What are the Benefits and Challenges of Using SAR Data to Detect and Monitor Wildfire Burn Scars in Peat Moorlands?
Overview

• What is SAR and why use it for burn scar detection?
• How is SAR used for burn scar detection?
• What are the results?
  – Benefits
  – Challenges
• So how could these findings be applied?
• Where next …..
What is the challenge?

Issues Caused by UK Wildfires in peat moorlands

- Moorland wildfires release CO₂ into the atmosphere
- Burn into the seed bank preventing vegetation recovery
- Erosion of burned areas cause discolouration of the drinking water supply increasing DOC and POC levels
- Destroy habitats of rare ground nesting birds

“The likelihood of wildfires occurring may increase between 10% and 50% by the 2080s with projected warmer, drier spring and summer conditions”
DEFRA Climate Change Risk Assessment 2012.
Requirement

• A technique to systematically monitor burn scars in peat moorland ecosystems
  • Inform land management
  • Monitor progress of peat moorland restoration projects
  • Better understand fire history and upland wildfire regimes
• Earth observation methods can:
  • Provide land cover change information at the landscape level
  • Reduce costly field surveys to GPS map burn scar perimeters
Limitations of current EO systems...

1. Why SAR?
2. How it is used?
3. Findings
4. Relevance
5. Next steps
Limitations of current EO systems

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Why SAR?

- See through clouds and smoke
- Active sensor: acquire images day and night
- Provides regular image updates (at least monthly)
- SAR very sensitive to moisture content ideal for mapping burn scars after wildfire events

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Source: Adapted from Landmap Radar Imaging Course [http://landmap.ac.uk]
How is SAR used?

SAR intensity signal

- At least monthly image updates of the peat moorland - Peak District National Park (PDNP)
- Relate SAR intensity inside the burned area with the baseline land cover signal outside the burned area
- Explore the response of SAR for different frequencies
- Identify optimal images showing differences spatially and temporally to create colour composites & burned area maps

Source: Adapted from Landmap Radar Imaging Course http://landmap.ac.uk
Findings – Bleaklow 2003

Bleaklow Burn Scar 2003 SAR C-band Intensity Timeseries

Pre-fire

Post-fire

Vegetation removal: increase surface roughness

Topographic features

Previous degraded moorland

Rainfall: increase surface wetness

Clear burn scar signal due to exposed peat and rainfall

Findings: Bleaklow 2003

Bleaklow Burn Scar Intensity Response 10/10/02 - 30/10/03

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Findings: Edale 2008

C-band Intensity response:
- Edale burn scar is brighter compared to the surrounding moorland for ERS-2 images, i.e. fire increases SAR intensity
- Confirms results for Bleaklow 2003 7km² burn scar (Millin-Chalabi et al., 2014)

Environmental variables:
- Importance of precipitation and preceding land cover class (peat bog)

Edale Burn Scar 2008
SAR Intensity Time series
Burned area = 0.10 km²
1) **Precipitation** post-fire enhances the burn scar signal especially for bare peat areas.

2) **Topography** does effect SAR intensity with flatter slopes producing a stronger return than steeper slopes facing away from the sensor.

3) **Fire size**
   - Small burn scars (0.20 km²) located on slopes were not detectable with SAR.
   - The Edale burn scar (0.10 km²) located on a plateau was detectable with C-band SAR over 1 year after the wildfire.
   - Large burn scars (>6 km²) such as Bleaklow and Dovestones detectable and persist for greater than 6 months post-fire.

4) **Land cover classes:** the majority of classes were significantly different between burned and unburned areas making burn scars at Bleaklow and Dovestones detectable.
Relevance: Challenges of Using SAR

- Unable to detect burned areas on slopes facing away from the radar beam.
- Strength of burned area detection is dependent on weather conditions with wetter conditions improving detectability when using SAR intensity.
- Cannot detect burned areas in peat moorlands using the longer wavelength L-band data.
- SAR intensity and InSAR coherence (degree of difference between two images) can provide a merged burned area signal with previously degraded peat moorland.
Relevance: Benefits of Using SAR

- Provides not just the location but the area burnt
- SAR provides at least monthly images for burned area detection and monitoring. This is set to improve with the new European Space Agency (ESA) Sentinel-1A and Sentinel-1B satellites
- New Sentinel-1A C-band data free to access so no data costs, potentially cheaper than GPS
- Could monitor the progress of peat moorland restoration work
- Provide landscape scale monitoring of peat moorlands
- Coherence highlights structural changes in the vegetation canopy
- Generate new burned area maps using a combination of the coherence and intensity signal
Relevance: New Product Creation

1. False Colour Composites

2. Burned Area Mapping

Legend

- Burn scar perimeters

False colour composite

RGB

- Red: Coherence - 19/04/03 and 24/05/03
- Green: Mean intensity - 24/05/03 and 08/02/03
- Blue: Intensity difference - 24/05/03 and 08/02/03

Recommendations

• Use C-band SAR data for burn scar detection in degraded UK peat moorlands e.g. ERS-2, ASAR, RADARSAT etc.

• Shorter C-band data of 5.7cm are more sensitive to vegetation removal and wetness than longer L-band data (23.5cm) when tested with ERS-2 & ALOS PALSAR data.

• Obtain an InSAR coherence pair as soon after the wildfire as possible to obtain coherent areas within the burn scar. Then use this signal when producing colour composites to distinguish areas where vegetation has been removed due to the fire.

• Always consider preceding weather conditions before acquiring SAR scenes.
1) Further SAR Parameter Investigation
   • Assess C-band Sentinel-1A SAR intensity and InSAR coherence data for recent burn scars
   • Assess X-band COSMO-Skymed SAR intensity and InSAR coherence data for recent burn scars
   • Explore optical and radar data fusion methods using new Sentinel-1A and Sentinel-2B datasets

2) Transferability Analysis – other areas of the UK
   • Apply SAR intensity and InSAR coherence techniques to the detection of *heathland* burn scars and for *upland moorland* areas which are less degraded than the PDNP
Next steps….

3) Obtain funding to create a UK Wildfires Geoportal
   • Deliver products created from SAR on the web. Case studies needed. Please get in touch if this is of interest!
Detecting a moorland wildfire scar in the Peak District, UK, using synthetic aperture radar from ERS-2 and Envisat ASAR

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Wildfires occur annually in UK moorland environments, especially in drought years. They can be severely damaging to the ecosystem when they burn deep into the peat, killing ground-nesting birds and releasing CO\textsubscript{2} into the atmosphere. Synthetic aperture radar (SAR) was evaluated for detecting the 18 April 2003 Bleaklow wildfire scar (7.4 km\textsuperscript{2}). SAR’s ability to penetrate cloud is advantageous in this inherently overcast area. SAR can provide fire scar boundary information which is otherwise labour intensive to collect in the field using a global positioning system (GPS). This article evaluates the potential of SAR intensity and InSAR coherence to detect a large peat moorland wildfire scar in the Peak District of northern England. A time-series of pre-fire and post-fire ERS-2 and advanced synthetic aperture radar (ASAR) Single Look Complex (SLC) data were pre-processed using SARScape 4.2 to produce georeferenced greyscale images. SAR intensity and InSAR coherence values were analysed against
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Datasets
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• MIDAS precipitation data
• Fire log, burn scar GPS data and pre-fire aerial photography
• ERS-2, ASAR & ALOS PALSAR data as part of Category 1 Project 2999 PI Dr. Kamie Kitmitto
Thanks for Listening
Any Questions?

Interested in a UK Wildfires Geoportal?
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