

Interactive comment on “Impact of Hurricanes Irma and Maria on the PTWC Tsunami Warning Capability for the Caribbean Region” by Victor Sardina et al.

Victor Sardina et al.

victor.sardina@noaa.gov

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Thank you very much for your time and careful review of our paper. We truly appreciate your comments and suggestions. Please find below our answers to them.

C1: A short discussion on the ML uncertainty as a result of reduced number of stations/phase readings, as ML is as a fast magnitude estimate suitable for the region complements also the detection and location of earthquakes, could support the valuable study provided by the authors.

A1: Using fewer stations in the ML magnitude estimations would have an impact on

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accuracy, but this gets somewhat mitigated by the fact that PTWC routinely computes ML magnitude corrections using the HUMP station as a reference. We did not address the accuracy of the ML magnitude estimates directly, however, because in practice it turns difficult to do, even under normal operational conditions. To verify the ML magnitude accuracy we would have to cross-validate them against the official catalog magnitudes, in this case those included in the NEIC catalog. The NEIC catalog, however, contains a variety of magnitudes for these rather small events, including mb and Md(duration) magnitudes, which makes a fair comparison difficult. Notwithstanding, we have done a comparison of the PTWC magnitude estimations for Caribbean events in the past, published as part of an article in Seismological Research Letters (SRL) in February of 2017 under the title “Evaluation of the Pacific Tsunami Warning Center’s Performance for the Caribbean Based on the Compilation and Analysis of Tsunami Messages Issued between 2003 and July 2017”. In general, PTWC magnitude estimations have a median residual of 0.2 magnitude unit when compared to the catalog magnitudes.

C2: It would also be advisable to provide a bit more information on the reasons of the station availability (instrument damage, power outage, communication lines etc.) and average recovery times based on actual experiences, and preferably not only related to the seismic network but also sea-level network, if possible.

A2: We do not know the specific reasons behind the outages at each seismic stations. We reported the end result on the PTWC end, regardless of the specific reasons. We know, however, that in many cases some stations suffered physical damage, while in other cases the communications’ infrastructure collapsed due to the direct impact of the hurricanes. The Puerto Rico Seismic Network (PRSN), however, should have a database containing these specific data regarding the damages and the measures implemented in the aftermath of the hurricanes.

Regarding the network of sea-level instruments, in this study we focused on the initial tsunami warning capability of the tsunami warning centers, which relies primarily on

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the analysis of seismic data. The water level data turns very useful to confirm the presence of a tsunami, adjust tsunami forecasts, and ultimately to safely cancel a tsunami warning. The initial tsunami warning messages issued by the PTWC, however, rely first and foremost on the analysis of seismic data. To make our focus on this aspect of the PTWC operations more apparent, we will add the word “initial” to the title of our paper so that it reads “Impact of Hurricanes Irma and Maria on the PTWC Initial Tsunami Warning Capability for the Caribbean Region”.

C3: In their conclusion, the authors correctly point out that the devastating impact of hurricanes on the PTWC local tsunami warning capabilities at the local level highlights the vital, and potentially lifesaving role of educating the population to self-evacuate in the event of prolonged or strong ground shaking instead of waiting for official tsunami messages. It would be advisable to elaborate more on this important conclusion, due to the fact that this might be the one and only solution applicable to the local tsunami risk, even if the seismic networks perform in full. Caribe Wave tsunami exercises successfully conducted since 2011, for example, where the last one was conducted on 14 March 2019 with more than 830,000 participants, is probably the most important remedy action which could be referred to in this paper in addressing the technical/operational challenges of a local tsunami warning system to complete the end-to-end chain.

A3: We agree with your assessment regarding the importance of both the role of educating the public to self-evacuate, and the Caribe Wave exercises as one of the most important remedy actions. We do not elaborate further or offer any specific recommendations, however, as a concrete course of action most come out as part of the conclusions of the working committees set up for these purposes. In a recent intervention during a workshop for disaster managers in Ponce, Puerto Rico, however, we mentioned the importance of these issues to those in attendance, mainly disaster managers from across Puerto Rico and the Virgin Islands.

C4: The Sendai Framework for Disaster Risk Reduction 2015-2030 recognizes the

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benefits of multi-hazard early warnings systems and places them in one of its seven global targets, namely to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030. Even though this falls out of the scope of this study, the authors in their conclusion may consider to provide a short elaboration on this aspect, specifically the need to analyse the feasibility and advantages of possible coupling the hurricane- and tsunami warnings in the multi-hazard context, especially in this region, to be addressed by an other future publication perhaps. One should not forget the remaining big question: what happens if a tsunami occurs in this region during one of the peak moments of a hurricane? Even the means of self-evacuation may not exist anymore in such apocalypse scenario...

A4: We agree with the importance of these issues, which in themselves would require independent studies to address them appropriately. Indeed, the prospect of having to deal with a large tsunami while receiving a direct hit by a category 5 hurricane that wipes out most of the infrastructure seems like a worst case scenario. We mentioned these potential case scenarios to the disaster managers in attendance to the aforementioned workshop in Ponce, Puerto Rico.

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