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Boundary and Estimation of the Flood Development Velocity Using Unmanned Aerial Vehicle (UAV)-Derived Imagery and Ground Observations: The Case of the 2017 Mandra Flash Flood in Greece

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Background

The use of Unmanned Aircraft Vehicle (UAV) can make a decisive contribution to response to hydro-meteorological natural disasters increasingly affecting the Mediterranean region. UAVs can be used to identify, study and recover environmental impacts, as well as to improve data monitoring and recording using on board innovative sensors. The UAV in disaster management provides direct and detailed impact recording even in inaccessible areas. It also provides images and maps of enhanced resolution, especially on flash flood phenomena, in the case of which the spatial and temporal scales of occurrence do not favor traditional monitoring processes. The flash flood of west Attica on November 15 2017 has caused enormous damage on human and natural environment and a tragic loss of 24 people. The complexity of impacts typology and its distribution in space, highlighted the need to study the event, in terms of evolution and mapping of its extent and physical characteristics. The analysis with the use of UAV produced detailed flood extent and provided a comprehensive description of the characteristics of floodwaters within the flooded area.

Objectives

The research team studied the area during the flood and the day after, using a combination of ground and aerial observations with the aid of an unmanned aerial vehicle (UAV). The aim of this study is to identify different types of flood extent indicators, including mudlines, debris lines and others, based on collected imagery, which were recorded and lead to flood boundary delineation across the inundated area. In this work, the rate of flood development velocity is also estimated using the data which were collected through aerial and ground observations, including snapshots with specific timeframe. This study shows how aerial observations can improve the accuracy of defining the extent of floods and the speed of their deployment that in turn is very useful for risk mitigation efforts. UAV flights took place a few hours after the flood of November 15, 2017 and on November 16, 2017. The flood affected the western part of Attica in the city of Mandra and Nea Peramos and reached 300 mm in 13 hours causing 24 deaths and extensive damage to property and infrastructure.

Methods

- Research was carried out with ground and aerial observations on the flight of a UAV. Photos and videos were captured using the UAV in several flights, as well as ground observations and images.
- The collected data were analysed and processed and the collected images were georeferenced.
- The types of high - water marks were studied, categorized. The depth and the extent of the flood were assessed.
- The estimation of the water flow rate was based on the hydraulic head and the flow of objects on the water surface was based on videos and photos material which taken during the flood.
- In order to evaluate the characteristics of the flow and its speed, video snapshots, images of terrestrial and aerial observations that were selected, were analyzed. This data involved flowing obstacles such as trees, buildings and other facilities.
- Regarding the estimation of the water velocity, the variation of the water level on the same position at different times was also studied.

Results

According to the analysis of the collected data from the combined use of the aerial and ground observations [Fig 1], we achieved the accurate estimation of the flood extent and the definition of its characteristics. These characteristics were related with the boundaries, the depth and the speed of the flood. In this study the types of the flood boundaries were analyzed and categorized. The speed of the water during the flood reached 10 m / s, the depth reached 4.2 m and the flood area was 4.03 km^2.

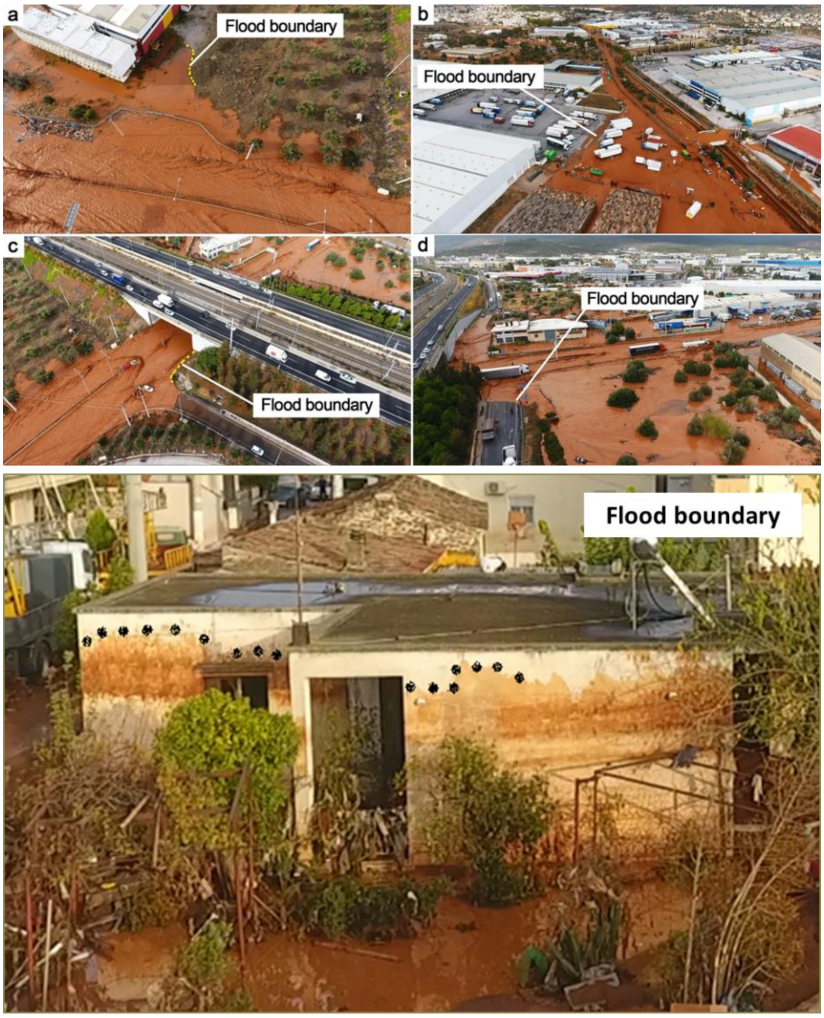

Figure 1. Display of the flood boundaries in the industrial area of Mandra with the use of UAV.

Conclusions

The UAV allowed the collection of aerial photographs in an extended area during flood flows despite that a large portion of it was inaccessible due to road closures and safety issues. This way a large part of the useful data was captured in short time during and after the flood. Especially in the case of flash floods which are characterized by a rapid rise and withdrawal of floodwaters, it is virtually impossible for a field survey team to reach different parts of the inundated area and make ground observations during the actual phenomenon. As flood effects and flood marks of all kinds (e.g. high water marks, flood deposits) were removed during cleanup efforts in the days following the disaster, there was limited time to cover the whole affected area with detailed ground observations. In this case, the integration of aerial observations in post-flood analysis provided guidance to intensify ground observations at key locations where it was needed, in time before crucial evidence disappeared. This work demonstrated that the combination of aerial and ground observations allowed an accurate reconstruction of the 2017 flood, contributing to flood extent and water depth determination, peak discharge estimation and detailed mapping of impacts. The approach is considered to have several advantages connected with the collection of data during flash flood investigations and is capable of providing a holistic overview of multiple aspects of a flood that can be valuable to both science and civil protection. Aerial observations can act as an extra point of observation that accompanies the traditional ground-based field survey and fits well in the opportunistic nature of this type of studies.

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