Editorial Manager(tm) for Monthly Weather Review
Manuscript Draft

Manuscript Number:

Title: Tornado Climatology of Finland

Article Type: Article

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Tornado Climatology of Finland

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Submitted to *Monthly Weather Review*: 31 July 2011

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Abstract

A tornado climatology for Finland is constructed from 1796 to 2007. The climatology consists of two datasets. A historical dataset (1796–1996) is largely constructed from newspaper archives and other historical archives and databases, and a recent dataset (1997–2007) is largely constructed from eyewitness accounts sent to the Finnish Meteorological Institute and news reports. This article describes the process of collecting and evaluating possible tornado reports. Altogether, 298 Finnish tornado cases comprise the climatology: 129 from the historical dataset and 169 from the recent dataset. An annual average of 14 tornado cases occur in Finland (1997–2007). A significant tornado (F2 or stronger) occurs on average every other year, comprising 14% of all tornado cases. All tornadoes in Finland have occurred between April and November. As in the neighbouring countries in northern Europe, July and August are the months with the maximum frequency of tornadoes, coincident with the highest lightning occurrence both over land and sea. Waterspouts tend to be favored later in the summer, peaking in August. The peak month for significant tornadoes is August. The diurnal peak for tornadoes is 1700–1859 local time.

1. Introduction

As late as the mid 1990s, Finnish meteorologists generally assumed that severe convective storms or tornadoes did not occur in Finland and, if they occurred, they were rare. Tornado reports were not collected, and no research on severe convective storms was published from the 1960s until recently. However, since 1997, severe thunderstorms, and especially tornadoes, have received a lot of media attention in Finland. Thus, Finnish meteorologists have started to appreciate the occurrence and threat of severe weather. This appreciation has led to several studies on severe weather in Finland: a climatology of mesoscale convective systems (Punkka and Bister 2005), a case study of a severe thunderstorm outbreak (Punkka et al. 2006), micrometeorological measurements of a microburst (Järvi et al. 2007), a severe-hail climatology (Tuovinen et al. 2009), and several case studies of tornadoes (e.g., Teittinen et al. 2006; Teittinen and Mäkelä 2008; Outinen and Teittinen 2008; Rauhala and Punkka 2008). Yet, no climatology of tornadoes exists for Finland.

Historically, in Italy and France, scientific papers on tornado cases were published by the 17th century (Peterson 1982). The first research covering all of Europe was Wegener (1917). Estonia, the southern neighbour of Finland, has a long history in tornado research: between the wars by Johannes Letzmann (Peterson 1992, 1995) and more recent case studies (Tooming et al. 1995; Tarand 1995). In Sweden, several case studies have been performed (Peterson 1998).

More recently, European tornado climatologies have been published for Ireland (Tyrrell 2003), Great Britain (Elsom and Meaden 1982; Reynolds 1999; Holden and Wright 2004), Lithuania (Marcinoniene 2003), and the former Soviet Union (Peterson 2000). The climatology of French tornadoes has been studied by Dessens and Snow (1989, 1993) and Paul (2001). Tornado statistics for Germany and Austria have been published by Dotzek (2001) and Holzer (2001). Climatologies for the Czech Republic by Setvak et al. (2003) and for Hungary by Szilard (2007) have been constructed. In southern Europe, tornado climatologies have been documented in Greece (Sioutas 2003, 2011), the Balearic Islands (Gayá et al. 2001), Spain (Gayá 2011), Portugal (Leitao 2003), and Italy (Giaiotti et al. 2007).

Despite a long history of observing tornadoes, not all European countries have a database of severe weather reports. The European Severe Weather Database (Brooks and Dotzek 2008; Dotzek et al. 2009) has improved the collection of severe-weather reports from around Europe. Because many European National Hydro-Meteorological Services are actively developing their severe thunderstorm forecast and warning services (Rauhala and Schultz 2009), many countries have acknowledged that understanding the local climatology is important for forecasting.

The purpose of this article is to create a tornado climatology for Finland. The definition of a tornado, methods to collect reports, and the credibility evaluation process are discussed in section 2. Sections 3–4 summarize the geographical and intensity distributions of tornadoes, and sections 5–6 summarize the monthly and diurnal distributions. Section 7 concludes this article.

2. Data

This section describes the development of the Finnish tornado climatology. Because 10% of Finland is covered by fresh water and because Finland has a relatively low population density, we take care in defining the criteria for tornadoes and waterspouts. Section 2a addresses this issue. Then, having described our definition for a tornado, the climatology is constructed in two steps. The first step was to collect historical reports of tornadoes from archived sources such as newspapers. The second step was to collect recent reports of tornadoes in near-real-time through the Finnish Meteorological Institute. Section 2b discusses the different methods employed to compile and evaluate tornado reports in these two datasets. Finally, section 2c describes how the tornado intensities are assessed.

a. Tornado definition and criteria

The *Glossary of Meteorology* (Glickman 2000) defines a tornado as "a violently rotating column of air, in contact with the ground, either pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud." Forbes and Wakimoto (1983) suggested that a vortex would be classified as a tornado if it were strong enough to cause at least F0 (Fujita 1981) damage. This definition was adopted in the United States where all tornadoes have been classified by the F-scale, even if there were no damage. Since 2007, tornado intensity has been rated in United States with the Enhanced Fujita scale (EF-scale) (Doswell et al. 2009). On the other hand, waterspouts that do not hit land are not classified as tornadoes in the United States. This definition would be a serious restriction for Finland, where almost 188 000 lakes cover the landscape. In this work, the following tornado definition (Teittinen 2001) is used: *A tornado is a vortex between a cloud* *and the land or water surface, in which the connection between the cloud and surface is visible, or the vortex is strong enough to cause at least F0 damage*. This definition allows all waterspouts to be included in the definition of a tornado. Also, tornadoes over land that do not cause damage, but have a visible connection between ground and the cloud base, are included.

In this article, we will also make use of the concept of a *tornado case*. In one tornado case, there might be many tornadoes. For example, several tornadoes might occur near each other (e.g., within the same storm, along the same boundary), but this would be classified as one tornado case. This concept improves the database because, in several waterspout cases, for example, the exact number, location or timing of each individual tornado is not known. Because waterspouts often occur in groups of 5–20 single tornadoes, if each were recorded as an individual event, the monthly, diurnal, intensity and geographical distribution of waterspouts would dominate the database of all tornadoes.

On the other hand, if tornadoes are known to occur in separate storms, or the starting points of the successive tornadoes can be resolved, they are considered to be separate cases. There is often not enough information to split a report into several cases. Particularly in the historical dataset, the path length would often suggest a series of tornadoes, but the event is still recorded as one case due to the lack of detailed information on damage tracks. The problem of distinguishing between long-track tornadoes and a series of short-track tornadoes is discussed by Doswell and Burgess (1988). The starting point of the first tornado path in each event characterizes the case on geographical maps. In several instances, the same tornado moves over both water and land surfaces. If a tornado is first observed over land, it is classified as a tornado over land. If it is first observed over water, it is classified as a waterspout. A tornado day in this article is defined as a day with at least one tornado case. A tornado report is the original tornado observation; several tornado reports may exist for each tornado case.

b. Collecting tornado reports

Because the methods of collection, evaluation and classification of tornado reports have changed over time, the tornado climatology of Finland comprises two datasets. The historical dataset covers 1796–1996 when no systematic tornado documentation was maintained at the Finnish Meteorological Institute. The recent dataset covers 1997–2007 when the Finnish Meteorological Institute has been actively collecting information on tornadoes in Finland.

The tornado reports in the 1796–1996 historical dataset were collected through five different approaches. First, most of the reports in the historical dataset come from old newspaper articles. The oldest articles were found in the microfilm archives and digital collections of major newspapers (*Finlands Allmänna Tidning, Ilmarinen, Keski-Suomi, Porin Kaupungin Sanomia, Sanomia Turusta, Tapio, Vesta Nyland, Åbo Tidningar*, and *Åbo underrättelser*) in the National Library of Finland. Second, the Finnish Meteorological Institute's archives contained an unsystematic collection of weather-related newspaper clips and of FMI-related articles from the 1990s. The more recent newspaper articles were from *Aamulehti, Borgåbladet, Etelä-Saimaa, Etelä-Suomi, Helsingin Sanomat, Iitinseutu, Ilta*

Sanomat, Kainuun Sanomat, Kaleva, Karjalainen, Keskisuomalainen, Kuorevesi-Mänttä-Vilppula, Lapin Kansa, Maakansa, Savon Sanomat, Suomenmaa, Suur-Keuruun Sanomat, Syd-Österbotten, Turun Sanomat, Uusi Aura, and *Uusi Suomi*. Altogether, newspaper articles resulted in 98 tornado cases. Third, 17 tornado cases were obtained from the general public during the 1970s and 1980s and were documented in the forecasters' notebook—an unsystematic collection of reports of strange phenomena received from the general public and noted in a book in the forecasting room. Fourth, 12 cases, mainly from the 1930s, come from published meteorological descriptions (Keränen 1930; Simojoki 1931, 1935; Angervo 1949; Rossi and Franssila 1960). Fifth, two tornado cases are from Wegener's (1917) book on European tornadoes. Due to the lack of detailed information on the tornado cases, these historical data did not go through an extensive quality control and most of the reported tornadoes were included in the statistics. This process resulted in 129 tornado cases.

In the recent 1997–2007 dataset, most of the preliminary reports were obtained from the general public. The main source for these reports was through a tornado observation report form placed on the Finnish Meteorological Institute Web site (http://www.fmi.fi) since 1998. In addition, preliminary reports were received from the general public by phone and by email. Reports from news media were collected also, including related newspaper articles and reporter information. Data from different sources were gathered into tornado cases and, in all except a few cases, eyewitnesses were interviewed. Photos and videos of the tornado and its damage were collected and, in some cases, a damage survey was performed.

The credibility of a report was evaluated in the recent 1997–2007 dataset based on the observed information available on the event. Each case was categorized as confirmed, probable, or possible (Table 1). Similar definitions have been used in Canada to evaluate tornado reports (Newark 1984). Only confirmed and probable tornado cases were accepted into the recent dataset, which has now become the official tornado database for Finland. Radar pictures were also studied for the tornado cases of the last eight years (2000–2007). If there was no radar echo during or after a reported tornado, and satellite pictures did not show cloudiness, the case was not included in the recent dataset. This process resulted in 169 tornado cases.

The historical dataset is probably incomplete, particularly the records of weak tornadoes, as indicated by the change in number of tornadoes per decade (Fig. 1a). Before the 1930s, there are only a few, if any, known reports per decade. In the 1930s, 30 tornadoes (10 of which were F2 and greater; Table 2) affected Finland, causing two deaths, several injuries and vast material damage, which awoke the interest of meteorologists during that period. Both the attention paid to tornadoes and the availability of documented reports are reflected in the statistics with a larger number of reports during the 1930s, 1990s and 2000s. The onset of active collecting of tornado reports show in the statistics, as during 1997–2007, a mean of 14 confirmed and probable tornado cases occurred each year, with a mean of 11 tornado days. The tornado dataset is likely to be more consistent over time for the more intense tornadoes (e.g., Brooks and Doswell 2001; Verbout et al. 2006). In 1930–2007, significant tornadoes (F2 or stronger; Hales 1988) occurred on average every second year (Fig. 1b).

c. Estimating tornado intensity

The tornado intensity assessment is based on a damage survey, photographs, or eyewitness description of the damage. The estimate is based on the Fujita scale (Fujita 1981) and guidance tables for assigning tornado damage to buildings (Minor et al. 1977, Table 4; Bunting and Smith 1993, appendix C). The estimates were made by a single person (the first author), so the data should not contain some of the inhomogeneities discussed by Doswell and Burgess (1988), although systematic biases may occur. The information available on events in the historical dataset is often so limited that an accurate F-scale estimate cannot be assigned. Instead, for the historical dataset, the F-scale estimate is the minimum intensity that could cause the described or photographed damage. In this article, tornadoes without damage are unrated on the Fujita scale. Only 22% of the cases in the historical dataset were unrated, whereas 56% of the cases in the recent dataset were unrated.

There is uncertainty in estimating the intensity of tornadoes using the F-scale. Damage is not equivalent to intensity because the damage depends, not only upon the wind speed, but also upon the object receiving damage (Doswell and Burgess 1988; Doswell 2007). Terrain, building codes, debris, speed of the tornado, or rapidly fluctuating winds can contribute to the damage and affect the estimate of intensity. For example, tornadoes without damage are often classified as weak, although the true intensity could not be determined. Doswell and Burgess (1988) argued that many tornadoes have inappropriate F-ratings, perhaps by two categories or more. On the other hand, the F-scale is largely based on damage to buildings, and the construction standards in Finland, as well as Europe as a whole, may differ from those in the United States (e.g., Feuerstein et al. 2011).

3. Geographical distribution

Tornadoes are most frequent in eastern and south-central Finland, as well as over the southern and southwestern seawaters (Fig. 2a). The occurrence is lowest in Lapland in northern Finland and in some inland areas of western Finland. The occurrence of waterspouts is high over the southern and southwestern seawaters, but also in the lakes of central Finland. If each waterspout were recorded separately instead of grouped into tornado cases, the frequency over the seas would be much larger. The large number of lakes and the large land area of fresh water helps to explain that 20% of all tornadoes in this dataset spend part of their time over land and part of their time over water.

The concentration of cases in eastern Finland is more evident when only the significant tornadoes are considered (Fig. 2b). The annual probability of significant tornadoes was calculated during 1930–2007 because significant tornadoes are less sensitive to changing reporting practice with time (e.g., Brooks and Doswell 2001; Verbout et al. 2006). The climatological probability of at least one significant tornado within an 80 km × 80 km area during a year in several areas in central southern and eastern central Finland is 5–7%. This means that an F2 or stronger tornado occurs in the area of maximum probability once every 14–20 years. The belt of highest risk extends from the coast of the Gulf of Finland over central Finland to the Gulf of Bothnia.

The geographical distribution of thunderstorm days is similar to the geographical distribution of tornadoes in Finland, although the cloud-to-ground lightning flash rate itself is not a good indicator of tornado occurrence (e.g., MacGorman et al. 1989; Perez et al. 1997; Teittinen and Mäkelä 2008). Indeed, some tornadoes in Finland have been observed without cloud-to-ground lightning (e.g., Rauhala and Punkka 2008). In southern Finland, where the yearly mean cloud-to-ground flash density is low (Tuomi and Mäkelä 2008; Mäkelä et al. 2011), tornadoes and significant tornadoes are relatively frequent. However, cloud-to-ground flash density is only one measure of the location of deep moist convection. Although the basic conditions necessary for tornadoes and cloud-to-ground lightning occurrence are not the same, both phenomena require the existence of a convective cloud and a strong updraft. Therefore the geographical distribution of thunderstorm days can be compared to the tornado occurrence. The frequency of thunderstorm days in Finland is highest in central Finland, where the yearly average is around 15 days (Fig. 2 in Mäkelä et al. 2011). This area coincides quite well with the relatively frequent areas for significant tornadoes. In Lapland, where the tornadoes are relatively infrequent, 4–11 thunderstorm days occur per year. Thus, the average number of thunderstorms days seems to correspond roughly to the significant tornado frequency.

Also, severe hail (Fig. 7 in Tuovinen et al. 2009) seems to have a similar geographical distribution as tornadoes in Finland, although only few of the cases in the two datasets are from the same events. The main differences in the geographical distributions are the larger number of severe-hail cases compared to tornado cases in agricultural areas in western

Finland, and the smaller number of severe-hail cases compared to tornado cases over coastal waters and in southeast Finland, where 30% of the surface are lakes. The likelihood of severe-hail events being recorded over agricultural areas and unlikelihood of them being recorded on water surfaces compared to tornadoes may partly explain these differences. Despite these differences, the similarity of geographical distributions of tornadoes and large hail motivates the question of whether geographically favoured locations exist for the most severe convective weather in Finland.

The small sample size of tornado cases in Finland at any given location allows only an estimate of the broad spatial patterns of tornado occurrence (e.g., Doswell 2007). Also, because of the sparse population of Finland (an average of 16 inhabitants km^{-2}, equal to that of Colorado), tornadoes may be underreported and may be biased towards population centers. Indeed, more tornado reports are received in areas of regionally high population density, especially for weak tornadoes. In Lapland in the northern part of Finland, where the population density is much lower (2 inhabitants km^{-2}, equal to that of Wyoming), the number of known tornado events is small, even though in southern and central Lapland there is an average of 8–11 thunderstorm days annually (Mäkelä et al. 2011).

4. Intensity distribution

Most (86%) of the 298 tornado cases were of F1 intensity or less (Fig. 3). A total of 43 significant tornadoes have been observed (Table 2). There have been only six F3 cases, one F4, and no F5s. The F4 tornado occurred on 11 July 1934 at Kiuruvesi in central Finland.

There are differences in the intensity distribution between the historical and recent datasets. Specifically, 29% of the tornado cases from 1796–1996 were significant tornadoes, but only 4% of the tornado cases from 1997–2007 were significant tornadoes. The smaller percentage of significant tornadoes in the recent dataset can be explained by the more efficient collection of tornado reports, especially for F1 and weaker tornadoes, similar to that seen in the United States (Brooks and Doswell 2001; Verbout et al. 2006), and the fewer number of intense tornadoes in the shorter 1997–2007 period (Fig. 3). Because stronger tornadoes typically have larger effects on society and influence larger areas (Brooks 2004), observations of the more intense tornadoes tend to be less sensitive to variations in reporting practice over time (e.g., Verbout et al. 2006), explaining the large proportion of significant tornadoes in the historical dataset.

By comparison, F4 tornadoes have been observed in several other European countries: Estonia (Tooming 2002), Germany (Dotzek 2001), and the Czech Republic (Setvak et. al. 2003). In France, a few F5 tornadoes have been observed (Paul 2001). As in Finland (Fig. 3), a relatively small number of tornadoes in these countries are weak, compared to the expected log–linear decline of events as the intensity increases (Brooks and Doswell 2001). This underreporting of weaker tornadoes has been observed in other countries (e.g., Germany, France). When greater attention is put into collecting reports or there is greater public awareness of tornadoes, as in Ireland (Tyrrell 2003), the relationship is closer to being straight. The impact of the onset of active collecting of reports can be also seen in Finland, where the number of weak tornadoes has increased in the recent dataset compared to the historical dataset (Fig. 3).

In east-central Finland, the fraction of tornadoes that were significant was higher than elsewhere in Finland. In Lapland and in large parts in western Finland, significant tornadoes have not been observed. However, because the F-scale rating depends on the damage the tornado causes, tornadoes in rural areas may be underrated (e.g. Doswell and Burgess 1988). Most tornadoes and waterspouts occurring at the coast were F1 or weaker. If all waterspouts were recorded as single events, the portion of non-damaging or weak tornadoes would be higher, especially in the recent dataset.

5. Monthly distribution

Tornadoes have only been observed in Finland during April to November, with almost three quarters of tornado cases (73%) occurring during the warmest months in July and August (Fig. 4a). In comparison, cloud-to-ground lightning may occur in Finland from April until November (Tuomi and Mäkelä 2008), with the cloud-to-ground flash rate the highest in continental Finland in July and highest over the seas in July and August (Tuomi and Mäkelä 2007).

Based on the 1997–2007 statistics, the mean number of tornado days by month is 1 in June, 5 in July, 4 in August, and 1 in September. Days with at least three tornadoes have been observed from July until October (Fig. 4b). For all tornadoes that start on the land, the maximum is in July (Fig. 4c). Of all tornadoes in July, more than half (54%) are weak and start on land. The maximum for significant tornadoes is in August when 17% of all observed tornadoes are significant (Fig. 4d). Days with at least two significant tornadoes have been observed only in July and August.

Waterspouts tend to occur towards late summer compared to all tornadoes (Fig. 4c). Therefore, if each waterspout were recorded as a single case instead of grouping them into tornado cases, the monthly distribution of tornado cases in Finland would shift more towards late summer and early autumn. The maximum number of waterspouts occurs in August when 53% of the tornado cases start over water, although the maximum percentage of waterspouts occurs in October when 83% of the tornado cases start over water. In July, the peak month in Finland for tornadoes, only 36% of tornado cases are waterspouts. There are only a few known waterspout cases in May, June, October, and November. This is consistent with the cold sea surface temperatures in the early summer being less favourable for convection than the warmer temperatures that occur in the late summer.

Some minor differences in the monthly distribution between different geographical locations can be found, although the small sample size affects the credibility of the interpretation (e.g., Doswell 2007). In western inland areas, tornadoes seem to occur mostly in July and August; in the east, they occur during the whole season. Most tornado cases offshore occur in August or September and only few rare events are known to occur in June.

As in Finland, tornadoes in neighboring Estonia (Tarand 1995) and Sweden (Peterson 1998) occur most frequently during July and August. In central European countries, the peak occurs earlier in the summer: in Germany and in Austria in July (Dotzek 2001; Holzer 2001) and in the Czech Republic and Hungary between May and July (Setvák et al. 2003; Szilard 2007). In Mediterranean countries, the peak is in late summer or autumn (e.g., Paul 2001; Gayá et al. 2001; Sioutas 2003, 2011; Giaiotti et al. 2007; Gayá 2011). Fujita (1973) found that July and August are the peak months for tornadoes from northern Russia to Germany, France and northern Italy, whereas in western and southern Europe, the peak moves toward the autumn. In the United States, the peak frequency for tornadoes is in May and June (Verbout et al. 2006).

6. Diurnal distribution

Most of the tornadoes occurred between 0900–2059 local standard time (LT) (Fig. 5a). There were only 10 tornado cases at night (between 2100 and 0659 LT), and no cases between 0100 and 0459 LT. The diurnal distribution of waterspouts was more evenly spread throughout the day than tornadoes over land (Fig. 5b). Most (69%) of the tornadoes over land occurred in the late afternoon and evening, between 1500–2059 LT, with a peak at 1700–1859 LT, whereas waterspouts peaked at noon (Fig. 5b). If single waterspouts were recorded separately instead of grouping them into tornado cases, the diurnal maximum of tornadoes in Finland would have two peaks, one before noon and one in the afternoon.

The afternoon maximum in tornadoes is consistent with the diurnal cycle of thunderstorms in Finland. The diurnal maximum in cloud-to-ground flash rate in mainland Finland typically peaks around 1500–1659 LT (Tuomi and Mäkelä 2008). Similar diurnal distributions of tornadoes occur in France (Dessens and Snow 1989), the United States (Kelly et al. 1978), and Germany (Dotzek 2001), for example.

The observed waterspout diurnal cycle in Finland with a noon peak is similar to that observed by Dotzek et al. (2009) with waterspouts near the German coast at the North Sea and Baltic Sea. Distributions with three maxima—two higher peaks near noon and in the late afternoon, and a lower peak in morning—have been observed by Golden (1973) with waterspouts in the Lower Florida Keys and by Sioutas (2011) in Greece (both tornadoes and waterspouts). A possible explanation to the more evenly spread diurnal distribution is that the warm water surface may be a favorable location for the development of convection at any time of the day or night. Accordingly, the cloud-to-ground flash rate over the sea is somewhat more evenly distributed throughout the day than over land areas, but there is still a distinct afternoon maximum and minor morning maximum (Tuomi and Mäkelä 2008). Although the diurnal cycle of thunderstorms over water likely has a large influence on waterspout occurrence, the lack of tornado reports at night may also be because of darkness (in the late summer) or the smaller number of people outdoors.

7. Conclusions

This study summarizes the tornado climatology of Finland derived from 298 observed tornado cases during 1796–2007. The reports are collected and evaluated, resulting in two datasets: a historical dataset from 1796–1996 with 129 cases and a recent dataset from 1997–2007 with 169 cases. The number of tornadoes is highest from the area extending from southern and southwestern seawaters to eastern Finland. The region of highest frequency of significant tornadoes extends from the Gulf of Finland to the Gulf of Bothnia. The geographical distribution of weak tornadoes shows higher concentrations of reports near densely populated areas, suggesting population bias and underreporting weak tornadoes in sparsely populated areas.

Likely underreporting of weak tornadoes can also be seen in the historical dataset when comparing the intensity distribution of the historical and recent datasets. Whereas in the historical dataset, 29% of tornadoes were significant, in the recent dataset only 4% were significant. In the recent dataset, the large number of weak tornadoes is the result of efficient collection of reports, whereas significant tornadoes are more likely to be independent of the efforts put into collecting reports. Altogether, 14% (43 cases) of all recorded tornadoes in Finland are significant. The strongest documented tornado is of F4 intensity.

An average of 14 tornado cases occurs every year in Finland from April until November. Coincident with the highest lightning occurrence both over land and sea, the peak tornado months are July and August. August is the peak month for both waterspouts (53% of all August tornadoes) and significant tornadoes (17%), whereas typically (52%) July tornadoes are weak tornadoes over land. Most tornadoes over land occur between 1500–2059 LT, whereas tornadoes over water tend to occur more equally throughout the day.

Acknowledgments. We thank Sylvain Joffre (Finnish Meteorological Institute) for his comments on an earlier version of the manuscript and Pentti Pirinen (Finnish Meteorological

Institute) for providing data for Fig. 2b. Partial funding for Schultz comes from Vaisala Oyj and grant 126853 from the Academy of Finland.

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FIGURE CAPTIONS

Fig. 1. a) All and b) significant tornado reports per decade in Finland. Last decade includes only 2000–2007.

Fig. 2. Geographical distribution of a) all reported tornadoes during 1796–2007 in Finland. b) Annual probability (in percent) of at least one significant tornado in an 80 km × 80 km area based on the 1930–2007 statistics.

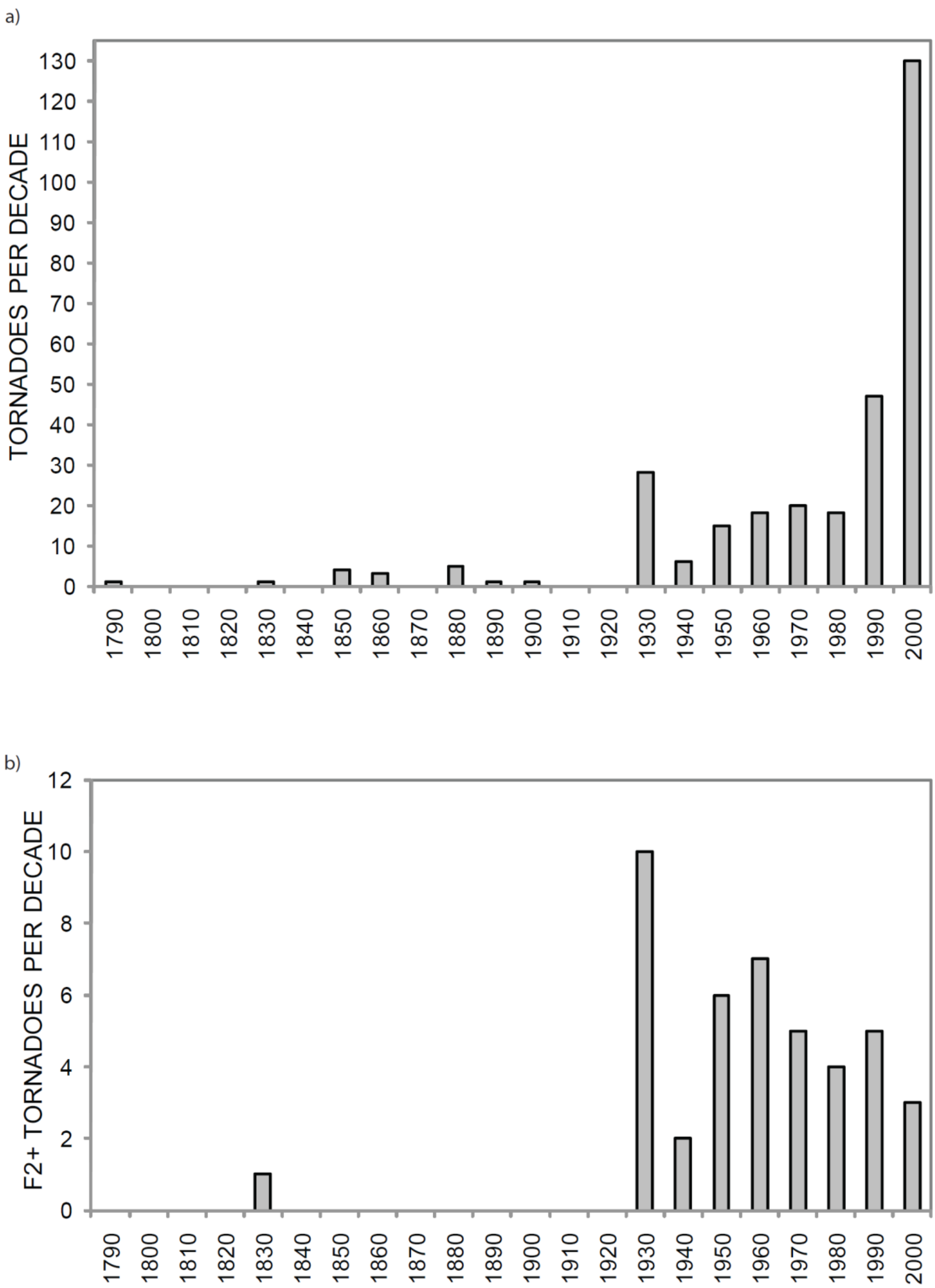
Fig. 3. Number of tornadoes both in historical (1796–1996) and more recent (1997–2007) datasets by F-scale.

Fig. 4. a) Monthly distribution of all tornadoes in Finland in 1796–2007. b) Distribution of days with at least three tornadoes. c) Distribution of tornadoes over land and water surface. d) Monthly distribution of significant (F2+) tornadoes.

Fig. 5. Diurnal distribution of a) all tornado cases and significant tornadoes and b) tornadoes over water and land surface in Finland. One column indicates a two-hour period ”0500–0659”, ”0700–0859”, etc. There are no tornadoes recorded between 0100-0459 LT.

Table 1. Credibility categories of tornado reports. The report is attributed to the highest class where any of the criteria are satisfied.

Table 2. Significant (F2 and greater) tornadoes in Finland.



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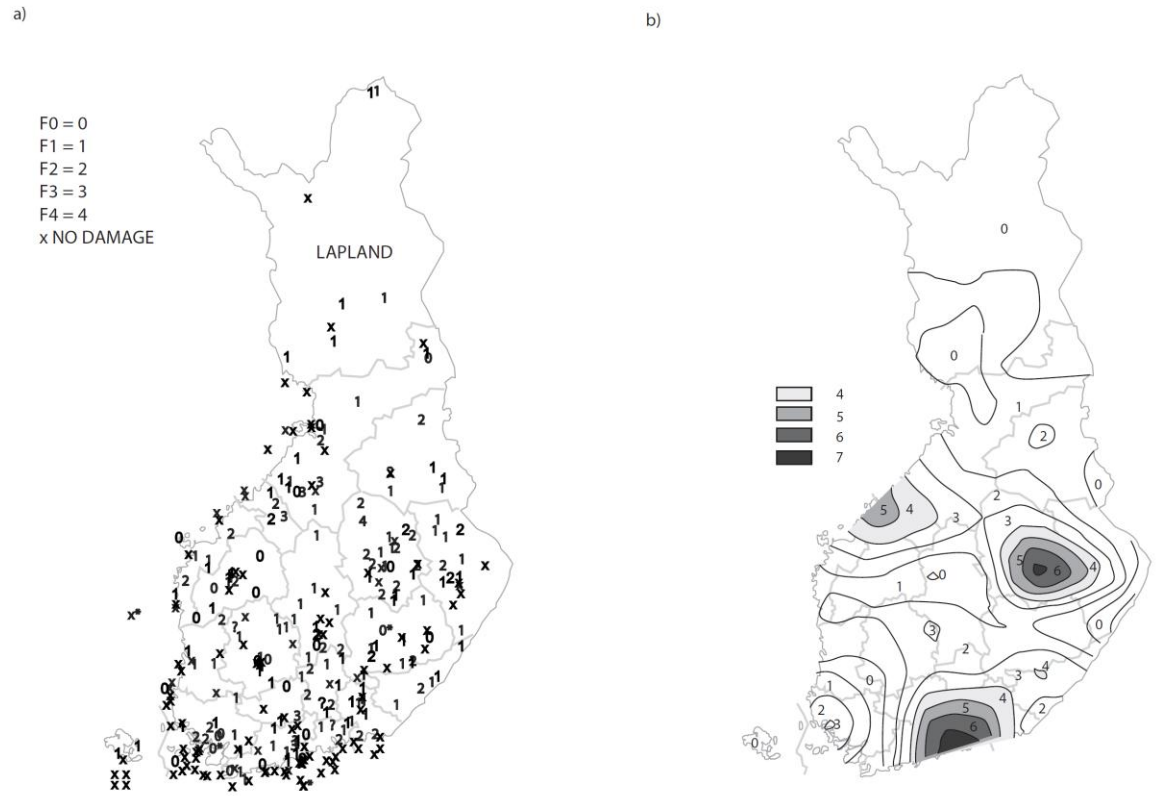
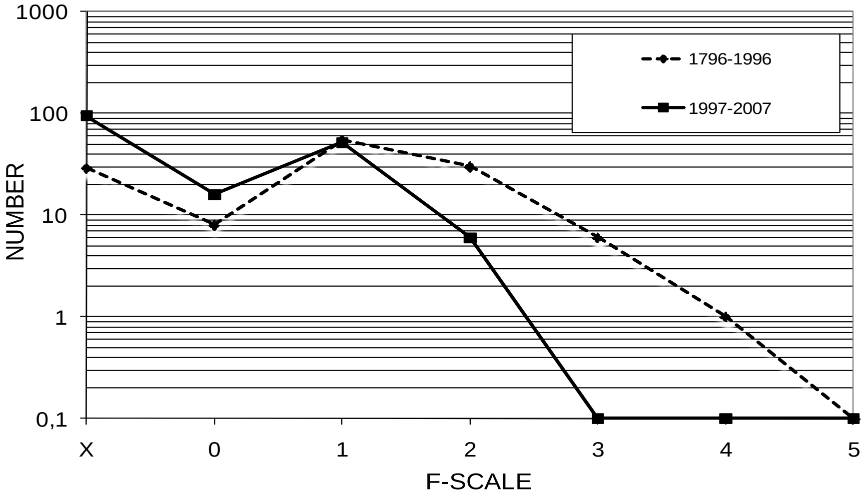


Fig. 2. Geographical distribution of a) all reported tornadoes during 1796–2007 in Finland, plotted by F-scale as in the legend. b) Annual probability (in percent) of at least one significant tornado in an 80 km × 80 km area based on the 1930–2007 statistics.



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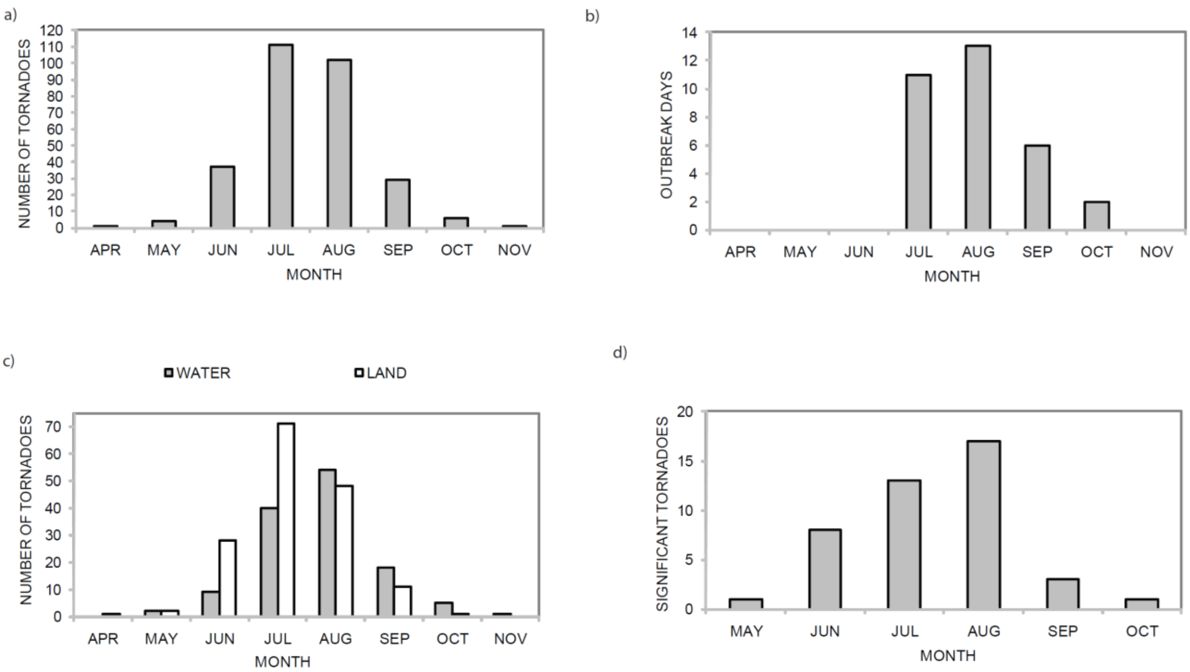

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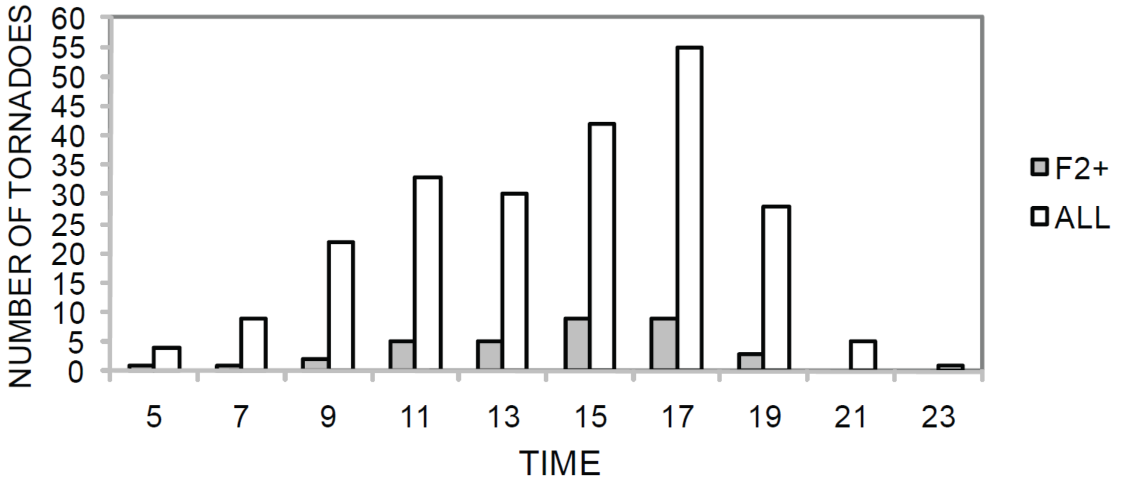
a)



b)

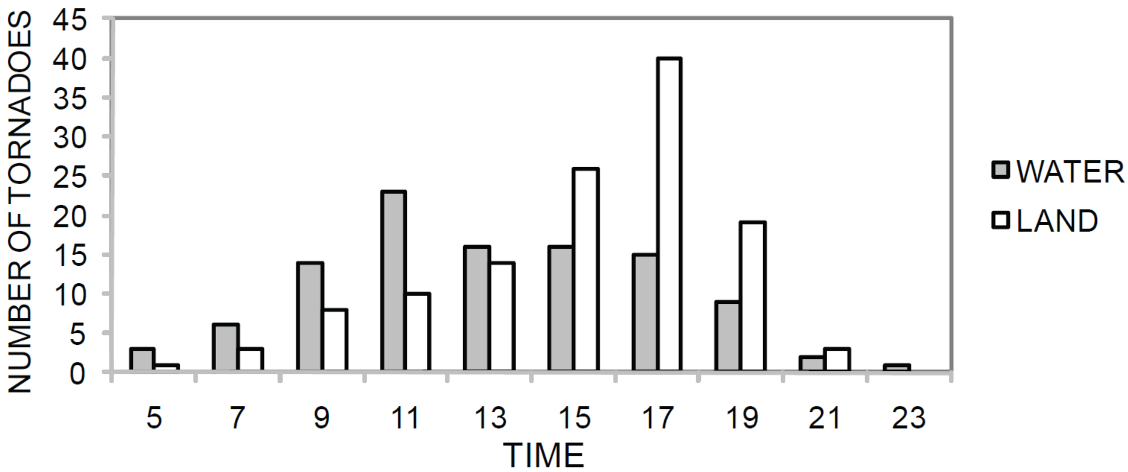


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Table 1. Credibility categories of tornado reports. The report is attributed to the highest class where any of the criteria are satisfied.

Category	Criteria
Confirmed	• A photograph or videotape of a tornado • Damage survey indicates tornado damage
Probable	• Credible eyewitness observation of a tornado • Credible eyewitness report of typical tornado damage • A photograph of a typical tornado damage
Possible	• No eyewitnesses • Cause of the damage is not confirmed by the observations of an eyewitness

Table 2. Significant (F2 and greater) tornadoes in Finland.

Date	Time (LT)	Location	Damage path width (m)	Damage path length (km)	Intensity	Number of fatalities	Number of injuries
1 July 1838	1600–1700	Turku	25–35		F2		
27 May 1930	1240–1250	Paltamo		3–4	F2		
29 June 1931	1600–1800	Vehmersalmi	60	2	F2		
4 August 1932	1500	Nurmijärvi	400–500	14	F3	1	1
4 August 1932	1530	Hausjärvi	100–150	39	F3		
6 August 1932	1700	Rautavaara, Nurmes	100–150	7	F2		
6 August 1932	1915	Kuopio	40–50	4	F2		
11 September 1932	1700	Kannus	100	10	F2		
12 July 1933	1400	Toholampi	2000	6	F3		
11 July 1934	1125	Kiuruvesi	200	15	F4	1	
11 July 1934	1330	Pulkkila	200	10	F3		1
9. August 1948	1200	Maaninka			F2		
1 October 1949	1615	Joutsa	100–150		F2		
29 July 1954	1200	Hamina, Vehkalahti, Anjalankoski		20	F2		
9 June1956		Nilsiä, Juankoski			F2		
27 July 1957	1800–1900	Imatra	2500–3000	10	F2	3	
27 July 1957	2000–2100	Luhanka		25–30	F2		
27 July 1957		Karvia			F2		
10 July 1958	1500	Polvijärvi			F2		
1 August 1961		Loviisa	250		F2		
1 August 1961		Orimattila, Hollola, Lammi			F2		
29 June 1967	evening	Vieremä	100		F2		
26 July 1967	0830	Nurmo		1.5	F2		
4 August 1967		Uusikaarlepyy	2000	7–8	F2		
26 August 1967	1400	Kaavi	300		F2		
7 September 1967	evening	Suomussalmi			F2		
8 July 1972	evening	Imatra, Joutseno, Puumala			F2	1	l
12 September 1974	0900	Pyhtää, Kotka	50		F2		1
15 August 1975	1750	Orimattila, Iitti, Kuusankoski	150	29	F2		1
30 August 1975	1035	Vantaa, Keimola	50	1	F3		
27 June 1976.	1200	Leppävirta	500	2	F2		
11 August 1985	1330	Liminka, Lumijoki	2000–3000	20	F2		
7 July 1988	1350	Lieto		0.5	F2		
22 July 1988	1630	Turku			F2		
3 August 1989	1800	Padasjoki	200		F2		
28 August 1994	0600	Ylivieska	150	0.35	F3		
15 June 1995	1730	Närpio			F2		
23 June 1997	1805	Lieksa	300	1.2	F2		
12 August 1997	1800–1900	Kaustinen	150	1	F2		
12 June 1998	1515–1540	Mikkeli	330	8.6	F2		
15 July 2000	1800	Jämsänkoski	50	15	F2		

9 August 2001	1900	Rautavaara	150	1	F2
20 August 2004	1655–1720	Polvijärvi, Kontiolahti		20.2	F2

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