Questions & Answers Session A

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Amita Mehta (amita.v.mehta@nasa.gov) or Steven Goodman (steven.j.goodman@noaa.gov).

Question 1: Can we detect how intense lightning will strike on the Earth's surface for future predictions?

Answer 1: We're making progress. There are numerical prediction models for this. NOAA has models (RAP, RFFS) with a lightning parameterization. These models can do a good job predicting lightning in the next 24 hours, especially in the spring and fall, but not a very good job in the summer. The predictions are based on the development of the updraft and precipitation and ice particles aloft.

There are also publications highlighting lightning parameterizations as well:

- McCaul, E. W., Jr.,2009: Forecasting lightning threat using cloud-resolving model simulations. Wea. Forecasting, 24, 709–729, https://doi.org/10.1175/2008WAF2222152.1
- McCaul et al., 2020 DOI: 10.1175/WAF-D-19-0101.1; Romps et al., Science, 14 NOVEMBER 2014 VOL 346 ISSUE 6211.

Continuing current is another categorization of intense lightning and is known to be a cause of forest fires. There are some initial algorithms to try to predict this.

- Fairman, S. I., & Bitzer, P. M. (2022). The detection of continuing current in lightning using the Geostationary Lightning Mapper. *Journal of Geophysical Research: Atmospheres*, 127(5), e2020JD033451. https://doi.org/10.1029/2020JD033451
- Pérez-Invernón, et al. (2023). On the role of continuing currents in lightning-induced fire ignition. Journal of Geophysical Research: Atmospheres, 128, e2023JD03889.

Question 2: Considering an area, what variables are the cause for lightning?

Answer 2: Atmospheric instability and the height of the cloud itself extending above the freezing level leads to electrification and the subsequent lightning. Vertical development plays a significant role in the lightning flash rate. Lightning development over the ocean is not as frequent but the lightning has higher peak currents on average.

Question 3: In hydrology, what potential applications does the use of lightning measurements have?
Answer 3: Mountainous terrain can be a factor such as in the Mountain West region of North America where the radars are beam blocked by the high terrain. Lightning can help fill in gaps of radar coverage as storms with frequent lightning are more likely to be heavy rain producers.

Question 4: There is an understandable emphasis on low latency solutions for detecting lightning. Are there any efforts made to assemble different data sources after the fact to provide more accurate, integrated datasets for research in other areas (e.g., forest fires)?
Answer 4: We have a 20-second latency to get the data to the user (near-real time). Regarding research data sets there is a WMO-sponsored effort to establish stewardship for global lightning space-based and ground-based data sets. The landing page will be at the NASA GHRC DAAC (https://www.earthdata.nasa.gov/eosdis/daacs/ghrc). This should be stood up by the end of 2024.

Question 5: What is the current status of monitoring upward lightning and incorporating those data into the models?
Answer 5: With ground- and space-based systems, lightning monitoring is important for tracking and predicting lightning events to help with potential damages to infrastructure such as wind turbines, tall buildings and towers.

Question 6: Is there a way to discriminate cloud-cloud from cloud-ground lightning with GLM?
Answer 6: For In-Cloud (IC) vs. Cloud-Ground (CG) lightning discrimination - see Jaqueline Ringhausen paper: Classification of GLM Flashes Using Random Forests. Energy of lightning, location, horizontal extent, and duration are all listed as attributes to discriminate between the two. Cloud to ground flashes can have a longer duration and larger horizontal extent even though they go to the ground.

Question 7: Question 4b is more about a final definitive best estimate of where lightning (ground strikes) had occurred.
Answer 7: We don't have as good spatial resolution (6km) in some of the satellite missions versus ground based commercial measurements. Tools such as the lightning

mapper can help to identify trends of where lightning can happen. The horizontally extensive mesoscale weather systems have lightning flashes that produce many ground strikes along their path with a flash duration up to 15 seconds (Peterson et al., 2020. New World Meteorological Organization certified megaflash lightning extremes for flash distance (709 km) and duration (16.73 s) recorded from space. Geophys. Res. Lett., 47, e2020GL088888, https://doi.org/10.1029/2020GL088888).

Question 8: Could you shed light on whether there's any empirical evidence or theoretical basis to suggest that mobile phones, particularly when in use outdoors, might serve as attractors for lightning strikes?
Answer 8: I think this is a myth. Cell Phone towers can attract lightning. Do not stand under trees and stay in your car (a faraday cage-like conductor of electricity) if applicable.

Question 9: Is there any relation of heavy lightning in regions with coal mining or mineral enriched areas?
Answer 9: There was the Sago Mine coal fire started by lightning in West Virginia, USA, which unfortunately led to casualties.
https://www.cbsnews.com/news/report-lightning-caused-sago-mine-blast/
https://www.miningmagazine.com/coal/news/1264191/acarp-investigates-lightning-risk-ug-coal-mines.
I've heard that methane (fracking, oil wells) can have an impact on the formation of clouds and aerosols.

Question 10: Is thunder speed affected by drift velocity? And if so, does the capacitance of the cloud have proportionality with its volume, and so the strength of the lighting? Is it what you meant when you showed us light speed as general velocity and its relation to volume or did I misunderstand?.
Answer 10: My previous answer was in reference to information relating to a public warning. If you have a strong updraft and more charge, you could have more sources for lightning to propagate.
References on lightning and thunder:

- https://www.weather.gov/safety/lightning-science-thunder
- https://scijinks.gov/lightning/

Question 11: One source described the stepped-leader as invisible. Is this so?

Answer 11: It is *not* invisible. It is easier to see with radio based measurements and if the light is bright enough.

Questions & Answers Session B

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Amita Mehta (amita.v.mehta@nasa.gov) or Steven Goodman (steven.j.goodman@noaa.gov).

Question 1: Why are South America and Africa more prone to lightning?

Answer 1: In the tropics, the thunderstorms take place year round. In the extratropics, the cold seasons have far fewer thunderstorms. Warm air and humidity are key ingredients for thunderstorms. Note that most lightning occurs over land where storm updrafts are much stronger than over oceans as well as land-ocean and mountains where the convergence of the air is stronger leading to stronger vertical updrafts.

Question 2: Is there any map of global lightning in GIS format?

Answer 2: There are maps in NetCDF and HDF5. Check the NASA GHRC Hydrometeorology Distributed Active Archive Center (DAAC) in Huntsville, AL USA (https://www.earthdata.nasa.gov/eosdis/daacs/ghrc). We will highlight this in Part 2 of this training. Also check the WWLLN and Earth Networks web sites for their ground based lightning climatologies. Part 3 will discuss products from EUMETSAT for Europe and Africa.

Question 3: Can UAVs flying lower than cloud level contribute to lightning predictions?

Answer 3: UAV data are not used in the numerical weather prediction models that I know of. If temperature and moisture measurements were transmitted in real-time to use in weather forecast models they could be useful. How practical they are over land is an open question.

Question 4: How likely is it that lightning can hit a UAV flying at a low altitude? Can "normal" (most used) UAVs withstand lightning? Is anti-lightning equipment for UAVs cheap?
Answer 4: On an airplane, the negative curve occurs around 7 km (18,000 ft), and flying an aircraft that low is prone to lightning strikes. UAVs can fill gaps and provide regional information that could help to improve forecasting and lead to better storm forecasting. This is not a proven method however.

Question 5: There is some evidence that the cloud-to-ground strike duration is correlated with fire ignitions. Is it possible to sense strike duration from satellite observations?
Answer 5: This is known as continuing current. Lightning discharge on average lasts tens of milliseconds, but continuing current can last longer. For a lightning strike, it is not necessarily how powerful the strike is but how long it lasts for. Factors such as humidity and fuel sources can also affect fires from lightning strikes as well. See lightning continuing current references in the answer to Question #2 in Part A.

Question 6: Is there a link with Atmospheric Gravity Waves?
Answer 6: Severe storms can be affected by Gravity Waves by invigorating storms ahead of them.

Question 7: Can a hydrostatic or non-hydrostatic model be used for prediction of lightning?
Answer 7: Models can be used for prediction and can help for prediction systems such as those being used by NOAA. These models include explicit microphysics which include additional details. Refer to the answers in Question #1.

Question 8: In the aircraft observations- How are measurements done of thunderstorms at higher altitude in the sky? Respective aircraft observation.
Answer 8: We will look into this further after clarification. If referring to penetrating aircraft, they are useful for measuring particle size and type but have limitations.