2021

United States Lightning Report

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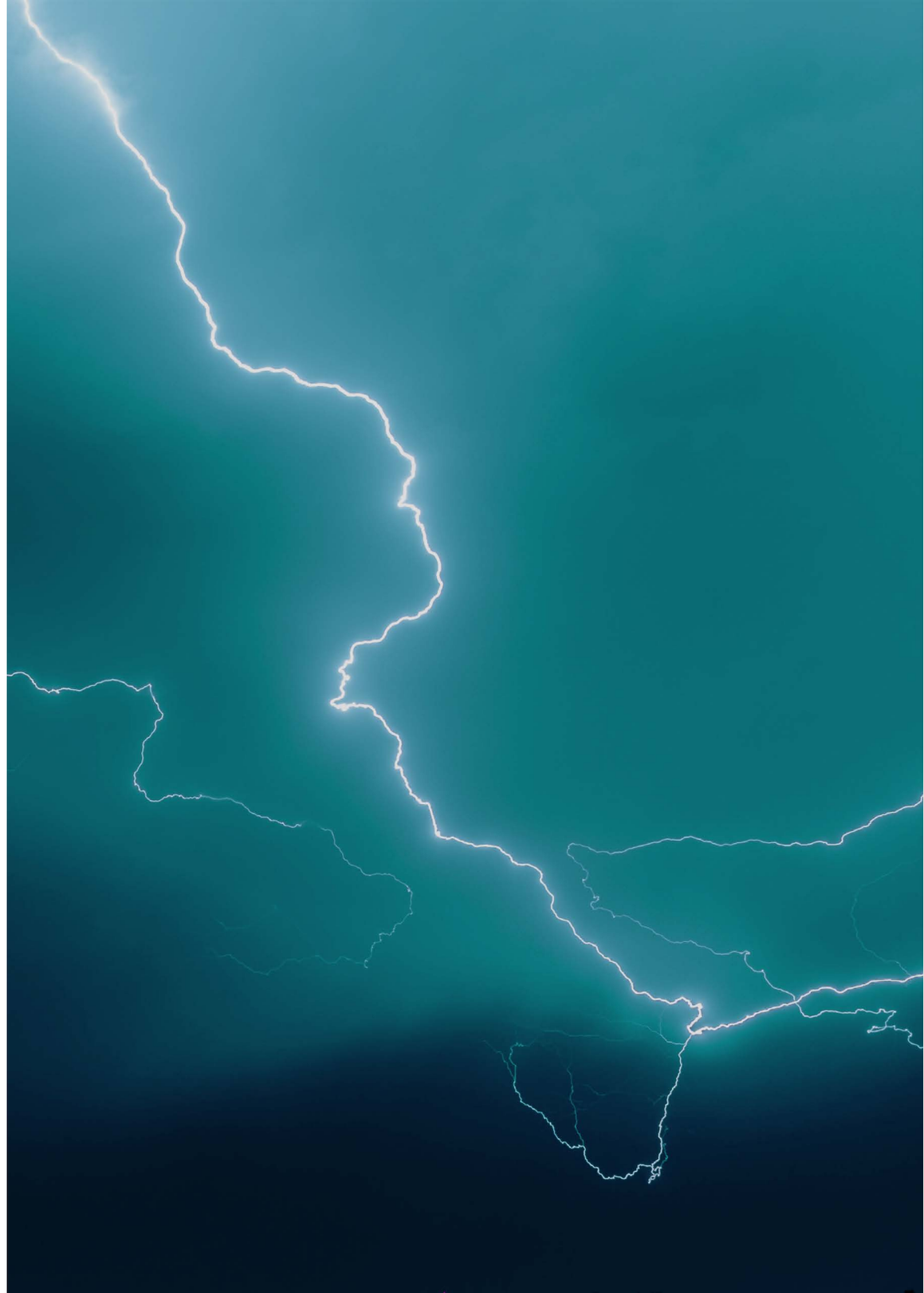


About this report

The 2021 Lightning Report was prepared by Earth Networks, an AEM brand, using the Earth Networks Total Lightning Network® (ENTLN).

The following report includes in-cloud, cloud-to-ground, and total lightning data from the continental United States and the surrounding water bodies throughout 2021. Counts, densities, currents, rankings, Dangerous Thunderstorm Alerts (DTAs), and Thunder Days in this report are from January 1, 2021 to December 31, 2021.

The Earth Networks Total Lightning Network (ENTLN)

The lightning data in this report is derived from the Earth Networks Total Lightning Network (ENTLN), which monitors the combination of in-cloud and cloud-to-ground lightning strikes over 100 countries. With over 1,800 sensors, the ENTLN is the most extensive and technologically advanced total lightning network in the world. ENTLN has been specifically deployed to detect real-time lightning and provide advanced warning for severe weather events that could threaten public safety and operational efficiency.

In this report

Report terminology

To help you better understand the insights from this lightning report, we've included definitions of our frequently used terminology.

Lightning Pulse:

This report measures lightning pulses. A pulse is a surge of electric current in lightning usually accompanied by a burst of light. Pulses are classified as in-cloud (IC) or cloud-to-ground (CG).

Lightning Flash:

A lightning flash is a collection of pulses close in space and time that approximates the continuous ionized channels of a complete bolt of lightning.

Cloud-to-Ground Lightning (CG):

Lightning that happens between opposite charges in a cloud and on the ground.

In-Cloud Lightning (IC):

Lightning that occurs between opposite charges within a thunderstorm cloud.

Total Lightning:

The combination of all in-cloud and cloud-to-ground lightning activity.

Pulse Density:

The number of lightning pulses per square mile per year.

Dangerous Thunderstorm Alerts (DTAs):

Earth Networks patented advanced severe weather warnings that notify users of incoming storms up to 45 minutes before storm arrival.

Thunder Days:

Any given day where lightning was detected within range of a certain location.

Total lightning

is the combination of cloud-to-ground (CG) and in-cloud (IC) lightning strikes

In-Cloud lightning:

Lightning that occurs between opposite charges within a thunderstorm cloud

+

Cloud-to-Ground lightning:

Lightning that happens between opposite charges in a cloud and on the ground

446,726,668

Total lightning pulses | 100%

411,322,119

In-Cloud

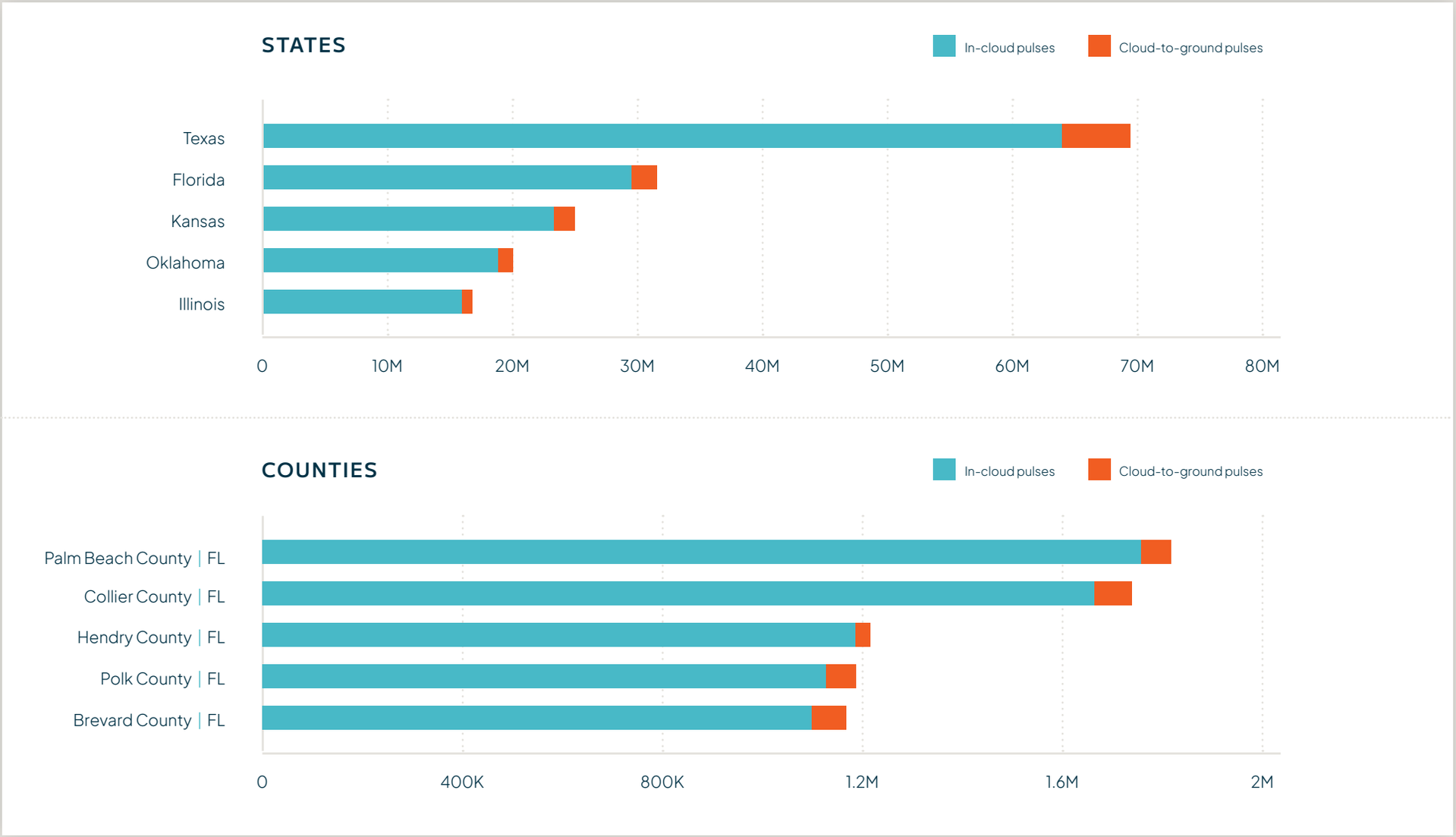
92%

35,505,549

Cloud-to-Ground

8%

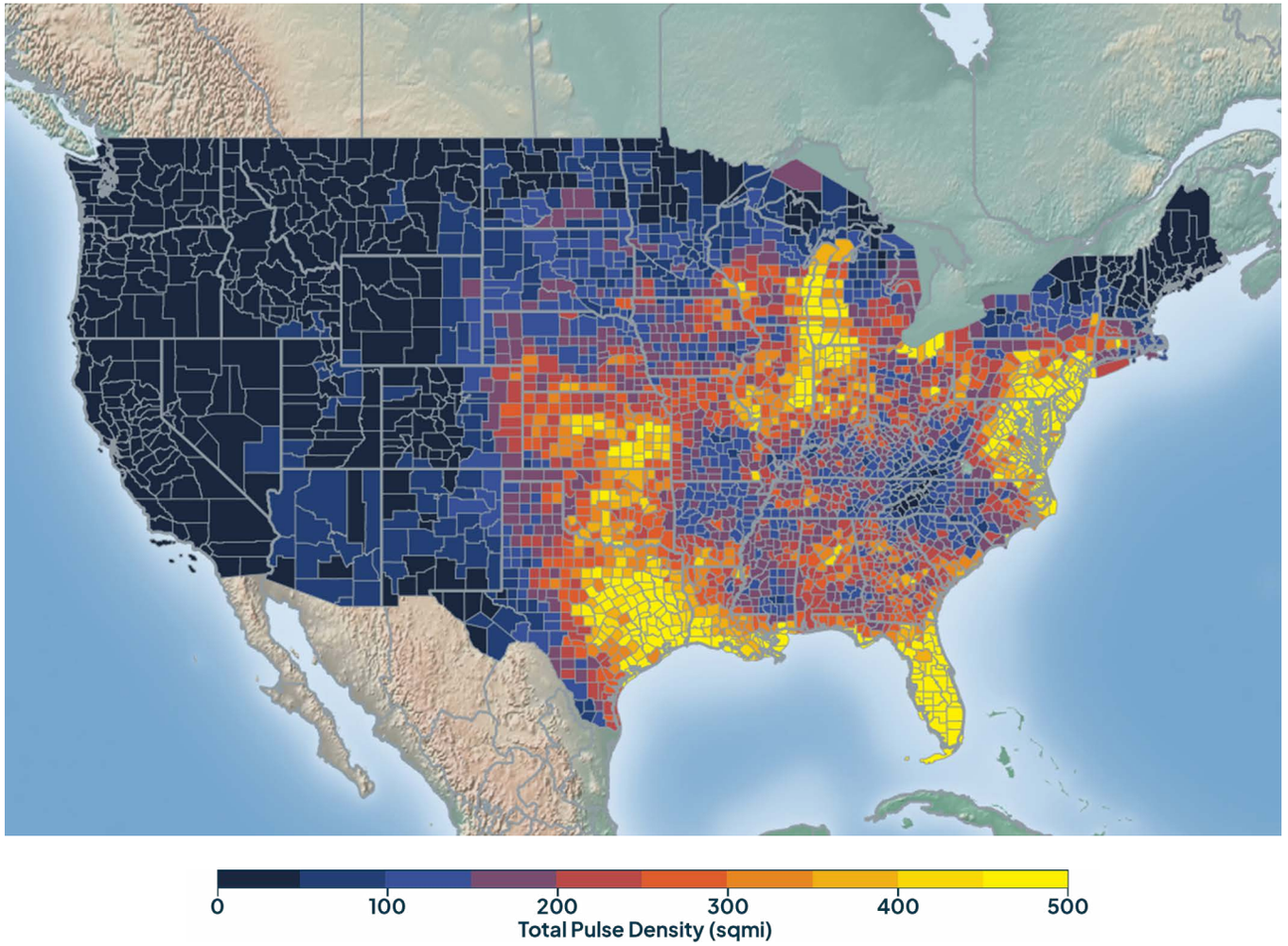
Lightning count rankings



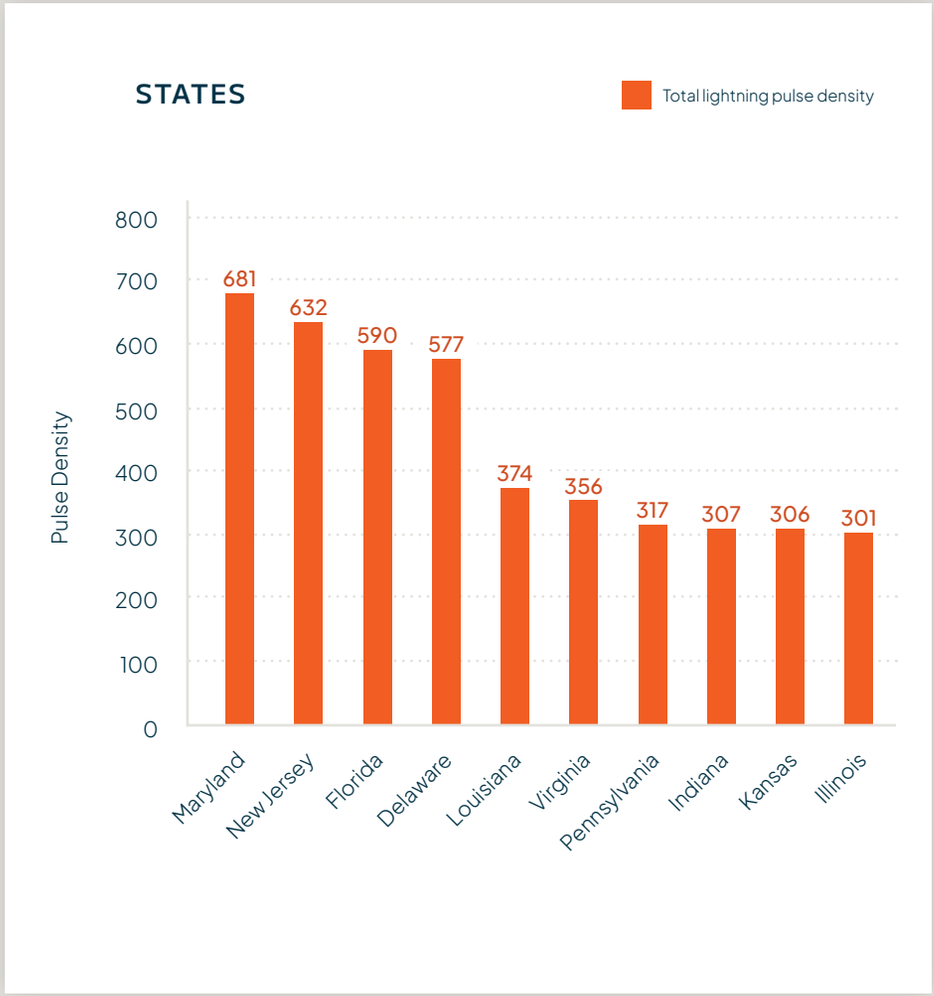
While the top 5 states remained the same from 2020, Florida reclaimed its status as the lightning king at the county level in 2021. Five counties in Florida had the highest lightning counts during 2021, including Palm Beach County, Collier County, Hendry County, Polk County, and Brevard County.

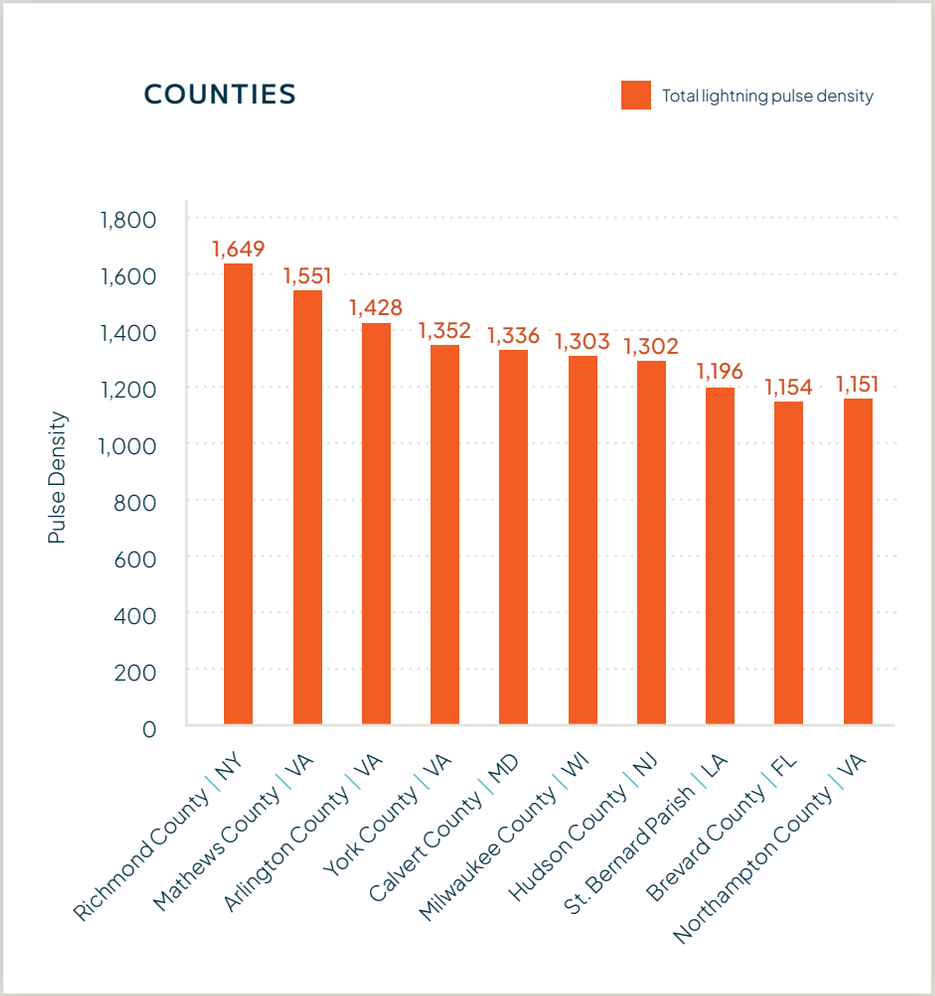
Total (CG+IC) pulse density map

Pulse density is a better indicator of lightning activity than total lightning counts because it enables us to compare different sized areas (like states and counties) fairly. With every pulse we detect, we receive a more precise measure of lightning activity. At right, areas in bright yellow experienced the highest lightning pulse density per square mile in 2021, clustered primarily in the Midwest and Eastern United States.



Total lightning pulse density rankings



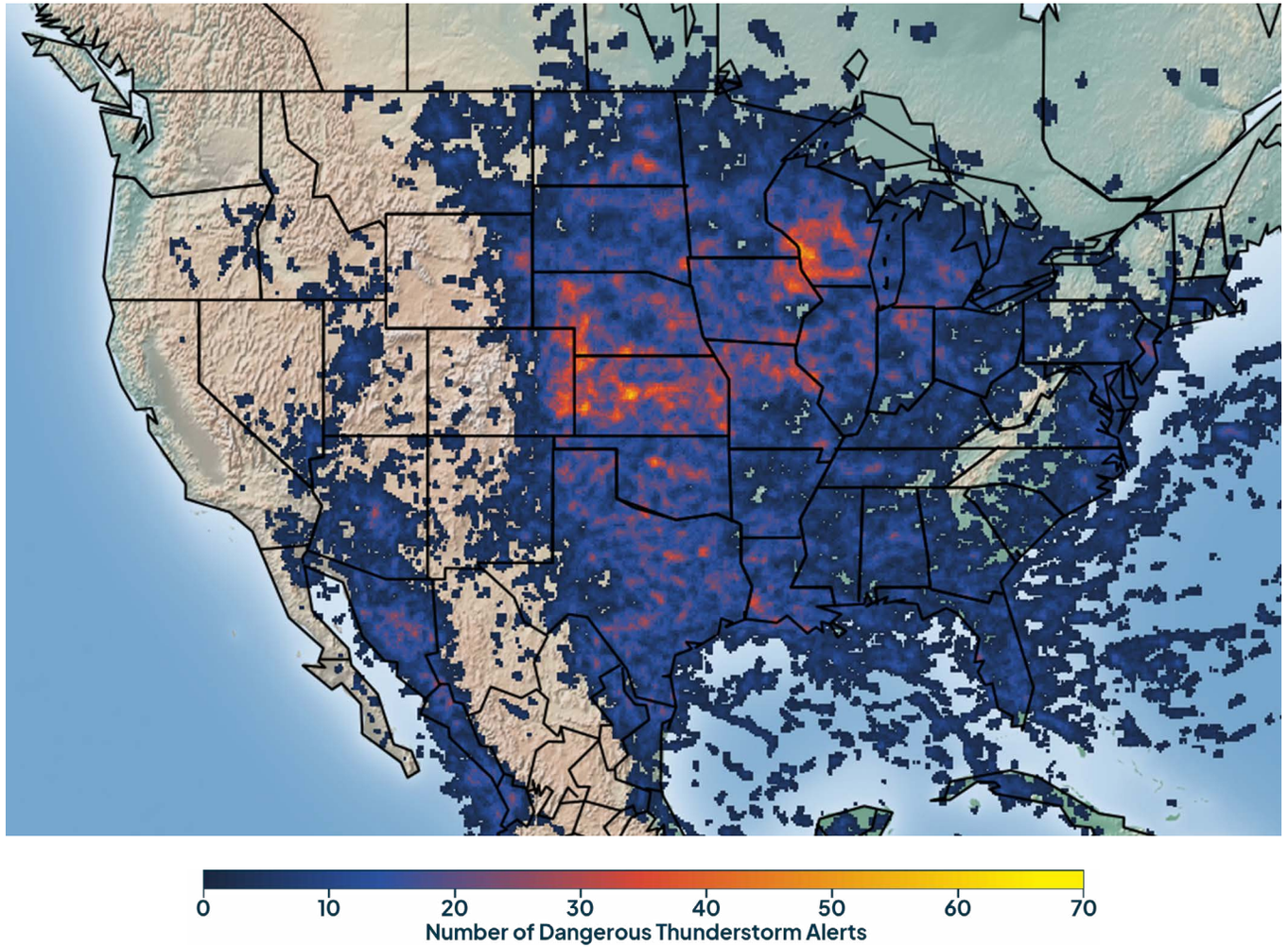


The top states for total lightning pulse density (the number of lightning pulses per square mile per year) reflect an extremely active severe weather season for the Mid Atlantic, with Maryland and New Jersey ranking highest for 2021. Not surprisingly, Florida and Louisiana made the list as well, thanks in part to the active hurricane season along the Gulf Coast. Four of the top ten counties were located in Virginia due to the high activity across the Mid Atlantic.

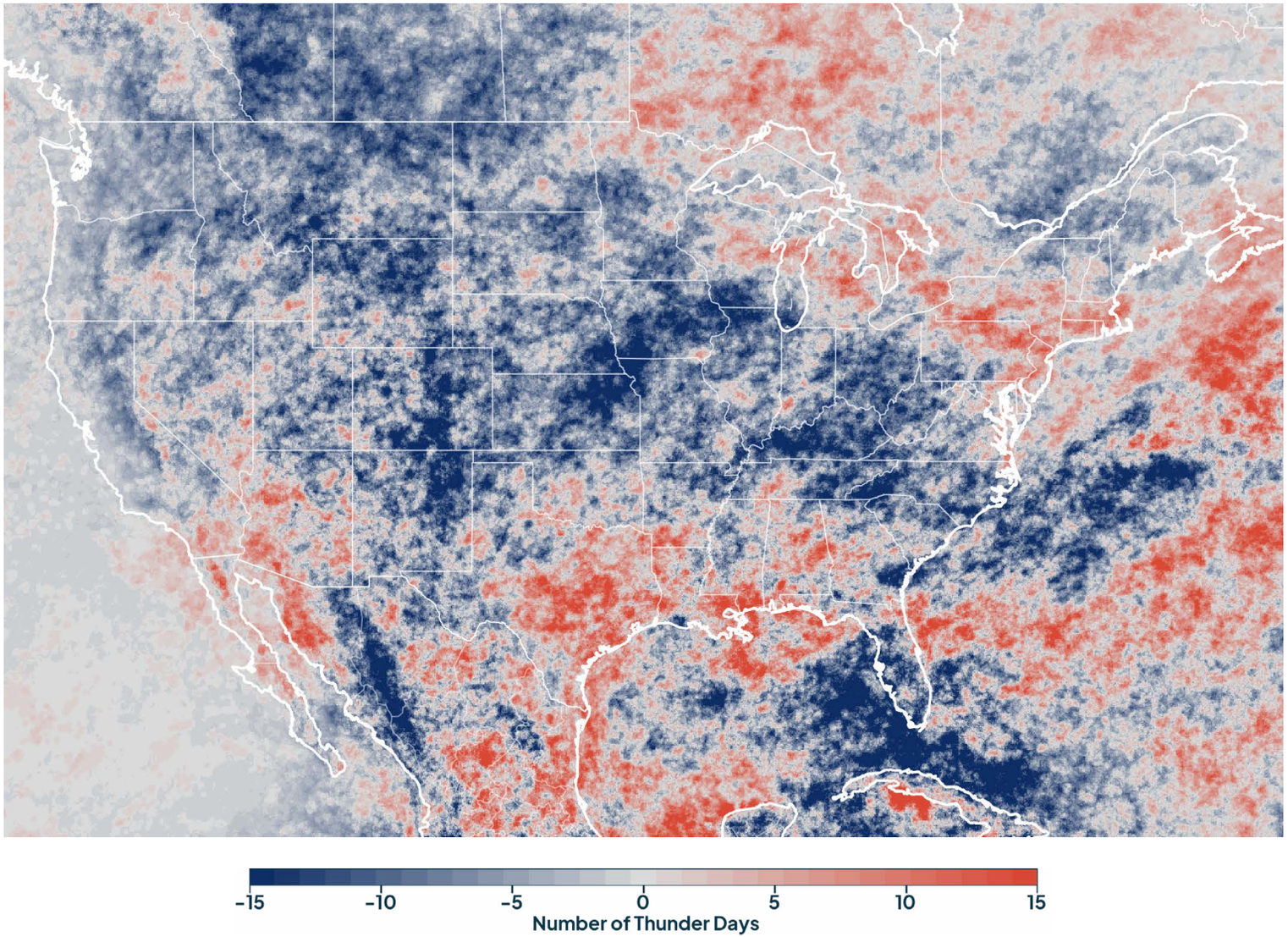
Dangerous Thunderstorm Alerts in the U.S.

Dangerous Thunderstorm Alerts (DTAs), available exclusively from Earth Networks, provide up to 50% more lead time to severe storms compared to publicly available alerts.

Earth Networks issued 29,245 Dangerous Thunderstorm Alerts (DTAs) in 2021. This year's map clearly shows how it was an active severe weather year for the Midwest and an active monsoon year for the Southwest.



Thunder Days anomalies for 2021



Thunder Days anomalies for 2021

The lightning data across the United States and southern Canada and adjacent waters for 2021 certainly tells the tale of various weather patterns that were evident during the year. The positive deviation from normal thunder days in the southwest U.S., especially over Arizona, is due to a very active 2021 Southwest Monsoon. This monsoon occurs in the summer, starting in late June and continuing through early September, and brings regular bouts of thunderstorms to this desert region. The busy monsoon season brought much needed rains to Arizona in particular this year.

Other locations that had abnormally high activity were along the Gulf Coast where sea breeze storm activity was active during the summer, and also stalled fronts in late Spring and early Fall generated thunderstorm clusters that were more frequent than normal.

A summer storm track from Wisconsin to Pennsylvania and the New York City area was very active in 2021. As a result, many areas across the Northeast experienced a higher frequency of summer storms than normal. Storms riding over an upper level high pressure ridge over the southeastern U.S. created these positive anomalies. And the antithesis to those positive areas caused by the ridge was a negative anomaly in the Tennessee and Ohio River Valleys, which created drier and more settled conditions, and thus fewer days with thunderstorms.

Below average storm activity in the Great Plains also contributed to expanding drought conditions in those areas.

2021 lightning recap

CASE STUDIES

Tornadoes and La Niña in first half of 2021

How are El Niño/Southern Oscillation (ENSO) and the frequency of tornadoes related?

The North American Monsoon

Was the 2021 monsoon one of the wettest on record across the Southwest United States?

December 2021 Tornado Outbreak

What caused the tornado outbreak in December 2021?

Lightning data depicts a vivid story about weather and climate across the United States. In the second half of this report, we'll illustrate how lightning activity was visible within specific events. The following case studies show the impact of several notable 2021 meteorological events shaped by severe weather.

Tornadoes and La Niña in first half of 2021

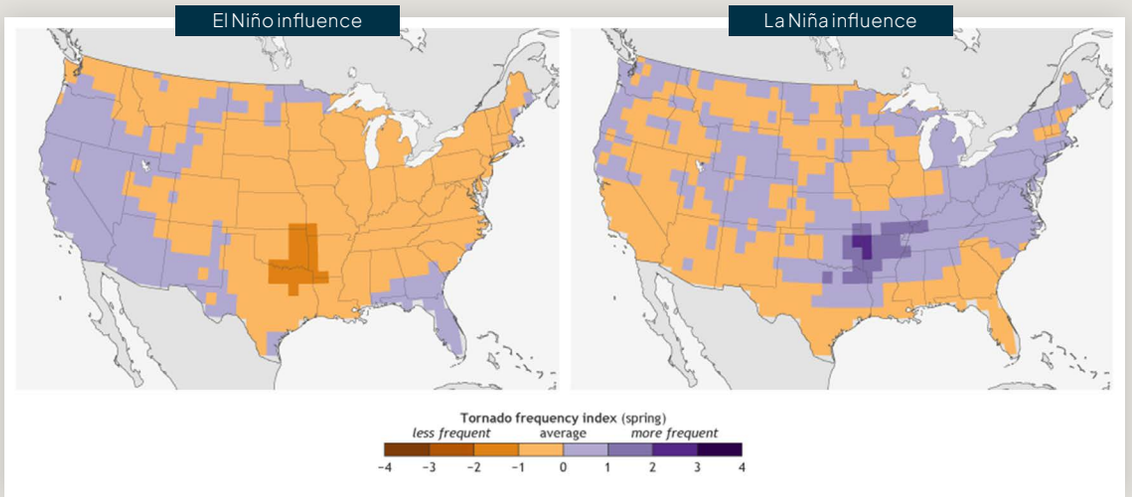
In 2021, there was below-average severe weather activity during the spring across much of the south. This surprised scientists who expected an active tornado season on the tail end of a moderately strong La Nina. You may be wondering, how are El Niño/Southern Oscillation (ENSO) and the frequency of tornadoes related? According to climate.gov, El Niño generally leads to fewer tornado events in the spring, while La Niña tends toward higher-than-normal frequency.

Dangerous Thunderstorm Alerts in first half of 2020

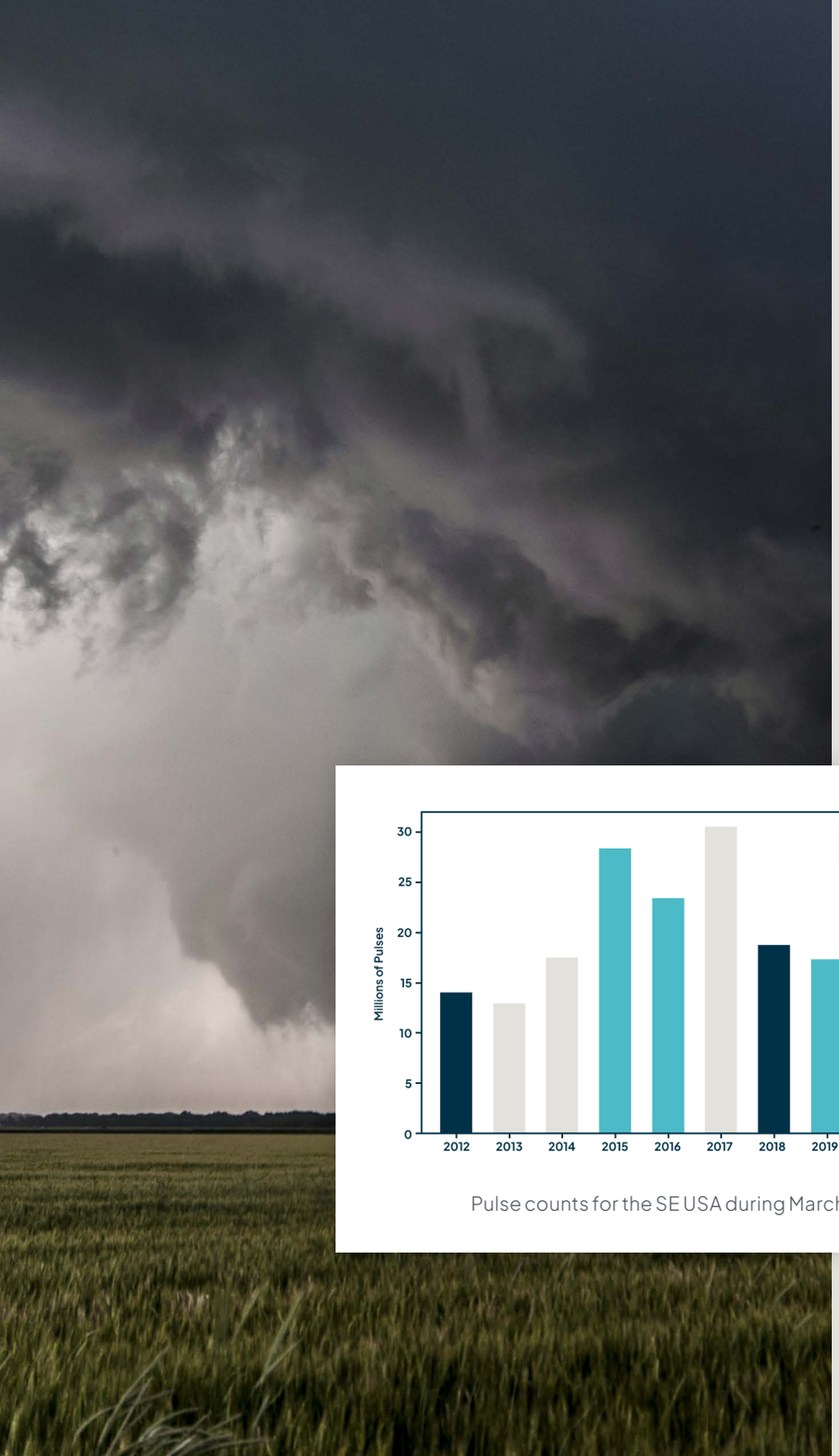
13,238

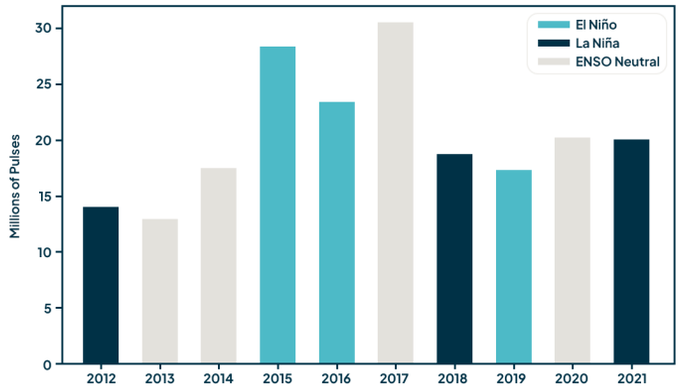
Dangerous Thunderstorm Alerts in first half of 2021

12,088



Influence of El Niño and La Niña on the frequency of tornadoes, March–May (Source: Climate.gov)





Pulse counts for the SE USA during March-May

Active tornado seasons are historically associated with La Niña. However, other atmospheric patterns overwhelmed this climate signal during Spring 2021. April in particular had significantly below-average tornado reports compared with the 20-year average.

According to climate.gov, the majority of the tornadoes in 2021 accumulated in March and May. Despite a relatively quiet tornado season, a total of 580 tornadoes were reported through May 31st, which was less than the 2000–2020 average of 676. These tornado events caused 13 fatalities and significant financial losses from severe weather, such as hail events thatimpacted major urban centers. For 2021, the United States is expected to exceed $10 billion insured losses to severe storms.

Overall, the first half of 2021 displayed unusual La Niña and tornado weather patterns. When comparing Earth Networks total pulse counts for the southeast U.S. over the course of several El Niño, La Niña, and ENSO-neutral years, we see that tornado activity isn't necessarily directly correlated to lightning. The decrease in DTAs for the U.S. this year compared to previous years suggests that the number of severe storms was lower than average, especially in this region, but there were still plenty of regular storms in the Southeast during the spring making plenty of lightning.

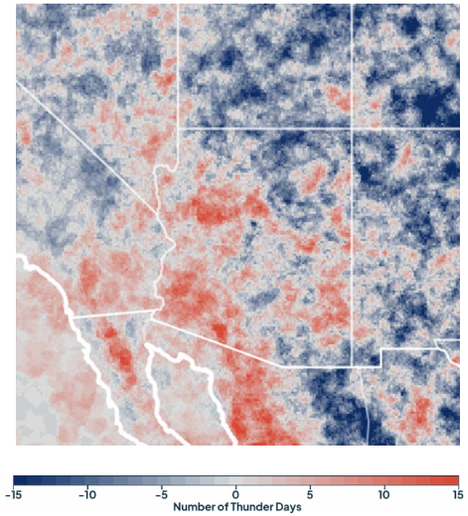
The North American Monsoon

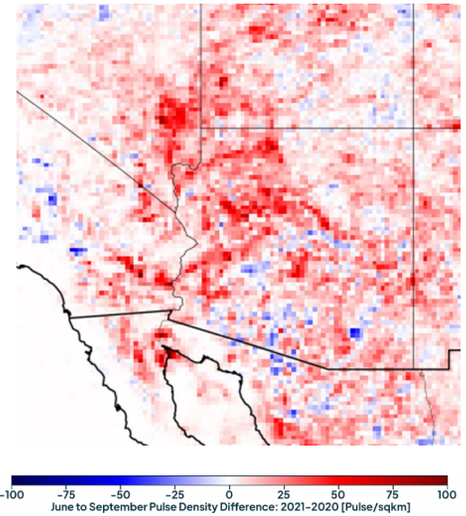
You may be wondering, what is the North American Monsoon? It is defined by climate.gov as a seasonal change in the atmospheric circulation that occurs as the summer sun heats the continental land mass. During much of the year, the prevailing wind over northwestern Mexico, Arizona, and New Mexico is westerly (blowing from the west) and dry.

The 2021 monsoon was one of the wettest on record across the Southwest United States. Average rainfall during the core monsoon months of June - September across the region was 7.93", which was the 20th wettest on record since 1895. According to weather.gov, the active monsoon season in 2021 was a result of a quicker than usual development and further northward location of the monsoon high, an increased frequency of easterly winds, record high levels of moisture in the atmosphere, Eastern Pacific tropical cyclone influence, a decrease in elevated wildfire smoke, and an early season snowpack across western North America.

Widespread positive thunder day anomalies in the Southwest United States reflects a wetter-than-average, and therefore stormier-than-average, North American Monsoon season. It stands in sharp contrast to the negative thunder day anomalies in the same region in 2020 (which was the driest North American Monsoon on record). We focus on the thunder day anomalies for recognizing this pattern because monsoonal thunderstorms are typically characterized by low lightning pulse and flash rates even though they produce a lot of rain.

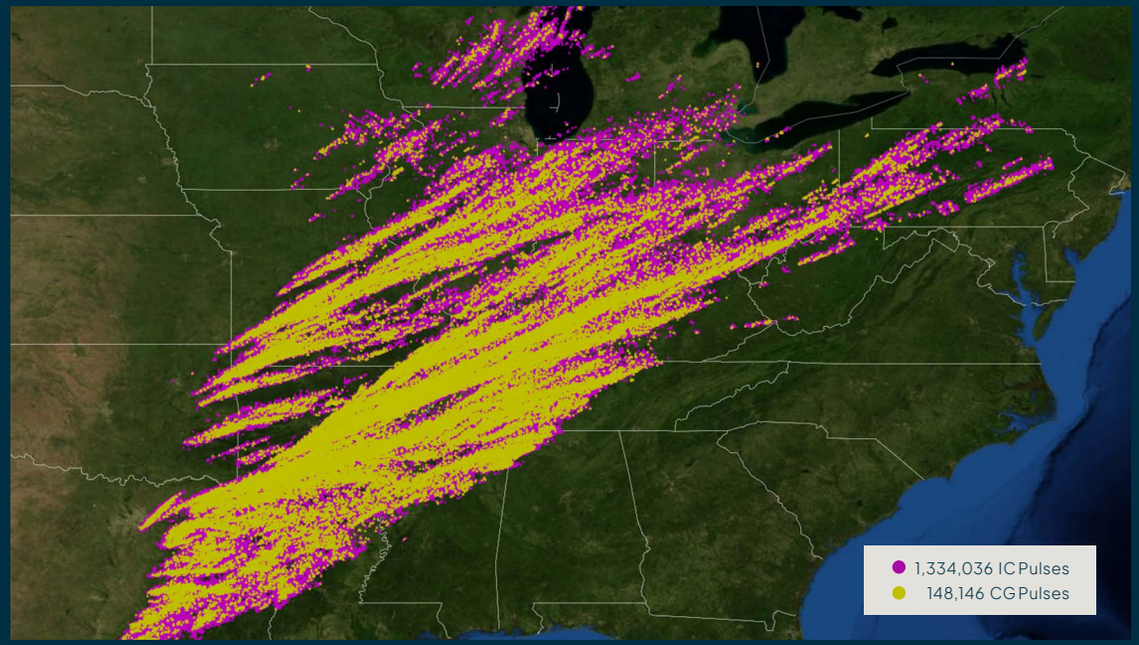
It is interesting to note, the difference between storm activity in the southwest US in 2020 and 2021 - two record-setting years - is also stark in terms of pulse density.





December 2021 Tornado Outbreak

Although the beginning half of 2021 did not experience high levels of tornado activity, December 2021 proved to be a doozy.



A view of IC and CG lightning pulses detected by ENTLN from December 10, 2021, 12:00 UTC to December 11, 2021, 12:00 UTC. During this period ENTLN detected 1.3M IC lightning pulses and 148K CG lightning pulses.

A strong storm system moving across the central and southern United States resulted in widespread severe weather across the region during those days. The severe weather outbreak included 66 confirmed tornadoes, including at least two with damage path lengths greater than 100 miles.

During this period, Earth Networks Total Lightning Network detected almost 1.5 million lightning pulses across the region.

The storms travelled from Arkansas towards the Great Lakes. The most significant damage occurred in Arkansas, Tennessee, Missouri and Kentucky. Eight states — Kentucky, Arkansas, Tennessee, Missouri, Illinois, Georgia, Ohio and Indiana — reported tornadoes that killed more than 80 people and brought devastating damage to communities. According to the NWS, there were nearly 400 reports of large hail, damaging winds and tornadoes across the area.

66 Tornadoes

1.5M Total lightning pulses detected by ENTLN

80 People killed

Thank you

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info@earthnetworks.com or call 1 301.250.4000

Appendix

This table ranks all U.S. states by total lightning pulses, including in-cloud and cloudto-ground from highest to lowest. Total number of thunder days in each state (the total number of days in the year when lightning was detected by ENTLN) are also included. The period covered is January 1, 2021 to December 31, 2021.

STATE	TOTAL LIGHTNING PULSES	TOTAL THUNDER DAYS
TX	69,427,345	270
FL	31,618,052	250
KS	25,004,904	182
OK	20,074,556	203
IL	16,712,423	168
LA	16,127,935	222
PA	14,158,124	168
VA	14,045,710	161
NE	13,866,596	171
MO	13,838,342	188
GA	13,652,668	193
AL	11,774,206	204
WI	11,195,683	136
IN	10,985,797	159
IA	10,396,568	141
AR	9,740,157	202
OH	9,492,186	165
MI	9,016,292	167
NC	8,898,714	181
CO	8,718,253	211
MS	8,633,268	214
SD	8,561,118	149
NM	7,761,955	197
AZ	7,123,725	178
TN	6,946,408	174
MD	6,600,843	125

STATE	TOTAL LIGHTNING PULSES	TOTAL THUNDER DAYS
MN	6,555,080	151
KY	6,494,644	166
NY	6,378,772	164
SC	5,698,671	171
ND	5,452,685	117
NJ	4,639,627	107
WV	4,558,400	139
WY	4,558,130	175
MT	3,629,465	156
UT	3,585,028	188
NV	2,534,493	157
ID	1,385,297	167
MA	1,300,275	89
CA	1,256,867	166
CT	1,155,341	72
DE	1,123,444	80
OR	787,723	124
VT	367,816	69
NH	319,441	69
ME	213,031	85
RI	135,698	52
WA	127,752	121
DC	68,807	40
AK	15,526	124
HI	12,827	101

Appendix

This table ranks the Top 100 U.S. counties by total lightning pulses including in-cloud and cloud-to-ground from highest to lowest. Total number of thunder days in each county (the total number of days in the year when lightning was detected by ENTLN) are also included. The period covered is January 1, 2021 to December 31, 2021.

STATE	COUNTY	TOTAL LIGHTNING PULSES	TOTAL THUNDER DAYS
FL	Palm Beach County	1,817,592	160
FL	Collier County	1,737,644	164
FL	Hendry County	1,217,362	151
FL	Polk County	1,187,779	150
FL	Brevard County	1,170,600	134
AZ	Coconino County	1,128,715	121
TX	Harris County	1,084,825	137
FL	Miami-Dade County	995,743	162
FL	Osceola County	988,195	141
FL	Highlands County	977,551	133
FL	Glades County	902,476	142
FL	Broward County	868,236	150
FL	Volusia County	857,959	138
TX	Houston County	853,690	102
AZ	Mohave County	831,390	102
OK	Osage County	829,695	84
FL	Lee County	816,156	141
AZ	Yavapai County	807,098	101
LA	Beauregard Parish	790,858	124
LA	Cameron Parish	787,842	125
FL	Monroe County	749,509	170
NE	Cherry County	723,144	90
FL	Hillsborough County	714,461	137
FL	Okeechobee County	700,243	137
TX	Leon County	677,673	99
AZ	Pima County	670,754	102
LA	Calcasieu Parish	666,250	132
LA	Vermilion Parish	656,420	125
MI	Berrien County	651,208	56
KS	Butler County	644,535	72
FL	Orange County	637,245	136
TX	San Saba County	634,586	82
FL	Marion County	616,808	132
TX	Anderson County	616,400	94
IL	Cook County	615,366	64
CO	Kit Carson County	610,779	83
PA	Lancaster County	607,586	61
TX	Liberty County	595,222	127
NV	Lincoln County	580,672	95
TX	Cherokee County	578,487	89
FL	Manatee County	576,547	132
AZ	Apache County	569,144	129
TX	Polk County	561,681	118
TX	Montgomery County	557,917	115
FL	Lake County	553,025	141
CO	Yuma County	545,946	83
TX	Falls County	539,831	79
CO	Las Animas County	538,462	123
TX	Coryell County	536,243	77
LA	Terrebonne Parish	535,675	140

STATE	COUNTY	TOTAL LIGHTNING PULSES	TOTAL THUNDER DAYS
NJ	Ocean County	534,191	57
TX	Fort Bend County	533,795	109
OK	McCurtain County	530,997	97
LA	Vernon Parish	529,796	127
FL	Martin County	529,443	137
FL	Charlotte County	526,722	136
PA	York County	523,347	65
FL	St. Lucie County	522,669	128
DE	Sussex County	520,034	60
NE	Lincoln County	519,877	79
FL	Levy County	515,834	123
TX	Hill County	510,854	86
FL	Sarasota County	509,228	125
TX	Fayette County	501,814	96
LA	Rapides Parish	499,817	119
NM	Catron County	497,267	125
TX	Matagorda County	494,798	111
PA	Lycoming County	493,889	65
TX	Bosque County	493,249	81
TX	Nacogdoches County	491,120	96
AZ	Maricopa County	489,622	91
NJ	Burlington County	486,208	59
TX	Burnet County	485,526	83
IL	Iroquois County	483,379	72
TX	Limestone County	482,598	92
IL	Champaign County	481,808	66
NM	Chaves County	479,217	109
KS	Sedgwick County	478,875	71
KS	Cowley County	477,987	72
CO	Weld County	477,719	109
OK	Grady County	477,021	77
NM	San Miguel County	475,274	117
AZ	Gila County	475,079	104
TX	Williamson County	474,552	91
KS	Greenwood County	472,976	71
TX	Brazoria County	472,935	121
TX	Trinity County	472,752	101
NE	Sheridan County	470,288	76
AZ	Navajo County	466,031	125
TX	Walker County	465,321	102
TX	Palo Pinto County	465,018	68
TX	Van Zandt County	461,461	81
MD	Anne Arundel County	459,762	68
TX	McLennan County	459,288	81
TX	McCulloch County	458,826	79
TX	Henderson County	458,703	87
PA	Berks County	457,208	59
TX	Jefferson County	456,625	117
TX	Freestone County	455,620	90
OK	Kingfisher County	455,085	72

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