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

E. E de Miranda.[1], L. John[2]

Abstract

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. Linking remote sensing, digital cartography and electronic communication, the Environmental Monitoring Center - NMA - and the National Institute for Space Research - INPE - research teams have been conducting a constant and effective monitoring of burned areas in the whole Brazilian territory, since 1989. The Agência Estado (AE) News Wire Service and the NGO Ecoforce started a public campaign to stop the Amazon burnings, using this data. All the mapping system is available on Internet, since 1991. One may consult weekly, monthly or annual maps, of either whole Brazil or its regions and states. It's the biggest data bank on burnings available on Internet (in portuguese and english) and the most visited site on active fires (http://www.nma.embrapa.br/projects/qmd_us/index.html), with an average of 150,000 hits per year, due to its reliabillity and avalability . The system routines are frequently updated and may be helpful to understand the limitations of remote sensing data on fire detection and mapping. The detection and mapping homogenity allowed NMA researchers to study the space and time patterns of the burnings.

The NMA team also does an hydrologic monitoring, based on satellite transferred 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 around 12,000 pages a week on Internet (http://www.agrocast.com.br). The follow up of over 450 farmers for the last 10 years, on the amazon region, has also helped to understand the causes of interannual burnings flutuactions, their relation with 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 NMA team was decisive on supporting the *in situ* fire combat, at Roraima state, in early 1998.

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 lighnings, not even if someone sets fire on them. Almost all the different kinds of forests that occurr in the Amazon Basin and in the Atlantic Costal areas are too humid to burn. Many of them - like igapó forests or palmtree forests - are litterally under the water, six to eight months a year. The "highlands" vegetation - called *terra firme* forests - are the driest ones. But, even there,

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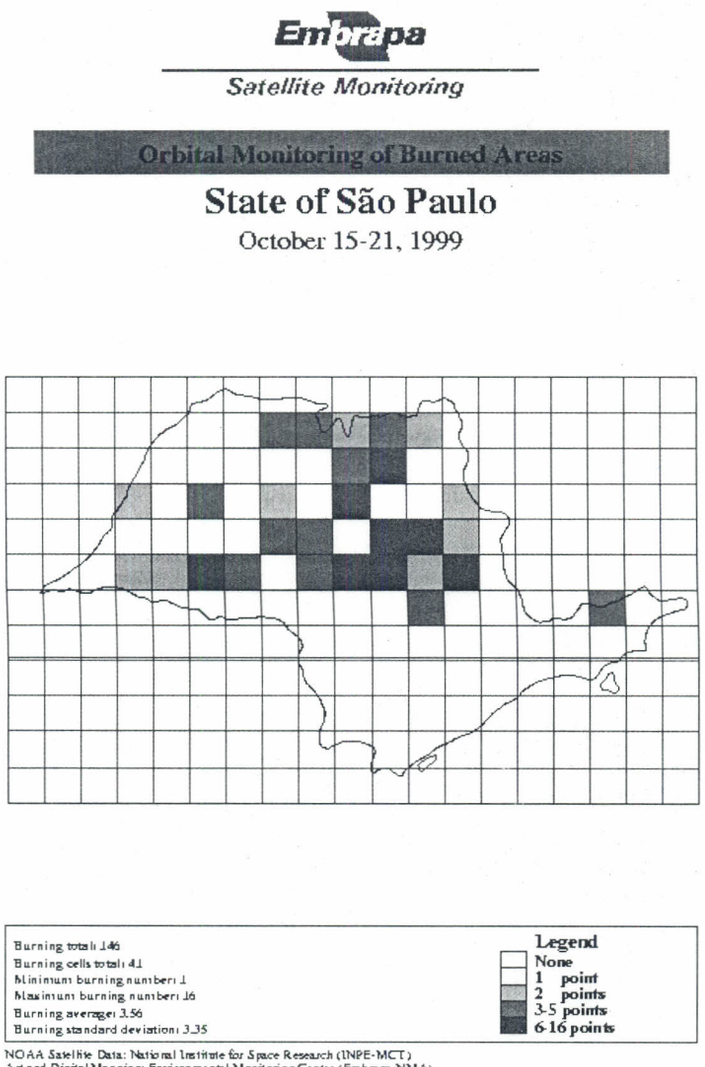
accidental fires only occur if the vegetation is disturbed: full of loggers and hunters trails, where dry branches and leaves are exposed to the sun and after a very dry season. On the last 10 years of burnings monitoring huge wildfires on uncut forested areas only happened twice: at a very disturbed area near Santarem, state of Pará, and at Roraima State; both during severe dry seasons, due to El Niño episodes. One way to study this phenomenon is to consult weekly (Figures 1 and 2), monthly (Figures 3 and 4) and annual burning maps (Figures 5 and 6).



Figures 1: Examples of weekly burning maps of Brazil

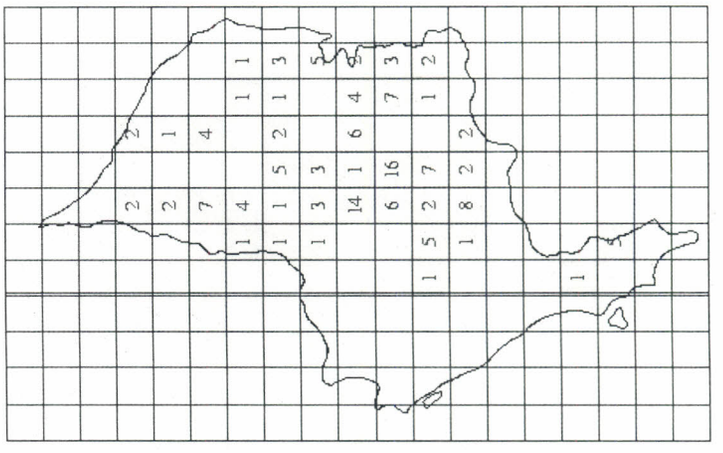
Embrapa

Satellite Monitoring

Orbital Monitoring of Burned Areas

State of São Paulo

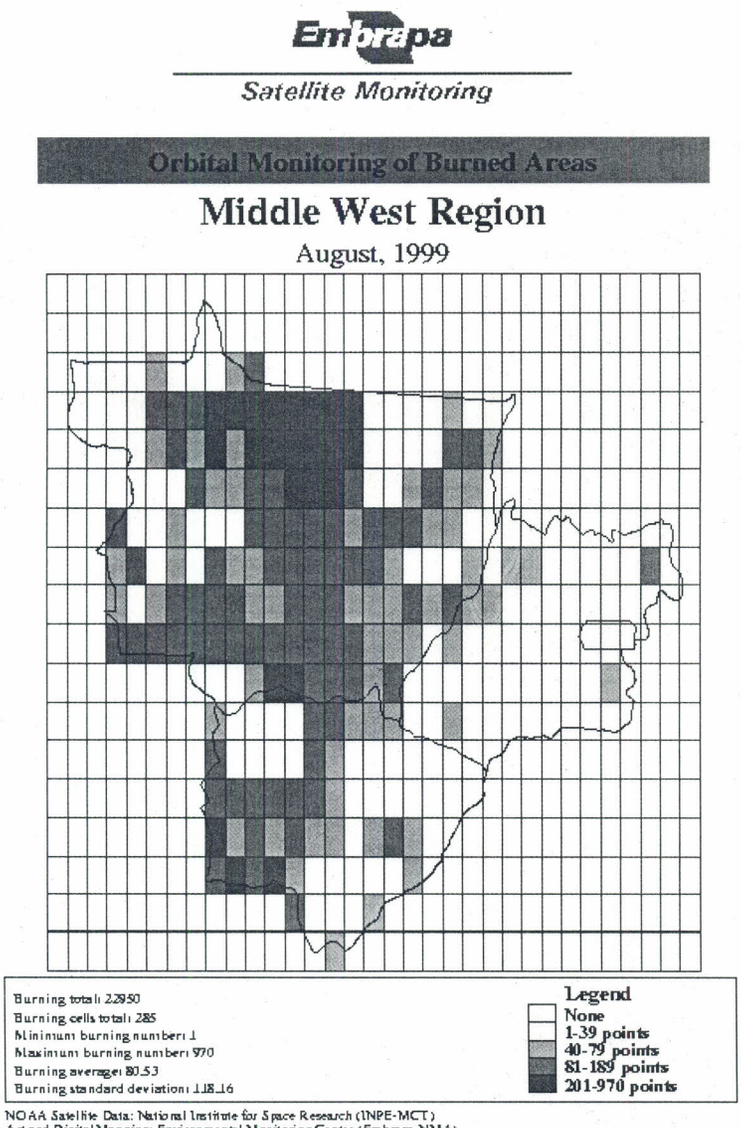
October 15-21, 1999



Burning total: 146
Burning cells total: 41
Minimum burning number: 1
Maximum burning number: 16
Burning average: 3.56
Burning standard deviation: 3.35

NOAA Satellite Data: National Institute for Space Research (INPE-MCT)
Art and Digital Mapping: Environmental Monitoring Center (Embrapa-NMA)
Satellite Data Interpretation and Environmental analysis (ECOFORÇA)
Diffusion: Agência Estado (AE)

Figures 2: Examples of weekly burning maps of Brazil



Figures 3: Examples of monthly burning maps of Brazil

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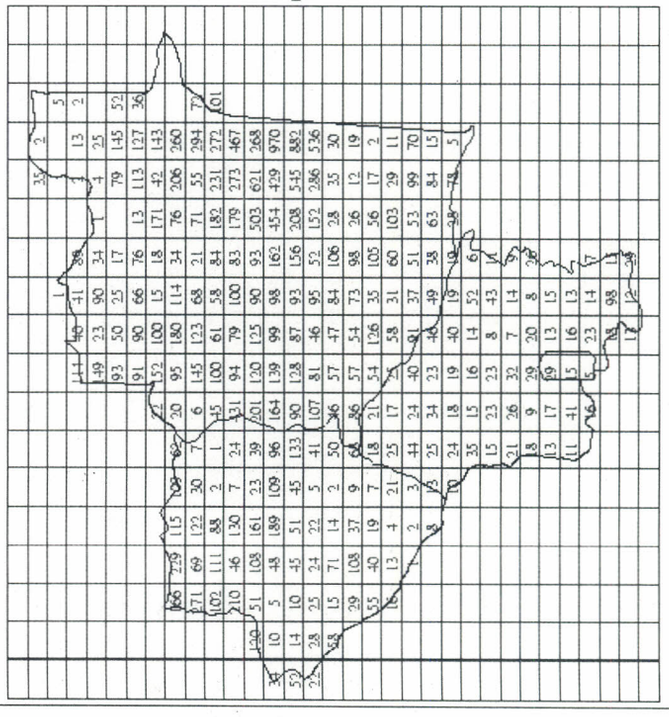
Satellite Monitoring

Orbital Monitoring of Burned Areas

Middle West Region

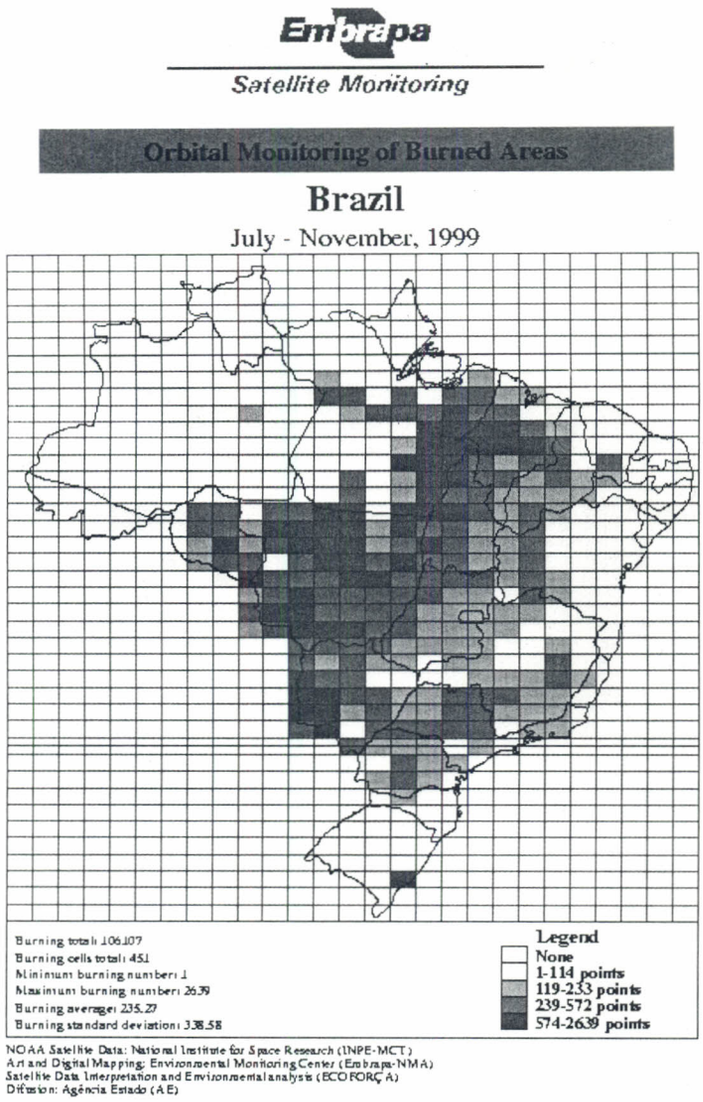
August, 1999



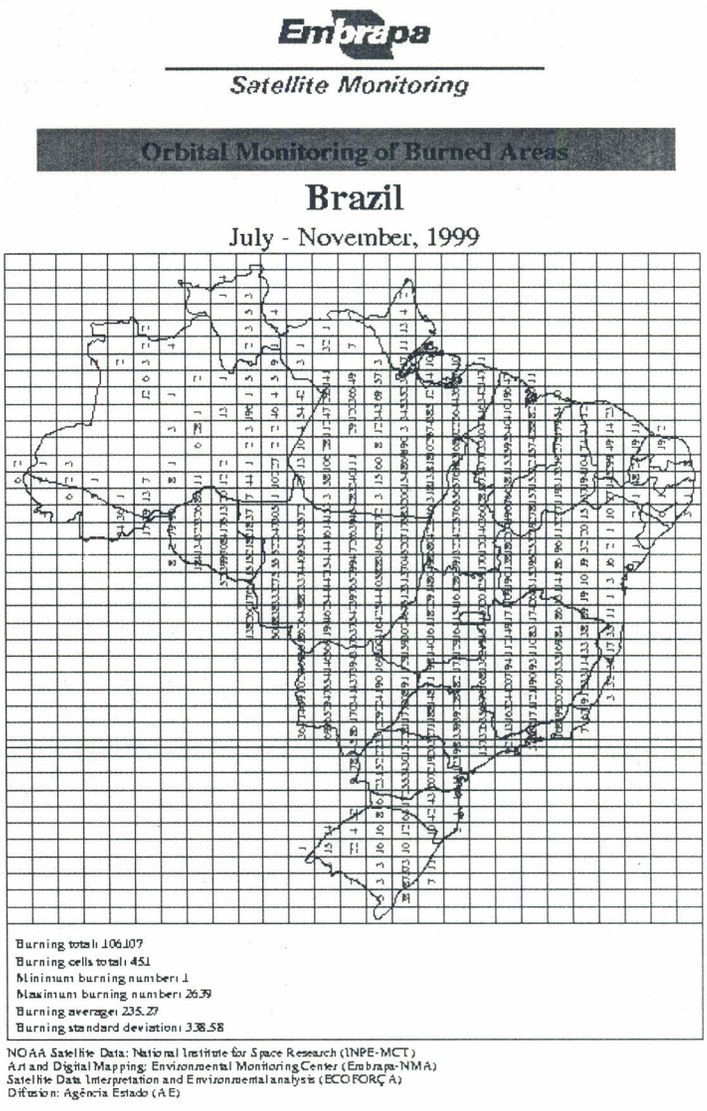
Burning totals 22950
Burning cells totals 285
Minimum burning numbers 1
Maximum burning numbers 970
Burning averages 80.53
Burning standard deviations 118.16

NOAA Satellite Data: National Institute for Space Research (INPE-MCT)
Art and Digital Mapping: Environmental Monitoring Center (Embrapa-NMA)
Satellite Data Interpretation and Environmental analysis (ECOFORÇA)
Diffusion: Agência Estado (AE)

Figures 4: Examples of monthly burning maps of Brazil



Figures 5: Examples of annual burning maps of Brazil



Figures 6: Examples of annual burning maps of Brazil

At the Brazilian Amazon forests the trees have to be cut down, then dryed during months, to catch fire. That's why Brazilians distinguish burnings (*queimadas*) from great fires or wild fires (*incêndios*). Burnings are made purposely. Not because Brazilians are incendiaries, but because the fire is the cheapest way to reduce the trees leftovers, to control weeds and pests, to renew pastures and to harvest some crops (specially sugar cane). Wild fires can be the result of uncontrolled burnings, that reach the native vegetation, besides all other weel known fire causes: cigarettes on roadside grasslands, glass under sunlight, lightnings, criminal fires...

Some 20% of the Amazon region, however, is covered by grasslands or savannahs with small dispersed trees, called *cerrados*. Like the African savannahs, this vegetation does burn. But, still there, natural fires are minory. 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 INPE, the National Institute for Space Research, in São Paulo state, Brazil, used the temperature sensor of the north american meteorologycal satellite to localize burned and burning areas. Their purpose was to produce a list of geographycal 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 and the Agência Estado (AE) news wire service started a public campaign to stop the Amazon burnings, using this data.

The burnings monitoring became a routine. Since 1988, burnings are listed and counted every day, during all dry season (from June to October or November), not only on the Amazon Basin, but all over Brazil and, sometimes also on neighbor 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 a NGO called Ecoforce[3], in order to produce maps that could be easily understood by general public. Developing activities, through agreements and scientific partnerships, the NMA adjusted and spreaded 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.

Current products and information networks

Since 1991, weekly burnings maps were published on several newspapers with an interpretation, as a public service of information. 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. It`s 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.

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The follow up of over 450 farmers for the last 10 years, on amazon region, has also helped to understand the causes of interannual burnings flutuactions, 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 NMA team was decisive on supporting the *in situ* wildfires combat, at Roraima state, in early 1998.

[3] Ecoforce - Research & Development (http://www.ecof.org.br)

Deforestation X 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 agression: the deforestation and the burnings. This happened, first, because both problems started to be monitored throught satellite data almost at the same time. Second, because, during sometime, scientists thought they could estimate the deforested area from the burned data. Third, because the burning's smoke were interesting to hide some developed countries pollution records. And, fourth, because most of the foreign journalists (and many Brazilian Southern journalists) didn't know the Amazon forests and its ecologycal 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.

The deforestation is the cutting of the forest for timber, settlements, agriculture, cattle raising or minning. It causes local climate changes and biodiversity reduction, but does not contribute to the greenhouse effect. The burnings are the main farmers tool to reduce the trees leftovers, 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.

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 a series of burnings and wild fires. The fires took place on its savannahs, grassland and decidous 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, once the Brazilian fixed antennas for NOAA data reception did not reach the North Hemisphere. The time gap from the image acquisition moment and its reception, by the militar operation command, at the fires fronts, was over a day. Therefore, its utilization was very limited, jeopardized by the delay.

By demand of the Terrestrian Operations Command (COTER), the NMA has moved for Roraima its NOAA imagery reception antenna. That allowed the imagery acquisition several times a day. The time gap from the data reception and the delivery of images, maps and analysis for the operation command turned to be less than one hour. All the fire combat logistic was optimized, with meaningfull practical results. Even after the first rainfalls, this monitoring allowed the detecction of isolated fire spots and their efective 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, governamental organismes 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 reasearch iniciatives, fire management and environmental policies could be implemented. The reliability and availability of the corrent 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 governamental and non governamental levels - in the search for agricultural technologies that can replace the fire on its several uses at the different 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 reception antenna for NOAA imagery. Communication networks are not enough to deliver images, maps and analysis from a remote center of acquision 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 trainned technicians, it is possible to adquire 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 meaningfull practical results. Even after the first rainfalls, this monitoring allowed the detecction of isolated fire spots and their efective 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 wants 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 futur 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 5 days in two spectral bands: 0,66 μm (green) and 0,83 μm (near infra-red). This use of the WFI will provide, if a developement 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 atributed by governamental institutions to its "fiscalization" are clearly linked to the occurence 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.