**Motivation**

Many more lightning flashes happen inside clouds than come to ground, and modern VHF Lightning Mapping Arrays (LMAs) readily detect these flashes in four dimensions. In addition to providing a count of flashes, these systems also map the complete extent of the flash in the cloud.

**Purpose**

Together these factors lead us to hypothesize that turbulence associated with eddy-scale convective overturning (Williams, 1986; Waiteheimmer, 1987) is largely responsible for organizing charge into small pockets which are discharged by lightning (Coleman et al., 2003; Maggs et al. 2005). The purpose of the 2014-2016 Kinematic Texture and Lightning Experiment is to quantitatively compare turbulence inferred from weather radar data to coincident lightning flash size variability.

**Methods**

Use lightning flash area and flash volume to characterize energy dissipated by each flash. Our ongoing work by Salinas (2015 AGU Fall Meeting) is retrieving charge densities constrained by the break-even electric field initiation threshold.

Characterize turbulent kinematics using mobile weather radar data. Berkseth et al. (poster this session) provides more details.

**Observation strategy**

As shown above, total flash energy can be calculated from LMA data and depends on moments of the flash size distribution (Bruning and Thomas, 2015). Furthermore, the flash energy distribution varies with length scale much like a Kolmogorov spectrum, including a 5/3 scaling regime (Bruning and MacGorman, 2013).

The distribution of flash sizes may shift depending on the average flash size (A) or the total number of flashes (C) or their width. Observed variability (including in volcanoes; Betfinke and Bruning, 2015) typically shows both (B).

Size and rate typically both increase as storm begins, and are anticorrelated during the rest of the storm’s life. Ware (2015) showed that flash size gradient ascends along storm relative shear and sedimentation trajectories, and that the smallest flashes and largest rates are near the tops of updrafts.

**Instruments**

- **West Texas Lightning Mapping Array**
  - Number of stations: 12 (3 mobile)
  - Receiver Frequency: 50-60 MHz
  - Mapping Technique: GPS Time of Arrival
  - Trigger rate: 2-3 Hz
  - Type point(s) per flash: 10-100
  - Location precision: 0.1 km (over network)
  - Range (2020): 100 km / 250 km
  - Temporal coverage: Continuous

**Monte-carlo simulation of WTLMa error characteristics**

This model characterizes location precision and detection efficiency. Sources are emitted with a realistic power spectrum, and propagated to each receiver. Station locations introduce azimuthal asymmetry that varies from day to day.

**Cases to Date**

<table>
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<tr>
<th>Case Date</th>
<th>Date (start/stop)</th>
<th>Deployment Location</th>
<th>Radiosonde Launch Time</th>
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**Observation strategy**

1. **Environment soundings in storm inflow**
2. **Flash extent density (count per pixel)**
3. **Mean flash area (km²)**
4. **Total energy (Ah) = 10³8 km²**
5. **E(l) limit:**
   - Number of stations: 12 (3 mobile)
   - Receiver Frequency: 50-60 MHz
   - Mapping Technique: GPS Time of Arrival
   - Trigger rate: 2-3 Hz
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**10 July 2015 - Multicellular storm**

- **Flash rates:**
  - Initial: 25 min⁻¹
  - Through core of cell: 5 flashes per minute
  - Dual-Doppler at RHI intersection:
    - Simultaneous scans intersected at 9 km range (vertical black line to 15 km altitude).
    - In 13 km minutes, velocities were less variable as the storm moved away from RHI (below, top row) and flash rates decreased to a few per minute.

**Acknowledgments**

The participation of numerous additional students and faculty in data collection is gratefully acknowledged. Jerry Quaroune contributes to provide capable design and maintenance of the TTU-Ka radars. This project is supported by the National Science Foundation CAREER program, grant AGS-1382144.

**BOLT: Ballooning and Observation Laboratory for Thunderstorms**

- **Vehicle:** Freightliner Sprinter 2500, high roof factory sun roof; battery: variable high site
  - 2x2 seating, roof-mounted AiC
  - Sounding system: Veranda D2Pi9/77/99, R52SDGF scintills, 400 kHz/2 fs antenna and launch site
  - Communications: VHF, cellular data modem, 4.5 m pneumatic mast, roof-mounted TTU Ka-band mobile Doppler radars

- **Transmit Frequency:** 34.86 GHz (beamwidth: 6.6 mm)
- **Transmitter Power:** 200 W peak, 100 W average
- **Twik, up to 50% duty cycle CW-excited signal, spotty reflector (environmental noise floor) introduces additional error. Use of observed receiver thresholds for/flash DE at 55 km.
- **6.33 degrees N/s (low, horizontal)**
- **5.33 degrees N/s (mid, horizontal)**
- **3 flash threshold, variable up to 33KHz**
- **-118 dBm**
- **65 MHz**
- **Orbit AL-4016**
- **Signal HP 9**
- **Chesay Creek (Dowell), 1.5 flatted Computer assisted hydraulic leveling, reflectivity, radial velocity, spectrum width**

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