Veðurstofa Íslands
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Meteorological Data Requirements and Availability in the North Atlantic

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Data Requirements

The requirements for meteorological data depend on the use to be made of them, and in particular on the physical scale of the phenomena to be studied. For example, the requirements are different for medium-range weather forecasting using coarse-mesh global models than for warnings and short-range forecasts using fine-mesh limited area models. It should be emphasized that the data requirements are not uniform in space, as some areas are more meteorologically active than others, and they are also variable in time and space, depending on the meteorological situation. Furthermore, it may be pointed out that the data are not only required for weather forecasting and near real time meteorological services, but also for climate research and climate change investigations. The oceans cover 71 percent of the surface of the earth and the interaction between atmosphere and oceans is of fundamental importance for climate and climate change.

Of course, the meteorological data requirements have been discussed many times within the World Meteorological Organization (WMO) and its Commissions for Basic Systems (CBS) and Marine Meteorology (CMM), as well as by the Regional Associations and other WMO bodies. In the WMO "Manual on the Global Observing System", Attachment II.2, entitled "Performance of the GOS achievable by the year 2005", a horizontal

resolution of 250 km or less is specified for the surface based observations. This represents what are considered realistic and achievable goals on a global scale. In the Manual's Attachment II.3, entitled "Requirements for Horizontal Spacing and Frequency of Reporting from the Regional Networks", an adequate surface observation density is specified as 250 km for regional purposes, 4 times per day, at the main standard times. As a minimum requirement, however, 500 km is specified for surface observations in oceanic areas and 1000 km for surface based upper-air observations.

With increasing horizontal resolution of advanced numerical weather prediction models (NWP models), requirements for a denser observing system are to be expected for data assimilation, data analysis and model validation.

Let us then look at a map of the North Atlantic and consider how many observing stations are needed to achieve an observation density of 250 km. The map, Fig. 1, is divided into squares, 10 by 10 degrees, and on the right hand side of it the number of observation points required to satisfy a resolution of 250 km is indicated. The map is taken from WMO Publication No. 823 (World Weather Watch; Seventeenth Status Report on Implementation; 1995). Let us consider the area from 20 degrees North to 70 degrees North, and from 60 degrees West eastwards to the coasts of Europe and Africa. I have written in the requirements for each square, and by adding them up we come to a total of approximately 280 stations or observation points. By extending the area to the equator and westwards to the coasts of North America as indicated by thick lines on the map, we would come to a total of approximately 470 stations simultaneously in operation.

This is then what may be termed the "nominal" requirement: Some 300-500 evenly spaced observing stations in continuous operation in the North Atlantic and reporting 4 times every 24 hours, on the main synoptic hours. The required number of observations is therefore 1200-2000 per day. However, this is neither practical nor achievable. Ships and drifting buoys do not keep fixed positions but move around, the ships mainly following standard shipping lanes. Drifting buoys would be very costly to deploy evenly spaced, and many buoys relatively close to coasts would drift ashore and have a short lifetime. Moored buoys would be extremely costly to deploy and service far from coasts and harbours.

Availability of Observations in the North Atlantic

Voluntary Observing Ships

Traditionally ships have been the main source of weather information on the oceans. The total number of WMO Voluntary Observing Ships has been between 7 and 8 thousand during the last decade and slightly decreasing. This is a reasonably satisfactory number but it has to be kept in mind that only some 40 percent of the ships are at sea at any one time and many of them are in coastal waters. They also have difficulties in making regular observations and communicating them timely via coastal radio stations to centers of the global telecommunication system (GTS) of WMO. At any one observation hour observations are usually only available from some 10-15 percent of the total number of voluntary observing ships.

Let us have a look at the actual reception of ship reports from the North Atlantic at the European Center for Medium-Range Weather Forecasts (ECMWF). I have selected a map from the Monitoring Report for February 1996, Fig. 2. We see that for each 10 degrees square between 30° and 50° North a typical mean for 24 hours is actually near 20 reports from ships. In order to satisfy the 250 km spacing we should need approximately 60 reports (15 for each of the 4 main synoptic hours). We are therefore far from meeting the requirements, even for the most favourable areas on the high seas.

Meteorological Buoys

Automatic meteorological buoys, drifting and moored, are becoming an increasingly important data source, especially in data sparse ocean areas. Fig. 3, also from the ECMWF Monitoring Statistics shows the world distribution of drifters observing air pressure during February 1996. By comparison with the map for ship observations we see that drifting buoys are now the main source for meteorological surface data in the otherwise data sparse area of EGOS North, north of 50 degrees North.

EGOS - The European Group on Ocean Stations has been the main operator of meteorological buoys in the North Atlantic but there are also other important contributors: France, USA and occasionally Canada. The

numbers and relative contributions vary, but the total number has usually been between 25 and 40 buoys simultaneously in operation in the N-Atlantic (Fig. 4). The contribution of EGOS has reached a fairly steady state, usually between 15 and 25 drifting buoys in operation at any one time, as shown in Fig. 5 and Table 1.

Drifting Meteorological Buoys
Operational in the North Atlantic

1996	January	February	March
EGOS	19	17	18
France	4	8	8
USA+Canada	2	4	7
Others	2	1	2
Total	27	30	35

Table 1

The EGOS Buoy Programmes are concentrated on the high seas, and in EGOS North we are trying to maintain a network of meteorological buoys. Fig. 6 shows the distribution of the EGOS buoys on the last day of April 1996. The drifting buoys appear as filled circles. In EGOS North they are deployed from ships of opportunity sailing between Iceland and the USA and between Denmark and Greenland. The filled squares represent the array of EGOS moored buoys West of Ireland, where it would be impractical to deploy drifting buoys, as many of them would drift ashore after a relatively short lifetime.

Fig. 7 shows the diurnal variation in the availability of observations from the EGOS drifting buoys. For EGOS North the availability is lowest around and shortly after midnight. The black columns show the mean number of observations per day, per hour and per buoy available within 90 minutes of the actual time of observation. The white columns show the availability within 210 minutes. To increase the availability every asynoptic report from an EGOS buoy is followed by an observation from the last synoptic hour. This explains the relatively high values on the synoptic hours: 03, 06, 09, 12 etc.

Oceanographic buoys

A great majority of the drifting buoys in operation on the high seas are oceanographic and most of them only report sea surface temperature and position (making it possible to calculate surface currents). A few of them, however, also measure air pressure and salinity. To give an indication of the oceanographic activity Fig. 8 shows the Global Drifter Program on the 2nd of October 1995. Unfortunately this is a copy in black and white, and it is therefore not possible to see which drifters were observing pressure and salinity and which were not.

To emhasize the importance of this work let us also look at Fig. 9 which is from the Bulletin Marisonde of Meteo France. It shows trajectories of drifters in the Indian Ocean during March 1996. Fig. 10 is from the Icelandic Meteorological Office and shows North Atlantic drifters from which reports were available at 17 UTC on 30th May, 1996. Filled circles inside triangles indicate observations of air pressure.

It is perhaps not necessary to emphasize the fact that observations of sea surface temperature do not only meet oceanographic needs but are also of considerable meteorological interest. They will increasingly be used in numerical weather prediction models. Obviously, observations of sea surface temperatures and changes of ocean surface currents are also of great climatological value.

Upper-air observations

Surface-based upper-air observations are a very important part of the composite observing system for the North Atlantic, both for providing detailed high quality upper-air observations and for providing comparison and ground truth for satellite-based observations.

Unfortunately the Agreement for Joint Financing of the North Atlantic Ocean Stations (NAOS) was terminated at the end of 1990. Since then two of the former Weather Ships have been operated as a national responsibility. At the beginning of June 1996 the operation of the UK ship, Cumulus, mainly operating at Station Lima, has been finally terminated. Only the Norwegian weather ship at Station Mike is still in operation, and its future is very uncertain.

The Automated Shipboard Aerological Programme (ASAP) was in a way intended to take over from the Ocean Weather Stations on the North

Atlantic. At present 12 ASAP units are in use on merchant vessels sailing between Europe and America: 4 units are operated by France, 4 units by Germany, 2 by Denmark, 1 by Spain, and 1 unit is jointly operated by Sweden and Iceland.

Fig.11, also from the ECMWF Global Data Monitoring Report for February 1996, shows the availability of TEMP observations at the 500 hPa level. For the whole North Atlantic we see that the mean number of observations available in 24 hours was only 15. The zeros indicate the routes of the ASAP ships across the N-Atlantic. The map shows clearly that there is a strong requirement for more upper air observations over the oceans, and that is also the case over vast land areas in the southern hemisphere. Evidently there is a need for additional ASAP ships on new routes over the Atlantic. On the other hand density of upper air stations may be unnecessarily high over some land areas in Europe.

As mentioned above the Swedish and Icelandic Meteorological Services jointly operate an ASAP unit. It was launched in November 1995 on the Icelandic vessel "Godafoss" sailing between Iceland, Newfoundland and USA. The route can be seen on Fig. 12, and on Fig. 13 aerological diagrams are shown for one of the observations from "Godafoss" as well as from land-based upper-air stations around the North Atlantic.

Conclusion and practical goals for the near future.

Clearly the meteorological requirements, as expressed by WMO, are far from being satisfied in the North Atlantic. With the greater resolution foreseen for numerical weather prediction models an even greater density of observing stations will become desirable.

On the other hand meteorological observing systems are very costly and due to economic restrictions it seems necessary to share burdens for increased observation activities outside national jurisdiction. Joint financing is therefore indicated. This seems fair on the North Atlantic as there will be benefits for all European nations.

What, then, might be practical goals for the near future?

Obviously one of the goals could be to improve the reception and timeliness of reports from the Voluntary Observing Ships. This could prove very helpful in some areas, especially between 30 and 50 degrees North.

A second practical and desirable goal could be doubling of the present number of meteorological buoys in operation in the North Atlantic. Part of this increase could possibly be achieved by using oceanographic buoys observing air pressure and transmitting 24 hours a day.

A third and probably the most important goal would be to radically increase the number of upper-air observations on the North Atlantic. One way of doing this could be to increase the number of ASAP units and find new routes for ASAP ships. An obviously desirable route would be from the north of Scotland to Newfoundland or the north-east coast of USA. Another could be from the English Channel to the east coast of the United States. Still another practical way for improvements might be the doubling of the number of daily soundings from ASAP ships.

To be able to achieve such costly improvements it may be necessary to find possible savings in the field of observations. One such possibility might perhaps be the automation and possibly also reduction of the number of upper-air stations on the European Continent. At the same time, however, it should be noted that the benefits from improved forecasts and services resulting from an improved ocean observing system might well outweigh the increase in costs several times over.

ANNEX II

Annual global monitoring for TEMP and SYNOP reports in relation to the Regional Basic Synoptic Networks

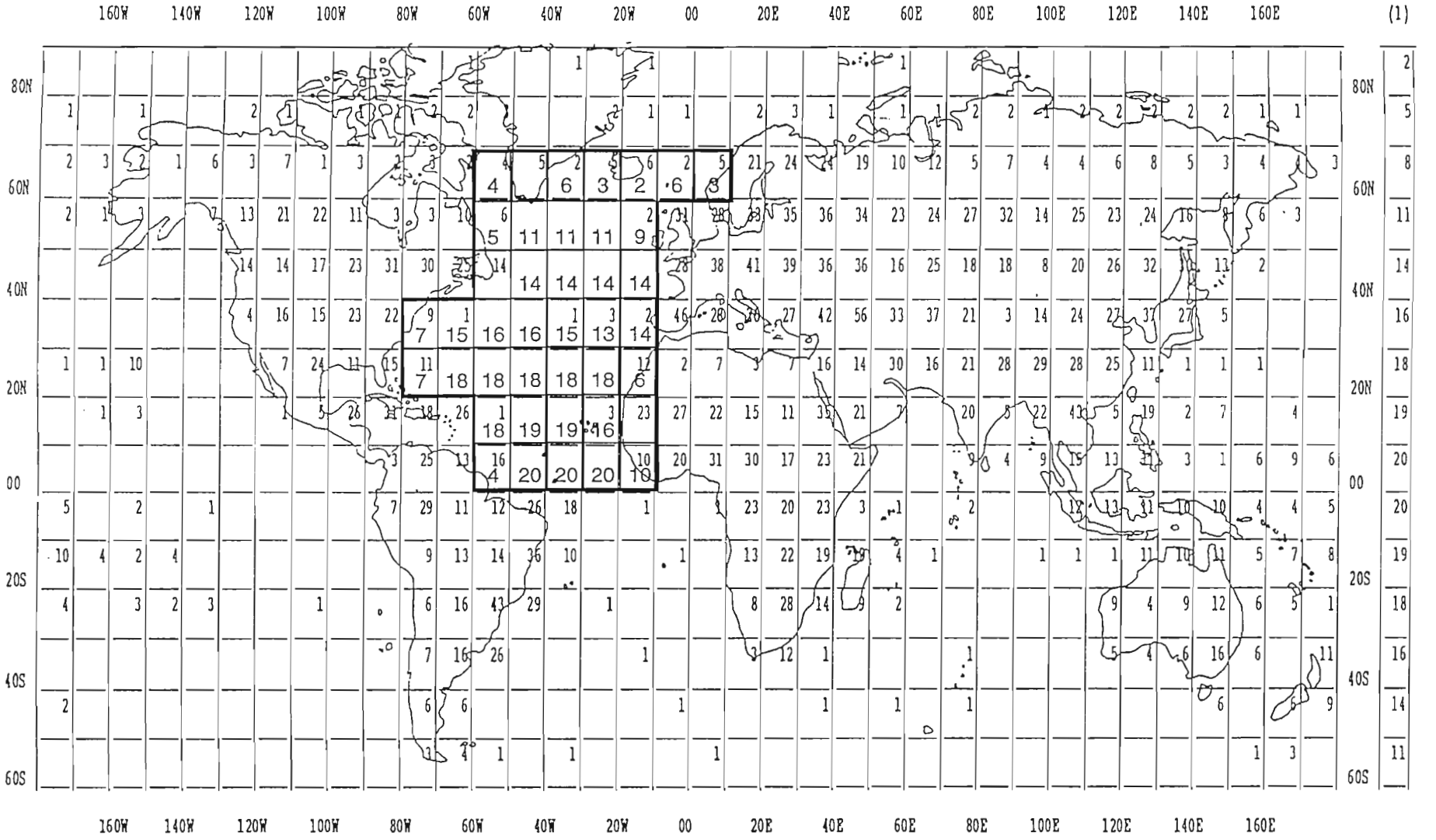


Figure II.1 — Number of surface stations comprising the RBSNs in 1994 (1).

(1) Number of stations required to satisfy a resolution of 250 km in each block (10 degrees by 10 degrees) at the corresponding latitude.

Fig. 1 Number of North Atlantic observing stations required to satisfy a resolution of 250 km.

ECMWF Monitoring Statistics - FEB 1996

Availability - SYNOP/SHIP pressure

Average number of observations in 24 hours - 41304

LAND - WMO Region I: 1999 II: 6938 III: 1324 IV: 2075

Region V: 3724 VI:20609 Antarctic: 341

OCEANS - N. Atlantic 2120 S. Atlantic 103 Indian 279 Pacific 1791

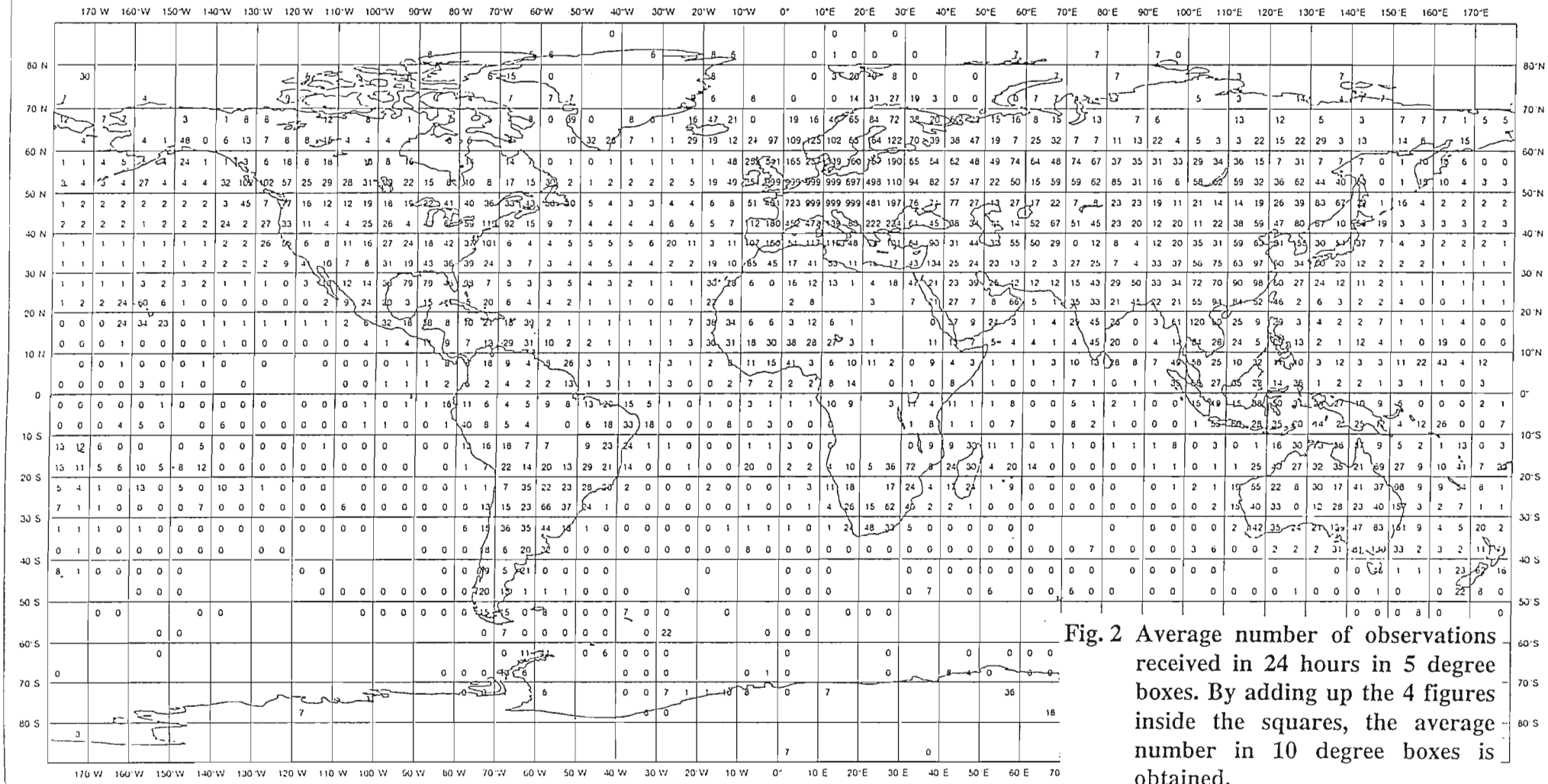


Fig. 2 Average number of observations received in 24 hours in 5 degree boxes. By adding up the 4 figures inside the squares, the average number in 10 degree boxes is obtained.

ECMWF Monitoring Statistics - FEB 1996

Availability - DRIFTER pressure

Average number of observations in 24 hours - 2959

OCEANS - N. Atlantic 924 S. Atlantic 410 Indian 470 Pacific 1155

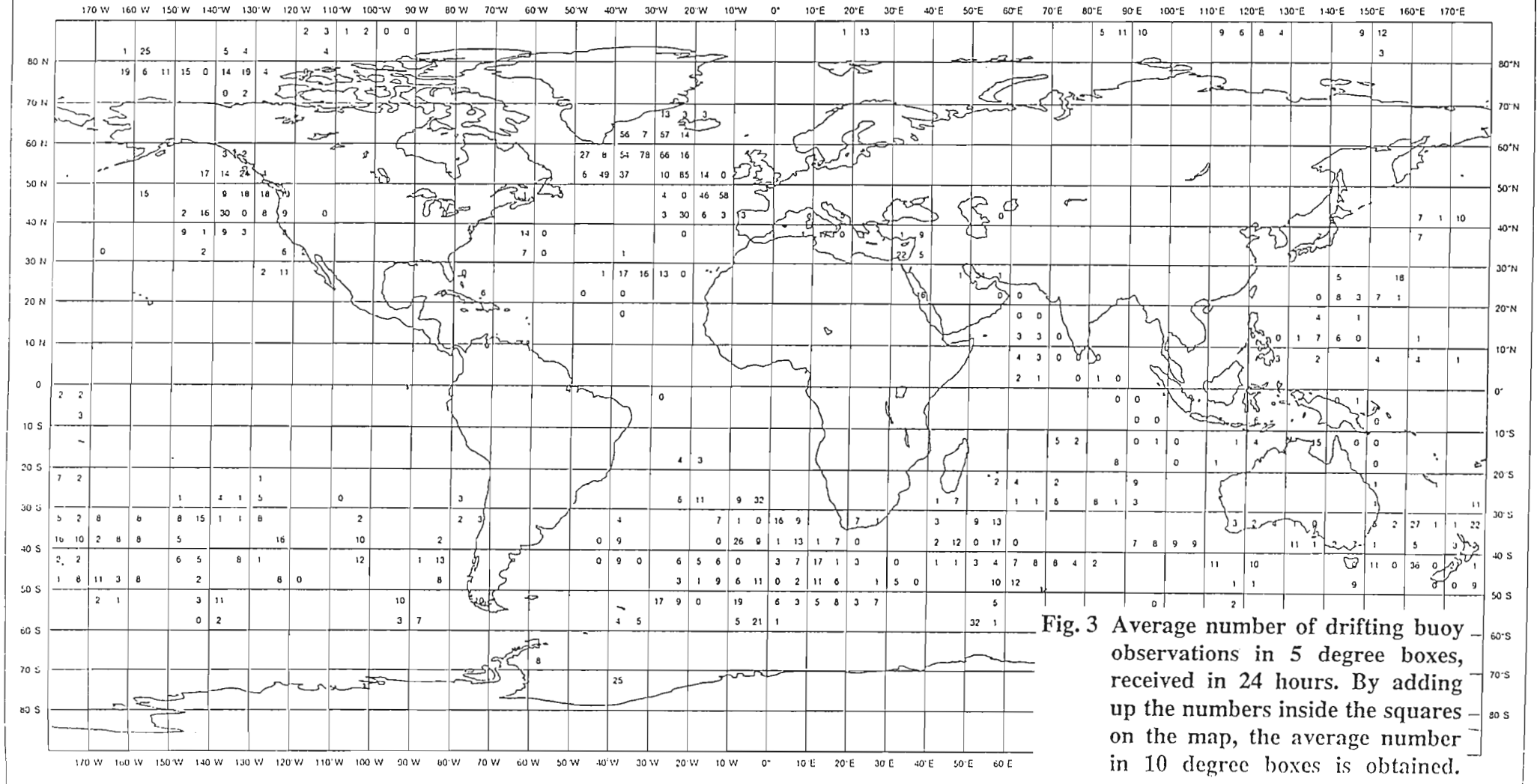


Fig. 3 Average number of drifting buoy observations in 5 degree boxes, received in 24 hours. By adding up the numbers inside the squares on the map, the average number in 10 degree boxes is obtained.

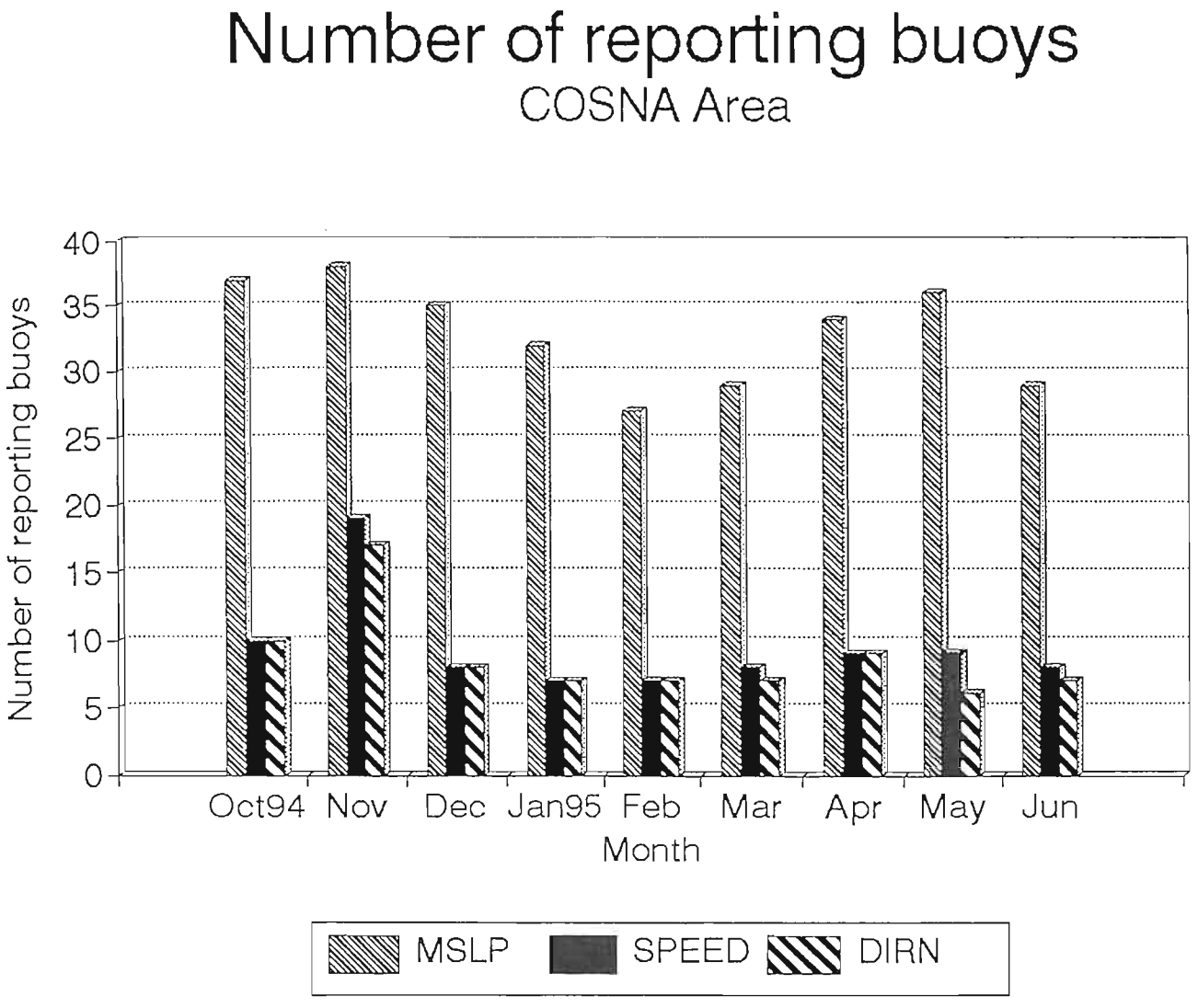


Fig. 4 Nuber of drifting buoys in the COSNA - Area reporting one or more of the Parameters mean sea level pressure (MSLP), wind speed (SPEED) and wind direction (DIRN) as available on GTS. From CGC-VI/Doc 3: Consolidated Monitoring Report on COSNA - Components - 1995.

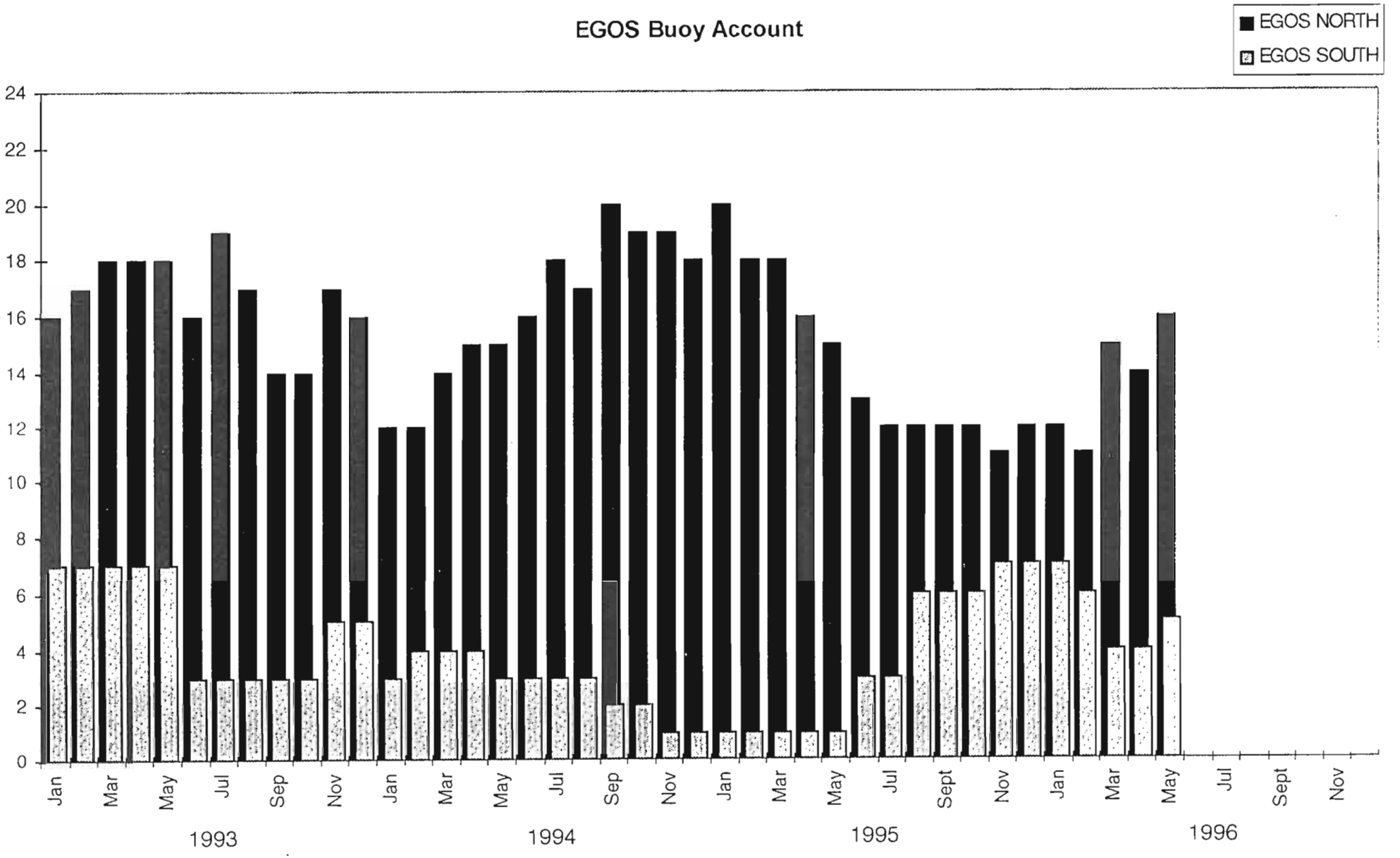
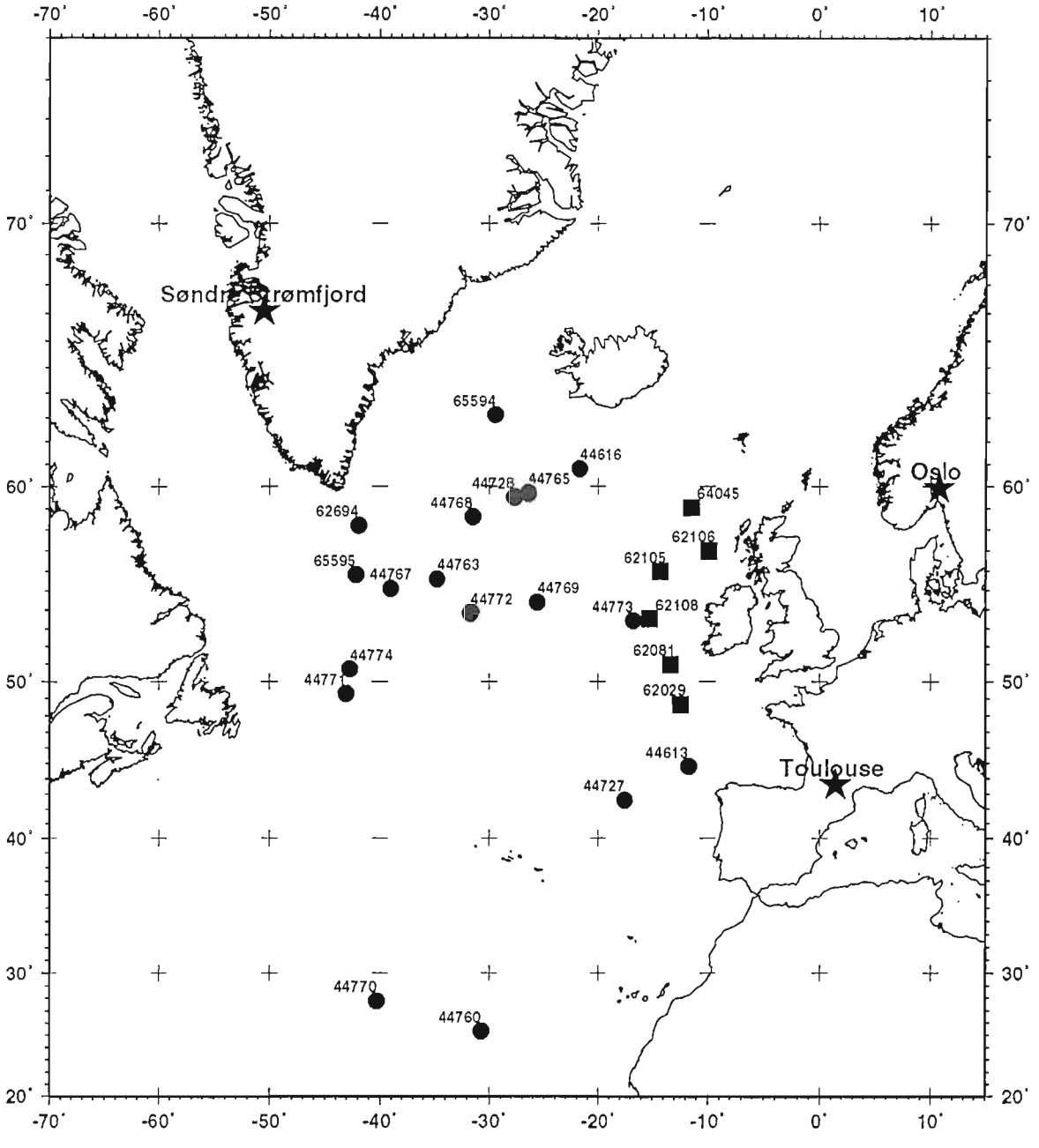

EGOS Buoy Account
EGOS NORTH
EGOS SOUTH
24
22
20
18
16
14
12
10
8
6
4
2
0
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sept
Nov
Jan
Mar
May
Jul
Sept
Nov
1993
1994
1995
1996

Fig. 5



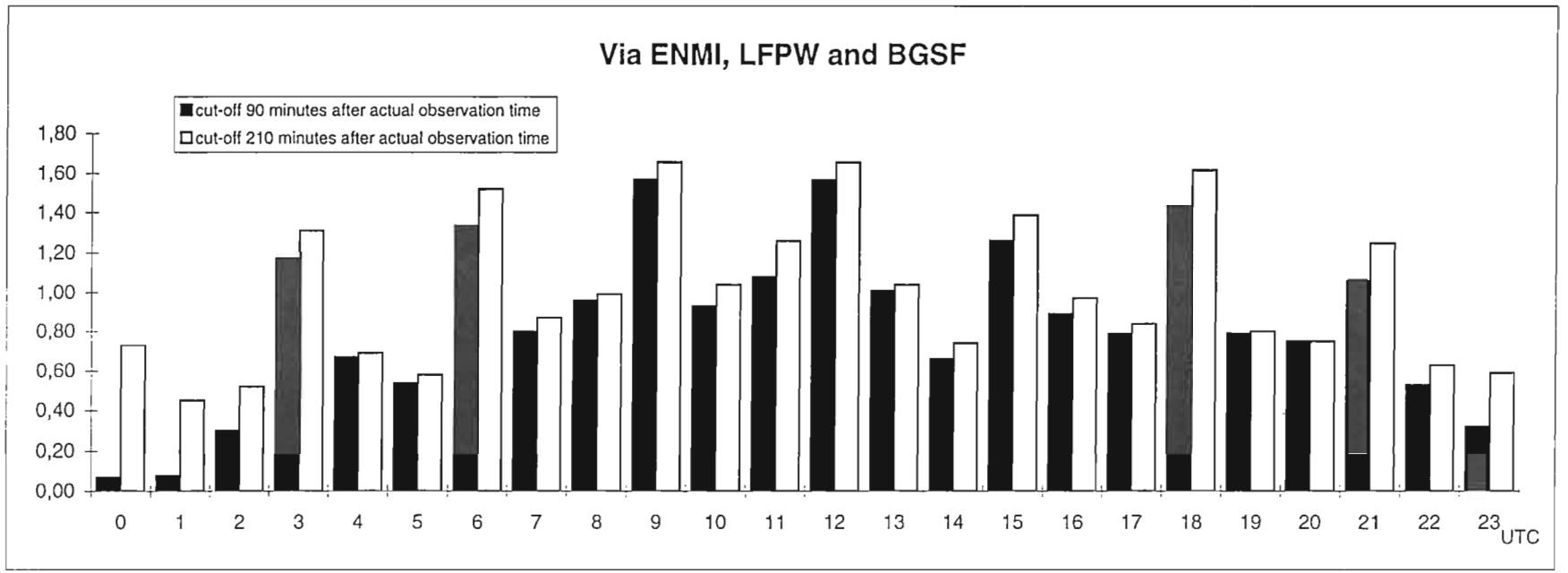
● Position of the EGOS drifting buoys on 30 April, 1996.
■ Position of the EGOS moored buoys.
★ The LUTs used in the EGOS drifting buoy programme.

Fig. 6

Diurnal Variation in EGOS-North Buoy Reception
Reykjavik, April 1996

Mean number of observations from 14 N-Atlantic EGOS-North buoys, observed during each hour of the day and received via GTS in Reykjavik within 90 minutes (black columns) and 210 minutes (white columns) from actual time of observation.

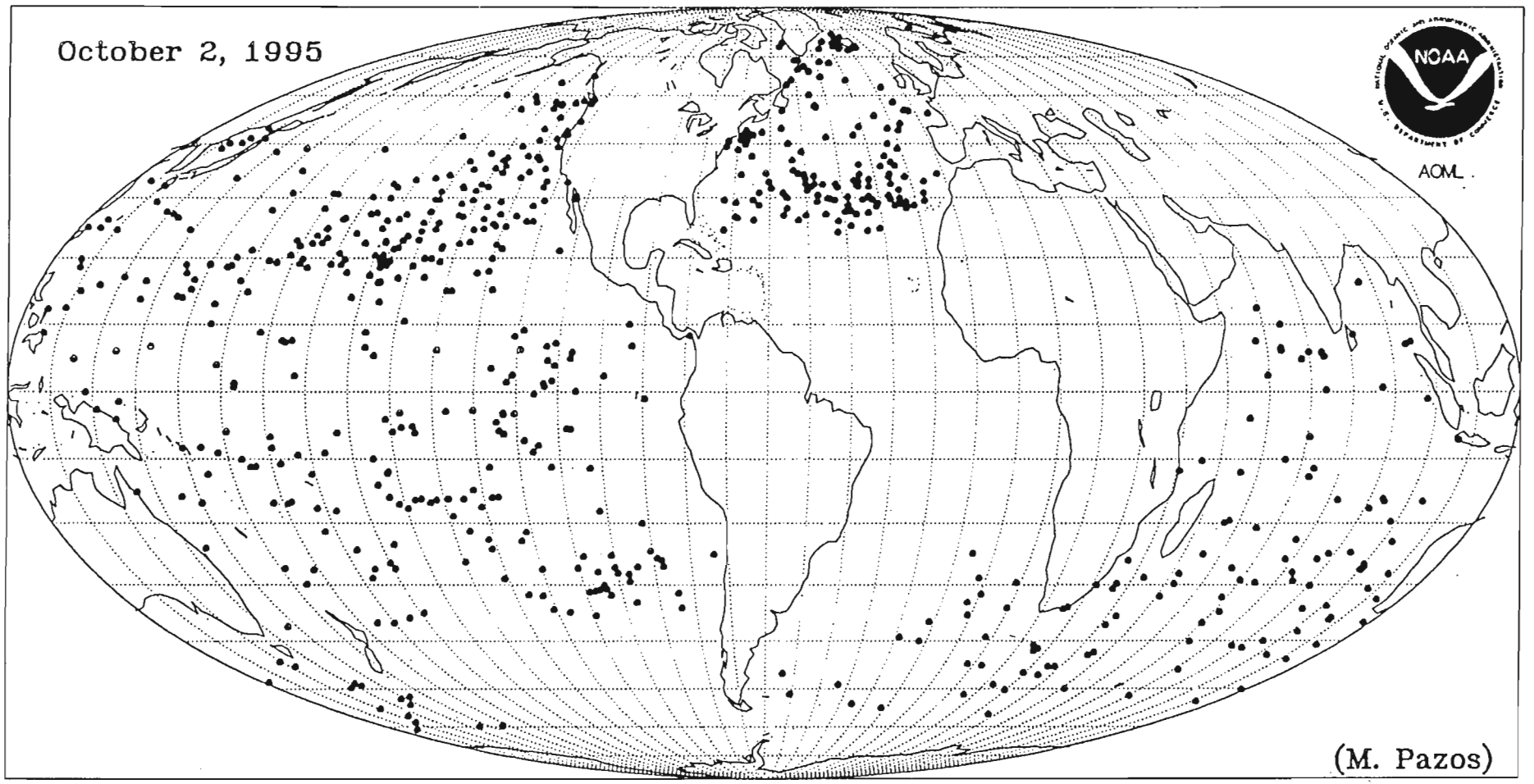
Vertical scale: Mean number of observations per day, hour and buoy
Horizontal scale: Hours UTC. 12 UTC means the period 11:31 - 12:30 UTC etc.



When the same observation has been received more than once or two or more observations made within 15 minutes have been received, only the first received has been included.

Fig. 7

STATUS OF GLOBAL DRIFTER ARRAY



- SST ONLY
- SST AND BAROMETRIC PRESSURE
- SST AND SALINITY

GLOBAL DRIFTER PROGRAM
Peter Niiler
Mark Swenson

Fig. 8

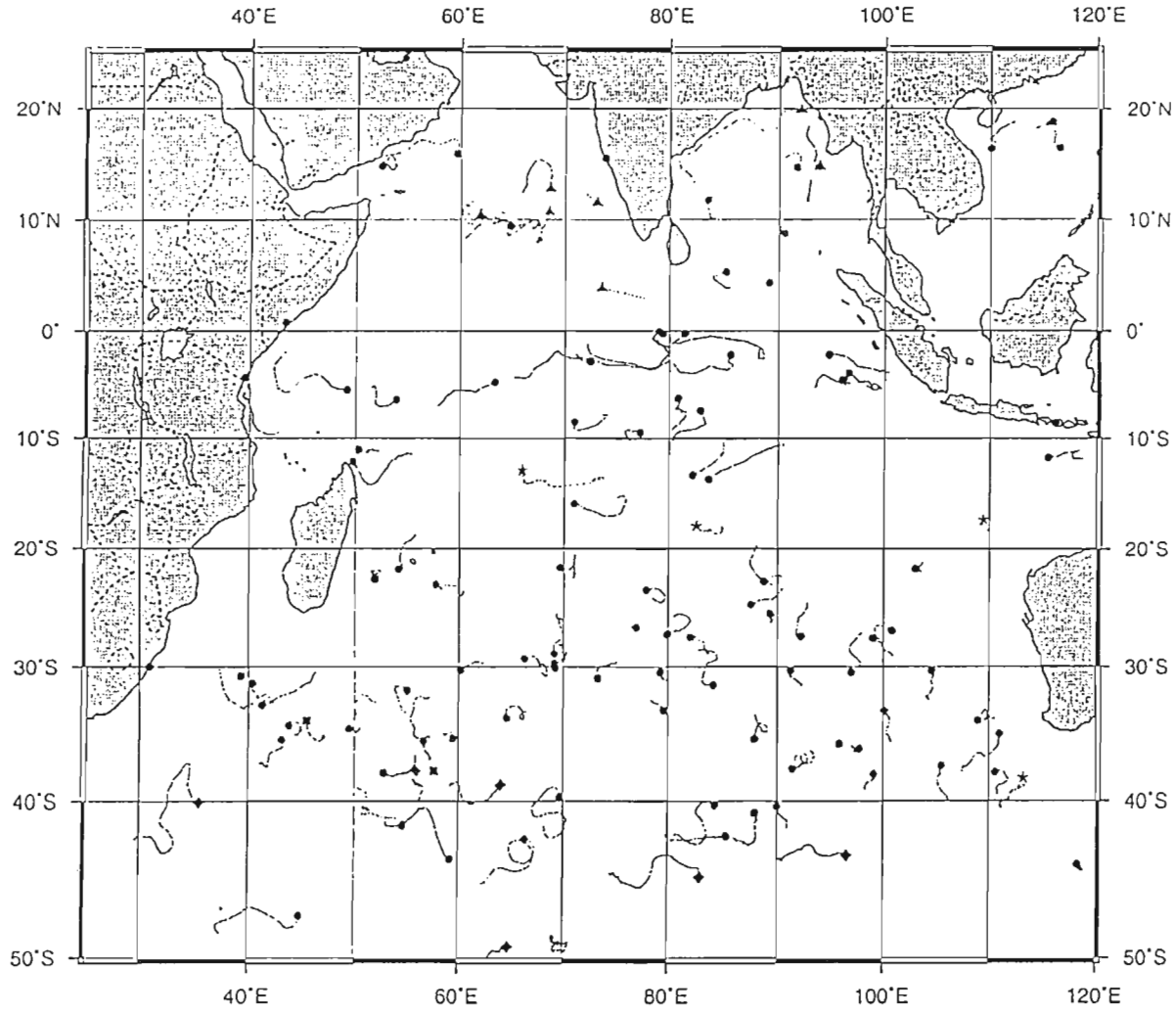
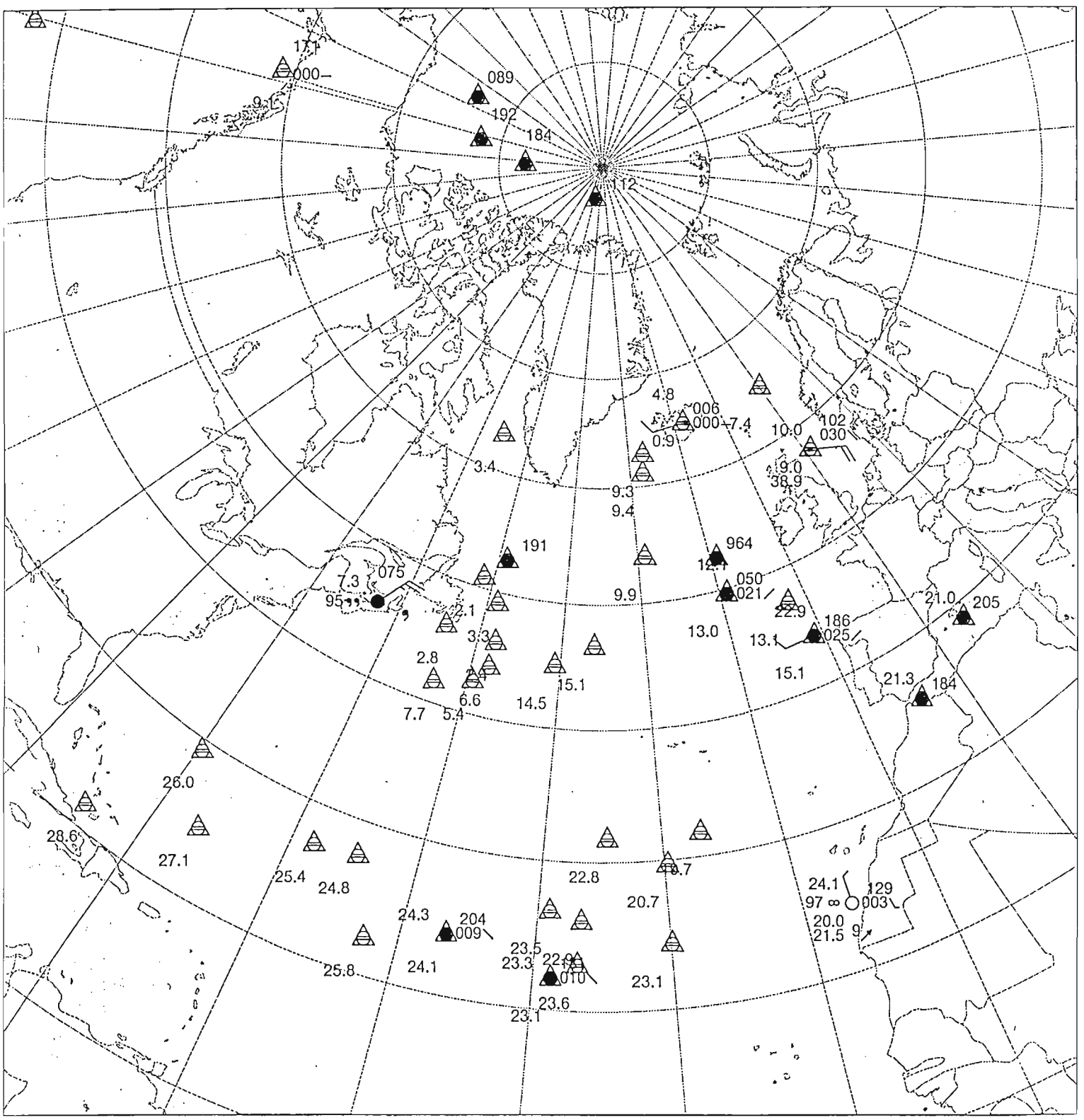


Figure 9 - Bouées dérivantes dans l'Océan Indien
Trajectoires du 1er au 31 mars 1996



30. May 1996, 17 UTC

Fig. 10

ECMWF Monitoring Statistics - FEB 1996

Availability - TEMP 500 hPa geopotential

Average number of observations in 24 hours - 1178

LAND - WMO Region I: 59 II: 438 III: 24 IV: 225

Region V: 103 VI: 294 Antarctic: 15

OCEANS - N. Atlantic 15 S. Atlantic 2 Indian 0 Pacific 3

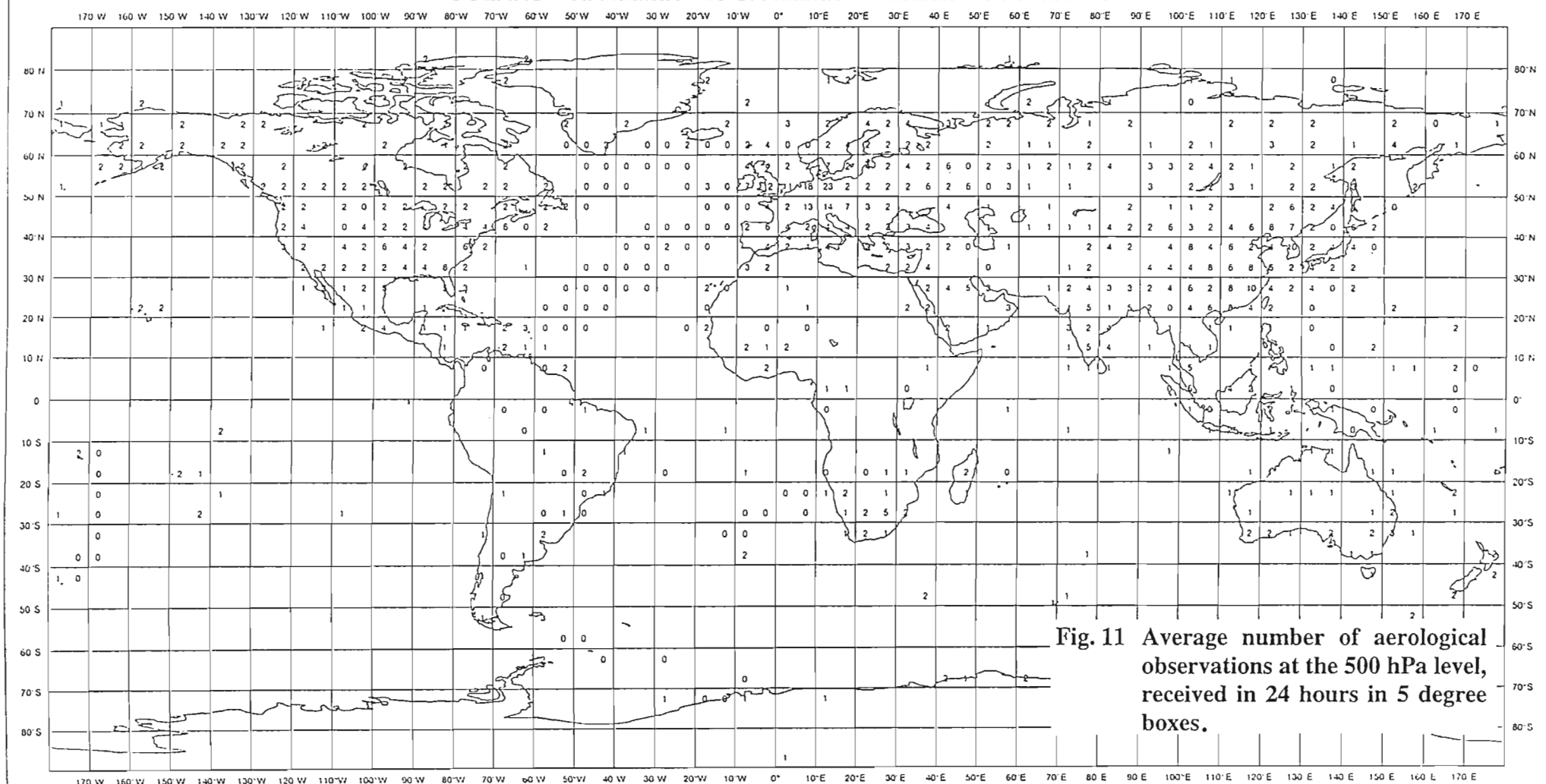


Fig. 11 Average number of aerological observations at the 500 hPa level, received in 24 hours in 5 degree boxes.

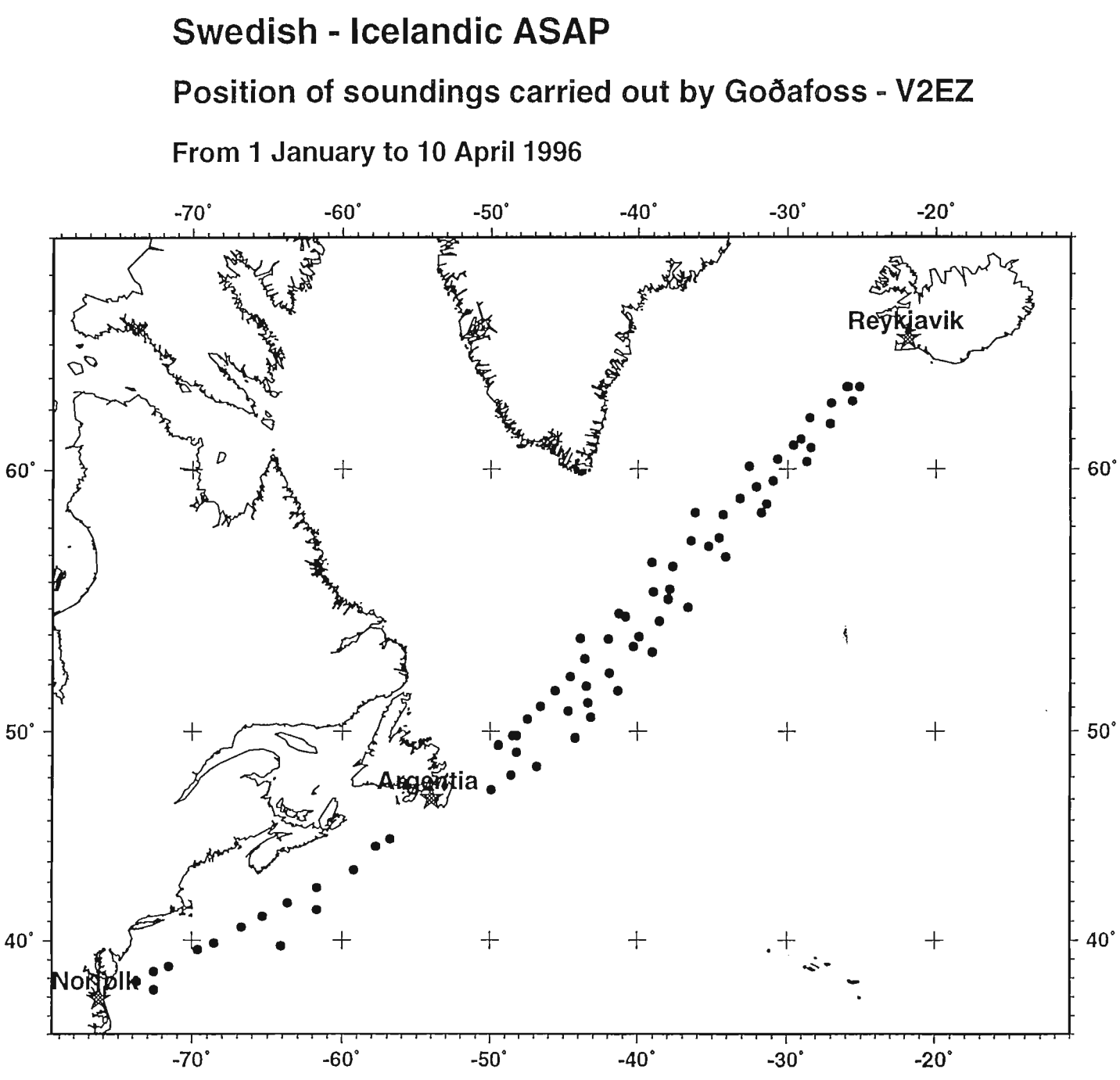

Swedish - Icelandic ASAP
Position of soundings carried out by Goðafoss - V2EZ
From 1 January to 10 April 1996
-70°
-60°
-50°
-40°
-30°
-20°
60°
50°
40°
Reykjavik
Argentia
Norfolk

Fig. 12

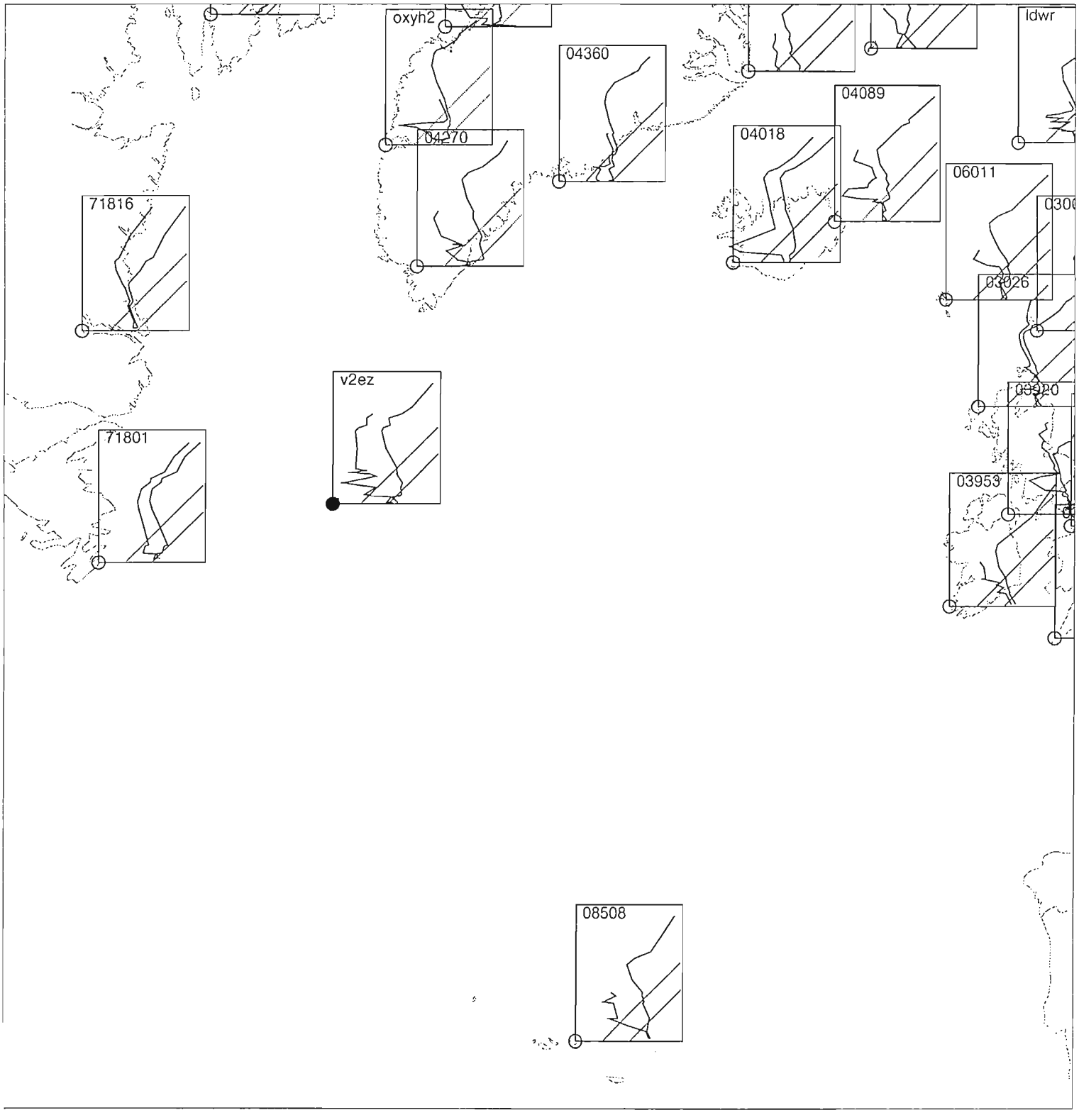


Fig. 13 Aerological diagrams from the North Atlantic, 19 March 1996 at 00 UTC V2EC is the call sign for the ASAP ship "Godafoss"