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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Maximum wind radius estimated by the 50 kt radius: improvement of storm surge forecasting over the Western North Pacific" *by* H. Takagi and W. Wu

H. Takagi and W. Wu

takagi@ide.titech.ac.jp

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Dear Editor and Reviewers, NHESSD,

First of all, we would like to say that we deeply appreciate the reviewers' efforts to evaluate the manuscript and provide a number of valuable comments, and also must thank them for the fact that they spent their precious time in conducting this reviewing process. The authors wish to express their gratitude for these constructive comments and advice given regarding the original manuscript, which much assisted the authors in its revision.

Please find below a detailed reply to the reviewer's comments and the attachment including new figures and table.

Kind Regards,

Hiroshi Takagi (Corresponding author, Tokyo Institute of Technology)

03 January, 2016

Comment #1 The method for the estimation of the radius of maximum winds depends on an estimation of R50, the radius of 50 knot winds. Once this is known, the authors have shown that the resulting estimate of Rmax is reasonably accurate. The reader immediately asks how easy it is to obtain the estimate of R50, and how actually this estimate is done scientifically. In the data that is analyzed in this study, is R50 obtained from the station data? Or from a forecast? This is not explained and needs to be, because then the reader will understand how forecasters might actually use this method in real time. On P. 6441, the authors say that R50 is easily obtained, but don't say how forecasters estimate this, nor how accurate are these estimates in real time.

Reply #1 We understand the reviewer's concerns associated with the accuracy of R50 issued by a meteorological agency (for this particular study, JMA). Indeed, possible errors of R50 are of vital interest when the relationship Rmax=0.23R50 is applied to a real-time forecast. In the revised manuscript, we address the procedure of R50 estimation and possible estimation errors, such as mentioned below:

Some TC parameters such as center positions, Pc, Vmax, and R50, are determined with full use of available observational data such as radar, surface synoptic observations (SYNOP), ship, buoy, and advanced scatterometer (ASCAT) (RSMC Tokyo, 2015), in addition to Dvorak techniques (Dvorak, 1982 and 1984). Moreover, the JMA uniquely uses a table, often referred to as the Koba table, for conversion from the Dvorak CI number to Pc or Vmax values as proposed by Koba et al. (1991). The R50 is estimated according to the statistical relationship between Pc and R50 in the absence of necessary observations (RSMC Tokyo, 2015).

Therefore, the estimation of R50 appears to be highly correlated with the reliability of Pc. Although JMA has adopted the Koba table to improve the estimation of TC intensities in the WNP, there exists a certain degree of estimation error in the conversion process of the Dvorak method. Nevertheless, a series of Dvorak methods using satellite images have been commonly used over the last couple of decades and are considered to be the most reliable estimation of TC intensities in the WNP, where aircraft reconnaissance had been terminated in 1987 (JMA, 2014).

Dvorak V. F. (1982) Tropical cyclone intensity analysis and forecasting from satellite visible or enhanced infrared imagery. NOAA NESS, Applications Laboratory Training Notes. Dvorak V. F. (1984) Tropical cyclone intensity analysis using satellite data. NOAA Tech. Rep. 11. JMA (2014) Typhoon intensity estimation, Meteorological Research Institute, http://www.mri-jma.go.jp/Dep/ty/ty2/tyest/tyest2.html Koba H., Hagiwara T., Osano S., Akashi S. (1991) Relationships between CI Number and Minimum Sea Level Pressure/Maximum Wind Speed of Tropical Cyclones, Geophysical Magazine, Vol. 44, No. 1, 15 – 25.

Comment #2 P. 6435, line 14. The focus on very intense tropical cyclones is understandable, since these are the ones causing the strongest storm surge, but more justification is needed of the specific central pressure threshold used here. Why 935 hPa specifically?

Reply #2 The aim of the present paper is to develop an Rmax estimation model which is expected to increase the reliability of forecasting for strong storm surges.

Recent major TCs, which caused more than 2,000 fatalities, such as 2004 Hurricane Katrina, 2007 Cyclone Sidr, 2008 Cyclone Nargis, and 2013 Typhoon Haiyan had very low central pressures (895–937 hPa) and caused severe storm surge disasters.

Therefore, only TCs with pressures below 935 hPa were including in constructing

the present model, excluding a majority of TCs which may not produce strong storm surges.

In order to justify this classification, we add a new table (Table.1) which demonstrates the relationship between TC central pressures and fatalities.

Comment #3 P. 6437, use of the Myers formula for pressure change from the center: there are other, more up-to-date methods for specifying the pressure and resulting wind field that might also give an improvement in the simulation of storm surge. This should at least be noted in the discussion section, with a few appropriate references.

Reply #3 We recognize Holland model is most commonly used particularly in the Atlantic Basin and the Gulf of Mexico. However, it is not necessarily the case in the WNP. In the revised manuscript, we clarify the reason of the selection of the Myers model, instead of Holland model.

Holland (1980) extended the Myers model, including a shape parameter B. The Myers model corresponds to the Holland model when B is taken to be unity. The B parameter plays an important role in modeling wind and pressure fields, because it has the effect of modulating both the maximum gradient wind speed and the shape of the outer wind profile. The estimation of B essentially requires calibration to wind and pressure observations. However, the development of a relation between B and other physical parameters such as pressure data appears to be difficult for TCs traveling over the WNP, where aircraft reconnaissance has been already terminated.

Thus, for the sake of simplicity and practicality of application, we adopted the Myers model to simulate wind – pressure fields to be used in the storm surge model.

Holland G. (1980) An analytic model of the wind and pressure profiles in hurricanes, Monthly Weather Review, 108, pp.1212-1218.

Comment #4 Figure 8. The real test of whether the new formulation of Rmax improves storm surge modeling is how the model performs for more than one tropical cyclone using the new Rmax estimate. The authors should note that more cases should be simulated to test this.

Reply #4 As per the reviewer's suggestion, one another typhoon has been assessed in order to confirm the reliability of the proposed model. New three figures, Figs 7, 8, 12, are included in the revised manuscript.

Figure 7 presents an application of the proposed method to a recent strong typhoon, Typhoon Goni, which traveled over the southern oceanic basin of Japan in August 2015. This severe typhoon brought about very strong winds, reaching up to 71.0 m/s in Ishigakijima, which were the strongest winds ever recorded on this island (JMA, 2015). The storm surge induced by strong winds and low pressures was successfully recorded by the tidal gauge in the port of Ishigakijima, which is being operated by JMA. The maximum storm surge height (= observed water levels – astronomical tides), which was recorded to have been 57 cm during the passage of the typhoon over the island was compared with storm surges simulated by the model with three different values of Rmax. The observed storm surge appears to lie in those with Rmax estimated by 0.15 R50 and 0.35 R50, which demonstrates the validity of the model.

The present analysis indicates that the larger the typhoon radius, the greater the storm surge height is at the tide station. Figure 8 also demonstrates how changes in Rmax would change the spatial distributions of water-level departures. The size of Rmax appears to be important for precise estimation. Impacts of the storm surge may be limited within a certain area in the case of a smaller radius, whereas the affected area would vastly extend if the size of the typhoon became large. However it should be noted that a smaller typhoon could have a very strong impact on a specific location, because the pressure gradient tends to be steep, which results in stronger winds near the TC center. These facts suggest that Rmax is indeed an important parameter in determining the intensity and size of TCs and, thus, should not be overlooked.

With regard to Typhoon Goni, the progress of Rmax during the typhoon passage es-

timated with the Doppler radar installed at Ishigakijima (JMA, 2015) can be compared with those estimated by the proposed method. When Goni approached Ishigakijima, the TC central pressure had dropped to 935 hP, as shown in Fig.12. The estimated Rmax value agrees well with those detected by the radar when the typhoon transited near the island, while the accuracy of the estimation appears to become lower when the typhoon was far away from the island.

This example implies that the new estimation is expected to provide a reliable Rmax value for a typhoon with a central pressure that is substantially low (lower than 940 hPa), while the method may not provide a good estimation in the case of a less violent typhoon. It is also recognized that the estimation from Pc appears to overestimate Rmax throughout the time period shown in Fig.12.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/3/C2880/2016/nhessd-3-C2880-2016-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 6431, 2015.