Geophysical Research Abstracts
Vol. 18, EGU2016-13628, 2016
EGU General Assembly 2016

Extreme-wave deposits in the Caribbean – towards an improved tsunami hazard assessment

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Coastal zones worldwide experience considerable population pressure and demand for a management of hazards such as tsunamis. Tsunami hazard assessment is the initial step of the management process and requires reliable information on frequency and magnitude. In areas with short historical documentation, these long-term frequency-magnitude patterns, which are best explained by inverse power-law functions, mainly rely on geological traces. According to the historical record covering the last 520 years, Caribbean tsunami hazard is demonstrated by more than 80 mostly regional or local seismically induced events. However, based on two numerical hydrodynamic models of tsunamis spawning at the Muertos Trough and the South Caribbean Deformed Belt (SCBD), two trigger scenarios only marginally considered so far, we show that pan-Caribbean tsunamis can be taken into account as well. We furthermore review more than 50 studies for possible geological evidence of tsunamis in the Caribbean including fine-grained subsurface deposits and subaerial coarse clasts, and re-evaluate their implications for tsunami hazard assessment against state-of-the-art models of tsunami deposition.

Only a limited number of reliable palaeotsunami records with consistent and robust age control were identified, hampering inter-island or interregional correlation of deposits. Separating between storm and tsunami transport of solitary boulders is very difficult in most cases. Those arranged in ridges or incorporated into polymodal ridge complexes or ramparts, respectively, which line many windward coasts of the Caribbean, can mainly be attributed to long-term formation during strong storms implying the overprinting of potential tsunami signatures. The quantification of parameters of tsunami flooding based on tsunami deposits, such as flow depth, inundation distance or flow velocity, by applying inverse and forward numerical models of sediment transport is still underdeveloped in the Caribbean and needs to be extended in the future, just as the transfer of sediment-derived hazard implications into spatial planning.

As extreme-wave deposits are unequivocally understudied in the Caribbean, there is still a great potential for coastal hazard assessment to become unfold. Thus, further palaeotsunami studies using common standards of high-resolution bedform and stratigraphical documentation, and robust chronological models with independent age control are required. They need to be combined with refined inverse and forward models of sediment transport and deposition to reconstruct reliable patterns of magnitude and frequency of tsunamis in different sectors of the Caribbean and to map hazard-prone areas. To date, known palaeotsunami deposits from the Caribbean probably represent a fraction of real prehistoric tsunamis only and, therefore, inadequately reflect major tsunami inundations of the past.