BACKSCATTER PROPERTIES OF MULTITEMPORAL TERRASAR-X DATA AND THE EFFECTS OF INFLUENCING FACTORS ON BURN SEVERITY EVALUATION, IN A MEDITTERANEAN PINE FOREST

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1. INTRODUCTION

Forest fire is a major ecological process that has a profound influence on the natural cycle of vegetation succession and ecosystem dynamics. The high number of forest fires occurring every year constitutes one of the major degradation factors of Mediterranean ecosystems.

The main goal of the study was to evaluate the temporal stability of backscatter response over a burned area for short-term severity assessment. In addition, analysis of the main factors influencing the retrieval of burn severity levels from high spatial resolution SAR data was carried out. Looking geometry, weather conditions and speckle reduction methods were assessed for their influence on backscatter/burn severity association strength.

2. METHODS

The dataset consisted of seven TerraSAR-X (TSX) and one pair of Landsat 5 Thematic Mapper (TM) images. Dual polarization TSX data were acquired between November 2008 and March 2009 in Stripmap (SM) mode at look angles of 25° and 40°.

Backscatter temporal trends and weather and viewing geometry effects on backscatter coefficient were analyzed using descriptive statistics. To evaluate the performance of speckle suppression methods on burn severity retrieval regression analysis was employed. Determination coefficients (R^2) were used to relate SAR data to optical sensor based estimates (dNBR) of burn severity. The effect of speckle reduction techniques (i.e. multi-look factors, temporal filtering, and plot size) on burn severity estimates were assessed using pseudo-plots formed of 10, 25 and 50 pixels for data geocoded to 10 m pixel spacing and of 4, 9 and 16 pixels for data geocoded to 25 m pixel spacing.

3. RESULTS AND DISCUSSIONS

A. Temporal backscatter properties, weather and viewing geometry effects

Temporal backscatter variation at HH and HV polarizations is presented for the images acquired at 40° look angle. The backscatter coefficient varies within 1-2 dB, values spread increasing from unburned to high burn severity levels at both polarizations. For unburned areas the backscatter is rather constant, variations of backscatter coefficient being within the absolute radiometric accuracy (~0.6 dB). At lower local incidence angles values spread increases slightly while at higher local incidence angles the maximum spread registers a certain decrease when compared to flat or near flat areas (i.e. 35-45° local incidence angle).

Light precipitations up to one day before acquisition do not seem to have large impact on backscattered energy, the average backscatter levels of the 20090121 dataset being similar to those of datasets acquired under dry conditions. However, heavy rainfall or vegetation surface moisture at the acquisition time of 20090306 and 20090212 datasets resulted in higher average backscatter coefficients at both polarizations and all burn severities especially on sensor oriented slopes.

The effect of looking geometry on backscatter coefficient of burned areas is illustrated by two datasets acquired only 4 days apart at 40° and 25 ° look angles. At HH polarization 2 dB higher values were registered for all severity levels in the image acquired at 25° due to the additional energy backscattered at steeper incidence angles and the lower attenuation of the forest canopy. At HV polarization the differences were much smaller especially for unburned areas. However, with increasing severity a small increase (~ 0.5 dB) in the averages of backscattered energy was also observed especially at higher severity levels where forest floor is more exposed.

B. Speckle suppression

Reduction of speckle can be achieved by averaging a sufficient number of independent samples with the loss of spatial resolution or combining several images within multitemporal filtering (MTF) and thus preserving spatial resolution. In this work the two methods were combined.

The relatively small temporal variation of backscatter coefficients at HH and HV polarization resulted in similar determination coefficients. No evident differences were noted for data acquired at steeper look angle (20081224) or for data acquired after light rainfall (20090121 and 20090212 datasets). However, for the image acquired after heavy rain (20090306 dataset) decrease of the determination coefficients is evident at higher local incidence angles.

Determination coefficients increased significantly with the number of pixels/pseudo-plot. Nevertheless, the real difference could be somewhat lower since for 25 and 50 pixels/pseudo-plot fewer samples were available at intermediate severity levels, model over fitting being likely. When strong multi-looking factors are applied additional processing using MTF improves little the retrieval of burn severity, very small differences of not filtered data compared to MTF data being observed. If higher spatial resolution is required the use of MTF greatly improves the performance of burn severity retrieval, higher R^2s (up to 0.2) for temporal filtered images (ENL 25 and 32) compared to the not filtered dataset (ENL9). Nevertheless, it appears that doubling the number of images used for temporal filtering (from 3 to 6) does not improve significantly burn severity retrieval.

V. CONCLUSIONS

For unburned areas average backscatter coefficient registered temporal differences within the radiometric accuracy limits over the forested areas. With increasing burn severity temporal variation increases reaching up to 2dB for highly burned areas on slopes oriented towards sensor. Light rain prior to acquisition does not seem to influence significantly the signal, average backscatter values and determination coefficients differences being rather small for rain vs. no rain datasets. However, after heavy rainfall or when vegetation presented surface moisture average backscatter levels increased with around 0.5 while a significant decrease of the determination coefficients was noted especially at higher local incidence angles. The look angle had a large influence on backscatter levels especially at HH polarization where difference up to 2.5 db have being found for 25° dataset with respect to data acquired at 40°. The backscatter shift did not diminish the association strength between backscatter coefficient and burn severity. Finally, speckle suppression was necessary if high spatial resolution estimates of burn severity are needed. Multitemporal filtering provided good results of speckle suppression, association strength between backscatter coefficient and burn severity increasing with the increase of ENL.