Dear reviewers:

We would like to thank the two reviewers for constructive comments and suggestions, which helped enhance the content of our manuscript. We have tried our best to carefully answer all your comments and questions. We provide response to the reviewers' comments in a question-answer format.

1. General

(1) The language is generally good, except some small mistakes. However, starting with paragraph 2.1, the explanations become very difficult. The outlier and the gap-filling algorithms are not clearly explained, several important information are missing (or postponed to the end) and therefore it is very difficult to read. The authors should make a further effort to better explain the algorithms in detail.

We agree to the reviewers' opinion. We reorganized the manuscript and expanded the analysis to highlight the performance of TADS (Tsunami Arrival time Detection System) as follows:

1 Introduction
2 TADS (Tsunami Arrival time Detection System)
  2.1 Outlier removal algorithm
    2.1.1 Start mode
    2.1.2 Keep mode
    2.1.3 End mode
  2.2 Gap filling algorithm
    2.2.1 SGFA (Short Gap Filling Algorithm)
    2.2.2 LGFA (Long Gap Filling Algorithm)
  2.3 Tsunami detection algorithm
    2.3.1 DART
    2.3.2 SLOPE
    2.3.3 TIDE
3 Calibration of TADS
  3.1 Calibration of outlier removal algorithm
  3.2 Calibration of gap filling algorithm
  3.3 Calibration of tsunami detection algorithm
4 Performance of TADS
  4.1 2011 Tohoku tsunami
  4.2 Performance of outlier removal and gap filling algorithms
  4.3 Performance of tsunami detection algorithm
5 Conclusion

The figures and tables were also reorganized accordingly.

(2) The schemes provided are also too complex and do not help to make the explanation clearer (figures 4, 5 and 6).

The complex schemes are modified completely to make it easy to understand the concept of each algorithm. Please see Figs. 4 – 7 in the revised manuscript.

(3) Some additional explanations come from the results and the discussion, however it would be better to anticipate them in order to understand what is being done.

Please see the answer in (1).

(4) The acronyms and symbols are too much alike and it is difficult to distinguish them. It would be easier to give very different names to parameters according to the outlier, gap-filling or the three tsunami detection algorithms.

Some parameters were named following the previous studies such as Mofjeld (1997), Bressan and Tinti (2011), and Lee and Park (2016). We agree that this might cause some confusion to readers who are not familiar with the previous studies. However, we decided to maintain the names for consistency. Instead, we added the definition in Tables 2, 3 for these parameters.

2. Methods

(1) In the abstract, it is clearly stated that the authors would make use of the concept of the event period, which is however addressed only at the end, in the discussions, while the event time is already used in paragraph 2.2. Its explanation should be anticipated.

We agree to the reviewers' suggestion. We added the purpose and the definition of the event period to section 2 where the event period was first mentioned.

3. Outlier algorithm

(1) Is the short and long outlier detection algorithm the same?

First of all, we changed the name of the outlier detection algorithm to 'outlier removal algorithm' because the algorithm not only detects the outliers but also removes them. The outlier removal algorithm is applicable to all kinds of outliers including long and short outliers. Please see section 2.1 in the revised manuscript for detailed description of the outlier removal algorithm.

(2) How is the difference in wave height between neighboring points computed? Is it the difference of wave height of the time "now" with the previous datum?

Point 5 (see Fig. 4 in the revised manuscript) is the target point which determines whether the point is an outlier or not. The difference in wave height is calculated between the target point and the neighboring point of the window. We gave an example of a way to calculate the difference of wave height in Fig. 4a, and the numerical expressions of total cases can be found in Table 1.

(3) The 8-points window is used only to detect long-term outliers or also single outliers?

Please see the answer in (1).

(4) How does the outlier algorithm search for outliers?

The outlier removal algorithm searches for outliers based on the starting conditions. The basic concept is that the point at which the difference in wave height between neighboring points surpasses the threshold is designated as an outlier. We added detailed description of the starting conditions in section 2.1.1.

(5) What does it mean that the algorithm is accelerated?

The expression "the algorithm is accelerated" signifies that the computing time of the keep mode is much faster than that of the start mode. Instead of using this equivocal expression, we added detailed description of the keep mode in section 2.1.2.

(6) Which is the stopping condition?

We changed the term "stopping condition" to "ending condition" to be consistent with the mode name, which is the end mode. The ending conditions are designed to find the last points of the outliers. We gave an example of the ending condition in Fig. 4c, and the numerical expressions of the total ending conditions can be found in Table 1. We added detailed description of the ending conditions in section 2.1.3.

4. Gap filling algorithm

(1) The explanation of the algorithm lacks some important details, so that the algorithm method, especially LGFA, cannot be understood. How long is n_LGFA? Please explicit it in the text. What do you mean with target data? How are the target data first estimated? Or what are the target and search data? How are they used? Do you use the target data to look for data in the past that could fill the gap? It is not clear. What is EPFM? What is the SWEP data?

We agree to the reviewers' opinion. In order to explain the important details clearly, we divided the section into two sub-sections: 2.2.1 SGFA and 2.2.2 LGFA. Also, we simplified the previous complex schemes by dividing the figure into Fig. 5 and Fig. 6 in the revised manuscript. Please see section 2.2.2 in the revised manuscript for detailed description of LGFA.

(2) Some acronyms are not defined.

We added the full name of an acronym whenever it appears for the first time.

5. Tsunami detection algorithms

(1) The description of the SLOPE and TIDE algorithms are not very clear. In particular, the explanation and the reference to the algorithm TIDE is ambiguous, since it is a tool for harmonic analysis and tide prediction and not for tsunami detection. It should be explained more clearly how this algorithm is used to set up a tsunami detection.

We agree to the reviewers' suggestion. We reconstructed the writing of the tsunami detection algorithm to facilitate the understanding of the explanation. Please see sections 2.3.2 and 2.3.3 in the revised manuscript for detailed description of SLOPE and TIDE.

(2) How is it used the tsunami detection index? Why is it computed? It should be explained before the end of the results.

The tsunami detection index is computed to discriminate the degree of tsunami detection triggered. Depending on the tsunami detection index, the TADS give different alarms such as warning, advisory, or watch alarms. Please see section 2.3 in the revised manuscript for detailed description of the tsunami detection index.

6. Results

(1) The results for outlier detection are here presented as a list of figure descriptions. It should be better to give a general explanation of the algorithm performance and use the figures as examples.

Following the reviewers' suggestion, we combined the writing of the result and discussion section and reconstructed it into two sections to give a general explanation of the algorithm: calibration of TADS and performance of TADS.

(2) The outlier algorithm seems very strict: from the few data shown, I would not mark the data in figure 7(h) or 7(g) as outliers, or even the data in 7(d) or 7(e), especially if the same data patterns happen often in the time series, as it could seem in figure 7(f).

We think that the definition of the outlier depends on the purpose of the system. The purpose of TADS is to remove the outliers which can cause a false alarm. Since all kinds of examples illustrated in Fig. 7 (Fig. 8 in the revised manuscript) can cause a false alarm, these examples should be considered as outliers.

(3) To discriminate outliers, it would be better to inspect time series longer than a month, in order to safely tell if the data shown are outliers or not.

We agree to the reviewers' suggestion and extended the dataset by one year to investigate the performance of the outlier removal algorithm. Please see section 4 in the revised manuscript for detailed description of the performance of the outlier removal algorithm.

(4) Where is the Ulleung-do tide-gauge located? Have you considered the possibility that some of the data shown are long period waves of about 5 cm height, which could be common in harbors or bays?

We thank the reviewer for pointing out the possibility of long period waves caused by the surrounding environment. Because the Ulleung-do surge gauge is hung on a guardrail of a coastal road near a bay, some of the outliers, which could not be explained by the weather report in Fig. 2, might be caused by a bay resonance. However, we did not consider the possibility in this study because the purpose of this study is not to demonstrate the origin of the outliers.

(5) Regarding the gap filling algorithm, the explanation of how the performance tests were computed is missing (page 7, line 24-25). It would be interesting to see the performance of gaps shorter than 3 h.

We added the explanation of how the calibration and performance of the gap filling algorithm were conducted in section 3.2 and section 4, respectively.

7. Discussions

(1) Some explanations should be anticipated, some other information are repeated from the introduction. In particular the explanations on how the event time works should be anticipated.

We agree to the reviewers' suggestion. After deleting the duplicated explanation of the event period, we delineated concisely how the event period works in section 2.

(2) I understand that so far only earthquake generated tsunamis could be detected, since the event time is triggered only by earthquake information and, without the activation of the event mode, there is no tsunami detection. Is this correct? This requires further discussions.

We corrected the manuscript following your recommendation. Please see section 2 in the revised manuscript for detailed description of the event period.

(3) There is some confusion about travel times and travel time delays. The sentences at page 9 lines 27-28 is not correct ("tsunami travel time delay is found ... This delay is caused by ... Watada et al, 2014"). Did you mean to take into account the propagation time of tsunamis?

The submitted manuscript focused too much on the event period which is not the main purpose of this study. Thus, we minimized the comments related to the event period including travel time delays and focused on the performance of TADS in section 4 instead.

(4) How is the alarm rate and the TDI rate defined in the sensitivity test?

First of all, since DART, IS, CF, TIDE are related not to alarms but to detection, we changed the terms of alarm rate and the TDI rate to detect rate and alarm rate, respectively. And we added the definition of the detection rate and the alarm rate in section 3.3.

8. Additional remarks

(1) Tsunamis can be generated by earthquakes. The term earthquakes should be preferred to seaquakes.

We used the term 'earthquake' just for two cases in the revised manuscript. One is for the 2011 Tohoku 'earthquake' and the other is when explaining the start point of event period in section 3. In the first case, we maintained the text because it is awkward to say 'the 2011 Tohoku seaquake.' In the second case, we corrected the manuscript according to your recommendation as follows:

"~ which starts when a seaquake occurs and lasts until a tsunami sufficiently passes by ~"

(2) Also terrestrial landslides is not correct: landslides that start over the land and fall in the water to generate tsunamis are usually called subaerial landslides.

We corrected the manuscript according to your recommendation.

(3) Page 3, line 6: The descriptions of the literature algorithms need to be more rigorous, for example please check the description of the algorithm by Beltrami and Risio 2011.

There are several tsunami detection algorithms based on filters (McGehee and McKinney (1995), Shimizu et al. (2006), etc.). Beltrami and Risio (2011) also developed a tsunami detection algorithm which is applicable to wind-wave gauges based on an infinite impulse response-time domain digital filter. According to the flow of the introduction where the algorithms related to DART are listed, we decided to delete the awkward sentence related to Beltrami and Risio (2011).

McGehee, D. and McKinney, J., 1995. Tsunami detection and warning capability using nearshore submerged pressure transducers - Case study of the 4 October 1994 Shikotan Tsunami. Proceedings of the 4th International Tsunami Symposium, IUGG, Boulder, Colorado, pp. 133-144.

Shimizu, K., Nagai, T., Lee, J. H., Izumi, H., Iwasaki, M., Fujita, T., 2006. Development of Real-Time Tsunami Detection System Using Offshore Water Surface Elevation Data. Proceedings of Techno-Ocean 2006 - 19th JASNAOE Ocean Engineering Symposium, Kobe, Japan, Paper No. 24.

(4) Table 3 is never mentioned in the text.

We added the description of Table 3 (Table 2 in the revised manuscript) in sections 2.2 and 3.2.

(5) Figure descriptions could be better explained.

We agree to the reviewers' suggestion and added more thorough descriptions of the figures.

(6) In the introduction, a broader view of the situation of tsunami detection and automatic data-processing could be addressed, with the more recent developments. For example, new technologies have been introduced, and worldwide and European tsunami warning systems are being developed, together with automatic data-processing algorithms.

We thank the reviewer for pointing out the new technologies for tsunami warning systems. However, we focused on the tsunami detection algorithms which are related to the TADS. Thus, instead of describing a broader situation, we added an example of a European tsunami warning system as follows:

“Pérez et al. (2013) introduced a real time automatic tsunami detection algorithm based on a variance method which was developed within the TRANSFER (Tsunami Risk And Strategies For the European Region) project.”