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Using simulations to forecast homeowner response to sea level rise in South Florida: Will they stay or will they go?

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ABSTRACT

Sea level rise threatens coastal communities around the world. Proactive investments in adaptive flood protection could reduce financial vulnerability, however it is unclear if local governments and homeowners will be willing to make those investments before it is too late. In this research we explore this issue by focusing on the case of South Florida, which is one of the most financially vulnerable regions in the world. We report the results of a novel online simulation that accelerates 348 South Florida homeowners thirty-five years into the future so that they can 'live' the effects of sea level rise. The results contain a mix of optimism and caution for the prospects of future adaptation. On the positive side, over 75% of participants indicated a willingness to support bond issues to pay for adaptation, even as the costs of the measures and effects of sea level rise increased over the years. Likewise, we find little evidence that politically conservative residents who normally have more skeptical views about climate change are any less inclined to support adaptation, or only look to information sources that downplay the threat. On the negative side, the number of homeowners interested in moving out of the region increases steadily over time as the sea level rises. This is driven by an increase in worry associated with viewing more information within the simulation.

1. Introduction

Sea level rise is a threat to coastal communities around the world. Recent research suggests that destabilization of ice sheets in Antarctica and Greenland is likely to combine with thermal expansion and land subsidence to cause a meter or more of sea level rise by 2100 (Carson et al., 2016; Church et al., 2013; Sweet et al., 2017). By 2025, it will be clear whether or not local sea levels have begun to accelerate away from historic rates sending us towards that future (Haigh et al., 2014). In response coastal cities will have to make substantial investments in flood protection or risk trillions of dollars in losses (Hallegatte et al., 2013; Hinkel et al., 2014). Because of variations in local geology and the built environment, cities' vulnerabilities differ. Some communities will have more options and more time than others to respond and adapt to rising sea levels. One obstacle they all face is overcoming the psychologically driven myopic tendency to focus on the present and avoid dealing with risks that feel distant because they are difficult to experience (Bazerman, 2006).

One location particularly vulnerable to the effects of sea level rise is South Florida, anchored by the densely developed Miami metropolitan area. The low-lying region rests on a porous limestone bedrock that limits the effectiveness of levee and pump systems as a means of dealing with flooding problems, such as those used in cities that are already below sea level like Amsterdam and New Orleans (Hughes and White, 2014; Park et al., 2011). One consequence of this geologic reality is that if no adaptation measures are taken a half-meter rise would threaten $3.5 trillion in assets by 2070, and potentially displace over 300,000 residents, many from inland communities that are only a few meters above sea level but miles from the coast, as flood controls begin to fail (Hanson et al., 2011; Hauer et al., 2016).

If sea levels rise within the intermediate range of NOAA's latest scenarios by 2050 (Sweet et al., 2017), annual flood losses in South Florida could exceed $25 billion. However, if adaptation investments are made to maintain current levels of flood protection annual losses could be reduced to $2.9 billion (Hallegatte et al., 2013). While proactive investments in flood protection would thus appear to make strong economic sense, such investments require taxpayers and city officials to see merits in spending money now to ward off a hazard that lies in the distant future – something many appear averse to doing (Buchanan et al., 2016; Hinkel et al., 2014; Lickley et al., 2014). Moreover, because the funding for improvements would need to come, in large part, from local real-estate taxes, adaptation may prove even

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more difficult if sea level rise spurs out-migration as residents retreat from projected extreme consequences of climate change (New et al., 2010).

In this paper we explore the likely future effects of sea level rise on the region's adaptation efforts by reporting the findings of a novel online, interactive computer simulation in which 348 South Florida homeowners experience and respond to 45.7 cm (18 in) of sea level rise at different points in time between 2016 and 2050. The simulation allows participants to "live" in a future South Florida that is experiencing worsening effects of sea level rise, and where residents are being asked to support adaptation efforts thorough costly bond measures. As in a natural setting, participants learn about conditions by accessing online media, watching television news broadcasts, and hearing the views of local residents. As such, the simulation helps participants overcome temporal distance in an experimental setting to produce a more realistic understanding of how individual homeowners and specific populations will respond to anticipated future sea level rise.

Below, we provide background for the research by reviewing the specific challenges facing South Florida and the psychological barriers that may impede adaptation to sea level rise there and elsewhere. We then describe the simulation, including reasoning behind the scenarios presented, and our findings. We describe substantive findings regarding planning for sea level rise in Florida and adaptation to climate change more broadly as well as methodological findings about the potential use of immersive simulations as a tool for forecasting long-term response to environmental changes. We conclude with a discussion of the implications of the work for future research and local governments in communities threatened by sea level rise.

2. Background

Sea levels have been rising globally, prior to the start of consistent measurement in the 1800s, contributing to increased flooding in coastal cities (Sweet et al., 2014). While the global rate of rise is currently about 3 mm/year, evidence suggests that the rate of sea level rise is accelerating, and could increase exponentially by the end of the century (Haigh et al., 2014). Increased coastal flooding is already being observed in many areas, and the costs could be massive, including over $400 billion in lost home value in Florida alone by 2100 if sea level rises 2 m (Rao, 2016). Uncertainty and range of projected rise makes incorporating sea level rise into long-range planning at the local level difficult (Akerlof et al., 2017).

As an example, since 2006 the city of Miami Beach has experienced an effective rate of seal-level rise of 9 millimeters a year from a combination of sea level rise and land subsidence, resulting in increased flooding (Wdowinski et al., 2016). In response, the city is in the process of investing $500 million over five years to elevate roads, install pumps, and reinforce sea walls against rising seas in select, high value areas (Flechas and Staletovich, 2015). It has also begun updating building codes and emergency management plans. Its response is supported by a regional network, the Southeast Florida Climate Change Compact, that has been advocating for a comprehensive regional response to sea level rise since 2009 and has created a unified sea level rise projection to guide decision makers, (see Fig. 1; (Sea Level Rise Working Group, 2015)).

As a relatively small and wealthy community, however, Miami Beach is the exception in terms of its active response to sea level rise and its financial capabilities to do so. At 25%, participation in the National Flood Insurance Program in Florida is relatively high (Michel-Kerjan, 2010), but uncertainty about the accuracy of current maps, lack of incentives for risk reduction, and changes in federal policy could result in rate increases for many participants (National Academy, 2015). Spatial and socio-economic impacts will not be felt uniformly along the coast. For example, poor populations are expected to have more trouble responding to increased flooding (Chakraborty et al., 2014). Likewise, Florida's regional real estate market is significantly supported by overseas investment. If wealthy investors with homes in other cities choose to leave first, that could lay the expensive burden of adaptation on middle and lower income residents who do not have the option to leave.

2.1. The psychology of resistance to preparedness

Given the threats posed by sea level rise, why are efforts to address the threat not more widespread? Although some communities' limited financial resources play a role, we suggest that psychology may be an even larger factor. As real as the threat may be, its most severe impacts are thought to remain thirty years or more in the future, well beyond the normal planning horizons of developers or homebuyers, impeding proactive planning (Akerlof et al., 2017; Spence et al., 2012). Studies show individuals living in areas of the United Kingdom threatened by sea level rise perceive it as a relatively unimportant hazard that is more likely to impact other people in other areas (Thomas et al., 2015). Similarly, residents in New Zealand believe it is more of a problem for the world or other parts of New Zealand than themselves (Evans et al., 2012)

One of the most robust findings in studies of decision making is that people have difficulty making good decisions about prospective, uncertain outcomes that lie in the distant future. They typically err by putting too much weight on that which is immediate and concrete over that which is temporally distant and vague (e.g., Frederick et al. (2002) and Laibson (1997)). This myopic decision making is common with climate change because the impacts are uncertain, temporally distant, physically diffuse, and difficult to experience (Spence et al., 2012; Weber, 2016; Weber and Stern, 2011). One immediate consequence of such myopia is that residents and planners responding to climate threats will be prone to under-estimate the present value of investing in preventive adaptation. While everyone might benefit from addressing the distant threat, these benefits will pale next to the immediate psychic pain of paying for them.

An even more insidious consequence of myopia is that it fosters procrastination (Fischer, 2001). Even if both planners and residents fully accept the risk posed by rising seas, the fact that the increase in risk from one year to the next is small makes it easy to rationalize postponing action. A decision maker might have every intention to invest in protection but imagines that the pain of the expenditure will be easier to swallow next year, when it is temporally distant, as opposed to this year, when it is immediate. The following year the same logical argument will return, leading to a cycle of delays.

Americans as a whole are divided about the threat of climate change, impeding coordinated response (Lee et al., 2015; Roser-Renouf et al., 2016). Those most skeptical of climate change are less likely to be moved by arguments for action, and are less likely to worry about climate change impacts (Whitmarsh, 2011). Moreover, such skepticism may be self-reinforcing. A well-known bias in decision making is that when individuals hold strong world views, they are prone to seek out information that works to confirm it − that is, engage in motivated reasoning (Kunda, 1990). This confirmation bias has been observed in experiments with climate skeptics, who have been found to actively avoid learning about climate change risks (Kahan et al., 2012). Additionally, longitudinal surveys indicate that the 25% of Americans who feel most engaged, proactively or skeptically, about climate change are more likely to fall victim to motivated reasoning, while the remaining 75% require experience to motivate them to learn (Myers et al., 2012). Thus, a skeptical resident who engages in motivated reasoning will, for example, be more likely to attend to news and media sources that express similar views and see nuisance flooding as a temporary inconvenience of nature, not a harbinger of future calamity. And a disengaged resident will wait until they experience flooding to pursue any information about rising seas. However, recent evidence from experimental research on home buying in coastal flood zones suggests that when individuals are immersed in the details of sea level rise risk they