Application of close-range photogrammetry to generate physical data of ephemeral gully development

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3D gully data

- Necessary to validate and calibrate soil erosion models.
- Should be:
  - Geo-referenced
  - Time-sequenced
  - High-resolution
  - In a digital format
  - Readily obtainable
  - Accurate
- Will be used to improve gully erosion model functionality.

Close-range photogrammetry

- Compares favorably with terrestrial laser scanning (Fig 1).
- Provides a high-mobility data collection platform (Fig 2).

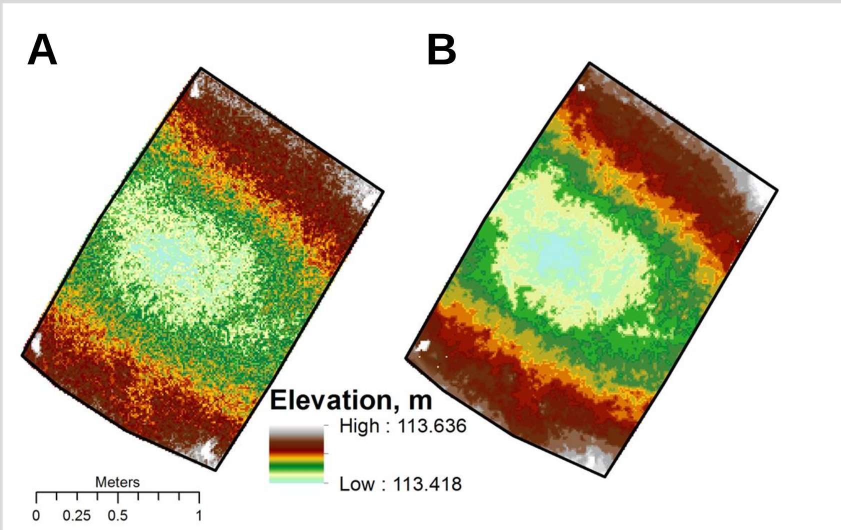

Fig 1. Laser scanning (A) and photogrammetry (B) yield similar point clouds.

Fig 2. Camera is mounted to a frame backpack and images are captured with an iPad.

- Pairs of stereo images are used to generate DEMs (Fig 3).
- DEMs are post-processed to determine volume change (Fig 4).

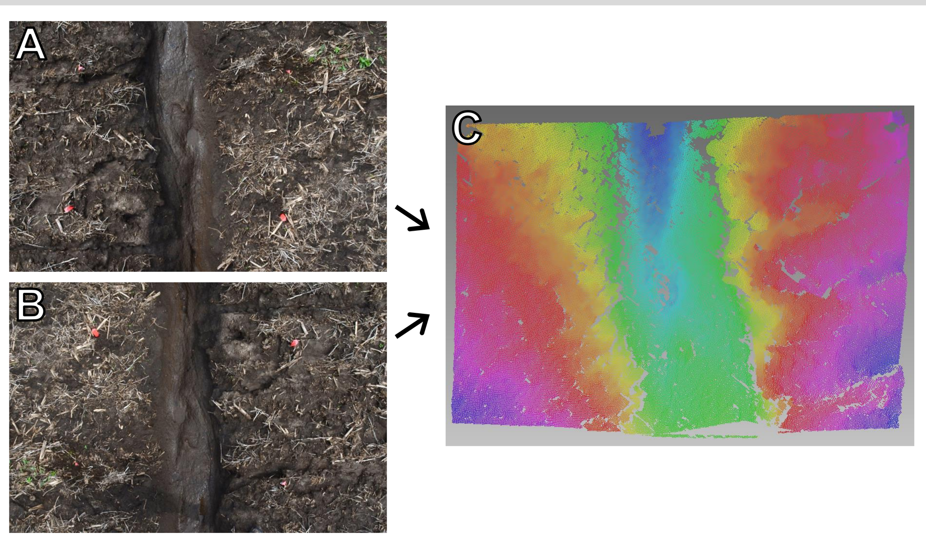

Fig 3. Upstream (A) and downstream (B) facing images are used to generate point clouds (C).

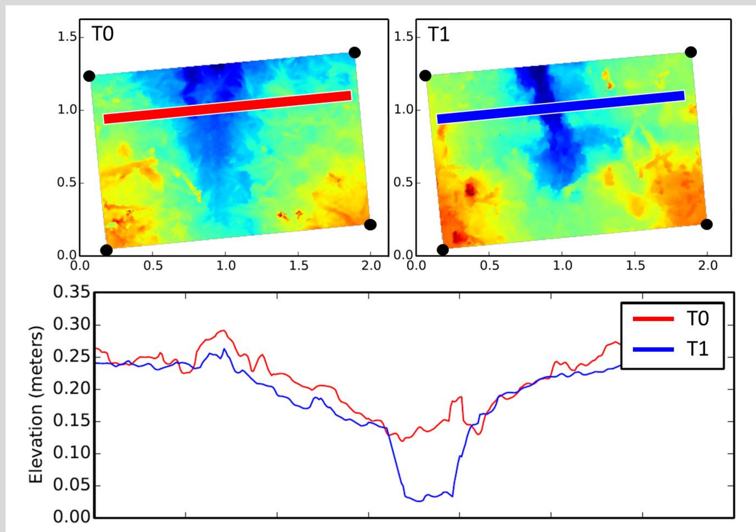

Fig 4. Sequential point clouds (T0 and T1) are compared to determine morphological changes.

Data quality

- Replicated DEMs were compared to quantify accuracy (Fig 5).
- Results of uncertainty analyses are summarized in Table 1.

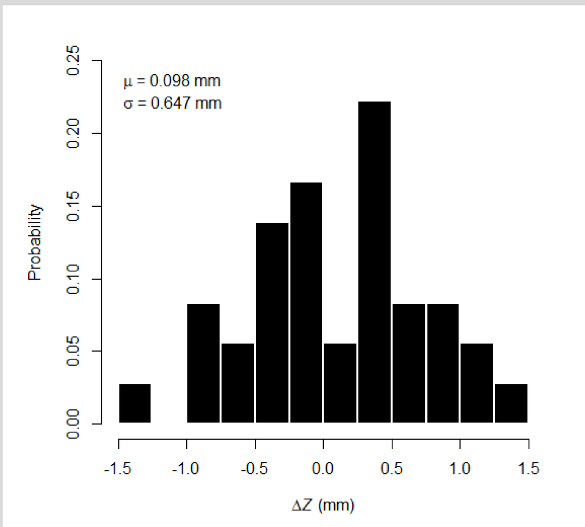

Fig 5. Distribution of vertical discrepancy (ΔZ) for 36 DEM comparisons.

Table 1. 2σ uncertainty values ($\delta\Delta Z$, elevation change; δZ_{rel}, relative vertical accuracy; $\delta Z_{geo\text{-}ref}$, geo-referenced vertical accuracy).

Uncertainty metric	Value
$\delta\Delta Z$*	1.29 mm
δZ_{rel}*	0.916 mm
$\delta Z_{geo\text{-}ref}$**	8.26 cm

*Photogrammetry 2σ uncertainty
**RTK-GPS survey 2σ uncertainty

Field application

- Monitoring sites (2 m^2) were established in April 2013.
- Sites were located along ephemeral gullies in 12 small fields.
- Each site was defined by four control points (Fig 6).
- Control points were surveyed with RTK-GPS (Fig 7).

Fig 6. Four reference markers were used as control points during DEM generation.

Fig 7. Surveyed control points were used to geo-reference photogrammetric point clouds.

- Stereo image pairs were obtained throughout 2013 and 2014.
- Volume change was calculated for each site and interpolated between sites to estimate total channel volume (Fig 8).

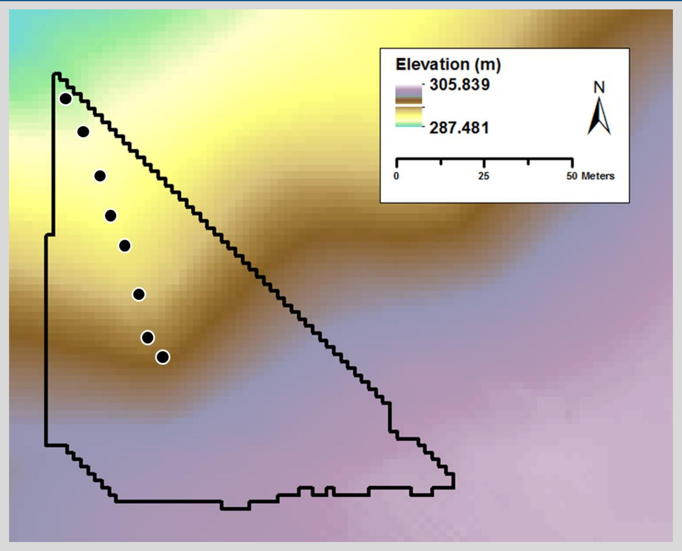

Fig 8. Locations of monitoring sites placed along channel. Interpolation of 2013 volume change at each site yielded gully volume of 6.39 (±0.20) m^3, or 10.87 (±0.34) Mg ha^{-1}.

- DEM post-processing also outputted geo-referenced tabular data of channel cross-sections for each time step.

Significance

- This photogrammetric method is rapid and easily repeated.
- The approach yields high accuracy 3D data.
- Digital geo-referenced data is easily integrated into models.
- Channel cross-sections can be used to validate gully models.

Want to learn more? *Watch for these forthcoming publications in the Soil Science Society of America Journal:*

R.R. Wells, H.G. Momm, K.R. Gesch, S.M. Dabney, R.M. Cruse. Quantification of ephemeral gully erosion in Iowa farm fields.

K.R. Gesch, R.R. Wells, R.M. Cruse, H.G. Momm, S.M. Dabney. Quantifying uncertainty of measuring gully morphological evolution with close-range digital photogrammetry.

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