

Ten Years Monitoring and Mapping Fires in Brazil Current Products and Information Networks

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Introduction

The burned areas in Brazil have been the cause of much concern and controversy. The burnings affect many ecological and agricultural systems, creating negative environmental impacts on both local and regional level. Unlike the temperate forests, the Brazilian tropical forests (Amazon and Atlantic forests) do not burn by accident, nor because of lightnings, not even if someone sets fire on them. Almost all the different kinds of forests that occur in the Amazon Basin and in the Atlantic Coastal areas are too humid to burn. Many of them - like *Igapó* forests or palm tree forests - are literally under the water, six to eight months a year. The so-called *terra firme* forests ("highlands" vegetation) are the driest forest types. But even there, accidental fires only occur if the vegetation is disturbed as a consequence of logging and trails formed by hunters trails. Here, branches and leaves are exposed to the sun and become dry and highly flammable after a very dry season. During the last 10 years of the fire monitoring programme extremely large wildfires on uncut forested areas were observed only twice: at a very disturbed area near Santarém, state of Pará, and at Roraima State, both during severe dry seasons, due to El Niño episodes.

In the Brazilian Amazon forests fire is used because it is the cheapest way to reduce the logging residuals, to control weeds and pests, to renew pastures and to harvest some crops (specially sugar cane). Trees have to be cut down, then dried during a period of several months, to be ready for burning. That is why Brazilians distinguish burnings (*queimadas*) from wildfires (*incêndios*). Burnings are made purposely. Wildfires can be the result of uncontrolled burnings, that reach the native vegetation, besides all other well known fire causes, e.g. cigarettes on roadside grasslands, lightnings, arson, etc.

Some 20% of the Amazon region, however, is covered by grasslands or savannahs (, called *cerrados*) with small dispersed trees. Like the African savannahs, this vegetation burns easily and periodically. But, still there, natural fires are minor. The *cerrados* usually are the first patches of wildland occupied by farmers and settlers, because it demands less efforts to be cultivated. The burnings, in fact, have been occurring all over Brazil for centuries.

By 1987, the NOAA/AVHRR images were first successfully tested to identify the burnings. The team at the National Institute for Space Research (INPE) in São Paulo state used the temperature sensor of the North American meteorological satellite (NOAA AVHRR) to localize burning and burned areas. Their purpose was to produce a list of geographical coordinates, spotting the major fires for the Brazilian Environmental Agency (IBAMA), supposed to fiscalize those burnings in the field. In 1988, the scientists decided to send the information also to the press. The Agência Estado (AE) news wire service started a public campaign to stop the Amazon burnings, using this data.

The monitoring of the burnings became a routine. Since 1988, burnings are listed and counted every day, during the whole dry season (from June to October or November), not only on the Amazon Basin, but all over Brazil and, sometimes also on the territories of neighbour countries. After the main media campaign against the Amazon burnings, in 1989 and 1990, Brazilian scientists started to produce better maps. An agreement was made among INPE, AE, the Environmental Monitoring Center (NMA) and an NGO called *Ecoforce* (Ecoforce - Research & Development <<http://www.ecof.org.br>>) in order to produce maps that could be easily understood by the general public. Developing activities, through agreements and scientific partnerships, the NMA adjusted and spread out knowledge in the

geoprocessing applications area (remote sensing and digital cartography) for agriculture and the environment. Acting over all national territory, it assists federal, state, and municipal entities and the private initiative.

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Since 1991, as a public service of information, weekly burnings maps were published on several newspapers with an interpretation. A mapping system is also available on Internet, since then. One may consult weekly, monthly and annual burning maps, of either whole Brazil or its regions and states (Fig. 1-2). It is the country biggest data bank on burnings available on Internet, as well as the most accessed site. This homepage (http://www.nma.embrapa.br/projects/qmd_us/index.html) gets around 150,000 hits per year, due to its reliability and availability.

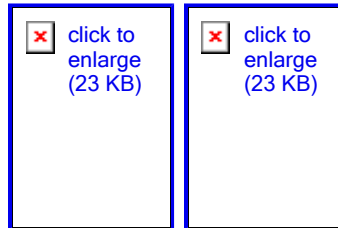


Fig.1 & 2. Orbital monitoring of burned areas, August & October 1998.

All the system routines are frequently updated. The detection and mapping homogeneity allowed NMA researchers to study the space and time patterns of the burnings.

The NMA team also does an hydrologic monitoring, based on satellite data, which gives information on water availability on 25 soil types at 11 states of Brazil, as an extra indicator of fire risk and generates weekly around 12,000 pages on the Internet (<http://www.agrocast.com.br>).

The follow up of over 450 farmers for the last 10 years, on amazon region, has also helped to understand the causes of interannual fluctuations of burnings, not related to climate (<http://www.nma.embrapa.br/projects/machadinho>) and the relationship between deforestation and burnings. Finally, the allocation and use of a mobile antenna for NOAA/AVHRR data reception, by the NMA team was decisive on supporting the *in situ* wildfires combat at Roraima state in early 1998.

Deforestation vs. Burnings: A Misunderstanding

Since the international "campaign" to preserve the Brazilian Amazon "caught fire", in 1988-89, almost all the international press has mixed up two different kinds of environmental concerns, the deforestation and the burnings. This happened, first, because both problems started to be monitored through satellite data almost at the same time. Second, because, during some time, scientists thought they could estimate the deforested area from the burned data. Third, because the smoke of the burnings were interesting to drive the attention away from the air pollution records of some developed countries. And fourth, because most of the foreign (and many Southern Brazilian) journalists didn't know the Amazon forests and its ecological and land-use peculiarities.

Now, the scientists have reviewed their methods. Some Brazilian journalists and authorities learned to point the difference. Even international organizations - like the World Bank and the World Resources Institute - seem to recognize the mistake. But the average international media maintain the misunderstanding.

Deforestation is defined as the conversion of forest for timber harvesting and to other land uses, e.g. agriculture, cattle raising, establishment of settlements, or mining. It causes local climate changes and

biodiversity reduction and contributes to the greenhouse effect. The **burnings** are the main tools of farmers to dispose residuals of trees, to control weeds and pests, to renew pastures and to harvest some crops. It causes local and regional pollution; reduces visibility on highways and airports; reduces the soil biological fertility and increases the risk of erosion. It also contributes to the greenhouse house effect, but only when the tree trunks are burned, during the first years after deforestation. Repeated burnings do not contribute to a net release of carbon to the atmosphere.

The measurements of the two environmental problems are distinct. Almost every burned area, in Brazilian Amazon, was first deforested. Most part of the burned areas will be hit by the fire every year, again and again. But there is a lot of deforested areas that do not burn. This means one cannot measure the deforestation by the burnings, because there would be areas not considered at all, while other areas would be counted several times.

Monitoring Forest Fires in Roraima State in 1998

Due to an exceptional dry period, related to the El Niño phenomenon, the Roraima State, located on the farthest northern part of Brazil, on the Northern Hemisphere, was severely hit by extended burnings and a series of wildfires. The fires took place on its savannahs, grassland and deciduous forests in early 1998. Until late March the fire combat actions were based on NOAA images, sent from United States and retransmitted by INPE for the 7th Forest Army Command, at Roraima, since the fixed antennas for NOAA data reception in Brazil do not receive data from the Northern Hemisphere. The timelag between image acquisition and its reception by the military operation command at the fires fronts was more than one day. Therefore, its utilization was very limited, jeopardized by the delay.

By demand of the Terrestrial Operations Command (COTER), the NMA has moved its NOAA imagery reception antenna to Roraima. This allowed imagery acquisition several times a day. The time gap from the data reception and the delivery of images, maps and analysis to the operation command turned to be less than one hour. All the fire combat logistic was optimized, with meaningful practical results. Even after the first rainfalls, this monitoring allowed the detection of isolated fire spots and their effective extinction. All obtained data were made available on Internet (<http://www.nma.embrapa.br/projetos/queimadas>).

Final Comments

In Brazil, the fire detection and mapping system is available, on a regular basis, for ten years. This information, through the Internet, is reaching a large audience, that includes NGOs, media, research institutions, governmental organisms and policy makers.

In terms of active fire detection, despite the physical limitations of the NOAA-AVHRR data, ten years of monitoring allowed researchers to validate patterns for the spatial and temporal dynamics of the fires, in different regions in Brazil. Several research initiatives, fire management and environmental policies could be implemented. The reliability and availability of the current products on fire detection and mapping increased the national awareness of the media and public opinion. Lately, a special effort has been done - from research to governmental and non-governmental levels - in the search for agricultural technologies that can replace the use of fire in some Brazilian farming systems (http://www.nma.embrapa.br/projetos/qmd/tab_qmd.html).

The forest fires in Roraima showed how relevant it was to have a mobile antenna for NOAA-AVHRR imagery reception. Communication networks are not enough to deliver images, maps and analysis from a remote center of acquisition of data, specially when there is an emergency on a remote and isolated area, as are almost all national parks and environmentally important sites in Brazil. On those regions, with appropriate support and trained technicians, it is possible to acquire and process the images several times a day. As it happened at Roraima, the time gap from the data reception and the

delivery of images, maps and analysis for the operation command responsible for the fire combat can be less than one hour. All the fire combat logistic can be optimized, with meaningful practical results. Even after the first rainfalls, this monitoring allowed the detection of isolated fire spots and their effective extinction.

With the regular monitoring and mapping, at the Amazon region, it was easier to compare the active fire maps and the deforestation maps, produced with Landsat images, also in a regular basis. For many years, the National Institute for Space Research (INPE) has been promoting the interpretation of images from the Landsat satellite to monitor the evolution of the extent and rate of gross deforestation in the Brazilian Amazon. This effort has generated results for the 1974 to 97 period (http://www.inpe.br/Informacoes_Eventos/amz/amz.html). This comparison showed that most part of the burnings occurred either on *cerrado* areas, or on occupied areas in the Amazon Southern and Eastern border, specially along the highways, where there are settlers and farmers. About 75% of the deforested areas are located within 50km of the highways and roads. Also, 87% of the newly deforested areas (cut down on the 90s) are within 25km of the old deforested areas (cut down until 1978). This means there are no new agricultural frontiers and there have been no big expansions, but, rather, a vegetative growing of the human presence in the region.

The public and policy makers want a fire product that allows, not only active fires detection and mapping, but also a reasonably accurate estimation of area burned. The NMA is starting a research proposal for the future use of the WFI camera, on board of the CBERS-1 (China-Brazil Earth Resources Satellite) (<http://www.inpe.br/programas/cbers/english/index.html>). The WFI has a ground swath of 890 km which provides a synoptic view with spatial resolution of 260m. The Earth surface is completely covered in about five days in two spectral bands: 0.66 μm (green) and 0.83 μm (near-infrared). This use of the WFI will provide, if a development of a burned area algorithms is achieved, the way to get an area burned fire product on the same information network.

There is also a high correlation between burnings and rainfall. Every time it rains out of season, burnings are delayed or reduced. One can almost tell the weather in different parts of Brazil, just looking at the burnings blanks on daily maps. That also means some burnings reductions self attributed by governmental institutions to its "fiscalization" are clearly linked to the occurrence of unexpected rainfalls. The rainfall explains, yet, some decreases on the total fire points detected by the monitoring system, during the last ten years. It is worth to remark that, even if the burnings number changes, the spatial pattern usually remains the same, showing how closely is the fire related with structural and permanent factors and how distant it is from accidents.

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