

On Sea Levels and Global Temperature Anomalies

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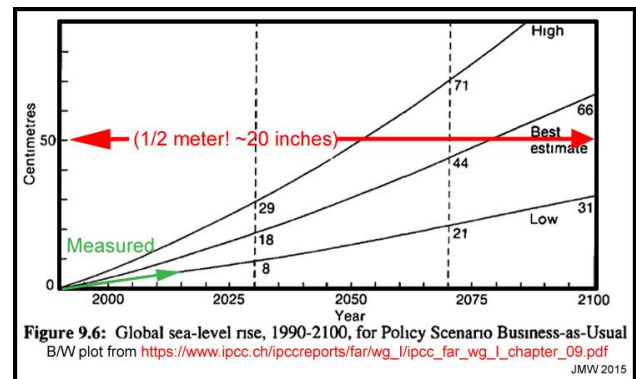
ABSTRACT

Global sea level behavior is addressed in terms of changes since the last ice age and evaluated in the context of IPCC projections. The NOAA satellite sea level data of the past 20 years is put into perspective with the past 100-year historical data. The seas have been rising for a 100 years. There is no increasing rate of sea level rise with time now, only an offset of data set rates. The current/projected GTA change is compare to the 7.6°C GTA change that led to the 112+ meter sea-level rise since the last ice age.

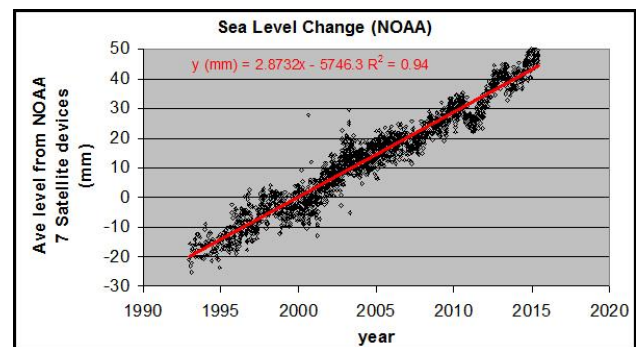
One of the concerns about extraordinary global warming due to increased CO₂ in the atmosphere is an undesirable increase in the level of the seas:

"One of the most significant potential impacts¹ of climate change is sea level rise that may cause inundation of coastal areas and islands, shoreline erosion, and destruction of important ecosystems such as wetlands and mangroves. As global temperatures increase, sea level rises due to a thermal expansion of upper layers of the ocean and melting of glaciers and ice sheets."

The figure on the right demonstrates that concern as presented in the IPCC report². This figure shows the estimates (High, Best, and Low) predictions for "Business-as-Usual". (Annotations in color are by the author.) The "High", of course, is the eye-catcher with eventual sea levels being many meters above the current level. The "Best" is modest with just a 2/3-meter rise in 85 years. Consider, however, the *Scientific American* article³ (published on July 9, 2015) that blares "Sea Level Could Rise at Least 6 Meters" - "even if global warming is limited to 2°C"! Headlines have to be outrageous to grab attention anymore.



Current "measured" levels⁴ (the green arrow in the figure above and the figure to the right) follow the "Low" estimate and would hardly seem to justify the great clamor/protest being raised. The ability satellite data collection to measure the sea level to ~1mm is indeed remarkable. One would guess that these values are the average of many (100s, 1000s, 1000000s?) datum. Still remarkable. But, does this 20-year plot present an accurate imagery of enormous rates of risings in the future? Note that, while the sea level is rising, **the rate of sea level rise is NOT increasing; the rate of sea level change is fairly constant and linear ($R^2 = 0.94$)!** How does this rate relate to how sea levels have changed in the past 100 years?



¹ <http://www.star.nesdis.noaa.gov/sod/lsa/SeaLevelRise/>

² https://www.ipcc.ch/ipccreports/far/wg_i/ipcc_far_wg_i_chapter_09.pdf

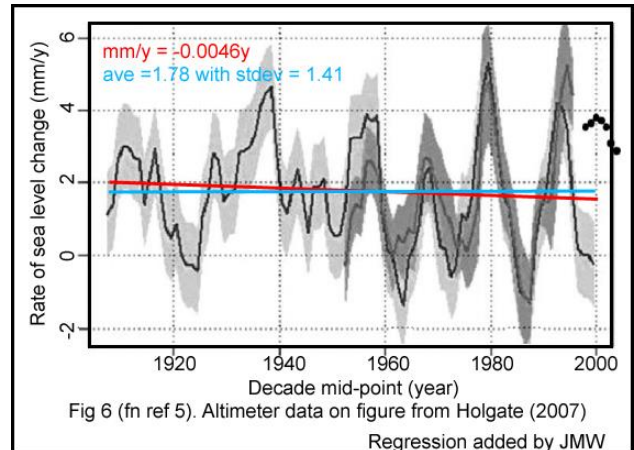
³ Kahn, B and Climate Central, <http://www.scientificamerican.com/article/sea-level-could-rise-at-least-6-meters/>

⁴ http://www.star.nesdis.noaa.gov/sod/lsa/SeaLevelRise/slr/slr_sla_gbl_free_all_66.csv

A 2011 report⁵ on the coastal levels of the US summaries that there have been

"decadal oscillations over the past 100 years, and it is not possible to determine if the increased trend measured by the altimeters is the leading edge of acceleration or merely a typical decadal oscillation". (The 10-20y oscillations have been from +5 to -1 mm/y - see figure on the right; the authors of the report added the altimeter data to the plot as dots around y2000.) The decelerations that we obtain are opposite in sign and one to two orders of magnitude less than the +0.07 to +0.28 mm/y² accelerations that are required to reach sea levels predicted for 2100"

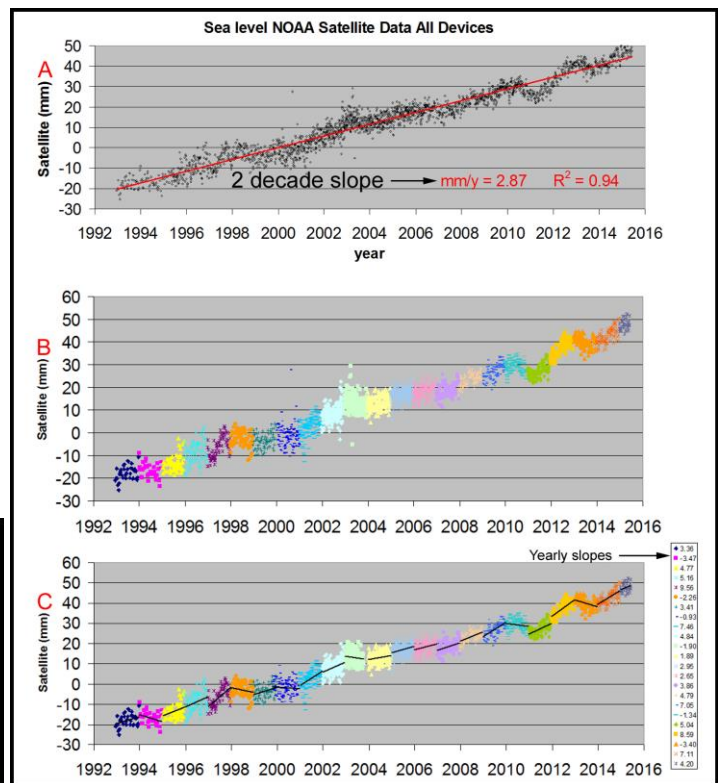
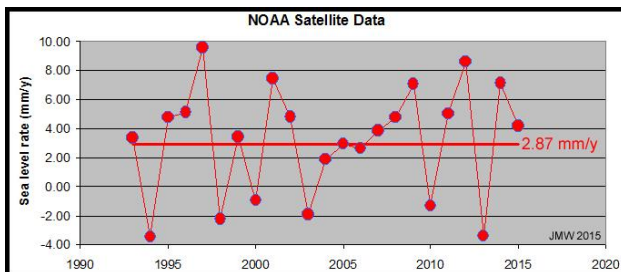
[The slightly negative slope of the regression line is hardly different than the "no change" average slope or even a slight positive slope. Without a sufficient number of decades to indicate the contrary, the currently acquired satellite sea level change data are nothing more than would be expected from normal oscillations.]



The report summary also concludes that

"it is essential that investigations continue to address why this worldwide-temperature increase (1906 to 2005 of 0.74°C)⁶ has not produced acceleration of global sea level over the past 100 years, and indeed why global sea level has possibly decelerated for at least the last 80 years."

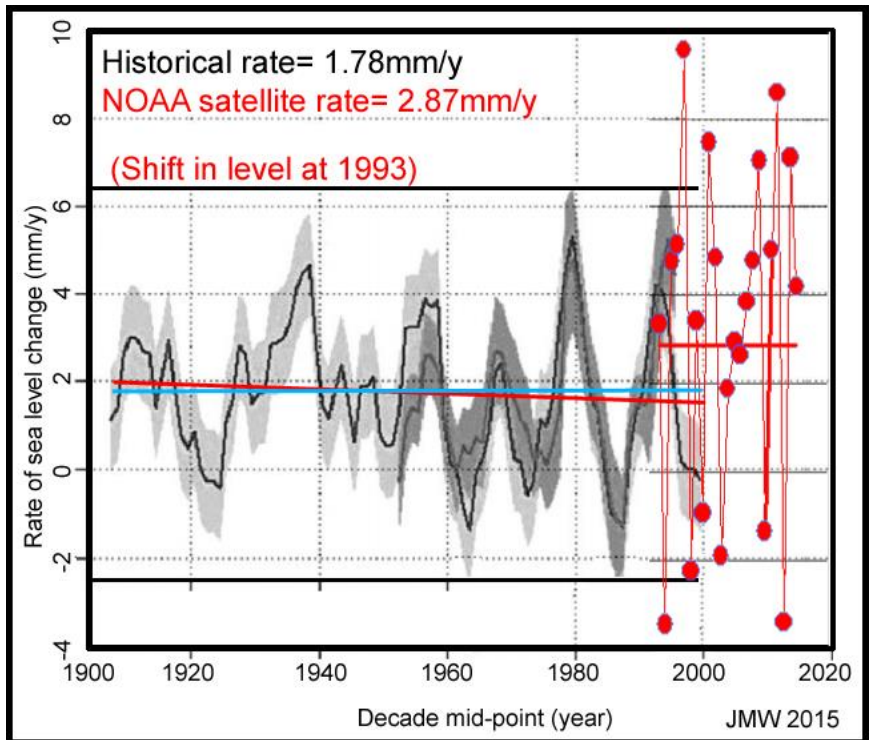
Following the lead of Houston and Dean, the NOAA satellite sea level data set has been evaluated by determining its yearly oscillations. The process is illustrated in the figure on the right. Yearly bins were from (y-1).96 to y.97 to include the first datum. The data⁴ contained some spurious points in the 2000-2004 range (see figure plot B) that were removed before the slope analyses. Only the 2011 region had an obvious hump, thus a linear regression was applied to the yearly ranges. The yearly slopes are given in the legend of part C and plotted below.



⁵ Houston, JR and Dean, RG, "Sea-Level Acceleration Based on U.S. Tide Gauges and Extensions of Previous Global-Gauge Analyses", J Coastal Research, 27 (3), 409–417 May 2011, <http://www.jcronline.org/doi/pdf/10.2112/JCOASTRES-D-10-00157.1>

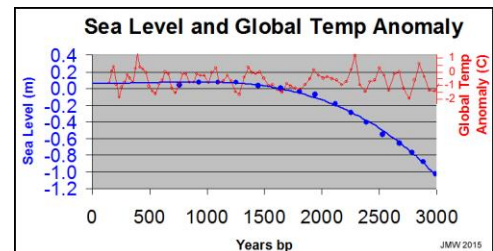
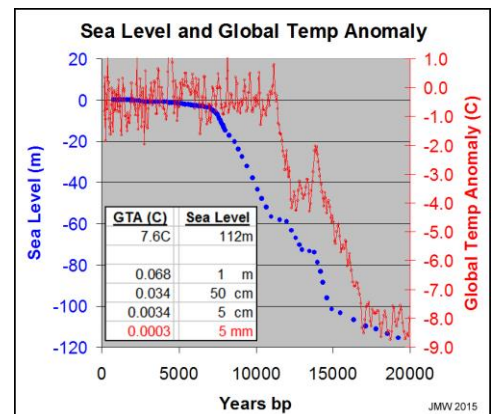
⁶ Bindoff et al. (2007); **In:** Solomon, S., et al. (eds.), *Climate Change 2007: The Physical Science Basis, Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press

The yearly NOAA satellite sea level rate changes have been added to the Holgate plot (shown earlier) in the figure on the right. The satellite rates are more variable than the historical ones. The difference between the two data sets is a change from the historical 1.78 mm/y to 2.87 mm/y in 1993. Both data sets indicate a positive and constant increase in sea level with time! The seas have been rising for the past 100 years! It is doubtful that there was a "real" (abrupt!) increase in 1993 to a new, constant behavior with the introduction of satellite monitoring; only a data set rate change in the overlap.



This brings up the question of just what is the relationship of global temperature anomaly and sea level. The figure on the right gives an association of the two for the most recent 20,000 years. The red "global temperature anomaly" (GTA) data are from the Vostok ice cores⁷. The blue "sea level" data has been digitized from two web sources: 0-7,000 bp⁸ and 7,000-20,000 bp⁹.

While the GTAs have fluctuated $\pm 1^\circ\text{C}$ or so for the past 11,000 years, the mean GTA has been fair constant. The previous 9,000 years changed by 7.6°C . Meanwhile, during this great global warming, the sea level rose 112 meters. Of course, there was a large lag-time between this global warming and the rise in the sea level. But, by 1000 years ago with global temperatures comparable (many warmer) to those current for 10,000 years, the seas had risen to today's level (figure on the right). Are we to believe that the seas will rise 6 meters more in the next 50-100 years after all of this past warming of the globe? Not even the IPCC's "High" with a "Business-as-Usual" scenario predicted that (first figure in this article).

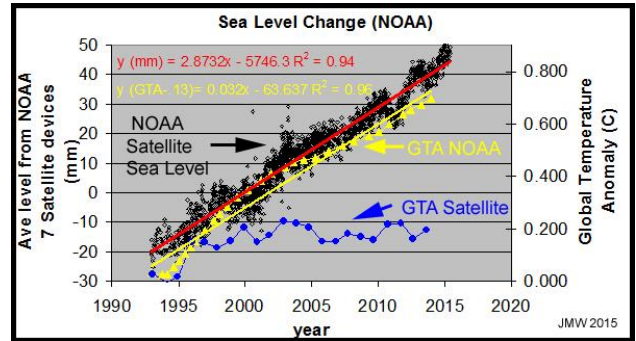


⁷ The data available from CDIAC represent a major effort by researchers from France, Russia, and the USA; Jouzel and others in these refs - Nature 329:403-8 (1987), Nature 364:407-12 (1993), Nature 399: 429-436 (1999) and Climate Dynamics 12:513-521 (1996); <http://cdiac.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat>

⁸ https://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png#/media/File:Holocene_Sea_Level.png

⁹ https://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png

Allowing that a global temperature anomaly of 7.6°C was related to the 112 meter rise in the global sea level (5 mm/y per 0.00034°C), it seems logical that changes in the annual global temperature anomaly would be in the noise for the current situation where the sea level oscillates around a 1.78-2.87 mm/y value. This is what the GTA satellite data would indicate: no difference for the past 18 years (figure on the right). The NOAA land-ocean global temperature anomaly⁴, on the other hand, parallels the current sea level change with a ratio of 90 mm/y per 1°C. At 5 mm/y per 0.056°C, the NOAA relationship is 164x greater than the warming effect from the last ice age to the current climate.



In summary, the "measured" (satellite) sea level data set correlates well with the "Low", "Business-as-Usual", IPCC estimate, even if it is "modestly" higher than the historical data set. Predictions that sea levels will be less than 1/2 meter above current in 2100 are in order. Projections that the rise could be 6 meters (20 ft) are ridiculous and unfounded.