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ORGANIZED MICROSCALE STRUCTURE OF THE WINDSTORM OF 12 MAY 1983 IN UTRECHT AND VICINITY

by

Gregory S. Forbes

1. Introduction

During the afternoon of 12 May 1983, beginning shortly before 1100 GMT, the Netherlands was harassed by a vicious windstorm accompanying a small but vicious cyclone. Figures 1 and 2 are maps of the maximum gusts and sustained 10-minute winds over the Netherlands and surrounding countries, interpolated from the plotted values at observation sites.

Winds were strongest over the western part of the country and over water. Gusts reached at least 70 kts over land and at least 72 kts over water. Sustained winds reached at least 44 kts over land and at least 60 kts over water. The winds along the coast and over the IJsselmeer caused chaos for a large number of recreational boaters, who were taking advantage of a day off. Buildings along the beaches were destroyed. Ten fatalities were reported associated with the storm, due to drownings.

Research is in progress by a number of scientists seeking to understand the cause of the storm and evaluate its predictability. Accordingly, further discussion of the general aspects of the storm is deferred to these investigators.

This report focuses on the nature of the windstorm at an inland location, specifically Utrecht. From Figs. 1 and 2, sustained winds and gusts of 30 and 48 kts, respectively, were expected there. As was probably true in many places, there is evidence that gusts in Utrecht may have been 20 kts higher than these expected values, in a small area.

Localized strong winds of this type might often be attributed to either random, unorganized turbulence or to a combination of site exposure, surface roughness, and terrain. In this case, however, there is overwhelming evidence that the strong winds in Utrecht were associated with an organized, microscale aspect of the storm structure. It is the conclusion of this author that the organization came in the form of a vortex.

2. Storm Observations

The author was at his residence on Tolsteegsingel at the time of the damaging windstorm. There had been a period of steady rain and it was fairly windy, but otherwise the day had been relatively unmemorable weatherwise in Utrecht. (At the time that the storm struck, the author was unaware of the strong winds which had already occurred in the southwestern part of the country.)

Winds increased dramatically at about 1410 local summer time (1210 GMT), accompanying rapidly brightening skies. A dark cloud had just passed overhead, without heavy winds or thunder, but there was a brief shower just prior to the windstorm.

The wind increased so suddenly that windows shuddered and there was a considerable increase in the background noise level. At this point the author looked out the southeast window, facing Absteder Dijk, and observed a blur of white blossoms and green leaves rushing horizontally past the window.

The first instinct of the author, having done a considerable amount of tornado research in the past (e.g. Forbes, 1978), was that it seemed like a tornadic wind. The author had experienced two or three non-tornadic windstorms of comparable speeds, but those did not have the sudden onset which accompanied this storm. However, the conditions were fairly bright and there was no sign of a funnel, so there was some uncertainty as to the nature of the storm in progress. Irregardless, the increasingly rattling windows suggested that abandoning this vantage point was wise.

Within 7 seconds after the onset of the storm, scientific curiosity had overwhelmed safety concerns and the author made a brief entrance onto the southeast balcony to make a southwest-to-northeast scan for a funnel. Seeing none, the author proceeded to the northwest balcony, facing Tolsteegsingel, for a similar scan. Again none was visible, but the winds were perceptibly weaker on this side of the house. During this excursion through the house, one half of a large, old (more than 100 years old) tree on the southeast side of the house broke and fell toward the northeast onto the roof of a storage shed. The author did not witness this, but the Diemer family (living downstairs) did.

The heavy winds let up no sooner than an estimated 20 and perhaps as many as 45 seconds after their onset, and the author proceeded to the roof for another storm scan. To the northeast a solid line of cumulus congestus clouds could be seen, with the darkest cloud due northeast of the house and moving away rapidly. This cloud had a very dark blue-black color and a very low cloud base that was obscured by intervening rooftops. The base could not have been more than several hundred meters above ground. Cloud rotation was not readily apparent.

3. Post-Storm Survey

Investigations soon revealed that this location had been part of a nearly-straight path of concentrated damage across the south and east portions of Utrecht, shown in Figure 3. The author's residence was near the mid-point of the path. The path extended at least as far south as Nieuwegein-Zuid and at least as far north as Maartensdijk. Herman Wessels of the KNMI performed the survey in the region northeast of Groenekan, and the author surveyed the remainder of the path.

Another survey was performed independently by two residents of Utrecht[1]. In fact, their report and damage survey map alerted the author to the damage in Nieuwegein-Zuid. S. Kruisinga of the KNMI also alerted the author to this damage.

The author's survey was performed on Thursday afternoon and evening, on Friday evening, and on Saturday afternoon, May 12 to 14. The damage in Nieuwegein-Zuid was surveyed on the evening of June 1. Most of the survey was performed on bicycle and on foot in order to gain access to areas not accessible by automobile. Nearly all streets, bicycle paths, and foot paths

[1] Jan Willem Bosselaar and Bennie Scholte van Mast. A portion of their report is reproduced by Zwart and Guerts (1983).

were traversed in the damage area. Searches were also made in areas peripheral to the heavy damage in order to ascertain that the damage was truly in a concentrated path.

Overall, the mapped path was 19 km long and between 50 and 560 meters wide. Damage was observed northeast of Maartensdijk, and may have been part of the same path. If so, the path length is lengthened by 5 km. The path might also have extended farther to the south. The damage path was narrowest in the southern part of the path. Additional damage may have occurred[2].

Only a fraction (perhaps 10%) of the trees in the path were noticeably damaged, and even fewer buildings were damaged. This is suggestive of wind gusts in the 80 to 100 km/hr range. In a few small portions of the path the damage was much more concentrated, and winds probably approached 130 km/hr here. This is especially true of the narrow path in Nieuwegein-Zuid, where nearly all trees were broken or uprooted in a 50-meter-wide swath along the Hollandsche Ijssel just east of expressway E-9. Some cabins and an automobile were also damaged here, at least partly by falling trees. Damage was also intense along the Vaartsche Rijn in Nieuwegein-Noord.

Windspeeds were estimated based upon the damage, using the Fujita (1973) scale. On his scale of 0 to 5, this path contained mostly F 0 damage (winds up to 115 km/hr), but had F 1 (116 to 180 km/hr) winds in a few places.

Deatiled path maps are presented in section 4 and are also available for inspection in the KNMI Bibliotheek, as exhibits accompanying this report. Also made available as exhibits are damage photographs[3] and newspaper clippings.

4. Detailed Mapping of the Damage

Mapping of the damage in Utrecht was performed on a detailed city map, reproduced in sections as Figure 4. The width of the damage path is shown by solid lines, and is somewhat subjective, but roughly approximates the zone where branches of at least 2 cm were broken from trees. Vectors attached to solid circles indicate directions of fall of uprooted trees or trees split at a fork in the trunk. Vectors with open circles indicate directions of fall of trees whose trunk was broken aloft. Vectors without circles depict the direction of fall of debris from buildings or of smaller tree branches (diameter of at least 5 cm).

The map (Fig. 4) is labelled by sections, and the heaviest damage on this map occurred in portions of the path in sections F-14 through G-11 and in sections J-8 and J-7. One of the spots of heavy damage was in the southwest corner of section F-14. Here several large trees were broken or uprooted and there was some roof damage to a building belonging to the ARAM corporation. Two spots of damage to the west, in section E-14, did not appear to be part of the concentrated path of damage.

In section F-13 there were at least three buildings damaged. The roof of the Autorama Warenhuis along Winthontlaan was damaged, and debris fell onto automobiles of the Nefkins Autohuis just to the west. About 20 automobiles were heavily damaged. Across Winthontlaan to the north, metal roofing of the Autorama Supermarkt was partially removed and blown against the fence of an outdoor swimming pool (De Liesbos). Some holes were also

[2] Mr. Tabak of Blaricum reported seeing a wide, disorganized funnel cloud east of Blaricum. He observed damage to trees, a farmhouse roof, and a trailer in Eemnes. This is on the same line as the Utrecht storm, and would extend the path length to about 30 km, if part of the same path.

observed in the south wall of the supermarket, and the name-sign of the store to the east (GEPU) was broken. Behind this building a fence was leaning northeastward. Several trees were uprooted in this neighborhood.

A number of trees were uprooted in sections F-12 through G-11, along and one block east of the Vaartsche Rijn. Most of these fell toward the north, at a 30-45 degree angle to the path of the windstorm. This direction of fall did not appear to be due to any path of least resistance, but rather to some aspect of the internal structure of the storm.

Strong damage was rather sparse in sections G-10 through H-9. This region was noticeably more populated with houses which may have frictionally reduced the strength of the winds. Nevertheless, the path of the storm was easily noticeable by the concentration of small broken limbs.

The storm apparently momentarily regained some strength near the corner of boxes H-9, H-8, and J-8. Here several trees were uprooted, the largest of which fell on the roof of a warehouse which was apparently abandoned due to a previous fire, along Oosterstraat. Clay tiles were also torn from roofs in this vicinity.

The storm path became wide in sections H-8 and J-8, and damage again became sparse. Large branches of a tree were observed about 70 meters northwest of their source along Reigerstraat; whether these were transported by wind or dragged by car is not known.

The damage pattern became very interesting in the northern portion of section J-8 and in section J-7. Large trees were uprooted and broken along Wolter Heukelslaan and fell toward the railroad tracks to the north. At least one automobile was damaged by these falling trees. Small debris from trees along Maliebaan, however, accumulated preferentially on the southeast sidewalk. The swath of heavy damage extended from Wolter Heukelslaan eastward to Museumlaan, along the northern portion of the damage path. Along Museumlaan one tree was broken aloft and several others were uprooted, one blocking the street.

Also in these sections, about 200 m to the southeast, some apparent circulation was observed in the damage. Pink blossoms from trees on Alphenplein were strewn in a curving swath toward the east-southeast across Oudwijkstraat and onto the sidewalk. At the eastern end of this trail of pink blossoms, a tree was uprooted toward the north.

Hereafter, damage was widely scattered in sections K-6 through L-3, and survey opportunities were limited by fewer streets and paths. A few trees were upoooted and fell into the canals surrounding Fort DeBilt and Fort Voordorp. Damage was minimal in De Voorveldse Polder Recreatiegebied.

Damage became more concentrated again in sections M-2 and M-1. Several trees were uprooted in an orchard at the triangle between the railroad tracks and Groenekanseweg, and a few trees were broken or uprooted along Beukenburgerlaan. About 9 trees of at least 30 cm diameter were broken or uprooted, in addition to some smaller trees, in a 50-meter-wide swath along Leijense Weg.

Beyond this point more trees were damaged (again, a small percentage) in a path extending to east of Maartensdijk. This path is shown in Fig.3, and a more detailed mapping (by Herman Wessels) is on exhibit in the KNMI Bibliotheek.

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[3] Photographs were taken by the author, and several were also submitted by Do Laout of Utrecht.

5. Discussion and Conclusions

The facts of the storm having been presented, their interpretation remains. It has been shown that the damaging wind came at the very rear of a growing towering cumulus cloud, moving toward the northeast. Radar (Figure 5) showed a line of showers moving toward the northeast at 60 to 80 km/hr. This line, with tops between 14,000 and 22,000 feet, occurred in the immediate vicinity of a sharp cold front (Figure 6). Passage of the front at DeBilt was marked by a 1.3 mb pressure rise.

Given the scale of the event, there is no way to know exactly what processes produced the windstorm in Utrecht. It is the conclusion of this author, however, that the damage was produced by a vortex which developed at the rear of the cloud along the cold front. A schematic diagram, Figure 7, indicates a conceptual model of the event.

The low-hanging cloud base at the rear of the towering cumulus probably marked the intersection with the cold front, and a region of vigorous updraft. Horizontal shear along the front provided a vorticity source, which the updraft concentrated. Tilting of vertical wind shear by the updraft also is likely to have contributed to the spin-up.

Vortices of this type are observed occasionally, and generally they occur without funnel clouds. A debris whirl usually accompanies the vortex. Ironically, references to such phenomena in the meteorological literature have been examined by Forbes and Wakimoto (1983).

The author has selected a vortex as the probable cause, as opposed to microbursts or confluence of thunderstorm outflows, for a number of reasons.

1. While there was evidence (e.g. radar) that there was a heavier shower to the southeast, there was no evidence that the Utrecht storm (or any other) was yet an organized thunderstorm capable of organized strong outflow. Even if thunderstorm outflow had been present, this would not have precluded a vortex, as Forbes and Wakimoto (1983) found 18 vortex paths in an area also traversed by microbursts.
2. The relatively narrow (50-560 m) width of damage over a straight path of at least 20 km is unlike damage paths produced by microbursts.
3. Diffluent damage, characteristic of microbursts, was not observed.
4. Confluence in the damage pattern and occasional signs of rotation in the damage were observed, and suggest a weak, rapidly-moving vortex.
5. A vortex moving at 70 km/hr (speed of radar echoes) or at about 55 km/hr (sustained winds at DeBilt) would have produced the damaging windspeeds of mostly 80 to 120 km/hr along its right side with winds rotating about its axis at only 10 to 65 km/hr. Winds on the left side of the vortex (facing in the direction toward which it is translating) would be much weaker due to the opposing effects of translation and rotation, explaining the absence of damage from northeasterly winds. The characteristic of a weak, rapidly-moving tornado is to produce damage from winds rarely deviating more than 45 degeees from the direction of storm movement, due to this effect.

6. Because of the weak rotation (10-65 km/hr), the central pressure in the vortex would not have been appreciably lower than that of the environment, making a funnel cloud unlikely. Assuming a Rankine-combined vortex, the pressure deficit due to a 10-20 m/s rotation is only about 1 to 4 mb, not sufficient to induce a discernable funnel.
7. The period of strong winds at Tolsteegsingel, 20-45 seconds, is consistent with a vortex of 390 to 880 m diameter. In this calculation, vortex radius was loosely defined as the outer limit of damaging windspeeds on the right side of the vortex; not the radius of maximum winds. The width of the damage path, roughly 120-560 m in Utrecht, is fairly consistent with the above figures, considering that the damage path width in a weak tornado is only about half that of the diameter of the vortex circulation. (Damage only occurs on the right side of the vortex.)

The author concludes that the damage was produced by a vortex translating at about 70 km/hr and with a component of rotation about the vortex axis of about 30 km/hr, and occasionally up to 60 km/hr. This rotation was probably maximum at a radius of about 100-150 m, with damaging winds extending outward to about 200-300 m on the right side, and much weaker winds on the left side. There is some suggestion of the existence of two vortices in the Oudwijk section, explaining the anomalously-wide damage path there.

In accordance with the classification scheme proposed by Forbes and Wakimoto (1983), this vortex does not classify as a tornado, because it was not associated with a thunderstorm. The storm was, therefore, classified as a tornadic (or, tornado-like) vortex along a cold front.

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Fujita, T. T., 1973: Tornadoes around the world. Weatherwise, 26, 56-83.

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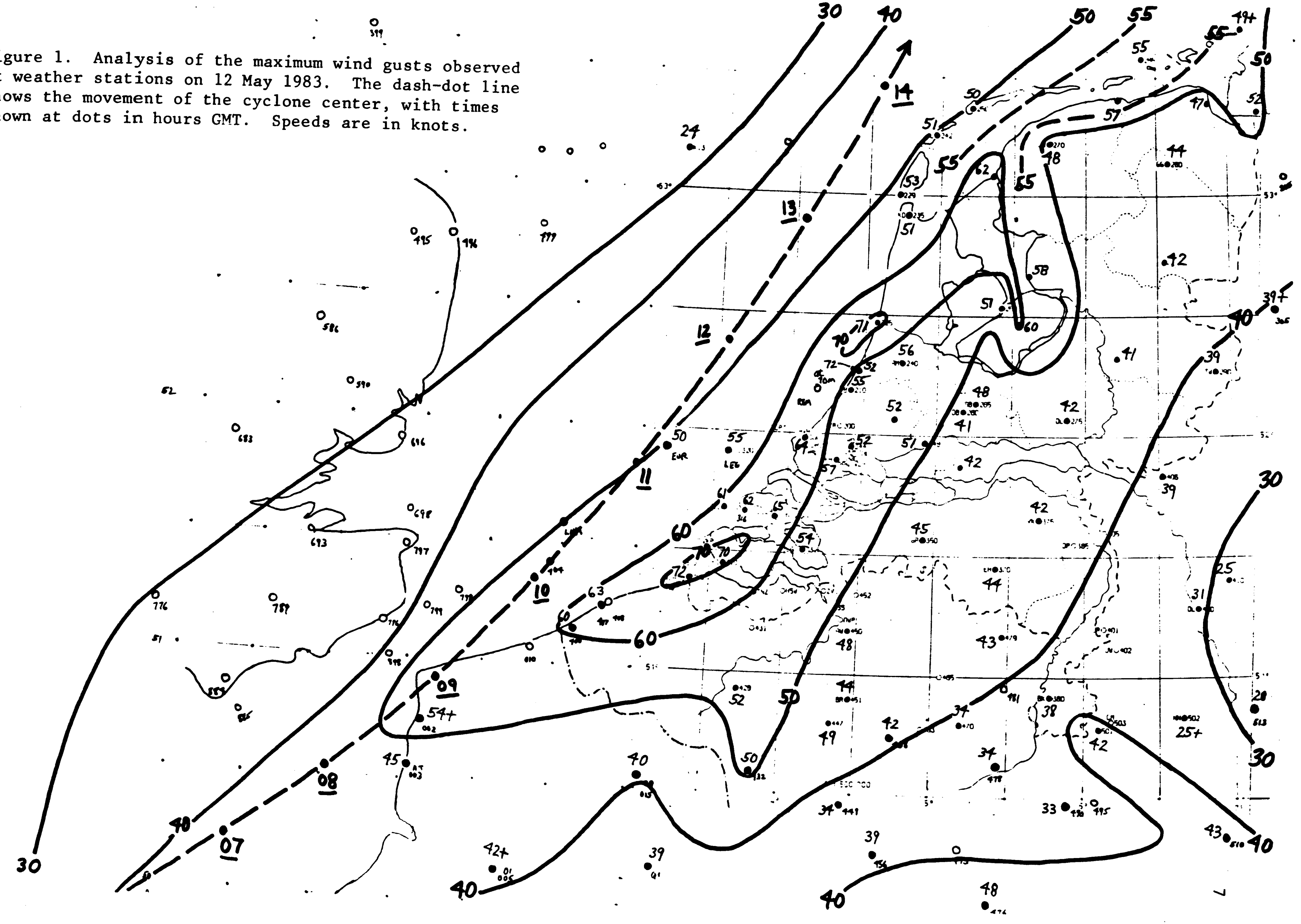


Figure 1. Analysis of the maximum wind gusts observed at weather stations on 12 May 1983. The dash-dot line shows the movement of the cyclone center, with times shown at dots in hours GMT. Speeds are in knots.

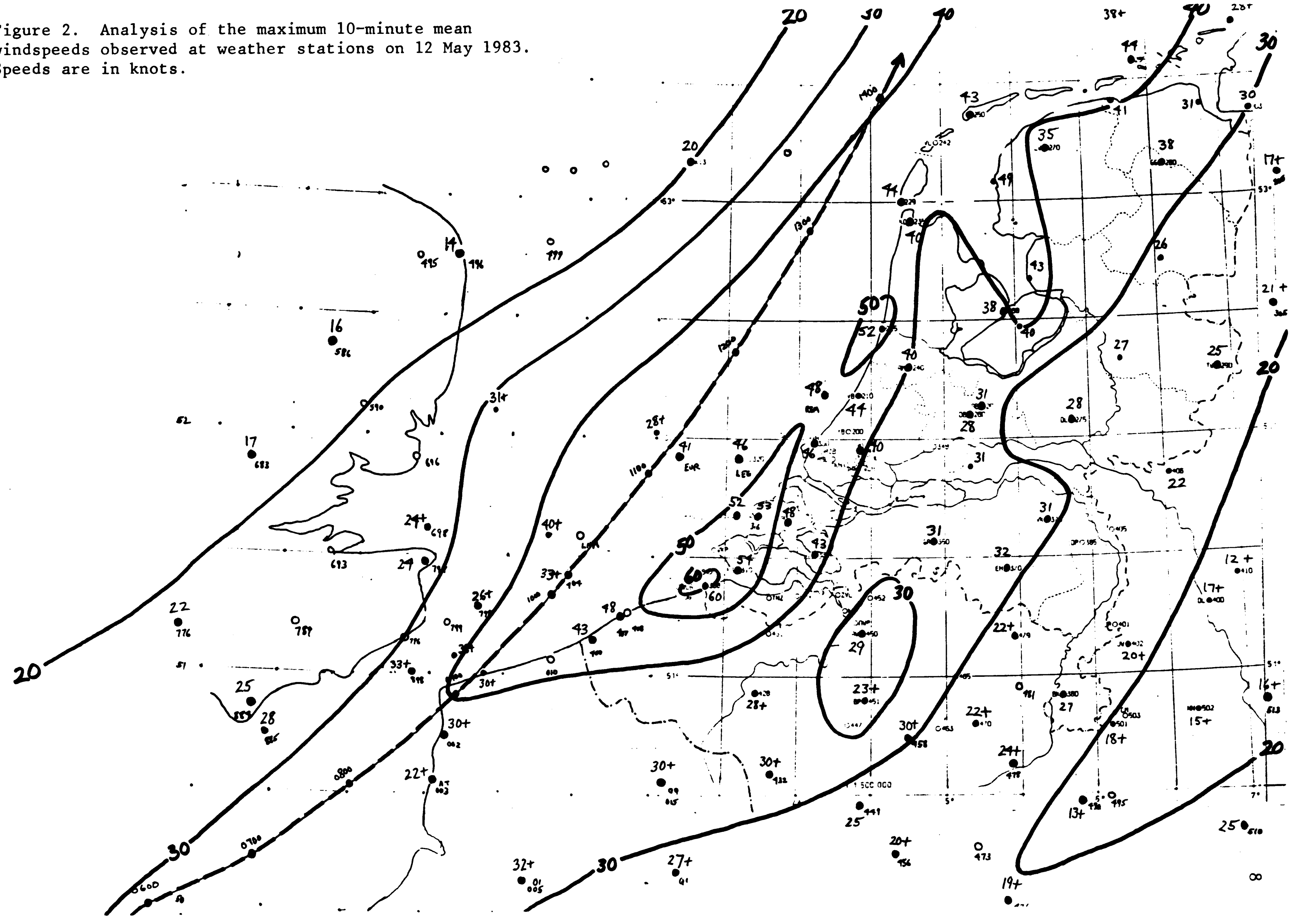


Figure 2. Analysis of the maximum 10-minute mean windspeeds observed at weather stations on 12 May 1983. Speeds are in knots.

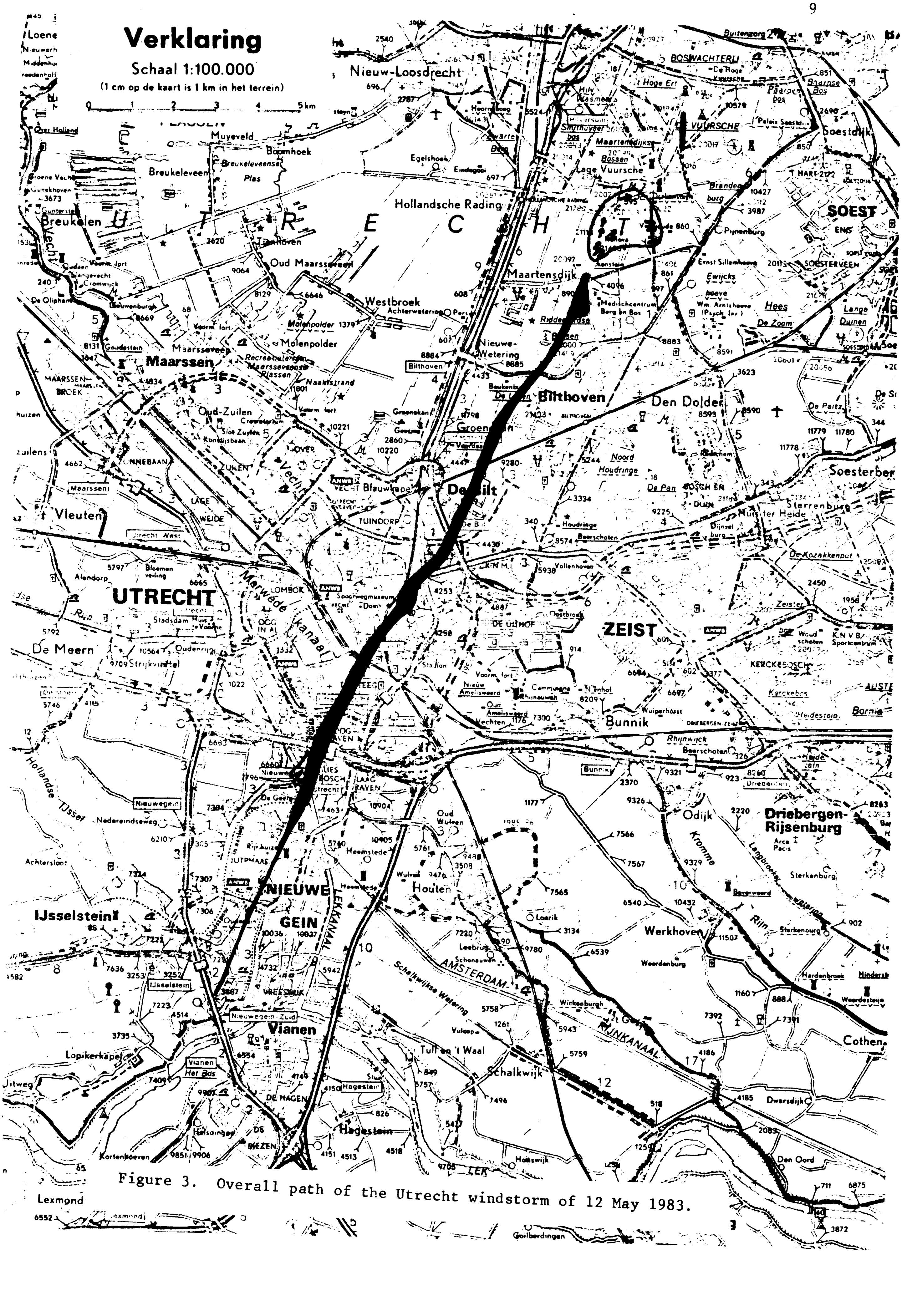


Figure 3. Overall path of the Utrecht windstorm of 12 May 1983.

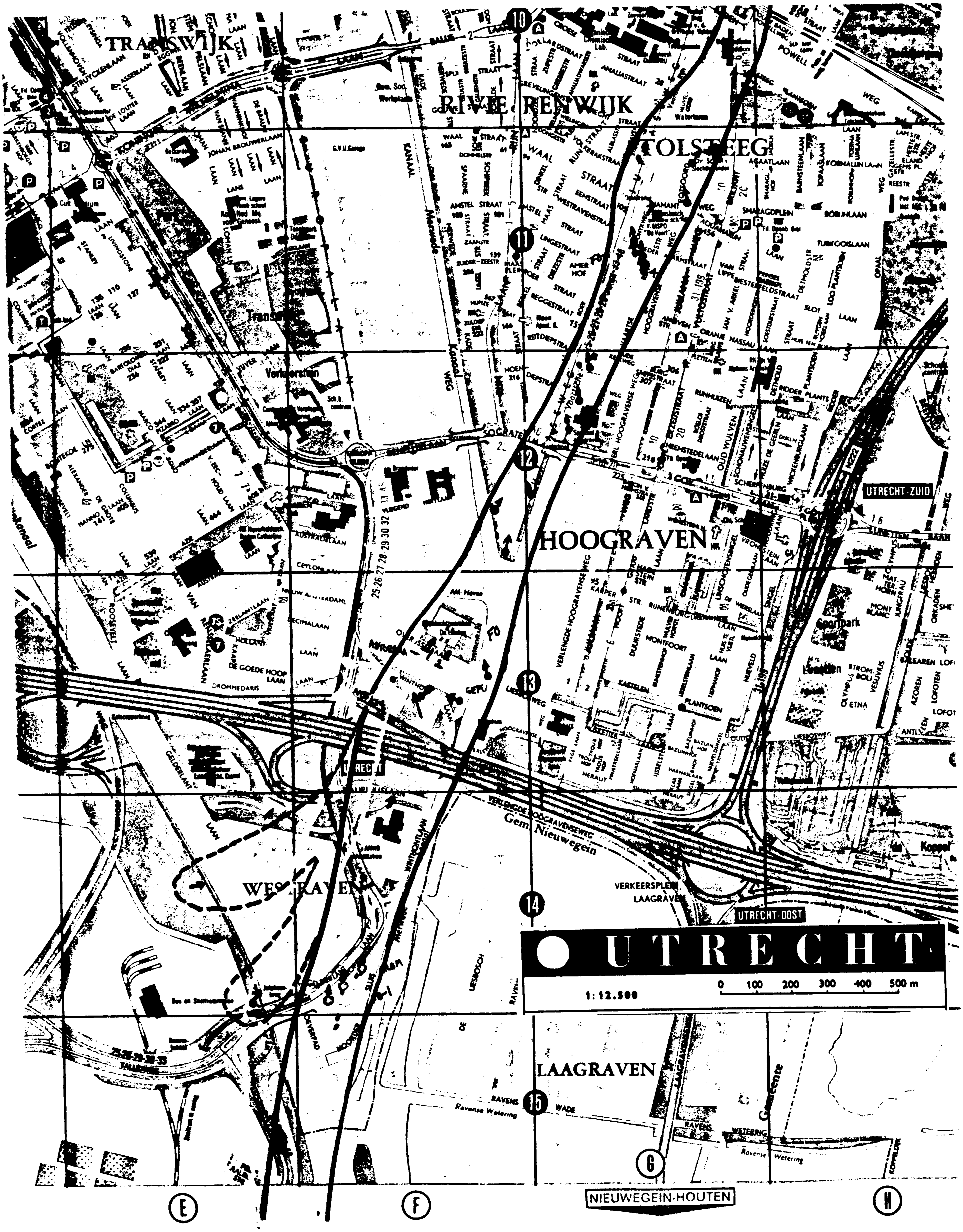
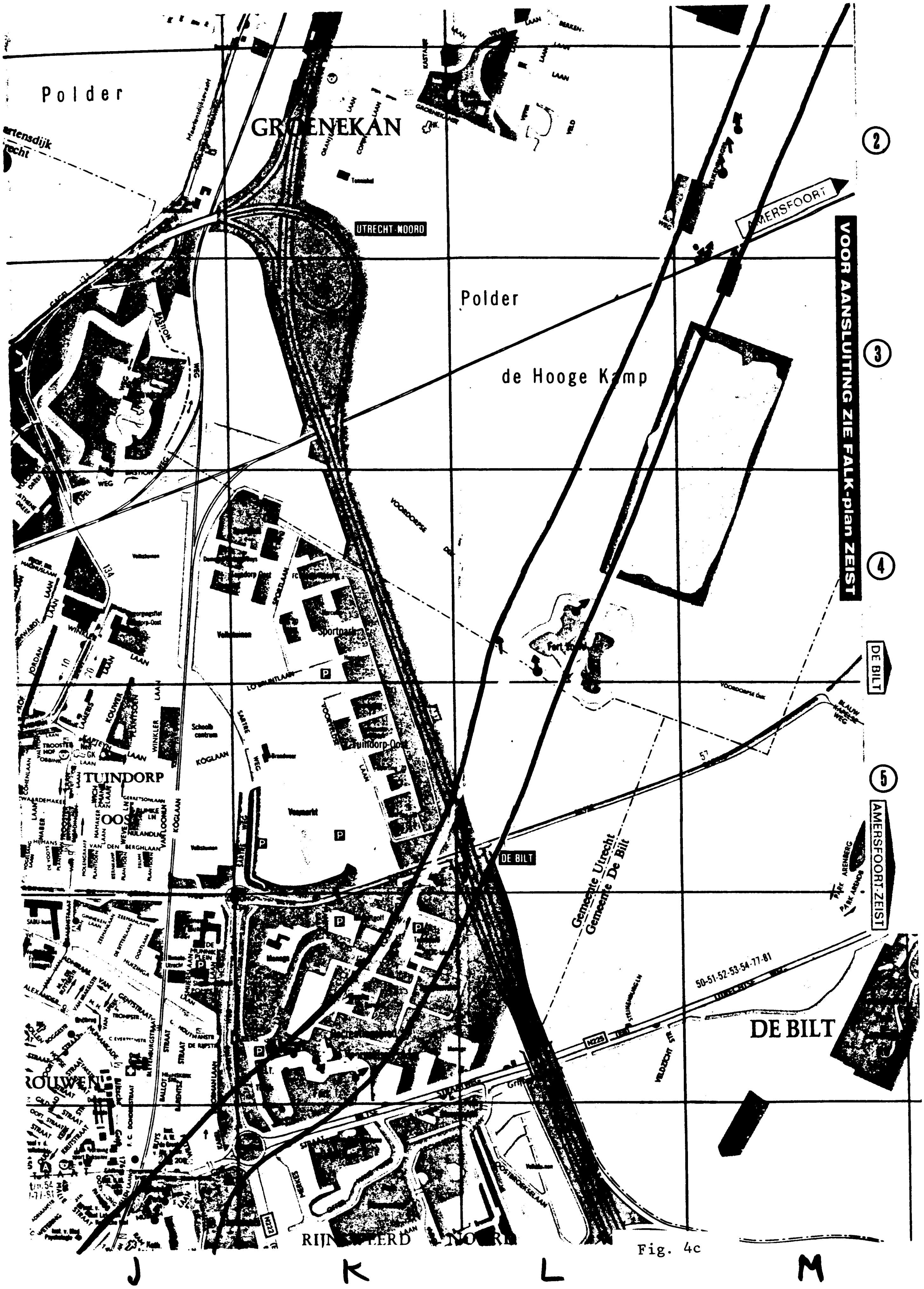


Figure 4a. Detailed path map of the windstorm in Utrecht on 12 May 1983. See text for explanation of symbols.

WITTEVROUWEN
RIJNSWEERD
Provinciehuis
OUDWIJK
Kromhout
kazerne
STADION
GALGENWAARD
TOLSTEEG
HERCULESPLEIN
RUBENS
LAAN
NUMANKADE
KLAVER
6
7
8
9
10
11

G H J K

Fig. 4b


Polder
GROENEKAN
UTRECHT-NOORD
Polder
de Hooge Kamp
AMERSFOORT
VOOR AANSLUITING ZIE FALK-plan ZEIST
2
3
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5
DE BILT
AMERSFOORT-ZEIST
TUINDORP
DE BILT
Gemeente Utrecht
Gemeente De Bilt
50-51-52-53-54-77-81
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Fig. 4c

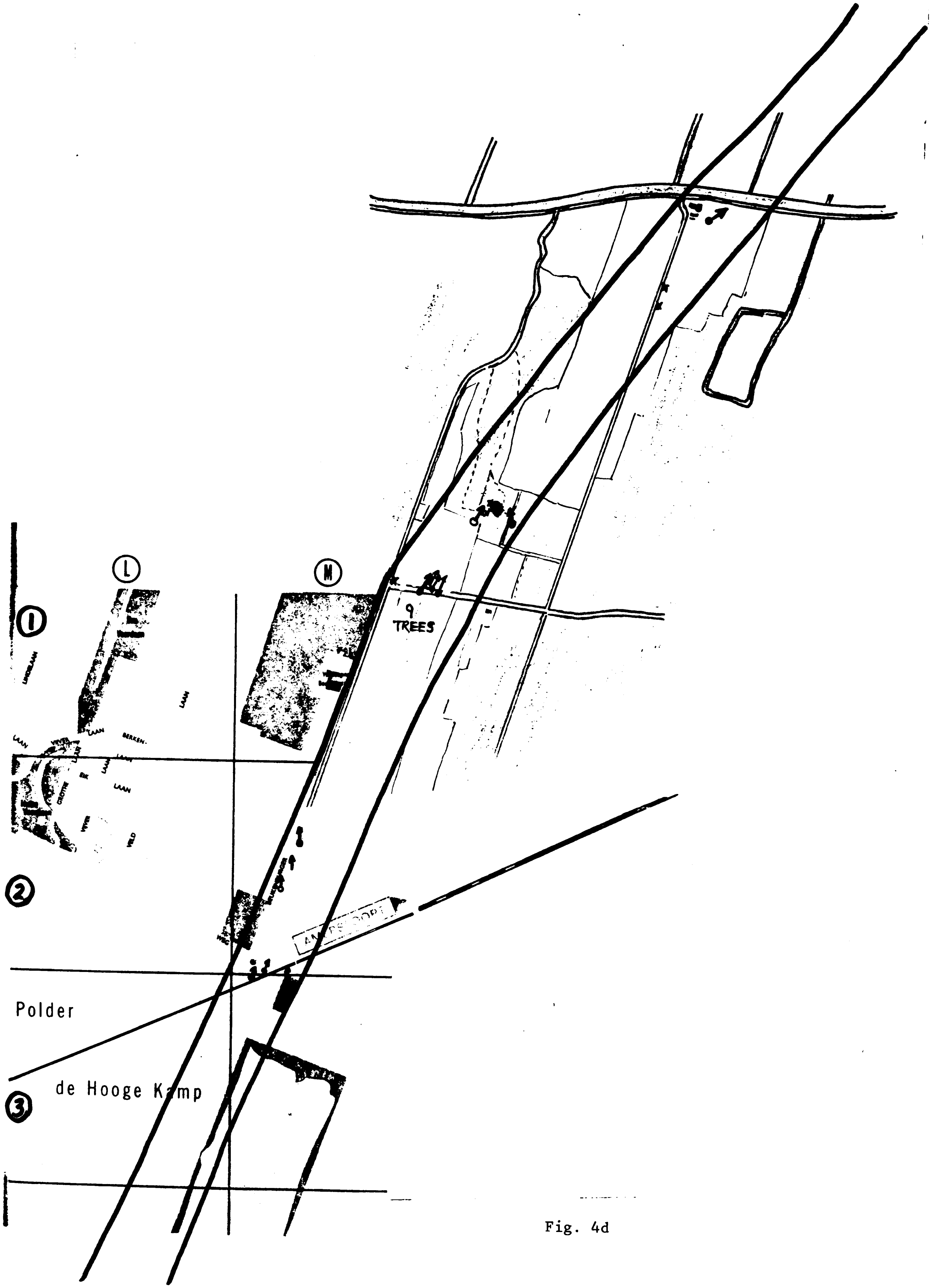

Fig. 4d

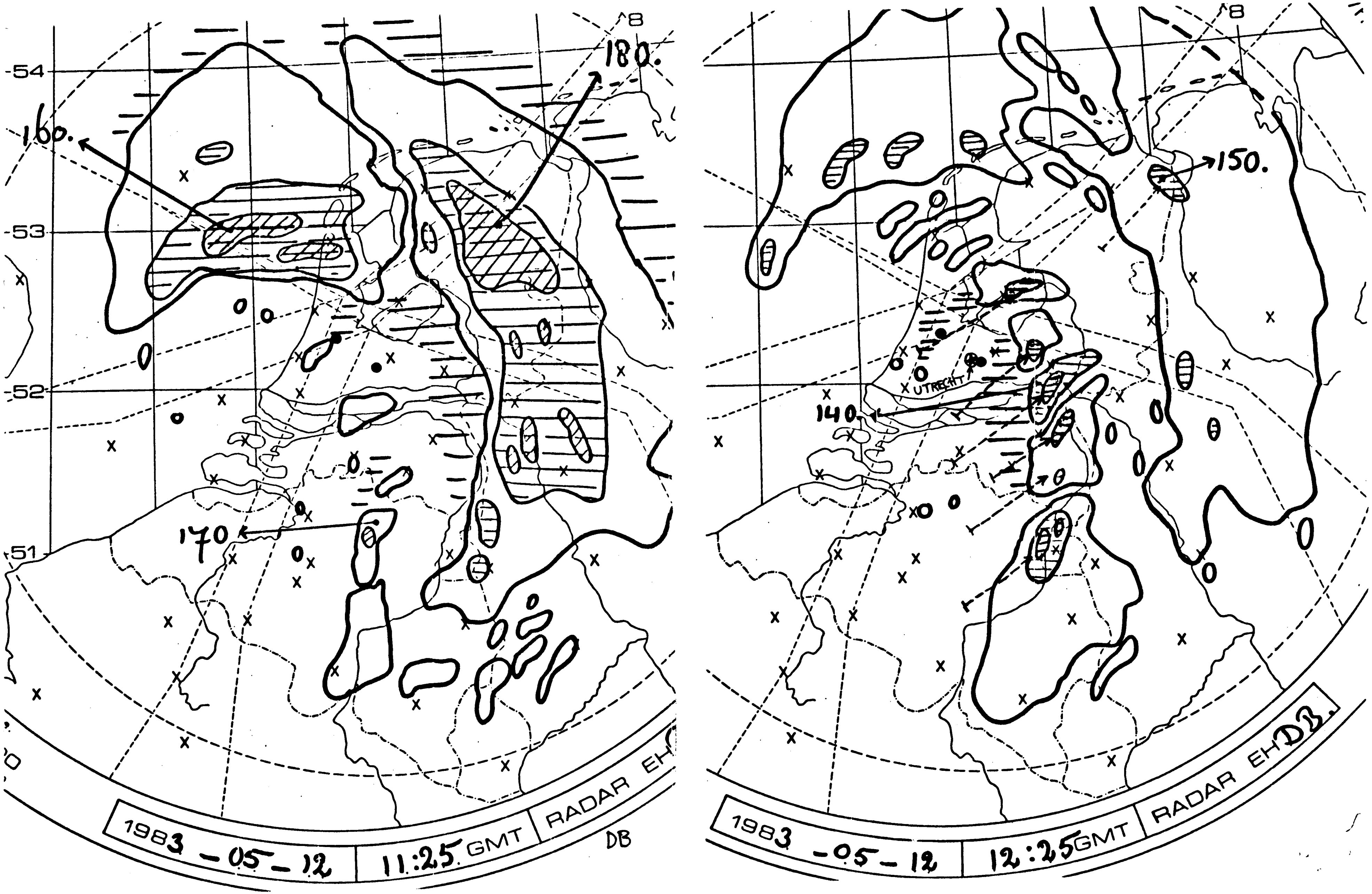

Figure 5. DeBilt radar echoes at 1125 and 1225 GMT on 12 May 1983.

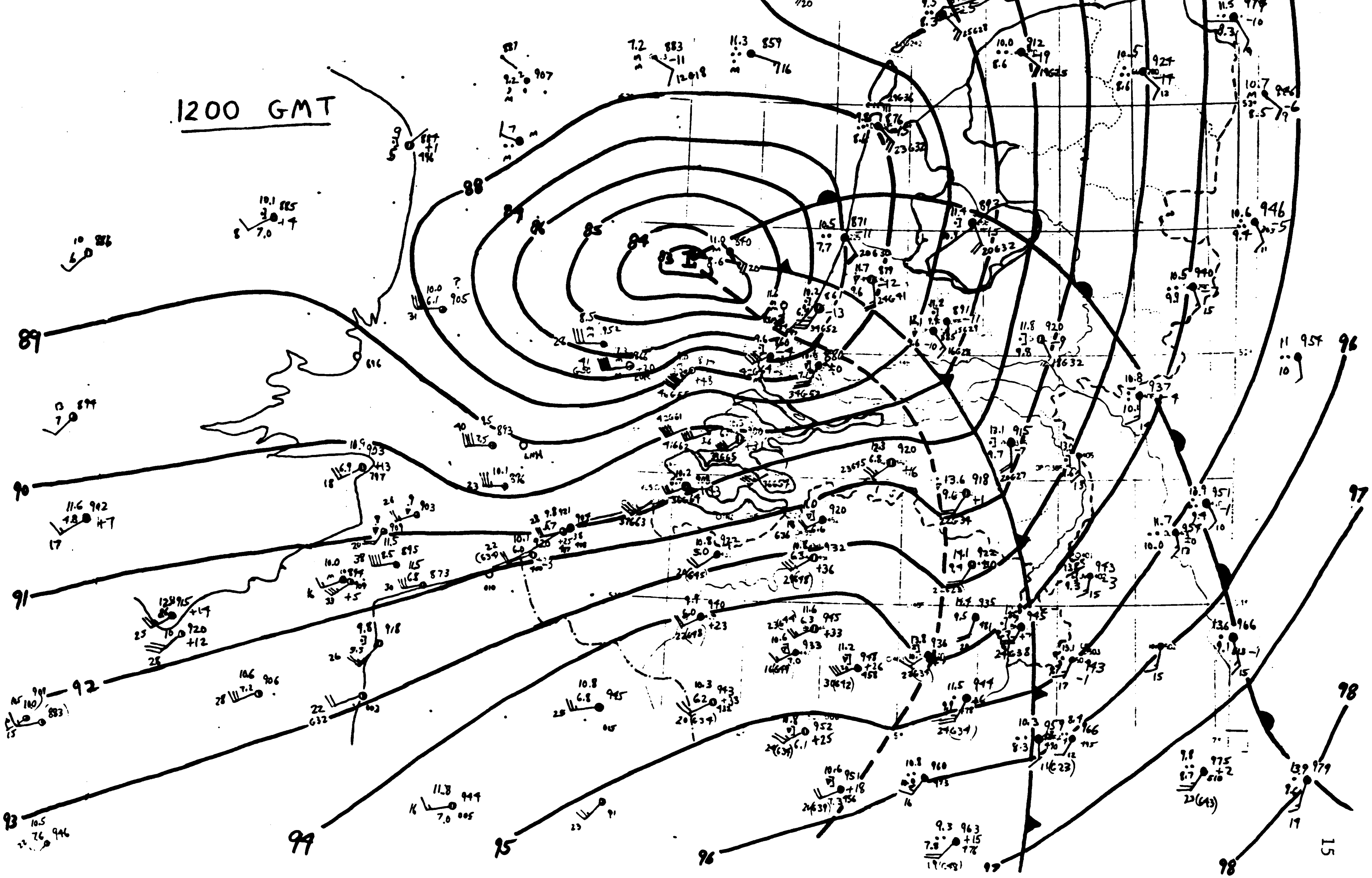

Figure 6. Analysis of the surface pressure on 12 May 1983, with fronts also analyzed. Station data are plotted conventionally, except that pressure change is over only a 1-hour period.

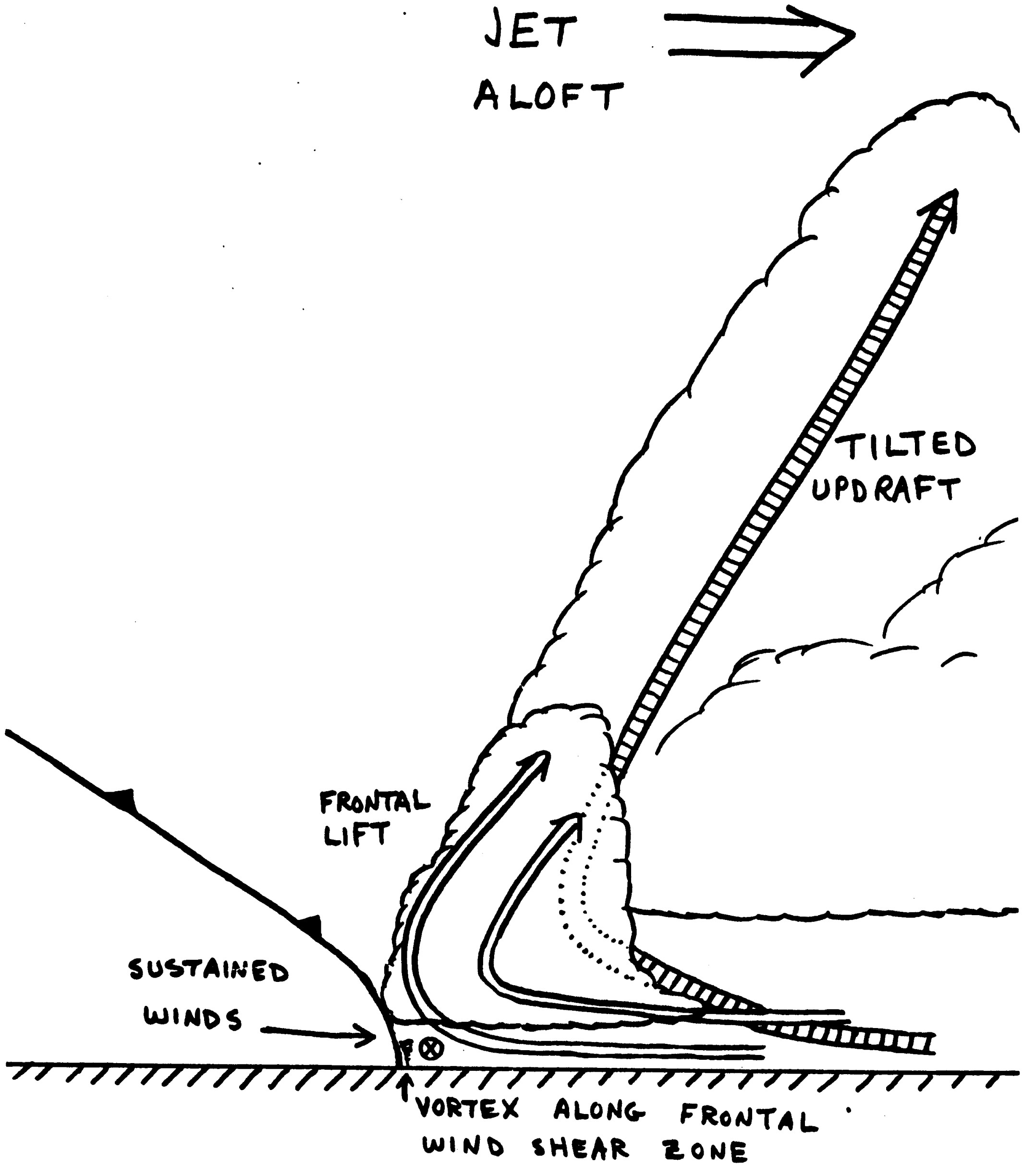

Figure 7. Conceptual model of the occurrence of the Utrecht windstorm.