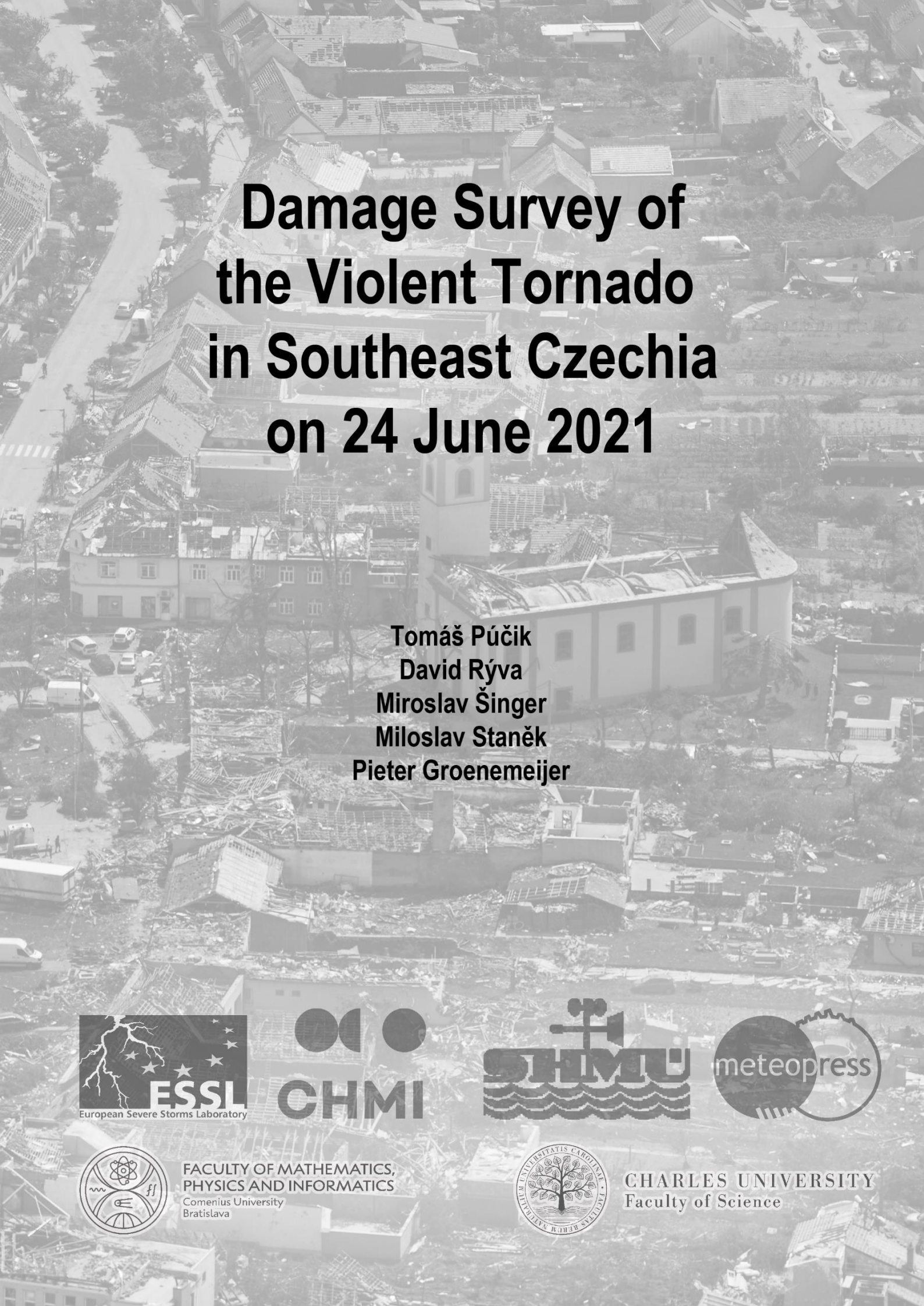

Damage Survey of the Violent Tornado in Southeast Czechia on 24 June 2021

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Contents

Introduction

This technical report contains a summary of information obtained from the damage surveys of the violent tornado that impacted southeastern Czechia on 24 June 2021. The report presents a brief summary of the event, followed by a detailed description of segments of the damage swath including ratings of the damage on the developmental International Fujita (IF) scale. The report also includes a comparison between ratings obtained from buildings and from vegetation-based damage indicators. We conclude with a number of recommendations for future tornado damage surveys and suggest a number of changes to the IF scale.

Disclaimer

The authors try to provide a detailed delineation of the tornado path and classification of the damage. However, the scale of the event did not allow a detailed ground survey covering the tornado path entirely, especially outside inhabited areas. It is possible that parts of the path were not identified due to a lack of damage indicators or that some of the weakly tornadic damage (IF0 - IF1) was caused by straight-line winds of the rear flank downdraft rather than the tornado. Such uncertainty is always highlighted in the text. The report is made solely for research purposes with inaccuracies that are typically too large to be used for insurance purposes or to support damage claims.

Damage survey and scale

The report is based on multiple surveys, both from the air and ground-based, performed by a number of individuals and institutions. A complete list of contributions and datasets is covered in the section ‘Acknowledgements‘, which can be found at the end of the report. The main sources of information were the aerial surveys of the tornado performed on the morning of 25 June 2021 and the ground surveys conducted on 25, 26, and 28 June 2021. Ground surveys were targeted at the areas of the most significant damage in inhabited areas. Despite the relative timeliness of the ground survey, demolitions of heavily damaged buildings and fast reparations of less damaged structures prevented the survey of some of them. Because of this, aerial surveys made shortly after the tornado became an indispensable tool to benchmark the damage caused by the tornado and to allow damage ratings over areas not covered by the ground surveys.

Damage rating was done using a draft version of the International Fujita scale created on 15 October 2018 (Groenemeijer et al, 2018). The scale uses a variety of damage indicators, such as buildings, vehicles, or trees to rate the damage. A damage rating is acquired by combining the vulnerability class of the damage indicator with the degree of damage. For example, the vulnerability (or sturdiness) of wall structures is based on their thickness and quality. The vulnerability of trees is determined by their type but also position within the forest, height/diameter ratio, soil wetness, and other factors. International Fujita scale was used instead of the original Fujita scale because it contains more damage indicators. It was also

chosen over the Enhanced Fujita scale, which does not reflect common building practices within central Europe.

A table of the wind speeds responsible for the various levels of damage is given here:

Table 1. The IF-scale.

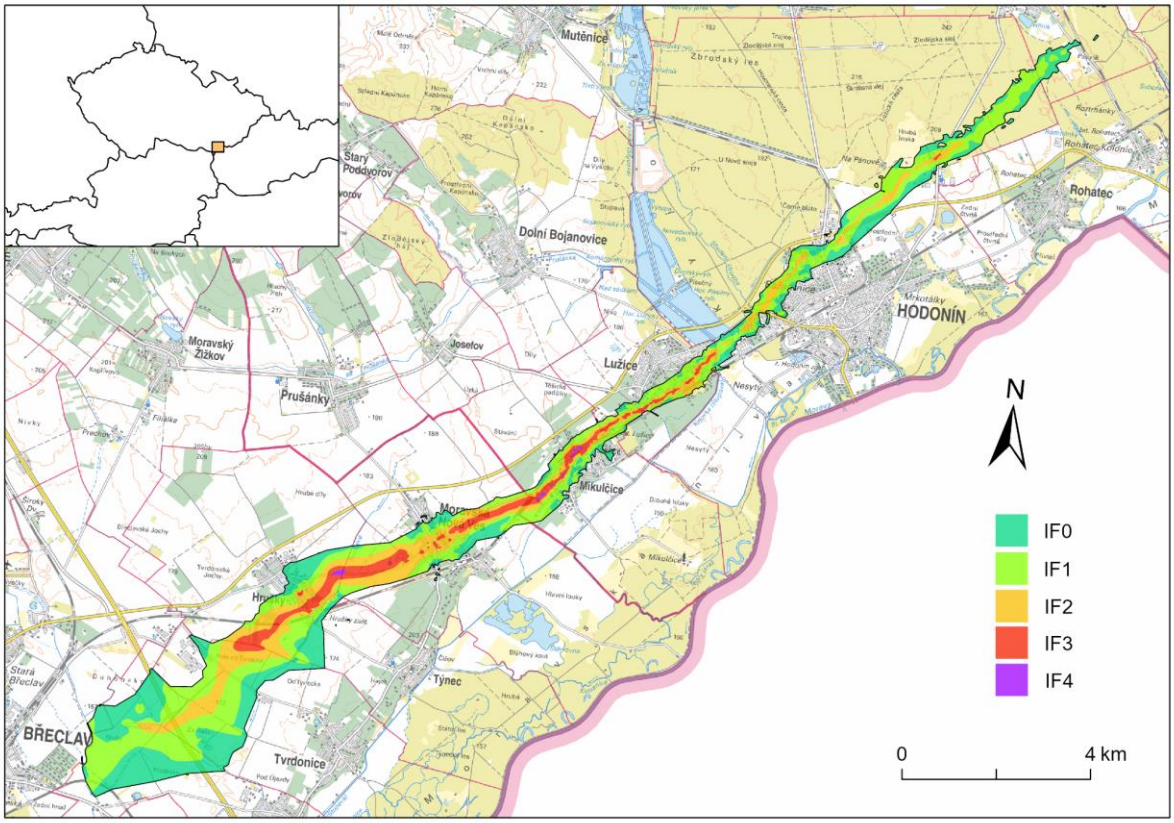
Class	speed m/s	error m/s	speed km/h	error km/h	Speed mph	error mph	speed knots	error knots
IF0-	20	± 6	72	± 22	45	± 14	39	± 12
IF0	25	± 7	90	± 27	56	± 17	48	± 15
IF0+	30	± 9	108	± 32	67	± 20	58	± 18
IF1-	36	± 11	128	± 38	70	± 24	69	± 21
IF1	41	± 12	149	± 45	92	± 28	80	± 24
IF1+	47	± 14	170	± 51	106	± 32	92	± 28
IF2-	54	± 16	193	± 58	120	± 36	104	± 31
IF2	60	± 18	217	± 65	135	± 40	117	± 35
IF2+	67	± 20	241	± 72	150	± 45	130	± 39
IF3	81	± 24	293	± 88	182	± 55	158	± 47
IF4	105	± 31	376	± 113	234	± 70	203	± 61
IF5	130	± 39	466	± 140	290	± 87	252	± 76

Tornadoes with lower wind speeds than IF2- are called “weak”. Tornadoes with an intensity of IF2- or higher are called “strong”, and tornadoes with an intensity of IF4 or IF5 are called “violent”.

Summary of the event

Tornado formation: ~17:14 UTC, 1 km east of Břeclav
Tornado decay: 17:53 UTC, 1 km south of Ratíškovice
Maximum intensity: IF4
Path length: 27.1 km
Maximum continuous path of IF2 or stronger winds: 15.3 km
Maximum path width: ~ 2800 m, east of Břeclav*
Maximum width of IF2 or stronger winds: 590 m, in Hrušky
Minimum path width: ~ 250 m, in Hodonín
The area impacted by the tornado (IF0 damage or stronger): 21.9 km²
The area impacted by the strong tornado (IF2 damage or stronger): 6.1 km²

*It can not be ruled out that part of the beginning of the damage swath was caused by straight-line winds in a rear flank downdraft surge.



Map of the tornado damage swath.

Following a merging of two storms at 16:00 UTC, a strong supercell developed on the Czech-Austrian border near Laa an der Thaya and tracked east-northeastward, subsequently crossing the border with Czechia. The supercell produced destructive hail, including hailstones with a diameter of up to 9 cm in Schrattenberg and 10 cm in Břeclav. Shortly after 17:00 UTC, a tornado formed east of Břeclav, crossing highway D2 (E65). Subsequently, it impacted the settlements of Hrušky, Moravská Nová Ves, Mikulčice, Lužice, Hodonín and Pánov. The tornado tracked near the main international railway and impacted it multiple times. The tornado decayed at 17:53 UTC in the forest near the village of Ratíškovice. While the exact time of the start of the tornado is unknown, the end time of the tornado is known thanks to a series of photographs documenting its decay.

In total, 1202 buildings were damaged by the tornado (CTK, 2021). 180 of the damaged buildings had to be demolished completely or partially. The railway was damaged, especially between Moravská Nová Ves and Lužice, where the tornado destroyed the catenary and signaling system. The tornado was rated **IF4** on the International Fujita scale. This rating was assigned as a result of the destruction of well-built brick walls and was supported by the complete debarking of trees by sand and similar small particles. IF4 damage was observed in 5 locations: one between Hrušky and Moravská Nová Ves, three in Mikulčice, and one in Lužice.

The tornado lasted approximately **39 minutes**, traveling **27.1 km**, which implies it had an average forward speed of 41.7 km/h. The path length of 27.1 km is comparable to the average path length of tornadoes of F4 intensity in Europe (Groenemeijer and Kühne, 2014). A

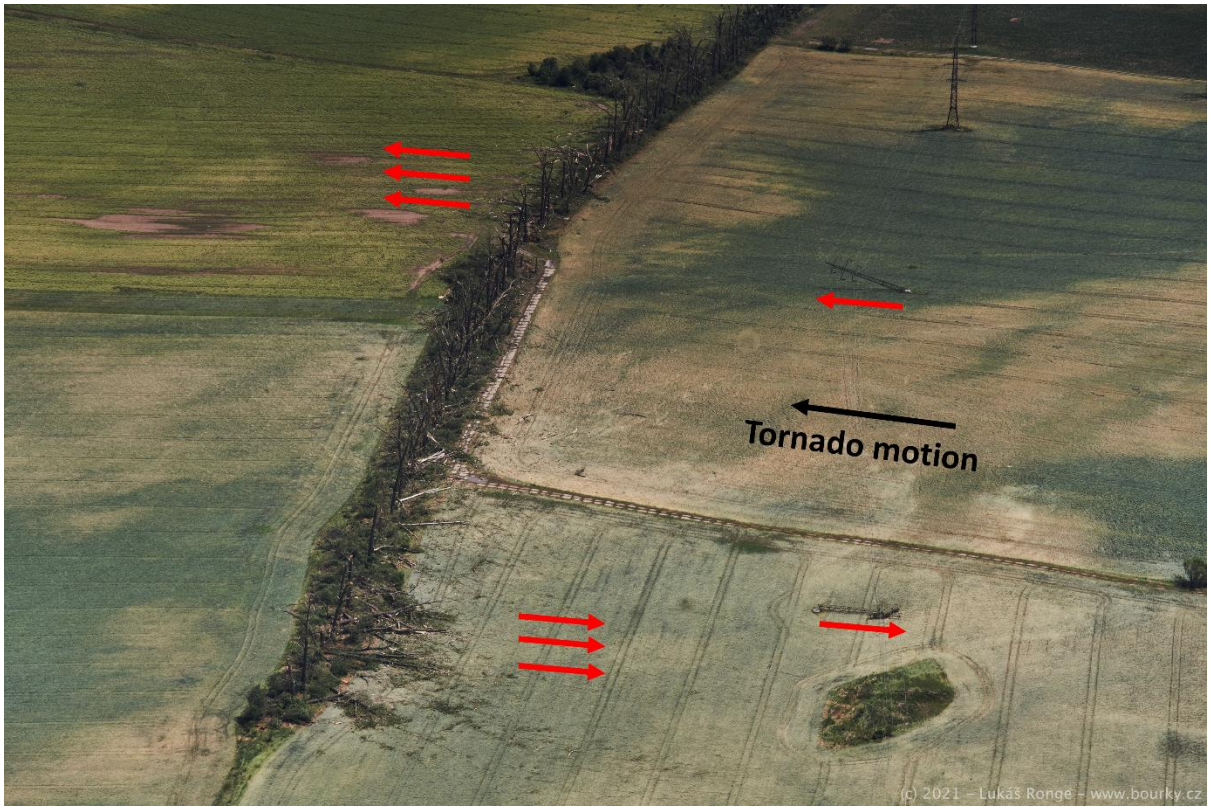
continuous swath of IF2 or stronger winds was found between Hrušky and Lužice, measuring 15.3 km in length and it is estimated that a surface area of 6.1 km² was affected by winds of such intensity. The tornado remained strong for the majority of its lifetime. The damage path was up to 2.8 km wide at the beginning. This is exceptionally wide both for European and American standards (Groenemeijer and Kühne, 2014, and Brooks, 2004). A part at the beginning of the swath may have been caused by straight-line winds adjacent to the tornado. The maximum width of the IF2 or stronger winds was 590 meters, observed in Hrušky. The tornado narrowed as it entered Lužice and Hodonín with a minimum width estimated 250 m and a swath of IF2 or stronger winds only 20 m wide. Apart from small wobbles in the path, the tornado steadily tracked northeast.

Detailed descriptions of path segments

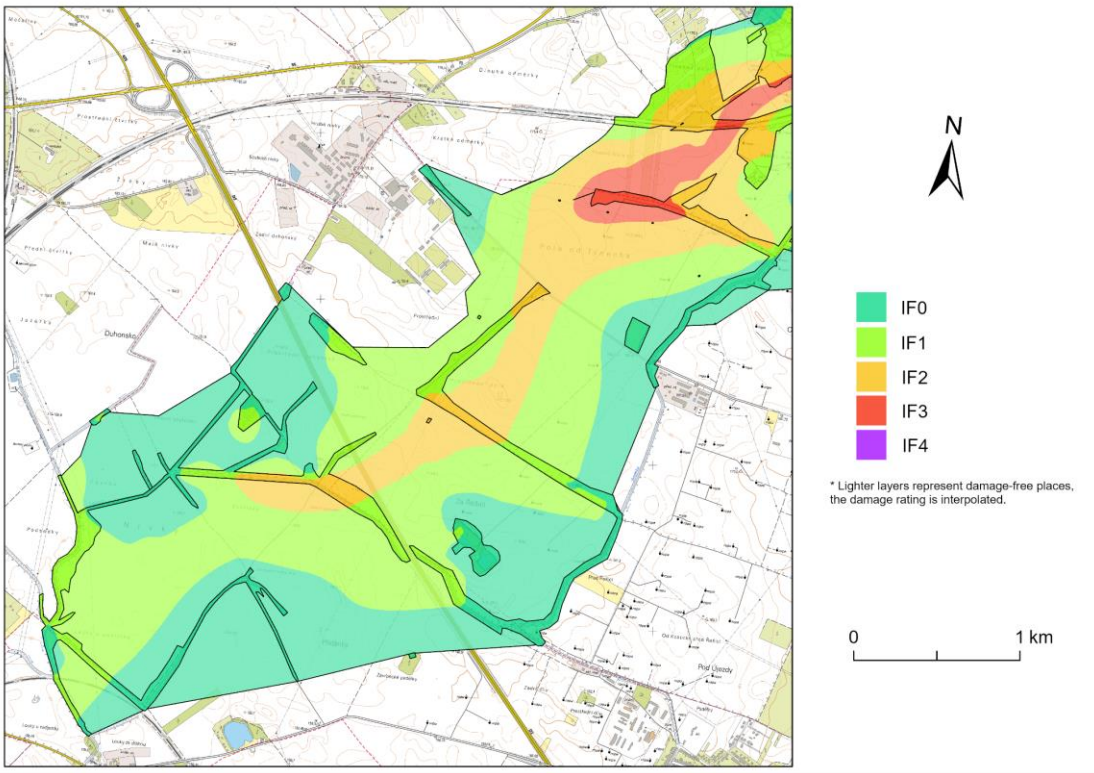
Břeclav - Hrušky

The tornado was the widest at the very beginning of its track. The damage swath east of Břeclav was measured to be up to 2.8 km wide. The tornado quickly became strong, bringing down multiple high-voltage power line pylons and snapping trees. The ground survey noted an impact of vehicles that had been pushed sideways by the tornado onto safety barriers, resulting in IF2 damage. The first IF3 rating was given to a segment of a tree alley to the east of the highway where trees were fully debranched. The tornado then crossed the railway and impacted a small industrial complex significantly damaging two brick buildings that were rated IF2. The railroad catenary was also damaged by the tornado.

Destroyed pylon of 400 kV power lines. Photo: Lukáš Ronge



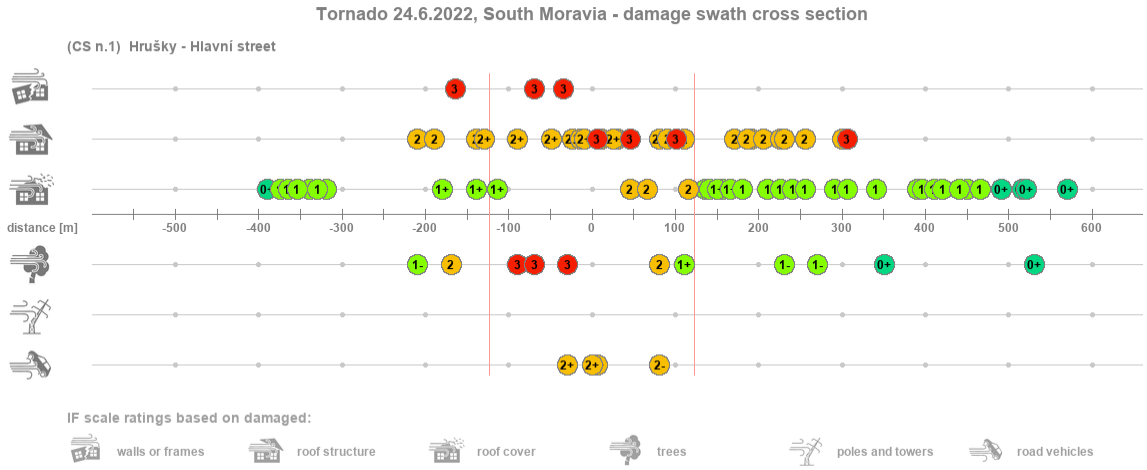
Damage to the tree stand and power line pylons. Note the difference in the fall direction of trees and the masts. Photo: Lukáš Ronge



Map of damage swath in the segment between Břeclav and Hrušky. Lighter colours denote that the tornado intensity at that location is interpolated because no damage indicators were present.

Hrušky

The southern part of Hrušky was most affected by the tornado. Out of 201 damaged houses, 58 had to be demolished, which is the largest fraction of all impacted settlements. The width of the winds with IF2 and higher intensity was up to 590 m. The width of the tornado based on the available damage indicators in a cross-section was almost 1200 m. The absence of indicators on the southeastern edge of the cross-section prevented us from mapping the full width of the tornado. Based on the damage found in the tree alley 800 m southwest of the end of the cross-section, we believe that the tornado was 300 - 500 m wider than the cross-section shows.

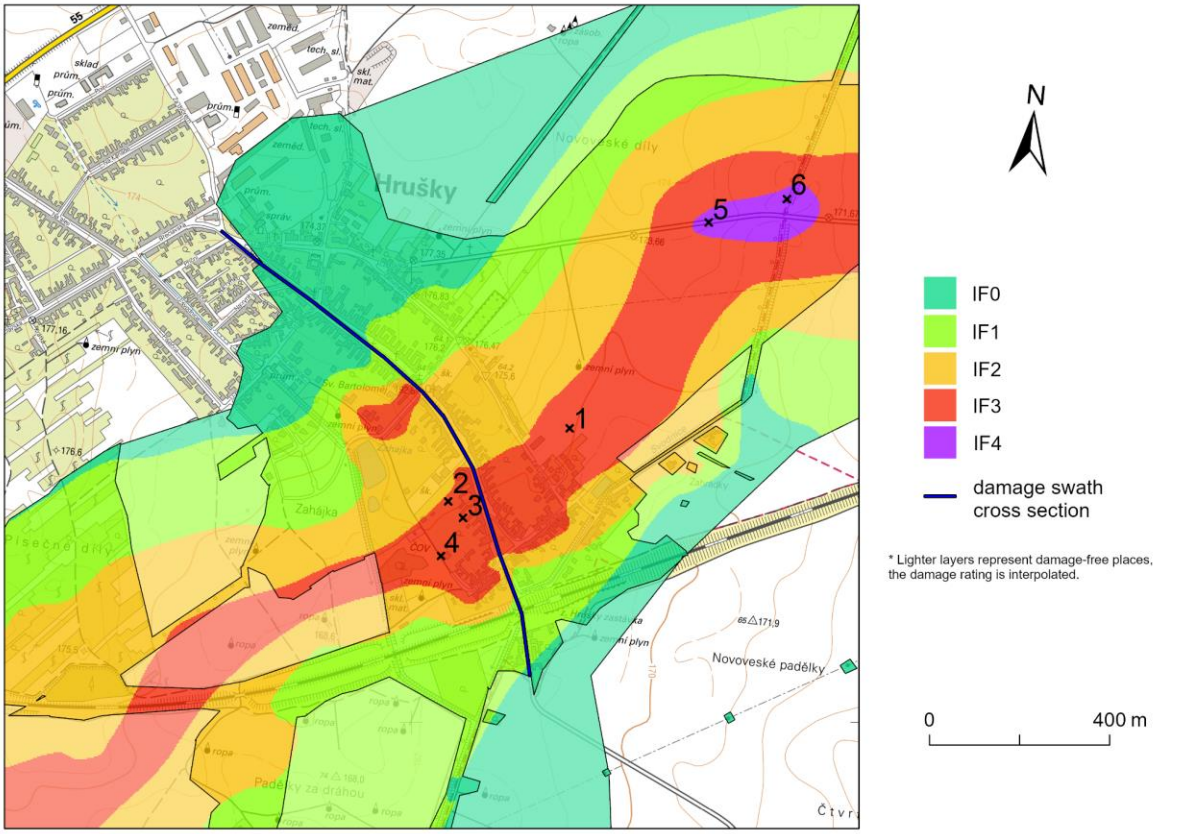


Cross-section through the damage swath in Hrušky. 0 on the x-axis represents the most likely location of the tornado center and red lines represent the margins of the possible tornado center track. Colors correspond to IF-scale ratings while icons represent different types of damage indicators. Position of the number on the x- and y-axis indicates the distance from the center of the tornado and the type of damage indicator.

The most common observed damage in Hrušky was partly or completely destroyed roofs. In addition, weaker brick walls of some houses were heavily damaged or destroyed. A church tower at the edge of the swath of the IF2 winds had partly collapsed. Numerous outbuildings were completely destroyed. A caravan weighing 7 tonnes was lifted and landed 20 meters away, flying over a garage of a house. Two fair attractions weighing several tonnes were also lifted and tossed several meters away from their original location. Several cars were found to be thrown against the walls of houses or into gardens. A large metal container was found wrapped around the iron pole of a gate. The highest damage rating assigned in Hrušky was **IF3**.

Aerial photo of significant damage in Hrušky. Photo: Lukáš Ronge

Photos showing damage found in Hrušky. The numbers correspond to the numbers on the map that indicate the location where it was taken. The locations of photos 1 - 4 can be found on the map of Hrušky below. Photos: Tomáš Púčik.



Map of damage swath in Hrušky. Numbers represent the locations of the photos.

Hrušky to Moravská Nová Ves

Between Hrušky and Moravská Nová Ves, the tornado crossed fields and a road and impacted a tree alley before moving through an agricultural complex with cattle. Grass and crops from the fields were plucked out by the tornado and deposited, along with debris from houses, on the damaged tree alley which was completely destroyed. Several isolated trees ahead of the alley were debranched and almost completely debarked, suggesting violent, **IF4** winds occurred at this stage. Most of the buildings in the agricultural complex were heavily damaged and included the collapse of load-bearing brick walls. A concrete wall of the cattle pen collapsed, killing tens of cows. Due to the weakened structural integrity of the investigated collapsed walls, the highest assigned rating in the complex was **IF3**. Several heavy trailers and tractors as well as large concrete blocks from a hay storing structure were lifted and thrown by the tornado.

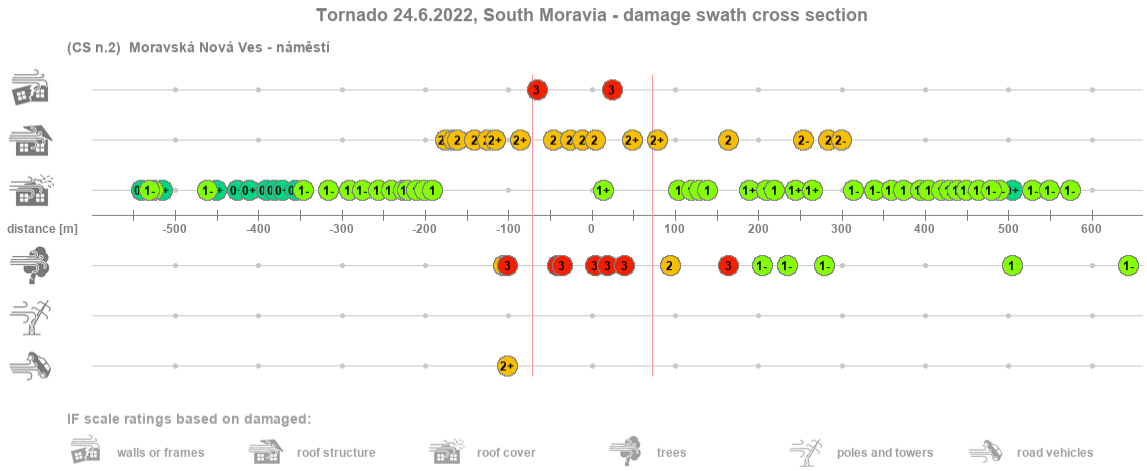
Photos showing damage to vegetation between Hrušky and Moravská Nová Ves. The locations of photos 5 - 6 can be found on the map of Hrušky. Photos: Tomáš Púčik.

Aerial photo showing significant damage to the cattle pen with the collapse of some of the concrete walls. Photo: Lukáš Ronge

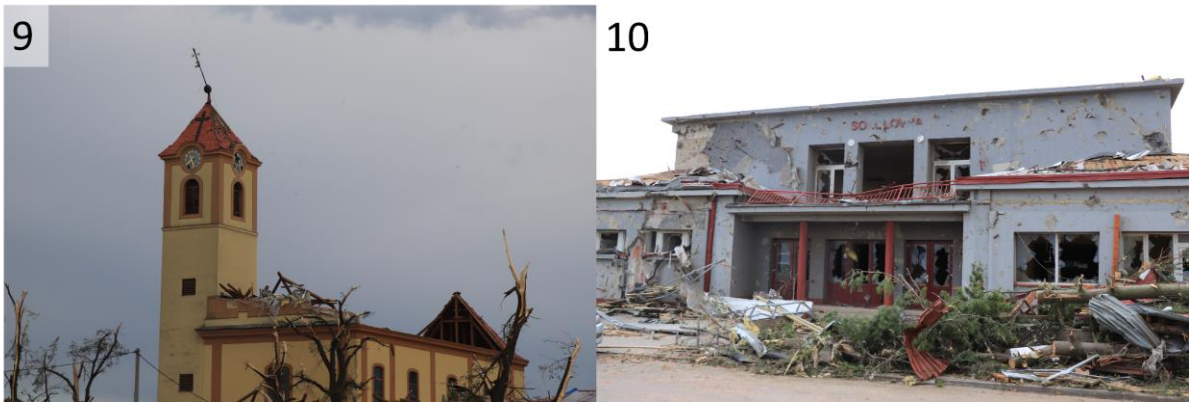
Photos showing damage to the agricultural complex between Hrušky and Moravská Nová Ves. The locations of photos 7 - 8 can be found on the map of Moravská Nová Ves. Photos: Tomáš Púčik.

Moravská Nová Ves

In this village, the highest number of buildings of any village, 369, was damaged. 31 of these had to be demolished, which is a lower fraction than in Hrušky. The tornado was still very wide when crossing the village, with an estimated width of almost 1200 m inferred from the cross-section. The most typical damage observed in the village was the removal of tiles from the roofs. In the central part of the tornado, more significant damage was observed. The widest span of IF2 and stronger winds was almost 500 m, similar to that in Hrušky. Within this swath, the roofs of some of the buildings were completely destroyed, trees debranched, and cars overturned. A truck was overturned at the town square. One of the more notable damage points was significant damage to the roof of the church. The church clocks stopped working at the time of the tornado, showing the time of the tornado: 7:25 p.m. local time. Isolated spots of **IF3** damage were identified in Moravská Nová Ves with damage to the brick walls of the houses. A complete collapse of load-bearing walls was noted with new buildings on the eastern edge of the village. Because the structures were either not entirely finished, or used rather light wall material and weak support between the walls and the ceiling, an IF4 rating was not warranted.

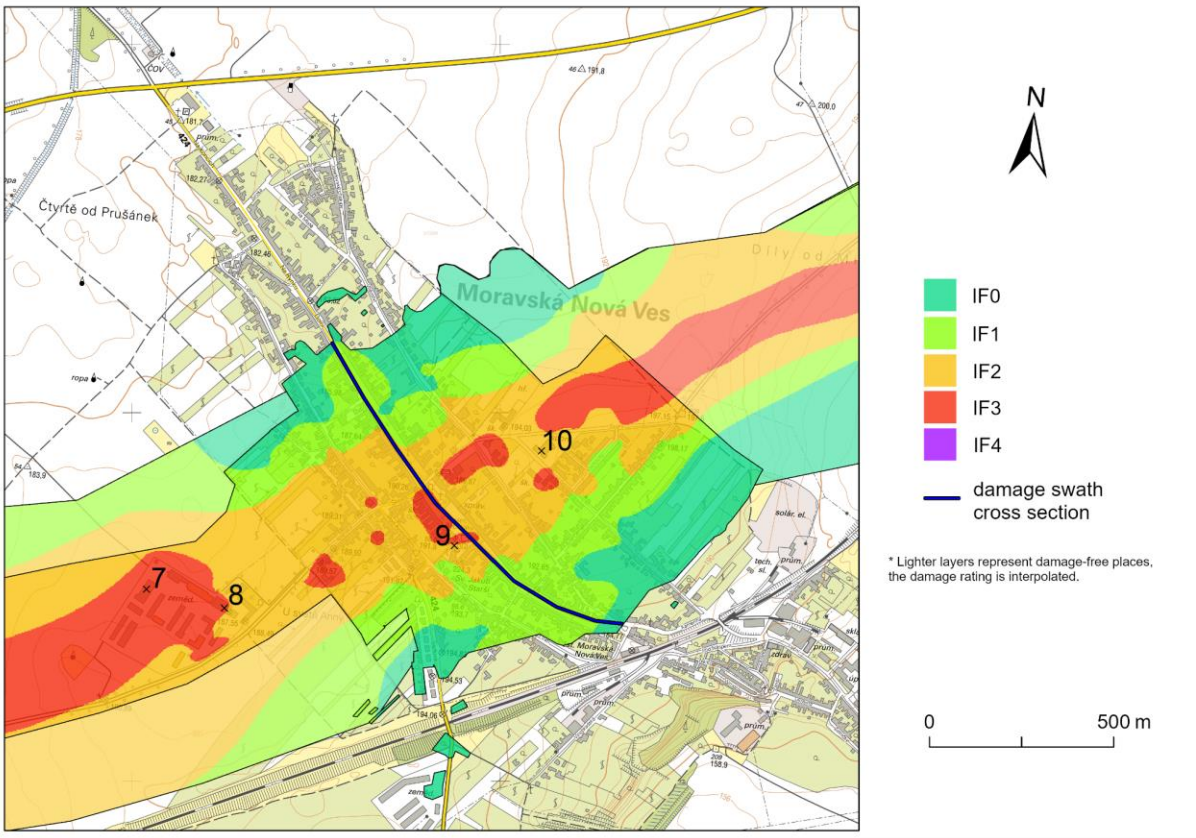


Cross-section through the damage swath in Moravská Nová Ves.



Photos showing damage in Moravská Nová Ves. The locations of photos 9 - 10 can be found on the map of Hrušky. Photos: Tomáš Púčik.

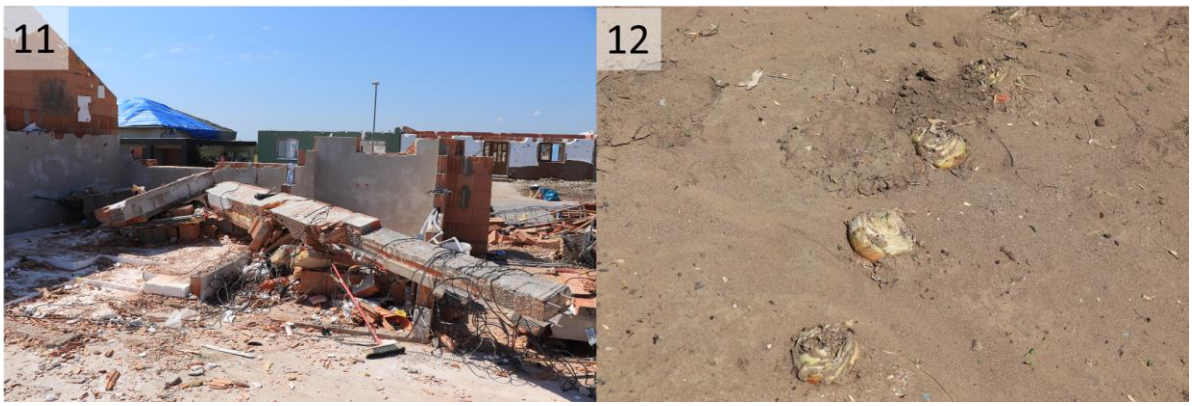
Aerial photo showing damage to the central part of Moravská Nová Ves. Photo: Miloslav Staněk.



Map of the damage swath through the agricultural complex (near 7 and 8) and in Moravská Nová Ves.

Mikulčice

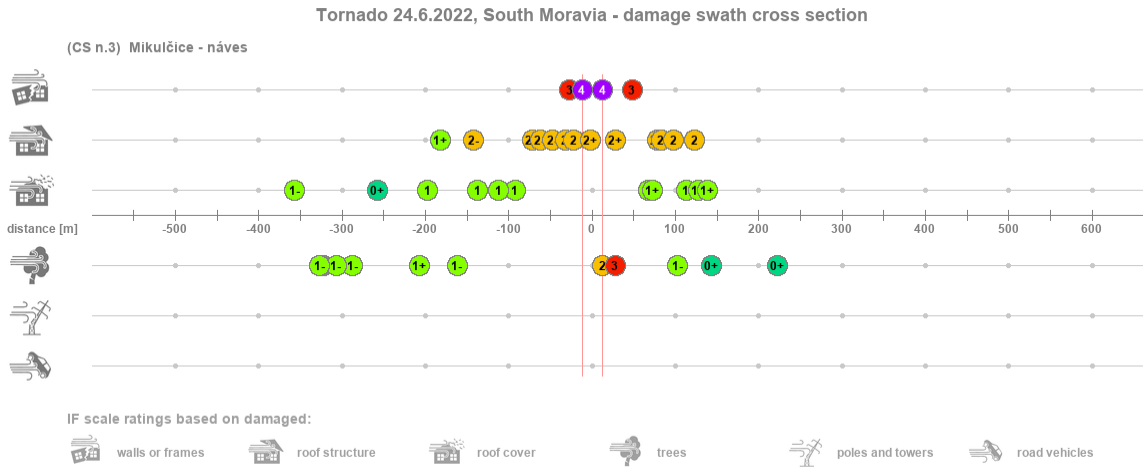
The tornado got narrower, but also more intense as it traveled from Moravská Nová Ves to Mikulčice. 300 houses were damaged by the tornado in Mikulčice, out of which 62 had to be demolished. Three locations with **IF4** damage were observed there. The tornado first impacted a row of newly built houses. Here, an IF4 rating was assigned to the damage of three well-built brick structures. One of the brick structures was completely destroyed, which would warrant an IF5 rating. However, a rather weak connection between the roof and the walls was found, which prevented the damage to be assigned an IF5 rating. Another structure that was completely destroyed was still under construction. Debris from the houses were carried over the following field along considerable distances. Both tree debarking and the removal of topsoil was noted in the field.



Photos showing damage in the western part of Mikulčice. The locations of photos 11 - 12 can be found on the map of Mikulčice. Photos: Tomáš Púčik.

Aerial photo showing the location of IF4-rated houses in western Mikulčice and the direction of debris fall. Photo: Lukáš Ronge.

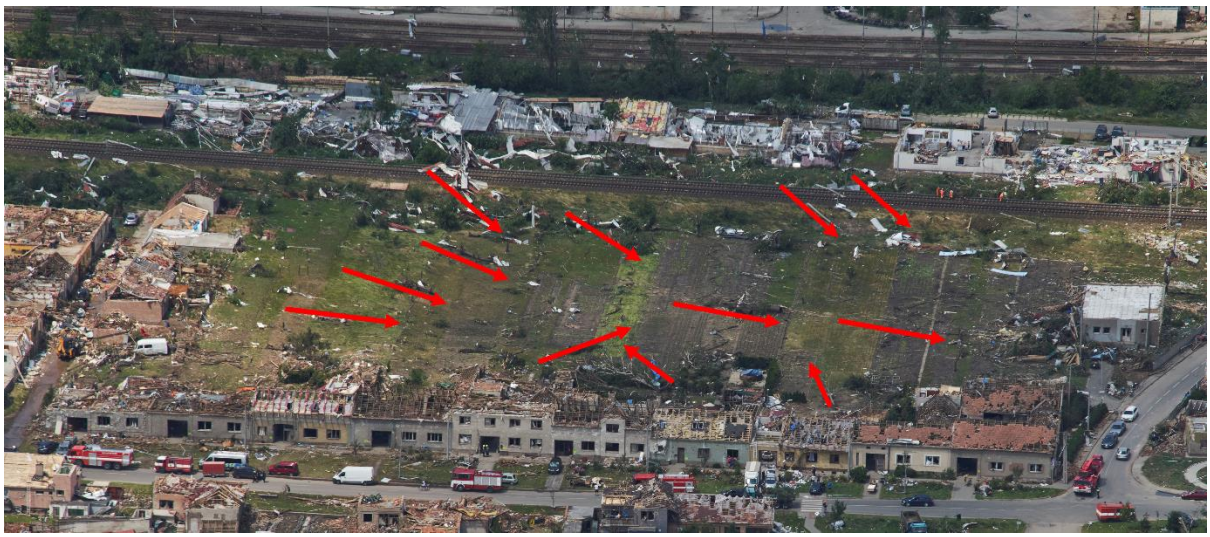
As the tornado moved through the village, numerous houses were damaged or destroyed along the main street and central part of the village with IF2 - IF4 ratings. The most typical damage was the destruction of roofs and collapse of the ceilings, but significant damage to brick load-bearing walls was also noted in some houses. Where the most severe damage occurred, trees were uprooted, snapped, or significantly debranched. Many damaged or destroyed cars were found, but most of them had already been moved from their original locations after the tornado impact. The damage swath was 600 m wide with the swath of IF2 and higher intensity being approximately 200 m wide.



A cross-section through the damage swath in central Mikulčice.

Aerial photo showing the location of an IF4-rated structure in central Mikulčice with a debris fall in the direction of tornado motion. Photo: Lukáš Ronge.

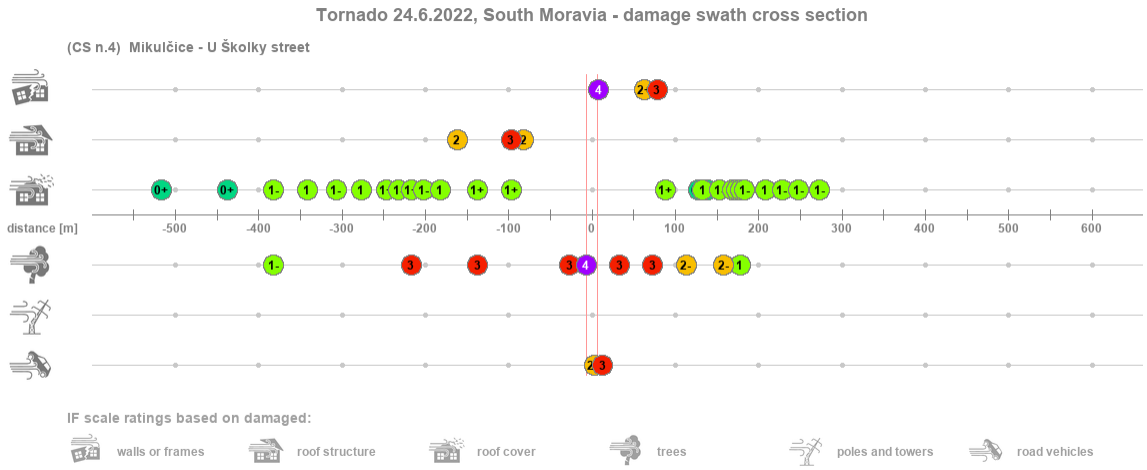
Photos showing damage in the central part of Mikulčice. The locations of photos 13 - 16 can be found on the map of Mikulčice. Photos: Tomáš Púčik.



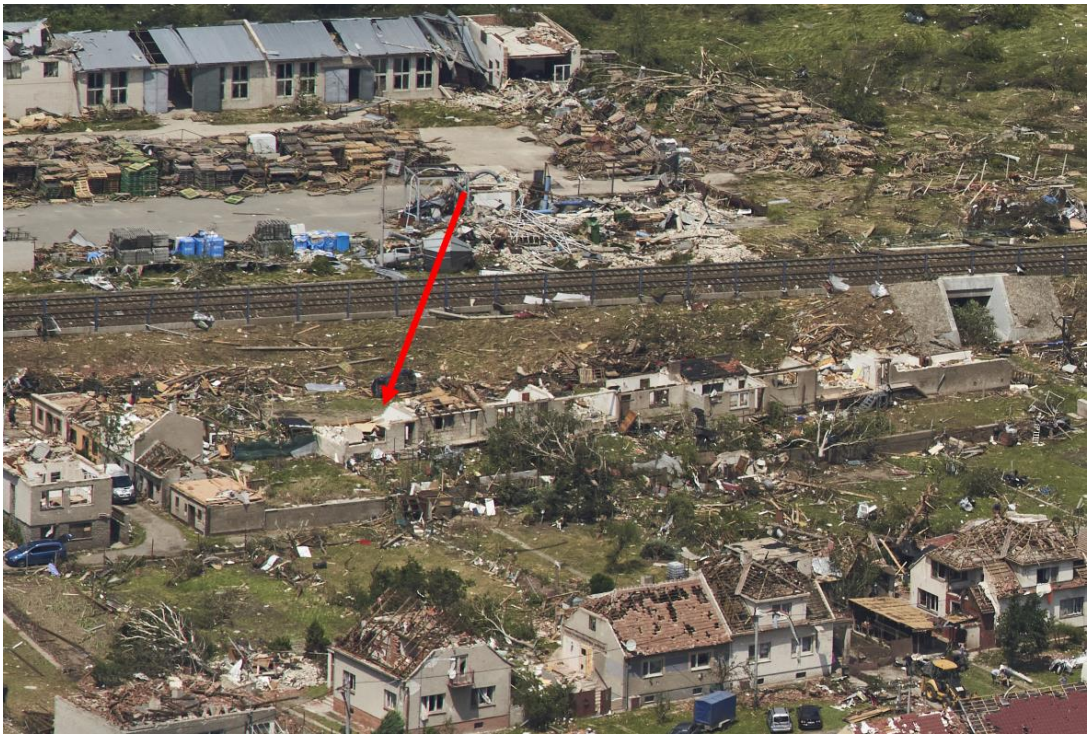
Aerial photo showing convergent debris patterns near the center of the tornado track in Mikulčice. Photo: Lukáš Ronge.

The most intense phase of the tornado occurred at the eastern end of Mikulčice where a narrow, 300 m long swath of IF4 damage was found as the tornado crossed the railway. Within the swath, several brick houses were destroyed. A bus with several passengers inside was thrown over a small hill, impacting a one-story high brick house. The first story of the house was completely destroyed, as well as two ground walls. Trees were debarked in the area and large concrete panels measuring 3 x 1 x 0.1 m were moved several meters. The railway was also badly damaged: Catenary along with large suspending pylons and railroad signals were

completely destroyed. Sound canceling barriers were destroyed as well, and the material from which they were made was scattered over large distances. The cross-section at this point shows a damage swath approximately 750 m wide with IF2 and stronger winds covering 250 m.

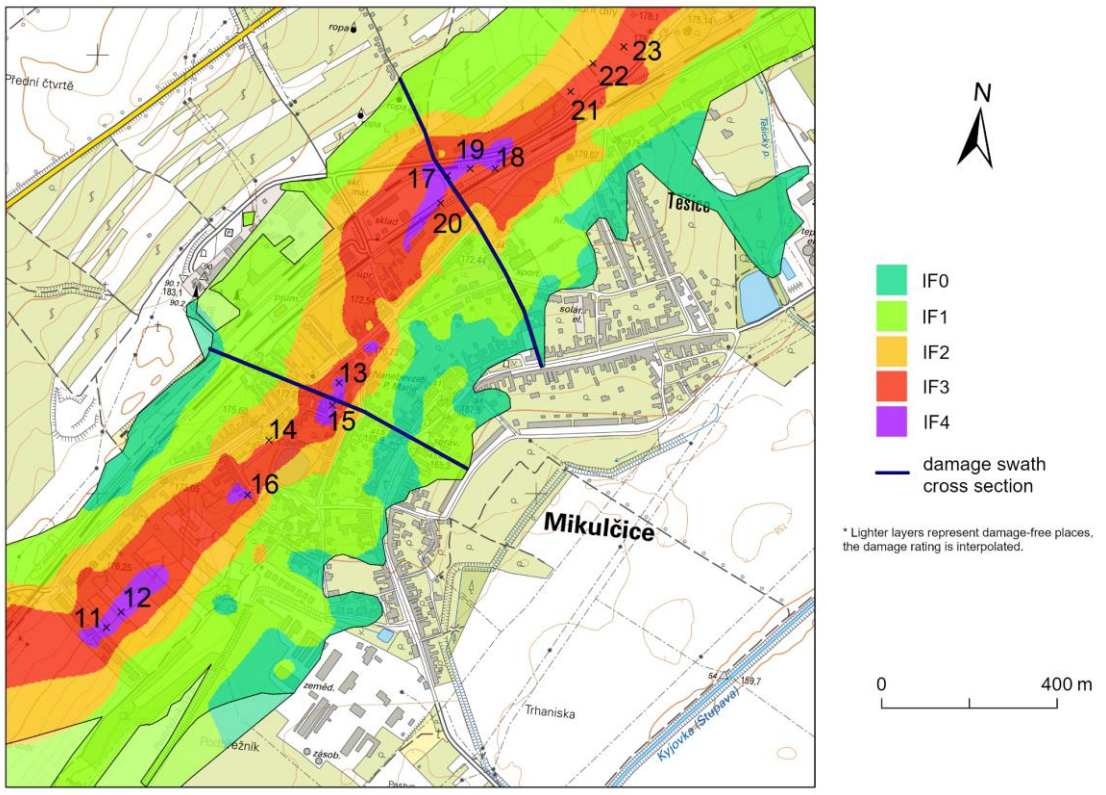


Cross-section through the damage swath in eastern Mikulčice.



Aerial photo showing the beginning of the IF4 swath in eastern Mikulčice. Photo: Lukáš Ronge.

Photos showing damage in eastern Mikulčice. The Locations of photos 17 - 20 can be found on the map of Mikulčice. Author: Tomáš Púčik.



Map of the damage swath in Mikulčice.

Mikulčice to Lužice

The tornado continued to become narrower as it moved towards Lužice, crossing fields and vineyards. Vineyards near the center of the tornado track were completely destroyed and iron wires used to hold the grapes were found mangled around trees. The center of the track was well visible as the tornado crossed corn field. Near the center, corn was reduced to several cm high stubs, with progressively less damaged towards the edges of the tornado path. The trees had been debranched or snapped and minor debarking was noted in some cases. Several smaller trees had been lifted by the tornado and thrown on the fields. Topsoil and crop/grass removal were observed in some segments. Several brick structures used as wine cellars had collapsed or had their brick walls damaged, but none of them was structurally sound enough to warrant an IF4 rating. The highest assigned rating to these structures was **IF3**. A layer of grass and mud was deposited on a bent fence surrounding one of the houses. A damaged vehicle was found in a field approximately 100 m away from the nearest road. Although the original location of the car is not known, its engine was found approximately 150 m away from the car in the opposite direction of the tornado's motion. Because no impact or drag marks were found in the field, it is likely that the car had been airborne for at least 200 m.

Photos showing damage between Mikulčice and Lužice. The locations of photos 21 - 23 can be found on the map of Mikulčice. The location of photo 24 can be found on the map of Lužice. Photos: Tomáš Púčik.

Lužice

100 houses were damaged in Lužice, of which 17 had to be demolished. The tornado first impacted the industrial park of MND Drilling & Services and the Lužice train station. Well-built concrete or brick structures of the complex had significantly damaged roofs and facades, but their walls were mostly intact except where they had been impacted by heavy debris. A smaller, weaker-built brick structure had been completely destroyed, but was not sturdy enough to warrant an IF4 rating. Empty large containers were thrown by the tornado. A spot of intense damage occurred near one of the parking lots, where small trees had been debranched and debarked, and many cars had been thrown from the parking lot against the adjacent industrial building. The building was heavily damaged by the tornado and only steel pylons (some of them bent) were left standing. The ground survey team was not able to rate the damage to this building, but given the other damages at least **IF3** winds had occurred.

Photos showing damage in the industrial park in western Lužice. The locations of photos 25 - 26 can be found on the map of Lužice. Photos: Tomáš Púčik.

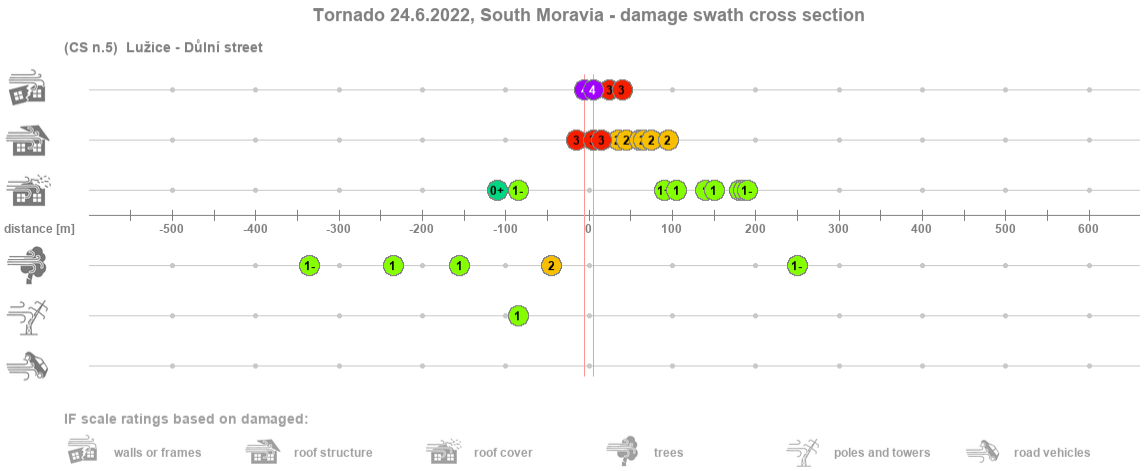
Aerial photo showing the displacement of cars from the parking lot in western Lužice. Photo: Lukáš Ronge.

Photos showing damage in the industrial park in western Lužice. Cars were towed back from the field, where they originally landed. The locations of photos 27 - 28 can be found on the map of Lužice. Photos: Tomáš Púčik.

The tornado subsequently damaged houses along the main street, Velkomoravská, while crossing it. Several structures had brick walls damaged or destroyed, but were not sturdy enough to warrant a violent tornado (i.e. IF4) rating. The parallel orientation of the terraced housing of the street to the track of the tornado may have prevented more intense damage in this section as the strongest wind blew parallel to the long line of houses. The center of the tornado then moved over gardens south of the street, debranching trees and destroying some outbuildings. A more serious impact was surveyed at the southern edge of Důlní street. Two structures were heavily damaged by the tornado and were rated **IF4**. Both were very sturdy houses with thick brick walls. A debarked tree was also found behind the row of heavily

damaged houses. The tornado was 580 m wide at this point while IF2 and stronger winds covered a width of about 150 m.

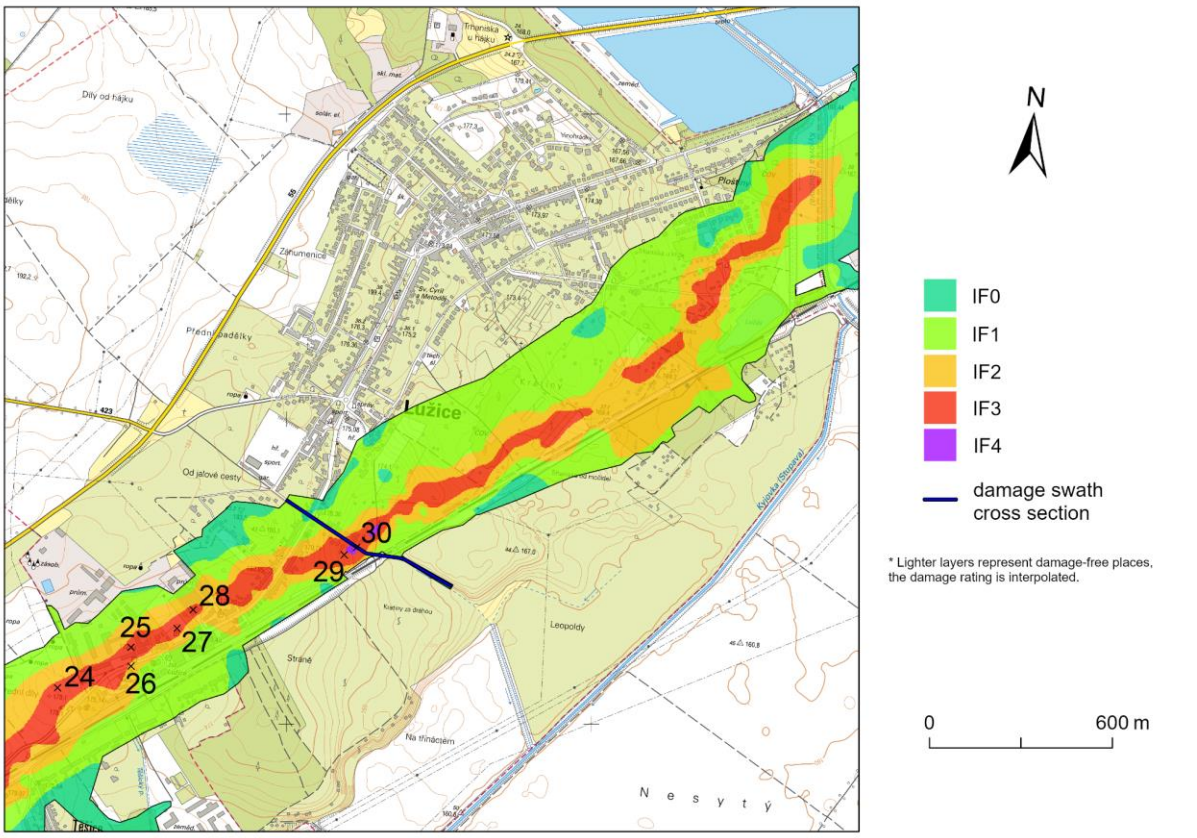
Photos showing damage in southern Lužice. The locations of photos 29 - 30 can be found on the map of Lužice. Photos: Tomáš Púčik.



Cross-section through the damage swath in Lužice.

The tornado subsequently traveled across fields and gardens, destroying several small wooden or weaker brick structures. Debranching of trees and vegetation removal was noted in a 30 - 50 m wide swath. Near lake Lužák, several wooden and brick houses were completely destroyed. These destroyed structures were not permanent residences and thus were not of a high construction level. Stronger structures in the area suffered mostly roof damage. Extreme tree debranching was noted in a narrow swath 20 m across. Nearby houses located within 40 m only suffered minor roof damage. The highest damage rating in the area of lake Lužák was **IF3**.

Aerial and ground photos showing a narrow swath of significant damage to the forest in southeastern Lužice. Note only light damage to the houses within 40 m of the swath. Photos: Lukáš Ronge and Tomáš Púčik.



Map of the damage swath in Lužice.

Lužice to Hodonín

The tornado further narrowed as it travelled towards Hodonín and its path curved slightly northward. Sections of two solar power plants with photovoltaic panels were destroyed. A large metal storage building collapsed, and a weak brick structure was significantly damaged. Combined with minor debranching and snapping of trees, the damage here was rated IF2 in some locations of the tornado path. The tornado then moved over a gardening colony. Here, trees were snapped, and wooden outbuildings were destroyed by the tornado with a highest damage rating of **IF2**. The swath of strongly tornadic winds (i.e.at least IF2) was still narrow, measuring only 50 m.

Aerial photo showing damage to the photovoltaic panels east of Lužice. Photo: Lukáš Ronge.

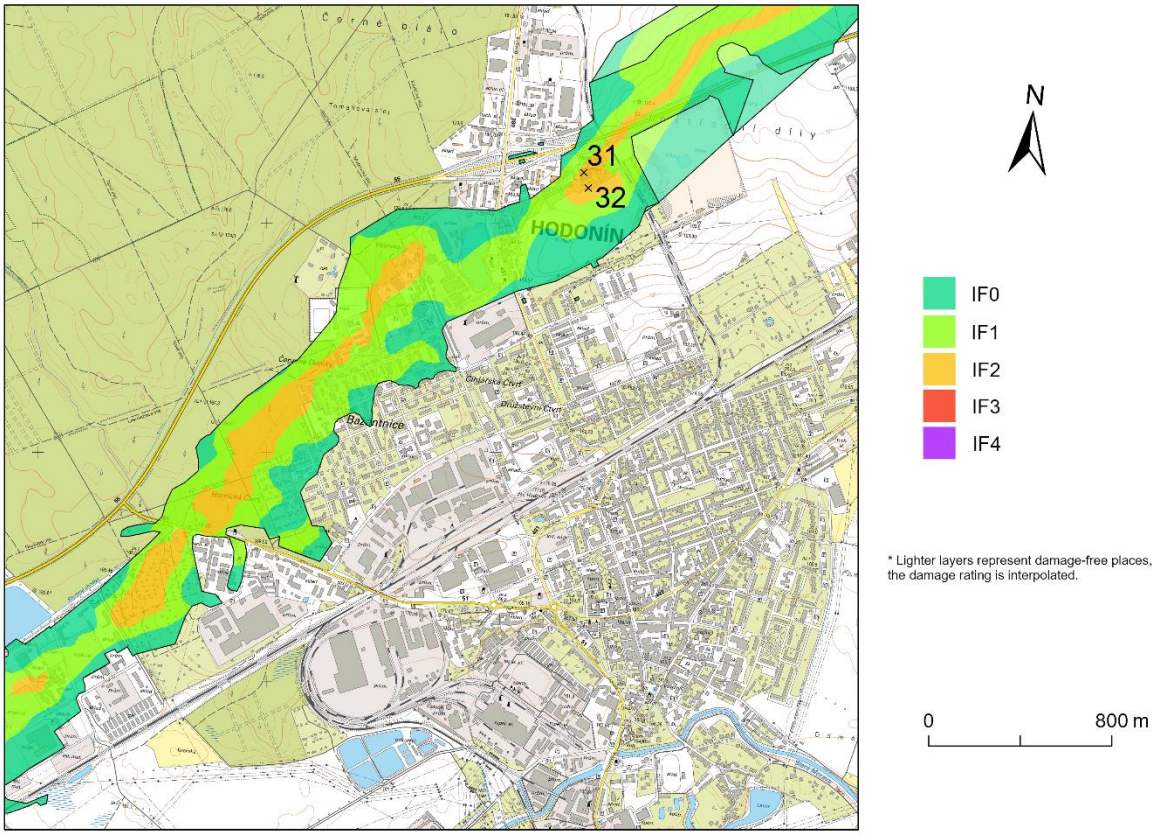
Hodonín

100 buildings were damaged in Hodonín (including Pánov, discussed later), of which 10 had to be demolished. Overall, the tornado was weaker in Hodonín than in the other settlements with a maximum assigned damage rating of **IF2**. The tornado affected the western outskirts of the town. The core of the tornado stayed mostly over the forest, preventing more building damage from the most intense part of the tornado. Had the tornado remained on its previous mean course between Hrušky and Lužice, it would have impacted the centre of the town.

Aerial photo showing damage gradient in Hodonín. Photo: Lukáš Ronge.

IF2 damage was observed in the forest where multiple trees snapped. Weak outbuildings were destroyed and the tornado partly impacted the local zoo. The local residential area Bažantice, consisting of large, 4-story high blocks of flats, was damaged by the tornado. The damage was mostly done to the roofs and was rated IF1, with the exception of an IF2 rating for the destroyed roof of a school. Several cars in parking lots were flipped. The tornado slightly grew in size as it crossed Hodonín. One of the most notable damage points in Hodonín was a home for the elderly, a large and multi-story building found at the northern edge of the town. Its roof and interior were significantly damaged, rendering the building unusable since the tornado. Wooden and steel beams from the roof were found impaled in the ground around the buildings and bent by the wind. Large concrete floor tiles were plucked out of the ground and thrown away.

Photos showing damage to the home for the elderly in northeastern Hodonín. The locations of photos 31 - 32 can be found on the map of Hodonín. Photo: Tomáš Púčik.



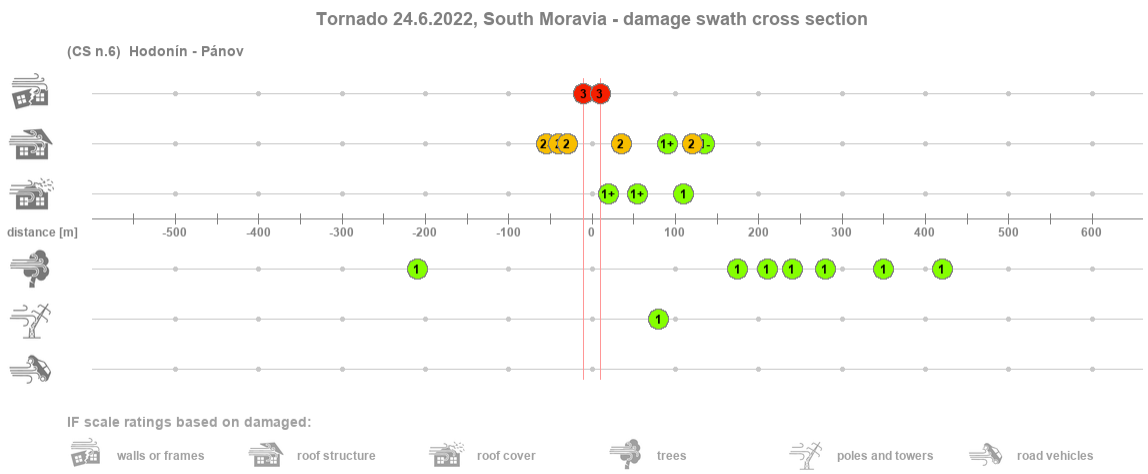
Map of damage swath in Hodonín.

Hodonín to Pánov and Ratíškovice

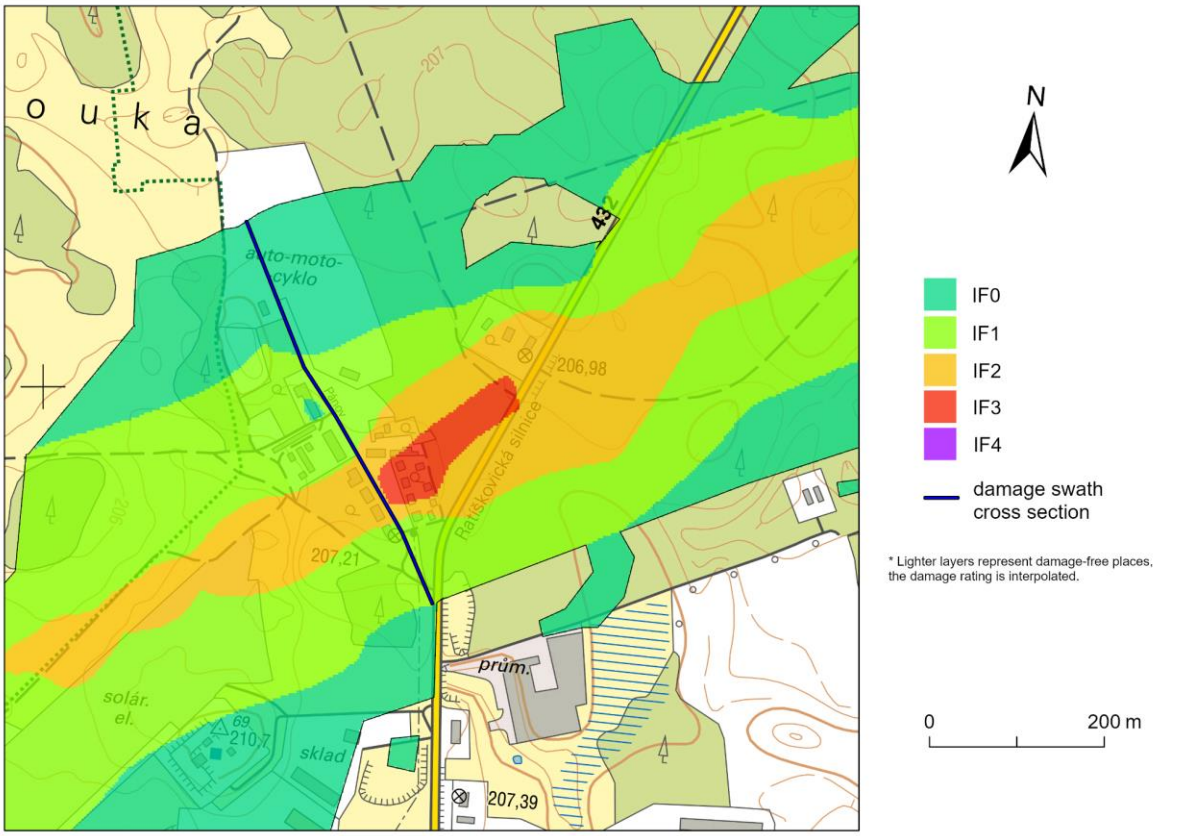
The tornado then crossed the road, field, and a forest between Hodonín and Pánov. Coniferous trees were mostly uprooted or snapped, while deciduous trees were sometimes partly debranched. High-voltage power lines were affected by the tornado with two pylons damaged. Just before Pánov, an edge of a photovoltaic power plant was damaged with many panels missing. The tornado then impacted the settlement Pánov. Sturdier-built houses suffered mostly roof damage. Several weaker brick walls collapsed in three smaller houses. By the time of the ground survey of this location (26 June, two days after the tornado), the structures had already been bulldozed down, preventing a precise assessment of their sturdiness. Taking into consideration the very conservative sturdiness rating and multiple wall failures, the resultant damage rating is **IF3**. The damage swath in Pánov was up to 600 m wide with winds of IF2 or stronger covering 100 m of the swath. The tornado finally moved over a forest, uprooting and snapping thousands of trees before decaying south of the village Ratíškovice.

Aerial photo showing the track of the tornado through the field northeast of Hodonín. Photo: Lukáš Ronge.

Aerial photo showing the damage in Pánov. Photo: Lukáš Ronge.



Cross-section through the damage swath in Pánov.



Map of the damage swath in Pánov.

Comparison of building and vegetation damage indicators

We found that high-end damage (IF3 - IF4) to buildings was very often accompanied by high-end damage to nearby trees. This high-end damage manifested itself as debranching and debarking. Debarking of trees happened when the nearby buildings suffered at least IF3 damage. In some cases, the damage rating from the vegetation exceeded that of nearby buildings. This occurred only with the damage indicator “debranching”. In the example shown in the figure below, two hardwood trees were significantly debranched, warranting an IF3 rating, while the surrounding houses show roof damage rated IF1 to IF2.

Aerial photo showing the vegetation and roof damage in western Mikulčice. Arrows point at the debranched trees with an IF3 damage rating. Photo: Lukáš Ronge.

Operational challenges of conducting the damage survey

The survey of this event proved to be challenging in many ways. First, a good organization of a survey for such a large-scale event is necessary. While several teams from different organizations visited the site, there was limited coordination, which could have allowed them to jointly survey larger areas in less time. As a result and because cleaning up of the damage started early, only a part of the tornado path could be surveyed in detail. This rendered the aerial surveys that were conducted the day after the tornado extremely valuable.

Another challenge was that, for most of the surveyors, this was the first violent tornado survey that they participated in. The scale of the event with hundreds of structures and trees damaged

that needed to be surveyed and processed in a short amount of time was overwhelming and psychologically demanding. A damage rating app that would allow saving the IF-scale ratings along with the GPS coordinates would have made the job easier. ESSL is currently developing such an app.

Suggestions for the improvement of the IF-scale

The authors suggest that the following considerations be discussed within the IF scale working group:

1. The fact that debranching of trees is given a high rating, while in some cases the surrounding buildings suffered only minor roof damage, which points to a potential inconsistency.

2. Damage to isolated trees often results in higher rating than the damage to the neary buildings.

3. The scale makes it difficult to rate a damage to well-constructed brick houses (sturdiness rating of E), the most ubiquitous type of building, as IF3. Roof destruction results in an IF2, while structural damage to the walls warrants IF4.

4. Some roof gables were apparently very unstable and seem to have failed easily, occasionally even when tiles were still attached to the roof. On the other hand, some gables were quite sturdy as the room under the roof was inhabited. The wide range of structural integrity of gables should be reflected in the IF-scale.

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