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Spatiotemporal assessment of ephemeral gully characteristics using low altitude aerial imagery: an approach for quantifying

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In agricultural fields, ephemeral gullies are defined as erosional channels formed primarily by overland flow from rainfall events. These channels are characterized by small dimensions, approximately 0.5 to 25 cm in depth, which allows their removal during regular farming operations. This dynamic characteristic coupled with their small size often can conceal soil losses by ephemeral gullies and poses challenges to efforts devised for soil loss quantification and mitigation. In this study, novel surveying and data processing techniques were employed to capture the small scale in topographic variation between two surveys and to assure that changes were due to erosional processes rather than survey miss-alignment. An agricultural field located in Iowa, U.S.A. with an area of approximately 54,500 m^2 was surveyed twice: right after the field was planted with corn and approximately one month later, following several rainfall events. A static benchmark point was established at the edge of the field and tied to public geodesic locations. A set of removable ground control points were spread throughout the field and surveyed in relation to the benchmark point. Low altitude aerial images were collected using a quadcopter UAS. Ground control points were used to aid in geospatial registration and to assess final survey accuracy. Standard off-the-shelf commercial software packages were unable compensate for less distortion and a new procedure using Micmac open-source photogrammetry software package was used to account for complex distortion patterns in the raw image data set. The undistorted images were then processed using Agisoft Photoscan for camera alignment, model georeferencing, and dense point cloud generation. Each point cloud representing a time period contained over 1 billion of points (file size > 100GB) and was processed using custom algorithms for filtering outliers and rasterization into a 2.5 cm raster grid (DEM). Analysis of differences between the two high spatial resolution DEMs revealed changes in the landscape due to natural (erosion/deposition) and anthropogenic (farming activities) factors. Specifically, for ephemeral gully analysis, morphological features in the form of headcut position and size, channel incision, sinuosity, lateral expansion, and depositional patterns were easily identified. Findings of this study shed light on potential pitfalls inherent to the utilization of off-the-shelf commercial software packages for such fine scale multi-temporal analysis, describe the need for standardization of procedures that assure accurate erosional response amongst different studies, and support the generation of accurate datasets critical in advancing our understanding of ephemeral gully

processes needed for improved model development and validation.