UNIVERSITY OF Southampton

Automated identification of invariant ground targets

-towards a UK Environmental Change Space Observatory (UK-ECSO)

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Problem

- Remote sensing can provide useful information on **environmental change**
  - Use multiple images and compare over time
- Simple in concept, difficult in practice
  - Influence of the atmosphere
  - Non-significant change (rainfall events etc.)
  - Gaps in data record (cloud cover etc.)
  - Dependence on sensing system used

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Towards UK-ECSO

- Change happens, but not everywhere
  - Some real-world objects will be 'invariant' over time/space/spectral/angular domain of interest.
- Invariant objects are important
  - Radiometric standards (atmospheric correction, sensor cal/val)
  - Image end-members (framework for classification)
  - Scene understanding

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Solution?

An **automated method** for identifying suitable invariant ground targets from satellite imagery

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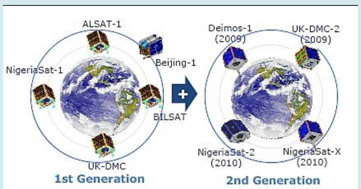
Sensors for UK-ECSO

Landsat: images too small, too infrequent
MODIS/MERIS: spatial resolution too low
DMC: High resolution (22m); Huge images; Near-daily repeat period



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DMC Time Series

- 6 images from March-June 2010
  - During vegetation green-up period
  - *Images provided courtesy of DMCii*
- All from SLIM-6-22 sensor on different DMC satellites
- Subset centred on Andover, Hampshire
  - Range of land covers (Water, Urban, Forest)

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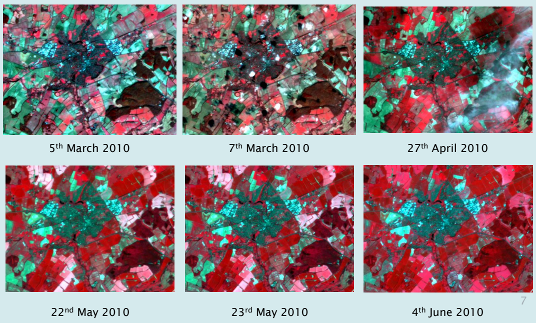
DMC time series Spring 2010 Proof-of-concept



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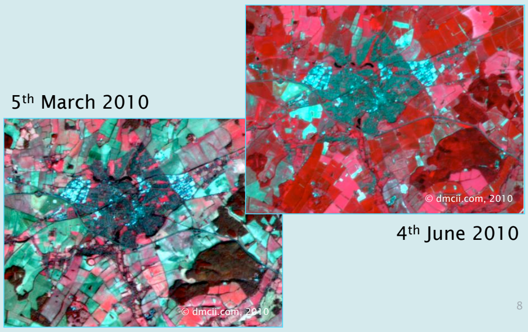
DMC images selected for use



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Site Selection Criteria

- Sites must be:
  - Spatially uniform
  - Wide ranging in reflectance
  - Stable over time
  - Flat
  - Large (at least 3 pixels)

Criteria from Karpouzli and Malthus(2003) & Smith and Milton (1999)

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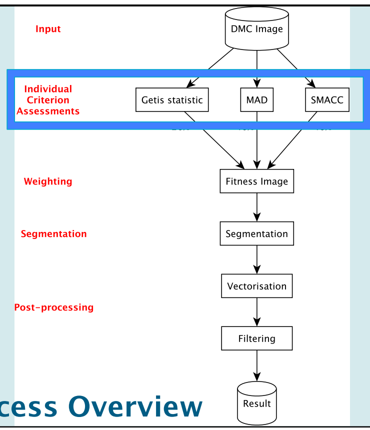

Process Overview

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Criterion: Spatial Uniformity

- Assessed using **Getis statistic**
- Shown to be more sensitive to small-scale local variation than other measures (Bannari et al., 2003)
- Calculated for each pixel by looking at variation in a 3x3 window around the pixel

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Getis image

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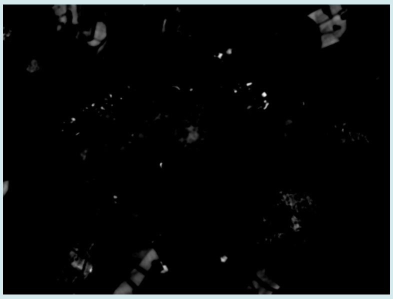
Getis image (best 5%)



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Criterion: Wide reflectance range

- Pixels which are **close to endmembers** are, by definition, near the edge of the pixel cloud
- Therefore they are some of the brightest and darkest pixels in each band
- Endmembers extracted using the SMACC algorithm (Gruninger, 2004) and maximum endmember abundance for each pixel selected

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SMACC image

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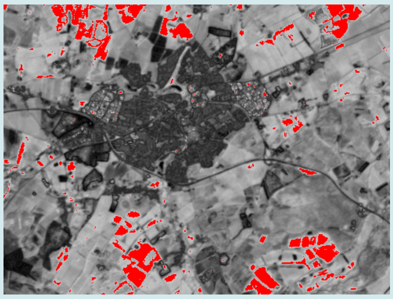
SMACC image (top 5%)



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Criterion: Stable over time

- Assessed using Multivariate Alteration Detection (MAD; Nielsen, 1998; 2005)
- Can be statistically processed to produce a **No Change Probability (NCP)** image
- Invariant to affine transformations – so can be used before atmospheric correction

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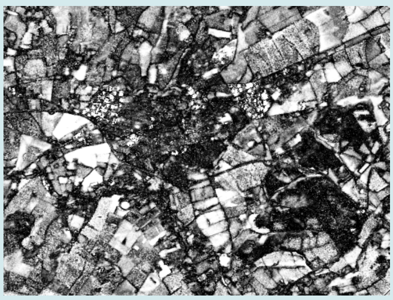
NCP image



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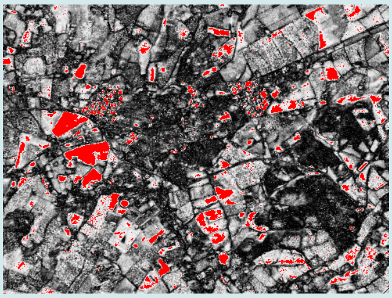
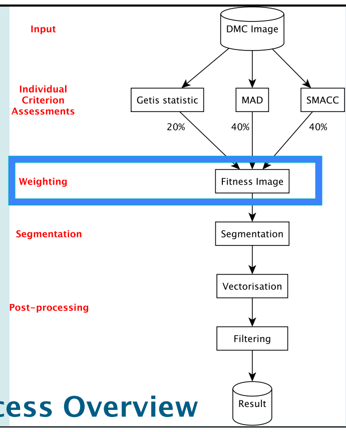
NCP image (top 5%)



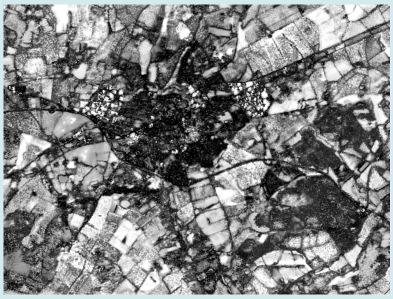


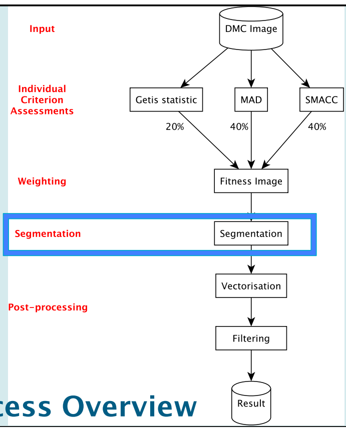
Process Overview

Fitness Image Calculation

- Each criterion can be independently weighted
- For example:
  - Temporal stability: 40%
  - Spatial uniformity: 40%
  - Spectral purity: 20%
- Resulting image stores the 'quality' of each pixel

Fitness Image





Process Overview

Segmentation/Classification

1st rule of segmentation:

~~**All pixel… in … only one, segment**~~

Segment and classify at the same time

Only create segments for possible calibration targets

Region Growing Segmentation

1. Start with a seed
   – The best pixel in the fitness image
2. Add surrounding pixels to the region **IF** they are spectrally similar and greater than a minimum fitness level
3. Repeat until the seed fitness is less than a threshold

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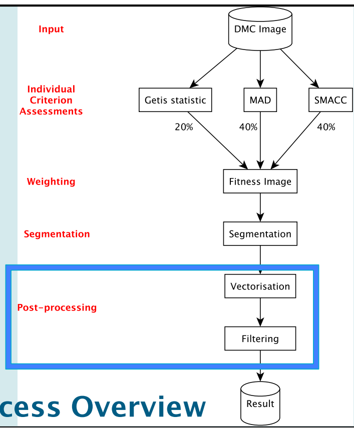

Process Overview

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Vectorising & Filtering

- Convert region pixels to ROIs
- Assess group attributes:
  – **Flatness:** Is StDev of elevation low?
  – **Size:** Is region < 3 pixels?

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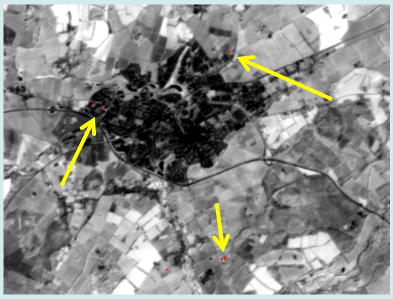
Results



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Conclusion

- DMC has the potential to provide a **UK-wide Environmental Change Observatory**.
- Procedure described has identified for the first time those **objects in the English landscape that are invariant** in the domain of DMC.
- Methods have wider application: **'fitness image' segmentation** & **statistical methods** to assess invariance
- Caveat : the risk of equifinality.

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Further Work

Environmental Change Observatory

- Use of invariant ground targets to improve DMC products
- Detailed study of candidate sites
- Automated ground measurement systems at these sites?

Object-Based Image Analysis (OBIA)

- Application of 'fitness-image' approach to other problems – end-user application?
- Extension of statistical approach
- Reproducible research in OBIA

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References

- Bannari, A., Omari, K., Teillet, P. & Fedosejevs, G., 2005, 'Potential of Getis statistics to characterize the radiometric uniformity image 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.
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