Detecting an area affected by forest fires using ALOS PALSAR

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Objectives
Objectives

- To find a specific polarization in L-band SAR best suited for detecting fire scars

- To assess the availability of the fine beam dual polarization mode (FBD) or polarimetric mode (PLR) of ALOS PALSAR for forest fires.
Study Areas and PALSAR Datasets
## Study Areas and PALSAR Datasets (1)

<table>
<thead>
<tr>
<th>Location</th>
<th>Evia Island, Greece</th>
<th>California, USA (Buckweed Fire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Event</td>
<td>2007.8.24</td>
<td>2007.10.25</td>
</tr>
<tr>
<td>PALSAR Data (before the fire)</td>
<td>2007.7.17 (FBD)</td>
<td>2006.9.8 (PLR)</td>
</tr>
<tr>
<td>PALSAR Data (after the fire)</td>
<td>2007.9.1 (FBD)</td>
<td>2007.10.27 (PLR)</td>
</tr>
<tr>
<td>Off-nadir Angle, Ascend./ Descend.</td>
<td>34.3A</td>
<td>21.5A</td>
</tr>
<tr>
<td>RSP Path No.</td>
<td>620</td>
<td>212</td>
</tr>
</tbody>
</table>
## Study Areas and PALSAR Datasets (2)

<table>
<thead>
<tr>
<th>Location</th>
<th>(1) Victoria, Australia (East Region)</th>
<th>(2) Victoria, Australia (Central Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Event</td>
<td>2009.2.7</td>
<td>2009.2.7</td>
</tr>
<tr>
<td>PALSAR Data (before the fire)</td>
<td>2008.5.31 (FBD)</td>
<td>2008.10.21 (FBD)</td>
</tr>
<tr>
<td>PALSAR Data (after the fire)</td>
<td>2009.3.3 (FBD)</td>
<td>2009.3.8 (FBD)</td>
</tr>
<tr>
<td>Off-nadir Angle, Ascend./ Descend.</td>
<td>34.3A</td>
<td>34.3A</td>
</tr>
<tr>
<td>RSP Path No.</td>
<td>379</td>
<td>382</td>
</tr>
</tbody>
</table>
Analysis Methods
Analysis Methods

• **Generate color composite image before and after fires**
  - To check visually whether some changes are detected or not

• **Calculate differences of backscatter coefficients between before and after fires**
  - Input data: geo-coded images (not ortho-rectified)
  - Calculation of the backscatter coefficients ($\sigma^0$) from the amplitude images (DN) before and after fires
    \[ \sigma^0 = 10 \cdot \log_{10} <\text{DN}^2> + \text{CF} \text{ (dB)}, \text{CF} = -83.0 \]
  - Change detection from the difference of backscatter coefficients
    \[ \Delta = \sigma^0_a - \sigma^0_b \text{ (dB)} \]
    $\sigma^0_a$: $\sigma^0$ after a fire, $\sigma^0_b$: $\sigma^0$ before a fire, $\Delta$: difference of backscatters

• **Compare PALSAR images with the image of AVNIR-2 or MODIS**
  - To confirm if the changes of PALSAR images are burnt areas or not
Results

Evia Island, Greece (Aug. 24, 2007)
Evia Island, Greece (2007) (1)

Color Composite Images (R: July 17, 2007 - G&B: September 1, 2007)

Areas in the yellow circles in the image of HV polarization are more reddish than in HH polarization
Evia Island, Greece (2007) (2)

Difference Images between July 17, 2007 and September 1, 2007

Dark areas in the yellow circles correspond to the red areas in RGB images. The areas of HV polarization are darker than that of HH polarization.

Volume scattering decreased after the fires.
In the AVNIR-2 image, vegetation was lost in the same areas as the changed areas in the PALSAR image.
Evia Island, Greece (2007) (4)

- Comparison of the backscatter coefficients before and after fires

No.1-7: Burnt areas
No.8-14: Un-burnt areas

Differences of HV polarization are larger than those of HH polarization in the changed areas.
Results

California, USA (Oct. 25, 2007)
The multi-temporal AVNIR-2 images show that change in this area is not the burned scar caused by the fire on Oct. 25, 2007.

HV polarization was more effective to detect fire scars than HH and VV polarization.
Buckweed, California (2007) (2)

Difference Images between September 8, 2006 and October 27, 2007

Dark areas in the yellow circles correspond to the red areas in RGB images

Volume scattering decreased after the fires
Buckweed, California (2007) (3)

No changes were detected. This area may be far slope from the antenna.
Buckweed, California (2007) (4)

- Comparison of the backscatter coefficients before and after fires

In the burnt areas, differences of HV polarization are larger than those of HH and VV polarizations.

No.1-5: Burnt areas
No.6-9: Un-burnt areas
Results

East Region of Victoria, Australia
(Febr. 7, 2009)
Forest region changed similarly in the images of both HH and HV polarizations.
East Region of Victoria, Australia (2009) (2)

Difference Images between May 31, 2008 and March 3, 2009

HH Pol.  HV Pol.

0  50  100 [km]
Region A is distinguished a little in the PALSAR difference image.
Region B is not distinguished clearly in both PALSAR images.
East Region of Victoria, Australia (2009) (4)

- Comparison of the backscatter coefficients before and after fires

No.1-2: Burnt areas
No.3-7: Un-burnt areas

In the burnt areas, differences of both HH and HV polarizations are similar.
Multi-temporal Variation of Backscatter Coefficients on Burnt / Un-burnt Areas using four data between Aug. 29, 2007 and Mar. 3, 2009

- Backscatter coefficients of Aug. 29, 2007 and May 31, 2008 show a slight difference
- Backscatter coefficients of Aug. 31, 2008 are higher than former two observation dates
- Backscatter coefficients of March 3, 2009 are lower than others

⇒ Seasonal variation? They have to be assessed further.
Results

Central Region of Victoria, Australia
(Febr. 7, 2009)
In the image of HV polarization, region A, B and C changed in the forest regions, but in the image of HH polarization, most of the forest regions (and farmlands) changed.
Central Region of Victoria, Australia (2009) (2)

Difference Images between October 21, 2008 and March 8, 2009
The regions A and B in PALSAR image are similar to the burnt areas in the MODIS image. The region C can not be seen in MODIS image because of cloud cover, however can be seen in PALSAR image.
Comparison of the backscatter coefficients before and after fires

- Mean = -0.66
  SD = 0.90

- Mean = -1.93
  SD = 0.64

- Mean = -0.25
  SD = 0.70

- Mean = -0.53
  SD = 0.88

In the burnt areas, differences of HV polarization are larger than those of HH polarization.

Central Region of Victoria, Australia (2009) (4)

No.1-5: Burnt areas
No.6-10: Un-burnt areas
Summary

• From the results of the analyses in the Greek, Californian and Australian forest fires, fire scars are detected clearly by using HV polarization.
  – HV polarization is more sensitive to detect fire scars than HH and VV polarizations.

• In the east region of Victoria, a fire scar is detected in HV polarization, but other un-burnt mountain areas also changed in both HH and HV polarizations.
  – It may be caused by seasonal dependency of backscatter variations, but it has to be investigated further.

• In some cases, it is difficult to detect fire scars or to identify cause of changes, dependent on the topography and land use. Ex. far-slope areas of mountainous region and farmland.
  – Future Work: The data of other forest fires have to be analyzed to increase the case studies of PALSAR data, to clarify issues and to confirm the further availability of cross-polarization data of PALSAR.