Step 1 and 2: Process MODIS images, crop and mask, select cloud free days. In these two steps R code was written to read each MODIS geotiff and crop and mask to each county keeping only the clearest days for further analysis. It was observed that in general an image with clouds contains higher reflectance values, and a larger standard deviation of reflectance values over a county so those days were excluded from further analysis in R using a very simple algorithm. Additional cloud analysis using a better algorithm, including cloud shadow masking, could be performed but the authors instead focused on trying to develop the burn scar analysis code. At some point further cloud analysis may be warranted as many days in the spring period are partially cloudy but these additional days may provide additional temporal resolution of when burns occur.

Step 3: Evaluate burn scars, estimate the burn area. Step 3 was the main focus of the initial study with the goal of creating an inexpensive easy to use tool that could automate the process of calculating burned area during the burning season using only the MODIS surface reflectance bands. Because the authors were new to both processing Raster data in R and remote sensing analysis in general much time was spent on learning the basic steps of manipulation of the data within R and graphical analysis and output. At the time of this conference (April 2015) the best estimating solution found was to use a k-means clustering technique to identify the burn scars using common burn indices. Because each day of MODIS data has a different spectral range varying by county throughout the growing season the automation of the analysis was challenging and no single approach tried worked across all counties across multiple years. However, because of the scripting ability in R it was possible to loop through various techniques and visualize the output of each. From this visualization it was clear which technique worked best on any given day and the user could then use that answer. The authors believe additional refinement of the methods could improve the tool and estimation accuracy.

The current solution calculates three indices, NDVI, GEMI, BAI (Mohler, 2011) and uses those indices along with the raw wave lengths from the Red and NIR MODIS bands to calculate k-means clusters for each day. The clusters identify like areas, such as recent burn scars, and the software provides a visual estimate of the burns identified along with a calculated area burned.

Results

Step 4: Mask areas that likely did not burn. For this step we used the 2011 National Land Cover Database available at a 30m resolution and excluded land cover types not likely to burn in a prescribed burning scenario. The NLCD dataset has 22 classifications. Of these 20 classifications two were retained for our study, the grassland/herbaceous and pasture/shrub classifications. Other classifications such as water, developed areas, etc. were excluded.

Step 5: Evaluate area burned estimate from R approach with KDHE estimate. In this final step we compare the answer from R after resampling and masking to the higher resolution NLCD data set. Overall the magnitude and spatial burn scar area identified between the two approaches are similar, generally less than a 20% area difference on any given day. Using the higher resolution mask removes some areas, such as roadways, that are not excluded in the KDHE estimate that uses a 250 meter resolution.

Conclusions

The freely available R statistical package is a tool that can be used to identify burn scars in the Flint Hills of Kansas and Oklahoma. The available R libraries contain all the tools needed to manipulate MODIS raster datasets and tools are available to do various statistics on the raster data including k-means clustering. Because of the ease in which R can be scripted the approach outlined in this poster could be applied to analyze multiple years and counties of burns. While the R statistical software does not contain all the features of commercial GIS packages, it is able to adequately estimate burn scars using unsupervised classification techniques giving results similar to other estimation techniques.

Future Work

Future work will include refining the R approach to better identify burn scars, including the potential of using other types of cluster approaches (neural net, random forest, etc.), and the investigation of additional remote sensing data including using additional MODIS bands. Ground Truth of this R approach is also needed and has not yet been performed other than comparing R results with the KDHE estimates.

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References
