A Tour of Lightning With HAMMA

Phillip M. Bitzer

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Fundamental question for scientific validation:

What is the best way from the ground to characterize what LIS “sees?”
HAMMA and NALMA
HAMMA
Huntsville Alabama Marx Meter Array

NALMA
North Alabama Lightning Mapping Array
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Wideband ~1Hz-500kHz
Sample Rate: 1MHz

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North Alabama Lightning Mapping Array
Narrowband VHF ~80 MHz
Sample Rate: 20MHz
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Both arrays can locate sources via time-of-arrival; HAMMA can also provide energetic information
preliminary breakdown pulse train
early return stroke
subsequent return stroke
Negative CGs produce a preliminary breakdown pulse train with negative polarity pulses.

Flashes with an initial intracloud component begin with positive polarity pulses.
HAMMA is “very” active in the beginning of a flash
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=> wideband sources are well tuned to identify initiation
What’s the difference in wideband and VHF?
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- Time difference: 680µs
- Distance difference: 318m
- Height difference: 641m
On average, initiation in the wideband and VHF are spatially and temporally similar...

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On average, initiation in the wideband and VHF are spatially and temporally similar...

...but what does this mean for the initiation mechanism?
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Assume:
- initiation height of 6km
- electric field of 175 kV/m

![Graph showing the relationship between electric field and characteristic length](image)
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Assume:
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- electric field of 175 kV/m

Implies:
- avalanche length is ~200m
- total length of the high field region is ~2km
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Further, Coleman and Dwyer (2006) show that the avalanche progresses with a speed of 0.89c
The modeling work provides a testable parameter if relativistic runaway breakdown is responsible for initiation.
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| Model                | ~7.5µs        | Dwyer, 2003  
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Further.... simulations *(Dwyer, 2010)* show the region of slow electrons is far too diffuse to yield the required conductivity.
LIS (and by extension, GLM) does not detect *flashes*...
LIS is an **optical event** detector
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These events can be classified into strokes groups and flashes.
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Validation of LIS/GLM measurements should use instruments sensitive to the part of the lightning discharge which produces optical emission
What is a hit?

3.5 V/m

2.6 V/m
What is a hit?

- Voltage (V): -0.095 to -0.085
- Altitude (km): 0.0 to 8.1
- Time: 4ms

- Voltage (V): -0.120 to -0.060
- Altitude (km): 0.0 to 8.1
- Time: 6ms

- Voltage (V): -0.120 to -0.040
- Altitude (km): 0.0 to 8.1
- Time: 6ms
What is a hit?

Wideband record indicates activity during LIS groups.
What is a miss?

1.1 V/m

0.8 V/m
What is a miss?

1.1 V/m

25ms

0.8 V/m

3ms
What is a miss?

Electric field measurements indicate that LIS missed these strokes because they are not very energetic.
What can VHF tell us?
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Nothing is really unique about VHF sources...
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Nothing is really unique about VHF sources...

...in fact, there are LIS groups without any detected VHF sources!
4.9 V/m
Again, the wideband record is active...
Again, the wideband record is active... ...and there are LIS groups without detected VHF sources.
13.9 V/m

10.8 V/m
Without an array of wideband sensors, these might have been misinterpreted as “misses”
Since LIS/GLM does not detect “flashes,” we must find a way to validate what LIS/GLM does detect.
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Clearly, wideband measurements are better correlated to these optical events...
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Clearly, wideband measurements are better correlated to these optical events...

and even suggest there is a lower limit to what LIS can detect!
Fundamental question for scientific validation:

What is the best way from the ground to characterize what GLM "sees?"
Wideband measurements are ideally suited to the processes in lightning that produce optical emission.

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