooding. Using the 2001–2015 time period as a baseline, we first determine how often tidal flooding currently occurs. Using localized sea level rise projections based on the Intermediate-Low, Intermediate-High, and Highest projections from the U.S. National Climate Assessment, we then determine the frequency and extent of such flooding at these locations for two near-term time horizons: 2030 and 2045. We show that increases in tidal flooding will be substantial and nearly universal at the 52 locations included in our analysis. Long before areas are permanently inundated, the steady creep of sea level rise will force many communities to grapple with chronic high tide flooding in the next 15 to 30 years.

Introduction

Sea level rise has the potential to inundate significant stretches of the U.S. coastline by the end of this century [1]. With higher sea levels, local flooding thresholds can be reached more easily during average high tides. In the absence of coastal adaptation measures to protect against rising seas, some coastal areas could fall below the high tide line by the end of the century. Before that permanent inundation occurs, however, unprotected coastal areas could experience more frequent flooding with high tides.

Global sea level rose by an average of 1.2–1.7 mm per year over the course of the 20th century [2,3]. The rise in sea level is accelerating both globally and regionally in many places. From 1993 to 2010, the global rate has accelerated to 3.0 ± 0.7 mm per year [2–5]. This acceleration is attributed mainly to ocean warming, a quickening pace of land ice loss, and a net transfer of groundwater from the land into the sea [6–9].

Local sea level trends can differ from the global average due to factors including land subsidence, tectonics, changes in ocean circulation, gravitational or sea level fingerprinting,

difference—and, potentially, differences at other sites—results from the different sea level rise projections or different methodologies could be a subject for future investigation.

Conclusion

When tidal floods occur, water can cover coastal roads for hours, making passage risky or impossible [57]. With water on the street, some residents can be effectively trapped in their homes, and homes can be damaged [58]. Entire neighborhoods can be affected, even isolated [59]. In many communities, retail stores, restaurants, other businesses, and public infrastructure are clustered in low-lying waterfront areas, in easy reach of tidal flooding [60].

In decades past, high tide flooding had little impact on coastal communities because our shorelines were not as heavily developed and sea level was not as high. Today, however, the reach and effect of the tides is changing, and many coastal towns and cities are already grappling with how best to protect their communities and infrastructure.

Based on localized sea level projections for 2030 and 2045, we project a nearly ubiquitous increase in the frequency and extent of tidal flooding along the U.S. East and Gulf coasts. Coastal communities and states, and the nation as a whole, need to prepare for near-term changes in tidal flooding, while working hard to minimize longer-term losses through efforts to both adapt to these changes and limit their extent. This preparation should include federal efforts to sustain and expand the nation's tide gauge network to ensure that local decision makers have access to the best possible data.

Ubiquitous
- present
- appearing
- or found
everywhere

Supporting information

S1 Table. Full study dataset. Tidal flooding events per year for all tide gauge locations and sea level rise scenarios evaluated in this study. (XLSX)

Acknowledgments

The authors would like to thank Ben Strauss and Dan Rizza for providing sea level rise projections, Matthew Pendleton, William Sweet, staff members at the Union of Concerned Scientists, and three anonymous reviewers for guidance on methods and reviews of our preliminary work, and countless individuals at NOAA and the National Weather Service for insight into the impacts of minor coastal flooding today.

Author contributions

Conceptualization: ESS KD MF.

Data curation: KD.

Formal analysis: KD.

Funding acquisition: ESS.

Investigation: KD MF ESS.

Methodology: KD MF.

Project administration: ESS KD.

Software: KD.

Validation: MF ESS.

RESOLUTION 12-B-17

A RESOLUTION SUPPORTING THE TOWN'S TRANSITION FROM FOSSIL FUELS TO 100%
RENEWABLE ENERGY SOURCES BY 2050

WHEREAS, an immense number of scientific, economic, religious, academic, governmental, business and civil society leaders acknowledge that steps must be taken to limit warming by the end of the century to avoid catastrophic effects of climate change;

WHEREAS, an overwhelming scientific consensus of credentialed climate scientists and scientists in related fields and numerous scientific and governmental organizations support the findings that climate change is happening and that human activities are a key contributor to it;

WHEREAS, an increase in global average temperature, if not stopped, will have major adverse impacts on both the natural and human-made environments due to longer, more intense heat waves, prolonged droughts, rising sea levels, ocean acidification and more intense and frequent extreme weather;

WHEREAS, renewable energy represents an enormous economic opportunity for our nation and our nation's cities and towns to create jobs in an emerging industry, increase economic security, expand prosperity for local residents, reduce air pollution and associated public health risks, reduce the strain on water resources, save consumers money, and address environmental justice challenges in communities;

WHEREAS, "renewable energy" includes energy derived from wind, solar, geothermal, and wave technology;

WHEREAS, "renewable energy" specifically excludes energy derived from fossil fuels, nuclear, incineration of municipal and medical waste, and any large-scale future hydroelectric development;

WHEREAS, the transition to renewable energy will improve air and water quality and protect the health of our families, particularly the most vulnerable across our communities;

WHEREAS, according to the Department of Energy, the cost of wind power is down 41 percent since 2008 and solar costs are down between 54 percent and 64 percent in that same period;

WHEREAS, the renewable energy industry is one of the fastest growing sectors of the national economy with jobs in the clean energy sector already exceeding jobs in the fossil fuel electric sector five to one;

WHEREAS, more than twenty-five U.S. cities, including Columbia, SC, San Diego, CA, Salt Lake City, UT, and San Jose, CA have already adopted ambitious 100 percent clean, renewable energy goals, and six U.S. cities, including Aspen, CO, Burlington, VT, Greensburg, KS, Kodiak Island, AK, and Rock Port, MO have already hit their targets to generate 100 percent of the energy used community-wide from clean, non-polluting and renewable sources;

WHEREAS, the Town of Blacksburg has already established itself as a clean energy leader within the Commonwealth for being the first locality in Virginia to create a Solarize campaign, which resulted in a dramatic

expansion of residential solar energy use in our community and garnered Blacksburg a 2015 U.S. Conference of Mayors Climate Protection Award;

WHEREAS, individuals, families, businesses, and institutions throughout the nation seek greater energy freedom through the expansion of local and distributed energy resources like photovoltaic solar and electric vehicles;

WHEREAS, rooftop solar, low-income community solar, energy efficiency, and demand control technologies offer the opportunity to equitably distribute resources, address poverty, stimulate new economic activity in our nation's cities and towns, and lift up those most impacted by high energy costs; and

WHEREAS, actions by local government and businesses are already a significant driver of renewable energy growth and can put the country on track to meet the goals of the Paris Agreement under the United Nations Framework Convention on Climate Change,

NOW, THEREFORE, BE IT RESOLVED that the Blacksburg Town Council adopts the following goals and urges subsequent Councils to continue this commitment to protect our community:

1. Support a policy of the Town of Blacksburg to work with regional and statewide allies and other organizations to significantly reduce greenhouse gas emissions by replacing fossil fuels with renewable energy along with conservation and energy efficiency.
2. Support the achievement of near-zero greenhouse gas emissions through policies that shift the energy supply strategy of our town from fossil fuels to 100% clean renewable energy by 2050.
3. Support tax incentives, when allowed per Virginia State Code, that promote the growth of preferred green jobs in our region to achieve full employment and protect the environment.
4. Continue discussion and policy implementations for well-planned, managed growth by protecting the Town's open spaces through current ordinances and the addition of other procedures such as cluster development policies.
5. Establish policies and procedures to modernize Blacksburg's infrastructure to focus on a clean economy.

BE IT FURTHER RESOLVED that the Blacksburg Town Council:

1. Supports cities and towns establishing a community-wide target of powering their communities with 100 percent clean, renewable energy by 2050;
2. Proclaims its commitment to equity, affordability, public participation, and access for all people in America as cities and towns pursue this transition to 100% clean, renewable energy;
3. Proclaims that priority should be given to the lowest cost measures to meet energy needs including efficiency, weatherization, cogeneration, district heating and cooling, decentralized electricity generation and smart grids/micro grids, the use of industrial waste heat, building controls, automated lighting, solar-powered hot water heaters and programs that create an energy-saving culture in our nation's cities and towns; and

4. Proclaims that, given the economic potential of clean, renewable energy, the transition to 100% clean, renewable energy nationwide should include structured mechanisms to include low-income citizens in the benefits to be derived from the transition, including creating quality careers adhering to local source hiring to facilitate a just transition for workers displaced by fossil fuel reduction.



Mayor

ATTEST:



Town Clerk

Date of Adoption: December 12, 2017

Alexandria Democratic Committee Resolution for 100% renewable City electricity by 2020 and renewable energy by the Alexandria community by 2030

A **RESOLUTION** requesting that the City of Alexandria obtain 100% of the electricity it uses from renewable energy by 2020 and 100% of the energy consumed in the City from clean, renewable energy by 2030.

WHEREAS, 100% renewable electricity means that the City of Alexandria would either produce renewable energy or purchase Renewable Energy Credits (RECs) to offset the equivalent of 100% of the greenhouse gas emissions associated with the City's current electricity consumption;

WHEREAS, a commitment to 100% renewable energy means that the amount of energy generated from renewable energy sources in the community (or brought to it) equals or exceeds 100% of the annual energy consumed within the community;

WHEREAS, the climate is changing and its cause is the burning of fossil fuels, but the current federal administration is doing little to reduce the effects of climate change, it is incumbent upon states and cities to lead the effort to move toward renewable energy;

WHEREAS, Virginia is ranked 33 out of the 50 states in producing electricity from renewable energy ranking it lower than the national average (13.3%) with less than 2% of Virginia's electricity coming from wind or solar energy;

WHEREAS, the City of Alexandria must lead by example and demonstrate its commitment to renewable energy by not only advocating for changes at the state government level, but by taking specific, concrete actions to increase its use of renewable energy thereby reducing the usage of greenhouse gases rather than just setting aspirational goals;

WHEREAS, no other city or locality within Virginia has committed to obtaining 100% of its electricity from renewable sources, thus the City of Alexandria would be the FIRST to be publicly recognized for its 100% renewable commitment by the Climate Reality Project, the Sierra Club and other environmental organizations;

WHEREAS, it is in Alexandria's financial best interest to invest in renewable energy and to move forward now and reduce climate effects on our children and their environment as well as improve public health by reducing air pollution;

WHEREAS, the ADC is proud of the City's 2007 Eco-City designation and meeting many of the goals of its Environmental Action Plan of 2009 and commends the Mayor for her commitment to meet the Paris Climate Agreement as well as her commitment to the Mayors for 100% Clean Energy initiative;

THEREFORE, BE IT RESOLVED, the Alexandria Democratic Committee (ADC) fully endorses the budget letter of the Alexandria's Environmental Policy Commission dated February 2, 2018 which asks the City to include sufficient funds to increase the City's purchase of

Renewable Energy Credits (RECs) such that they offset the equivalent of 100% of the greenhouse gas (GHG) emissions associated with the City's current electric consumption no later than January, 2020. To make this request in effect budget neutral, the EPC recommends accelerating energy efficiency projects planned for City facilities (e.g. LED replacements) such that the first year expected savings in the form of lower energy bills is equal to the incremental cost of purchasing the additional RECs.

BE IT FURTHER RESOLVED, that the EPC indicates that the City currently offsets only 19% of its electricity consumption by purchasing RECs, however with the investment of an additional \$80,000-\$100,000 Alexandria could be one of the first localities in this region (and first in Virginia) to offset its electricity consumption with 100% renewable electricity.

BE IT FURTHER RESOLVED, that the ADC strongly recommends that the Mayor, City Council members, Environmental Policy Commission members and City Staff work with its citizens and other interested stakeholders to revise the City's Environmental Action Plan to set specific, measurable, achievable policies and programs to transition the City to 100% renewable energy by 2030.

PASSED and APPROVED this RESOLUTION on the ____ day of _____, 2018.

AT A REGULAR MEETING OF THE BOARD OF SUPERVISORS OF FLOYD COUNTY, VIRGINIA, HELD ON TUESDAY, OCTOBER 24, 2017 AT 7:00 P.M. IN THE BOARD ROOM OF THE COUNTY ADMINISTRATION BUILDING THEREOF:

PRESENT: Case C. Clinger, Chairman; Joe D. Turman, Vice Chairman; J. Fred Gerald, Linda Devito Kuchenbuch, Lauren Yoder, Board Members; Terri W. Morris, County Administrator; Cynthia Ryan, Assistant County Administrator

The following action was taken:

On a motion of Supervisor Kuchenbuch, seconded by Supervisor Yoder, and carried, it was resolved to adopt the following resolution.

RESOLUTION

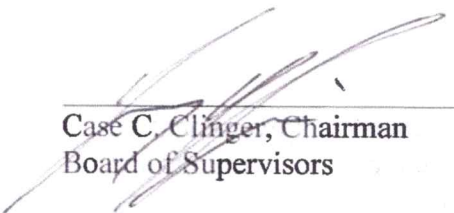
WHEREAS, an immense number of scientific, economic, religious, academic, governmental, business and civil society leaders acknowledge that steps must be taken to limit warming by the end of the century to avoid catastrophic effects of climate change; and

WHEREAS, an overwhelming scientific consensus of credentialed climate scientists and scientists in related field and numerous scientific and governmental organizations support the findings that climate change is happening and that human activities are a key contributor to it; and

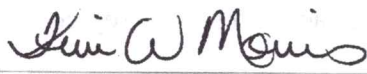
WHEREAS, an increase in the global average temperature, if not stopped, will have major adverse impacts on both the natural and human-made environments due to longer, more intense heat waves, prolonged droughts, rising sea levels, ocean acidification and more intense and frequent extreme weather events.

NOW, THEREFORE, BE IT RESOLVED THAT, the Floyd County Board of Supervisors, adopted the following goals and urge subsequent Boards to continue this commitment to protect our community:

1. Support a policy of the Floyd County government to work with regional allies and other local organizations to significantly reduce greenhouse gas emissions by replacing fossil fuels with renewable energy along with conservation and energy efficiency.
2. Support the achievement of near zero greenhouse emissions through policies that shift the energy supply strategy of our County from fossil fuels to 100% clean renewable energy.
3. Support tax incentives, when allowed per Virginia State Code, that promote the growth of preferred green jobs in our region to achieve full employment and protect the environment.
4. Continue discussion and policy implementations for well-planned, managed growth by protecting the County's open spaces through current ordinances and the addition of other procedures such as cluster development policies.
5. Establish policies and procedures to modernize Floyd County's infrastructure to focus on a clean economy and to always be aware of the footprint that we're leaving behind.


Case C. Clinger, Chairman
Board of Supervisors

ATTEST


Terri W. Morris
County Administrator