Deriving a relationship between the radiative power and the SWIR radiance for Gas Flares

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1 – INTRODUCTION

Flaring occurs in many regions and is a source of black carbon (BC) globally, among other pollutants. At higher latitudes, it is estimated to be the main source of BC which, upon deposition on snow, lowers its albedo. Therefore, knowing the location and emissions of flares would be a valuable input to climate models.

The main goal of this work is to derive a working relationship between Shortwave Infrared radiance at 1.6 µm (SWIR) and Radiative Power (RP). This will be helpful in the processing chain used to determine the emissions from gas flares for upcoming instruments, such as the SLSTR on Sentinel-3.

2 – OVERALL WORKFLOW

BIRD
- BIRD hot spot algorithm run on a selection of images (74) likely to contain GFs ;
- The fire clusters produced (and some bright spots) were checked for co-location with previously reported GFs [4][5][6]) and high resolution images. Production of a database of 417 Gas Flares

- Retrieval of SWIR radiances in NADIR view for the locations reported by BIRD in a timespan > 2 months

AATSR
- Development of an algorithm to detect and determine the radiative power of GFs ;
- Comparison with the BIRD database

Sentinel-3 and FireBIRD
- Application of the algorithm to Sentinel-3 data
- Verification of the algorithm output with FireBIRD images

Completed task | To be implemented

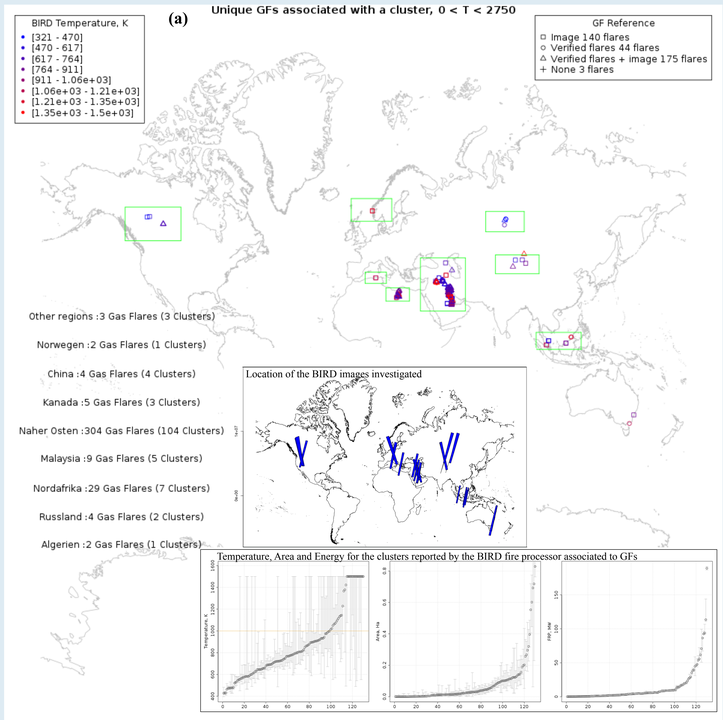
3 – BIRD RESULTS

The complete BIRD data acquisitions consists of 430 dataset over all continents, of which 74 are considered suitable based on a minimum coverage of verified GFs present in a gas flaring map extracted from previous works [4, 5, 6].

The fire-clusters detected on those images by the BIRD algorithm [2, 3] are tested for GFs by means of comparison with high resolution images and the collection of verified GFs.

The identified Gas Flares locations were confirmed by high-resolution imagery (*Image*), by other datasets (*Verified flares*) or by both (*Verified flares + Image*).

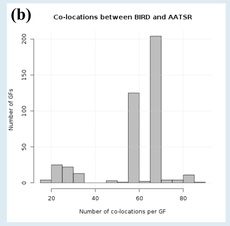
After removing GFs associated to clusters with an unlikely temperature (T<0K or T>2750K), the database comprises 362 GFs associated to 130 clusters. 27 gas flares that are not associated to a BIRD-fire-cluster but close to a bright spot are also identified.



4 – BIRD / AATSR CO-LOCATIONS

In order to derive the relationship between RP and SWIR, RP assigned to GFs observed by BIRD is related to the SWIR radiance time series as observed by AATSR at that location in a temporal window of > 2 months around the BIRD observation.

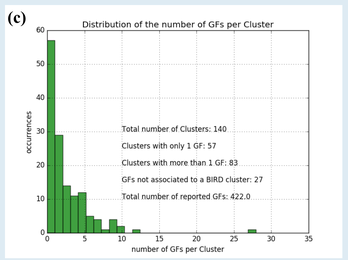
For most GFs, the number of co-locations is 55 – 70 (b).

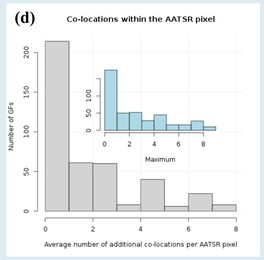


5 – SWIR RADIANCE FROM AATSR

The SWIR signal from the AATSR pixel where the GF was identified by BIRD was retrieved. The signal is considered as being above the detection limit if its value is > 3× background standard deviation. The background is a window of ~10×10 km^2 around the GF pixel. The reported radiance value is the radiance minus the background average.

Since the BIRD Fire Processor reports Radiative Power for clusters of cells to which more than one reported GF may be associated (c), the Radiative Power was normalized. Also, more than one GF Location may be within the borders of the AATSR pixel (d). Therefore, the SWIR radiance must also be normalized.





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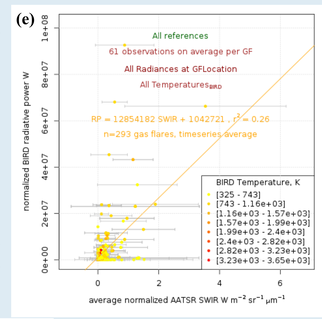
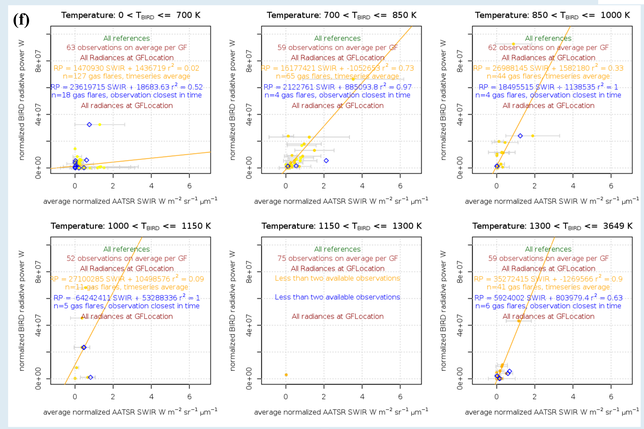
6 – RADIATIVE POWER vs SWIR

In order to derive a working relationship between SWIR radiance and RP, the normalized cluster energy as output by BIRD allocated to the GFs was compared to the normalized SWIR radiance (average of the time series) at the co-located AATSR pixel (e).

The two variables are poorly correlated when considering the whole dataset (e).

However, it is possible to subset the data regarding the temperature reported by the BIRD fire processor (f). The reported temperatures span a wide range, from close to 0K to about 3650K. For GFs, it is expected that the temperature is around 1800K.



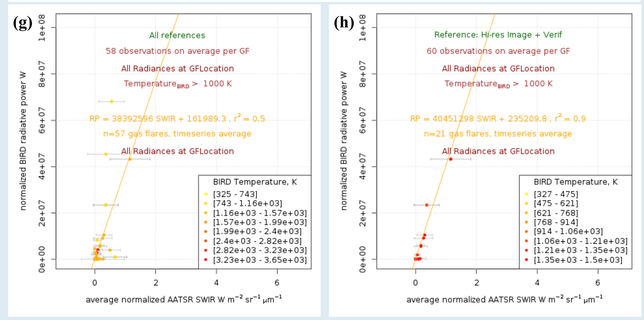


When subsetting the data based on the Temperature reported by BIRD (f), it can be seen that for higher temperatures, the linearity between the two variables increases.

The dataset comprehends 57 GFs with T>1000K. Lower temperature values are very unlikely for GFs. For those 57 GFs, the correlation between the normalized RP and the normalized SWIR radiance is moderate (g).

Another way to subset the data is taking into account the reference by which the GF location was confirmed.

In order to increase the certainty of a GF detection by BIRD, of the GFs with T>1000K only those which were verified by both high-resolution images and other datasets (21 GFs, (h)) are considered. In this case, the linearity between the two variables is further increased.



7 - CONCLUSIONS

Two datasets were compared to investigate a possible relationship between RP and SWIR radiance for gas flares. The first one is the clusters produced by the BIRD Fire Processor. Each was investigated as to whether the signal was caused by a GF and their temperature, area and energy were reported. The second dataset is the time series of the SWIR radiance from AATSR at the same locations within at least 2 months around the BIRD observation.

The relationship between both variables is poor when considering the whole dataset. However, when the data is narrowed down to high-temperature flares, the linearity is high. Further subsetting (high-certainty locations) increases the linearity.

This study indicates that, for GFs of a given temperature, there is a linear relationship between RP and SWIR.