A new algorithm for the ATSR World Fire Atlas

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ABSTRACT: A new fire detection algorithm ALGO3 has been developed and tested (based on basic threshold on the ATSR NIR 1.6 μm channel) in order to fully exploit the ATSR time series back to 1991 by using the ATSR-1 measurements. The algorithm has been prototyped and tested under different conditions, and results are discussed with respect to the ALGO1 and ALGO2 products currently available from the ESA ATSR World Fire Atlas web sites. Pros and cons of using the results of ALGO3 instead of (or in synergy with) ALGO1 and ALGO2 are discussed and some specific cases are analysed in detail.

1 ATSR-WFA hot spot detection algorithms

During his long history the ATSR World Fire Atlas demonstrated its usefulness in many research areas. The basic ALGO1 and ALGO2 approaches have been recognised to be extremely efficient and related results satisfactorily accurate [Arino, 2005 and 2007]. ALGO1 and ALGO2 consist in the detection of ATSR 3.7 μm night-time brightness temperatures exceeding 312 and 308 K respectively. The radiometric stability of the ATSR instrument series ensures the consistency of the detection capability for long time periods. The ATSR WFA products are freely available to public at the following site: http://dup.esrin.esa.int/ionia/wfa/index.asp.

The ATSR time coverage spans from 1991 to now but the above described approach was limited by the absence of the 3.7 μm band for ATSR-1 due to an instrumental problem occurred in early 1992. In order to complement the actual algorithms and to take benefit from the ATSR-1 mission data (1991-1996) we developed a new retrieval scheme, called ALGO3, based on the analysis of ATSRs’ 1.6 μm band reflectance. The processing chain was completely revised, making the processing more efficient and expandable. The introduction of more complex fire detection algorithms is being considered for future developments. The analysis reported in this paper focuses on some of the preliminary results of the reprocessed ATSR-1, ATSR-2 and AATSR TOA products relative to the period August 1991 – February 2008, i.e. around 16 full years of data, and in particular on the gas flaring monitoring for a number of selected areas worldwide.

One of the ALGO1 and ALGO2 drawbacks is the dependence of the 3.7 μm brightness temperature values from the background temperature, i.e. from the temperature of the non burning area. In fact, being the total radiance that
reaches the satellite instrument the combination of the contributions from both burning and non burning fractions of the ground pixel, a fixed threshold for the hot spot detection cannot account for seasonal variations of the contributing background. ALGO3 overcomes this problem considering the 1.6 $\mu$m band behaviour during night-time observations. Alternative approaches, e.g. contextual algorithms, are under development. At NIR wavelengths the contribution of background to night-time radiation is negligible (far below the noise level of the ATSR detectors) while it can be demonstrated that a useful signal is detected for active fires even for very small fire fractions. The ALGO3 method is based on the detection of 1.6 $\mu$m band reflectance values larger than a fixed threshold (=0.1) which is twice the detector noise level. The following considerations hold:

1. The solar proton and electron flux produces a quantity of spurious spots in the region interested by the South Atlantic Anomaly (SAA) [Cabrera, 2005], and for high latitudes
2. Outside SAA the spot density is very similar to that of usual global fire maps (not shown here)

Observation 1 could lead to the conclusion that ALGO3 cannot be used for global fire monitoring because Southern America, a small portion of South Africa, and high latitudes are impacted by the solar flux.

2 Monitoring of Gas Flaring site using ALGO3

Outside the SAA zone of influence ALGO3 proves to be more efficient than ALGO2 in detecting gas flares from oil-gas industrial sites. A characteristic of these sites is that their position is, in general, not changing in time, and this is crucial for their individuation.

The gas flaring detection method adopted in this work consists in individuating small areas (roughly 1.2 km wide, slightly larger than the ATSR ground pixel size) in which hot spots are found more than twice a year. The time series of ALGO2/3 spots are recorded for each of these sites and results analysed in terms of flaring frequency, flame temperature and size, and background temperature. The North Sea area has been preliminarily selected for testing and the related gas flaring locations are shown in left panel of figure 1. The map of exploration lease in the same area is reported in the right panel for qualitative comparison. In figures 3 the red circles are centred on the flaring site and the circle’s radius is proportional to the number of detected spots for each site. The red circles are relative to ALGO3 while the blue circles refer to ALGO2 spots. As can be depicted from figure 1 it was possible to detect more than 1700 gas flaring sites using ALGO3 products, while the previous thermal signal analysis only allowed the individuation of 33 sites. The position of the detected flaring sites corresponds exactly to the exploration lease areas shown in the right panel of figure 1. The larger number of hot spots for a single station in this area is 215 for the entire time period considered. The
number of satellite overpasses at these latitudes for the area in question (and the time frame considered) is roughly 2300. This implies that the (maximum) gas flare detection probability is around 10% for ALGO3, while for ALGO2 it is 1%. If we consider all factors influencing the detection, e.g. cloudiness, real flaring frequency, and ground pixel sensing time (0.15 seconds per overpass), the ALGO3 detection probability is surprisingly high.

Italy was considered for a second test. There the number of industries related to oil and gas refinery is known to be small. As a matter of fact, very few sites were individuated. The most active gas flaring sites are close to the cities of Cagliari and Taranto, the latter being characterised by a maximum of 278 spots for a single site. Considering that the satellite overpass frequency at these latitudes is slightly smaller than for the North Sea case, the (maximum) detection probability is above 12%. It should be noted that with the adopted method it is possible to monitor the activity of volcanoes (Etna and Vulcano in this case).

The other areas analysed in our work are The Gulf, Mexico Gulf, the West Coast of Africa, Mediterranean Africa, and Arctic Russia, with good results.

3 Conclusions
A new fire detection algorithm has been developed and tested in the context of the ATSR WFA project. This new approach appears to extremely useful for global and long term gas flaring detection and
monitoring, making use of the whole ATSR family data, spanning from 1991 to present. A preliminary analysis of ALGO3 data has been performed and results discussed in details. At present, the most important limitation of ALGO3 is represented by the large number of spurious spots in correspondence of the South Atlantic magnetic Anomaly (SAA). Nevertheless, outside the SAA influence ALGO3 has proven to be extremely efficient with respect to the well established thermal IR algorithms. In table 1 a summary of the numbers of detected flaring sites and maximum probability of detection per site is reported for ALGO2 and ALGO3. These numbers clearly demonstrate the potential of this new algorithm for gas flaring detection and monitoring on global scale. In addition, the monitoring of volcanic activity is also possible from ALGO3 product analysis.

<table>
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<th>Selected Area</th>
<th>ALGO2</th>
<th>%</th>
<th>ALGO3</th>
<th>%</th>
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<td>6769</td>
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<td>TOTAL</td>
<td>5078</td>
<td>-</td>
<td>34639</td>
<td>-</td>
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*Table 1 Number of Gas Flaring sites for different areas and detection algorithm*

The complete reprocessing of the ATSR family radiances is on-going and the long time series of ALGO1/2/3 products will be made available to public after the necessary validation exercise will be successfully completed.

REFERENCES

