Tornadoes in Germany

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Introduction

Tornadoes present a violent threat to society even in central Europe where they are less frequent than in the tornado belt in the USA. The extremely high values of windspeed and shear inside the funnel yield a high damage potential even for massive buildings. Therefore it is desirable to obtain a complete statistical record of the spatial and temporal distribution of tornadoes in Europe to be able to better estimate tornado risk. This record, however, will only be suitable for comparison with data from other regions of the world after a universal method of estimating tornado intensity depending on windspeed alone has been developed.

Statistics

Tab. 1 shows information on the 512 tornado cases recorded in Germany since 1587. The record is not yet complete for the periods of World War I and II and for eastern Germany in the cold war era. However, the general statistics are robust already. According to Tab. 1 a, approximately from 1870 the number of observations has stongly increased in Germany due to greater public interest in tornadoes. A decadal average starting in 1870 yields a value of 36 tornadoes with a large standard deviation of ± 25 per decade. The monthly values (Tab. 1 b) reveal only few cases in winter. These are mostly due to the passage of strong cold fronts within storm cyclones and preferably occur over the plain and homogeneous terrain of northern Germany. The maximum values from June to August follow the annual trend of thunderstorm activity, however. In the summer season local terrain forcing effects become increasingly important. In structured terrain they lead to isolated regions of enhanced tornado activity. Using the Upper Rhine valley in SW Germany as a prototype of such a zone, Hannesen et al. (1998) using C–band Doppler radar data and Dotzek (1999) using mesoscale model simulations were able to analyze the relevant tornado genesis mechanisms. Concerning the daily trend of tornado activity, Tab. 1 c again shows the resemblance to the trend of thunderstorm activity with a broad maximum of the distribution between 16:00 and 19:00 LST. For Germany as a whole a recurrence density for tornadic thunderstorms of $0.1\ \mathrm{a}^{-1}\ 10^{-4}\ \mathrm{km}^{-2}$ is found, similar to the values for Switzerland and Austria and roughly 20 times less than for the US tornado belt.

Table 1: a) Tornado cases per decade, b) monthly and c) daily distributions of tornadoes. In b) the "?" denotes cases without exact assignment to a month and in c) the time of the tornado is not known in 329 cases.

a) 20. Cent.: 404 cases (1900 - 1999)

00-09	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
19	19	25	28	7	83	41	35	69	78

19. Cent.: 96 cases (1800 - 1899)

00-09	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
5	5	7	5	3	2	1	10	33	25

b)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	?
6	2	10	14	56	109	134	97	38	17	4	2	23

c)

00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12
-	1	1	1	1	-	1	12	1	2	3	10

12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
9	12	12	20	24	27	24	12	10	4	1	-

Tornado Alleys

The locations and / or damage swaths of recent and historical tornadoes in SW Germany are depicted in Fig. 1. They group into a tornado alley in the area Strasbourg–Heidelberg and northern Vosges mountains–northern Black Forest. In addition a climatological analysis of synoptic situations with deep convection using precipitation accumulation derived from radar data also yields a preference for convection in the same area (Gysi, 1998). Non-hydrostatic mesocale model simulations for the Upper Rhine valley region provide evidence for a strong influence of topography for the generation and intensification of local convective cells (Dotzek, 1999). Typically a low–level pool of warm and moist air is found at the valley bottom. Winds veer with height due to the superposition of southerly flow in the Rhine valley and westerly flow at the boundary layer top and above. In the region of the tornado alley these orographic effects are most pronounced and facilitate the development of supercell storms with hail or tornadoes. The most severe case has been the T7–8 / F3–4 Pforzheim tornado (No. 9 b in Fig. 1) in July 1968 leading to over 100 million DM damage within the city of Pforzheim alone.

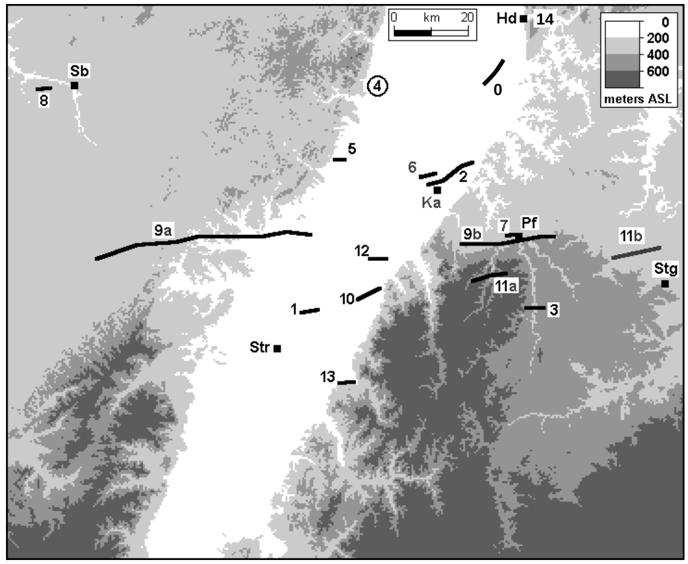

Figure 1: Tornados in the Upper Rhine valley region: 0) 29 Jul 1845, 1) 24 May 1878, 2) 4 Jul 1885, 3) 1 Jul 1895, 4) 11 May 1910, 5) End Sep 1913, 6) 7 Jun 1952, 7) 13 Aug 1952, 8) 27 Apr 1960, 9 a,b) 10 Jul 1968, 10) 8 May 1985, 11 a,b) 23 Jul 1986, 12) 21 Jul 1992, 13) 9 Sep 1995, 14) 23 Jul 1996. Ka = Karlsruhe, Hd = Heidelberg, Sb = Saarbrücken, Str = Strasbourg, Stg = Stuttgart, Pf = Pforzheim.

Intensity Estimation and Recording of Tornadoes

The network TorDACH (http://www.op.dlr.de/˜pa4p/TorDACH.html) was initiated in the three countries Germany, Austria, and Switzerland (D–A–CH) in 1997 and aims at a complete tornado record for these countries (cf. Dotzek et al., 1998). Two requirements arise (Dotzek et al., 2000). First to correctly relate tornado damage to tornado intensity by introducing a definition of the T- and F–scales suited for central Europe. Intensity can then be inferred from the observed loss ratio S for damaged objects, i. e. loss occurred divided by reinstatement value in percent. Second, to find a terse data format that facilitates data interchange between different countries. A group of individual data sets which describe tornado damage, terrain / land–use characteristics, loss ratios, fatalities etc. can meet both these requirements.

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