Center for Disaster Management and Risk Reduction Technology

CEDIM Forensic Disaster Analysis Group (FDA)

Winterstorm Xaver – Report

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Authors: Michael Kunz, Bernhard Mühr, Kai Schröter, Tina Bessel, Stella Möhrle, Thomas Münzberg, Susan Brink, Hanns-Maximilian Schmidt

Part I: SUMMARY

Name of the storm	Date	Start CET	Duration (PHL)
Xaver	**5-6 Dec**	**5 Dec 12:00**	**24 hours**

Hazard Information:

Path	Propagation Speed	Minimum Pressure	Extent of storm field	Wind speeds (gusts)
Low pressure Center: **South of Greeland, south of Iceland**, Shetland Islands, Southern Scandinavia **Maximum wind speed:** southwest of the center	**80 km/h**	**961 hPa (19:00 CET)**	**~ 1000 km**	**Coast: 185 km/h (List/Sylt-Ellenbogen)** **158 km/h (Glücksburg-Meierwik)** **122 km/h (10-min mean; Spiekeroog)** **Inland: 155 km/h (Brocken)**

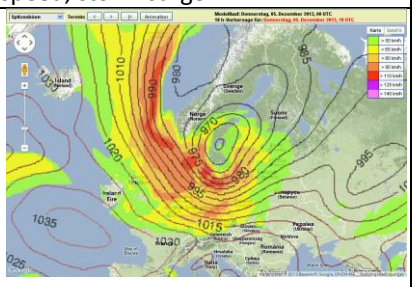
Location Information:

Country	Region with highest Impact	Economic Exposure	HDI (2012)	Urbanity	Pop. affected
Great Britain	**Scotland**				
Germany	**Northern Germany**				
Denmark					

Preferred Hazard Information:

Great Britain	Germany	Denmark	**Key Hazard Metrics**
			wind speed, storm surge

Hazard Description



- Storm Xaver developed on 4 Dec in a zone of high horizontal temperature contrast between Newfoundland and Greenland. During continuous intensification, the storm moved further over Scotland to Southern Sweden on 5-6 Dec. Highest wind speeds occurred on the western and south-western flank of the storm, additionally intensified in the unstable cold air masses from the north.
- Highest gust speeds were measured over Scotland (228 km/h; Aonach Mor, 1130 m); over Germany, highest wind speeds occurred over the islands and near the coasts of North and Baltic Sea (Max: 185 km/h Sylt), but also over the low mountain ranges.
- Gale wind force from the north over a long-term period of > 24 hrs in connection with high astronomical tides due to new moon caused high water level at the Elbe river. In Hamburg, the water level (St. Pauli) was 4 m over the mean high water, which was near the historic flood event 1962 (considering hydraulic engineering).

Additional hazard information on Xaver: http://www.wettergefahren-fruehwarnung.de/Ereignis/20131205_e.html

Vulnerability and Exposure Metrics (Population, Infrastructure, Economic)

Impact on traffic

Storm Xaver had moderate impacts on traffic in Northern Germany on 5 and 6 Dec. The storm caused only low impacts in road traffic. The impact on local ferry traffic from and to the East and North Frisian Islands was severely affected for two days. Impacts on flight and rail traffic were moderate. The airports of Hamburg and Bremen had cancelled several flights. German Railways cancelled some intercity connections and a lot of regional trains. Since no high damages occurred to traffic infrastructure, traffic services will rapidly return to normality.

Road traffic
Storm Xaver caused minor disruptions in road traffic. Obstacles blocked streets and drivers were at risk of accidents due to an increased number of objects on the road surface. In Hamburg several roads had been closed in prevention of the expected storm surge. Due to high wind gusts, trucks and other vehicles with superstructures had to drive slowly or even stop their journey. No sever accidents or traffic fatalities due to the storm have been reported.

Rail traffic
Rail traffic has been moderately affected by the storm in Northern Germany. German Railways (DB) cancelled more than 20 intercity train connections in the night of 5 to 6 Dec, and 6 to 7 Dec. In addition, since 5 Dec in the afternoon all intercity trains to Westerland, Flensburg, Kiel and Kopenhagen have to stop in Hamburg. The train track connecting Norddeich Mole and Emden is closed for traffic day due to storm damage. Furthermore, several regional train connections in Schleswig-Holstein, Niedersachsen, Bremen, Hamburg, Mecklenburg-Vorpommern, Brandenburg and Berlin were cancelled preventatively or due to infrastructure damage. Also private train companies, such as Metronom, NordWestBahn and Hamburger Hochbahn had cancelled most of their connections. Due to the storm surge in Hamburg, service will be restricted for some days longer than in other parts of Northern Germany. Since the rail infrastructure suffered no severe damages, rail connections and service operations should rapidly be restored.

Air traffic
Concerning air traffic, mainly the airports Hamburg Airport and City Airport Bremen were affected by Storm Xaver. Largely due to high wind gusts, about 50% of flights at these two airports were cancelled on 5 Dec, and 20% on 6 Dec. Long delays or detours also occurred and had minor impacts on other airports, such as Hannover Airport, Düsseldorf Airport and Köln Bonn Airport. Flight service at the affected airports will shortly return to normal.

Ferry Traffic
Ferry traffic from and to the East and North Frisian Islands was nearly shut down on 5 and 6 Dec. More than 90% of the ferry trips have been cancelled due to the storm. Furthermore, also ferry companies operating trips to other countries at the North and Baltic Sea had been affected. For instance, the ferry company Stena Line had to cancel more than 20 trips on seven routes. Most of the affected ferry companies will resume operation tomorrow or in the following days.

What have been the 3 largest comparable damaging events in the past for Germany?

Name - Date	Lowest pressure / Max gust (Location)	Insured / Economic loss (million €)*	remarks
Kyrill - 18/19 Jan 2007	960 hPa / 202 km/h (Wendelstein)	2 900 / 5 090	
Lothar - 26 Dec 1999	965 hPa / 259 km/h (Wendelstein)	823	Baden-Württemberg (SW Ger) most affected
Daria / Vivian / Wiebke - 1990	170-180 km/h	875 / 1 750 each	

Secondary Effect Information:

Type	Impact
Storm Surge	Surge over the North Sea 2 to 3.5-m above mean high water Difference to the astronomical tide at Elbe river of up to 4 m
Snow	New snow over the low mountain ranges; Maximum Brocken ~ 20 cm; substantial snow drift

Further information with details on the evolution of the storm, estimates of return periods, storm surges, impact, and prevention measures can be found in Part II of this Report

Part II: Details

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1 Hazard Information

1.1 Description of the storm and temporal evolution

Storm Xaver developed on 4 Dec between Newfoundland and Greenland in a zone with a high temperature gradient between cold polar and warm subtropical air masses. At this time, the pressure in the center of the new low was 1015 hPa. Due to the high horizontal temperature gradient, a substantial jet stream formed with wind speeds of more than 300 km/h in a height of 9 km. In the exit region on north-east side of the jet stream maximum, the flow was strongly divergent. This divergent flow and advection of warm and moist air at the low and mid levels of the troposphere resulted in strong vertical lifting and a fast drop of the surface pressure. While approaching Scotland, rapid cyclogenesis begun and the pressure dropped down to 975 hPa on 5 Dec 7:00 CET (decrease of > 25 hPa in 24 hrs; 17.1 hPa in 3 hrs). In the Scottish Highlands, 10 m wind speeds of 228 km/h have been registered at the weather station of Aonach Mor).

While further intensifying, the storm approached the coast of Northern Germany. On 5 Dec 19:00 CET the center pressure dropped down to 965 hPa. At this time, the center was located over Denmark. At the southern and western flank of the surface low, the thermal stratification of the air masses was unstable and thunderstorms could develop. The more unstable the stratification of the air, the higher is the vertical transport of horizontal momentum and, thus, wind speed from the jet stream. Thus, highest wind speeds in the evening and in the morning of 6 Dec occurred over the islands and the coast of Northern Germany. Afterwards, the storm moved slowly further east. While wind speeds at the coast of the Baltic sea increased in the morning hours and at noon of 6 Dec (gusts of 137 km/h at Kiel-Leuchtturm and Rostock-Warnemünde), gale force winds (> 119 km/h) still remained over the North Sea (130 km/h List, 122 km/h Norderney).

In general, highest wind speeds were restricted to the islands and the coast of Northern Germany. In the inland, gale force winds were only measured over exposed low mountain ranges such as Brocken (148 km/h) or Feldberg/Black Forest (122 km/h).

In the evening and night hours of 6 Dec, the storm will move further to the east towards the Baltic States and Belarus. Due to the friction over land, the center pressure will slowly decrease causing the storm to weaken substantially.

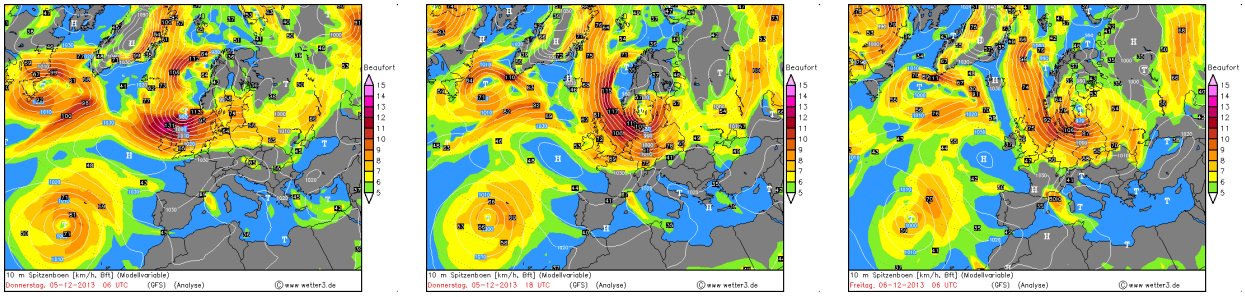

Figure 1: Analyses of surface pressure and gust wind speed from Global Forecast System (GFS) on 05 Dec, 07:00 CET (left), 19:00 CET (middle), and 06 Dec, 07:00 CET (right). Image Credit: www.wetter3.de.

1.2 Estimation on Return period and probability

The return periods of the observed gusts can be estimated from historic data and by application of extreme value statistics. Such an approach was performed within the former CEDIM project “Risk Map of Germany”, where wind speeds from historic severe storm events were simulated

with a numerical model *(Hofherr and Kunz, 2010)*. Extreme value statistics applied to the storm fields of various events (87 storms between 1971 and 2000) provide gust wind peaks related to the probability (Figure 1). Based on those analyses, the return period for the observed wind speeds from Xaver over land can be estimate between 2 and 10 years. For further details of the methods and the results it is referred to the CEDIM webpage (http://www.cedim.de/english/1016.php).

1.3 Secondary hazards: Storm Surge

Winter storm 'Xaver' causes a severe storm surge hazard for the entire North-Sea coastline in Germany and in particular for the Elbe estuary. 'Xaver' can be classified as a Scandinavian type cyclone which causes strong onshore winds from north westerly directions and hence via wind shear stress induces a directional flow on the water surface. The superposition of storm surges with high tides, spring tides or external surges induces extreme water levels. As a consequence of the surge also the level of low tides is considerably increased. This may disrupt the drainage of inland waters which are protected by flood barriers and/or tidal outlets and thus during closing cannot release inland discharges to the sea. In combination with inland flood discharges this may provoke an inland flood hazard.

In the ongoing situation the higher high water observed at the gauge in Hamburg St. Pauli at 6:01 on 6.12.2013 was about 6,09 masl which is 3,98 meters above the mean high water level (2,11 masl in 2013) and the second highest absolute water level ever recorded at this location since 1825. See Table X for a compilation of Top 10 absolute high water levels at Hamburg St. Pauli. However, as the mean high water level is subject to continuous change in particular as a result of river construction measures, in terms of exceedance of the mean high water level, the current storm surge is clearly below the record flood of January 1976 and slightly below the disastrous flood of February 1962.

Table 1: Top 10 absolute high water levels at gauge Hamburg St. Pauli since 1825

Date	Meters above sea	Meters above mean high water
03.01.1976	6,45 m	4,67 m (MHW = 1,78 m)
06.12.2013	6,09 m	3,98 m (MHW = 2,11)
28.01.1994	6,02 m	
10.01.1995	6,02 m	
03.12.1999	5,95 m	
24.11.1981	5,81 m	
23.01.1993	5,76 m	
28.02.1990	5,75 m	
05.02.1999	5,74 m	
17.02.1962	5,70 m	4,03 m (MHW = 1.67)

* Based on LSBG Hamburg, "Gewässer und Hochwasserschutz in Zahlen", Berichte des Landesbetriebes Straßen, Brücken und Gewässer Nr. 14/2012, Hamburg 2012

Furthermore, new highest high tide water levels (since the year 2000) have been recorded at numerous gauges along the North-Sea coastline of Schleswig-Holstein and Lower Saxony, e.g.

- Dagebüll (4,05 masl, 15:10 5.12.2013)

- Husum (4,93 masl, 3:37 6.12.2013)
- Büsum (4,54 masl 3:05 6.12.2013)
- Eidersperrwerk (4,49 masl 3:10 6.12.2013)
- Cuxhaven (4,65 masl 2:16 6.12.2013)

Despite of the extreme magnitude of the current storm surge, the coastal flood protection schemes including dikes and flood barriers have prevented major damages so far.

Induced by the storm surge, the current low water levels significantly exceed the mean low water level (up to 3 meters at the gauge of St. Pauli in Hamburg). According to the prediction of BSH (issued 12:20 6.12.2013), the situation of increased low water levels will persist until the afternoon of 7.12.2013. However, the inland flood hazard is low because inland water levels are at medium or low levels in Schleswig-Holstein, see Fig. X, in Hamburg and Lower Saxony. Hence, major damage is not expected as a consequence of inland flooding.

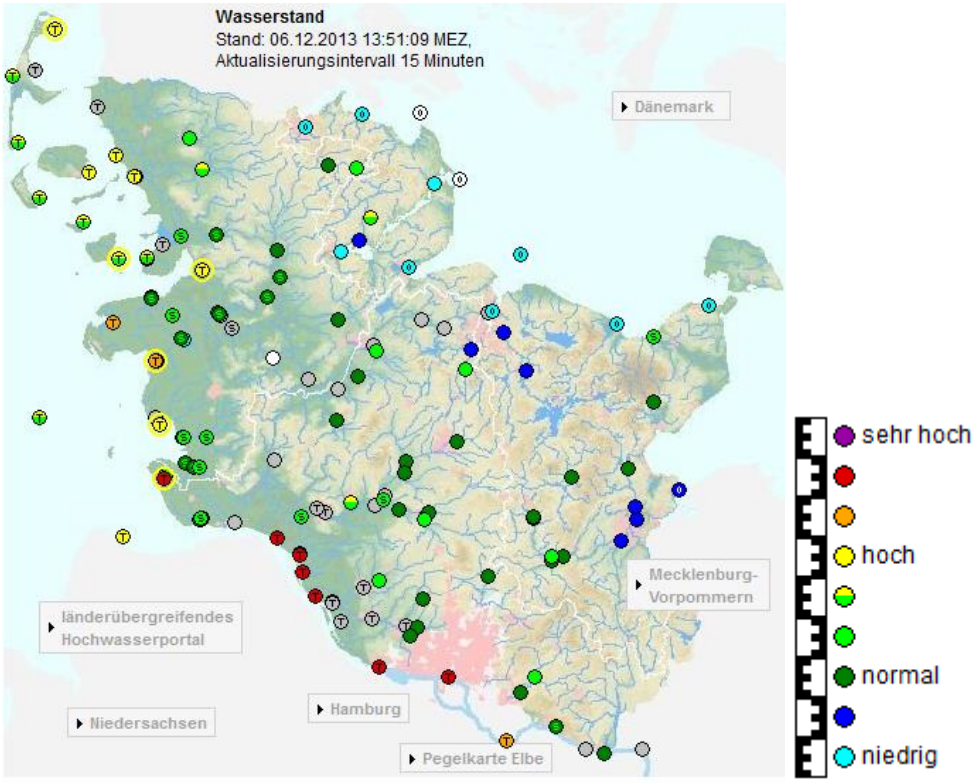

Figure 2: Classification of coastal and inland water levels in Schleswig-Holstein on 6.12.2013 13:51. Credit: Ministry of Energy, Agriculture, the Environment and Rural Areas Schleswig-Holstein and Waterways and Shipping Administration of the Federal Government (http://www.umweltdaten.landsh.de/public/hsi/index.html)

1.4 Relation to Climate Change

Climate is a statistical measure of the mean and variability of climate parameters or weather systems averaged over a long-term period, e.g. 30 years according to the World Meteorological Organization (WMO). Thus, single events such as Xaver cannot be attributed to any changes in the local or regional climate.

According to statistical analyses from regional climate models, extreme wind speeds will slightly increase in the future over several European regions such as Northern Germany. On the other hand, for other regions such as Southern Germany, these models project a slight decrease in storm speeds (Ulbrich et al., 2009; Rauthe et al., 2011).

2 Loss and Damage Analysis

2.1 Overview

News reports indicate that winter storm Xaver has been associated with 6 deaths (BBC 2013). Thousands of people were evacuated from low lying coastal areas in the UK due to flooding (BBC 2013b). In addition, closures in the city of Hamburg (Hamburg.de 2013), electricity outages (Gazeta Wyborcza 2013) and cold weather (Spiegel 2013) could lead to additional temporary shelter needs. However, significant numbers of long term displaced are unlikely due to the limited building damage.

2.2 Industrial Vulnerability

The estimation of direct losses due to business interruptions corresponds to the exposure of facilities and offices to the wind and flooding caused by Xaver. The city of Hamburg is expected to be highly affected by the flood that came along with the storm. The Fischmarkt, one of Hamburg's most famous tourist features and the center of the area's fishing industry, is completely flooded along with the Elbstraße along the waterside. As there are no reports on that specific topic available yet, the influence on the manufacturing industry can be estimated by focusing on their location in the area. The European Pollutant Release and Transfer Register (E-PRTR) provides information on the location of registered facilities all over Europe. Several critical industries can be found in the zip code area around the harbor in Hamburg and waste collection and management facilities, metal processing and chemical manufacturing are all within the region. Further analyses and the upcoming reports from the insurance companies could provide more insights into this specific field concerning the vulnerability of heavy or critical industries. The number of facilities is shown in the table.

Table 2: Facilities registered at the E-PRTR (2013) sorted by main activity

Data for Hamburg		*Data for zip code area 20**	
Building and dismantling of ships	19	Manufacture of chemicals, oil	12
Treatment of waste (hazardous)	51	Metal processing	18
Treatment of waste (non-hazardous)	9	Sewerage and similar activities	10
Energy, steam and hot water supply	11	Steam and air conditioning supply	3
Fuel depot	5	Treatment of waste	66
Manufacture of chemicals	87		
Manufacture of oil, fats and petroleum products	21		
Manufacture of rubber products	8		
Metal processing	57		
Other manufacture	15		
Sewerage and similar activities	13		

2.3 Preparedness Measures and Impacts

Overview for the period 4 – 6 Dec 2013

The northern federal states prepared long before the storm arrived. The prepared measures to resist storm surges were conducted. Additionally, measures were, among others, the closure of Christmas markets, public events, several public facilities and the cancellation of classes of

public schools. All these measures potentially helped to minimize the effects of Xaver.

A general closure of all schools was declared in the federal states Schleswig-Holstein and Mecklenburg-Vorpommern as well as in the city states Hamburg and Bremen for 06.12. In Lower Saxony, each administrative districts and independent cities was responsible to declare a school closure on its own (see List XY).

In *Mecklenburg West-Pomerania*, the floating crane on the construction area of the wind park Baltic 2 was removed on Wednesday. On the next day, the wind park Baltic 1 was shut down. The German-Danish ferry company Scandlines has stopped its service between Rostock and Gedser until Friday 11.15 o'clock. Transportation of pupils in the administrative districts and independent cities of Landkreis Rockstock, Vorpommern-Rügen, Vorpommern-Greifswald, and Mecklenburgische Seenplatte were cancelled. In Schwerin and Nordwestmecklenburg a hotline-service was implemented. Wind gusts and packed snow caused several accidents. A bus slipped down a slope with no pupils inside due to cancellation of classes. Because of an accident of an ambulance, a 82-year old patient died. There were a total of 600 operations from police and fire brigade mostly due to trees and branches on roads and rail tracks. Hundreds of trees were disrooted. In the grid area of Wemag, 4000 customers were affected by power outages. Due to the expected flood, people are asked not to stay near the east sea. At the port of Wismar sand bags are piled. At the administrative district Vorpommern-Greifswald 50000 sandbags are prepared.

In *Hamburg* the Deutsche Bahn prepared themselves with additional staff and 64 snow clearance vehicles. The Hamburg Fire Service Association (Landesfeuerwehrverband) published security recommendation. Furthermore, shipping transport was shut down and during the night from Thursday to Friday the St. Pauli Elbtunnel was closed as well the harbor and several districts. Some residents had to leave their homes. The 38 protective gates were closed and the Hamburger Hochbahn provided four groups to remove trees fallen on the tracks. The fish market was flooded as well as some streets along the Elbe. 1500 firemen were deployed with 600 operations. No greater impacts are known. The dikes were enlarged after the storm tide 1962 and resisted the onslaught.

Schleswig-Holstein, in particular Kiel, provides an interactive map with closed facilities and security recommendations were published. Ferries were cancelled and the locks in Kiel Holtenau and Brunsbüttel were closed. Furthermore, the gates of the dikes at Dagebüll were fortified. No greater damages are known in Schleswig-Holstein since the dike resisted the onslaught. More than 2000 operations from the fire brigade since Thursday and about 550 from the police until Friday morning have been counted, mostly due to broken and disrooted trees. The low impacts can also be explained by the storm Christian and its already caused damage. Also at Lübeck, there were less operations in the night from Thursday to Friday. Rotten or dead wood have already been fallen down or the crowns have broken out during Christian.

In *Bremen*, in particular, Bremerhaven, about 50 gates and dike openings of the dike line were closed as well as the flood barrages (Sturmflutsperrwerk) at the Kennedy bridge. The dike was observed during the tide and a truck with sandbags were prepared. Moreover, 3000 filled and further 25000 empty sandbags were provided in a storage building. Furthermore, the new Weser dike was recently enhanced.

In *Lower-Saxony*, the nine barrages at Ems, Hunte, Weser and Unterelbe were closed. No greater damages are known. Since 2008, Niedersachsen has invested more than 400 million Euro for the coast protection. On the island Spiekerkoog and Wangerooge, the protective dunes were reinforced 2012. On the East Frisian Islands, all dike openings were closed. The dikes were controlled during the night. First destruction of dunes are expected at the island Juist, Spiekeroog, and Wangeroog. Thursday, the evacuation of the residents of the roadsted at Borkum was prepared. On Nordeny, buildings near the water were protected with sandbags. Damages on the island are not known at the moment. Destruction of dunes are expected. In

Cuxhaven-Sahlenburg, some residents near a dike restocked by sandbags needed to be taken away during the night.

Table 3: School closures in Lower Saxony

Administrative Divisi-ons (Land-kreis/kreisfreie Stadt)	Do, 05.12.	Fr. 06.12.
Ammerland	closed	closed
Aurich	closed	closed
Celle		
Cloppenburg	closed	open
Cuxhaven	closed	closed
Diepholz	closed	open
Emsland	closed	open
Friesland	closed	closed
Gifhorn		open
Goslar		open
Göttingen		
Grafschaft Bentheim	closed	
Hameln-Pyrmont		
(Region) Hannover		
Harburg	closed	open
Heidekreis	closed	
Helmstedt		
Hildesheim		closed
Holzminden		
Leer	closed	closed
Lüchow-Dannenberg		closed
Lüneburg	closed	open, except Amt Neuhaus
Nienburg	closed	
Northeim		
Oldenburg		closed
Osnabrück		
Osterholz	closed	
Osterode		
Peine		
Rotenburg (Wümme)	closed	
Schaumburg	closed	
Stade	closed	closed
Uelzen		closed
Vechta	closed	
Verden	closed	
Wesermarsch	closed	closed
Wittmund	closed	closed
Wolfenbüttel		closed
Braunschweig		
Delmenhorst	closed	
Emden	closed	closed
Oldenburg	closed	closed
Osnabrück		
Salzgitter		
Wilhelmshaven	closed	closed
Wolfsburg		

Table 4: Christmas trees that broke due to high wind load

City	Location	Height oft he tree	Kind of tree
Anklam	Südstadt		
Berlin	Bellevue Castle	13 meter	Nordmann fir
Burg Stargard	Marktplatz		Fir
Düsseldorf	Schwabenmarkt	1,5 meter	
Düsseldorf	Königsallee	10 meter	Fir
Emsbüren	Bahnhofstraße		
Hamburg	HSV-Parkplatz		
Hohenstein-Ernstthal	Markt	10 meter	Pine
Kreis Osterholz		5 meter	
Merzenich	Lindenplatz	6 meter	
Prenzlau	Friedrichstraße		Fir
Roßwein	Markt	16 meter	Blue spruces
Schwerin	Marktplatz	3 meter	
Templin	Marktberg		Fir
Uebigau-Wahrenbrück	Uebigauer Markt		Fir
Weimar	Marktplatz	23,5 meter	Fir

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4 Contact

KIT Public Relations

Monika Landgraf

E-mail: monika.landgraf@kit.edu

Tel: +49-72160848126

GFZ Public Relations

Franz Ossing

E-mail: ossing@gfz-potsdam.de

Tel: +49-3312881040