MICROPHYSICS AND ELECTRIFICATION OF HAIL PRODUCING TROPICAL STORMS DURING SOS-CHUVA PROJECT

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ABSTRACT

Two hail producing storms that occurred in 2017 were analyzed using weather radars, a lightning detection network and a hailpad network deployed during SOS-CHUVA Project in the Metropolitan Region of Campinas. The most intense case according to radar and hailpads occurred in 2017-11-15, but showed low electrical activity during its life cycle, while the 2017-03-14 case showed higher lightning rates with less intensified large ice particles cores. Two relationships could be determined: an increase in lightning rate before hailfall, consistent with severe storms observations, and an increase in lightning rate after hailfall. These findings will be further related to an Dual-Doppler analysis of the kinematics of the events.

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INTRODUCTION

- Hailstorms are frequent and well known in mid-latitudes, specially in the United States; In the Tropics, these storms are rare and less intense
- **In South America**: severe hail reports in subtropical Argentina and south Brazil (*Martins et al., 2017*) but few scientific studies about these events exist, specially in Brazil
- **Study area**: Southeastern Brazil - Metropolitan Region of Campinas, São Paulo (~ 22.9° S, 47° W)
- **SOS-CHUVA Project**: developed research in thunderstorm nowcasting specifically in the study area during the summers of 2016-2017 an 2017-2018, integrating several meteorological databases including weather radars, meteorological stations, lightning detection networks and a hail detection network

Objective: Describe hail producing storms occurred during SOS-CHUVA Project, classifying its intensity using hailpad measurements and relating main storm features with electrical activity.

DATA AND METHODS

Date of the Event	Description	Affected Regions
2017-03-14	Heavy rains and hailfall in the division between Campinas and Indaiatuba and in Jacareí	Campinas, Indaiatuba, Jacareí
2017-11-15	Favorable thermodynamical conditions led to the formation of convective systems concentrated in the center of São Paulo state	Indaiatuba, Bebedouro

Table 1. Selected cases. Source: https://topicssoschuva.blogspot.com.br/

FCTH	São Roque
S-Band	S-Band
Doppler	Doppler
Dual Polarization	Single Polarization
Hydrometeor identification and classification	Storm tracking (ForTraCC-Radar)

Table 2. Radars features and applications

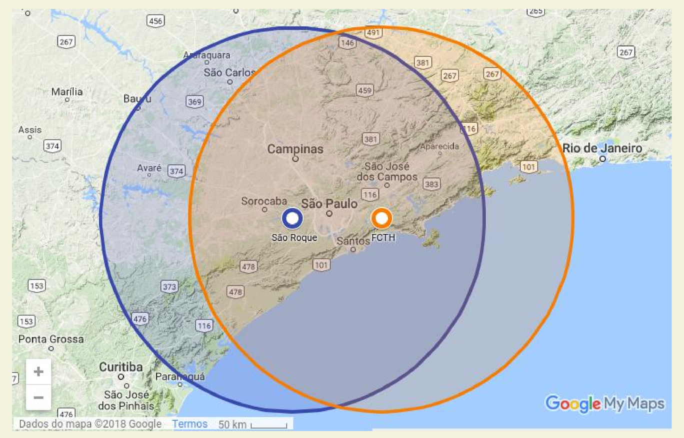

Figure 1. FCTH (orange) and São Roque (blue) radars locations and 250-km range.

Lightning data: BrasilDAT Network (*Naccarato et al., 2014*)

- LF - HF frequency band
  - Differentiates intracloud (IC) and cloud-to-ground (CG) lightning
- Detects electromagnetic pulses (strokes) using time of arrival technique
- Detection efficiency of 60-70% (IC) and 95% (CG) (*Dr. Kleber Naccarato, ELAT-CCST-INPE, personal communication, 2018*)

TORRO (*Webb et al., 1986*) and **ANELFA** (*Dessens et al., 2007*) scales indicate hailstorm intensity comparing typical or maximum diameter of hail with the **kinetic** energy (E_t) of the hailpad, defined by (Mezeix et al., 1981):

$$E_t = 4{,}58e^{-6} \sum_{i=1}^{k} n_i d_i^4 \ [\mathrm{J\ m^{-2}}]$$

Diameter intervals

Number of hailstones (m⁻²)

Mean diameter of the interval (mm)

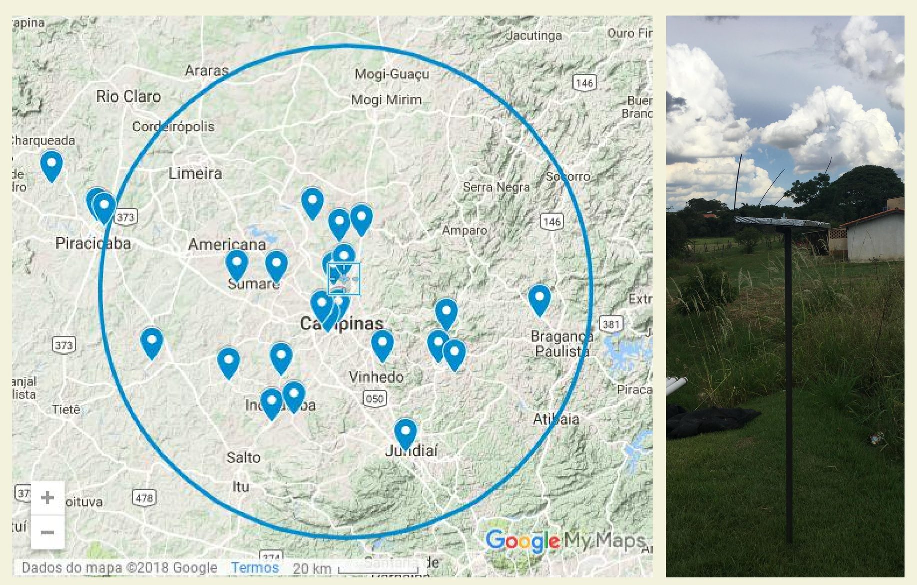

Figure 2. Hailpad network with 80-km range of XPOL Radar (left) and a hailpad installed in Indaiatuba (right).

RESULTS

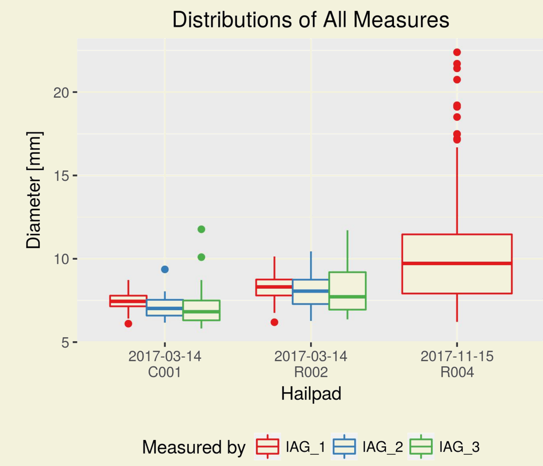

Figure 3. Hail diameter distributions for each hailpad.

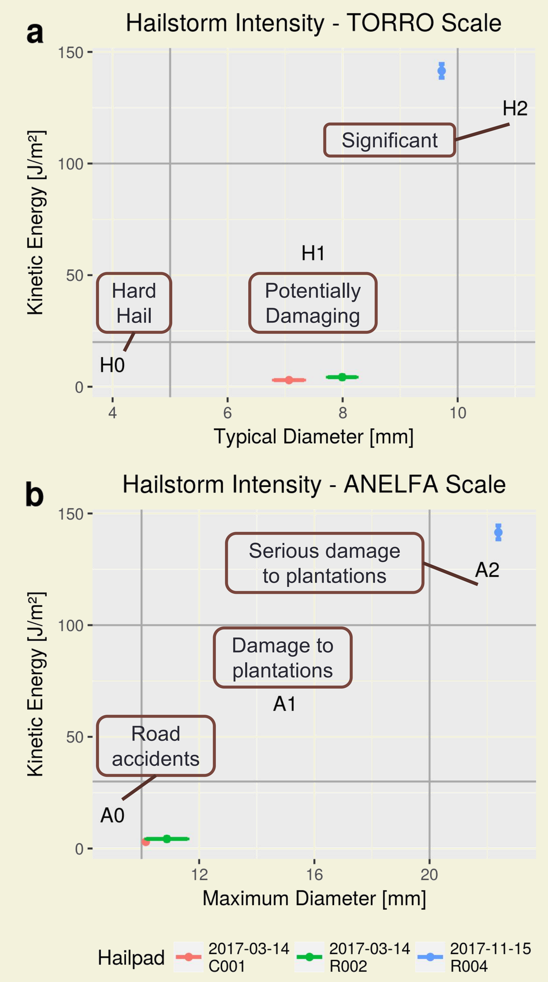

Figure 4. Hailstorms intensity according to TORRO (a) and ANELFA (b) scales.

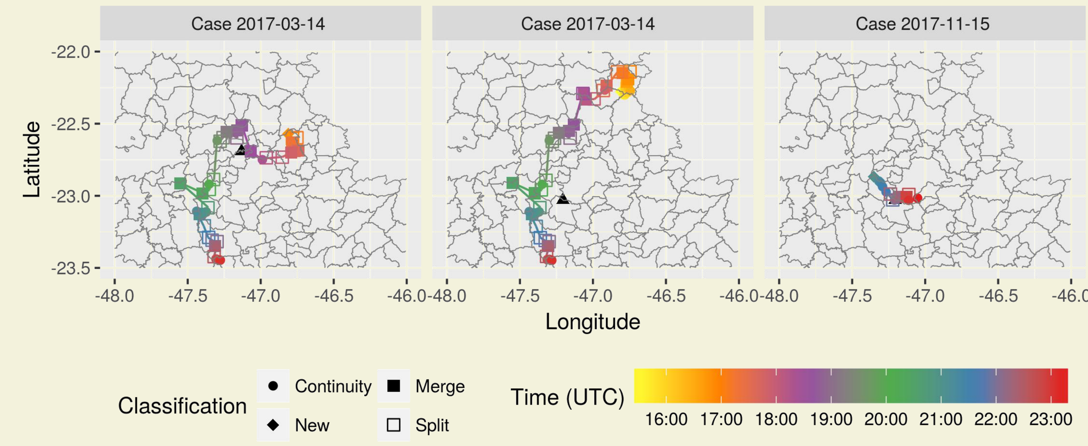

Figure 5. Temporal evolution and trajectory of selected convective systems. The black triangles indicate the location of the hailpads.

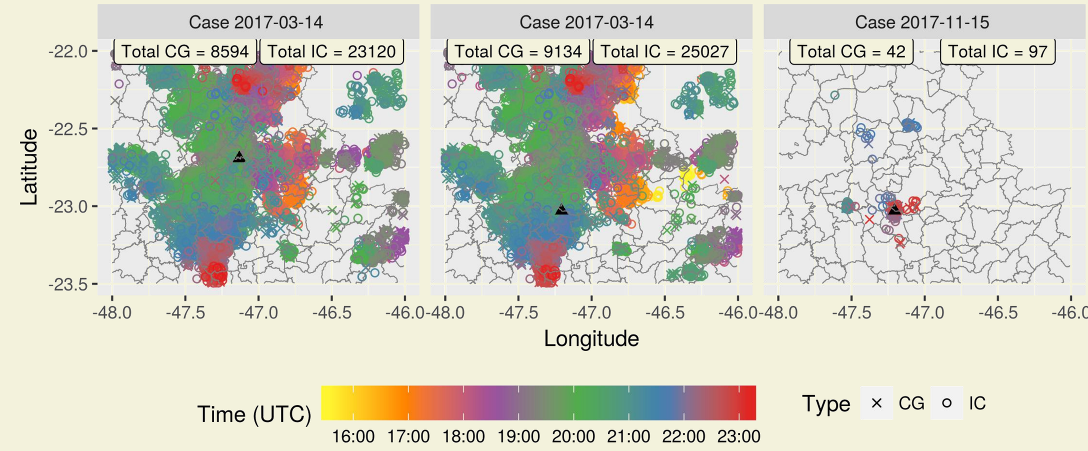

Figure 6. Cloud-to-ground (CG) and intracloud (IC) lightning distributions during time for the selected cases. The black triangles indicate the location of the hailpads.

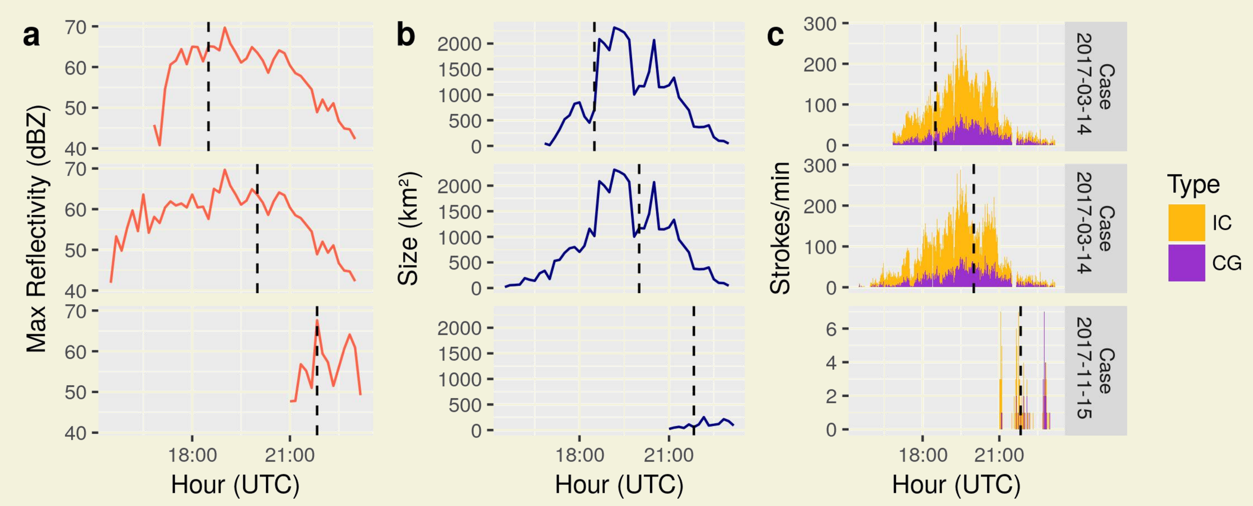

Figure 7. Temporal evolution of maximum reflectivity (a), storm size (b) and cloud-to-ground (CG) and intracloud (IC) lightning rate (c). The dashed lines indicate hailfall occurrence.

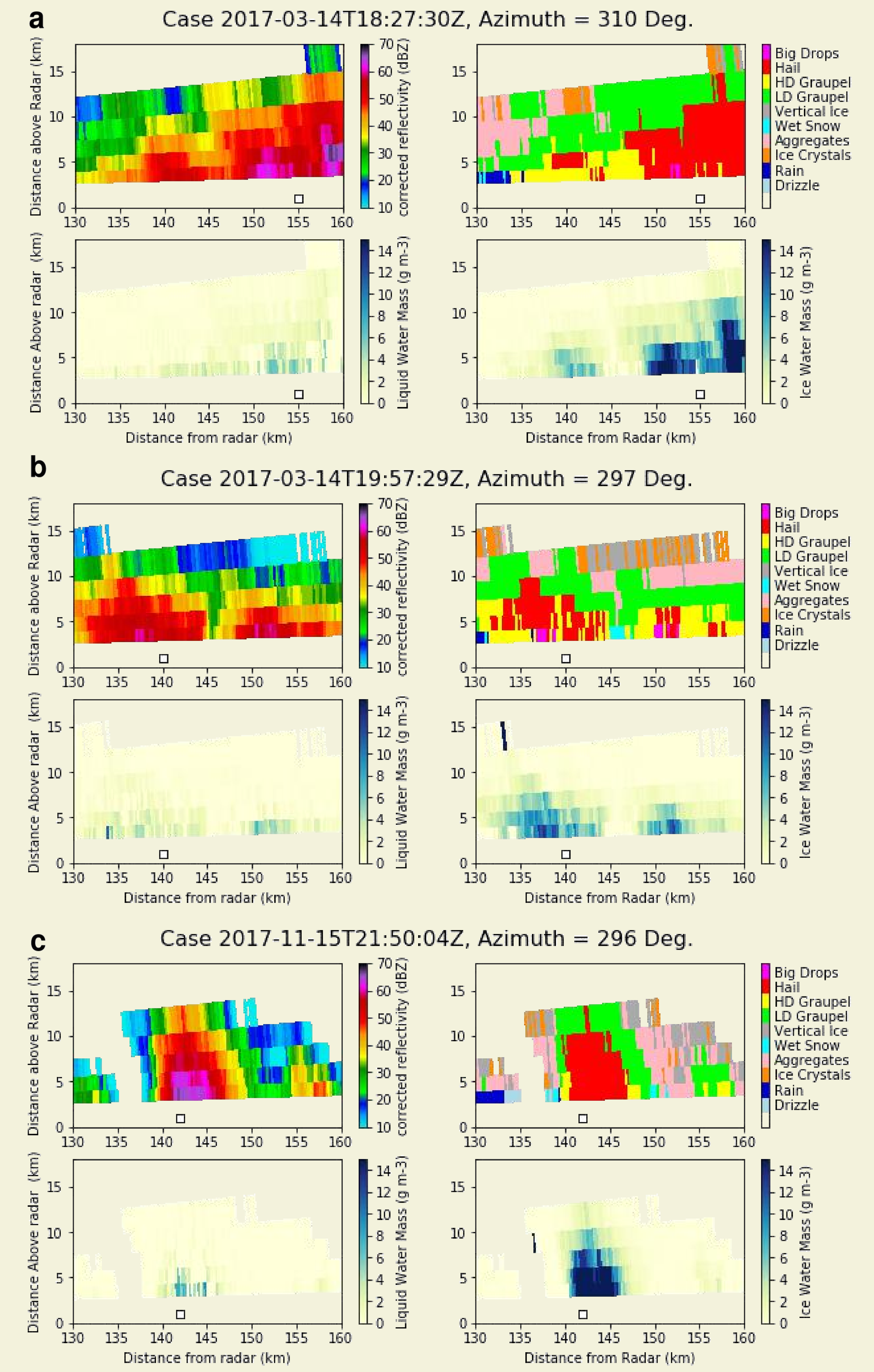

Figure 8. Cross section of reflectivity, hydrometeor classification and liquid and ice water mass for the 2017-03-14 case in Cosmópolis (a) and Indaiatuba (b) and the 2017-11-15 case (c). The squares represent the location of the hailpads.

Event	Duration (Hours)	Max Reflectivity (dBZ)	Max Area (km²)	Mean Hail (mm)	Max Hail (mm)	Total Lightning (Strokes)		Max Lightning Rate (Strokes/min)	
						IC	CG	IC	CG
2017-03-14	6,8	69,7	2312	7,8	11,8	24074	8864	215	74
2017-11-15	2,2	67,6	253	10,3	22,4	97	42	9	5

Table 3. Summary of physical and electrical features of the selected cases.

CONCLUSIONS

Two distinct cases of hail producing storms were presented:

In 2017-03-14, a long-lasting convective system passed through the entire Metropolitan Region of Campinas, with elevated electrical activity and generating low-intensity hailfall at least twice in the region

In 2017-11-15, a smaller system affected a few cities in the region, with low electrical activity and significant hailfall

It was possible to identify peaks of lightning rate before hailfall occurrence in two out of three situations (2017-03-14 in Indaiatuba and 2017-11-15).

At the approximate time when hailfall occurred, radar profiles show accentuated cores of large ice particles, including hail and graupel.

The kinematic of these events will be further investigated using Dual-Doppler analysis.

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