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Long range transport of air pollution during summer fair weather episodes in West and Central Europe; a meteorological contribution to the SHELL-LAPSE-project

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Long Range Transport of Air Polluttion during summer fair weather episodes in West and Central Europe

(a meteorological contribution to the SHELL-LAPSE-project)

by

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De Bilt, december 1984

Samenvatting

In opdracht van de SHELL, die een oriënterend onderzoek uitvoert van het Europese zure regen probleem, heeft het KNMI een deelstudie verricht naar het voorkomen en de meteorologische eigenschappen van een aantal droge, warme en zonnige episodes in het recente verleden. Na een analyse van deze "mooi weer" situaties gemaakt te hebben van de zomers van 1976, 1978-1983 werd het onderzoek toegespitst op 25 episodes met een lengte van 3 dagen. Voor deze episode en voor 5 locaties in Europa (Soissons, Nancy, Freiburg, Soltau en De Bilt) zijn 72 uur trajectoriën bepaald. Langs sommige trajectoriën is een analyse gemaakt van temperatuur, vochtigheid, bedekkingsgraad en inversiehoogte. Voor deze 25 episodes bleek dat de herkomst van de trajectoriën voor de zuidelijke 3 locaties bij voorkeur in de Noord-Oostelijke sector lag. De aanvoer van luchtmassa's in de Bilt en in sterkere mate in Soltau, was gelijkmatiger over de windrichtingen verdeeld. De gebieden waarover luchtmassa's voor deze laatste twee locaties werden aangevoerd, hadden i.h.a. een minder dicht bevolkt, landelijk of maritiem karakter.

Executive Summary

Currently SHELL International Petroleum Company is carrying out a study on the acid deposition phenomenon in Europe. This study, the Long Range Air Pollution Study Exercise (LAPSE), has an orientational character and attempts to quantify the impact of some of the major air pollution components at some sensitive receptor locations in Europe.
The most suspect air pollution components in the European acid rain problem are sulphur and nitrogen oxides, but also ozone is presumably playing a role. With respect to the last component damage to forests and crops are thought to occur mainly during short lasting episodes, with unusually high ozone concentrations. These episodes occur predominantly in summer during spells of warm, dry and sunny weather, which may last for a number of days.
This report is a separate investigation of the occurrence of these episodes and their meteorological properties during the years 1976-1983. KNMI (Royal Netherlands Meteorological Institute) was asked to carry out this analysis.

- First a selection was made of sunny and warm weather episodes over large parts of Europe, lasting at least three consecutive days. It appeared that in the years 1976, 1978-1983 24 episodes, varying in length from 4-30 days, roughly met the above criteria. The total amount of days involved was 250, which is unusually high in view of the climatic average.
  In Europe five locations were suggested by SHELL to focus our attention on. These were: Soissons, Nancy (France), Freiburg, Soltau (FRG) and de Bilt (The Netherlands).
  The intention was to calculate air mass trajectories for these five locations, so that the origin, pathways and pollution of air masses arriving in these locations could be traced. The trajectories went back three days in time. These trajectories were contained fully in the above mentioned 24 fair weather episodes. A further inspection of the weather at the five locations and along their estimated trajectories led to a final selection of 25 non-overlapping three day fair weather episodes.

- Trajectories were determined for each of the above locations both near the surface of the earth and at a height of ca. 1500 metres, the 850 mbar pressure level. The main results are that trajectories for Soissons, Nancy and Freiburg originate preferentially in the North-Eastern wind directions sector, whereas trajectories for Soltau and de Bilt are more equally distributed over all wind direction sectors. Considering the geographic locations of the above sites we observe also that trajectories for de Bilt and to a larger extent for Soltau pass over more sparsely populated, rural or even maritime areas.
  Another conclusion is that 72 hr trajectories for Soisson, Nancy and Freiburg are generally shorter, which indicates that the air flow in and around these cities was weaker than for de Bilt and Soltau.
- For the first ten episodes an analysis was made of some weather elements along the trajectories. The maximum mixed layer height varied between 1300 and 2200 m. During the night, due to the generally cloudless weather, shallow nocturnal inversions developed, not extending beyond an altitude of 200 m. There was a marked variation in the air temperature and humidity. The daily maximum temperature varied between 17°C and 33°C with an average value of 26°C. The daily maximum temperature had a range from 8°C to 21°C with an average value of 14°C. The relative humidity varied between 34 and 77%. Cloud cover was small though along some trajectories fog was observed during the night and early morning.

- When the emissions along a trajectory are known it is possible to evaluate the (photo)chemical reactions in the travelling air-mass and estimates of the ozone concentrations might be obtained.
  Apart from the problems and uncertainties inherent to atmospheric chemistry, we would like to point out here that the considered air-mass should remain relatively undistorted by the flow field, and should travel more or less as an entity. This requirement is obviously not met when surface and 1500 m trajectories strongly diverge. Therefore, also the coherence of upper air and surface trajectories was determined. In roughly one third of the cases the coherence was so poor that the determination of source areas could be uncertain if not impossible.

- A preliminary analysis of ozone data in the Netherlands during these 25 episodes, suggests a relationship between the ozone peak values and the origin of the air mass: the higher the ozone peak values the more the trajectories have a continental, stagnant character.

1. Introduction (including project description and objectives).

The SHELL-LAPSE project covers a Long Range Air Pollution Study Exercise. This study tries to estimate ozone levels in West and Central Europe by a mathematical model of atmospheric transport and chemistry. High photo oxidant levels are most likely during "anticyclonic" episodes, in particular when they last for more than 3 days, in the summer season (Cox et al., 1976; Guicherit and Van Dop, 1977; Guicherit, 1978). Such episodes are characterized by dry, warm and sunny weather. The model computations have the objective to estimate the ozone levels for five receptor stations. Two stations are chosen in regions threatened by forest die-back: Freiburg, near the Black Forest in SW-Germany, and Nancy (NE-France). Two stations are situated in agricultural regions where only little or no damage by "acid deposition" processes is observed: Soltau (N-Germany) and Soissons, (NW-France).
The choice of the fifth station has a reference function, since observed O_3-concentrations of the episodes which have to be investigated, are available. The observed values can be compared with the computed ones to test the reliability of the model. This reference station is De Bilt, in The Netherlands. One of the objectives of the LAPSE-project is to investigate the role of high O_3-levels in the forest damage, which is chiefly attributed to "acid deposition" processes. The required background information on appropriate meteorological parameters for this study is related to the (polluted) air mass advection, the weather in the receptor locations and the diurnal variability of the mixing height along the trajectories.
A trajectory is defined as the path of an air parcel or particle in an airstream when it assumes at each time the velocity of the surrounding fluid. In the atmosphere this concept is often used when only the horizontal motions of a particle are taken into account.
In the first place a selection has been made of fair weather episodes which can be used for the model study (section 2). In the second place trajectories have been determined which transport the air towards the chosen receptor places (section 3).
In the third place the weather data, along the trajectories like cloud cover, maximum temperature, minimum temperature, dewpoint (humidity) and mixing height, are gathered as extra meteorological data for the photochemical model (section 4).

Although the knowledge of the relationship between the die-back of spruce forests in Europe, -but also in the U.S.A. and Canada- and different aspects of the pollution of the air, the soil and the surface waters is considerable, many problems are still in discussion. One of the questions is whether high short lasting O_3-concentrations, possibly in combination with actual and preceding damage by acid deposition, may be responsible for the impending catastrophe in the European forests since 1976.

Suggestions that during the long, dry and hot summer of 1976 the increase of injuries possibly has to be correlated with occasional high O_3-concentrations, caused by photochemical processes, may not be ignored.

In view of the lifetime of ca. 5 year of pine needles the SHELL-study is restricted to recent summer periods (1978-1983). The summer of 1976 was also included because it was a particularly dry summer, with generally high ozone levels all over Europe.

Because the ozone study concerns the rural variety of the concentrations, the requested meteorological parameters are related to horizontal transport, vertical mixing and the weather.

2. Analysis of dry, sunny episodes

Instead of looking to anticyclonic episodes of more than 3 days, the episode selection may be based more adequately on the weather itself. The following considerations have contributed to the selection of the episodes:

- Episodes of three days for which trajectories can be traced backwards. Arrival of the trajectory at the receptor places on the third day of the episode.
- As much as possible similar weather conditions in all the 5 receptor places during the episodes. The episodes which are used, are similar for all the receptor places.
- Choice of the episode at the end of a fair weather period, with the third day, if possible, preceding to the weather break.
- Maximum temperatures by preference > 20°C, or possibly > 25°C on the three consecutive days of the episode.
- Maximum mixing height < 2000 m, or preferably < 1600 m, both in the receptor places itself as along the trajectories.

- Total amount of episodes: 25, proportional to the length of the fair weather periods of the summer seasons of the years considered.
- The summer season covers the period May-September.

This selection includes days on which photochemical air pollution is likely to occur in large parts of West and Central Europe if there are emissions of NO_x and HC in the mixing layer (Guicherit and Van Dop, 1977). To exclude secundary effects on the computed and/or measured O_3-concentration levels the choice of similar weather conditions in the 5 receptor places and also as much as possible along the trajectories may contribute to a better understanding of the relation between the emissions and the photochemical processes along the trajectories.
An investigation of the 3 hourly surface weather maps of the total period (5 months, 7 years; 1071 days) showed that the following periods could be used for the final selection:

1976:	5-9 May;	6-15 June;	18 June-17 July;	7-30 August.		
	(5 days)	(10 days)	(30 days)	(24 days)	=	69 days
1978:	26 May-5 June;	23-31 July;	18-27 August.			
	(11 days)	(9 days)	(10 days)		=	30 days
1979:	13-16 May;	1-5 June;	17-21 June;	28 Aug-1 Sept.		
	(4 days)	(5 days)	(5 days)	(5 days)	=	19 days
1980:	30 April-4 May;	9-19 May;	3-6 June;	22 July-3 Aug.		
	(5 days)	(11 days)	(4 days)	(13 days)	=	33 days
1981:	11-15 August;	2-7 September				
	(5 days)	(6 days)			=	11 days
1982:	10-15 May;	29 May-10 June;	8-15 July;	8-20 Sept.		
	(6 days)	(13 days)	(8 days)	(13 days)	=	40 days
1983:	6-24 June;	8-18 July;	14-31 Aug.			
	(19 days)	(11 days)	(18 days)		=	48 days
					total	: 250 days

The number of days which potentially may be considered for selection is 250. For each day the type of the general weather circulation ("Groszwetterlage") is determined (Hess and Brezowski, 1969). This yields the following distribution:

• HM	Anticyclone over Central Europe	45 days
• BM	Ridge of high pressure over West and Central Europe	38 days
• HNF_a	Anticyclone over Scandinavia and the NE-Atlantic with anticyclonic circulation over Central Europe	29 days
• HF_a	Anticyclone over Finland and Scandinavia with anticyclonic circulation over Central Europe	31 days
• HN_a	Anticyclone ove the NE-Atlantic with anticyclonic circulation over Central Europe	10 days
• NE_a	Anticyclonic NE-circulation over Central Europe	23 days
• HB	Anticyclone over the British Isles and/or the Northsea	12 days
• S_a,SE_a	Anticyclonic circulation from the S or SE over the investigated area	10 days
• SW_a,NW_a • W_a,N_a	Idem but from the SW, NW, W or N	26 days
• var.	Cyclonic circulations	26 days

Generally spoken: the days which may be considered for selection are for 90% characterized by anticyclonic weather. But the reverse, that anticyclonic circulations will always cause the described weather situation, is not true.

The number of 250 days which have to be considered, is 23% of the total amount of 1071 summerdays. This fraction is rather large, due to three warm summers out of this period: 1976, 1982 and 1983. The percentage of 23 is much higher than the climatological one, based on a serie of 30 consecutive years. The difference, however, is not determined, since no selection of days, as described for this episode qualification, is available over the normal climatic period 1950-1979 or other climatic periods. Furthermore, not all the days of the periods given, fit as well as may be desired with the aim of the study.
Therefore a further selection is carried out. In the first place those 3-day-episodes are determined which fit as good as possible in the con-

siderations made before. A more detailed study of the weather situations shows that 29 not overlapping episodes can be selected. In the second place the division of the episodes over the different years is proportionally to the length of the different periods, as is illustrated in the following table:

Table 2.1 A listing of all fair weather episodes during 1976, 1978-1983. The 5th column shows how the finally selected 3-day episodes are distributed over these years.

year	Period length (days)	total number of days	Number of selected episodes	Total	Available number of episodes
1976	5, 10, 30, 24	69	0, 1, 3, 2	6	8
xxxx					
1978	11, 9, 10	30	1, 1, 1	3	3
1979	4, 5, 5, 5	19	0, 0, 0, 1	1	1
1980	5, 11, 4, 13	33	0, 1, 0, 1	2	2
1981	5, 6	11	1, 1	2	2
1982	6, 13, 8, 13	40	0, 2, 1, 2	5	6
1983	19, 11, 18	48	2, 1, 3	6	7
Total number of days		250	Total	25	29

The final selection of the 25 episodes results in the following classification, which is numbered 1-25, corresponding with the numbers on the trajectory charts.

The weather situation of the 25 last episode days is illustrated by a weather map of 1200 GMT, which gives a somewhat better idea of the pressure distribution than the classification of the "Groszwetterlagen" (see appendix I).

Table 2.2. Classification of the 25 selected LAPSE-episodes. Between brackets the "Groszwetterlagen", i.e. the large scale weather patterns, over West and Central Europe.

1 : 6-9 May 76 (4 SE_a)	4 : 4-7 July 76 (4 HN_a)
2 : 11-14 June 76 (2 HNF_a, 2 HF_a)	5 : 7-10 Aug 76 (4 NE_a)
3 : 25-28 June 76 (3 BM, 1 NW_z)	6 : 23-26 Aug 76 (1 HF_a, 3 HM)
7 : 29 May-1 June 78 (2 NE_a, 2 HM)	
8 : 27-30 July 78 (4 HF_a)	
9 : 19-22 Aug 78 (4 BM)	
10: 29 Aug-1 Sept 79 (4 HM)	
11: 11-14 May 80 (4 HF_a)	12: 22-25 July 80 (4 HM)
13: 12-15 Aug 81 (2 NE_a + 2 W_a)	14: 3-6 Sept 81 (1 HN_a, 3 HM)
15: 31 May-3 June 82 (3 HM, 1 SE_a)	18: 9-12 Sept 82 (4 BM)
16: 7-10 June 82 (4 HN_a)	19: 14-17 Sept 82 (1 BM, 3 HM)
17: 10-13 July 82 (1 HM, 3 HF_a)	
20: 17-20 June 83 (4 HB)	23: 16-19 Aug 83 (2 SW_a, 2 HM)
21: 9-12 July 83 (1 HF_z, 3 HNF_a)	24: 24-27 Aug 83 (4 BM)
22: 13-16 July 83 (3 NW_a, 1 T_rW)	25: 28-31 Aug 83 (4 BM)

Distribution of circulation types in %:

HM	BM	HNF_a	HF_a	HN_a	NE_a	HB	S_a+SE_a	SW_a, W_a NW_a, N_a	cyclonic
25	20	5	14	9	8	4	5	7	3

As is evident from the frequency distribution of the circulation types, (Table 2.2), anticyclonic weather patterns prevailed. Only 3% of the episode days was characterized by cyclonic weather, 2 cases at the last episode day (ep. 3 and 22) and 1 case with a cyclonic start (ep. 21).

The highest frequencies have HM (25%), BM (20%), HF_a + HNF_a (19%) and HN_a (9%). This is interesting in relation to the selection of the episodes for the LAPSE project when this frequency distribution is compared with the conclusions of a study of photochemical oxidants in North-Western Europe during 1976-1979 (Schjoldager et al., 1981). In this study high ozone concentrations at different locations in Europe (U.K., FRG, Netherlands, Austria) are also related to the circulation types of the weather. One of the conclusions in this study is that "even if high ozone levels are strongly associated with some weather categories, e.g. HM, BM, HN_a, HF_a and HNF_a, the majority of these weather events did not necessarily imply high ozone concentrations. Thus, it seems that the large scale weather pattern does not alone determine the sufficient conditions for ozone formation. An exception to this is the category HM, showing high ozone concentrations in Great Britain and the European Continent during 16 of a total of 27 days".
These conclusions have to be taken in consideration because 73% of the selected days for the LAPSE-study were characterized by these circulation types!
Becker et al. (1979) have reported on a series of studies in the Cologne/Bonn area in 1975-1978. For the episode in June/July 1976 their conclusion was similar to that of the English Groups, namely that local emissions had contributed significantly to the ozone levels, in addition to the large scale formation and transport.
The local influence was assessed by simultaneous measurements of olefins, PAN and ozone.

3. Trajectory calculations

For each of the 25 episodes trajectories have been computed which end in the receptor sites at the end of the episode.
As time of arrival is chosen 1500 or 1600 GMT. At this time the mixing layer will have reached its maximum height during warm (hot) and sunny summerdays. Also O_3-concentrations have peak values around that time.
The advection trajectories are traced back during three days (72 hours) so that they also start at 1500 or 1600 GMT. During the time that the air is well mixed, up to 1600-2000 m, the air transport through the whole layer has to be considered, but during the evening and night however, when vertical exchange is often restricted to an altitude of

200 m, the air which is transported at higher levels is "decoupled" from this shallow layer. The air mass will generally follow different trajectories, since the variation of the wind velocity and the wind direction between the two layers is mainly larger during night time. Therefore the diurnal variation of the stability and the depth of the mixing layer causes complications in the determination of which source areas finally contribute to the air mass which reaches the receptor place at the time of arrival. (fig. 3.1)

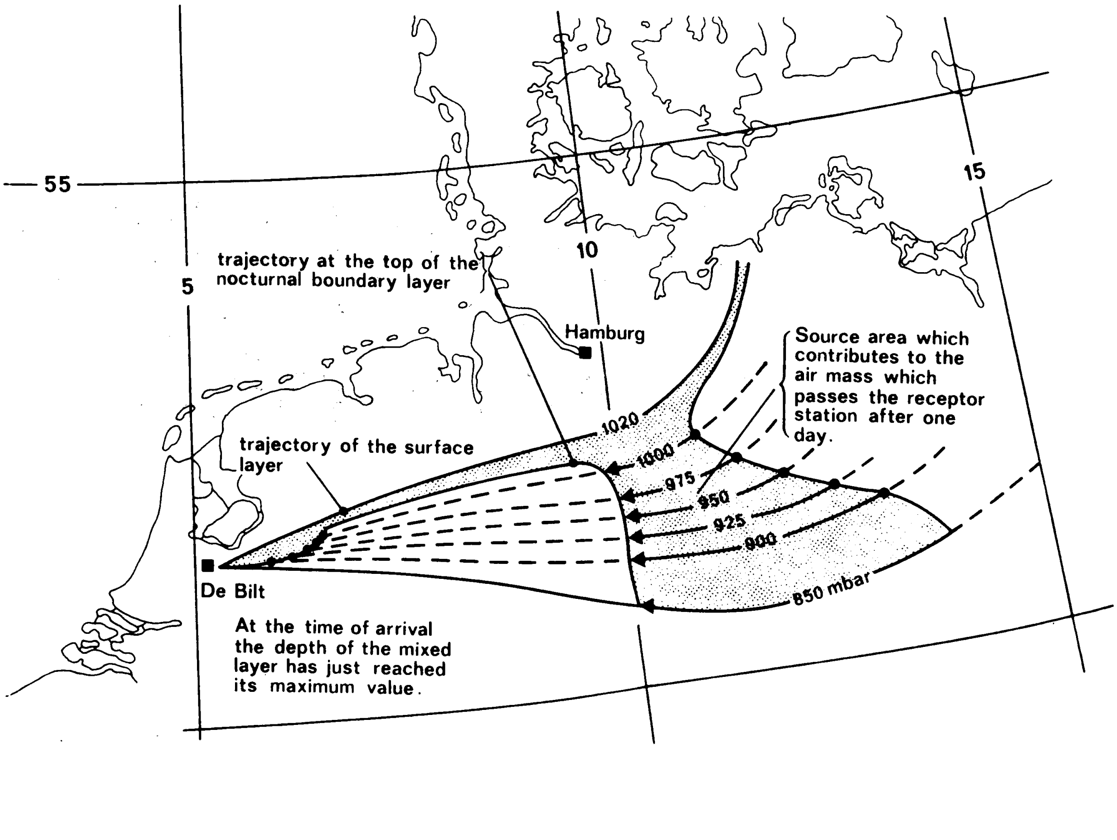

Fig. 3.1. Example of the contribution of different trajectories passing a source area which contributes to the air mass which reaches a receptor location after one day. Normally the windspeed increases with height. Also the wind direction changes, mainly with a veering effect, which means turning clockwise. In general the trajectories of different pressure levels will follow different pathways. The air pollution which

will be picked up originates in different source areas. The dots show the start of the trajectory part which during day time is contained in the mixing layer. The arrows give the end of these trajectory parts. Due to the growing time of the mixing layer the starting time of the dot of the 1000 mbar trajectory lies earlier than the one of the 975 mbar trajectory, etc. The arrows, however, end practically all at the same time, i.e. at sunset. Due to the larger windspeed at higher altitudes the enclosed part of the 850 mbar trajectory will be mainly larger than those of the lower pressure levels, in spite of the somewhat smaller time period during which it is included in the mixing layer.
The receptor station is reached at the moment at which the boundary layer has mixed again on the next day onto its maximum height. The lower level trajectories therefore are already partly mixed in the growing boundary layer. For 72 hour trajectories the procedure described above has to be repeated three times, as is illustrated schematically in fig. 3.2.

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Only in case the transport velocity does not vary very much up to ~ 1500 m along the trajectory (i.e. when trajectories, which are determined at different heights approximately coincide) the locations of the sources can be taken along that trajectory. When the surface trajectory does not coincide with a trajectory at a higher altitude, it is not unreasonable to assume that some sources which are situated in the enclosed region between both trajectories also contribute.
It is, however, very difficult to determine the exact locations of these sources and to what extent they contribute. See fig. 3.2.
This should be borne in mind when including emissions and chemistry and included in trajectory models.

Since during the selected episodes this mixing extends to 1500-2000 m, it is obvious to compute one of the trajectories in this layer.
For this purpose the <u>850 mbar trajectory</u> is chosen. The 850 mbar level, which is mainly situated at 1500 m, has the advantage to be one of the standard atmospheric levels in meteorology.

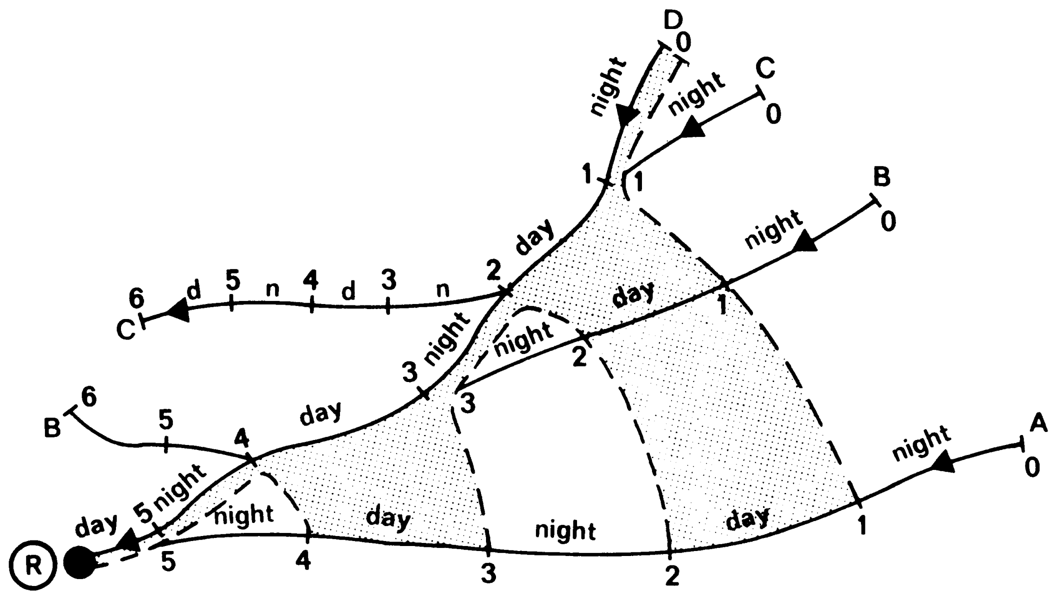

Fig. 3.2. Idealized sketch to illustrate which emissions contribute to the surface concentrations in the receptor location R, when the surface trajectory does not coincide with trajectories at higher altitudes. (It is for simplicity assumed that upper air trajectories are different only during nighttime and that the day-night-day transitions are instantaneous. It is further assumed that during daytime upper air and surface air mass mix and that no vertical exchange exists during nighttime.

One surface trajectory (D) and three upper air trajectories (A,B,C) are drawn.

Sources which eventually contribute to the concentration in R are situated in the shaded areas. They are all located in the region enclosed by the surface (D) and the upper air trajectory (A) ending in R.

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Generally spoken the air which arrives at the receptor point will have picked up pollution contaminants anywhere in the sector between the 850 mbar and 1000 mbar trajectory starting point and the receptor site.

The fundamental question how to construct the most representative trajectory for each episode is difficult to answer.

It depends mainly of the diurnal variation in the mixing height, and the divergence of surface and upper air trajectories. During the period between ca. 1700 GMT and 0600 GMT the surface trajectory is the most representative. During daytime this trajectory has to be continued but air from the layers between 200 and 2000 m will be mixed with the surface layer air and will also contribute to the air composition (cf. Fig. 3.2).

For reasons of simplicity the 925 mbar trajectory may be chosen as an average representative trajectory with respect to the source locations. This trajectory is usually situated in the sector between the 850 mbar and 1000 mbar trajectory. The average height is ca. 600 m.

For the episodes of 1980, 1982, 1982 and 1983 (15 cases) the trajectories are computed with the KNMI trajectory model (Reiff et al., 1984) which uses the meteorological data which are collected in the ECMWF at Reading. For these cases also the 925 mbar trajectory is computed.

This model delivers the trajectories which arrive at the receptor point at 1000 mbar, 925 mbar and 850 mbar. This does not mean that the flight level of the air through the whole episode was constantly at these pressure levels.

Influenced by different meteorological processes the trajectories which arrive at 1000, 925 and 850 mbar are subjected to vertical movements during their pathway.

In the figures (appendix II) the selected trajectory value is given at the starting point: 1000 or: (000), (925) and 850 or (850). Furthermore the pressure levels at which the trajectory was at the start and during the advection route are also given.

The ascending parts of the track are drawn intersected (----) and the descending parts are drawn fully (——).

The trajectory consists of steps with 6 hr time intervals, starting and ending at 1500 GMT (episode 1-10) or 1600 GMT (episode 11-25).

Since the ECMWF-trajectories were only available from 1980, the trajectories of the other 10 episodes are computed by hand. Only two sets are made: trajectories of the surface layer and of 850 mbar.

The surface layer trajectories are determined by using three hourly surface weather maps. From these maps the wind direction and the windvelocity at a height of 10 m are derived from the plotted values and from the gradient wind which is a function of the isobaric pattern.

The 850 mbar trajectories could be constructed by using upper air charts of the 850 mbar level, drawn with 6 hr intervals. To compute the air displacement over a time step of 6 hrs the average wind direction and wind speed have been taken of the values at the beginning and at the end of this timestep.

The 925 mbar trajectory has to be situated about half the way between the 850 mbar and the surface trajectory as is evident from the examples given for 1980-1983.

Sometimes the trajectory covers a long track, but during stable weather situations with little air displacement the trajectory length will be much shorter.

For reasons of clarity the trajectories are drawn on a varying map scale. On the underlying maps the contours of the coastlines and the borders of the Benelux countries are indicated. In order to allocate the geographical position, also the longitude and the latitude at intervals of five degrees, are given.

3.1. Origin of air masses

An interesting point of discussion is the question whether there are significantly different sectors of origin of the trajectories for each of the 5 receptor stations. And, furthermore, whether "sectors of preference" could be discovered for the different receptor locations.

To give an answer to these questions all the surface/1000 mbar and all the 850 mbar trajectories, belonging to one receptorpoint, are drawn on two separate maps, one for the collected 850 mbar and one for the surface trajectories (Appendix III).

Putting an overlay with eight sectors on each of the receptor stations, for each of the trajectories can be determined in which section its starting point (i.e. the origin) is situated.

The chosen sectors are: N-NE, NE-E, E-SE, etc.

The results are collected in table 3.1.1.

Table 3.1.1 Origin of the trajectories.

Site \ Sector		N — NE	NE — E	E — SE	SE — S	S — SW	SW — W	W — NW	NW — N
Soisson	850	0	13	3	2	3	3	1	0
	surf	3	13	2	1	1	1	1	3
Nancy	850	7	7	4	2	2	3	0	0
	surf	4	15	0	1	0	0	2	3
Freiburg	850	8	5	6	0	1	2	0	3
	surf	6	13	2	0	0	0	0	4
Soltau	850	3	1	5	0	2	9	3	2
	surf	4	4	4	2	1	3	3	4
de Bilt	850	5	3	5	0	2	8	0	2
	surf	5	6	4	1	0	5	1	3

As is evident from the table and fig. 3.3 one of the most striking features is the preference for the NE-E sector for the points of origin of the surface trajectories of Soisson, Nancy and Freiburg: 13 or more cases out of 25.

This predominant preference is less for the 850 mbar trajectories, although the total number of points of origin situated in the sector between North and East is also 13 or more.

The surface trajectories of Soltau and de Bilt does not show any pronounced preference. The sector between NE and E counts only 4, resp. 6 starting points.

In the sector between SW and NW 6 points of origin are situated for both Soltau and de Bilt, against 2,2 and 0 for Soisson, Nancy and Freiburg. The 850 mbar trajectories of Soltau and de Bilt find their origin in 9, resp. 8 cases in the sector SW-W, against 3 or 2 for the other 3 receptor places.

Another approach could be to look to the sectors in which the last 48 hr part of the trajectories are situated, to get an impression about the contribution of the different air pollution sources in Europe for each of the investigated receptor stations.

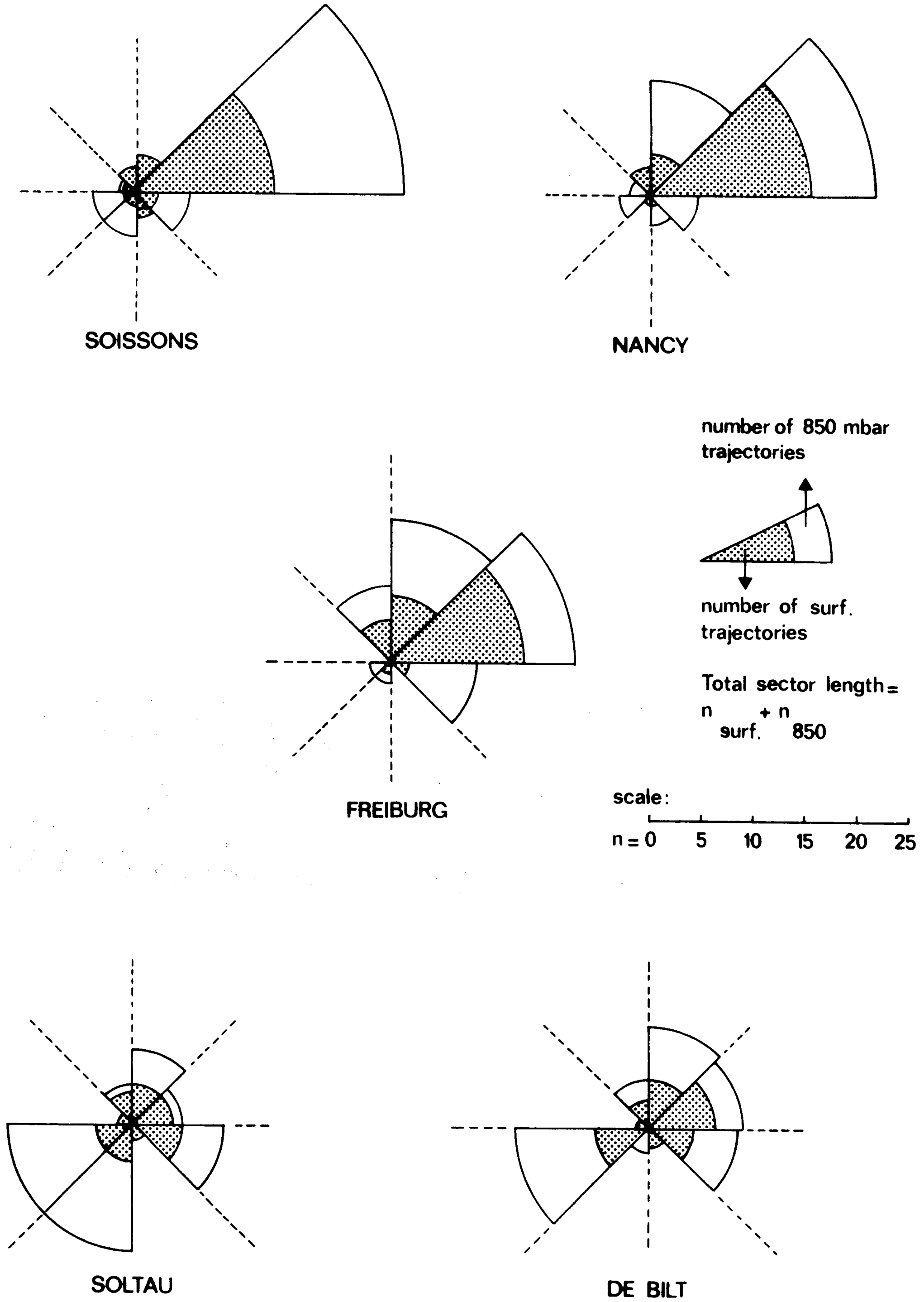

Fig. 3.3. Origin of the surface- and 850-mbar trajectories. The shaded sectors correspond with the number of surface trajectories. Their radii are proportional to their frequency of occurrence. The open segments on top correspond with the number of 850-mbar trajectories.

There is a main indication that the preference for NE-ly advection directions for Soissons, Nancy and Freiburg is rather pronounced, a preference which is not found for Soltau and de Bilt.
It is not the aim of the KNMI-contribution to the SHELL LAPSE-project to study these aspects, but when the results of the LAPSE project have to be discussed the above meteorological aspects may play an important role in the explanation of these results.

3.2. Coherency and stagnancy of surface and upper air trajectories.

In the study of the trajectories in the mixing layer one of the aspects of consideration is the coherency between the advection directions of the air at different levels in the mixing layer, especially during the daytime period.
In the framework of this study only a very general definition of "coherency" is used. When the area of the sector between the 1000 mbar and 850 mbar trajectory is "small" the term "good coherency" is used. For this 25 episodes no objective qualification has been used, but only a subjective criterium. The same holds for qualifications like "moderate" and "poor coherency". When the area of the sector is "large", the coherency is poor or even nil.
Similar considerations are used for the definition of the stagnancy of the weathertype. When the trajectories are "short" the weather is stagnant and when they are "long", there is no stagnancy. Doubtfull cases are classified as moderate.

Table 3.2.1. Coherency (C) between the 1000 mbar and 850 mbar trajectory.
Stagnant character of the weather situation (S).

Location / Episode	Soissons C			Soissons S			Nancy C			Nancy S			Freiburg C			Freiburg S		
	+	0	-	yes	mod	no	+	0	-	yes	mod	no	+	0	-	yes	mod	no
1		•				-		•				-			-			-
2	+					-			-			-			-			-
3	+					-	+					-	+					-
4	+				•		+				•		+					-
5		•				-			-			-		•				-
6	+			+		-	+					-	+					-
7			-			-			-			-			-			-
8			-			-		•			•				-		•	
9		•				-			-			-			-	+		
10			-			-		•		+					-	+		
11	+					-	+					-	+					-
12			-		•				-	+					-	+		
13	+			+			+			+			+			+		
14	+				•		+				•		+				•	
15		•				-			-			-		•			•	
16	+					-	+					-	+				•	
17	+					-		•				-		•				-
18			-	+					-	+					-	+		
19			-	+					-	+					-	+		
20		•				-	+					-	+					-
21	+					-	+					-	+					-
22	+					-	+			+			+			+		
23			-	+					-	+			+			+		
24			-			-		•				-		•				-
25	+			+			+			+			+			+		

+ = good 0 = moderate - = poor

Table 3.2.1. (cont) Coherency (C) between the 1000 mbar and 850 mbar trajectory. Stagnant character of the weather situation (S).

Location / Episode	Soltau C			Soltau S			de Bilt C			de Bilt S			all stations C			all stations S		
	+	0	−	yes	mod	no	+	0	−	yes	mod	no	+	0	−	yes	mod	no
1	+					−		.				−		.				−
2			−			−			−			−			−			−
3		.				−			−			−	+					−
4	+					−	+					−	+					−
5		.				−		.				−		.				−
6		.		+			+			+			+				.	
7		.				−			−			−			−			−
8	+					−	+				.			.			.	
9			−			−	+					−			−			−
10			−			−			−			−			−		.	
11	+					−	+					−	+					−
12		.			.				−			−			−	+		
13	+					−	+					−	+				.	
14			−		.			.			.		+				.	
15		.				−		.				−		.				−
16			−			−	+					−		.				−
17			−			−			−			−		.				−
18		.				−		.				−			−	+		
19	+					−	+				.				−	+		
20	+					−		.				−		.				−
21		.		+				.			.		+				.	
22	+					−			−		.		+				.	
23			−	+					−	+					−	+		
24	+					−	+					−		.				−
25	+			+			+			+			+			+		

+ = good 0 = moderate − = poor

An overview is given in table 3.2.1. The classification has been made for each of the stations separate and for all the stations together. The sum of each of the classes is given in table 3.2.2.

Table 3.2.2. Classes of coherency and stagnancy for the 1000 mbar and 850 mbar trajectories ending in the given locations.

	Coherency C			Stagnancy S		
	+	0	-	yes	mod	no
Soisson	12	5	8	6	3	16
Nancy	11	5	9	8	3	14
Freiburg	12	4	9	9	4	12
Soltan	10	8	7	4	2	19
de Bilt	10	7	8	3	5	17
All stations	9	8	8	5	7	13

The following conclusions can be made:

- The number of "good", "moderate" and "poor" coherency situations has the same order of magnitude
- The stagnancy is twice as small in Soltau and de Bilt as in Soisson, Nancy and Freiburg.
- The total number of stagnant weather situations is small: 3-9 episodes. Mainly there was considerable advection during the 72 hr period: 12-19 episodes.

When a combination of coherency and stagnancy of the 25 episodes is considered, the conclusion is:

- good coherency occurs when there is no or only moderate stagnancy, except in 3 cases for Soisson, Nancy, 4 for Freiburg, 1 for Soltau and 2 for de Bilt.
- during stagnant weather situations the trajectories have no clear preference for one of the three coherency classes.

4. Weather elements along the trajectories

Part of the modelling of lang range transport of air pollution is the implementation of the "weather" phenomena along the trajectories during

the time of transport.
The choice of the meteorological parameters depends largely on the objections of the model. Within the framework of the photochemical model of the SHELL LAPSE-project the selection of the meteorological parameters has been restricted to the diurnal variation along the surface trajectory of the:

- mixing height
- temperature at the earth surface (observation height)
- humidity; idem
- cloudiness.

4.1. The mixing height

The maximum mixing height is usually determined by using the vertical temperature and humidity profile of the 1200 GMT radiosonde ascent and the afternoon maximum temperature at the sites where the trajectory passes at about 1300-1400 GMT. Additional information which can be used, is the type, the height of the base and the amount of the convective clouds over the trajectory area.
It would be a coincidence when the early afternoon part of the trajectory is just passing a station where radiosondes are launched. For the SHELL LAPSE-project the radiosonde ascents of surrounding stations, as far as availabe, are used, in combination with the data of - mainly small amounts - cumulus clouds, plotted in the surface weather maps.
Since 25 rather similar weather situations are selected, it is not surprising that the range of the diurnal variation of the mixing heights will show more or less identical pictures.
For the first 10 episodes - with the hand computed trajectories - the mixing height is determined with 6 hr time intervals; i.e. at 03.00, 09.00, 1500 and 2100 GMT, and, in some cases, also at 00.00, 06.00, 12.00 and 18.00 GMT.
Using this values an average curve of the diurnal variation for each of the trajectories can be derived. An example is given in the figure below, for Freiburg (fig. 4.1.1.).
For reasons of simplicity, these average values can be used in the model as a "standard-value" for all the episodes, as long as the trajectories are situated over land. This includes a marked diurnal variation in the mixing height. However, this approach is not valid when trajectories

cross the Baltic, the Northsea, the Bay of Biscay and the North Atlantic. Due to the absence of a diurnal variation of any importance in the air temperature over a water surface, we have then to consider the mixing height practically constant, with a value between 100 and 200 m, during the whole day.

Due to the fact that the trajectories of the last 15 episodes are computed by a standard trajectory model, no values of the mixing height are available. They have to be derived from other methods, mainly by hand, using surface weather maps and radiosonde data of these episodes, a time consuming procedure. Based on our experience with the first ten episodes and the similarity of the selected episodes we expect that an average mixed layer height variation as depicted in fig. 4.1.1 may be adopted for the other episodes as well without making large errors.

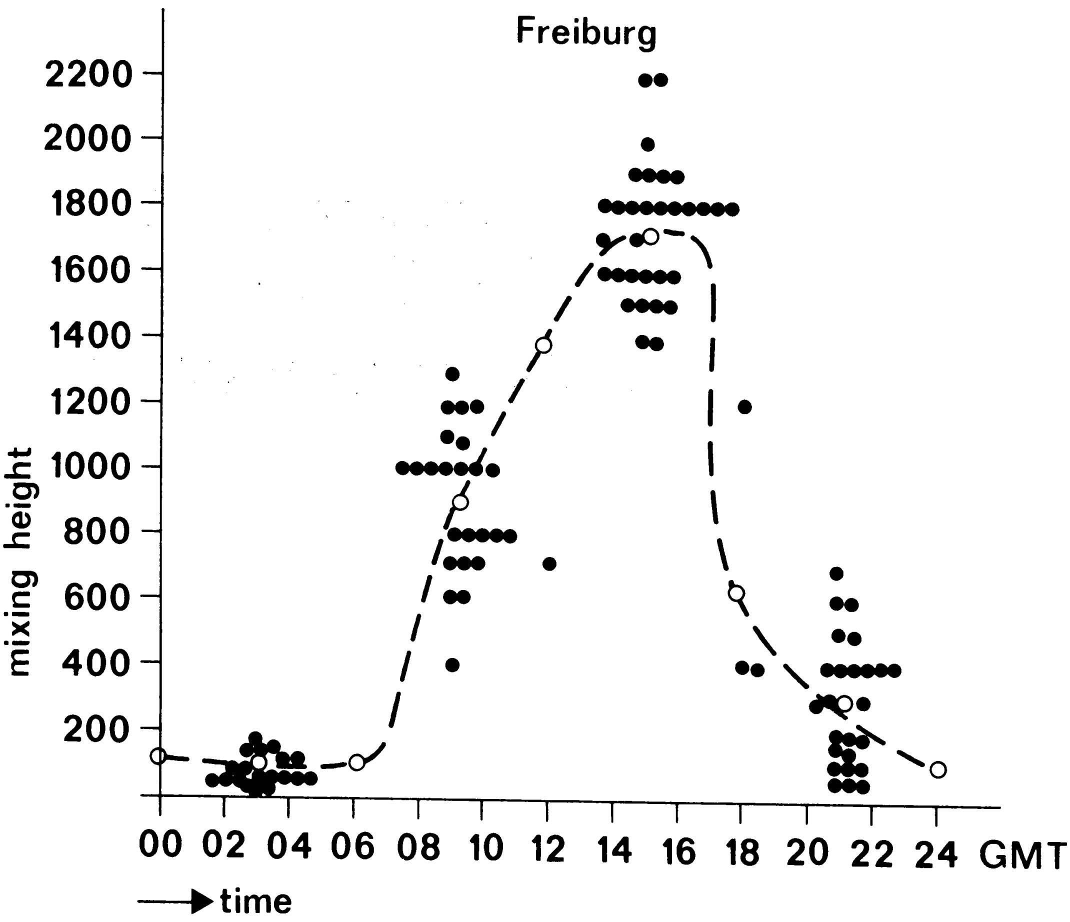

Fig. 4.1.1. The average diurnal variation of the mixing height along the trajectories reaching Freiburg during episodes of warm (hot) sunny summer days (10 cases).

4.2. Diurnal variation of the temperature and the humidity along the surface trajectories

Similar problems as described for the determination of the mixing height, arise with relation to the diurnal variation of the temperature and the humidity along the surface trajectories.

For the first 10 episodes, with the trajectories computed by the hand method, the temperature and the dewpoint temperature are determined with 6 hr time interval. This means at 03.00, 09.00, 15.00 and 21.00 GMT, and also in some cases at 00.00, 06.00, 12.00 and 18.00 GMT. The values are derived from the surface weather maps, following the trajectories and interpolating between the synoptic stations which are plotted in the area which is passed by the trajectory.

Using the values of these first 10 episodes an average diurnal variation of the air temperature and of the dewpoint temperature can be determined (fig. 4.2.1; 4.2.2). The combination of the air temperature and the dewpoint yields the humidity of the air in the surface air layer which has a depth of 1½-2 metres.

For the last 15 episodes these average values can be used instead of the actual values for each of the trajectories. Again this approach only holds as long as the surface trajectories are situated over land.

When they cross the Baltic, the Northsea, the English Channel, the Bay of Biscay and the North Atlantic the surface air temperature will be rather constant during the whole 24 hr period. The value will be approximately the same like the sea surface water temperature.

The diurnal range of the humidity depends largely on the type of air mass. In extreme cases the humidity falls in the afternoon to less than 20% (for example Soltau, 9-5-76, 1500 GMT, TT = 30°C, T_dT_d = 4°C; Soissons, 28-6-76, 1500 GMT, TT = 35°C, T_dT_d = 8°C). The highest afternoon values range from 50% to 60%.

At the moment of sunrise when the temperature reaches its minimum value, the humidity reaches its highest value, especially during calm and clear weather. When the air temperature and the dewpoint have the same value, the humidity increases to 100% (for example Soissons 30-7-78, 0300 GMT; TT = 18°C, T_dT_d = 18°C; Soltau 28-7-78, 0300 GMT, TT = 10°C, T_dT_d = 10°C).

To get an impression of the "average" values, the relative humidities are determined on the base of the average values of TT and T_dT_d. This gives the following results:

Time	:	00	03	06	09	12	14	18	21	GMT
TT	:	16	14	14.4	21.5	25.5	26.4	24.4	18.6	°C
T_dT_d	:	9	9.5	8.6	11.5	11.6	9.7	9.8	9.5	°C
Rel. hum.	:	62	77	66	52	41	34	38	55	%

To determine the relative humidity for the separate case studies, a table is added which gives the humidity in % along the vertical axis, as a function of TT, and T_dT_d (fig. 4.2.3)

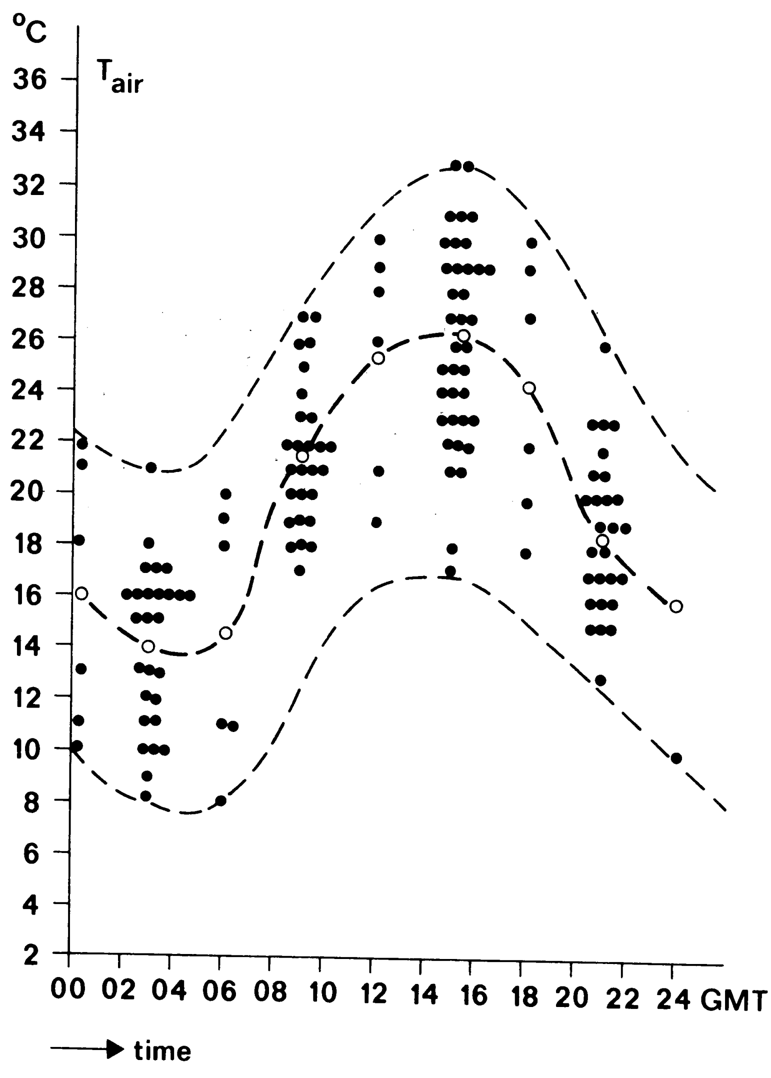

Fig. 4.2.1. The average diurnal variation of the air temperature along the trajectories, reaching Nancy, during episodes of warm (hot) sunny summer days (10 cases), and the range around the mean curve.

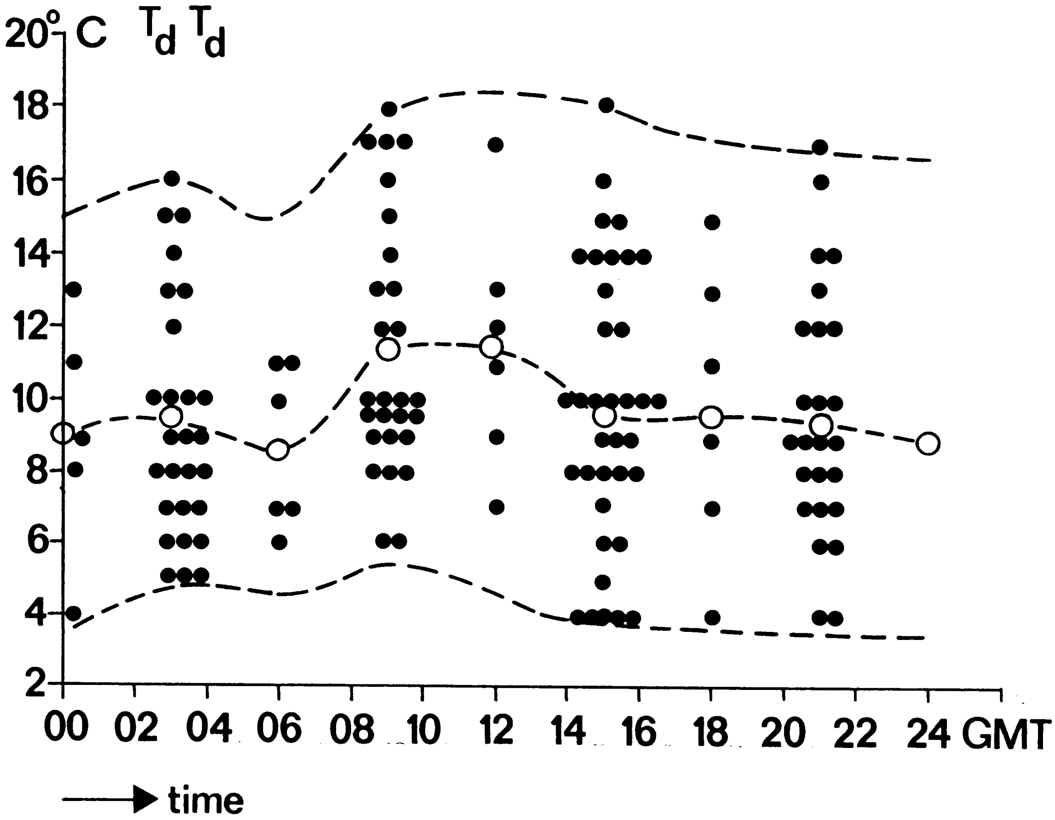

Fig. 4.2.2. The average diurnal variation of the dewpoint temperature along the trajectories, reaching Nancy during episodes of warm (hot) sunny summer days (10 cases) and the range around the mean curve.

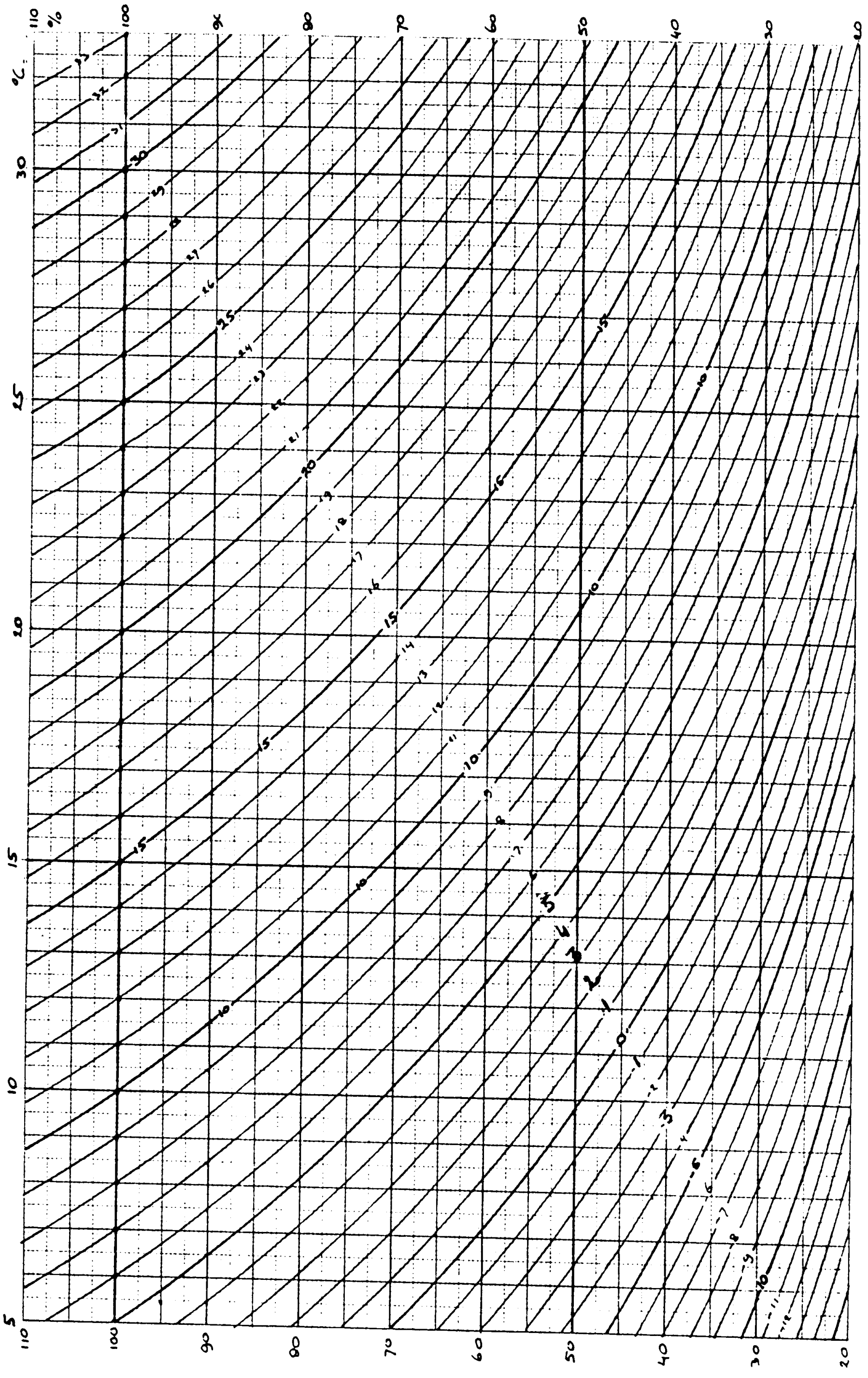

Fig. 4.2.3. The relative humidity (in %) is given along the vertical axis as a function of TT (the horizontal axis) and T_dT_d (the curves).

4.3. Clouds

The determination of the trajectories of the first 10 episodes by using surface weather maps offered also the opportunity to look to the cloud observations of the synoptic stations along and around the trajectories. The weather was predominantly cloudless, which was no surprise, due to the conditions on which the episode selection has been based. More correctly, the conditions are only valid for the terminal stations, so it may be possible that clouds appear along the trajectories when these are traced back during 72 hrs. Sometimes clouds appear indeed, as is evident from the weather tables belonging to episode 1-10 (Appendix IV). The following abbreviations are used.

st = stratus; fogp = fogpatches
sc = stratocumulus
cu = cumulus
cb = cumulonimbus
ac = altocumulus (cloud base above 2000 m)
as = altostratus
ci = cirrus (cloud base above 5000 m).

When it was possible the height of the cloud base is added in the columns.

The cloud amount is given in octa's. This means that when for example 7 is given, 7/8 part of the sky is covered with that type of clouds.

Mainly the cloudiness is nil or very small (0-4 octa's), which means that photochemical processes are not impeded by clouds. Only very seldom the weather was cloudy or overcast (5-8 octa's) with stratocumulus or stratus.

Only cloud observations of the first 10 episodes are available. It is expected that practically all the surface trajectories which are situated over land will show no or only small cloudiness. Discrepancies may occur for the surface trajectories which follow an oceanic pathway.

4.4. Temperatures along the 850 mbar trajectories

For the episode numbers 1-10, the 850 mbar trajectories, which are determined from upper air charts, it was also possible to select the temperatures along the trajectories.

For a good understanding it is necessary to make a distinction between

the first 10 and the last 15 episodes. The first ten episodes contain trajectories in a constant pressure plane (850 mbar).
So it was simple to determine the temperature values by interpolation of the isotherms at the 850 mbar level.
The trajectories of the last 15 episodes, however, are determined by a full 3-D analysis of the windfield during the 72 hr advection period. This implies that the changes in temperature along the trajectories of these episodes will be larger and more complicated than in the first episode.

5. Observed O_3-concentrations during the episodes

In order to be informed about the observed ozone concentrations in the reference station de Bilt, the Netherlands, during the investigated episodes, the available measurements are collected and summarized in Appendix V. The values indicate the order of magnitude, since they are based on the recorded values during 2-3 hours around 1600 GMT. The peak values are smoothed. Sometimes they were observed between 1600 GMT and 1900 GMT, but in other cases from 1400 GMT - 1700 GMT.
Measurements from the Cabauw tower (25 km SW of de Bilt) are taken in a rural area, at three levels: 3 m, 100 m and 200 m. They are available for episode 1, 7-9 and 11-25.
Especially from 15-5-1979 onwards these measurements are very reliable. In the preceding years the instrumentation was not uniformely calibrated and some uncertainties have to be included.
The missing observations are supplied with observations from TNO-Delft, situated in an urban area, 60 km WSW of de Bilt, between Rotterdam and the Hague.
These observations are made at a height of 3 m only. One has to take into account that they are less reliable than the more recent observations. To compare the order of magnitude the 3 m ozone peak values of Delft and Cabauw are both given for 3 episodes (7, 8 and 9). Since no recordings of Cabauw from episode 11 are available, the 3 m observations of de Bilt and Delft are both supplied.
Now the question arises whether there may be a possible relation between the height of the mean afternoon ozone peak, the geographical sector in which the surface and 850 mbar trajectories originate, the stagnant character of the weather situation and the air mass properties, i.e. its

continental or maritime character.
For this study the ozone concentrations were distributed over five classes. The lowest class contains less than the natural background concentration in clean, not urbanized areas: < 80 $\mu gr/m^3$. When the concentration in such areas increases to higher levels, this is mainly due to photochemical processes.
The ozone concentrations are used of the final episode day, the day at which the trajectory arrives. The concentrations concern the 3 m level observations, although in doubtfull cases also the concentration of the 100 m and 200 m level has been taken into account. The data are summarized in table 5.1.

As is evident fromt able 5.1, the following conclusions can be made:

- The lowest concentration (<80 $\mu gr/m^3$) belongs to a non-stagnant weather situation with advection from the NNW-sector.
- The highest concentrations (>230 $\mu gr/m^3$) are associated with continental advection with a predominantly Southerly component, except for the 1000 mbar trajectory of episode 19. Of the four episodes in this class two were moderate stagnant and two not stagnant.
- The moderate and predominant stagnant weather situations were all related with high ozone concentrations: > 180 $\mu gr/m^3$; 7 episodes. However, as is also evident from table 5.1, seven non stagnant weather situations have also contributed to high ozone concentrations, where of five were associated with advection of continental air and only two (ep. 3 and 13) with advection of maritime air.
- The three lower classes (<180 $\mu gr/m^3$) are all occupied by non stagnant weather situations, except one episode, with moderate stagnancy (ep. 21).
- The percentages with maritime and continental trajectory pathways are distributed as follows:

ozone class	< 80	80-130	130-180	180-230	> 230
% maritime adv.	100%	66%	66%	40%	0%
% continental adv.	0%	34%	34%	60%	100%

This means that the contribution of continental air advection increases in the higher ozone concentration classes.

Table 5.1:

Five different classes of ozone concentration with the associated episodes. For each episode is given the sector in which the surface and 850 mbar trajectory originates, the stagnancy classification, and the maritime or continental character of the advected air.

O_3-conc.											
< 80 $\mu gr/m^3$	episode nr	24									
	1000 mb sect	NNW									
	850 mb sect	NNW									
	stagnancy	–									
	air mass	m									
80–130 $\mu gr/m^3$	episode nr	5	9	18							
	1000 mb sect	NNE	WSW	WSW							
	850 mb sect	NNE	WSW	WSW							
	stagnancy	–	–	–							
	air mass	c	m	m							
130–180 $\mu gr/m^3$	episode nr	2	11	12	16	20	21				
	1000 mb sect	WSW	NNE	ESE	NNW	NNW	NNW				
	850 mb sect	WSW	NNE	WSW	NNW	NNE	ESE				
	stagnancy	–	–	–	–	–	mod				
	air mass	m	c	m	c	m	m				
180–230 $\mu gr/m^3$	episode nr	1	3	6	10	13	14	17	22	23	25
	1000 mb sect	ENE	NNE	ENE	SSE	WSW	ENE	NNE	WNW	ESE	ENE
	850 mb sect	ENE	WSW	NNE	SSW	WSW	ESE	ENE	WSW	WSW	ENE
	stagnancy	–	–	+	–	–	mod	–	mod	+	+
	air mass	c	m	m	c	m	c	c	m	c	c
> 230 $\mu gr/m^3$	episode nr	7	8	15	19						
	1000 mb sect	ENE	ESE	ESE	WSW						
	850 mb sect	ESE	ESE	ESE	SSW						
	stagnancy	–	mod	–	mod						
	air mass	c	c	c	c						

6. Conclusions

- Spells of dry, warm and sunny weahter, conducive to photochemical smog formation have been more frequent in the years 1976, 1978-1983 than normal.
- Predominant European Weather types according to a classification by Hess and Brezowski during these episodes were HM (25%), BM (20%) and the similar groups HF_a, HNF_a, HN_a (28%).
- 72-hour back-trajectories for the locations Soissons, Nancy and Freiburg originate preferentially from North-Easterly directions. The trajectories for de Bilt and Soltau are more evenly distributed over all wind directions.
- The Soltau and de Bilt trajectories tend to pass over less densely populated, rural or maritime areas.
- The flow fields in and around Soissons, Nancy and Freiburg are generally more stagnant than those of Soltau and de Bilt.
- The determination of trajectories of air masses (extending up to an altitude of ca. 1500 m) has only physical significance when trajectories determined at 1500 m altitude coincide reasonably with surface trajectories (otherwise the air mass becomes to much distorted by the flow field in order to consider the airparcel as one consistent entity). In roughly one third of the cases the coherency of trajectories was so small that the determination of air pollution source areas is doubtful.
- The diurnal variation of temperature, humidity and mixed layer height during the first 10 episodes was pronounced. The daily maximum temperature varied between 17°C and 33°C with an average value of 26°C. The daily minimum temperature had a range from 8°C to 21°C with an average value of 14°C. The average daily maximum mixed layer height was 1700 m. The nocturnal inversion height did not exceed 100 m. It is expected that these data are also representative for the other 15 episodes.
- During most episodes cloud cover could be neglected, though during night and early morning fog or fog patches were frequently observed.
- A preliminary analysis of ozone data in the Netherlands during these 25 episodes suggests a relationship between the ozone peak values and the origin of the air mass: the higher the ozone peak values the more trajectories have a continental, stagnant character.

Acknowledgements

The authors express their thanks to Cecil Engeldal who organised the computer analysis of the trajectories of 15 episodes. They also thank Kees van Stralen for preparing the figures and Marlie Collet-van Laere and Birgit Kok who typed this report. Ozone data were made available by the Institute for Public Health and Environmental Hygiene (RIVM) and by the Institute for Applied Research (TNO). The study was sponsored by SHELL International Petroleum Company.

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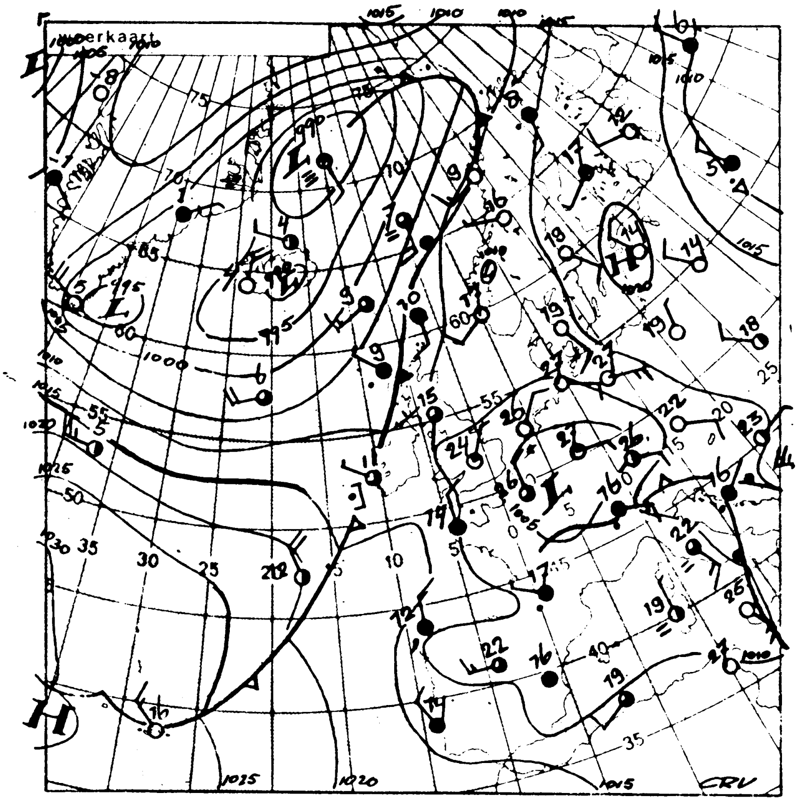
Appendix I

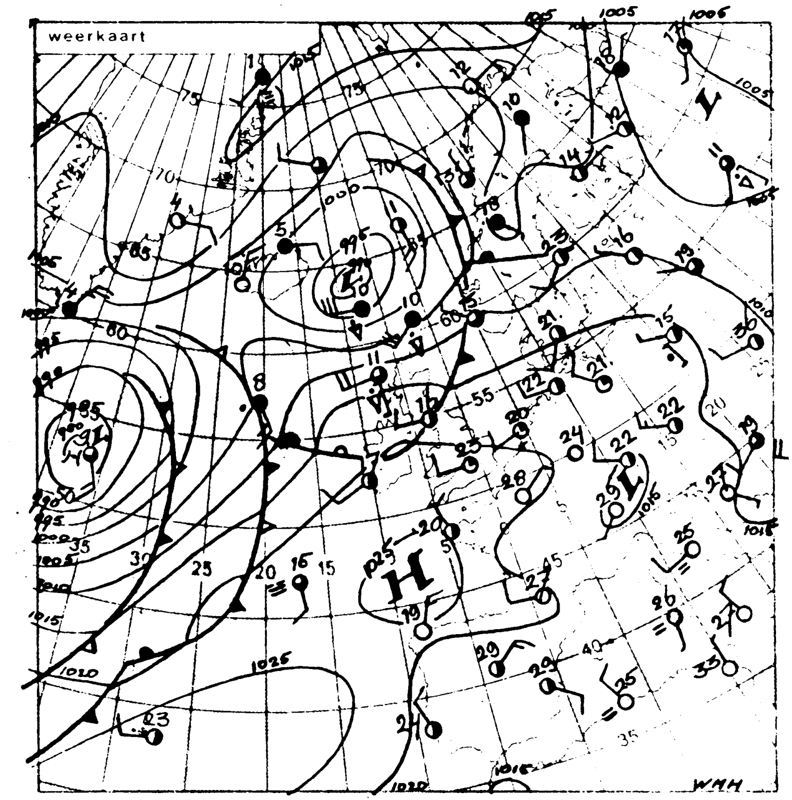
12.00 GMT Weathermaps from the final days of the 25 selected episodes.

zon dag 9 mei 1976 12 00 GMT



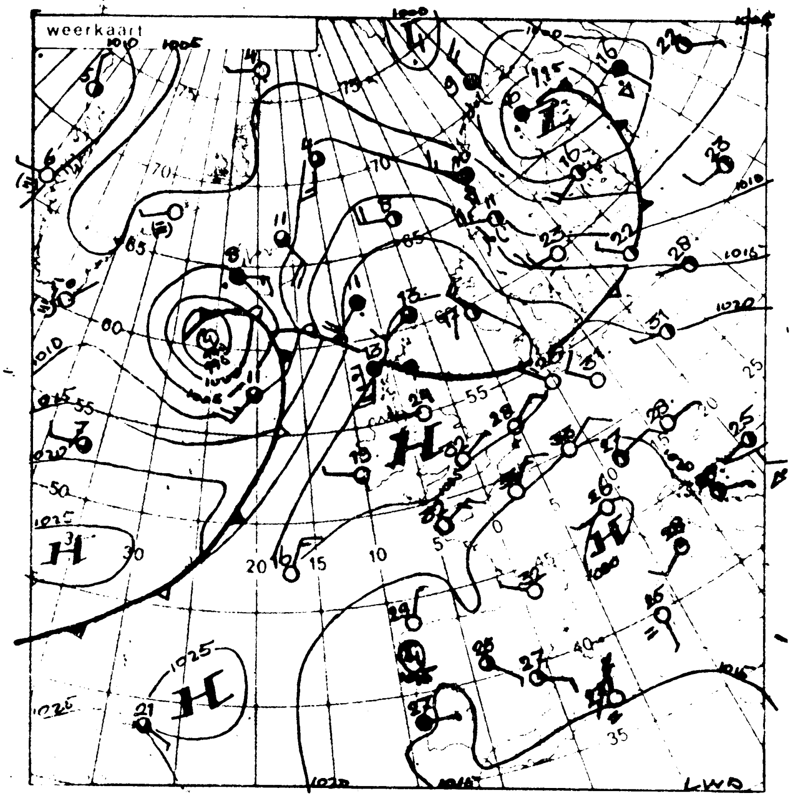
End of episode nr:1

maan dag 14 juni 1976 12 00 GMT



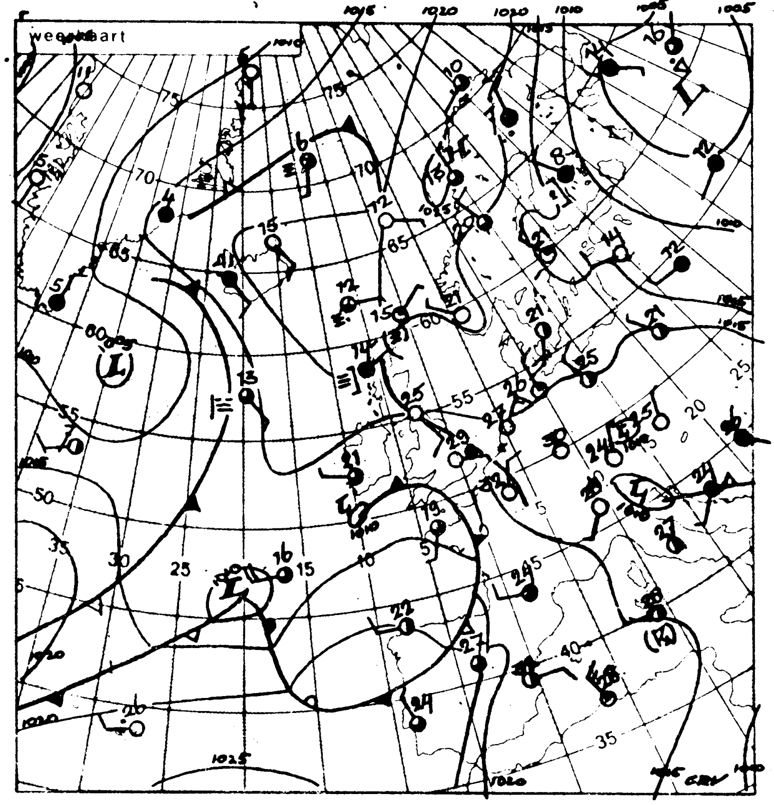
End of episode nr: 2

maandag 28 juni 1976 12 00 GMT



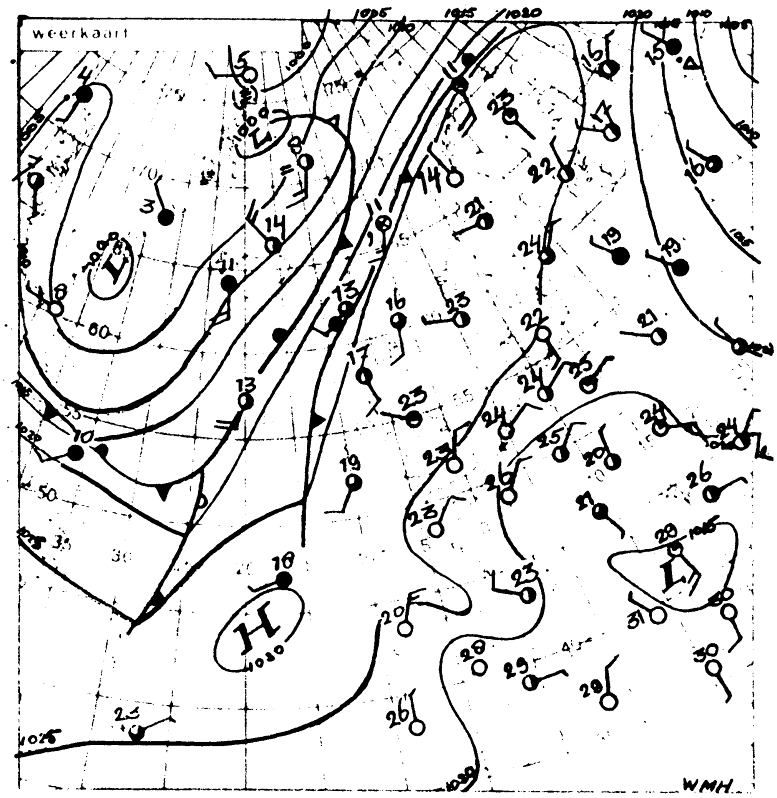
End of episode nr: 3

woensdag 7 juli 1976 12 00 GMT



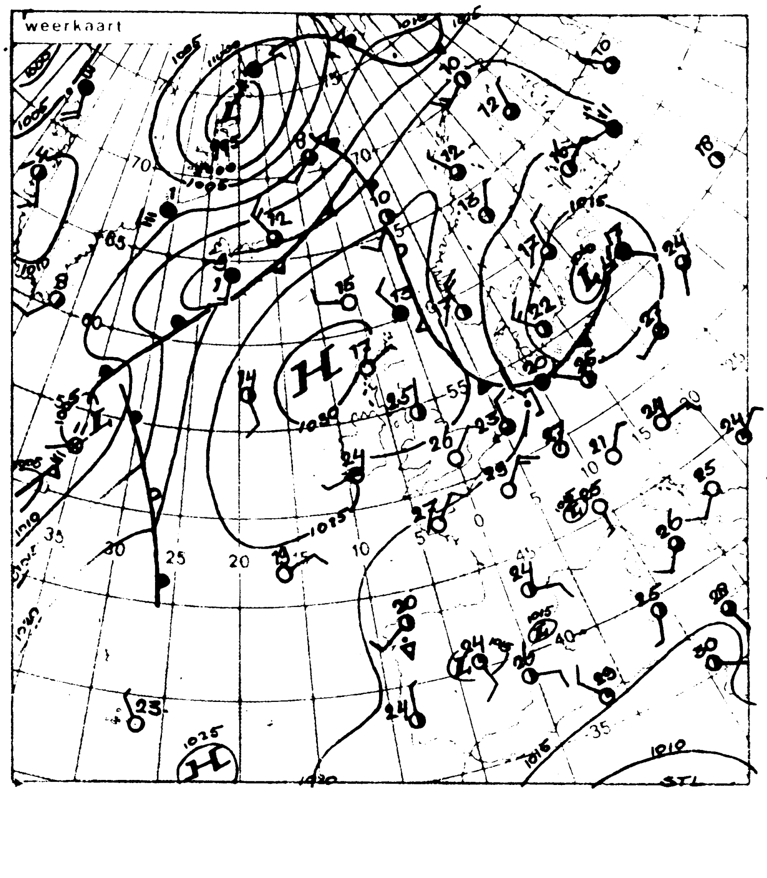
End of episode nr: 4

dinsdag 10 augustus 1976 12 00 GMT

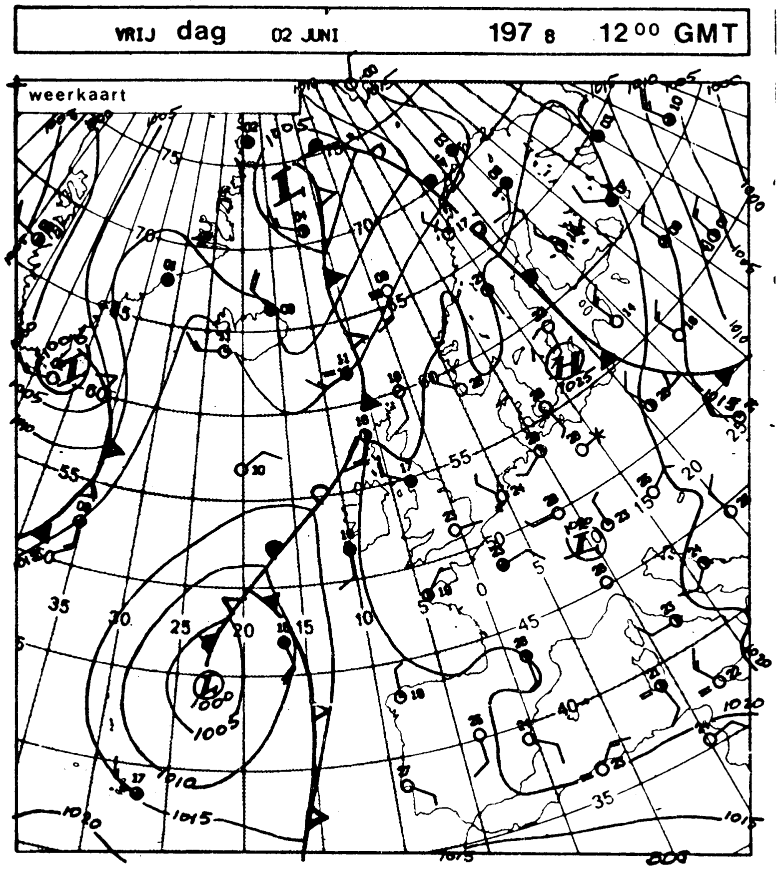


End of episode nr: 5

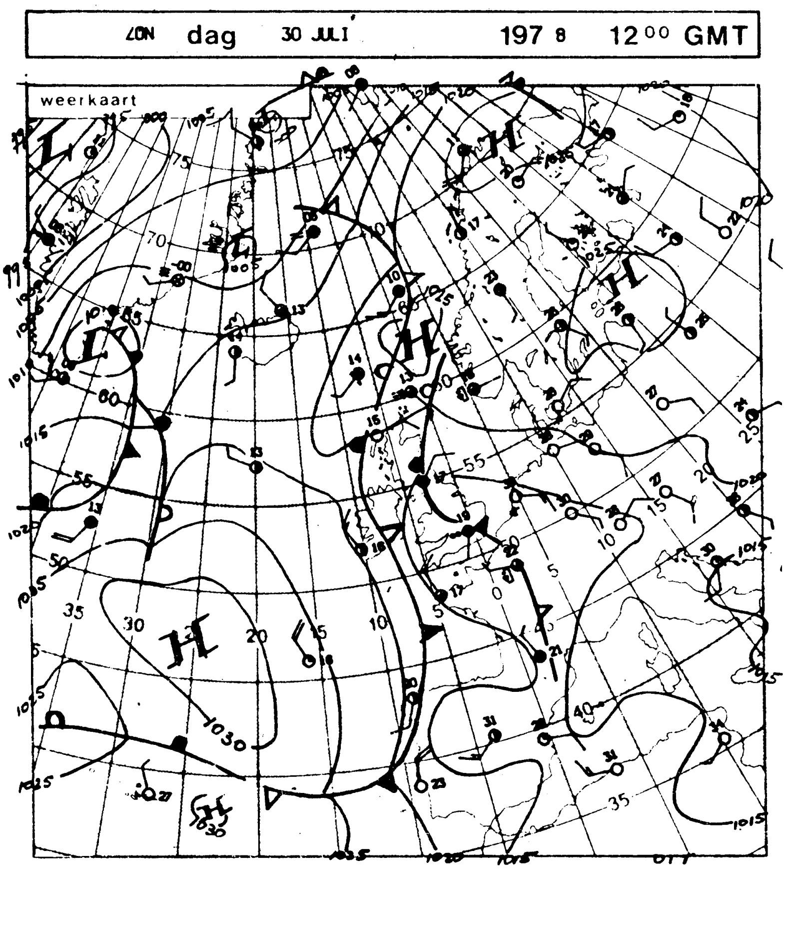
dondedag 26 augustus 1976 12 00 GMT



End of episode nr: 6

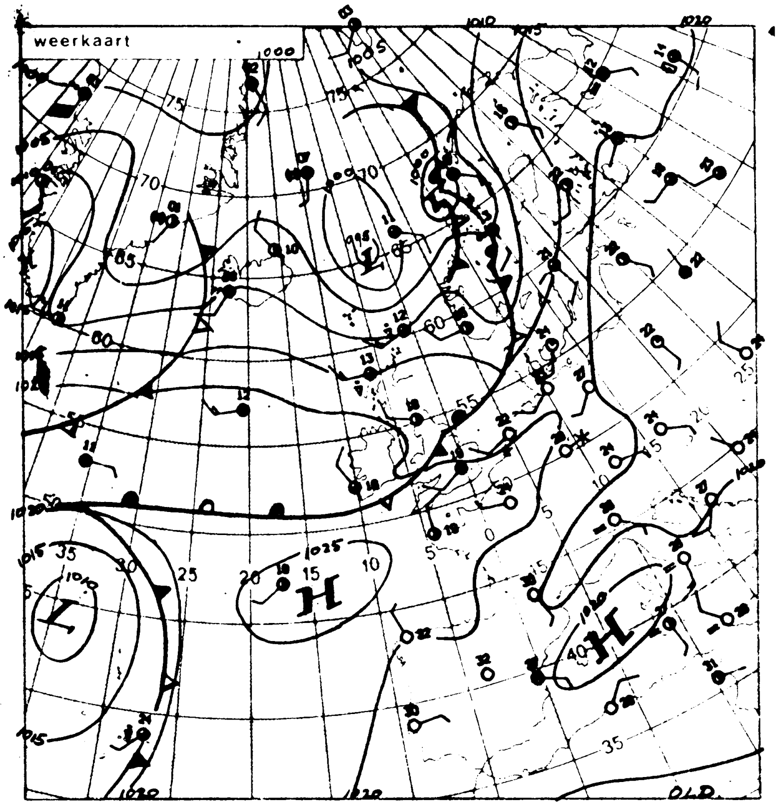


End of episode nr: 7



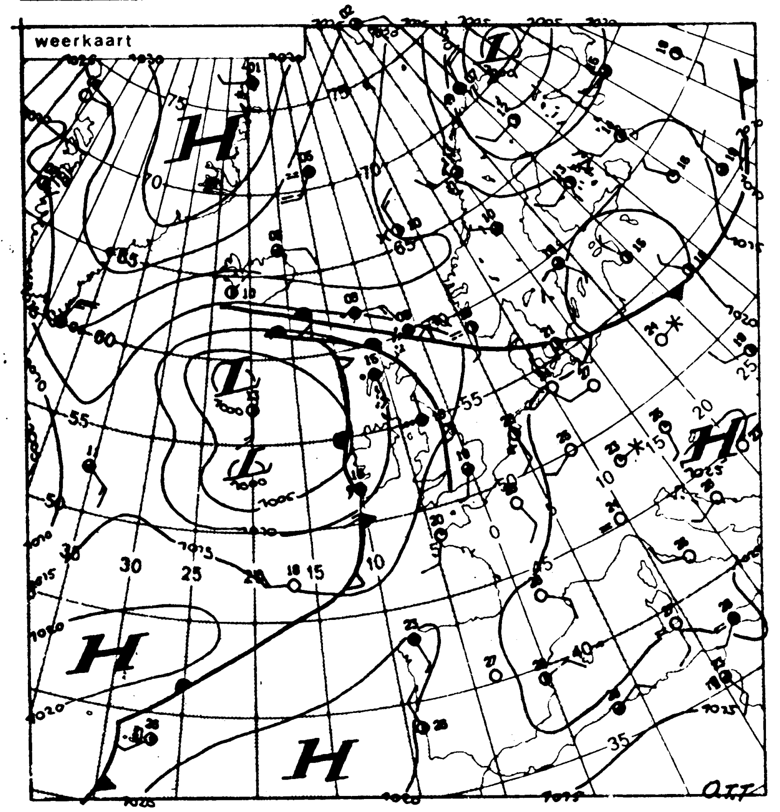
End of episode nr: 8

DINS dag 22 AUGUSTUS 197 8 12 00 GMT

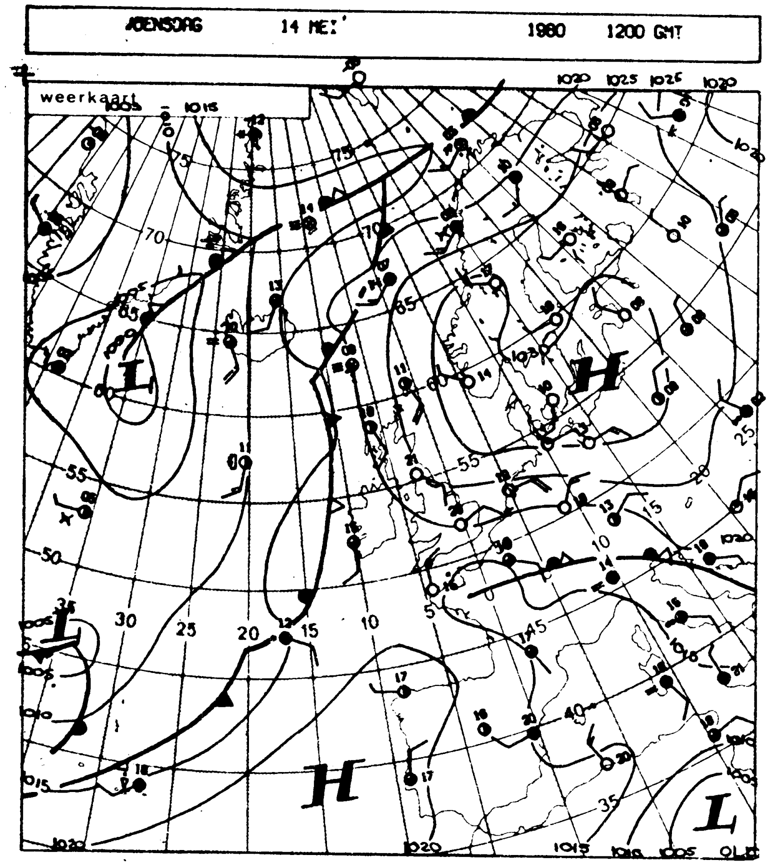


End of episode nr: 9

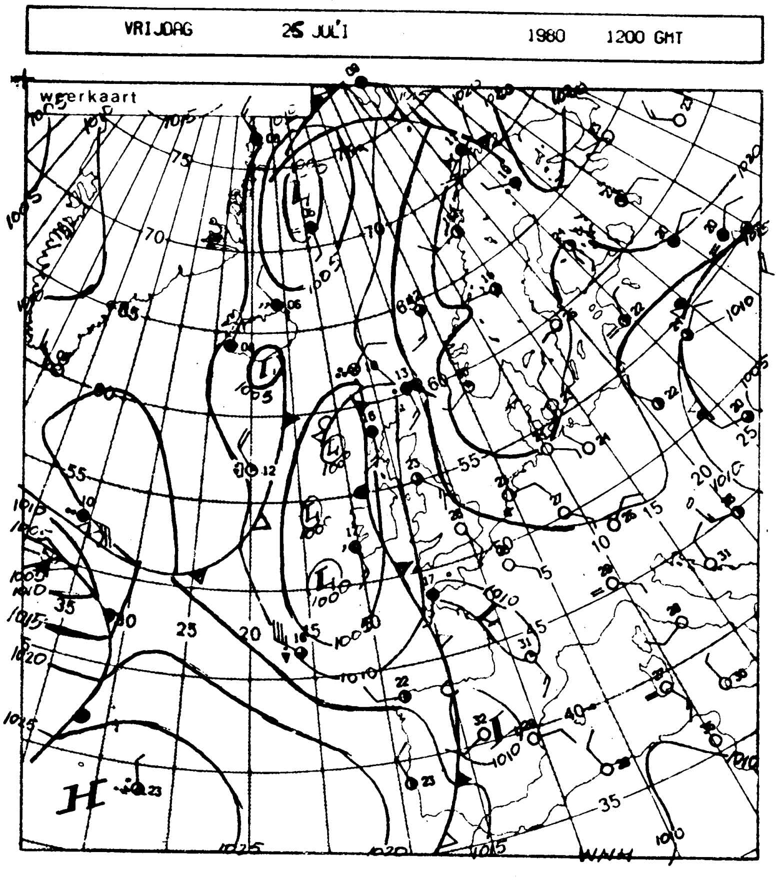
ZATER dag 01 SEPTEMBER 197 9 12 00 GMT



End of episode nr: 10



End of episode nr: 11



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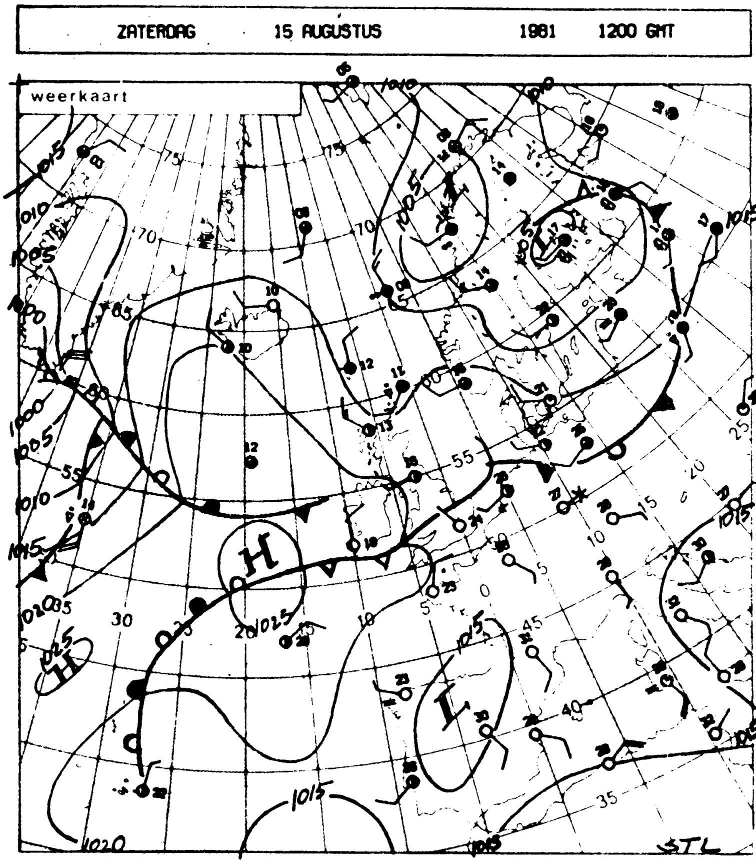
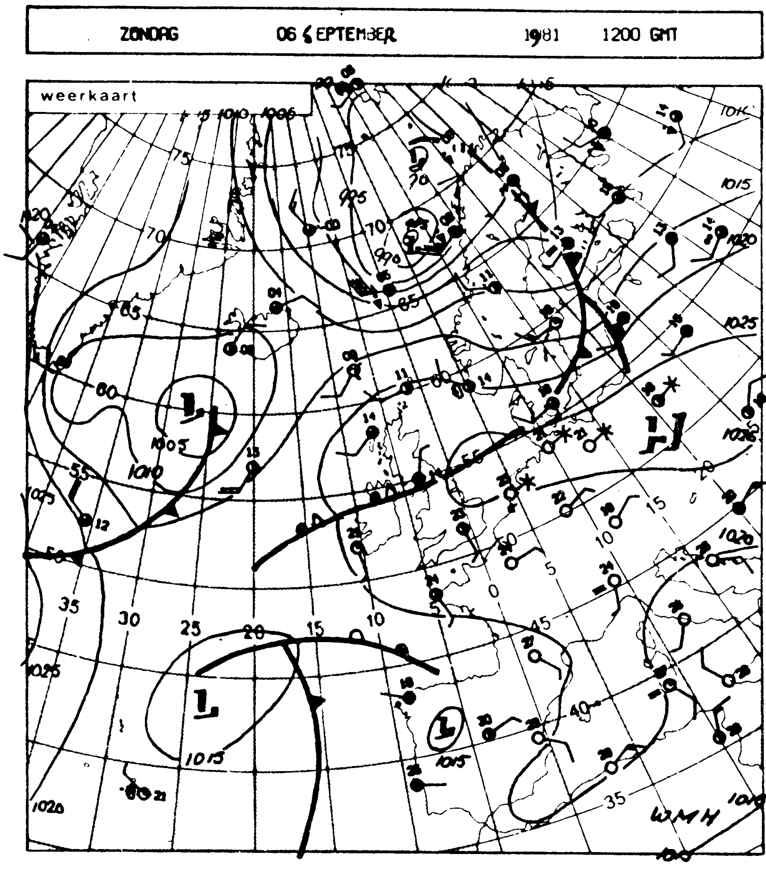
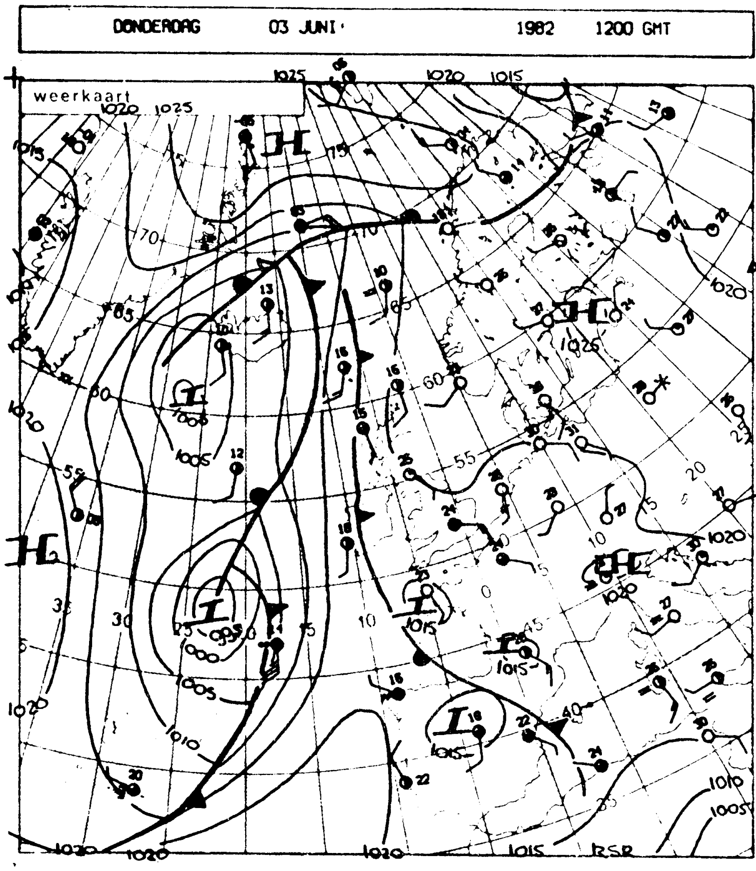


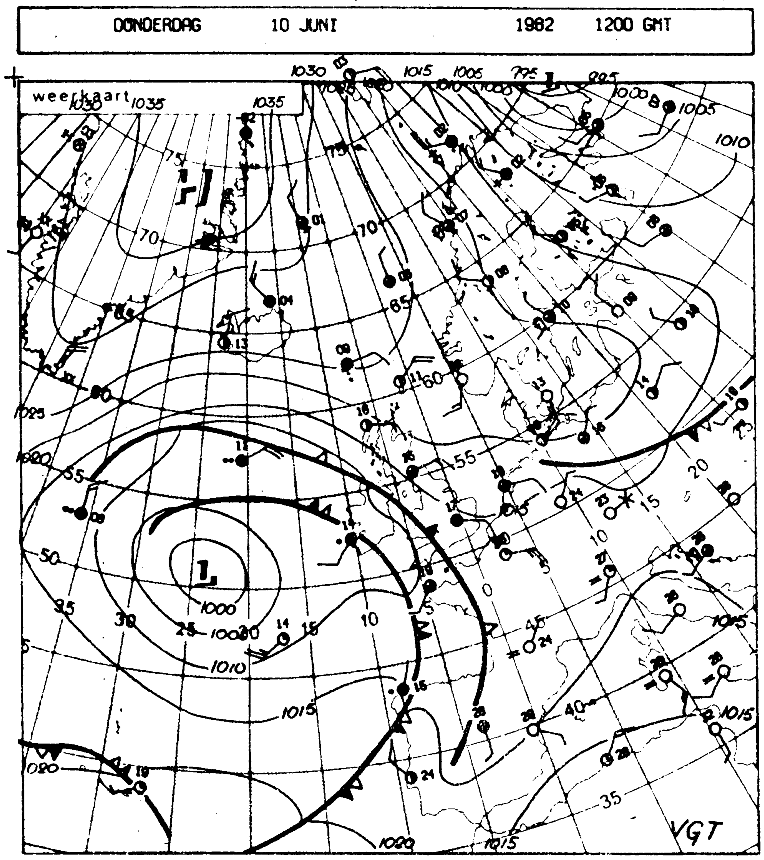
End of episode nr: 13



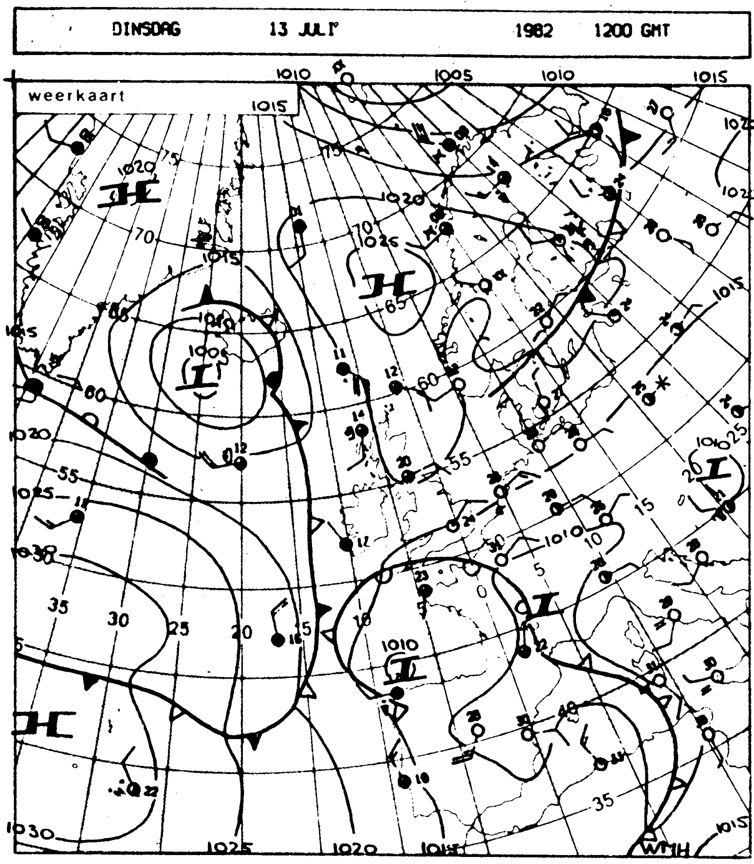
End of episode nr: 14



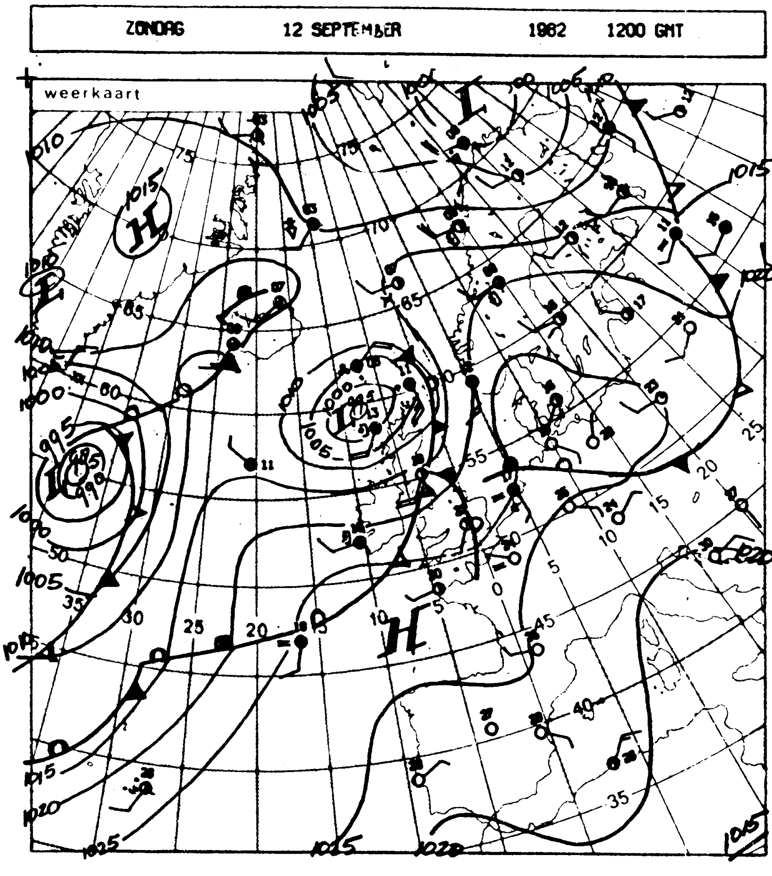
End of episode nr 15



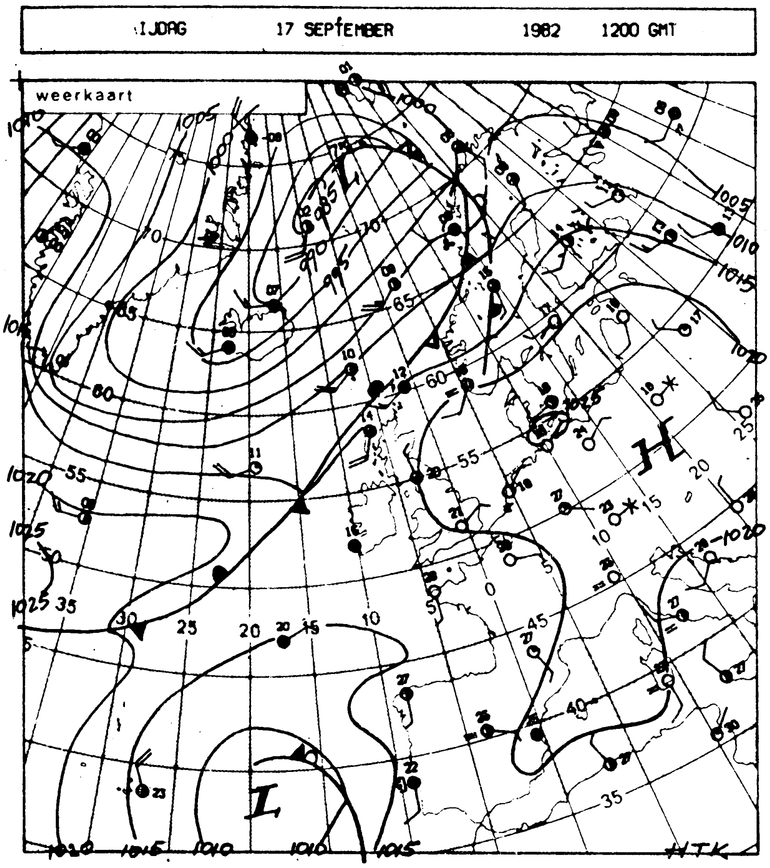
End of episode nr: 16



End of episode nr:17

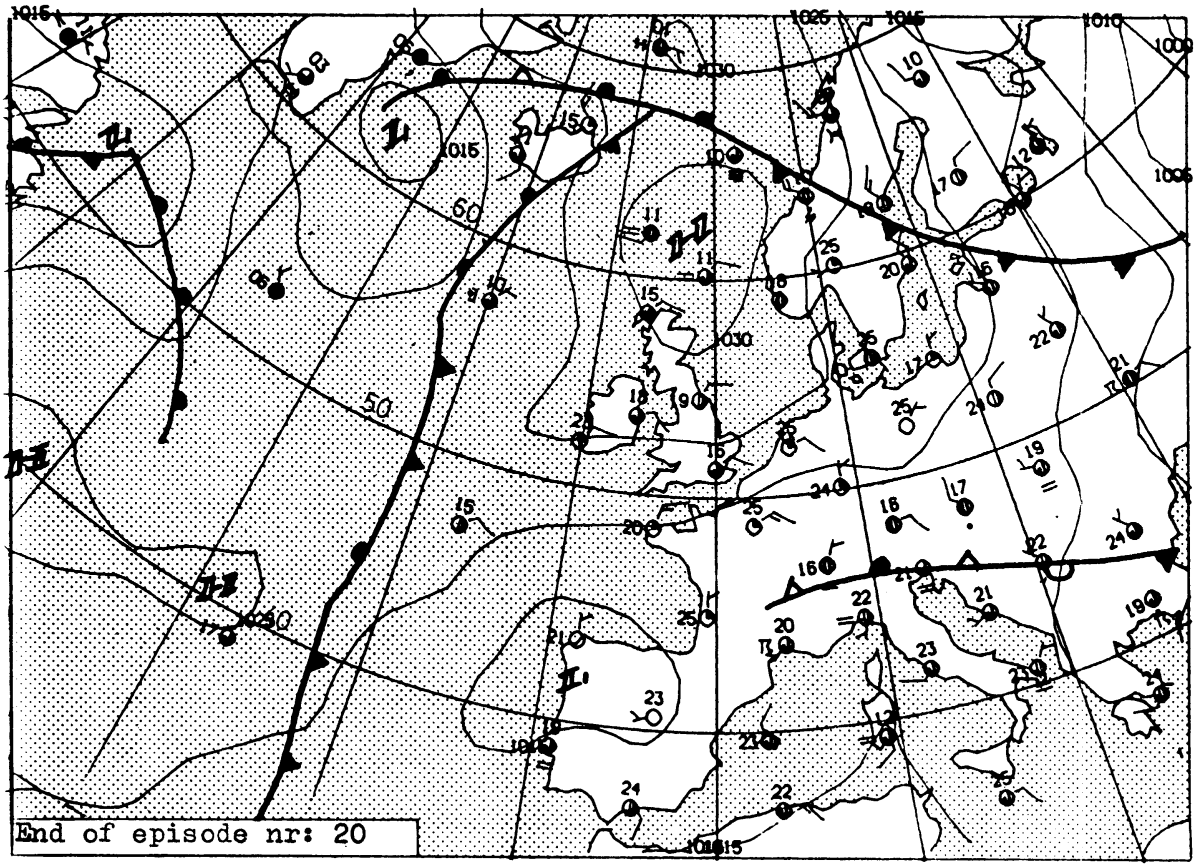


End of episode nr: 18

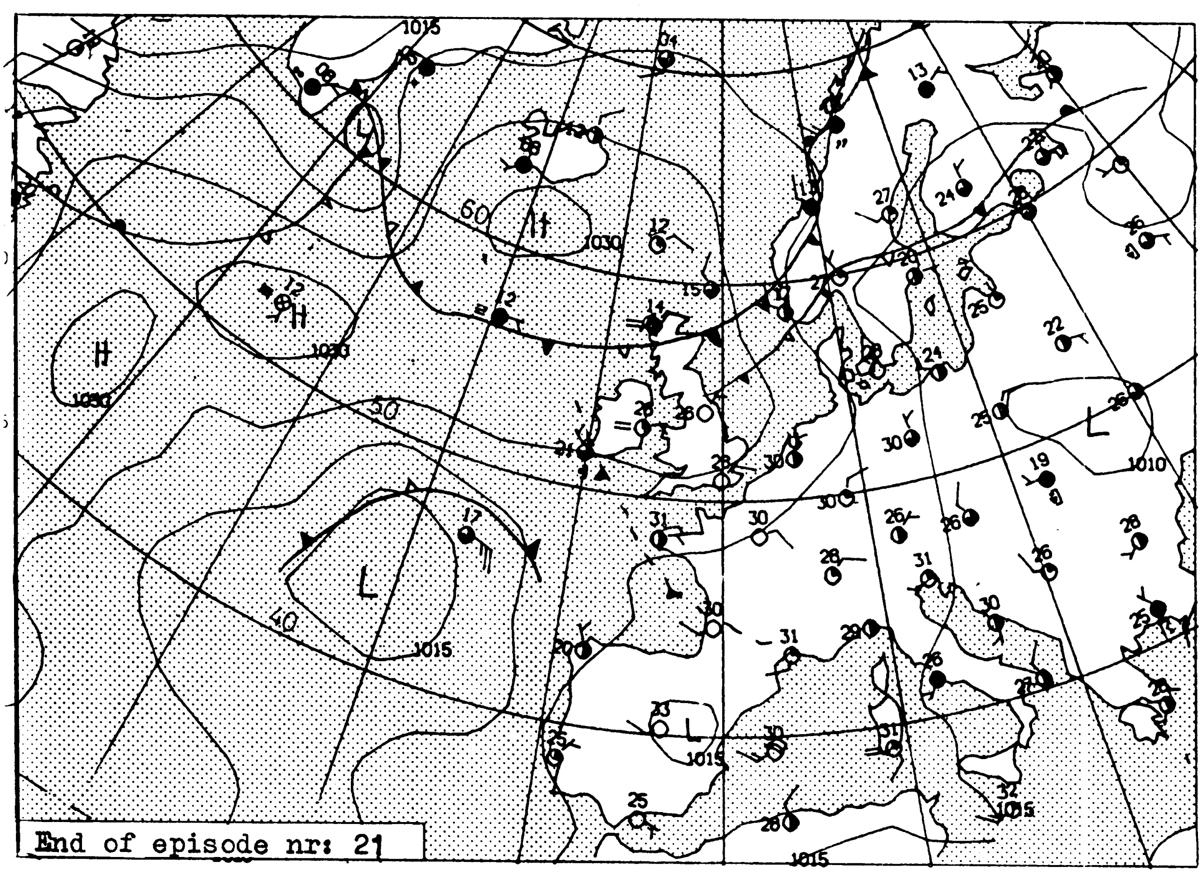


End of episode nr: 19

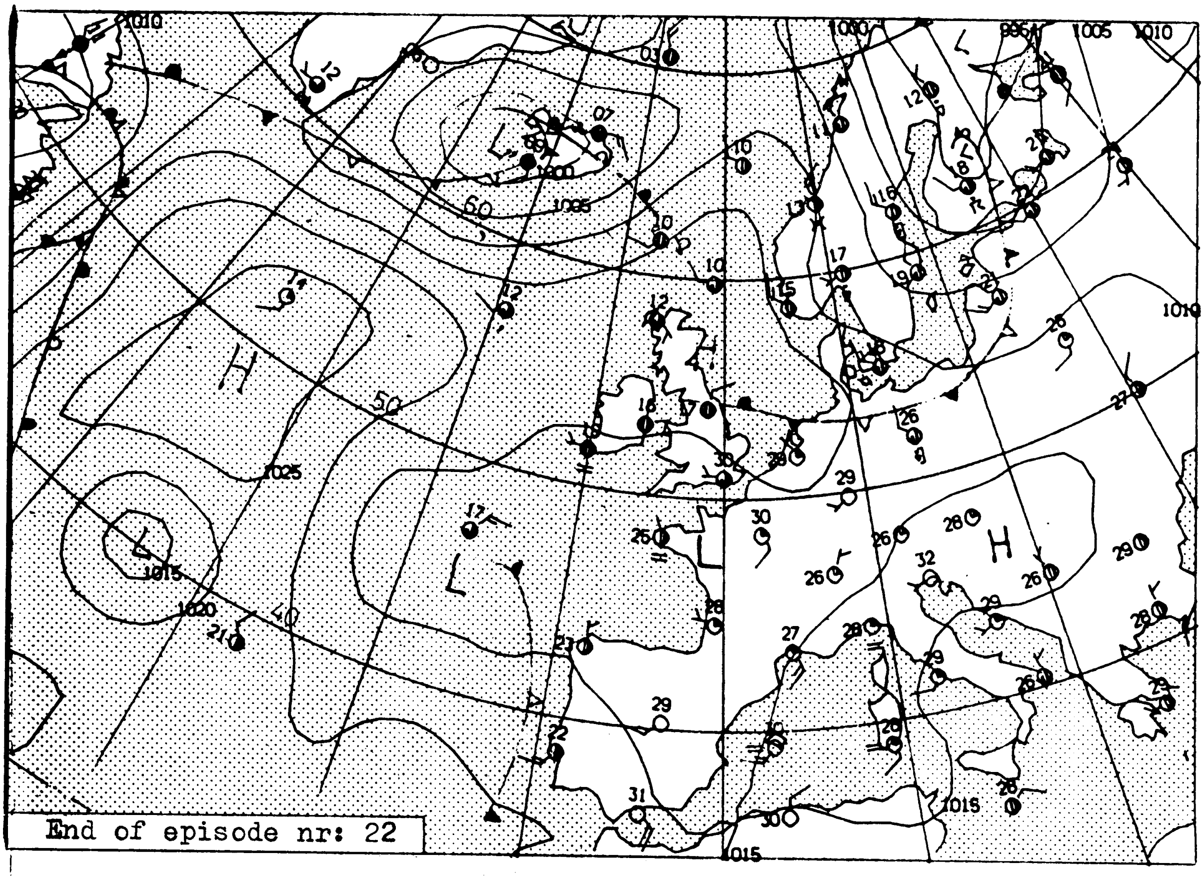
MAANDAG 20 JUNI 1983 1200 GMT



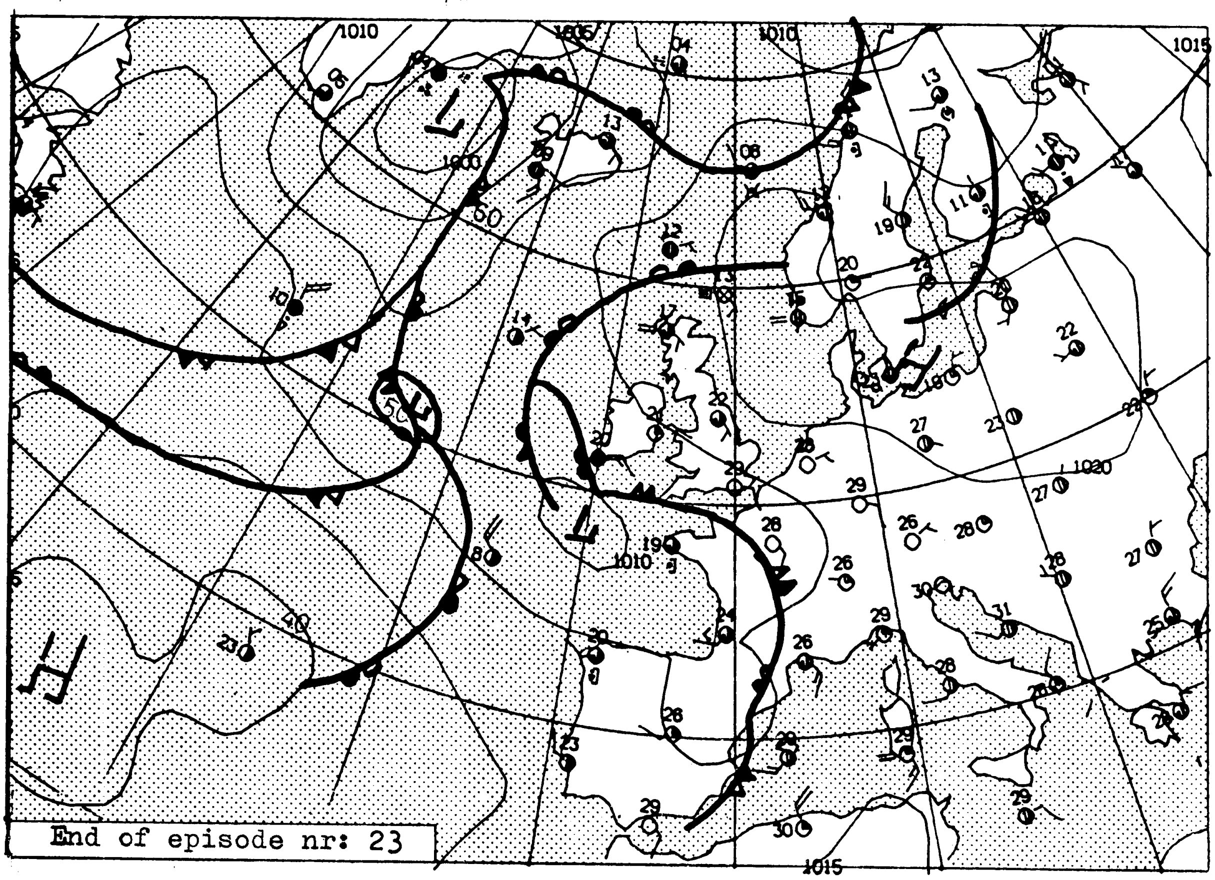
DINSDAG 12 JULI 1983 1200 GMT



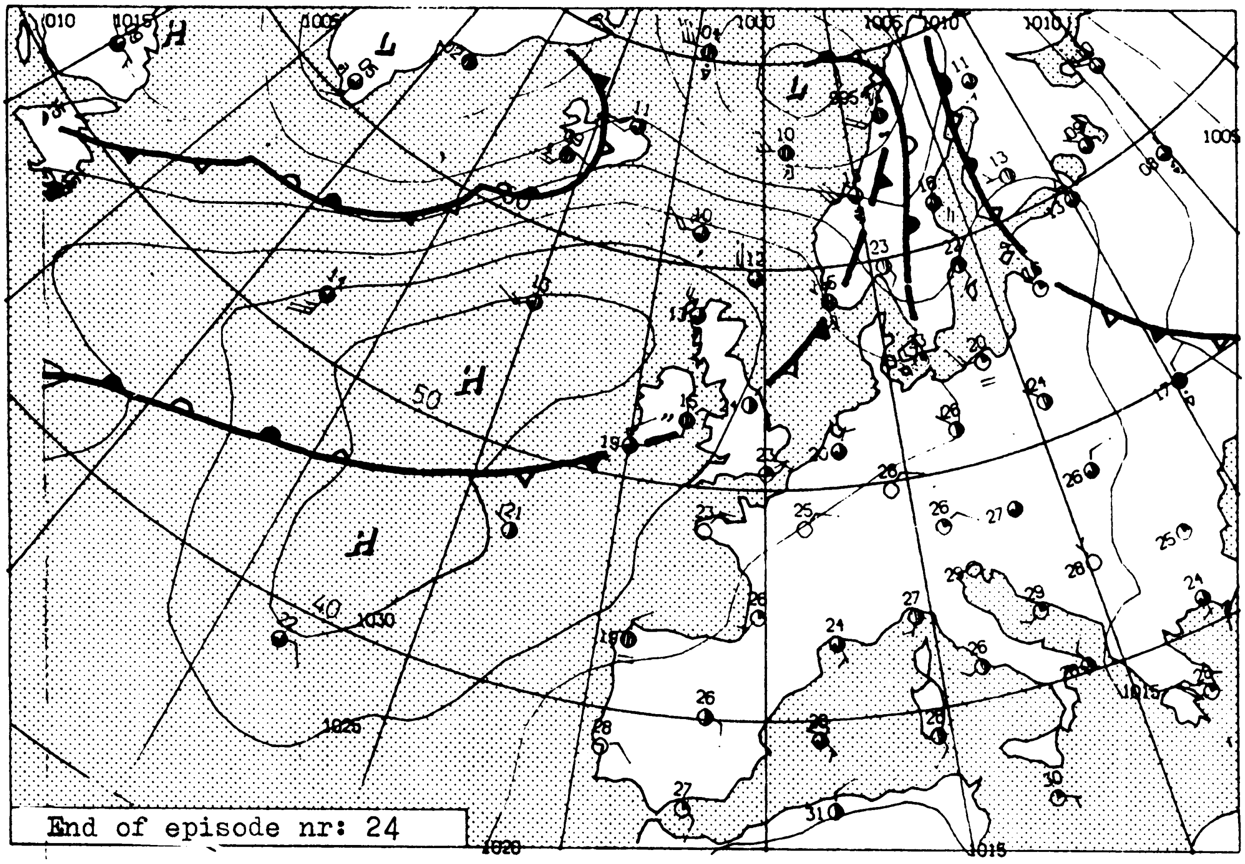
ZATERDAG 16 JULI 1983 1200 GMT



VRIJDAG 19 AUGUSTUS 1983 1200 GMT

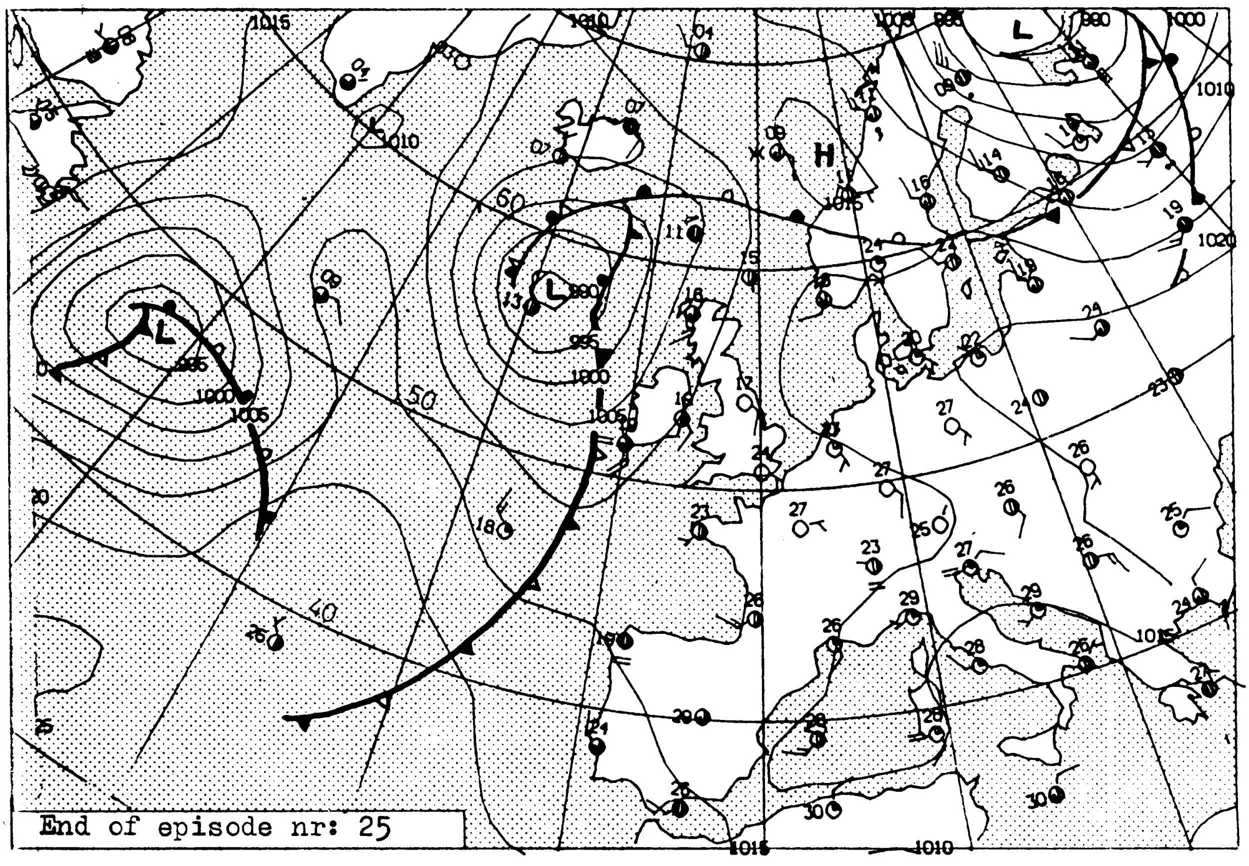


ZATERDAG 27 AUGUSTUS 1983 1200 GMT



End of episode nr: 24

WOENSDAG 31 AUGUSTUS 1983 1200 GMT

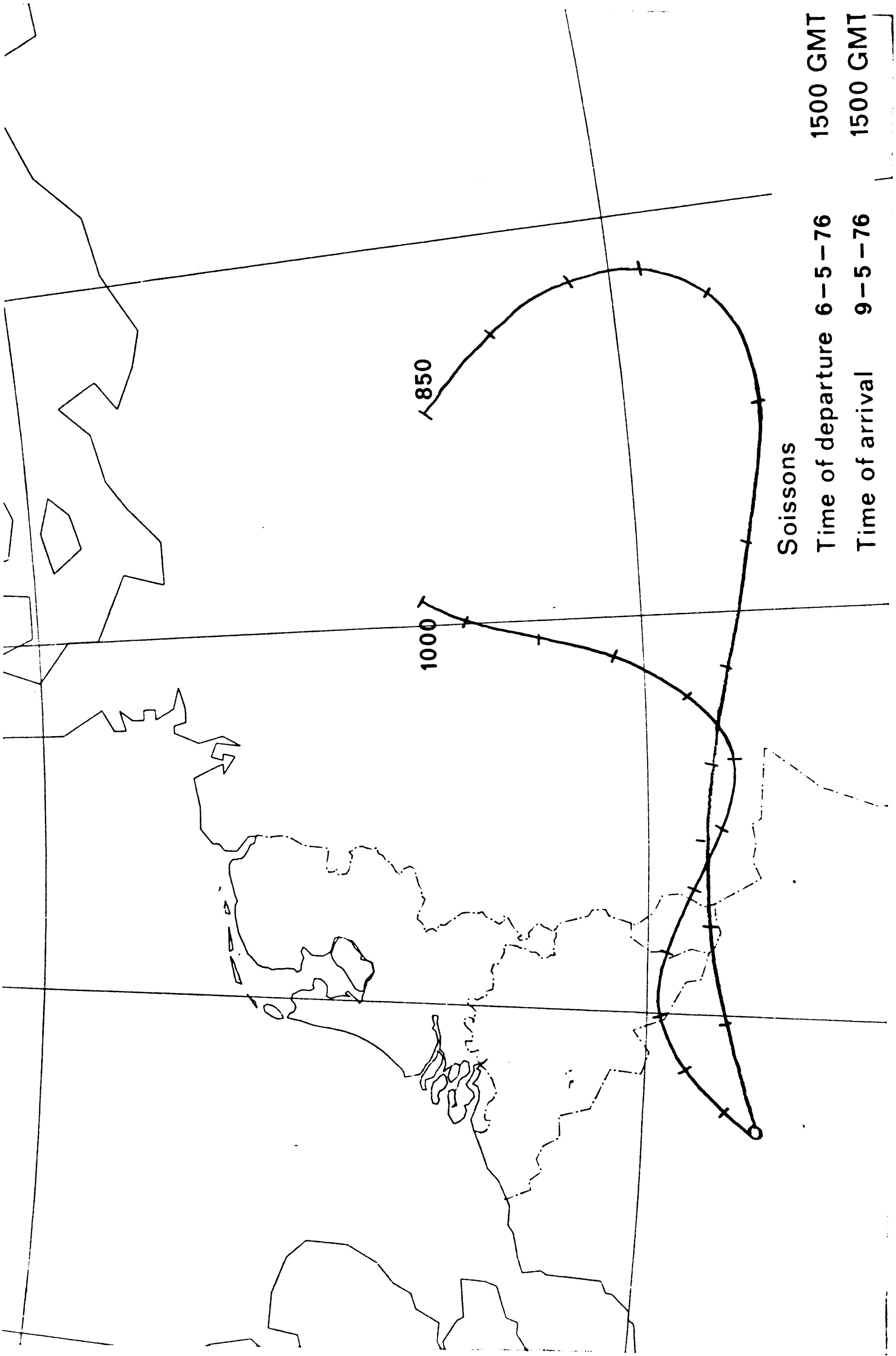


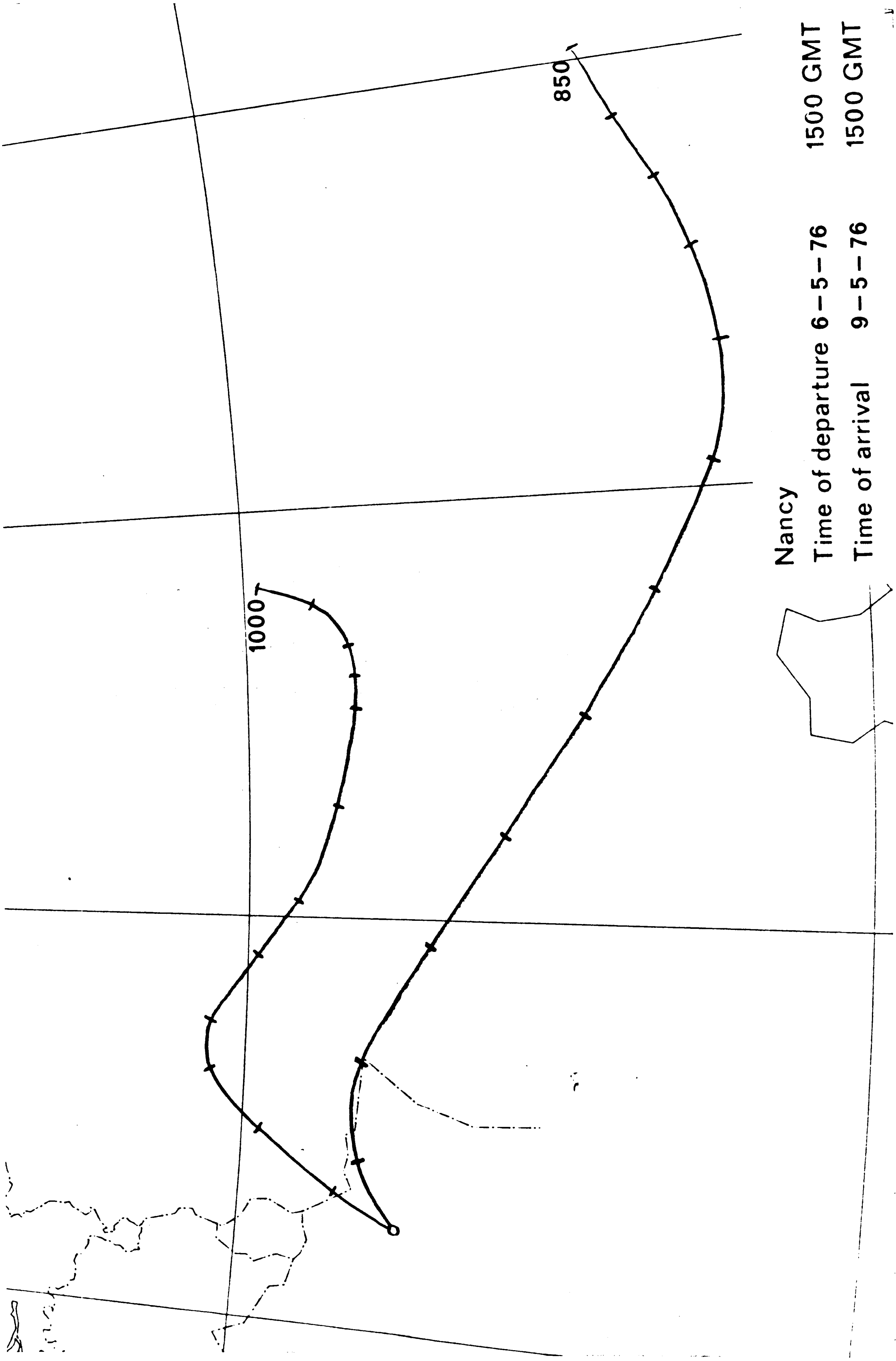
End of episode nr: 25

Appendix II

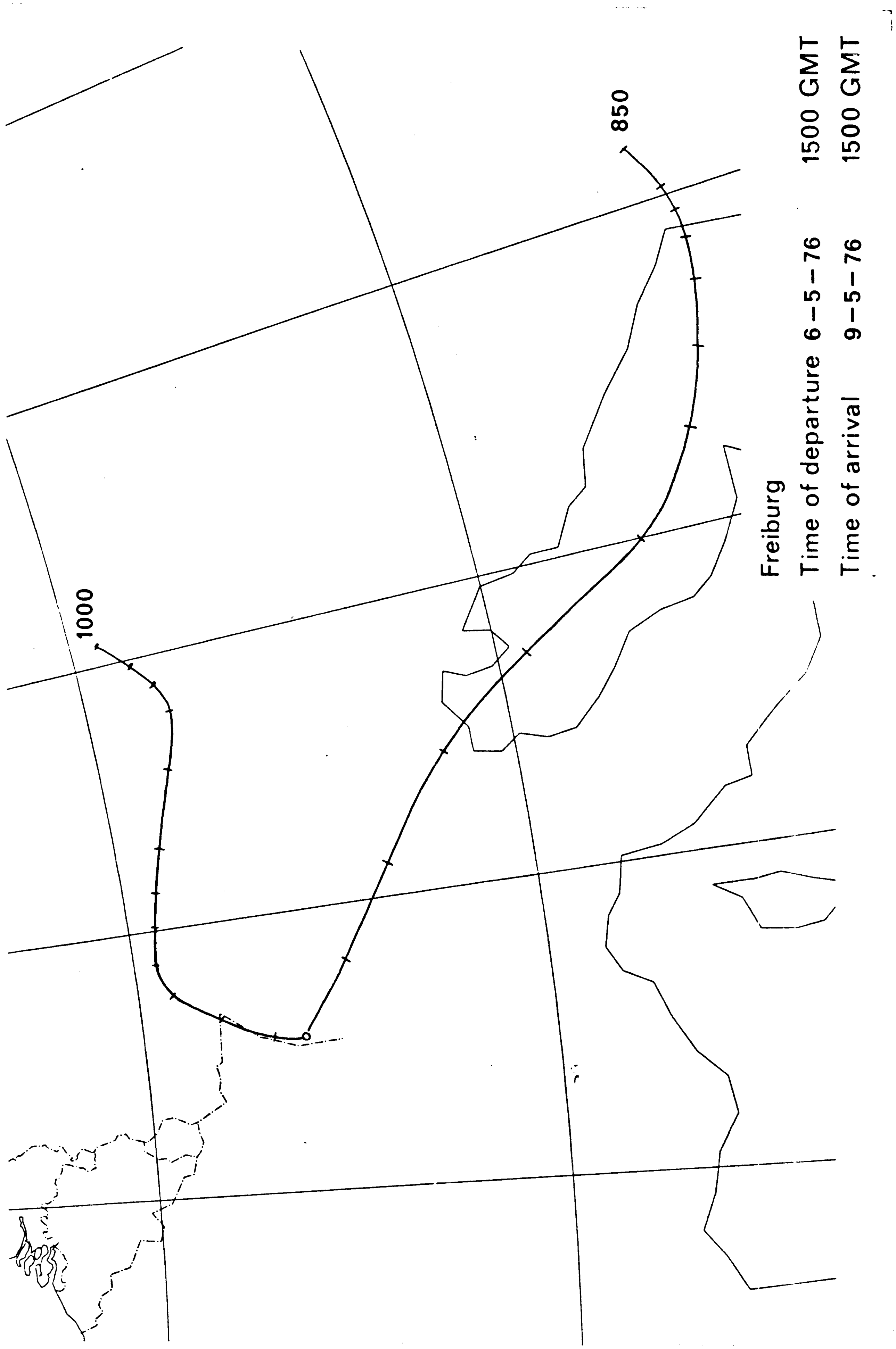
1000 mbar/surface and 850 mbar trajectories for all the 25 episodes and the 5 locations

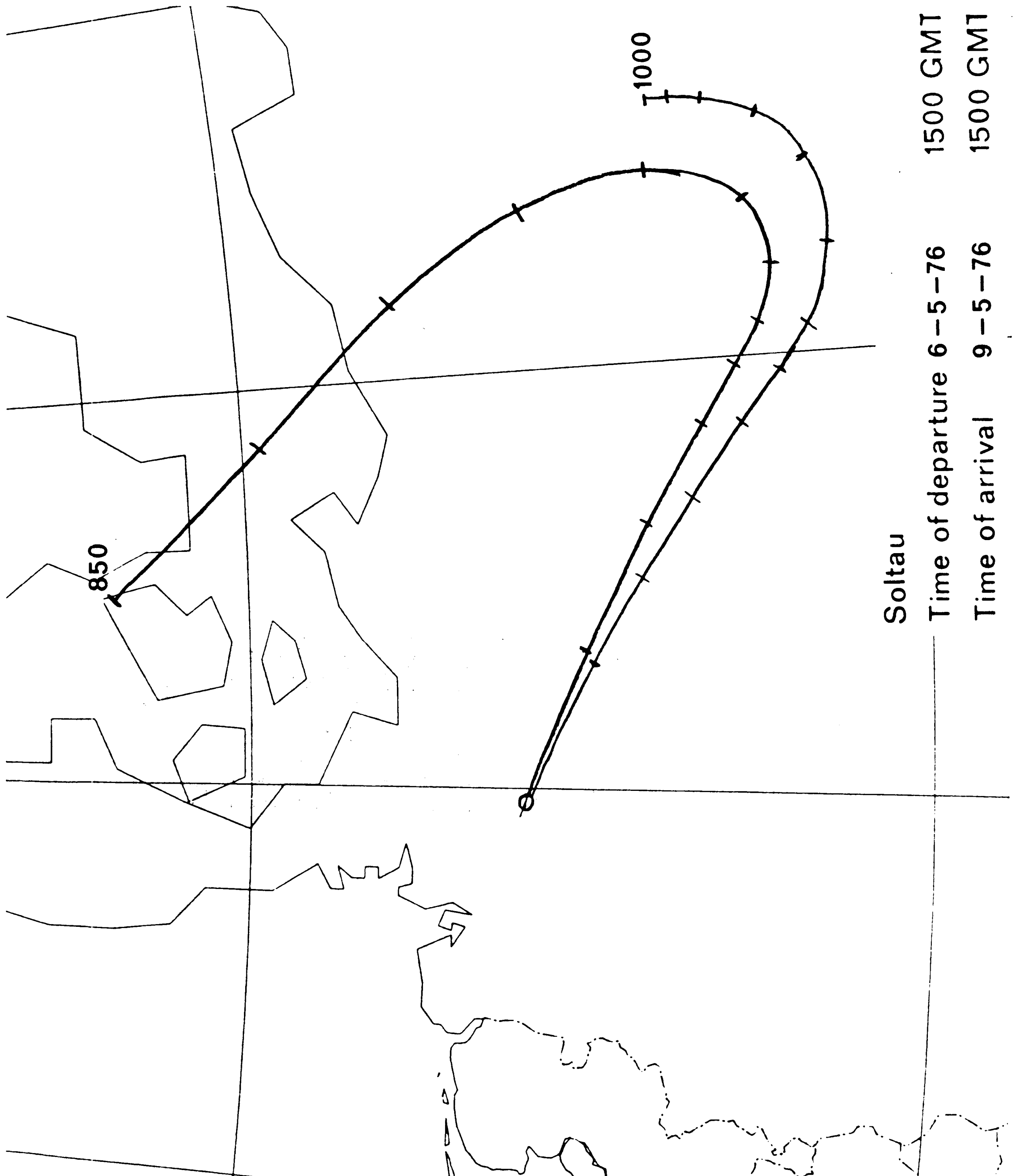
In the figures the selected trajectory value is given at the starting point: 1000 or (000), (925) and 850 or (850). Furthermore the pressure levels at which the trajectory was at the start and during the advection route, are also given. The ascending parts of the track are drawn intersected (----) and the descending parts are drawn fully (——).
The trajectory consists of steps with 6 hr time intervals, starting and ending at 1500 GMT (episode 1-10) or 1600 GMT (episode 11-25).

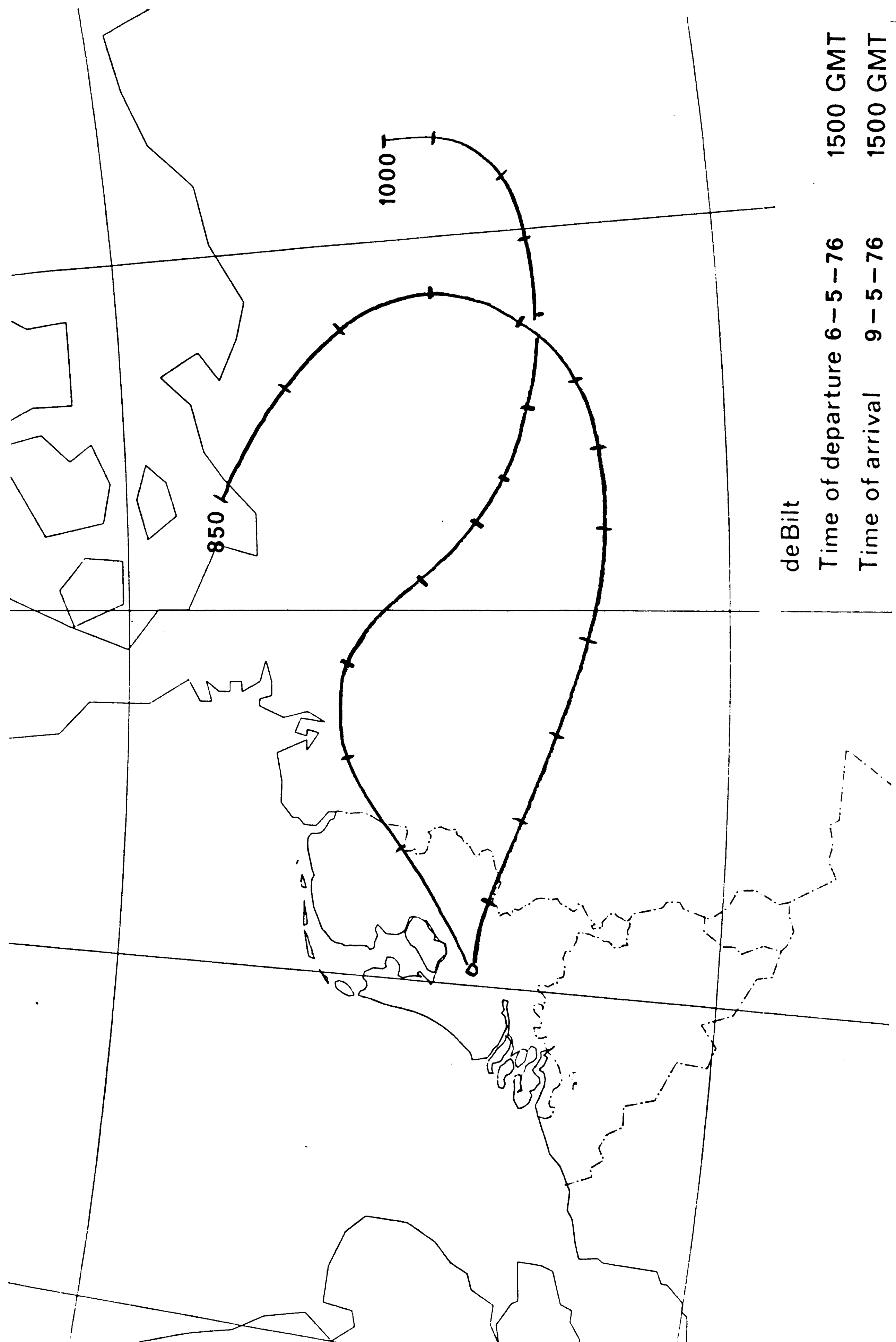

850
1000
Soissons
Time of departure 6–5–76 1500 GMT
Time of arrival 9–5–76 1500 GMT

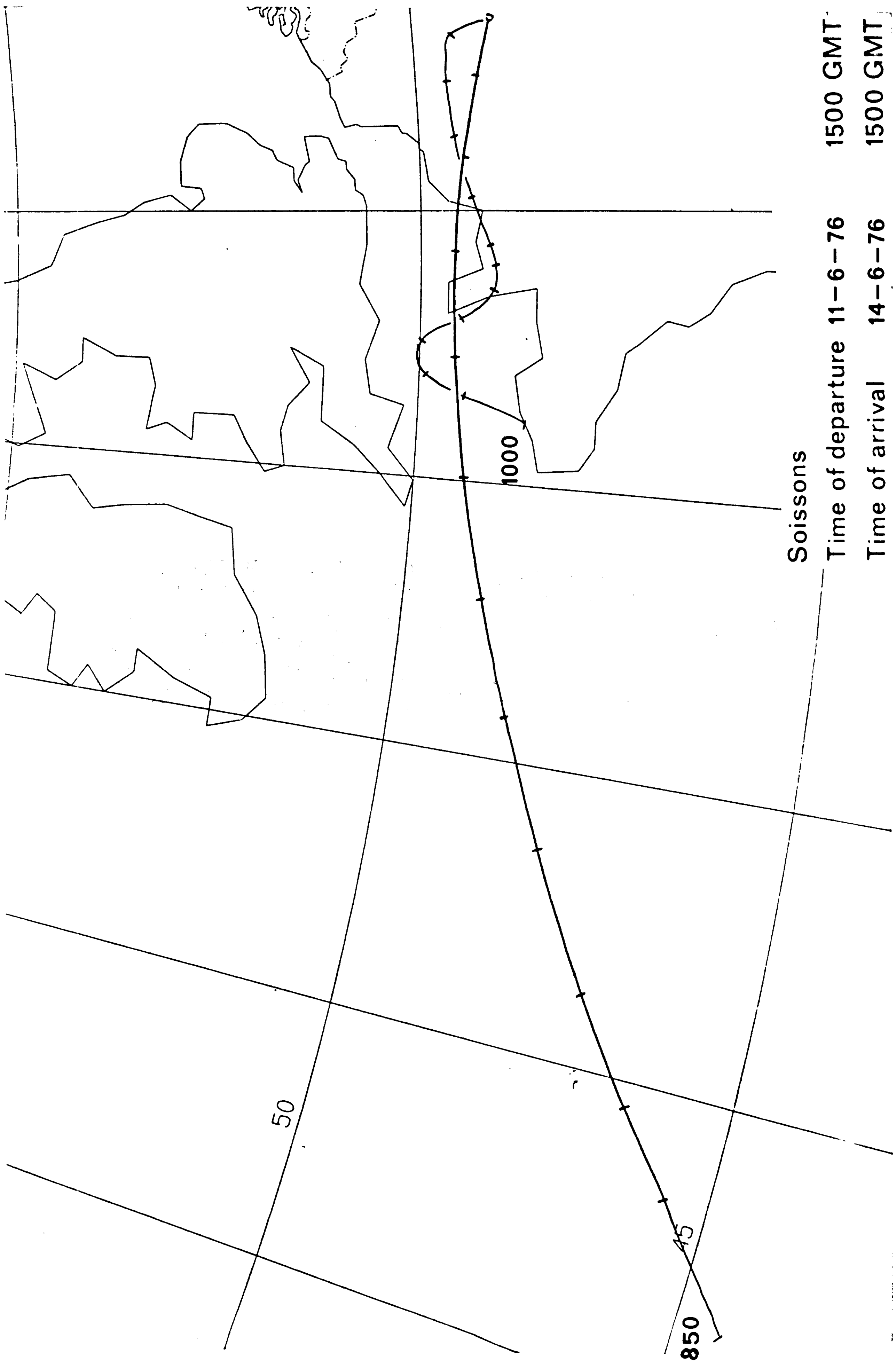


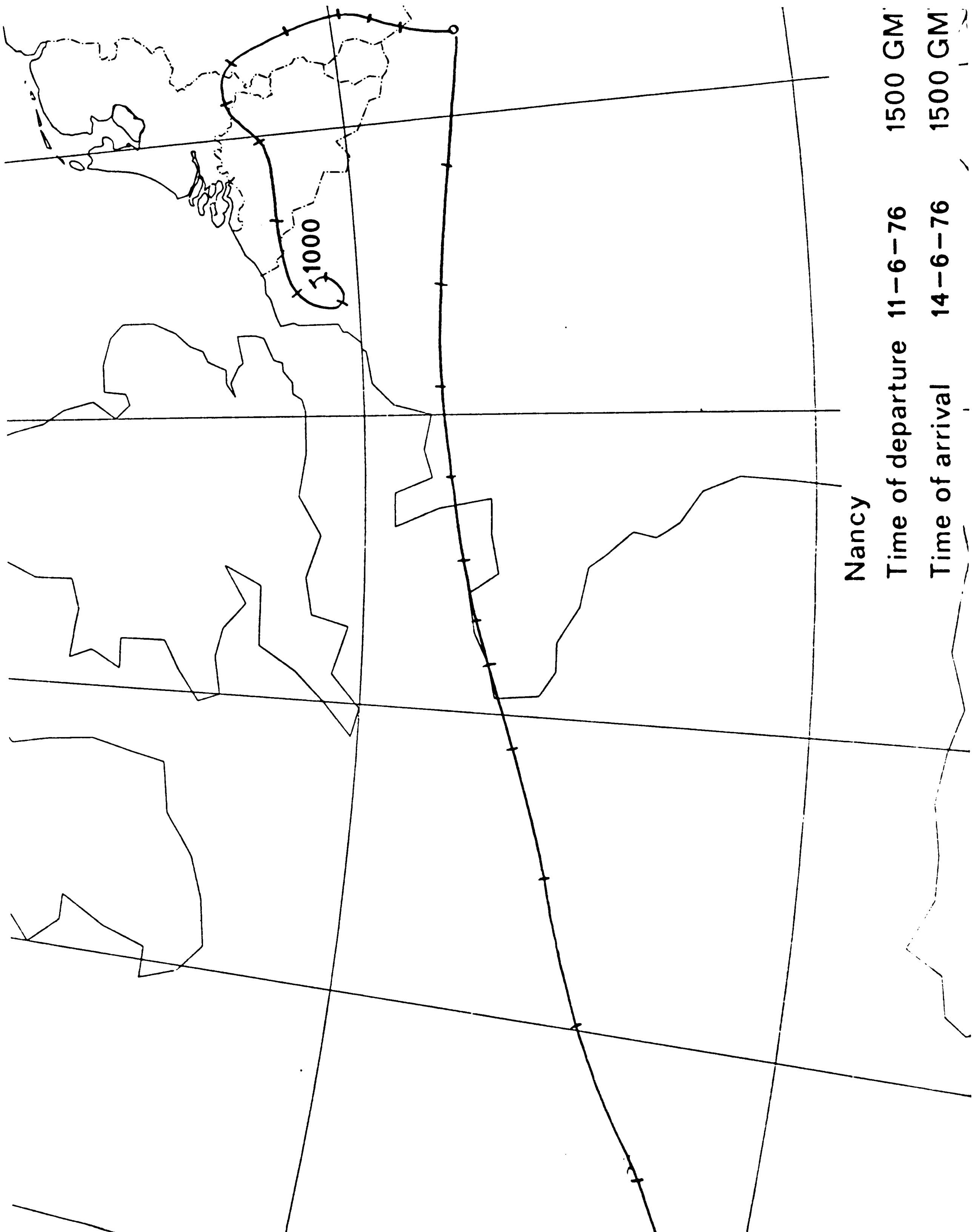
850
1000
Nancy
Time of departure 6–5–76 1500 GMT
Time of arrival 9–5–76 1500 GMT

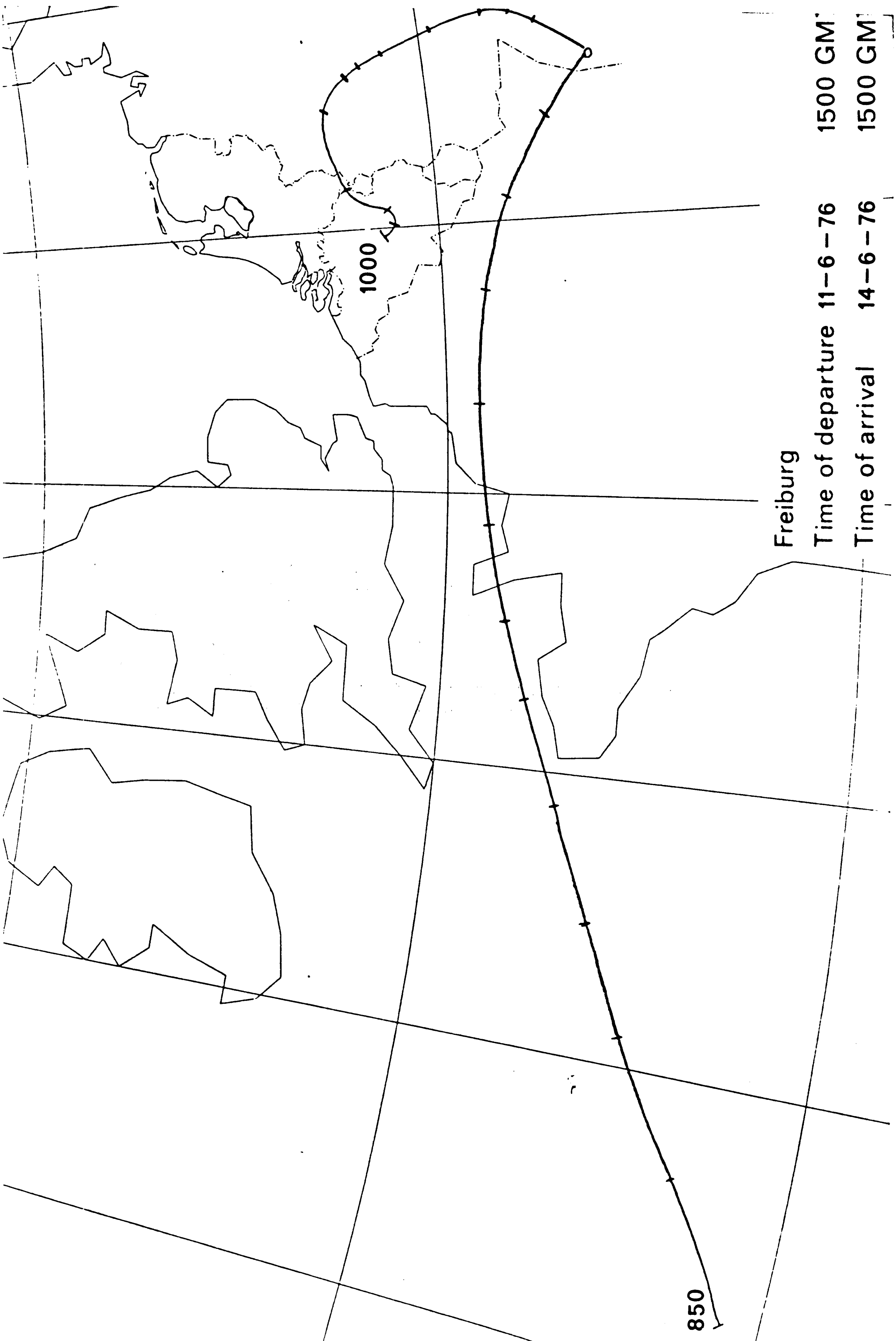

850
1000
Freiburg
Time of departure 6 – 5 – 76 1500 GMT
Time of arrival 9 – 5 – 76 1500 GMT

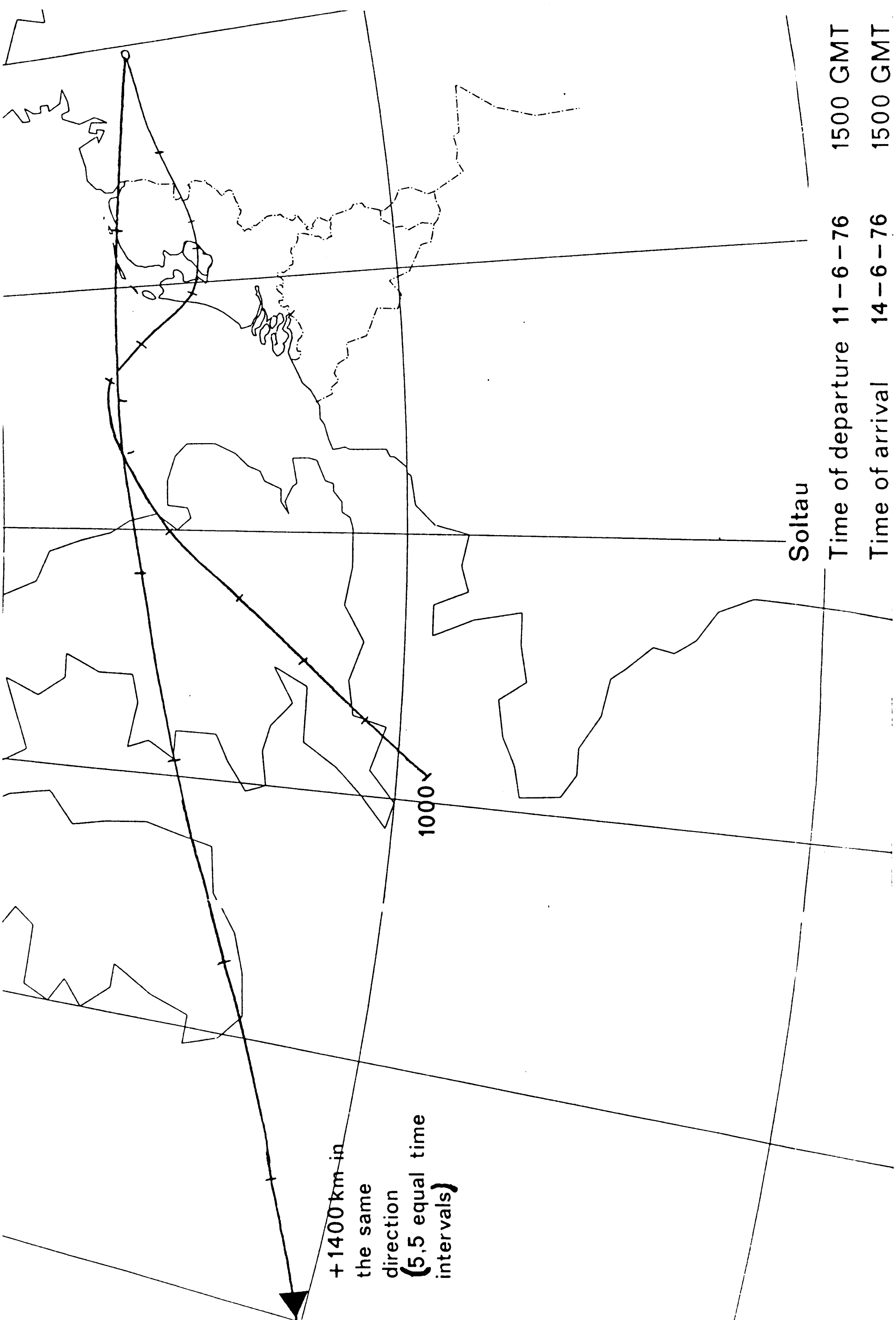

1000
850
Soltau
Time of departure 6 – 5 – 76 1500 GMT
Time of arrival 9 – 5 – 76 1500 GMT


1000
850
deBilt
Time of departure 6 – 5 – 76 1500 GMT
Time of arrival 9 – 5 – 76 1500 GMT

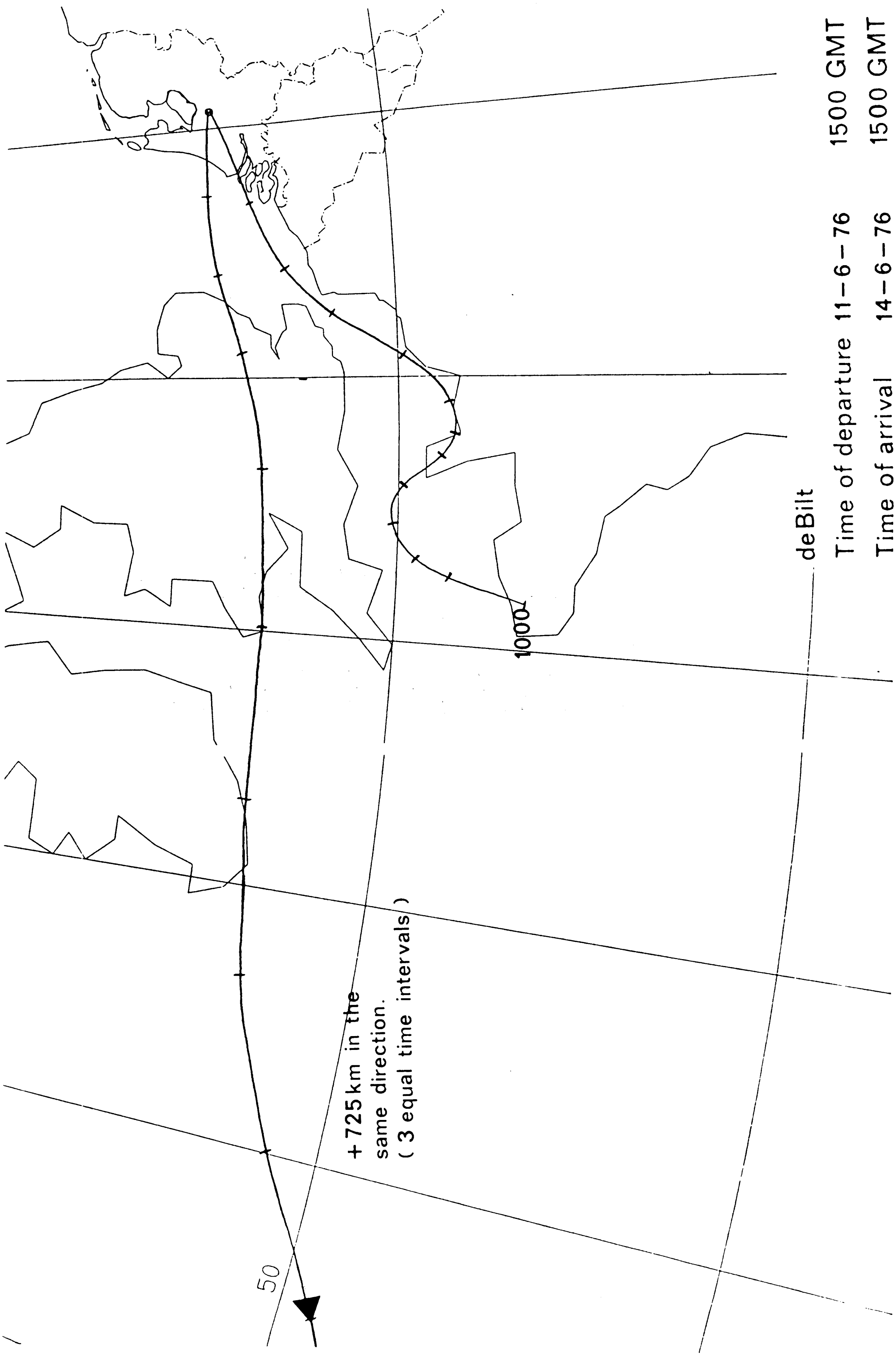

Soissons
Time of departure 11-6-76 1500 GMT
Time of arrival 14-6-76 1500 GMT
1000
850
50
45

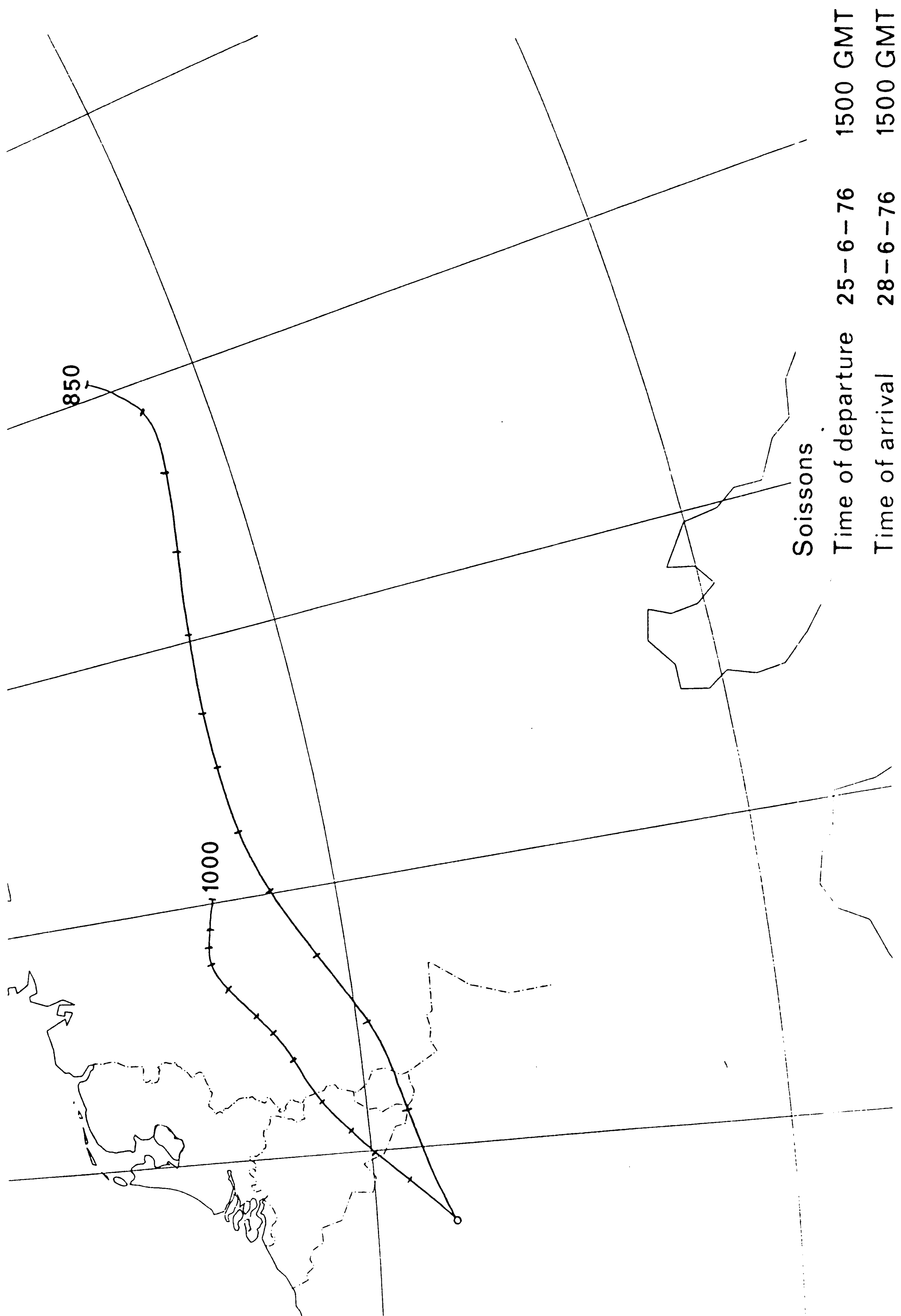

Nancy
Time of departure 11-6-76 1500 GM
Time of arrival 14-6-76 1500 GM
1000
850
50

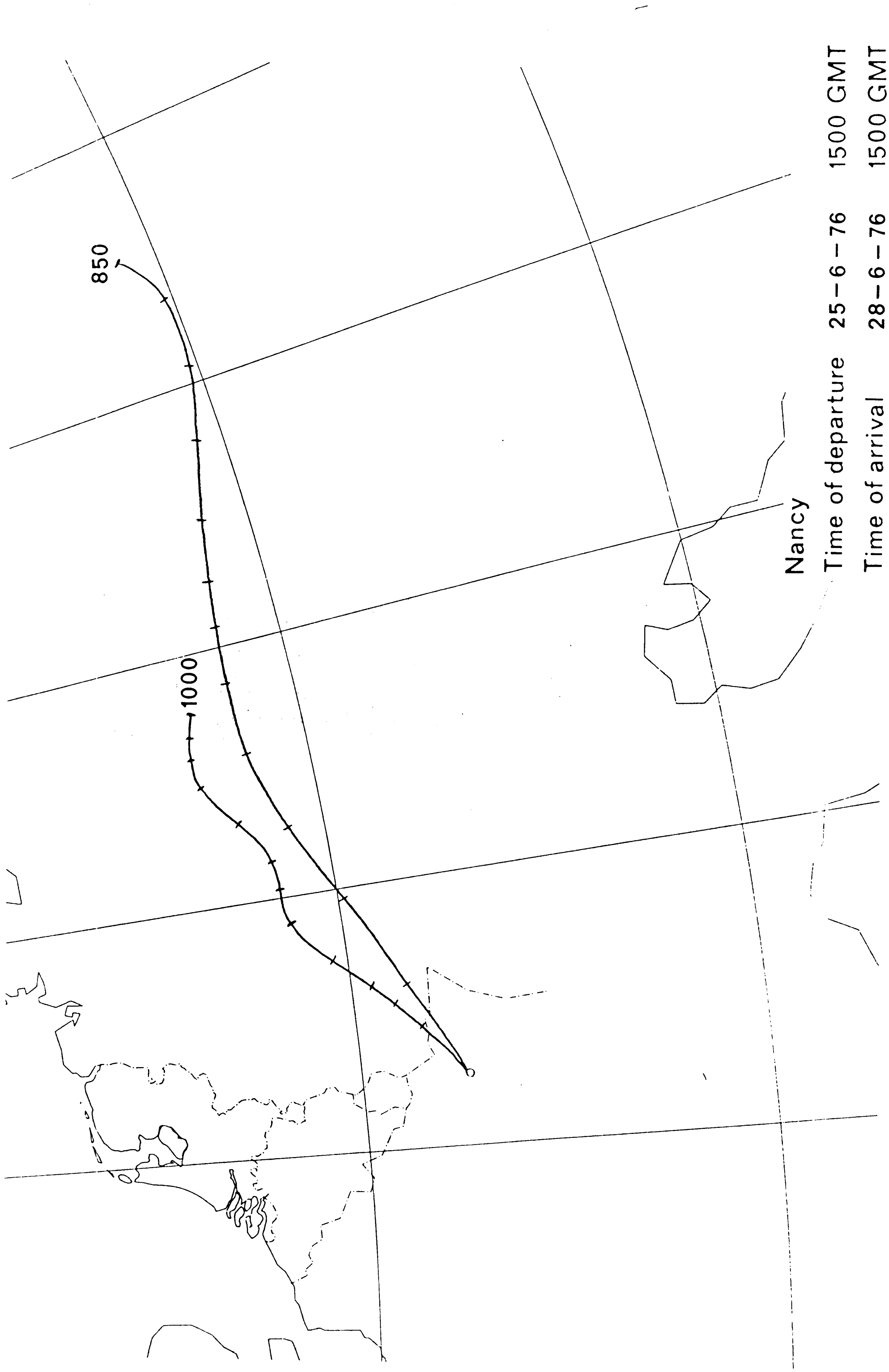

1000
850
Freiburg
Time of departure 11-6-76 1500 GMT
Time of arrival 14-6-76 1500 GMT

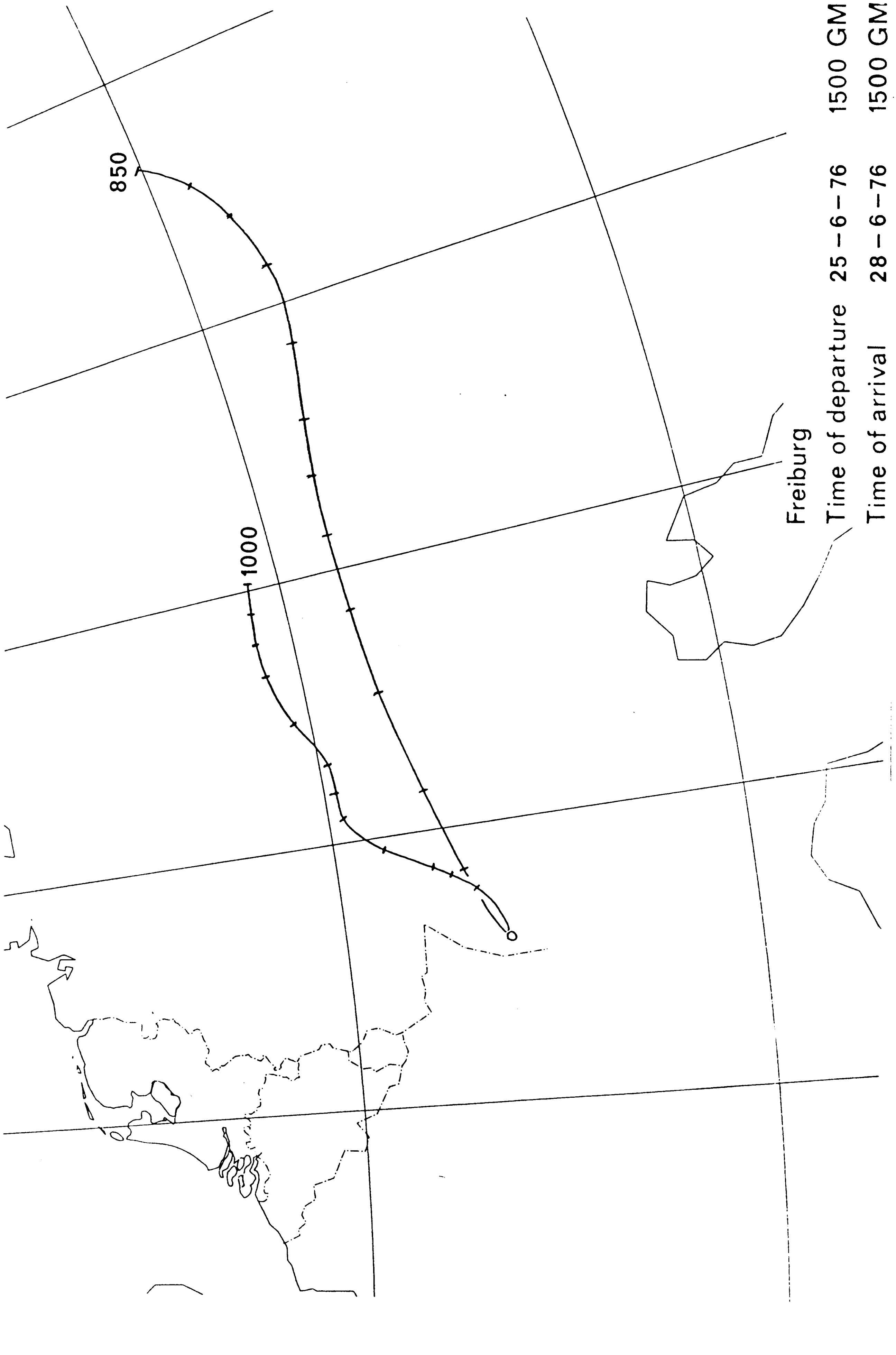


Soltau
Time of departure 11-6-76 1500 GMT
Time of arrival 14-6-76 1500 GMT
1000
+1400 km in the same direction (5,5 equal time intervals)

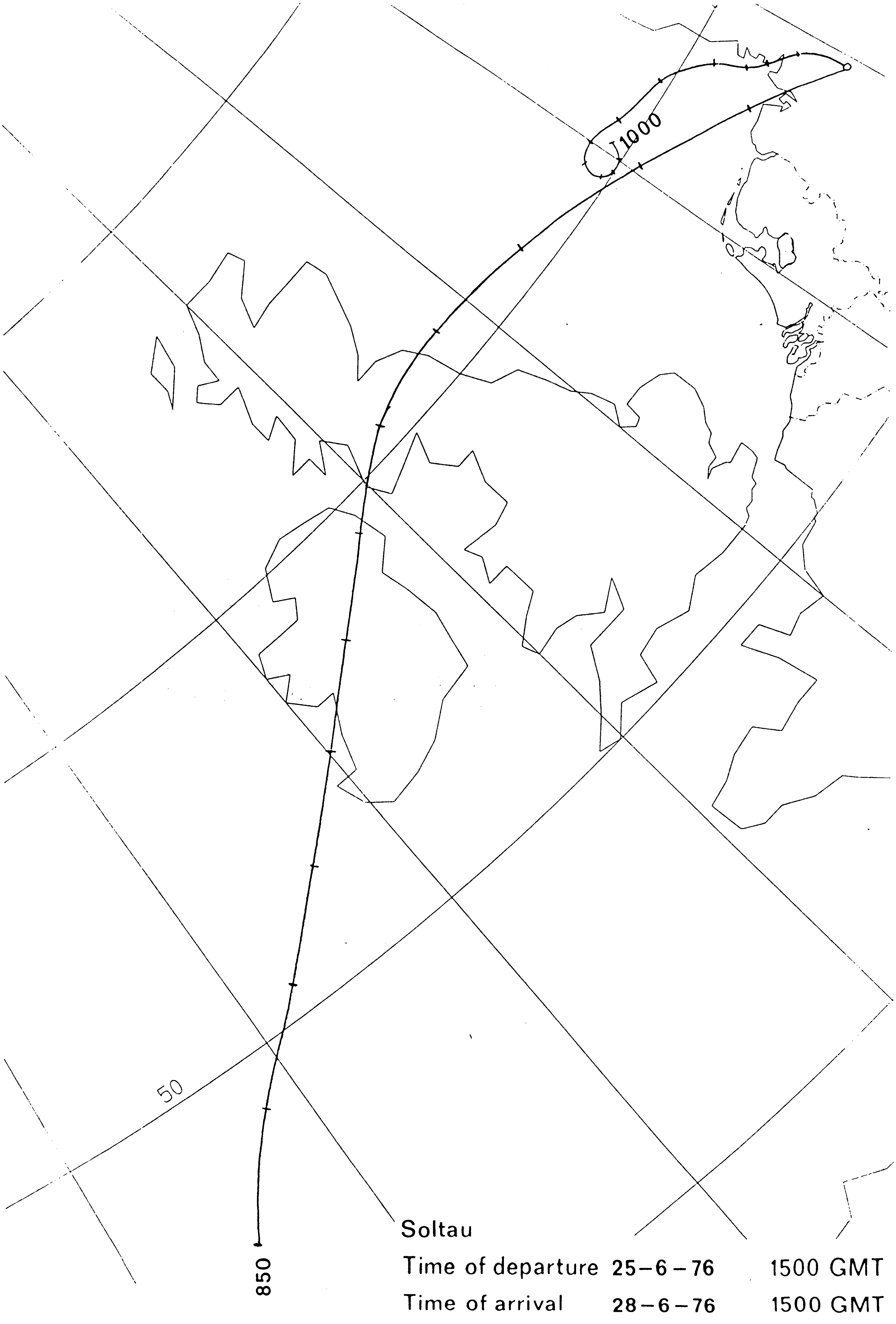

deBilt
Time of departure 11-6-76 1500 GMT
Time of arrival 14-6-76 1500 GMT
1000
+725 km in the
same direction.
(3 equal time intervals)
50


Soissons
Time of departure 25-6-76 1500 GMT
Time of arrival 28-6-76 1500 GMT
850
1000


850
1000
Nancy
Time of departure 25 – 6 – 76 1500 GMT
Time of arrival 28 – 6 – 76 1500 GMT



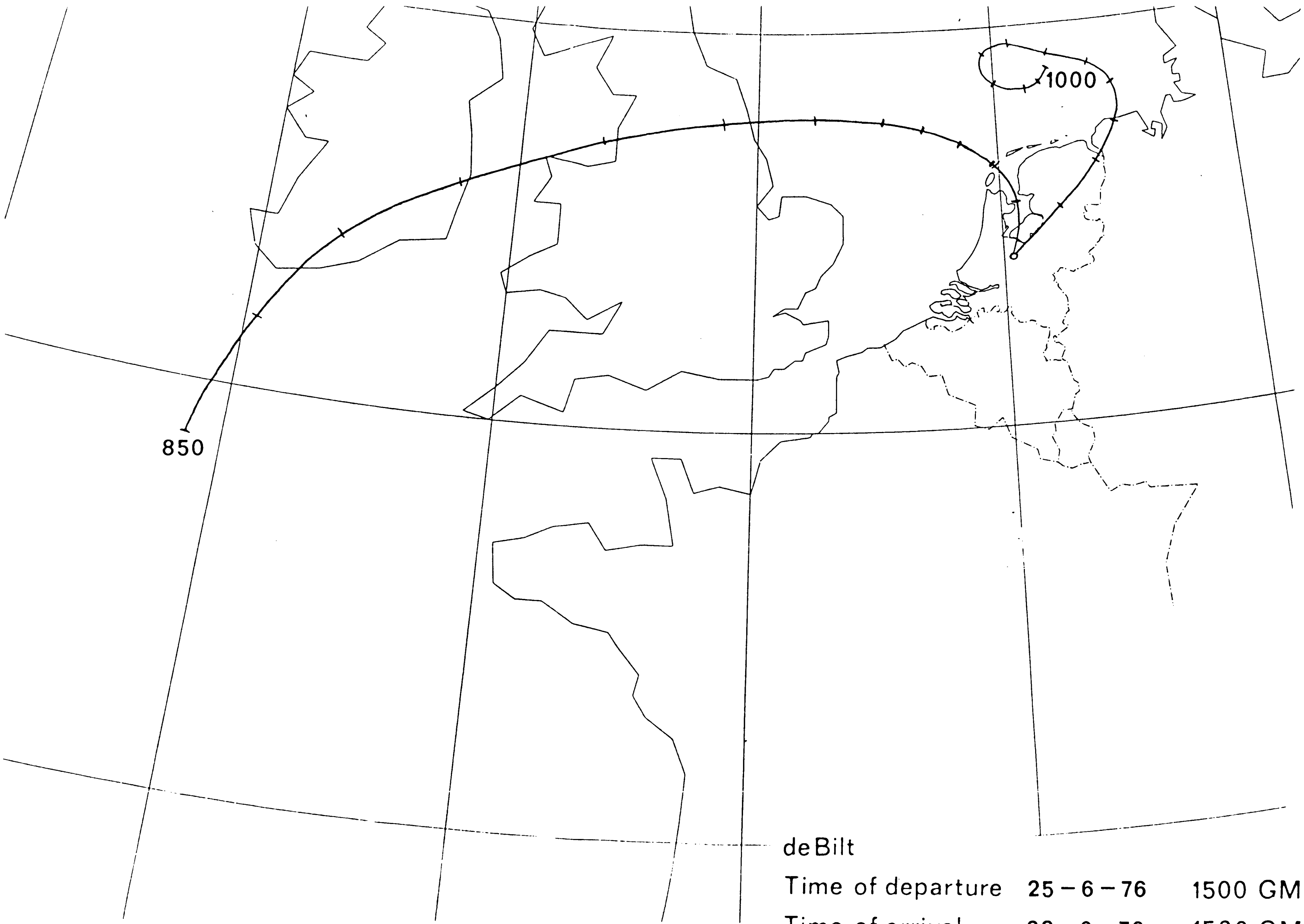
850
1000
Freiburg
Time of departure 25 – 6 – 76 1500 GMT
Time of arrival 28 – 6 – 76 1500 GMT



Soltau

Time of departure 25–6–76 1500 GMT

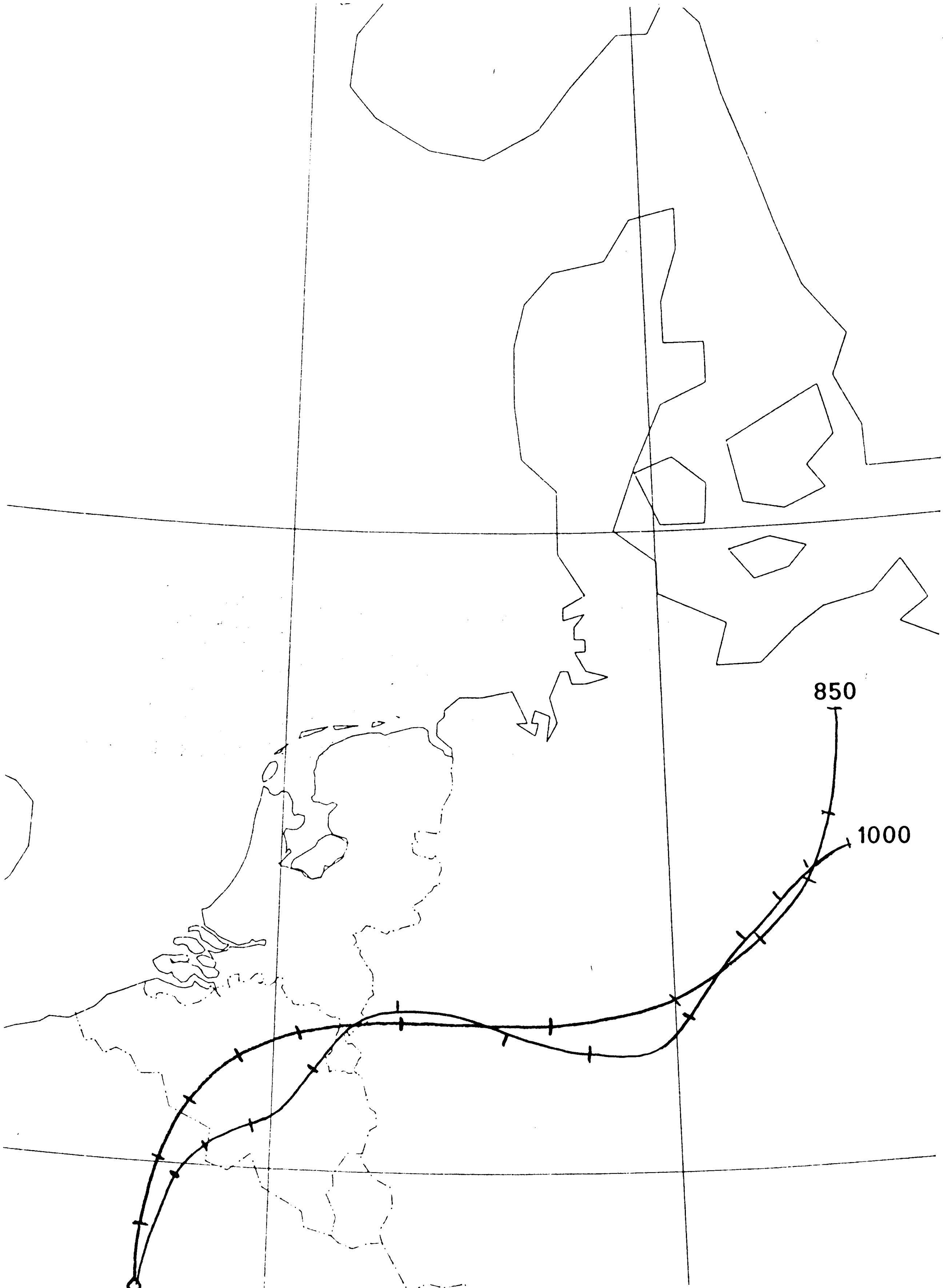
Time of arrival 28–6–76 1500 GMT



deBilt

Time of departure 25 – 6 – 76 1500 GMT

Time of arrival 28 – 6 – 76 1500 GMT



Soissons

Time of departure 4 – 7 – 76 1500 GMT

Time of arrival 7 – 7 – 76 1500 GMT .

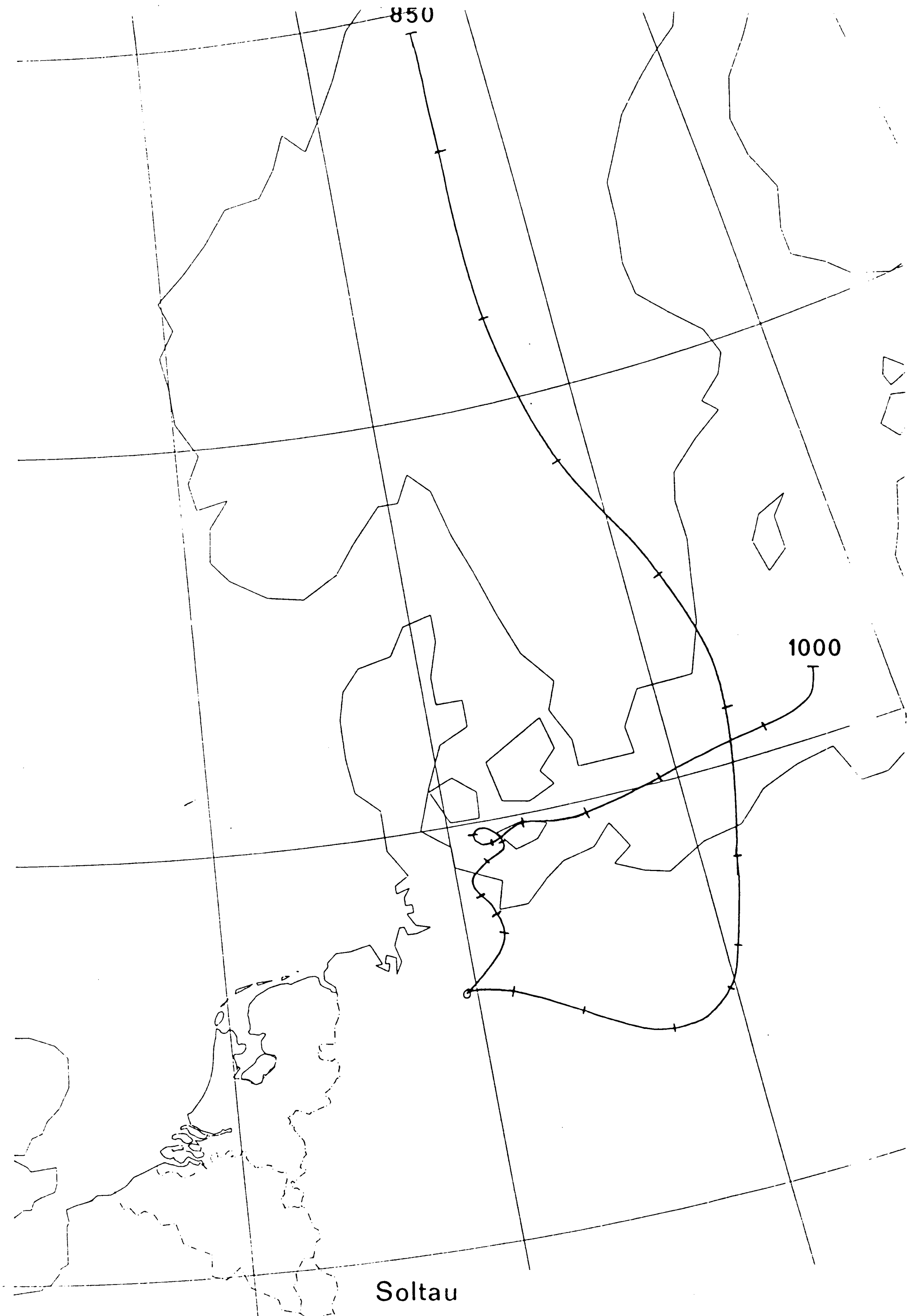
Nancy

Time of departure 4 – 7 – 76 1500 GMT

Time of arrival 7 – 7 – 76 1500 GMT

Time of departure 4 – 7 – 76 1500 GMT

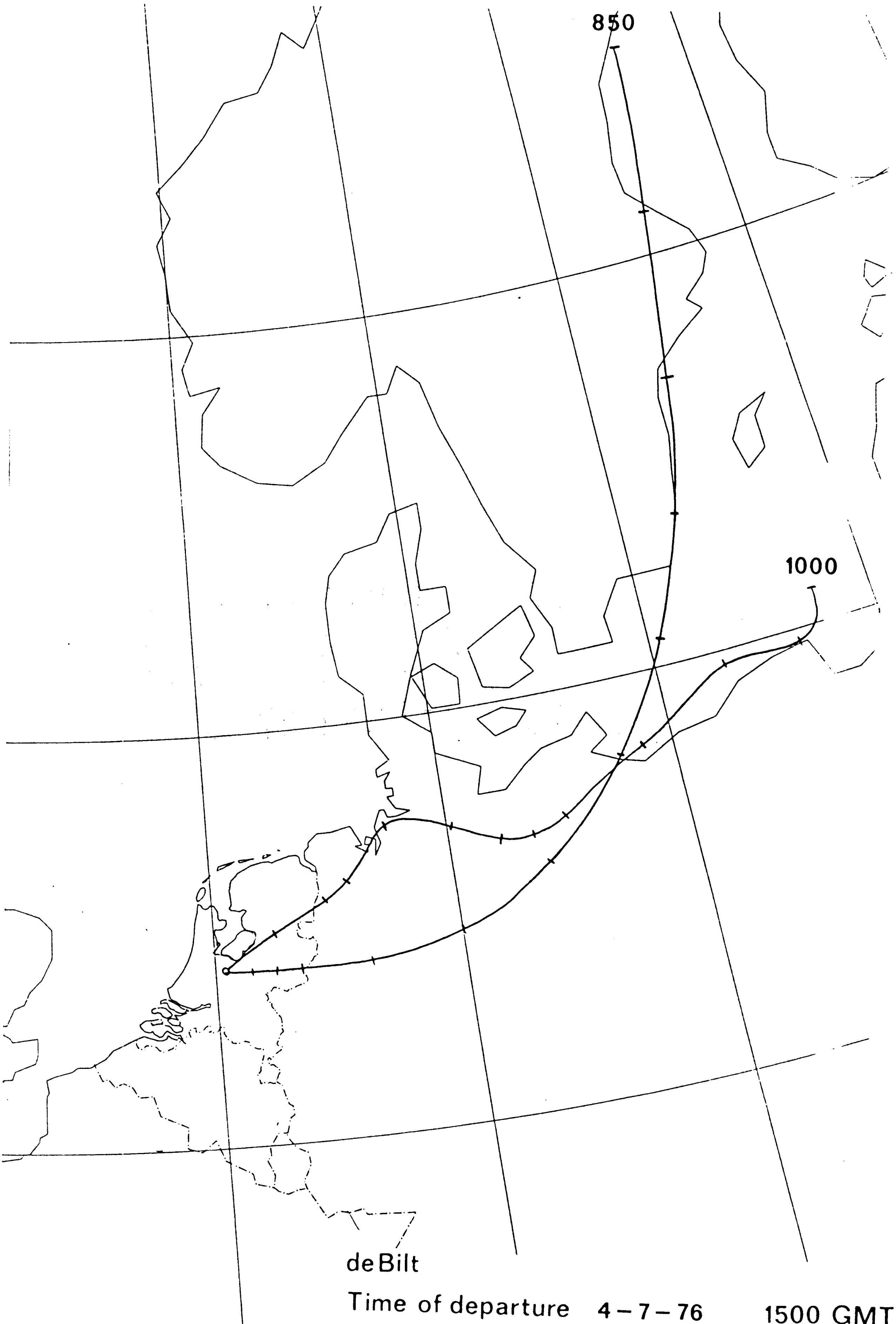
Time of arrival 7 – 7 – 76 1500 GMT



Soltau

Time of departure 4 – 7 – 76 1500 GMT

Time of arrival 7 – 7 – 76 1500 GMT



deBilt

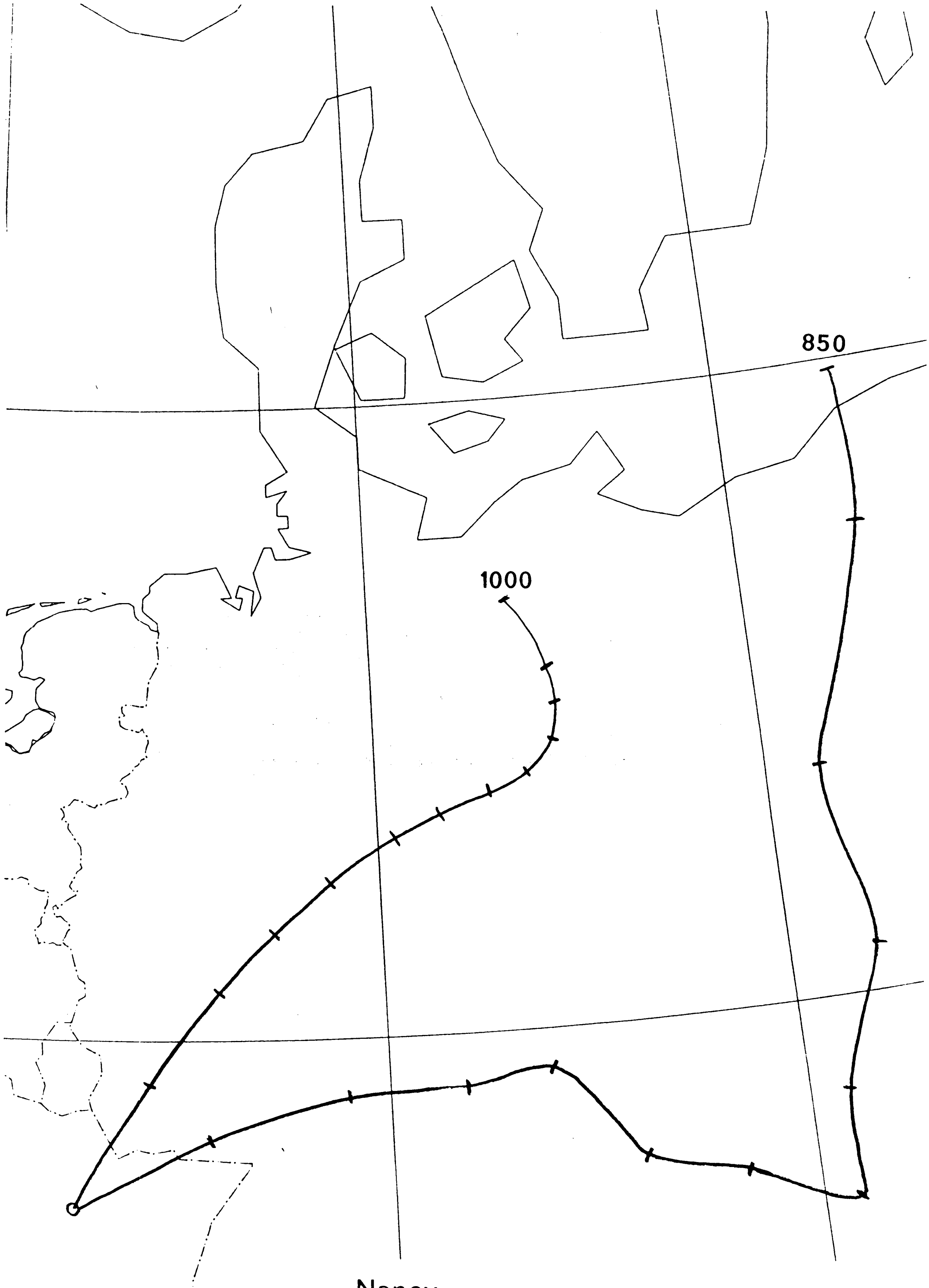
Time of departure 4 – 7 – 76 1500 GMT

Time of arrival 7 – 7 – 76 1500 GMT

Soissons

Time of departure 7 – 8 – 76 1500 GMT

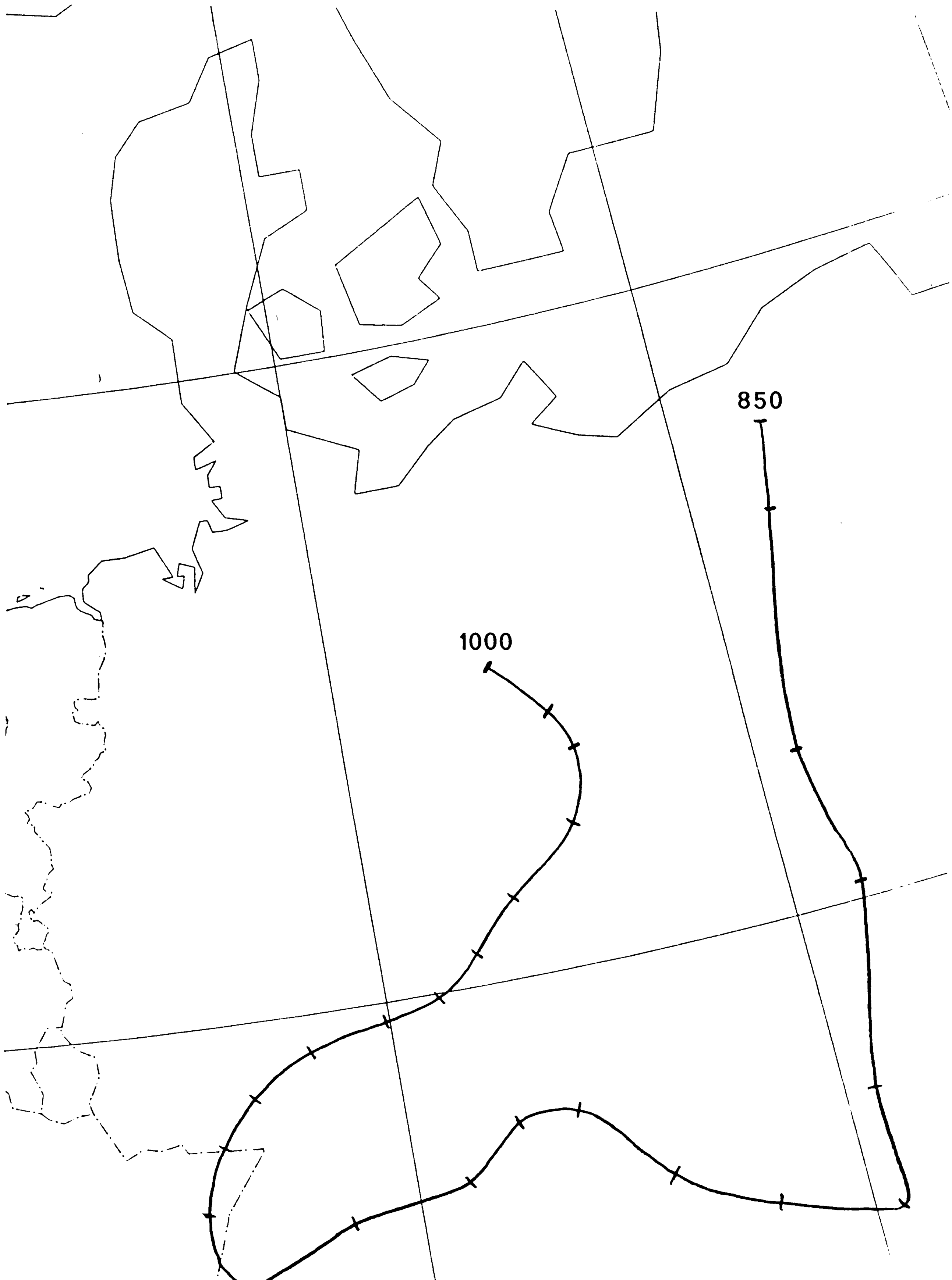
Time of arrival 10 – 8 – 76 1500 GMT



Nancy

Time of departure 7 – 8 – 76 1500 GMT

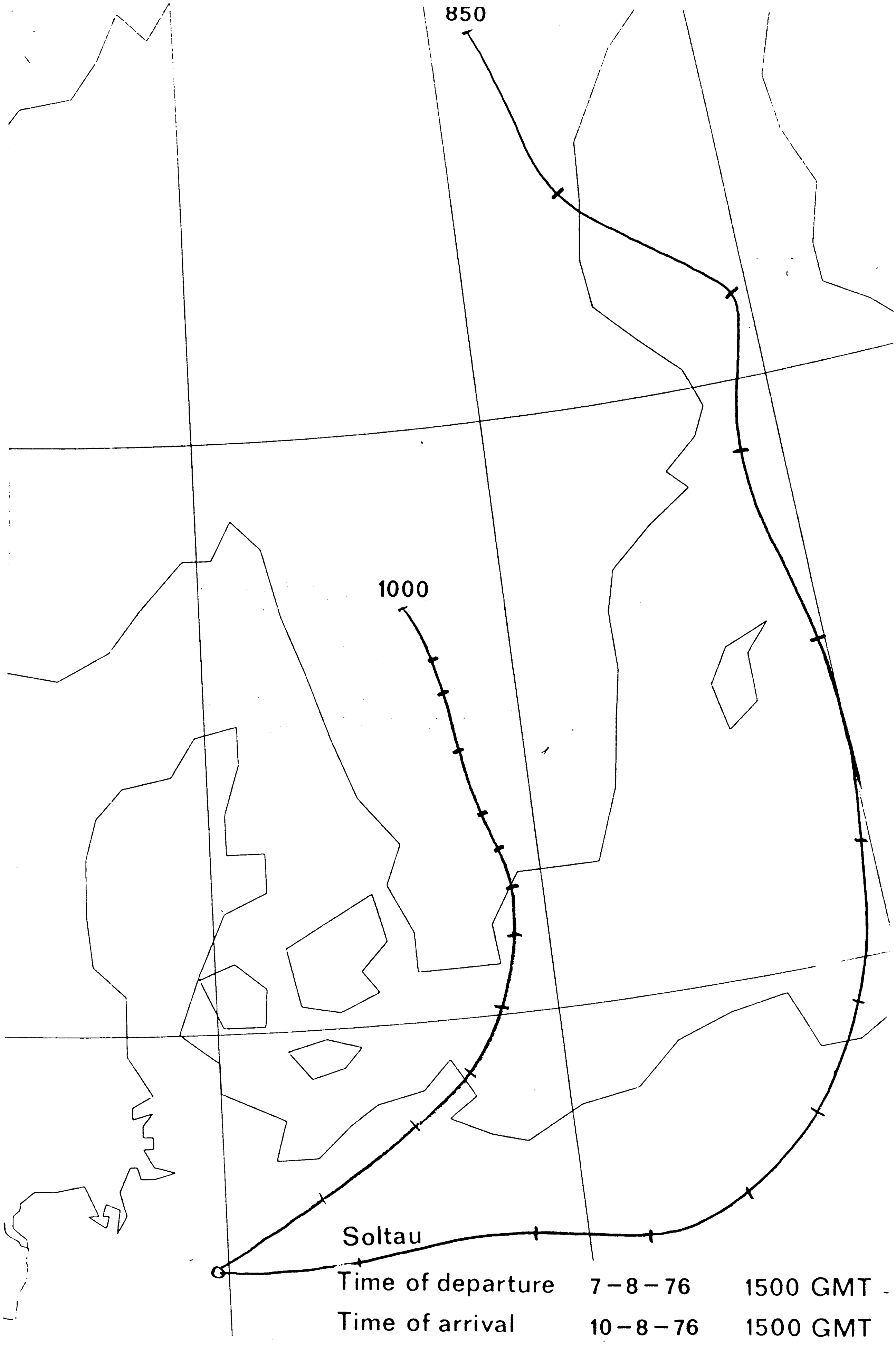
Time of arrival 10 – 8 – 76 1500 GMT

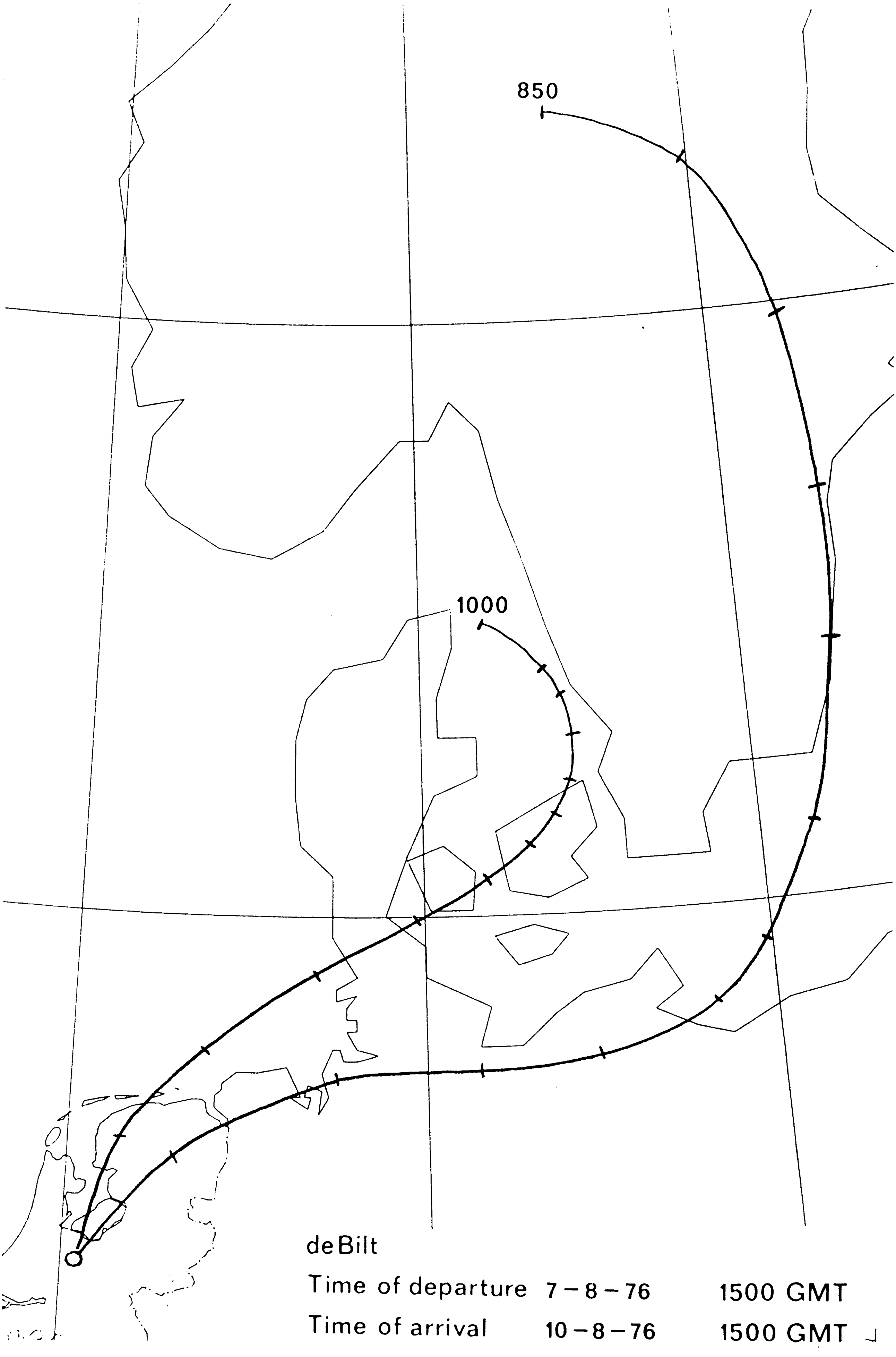


Freiburg

Time of departure 7-8-76 1500 GMT

Time of arrival 10-8-76 1500 GMT

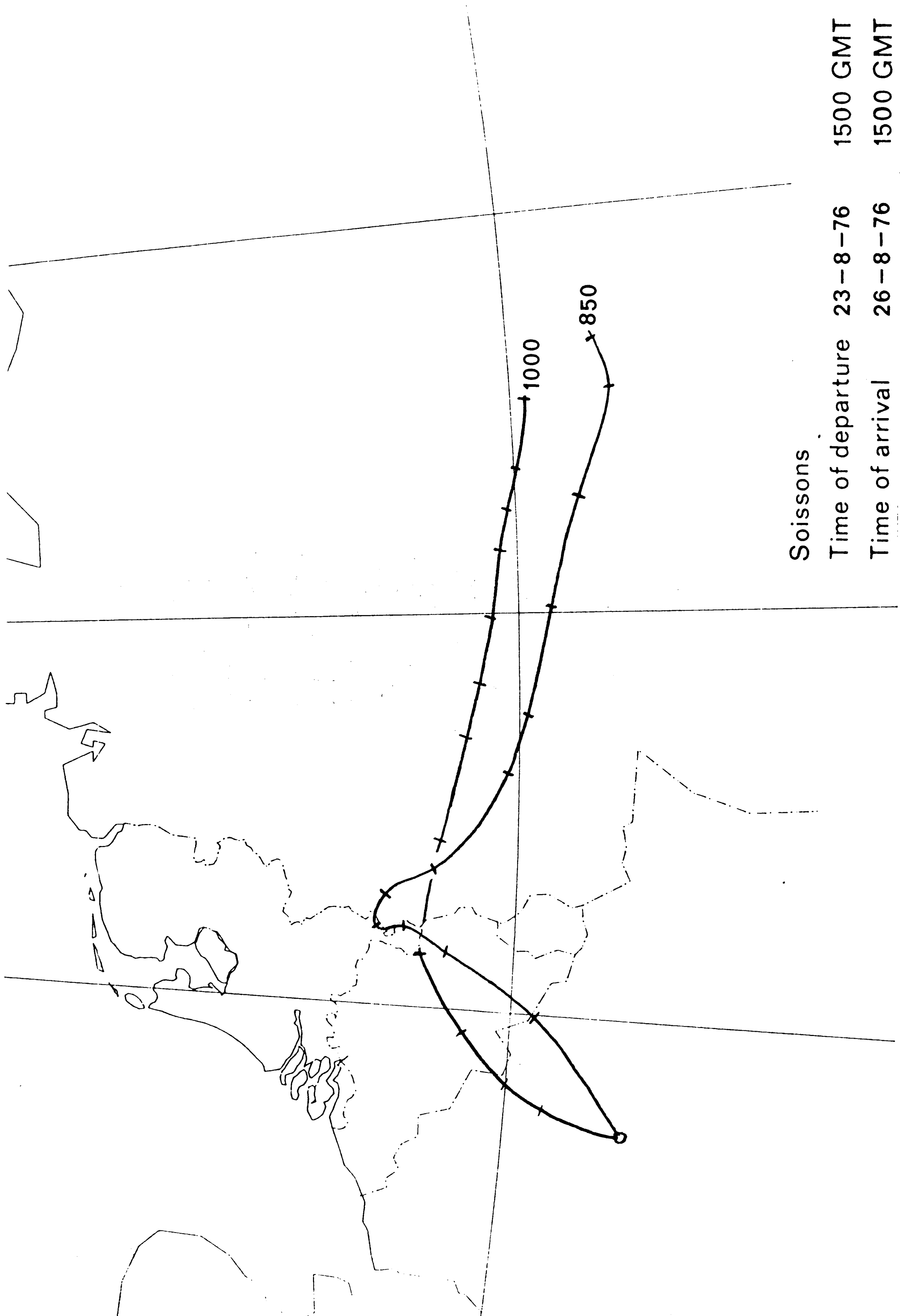

850
1000
Soltau
Time of departure 7-8-76 1500 GMT
Time of arrival 10-8-76 1500 GMT

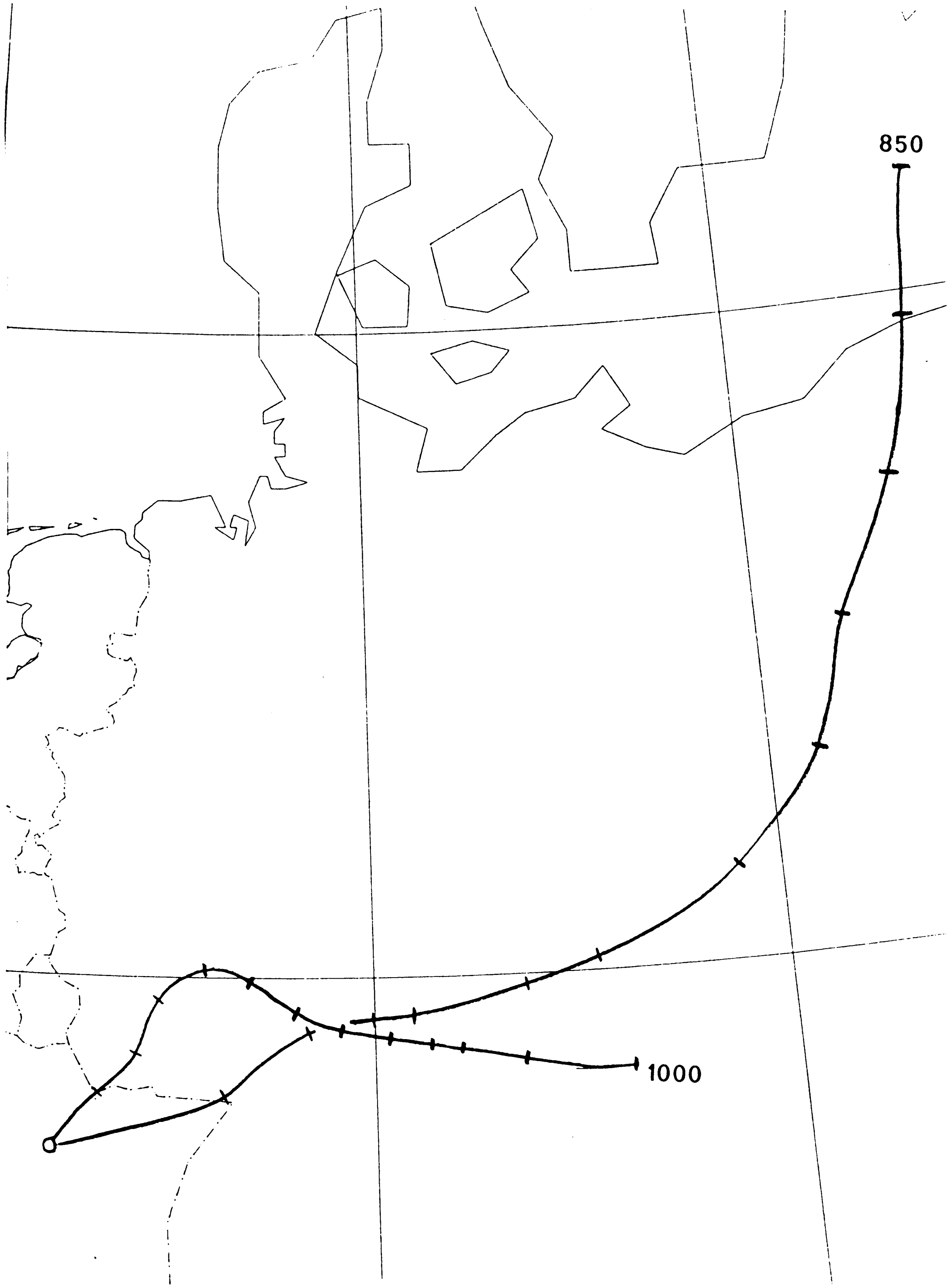


de Bilt

Time of departure 7 – 8 – 76 1500 GMT

Time of arrival 10 – 8 – 76 1500 GMT


1000
850
Soissons
Time of departure 23-8-76 1500 GMT
Time of arrival 26-8-76 1500 GMT



Nancy

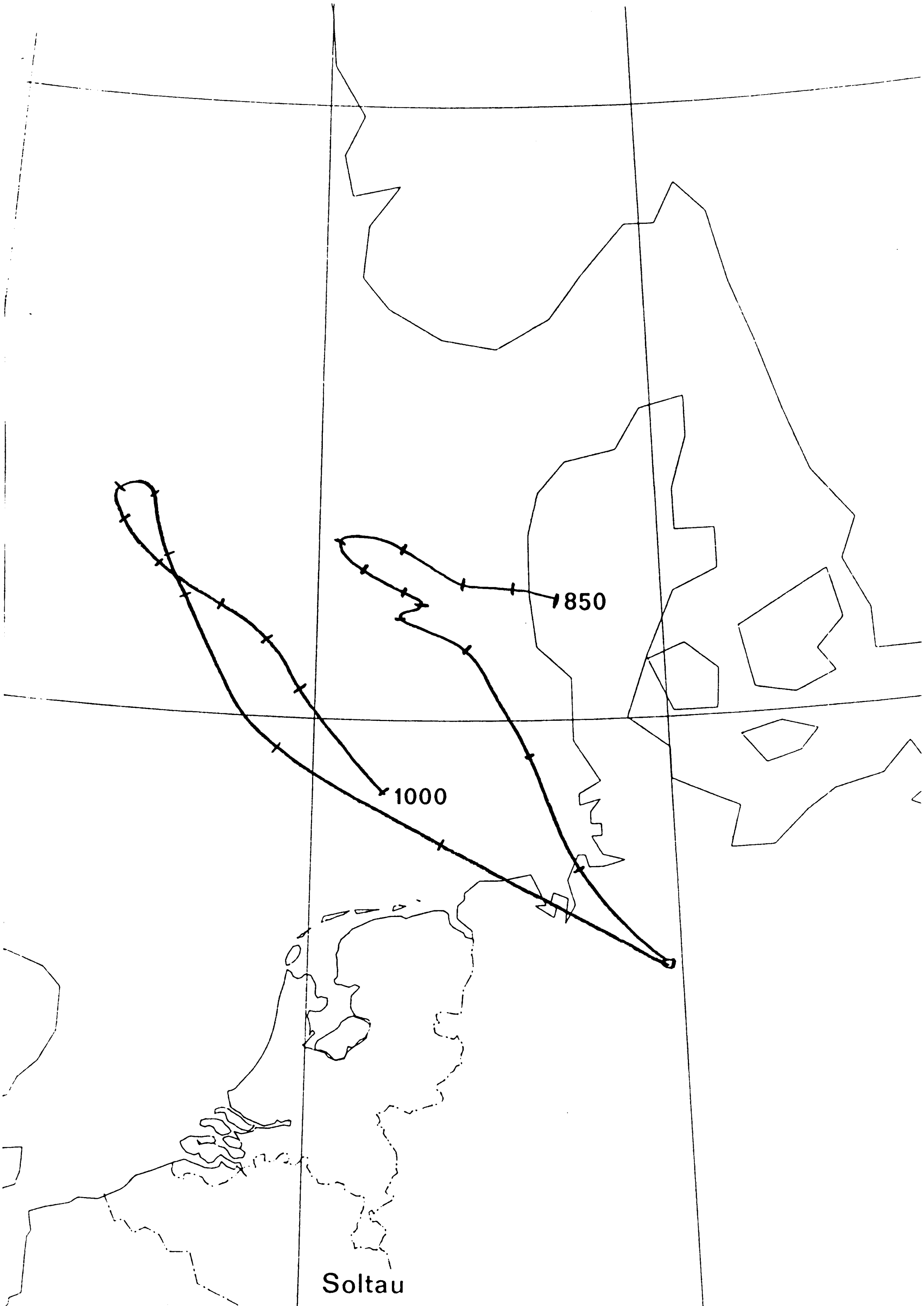
Time of departure 23 – 8 – 76 1500 GMT

Time of arrival 26 – 8 – 76 1500 GMT

Freiburg

Time of departure 23 – 8 – 76 1500 GMT

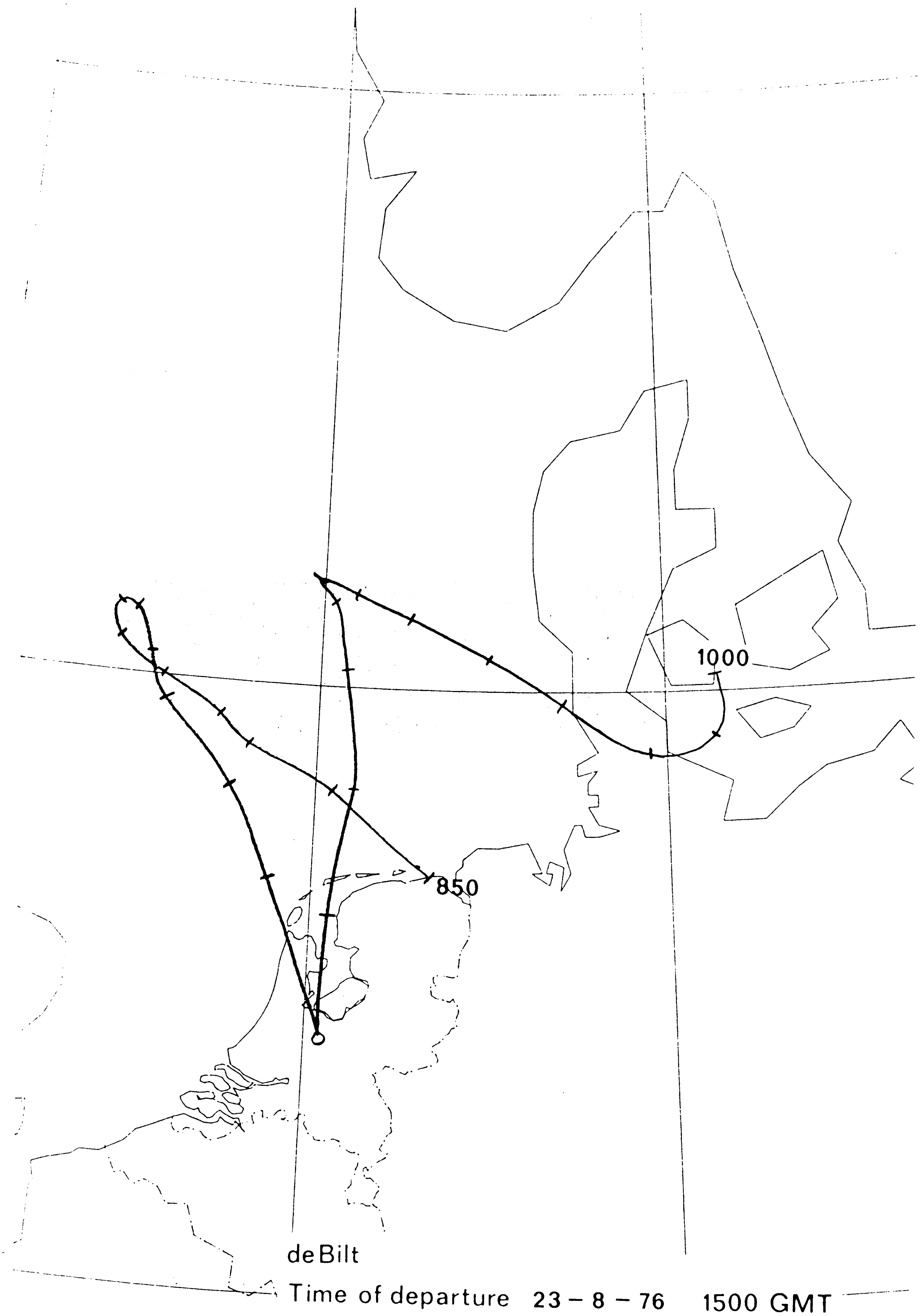
Time of arrival 26 – 8 – 76 1500 GMT



Soltau

Time of departure 23 – 8 – 76 1500 GMT

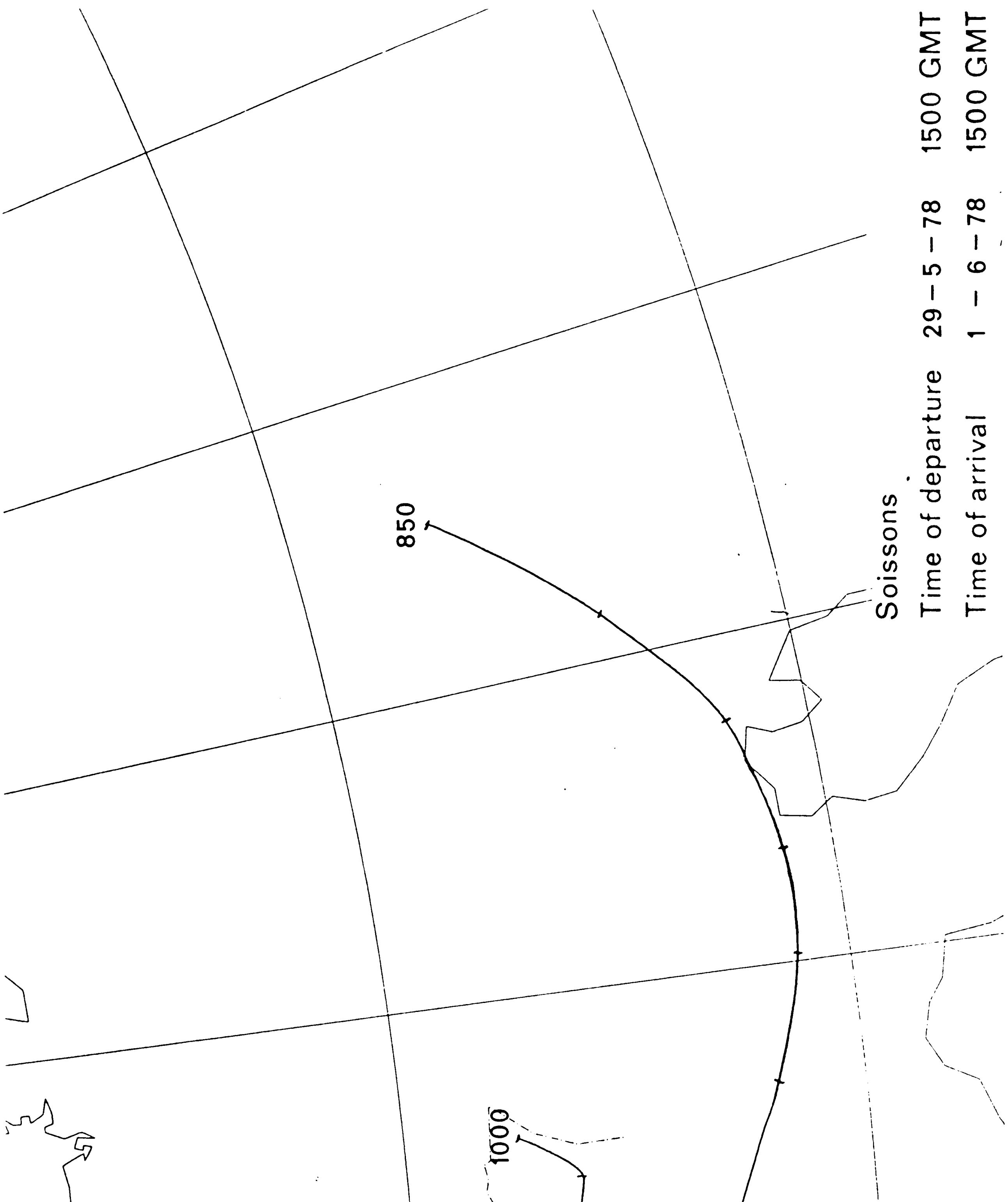
Time of arrival 26 – 8 – 76 1500 GMT

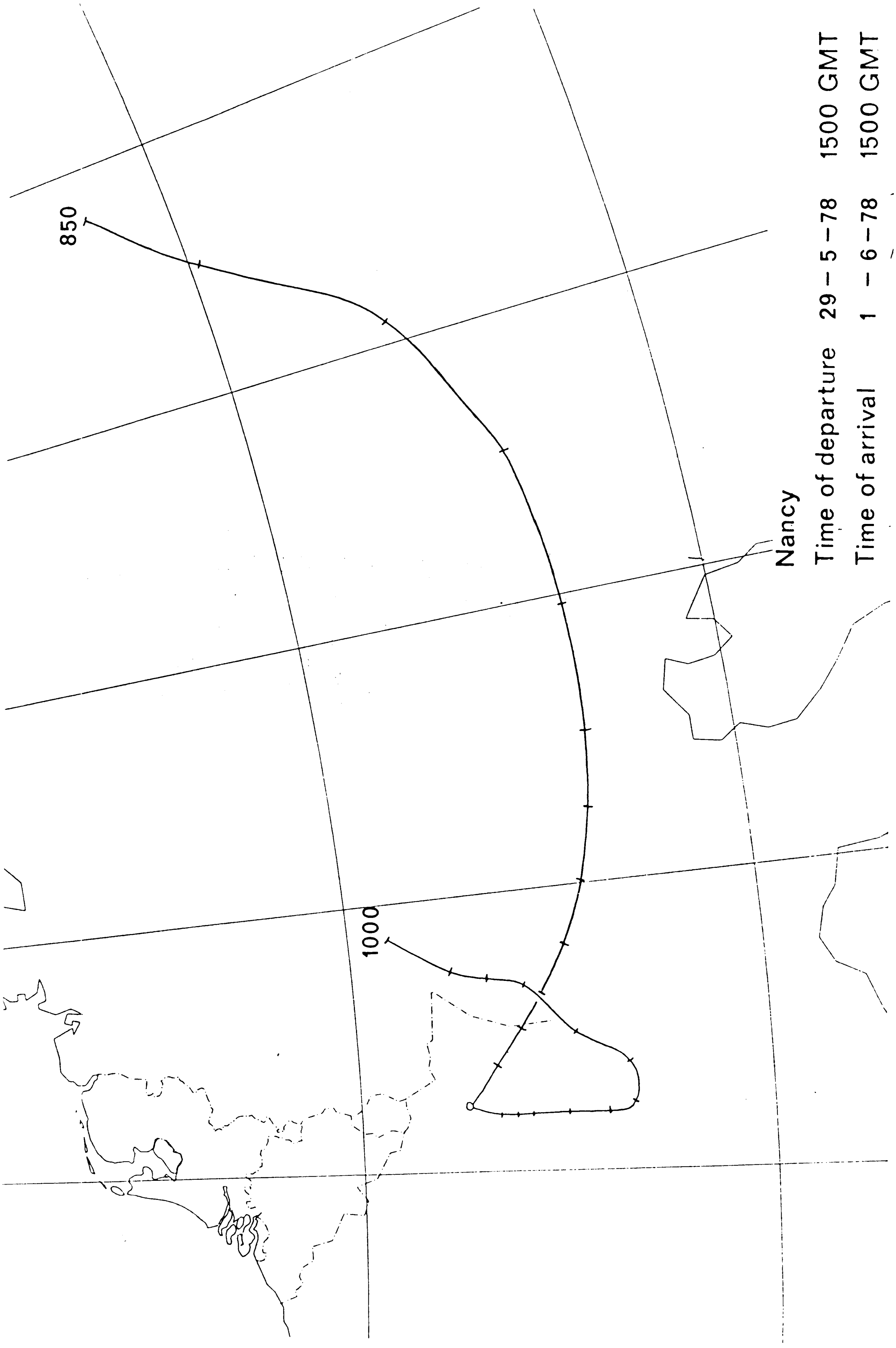


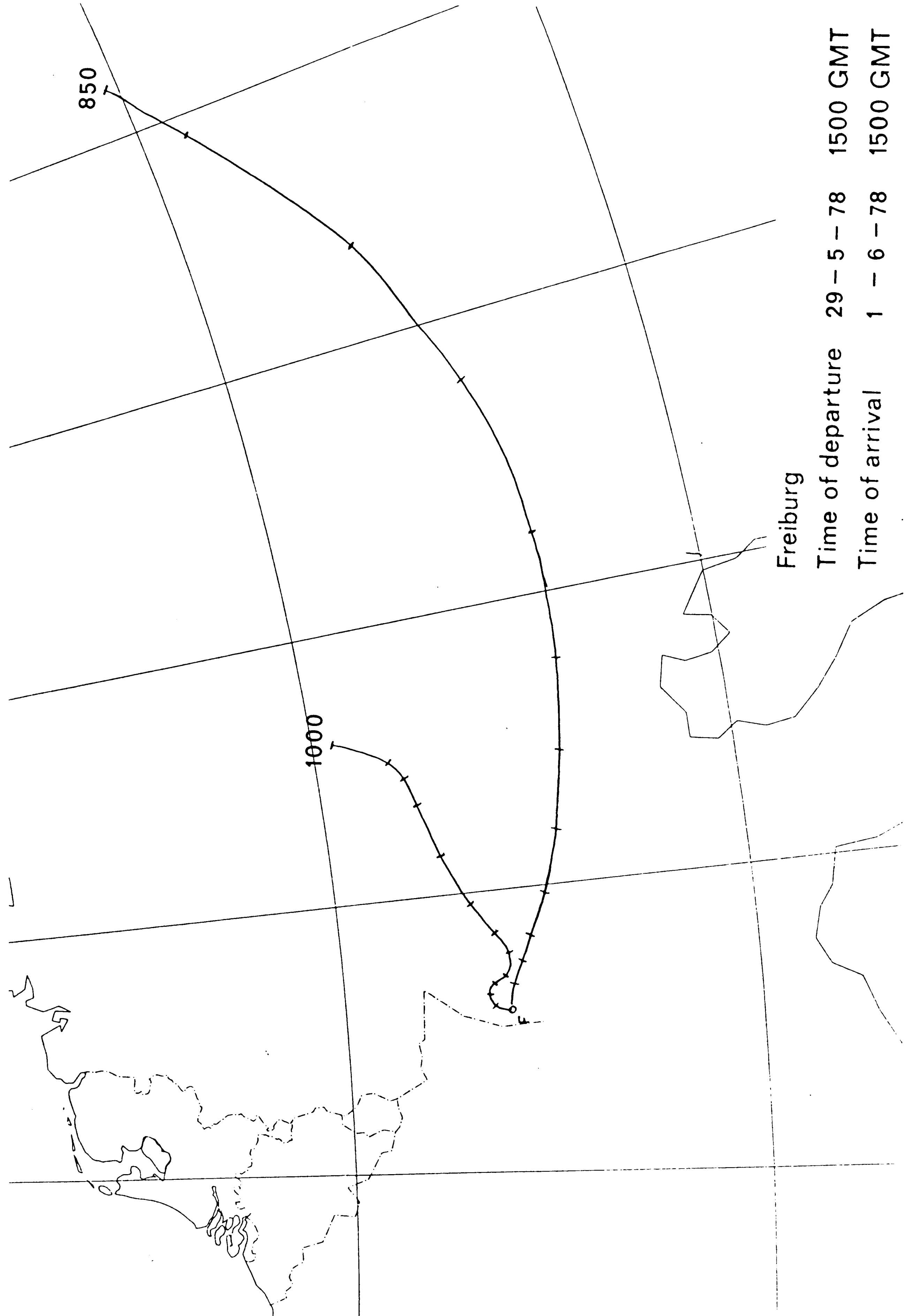
deBilt

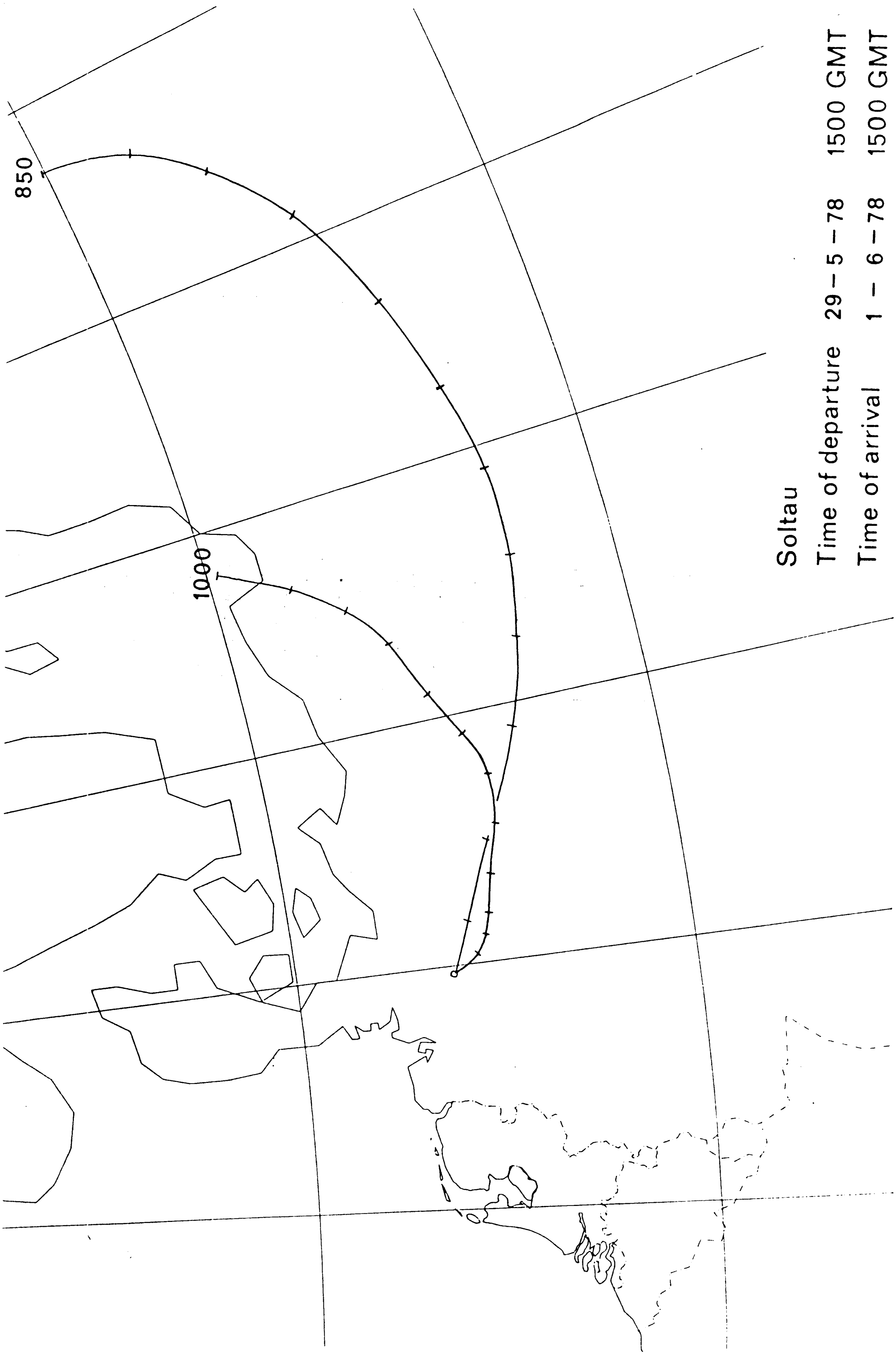
Time of departure 23 – 8 – 76 1500 GMT

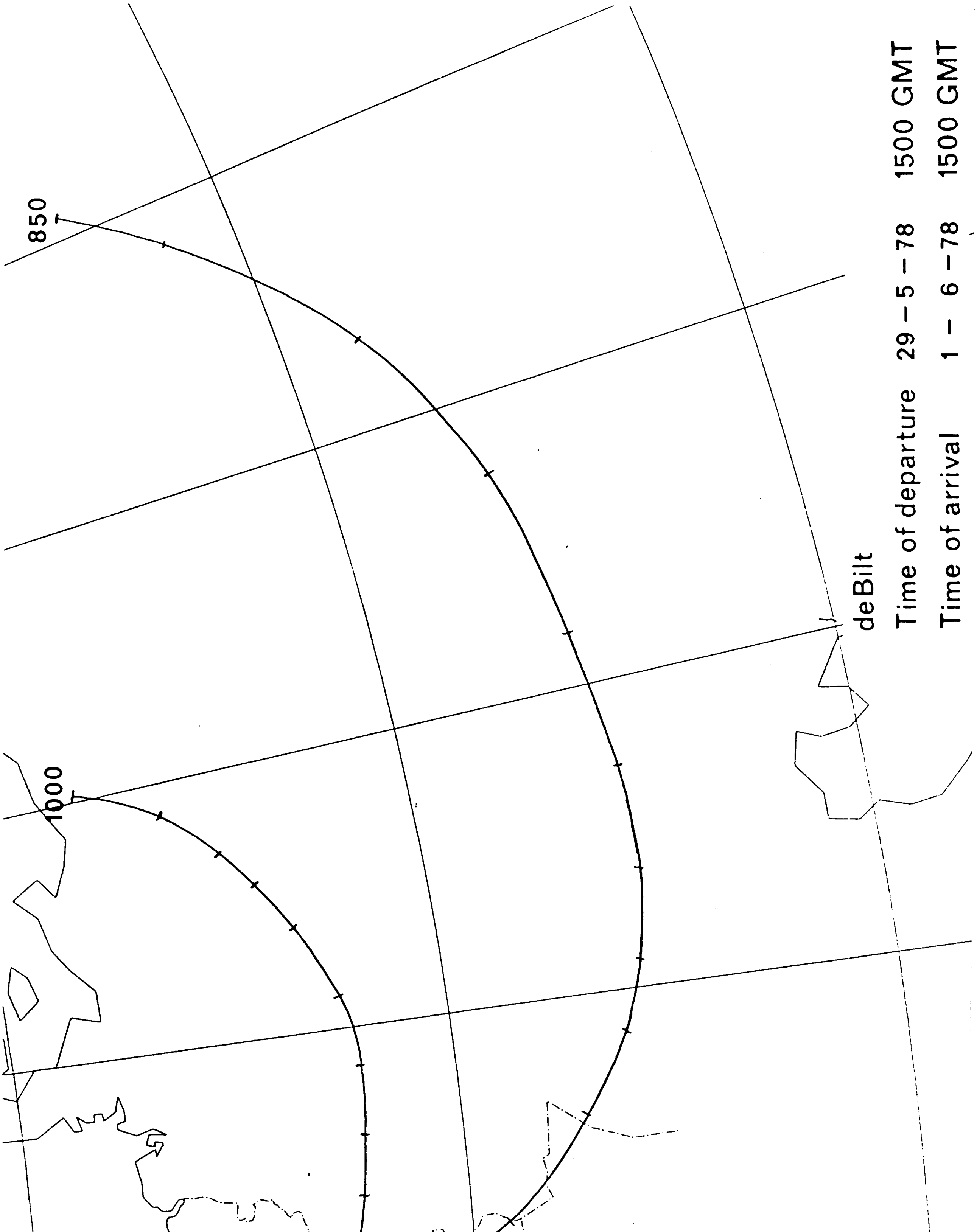
Time of arrival 26 – 8 – 76 1500 GMT

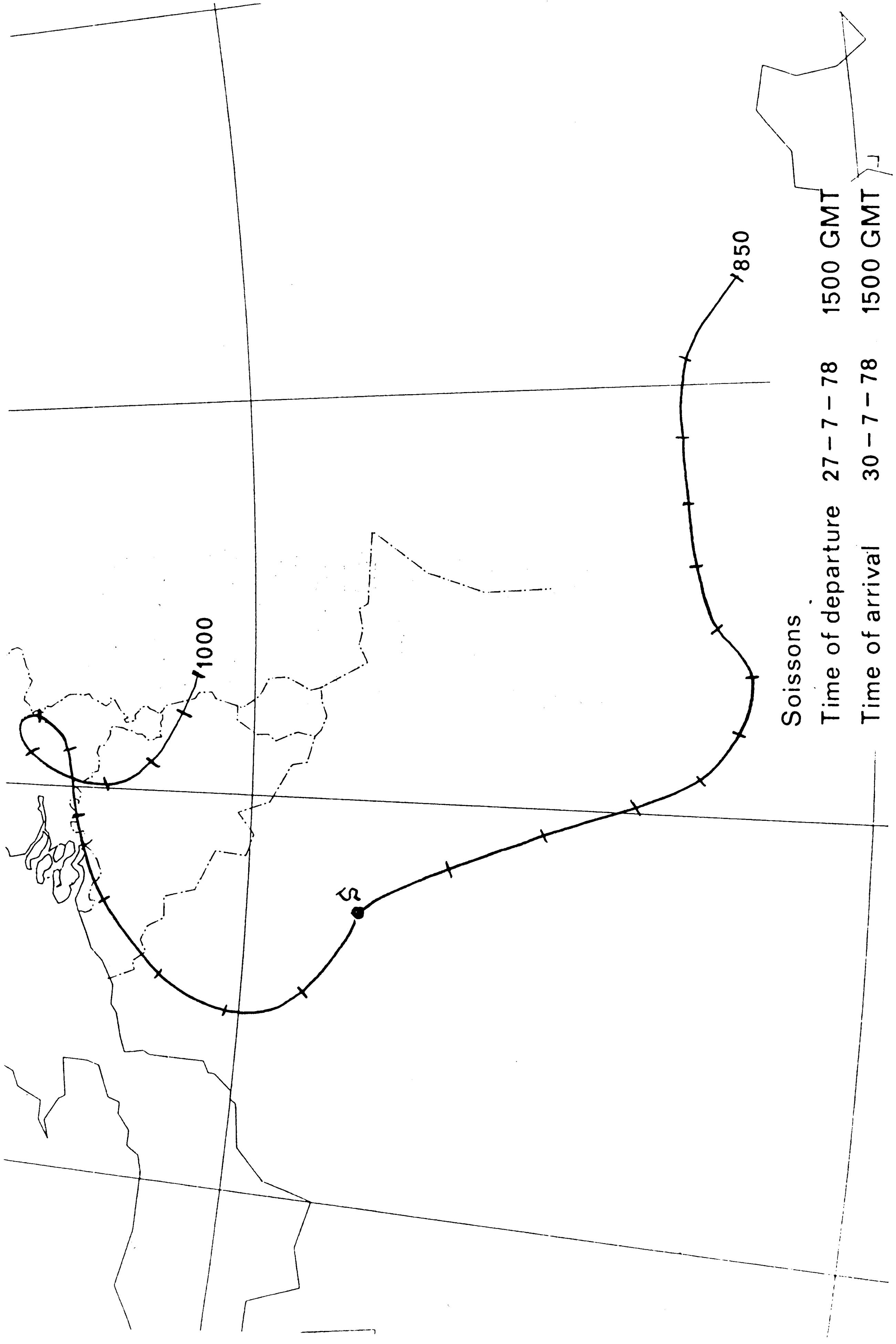

Soissons
Time of departure 29 – 5 – 78 1500 GMT
Time of arrival 1 – 6 – 78 1500 GMT
850
1000

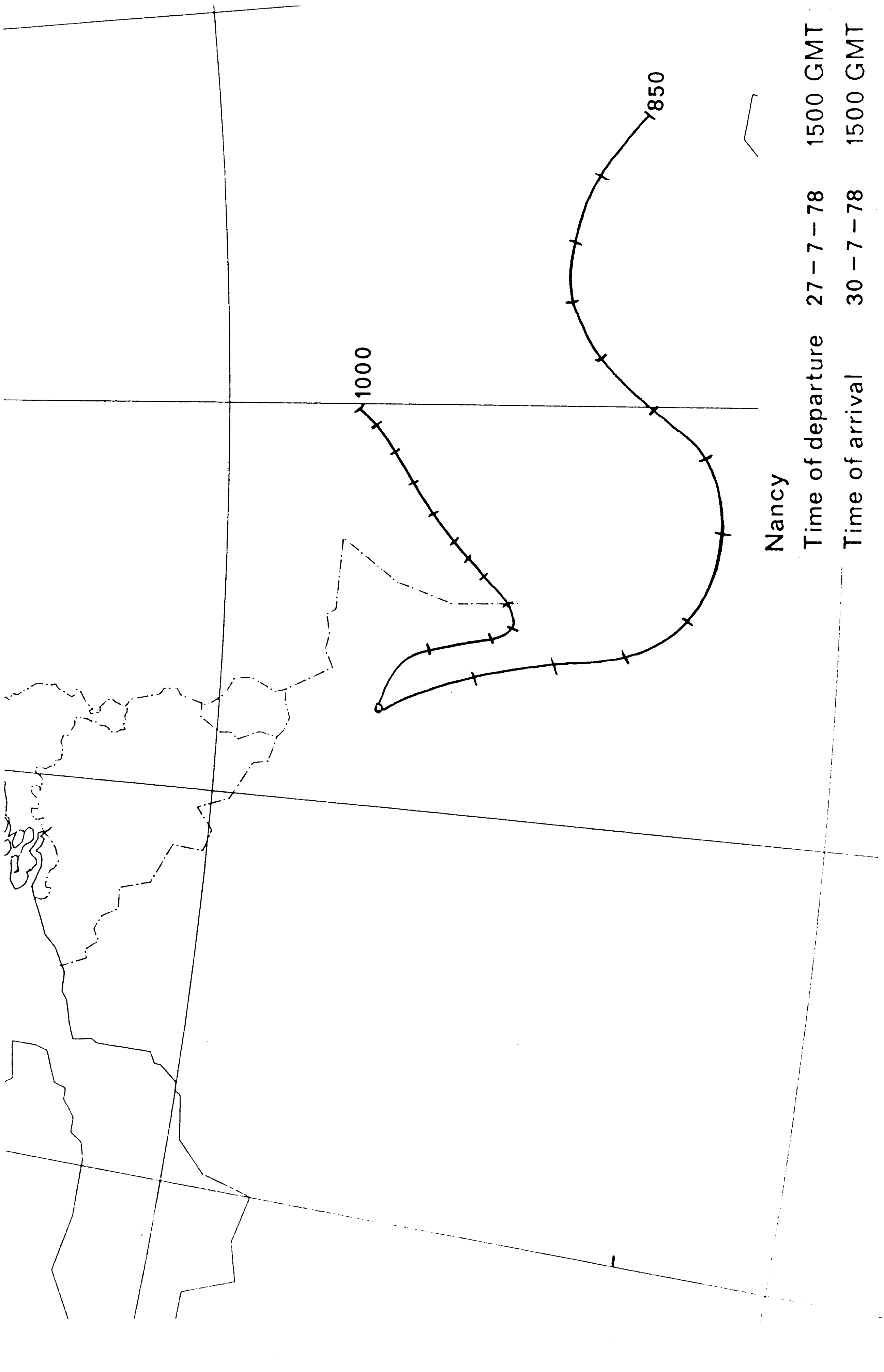

850
1000
Nancy
Time of departure 29 – 5 – 78 1500 GMT
Time of arrival 1 – 6 – 78 1500 GMT


850
1000
Freiburg
Time of departure 29 – 5 – 78 1500 GMT
Time of arrival 1 – 6 – 78 1500 GMT

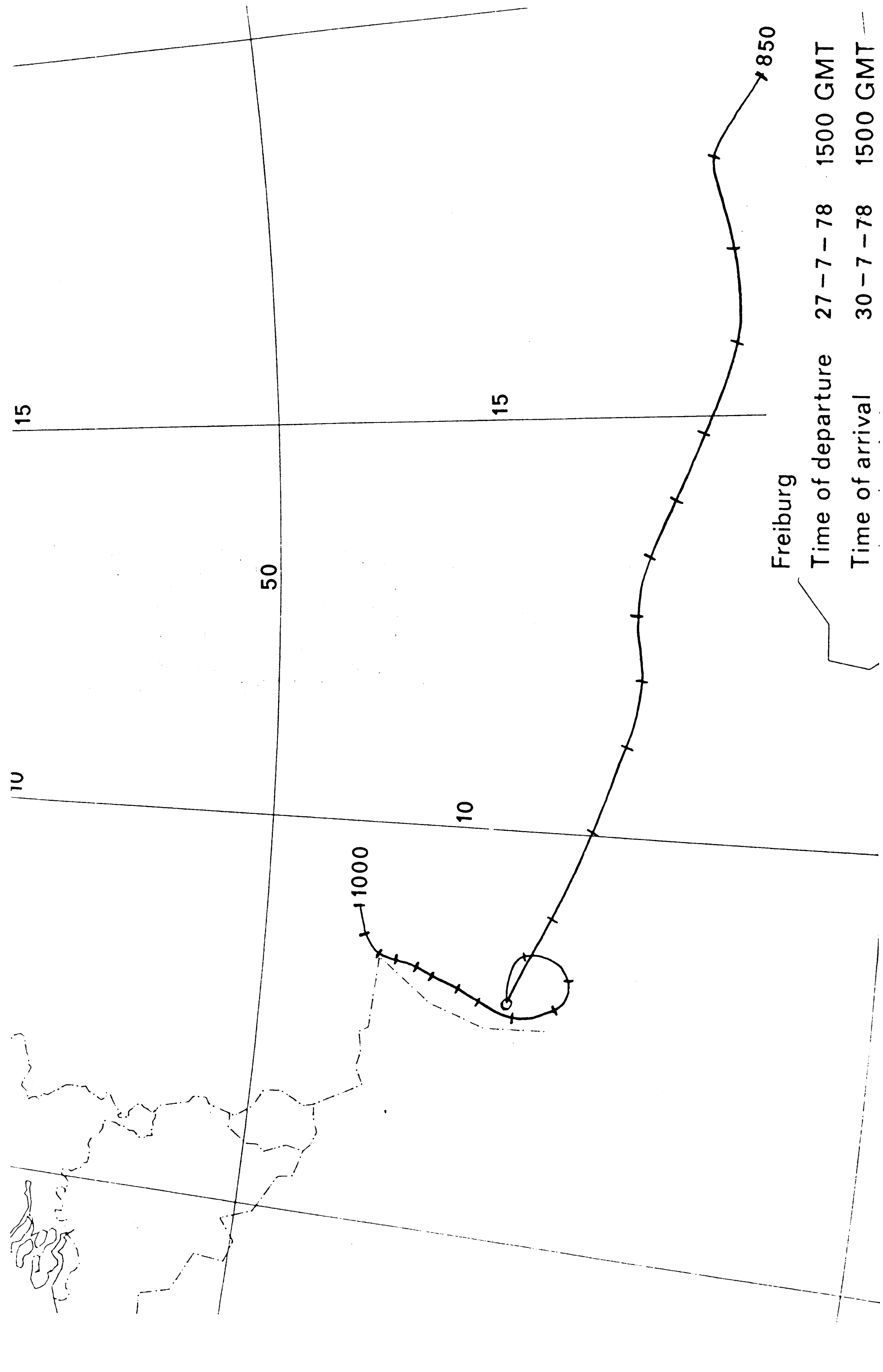

850
1000
Soltau
Time of departure 29 – 5 – 78 1500 GMT
Time of arrival 1 – 6 – 78 1500 GMT


850
1000
deBilt
Time of departure 29 – 5 – 78 1500 GMT
Time of arrival 1 – 6 – 78 1500 GMT

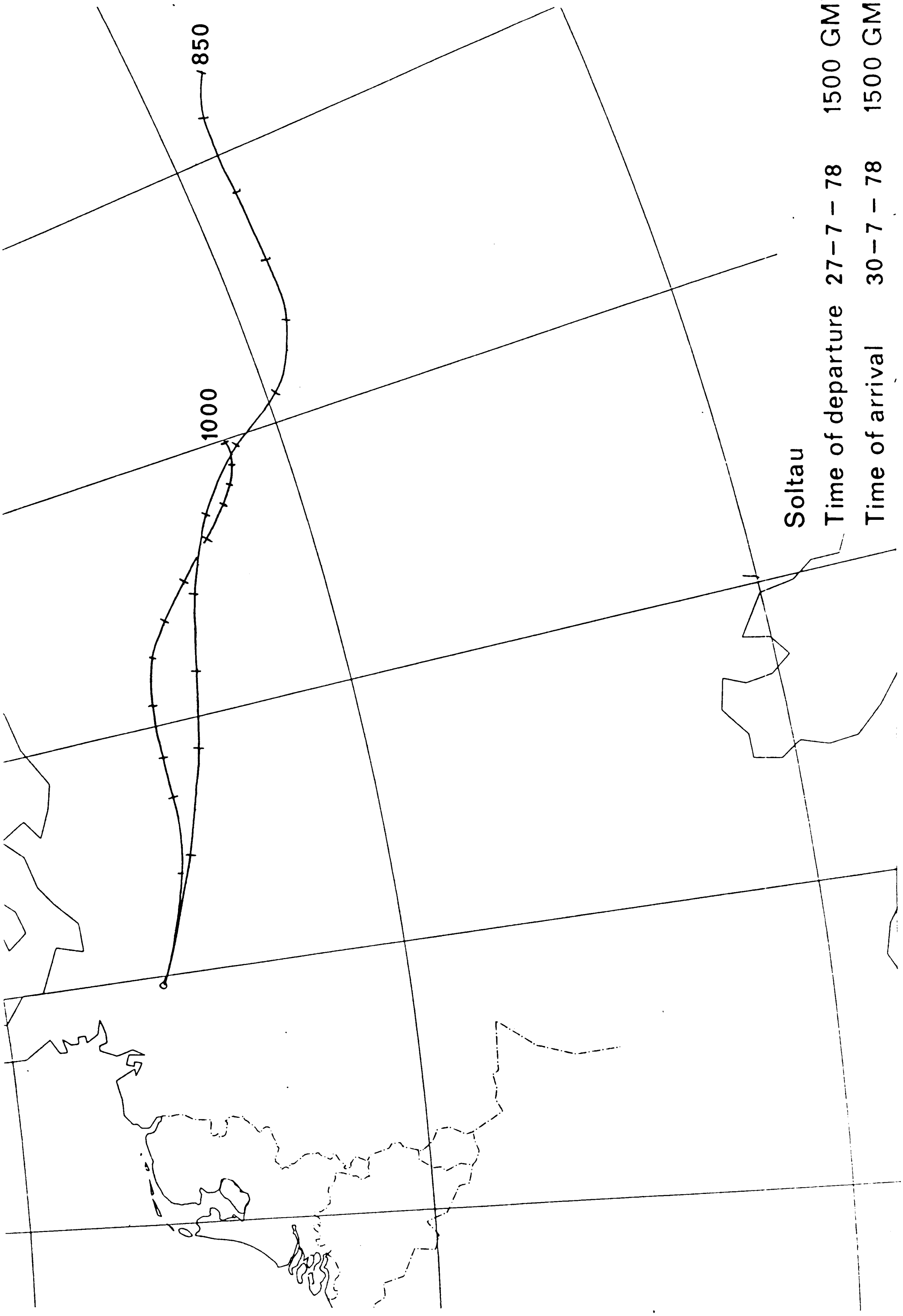

1000
850
S
Soissons
Time of departure 27 – 7 – 78 1500 GMT
Time of arrival 30 – 7 – 78 1500 GMT

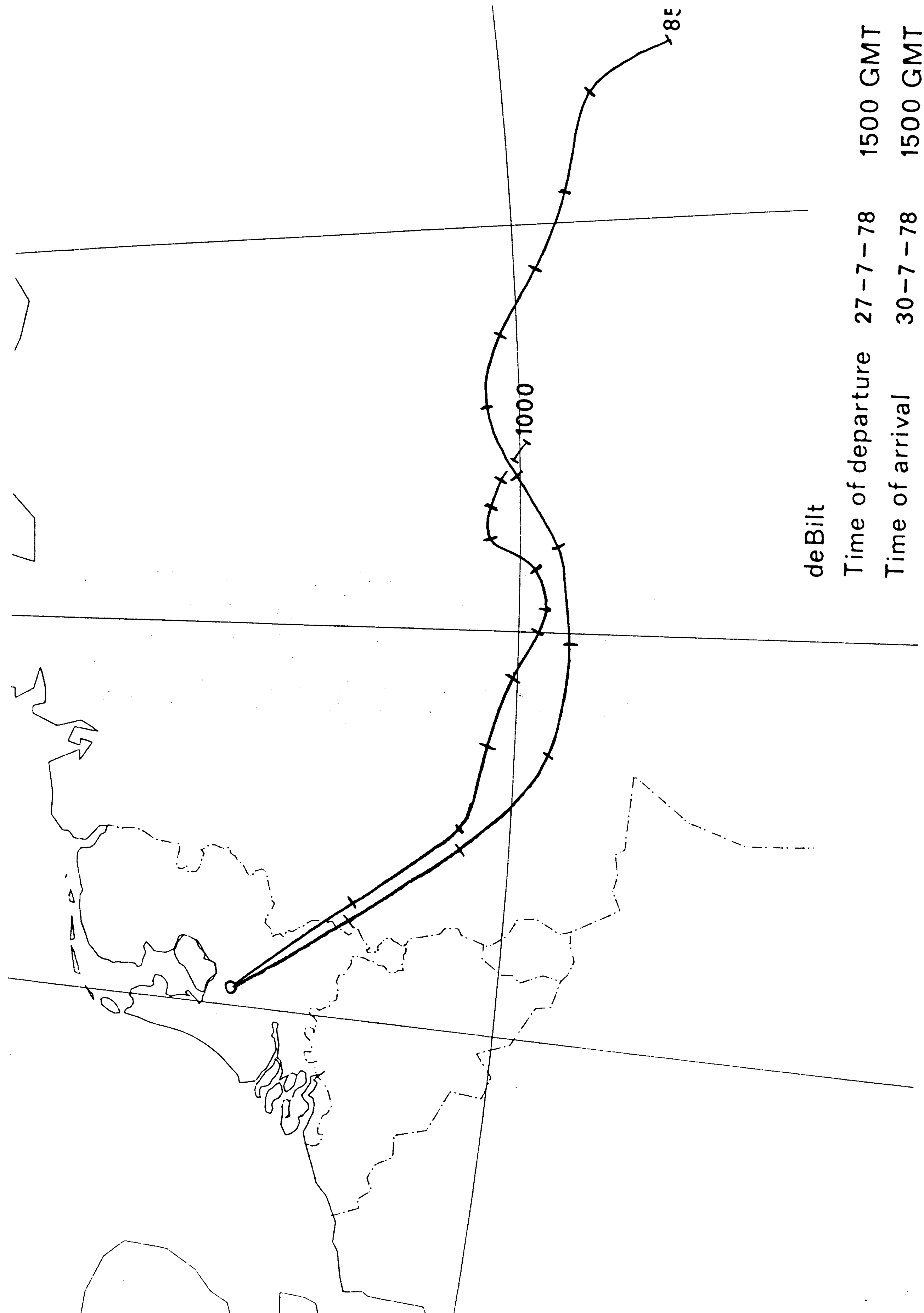


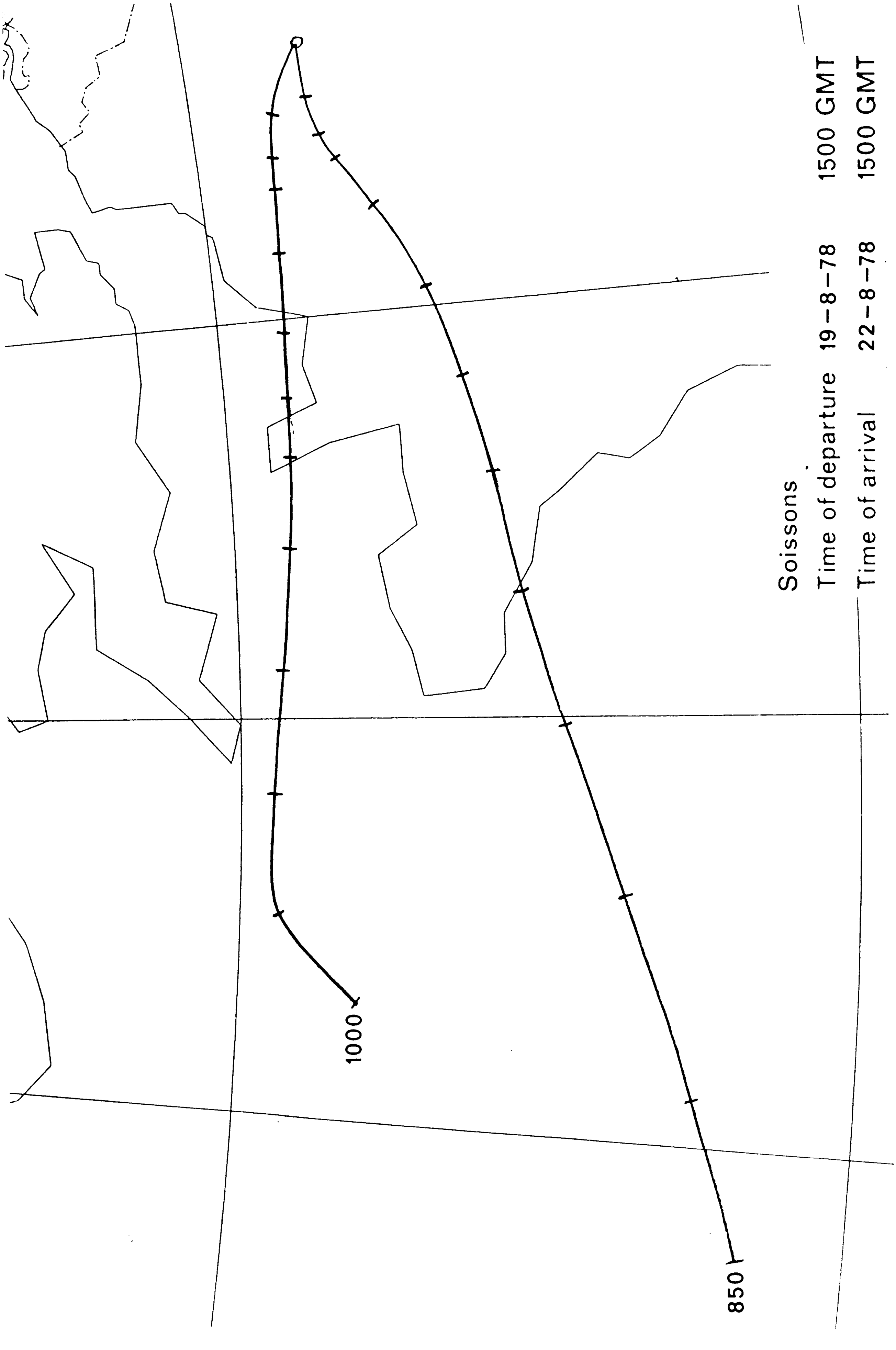
850
1000
Nancy
Time of departure 27 – 7 – 78 1500 GMT
Time of arrival 30 – 7 – 78 1500 GMT

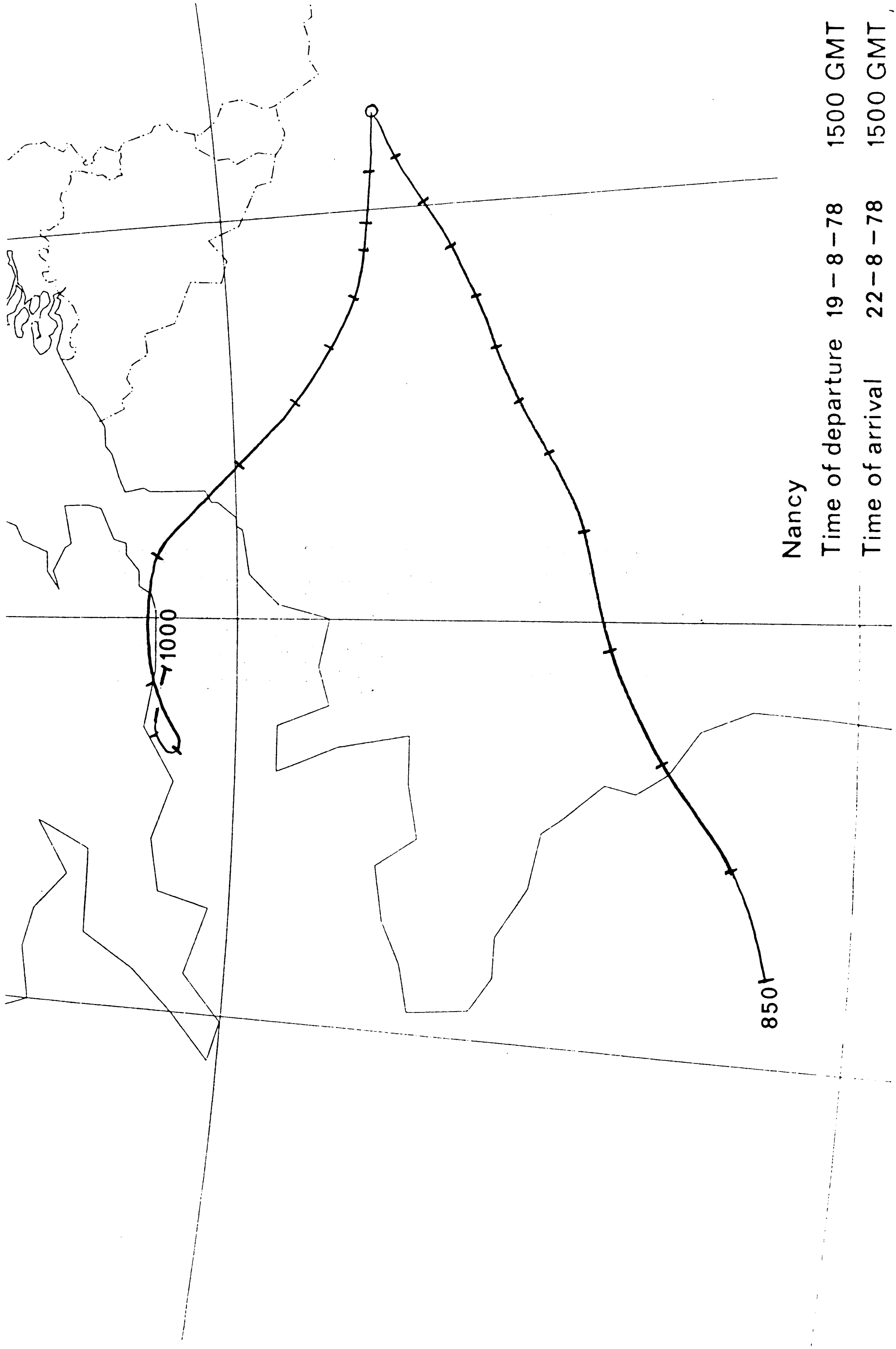


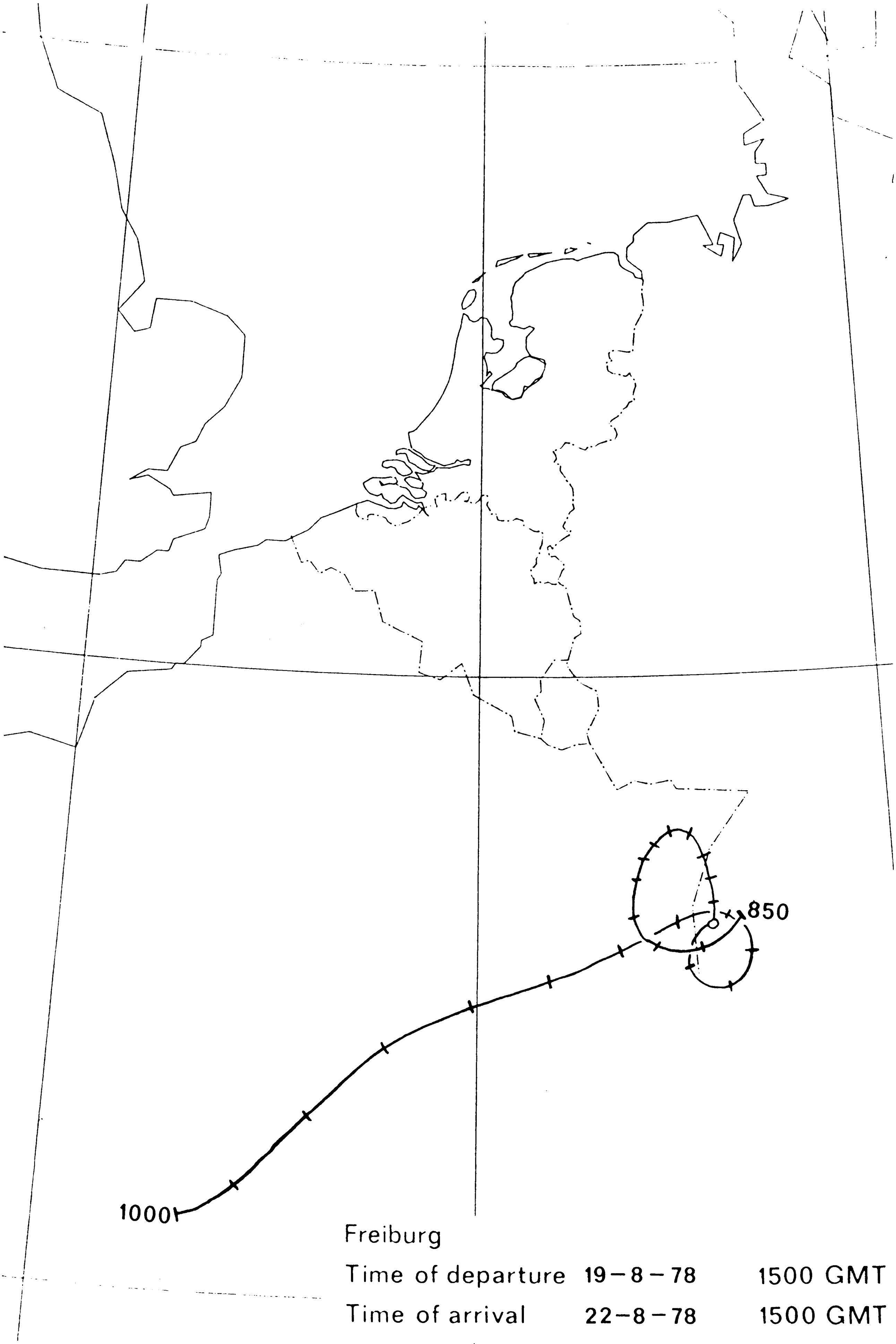
850
1000
15
15
50
10
10
Freiburg
Time of departure 27 – 7 – 78 1500 GMT
Time of arrival 30 – 7 – 78 1500 GMT


850
1000
Soltau
Time of departure 27-7-78 1500 GMT
Time of arrival 30-7-78 1500 GMT


85
1000
deBilt
Time of departure 27-7-78 1500 GMT
Time of arrival 30-7-78 1500 GMT


Soissons
Time of departure 19-8-78 1500 GMT
Time of arrival 22-8-78 1500 GMT
1000
850

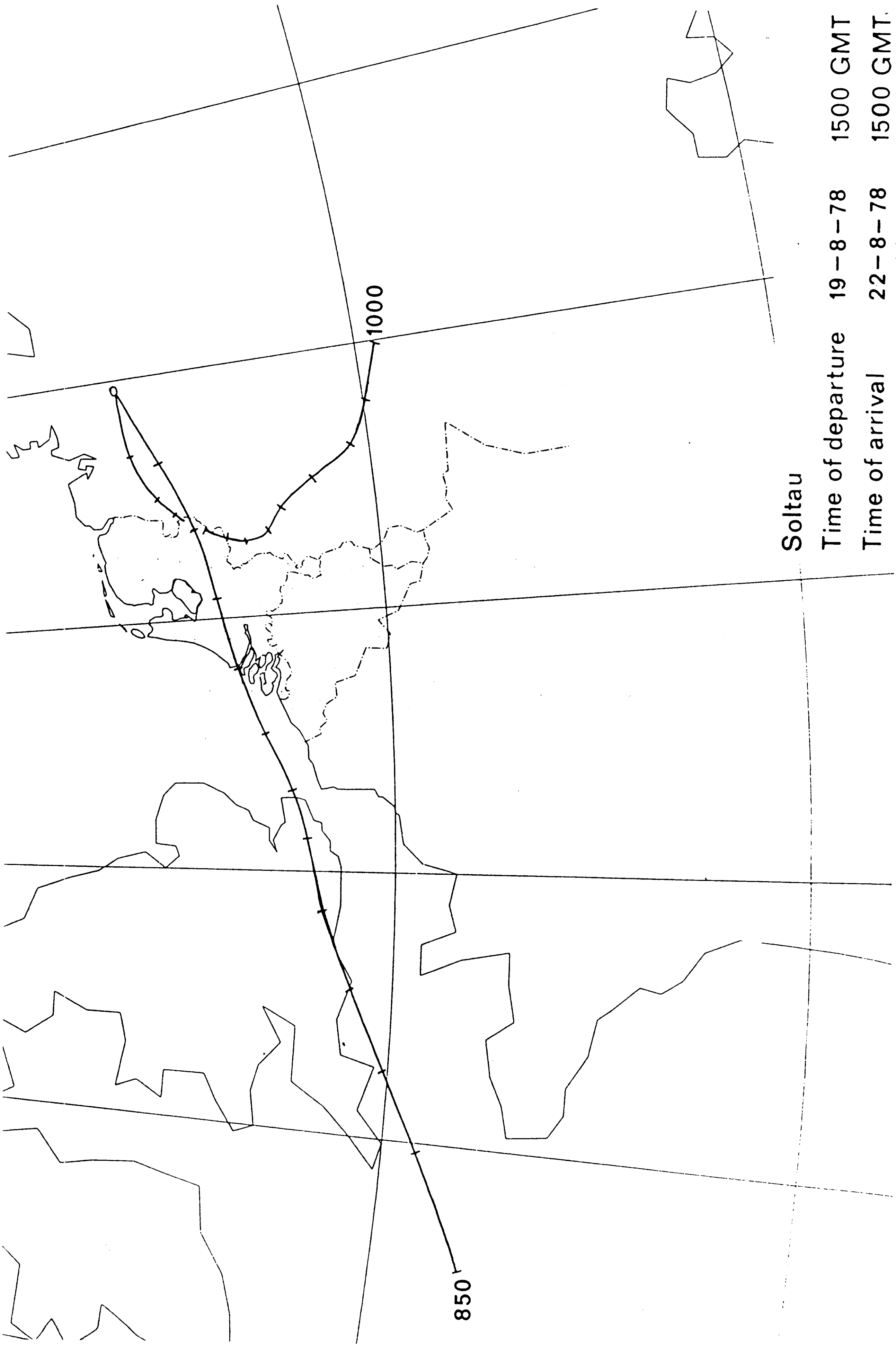

Nancy
Time of departure 19 – 8 – 78 1500 GMT
Time of arrival 22 – 8 – 78 1500 GMT
1000
850

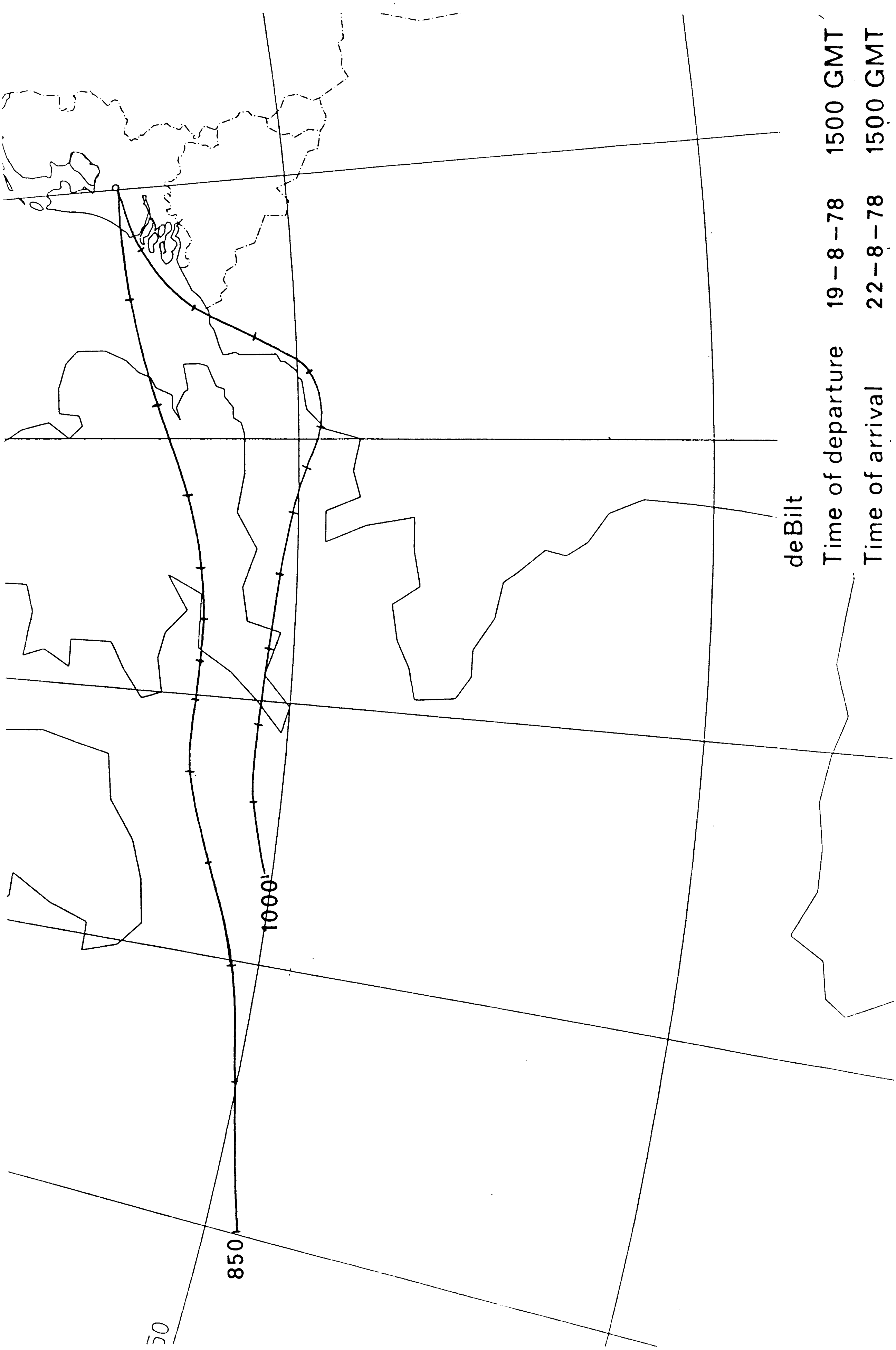


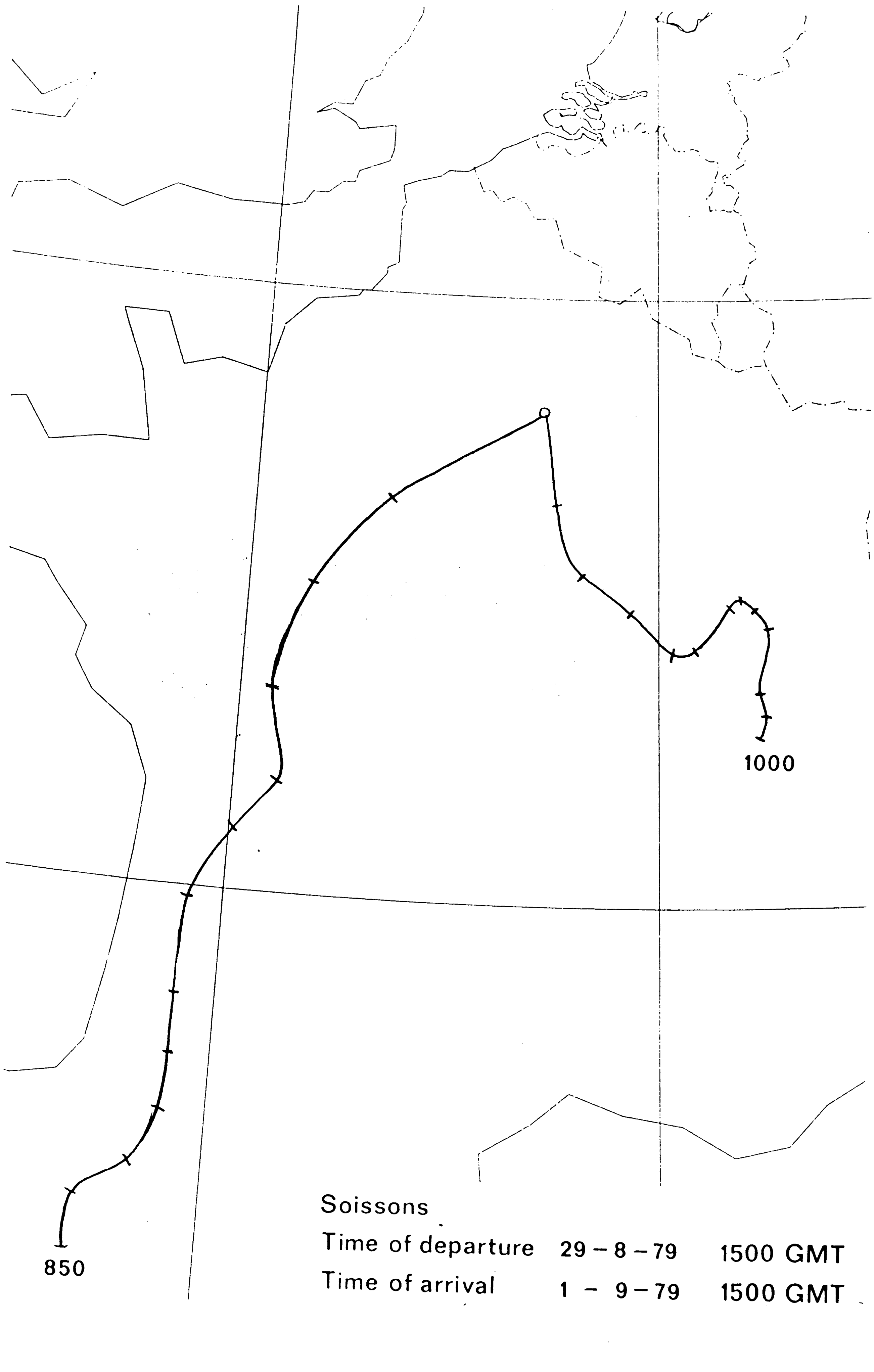
Freiburg

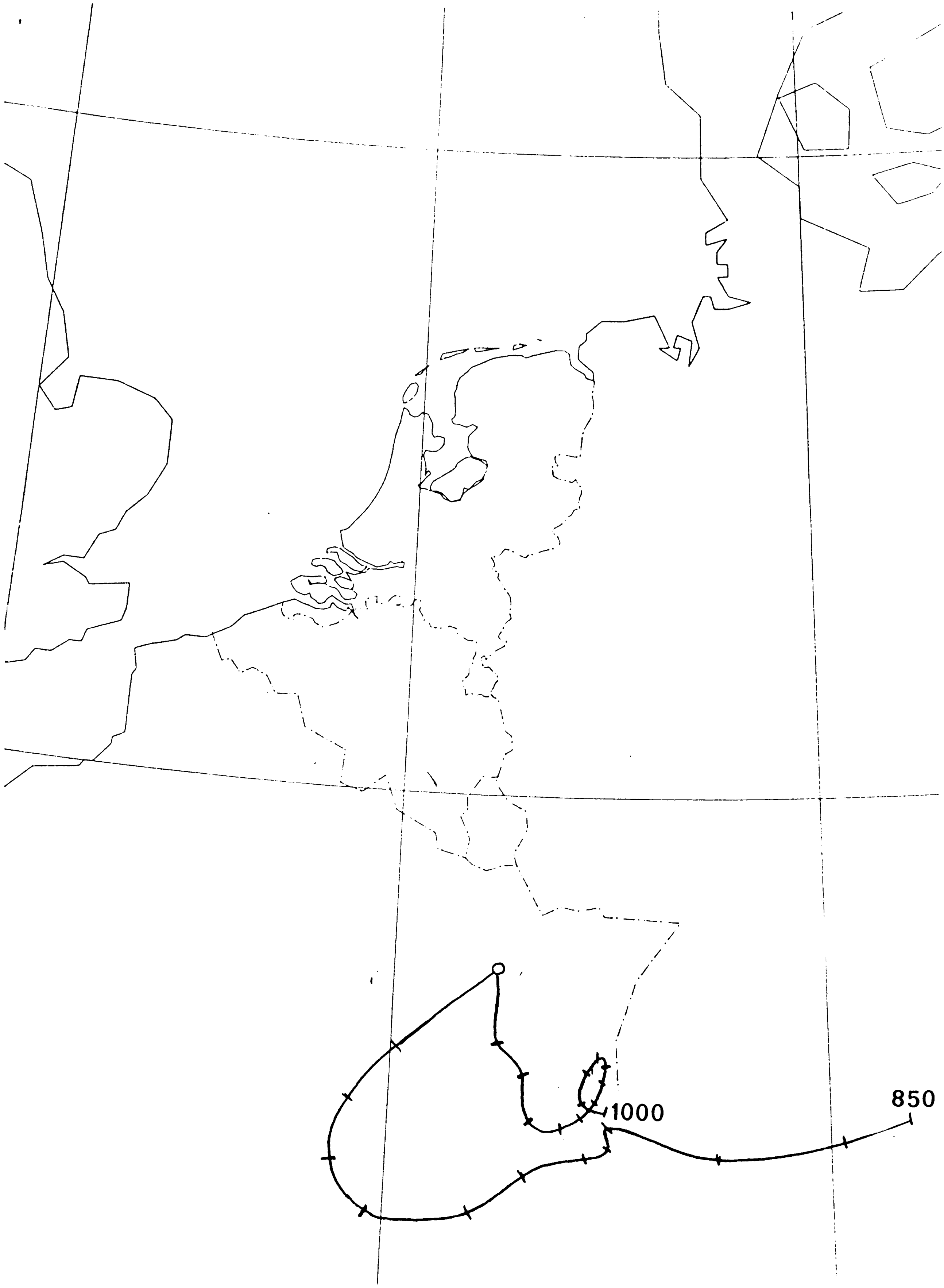
Time of departure 19–8–78 1500 GMT

Time of arrival 22–8–78 1500 GMT


1000
850
Soltau
Time of departure 19 – 8 – 78 1500 GMT
Time of arrival 22 – 8 – 78 1500 GMT.


de Bilt
Time of departure 19 – 8 – 78 1500 GMT
Time of arrival 22 – 8 – 78 1500 GMT
1000
850

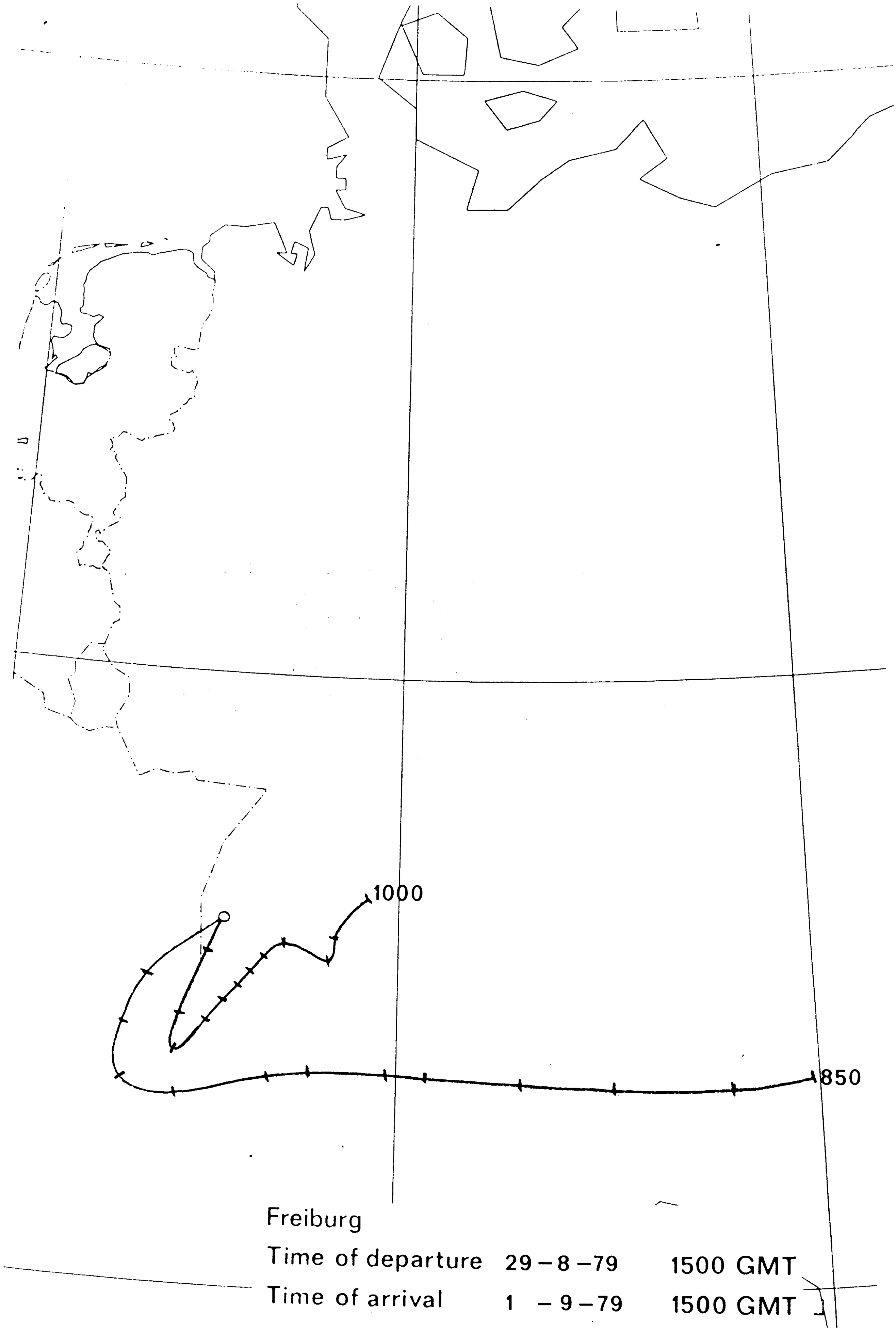

1000
850
Soissons
Time of departure 29 – 8 – 79 1500 GMT
Time of arrival 1 – 9 – 79 1500 GMT



Nancy

Time of departure 29-8-79 1500 GMT

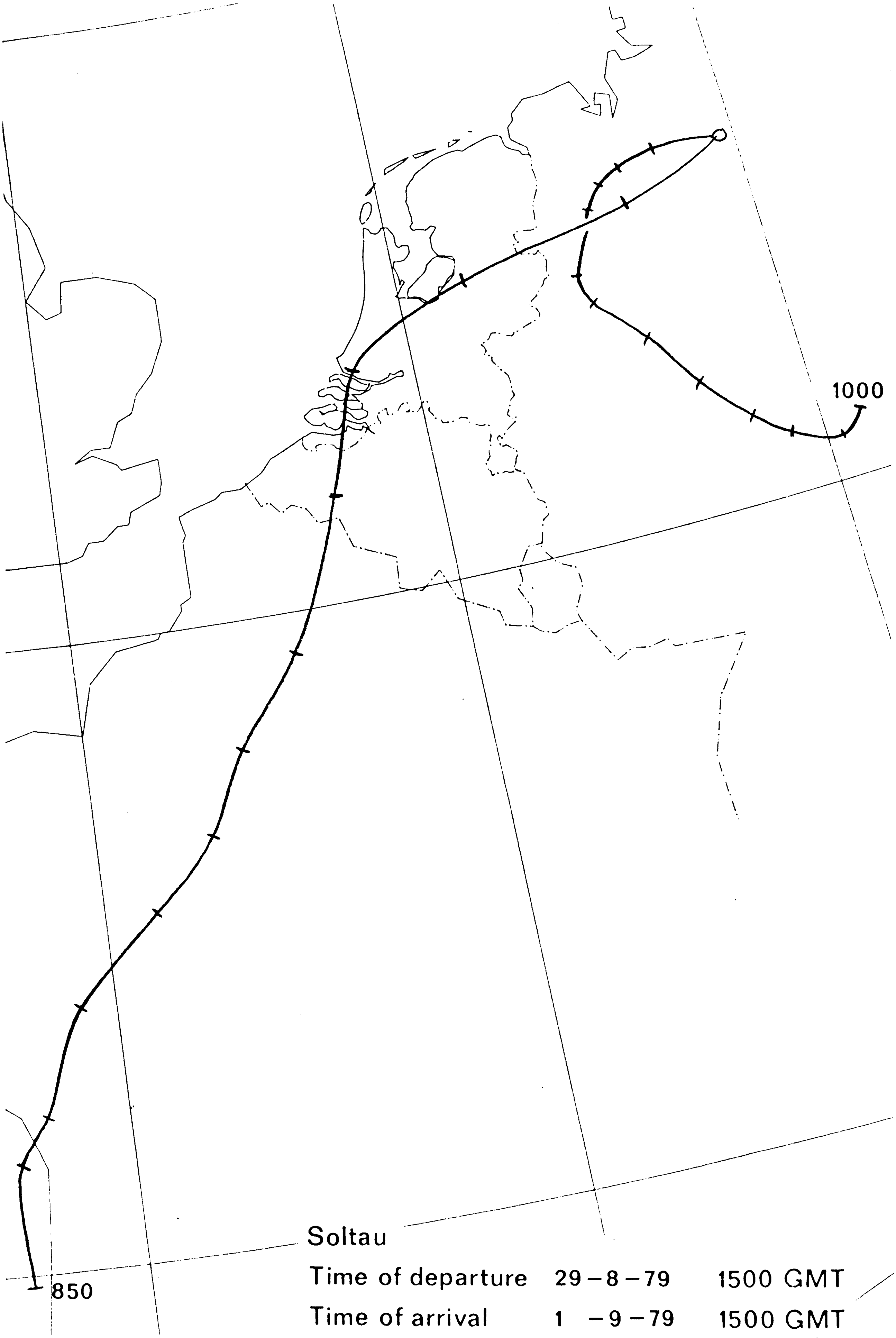
Time of arrival 1 -9-79 1500 GMT



Freiburg

Time of departure 29-8-79 1500 GMT

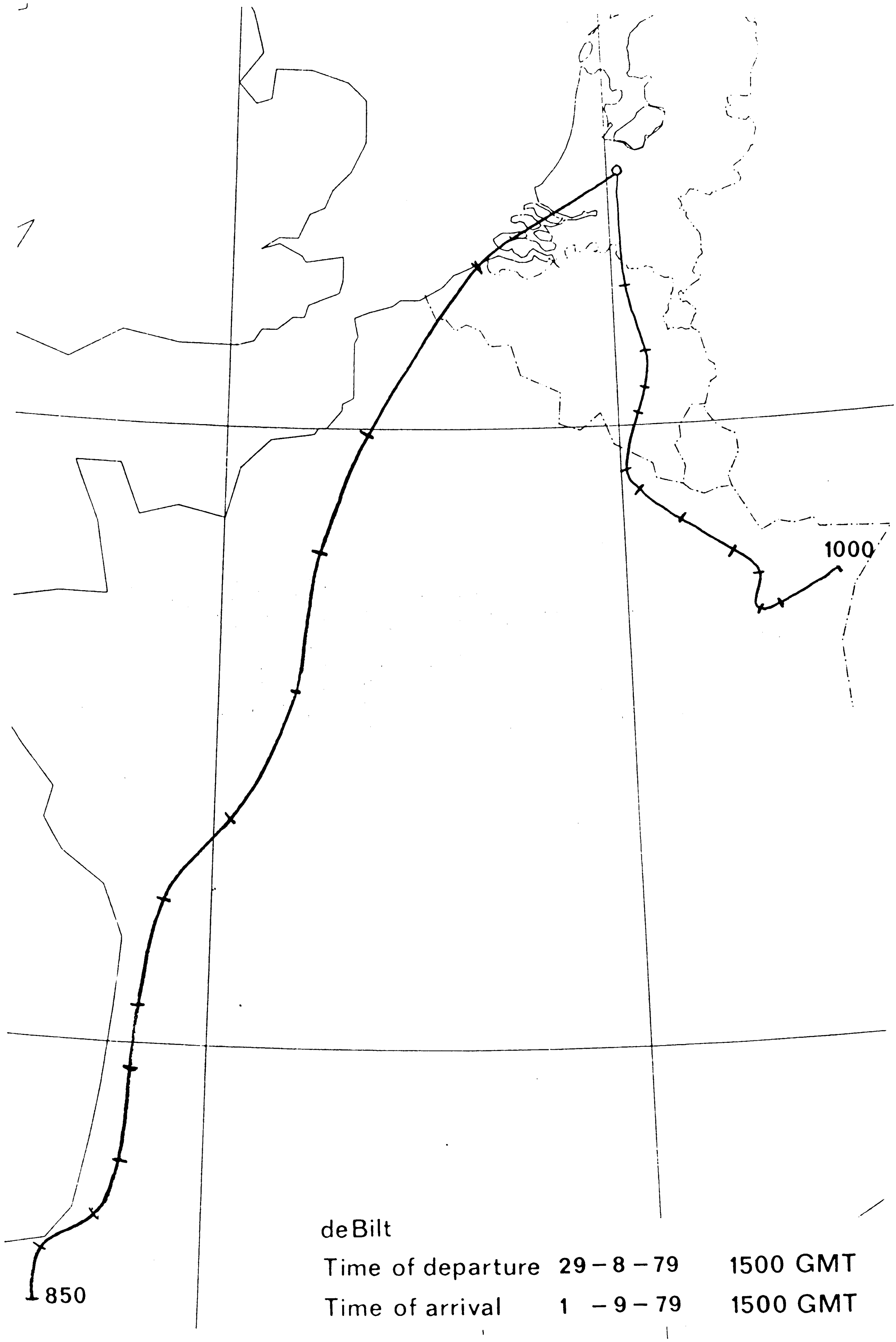
Time of arrival 1 -9-79 1500 GMT



Soltau

Time of departure 29-8-79 1500 GMT

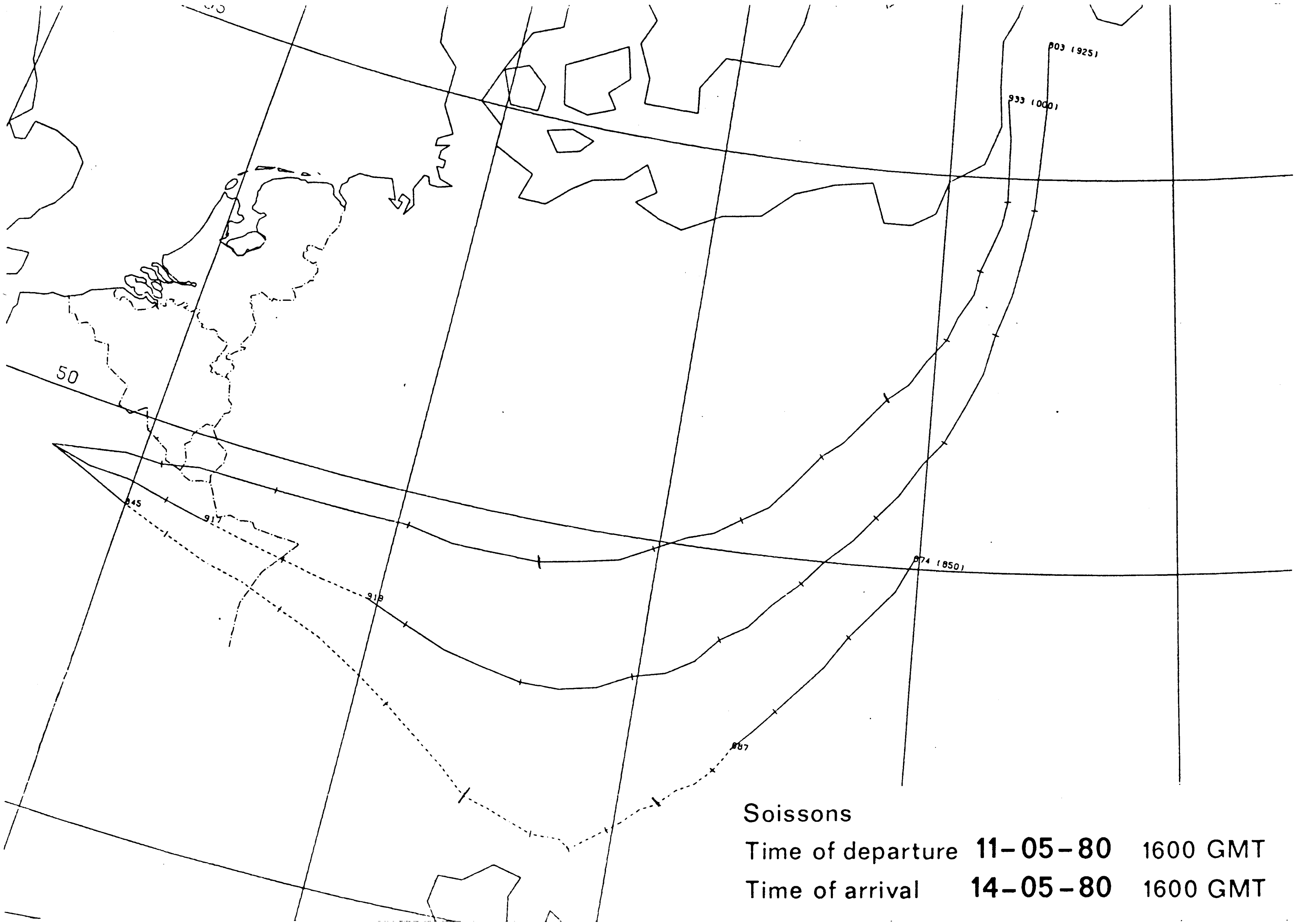
Time of arrival 1 -9-79 1500 GMT

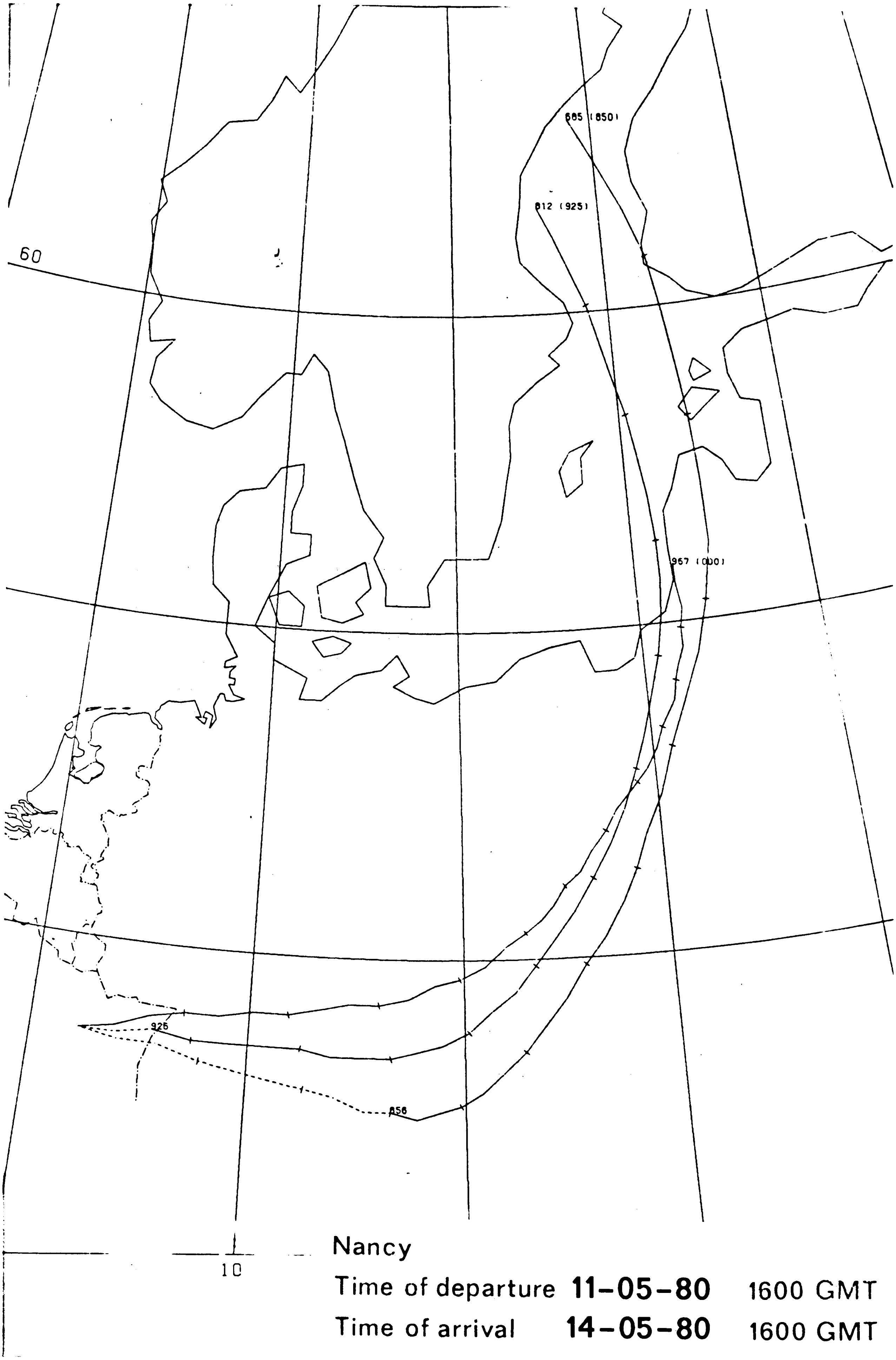


deBilt

Time of departure 29 – 8 – 79 1500 GMT

Time of arrival 1 – 9 – 79 1500 GMT


803 (925)
933 (1000)
874 (850)
887
919
917
845
50
Soissons
Time of departure 11-05-80 1600 GMT
Time of arrival 14-05-80 1600 GMT



Nancy

Time of departure **11-05-80** 1600 GMT

Time of arrival **14-05-80** 1600 GMT

Freiburg

Time of departure **11-05-80** 1600 GMT

Time of arrival **14-05-80** 1600 GMT

Soltau

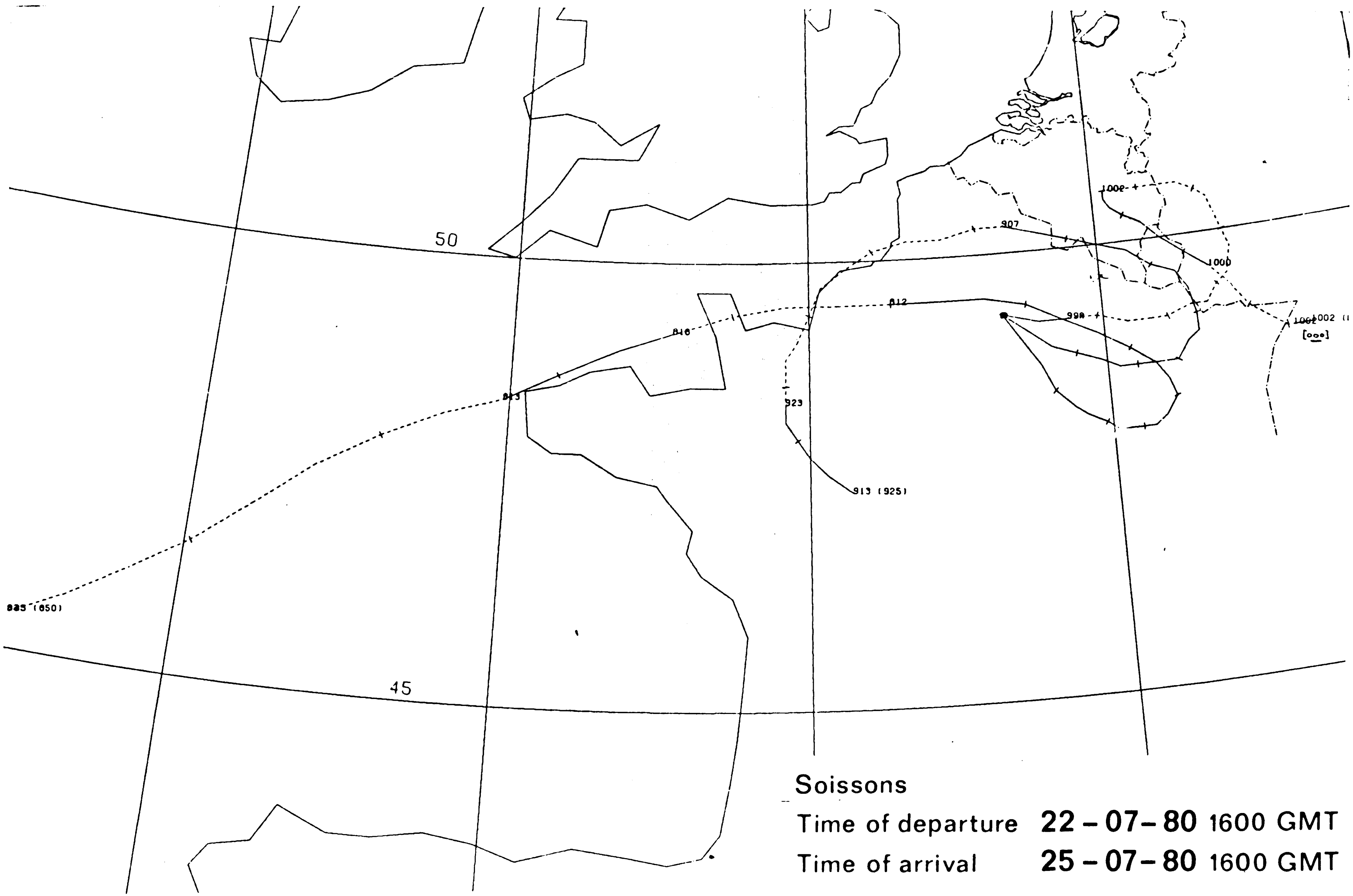
Time of departure **11-05-80** 1600 GMT

Time of arrival **14-05-80** 1600 GMT

de Bilt

Time of departure **11-05-80** 1600 GMT

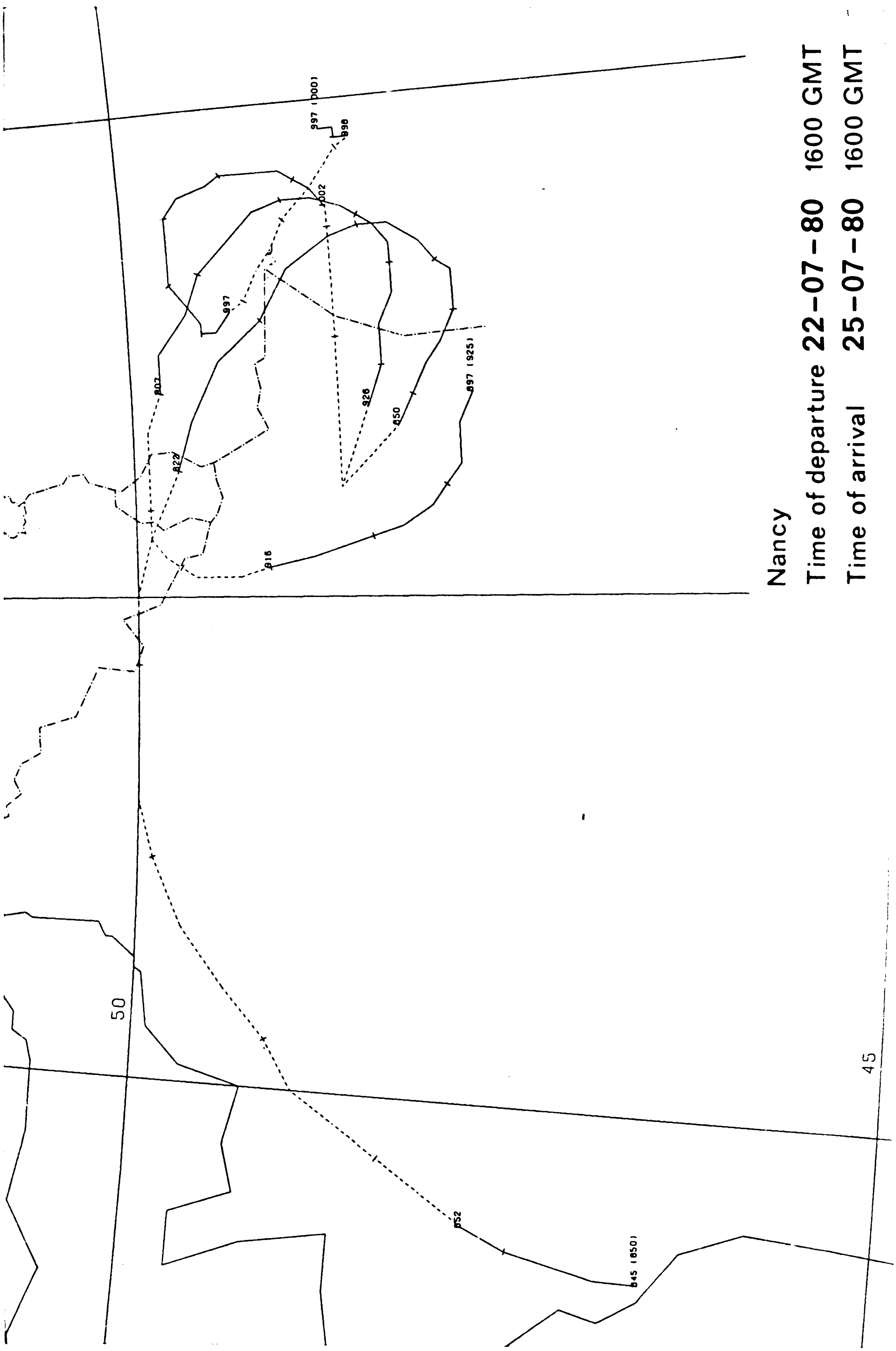
Time of arrival **14-05-80** 1600 GMT

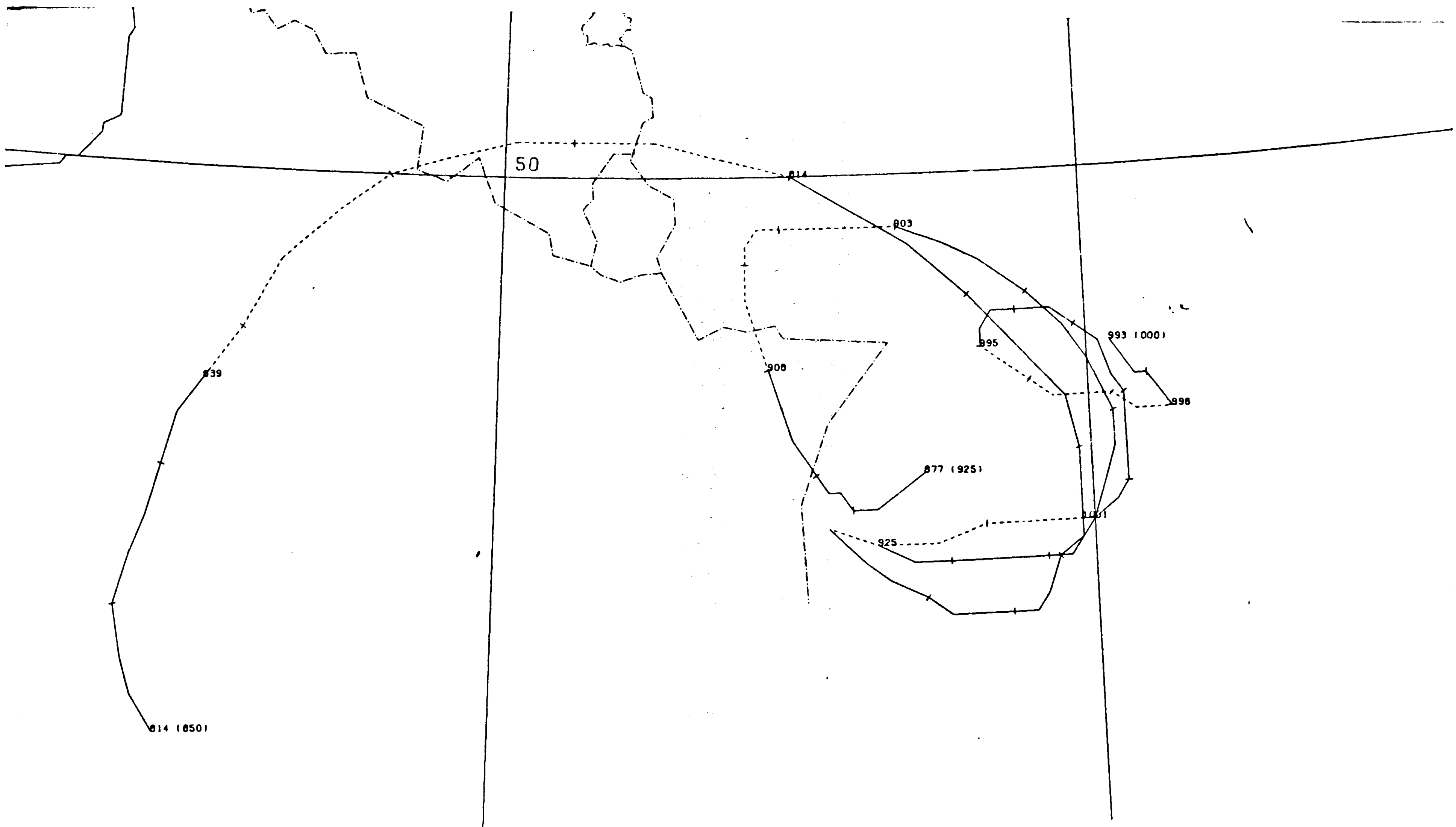


Soissons

Time of departure **22 - 07 - 80** 1600 GMT

Time of arrival **25 - 07 - 80** 1600 GMT

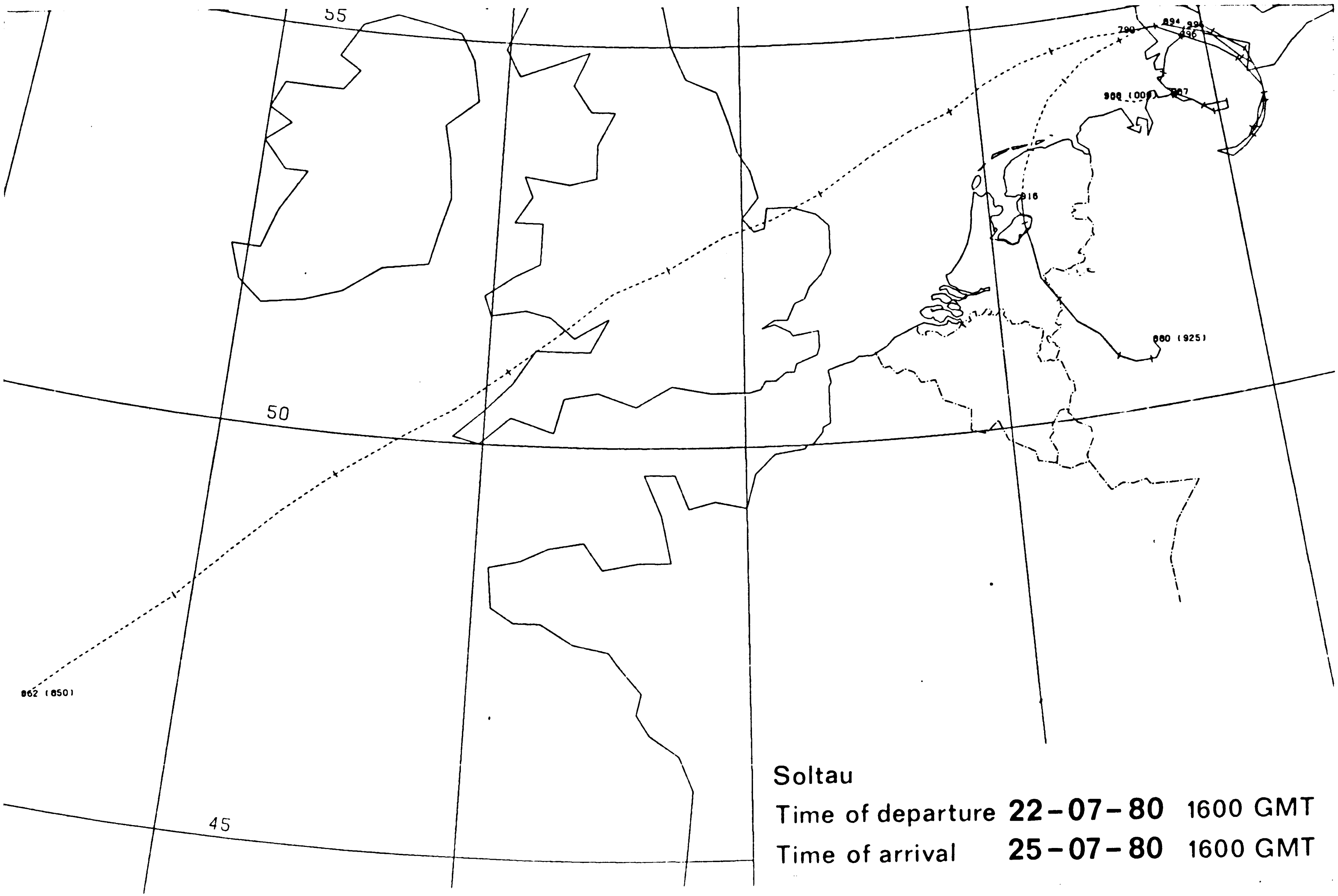

Nancy
Time of departure 22-07-80 1600 GMT
Time of arrival 25-07-80 1600 GMT
50
45



Freiburg

Time of departure **22-07-80** 1600 GMT

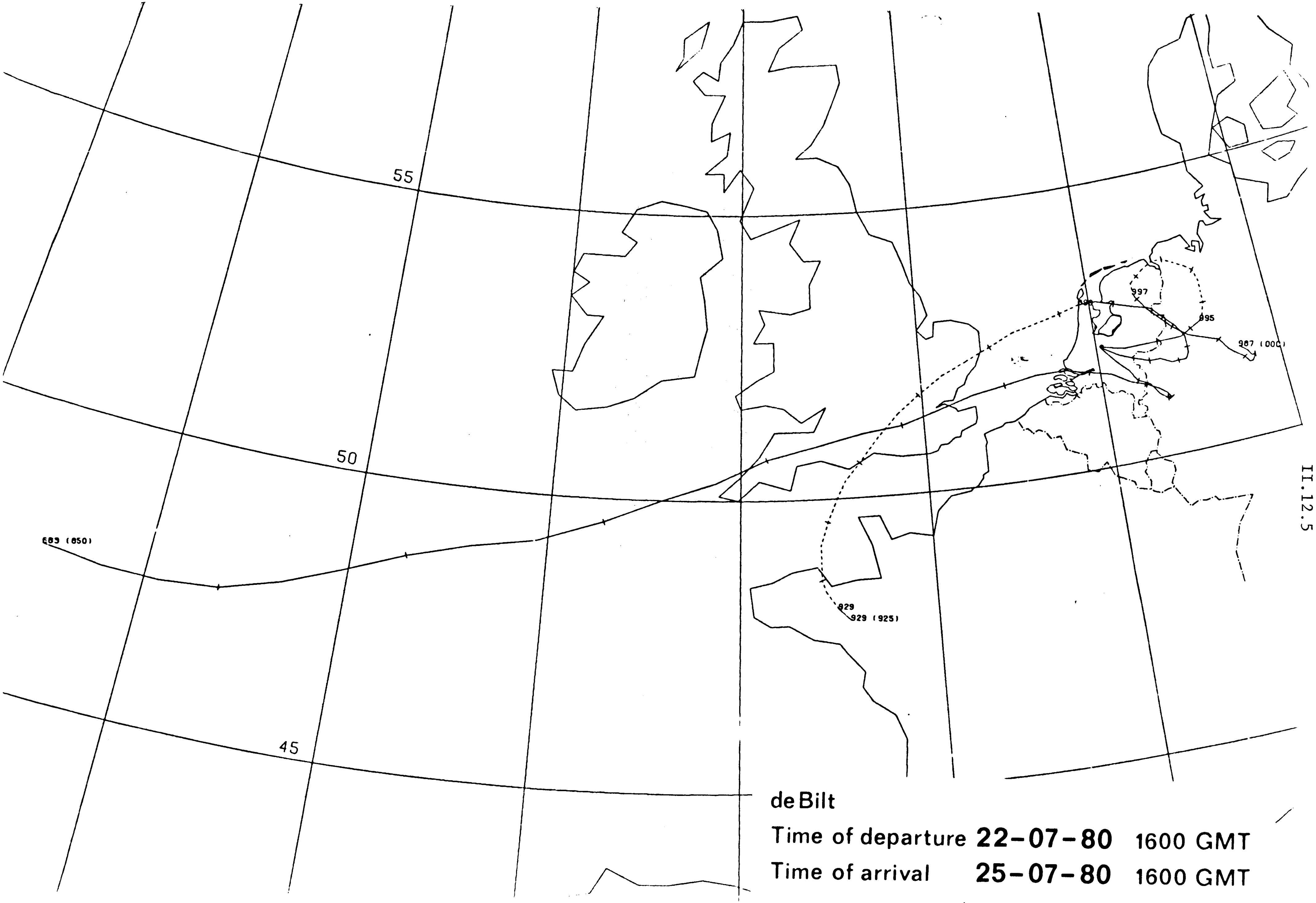
Time of arrival **25-07-80** 1600 GMT



Soltau

Time of departure **22-07-80** 1600 GMT

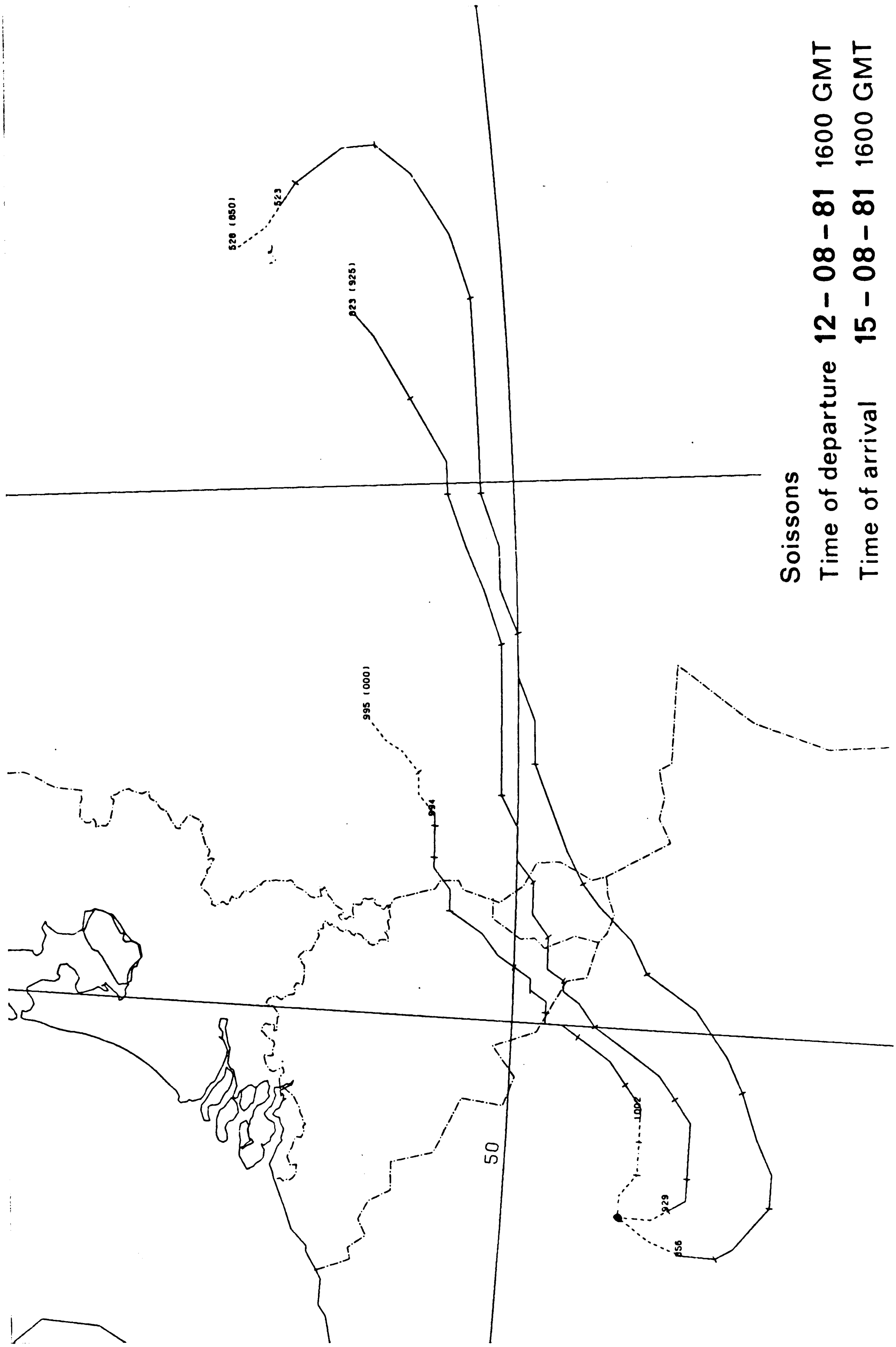
Time of arrival **25-07-80** 1600 GMT

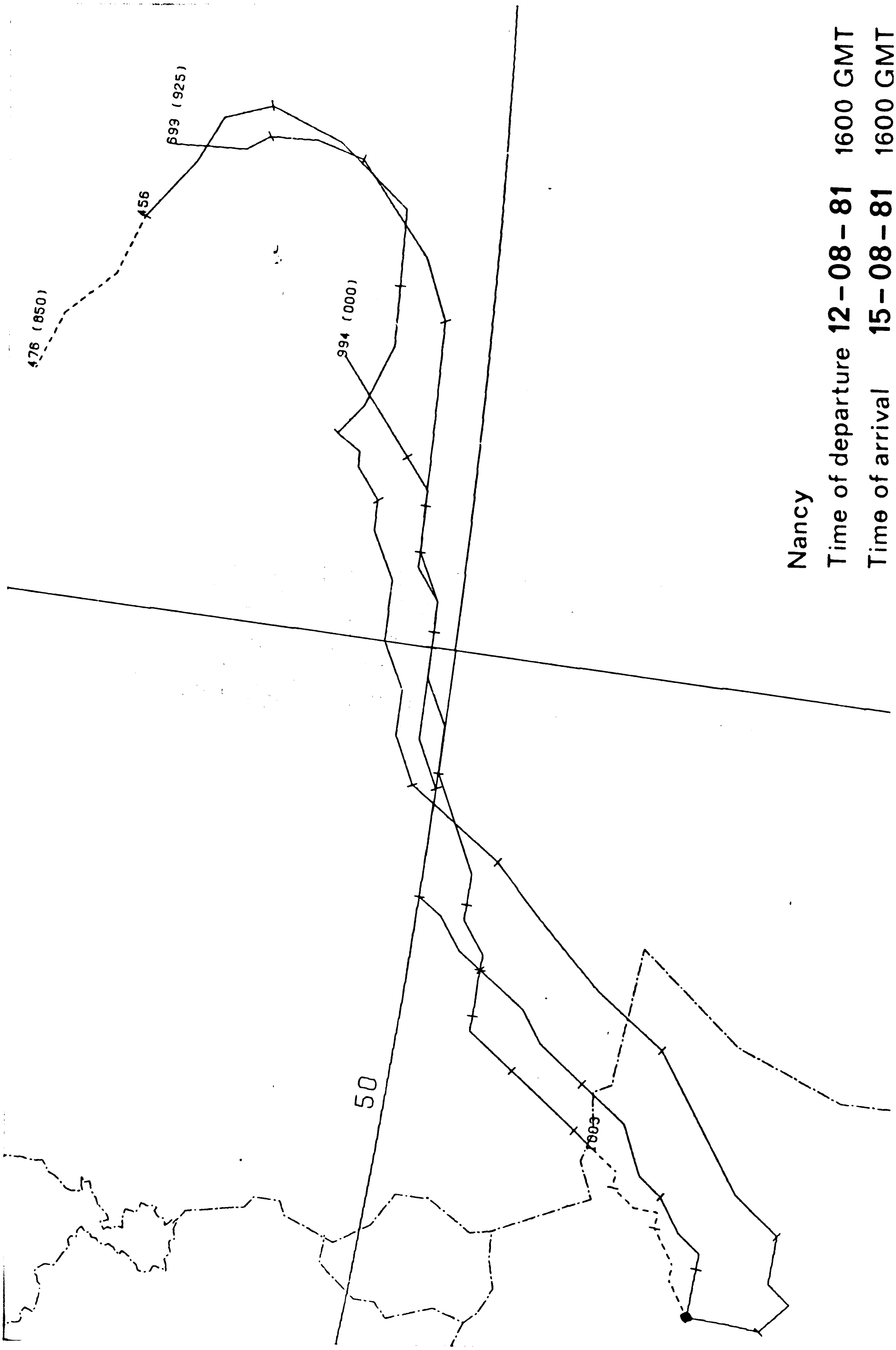


de Bilt

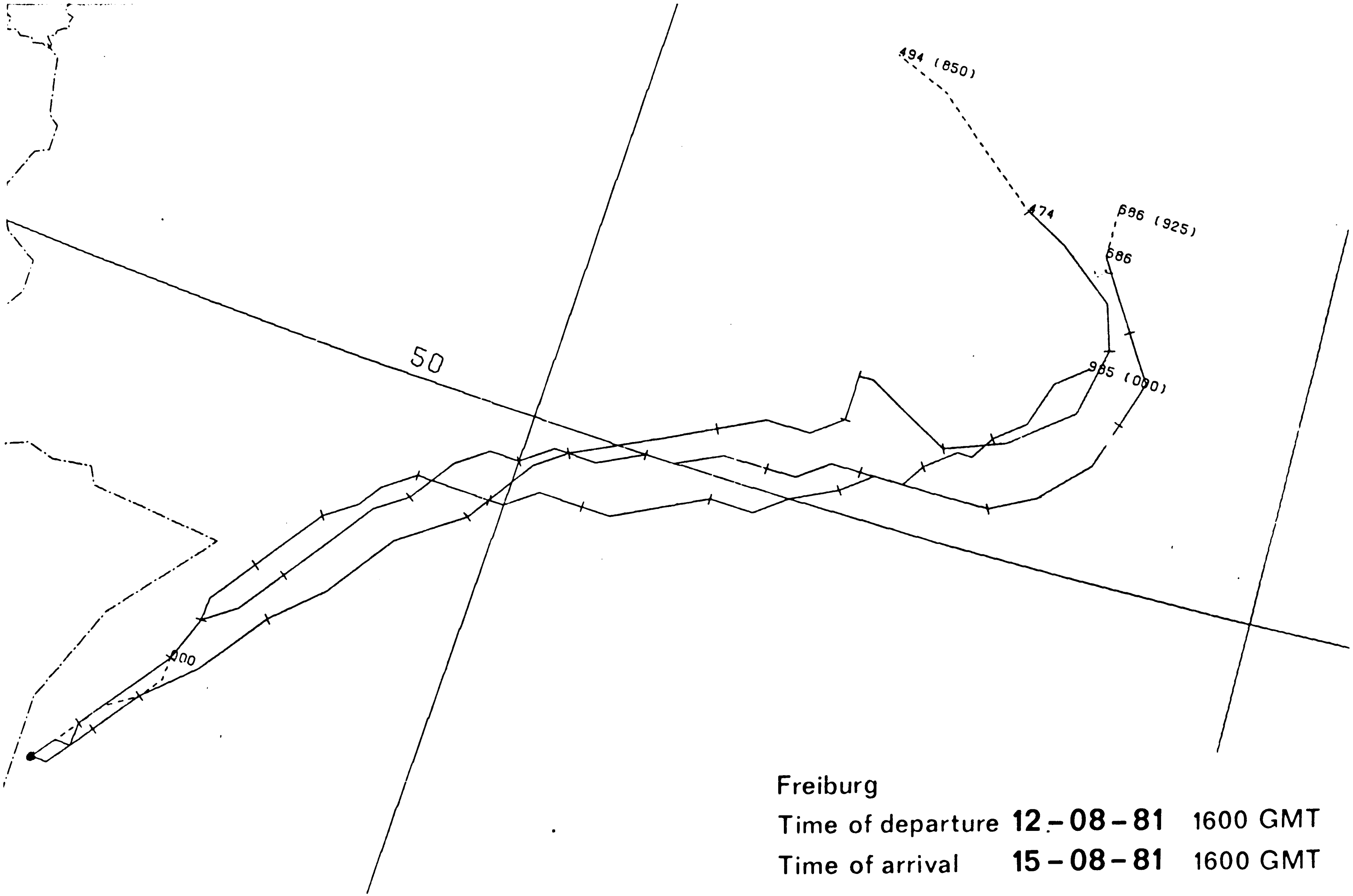
Time of departure **22-07-80** 1600 GMT

Time of arrival **25-07-80** 1600 GMT


Soissons
Time of departure 12 - 08 - 81 1600 GMT
Time of arrival 15 - 08 - 81 1600 GMT
528 (850)
523
823 (925)
995 (000)
994
1002
929
856
50



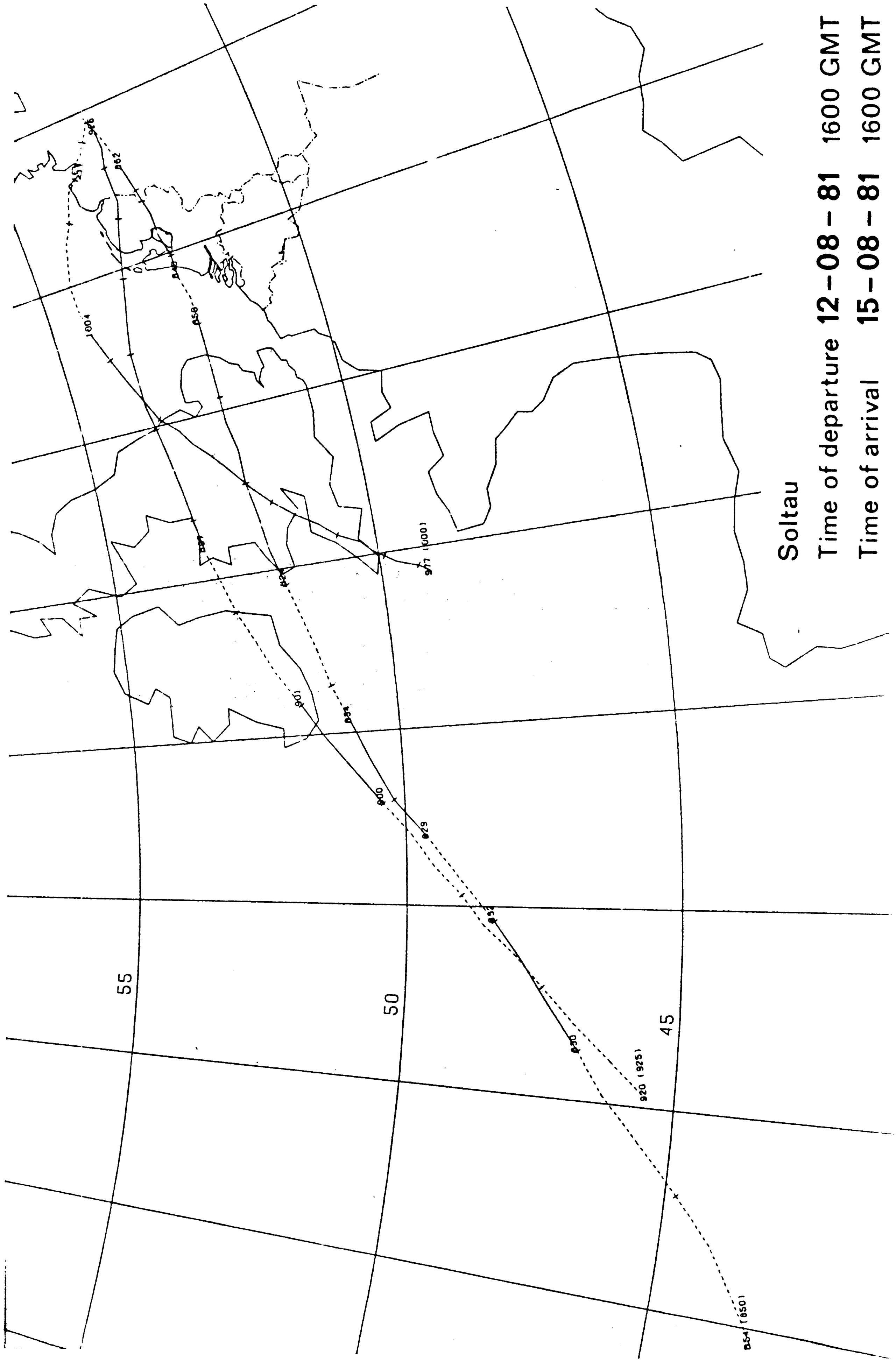
Nancy
Time of departure 12-08-81 1600 GMT
Time of arrival 15-08-81 1600 GMT
693 (925)
456
476 (850)
994 (000)
50
1003



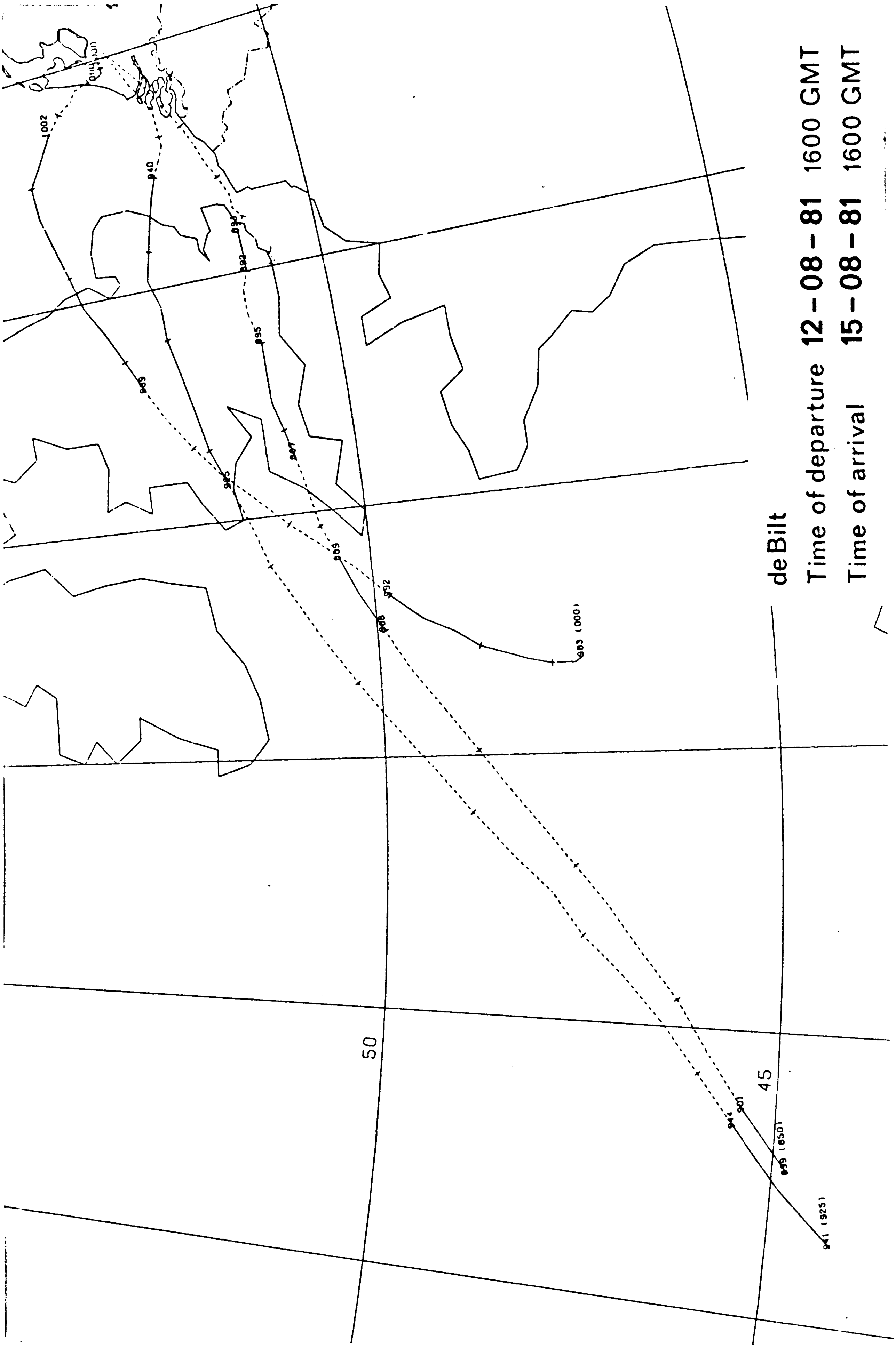
Freiburg

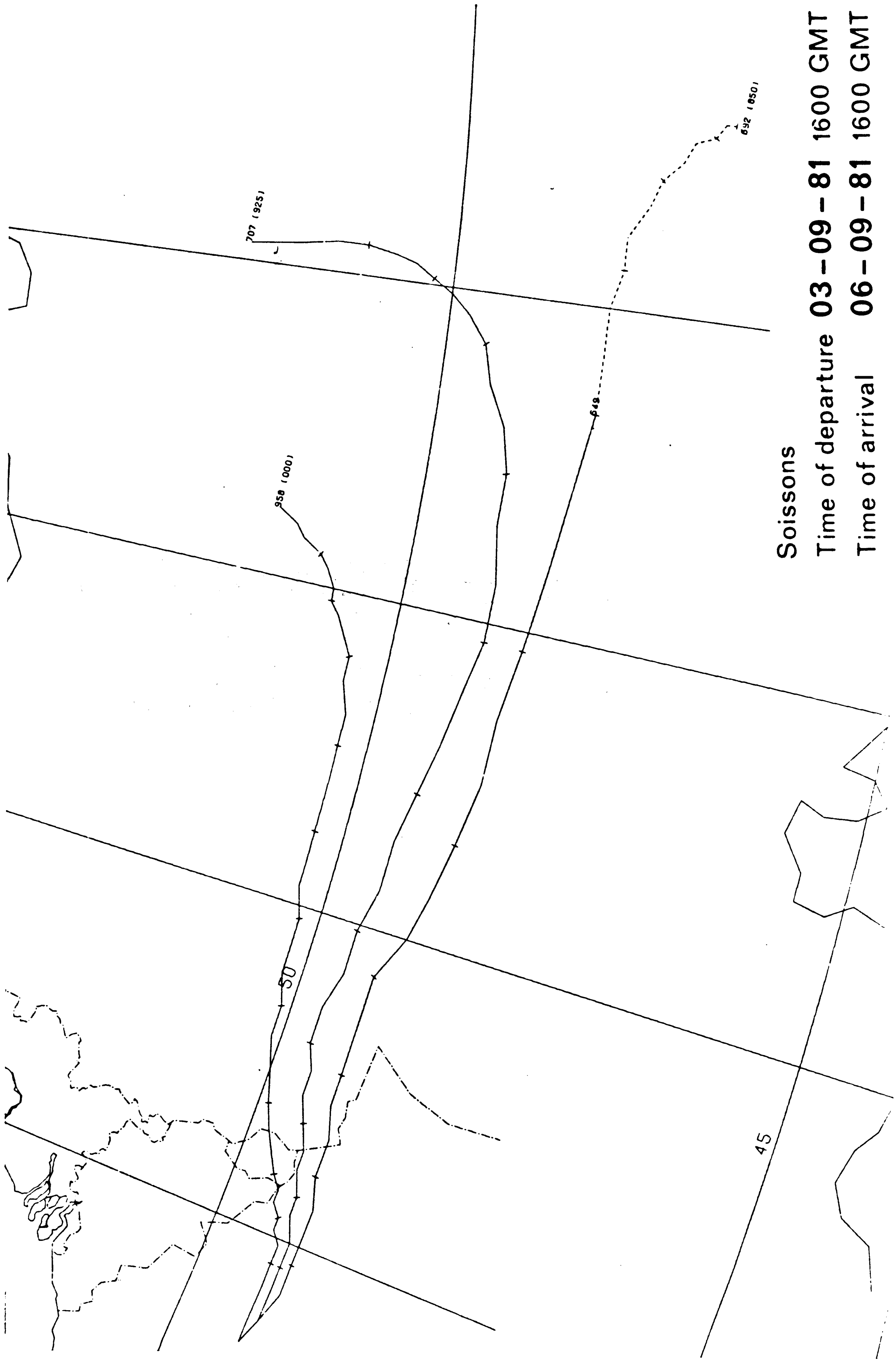
Time of departure **12-08-81** 1600 GMT

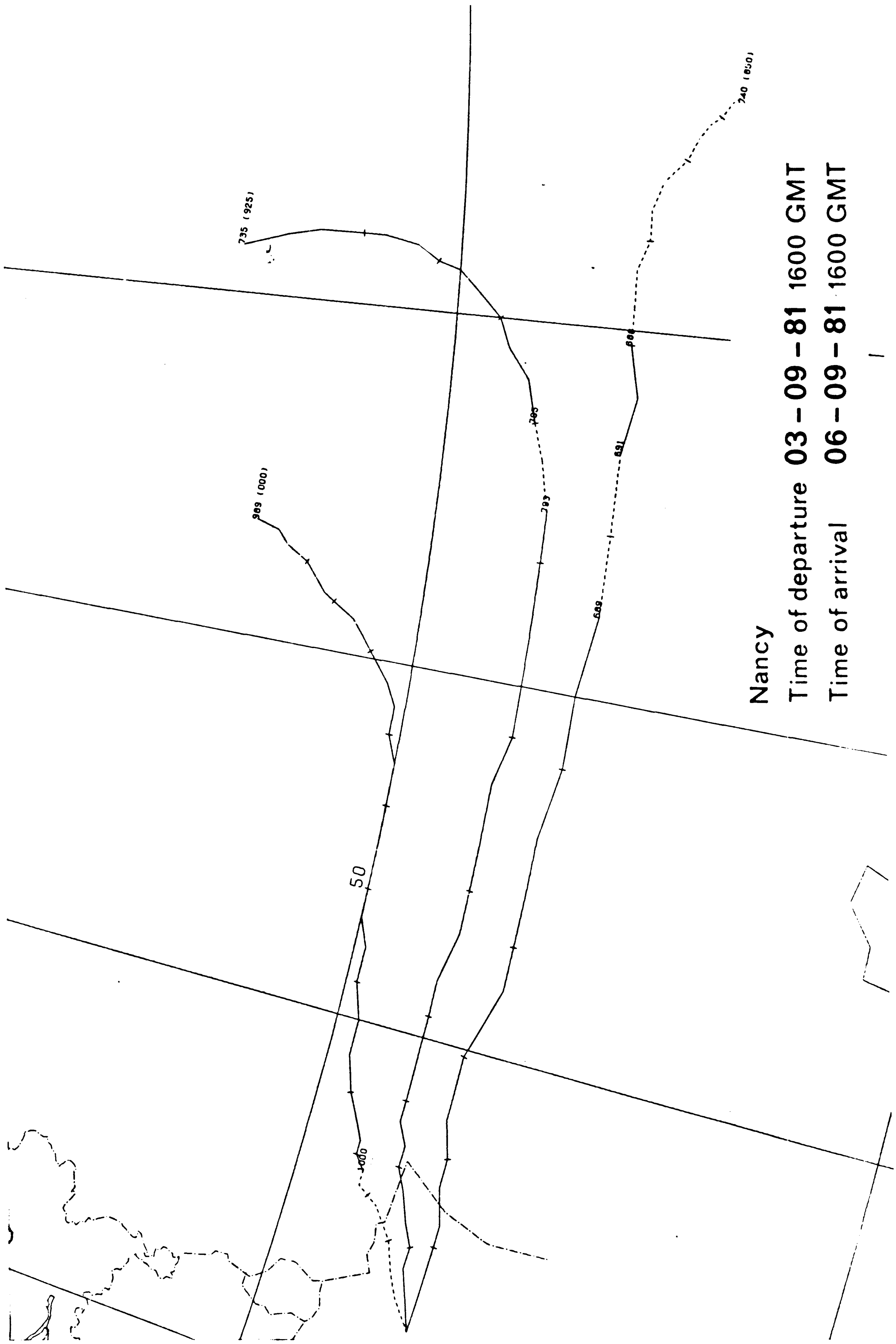
Time of arrival **15-08-81** 1600 GMT

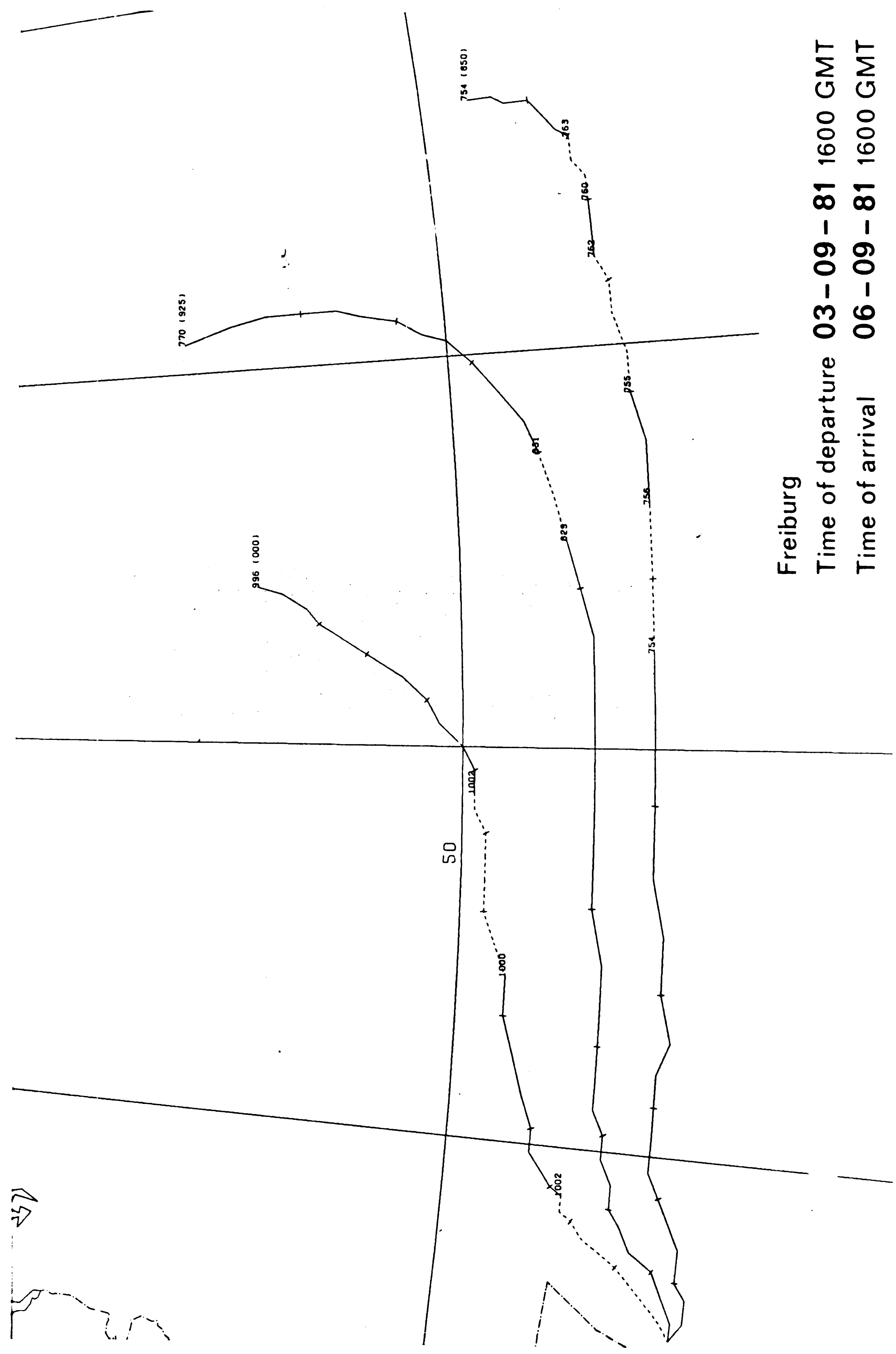


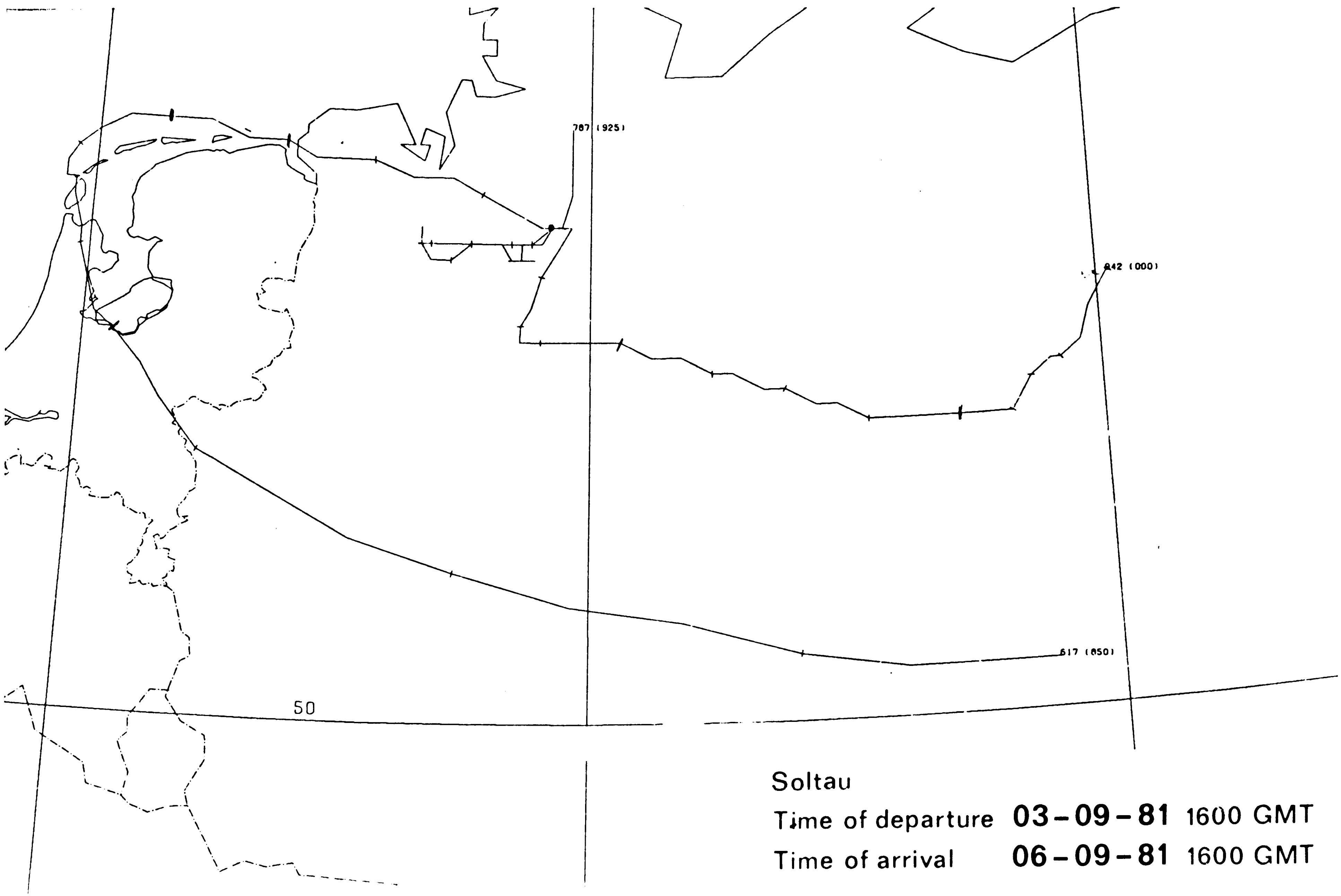
Soltau
Time of departure **12 - 08 - 81** 1600 GMT
Time of arrival **15 - 08 - 81** 1600 GMT


de Bilt
Time of departure 12-08-81 1600 GMT
Time of arrival 15-08-81 1600 GMT
50
45


Soissons
Time of departure 03-09-81 1600 GMT
Time of arrival 06-09-81 1600 GMT
707 (925)
958 (1000)
692 (850)
649
50
45


Nancy
Time of departure 03 – 09 – 81 1600 GMT
Time of arrival 06 – 09 – 81 1600 GMT
50
735 (925)
989 (000)

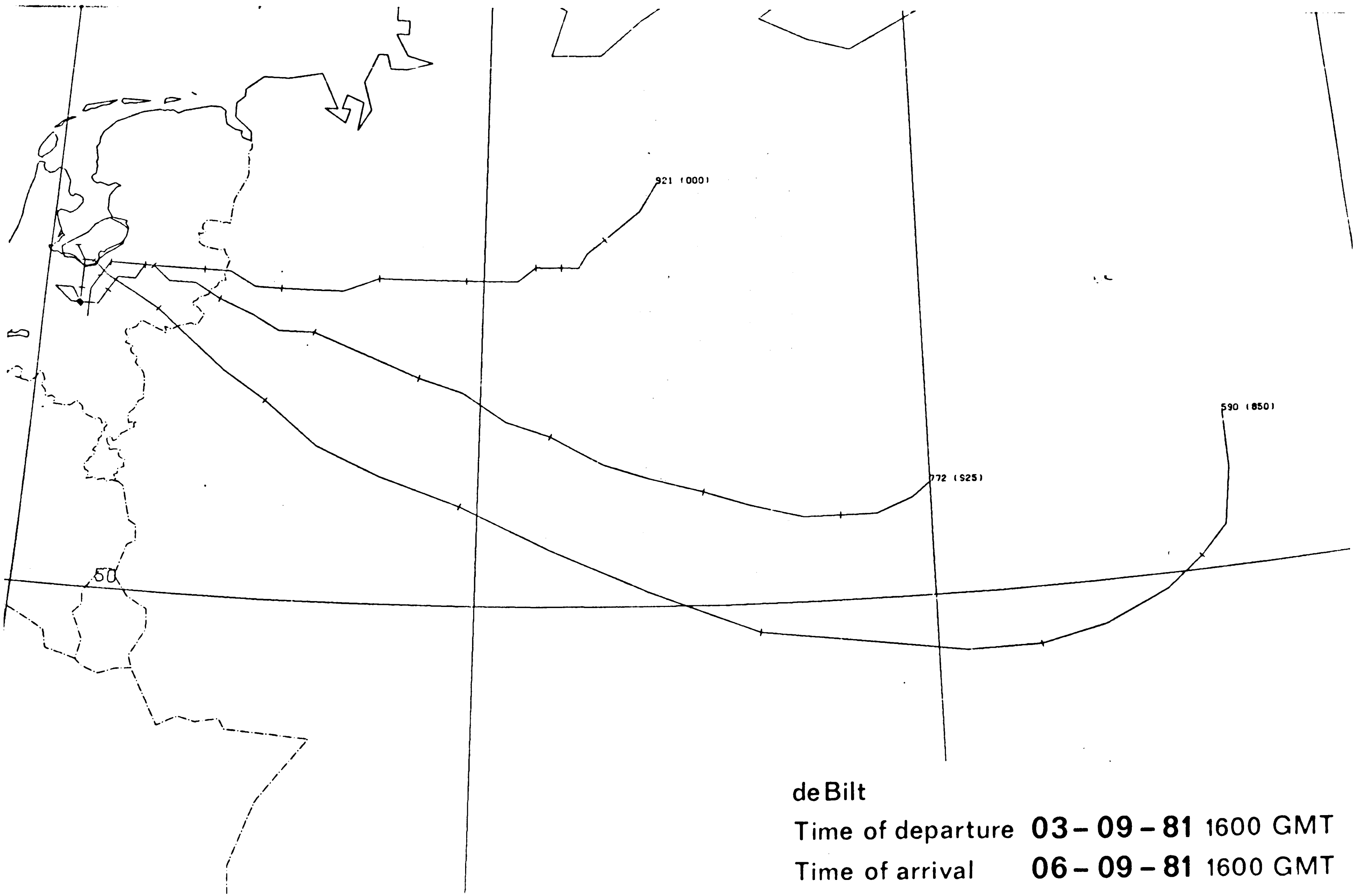

Freiburg
Time of departure 03-09-81 1600 GMT
Time of arrival 06-09-81 1600 GMT
754 (850)
770 (925)
996 (000)
50



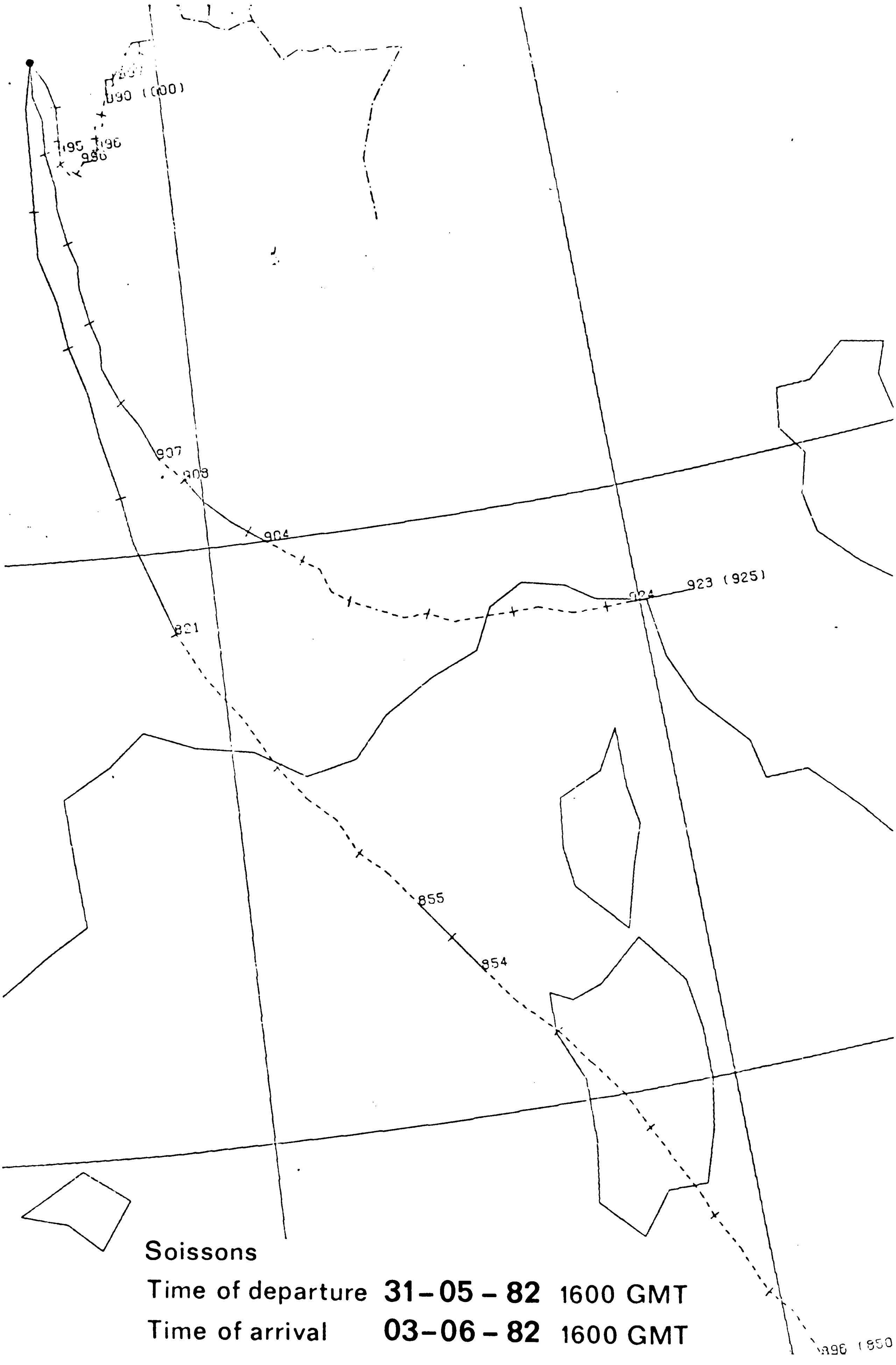
Soltau

Time of departure **03-09-81** 1600 GMT

Time of arrival **06-09-81** 1600 GMT



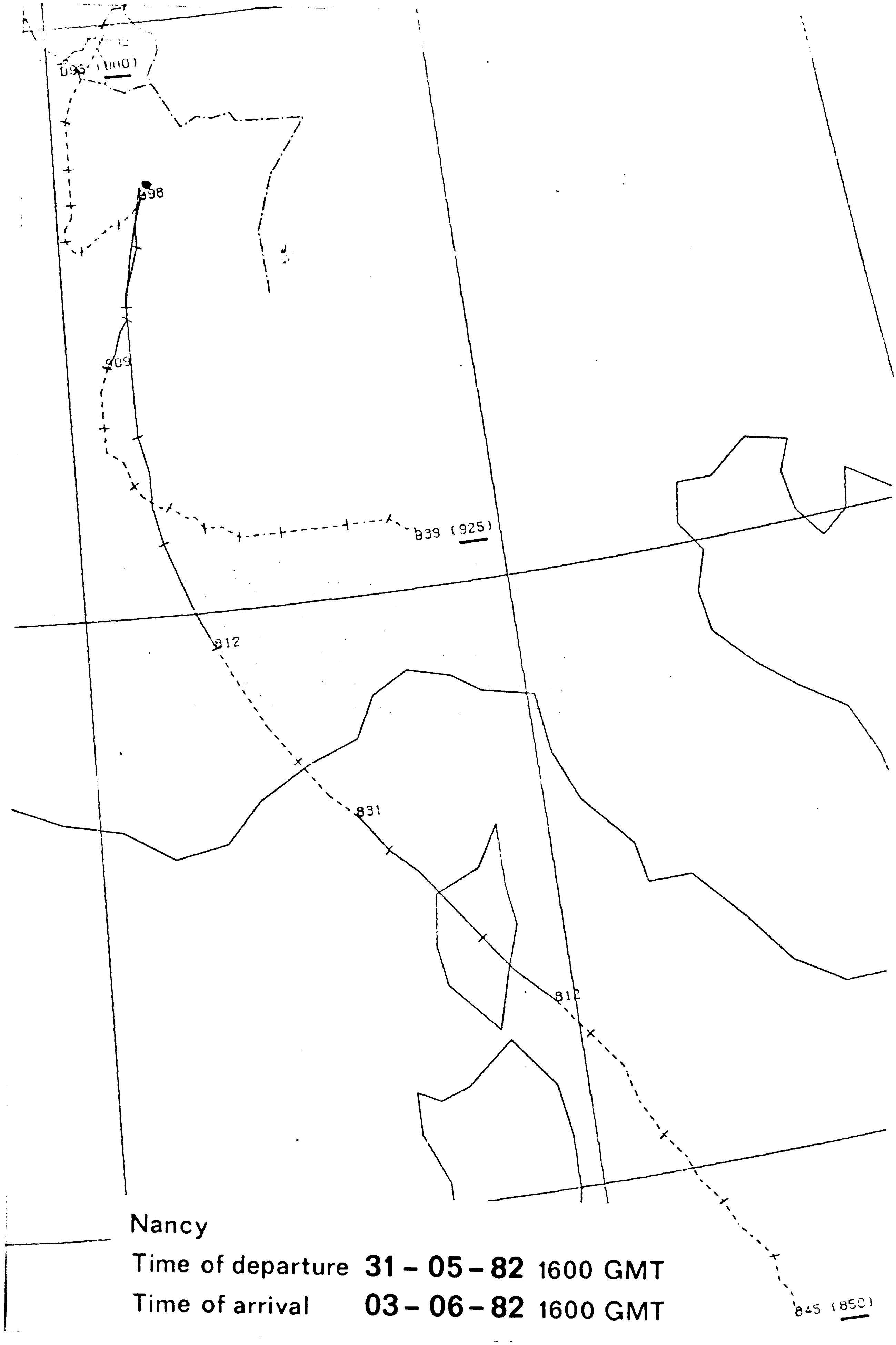
de Bilt
Time of departure **03-09-81** 1600 GMT
Time of arrival **06-09-81** 1600 GMT



Soissons

Time of departure **31–05–82** 1600 GMT

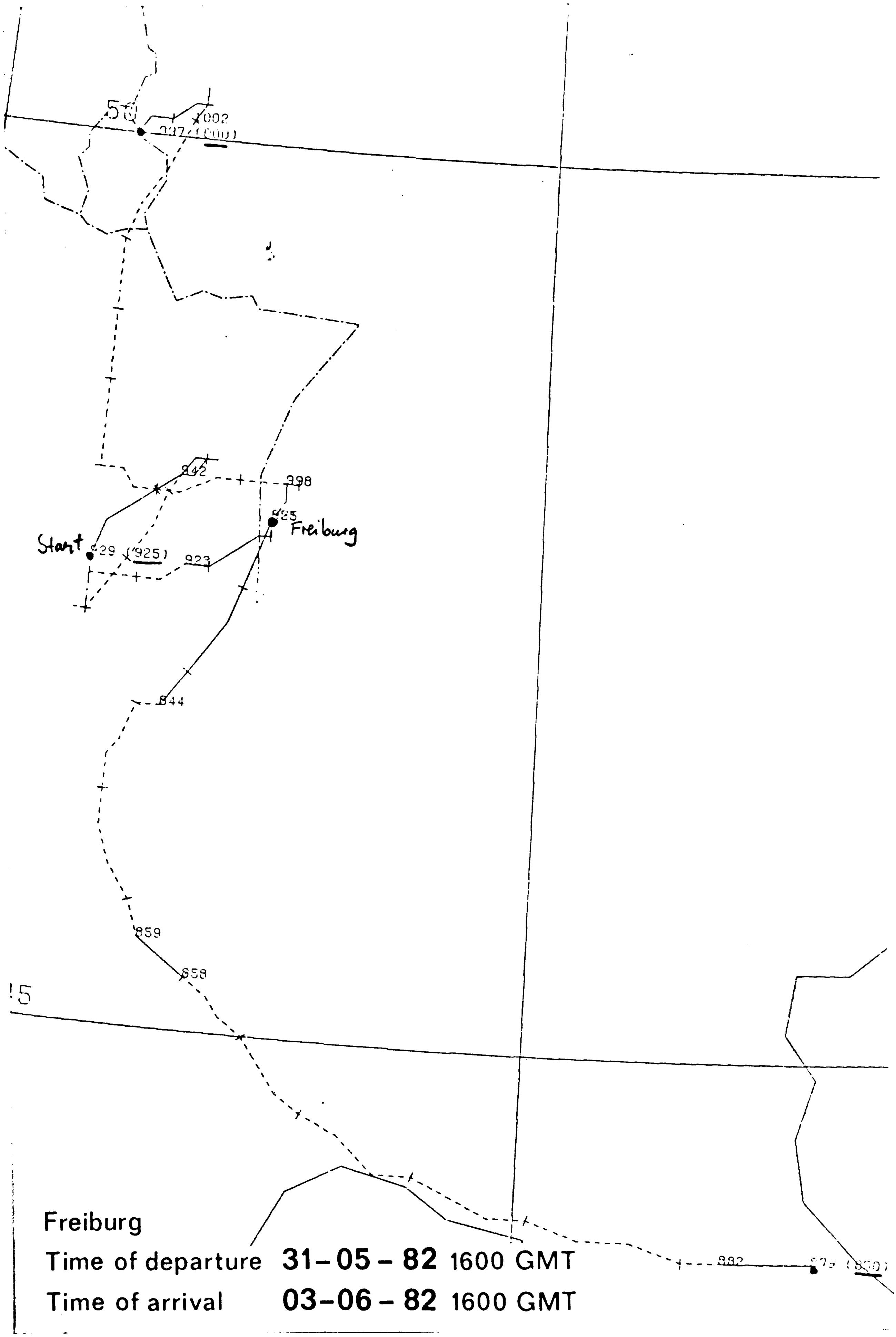
Time of arrival **03–06–82** 1600 GMT



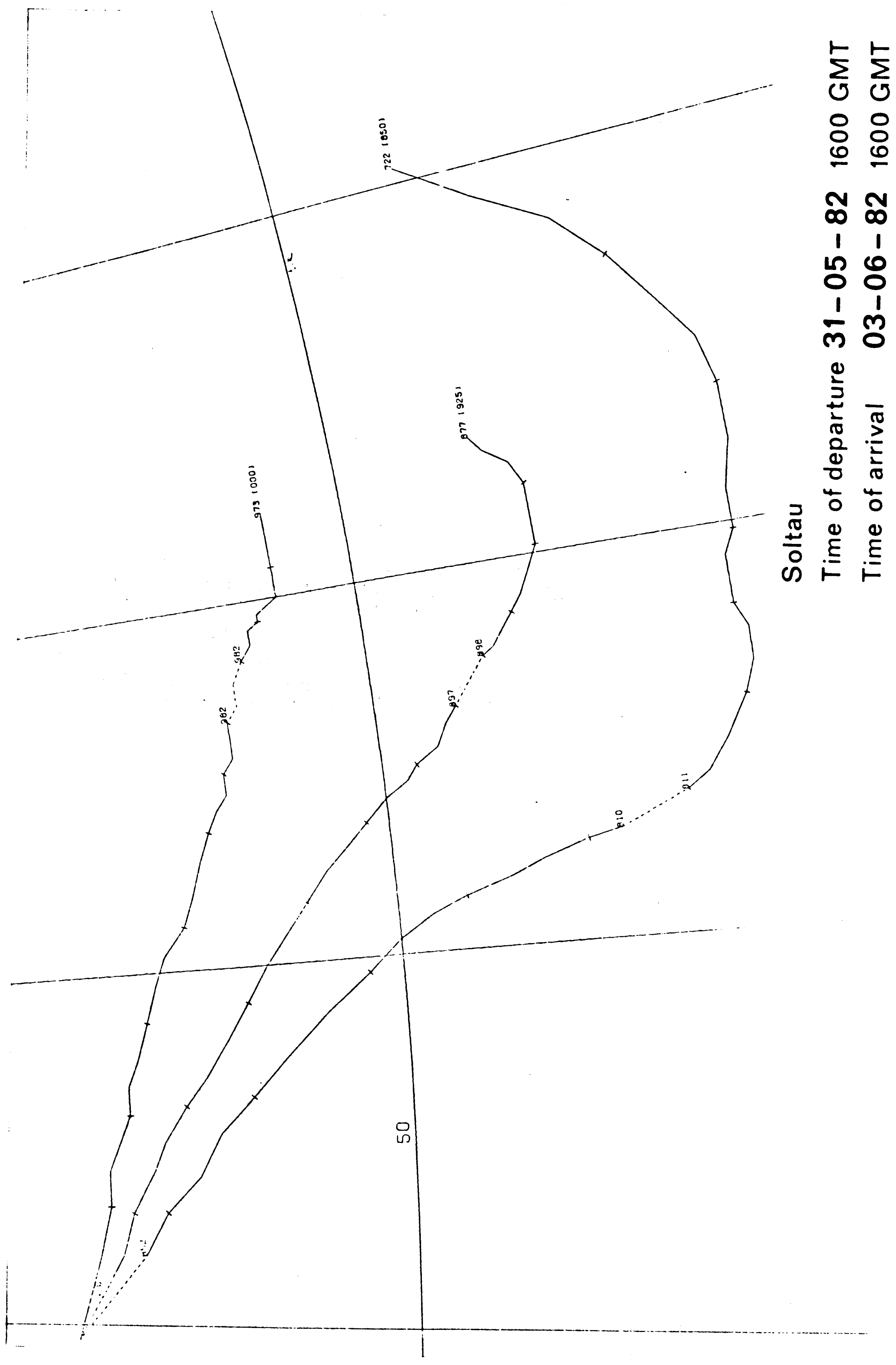
Nancy

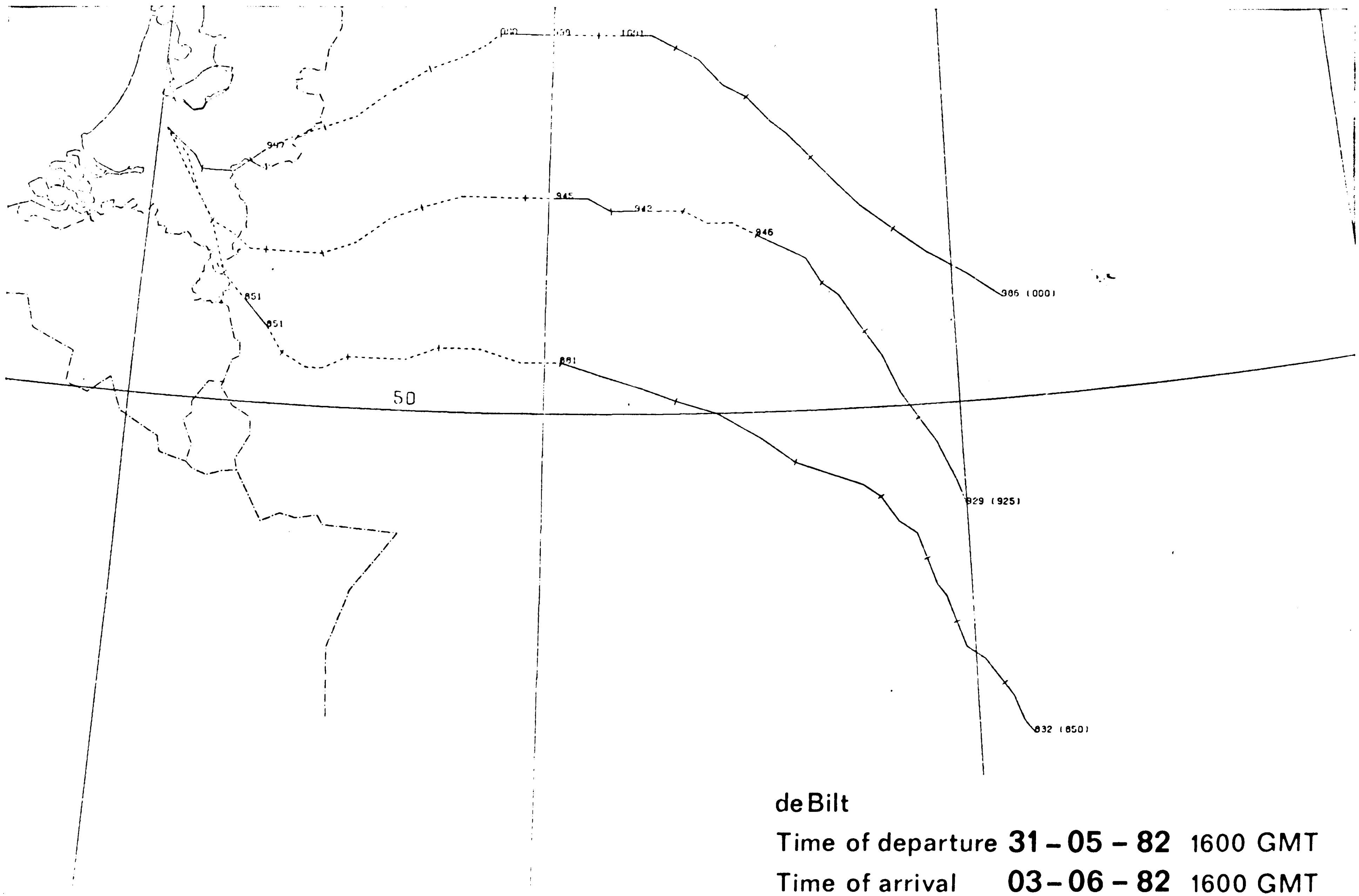
Time of departure **31 – 05 – 82** 1600 GMT

Time of arrival **03 – 06 – 82** 1600 GMT



Freiburg
Time of departure **31-05-82** 1600 GMT
Time of arrival **03-06-82** 1600 GMT

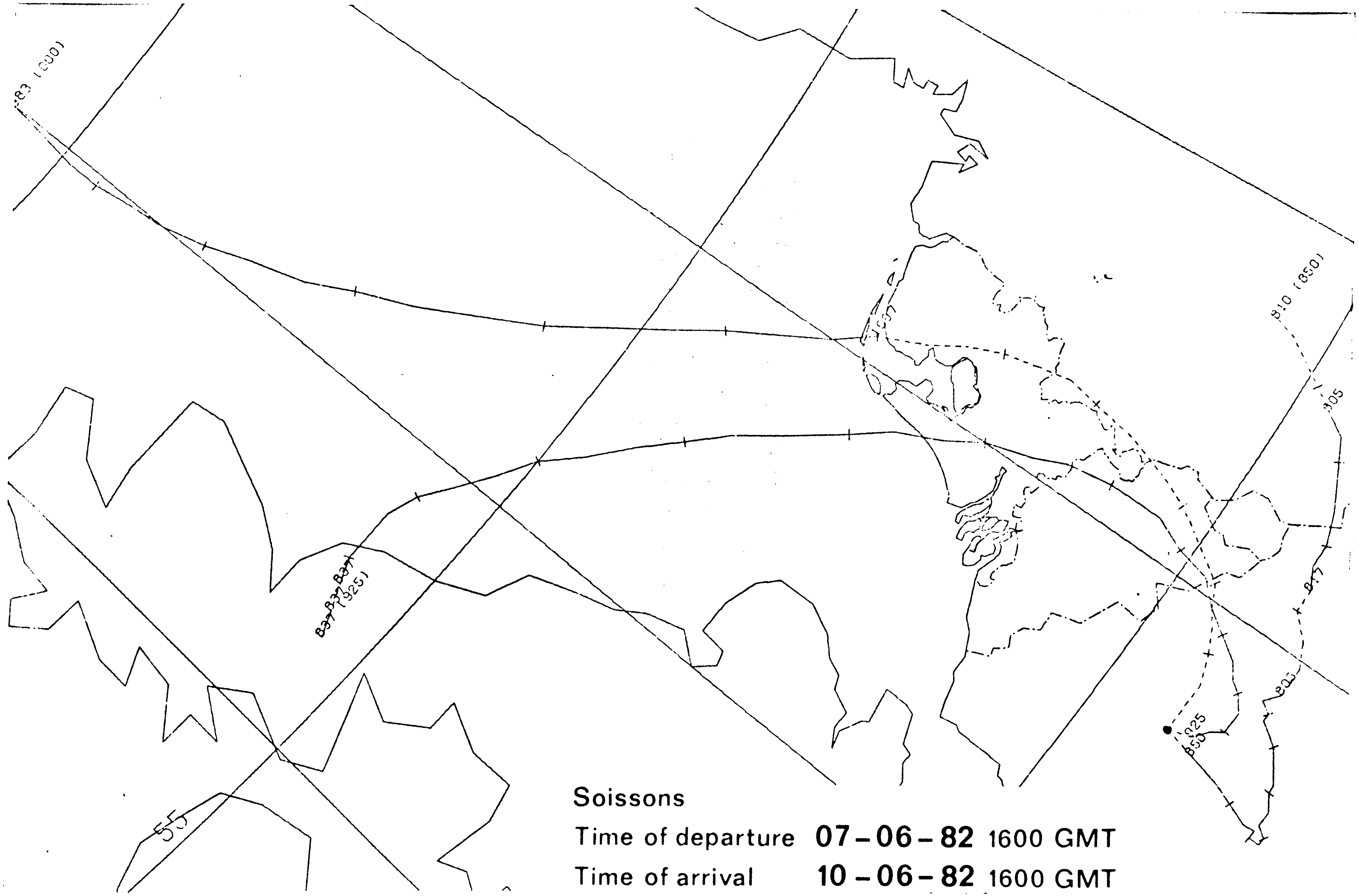

Soltau
Time of departure 31-05-82 1600 GMT
Time of arrival 03-06-82 1600 GMT
722 (850)
877 (925)
973 (1000)
50



de Bilt

Time of departure **31 - 05 - 82** 1600 GMT

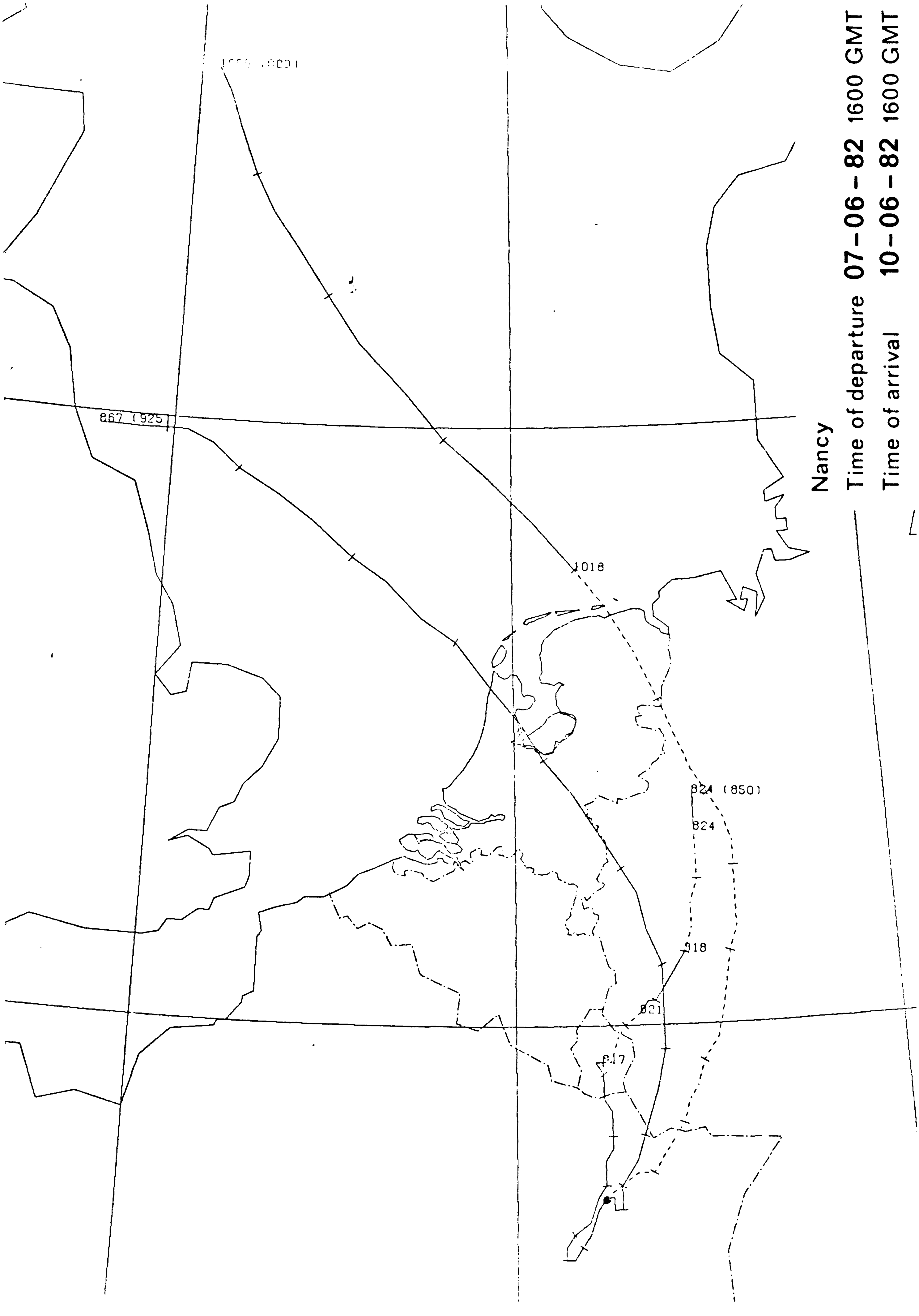
Time of arrival **03 - 06 - 82** 1600 GMT

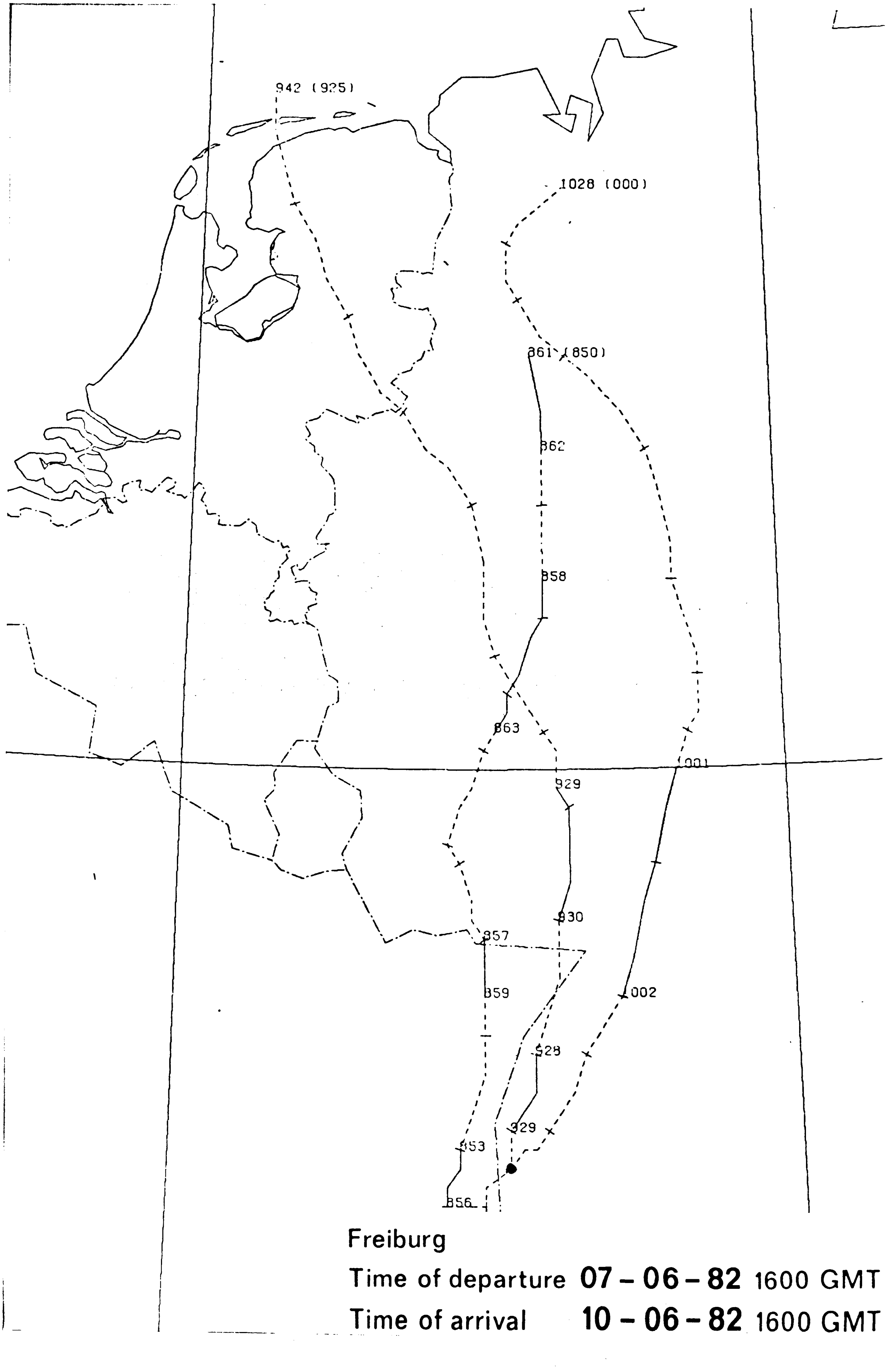


Soissons

Time of departure **07-06-82** 1600 GMT

Time of arrival **10-06-82** 1600 GMT

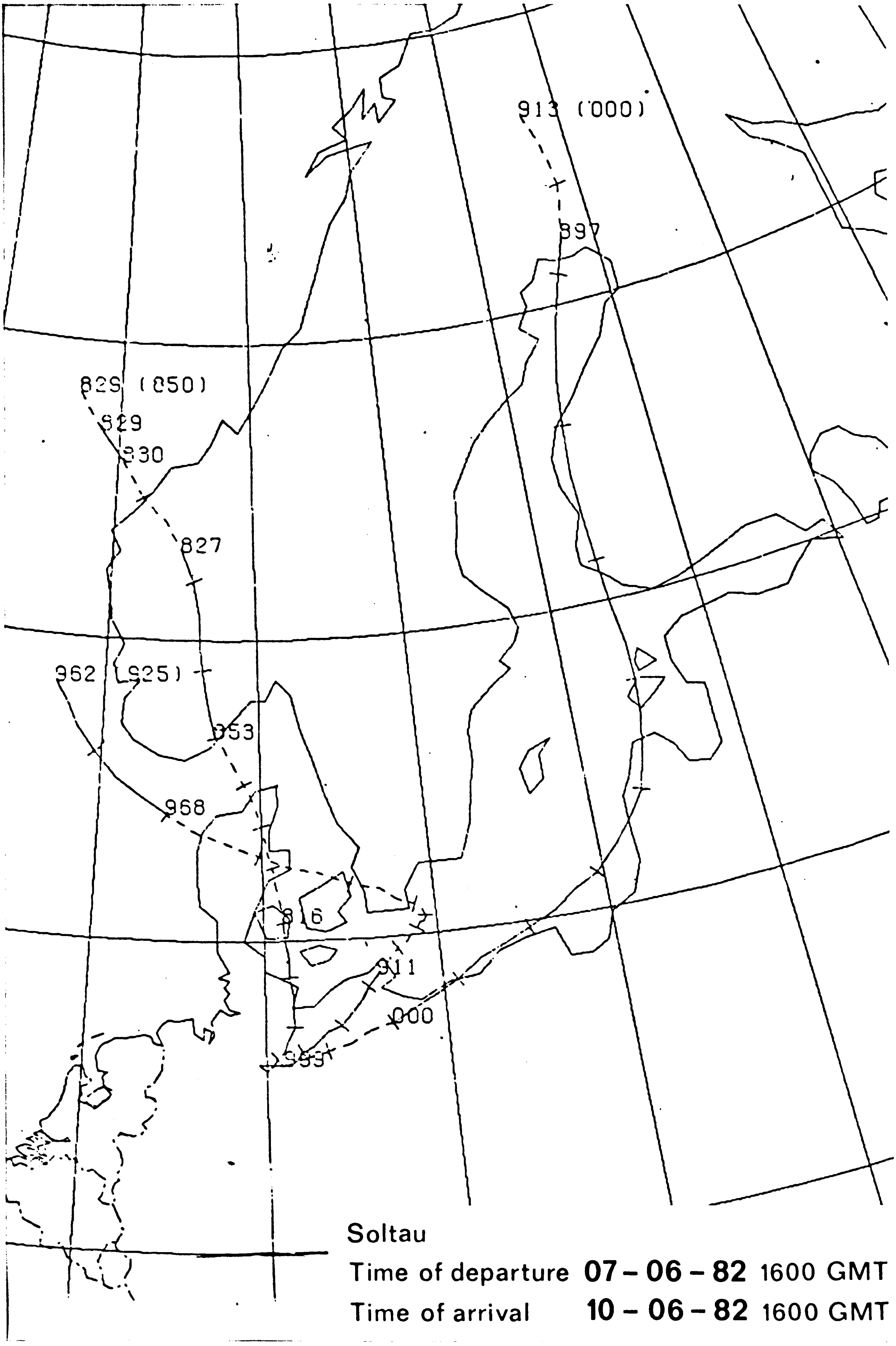

Nancy
Time of departure 07-06-82 1600 GMT
Time of arrival 10-06-82 1600 GMT
867 (925)
1018
824 (850)
824
818
821
817



Freiburg

Time of departure **07 - 06 - 82** 1600 GMT

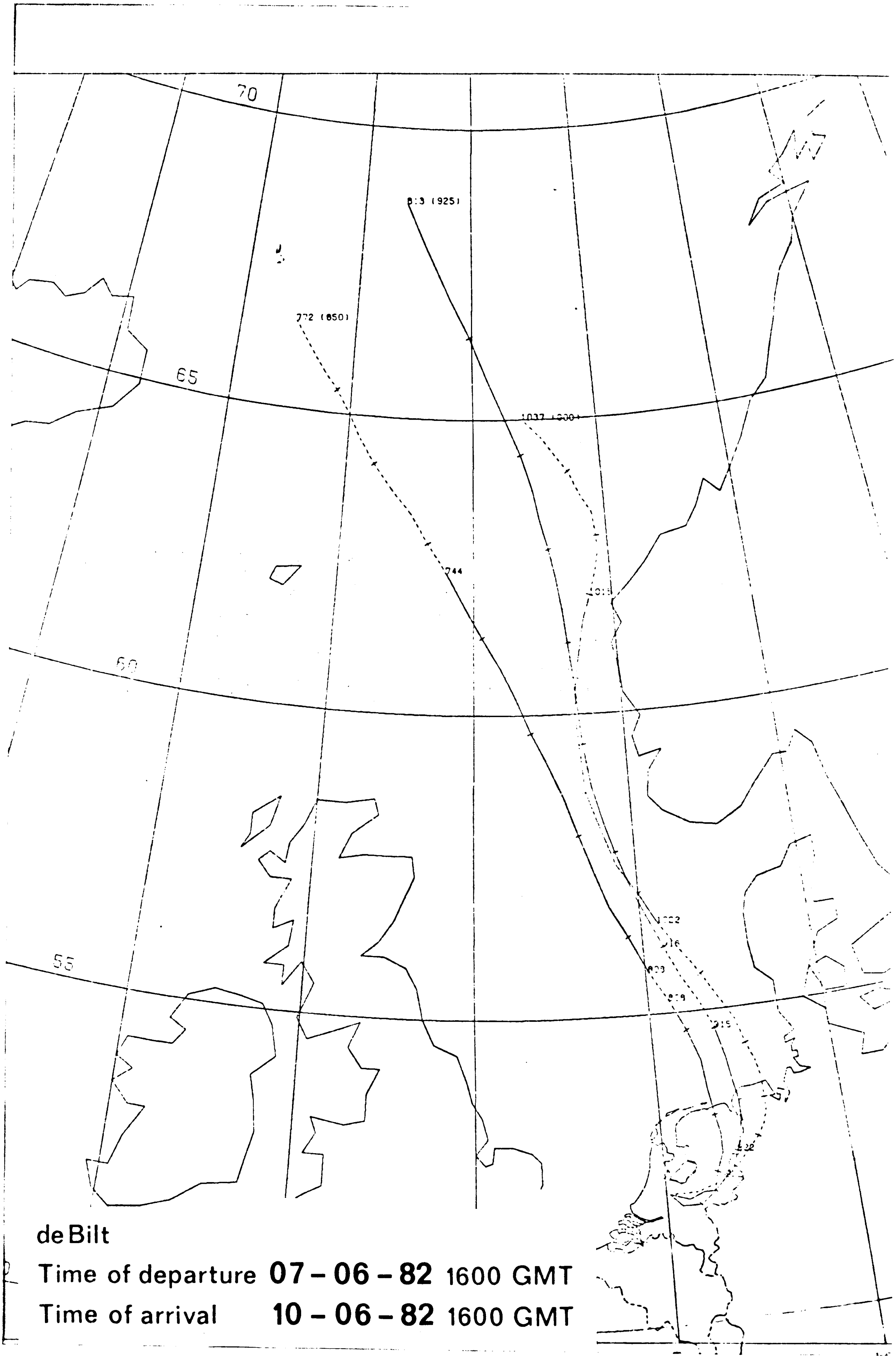
Time of arrival **10 - 06 - 82** 1600 GMT



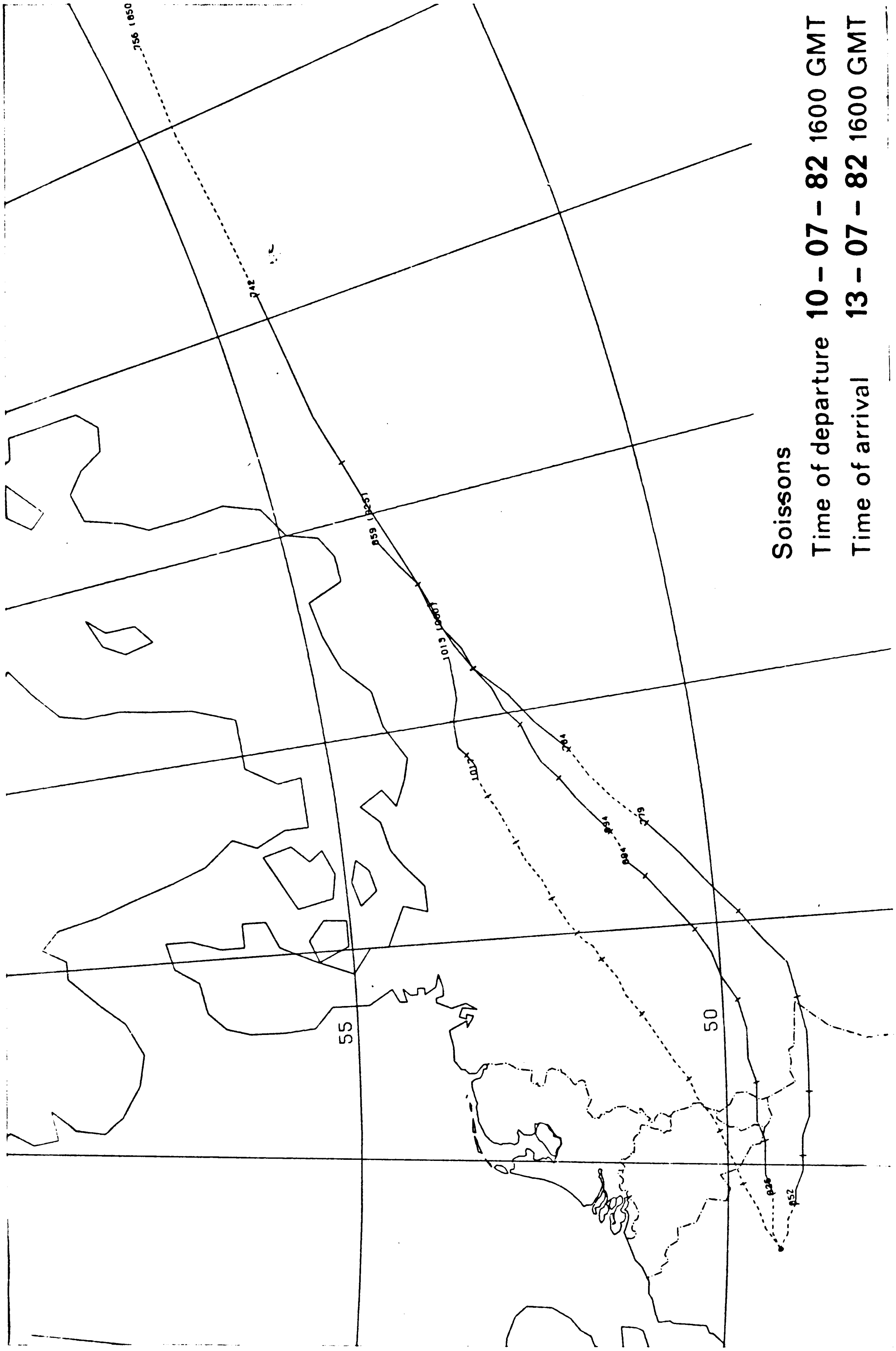
Soltau

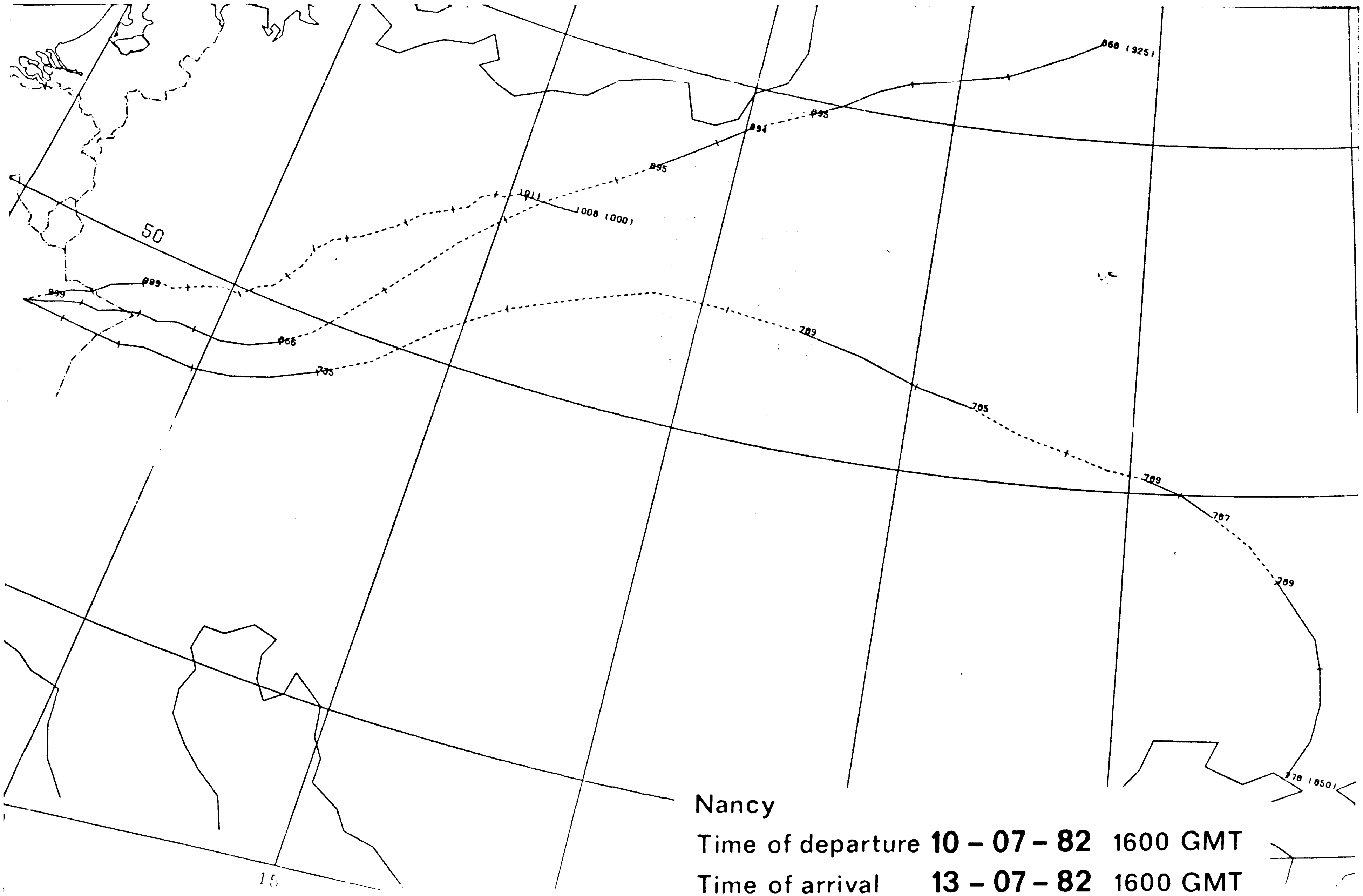
Time of departure **07 - 06 - 82** 1600 GMT

Time of arrival **10 - 06 - 82** 1600 GMT

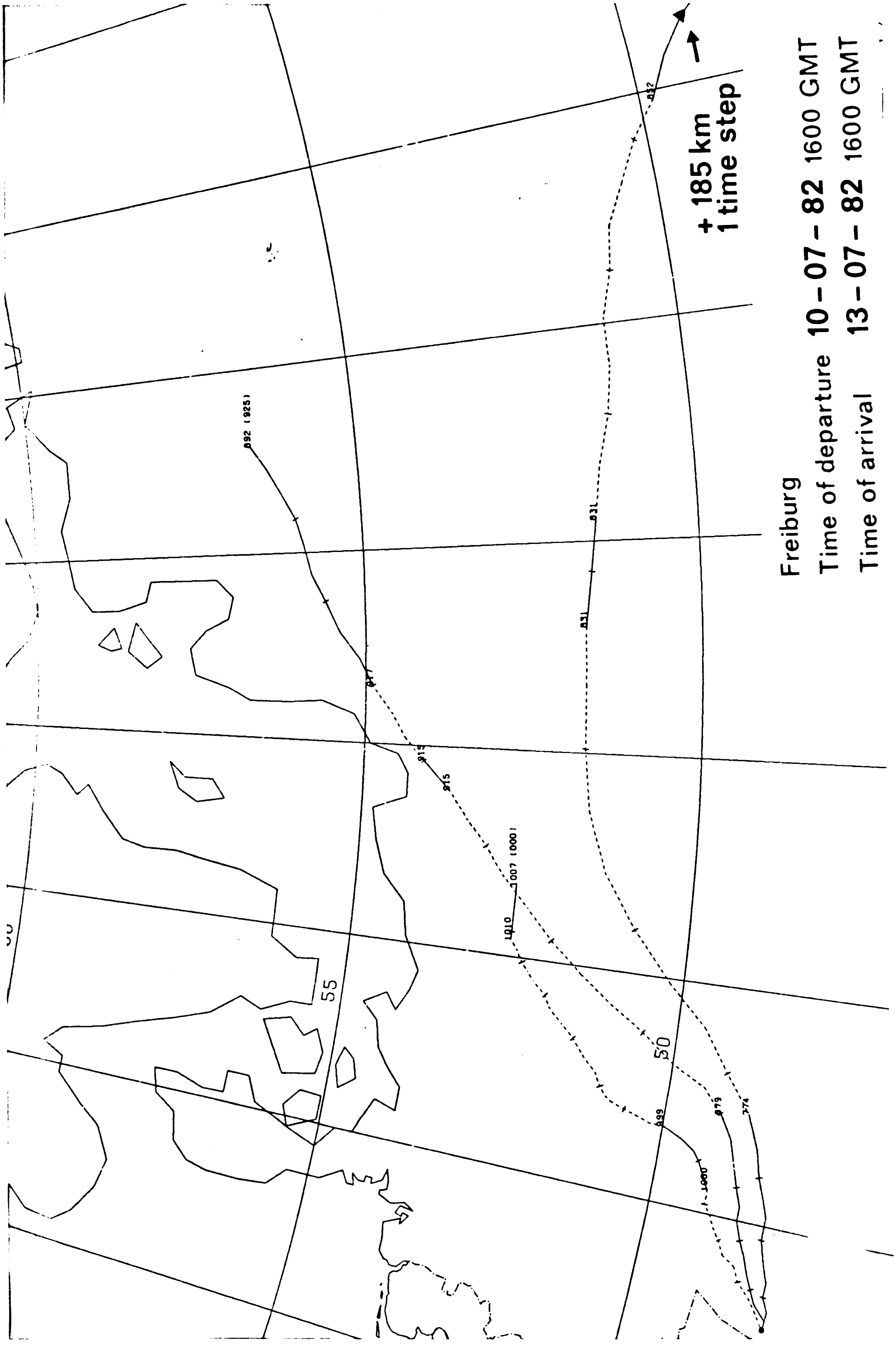


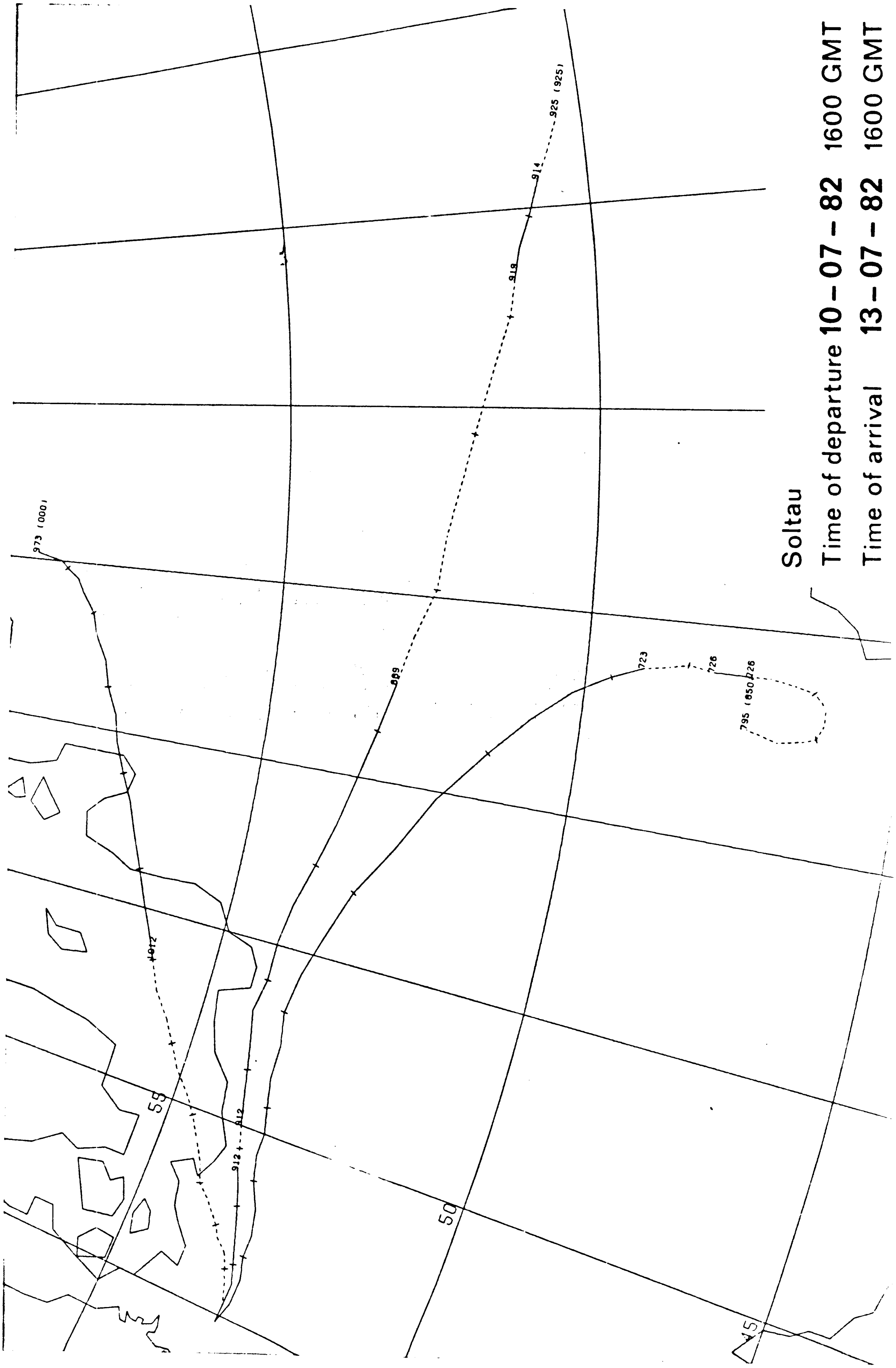
70
65
60
55
de Bilt
Time of departure 07 – 06 – 82 1600 GMT
Time of arrival 10 – 06 – 82 1600 GMT


Soissons
Time of departure 10 - 07 - 82 1600 GMT
Time of arrival 13 - 07 - 82 1600 GMT
55
50

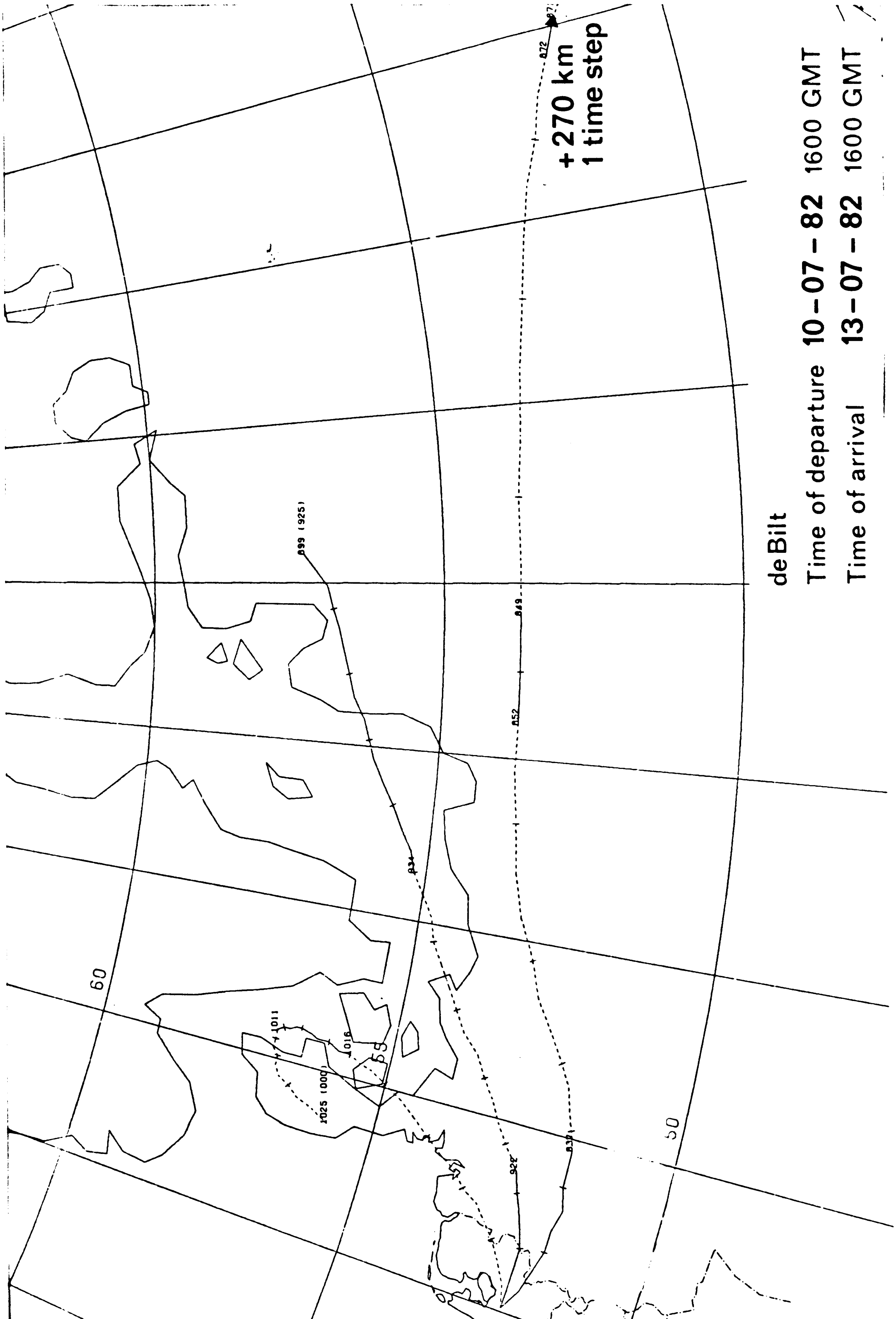


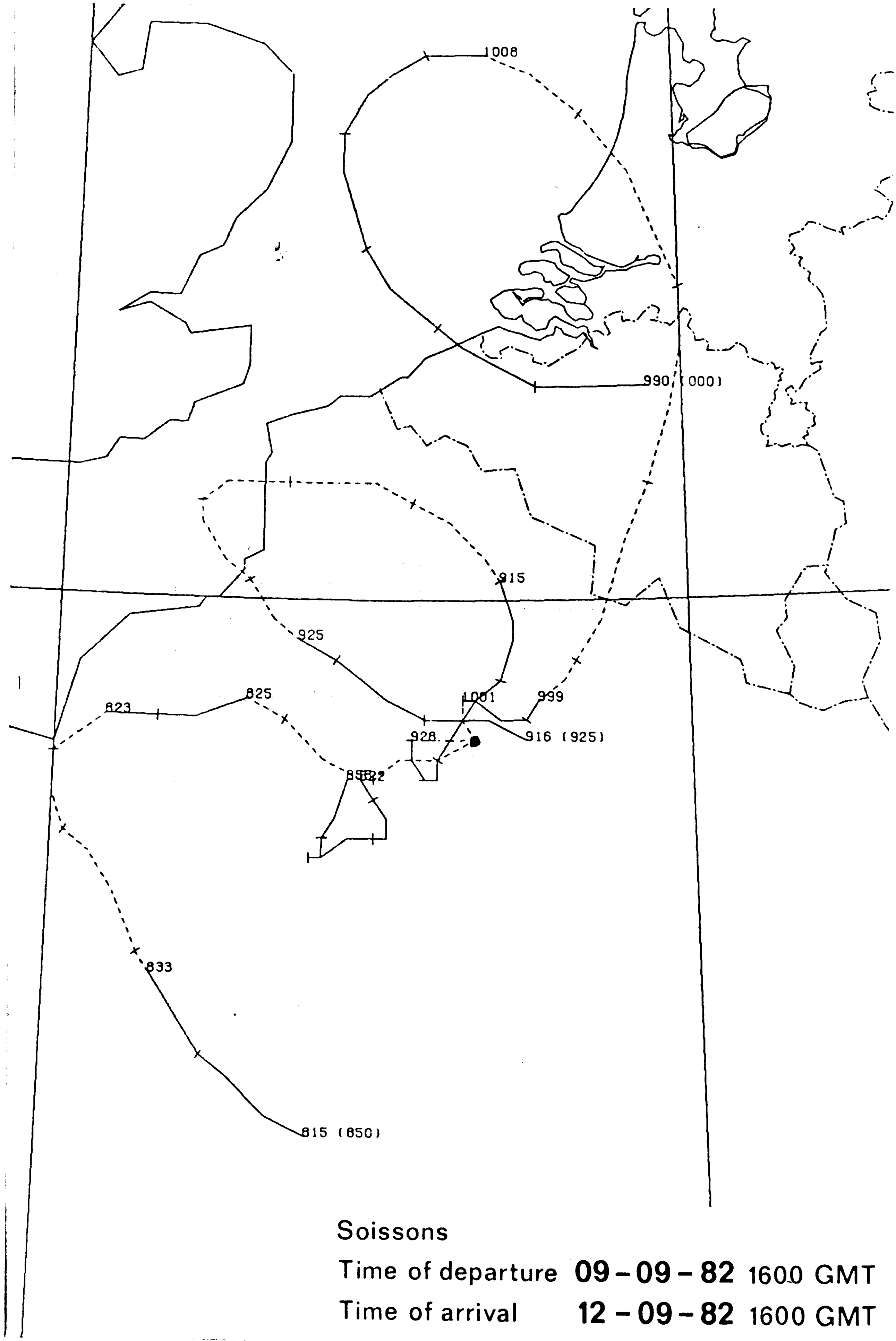
Nancy
Time of departure **10 – 07 – 82** 1600 GMT
Time of arrival **13 – 07 – 82** 1600 GMT


+ 185 km
1 time step
Freiburg
Time of departure 10 – 07 – 82 1600 GMT
Time of arrival 13 – 07 – 82 1600 GMT
55
50



Soltau
Time of departure 10-07-82 1600 GMT
Time of arrival 13-07-82 1600 GMT
973 (000)
925 (925)
914
918
889
1012
912
723
726
55
50
45

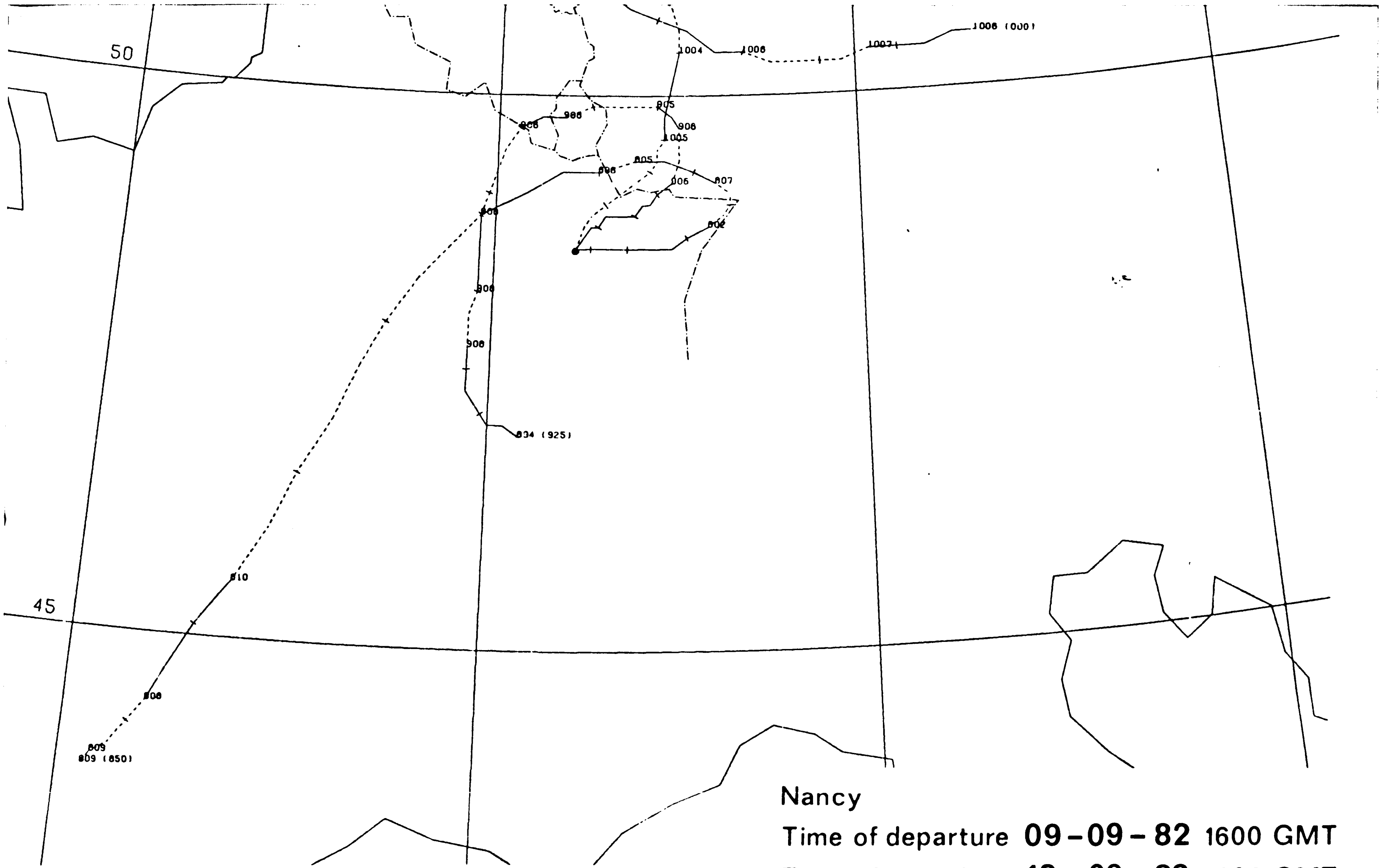

+270 km
1 time step
deBilt
Time of departure 10-07-82 1600 GMT
Time of arrival 13-07-82 1600 GMT
60
50
55



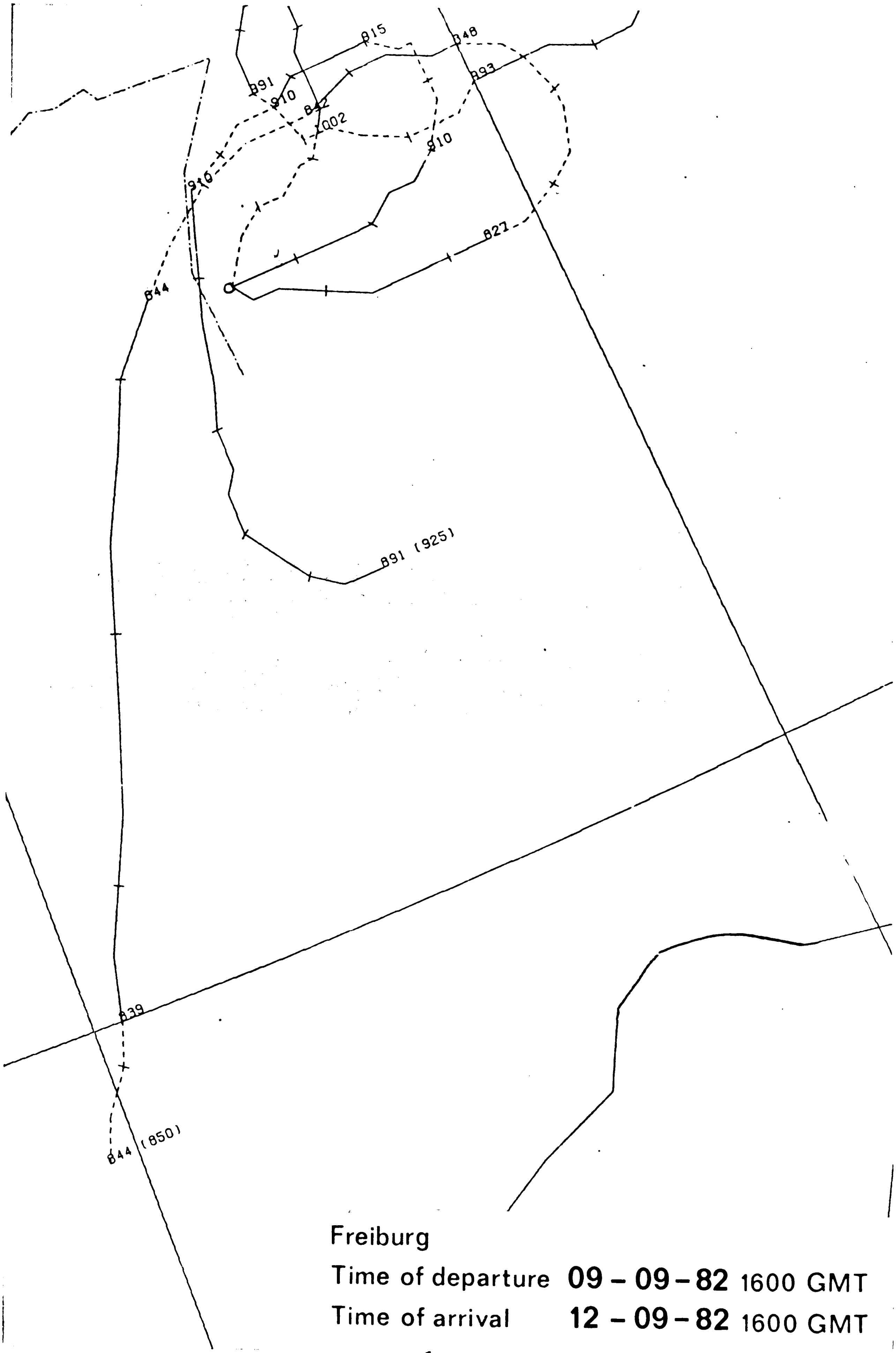
Soissons

Time of departure **09 – 09 – 82** 1600 GMT

Time of arrival **12 – 09 – 82** 1600 GMT



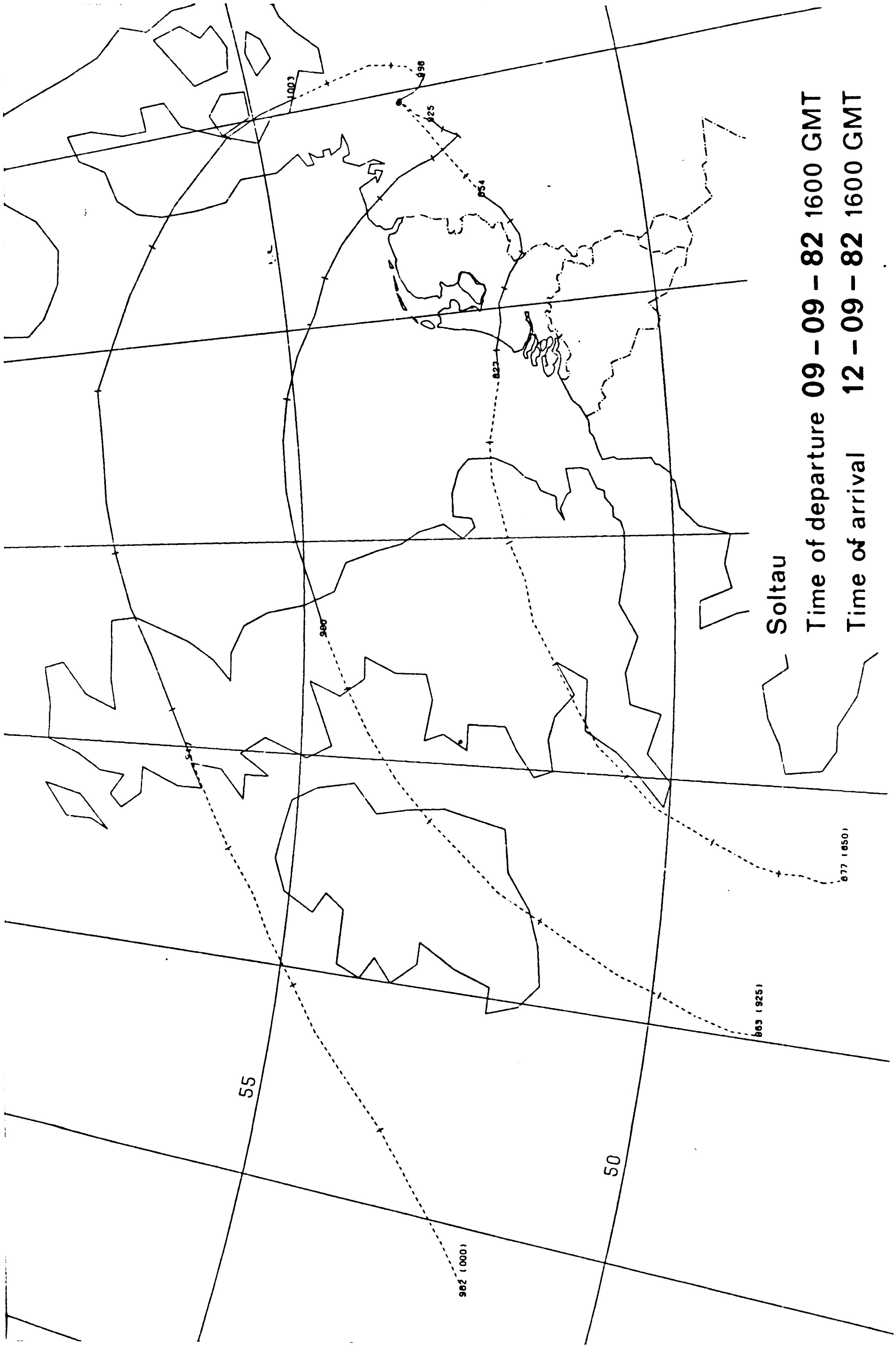
Nancy
Time of departure **09-09-82** 1600 GMT
Time of arrival **12-09-82** 1600 GMT

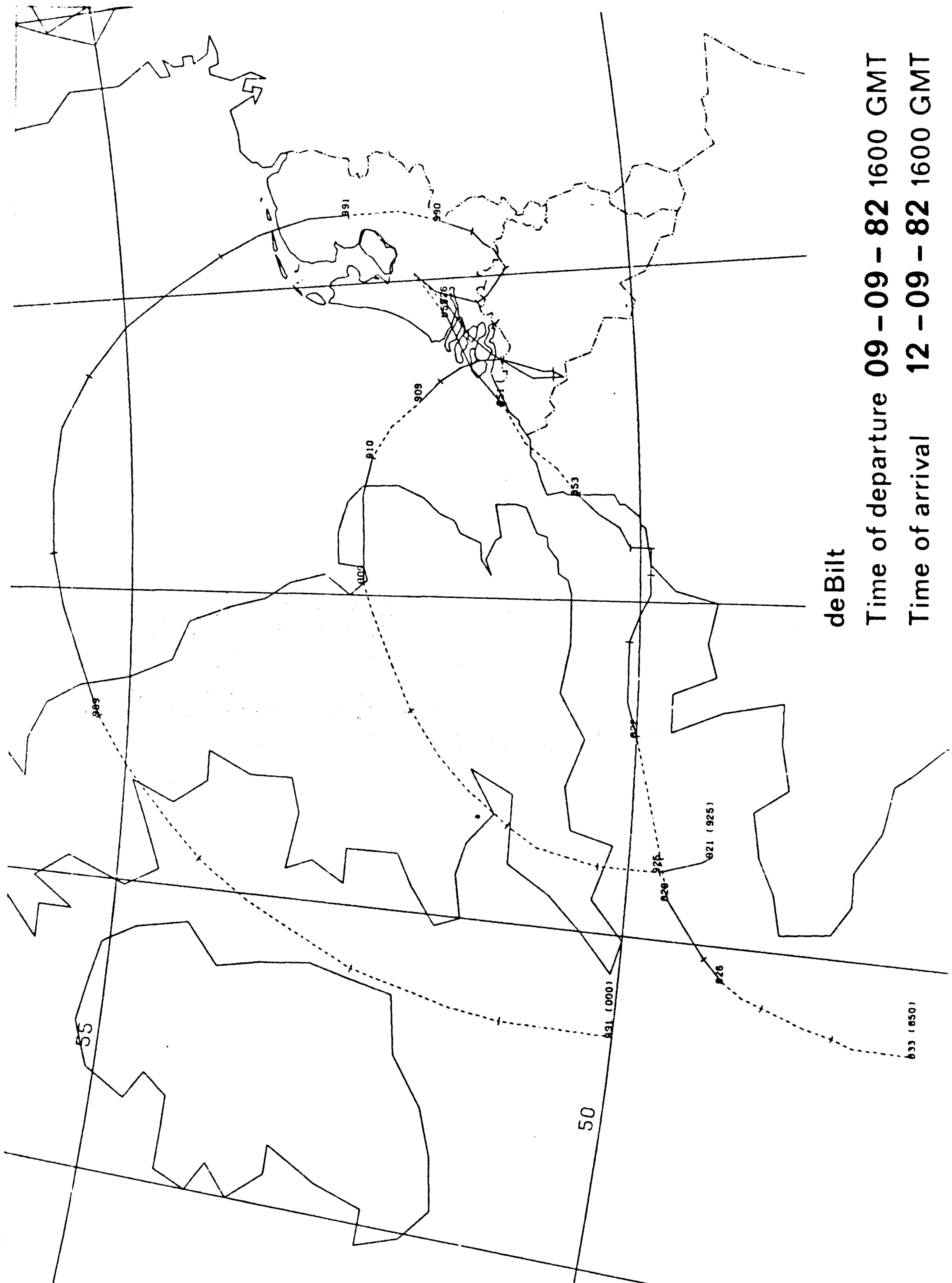


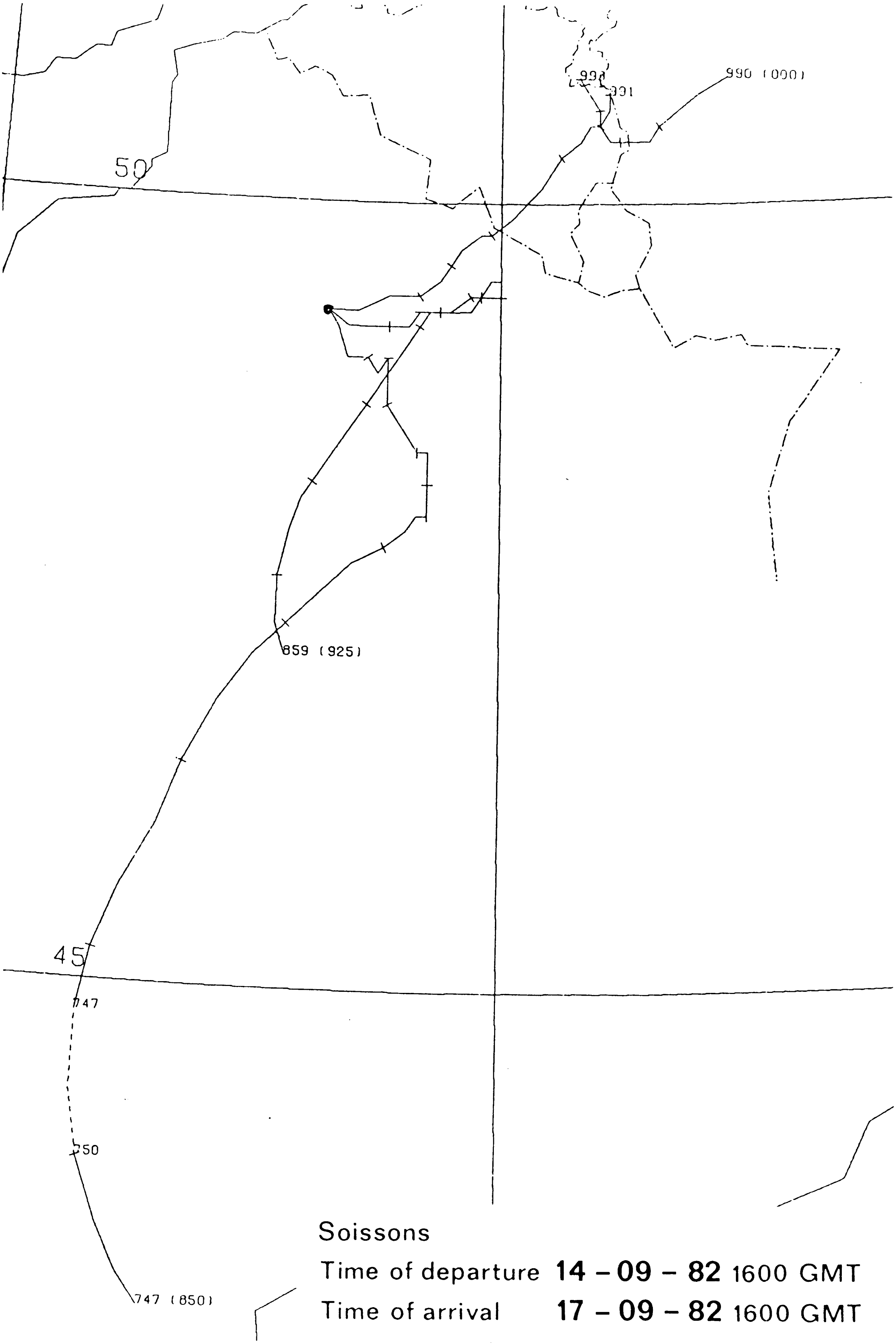
Freiburg

Time of departure **09 – 09 – 82** 1600 GMT

Time of arrival **12 – 09 – 82** 1600 GMT


Soltau
Time of departure 09-09-82 1600 GMT
Time of arrival 12-09-82 1600 GMT
55
50
982 (000)
863 (925)
877 (850)

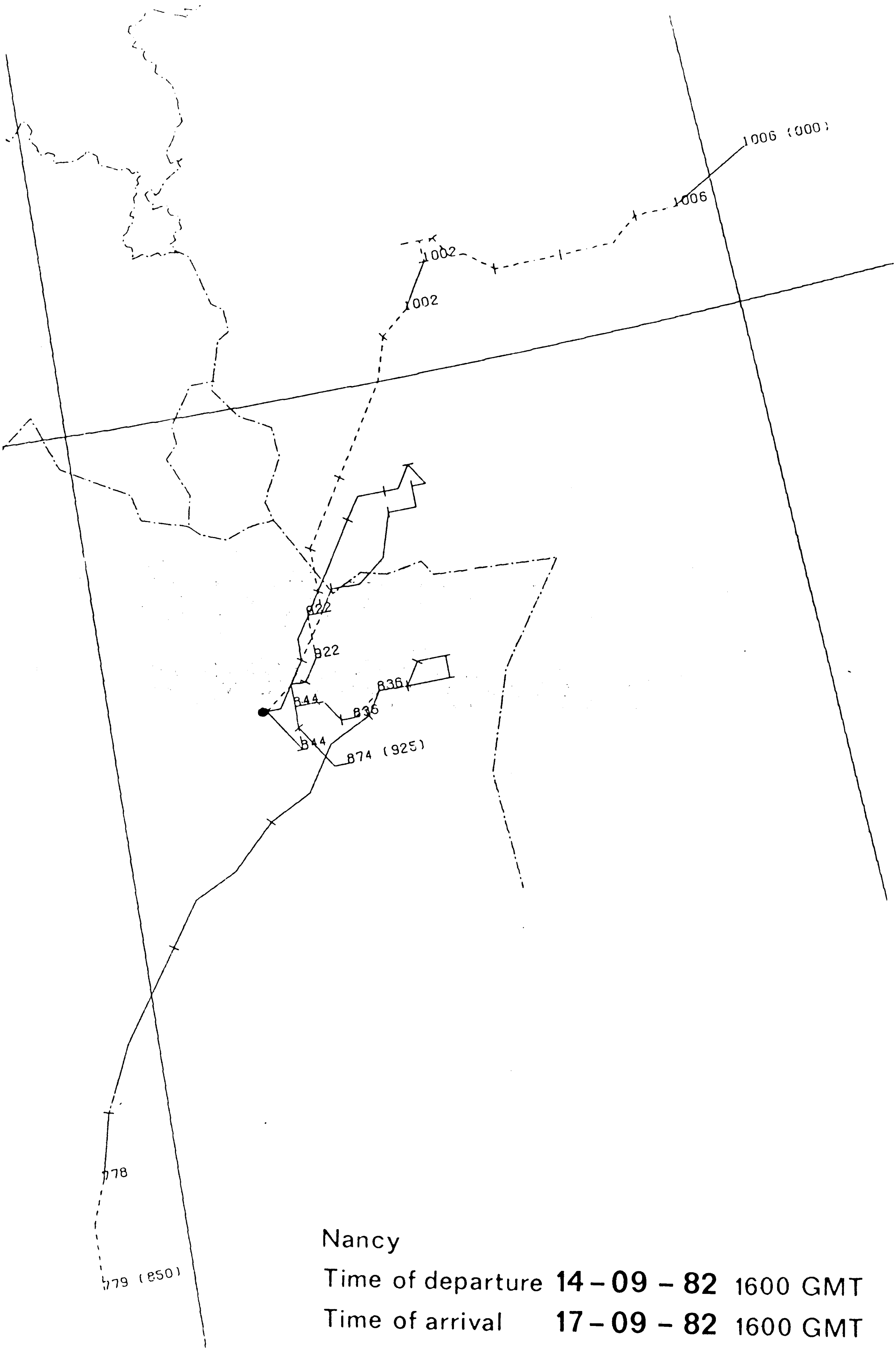

de Bilt
Time of departure 09-09-82 1600 GMT
Time of arrival 12-09-82 1600 GMT
55
50



Soissons

Time of departure **14 – 09 – 82** 1600 GMT

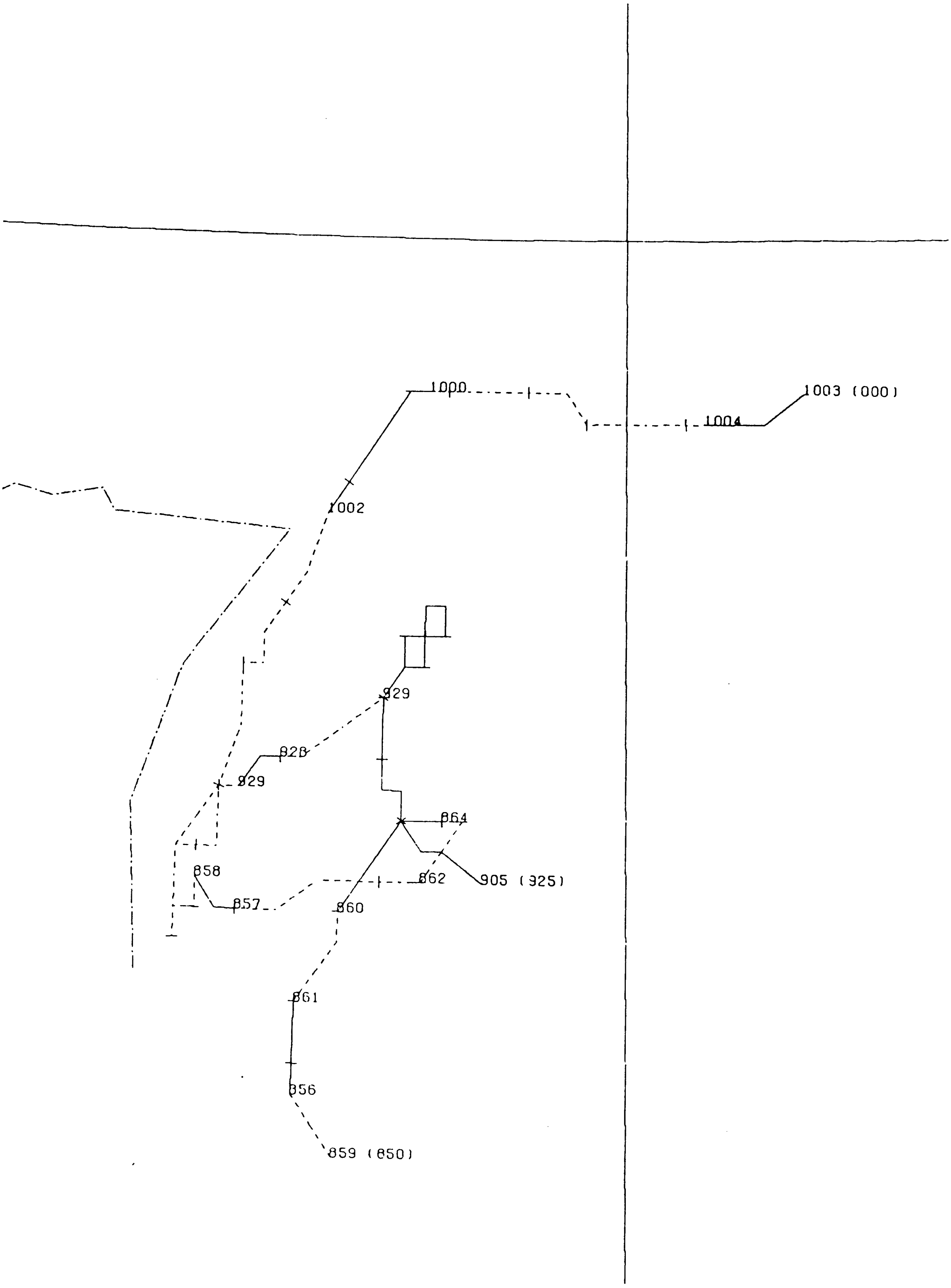
Time of arrival **17 – 09 – 82** 1600 GMT



Nancy

Time of departure **14 – 09 – 82** 1600 GMT

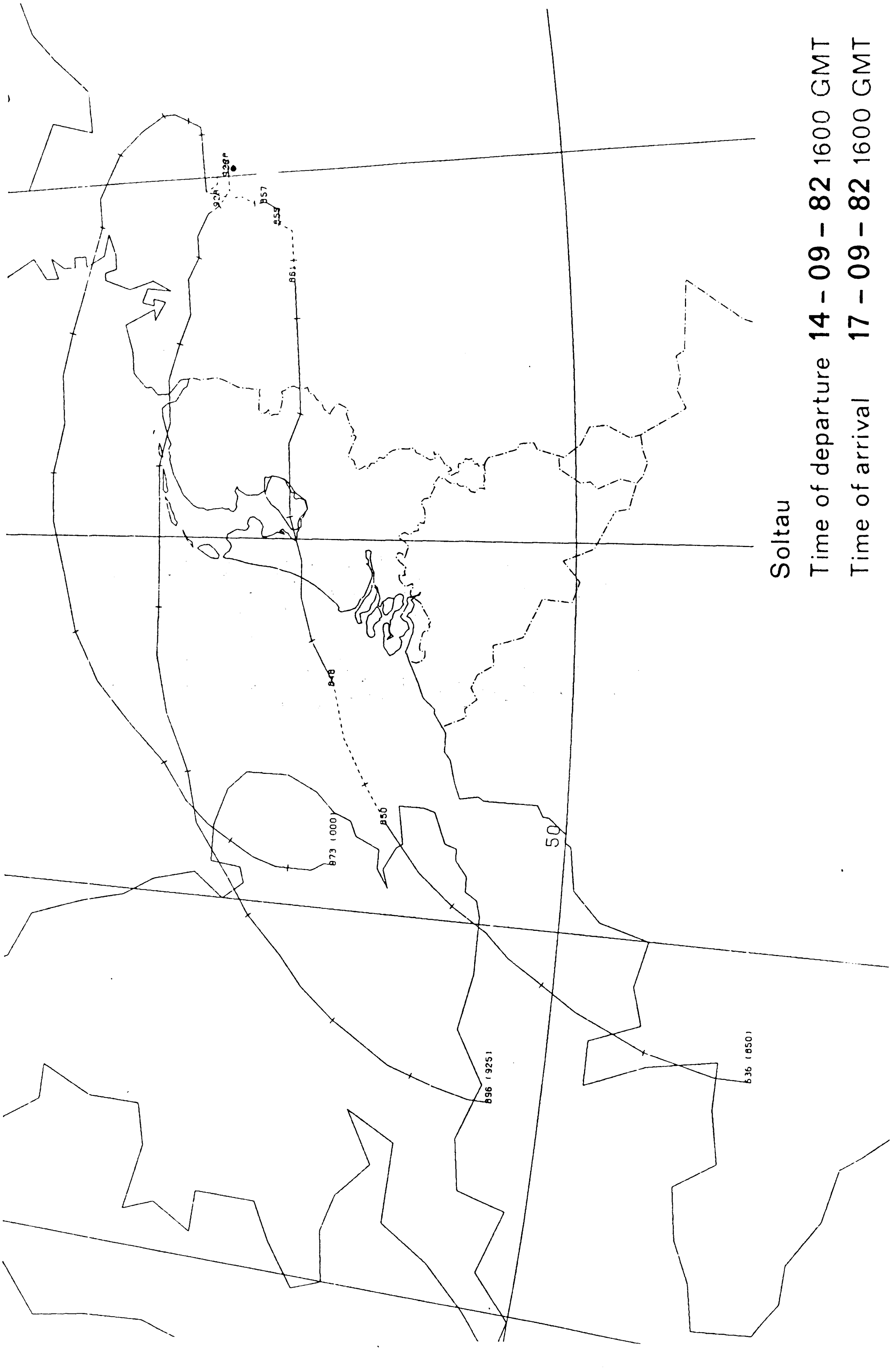
Time of arrival **17 – 09 – 82** 1600 GMT



Freiburg

Time of departure **14 - 09 - 82** 1600 GMT

Time of arrival **17 - 09 - 82** 1600 GMT



Soltau
Time of departure 14 - 09 - 82 1600 GMT
Time of arrival 17 - 09 - 82 1600 GMT

de Bilt

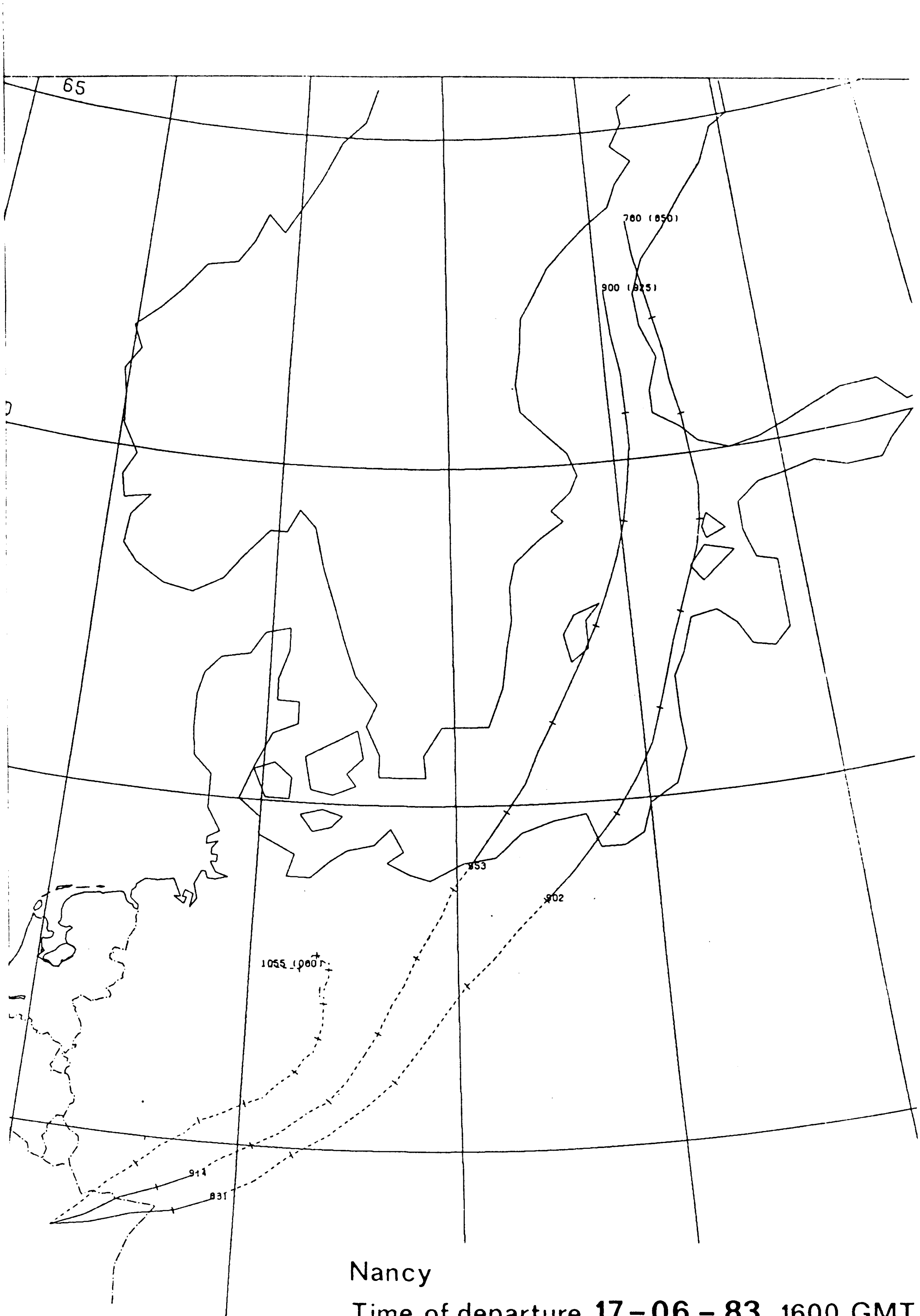
Time of departure **14 – 09 – 82** 1600 GMT

Time of arrival **17 – 09 – 82** 1600 GMT

Soissons

Time of departure **17 – 06 – 83** 1600 GMT

Time of arrival **20 – 06 – 83** 1600 GMT

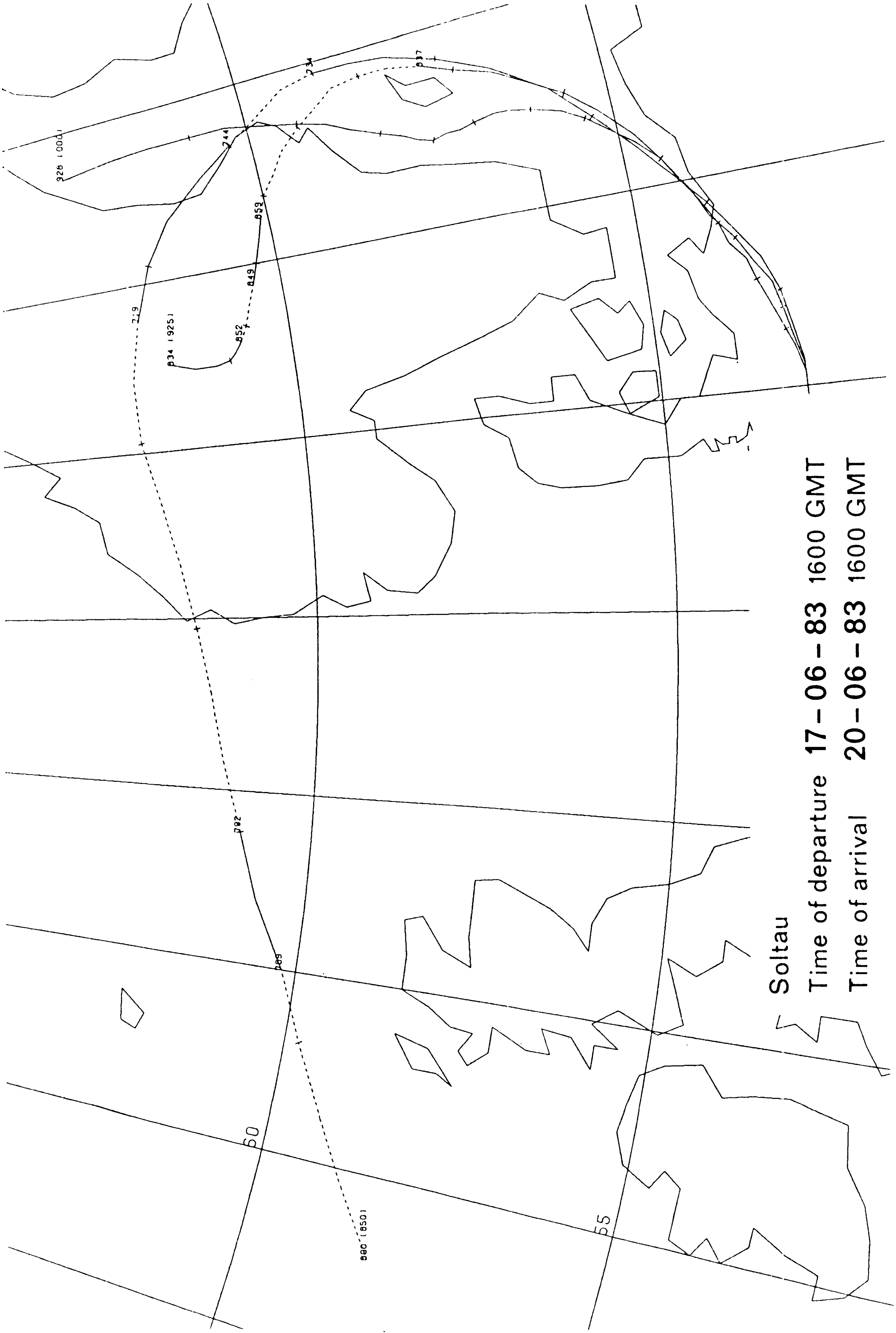


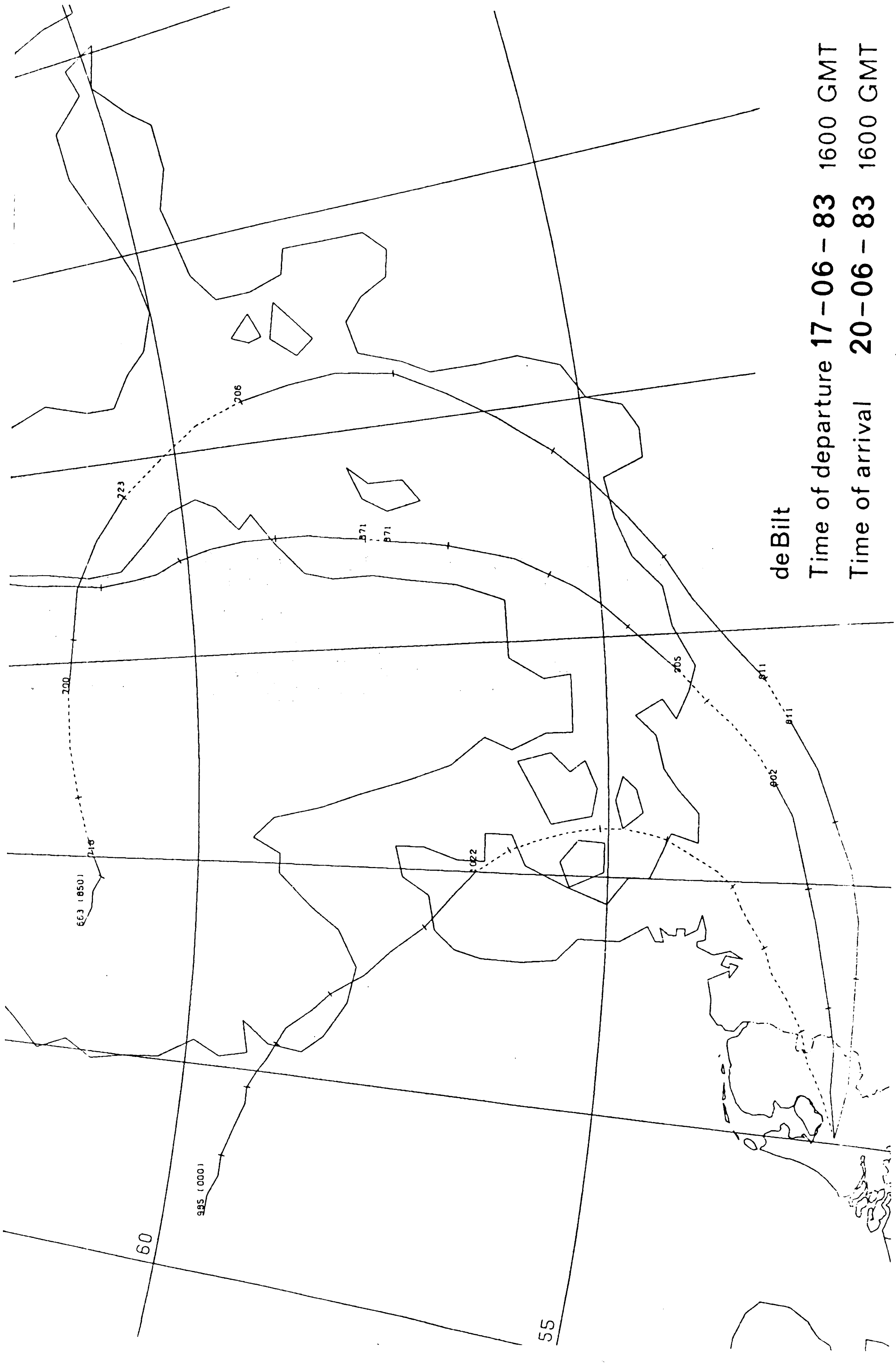
Nancy

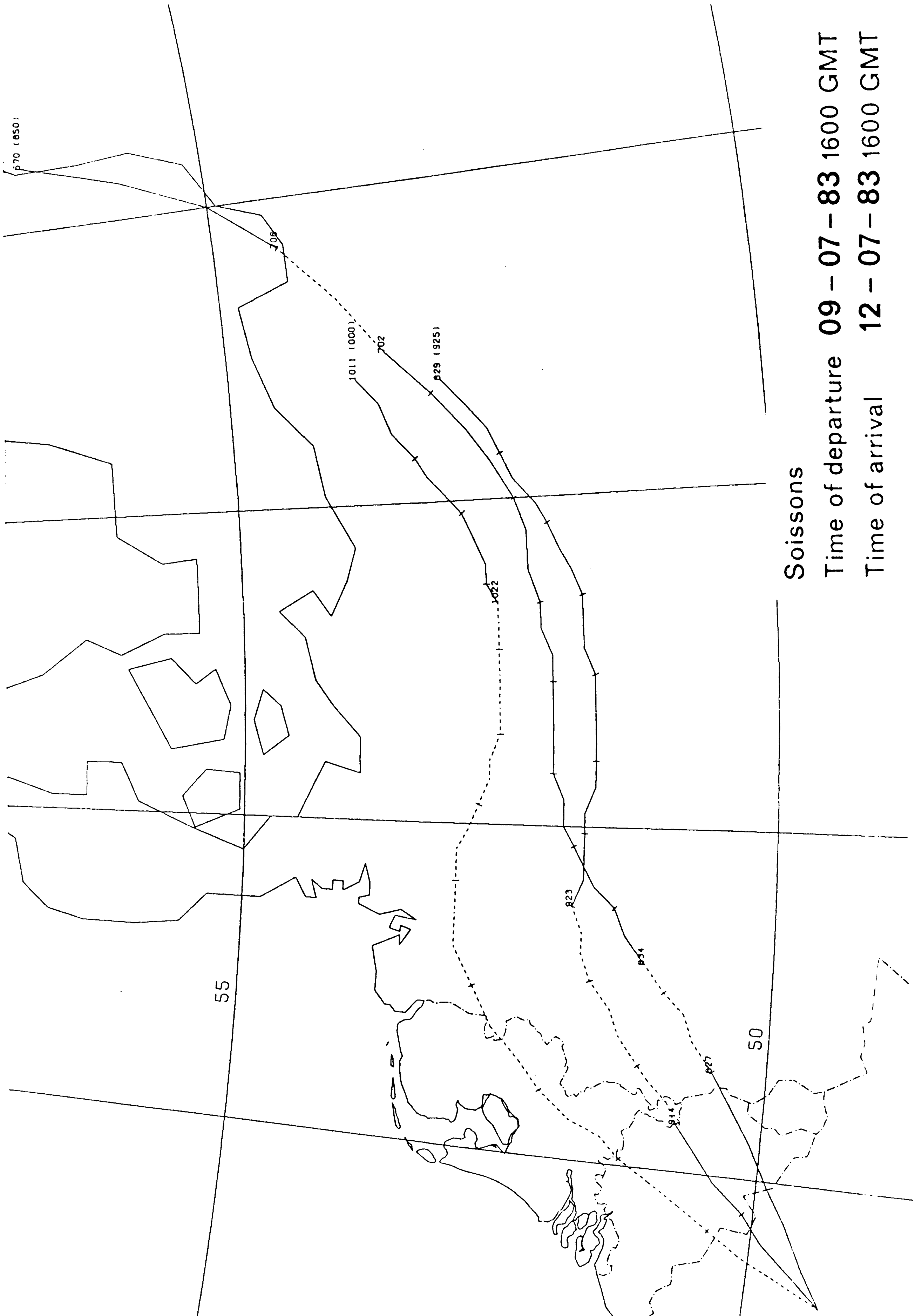
Time of departure **17 – 06 – 83** 1600 GMT

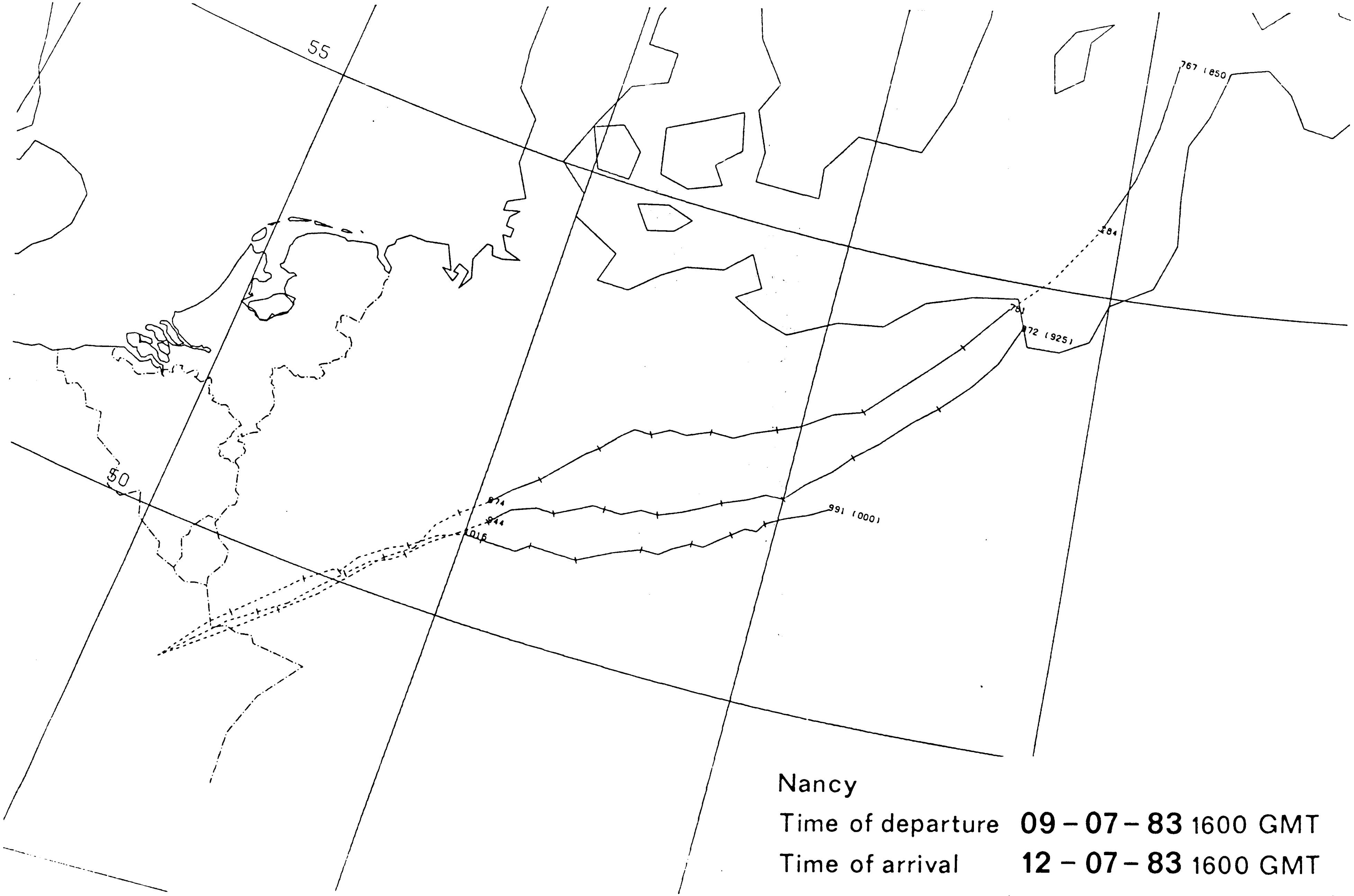
Time of arrival **20 – 06 – 83** 1600 GMT


60
55
838 (650)
943 (925)
873
832
1035 (1000)
1002
1002
922
845
Freiburg
Time of departure 17 – 06 – 83 1600 GMT
Time of arrival 20 – 06 – 83 1600 GMT


60
55
Soltau
Time of departure 17-06-83 1600 GMT
Time of arrival 20-06-83 1600 GMT


de Bilt
Time of departure 17-06-83 1600 GMT
Time of arrival 20-06-83 1600 GMT
60
55


Soissons
Time of departure 09 - 07 - 83 1600 GMT
Time of arrival 12 - 07 - 83 1600 GMT
55
50
570 (850)
706
1011 (1000)
702
829 (925)
1022
823
834



Nancy

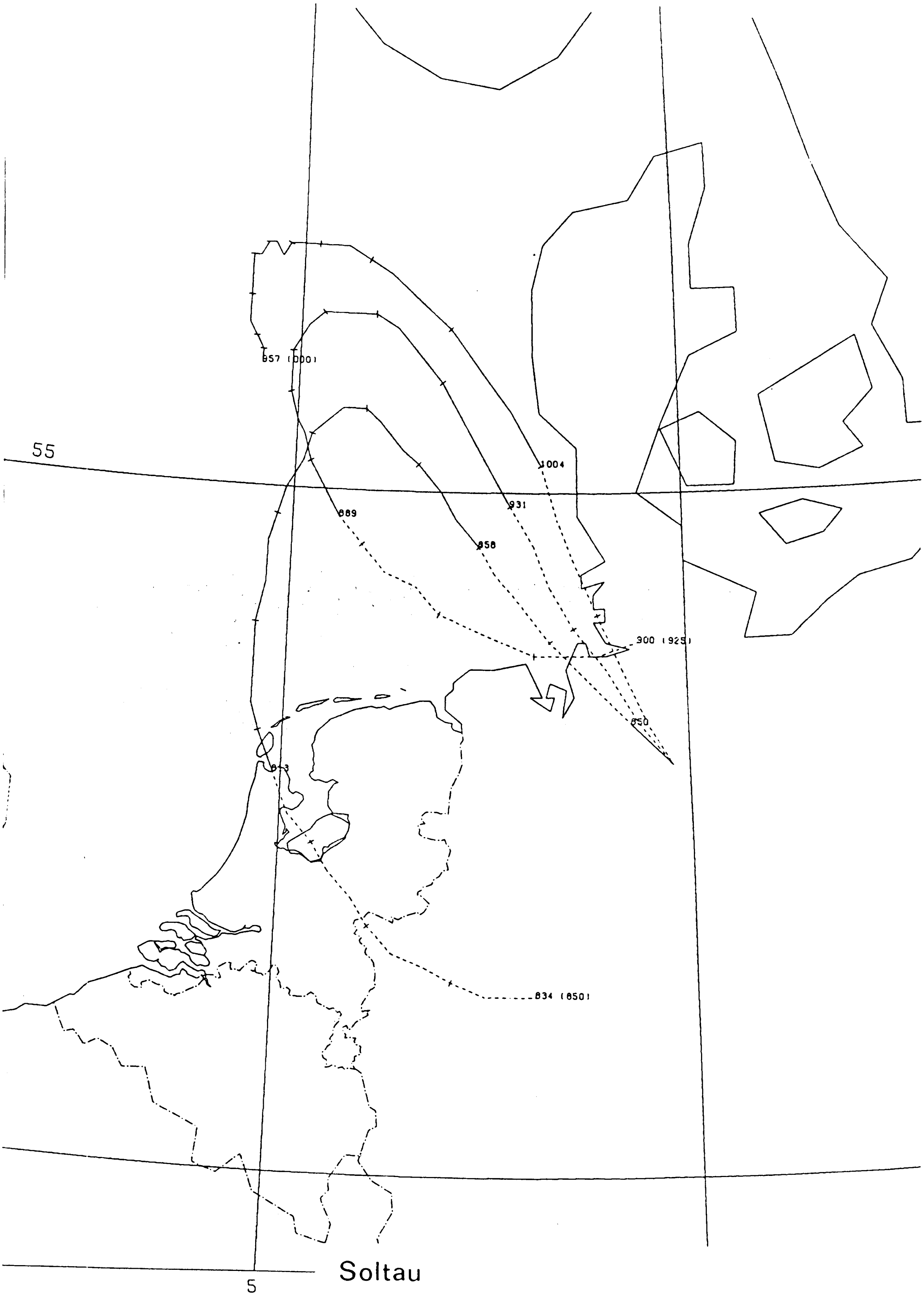
Time of departure **09 – 07 – 83** 1600 GMT

Time of arrival **12 – 07 – 83** 1600 GMT

Freiburg

Time of departure **09 – 07 – 83** 1600 GMT

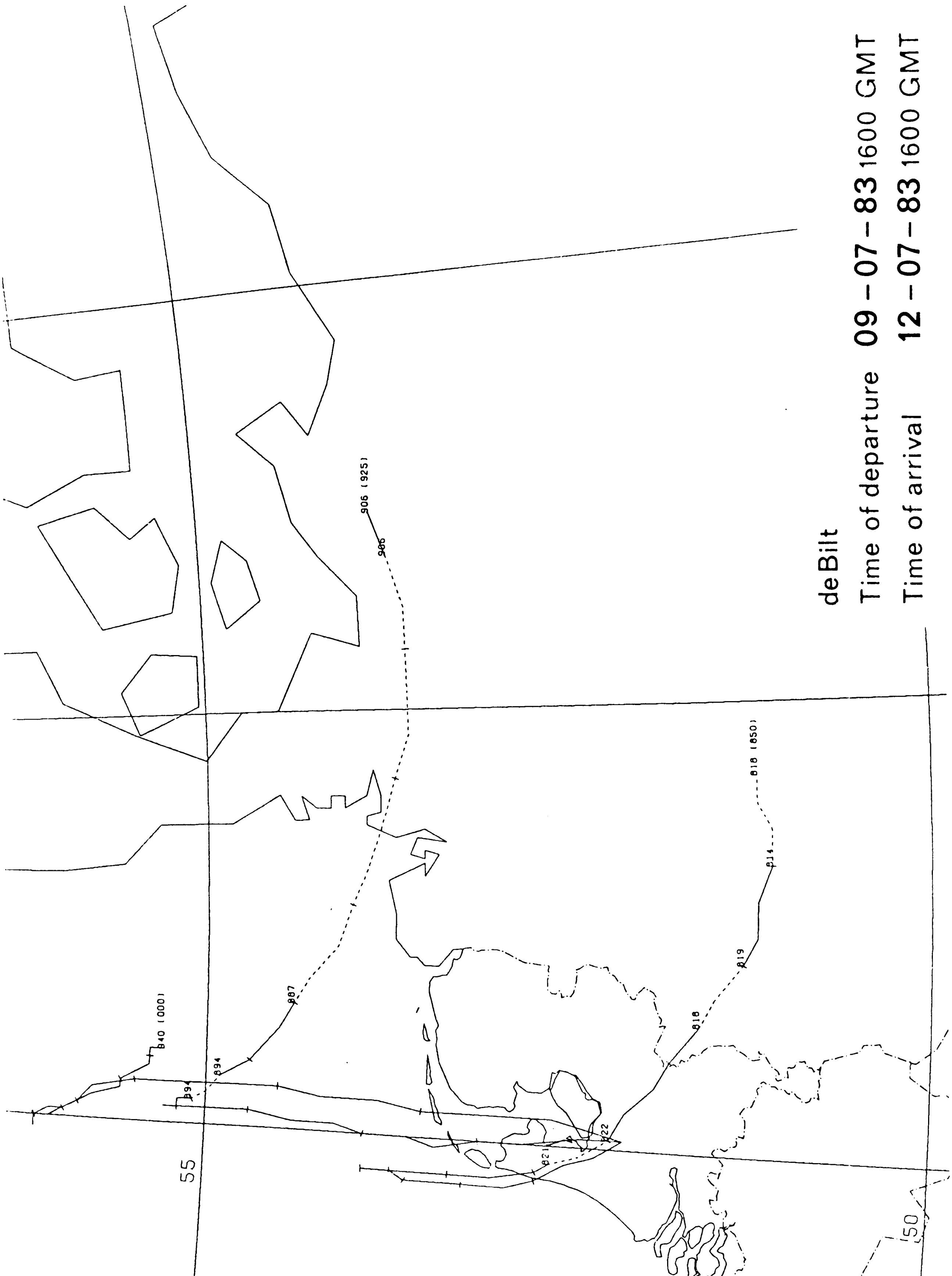
Time of arrival **12 – 07 – 83** 1600 GMT

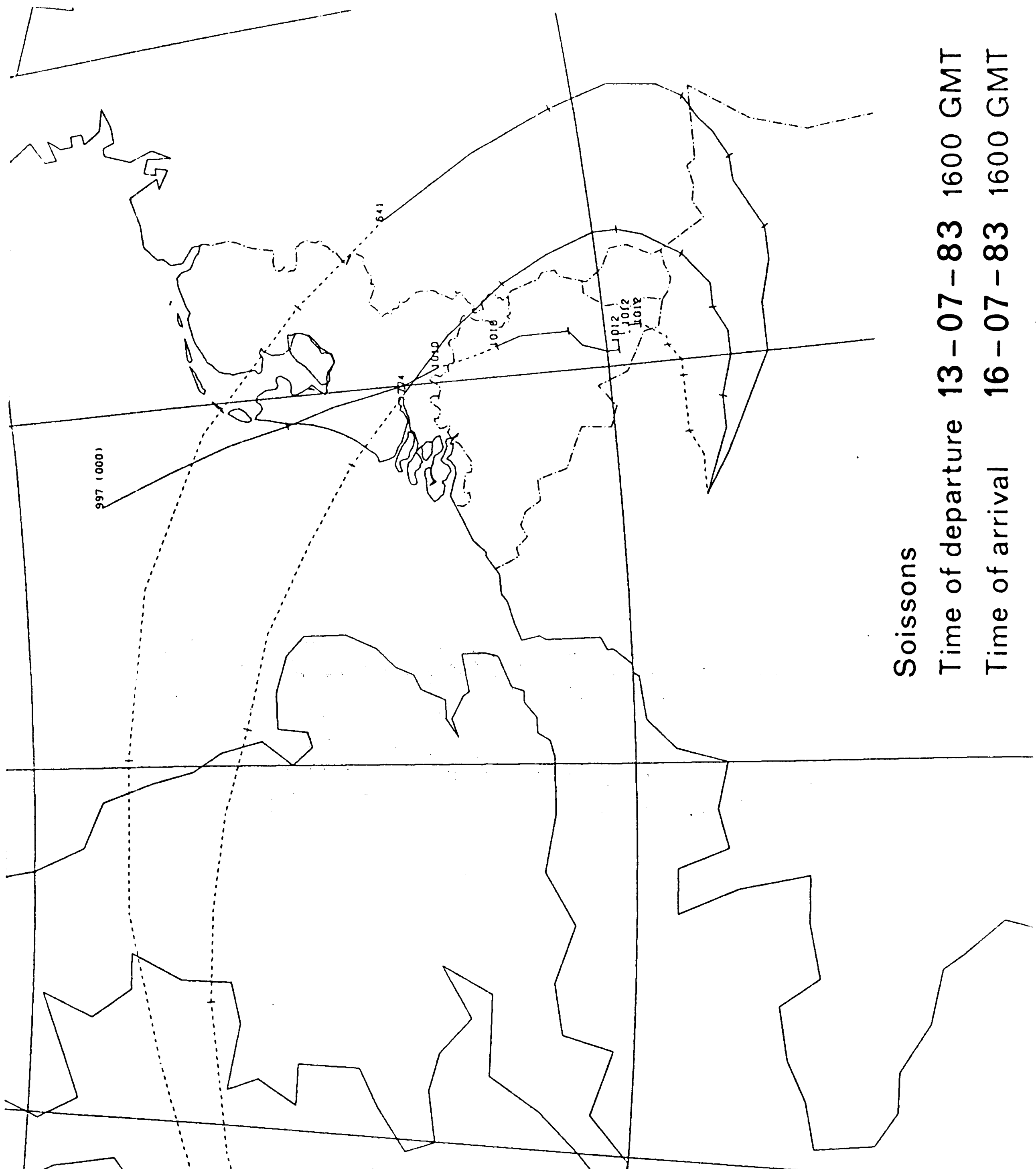


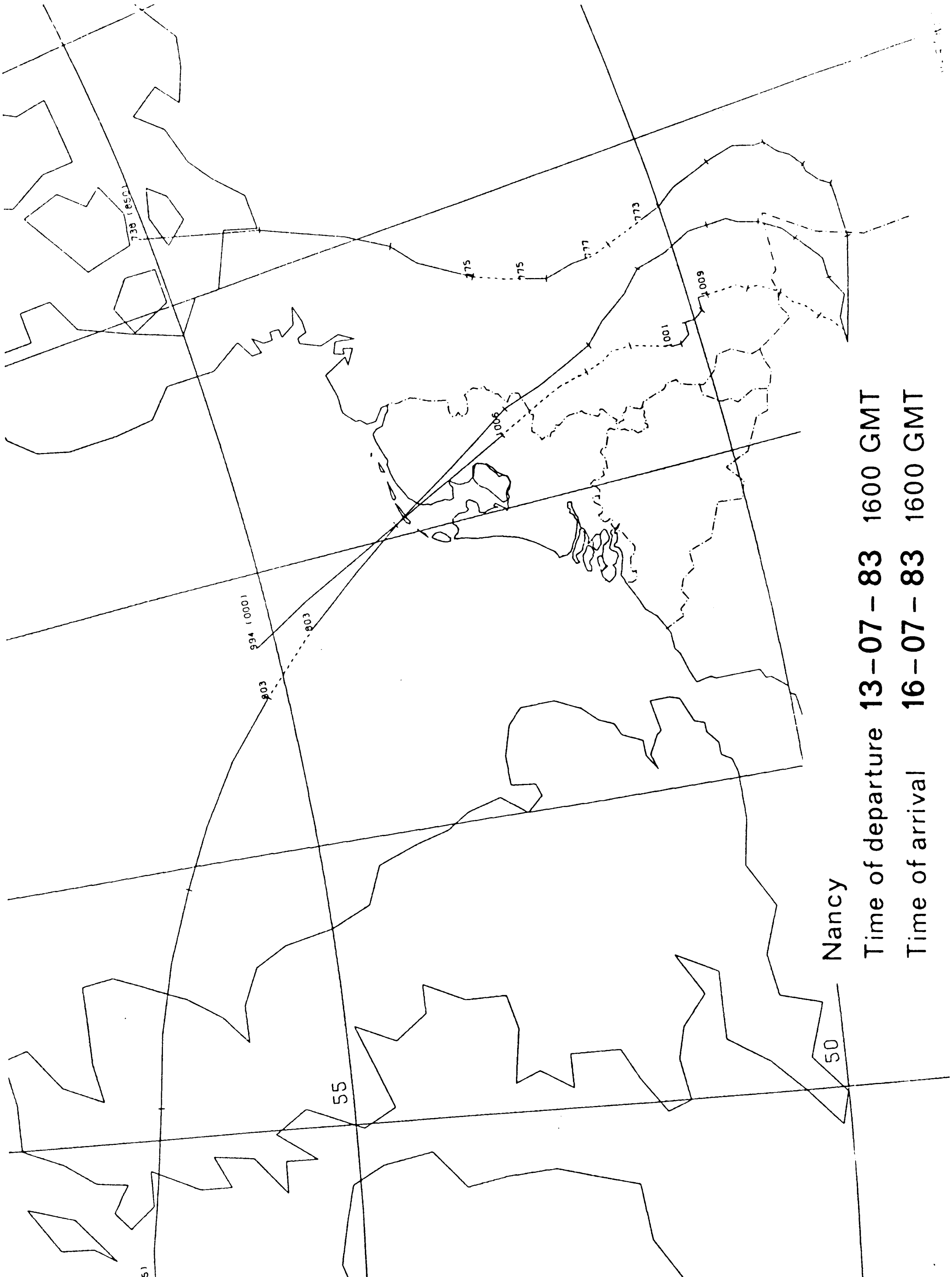
Soltau

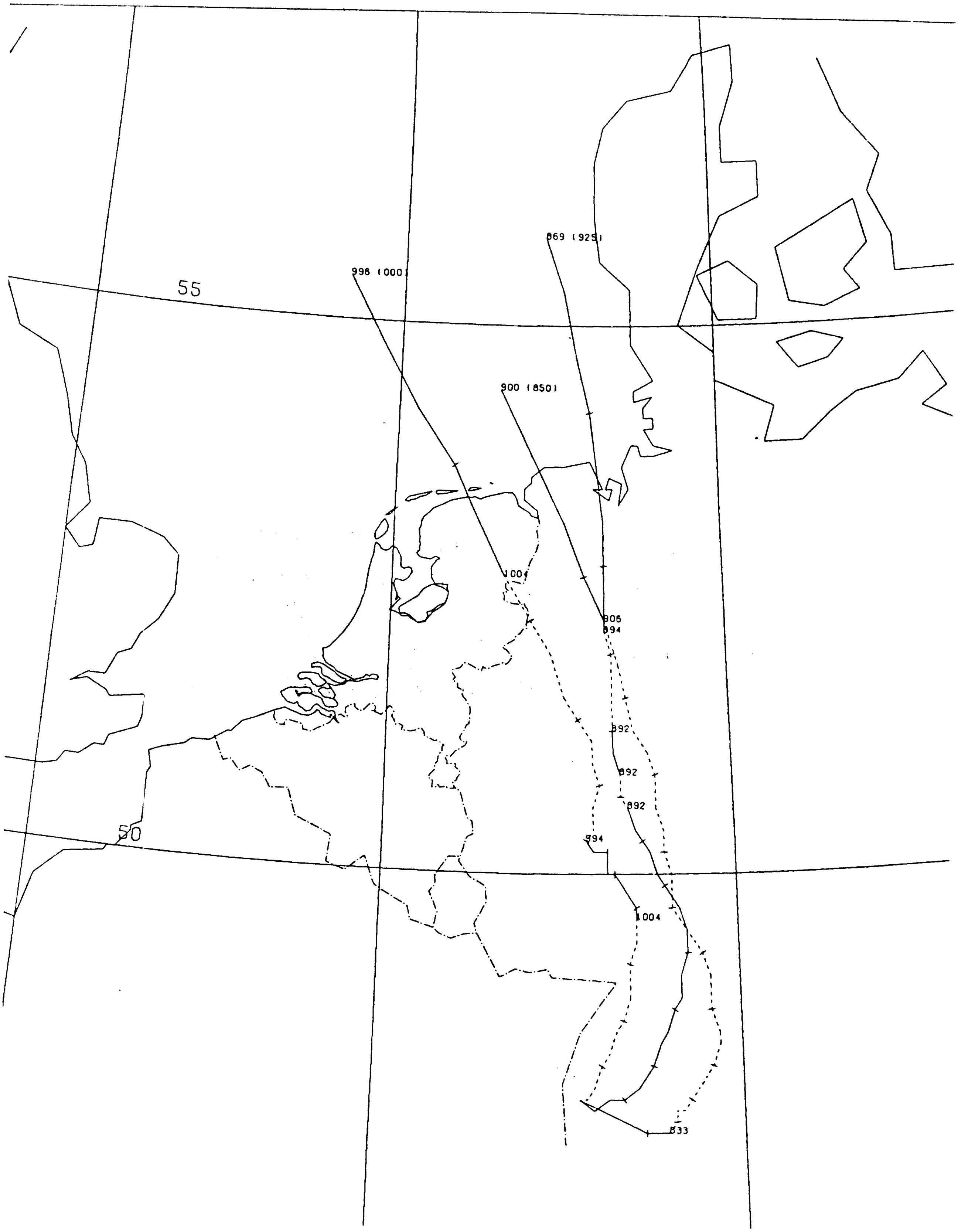
Time of departure **09 - 07 - 83** 1600 GMT

Time of arrival **12 - 07 - 83** 1600 GMT


deBilt
Time of departure 09-07-83 1600 GMT
Time of arrival 12-07-83 1600 GMT
906 (925)
818 (850)
840 (000)
55
50


Soissons
Time of departure 13-07-83 1600 GMT
Time of arrival 16-07-83 1600 GMT
641
997 (1000)
724
1010
1018
1012
1012
1012
923
922
922 (925)
714 (850)
734
50

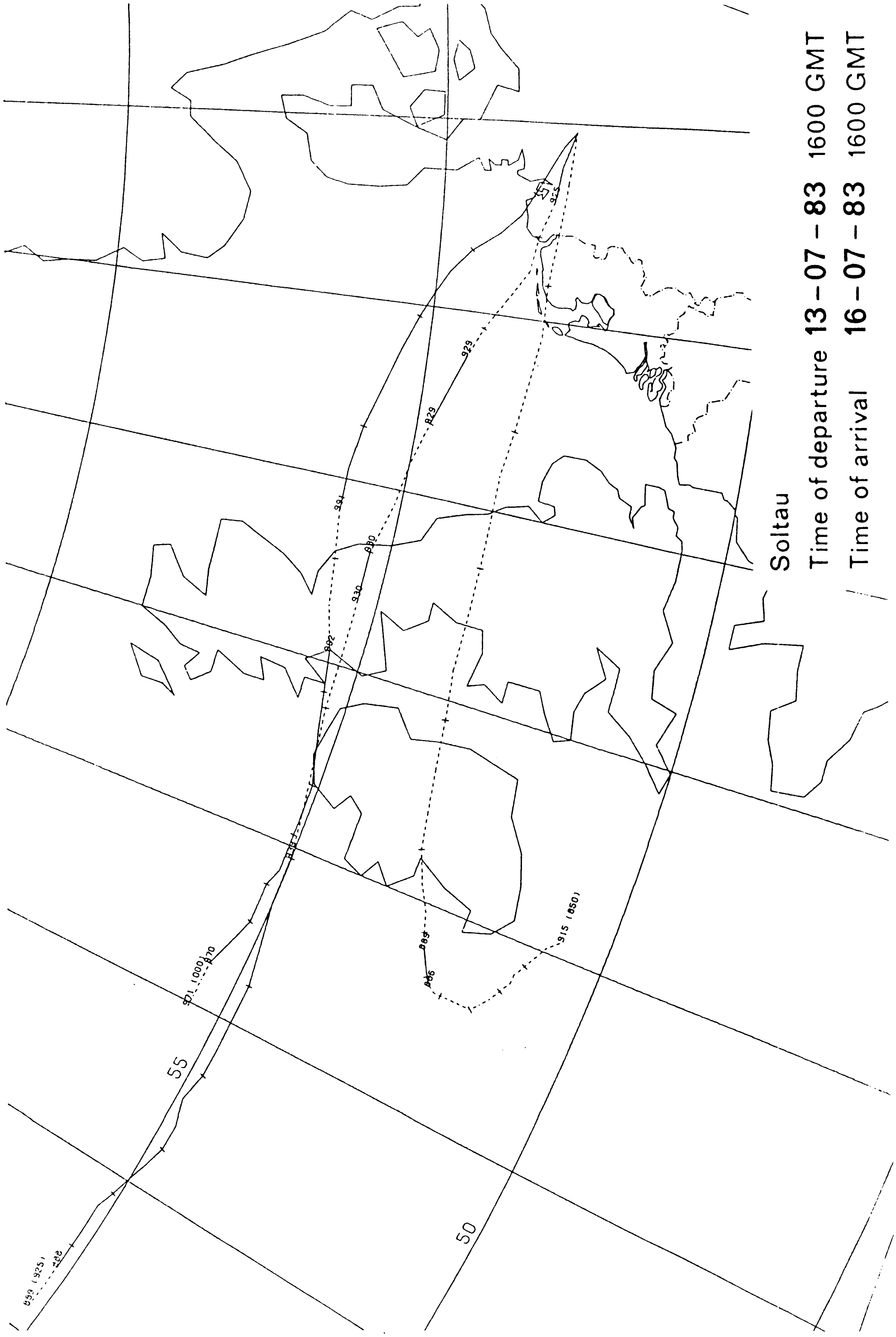

Nancy
Time of departure 13-07-83 1600 GMT
Time of arrival 16-07-83 1600 GMT
55
50

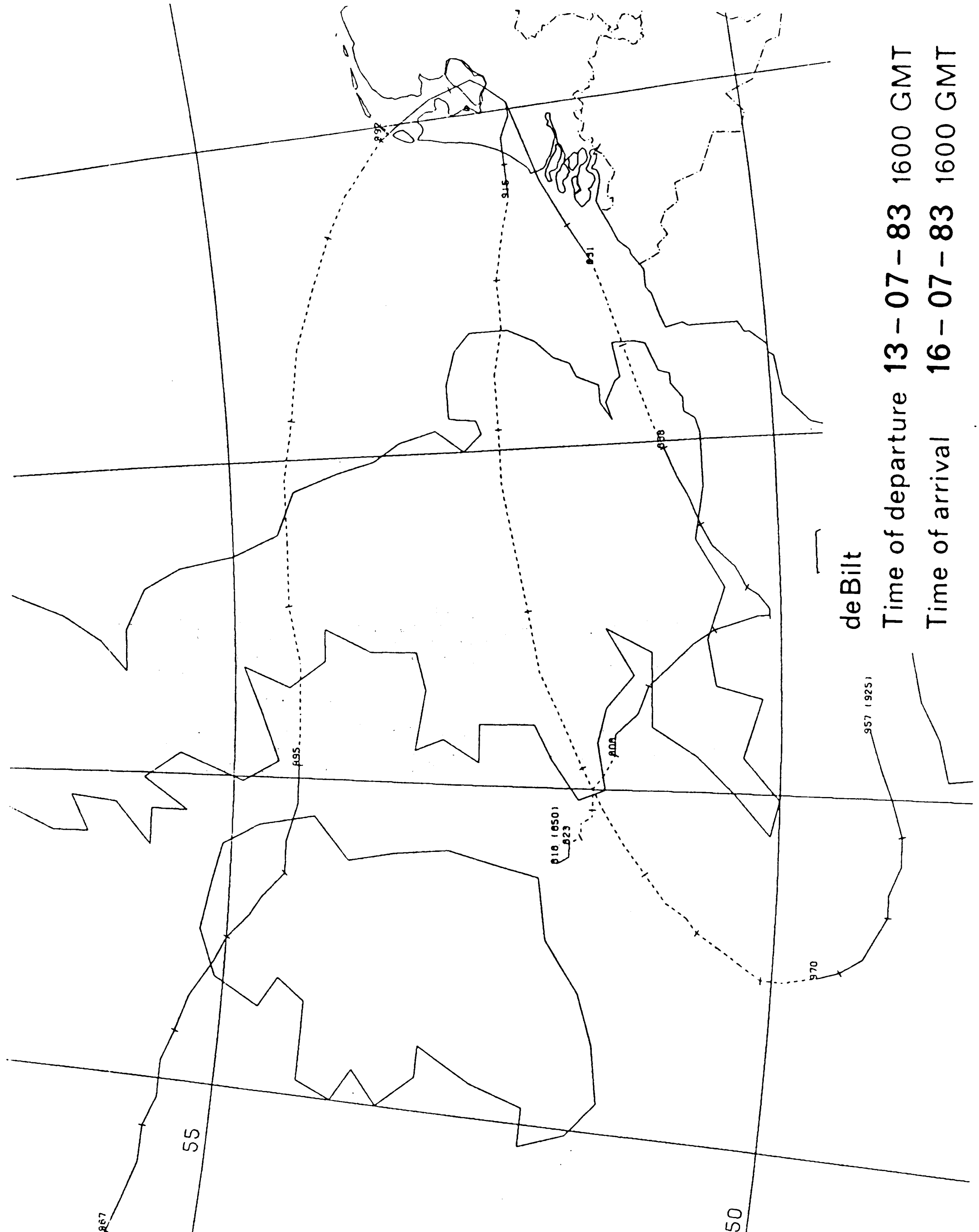


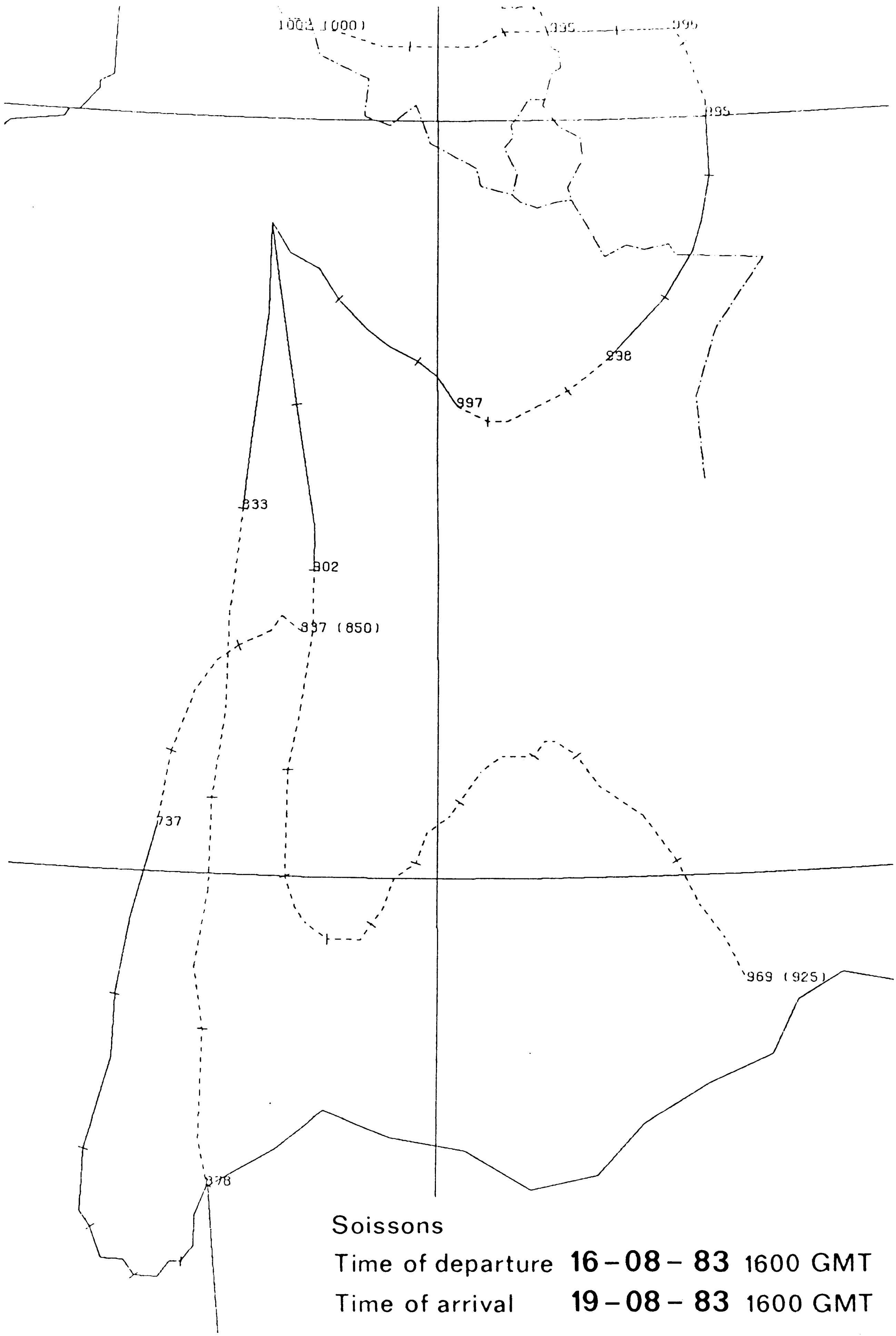
Freiburg

Time of departure **13-07-83** 1600 GMT

Time of arrival **16-07-83** 1600 GMT


Soltau
Time of departure 13-07-83 1600 GMT
Time of arrival 16-07-83 1600 GMT
55
50

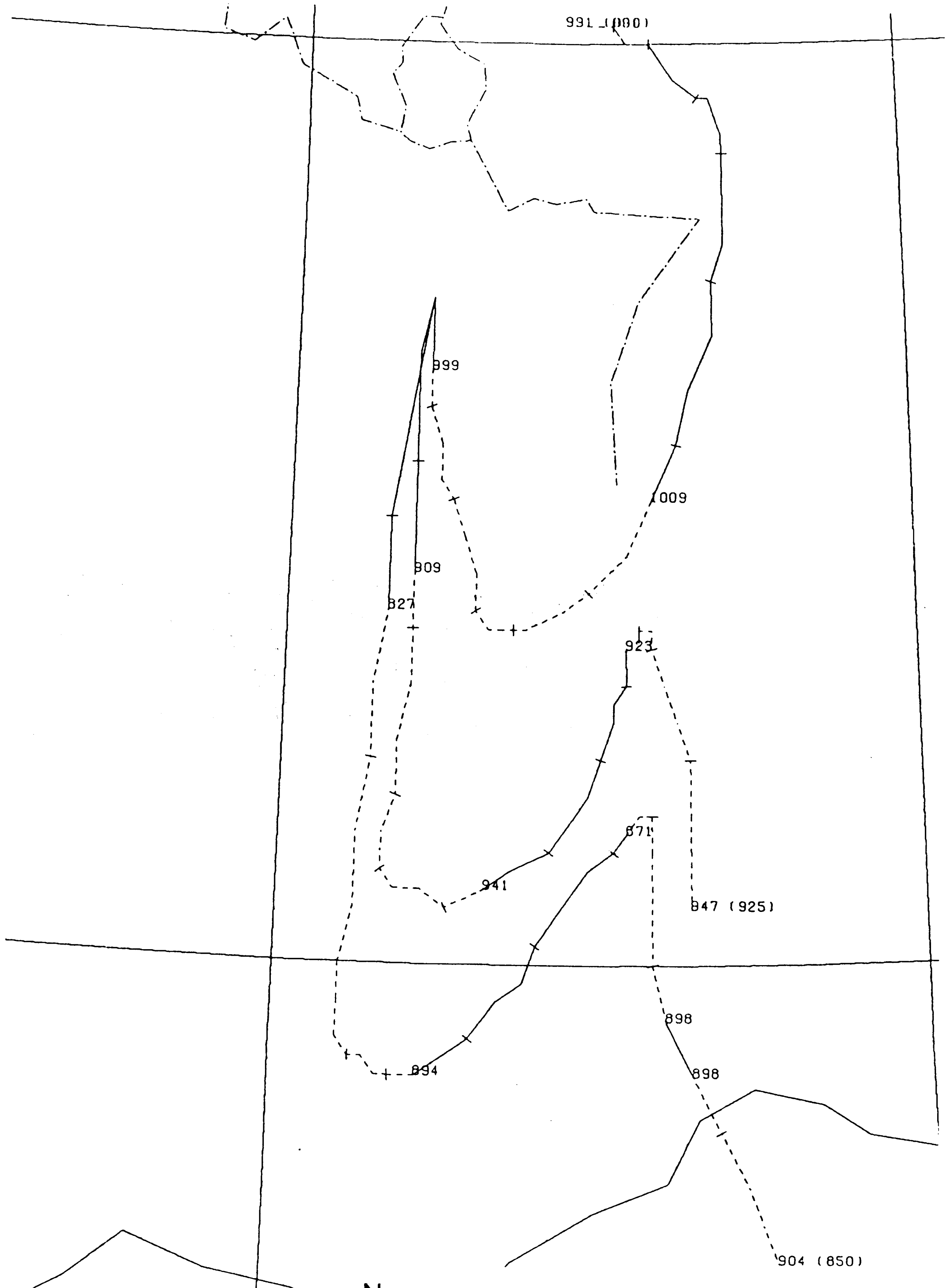

deBilt
Time of departure 13-07-83 1600 GMT
Time of arrival 16-07-83 1600 GMT
55
50



Soissons

Time of departure **16 - 08 - 83** 1600 GMT

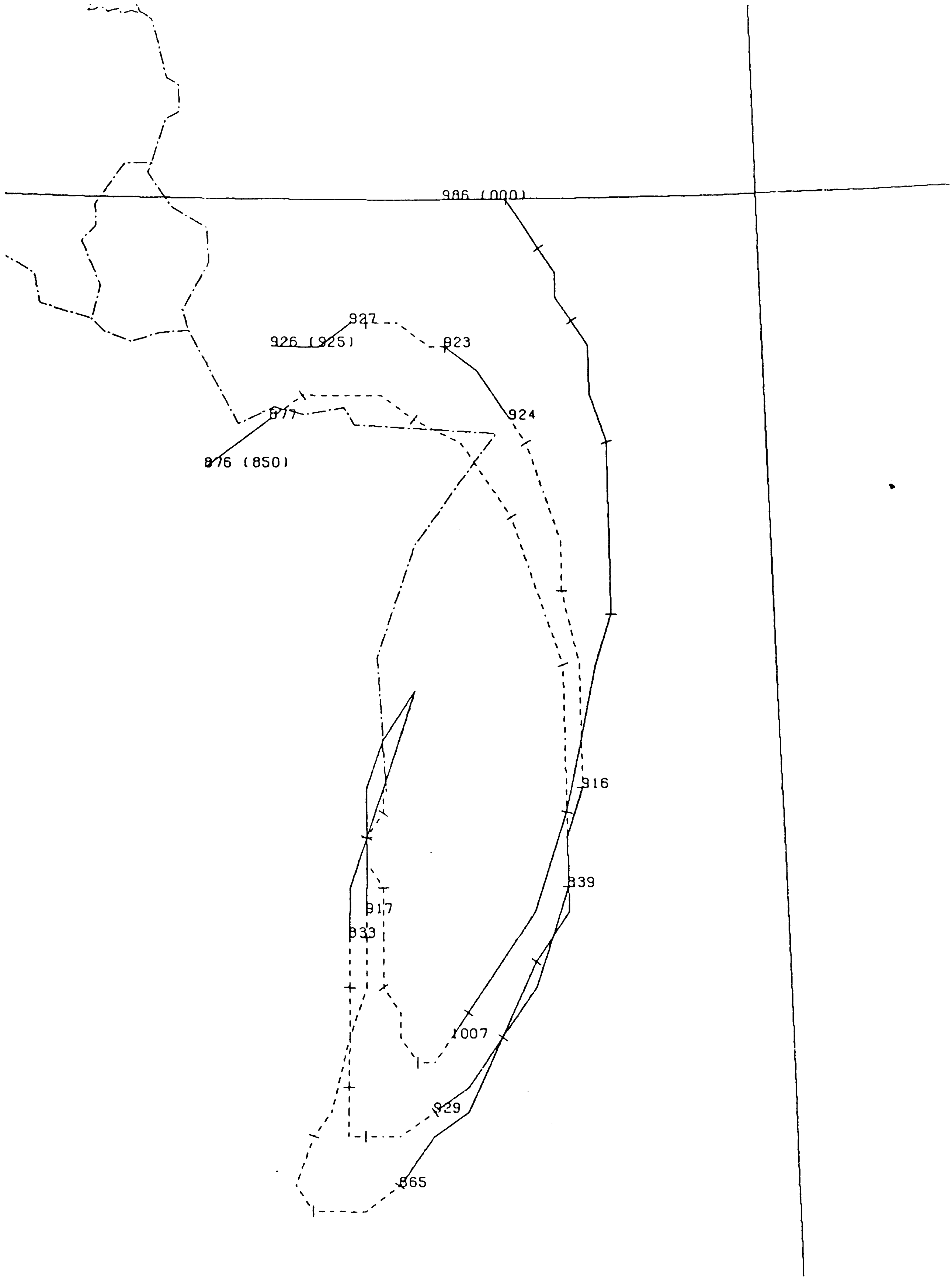
Time of arrival **19 - 08 - 83** 1600 GMT



Nancy

Time of departure **16-08-83** 1600 GMT

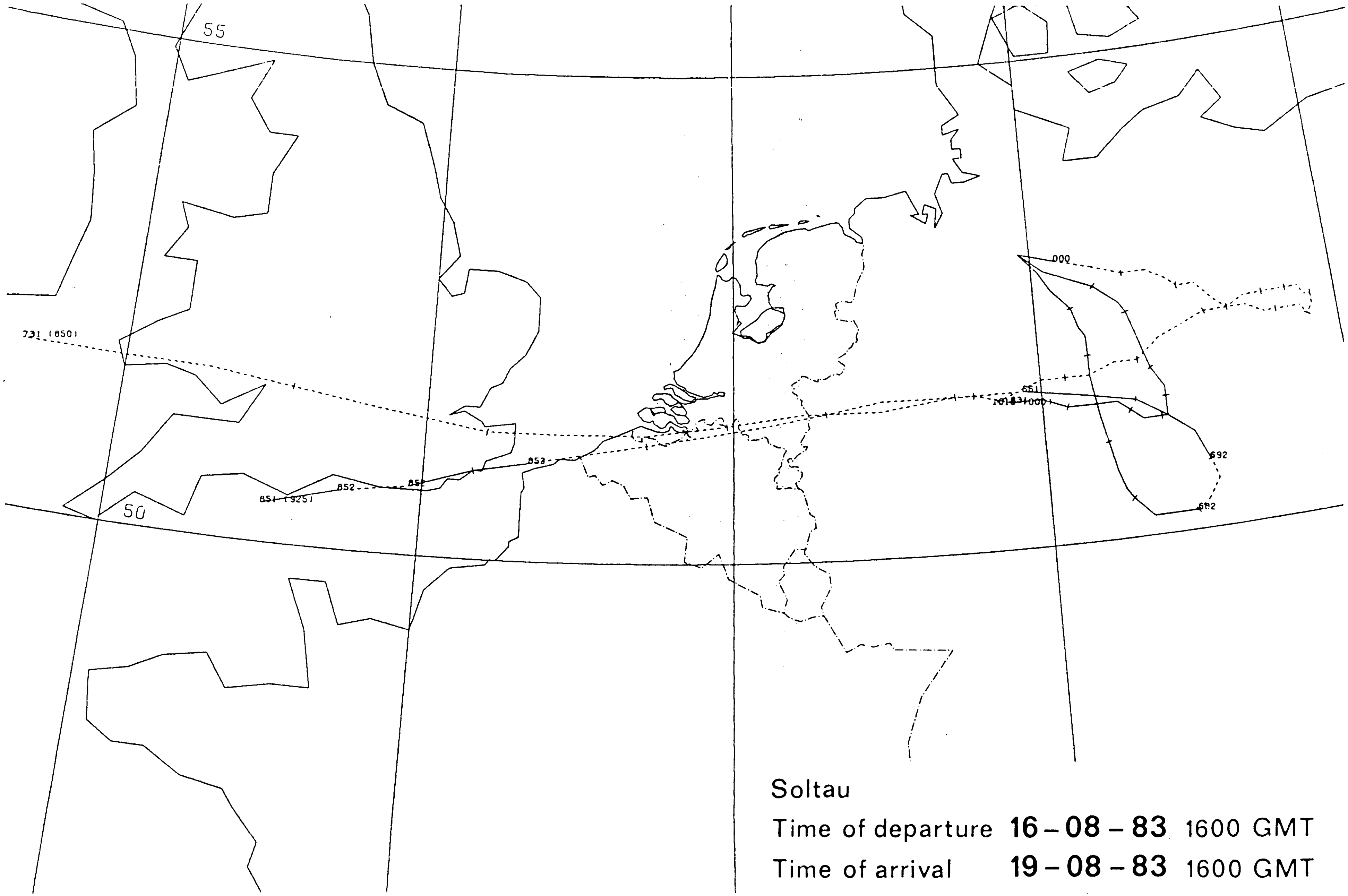
Time of arrival **19-08-83** 1600 GMT



Freiburg

Time of departure **16-08-83** 1600 GMT

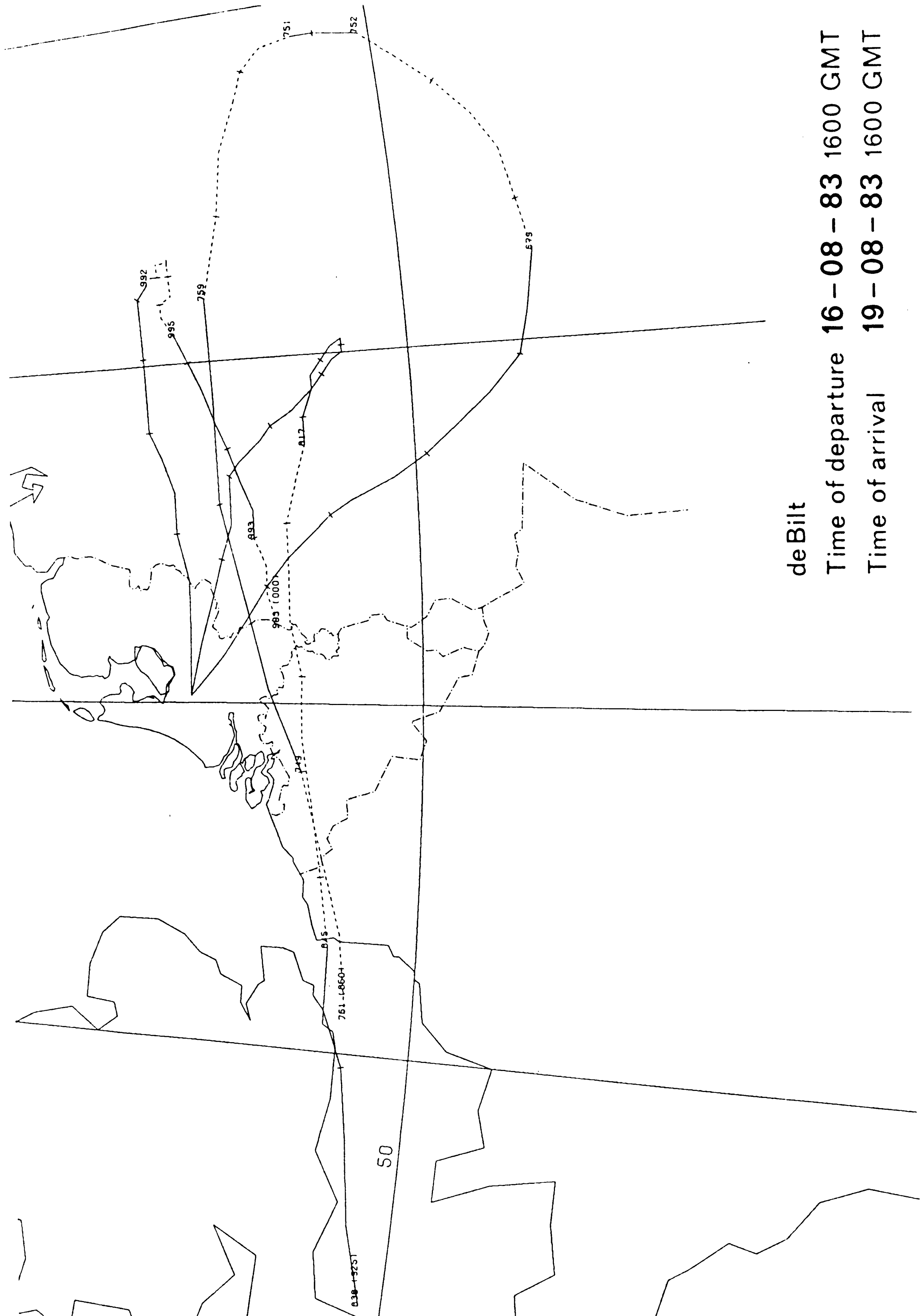
Time of arrival **19-08-83** 1600 GMT

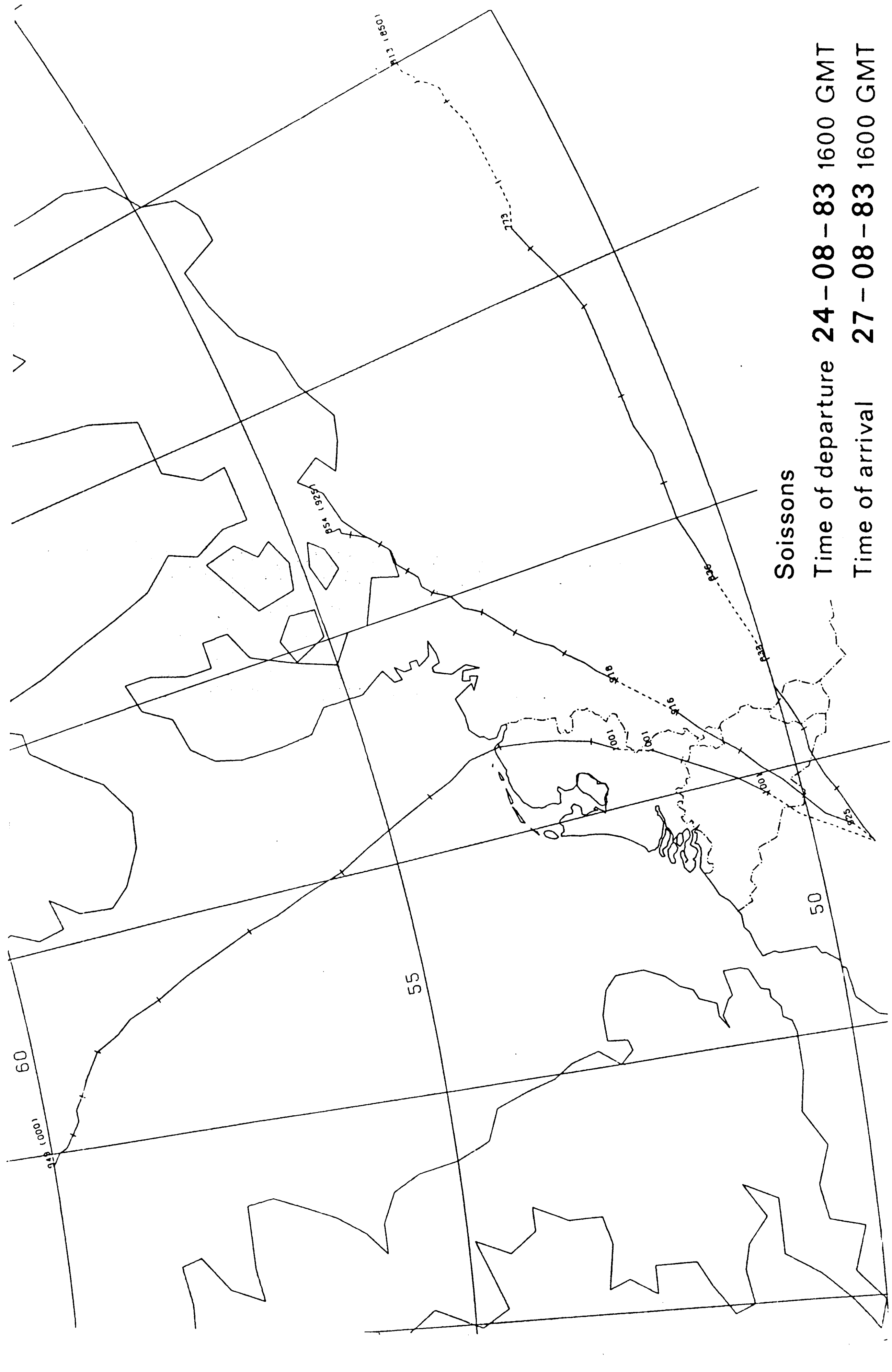


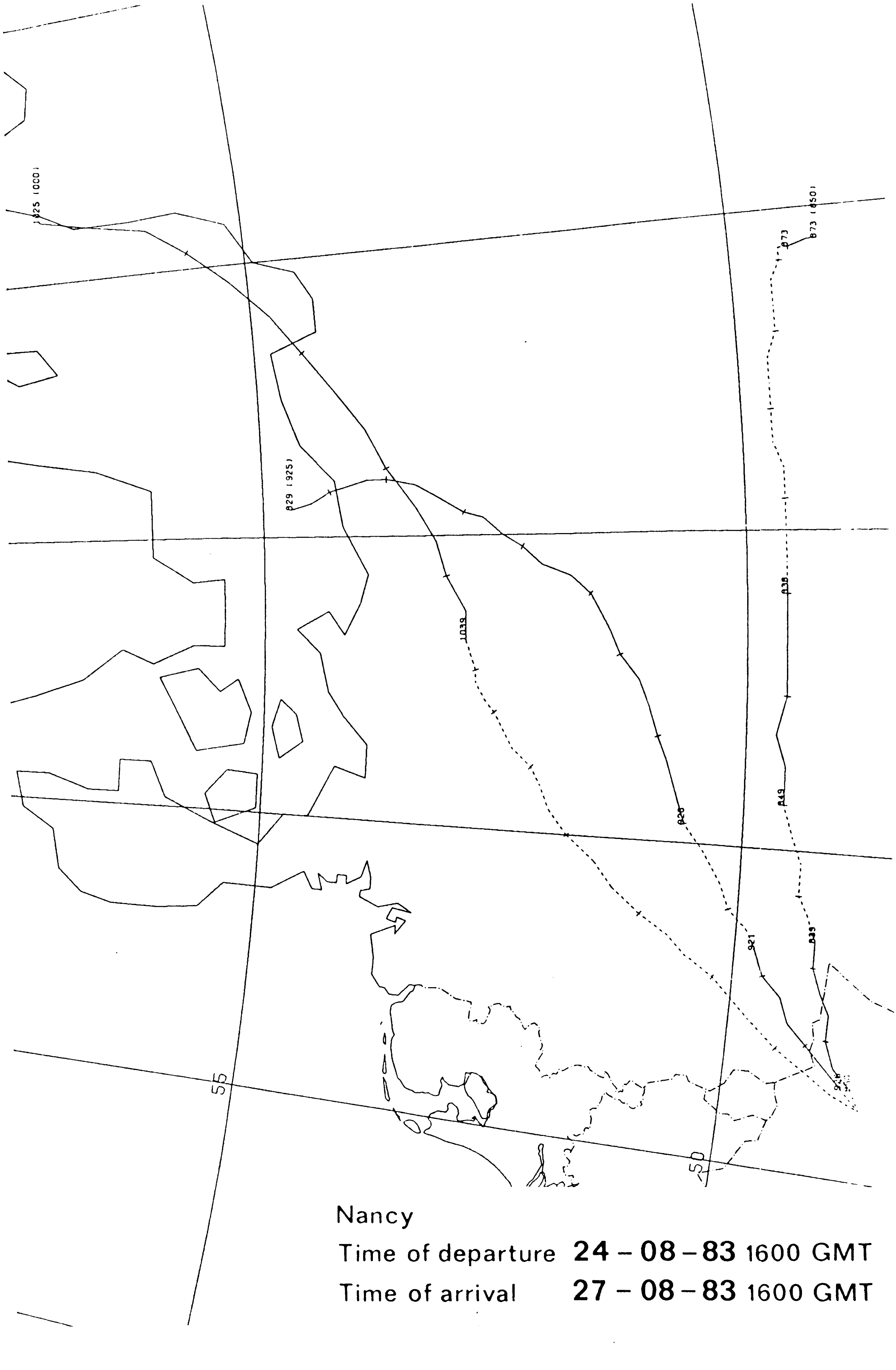
Soltau

Time of departure **16 – 08 – 83** 1600 GMT

Time of arrival **19 – 08 – 83** 1600 GMT


de Bilt
Time of departure 16-08-83 1600 GMT
Time of arrival 19-08-83 1600 GMT
50

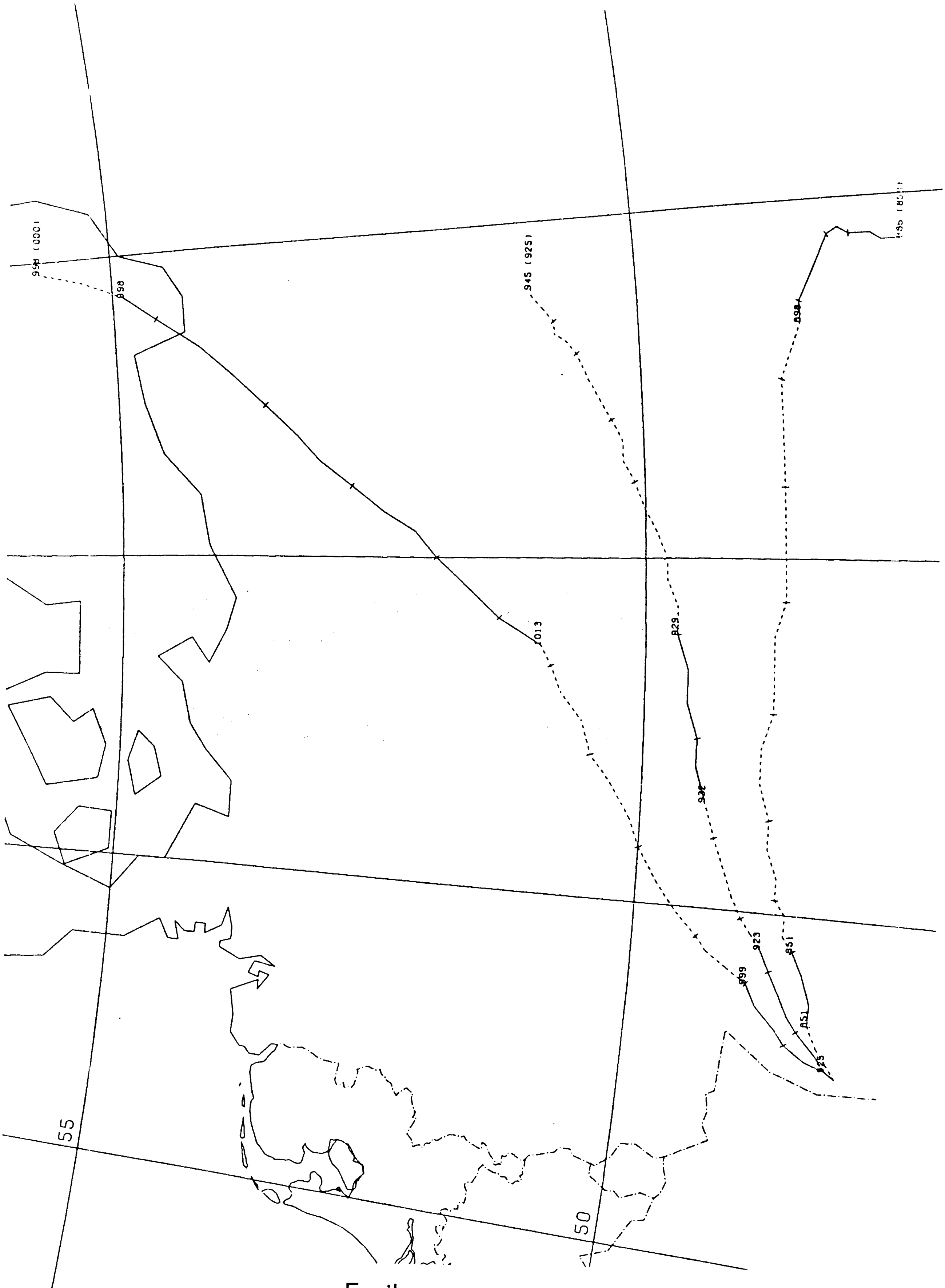

Soissons
Time of departure 24-08-83 1600 GMT
Time of arrival 27-08-83 1600 GMT
50
55
60



Nancy

Time of departure **24 – 08 – 83** 1600 GMT

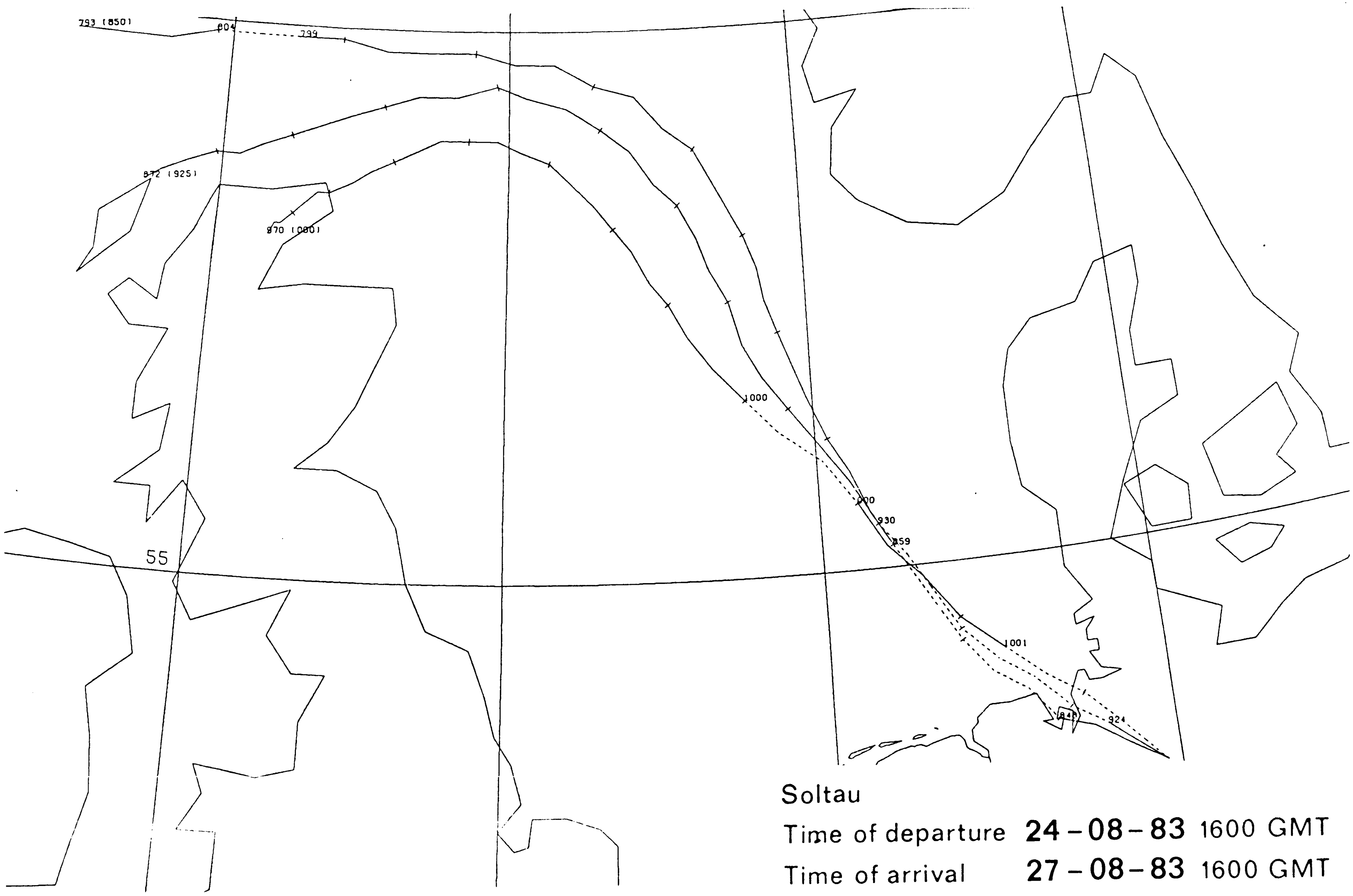
Time of arrival **27 – 08 – 83** 1600 GMT



Freiburg

Time of departure **24-08-83** 1600 GMT

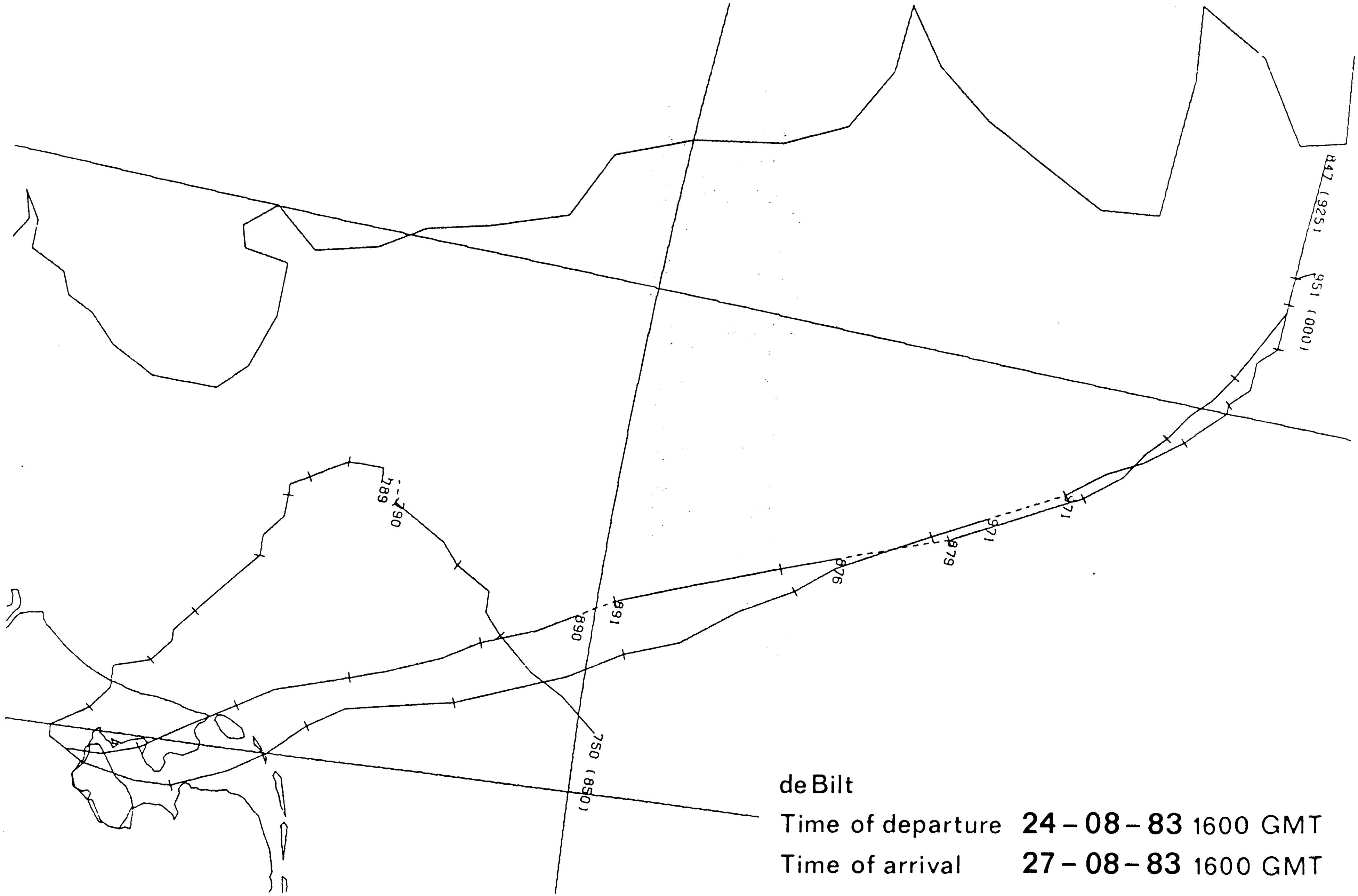
Time of arrival **27-08-83** 1600 GMT

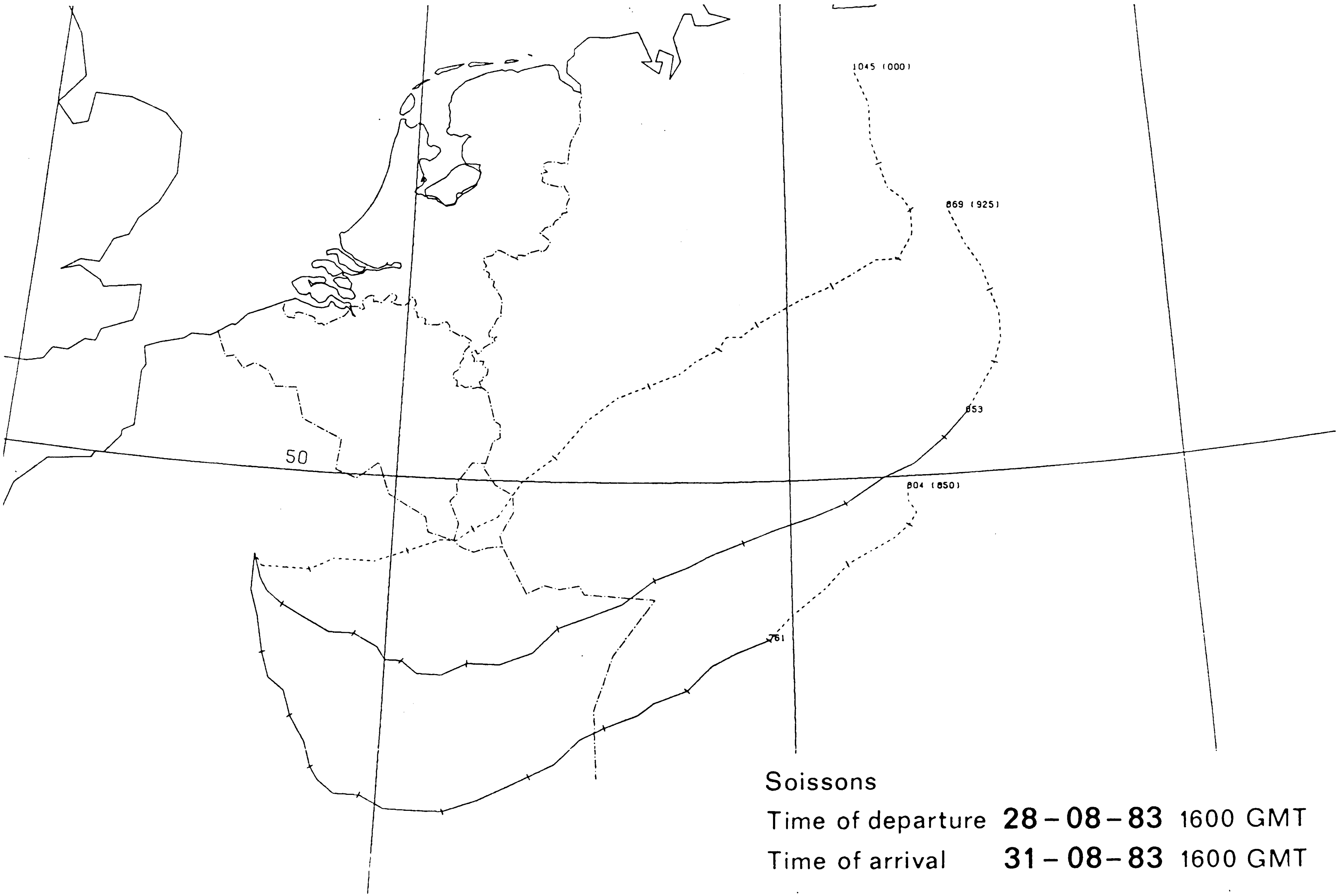


Soltau

Time of departure **24 – 08 – 83** 1600 GMT

Time of arrival **27 – 08 – 83** 1600 GMT

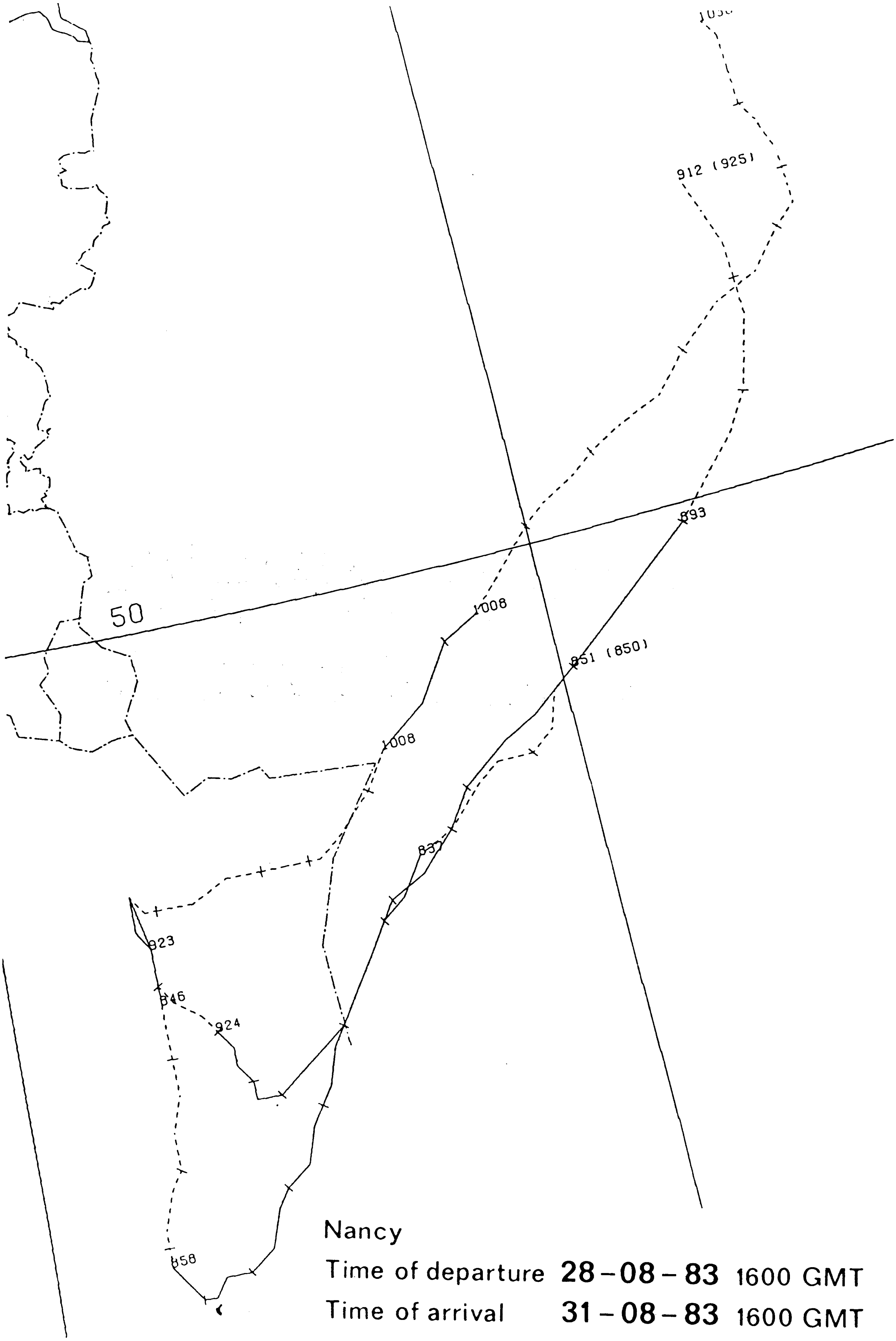

847 (925)
951 (000)
971
971
879
876
891
890
750 (850)
790
789
de Bilt
Time of departure 24 - 08 - 83 1600 GMT
Time of arrival 27 - 08 - 83 1600 GMT



Soissons

Time of departure **28-08-83** 1600 GMT

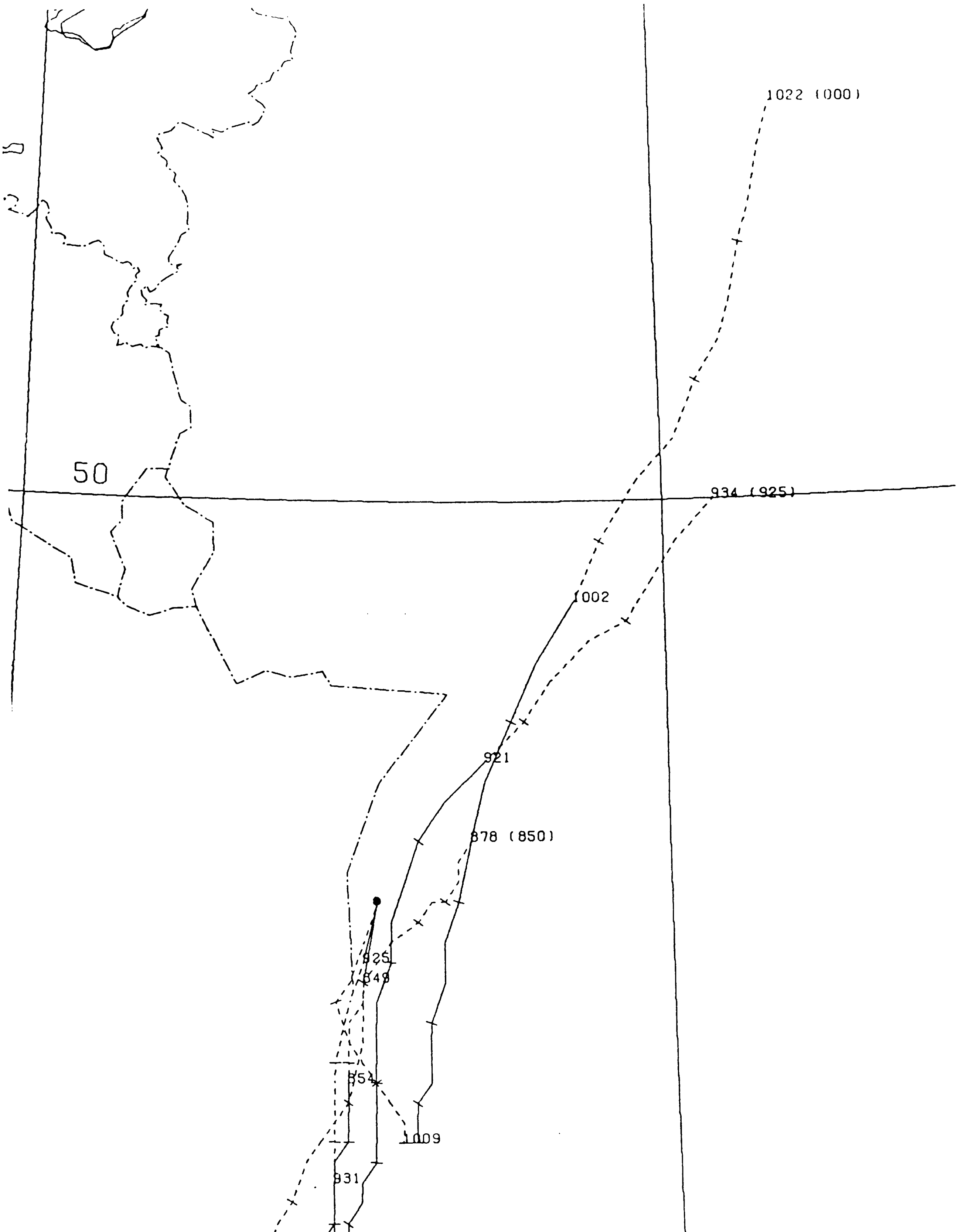
Time of arrival **31-08-83** 1600 GMT



Nancy

Time of departure **28 – 08 – 83** 1600 GMT

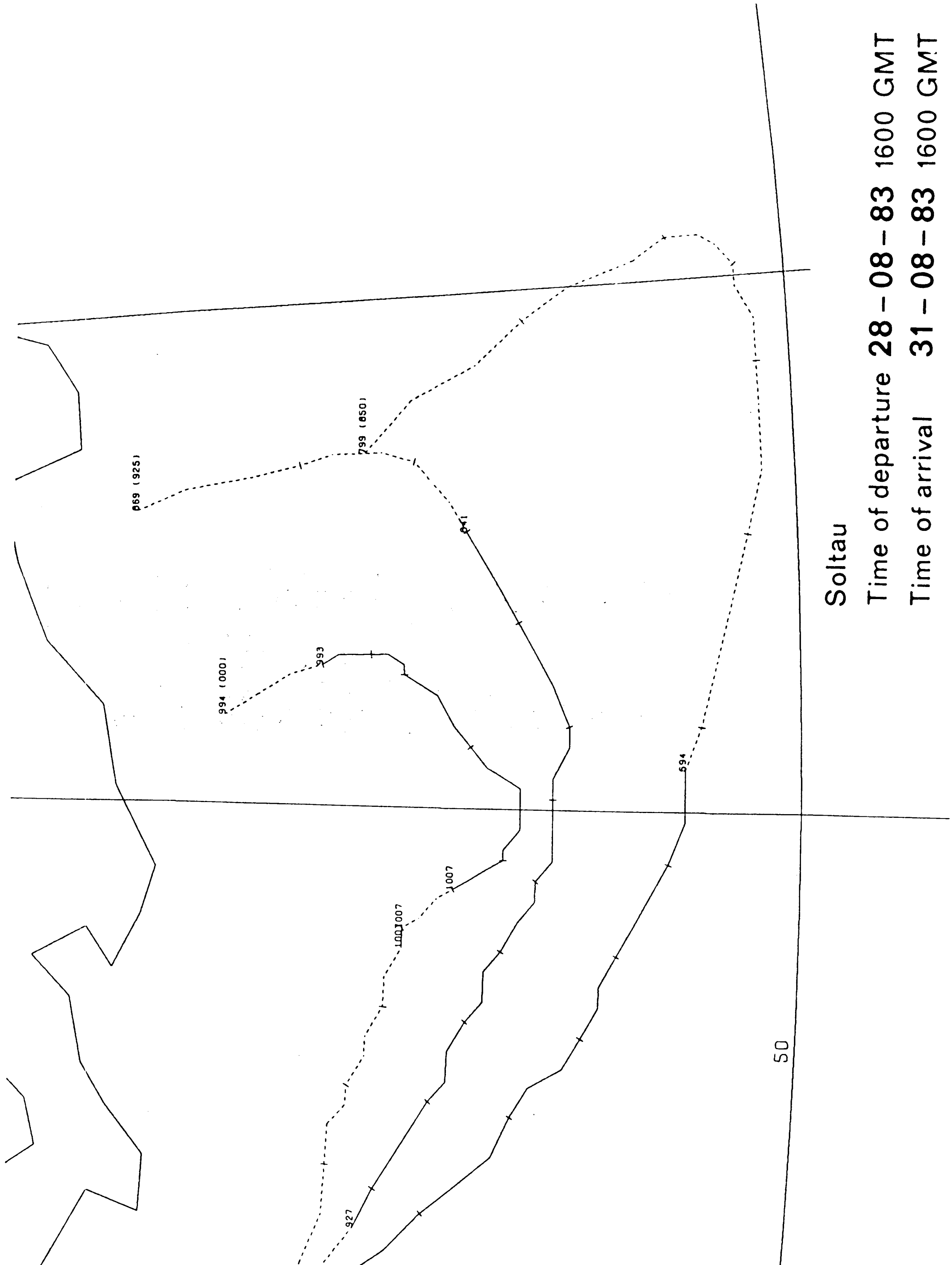
Time of arrival **31 – 08 – 83** 1600 GMT

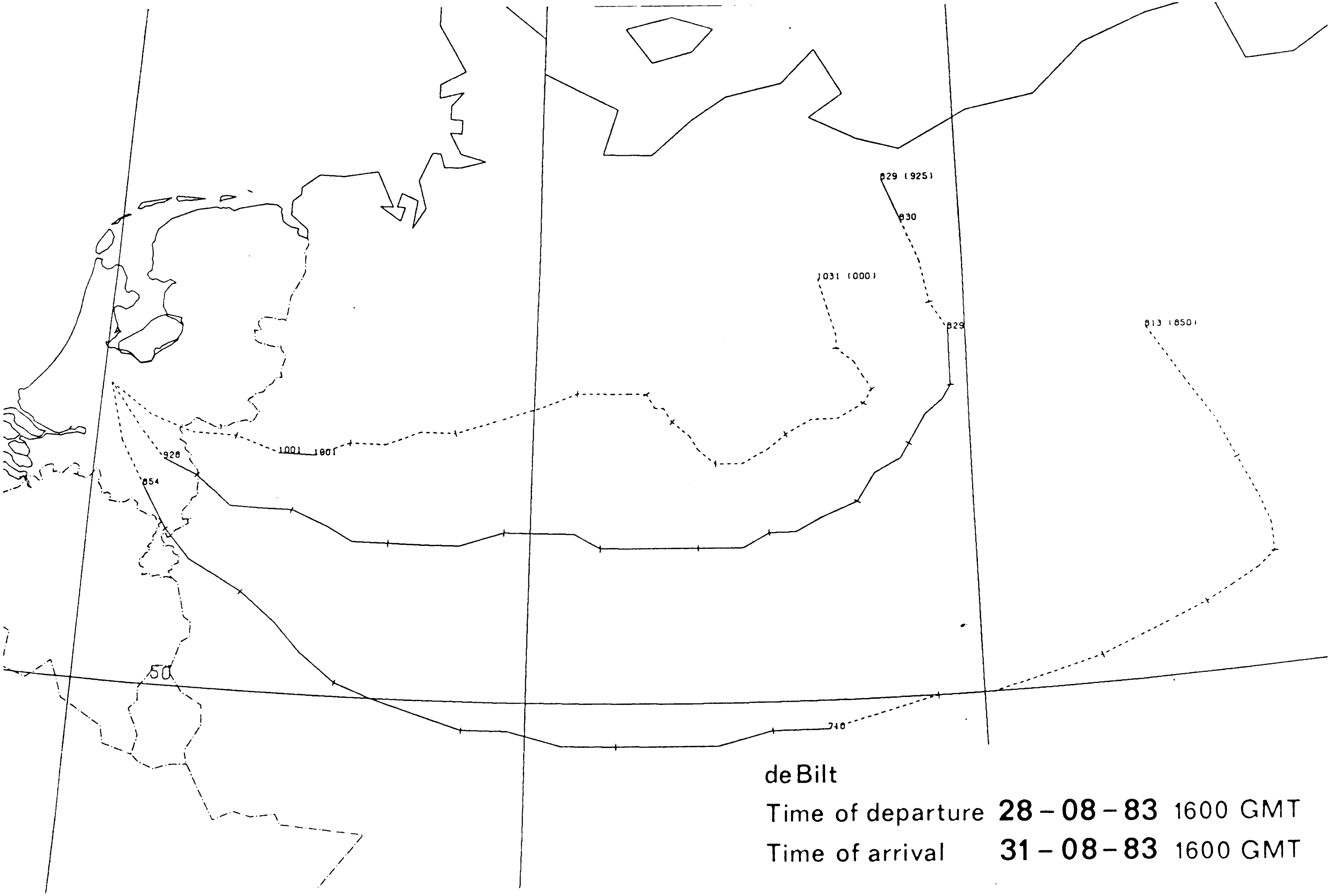


Freiburg

Time of departure **28 - 08 - 83** 1600 GMT

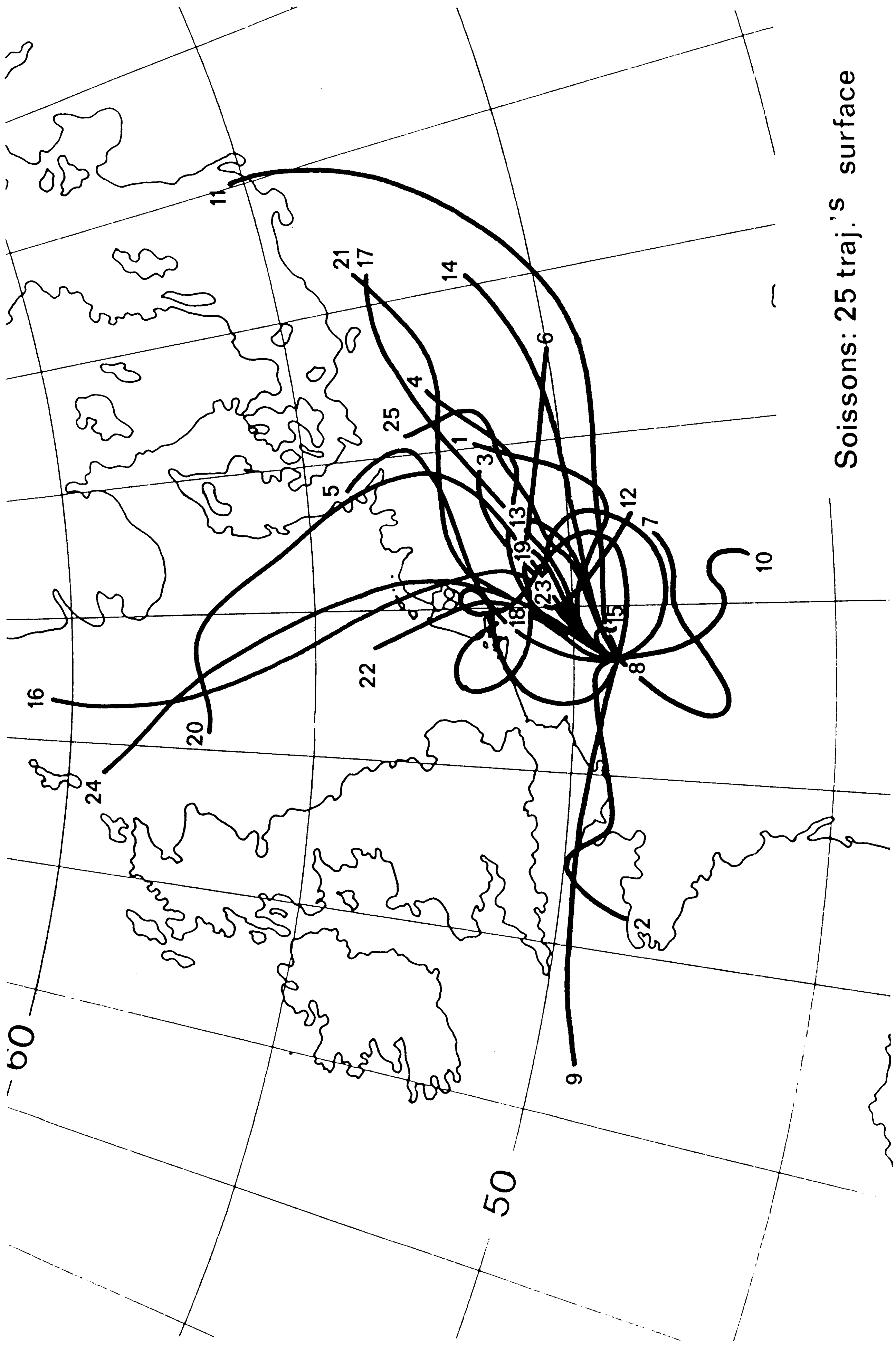
Time of arrival **31 - 08 - 83** 1600 GMT


Soltau
Time of departure 28 - 08 - 83 1600 GMT
Time of arrival 31 - 08 - 83 1600 GMT
50
869 (925)
799 (850)
994 (000)
993
1007
927
852

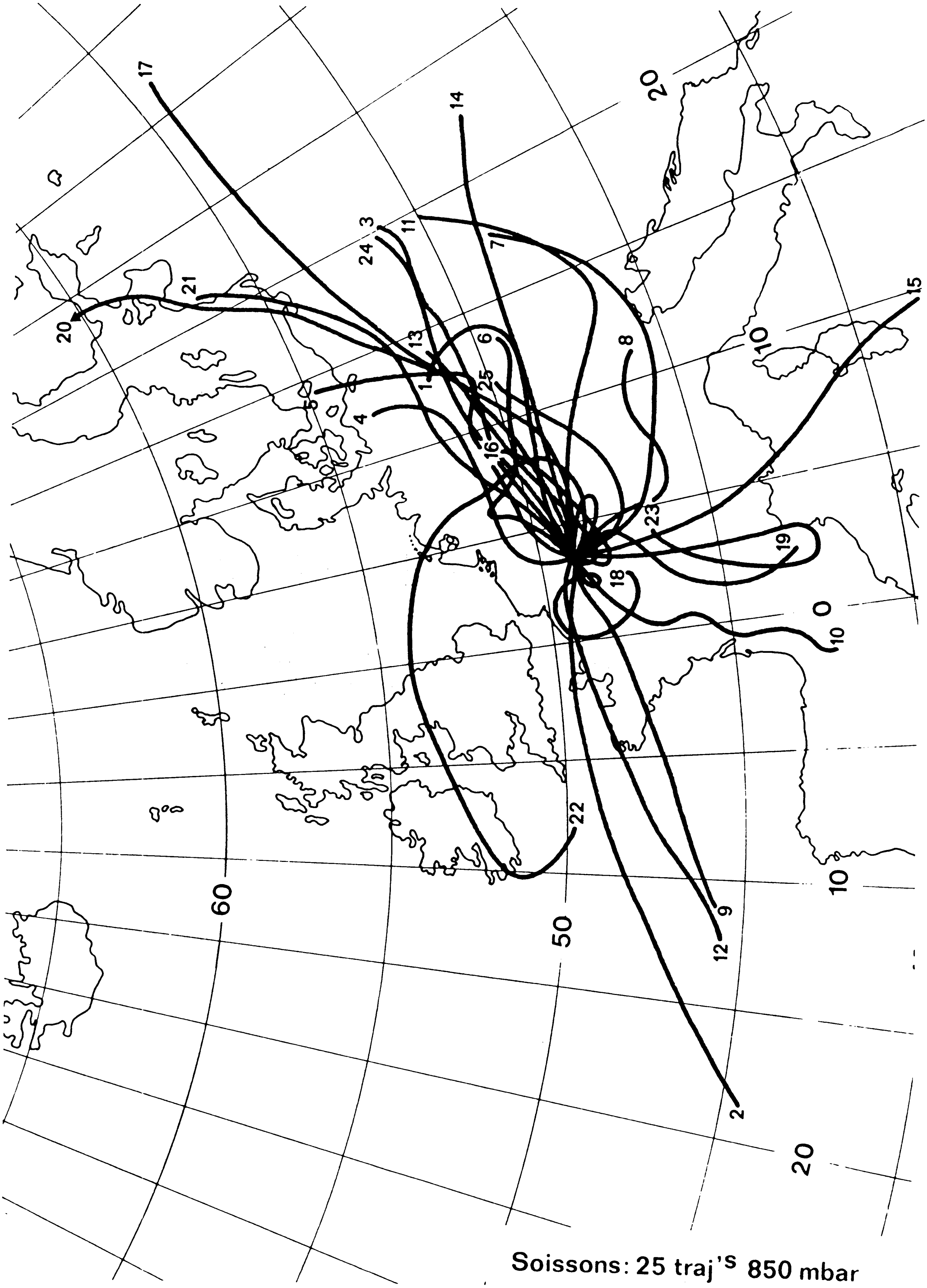

829 (925)
830
1031 (000)
829
813 (850)
1001 1801
928
854
50
710
de Bilt
Time of departure 28-08-83 1600 GMT
Time of arrival 31-08-83 1600 GMT

Appendix III

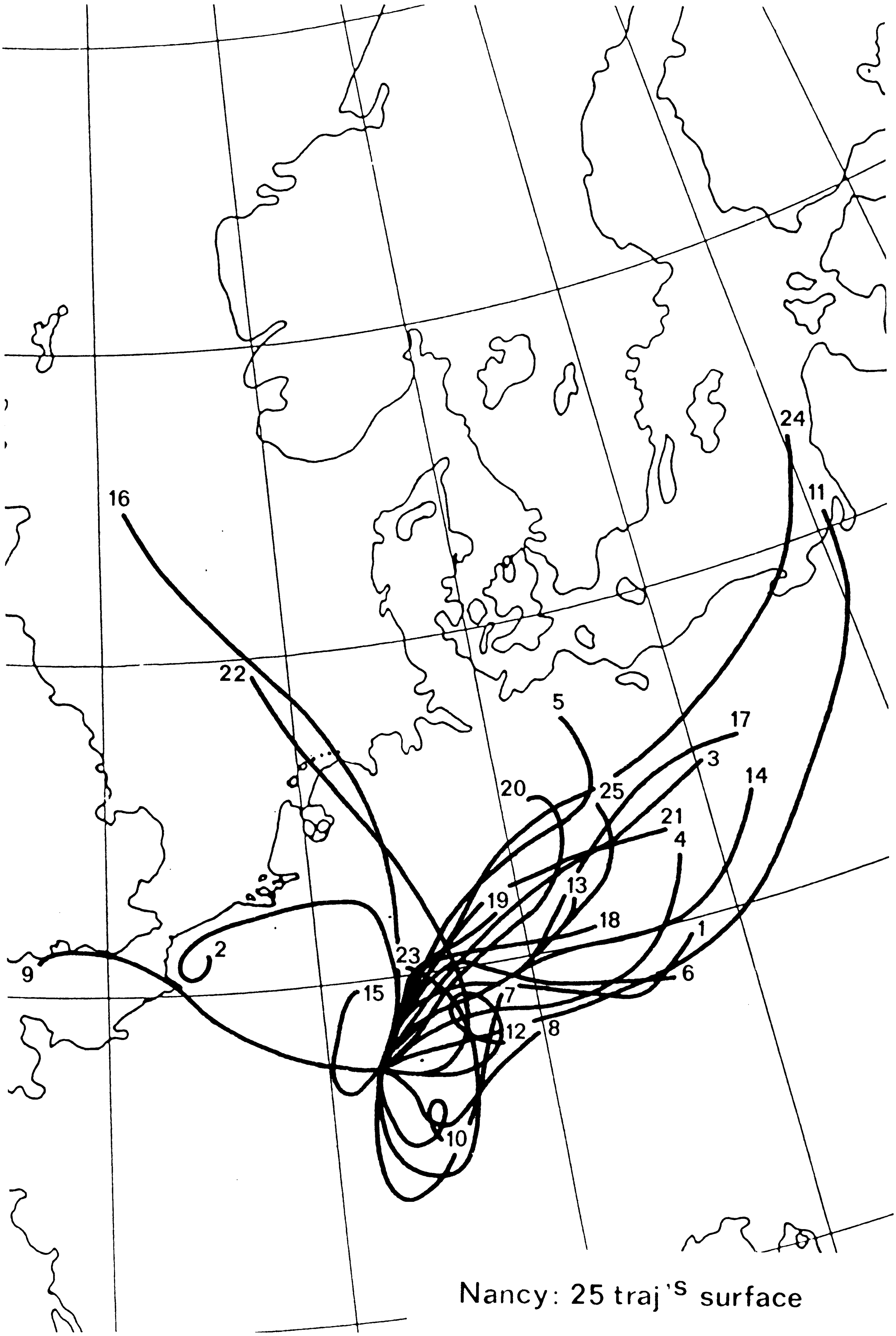
A summary of 1000 mbar/surface and 850 mbar trajectories for the 5 locations.



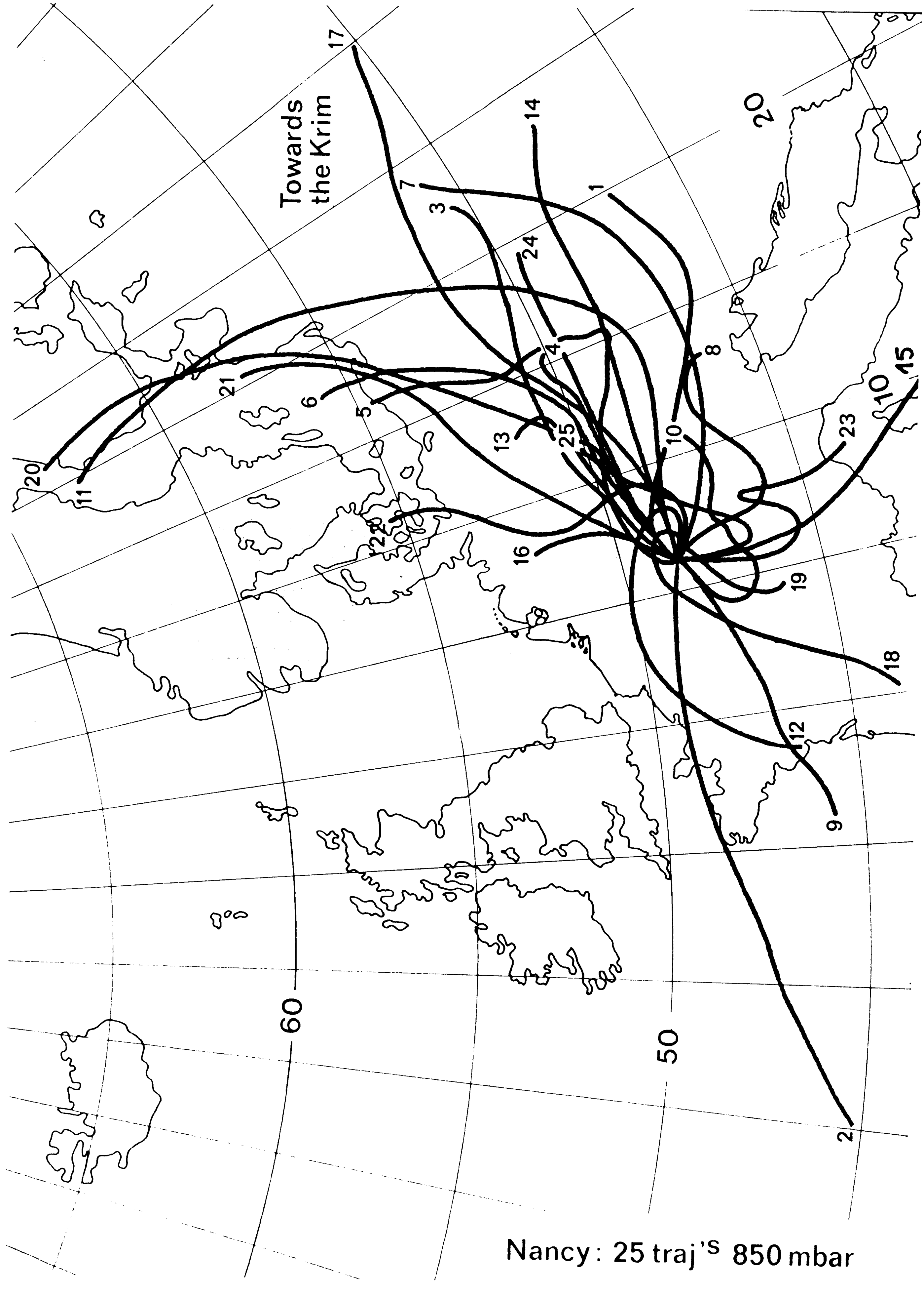
Soissons: 25 traj.'s surface



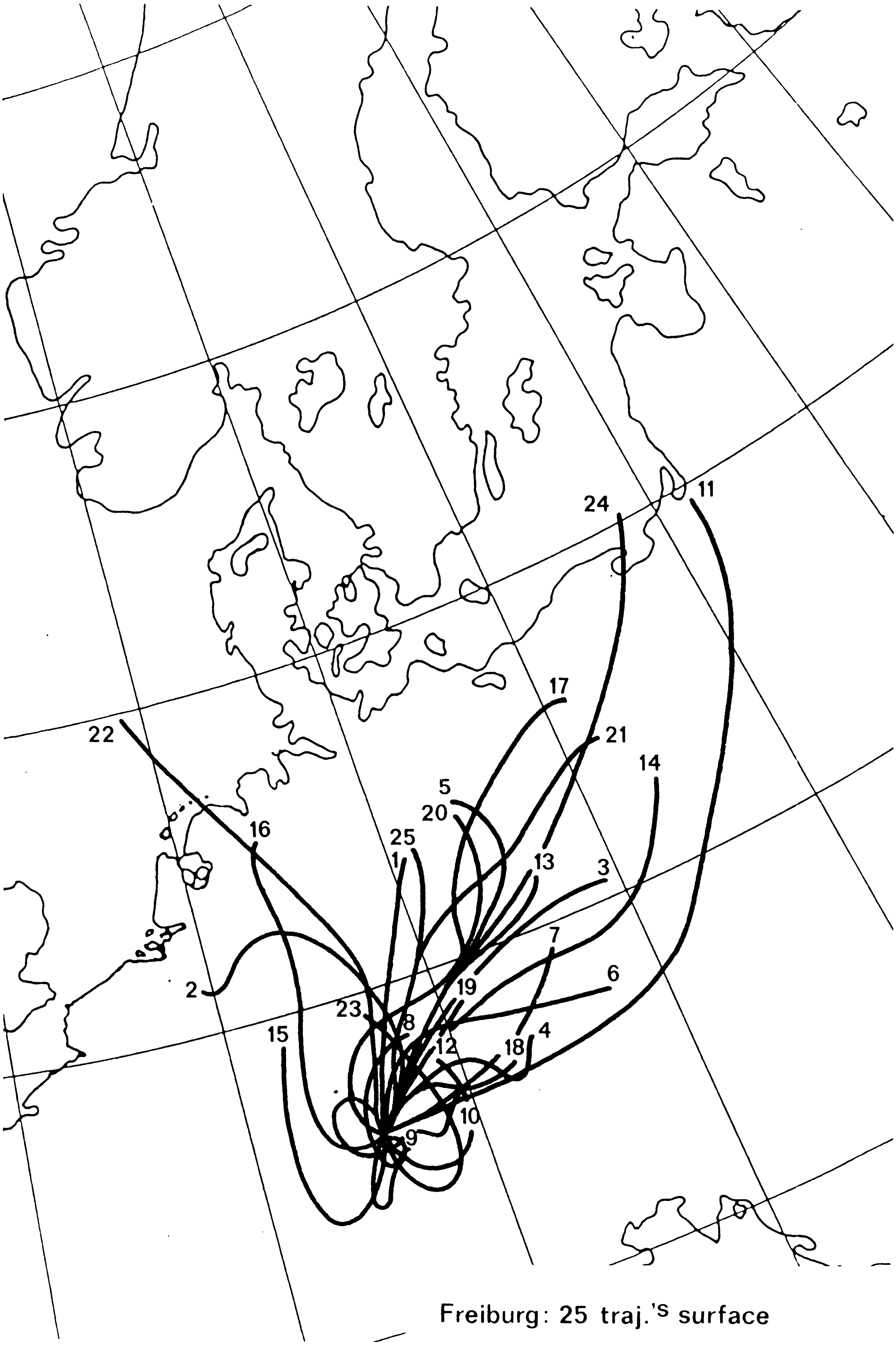
Soissons: 25 traj's 850 mbar



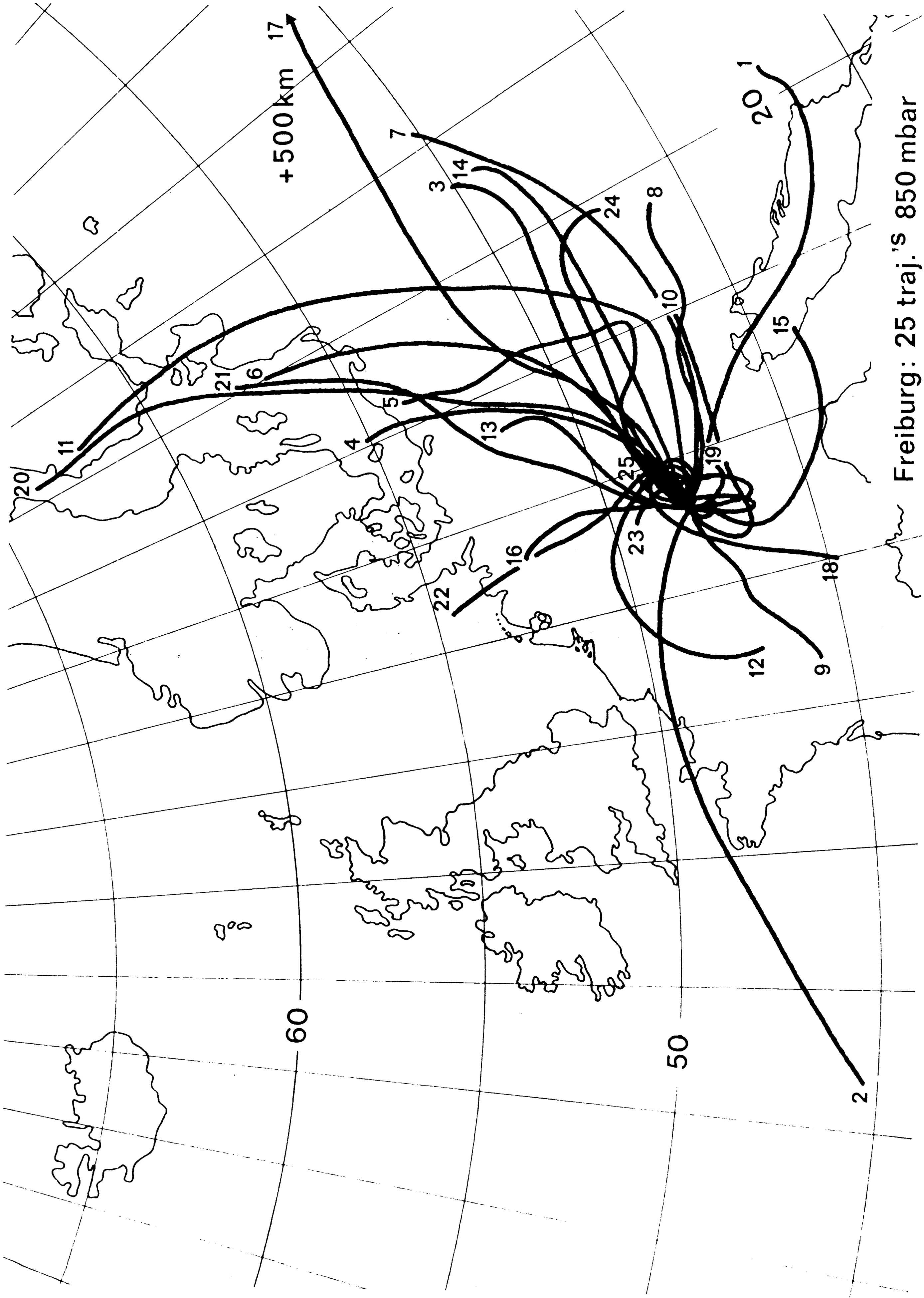
Nancy: 25 traj's surface

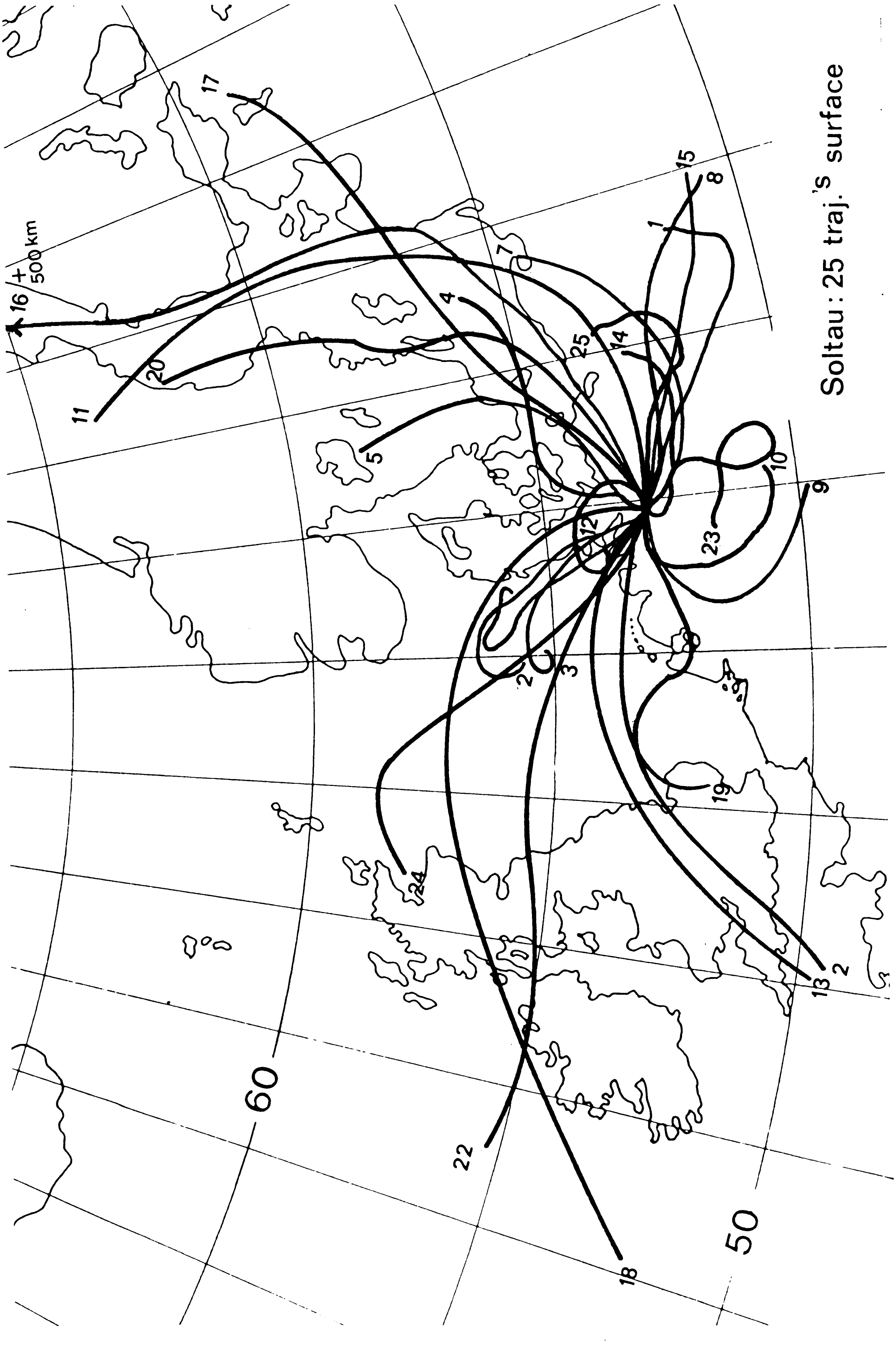


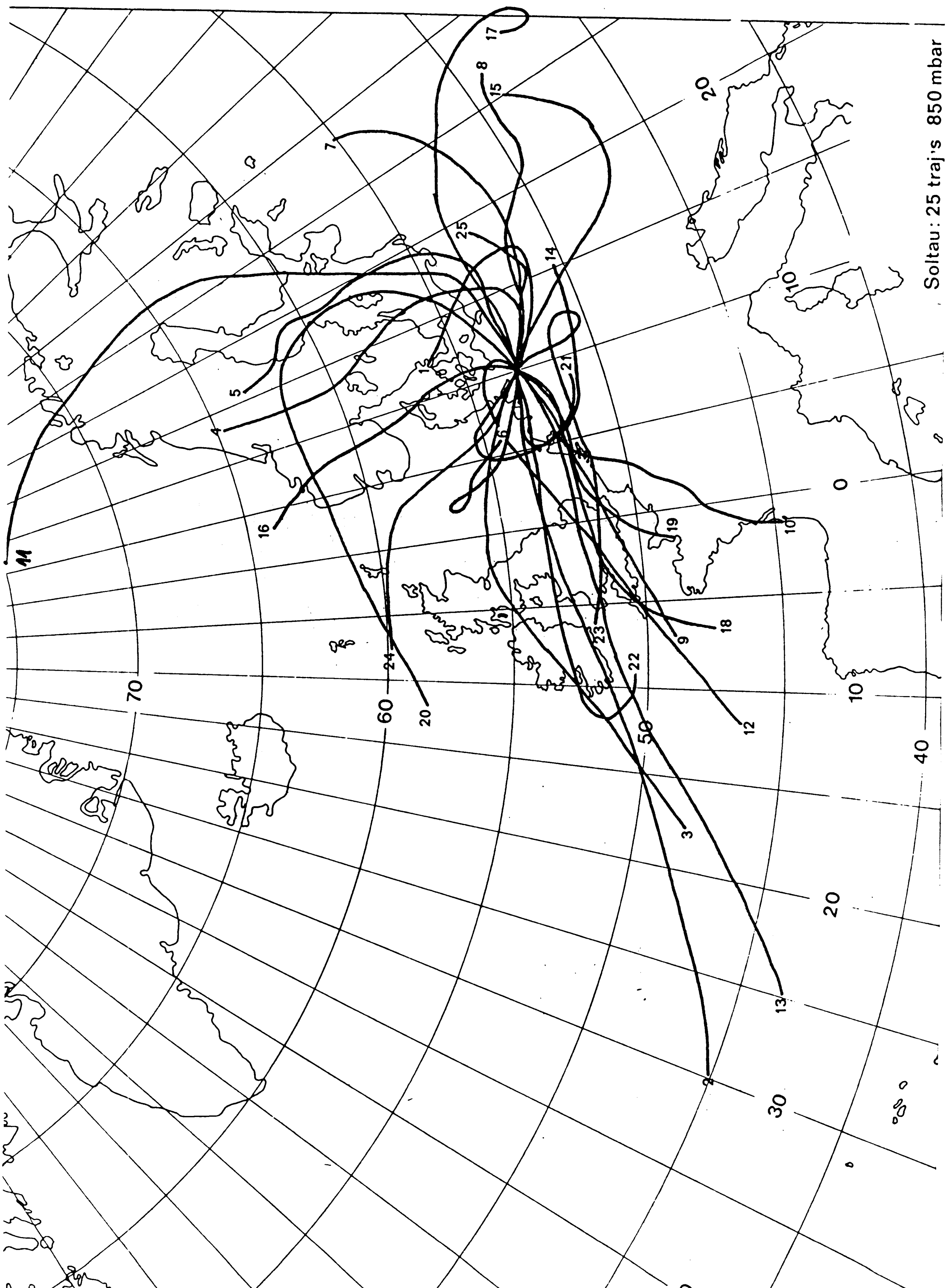
Nancy: 25 traj's 850 mbar

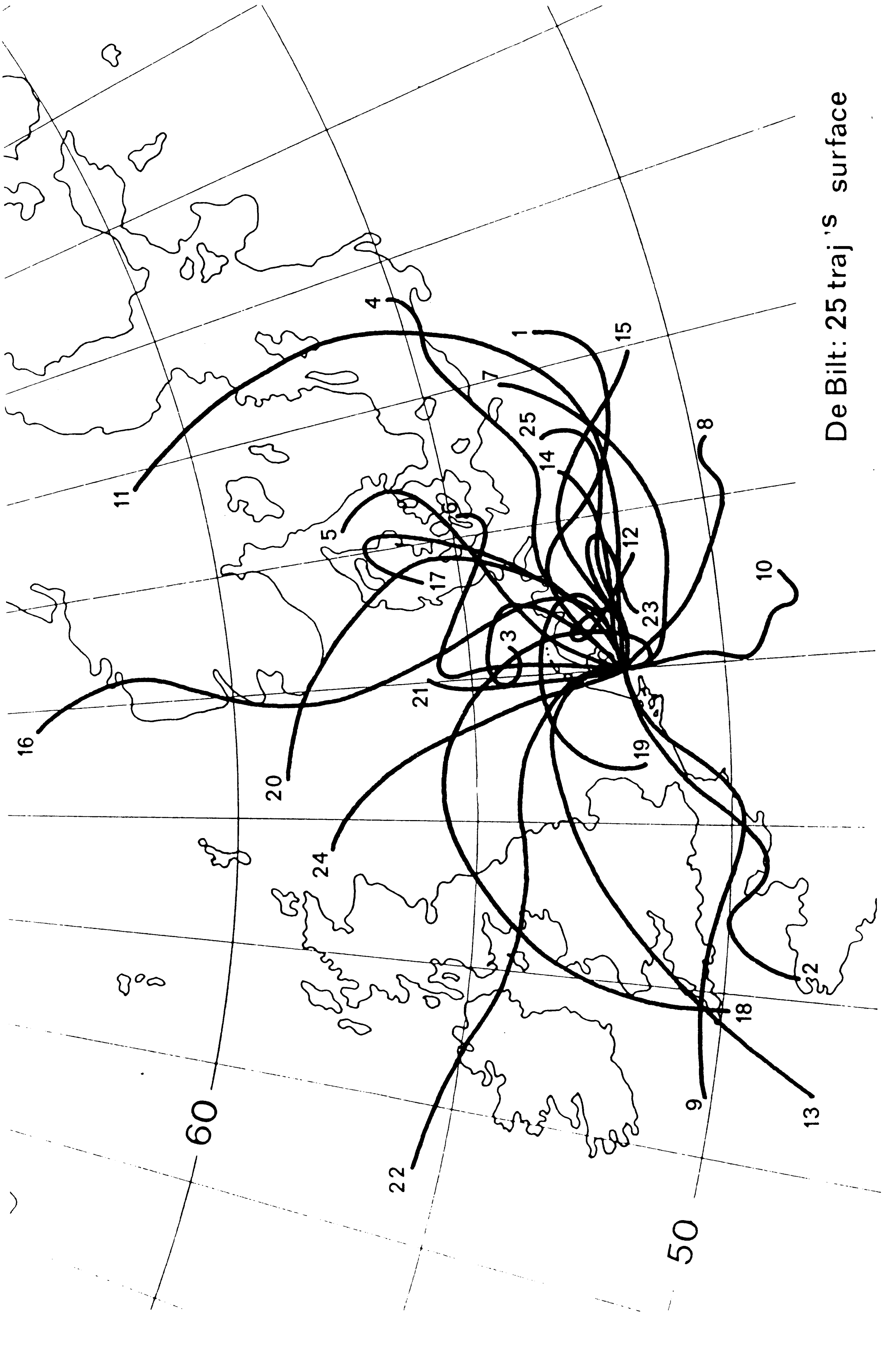


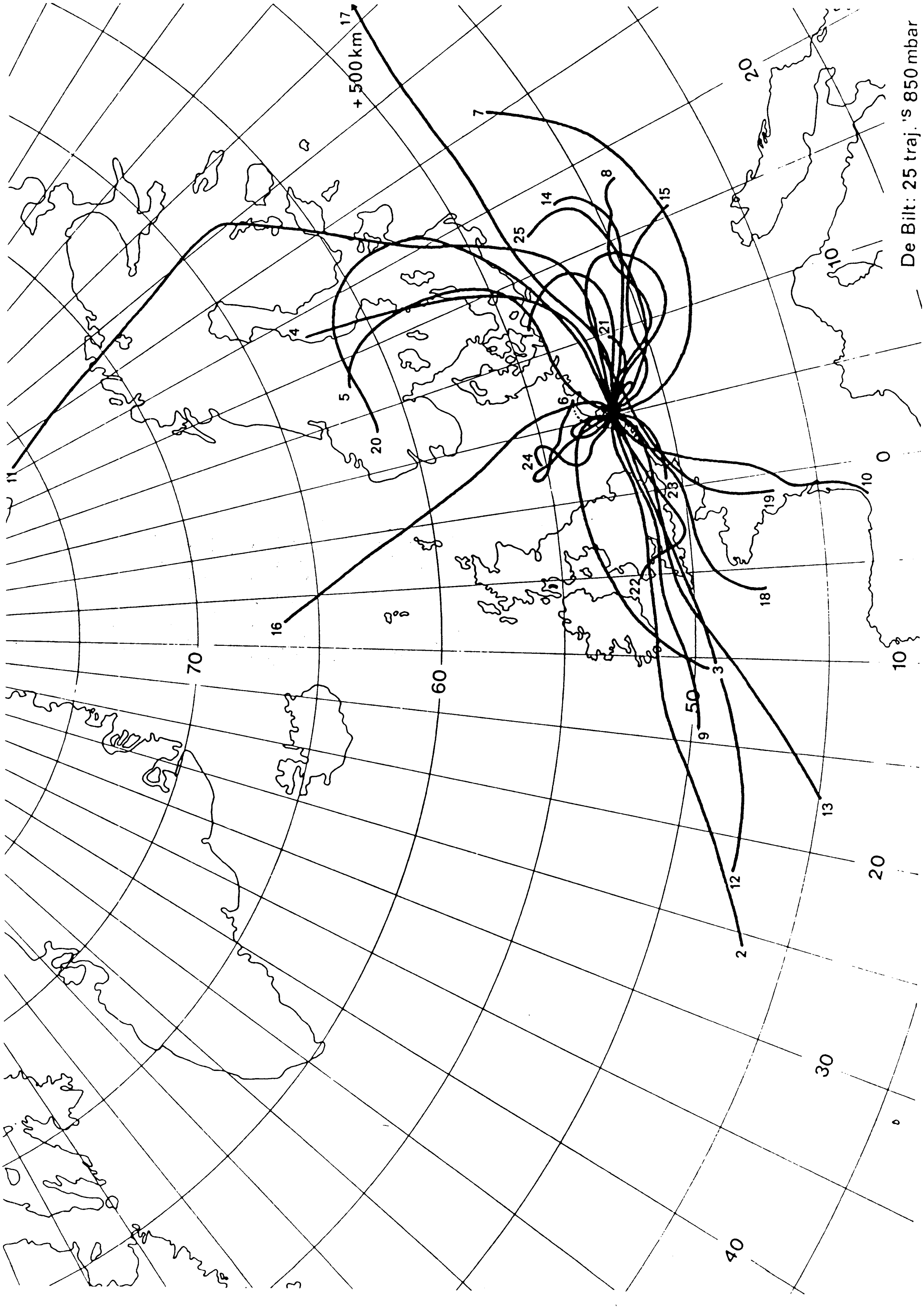
Freiburg: 25 traj.'s surface


Freiburg: 25 traj.'S 850 mbar
+500km
60
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
20


Soltau : 25 traj.'s surface
16/+
500 km
60
50
1
2
3
4
5
7
8
9
10
11
12
13
14
15
17
18
19
20
22
23
24
25


Soltau: 25 traj's 850 mbar


De Bilt: 25 traj's surface
60
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25


De Bilt: 25 traj.'s 850 mbar
+ 500 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
70
60
50
0
10
20
30
40

Appendix IV

Weather (temperature, dewpoint temperature, cloud cover and mixed-layer height) at six hourly intervals along the trajectories of episodes 1-10.

Episode 1 Date: 6-9 May 1976 Code: TT/T_dT_d, L, N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
9/5										
15	28/11	1200	27/12	1500	27/12	1500	30/04	2000	30/10	1900
	7 ac thin		7 ac thin		7 ci thin		0		0	
12		16°		15°		16°		14°		15°
09	22/10	500	22/10	500	26/13	800	23/8	700	24/15	700
	0		5 ci thin		6 ci thin		0		0	
06		16°		15°		16°		14°		15°
03	13/10	150	16/5	200	16/4	150	10/9	100	13/7	150
	0		0		0 0	0				
8/5										
00		16		16		15		14		14
21	19/4	200	19/8	200	18/4	200	18/3	200	21/6	200
	1 cu 1800		0		0 0	0				
18		15°		16°		13°		14°		12°
15	28/9	1700	29/8	1700	29/5	1700	25/6	1600	28/8	1800
	1 cu 1600		1 cu 1600		1 cu 1600		0			
12		14°		16°		12°		13°		13°
09	20/8	400	22/10	400	21/8	400	20/5	600	20/10	600
	0		0		0 4 ci thin		0			
06		13°		14°		12°		11°		12°
03	14/5	100	12/6	60	14/6	60	9/2	100	12/8	100
	0		0		0 0	0				
7/5										
00		13°		12°		12°		9°		10°
21	19/8	200	20/7	200	20/7	200	15/1	200	15/2	200
	0		0		0 0	0				
18		12°		12°		11°		9°		10°
15	23/12	1700	26/7	1700	26/8	1600	18/7	1500	21/3	1500
	1 cu 1600		0		0 0	0				
12		10°		11°		10°		8°		9°
09	22/7	1000	22/6	900	19/8	900	13/8	800	17/8	800
	0		0		0 0	0				
06		10°		11°		11°		8°		9°
03	9/9	200	11/10	100	9/5	100	7/5	100	10/8	100
	0		0		0 0	0				
6/5										
00		10°		12°		12°		7°		9°
21	18/8	200	15/6	200	10/5	200	11/5	200	11/10	200
	0		0		0 6 ci thin		8 ci thin			
18		9°		10°		11°		6°		7°
15	23/6	1600	22/4	1800	21/3	1800	17/1	1800	19/6	1700
	0		0		0 0	0				

Episode 2 Date: 11-14 June 1976 Code: TT/T_dT_d, L, N,h T_{850}

GMT	Soisson	Nancy	Freiburg	Soltau	de Bilt
14/6					
15	28/14 1700 0	28/8 1700 1 cu 1600	28/11 1700 2 cu 1600	26/9 1100 5 cu 1000	22/14 1200 3 cu 1000
12	14°	14°	14°	10°	10°
09	22/16 800 0	20/10 1100 1 cu 1000	20/11 1300 3 cu 1100	20/11 800 0	16/13 250 2 cu 1000
06	14°	13°	13°	10°	10°
03	10/10 50 0 fog	15/9 100 0	14/10 150 0 6 ac 2200	12/10 120 0	14/12 200
13/6					
00	14°	12°	13°	10°	9°
21	16/4 150 0	17/10 200 0	19/10 400 0 0 0	13/10 50	15/12 300
18	14°	13°	13°	10°	7°
15	23/14 1200 1 cu 1000	26/12 1600 3 cu 1500	27/11 1700 1 cu 1600	19/9 1300 2 cu 1200	16/13 1000 2 cu 800
12	13°	14°	13°	9°	6°
09	15/13 150 7 st 200	21/13 900 1 sc 800	24/10 1100 0 3 ac 2100	14/12 200 7 st 200	15/14 150
06	13°	13°	13°	9°	7°
03	12/12 100 fog	16/12 100 6 sc 1000	13/8 150 0 7 ac 2000	14/12 150 6 st 100	12/12 100
12/6					
00	12°	12°	13°	9°	8°
21	13/13 200 fog	20/9 500 4 ac 2000	21/9 400 0 6 ac 2200	14/13 150 fog	13/13 100
18	12°	12°	13°	9°	8°
15	22/14 1000 0	25/8 1400 0	28/10 1800 2 cu 1700	20/14 600 8 sc 600	20/13 700 0
12	12°	11°	11°	8°	7°
09	19/12 350 0	23/9 1100 0	24/13 1200 0 5 ac 2500	17/13 500 0	16/13 400
06	11°	12°	11°	7°	7°
03	13/12 100	11/8 100	13/9 150	13/12 150	13/12 100
11/6					
00	10°	12°	12°	5°	7°
21	15/4 200 0	16/12 400 0	18/6 400 4 sc 2500	15/14 100 8 st 200	15/14 200 0
18	10°	11°	11°	6°	7°
15	18/10 700 2 cu 600	22/10 1500 5 sc 2500	24/2 1500 7 ci>4000thin	18/10 800 2 cu 800	18/10 1000 2 cu 600
	9°	10°	10°	8°	7°

Episode 3 Date: 25-28 June 1976 Code: TT/T_dT_d L,
N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		De Bilt	
28/6										
15	35/8	1800	33/9	1700	32/9	1700	30/11	1800	29/15	1900
	1 cu 1750		0		0 0	0				
12		17°		16°		17°		15°		15°
09	29/15	1000	27/12	1000	26/12	1000	24/13	1000	24/16	1000
06		17°		16°		16°		15°		15°
03	18/12	100	21/7	100	15/9	100	17/13	100	17/16	100
	0		0		0 0	0				
27/6										
00		18°		16°		15°		15°		15°
21	24/11	600	26/8	600	21/11	600	18/7	100	17/16	100
	0		0		0 0 hazy	0 hazy				
18		17°		15°		15°		15°		16°
15	34/10	1900	33/9	2000	31/7	1800	20/15	200	19/18	150
	0		0		0 0	0 misty				
12		16°		14°		14°		15°		16°
09	29/13	1000	26/10	1000	26/16	1000	20/16	100	19/18	100
	0		0		0 0 hazy	0 hazy				
06		16°		14°		14°		15°		16°
03	16/12	100	15/10	100	13/7	100	18/17	50	18/17	50
	0		0		0 0 hazy	0 hazy				
26/6										
00		15°		13°		13°		15°		15°
21	24/14	600	23/10	600	22/8	700	20/18	80	20/18	80
	0				0 0 hazy	0 hazy				
18		13°		12°		12°		12°		15°
15	32/10	1800	29/10	1800	30/10	1800	21/16	200	21/6	200
	0		0		0 0 hazy	0 hazy				
12		11°		11°		11°		10°		15°
09	28/14	1100	27/10	1200	25/11	1100	18/16	50	18/16	50
	0		0		0 0 fog	0 fog				
06		11°		11°		9°		8°		15°
03	17/13	100	16/10	100	14/10	100	18/16	50	17/16	50
	0		0		0 0 fogpatches		0 fogpatches			
25/6										
00		11°		11°		8°		7°		15°
21	25/14	600	21/10	500	21/9	500	19/16	70	19/16	70
	0		0		0 0 fog	0 fog				
18		10°		9°		8°		8°		12°
15	31/10	1800	27/8	1700	27/8	1700	20/17	200	20/17	200
	0		0		0 fogpatches		fogpatches			
		8°		7°		7°		8°		9°

Episode 4 Date: 4-7 July 1976 Code: TT/T_dT_d, L,
N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
7/7										
15	33/14 0	1800	30/11 2 cb 1700	2000	23/11 2 cb 2000	2200	30/9 0	1300	29/3 0	1200
12	30/14 0 1600	17°	29/13 0 1700	16°	30/11 0 1800	15° 0 1200	26/8 0 1200	11°	28/7	15°
09	26/14 0	800	24/8 0	700	24/8 0 0	700 0	23/11	700	24/8	800
06	18/8 0	17°	19/6 0	16°	18/7 0 0	15° 0	17/10	11°	17/6	15°
03	19/4 0	100	17/7 4 sc 1700	100	14/8 0 0	100 0	16/14	100	13/4	100
6/7										
00	20/9 0	18°	22/4 0	16°	20/10 0 0	14° 0	15/9	10°	17/5	15°
21	23/10	400	20/10	300	21/10	300	18/6	200	18/11	200
18	28/10 0	17°	29/11 0	16°	28/12 0 0	14° 0	22/6	10°	18/5	12°
15	31/10	1800	30/4	1900	30/4	1900	25/4	1100	24/4	1000
12	30/11 0	16°	28/9 0	16°	28/9 0 0	14° 0	24/5	9°	24/5	10°
09	27/12	800	22/8	700	22/8	700	21/4	600	21/6	600
06	17/6 0	15°	18/7 0	16°	17/10 0 0	15° 0	17/8	7°	15/7	9°
03	18/6	100	18/8	100	15/10	100	10/7	50	10/5	50
5/7										
00	21/11 0	13°	21/9 0	17°	21/9 0 0	16° 0	11/9	5°	10/3	9°
21	24/11	400	23/9	300	24/10	300	16/9	200	14/6	200
18	25/11 0	14°	27/10 2 cu 1800	17°	27/10 4 cu 1400	16°	17/7 1 cu 800	5°	19/5 0	9°
15	30/13 0	1800	30/10 0	1900	30/7 0 0	1900 0	22/10	900	22/8	1200
12	30/10 0	16°	30/7 0	18°	30/11 0 0	16° 0	22/11	6°	22/9	8°
09	25/11 0	700	26/10 0	700	27/13 0 3 cu 700	800	18/13 4 cu 800	800	20/14	900
06	18/11 0	16°	20/10 0	18°	18/11 0 3 cu/Sc 1100	16°	16/13 3 cu 900	5°	16/13	7°
03	16/14 0	100	15/7 0	100	16/9 0 7 ac 2500	100	13/12 7 ac 2500	100	15/13	100
4/7										
00	18/7	17°	18/8	18°	20/10	16°	14/10	4°	14/12	6°
21	24/13 0	300	23/6 0	300	23/8 0	300 4 cu	16/8	300 0	11/9	200
18	24/7 0	15° 0	30/4 0	18°	28/6 1200 1 cu 1600	15°	16/10 5 cb 600	3°	15/6 600 8 cb 600	4°
15	33/6 0	2000	31/4 0	2000	34/3 1 cu 2200	2200	17/5 5 cu 600	700	17/5 5 cu 600	700
		13°		17°	14°	2°		2°		

Episode 5 Date: 7-10 aug. 1976 Code TT/T_dT_d, L, N,h T_{850}

GMT	Soisson		Nancy		Freiburg		Soltau		de Bilt	
10/8										
15	16/10	2000	24/10	1900	23/8	1800	28/9	1900	26/14	2000
	2 cu 1700		4 cu 1300		8 ac 2100		3 cu 1700		3 cu 1400	
12		9°		10°	10°	9°		9°		
09	18/13	1500	20/9	1400	18/10	1000	22/10	1100	21/14	700
	3 cu 1400		3 cu 1200		7 ci	0		0		
06		9°		10°	10°	9°		9°		
03	15/9	180	17/8	140	9/7	80	14/13	160	18/10	200
	3 cu 2500		7sc 1600		0	5 ac 2200			0	
9/8										
00		10°		9°	10°	8°		9°		
21	19/10	400	19/7	400	20/0	500	17/11	400	16/15	250
	2 cu 2200		3 Sc 2000		0	6 Sc 2000			0	
18		10°		10°	9°	9°		9°		
15	25/7	2000	23/8	1800	23/8	1800	20/14	1100	26/9	1700
	2 cu 1700		5 cu 1600		4 cu 1700		0		2 cu 1600	
12		9°		9°	9°	8°		9°		
09	19/10	1000	18/10	800	20/8	1000	20/12	800	24/16	1000
	0		0		0	0	0			
06		8°		8°	8°	7°		7°		
03	14/13	120	13/9	80	14/8	80	8/6	60	14/10	60
	0		0		0	0	0			
8/8										
00		7°		8°	8°	7°		7°		
21	17/10	700	17/9	700	16/8	600	11/10	100	16/10	300
	4 ac 2500		0		3 ac	0		0		
18		7°		6°	7°	7°		8°		
15	24/7	1700	23/14	1800	21/8	1700	22/10	1600	23/10	1600
	3 cu 1600		4 cu 1600		2 cu 1600		1 cu 1500		2 cu 1600	
12		6°		7°	7°	7°		7°		
09	16/13	700	19/12	600	17/8	800	21/10	1200	19/18	1200
	1 cu 600		0		1 cu 800	0	1 cu 1200			
06		6°		6°	6°	5°		6°		
03	11/11	80	8/6	50	11/10	80	7/6	50	11/10	100
	0		0		0	0	0			
7/8										
00		7°		7°	7°	6°		6°		
21	14/13	300	16/12	500	16/11	400	14/9	500	15/13	200
	1 cu 1100		0		0	0	0			
18		6°		6°	6°	6°		6°		
15	18/11	1500	18/14	1600	21/10	1500	19/9	1400	21/9	1500
	3 cu 1500		4 cu 1500		3 cu 1300		0		0	

Episode 6 Date: 23-26 aug. 1976 Code: TT/T_dT_d, L,
N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
26/8										
15	30/6 0	2000	29/6 0	2000	27/8 0	2000 7 cu 600	17/13	1000	22/14 7 ac 2800	1000
12		13°		13°	12°	11°		13°		
09	23/8 0	1100	22/9 0	1100	19/9 0	1000 6 cu 1500	20/12	1600	21/12 0	300
06		12°		12°	12°	12°		12°		
03	19/3 0	60	16/6 0	60	10/5 0	60 0	18/5 0	100	18/15	100
25/8										
00		13°		13°	11°	11°		11°		
21	22/9 0	300	18/4 0	160	17/7 0	120 0	17/16 0 fog	100	19/18	100
18		14°		12°	10°	11°		11°		
15	30/6 0	1900	28/4 0	1900	25/4 0	1900 0	21/13 0	300	18/5	300
12		14°		10°	10°	10°		10°		
09	26/7 0	1200	20/8 0	800	17/7 0	700 0	18/13 0	100	18/5	100
06		13°		10°	8°	10°		12°		
03	12/3 0	120	10/5 0	80	9/4 0	40 0	17/13 0	40	18/15	60
24/8										
00		12°		11°	10°	12°		12°		
21	18/5 0	200	16/7 0	200	15/7 0	120 0	16/14 0	80	15/14	70
18		11°		8°	8°	10°		11°		
15	21/4 0	700	25/4 0	1800	25/4 0	1800 0	20/11 0	120	11/16	120
12		11°		8°	8°	12°		12°		
09	18/4 0	700	19/6 0	700	17/7 0	600 0	20/15 0	120	18/15	400
06		8°		7°	6°	12°		12°		
03	9/5 0	40	9/5 0	40	9/4 0	40 0	16/14 0	80	15/11	70
23/8										
00		11°		10°	8°	11°		11°		
21	12/1 0	100	13/4 0	160	16/3 0	160 0	13/8 0	90	11/11	60
18		7°		10°	9°	9°		10°		
15	22/3 0	1400	21/5 0	1400	20/7 0	1400 0	20/7 0	800	18/13	600

Episode 7 Date: 29 May - 1 June 1978 Code: TT/T_dT_d, L, N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
1/6										
15	26/15	1400	21/15	1400	25/10	1600	29/9	1600	28/10	2000
	3 cu 1200		2 cu 1200		1 cu 1500		3 cu 1500		2 cu 1600	
12		11°		11°	11°	12°		11°		
09	21/17	800	18/18	600	21/11	1200	26/10	1300	25/13	1400
	0		0		0	0	0			
06		10°		11°	11°	12°		11°		
03	16/13	60	10/10	20	12/11	20	11/9	40	17/11	60
	0		0 fogpatches		0	0	0			
31/5										
00		10°		11°	11°	12°		11°		
21	17/12	300	19/9	400	19/10	400	18/11	120	21/11	300
	0		4 cb 1500		0	0	0			
18		11°		11°	11°	11°		11°		
15	25/12	1600	23/10	1800	21/11	1700	27/7	1700	26/7	1800
	2 cu 1300		4 cb 1400		3 cu 1400		2 cu 1500		3 cu 1600	
12		12°		12°	12°	11°		11°		
09	20/12	800	21/13	1200	19/11	1200	24/11	1400	23/11	1400
	0		0		0	0	0			
06		11°		10°	11°	10°		10°		
03	12/9	100	12/9	80	11/8	60	13/10	140	12/7	160
30/5										
00		11°		9°	9°	9°		10°		
21	18/11	160	17/9	160	17/10	140	18/9	200	13/7	200
	1 cu 1500		0		0	0	1 cu 1500			
18		11°		9°	9°	9°		10°		
15	26/8	1800	22/6	1700	19/8	1800	25/7	1800	26/8	1800
	2 cu 1600		1 cu 1300		3 cu 1600		1 cu 1600		2 cu 1600	
12		12°		9°	9°	8°		9°		
09	23/13	1200	19/10	1000	17/8	1000	21/8	1000	19/11	1000
	0		0		0	0	0			
06		11°		9°	9°	7°		9°		
03	9/8	40	10/8	40	9/8	20	10/8	140	10/8	120
	0		0		0	0	0			
29/5										
00		11°		9°	9°	7°		9°		
21	16/10	200	18/8	180	16/10	120	13/6	160	15/10	200
	0		4 cu 1600		1 cu 1000		0		0	
18		9°		8°	8°	7°		8°		
15	22/8	1800	24/10	1800	24/9	1700	18/8	1200	23/8	1600
	3 cu 1600		3 cu 1600		2 cu 1600		0		2 cu 1400	
		7°		7°	8°	6°		8°		

Episode 8 | Date: 27-30 July 1976 | Code: TT/T_dT_d, L, N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
30/7										
15	31/20	2000	31/18	1800	29/11	1900	30/12	2000	33/13	2000
	5 cb 1400		3 cu 1500		1 cu 1700		1 cu 1800		9	
12		1200 16°		16°	16°	15°		1000 16°		
09	24/21	800	21/18	600	23/14	600	24/10	700	25/16	800
	2 cu 1400		0		0	0	0			
06		16°		16°	16°	15°		16°		
03	18/18	120	17/16	80	17/16	100	16/14	100	19/16	160
	2 Sc 1700		0		0	0	0			
29/7										
00		17°		17°	16°	15°		16°		
21	23/20	400	22/17	500	22/14	400	21/15	400	25/18	500
	6 ac 3000		0		0	0	5 ac 3000			
18		17°		16°	16°	15°		16°		
15	29/20	1700	31/14	1800	31/13	1800	27/13	1800	32/16	1600
	2 cu 1500		0		0	2 cu 1600			0	
12		17°		16°	15°	14°		16°		
09	24/18	800	25/17	900	25/17	1000	26/15	1200	24/17	600
	0		0		0	0	0			
06		17°		16°	15°	15°		16°		
03	15/14	100	16/15	60	17/14	60	17/12	100	16/14	60
	0 fogpatches		0		0	3 ac 3000			0	
28/7										
00		17°		16°	15°	17°		16°		
21	19/16	400	21/16	300	21/17	300	23/13	400	23/16	300
	4 ac 3000		0		0	7 ac 3000			0	
18		16°		15°	14°	14°		16°		
15	26/13	1400	29/13	1700	31/16	1700	28/12	1700	27/13	1900
	2 ac 3000		1 cu 1600		1 cu 1600		1 cu 1500		4 cu 1700	
12		15°		14°	13°	11°		16°		
09	23/14	800	23/17	900	24/18	900	25/11	1000	22/15	700
	0		0		1 cu 1600		0		0	
06		15°		14°	12	11°		15°		
03	14/12	120	16/14	100	14/12	60	10/10	40	13/13	40
27/7										
00		15°		14°	12°	12°		13°		
21	17/12	300	20/14	300	21/16	300	18/14	200	19/14	200
	0		0		0	0	0			
18		13°		13°	12°	12°		12°		
15	24/14	1600	23/14	1700	24/16	1600	21/15	1700	23/16	1600
	2 cu 1400		2 cu 1600		1 cu 1500		0		1 cu 1500	
		12°		12°	12°	11°		12°		

Episode 9 — Date: 19-22 Aug. 1978 — Code: TT/T_dT_d, L, N,h, T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
22/8										
15	/26/25	1600	27/14	1800	29/15	1600	25/14	1600	25/13	1200
	1 cu 1400		1 cu 1700		2 cu 1500		1 cu 1400		2 cu 1000	
12		13°		13°	14°	12°		13°		
09	14/13	200	21/16	600	22/15	800	20/13	600	20/13	600
	0		0		0	0	0			
06		13°		13°	14°	12°		12°		
03	12/10	40	16/15	80	15/13	60	17/12	80	17/14	180
	0		0		0	0	0			
21/8										
00		14°		13°	14°	13°		12°		
21	13/11	60	17/14	200	19/17	60	15/14	60	15/14	200
	0		0		2 cu 3000		0		0	
18		14°		12°	13°	13°		12°		
15	22/10	1000	25/16	1600	26/12	1700	26/14	1400	18/15	300
			1 cu 1500		1 cu 1700		0		4 sc 600	
12		13°		12°	13°	13°		11°		
09	15/13	500	18/14	200	23/6	800	22/14	600	17/15	200
	4 cu 300		0 fogpatch		0	0	7 st 300			
06		13°		12°	13°	11°		10°		
03	12/11	80	13/13	120	14/13	60	10/10	60	13/13	100
	0		7 St 200		0 fogpatches		0 fogpatches		0	
20/8										
00		12°		12°	13°	9°		9°		
21	13/12	100	15/13	160	18/16	60	21/12	60	15/11	100
	0		0		0	0	0			
18		11°		12°	13°	9°		10°		
15	18/14	800	17/14	700	26/15	1700	27/12	1700	22/16	1200
	4 cu 600		7 Sc 600		2 cu 1600		0		4 cu 1000	
12		10°		13°	13°	9°		11°		
09	16/14	100	17/15	200	23/16	800	19/10	400	16/14	400
	6 sc 400		3 ac 2000		0	0	7 sc 400			
06		10°		14°	15°	9°		10°		
03	13/13	100	13/13	100	13/12	60	11/8	120	14/14	200
	0		4 ac 3000		0	0	8 sc 200			
			fogpatches							
19/8										
00		10°		15°	16°	9°		8°		
21	14/14	200	15/13	200	15/14	60	16/9	120	14/14	200
	8 St 300		3 ac 3000		0 fogpatches		0		8 st 300	
18		10°		15°	16°	10°		8°		
15	16/16	100	24/10	1200	25/12	1800	22/8	1800	15/15	100
	0 fog		3 ac 3000		0	0	8 st 100			
		11°		15°	15°	12°		8°		

Episode 10 Date: 29 Aug.- 1 Sept. 1979 Code: TT/T_dT_d, L,
N,h T_{850}

GMT	Soissons		Nancy		Freiburg		Soltau		de Bilt	
1/9										
15	30/14	1600	29/15	1600	28/14	1600	27/15	1600	26/18	1200
12	28/13	1400	26/17	1300	26/16	1400	25/14	1400	25/17	1100
	0	14°	0	15°	1 cu 1400	15°	0	11°	0 13°	
09										
06	14/13	200	11/11	100	12/12	100	13/13	100	15/15	100
	0	13°	0	14°	0 14°	4 sc 1500 10°		0 fog	12°	
03										
31/8										
00	17/13	100	13/13	100	12/10	100	17/14	100	17/15	100
	0	14°	0	14°	0 14°	fog	12°	0	13°	
21										
18	25/12	500	22/13	400	22/13	400	21/15	400	21/16	500
	0	14°	0	13°	0 13°	011°	0	12°		
15		1700		1600	1600	1400		1400		
12	27/16	1400	21/12	1400	22/12	1400	24/16	1500	24/17	1600
	0	15°	0	13°	0 12°	011°	2 cu 1600	11°		
09										
06	12/11	100	11/11	100	10/9	100	14/12	100	14/14	100
	0 fogp	13°	0 fogp	12°	0 fogp	12°	0	11°	0 fogp	13°
03										
30/8										
00	11/11	100	11/11	100	13/11	100	14/13	100	14/9	100
	0	15°	0	12°	0 12°	013°	0	14°		
21										
18	22/15	500	20/15	500	20/11	600	22/11	500	20/9	500
	0	13°	0	12°	0 10°	012°	0	13°		
15		1500		1500	1400	1200		1400		
12	20/12	600	19/11	700	20/10	700	23/9	600	22/14	500
	0	12°	0	12°	0 11°	012°	0	13°		
09										
06	9/9	100	8/7	100	6/5	100	9/8	100	7/7	100
	0	12°	0	11°	1 8°	012°	0	12°		
03										
29/8										
00	11/10	100	10/9	100	11/8	100	11/9	100	13/10	100
	0	13°	0 fogp	10°	0 5°	013°	0	13°		
21										
18	18/7	400	18/7	400	16/10	400	18/8	500	18/11	400
	0	15°	0	6°	1 5°	014°	0	14°		
15		1500		1500	1500	1300		1500		

Appendix V

Observed ozone concentrations during the episodes.

Mean afternoon peak concentrations of O_3 (μ gr/m^3) during a 2-3 hourly period around 1600 GMT, observed at a height of 3, 100 and 200 m at Cabauw, 25 km SW of de Bilt.
The values with * are taken from Delft, 60 km WSW of de Bilt.

Date 200 m	3 m	100 m	200 m
1:			
6-5-76	190	232	
7-5-76	172	203	
8-5-76	255	253	
9-5-76	190	220	
2)			
11-6-76	185*		
12-6-75	100*		
13-6-76	125*		
14-6-76	145*		
3)			
25-6-76	300*		
26-6-76	240*		
27-6-76	300*		
28-6-76	190*		
4)			
4-7-76	missing		
5-7-76	missing		
6-7-76	missing		
7-7-76	missing		
5)			
7-8-76	65*		
8-8-76	75*		
9-8-76	100*		
10-8-76	105*		
6)			
23-8-76	80*		
24-8-76	130*		
25-8-76	215*		
26-8-76	175*		

Date	3 m		100 m	200 m
	Cab.	Delft		
7:				
29-5-78	97	115*	60	85
30-5-78	135	115*	90	120
31-5-78	156	120*	100	140
1-6-78	225	250*	140	185
8)				
27-7-78	140	85*	90	115
28-7-78	205	155*	135	190
29-7-78	245	135*	145	210
30-7-78	240	155*	155	220
9)				
19-8-78	95	105*	165	60
20-8-78	120	175*	200	75
21-8-78	75	115*	140	60
22-8-78	75	95*	135	55
10)				
	deBilt	Delft		
29-8-79	170	250*		
30-8-79	130	85*		
31-8-79	190	190*		
1-9-79	175	180*		
11)				
	Cabauw			
11-5-80	145		150	130
12-5-80	155		155	140
13-5-80	145		145	130
14-5-80	140		140	125
12)				
22-7-80	135		150	150
23-7-80	135		145	150
24-7-80	120		140	145
25-7-80	165		180	180

Date	3 m	100 m	200 m
13)			
12-8-81	100	105	120
13-8-81	130	135	160
14-8-81	270	265	320
15-8-81	215	215	250
14)			
3-9-81	165	95	105
4-9-81	105	105	120
5-9-81	125	120	140
6-9-81	195	185	220
15)			
31-5-82	210	205	185
1-6-82	290	285	260
2-6-82	205	200	180
3-6-82	250	230	215
16)			
7-6-82	185	190	180
8-6-82	160	160	145
9-6-82	120	120	105
10-6-82	160	150	135
17)			
10-7-82	105	105	105
11-7-82	185	175	170
12-7-82	195	180	170
13-7-82	200	185	170
18)			
9-9-82		90	85
10-9-82	120	165	155
11-9-82	90	120	115
12-9-82	80	160	210
19)			
14-9-82		150	140
15-9-82		245	260
16-9-82		155	155
17-9-82	230	235	215

Date	3 m	100 m	200 m
20)			
17-6-83	100	90	100
18-6-83	120	105	120
19-6-83	110	95	105
20-6-83	155	135	145
21)			
9-7-83	165	170	175
10-7-83	180	180	180
11-7-83	200	200	195
12-7-83	155	155	160
22)			
13-7-83	110	110	120
14-7-83	130	130	130
15-7-83	210	210	215
16-7-83	220	220	205
23)			
16-8-83	110	110	110
17-8-83	20	40	5
18-8-83	105	105	105
19-8-83	20	215	210
24)			
24-8-83	130	135	135
25-8-83	150	165	165
26-8-83	100	100	100
27-8-83	70	70	70
25)			
28-8-83	90	75	75
29-8-83	85	90	90
30-8-83	150	150	145
31-8-83	195	205	190