ADDENDUM TO THE
NORTH CAROLINA SEA-LEVEL RISE ASSESSMENT REPORT (NCSLRAR) OF 2010
April 4, 2012

(Corrected April 20, 2012, see Errata on page 9).

Background

The North Carolina Sea-Level Rise Assessment Report was published in March 2010 and is available at http://dcm2.enr.state.nc.us/news/2010%20Releases/slrreport.html. The Science Panel on Coastal Hazards prepared the report in consultation with additional coastal scientists working in the State and invited by the Division of Coastal Management to participate in the process.

In the Fall of 2011, the Science Panel on Coastal Hazards was asked to review the initial report and answer the following questions:

- ***Why does the report apply the Duck gauge, which has the highest rate and shortest record, to the entire coast? Why not use Wilmington for the south?***
- ***Why is acceleration expected this century when past data shows none?***
- ***Why does the report accept the IPCC's AR4 emissions and temperature projections but not its SLR projections?***
- ***How does updated work by Rahmstorf, Church & White, and others affect the Panel's assessment?***

In the following sections, these questions are addressed individually.

Why does the report apply the Duck gauge, which has the highest rate and shortest record, to the entire coast? Why not use Wilmington for the south?

There are four long-term (period greater than 30 years) tide gauges currently operational along the North Carolina Atlantic coast: Duck (established 1977), Oregon Inlet Marina (established 1974), Beaufort (established 1964), and Wilmington (established 1908). NOAA reports sea level trends for Oregon Inlet, Beaufort, Wilmington, and Southport (established 1974, removed 2008). These stations (Oregon Inlet, Beaufort, Wilmington, and Southport) fit the stated criteria of consisting of data records longer than 30 years as of 2006 (http://tidesandcurrents.noaa.gov/sltrends/index.shtml).

The Duck gauge was chosen to evaluate sea level trends for three reasons: (1) because it is on the open coast, (2) it is the least disturbed by anthropogenic processes, and (3) it has a solid, well-documented installation and continuous operational history. The Duck gauge has never been abandoned and with time, will improve as a long-term source of relative SLR data.

The Wilmington, Beaufort and Oregon Inlet sites have undergone an increase in tidal range due to widening and deepening of nearby navigation channels (Zervas, 2003, 2004); thus the records have added uncertainties that have not been fully quantified. Additional research is needed to evaluate the effects of the channel modifications.

Relative sea-level rise reported by Zervas (2004) is 4.27 ± 0.74 mm/yr and 2.12 ± 0.23 mm/yr at Duck and Wilmington, respectively. The northeast NC coastal segment (north of Cape Lookout, approximately), exhibits relative SLR (RSLR) rates that are higher than those to the south due to several geological factors (underlying geologic framework, isostatic adjustments, etc.) (Peltier, 2004; Mallinson et al., 2005, 2008, 2010; Horton et al., 2009; Kemp et al., 2009). Kemp et al. (2011) incorporate a 1 mm/yr subsidence factor due to glacio-isostatic adjustment (GIA) in their work in North Carolina, to compute a detrended sea-level curve from salt marsh sedimentary sequences. This curve approximates global sea-level rise over the last 2000 years.

The rate that is used clearly impacts the lower estimate (assuming no acceleration) of sea-level rise in 2100 as reported in NCSLRAR. Since the Duck rate is approximately double that of the Wilmington rate, the rise in sea-level is also double for the same time period. The mid-range and upper curves are developed based on projections that assume increased temperature and ice sheet melt will cause an increase in the rise of sea-level to 1 m and 1.4 m by 2100, respectively. The initial rate influences the shape of the curve and thus intermediate (shorter time frame) projections. In future studies, local tide gauge data may be incorporated to establish regional gradients in the rate of relative sea-level rise with greater confidence. The panel may consider how best to present the variation in RSLR within the State's coastal system in a future revision of the NCSLRAR.

Why is acceleration expected this century when past data shows none?

The question of whether or not SLR is *currently* accelerating is a valid question that warrants continued research and is the primary reasoning behind the Science Panel's request to update the NC SLR Assessment Report every five years.

The current literature reports a range of global rates of sea-level rise and change in the rate of sea-level rise for different time periods using a variety of data sources and analysis techniques. These are summarized in Tables 1 and 2 below. Change of rate in sea-level rise from a smaller to a larger value in subsequent time periods supports the view that acceleration (positive acceleration) has taken place. Conversely, change in rate of sea level rise from a larger to a smaller value in subsequent time periods supports the view that deceleration (negative acceleration) has taken place.

The longer records (greater than 125 years) uniformly support a positive change in the rate (or acceleration) of sea-level rise. It is generally noted in the literature that an acceleration in the rate of sea level rise occurred between the nineteenth and twentieth centuries. It is also possible to break the tide record into decadal periods and observe a change in the rate of sea-level rise. Both acceleration and slight deceleration have been reported in the literature.

Further, it is important to separate the SLR record from the last century from the expectation of an increase in the rate of acceleration over the next century. Expectations of an increase in the rate of sea-level rise in this century are based primarily on projections of increases in temperature (IPCC 2007) and increasing rates of glacial ice melting (e.g., Wouters et al., 2008, Slobbe et al., 2009, Velicogna 2009, Cazenave and Llovel, 2010, Rignot 2011). Given that the contribution to SLR from land ice loss has increased since 1993, and the thermal models and observations indicate increasing temperatures in the future, it is reasonable to expect an acceleration in the rate of SLR over the next century. However, it is still unclear from the existing data if the expected acceleration has begun.

Table 1. Global Rates of Sea-Level Rise

Author	Data Source	Data Period	Rate, mm/yr	Uncertainty ± mm/yr
Gehrels et al., 2008	Foraminiferal	1500-1900 1900-2000	0.3 2.8	0.3 0.5
Kemp et al., 2011	NC data: Salt marsh sedimentary sequences with GIA adjustment of 1.0 mm/yr	BC 100-AD 950 950-1350 1350-1900 1900-present	Stable (0.0 to 0.1) 0.4 to 0.8 Stable to slightly falling (0.0 to -0.2) 1.9 to 2.2	
Ablain et al., 2009	Satellite altimetry	1993-2008	3.11	0.6
Cazenave & Llovel, 2010	Tide gauge	1900-1930 1993-2008	1.8 3.4	0.3 0.4
Merrifield et al., 2009	Tide gauge	1962-1990 1993-2007	1.5 3.2	0.5 0.5
Holgate, 2007	Tide gauge	1904-1953 1954-2003	2.03 1.45	0.35 0.34
IPCC, 2007	Tide gauge Satellite altimetry	1962-2003 1993-2002	1.8 3.1	0.5 0.7

Table 2. Reported Acceleration of Global Sea Level Rise

Author	Data Source	Data Period	Acceleration mm/yr^2	Uncertainty ± mm/yr^2
Church & White, 2006	Tide gauge	1870-2004	0.013	0.006
Church & White, 2011	Tide gauge	1880-2009 1900-2009	0.009 0.009	0.003 0.004
Jevrejeva et al., 2008	Tide gauge	Since 1800	0.01	
Douglas, 1992	Tide gauge	1905-1985	-0.011	0.012
Houston & Dean, 2011	Tide gauge	variable 1930 - 2010	-0.0014 -0.0123	0.0161 0.0104

Why does the report accept the IPCC's AR4 emissions and temperature projections but not the SLR projections?

IPCC AR4 (2007) emissions and temperature projections have been shown to be relatively accurate, with observed temperature increase following the maximum rate of the projected increase (Rahmstorf et al., 2007; Horton et al., 2008). The IPCC decided not to include estimates of future land-based ice loss, primarily from the Greenland and Antarctic ice sheets, in the projections. In addition, the relatively simple treatment of land ice dynamics in the climate models precluded simulation of rapid dynamics. Ice sheets were treated as fixed geographic features that could gain and lose mass through accumulation and ablation, but would not otherwise change size or undergo variations in flow. It has since been shown that the contribution of melting ice sheets (the cryosphere) to SLR is increasing and will likely be a significant contributor to SLR during the 21st century (Rignot et al., 2011). Thus, our understanding has evolved since 2007, and will continue to evolve as new data become available and vetted through the peer-review process.

How does updated work by Church & White, Rahmstorf, and others affect the Panel's assessment?

Church and White (2006) used a reconstruction of global mean sea level from 1870 through 2004 and found a twentieth century sea-level rise of 1.7 ± 0.3 mm/yr and an acceleration of 0.013 ± 0.006 mm/yr^2. In Church and White (2011) a variety of rates are computed using various sources and time frames. For example, satellite altimeter data for 1993-2009 yielded an estimated 3.2 +/-0.4 mm/yr rate while coastal and island sea-level measurements from 1880 to 2009 were used to compute a rate of 1.7 ±0.2 mm/yr between 1900 and 2009 and 1.9 ±0.4 mm/yr from 1961 to 2009. Acceleration from 1880 and 1900 to 2009 is found to be 0.009±0.003 mm/yr^2 and 0.009±0.004 mm/yr^2, respectively. Though the rates of sea-level rise are similar in the two papers, the 2011 estimate of acceleration is lower than the 2006 and is more in line with other investigators (Table 2). Further, in the discussion section of the 2011 paper the authors emphasize the importance of maintenance and continuation of the observing network and associated infrastructure needed to update and maintain datasets. They note the increasing importance of GPS measurements at tide-gauge location to provide vertical land motion estimates and the continued need for high quality satellite altimeter observations.

Rahmstorf (2007) developed a semi-empirical relation that connects global sea-level rise to global surface temperature. The rate of sea-level rise is determined to be proportional to temperature (3.4 mm/yr of sea-level rise per 1^{o}C of temperature rise). Using this relationship and applying the IPCC future warming scenarios, 0.5 to 1.4 m of sea-level rise is projected in 2100 above the 1990 level. In Rahmstorf, Perrette and Vermeer (2011) the robustness of the projections is tested by 1) determining the parameters for the semi-empirical relationship between temperature and sea-level rise from a variety of datasets, equations and statistical techniques and 2) by comparing projections from the models for a moderate warming period (1.8^{o}C) from 2000 to 2100. Over 20 different model versions were tested and nine different projections were made. Using a 1.8^{o}C temperature scenario, approximately 1 m of sea-level rise is projected from 2000-2100. Two exceptions are noted. One is that disregarding the correction for water storage lowers the projections by 25 cm. (Note: building artificial reservoirs lowers sea level rise and pumping groundwater raises sea level). Two is the use of the Church and White (2011) data set lowers the projections 30 cm when compared to the use of other datasets (Church and White (2006) and Jevrejeva et al. (2008).

Table 3 presents sea-level rise projections from the literature, including the IPCC (2007), Rahmstorf (2007) and Rahmstorf et al. (2011) as well as others. The Panel's assessment indicated a range of expected SLR projections over the next century. The updated information on detection of more modest rates of acceleration in the historical record and the updated information based on more refined projection models confirm the Panel's recommendation for the need to update on a 5 year basis. The analysis and synthesis of data and development of predictive models by the research community, as evidenced in the peer reviewed literature will continue and as a result our understanding of sea level rise and its prediction will improve. Further, comments in Church and White (2011) as well as in Woodworth et al. (2011) support the Panel's position that high quality data sets with good spatial and temporal coverage are needed to support sea-level rise studies.

Table 3. Projections of global sea level rise.

Author	Projected period	Range, cm
Rahmstorf, 2007	1990-2100	50 to 140
IPCC, 2007 (Six scenarios based on different temperature projections.)	1980-1999 to 2090-2099	18 to 38[*] 20 to 43[*] 21 to 48[*] 20 to 45[*] 23 to 51[*] 26 to 59[*]
Vermeer & Rahmstorf, 2009	1990-2100	75 to 190
Rahmstorf et al., 2011	2000-2100	80 to 120[**]
Jevrejeva et al., 2010	2000-2100	60 to 160
Horton et al., 2008	2000-2100	47 to 100
Grinsted et al., 2009	2000-2100	90 to 130
Jevrejeva et al., 2012	2000-2100	57 to 110

[*] If ice discharges were to scale up in the future, it would add 10 to 20 cm to the upper bound of sea-level rise in the IPCC projections (IPCC, 2007).

[**] Exceptions as noted from Rahmstorf et al. (2011) are described in the above paragraph.

Summary

It is helpful to put the North Carolina SLR Assessment Report into perspective. Many scientific organizations in the United States and worldwide have issued statements regarding the importance of global climate change. An acceleration in the rate of sea level rise is an explicit or implicit concern of all. These include 1) American Association for the Advancement of Science (AAAS, 2006); 2) Research Council of the National Academies (2011); 3) Geological Society of America (GSA, 2010); 4) American Geophysical Union (AGU) 2012; and 5) European Geosciences Union (EGU, 2005).

In addition, SLR assessments produced by expert panels in other states reference numbers very similar to those in the North Carolina SLR Assessment Report. Maine is establishing plans to deal with the impacts of a 0.5, 1.0 and 2.0 m rise by 2100 (EPA, 1995). Delaware is adopting management plans for sea-level rise scenarios of 0.5, 1.0 and 1.5 m by 2100 (DNREC, 2009). The Louisiana Applied Coastal Engineering and Science (LACES) Division produced a comprehensive report in which they recommend that Coastal Protection and Restoration Authority staff assume a SLR of 1 m by 2100 for the Gulf coast, with lower and upper bounds of 0.5 and 1.5 m (LACES, 2012). The California State Lands Commission is preparing for a projected sea-level rise of 1.4 m (55 inches) by 2100 (CSLC, 2009). Southeast Florida is projecting a 9 to 24 inch rise by 2060 (SEFRCCC, 2011). Further, the U.S. Army Corps of Engineers requires that potential sea level rise changes must be considered in all USACE coastal activities (USACE, 2011). These states and organizations are concerned with the implications of a rising sea level, even if the magnitude of the rise is uncertain.

This document is intended to clarify the questions asked about the Science Panel's first SLR Assessment Report. Based on this review, the broad recommendations of the original report stand. As recommended, the next anticipated update is in 2015.

References

Ablain M, A. Cazenave, G. Valladeau, S. Guinehut, 2009. A new assessment of the error budget of global mean sea level rate estimated by satellite altimetry over 1993–2008. *Ocean Sci.* 5:193–201

American Association for the Advancement of Science (AAAS), 2006. *AAAS Board Statement on Climate Change*. Approved by the Board of Directors http://www.aaas.org/news/releases/2009/media/1021climate_letter.pdf

American Geophysical Union (AGU), 2012. *Humans Impact Climate, and the Scientific Community has the Responsibility to Educate and Communicate the Implications of Climate Change to the Public and Policy Makers.* Position Statement, initially adopted December 2003; Revised and Reaffirmed December 2007, February 2012. http://www.agu.org/sci_pol/pdf/position_statements/AGU_Climate_Statement.pdf

(CSLC) California State Lands Commission, 2009. A Report on Sea Level Rise Preparedness. 62 pp. http://www.slc.ca.gov/reports/sea_level_report.pdf

Cazenave, A. and W. Llovel, 2010. Contemporary Sea Level Rise. Annu. Rev. Mar. Sci. 2:145-173.

Church JA, N.J. White, 2006. A 20th century acceleration in global sea-level rise. *Geophys. Res. Lett.* 33:L01602, doi:10.1029/2005GL024826Church, J.A., and N.J. White, 2011. Sea-level rise from the late 19th to the early 21st century. Surv. Geophys. 32:585-602.

Douglas, B.C., 1992. Global sea level acceleration. Journal of Geophysical Research, 97(C8), 12699–12706.DNREC, 2009. Recommended Sea Level Rise Scenarios for Delaware. Delaware Department of Natural Resources and Environmental Control report. 13 pp. http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/Final%20and%20Signed%20DNREC%20SLR%20scenarios.pdf

European Geosciences Union (EGU), 2005. *EGU Position Statement on Climate Change and Recent Letters from the Chairman of the U.S. House of Representatives Committee on Energy and Commerce*, European Geosciences Union, Divisions of Atmospheric and Climate Sciences, 7 July 2005. http://www.egu.eu/statements/position-statement-of-the-divisions-of-atmospheric-and-climate-sciences-7-july-2005.html

(EPA) Environmental Protection Agency, 1995. Anticipatory Planning for Sea-Level Rise Along the Coast of Maine. http://papers.risingsea.net/federal_reports/maine_0.pdf

Gehrels, W.R., B.W. Hayward, R.M. Newnham, and K.E. Southall, 2008. A 20th century acceleration of sea-level rise in New Zealand. Geophysical Research Letters 35, L02717.

Geological Society of America (GSA), 2010. *Climate Change*. Position Statement, Adopted in October 2006; revised April 2010. http://www.geosociety.org/positions/position10.htm

Grinsted, A., J. C. Moore, and S. Jevrejeva, 2010. Reconstructing sea level from paleo and projected temperatures 200 to 2100 AD, Clim. Dyn., 34, 461–472, doi:10.1007/s00382-008-0507-2.

Holgate, S., S. Jevrejeva, P. Woodworth, and S. Brewer, 2007. Comment on ‘‘A semi-empirical approach to projecting future sealevel rise.’’ Science, 317,1866.

Horton R, C. Herweijer, C. Rosenzweig, J. Liu, V. Gornitz, and A.C. Ruane, 2008. Sea level rise projections from current generation CGCMs based on the semi-empirical method. *Geophys. Res. Lett.* 35:L02715,doi:10.1029/2007GL032486

Horton, B.P., Peltier, W.R., Culver, S.J., Drummond, R., Engelhart, S.E., Kemp, A.C., Mallinson, D., Thieler, E.R., Riggs, S.R., and Ames, D.V. 2009. Holocene sea-level changes along the North Carolina coastline: implications for glacial adjustment models and current rates of sea-level change. Quaternary Science Reviews 28, 1725-1736.

Houston, J.R., and R.G. Dean, 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. Journal of Coastal Research 27: 409-417.

IPCC. 2007. *Fourth Assessment Report (AR4), Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. S Solomon et al. Cambridge, UK: Cambridge Univ. Press

Jevrejeva, S., J. C. Moore, A. Grinsted and P. L. Woodworth, 2008. Recent global sea level acceleration started over 200 years ago?, Geophys. Res. Lett., 35, L08715, doi:10.1029/2008GL033611.

Jevrejeva J.c. Moore, A. Grinsted, 2010. How will sea level respond to changes in natural and anthropogenic forcings by 2100? Geophysical Research Letters 37, L07703, doi:10.1029/2010GL042947

Jevrejeva J.c. Moore, A. Grinsted, 2012. Sea level projections to AD2500 with a new generation of climate change scenarios. Global and Planetary Change 80-81:14-20.

Kemp, A.C., B.P. Horton, S.J. Culver, D.R. Corbett, O. van de Plassche, W.R. Gehrels, B.C. Douglas, 2009. Timing and magnitude of recent accelerated sea-level rise (North Carolina, USA). Geology 2009 37: 1035-1038.

Kemp A, B. Horton, J. Donnelly, M.E. Mann, M. Vermeer, S. Rahmstorf, 2011. Climate related sea-level variations over the past two millennia. Proc Natl Acad Sci USA. doi:10.1073/pnas.10156 19108

(LACES) Louisiana Applied Coastal Engineering and Science Division, 2012. Recommendations for Anticipating Sea-Level Rise Impacts on Lousiana Coastal Resources During Project Planning and Design: Technical Report. 65 pp. http://www.lacpra.org/assets/docs/LACES/LACEStech02_06_12.pdf

Mallinson, D., S. Riggs, S. Culver, E.R. Thieler, D. Foster, D. Corbett, K. Farrell, J. Wehmiller, 2005. Late Neogene and Quaternary evolution of the northern Albemarle Embayment (Mid-Atlantic Continental Margin, USA). Marine Geology 217, 97-117.

Mallinson, D., K. Burdette, S. Mahan, G. Brook, 2008. Optically Stimulated Luminescence Age Controls on late Pleistocene and Holocene Coastal Lithosomes: North Carolina, USA. Quaternary Research 69, 97-109.

Mallinson, D., S. Culver, S. Riggs, E.R. Thieler, D. Foster, J. Wehmiller, K. Farrell, J. Pierson, 2010. Regional seismic stratigraphy and controls on the Quaternary evolution of the Cape Hatteras region of the Atlantic passive margin; USA. Marine Geology 268, 16-33.

Merrifield M. A., S.T. Merrifield, and G.T. Mitchum, 2009. An Anomalous Recent Acceleration of Global Sea Level Rise. Journal of Climate, vol. 22, pp. 5772-5781, DOI: 10.1175/2009JCLI2985.1.

National Research Council of the National Academies, 2011. *America's Climate Choices,* The National Academies Press, 500 Fifth Street, N.W., Washington, DC 20001, http://dels.nas.edu/Report/Americas-Climate-Choices/12781

Peltier,W.R., 2004. Global glacial isostasy and the surface of the ice-age earth: the ice-5G(VM2) model and grace. Annual Review Earth Planetary Science 32, 111–149.

Rahmstorf S. 2007. A semi-empirical approach to projecting future sea level rise. *Science* 315:368

Rahmstorf S, A. Cazenave, J. Church, J. Hansen, R. Keeling, D. Parker, R. Somerville, (2007) Recent climate observations compared to projections. *Science* 316:709.

Rahmstorf, S., M. Perrette, M. Vermeer, 2011. Testing the robustness of semi-empirical sea level projections. Climate Dynamics DOI 10.1007/s00382-011-1226-7.

Rignot E, I. Velicogna, M.R. van den Broeke, A. Monaghan, J. Lenaerts, 2011. Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise. Geophys Res Lett 38:L05503. doi:10.1029/2011gl046583

Slobbe DC, P. Ditmar, and R.C. Linderbergh, 2009. Estimating the rates of mass change, ice volume change and snow volume change in Greenland from ICESat and GRACE data. *Geophys. J. Int.* 176:95–106

(SEFRCCC) Southeast Florida Regional Climate Change Compact Technical Ad hoc Work Group, 2011. A Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast

Florida Regional Climate Change Compact Steering Committee. 27 pp. http://www.southeastfloridaclimatecompact.org/documents/SLR.pdf

(USACE) US Army Corps of Engineers, 2011. Sea-Level Change Considerations in Civil Works Programs. Circular No. 1165-2-211, 32 pp. http://planning.usace.army.mil/toolbox/library/ECs/EC11652212Nov2011.pdf

Velicogna, I., 2009. Increasing rates of ice mass loss from the Greenland and Antarctic ice Sheets revealed by GRACE. Geophysical Research Letters, vol. 36, L19503, 4pp. DOI: 10.1029/2009GL040222.

Vermeer, M. and S. Rahmstorf, 2009. Global sea level linked to global temperature. Proceedings of the National Academy of Sciences 106, 21527-21532.

Woodworth, P.L., M. Menedez, W. R. Gehrels, 2011. Evidence for Century-Timescale Acceleration in Mean Sea Levels and for Recent Changes in Extreme Sea Levels. *Surv Geophys*. 32:603-618.

Wouters B., D. Chambers, E.J.O. Schrama, 2008. GRACE observes small scale mass loss in Greenland. *Geophys. Res. Lett.* 35:L20501, doi: 10.1029/2008GL034816

Zervas, C.E., 2003. Long term changes in tidal response associated with the deepening of navigational channels, *Proceedings, Coastal Zone 03: Coastal zone management through time*, Baltimore, MD, July 13-17, 2003, NOAA Coastal Services Center.

Zervas, C. 2004. North Carolina bathymetry/topography sea level rise project: determination of sea level trends. NOAA Technical Report NOS CO-OPS 041.

Additional Bibliography on Sea Level Rise:

Church, J.A., N.J. White, L.F., Konikow, C.M. Domingues, J.G. Cogley, E.Rignot, J.M. Gregory, M.R. van den Broeke, A.J. Monaghan, and I. Velicogna, 2011. Revisiting the Earth's sea-level and energy budgets from 1961 to 2008. Geophysical Research Letters 38, doi:101029/2011GL048794.

Domingues, C.M., J.A. Church, N.J. White, P.J. Gleckler, S.E. Wijffels, P.M. Barker and J.R. Dunn, 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise. *Nature*, 453, 1090-1094, doi:10.1038/nature07080

Douglas, B.C., 2008, Concerning evidence for fingerprints of glacial melting: Journal of Coastal Research, v. 24, p. 218–227, doi:0.2112/06-0748.1

Hansen, J., M. Sato, P. Kharecha, and K. von Schuckmann, 2011 Earth's energy imbalance and implications. Atmospheric Chemistry and Physics 11, 13421-13339.

Leuliette, E.W. and Miller, L. 2009. Closing the sea level rise budget with altimetry, Argo, and GRACE. *Geophysical Research Letters* 36: 10.1029/2008GL036010.

Meier, M.F., M.B. Dyurgerov,U.K. Rick, S. O'Neel, W.T. Pfeffer, R.S. Anderson, S.P. Anderson, A.F. Glazovsky, 2007. Glaciers dominate eustatic sea-level rise in the 21st century. Science 317, 1064-1067.

Mitchum, G.T., 2011. Sea Level Changes in the Southeastern United States: Past, Present, and Future. Florida Climate Institute, Southeast Climate Consortium. 20 pp. http://www.seclimate.org/pdfpubs/201108mitchum_sealevel.pdf

Rahmstorf S., (2007b) Response to comments on ''A semi-empirical approach to projecting future sea-level rise''. Science 317 (5846).doi:10.1126/science.1141283Rahmstorf, 2011

Rahmstorf S, M. Vermeer, 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. J Coast Res 27:784–787

Schmith T, S. Johansen S, and P. Thejll, 2007. Comment on ''a semiempirical approach to projecting future sea-level rise.'' *Science* 317:1866c.

Woodworth, P.L., N.J. White, S. Jevrejeva, S.J. Holgate, J.A. Church, and W.R. Gehrels, 2009. Evidence for the accelerations of sea level rise on multi-decade and century timescales. International Journal of Climatology, 29, 777–789, doi:10.1002/joc.1771.

Other Assessment Reports:

http://www.floridaoceanscouncil.org/reports/Climate_Change_and_Sea_Level_Rise.pdf

http://www.seclimate.org/pdfpubs/201108mitchum_sealevel.pdf

http://coastal.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=240

http://www.lacpra.org/assets/docs/LACES/LACEStech02_06_12.pdf

http://epa.gov/climatechange/effects/coastal/sap4-1.html

http://epa.gov/climatechange/effects/coastal/pdfs/SAP_4-1_SynthesisandAssessmentProduct.pdf

Significant links:

http://sealevel.colorado.edu/

http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/

http://climate.nasa.gov/keyIndicators/index.cfm#seaLevel

http://rads.tudelft.nl/rads/rads.shtml

http://www.aviso.oceanobs.com/

http://www.cmar.csiro.au/sealevel/index.html

http://www.cmar.csiro.au/sealevel/sl_data_cmar.html

http://grace.jpl.nasa.gov/

http://www.psmsl.org/

http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/LSA_SLR_timeseries_global.php

http://tidesandcurrents.noaa.gov/sltrends/index.shtml

Errata:

1. The acceleration reported for Church and White 2006 in Table 2 was erroneously reported as 0.13 mm/yr^2. The correct acceleration is 0.013 mm/yr^2.
2. Corrected a formatting error in the References section for Holgate *et al.* 2007.