Analysis of Long-term Fire Dynamics and Impacts in the Amazon Using Integrated Multi-source Fire Observations

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Biomass burning is a major factor contributing to land use and land cover change globally and in particular in South America and the Amazon region. Space-borne sensors provide valuable information on active fire detection; however, their application for quantitative studies of fire activity has been limited due to variations within and among existing systems. In this study, which is part of the LBA-Eco Phase III experiment, we developed methods to allow multi-year analyses of fire dynamics and impacts with a focus in Amazonia. The proposed research aimed to create a standardized fire data record for Amazonia derived from multiple satellite sensors and to apply the resulting data set for the quantification of fire impacts in the region. Here we present some of the results from this project including: (i) the analyses of biomass burning in Amazonia using multi-sensor data (ASTER, ETM+, MODIS, GOES), (ii) the development of an improved active fire detection product to run on geostationary imagery providing additional information to help the interpretation of the fire data, (iii) the production of a longer term active fire time series for Amazonia as a result of the reprocessing of 10+ years of 30-min GOES imager 4km data using the refined fire detection product algorithm, and (iv) the production of baseline biomass burning emission estimates for South America using the new fire data record.

Near simultaneous MODIS, and GOES active fire data (MOD14 and WFABBA, respectively) were analyzed using ASTER and ETM+ reference fire information [1,2]. Aside from the expected difference in the instantaneous omission errors resulting from contrasting instrument characterisitcs (namely spatial resolution), the MODIS and GOES fire products showed very similar false alarm rates. Commission errors were largely a function of vegetation condition and peaked at approx. 35% for areas with high percentage tree cover. However, a large majority of the false alarms were found coincident with fresh burn scars from previous fires. Overall fire-unrelated false alarm rates was only ~2%.

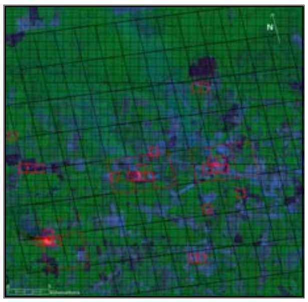

Figure 1: ASTER scene (RGB bands 8-3-10) acquired on 07 Aug 2004 1407UTC over central Mato Grosso state in Brazil (12º15'S 56º44' W). Active fires are depicted in orange-red tones, vegetation in green, burn scars in dark blue. Fine grid represents the coincident MODIS 1km nominal pixel footprints, where red pixels indicate a fire detection. Coarser grid represents the coincident GOES 4km nominal pixel footprints, similarly the red pixels indicate a fire detection.

MODIS and GOES fire characterization (temperature&area (GOES only), and radiative power) was evaluated using ASTER, ETM+ and ground reference data [3]. Fire temperature and area estimated using GOES data were only poorly correlated with our reference data suggesting large and variable errors. Fire radiative power (FRP) data derived from MODIS and GOES were found to respond to different vegetation conditions (Fig 2), although the pixel level FRP data calculated from those two instruments were found to be rather poorly correlated.

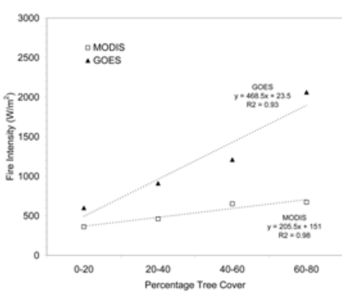

Figure 2: Fire radiative power estimates (median) derived from MODIS and GOES data as a function of percentage tree cover.

An improved Wildfire Automated Biomass Burning Algorithm has been developed. The new version 6.5 incorporates a mask which resembles the MODIS *Fire and Thermal Anomalies* product, including discrimination between water, cloud and clear sky land surface pixels, blockout zones, etc (Fig 3). Additional fire characterization information (fire radiative power) has also been added to WF_ABBA v6.5. The new algorithm was used to reprocess the entire archive of 30min GOES East data from 1997-2007 (Fig 4).

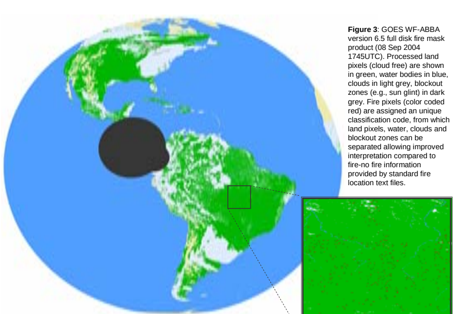

Figure 3: GOES WF-ABBA version 6.5 full disk fire mask product (08 Sep 2004 1745UTC). Processed land pixels (cloud free) are shown in green, water bodies in blue, clouds in light grey, blockout zones (e.g., sun glint) in dark grey. Fire pixels (color coded red) are assigned an unique classification code, from which land pixels, water, clouds and blockout zones can be separated allowing improved interpretation compared to fire-no fire information provided by standard fire location text files.

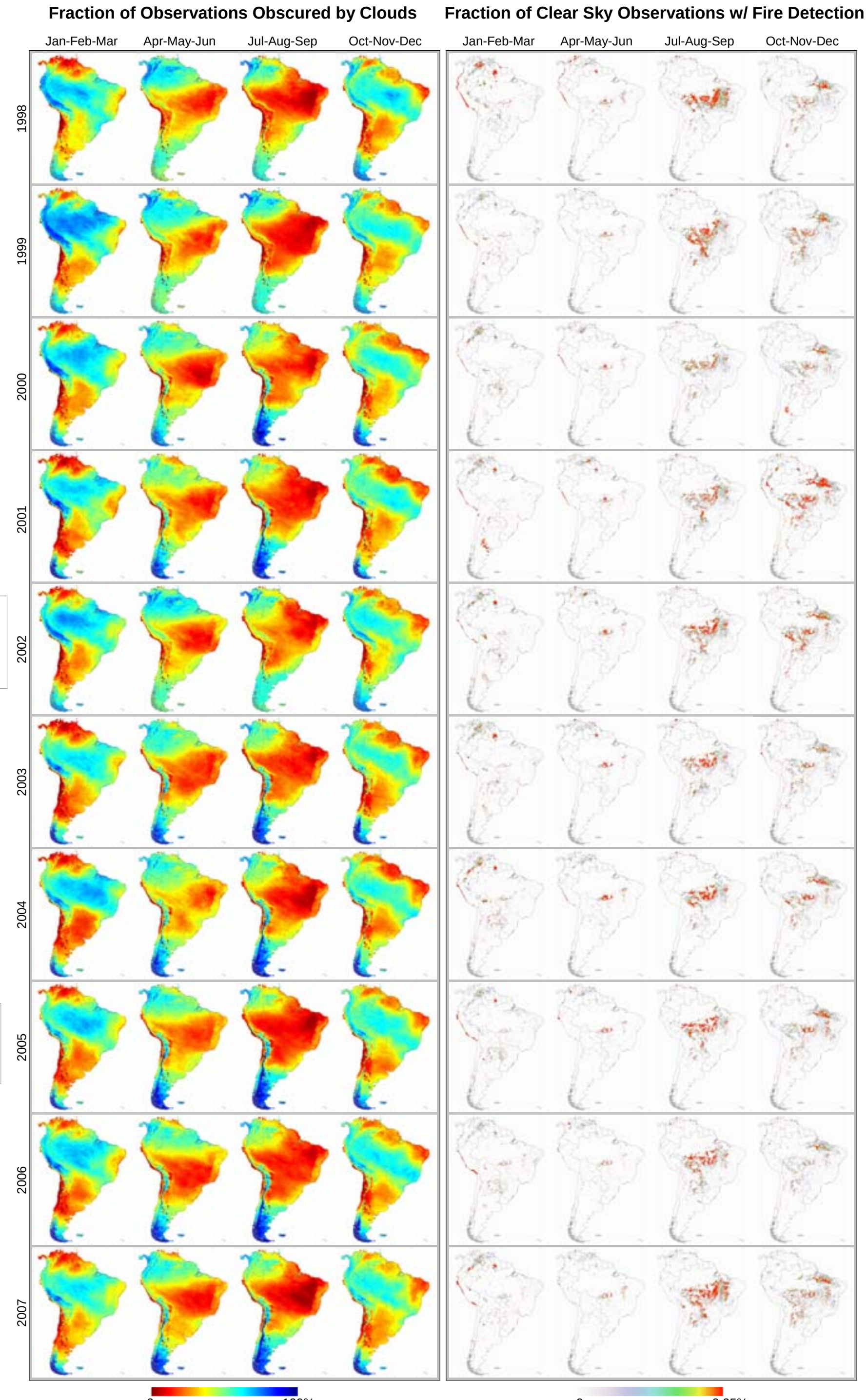

Figure 4: Fraction of GOES imager observations obscured by clouds (left panel), and fraction of clear sky observations with fire detection (right panel) calculated for each trimester during the 1998-2007 period.

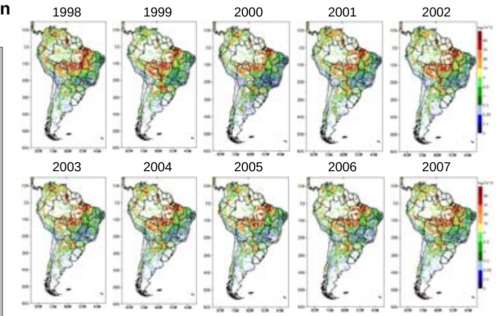

Figure 5: Annual CO_2 biomass burning emissions derived from GOES WF-ABBA v6.5 active fire data for South America.

Baseline biomass burning emissions were derived for 1997-2007 using the Coupled Aerosol and Tracer Transport model to the Brazilian developments on the Regional Atmospheric Modeling System (CATT-BRAMS) [4, 5](Fig 5). The model used 30min GOES imager active fire data for South America. During the period above, a total of 16.3million 4km pixels were classified as fire by the WF-ABBA version 6.5 fire algorithm (ranging from low to high probability fires). The two most active fire years in South America corresponded to 1998 and 2007, each showing approximately 1.8million (2007 having only 15,000 fewer fires than observed during 1998). On the other end, 2006 was the least active fire year in South America with a total of 1.2million fire pixels.

The biomass burning emissions calculated for areas of major deforestation in Amazonia (states of Mato Grosso and Pará) are shown in Fig. 6. Note that in the selected subset there is a systematic increase in peak fire emission from 2000-2007.

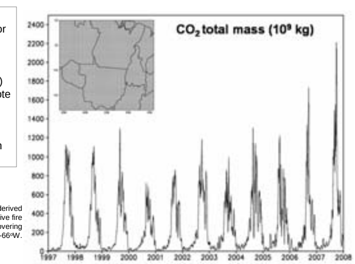

Figure 6: CO_2 mass emission derived from GOES WF-ABBA v6.5 active fire data for a geographic region covering 0-18ºS 44-66ºW.

Conclusions

This poster summarizes some of the analyses performed and makes public some of the longer term vegetation fire data sets produced as part of the NASA funded LBA-Phase III LC-35 research project entitled "Analyses of long-term fire dynamics and impacts in the Amazon using integrated multi-source fire observations". As part of this project, multi-sensor active fire and emissions data were analyzed/produced for South America, focusing on the Amazon region.

Using reference active data available primarily from coincident/near-coincident higher spatial resolution ASTER and ETM+ imagery, we quantified and compared the performance of the *Fire and Thermal Anomalies* product (MOD14) derived from MODIS/Terra, and the *Wildfire Automated Biomass Burning Algorithm* (WF-ABBA) product derived from GOES/East imager. Large differences in probability of detection between MOD14 and WF-ABBA could be explained by the difference in spatial resolution of each satellite instrument, whereas false alarm rates were much more comparable (similar algorithm design helped explain false alarm rates in this case). Problem areas showing higher false alarm rates were spatially coincident with major deforestation sites, in particular across Mato Grosso state. It is worth mentioning though, that the majority of false alarms in those areas were associated with fresh burn scars and therefore may provide evidence of previous fire activity. Fire-unrelated commission error was small, representing less than 2% of all MODIS and GOES detections observed at ~1030am. Nighttime data showed no false alarm and therefore can be used to assist/support the interpretation of daytime data. The relationship between MODIS and GOES active fire products is being explored to build a modified active fire data base for South America designed to improve fire detection rates and reduce false alarms.

The biomass burning data emissions shown in Figs. 5&6 was derived solely from the original WF-ABBA version 6.5 product and therefore represents our baseline emissions for South America. An alternative emissions inventory is being produced using the enhanced fire information derived from MODIS and GOES data. This new fire & emissions data is expected to be released by summer of 2010.

The data sets resulting from this study are being gradually transferred to the main LBA science data repository for further archival at Oak Ridge National Laboratory. Interested fire data users are encouraged to check the LBA-Phase III LC-35 investigation profile [6] or to contact the authors directly to gain access to the fire data produced.

Acknowledgements

Funding for this work was provided through NASA's Phase III Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA).

References

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