EGU24-5841, updated on 23 Jan 2025
https://doi.org/10.5194/egusphere-egu24-5841
EGU General Assembly 2024

Augmenting Tsunami Detection with a Ship-based GNSS Network

James Foster[1], Todd Ericksen[2], Bruce Thomas[1], Jonathan Avery[3], Yuke Xie[4], and Robin Knogl[1]
[1]University of Stuttgart, Institute of Geodesy, Stuttgart, Germany (james.foster@gis.uni-stuttgart.de)
[2]U.S. Geological Survey, Earthquake Science Center, Moffett Field, CA
[3]University of Hawaii at Manoa, Honolulu, HI, USA
[4]MINES, L'Université PSL, Paris, France

We demonstrated the potential for ship-based GNSS systems to contribute to tsunami warning with a pilot network of 10 ships – 8 commercial and 2 research vessels - equipped with a tsunami detection package that included a geodetic-grade GNSS antenna and receiver, and a satellite internet communication system. The ships we instrumented operated throughout the Pacific, and transmitted real-time precise positions to our shore server from 2015-2018. This data set is used to examine the performance that an operational system would be able to expect if employed for tsunami detection. The estimated accuracy for our real-time vertical position solutions is 5.6 cm, commensurate with the advertised accuracy of the positioning service we employed. This indicates it is plausible to expect to observe the sea surface perturbation of a potentially dangerous tsunami with open ocean wave amplitude of more than 10 cm. Significant numbers of long period (10s of minutes) excursions, however, appear in the data in the absence of actual tsunami. The similarity of these excursions with the signals expected from a tsunami would result in a high rate of false positive detections if the ship data were used to independently identify tsunami events. A significant number of these were associated with ships changing speed as they were approaching or leaving port. A simple masking strategy based on the ship's speed reduces the number of these artifacts by 48%. The rate of false positive detections can be reduced to negligible levels by treating the network as an ensemble detection system and examining the data from 4 or more ships together. The density of ships in the open oceans are shown to be well matched to the source regions of historical fatal tsunamis, confirming this approach could provide valuable additional data to tsunami warning centers. We suggest that a network of ships, equipped with geodetic GNSS packages, based on a voluntary participation model, and leveraging the results from our pilot project would provide a valuable low-cost augmentation to the current tsunami detection systems. Furthermore, extended tsunami detection capability from this proposed ship network is possible by leveraging the ability of dual frequency GNSS to detect ionospheric perturbations. Tracking perturbations in the total electron count along the ray paths between each ship and each GNSS satellite provides multiple additional time series that have demonstrated capability to detect the ionospheric signals induced by open ocean tsunamis. Implementing these data streams would therefore expand the effective monitoring zone of each ship in the network from a single tide-gauge-like point to multiple observations within a circle with radius more than 500 km.