The Electrification of New Mexico Thunderstorms

1. Relationship Between Precipitation Development and the Onset of Electrification (1989)

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Introduction

https://tau0.wordpress.com/tag/lightning/

dBZ = decibel relative to Z (equivalent reflectivity)

dBZ	Rain Rate (in/hr)
65	16+
60	8.00
55	4.00
52	2.50
47	1.25
41	0.50
36	0.25
30	0.10
20	Trace
< 20	No rain

http://oceanservice.noaa.gov/education/yos/resource/JetStream/doppler/baserefl.htm

Background

- *Workman and Reynolds* – 12 clouds exhibited a radar return followed by a developing electric field with initial discharge occurring 10 minutes after radar return.

- *Reynolds and Brook* – Precipitation is necessary but not sufficient condition for electrification. Precipitation preceded onset of electrification as much as 30 minutes beforehand.

- *Moore et al.* – Radar reflectivity always less than 33 dBz before onset of electrification.

GOAL: Investigate onset of electrification in relation to the development of

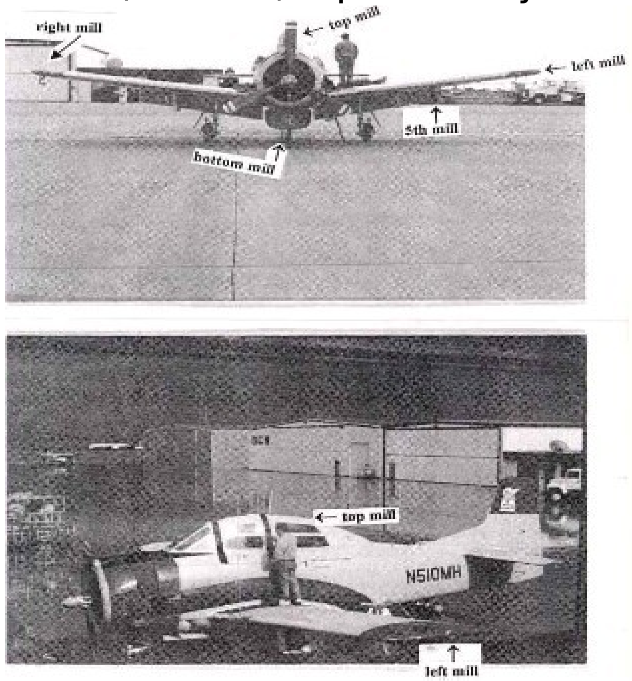
Instrumentation

Aircraft Electric Field Measurements

Explorer Sailplane, operated by NCAR

http://soaringcafe.com/2013/05/explorers-sailplane-the-four-lives-of-two-nine-juliet//

Special Purpose Test Vehicle for Atmospheric Research (SPTVAR), operated by NMT



http://www.antennadesignconsultant.com/blog/

Instrumentation

Surface Electric Field Measurements

Five rotating shutter electric field mills located along mountain ridge

Case removed; view of interior circuit boards.	Field meter in use on an outdoor stand.	Rotating shutters on downward-facing end.

Instrumentation

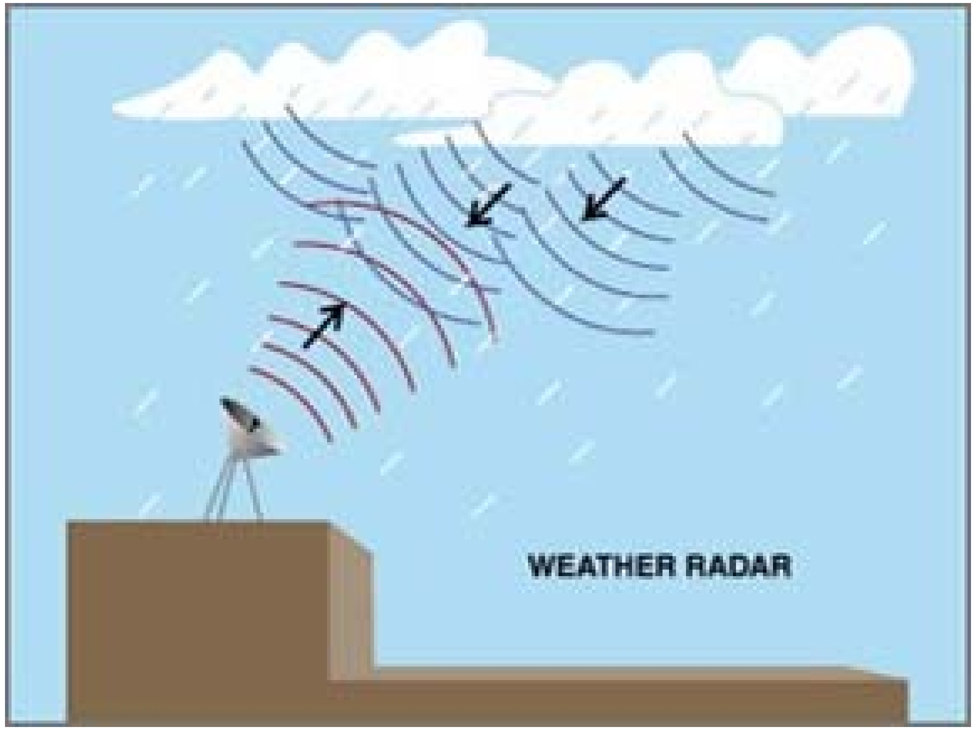
Radar Reflectivity

NCAR Doppler 5-cm-wavelength radars

- CP-3
- CP-4

NOAA 3-cm-wavelength radars

- C
- D



http://www.windows2universe.org/earth/Atmosphere/weather_instruments.html

Instrumentation

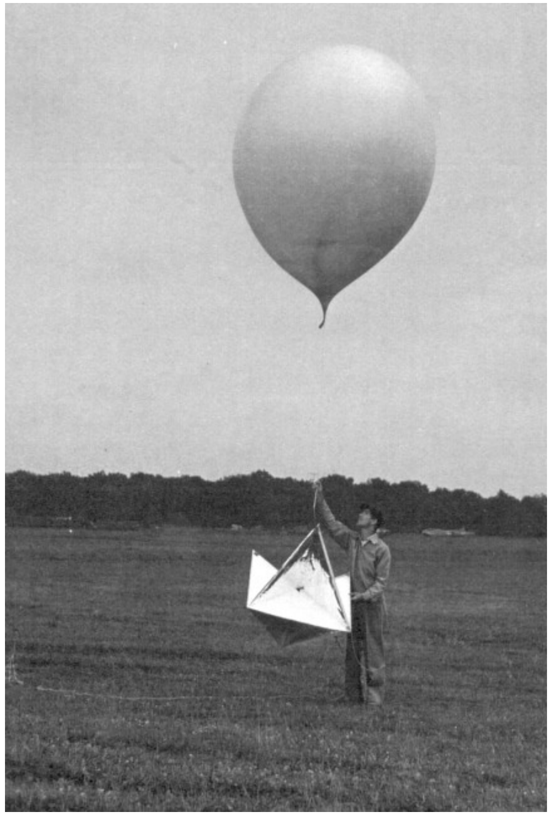
Rawinsondes and Time-Lapse Photograph

Rawinsondes

- Radiosonde that measures winds, pressure, temperature and humidity.
- Released daily at 0730 MST from the Socorro airport.

Camera

- Photos taken every 20 seconds from Socorro.
- 16-mm time-lapse camera system.

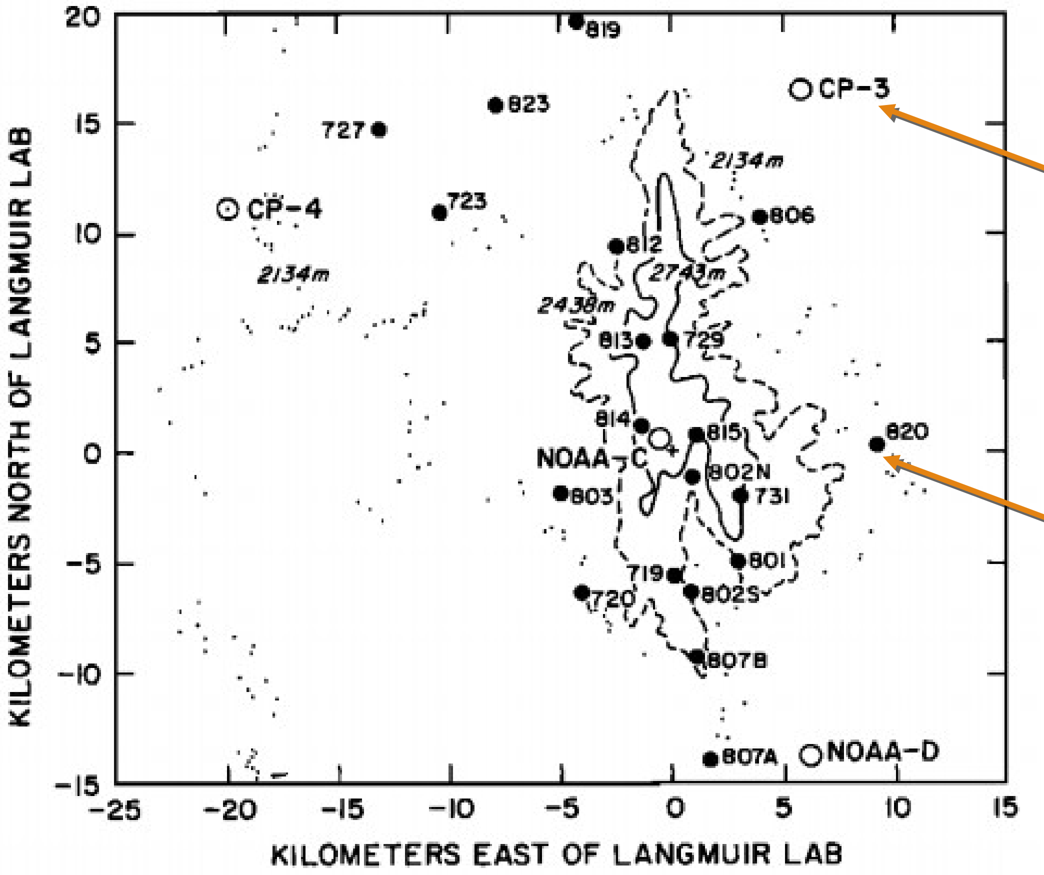


http://roswellproof.homestead.com/balloon_use.html

Storms

Observational Period:
July 14 through August 24, 1984

Number of storms:
20 on 18 different days

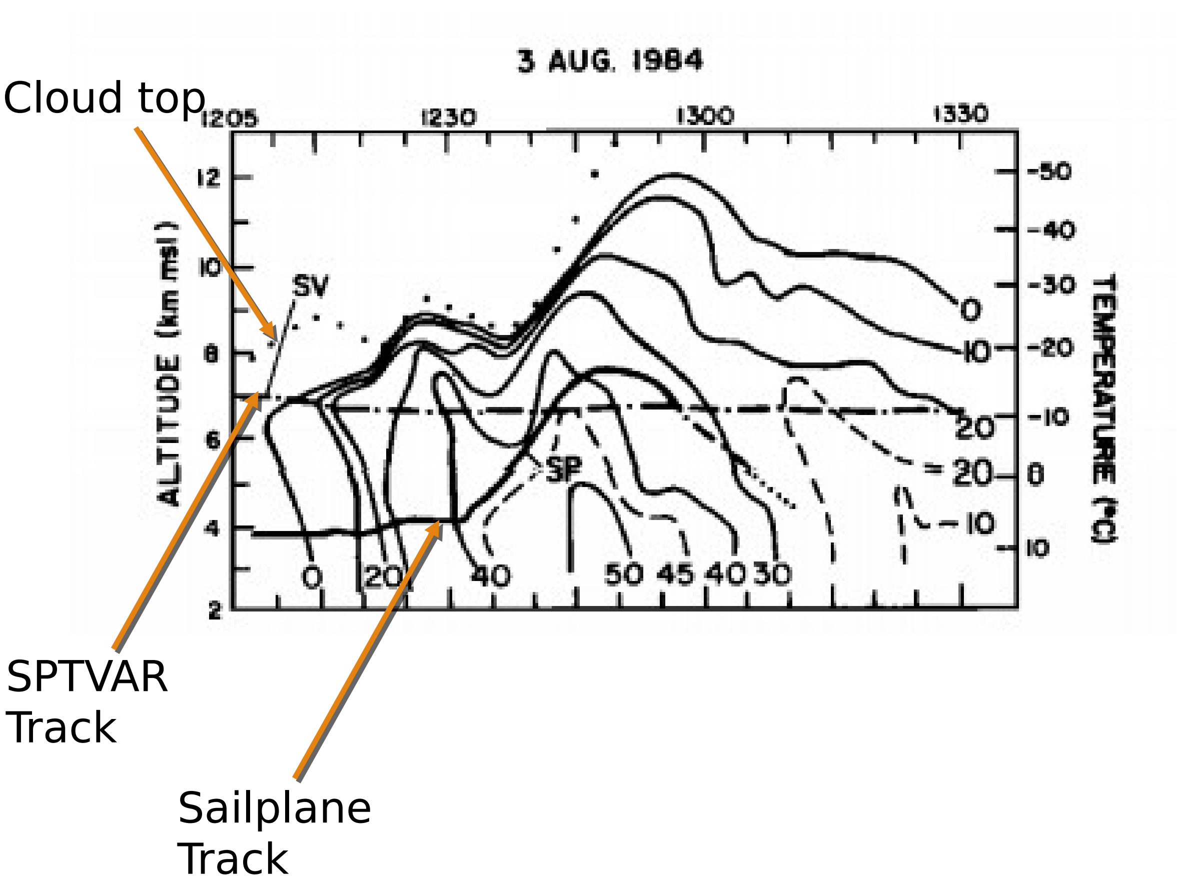


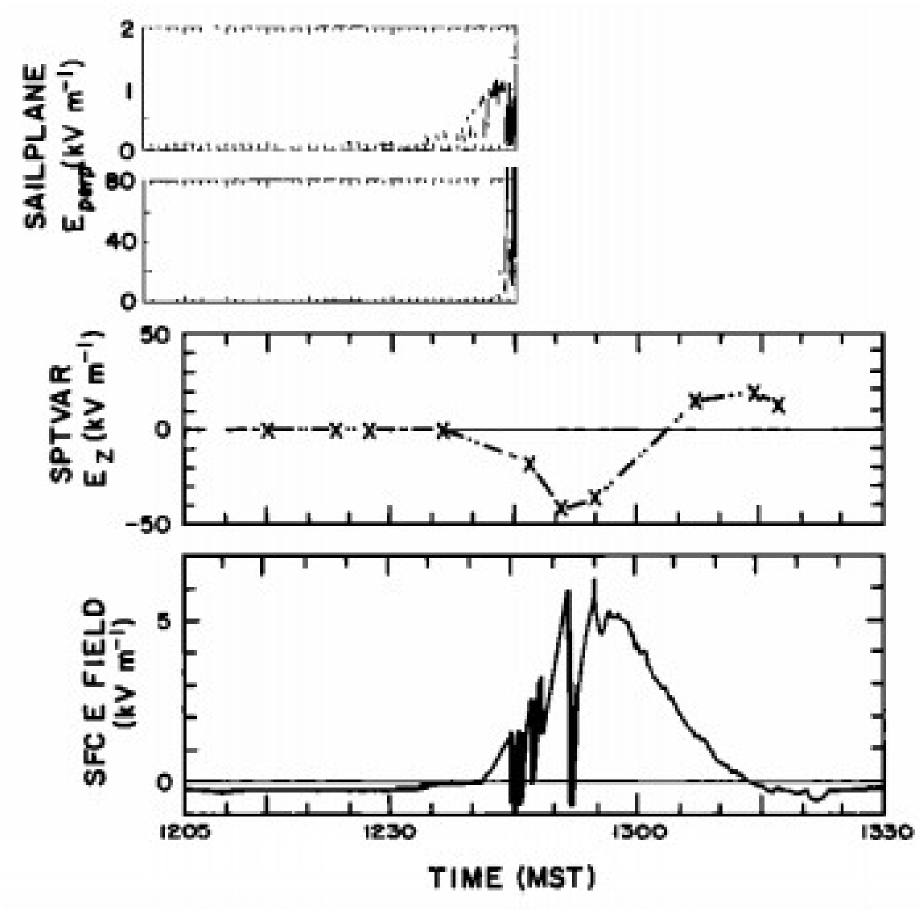
Location of radars

Location of core of storms near the time of the onset of electrification

Specific Cases

August 3, 1984: Moderate with Delayed Electrification





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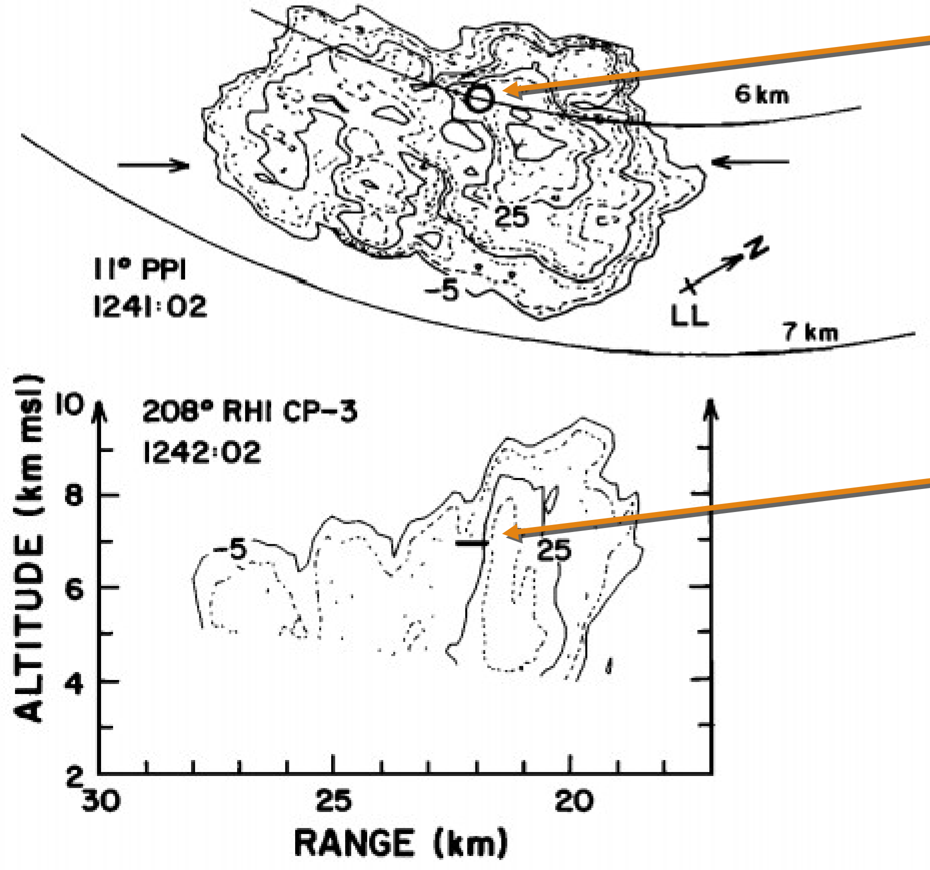

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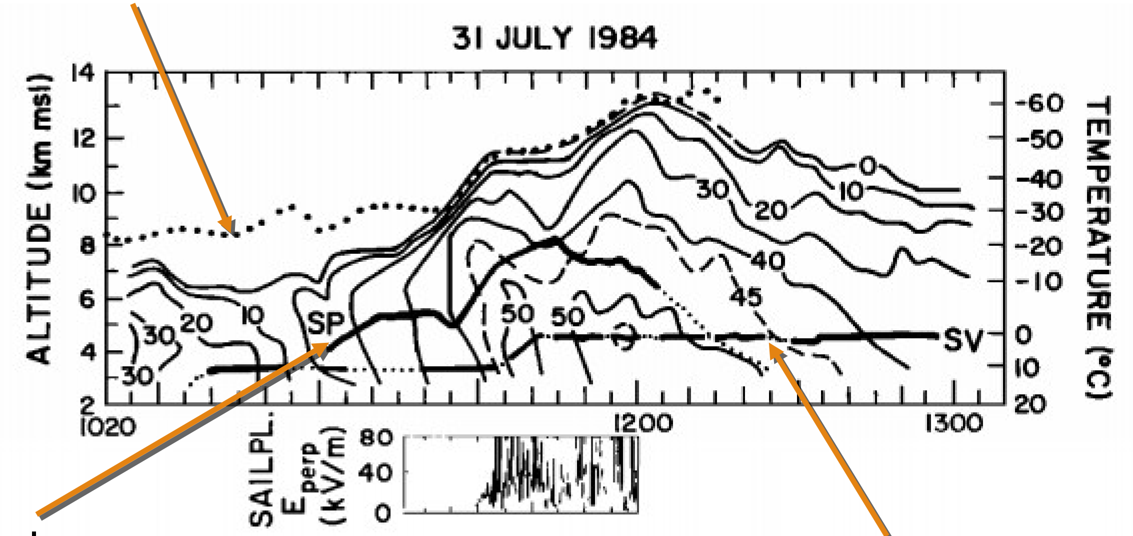
Specific Cases

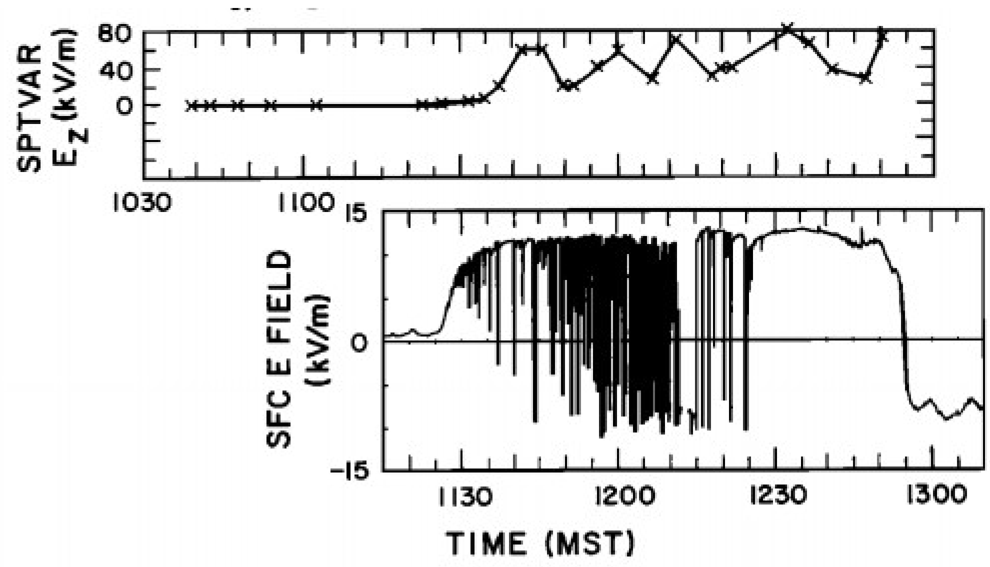
July 31, 1984: Electrically Intense

Cloud top

Sailplane Track

SPTVAR Track





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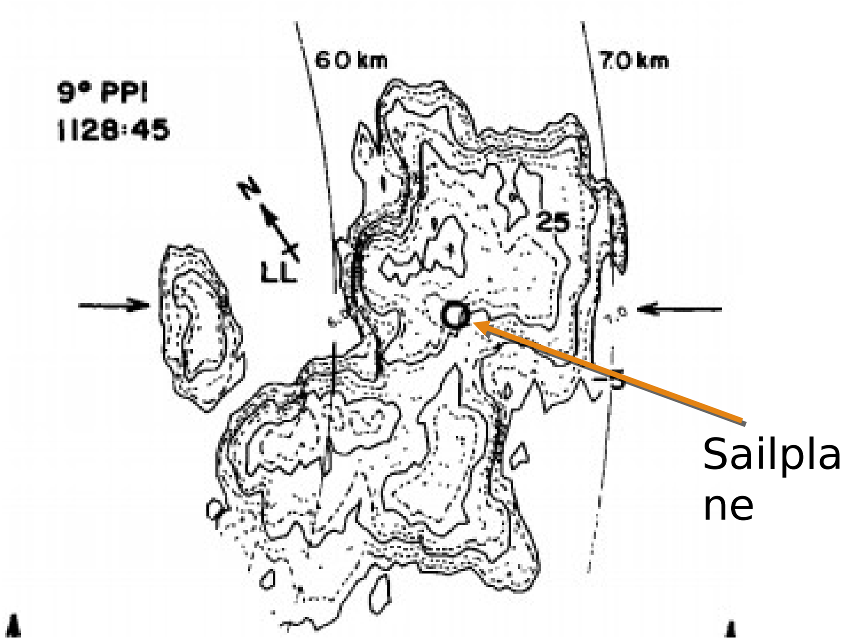
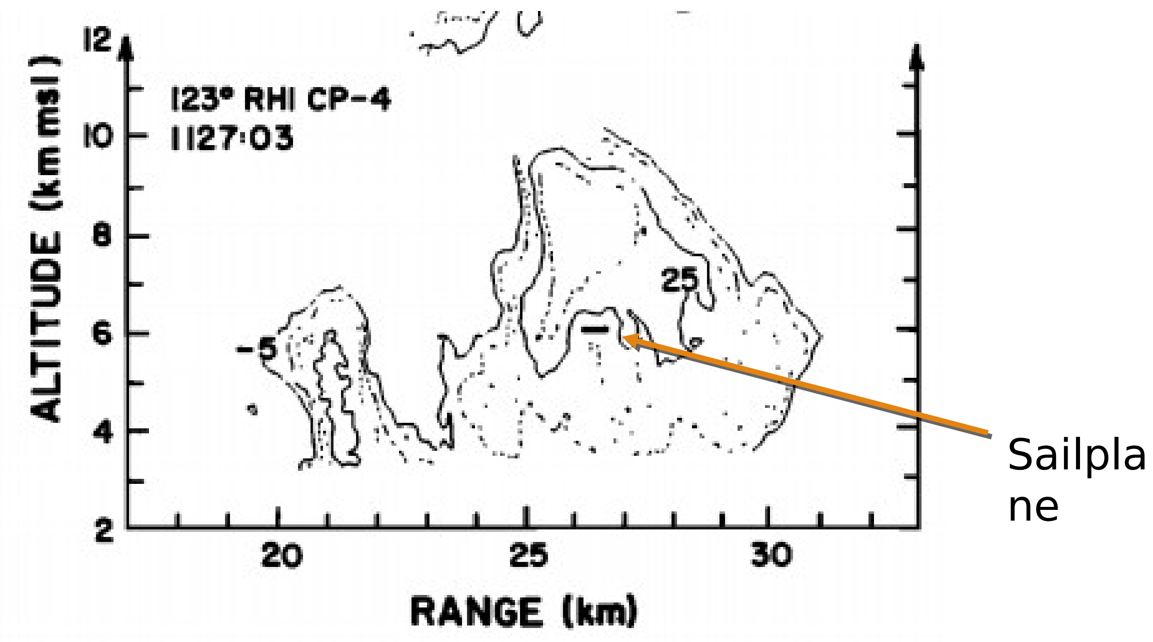
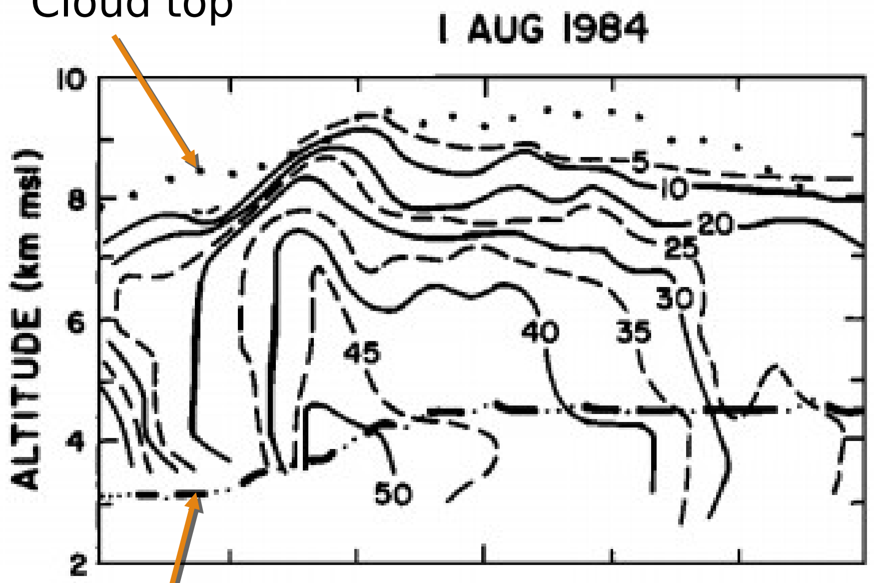




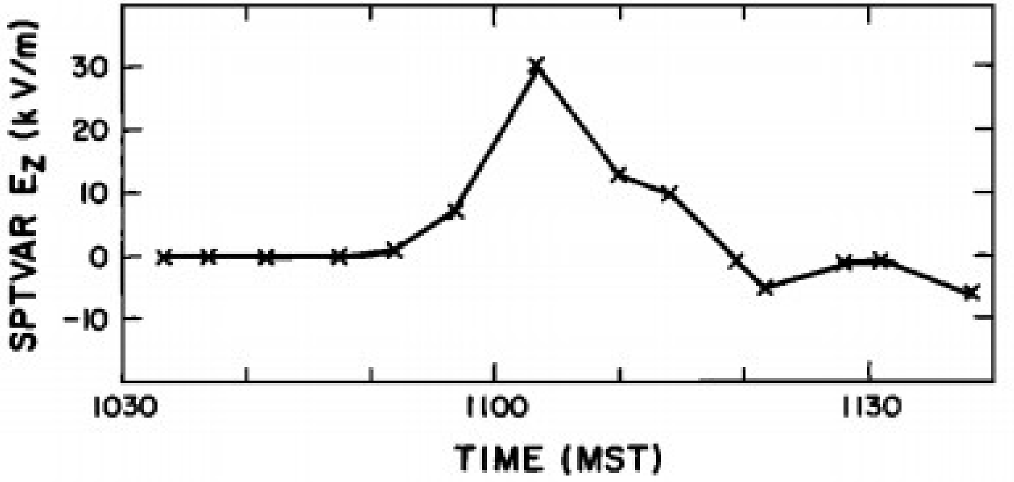
Specific Cases

August 1, 1984: Electrified Cloud without Lightning

Cloud top



SPTVAR
Track



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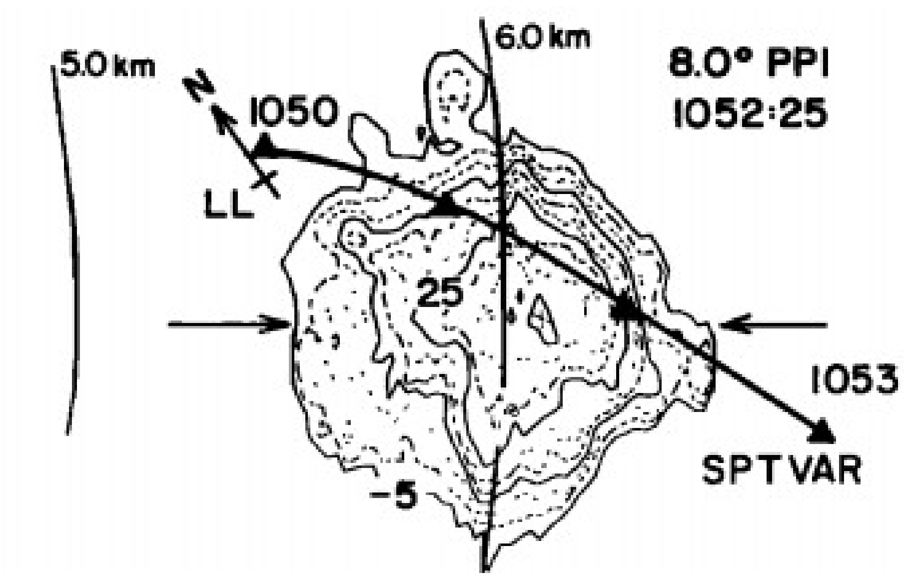
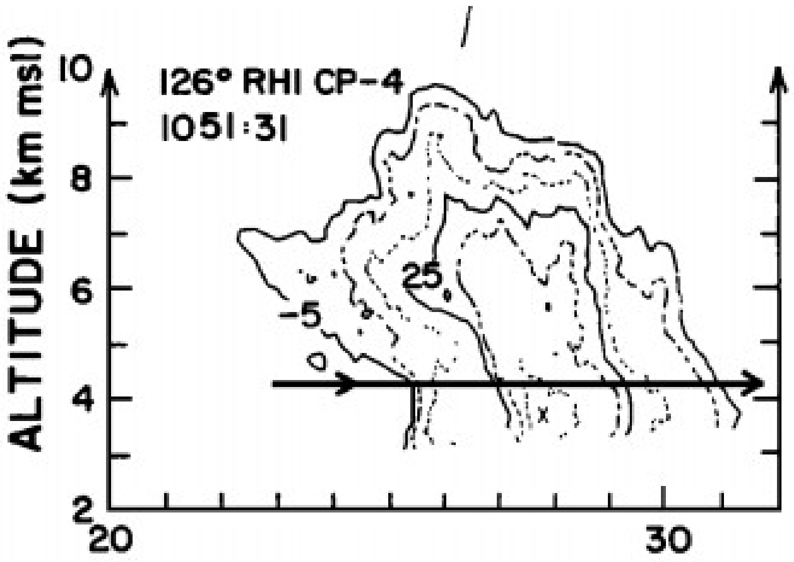
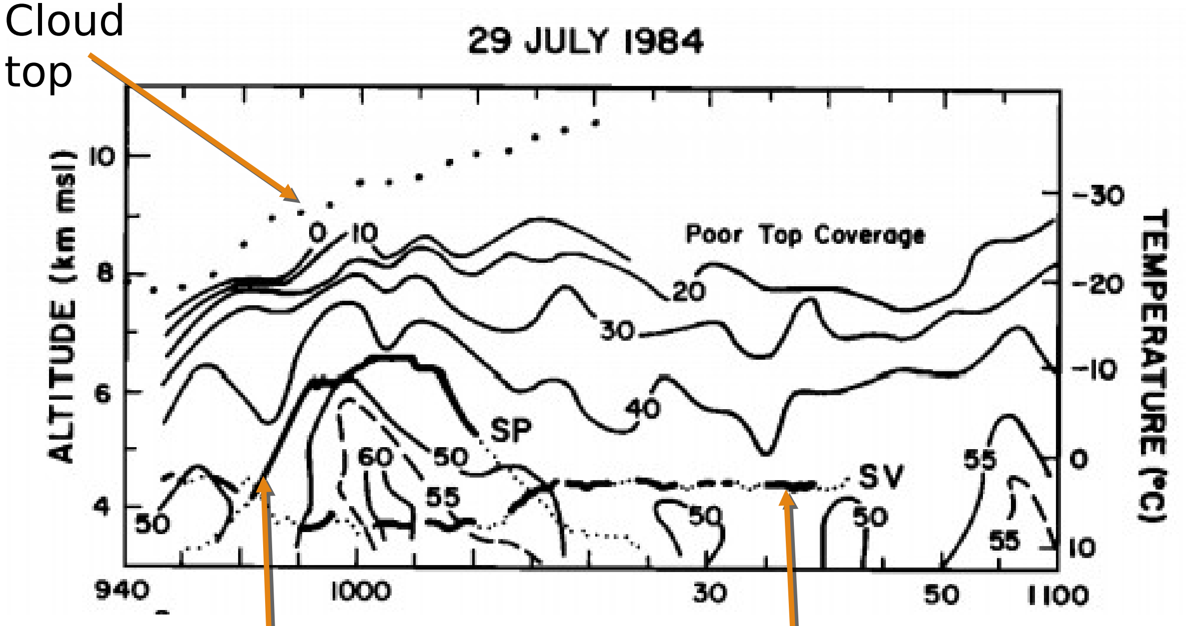




Specific Cases

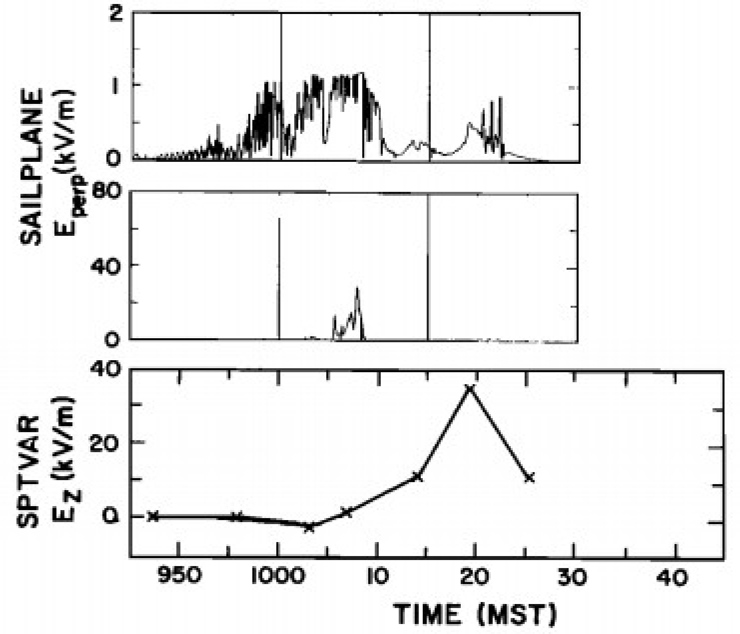
July 23, 1984: Weak Storm with Little or No Electrification

Cloud top



Sailplane Track

SPTVAR Track



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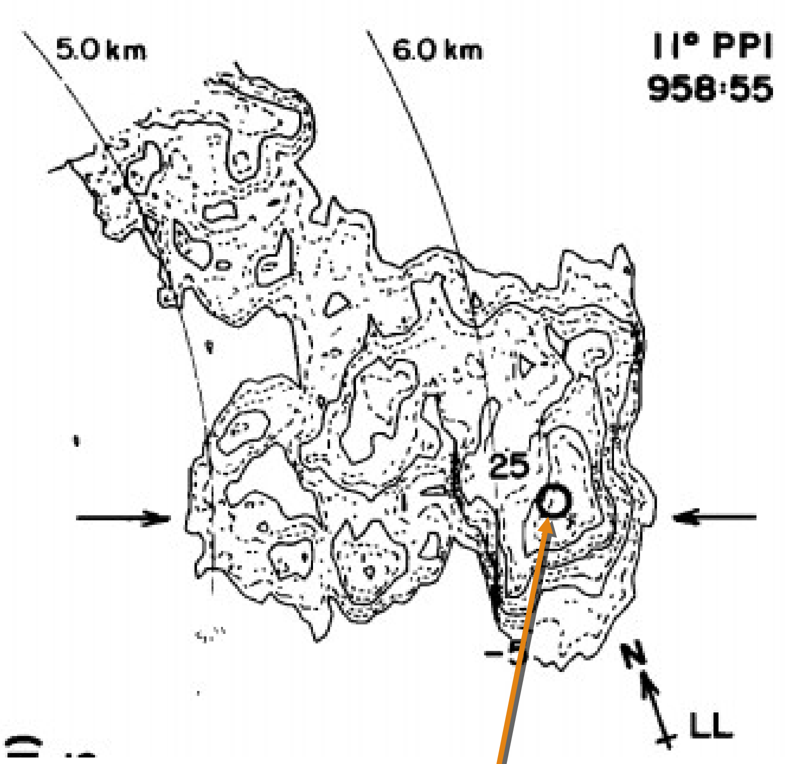
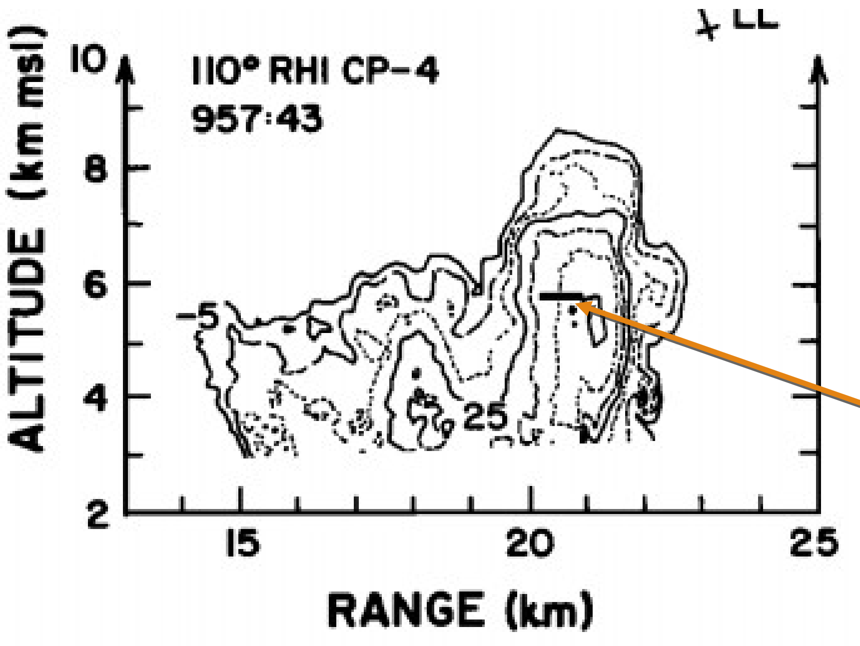


Sailplane



Sailplane

TABLE 2. Summary of 1984 Initial Electrification Cases

	Time of IE[a]	Time of Precipitation before IE, min. 10 dB_Z	Time of Precipitation before IE, min. 40 dB_Z	Z_6 at IE	Maximum Z_6	Observed $\lvert E_{max} \rvert$, kV/m[a]	Lightning First	Lightning Total Number	Radar Top, km at IE	Radar Top, km Maximum	Comments
July 19 (201)	none	—	—	—	15	~0.2	none		—	8	No electrification
July 20 (202)	<1202 (SFC)[b]	>32	14	≳40	50	55 (SV)	1204	~50	~11.5	13	IE with top growth
July 23 (205)	1041 (SV)[c]	27	2	~36	~40	3 (SV)	none		~7.5	~9	Very weak electrification
July 27 (209)	1132 (SV)[c]	62	11	>40	46	95 (SV)	1149	>3[d]	>8	~10.5	IE with slow growth
July 29 (209)	0958 (SP)	>15	13	50	52	36 (SV)	none		9	9	IE with slow growth
July 31 (213)	1127 (SP,SFC)	>62	2	43	50	80 (SV)	1129	>100	10.5	14	IE with growth
Aug. 1 (214)	~1050 (SV)	27	9	41	46	60 (SV)	none		9.5	9.5	IE at maximum top
Aug. 2 (215)N	1048 (SFC)	>20	6	45	52	17 (SV)	1053	~11	~9	13.5	IE with growth
Aug. 2 (215)S	~1131 (SP)	~25	~10	51	52	~80 (SP)	?	3?	10.5	13.5	IE with growth
Aug. 3 (216)	1242 (SP)	26	12	40	43	40 (SP,SV)	1245	6	9.5	12	IE with growth
Aug. 6 (219)	none	—	—	—	12	<0.2	none		—	~8	No electrification
Aug. 7 (220)A	between 1218 and 1226 (SV)	>23	>8	~47	50	65 (SV)	≈1225	?	~10	12	IE with growth
Aug. 7 (220)B	1259 (SP)	23	1	44	50	>65 (SV)	<1306	?	10.5	11.5	IE with growth
Aug. 12 (225)	1118 (SFC)	>16[e]	>10[e]	42	51	55 (SV)	1134	~10	>10.5	~12.5	IE with weak growth
Aug. 13 (226)	0907 (SFC)	?[f]	?	~55	61	70 (SV)	0908	18	~11	12	IE with growth
Aug. 14 (227)	1136 (SP,SFC)	16	4	44	45	15 (SP)	none		9	9.5	IE near relative maximum
Aug. 15 (228)	1036 (SFC,SV,SP)	26	3	38	43	28 (SV)	1059	6	10	11	IE at maximum top
Aug. 19	1017 (SV)	>23	6	44	46	60 (SV)	1044	~10	>7.5	?	uncertain
Aug. 20 (233)	1136 (SFC,SV)	24	6	47	55	40 (SV)	1140	~50	12.5	14	IE with growth
Aug. 23 (236)	~1220 (SV)	25	~6	52	53	80 (SV)	1220	30	11	12	IE with growth

Abbreviations are as follows: IE, initial electrification (see text); Z_6, reflectivity at 6 km altitude; SFC, surface measurements; SV, SPTVAR measurements; and SP, sailplane measurements.

[a] Source is indicated in parentheses.
[b] Sensitivity reduced by distance from LL.
[c] Too far from LL for good surface data.
[d] Based on SPTVAR coverage, some could be missed.
[e] Radar coverage started after precipitation.
[f] Radar coverage started 3 min after IE; z_6 was already 55.

Comparisons to Previous Work

- *Reynolds and Brook* – Confirmed that electrification follows precipitation and in most cases, electrification is associated with vertical growth.
- *Moore et al.* – Reported electric fields of 1 to 2 kV m^{-1} before detectable precipitation, reflectivity was never more than 33 dBZ.
  - This study showed precipitation before 1 kV m^{-1} and radar reflectivity over 33 dBZ at initial electrification in some storm cases.
  - Big difference is surface measurements versus measurements made below and inside the cloud.

Conclusions

- All 20 storms showed the development of precipitation leading to the onset of electrification by at least 15 minutes.
- The radar top had to exceed about 8 km for the cloud to become electrified and had to exceed 9.5 for lightning to be produced.
- Electrification is associated with vertical growth.
- Reflectivity is not a reliable indication of electrification by itself.