**AR 5 Working Group II Frequently Asked Questions**

**FAQ 2: How much can we say about what society will be like in**

**the future, in order to plan for climate change impacts?**

[Chapters 1, 2, 14, 15, 16, 17, 20, and 21; TS]

Overall characteristics of societies and economies, such as population

size, economic activity, and land use, are highly dynamic. On the

scale of just 1 or 2 decades, and sometimes in less time than that,

technological revolutions, political movements, or singular events can

shape the course of history in unpredictable ways. To understand

potential impacts of climate change for societies and ecosystems,

scientists use scenarios to explore implications of a range of possible

futures. Scenarios are not predictions of what will happen, but they can

be useful tools for researching a wide range of “what if” questions

about what the world might be like in the future. They can be used to

study future emissions of greenhouse gases and climate change. They

can also be used to explore the ways climate-change impacts depend

on changes in society, such as economic or population growth or

progress in controlling diseases. Scenarios of possible decisions and

policies can be used to explore the solution space for reducing greenhouse

gas emissions and preparing for a changing climate. Scenario analysis

creates a foundation for understanding risks of climate change for

people, ecosystems, and economies across a range of possible futures.

It provides important tools for smart decision making when both

uncertainties and consequences are large.

**FAQ 7: Are the future impacts of climate change only negative?**

**Might there be positive impacts as well?**

[Chapters 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 19, 22, 23, 24, 25, 26, 27,

and 30]

Overall, the report identifies many more negative impacts than positive

impacts projected for the future, especially for high magnitudes and

rates of climate change. Climate change will, however, have different

impacts on people around the world and those effects will vary not only

by region but over time, depending on the rate and magnitude of climate

change. For example, many countries will face increased challenges for

economic development, increased risks from some diseases, or degraded

ecosystems, but some countries will probably have increased opportunities

for economic development, reduced instances of some diseases, or

expanded areas of productive land. Crop yield changes will vary with

geography and by latitude. Patterns of potential catch for fisheries are

changing globally as well, with both positive and negative consequences.

Availability of resources such as usable water will also depend on

changing rates of precipitation, with decreased availability in many

places but possible increases in runoff and groundwater recharge in

some regions like the high latitudes and wet tropics.

Chapter 13 AR5 I

Section 3.7 also concludes that it is likely that the rate of sea level rise increased from the 19th century to the 20th century. Taking this evidence in conjunction with the proxy evidence for a change of rate (Sections 5.6.3 and 13.2.1; Figure 13.3b), there is high confidence that the rate of sea level rise has increased during the last two centu­ries, and it is likely that GMSL has accelerated since the early 1900’s. Because of the presence of low-frequency variations (e.g., multi-dec­adal variations seen in some tide gauge records; Chambers et al. (2012)), sea level acceleration results are sensitive to the choice of the analysis time span. When a 60-year oscillation is modelled along with an acceleration term, the estimated acceleration in GMSL (twice the quadratic term) computed over 1900–2010 ranges from 0.000 [–0.002 to 0.002] mm yr–2 in the Ray and Douglas (2011) record, to 0.013 [0.007 to 0.019] mm yr–2 in the Jevrejeva et al. (2008) record, and 0.012 [0.009 to 0.015] mm yr–2 in the Church and White (2011) record. For comparison, Church and White (2011) estimated the accel­eration term to be 0.009 [0.004 to 0.014] mm yr–2 over the 1880–2009 time span when the 60-year cycle is not considered.

The time mean rate of GMSL rise during the 21st century is very likely to exceed the rate of 2.0 [1.7 to 2.3] mm yr–1 observed during 1971–2010, because the process-based GMSL projections indicate a significantly greater rate even under the RCP2.6 scenario, which has the lowest RF. It has been asserted that the acceleration of GMSL rise implied by the IPCC AR4 projections is inconsistent with the observed magnitude of acceleration during the 20th century (Boretti, 2011, 2012b, 2012a, 2012c, 2013a, 2013b. 2013c; Boretti and Watson, 2012; Parker, 2013a, 2013b, 2013c). Refuting this argument, Hunter and Brown (2013) show that the acceleration projected in the AR4 is consistent with observa­tions since 1990s. Present understanding of the contributions to GMSL rise (Section 13.3) gives an explanation of the rate of 20th century GMSL rise and confidence in the process-based projections, which indi­cate a greater rate of rise in the 21st century because of increasing forcing.

The improved agreement of process-based models with observations and physical understanding represents progress since the AR4, in which there was insufficient confidence to give likely ranges for 21st century GMSL rise, as we have done here. For scenario SRES A1B, which was assessed in the AR4, the likely range on the basis of science assessed in the AR5 is 0.60 [0.42 to 0.80] m by 2100 relative to 1986–2005, and 0.57 [0.40 to 0.76] m by 2090–2099 relative to 1990. Compared



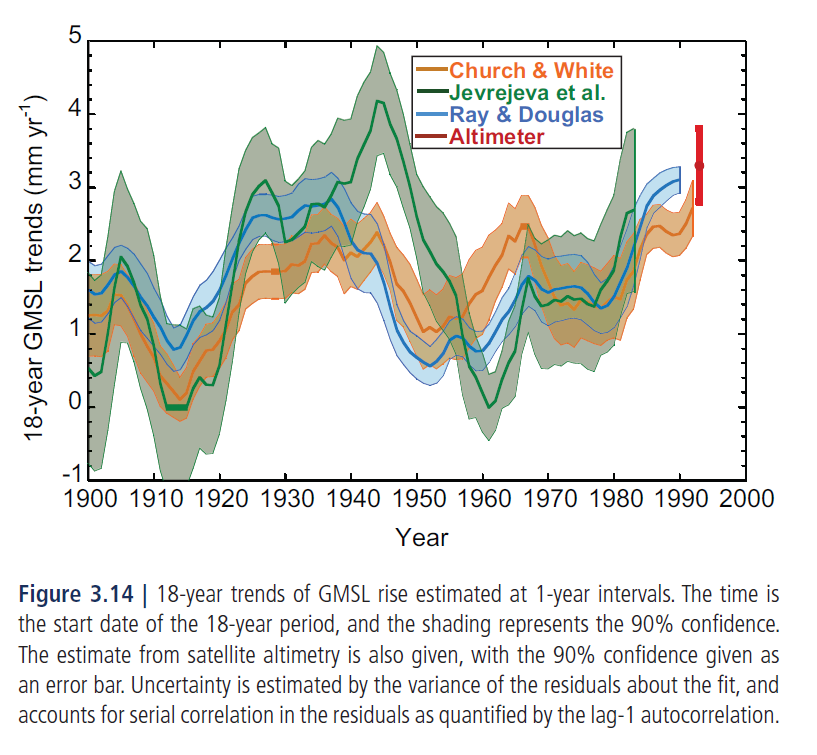
**3.7.4 Assessment of Evidence for Accelerations in Sea Level Rise**

AR4 concluded that there was “high confidence that the rate of global sea level rise increased from the 19th to the 20th century” but could not be certain as to whether the higher rate since 1993 was reflective of decadal variability or a further increase in the longer-term trend. Since AR4, there has been considerable effort to quantify the level of decadal and multi-decadal variability and to detect acceleration in GMSL and mean sea level at individual tide gauges. It has been clear for some time that there was a significant increase in the rate of sea level rise in the four oldest records from Northern Europe starting in the early to mid-19th century (Ekman, 1988; Woodworth, 1990, 1999; Mitchum et al., 2010). Estimates of the change in the rate have been computed, either by comparing trends over 100-year intervals for the Stockholm site (Ekman, 1988; Woodworth, 1990), or by fitting a quadratic term to all the long records starting before 1850 (Woodworth, 1990, 1999). The results are consistent and indicate a significant acceleration that start­ed in the early to mid-19th century (Woodworth, 1990, 1999), although some have argued it may have started in the late 1700s (Jevrejeva et al., 2008). The increase in the rate of sea level rise at Stockholm (the longest record that extends past 1900) has been based on differenc­ing 100-year trends from 1774–1884 and 1885–1985. The estimated change is 1.0 [0.7 to 1.3] mm yr–1 per century (1 standard error, as cal­culated by Woodworth, 1990). Although sites in other ocean basins do show an increased trend after 1860 (e.g., Figure 3.12), it is impossible to detect a change in the early to mid-1800s in other parts of the ocean using tide gauge data alone, as there are no observations.

Numerous studies have attempted to quantify if a detectable accelera­tion has continued into the 20th century, typically by fitting a quadratic to data at individual tide gauges (Woodworth, 1990; Woodworth et al., 2009, 2011; Houston and Dean, 2011; Watson, 2011) as well as to reconstructed time series of GMSL (Church and White, 2006; Jevrejeva et al., 2008; Church and White, 2011; Rahmstorf and Vermeer, 2011), or by examining differences in long-term rates computed at different tide gauges (Sallenger et al., 2012). Woodworth et al. (2011) find significant quadratic terms at the sites that begin before 1860 (all in the NH). Other authors using more numerous but significantly shorter records have found either insignificant or small negative quadratic terms in sea level around the United States and Australia since 1920 (Houston and Dean, 2011; Watson, 2011), or large positive quadratic values since 1950 along the U.S. east coast (Sallenger et al., 2012). However, fitting a quadratic term to tide gauge data after 1920 results in highly varia­ble, insignificant quadratic terms (Rahmstorf and Vermeer, 2011), and so only studies that use data before 1920 and that extend until 2000 or beyond are suitable for evaluating long-term acceleration of sea level.

A long time scale is needed because significant multi-decadal varia­bility appears in numerous tide gauge records during the 20th century (Holgate, 2007; Woodworth et al., 2009, 2011; Mitchum et al., 2010; Chambers et al., 2012). The multi-decadal variability is marked by an increasing trend starting in 1910–1920, a downward trend (i.e., level­ing of sea level if a long-term trend is not removed) starting around 1950, and an increasing trend starting around 1980. The pattern can be seen in New York, Mumbai and Fremantle records, for instance (Figure 3.12), as well as 14 other gauges representing all ocean basins (Chambers et al., 2012), and in all reconstructions (Figure 3.14). It is also seen in an analysis of upper 400 m temperature (Gouretski et al., 2012; Section 3.3.2). Although the calculations of 18-year rates of GMSL rise based on the different reconstruction methods disagree by as much as 2 mm yr–1 before 1950 and on details of the variability (Figure 3.14), all do indicate 18-year trends that were significantly higher than the 20th century average at certain times (1920–1950, 1990–present) and lower at other periods (1910–1920, 1955–1980), likely related to multi-decadal variability. Several studies have suggest­ed these variations may be linked to climate fluctuations like the Atlan­tic Multi-decadal Oscillation (AMO) and/or Pacific Decadal Oscillation (PDO, Box 2.5) (Holgate, 2007; Jevrejeva et al., 2008; Chambers et al., 2012), but these results are not conclusive.

While technically correct that these multi-decadal changes represent acceleration/deceleration of sea level, they should not be interpreted as change in the longer-term rate of sea level rise, as a time series longer than the variability is required to detect those trends. Using data extending from 1900 to after 2000, the quadratic term computed from both individual tide gauge records and GMSL reconstructions is signif­icantly positive (Jevrejeva et al., 2008; Church and White, 2011; Rahm­storf and Vermeer, 2011; Woodworth et al., 2011). Church and White (2006) report that the estimated acceleration term in GMSL (twice the quadratic parameter) is 0.009 [0.006 to 0.012] mm yr–2 (1 standard deviation) from 1880 to 2009, which is consistent with the other pub­lished estimates (e.g., Jevrejeva et al., 2008; Woodworth et al., 2009) that use records longer than 100 years. Chambers et al. (2012) find that modelling a period near 60 years removes much of the multi-decadal variability of the 20th century in the tide gauge reconstruction time series. When a 60-year oscillation is modeled along with an accelera­tion term, the estimated acceleration in GMSL since 1900 ranges from: 0.000 [–0.002 to 0.002] mm yr–2 in the Ray and Douglas (2011) record, 0.013 [0.007 to 0.019] mm yr–2 in the Jevrejeva et al. (2008) record, and 0.012 [0.009 to 0.015] mm yr–2 in the Church and White (2011) record. Thus, while there is more disagreement on the value of a 20th century acceleration in GMSL when accounting for multi-decadal fluc­tuations, two out of three records still indicate a significant positive value. The trend in GMSL observed since 1993, however, is not signif­icantly larger than the estimate of 18-year trends in previous decades (e.g., 1920–1950).



**3.7.6 Conclusions**

It is virtually certain that globally averaged sea level has risen over the 20th century, with a very likely mean rate between 1900 and 2010 of 1.7 [1.5 to 1.9] mm yr–1 and 3.2 [2.8 and 3.6] mm yr–1 between 1993 and 2010. This assessment is based on high agreement among multi­ple studies using different methods, and from independent observing systems (tide gauges and altimetry) since 1993. It is likely that a rate comparable to that since 1993 occurred between 1920 and 1950, pos­sibly due to a multi-decadal climate variation, as individual tide gauges around the world and all reconstructions of GMSL show increased rates of sea level rise during this period. Although local vertical land motion can cause even larger rates of sea level rise (or fall) relative to the coastline, it is very likely that this does not affect the estimates of the global average rate, based on multiple estimations of the average with and without VLM corrections.

It is virtually certain that interannual and decadal changes in the large-scale winds and ocean circulation can cause significantly higher or lower rates over shorter periods at individual locations, as this has been observed in tide gauge records around the world. Warming of the upper 700 m of the ocean has very likely contributed an average of 0.6 [0.4 to 0.8] mm yr–1 of sea level change since 1971. Warming between 700 m and 2000 m has likely been contributing an additional 0.1 mm yr–1 [0 to 0.2] of sea level rise since 1971, and warming below 2000m likely has been contributing another 0.1 [0.0 to 0.2] mm yr–1 of sea level rise since the early 1990s.

It is very likely that the rate of mean sea level rise along Northern European coastlines has accelerated since the early 1800s and that this has continued through the 20th century, as the increased rate since 1875 has been observed in multiple long tide gauge records and by different groups using different analysis techniques. It is likely that sea level rise throughout the NH has also accelerated since 1850, as this is also observed in a smaller number of gauges along the coast of North America. Two of the three time series based on reconstructing GMSL from tide gauge data back to 1900 or earlier indicate a significant positive acceleration, while one does not. The range is –0.002 to 0.019 mm yr–2, so it is likely that GMSL has accelerated since 1900. Finally, it is likely that extreme sea levels have increased since 1970, largely as a result of the rise in mean sea level.

Chapter 9 Models

**The simulation of large-scale patterns of precipitation has improved somewhat since the AR4, although models continue to perform less well for precipitation than for surface tempera­ture.** The spatial pattern correlation between modelled and observed annual mean precipitation has increased from 0.77 for models availa­ble at the time of the AR4 to 0.82 for current models. At regional scales, precipitation is not simulated as well, and the assessment remains dif­ficult owing to observational uncertainties. {9.4.1, 9.6.1, Figure 9.6}

**The simulation of clouds in climate models remains challeng­ing.** There is very high confidence that uncertainties in cloud processes explain much of the spread in modelled climate sensitivity. However, the simulation of clouds in climate models has shown modest improve­ment relative to models available at the time of the AR4, and this has been aided by new evaluation techniques and new observations for clouds. Nevertheless, biases in cloud simulation lead to regional errors on cloud radiative effect of several tens of watts per square meter. {9.2.1, 9.4.1, 9.7.2, Figures 9.5, 9.43}