TORRO SITE INVESTIGATION

SUMMARY REPORT

Stalybridge, Greater Manchester, Cheshire

27 December 2023

Report number: SI20231227_stalybridge

Site Investigator: Kay Morrison

Site Investigator: Jon Bayliss

Site Investigator: Sarah Horton

Authors **Site Investigator:** Kay Morrison krazy413@gmail.com

Site Investigator: Sarah Horton sarah.horton@torro.org.uk

Site Investigator: Jon Bayliss

David Smart: david.smrt@gmail.com

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Site Investigation summary

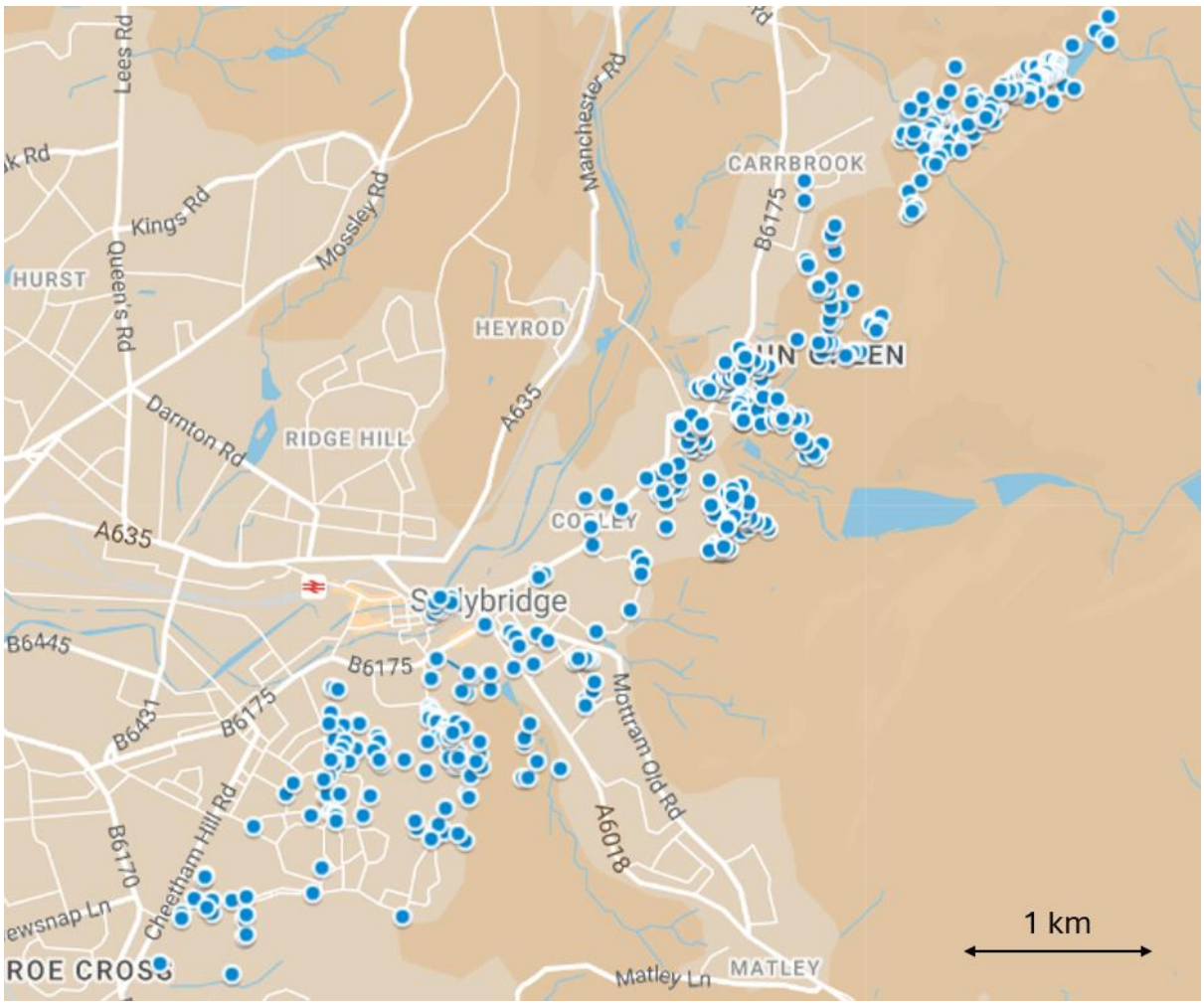

Figure 1: Damage track of the Stalybridge tornado (2023). Map data ©2024 Google

Cause of Damage:	Tornado
Strength:	T4/5
Track Length:	6.7km
Maximum Width:	Estimated 1km. See Comment 1
Time / Duration	2305 UTC / 5 min
Map Location	Multiple postcodes in Dukinfield, Stalybridge, Millbrook and Carrbrook

Key damage indicators

Dukinfield

1. The most southwesterly area of damage found was around SK16 5BJ where multiple small trees had been damaged or uprooted over a width of around 300m. One conifer had fallen NE, dislodging a low concrete wall which had been situated over the roots. The tree impacted the gable end of a house. **Intensity rating: T2**
2. Relatively few homes were impacted until around the postcode SK16 5HP where several homes lost some roof and ridge tiles. At 53.4754, -2.0627 these had been moved NW. **Intensity rating: T2**
3. A garage roof (location: 53.4749, -2.0621) was thrown 45m to the WNW, landing in two sections 5m apart. **Intensity rating: T2/T3**
4. On Highcroft Close (SK16 5HU) and Hill Mount (SK16 5HT), consistent roof damage was found across multiple properties. These are roads parallel to each other oriented SW-NE. Sections of roof tiles and ridge tiles were lost and chimney stacks damaged. **Intensity rating: T2**
5. A cluster of roof damage was found around Macauley Close SK16 5DT, giving a discontinuous track width of 600m. Multiple roofs suffered loss of more than 20 tiles. Tiles were thrown into the local field to the N. At least 6 cars suffered damage from debris impact. **Intensity rating: T2**

Stalybridge

1. Rose Hill (SK151UT), to the NW and parallel to Highcroft Close in Dukinfield suffered similar damage to Highcroft Close, with ridge tiles and sections of roof tiles removed. **Intensity rating: T2**
2. Two adjacent terraced homes in Hough Hill Road (SK15 2HB) lost the SW aspects of their roofs (location: 53.4779, -2.0530). The most southerly property's roof was thrown 20m WNW. This building also suffered collapse of most of the SE gable wall to attic floor height. The other homes roof detached from the building, to overhang the front. This property also lost up to a maximum of 12 courses of bricks from the front of the property above the bedroom windows. **Intensity rating: T4/5**

3. Other homes close to those severely damaged in Hough Hill Road suffered mild-severe damage to their roofs. ranging from a small number of tiles off the SW side of a home at 53.4778, -2.0542 to many tiles off (53.4778, -2.0527) and a collapsed chimney at 53.4780, -2.0537. Outside of a swath of around 70m wide, the roof damage severity dropped off sharply. **Intensity rating: T1-T3**
4. Around SK15 2RU a small cluster of trees were damaged or were felled. Fall directions ranged from N-NE. Overall across this area, the damage width was around 400m, though with a field to the SE, it is not known whether this is representative of the track width at this point. **Intensity rating: T1-T3**
5. Isolated tree damage was found in Cheetham Park around 53.4766, -2.0466. Large branches fell N and NE, but in one location 53.4775, -2.0476, they fell S. Other trees around here appeared not to be affected. Other isolated tree damage occurred at 53.4798, -2.0523, where multiple trees (trunk diameter 0.5m) fell NNE and around 53.4832, -2.0544 where willow trees fell in various directions W-N-E. There were also a small number of houses with light roof tile damage in this location. There was an apparent swath width of 1km of intermittent clusters of damage. See comment 1. **Intensity rating: T1-T3**
6. At 53.4810, -2.0468 a house had damage to a chimney stack and roof tiles were missing. A local report described a car and kitchen window as being damaged by a flying trampoline and that electricity cables were hanging down. **Intensity rating: T2**
7. A similar pattern of damage was noted throughout Stalybridge of more intense areas of damage in some parts, and other parts with very little to no damage.

Millbrook

1. Around SK15 3JB there were multiple examples of T3 damage. This includes a van being pushed by wind up to 1.5m, a motorbike being rotated around its axis and a large oak tree landing on a house falling through the roof. There were many other large trees that had been felled or badly damaged. These generally fell N to NNE. Some roofs were damaged sufficiently to require complete replacement. **Intensity rating: T3**
2. At 53.4934, -2.0326 the light fitting from a street lamp was ripped off. The damage path width here was around 600m.
3. At 53.4979, -2.0252 a barn of stone and brick construction was severely damaged. The corrugated metal roof was removed, and heavy wooden joists

were lifted and replaced by the tornado. The end walls of the barn had partially collapsed. Corrugated metal, resembling that of the barn was found 850m and 950m away to the north. **Intensity rating: T3/4**

Carrbrook to Cowbury reservoir

1. At 53.5014, -2.0180, a utility pole had been snapped. A segment of this pole landed 10m to the NE. Close by, a house was relatively undamaged, but there was severe tree damage on both sides of the house. Major debranching occurred to at least two strong, mature trees at this location and also to a large tree across the field to the northwest at 53.5024, -2.0198. **Intensity rating: T4/5**[1]
2. Across a field to the east of Swallow Lane (SK15 3PH) many items of debris were found. This included corrugated metal sheets, plastic and wooden panels, and large tree branches.
3. On Castle Lane (SK15 3FJ) gable ends of several semi-detached and terraced houses along an 80m stretch of road collapsed, though the roofs remained generally intact, with T2-T3 tile damage. On some of these properties, the gable end at both ends of each block of properties collapsed, with the gable end collapsing into the loft at one end and out on to the ground at the other. The construction of these buildings appeared to be breeze-block and limestone. **Intensity rating: T4**
4. To the NE of Carrbrook there were many severely damaged trees. In a focused area of damage within a larger section of woodland (53.5056, -2.0128 and around) almost all trees were felled or severely damaged by the tornado. These mostly consisted of large, mature deciduous trees that were out of leaf. Some had been snapped halfway up the trunk. Of those that remained upright, the majority of branches were torn off, with a shredded look characteristic of strong tornadoes. The most heavily debranched trees had no small branches remaining. **Intensity rating: T4/5**[1]
5. Around 53.5060, -2.0119 (approximate location) a small motorboat attached to the trailer was thrown by the tornado and landed upside down.
6. In various locations around 53.5067, -2.0108, roof tiles were found within woodland. The closest known property to these was around 100-160m to the south.

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[1] The intensity rating at these locations may be subject to further revision.

7. Within Cowbury Dale, numerous small trees and several large trees were uprooted or damaged across an area of woodland around 800m^2, up to the SW edge of Cowbury Reservoir. The most north-easterly instance of damage from the tornado was to some small trees growing on the hillside above the northeastern shore of the reservoir. **Intensity rating: T2/3**

Meteorological summary and remarks

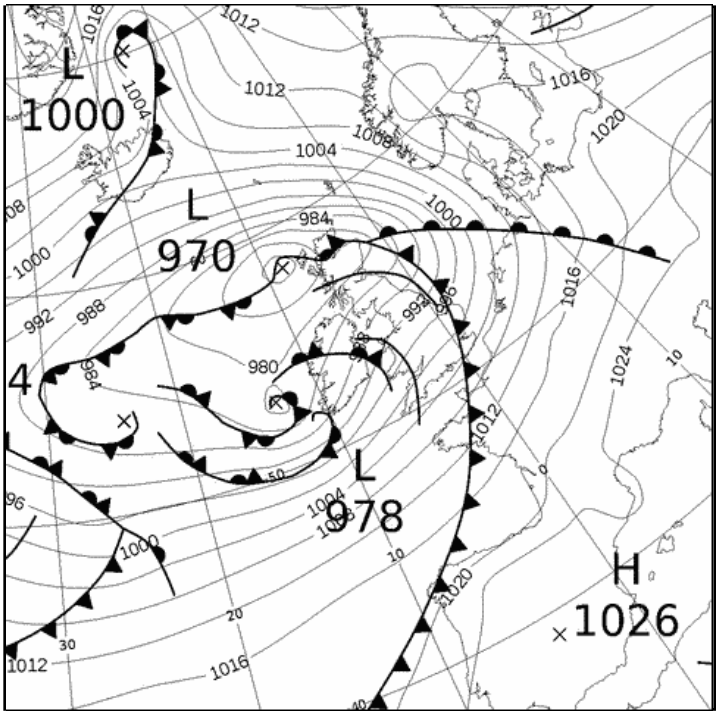

Figure 2: UKMO ASXX 1800 UTC 27 December 2023. Original: Crown copyright. This event occurred during Storm Gerrit (named by the Met Office), see Kendon (2023)

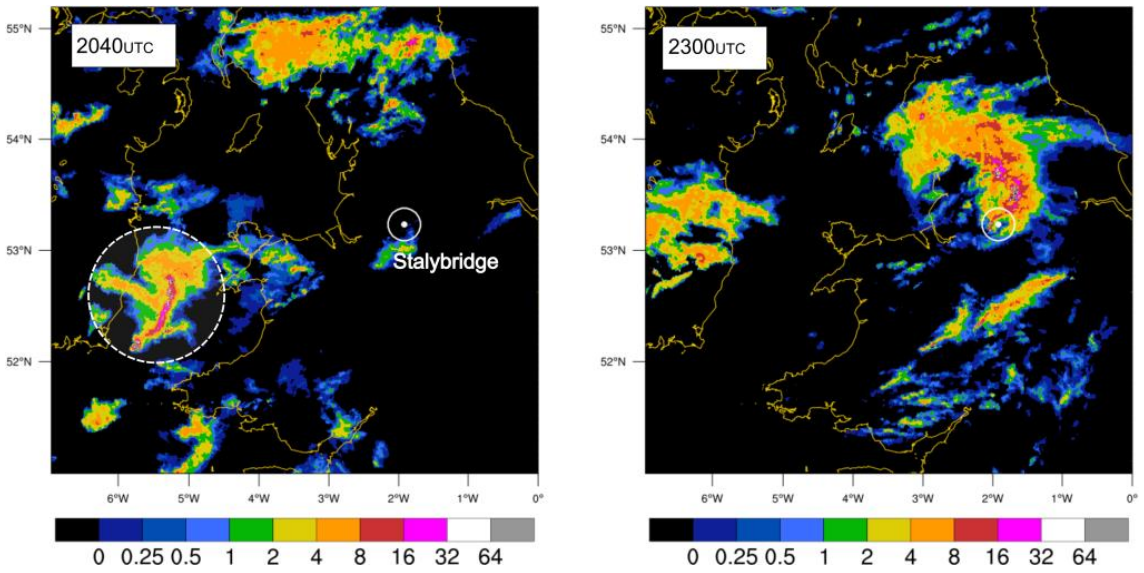

Figure 3: UKMO network radar images at (left) 2040 UTC 27 December and (right) 2300 UTC. The 'Bow-and- Arrow MCS' over Ireland is highlighted by the dashed circle and the location of Stalybridge by the target marker. Original data: UKMO, Crown copyright.

The Mesoscale Convective System (MCS) that produced the Stalybridge tornado evolved on the occluded front/short wave over Ireland seen in Figure 2. Over Ireland it had a peculiar `Bow and Arrow' presentation in radar imagery, see figure 3 left panel. This morphology has been described in studies in the United States[2], but not so far in the UK literature. Over the North Channel and into Lancashire the system took on a more conventional pattern characteristic of strongly forced short wave troughs in the UK with a bowing arc of heavy precipitation. Around the time of the Stalybridge tornado the equatorward arc of the bow developed an appendage echo with a trailing echo hook resembling the hook of a supercell.

The intensity of the tornado is remarkable, given that it occurred in an environment characterized by a surface air temperature of 7–8°C and a surface dewpoint of 5–6°C, in the *polar maritime* air mass behind the cold front of Storm Gerrit. A proximity sounding from the AROME model suggest CAPE was only around 400 to 500 JKg^{-1}, but with strong bulk shear of up to 20ms^{-1} and a long, curved 0–1km hodograph. Thus the environment can be characterised as High-Shear Low-CAPE (HSLC) with strong

[2] See for example: Keene, K. M., and R. S. Schumacher, 2013: The Bow and Arrow Mesoscale Convective Structure. *Mon. Wea. Rev.*, 141, 1648–1672

dynamic forcing and is consistent with other cold season severe convective environments in the UK.

Comments

1 The event occurred during named Storm Gerrit. See: Storm_Gerrit_Kendon (External link).

2 There is some uncertainty as to the cause of all the damage found. Damage was clustered in some locations with intense damage in places contrasting with no damage in others across the width of the main swath perpendicular to the travel of the tornado. At several locations there was strong evidence to support the presence of sub-vortices within the tornado. It is possible that the tornado was up to 1km wide at its widest location, perhaps as a multi-vortex tornado. It is also possible that some damage was due to straight-line winds. If the damage were all tornadic, this would make this the widest tornado ever recorded in the UK. The widest tornado recorded (at the time of writing) being the Selsey, West Sussex, tornado on 7 January 1998 which was 900m wide. See https://www.torro.org.uk/research/tornadoes/extremes

3 134 households whose property damage came under Sections 77 and 78 of the Building Act 1984 (which come into force when buildings are deemed by local authorities to be dangerous) were supported by the Greater Manchester Disaster Relief Fund. Report from Forever Manchester. (External link)

4 A TORRO severe thunderstorm watch had been issued:
Severe Thunderstorm Watch 21:17 GMT Wed 27 Dec 2023 – 02:00 GMT Thu 28 Dec 2023.
Areas affected N Wales N England
Hazards Wind gusts 60-70mph CG lightning Hail 15-20mm in diameter Isolated tornadoes
Discussion. A compact shortwave trough is moving into NW Wales and will continue to move rather quickly north-east over N England. An arc of showers and thunderstorms is accompanying this. Strong flow aloft may be mixed down to the surface as this bowing structure crosses the area, bringing the risk of strong wind gusts in and close to the watch polygon. Isolated tornadoes cannot be ruled out.
Last updated by RPK at 22:26 GMT Wednesday 27th December 2023

5 A level-2 warning had been issued by ESTOFEX: Storm Forecast
Valid: Wed 27 Dec 2023 06:00 to Thu 28 Dec 2023 06:00 UTC

Issued: Tue 26 Dec 2023 22:17 Forecaster: TUSCHY
A level 2 was issued across parts of far SE-Ireland/NW-UK mainly for (extremely) severe wind gusts but also for a nocturnal tornado threat with a strong event possible.
A level 1 surrounds the level 2 with similar hazards but lower probabilities.

SYNOPSIS An initially wavy streamline pattern over NW Europe turns more zonal already during this forecast as the steering vortex over NW Europe de-amplifies. Of interest is the breakup of this cyclone into numerous smaller scale vortices which cross Ireland/UK as filling but still healthy short waves.

DISCUSSION... Ireland and UK/Scotland...
Of interest will be 2 time frames:
The first one evolves during the late afternoon hours from the Irish Sea into Scotland, as a NE-ward surging dry and IPV[3]-rich mid/upper-level airmass overspreads an occluding surface (cold) front and results in a split-front structure. Forecast soundings indicate cloud tops in the -15/-20C range and an isolated thunderstorm is possible. Kinematics are not supportive for anything severe so expect mainly strong gusts.

The main time slot for severe evolves with a short-wave, which crosses Ireland between 18-21Z and affects N-UK/Scotland thereafter. This wave approaches with a reinforced surge of better LL moisture (occlusion) beneath cold mid-levels and an IPV-rich/dry mid/upper airmass. ...

Thermodynamics are marginal, but sufficient for DMC activity and reside in the 200-400 J/kg MUCAPE range. Kinematics are very good but differ in magnitude as GFS 12Z indicates pockets of 90kt plus winds at 850 hPa over the Saint George's Channel (21-00Z) with other models remaining more in the 65-80 kt range. Long and curved hodographs are forecast and expect severe to a few extremely severe gusts with any convection, which manages to build a strong/persistent downdraft into the well mixed BL...
The other concern arises regarding abundant streamwise inflow into any updraft up to 2 km AGL within an unstable BL and with some 0-3 km CAPE. Hodograph appearance depends on the wave's structure but a few solutions show rather

[3] IPV- Isentropic Potential Vorticity

impressive curved/elongated hodograph signatures. Low LCLs and a semi-discrete storm mode both increase the concern of organized mesocyclones and an attendant tornado risk. Even a strong event cannot be ruled out. See Estofex forecast (External link)

6 Relevant forum thread: TORRO Forum ACCESS RESTRICTED TO TORRO MEMBERS.