The development of strategies for assessing tsunami hazard for the Italian coasts has received increasing interest in the last decade, as part of both European and national efforts and projects. In the framework of the EU-funded project called ASTARTE (“Assessment, STrategy And Risk Reduction for Tsunamis in Europe”), the portion of the eastern Sicily coastline (southern Italy) including the towns of Augusta and Siracusa has been selected as a test site for the development and testing of innovative methods for tsunami hazard assessment. The choice sounds very reasonable based on a number of facts, among which one can recall that 1) this area was hit by at least seven tsunamis in the approximate time interval from 1600 B.C. to present, the most famous being the A.D. 365, 1169, 1693 and 1908 tsunamis, 2) the district hosts one of the largest petrochemical poles in the Mediterranean, 3) Siracusa is listed among the UNESCO World Heritage Sites since 2005.

Two main approaches to tsunami hazard assessment have been explored, one based on a probabilistic approach, the other on a worst-case credible scenario technique (see ASTARTE Deliverable D8.8, available at http://www.astarte-project.eu/files/astarte/documents/deliverables/d8-8/ASTARTE%20D8%208%20-%20v0.9.4.pdf). The worst-case credible scenario approach and the ensuing results for Augusta and Siracusa will be illustrated and discussed in this presentation.

The definition of credible worst-case tsunami scenarios for eastern Sicily involves suitable knowledge on:
- the historical occurrence of tsunami in the area: we used the Euro-Mediterranean Tsunami Catalogue published by Maramai et al. (2014);
- historical and pre-historical inundation deducible from paleotsunami investigations (see for instance De Martini et al., 2012);
- the known and potential tsunamigenic sources, in both the near- and far-field: we used information coming from earthquake catalogues (e.g. EMEC, Grünthal and Wahlström, 2012), databases of seismogenic faults (e.g. SHARE-EDSF, Basili et al., 2013), and published papers presenting and discussing data acquired through marine geophysical surveys, with special reference to offshore eastern Sicily;
- available literature on past large tsunamigenic earthquakes hitting eastern Sicily.

As a result, we selected five main source areas to construct the worst credible scenarios for the application of the scenario-based approach to the tsunami hazard assessment for the Augusta-Siracusa area:
- Hyblean-Malta escarpment (HM);
- Messina Straits (MS);
- Ionian Subduction region (IS);
- Calabria Offshore domain (CO);
- Western Hellenic arc (WH), subdivided into a northern and a southern part (the Cephalonia strike-slip zone representing the separation between the two domains).

The selection of the faults, of their characteristics and of the earthquake magnitude intervals was made based on the published literature and of public seismogenic fault databases (mainly the SHARE-EDSF, see Basili et al., 2013). Overall, we selected 32 faults covering the five tsunamigenic source areas listed above. The southern part of the WH is assigned the largest credible magnitude interval (8.3 - 8.5); faults belonging to CO, HM and MS do not exceed maximum magnitudes of 7.1 - 7.4, while the sources found in correspondence with IS exhibit a larger variability, based on their position and mechanical role in the frame of the subduction zone (7.1 – 8.3).
For each of the 32 sources, the tsunami initial condition was computed by means of the Okada (1985) analytical formulae, holding for a rectangular fault embedded into a perfectly elastic, homogeneous and isotropic half-space. The tsunami propagation and impact was simulated through the UBO-TSUFD code (Tinti and Tonini, 2013) on a set of properly nested finite-differences grids. The grid-nesting facility implemented in UBO-TSUFD allows one to investigate tsunami impact on natural and man-made coastal features with detail limited by the sole resolution of the available topography and bathymetry. In the case of Augusta and Siracusa, we used a set of five nested grids with resolutions of 3 km (grid 1, covering a large portion of the Ionian sea ranging from eastern Sicily to western Greece), 1 km (grid 2, covering only western Ionian), 200 m (grid 3, along the entire eastern Sicily coast) and 40 m (grid 4: Augusta; grid 5: Siracusa).

Performing the tsunami simulations for each of the 32 faults over the entire set of nested grids would be not only severely demanding from a computational point of view, but also of limited sense from a methodological perspective. In general, the goal must be to recognise those faults in the selected ensemble whose ensuing tsunami impact on the target areas is expected to be the largest. This can be accomplished by developing a suitable selection algorithm: we rank the faults based on the maximum water elevation computed on each of the coastal nodes in grid 3 (200-m resolution), and hence on the relative frequency of their appearance in the first n positions (e.g. n=10) of the ranking for all nodes.

This approach is first applied to the entire eastern Sicily coasts first, and then on the coastal nodes in the areas around Augusta and Siracusa. The results highlight that the faults that produce the largest effects at regional level are not necessarily those with the most severe effects in the target areas. Moreover, despite the limited spatial distance between Augusta and Siracusa, the selection procedure can lead to slightly different results for the two districts.

As a result of the selection approach, we are able to single out the sources expected to produce the largest tsunami effects in the target areas, reducing the number of faults of interest from 32 to only 9, for which full-resolution inundation modelling is performed.

The most synthetic and most useful way to summarize the results produced in the frame of our scenario-based approach is to combine all the information coming from the single scenarios into a unique aggregated scenario. Building an aggregate scenario for a given tsunami physical variable means selecting for each grid node the maximum value of that variable among the individual scenarios. The simulation results presented and discussed in this contribution consist of fields of maximum water elevation, of maximum water column, of maximum velocity and of maximum momentum flux obtained after aggregating the outputs relative to the 9 individual tsunamigenic faults. Among the main results relative to the maximum water elevation aggregated field, it is worth noting that:

1) the entire Augusta-Siracusa district is interested by significant wave impact, with local variations determined by the local coastal morphology or by the presence of coastal structures, such as the three breakwaters protecting the inner Augusta Bay;
2) the areas were largest inundation extents are predicted coincide with the zones were paleotsunami evidences have been found and discussed in the literature (e.g. De Martini et al., 2012). It is the case, for example, of the area north-east of the Augusta peninsula and of the Priolo site;
3) the largest inundation are produced by the far-field faults located in correspondence with different portions of the WH arc.

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References


