Convection and precipitation in the Southern Amazon region: Comparison between a normal and dry year

Beatriz Funatsu, Olivier Dubreuil, Chantal Claud

To cite this version:

Beatriz Funatsu, Olivier Dubreuil, Chantal Claud. Convection and precipitation in the Southern Amazon region: Comparison between a normal and dry year. LES SATELLITES GRAND CHAMP pour le suivi de l'environnement, des ressources naturelles et des risques, Clermont-Ferrand : France (2010), Jan 2010, Clermont-Ferrand, France. <hal-00545444>

HAL Id: hal-00545444

https://hal.archives-ouvertes.fr/hal-00545444

Submitted on 10 Dec 2010

Convection and precipitation in the Southern Amazon region: Comparison between a normal and dry year

Beatriz M. Funatsu[1], Vincent Dubreuil[1], Chantal Claud[2]

1. *Laboratoire COSTEL UMR 6554 CNRS (LETG), Université Rennes 2; Place du Recteur Henri Le Moal, CS 24 307, 35043 RENNES CEDEX*
2. *Laboratoire de Météorologie Dynamique UMR 8539 CNRS/IPSL, Ecole Polytechnique; 91128 Palaiseau CEDEX*

Email: beatriz.funatsu@lmd.polytechnique.fr

ABSTRACT

We examine the diurnal cycles of deep convection and precipitation in the Southern Amazon region, using mainly the Advanced Microwave Sounding Unit, contrasting a year of drought (2004-2005) with a "normal" year (2005-2006). MODIS 550nm aerosol optical thickness data and TRMM 3B42 precipitation products were also used to investigate whether a significant relationship between these two parameters can be identified. We use a simple, tractable method to identify convective areas based on humidity channels of AMSU. We found through comparisons with independent ground precipitation data that the diurnal cycle of convection in regional scale can be realistically described by this method. We observe that deep convective areas have a slow build-up early in the rainy season of the dry year, and rapid in the normal year, and in both cases, convection starts around midday. As the rainy season advances, the peak hour of maximum convective activity shifts towards mid-afternoon, and eventually spreads towards the night. During the peak of rainy season (December through February) convective activity was up to 12% larger in the "normal" year. Convective overshooting was found to be 50% less frequent in the drought year compared to the following year. A simple spatial correlation analysis of MODIS 550nm and TRMM 3B42 monthly mean data showed that by the end of dry season, aerosol loading and precipitation amounts have a positive (albeit low) significant correlation.

I. INTRODUCTION

The Amazon region is the largest continuous tropical ecosystem in the world, and plays an important role in controlling the climate in the tropics. However, its southern edge has been changing dramatically since the 70's due to the expansion of the "pioneer frontier", with large sections of the forest being replaced by agricultural fields or pastures for cattle grazing. Biomass burning is increased by the end of the dry season for clearing areas and preparing the soil for seeding. The impact of increased aerosol loading and transformation of land cover on convection and precipitation are not well known, especially so in regional and local scales. In order to identify anthropogenic-related changes it is imperative to know the climatology and natural variability of the climate system. This work thus provides a description of the diurnal cycle of convection and precipitation in Southern Amazon, particularly, for the state of Mato Grosso, in central Brazil, stressing the similarities and differences between a year of extreme drought (2005) and a "normal" year (2006).

II. DATA AND METHODS

In the tropical region, deep convection and precipitation are key elements. Measurements of these quantities in the Amazon region rely nearly entirely on satellite-derived data, due to the scarcity of ground measurements. In particular, the diurnal cycle of convection is generally described with infrared data from geostationary satellites, due to their high temporal sampling. In the present work, we choose alternatively to use data from the Advanced Microwave Sounding Unit (AMSU), onboard NOAA-15 through -17 satellites covering the period July 2004 – June 2006. Notice that the rainy season in the southern part of Amazon starts around October and ends towards April, while dry season runs from June through September. In addition to AMSU, we use as well the daily 3-hourly precipitation products from the Tropical Rainfall Measurement Mission (TRMM) 3B42 with a resolution of 0.25°x0.25°, and daily and monthly MODIS 550nm 1°x1° aerosol optical depth, for the same period. The target area is bounded by [18°S, 8°S] [63°W, 50°W], which comprised the entire state of Mato Grosso, Brazil, and include immediate neighboring regions.

Deep convective areas were identified using a criterion proposed by Hong et al. (2005), based on the three water vapor channels (183.3 ± 1, 183.3 ± 3, 183.3 ± 7 GHz) of AMSU-B. The criterion $\Delta T_{17} \geq 0$ K, $\Delta T_{13} \geq 0$ K, $\Delta T_{37} \geq 0$ K (i.e., differences between water vapor channels, e.g., ΔT_{17} = difference between brighteness temperatures of channels 183.3 ± 1 and 183.3 ± 7) is able to discriminate convective clouds, while convective overshooting is detected whenever $\Delta T_{17} \geq \Delta T_{13} \geq \Delta T_{37} > 0$ K. AMSU-B data was first re-sampled to a grid of 0.25°x0.25°; then the relative area of deep convection (DC) and convective overshooting (COV) relative to the area covered by the satellite pass for every available hour was computed. Because we use data from the three NOAA KLM series (-15 through 17) it provides a 6-daily coverage of the target region. Figure 1a shows the number of passes per hour for each month (from July 2004 through June 2006); some months do not contain information for some hours. Therefore, we opt to make a 3 hour running mean for every day to obtain the daily cycle, and then we average over the total number of measurements in the month.

III. RESULTS

a. Diurnal cycles of Deep Convection and Convective Overshooting

The diurnal cycles of DC is displayed in Figure 1b. We observe that for both years, there is a rapid build-up of DC at around midday starting from October. Deep convection peaks between 14-17 Local Time (LT) and slightly later in 2005/2006. As the rainy season advances, DC “extends” into the night hours. By the end of rainy season, DC finishes rather abruptly. The maximum area of DC in the drought year had a maximum of around 3%, while the next year had a maximum of around 3.5%, i.e., more than 15% larger than the previous year.

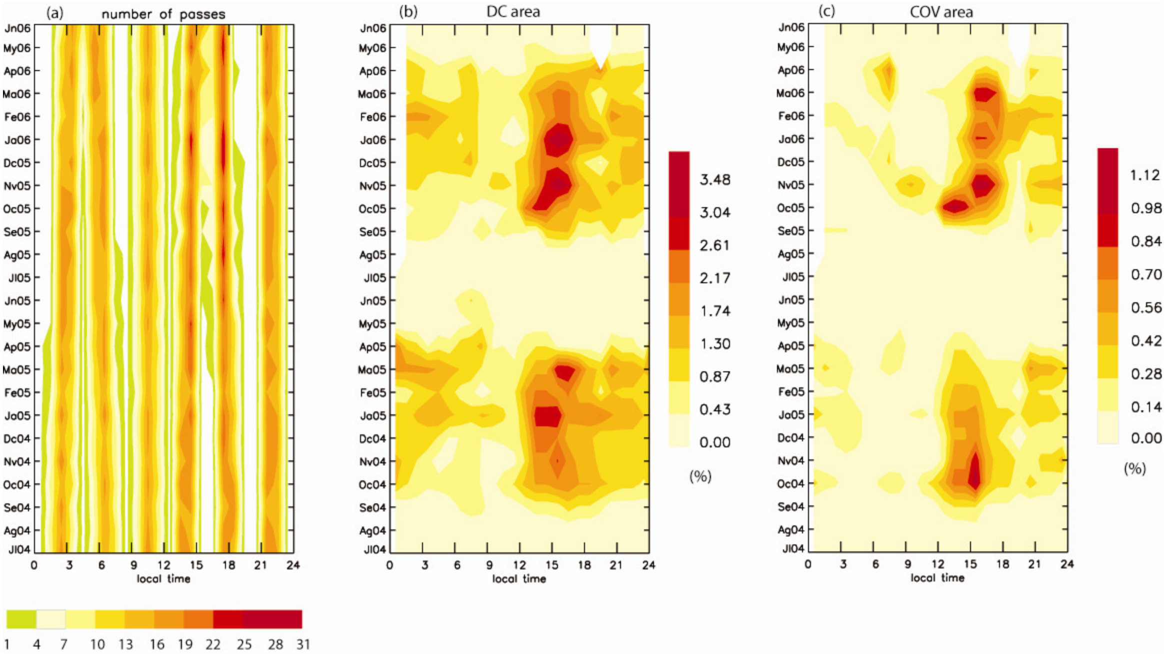

Figure 1: (a) Number of passes per hour and per month covering at least 30% of the target area [18°S, 8°S] [63°W, 50°W], (b) monthly mean relative area of DC per hour, and (c) monthly mean realative area of convective overshooting.

In order to examine whether the daily cycle description is realistic, we compared the annual hourly mean DC relative area with precipitation amounts from the station of Alta Floresta (near 10°S, 55°W) for the hydrological year 2006-2007 (Figure 2). The correlation between these two parameters is 0.73 (with 99.9% significance). Because these datasets are completely independent, we conclude that AMSU provides a realistic description of the diurnal cycle of convection. The daily amounts of AMSU have a very good correlation with TRMM data as well (> 0.8 for daily values, > 0.9 for monthly values), but these datasets are not independent since TRMM use AMSU data (among other sources) for precipitation estimates.

The convective overshooting area represents on average 20 to 40% of the monthly mean DC area in agreements with results of Hong et al. (2005) who estimated the ratio (COV/DC) of 26% for the whole tropical belt for the period of March 2003-February 2004; in our study this ratio can reach 100% in a daily mean (not shown), indicating the large day-to-day variability. Convective overshooting is fairly intense in October 2004 but its relative area shrinks as the drought conditions persist (Figure 1c). The contrast of COV area between this drought-affected year and the following year is remarkable, with a 100% increase in COV fraction compared to the previous year.

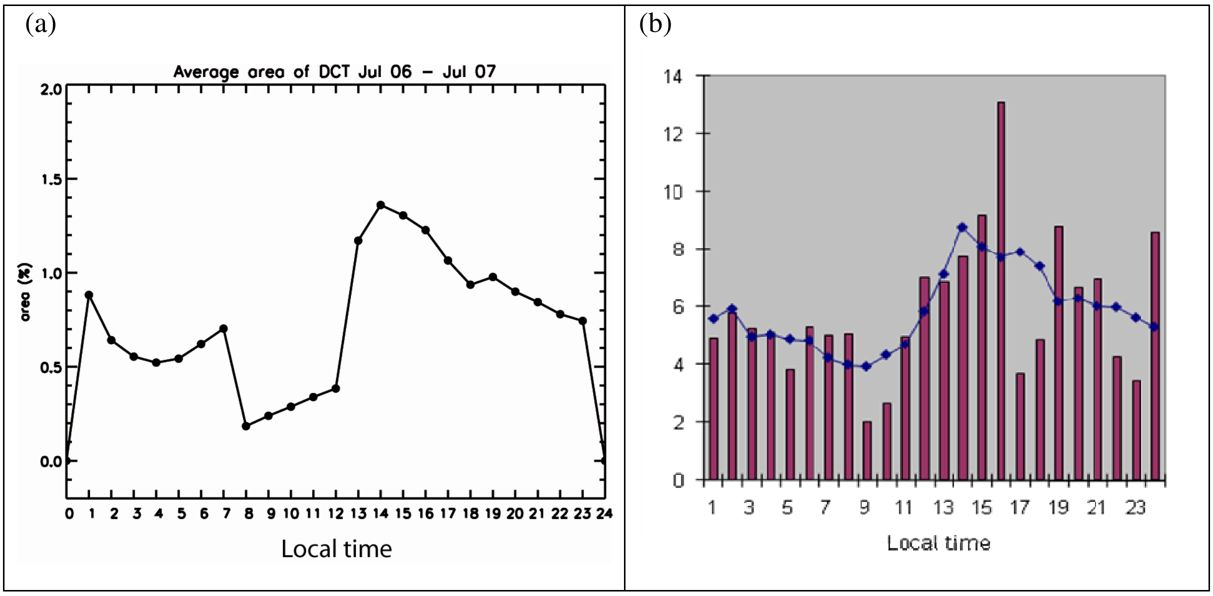

Figure 2: Annual hourly mean of (a) relative area of DC (%) for the period July 2006 to July 2007, and (b) accumulated precipitation (mm/day; bars) for the period August 2006 to September 2007, with superimposed 3-hour mean curve (blue).

b. Comparison with aerosol optical depth

In the southern edge of the Amazon forest, biomass burning season starts around July and has a peak in September. The impact of aerosols on cloud development and precipitation is not conclusive. Some studies indicate that there is suppression of convection and precipitation with increased aerosol content (e.g., Rosenfeld 1999, Jiang et al. 2006), while others observe the opposite effect (e.g. Lin et al. 2006). Koren et al. 2008 proposes that these two observations coexist and the final effect depends on the initial cloud fraction: while cloud fields with large cloud coverage will be invigorated through microphysical effects, fields with low fraction will be strongly inhibited by aerosol absorption. Here we performed a simple correlation analysis of monthly mean aerosol optical depth (AOD) and TRMM precipitation (used here as a proxy for convection since they have high correlation) for the end of dry season, i.e., July through September, when the region experiences consistent meteorological conditions. We found that there is positive (albeit small) and significant correlation between these two quantities (Figure 3). As the rainy season starts, there is a sharp decrease in AOD due to wet deposition, and the possible relationship between AOD and DC is overruled by dynamical effects.

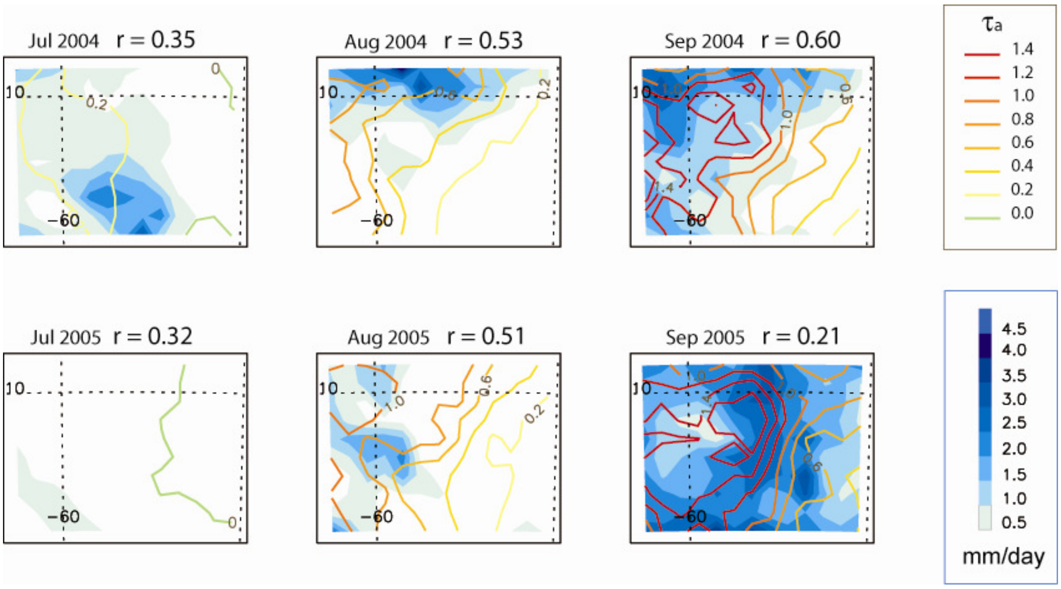

Figure 3: Monthly mean AOD (dimensionless, contours), and TRMM 3B42 accumulated precipitation (mm/day; shaded), for months/years indicated on top of each panel. Correlation r is significant at 98%.

IV. CONCLUSIONS AND PERSPECTIVES

This work presents an effort to characterize the regional scale variability of deep convection and precipitation in the southern Amazon region. To our knowledge, it is the first time that a constellation of polar orbiting satellites has been used to this purpose. Our results show that convective activity was decreased in ~10% in a year of severe drought, but convective overshooting was reduced by 50%. These results have implications for example, to climate modeling as it is desirable that they will capture such variability, and for troposphere-stratosphere exchanges. Future work include extending this work for the entire span of AMSU data availability, as well as studying the variability of convection at local scale using geostationary data.

REFERENCES

Hong, G., G. Heygster, J. Miao, and K. Kunzi (2005), Detection of tropical deep convective clouds from AMSU-B water vapor channels measurements. *J. Geophys. Res.*, *110*, D05205, doi:10.1029/2004JD004949.

Jiang, J.H., H. Su, M. R. Schoeberl, S.T. Massie, P. Colarco, S. Platnick, and N.J. Livesey (2008), Clean and polluted clouds: Relationships among pollution, ice clouds, and precipitation in South America. *Geophys. Res. Lett.*, *35*, L14804, doi:10.1029/2008GL034631.

Koren, I., J.V. Martins, L.A. Remer, H.Afargan (2008), Smoke invigoration versus inhibition of clouds over the Amazon, *Science*, *321*, 946-949, doi:10.1126/science.1159185.

Lin, J.C., T. Matsui, R.A. Pielke Sr., and C. Kummerow (2006), Effects of biomass-burning-derived aerosols on precipitation and clouds in the Amazon Basin: a satellite-based empirical study. *J. Geophys. Res.*, *111*, D19204, doi:10.1029/2005JD006884.

Acknowledgements

NOAA AMSU data was provided by the French Mixed Service Unit ICARE. MODIS 550nm AOD and TRMM 3B42 data was obtained using the GES-DISC Interactive Online Visualization ANd aNalysis Infrastructure (Giovanni) as part of the NASA's Goddard Earth Sciences (GES) Data and Information Services Center (DISC). We acknowledge the mission scientists and Principal Investigators who provided the data used in this research effort.