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Ocean Science Discussions

Interactive comment on "Technical Note: Mean sea level variation in the Singapore Strait from long-term tide data" *by* P. Tkalich et al.

P. Tkalich et al.

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Firstly, we would like to thank the reviewer for his/her careful review and the critical comments. We know that they helped us to improve the manuscript to a large extent. We have toned down and thoroughly revised the manuscript to meet the journal standard as described below.

Reviewer #2's comment:

1/Suitability: The subject of the paper, i.e. mean sea level variation in the Singapore Strait falls within the field of the Ocean Sciences journal.

2/Summary: The paper investigates the mean sea level variations in the Singapore Strait, using mainly water level data from one tidal gauge. Analysing the residual water

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Interactive Discussion

Discussion Paper

level (the original signal has been de-tided), the authors discuss the behavior of annually averaged residual water level, as well as trend and seasonal variability. The authors explain the interannual variability by the El Nino events, and the seasonal variability by the monsoon.

3/General comments: The aim of the paper is quite interesting from a research and practical point of view. However, the methods are not sufficiently explained to guarantee that the results are valid and well interpreted. I identified at several points which make the paper questionable, and make some propositions of improvement (see the specific comments below).

Answer:

Problems regarding methodologies (use of single tide gauge, and technique of filling data gaps) addressed by the reviewer have been appropriately resolved in the revised manuscript as described below.

Reviewer #2's comment:

4/Specific comments

Initial assumptions

Authors refer to Pavel et al (2011, 2012) to justify some choices like for instance that wind is the main driver of observed variability of sea-level anomaly in the Singapore Strait. However, this reference is not in the reference list. The only Pavel et al. reference I could find on internet is " Pavel Tkalich, Vethamony P., Babu M.T., Pokratath R., "Seasonal sea level variability and anomalies in the Singapore Strait", Third International Conference in Ocean Engineering (ICOE2009), 1-5 February 2009, Chennai India, pp. 874-880". I read the paper, but I did not understand why this work justify that wind is the main driver of observed variability, and moreover on season, year and decades time scale. This point has to be explained. Indeed, mean sea level variations can also be due to pressure, general 3D circulations.

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Answer:

This citation is corrected to Tkalich et al. (2012) which has been published as Tkalich, P., P. Vethamony, M. T. Babu, and Malanotte-Rizzoli, P., 2012: Storm surges in the Singapore Strait due to winds in the South China Sea, Nat. Hazards, doi:10.1007/s11069-012-0211-8. Here, annual and inter-annual sea level variability is caused by the Asian monsoon system, modulated by coupled ocean-atmosphere oscillations, such as ENSO, and wind acts as a main driver as described in Tkalich et al. (2012). Of course, mean sea level with temporal scales in the order of decades to centuries are controlled by the climate change and global variability which involve the pressure and general circulation.

Reviewer #2's comment:

Used Data

The authors explain they use several types of data (for instance NCEP wind). They describe it (table 1 and Figure 1a), but no analysis of these data is shown. It seems it is the same for the altimeter measurements. At the end, all the conclusions are based only on one dataset of water level in one location. This makes the conclusions questionable.

Answer:

Since the NCEP wind is not explicitly used as pointed out by the reviewer, redundant texts associated with it in the Data and Methodology section were removed. Moreover, Table 1 describing those datasets was deleted in the revised version. Figure 1a is cleaned excluding wind and irrelevant labels. In present study, we used the merged global dataset of the 1/3ox1/3o-gridded daily Delay Time products of AVISO (http://www.aviso.oceanobs.com/en/data.html) to verify our analysis at tide gauge as shown in Fig. 2. Instead of using 1-year data to validate analysis of Tanjong Pagar, long-term datasets of Raffles Lighthouse, Sultan Shoal and Sembawang stations are

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now involved in the analysis of sea level rises as show below. This improvement consolidates our argument.

Reviewer #2's comment:

Data processing: de-tiding and trend significance

Authors explain they de-tided the signal. Some further explanations are needed. Which method or software has been used to do this? Furthermore, I do not think that the entire table 2 of all the constituents is necessary for the paper, regarding the aim of the paper which is mean sea level: we need to be sure that the entire tidal signal is removed, but we do not need to know perfectly what is the tide at this place. Regarding trend results, there is no statistical test of significance (like T-test ?). Such test would strengthen the credibility of the paper.

Answer:

The tide gauge data were subject to harmonic analysis using T_Tide (Pawlowicz et al., 2002), and thereby computed amplitude and phase of tidal constituents, which were used to reconstruct tidal elevations. It aims at archiving the sea level anomaly (this paper is no longer reconstructing other signals from tidal constant). Mean sea level was calculated as the average of sea level anomalies available within a certain (monthly, annual) period. In case the gaps are with discontinued longer than a portion, says 1/5, of a considered period (e.g., monthly, annually), these data were not taken into account. For example, the data in 1995 with several discrete gaps are not used in our calculation of mean sea level. Although our treatment is different from what might have been used in PSMSL dataset or others that may lead to losing of certain unknown information, the consistency of our analysis with what achieved in PSMSL (Fig. 2d) as well as satellite data (Fig. 2b-c) allows us to move forward with the analysis. That is why 4 tide gauge datasets have been used simultaneously as recommended by the reviewer. The consistent rising tendency from these tide gauge data and the similarity with global and regional (SCS) trend (as given in the above answer) give a reasonable

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standpoint for discussion. In addition, we also removed the old Fig. 2 and Table 2 along with their redundant texts in the revised manuscript.

Reviewer #2's comment:

Analysis and interpretation: trend and subsidence

Regarding the observed trend and the way to check if there is subsidence or not, the authors compare the total water signal with other gauges, over one year. To me, it is not a proper way to check it. A proper way would be to use permanent GPS measures. It seems that such type of measure is available: http://www.sbsm.gov.cn/pcgiap/95wg/wg3/geodinf.htm#Singapore. If no measures are available, then a water level comparison could be done, but on several decades, and plotting the annual mean sea level rather than the total water level (which includes tide and make the figures not readable regarding the initial question of subsidence existence). Also, on Figure 2, it seems that at the studied gauge (Tangon Pagar), the behaviour between august 1998 and December 1998 is quite different from the other gauges, with a mean water level which seem to first increase and then decrease. Of course, it is difficult to see this behaviour on such plot. Also, on trend results, some important references and discussion are missing, like (Becker et al, 2012; Meyssignac et al, 2012a,b,c) which show results on sea-level variations the global scale and on tropical Pacific islands since 1950.

Answer:

No scientific work has been done to assess subsidence rate in Singapore, and therefore, we examinined 4 independent tide gauge datasets at different locations, namely Raffles Lighthouse, Sultan Shoal, Sembawang and Tanjong Pagar. The revision replaces Fig. 2 by the new one which demonstrates the detide process. The sea level anomaly and mean sea level become intuitive, thus, subsidence trend is not likely to be found. The paper also added references recommended by reviewer (and others) with detailed review in the Introduction as well as Results and Discussion sections.

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Reviewer #2's comment:

Analysis and interpretation: interannual variability Regarding interannual variability, the paper would benefit of a more quantitative analyses, for instance, by using teleconnection patterns indices (http://www.cpc.ncep.noaa.gov/data/teledoc/teleindcalc.shtml) and compare it to the annual mean sea level.

Answer:

The interannual pattern is now analyzed against Multivariate ENSO Index.

Reviewer #2's comment:

Presentation The paper is sometimes difficult to read in reason of a lack of supporting arguments and figures (for instance when the authors describe the dynamics of the site, or when they compare mean sea level variability with El Nino events). Also, I strongly recommend a reading and correction by an English native speaker.

Answer:

In line with the reviewer's comment, arguments are now strengthened by the consolidated use of four tide gauge data, in line with comparison with previous studies associated with sea level rise as mentioned in the revision. In addition, figures are better prepared in the revision. For example, analysis results of mean sea levels are now compared and plotted in accordance with the Multivariate ENSO Index in the same period (Fig 4). Figure 2 demonstrates detailed process of detiding, comparison with altimetry data and PSMSL database with consistent legends and axis.

Reviewer #2's comment:

5/Acceptability: Although the subject of the manuscript is interesting, the limits of the method used by the authors (as it is presented in the manuscript) seem to me too strong to be confident in the conclusions. That is why I do not recommend publication of the paper in this form. Lot of work is needed to improve the method and strengthen

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the results, but I strongly encourage the authors to do it.

Answer:

Significant work has been done by us to revise the manuscript. As answered above, we fulfill the analysis of mean sea level by adding data from 3 more tide gauges instead of a single station and compared it with observations. It provides a consolidation to our conclusion (as mentioned in the answer above and can be seen in the manuscript). The construction of data from tidal harmonic constants is no longer used as discrete data, and are not taken into account because they are relatively short with respect to the whole period (e.g. at Tanjong Pagar, less than 1 year-data are missing for the period of 28.2 years). Thus, do not alter the mean sea level trend and misinterpret their beneath behaviors (Fig. 2d). From above, we can say it is an intensive revision with majority of sections (Data and Methodology, Results and Discussion, Conclusions and Abstract); new figures are added and earlier figures are improved. It is hoped that this revised form is worth reconsidered.

Reviewer #2's comment:

6/Technical corrections

Since many points have to be improved (from a scientific point of view), I did not check the form/presentation of the entire manuscript. Thus, this list of technical corrections is not exhaustive. I recommend a careful check by the authors before a new submission.

Answer:

As answered above, issues associated with problems addressed by the reviewer are resolved in the revision. They include replacement of all figures, rewriting of major sections Data and Methodology, Results and Discussion and Abstracts in correspondence with improvement in analysis as described above. It is also intensively checked by authors, prior to resubmission to Ocean Science, though a few bugs left may be unavoidable.

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Reviewer #2's comment:

- P 2257 – line 2: a problem in the sentence (something is missing)

Answer:

This sentence is redundant, and removed

Reviewer #2's comment:

- P 2257 – line 13 to 19: a figure would help a lot the reader to understand the dynamics of this study site

Answer:

Figure 1a is simplified and labeled for an easy reading of the geographic names used in the manuscript.

Reviewer #2's comment:

- P 2259 – line 6 to 9: I do not understand why gaps are filled by tidal signal. Indeed, looking at the end to mean sea-level, I do not see the necessity of this operation. It has to be better explained.

Answer:

This is a relevant comment which has been answered above. It is noted again that technique of filling gaps by tidal signals is no longer used in the revised version.

Reviewer #2's comment:

-P 2263 – reference list: references cited in the text are not present in these list. 7/References

M. Becker, B. Meyssignac, C. Letetrel, W. Llovel, A. Cazenave, T. Delcroix, Sea level variations at tropical Pacific islands since 1950, Global and Planetary Change, Volumes 80–81, January 2012, Pages 85-98, ISSN 0921-

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8181,10.1016/j.gloplacha.2011.09.004.(http://www.sciencedirect.com/science/ article/pii/S0921818111001445)

Meyssignac B. and Cazenave A. (2012) Sea level: a review of present-day and recent-past changes and variability. Journal of Geodynamics, 58:96-109. doi:10.1016/j.jog.2012.03.005.

Meyssignac B., Llovel W., Cazenave A., Salas-Melia D., Becker M. (2012) Tropical Pacific spatial trend patterns in observed sea level: internal variability and/or anthropogenic signature? Climate of the Past. 8:787-802. doi:10.5194/cp-8-787-2012.

Meyssignac B., Becker M., Llovel W., Cazenave A. (2012) An assessment of twodimensional past sea level reconstructions over 1950-2009 based on tide gauge data and different input sea level grids. Survey in Geophysics, online. doi:10.1007/s10712-011-9171-x.

Answer:

Citation bugs are corrected in the revised manuscript.

We appreciate the reviewer's valuable suggestions for revision of this manuscript, which is added in the Acknowledgement section in the revised paper.

Interactive comment on Ocean Sci. Discuss., 9, 2255, 2012.

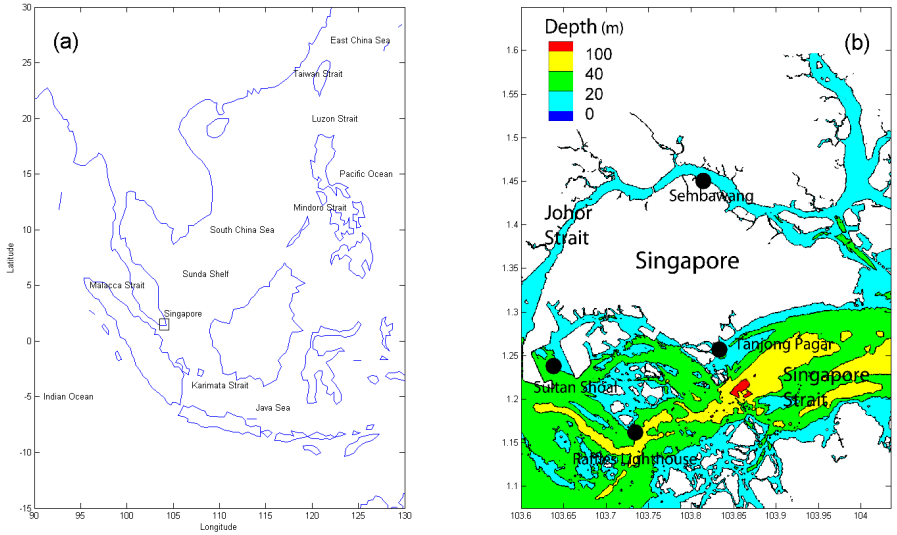

Fig. 1. (a) Study area. (b) The Singapore Strait and its vicinity.

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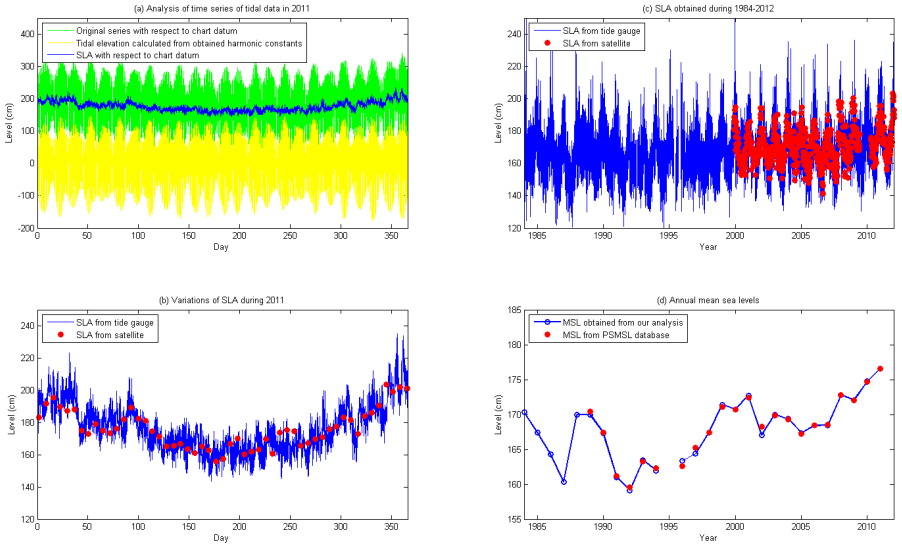

Fig. 2. (a) Typical one year analysis. Comparison of SLA from gauge (blue) and AVISO (red) during (b) one year and (c)1984–2012. (d) Annual MSL (blue lines) in accordance with PSMSL (red symbols).

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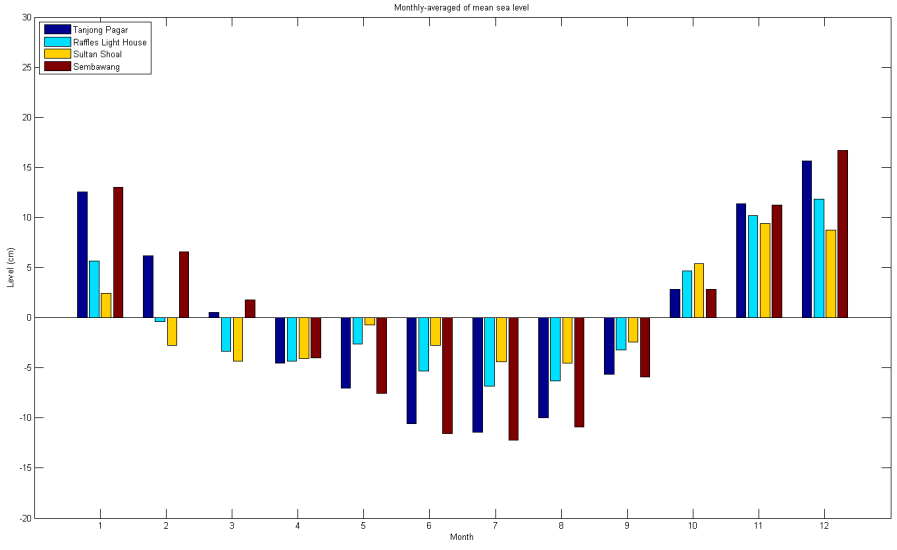

Fig. 3. Monsoonal and seasonal influence on sea level variations (monthly sea level).

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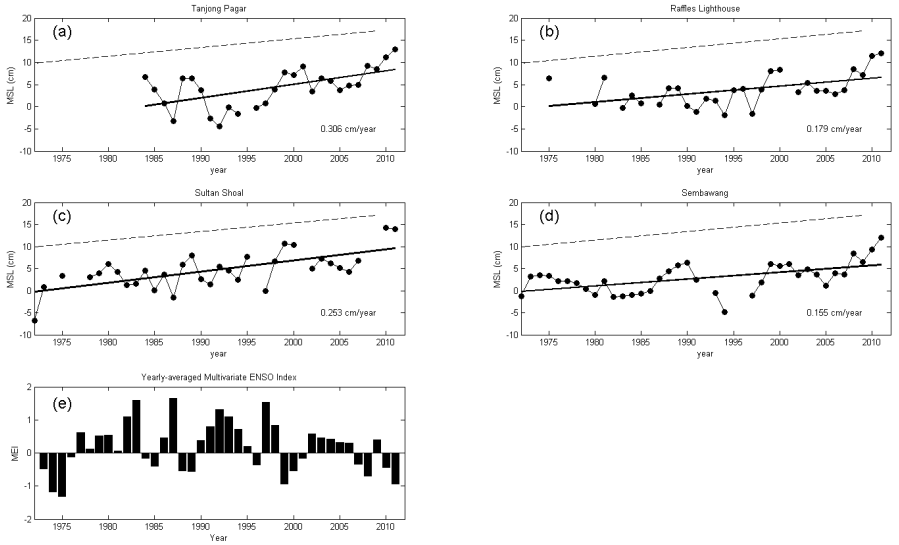

Fig. 4. Trends of annual MSL at (a) TP, (b) RL, (c) SH and (d) SE, in correspondence with (e) ENSO index. Thick lines represent tendency from local MSL; dash lines indicate global trend during 1972–2009.

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