UAV- SfM-MVS, Low-cost SLAM, and GPR Shallow Geophysics to monitor the Anthropogenic Evolution post-tsunami of the Sendai shore.

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Japanese coasts are some of the most reworked in the world, with even seemingly natural environments being man-made or the products of human influence in the present or during the historical period. North of Sendai, next to the port built during the mid-20th Century, a short stretch of sandy shore, remodelled by the tsunami and the human influence is now rebuilding new sand-dunes under wind deflation effects. What is the vertical amplitude of this process? Where does the post-tsunami surface starts? Can we detect pre-tsunami structures? In the Anthropogencic age, what material is composing the sand dunes and the shore sedimentary deposits? All those important questions have driven the present research, which aims to image in 3D the surface of the shorelines, as well as its underlying structure, and how these interactions operate in the age of the Anthropocene.

The methodology is thus based on the combination of UAV- SfM-MVS, with a 3D model registered in local coordinates against a 3D model generated by Slam (from iPad-pro), in order to ensure that the 3D model does not generate disproportionate distorsion. The iPad-pro Slam model have been tested at the laboratory with error > 5 cm for one pass (i.e. the error due to the laser), and < 45 cm on flat wall surfaces due to the IMU (i.e. the internal accelerator of the ipad is not sufficient to position it perfectly. Using this error margin, the 3D model from UAV was then used as topographic dataset, and also for topographic corrections in the Ground Penetrating Radar data.

The topographic data reveals a typical rising shoreface in the swath zone, and above it (where the grains are dryer) the generation of small dunes > 2 m height generated by deflaction. The Ground Penetrating Radar shows the pre-tsunami surface that has been eroded and potentially further cut flat during cleaning up operations, from which anthropogenic debris (cars and others) that remained on the shore are now part of the sand dune system, and partly recovered by the sand. Due to their position above the swath zone and in the vadose zone, the alternation of wet/dry environment is most likely to create further "rust-related" pollution and long-term modification of the geochemistry of the surrounding deposits. From both a topographic perspective (post-tsunami deposits being remodelled by mechanical cleaning activities) and a subsurface composition perspective, the investigated shoreline can be considered as the product of high-energy event and anthropogenic activity.

Keywords: tsunami, Ground Penetrating Radar, Anthropocene, Sendai, SLAM, SfM-MVS