

DO UAV-DERIVED BOULDER DIMENSIONS MATCH TRADITIONAL FIELD MEASUREMENTS AT THE GRIND O' DA NAVIR, SHETLAND?

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1. Introduction

- Coastal boulder deposits (CBD) are found worldwide on rock coasts and are increasingly researched as a record of extreme wave events^[1].
- Traditional methods for measuring CBDs are time consuming and may not be representative of whole deposits.
- Orthomosaics generated by unmanned aerial vehicles (UAV) enable individual boulders to be measured using either manual or automated digitisation techniques^[2].
- However, while this digitisation approach has seen some use^[2, 3], the measurements are yet to be statistically validated.

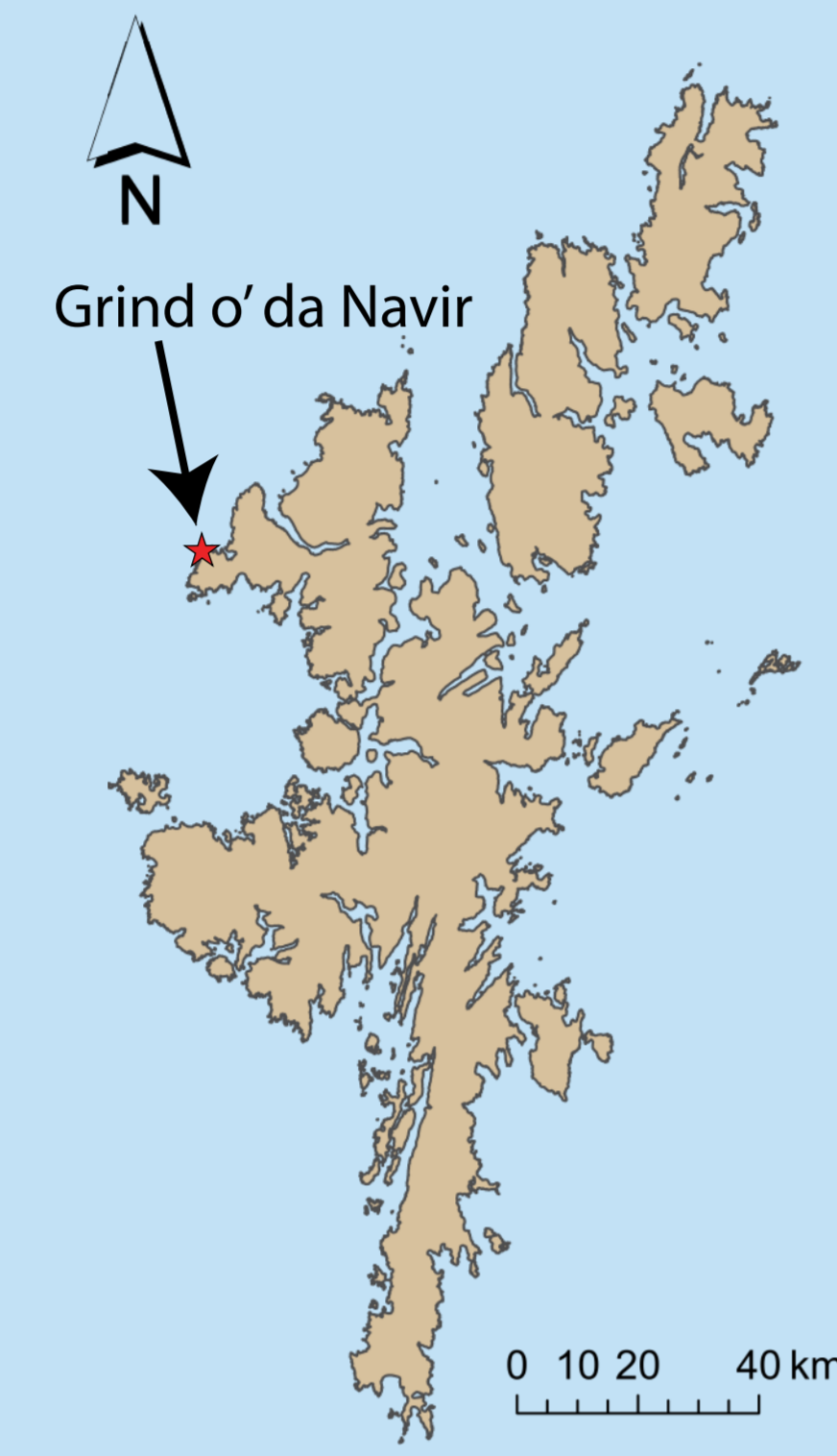


Fig. 2., Map of Shetland and the location of the Grind o' da Navir field site.

2. Methods

To gather UAV imagery a DJI Phantom 4 drone survey was conducted over the site. The imagery was used to generate a 3D model for visualisation (Fig. 3) and an orthomosaic from which boulder measurements are derived (Fig. 5). To make comparisons with traditional boulder measurements, boulders were measured across three transects at the Grind perpendicular to the ridges (Fig. 5).

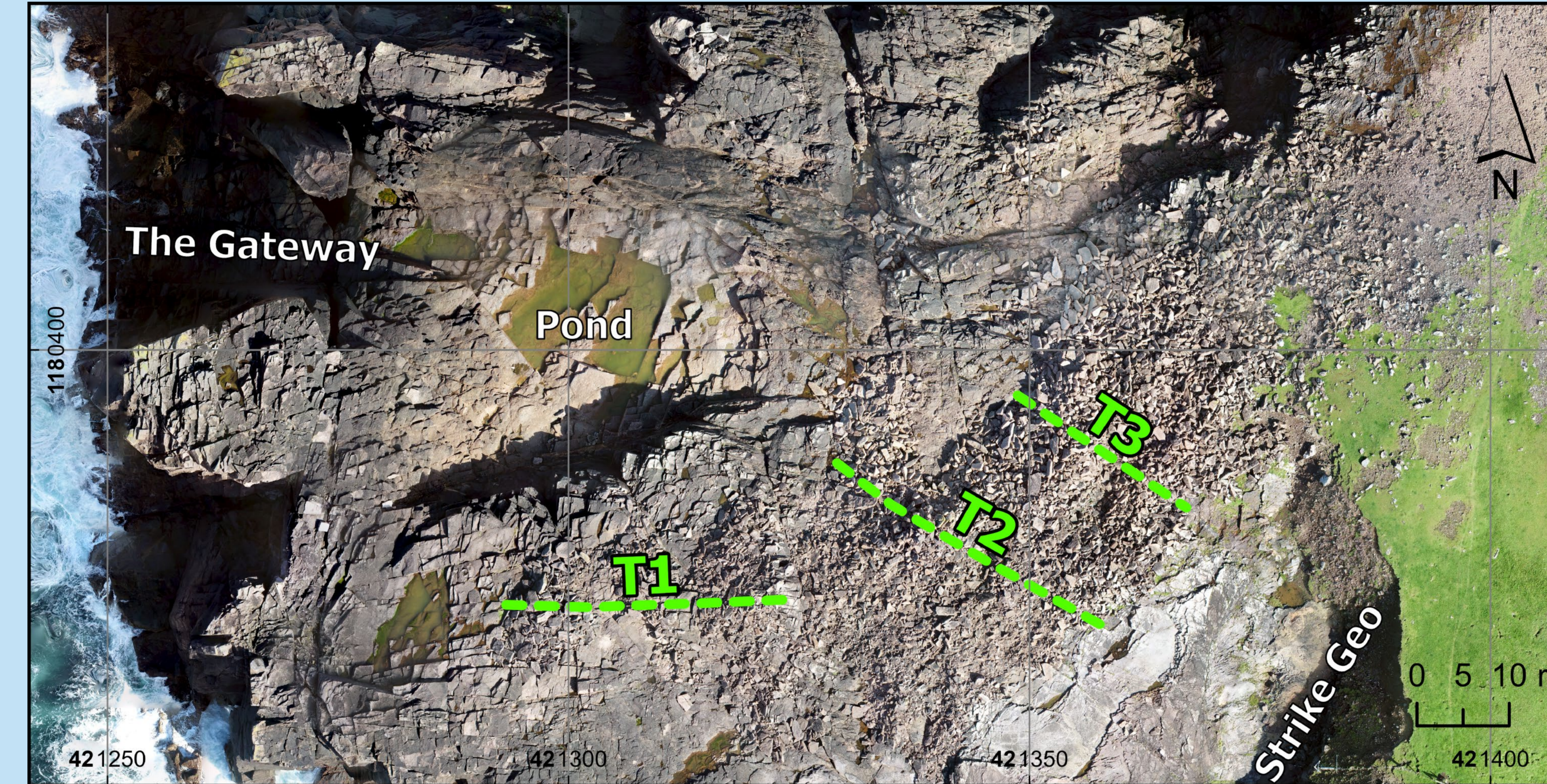


Fig. 5., Orthomosaic of drone photos at the Grind o' da Navir. Transects 1 (T1), 2 (T2) and 3 (T3) are labelled and shown by green dashed lines. Coordinates in British National Grid.

UAV Digitisation Method

Boulder outlines are digitised in ArcGIS Pro from an orthomosaic of UAV photographs (Fig. 6). A minimum bounding box is fitted to each polygon to extract measurements (Fig. 7).

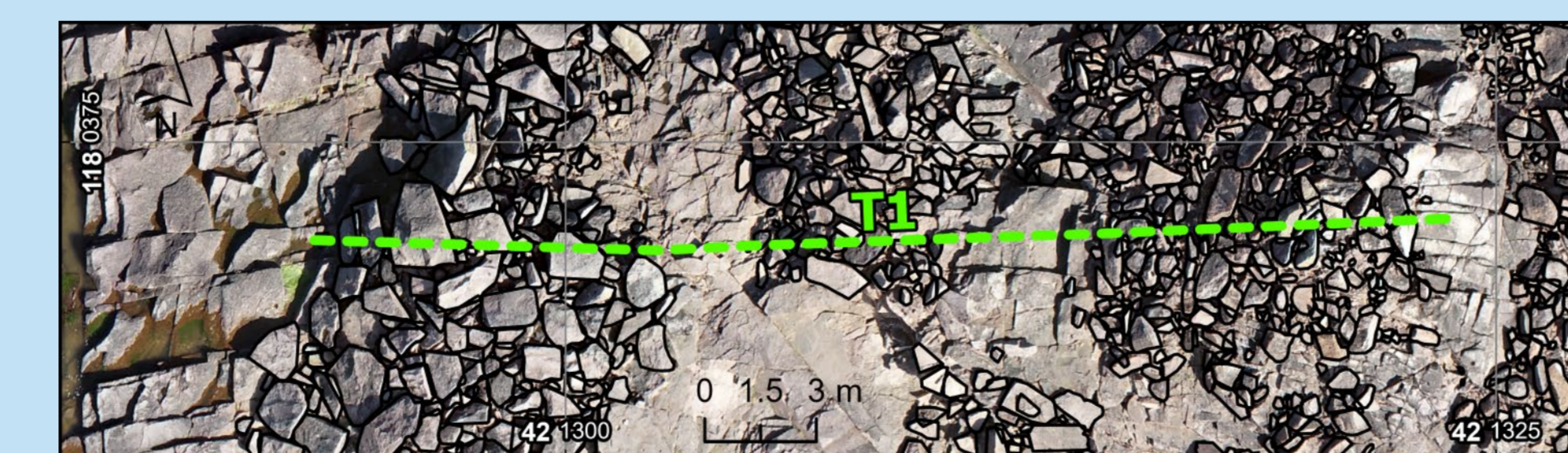


Fig. 6., A zoomed in section of Transect 1 with boulder outlines created using the digitisation method shown in black.

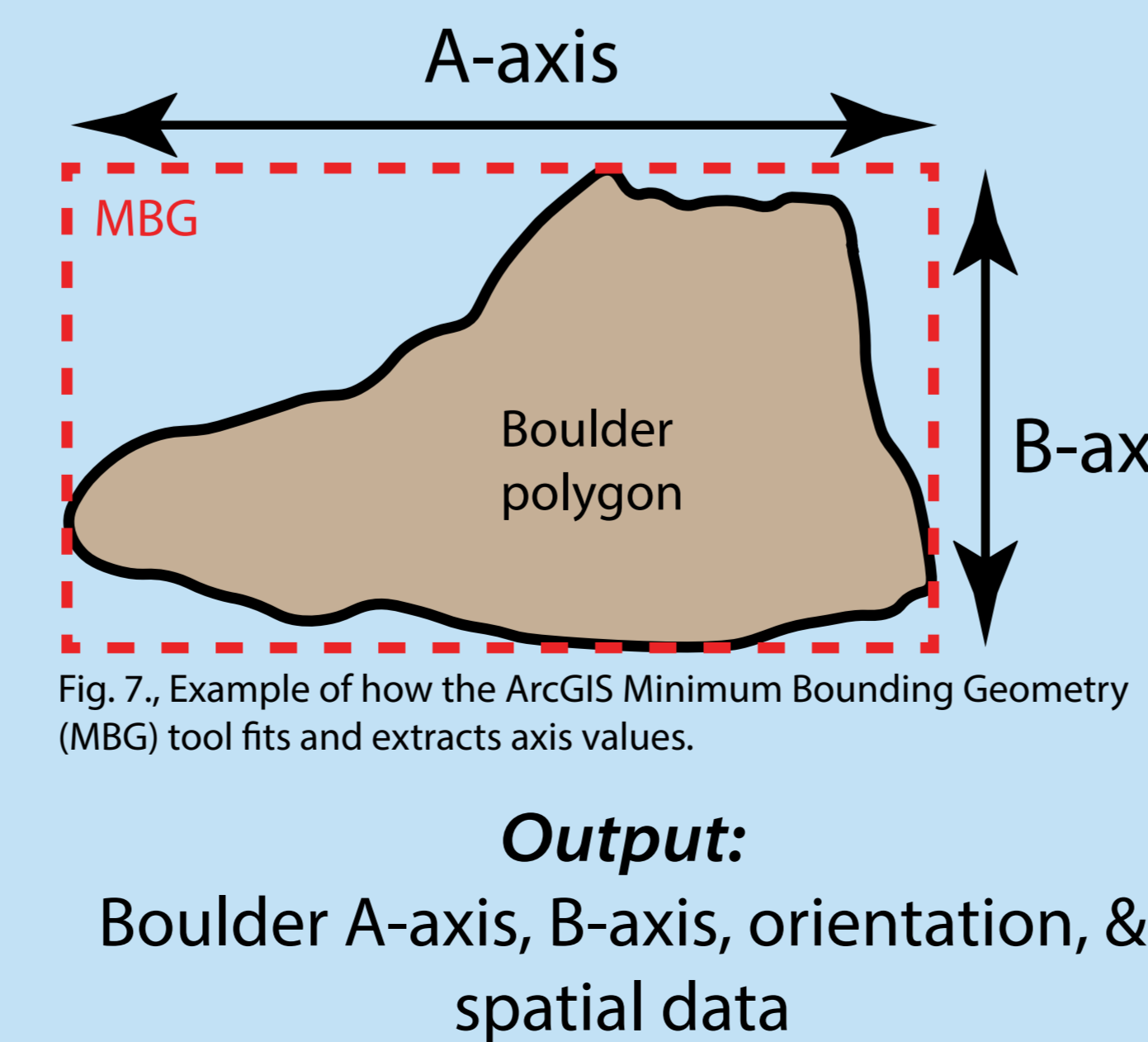


Fig. 7., Example of how the ArcGIS Minimum Bounding Geometry (MBG) tool fits and extracts axis values.

Traditional Field Method

The traditional field technique for measuring boulders uses a tape measure to extract three axis values, treating the boulder as a cuboid (Fig. 8). GPS is used to gather clast spatial data.

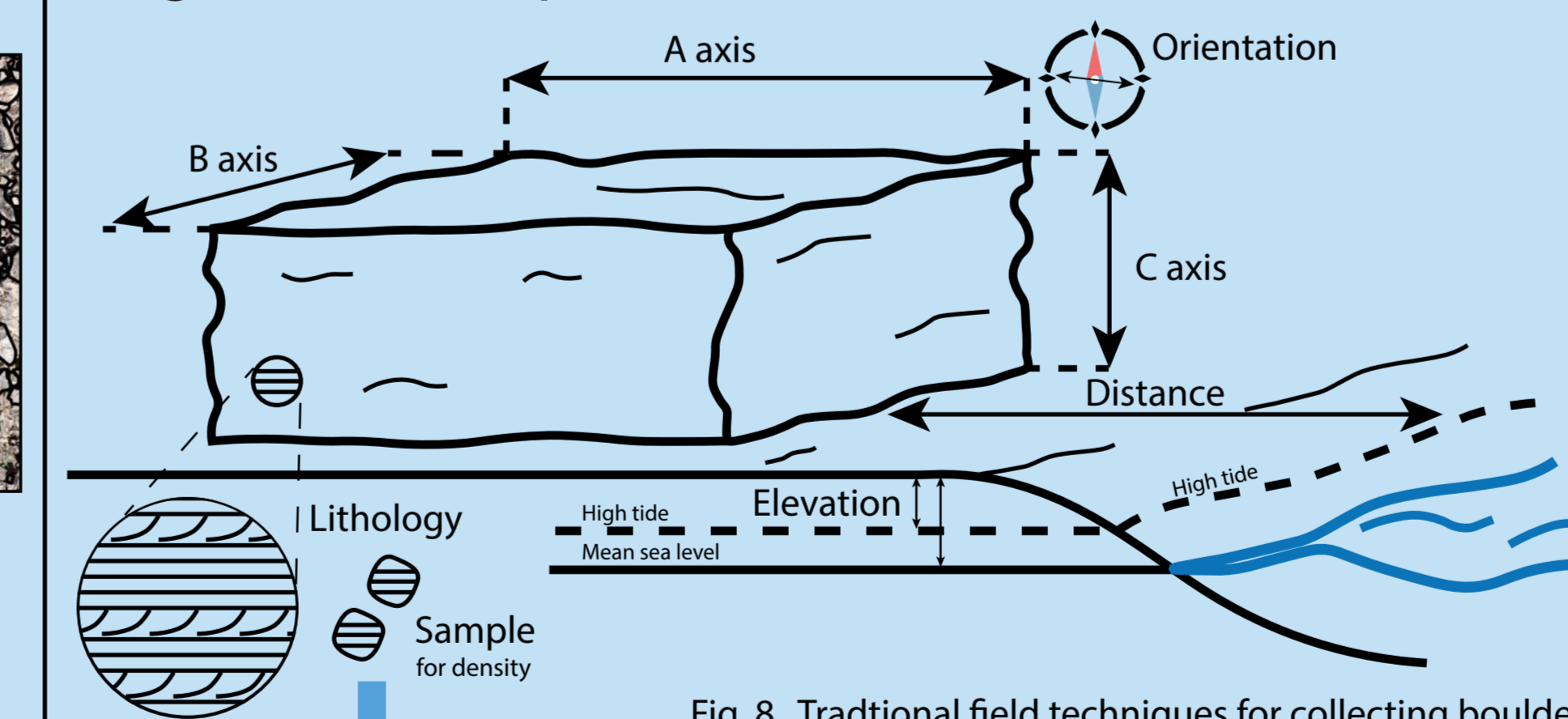


Fig. 8., Traditional field techniques for collecting boulder data.

Fig. 9., Field photograph of traditional boulder measurement including taking DGPS measurements.



Output:
Boulder A-axis, B-axis, C-axis, orientation, density, dip, transport indicators & spatial data

3. Results

Overall the transects showed similar distributions in A-axis and B-axis size (Fig. 10), as well as similar A-axis orientation variability (Fig. 11).

On a paired subsample of the data (Fig. 12) a t-test was conducted and mean difference and 95% limits of agreement (LoA) were assessed:

- The digitisation method yielded mean differences of +0.05 m (± 0.28 LoA) for the A-axis and +0.02 m (± 0.23 LoA) for the B-axis compared to traditional measurements.
- t-test resulted in p-values of 0.001 for the A-axis and 0.068 for the B-axis, indicating the difference between the methods is unlikely to be random.

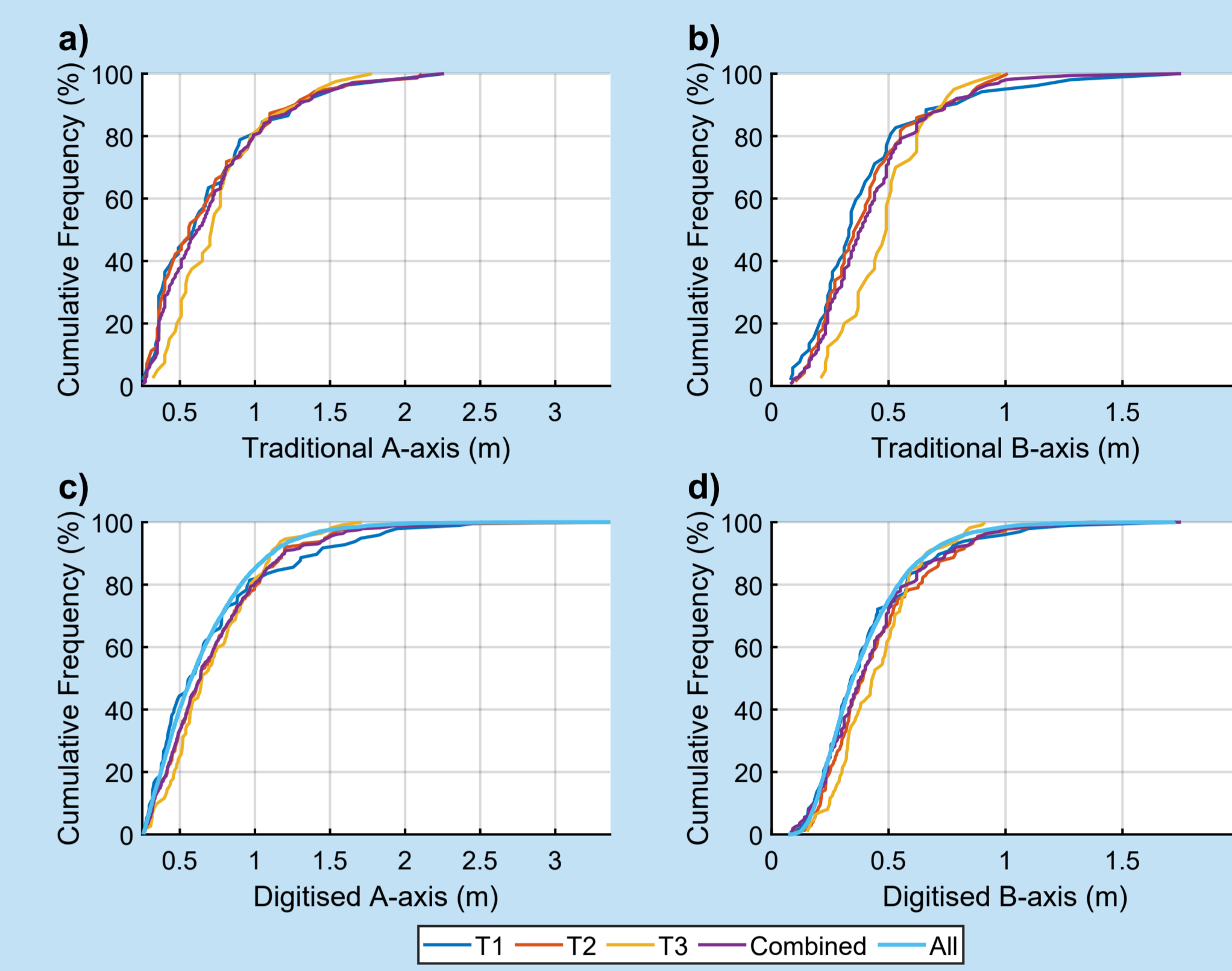


Fig. 10., Cumulative histograms of: a) traditional method A-axis length, b) digitised method A-axis length, c) traditional method B-axis length, and d) digitised method B-axis length.

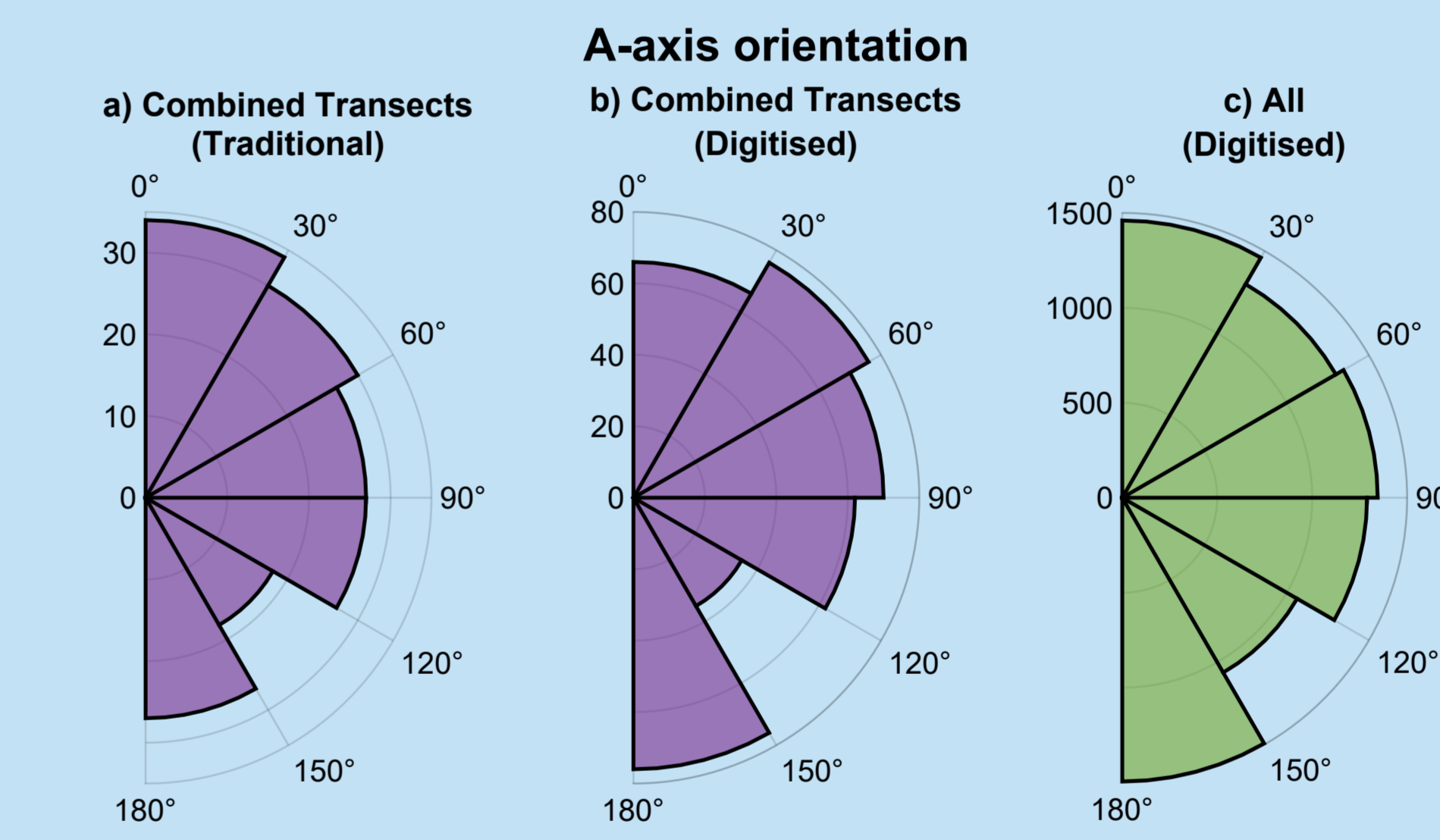


Fig. 11., Rose diagrams of A-axis orientation for a) the three transects measured traditionally (N = 163), b) the three transects measured digitally (N = 385), and c) the digitised boulders across the whole site (N = 7950).

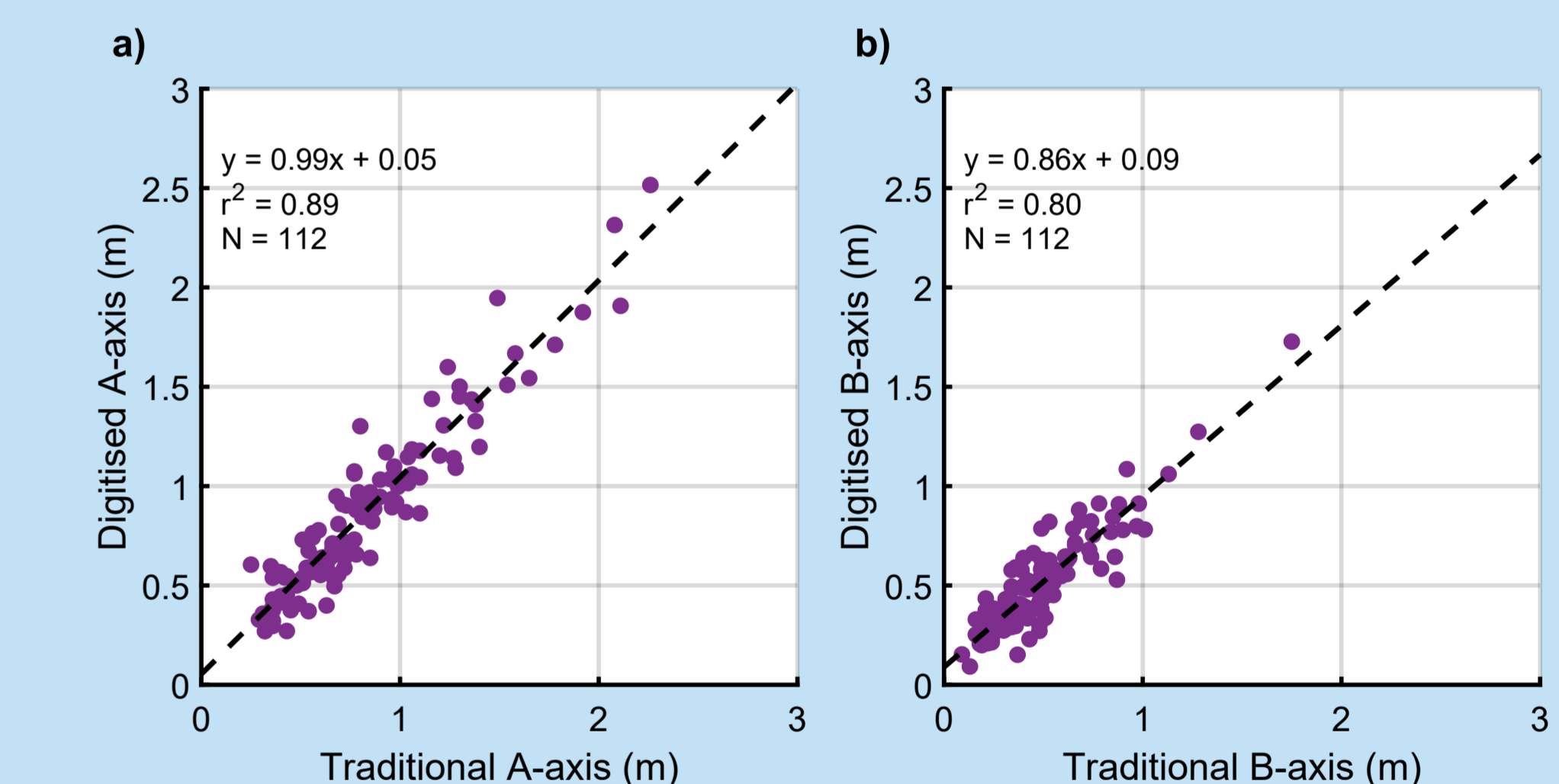


Fig. 12., Scatter plots comparing a paired subsample of the A-axis and B-axis measurements from the three transects with the traditional and digitised methodologies.

4. Conclusions

- Average results were broadly comparable between the digitisation method and the traditional field measurements in terms of axis lengths, aspect ratios, and orientation.
- Differences in individual measurements between the two methodologies are largely attributed to boulder dip, as the 2D outline of a boulder changes with vertical axis rotation. This influence could be minimised by applying the method to isolated boulders on flat beaches and platforms rather than in ridge systems like at the Grind.
- The digitisation method offers considerable advantages for large or inaccessible sites: it reduces time in the field, enables rapid data acquisition, and allows retrospective analysis of whole deposits. The method also facilitates spatial analysis and comparison of datasets across studies.
- However, limitations of the digitisation method include a lack of C-axis data making boulder volumes difficult to estimate, an absence of transport indicators, and difficulty automating the boulder outline digitisation in complex settings like the Grind.