Challenges in Determining the Most appropriate Digital Elevation Model (DEM) Resolution for orthorectifying 0.25m Aerial Imagery

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SUMMARY

Accurate orthorectification of high-resolution aerial imagery requires a Digital Elevation Model (DEM) whose spatial resolution and vertical accuracy match the imagery's ground sampling distance. Determining the most appropriate DEM resolution remains a significant challenge, particularly in operational photogrammetric workflows, where terrain complexity, vegetation cover, and surface discontinuities can substantially affect orthorectification outcomes. This study evaluates the suitability of photogrammetrically generated DEMs at 2 m, 5 m, and 10 m resolutions for orthorectifying 0.25 m imagery over four test grids (W47, W56, W57, W58) in the Western Cape, South Africa.

DEM comparisons were made against a high-resolution LiDAR-derived reference surface. Raster differencing was applied, and areas with elevation differences exceeding one meter primarily corresponding to cliffs, were masked to prevent distortion of statistical assessments. Metrics including mean error, standard deviation, and root mean square error were calculated to evaluate systematic bias and variability.

Results indicate a consistent negative bias, with LiDAR elevations slightly lower than the photogrammetric DEMs. The bias increased from −0.128 m for the 2 m DEM to −0.224 m for the 5 m DEM and −0.340 m for the 10 m DEM, while standard deviation remained stable (≈ 0.42–0.44 m). The 2 m DEM captured fine-scale terrain features but exhibited higher local variability. The 5 m DEM achieved a balance between surface detail and smoothness, and the 10 m DEM provided a generalized but stable representation suitable for regional applications.

The study concludes that a 5 m photogrammetric DEM offers the optimal compromise between geometric accuracy, terrain fidelity, and computational efficiency for orthorectifying 0.25 m aerial

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imagery. With appropriate masking and statistical verification, photogrammetric DEMs can provide a reliable alternative to LiDAR for operational orthorectification.

Beyond its immediate relevance in South Africa, this research provides a replicable framework for DEM selection in other nations of the Global South, where limited LiDAR availability, variable terrain, and resource constraints necessitate cost-effective yet accurate elevation products. By providing a quantitative, evidence-based approach, the study contributes to improving photogrammetric standards, enhancing geospatial data consistency, and supporting sustainable mapping and land administration practices in data-scarce environments