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SHORT COMMUNICATION

PACIFIC SEA LEVELS RISING VERY SLOWLY AND NOT ACCELERATING

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Abstract: Over the past decades, detailed surveys of the Pacific Ocean atoll islands show no sign of drowning because of accelerated sea-level rise. Data reveal that no atoll lost land area, 88.6% of islands were either stable or increased in area, and only 11.4% of islands contracted. The Pacific Atolls are not being inundated because the sea level is rising much less than was thought. The average relative rate of rise and acceleration of the 29 long-term-trend (LTT) tide gauges of Japan, Oceania and West Coast of North America, are both negative, −0.02139 mm yr^{-1} and −0.00007 mm yr^{-2} respectively. Since the start of the 1900s, the sea levels of the Pacific Ocean have been remarkably stable.

Key words: sea level rise, tide gauges, subsidence, Pacific Ocean

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Introduction

Duvat (2018) recently pointed out that over the past decades, the atoll islands of the Pacific (and Indian) Ocean exhibited no sign of drowning because of sea-level rise. The data, that covers 30 atolls including 709 islands, reveal that no atoll lost land area, 88.6% of islands were either stable or increased in area, and only 11.4% of islands contracted. Duvat (2018) reports for the atoll islands investigated rates of rise from tide gauges, and not from satellites, as it is reasonable, observing that atoll islands affected by alleged rapid sea-level rise did not show a distinct behaviour compared to other islands. The rates of rise of the sea level reported in Duvat (2018) vary from the +2 mm yr^{-1} of Pingelap and Mokil, Federated States of Micronesia, to the +5.1 mm yr^{-1} of Funafuti, Tuvalu. These rates originate from subjective analyses of tide gauge data of poor quality and length. Other studies of the sea levels such as Parker (2013a, 2016a, d, 2018d), and Parker and Ollier (2018b), suggest much smaller rates of rise while explaining the reasons for uncertainty.

The oscillatory pattern of the Pacific sea level

The sea level of the Pacific Ocean is characterized by multi-decadal oscillations with periodicities up to quasi-60 years very well evidenced in the long-term-trend (LTT) tide gauges, Chambers et al. (2012), Parker (2013a, 2016a, d, 2018d), and Parker and Ollier (2018b). Hence at least 60 years of data of continuous recording in a same tide gauge location, not affected by biasing factors, are needed to compute reliable rates of rise. Possible thermosteric effects and possible

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sinking of the instrument must be considered to produce reliable assessments. The Pacific atolls mentioned in Duvat (2018) do not have tide gauge records of adequate length and quality to infer accurate estimates of the sea level rates of rise. But in the same basin there are many long-term-trend (LTT) tide gauge records that satisfy the requirements of quality and length.

The tide gauges of Funafuti

The rates of rise estimated in Parker (2013a, 2016a, d, 2018d) and Parker and Ollier (2018b), are much smaller than the estimations of the values mentioned by Duvat (2018). For what concerns the specific of Funafuti, Tuvalu, that is the tide gauge with the highest sea level rise mentioned in Duvat (2018), there are data from two tide gauges. The short FUNAFUTI tide gauge record, from an instrument that was subsiding vs. the primary benchmark, has data 1977 to 2000 suggesting an apparent relative rate of rise of the sea level of +0.43 mm yr^{-1} (Fig. 1a). The similarly short, FUNAFUTI B tide gauge record, from a much better instrument that is minimally subsiding vs. the primary benchmark, has data suggesting an apparent relative rate of rise of the sea level of +3.65 mm yr^{-1} over the time window 1993 to 2018 (Fig. 1b). This latter result is biased by the extremely low ENSO waters of 1998. Since January 1999, the apparent rate of rise reduces to +1.32 mm yr^{-1}. Hence, in Funafuti, Tuvalu, the rate of rise of the sea level is not the +5.1 mm yr^{-1} considered in Duvat (2018), but very likely much less than 1 mm yr^{-1}. From the vertical position of the TUVA GPS antenna, close to the primary benchmark (Fig. 1c), land subsidence fully explains the rate of rise of the sea level relative to the instrument.

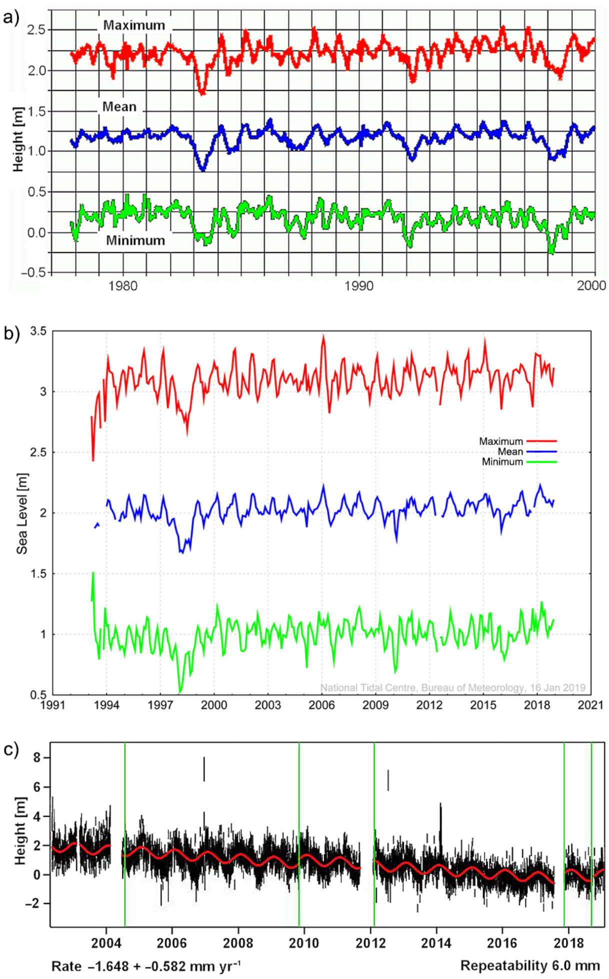

Fig. 1. a) Monthly maximum, mean and minimum sea level in FUNAFUTI (image reproduced and modified from a report of the Australian Government Bureau of Meteorology proposed by Daly (2002), b) Monthly maximum, mean and minimum sea level in FUNAFUTI B (image reproduced and modified after BoM (2019), c) Vertical position of the TUVA GPS antenna, close to the primary benchmark (image reproduced modified after JPL (2018).

The 29 long-term-trend tide gauges of the Pacific Ocean

More appropriate statements about the Pacific sea levels may be inferred from the analysis of the long-term-trend (LTT) tide gauges of the Pacific. The East coast of Asia has the five LTT tide gauges, Oshoro, Wajima, Hosojima and Tonoura, that are affected to a lesser extent by crustal movement, and Aburatsubo, that is affected by crustal movement, in Japan. Without Aburatsubo, Japan-4 data set, the average relative rate of rise is +0.08 mm yr^{-1}, and the average acceleration is negative, −0.01105 mm yr^{-2}. With Aburatsubo, Japan-5 data set, the average relative rate of rise is +0.79 mm yr^{-1}, and the average acceleration is about same negative, −0.01016 mm yr^{-2}. Figure 2 presents the time series of the monthly average mean sea levels (MSL) of Hosojima. The first measurement is January 1894, the last measurement is September 2018. This high-quality record has very few gaps, filled by interpolating neighbouring years or months. Linear and parabolic fittings are indistinguishable. The rate of rise is slightly negative, −0.01 mm yr^{-1}. The time series of a GPS dome nearby the tide gauge is also presented. The most likely vertical velocity that can be computed over the short time window 2003 to 2011 is about +0.75 mm yr^{-1}, for an absolute rate of rise of +0.74 mm yr^{-1}.

Oceania has also five LTT tide gauges: Fremantle, that is however in the Indian Ocean, and Sydney in Australia, Auckland and Dunedin in New Zealand, and Honolulu, in the Hawaii Islands, USA. With Fremantle, Oceania-5 data set, the average relative rate of rise is +1.306 mm yr^{-1}, and the average acceleration is +0.00490 mm yr^{-2}. Without Fremantle, Oceania-4 data set, the average relative rate of rise is +1.209 mm yr^{-1}, and the average acceleration is +0.00469 mm yr^{-2}.

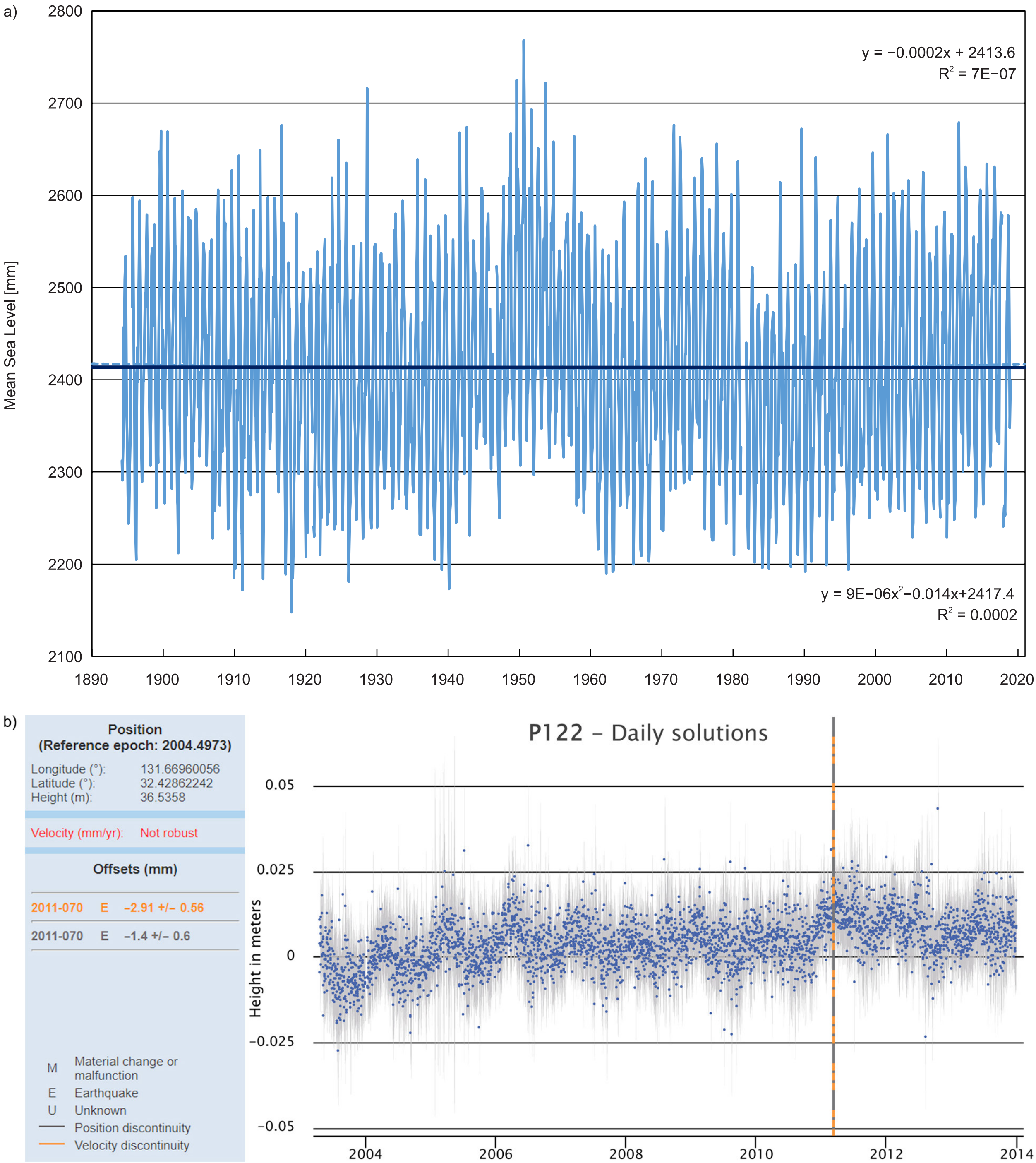

Fig. 2. a) Monthly average mean sea levels in Hosojima, Japan after GIAJ (2018), b) Position of a nearby GPS dome after SONEL (2018).

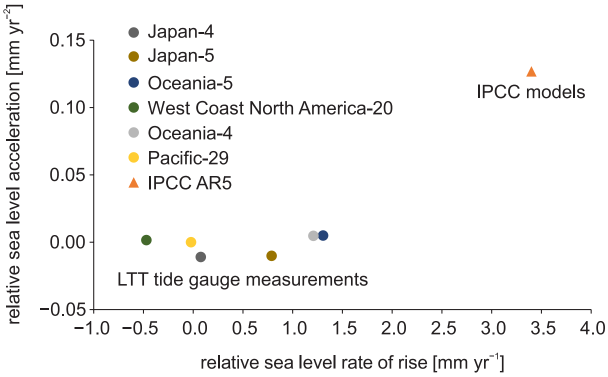

Fig. 3. Relative sea level rate of rise and acceleration of the long-term trend (LTT) tide gauges of the Pacific. On average, the relative rate of rise and acceleration are both negative, −0.02139 mm yr^{-1} and −0.00007 mm yr^{-2}, respectively.

Along the West Coast of North America, in the 20 LTT tide gauges of Juneau (AK, USA), Ketchikan (AK, USA), Sitka (AK, USA), Unalaska (AK, USA), Crescent City (CA, USA), La Jolla (CA, USA), Los Angeles (CA, USA), San Diego (CA, USA), San Francisco (CA, USA), Santa Monica (CA, USA), Astoria (OR, USA), Friday Harbour (WA, USA), Neah Bay (WA, USA), Seattle (WA, USA), Prince Rupert (Canada), Point Atkinson (Canada), Vancouver (Canada), Victoria (Canada), Tofino (Canada), and Balboa (Panama), the average relative rate of rise is −0.47 mm yr^{-1}, and the average acceleration is +0.0015 mm yr^{-2}, "West Coast of North America-20" data set. To be noted, there is no LTT station for the Pacific coast of South America.

By considering the average of the 29 tide gauges included in the Japan-5, Oceania-4 and West Coast of North America-20 data sets, Pacific 29 hereafter, both the relative rate of rise and the acceleration are negative, −0.02139 mm yr^{-1} and −0.00007 mm yr^{-2} respectively (Fig. 3).

The global lack of acceleration in the long-term-trend tide gauges

Figure 3 confirms the lack of any sign of the climate models' predicted accelerated sea level rise already evidenced in many works, such as Douglas (1992), Douglas, Peltier (2002), Mörner (2004, 2007, 2010a, b, c, 2011a, b, 2013, 2016), Jevrejeva et al. (2006, 2008), Holgate (2007), Wunsch et al. (2007), Wenzel, Schröter (2010), Houston, Dean (2011), Watson (2011), Beenstock et al. (2012, 2015), Boretti (2012a, b), Boretti, Watson (2012), Schmith et al. (2012), Dean, Houston (2013), Parker (2013b, c, d, 2014a, b, 2016a, b, c, d, e, 2018a, b, c), Scafetta (2014), Parker, Ollier (2015, 2017a, b, 2018a, b), Okunaka, Hirahara (2016), unfortunately usually neglected in the mainstream literature.

Discussion

The Japan Meteorological Agency has recently, courageously, acknowledged the lack of any significant sea level rise in Japan (JMA 2018). They say *A trend of sea level rise has been observed in Japanese coastal areas since the 1980s, but no clear long-term trend of rise is seen for the period from 1906 to 2017*. Their four stations (Oshoro, Wajima, Hosojima and Tonoura) time series shows a small, average rate of rise of the sea levels of +0.288 mm yr^{-1}, and a small, average acceleration of +0.010 mm yr^{-2}. As shown in Parker (2018e), this is the result of having considered the tide gauge record for Hamada as a single record when it is actually the composite of two tide gauge records: the long-term-trend tide gauge record of Tonoura, of data 1894 to 1984, not affected by subsidence, and the short-term tide gauge record of Hamada II, of data 1984 to present, that is affected by subsidence. The composition of different records to produce a composite record introduces many uncertainties. Apart from datum shifts, every tide gauge has an individual sea and land component. The sea level trend since 1894 of the composite record of Hamada is +0.7626 mm yr^{-1}, and the acceleration is +0.0198 mm yr^{-2}. NOAA (2018) proposes a different composite record for Tonoura and Hamada, spanning the period 1894 to 2011, with relative sea level trend of 0.46 mm yr^{-1}. A possible datum shift in April 1984 at the time of the start of the second record is mentioned by NOAA. We prefer to consider only the result for Tonoura. With data 1896 to 1984, Tonoura is characterized by a relative sea level trend of +0.34 mm yr^{-1}, about same of the three other records of Oshoro, Wajima, Hosojima, and acceleration of −0.0446 mm yr^{-2}. The extra subsidence of Hamada II vs. Tonoura is also mentioned in Okunaka and Hirahara (2016). The sea levels of the, long-term-trend tide gauges of Japan show sea level is almost stable and any rise is slightly decelerating. This pattern of stable sea levels is common to all the Pacific Ocean. The average relative rate of rise and acceleration of the 29 long-term-trend (LTT) tide gauges of Japan, Oceania and West Coast of North America, are both negative, −0.02139 mm yr^{-1} and −0.00007 mm yr^{-2}, respectively.

Despite the many uncertainties, we may conclude that the relative rate of rise and the relative acceleration of the Pacific sea levels are negligible, and very far from the model predictions of the IPCC AR5 Chapter 13 that assume a present rate of rise absolute of 3.4 mm yr^{-1} and require an acceleration of +0.1268 mm yr^{-2} to support their claims for 2050 and 2100. Unlike the Japan meteorological office, the Australian meteorological office does not consider the historical tide gauge records since 2009. The Australian National Tidal Centre (NTC), now part of the Australian meteorological office, had periodical survey of sea level rise from historical tide gauges, but these incorrect surveys were terminated by censorship in 2009 (BoM 2009). To claim unprecedented recent natural oscillations it is necessary to erase past measurements or adjust them.

Conclusion

The Pacific Atolls are not drowning because the sea level is rising much less than what was once thought. By considering the average of the 29 long-term-trend (LTT) tide gauges of Japan, Oceania and West Coast of North America, both the relative rate of rise and acceleration are negative, −0.02139 mm yr^{-1} and −0.00007 mm yr^{-2}, respectively. Since the start of the 1900s, the sea levels of the Pacific have been remarkably stable, rising or falling mostly because of subsidence. The evidence proposed by Duvat (2018) is supported by the long-term tide gauge indication.

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Author contributions

AP collected and analysed the data, that were discussed with CO. AP and CO equally contributed to the writing of the paper.

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