Near Real-Time Wildfire Mapping Using Spatially Refined Satellite Data: The Rim Fire Case Study

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Fire incident teams depend on accurate fire diagnostics and predictive data to guide daily positioning and tactics of fire crews. Currently, the U.S. Department of Agriculture—Forest Service National Infrared Operations (NIROPs) nighttime airborne data provides daily information about the fire front and total fire affected area of priority fires to the incident teams on the ground. During the peak of the fire season, NIROPs aircraft can fly over 30 incidents per night to monitor active fires. The total flight hours performed by NIROPs aircraft have increased in the last five years, highlighting the growing demand for timely and accurate active fire mapping. Despite efforts of the NIROPs team, numerous low priority fires are not monitored by NIROPs aircraft. In this context, satellite-based remote sensing of active fires may provide timely information to monitor events lacking thermal airborne data.

Remote sensing of active fires offers consistent near real-time geospatial information that has proven useful for strategic operations (Davies and others 2009). However, fire managers may require higher spatial resolution products for tactical operations. The recently developed 375 m Visible Infrared Imaging Radiometer Suite (VIIRS) active fire detection algorithm improves the current spatial resolution of active fire detection products, showing a higher level of agreement with available airborne data (Schroeder and others 2014). In addition, the improved spatial sampling of the VIIRS sensor and the 12 h revisiting time produce consistent daily data, allowing multiple observations of fires lasting several days. In this study we present the application of 375 m VIIRS active fire detection product to map the active fire front and monitor the Rim fire.

Having burned 257,314 acres (1,041.31 km^2), the Rim fire was one of the largest wildfires in California's history. The fire started on August 17, 2013 in the Sierra Nevada region, and was contained on September 27, 2013. The vegetation affected by the fire consisted mainly of chaparral, ponderosa and Jeffrey pines (*Pinus ponderosa* and *Pinus jeffreyi*), white fir (*Abies concolor*) and red fir (*Abies magnifica*).

First, we performed a qualitative assessment of VIIRS 375 m active fire detections (AFD) to map the active fire front by comparing the VIIRS 375 m AFD with near-coincident NIROPs data, VIIRS 750 m AFD, and 1 km MODIS Terra and Aqua AFD (figure 1). VIIRS 375 m showed an improved spatial agreement with the airborne data in comparison with the coarser resolution satellite active fire detection products.

We also built animated displays of the Rim fire growth using the consecutive active fire detections of VIIRS 375 m, VIIRS 750 m and MODIS-Aqua AFD products.[1] The VIIRS display showed finer spatial resolution producing a smooth transition between consecutive active fire detections. In addition, the number of observations tripled in the VIIRS 375 fire growth display in comparison with the MODIS-Aqua fire growth. VIIRS can provide two to four acquisitions each day depending on the latitude due to its 12 h revisit cycle and wide swath whereas MODIS data offer two acquisitions a day (four when Terra and Aqua are combined). In addition, the VIIRS 375 m AFD product showed higher sensitivity to fire activity than the VIIRS 750 m AFD product, as the latter missed many active fires at nighttime during the last six days showed in the display.

To evaluate the ability of VIIRS 375 m AFD to monitor fire growth, we used the total affected area mapped by NIROPs as reference data. The VIIRS 375 m AFD were aggregated consecutively to obtain a daily estimation of affected area. To perform a proper comparison between the VIIRS estimation and the NIROPs map, we used the lower time difference between NIROPs and VIIRS acquisition times to select the last VIIRS image aggregated in the burned area estimation. The period analyzed ranged from the first NIROPs data acquisition on August 20th to September 16th, when the fire perimeter had stabilized. NIROPs provided maps of affected area each day of the period studied except for August 23rd and September 5th when data were not collected.

The quantitative assessment showed how VIIRS 375 m fire-affected area followed the same trend as the total affected area mapped by NIROPs (figures 2 and 3). VIIRS 375 m produced an average overestimation of 12 percent despite the variable time difference between NIROPs and VIIRS acquisition times. The effect of larger time difference was only visible on August 21st. The high fire spread rate experienced that day tripled the fire-affected area from August 21st to August 22nd. As a result, the closest VIIRS image acquired almost five hours later than the NIROPs thermal data produced an overestimation of 48 percent.

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1 Animated display VIIRS 375 m: http://blaze.umd.edu/_img/IBand_Rim_fire_Movie_v2.mp4
Animated display VIIRS 750 m: http://blaze.umd.edu/_img/MBand_Rim_fire_Movie_v2.mp4
Animated display MODIS-Aqua: http://blaze.umd.edu/_img/MYD14_Rim_fire_Movie_v2.mp4

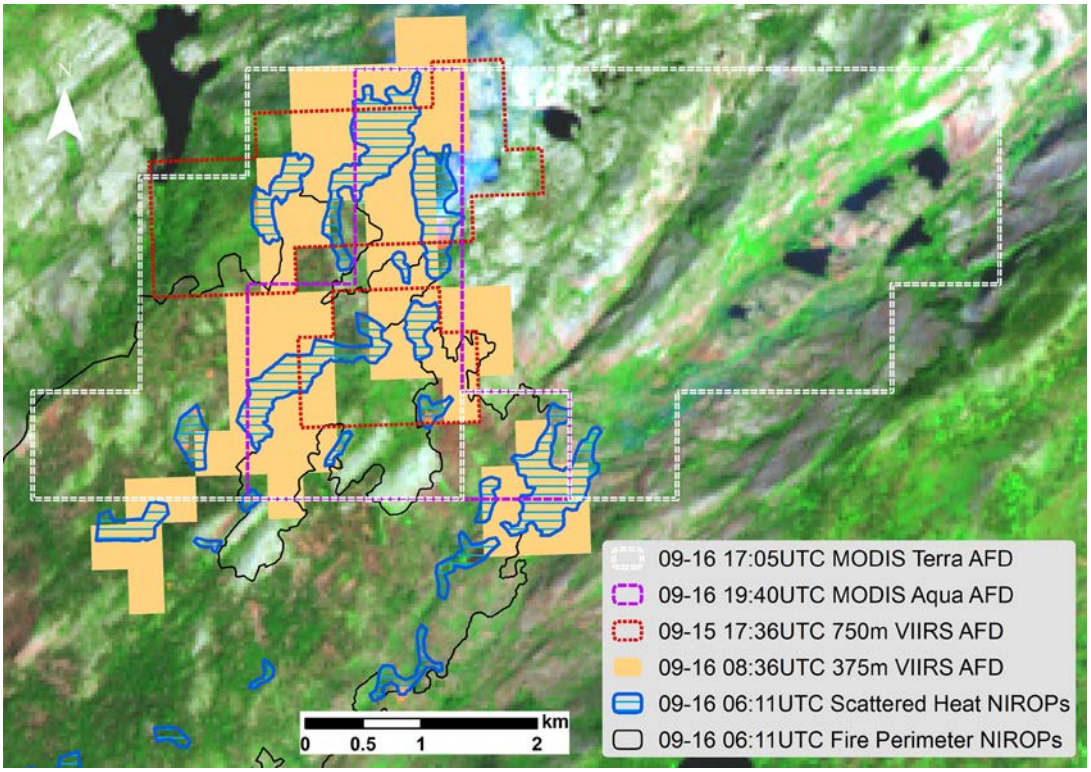

Figure 1—Visual comparison of the active fire front mapping from several active fire detection products and NIROPs scattered heat on September 16th over the northeast region of the Rim fire. The VIIRS 750 m active fire detection product did not generate detections on the morning of September 16th, therefore we used data from the previous overpass on the afternoon of September 15th. The background image is the Landsat 8 image acquired on September 16th (color composite 7-5-2).

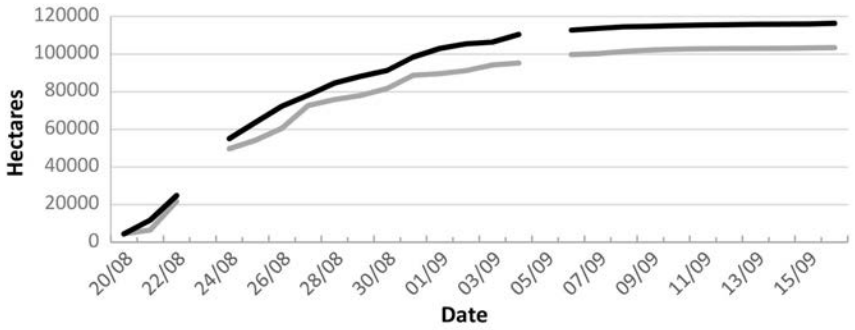

Figure 2—Daily comparison of total fire affected area mapped by NIROPs (grey line) and by aggregated VIIRS 375 m AFD (black line) in the Rim fire.

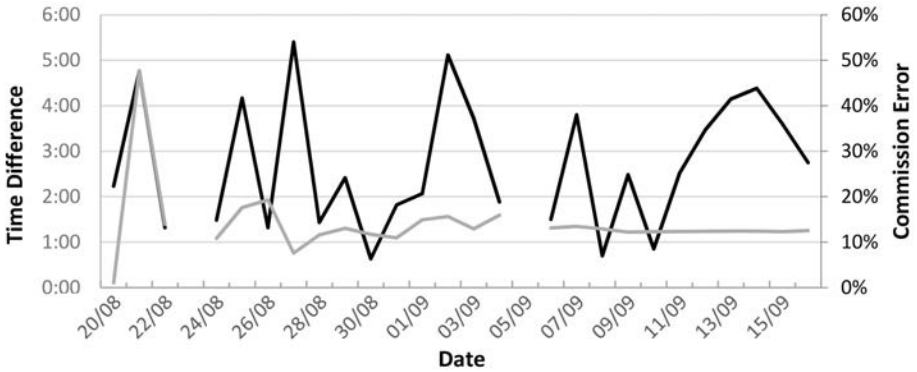

Figure 3—Representation of the time difference between the acquisition time of NIROPs data and the closest VIIRS 375 m image (black line); and the commission error produced by VIIRS 375 m fire affected area estimation (grey line). The commission error measures the overestimation produced by the VIIRS burned area estimation.

Conclusions

Results of our Rim fire case study showed that the VIIRS 375 m AFD product offers valuable information for near real-time wildfire mapping. VIIRS 375m enhanced spatial and temporal resolution enabled the production of more frequent active fire detections and at higher detail compared to existing MODIS fire product. As a result, VIIRS 375 m AFD showed an improved spatial agreement with the airborne data acquired by NIROPs producing a consistent estimation of the daily total affected area.

Consequently, VIIRS 375 m AFD could be used to supplement nighttime airborne imaging resources in support of tactical fire applications providing daytime active fire information. VIIRS 375 m AFD product may be particularly useful to monitor controlled fires and low priority fires supplementing the information provided by the airborne thermal data. In addition, the aggregation of VIIRS 375 m AFD could serve as a near real-time method to estimate burned area providing a first and timely estimation of the extent of areas impacted by fire.

References

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The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.