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How can coastal parks contain the destructive impact of a tsunami? A numerical approach to the understanding of tsunami-triggered waves in the presence of coastal hills

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From the now common idea that vegetated shores may reduce the power of a destructive storm surge, an increasing number of coastal communities around the world are extending this thinking to the design of coastal parks as a way to limit the impact of a tsunami. Tsunamis and storm surges are significantly different in nature and behavior, and it is implausible that vegetation alone could act as a tsunami mitigation tool. A more comprehensive approach relies on the installation of vegetated, scattered mitigation hills in front of the shore to deviate the incoming tsunami wave instead.

The analysis of how natural obstacles affect non-linear tsunami waves is still very limited and consists mostly of one-dimensional studies (e.g., [1, 2]). To that end, this work aims to extend the analysis of the interaction of waves of different shapes (solitary wave, N-wave), sizes (amplitude and wave length), and configurations with large obstacles to two-dimensional flows. The following metrics are used for a quantification of the results: 1) tsunami run-up and run-down and 2) a measure of channelization (via the flow kinetic energy and discharge).

First, preliminary results show that the configuration of the obstacles is consequential as long as the amplitude of the incoming wave is large enough relative to the obstacles. In second instance, we also observed that the channelization of the flow between two neighboring obstacles may not be greatly affected solely by the distance between obstacles, but must be analyzed in relationship to the initial wave/wave train.

This study is based on the numerical solution of the viscous shallow water equations via high order discontinuous finite elements method (DG) using a quadrilateral version of the model described in [3] and with fully implicit time integration [4].

Large and relatively massive hills appear to be a better solution than any offshore concrete walls, which have shown to possibly enhance the tsunami catastrophic power rather than reducing it. Nevertheless, without a thorough understanding of the behavior of non-linear waves when they approach coastal configurations such as hills, coastal parks may still be far from a safe reality.

References

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