



Radley Horton

Lamont Associate Research Professor, Lamont-Doherty Earth Observatory

Radley Horton is a Lamont Associate Research Professor at Columbia University's Lamont-Doherty Earth Observatory. His research focuses on climate extremes, sea level rise, tail risks, climate impacts, and adaptation. Radley was a Convening Lead Author for the Third National Climate Assessment. He currently Co-Chairs Columbia University's Climate Adaptation Initiative, and is Principal Investigator for the NOAA-Regional Integrated Sciences and Assessments-funded Consortium for Climate Risk in the Urban Northeast. Radley is also the Columbia University lead for the Department of Interior-funded Northeast Climate Adaptation Science Center. He has served on numerous national and international task forces and committees, including the Climate Scenarios Task Force in support of the 2018 National Climate Assessment. Radley teaches in Columbia University's Sustainable Development department.

Dr. Radley Horton

Curriculum Vitae

Lamont-Doherty Earth Observatory
Columbia University Earth Institute
61 Route 9W, P.O. Box 1000, Palisades, NY 10964
Tel: (845) 365-8496 / Email: rh142@columbia.edu
<http://www.radleyhorton.com> / twitter: @radleyhorton

RESEARCH INTERESTS AND EXPERTISE

Sea level rise, extreme climate events, adaptation, tail risks

EDUCATION

2007 Ph.D., Earth and Environmental Sciences, Columbia University, New York, NY
2001 M.A., Earth and Environmental Sciences, Columbia University, New York, NY
1995 B.A., Environmental Policy Studies, Brown University, Providence, RI

PROFESSIONAL APPOINTMENTS

2017- Lamont Associate Research Professor (Tenured Senior Staff), Columbia University
2017- Adjunct Research Scientist, Center for Climate Systems Research, Columbia U.
2013- Adjunct Professor, Ecology, Evolution, and Environmental Biology, Columbia U.
2016-2017 Research Scientist, Center for Climate Systems Research, Columbia University
2007-2016 Associate Research Scientist, Center for Climate Systems Research, Columbia U.

AWARDS/RESEARCH GRANTS (LEAD PI OR UNIVERSITY LEAD PI ONLY)

Select Current funding as Project Lead-PI or Columbia Lead-PI

2015-2020 NOAA-RISA Program, “Consortium for Climate Risk in the Urban Northeast (CCRUN)”, Lead-PI: R.M. Horton
2017-2019 Consolidated Edison Climate Change Vulnerability Study, Lead-PI: R.M. Horton
2012-2019 Department of Interior/United States Geological Survey, “Northeast Climate Science Center (NECSC)”, Columbia Lead-PI: R. M. Horton

SELECT PROFESSIONAL ACTIVITIES

Select Advisory Experience, Task Force, Committee, and Project Membership

2017- Columbia University Department of Earth and Environmental Sciences Graduate Student Admissions Committee
2017- Member, Columbia Campaign Climate Change Task Force
2017- Member, Earth Institute Associate Faculty
2017- Member, Curriculum Committee, Masters Program in Sustainability Science
2017- Advisor, Transportation Team, Sustainable Columbia
2016- Co-chair, Columbia University Initiative on Adaptation to Climate Change
2016- U.S. Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force Member
2016-2017 Member, Climate Science Special Report Author Team in Support of the 4th National

- Climate Assessment
- 2015-2017 Climate Scenarios Task Force Member, US Global Change Research Program, Fourth U.S. National Climate Assessment and Sustained Assessment
- 2008-2017 Climate Science Lead, New York City Panel on Climate Change
- 2015 Member and Author, U.S. National Climate Assessment Special Report on Health Impacts of Climate Change
- 2009-2015 Deputy to Lead, NASA Climate Adaptation Science Investigator Working Group
- 2011-2014 Convening Lead Author, Northeast Region, Third U.S. National Climate Assessment
- 2011-2012 Member, Sea Level Rise Task Force, Third U.S. National Climate Assessment

Select Conference and Workshop Convening

- 2019 Lead Convener, “Workshop on Correlated Extreme Events” (May 28-31, Columbia University, planned)
- 2019 Co-Convener, “Workshop on Managed Retreat” (June 18-21, Columbia University, planned)

TEACHING EXPERIENCE

Courses

- 2013- Instructor/Faculty Advisor (two semesters per year): *Capstone Workshop in Sustainable Development (SDEV3280)* Earth Institute, Columbia University, New York, NY. Mean Evaluation as an Instructor: 4.7, on a scale of 1-5

Graduate Students (Primary Advisor Only)

- 2013-2018 Ethan Coffel, Department of Earth and Environmental Sciences, Columbia U. (Now a Postdoctoral Fellow at Dartmouth College)
- 2014- Colin Raymond, Department of Earth and Environmental Sciences, Columbia U.
- 2017- Corey Lesk, Department of Earth and Environmental Sciences, Columbia U.

Postdoctoral Mentees

- 2019- Kai Kornhuber, 2018 Ph.D from Potsdam Institute for Climate Impact Research (Columbia offer accepted)
- 2017-2018 Deepti Singh, Columbia University (shared; now an Assistant Professor at Washington State University Vancouver)
- 2015-2017 Justin Mankin, Columbia U. Earth Institute Post-Doc Fellow (shared; now an Assistant Professor at Dartmouth College)

SELECT PUBLICATIONS

Peer-Reviewed Articles

- Garner, A., J. L. Weiss, A. Parris, R.E. Kopp, R. M. Horton, J. T. Overpeck, and B. P. Horton. Evolution of 21st Century Sea-level Rise Projections. *Earth’s Future*, Accepted September 2018.
- Hall, J., C. P. Weaver, J. Obeysekera, M. Crowell, R. M. Horton, R. E. Kopp, J. Marburger, D. C. Marcy, A. Parris, W. V. Sweet, W. C. Veatch, and K. D. White. Rising Sea Levels: Helping Decision-Makers Confront the Inevitable. *Coastal Management*, Accepted October 2018.
- Coffel, E. D., Horton, R. M., & de Sherbinin, A. (2017). Temperature and humidity based projections of a rapid rise in global heat stress exposure during the 21st century. *Environmental Research Letters*, 13(1), 014001.
- Lesk, C., Coffel, E., D’Amato, A. W., Dodds, K., & Horton, R. (2017). Threats to North American forests from southern pine beetle with warming winters. *Nature Climate Change*, 7(10), 713.

- Kopp, R. E., DeConto, R. M., Bader, D. A., Hay, C. C., Horton, R. M., Kulp, S., ... & Strauss, B. H. (2017). Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections. *Earth's Future*.
- Raymond, C., Singh, D., & Horton, R. M. (2017). Spatiotemporal Patterns and Synoptics of Extreme Wet-Bulb Temperature in the Contiguous United States. *Journal of Geophysical Research: Atmospheres*, 122(24).
- Coffel, E. D., Thompson, T. R., & Horton, R. M. (2017). The impacts of rising temperatures on aircraft takeoff performance. *Climatic Change*, 144(2), 381-388.
- Horton, R. M., Mankin, J. S., Lesk, C., Coffel, E., & Raymond, C. (2016). A Review of Recent Advances in Research on Extreme Heat Events. *Current Climate Change Reports*, 2(4), 242-259.
- Lentz, E., E.R. Thieler, N.G. Plant, S.R. Stippa, R.M. Horton, and D.B. Gesch (2016), Evaluation of dynamic coastal response to sea-level rise modifies inundation likelihood, *Nature Climate Change*.
- Horton, R. M., Coffel, E. D., Winter, J. M., & Bader, D. A. (2015). Projected changes in extreme temperature events based on the NARCCAP model suite. *Geophysical Research Letters*, 42(18), 7722-7731.
- Horton, R.M., D. Bader, Y.Kushnir, C. Little, R. Blake, and C. Rosenzweig (2015). Climate Observations and Projections. *Annals of the New York Academy of Sciences* 1336 (1), 18-35.
- Horton, R.M., C. Little, V. Gornitz, D. Bader, and M. Oppenheimer (2015). Sea Level Rise and Coastal Storms. *Annals of the New York Academy of Sciences* 1336 (1), 36-44.
- Little, C. M., Horton, R. M., Kopp, R. E., Oppenheimer, M., Vecchi, G. A., & Villarini, G. (2015). Joint projections of US East Coast sea level and storm surge. *Nature Climate Change*.
- Liu, J., Song, M., Horton, R. M., & Hu, Y. (2015). Revisiting the potential of melt pond fraction as a predictor for the seasonal Arctic sea ice extent minimum. *Environmental Research Letters*, 10(5), 054017.
- Little, C., R.M. Horton, R. Kopp, M. Oppenheimer, and S. Yip (2015): Uncertainty in 21st Century CMIP5 Sea Level Projections. *Journal of Climate* 28 (2), 838-852.
- Schwartz, J., M. Lee, P. L Kinney, S. Yang, D. Mills, M. Sarofim, R. Jones, R. Streeter, A. St. Juliana, J. Peers and R. M. Horton (2015). Projections of temperature-attributable deaths in 209 U.S. cities using a cluster-based Poisson approach. *Environmental Health*, 14(1), 85.
- Horton, R. M., & Liu, J. (2014). Beyond Hurricane Sandy: What Might the Future Hold for Tropical Cyclones in the North Atlantic? *Journal of Extreme Events*, 1(01).
- Rosenzweig, C., Horton, R. M., Bader, D. A., Brown, M. E., DeYoung, R., Dominguez, O., ... & Toufexis, K. (2014). Enhancing Climate Resilience at NASA Centers: A Collaboration between Science and Stewardship. *Bulletin of the American Meteorological Society*, 95(9), 1351-1363.
- Kopp, R. E., Horton, R. M., Little, C. M., Mitrovica, J. X., Oppenheimer, M., Rasmussen, D. J., ... & Tebaldi, C. (2014). Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. *Earth's Future*, 2(8), 383-406.
- Li, T., Horton, R. M., & Kinney, P. L. (2013). Projections of seasonal patterns in temperature related deaths for Manhattan, New York. *Nature Climate Change*.
- Liu, J., Song, M., Horton, R. M., & Hu, Y. (2013). Reducing spread in climate model projections of a September ice-free Arctic. *Proceedings of the National Academy of Sciences*, 110(31), 12571-12576.

- Liu, J., J. A. Curry, H. Wang, M. Song, and R. M. Horton. 2012. Impact of declining Arctic sea ice on winter snowfall. *Proceedings of the National Academy of Sciences USA* 109 (2012).
- Horton, R.M., V. Gornitz, D.A. Bader, A.C. Ruane, R. Goldberg, and C. Rosenzweig, 2011: Climate hazard assessment for stakeholder adaptation planning in New York City. *J. Appl. Meteorol. Climatol.*, 50, 2247-2266, doi:10.1175/2011JAMC2521.1.
- Horton, R., Herweijer, C., Rosenzweig, C., Liu, J., Gornitz, V., & Ruane, A. C. (2008). Sea level rise projections for current generation CGCMs based on the semi-empirical method. *Geophysical Research Letters*, 35(2) L02715, doi:10.1029/2007GL032486.

Additional Publications

- Sweet, W. V., Kopp, R. E., Weaver, C. P., Obeysekera, J., Horton, R. M., Thieler, E. R., & Zervas, C. (2017). Global and regional sea level rise scenarios for the United States.
- Kopp, R., Easterling, D. R., Hall, T., Hayhoe, K., Horton, R., Kunkel, K., & LeGrande, A. (2017). Potential surprises—compound extremes and tipping elements. Chapter in USGCRP Climate Science Special Report.
- Sweet, W., Horton, R., Kopp, R., & Romanou, A. (2017). Sea level rise. Chapter in USGCRP Climate Science Special Report.
- Horton, R., Rosenzweig, C., Solecki, W., Bader, D., & Sohl, L. (2016). Climate science for decision-making in the New York metropolitan region. *Climate in Context: Science and Society Partnering for Adaptation*, 51-72.
- Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, , and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1–16-nn.
- Horton, R. M., Bader, D. A., Rosenzweig, C., DeGaetano, A. T., & Solecki, W. (2014). Climate Change in New York State Updating the 2011 ClimAID Climate Risk Information Supplement to NYSEDA Report 11-18 (Responding to Climate Change in New York State).
- Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

SELECT MEDIA APPEARANCES

Television

Showtime “Years of Living Dangerously”, PBS Newshour (frequent), PBS NOVA “Inside the Megastorm”, ABC News 20/20, CNN New Day (multiple), CNN International (multiple), MSNBC All-in with Chris Hayes (multiple), MSNBC Up with Steve Kornacki (multiple), MSNBC Alex Witt Show (multiple), NPR Democracy Now, StarTalk with Neil Degrasse Tyson, Star Talk with Bill Nye, CBS News, CBC Nightly News (Canada), Huffington Post Live (multiple), etc.

Radio

NPR Science Friday, NPR Fresh Air, NPR On Point, NPR Morning Edition, Voice of America, StarTalk Radio with Bill Nye, Sirius-XM, BBC (UK), CBC (Canada), etc.

Op-Eds

- Coffel, E., R.M.Horton, and C. Raymond, “Heat and Humidity are a Killer Combination”, *New York Times*, October 11th, 2018.
- Horton, R.M., K. Hayhoe, R. Kopp, and S. Doherty, “The climate risks we face”, *New York Times*, November 6th, 2017.
- Coffel, E. and R.M. Horton, “How hot weather – and climate change – affect airline flights”, *The Conversation*, August 2nd, 2017.

Written Testimony of Radley Horton
Lamont Associate Research Professor, Columbia University

before the
Committee on Science, Space, and Technology
Subcommittee on Environment
Sea Change: Impacts of Climate Change on Our Oceans and Coasts
February 27, 2019

Madam Chair and Members of the Subcommittee, my name is Radley Horton. I am a Lamont Associate Research Professor at Columbia University's Lamont-Doherty Earth Observatory. Thank you very much for the opportunity to participate in this important hearing on the impact of climate change on our oceans and coasts. I have served as an author on the 3rd and 4th U.S. National Climate Assessments, and as a Lead Principal Investigator within NOAA's RISA Program. I speak to you today though in my personal capacity as a private citizen.

Primarily as a result of human activities including the burning of fossil fuels and land use change, carbon dioxide concentrations in the atmosphere have increased by more than 40 percent since the Industrial Revolution (Wuebbles et al. 2017). For most people, warming of the *atmosphere* is probably the first thing that comes to mind when they think about the climate changes that have resulted from these human activities. Indeed, based on records going back to the 19th century, surface air temperatures the last five years have been the five warmest on record, and the 20 warmest years have all occurred within the last 22 years (Climate Central, 2019).

It may come as a surprise therefore that since the middle of the 20th century, 93 percent of the excess heating associated with human activities has actually gone towards warming the *oceans* (Wuebbles et al. 2017). As a result, the surface of the ocean has warmed by well over 1°F on average since 1900. The enormous energy imbalance required to heat the upper oceans so rapidly can only be plausibly explained by human activities (Wuebbles et al. 2017).

This warming, in conjunction with related ocean acidification and deoxygenation, has directly affected all living organisms in the upper ocean, as other speakers today will describe. It is also affecting sea level, which will be the subject of the majority of my brief remarks today.

We have seen about 7-8 inches of sea level rise since 1900 (Wuebbles et al. 2017). Although there is a delay between carbon dioxide emissions and sea level change, acceleration of the rate of sea level rise has been observed during the past generation (Wuebbles et al. 2017). I'd now like to briefly discuss the causes, impacts observed to date, and where we could be headed later this century.

Globally, there are two predominant ways that climate change is causing sea levels to rise. First, as the ocean warms, it expands. Second, the ice sheets and glaciers that that

sit on land are disgorging ice and water into the oceans, thereby adding mass. Although the first process had a bigger impact on sea level during the 20th century, it is thought that the second now rivals the first, and is set to surpass it this century. (Other drivers of sea level, of less importance globally, include 1) global storage of freshwater on land, 2) changes in local land height, and 3) regional variations in the change in ocean height due to factors ranging from ocean currents to the gravitational attraction of ice sheets (Sweet et al. 2017).)

But what about the future of sea level rise? It is often said that there is a lot of uncertainty about sea level rise, and in one sense, it is true. But it is asymmetric or ‘high tail’ uncertainty. According to Volume 1 of the Fourth National Climate Assessment (Wuebbles et al. 2017): “[Global mean sea level) is *very likely* to rise by...1.0–4.3 feet by 2100.” There has been a lot of focus on whether the plausible worst-case scenario for 2100 is 4.3 feet, six feet, or even 8 feet of sea level rise. But I would like to highlight a less appreciated point. Even the most optimistic scenario imaginable--of one foot of sea level rise by 2100--would have direct and profound impacts. I am going to focus on the most obvious impacts, but there will be less direct ones as well.

Sea level rise means more frequent coastal flooding and more intense/higher magnitude coastal flooding (Wuebbles et al. 2017). Already we are seeing nuisance (also known as ‘sunny-day’) flooding happen far more often than it used to across the U.S. coastline, as shown in Figure 1. For some locations, the past two generations have seen a 5 to 10-fold increase in the number of days with nuisance flooding. (It should be noted that some of these places, including the Mid-Atlantic states, have had more sea level rise than the global average, but even for those states that have not, the trend towards more nuisance flooding is clear.) From Miami to Norfolk, this means for example: 1) more stores unable to open for normal business, with associated ripple effects on the economy; 2) people not able to drive home along their normal routes, leading to delays, and 3) more water in people’s basements. These events perhaps deserve to be called a mere ‘nuisance’ when they only happen a few times per year—but at what point does it become something more than a nuisance?

Now let's look to the future of coastal flooding. And instead of looking at nuisance flooding, let's look at the big coastal floods—what are colloquially known as the ‘1 in 100 year’ events—heights that flood insurance, and zoning decisions are made based upon (Figure 2). With just one foot of sea level rise, and even if coastal storms do not change at all, the 1 in 100 year high water levels of the past become events that for most of the U.S. coast will be experienced within the 30-year lifetime of the typical home mortgage. In some areas, these high water levels could happen every couple of years in the future. Rather than focusing on the exact numbers in any one location, I would encourage you to note how the statistics shift strongly across the entire U.S. And once again, this is a lower end sea level rise scenario of one foot, and one that includes no assumptions about coastal storms changing in the future. For hurricanes, this assumption is probably somewhat optimistic, since the balance of evidence suggests that major hurricanes will become more frequent and intense, in large part due to the warming of the upper oceans (Wuebbles et al. 2017).

But sea level rise does more than just cause more frequent flooding. It means that when a coastal storm makes landfall, additional areas are flooded that would not have flooded before. And deeper floodwaters, which allow for greater wave penetration, cause more economic damage and loss of life. If the foot of sea level rise in the Greater New York/New Jersey Metropolitan Region since 1900 had somehow not occurred, 2012's Superstorm Sandy would have flooded the residences of 80,000 fewer people (Climate Central 2013; Miller et al. 2013). One recent study found that three feet of sea level rise would inundate 2 million American's homes (Hauer et al., 2016). Globally the number would be approximately two orders of magnitude larger.

The more frequent and intense coastal flooding brought on by sea level rise will impact all Americans. Along our coasts are assets worth trillions of dollars. From our homes, to critical service providers, to critical infrastructure including interstates like I-95, rail lines including Amtrak, airports including the 'big three' in the New York Metropolitan Region, and municipal water treatment plants.

And sea level rise is also a public health and safety issue. It means less time to evacuate from low lying areas in advance of a coastal storm, and greater risk of injury and death for those vulnerable members of our communities who are unable to evacuate. Sea level rise also mobilizes hazardous pollutants from our soils.

And just as all Americans suffer when the health and safety of any American is imperiled, so too will all Americans suffer the economic costs of sea level rise. It is after all U.S. taxpayers who bear much of the bill for coastal flood damages. And coasts are economic hubs for the entire nation. Our ports, which almost by definition are vulnerable to sea level rise, serve inland interstates and rail systems, as well as regional distribution centers. If ports are damaged or operating at reduced capacity, we therefore see supply chain implications, and economic disruption.

And then there are the national security implications. From NASA's Kennedy Space Center on Florida's Space Coast and Johnson Space Center outside Houston, to Norfolk's Naval Base and shipyards, what happens along U.S. coasts can have global implications. Recent coastal storm damages made worse by climate change have led to billions in damages at an Air Force base and a Marine Corps camp.

In my remarks, I have focused on a linear story—describing how *small* amounts of sea level rise profoundly increase the frequency of coastal flooding, and pointing primarily to relatively direct impacts of coastal flooding, like local damage. However, I feel an obligation to mention that the more greenhouse gases we emit into the atmosphere, the greater the potential for tipping points or 'surprises', such as sea level rise far in excess of the 4.3 feet described above. There is growing evidence from the ice sheets that further warming of the atmosphere and ocean could unleash positive feedbacks that lock us into more rapid ice sheet losses, and resultant high end sea level rise. Because extreme sea level rise of say 6 to 8 feet this century would be so difficult to adapt to, it follows that the further we increase greenhouse gas concentrations, the greater the odds of other

impact/societal ‘surprises’ like conflict, which would presumably make it that much more difficult to reduce greenhouse gas emissions at the scale needed given the magnitude of the problem.

While I have focused my brief remarks here on how human activities lead to sea level rise and its impacts, it is important to remember that earth systems are connected. On land, the impacts of warming oceans extend far inland. Warming oceans are loading the dice towards 1) heavier rain events; 2) combinations of high heat and humidity that put the health of our vulnerable populations, as well as outdoor labor productivity, at risk; and 3) all other things being equal, stronger hurricanes. And of course, these changes interact. For example, for a low lying coastal city, even a small increase in rainfall intensity, combined with a small increase in a hurricane’s storm surge could lead to a large increase in flooding if accompanied by even modest sea level rise.

While my training is in climate science, during the past decade I have had the good fortune to learn a great deal from decision-makers (including large municipalities, federal agencies, small communities, the private sector, and NGOs) as they devise solutions to climate change. These experiences have convinced me that, although we are running out of time, a window still remains open for the ultimate tipping point/surprise—specifically, rapid societal action to reduce greenhouse gas emissions and make society more resilient in the face of growing climate risks.

Thank you for inviting me to testify, and I look forward to our discussion.

References

- Climate Central, 2003. Surging Seas Sea level rise analysis by Climate Central. Retrieved February 25, 2019, from <http://sealevel.climatecentral.org/>
- Climate Central, 2019. The 10 Hottest Global Years on Record. Retrieved February 25, 2019, from <https://www.climatecentral.org/gallery/graphics/the-10-hottest-global-years-on-record>
- Hauer, M. E., J. M. Evans, and D R. Mishra (2016). Millions projected to be at risk from sea-level rise in the continental United States. *Nature Climate Change*.
- Miller, K. G., Kopp, R. E., Horton, B. P., Browning, J. V., & Kemp, A. C., 2013. A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast. *Earths Future*, 1(1), 3-18. doi:10.1002/2013ef000135
- Moser, S. C., M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes, and D. Reed, 2014: Ch. 25: *Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 579-618. doi:10.7930/J0MS3QNW.
- Sweet, W.V., R. Horton, R.E. Kopp, A.N. LeGrande, and A. Romanou, 2017: Sea level rise. In: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 333-363, doi: 10.7930/J0VM49F2.
- Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J.P. Kossin, P.C. Taylor, A.M. Waple, and C.P. Weaver, 2017: *Executive Summary of the Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 26 pp.

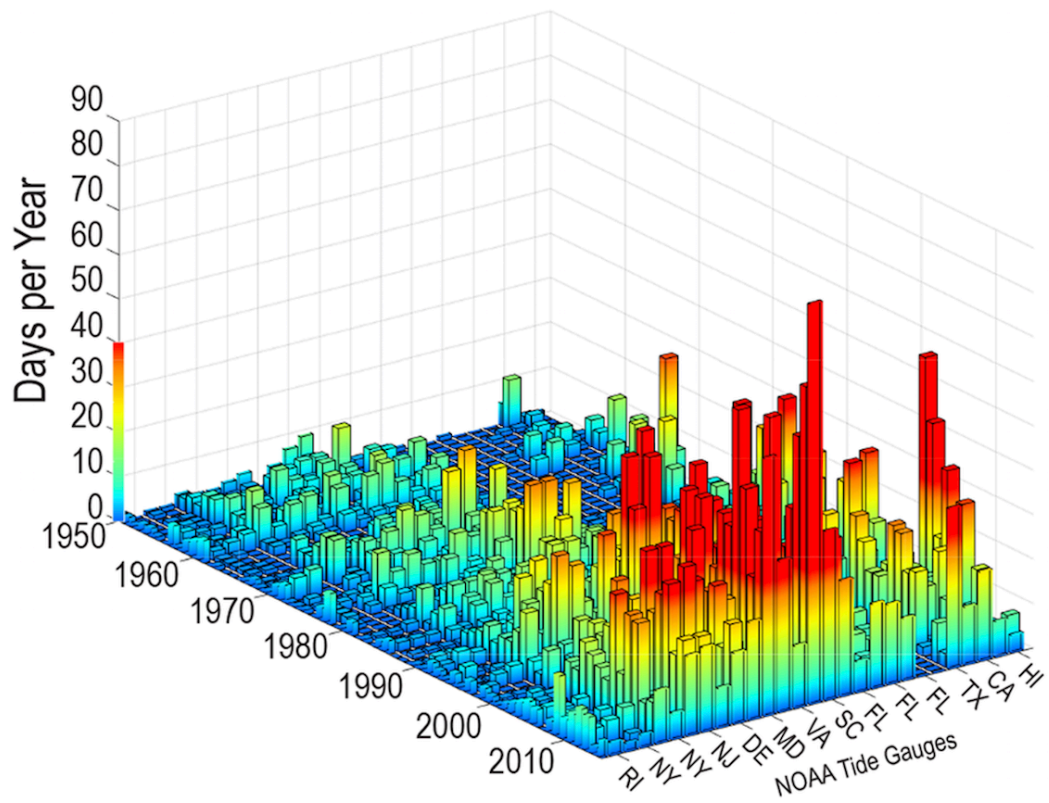
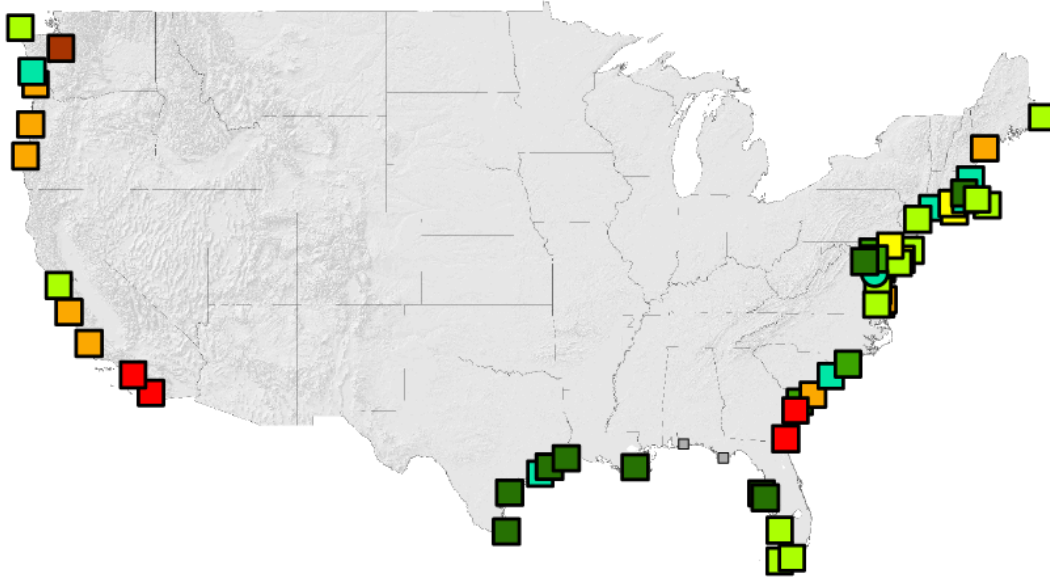


Figure 1. Tidal floods (days per year) exceeding NOAA thresholds for minor impacts at 28 NOAA tide gauges through 2015. Source: Sweet et al., 2017.

Revised Return Time for Current 100-Year Event



100-year event return time (years)



Figure 2. The amount of sea level rise (SLR) by 2050 will vary along different stretches of the U.S. coastline and under different SLR scenarios, mostly due to land subsidence or uplift. This figure shows how a 1.05-foot SLR by 2050 could cause the level of flooding that occurs during today's 100-year storm to occur more frequently by mid-century, in some regions as often as once a decade or even annually. All estimates include the effect of land subsidence. Source: Moser et al., 2014.