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Projecting sea-level rise out to 2300 for Paris Agreement commitments

Ivan Haigh (1), Phil Goodwin (1), Sally Brown (2), and Robert Nicholls (2)

(1) Ocean and Earth Science, National Oceanography Centre, University of Southampton, European Way, Southampton, SO14 3ZH, UK., (2) Faculty of Engineering and the Environment, University of Southampton, Southampton, SO17 1BJ, UK.

Sea-level rise is one of the most certain and costliest impacts of climate change. The Paris Agreement committed signatories to 'Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels recognizing that this would significantly reduce the risks and impacts of climate change'. However, while reducing human emissions of greenhouse gases will stabilise temperature and other climate factors, sea-level rise will continue for many centuries. This is due to the long timescale of cryospheric adjustment to elevated air temperatures (especially the large ice sheets), and the long timescale of the deep ocean temperature warming to surface warming.

Here we present a new novel hybrid approach to projecting sea-level rise out to 2300 to accurately assess our 'commitment to sea-level rise'. This new approach combines a mechanistic representation of thermosteric sea-level rise with a semi-empirical representation of the ice volume component of sea-level rise, embedded within an efficient conceptual Earth System Model. We use the Warming Acidification and Sea-level Projector (WASP) Earth system model. WASP is an 8-box representation of the atmosphere-ocean and terrestrial carbon system. It calculates surface temperature changes due to cumulative carbon emissions and additional terms to take account of radiative forcing. WASP is very computationally efficient and therefore can be run 10 million times with random perturbations to multiple parameters, allowing us to calculate a probabilistic projected range. Future projections are made only from the simulations that are historically consistent. The projections from our hybrid approach are found to be consistent with the dominant process-based global sea-level projections out to 2100 from the Climate Model Intercomparison Project phase 5 (CMIP5) ensemble.

We then use a novel Adaptive Mitigation Pathway (AMP) approach to restrict future warming to policy-driven targets, in which future emissions reductions are not fully determined now but respond to future surface warming each decade in an adaptive manner. A large ensemble of Earth system model simulations demonstrates our adaptive mitigation approach for a range of climate stabilization targets ranging from 1.5 to 4.5°C, and generates AMP scenarios up to year 2300 for global mean sea level.

Our AMP ensemble restricting temperatures to 1.5°C results in a median global sea-level rise of 0.4m and 0.99m by 2100 and 2300, respectively. For our AMP to 2.0°C ensemble we predict a median global sea-level rise of 0.46m and 1.26m by 2100 and 2300, respectively. For a comparison with a policy of stringent climate change mitigation, a high emissions scenario (RCP8.5) was generated assuming policies of no climate change mitigation. For RCP8.5 our ensemble results in a median global sea-level rise of 0.78m by the year 2100 and 4.5m by 2300.

In conclusion, we show that Paris Agreement commitments will reduce global sea-level rise by around 20cm by 2100, but targets will avoid up to 4m of sea-level rise by year 2300 relative to a high-end (RCP8.5) scenario.