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Modern Eyes on the Historical 551 AD Earthquake and Tsunami Offshore Phoenicia, Lebanon of Today

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On July 9th, 551 AD, a destructive earthquake, estimated magnitude 7.5, impacted the Phoenician coast, nowadays Lebanon, Easternmost Mediterranean. Historical accounts describe a sudden withdrawal of the sea from Berytus (Beirut at the time) and other towns along the Phoenician littoral, for a distance of two miles and then return to its normal position, causing many casualties. Critical reading of the historic descriptions raises questions regarding the possible seismogenic and tsunamigenic sources of this catastrophe. Previous researchers presumed inland and offshore seismogenic sources, and submarine earthquake and submarine landslide as tsunami triggers.

Lebanon lies along the Yammouneh restraining bend of the left-lateral Dead Sea Transform (DST), the boundary between the Sinai Sub-Plate (Africa) and Arabia Plate. The bend resulted from a right stepping offset of the DST and thus induces transpressional deformation formed of several thrust faults, such as the recently identified Mount Lebanon thrust (MLT). On the base of extensive geological investigation, marine survey and submarine study (e.g., Elias et al. 2007), the MLT was found to be an active fault that underlies Lebanon and was interpreted to crop out at the seabed, just offshore the coast. It was thus proposed as the source for both the earthquake and the tsunami. Yet, we were puzzled how the significant retreat of the sea and the return to its original state without noticed inundation, conforms inundation expected from near offshore thrust fault.

First, we constructed a grid of the SRTM Lebanon topography merged with the EMODnet bathymetry of the northeastern Mediterranean Basin, and modified the present-day Beirut coastline so as to reflect its pattern at the time. We then modelled the coseismic deformation of an M7.5 thrust earthquake on the MLT, constraining the vertical offset according to evidence of uplifted marine-cut terraces along the Lebanese coast. The calculated seafloor deformation was used for tsunami wave generation, and non-linear shallow water equation for numerical modelling of tsunami propagation and inundation.

Preliminary assessment shows that, as expected, the simulated scenario exhibits a series of waves. However, the general effect of the simulation is a notable drawdown and minimal inundation, which in our eyes is compatible with the historical observations. The results also

suggest that the modelled M7.5 MLT offshore scenario, can explain the 551 AD tsunami description with no need to consider secondary submarine and/or subaerial landslide sources. The review of historical events is thus an important tool to characterize earthquake and tsunami hazards in this area. While further elaboration is certainly needed, we already learnt the need to consider coseismic deformation in tsunami inundation modelling. This effect is critical in the case of near-shore sources leading to coseismic subsidence of coastal areas, which in turn can amplify the expected inundation.