MÉTÉORAGE

TECHNICAL NOTE

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Calculation principle of peak intensity of stroke current

The Météorage network gives an estimate of the intensity of the stroke current that flows through lightning strikes that are produced between clouds and the ground and those that remain in the air. This calculation is carried out by the central calculator in real time using the peak magnetic field amplitude measured by the sensors.

Calculation principle

The first step consists of 'correcting' the measurements to take into account the attenuation of the signal while travelling to the sensor. This is because the propagation of an electromagnetic wave on the ground causes a modification to the form of its signal [1][2]. Furthermore, the sensors' measurements must be 'standardised' in order to be able to determine the average magnetic field radiated by the return stroke. This operation consists of calculating, for all the sensors, the field that would have been detected if they had been located 100 km from the return stroke.

The formula below is used to standardise the measurements (first part of the equation) and to correct the propagation effect (second part of the equation) [3].

$$RNSS = SS * \left(\frac{r}{100}\right)^{b} * \exp\left(\frac{r - 100}{L}\right)$$

SS, value of the magnetic field measured by a sensor
r, distance between the sensor and the return stroke in km
b and L, parameters of the model
RNSS, standardised and corrected value of field B of the attenuation of the ground used in the average

In the second step, it is possible to convert the value of the magnetic field measured by the sensors (V/m) into electrical intensity (kA). To achieve this, the calculator uses a model of the return stroke that expresses the value of a field radiated by a vertical antenna according to the current circulating in the antenna and the distance at which the field is measured [4]. This so-called 'Wire Antenna Model' was calibrated according to measurements taken on currents in triggered flashes at Camp Blanding in Florida (USA) [5] or from instrumented towers [6][7]. Using a simple multiplication, it is possible to transform the radiated magnetic field into a return stroke current.

Estimation of measurement errors

To measure the performance of the calculation of the return stroke current, heavy technical means must be implemented. Therefore, it is necessary to be able to obtain a direct measurement of the current, i.e. to be able to know where the lightning will strike in order to measure its characteristics. For the moment, only two techniques exist: triggered lightning and instrumented towers.

A recent study based on current measurements carried out at Camp Blanding in Florida (USA) show that the median error made on the estimation of the return stroke current provided by the National Lightning Detection Network (NLDN) in the USA, whose technology is identical to Météorage's, is estimated at 14% [8].

Limitations in the use of the data

The calibration mode described above implies that, strictly speaking, only the subsequent negative return stroke currents provided by Météorage are calibrated. The strokes obtained by triggered lightning methods or instrumented towers, only have the characteristics of natural negative subsequent return strokes. Hence, there is still some uncertainty regarding the intensity values calculated for the first negative return strokes, positive return strokes and intracloud discharges.

Lastly, one study questions the detection networks' ability to correctly estimate the intensity of the first negative return strokes of a very high intensity [9], which is coherent with the previous remark. There is a theoretical limit estimated at 300 kA for discharges with an ionised channel 4 km high, which corresponds, in general, to the centre of the negative charge in a cumulonimbus in our latitudes. This value could increase to 450 kA in the case of tropical storms which have greater vertical extensions.

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