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Fire Radiative Power – GOES Product User Manual

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Executive Summary / Abstract

This document describes the Fire Radiative Power (FRP) Product generated on an operational basis from the Geostationary Operational Environmental Satellites (GOES) operated by NOAA. FRP describes the overall rate of radiative energy emission from landscape fires, which in turn is related to the combustion rate of vegetation and the rate of emission of smoke to the atmosphere. The GOES satellites cover the America's and offer much higher temporal sampling than polar orbiting systems, albeit at a lower spatial resolution. They therefore offer the potential to obtain a more temporally consistent view of FRP evolution over the diurnal cycle, and improved chances of detecting fires between instances of cloud cover. The GOES FRP product contains information on the detected fire pixels, their FRP and uncertainty estimate, and the underlying characteristics of the data from which these values were obtained.

Table of Contents

1 Introduction

This document describes the Fire Radiative Power (FRP) Product generated on an operational basis from the Geostationary Operational Environmental Satellites (GOES) operated by NOAA. FRP describes the overall rate of radiative energy emission from landscape fires, which in turn is related to the combustion rate of vegetation (Wooster et al., 2005). Thus the characterization of the radiative power of active fires allows for the near real time quantification of open biomass burning from satellites (Roberts and Wooster, 2008, Kaiser et al. 2012). Though geostationary coverage is limited at high latitudes, and they generally offer lower spatial resolutions and larger detection thresholds compared with polar-orbiting satellites, geostationary platforms provide observations with much higher temporal sampling (ranging from 15 min to 3-hourly, depending on the sensor and geographical location). They therefore allow the estimation of fire related emissions to the atmosphere more frequently and more consistently spaced in time over the full diurnal cycle, and also offer many more opportunities to catch fires burning between instances of cloud cover.

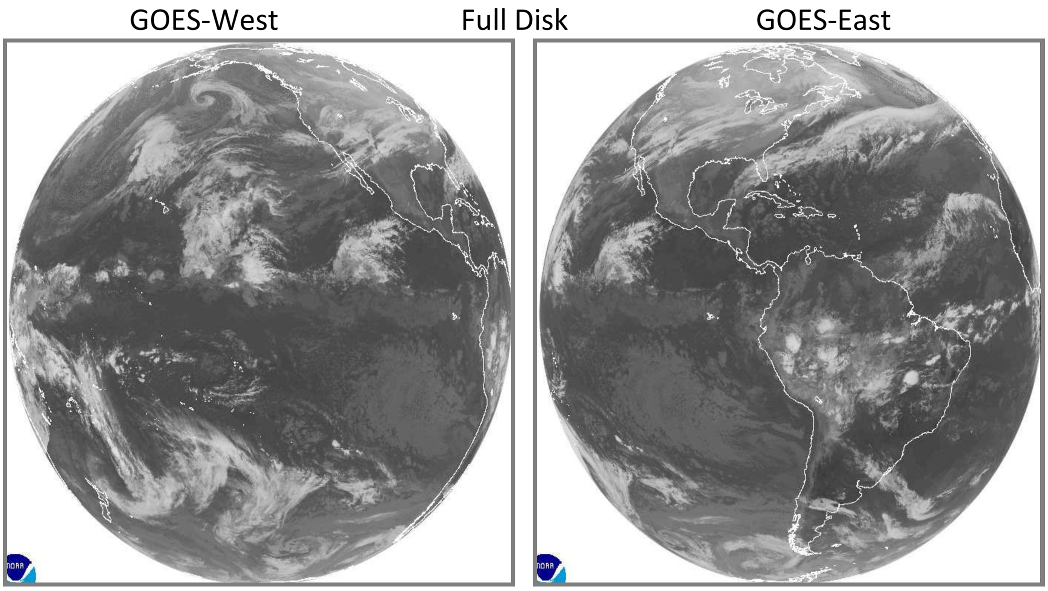


Figure 1 Full disk area coverage of GOES-West and GOES-East, respectively. Source: http://www.goes.noaa.gov/goesfull.html

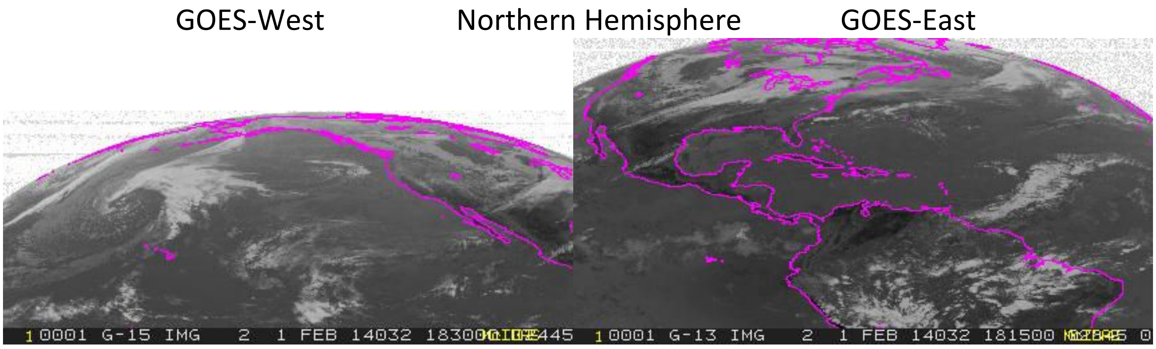
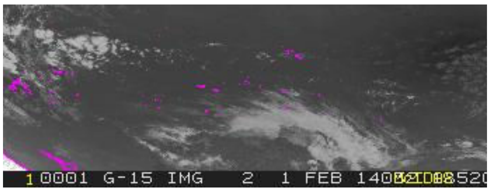


Figure 2 Northern Hemisphere area coverage of GOES-West and GOES-East, respectively. Source: http://www.ssec.wisc.edu/datacenter/standard_GOES8-15.html

Southern Hemisphere

GOES-West



GOES-East

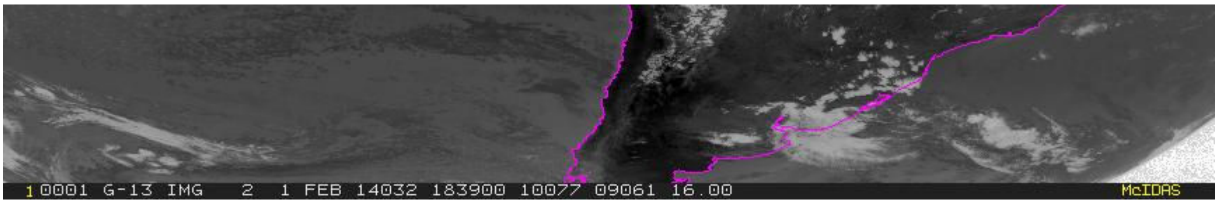


Figure 3 Southern Hemisphere area coverage of GOES-West and GOES-East, respectively. Source: http://www.ssec.wisc.edu/datacenter/standard_GOES8-15.html

2 GOES Fire Radiative Power Product

For this product, active fires within the GOES footprint are detected using data from both the GOES-East and GOES-West satellites using the algorithm described in Xu et al. (2010), and then the FRP of the detected fires is estimated according the algorithm of Wooster et al. (2005). These algorithms are applied to the original GOES imagery which are not spatially resampled prior to the algorithm application, and thus have oversampling in the E-W direction. Applying the algorithm in this way avoids the potential for removing pixels containing fires during any spatial resampling step conducted during pre-processing (Xu et al., 2010). The coverage of the full disk GOES imagery is shown in Figure 1, and this is available 3-hourly; with the duration of each full scan taking about 20 min. Scans of smaller sections of the disk (northern and southern hemispheres) are also conducted. Since FRP is based on the identification of active fires and respective radiative energy release rate estimated on a per-pixel basis, the product spatial resolution corresponds to that of the (coarser) GOES middle- and thermal infrared channels, with a pixel area of around 2.3 km x 4 km at sub-satellite point. See Xu et al. (2010) for a full description of the GOES Active Fire Detection & FRP algorithms used to generate the product, and details of their performance.

The output is currently available in 3 different format files, for both GOES-East and GOES-West observations:

- GOES_<Sat_ID>_<AREA>_<yyyymmdd>_<hhmmss>_ECMWF.txt
- GOES_<Sat_ID>_FD_<yyyymmdd>_<hhmmss>_MET.txt
- GOES_<Sat_ID>_FD_<yyyymmdd>_<hhmmss>ASCII_results.dat

Where:

- Sat_ID is “WEST” or “EAST”

- AREA is “FD”, “NH”, or “SH” standing for Full Disk, Northern Hemisphere and Southern Hemisphere, respectively
- <yyyymmdd> is the date of the product
- <hhmmss> is the observation time, corresponding to the mid scanning; for 3-hourly full disk observations, these are (UTC): 2:45; 5:45; 8:45; 11:45; 14:45; 17:45; 20:45; 23:45

2.1 File Content

2.1.1 GOES_<Sat_ID>_FD_<yyyymmdd>_<hhmmss>_ECMWF.txt

Text file containing the following header:

lat (deg) lon (deg) FRP (W) FRP_error (W) pixel_size (m2) view_angle (deg)

Followed by an integer:

<number of processed pixels>

The following lines contain information provided on each processed pixel, which may or may not correspond to an active fire:

<lat>	<lon>	<FRP>	<FRP_error>	<pixel_size>	<view_angle>

2.1.2 GOES_<Sat_ID>_FD_<yyyymmdd>_<hhmmss>_MET.txt

Text file containing the information on the location of each identified active fire (latitude and longitude) and the respective FRP (MW), organised as follows:

Header:

lat (deg) lon (deg) FRP (MW)

Data:

<Total number of events detected>
<Information per event, as indicated in the header>

2.1.3 GOES_<Sat_ID>_FD_<yyyymmdd>_<hhmmss>ASCII_results.dat

ASCII file, where each line contains all relevant information for each detected fire pixel, corresponding to the following variables:

1. Column in GOES image of the detected fire pixel
2. Line in GOES image of the detected fire pixel
3. Longitude of the detected fire pixel
4. Latitude of the detected fire pixel
5. FRP (MW)of the detected fire pixel
6. Standard deviation of fire radiation power
7. Brightness temperature (K) at 3.9 µm of the detected fire pixel
8. Mean brightness temperature (K) at 3.9 µm of the normal pixels in

the background window
9. Standard deviation of brightness temperature (K) at 3.9 µm of the normal pixels in the background window
10. View zenith angle to the detected fire pixel
11. Pixel size (m^2) of the detected fire pixel
12. Brightness temperature difference (K) of the detected fire pixel: 3.9 minus 11.0 µm channels
13. Mean brightness temperature difference (K) of the normal pixels in the background window: 3.9 minus 11.0 µm channels
14. Standard deviation of the brightness temperature difference (K) of the normal pixels in background window: 3.9 minus 11.0 µm channels
15. Brightness temperature (K) at 11.0 µm of the detected fire pixel
16. Mean brightness temperature (K) at 11.0 µm of the normal pixels in the background window
17. Standard deviation of brightness temperature (K) at 11.0 µm of the normal pixels in the background window
18. Ratio of the spectral radiances at 3.9 µm and VIS channel of the detected fire pixel
19. Mean ratio of the spectral radiances at 3.9 µm and 11.0 µm channel of the normal pixels in the background window
20. Standard deviation of the Ratio of the 3.9 µm and VIS channel spectral radiances of the normal pixels in the background window
21. Fire pixel spectral radiance: 3.9 µm channel
22. Mean spectral radiance of the normal pixels in the background window: 3.9 µm channel
23. Standard deviation of radiance at 3.9 µm of the normal pixels in the background window
24. Temporal brightness temperature difference at 3.9 µm (K): difference of fire pixel with respect to previous same pixel (i.e 1 hour before).
25. Mean temporal difference of brightness temperature at 3.9 µm between the normal pixels in the background window and corresponding previous pixels
26. Standard deviation of the temporal difference of brightness temperature at 3.9 µm between the normal pixels in the background window and corresponding previous same pixels
27. Variance of the temporal brightness temperature difference at 3.9 µm between the detected fire pixel and corresponding previous same pixel
28. Variance of temporal brightness temperature difference at 3.9 µm between the normal pixels in the background window and corresponding previous pixels
29. Variance of difference between brightness temperature at 3.9 µm and 11 µm of detected fire pixel
30. Mean variance of difference between brightness temperature at 3.9 µm and 11 µm of the normal pixels in the background window
31. Standard deviation of variance of difference between brightness temperature at 3.9 µm and 11 µm of the normal pixels in the background window
32. Number of fire pixels in the background window
33. Size of the background window
34. Coded Land Cover Class
35. Solar zenith angle (degrees)
36. Sun glint angle (degrees)

37. Number of cloudy pixels in the background window
38. Number of water body pixels in the background window
39. Fire detection confidence metric
40. Albedo of the visible band of the fire pixel
41. Flag: 0 for fire pixels; > 0 for pixels with false alarms /no fire detected. Only pixels with Flag = 0 are included in the file.
42. Satellite Number (e.g., 12 for GOES-12)
43 Year
44 Day of Year
45 Mid scanning observation time (UTC)in the form <hhmmss>, where hh=hour, mm=minute, ss= second
46. Mean brightness temperature at 3.9 um of fire pixels in the background window
47. Standard deviation of brightness temperature of the fire pixels in the background window
48. Mean difference between channel 3.9 µm and 11 µm of the fire pixels in the background window
49. Standard deviation of brightness temperature difference between channel 3.9 µm and 11 µm of the fire pixels in the background window
50. End of line = 0.00000

2.2 Product Distribution

The data are available in Near Real Time via ftp from the following site:

geoland2.meteo.pt
Login: frp_public
Password: frp

ftp://frp_public:frp@geoland2.meteo.pt

The above address maintains all data produced within the previous 15 days. All the generated files (from 2014 onwards) are archived at IPMA and can be ordered off-line to:

Isabel.trigo@ipma.pt or joao.macedo@ipma.pt

The data archived locally at IPMA and available at the ftp site indicated above are compressed (.bz2). To uncompress use

bunzip2 <filename>

or bzip2 –d <filename>

Further documentation/software on compression at: http://www.bzip.org/

The products are listed and can be accessed through the MACC-II catalogue at http://atmosphere.copernicus.eu/catalogue; select product family "fire".

The GOES_*_ECMWF.txt are also acquired and archived by ECMWF in real time.

2.3 Product Timeliness

The FRP product is available in Near Real Time (NRT).
Under nominal production, GOES observations are regularly searched and downloaded from NOAA. Under nominal production, the timeliness – time lag between the most recent satellite image needed to generate the product and availability to users – is below 3 hours.

In case of failure in the processing chain, data may still be back-processed up to 3 working days prior to the current NRT date.

3 References

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Wooster, M. J., G. Roberts, G. L. W. Perry, and Y. J. Kaufman (2005). Retrieval of biomass combustion rates and totals from fire radiative observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release. *J. Geophys. Res.*, 110, D24311, doi: 10.1029/2005JD006318.

Xu, W., Wooster, M. J., Roberts, G., and Freeborn, P. (2010). New GOES imager algorithms for cloud and active fire detection and fire radiative power assessment across North, South and Central America. Remote Sensing of Environment, 114, 1876-1895.

Annex

#	Problems	Status	Mitigation Measures
1	**Requirement for IDL license to run FRP-GOES**	Closed	Acquisition of one license
2	**Non-compliance of code with I/O and system interfaces at IPMA**	Open	Code was implemented from KCL as is. Long-term solution: rewrite the FRP-GOES to be compliant with IPMA system and better allow its maintenance/evolution.