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Comparison of latest US and global tide gauge results with the IPCC AR4 sea level projections: The acceleration free US and world average tide gauges

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ABSTRACT

It is proposed here a compilation of US tide gauges with more than 70 years of measurements. The average sea level rise was 2.19 mm/year in 1999, 2.14 mm/year in 2006 and it is 2.14 mm/year in the last computation with data updated to 2011. This result is consistent with all the other compilations of tide gauges of enough length for other geographical areas as well as for the worldwide average tide gauge. The result is compared with the IPCC AR4 sea level projections. While the IPCC projections suppose the sea levels are positively accelerating at various rates, the US tide gauge results show a small negative acceleration.

KEYWORDS

Sea level rise;
Sea level acceleration;
Tide gauge measurements;
Satellite reconstructions;
Computations.

INTRODUCTION

Despite the claims that the sea level accelerates because of ocean warming and expansion and glacier melting, everything measured when properly analysed shows the lack of any acceleration[1-3, 6-11, 13-17, 21-24].

As already written many times[13-17], sea levels around the world are certainly rising, but absolutely not accelerating. Different claims follow the lack of data, for example almost one half of the oceans, the Pacific, has no tide gauge recording before the 1850, only 1 tide gauge recording in the second half of the 1800s, and still very scattered and insufficient coverage at the present time, the neglected naturally oscillating behaviour of the oceans exhibiting different periodicities, with the quasi-60 years periodicity introducing a minimum length of 60-70 years of continuous recording to infer a proper sea level velocity, the naturally oscillating behaviour of everything derived from tide gauge results including the time derivative of this velocity, the estimation of the error in the velocity and acceleration that is not the statistical error of the linear fitting.

If y is the monthly average mean sea level (MSL) and x is the time, by linear $y=a\cdot x+c$ fitting of the recorded monthly averaged mean sea levels xi, yi, the slope a indicates the sea level velocity (SLR) if an only if more than 60-70 years of data have been recorded at any time. The sea level acceleration (SLA) is then at any time the time rate of change of this velocity.

The analysis of the Maassluis and San Francisco tide gauges is proposed in Figure 1. Only the data 1900 to present are considered, being the research question if the sea levels are presently accelerating because of global warming and not if the sea levels are higher in the

1900s and 2000s than in the 1800s. Maassluis and San Francisco are only two of the tide gauges of enough length and quality exhibiting the same behaviour. The monthly average sea levels oscillate about the linear trend. The periodogram of these oscillations show many periodicities. The sea level velocity SLR evaluated as the slope of the linear fitting of all the data available at a certain time is a reasonable estimation of the long term trend only after more than 60-70 years. The acceleration SLA only oscillates about zero from small positive to small negative values over the last 2 decades that is the time window covered by the satellite radar altimetry. The average accelerations over the last 60 years is in magnitude is a negligible 1•10-6 m/years2. The sign may be positive or negative moving from a long term tide gauge to another.

From Figure 1, it is clear that a reasonable estimation of the sea level velocity may only be inferred from consideration of tide gauges having more than 70 years of recording at the present time, and the sea level acceleration SLA may be assessed as the time rate of change of these SLR between two subsequent updates.

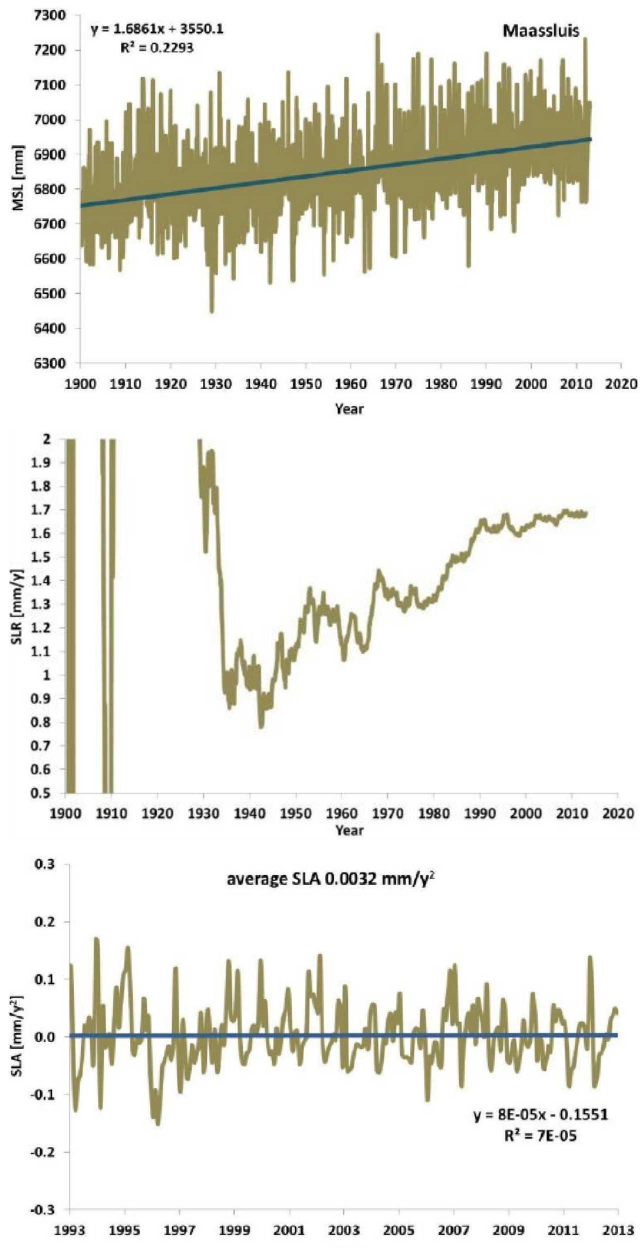

Figure 1 (a) : Analysis of the massluis tide gauge 1900-2013: mean sea level, sea velocity and sea acceleration

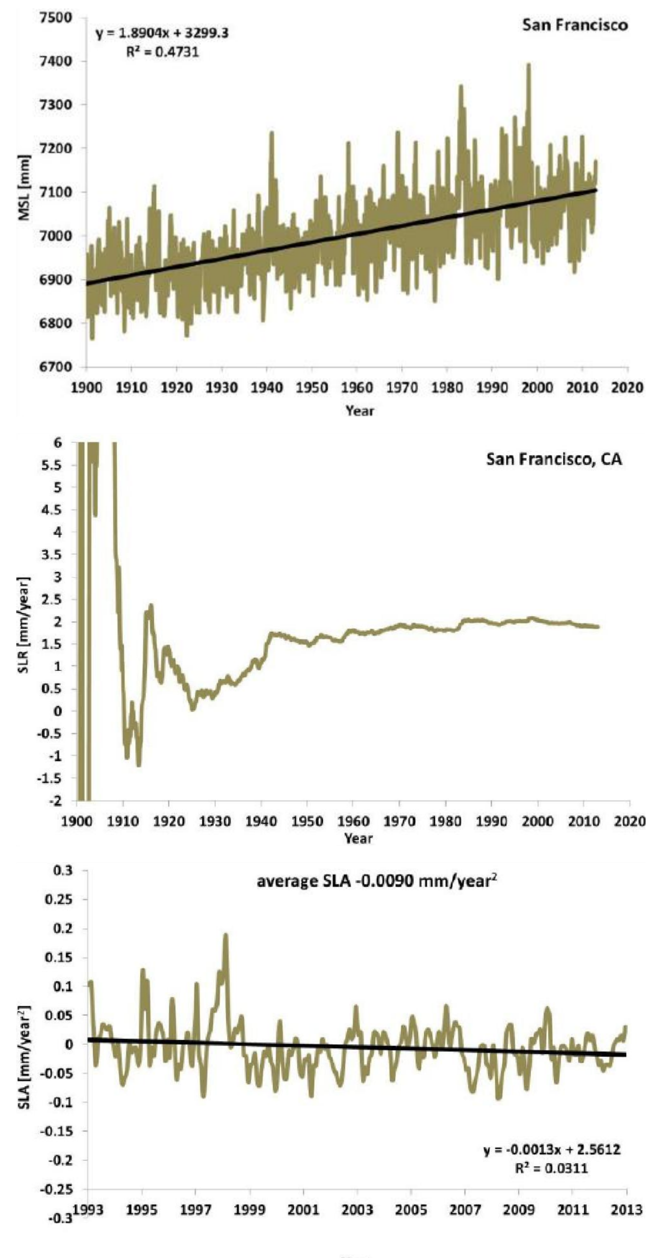

Figure 1 (b) : Analysis of the San Francisco tide gauge 1900-2013: mean sea level, sea velocity and sea acceleration

US AVERAGE TIDE GAUGE RESULTS

It is then proposed here in TABLE 1 a compilation of US tide gauges with more than 70 years of measurements. These data are proposed in[12] as well as in[18] with different updates. The data of[18] are used here. These data are analysed in[20] with the other global tide gauges of NOAA and other US tide gauges of shorter length. TABLE 1 presents the sea level rises computed for the 36 stations with data up to 1999, 2006 and 2011.

TABLE 1 : Sea level rise in the US tide gauges with more than 70 years of recording

Coast station	NOAA station	location	lat.	lon.	first	last	Inst.	To 2011 year range	To 2011 trend mm/y	To 2006 trend mm/y	To 1999 trend mm/y
960-121	8518750	The Battery, NY, USA	40.7	-74.015	1856-01	2012-07	05/24/1920	156	2.82	2.77	2.77
823-031	9414290	San Francisco, CA, USA	37.807	-122.465	1854-07	2012-07	06/30/1854	115	1.92	2.01	2.13
960-021	8720030	Fernandina Beach, FL, USA	30.672	-81.465	1897-05	2012-07	05/18/1898	115	2.00	2.02	2.04
823-011	9447130	Seattle, WA, USA	47.603	-122.338	1899-01	2012-07	01/01/1899	114	1.99	2.06	2.11
960-087	8545240	Philadelphia, PA, USA	39.933	-75.142	1989-10	2012-07	02/28/1989	112	2.91	2.79	2.75
960-081	8574680	Baltimore, MD, USA	39.267	-76.578	1902-07	2012-07	7/01/1902	110	3.12	3.08	3.12
760-031	1612340	Honolulu, HI, USA	21.307	-157.867	1911-05	2012-07	1/01/1905	107	1.42	1.50	1.5
823-081	9410170	San Diego, CA, USA	32.713	-117.173	1906-01	2012-07	01/26/1906	106	2.02	2.06	2.15
940-008	8771450	Galveston Pier 21, TX, USA	29.31	-94.793	1908-04	2012-07	1/01/1908	104	6.35	6.39	6.5
960-091	8534720	Atlantic City, NJ, USA	39.355	-74.418	1911-08	2012-07	08/15/1911	101	4.07	3.99	3.98
960-181	8418150	Portland, ME, USA	43.657	-70.247	1912-01	2012-07	3/04/1910	100	1.87	1.82	1.91
940-071	8724580	Key West, FL, USA	24.553	-81.808	1913-01	2012-07	01/18/1913	99	2.27	2.24	2.27
821-051	9450460	Ketchikan, AK, USA	55.333	-131.625	1918-11	2012-07	10/01/1919	93	-0.22	-0.19	-0.11
960-041	8665530	Charleston, SC, USA	32.782	-79.925	1856-01	2012-07	09/13/1899	91	3.09	3.15	3.28
960-171	8443970	Boston, MA, USA	42.355	-71.052	1921-01	2012-07	5/03/1921	91	2.77	2.63	2.65
823-051	9410660	Los Angeles, CA, USA	33.72	-118.272	1923-12	2012-07	11/28/1923	89	0.81	0.83	0.84
940-041	8729840	Pensacola, FL, USA	30.403	-87.213	1923-05	2012-07	04/30/1923	89	2.12	2.10	2.14
821-031	9451600	Sitka, AK, USA	57.052	-135.342	1938-06	2012-07	05/19/1938	88	-2.11	-2.05	-2.17
823-071	9410230	La Jolla, CA, USA	32.867	-117.258	1924-11	2012-07	8/01/1924	88	2.00	2.07	2.22
960-076	8594900	Washington, DC, USA	38.875	-77.023	1931-05	2012-07	11/10/1924	88	3.22	3.16	3.13
823-013	9439040	Astoria, OR, USA	46.208	-123.767	1925-02	2012-07	07/10/1853	87	-0.35	-0.31	-0.16
760-061	1617760	Hilo, HI, USA	19.73	-155.057	1946-12	2012-07	11/30/1946	85	3.05	3.27	3.36
960-071	8638610	Sewells Point, VA, USA	36.947	-76.33	1927-08	2012-07	7/01/1927	85	4.54	4.44	4.42
960-011	8720218	Mayport, FL, USA	30.397	-81.43	1995-10	2012-07	06/29/1995	84	2.39	2.40	2.43
960-080	8575512	Annapolis, MD, USA	38.983	-76.48	1928-09	2012-07	8/07/1928	84	3.46	3.44	3.53
960-201	8410140	Eastport, ME, USA	44.903	-66.985	1929-10	2012-07	9/12/1929	83	2.10	2.00	2.12
960-161	8452660	Newport, RI, USA	41.505	-71.327	1930-10	2012-07	9/11/1930	82	2.70	2.58	2.57
960-141	8516945	Kings Pt/Willets Pt, NY, USA	40.81	-73.765	1998-11	2012-07	10/27/1998	81	2.48	2.35	2.41
950-011	2695540	St Georges / Esso Pier, Bermuda	32.373	-64.703	1989-01	2012-07	9/09/1978	80	2.09	2.04	1.83
960-101	8531680	Sandy Hook, NJ, USA	40.467	-74.01	1932-11	2012-07	1/07/1910	80	4.05	3.90	3.88
960-165	8447930	Woods Hole, MA, USA	41.523	-70.672	1932-08	2012-07	07/16/1932	80	2.77	2.61	2.59
823-021	9419750	Crescent City, CA, USA	41.745	-124.183	1933-05	2012-07	4/10/1933	79	-0.82	-0.65	-0.48
823-001	9443090	Neah Bay, WA, USA	48.368	-124.617	1934-08	2012-07	07/23/1934	78	-1.76	-1.63	-1.41
823-006	9449880	Friday Harbor, WA, USA	48.547	-123.01	1934-02	2012-07	01/25/1932	78	1.04	1.13	1.24
960-031	8670870	Fort Pulaski, GA, USA	32.033	-80.902	1935-07	2012-07	7/01/1935	77	2.95	2.98	3.05
960-060	8658120	Wilmington, NC, USA	34.227	-77.953	1935-05	2012-07	1/01/1908	77	1.98	2.07	2.22

Because of the interannual and multi decadal oscillations, the sea level rises computed by linear fitting of even more than 70 years of data still fluctuate[13-17]. If the positive acceleration theory would be true, clearly the computed sea level rises should increase at every update. This is not the case in Figure 1 and this is not the case in TABLE 1. The conclusion of TABLE 1 is that the sea levels on average are not accelerating in these US stations. The average sea level rise was 2.19 mm/year in 1999, 2.14 mm/year in 2006 and it is 2.14 mm/year in the last computation with update 2011.

WORLD AVERAGE TIDE GAUGE RESULTS

The 2012 Permanent Service on Mean Sea Level (PSMSL) table of relative mean sea level secular trends of[19] with entries from 524 tide gauges of average length 54 years gives a worldwide average sea level rise of 1.14 mm/year. Unfortunately this table has no prior counterpart to compare with. The PSMSL 2012 table has one half of the stations of the previous PSMSL tables 2007, 2005 and 2001, with many stations removed and a few new stations added, but the records have been altered, the data before 1900 are neglected and the computational procedure has been changed in the latest release. In the old PSMSL tables a trend was fitted to all available data. In the latest PSMSL table, only the longest available period at each station with at least 70% of annual means present and covering a window of at least 30 years and filtering out the data prior of 1900 is considered. This clearly makes impossible to compare the 2012 sea level rise values with the 2007, 2005 and 2001 values. Furthermore, the year of the table is the year of the computation of sea level rises. Finally, worth of mention the data used have random updates to prior years.

If we only focus on the tables 2007, 2005 and 2001 of[19], the worldwide average sea level rise is about the same, 1.40, 1.42 and 1.43 mm/year respectively considering all the records no matter the length. But restricting our attention to the tide gauges of length above 70 years, the 2001 table has 84 tide gauges of average length 92 years and average sea level rise 0.006 mm/year; the 2005 table has 93 tide gauges of average length 93 years and average sea level rise 0.053 mm/year; the 2007 table has 98 tide gauges of average length 94 and average sea level rise 0.024 mm/year. Therefore, the worldwide average tide gauge shows pretty much same values of sea level rise over the first decade of 2000 with no sign of acceleration.

COMPARISON WITH IPCC AR4 PREDICTIONS AND SATELLITE GMSL RECONSTRUCTION

The US and worldwide average tide gauge result is compared with the satellite radar altimeter reconstruction of the global mean sea level (GMSL)[5] and the IPCC AR4 sea level projections[4]. While the IPCC projections suppose the sea levels are positively accelerating at various rates, the US and worldwide tide gauge results show a lack of acceleration.

The projections for global averaged sea-level change for the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) were based on global climate model simulations. For the twentieth century, the models used observed changes in greenhouse gas concentrations and other climatic forcings while for the twenty-first century, they used greenhouse-gas emissions from the IPCC Special Report on Emission Scenarios (SRES). Unfortunately, these simulations were never validated versus properly analysed measured data.

The satellite radar altimeter reconstructions of the GMSL are more computations than true measurements, with nearly flat raw satellite signals pivoted around selected short term tide gauges.

Figure 2 presents the IPCC AR4 GMSL, the satellite GMSL and the US and worldwide average MSL.

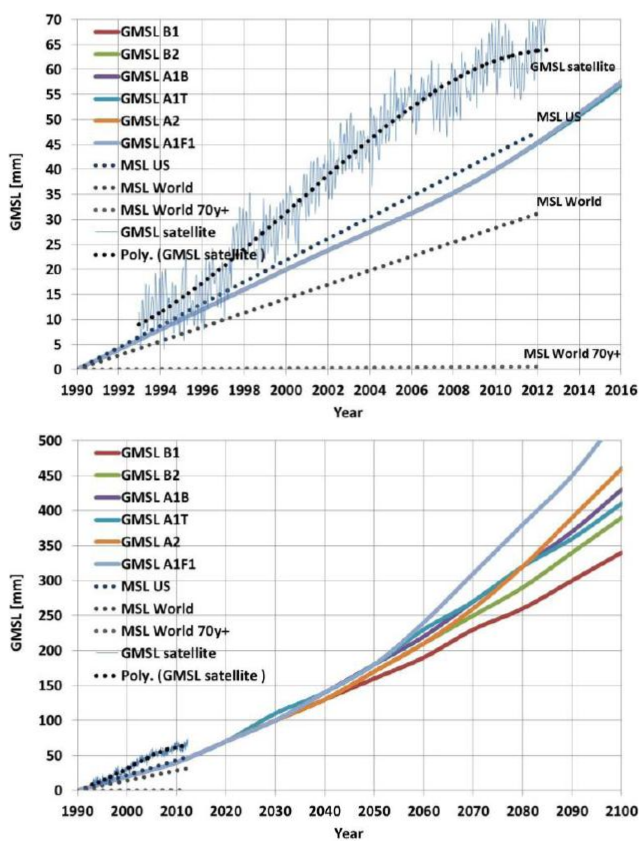

Figure 2 : Satellite GMSL, tide gauge US and worldwide MSL and GMSL of IPCC AR4 scenarios.

The average sea level accelerations over the period 1993 to 2011 of all the IPCC AR4 GMSL predictions are all positive with a range from 0.018 to 0.059 mm/year^2, as positive are the 2011 values with a range 0.021 to 0.060 mm/year^2. The IPCC AR4 GMSL predictions are not supported by the US and the worldwide average tide gauge results of enough length. The satellite radar altimeter reconstruction of GMSL has an average negative acceleration over the period 1993 to 2011 of -0.069 mm/year^2 in addition to the high rate of rise that suggest some doubt about the evaluating procedure.

CONCLUSIONS

It is proposed here a compilation of US tide gauges with more than 70 years of measurements. The average sea level rise was 2.19 mm/year in 1999, 2.14 mm/year in 2006 and it is 2.14 mm/year in the last computation with update 2011. This translates in a lack of positive acceleration along the US coastline. This result is consistent with the worldwide average tide gauge as well as for the average tide gauges of other geographical locations.

The satellite radar altimeter suggests conversely a much larger rate of rise of sea level, but also a very large negative acceleration of sea levels. The large negative acceleration of the satellite radar altimeter reconstruction is worth of further investigation, because all the individual tide gauge records of enough quality and length substantially show a lack of acceleration.

TABLE 1 and Figures 1 and 2 do not support that the IPCC AR4 predictions. What is important to note is the presence or absence of a positive acceleration. All the IPCC AR4 predictions assume the sea levels are positively accelerating and the acceleration will continue to increase. All the measured quantities show about zero acceleration.

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