Automated Selection of Suitable Atmospheric Correction Sites

R.T. Wilson and E.J. Milton

School of Geography, University of Southampton, Southampton, UK, SO17 1BJ

A method was developed to select suitable ground calibration targets (GCTs) for use with empirical methods of atmospheric correction. The procedure was tested on a SPOT-5 HRG image of Andover, England.

Desirable Criteria for Calibration Sites

Criterion	Justification
Large	Minimises the effect of the point spread function. Slater (1980) recommends an area at least 8x the nominal pixel size.
Range of reflectances	Avoids extrapolating the regression line beyond the limits of the GCT data. Mid-range reflectance GCTs are also useful to check the linearity of the relationship.
Stable over time	Few if any GCTs are spectrally invariant over time, but the changes in some surfaces can be accounted for by use of a BRDF model (Moran et al., 2001).
Spatially homogenous	Reduces the importance of positional accuracy in the ground measurements and minimises the effect of image misregistration. Reduces the probability of mixed pixels occurring.
Flat	Reduces the importance of the time of image acquisition.
Sites spread throughout the image	Ensures the variation in atmospheric conditions across the image to be accounted for.

Table 1 - Overview of desirable criteria for calibration sites (Smith and Milton, 1999; Karpouzli and Malthus, 2003)

Site Selection

Object-based Image Analysis

This was performed using fuzzy object-based classification in Definiens eCognition version 4. The image was segmented at two levels and classified according to a set of rules (Figure 2). The Customised Feature function in eCognition was used to allow rules to be created based on the percentage of the image object selected in the binary masks derived above. When studying the images it was found that a number of buildings had sawtooth roofs. These are unsuitable for use as GCTs as their reflectance varies considerably with changes in sun angle. These were excluded by a rule checking the coefficient of variation of an aspect image created from the DSM. It was found that this rule worked even when the sawtooths had a periodicity less than the resolution of the sensor.

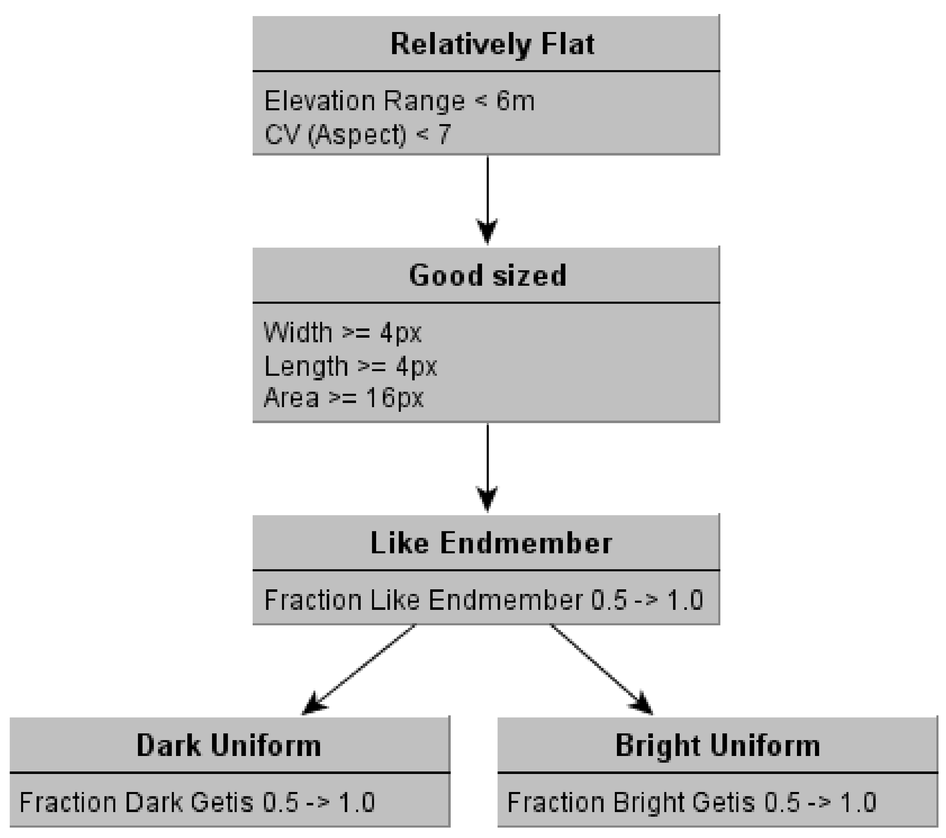

Figure 2 - Rules used for object-based classification in eCognition

Refinement of selected sites

The selected sites (Figure 3) were then subjected to a second stage of screening as to their suitability for the specific application. In the present study this stage was performed manually (Table 2).

Target	Assessed suitability
Dark targets	Positively skewed distribution caused by aquatic macrophytes. Darkest 30 pixels across all the dark targets were chosen as a pseudo calibration site.
B757	Bright in all VNIR bands (as high as the vegetated field in NIR) and almost normally distributed. The best overall target.
B1095	Close to a normal distribution, but with significant negative skew. Large flat roof with shadowed section.
B1297	Close to a normal distribution. Composed of multiple buildings so not suitable for use with high-resolution sensors.

Table 2 - List of selected sites and assessed suitability

Processing and Thresholding

Assessment of uniformity

Getis-Ord statistics were used (Getis, 1994) to measure spatial uniformity. This has been shown to be more sensitive to variations than the coefficient of variation (Bannari, 2005). IDL code was written to calculate G_i^* with a variable moving window size. Large positive values show bright uniform areas, large negative values show dark uniform areas.

Assessment of brightness range

A novel method was developed to ensure the selected calibration sites were some of the brightest and darkest pixels in each band (Figure 1). Calibration sites were selected which were close to the endmembers of the image, as this ensures they are close to the edges of the pixel cloud, and therefore the minima and maxima of the image. The SMACC algorithm (Gruninger, 2004) was used, and was set to find 5 endmembers, producing abundance images.

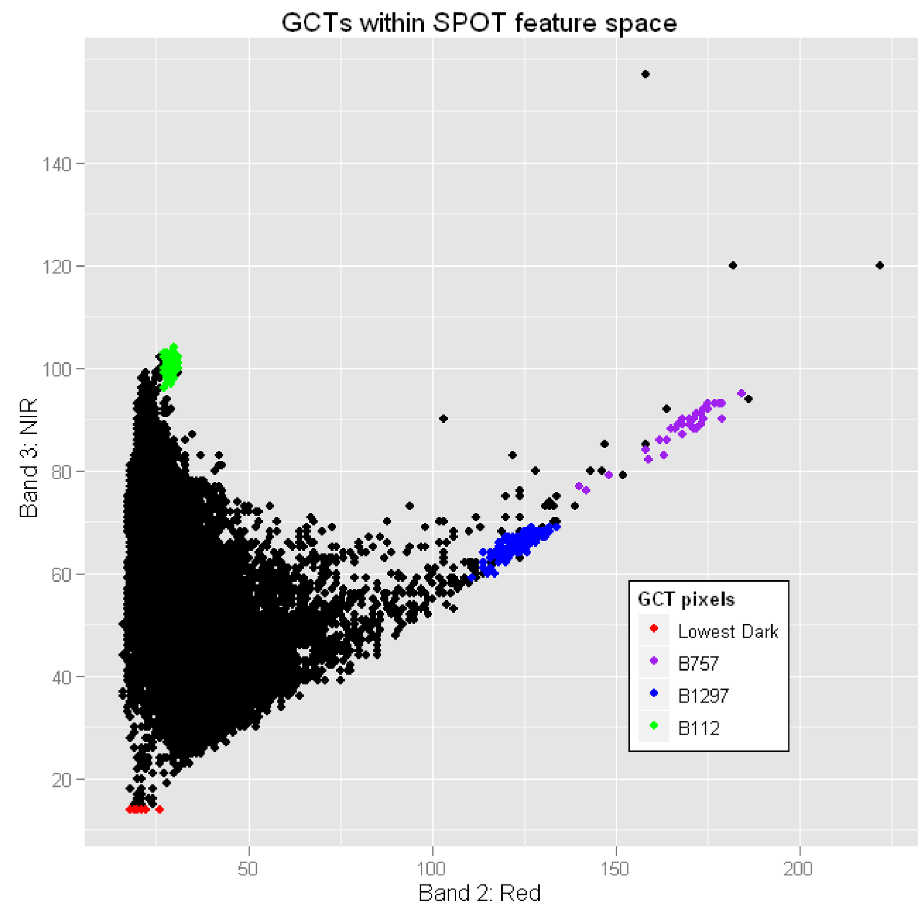

Figure 1 - Selected GCTs shown within the SPOT feature space

Thresholding

The Getis and endmember abundance images created in the processing stage were converted to a binary mask image by selecting the top and bottom 0.3% of the Getis values, and the top 0.3% of the endmember abundances (thresholds were derived empirically and are user-definable).

Figure 3 - Selected GCTs shown on a SPOT false colour composite. Yellow areas are selected dark targets and purple areas are selected bright targets.

Questions raised by the research

1. Is it better to have one high-quality GCT or several lower quality ones scattered across the image?

Need both. For example, could combine Moran's Refined Empirical Line Method applied to the primary GCT with a spatial map of aerosol optical thickness, e.g. from Kauth-Thomas tasselled cap 'yellowstuff' axis derived from secondary GCTs.

2. To what extent can the eCognition rules be generalised for other sensors / data sources?

The processing routine uses percentile thresholds, which allows it to be generalised to other images. However, the algorithms (particularly the Getis-Ord statistics) are resolution dependent. Strahler's (1986) H-resolution & L-resolution scene models are key to this.

3. How to assess the temporal stability of GCTs?

A role for spectral signature libraries, however, the dynamics of spectral reflectance is under-represented. Most libraries have measurements from one point in time, or at most a few times during a season. More short-term time series needed (hours to weeks).

Acknowledgements: SPOT HRG data from the NCAVEO Field Campaign were provided by CNES, the NEXTMap data were provided by Intermap Technologies, and both were sourced via the NERC Earth Observation Data Centre (NEODC).

Bannari, A., Omari, K., Teillet, P. & Fedosejevs, G., 2005, 'Potential of Getis statistics to characterize the radiometric uniformity and stability of test sites used for the calibration of Earth observation sensors', *IEEE Transactions on Geoscience and Remote Sensing*, 43 (12), pp. 2918-26.

Getis, A., 1994, 'Spatial dependence and heterogeneity and proximal databases', *Spatial analysis and GIS*, pp. 105–20.

Gruninger, J., Ratkowski, A. & Hoke, M., 2004, 'The sequential maximum angle convex cone (SMACC) endmember model', *Proceedings SPIE, Algorithms for Multispectral and Hyper-spectral and Ultraspectral Imagery*, 5425, pp. 1–14.

Karpouzli, E. & Malthus, T., 2003, 'The empirical line method for the atmospheric correction of IKONOS imagery', *International Journal of Remote Sensing*, 24 (5), pp. 1143-50.

Smith, G. & Milton, E., 1999, 'The use of the empirical line method to calibrate remotely sensed data to reflectance', *International Journal of Remote Sensing*, 20 (13), pp. 2653-62.