Aquifers, Faults, Subsidence, and Lightning Databases

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OUTLINE

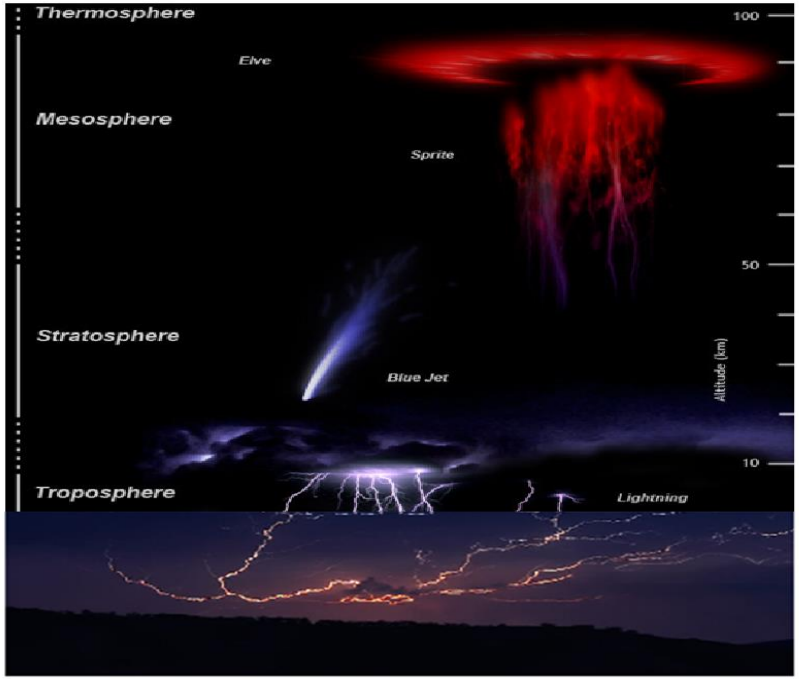
1. Introduction and Theory
2. Geologic Setting in Texas Study Area
3. Aquifers / Earth Tides / Geothermal Gradient
4. Conclusions

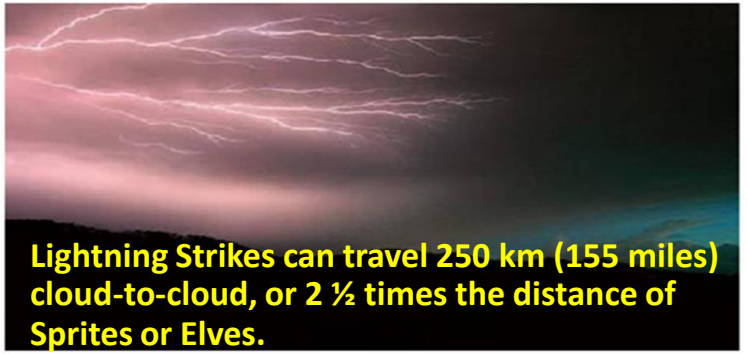
Lightning Theories and Facts

- Lightning occurs everywhere.
- Cloud to cloud lightning travels up to about 150 miles (250 km).
- Cloud to ground lightning follows terralevis/shallow earth currents which reflect geology. Some strikes do hit topography, vegetation, and infrastructure, but can be edited out from location and attribute data.
- Lightning Attributes contain data from various depths and image subsurface features and lineaments such as transforms, faults, drainage basins, and paleo channels.

Main lightning bolt tied to geology

350 million annual Lightning Strikes - a rich database to mine

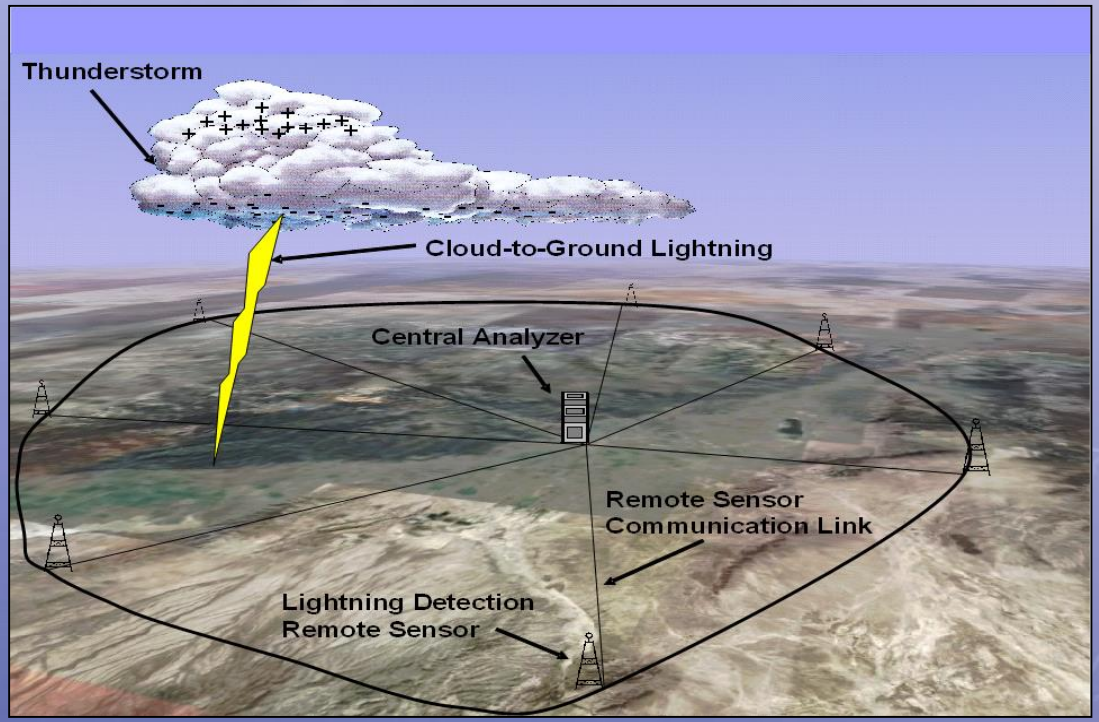




Lightning Strikes can travel 250 km (155 miles) cloud-to-cloud, or 2 ½ times the distance of Sprites or Elves.

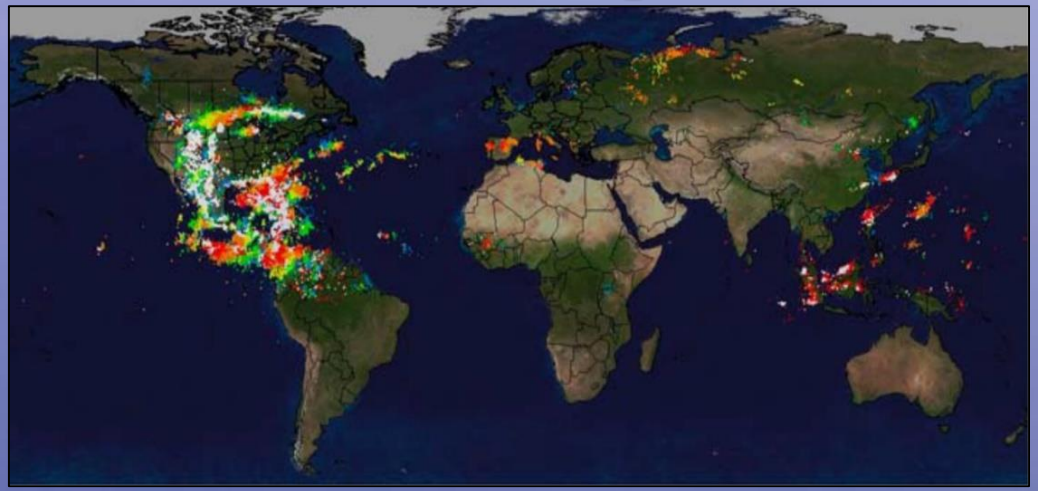
Lightning Strike locations primarily controlled by terralevis (shallow earth) currents.

330 Sensors record U.S. lightning strike locations
with 100-500 feet (30-150 meter) horizontal resolution

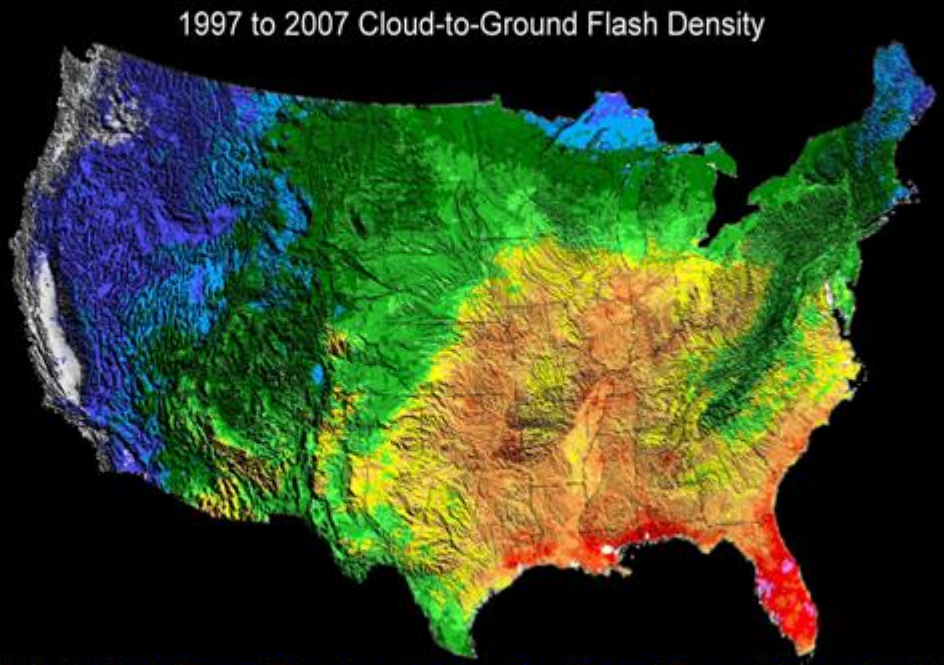


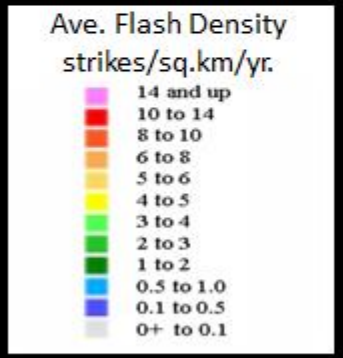
Vaisala Partnership

Exclusive worldwide license with Vaisala of Finland to use their data in the NLDN and GLD-360 for natural resource exploration.



Strike Density (NLDN) and Topography





Lightning density regionally controlled by meteorology, and locally controlled by terralevis (shallow earth)
currents.

330 Lightning Detectors in the Continental US.
Evergreen Data Set -16 years of data available.

Proven and Patented Technology

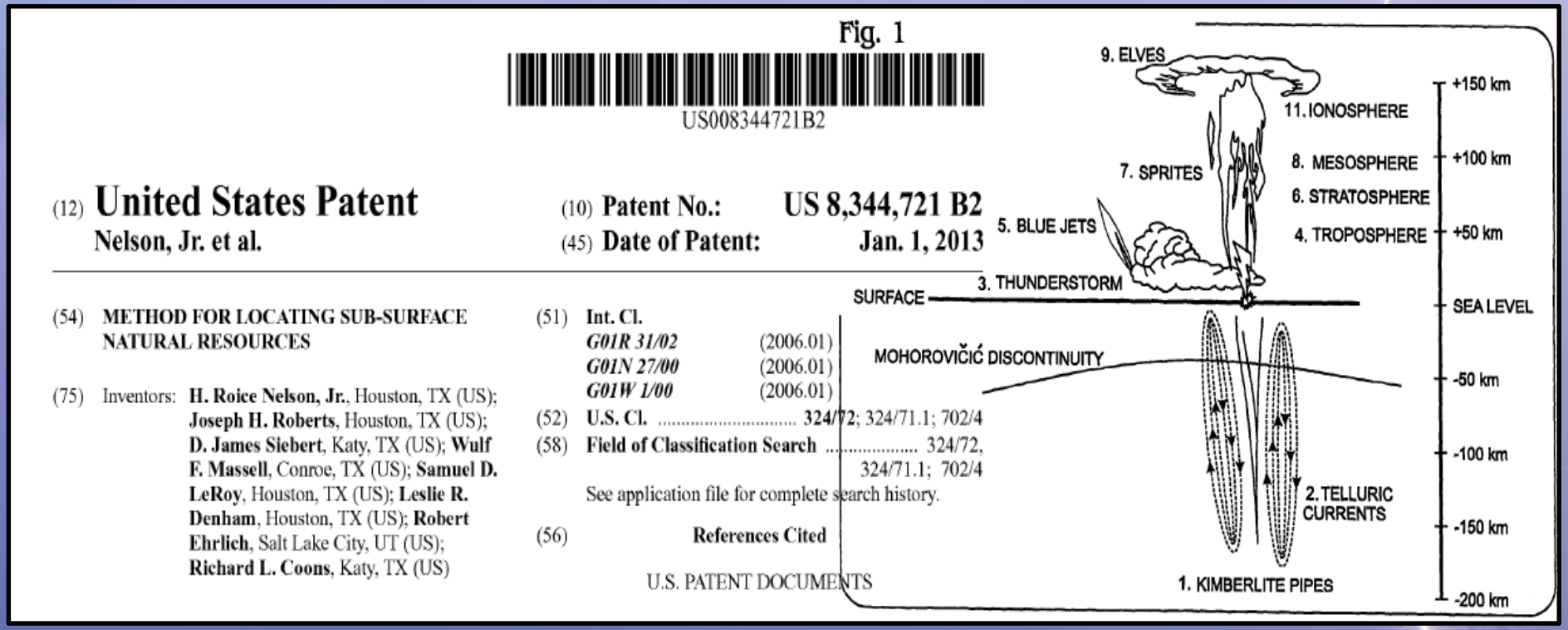


Fig. 1

US008344721B2

(12) **United States Patent**
Nelson, Jr. et al.

(10) **Patent No.: US 8,344,721 B2**
(45) **Date of Patent: Jan. 1, 2013**

(54) **METHOD FOR LOCATING SUB-SURFACE NATURAL RESOURCES**

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(51) **Int. Cl.**
G01R 31/02 (2006.01)
G01N 27/00 (2006.01)
G01W 1/00 (2006.01)

(52) **U.S. Cl.** 324/72; 324/71.1; 702/4

(58) **Field of Classification Search** 324/72, 324/71.1; 702/4

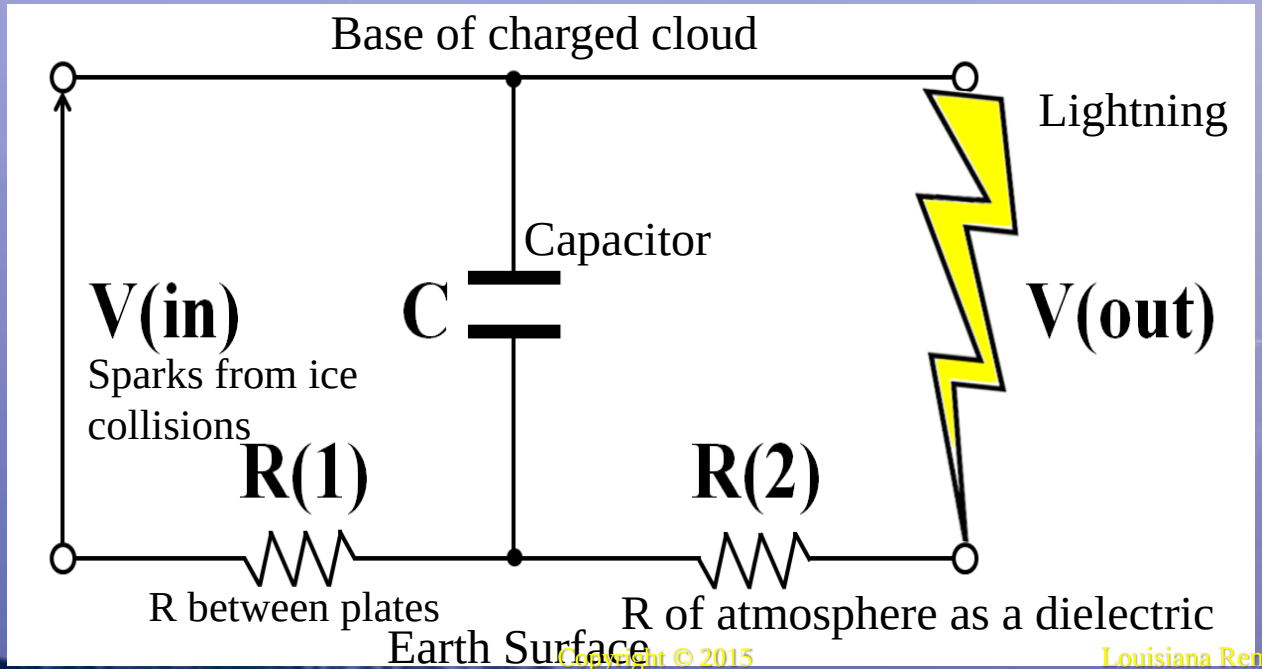
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

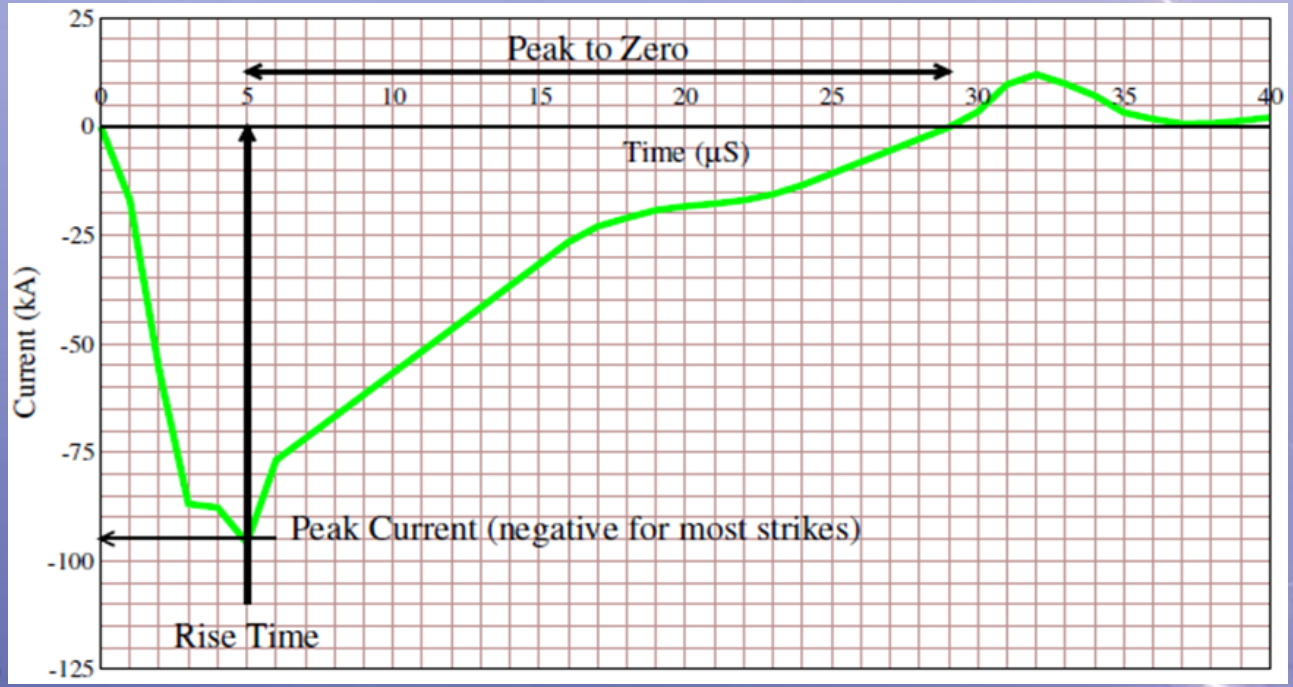
Lightning

Two conducting plates, the storm cloud and the earth, are separated by an insulating dielectric, the atmosphere. Voltage is created by collision of ice within the cloud and lightning bolts rebalance the charge between the plates.



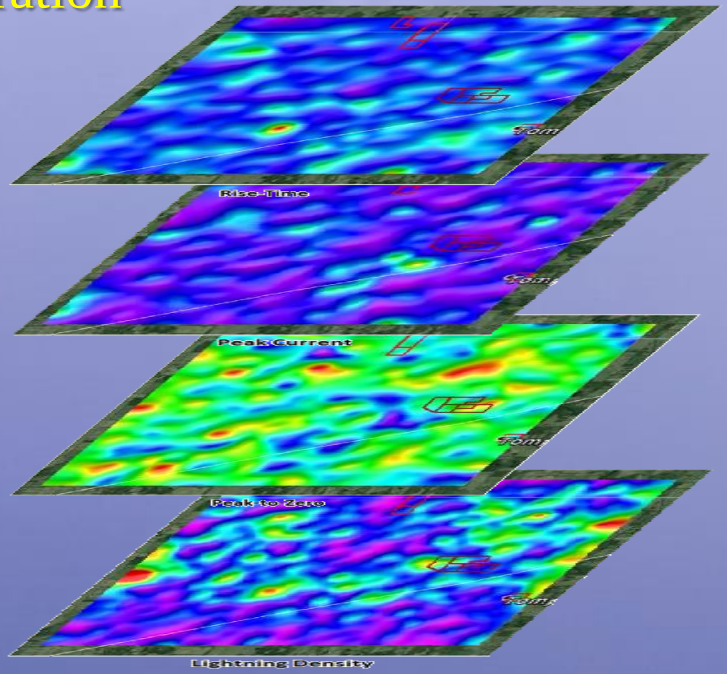
Lightning Measurements/Attributes, & Wave Form

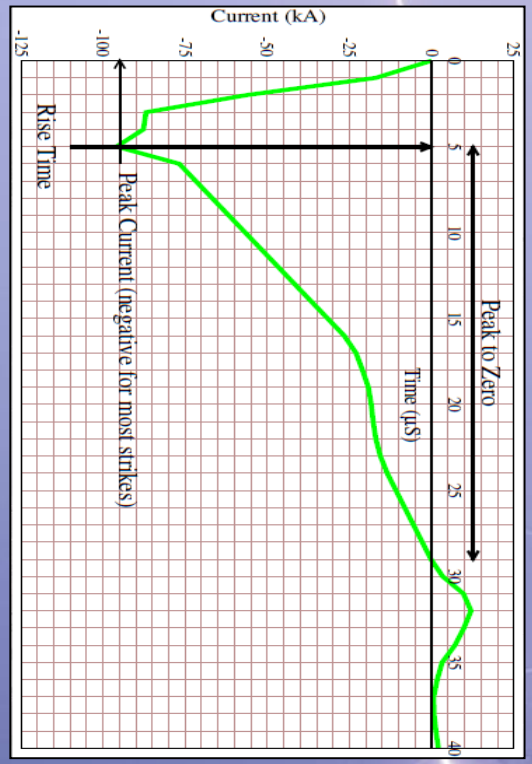
- Location / Time and Duration / # of Sensors
- Rise Time
- Peak Current
- Peak to Zero
- Polarity
- Chi Squared
- Number of Sensors



Lightning Strike Measurements

- Location
- Time and Duration
- Rise Time
- Peak Current
- Polarity
- Peak-to-Zero
- Density

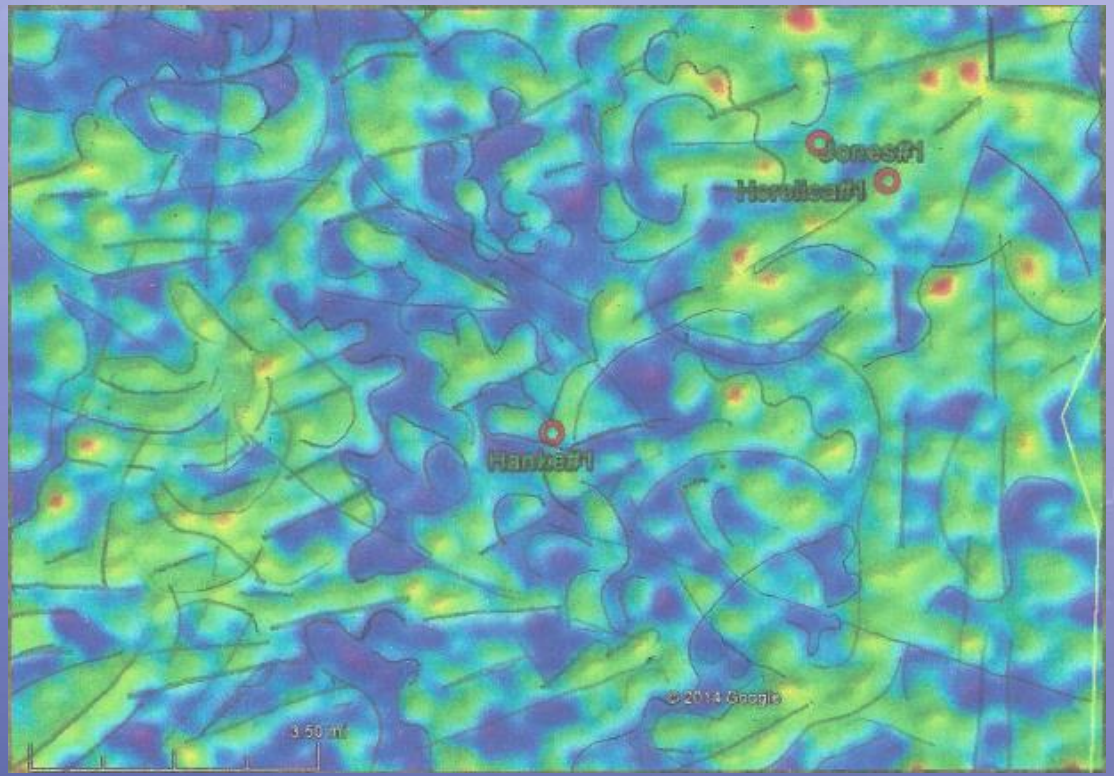




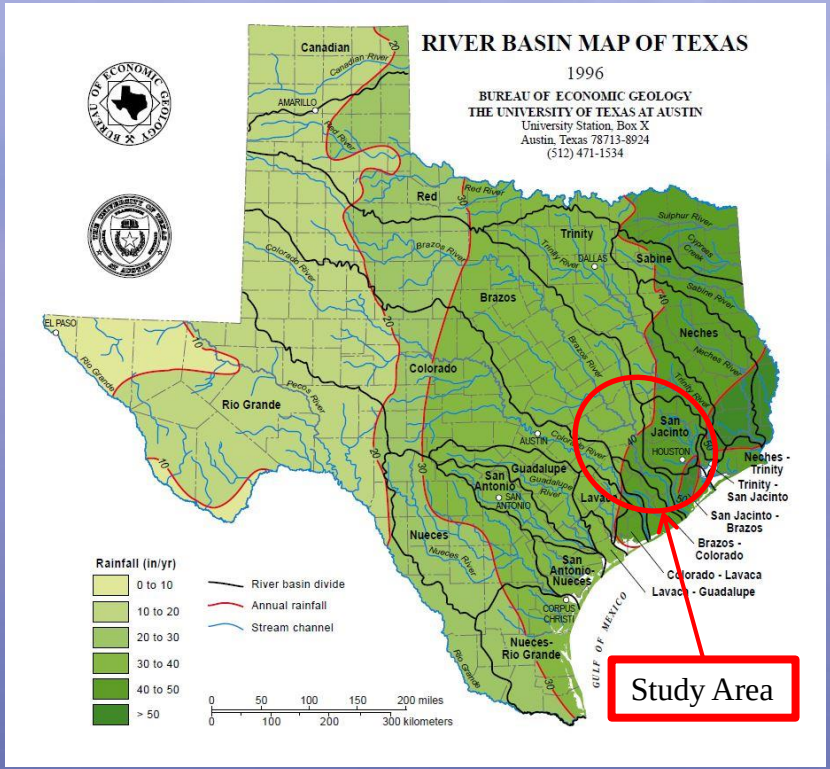
2. Geologic Setting in Texas Study Area

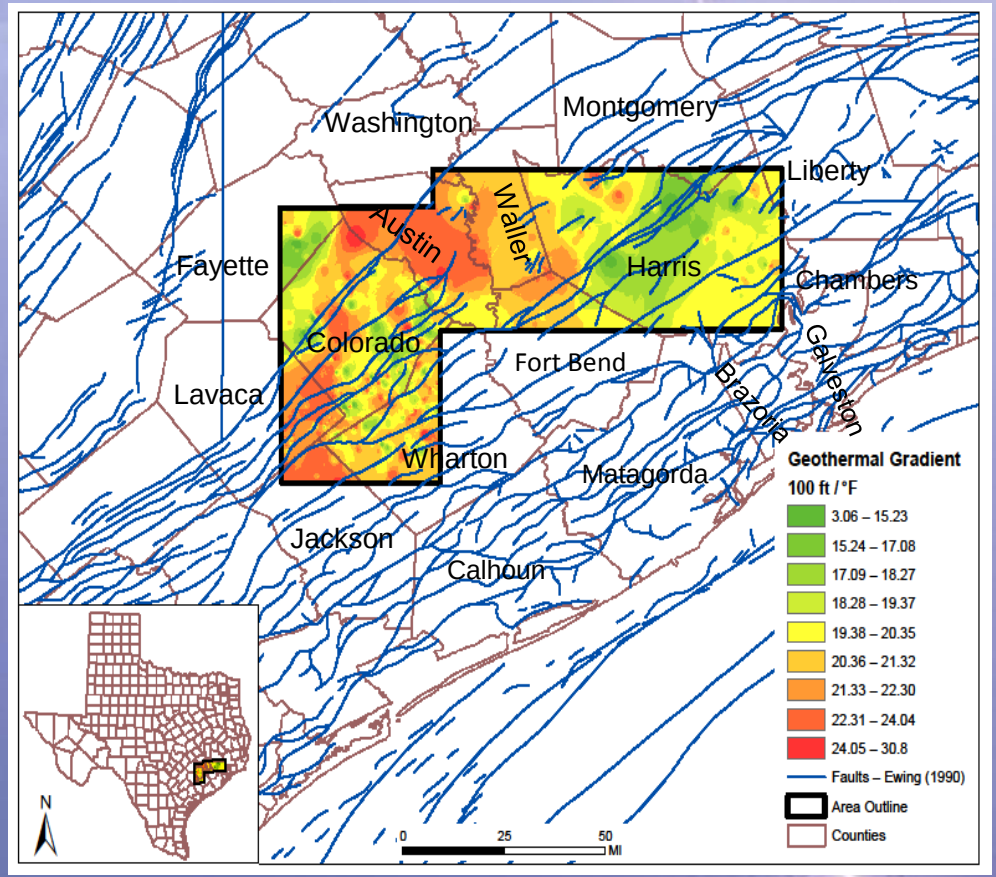
Aquifers / Faults / Stratigraphy / Subsidence

Rise-Time
Central Texas



Fault Trends and Geothermal Gradient





Fault trends by Ewing 1990
Geothermal Gradient Map

Aquifers

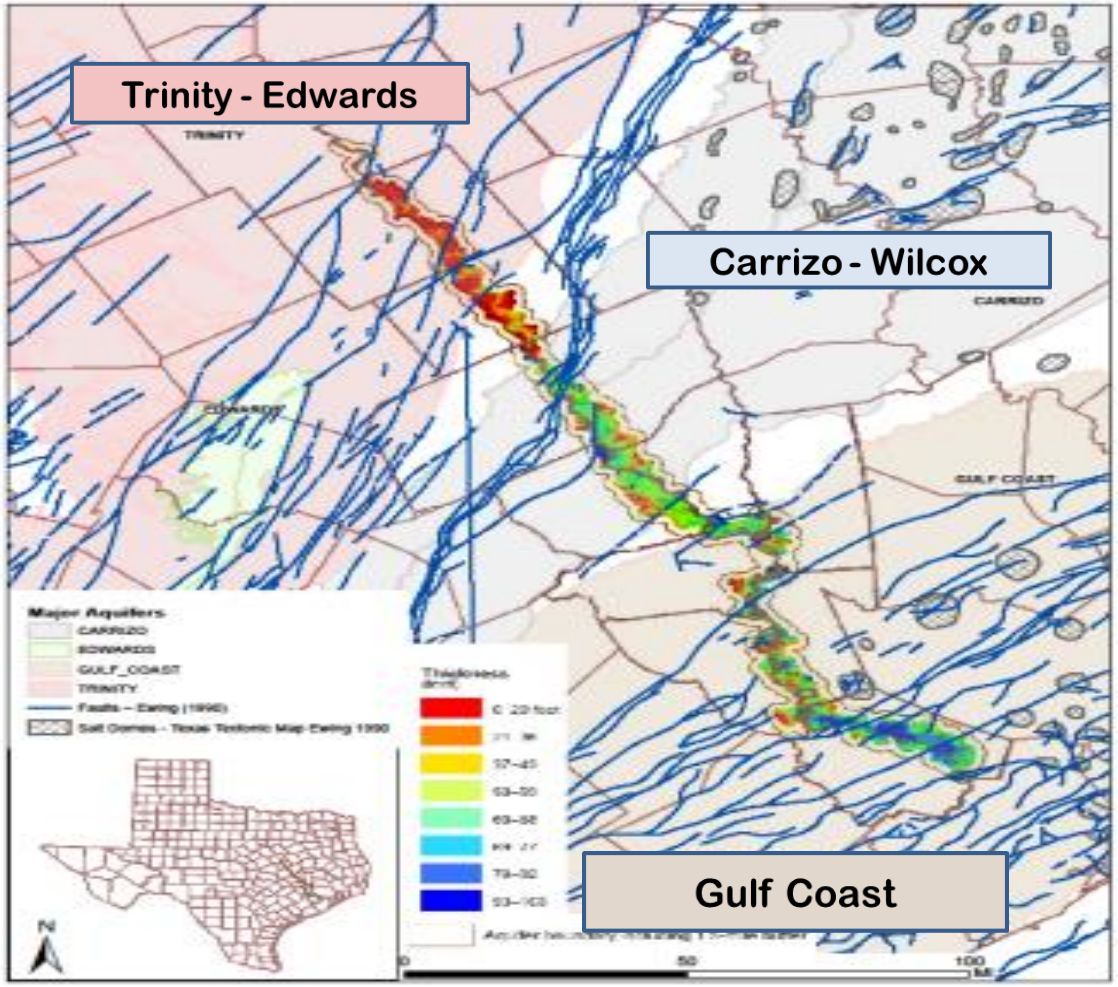
Brazos River Alluvium Aquifer

Trinity - Edwards

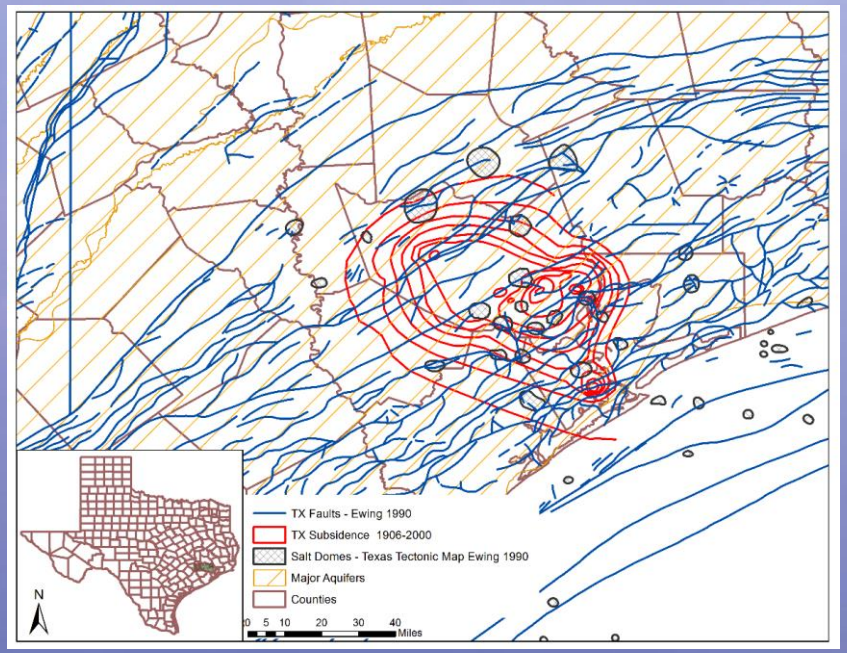
Carrizo - Wilcox

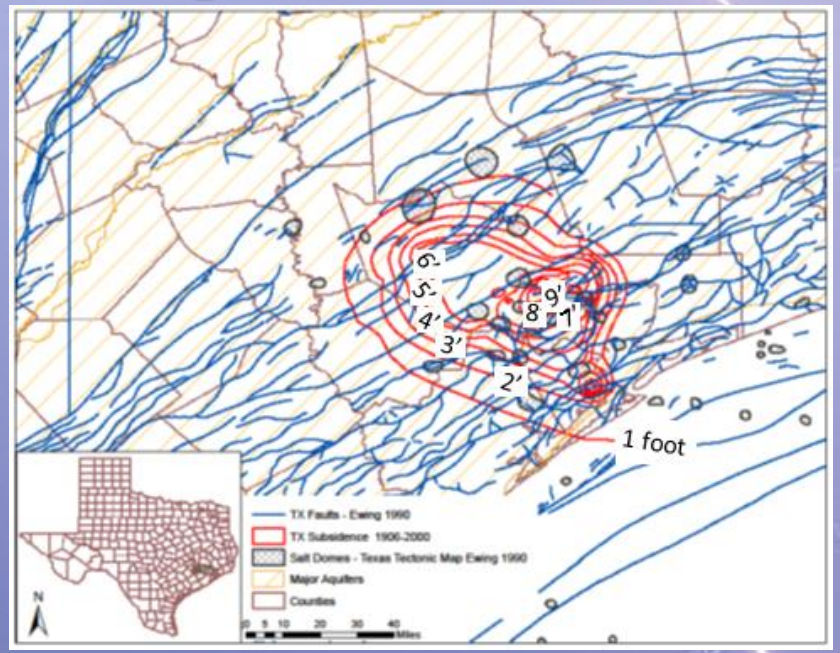
Gulf Coast

Aquifers from Texas Water Development Board Report 380.



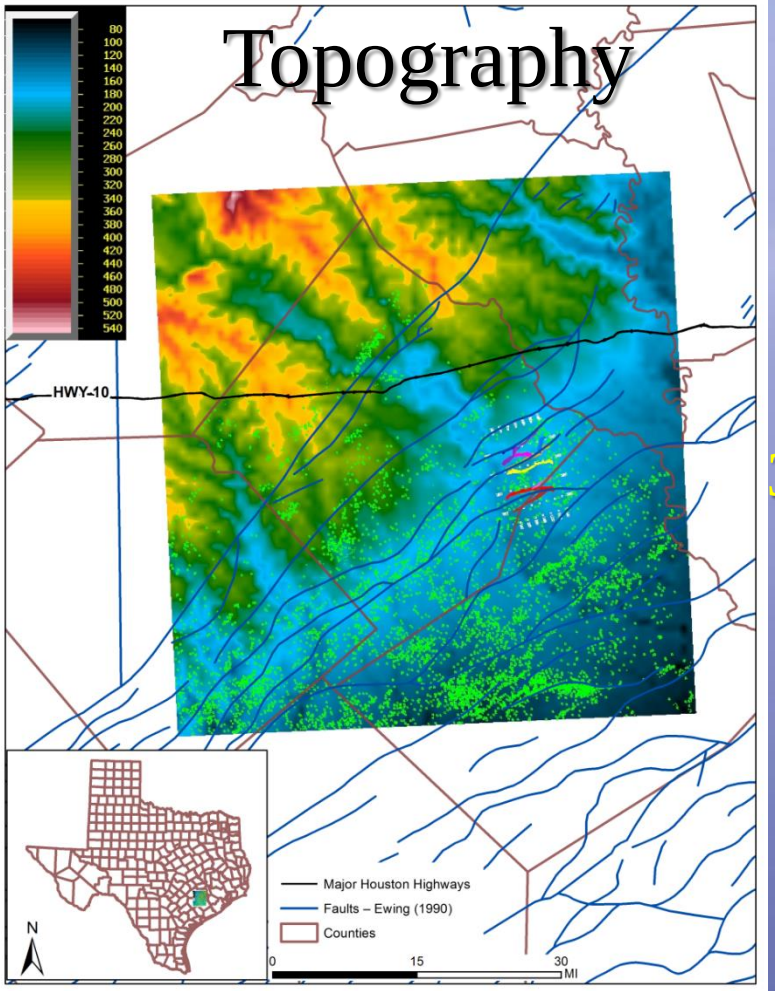
Houston – Galveston Area Subsidence in Gulf Coast Aquifer





From Houston Galveston Subsidence District 1906-2000 with permission

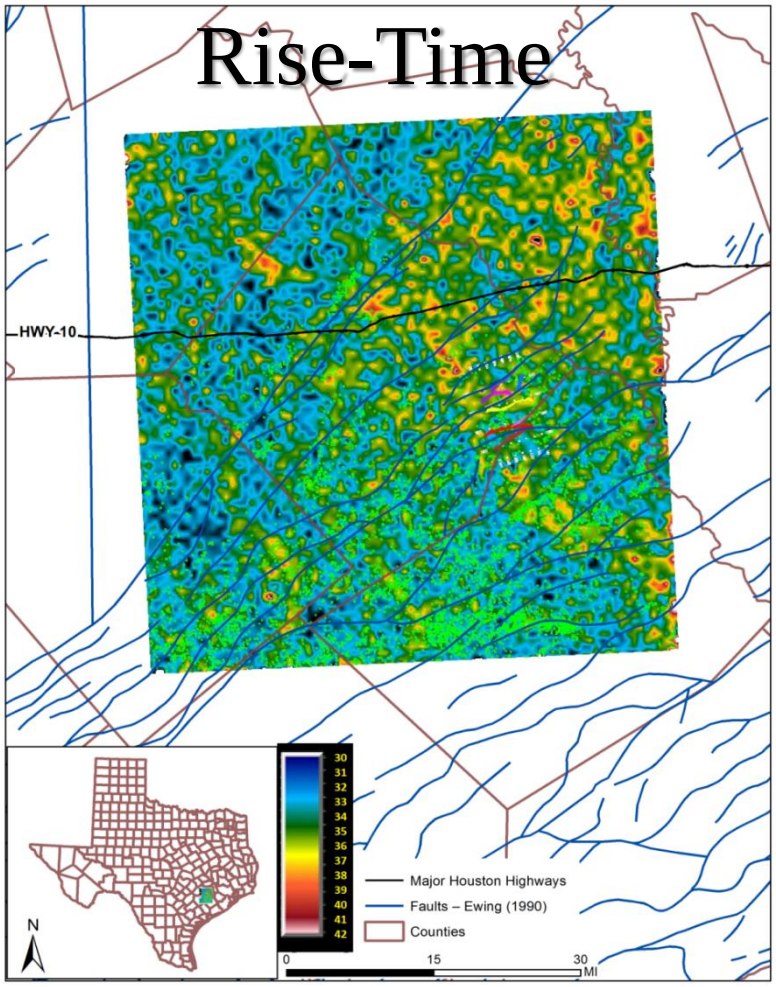
Topography



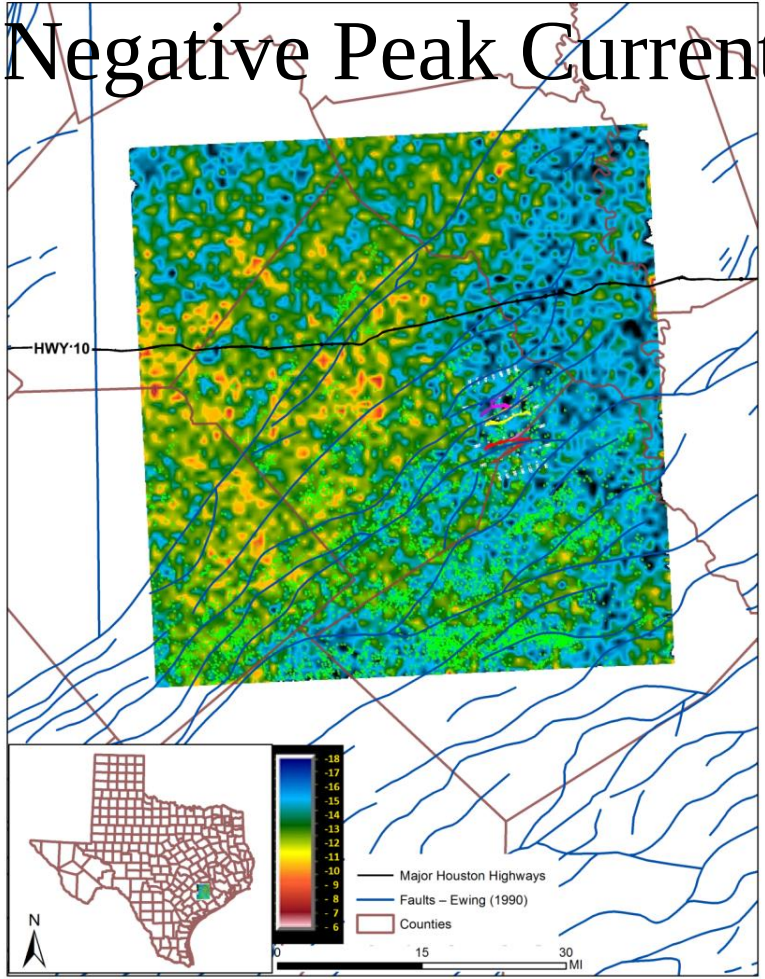
Well Data, Faults, and 3-D Seismic

Green Dots are Well Locations

Rise-Time



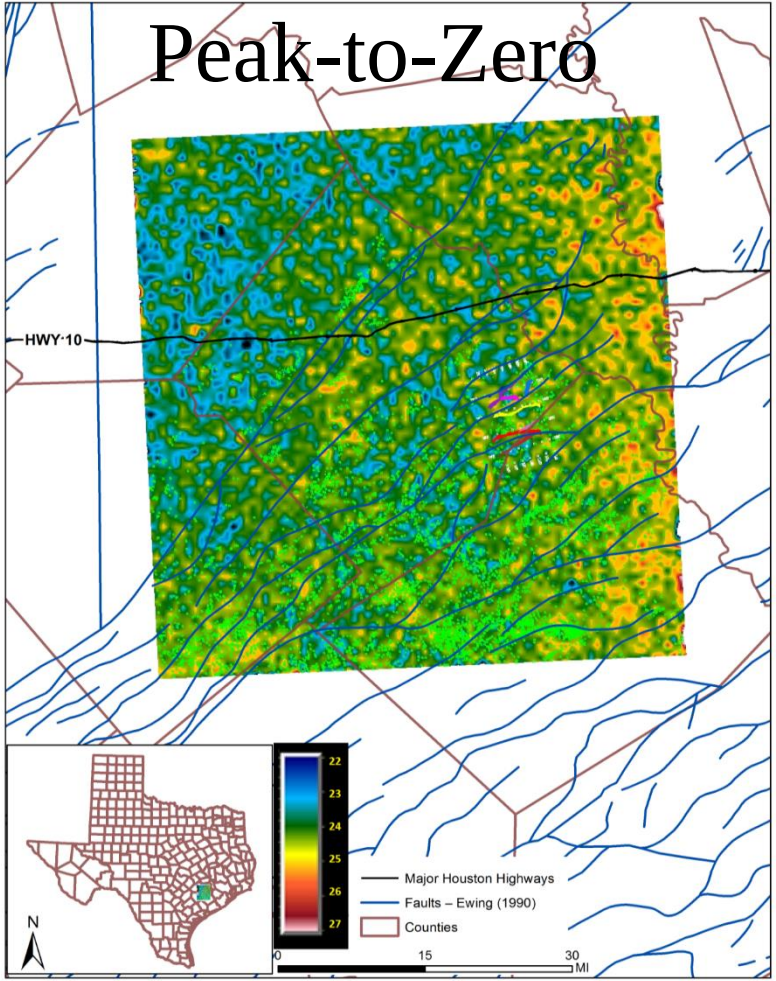
Negative Peak Current



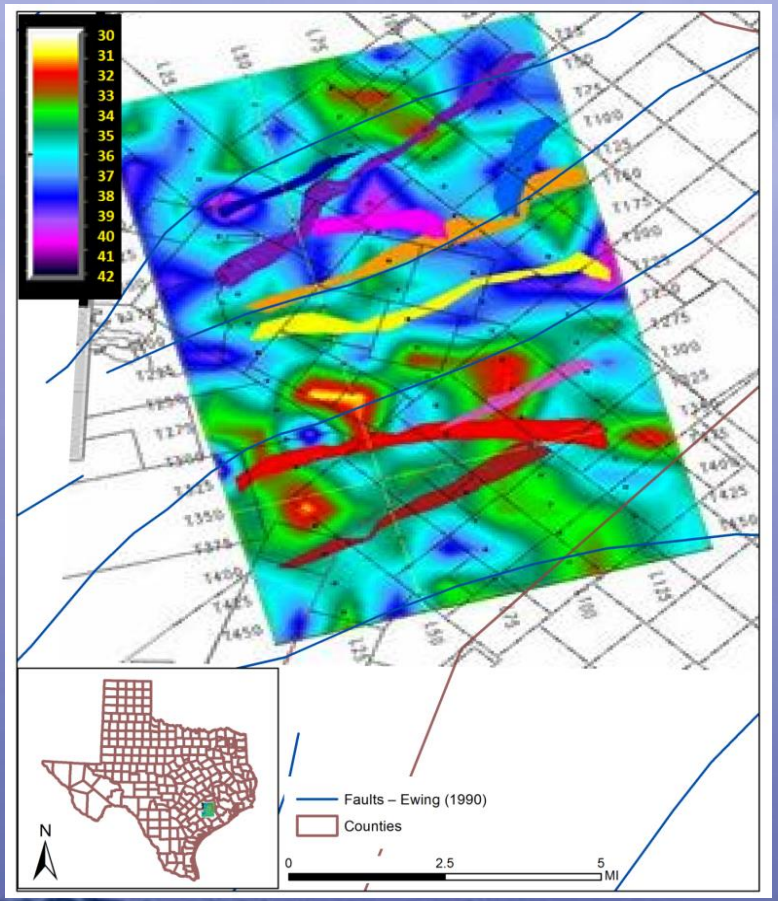
Regional Scale

Colorado County, Texas

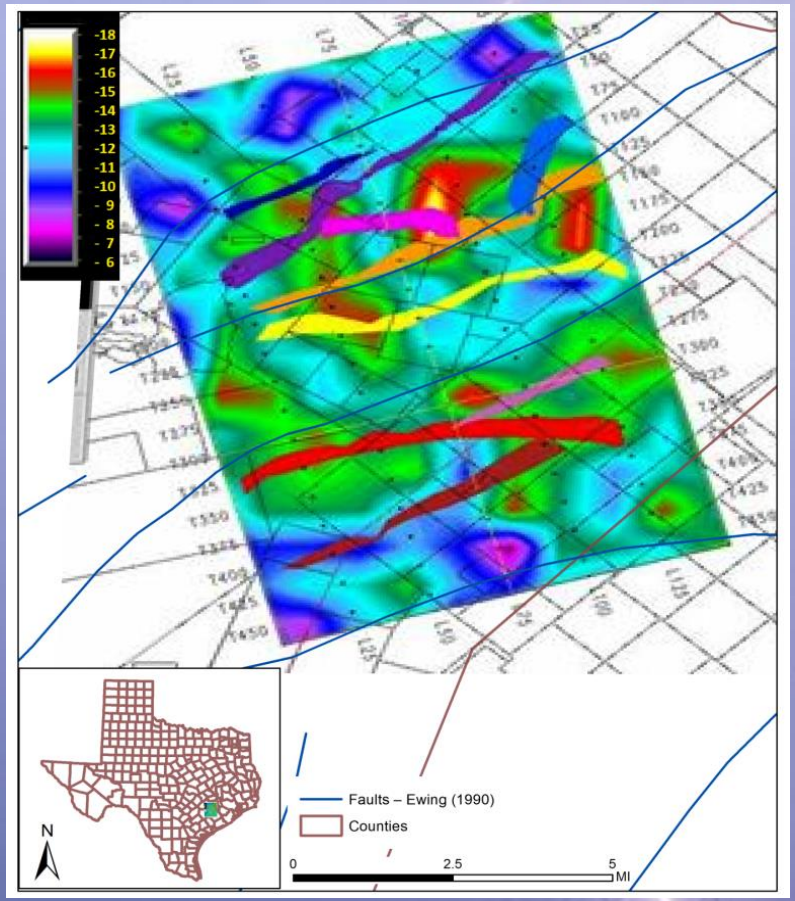
Peak-to-Zero



Rise-Time



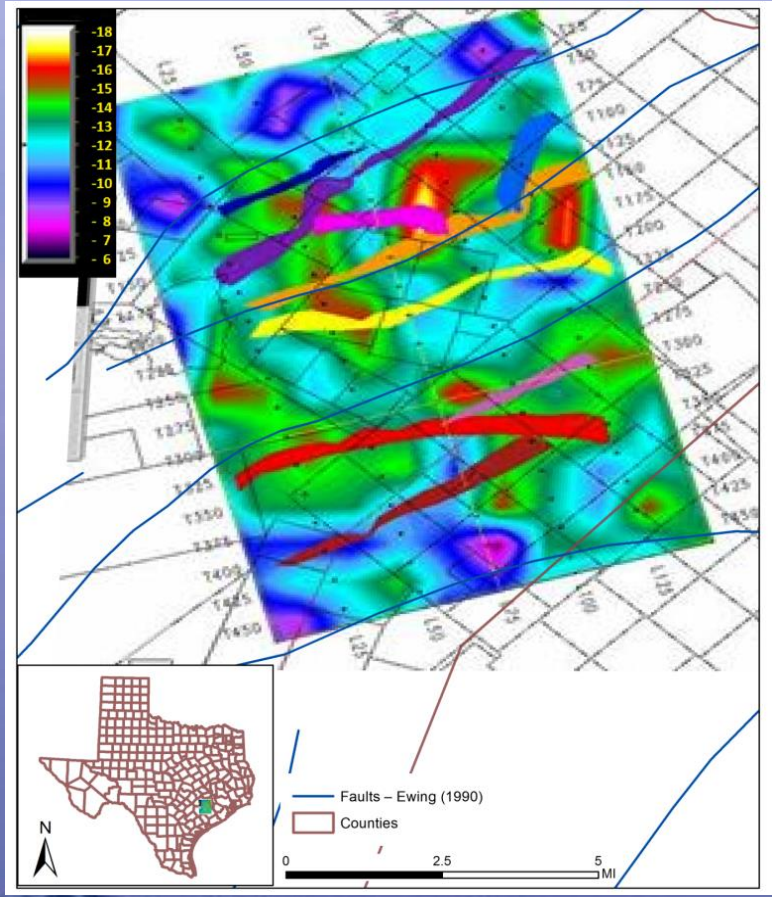
Peak Current



Prospect Scale

Colorado County, Texas

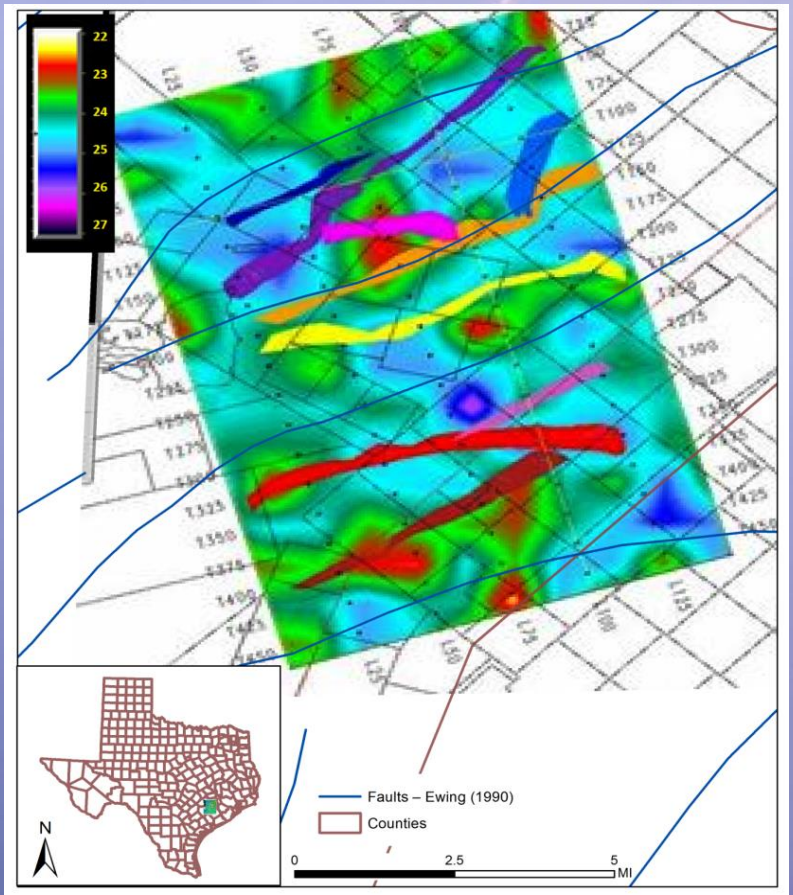
Peak Current



Prospect Scale

Colorado County, Texas

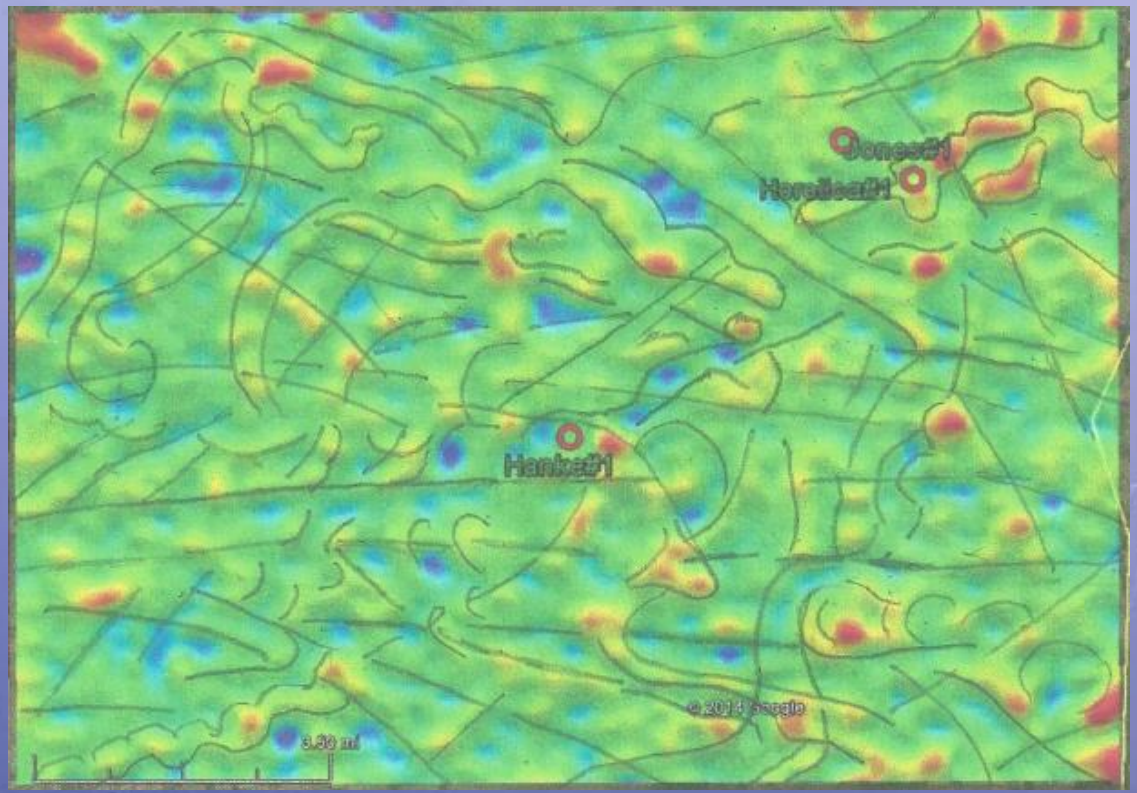
Peak-to-Zero



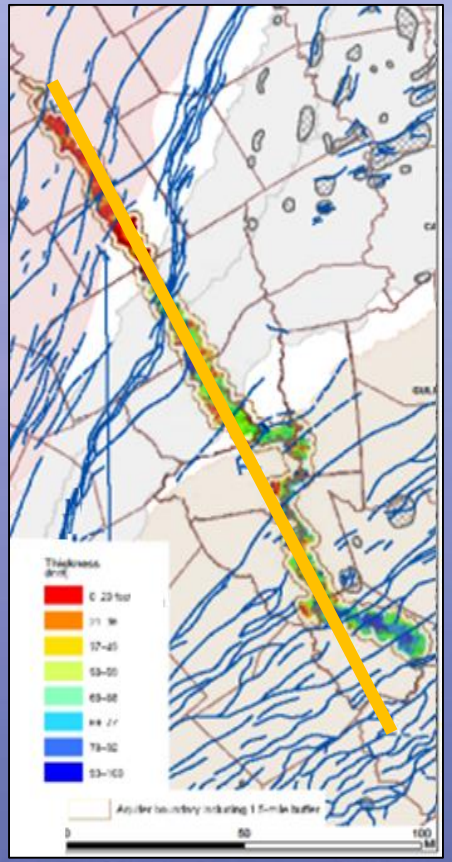
3. Applied Lightning Data in Texas Study Area

Earth Tides / Geothermal Gradient

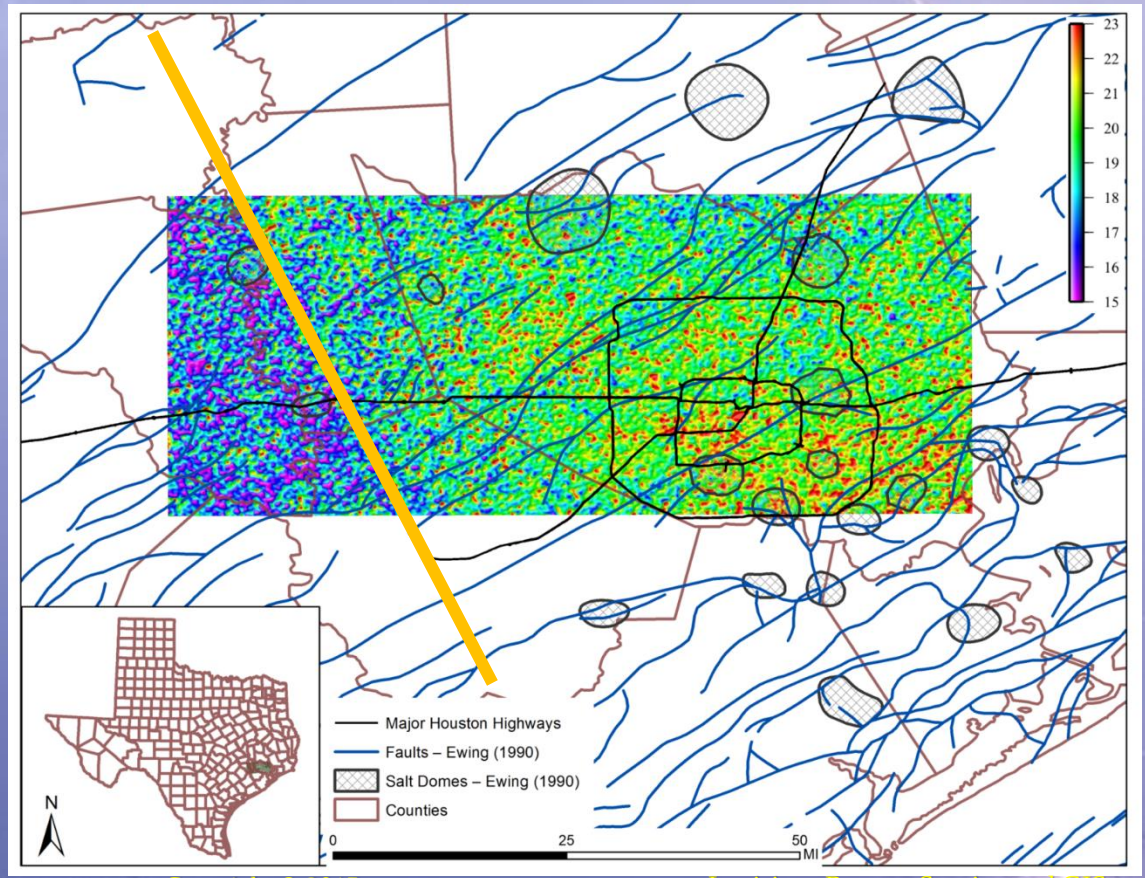
Peak-to-Zero
Central Texas



Brazos Aquifer



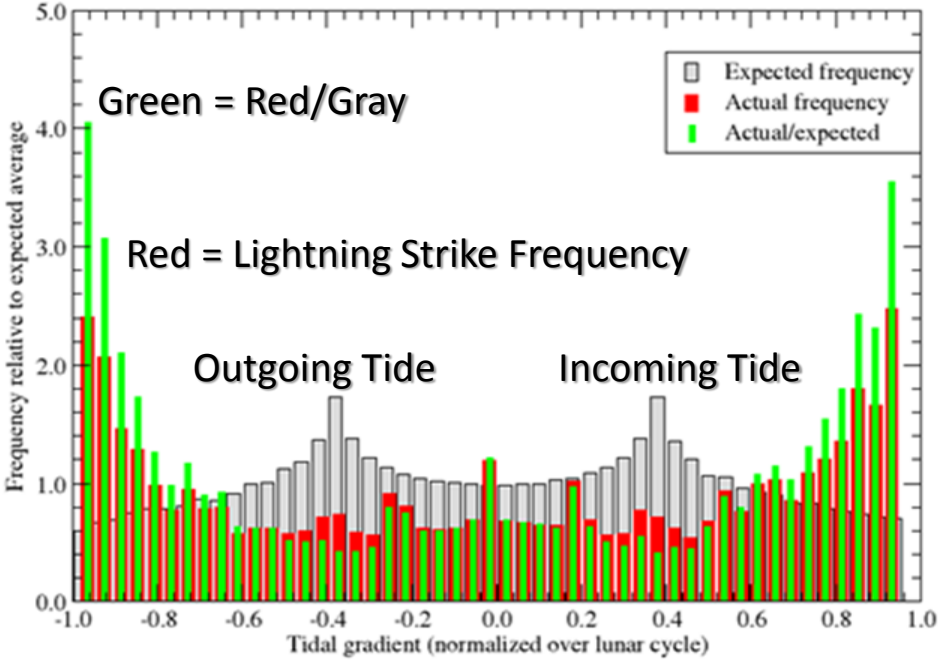
Absolute Peak-Current



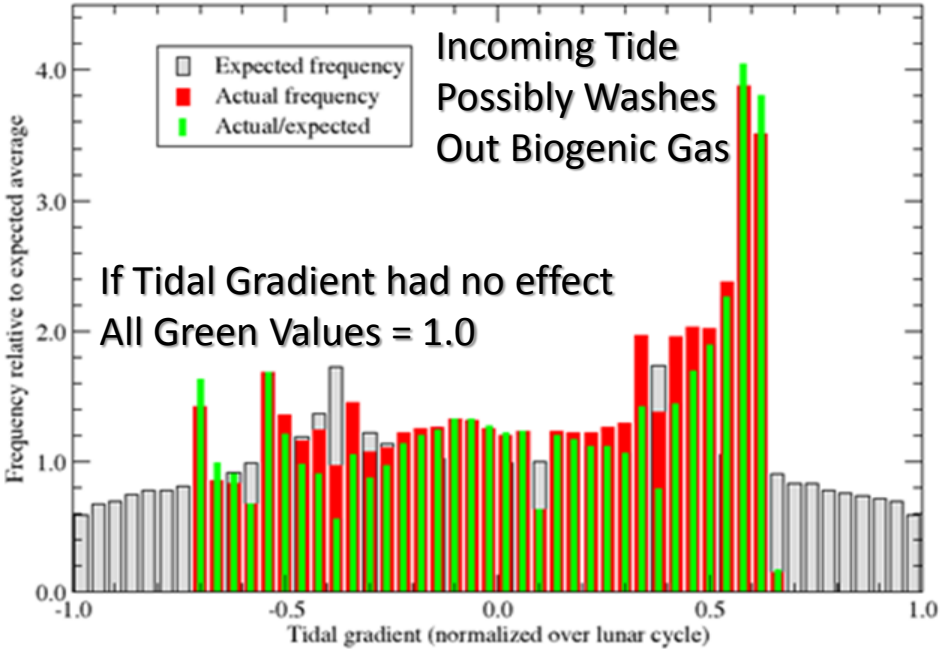
Rate of Change of Lunar/Solar Tides

(Normalized Over Lunar Cycle)

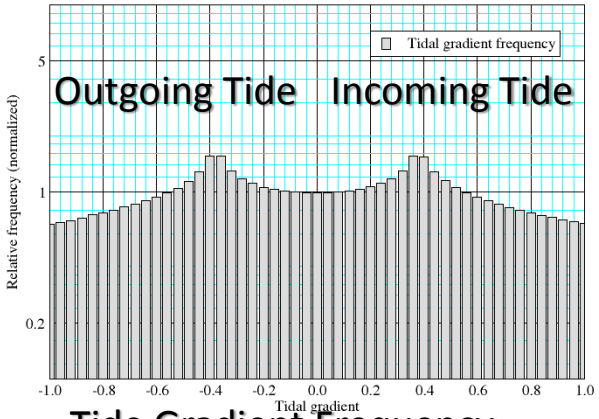
North Texas Example



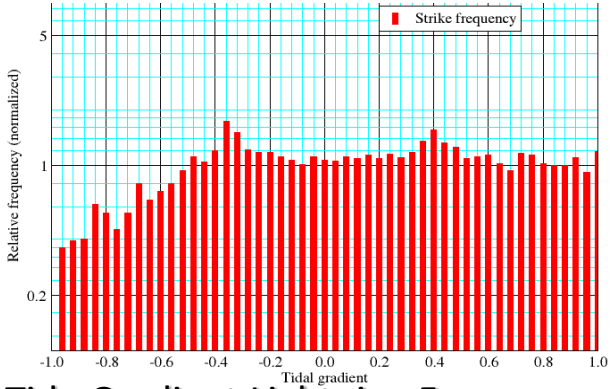
Florida Example



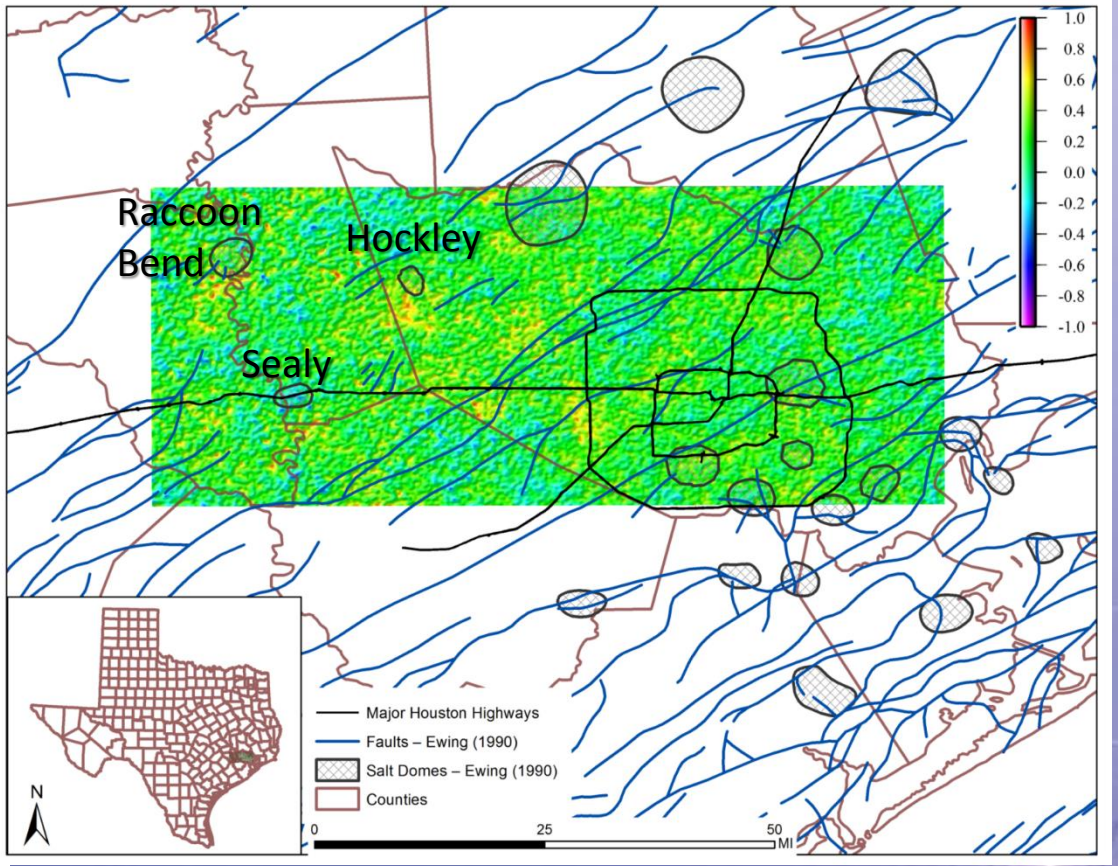
Tidal Gradient when Strikes Occur



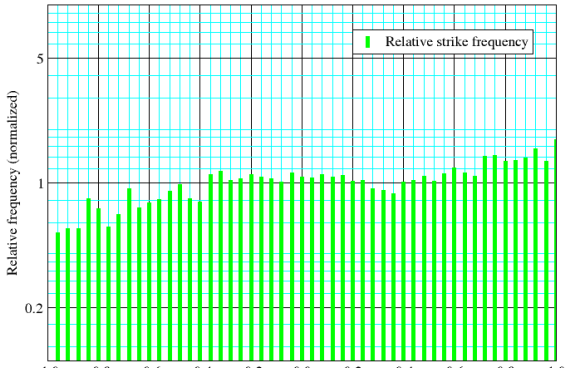
Tide Gradient Frequency



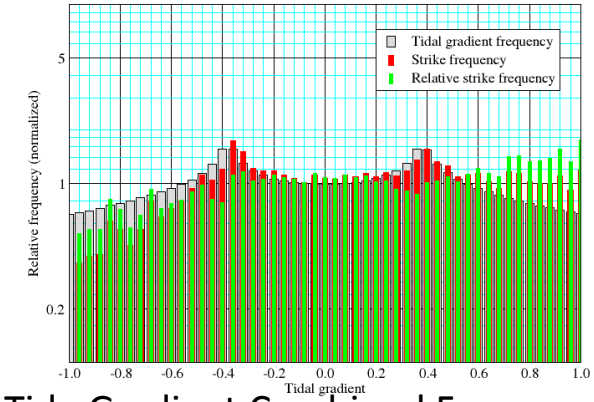
Tide Gradient Lightning Frequency



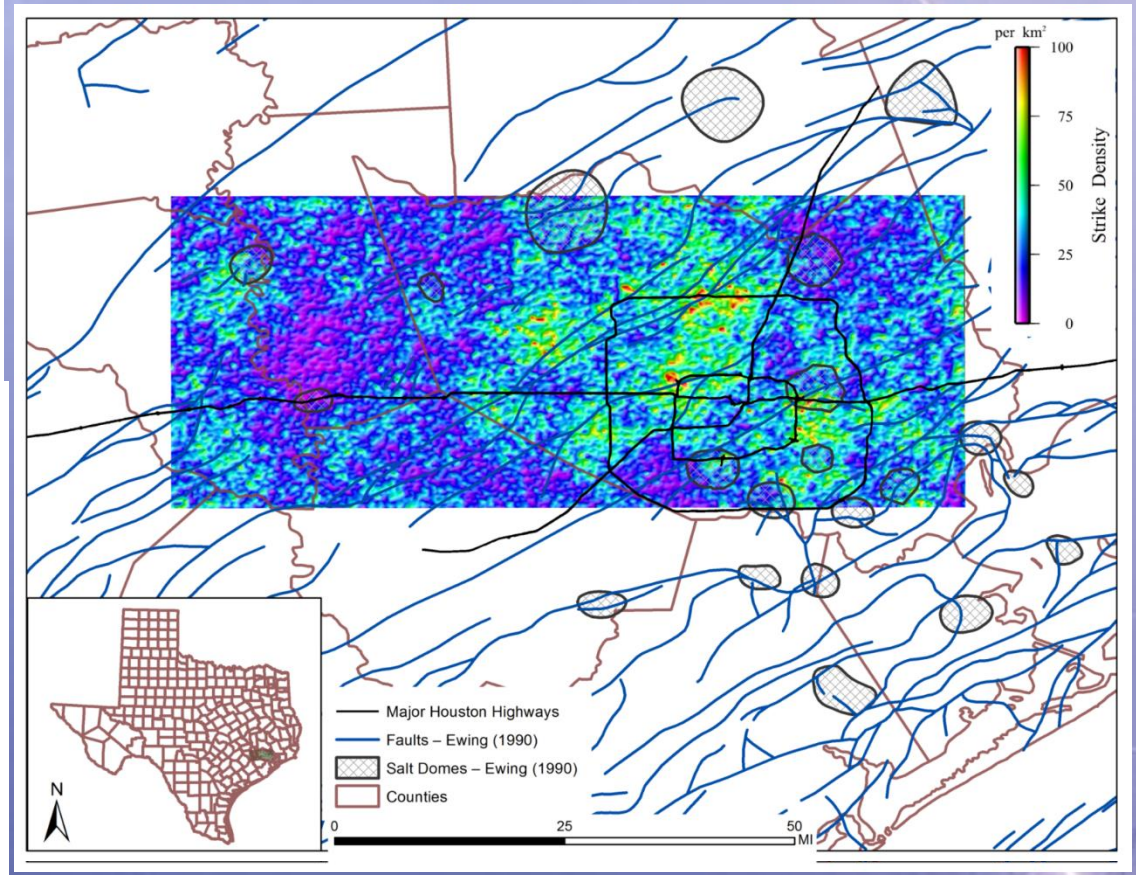
Strike Density at High Tidal Gradient



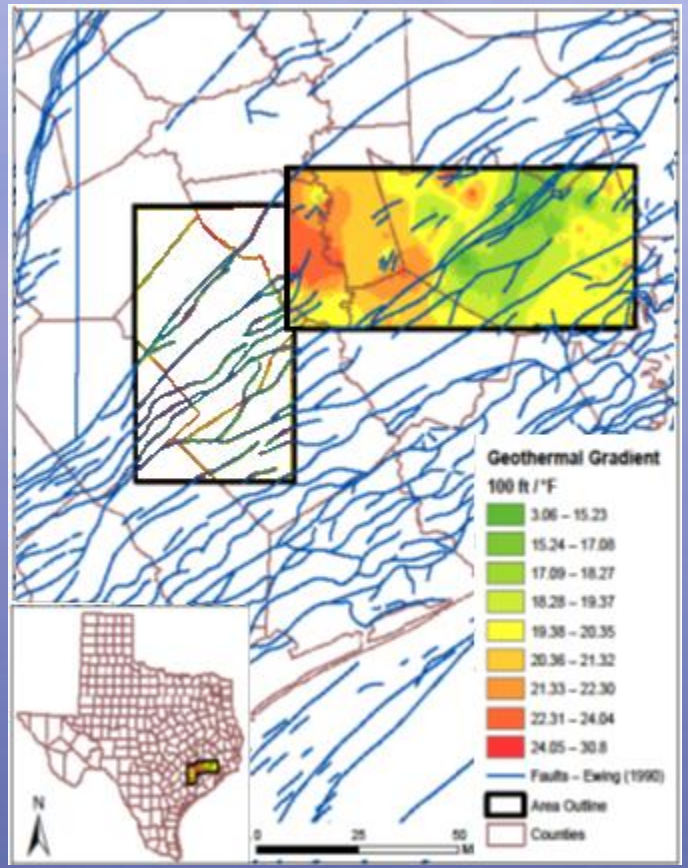
Tide Gradient Normalized Lightning Frequency

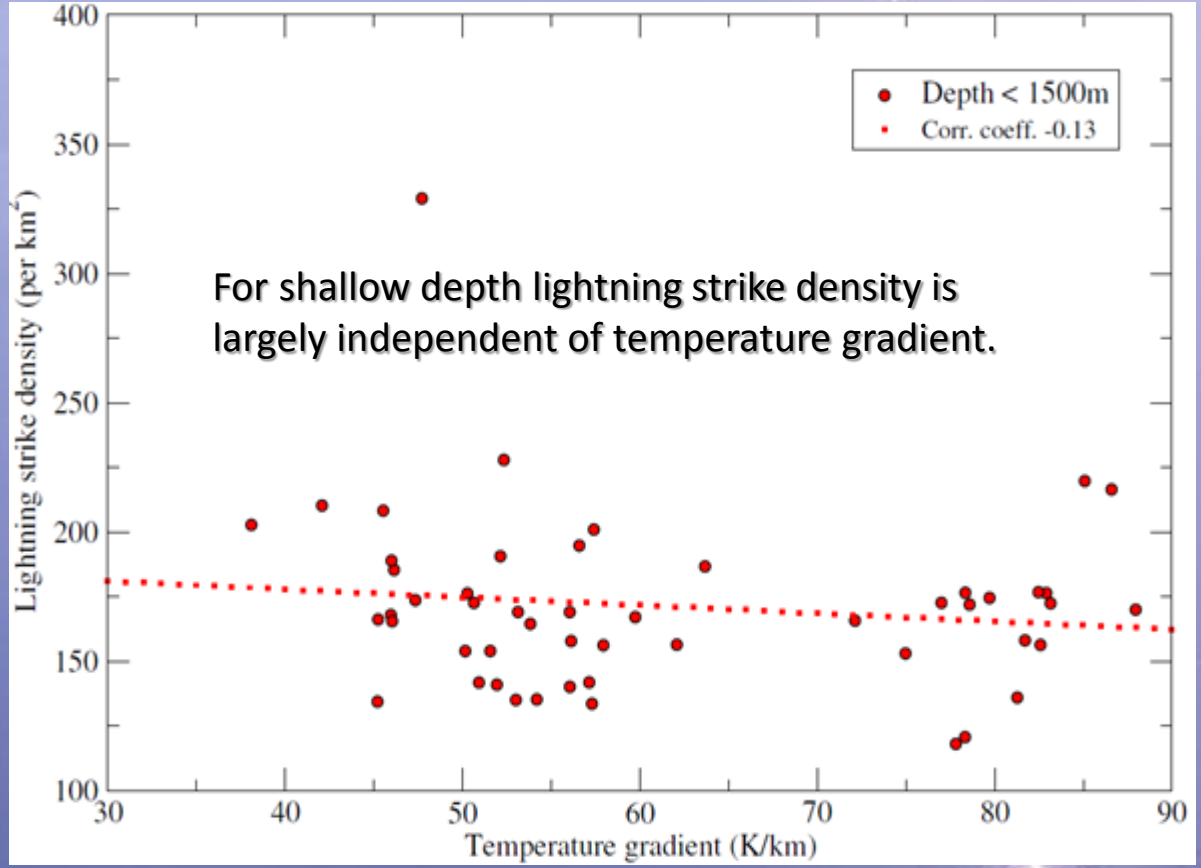


Tide Gradient Combined Frequency

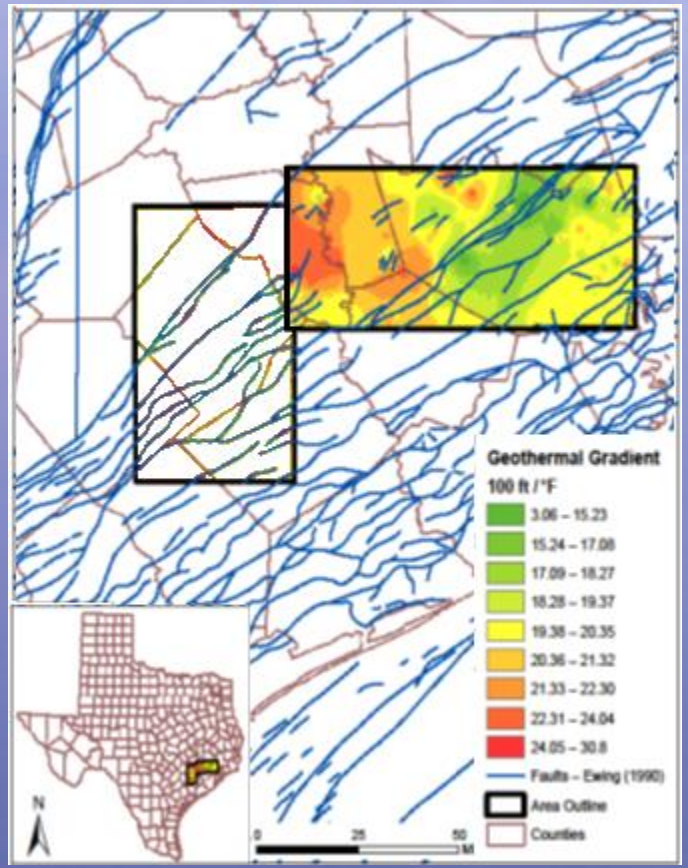


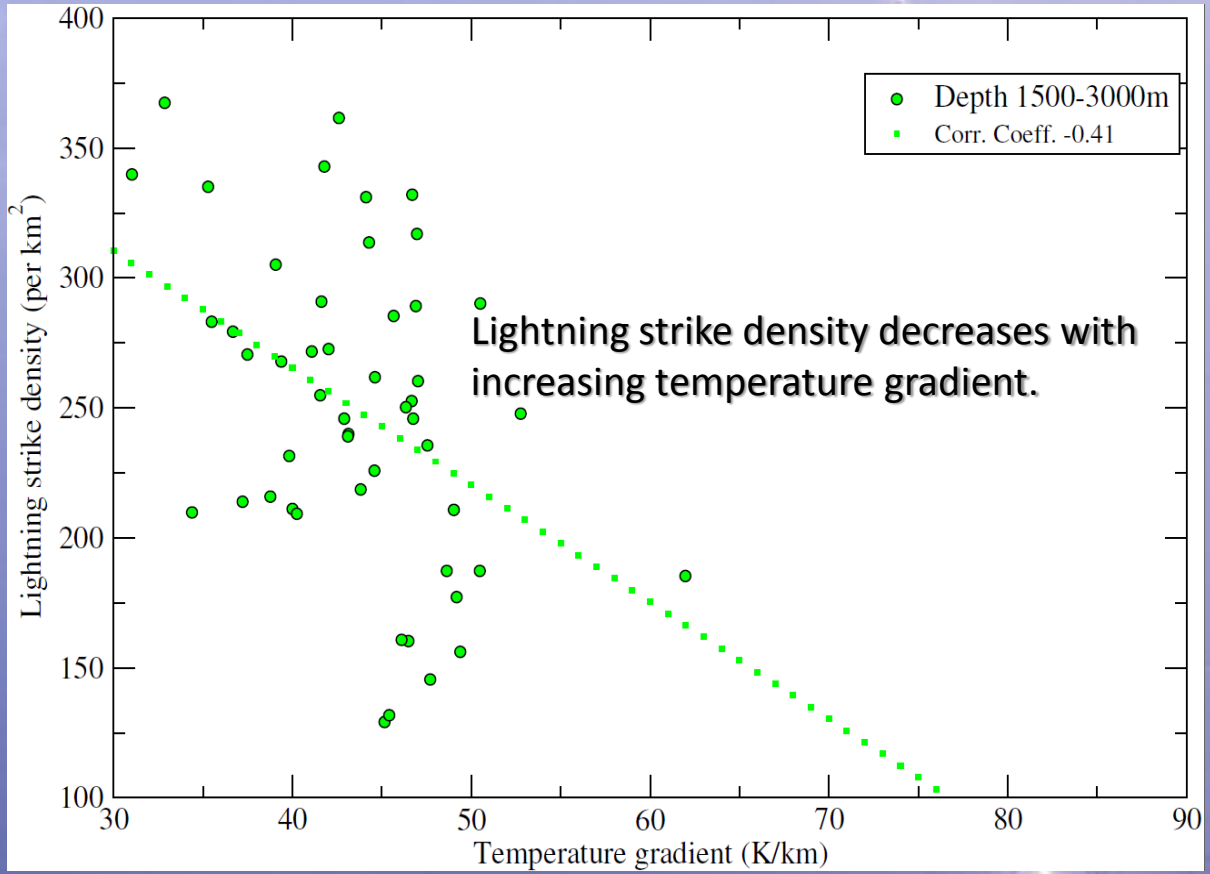
Strike Density Wells <1,500 m (4,920 Feet) Vs. Geothermal Gradient



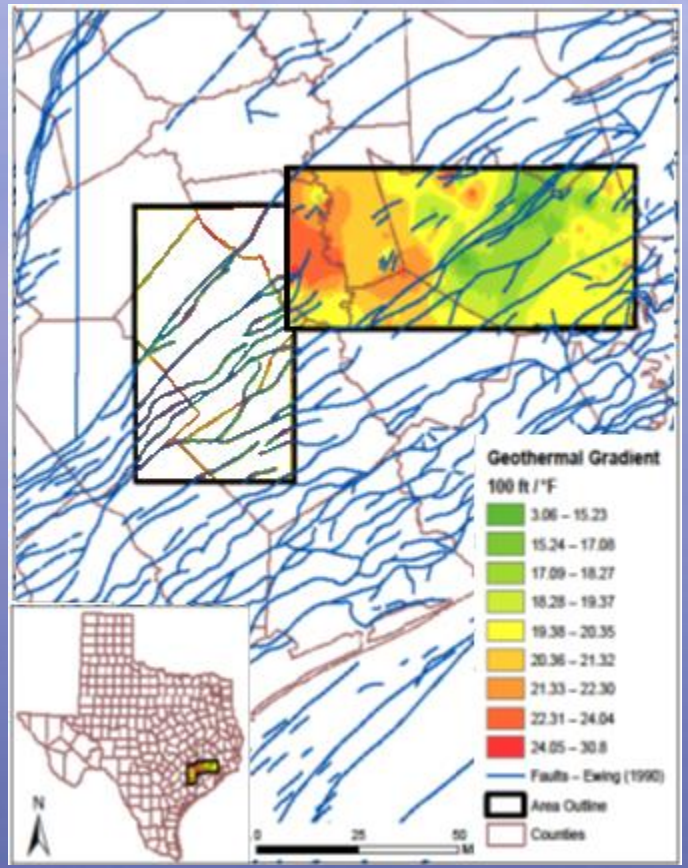


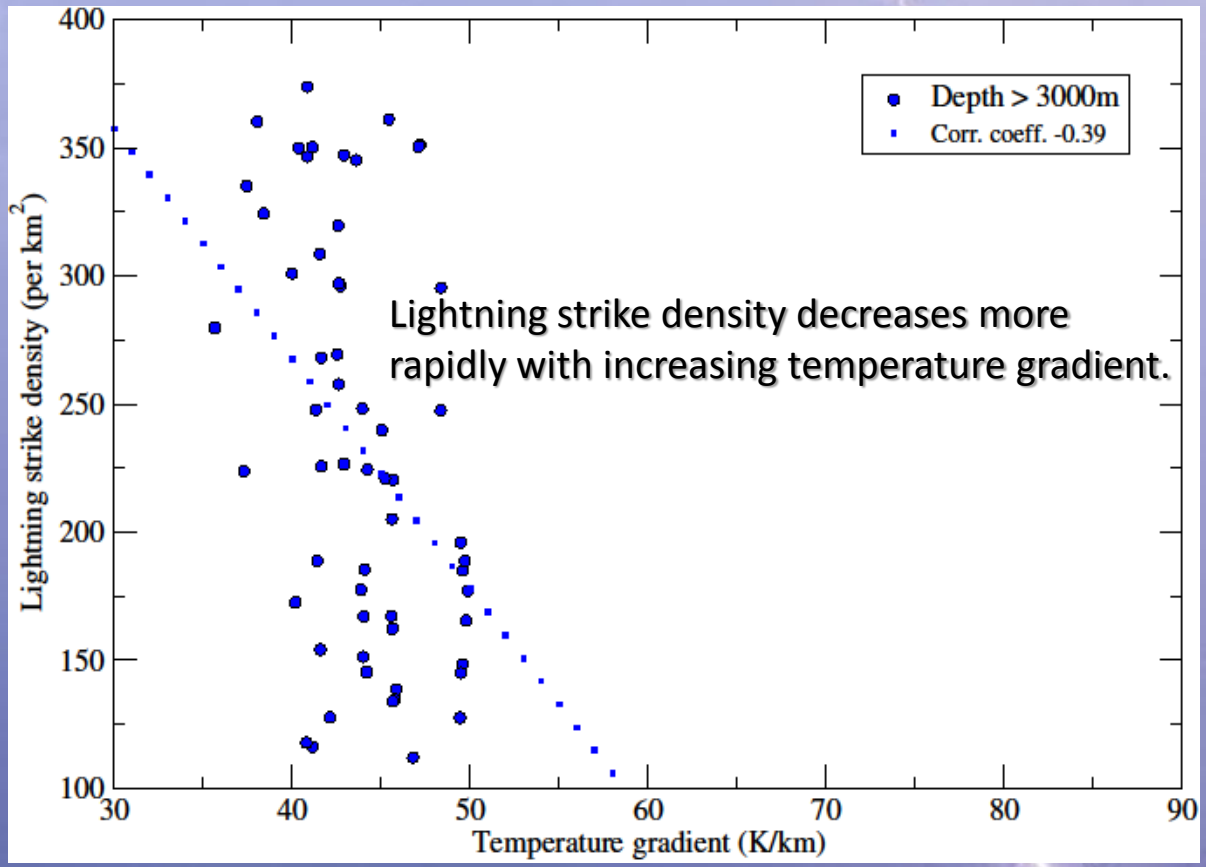
Strike Density for Wells 1500-3000m (4920-9843 feet) Vs. Geothermal Gradient



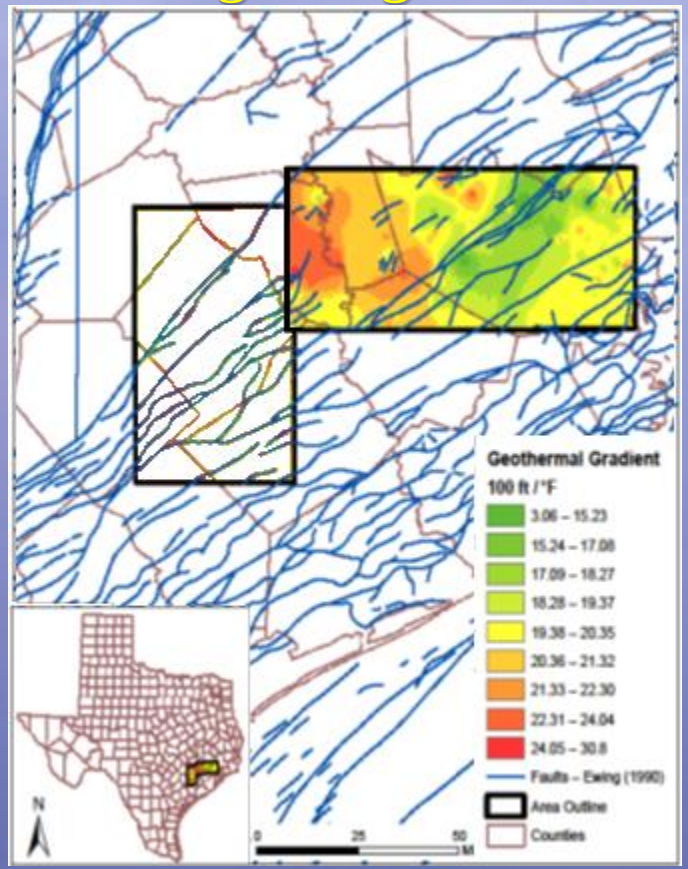


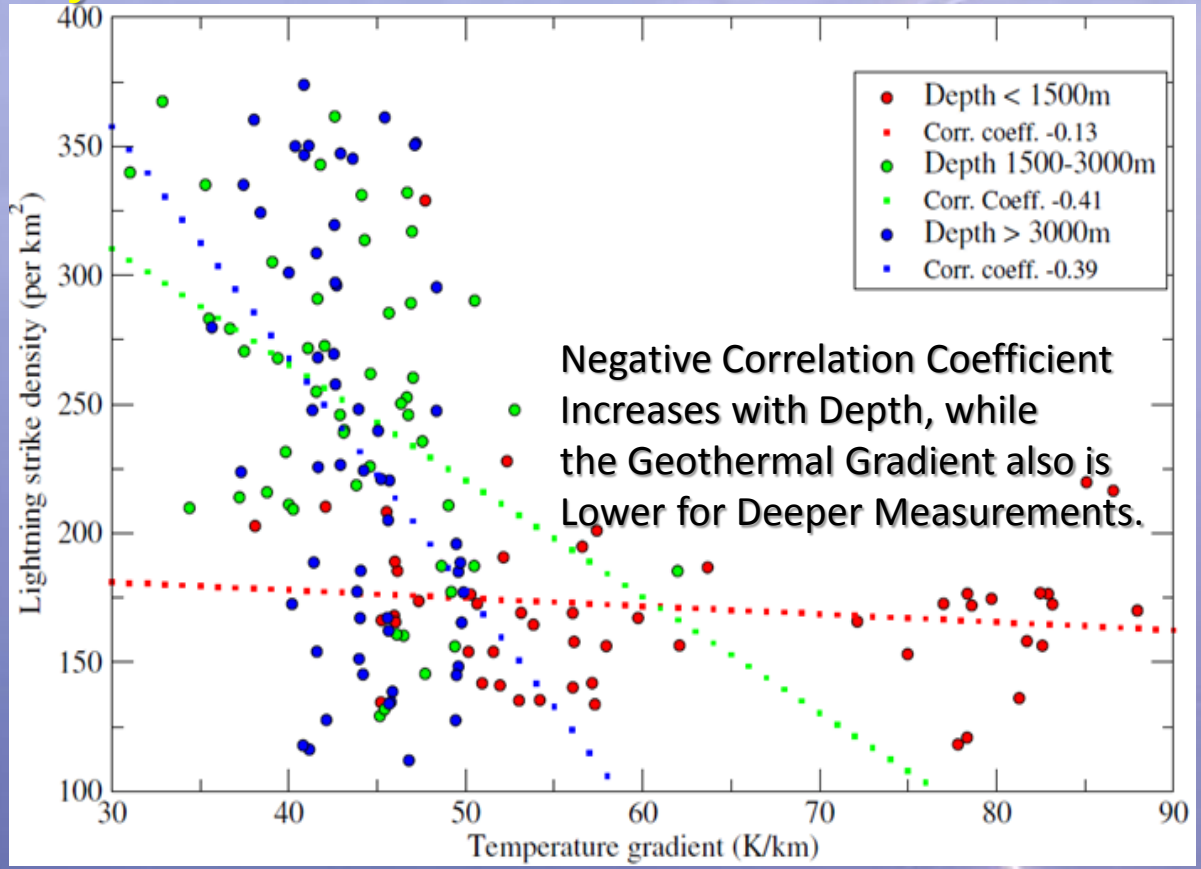
Strike Density for Wells >3000 m (>9,843 Feet) Vs. Geothermal Gradient





Lightning Strike Density for All Wells Vs. Geothermal Gradient





Negative Correlation Coefficient Increases with Depth, while the Geothermal Gradient also is Lower for Deeper Measurements.

Conclusions and Lagniappe…

- Lightning is a new geophysical data type.
- Strike locations and attributes primarily controlled by earth currents and geology.
- Lightning strikes highlight geological features and sediment/rock characteristics.
- Integration of lightning data provides a better understanding of the subsurface.

Thanks You for your Time!

Slides on-line at http://www.dynamicmeasurement.com/TAMU

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LIFE, 25-26 August 2015, Houston
GCAGS, 21-22 September 2015, Houston
SEG, 19-22 October 2015, New Orleans