

Lightning Applications in Weather and Climate

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Thunderstorms, and lightning in particular, are a major natural hazard to the public, aviation, power companies, and wildfire managers. Lightning causes great damage and death every year, but also tells us about the inner working of storms. Since lightning can be monitored from great distances in storms, it may allow us to provide early warnings for severe weather phenomena such as hail storms, flash floods, tornadoes and even hurricanes. Furthermore, lightning itself may impact the climate of the Earth by producing NO_x in the lightning channel, a precursor of tropospheric ozone, which is a powerful greenhouse gas. Thunderstorms themselves influence the climate system by the redistribution of heat, moisture and momentum in the atmosphere.

1. General

There are approximately 50 lightning flashes every second somewhere on the planet [1]. The distribution is not random, with 90% of the thunderstorms and lightning being over the tropical landmasses, and in the summer hemisphere. This is also the planetary distribution of TLEs that occur above these thunderstorms, although the distribution of sprites and elves appear to be somewhat different, with elves more prevalent over the oceans [2].

2. Lightning and Weather

Lightning in thunderstorms tells us a lot about the microphysics and dynamics of thunderstorms, and hence changes in the lightning activity can tell us about changes in the internal processes within the thunderstorms.

Lightning discharges can be monitored from great distances, with information about the time, location, polarity, peak current and multiplicity available from ground detection networks. Research has shown that many severe weather storms show anomalous lightning activity, whether due to changes in the amount of lightning activity, the ratio of incloud vs. cloud-to-ground lightning, or the polarity of the lightning in storms [3].

Lightning is also a major cause of forest fires in high latitudes, causing huge damage every year. Since we can track lightning activity remotely in real time using ground-based lightning detection networks, lightning can be used in early warning systems for short term forecasts of severe weather and for fire management [4]. In the future this may be done using satellite lightning sensors that are planned for launch in the next few years.

3. Lightning and Climate

While future climate change may have direct impacts on the distribution and intensity of lightning and thunderstorms [5], lightning itself impacts the Earth's climate by the production of nitrogen oxides (NO_x) that later influence tropospheric ozone concentrations [6]. Ozone is a strong greenhouse gas, and hence influences the radiation balance of the planet. Hence, changes in lightning activity in a warmer climate may result in positive feedbacks that amplify the initial warming.

Lightning is also a sensitive indicator of regional surface temperatures [7], and upper tropospheric water vapour [8], and hence lightning may actually be a convenient tool to monitor changes in the climate system. Of course, any changes in future thunderstorm activity will also have implications on severe weather patterns across the globe, and perhaps TLE, and TGF production.

4. References

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