# Excessive Lightning Outlooks

Research has shown that excessive lightning production is favored in areas where moisture (the presence of graupel is essential for electrification) and instability (especially aloft; the greater the buoyancy, the more vigorous the updrafts) are maximized.

| Parameter | Evaluation (*use actual numbers*) | | |
|---|---|---|---|
| | Low | Medium | High |
| **K Index:** Gives storm potential as a function of mid-level lapse rate and low/mid-level moisture; values > 40 may indicate excessive cloud cover that could suppress activity<br>RAH-WRF NMM12 | < 20 | 25-30 | > 30 |
| | | | |
| **Most Unstable CAPE**<br>Use wforah procedure: **8__i. LIGHTNING** or<br>RAH-WRF NMM12 | < 1000 | 1000 - 2500 | > 2500 |
| | | | |
| **Mixed Layer CAPE:** Average CAPE of parcels lifted from the lowest ~1km of the atmosphere (AWIPS procedure --> lowest 1km; SPC mesoanalysis --> lowest 100mb)<br>Use wforah procedure: **8__i. LIGHTNING** | < 500 | 501-1500 | > 1500 |
| | | | |
| **Layer CAPE from -10° to -30°**<br>Use wforah procedure: **8__i. LIGHTNING, RAOB Program or**<br>SPC Sounding Analysis | < 200 | 201 - 600 | > 600 |
| | | | |
| **Normalized CAPE:** ≥ 0.1, preferably 0.2-0.3. Larger N-CAPE= "fatter" CAPE; favors vigorous updrafts (found on BUFKIT) | 0 - 0.09 | 0.10 - 0.19 | > 0.20 |
| | | | |
| **SPC: NAM-based probability of > 100 strikes**<br>Click here for summary page | < 25% | 25 - 50% | > 50% |
| | | | |
| **SPC: SREF-based probability of > 100 strikes**<br>Click here for summary page | 0 - 2.5% | 4 - 6% | 10+ % |
| | | | |
| **Persistence:** Is the weather pattern relatively unchanged? If yes, what was the intensity of flash rates from yesterday's storms | None | Low | High |
| | | | |
| **Precipitable Water:** Steady or increasing normal to above normal PW's are indicative of excessive lightning strike potential, especially with high instability. | *12z* | *18z* | *00z* |
| | | | |

| Other factors to consider: | Notes |
|---|---|
| **Moisture in the 0 to -20 C layer**: This is an estimate of the potential graupel mass in the mixed-phase layer, which is needed for electrification. **Note:** total saturation, such as in a tropical environment, may mean a low wet-bulb lapse rate and less ins | |
| **Synoptic Triggers:** Look for upper divergence, DPVA, an approaching MCV, etc. that might increase coverage and/or intensity of convection | |
| **850mb $\theta_e$ ridge:** Extending into the CWA from the south or southwest | |

**Occasional = <1 flash/min; frequent = 1-6 /min; continuous = 6-12 /min; extreme/excessive = >12 /min**

Moisture and instability; K-index over 35 is best, provided it doesn't mean overcast clouds that could lower the instability

High instability/high CAPE is best. $CAPE_{(-10 \text{ to } -30°C)}$ should ideally be over 800 J/kg, with N-CAPE over 0.25, for a major lightning day

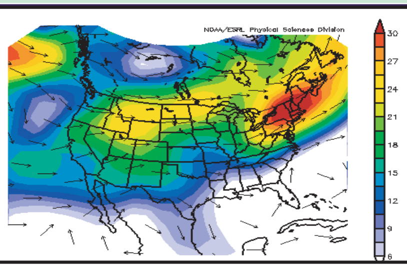
High probabilities of excessive lightning (over 50% on NAM-based perfect prog guidance and over 10% on SREF-based guidance) is favorable

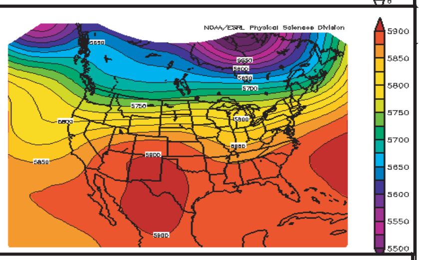
Excessive lightning often occurs on successive days

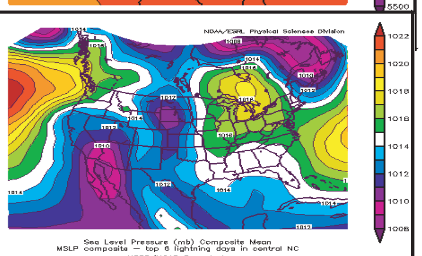
Above-normal PW, increasing through the day, is favorable

Look for large scale dynamic forcing mechanisms that might help organize and increase convection

Theta-e ridging and advection implies increasing graupel aloft




Synoptic signatures indicating favorable conditions for excessive lightning days include:

- Upper jet core over the northeast US (top image)

- Mid level shortwave trough to our west (middle image)

- Surface cold front or trough to our northwest, with deep southwest flow (bottom image)

Comparison of high strike count days with lesser strike count days reveals thresholds of key parameters favoring high lightning activity.

| | High strike density | Low strike density |
|---|---|---|
| K-index | 33.26 | 30.05 |
| MLCAPE | 2050 | 593 |
| MUCAPE | 3175 | 1143 |
| Layer CAPE (-10C to -30C) | 710 | 195 |
| Days of layer CAPE ≥ 600 J/kg | 90% | 5% |
| Normalized CAPE (N-CAPE) | 0.18 | 0.07 |
| % with strong upper div | 45% | 20% |
| PW (in.) | 1.64 | 1.59 |

References: Watson and Holle 1996; Bright et al 2005; Wolf 2006; Cope 2006; Bothwell 2005; McCaul et al 2008; Deierling et al 2005; Shafer 2005; Blanchard 1998; Kehrer et al 2008; Livingston et al 1996; Hartfield 2009; WFO Raleigh local studies.

# "First Strike" Lightning Detection

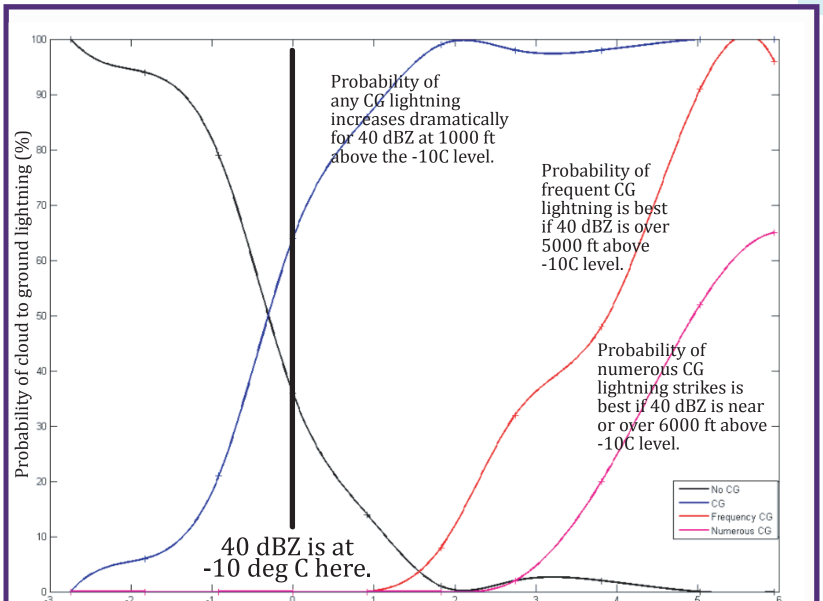
Research has shown that a **40 dBZ** radar reflectivity echo extending up to the **-10 degrees C AGL** can give a nearly **15 minute lead time** for the first lightning strike. Ideally, the updraft should continue to grow beyond this level with high reflectivities above -10°C.

**Situations where you can consider nowcasting a developing storm's first strike:**

- First storms of the day
- Unexpected isolated storms
- Storms developing in haze
- Developing storms threatening:
  - Highly populated areas
  - Outdoor recreational areas (e.g., lakes)
  - Large outdoor gatherings

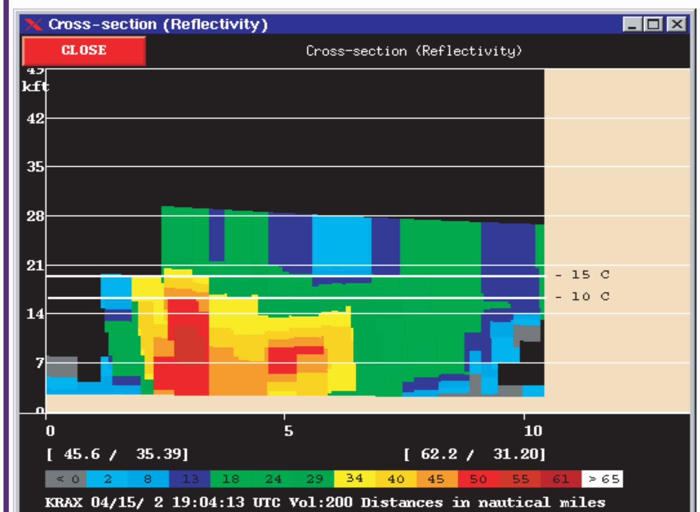
Probability of No CG, any CG, frequent CGs, and numerous CGs with 40 dBZ to:

| | No CG | CG | "Frequent" CG | "Numerous" CGs |
|---|---|---|---|---|
| -10°C, less 8+ kft | 100% | 0% | 0% | 0% |
| -10°C, less 5 to 7 kft | 94% | 6% | 0% | 0% |
| -10°C, less 2 to 4 kft | 79% | 21% | 0% | 0% |
| Near -10°C (+/- 1 kft) | 36% | 64% | 0% | 0% |
| -10°C, plus 2 to 4 kft | 14% | 86% | 0% | 0% |
| -10°C, plus 5 to 7 kft | 1% | 99% | 8% | 0% |
| -10°C, plus 8 to 10 kft | 2% | 98% | 32% | 2% |
| -10°C, plus 11 to 14 kft | 2% | 98% | 48% | 20% |
| -10°C, plus 15 to 18 kft | 0% | 100% | 91% | 52% |
| -10°C, plus 18+ kft | 0% | 100% | 96% | 65% |




Differential altitude between 40 dBZ and -10 deg C (in thousands of feet). From Wolf (2007).

False alarms can happen when the reflectivity drops off quickly with height in the 0C to -20C layer.

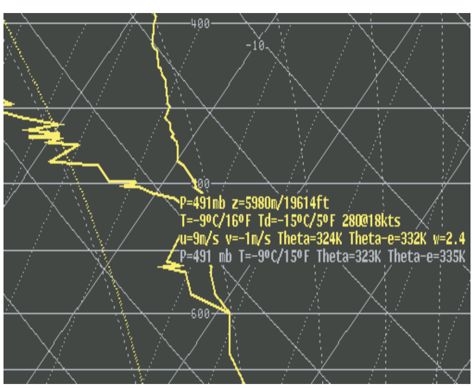


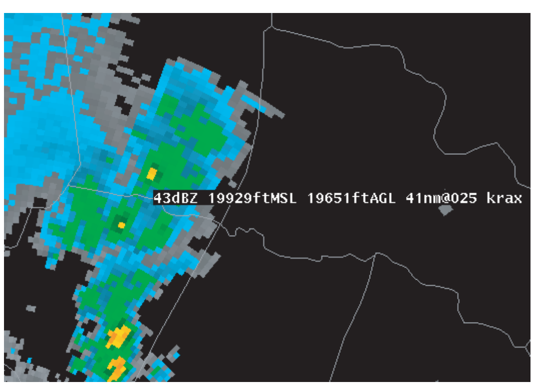

## Steps for First Strike Detection:

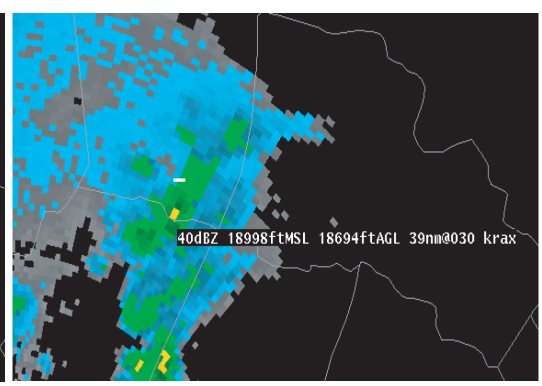
1) Using observed (raobs or aircraft) and/or forecast soundings, decide approximate height of -10°C AGL.

2) Monitor radar returns at this level, using all appropriate radars. (You may even want to filter echoes below 40 dBZ to make them stand out.) When a 40 dBZ echo is seen, and the cell maintains strength or continues to grow, expect a lightning strike within 15 minutes.

3) Ice crystals develop into graupel via the riming process near -10°C. The graupel colliding with ice crystals results in charge transfer. The falling graupel and rising crystals (in the updraft) lead to charge separation, resulting in an electric field and lightning production.




References: Vincent et al 2003; Orville and Huffines 2001; Carey and Rutledge 1996 and 2000; Zajac and Rutledge 2001; Goodman et al 1988; Reynolds and Brook 1956;Dye et al 1989; Michimoto 1990.