FORECASTING PRODUCTS MONITORING NOTE NO. 3

MONITORING STATISTICS FOR SATEMs AND SATOBs, SEPTEMBER-NOVEMBER 1989

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Contents

1. Introduction

Met O 8 Monitoring Notes 1 and 2 presented statistics derived from the OPD archive of observational data for all observation types for the years 1987 and 1988. A similar Note will be produced for 1989 statistics. The present Note considers satellite temperature and satellite wind data only (namely, SATEMs, LASS and SATOBs) for the three-month period September-November 1989. It is intended that similar Notes will be produced regularly for these data types covering consecutive three month periods.

The purpose of these Notes is two-fold : firstly to monitor the quality of the observations used in the NWP suite; secondly to assist in decisions designed to improve the data input to the model. As a by-product of the work, it is expected that deficiencies in the NWP model (as measured by the 6 hour forecast forming the background field) will also be revealed.

The regular exchange of monitoring data between various National Meteorological Centres is now being undertaken. NMC Washington are the WMO-designated lead centre for SATEM and SATOB monitoring statistics. Details of the statistics that are to be provided to the lead centre and the format in which they should be presented were formulated at a recent ECMWF seminar. The data presented in this Note are to a large extent based on these requirements. Some details remain to be defined and for some the code is not yet written - in these cases subsequent Notes will incorporate the precise requirements laid down by the lead centre. Also, results here include those for LASS, TEMPs, and AIREPs which are not part of the WMO requirement for SATEM/SATOB data exchange but are included for comparison with the SATEM and SATOB statistics.

2. Results

Results are presented in the form of charts of mean and RMS differences between observation and background field values (O-B) for

i) Temperatures : Compressed Code SATEMs (referred to as SATEMs)

AIREPs

TEMPs

LASS

ii) Winds : SATOBs

AIREPs

TEMPs and PILOTs (referred to as TEMPs)

When comparing statistics from the different types, the representativeness of the observations needs to be borne in mind. The satellite temperatures (and to a lesser extent winds) are in reality areal averages in the horizontal and vertical although presented to the model as values at a point. TEMP observations are also averaged in the vertical to form layer means before they are passed to the model. AIREP reports, however, can be considered as 'point' observations and these are not averaged. Since the model values are essentially averages over tens of millibars in the vertical and 100 km or so in the horizontal the representativeness 'errors' for AIREPs are likely to be larger compared to the other types. The RMS differences quoted below will include a contribution due to differences of representativeness.

The selection of observations for the samples used also needs to be considered. TEMPs report at fixed times regardless of synotic conditions. However reports from AIREPs are biased towards jets (where wind gradients are large) , satellite temperatures towards clear or partly cloudy conditions (associated usually with quiet synoptic conditions and weak gradients) and SATOBs can only occur where cloud exists. The latter tend to be associated with areas of convection in the Tropics and strong winds in mid-latitudes where gradients are relatively large.

Statistics have been obtained from the OPD archive of operational data. Except where stated, background field values relate to the global model.

2.1 Temperatures

2.1.1 SATEMs

Figs 1-3 show mean O-B temperatures in the three levels 1000-850, 300-100 and 50-30 hPa respectively. Results are given in 10 degree latitude/longitude boxes for boxes that contain more than 100 observations (the actual number of observations are also available in chart form but are not presented here for brevity). Results are for NOAA-10 and NOAA-11 combined - O-B statistics from these two satellites in the past have indicated little difference between them. Data from both these satellites are used in the NWP model. Note that SATEMs are presented to the model and stored in the OPD as temperatures at the mid-points of standard levels.

Fig 1 shows that for the band 1000-850 hPa (i.e. temperatures at 922 hPa), increments are generally positive but are negative over much of Africa. There are some very large values over high ground. (The model does not use satellite temperatures over land nor at the 922 hPa level north of 30 deg south). At 300-100 hPa (fig 2), increments are in general within +/- 1 deg C but with much larger values over the Himalayas. For 50-30 hPa (fig 3), increments are generally negative, particularly polewards of 50 degrees. In particular there are large negative differences south of 60 deg S between 180-20 deg W. (Satellite temperatures are not used by the model above 100 hPa south of 60 deg S).

Figs 4-6 show corresponding charts of RMS O-B differences. At 1000-850 hPa, there is a marked variation in the values between land and sea with those over land far greater. At 300-100 hPa, this distinction is much less marked, as expected. Values fall below 1 deg C over the equatorial oceans. At 50-30 hPa, RMS quantities are relatively high between 40-70 deg N (particularly 60 W-10 E) and south of 50 deg S. As for the 300-100 hPa band, there is little if any land/sea variation.

2.1.2 <u>AIREPs</u>

Figs 7 and 8 display mean and RMS O-B values for AIREPs at the 100-299 hPa band. The mean values, like those for SATEMs at this band, are mostly between -1 and +1 deg C. The RMS quantities, however, are about 50% higher. Note that for AIREPs, observations that have been rejected by CFO or by the quality control scheme are excluded from the statistics. All AIREP observations at this band are used by the model (unless of course they have been flagged or rejected by CFO) and are presented at reported level.

2.1.3 <u>TEMPs</u>

Figs 9 and 10 show mean O-B temperatures for TEMPs in the two lower bands used for SATEMs. One station per 10 degree box has been chosen. The choice of station for those grid boxes where more than one station reports, was made earlier in 1989 depending on frequency of observations over a three month period. Stations that were thus selected but were then found clearly to be reporting erroneous observations as gauged by monthly O-B statistics were discarded in favour of other stations. However since the situation is constantly evolving there may be more representative stations for September-November 1989 than those selected here; also, where there is only one station in a particular box this station has been used regardless of its quality provided more than 100 observations were present in the period.

Temperatures (and humidities) from stations with block numbers 42 and 43 (India) are permanently rejected from the model and unfortunately are therefore not stored in the OPD, thus not appearing in figs 9-11. For the figures all observations have been included in the statistics. They are presented to the model and stored in the OPD on model sigma levels.

Fig 9 shows the mean biases to be smaller at 1000-850 hPa than for SATEMs (fig 1) but there are relatively large values (outside +/- 2 deg) along the western coast of North America, Central and Southern Australia and near the poles. Most of these reflect systematic model biases. At 300-100 hPa the biases are within +/- 1 deg. Very few stations regularly report higher than 50 hPa and so results for the 50-30 hPa band are not shown.

Fig 11 shows the RMS O-B statistics for TEMPs for 1000-850 hPa. Values are in general smaller than for SATEMs at the same band (fig 4), although south of about 30 deg S there is little overall difference. For the 300-100 hPa band, fig 12, the SATEM values are smaller roughly south of 40 deg N but north of this latitude the TEMP RMS quantities are generally lower. The very high value of 10.6 in the north Atlantic is based on observations from OWS 'C', presumably the result of a small number of gross errors.

2.1.4 LASS

LASS statistics are stored only for observations used in the regional (fine-mesh) model and are therefore not strictly compatible with those for the other types referred to above, where O-B differences were based on global model fields.

LASS observations are presented to the model on standard levels from 850 hPa upwards. Temperatures at 1000 hPa are also available but are not used by the model. Soundings over land are also not used. During the period September - November 1989 not all the 1000 hPa level observations were stored in the OPD and values over land were also not archived for the complete period. In addition, some LASS values in the OPD during this period are averaged (approximately 240 km resolution) and others unaveraged (120 km resolution), although the characteristics of each are similar. The 'combined' records data-set, from which the LASS results below are derived, holds statistics on the observations regardless of quality control flags and therefore some wild observations (particularly for example over high ground) are included in the statistics.

Mean differences for LASS at the same bands as for SATEMs are shown in figs 13-15. For 1000-850 hPa (which comprises two levels of data, 1000 and 850 hPa), differences are close to zero except for grid boxes where high ground is present, in which case temperatures at these levels are hypothetical. Differences at 300-100 hPa are also close to zero (except over Greenland). At 50-30 hPa they are negative, again except over Greenland, a result which is consistent with the SATEM values at that band.

RMS differences at 1000-850 hPa, fig 16, are similar over most land grid boxes to those for SATEMs but larger over some e.g France, Eastern Mediterranean and Greenland. Over the sea the values are smaller than for SATEMs, which would be expected given that the background field is used as a 'first guess' for the LASS soundings. For the other two bands, figs 17 and 18, RMS differences are smaller nearly everywhere than corresponding SATEM values (figs 5 and 6).

2.2 Winds

2.2.1 SATOBs

Mean vector winds for SATOBs have been calculated from observed u and v components in 10 degree boxes and plotted in figs 19-21 for bands 700-999, 400-699 and 100-399 hPa respectively. These plots comprise results from four geostationary satellites : GOES, METEOSAT, INSAT and GMS. Roughly, the area of coverage of GOES extends from 160 deg W to 70 deg W, METEOSAT from 60 deg W to 60 deg E and GMS from 90 deg E to 170 deg W. The number of INSAT observations is small compared with numbers from the other satellites and for most grid boxes in its area of coverage the number does not meet the specified criterion. The few grid boxes that do have sufficient INSAT observations are all in the immediate vicinity of India. Where overlaps of coverage occur, results are averages weighted according to the respective numbers of observations.

Figs 22-24 show mean O-B vector winds in the same format as figs 19-21. A striking feature of fig 22 is the convergence of the wind biases near the equator. At higher levels, 400-699 hPa, (fig 23), there is a very marked bias for one of the grid boxes covered by METEOSAT in the south Atlantic; also a tendency for under-estimation of the westerly component of wind south of Australia by the GMS satellite.

For the 100-399 hPa level, fig 24, there is a general tendency for under-estimation of wind strengths at mid-latitudes, as evidenced by an easterly bias (although in the south Atlantic the bias is northerly despite the mean westerly flow in this area, indicated by fig 19). Near the equator there is a divergence of wind biases, corresponding to the convergence at 700-999 hPa i.e. enhanced Hadley circulation at the equator implied by the mean SATOB O-B increments.

Figs 25 and 26 show mean speed O-B and RMS vector O-B differences at 700-999 hPa. Mean differences from METEOSAT and GOES are mostly positive (observations stronger than background). There are very large RMS values contributed by INSAT around India. (INSAT winds are not used by the model).

At higher levels, 100-399 hPa, figs 27 and 28, differences are generally negative (observations lighter than background) in mid-latitudes and positive around the equator. The largest negative differences occur over East Asia and Australia (as large as -11.2 m/s north of Japan) - areas covered by the GMS satellite. In contrast, biases tend to be positive in the south Atlantic, an area covered by METEOSAT. Further north, however, over Arabia and the eastern Mediterranean, there are relatively large negative biases for these latitudes. The RMS vector quantities, fig 28, vary from 6 m/s over Central Africa to 12 m/s typically in mid-latitudes but as high as 17 m/s north of Japan (where there is a large negative bias).

2.2.2 AIREPs

Figs 29 and 30 display mean O-B and RMS vector O-B differences for AIREPs in the band 100-399 hPa. The mean biases for all but one grid box are positive : + 3 m/s generally over Australia and as large as 4 m/s east of Japan. RMS values are approximately the same as for SATOBs over the Tropics and the north Atlantic but elsewhere are smaller e.g. over Australia 9 m/s compared with 14 m/s for SATOBs.

2.2.3 TEMPs

Fig 31 shows mean O-B vector wind differences for TEMPs between 100-399 hPa. As for section 2.1.3, one station per grid box has been selected and the same comments as for 2.1.3 apply (but winds from stations with block numbers 42 and 43 are used). Fig 31 for TEMPs may be compared with fig 24 for SATOBs.

As expected, there is much less coherence in the results for TEMPs compared to SATOBs with some isolated very large biases which probably reflect problems with individual stations. Of interest is a consistent westerly bias over Australia contrasting with the much stronger easterly bias for the SATOBs.

Figs 32 and 33 show mean speed O-B and RMS vector O-B differences in the 700-999 hPa band. Extensive areas of largely negative differences are evident in northern mid-latitudes. The RMS differences are similar to, perhaps slightly greater than, those of SATOBs (fig 26), ignoring the SATOB observations from INSAT.

At 100-399 hPa, the means (fig 34) are generally within the range -2 to +2 m/s but at a number of grid boxes (stations) as high as +/- 5 m/s. There is a large range in RMS vector differences (fig 35) but most lie in the range 4-9 m/s and are considerably lower than SATOB and AIREP values in northern mid-latitudes.

3. Implications for the operational suite

3.1 SATEMs

a) The large mean O-B differences in the western hemisphere south of 60 deg S at 50-30 hPa (fig 3), in an area where little TEMP data is available and where SATEMs are excluded (above 100 hPa south of 60 deg S) does beg the question whether SATEMs should be reinstated at these latitudes and levels. The decision to reject them was made over six years ago and the justification for it may no longer be valid. At present, though, the data would still not be used over Antarctica since SATEMs are excluded over land (but see (b) below)

b) The lack of a land/sea distinction in the magnitude of the RMS O-B differences for SATEMs at 50-30 hPa (fig 6), when SATEMs are currently excluded over land, suggests it may be beneficial to include them over land at some level above 100 hPa, say (as is carried out at ECMWF), where TEMP coverage becomes poor. This would be particularly significant for the 20-level model which has more levels in the stratosphere and a highest level of 7 hPa compared to 25 hPa in the current scheme.

c) The similarity of the RMS O-B differences for SATEMs and TEMPs at 1000-850 hPa south of 30 deg S (comparing fig 11 with fig 4) and the larger SATEM values compared with the TEMPs' north of 30 deg S justifies the decision to exclude bottom level (922 hPa) SATEMs from the model north of 30 deg S but retain them elsewhere.

Data at the bottom level of LASS retrievals (1000 hPa) are also excluded and this too is justified by statistics of RMS O-B differences for the various levels, taking sea areas only. (Results not shown in this Note)

3.2 SATOBs

a) In spite of the uncertainties associated with representativeness and sampling, the RMS O-B differences and negative mean biases for GMS are so large at high levels compared to values from the other satellites and relative to TEMP and AIREP values that there seems a very strong case for rejecting all high level GMS winds polewards of 20 degrees, say. Since November 1989, ECMWF have rejected GMS winds polewards of 20 degrees but at all levels. The results presented here and also produced by regular monthly monitoring statistics do not suggest GMS low level winds are worse than those from GOES or METEOSAT, or indeed than those from low-level TEMPs.

b) METEOSAT winds above 500 hPa and north of 30 deg N are currently excluded from the model. The decision to exclude them was made about four years ago on the basis of observed large negative biases in jets. Since then it appears that their quality in strong winds has improved to such an extent they are probably of higher quality and certainly no worse than either GMS or GOES. This is based on work carried out recently by the author on the quality of high level SATOB winds and the findings of other workers in the field. Resources have not, however, permitted a test of whether their inclusion would improve the model's performance.

It is also worth pointing out here that since November 1989 ECMWF exclude GOES high level winds north of 20 deg N, in addition to their more extensive rejection of GMS winds. No METEOSAT winds are excluded by ECMWF per se but SATOBs over land are not used, whereas they are by the Met. Office model.

Fig 1

MEAN O-B TEMPERATURES (DEG C) BETWEEN 1000 AND 850 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

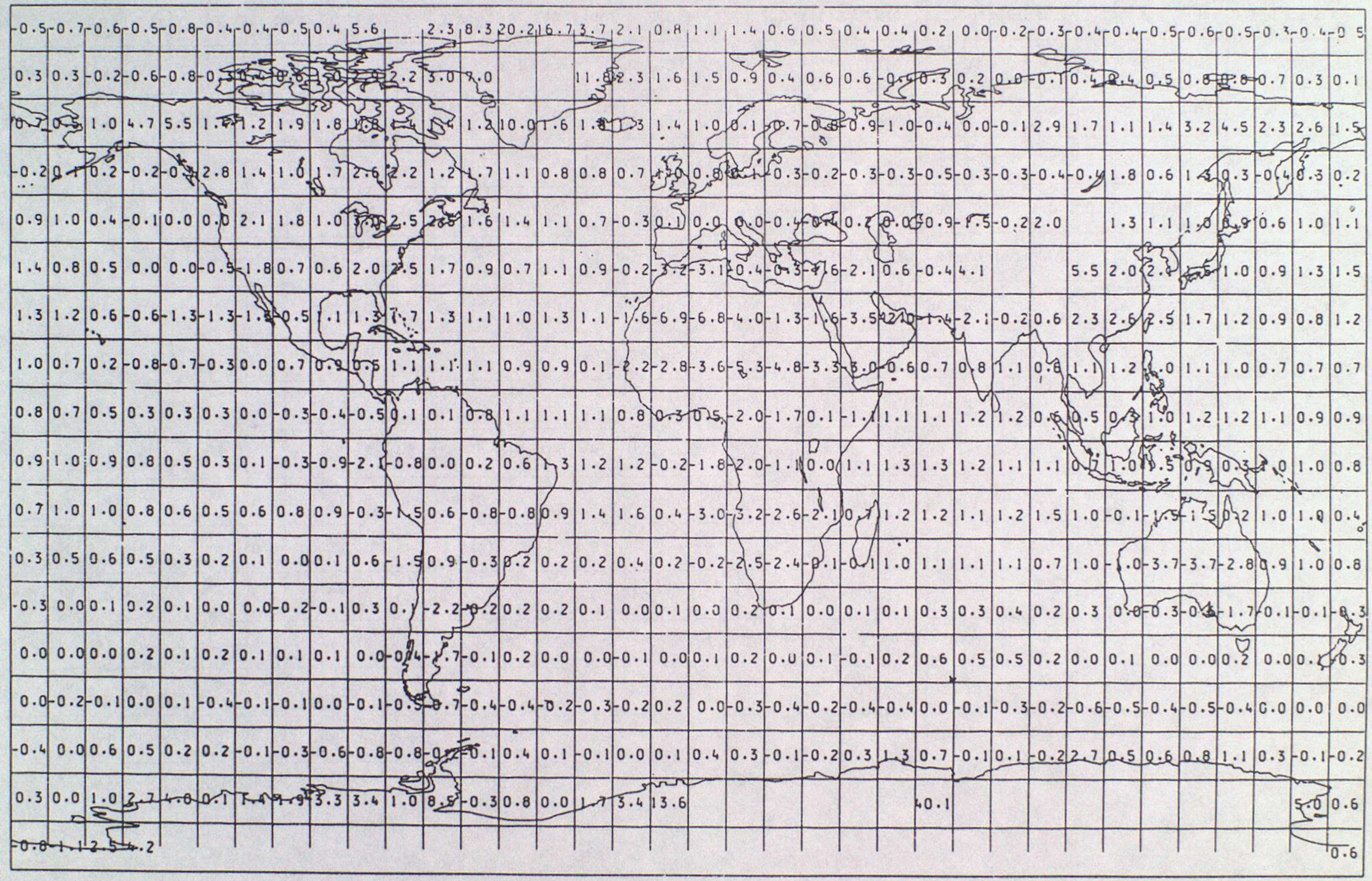


Fig 2

MEAN O-B TEMPERATURES (DEG C) BETWEEN 300 AND 100 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

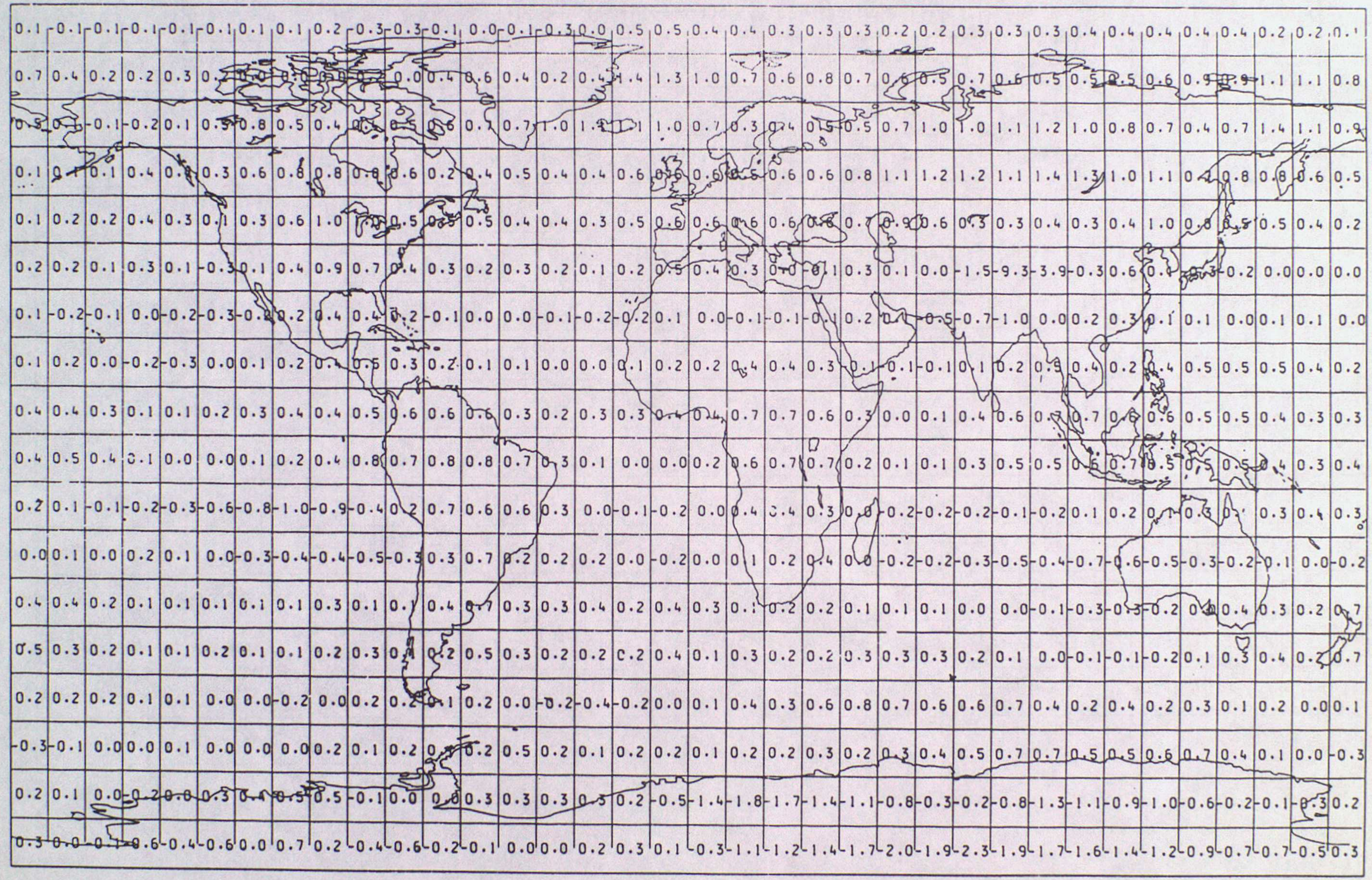


Fig 3

MEAN O-B TEMPERATURES (DEG C) BETWEEN 50 AND 30 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

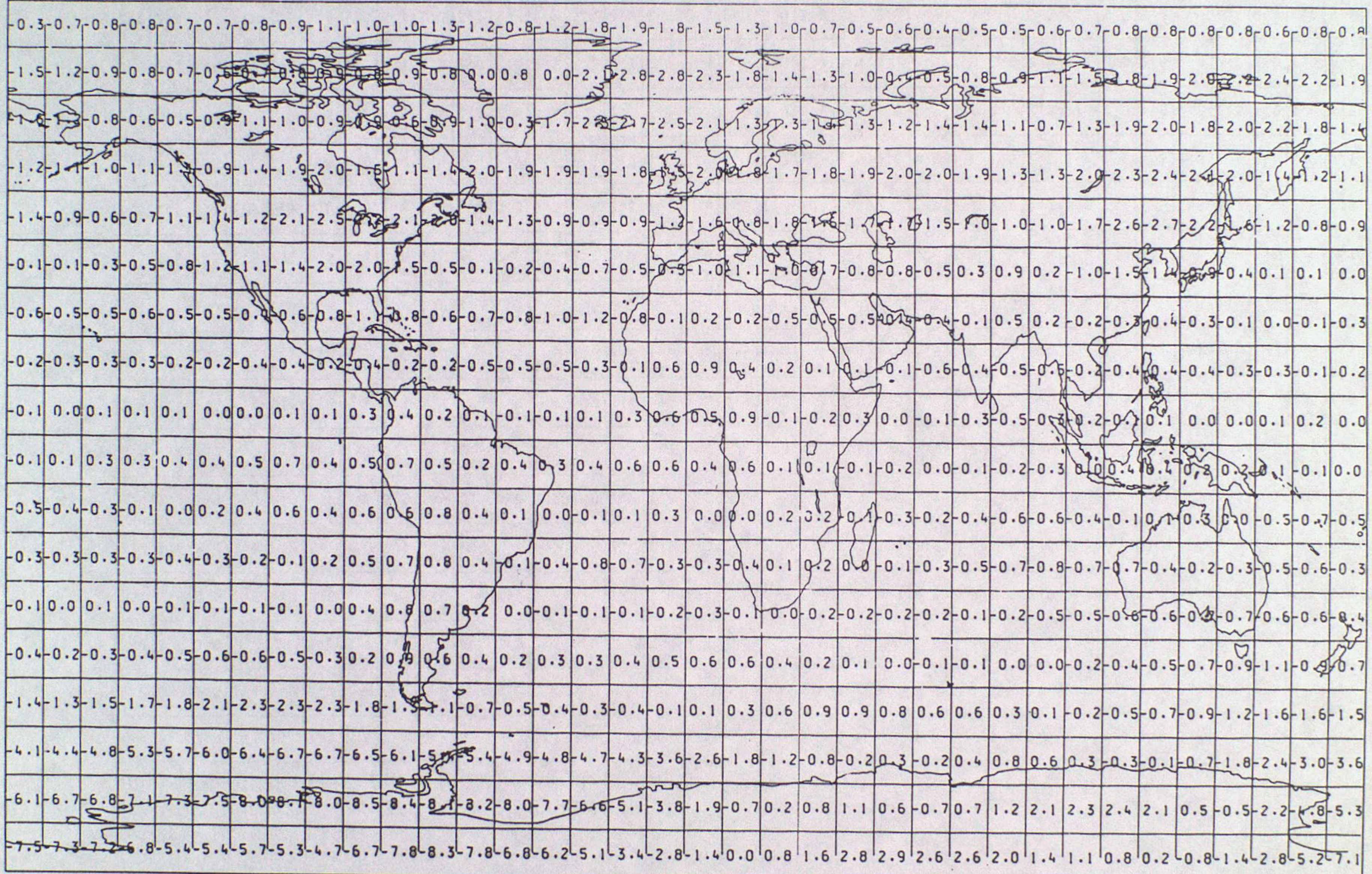


Fig 4

RMS O-B TEMPERATURES (DEG C) BETWEEN 1000 AND 850 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

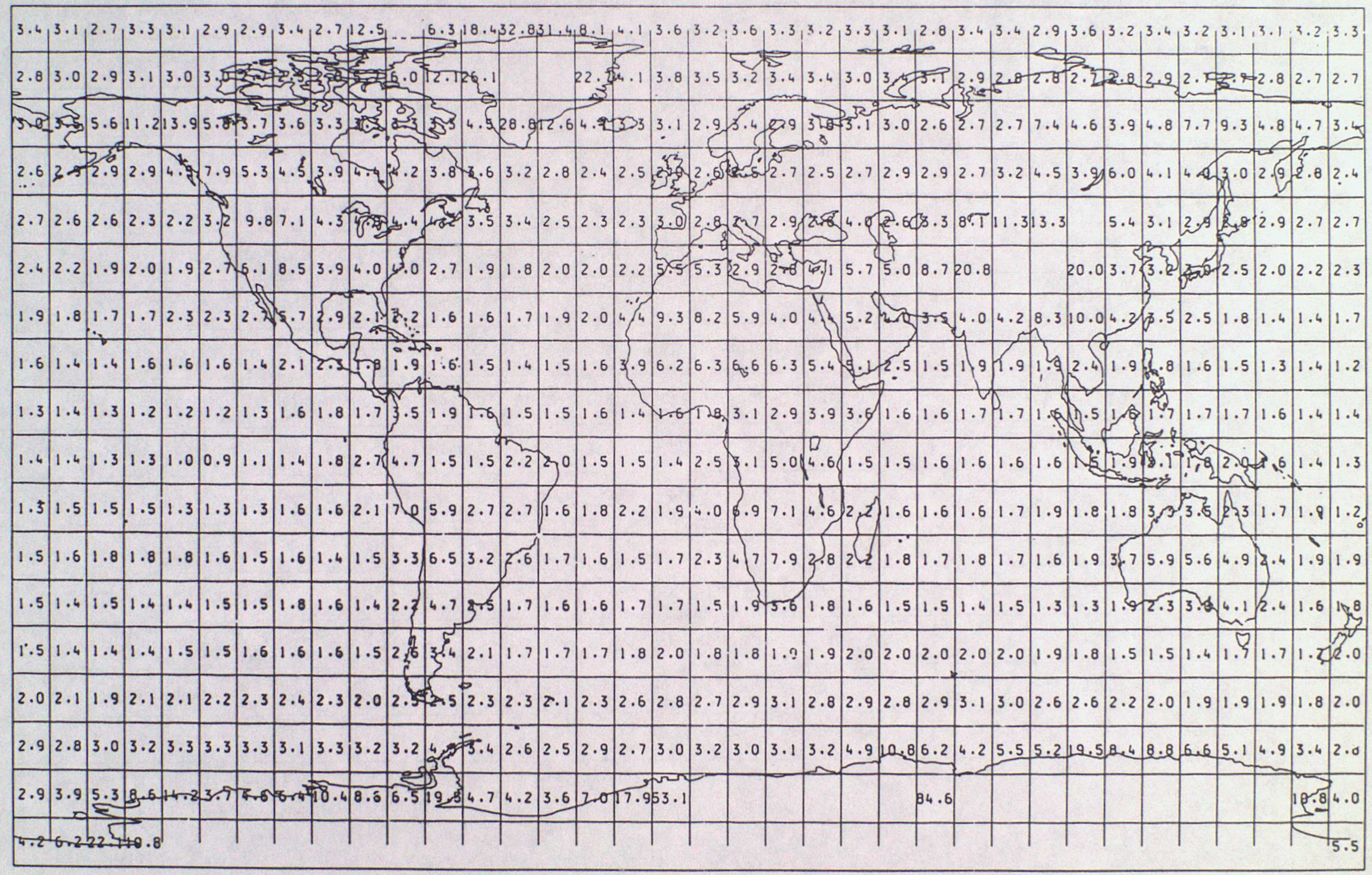


Fig 5

RMS O-B TEMPERATURES (DEG C) BETWEEN 300 AND 100 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

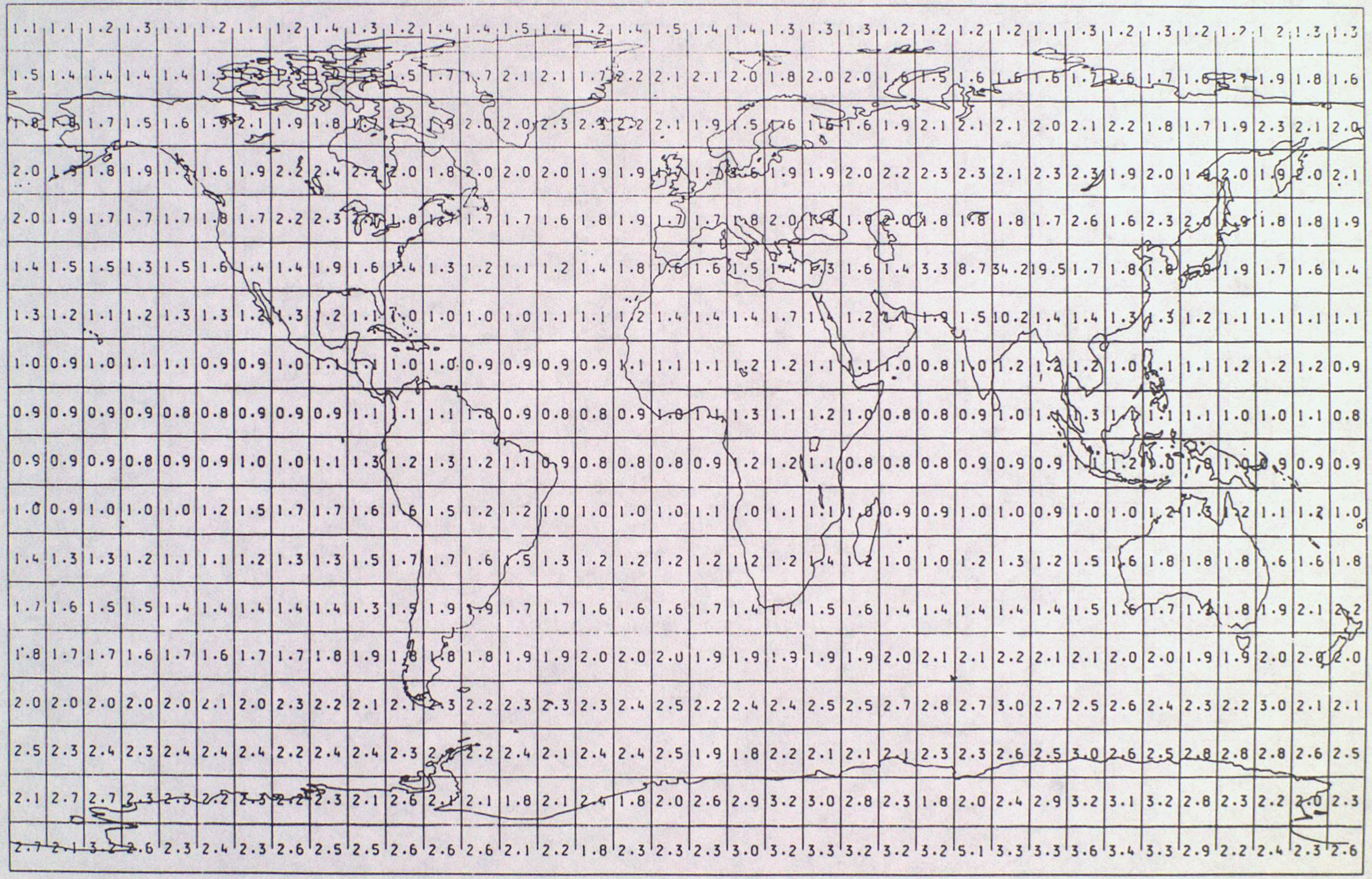


Fig 6

RMS O-B TEMPERATURES (DEG C) BETWEEN 50 AND 30 HPA : SATEMS
1/9/89 TO 30/11/89
NOAA-10 AND NOAA-11 STATISTICS COMBINED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

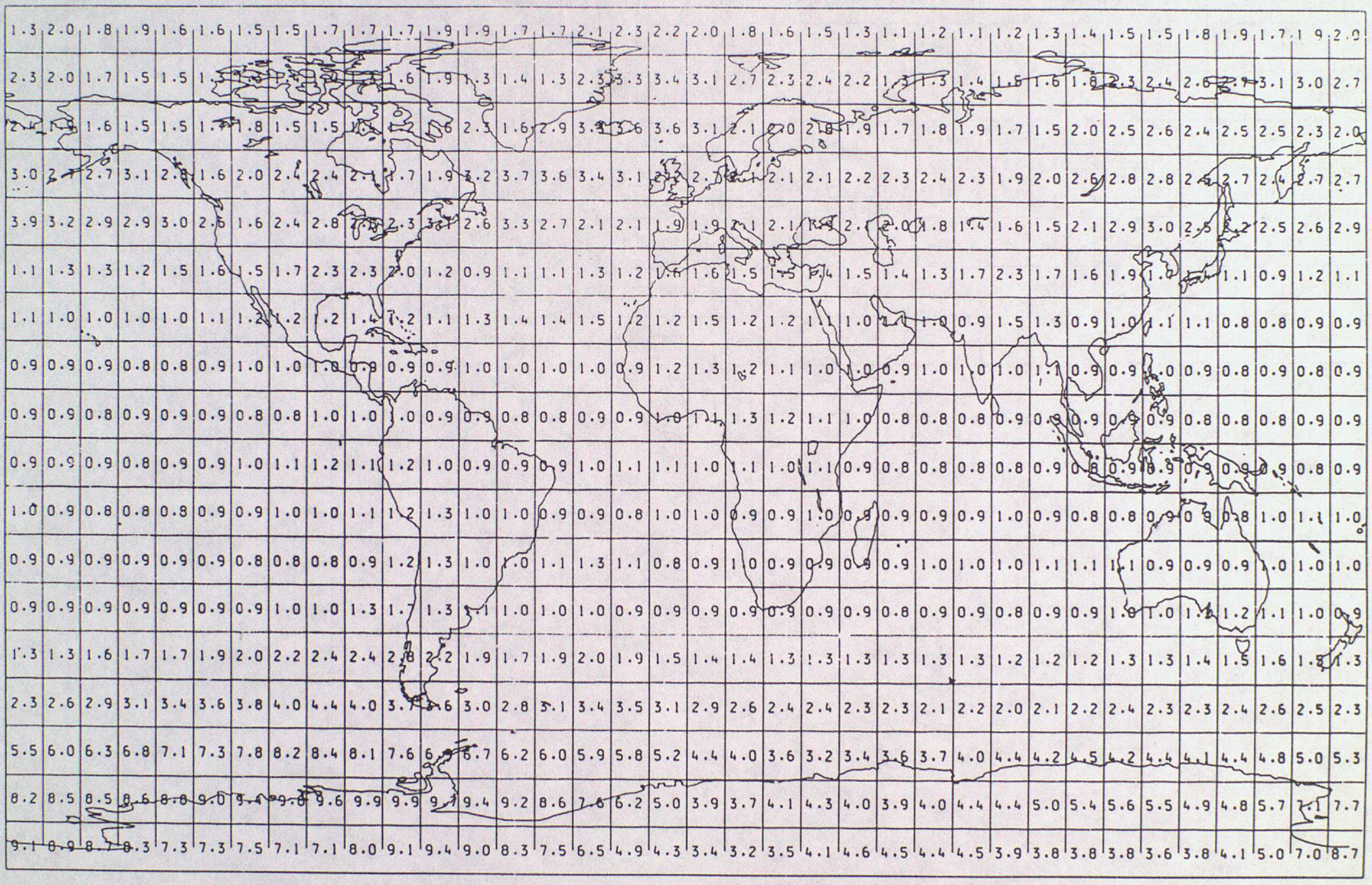


Fig 7

AIREPS : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 299 HPA
1/9/89 TO 30/11/89
FLAGGED OBSERVATIONS EXCLUDED
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

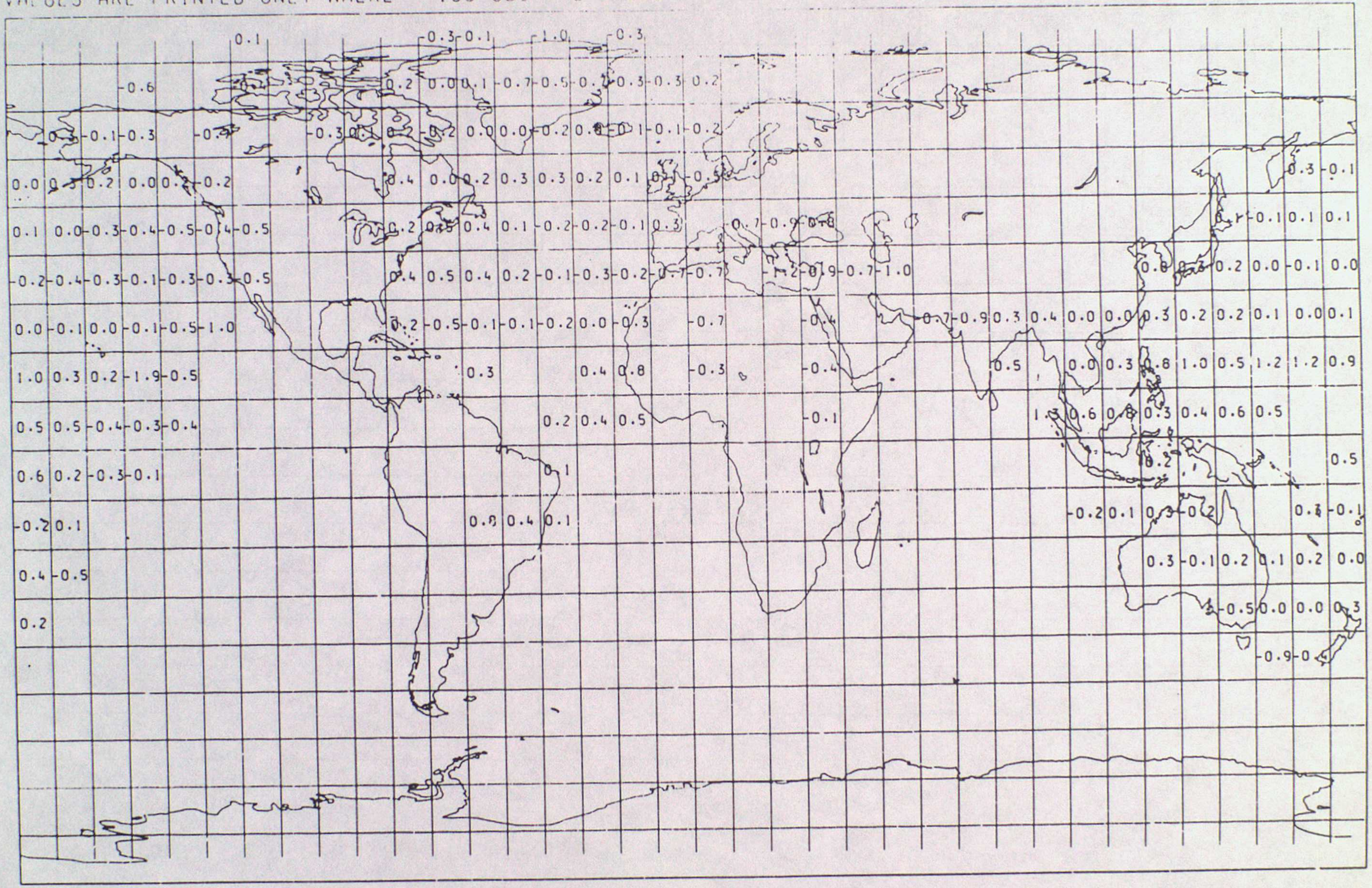


Fig 8

AIREPS : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 299 HPA
1/9/89 TO 30/11/89
FLAGGED OBSERVATIONS EXCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

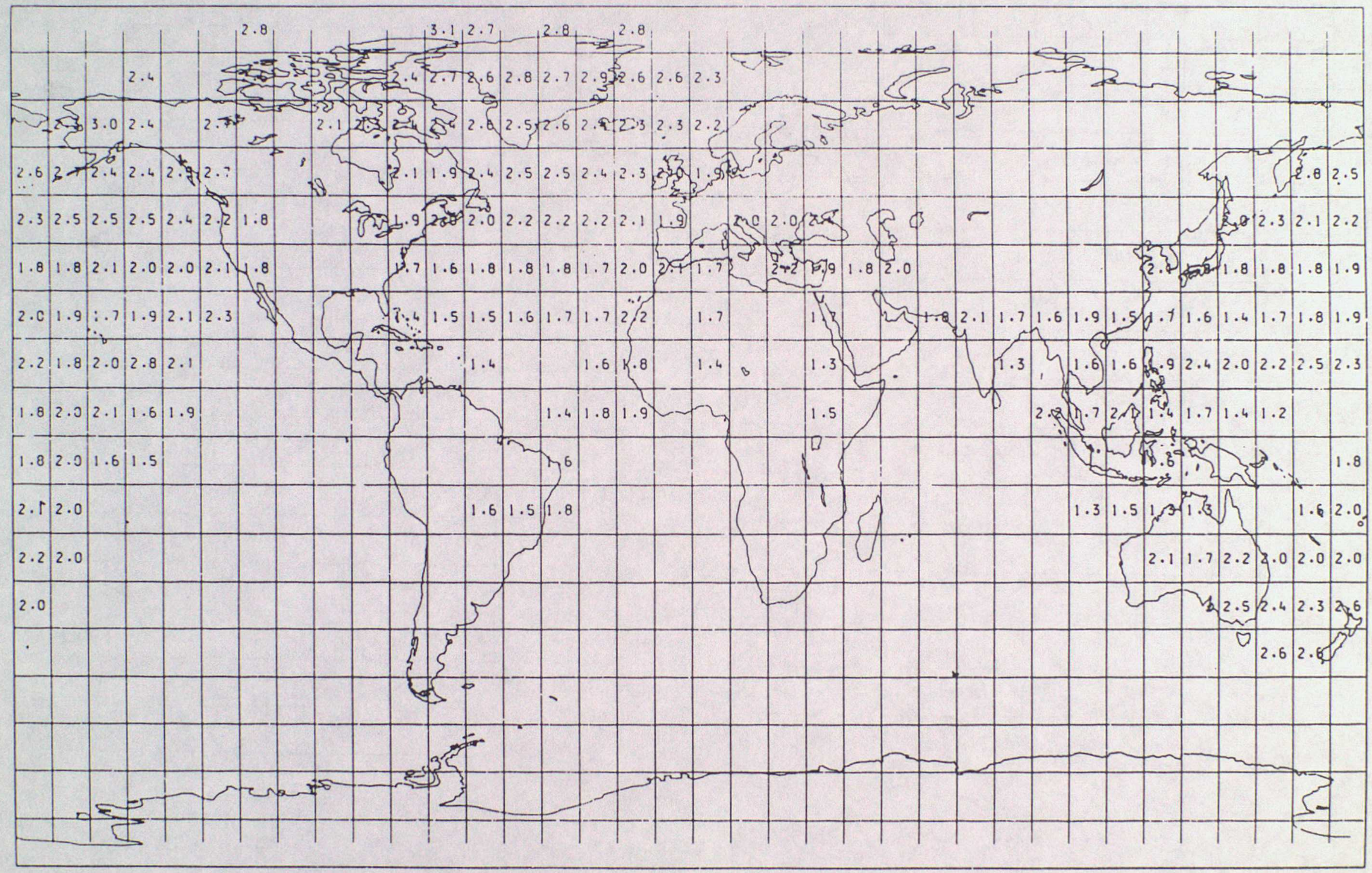


Fig 9

SONDES : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/9/89 TO 30/11/89
DATA FROM ONE SONDE STATION PER 10 DEG GRID BOX
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

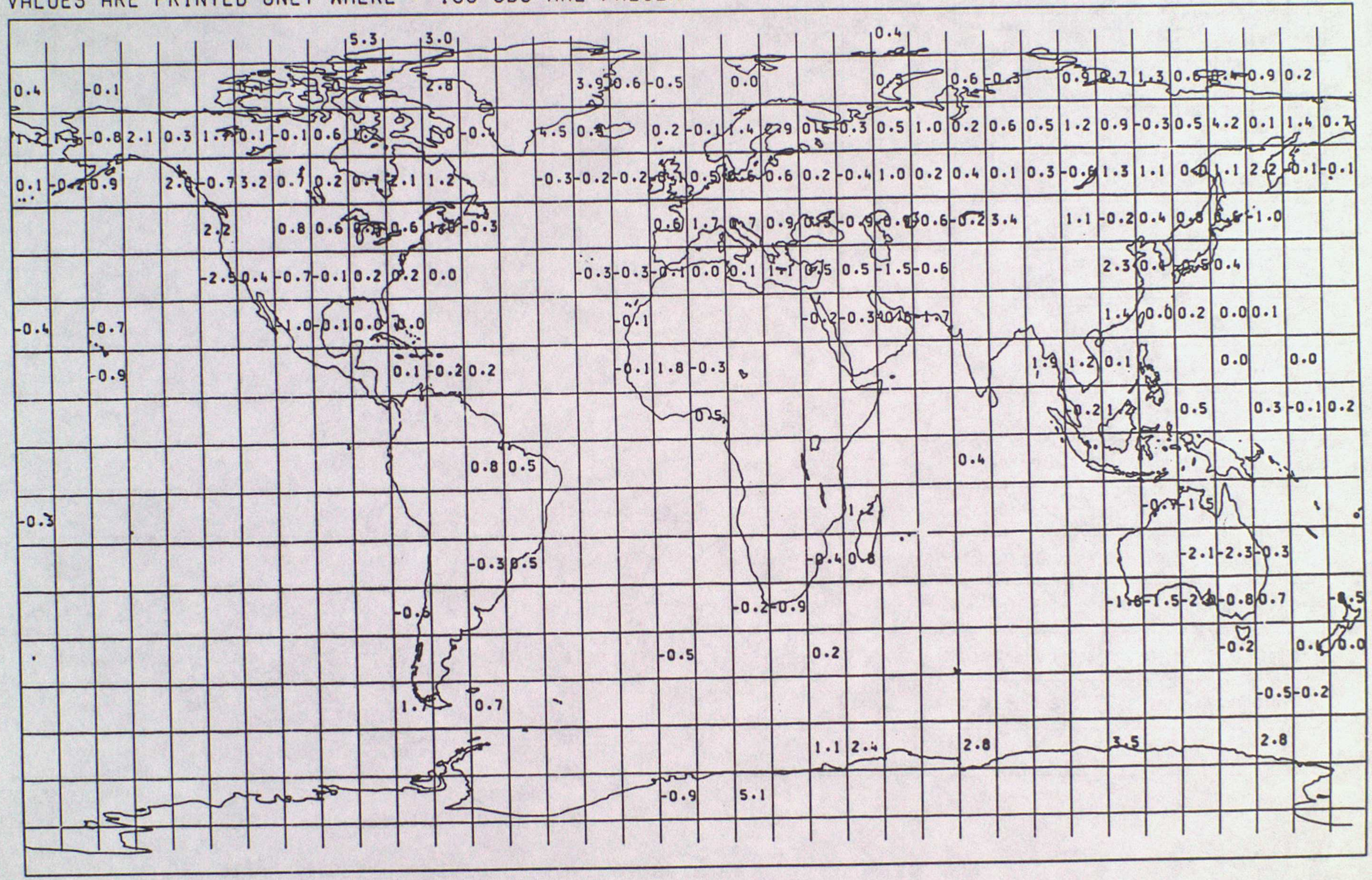


Fig 10

SONDES : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/9/89 TO 30/11/89
DATA FROM ONE SONDE STATION PER 10 DEG GRID BOX
VALUES ARE PRINTED ONLY WHERE > 100 OBS ARE PRESENT

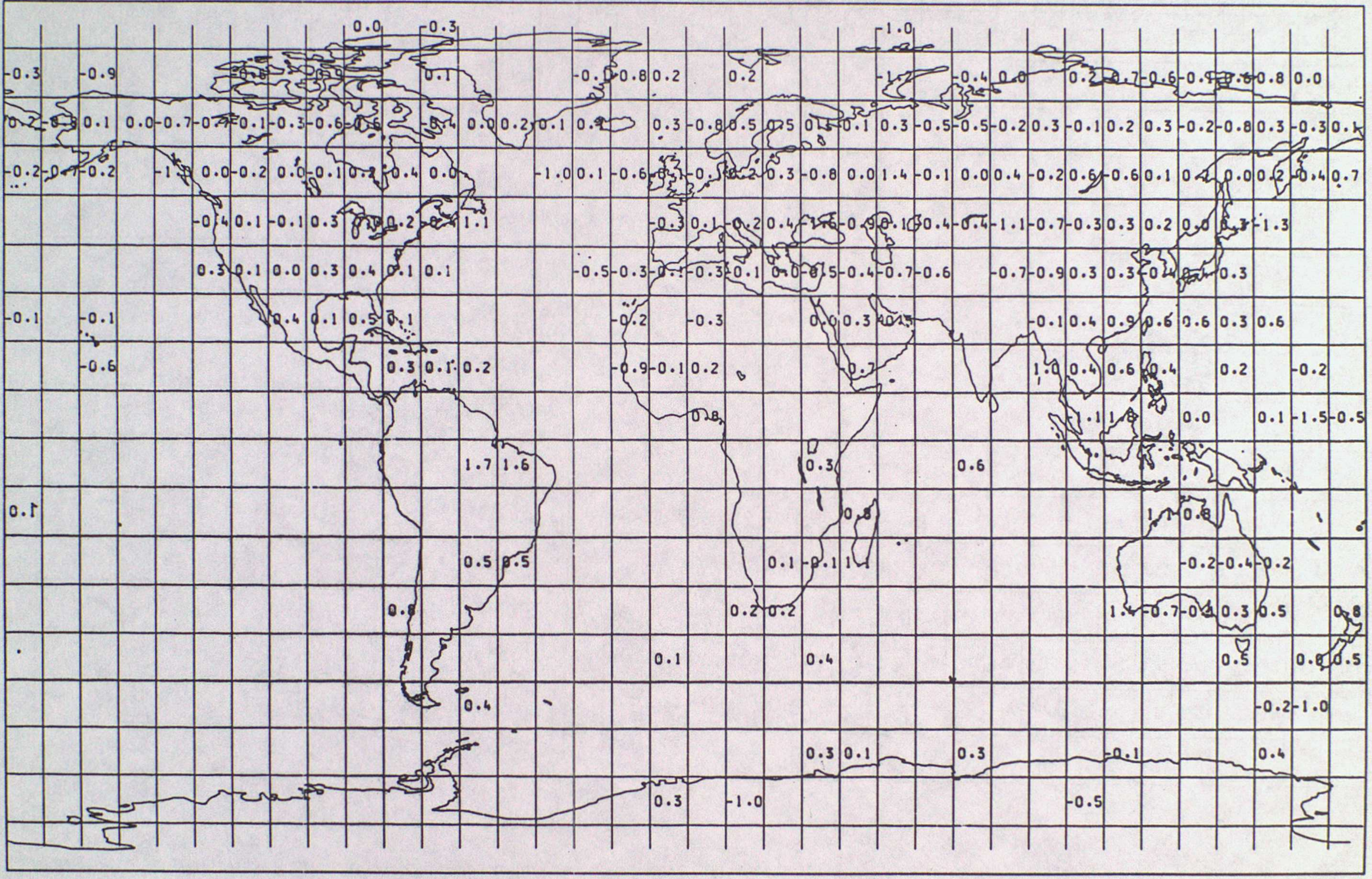


Fig 11

SONDES : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/9/89 TO 30/11/89
DATA FROM ONE SONDE STATION PER 10 DEG GRID BOX
ALL OBSERVATIONS INCLUDED

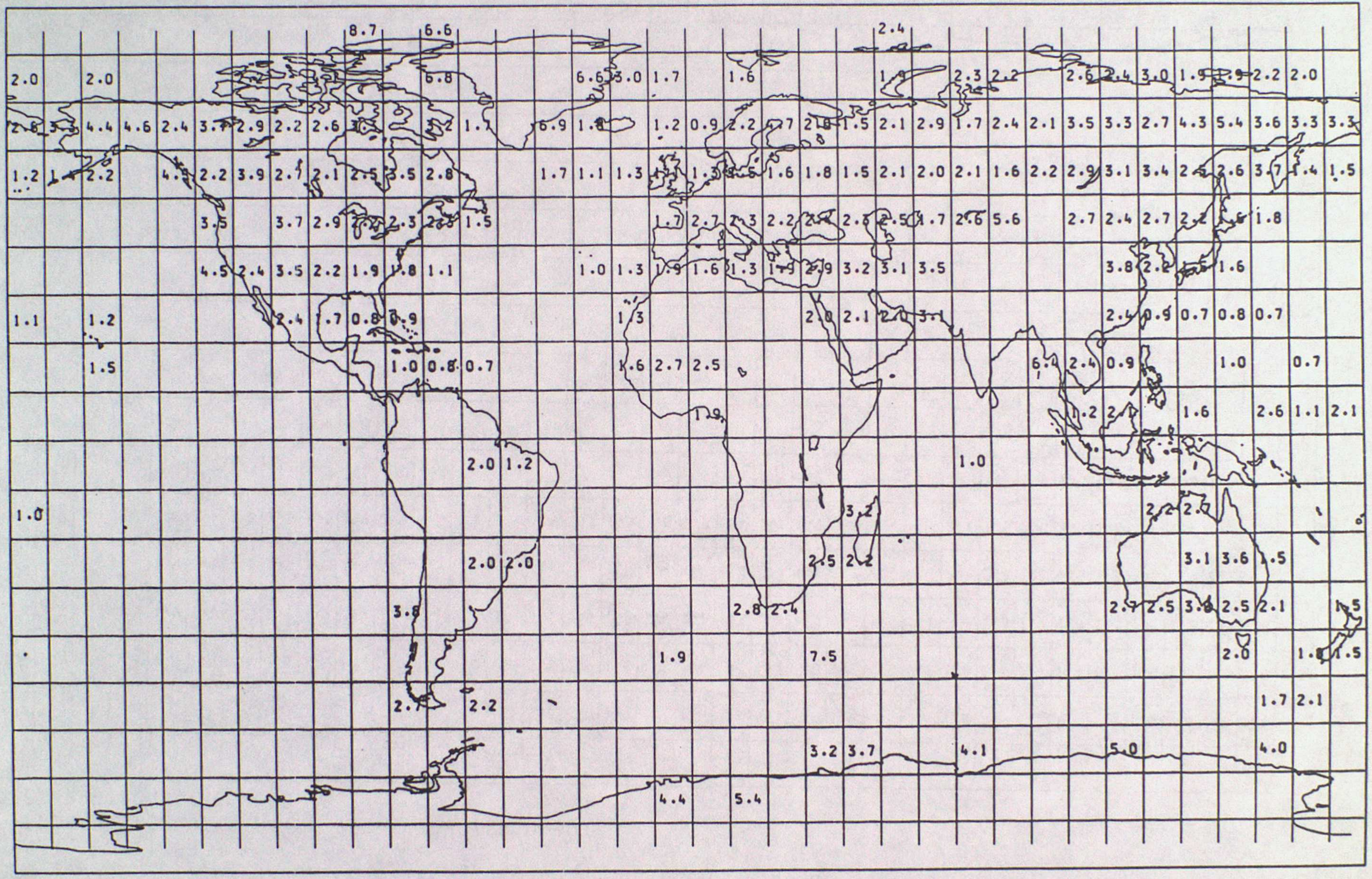


Fig 12

SONDES : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/9/89 TO 30/11/89
DATA FROM ONE SONDE STATION PER 10 DEG GRID BOX
ALL OBSERVATIONS INCLUDED

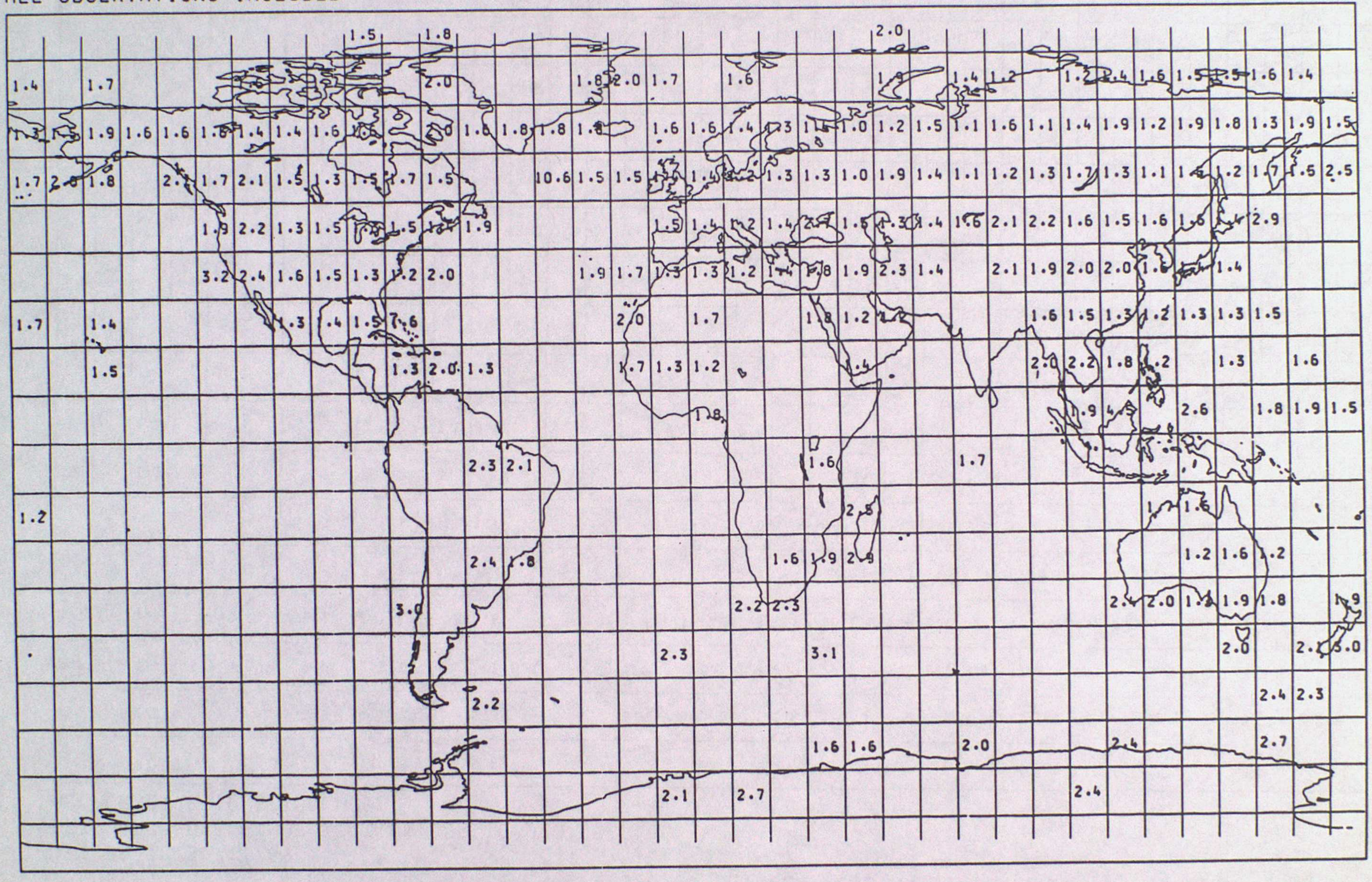


Fig 13

LASS : MEAN O-B DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

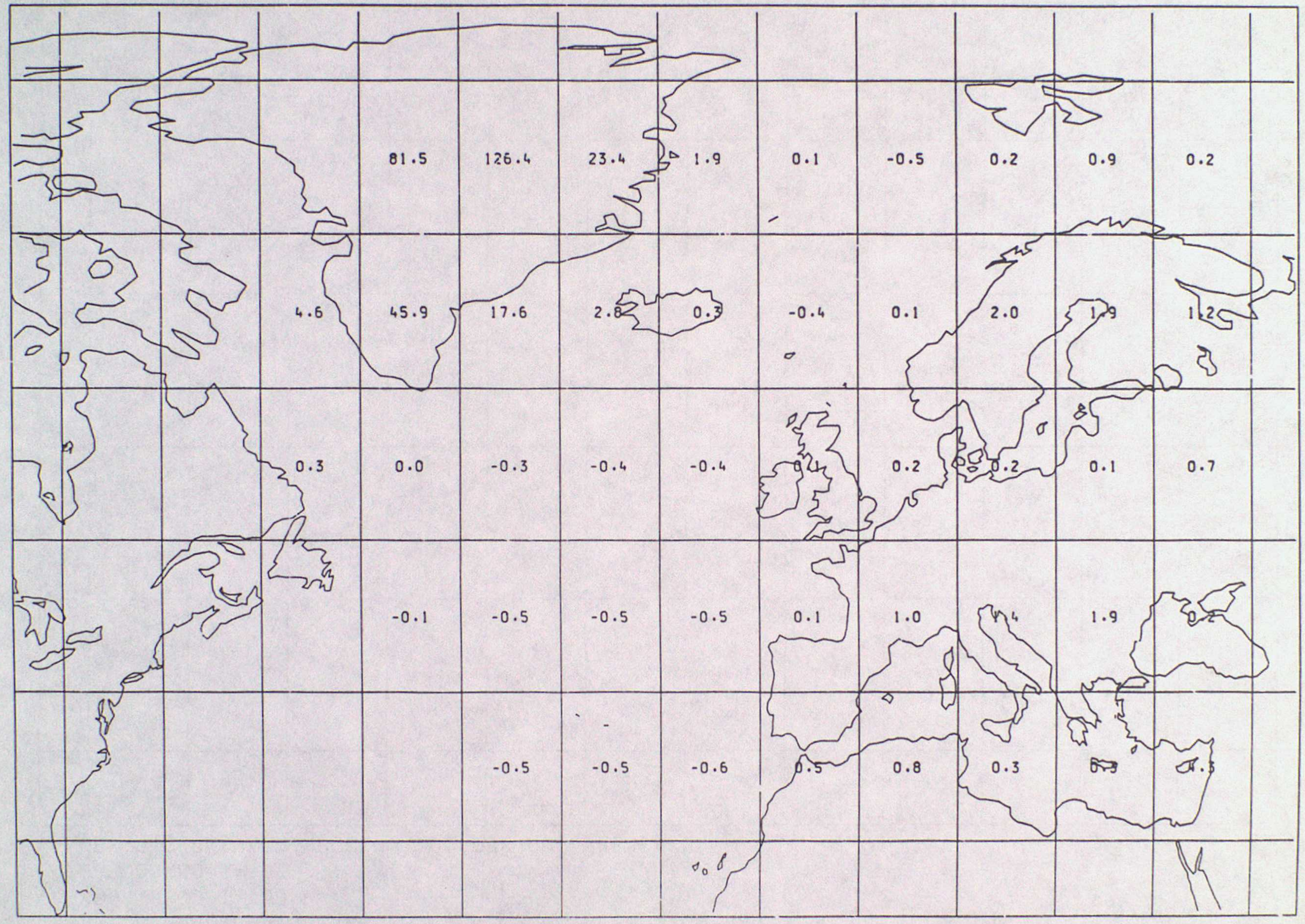


Fig 14

LASS : MEAN O-B DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

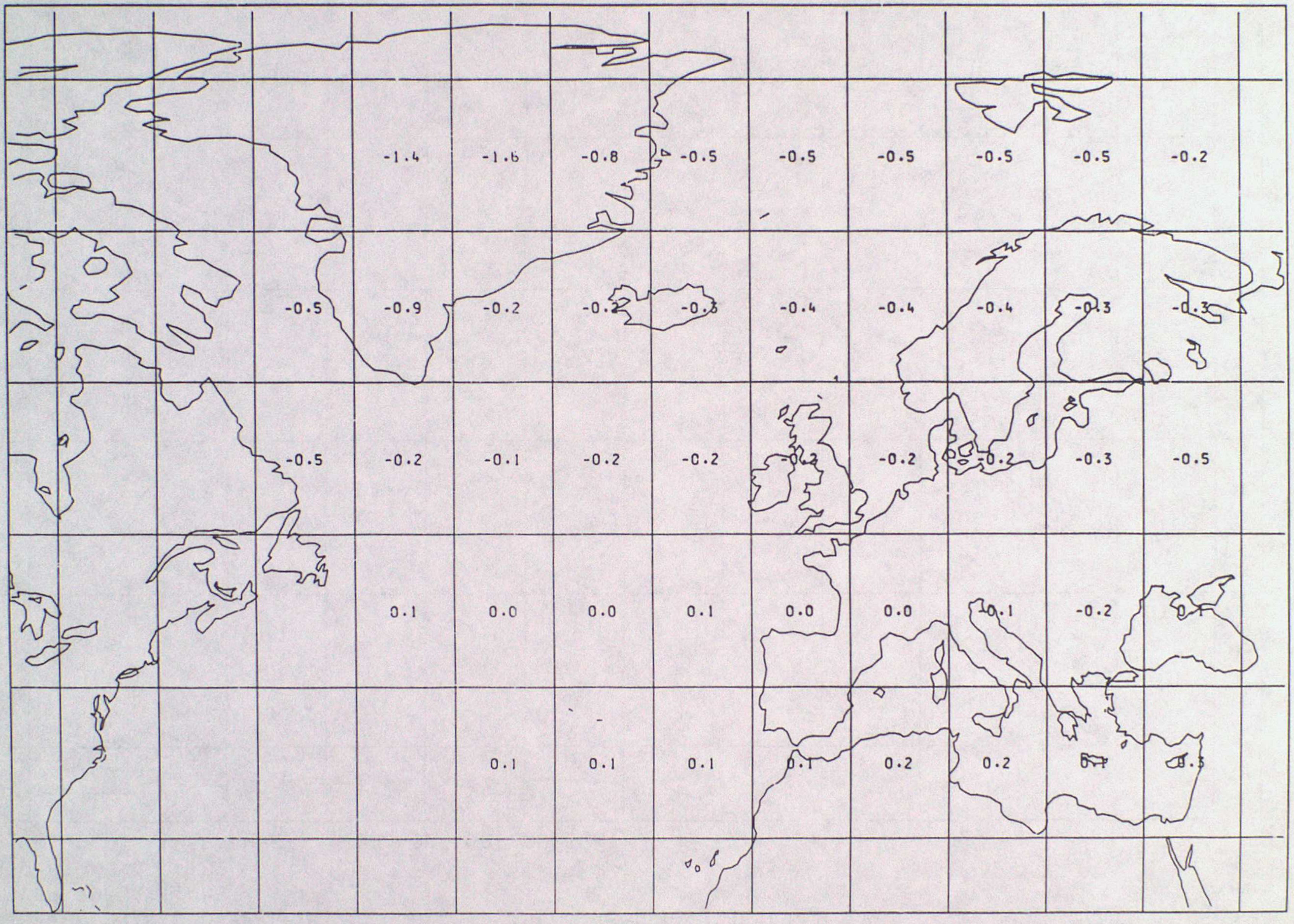


Fig 15

LASS : MEAN O-B DIFFERENCES (DEG C) BETWEEN 30 AND 50 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

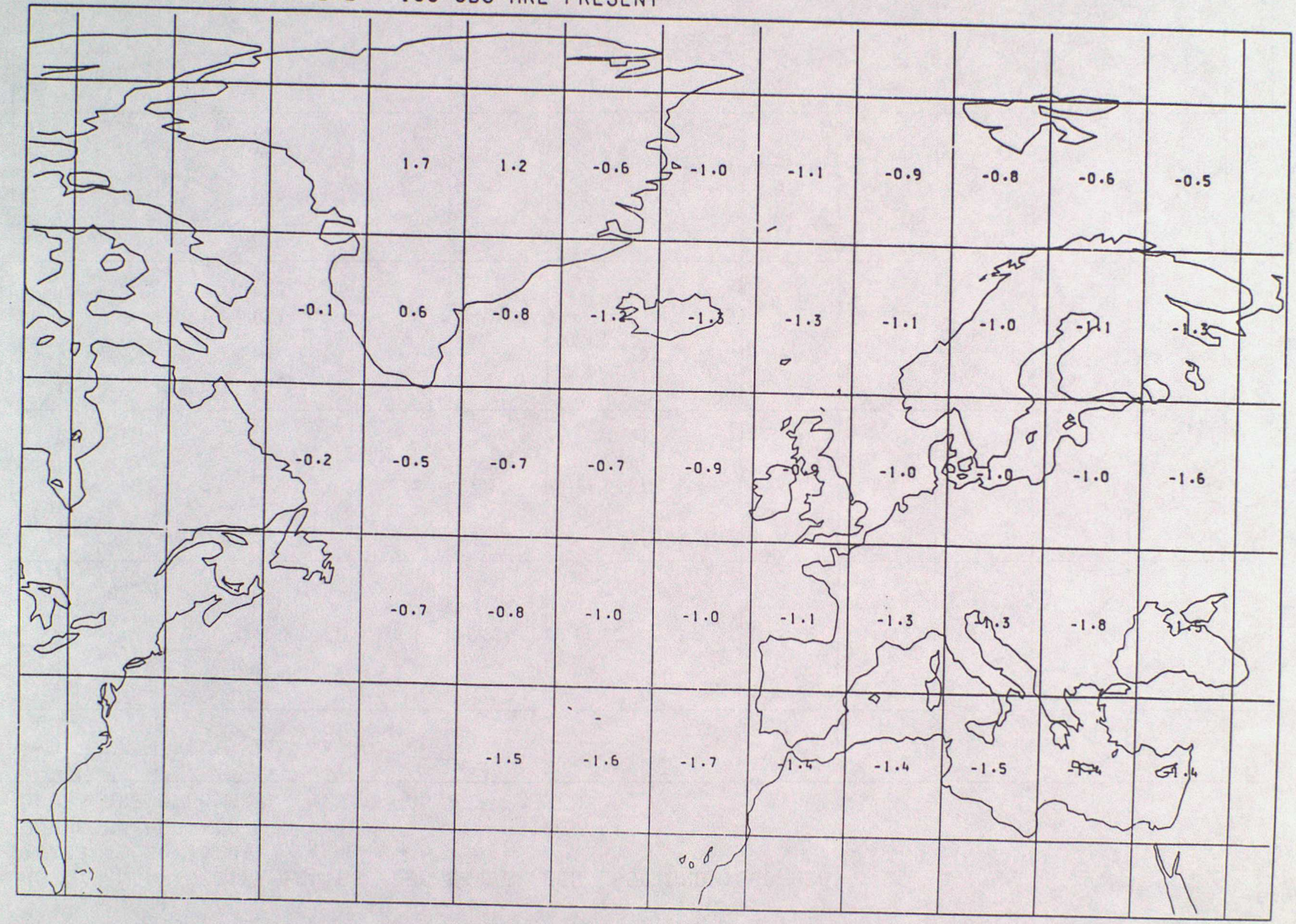


Fig 16

LASS : RMS O-B DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE USED WHERE > 100 OBS ARE PRESENT

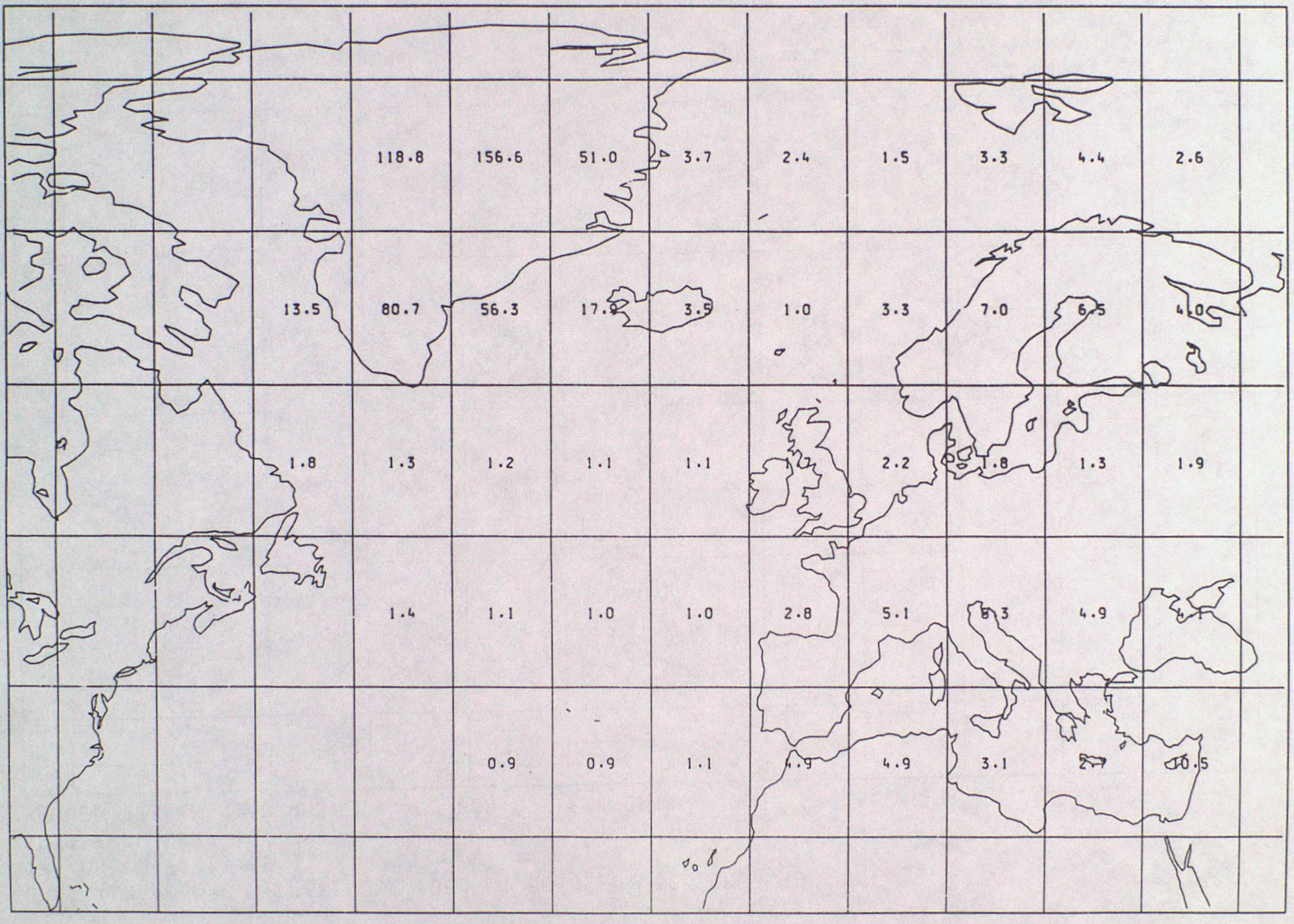


Fig 17

LASS : RMS O-B DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE USED WHERE > 100 OBS ARE PRESENT

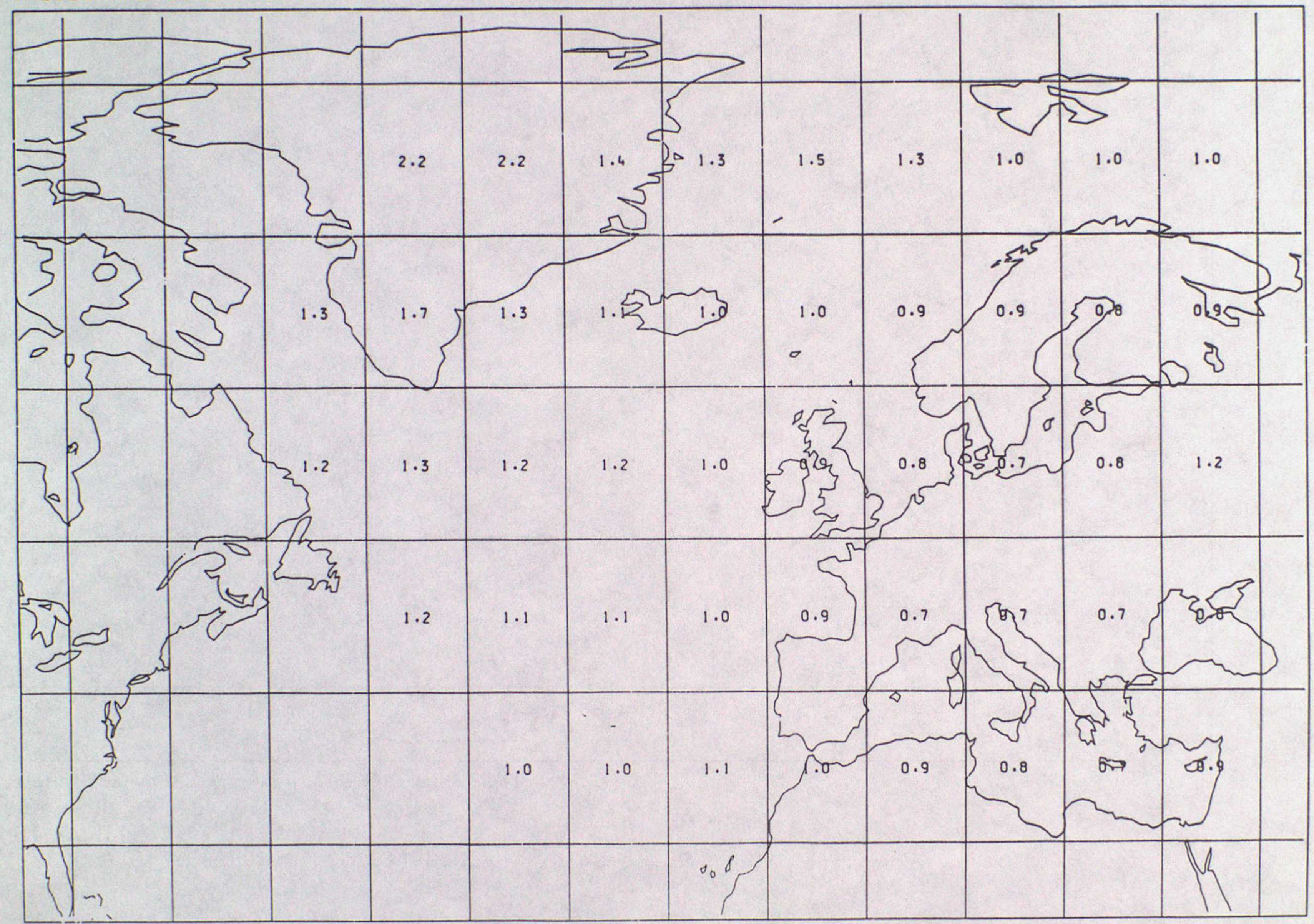


Fig 18

LASS : RMS O-B DIFFERENCES (DEG C) BETWEEN 30 AND 50 HPA
1/9/89 TO 30/11/89
DATA FROM NOAA-10
VALUES ARE USED WHERE > 100 OBS ARE PRESENT

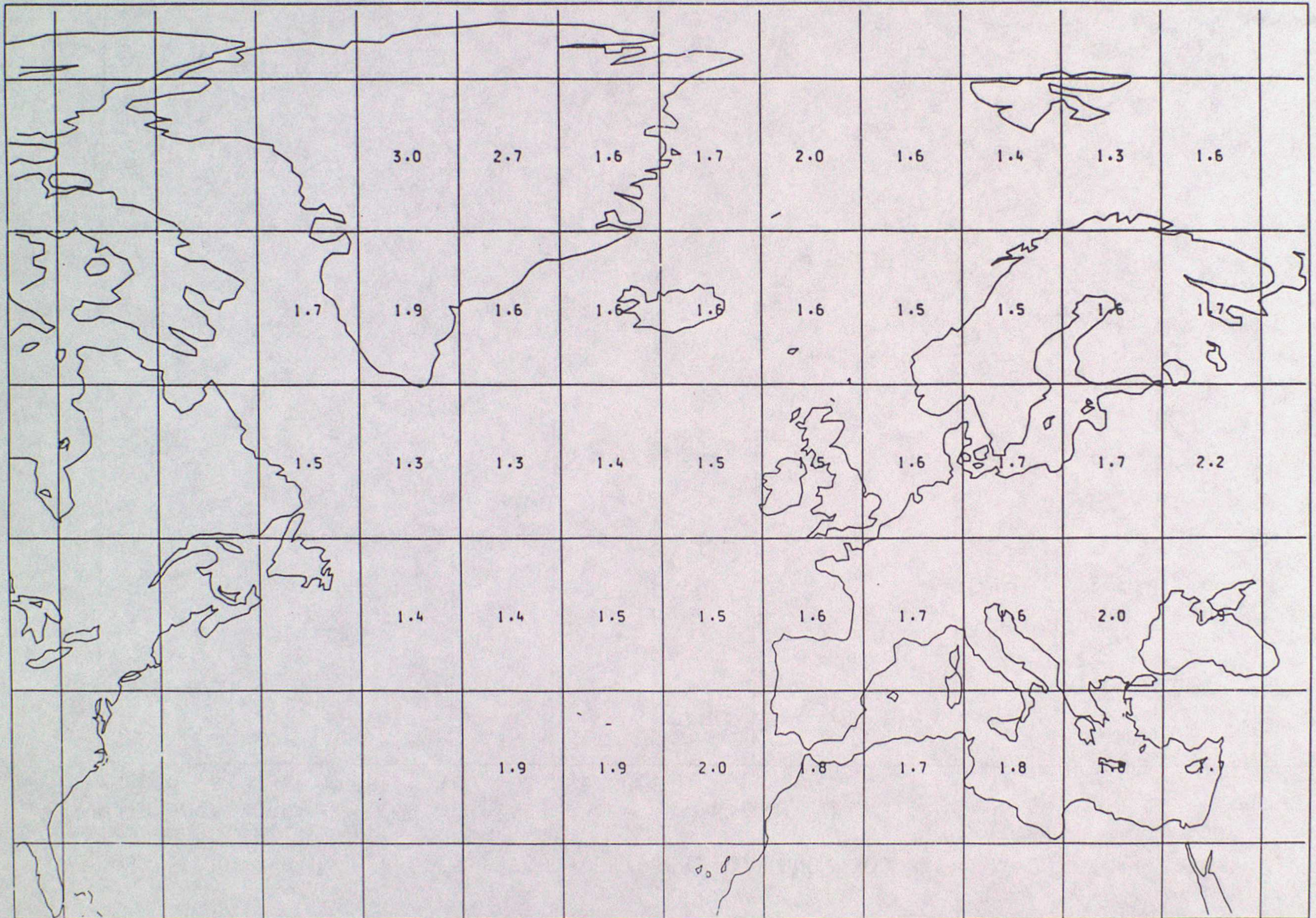


Fig 19

SATOB VECTOR MEAN WINDS BETWEEN 700-999 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

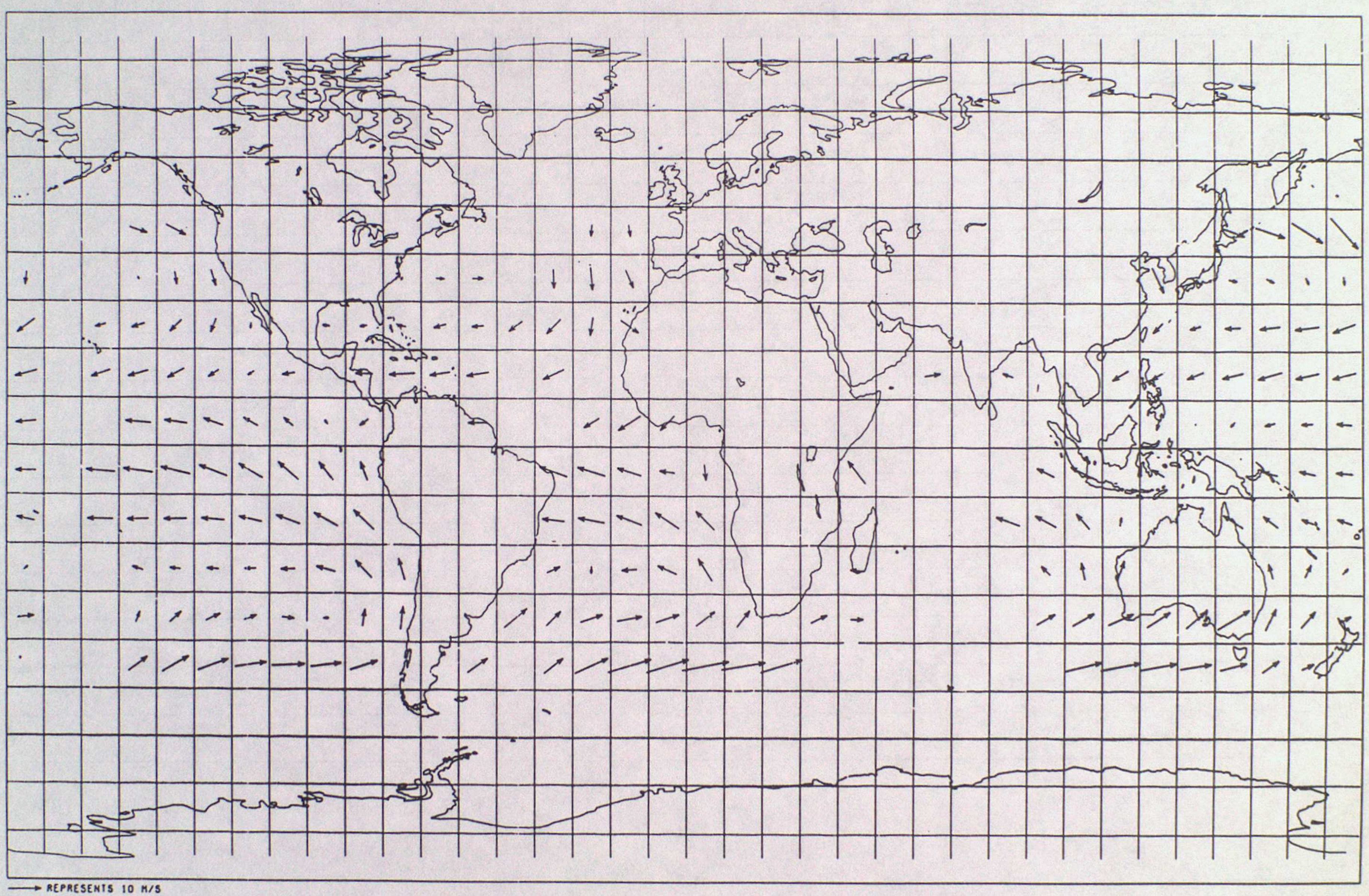


Fig 20

SATOB VECTOR MEAN WINDS BETWEEN 400-699 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

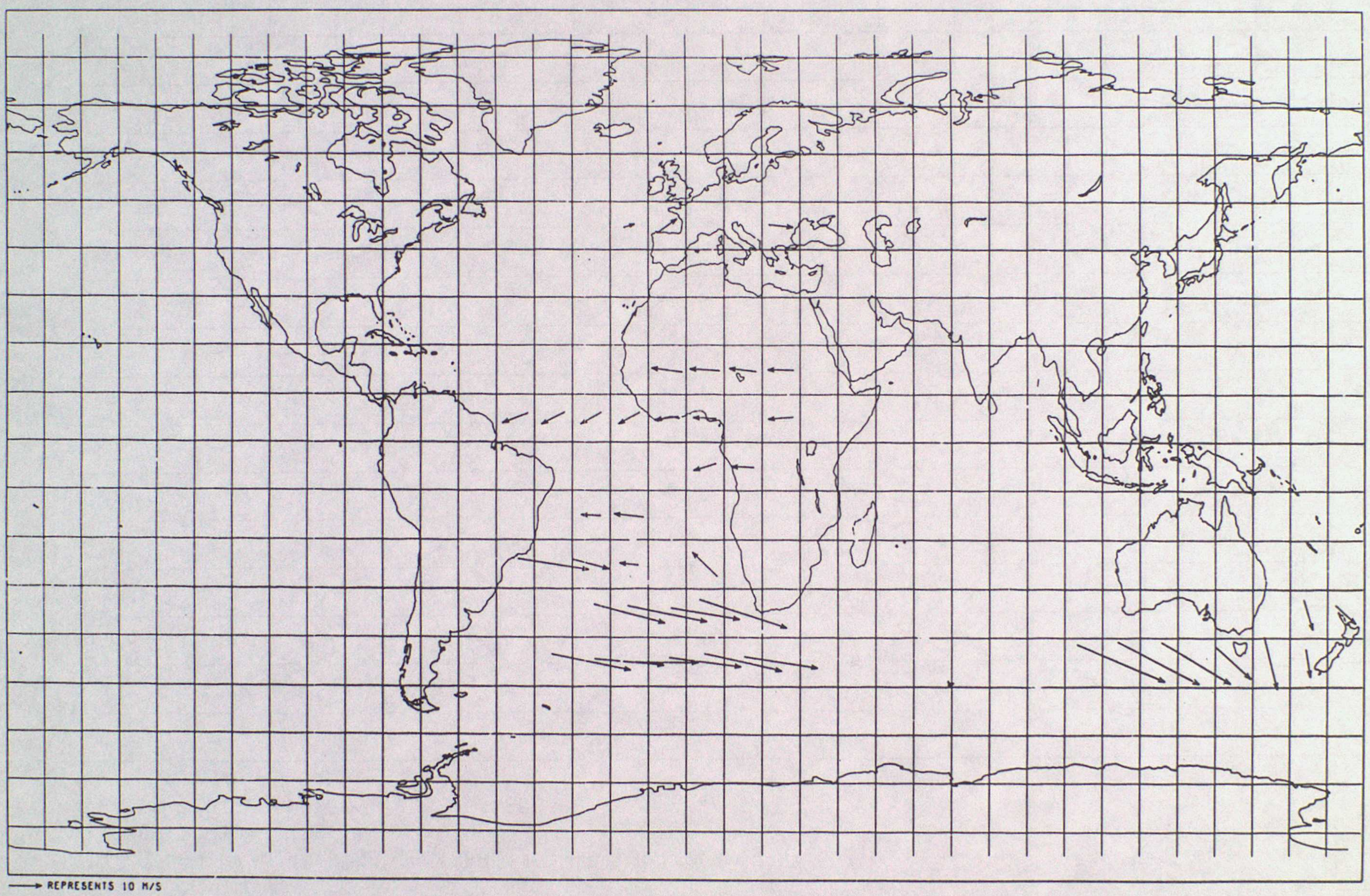


Fig 21

SATOB VECTOR MEAN WINDS BETWEEN 100-399 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

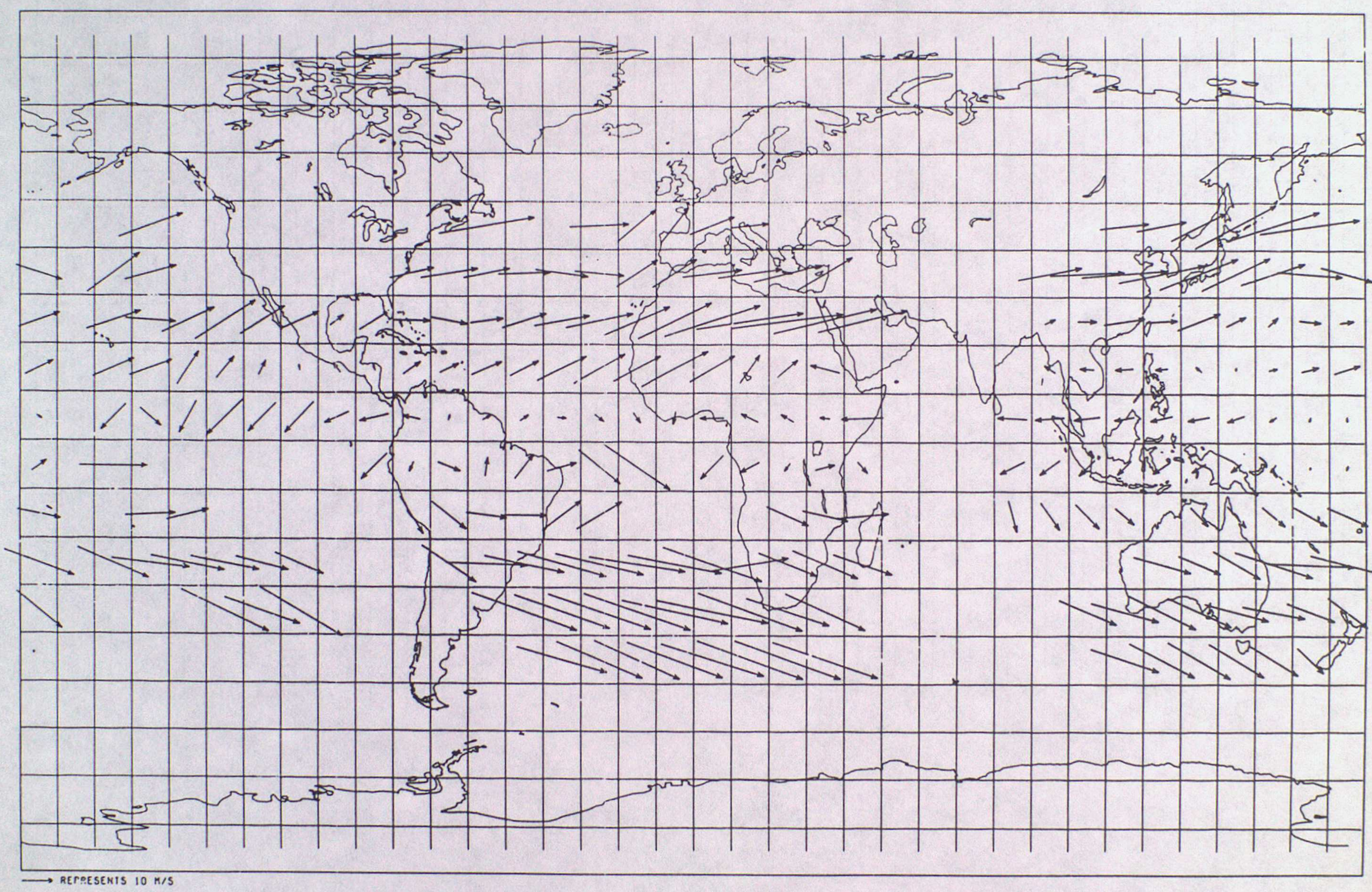


Fig 22

SATOB O-B VECTOR WIND DIFFERENCES BETWEEN 700-999 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

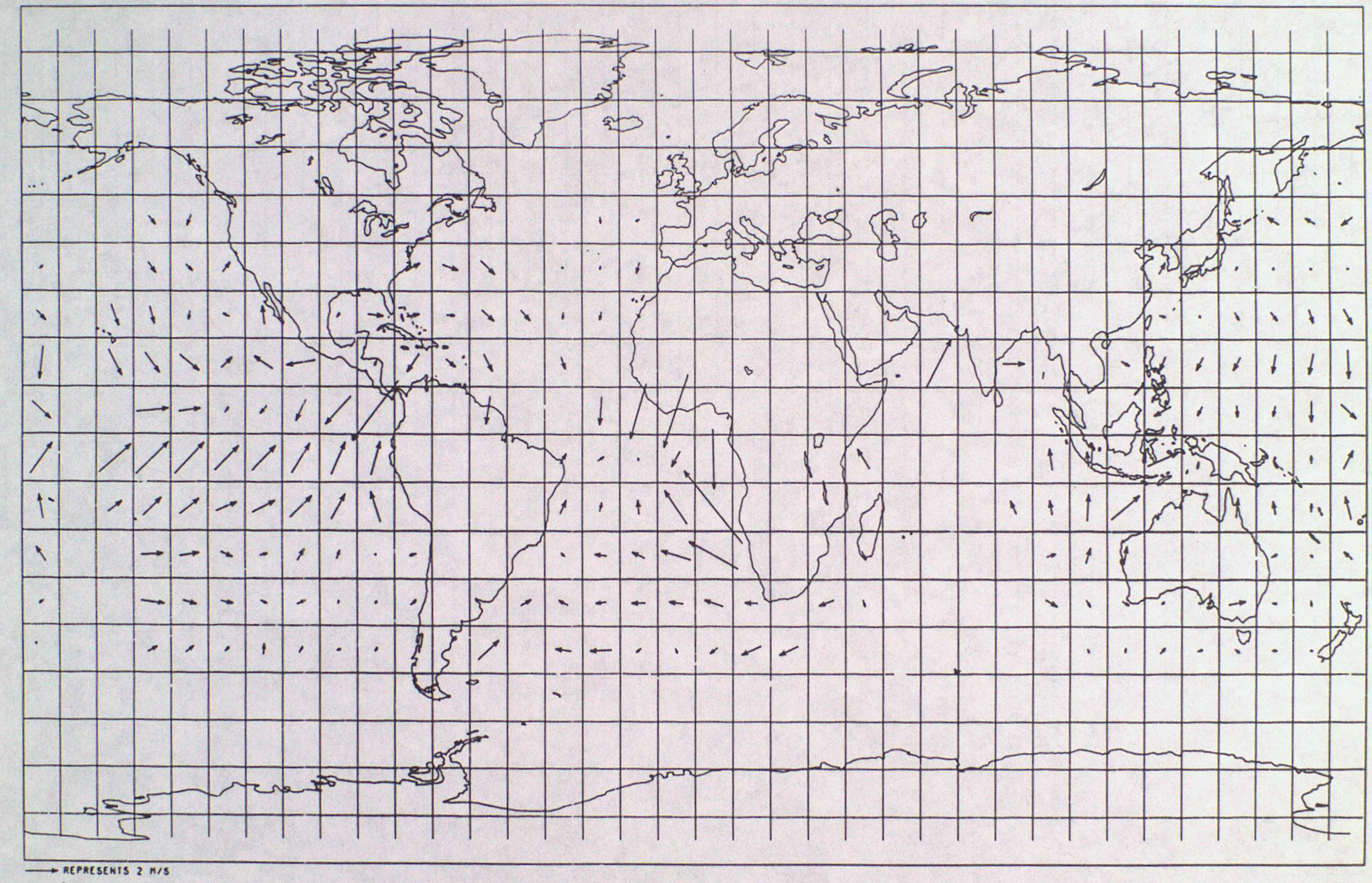


Fig 23

SATOB O-B VECTOR WIND DIFFERENCES BETWEEN 400-699 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

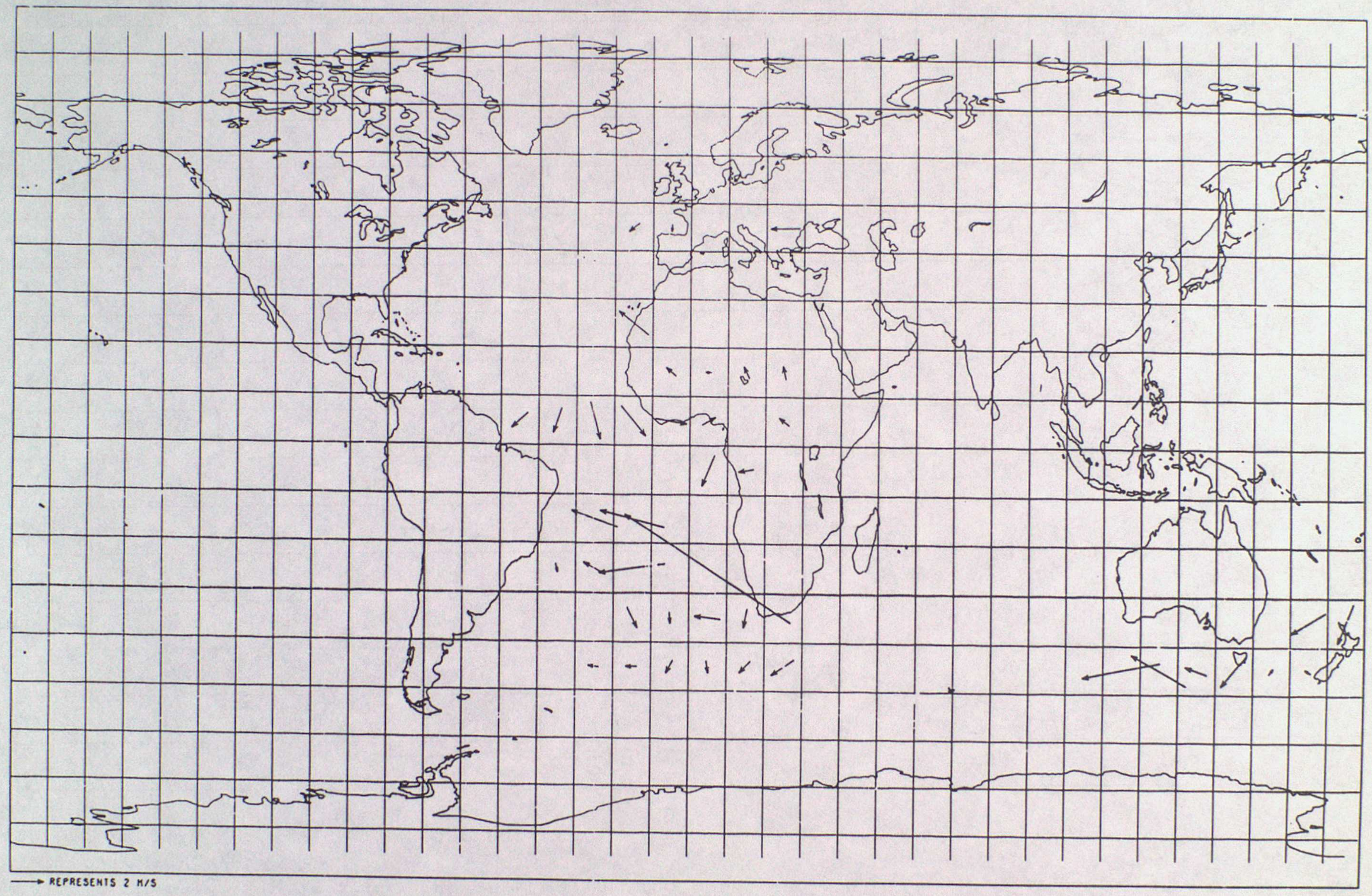


Fig 24

SATOB O-B VECTOR WIND DIFFERENCES BETWEEN 100-399 HPA
1/9/89 TO 30/11/89
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

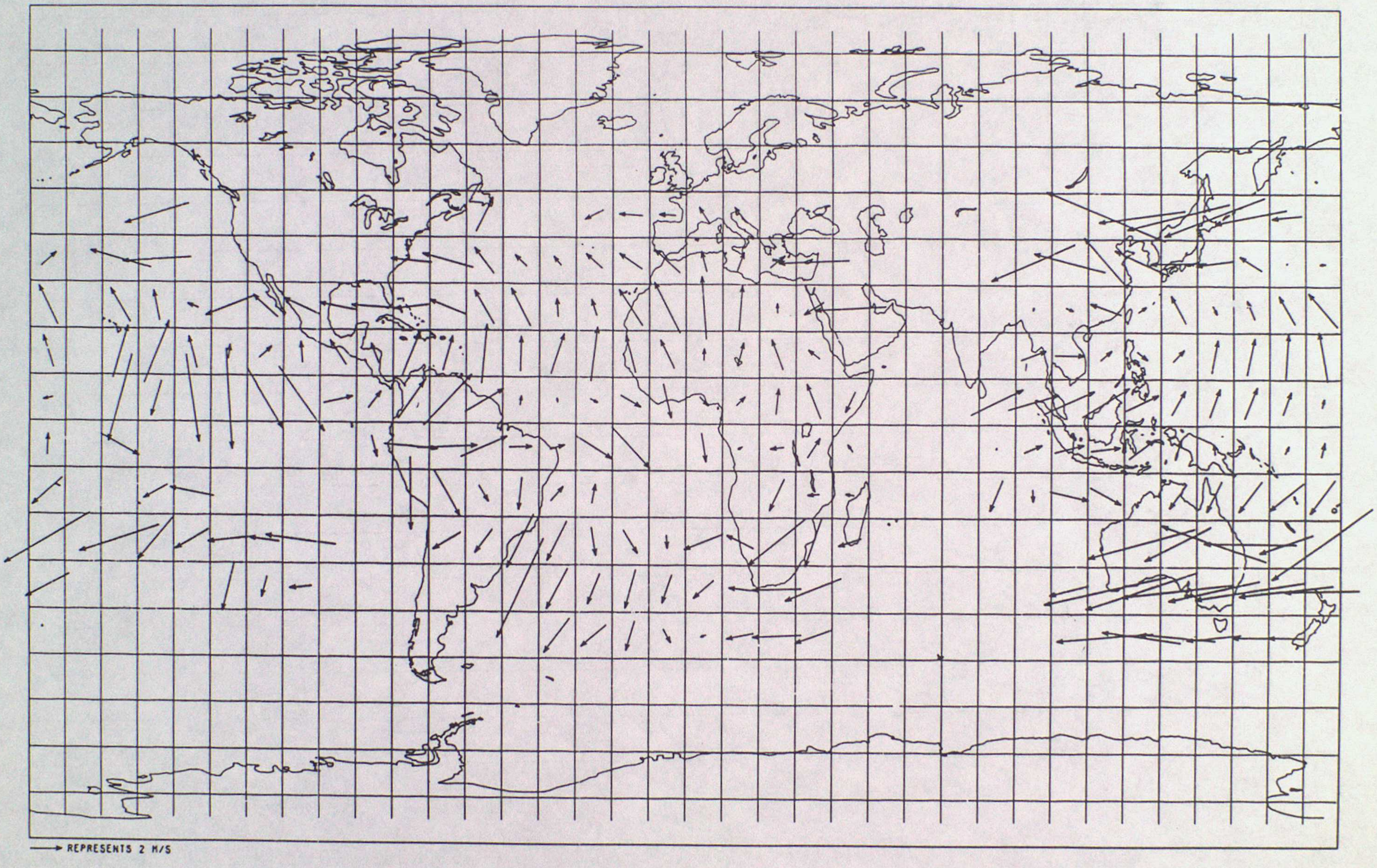


Fig 25

SATOBS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 999 AND 700 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

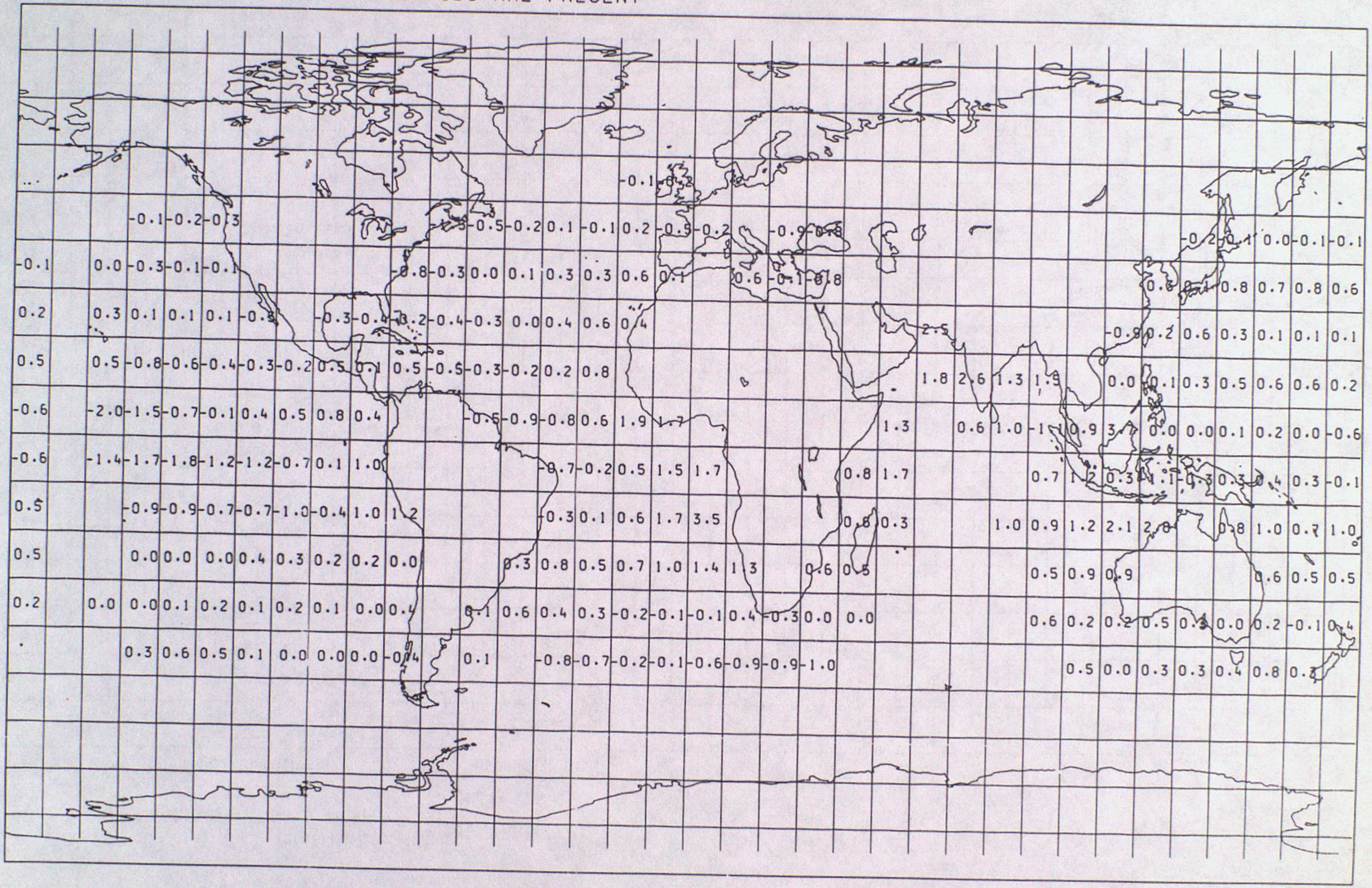


Fig 26

SATOBS : RMS O-B VECTOR DIFFERENCES (M/S) BETWEEN 999 AND 700 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

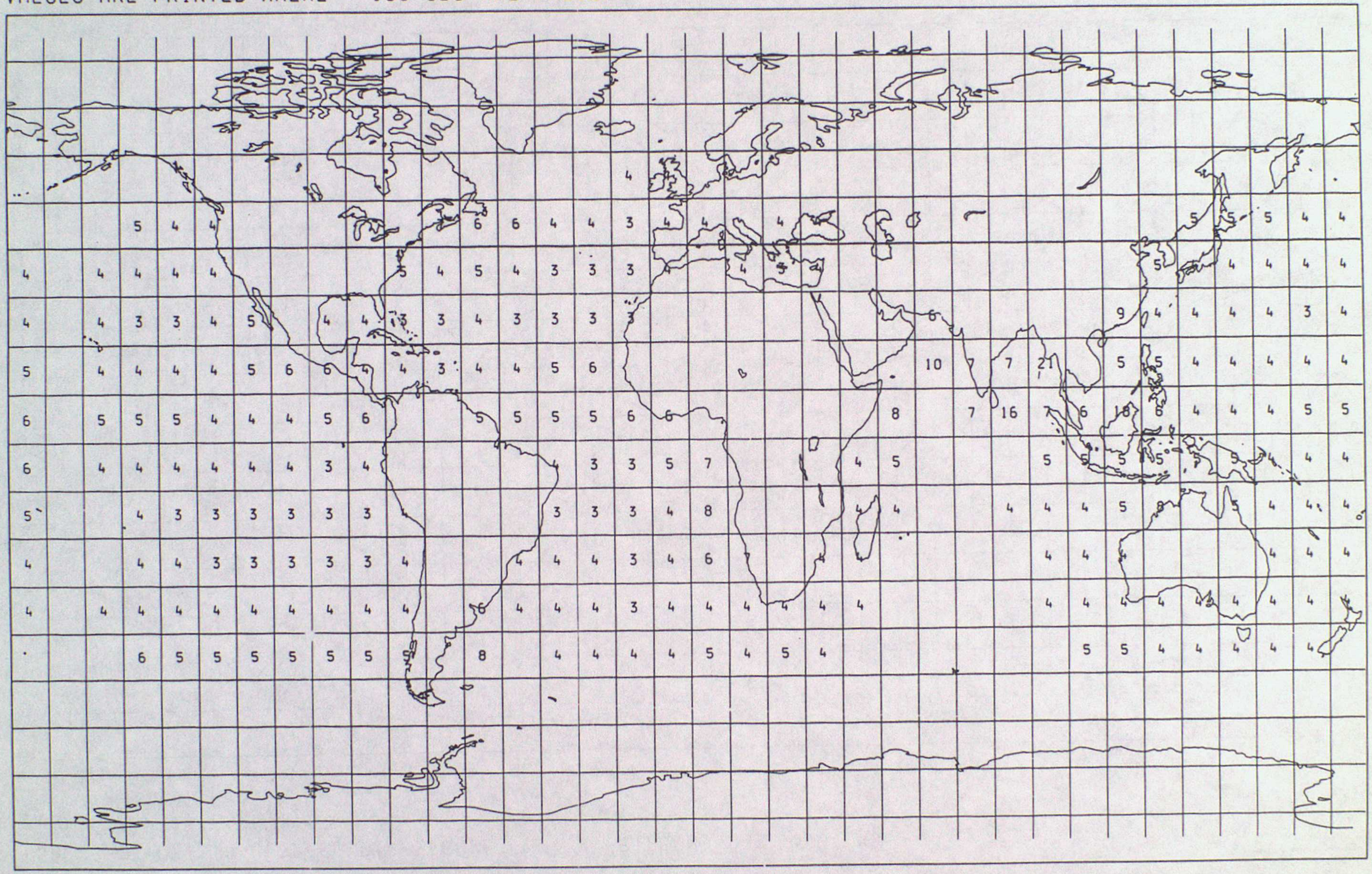


Fig 27

SATOBS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

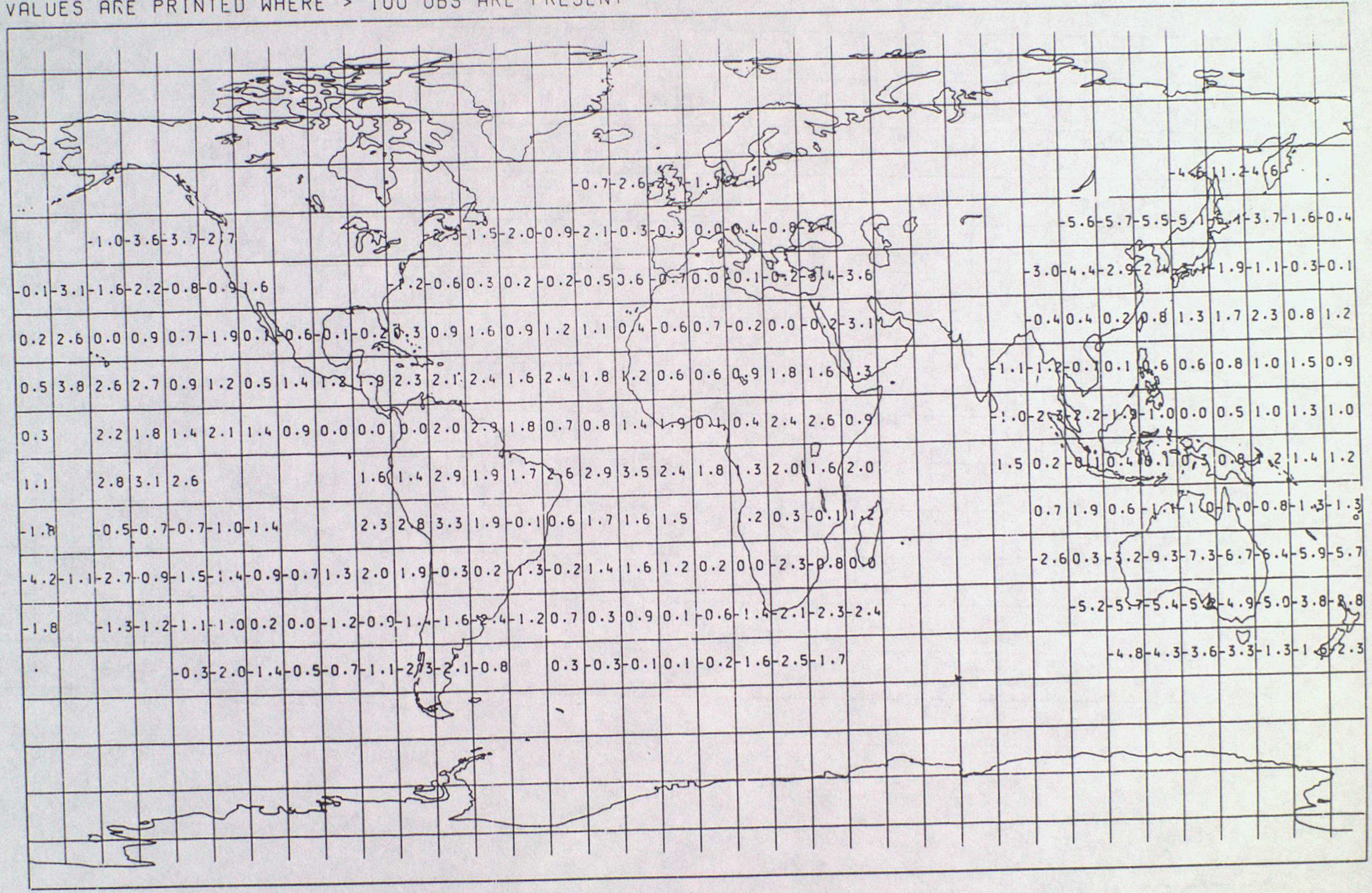


Fig 28

SATOBS : RMS O-B VECTOR DIFFERENCES (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

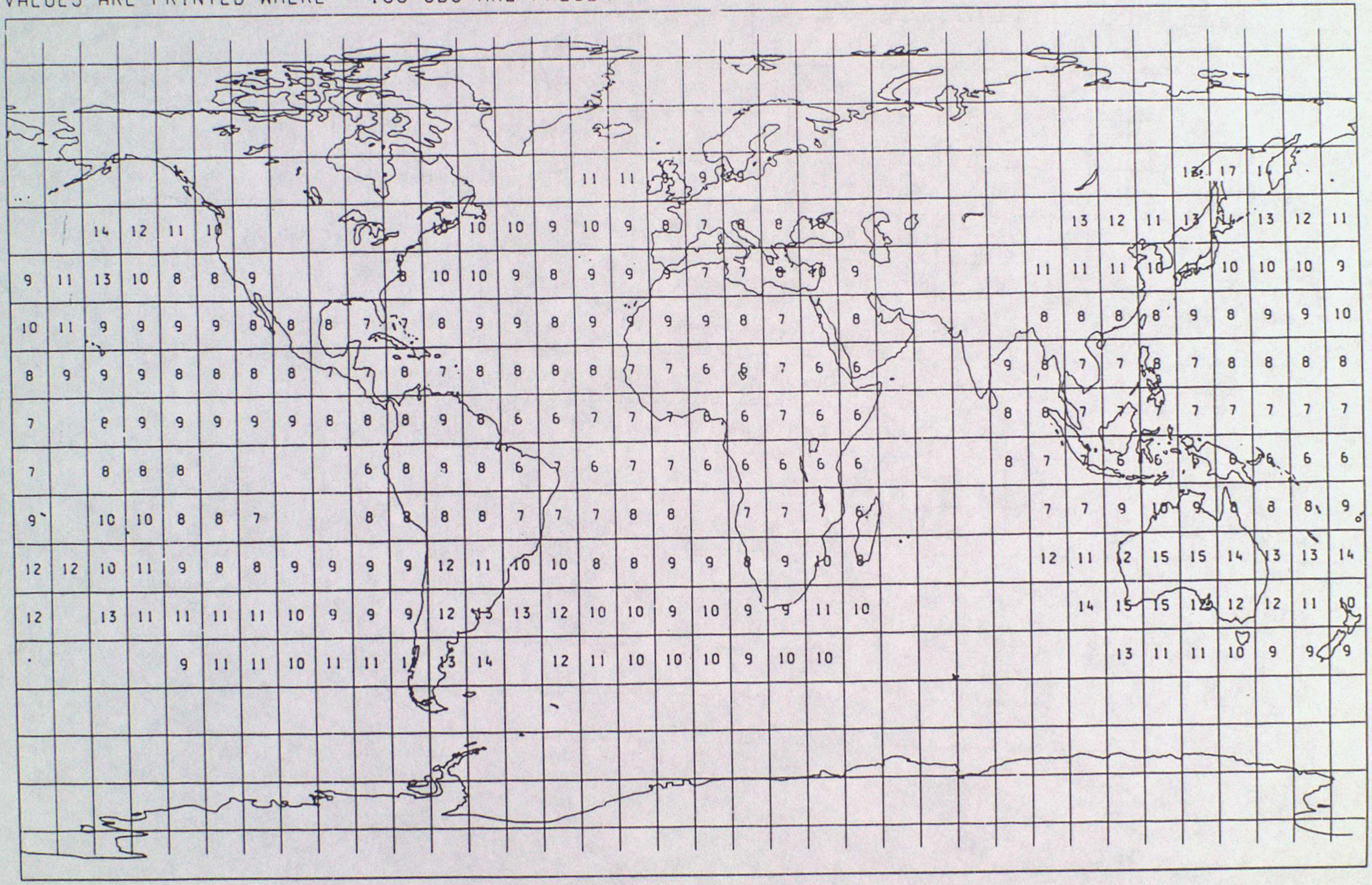


Fig 29

AIREPS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
FLAGGED OBSERVATIONS EXCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

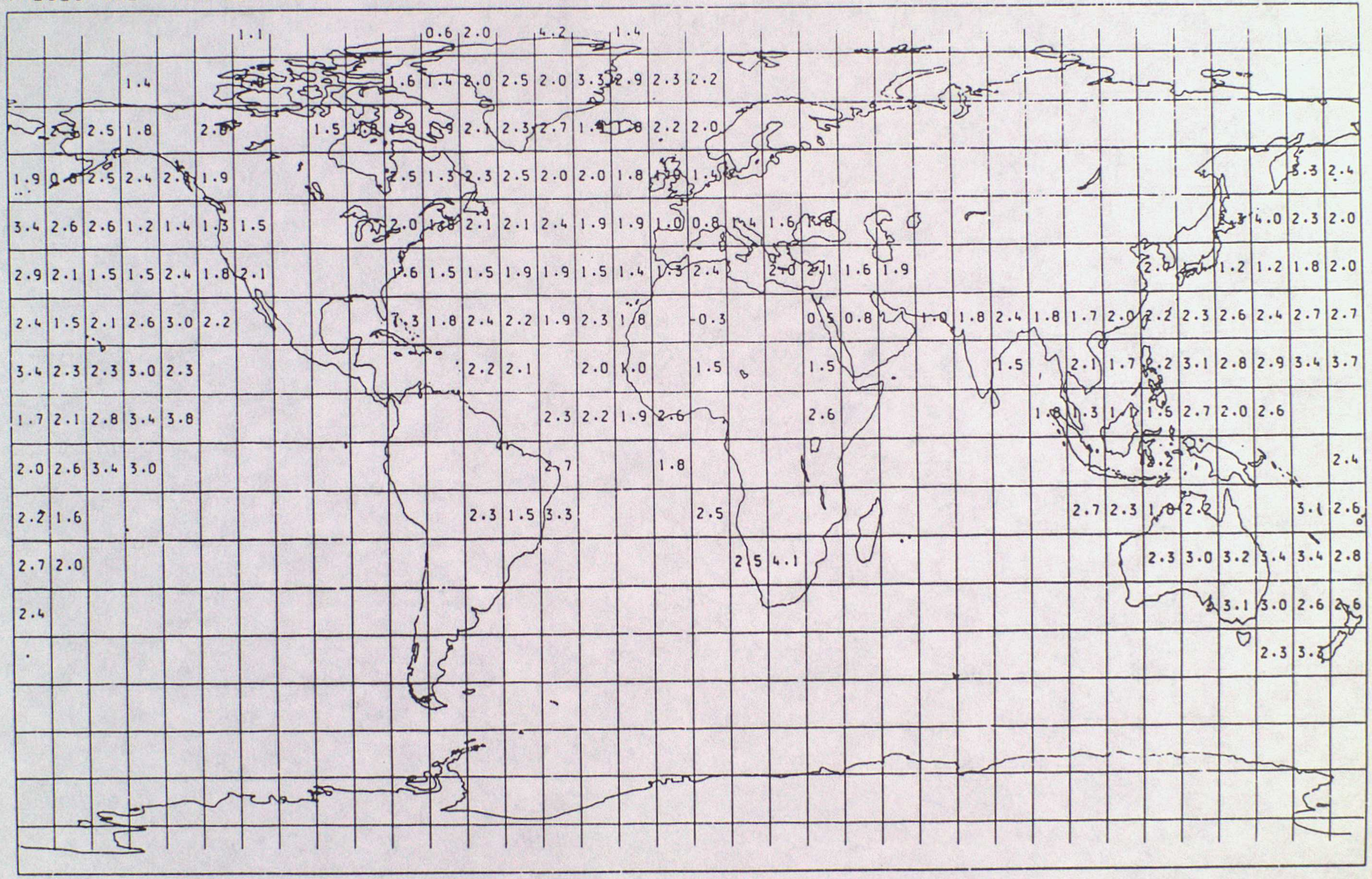


Fig 30

AIREPS : RMS O-B VECTOR WIND DIFFERENCES (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
FLAGGED OBSERVATIONS EXCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

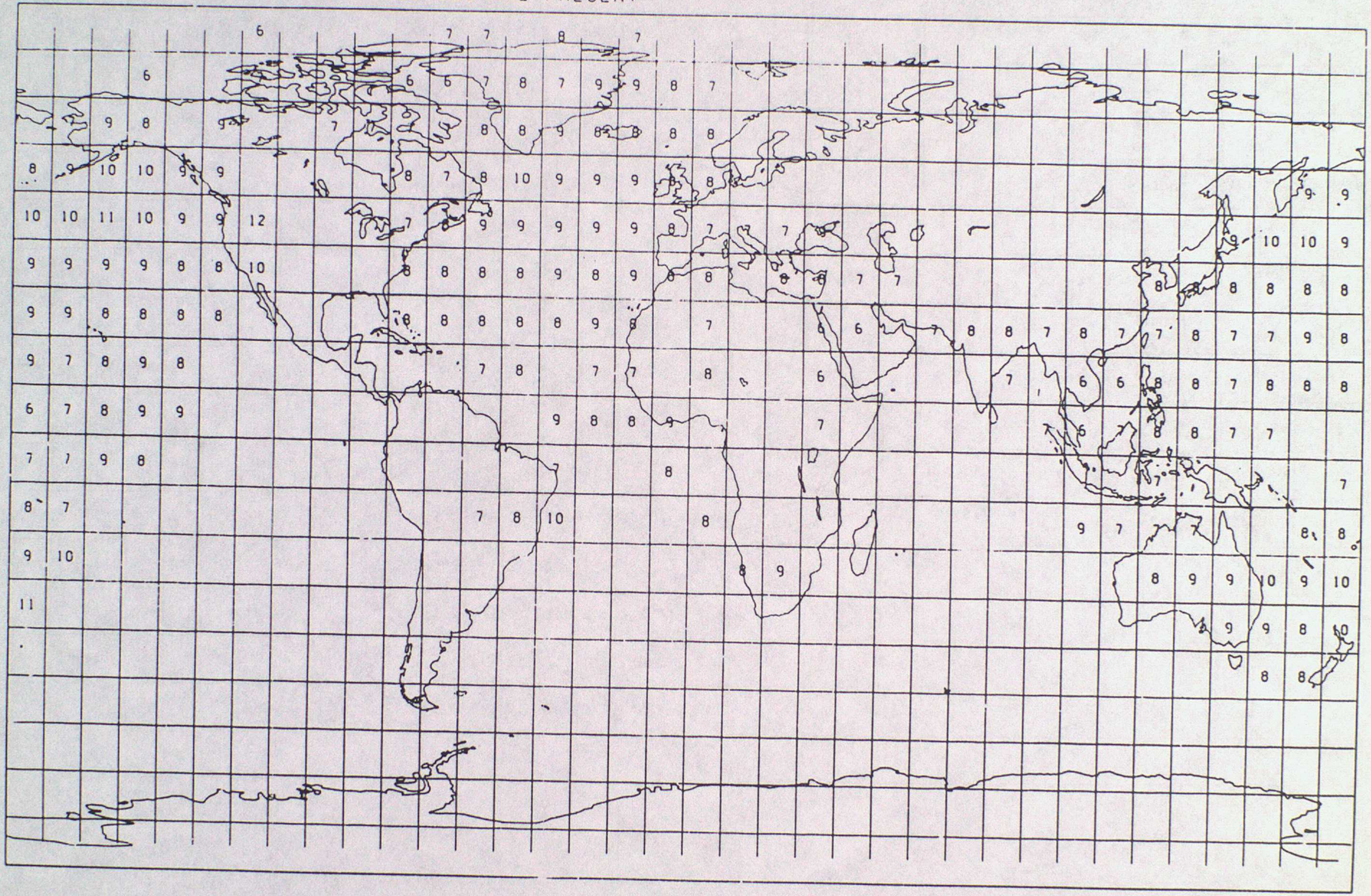
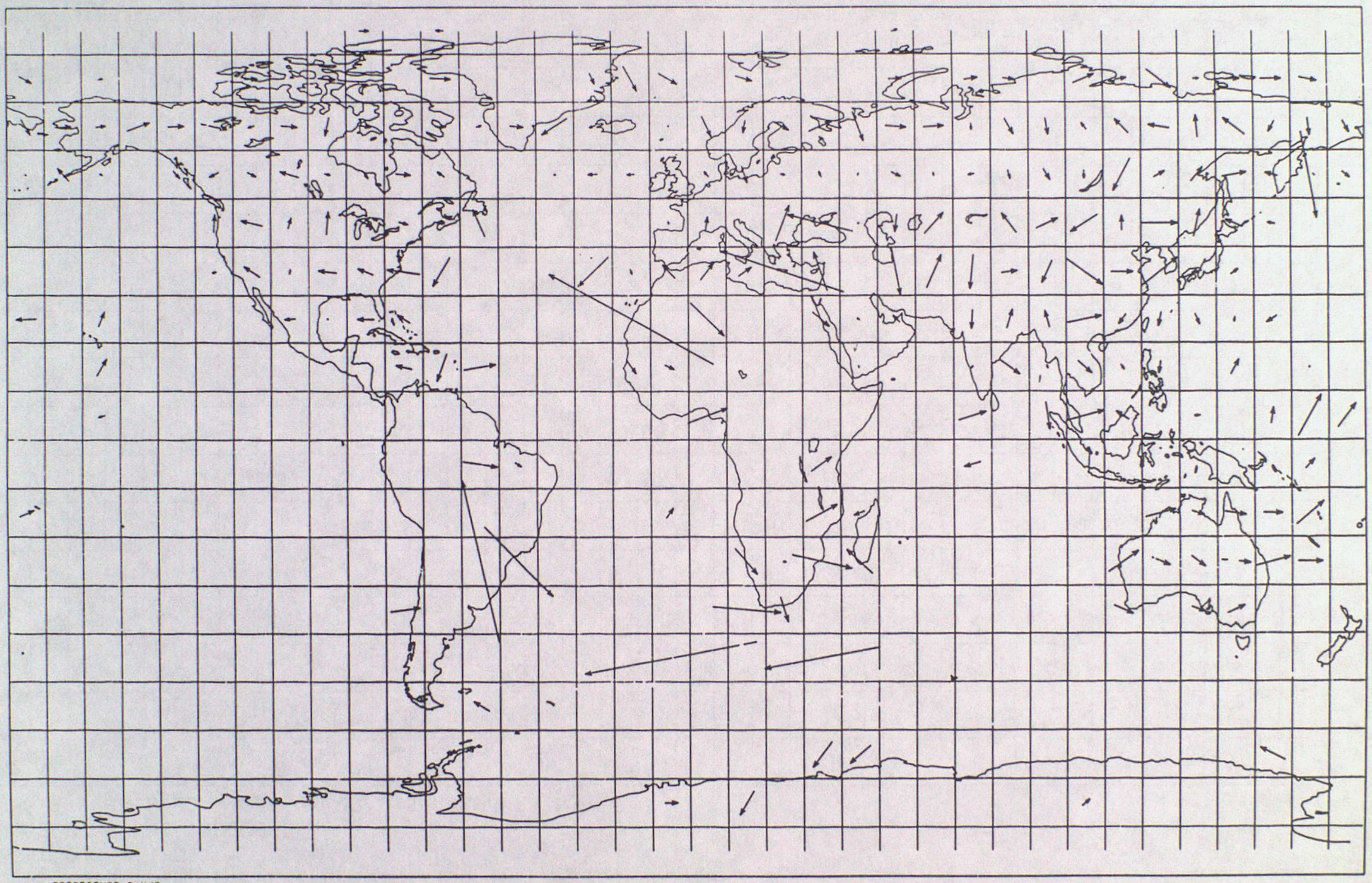


Fig 31

SONDES/PILOTS : O-B VECTOR WINDS BETWEEN 100-399 HPA
1/9/89 TO 30/11/89
DATA FROM ONE SONDE STATION PER 10 DEG GRID BOX
VALUES ARE PLOTTED WHERE > 100 OBS ARE PRESENT



→ REPRESENTS 2 M/S

fig 32

SONDES : O-B SPEED DIFFERENCES (M/S) BETWEEN 700 AND 999 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

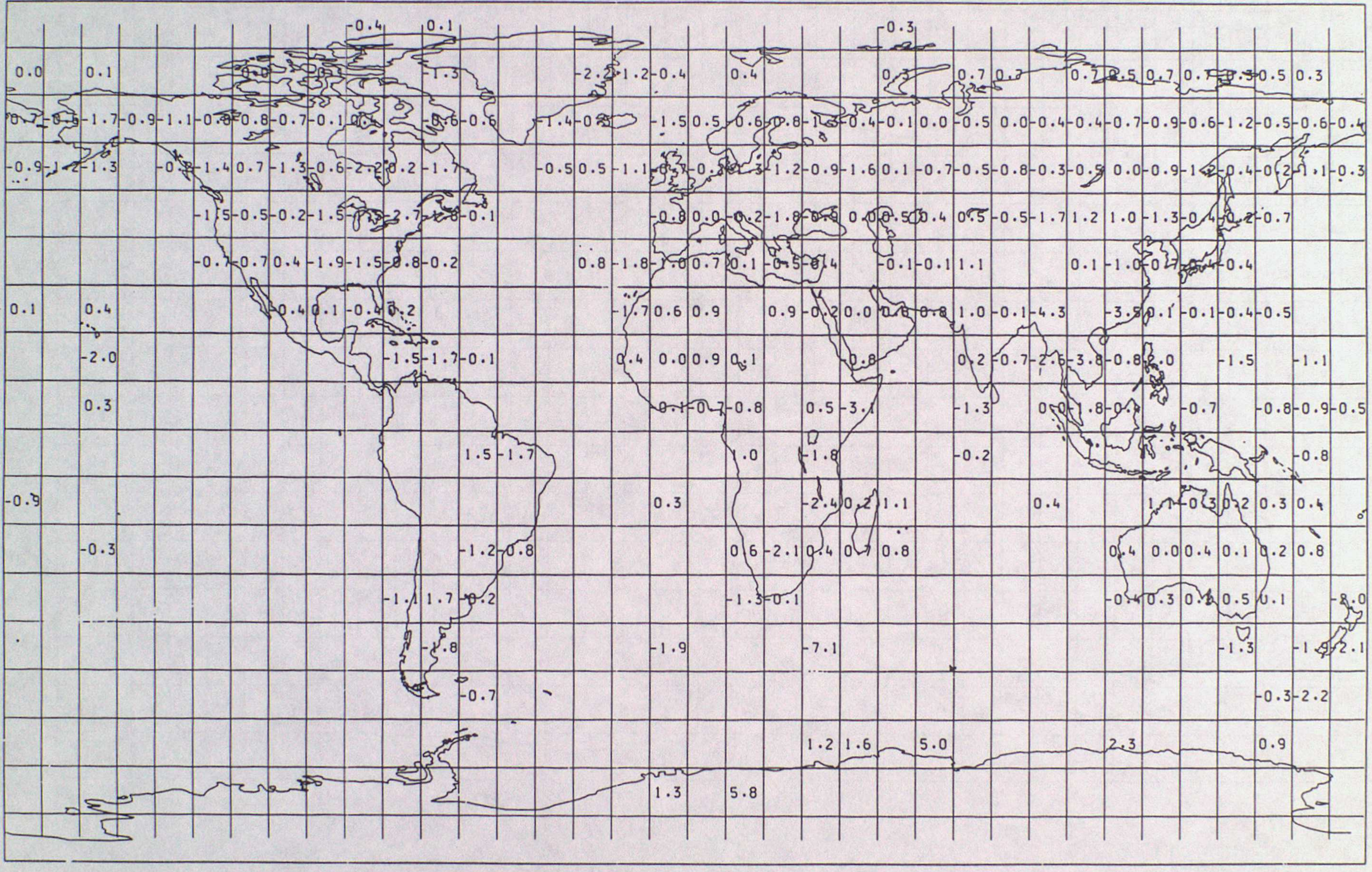


Fig 33

SONDES : RMS O-B VECTOR WIND DIFFERENCES (M/S) BETWEEN 700 AND 999 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

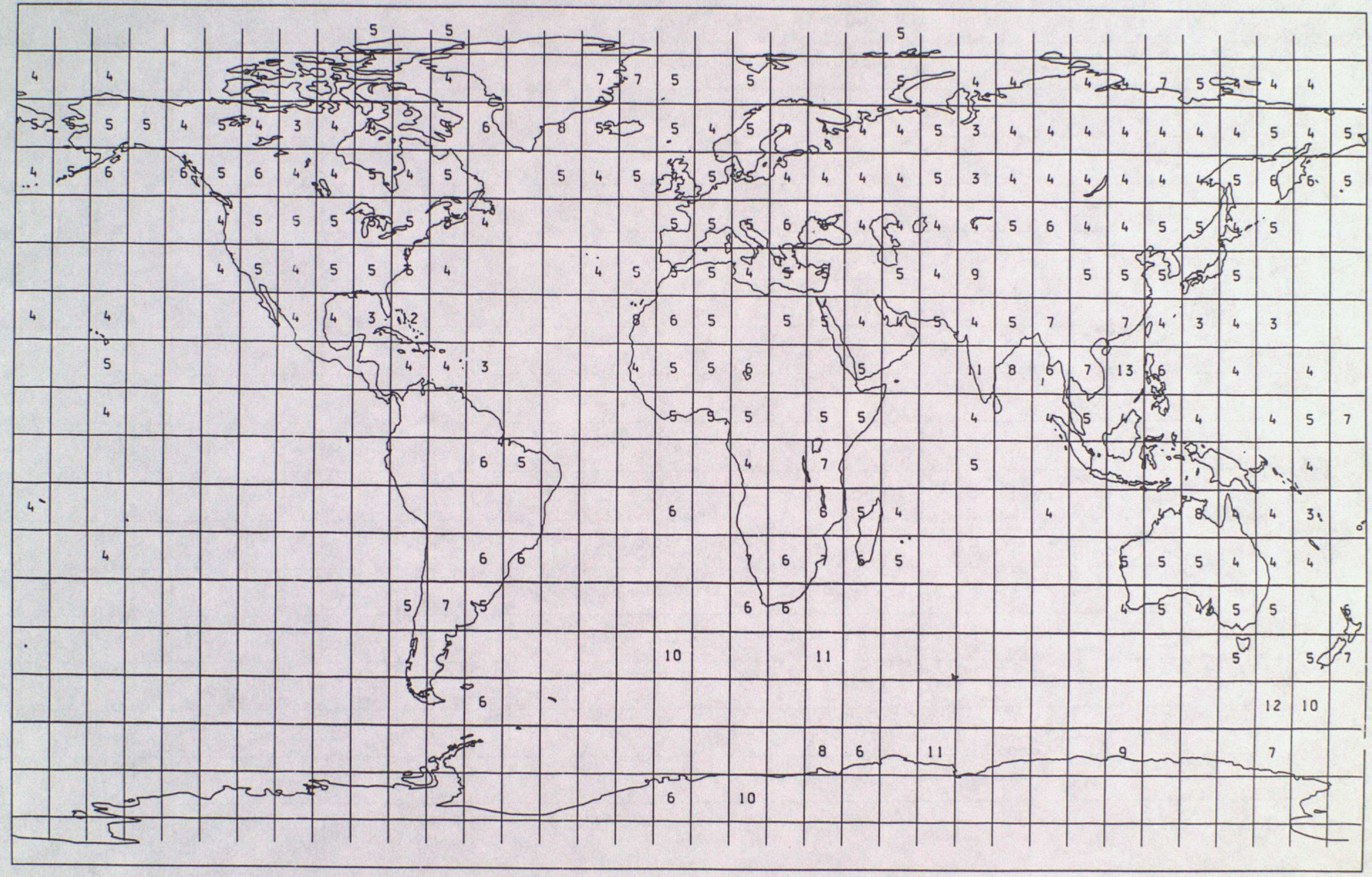


Fig 34

SONDES/PILOTS : O-B MEAN WINDS (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

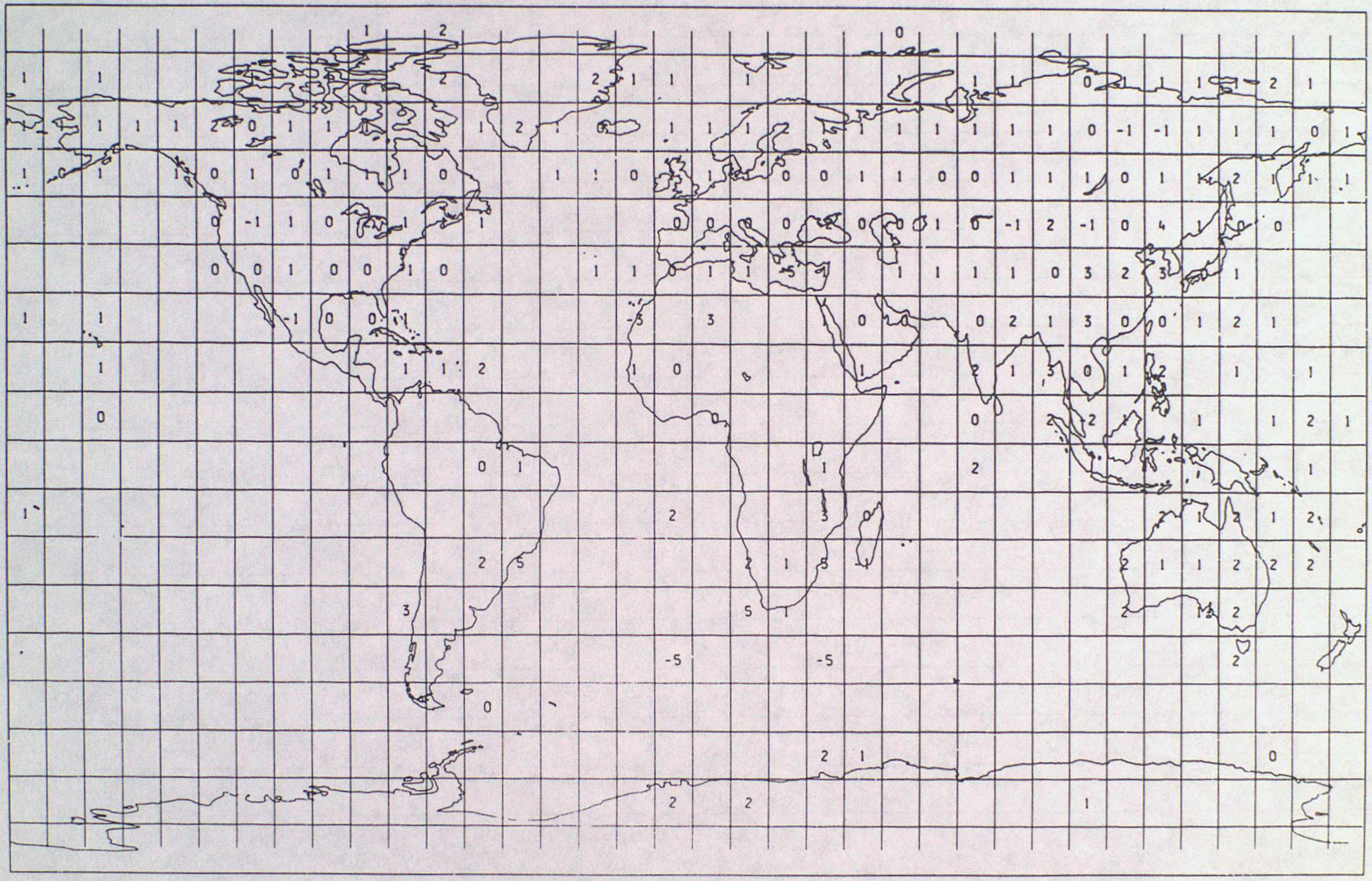


Fig 35

SONDES/PILOTS : RMS O-B VECTOR DIFFERENCES (M/S) BETWEEN 100 AND 399 HPA
1/9/89 TO 30/11/89
ALL OBSERVATIONS INCLUDED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT