

Analysis of the TLS200 Network Deployed During the CHUVA Campaign in Brazil

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VAISALA

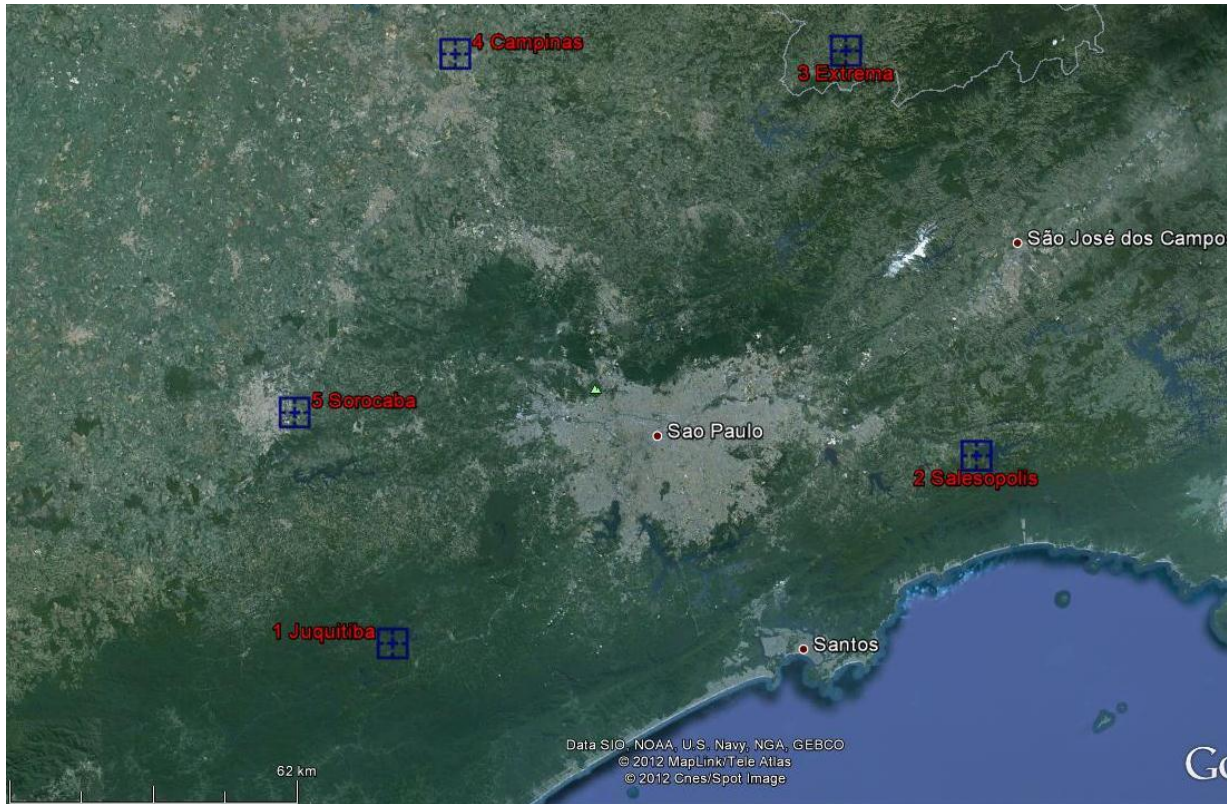
Analysis of the TLS200 Network Deployed During the CHUVA Campaign In Brazil

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- Summary

Introduction

- The CHUVA campaign was held in the vicinity of São Luiz do Paraitinga, Brazil from October 2011 to March 2012.
- One of the objectives of the campaign was to perform measurements of total lightning activity, map lightning channels, and characterize in detail the lightning discharges in the region.
- Vaisala installed a five sensor network consisting of its **TLS200 Total Lightning Sensor**
 - combines VHF interferometry with LF magnetic direction finding and time-of-arrival technologies.
- The network was operational from **January to March 2012**
 - detected total lightning activity over a region with an approximately 100 km radius around São Paulo.
 - during this period several severe thunderstorms occurred in the region.

TLS200 network



5-sensor network

distances between neighboring stations: 55-130 km

largest distance across network: 160 km

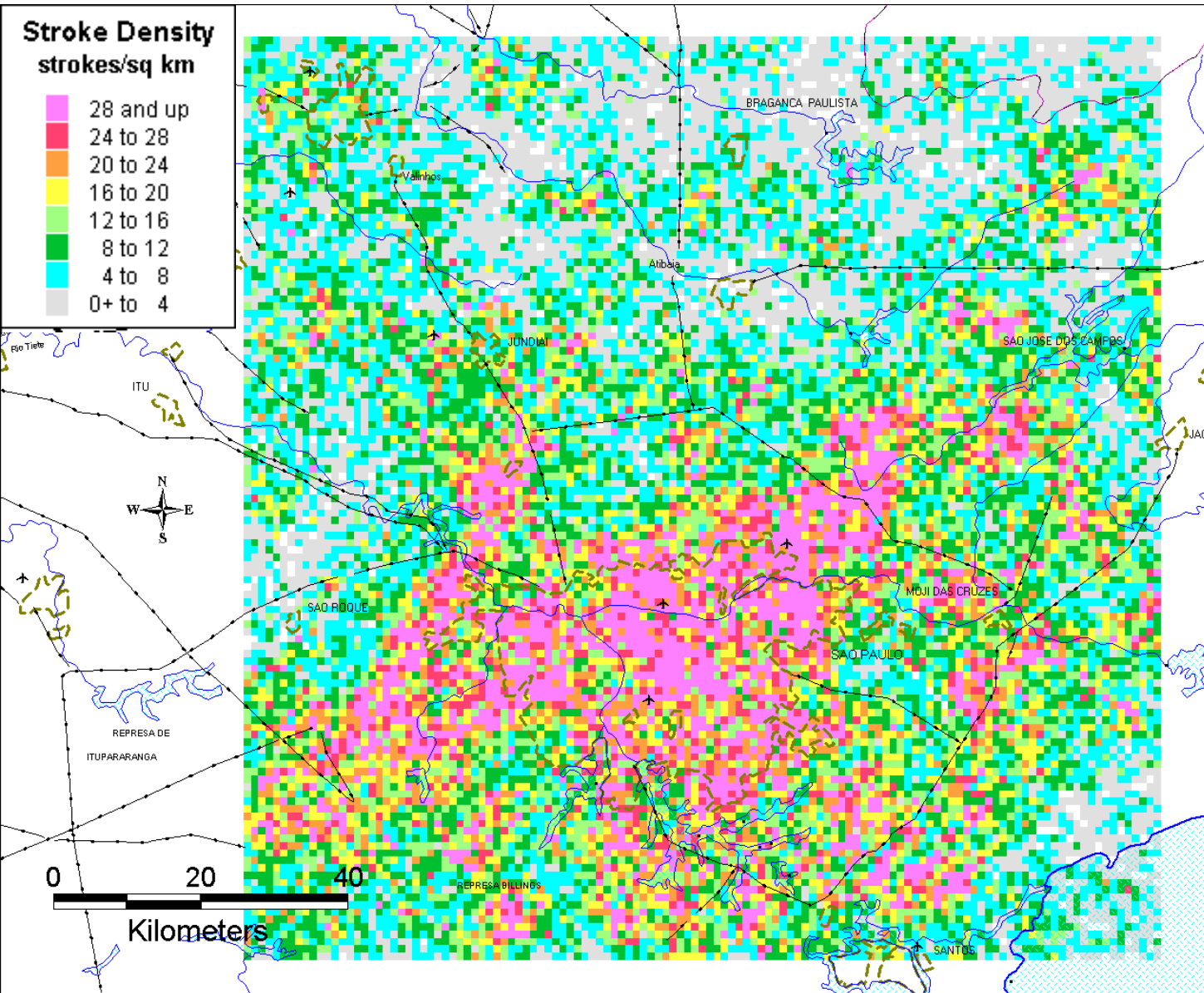


Jujutiba station

Sensors and Data

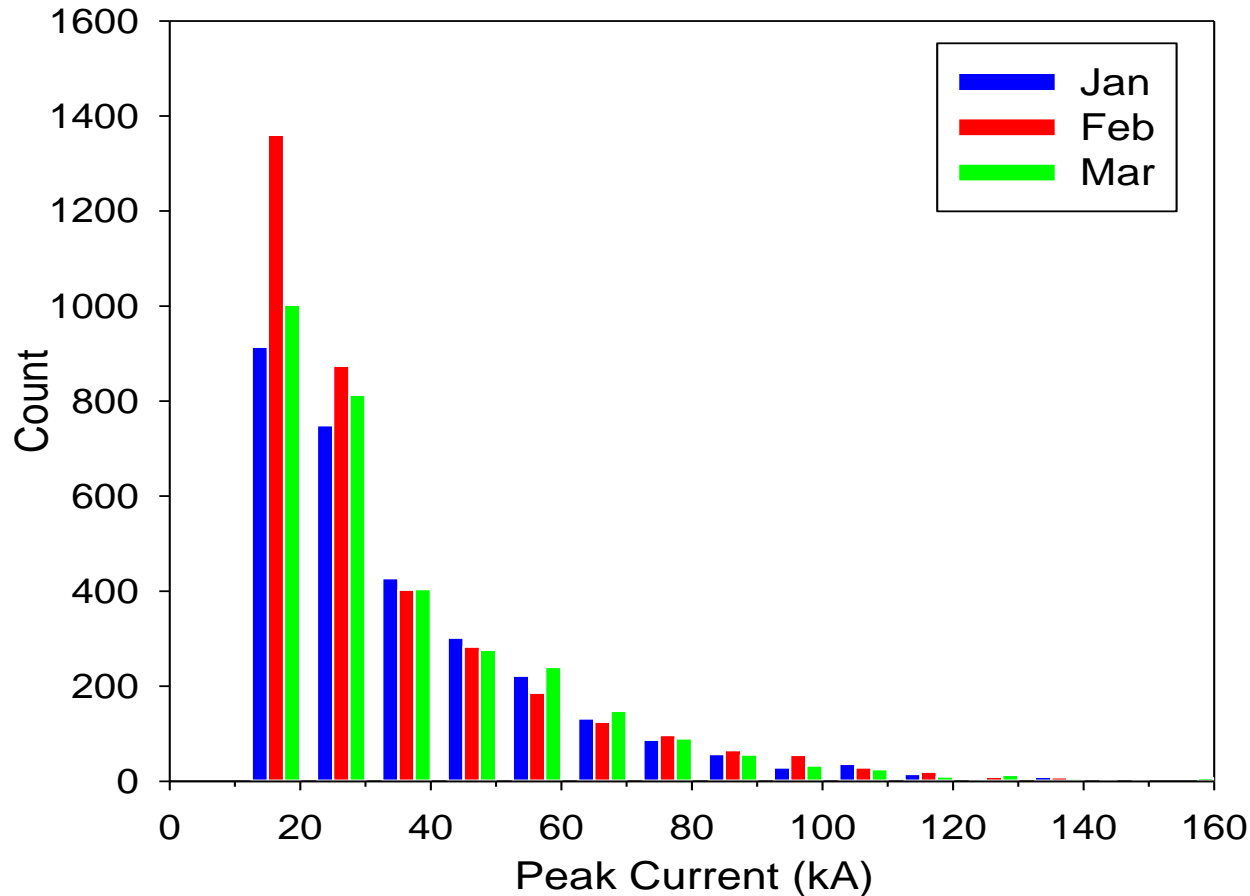
- The **VHF portion** of the TLS200 sensor consists of an array of five dipoles and uses interferometry to measure the arrival azimuth of electromagnetic sources by integrating over a specific time range.
- The **LF portion** of the TLS200 consists of a sensor containing the same electronics as the Vaisala LS7001 sensor (currently used in the U.S. NLDN, for example).
- This allows a single deployed network to perform both total lightning mapping (at VHF) and CG and IC pulse detection and geolocation (at LF) .
- The TLS200 network detected a total of **294810 cloud-to-ground flashes** in January to March, 2012. 8874 (**3%**) of these CG flashes were **positive** and 285936 (**97%**) were **negative**.
- A **larger number of CG flashes** (117459) **occurred during February** than in January and March (86744 and 90607, respectively).

Analysis: Cloud-to-Ground Stroke Density



Cloud-to-ground stroke density (number of strokes per km²) in the Sao Paulo region (125 x 125 km box with grid size of 1 x 1 km) for the period of January to March, 2012.

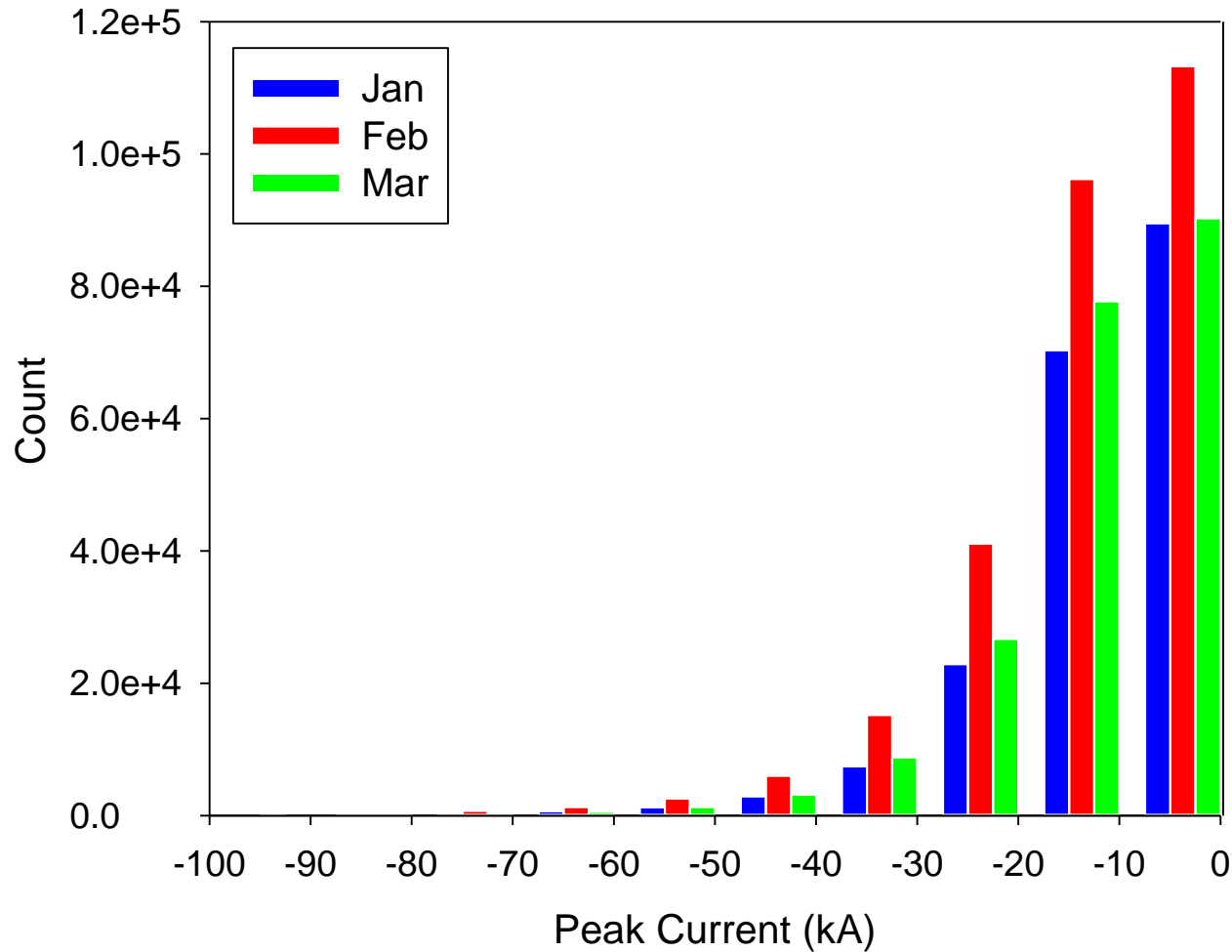
Analysis: Peak Current Distribution for Positive Lightning



Histogram of TLS200 network-estimated peak currents for positive return strokes occurring in the Sao Paulo region in January, February, and March, 2012. The horizontal axis of the histogram is truncated at 160 kA due to the small percentage (only 0.2%) of return strokes having peak currents greater than that value.

	Jan	Feb	Mar	Jan-Mar
Min, kA	15	15	15	15
Max, kA	235	184	193	235
Median, kA	27	23	26	25
AM, kA	35	33	35	34

Analysis: Peak Current Distribution for Negative Lightning

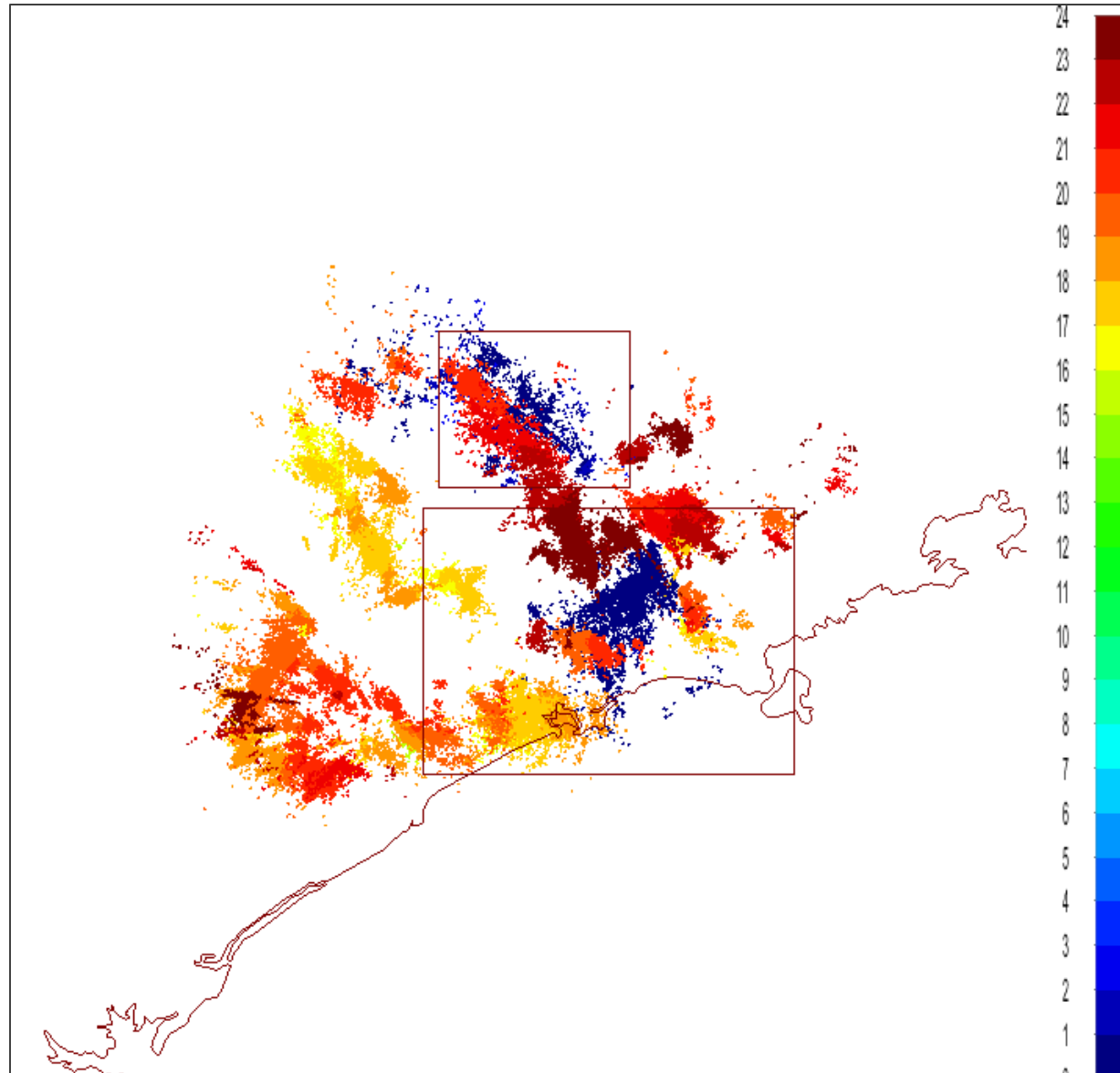


Histogram of TLS200 network-estimated peak currents for negative return strokes occurring in the Sao Paulo region in January, February, and March, 2012. The horizontal axis of the histogram is truncated at -100 kA due to the small percentage (only 0.05%) of return strokes having absolute values of peak current greater than 100 kA.

	Jan	Feb	Mar	Jan-Mar
Min, kA	-0.6	-0.5	-0.5	-0.5
Max, kA	-333	-219	-158	-333
Median, kA	-11	-12	-11	-11
AM, kA	-13	-15	-14	-14

Comparison with LMA Data

- 16 January 2012 chosen as test case
 - small, fairly isolated thunderstorms with low total flash rates
 - flashes were discrete and could be counted manually in order to have an independent check on the VHF flash algorithm results
- Color code = time of day in 24 steps
- Boxes denote analysis regions (hereafter, “northern box” and “southern box”)



Comparison with LMA Data

- VHF data from the LMA and TLS200 were processed through a source-grouping algorithm to identify flashes (Lajou and Cummins, 2005) for direct comparison.
- VHF flashes were then correlated with CG strokes from TLS200 so that we could partition into “known CG” and “known IC” sets.
- LF cloud discharge data from TLS200 network was the test set.
- Reference set was either the LMA or TLS200 network VHF data.
- Detection efficiency: fraction of VHF flashes from each set having at least one associated IC event from the TLS200 LF network.

IC Detection Efficiency of LF Portion of TLS200 Network

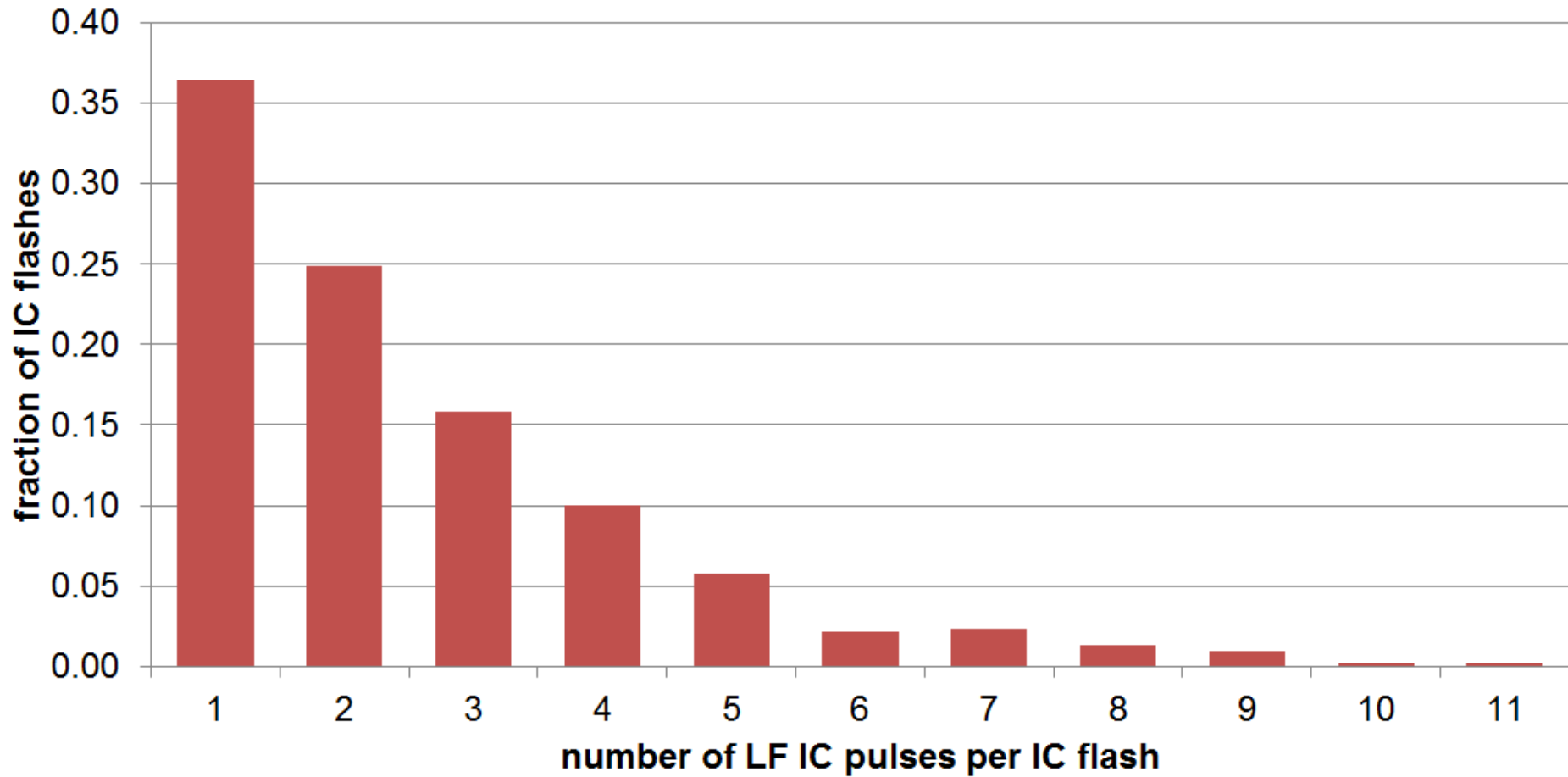
VHF flash counts in each box over the 24-hour period

	southern box		northern box	
	LMA	TLS200	LMA	TLS200
known IC	1097	1089	720	795
known CG	418	502	126	181
total	1515	1591	846	976

LF IC detection efficiency (%) in each box over the 24-hour period

	southern box		northern box	
	LMA	TLS200	LMA	TLS200
known IC	47.3	54.5	48.8	39.6
known CG	68.7	66.5	84.1	74.0
total	53.2	58.3	54.0	46.0

IC Detection Efficiency of LF Portion of TLS200 Network



Taken from the “known IC” flash set in the southern box

Summary

- This analysis of the Vaisala TLS200 network shows the major features of lightning activity in the Sao Paulo region.
- The network detected a total of 294810 cloud-to-ground flashes in January to March, 2012 of which 3% were positive and 97% were negative.
- The VHF portion of the network had flash detection efficiency similar to the LMA network.
- LF portion of the TLS200 network detected at least one IC discharge event in ~50% of all flashes.
- The majority of flashes have multiple LF IC discharge events, not just a single one.
- Future work needs to be done to extend this analysis over more number of thunderstorm days.

Thank You

CHUVA Network Layout



The Vaisala TLS200 sensor installed in Sorocaba, Brazil.

CHUVA Network Layout



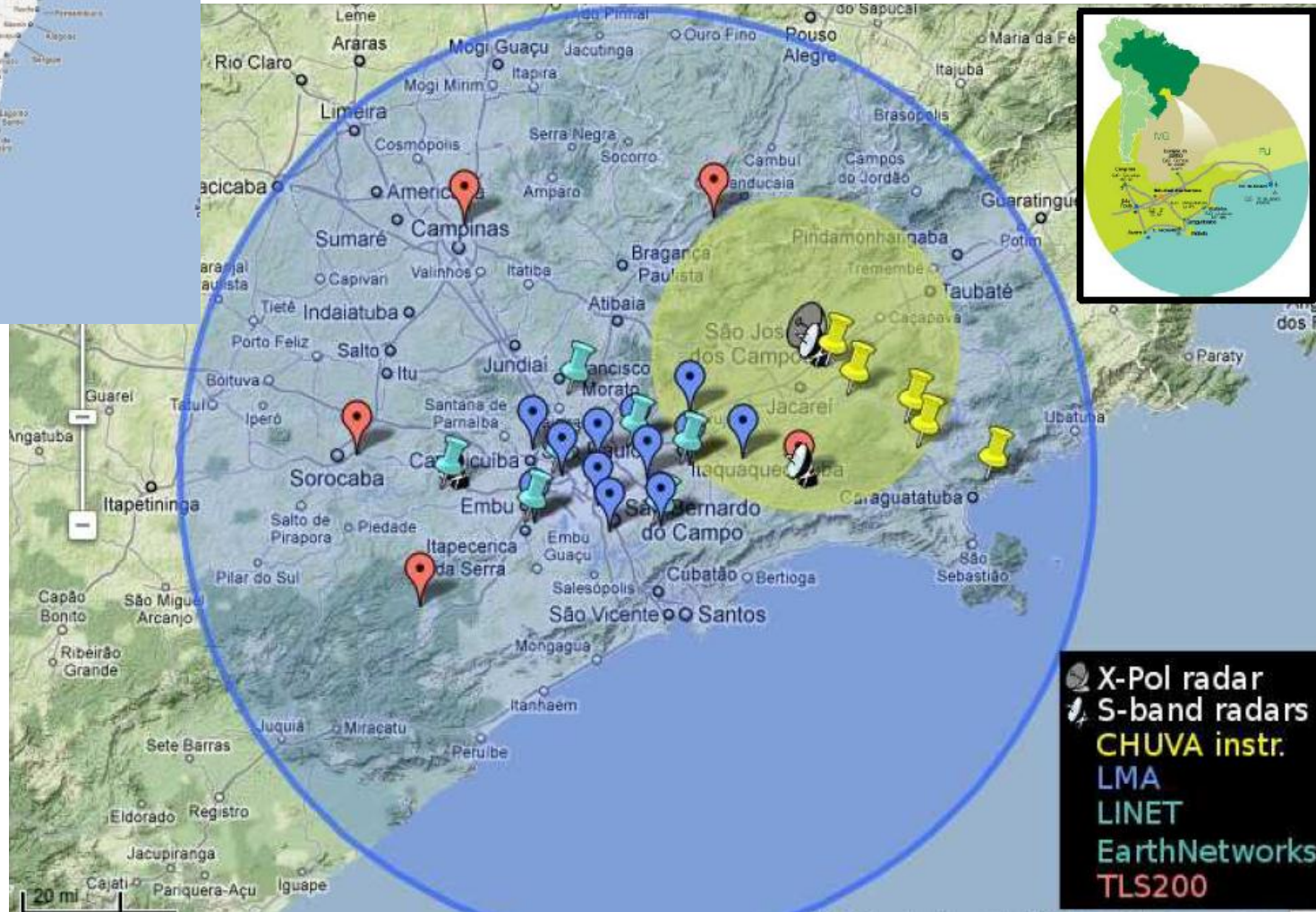
Photo by Bryan Brady



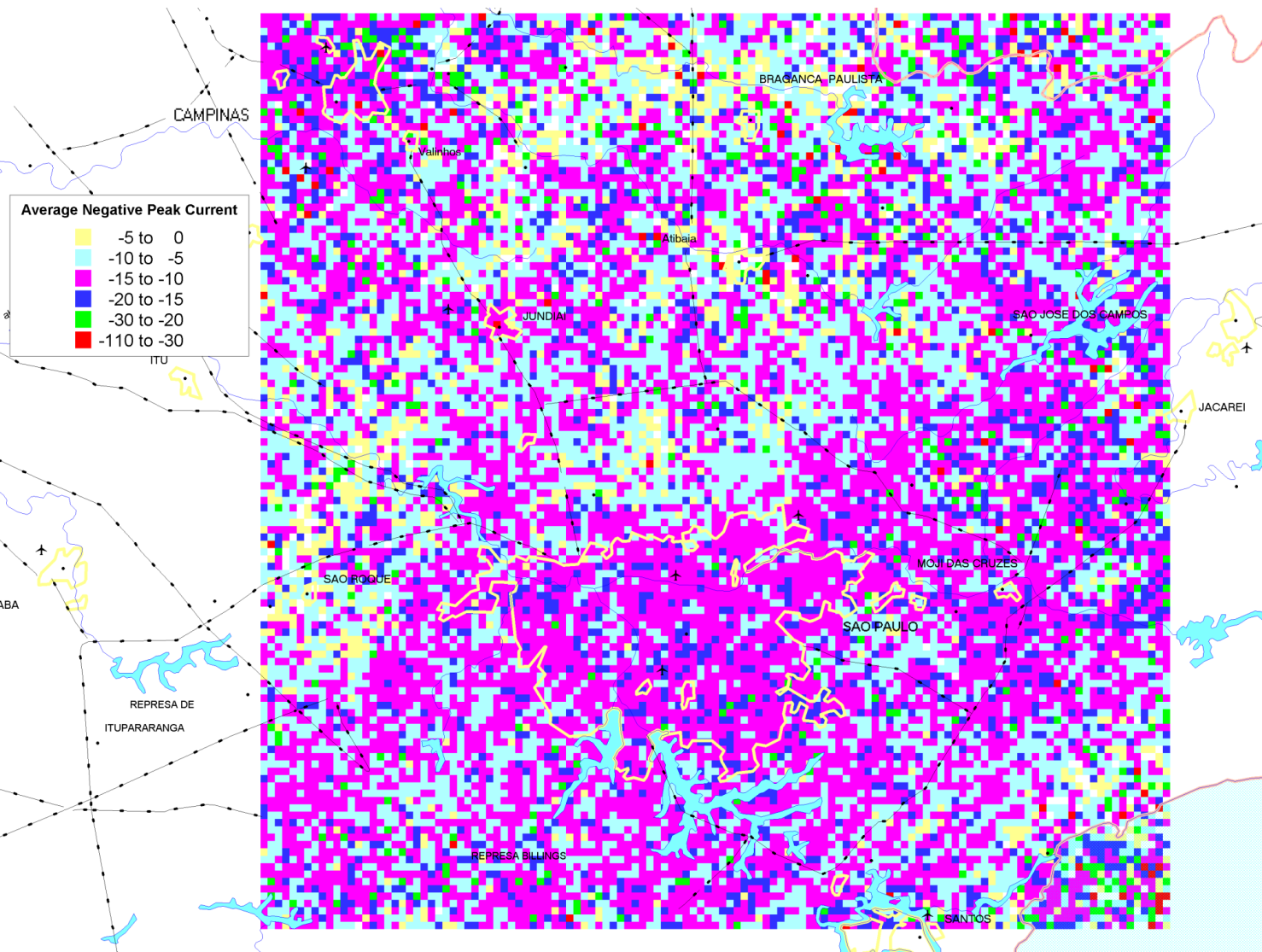
Photo by Bryan Brady

The Vaisala TLS200 sensor installed in Juquitiba, Brazil.

CHUVA Network Layout

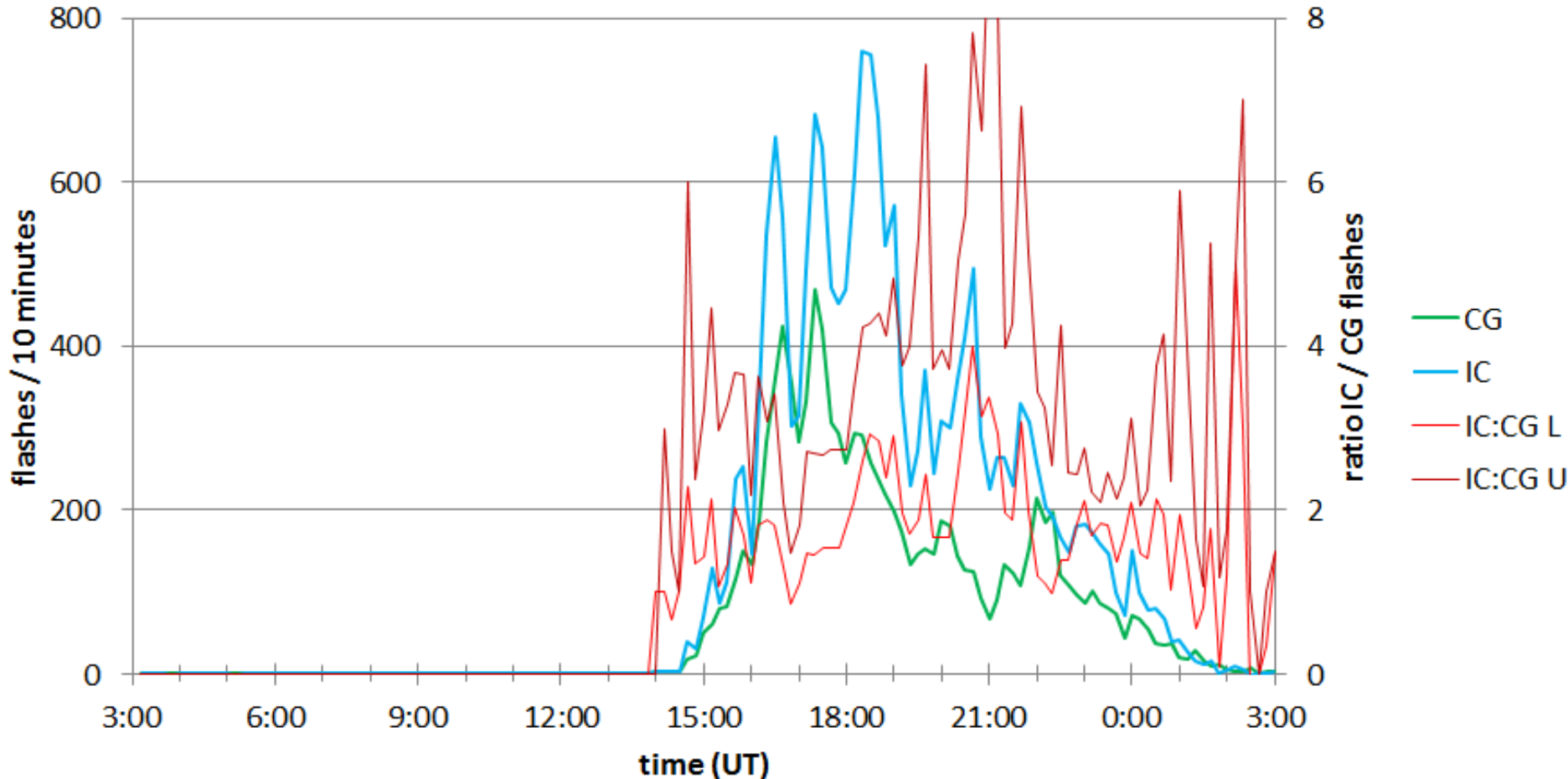


Analysis: Average Peak Current for Negative Lightning



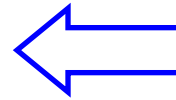
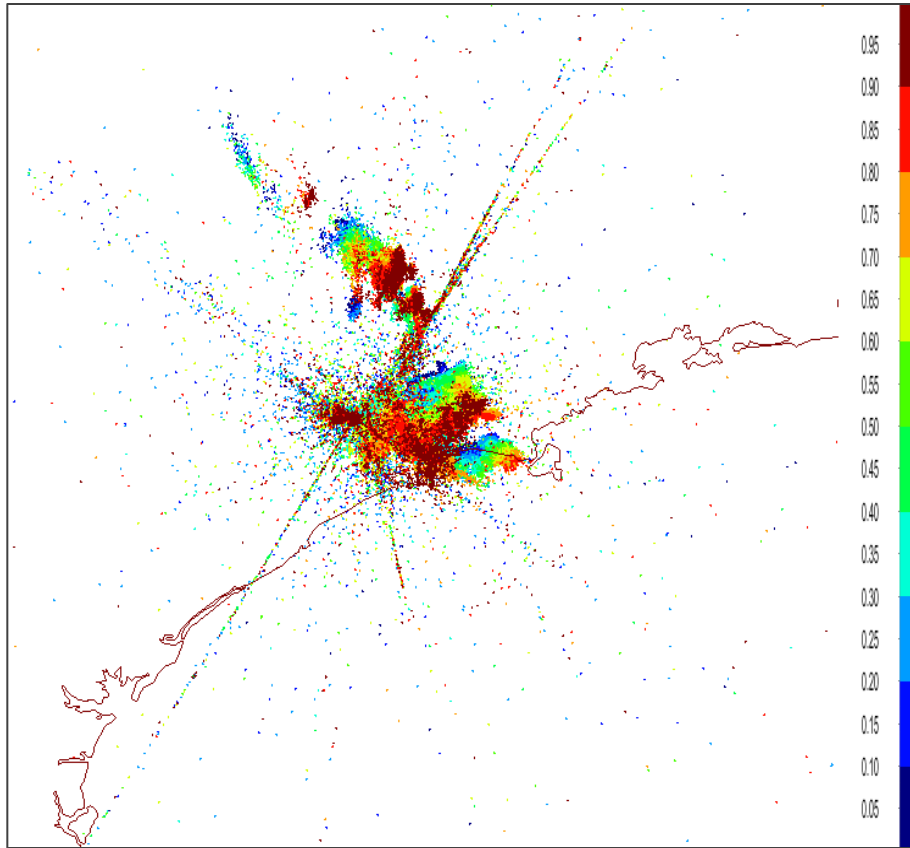
The average negative return stroke peak current in the Sao Paulo region (125 x 125 km box with grid size of 1 x 1 km) for the period of January to March, 2012.

Analysis: IC to CG Flash Ratio



Aggregate of IC and CG flash counts over the period 16 – 19 January, shown as a function of time of day. Approximate **lower (IC:CG L)** and **upper (IC:CG U)** bounds on the IC-CG flash ratio are also shown as the two red curves.

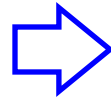
Comparison with LMA Data



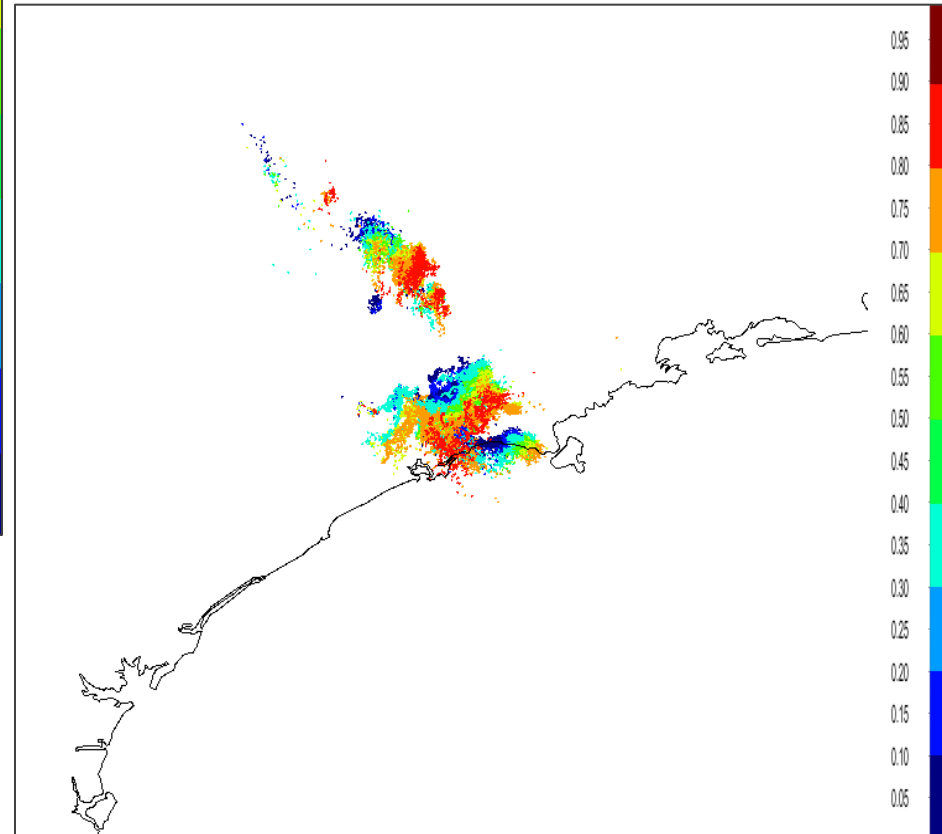
raw LMA data, 00:00 – 01:00 UTC on 16 January

(color code represents time)

filtered by (1) removal of sources detected by only 6 sensors, (2) removal of sources below 3.5 km altitude



(after source grouping, also removed all flashes having only 1-2 sources)



Comparison with LMA Data

	time constraint (msec)							
km	200	300	400	500	600	700	800	900
2	1335	1249	1209	1184	1177	1174	1173	1173
4	614	554	528	521	515	514	512	512
6	354	323	302	296	290	290	290	290
8	265	231	219	212	208	208	208	208
10	224	194	182	176	173	173	173	173
12	211	182	169	<u>163</u>	161	161	161	161
14	193	163	152	147	145	145	145	145
16	189	157	146	139	136	136	136	136
18	186	154	144	137	134	134	134	134
20	185	152	142	134	131	130	130	130

TLS200 VHF data – 00:00 – 01:00 UTC

manual flash count was 161

nominal space / time constraints are 12 km and 500 msec, respectively

flash count at nominal settings = 163

	time constraint (msec)							
km	200	300	400	500	600	700	800	900
2	799	787	788	792	793	796	795	797
4	266	266	273	282	280	280	280	283
6	185	189	196	202	201	200	199	202
8	156	162	169	176	174	173	172	175
10	147	151	156	164	161	160	158	161
12	145	150	157	<u>164</u>	161	160	158	161
14	142	148	155	163	160	159	157	160
16	142	148	155	163	160	159	157	160
18	142	148	155	163	160	159	157	160
20	141	147	154	162	159	158	156	159

LMA data – 00:00 – 01:00 UTC

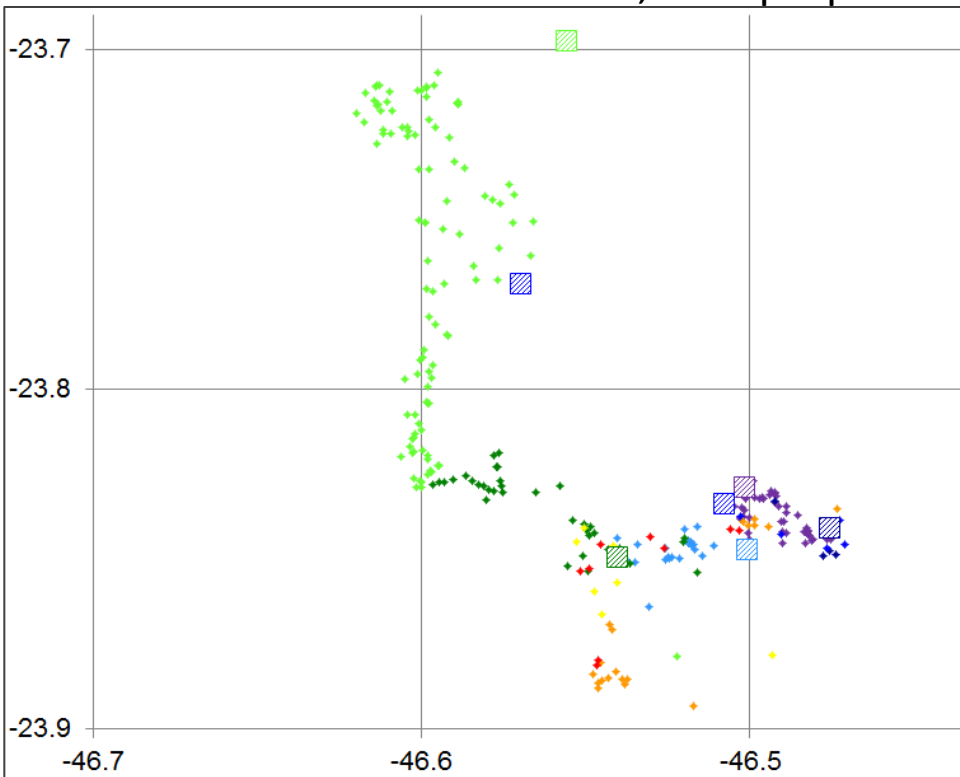
flash count at nominal settings = 164

green indicates all flash counts within 10% of the nominal

conclusions:

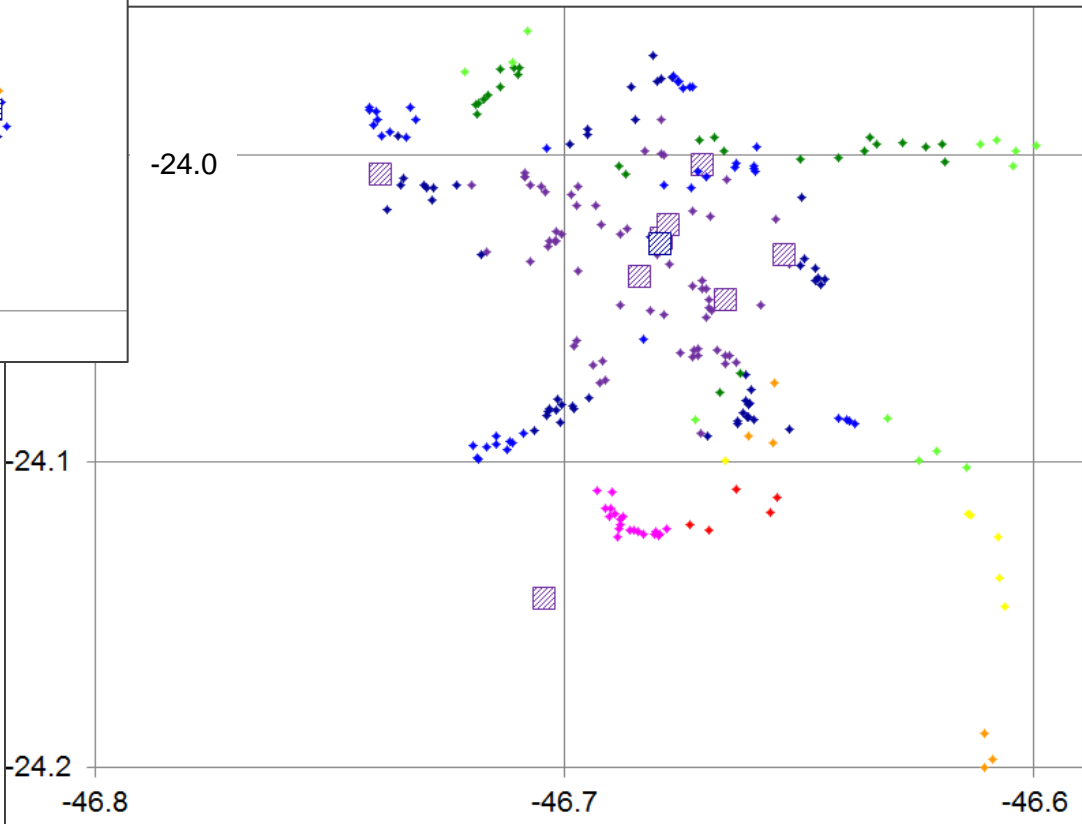
- consistent flash counts between two VHF systems and manual count
- appropriate parameter settings

Lat, lon plots of two flashes (LMA = small dots, LF IC = squares, color = time, with purple at start, red/pink at end)



17:35:42

(620 ms)



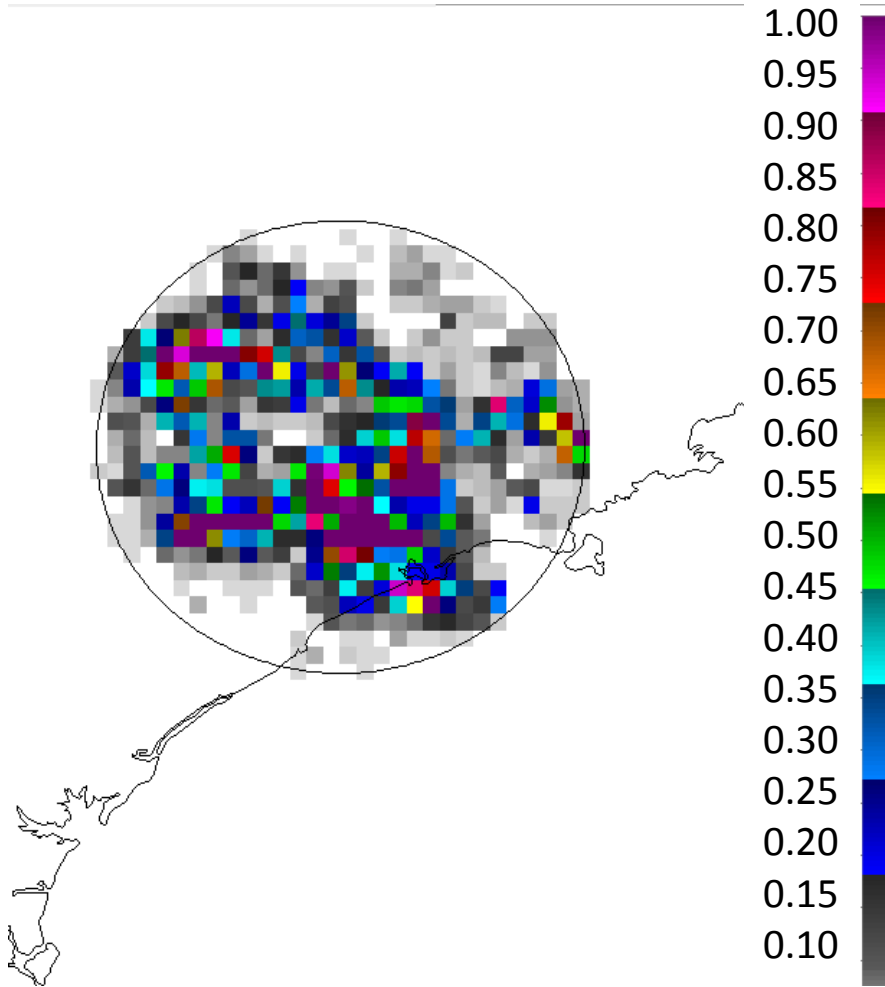
18:24:49

(370 ms)

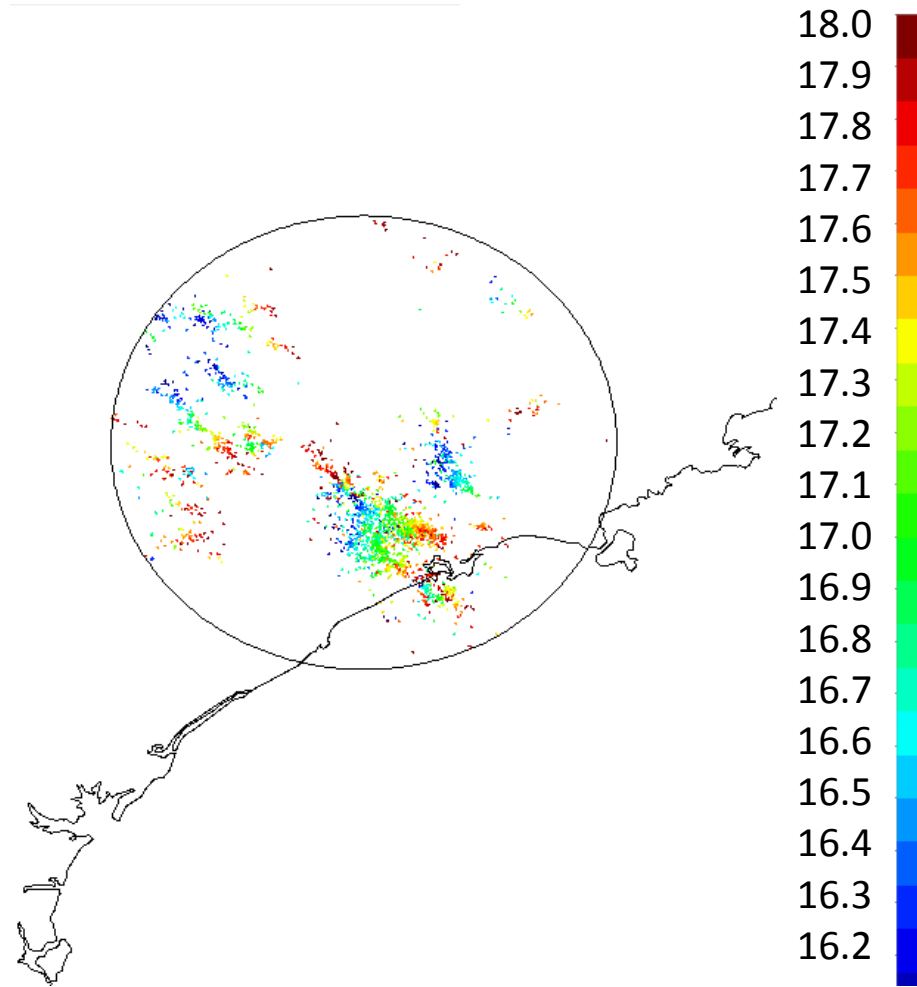
Conclusions and future work

- LF component of the TLS200 network detected at least one IC discharge event in ~50% of all flashes
 - higher percentage of known CG flashes have LF IC discharges associated with them
 - characteristics of what is being detected as LF IC within CG flashes has not been investigated yet
- the majority of flashes have multiple LF IC discharge events, not just a single one
- some rudimentary channel following is noted in the positions of LF IC discharges relative to VHF data
 - but with some events clearly misplaced in time/position
- new LF IC pulse burst detection and processing capability should improve both detection efficiency and reduce misplaced events – to be tested and released in early 2013

Analysis: VHF Flash Extent Density



Flash extent density on a 10 X 10 km grid between 16:00 – 18:00 UTC on 17 January. The color scale saturates at 1 flash/km², although the maximum value observed was 4 flashes/km².



CG flashes between 16:00 – 18:00 UTC on 17 January, color-coded by time.