Application of Structure-from-Motion (SfM) technique for measuring near-field earthquake-induced failures; case studies from Greece

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Extended abstract

Documentation of earthquake environmental effects (surface ruptures, landslides etc.) is a very critical issue, since based on the accuracy of the provided information, protection and mitigation measures can be designed. However, it is well known that mapping these features is not always feasible due to several adverse factors e.g. near-vertical slopes, coastal cliffs, imposing high risk to human surveys. In order to overcome this issue and to quantitatively describe the earthquake-induced geological failures e.g. landslides and liquefaction-induced lateral spreading, remote sensing techniques were applied during the last two decades such as Interferometric Synthetic Aperture Radar (InSAR), Light Detection and Ranging (LiDAR) and photogrammetric surveys. The latter one, a photogrammetric survey, is frequently conducted by use of Unmanned Aerial Vehicles (UAV), such as multicopters equipped with webcams, digital cameras and other sensors (Colomina and Molina, 2014; Lindner et al., 2016; Rossi et al., 2017, Yu et al., 2017). UAVs provide a convenient remote sensing platform for post-earthquake surveys given their ability to collect ultra-high-resolution imagery in short time over terrain that is often difficult to access. Using the Structure from Motion (SfM) image processing technique, a 3D point cloud can be created by intersecting the matched features between the overlapping, offset images. Point clouds from optical images enable the detailed representation of complex 3D surfaces, better editing and classification of the dataset and creation of further products like orthophotos, DSMs, DTMs, textured models etc. Comparison between different point cloud sets enables highly accurate change detection analysis, using recently developed matching algorithms. This work presents the mapping of earthquake-induced failures from two strong and shallow earthquakes occurred on November 17, 2015 onshore Lefkada (Mw 6.5; Ganas et al. 2016; Papathanassiou et al. 2017) and July 20, 2017 offshore Kos (Mw 6.6; Papathanassiou et al. 2019) , Greece. In the latter case, the SfM-based technique was applied using a ground-based digital camera, while in the former one a UAV DJI Phantom 3 was used. The Lefkada case study focuses on a deep-seated landslide triggered at the coastal area of Athani village (Okeanos site), SW Lefkada that induced severe damages to a recently constructed luxury hotel, while the Kos case study deals with the lateral spreading reported in the old harbor of the city.

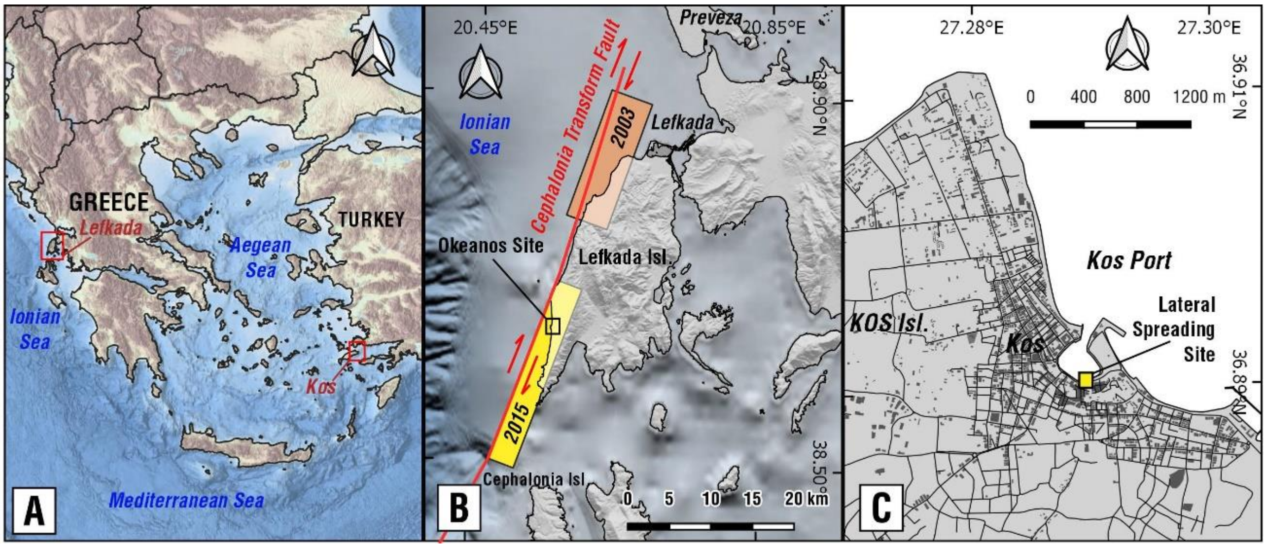

Figure 1. A) Overview map of Greece showing the location of the two case study sites. B) Relief map of Lefkada Island with the location of the Okeanos landslide site. The 2015 earthquake rupture extent is shown with a yellow polygon (Ganas et al. 2016). C) Map of Kos city with the location of the lateral spreading site.

The outcomes arisen by this study are that i) in the case of Okeanos landslide, the extraction of a detailed point cloud enabled the high-resolution modeling of the landslide at a site with challenging conditions such as limited accessibility and complex relief. It was demonstrated that both change analysis and volumetric calculation for co-seismic landslides demand a pre-event detailed point cloud set that can be co-registered and compared with the post-event set. Coastal areas are usually covered by multi-temporal aerial imagery in working scales (1:5K – 1:30K) that can be used to extract point clouds suitable as a reference (Valkaniotis et al., 2018).

Regarding the effects mapped on Kos, it was found that the SfM-based technique provides reliable data (on horizontal axis) for documenting and modeling lateral displacement features and accordingly, could be used for the purposes of a rapid post-earthquake field survey (Papathanassiou et al., 2019). Furthermore, this technique can be applied even with a low-cost ground-based technique e.g. a simple hand-held digital camera. However, it cannot be characterized as satisfactory on vertical axis since a 12% deviation exists between the measurements obtained by these two techniques (SfM and traditional one), and some caution should be applied when using SfM-based technique.

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