Algorithm Testing and Verification of the VIIRS Active Fires EDR

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Introduction

Abstract:
The VIIRS active fires Environmental Data Record (EDR) include the geolocation of the pixel where the fire is detected (fire mask) and the sub-pixel temperature and area of the fire.
This presentation provides background on these products and focuses on testing and verification of the fire mask which is a necessary precursor to the EDR. Comparisons with the heritage MODIS fire algorithm version 3 and 4 are presented below as well as comparison with ASTER data and show excellent performance for the fire detection algorithm.

Background:
The VIIRS Active Fires algorithm is a suite of two separate algorithms. First a fire detection algorithm and then the Dozier algorithm for the retrieval of the sub-pixel temperature and area of the fire.
The fire detection algorithm is based on MODIS version 4 fire detection algorithm. It is basically a combination of absolute (threshold) fire tests and relative or contextual fire tests. The contextual analysis is based on the comparison of the pixel brightness temperature to the background temperature. The subtleties of the algorithm comes from deriving meaningful background statistics by ruling out pixels that could skew these statistics (for example water pixels in coastal areas) and therefore yield false alarms.

The Dozier algorithm for the retrieval of the sub-pixel temperature and area of the fire assumes that the mid-wave IR (4.05 mm) and the long-wave IR (10.75 mm) radiances are explicit functions of the area and temperature of the fire for each pixel. Then the algorithm inverts these relationships to retrieve temperature and area. However, These explicit relations between MWIR/LWIR radiances and temperature and area of the fire are only valid under many simplifying assumptions. The simplifying assumptions used in the algorithm induce large uncertainties in the retrieval of the area and temperature of the fire which currently exceed the VIIRS specifications for this product.

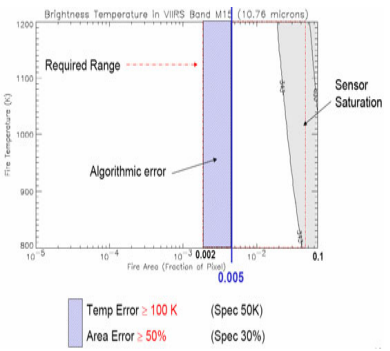
VIIRS system specifications for Active Fires EDR

The appendix D of the VIIRS system specification document states that the Active surface fires EDR provides (a) geolocation of the pixels in which active fires are detected, (b) the sub-pixel average temperature of each active fire, and (c) the sub-pixel area of each active fire. Range of retrievals and uncertainties for each product are given below:

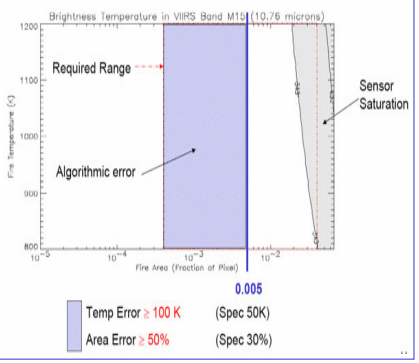
Subject	Specified Value
a. Horizontal Cell Size	
1. At Nadir [VIIRS Guarantee]	0.75 km
2. Worst Case [VIIRS Guarantee]	1.6 km
d. Measurement Range	
1. Sub-pixel Aver. Temp. of Active Fire	800 K – 1200 K
2. Sub-pixel Area of Active Fire	From 1000 m^2 to 50 m Times Ground Sample Distance in Scan Direction
e. Measurement Uncertainty	
1. Sub-pixel Ave. Temp. of Active Fire	50 K
2. Sub-pixel Area of Active Fire	30%

Sensitivity studies of the Dozier algorithm used to perform the retrieval of the sub-pixel temperature and area (**Giglio and Kendall, 2001**) indicate that under realistic conditions the random errors in fire temperature and area are +/- 100 K and +/- 50% respectively at one standard deviation for fires occupying a fraction greater than 0.005. Furthermore saturation issues in the VIIRS M15 VIIRS band (10.75 μm) restrict the range of applicability of the retrieval algorithm.

Nadir

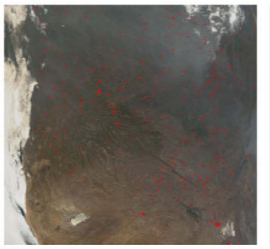


Edge of Scan

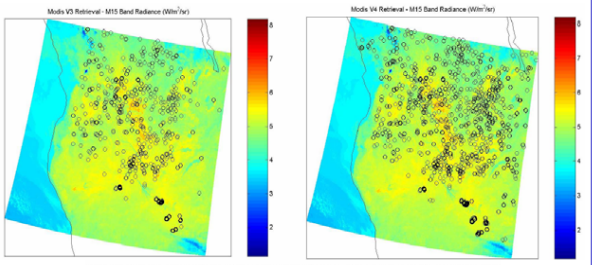


Fire Mask Testing

The VIIRS fire mask, based on the MODIS version 4 algorithm, improved upon MODIS version 3. In particular smaller fire are detected with version 4.

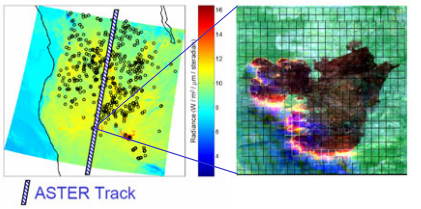


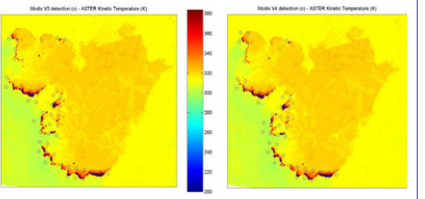
Color composite of MODIS data collected over southern Africa at 905 UTC on 17 August 2001. Red dots are fires from the NASA Rapid Response website.



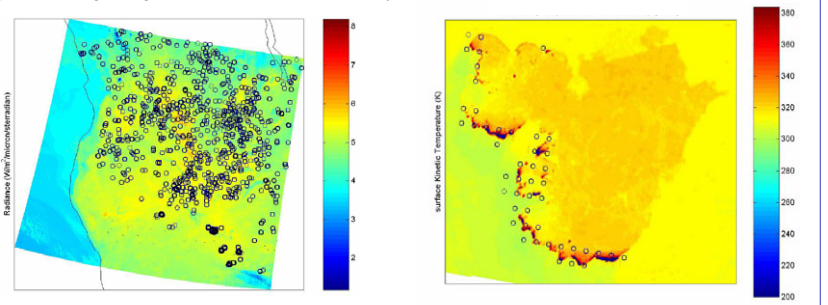
Comparison of active fires detected by MODIS V3 (left) and MODIS V4 (right). V3 detected 964 fires whereas V4 detected 1792 fires. V3 and V4 similar at Nadir. Modis V4 detects a lot more fires at Edge of Scan.

Near nadir both algorithm show good correlation with ASTER kinetic temperature.

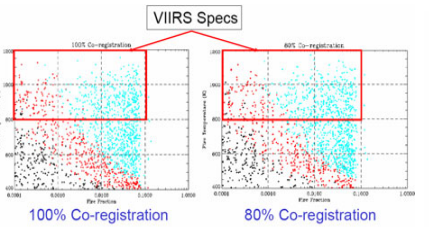




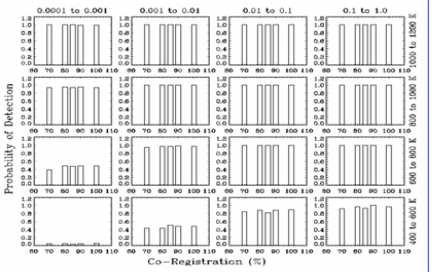
Comparison of the VIIRS fire algorithm and MODIS version 4 show very good correlation between the two fire mask as expected. Also good agreement with ASTER kinetic temperature is observed for both algorithms.



MODIS V4 Detection (circles) – VIIRS Detection (square)



Scatter plot of all simulated non-detected (black) and detected (red/blue) fires with fractions greater than 0.0001.



The effect of MWIR to LWIR co-registration error on Fire detection seems to be very small.

Conclusions

The tests and evaluation of the VIIRS fire mask algorithm shows excellent performance for detection in particular as compared to the heritage MODIS version 4 algorithm and compared (at nadir) to ASTER data. Band to band registration errors and saturation of the 10.75 mm band have little impact on fire detection.