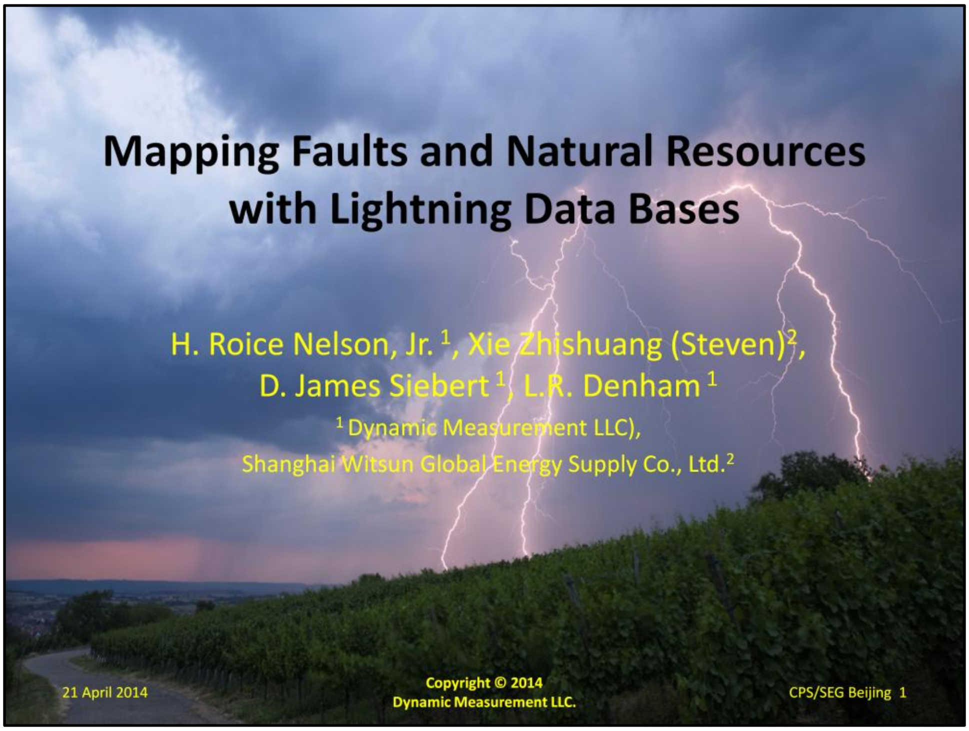
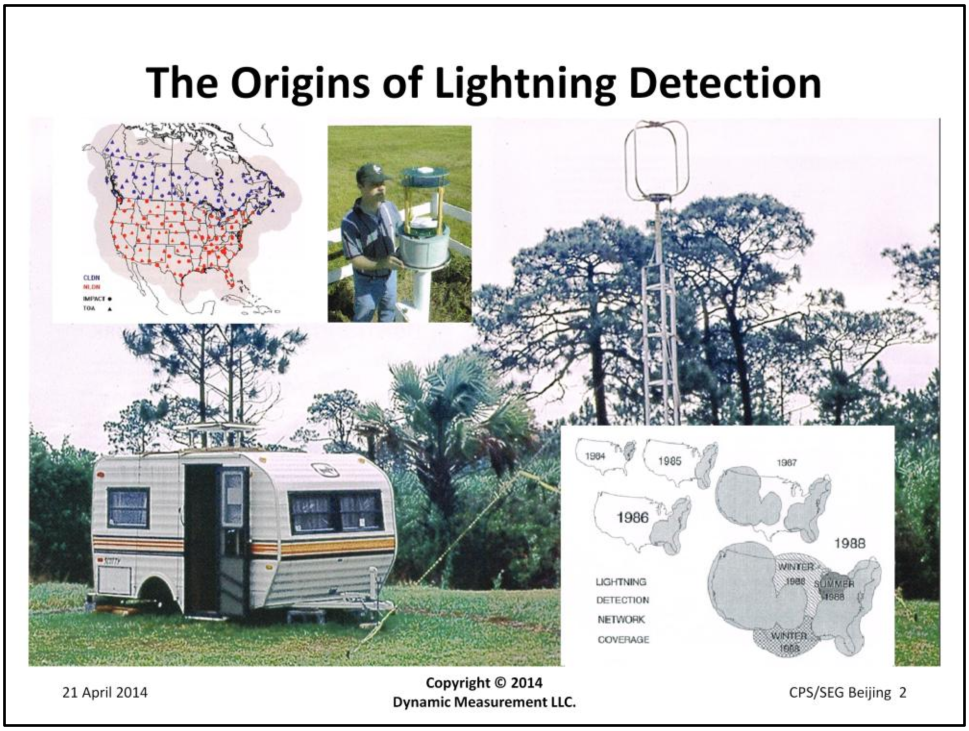


Today we introduce you to a new way to explore for natural resources. We have found that lightning strike locations are not random. They are affected by earth currents. The new approach is data mining of the lightning strike data bases collected for insurance, meteorological and other purposes.

The title of our talk is "Mapping Faults and Natural Resources with Lightning Data."

Roice has been developing new exploration technologies since before starting Landmark Graphics Corporation in 1982. Dr. Jim Siebert is the Chief Meteorologist at Fox News, a Houston television channel, and teaches geology and meteorology at a Houston University. Les Denham is a very experienced geophysicist who has wintered in Antarctica and worked in Greenland for 2 years. He has also worked in tropical and temperate areas of Australia, the Americas, Europe, Asia, and Africa. All three are co-founders of Dynamic Measurement LLC. Xie Zhishuang is an entrepreneur who represents Dynamic Measurement's services in China and to Chinese based companies.

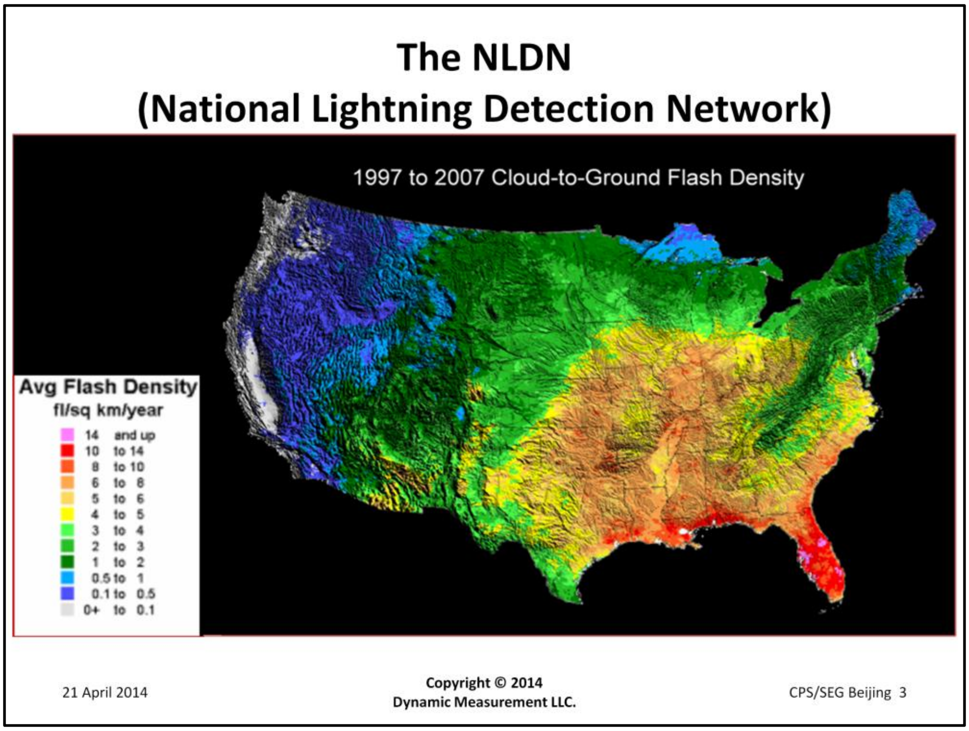


This slide summarizes the origins of lightning detection. Dr. Richard E. Orville, now at Texas A&M University, started the NLDN (National Lightning Detection Network) in March 1982, when at the State University of New York in Albany.

The background image is an early direction finder installation. It consisted of a trailer supporting a flat-plate antenna for detecting the electric field. Supporting electronics and communication equipment were inside the trailer. An orthogonal crossed-loop antenna on a tower for detecting the magnetic field was typically 20m to the side of the trailer.

The inset at the bottom right shows expanding coverage of the lightning detection network in the USA from 1984 to the end of 1988. The NLDN has been in continuous operation by Vaisala, Inc. since January 1989. The map in the upper left shows sensor location in the Canadian Lightning Detection Network (CLDN) in blue, and sensor locations in the NLDN in red.

The IMPACT sensor shown in the upper center replaced the original sensors in the early 1990's. (from Sparked by Technology – The History of the National Lightning Detection Network, American Meteorological Society, February 2008, pages 180-190). Insurance companies funded ongoing running and development of the NLDN because up to 60% of insurance claims for homes damaged or destroyed by lightning were found to be fraudulent or misrepresented (Orville, 2012).



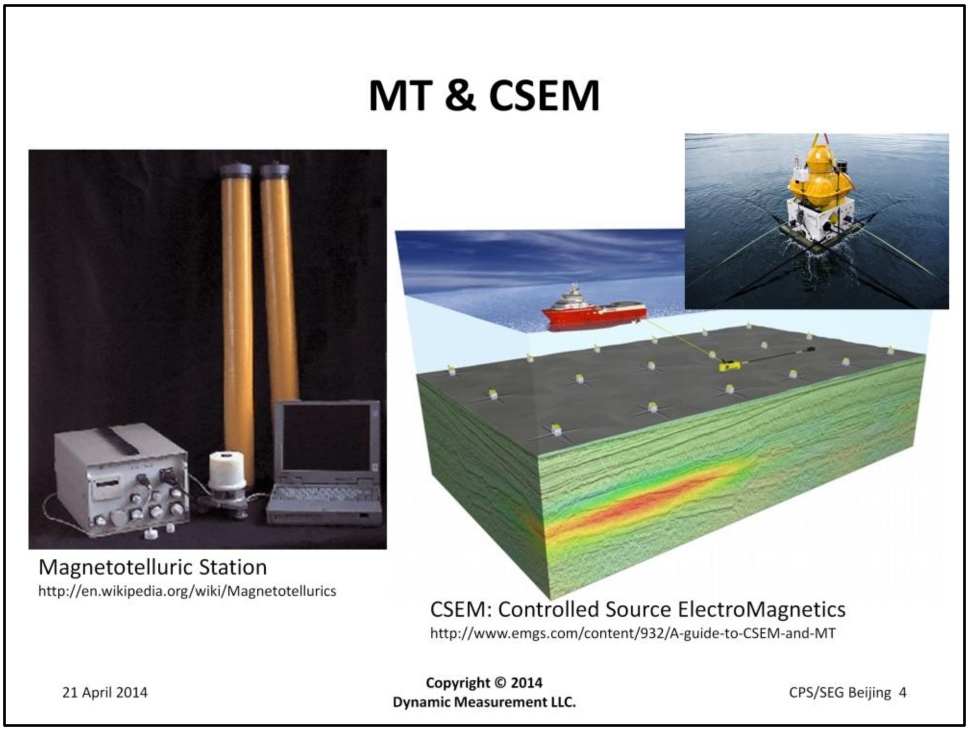
This map shows the number of lightning strikes per square kilometer between 1997 and 2007 in the National Lightning Detection Network (NLDN) data base.

Gray areas, like in the Mojave Desert in California, have up to 0.1 strikes per year per square kilometer. The dark blue area has 0.1 to 0.5 lightning strikes per square kilometer per year. Note how there are fewer lightning strikes along the Snake River Plains volcanic flows in Idaho. Most of the lightning strikes in the continental United States are between the Rocky Mountains and the Appalachian Mountains. This is a natural path for the cold weather from Canada to flow down across the mid-continent. This cold air collides against the warm air from the Gulf of Mexico, setting up the meteorological conditions for a lot of lightning strikes.

Lightning is a meteorological phenomenon (Rakov and Uman, 2003). Exactly where lightning strikes is a geologic phenomenon. The meteorological effect is clearly seen in Florida where storms come ashore almost every day from both the Atlantic and the Gulf of Mexico. In that state there are over 14 strikes per square kilometer per year, or in the 15 year NLDN data base over 210 lightning strikes per square kilometer. Another area in the United States with such frequent lightning strikes lies along the Gulf Coast from Alabama to east Texas, an area including many large oil and gas fields.

The NLDN generates a large and growing database of lightning strikes to mine. The network and the database are owned by Vaisala, Inc.

Dynamic Measurement has a worldwide license to use Vaisala's data bases for natural resource exploration. These databases include 4 years of data outside the continental United States from Vaisala's GLD-360 satellite-based network (Hembury, et. al., 2011).

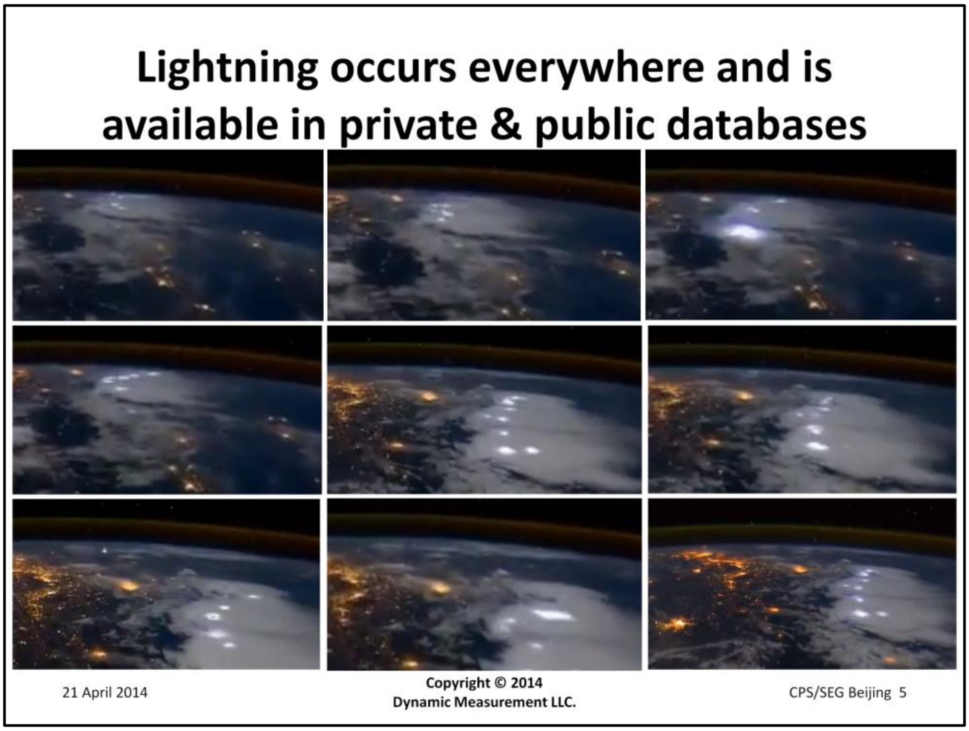


Electrical methods have been used for exploration for a long time. It can be argued the first geophysical measurement of an earth system was made when Benjamin Franklin flew a kite to demonstrate that lightning is an electrical phenomenon.

Magnetotellurics (MT) has been used as an exploration tool since the 1950's (Cagniard, 1953).

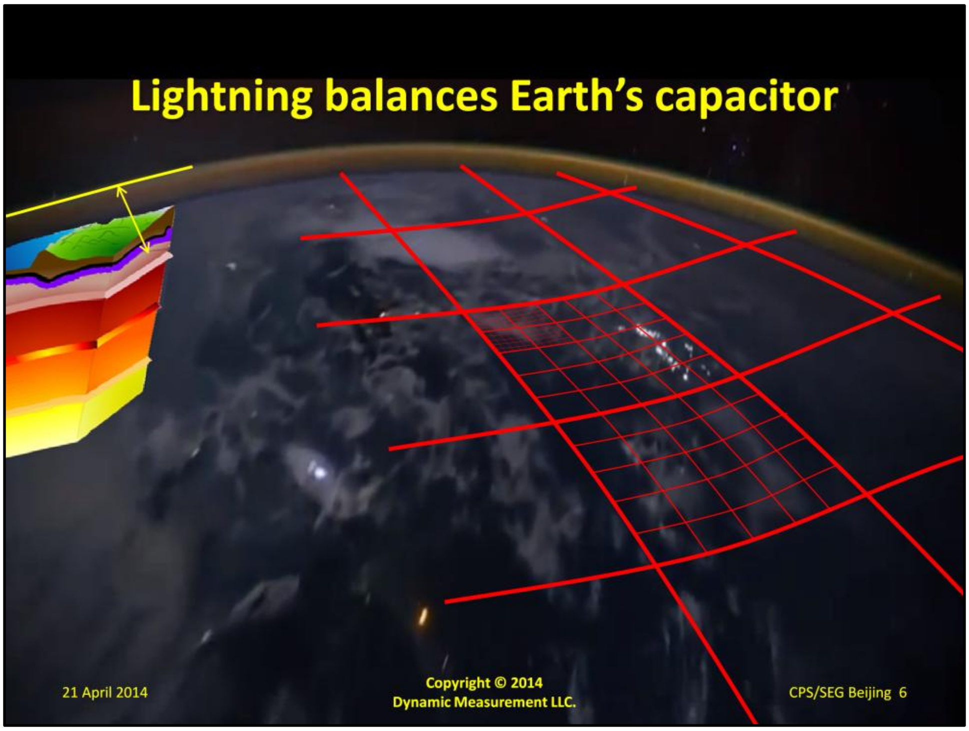
The Controlled Source Electromagnetic technique (CSEM) has been discussed in the literature since 1967 (Keller and Frischknecht, 1967; Cheesman, et. al., 1987; Wilt, et.al., 1989; and Nabighian, 1991).

New developments in passive measurements of seismic events (Duncan and Eisner, 2010) have similarities to the study of passive measurements of lightning strikes. The big differences for lightning are the existence of a database with hundreds of millions of records available for data mining, and that it is an entirely new exploration data type.

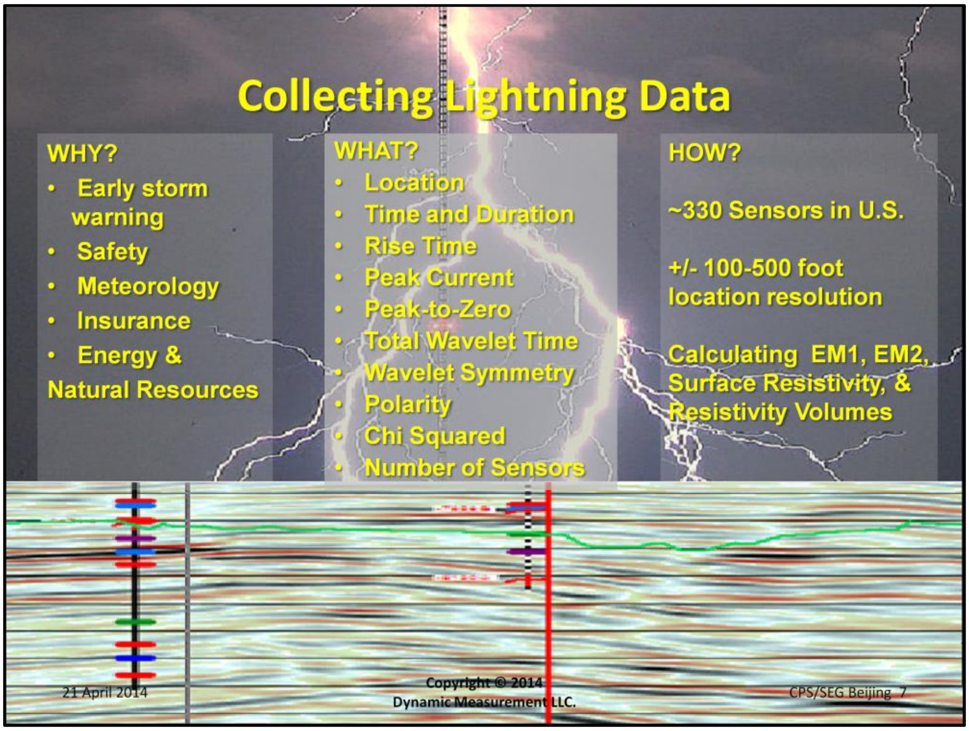


A key advantage for lightning as an exploration tool is that it occurs everywhere, and is available in both private and public data bases.

These photos are from a movie taken from the International Space Station showing lightning strikes around the world. Only since the mid 1990s have scientists discovered, and astronauts and cosmonauts confirmed, upper atmospheric lightning events now known as sprites and elves. What is the source of the energy allowing some of these events to travel up to 60 km beyond the atmosphere?



The ionosphere and the crust (from the surface to the top of the mantle) form the two plates of an electrical capacitor surrounding the earth. Lightning strikes, while meteorological in origin, bridge the gap and balance charge differences between the plates. Lightning strike locations are not random. The strike location is primarily controlled by earth currents, which guide the lightning leaders and provide a location for the up-going return stroke. Because lightning strikes occur everywhere, they can form the base layer in a worldwide raster Geographical Information System (GIS) known as the Infinite Grid(SM) or IG. The IG provides a mechanism for taking legacy geologic maps, registering them against IG longitude and latitude boundaries, and integrating this legacy geological and geophysical data with lightning strike attribute maps. There is anywhere from a few to a few hundred lightning strikes per square kilometer in the available lightning strike data base. These strikes and their attributes can be summed, averaged and mapped to provide maps of disruptions in subsurface earth currents caused by faults and things resistive (aquifers, oil fields, gas fields, salt domes, etc.) and things conductive (thermogenic alteration, brines, minerals, etc.)

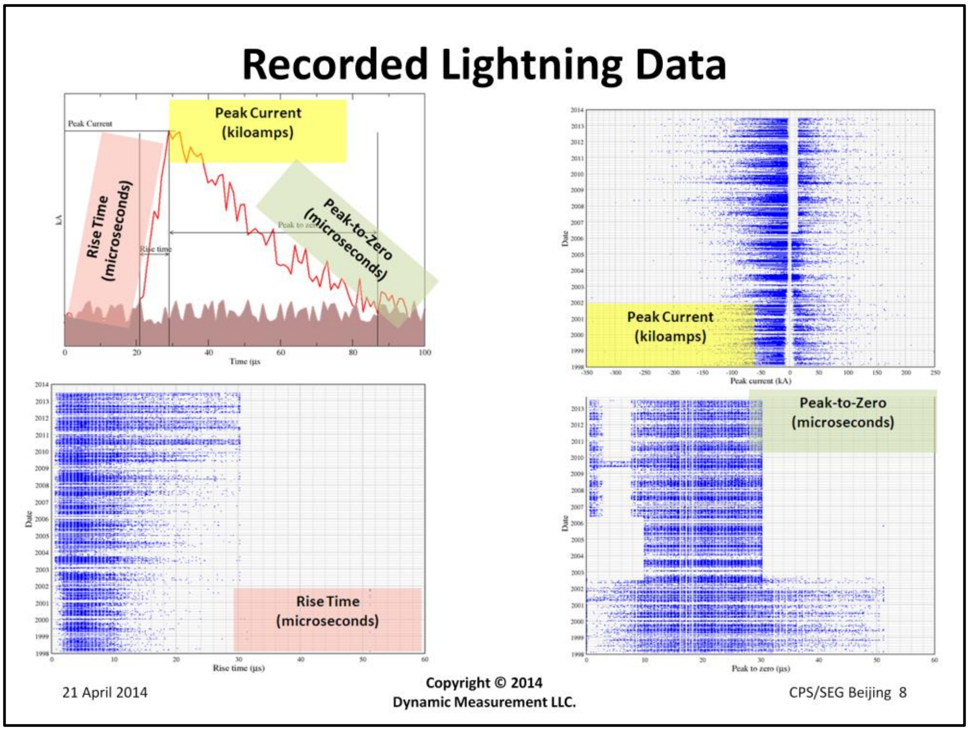


The lightning strike records were collected at first for meteorological purposes: early storm warning, safety, and for weather reports. The data collection and processing procedures are described in meteorological literature (Murphy, et. al., 2008 and Baba and Rakov, 2008).

Then insurance companies found out this data was available, and used it to validate damage claims such as houses burning down, destroyed transformers, etc., by demonstrating whether or not lightning occurred near the location of the damage and at the time of the damage.

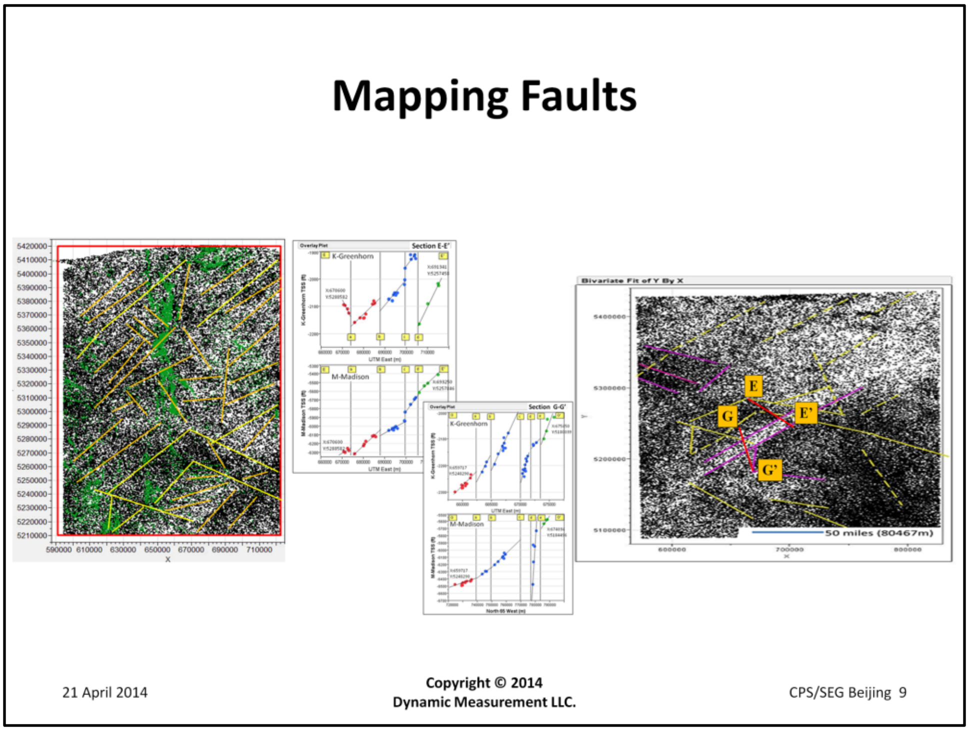
Only been since 2008 have we been studying the implications of lightning strike location, density, and attribute maps on natural resource exploration. The NLDN database includes the location of the lightning strike, with 60-100 meter resolution in the continental United States, while the GLD-360 database resolution is 100-300 meters elsewhere.

As an example, in Texas each lightning strike is recorded by 8-14 sensors. These sensors record the time of each strike is recorded with microsecond (10^{-6} microseconds) accuracy. Attributes measured by the various sensors are reconciled and a quality measurement recorded called Chi Squared. Attributes measured by the NLDN include, polarity, Rise Time, or the time to go from background electrical noise to the Peak Current, Peak Current, and Peak-to-Zero, or the time to back down to the background electrical noise. Most lightning strikes have negative polarity. Positive polarity lightning strikes tend to come at the end of a thunderstorm and tend to have higher peak current. From these attributes are calculated Total Wavelet Time, Wavelet Symmetry, Surface Resistivity, Resistivity Volumes, EM1, EM2, etc. The key lightning attribute measured and recorded by the GLD-360 is Peak Current. There are 330 ground based sensors in the NLDN. The GLD-360 network consists of a combination of satellite and ground based sensors. Private networks, like the NLDN, can be set up anyplace in the world.



The upper left cartoon summarizes the key lighting attributes: Rise-Time, Peak Current, and Peak-to-Zero (Denham, et.al., 2013). The other three displays shows lightning strike measurements for a commercial lightning analysis project in Texas. Note there is a 30.2 microsecond cut-off of Rise-Time on the lower left chart. The upper right Peak Current chart shows lower (less than +10 kiloamp) lighting strikes were not recorded after mid-2006. This was to reduce the number of cloud-to-cloud lightning strikes included in the database. It also shows a majority of the strikes have negative polarity. The Peak-to-Zero measurements, in the lower right, have had the biggest change in attribute cutoffs. This chart shows instrument upgrades occurred in 2002 and 2006, and the 30.2 microsecond cut-off has been consistent since mid 2002.

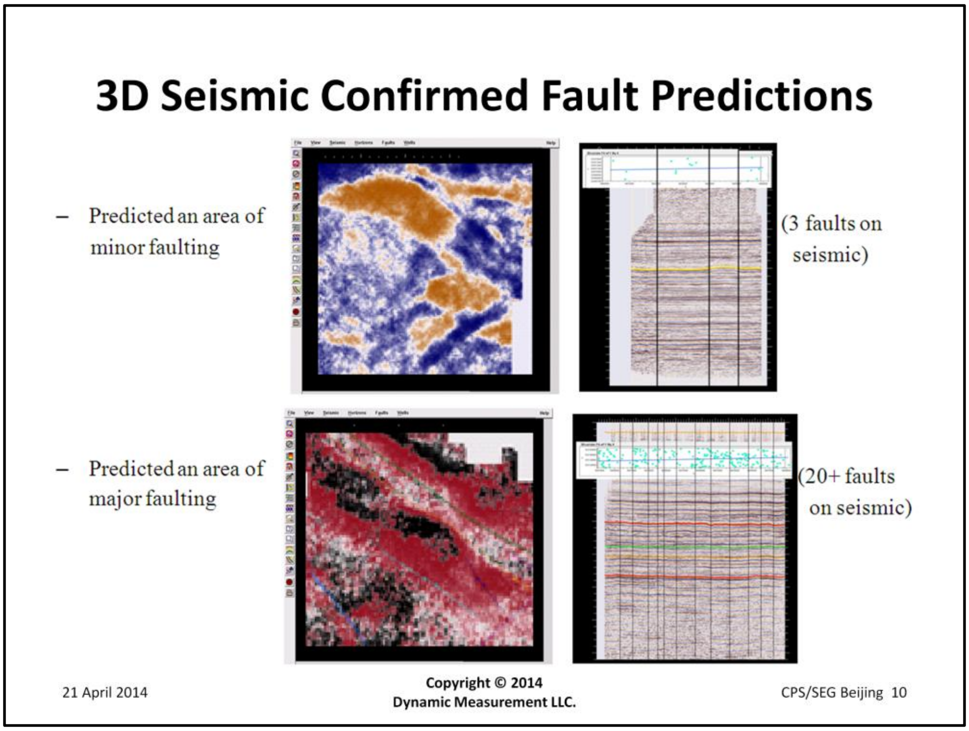
The most recent sensors have the ability to record lobes of full-waveform lightning strike data. However, with sub-micro-second sampling there is so much data generated that this can only be used when sensors are connected to the central repository by fiber, and then only for research purposes. DML anticipates being able to develop algorithms to invert full-waveform data and create the equivalent of an acoustic impedance log everywhere there is a lightning strike. We recently developed the mathematics to calculate surface resistivity and resistivity volumes from the electrical properties recorded in the NLDN database.



The next six slides demonstrate that consistent geologic features DML has been able to derive from lightning strike data mark the locations of faults. A 2013 article in the International Journal of Geosciences describes a correlation between lightning density and modern seismic events in Sichuan Province, China (Xiaobing, et. al., 2013). This paper focuses on much older geologic faults.

The first example, shown on this slide, is from North Dakota and shows fault interpretation based on picking geological markers in wells correlated against faults interpreted from lighting data. The map on the left shows a map of lightning strikes across the Nesson Anticline in Western North Dakota. The general pattern of lightning strike density across the most heavily drilled field on the Anticline, the Beaver Lodge Field, and 50 miles to the east or 50 miles to the west where there is no infrastructure, is very similar. DML does not think infrastructure has a significant impact on where lightning strikes.

The lineaments drawn on the map show an interpretation of faulting. The map on the right shows a zoom in on Dunn County, at the southern end of the Nesson Anticline. It highlights the location of the two horizon top cross-sections (E-E’ and G-G’) is shown in the center of the slide. Two of 23 sets of geological markers, the Greenhorn (upper) and Madison (lower), were extracted and plotted from the many wells in this area along each cross-sections. This is an intracratonic basin, with old, hard, and brittle rocks. When basement faults move they displace all of the rocks above each basement fault block like sheets of glass. Where the dip of the tops change on many of these 23 horizon tops, a vertical line is drawn, representing a fault. These fault lines match the location of the lineaments drawn on the lightning analysis.



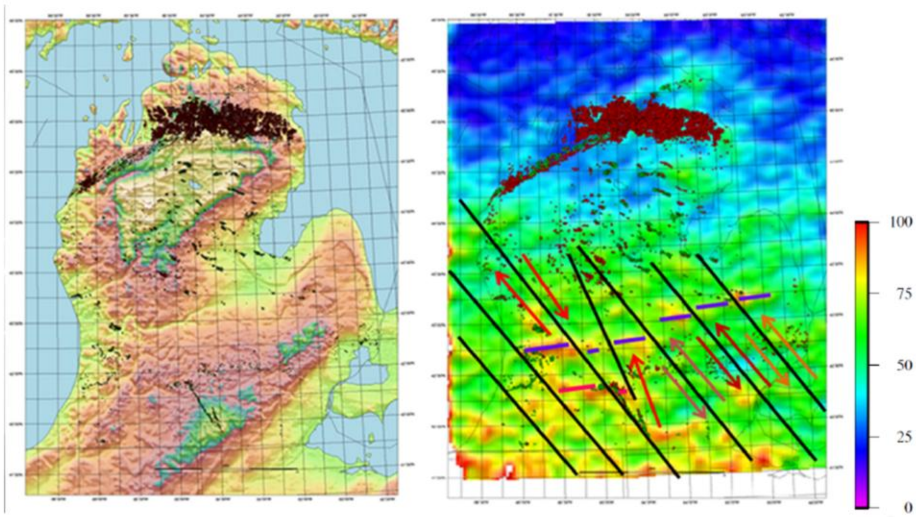
This example shows 3-D seismic data together with fault locations picked from lighting data.

From analysis of lightning strike density, DML predicted an area where we expected to see few faults and another area where we expected to see many faults. We were able to obtain 3-D seismic surveys over both areas.

In the area where we predicted minor faulting, independent seismic interpretation showed three faults on the seismic sections. The locations of nearby lightning strikes are shown in the panel at the top of the vertical cross-section. The lightning strikes cluster between the faults.

In the area where we predicted major faulting, seismic interpretation showed over 20 faults. Again, the lightning strikes cluster between the seismic-interpreted fault locations. Trace spacing on the 3-D seismic surveys was 25 meters, and lightning strike spatial resolution is between 60 and 100 meters.

Michigan Topography and Infrastructure



21 April 2014

CPS/SEG Beijing 11

This example shows interpreted strike-slip faults, along with topography, infrastructure and lightning strike density both onshore and offshore in the Lakes Michigan, Huron, and Erie (Nelson, et. al., 2013). The topography map on the left shows the Michigan peninsula.

Like North Dakota, this is an intracratonic basin. Pinnacle reefs grew around the edge of the basin, and form one of the main traps for hydrocarbons. The red dots at the top of the maps are gas wells tapping into these pinnacle reefs, and if you know where to look you can see the reefs at the southern end of this circle.

The green dots are the locations of oil wells, with the most significant being the Albion Scipio and Stoney Point oil fields in the lower center of the maps. These two fields were created by hydrothermal fluids moving along strike-slip and right-lateral splay faults, replacing calcium carbonate (calcite) molecules with calcium magnesium carbonate (dolomite) molecules, and creating a dolomite with significant porosity.

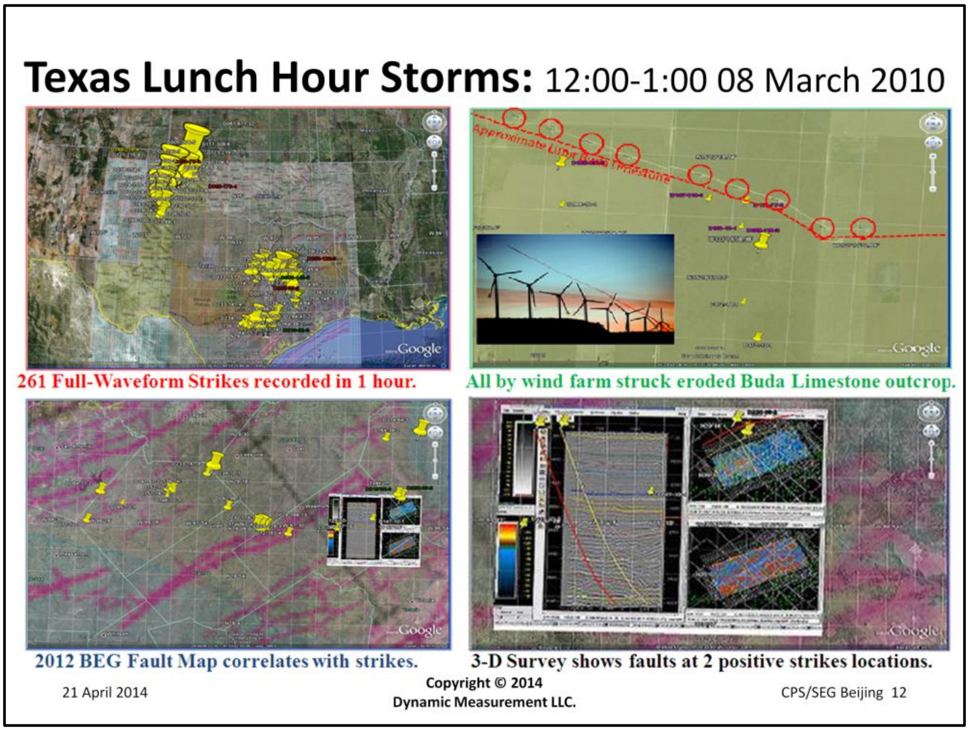
In looking at the lightning density map on the right, a series of breaks in lightning anomalies (marked in purple) showed where faults might run. A series of parallel lineaments were interpreted, showing where there might be other strike-slip faults.

When an interpreter who had worked this area for 20 years was shown this map, he said: “I know those faults are there. I never could see them on seismic. This is the first map I’ve seen which shows where these faults are located.”

In addition, note that there are no patterns in the lightning data on the right corresponding to the topography.

Detroit, a major industrial city, and Windsor, Ontario, another industrial center, are located about a third up from the bottom on the right. There are no lightning anomalies in this area, although there is a lot of iron and infrastructure on the ground. Also note that there are no changes in lightning density at the shoreline. In other projects, DML has demonstrated patterns in lightning density and attribute maps continue out to about the shelf break offshore Texas.

Lightning strike density is lower in the northern than in the southern parts of the map. This is a meteorological effect due to fewer thunderstorms.



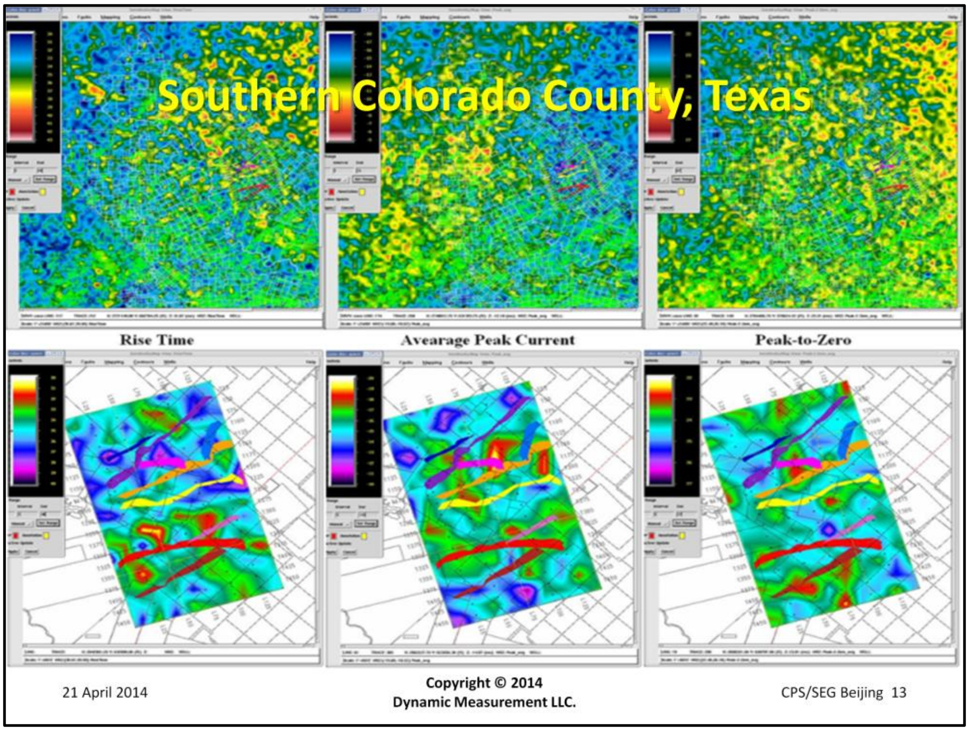
These examples show the effects of infrastructure and faults from 755 full waveform lobes from 266 lightning strikes Vaisala provided DML. The full waveform lightning strike data was provided for DML's on-going research into inverting lightning strike data. The data comes from 3 thunderstorms between 12:00 and 1:00 PM on March 8th, 2010 as shown in the upper left image.

Eight strikes in the Texas Panhandle stood out. They were near a set of nine large wind turbines on a ridge formed by Buda Limestone outcrop. The windmills are about 50 meters tall. The ~6 meter Buda outcrop overlays ~44 meters of Washitah and Fredericksburg Group shales, which grade to the valley floor.

None of the lightning strikes hit a windmill, even though these windmills are about 100 meters above the valley floor. All of the 8 lightning strikes in this area hit the downdip shales, which are more conductive than the resistive Buda Limestone. One of the lightning strikes was closer to the wind turbine than the height of its tower.

Neither topography nor infrastructure control where lightning strikes. Further south, the lightning strikes were plotted on latest map of faults from the Texas Bureau of Economic Geology. Note on the bottom left all of the 19 strikes in this area are along fault lines. A small 3-D seismic survey was available in this southern area, and the two lightning strikes just north of the survey are right where faults interpreted on the seismic data project to the surface.

Our conclusion is faults impact earth currents, and thus impact the location of lightning strikes.



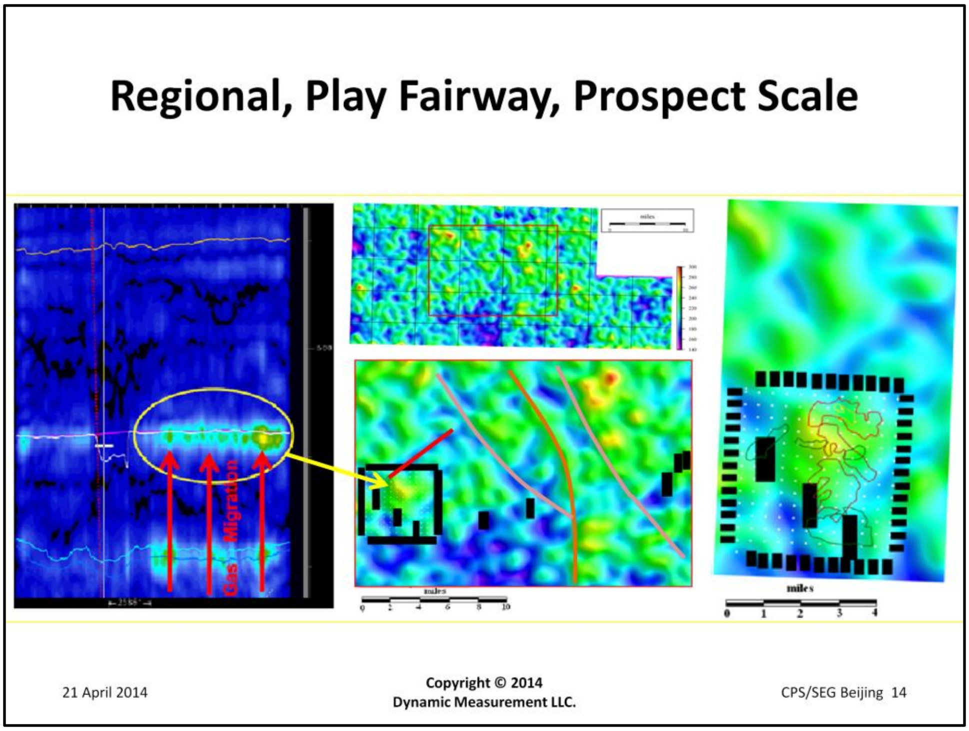
DML has found a possible minor correlation between the location of oak trees and positive lightning strikes in Colorado County, but in general vegetation appears to have little impact on lightning location. The effects of faults are much more important. The correlation between lightning strikes and oak trees could be tied to their root systems, the soils where they thrive, or the electrical properties of the trees themselves.

There are plenty of questions surrounding this topic for graduate students to analyze.

In this display there are two maps of Rise Time, two maps of Peak Current, and two maps of Peak-to-Zero time. The top maps are regional and the bottom maps have the lightning data written into a seismic interpretation horizon file.

Looking at the top three maps, notice how much difference there is between the Rise-Time, Average Peak Current, and Peak-to-Zero maps, going from left to right. On each of these maps a small 3-D seismic survey is marked, with faults interpreted from the seismic data. The bottom maps show just the seismic survey area. The same differences are apparent from the three lightning
attribute maps.

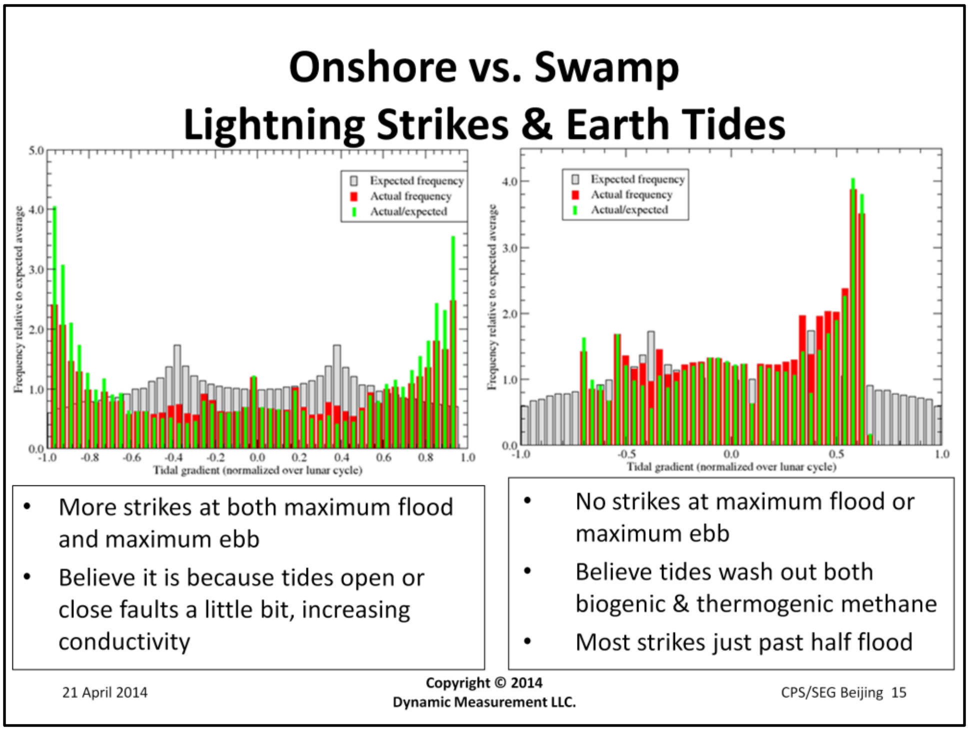
However, if you look north or south of most of the seismic interpreted faults, nyou see there are differences in the patterns which tie to the seismic fault interpretation for each of the three different lightning attributes (Nelson, et. al., 2012). DML uses this consistency in patterns to drive interpretation of lineaments during a lightning analysis project. DML hopes to automate this lineament interpretation process within the next few years.



This example shows regional, play fairway, and prospect scale maps, highlighting a relationship between possible seeps and faults. This project is in Texas, and started after Roice Nelson presented preliminary maps of a contracted 3-D seismic interpretation. One map showed amplitude extraction from the Cepstrum seismic attribute, which has been demonstrated to be related to traditional Amplitude vs. Offset direct hydrocarbon indicators. The seismic attribute cross-section on the left shows the anomaly circled in yellow.

The manager of the ranch asked what that anomaly was. When we explained it is a possible direct hydrocarbon indicator, he said, “That is where we have an anomalous number of lightning strikes on the Ranch.”

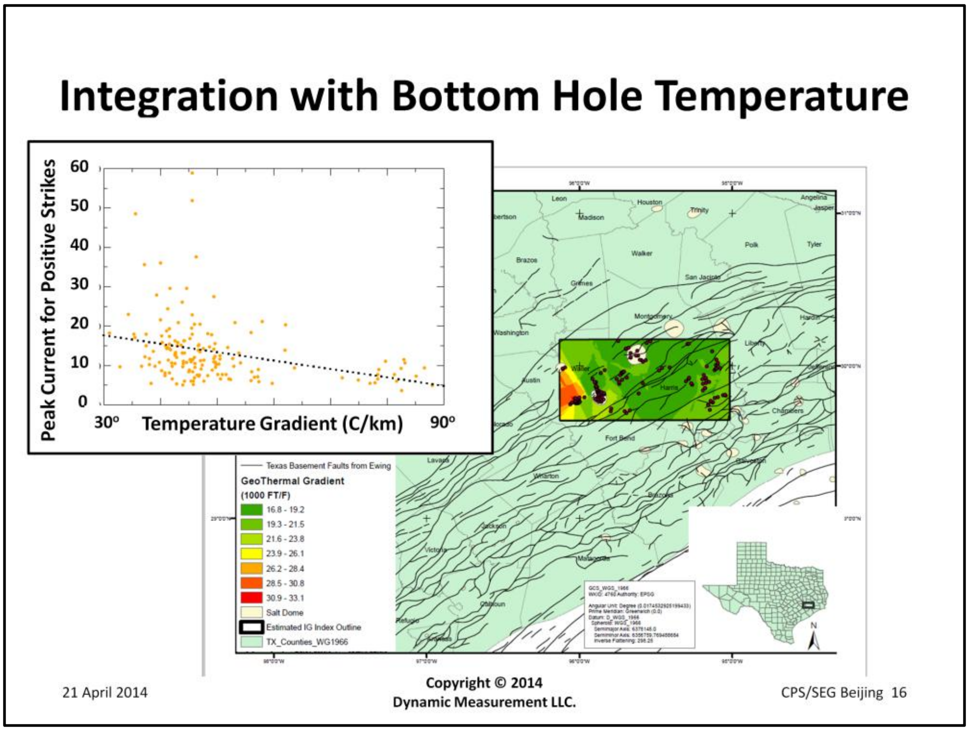
The client contracted for a lightning analysis of the area, and these maps show a redacted version of the results. The regional image in the top center shows an area almost 200 x 100 miles in size. Notice the clustering of the lightning strike densities. The play fairway map, lower center shows a zoom to a 25 x 15 mile area. Probable faults are interpreted, and the expected area
of anomalous lightning strikes on the ranch shows up as a yellow blob within the bounds of the 3-D seismic survey. Notice the interpreted red fault, which follows a low lightning density lineament. This lines up exactly with a standalone prospect identified on the seismic data, and shown with a green outline on the prospect scale map, which is a 4 x 10 mile area. The other key mapped Prospects fall on the lightning anomaly, and fit the model of seeps disrupting the electrical properties of the atmosphere and creating a path for more lightning strikes.



National Geographic published an article about lightning tied to gas seeps at the south end of Lake Maracaibo in Venezuela.

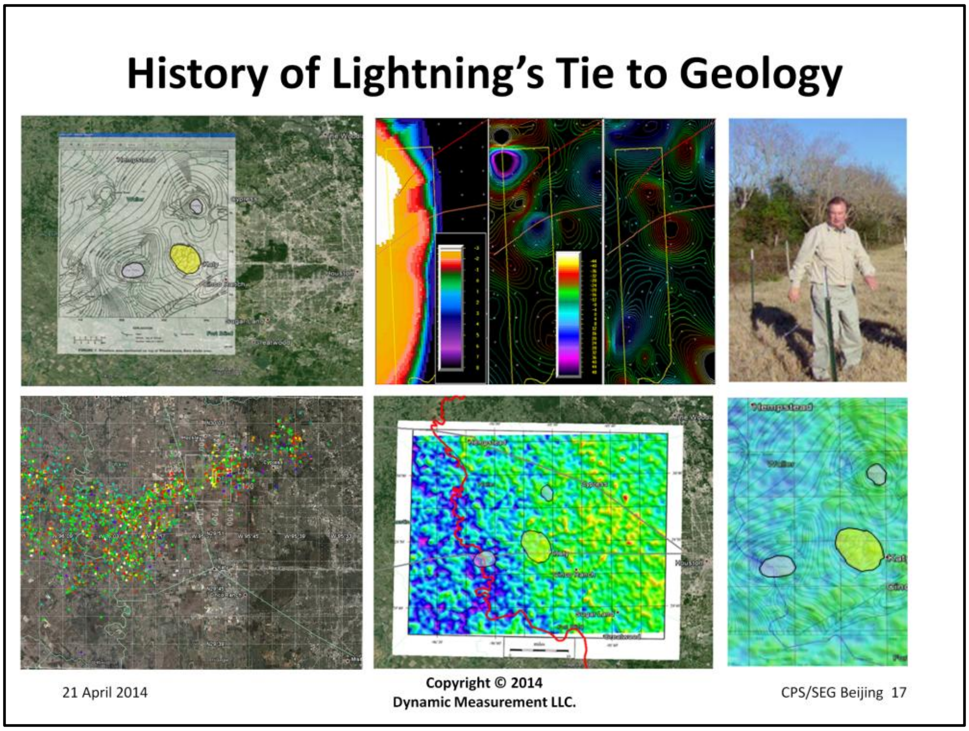
A ring of mountains around the southern end of the lake pushes up the prevailing winds off the Caribbean, making meteorological conditions leading to thunderstorms almost every day in one area. The unique colors of lightning strikes are believed to be caused by methane seeps, described as disrupting the atmospheric dielectric.

DML routinely calculates earth tides and ties each lightning strike to the earth tide. From North Dakota to Texas there are 20-50% more lightning strikes during periods of most rapid change of tide than there are when the tide is not changing. This is illustrated on the left for a project in Texas. The interpretation is tides open or close faults a little bit, and increase conductivity, or possibly increase seeps. The slide on the right shows the results for a swampy area near the Gulf Coast. There is a similar increase in the number of strikes approaching the maximum rate of flood. However, in this area there are no lightning strikes over 15 years at neither the maximum flood nor maximum ebb of the combined earth and solar tides. The earth tides are known to move water up and down in water wells in this area, and the current interpretation is biogenic gases are being washed out by the tides, leaving no escaping methane to disrupt the atmospheric dielectric.



Even though DML has studied the relationship between lightning and geology for several years, there are many earth characteristics to consider. Recently the Texas Bureau of Economic Geology provided bottom hole temperature data for an area being evaluated. Cross-plots of the Peak Current of positive lightning strikes against temperature gradient, as shown above show strong negative correlation. Several other lightning attributes show a similar correlation.

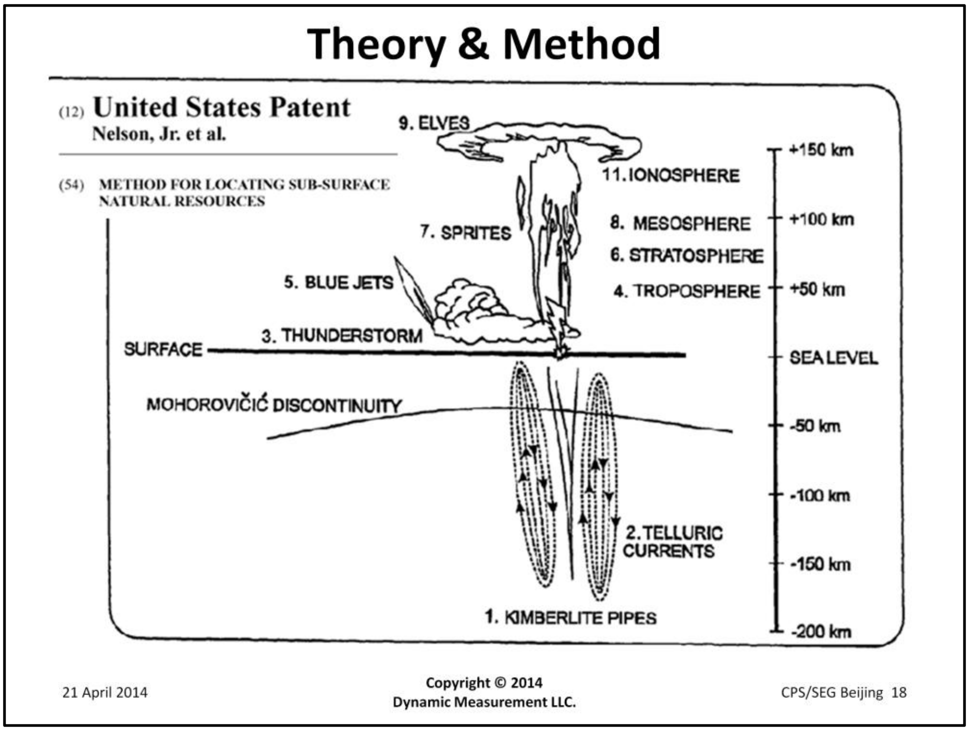
DML plans to report new results of this work at the Annual SEG Convention in Denver



The idea that lightning describes the subsurface evolved from several conversations which occurred about the same time.

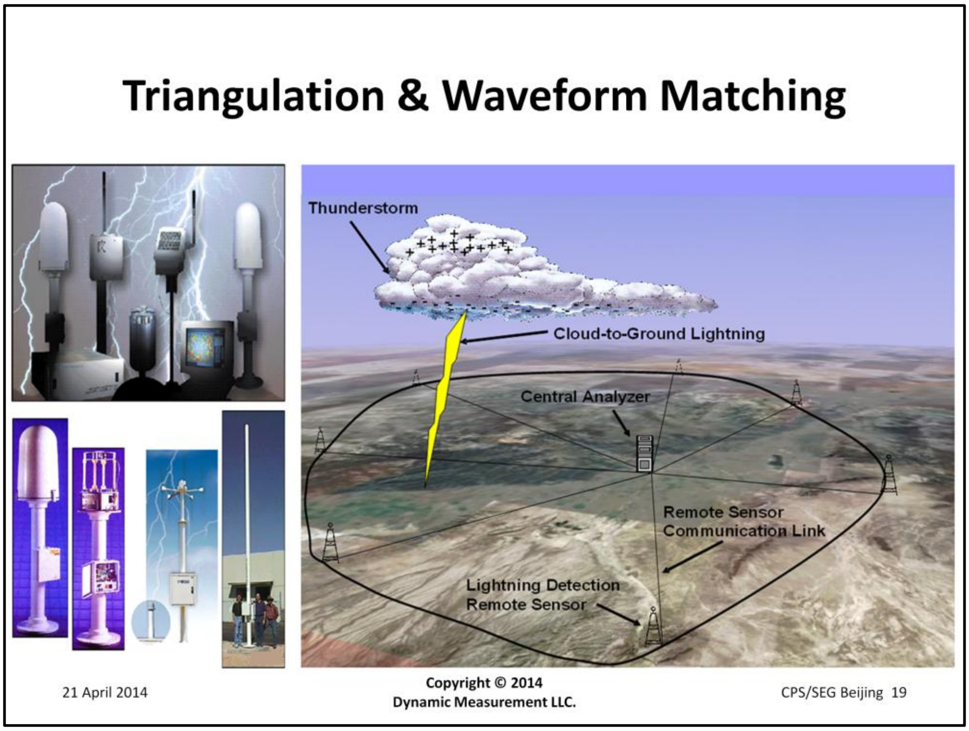
Joseph Roberts (upper right photo) was hunting ducks on the Hockley Dome in northwest Harris County, Texas (upper right dome in upper left map, zoomed into on the upper center map). He was aware of the location of the edge of the Hockley Dome caprock. He saw a large cloud form and it seemed to wrap around the edge of the dome with a large lightning strike hitting the edge of the dome. The next year he saw a similar event, and inquired about it.

Several years later, on the 27th of September 2011, he observed the phenomenon a third time, and we confirmed these strikes with data from the NLDN database (lower left map shows lightning strikes from this one storm). Lightning strike density around the dome, overlayed on a legacy map of the Wilcox formation, shows patterns following the contours around the dome (lower center map). On a larger scale, Peak Current across this area shows a significant difference between lightning strikes on either side of the Brazos River (lower center map). One explanation is that Brazos River runs along a Cretaceous transform fault. This fault was mapped by Roice Nelson on regional seismic interpretation done offshore, and could explain why the Brazos River is straighter than the other Texas Gulf Coast rivers.



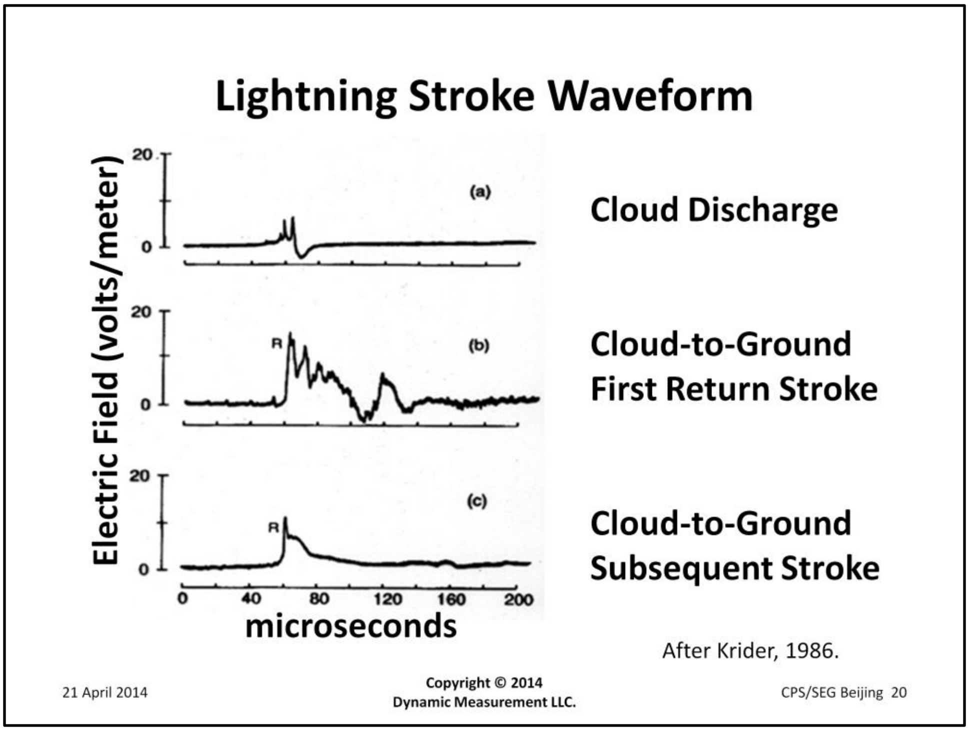
Lightning is a meteorological phenomenon (Rakov, 2003). But lightning strike location and lightning strike attributes appear to be controlled by geology.

Figure 1 summarizes our working theory: telluric currents, which are modified by faults, mineralization, and fluids, control lightning strike locations, shown with an example of Kimberlite pipes (Nelson, et. al., 2011). Similar modifications of telluric currents occur at faults, or where there are fluids or anisotropy. This fits the observation by meteorologists that Cloud to Cloud lightning can travel 80 to 200 km before becoming a Cloud to Ground strike (Murphy, 2011 personal communication).



Lightning data collection and processing procedures are described in meteorological literature (Murphy, et. al., 2008, and Baba, 2008).

This slide shows Vaisala's lightning detection sensors. The cartoon on the right shows how data from sensors are brought into a central analyzer. Lightning strike locations are determined from direction, time differences, and amplitude differences, measured by at least three sensors. Peak current, rise time, and Peak to Zero time are determined from the measured pulse shape. Each strike is given several quality values, and stored in the database.

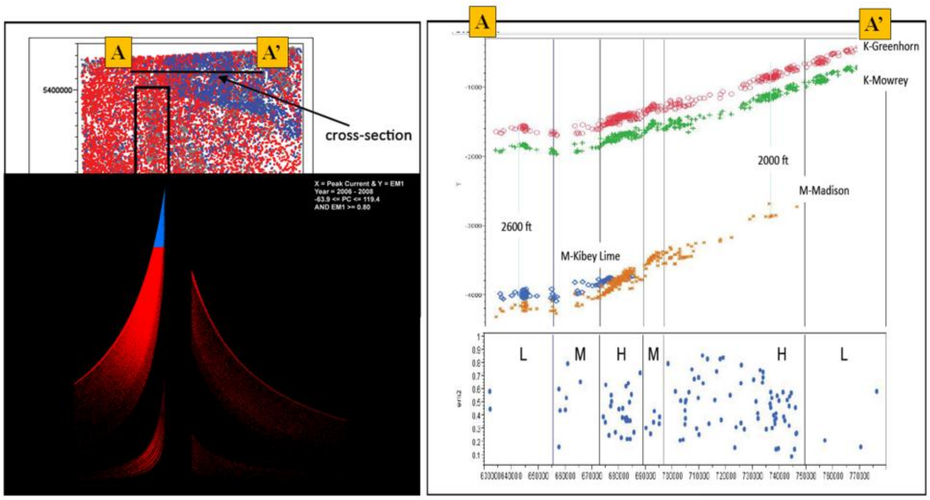


This slide shows typical lightning waveform:

(a) cloud discharge;
(b) cloud-to-ground first return stroke;
(c) cloud-to-ground subsequent stroke (Krider, 1986).

Again, key attributes of the waveform are the rise time (RT in microseconds), Peak Current (PC in kiloampres), and Peak-to-Zero (P2Z in microseconds). Because of the large volume of data the full waveform is typically not recorded except for scientific studies. DML anticipates there is significant useful information in full waveform data, and will be studying this data for the foreseeable future.

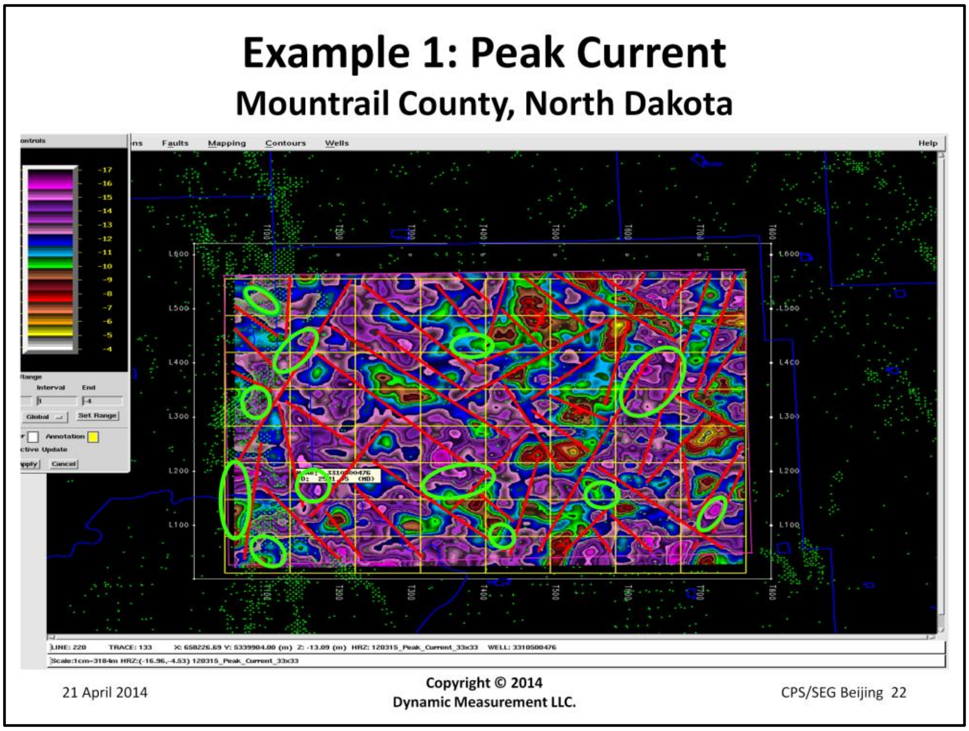
Lightning Strike Polarity



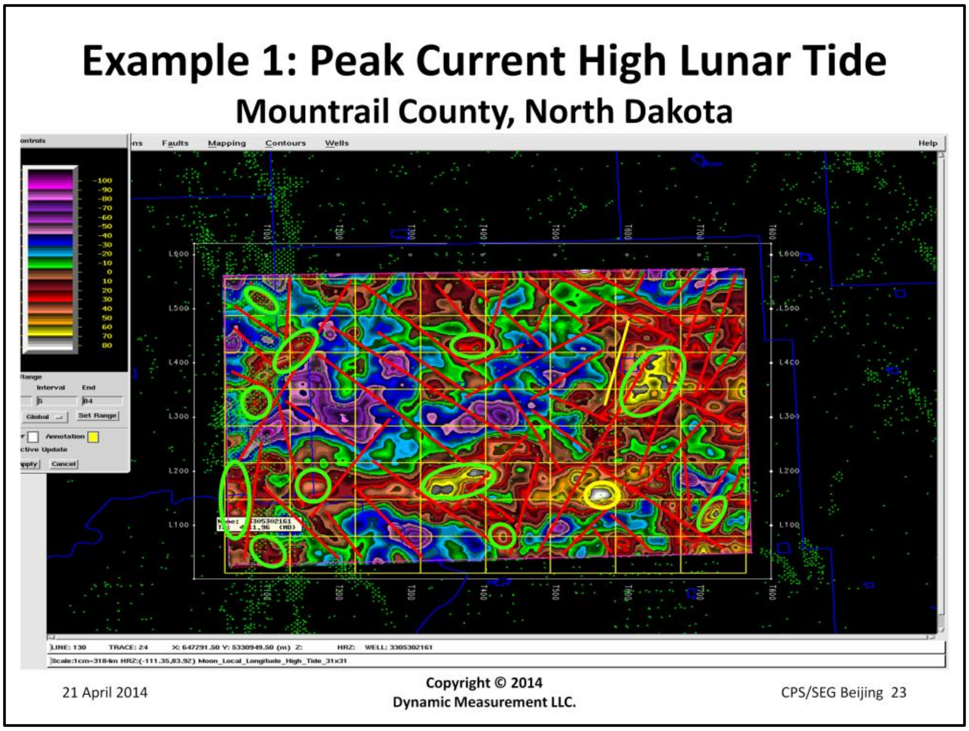
21 April 2014

CPS/SEG Beijing 21

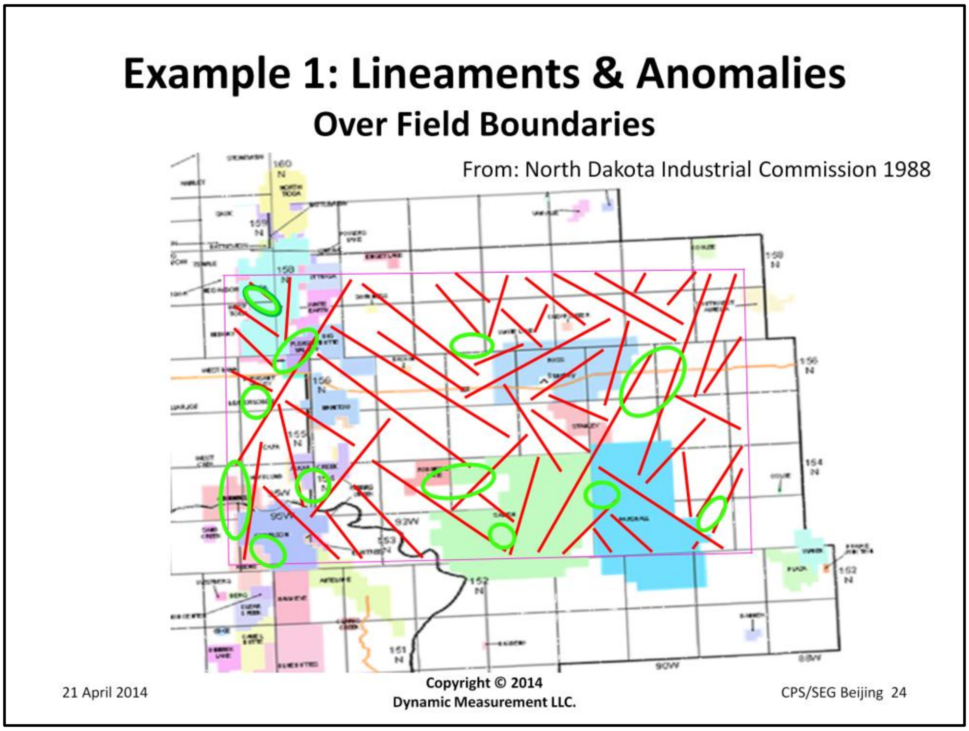
There is a significant difference between positive lightning strikes and negative lightning strikes. This example from North Dakota (at the northern edge of the Williston Basin) summarizes one difference with a plot of peak current in the horizontal axis vs. the EM1 attribute derived from Rise-Time, Peak Current, and Peak-to-Zero time. The highest EM1 values are shown in blue on the map and on the cross-plot. The cross-section A-A’ to the right shows how these higher amplitudes occur after the Kibey Lime pinches out against the Madison. These high values of the EM1 lightning attribute at the bottom of this cross-section within fault blocks determined by mapping dip changes on each of the 4 sets of tops, as mapped at the top of this cross-section. The vertical axis of this plot is the derived attribute EM2.



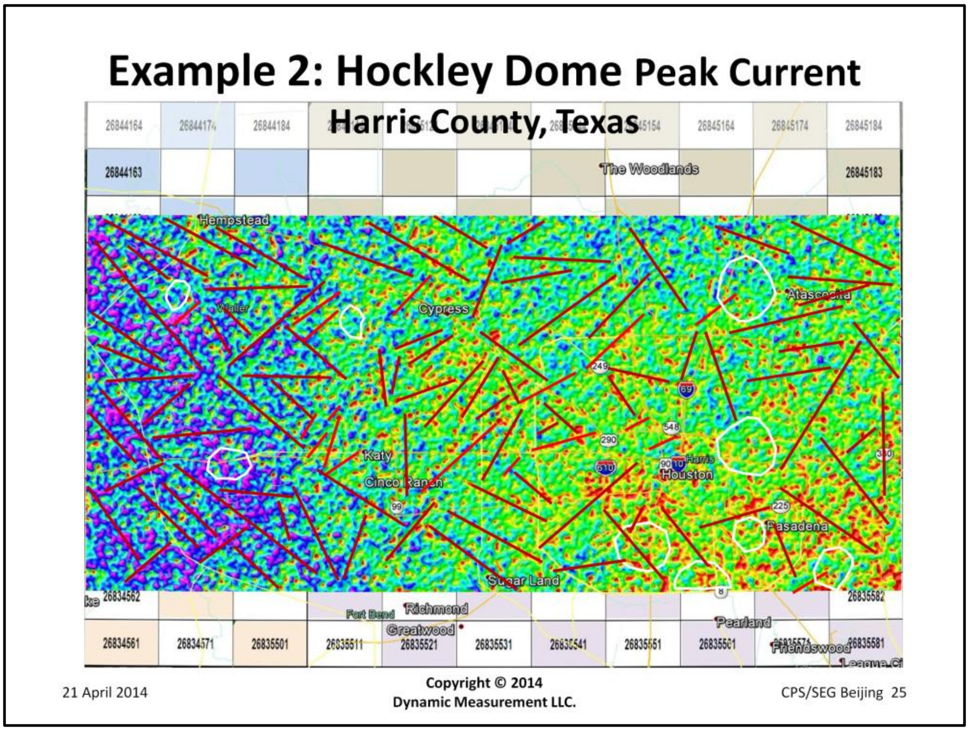
Example 1 of a lightning analysis project results shows spatial variation of lightning peak current in Mountrail County, North Dakota. Lightning data were retrieved from the NLDN database and mapped using Landmark Graphics' Seis-Work software package. The map is of Peak Current of lightning strikes from 2008 through 2010 within this area. Similar spatial variations occur for the strike density over various time intervals, the Rise Time, positive Peak Current, negative Peak Current, absolute Peak Current, Peak to Zero, and other derived attributes. The overlaid interpretation consists of lineaments drawn between lightning clusters, and anomalies noted on other lightning attribute maps.



The specific anomalies noted in green are where there is the largest density of lightning strikes at high lunar tide. One of the surprises of DML's initial studies was the impact of lunar tides on lightning strike density. In western North Dakota there are 25% more lightning strikes during high lunar tide than during low lunar tides. This variation is possibly related to hydrocarbon seepage (hydrocarbons are resistive in reservoirs and highly electrostatically charged as a gas), or probably due to brines in the fault plane as the tides open up the faults. Following the first time this map was shown in public, without an interpretation, a member of the audience came up and said he had just interpreted a 3-D seismic survey in this area, and it appeared the lightning analysis was showing a major fault he could not see on the seismic, and which he had mapped with tops. This fault appears to be the yellow fault shown above. When shown this, he said, "Yes, but did you notice how the most prolific part of the Parshall4 Field is where the highest density of lightning strikes occur" (also colored yellow above).

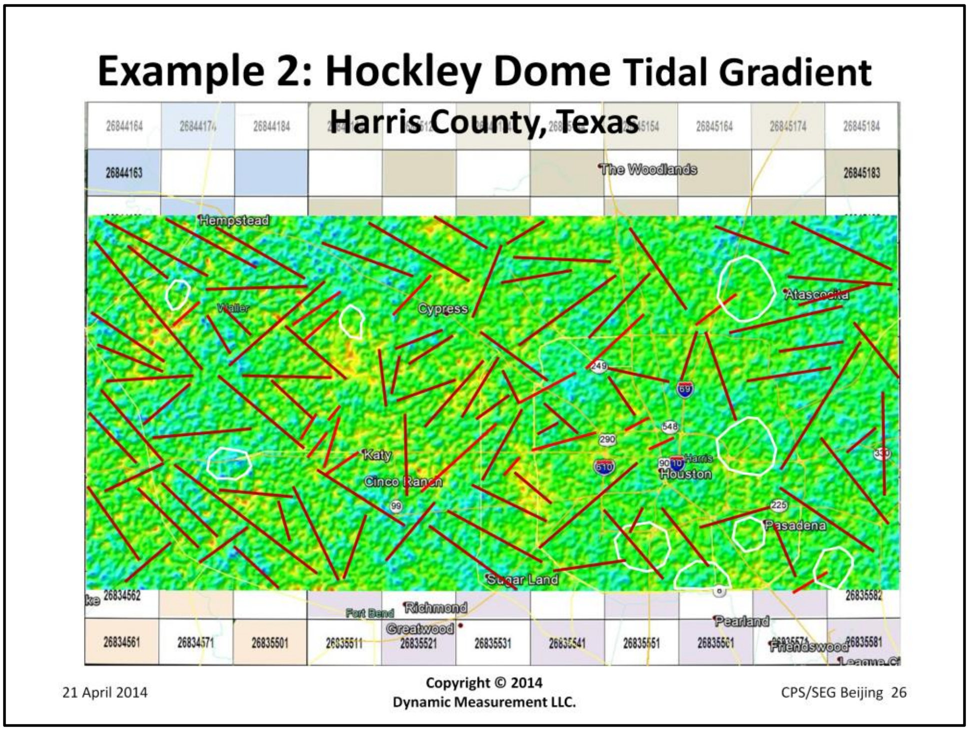


This slide shows the lineaments and anomaly interpretation from lightning data overlaid on oil and gas field boundaries from the North Dakota Industrial Commission.

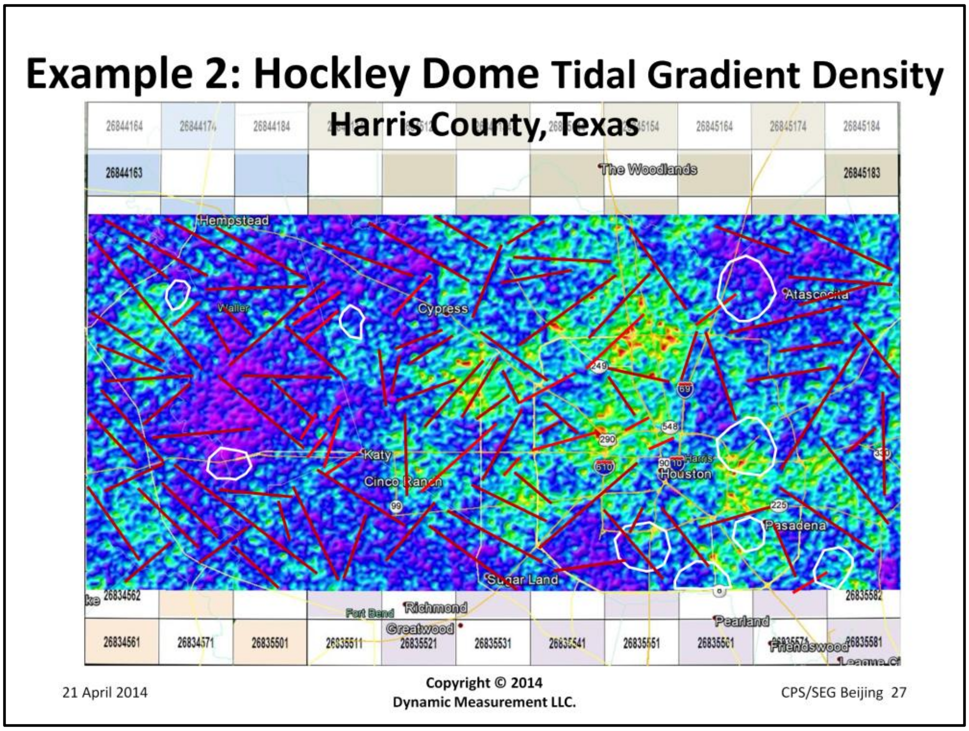


Example 2 is from the Hockley Dome, project in South Texas. These examples cover a larger area than earlier examples, and do not show the relative consistency of lightning strike density maps from 2000 through 2011.

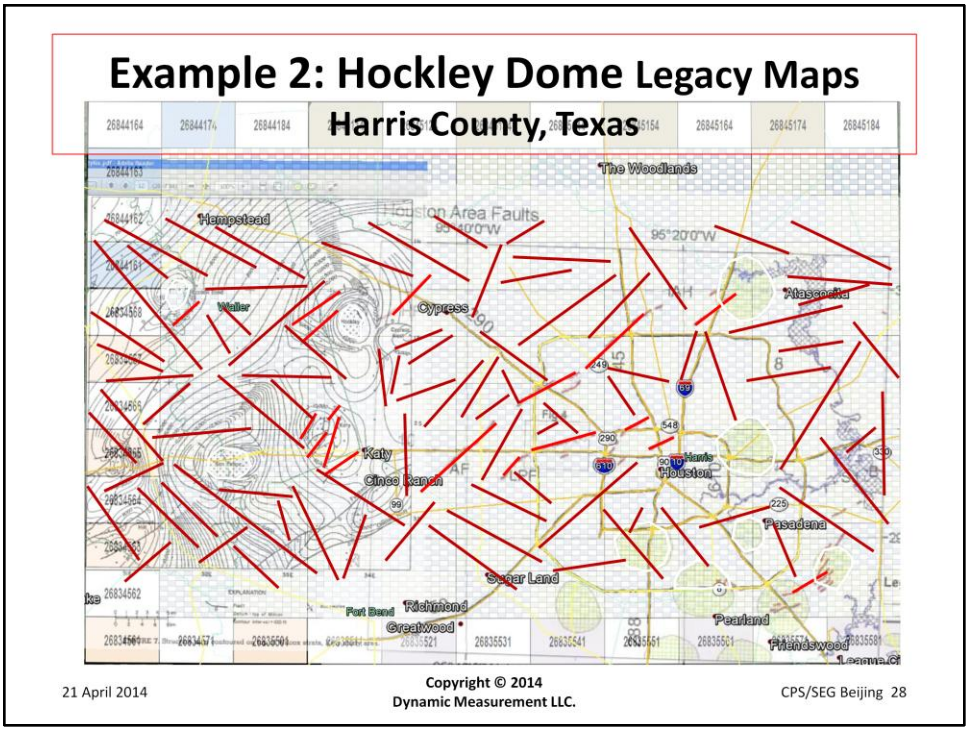
However, this area includes 8½ salt domes, the large Peak Current boundary along the Brazos River, and numerous lightning derived lineaments are tied to known and mapped faults in this area. It extends over most of the Houston metropolitan area. Again, the data were retrieved from the NLDN database, cleaned, normalized, and contoured. These maps show the absolute value of the Peak Current for each year after normalizing against the strongest strikes for each year. The white contour overlays highlight salt domes; light red lines are published faults; and the dark red lines are lineaments mapped from the lightning attribute maps.



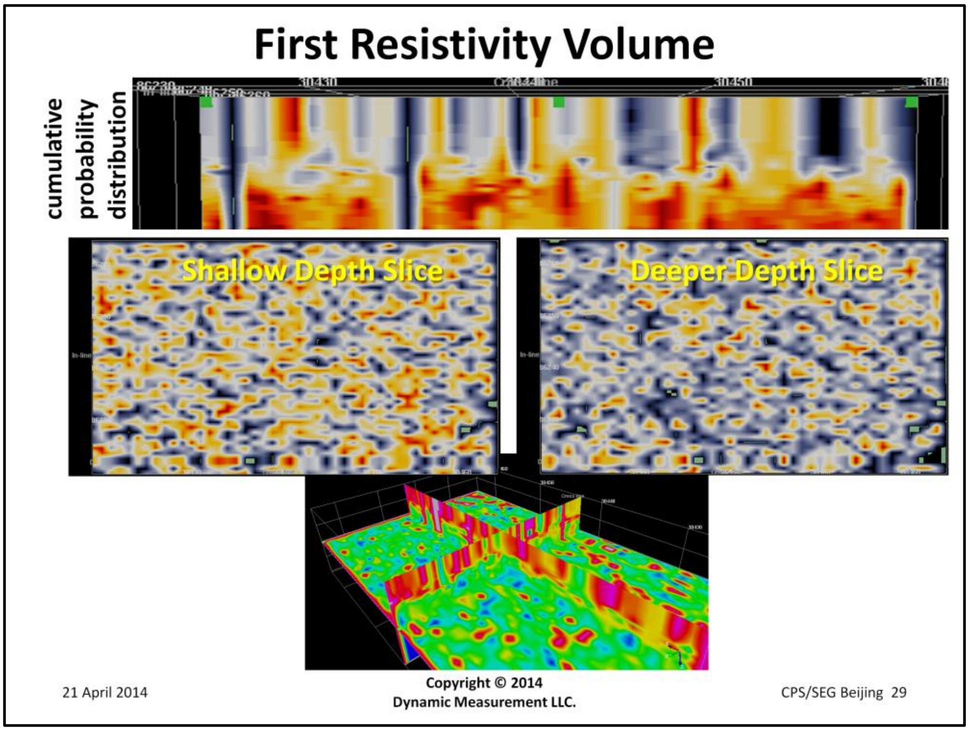
This slide shows the lineaments and salt dome locations overlaid on a map of the tidal gradient when lightning strikes occurred, averaged over cells with an area of approximately 12,000 square meters.



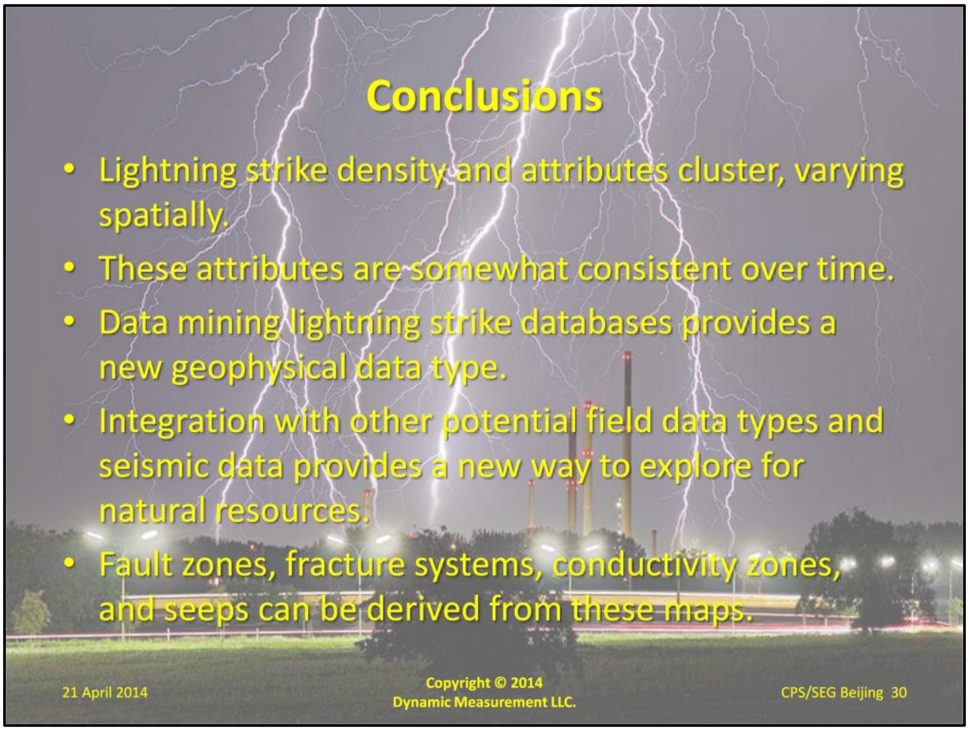
This slide shows the lineaments and salt dome locations overlaid on a map of the density of lightning strikes during times when tidal gradient was between 75% and 100% of maximum.



This slide shows lineaments and salt dome outlines overlaid on legacy maps of the Wilcox on the west and of salt domes and known faults on the east side of the survey area. Deliverables for typical lightning analysis projects include derivative lightning data, many lightning attribute maps, an interpretation of lineaments correlated across the many lightning attribute maps, and lineament and anomaly interpretation overlays on legacy and/or base maps. Where applicable, an analysis of any correlation between lightning and a spatial or temporal data type publicly available or supplied by the client can also be included.



DML has recently determined how to calculate surface resistivity from lightning attributes in the NLDN database. Surface resistivity is not as definitive as borehole resistivity because stratigraphic geology is thin and covers a large area, which easily shows up with 2 foot sample spacing from borehole resistivity readings. However, given assumptions which DML anticipates will be described in more detail at the SEG Convention in Denver later this year, resistivity volumes can also be calculated. This slide shows the first two calculated resistivity volumes. Note the shallow slice has higher resistivity (more red) than the deeper depth slice. The vertical axis of these first displays is an uncorrected function, and so does not tie to the two depth slices. As our software and techniques are improved, we anticipate the depth slices will be able to take advantage of the large lateral areas tied to stratigraphic geology to map the extent of aquifers, hydrocarbon deposits, as well as mineralization. While lightning data is not “a silver bullet,” when this work is integrated with other geologic and geophysical data and interpretation processes, it will provide a new way to look at and evaluate subsurface geology.



Conclusions:

• Lightning strike density and lightning attributes cluster, varying spatially.

• These variations are somewhat consistent over time. Removing purely meteorological variations is not a perfected technique

• Data mining lightning strike databases provides a new geophysical data type.

• Integration, with other potential field data types and with seismic data provides a new way to explore for natural resources.

• Fault zones and fracture systems in particular, but also conductivity zones, and possibly seeps can be interpreted from these maps.

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21 April 2014

CPS/SEG Beijing 32

References from Expanded Abstract

Lightning database analysis is a new business enterprise.

Thank you for your attention.