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Without gaps – 3D photo-reconstruction of gully headcuts by combined utilisation of UAV and close-range photogrammetry

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Gully erosion is a worldwide phenomenon causing permanent degradation of fertile land. Especially in the Mediterranean, gullies contribute to high soil loss rates which necessitate multi-temporal and high resolution monitoring. Gullies naturally exhibit complex surface morphologies and hence are difficult to measure. Images acquired airborne or terrestrial are possible data sources for digital gully modelling due to availing of photogrammetric methods to achieve 3D models. In this regard unmanned airborne vehicles (UAVs) allow for low cost, flexible and frequent areal gully monitoring, but exhibit limitations as a result of the birds-eye view - i.e. at steep sidewalls and overhanging areas. Terrestrial images offer advantages at local assessments and can be obtained spontaneously as needed. However, images acquired from ground are not able to ensure areal coverage. To integrate the advantages of both data sources and to overcome the above mentioned limitations, this study introduces a methodological approach of combined utilisation of nadir UAV data and oblique terrestrial images for 3D photo reconstruction. Two gully headcuts in Andalusia (Spain) are analysed to confirm the suitability of the synergetic data usage. The results show that the UAV model of the gully, generated from images from flying heights of 15 m, implies inconsistency of data at slope gradients of 50 to 60 °. To eliminate these gaps additional terrestrial images can be integrated, which are geo-referenced solely using information of the already calculated 3D model and orthophoto from the UAV images. Referencing errors of the terrestrial point clouds are fixed by applying fine registration. The final merged digital gully model reveals a resolution of 0.5 cm and an accuracy of 1 cm. Concluding, high density point clouds based on the fusion of UAV and terrestrial image data show a significant improvement of 3D photo-reconstruction of two gully headcuts compared to detached processing of single data sources. This allows for new insights into gully morphology because comprehensive gully models can be calculated with high spatial resolution and at frequent intervals, which enables multi-temporal monitoring and 3D volume change computations.