LOCATIONAL ACCURACY ELLIPSES

CONTEXT

Estimating the location of cloud-to-ground and intra-cloud discharges is subject to an absolute error that consists of:

- a systematic error, related to the accuracy of angle and time measurements,
- and a random error that depends on interference with radio transmitters, the intensity of the current in the discharge, the shape of the flash and other factors.

A statistical analysis of archived data can be used to determine a number of correction parameters. These are used by the calculator to correct each location.
The random error cannot be corrected, but it can be estimated by an ellipse centred on the calculated position of each discharge, indicating the minimum and maximum error. This estimate is important for certain applications, including incident correlations.
As the systematic error is corrected, the absolute error is reduced to the random error.

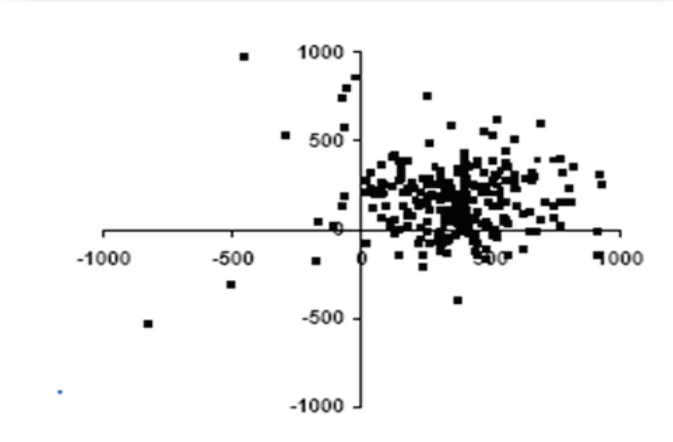


Figure 1. *This graph shows the locations of the discharges as calculated by a lightning locator network. In reality, the discharges all have the same position (the centre of the axes), namely the top of a communication tower. As can be seen, the barycentre of the cluster of points is displaced to the right:* ***this is the systematic error.***

The dispersal of the points with respect to the cluster's barycentre represents the ***random error.*** *The distance from a given point to the centre of the axes represents its* ***absolute*** *location* ***error*** *de localisation. It can be seen that each point has a different absolute error.*

PRINCIPLE

The ellipse is derived from the use of the **least squares method** which allows the calculator to process sensor measurements and locate the discharges. This method minimises measurement errors and leads to an optimal location estimate. Residual measurement errors determine the theoretical random error used to calculate the ellipse.

According to the **work of Standsfield (1947)**, the random error of a lightning location can be estimated with a given probability by an ellipse of which:

- **The semi-major axis** represents the theoretical maximum error
- **The semi-minor axis** represents the theoretical minimum error
- **The orientation** represents the direction of the maximum error

For this to apply:

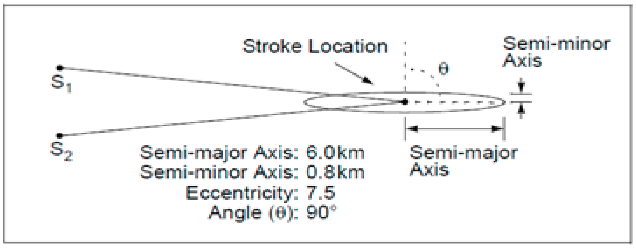
- The measurement errors must follow a Gaussian law
- The systematic errors must be eliminated.

HOW IT WORKS

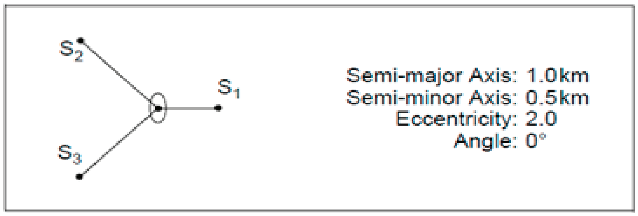
Each calculated location is accompanied by the values of its estimated accuracy ellipse for a probability of 50%. The probability can be changed by simply multiplying the values at 50% by a factor given in the following table:

Scaling Constant	Probability
1	50%
1,82	90%
2,57	99%

Thus, if the semi-major axis is 1 km at a probability of 50%, it will increase to 1.82 km at 90% and 2.57 km at 99%.



Ellipse of a poor location estimate



Ellipse of a good location estimate

NOTE

- THE ELLIPSE IS A STATISTICAL INDICATOR BASED ON THE MEASUREMENT ERRORS MADE BY THE SENSORS. THE POSITION REPORTED BY MÉTÉORAGE REMAINS THE MOST LIKELY BASED ON THE MEASUREMENT DATA. THE ELLIPSE THUS SERVES AS A CONFIDENCE INDEX FOR DISCHARGE POSITIONAL DATA; IT DOES NOT REPRESENT AN ABSOLUTE AND REAL MEASURE OF THE ERROR MADE.
- SYSTEMATIC ERRORS ARE CONSIDERED TO BE ALMOST ZERO IN THE MÉTÉORAGE NETWORK. THIS IS CONFIRMED BY REGULARLY CHECKING THE DATA AGAINST 'FIELD' DATA. THE ABSOLUTE ERROR.CAN THEREFORE BE CONSIDERED TO CONSIST OF THE RANDOM ERROR.