Commentary

Discussion of A modelling study of coastal inundation induced by storm surge, sea-level rise, and subsidence in the Gulf of Mexico: the US average tide gauge is not accelerating consistently with the worldwide average

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ABSTRACT

Yang et al [26]assume sea level rise induced by global warming is real, and that sea levels may rise by 1 meter by 2100. They then go on to derive ecological conclusions from these assumptions. There is of course no foundation for the ecological speculation if the basic assumptions are false. Real tide gauge data show that sea level is rising slowly, both worldwide and the US, without any acceleration. As shown in this comment, the last 3 NOAA surveys of sea level rises, compiled in 1999, 2006 and 2013, indicate that the rate of sea level rise is reducing from one survey to the next.

Keywords: sea level velocity, sea level acceleration, tide gauge measurements, United States

1. INTRODUCTION

The IPCC WGI Fifth Assessment Report Chapter 13: Sea Level Change [9] claims as "*Sea Level Observations*" that it is very likely that the rate of global mean sea level rise has increased during the last two centuries. According to the IPCC, paleo sea level data from many locations around the globe indicate low rates of sea level change during thelate Holocene (order tenths of mm yr–1) and modern rates (order mm yr–1) during the 20th century, and it is verylikely that global mean sea level has risen ~1.7 [1.5 to 1.9] mm yr–1 during the 20th century, and between 2.8and 3.6 mm yr–1 since 1993. It is likely that global mean sea level has accelerated since the early 1900s, withestimates ranging from 0.000 to 0.013 [–0.002 to 0.019] mm yr–2. . As we prefer to consider evidence what is really measured and not the result of computer models, we already pointed out many times [1,2,15,16,17,18,19,20,21,22] as the actual experimental evidence from tide gauges is very scattered, with only very few tide gauges worldwide providing data since the late 1800s, but consistently the analysis of all the tide gauges of the world of enough length tell us a completely different story from the global warming narrative.

The long term tide gauges of the world are on average not accelerating over the last few decades, i.e. the relative rate of rise sea level to tide gauge computed by linearly fitting the monthly average mean sea levels up to a certain time is not increasing on average in these locations. Clearly, a reconstruction of global mean sea levels may not provide a genuine positive acceleration when the components are all acceleration free and the IPCC claim is therefore only the result of a flawed stacking procedure of information from cherry picked tide gauges of variable subsidence and length, As the tide gauge signals are characterized by multi decadal oscillations with up to a quasi 60 years' periodicity detected, it is clearly meaningful to cherry pick some tide gauges where the longer term oscillation is phased to magnify in the short term window the relative rate of rise while neglecting those suggesting much smaller relative rates of rise. Similarly meaningful is the cherry picking of the tide gauges in a subsidence area and neglecting the tide gauges in areas of uplift. As a proper analyses of the worldwide PSMSL tide gauges [23] tell us, the average sea level rise at the worldwide tide gauge is very small, much less than the 3 mm/year that are a purely speculative computational result correcting a flat raw satellite altimeter signal, in addition to be acceleration free. It is shown here that also the US average tide gauge is slow rising and acceleration free.

Figure 1 presents an analysis of the tide gauge of The Battery (NY). As also shown in [17,18,19], the tide gauge signal is oscillating and not accelerating. The short term time window proposes much larger than the legitimate relative sea level rises. Moving from the Atlantic coast to the Pacific coast, for example in San Diego, the short term time window proposes much smaller than the legitimate relative sea level rises, but no cherry picker claims cold spot of negative sea level acceleration along the Pacific coast of the US.

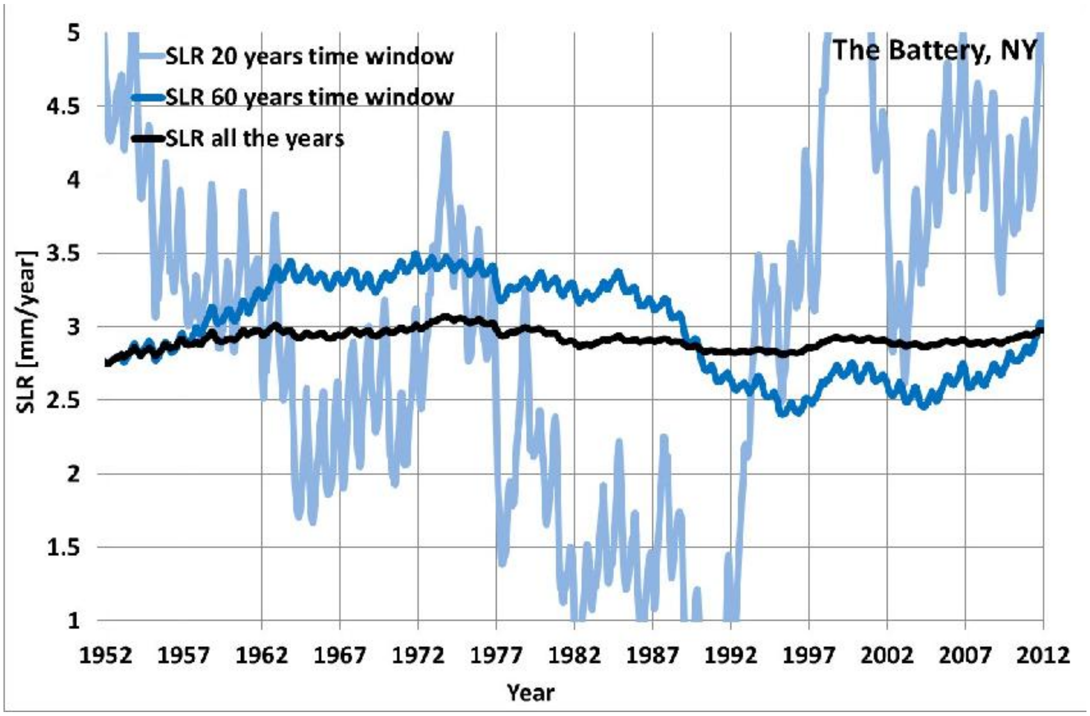

Figure 1 – Sea level rises computed for The Battery (NY) by using at any time all the data collected since 1893, only the last 60 years of data, or only the last 20 years of data. The computation over the 20 years' time window is particularly misleading going off-scale because of the multi decadal oscillations. The 60 years and the all the years computations are much more realistic. The signal of this tide gauge on the Atlantic coast is presently positively accelerating, but over a 60 years' time window has been accelerating and decelerating reaching sea level rises in the 1970 still unsurpassed 16, 17, 18]. A similar analysis for San Diego (CA) on the Pacific coast where the oscillations are not in phase shows a presently decelerating signal [16, 17, 18]. Claims of positive acceleration only follow a cherry picking of the information being very selective in what to consider and what to neglect.

According to Yang et al [26], "*The northern coasts of the Gulf of Mexico are highly vulnerable to the direct threats of climate change, such as hurricane-induced storm surge, and such risks are exacerbated by land subsidence and global sea-level rise*". The paper then presents an application of a coastal storm surge model to study the coastal inundation process induced by tide and storm surge, and its response to the effects of land subsidence and sea-level rise. Model results suggest that hurricane-induced storm surge height and coastal inundation could be exacerbated by future global sea-level rise and subsidence.

It has already been documented[15,16,17,18,19,20,21,22]the rates of rise of sea levels are not accelerating but only oscillating with a quasi-60 years periodicity over the last few decades, while the surface air temperatures have been warming since 1910 (not since 1950 as the IPCC suggests), and also show a quasi-60 years oscillation about the longer term warming trend.

Several other investigations have shown that the local or global rate of rise of sea levels have been decreasing more than increasingover the last 50 years [1,2,5,7,8,27]. Similarly, the changes in the rate of global sea-level are known to be influenced by a quasi-60 year oscillation [3,6,11,12,24,25]. Finally, the mismatch of global sea level rise as reconstructed from tide gauges or satellite altimetry is seen as one of the biggest unsolved problems in sea level studies [1,7,8,10,13].

If we look at the tide gauge measurements, the latest PSMSL survey [23]tells us that the 170 worldwide tide gauges with more than 60 years of recording history indicate an average relative rate of sea level rise of 0.25mm/year. Moreover, if we focus on the 100 tide gauges with more than 80 years of recording (more than 60 years of recording 20 years ago when the satellite altimetry started), the average relative rate of rise is much the same, 0.24 mm/year, and this value has not changed over the last 20 years. In other words the relative sea level acceleration has been zero over the last 20 years.

2. THE SEA LEVEL AT THE US TIDE GAUGES IS NOT ACCELERATING

For the United States, consistently with the worldwide average result, the long term tide gauges are only oscillating and not accelerating over the last decades (see for example [15,16,17,18]). The latest survey published by NOAA [15] shows thatthere is nothing actually measuredthat suggests sealevels have risen faster recently. Whilethe rate of local relative change, both rises and falls, maychangesignificantly from one location toanother because of subsidence or uplift at the tide gauge, or because of phases and amplitudes of the oscillations and the time window covered, the rate of change of sea level is unequivocally small and of zero acceleration.

The publication by NOAA of their latest 2013 sea level survey (U.S. Linear Relative Mean Sea Level (MSL) trends and 95% Confidence Intervals (CI) Revised 10/15/2013 and downloaded on 29/10/2014), when coupled to their prior surveys of 2006 and 1999, allows us to assess the non-accelerating trends along the US continental coastline, and the US territories and islands or naval bases included in the surveys.

To compare the results of the different surveys, we should only consider records from the same locations, with difference in the time window only originating from the additional years recorded. The comparisons of records from different starting years in the same location is misleading like the comparison of the relative rate of rise in different locations. The relative rate of rise of sea levels SLR is computed as the slope of the linear fitting curve of all the recorded monthly averaged mean sea levels relative to the tide gauge location. The land movement of subsidence or uplift at the tide gauge is same order of magnitude of the relative sea level rise. For every station satisfying the comparison criteria, the conventional acceleration $SLA(t_i)$ is computed as the difference in between the NOAA conventional rates of rise $SLR(t_i)$ and $SLR(t_{i-1})$ divided by the time increment t_i-t_{i-1}. The tabled NOAA surveys and the acceleration estimation are presented in the appendix.

This simple exercise tells us that the survey of 2006 showed a reduction of the average sea level rise compared to the values of 1999, and the latest survey of 2013 shows a further reduction of the average sea level rise compared to the 2006 survey.

The negative conventional acceleration was -0.019 mm/year^2 in 2006 (an average reduction of the SLR of -0.14 mm/year), and it is -0.009 mm/year^2 in 2013 (an average reduction of the SLR of -0.06 mm/year).

The 110 stations qualifying for the computation of the acceleration in 2013 and 2006 have an average SLR of 1.63±0.58 mm/year in 2013. In 2006 the same stations had an average SLR of 1.69±0.78 mm/year.

The 107 stations qualifying for the computation of the acceleration in 2006 and 1999 had averaged SLR of 1.47±0.60 mm/year in 2006. The same stations had an average SLR of 1.61±0.41mm/year in 1999.

This evidencefrom recent NOAA surveys [15] shows unequivocally that there has been no recent acceleration of sealevels fortheUS, justasthe PSMSLsurveys [23] suggest no acceleration of sea levels worldwide, as elaborated in the discussion.

3. DISCUSSION

To understand the global sea level rise from the relative rate of rise of sea levels from individual tide gauges is certainly very difficult. The vertical velocity of subsidence or uplift of the tide gauge is strongly variable from one site to the other. The record length is also greatly differing from one location to the other with very few tide gauges covering more than 100 years worldwide. Then, because of the multi decadal oscillations, with less than 60 years of recorded data, the relative sea level rise at the tide gauge may be largely overrated or underrated.

The relative rates of rise computed in the 560 tide gages of the latest PSMSL [23] are variable from +9.72 mm/year to -17.42 mm/year with an average estimation of +1.04 mm/year. By using only the tide gauges with more than 60 years of recording, the average rate of rise in the 170 tide gauges satisfying this criteria is +0.25 mm/year.

We always suggest to look at the relative acceleration of the tide gauges of enough length worldwide and for specific areas. In the latest survey of PSMSL, the 100 tide gauges satisfying the minimum requirement of 60 years recorded in the mid-1990s have an average relative rate of rise of +0.24 mm/year and a zero relative acceleration. Therefore, the US average tide gauge and the worldwide average tide gauge both exhibit a low relative rate of rise and no acceleration.

The distribution of tide gauges for the United States is relatively uniform, much better than any other location of the world except Northern Europe. More than the geographical location it is the record length that may bias considerably the surveys. The source of data are usually port authorities and independent organizations. The reliability of the relative sea level data collated by NOAA is good. The sea level data of the NOAA surveys or the PSMSL surveys have not been manipulated so far as it has been the case of other products, as for example the individual temperature records of the GISS reconstruction of the global temperature.

We suggest that to investigate relative acceleration of sea level only those tide gauges of sufficient length should be used. In the latest survey of PSMSL, the 100 tide gauges satisfying the minimum requirement of 60 years recorded in the mid-1990s have an average relative rate of rise of +0.24 mm/year and a zero relative acceleration. In other words, the US average tide gauge and the worldwide average tide gauge both exhibit a low relative rate of rise of sea level and no acceleration.

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Subsidence or uplift may occur on a longer time scale than sea level rise induced by thermal expansion and ice melting. The subsidence or uplift at the tide gauges should therefore not affect the relative acceleration of tide gauges. The relative sea level rise induced by thermal expansion and ice melting should conversely translate in a positive relative acceleration detected by the tide gauges recording good quality data over a significant time frame. If the relative acceleration of sea level is zero in that the US or worldwide it means the effects of thermal expansion and ice melting are negligible.

The simple average of the worldwide tide gauges of length above 60 years, with a 0.25 mm/year rate of rise lacking any acceleration, indicates that a tide gauges based coastal sea level rise of 1.8 mm/year (reconstructed GMSL for 1880 to 2009 as from CSIRO [6]) is a gross exaggeration, and a satellite based global absolute mean sea level rise of 3.2 mm/year (combined TOPEX/Poseidon, Jason-1 Jason-2/OSTM sea level fields as also from CSIRO [6]) is an extreme claim.

The "*naïve*" averaging of the 170 or 100 worldwide tide gauges satisfying minimum length requirements is certainly not a measure of the global mean sea level, just as the "naïve" averaging of the 107-110 US tide gauges does not represent the sea level rise along the coastline of the US. However, the cherry picking of very few short tide gauge records is very much more questionable.

To make a sea level rise of 1 meter by 2100 at the worldwide average tide gauge, after 15 years of this century there are still 996.25 millimeters to go There seems to be no possibility that sea level could suddenly rise the 996.25 millimeters left for this century when they are growing 0.25 mm/year with zero acceleration over the last few decades.

The definition of acceleration is conventional, like the usual definition of velocity (rate of rise). It is customary to define the rate of rise (velocity) as the slope of the linear fitting of the monthly average mean sea level observations. It is then logical to define a conventional acceleration based on the tabled data as the time rate of change of this velocity from one survey to another. This parameter is positive if the rate of rise increases from one survey to the other, or negative otherwise. A parabolic fitting of the monthly average mean sea level observations returns a different acceleration parameter, the average acceleration over the full length of the record that is less relevant to the present debate and cannot be computed from the tabled data.

The large table comparing the US Linear Relative Mean Sea Level at various locations in 1999, 2006 and 2013 showing that on average sea level rate in the US has been of the order of 1.5 mm/year with a nearly vanishing acceleration, negative rather than positive, is surely useful in the US sea level debate.

4. CONCLUSIONS

Any acceleration in sea level rate rise is very likely close to zero in the US, as everywhere else in the world. With relative sea level rises of about 1.5 mm/year without any acceleration, a sea level rise of 1 meter in the US would require 666 years. This slow rate of rise, based on observations, does not support the alarmist exercise of Yang et al [26] based on modelling.

REFERENCES

[1] Boretti, A.A. (2012a), Short term comparison of climate model predictions and satellite altimetermeasurements of sea-levels, *Coastal Engineering* **60**: 319–322.

[2] Boretti, A.A. (2012b), Is there any support in the long term tide-gauge data to the claims that parts of Sydney will be swamped by rising sea-levels?, *Coastal Engineering* **64**: 161-167.

[3] Chambers, D.P., Merrifield, M.A. and Nerem, R.S. (2012), Is there a 60-year oscillation in global mean sea level?, *Geophysical Research Letters* **39**(18): L18607.

[4] Commonwealth Scientific and Industrial Research Organization (CSIRO) (2014). www.cmar.csiro.au/sealevel/sl_data_cmar.html

[5] Hannah, J. and Bell, R.G. (2012), Regional sea-level trends in New Zealand, *Journal of Geophysical Research* **117**: C01004-C01004.

[6] Holgate, S. (2007), On the decadal rates of sea level change during the twentieth century, *Geophysical Research Letters* **34**: 10.1029/2006GL028492.

[7] Houston, J.R. (2013), Global sea level projections to 2100 using methodology of the Intergovernmental Panel on Climate Change, *Journal of Waterway, Port, Coastal, and Ocean Engineering* **139**: 82–87.

[8] Houston, J.R. & Dean, R.G. (2012), Comparisons at tide-gauge locations of glacial isostatic adjustment predictions with global positioning system measurements, *Journal of Coastal Research* **28**: 739–744.

[9] IPCC (2013). **ipcc**-wg2.gov/**AR5**/images/uploads/WGII**AR5**-Chap**13**_FGDall.pdf

[10] Jevrejeva, S., Moore, J.C., Grinsted, A., Matthews, A.P. &Spada, G. (2014), Trends and acceleration in global and regional sea levels since 1807, *Global and Planetary Change* **113**: 11-22.

[11] Marcos, M., Tsimplis, M.N. & Calafat, F.M. (2012), Inter-annual and decadal sea level variations in the north-western Pacific marginal seas, *Progress In Oceanography* **105**: 4–21.

[12] Mazzarella A. (2007), On the 60-year solar modulation of global air temperature: the Earth's rotation and atmosphere circulation connection, *Theor. Appl. Climatol.*, **88**:193-199, DOI: 10.107/s00704-005-0219-z.

[13] Munk, W. (2002), Twentieth century sea level: An enigma, *Proceedings of the National Academy of Sciences* **99**: 6550-6555.

[14] National Ocean and Atmospheric Administration (NOAA) (2014). tidesandcurrents.noaa.gov/sltrends/

[15] Parker, A. (2013a), WHY GLOBAL WARMING WENT MISSING SINCE THE YEAR 2000, *Nonlinear Engineering* **2**(3-4):129–135.

[16] Parker, A. (2013b), Oscillations of sea level rise along the Atlantic coast of North America north of Cape Hatteras, *Natural Hazards* **65**(1):991-997.

[17] Parker, A. (2013c), SEA LEVEL TRENDS AT LOCATIONS OF THE UNITED STATES WITH MORE THAN 100 YEARS OF RECORDING, *Natural Hazards* **65**(1):1011-1021.

[18] Parker, A. (2013d), The non-linear, naturally oscillating pattern of sea-levels in the Chesapeake Bay, East Coast, USA, *Nonlinear Engineering* **2**(1-2)1-10.

[19] Parker, A., M. SaadSaleem and M. Lawson (2013), Sea-Level Trend Analysis for Coastal Management, *Ocean & Coastal Management* **73**:63–81.

[20] Parker, A. (2014a), MINIMUM 60 YEARS OF RECORDING ARE NEEDED TO COMPUTE THE SEA LEVEL RATE OF RISE IN THE WESTERN SOUTH PACIFIC, *Nonlinear Engineering* Article in Press. DOI: 10.1515/nleng-2013-0011.

[21] Parker, A. (2014b), PRESENT CONTRIBUTIONS TO SEA LEVEL RISE BY THERMAL EXPANSION AND ICE MELTING AND IMPLICATION ON COASTAL MANAGEMENT, *Ocean and Coastal Management* **98**:202-211.

[22] Parker, A.(2014c), Persisting problems affecting the reliability of the satellite altimeter based Global Mean Sea Level computation, *Pattern Recognition in Physics* **2**(2):65-74.

[23] Permanent Service for Mean Sea Level (PSMSL) (2014). www.psmsl.org/products/trends/trends.txt
[24] Scafetta N. (2014), Multi-scale dynamical analysis (MSDA) of sea level records versus PDO, AMO, and NAO indexes, *Clim.Dyn.*,**43**:175-192 , DOI 10.1007/s00382-013-1771-3.
[25] Soon W. & Legates D.R. (2013), Solar irradiance modulation of Equator-to-Pole (Arctic) temperature gradients: empirical evidence for climate variation on multi-decadal timescales, *Journal of Atmospheric, Solar & Terrestrial Physics***93**: 45–56.
[26] Yang, Z. , Wang, T., Leung, R., Hibbard, K., Janetos, T., Kraucunas, I., Rice, J., Preston, B., Wilbanks, T. (2014), Amodeling study of coastal inundation induced by storm surge, sea-level rise, and subsidence in the Gulf of Mexico, *Natural Hazards***71**(3):1771-1794.
[27] Watson, P.J. (2011), Is there evidence yet of acceleration in mean sea-level rise around mainland Australia?,*Journal of Coastal Research***27**: 368-377.

COMPETING INTERESTS

The authors have no financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

AUTHOR'S CONTRIBUTION

All work, thoughts, interpretations are done by the authors.

APPENDIX – Latest NOAA surveys of the relative sea level rise along the U.S. coastline

Table 1 – Summary of NOAA surveys and evaluation of the relative sea level rise variations.

NOAA Survey 2013									2013 vs 2006`			NOAA Survey 2006					2006 vs 1999			NOAA Survey 1999			
Station ID	Station Name	First Year	Last Year	Year Range	% Completeness	Equivalent length	SLR (mm /y)	+/- 95% CI (mm /y)	Delta SLR vs. 2006 (mm /yr)	SLA (mm /y2)	Notes	First Year	Last Year	Year Range	SLR (mm /y)	+/- 95% CI (mm /y)	Delta SLR vs. 1999 (mm /y)	SLA (mm /y2)	Notes	First Year	Year Range	SLR (mm /y)	+/- 95% CI (mm /y)
1611400	Nawiliwili, HI	1955	2013	58	92	53.36	1.37	0.47	-0.16	-0.023		1955	2006	52	1.53	0.59	0.00	0.000		1954	46	1.53	0.38
1612340	Honolulu, HI	1905	2013	108	85	91.8	1.41	0.22	-0.09	-0.013		1905	2006	102	1.5	0.25	0.00	0.000		1905	95	1.5	0.14
1612480	Mokuoloe, HI	1957	2013	56	53	29.68	1.09	0.56	-0.22	-0.031		1957	2006	50	1.31	0.72	0.19	0.027		1957	43	1.12	0.46
1615680	Kahului, HI	1947	2013	66	66	43.56	1.99	0.44	-0.33	-0.047		1947	2006	60	2.32	0.53	0.23	0.016	Since 1954	1954	46	2.09	0.43
1617760	Hilo, HI	1927	2013	86	72	61.92	2.97	0.32	-0.30	-0.043		1927	2006	80	3.27	0.35	-0.09	-0.013		1927	73	3.36	0.21
1619000	Johnston Atoll	1947	2003	56	93	52.08	0.75	0.56			No Upd	1947	2003	57	0.75	0.56	0.07	0.018		1947	53	0.68	0.31
1619910	Midway Atoll	1947	2013	66	90	59.4	1.19	0.47	0.49	0.070		1947	2006	60	0.7	0.54	0.61	0.087	Sand Islan	1947	53	0.09	0.31
											Post EQ 1993	1993	2006	14	8.58	8.93			NA 1999				
1630000	Apra Harbor, Guam	1993	2013	20	96	19.2	8.6	4.88	0.02	0.003	Pre EQ 1993	1948	1993	46	-1.05	1.72			EQ	1948	52	0.1	0.9
1770000	Pago Pago, American Samoa	1948	2006	58	94	54.52	2.07	0.9			No Upd	1948	2006	59	2.07	0.9	0.59	0.084		1948	52	1.48	0.56
1820000	Kwajalein	1946	2013	67	93	62.31	2.44	0.84	1.01	0.144		1946	2006	61	1.43	0.81	0.38	0.054		1946	54	1.05	0.51
1840000	Chuuk	1947	1995	48	91	43.68	0.6	1.78			No Upd	1947	1995	49	0.6	1.78			No Upd	1947	49	0.68	0.9
1890000	Wake Island	1950	2013	63	87	54.81	2.02	0.49	0.11	0.016		1950	2006	57	1.91	0.59	0.02	0.003		1950	50	1.89	0.35
2695540	Bermuda, Atlantic Ocean	1932	2013	81	22	17.82	2.05	0.4	0.01	0.001		1932	2006	75	2.04	0.47	0.21	0.030		1932	68	1.83	0.3
8410140	Eastport, ME	1929	2013	84	90	75.6	2.13	0.19	0.13	0.019		1929	2006	78	2	0.21	-0.12	-0.017		1929	71	2.12	0.13
8413320	Bar Harbor, ME	1947	2013	66	86	56.76	2.22	0.23	0.18	0.026		1947	2006	60	2.04	0.26	-0.14	-0.020		1947	53	2.18	0.16
8418150	Portland, ME	1912	2013	101	96	96.96	1.9	0.16	0.08	0.011		1912	2006	95	1.82	0.17	-0.09	-0.013		1912	88	1.91	0.09
8419870	Seavey Island, ME	1926	2001	75	74	55.5	1.76	0.3			No Upd	1926	2001	76	1.76	0.3	0.01	0.001		1926	61	1.75	0.17
8443970	Boston, MA	1921	2013	92	95	87.4	2.8	0.17	0.17	0.024		1921	2006	86	2.63	0.18	-0.02	-0.003		1921	79	2.65	0.1
8447930	Woods Hole, MA	1932	2013	81	95	76.95	2.82	0.19	0.21	0.030		1932	2006	75	2.61	0.2	0.02	0.003		1932	68	2.59	0.12
8449130	Nantucket Island, MA	1965	2013	48	89	42.72	3.55	0.4	0.60	0.086		1965	2006	42	2.95	0.46	-0.05	-0.007		1965	35	3	0.32
8452660	Newport, RI	1930	2013	83	83	68.89	2.74	0.17	0.16	0.023		1930	2006	77	2.58	0.19	0.01	0.001		1930	70	2.57	0.11
8454000	Providence, RI	1938	2013	75	86	64.5	2.25	0.26	0.30	0.043		1938	2006	69	1.95	0.28	0.07	0.010		1938	62	1.88	0.17
8461490	New London, CT	1938	2013	75	92	69	2.56	0.24	0.31	0.044		1938	2006	69	2.25	0.25	0.12	0.017		1938	62	2.13	0.15
8467150	Bridgeport, CT	1964	2013	49	91	44.59	2.85	0.49	0.29	0.041		1964	2006	43	2.56	0.58	-0.02	-0.003		1964	36	2.58	0.41

8510560	Montauk, NY	1947	2013	66	88	58.08	3.21	0.29	0.43	0.061		1947	2006	60	2.78	0.32	0.20	0.029		1947	53	2.58	0.19
8514560	Port Jefferson, NY	1957	1992	35	98	34.3	2.44	0.76			No Upd	1957	1992	36	2.44	0.76			No Upd	1957	36	2.44	0.39
8516945	Kings Point, NY	1931	2013	82	14	11.48	2.51	0.22	0.16	0.023		1931	2006	76	2.35	0.24	-0.06	-0.009		1931	69	2.41	0.15
																			New Rochelle	1957	25	0.54	0.85
8518750	The Battery, NY	1856	2013	157	88	138.16	2.83	0.09	0.06	0.009		1856	2006	151	2.77	0.09	0.00	0.000		1856	144	2.77	0.05
8531680	Sandy Hook, NJ	1932	2013	81	95	76.95	4.06	0.22	0.16	0.023		1932	2006	75	3.9	0.25	0.02	0.003		1932	68	3.88	0.15
8534720	Atlantic City, NJ	1911	2013	102	87	88.74	4.08	0.16	0.09	0.013		1911	2006	96	3.99	0.18	0.01	0.001		1911	89	3.98	0.11
8536110	Cape May, NJ	1965	2013	48	84	40.32	4.6	0.59	0.54	0.077		1965	2006	42	4.06	0.74	0.18	0.026		1965	35	3.88	0.53
8545240	Philadelphia, PA	1900	2013	113	18	20.34	2.93	0.2	0.14	0.020		1900	2006	107	2.79	0.21	0.04	0.006		1900	100	2.75	0.12
8551910	Reedy Point, DE	1956	2013	57	55	31.35	3.61	0.53	0.15	0.021		1956	2006	51	3.46	0.66			NA 1999				
8557380	Lewes, DE	1919	2013	94	57	53.58	3.39	0.25	0.19	0.027		1919	2006	88	3.2	0.28	0.04	0.006		1919	81	3.16	0.16
8570283	Ocean City, MD	1975	2013	38	23	8.74	5.67	1.07	0.19	0.027		1975	2006	32	5.48	1.67			NA 1999				
8571892	Cambridge, MD	1943	2013	70	54	37.8	3.7	0.34	0.22	0.031		1943	2006	64	3.48	0.39	-0.04	-0.006		1943	57	3.52	0.24
8573927	Chesapeake City, MD	1972	2013	41	42	17.22	3.93	0.87	0.15	0.021		1972	2006	35	3.78	1.56			NA 1999				
8574680	Baltimore, MD	1902	2013	111	97	107.67	3.14	0.13	0.06	0.009		1902	2006	105	3.08	0.15	-0.04	-0.006		1902	98	3.12	0.08
8575512	Annapolis, MD	1928	2013	85	93	79.05	3.51	0.21	0.07	0.010		1928	2006	79	3.44	0.23	-0.09	-0.013		1928	72	3.53	0.13
8577330	Solomons Island, MD	1937	2013	76	62	47.12	3.68	0.26	0.27	0.039		1937	2006	70	3.41	0.29	0.12	0.017		1937	63	3.29	0.17
8594900	Washington, DC	1924	2013	89	94	83.66	3.22	0.3	0.06	0.009		1924	2006	83	3.16	0.35	0.03	0.002		1931	69	3.13	0.21
8632200	Kiptopeke, VA	1951	2013	62	94	58.28	3.56	0.35	0.08	0.011		1951	2006	56	3.48	0.42	-0.11	-0.016		1951	49	3.59	0.27
8635150	Colonial Beach, VA	1972	2010	38	88	33.44	4.89	0.97	0.11	0.016		1972	2003	32	4.78	1.21	-0.49	-0.123		1972	28	5.27	0.72
8635750	Lewisetta, VA	1974	2013	39	91	35.49	5.5	0.76	0.53	0.076		1974	2006	33	4.97	1.04	0.12	0.017		1974	26	4.85	0.79
8637624	Gloucester Point, VA	1950	2003	53	97	51.41	3.81	0.47			No Upd	1950	2003	54	3.81	0.47	-0.14	-0.035		1950	50	3.95	0.27
8638610	Sewells Point, VA	1927	2013	86	95	81.7	4.57	0.24	0.13	0.019		1927	2006	80	4.44	0.27	0.02	0.003		1927	73	4.42	0.16
8638660	Portsmouth, VA	1935	1987	52	100	52	3.76	0.45			No Upd	1935	1987	53	3.76	0.45			No Upd	1935	53	3.76	0.23
8638863	Chesapeake Bay Bridge Tunnel, VA	1975	2013	38	96	36.48	5.96	0.83	-0.09	-0.013		1975	2006	32	6.05	1.14	-0.96	-0.137		1975	25	7.01	0.86
8651370	Duck, NC	1978	2013	35	89	31.15	4.57	0.84			NA 2006								NA 1999				
8652587	Oregon Inlet Marina, NC	1977	2013	36	52	18.72	3.65	1.36	0.83	0.119		1977	2006	30	2.82	1.76			NA 1999				
8656483	Beaufort, NC	1953	2013	60	61	36.6	2.71	0.37	0.14	0.020		1953	2006	54	2.57	0.44	-1.14	-0.042		1973	27	3.71	0.64
8658120	Wilmington, NC	1935	2013	78	93	72.54	2.02	0.35	-0.05	-0.007		1935	2006	72	2.07	0.4	-0.15	-0.021		1935	65	2.22	0.25
8659084	Southport, NC	1933	2008	75	16	12	2	0.41	-0.08	-0.040		1933	2006	74	2.08	0.46			NA 1999				
8661070	Springmaid Pier, SC	1957	2013	56	58	32.48	3.73	0.6	-0.36	-0.051		1957	2006	50	4.09	0.76	-1.08	-0.154	Springmaid	1957	43	5.17	0.49

8665530	Charleston, SC	1921	2013	92	81	74.52	3.11	0.22	-0.04	-0.006		1921	2006	86	3.15	0.25	-0.13	-0.019	Charleston	1921	79	3.28	0.14
8670870	Fort Pulaski, GA	1935	2013	78	92	71.76	3.01	0.28	0.03	0.004		1935	2006	72	2.98	0.33	-0.07	-0.010	Fort	1935	65	3.05	0.2
8720030	Fernandina Beach, FL	1897	2013	116	75	87	2.01	0.18	-0.01	-0.001		1897	2006	110	2.02	0.2	-0.02	-0.003	Fernandina	1897	103	2.04	0.12
8720218	Mayport, FL	1928	2013	85	11	9.35	2.44	0.27	0.04	0.006		1928	2006	79	2.4	0.31	-0.03	-0.004	Mayport	1928	72	2.43	0.18
8721120	Daytona Beach Shores, FL	1925	1983	58	11	6.38	2.32	0.63			No Upd	1925	1983	59	2.32	0.63			NA 1999				
8723170	Miami Beach, FL	1931	1981	50	93	46.5	2.39	0.43			No Upd	1931	1981	51	2.39	0.43			No Upd	1931	51	2.39	0.22
8723970	Vaca Key, FL	1971	2013	42	91	38.22	3.18	0.49	0.40	0.057		1971	2006	36	2.78	0.6	0.20	0.029		1971	29	2.58	0.44
8724580	Key West, FL	1913	2013	100	89	89	2.31	0.15	0.07	0.010		1913	2006	94	2.24	0.16	-0.03	-0.004		1913	87	2.27	0.09
8725110	Naples, FL	1965	2013	48	93	44.64	2.4	0.48	0.38	0.054		1965	2006	42	2.02	0.6	-0.06	-0.009		1965	35	2.08	0.43
8725520	Fort Myers, FL	1965	2013	48	89	42.72	2.63	0.51	0.23	0.033		1965	2006	42	2.4	0.65	0.11	0.016		1965	35	2.29	0.45
8726520	St. Petersburg, FL	1947	2013	66	94	62.04	2.54	0.26	0.18	0.026		1947	2006	60	2.36	0.29	-0.04	-0.006		1947	53	2.4	0.18
8726724	Clearwater Beach, FL	1973	2013	40	89	35.6	2.99	0.64	0.56	0.080		1973	2006	34	2.43	0.8	-0.33	-0.047		1973	27	2.76	0.65
8727520	Cedar Key, FL	1914	2013	99	80	79.2	1.89	0.18	0.09	0.013		1914	2006	93	1.8	0.19	-0.07	-0.010		1914	86	1.87	0.11
8728690	Apalachicola, FL	1967	2013	46	87	40.02	1.76	0.69	0.38	0.054		1967	2006	40	1.38	0.87	-0.15	-0.021		1967	33	1.53	0.58
8729108	Panama City, FL	1973	2013	40	98	39.2	1.6	0.67	0.85	0.121		1973	2006	34	0.75	0.83	0.45	0.064		1973	27	0.3	0.64
8729840	Pensacola, FL	1923	2013	90	98	88.2	2.19	0.23	0.09	0.013		1923	2006	84	2.1	0.26	-0.04	-0.006		1923	77	2.14	0.15
8735180	Dauphin Island, AL	1966	2013	47	83	39.01	3.19	0.65	0.21	0.030		1966	2006	41	2.98	0.87	0.05	0.006		1966	32	2.93	0.59
8761724	Grand Isle, LA	1947	2013	66	50	33	9.07	0.47	-0.17	-0.024		1947	2006	60	9.24	0.59	-0.61	-0.087		1947	53	9.85	0.35
8764311	Eugene Island, LA	1939	1974	35	51	17.85	9.65	1.24			No Upd	1939	1974	36	9.65	1.24			No Upd	1939	36	9.74	0.63
8770570	Sabine Pass, TX	1958	2013	55	49	26.95	5.46	0.83	-0.20	-0.029		1958	2006	49	5.66	1.07	-0.88	-0.126		1958	42	6.54	0.72
8771450	Galveston Pier 21, TX	1908	2013	105	98	102.9	6.35	0.25	-0.04	-0.006		1908	2006	99	6.39	0.28	-0.11	-0.016		1908	92	6.5	0.16
8771510	Galveston Pleasure Pier, TX	1957	2011	54	91	49.14	6.62	0.69	-0.22	-0.044		1957	2006	50	6.84	0.81	-0.55	-0.079		1957	43	7.39	0.53
8772440	Freeport, TX	1954	2008	36	100	36	4.43	1.05	0.08	0.040		1954	2006	53	4.35	1.12	-1.52	-0.217		1954	46	5.87	0.74
8774770	Rockport, TX	1948	2013	65	74	48.1	5.53	0.55	0.37	0.053		1948	2006	59	5.16	0.67	0.56	0.080		1948	52	4.6	0.41
8778490	Port Mansfield, TX	1963	2006	43	94	40.42	1.93	0.97			No Upd	1963	2006	44	1.93	0.97	-0.12	-0.013		1963	35	2.05	0.75
8779750	Padre Island, TX	1958	2006	48	0	0	3.48	0.75			No Upd	1958	2006	49	3.48	0.75	0.04	0.003		1958	37	3.44	0.56
8779770	Port Isabel, TX	1944	2013	69	71	48.99	3.8	0.36	0.16	0.023		1944	2006	63	3.64	0.44	0.26	0.037		1944	56	3.38	0.27
9410170	San Diego, CA	1906	2013	107	95	101.65	2.04	0.18	-0.02	-0.003		1906	2006	101	2.06	0.2	-0.09	-0.013		1906	94	2.15	0.12
9410230	La Jolla, CA	1924	2013	89	92	81.88	2.02	0.25	-0.05	-0.007		1924	2006	83	2.07	0.29	-0.15	-0.021		1924	76	2.22	0.17
9410580	Newport Beach, CA	1955	1993	38	100	38	2.22	1.04			No Upd	1955	1993	39	2.22	1.04			No Upd	1955	39	2.22	0.53
9410660	Los Angeles, CA	1923	2013	90	96	86.4	0.82	0.23	-0.01	-0.001		1923	2006	84	0.83	0.27	-0.01	-0.001		1923	77	0.84	0.16

9410840	Santa Monica, CA	1933	2013	80	82	65.6	1.36	0.34	-0.10	-0.014		1933	2006	74	1.46	0.4	-0.13	-0.019		1933	67	1.59	0.25
9411270	Rincon Island, CA	1962	1990	28	92	25.76	3.22	1.66			No Upd	1962	1990	29	3.22	1.66			No Upd	1962	29	3.22	0.85
9411340	Santa Barbara, CA	1973	2013	40	52	20.8	0.32	1.17	-0.93	-0.133		1973	2006	34	1.25	1.82	-1.52	-0.190		1973	26	2.77	0.99
9412110	Port San Luis, CA	1945	2013	68	90	61.2	0.63	0.4	-0.16	-0.023		1945	2006	62	0.79	0.48	-0.11	-0.016		1945	55	0.9	0.32
9413450	Monterey, CA	1973	2013	40	91	36.4	0.82	0.94	-0.52	-0.074		1973	2006	34	1.34	1.35	-0.52	-0.074		1973	27	1.86	1.09
												1897	2006	110	2.01	0.21	-0.12	-0.008	Post EQ 1906	1906	94	2.13	0.14
											Pre 1897	1854	1897	44	2.05	0.85			Pre EQ 1906	1854	52	1.12	0.35
9414290	San Francisco, CA 1897	1897	2013	116	97	112.52	1.89	0.19	-0.12	-0.017									Since 1854	1854	146	1.41	0.08
9414523	Redwood City, CA	1974	2013	39	33	12.87	1.25	1.92	-0.81	-0.116		1974	2006	33	2.06	3.12			NA 1999				
9414750	Alameda, CA	1939	2013	74	95	70.3	0.6	0.44	-0.22	-0.031		1939	2006	68	0.82	0.51	-0.07	-0.010		1939	61	0.89	0.32
9415020	Point Reyes, CA	1975	2013	38	91	34.58	1.39	1.05	-0.71	-0.101		1975	2006	32	2.1	1.52	-0.41	-0.059		1975	25	2.51	1.27
9415144	Port Chicago, CA	1976	2013	37	90	33.3	1.23	1.83	-0.85	-0.121		1976	2006	31	2.08	2.74			NA 1999				
9418767	North Spit, CA	1977	2013	36	89	32.04	3.86	1.1	-0.87	-0.124		1977	2006	30	4.73	1.58			NA 1999				
9419750	Crescent City, CA	1933	2013	80	88	70.4	-0.89	0.32	-0.24	-0.034		1933	2006	74	-0.65	0.36	-0.17	-0.024		1933	67	-0.48	0.23
9431647	Port Orford, OR	1977	2013	36	74	26.64	-0.83	1.41	-1.01	-0.144		1977	2006	30	0.18	2.18			NA 1999				
9432780	Charleston, OR	1970	2013	43	91	39.13	0.59	0.88	-0.70	-0.100		1970	2006	37	1.29	1.15	-0.45	-0.064		1970	30	1.74	0.87
9435380	South Beach, OR	1967	2013	46	92	42.32	2.04	0.8	-0.68	-0.097		1967	2006	40	2.72	1.03	-0.79	-0.113		1967	33	3.51	0.73
9437540	Garibaldi, OR	1970	2013	43	35	15.05	1.87	0.87	-0.11	-0.016		1970	2006	37	1.98	1.82			NA 1999				
9439040	Astoria, OR	1925	2013	88	92	80.96	-0.34	0.35	-0.03	-0.004		1925	2006	82	-0.31	0.4	-0.15	-0.021		1925	75	-0.16	0.24
9440910	Toke Point, WA	1973	2013	40	88	35.2	0.26	1.05	-1.34	-0.191		1973	2006	34	1.6	1.38	-1.22	-0.174		1973	27	2.82	1.05
9443090	Neah Bay, WA	1934	2013	79	93	73.47	-1.81	0.32	-0.18	-0.026		1934	2006	73	-1.63	0.36	-0.22	-0.031		1934	66	-1.41	0.22
9444090	Port Angeles, WA	1975	2013	38	91	34.58	-0.35	1.02	-0.54	-0.077		1975	2006	32	0.19	1.39	-1.30	-0.186		1975	25	1.49	1.1
9444900	Port Townsend, WA	1972	2013	41	91	37.31	1.45	0.86	-0.53	-0.076		1972	2006	35	1.98	1.15	-0.84	-0.120		1972	28	2.82	0.88
9447130	Seattle, WA	1898	2013	115	97	111.55	1.97	0.16	-0.09	-0.013		1898	2006	109	2.06	0.17	-0.05	-0.007		1898	102	2.11	0.1
9449424	Cherry Point, WA	1973	2013	40	90	36	-0.11	0.88	-0.93	-0.133		1973	2006	34	0.82	1.2	-0.57	-0.081		1973	27	1.39	0.94
9449880	Friday Harbor, WA	1934	2013	79	77	60.83	1.02	0.29	-0.11	-0.016		1934	2006	73	1.13	0.33	-0.11	-0.016		1934	66	1.24	0.2
9450460	Ketchikan, AK	1919	2013	94	89	83.66	-0.28	0.24	-0.09	-0.013		1919	2006	88	-0.19	0.27	-0.08	-0.011		1919	81	-0.11	0.16
9451600	Sitka, AK 1924	1924	2013	89	92	81.88	-2.26	0.29	-0.21	-0.030		1924	2006	83	-2.05	0.32	0.12	0.006	Since 1938	1938	62	-2.17	0.21
9452210	Juneau, AK	1936	2013	77	92	70.84	-13.16	0.37	-0.24	-0.034		1936	2006	71	-12.92	0.43	-0.23	-0.033		1936	64	-12.69	0.26
9452400	Skagway, AK	1944	2013	69	79	54.51	-17.59	0.56	-0.47	-0.067		1944	2006	63	-17.12	0.65	-0.44	-0.063		1944	56	-16.68	0.42
9453220	Yakutat, AK 1988	1988	2013	25	92	23	-14.56	1.69			Post EQ 1979	1979	2006	28	-11.53	1.46			NA 1999				

											Since 1940	1940	2006	67	-6.44	0.47	-0.69	-0.099		1940	60	-5.75	0.27
											Pre EQ 1979	1940	1979	40	-4.81	0.89			NA 1999				
											Post EQ 1964	1964	2006	43	5.76	0.87	-1.21	-0.173		1964	36	6.97	0.6
9454050	Cordova, AK 1988	1988	2013	25	88	22	-0.53	1.55			Pre EQ 1961	1949	1961	13	5.01	10.92			NA 1999				
9454240	Valdez, AK 1988	1988	2013	25	88	22	-9.35	1.69			Since 1973	1973	2006	34	-2.52	1.36	-2.18	-0.311		1973	27	-0.34	1
											Post EQ 1964	1964	2006	43	-1.74	0.91	-0.28	-0.040		1964	36	-1.46	0.61
9455090	Seward, AK 1964	1964	2013	49	83	40.67	-2.74	0.74	-1.00	-0.143	Pre EQ 1964	1925	1964	40	-0.11	1.08			No Upd	1925	39	-0.13	0.57
9455500	Seldovia, AK	1964	2013	49	89	43.61	-10.47	0.85	-1.02	-0.146		1964	2006	43	-9.45	1.1	0.48	0.069		1964	36	-9.93	0.78
9455760	Nikiski, AK	1973	2013	40	45	18	-10.65	1.16	-0.85	-0.121		1973	2006	34	-9.8	1.5	0.91	0.130		1973	27	-10.71	1.17
9455920	Anchorage, AK	1972	2013	41	85	34.85	-0.75	1.19	-1.63	-0.233		1972	2006	35	0.88	1.54	-1.88	-0.269		1972	28	2.76	1.16
											Post EQ 1975	1975	2006	32	-10.42	1.33	1.66	0.237		1975	25	-12.08	1.06
9457292	Kodiak Island, AK 1975	1975	2013	38	46	17.48	-11.05	0.95	-0.63	-0.090	Pre EQ 1964	1949	1964	16	1.19	3.7			NA 1999				
9459450	Sand Point, AK	1972	2013	41	88	36.08	0.38	0.97	-0.54	-0.077		1972	2006	35	0.92	1.32	0.85	0.121		1972	28	0.07	0.93
											Post EQ 1957	1957	2006	50	-2.75	0.54	-0.12	-0.017		1957	43	-2.63	0.35
9461380	Adak Island, AK 1972	1957	2013	56	89	49.84	-3.07	0.43	-0.32	-0.046	Pre EQ 1957	1943	1957	15	2.45	3.61			No Upd	1943	14	2.48	1.84
											Post EQ 1957	1957	2006	50	-5.72	0.67	0.72	0.103		1957	43	-6.44	0.44
9462620	Unalaska, AK 1957	1957	2013	56	62	34.72	-5.47	0.53	0.25	0.036	Pre EQ 1957	1934	1957	24	-0.57	2.16			No Upd	1934	23	-0.57	1.11
9731158	Guantanamo Bay, Cuba	1937	1971	34	57	19.38	1.64	0.8			No Upd	1937	1971	35	1.64	0.8			No Upd	1937	35	1.64	0.41
9751401	Lime Tree Bay, VI	1977	2013	36	86	30.96	2.21	0.87	0.47	0.067		1977	2006	30	1.74	1.2			NA 1999				
9751639	Charlotte Amalie, VI	1975	2013	38	90	34.2	1.6	0.71	0.40	0.057		1975	2006	32	1.2	0.96	0.70	0.100		1975	25	0.5	0.74
9755371	San Juan, PR	1962	2013	51	85	43.35	1.77	0.43	0.12	0.017		1962	2006	45	1.65	0.52	0.22	0.031		1962	38	1.43	0.36
9759110	Magueyes Island, PR	1955	2013	58	96	55.68	1.52	0.32	0.17	0.024		1955	2006	52	1.35	0.37	0.11	0.016		1955	45	1.24	0.25
averages survey 2013							**1.56**	**0.64**	**-0.06**	**-0.009**	**averages survey 2006**				**1.59**	**0.93**	**-0.14**	**-0.019**	**averages survey 1999**			**1.67**	**0.44**