Aspen Global Change Institute Energy Project

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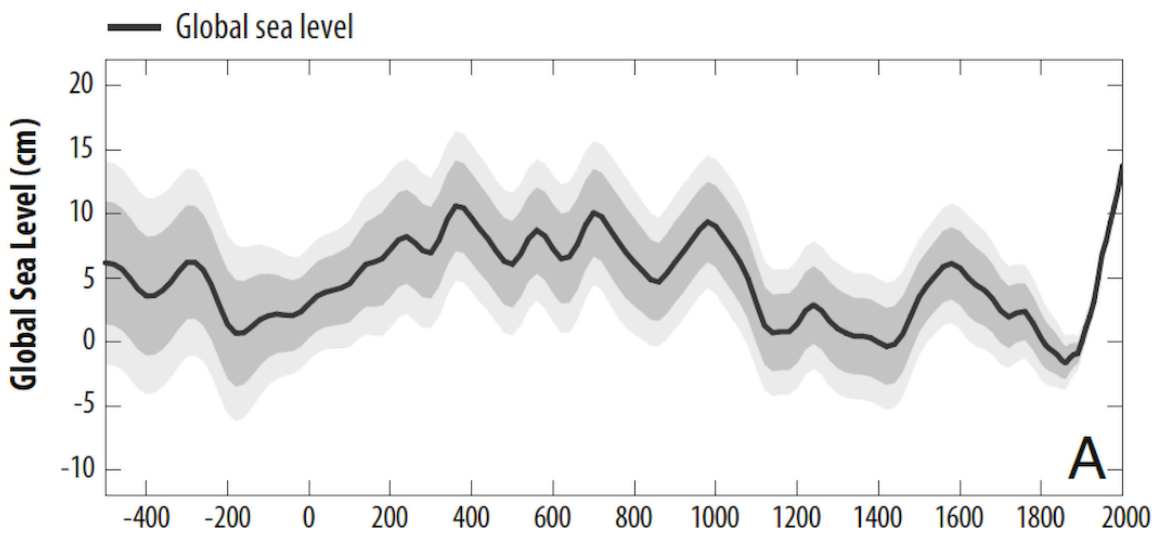
THE UNPRECEDENTED SPEED [AND COST] OF SEA LEVEL RISE

A recently published article in the Proceedings of the National Academy of Sciences (PNAS) by Kopp et al. found that the rate of sea level rise in the 20th century was greater than in any other over the last 3,000 years. This unprecedented rate translated to a mean increase in global sea level rise of 13.8cm (5.5in) between 1900 and 2000 (illustrated in the figure below). The study goes on to compare models with and without anthropogenic climate change, and found that in the absence of global warming, sea levels would have risen by less than half of what was observed.



Determining global rates of sea level rise is harder than one might think. Regional sea levels can vary immensely depending on local conditions such as prevailing winds, ocean currents, vegetation, and ice cover. Likewise, the gravitational pull of certain geological features – like the polar ice sheets, or above- and below-sea level mountain ranges – attracts water towards them resulting in regions with permanently higher sea levels. Kopp et al. accounted for these factors as well as global surface temperatures, historical records from 24 locations around the world (reconstructed from carefully vetted datasets of indicators from marshes, coral atolls, and archaeological sites dating back three millennia), and 66 tidal gauge records (the earliest dating back to 1700) – all then analyzed in their custom-developed statistical model to generate data about global sea level rise.

As if the process of determining global sea level rise isn't complicated enough, climate change is projected to alter the patterns and intensity of many of the regional conditions that affect regional sea level rise. Prevailing wind patterns, ocean currents, and the gravitational pull of dwindling polar ice caps are all forecasted to be affected in the coming centuries if society continues to rely upon burning carbon-intensive fossil fuels for energy production.

The implications of this rapid sea level rise are countless. Saltwater intrusion on freshwater aquifers, extreme tidal and storm conditions, flooding, erosion, and degradation of valuable wetlands and their many ecosystem services. Many modelers including Kopp et al. (2016) forecast a rise in sea level of over 1m (3ft) by 2100, enough to wipe out 78% of the world's wetlands (Spencer et al. 2016). Wetlands, which are naturally adaptive, are compromised in their ability to move with changing sea level due to upland development and building of dams that disrupt normal sediment deposition in coastal areas.

Quantifying the costs of damages expected from projected sea level rise is difficult, but the latest estimates indicate that for every doubling in projected rise of sea level, there is a quadrupling in cost of associated damages (Boettle et al. 2015). This effect may very well be compounded by the fact that models show storms (like Superstorm Sandy) intensifying in strength, size, heavy rainfall, and destructive potential when forming over warmer oceans (Lau et al. 2016). Improved climate and cost modeling will be increasingly important tools for present and future planners, who will face sudden and significant sea level rise in the coming decades, even if carbon emissions were to cease immediately.

Boettle, M., D. Rybski, and J.P. Kropp. 2015. Quantifying the effect of sea level rise and flood defence – a point process perspective on coastal flood damage. *Nat. Hazards Earth Syst. Sci. Discuss.* (3) 6229-6269.

Lau, W.K.M., J. J. Shi, and K.M. Kim. 2016. What would happen to Superstorm Sandy under the influence of a substantially warmer Atlantic Ocean? *Geophysical Research Letters* (43) 802-811.

Kopp, R. E., A. C. Kemp, K. Bittermann, B.P. Horton, J.P Donnelly, W. R. Gehrels, C.C. Hay, J. X. Mitrovica, E.D. Morrow, and S.Rahmstorf. 2016. Temperature-driven global sea-level variability in the Common Era. *PNAS Early Edition*. 02/29/2016. http://www.pnas.org/content/early/2016/02/17/1517056113

Spencer, T., M. Schuerch, R.J. Nicholls, J. Hinkel, D. Lincke, A.T. Vafeidis, R. Reef, L. McFadden, and S. Brown. 2016. Global coastal wetland change under sea-level rise and related stresses: The DIVA Wetland Change Model. *Global and Planetary Change* (139) 15-30.