DISCRIMINATION OF IR EMITTER TYPES USING NIGHTTIME VIIRS DATA

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ABSTRACT: The Visible Infrared Imaging Radiometer Suite (VIIRS) collects global day and night data uwing 22 spectral bands. The nighttime data are particularly useful for defining the temperature of hot objects (IR emitters). Using a full year of VIIRS data it is possible to divide IR emitters into two classes: ephemeral and persistent. Among the persistent set, sites can be divided into gas flares and industrial sites. The gas flares are 1400 K and higher. The industrial sites are under 1400 K. For the ephemeral IR emitters there are two primary classes: biomass burning and gas flares. Biomass burning typically dominates, in terms of numbers of detections. If a site is ephemeral and 1500 K or higher, it can be assigned as a gas flare. Ephemeral emitters with temperatures less than 1500 K are biomass burning.

1. INTRODUCTION

One of the widely used datasets derived from earth observation sensors is the “fire product”. These can be broadly divided into ephemeral events and persistent infrared (IR) emitters. The ephemeral events are primarily biomass burning, with the lack of persistence attributed to the fact that biomass burning events finish relatively quickly and not on a repeated basis. The persistent sources are manmade, arising from gas flares, power plants, steel mills and other industrial sites. This paper examines the discrimination of different types of IR emitter types using data from the Visible Infrared Imaging Radiometer Suite (VIIRS) nightfire (VNF) product. VNF (Elvidge et al., 2013 and 2016) is a multispectral product, using a combination of near-infrared (NIR), short-wave infrared (SWIR) and mid-wave infrared (MWIR) channels. VNF calculates temperature, source area, and radiant output using Planck’s Law and its derivatives.

2. DATA SOURCES AND COMPOSITING

India is used as the study area. VNF data of India are analyzed from 2015. Composite images at 15 arc second resolution are made for the average temperature of VNF detections, number of VNF detections, and total number of VIIRS nighttime observations. The percent frequency of detection is then calculated by dividing the number of detections by the number of observations. The detections are divided into two groups. The persistent set were detected 3% of the time and up. The remaining detections are taken as ephemeral. Temperature histograms were then produced for the ephemeral and persistent detections.

3. RESULTS

Figure 1 shows a temperature histogram of the ephemeral sources, detected less than 3% of the time. The distribution has a prominent peak at 1070 K. This feature runs from 800 to 1400 K. This is interpreted as biomass burning. A tail with small numbers of detections extends from 1400 to 2500 K. Those above 1600 K are sure to be arising from ephemeral gas flaring.

Figure shows a temperature histogram for persistent IT emitters from India in 2015. These are sites where the detection occurred 3% or more of the time. This is basically a bimodal distribution, with a set of high temperature sites in the range from 1500 to 2200 K. These are from gas flares, which generally operate temperatures above biomass burning. The second feature on Figure 2 is a cluster of lower temperature sites. This is interpreted as industrial sites where one or more hot objects are exposed to the sky.

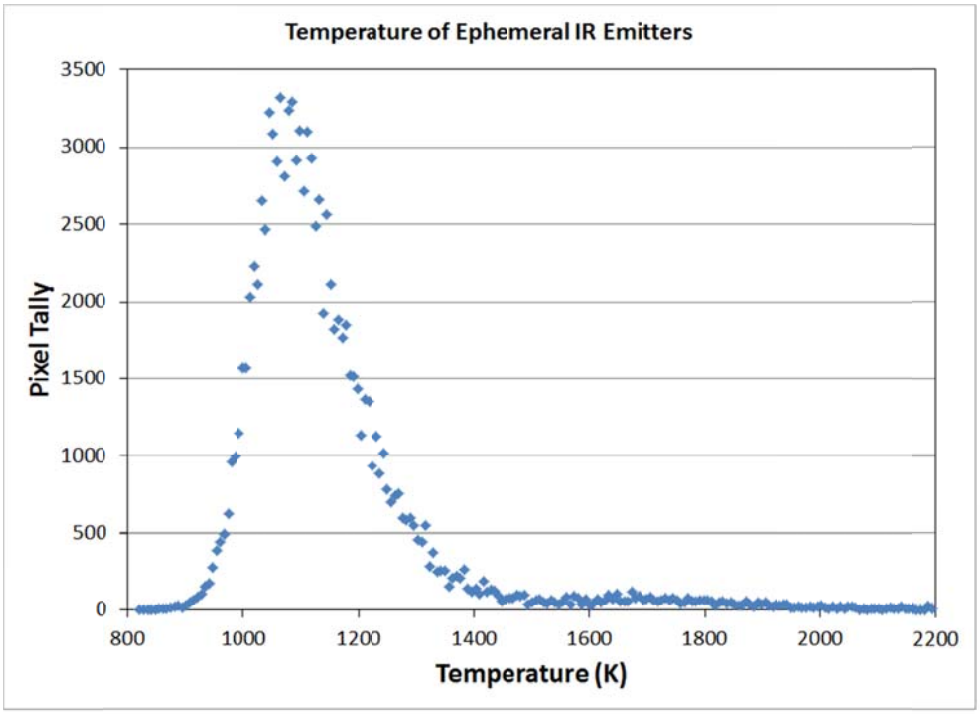

Figure 1. Temperature histogram of cloud-free VIIRS Nightfire composite of India from 2015. The pixel tally peaks near 1070 K, indicating the vast majority of ephemeral VNF detections are from biomass burning.

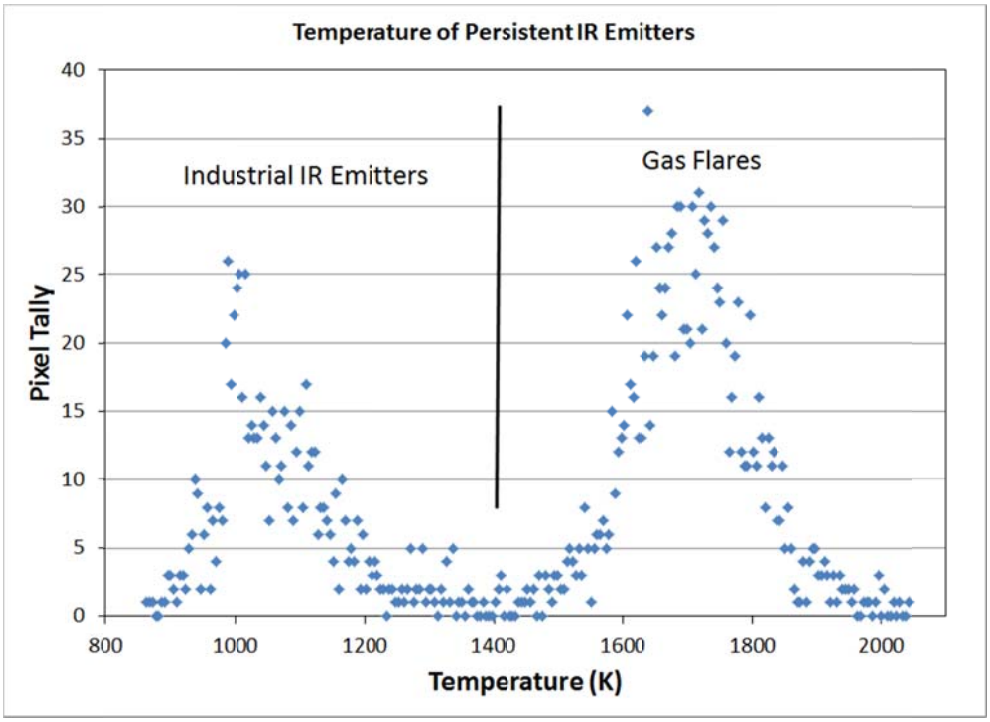

Figure 2. Temperature histogram for persistent IR emitters detected by VIIRS Nigthfire in India from 2015.

4. VALIDATION

Three sites were visually inspected using google earth. The first site is from the hot end of the persistent set, near 1700 K. . The second site is from the cool end of the persistent set, near 1100 K. The third site from near 1000 K from the ephemeral set. The details on the three sites are listed in Table 1.

Table 1

Latitude	Longitude	Percent detection	Temperature (K)	IR emitter type	Placename
27.60628	95.40208	67.5%	1686 K	Gas flare	Baghjan Gaon
21.9229	83.3478	54.2%	1046 K	Steel mill	Jindal Steel Plant
16.2979	75.3146	0.86%	1067 K	Agricultural burning	Ingalagi

Figure 3. Gas flare detected from the persistent IR emitter set from 2015 VIIRS data. Average temperature is 1686 K. The location identified in VIIRS is 120 meters away from the actual flare.

Figure 4. Jindal steel mill, detected as a persistent site with lower temperature than a gas flare. Average temperature is 1046 K.

5. DISCUSSION

Temperatures derived from nightfire follow a biomodal pattern, representing two distinct populations of IR emitters, high and lower temperature sites. This bimodal pattern is still clear in the persistent pixel set. In contrast, the ephemeral pixel set is heavily skewed to the lower temperature set. Spot checking using Google Earth confirms that the vast majority of ephemeral sites are biomass burning. Among the persistent set it is possible to divide sites into industrial and gas flaring. The dividing line is at 1400 K. Pixels higher than 1400 K are typically gas flares. Site with temperatures less than 1400 K are industrial sites. For the gas flares the IR emitter is the flame of burning gas. For the industrial site the detection if arising from hot objects such as furnaces, boilers, and molten slag.

It should be noted that there is some temperature overlap between gas flares and biomass burning in the 1400 to 1500 K range. If a site is persistent and over 1400 K, it can be assigned to the gas flare category. If the site is ephemeral, it is better to notch up the distinction between biomass burning and gas flaring to 1500 C.

It is possible to use a rule set to distinguish between the three basic types of IR emitters. If the temperature is greater than 1500 K and the site is ephemeral it can be assigned to the gas flaring set. If the site is persistent and 1400 K and higher, it is a gas flare. If the site is ephemeral and less than 1500 K, it is biomass burning. Industrial sites are persistent and less than 1400 K.

6. CONCLUSION

It is possible to distinguish types of hot IR emitters based on temperature and persistence. To determine persistence, use a full year of observations. In general, persistent sites are detected three or more percent of the cloud-free observations. The persistent group can be divided into industrial sites and gas flares using a threshold at 1400 K. Persistent sites 1400 K and over are gas flares. Persistent site less than 1400 K are industrial. For ephemeral sites, we recommend using a threshold of 1500 to separate gas flares and biomass burning.

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