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An N-wave with a leading depression entering a shoaling bay with a U-shaped cross section

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When a tsunami wave, approximated as an N-wave, hits a shoaling bay with a U-shaped cross section, it leads to various situations. A peculiarity of the solution of the shallow water equations written for this particular bay geometry is that it approximately preserves the shape of the wave in a coordinate system discovered by Didenkulova and Pelinovsky (2011)+. They looked at the case where the bay deepens indefinitely, rather than looking at a bay that opens to a relatively flat ocean basin. Because of this, they did not consider the waves that reflect back into the bay from the mouth. This retro-reflection from the mouth will have opposite polarity. If the length of the bay and the phase difference between the leading depression and the tail (rise) of the N-wave is such that, at the instant of the retro-reflection, the tail catches up with the front of the N-wave, then, two waves with same polarity will add up leading to a constructive interference. This is a very peculiar phenomenon that does not occur in shoaling bays with a bathymetry that only depends on the incident wave propagation direction.
We treat the scattering from the mouth using an integral equation which we solve using semi-analytical means. If the time necessary for the wave to cover the width of the mouth is much smaller than the period of the free modes of the bay, then the scattered field outside is much smaller than the amplitude of the incident wave as long as the amplitude of normal mode oscillation inside of the bay is of the same order as the incident wave. This may not be the case when the full resonance develops within the bay because the waves inside the bay would be very large. Tsunamis are transient phenomena where there is not much time for the resonance to establish. So it is not surprising that the maximum tsunami run-up often occurs at a time range not exceeding twice the period of the lowest free mode of the bay. In most cases the scattered field outside can be neglected and therefore the effective boundary condition at the mouth is that the wave height there is twice that of the incident wave. This boundary condition is identical to that applied by Stefanakis et al (2011)++. This simplified boundary value problem can be exactly solved by a series of residues or by means of the fast Fourier transform. In this work we compare various cases where the scattered field is significant to various degrees. Abnormal run-up amplifications observed in some tsunamis may be related to the mechanism we take into consideration in this work.
+Phys. Fluids 23, 086602 (2011)
++Phys. Rev. Lett. 107, 124502(2011)