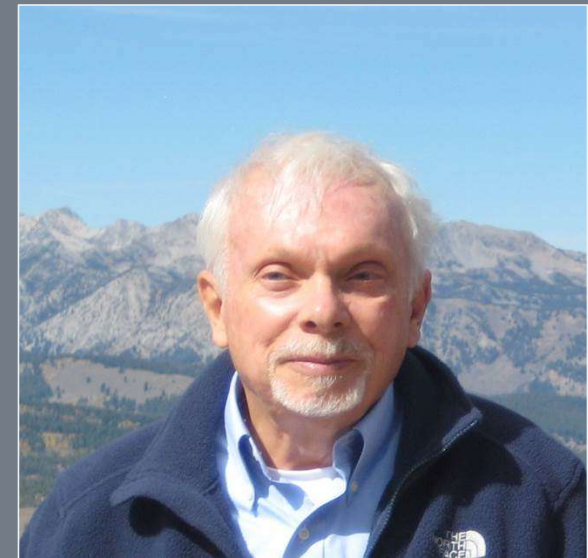


International Lightning

CoCoRaHS, 28 July 2022



Ronald L. Holle
Holle Meteorology & Photography
Oro Valley, Arizona
rholle@earthlink.net



Lightning is fascinating!

Miami



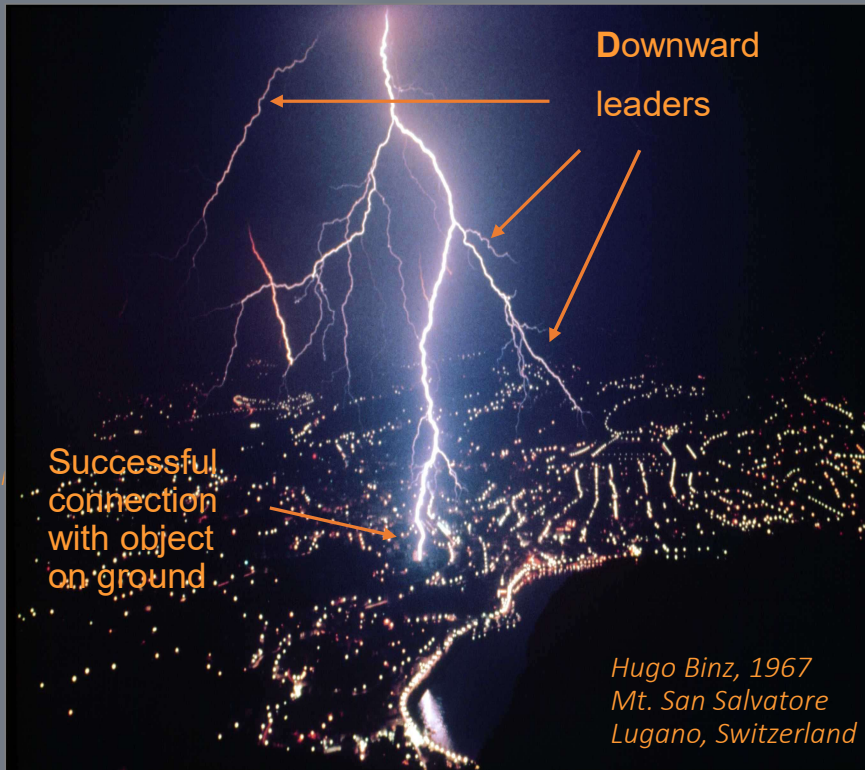
Norman



Tucson



Lightning is fascinating!

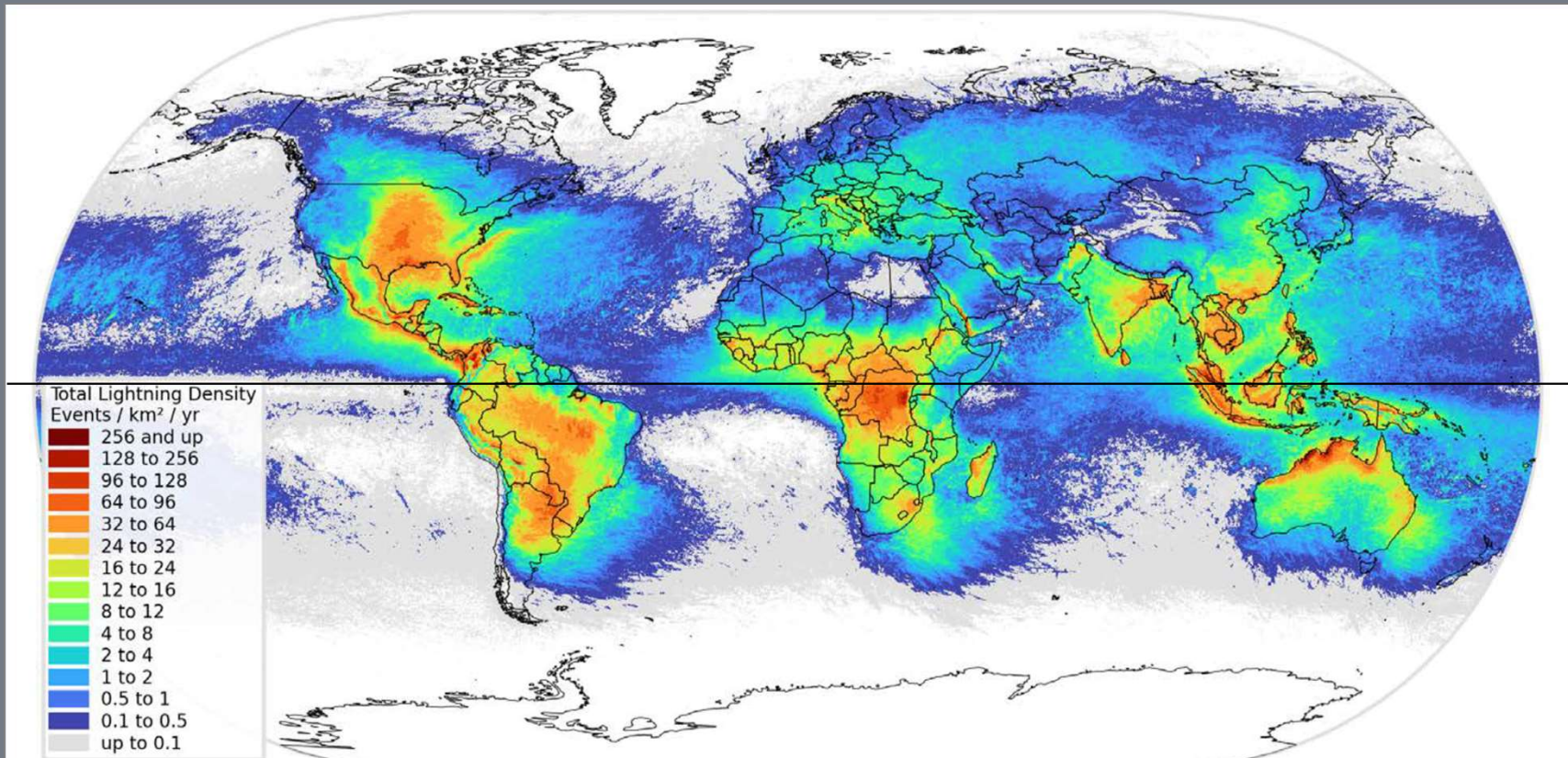


Lightning topics today

1. What nations have the most lightning strokes in the world?
2. Which countries have the most lightning strokes per area per year?
3. What U.S. state has the most lightning flashes and largest stroke density by area?
4. What are the main reasons for stroke density differences?
5. Which nation has the most lightning deaths per year?
6. Which country has the largest lightning death rate per capita?
7. Which U.S. state has the most lightning deaths, and which has the most per capita?
8. What are the main reasons for these fatality differences?

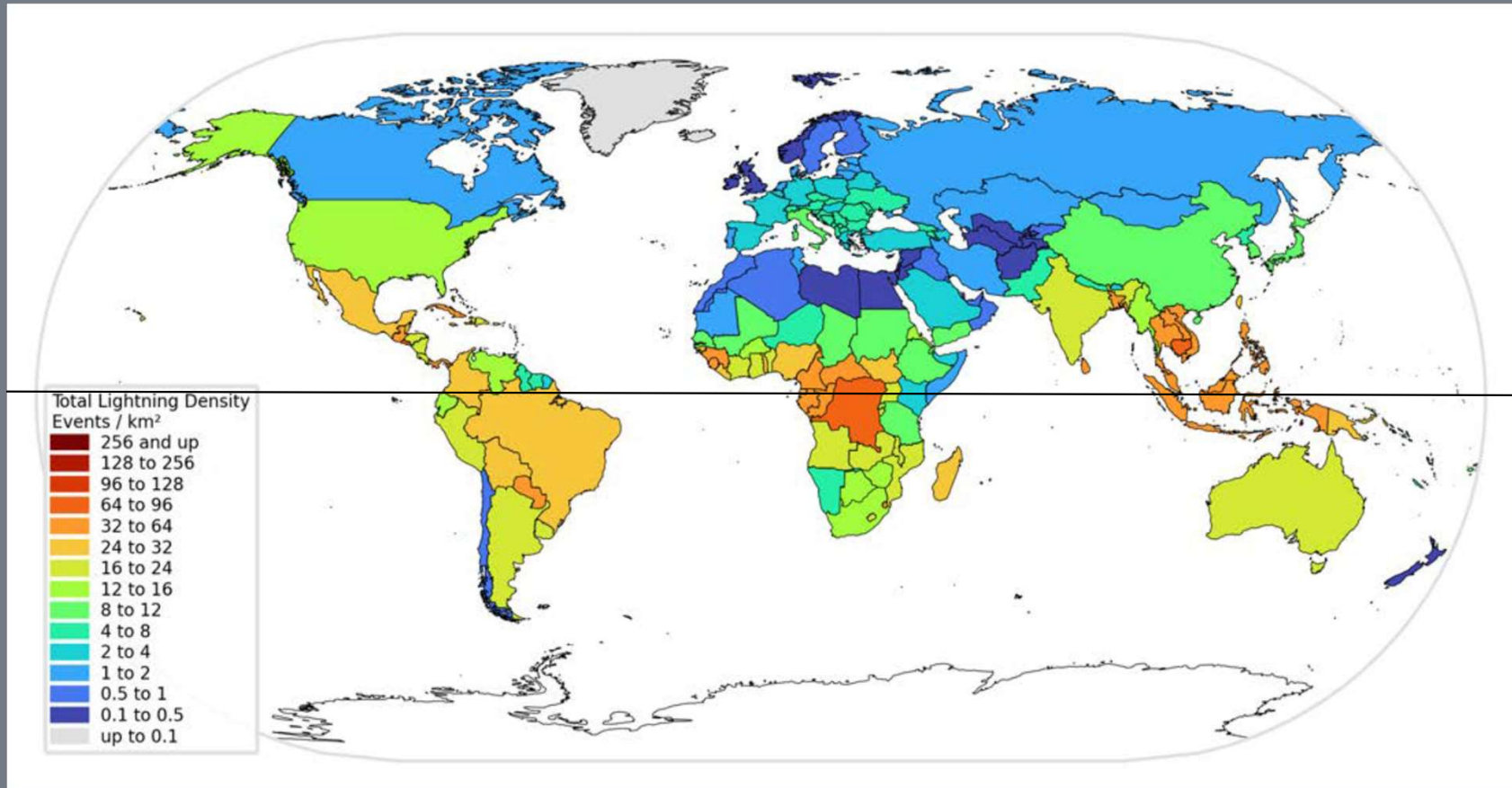
Lightning density

1. What nations have the most lightning strokes in the world?



www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

1. What nations have the most lightning strokes in the world?



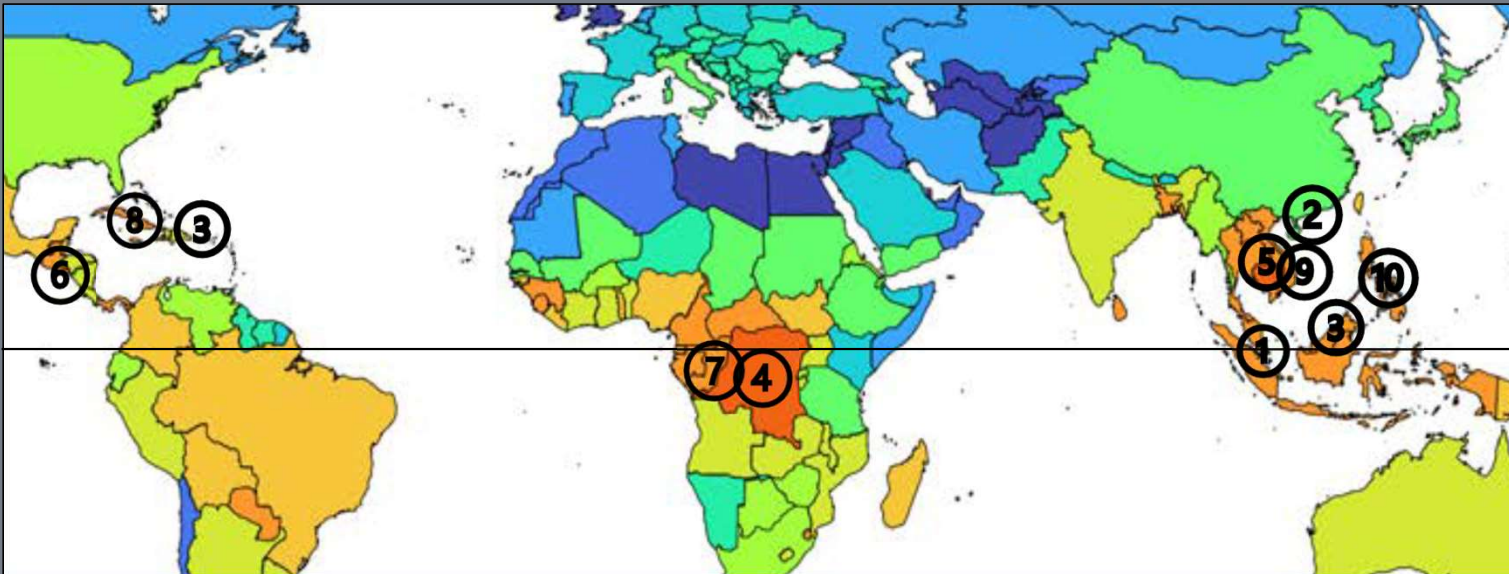
1. What nations have the most lightning strokes in the world?

1 Brazil	225,607,575
2 United States of America	194,549,696
3 Democratic Republic of the Congo	180,105,987
4 Australia	146,629,026
5 Mainland China	86,102,056
6 Indonesia	81,767,821
7 India	51,501,500
8 Mexico	50,751,946
9 Argentina	44,924,969
10 Colombia	36,435,131

<https://www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf>

2. Which countries have the most lightning strokes per area per year?

- 1 Singapore
- 2 Macao
- 3 Brunei
- 4 Democratic Republic of the Congo
- 5 Cambodia
- 6 El Salvador
- 7 Republic of the Congo
- 8 Cuba
- 9 Vietnam
- 10 Philippines



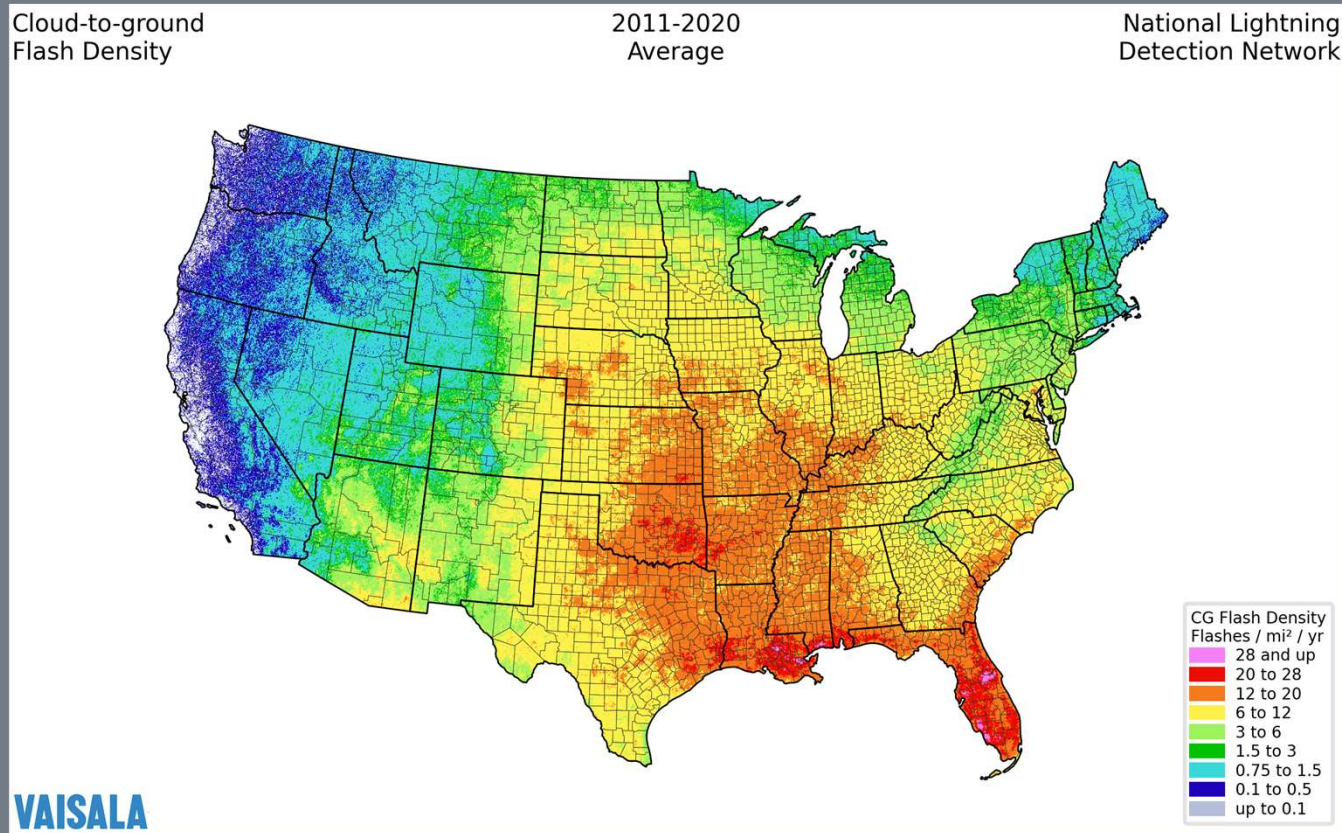
www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

2. Which countries have the most lightning strokes per area per year?

1 Singapore	163.1 strokes km ⁻² year ⁻¹
2 Macao S.A.R.	135.6
3 Brunei	105.2
4 Democratic Republic of the Congo	77.1
5 Cambodia	67.5
6 El Salvador	65.3
7 Republic of the Congo	60.8
8 Cuba	60.6
9 Vietnam	58.0
10 Philippines	56.6

www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

3. What U.S. state has the most flashes?



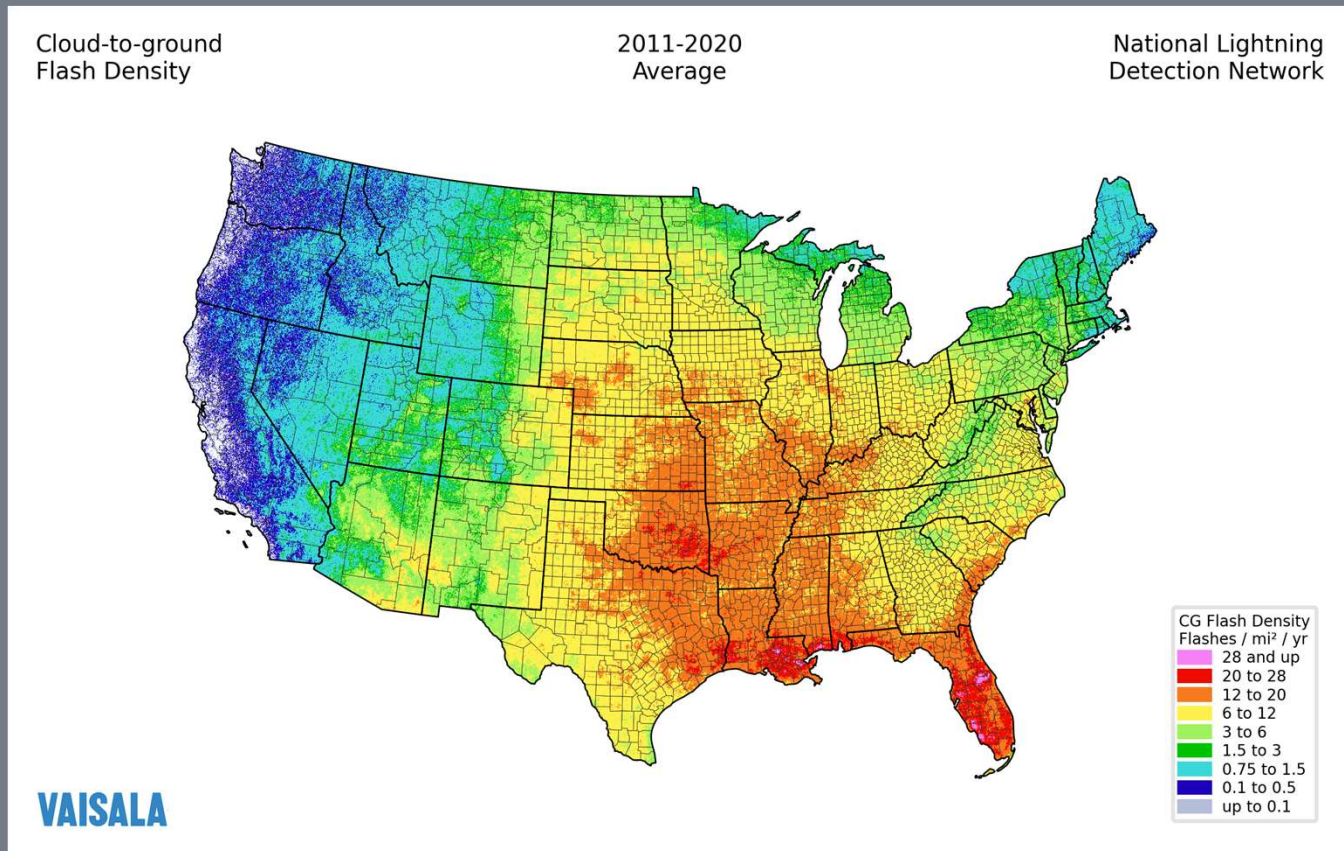
www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

3. What U.S. state has the most lightning?

1 Texas	41,914,516	cloud-to-ground strokes plus cloud pulses
2 Florida	14,645,013	
3 Louisiana	11,071,444	
4 Oklahoma	9,940,752	
5 Kansas	8,855,790	
6 Missouri	7,690,990	
7 Mississippi	6,999,388	
8 Illinois	6,263,862	
9 Nebraska	6,143,147	
10 Arkansas	5,659,900	

www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

3. What U.S. state has the largest flash density by area?

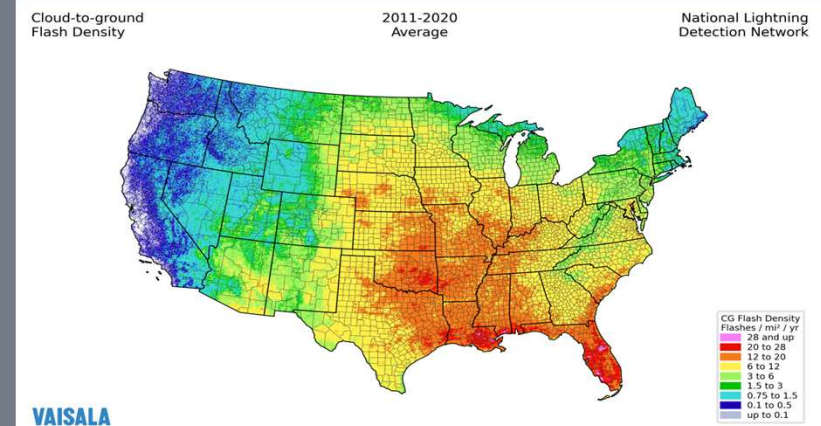
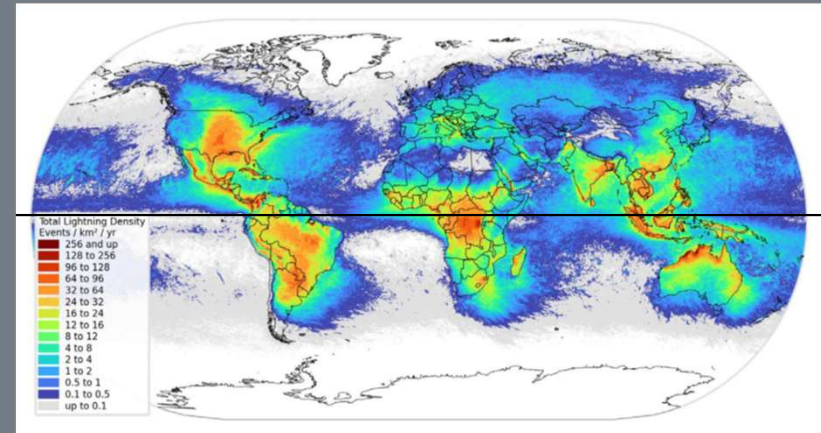


- 1 Florida
- 2 Louisiana
- 3 Texas
- 4 Mississippi
- 5 Oklahoma
- 6 District of Columbia
- 7 Missouri
- 8 Illinois
- 9 Kansas
- 10 Arkansas

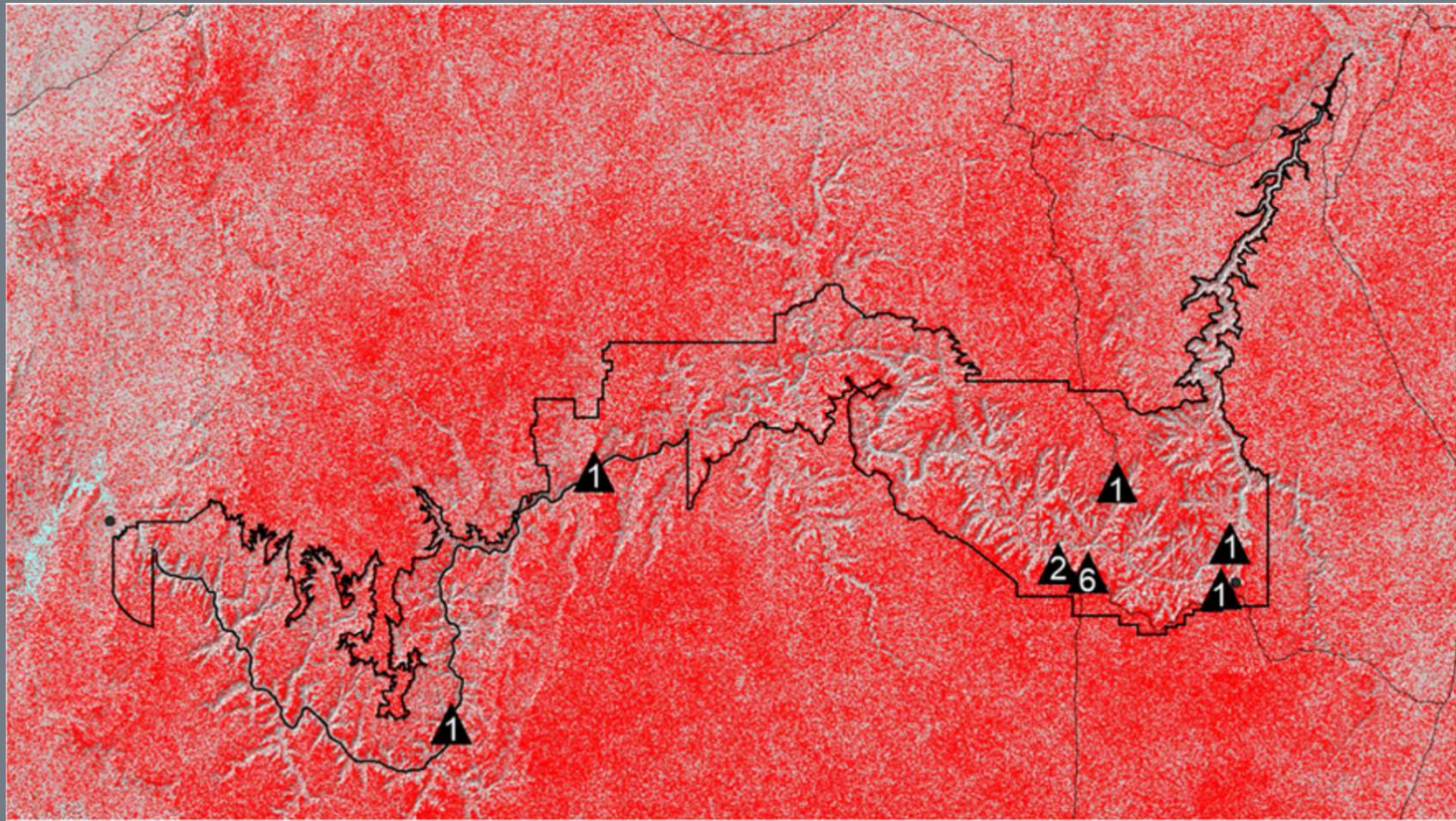
www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

4. What are the main reasons for stroke density differences?

- Tropical latitude
- Length of tropical season
- Near warm oceans
- Near large mountains
- Lee of large mountains
- Over large tropical lakes



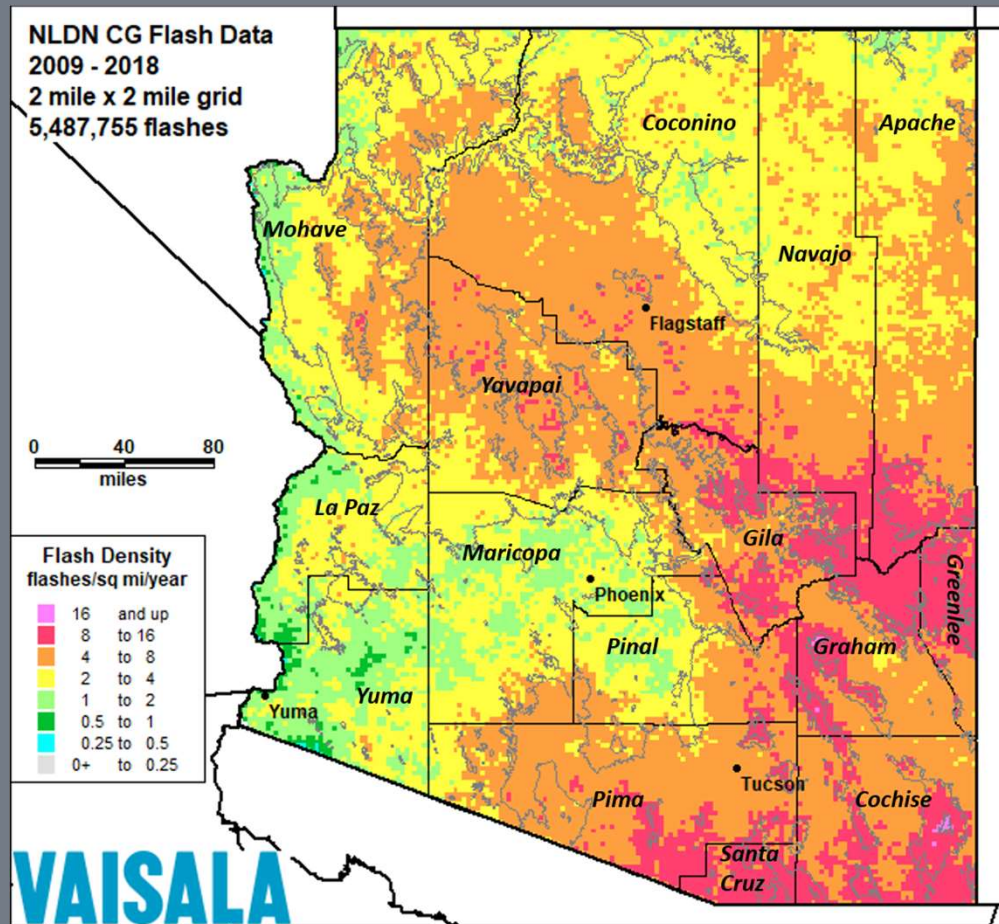
Specific Case: Grand Canyon



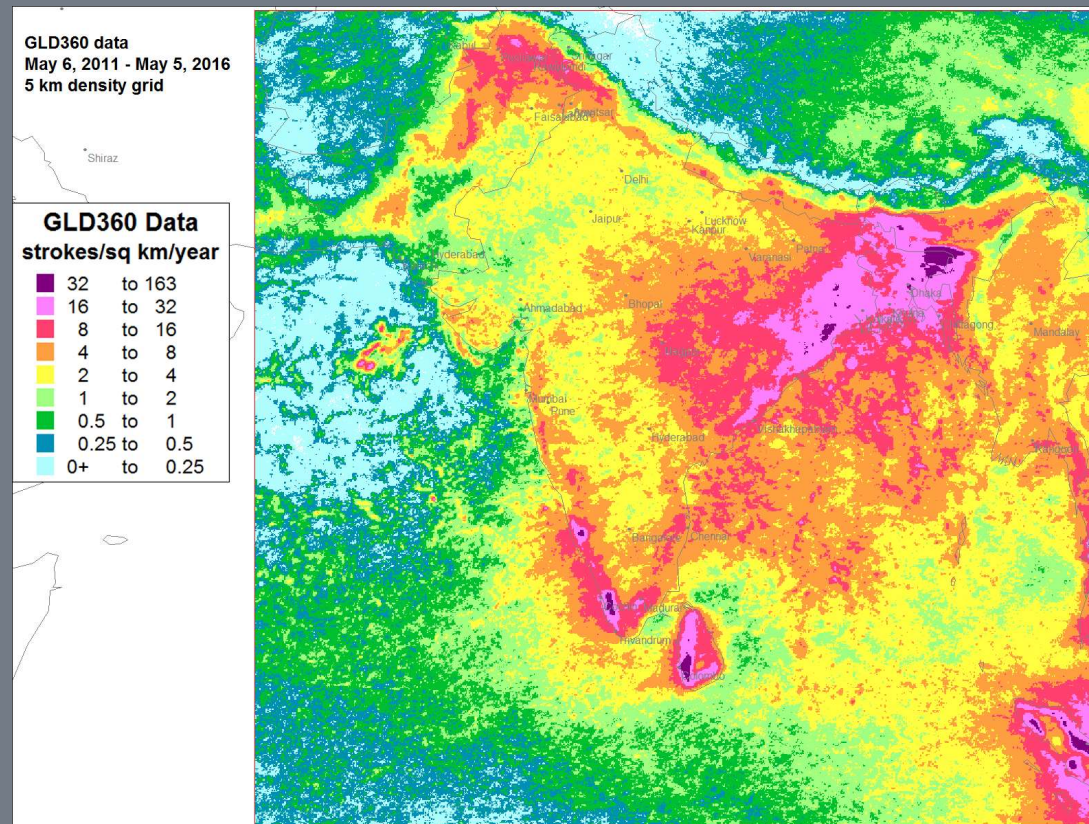
Holle, R.L., W.A. Brooks, and K.L. Cummins, 2021: Lightning occurrence and casualties in U.S. national parks. *Weather, Climate, and Society*, **13**, 525-540.

ACLENet, 11 March 2022

Specific Case: Arizona



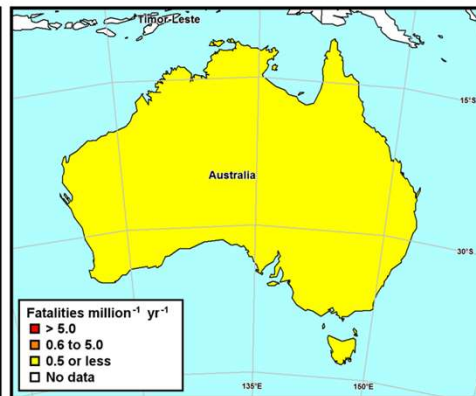
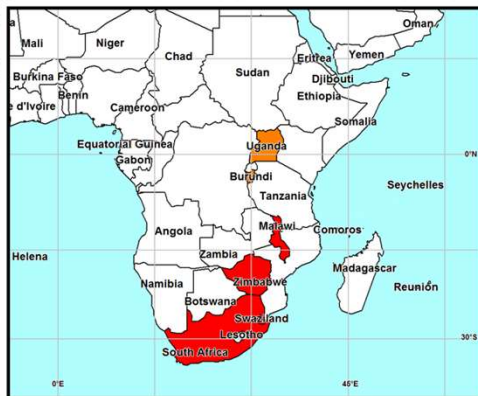
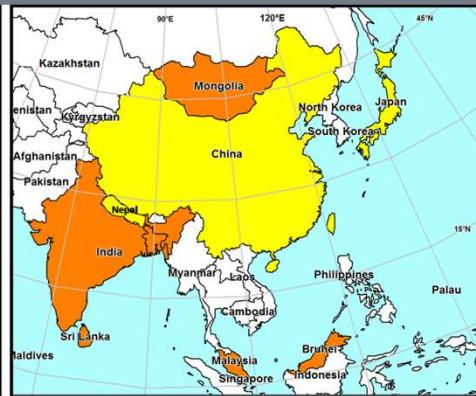
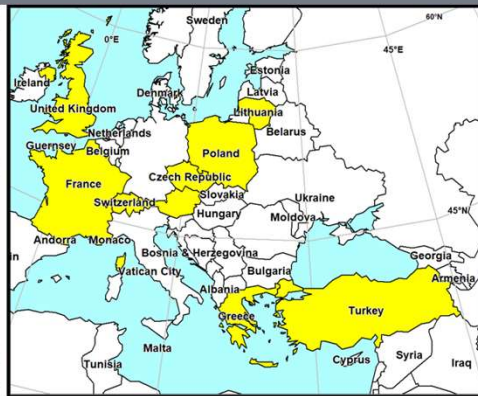
Specific Case: Indian Subcontinent



Nag, A., R.L. Holle, and M. Murphy, 2017: Cloud-to-ground lightning over the Indian subcontinent. Postprints, 8th Conference on the Meteorological Applications of Lightning Data, Seattle, American Meteorological Society, 6 pp.

Lightning fatalities

5. Which nation has the most lightning deaths per year?



1 India	1,755
2 Malawi	1,008*
3 China	360
4 Bangladesh	251
5 South Africa	264
6 Mexico	230
7 Brazil	132
8 Zimbabwe	125
9 Nepal	94
10 Colombia	76

Updated from: Holle, R.L., 2016: A summary of recent national-scale lightning fatality studies. *Weather, Climate, and Society*, 8, 35-42.

Published national lightning fatalities per year for multiple years since 1979

Documented: 4,491 ... My estimate: Up to 24,000 deaths per year for world

Africa: 1,443 fatalities per year

- Burundi: 26
- Malawi: 1,008*
- South Africa: 264
- Swaziland: 15
- Uganda: 30
- Zimbabwe: 100 to 150

Asia: 2,519 fatalities per year

- Bangladesh: 251
- China: 360
- India: 1,755
- Japan: 2
- Malaysia: 2
- Mongolia: 5
- Nepal: 94
- Singapore: 3
- Sri Lanka: 49

Australia: 2 fatalities per year

- Australia: 2

Europe: 57 fatalities per year

- Austria: 1
- Czech Republic: <1
- France: 11
- Greece: 5
- Lithuania: 2
- Poland: 8
- Turkey: 28
- U.K.: 2

North America: 262 fatalities per year

- Canada: 9 to 10
- Mexico: 230
- U.S.: 23

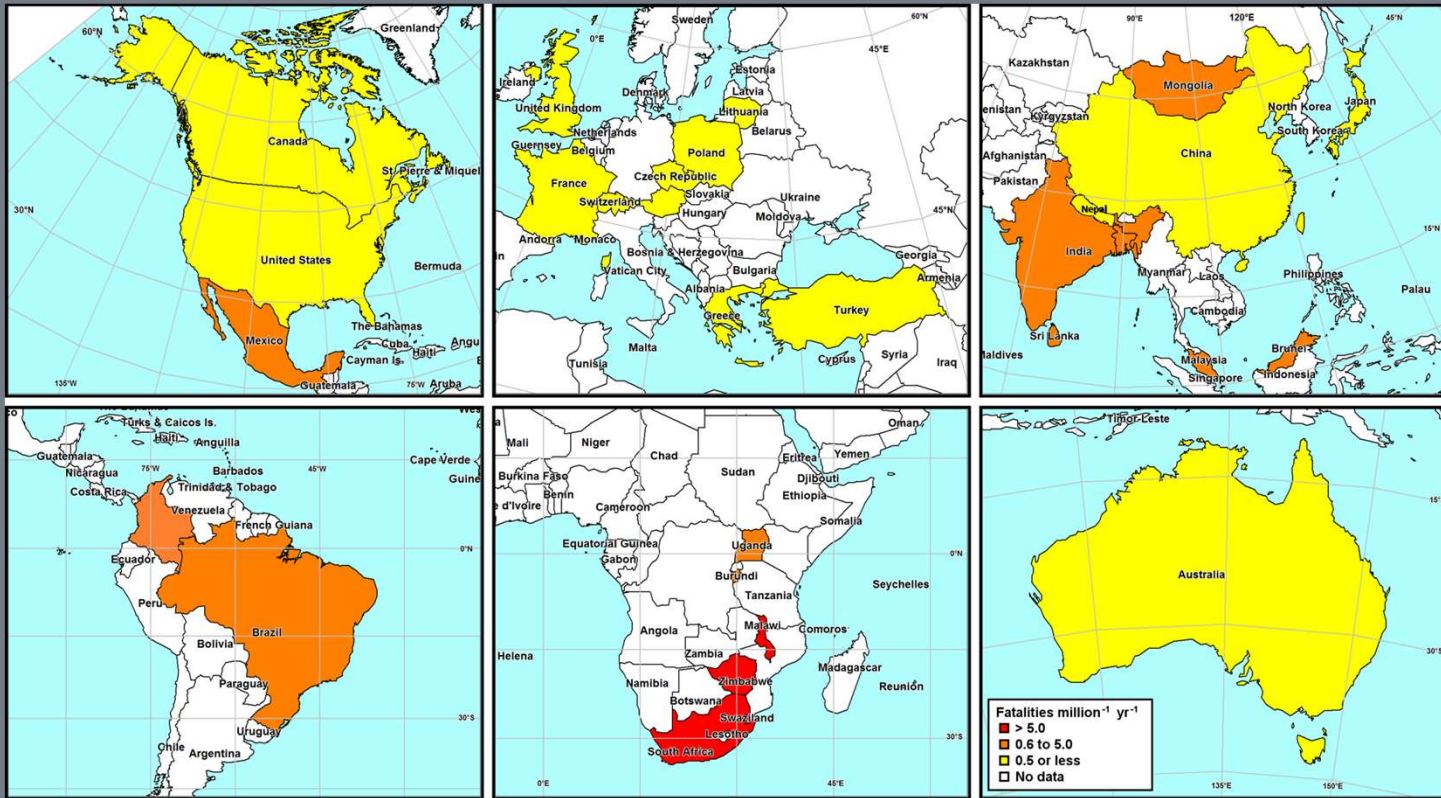
South America: 208 fatalities per year

- Brazil: 132
- Colombia: 76

Documented sum for all continents

4,491 fatalities per year

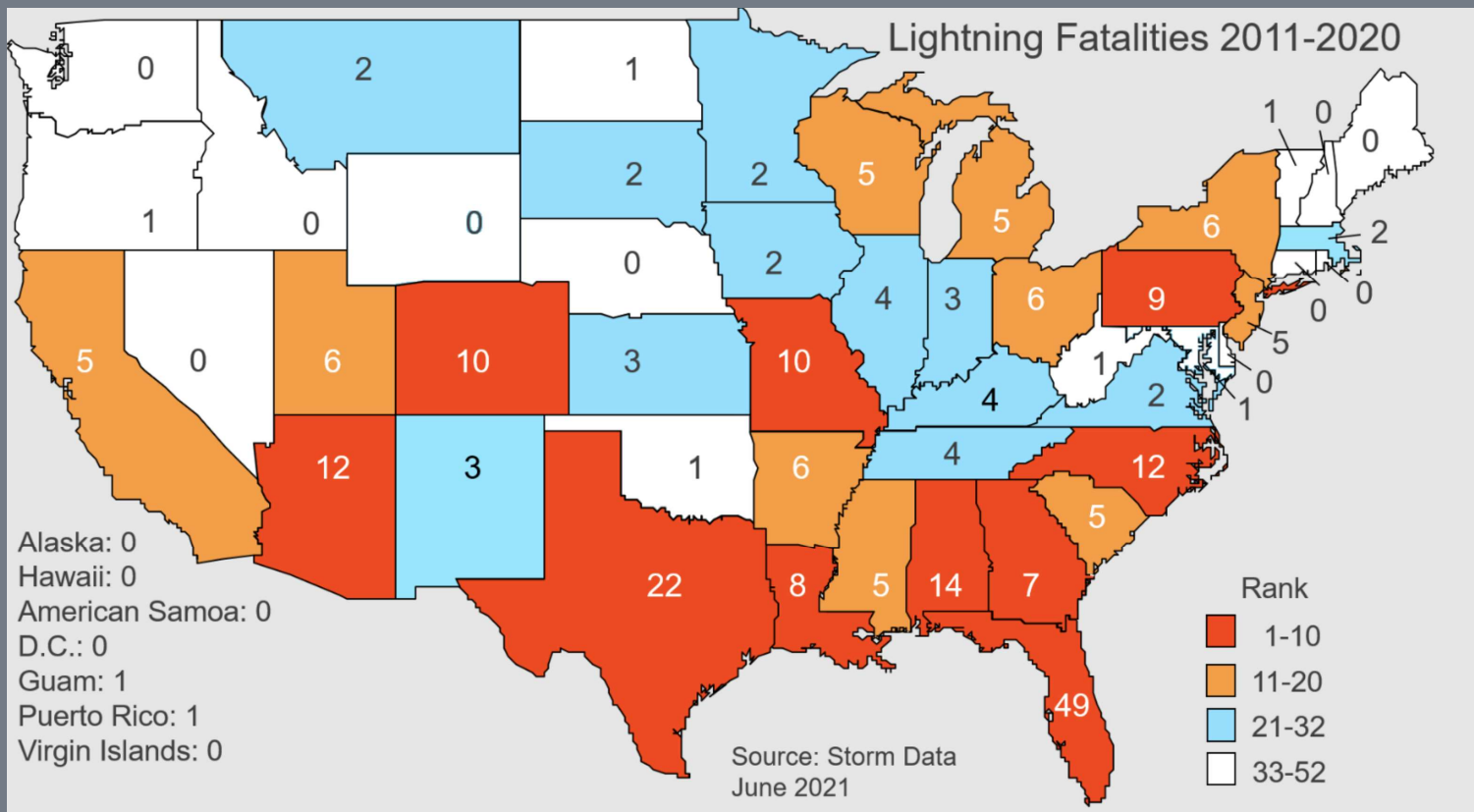
6. Which nation has the largest lightning death rate per capita?



1 Malawi	84.0*
2 Zimbabwe	17.0
3 eSwatini	15.5
4 South Africa	6.3
5 Burundi	5.0
6 México	2.7
7 India	2.0
8 Bangladesh	1.7
9 Colombia	1.7
10 Mongolia	1.5
10 Singapore	1.5

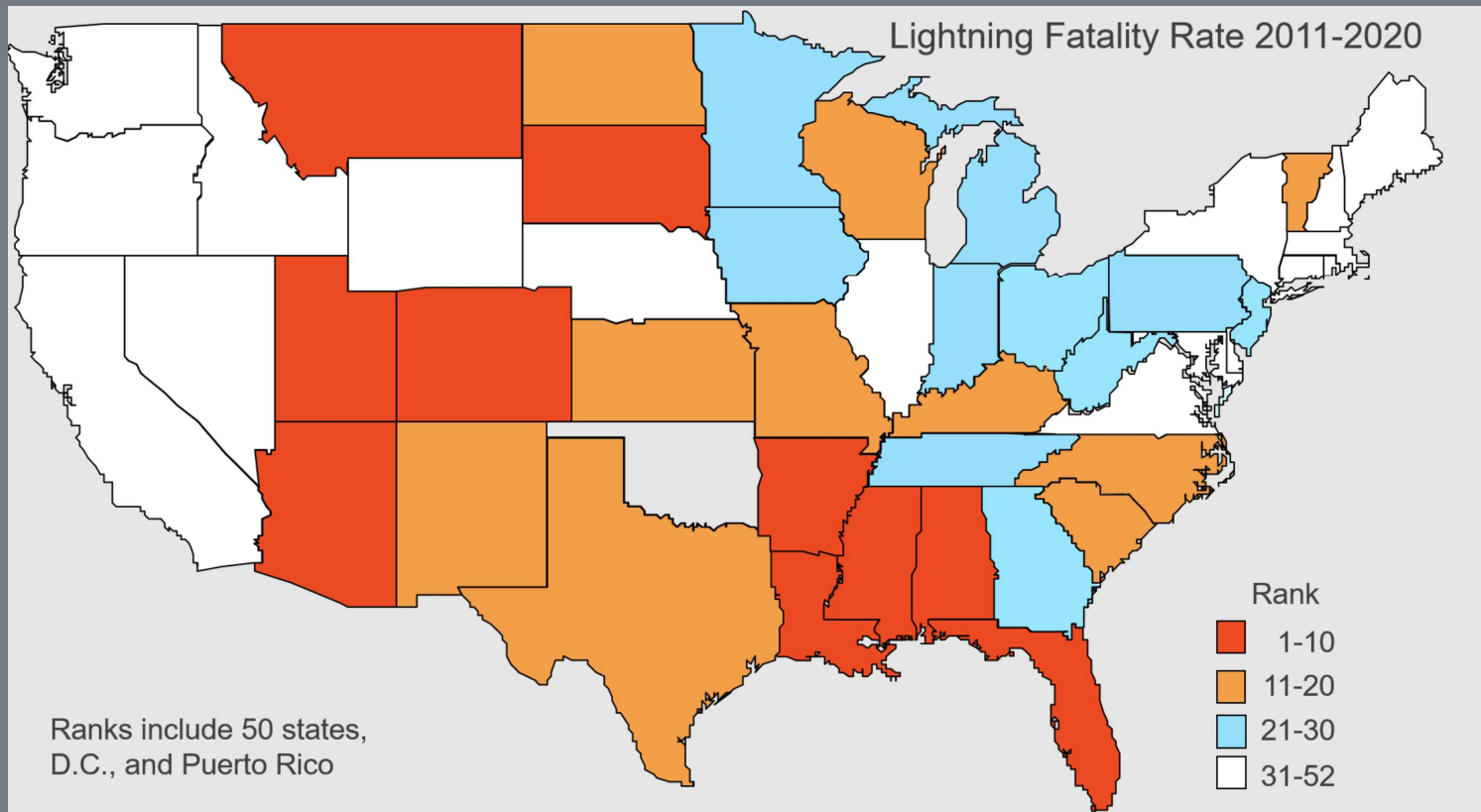
Holle, R.L., 2016: A summary of recent national-scale lightning fatality studies. *Weather, Climate, and Society*, 8, 35-42.

7. Which U.S. state has the most lightning deaths?

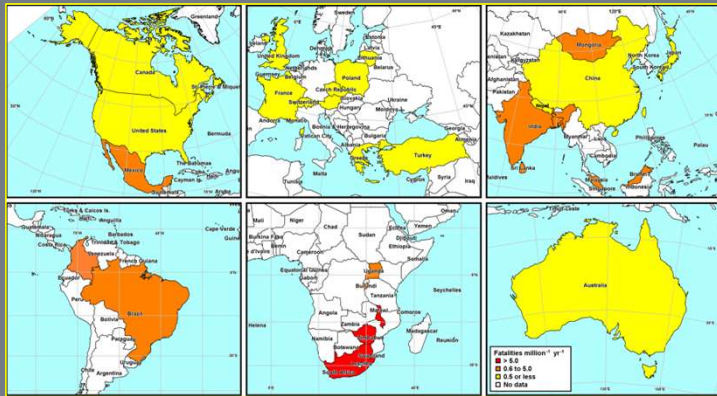


<http://lightningsafetycouncil.org/Deaths%20by%20State%20Map.png>

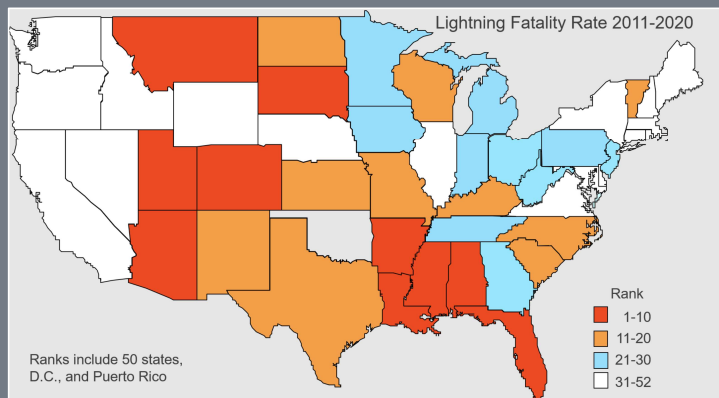
7. Which U.S. state has the most lightning deaths per capita?



8. What are the main reasons for these fatality rate differences?

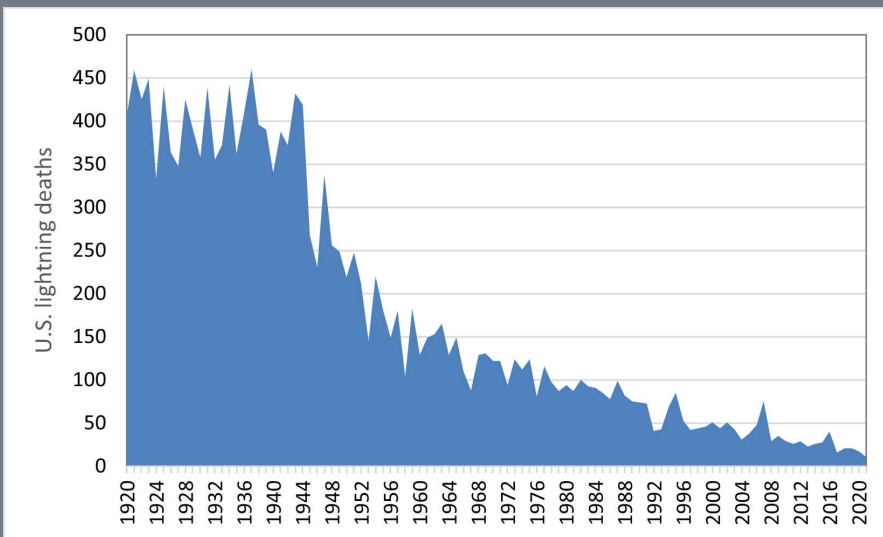


- Density of lightning
- Density of population
- Quality of housing and other buildings
- Amount of labor-intensive agriculture
- Awareness of threat
- Ready availability of vehicles
- Public education
- Medical care



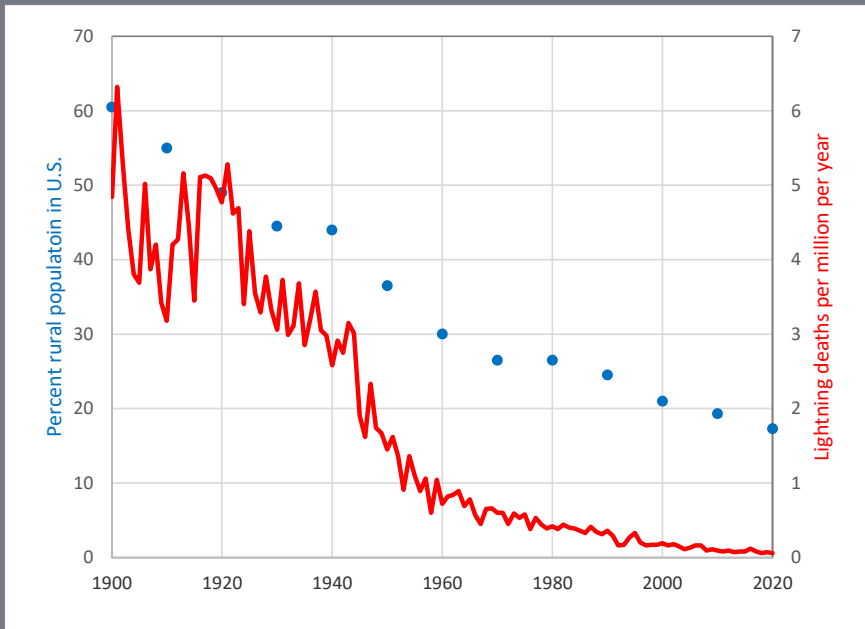
8. What are the main reasons for these fatality rate differences?

U.S. lightning deaths per year, 1920-2021



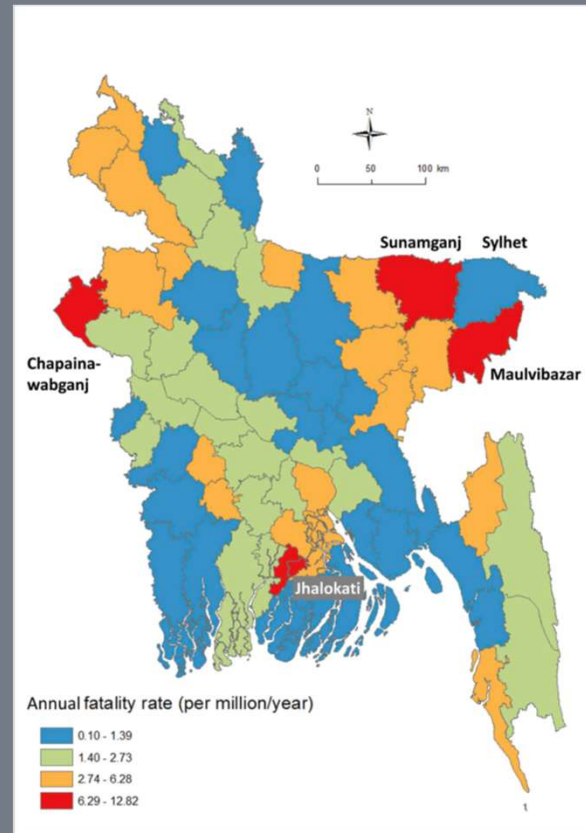
- Density of lightning
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- Density of lightning
- Density of population
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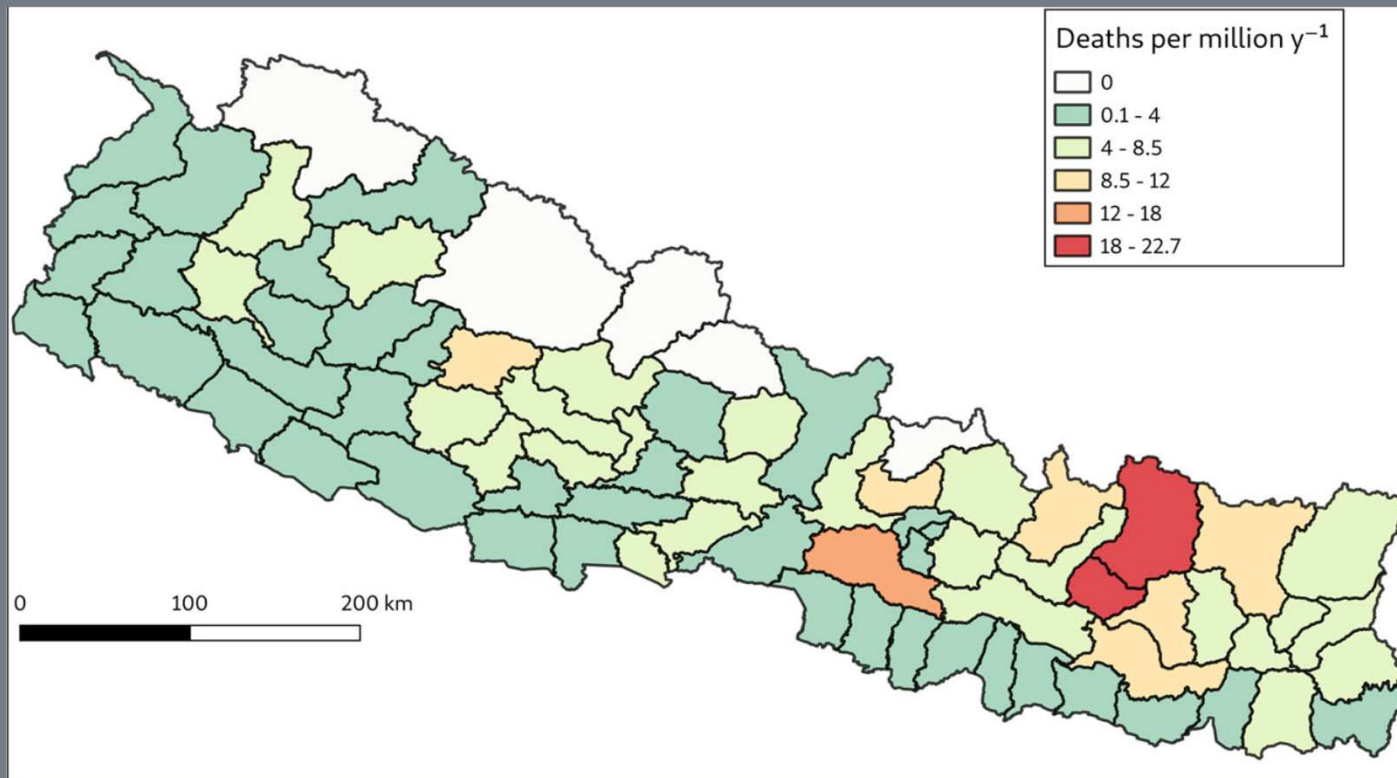
Specific Case: Bangladesh



Holle, R.L., A. Dewan, R. Said, W.A. Brooks, M.F. Hossain, and M. Rafiuddin, 2019: Fatalities related to lightning occurrence and agriculture in Bangladesh. *International Journal of Disaster Risk Reduction*, 41, 15 pp.

ACLNet, 11 March 2022

Specific Case: Nepal



Sharma, S., B. Neupane, H.B. KC, M.P. Koirala, N.P. Damase, S. Dhakal, C. Gomes, M.A. Cooper, R.L. Holle, R.J. Bhusal, J. Cramer and R. Said, 2022: Lightning threats in Nepal: occurrence and human impacts. *Geomatics, Natural Hazards and Risk*, **13**, 1-18.

Specific Case: Jamaica



Holle, R.L., A. Laing, J.A. Cramer, and E.G. Thomson, 2022: Jamaica lightning occurrence, damage, and casualties. Preprints, 36th International Conference on Lightning Protection, 02-07 October, Cape Town, South Africa, 4 pp.

ACLNet, 11 March 2022

Some websites for lightning



Vaisala lightning booklet in English

<https://www.vaisala.com/en/system/files/documents/Lightning-Booklet.pdf>



National Lightning Safety Council (U.S.)

<http://lightningsafetycouncil.org/>



African Centres for Lightning and Electromagnetics Network

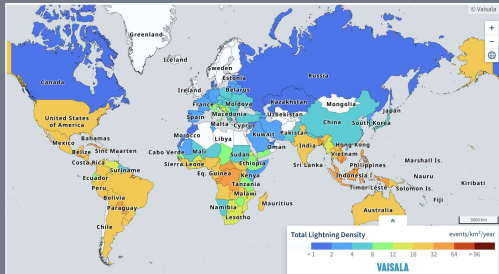
www.ACLEnet.org

More websites for lightning



National Weather Service, Lightning Safety

<https://www.weather.gov/safety/lightning>



Vaisala interactive global map

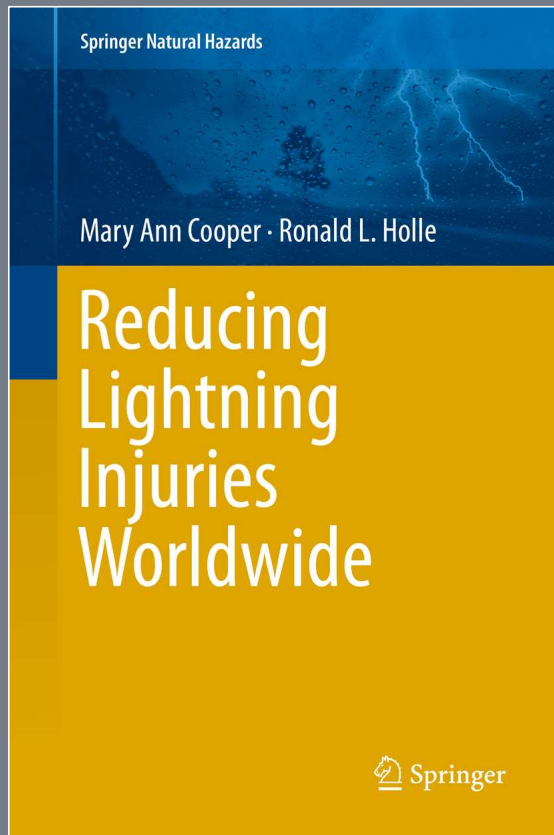
<https://interactive-lightning-map.vaisala.com/>



Vaisala 2021 Annual Report

<https://www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf>

Springer Press Books



Ronald L. Holle • Daile Zhang

Everything You Need to Know about Arizona Lightning

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