USING THE GOAMAZON-CHUVA MEASUREMENTS TO UNDERSTAND WHAT CAUSES THE BIASES IN THE ONSET OF THE RAINY SEASON IN AMAZONIA IN CLIMATE MODELS

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Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

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The onset of the Amazon rainy season shows a large temporal and spatial variability, delays on the data of the onset may have strong impacts on local agriculture, hydroelectric power generation, as well as on the hydrology of large rivers. Two "once-in-a-century" droughts occurred in 2005 and 2010, and it was shown that on those events the rainy season started later than normal, and also that on the last 10 years the dry season has increased in length by about one month (Figure 1). These events highlight the urgency for improving our understanding and capability to model onset of the rainy season and drought variability, for the present and future

Global climate models run on seasonal climate forecast mode still show large uncertainties on the forecast of onset of the rainy season. As for climate change, the CMIP3 and CMIP5 appear to underestimate the past variability, and also project virtually no future change of the onset of rainy season over the Amazon even when they are forced by strong greenhouse forcing under the RCP8.5 emission scenario.

This proposal aims to explore use of the measurements provided by the Atmospheric Radiation Measurement (ARM) Mobile Facilities (AMF)-GoAmazon project and the Cloud processes of the main precipitation systems in Brazil (CHUVA) Field Experiments, along with global and regional model experiments and data sets from Amazonia, to explore the sources of the above described uncertainty, in order to improve the US CESM and the Brazilian Eta regional Model and the BESM (Brazilian Earth System Model).

Based on previous and ongoing studies, it is hypothesized that the underestimation of changes of the rainy season onset over the Amazon and its climate variability and sensitivity to anthropogenic forcing are in part related to: a) The inadequate

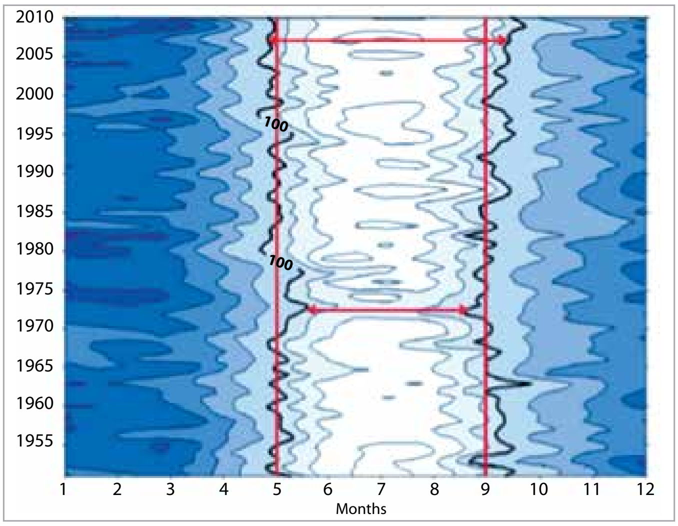

Figure 1. Hovmoller diagram of monthly rainfall from 1951 to 2010 for southern Amazonia. Units are in mm/month. The 100 mm/month isohyet is marked in bold and is an indicator of dry season (modified from Marengo et al 2011)

representation of the types of convection (i.e., maritime versus continental) and their relationships to aerosols, land surface and atmospheric circulation, as represented in climate models; b) Inadequacies of the modeled oceanic variability, land surface processes and their coupling to the atmosphere.

To evaluate these hypotheses, the team proposes to clarify the following questions: a) How would changes of land surface conditions and aerosol influence the intensity and type of the convection over the Amazon? How adequately are these influences represented in NCAR/DOE CESM 1.2/CAM5.3/CLM4.5 climate model and the Eta regional and the BESM models?; b) How would a change of convective type influence the vertical profiles of diabatic heating, surface fluxes and large-scale circulation during the dry to wet season transition? c) What are the relative contributions from uncertainties of the local processes (land surface and aerosols) vs. those of Atlantic and Pacific ITCZ to the underestimation of the variability of the dry season length in CESM and BESM?

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Most studies have attributed the variability of the rainy season onset over Amazonia to the variability of the tropical oceans, such as El Niño-Southern Oscillation (ENSO) and anomalies in the north-south gradient of the tropical Atlantic SST.

The CMIP3 multimodel ensemble simulations that the percentages of the modeled 20-year trends of rainy season onset (an indicator of decadal variability or/and forced change) that agree with the observed trends during 1979-1999 within the range of uncertainty is similar between the 20th century coupled ocean-atmosphere models' ensemble simulations (CMIP simulations) and the atmospheric models' ensemble simulations forced by observed SST. Thus, the large discrepancy between the CMIP3 models and the observations is not reduced by use of realistic SSTs in the CMIP simulations. On the other hand, a subgroup of the CMIP ensemble simulations that include black and organic carbon aerosols (AREO simulations) shows a statistically significant greater agreement between the modeled and observed 20-year trends for rainy season onset compared to the AMIP ensemble simulations; land use could also contribute to a greater variability (Ying et al 2014).

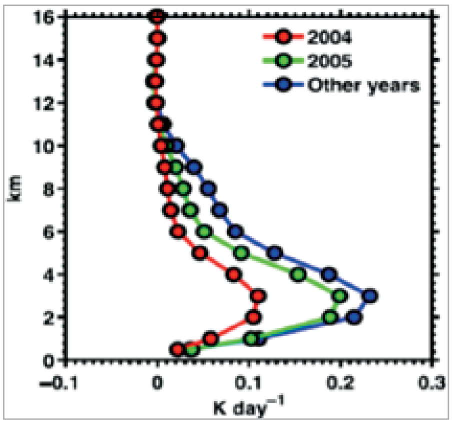

Figure 2. Latent heating profile derived from TRMM over southern Amazonia in JJA of 2004, 2005, and other years' climatology (1998-2003, 2006-2010). Rainy season onset was strongly delayed over southwestern Amazon in 2004 and 2005, respectively (Source: Fu et al 2013)

The dry to wet transition season is led by an initial increase of continental convective type rainfall, followed by a transition to maritime type rainfall. Such a seasonal change of convective types changes the diabatic heating profile and drive the atmospheric circulation transition.

This report focuses on ongoing work with the LHP based on TRMM data (Figure 2), on dry years 2004 and 2005 in Amazonia. The late rainy season onsets in October–November 2004 and 2005 are led by shallower and weaker peaks of the diabatic (latent) heating profiles in (latent) heating profiles in June–August, whereas the normal rainy season onset is led by a deeper and stronger latent heating profile, as derived from the TRMM 2004. This link suggests that variation of the diabatic heating profile is an important source of variability for rainy season onset.

Further studies are being performed using CMP3 and 5 models simulations and projections. In particular, we want top know how do aerosols and land surface influence the dry to wet season transition?

MAIN PUBLICATIONS

Marengo et al. 2011. The drought of 2010 in the context of historical droughts in the Amazon region. *Geophysical Research Letters.* **38**: L12703.

Yin et al. 2014. What controls the interannual variation of the wet season onsets over the Amazon? *J. Phys. Res-Atmosphere*. Accepted.

Fu et al. 2013. Increased dry season length over southern Amazonia in recent decades, PNAS. Oct. 21, 2013. DOI:10.1073/pnas.1302584110.

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