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Confirming the lack of acceleration in the pacific sea levels

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ABSTRACT

There are few tide gauges on the shores of the Pacific Ocean that have the quality and length demonstrating the non-accelerating naturally oscillating pattern of sea levels. A simple but reliable analysis of these tide gauges based on linear regressions shows that the average relative rate of rise is below 1 mm/year without any detectable accelerating component. The land motion analysis based on the satellite GPS suggests this rate is mostly the result of subsidy, and therefore the average absolute rate of rise is very likely close to 0 mm/year. The much larger rates of rises that were computed in other studies are the result of selectively focusing on the short time windows magnifying the effect of the multi decadal oscillations and/or of the use of incomplete scattered data arbitrarily extended from the past and reconstructed to the present with procedures that are everything but transparent. The sea level behaviour within the Pacific appears to be substantially free of any acceleration and is driven mostly by the natural, periodic causes, similarly to the rest of the world Oceans.

KEYWORDS

Sea level rise;
Sea level acceleration;
Land motion;
Multi-decadal oscillations;
Linear regression;
Non-linear regression.

INTRODUCTION

The sea levels oscillate with important multi-decadal periodicities and this requires a proper procedure and good quality and length of data to infer the long term sea level rate of rise and the presence or the absence of accelerating patterns.

The oscillatory motion of the ocean with short time scales is very well known in the many text books of physical oceanography as for example Talley, Pickard, Emery, Swift[45]. The tidal rise and fall of the sea levels caused by the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth are the largest source of short-term sea-level fluctuations. Tidal patterns differ from one location to another. Tides vary on timescales ranging from hours to years due to numerous influences. Some locations show two high and two low tides each day, some other locations only show one high and one low tide each day, some other locations experience two uneven tides a day or sometimes one high and one low each day. Timings and amplitude of the tidal oscillations are also variable from one location to the other. In addition to tides and waves, sea levels are also subject to forces such as wind and barometric pressure influencing the short time scale motions.

Some other phenomena are responsible of longer term fluctuations of climate parameters including sea levels[23,48,49]. For the specific of the Pacific, the Pacific

Decadal Oscillation (PDO), the El Niño–Southern Oscillation (ENSO), the inter-decadal Pacific oscillation (IPO or ID), the quasi-decadal oscillation (QDO) are all well-known periodic oscillations.

The PDO is patterns of change detected as warm or cooling the surface of waters of the Pacific Ocean, to 20°N, shifting phases at least on an inter-decadal time scale, usually between 20 to 30 years[14]. The PDO is possibly initiated by a reddening of ENSO that is combined with stochastic atmospheric forcing[23]. The IPO or ID display a similar sea-surface temperature and sea-level pressure patterns, over a cycle of 15–30 years, however these affects are both north and south Pacific. This is quite different from the QDO with periods of 8-to-12 years and having maximum sea-surface temperature anomalies, spanning the equator, thus resembling the ENSO. The ENSO is a global activity that couples the ocean-atmosphere phenomenon. The Pacific Ocean signatures, El Niño and La Niña are important temperature fluctuations of the surface waters from the tropical Eastern Pacific Ocean. This atmospheric signature, the Southern Oscillation index (SOI) reflects the monthly or the seasonal fluctuations of the air pressure difference across the Pacific.

A good data base of tide gauge records is maintained by the Permanent Service on Sea Level[13].

The longest periodicity detected in the tide gauge record is limited by the length of the record. Statistical analysis of tide gauges spanning more than 100 years has recently shown the presence of a quasi-60 year oscillation in the sea levels as in the surface air temperature. The multi-decadal oscillations up to a quasi-60 years periodicity on sea levels and other climate parameters are discussed in Chambers, Merrifield and Nerem[8]; Jevrejava, Moore, Grinsted and Woodworth,[13]; Parker[28-34]; Parker, Saad Saleem and Lawson[33]; Mazzarella, Giuliacci and Scafetta[15]; Scafetta[39-43]; Mazzarella and Scafetta[16]. If the sea levels oscillate with a quasi-60 years periodicity, clearly records shorter than 60-70 years should not be considered to infer any trend in the rate of rise of sea levels.

The tide gauges measure the water level over time ignoring variations caused by waves with periods shorter than minutes. These data are then compared to the reference (or datum) level. The datum is unfortunately not fixed, but subject to vertical motion because of subsidy or isostasy due to global (as the global isostatic adjustment GIA) or local phenomena. The tide gauge records are supposed to be adjusted for vertical land motion to give the absolute sea level (ASL).

The naturally oscillatory behaviour of the relative sea level (RSL) measured by the tide gauges of enough quality and length in areas of relatively good land stability, i.e. land motion not certainly negligible but constant, is already enough to conclude that the rate of rise of sea levels is not increasing because of global warming, and therefore the locally inferred rate of rise is the best parameter for coastal and ocean management (Boretti and Watson[2]; Boretti, 2012[3-7]; Morner[17-22]; Parker[28-34]; Parker, Saad Saleem and Lawson[33]).

While the local relative sea levels are acceleration free if the tide gauge has enough quality and length, the reconstructions of global absolute mean sea level (GMSL) are continuously accelerating[9]. As demonstrated by Parker, 2014a,b, this GMSL result is produced by "*cherry picking*" in space and time window the tide gauge record in a scattered data base where the information for the past are limited to few geographical areas of mostly isostasy (all the southern Hemisphere has 2 (two) tide gauges with good records recording since more than 100 years) and the more recent information is from areas of mostly subsidy and suffering for the short record length (the Pacific has for example many short term records of about 20 years started during a valley of the peak and valley oscillations and land subsidy).

The tide gauge records are adjusted for vertical global glacial isostatic adjustment (GIA) using models as for example those of Douglas, Kearney and Leatherman[10]. GIA models only provide the broadest scale resolution of vertical land motion and do not have resolution to provide information at local scales[52]. Local processes associated with tectonics, volcanism, sediment compaction, and subsurface mineral and water extraction are generally not accounted for in the GIA models. Emerging methods for local vertical movements are based on the data from high accuracy GPS receivers preferably co-located with tide gauges. However, the GPS data (as example the one from SONEL, 2013) are a very recent tool still being refined to track the vertical land motion of a GPS dome with still significant inaccuracies, with the tide gauges often located far from the GPS dome and without any levelling to the GPS datum. Therefore, while the measure of the relative sea level velocity is relatively straightforward, the determination of the absolute sea level velocity is certainly more troublesome, and corrections for barometric pressure and vertical land motion are often the reason of more uncertainty rather than better accuracy in estimating sea level trends.

The temperatures of the world oceans have been finally measured since 2004 in the Argo project (Argo, 2013). A float of 3600 buoys samples the world ocean with target a 3º x 3º array from 0 to 2000 m depth measuring temperatures and other parameters as salinity 60 S to 60 N. While the land temperature may be biased by anthropogenic factors not related to the changed composition of the atmosphere (for example urban heat islands), the ocean temperatures are a very direct measurement of the heat uptake (if any) as well as of the thermal expansion contribution to sea level rise. The isotherms average 0 – 2000 m depth, as well as the time series of the world ocean average temperatures 2004 to 2013, show a surprisingly stability, with no detectable difference after 10 years of recording[35]. The time series show no gradient, with linear fittings returning value well below the accuracy of the measurements of one over one thousand K per year. Over the same decade, above 60 N and below 60 S, the additional information is that the sea ice extent has been expanding rather than contracting, with the growth in Antartctica more than compensating the reduction in the Arctic[27]. Without a clear mass contribution (while water shift is more difficult to be measured, but the supposed melting of ice caps in the North and South poles computed by the models has not been confirmed by the experiments) or a significant thermo steric effect (the world oceans haven't been warmed as computed in the models), there may be further acceleration in the GMSL computation as Church and White[9] only because of the "*cherry picking*" and the everything but transparent computing procedure.

The lack of positive acceleration in sea levels is consistent with many other analyses indicating an absence of any signs of acceleration (e.g. Boretti and Watson[2]; Boretti, 2012[3-7]; Holgate[11]; Houston and Dean[12]; Morner[17-22]; Parker[28-32]; Parker, Saad Saleem and Lawson[33]; Unnikrishnan and Shankar[46]; Watson[47]; Wenzel and Schröter[50]; Wunsch, Ponte and Heimbach[51]).

THE NOT ACCELERATING PACIFIC TIDE GAUGES

The non-accelerating tide gauges of the Pacific have been already analysed many times, as for example Parker, Saad Saleem and Lawson[33] and Parker[34]. Parker, Saad Saleem and Lawson[33] discuss the opportunity to analyse monthly average sea level records with linear, parabolic and linear plus sinusoidal fittings, as well as applying a thorough time series of the sea level rates of rise, computed by linear fittings with different time windows, and inferring the acceleration from these latter variations. The two ultra-centenary Australian tide gauges in Sydney (Pacific) and Fremantle (Indian Ocean) both exhibit no-accelerating naturally oscillating trends with important multi-decadal periodicities. The authors also discuss the sea level data for selected long term Pacific tide gauges and present a monthly average sea level and linear trend for the other Pacific tide gauges covering more than 70 years which have good quality data to conjecture the lack of any positive acceleration.

Parker[34] discusses the natural oscillations and trends in all the ultra-centenary long term tide gauges of the Pacific showing the 12 month moving averages of sea levels, the periodogram of the monthly departures vs. the linear trend with the computed sea level rise rates of 20, 30, and 60 years or all the data of sea level acceleration to detect similarly oscillating trends, are free of any acceleration.

The present contribution further expands this later analysis to completely cover the Pacific area including tide gauges of reduced length and better covering the oscillating pattern.

The tide gauge records for the Pacific locations are of interest are obtained from the Permanent Service for Mean Sea Level[38]. The selected tide gauges analysed included the entire Pacific which had more than 100 years of recorded data: Sydney NSW is the composite record of two tide gauges, SYDNEY, FORT DENISON of time span of data: 1886 – 1993 and completeness (%): 100 and SYDNEY, FORT DENISON 2 of time span of data: 1914 – 2010 and completeness (%): 98. The two records of Sydney are overlapping for almost 80 years with only very minor differences and they can be used to produce a longer record of good quality; Honolulu HI (HONOLULU) has time span of data: 1905 – 2011 and completeness (%): 100; San Diego CA (SAN DIEGO QUARANTINE STATION) has time span of data: 1906 – 2011 and completeness (%): 98; San Francisco CA (SAN FRANCISCO) has time span of data: 1854 – 2011 and completeness (%): 100. This is by far the best tide gauge of the area spanning without gaps more than 150 years; Seattle WA (SEATTLE) has time span of data: 1899 – 2011 and completeness (%): 100; Victoria BC (VICTORIA) has time span of data: 1909 – 2011 and completeness (%): 99; Auckland NZ (AUCKLAND II) has time span of data: 1903 – 2000 and completeness (%): 96. This tide gauge is (unfortunately) not updated since the year 2000; Vancouver BC (VANCOUVER) has a quality issue, because many years of data are missed. The tide gauge has time span

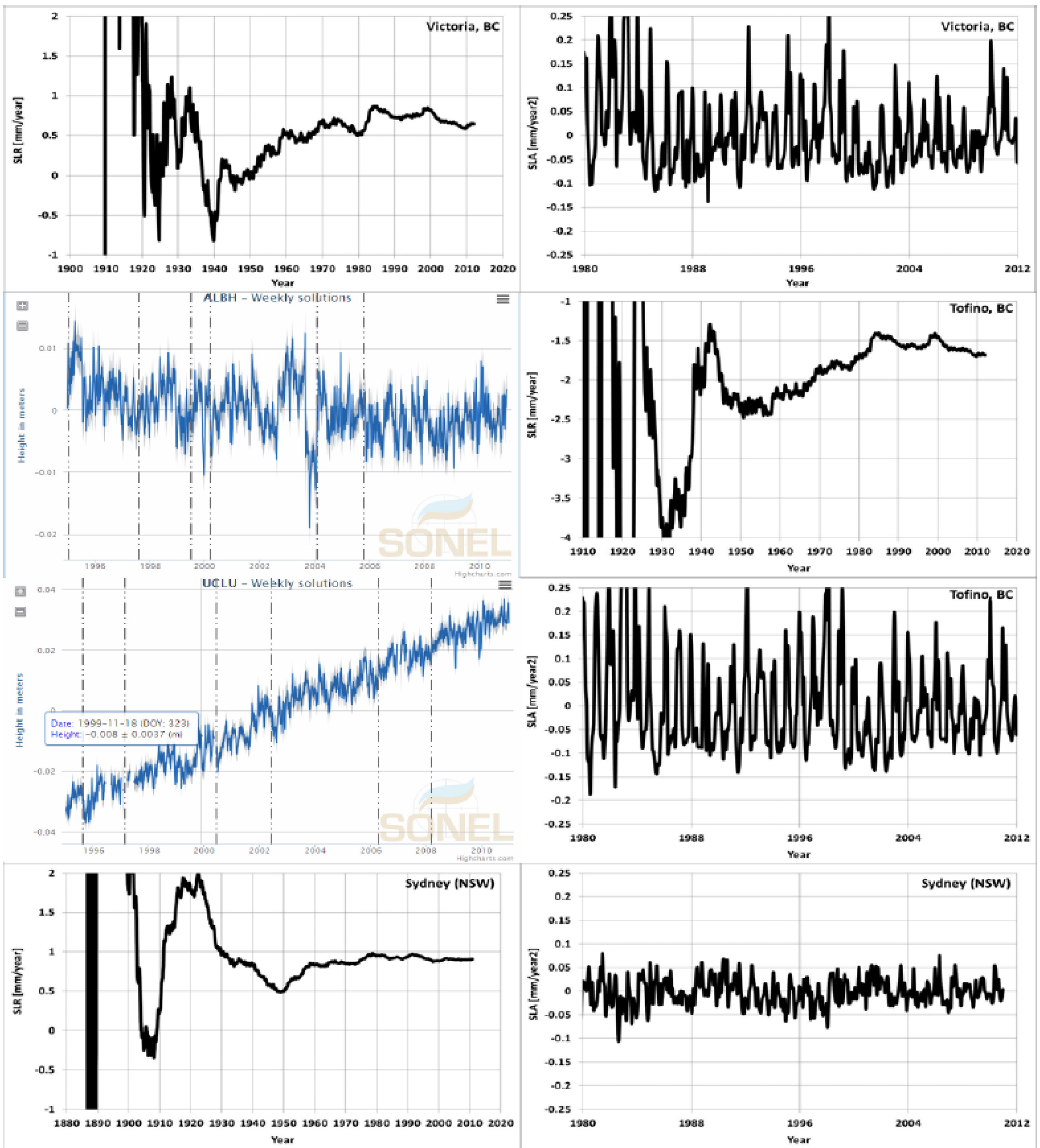


Figure 1: Relative SLR, relative SLA and GPS results for the Pacific tide gauges with more than 100 years of recording (data from PSMSL, 2013; pictures from SONEL 2013). No GPS data is available for Prince Rupert and Vancouver

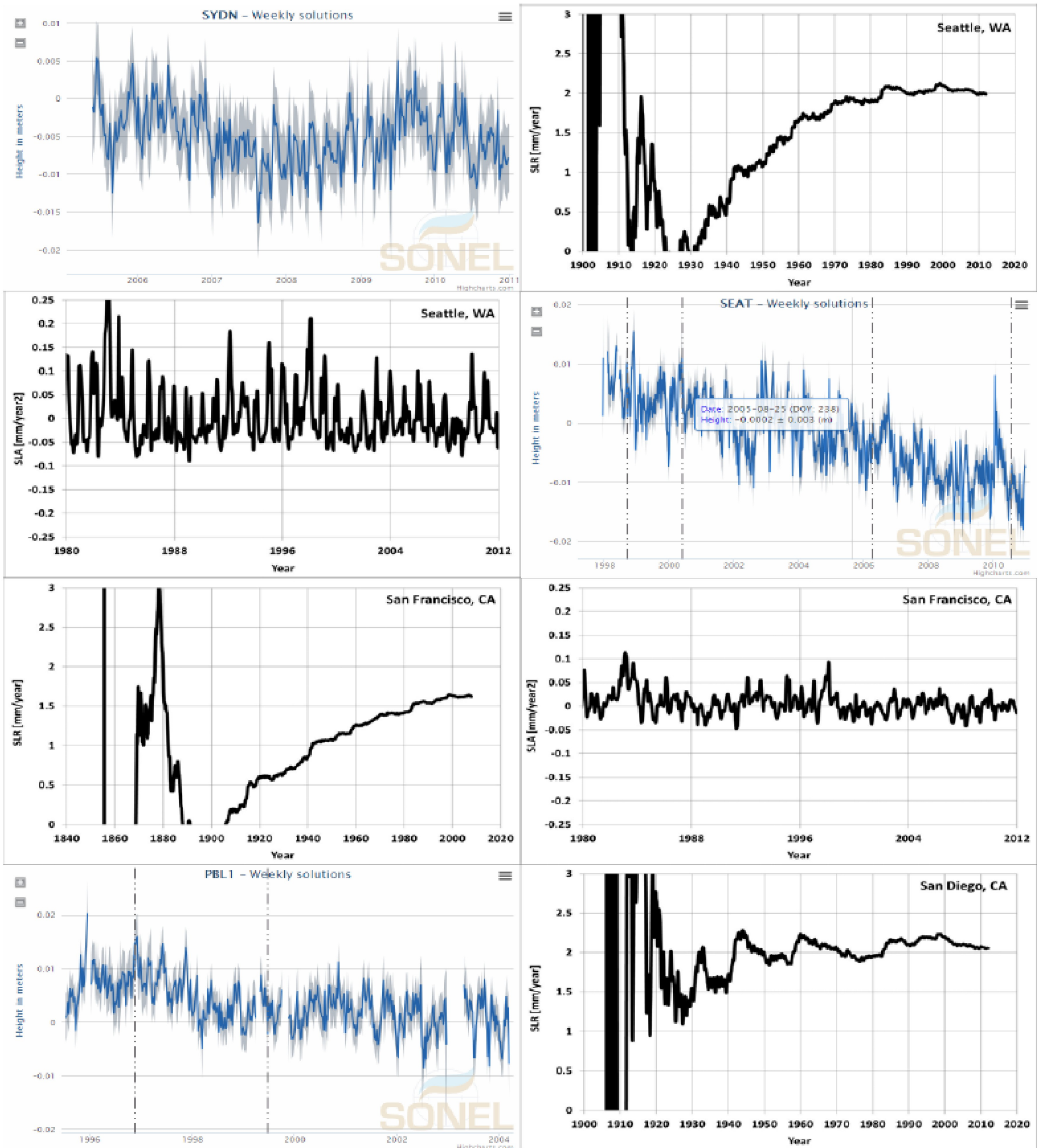
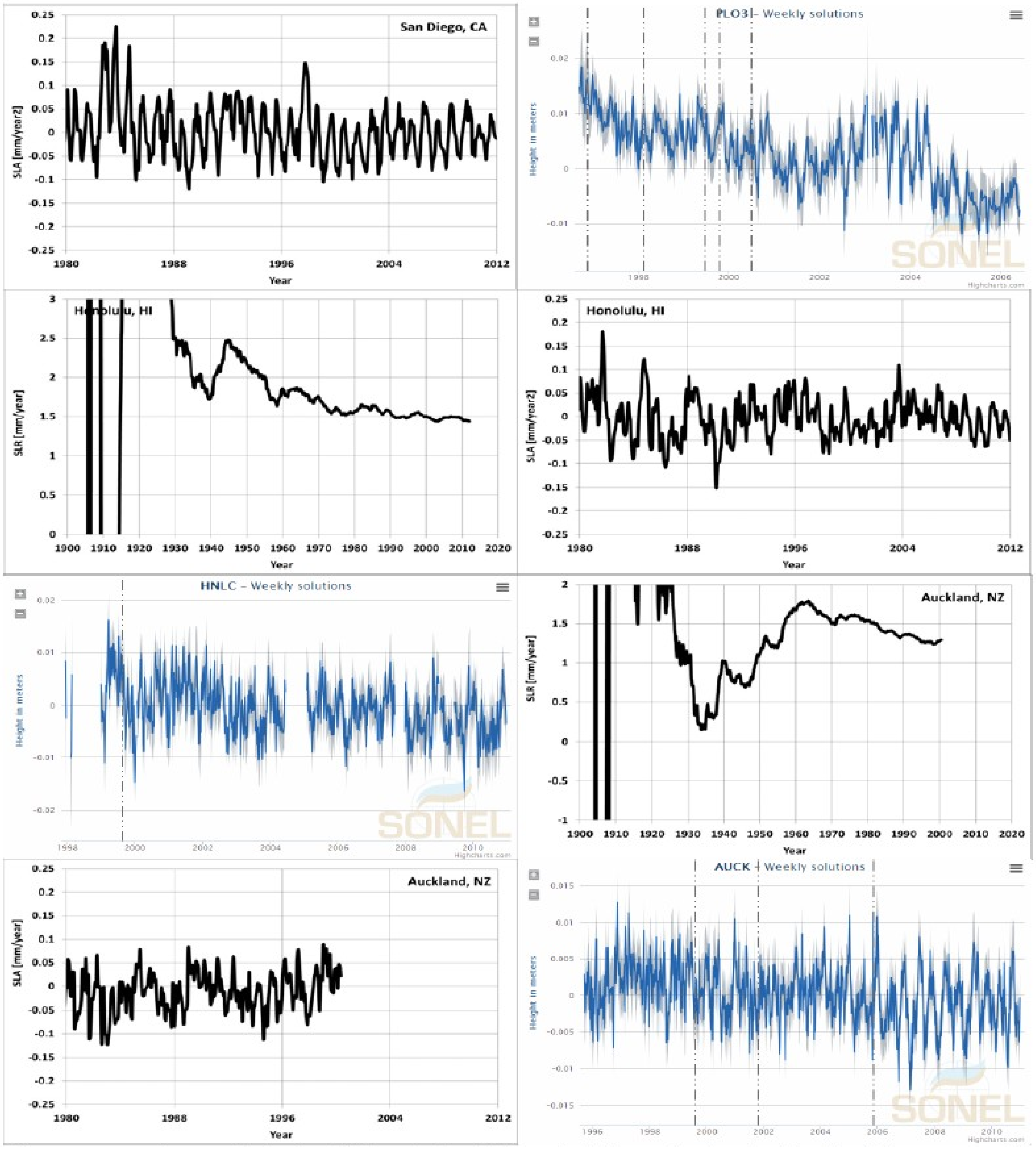


Figure 1: Continues – Relative SLR, relative SLA and GPS results for the Pacific tide gauges with more than 100 years of recording (data from PSMSL, 2013; pictures from SONEL 2013). No GPS data is available for Prince Rupert and Vancouver

of data: 1910 – 2011 but completeness (%): 82; Tofino BC (TOFINO) also has a quality issue, because of the many years missed. The tide gauge has time span of data: 1909 – 2011 but completeness (%): 76; Prince Rupert BC (PRINCE RUPERT) has time span of data: 1909 – 2011 but completeness (%): 81.

Records 1-6 are free of quality issues and their analysis may produce reliable results. Tide gauge 7 is not updated since more than a decade. Tide gauges 8-10 have missed data but however more than 70-80 years of continuous recording up to the present point.

If the monthly averaged mean sea levels data for every location are given as a time series x_i, y_i for i=1,N, where x is the time and y the mean sea level over the time interval, the traditional approach to compute the rate of rise of sea levels at a certain time x_k is to fit all the data x_i, y_i for i=1,k with a line and to compute the SLR_k as the slope of the line. By the graphs of SLR_k we may then appreciate the importance of the multi-decadal oscillations of the rate of rise. Providing that



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more than 60–70 years of continuously recorded data, without any quality issues, are available in a given location, the SLR_k usually returns a reasonable estimation of the velocity of sea level at any time x_k and the (conventional) acceleration of sea level SLA_k may then be computed as the time derivative of this velocity. This conventional velocity and acceleration might clearly oscillate, and their time history, rather than a single value, is of interest.

In a case with non-accelerating tide gauge records as the norm so far, if x_N is the present time, SLR_N returns the present sea level rate of rise, and the graphs of SLR_k and SLA_k are helpful to confirm the lack of any acceleration. In a case of accelerating tide gauge records as sometimes reconstructed, but so far, has never been measured, this approach confirm the presence of acceleration in the form of a consistently increasing SLR_k and a consistently positive SLA_k rather than the oscillating values over the longer term trend to the zero[33].

Figure1 presents the relative SLR, the nearby GPS

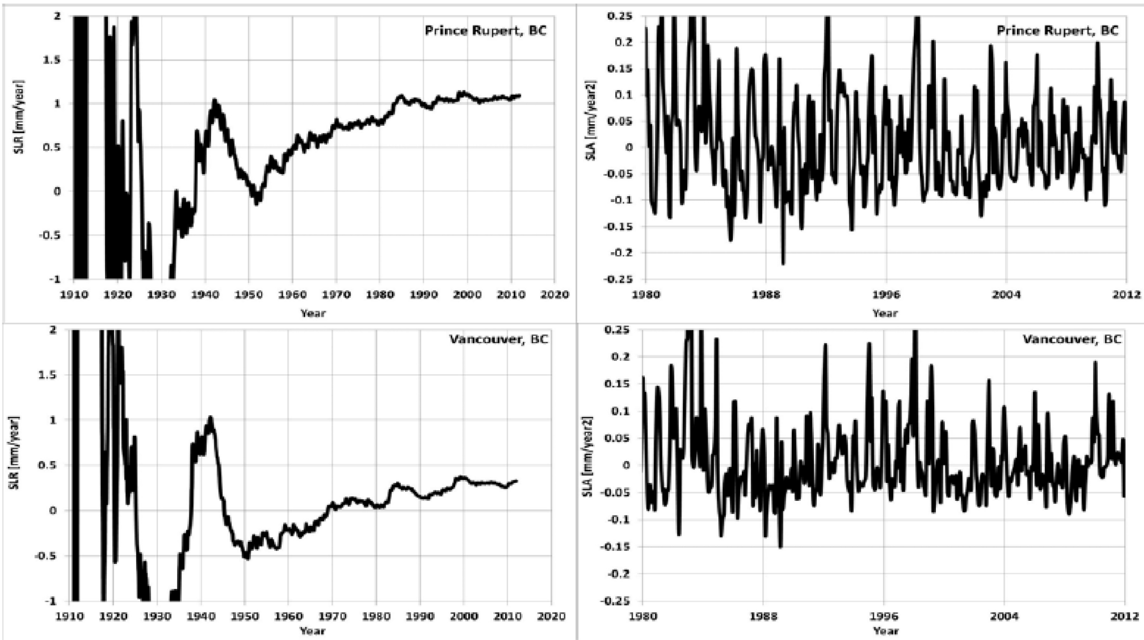

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TABLE 1 : Relative SLR averaged over different time windows (computational procedure in Parker 2013f; data from PSMSL 2013, results from Parker 2013f), land velocity in nearby GNSS Stations (data from SONEL 2013) and relative SLA averaged over different time windows (computational procedure in Parker 2013f; data from PSMSL 2013; results from Parker 2013f)

PSMSL	GNSS	Land Velocity [mm/y]	Relative SLR [mm/y]			Relative SLA [mm/y^2]		
			10y average	20y average	30y average	10y average	20y average	30y average
Sydney, NSW	SYDN	-0.89 +/- 0.65	0.905	0.912	0.918	0.004	-0.004	-0.003
Auckland, NZ	AUCK	-0.22 +/- 0.15	1.295	1.354	1.425	-0.007	-0.012	-0.007
Honolulu, HI	HNLC	-0.36 +/- 0.16	1.472	1.489	1.518	-0.002	-0.002	-0.007
San Diego, CA	PLO3	-1.65 +/- 0.41	2.082	2.133	2.125	-0.008	-0.003	0.003
San Francisco, CA	PBL1	-1.12 +/- 0.25	1.618	1.611	1.584	-0.001	0.004	0.006
Seattle, WA	SEAT	-1.34 +/- 0.23	2.026	2.037	2.035	-0.006	0.001	0.002
Tofino, BC	UCLU	4.10 +/- 0.14	-1.633	-1.582	-1.555	-0.012	-0.004	-0.001
Vancouver, BC	NA	NA	0.296	0.281	0.255	0.002	0.009	0.009
Victoria, BC	ALBH	-0.34 +/- 0.31	0.643	0.705	0.727	-0.007	-0.003	0.001
Prince Rupert, BC	NA	NA	1.058	1.058	1.04	0.004	0.007	0.007

data (to understand if the tide gauge is subject to isostasy or subsidy) and the SLA for the different tide gauges. The GPS data may only help understanding if the land motion contributes to the tide gauge result. However, it is not suggested to simply reduce the sea level rate of rise by the subsidy velocity of the nearby GPS station, being

TABLE 2 : Latest SLR of Pacific tide gauges with more than 60 years of recording (computational procedure in NOAA 2013b, c; results from NOAA 2013b,c)

ID	Station Name	First Year	Last Year	Year Range	Trend (mm/y)	± 95%Conf. Int. (mm/y)
545-001	Ko Taphao Noi, Thailand	1940	2010	71	0.9	0.96
600-021	Ko Lak, Thailand	1940	2010	71	0.08	0.27
609-001	Macau, China	1925	1985	61	0.25	0.5
611-010	Quarry Bay & North Point, China	1929	2011	83	1.36	0.54
641-021	Kushiro, Japan	1947	2011	65	9.39	0.3
642-061	Mera, Japan	1931	2011	81	3.78	0.2
642-091	Aburatsubo, Japan	1930	2011	82	3.63	0.21
645-011	Hosojima, Japan	1930	2011	82	-0.43	0.29
647-023	Hamada II & Tonoura, Japan	1894	2011	118	0.48	0.24
647-071	Wajima, Japan	1930	2011	82	-0.2	0.23
660-021	Legaspi, Albay, Philippines	1947	2009	63	5.38	0.72
680-135	Newcastle III & V, Australia	1925	2010	86	1.04	0.69
680-140	Sydney, Fort Denison 1 & 2, Australia	1886	2010	125	0.65	0.1
690-002	Auckland II, New Zealand	1903	2000	98	1.29	0.2
690-011	Wellington Harbour, New Zealand	1944	2011	68	2.45	0.29
690-022	Lyttelton II, New Zealand	1924	2000	77	2.36	0.29
690-041	Bluff/Southland Harbour, New Zealand	1917	2011	95	1.57	0.24
822-001	Prince Rupert, Canada	1909	2011	103	1.12	0.24
822-071	Vancouver, Canada	1910	2011	102	0.37	0.23
822-101	Victoria, Canada	1909	2011	103	0.63	0.21
822-116	Tofino, Canada	1909	2010	102	-1.7	0.3
840-011	Balboa, Panama	1908	2003	96	1.49	0.25
850-012	Antofagasta 2, Chile	1945	2010	66	-0.8	0.43
	Honolulu, HI	1905	2006	102	1.5	0.25
	Kahului, HI	1947	2006	60	2.32	0.53
	Hilo, HI	1927	2006	80	3.27	0.35
	Midway Atoll	1947	2006	60	0.7	0.54
	Kwajalein, Marshall Islands	1946	2006	61	1.43	0.81
	San Diego, CA	1906	2006	101	2.06	0.2
	Los Angeles, CA	1923	2006	84	0.83	0.27
	Santa Monica, CA	1933	2006	74	1.46	0.4
	Port San Luis, CA	1945	2006	62	0.79	0.48
	San Francisco, CA	1897	2006	110	2.01	0.21
	Alameda, CA	1939	2006	68	0.82	0.51
	Crescent City, CA	1933	2006	74	-0.65	0.36
	Astoria, OR	1925	2006	82	-0.31	0.4
	Neah Bay, WA	1934	2006	73	-1.63	0.36
	Seattle, WA	1898	2006	109	2.06	0.17
	Friday Harbor, WA	1934	2006	73	1.13	0.33
	Ketchikan, AK	1919	2006	88	-0.19	0.27
	Sitka, AK	1924	2006	83	-2.05	0.32

then accuracy of the GPS measurement still poor and being the relative motion of the tide gauge vs. the GPS station unknown. However, for the most part of the long term tide gauges of the Pacific except than those in Canada, the nearby SONEL GPS signals show subsidy. Therefore, what is measured by the tide gauge, the relative motion sea-to-land, has very likely to be reduced to account for the land motion if the interest is focused on the absolute sea level rate of rise. In the limit of the data available, we may assume for now that the sea level acceleration is unaffected by the land motion.

TABLE 1 presents the relative SLR averaged over different time windows (computational procedure in Parker 2013f; data from PSMSL 2013, results from Parker 2013f), land velocity in nearby GNSS Stations (data from SONEL 2013) and relative SLA averaged over different time windows (computational procedure in Parker 2013f; data from PSMSL 2013; results from Parker 2013f).

The SLR is the long term velocity. The SLA is more a parameter helpful to assess the lack of any acceleration and consequently, legitimizes the SLR estimate rather than showing the true acceleration. In all cases the SLA is oscillating about the zero value and averaging over the last 10, 20 and 30 years produce values very close to zero. In all the cases, the SLR approach reasonable long term estimations after 60 to 70 years. Before this time, the SLR assumes values completely unrealistic that may be either larger or smaller than the justifiable long term values. The SLR generally approaches the final long-term value after 60-70 years, as in Sydney and Honolulu, however, sometimes it requires more than the 60-70 years, as in San Francisco, where the SLR is remarkably still changing significantly after 150 years. With more data in the record, the more complex is the sea level behaviour.

The average (relative) rise rate of sea level in the stations of TABLE 1 is 0.99 mm/year. Note here that the computed accelerations are negligible at all stations, with small positive and negative values, alternating depending on the window adopted. The average acceleration at these sea level stations from this table is a mere – 0.001 mm/year^2 that we prefer to state as negligible. The land motion analysis based on the satellite GPS suggests this rate is mostly the result of subsidy, and therefore the average absolute rate of rise is very likely close to 0 mm/year.

TABLE1 is limited to only 10 locations with more than 100 years of recording that are mostly distributed along the North American coast of the Pacific. Relaxing the requirement on the minimum number of years of recorded data, a more densely populated table can be generated. However, shorter records produce inaccuracies in the SLR that is then subject to positive or negative SLA depending on when the record starts.

TABLE 2 presents the rise rate of sea levels computed with linear fitting for the stations within the Pacific included in the NOAA data base[24] with more than 60 years of data. Outliers with SLR values above 10 mm/year or below -10 mm/years are removed. The average SLR in this compilation is 1.24 mm/year. These SLR may change from an update to the other because of the multi-decadal oscillations.

TABLE 3 : SLR results short term pacific island tide gauges (data from PSMSL, 2013)

Tide gauge	First Year	Last Year	Year Range	Trend (mm/y)
Rarotonga A&B	1977	2011	35	1.51
Chuuk	1947	1995	49	0.6
Enewetok	1951	1972	21	0.5318
Fanning B	1973	1988	14	1.4815
Funafuti A&B	1977	2011	35	3.74
Guam APRA	1948	2013	65	1.786
Honiara B&II	1974	2011	38	2.8
Kanton Is. A&B	1949	2007	59	0.58
Kapingamarangi	1978	2008	31	2.53
Kwajalein	1946	2006	61	1.43
Lombrun	1995	2013	18	8.1806
Majuro B & C	1968	2011	44	3.6
Malakal B	1969	2009	41	1.73
Nauru AB	1974	2013	39	1.01
Noumea Numbo & Chaleix	1970	2011	42	-1.85
Nuku'alofa B	1993	2013	20	8.9537
Pago Pago	1948	2006	59	2.07
Papeete-B	1975	2009	35	2.51
Penrhyn	1977	2010	34	2.4
Pohnpei B & C	1974	2011	38	3.87
Rabaul	1966	1997	32	-2.59
Rikitea	1969	2003	35	1.72
Saipan	1979	2012	33	2.3777
Suva A	1972	2011	40	6.3
Tarawa ABC	1974	2002	28	2.5304
Xmas IS I&II	1956	2012	56	0.474
Yap	1969	2012	43	2.5318

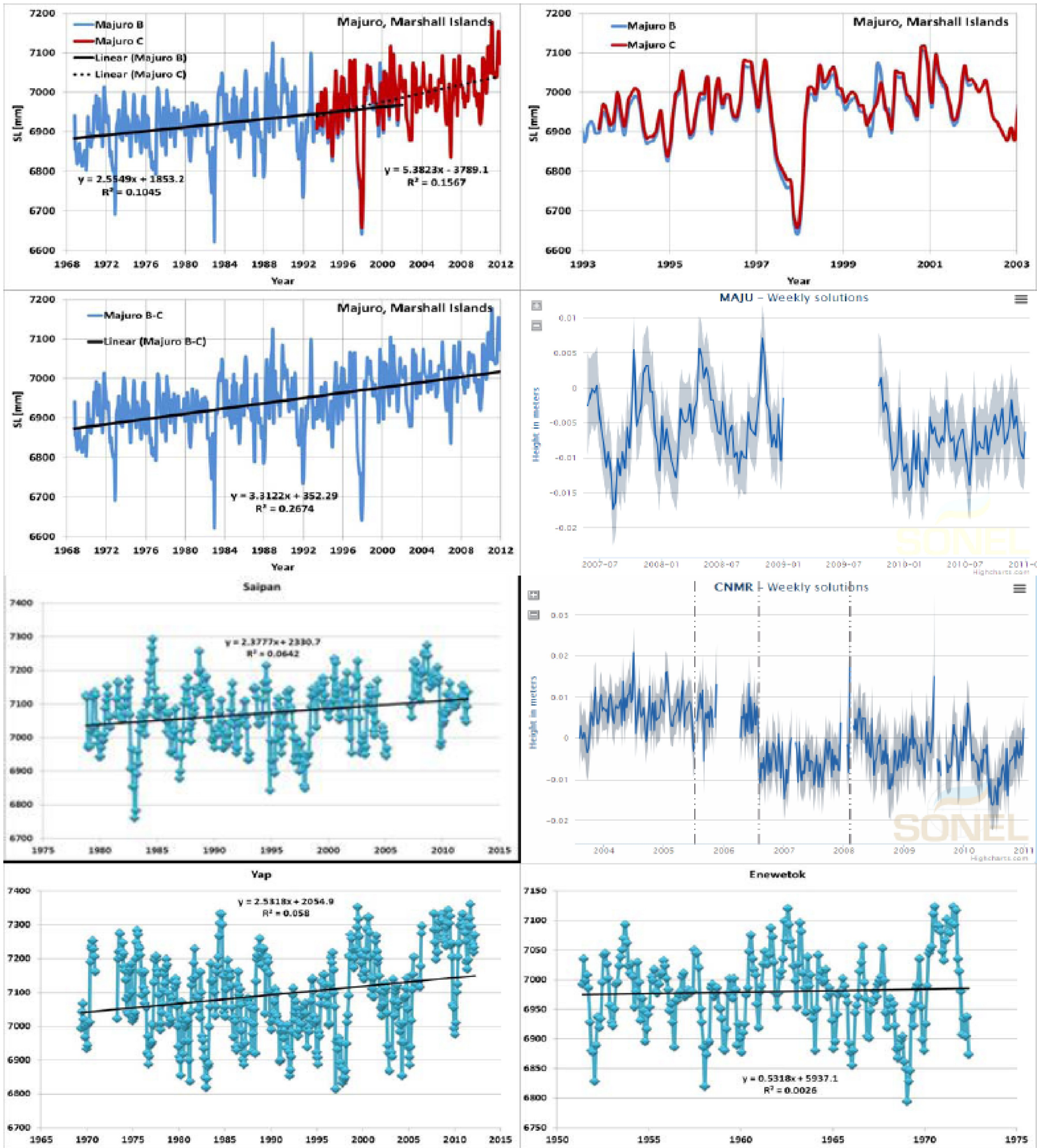


Figure 2 : Relative SLR and GPS results for the short Pacific Island tide gauges (data from PSMSL, 2013; pictures from SONEL 2013). No GPS data is available for Yap, Enewetok, Fanning and Christmas Is. GPS signal of Nauru and Nuku'alofa indicated as not robust by SONEL and not presented

Much larger sea level rises may be computed by selectively focusing on short time windows that magnify the effect of the multi-decadal oscillations. Figure 2 and TABLE 3 presents some results for the short term tide gauges of the Pacific islands. Figure 2 includes SLR and GPS data.

For the specific of Majuro, Marshall Islands, a prior tide gauge was providing results with almost a decade of successful overlapping data with the latest tide gauge and a longer composite record may be produced. MAJURO C has a time span of data: 1993 – 2011 and completeness (%): 97. MAJURO B has a time span of data: 1968 – 2001 and completeness (%): 90. The missed data was obtained by interpolating the neighbouring months or years. The actual long term sea level rise of Majuro is certainly closer to the 3.3 mm/year of the longer composite record than the 5.7 mm/year of the shorter record. From the nearby GNSS station of MAJU, that is considered not robust by SONEL, this tide gauge may be subject to significant subsidy.

None of the tide gauges of TABLE 3 or Figure2 satisfy the minimum requirement to assess the sea level trend. However, if not cherry-picked these short term tide gauges show fluctuating rates correlated to the land motion that just need more data to approach even better the land motion.

SUMMARY AND CONCLUSIONS

The paper has provided the latest local trends from the tide gauges of the Pacific with more than 100 years of recording, with more than 60 years of recording, and finally with short record lengths that prevent a proper assessment of the trend in the Pacific islands.

By considering the high quality, long data records exceeding 100 years, the Pacific sea levels are oscillating without any accelerating behaviour. In the selected locations, the average relative rate of rise of the sea level is about 1 mm/year. Considering the presence of subsidy, the absolute rate of rise is much less than that

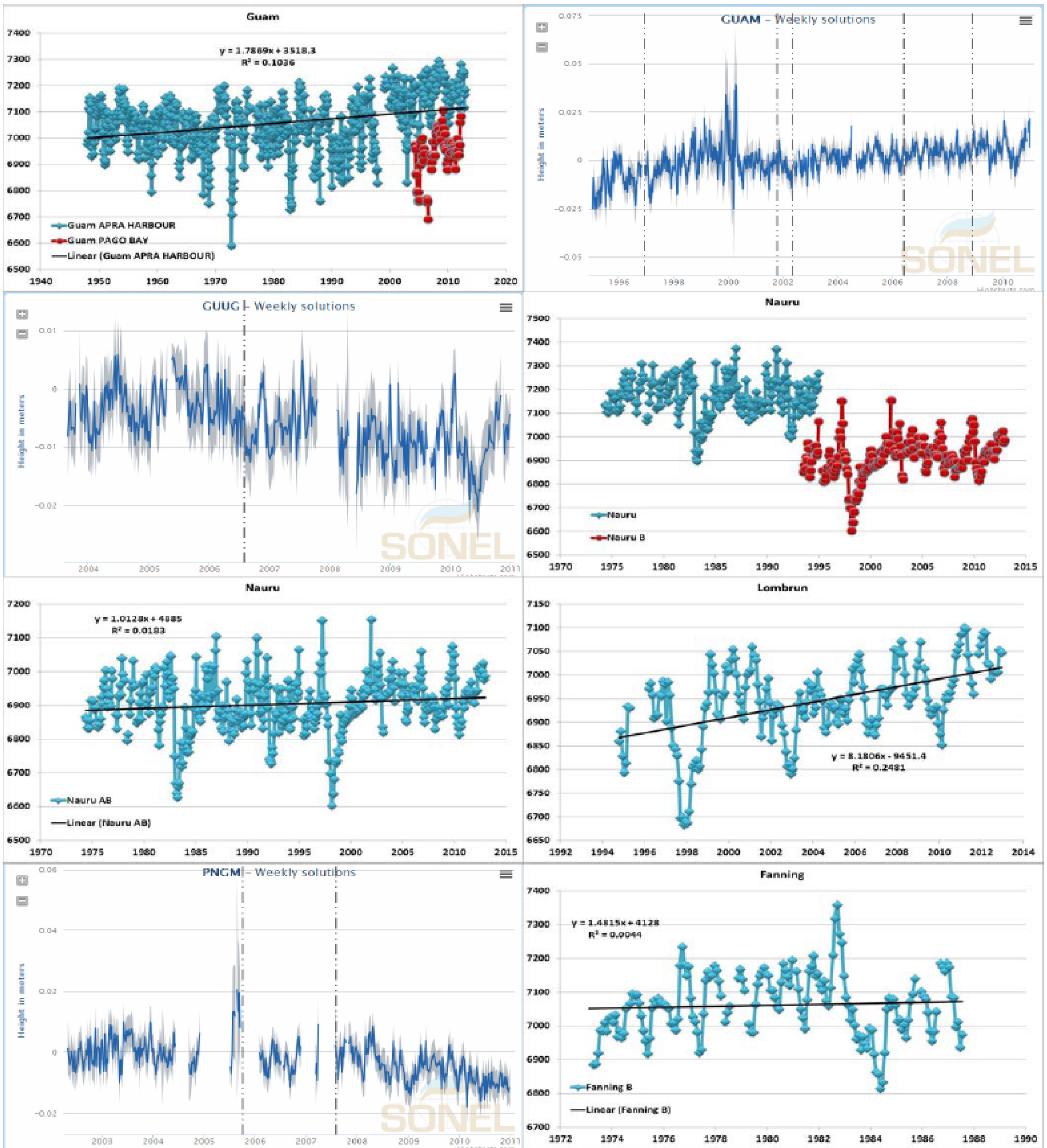
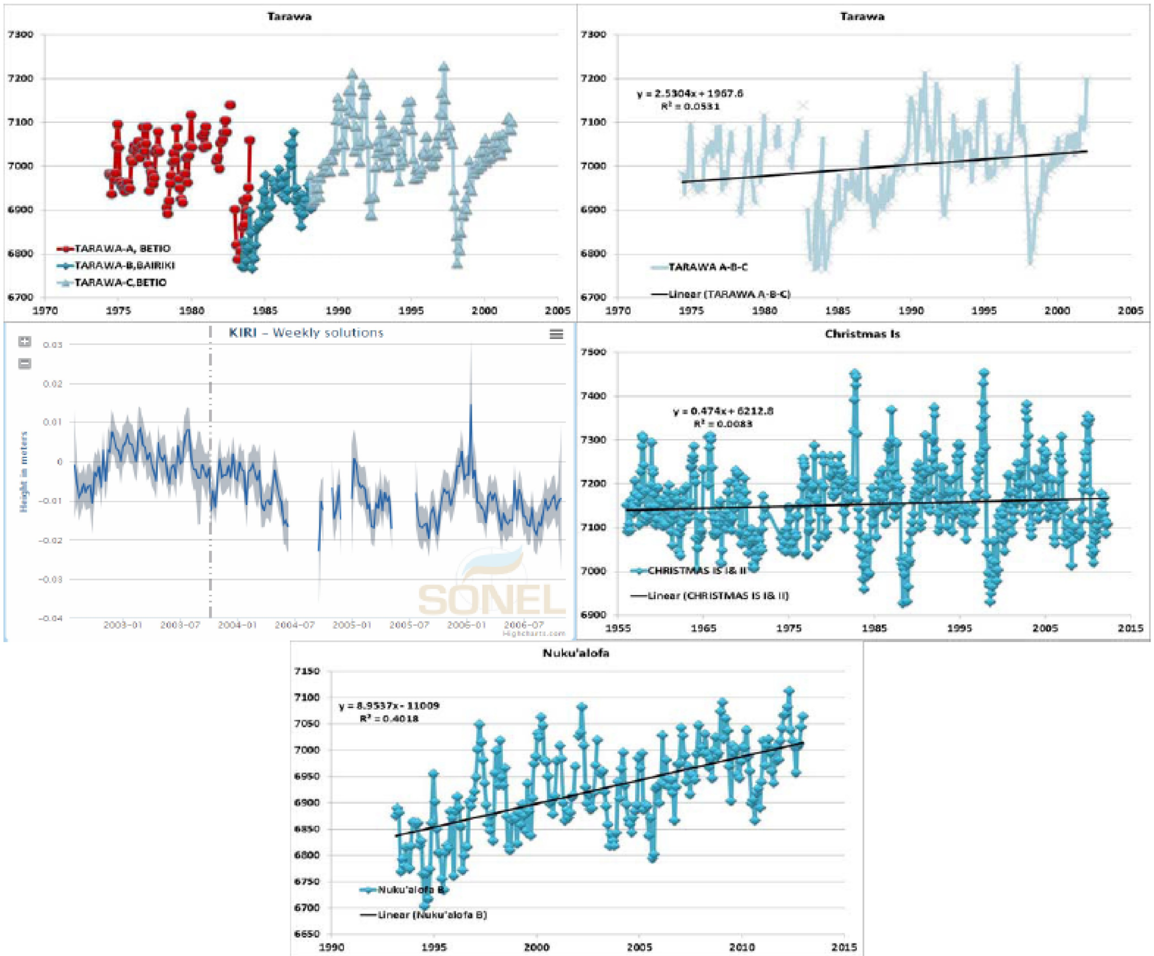


Figure 2 : Continues - Relative SLR and GPS results for the short Pacific Island tide gauges (data from PSMSL, 2013; pictures from SONEL 2013). No GPS data is available for Yap, Enewetok, Fanning and Christmas Is. GPS signal of Nauru and Nuku'alofa indicated as not robust by SONEL and not presented



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and very close to 0 mm/year.

The multi-decadal periodicities recorded in the Pacific tide gauges imply that the search for meaningful long-term trends must, at least, cover a period of no less than, 60-70 years. None of the 10 long-term tide gauge records analyses show any increase in sea level rise over the last two decades. Different conclusions may be inferred by wrongly considering short records, with however much larger or much smaller rates than legitimate of rise that may be computed without a careful cherry picking of the short record.

The land motion and the record length have a significant influence on the sea level rates of rise in the Pacific Islands. The land motion is difficult to be included because of the accuracy and the space and time coverage of the GPS. However, the high rates of rise of sea levels in some of the Pacific Islands are often explained by subsidy and the start of the short record in a valley of the peak and valley oscillations.

The lack of positive acceleration is consistent with the lack of any warming of the world oceans since the times accurate measurements have been started in the ARGO project, and the increasing sea ice extent of the North and South poles as measured by the satellite. Without significant mass and thermo steric components, there is no reason why the global or the Pacific sea levels could have accelerated this century and the analysis of all the tide gauge and satellite GPS data provides same conclusion.

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