EUCLID NETWORK PERFORMANCE AND DATA ANALYSIS

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1. INTRODUCTION

Currently in almost every country in Europe lightning location systems are installed. Some of them are in operation for more than 10 years. In 2001 several countries (Austria, France, Germany, Italy, Norway, Slovenia) formed a cooperation called EUCLID (**EU**ropean **C**ooperation for **LI**ghtning **D**etection). The goal of this cooperation is to provide European wide lightning data with homogeneous quality.

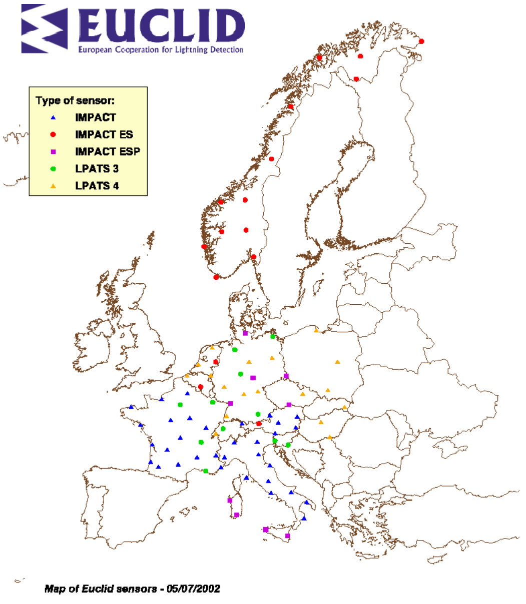

Fig. 1: EUCLID network configuration

The EUCLID network consists of 12 LPATSIII, 17 LPATSIV, 33 IMPACT and 25 IMPACT ES/ESP sensors (see Fig. 1).

2. EUCLID NETWORK PERFORMANCE

Fig. 1 shows very clearly that the system is not designed as a European wide network but it is an interconnection of originally designed national systems. This explains also why there are that many sensor types and why the baselines between the individual sensors are in a range from 120 km to 300 km. Therefore it is unlikely that the performance of the EUCLID system is uniform over the whole area.

To evaluate the differences in performance in the individual regions of the network the average number of sensors reporting (ANSR) is evaluated because this parameter is related to the detection efficiency (DE) of the network. Fig. 2 shows the ANSR for EUROPE for the time period from 09/2001 to 07/2002. During a test period in July 2002 already some sensors from the Swedish network contributed to the EUCLID data and therefore data from these sensors are included in the ANSR statistics. We consider an ANSR of

5 sensors as sufficient. It can be seen that the main part of the EUCLID network has an ANSR of greater than 5 but that there are also regions with ANSR < 5. These regions are mainly

- Norway
- Sicily and Sardinia

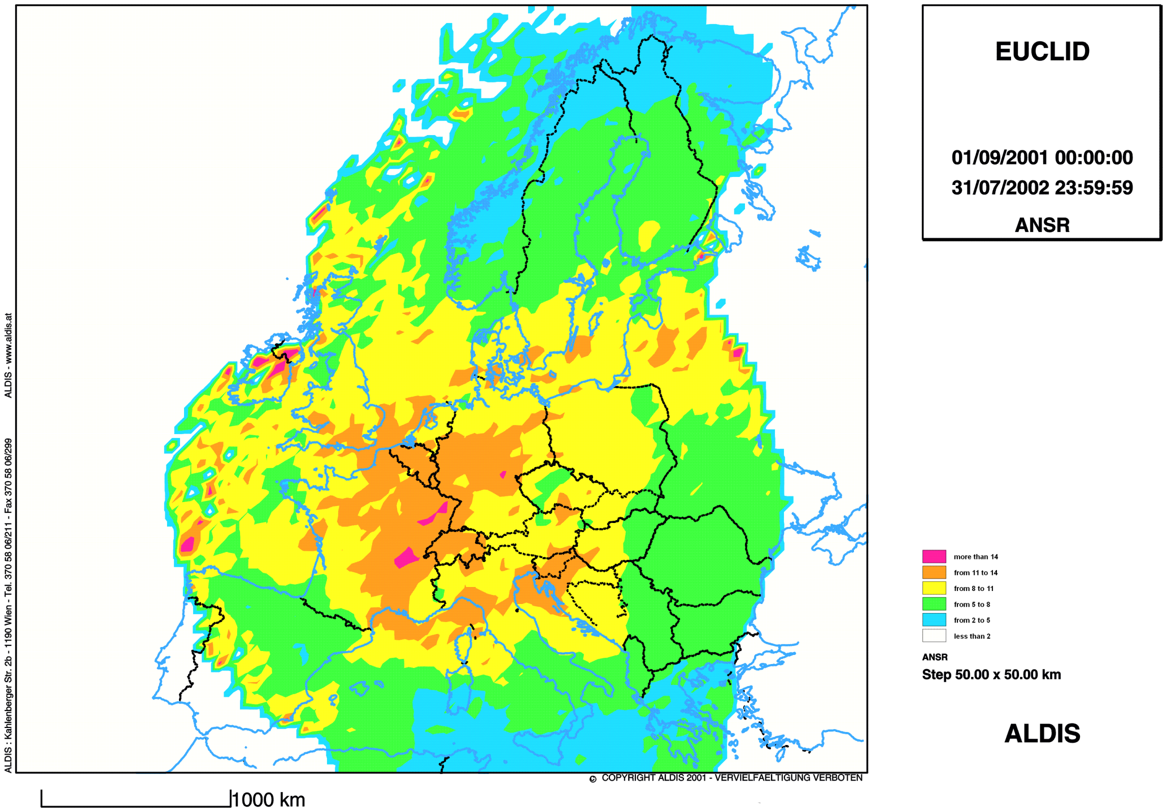

Fig. 2: Average Number of Sensors Reporting (ANSR)

The Norwegian network has the problem of a bad geometry. The shape of Norway permits in the northern part almost only sensor locations which are on a line. The recently integrated sensors in Sweden could help to solve this problem. The current online time of the Swedish sensors was too short to see a significant effect on the ANSR. The reason for the reduced performance in Sicily and Sardinia is quite similar. An upgrade of the sensors to the newest technology or the interconnection of Tunisian sensors could improve the performance of the network in this region.

Anyhow the performance of the EUCLID network is always better than the performance of the individual networks.

Nevertheless there are also some drawbacks of interconnecting networks. One drawback of a large network is the possibility to create false detections by detecting the ionospheric reflections of lightning radiated fields by remote sensors. The following figure shows such an event.

Fig. 3A shows a stroke with negative polarity of about 23 kA which was detected by eight very close sensors. The stroke detected 600 µs after the event shown in Fig. 3A is a positive event with an amplitude of about 29 kA (see Fig. 3B). This stroke was detected by 9 more than 600 km distant sensors.

A) B)

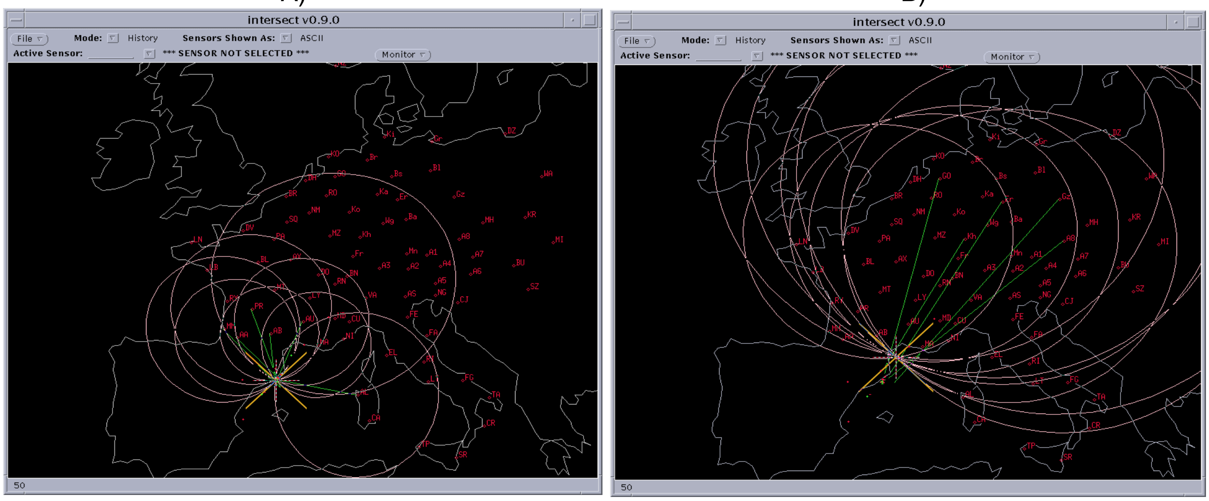

Fig. 3: Location based on the ground wave (A) and the ionospheric reflection (B)

Although 600 µs is less than the dead time of the sensors we think that the stroke in Fig. 3B is not a real stroke but the detection of the ionospheric reflection of event shown in Fig. 3A.

3. FIRST LIGHTNING STATISTICS

Although there is not a complete year of data available for the statistics (even a summer month is missing) the main areas with large lightning activity are visible in the lightning density map (Fig. 4). These regions are the Italian-Slovenian border south of Austria and the Italian-Swiss border. We tried to verify the EUCLID densities and compared these regions with large lightning density with results from the optical transient detector (OTD). Although the OTD data is from the years 1995 to 1999 it shows the same areas with increased lightning density. The OTD data further shows that with the current extent of the EUCLID network already the regions with the highest lightning activity in Europe are covered.

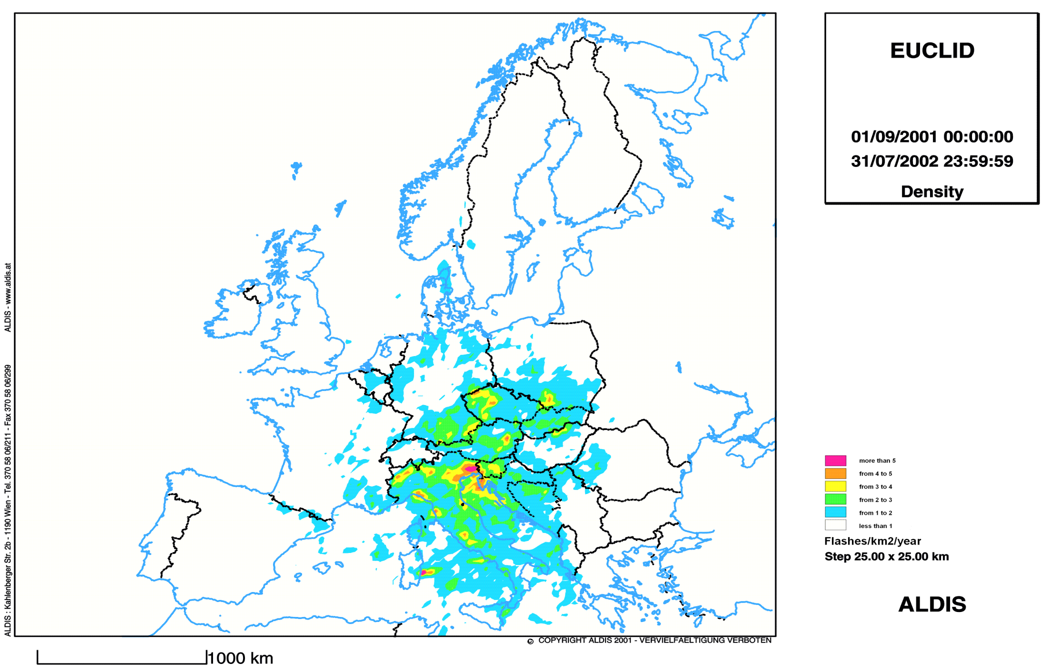

Fig. 4: Flash density over Europe

Amplitude characteristics for positive and negative flashes are extracted in the center of the network for an area with latitude in the range from 45° to 52° and longitude in the range from 5° to 18°. For the EUCLID network the lightning peak current is calculated from the range-normalized field signal S_n with a calibration factor of 0.23 [Diendorfer et al., 1998].

$$i_p=0.23\ S_n$$

where i_p is the lightning peak current in kA and S_n is the mean of the signal strengths from the sensors participating in the location in LLP-units range-normalized to 100 km.

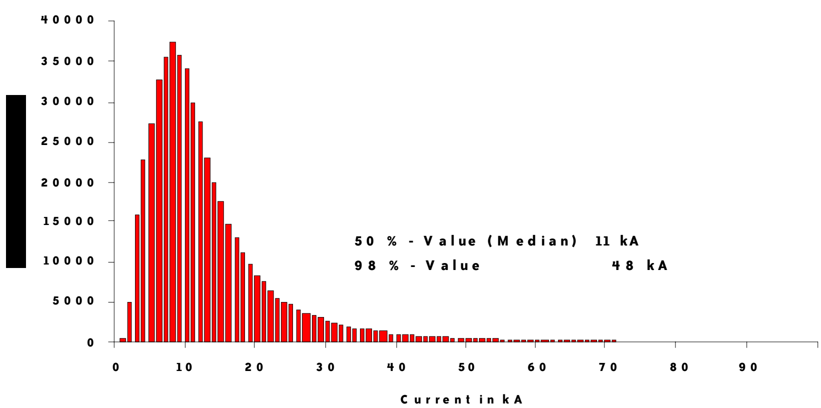

Fig. 5: Lightning peak current distribution for negative flashes

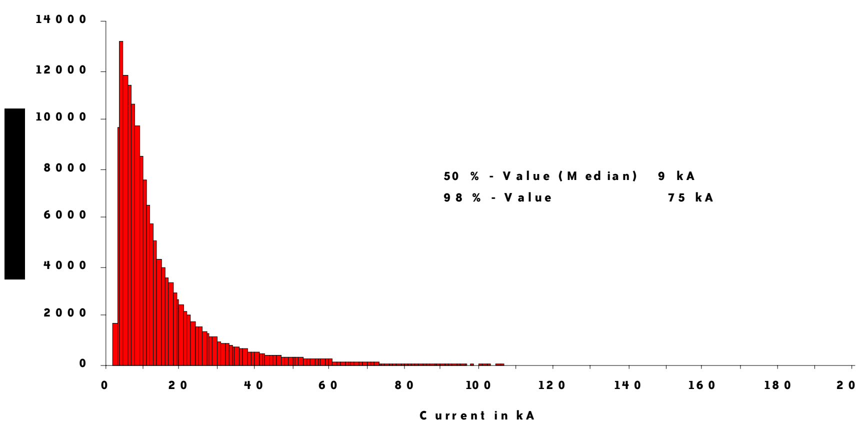

Fig. 6: Lightning peak current distribution for positive flashes

The peak current distribution for negative lightning (Fig. 5) shows a small median value which reflects the good DE of the network in the region of investigation.

The peak current distribution for positive lightning (Fig. 6) shows an even smaller median value compared to negative lightning. One likely reason for this behavior is the false assignment of cloud to cloud strokes (CC) as cloud to ground strokes (CG) [Cummins et al., 1998]. This could be due to two reasons:

a) The EUCLID lightning processor (LP2000) is running with the default configuration regarding the CC assignment of a stroke, that means, a stroke is assigned as CC if all the sensor reports are assigned as CC.

b) The criteria to distinguish between CC and CG strokes at the level of the sensor data is not optimized.

Further work is necessary to improve both criteria.

The mean of flash peak current for negative strokes also varies by region. From Fig. 7 it can be seen that the average amplitude is low in a region in the Czech Republic. This region of low amplitude flashes could be also related to the false assignment of CC strokes to CG strokes as describe above. CC strokes normally have smaller current amplitudes and all the sensors in and around the Czech Republic are capable of detecting CC strokes and therefore there is a higher probability to misinterpret a CC as CG stroke.

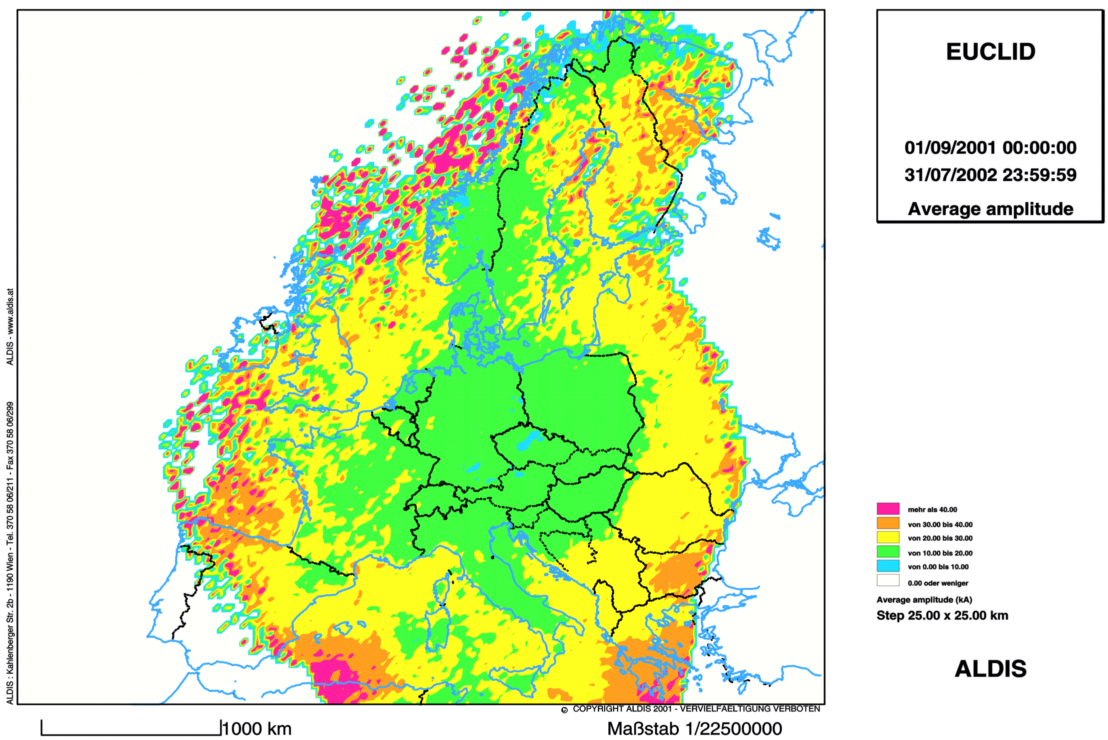

Fig. 7: Average amplitude over Europe

It is further interesting to note that also in the north of Norway in a region with poor DE the average amplitude for negative flashes is quite low. This should not be a system effect because bad DE is normally related to high amplitudes as it can be seen in regions far away from any sensor location (mainly red areas in Fig. 7).

The effect of greater amplitudes over the sea reported by Orville and Huffines [2001] for the NLDN data is not seen very clear in this first statistics. Also we are not sure whether this effect is real or is an effect of higher ground conductivity over the sea.

We did not analyze the multiplicity of flashes during the first year of operation very detailed because during the first year the system was running with a bug in the flash grouping algorithm till spring 2002. Further the algorithm was configured with a maximum multiplicity of 15. After the upgrade and reconfiguration of the maximum allowed multiplicity to 99, the highest multiplicity of a flash we detected was 28!

REFERENCES:

Cummins K.: A Combined TOA/MDF Technology Upgrade of the U.S. National Lightning Detection Network, *Journal of Geophysical Research*, Vol. 103, No. D8, Pages 9035-9044, 1988.

Diendorfer G., Schulz W., Rakov A.V.: Lightning Characteristics Based on Data from the Austrian Lightning Locating System. *Transactions on Electromagnetic Compatibility (EMC*), Vol. 40, No. 4, Nov., 1998.

Orville R. and Huffines G.: *Cloud-to-Ground Lightning in the United States: NLDN Results in the first Decade*, 1989-98. American Meteorological Society, 2001.