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Bare Earth – enhanced multi-spectral satellite imagery for mapping soil and exposed rock.

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Satellite multi-spectral remote sensing has been used extensively in mapping the nature and characteristics of the terrestrial land surface including vegetation, rock, soil and landforms across global through to local scales. However, with the exception of hyper-arid regions mapping rock and soil from space has been problematic due to vegetation that either masks the underlying substrate or confuses the spectral signatures of geological materials (i.e. diagnostic mineral spectral features) making them difficult to resolve. A barest earth multi-spectral algorithm operating on time series satellite archives can now significantly reduce the influence of vegetation and provide enhanced mapping of soil and exposed rock from space.

The methodology firstly applies a high-dimensional statistic called a ‘weighted geometric median’ which is robust to outliers or contamination (such as cloud cover, shadows, detector saturation, and pixel corruption) by removing sub-populations in the data. The weighted geometric median also maintains the relationship between all the spectral wavelengths which is important for the later implementation of image enhancement techniques based on the spectral signatures of minerals. The second component of the methodology applies a weighting scheme that preferences the bareness of pixels from those pixels that exhibit a vegetation influence. After considerable experimentation a single model weighting scheme using a loss function that minimises NDVI was found to be the most robust for application at the continent scale. Customised calibration and weighting schemes can also be developed for local study areas. The result of this process for a given time series is an estimation of the barest state relating to either soil or exposed rock. The approach does not require local calibration and can be applied to other satellite archives globally.

We have applied the barest earth algorithm on Landsat and Sentinel-2 multispectral datasets to develop a suite of enhanced image products over the Australian continent to support digital soil mapping, geochemical modelling and mineral exploration. Image enhancements include individual band composites, ratio bands and selected principal component analysis. These enhanced mineral products provide new and improved inputs for machine learning and more broadly geo-spatial

modelling/mapping. The bare earth products significantly reduce the effects of fire scars in semi-arid areas of the continent and seasonal variations in vegetation cover that to-date have limited the use of satellite remote sensing in mapping soils in agricultural landscapes. The bare earth algorithm can be applied across different time intervals (e.g. annually, deeper time since mid-1980's) and has the potential to establish environmental baselines for understanding and responding to food security, climate change, environmental degradation, water scarcity, and threatened biodiversity.