Lead Times Between In-Cloud and Cloud-to-Ground Lightning Flashes in the South Texas Sea Breeze Regime

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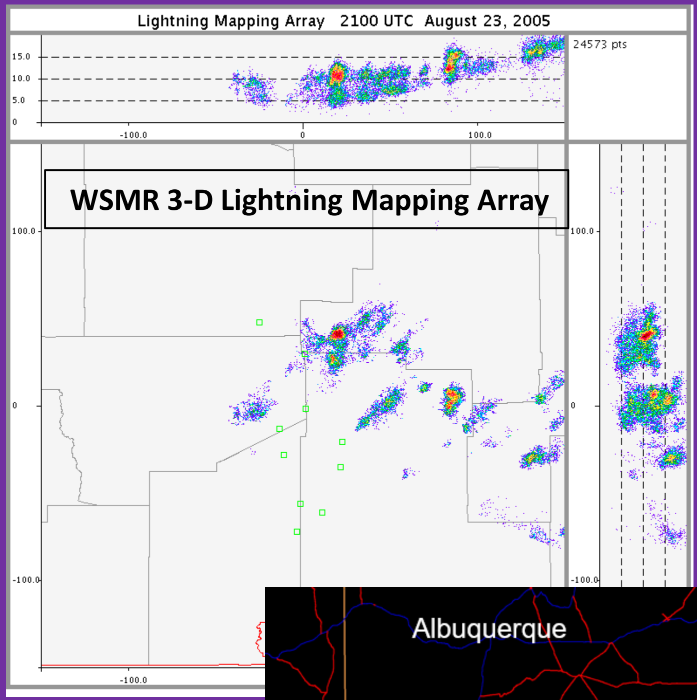
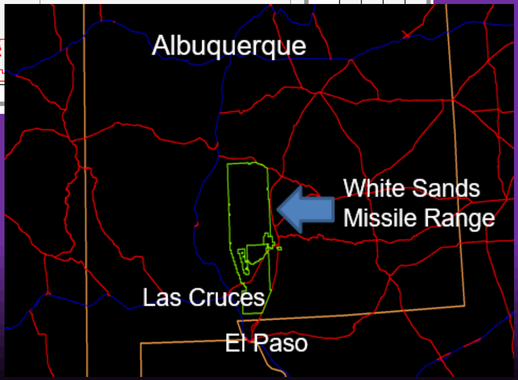
“When thunder roars, go indoors” is great for the *general public*…

…but other users have different needs:

“OK, I’m hearing thunder. Call me back when you detect a cloud-to-ground strike, because that’s what my safety regs are written to.”

- Paraphrased from many conversations with test officers building missiles in the field at WSMR.





Wouldn't it be great to tell an EM or Safety Officer…

"OK, you've probably heard thunder, since we've detected in-cloud lightning. You've got 'X' minutes before a cloud-to-ground strike is likely. Take any final precautions NOW."

But what is X??

There is little published work on what values of 'X' are.

Consider *Δt*, the lag time between first In-Cloud (IG) lightning activity and first Cloud-to-Ground (CG) flash in a particular storm.

MacGorman, *et al*. (2011) in *MWR*

- **Found *Δt* to be in the range of 3-31 min (at 50th percentile).**
- ***Wide variability* across three *geographical regions* (OK, N. Texas, High Plains of CO/KS/NE).**
- **Used VHF 3-D Lightning Mapping Networks vs. NLDN.**

Initial, limited analysis of orographic thunderstorms at @ WSMR generally showed 5-15m lead time from IC to CG activity.

Who Might Want to Know This Number for South Texas?

BROWNSVILLE

The Herald

WEDNESDAY, AUGUST 28, 2019 — BORN ON THE FOURTH OF JULY 1892 — 75 CENTS

GAME ON!

The Herald previews nine Metro-area high school football teams. Catch your copy today!

➤ INSIDE

LOCAL

INTERNATIONAL PARADE

International students, staff and the music band "Halcones" from Preparatoria Ricardo Flores Magón in Matamoros made their way through the Brownsville campus on Tuesday in a parade of flags to celebrate a new school year at UTRGV.

➤ PAGE A2

NATION

BAN BLOCKED

A new Missouri ban on abortions at or after eight weeks of pregnancy won't take effect Wednesday after a federal judge temporarily blocked it from being implemented.

➤ PAGE A6

OBITUARIES

Antonia Garcia
Hilda Santillan
Enrique Narvaez
Monica Hoeck
Lawrence McDaniel
Prentice Gipson Jr.
Carlos Regalado

SPACEX

THE BIG ONE

Starhopper completes successful 150-meter flight

MIGUEL ROBERTS/THE BROWNSVILLE HERALD

BY STEVE CLARK
STAFF WRITER

At one minute past 5 p.m. on Tuesday, SpaceX flew its Starhopper test vehicle to an altitude of 150 meters, about 500 feet, at the company's Boca Chica Beach launch/test site.

PLEASE SEE **TEST, A12**

View the test hop of SpaceX's Starhopper.
www.myBrownsvilleHerald.com

Above: SpaceX's Starhopper rockets above the launch site before safely landing Tuesday at Boca Chica Beach. **Right:** This screen-capture image of SpaceX's video stream, shows the SpaceX prototype vehicle Starhopper propel itself from its Boca Chica launch pad on its way to a nearby landing pad during a test hop Tuesday outside of Brownsville.

SPACEX

4,000-seat amphitheater opened Oct 2019 on South Padre Island

Liquified Natural Gas export plants coming on-line at Port of Brownsville

Need Two Datasets to Determine Δt

National Lightning Detection Network (NLDN)

- *Primarily* detects CG flashes
- Magnetic/ToA sensors
- Detection efficiency ~95%.
- Operated by Vaisala; download available to NWS users via NCEI.

Earth Networks Total Lightning Detection Network (ENTLN)

- Detects lightning electric field waveforms at ~700 sites in CONUS.
- Processes “pulses”.
- Can discriminate between IC and CG flashes.
- *Data available upon request to NWS users.*

Focused on Warm-Season Sea-Breeze Thunderstorms

Relatively easy to isolate individual storms around sea-breeze initiation time.

- Analysis was all done "manually".
- Look at *first storms of the day*, usually around 1500-1800 UTC, for months Jun-Sep 2018.
  - Convection pattern usually gets "messy" quickly.
  - Looked at storms within range of KBRO NEXRAD.
  - Did not consider widespread convection forced by upper-level lows, tropical waves, etc.
- Goal was to identify *at least 30 storms* where Δt could be determined to allow for semi-robust statistics.

Start with the CG Data and Work Backward

1. Find the first CG strike occurring around the time of sea-breeze initiation (will often follow a significant break in lightning activity):

2018	7	6	13	13	46.396	25.053	-96.986	13	N	38.4	1
2018	7	6	13	33	15.749	25.087	-96.98	12	N	118.8	2
2018	7	6	13	33	50.012	25.078	-96.995	12	N	39.6	2
2018	7	6	13	34	59.059	25.074	-96.994	11	N	73	2
2018	7	6	13	41	5.956	25.133	-97.032	4	N	18.4	1
2018	7	6	13	56	33.544	25.322	-98.144	3	P	11.2	1
2018	7	6	14	49	34.625	26.146	-97.25	6	P	11.2	1
2018	7	6	14	53	17.763	26.149	-97.22	6	P	27.5	3
2018	7	6	15	42	21.091	25.623	-97.293	10	N	22.2	1
2018	7	6	15	57	18.497	25.667	-97.396	12	N	22.8	2

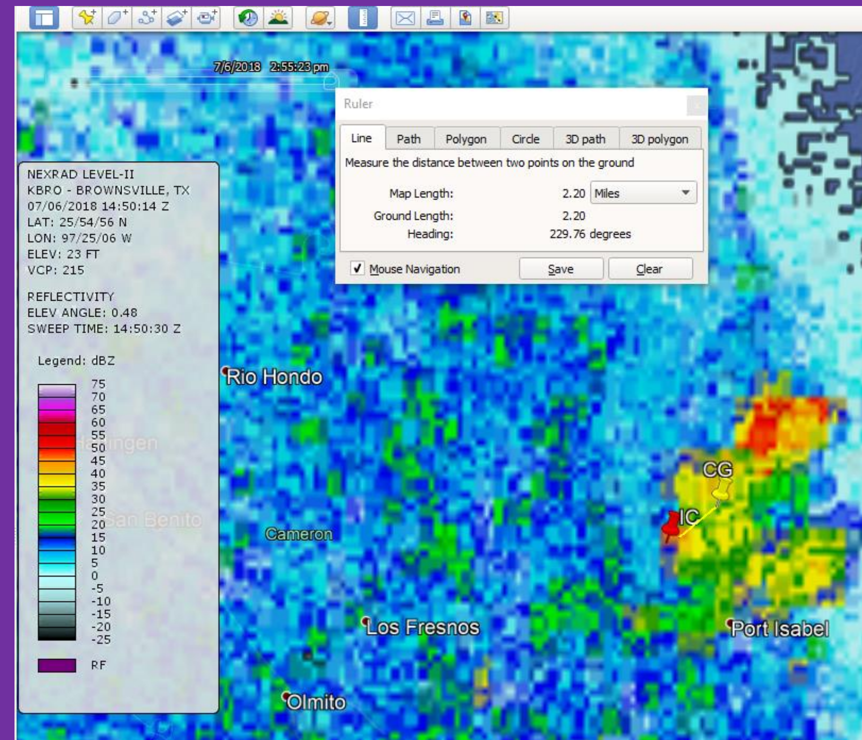
2. Use Weather and Climate Toolkit or GR2Analyst to review the radar reflectivity imagery from previous 60 min.
   - Look for signs of sea-breeze storm development around the time of the CG strike identified.

Look for a Prior IC Pulse

3. **Export the radar data to a *kmz* file for use in Google Earth.**
   - **Plot the lat./lon. of CG strike.**

4. **Try to find a corresponding IC source that occurred nearby and in prior *60 min*.**

1	2018-07-06T13:34:59.089827299	25.07111	-96.971	6102	18534	18	0.74	0.63	4.4
0	2018-07-06T13:34:59.130824804	25.09564	-96.972	-9263	0	19	0.27	0.1	4.2
1	2018-07-06T14:49:34.491731882	26.12556	-97.2564	-8485	14316	13	0.57	0.56	11.1
1	2018-07-06T14:49:34.644515991	26.13103	-97.2388	3231	7640	9	0.6	0.38	28.8
1	2018-07-06T14:49:34.679929972	26.12876	-97.2364	5266	17971	11	0.25	0.1	7.9
1	2018-07-06T15:28:11.252523661	25.75568	-97.2557	-8906	10728	16	0.38	0.21	49.6
1	2018-07-06T15:31:18.040844202	25.67185	-97.2278	-2847	10552	5	2.13	0.2	8.8

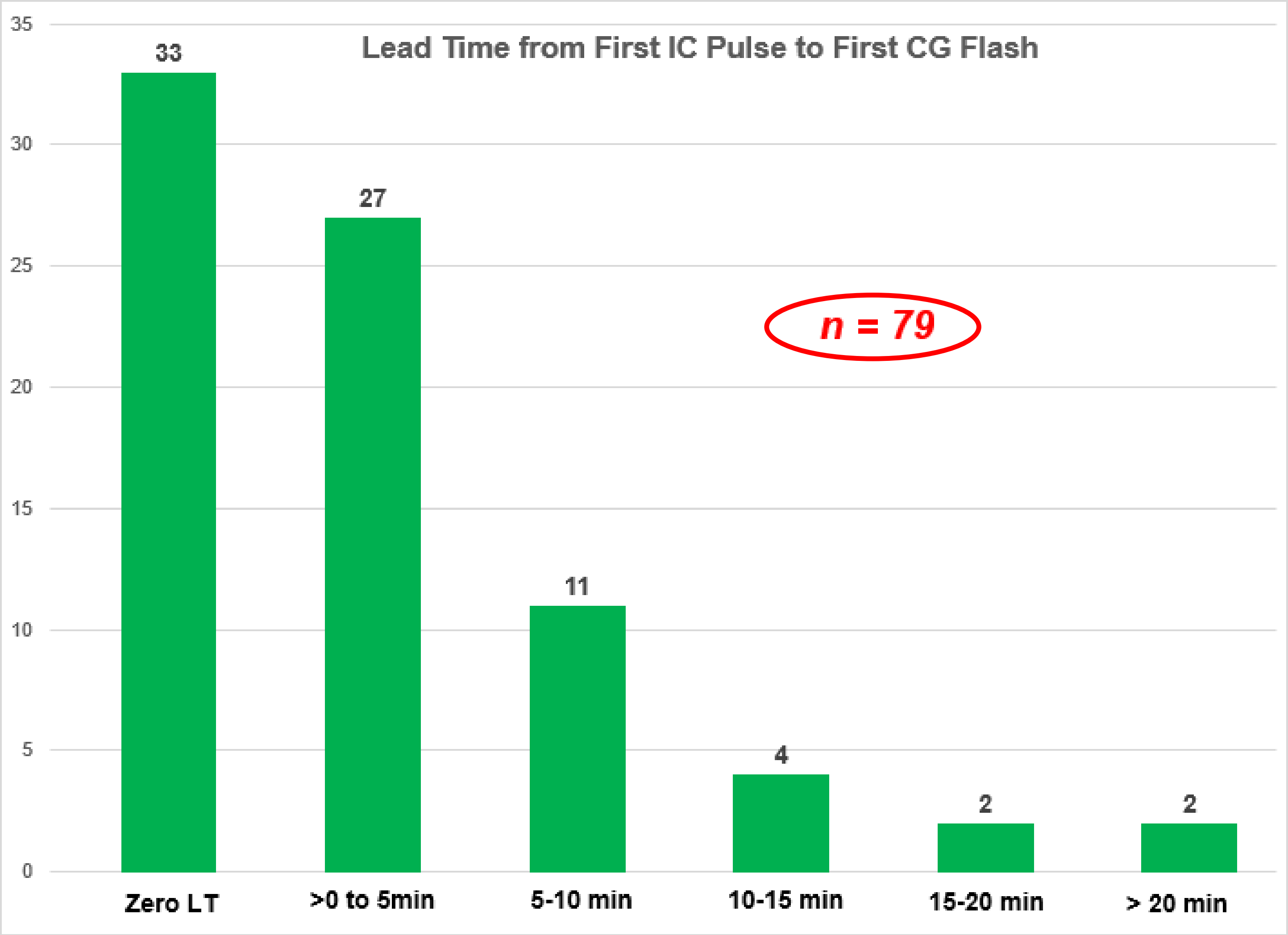


5. **Plot location of first IC source. Determine spatial separation between the IC and CG strikes.**

IC source must have occurred within 10 miles of CG strike and be visually associated with the same storm cell.

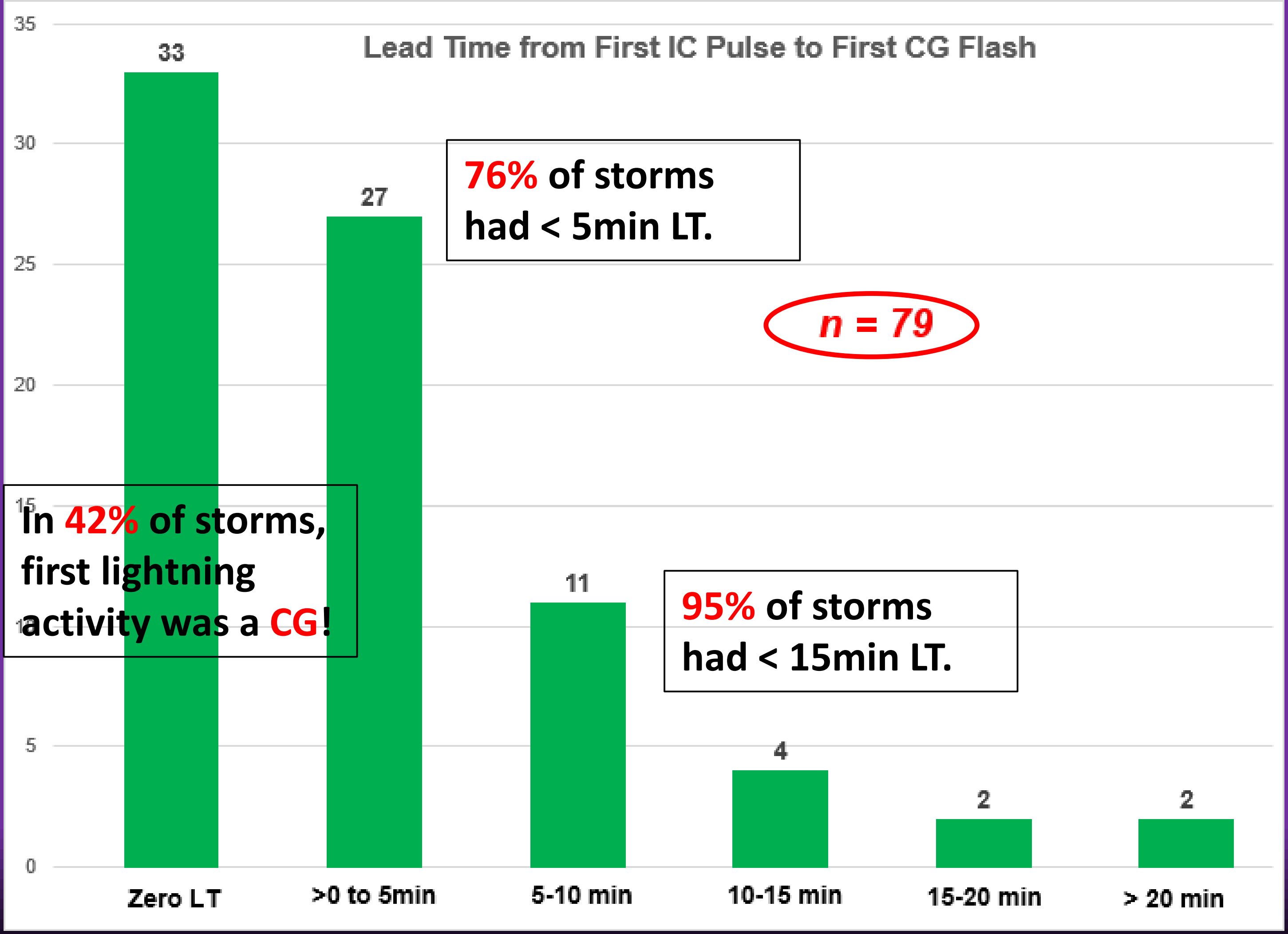
6. **If possible, analyze other cells on same day; else, back to Step 1…**

What Did We Learn?



Note: "Null" cases not considered.

What Did We Learn?



Note: "Null" cases not considered.

There was *some* variability in LT's.

Cumulative	Mean lead time	Median lead time	Max lead time	Std. Dev.
	0:03:25	0:01:08	0:25:42	0:05:12

June	n	Mean lead time	Median lead time	Max lead time	Std. Dev.
	10	0:05:01	0:00:55	0:19:00	0:07:37

July	n	Mean lead time	Median lead time	Max lead time	Std. Dev.
	17	0:02:49	0:01:05	0:12:21	0:03:51

August	n	Mean lead time	Median lead time	Max lead time	Std. Dev.
	31	0:04:05	0:01:23	0:25:42	0:06:07

September	n	Mean lead time	Median lead time	Max lead time	Std. Dev.
	21	0:02:09	0:00:44	0:09:17	0:02:40

Measures of central tendency, especially median, fairly consistent month-to-month from Jun-Sep.

"You Can't Always Get What You Want…"

At least for South Texas sea-breeze storms

- IC lightning does ***not*** precede CG strikes reliably enough or early enough to aid with provision of IDSS.
- Not nearly enough safety margin, especially when considering latency in networks, time for communication, etc.

Concluding Thoughts

Clearly there are climatological differences in IC/CG lead times; concurs with MacGorman, *et al*. (2011).

- **Different storm electrification processes/timeframes.**

How would the distribution in LT's differ in other environments, e. g. desert/mountain?

- **In more synoptically forced situations?**
- **Need to automate to really expand the sample size.**

At what value *does* Δt become useful??

- **Would calculated Δt be any different using GLM sources?**

Do other thresholds/predictors (e. g., reflectivity at isotherms) provide more value?