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A COMPARISON OF THE GOES-8 ABBA AND INPE AVHRR FIRE PRODUCTS FOR SOUTH AMERICA FROM 1995-2000

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1. INTRODUCTION

Since 1995 the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin - Madison has been using the Geostationary Operational Environmental Satellite (GOES)-8 Automated Biomass Burning Algorithm (ABBA) to monitor diurnal biomass burning activity throughout South America during the height of the fire season (June - October). The Brazil Instituto Nacional de Pesquisas Espaciais (INPE) has monitored fire activity in Brazil using the Advanced Very High Resolution Radiometer (AVHRR) sensor on board the NOAA-12 polar orbiting satellite since 1987. This paper presents a comparison of these two fire products during each fire season from 1995 to 2000. It will include an overview of the spatial and temporal observing characteristics of both the GOES and AVHRR instruments and discuss advantages of each system for fire identification in the region. This comparison will show that the higher temporal resolution of the GOES and the higher spatial resolution of the NOAA AVHRR provide complementary information about fire activity in South America.

2. THE GOES-8 ABBA AND NOAA AVHRR INPE FIRE PRODUCTS

The GOES-8 ABBA is a fully automatic fire detection algorithm which uses the visible (near 0.65 micron), short-wave infrared window (near 4 micron), and the long-wave infrared window (near 11 micron) data, along with moisture information from other data sets, to identify and characterize sub-pixel fire activity. The GOES-8 spatial resolution is 4 km at the sub-satellite point, but studies have shown that GOES-8 can accurately identify fires a few acres in size (Menzel and Prins, 1996a; 1996b; Prins and Menzel, 1996a; 1996b). The geostationary orbit of GOES-8 provides the opportunity to view and estimate fire activity over portions of South America every half-hour, with complete continental coverage at three-hour intervals. These data can then be studied individually or combined in a daily unique fire composite. Fire pixels from four different time periods (1145, 1445, 1745, and 2045 UTC) are combined in the daily unique fire composite. If a fire pixel is observed in more than one time period, only one occurrence of the fire pixel is selected for the daily unique fire pixel composite. Typically, over 80% of the fire pixels observed in one time period are not observed at any of the other three observation periods (Prins et al., 1998; 2000; 2001).

The AVHRR sensors on the NOAA polar orbiting series of satellites have a spatial resolution of 1 km at the sub-satellite point. Generally, INPE reports fire pixels from the NOAA-12 sensor with the exception of 1-14 August 1995, when the NOAA-14 sensor was used to report the fire pixels. The fire detection method employed by INPE is a digital nonsupervised clustering algorithm which selects pixels as burning if the AVHRR radiometric temperature exceeds 46°C (Setzer and Pereira, 1991). Data from the afternoon overpass are used to identify fire pixels. Fire counts from INPE are provided in a weekly email in grid format. They consist of a 7-day sum at 0.5-degree increments from 7°N to 40°S and 75°W to 34.5°W. A second receiving station, added in 1999, increased the observation region. However, the smaller region is used in this study for consistency between years.

Previous studies have characterized the GOES-8 observed diurnal, spatial, seasonal, and interannual trends in fire activity, clouds, and aerosols throughout South America for each fire season (June –October) from 1995 to 1999 (Prins et al., 1998; 2000). This study will focus on the combined spatial and temporal distribution of fires provided by GOES and AVHRR for the months of August-October 1995-2000. This captures the peak of the burning season and minimizes the number of missing days.

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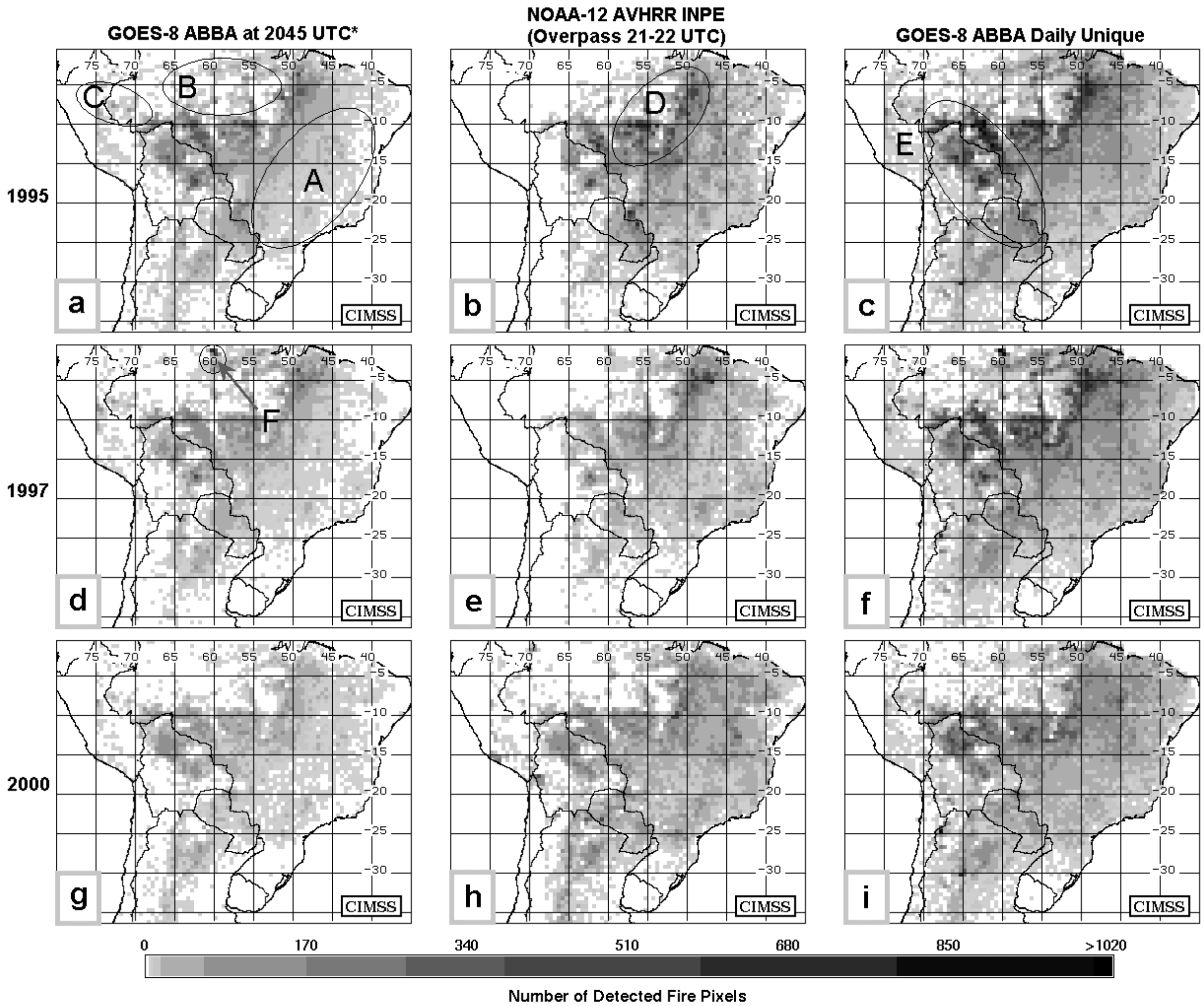

*August 1-14, 1995: GOES-8 1745 UTC data used to correspond to the NOAA-14 overpass (17-18 UTC) used for the INPE fire product

Figure 1: A comparison between the GOES-8 ABBA and NOAA-12 AVHRR INPE detected fire pixels for the months of August-October 1995, 1997, and 2000. The grid spacing is 0.5 degrees.

3. FIRE DISTRIBUTIONS IN SOUTH AMERICA AS OBSERVED BY GOES and NOAA AVHRR IN 1995, 1997, AND 2000

Fire distributions for all the years from 1995-2000 were plotted, and three representative years are shown in figure 1. The GOES-8 ABBA fire product at 2045 UTC (fig 1a, 1d, 1g), the NOAA-12 AVHRR INPE detected fire pixels from the afternoon overpass (fig 1b, 1e, 1h), and the GOES-8 ABBA daily unique fire product (fig 1c, 1f, 1i) are shown for comparison. The most active year was 1995 followed by 1997. The 1997 season was also selected to show the effect of drought in northern Amazonia. Both sensors observed less burning in 2000, providing an opportunity to compare a year with lower activity to the peak years. Examples from these three years show that satellite regional coverage, view angle, time of observation, and sensor spatial resolution all affect fire detection.

Overall, the NOAA-12 AVHRR INPE algorithm detects more fire pixels in a single time period than the GOES-8 ABBA at that same time period. This pattern is especially pronounced in the cerrado regions (region A) where narrow flame fronts are difficult to detect with GOES-8 due to its reduced spatial resolution. It is sometimes possible for GOES-8 to detect cerrado fires in the initial flaming stage, and the GOES-8 ABBA daily unique fire product shows many fires in the cerrado region which were missed in the 2045 UTC GOES-8 ABBA, but reported in the NOAA-12 AVHRR INPE fire pixel product. The two instruments tend to show the same patterns in regions where the view angle for both sensors is low and the coverage for AVHRR is good.

Burning along roads and the Amazon river (region B) is observed in all of the images, but the single time period distributions neither capture the extent nor the intensity of activity. Every year fires along the road being constructed west from Rondonia (region C) to the Pacific coast appear in the GOES-8 ABBA fire composites. However, the road is not well defined in the NOAA-12 AVHRR INPE fire pixel product except in year 2000. The detection of burning along the road in 2000 by the AVHRR sensor resulted from the addition of a western receiving station providing more consistent information in western South America. The sensors also consistently show that most fire activity is concentrated in the “arc of deforestation” (region D). The GOES-8 ABBA also indicates that the borders between Bolivia and Rondonia, and Acre and Paraquay (region E) are places of more persistent activity. In peak years the GOES-8 ABBA 2045 UTC fire pixel product compares well with the NOAA-12 AVHRR INPE fire pixel product. However, the single time period quantities underestimate the number of fires reported throughout the day. In addition, the NOAA-12 AVHRR INPE product underestimates burning along the border regions as compared to the GOES-8 ABBA daily unique and in 1997 and 2000, the GOES-8 ABBA 2045 UTC data. It is near these border regions, close to the GOES-8 sub-satellite point of 0°N and 75°W, where the view angle for GOES-8 is optimal. The 1997 drought in Northern Amazonia caused a lake north of Manaus to dry (region F). The exposed timber on the bottom of the lakebed subsequently caught fire. Both sensors captured this event, but the AVHRR did not observe as many instances of that fire. The fire burned for days, but the AVHRR observed the Manaus region less than 2% of the time from August-October 1997.

4. COMPARISONS OF FIRE QUANTITIES DERIVED FROM GOES AND NOAA AVHRR FROM 1995-2000

The number of fires reported by both GOES and AVHRR are displayed in table 1. Since each year covers a different date range, the 1995 totals are a combination of two different time periods, and a second AVHRR receiving station was added in 1999, interannual comparisons of the totals are not possible. Two of these caveats produce results that are easily distinguished in the data shown in table 1. First, the contribution of the 1745 UTC period to the GOES-8 ABBA daily unique composite is significant. Therefore, the fire pixel totals for both GOES-8 ABBA at a single time period and the NOAA-12 AVHRR INPE are closer to the total fire pixel estimates of the ABBA daily unique algorithm in 1995 than in other years. Secondly, the 1999 and 2000 INPE totals are closer to the GOES-8 ABBA daily unique totals in the respective years, reflecting the extended coverage of the AVHRR.

The GOES-8 ABBA daily fire pixel counts range from 1.5 to 4.5 higher than the single time period NOAA-12 INPE AVHRR observations between 21-22 UTC. The ratio of ABBA daily unique fire pixels to the single time period ABBA estimates is even higher, ranging from 3 to 5. Grid subsets were used to allow a comparison between the GOES-8 ABBA daily unique and the NOAA-12 AVHRR INPE fire pixel products where the NOAA-12 AVHRR has better coverage (table 2).

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Table 1

Year	Julian Day (NOAA Overpass)	INPE	GOES Single Time Period	GOES Daily Unique
1995	209-226 (17-18 UTC) 227-303 (19-22 UTC)	134417	86827	267584
1996	208-305 (19-22 UTC)	45137	42393	205293
1997	213-304 (19-22 UTC)	66097	56449	260696
1998	213-309 (19-22 UTC)	110675	60326	248018
1999	213-304 (19-22 UTC)	141516	62340	247583
2000	214-305 (19-22 UTC)	103272	29107	169095

Table 2

	Fire Pixel Counts (Ratio of GOES/INPE)		
	Entire Grid	60% Coverage	80% Coverage
1995	2.0	1.3	1.1
1996	4.5	3.0	2.5
1997	3.9	2.5	2.2
1998	2.2	1.6	1.4
1999	1.7	1.7	1.8
2000	1.6	1.6	1.6

When the NOAA-12 AVHRR views a region at least 60% of the time, the ratio of GOES-8 ABBA daily unique fire pixel observations to NOAA-12 AVHRR INPE fire pixels decreases to a ratio ranging from 1.3 to 3. At 80% coverage, the ratio is between 1.1 and 2.5. The lack of variability in the ratios for 1999 and 2000 are a result of the increased AVHRR coverage following the addition of the second receiving station. Prior to 1999, less than 30% of the study area had 60% or greater overpass coverage. This value increased to 50% in 1999 and to 91% in 2000.

The 1 km resolution of the NOAA-12 AVHRR generally provides the capability to detect more fires at a single time period, and provides enhanced information where the overpass coverage is high. However, the ability to capture fires as they burn throughout the day is also extremely important since previous studies have shown that many fire signatures are often only intense enough to be detected by satellite for a short time period (Prins et al, 1998; 2000).

5. CONCLUSIONS

Comparisons of the NOAA-12 AVHRR INPE and the GOES-8 ABBA fire pixel products show similar features in the spatial distribution of fires in South America. The higher spatial resolution of the NOAA-12 AVHRR results in more fire pixel observations at an instantaneous point in time and allows for the identification of fires with smaller flaming fronts. Since GOES-8 is in geostationary orbit, it can capture the diurnal cycle of anthropogenic fires for better definition of regions with strong temporal signatures. It is also able to capture some fires in the flaming stages that are below the threshold of detection in later time periods. The consistent and complete continental coverage of GOES-8 allows it to observe fires in regions not adequately covered by a single overpass of the NOAA-12 satellite. The addition of the second NOAA polar orbiting satellite receiving station in 1999 made a significant impact on regional coverage. GOES-8 and AVHRR provide distinct and complementary capabilities for monitoring fire activity in South America.

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