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The Global Long-term Effects of Storm Surge Damages on Human Settlements

Sven Kunze

Heidelberg University, Germany (sven.kunze@awi.uni-heidelberg.de)

The influence of natural conditions on human settlements are immense. While a friendly and calm environment can lead to prosperity and growth, a hostile one with frequent natural disasters can result in stagnation, collapse, and even death. Tropical cyclones, as an unpredictable and recurring disastrous events, pose a considerable threat to prosperous development of human societies. The IPCC estimates that globally around 250 million people are vulnerable to storm surge events every year. If the threat is too large, a natural adaptation strategy would seem to move away to less dangerous places. It thus can be considered puzzling that there is a positive trend of moving to coastal flooding zones in Sub-Saharan Africa, North America and Asia, and this is projected to continue in the future. Additionally, climate change may increase the local exposure to storm surge by rising sea levels and changing intensity of tropical cyclones.

Given this worrisome development, a systematic analysis of the relationship between settlement structures and tropical cyclones is called for. In this paper we analyze whether people relocate from hazardous areas impacted by tropical cyclones. Importantly, the greatest threat from a tropical cyclone is generally due to the accompanying storm surge. But, because storm surge levels are hard to model, as of date no global (economic) impact study has attempted to model or used historic storm surge data to estimate the economic impact of tropical storms. Rather most studies only focus on wind damages, while other also include rain damages. Within this paper, we are closing this gap by explicitly modeling historic storm surge data worldwide from 1850-2015 and linking this to local population settlement.

By combining data on bathymetry, tidal cycles, weather conditions, and pressure drop models for the tropical cyclones we are able to estimate spatial storm surge data at a resolution of 5 arc minutes. This data then allows us, in a first step, to analyze its systematic impact on historical geo-referenced population and settlement structure data at a spatial scale of 5 arc minutes. We are able to show some interesting population patterns in response to tropical cyclones. Contrary to many empirical studies, we find that people do settle away from hazardous areas. This effect is especially large for low elevation coastal zones, while for non low elevation coastal areas we find no effect. The same pattern can be found for developing and developed countries, but the shrinking of the population is 39 percent larger in developing countries.