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Climate scientists worry about the costs of sea level rise

New research addresses the economic costs of damages associated with sea level rise

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As humans add greenhouse gases to the atmosphere, it not only warms the planet, but also raises the oceans. Ocean waters are rising for a number of reasons including thermal expansion of water (as water warms, it expands to a larger volume), as well as ice melt which then flows as liquid into the ocean. My next post will cover four recent studies that quantify how much ocean levels will rise in the future. However, here I will focus on the economic costs of rising seas.

A paper was just published by Drs. Boettle, Rybski and Kropp that dealt with this question. The authors of this study note that if you are concerned about societal and economic costs, the rate of sea rise isn't the entire story. Much of the damage is caused by extreme events that are superimposed on a rising ocean. Damage is highly nonlinear with sea rise.

To explain this, let's think about flooding. Consider a river that has a dike system capable of confining a rise of water up to six feet. Such a system would have little or no economic/societal damage for "floods" up to six feet, but just one more foot of water rise would put the waters over the dike and could cause significant losses. So what really matters is, do events overshoot some level that commences damage?

How does this relate to climate change? Well as we warm the planet we are raising the baseline level of water from which extremes happen. Second, we are making some extreme weather events more likely. To measure the changes to extreme events in the future, the authors use a statistical method to estimate economic losses from coastal flooding. Using Copenhagen and other locations as test cases, they found that economic losses double when water rises only 11 cm. They also find that the costs rise faster than sea level rise itself. So, if we expect a linear increase in sea level over the next century, we should anticipate costs that increase more rapidly.

The authors also look at what are called "tail events" of storm surges. These are unusual events that can cause a large fraction of losses. Superstorm Sandy is an example; the storm surge from that event was very extreme and cause more loss than the combination

of many smaller storm surge events.

I asked the authors why this study is important. They told me,

While there is considerable progress in the understanding and projections of future sea level rise, there is little understanding about the damage costs from coastal floods which are expected to intensify with sea level rise. Most work focuses on case studies and there was no general understanding. Due to limited funds for adaptation it is very valuable to have a transferable and comparable approach for any coastal region.

I also asked how this work was novel and different from prior research.

For the first time we derive general relations on how damage from coastal floods increases with sea level rise and on how the damage decreases with the height of hypothetical protection measures such as sea walls. The results are based on mathematical proofs exploring extreme value statistics and are of universal validity. We conclude that the expected annual damage always, i.e. for an arbitrary case study, increases faster than the sea level itself.

Additionally, despite growing awareness of sea level rise, knowledge about the economic consequences in the form of damage costs is still very limited. A concise estimation, however, is essential in order to perform a reliable cost-benefit analysis regarding potential adaptation measures.

Our paper presents an entirely new view of the assessment of sea level rise impacts. Within a stochastic framework we provide for the first time universal expressions to describe the behavior of future damages, as well as their variability, for a varying mean sea level. Furthermore, an accurate characterization of the damage-reducing effect of coastal protection is included. All results are derived analytically and are confirmed by real-world examples (as shown in the study e.g. by two examples, however we applied the methodology already to more than 100 cities in Europe. This is, however, content of a subsequent paper).

We prove that sea level rise leads to an increase in coastal flood damages following one of three possible patterns. Additionally, the uncertainty of the estimations is analyzed in terms of the standard deviation quantifying the enormous variability of annual damages due to the stochasticity of flood events. The generality and simplicity of our findings facilitate an easy incorporation into integrated assessment models in the context of climate impact research.

Our work is ground-breaking since it bridges the gap between several fields of research and provides a full picture of the interplay between sea level rise, extreme events and the corresponding economic impacts. The manuscript addresses climate change, natural hazard and coastal research scientist.

The research was performed in the broader context of a European funded research framework, namely RAMSES, which is coordinated by Dr. Kroppf.

This work is important for a few reasons. First, we need tools to better understand what a future world will look like in a changed climate. We also need to make decisions to allocate resources toward adaption or mitigation. But how do we make decisions unless we have good information about costs and consequence? This study helps get us to an informed state.

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