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Numerical modelling of tsunamis generated by mass flows at Stromboli Volcano

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As demonstrated by the Anak Krakatau eruption-induced flank collapse in 2018 in Indonesia, tsunamis generated by large mass flows like landslides and pyroclastic density currents can have devastating effects in volcanic areas. However, these phenomena are still poorly understood as they are unusual and complex events, largely unpredictable and often poorly constrained.

Stromboli is one of the most active volcanoes in the world, extensively monitored and studied in the last few decades. Many tsunamigenic landslides (sub-aerial and/or submarine) have taken place; at least seven have occurred in the last 150 years and a devastating one is believed to have reached the coast of Naples, at more than 200 km distance, during the Middle Ages. Because the level of activity of the volcano has remained similar ever since and the likelihood of such disastrous events is not negligible, the hazard related to tsunamigenic mass flows in this area needs to be carefully assessed.

Associated with the 3rd of July 2019 eruption, at least three mass flows were triggered along the Sciara del Fuoco slope; two subaerial Pyroclastic density currents (PDCs) and a submarine landslide. Simultaneously, three buoys registered the height of the resulting tsunami wave ranging from 0.2 m in front of the Ginostra village to 1.5 m in front of the Sciara del Fuoco. Thanks to the dense monitoring network and the accurate bathymetry survey carried out by the IGAG-CNR, these events have been well constrained.

The tsunami waves studied here are smaller than those that could constitute a threat for the population living in this area, nevertheless they can be used to characterize the behaviour of the tsunamigenic mass flows. Back analysis of these events were undertaken with the two-fluids version of VolcFlow; this is a continuum mechanics model based on the depth-average approximation that has been developed for the simulation of volcanic flows. VolcFlow can take into account several different rheologies for each of the two fluids. In the present case, one fluid

was used for the water body and one for simulating the mass flow. For the latter one, a constant retaining stress type of rheology was used (Dade and Huppert, 1998). Backanalysis suggested that it was the PDC which generated the tsunami wave during the events of July 2019 and best fitting simulations identified a constant retaining stress of 7kPa. With these input parameters it has been possible to run a large number of numerical simulations of possible scenarios. This has allowed to assess threshold values of volume and discharge of mass flows which could generate significant and potentially destructive tsunami waves. This constitutes an important input to improve early warning systems and to reduce the risk related to these unpredictable but extremely dangerous phenomena.