Pressure from Future Sea-Level Rise on Coastal Power Plants: Near-Term Extremes and Long-Term Commitment

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Abstract

Greenhouse gas emissions lead to an increase in global mean temperature, which results in thermal expansion of the oceans, melting of glaciers and ice sheets on Antarctica and Greenland. Consequently, global mean sea-level rises and impacts coastal ecological and human systems. In a first study, I focus on future greenhouse gas emissions. The rate of future sea-level rise can be reduced through the mitigation of greenhouse gas emissions. Cities worldwide, which are home to more than half of the world's population, are responsible for three quarters of global greenhouse gas emissions (IPCC 2014). Urban areas continue to grow in many regions of the world. By analyzing energy use and greenhouse gas emissions of 274 cities in the world, we found that policy interventions on urban form and the transport sector could potentially reduce the increase of future urban emissions by 25\% until 2050 (Section 2.1).

If greenhouse gas emissions continue to increase in a business-as-usual scenario, sea-level may rise up to one meter until the end of the century (IPCC 2013). More recent studies found that sea-level may even rise more (Favier et al. 2014; Feldmann \& Levermann 2015; Joughin et al. 2014; Kopp et al. 2016; Levermann et al. 2014; Levermann et al. 2013; Mengel et al. 2016; Rignot et al. 2014). As a consequence, extreme sea-level events become more likely (IPCC 2012). In a second study, I assess the risk of extreme sea-level events under a sea-level rise of one meter on US coastal power plant sites if emissions remain unabated (Section 2.2). I determine those power plant sites that cannot be reached by 100-year floods today but can be reached at the end of this century. Possible protection measures such as levees were not accounted for. I found that power plant sites at risk in the year 2100 aggregate 25 GW of today's net power generating capacity.

It is clear that sea-level rise will not halt after this century. On the very long term unabated greenhouse gas emission may cause global mean sea-level to rise by 50 meters within 10 millennia (Clark et al. 2016). Nuclear reactors that are not dismantled represent nuclear waste disposals on long time scales, even if shut down. For cooling purposes nuclear reactors are often constructed in the direct vicinity of today's shorelines. If their ground-level elevation submerges below future sea-level, they cannot be considered safe for humans or the environment. In a third study, I assess the time it takes for sea level to reach coastal nuclear reactor sites worldwide (Section 2.3). Using high-resolution elevation data and state-of-the-art sea-level projections it is found that no reactor site will be located below sea-level within the

next 200 years. However, more than one third of all reactors worldwide, which are not yet dismantled, including those under construction, are exposed to sea-level rise within this millennium. This number rises to 50 percent within 10 millennia.

In an additional line of research, I investigated indirect economic damages due to climatic extremes. Sea-level rise, for example, increases the risk of coastal flooding, which pressures economic facilities. Such direct damages that reduce the functionality of manufacturing capital or infrastructure are capable to induce production losses in other places (Hallegatte 2008, Levermann 2014). Besides coastal flooding, these indirect systemic losses can be initiated by various natural disasters, as well as man-made ones. Such extreme weather events are expected to become more intense and frequent with an increasing global mean temperature (IPCC 2012). During my Ph.D., I co-developed the global damage propagation model, *acclimate*, which simulates the response behavior of the global supply network in the aftermath of a local disaster to assess these indirect effects (Sections 2.4 and 2.5).