Process-based projections for GMSL rise by the end of the 21st century (over an interval of 95 years, 33 between the 20-year mean of 2081–2100 and the 20-year mean of 1986–2005) are shown in Figure 13.8 and 34 Table 13.5. Time series of projected GMSL and its rate of rise are shown in Figure 13.9. The central 35 projections for GMSL in all scenarios lie within a range of 0.05 m until the middle of the century, because 36 the divergence of the climate projections has a delayed effect owing to the time-integrating characteristic of 37 sea level. By the end of the century, they have a spread of about 0.2 m, with RCP2.6 giving the least amount 38 of rise (0.42 [likely range of 0.29–0.55] m) and RCP8.5 giving the most (0.64 [0.48–0.82] m). RCP4.5 and 39 RCP6.0 are very similar at the end of the century (0.49 [0.36–0.63] m and 0.50 [0.37–0.64] m respectively), 40 but RCP4.5 has a greater rate of rise earlier in the century than RCP6.0. 41

P13-45

15 **Table 13.5:** Central estimates and likely ranges for projections of global-mean sea level rise and its contributions in 16 metres in 2081–2100 relative to 1986–2005 for the four RCP scenarios, GMSL rise at 2100, and rates of GMSL rise in 17 mm yr–1 in 2081–2100. Because some of the uncertainties in modelling the contributions are treated as uncorrelated, the 18 sum of the lower bound of contributions does not equal the lower bound of the sum, and similarly for the upper bound 19 (see Appendix 13.A). Because of imprecision from rounding, the sum of the central estimates of contributions may not 20 exactly equal the central estimate of the sum. The contributions from ice sheet dynamical change and anthropogenic 21 land water storage are treated as independent of scenario, since scenario dependence cannot be evaluated on the basis of 22 existing literature, and as having uniform probability distributions, uncorrelated with the magnitude of global climate 23 change. Regional sea level change is expected in general to differ from the global mean (see Section 13.6).

Thermal Expansion Glaciers Greenland Ice Sheet SMB

Antarctic Ice Sheet SMB

Greenland Ice Sheet Dynamics Antarctic Ice Sheet Dynamics Land Water Storage

Sea Level Rise

Rate of Sea Level Rise

Sea Level Rise at 2100

RCP2.6

0.14 [0.10 to 0.18]

0.13 [0.07 to 0.19]

0.02 [0.00 to 0.05]

–0.02 [–0.05 to – 0.00]

0.04 [0.01 to 0.06] 0.07 [0.03 to 0.11] 0.04 [–0.01 to 0.08]

0.42 [0.29 to 0.55]

4.7 [2.9 to 6.6]

0.46 [0.32 to 0.61]

RCP4.5

0.19 [0.14 to 0.23]

0.16 [0.10 to 0.22]

0.04 [0.00 to 0.07]

–0.03 [–0.06 to – 0.01]

0.04 [0.01 to 0.06] 0.07 [0.03 to 0.11] 0.04 [–0.01 to 0.08]

0.49 [0.36 to 0.63]

6.4 [4.4 to 8.4]

0.56 [0.41 to 0.71]

RCP6.0

0.19 [0.15 to 0.24]

0.16 [0.09 to 0.22]

0.04 [0.00 to 0.07]

–0.03 [–0.06 to – 0.01]

0.04 [0.01 to 0.06] 0.07 [0.03 to 0.11] 0.04 [–0.01 to 0.08]

0.50 [0.37 to 0.64]

7.8 [5.6 to 10.0]

0.58 [0.42 to 0.74]

RCP8.5

0.27 [0.21 to 0.33]

0.20 [0.13 to 0.27]

0.07 [0.01 to 0.13]

–0.05 [–0.09 to – 0.01]

0.04 [0.01 to 0.06] 0.07 [0.03 to 0.11] 0.04 [–0.01 to 0.08]

0.64 [0.48 to 0.82]

11.4 [8.0 to 15.1]

0.76 [0.56 to 0.96]

24 25

13-46

In our assessment, GMSL rise during the 21st century for each RCP scenario is likely to lie within the range 12 given by the process-based projections (Section 13.5.1.1 and Table 13.5; see Section 13.5.2 for following 13 centuries), which are based on the likely ranges projected for global-mean surface air temperature change 14 (Section 12.4.1.2). Projections must be accompanied by an indication of confidence in order for them to be 15 practically useful. We have high confidence that the time-mean rate of GMSL rise during the 21st century is 16 very likely to exceed the rate of 2.0 [1.7–2.3] mm yr–1 observed during 1971–2010, because the GMSL 17 projections indicate a significantly greater rate even under the RCP2.6 scenario, which has the lowest 18 radiative forcing. It is more difficult to set an upper bound because there is a relationship between the level 19 of confidence and the width of the range delimited. Extremely high bounds to GMSL rise in the 21st century 20 could easily be set with confidence, but being physically unachievable makes them of little value. Our likely 21 ranges are narrower, in order to be more useful, but they are consequently accompanied by lower confidence. 22 Under the scenario with the highest radiative forcing (RCP8.5), the likely range reaches 0.84 m by 2100 23 relative to 1986–2005, similar to the lower estimate of Pfeffer et al.

13-51

31 ***13.6.6 Uncertainties and Sensitivity to Ocean/Climate Model Formulations and Parameterizations*** 32 33 Sea level is a property of the ocean connected to nearly all dynamical and thermodynamical processes over 34 the full ocean column, from the surface fluxes to the ocean bottom. While many of the processes are to first 35 order correctly simulated in climate models, differences between models indicate that uncertainties in 36 simulated and projected steric sea level remain poorly understood (Figure 13.18). Moreover, the ocean heat 37 uptake efficiency differs between models leading to a spread of 50% in heat storage changes (Kuhlbrodt and 38 Gregory, submitted). In addition, some processes are not yet properly simulated, such as the dynamical 39 response of the ocean to melt-water input or processes in the solid Earth associated with this ice mass loss. In 40 addition, Stammer and Hüttemann (2008) showed that coupled climate models that do not include the effect 41 of changes in atmospheric moisture content on sea level pressure will underestimate future regional 42 atmospheric pressure loading effects by up to 2 cm. Other uncertainties result form 43 GIA/rotational/gravitational effects as well as from uncertainties in air-sea fluxes.

13-59

***13.6.7 Summary Assessment*** 27 28 During the 20th century, sea level relative to the coast has varied as a result of natural variability in the 29 climate system, longterm trends in ocean height and vertical land motion. These variations will continue 30 during the 21st century. 31 32 For much of the coastline, the largest sea level changes over the next few decades will continue to be 33 associated with natural (dynamical) climate modes superimposed on the long term trends (high confidence), 34 with good correspondence between regional sea level variability, and changes in ocean currents and upper- 35 ocean heat and salt content. It is *very likely* (high confidence) that toward the end of the 21st century sea 36 level change will remain to have a strong regional pattern, with significant deviations of local and regional 37 sea level change from the global mean change. The dynamical variability of sea level will continue and will 38 be critical component of sea level impacts and extreme events (Section 13.8). However, on those longer time 39 scales, regional sea level changes will result increasingly from mass changes of the ocean from glaciers and 40 ice sheets, including the regional patterns from both contemporary and past changes in land ice, changes in 41 atmospheric loading, and vertical land motions, with relative contributions from each varying significantly 42 around the Earth. 43 44 It is *very likely* (high confidence) that over about 95% of the world ocean, regional sea level rise will be 45 positive with mostly regions near current and former glaciers and ice sheets experiencing a sea level fall. 46 About 72% and 77% of the coastline will experience a sea level change within ±20% of the GMSL change 47 for RCP4.5 and 8.5, respectively. In both cases the maximum of the PDF is larger than the GMSL, however, 48 the arithmetic mean is lower than the global mean (0.3 m vs. 0.37 m for RCP4.5; 0.56 m vs. 0.68 m for 49 RCP8.5, respectively). Only some coastlines will experience a sea level rise of up to 50% above the GMSL 50 change.

13-60

Wave size projections

In the Pacific, Graham et al. (submitted) used multi-model projections under the SRES A2 scenario and

23 found a decrease in boreal winter significant wave heights over the mid-latitude North Pacific associated 24 with a projected decrease in westerly wind speeds, and a tendency for higher extreme waves at higher 25 latitudes.

On the Australian east coast, Hemer et al. (submitted-c) reported a small projected decrease in 26 mean SWH (<5cm) and a shift to a more southerly wave direction under SRES A2 and B1 scenarios,

27 consistent with a projected southward shift of the sub-tropical ridge in the forcing fields.

13-64.