**Automated identification of invariant ground targets**
- towards a UK Environmental Change Space Observatory (UK-ECSO)

Robin Wilson¹, Ted Milton¹ and Steve Mackin²
r.t.wilson@soton.ac.uk

¹ Geography & Environment, University of Southampton
² DMCii

---

**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

---

**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

---

**Solution?**

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

---

**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

---

**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)
Site Selection Criteria

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


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
**Getis image (best 5%)**

**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

**SMACC image**

**SMACC image (top 5%)**

**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

**NCP image**
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

Segmentation/Classification

1st rule of segmentation:

All pixels must be in one, and 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

Vectorising & Filtering

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

Process Overview

Results

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.

Further Work

- 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
References


• Nielsen, A.A., Conradsen, K. and Simpson, J.J., 1998, Multivariate alteration detection (MAD) and NMF postprocessing in multispectral, bitemporal image data: new approaches to change detection studies, Remote Sensing of Environment, 64 (1), 1-19