Learning about Lightning

By Caleb Clarkson

As the sun sets over the horizon, dark clouds sweep through the plains, covering the landscape in deep night. The rumblings of thunder announce a storm's arrival, and previously unseen silhouettes are revealed against the night sky with every flash of lightning. The world goes quiet, and electricity fills the air. Lightning is just one of the many ways that electricity can be seen in our atmosphere. These brilliant bolts of electricity in the sky have captivated the imagination of storytellers and scientists alike. However, despite many years of research, much remains unknown about electricity in our atmosphere and how, exactly, lightning forms.

Lightning can form in many types of atmospheric disturbances, such as snowstorms and even volcanic eruptions! However, lightning is more often observed in thunderstorms, special clouds characterized by their ability to create lightning and thunder.

Thunderstorms usually occur in cumulonimbus clouds—wet, dense, and tall clouds that can vary in size, frequently extending upwards of 40,000 feet into the air. In the soaring columns of a cumulonimbus, air drafts move freely up and down the cloud, with warm air rising and cold air sinking. Riding on those air drafts are tiny bits of water. As the air rises, it reaches a point high enough in the atmosphere that the water freezes and becomes ice crystals. Simultaneously, frozen water high in the cloud sinks on downdrafts and becomes a form of soft hail called graupel.

Rising ice crystals and falling graupel pass by each other most frequently near the center of the cloud, where the fastest drafts of air move. As they pass closely, falling graupel and rising ice crystals collide. A phenomenon occurs: the falling graupel takes electrons from the rising ice crystals. The slightly positive ice crystals continue to rise, and the slightly negative graupel particles continue to sink, resulting in the top section of the cumulonimbus being positively charged and the lowest section being negatively charged.

Over time, the positive and negative charges in the cloud grow and begin to separate until two well-defined electrical regions form. As the charges continue to separate, a strong electrical field develops, and the stage is set for lightning.

The separation between the positive and negative areas prevents electricity from flowing freely. However, when the charges grow strong enough, they overcome the resistance and jump the gap, creating lightning. Because the electrical field between the charged areas is strongest inside the cloud, most lightning occurs within the cloud, from one charged area to another. This type of lightning is called cloud-to-cloud lightning. In some cases, the charge is strong enough to jump between the ground and the cloud, forming ground-to-cloud lightning.

The jagged shape of a ground-to-cloud lightning strike results from the step-by-step path negative charges take as they approach the ground. The negative charge moving from the cloud to the ground is called a stepped leader. Its forked shape searches for the path of least resistance.

As one of the negative leaders approaches the ground, a positive leader moves upward from the ground to meet it. When the leaders touch, the electrical current is complete, and large amounts of electricity are transferred, forming the iconic lightning bolt that we see lingering behind. The leaders move faster than the human eye can follow, leaving only the lightning visible.

Though much has been learned about lighting over the years, mysteries remain. Exact mechanisms for when lightning strikes and where have not been discovered, and the full effects of lightning on the atmosphere have yet to be fully realized. Even less is known about the mysterious ball lightning, a phenomenon where an orb of lightning floats slowly through the air.

As scientists learn more about lightning, one thing remains clear: lightning will continue to captivate us.

Photo caption: A bolt of ground-to-cloud lightning