A fast tsunami data assimilation approach on 2012 Haida Gwaii earthquake: based on the employment of Green’ s function

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Tsunami data assimilation has been proposed for tsunami hazard forecasting. It estimates the tsunami wave field by assimilating tsunami data observed offshore into a numerical simulation, without calculating initial sea surface height at the source. The Optimum Interpolation (OI) method is widely adopted in assimilating observed data. However, the traditional data assimilation approach requires quite large calculating time, because the forecasted waveforms are still calculated with tsunami propagation model for the entire region.
In this study, we present a new approach based on the employment of Green’ s function to improve the speed of tsunami data assimilation. For the OI method, if the residual between observed and calculated tsunami height is not zero, there will be an assimilation response around the station. We consider the occurrence and linear propagation of such tsunami-height response as the ‘Green’ s function’ of a station. Then the forecasted tsunami wave field can be calculated as the superposition of the Green’ s functions corresponding to different stations. Similarly, the observed tsunami data is repeatedly assimilated during the time window, and more Green’ s functions are superposed to the forecasted waveforms at Points of Interest (PoI).
This approach greatly reduces the time cost for tsunami forecasting because it no longer needs to run the tsunami propagation model, as long as the Green’ s functions are calculated in advance. The forecasted waveforms at PoIs can be obtained by simple matrix manipulation. This method requires additional computer memory space for pre-calculated Green’ s function from stations to PoIs, but it does not have a significant impact on computational efficiency for regional scale tsunami data assimilation.
We apply our method to synthetic and real-time tsunami of the 2012 Haida Gwaii earthquake. The comparison with traditional data assimilation method reveals that this approach could achieve an equivalent high accuracy while saving much time. And this approach is also helpful for studying different lengths of assimilating time windows.

Keywords: Tsunami, Data assimilation, Green's function

