

# Cyclone Washover Fan Anatomy – processing Unmanned Aerial System Structure-from-Motion (UAS-SfM) point clouds.

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## **Abstract:**

Field geomorphology requires tools to reconstruct landscape features at appropriate scales, resolution and accuracy to understand environmental processes and their implications. Washover fans form during extreme wave events (tsunami and cyclones) when a foredune beach ridge is overtopped by wave action and sediment is deposited into a low-elevation backwater environment as a sedimentary fan. There is limited high resolution topographic models of fans and as such, the controls on fan formation limits our understanding of how washover fans are dated and analysed as paleotempestological archives – that is a sedimentary record of past cyclone events. We explore the use of an Unmanned Aerial System (UAS) to collect images for Structure-from-Motion (SfM) photogrammetry to create a high-accuracy three-dimensional point cloud models of the sedimentary fan and then use novel techniques to process dataset to create a bare-earth surface DEM (to support dating, Ground Penetrating Radar (GPR) and sedimentary analysis).

Using an UAS “octocopter”, we captured 1208 photos above a tropical cyclone-induced washover fan in the Exmouth Gulf (Western Australia) using a DSLR camera (Canon EoS-M) at the height of 50m AGL with a ground pixel resolution of 9mm. The fan measured about 500m inland by 300m wide. Based on 38 ground control point targets (with between 4 and 45 individual photographs per target) the SfM surface had an absolute total (XYZ) accuracy of 51mm (34mm X-Y and 14mm Y) and an overall relative point accuracy of 7mm, based on RTK-DGPS surveying from a local ground reference station. A sparse point cloud of over 5.5 million data points was generated using only points with a reconstruction accuracy of <50mm. Conventional topographic filtering techniques were unable to separate out ground and non-ground returns, largely due to the dense spinifex hummocks covering the site. We trialled a novel spectral unsupervised clustering technique using K-Means clustering of the RGB colour of each XYZ pixel implemented in Python (Fig 1B). The point cloud was then manually classified into points from “ground” and “non-ground clusters” against the aerial photograph (Fig 1C). The geostatistical analyst functionality of ArcGIS was used to interpolate a 5cm spline-based bare-earth Digital Terrain Model (DTM) (Fig 1D). This has allowed insight into the morphological features such as the backwater heights and deposition and wash-up channel connectivity with the fan. This has allowed strategic targeting and interpretation of

field trenches, OSL dating and GPR transects that would otherwise have been complex to impossible to achieve via conventional survey methods (i.e. Terrestrial Laser-Scanning or RTK-DPS survey) and uneconomic to collect via airborne-LiDAR. UAS-SfM and unsupervised clustering has allowed the study team to economically collect and process an unprecedented high-resolution and accuracy bare-earth topographic model of this feature. This has complimented on-ground sediment, geophysics and dating work to analyse the complex evolution structure of the washover sequence with new insight into cyclone frequency on the Australian NW coast over the last few millennia.

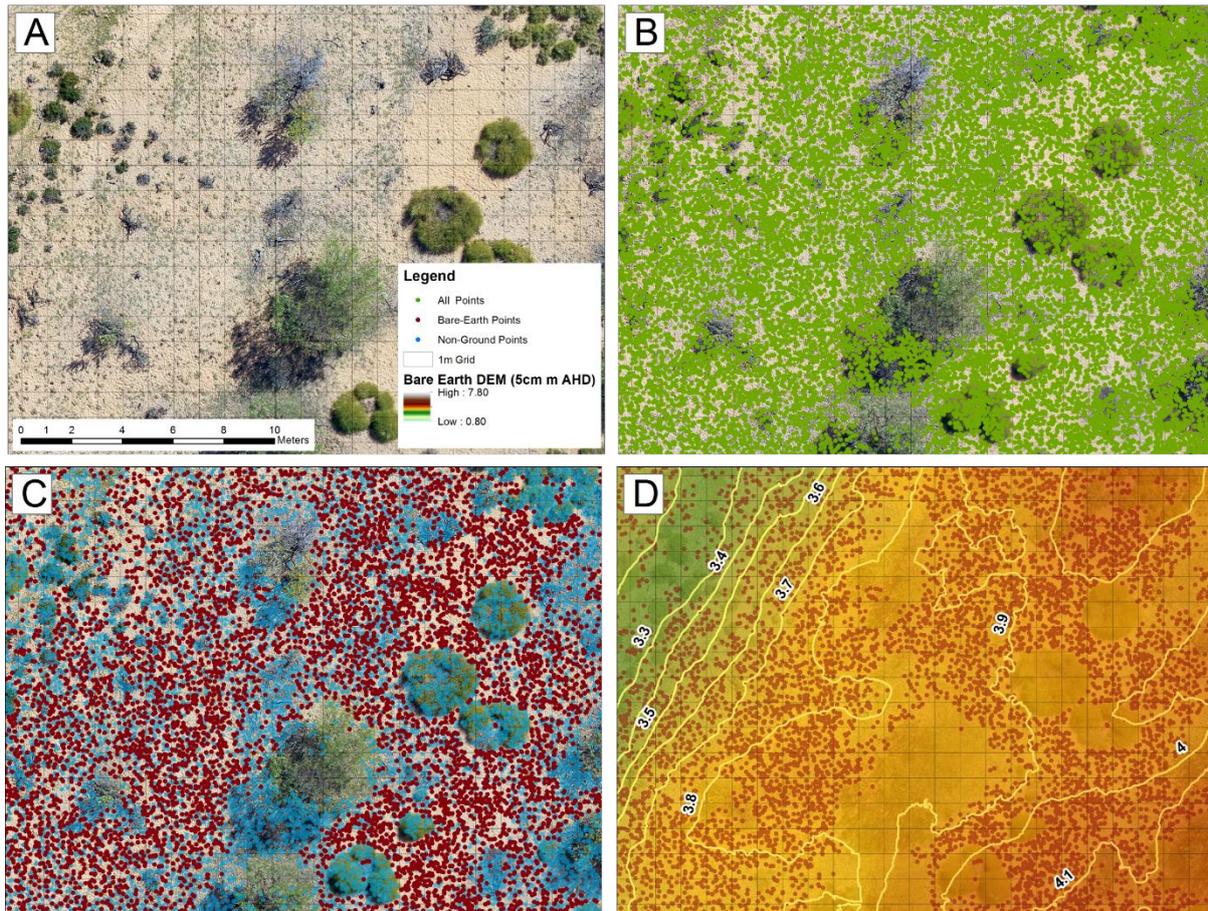


Figure 1. Image of the sample point cloud dataset, showing a section of the study site (A), the raw point cloud (green points) (B), the K-Means clusters corresponding to ground or bare-earth (red) and non-ground points (blue), and the final bare earth points and interpolated 5cm bare-earth DTM (Digital Terrain Model) and 10cm contours lines (D).