Population Projections and Risk of Inundation from SLR for the United States in 2100

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Background

Although there is growing worry that climate change is likely to cause widespread human migration over the next century, relatively few studies have attempted to merge climate change scenarios with population growth trends and projections in high-risk areas. The few that have suffer from methodological shortcomings related to both spatial and temporal mismatch. For example, previous estimates of the populations at-risk of future sea level rise (SLR) inundation have been based solely on current population data. Given the rapid growth of population in coastal areas, such temporal mismatch of datasets (i.e., present population and future SLR) appears likely to underestimate the impacts SLR will have on future populations. Other research has coupled county-scale populations with small-area flood inundation risk. Such spatial mismatch is likely to overestimate the future populations at risk of SLR, as no accounting is provided for populations located on higher ground within a county.

This approach addresses two fundamental questions concerning the vulnerability of future coastal populations in the United States: 1) How many people are potentially at risk of displacement from SLR? and 2) What areas in the United States will likely experience the greatest population displacement from inundation? Accordingly, our results can be used to inform local adaptation infrastructure and growth management strategies, alerting officials to the areas where interventions and policies are most needed.

Materials and Methods

We assess the populations at risk of SLR by using the National Oceanic and Atmospheric Administration's (NOAA) 0m, 0.9m (3 feet), and 1.8m (6 feet) SLR datasets for twenty-two coastal states and the District of Columbia. These datasets simulate expected changes in the mean higher high water (MHHW) mark on areas that are hydrologically connected to coastal areas without taking into account additional land loss caused by other natural factors such as erosion.

We utilize a linear/exponential extrapolation approach for projecting Census Block Groups from 2010 to 2100. We included only Census Block Groups (n=72,664) located in counties (n=319) expected to experience any inundation under the 1.8 m scenario. The population at risk of SLR is dynamically assessed as the proportion of the census block group underwater when SLR is expected to exceed 0.3m intervals under the 0.3m, 0.9m, and 1.8m scenarios. As populations become displaced under each SLR scenario in each block group, projected populations are dynamically adjusted to account for this displacement.

Results

Figure 1. Cumulative Potentially Displaced Populations for the Continental United States, 2010-2100. Projections reflect assumed growth/decline rates for 72,664 census block groups in 319 coastal counties. Error bars were generated as the 90% confidence interval from the projection models.

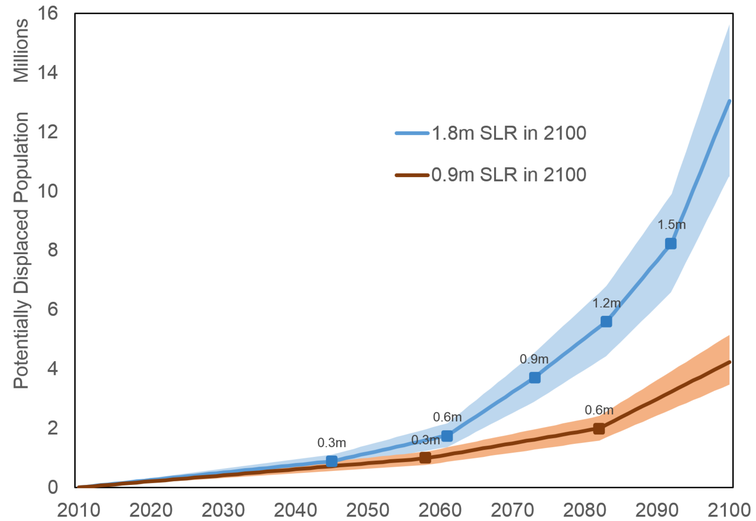


Figure 2. Projected Cumulative Populations at Risk of Sea Level Rise in 2100 under the 1.8m scenario. We considered 22 states and the District of Columbia. Current populations are based on Census 2010.

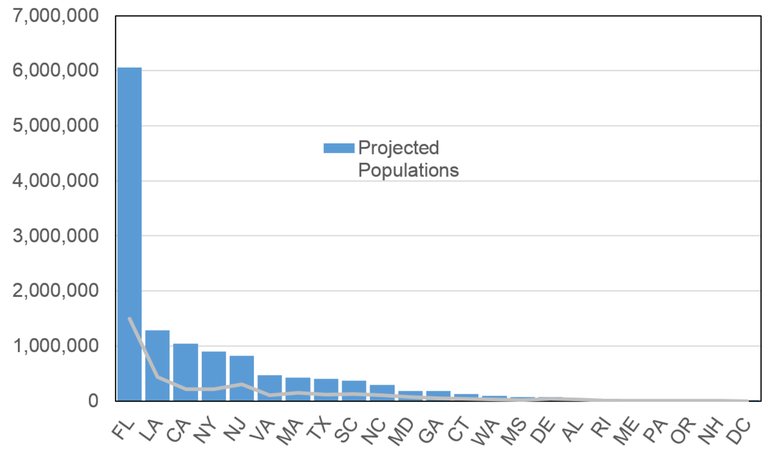
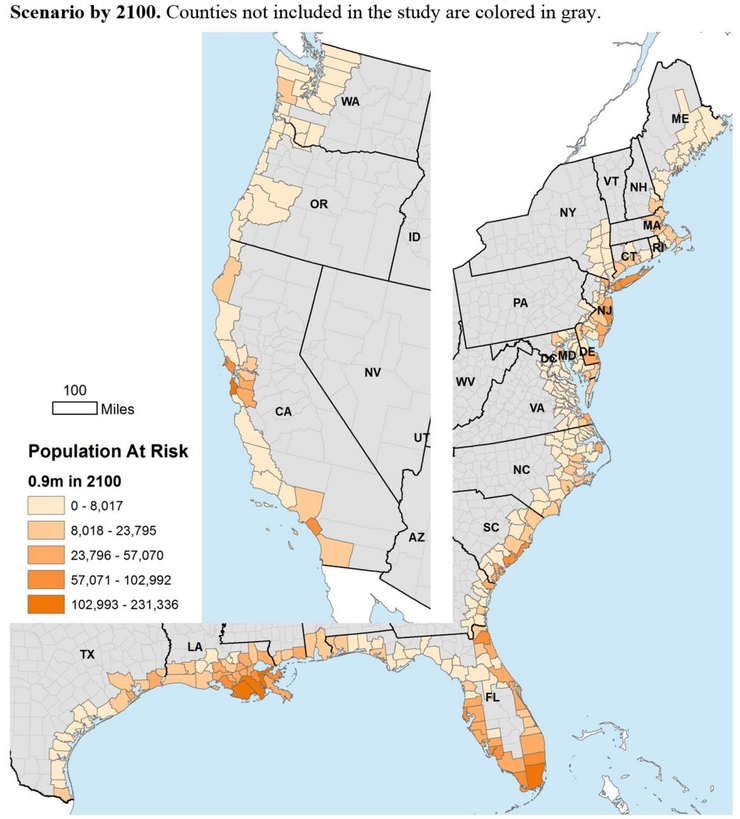


Figure 3. Cumulative Projected Populations at risk of Displacement under the 0.9m Scenario by 2100. Counties not included in the study are colored in gray.



Conclusions

We find that in the continental United States approximately 13.1 million people are at risk under the 1.8m scenario (Figure 1) with over 600,000 people at risk of displacement as soon as 2045. The projected number for the US is nearly triple what the current population estimates for 2010 suggest (Figure 2). Florida accounts for nearly half of the total at risk population and while other southeastern states have substantially fewer people at risk, states such as Georgia and South Carolina have over 10% of future coastal populations at risk of displacement under the 1.8m scenario. The southeastern United States alone represents nearly 70% of the entire projected populations at risk of displacement, suggesting the impacts of SLR will be highly regionalized nature.

Our results also suggest a hyperlocalized impact of inundation from SLR (Figure 3 and Table 1). While the median percentage of the population subject to inundation across all 319 coastal counties is just 3.5%, several counties would likely experience displacement far in excess of 3%. Three counties in particular—Tyrrell, North Carolina (94% of the projected population at risk of inundation), Monroe, Florida (88%), and Hyde, North Carolina (82%)—should experience population inundation that is catastrophic in nature with 1.8m SLR. Broward, Miami-Dade, Pinellas, and San Mateo counties and Jefferson and Orleans parishes are projected to see more than 100,000 residents potentially displaced with a 0.9m SLR, and an additional 23 counties could have more than 100,000 potentially displaced persons with a 1.8m SLR. Miami-Dade and Broward counties in Florida alone account for a quarter of the people expected to be displaced under the 1.8 m scenario.

Proposed managed retreat solutions could also prove troublesome if population projections are left out of the equation. To date, managed retreats have tended to involve small populations and areas, but in the future, action could be needed in areas with currently small but growing populations. Not only could the costs of relocating a community be greatly underestimated if that population is growing, but the challenge of finding suitable areas for relocation could be problematic as well. With current estimates as high as $US1 million per resident in some small Alaskan villages, each decade both increases a population's exposure to sea level rise and increases their vulnerability to the economic costs of inaction. Potential growth management strategies in high risk areas experiencing rapid population growth could also prove more effective than relocation. Population projections are not a panacea for these problems, but they move us toward evaluating the potential SLR impacts on future, rather than current, populations.

Supplementary Results

Table 1. Selected coastal counties' projected populations at risk of displacement. %0.9m and %1.8m are the percentage of the 2100 population at risk of displacement under each prescribed scenario.

State	County	At Risk Population, 0.9m	At Risk Population, 1.8m	% 0.9m	%1.8m	Rank of Total 1.8m Displaced Population
NC	Tyrrell	4,574	6,046	69.4%	91.8%	184
FL	Monroe	91,557	138,886	54.8%	83.1%	23
NC	Hyde	6,672	7,598	70.5%	80.2%	164
LA	Cameron	9,039	10,457	63.0%	72.9%	145
LA	St. Mary	45,930	75,426	43.5%	71.5%	42
LA	St. Charles	53,299	82,914	45.9%	71.4%	39
LA	Assumption	23,810	28,623	56.7%	68.2%	85
VA	City of Poquoson	8,626	21,049	27.7%	67.6%	109
LA	St. Bernard	48,689	67,865	47.5%	66.2%	46
LA	St. James	18,938	25,955	48.0%	65.8%	93
LA	Terrebonne	88,080	156,439	36.8%	65.4%	18
LA	Lafourche	88,242	122,834	44.2%	61.6%	28
NC	Dare	25,737	39,989	32.9%	51.1%	62
NC	Currituck	16,667	24,604	33.2%	49.0%	97
LA	Plaquemines	15,578	23,331	32.4%	48.6%	101
LA	St. John the Ba	19,996	46,035	19.8%	45.6%	55
NC	Camden	2,627	7,286	14.9%	41.2%	168
NJ	Cape May	38,168	79,345	18.7%	38.9%	41
FL	Broward	102,992	1,543,944	2.5%	36.8%	2
MD	Somerset	10,720	14,284	27.1%	36.1%	128
FL	Miami-Dade	231,336	1,967,018	4.2%	35.9%	1
VA	Mathews	2,665	5,762	16.2%	34.9%	187
MD	Worcester	10,987	34,872	10.7%	33.9%	72
NC	Pasquotank	7,209	23,399	9.4%	30.7%	100
VA	Accomack	12,618	16,910	22.6%	30.3%	116
GA	Glynn	23,795	48,127	14.4%	29.0%	53
FL	Charlotte	33,408	108,100	8.9%	28.8%	32
LA	Jefferson	196,995	289,706	18.9%	27.8%	5
NC	Pamlico	3,228	6,656	13.1%	26.9%	174
SC	Charleston	81,943	195,698	11.3%	26.9%	9

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