Every area where cloud lightning is overhead is at risk from cloud-to-ground (CG) lightning. The only effective way to capture the full extent of the threat from CG lightning is with VHF (very high frequency) total lightning mapping provided by Vaisala Total Lightning Sensor TLS200 and Vaisala Thunderstorm Total Lightning Sensor LS8000 technology.

As a thunderstorm approaches a fixed asset (90% of the time) where people are located, VHF cloud lightning mapping provides tens of minutes of lead time before the first CG strokes reach the asset. When a thunderstorm develops directly over a fixed asset (approximately 10% of the time), the high cloud flash detection efficiency – which exceeds 90% – enabled by this technology maximizes lead time during thunderstorm growth, because cloud flashes usually precede CG lightning.
Most importantly, VHF cloud lightning mapping vastly improves CG lightning warnings by eliminating all false alarms. For severe weather nowcasting, lightning data provides more frequent updates than radar. Rapidly increasing cloud lightning rates indicate a strengthening storm updraft capable of producing large hail. Rapidly decreasing cloud lightning rates indicate a weakening storm updraft as rainfall and strong winds reach the ground. Meteorological agencies and universities around the world have shown how VHF total lightning mapping has improved protection and nowcasting.

**Combining VHF and LF Enables High Efficiency and Accurate Stroke Location**

The Vaisala Thunderstorm Information System combines highly accurate lightning sensing, lightning location and parameters, as well as real-time and historic application software. The system integrates two effective lightning detection technologies: VHF interferometry and low-frequency (LF) combined magnetic direction finding and time of arrival.

VHF interferometry technology enables highly accurate detection and mapping of cloud lightning, while LF combined magnetic direction finding and time-of-arrival technology offers the highest detection efficiency and most accurate location for CG lightning strokes. By combining these two technologies, more than 90% of all lightning can be detected.

**Limitations of Cloud Lightning Detection with LF and VLF Technology**

Cloud-to-ground lightning emits the highest amplitude pulses in the LF (low frequency) to VLF (very low frequency) range due to the large amount of current traveling over long distances. In contrast, cloud lightning results in short-range discharges with weaker current, producing small LF pulses near the origination of the cloud flash but larger VHF pulses throughout all branches of the cloud flash. Since the overall electrification and lightning discharge process involves many electrical events, single origination points detected in the VLF/LF range are not at all representative of the true spatial extent of the lightning threat.
Lightning Mapping Enables Improved Storm Detection and Protection

Every area where cloud lightning is overhead is at risk from CG lightning. The only effective way to capture the full extent of the threat from CG lightning is with the VHF total lightning mapping technology of TLS200 and Vaisala Thunderstorm Total Lightning Sensor LS8000 VHF. Mapping provides a much more comprehensive picture of the lightning threat through all phases of thunderstorm activity, from growth and development through to maturity and decay. This feature provides a clear picture of the full electrification of the thunderstorm cloud, including the potentially dangerous anvil and stratiform areas that appear later in the storm life cycle. At each stage of the storm, detailed lightning mapping provides a clearer picture of the storm life cycle and potential lightning risks to ground-based activities. Simply detecting the cloud-flash origination point using VLF/LF technology is not enough.

Consider the most common situation of a thunderstorm approaching a fixed asset where people are located (occurs approximately 90% of the time). VHF cloud lightning mapping provides tens of minutes of lead time before the first cloud-to-ground strokes approach the fixed asset.

In the relatively infrequent situation where a thunderstorm develops directly over a fixed asset (approximately 10% of the time), the high cloud flash detection efficiency—which exceeds 90%—enabled by VHF cloud lightning mapping technology maximizes the lead time during the growth phase of a thunderstorm, because cloud flashes usually precede CG lightning.

Continuous Monitoring of Storm Activity Using VHF Total Lightning Mapping

VHF total lightning mapping improves thunderstorm nowcasting. It enables monitoring of rapid changes in updraft intensity and new updraft development as well as any rapid changes in thunderstorm organization. (See the figure on the left) VHF total lightning mapping allows continuous monitoring of thunderstorm growth and dissipation. Forecasters can use the valuable dataset provided by continuous total lightning mapping to monitor thunderstorm activity at much shorter timescales than 5-15 minute intervals typically possible through radar volume scan updates. Total lightning rates and areas of coverage help forecasters to identify updraft intensification and new updraft development in a storm.
Improved Location and Timing of Severe Weather Events

Lightning data provides decision makers with updates at much more regular intervals than radar reflectivity data – every two minutes or less compared to approximately every five to 15 minutes. Studies have also proven that mapped cloud lightning data can provide a better indication of the severity of a storm than CG lightning information, especially when combined with high-quality radar information. The high detection efficiency (over 90%) of cloud lightning enabled at VHF frequencies with more precise mapping of total lightning provides earlier warning of the locations and times of severe weather events that can follow rapid changes in lightning rates and spreading in areal coverage as the storm matures. A rapid increase in cloud lightning rates indicates that the storm updraft has strengthened and is capable of producing large hail. A rapid decrease in cloud lightning rates indicates that the storm updraft strength has weakened as rainfall and strong winds reach the ground. As it spreads, this downdraft presents a significant danger to aircraft, power lines, and other surface assets.

Weather Prediction Modeling with Lightning Data Assimilation

The assimilation of lightning data into weather models has also enabled the production of more accurate forecasts of thunderstorm activity and other weather activity. Notable examples include the Rapid Update Cycle model used by the National Weather Service and the aviation community.

Time series of VHF total lightning mapping in red and VLF/LF cloud-to-ground strokes in blue for a severe thunderstorm in southern Arizona during a 100-minute period. Note the occurrence of hail (0120 UTC) at the time of increasing cloud flashes and wind (0130 UTC) as cloud flashes are decreasing, while there is an absence of CG strokes at the time of severe weather and peak cloud activity.