A GIS-Based Approach to Lightning Studies for West Texas and New Mexico

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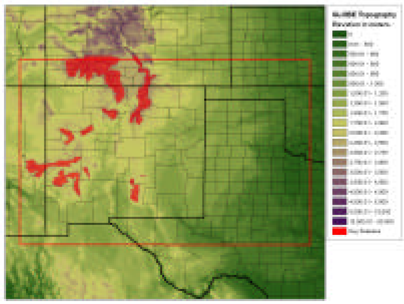
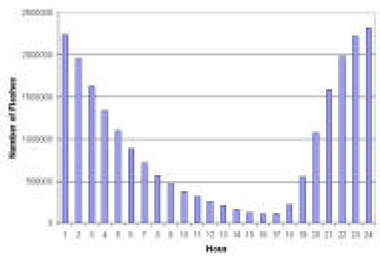
Introduction



NGDC GLOBE Topographic data for the study domain, with topographic features over 2,500 m in elevation highlighted in red.

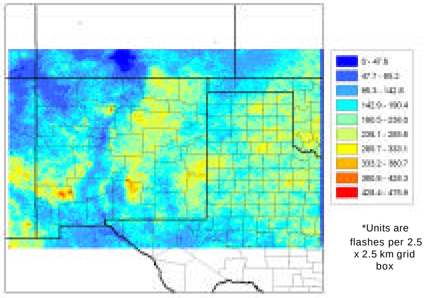
Precipitation forecasting in the presence of synoptic-scale systems generally is reliable, especially when conducted by experienced forecasters using good guidance. However, in the absence of these large-scale systems, forecasting for spottier precipitation patterns produced by the interaction of large-scale flow and small scale topography becomes more difficult.

The domain of this study (pictured at left) consists of two components: New Mexico and West Texas. New Mexico is denoted as the West Region, and West Texas as the East Region. The topography varies significantly between the two regions; New Mexico is more mountainous, with several features over 2500 m in elevation, while West Texas is relatively flat, with caprock and canyons comprising a majority of the variation. For each of these regions, the warm season months of May through September represent a time with a relative lull in synoptic scale activity, with the exception of the Southwest Monsoon (especially for New Mexico), and dryline activity across the eastern plains of New Mexico and across West Texas.



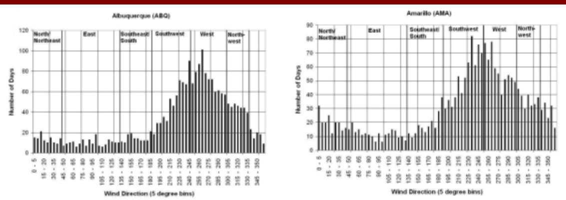
Hourly flash counts for all days and hours during the 1989-2004 warm seasons. Hour is UTC.

Lightning activity within the entire domain shows a consistent increase beginning at ~1800 UTC (pictured at left). These lightning data were obtained from the National Lightning Detection Network, operated by Vaisala Global Atmospherics Inc. Data comprise the warm seasons (May-September) of 1989 through 2004. The spatial distribution of these strikes is shown at right. Values plotted are total flash counts per 2.5 x 2.5 km grid box for all hours and days. New Mexico experiences the greatest number of flashes (over 450 flashes per grid box) as well as the greatest variation in the number of flashes, while the flashes over West Texas are more uniform, but smaller in number than those in New Mexico.



Flash counts per 2.5 x 2.5 km grid box for all days and hours during the 1989-2004 warm seasons.

Regimes



700 – 500 hPa Daily Mean Vector Wind Direction Distribution for AME (right) and ABQ (left)

To assess the effect of topographic interaction with the large scale flow, we next relate lightning activity to the prevailing synoptic wind direction and speed. The 500– 700 hPa vector mean wind was calculated each day during the period based on a 1200 UTC sounding from a site c onsidered representative of the synoptic flow over each region. Albuquerque (ABQ) was chosen for New Mexico, and Amarillo (AMA) for West Texas. Both sites are in the center of their respective regions. Thisvector mean wind then was used to classify each day into one of seven subjectively chosen regimes: North/Northeasterly (340° – 45°), Easterly (45° – 135°), Southeasterly/Southerly (135° – 190°), Southwesterly (190° – 250°), Westerly (250° – 300°), Northwesterly (300° – 340°), and Calm (mean wind speed < 5 knots). The histograms above r epresent the distribution of daily wind direction for AMA (right) and ABQ (left). These histograms first were used to choose the regimes that are indicated on the histograms. The pie charts below depic t the distribution of days within each regime. Both regions exhibit a large number of days with a vector mean wind with southerly and/or westerly components; West Texas has a greater number of days with southwesterly flow, while New Mexico has more days with westerly winds.

Distribution of days within each regime for New Mexico (West Region) and West Texas (East Region)

Regional Lightning Activity

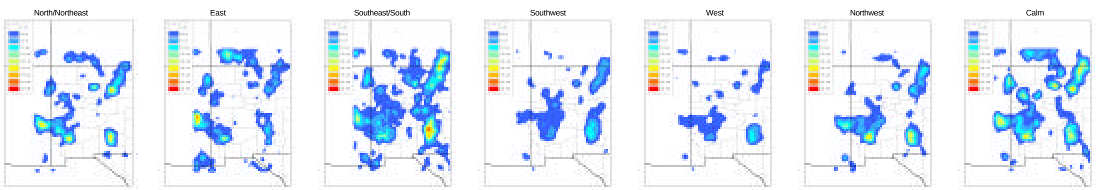
Wind direction has a major influence on lightning activity and its spatial distribution. The total flash characteristics for each flow regime of each region are displayed at right; the top table is West Texas, while the bottom summarizes New Mexico. The density per square degree of the first 10% of flashes each day after 1800 UTC is shown below for each flow regime in New Mexico. Corresponding figures for West Texas (not shown) indicate that West Texas exhibits considerable flash variability among regimes, as well as strong variation in placement depending on the vector mean wind direction. This could be due to interaction with direction-specific features such as canyons, and on differing synoptic-scale parameters such as moisture and stability. In addition, dryline activity can be influencing the spatial distribution. New Mexico exhibited a strong relation between flash activity and topography, with features over 2500 m consistently producing maxima whose placement and strength varied depending on flow direction.

West Texas

Regime	No. flashes	No. flow days	No. lightning days	Percent lightning days	Mean flashes per lightning day	Mean flashes per regime day	Median flashes per lightning day
North/Northeast	714 056	258	196	76	3 643	2 768	1 108
East	371 854	179	149	83	2 496	2 077	682
Southeast/South	468 292	162	140	86	3 345	2 891	1 255
Southwest	2 814 114	629	567	90	4 963	4 474	2 348
West	2 845 534	536	454	85	6 268	5 309	3 496
Northwest	1 181 205	262	216	82	5 469	4 508	2 394
Calm	510 549	191	164	86	3 113	2 673	1 466

New Mexico

Regime	No. flashes	No. flow days	No. Lightning days	Percent lightning days	Mean flashes per lightning day	Mean flashes per regime day	Median flashes per lightning day
North/Northeast	965 200	154	131	85	7 368	6 268	5 685
East	900 613	138	125	91	7 205	6 526	4 869
Southeast/South	1 203 110	124	113	91	10 647	9 703	9 160
Southwest	3 555 911	603	553	92	6 430	5 897	4 050
West	3 129 316	673	591	88	5 295	4 650	2 086
Northwest	1 902 825	314	272	87	6 996	6 060	3 394
Calm	1 755 952	223	199	89	8 824	7 874	7 943



Initiating Flash Densities (first 10% of daily flashes after 1800 UTC) for each regime in New Mexico. Units are flashes per square degree per day

Current and Future Work

The results to date clearly indicate that topography exerts a s trong influence on the flash density and the location of thunderstorm initiation in the study domain. This makes it a useful to ol in forecasting lightning and precipitation patterns. Current work focuses on u sing the ArcGIS software (ESRI) to forecast areas of thunderstor m genesis based on overlays of topographic forcing and environmental parameters such as moisture and stability. Later, this product will be adapted so that forecast maps can be generated quickly, based on either observational or gridded forecast data. These maps can be used in an operational setting to improve overall forecast quality.

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