On the Trigger and Time-Scales of Shallow-to-Deep Convection in Amazonia

Henrique M. J. Barbosa[1], Carlos Alves[2,3], Theotonio Pauliquevis[3], Diego A. Gouveia[1], Amanda V. Santos[1], Alan J. P. Calheiros[2], David K. Adams[4]

(1) Universidade de São Paulo, São Paulo, Brasil, (2) Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brasil; (3) Universidade Federal de São Paulo, Diadema, Brasil; (4) Universidad Nacional Autónoma de México, Ciudad de México, Mexico

INTRODUCTION

Deep atmospheric convection covers a range of spatial and temporal scale that are difficult to capture in numerical models. In tropical continental regions, in particular, this difficulty is exacerbated by the lack of observational data. Representing the shallow-to-deep (STD) convective transition is problematic and is often misrepresented in numerical models, hampering our ability to trust, for instance, important studies about climate change impacts on the hydrological cycle.

This work characterizes the shallow-to-deep convection transition using deep convection events during the Observations and Modeling of the Green Ocean Amazon (GoAmazon2014/5) field campaign in the Central Amazon, near Manaus-AM, Brazil (Martin et al., 2017).

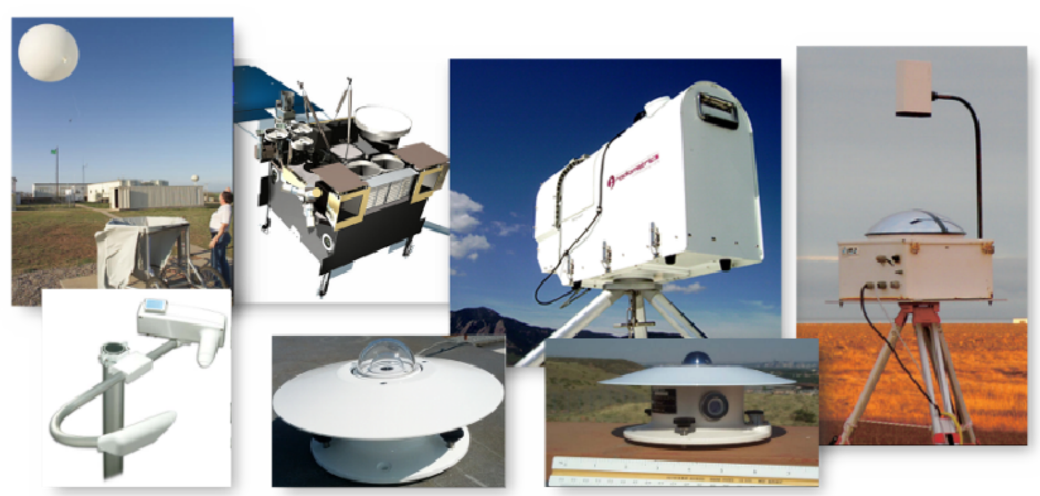
GoAmazon2014/5 T3 site location,
(-3.2133 S,-60.5987 W).

T3 site, photo: B. Schmid

DATASETS & METHODS

We utilize 2-years of data from the GoAmazon 2014/5 experiment (Martin et al., 2017) to study the evolution of deep convective events over the T3 site, in central Amazonia (3° 12' 47.88" S, 60° 35' 55.32" W). Cloud top brightness Temperature (CTT) from GOES13 infrared channel 4 (10.7 µm) was used to identify 151 afternoon transition events following Adams et al. (2013 & 2017). In an Eulerian approach, we built composites (centered at time of minimum CTT, t_0) to investigate the STD timescale and evaluate thermodynamic and environmental conditions. The events were selected by:

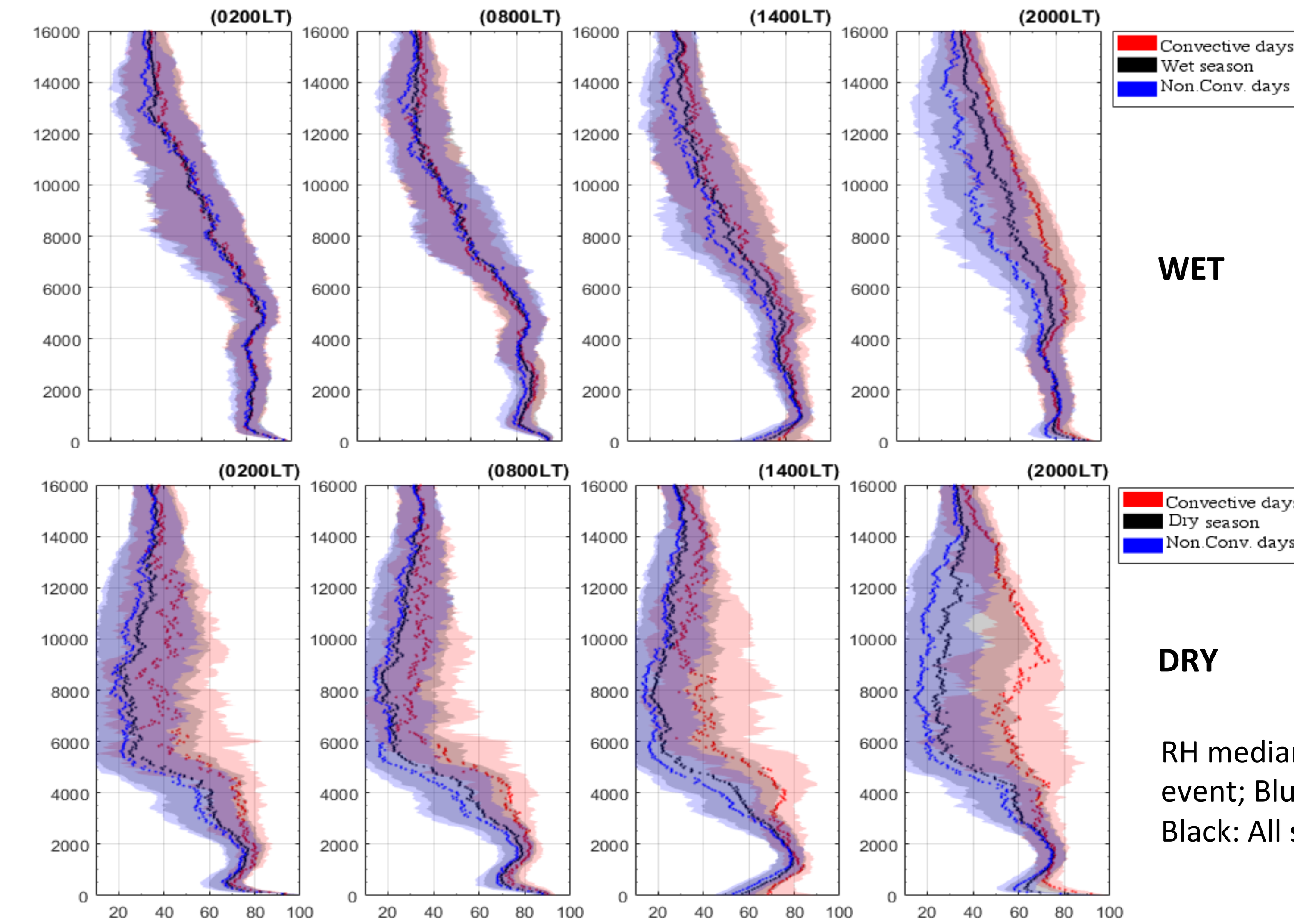
1. Drop in CTT, at a rate of at least 25K/h, to values colder than 235K;
2. Time of the coldest CTT of each event between (1100 LT and 1900 LT);
3. Events have initial development at a 4x4 pixel boxes centered in T3 and full development in a $100km^2$;



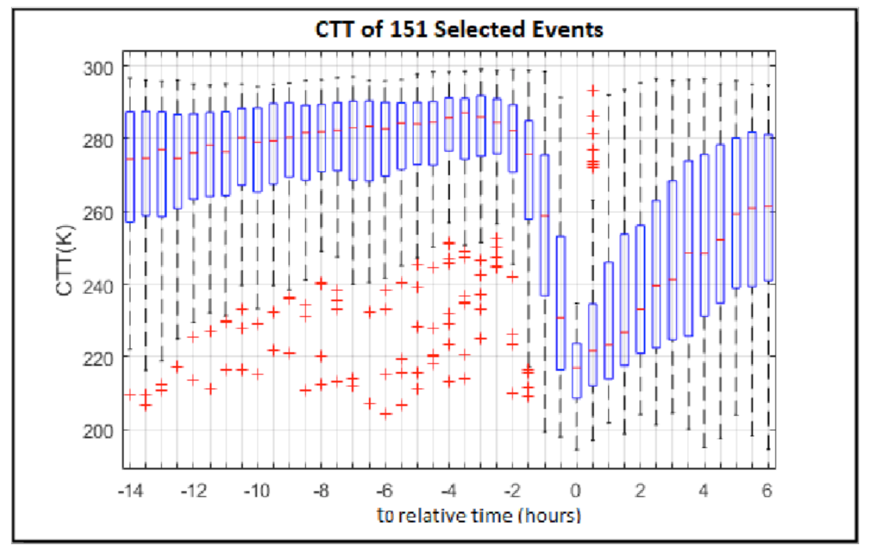
Subset of AMF-1 instruments used in this study (Mather et al. 2013).

RESULTS

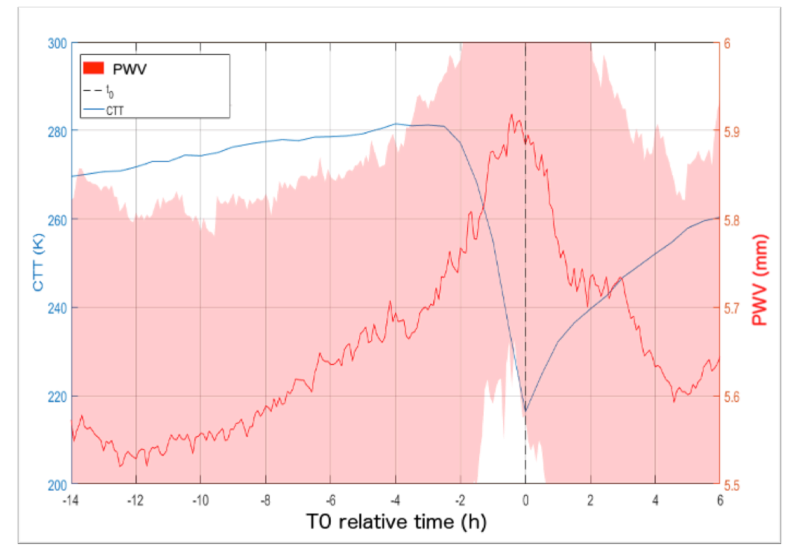
Our analysis indicates that the typical STD transition begins at sunrise. The boundary layer height and the lifting condensation level (LCL) rise from 200m (t_0-8h) to 600m (t_0-4h), at the same time as the level of free convection (LFC) drops from 1800m to 600m, and CAPE increased from 200 J/kg to 1000 J/kg. During this period, the warm-cloud fraction (CTT > 0ºC) comprises 25% of cloud fraction, and deep-cloud contribution is negligible (<3%, CTT < -38ºC). After the atmospheric trigger (LFC = LCL), shallow clouds grow into congestus (t_0-4h to t_0-2h), with warm-cloud fraction decreasing to 15% and cold- fraction increasing to 15%. From sunrise (t_0-8h), column water vapor increases from 5.5 to 5.8 cm. The next phase is the congestus phase organizing into deep convection, which happens from t_0-2h to t_0, at the expense of CAPE consumption. CTT drops from 280K to 220K. Evaporation of rain, which starts at t_0-2h, moistens the PBL, increasing RH and lowering the LCL, which decouples from the LFC that begins to rise, as CAPE is reduced. Precipitation persists until t_0+2h. Warm-cloud fraction reaches a minimum of 8% around t_0+1h, when cold-fraction is maximum (60%).



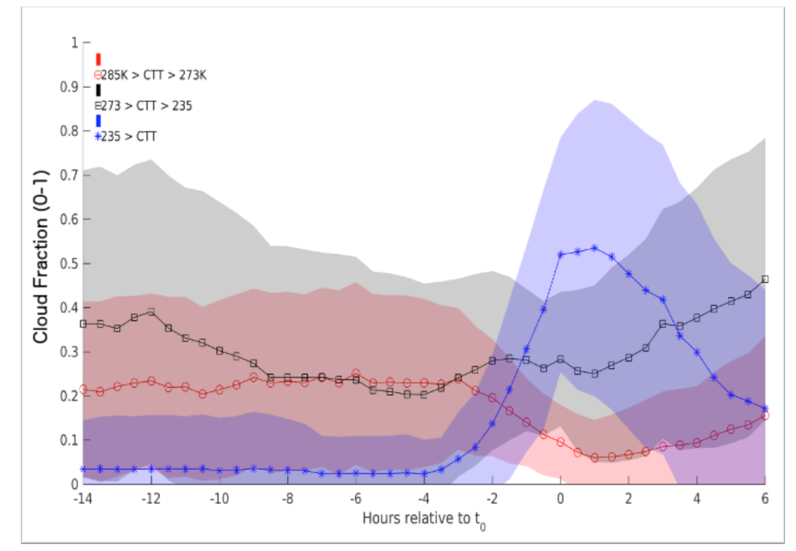
RH median profile. Red: Days with event; Blue: Days without events; Black: All season; Shadow: IQR.



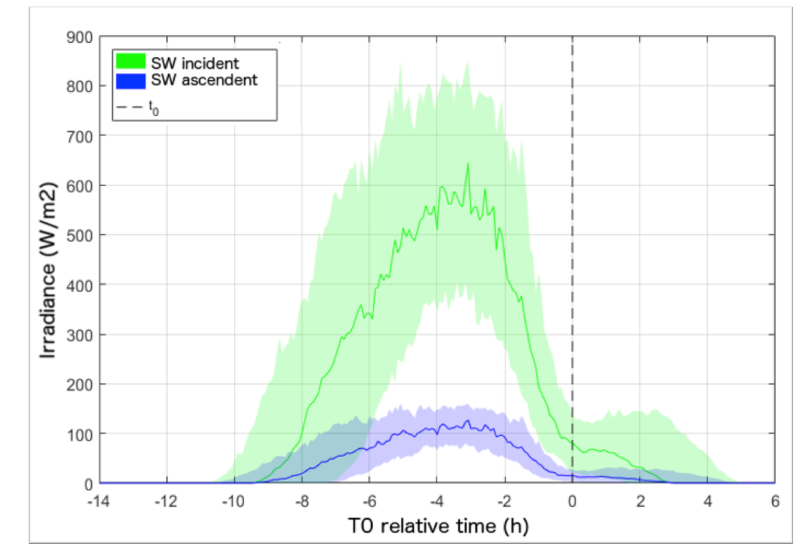
Boxplot of all selected events relative t0 (min CTT of each event) of 2014 - 2015.



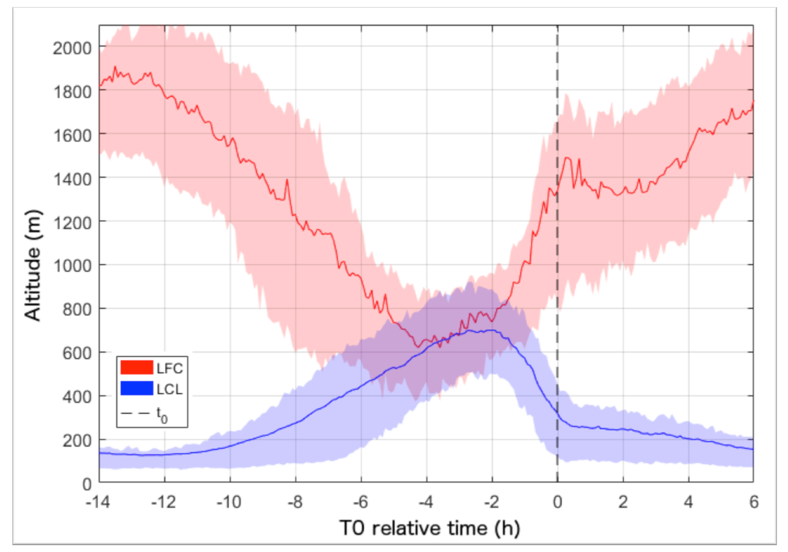
Red: PWV median value; (Oct 2014-Dez 2015)



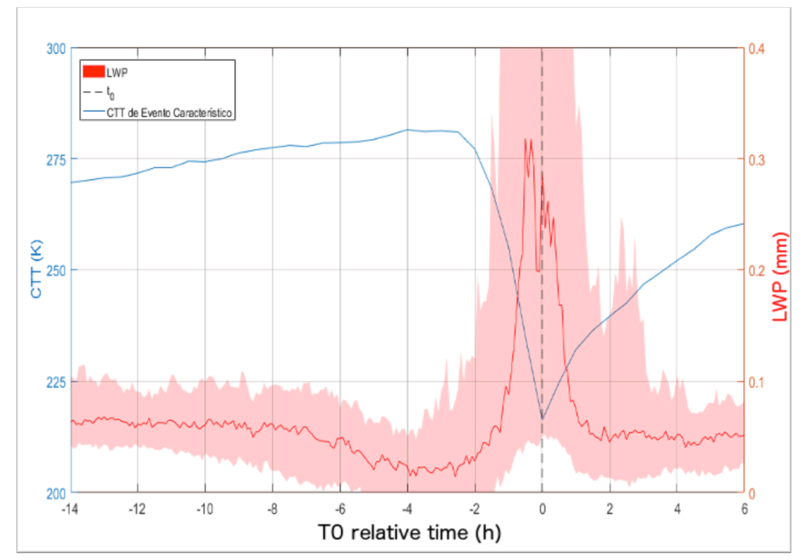
Red: Precipitation and Blue: 10m wind speed



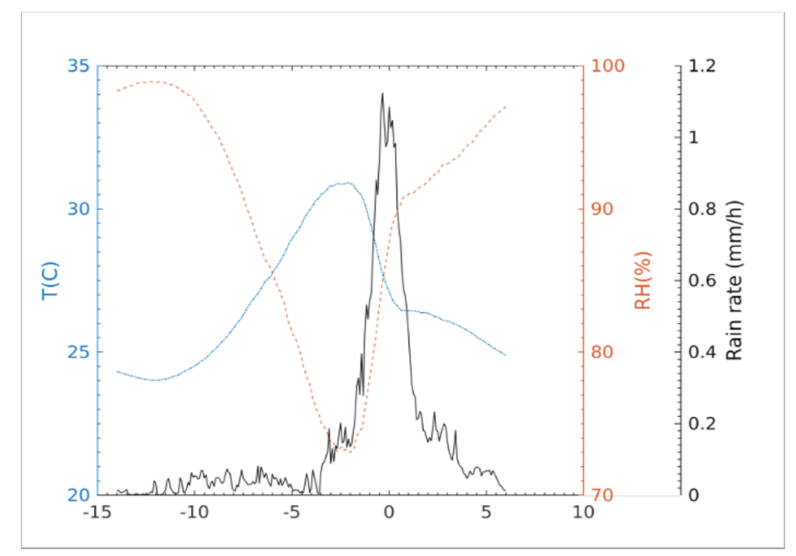
SW balance at the surface



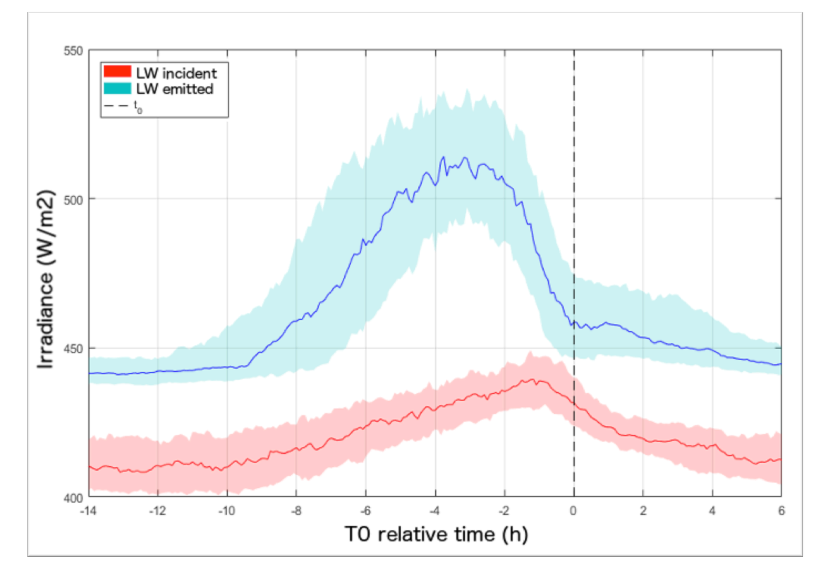
Red: LFC median; Blue: LCL median; Shadow: IQR.



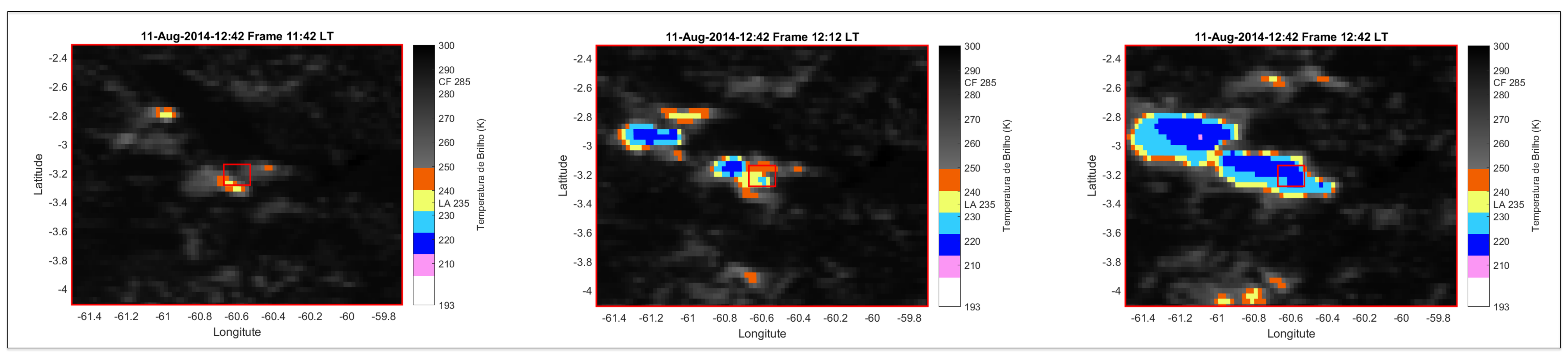
Red: LWP median value; (Oct 2014-Dez 2015)
Blue: CTT median value (2014-2015)



Red: RH, Black: Precipitation and Blue: 2m-Temperature.



LW balance at the surface



Successive images of 100km2 box centered in T3 site that shows the development of deep convection of 11/Ago/2014.

CONCLUSIONS

Our results suggest that the deep convection event is already organized two hours before precipitation, indicating that it can no longer be reversed on both wet and dry seasons. We found that PWV convergence occurs gradually. In addition, the analysis of the mean relative humidity (RH) profile in the rainy season does not indicate it plays an important role controlling the transition from shallow to deep convection in wet season.

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CONTACT: hbarbosa@if.usp.br