SAFARI 2000 Global Burned Area Map, 1-km, Southern Africa, 2000

Abstract

Over large regions of the globe, fires are known to contribute significantly to the injection of gases and aerosols into the atmosphere, and to be a major disturbance to the vegetation cover. Biomass burning contributes up to 50%, 40%, and 16% of the total emissions of anthropogenic origin for carbon monoxide, carbon dioxide and methane, respectively. Both the scientific community and the policy makers are looking for reliable and quantitative information on the magnitude and spatial distribution of biomass burning. It is in this context that the Global Burned Area 2000 initiative (GBA2000) was launched by the Global Vegetation Mapping (GVM) Unit of the Joint Research Centre (JRC) of the European Commission (EC), in partnership with several other institutions. The objective of GBA2000 was to produce a map of the areas burned globally for the year 2000, using the medium resolution (1 km) satellite imagery provided by the SPOT-Vegetation (VGT) system and to derive statistics of area burned per type of vegetation cover. A subset of the global GBA20000 map was prepared for SAFARI 2000 to map the area burned in sub-Saharan Africa during 2000 on a monthly basis using VGT imagery.

Background Information

Investigators:
Joint Research Centre, European Commission

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Project: SAFARI 2000
Global Burned Area 2000 (GBA2000)

Data Set Title: SAFARI 2000 Global Burned Area Map, 1-km, Southern Africa, 2000

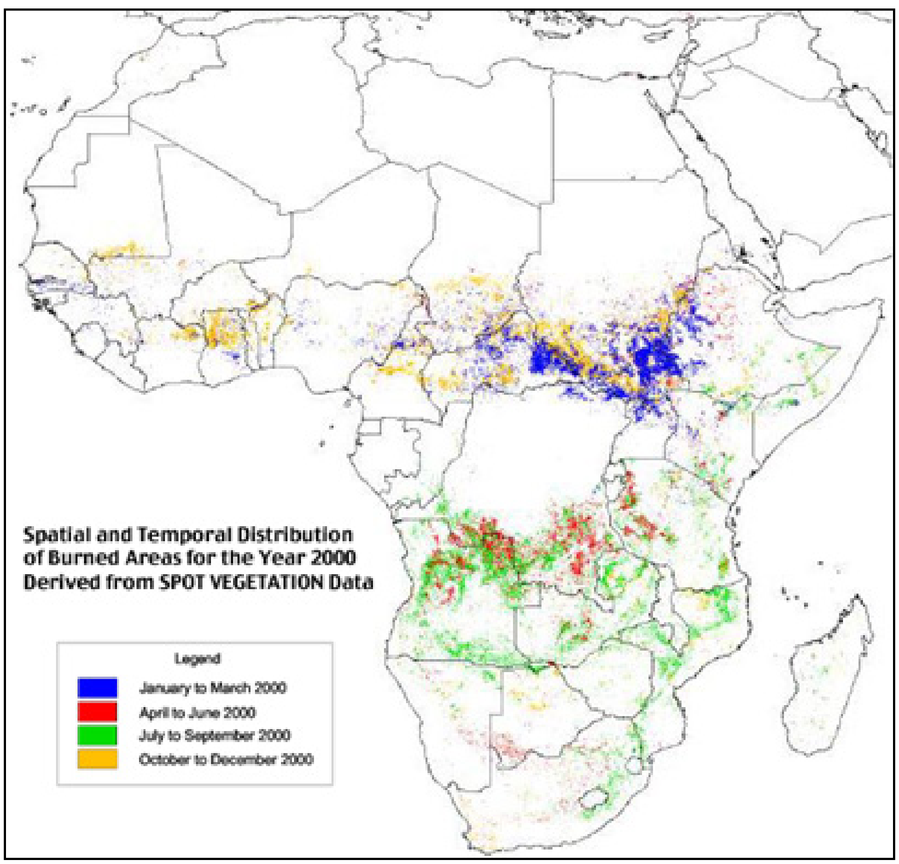
Site: Sub-Saharan Africa
Westernmost Longitude: 18 W
Easternmost Longitude: 55 E
Northernmost Latitude: 18 N
Southernmost Latitude: 35 S

Data Set Citation:

Joint Research Centre, European Commission. 2005. SAFARI 2000 Global Burned Area Map, 1-km, Southern Africa, 2000. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Web Site: http://www-gvm.jrc.it/fire/gba2000/index.htm

Figure 1. Spatial and Temporal Distribution of Burned Areas for the Year 2000 in Southern Africa



Data File Information

The data are binary image files of area burned, BSQ format in geographic projection. There is one file for each month of 2000 and one file for all of the year 2000. The data files are compressed (.zip). Each zip archive contains a monthly or annual .bsq image file and the associated .hdr header file. The zip files are named as follows:

Burned Area Image Files
africa_gba2000-01.zip
africa_gba2000-02.zip
africa_gba2000-03.zip
africa_gba2000-04.zip
africa_gba2000-05.zip
africa_gba2000-06.zip
africa_gba2000-07.zip
africa_gba2000-08.zip
africa_gba2000-09.zip
africa_gba2000-10.zip
africa_gba2000-11.zip
africa_gba2000-12.zip
africa_gba2000-total.zip

where 01 is for January, 02 is for February, and so forth.

Image Parameters

Samples	8200
Lines	6000
Bands	1
Header offset	0
Number of bytes per pixel	1

Companion Files

There is also a companion comma-delimited ASCII text file (**africa_gba2000-total_csv.zip**) that provides geographic coordinates (latitude and longitude) of the center of each pixel indicated as a burned area for all of 2000. Please note that this file has been altered from that which is distributed on the GBA2000 web site. The coordinates of the location of each pixel within the SPOT VEGETATION S1 global product are also given in the original version. This information has been removed to reduce the file size.

In addition, there are several companion spreadsheet files that provide additional data derived from SPOT-VEGETATION imagery. These are: **gba2000_country_month_totals.csv** [burned area (km^2) per country and month for the year 2000]; **gba2000_country_month.csv** [comma delimited burned area (km^2), number of scars (all clusters and individual pixels), average size of the scar (km^2), % of total area of country burned (shown for the year 2000 synthesis only)]; and **gba2000_country_vegetation_2000.csv** [burned area (km^2), number of scars, average burn scar size, and % of the category burned per country and broad vegetation type for the year 2000].

Africa Fires

Natural fires in most African ecosystems are ignited by lightning generated by convective thunderstorms which are frequent at the end of the dry season. Nowadays, however, human activity is responsible for the majority of fires in Africa, particularly in the grassland and savanna biomes (Bond, 1997). It is estimated that approximately 90% of the biomass burned in Africa results from savanna fires, in contrast to South America and Southeast Asia, where forest fires play a more significant role (Delmas et al., 1991). At the global scale, burning of African savannas is believed to account for almost one third of annual gross emissions from biomass burning (Andreae, 1991; 1997), but these estimates still suffer from significant levels of uncertainty, namely regarding the extent of area burned. Levine (1996) considered the accurate assessment of the spatial and temporal distribution of burning as the greatest single challenge to the scientific community studying biomass burning.

The area burned in sub-Saharan Africa during 2000 was mapped on a monthly basis using SPOT VGT satellite imagery at 1 km spatial resolution. Burned areas were identified with a classification tree, relying only on the near-infrared channel of VGT. For complete details of the data processing effort and algorithms, see Tansey (2002).

SPOT-VEGETATION Data

The VEGETATION instrument on board SPOT-4 has four spectral bands: blue (0.43-0.47 µm), red (0.61-0.68 µm), near-infrared (NIR, 0.78-0.89 µm), and shortwave infrared (SWIR, 1.58-1.74 µm). The spatial resolution is 1 km at nadir. The 2200 km swath width allows daily imaging of about 90% of the equatorial regions, the remaining 10% being imaged the following day. At latitudes higher than 35° (North and South), all regions are observed daily.

The data used in this work are in the S1 daily synthesis format (i.e., the data are radiometrically calibrated, precisely geo-located, and corrected for atmospheric effects). Atmospheric corrections are performed using the Simplified Method for Atmospheric Corrections (SMAC) (Rahman and Dedieu, 1994). In this procedure, water vapor data are obtained from short term forecasts provided by Meteo-France four times a day, in a 1.5° by 1.5° grid. Correction of aerosol effects relies on constant values by latitudinal bands (Passot, 2000). Handling of the aerosol atmospheric effect with climatological data may undercorrect its effect during severe episodes of biomass burning. This undercorrection may reduce NIR reflectance of vegetated areas and thus reduce the spectral contrast with burned surfaces.

Multitemporal geo-location accuracy of the VGT data is particularly good [absolute location <0.8 km, multispectral registration <0.2 km, and multitemporal registration for one year <0.5 km; (SPOT-VEGETATION Technical Information, http://www.spotimage.fr/html/_167_224_.php)], and thus the data are well suited for change detection applications.

Because of the characteristics of the satellite, repeat acquisitions are made in a single day at moderate to high latitudes in both hemispheres. Where this has occurred the pixel chosen to represent the S1 product is that pixel with the highest normalized difference vegetation index (NDVI) value. This leads to significant speckling in some areas and methods to remove or automatically detect these areas of speckle have proved difficult. Therefore, it was a task of the algorithm development team to ensure their burned area algorithm was sufficiently robust enough to cope with these overlap regions. It was impossible to retrieve the original data so that just one overpass could be used instead of a composite of both overpasses.

Creation of the Burned Area Product for Sub-Saharan Africa

Pre-processing

The pre-processing requirements of the burned area algorithm for sub-Saharan Africa are the effective removal of cloud and cloud shadow, non-vegetated surfaces, saturated pixels in the MIR band, and pixels acquired at extreme viewing zeniths from daily SPOT Vegetation data sets.

Compositing

The pre-processed SPOT Vegetation data were composited over a time period of one month. The compositing criteria based on the pixel with the lowest value in the SPOT Vegetation channel B3 (near-infrared) with an additional temporal test to avoid cloud shadows, the minNIR, was used as it was believed that if a pixel was burned, then that pixel would be chosen to be represented in the composite due to the changes in the spectral signature of that pixel. Problems associated with this method include the possible inclusion of cloud shadow pixels in the final composite, as these pixel values are also lower than background vegetation in the B3 channel. Also, pixels that are permanently cloudy or contaminated by some other phenomena throughout the whole of the compositing time period will be included in the compositing product. Because of these concerns, tests were made on the quality of the output composites using S1 products that had been pre-processed prior to compositing and deriving composites and associated pixel status maps according to a temporal calculation made on the series of near-infrared values in the compositing period. The compositing algorithm was developed initially by Stroppiana et al. (2002).

Burned Area Algorithm (GBA2000 UTL Africa 2 module)

A training data set was extracted from all of the monthly composite images with significant burning activity and pooled together to create a single classification applicable to the entire fire season. A total of 30,075 pixels (14,924 of which corresponded to burned areas and 15,151 pixels to unburned areas) were extracted from sub-Saharan Africa. Training data were chosen from all major vegetation types by visual inspection of pre-fire and post-fire color composite images, assisted by ancillary Along Track Scanning Radiometer (ATSR)-2 active fire data (Arino et al., 2001) and the University of Maryland (UMD) global land cover product. Two composites were used to derive the burned areas: **t** is the monthly composite being processed for burned areas and **t-1** is the previous month's composite. The threshold values were applied to the red (B2) and near-infrared (B3) channels at time **t**, the normalized difference water index (NDWI) (Gao, 1996) at time **t** and also the NDVI at time **t**. The value of the NDWI is computed by taking the ratio of the B3 value minus the MIR value over the B3 value plus the MIR value. The value of the NDVI is computed by taking the ratio of the B3 value minus the B2 value over the B3 value plus the B2 value. The temporal differences (**t-1** minus **t**) of the NIR and NDWI values between successive composite images are also compared.

The burned area mapping algorithm was developed using a supervised classification tree (Breiman et al., 1984). Classification trees are a non-parametric method based on binary recursive partitioning. In this study, classification trees were applied to the SPOT Vegetation monthly composites in a change detection approach. The classification rules to determine burned surface are summarized in Table 1.

Table 1: The classification rules for the burned surface class. A pixel is classified as burned if satisfies all the conditions of any classification rule. The variables used are the SPOT Vegetation Red (B2), NIR (B3), and middle-infrared (MIR) channels, and the NDVI and NDWI indices.
DijVARIABLE = $\text{VARIABLE}_{\text{time i}}$ -$\text{VARIABLE}_{\text{time j}}$, where times i and j refer to the composite images at time 1 and 2, respectively. The values shown are in DN.

Rule	Conditions (AND)
A	$nir_2 \leq 256.5$; $\Delta_{12}(nir) > 51.5$; $\Delta_{12}(nir) \leq 70.5$; $ndvi_2 \leq 0.309$
B	$nir_2 \leq 256.5$; $\Delta_{12}(nir) > 51.5$; $\Delta_{12}(nir) > 70.5$
C	$nir_2 > 256.5$; $ndvi_2 \leq 0.198$; $\Delta_{12}(ndwi) > 0.06$; $ndwi_2 \leq -0.19$
D	$nir_2 > 256.5$; $ndvi_2 > 0.198$; $nir_2 \leq 272.5$; $\Delta_{12}(nir) > 80.5$; $ndvi_2 \leq 0.290$
E	$nir_2 > 256.5$; $ndvi_2 > 0.198$; $nir_2 > 272.5$; $ndvi_2 \leq 0.231$; $\Delta_{12}(ndwi) \leq 0.076$; $\Delta_{12}(nir) > 69.5$; $red_2 \leq 213.5$;
F	$nir_2 > 256.5$; $ndvi_2 > 0.198$; $nir_2 > 272.5$; $ndvi_2 \leq 0.231$; $\Delta_{12}(ndwi) > 0.076$; $ndwi_2 \leq -0.212$

Data Limitations

In all cases, the year 2000 product is a sum of the monthly products. This binary (0/1) product reflects the total land area burned in the year 2000. However, for some countries, the same areas may have burned twice, once in the 1999-2000 fire season and again in the 2000-2001 fire season. This is not reflected in the year 2000 product which is coded only burned or not burned. Therefore, for emission studies, the amount of vegetation burned in the year 2000 is greater than the annual GBA2000 product suggests for some areas. For studies such as these, the monthly products should be used to derive statistics and not the annual (year 2000) product.

Additional Sources of Information

The final version of the global burned area map was completed in December 2002 and made accessible to the user community via the Internet at http://www-gvm.jrc.it/fire/gba2000/index.htm, and through the UNEP-GRID web site at http://www.grid.unep.ch/activities/earlywarning/preview/ims/gba/.

NOTE: Data Distribution Rules Set by GBA2000

Use of the GBA2000 data sets are provided freely as long as the following rules are adhered to:

- The user does not obtain title to the intellectual property of the data, nor any copyright or propriety rights to its content.
- The users are not allowed to transfer, sublicense, rent, lease, or sell the data therein.
- As the data provided are the intellectual property of the organizations which supplied the information, the original source of the data must be fully acknowledged. Please refer to the respective organizations for further inquiries regarding copyright and user limitations (see sources).
- Under no circumstances will the Joint Research Centre be liable for any damages resulting from use of the "Global Burned Area 2000 data sets" provided.

References

Arino, O., M. Simon, I. Piccolini, and J.-M. Rosaz. 2001. The ERS-2 ATSR-2 World Fire Atlas and the ERS-2 ATSR-2 World Burned Surface Atlas projects. 8th ISPRS Conference on Physical Measurement and Signatures in Remote Sensing, 8-12 January 2001 (Aussois: International Society for Photogrammetric and Remote Sensing).

Andreae, M. O. 1991. Biomass burning: its history, use, and distribution, and its impact on environmental quality and global climate, pp. 3-21, in Levine, J. S. (ed.). Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications, MIT Press, Cambridge, MA, USA.

Andreae, M. O. 1997. Emissions of trace gases and aerosols from southern African savanna fires, pp. 161-184, in van Wilgen, B. W., M. O. Andreae, J. G. Goldammer, and J. A. Lindesay (eds.). Fire in Southern African Savannas: Ecological and Atmospheric Perspectives, Witwatersrand University Press, Johannesburg, South Africa.

Bond, W. J. 1997. Fire, pp. 421-446, in Cowling, R. M., D. M. Richardson, and S. M. Pierce (eds.). Vegetation of Southern Africa, Cambridge University Press, Cambridge, UK.

Breiman, L., J. H. Friedman, R. A. Olshen, and C. J. Stone. 1984. Classification and Regression Trees, Wadsworth & Brooks, California, 173 pp.

Delmas, R. A., P. Loudjani, A. Podaire, and J. C. Menaut. 1991. Biomass burning in Africa: an assessment of annually burned biomass, pp. 126-132, in Levine, J. S. (ed.). Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications, MIT Press, Cambridge, MA, USA.

Gao, B.-C. 1996. NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment, 58: 257-266.

Grégoire J. -M., K. Tansey, I. Marengo, D. Stroppiana, and S. Fritz. 2002. The Global Burned Area 2000 Initiative: GBA-2000. Mapping the areas burned globally during the year 2000. Publication of the European Commission, Technical Note I.01.117, Joint Research Centre, Ispra, Italy, p. 40.

Grégoire J. -M., K. Tansey, and J. M. N. Silva. 2003. The GBA2000 initiative: Developing a global burned area database from SPOT-VEGETATION imagery. International Journal of Remote Sensing, 24 (6): 1369-1376.

Levine, J. S. 1996. Introduction, pp. xxxv-xliii, in Levine, J. S. (ed.). Biomass Burning and Global Change. Remote Sensing, Modeling and Inventory Development, and Biomass Burning in Africa, Vol. 1. MIT Press, Cambridge, MA, USA.

Marengo I., J-M. Grégoire, K. Tansey, and P. Peduzzi. 2002. Global Burned Area 2000: Analysis module. Publication of the European Commissionn Technical Note I.02.39, Joint Research Centre, Ispra, Italy, p. 12.

Passot, X. 2000. VEGETATION image processing method in the CTIV, pp. 15-31, in Saint, G. (ed.). Proceedings of VEGETATION 2000: 2 years of operations to prepare the future, Lake Maggiore, Italy, April 3rd- 6th 2000.

Rahman, H. and G. Dedieu. 1994. SMAC: a simplified method for the atmospheric correction of satellite measurements in the solar spectrum. International Journal of Remote Sensing, 15(1): 123-143.

Stroppiana, D., S. Pinnock, J. M. C. Pereira, and J.-M. Grégoire. 2002. Radiometric analysis of SPOT-VEGETATION images for burned area detection in Northern Australia. Remote Sensing of Environment, 82(2002): 21-37.

Silva, J. M. N., J. M. C. Pereira, A. I. Cabral, A. C. L. Sá, M. J. P. Vasconcelos, B. Mota, and J.-M. Grégoire. 2003. An estimate of the area burned in southern Africa during the 2000 dry season using SPOT-VEGETATION satellite data. Journal of Geophysical Research, 108(D13), 8498, doi:10.1029/2002JD002320.

Tansey, K. 2002. Implementation of regional burned area algorithms for the GBA2000 initiative. Publication of the European Commission, EUR 20532 EN, p. 170.

Tansey, K., J. M. Gregoire, E. Binaghi, L. Boschetti, P. A. Brivio, D. Ershov, S. Flasse, R. Fraser, D. Graetz, M. Maggi, P. Peduzzi, J. Pereira, J. Silva, A. Sousa, and D. Stroppiana. 2004. A global inventory of burned areas at 1km resolution for the year 2000 derived from SPOT VEGETATION data. CLIMATIC CHANGE, 67(2-3): 345-377.

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Regional Algorithms - Sub-Sahran Africa

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