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Hot pixels and public policy in southwestern Amazonia: the role of accuracy assessment in dissemination of satellite-derived estimates of fire events

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Introduction

During the intense drought of 2005 in southwestern Amazonia, with resulting widespread use of fire by the rural population, the INPE Internet database of fire pixels was frequently accessed by different segments of society and became an important tool in management policy decisions concerning forest fires in the eastern region of the state. (Figure 1). Based on field experience this paper discusses how accurate, complete, and useful the satellite-derived fire data are, and how valid their use is by the government and officials dealing with emergency situations.

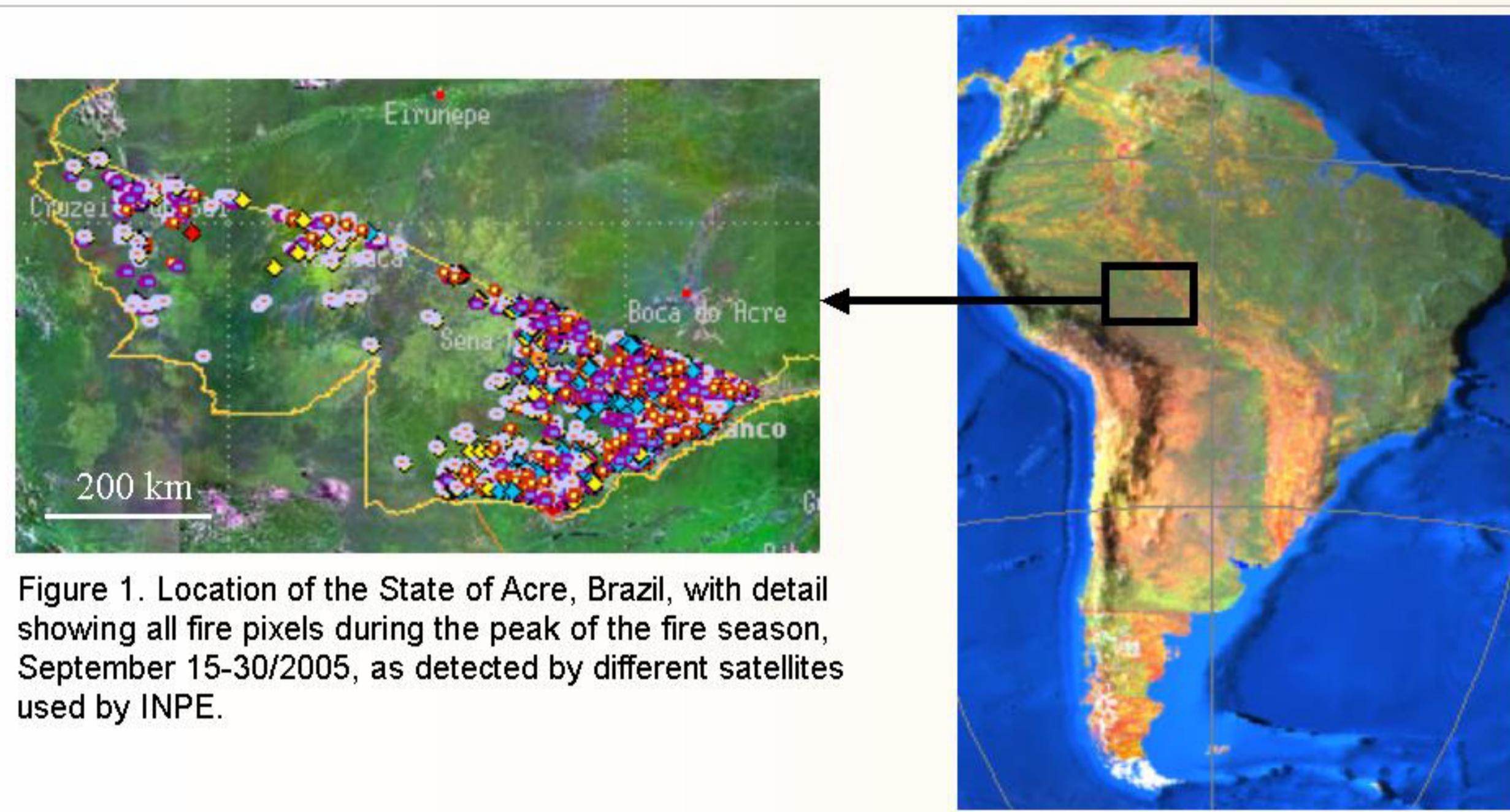


Figure 1. Location of the State of Acre, Brazil, with detail showing all fire pixels during the peak of the fire season, September 15-30/2005, as detected by different satellites used by INPE.

Material and Methods

Helicopter overflights and road observations in 2004 had shown that omission errors for hot pixel detection of fire events were high in eastern Acre State. Inter-comparison of satellites for fire detection in 2005 indicated that fire detection suffers frequently from limited or missing satellite coverage (NOAA and MODIS) that cause errors of omission on individual days. Consequently, we used hot pixels from multiple satellites (www.cptec.inpe.br/queimadas), combined with Rapidfire products (<http://rapidfire.sci.gsfc.nasa.gov/> subsets/ ?AERONET_Rio_Branco) to determine patterns of fire events.

Chronology

- Aug/02/2005 "Página 20" newspaper article "Drought in the River and Fire in the Forest" published to alert local society -Figure 2.
- Aug/08/2005 Meeting of the state committee on fire prevention.
- Aug/17/2005 State issues Decree # 04/05 prohibiting vegetation burning in Acre.
- Aug/31/2005 Dramatic increase of fire pixels in Acre.
- Sept/21/2005 State of Emergency adopted for 11 counties in Acre - Figure 3.
- Sept/28/2005 Reinforcement of 120 fire fighters arrives from Brasilia
- Oct/11/2005 State issues Decree # 07/05 suspending the prohibition to burn in Acre.

The public's interest in such information grew in 2005 as an extended dry season created a 34-year low in river levels and made regional forests inflammable. During August and September 2005, in presentations to the Acre State Fire Committee, to Civil Defense representatives of Brazil, Bolivia and Peru, and in radio and TV interviews, we frequently received direct questions as to the reliability of hot pixels as detectors of fire events. These data were then used to help justify a month-long fire moratorium declared by Acre's governor on 18 August.

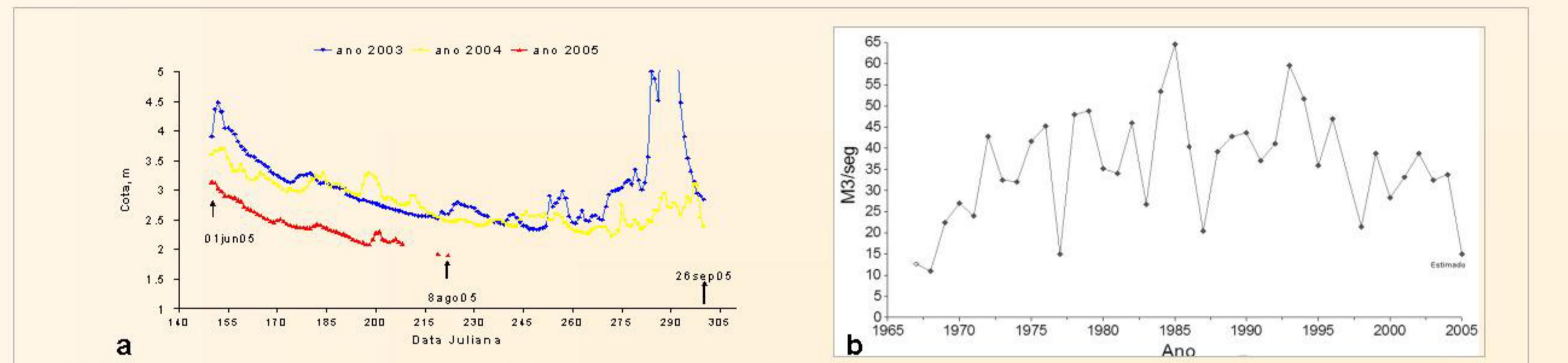


Figure 4. (a) Level of Acre River in the last 3 years (partial for 2005). (b) Water flow for the River Acre since 1967. Source: Coordenadoria de Defesa Civil do Estado do Acre.

During June/01-October/15, 2004, the NOAA-12 satellite (and INPE algorithm) detected 900 fire pixels for Acre, while in the MODIS images from the Terra and Aqua satellites (NASA & UMD algorithm) registered 4,382 fire pixels in the same period. In 2005 NOAA-12 and the two MODIS sensors detected 4,722 e 7,729 fire pixels, respectively.

Figure 5. Bi-weekly evolution of the fire pixels detected by the NOAA-12 satellite and by the combined MODIS Terra and Aqua satellites during the period June/01 to October/15 in the years 2004 (a) e 2005 (b). Source: www.cptec.inpe.br/queimadas

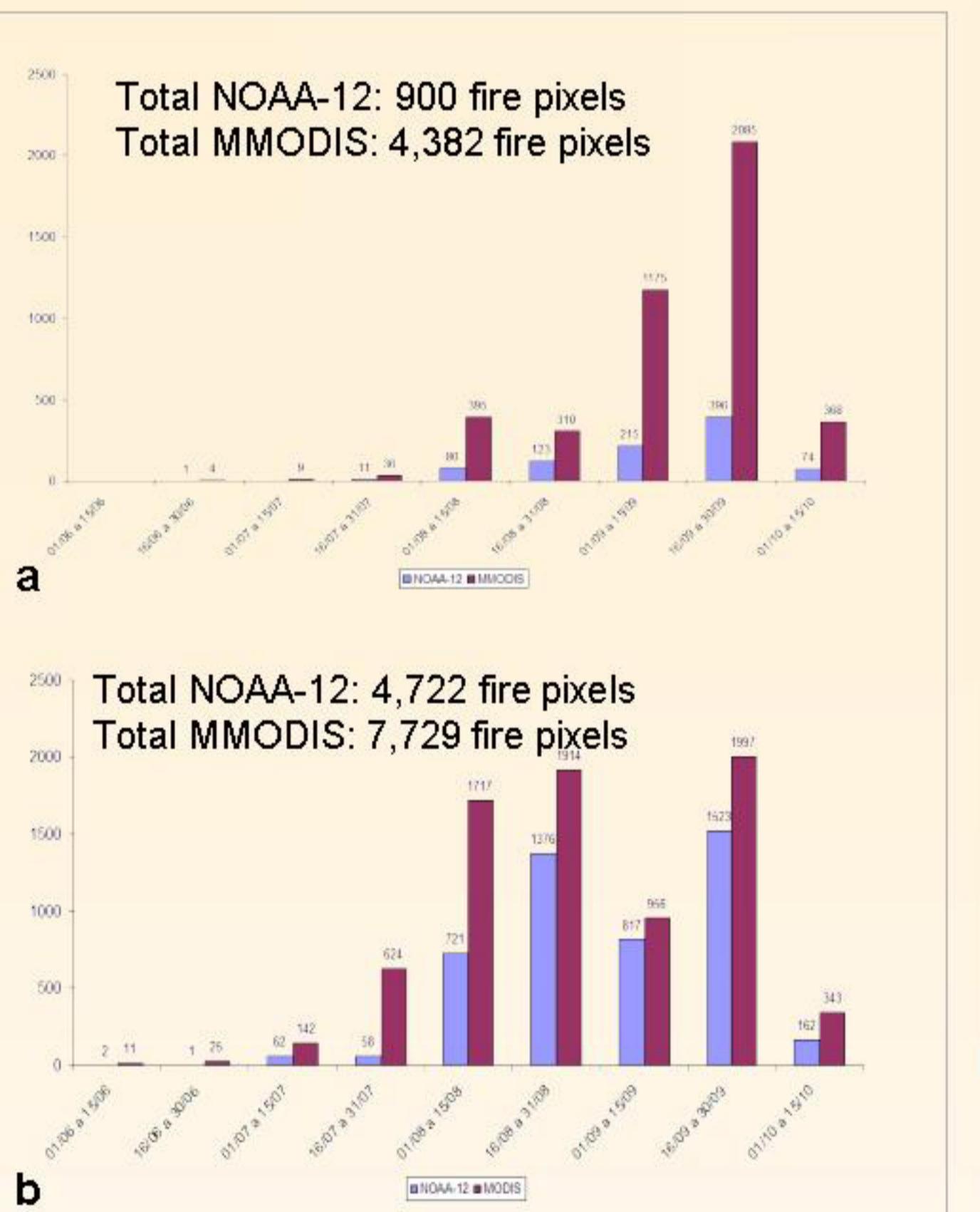


Figure 2. Newspaper clipping, "Drought in the River and fire in the forest" from "Página 20".

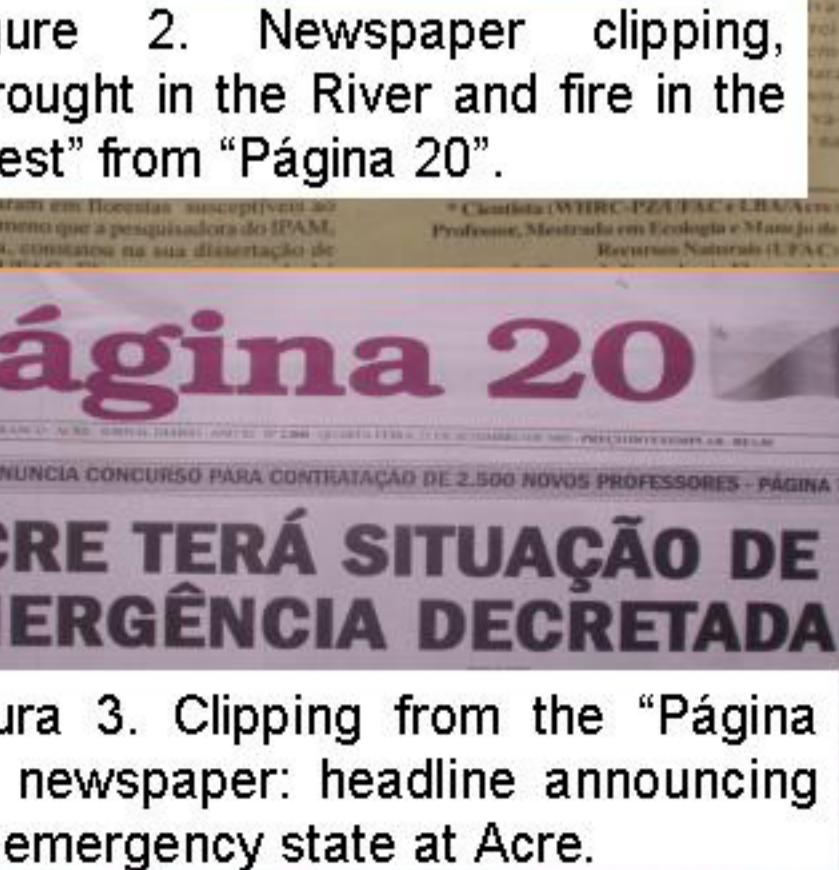


Figura 2. Clipping from the "Página 20" newspaper: headline announcing the emergency state at Acre.

Results

15 overflights with an helicopter and an airplane were made during the months of September and October, when areas of burned pastures and forests in the state of Acre were geo-referenced. For each mission an average of 100 points were acquired with a GPS, of which about half referred to active fires that took place mainly in natural forests. Figure 6 shows the flight on September/28, between 09:00 e 12:30, local time (GMT-05:00). 40 events of active fires were analyzed and the omission errors of the NOAA-12 e MODIS (Terra and Aqua) images, were in the 90% and 100% range, respectively. This very high value was interpreted as an extreme case, when the satellite detections were precluded by cloud cover, low fire intensity below the sensor detection limit, and mainly, by difference in the timing between the flight and the satellite imaging.

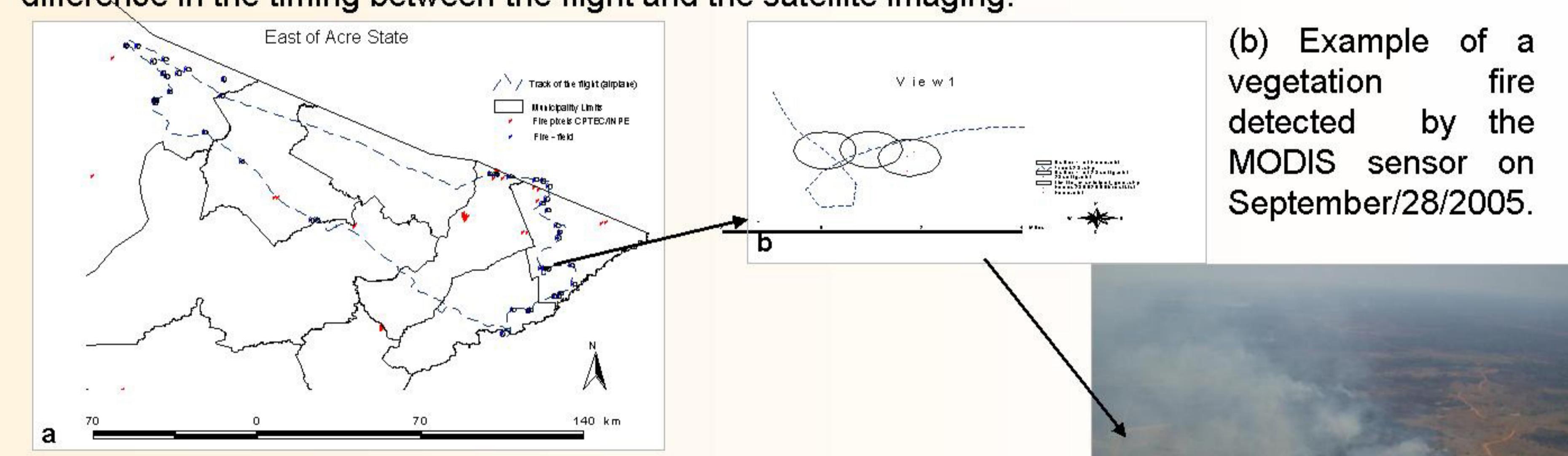
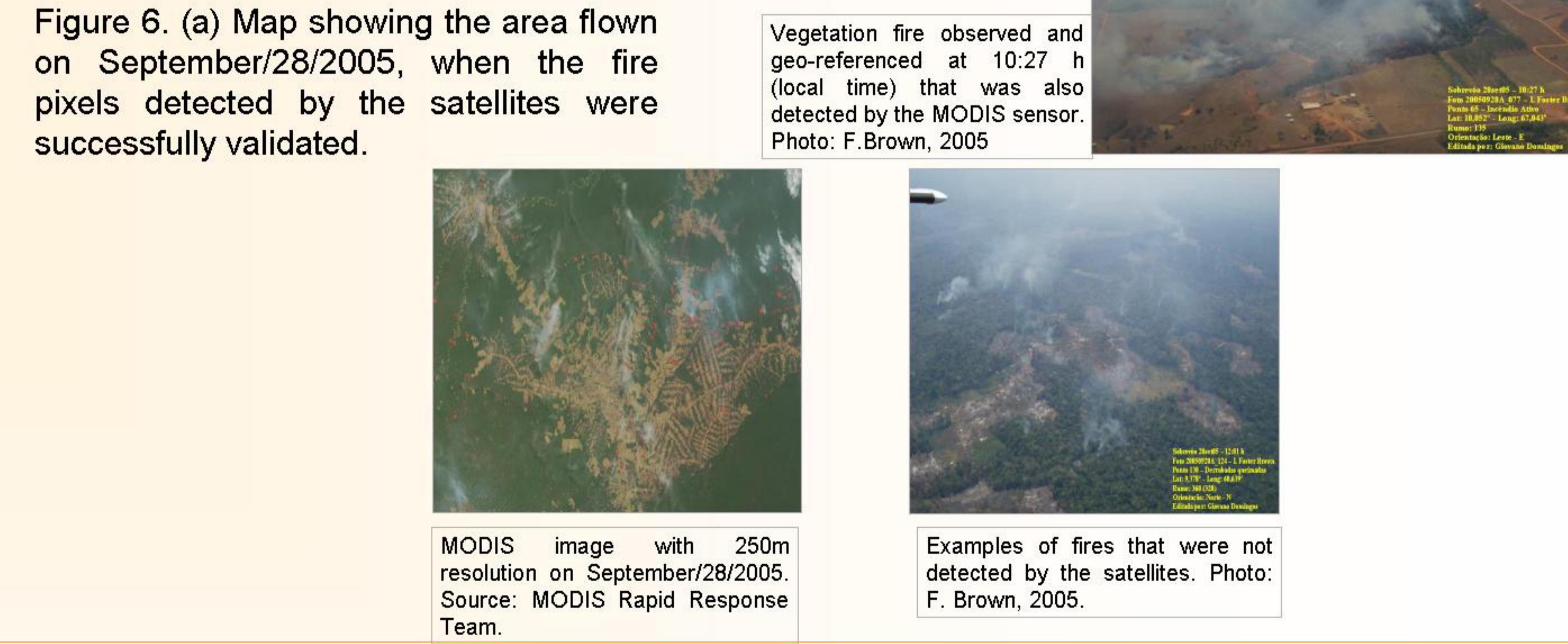


Figure 6. (a) Map showing the area flown on September/28/2005, when the fire pixels detected by the satellites were successfully validated.



Conclusion

• Omission errors can be very high, up to 100% if just one satellite overpass is used because of lack of coverage for the area of interest, cloud cover, small low energy fires and inadequate timing. When multiple satellites are used, which in this case were NOAA (12,14, 15, 16, 17 and 18), Terra/Modis, Aqua/Modis and the geostationary GOES-12, omission errors are reduced considerably. Commission errors were not found. Location errors were not significant in terms of locating the fires from the helicopter, airplane and ground vehicles; for accurate mapping, however, they are limited by the navigation of the satellite imagery which is usually of the order of one to three km. Analysis of the several hundred aerial photos taken during the peak of the fire events will help establish bounds on the commission, omission and locational errors.

• In Acre, the multiple satellite data set was essential to help establish the moratorium on burning, establish and then end the state of emergency. During late September and early October this data set was used daily in the Civil Defense Situation Room to direct fire fighting crews and set up monitoring overflights.

• The use of multiple satellites provides adequate information about where areas are affected by fire and also about the extent and temporal evolution of the use of fire. In regions where no other means exist to monitor the fires, as is the current situation in Acre and Amazonia in general, multiple satellite data are the only available tool.