Enhanced Atlantic Sea-Level Rise Under High Carbon Emission Rates

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Thermal expansion of the ocean in response to warming is an important component of historical sea-level rise. Basin-scale differences in heat uptake coincide with decadal climate variations, but in recent decades, observations show that the Atlantic and Southern oceans are warming faster than the Pacific Ocean. Here, we present results from simulations performed with the GFDL-ESM2G model - a numerical atmospheric-ocean general circulation model with an interactive carbon cycle - that examine the impact of carbon emission rates, ranging from 2 to 25 GtC yr^{-1}, on basin-scale ocean heat uptake and sea level. For simulations with emission rates greater than 5 GtC yr^{-1}, sea-level rise is larger in the Atlantic than Pacific Ocean on centennial timescales. This basin-scale asymmetry is related to the shorter flushing timescales and weakening of the overturning circulation in the Atlantic. These factors lead to warmer Atlantic interior waters and greater thermal expansion. In contrast, low emission rates of 2 and 3 GtC yr^{-1} will cause relatively larger sea-level rise in the Pacific on millennial timescales. For a given level of cumulative emissions, sea-level rise is largest at low emission rates. While global sea level rise is not proportional to cumulative emissions, there is a robust relationship between cumulative emissions and upper ocean (0-700m) Atlantic-minus-Pacific temperature differences across the range of emission rates tested with the model. In addition to local subsidence, changes in offshore winds, and ocean dynamical changes, we conclude that present-day high greenhouse gas emission rates make Atlantic coastal areas more vulnerable to sea-level rise over the coming decades. These results give further evidence that single global average measures become less representative of regional scale changes in sea level rise.

Keywords: sea level, modeling, heat uptake, emissions, carbon