Using ASAR & ERS-2 to Detect a Moorland Fire Scar in the Peak District National Park

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Introduction

Aim
To explore whether Synthetic Aperture Radar (SAR) intensity and coherence images can be used to detect a fire scar in a degraded UK peat moorland environment.

Objectives
- Determine the ability of a time series of SAR (ENVISAT ASAR and ERS-2) intensity and coherence images to detect a fire scar.
- Improve understanding of how scene variables (soil moisture, vegetation, fire behaviour) affect the SAR fire scar signal.
- Investigate the effect of filtering during pre-processing.

Why is Moorland Fire Scar Monitoring Needed?
- Wildfires which burn into blanket peat contribute to climate change by releasing carbon dioxide into the atmosphere. Can permanently damage protected wildlife habitats and discolour drinking water supplies.
- Fire ground location on UK moorlands is poorly recorded. PDNP is unusual in having a fire log (1967 - present) (Fig 1).
- GPS mapping of fire scars is rare because it is costly and operationally difficult, especially on remote moorlands.

Methods are needed to record fire scars, and allow calculation of burnt area and GIS analysis.
- Important for fire responders e.g. PDNP Fire Operations Group (FOG); moorland restoration groups e.g. Moors for the Future (MFF); other land managers (water companies, the National Trust and gamekeepers).

Study Area
Bleaklow moor, area of blanket peat in the Peak District National Park (PDNP) UK.

Why Use Radar Images?
- Landat and other optical images detect fire scars but use in the UK is limited by frequent cloud cover.
- SAR can image through cloud and at night.
- SAR successfully used to detect fire scars because image brightness (intensity) relates to surface roughness, terrain and soil/fuel moisture properties which are changed by burning (Bourgeau-Chavez et al., 1997).

Methodology

SAR Pre-processing
- All pre-processing was done in SARscape 4.2. The processing chain for producing the intensity images is shown in Fig 2. Intensity values were calculated in ENVI 4.7.
- Frost, Lee and Degrandi filtering methods have been used during pre-processing to reduce speckle (noise) (Fig 3).
- Frost filter (Fig 3a & 3b) and Lee filter (Fig 3b & 3e) outputs are similar. Fire scar is high intensity (bright) on both, but could be confused with topographic effects.
- Multitemporal Degrandi filter smoothed speckle more effectively and was preferred.

Coherence:
- Coherence image measures the degree of correlation between two SAR images, acquired at different times. Produced during interferometric SAR (InSAR) pre-processing, using the phase portion of the radar signal. Measured on a scale of 0 - 1 (Rykhlevs and Lu, 2000).

Coherence:
- 0 = No coherence (no correlation, temporal decorrelation, significant change on the ground)
- 1 = High coherence (temporal correlation, no change on a fire scar in a peat moorland environment)
- A peak in intensity occurs on 03/04/03 (JD 93) (Fig 4d) following 15.2mm of rainfall on JD 91 (Fig 5).
- Post-fire period was wet (Fig 6). Peak rainfall of 20.6mm occurred 3 days before 24/03/03 image. JD 44 (Fig 4e).
- Intensity values post-fire (Fig 4e) and (f) increased significantly following rainfall events.

Therefore, amount and timing of rainfall is an important variable affecting detectability of the fire scar in a moorland environment. Bourgeau-Chavez et al. (1997) also found intensity increased after rainfall events just prior to image acquisition.

Conclusion & Future Work

A large fire scar in a degraded moorland environment can be detected using SAR intensity and coherence.

The occurrence of rainfall is a critical environmental variable affecting the radar intensity signal.

Investigate the effect of filtering during pre-processing.
- Further investigation is required for fire scars of different sizes, on different land cover types, and critically, with different preceding and post-fire rainfall patterns.

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References


Satellite Imagery

Despeckling steps: 1) Frost; 2) Lee; 3) Multitemporal Degrandi (no speckle).

Fire occurred on 03/04/03 (JD 93) following 15.2mm of rainfall on JD 91.

Figure 1: Pre-processing steps in SARscape 4.2 to produce the intensity images appropriate for fire detection (Kitmitto et al., 2011).

Figure 3(a-f) – Comparison of filtering methods for ERS-2 (a for reflecting fire line free) and ERS-2 (b) for reflecting fire line free (Fig 3f).

Figure 2 – InSAR processing steps in SARscape 4.2 to produce low coherence image adapted from (Kitmitto et al., 2011).

Figure 3. (a-f) – Comparison of filtering methods for ERS-2 (a for reflecting fire line free) and ERS-2 (b) for reflecting fire line free (Fig 3f).

Figure 4(a-f) – Time series of SAR intensity images of Bleaklow fire occurred on 08 April 2003 (top row) and 28 April 2003 (bottom row). Bottom row, post-fire. It is possible that the difference between scenes may affect intensity.

Figure 4 – Time-series of SAR intensity images of Bleaklow fire occurred on 08 April 2003 (top row) and 28 April 2003 (bottom row). Bottom row, post-fire. It is possible that the difference between scenes may affect intensity.

Figure 5 – Average intensity values (dB) inside and outside the Bleaklow fire scar date 04/03/03.

Figure 5 – Figure 7(b) – Pair 2, pre- and immediately post-fire, Frost (a, d), Lee (b, e), multitemporal Degrandi (c, f) outputs.

Figure 6 – Figure 7(d), six and ten days post-fire, shows overall increase in coherence for all classes. Figures 7(a-c) shows peak coherence between intact and exposed peat, so need to try other classes.