Examples of severe destruction of trees caused by lightning

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Abstract: The paper presents two examples of trees severely damaged by lightning strikes. The trees literally burst, when the lightning current passed through the trunk. Huge fragments were blasted away from the trunk and the roots, over distances of several tens of meters. The bursts even caused considerable damage in the surroundings, e.g. removing large patches of bark from nearby trees, when hit by fragments at high speed. The data of lightning location systems revealed that the trees were most likely struck by high amplitude positive cloud-to-ground lightning.

Keywords: Tree, damage, positive stroke

1. Introduction

There are numerous reports every year of people who have been killed or injured while seeking protection from lightning under isolated trees. Fatality is usually caused by either a side flash from the tree trunk or one of the branches or by step voltages in the vicinity of the trunk. Sometimes, persons when surprised by lightning during outdoor activities are recommended to move to tall trees to be protected against direct lightning strikes. The protection zone (e.g. [1]) of such a tall tree is comparable to that of Franklin rod with the same height. A minimum protection distance of some meters (about 3 m) should be kept from the trunk or the branches to avoid the flash-over and both feet should be kept closely together to minimize step voltages (e.g. [2]).

Following we present some examples showing an additional threat by trees, which virtually exploded during a direct lightning strike. In such a case, big fragments of the tree are blasted away over distances of several tens of meters. The extent of damages is so severe, that persons standing nearby will be seriously injured or even killed.

Norinder [3] reports about a fir, which virtually exploded during a lightning strike on July 1940 nearby Upsala, Sweden. The trunk of the fir had a diameter of about 45 cm at the base. Obviously the trunk splintered, when a lightning current of high amplitude entered the trunk. Besides smaller pieces also big fragments in the meter range were blasted away up to about 30 meters. ***Norinder*** classified this event as "cold lightning strike", because no scorch marks could be detected. ***Tayler*** [4] gives a review about the phenomenon of virtually destroyed trees by lightning. Almost exclusively old and therefore large conifers exploded. Commonly the trunks of old conifers have internal defects as voids or ruptures, where the breakdown strength is comparable to that of air outside the trunk. If a flashover occurs to such internal defects, this may explain the demolition of the tree.

2. Demolition of a fir in a forest 100 km north from Munich in spring 2000

A severe demolition of a fir occurred during a thunderstorm in the spring 2000 about 100 km north from Munich, Germany (latitude 11° 51' 34" east, longitude 48° 41' 41" north). The fir was located at the boundary of a forest with grassland.

The fir had a diameter of more than 60 cm at the base and a height of about 32 m. Such a tall tree belongs to the category of the largest firs in German forests. The fir splintered into three major fragments, (1) an about 14 m long top fragment, (2) an about 8 m long bottom trunk fragment and (3) an about 10 m long fragment of the trunk mid-section (see fig. 3). The most severe demolition occurred in the lower part of the trunk. The major bottom trunk fragment only comprised about 1/3 of the former trunk. The rest was blasted away in smaller fragments with weights up to more than 100 kg. Each of these major fragments is estimated to have a weight in the order of half a ton.

When a tree is cut, typically the top of the tree is farthest away from the stump. Opposite to that, here the top fir segment was located closest to the stump fragment (Fig. 1). The major bottom fir fragment was blasted away about 16 m and the major mid-section fir fragment more than 20 m, respectively.

Fig. 3 shows the locations of the fragments. The major top and mid-section fragments are marked by "1" and the major bottom trunk fragment by "4", respectively. The area surrounding the fir was peppered with debris of various size. At the base of the fir only an about 3 m high thin stub remained, while major parts of the roots were blasted away leaving a crater about 70 cm deep (Fig.1).

Parts of the roots were found even in distances of several ten meters, e.g. a root fragment of about 40 kg was located in about 40 m distance. These very severe destructions corroborate, that the trunk and the root violently exploded.

Figure 2 shows the major top fir fragment in detail. An about 5 cm wide sheet of the bark is removed at a length of about 2,1 m. Such sheets of stripped off bark are typical for trees struck by lightning.

Figure 1: Remnant stub with the top fir fragment just behind

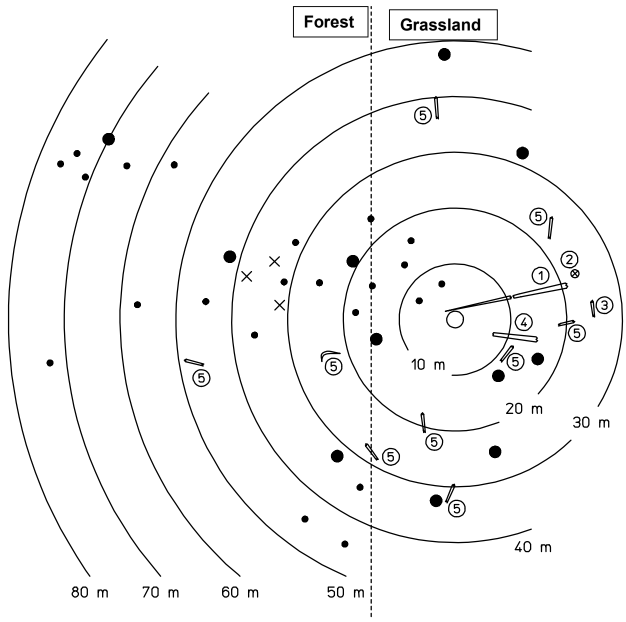
Figure 2: Major top fir fragment showing a strip of removed bark by the lightning current

Figure 3 shows the distribution of the fragments around the fir. The numerous small splinters and fragments with weights less than 1 kg are disregarded. About 10 fragments weighing between 20 kg and 70 kg were found in distances of up to 50 m around the fir. More than 10 smaller fragments between 10 kg and 20 kg were located in distances of up to 70 m from the fir. Smaller fragments between 1 kg and 10 kg were blasted over distances of up to 80 m.

Generally, the specific weight of the fragments was comparatively low and the wood pretty dry. At the fragments and the splinters no scorch marks could be found. Also no scorch marks could be detected at the trunk surface, where the strip of bark was removed (Fig. 2). These observations are in concordance to the report of ***Norinder*** (see above).

Most of the larger fragments were found on the grassland (see Fig. 3). Figure 4 shows an about 3 m long fragment sticking like a spear in the grassland about 23 m away from the fir (see number 2 in fig. 3).

Opposite, the smaller fragments were preferably blasted towards the forest. The explosion was so intense, that at more than 10 surrounding trees large patches of the bark were removed obviously by fragments hitting them with high speed (Fig. 5). Even at three trees in distances of more than 20 m large bark patches were missing (see "x" in fig. 3). E.g. in a distance of about 23 m a tree was found, with a nearly 1 m^2 patch of bark missing at a height of about 18 m.



1: Top fir and mid-section fir fragments (total length about 24 m)
2: Spear shape fragment of the trunk (~ 3 m length)
3: Trunk segment of more than 100 kg weight
4: Major base trunk fragment (1/3 of the trunk diameter, ~ 8 m length)
5: Trunk segments of 20 … 70 kg
● Trunk or root segments of 10 … 20 kg
• Trunk or root segments of 1 … 10 kg
x Remote trees with large patches of removed bark (more than 30 m distance)

Figure 3: Location of fragments with a weight of > 1 kg around the damaged fir

Figure 4: Spear shape fragment of the trunk (~ 3 m length)

Figure 5: Trees with bark damages marked by arrows

Fig. 6 shows the reconstruction of the current paths along and through the fir. The lightning current attached the bark about 4 m below the top. From there, the current obviously flew just below the bark stripping off the above mentioned sheet of bark (about 5 cm wide and about 2,1 m long). At the height of about 26 m a hole was found, where obviously the current entered the trunk. The current then flew internally through the trunk to the roots, where it entered the ground. At this transition to ground probably the earth resistance was too high resulting in arcing at the roots. These arcs may be the reason, why the trunk and major parts of the roots were blasted away, leaving the 70 cm deep crater.

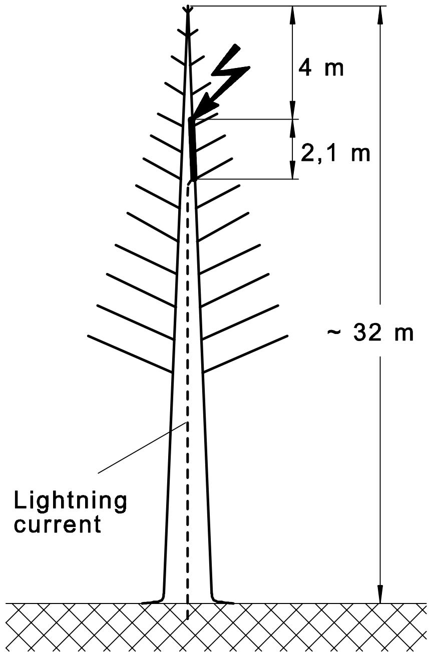


Figure 6: Schematic sketch of the lightning current path

The forest official informed us some days after this event. Some workers staying in the vicinity of the forest believed to having heard an unusual loud thunder in the morning of the 12th of May 2000, possibly enhanced by the bang of the fir explosion. This assumption is corroborated by the German BLIDS lightning location system [5]. During the period from mid-April until end of May lightning activities in this area were registered only for May, 12th. That day, a first period of lightning activity occurred between 7 and 9 a.m. However, the recorded lightning strikes had comparable low current amplitudes. The lightning activity resumed about one and a half hour later. During this second thunderstorm the BLIDS location system detected three positive cloud-to-ground lightning.
Table 1 contains the data of these three positive strokes, where the closest one (location distance 1 km) had the highest current amplitude of about 47 kA. Thus it is likely, that the fir was struck by one of these positive strokes.

Date	12/May/2000	12/May/2000	12/May/2000
Time (UTC)	10:33:44	10:37:48	10:40:37
Latitude	11,856°	11,840°	11,874°
Longitude	48,703°	48,708°	48,712°
Typ	Positive	Positive	Positive
Current amplitude	46,8 kA	36,7 kA	35,5 kA
Location distance	1,0 km	2,3 km	2,1 km

Table 1: Data from the German BLIDS lightning location system

3. Lightning caused tree damage in Austria

Similar destructions on a tree occurred in Austria at about midnight of July, 3rd 2000. At this time in the area of Frankenburg (Upper Austria) an exceptional loud thunder was heard by local residents. In the morning of July 4th a fir tree with a diameter of about 100 cm at the base was found completely destroyed by the lightning strike at a location 48° 02' 32"N and 13° 25' 46" E.
Fig.7 shows the remaining stub splintered down to the ground level. Pieces of different size and weight were found at distances of up to 30 meters. We have to note that this tree was surrounded by other trees of similar height in all directions and therefore we have to assume that the pieces did hit surrounding trees. Also in this case the top section of the tree was more or less intact (wood was not splintered) showing scorch marks on the surface (Fig.8).

Figure 7: Remnant, splintered stub of a fir tree of about 100 cm diameter (Photo courtesy of C. Kretz)

Figure 8: Top section of the tree showing scorch marks (Photo courtesy of C. Kretz)

A search in the database of the Austrian lightning detection system (ALDIS) [6] resulted in a located positive lightning flash on July 4th, 2000 at 00:00:52 (local time) with amplitude of +112 kA. Distance of this stroke location to the tree coordinates is about 2 km and somewhat outside of the location accuracy of the ALDIS network of 500m – 1000 m estimated in this area.
To verify that this positive flash was the real cause for the tree destruction, we performed a very detailed analysis of the entire sensor data set contributing to the location of this particular stroke. This analysis revealed that 30 sensors at distances of up to more than 1000 km contributed to the location calculation. On the other hand sensors next to the site were saturated by the strong electromagnetic field pulse radiated by the 112 kA stroke and did not contribute to the locating of the flash. Reprocessing with a small subset of sensor messages (excluding very remote sensors) confirmed the correlation of the two events.

4. Conclusion

In Germany and Austria 2 trees were found with severe destructions. These severe damages obviously occur, when the high currents of positive cloud-to-ground lightning flows through the trunks. As a conclusion, we recommend: Avoid trees at any rate!

5. Acknowledgment

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6. References

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[5] BLIDS: "*German lightning location system*". Internet address: www.BLIDS.de

[6] ALDIS: "*Austrian lightning detection and information system*". Internet address: www.aldis.at