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Rising Sea Level in a Changing Climate: A Synopsis

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Advances in climate change modeling enable us to obtain best estimates of temperature, rainfall, and sea level and their *likely* uncertainty ranges given a projected warming with different emission scenarios. Results for different emission scenarios are provided explicitly in the Intergovernmental Panel on Climate Change (IPCC) report. Projected global average surface warming for the end of the 21st century (2090–2099) relative to 1980–1999 with best estimates and *likely* ranges for global average surface air warming for six *Special Reports on Emission Scenarios* (SRES) are shown in Table 1. The model-based projections of global average sea level rise at the end of the 21st century (2090–2099) are also shown in Table 1.

Table 1: Projected global average surface and sea level rise at the end of the 21st century (Source: IPCC, 2007: Table SPM. 3)

	Temperature Change (°C at 2090-99 relative to 1980-99)[a]		Sea level Rise (m at 2090-99 relative to 1980-99)
Case	Best Estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentration[b]	0.6	0.3-0.9	NA
B1 scenario	1.8	1.1-2.9	0.18-0.38
A1T scenario	2.4	1.4-3.8	0.20-0.45
B2 scenario	2.4	1.4-3.8	0.20-0.43
A1B scenario	2.8	1.7-4.4	0.21-0.48
A2 scenario	3.4	2.0-5.4	0.23-0.51
A1F1 scenario	4.0	2.4-6.4	0.26-0.59

Notes:
[a]These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).
[b]Year 2000 constant composition is derived from AOGCMs only.

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The models used to date do not include uncertainties in climate-carbon cycle feedback nor do they include the full effects of changes in ice sheet flow, arguing that they could not yet be modeled, and consequently do not present an upper limit of the expected rise. While the projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993 to 2003, they do not include the dynamics of flow rates that could increase or decrease in the future. For example, according to many recent studies, if this ice flow contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for the SRES scenarios shown in Table 1 would increase by 0.1 to 0.2 m. Observations have already revealed that, without the contribution of ice flow, global average sea level rose a rate of 1.8 [± 0.5] mm per year over the period from 1961 to 2003. With the contribution of increased ice flow at the rates observed from 1993 to 2003, the average sea level rose about 3.1 [± 0.7] mm per year.

So, what I want to emphasize here is that the IPCC-Fourth Assessment Report (AR4) did not include the full effects of rapid ice flow changes in its projected sea level ranges. More clearly it can be mentioned here that the IPCC projections for future sea-level rise were based on thermal expansion only, without giving adequate considerations to the consequences of future ice melt. It is very important to note here that the same IPCC report concluded that thermal expansion can explain about 25% of observed sea level rise for 1961–2003 and 50% for 1993–2003, but with considerable uncertainty. The remainder is mostly caused by ice melt. Other climate-induced changes in land water storage likely played a minor, but not negligible, role. A recent analysis concludes that during 2003–2008 the relative contributions were 20% for thermal expansion and 80% for ice melt. While a 5-year period is likely to be dominated by natural variability, there is some reason for concern that ice melt could make an increasingly larger relative contribution in the course of this century.

Considering the dynamic effect of ice-melt contribution to global sea level rise, several new studies [(see Vermeer and Rahmstorf (2009), available at: *http://www.pnas.org/content/early/2009/12/04/0907765106.full.pdf)*] have estimated that by 2100 the sea level rise would be approximately three times as much as projected by the IPCC-AR4 assessment. Even for the lowest emission scenario (B1), sea level rise is then likely to be about 1 m and may even come closer to 2 m. However, despite uncertainties, recent studies have emphasized that we have to consider the possibility of faster sea level rise than suggested by the IPCC-AR4 assessment. In fact, the author and his team have already observed a faster rate of rise of sea level in the vicinity of western Pacific islands. Similar studies for Hawiian Islands are yet to be done and results will most likely be the same, as Hawiian Islands have been recording a positive trend.

At this stage we have reasons to believe that snow-melt is a major cause for this faster rate of rise in these small island countries. This will continue to be a factor and, as a consequence, if we can incorporate the dynamic effect of snow-melt in our projection the rise will be faster, resulting in considerably higher final rise values than the IPCC projections in different horizons, 2010 to 2099, regardless of the exact amount.

For a related discussion see Dr. Chowdhury's "Likelihood of High Sea Levels in the Hawaiian Islands" in the Spring 2011 e-Blast newsletter – archives section of the Hawai'i APA website.