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Estimation of flash flood peak discharge using Unmanned Aerial Vehicle (UAV)-derived imagery. The case of the 2017, Mandra flood in Greece

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The spatial and temporal scale of flash flood occurrence provides limited opportunities for measurements and observations using of conventional monitoring networks. These observational difficulties, often accompanied by a lack of instrumental data have turned the focus to event-based, post-disaster studies. Post-flood surveys are particularly useful, as they provide the opportunity to observe aspects of hydrological behaviour of catchments under rare runoff conditions and extreme meteorological forcing, by capitalizing on field evidence.

Recently, unmanned aerial vehicles (UAVs) and the Structure for Motion (SfM) technique have been used to enhance field surveys and monitoring related to different aspects of disasters. The simple consumer-grade equipment required, its enhanced observation capabilities and certain conveniences they offer in field surveys indicate a strong potential of these technologies in many aspects of flash floods, especially given the opportunistic nature of their study.

This work explores further this potential, aiming to demonstrate the application of UAVs in post-flood peak flow estimation. The research team surveyed two selected cross sections after the catastrophic 2017 flood of Mandra, developing a high resolution (2.7cm) digital surface model (DSM) using UAV imagery and the Structure from Motion technique (SfM). The detailed DSM was used to study channel geometry and flow obstructions, extract cross sections and calculate the cross sectional area and wetted perimeter. Water energy slope was defined with the use of high water marks that were placed on the DSM on the appropriate elevation.

Peak discharge in the two ungauged sections were estimated at 170m3/s and 140m3/s (with a range to account for the uncertainty inherent in the dynamic nature of Manning coefficient), using the slope-conveyance method, indicating a unit peak discharge of approximately 9-10m3/s/km2. Following recommendations described in relevant literature on the integration of survey observations by means of hydrological modelling, we applied a spatially distributed hydrologic model to simulate discharge at the surveyed cross-sections (the Kinematic Local Excess Model (KLEM)) and other checks, all of which were in agreement, with the peak flow estimates provided by the UAV-aided survey analysis.

The UAV allowed the collection of aerial imagery in a rapid way from an extensive area, despite that a large portion of it was inaccessible due to road closures and safety issues. In addition, detailed DSMs created using aerial imagery and the SfM technique was found to be particularly useful for studying channel geometry, obstructions and other characteristics of flow as well as for measuring cross sectional areas on demand, even at a later time, when the channel had changed due to human intervention (e.g. cleanup using heavy machinery) and water flow. These capabilities fit to the opportunistic context of studying flash flood events in the sense that UAVs can rapidly collect information within the short time frame that it is available. Nevertheless, it has to be noted that combination of ground with aerial observations is preferable.