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Modelisation of the impact of tsunamis and free oscillation in French Polynesia

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The agitation inside basins (closed or semi-enclosed) depends on the period of the waves which force agitation, reflection and energy dissipation, characteristics of the boundary and the geometrical properties of the basin. When waves continuously enter the basin, they cause abnormal water level fluctuations and unexpected damage if their periods are close to those of free oscillation of the basin. These are called resonant oscillations. The resonant oscillations inside harbors, bays, or other semi-enclosed or closed basins can have a direct influence on the management of harbors, shipping and coastal uses. So, it is important to determine these free oscillations. These resonant characteristics were observed in the Marquesas archipelago (French Polynesia) during the Samoa tsunami of 29/09/2009 (Mw 8.0). They had previously been observed for the tsunamis generated by Kurile earthquakes (November 2006 and January 2007), Chilean and Peruvian earthquakes (August and November 2007). According to the observations of the tsunami produced by the Samoa earthquake, strong amplification and a long duration of water agitation were reported in this archipelago. Observations coming from monitored bays and human reports make this event among the important tsunamis recorded in the Marquesas. In this archipelago there are two monitored bays: the first, located in Hiva Oa Island (Tahauku bay), recorded an amplitude of 40 cm and 2 days of agitation. The second in Nuku Hiva Island (Taihoae bay) had an amplitude of 45 cm and 3 days of agitation. During last century, this archipelago has been frequently hit by several trans-Pacific tsunamis. It is interesting to note that, following different tsunami reports, the bays had different responses depending on the region of the earthquake source. For instance, Tahauku and Atuona, two bays in Hiva Oa Island distant 1 km apart, have different effects depending on the tsunami, as it was observed in 1946 (Aleutian earthquake) and 1960 (Chile earthquake). In this study, we determine the periods of oscillations (eigenperiods). To this aim, we use the real tide gauge data, and numerical tsunami simulation (based on non linear shallow water theory) to make spectral analysis based on Fourier transform and frequency-time analysis of the real seismic sources. We also use synthetics sources to study the possible azimuthal dependence of excitation of these eigenperiods. An alternative way to determine free oscillations is to use analytic calculation of different eigenfunctions of the wave equation to find the oscillations periods.