Testing the ArcGIS Python implementation 'Rillstats' to calculate volume of soil erosion

School of Science and the Environment, University of Worcester, UK

Email: j.lynch@worc.ac.uk

Josie Lynch

1. Context

- **Erosion** of **fertile topsoil** poses **significant environmental impacts** to terrestrial and fluvial environments globally (Smith et al., 2016) as this can result in lowered crop yield, decreased water quality and heightened flood risk (Mahabaleshwara and Nagabhushan 2014; Lal 2014; Pierce and Lal 2017; Koirala 2019).
- The Environment Agency (EA) in England (2016) declared **soil erosion** and sediment management an **important research priority.** Looking ahead, the government's **25 Year Environment Plan** states that UK **soils must be sustainable by 2030.**
- **Traditional methods** of soil erosion monitoring are **labour intensive**, **time consuming** and **provide sparse, point data** which is not representative of overall erosion rates. However, **technological advances using Unmanned Aerial Vehicles (UAVs)** and **photogrammetry** to create high resolution, spatially continuous **digital elevation models (DEMs)** and **orthophotomosaics** are present.

2. Issues and Aims

Issues: Current techniques for soil erosion monitoring require a **survey pre and post erosion event** to be obtained (Wheaton 2008).

Solution?: Báčová et al., (2019) presents an algorithm and Python implementation '**Rillstats**' in ArcGIS performs automatic calculations of rill/gully erosion volume generated by inputting **a single, post-erosion** DSM.

Aims:

1) To test the impacts of **Ground Sampling Distance** (GSD) has on the ability of Rillstats to calculate soil erosion volume.
2) To test the impacts that **flight planning** (2D linear, 2D cross, 3D) modes have on the ability of Rillstats to calculate soil erosion volume.

3. Site Details

Site Details: This research was undertaken at **Clent Hills**, UK (SO936793), with permission granted by the National Trust.

Figure 1. Photograph of the gully mapped for this research (captured: March 2022).

2. Research Design

The **method** of this research as seen in figure 2:

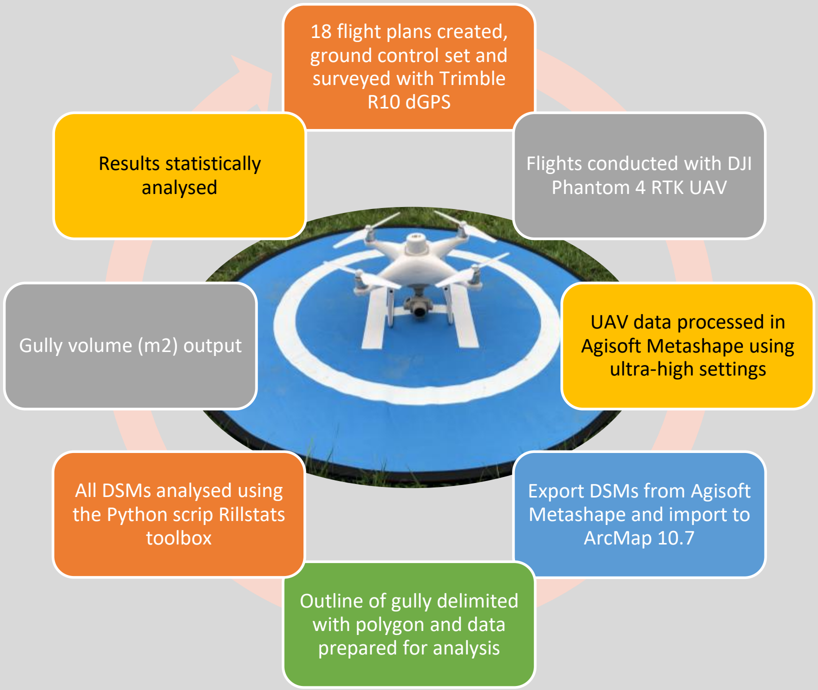

Figure 2. Method taken for this research.

5. Next Steps

Future work in this area to include:

1) **Further statistical analysis** of Rillstats estimates of eroded soil **volume**.

2) Statistical analysis performed on Rillstats generated **mean depth and maximum gully depth.**

3) Only subsampled 2D cross and 3D, needs **replication** across all GSD.

4) **Terrestrial Laser Scanner** data was collected as reference data to **validate** the volume loss calculated with Rillstats. Analise this data and determine which GSD provides the model that reflects the real-world most closely.

4. Findings, Analysis and Conclusions

Gully edge delimited and shape used for all 18 DSM analysis (figure 3). Line drawn in center of gully and a **Spatial Join** used:

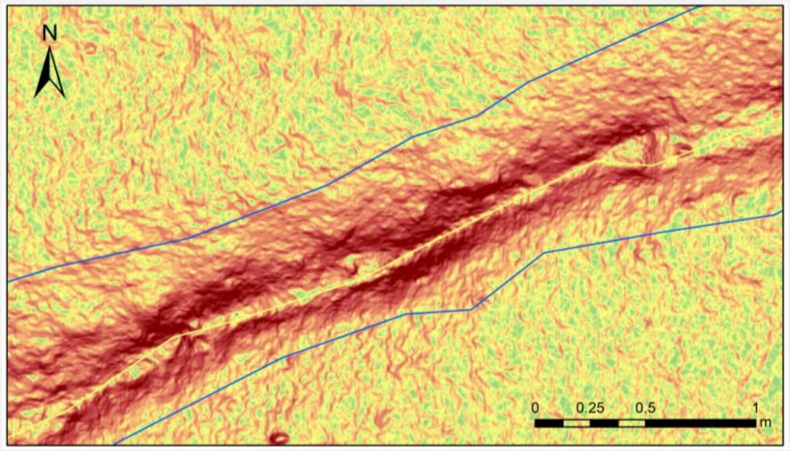

Figure 3. DSM of gully obtained with a UAV at 25m with 0.68 cm /pix GSD, featuring a hillshade and slope (ArcGIS 2022). .

Preliminary results:

1) A **clear decreasing linear relationship across** all flight modes – greater height UAV flown the lower the estimates of soil erosion by Rillstats.
2) The R^2 **value** for 3D double grid is 0.974, 2D cross is 0.949 and 2D linear 0.769.
3) **Similar results** obtained across all flight modes **at 25m** AGL (smaller GSD).

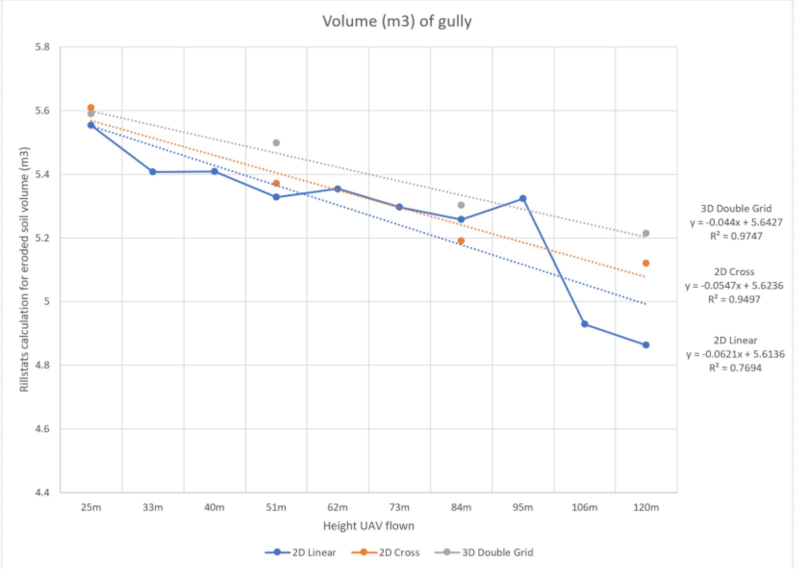

Figure 4. Graph displaying the preliminary results of this study.

Reference list: AgiSoft (2020) AgiSoft Metashape Professional Version 1.5.3. Available at: https://www.agisoft.com (Accessed: 2nd May 2022); ArcMap (2020) ArcMap 10.7. Available at: https://desktop.arcgis.com/en/arcmap/ (Accessed: 2nd May 2022); Báčová, M., Krása, J., Devátý, J., Kavka, P., (2019). A GIS method for volumetric assessments of erosion rills from digital surface models. European Journal of Remote Sensing, 52(sup1), pp.96-107; DJI (2020) Phantom 4 RTK. Available at: https://www.dji.com/uk. (Accessed 2nd May 2022); Hugenholtz, C.H., Walker, J., Brown, O., Myshak, S., (2015). Earthwork volumetrics with an unmanned aerial vehicle and softcopy photogrammetry.Journal of Surveying Engineering,141(1), p.06014003; Koirala, P., Thakuri, S., Joshi, S., Chauhan, R., (2019). Estimation of soil erosion in Nepal using a RUSLE modeling and geospatial tool. Geosciences, 9(4), p.147; Lal, R., (2014). Soil conservation and ecosystem services. International Soil and Water Conservation Research, 2(3), pp.36-47; Mahabaleshwara, H., Nagabhushan, H.M., (2014). A study on soil erosion and its impacts on floods and sedimentation. International Journal of Research in Engineering and Technology, 3(3), pp.443-451; Pierce, F.J., Lal, R., (2017). Monitoring the impact of soil erosion on crop productivity. In Soil erosion research methods (pp. 235-263). Routledge; Wheaton (2008). Geomorphic Change Detection Software. Available at: http://gcd.riverscapes.xyz. (Accessed 4th May 2022); Woodget, A.S., Carbonneau, P.E., Visser, F., Maddock, I.P., (2015). Quantifying submerged fluvial topography using hyperspatial resolution UAS imagery and structure from motion photogrammetry. Earth Surface Processes and Landforms, 40(1), pp.47-64.