Automated detection and characterisation of homogeneous, stable ground targets on DMC images: towards a UK Environmental Change Space Observatory

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1 Introduction

Earth observation from space can provide important information on environmental change at a global scale, and in principle could do the same for regional and local scale environmental monitoring in the UK. However, to do this we require a spaceborne sensing system with spatial resolution compatible with the typical land parcel size and with frequent coverage, so as to allow for the many days when cloud cover prevents sensing in optical wavelengths. Established global scale sensing systems (e.g. MODIS, MERIS, SPOT-VGT) lack the spatial resolution required; the MODIS land cover product has 250 m resolution, but around 20 m is needed. Complete coverage of the UK using data from higher resolution sensors such as Landsat-ETM+ or SPOT-HRG requires many images to be mosiaced together, which is a problem as so few are collected each year due to the problem of cloud cover.

The constellation of DMC satellites offers a potential solution to this problem. There are currently five satellites in operation, each with a high resolution multispectral sensor equipped with bands in green, red and near infra-red wavelengths (Table 1). Crucially, the swath width of these instruments is up to 650 km, and the along-track imaging capability is up to 2,100 km, making them ideally suited to acquiring synoptic data from the whole of the UK. A near daily repeat period is also possible because the individual satellites in the constellation are operated as a single system, and all the sensors are intercalibrated.

Table 1. Characteristics of the DMC constellation of satellites (source: DMCii)

Ground sampling distance (GSD)	22 m (SLIM-6-22)
Spectral bands (SLIM-6-22)	0.52-0.60μm, 0.63-0.69μm, 0.77-0.89μm
Swath width	Up to 650 km
Along-track capability	Up to 2,100 km
Equatorial revisit	1-2 days (all satellites)
Geolocation accuracy	< 17 m (22 m GSD L1T)
Equatorial crossing time	09:00 – 10:50 UTC

Whilst the DMC constellation can provide suitable satellite data to populate a national scale database in a timely manner, this by itself is insufficient to create a UK Environmental Change Observatory (UK-ECSO). It is also important that the data are corrected for changes in the conditions of measurement, caused for example by atmospheric variation (time and space), differences in solar view angle or differences in sensor view geometry. The requirement of such a system to provide accurate, timely products but without detailed contemporaneous ground data means that empirical correction methods are likely to most useful. This paper investigates an empirical approach to the automated detection and characterisation of homogeneous stable targets on a time series of DMC images, as a first step towards creating an Environmental Change Space Observatory for the UK.

2 Methods

Selection of homogeneous, stable areas of an image is a key step for many remote sensing procedures such as empirical atmospheric correction, radiometric normalisation and vicarious calibration of satellite sensors. We present a method for automating the extraction of these areas, building on the work of Wilson and Milton (2010) and extending it into the temporal domain. As the selected areas must be real-world objects, the method uses an image segmentation procedure which takes into account both spectral information and a derived 'fitness image'. This fitness image provides information regarding the suitability of each pixel for inclusion in a site and is created from three separate procedures for assessing spectral purity, spatial uniformity and temporal stability.

Spectral purity is assessed by extracting image endmembers and calculating the maximum percentage abundance for each pixel. Spatial uniformity is assessed using the Getis statistic, which has been shown to be more sensitive to small-scale local variations than the coefficient of variation (Bannari et al, 2005). Temporal stability is assessed using the Multivariate Alteration Detection method (Canty et al., 2004), from which a No-Change Probability (NCP) can be extracted for every pixel. This represents the likelihood that the pixel has undergone change between two images, and is therefore a measure of temporal stability over the time. The output from these three assessment procedures are combined using a weighted sum to produce the fitness image, allowing the relative importance of spectral, spatial and temporal uniformity to be varied for different applications of the method. As this fitness image is used as one of the controls on the segmentation, the only image objects that are created are those which are likely to be suitable as uniform sites, and the majority of the image is not split into objects, saving both processing time and memory. Once segmentation has been performed, image objects are filtered using aggregate properties of the pixels within the image objects (for example to remove objects that have a large elevation range within them) before output to the user.

3 Data

The data used in this study were acquired by DMC International Imaging Ltd during the vegetation green-up period, between March and June 2010 (Table 2). All six images were acquired using similar SLIM-6-22 sensors on different DMC satellites. A small subset centred on the town of Andover in Hampshire was extracted from each of the DMC images as representative of the landscape of southern England (Figure 1). The image includes an urban area with associated commercial and retailing centres, as well as agricultural fields, woodland and small areas of water.

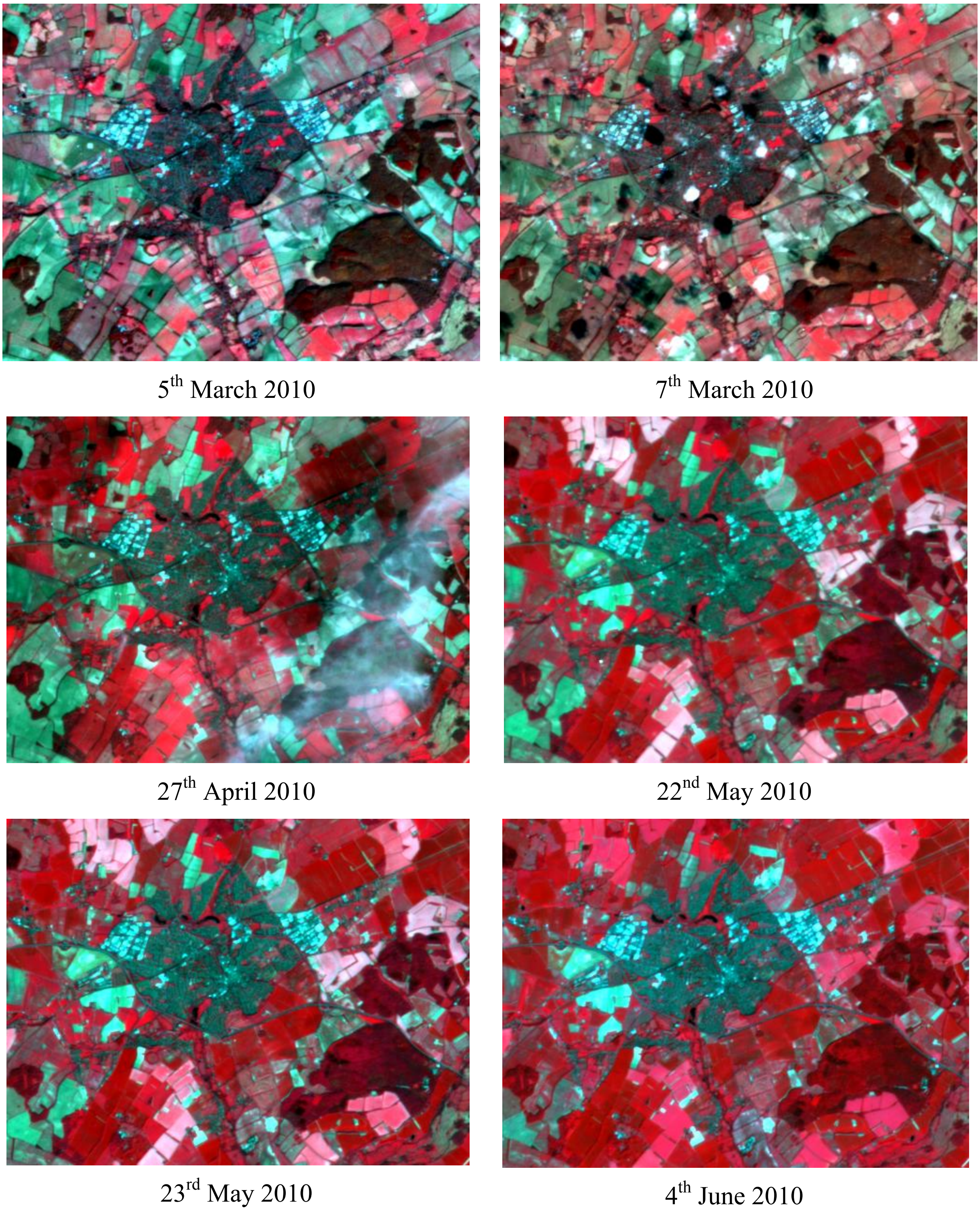


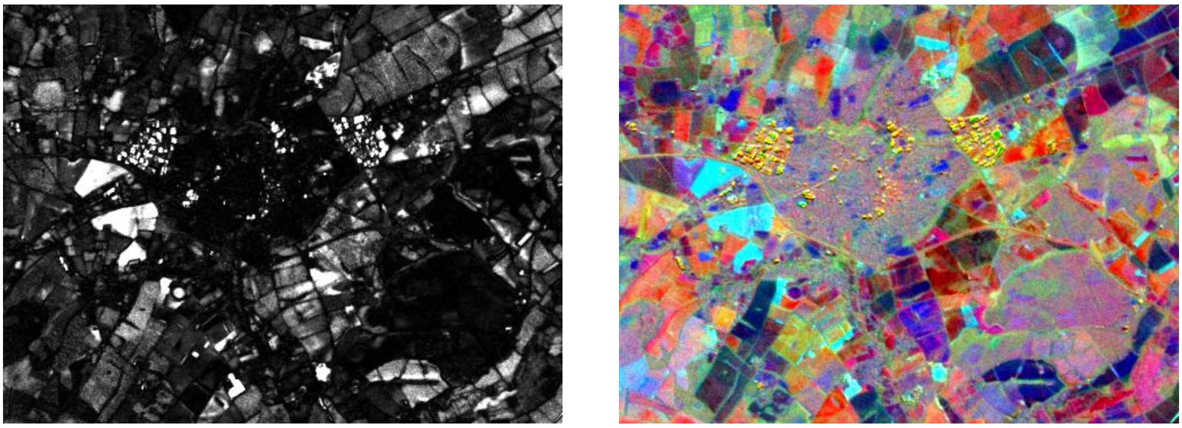
Figure 1. Time series of DMC images of the study area, centred on the town of Andover.

Table 2. DMC data used in this study

Date	Time (UTC)	Solar azimuth angle (deg.)	Solar zenith angle (deg.)
5th March 2010	09:46	140.1	66.3
7th March 2010	09:55	140.3	64.8
27th April 2010	10:08	139.1	44.4
22nd May 2010	09:51	130.0	40.8
23rd May 2010	09:52	130.0	40.2
4th June 2010	09:57	128.6	38.0

4 Results

Figure 2 shows some intermediate results from application of the multivariate alteration detection (MAD) procedure. The Chi-squared image identifies several areas having a high probability of being unchanged between March and June. There are several bare fields, the largest being the two west of Andover, and there are many smaller stable areas, including the roofs of large warehousing facilities clustered at the eastern and western approaches to the town. The MNF composite image is helpful in allowing us to distinguish different types of change (or no-change, in our case). In this image, the highly reflective warehouse roofs are clearly separated from the bare fields which although stable, have a much lower reflectance.



(a) (b)

Figure 2. Intermediate results from MAD change detection applied to the DMC images from 5th March and 4th June. (a) Chi-squared image showing areas of highest 'no change probability (NCP)' in lighter tones. (b) Colour composite of MAD variates 1,3, and 2 [RGB].

This work is on-going, and the conference paper will present the method in more detail and develop a generic approach to change detection which considers separately information in the spectral, spatial and temporal domains.

5 Acknowledgements

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