**NASA DEVELOP National Program**



NASA John C. Stennis Space Center

*Summer 2015*

Southern California Disasters II

Assessing the Effectiveness of Simulated HyspIRI Data for Use in USDA Forest Service Post-Fire Vegetation Assessment and Decision Support

 **Technical Report**

Rough Draft – June 25, 2015

Heather Nicholson (Project Lead)

Amber Todoroff

Madeline LeBoeuf

Joseph Spruce, Senior Scientist and Lead Science Advisor at NASA SCC, (Science Advisor)

James “Doc” Smoot, Senior Scientist and Assistant Science Advisor at NASA SCC, (Science Advisor)

Dr. Kenton Ross, DEVELOP National Science Advisor, LaRC (Science Advisor)

Previous Contributors:

Timothy Sutherlin

Eric Mack

Caitlin Ruby

Luke Wylie

# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

HyspIRI, NBR, AVRIS, MASTER, Hyperspectral, Burn Detection, (Name of program used for quantitative comparison), (type of quantitative comparison)

# II. Introduction

*Background Information*

According to Swain, et al., the 2013 - 2014 California drought was the most severe in history. The record low levels of precipitation led to a drought in 2014 (Swain, et al. 2014). This drought, as well as other factors such as a warmer than average temperature and human interference, caused an increase in wildfires in California (Faivre, et al. 2014; AghaKouchak, et al. 2014). In 2014 alone, approximately 5,500 wildfires burned around 90,000 acres. The previous five year average was only around 4,500 fires. (Cal Fire 2014). The increase in wildfires is a concern because of the effects that wildfires can have on their surrounding locations. Known effects of fires include erosion of soil, which can lead to flooding, loss of life and personal property, and invasion of non-native plant species (Hebel, Smith and Cromack Jr. 2009; Parsons 2003).

The USDA Forest Service (USFS) currently uses the Burned Area Emergency Response (BAER) and the Rapid Assessment of Vegetation Condition (RAVG) programs to quickly map and characterize vegetation and soil impacts due to major wildfires; these programs employ multiple burn indices to create post-fire change and burn severity products (USDA Forest Service 1999; van Wagtendonk, Root and Key 2004). Some of the most standard indices being used are the Normalized Burn Ratio (NBR), Differenced Normalized Burn Ratio (dNBR), Relative Differenced Normalized Burn Ratio (RdNBR). Currently these programs are using multispectral sensors onboard different Landsat platforms. Recent studies suggest that Landsat-derived burn severity products overvalue the cover of burned areas and undervalue the cover of unburned areas because of Landsat’s coarse spectral resolution (Kokaly, et al. 2007).

When launched, the HyspIRI satellite will include two instruments: an imaging spectrometer measuring the visible to short wave infrared (VSWIR: 380 nm – 2500 nm) in 10 nm contiguous bands and a multispectral imager measuring from 3 to 12 μm in the mid and thermal infrared (TIR) (Jet Propulsion Laboratory 2014). Not only will HyspIRI be spectrally superior to Landsat, but recent announcements suggest that HyspIRI’s VSWIR will have a 30m spatial resolution and a 16 day revisit time, which is comparable to Landsat (Green, Hook and Middleton 2014). HyspIRI TIR sensing capabilities will have a 60m spatial resolution with a 5 day revisit time. In order to assess the capability of HyspIRI data, airborne campaigns were conducted in 2013, 2014, and continuing into 2015. Simulated HyspIRI data were collected during said flights using data from co-flown AVIRIS and MASTER data on a NASA ER-2 aircraft (Jet Propulsion Laboratory 2014). Comprehending the possibilities of HyspIRI’s fine spectral resolution is crucial in explaining burn severities and patterns in such detail that is not available with Landsat-based ratios.

Part one of this project was conducted in the summer of 2014 and focused on qualitatively compared indices such as the Relative difference Normalized Burn Ratio, Soil Adjusted Vegetation Index, and Normalized Difference Shortwave Infrared Formula between Landsat and HyspIRI. Indices that utilized HyspIRI’s finer spectral resolution were also computed to see the feasibility of single date burn severity detection. The goals of this term expanded on the previous term by using similar methodology and quantitatively comparing the HyspIRI produced products to those produced by the Forest Service using Landsat.

*Project Objectives*

The goals of this research project were to utilize and assess simulated HyspIRI data as a means to produce wildfire burn severity and vegetation monitoring products, such as dNBR and RdNBR that are valuable for supporting wildfire mitigation and wild land restoration. These products were quantitatively compared to Landsat-based products from the USDA Forest Service in order to determine how HyspIRI can be used to improve on current monitoring capabilities and decision making.

*Study Area*

The study areas include three southern California fires: the Aspen Fire, the French Fire, and the King Fire. Collectively, the fire damage from all three fires covers approximately 134,354 acres.

*Study Period*

The Aspen fire was discovered on July 22, 2013 and was considered contained and controlled by August 11, 2013. The French fire was discovered on July 28, 2014 and was considered contained by September 3, 2013. The King fire was discovered on September 13, 2014 and was considered contained around October 9, 2014.

*National Application(s) Addressed*

This project focused on the Disasters application area, whose goals include utilizing NASA Earth Observations in order to better predict and recover from natural disasters. This project furthered the Disasters application area by providing new geospatial methods to detect fire burn severity to different fire response agencies located within the U.S. forest service.

*Project Partners*

The end-users were the USDA Forest Service Remote Sensing Applications Center (RSAC) and the USDA Forest Service Eastern Forest Environmental Threat Assessment Center (EFETAC). Currently, RSAC and EFETAC use multi-spectral imagery, such as Landsat, to create data products for post-fire decision support. The results from this project assisted in determining the practicality of utilizing future HyspIRI data for Forest Service post-fire decision support. Partner and boundary organizations included the USDA Forest Service Rocky Mountain Research Station and the HyspIRI Science Team at the Jet Propulsion Laboratory.

# III: Methodology

*Data Acquisition*

Simulated HyspIRI data was collected for the Aspen (2013), French (2014), and King (2014) fires, from the NASA Jet Propulsion Laboratory Master and AVIRIS websites. MASTER imagery was level 1B, and includes 50 bands that simulate the imagery that will be collected from HyspIRI’s thermal infrared (TIR) sensors. AVIRIS imagery was level 2, and includes 250 bands that simulate the imagery that will be collected from HyspIRI’s Very Short Wave Infrared (VSWIR) sensors. Images were collected for both before and after each fire occurred, with special emphasis on collecting images for individual fires within the same season (although this was not always possible). Georeferenced Landsat images were also obtained from USGS’s Earth Explorer website for each fire to use as background images for future map making. Shape files for all the fire perimeters were collected from databases on ArcGIS online.

Because the primary objective of this project is quantitative comparison between currently used multispectral-derived products and the new HyspIRI sensor, RAVG and BARC (produced by BARC) images were also collected from the US Forest Service website.

*Data Processing*

The MASTER data was georeferenced in ENVI and a model was created in ERDAS to perform the NBR, dNBR, and RdNBR indices. This model was also used to process the AVIRIS imagery..

Standard indices calculated are as follows:

Normalized Burn Ratio (NBR) – standard (Hudak, et al. n.d.)

Differenced Normalized Burn Ratio (dNBR) – standard (Hudak, et al. n.d.)

Relative Differenced Normalized Burn Ratio (RdNBR) – standard (Williams 2007)

*Methodology development and implementation still in progress*

# IV. Results & Discussion

**[TBD]**

Insert images, graphs, maps, charts, etc. here. Choose the most important results to highlight here. No word cap, but two to six pages is a good range.

Things to discuss:

* Analysis of Results: What can you tell from your graphs, images, etc? What does this mean for your project?
* Errors & Uncertainty: What factors could you not account for, what things didn’t work out like you expected they would, etc.
* Future Work: If this project was to be selected for another term, what would be the focus? What other areas would be of interest?

# V. Conclusions

**[TBD]**

Final conclusions. Word count: 200-600 (~a page).

# VI. Acknowledgments

**[TBD]**

Insert here. Keep to a concise paragraph or bullets of names. End with the following sentence.

This material is based upon work supported by NASA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

# VII. References

AghaKouchak, Amir, Linyin Cheng, Omid Mazdiyasni, and Alireza Farahmand. 2014. "Global Warming and Changes in Risk of Concurrent Climate Extremes: Insights from the 2014 California Drought." *Geophysical Research Letters.*

Cal Fire. 2014. *Cal Fire: Incident Information.* Accessed June 24, 2015. http://cdfdata.fire.ca.gov/incidents/incidents\_stats?year=2014.

Faivre, Nicolas, Jin Yufang, Michael Goulden, and James T. Randerson. 2014. "Controls on the Spatial Pattern of Wildfire Ignitions in Southern California." *International Journal of Wildland Fire.*

Green, Robert, Simon Hook, and Elizabeth Middleton. 2014. *Status of the HyspIRI Mission Concept.* Pasadena: Jet Propulsion Labratory, California Institute of Technology.

Hebel, Cassie L., Jane E. Smith, and Kermit Cromack Jr. 2009. "Invasive Plant Species and Soil Microbial Response to Wildfire Burn Severity in the Cascade Range of Oregon." *Applied Soil Ecology.*

Hudak, Andrew T., Peter R. Robichaud, Jeffrey S. Evans, Jess Clark, Keith Lannom, Penelope Morgan, and Carter Stone. n.d. "Field Validation of Burned Area Reflectance Classification (BARC) Products for Post Fire Assessment."

Jet Propulsion Laboratory. 2014. *HyspIRI Mission Study.* Accessed June 2014. hyspiri.jpl.nasa.gov.

Kokaly, Raymond F., Barnaby W. Rockwell, Sandra L. Haire, and Trude V.V. King. 2007. "Characterization of Post-Fire Surface Cover, Soils, and Burn Severity at the Cerro Grande Fire, New Mexico, Using Hyperspectral and Multispectral Data." *Remote Sensing of the Enviroment.*

Parsons, Annette. 2003. "Burned Area Emergency Rehabilitation (BAER): Soil Burn Severity Definitions and Mapping Guidlines." Guidlines.

Sutherlin, Timothy, Eric Mack, Heather Nicholson, Caitlin Ruby, and Luke Wylie. 2014. *Assessing the Effectiveness of Simulated HyspIRI Data for Use in USDA Forest Service Post-Fire Vegetation Assessment and Decision Support.* NASA DEVELOP.

Swain, Daniel L., Micheal Tsiang, Matz Haugen, Singh Deepti, Allison Charland, Bala Rajaratnam, and Noah S. Diffenbaugh. 2014. "The Extroridinary California Drought of 2013/2014: Character, Contex, and the Role of Climate Change." *American Meteorological Society.*

1999. *USDA Forest Service.* Accessed June 2014. www.fs.fed.us.

van Wagtendonk, Jan W., Ralph R. Root, and Carl H. Key. 2004. "Comparison of AVIRIS and Landsat ETM+ detection capabilities for burn severity." *Remote Sensing of Environment* 92: 397-408.

# VII. References

# VIII. Content Innovation

In preparation for DEVELOP’s coming microjournal, please select two content innovation features to support your paper. For each item, please list the name of the feature, and include the tool itself if possible (eg. glossary terms and definitions). If the tool does not work in Microsoft Word (eg. Interactive MATLAB Figure Viewer), please list the file name and upload the related file to the microjournal folder on the DEVELOP Exchange. If you choose to use Inline Supplementary Material, please also include where the material should appear in the text.

**Some options include:**

AudioSlides

Database Linking Tool

Data Profile

Executable Papers

Featured Author Videos

Featured Multimedia for this Article (video and podcast options)

Glossary Viewer

Inline Supplementary Material (figures, tables, computer code)

Interactive Map Viewer

Interactive MATLAB Figure Viewer

Interactive Plot Viewer

Nomenclature Viewer

# IV. Appendices

Insert here