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Probabilistic projection of regional sea-level changes

Mahé Perrette (1), Riccardo Riva (2), Felix Landerer (3), Katja Frieler (1), and Malte Meinshausen (1)

(1) Potsdam Institute for Climate Impact Research, RD1: Earth System Analysis, Potsdam, Germany (mahe.perrette@pik-potsdam.de), (2) Delft Institute of Earth Observation and Space Systems, Delft Institute of Technology, Delft, Netherlands , (3) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA

Sea-level projections for 21st century are often addressed in term of global mean change or with a focus on spatial patterns resulting from a single component. Here we present an aggregated view of regional sea-level change in a probabilistic framework, for the new "Representative Concentration Pathways" scenarios. We decompose the global mean rise into its various contributions and then combine them with their respective regional sea-level fingerprints, i.e. AOGCM spatial patterns of steric expansion and gravitational effects of continental-ice melt. Unlike thermal expansion and glaciers, which are calculated directly, Antarctica and Greenland ice contributions (including nearby glaciers) are assumed in our default setting as residual from a semi-empirical model for total sea-level rise. This results in rapid rise at low latitudes because of water moving away from ice sheets and polar glaciers due to changes in the gravity field. A zonal structure is present as well, sea-level rise being up to 20% greater along Chinese coast than along Europe at the same latitude. Changes in ocean dynamics are secondary in this context, but they tend to strengthen an east-west gradient in Pacific sea-level rise and amplify the rise in the Indian Ocean. However, they significantly contribute to regional spread in the projections, meaning that a large contribution of ocean dynamics in certain locations is within the range of uncertainty. We compare our default results with patterns reconstructed from independent estimates of global mean ice-sheet contributions, namely from the IPCC AR4 “scaled up” estimate and a high-end estimate based on glaciological constraints. The SLR patterns based on the IPCC are influenced primarily by ocean dynamics and high-latitude glaciers because ice sheets are projected to have a small contribution over the 21st century. On the other hand, our pattern is found to vary little as compared to the glaciological limit estimate where land-ice plays a larger role, which cannot be ruled out in the context to their currently observed acceleration. Our study is a first step toward probabilistic forecast of regional sea-level from knowledge of global mean quantities and associated patterns, and could easily be updated with new estimates of land-ice contributions when process-based model simulations become available that more closely reflect observed ice-sheet behavior.