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Modeling sediment transport associated with the AD 1755 tsunami

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Numerical models of tsunami inundation and sedimentation can provide useful insights to better understand the dynamics of paleotsunamis. We applied a coupled field data and numerical modeling approach for the AD 1755's tsunami at Salgados, a lowland on the south coast of Portugal where tsunami deposits from AD1755 mostly consist of massive or normally-graded, landward thinning layers of shell-rich sand with an erosive base within the mud-dominated lowlands. Landward of the foredune, the AD1755's deposit is roughly 10 cm thick and thins in the landward and alongshore directions. It is possible to ascribe the source of this deposit to the dune and/or beach based on mineralogical and grain-size comparisons with modern surface samples. From the combination of spatial distribution of the deposit thickness and GPR data, which shows an erosional surface at approximately 6m above MSL, we infer that the maximum tsunami water level at the coast was between 6 and 10m. Regional tsunami historical records, however, suggest higher heights, up to 12m above MSL at the coast.
This work used geological signatures (both depositional and erosional) of the AD 1755's tsunami to validate tsunami hydrodynamic and sediment transport models from 7 different proposed fault ruptures. These epicentral areas have been previously proposed in literature and include Marquês de Pombal Fault, Gorringe Bank, Cadiz Accretionary Wedge, Horseshoe Fault and 3 different scenarios combining some of these structure with deeper (30-60 km) ones.
A classification of more likely scenarios was established based on physical and validated numerical parameters (tsunami travel time, run-up, erosion depth, volume of sediment and post-event coastal profile). Model results suggest that the Cadiz Accretionary Wedge source largely exceeds the field and historical data. By contrast, Gorringe Bank, two combined scenarios display modeled results that are insufficient to reflect the real damage and imprints in the geological record. Moreover, the Horsheshoe Fault presents a partial correspondence between hydrodynamic and sediment transport models and its field data. Finally, the best correlation between field and modeled data is presented by the Marquês de Pombal Fault and by one combined scenario. These present extremely good compatibility in travel time, depth of erosion, sediment volume and also presents a good correlation with the observed run-up and the best matches between modeled and field coastal profile after the AD 1755.

This modeling exercise results puts in evidence the shortcomings related with the discussion surrounding the AD 1755's source: no known structure seems to have enough dimension to cause an AD 1755-tsunami like event or the available models do not respond well to far distance sources. Either way, the methodological approach followed here stresses the importance of further modeling developments and the need to address this topic from a combined perspective.

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