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Analytical results for resonance and runup in piecewise linear bathymetries

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A general method of solution for the runup evolution and some analytical results concerning a more general bathymetry than a canonical sloping beach model are presented. We studied theoretically the water wave elevation and runup generated on a continuous piecewise linear bathymetry, by solving analytically the linear shallow water wave equations in the 1+1 dimensional case. Non-horizontal linear segments are assumed and we develop an specific matrix propagator scheme, similar to the ones used in the propagation of elastic seismic wave fields in layered media, to obtain an exact integral form for the runup. A general closed expression for the maximum runup was computed analytically via the Cauchy's residue Theorem for an incident solitary wave and isosceles leading-depression N-wave in the case of $n+1$ linear segments. It is already known that maximum run-up strongly depends only on the closest slope to the shore, although this has not been mathematically demonstrated yet for arbitraries bathymetries.

Analytical and numerical verifications were done to check the validity of the asymptotic maximum runup and we provided the mathematical and bathymetrical conditions that must be satisfied by the model to obtain correct asymptotic solutions. We applied our model to study the runup evolution on a more realistic bathymetry than a canonical sloping beach model. The seabed in a Chilean subduction zone was approximated - from the trench to the shore - by two linear segments adjusting the continental slope and shelf. Assuming an incident solitary wave, the two linear segment bathymetry generates a larger runup than the simple sloping beach model. We also discussed about the differences in the runup evolution computed numerically from incident leading-depression and -elevation isosceles N-waves. In the latter case, the water elevation at the shore shows a symmetrical behavior in terms of theirs waveforms. Finally, we applied our solution to study the resonance effects due to the bathymetry modeled by linear segments, which is in agreement with published studies and numerical tests.