CENTRAL FORECASTING MONITORING NOTE NO. 8

MONITORING STATISTICS FOR SATEMs AND SATOBs,

DECEMBER 1991 - FEBRUARY 1992

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Contents

Figures

1. Introduction

Two previous Monitoring Notes in this series, numbers 3 and 5, have presented monitoring results for SATEMs and SATOBs for different three-monthly periods :

- Number 3 - September - November 1989
- Number 5 - December 1989 - February 1990 and June - August 1990

In both Notes, the satellite results have been compared with similar statistics for TEMPs/PILOTs and AIREPs. This Note continues the series by presenting statistics for December 1991 - February 1992.

Although the Notes are primarily produced to show the quality of SATEMs and SATOBs relative to other observation types, and highlight variations of quality with time, this Note is of particular interest because it is the first comprehensive set of results of observation minus background (O-B) values for observations used in the model since the 20 level Unified Model was implemented operationally in June 1991. The format and content of the results given in the previous Notes is retained here to enable direct comparison with the earlier findings. Reference will often be made to Monitoring Note 5, which contains results for the same three month period in 1989-1990 as this Note. This period will be referred to as P1, the 1991-1992 period as P2.

When comparing statistics from different observation types, it is important to bear in mind the possible differences in representativeness there may be and also the variations in circumstances under which the observations are made. These factors are discussed in the introduction of Monitoring Note 5 and are not repeated here.

Results are presented in the form of charts of mean and rms O-B differences by observation type and by vertical band. The background field is a six hour forecast from the global version of the Unified Model. Observations from all hours are used and treated together.

Enhancements are continually being made to the formulation of the forecast model. Since February 1992 these include changes to the vertical diffusion and radiation schemes. Either or both may alter the characteristics of O-B differences. Subsequent Notes should be able to quantify the combined effect of these changes.

2. Temperatures

2.1 SATEMs

The observations considered here are 500 km resolution satellite soundings distributed widely over the GTS. Results are for NOAA-11 and NOAA-12 observations combined (though differences between satellites are not significant). In previous Notes, compressed code SATEMs - at 240 km resolution - were used. Any differences in mean seasonal O-B quantities between the different resolution observations should be negligible.

Although the 500 km data are used in the assimilation, any observation within 3 degrees latitude or longitude of a 120 km resolution sounding (received in BUFR as opposed to character format) are omitted and so do not influence the model fields. However I have found that there is good agreement between the 500 and 120 km resolution observations on a monthly time scale. The 120 km data were in any case only included in the assimilation from mid-February 1992.

The 500 km resolution observations (simply referred to as SATEMs from now on) are used over the sea and until 4th February were also used over Antarctica above 100 hPa. Since 4th February, they have been used over all land above 100 hPa. Temperatures at the lowest band, 1000-850 hPa, are not used north of 30 deg S.

SATEMs are presented to the assimilation as temperatures at the mid-points of standard levels.

Figs 1 and 2 show mean and rms O-B values respectively for the 1000-850 hPa band. Mean differences are generally positive except over land where the observations are not used. There is a wide range in the rms values, from 1.2 deg C in the Tropics to over 5 deg C over the eastern seaboard of North America. Comparing these results with those for P1, it is noted that for the means in the earlier period the positive bias was not as pronounced and for the rms's the values are about 10% higher in P1.

Figs 3 and 4 give results for the 300-100 hPa band. Here again the mean values are generally positive, which is consistent with values for P1. The rms values are again about 10% lower in P2 compared to P1.

Figs 5 and 6 show the values for 50-30 hPa. Mean differences are fairly close to zero. This is probably because at these heights and particularly over the sea there are little other data available. Over Antarctica means are also small, reflecting the fact that SATEMs have been used over that continent throughout the period. RMS differences are strikingly small in the southern hemisphere, again a reflection that few other observations are available there. The absolute mean values are lower in P2 than P1 (when there was a distinct negative bias over much of the northern hemisphere and south of 60 deg S). Over these areas the rms differences are also smaller in P2 but in some others eg South America they are somewhat higher.

2.2 <u>TEMPs</u>

Figs 7 and 8 give mean and rms O-B differences for TEMPs in the band 1000-801 hPa. This band rather than 1000-850 hPa is used because statistics are more readily available for TEMPs in 100 hPa intervals. For the results shown in the figures, values have been obtained by combining results from individual months and from separate 100 hPa bands. Results for any single band and month have been excluded if more than 5% of the observations were flagged at the final stage of the quality control in order to exclude the poorest quality TEMPs. Temperature observations from WMO blocks 42 and 43 (India) are permanently rejected due to long-standing poor quality and are not included in these figures.

The majority of mean differences in fig 7 are within +/- 1 deg C, mostly positive in the northern hemisphere and mostly negative in the southern. The rms values are considerably smaller than those for the lowest layer SATEMs (fig 2) in the northern hemisphere but about the same in the southern. The sonde rms differences are generally lower in P2 than P1, as they are for SATEMs.

Figs 9 and 10 show the same charts for the 300-101 hPa band. Biases are small and rms differences generally below 2 deg C. The biases are slightly less positive than for SATEMs (fig 4) and the rms's are significantly lower except in the southern oceans.The biases are about the same in P2 as in P1 but the rms differences are smaller.

For the top band, above 100 hPa, figs 11 and 12, mean differences are mostly between 0 and -2 deg C and rms's below 2.5 deg C. Strict comparison with the SATEM results is not possible since the bands are not identical. However the biases are different in sign and the rms differences for TEMPs are mostly greater than for SATEMs though not everywhere. The negative biases for P2 are in contrast to the positive biases in P1. The rms values are significantly smaller in P2 compared to P1.

2.3 AIREPs

Figs 13 and 14 present results for AIREPs in the band 300-101 hPa. Mean differences are within +/- 1 deg C and rms values are below 3.3 deg C. The means are similar to those for TEMPs, however the rms's are larger than for TEMPs and for SATEMs in the same band. As for the other types, the rms values are lower in P2 than P1.

2.4 LASS observations

LASS data are presented to the model as temperatures on standard levels from 1000 hPa upwards. Here the bottom level value is used in the assimilation in contrast to the lowest band for the other satellite soundings in the same area. Excluded from the statistics are observations that have been flagged by the LASS processing scheme(i.e. data over surface elevation of more than 500m, those with all HIRS and MSU channel data missing and those with differences in brightness temperature between background field and sounding greater than a specified threshold).

Mean and rms O-B differences for LASS observations are given in figs 15 and 16. The means are close to zero with a tendency, as noted in P1 and subsequent months, for positive biases in the north and negative in the south of the area. The rms values as expected are much smaller than for the other types because use is made of the background field in the retrieval.

3. Winds

3.1 SATOBs

SATOBs derived from cloud motion vectors in the infra-red are available from four satellites : METEOSAT, GMS,GOES and INSAT. The area of coverage of these satellites is approximately :

METEOSAT	60 deg W to 60 deg E
INSAT	70 deg E to 100 deg E
GMS	90 deg E to 170 deg E
GOES	160 deg W to 70 deg W

During P2, GMS observations north of 20 deg N and south of 20 deg S above 500 hPa were excluded from the assimilation as were GOES SATOBs north of 20 deg N above 500 hPa. All INSAT reports were also excluded. These exclusions were based on the results from previous monitoring statistics.

In mid-February 1992, a new wind retrieval scheme was introduced for GOES winds (employing a CO_2 slicing algorithm) which is expected to improve the height assignment of their winds. However the effect of that change is not likely to be significant over the period studied here.

Figs 17 to 20 show mean vector wind, mean O-B vector wind, mean O-B speed and rms O-B vector winds for the band 701-1000 hPa. The charts indicate a positive bias in speed for METEOSAT winds off the west coast of South Africa and the continuing poor quality of INSAT data. In terms of rms vector differences, the GOES winds in mid-latitudes seem rather poorer than METEOSAT and GMS (assuming the quality of the background field is similar at these latitudes across the globe).

Figs 21 to 24 display the same charts for the band 101-400 hPa. There is divergence in the O-B winds near the equator (not present in ECMWF results). There is also a negative bias in speeds in mid-latitudes, particularly for GOES in the northern hemisphere and a marked positive bias in the equatorial Pacific, over and off East Africa and in the south Atlantic. INSAT contributes to only one grid box at this band, to the north-east of Madagaskar, since the number of observations it produces are quite low. Rms vector differences (fig 24) are greatest for GOES at all latitudes, particularly in the northern hemisphere. The values of 10 and 12 for the two boxes north of Madagaskar, which for METEOSAT results separate from INSAT become 10 and 11, are also quite high and are probably as a result of the positive speed difference in this area.

Comparing results with those for P1, those for the lower band are similar except that the convergence of O-B vectors around 0-10 deg S in P1 is only marginally present in P2. The mid-latitude negative biases at the higher band are much reduced for GMS in P2 compared to P1 (when they exceeded -10 m per s) and slightly less for METEOSAT and GOES where the discrepancy was not as great. These differences are almost certainly mostly due to improvements made by the satellite operators to the wind retrievals. The positive biases present for both bands are present in P1 and P2. RMS vector differences are lower in P2 compared to P1 in both bands especially at mid-latitudes for the higher band.

3.2 TEMPs/PILOTs

Figs 25 and 26 show the mean O-B speed and vector differences for TEMPs and PILOTs between 701-1000 hPa. Observations for an individual month and station have been excluded if more than 5% had been flagged at the final quality control stage. The mean speed differences tend to be negative over Asia and North America and positive over Australia. RMS vector differences range between 3 and 6 m per s.

Figs 27 and 28 display corresponding results for 101-400 hPa. Most mean speed biases are positive and vector wind differences range from 3 to 11 m per s.

Comparison with the results for SATOBs is not easy to make due to the different geographical coverage; however the negative speed bias for SATOBs at the higher band in mid-latitudes is clearly not present for TEMPs but there is evidence for the positive speed difference in the TEMP data as well as the SATOB data in the equatorial Pacific. RMS differences are similar between SATOB and TEMPs at 701-1000 hPa but significantly larger for SATOBs at the higher band.

Results for the mean speed differences in P2 are in broad agreement with those found in P1. RMS differences though are somewhat lower for P2, particularly for the lower band.

3.3 AIREPs (including ASDAR and Australian ACARS data)

Aircraft reports over Australasia in AMDAR code have been used in the assimilation for most of the three month period in addition to the normal AIREP reports. Problems with the coding of aircraft reports by the Carswell collecting centre in the United States and also with the format of a significant number of reports from aircraft flying over the States led to the decision to omit from the assimilation all reports over mainland United States from 9th January.

Figs 29 and 30 for the AIREPs show large positive speed differences at the 100-400 hPa band except in parts of the north Pacific and north Atlantic. RMS differences are relatively large over the eastern part of the north Pacific and North and South America. They are lower than SATOB differences where the SATOBs have a significant mean bias in northern mid-latitudes; elsewhere they are equal to or somewhat higher than the SATOB values. They are lower than they were in P1 over most areas but larger in a few boxes eg over South America.

4. Summary and implications

• the quality of the satellite soundings has not appeared to vary significantly between 1989-1990 and 1991-92. The rms differences for the lowest band are still substantially higher in the northern hemisphere than at equivalent levels for sondes. There seems no reason to alter the permanent rejection of SATEMs currently applied ie lowest band north of 30 deg S.

• the quality of GMS high level SATOBs at mid-latitudes has improved in the last two years and the quality of GOES SATOBs for the same levels and latitudes is now significantly worse than METEOSAT and GMS. A Monitoring Note by Waters (number 6) on the quality of high level SATOBs from the different satellites between February 1990 and April 1991 also bears this out. However the routine monitoring of monthly statistics since February 1992 has indicated that the change made to the GOES wind retrieval scheme in February 1992 has significantly improved the quality of the GOES winds.

· it follows that the current practice of rejecting all high level GMS winds polewards of 20 deg N/S and high level GOES winds north of 20 deg N but accepting the METEOSAT winds may now be no longer justifiable on statistical grounds. Whether their inclusion would benefit the model can at present only be speculative. It is also important to note that rms differences for all satellites at the higher levels are still significantly higher than for sondes and PILOTs, so their inclusion over land may well be detrimental.

· from the model point of view, it is encouraging that in almost all cases the rms O-B differences in 1991-92 are lower than they were in 1989-90. Some of the reduction may be due to more accurate observations (eg the high level GMS SATOBs) but the fact that the differences occur with most observation types suggests that there has been a significant improvement in the quality of the background temperature, height and wind fields during the two years.

Figure 1

SATEMS : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

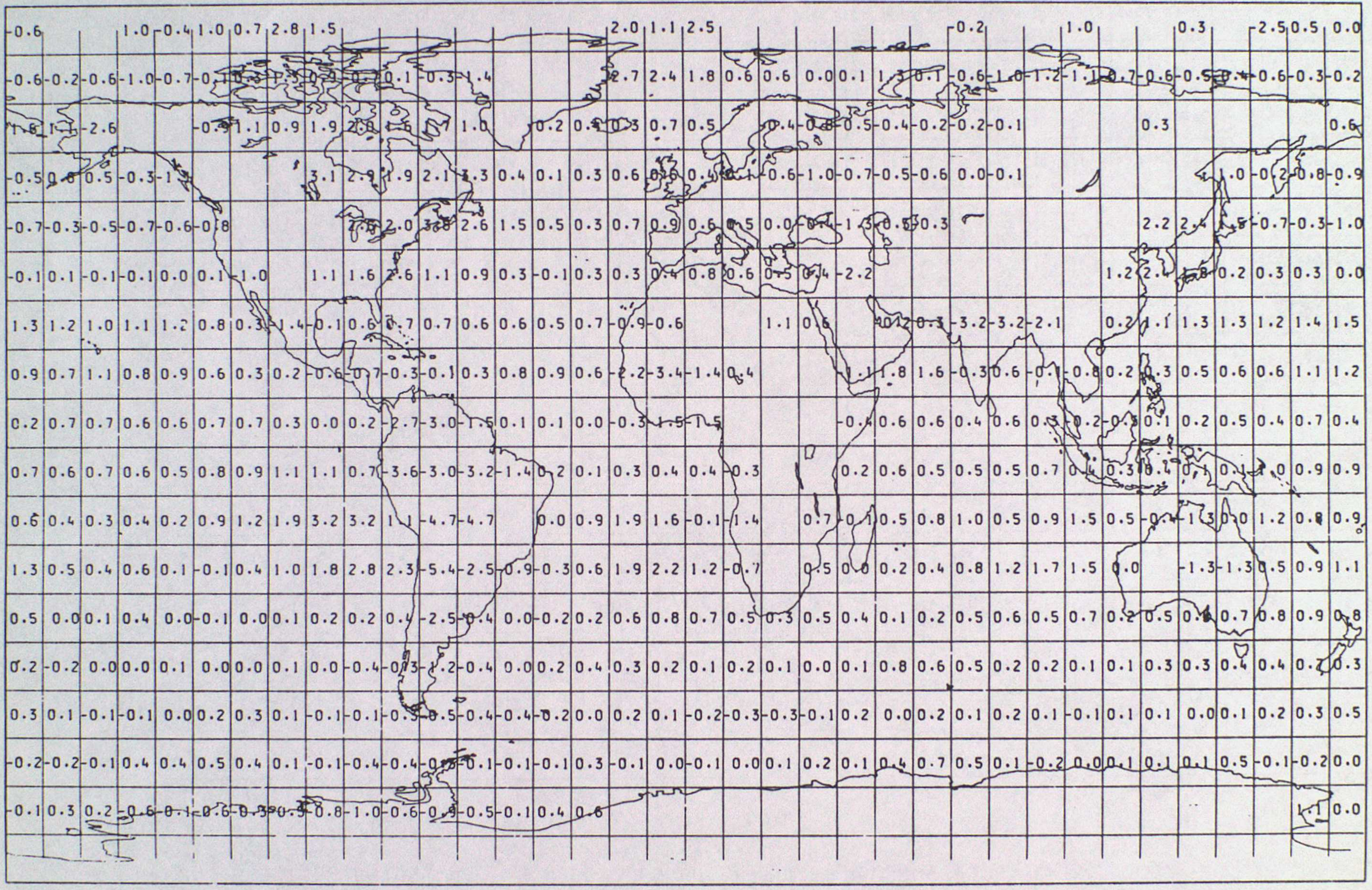

Figure 2

SATEMS : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 850 AND 1000 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

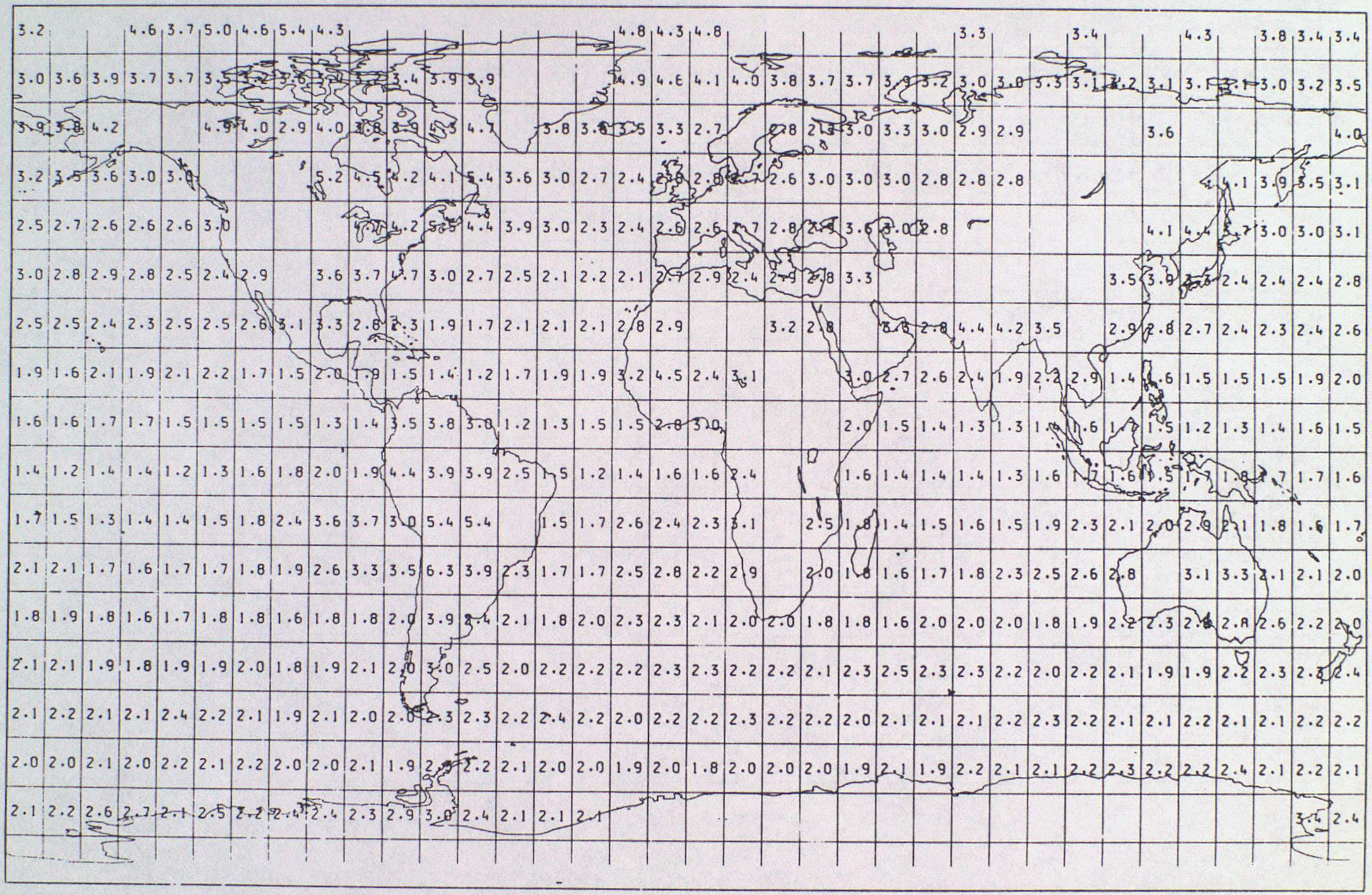

Figure 3

SATEMS : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

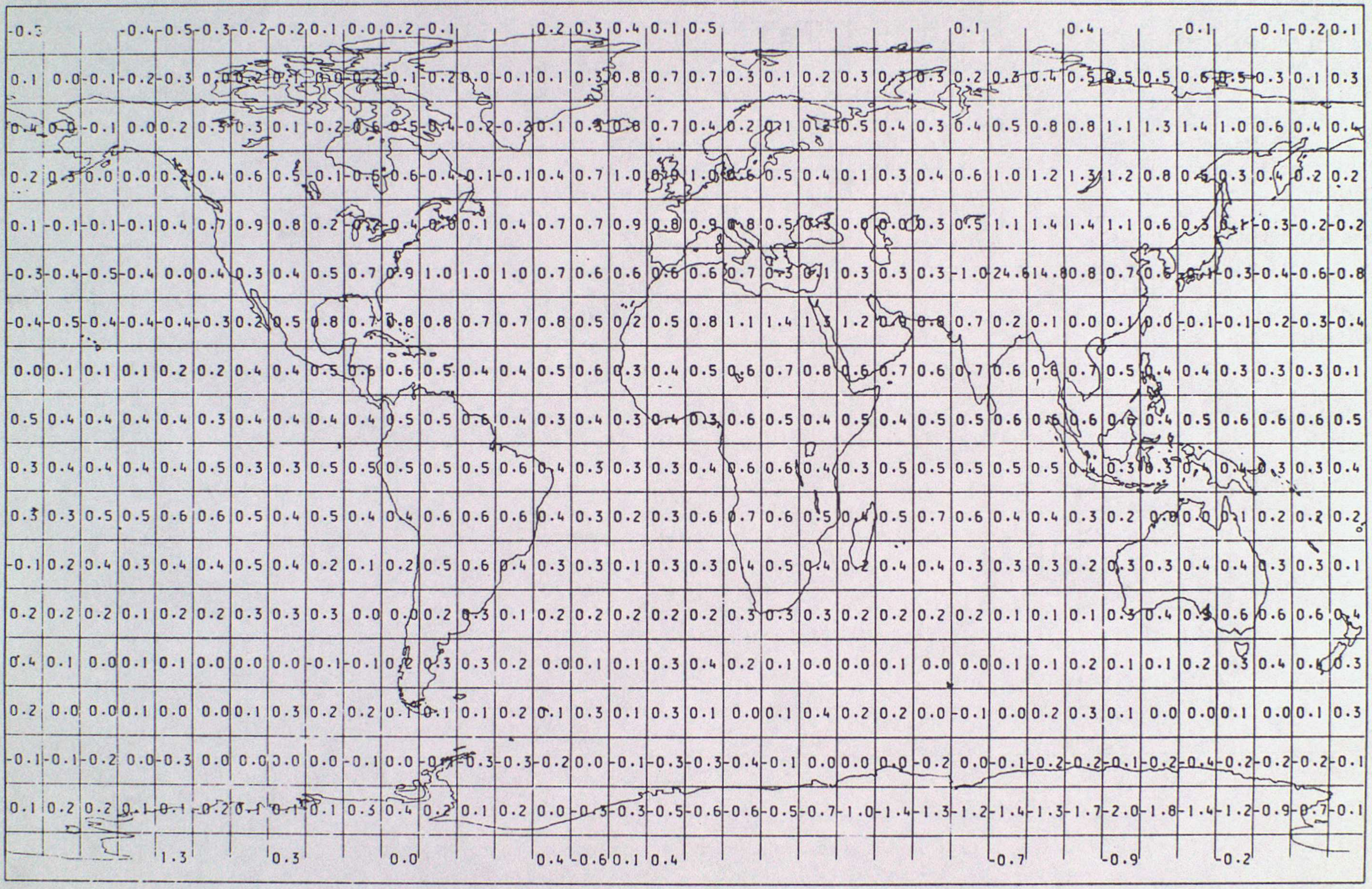

Figure 4

SATEMS : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 100 AND 300 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

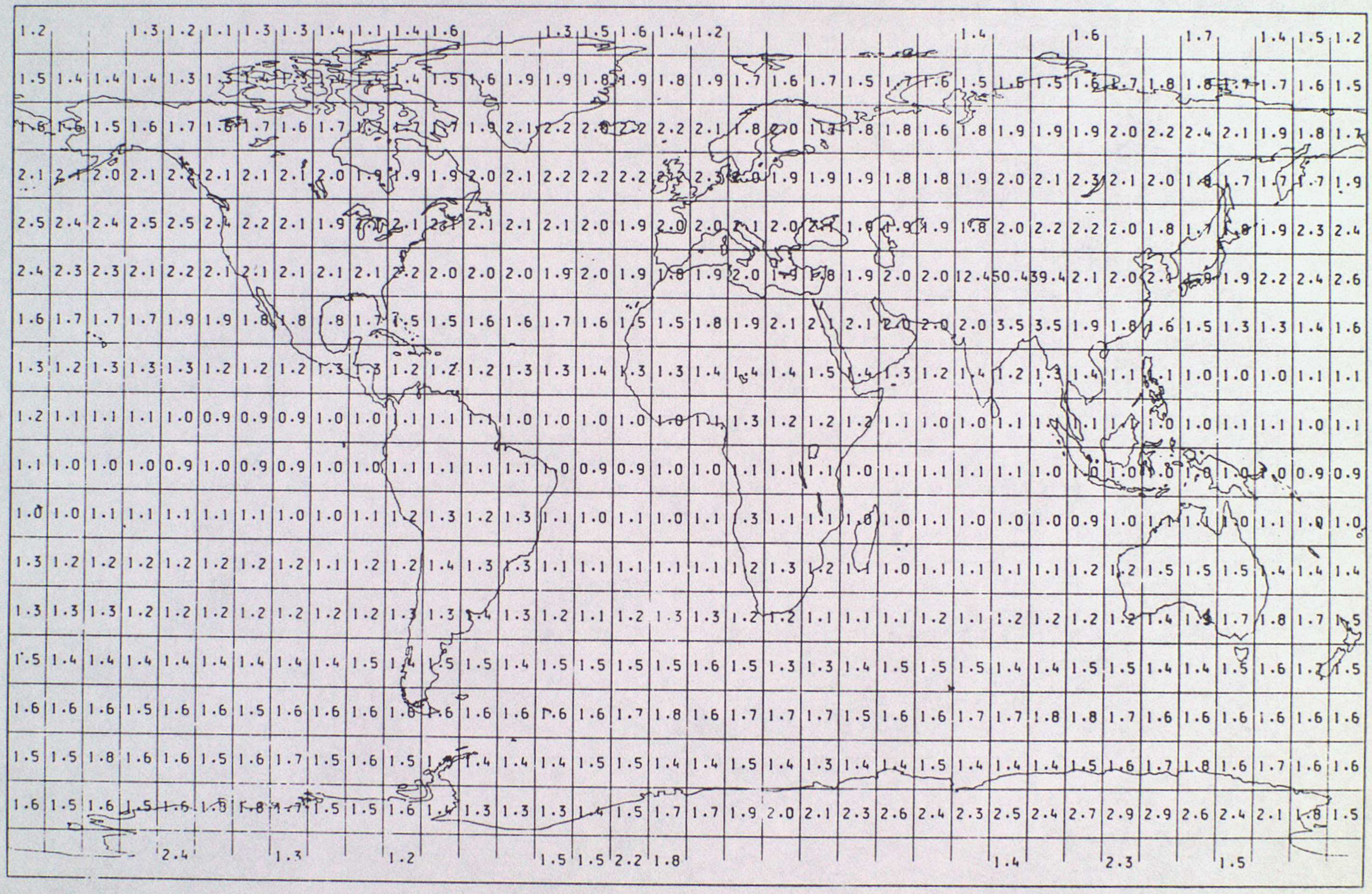

Figure 5

SATEMS : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 30 AND 50 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

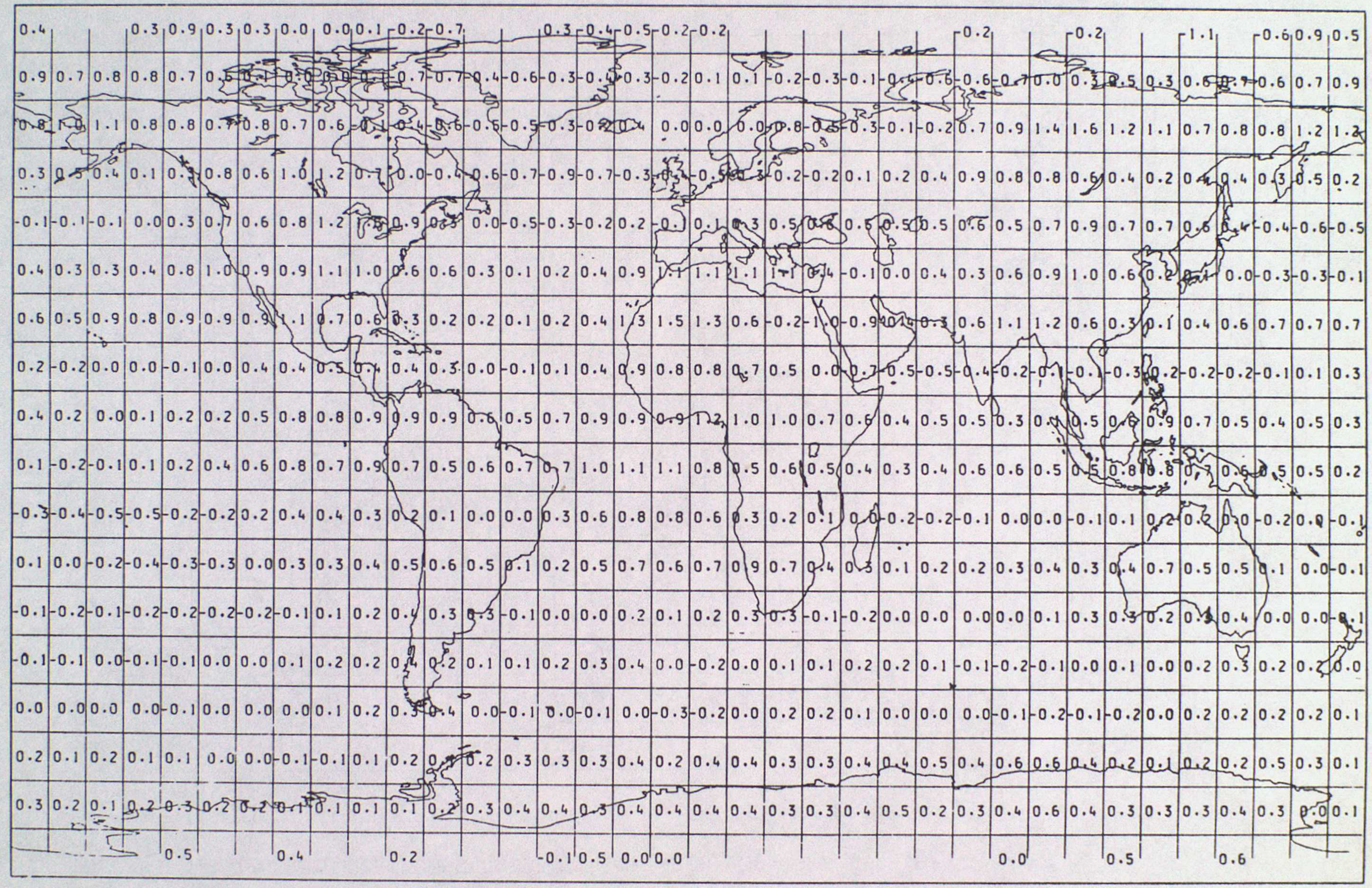

Figure 6

SATEMS : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 30 AND 50 HPA
1/12/91 TO 29/02/92
NOAA-11 AND NOAA-12 STATISTICS COMBINED
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

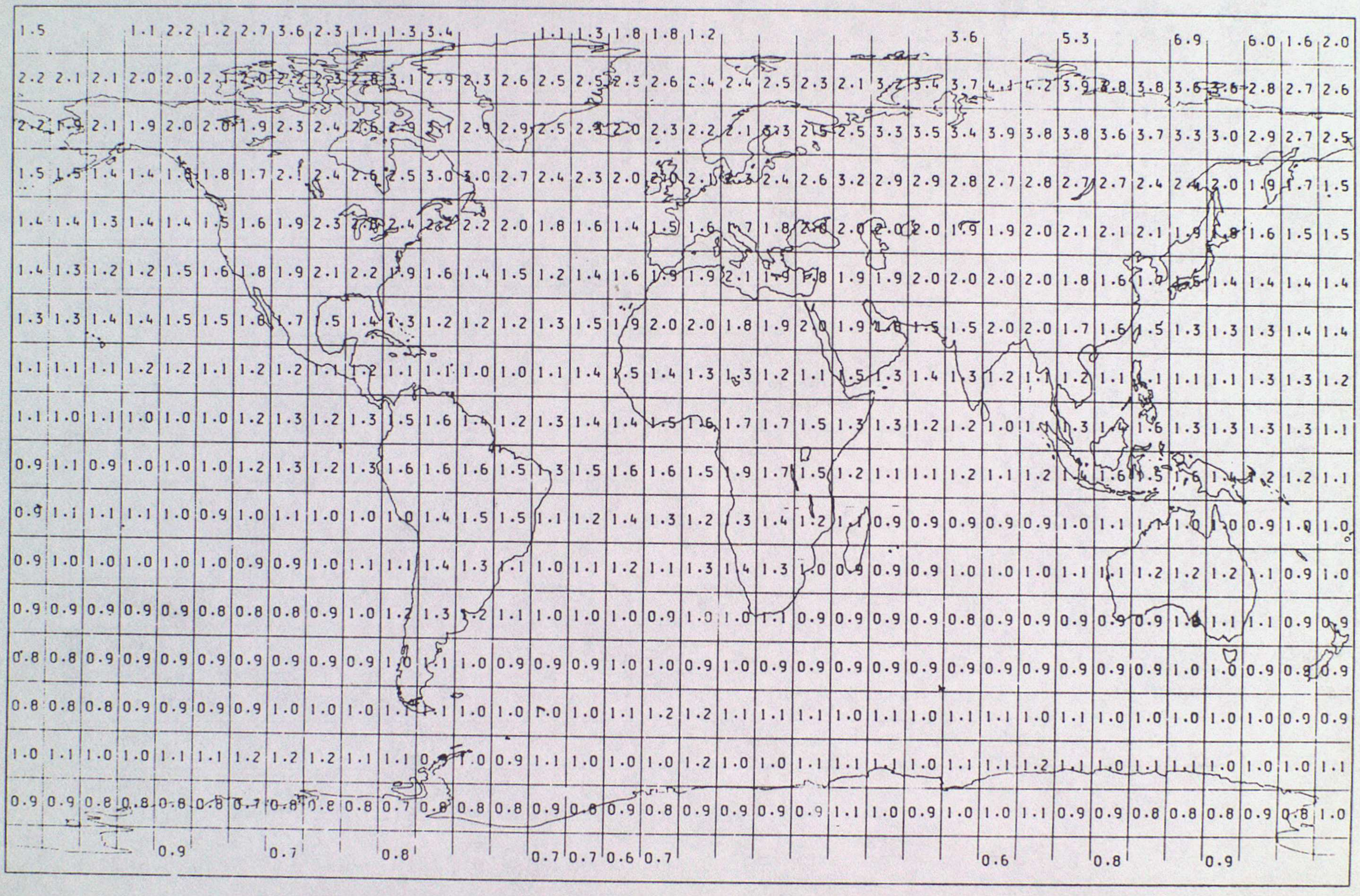

Figure 7

SONDES : O-B TEMPERATURE DIFFERENCES (DEG C) 801 TO 1000 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

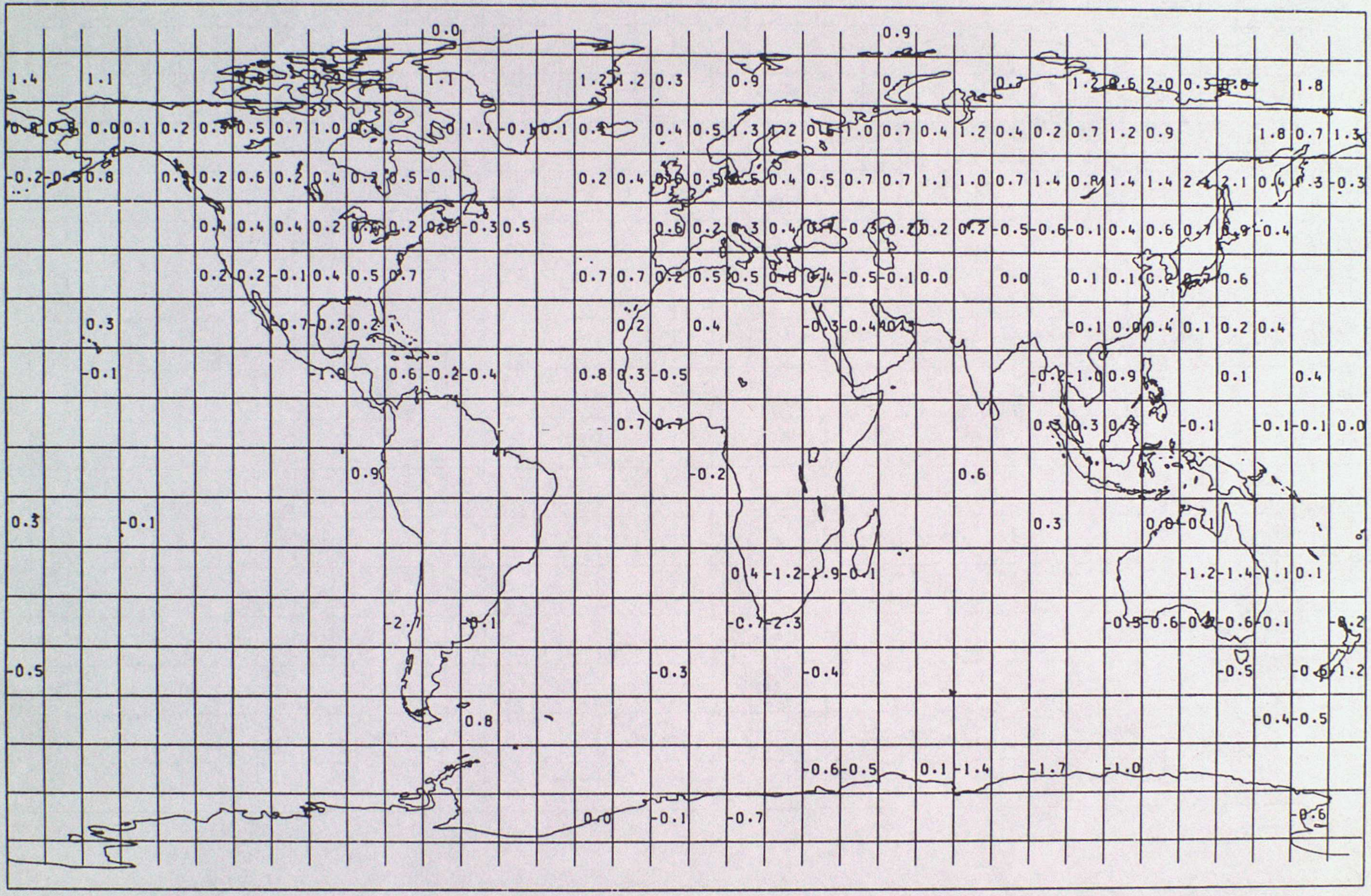

Figure 8

SONDES : RMS O-B TEMPERATURE DIFFERENCES (DEG C) 801 TO 1000 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

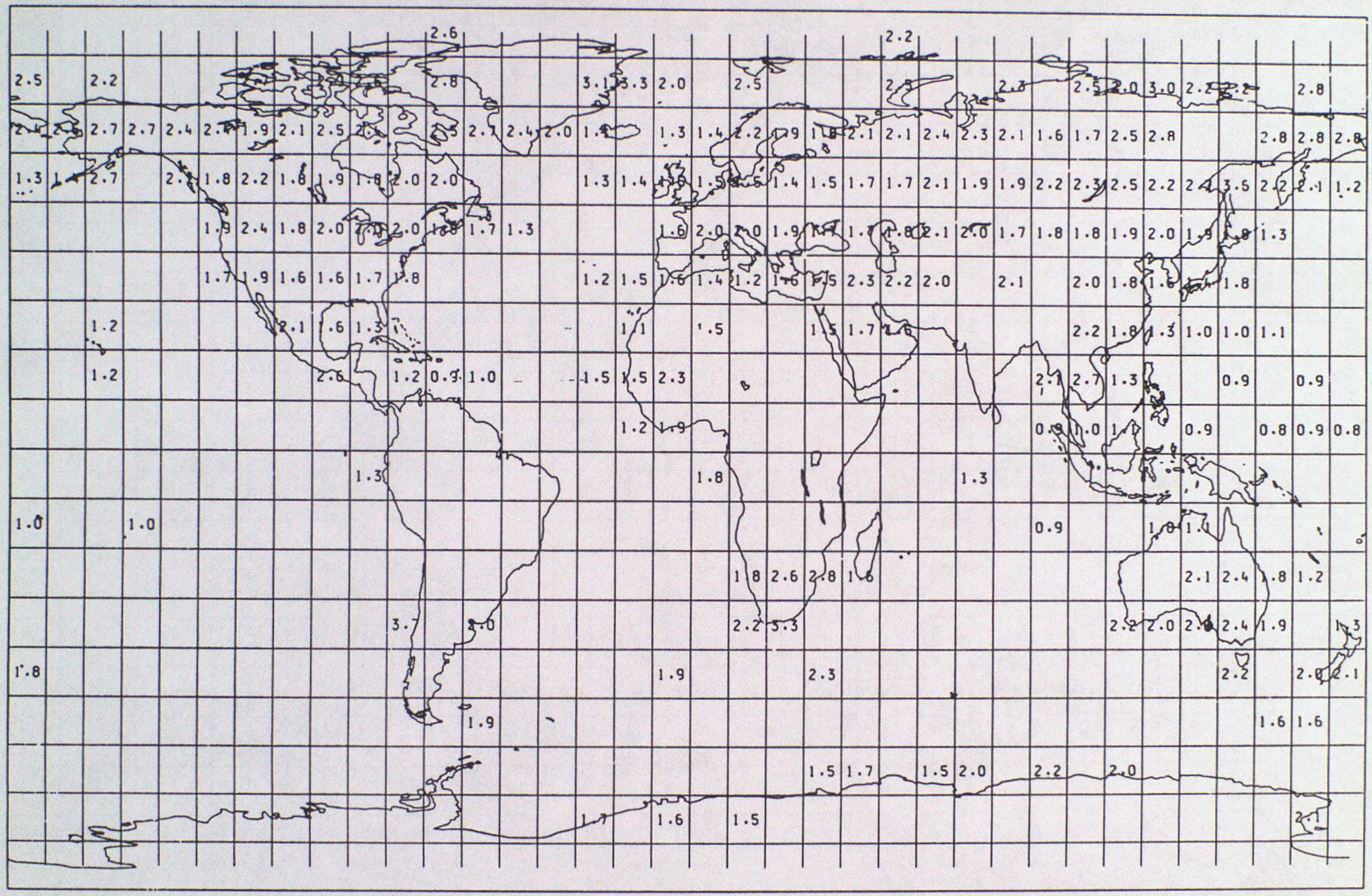

Figure 9

SONDES : O-B TEMPERATURE DIFFERENCES (DEG C) 101 TO 300 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

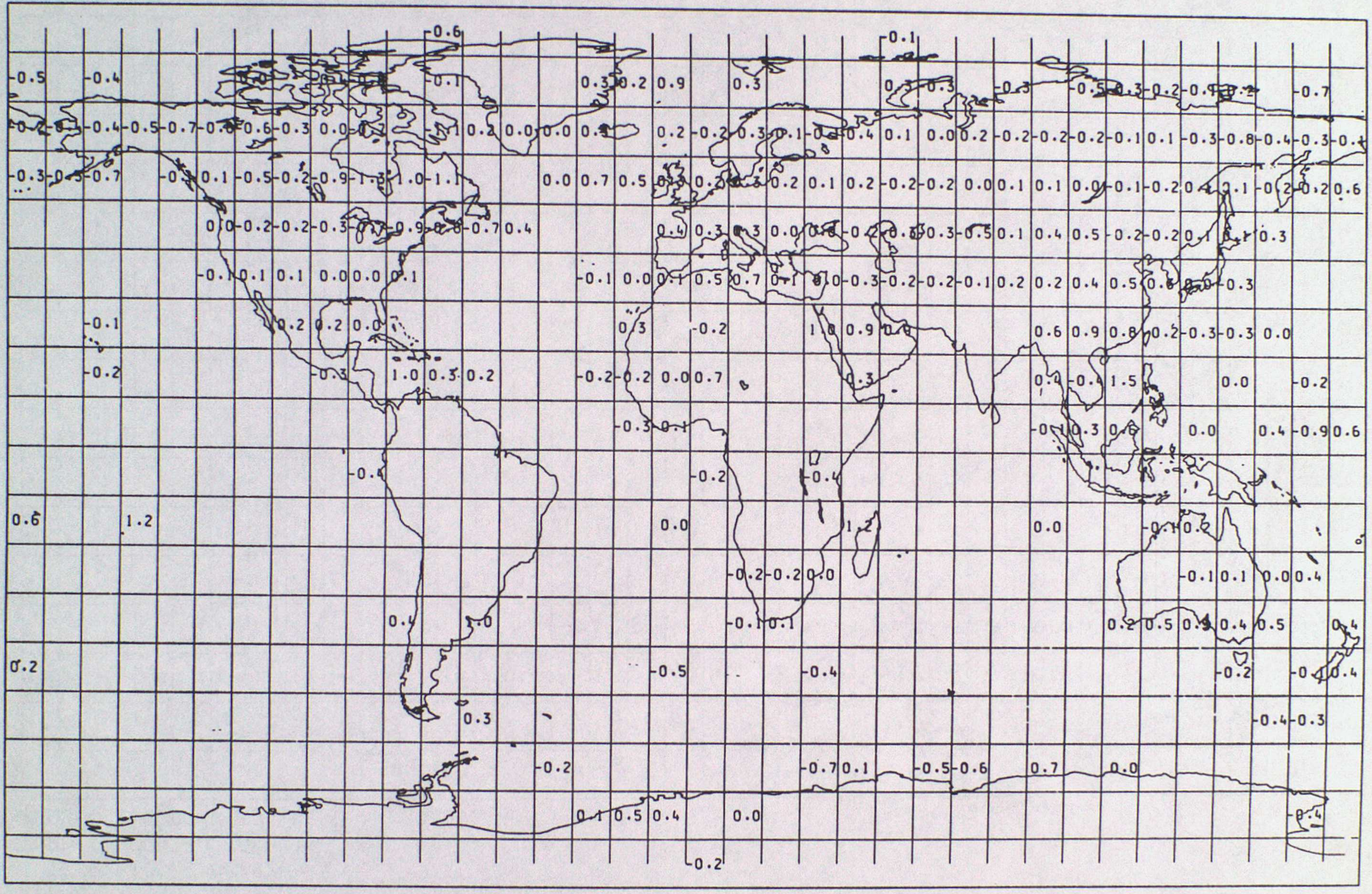

Figure 10

SONDES : RMS O-B TEMPERATURE DIFFERENCES (DEG C) 101 TO 300 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

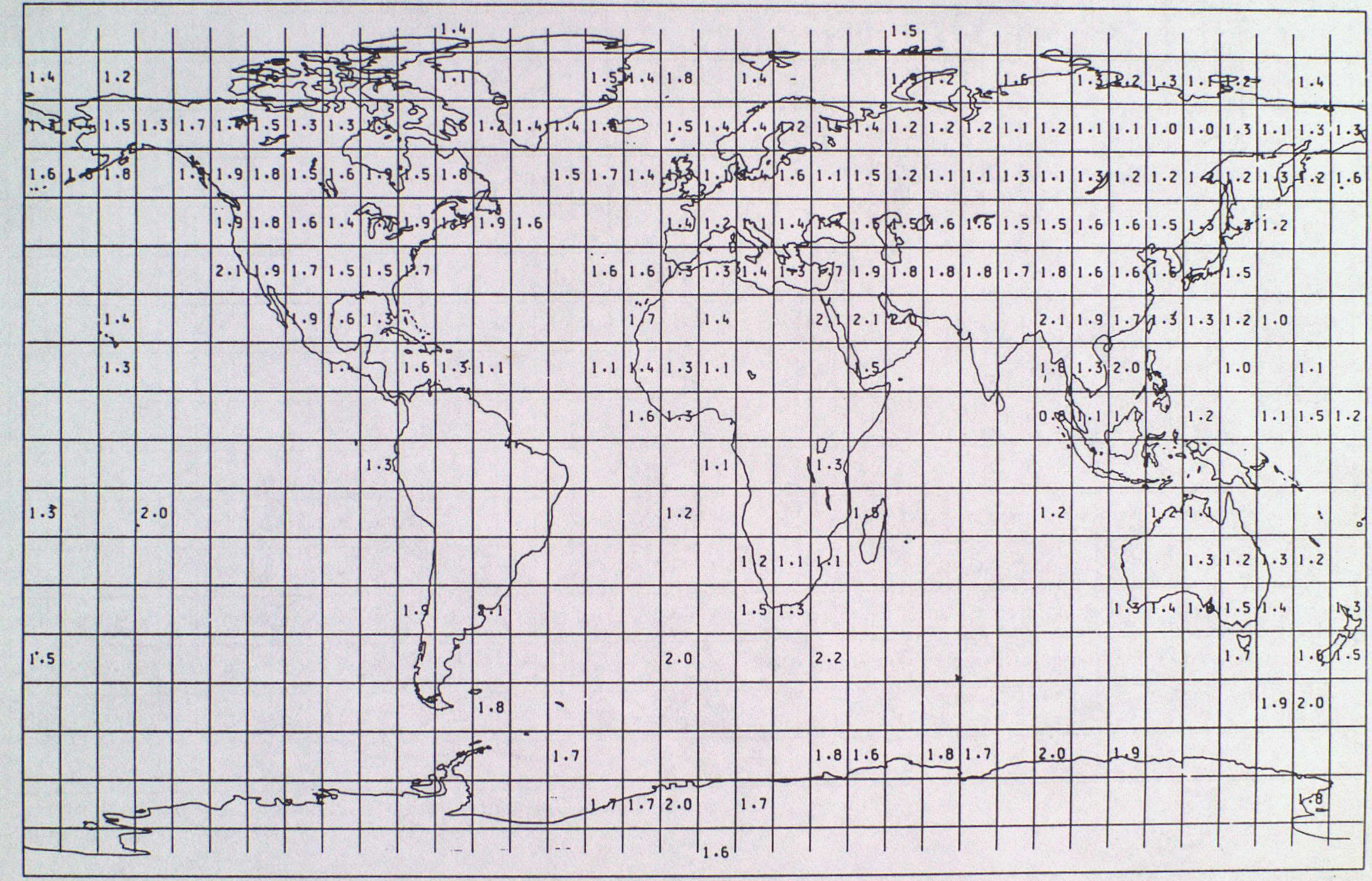

Figure 11

SONDES : O-B TEMPERATURE DIFFERENCES (DEG C) 11 TO 100 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

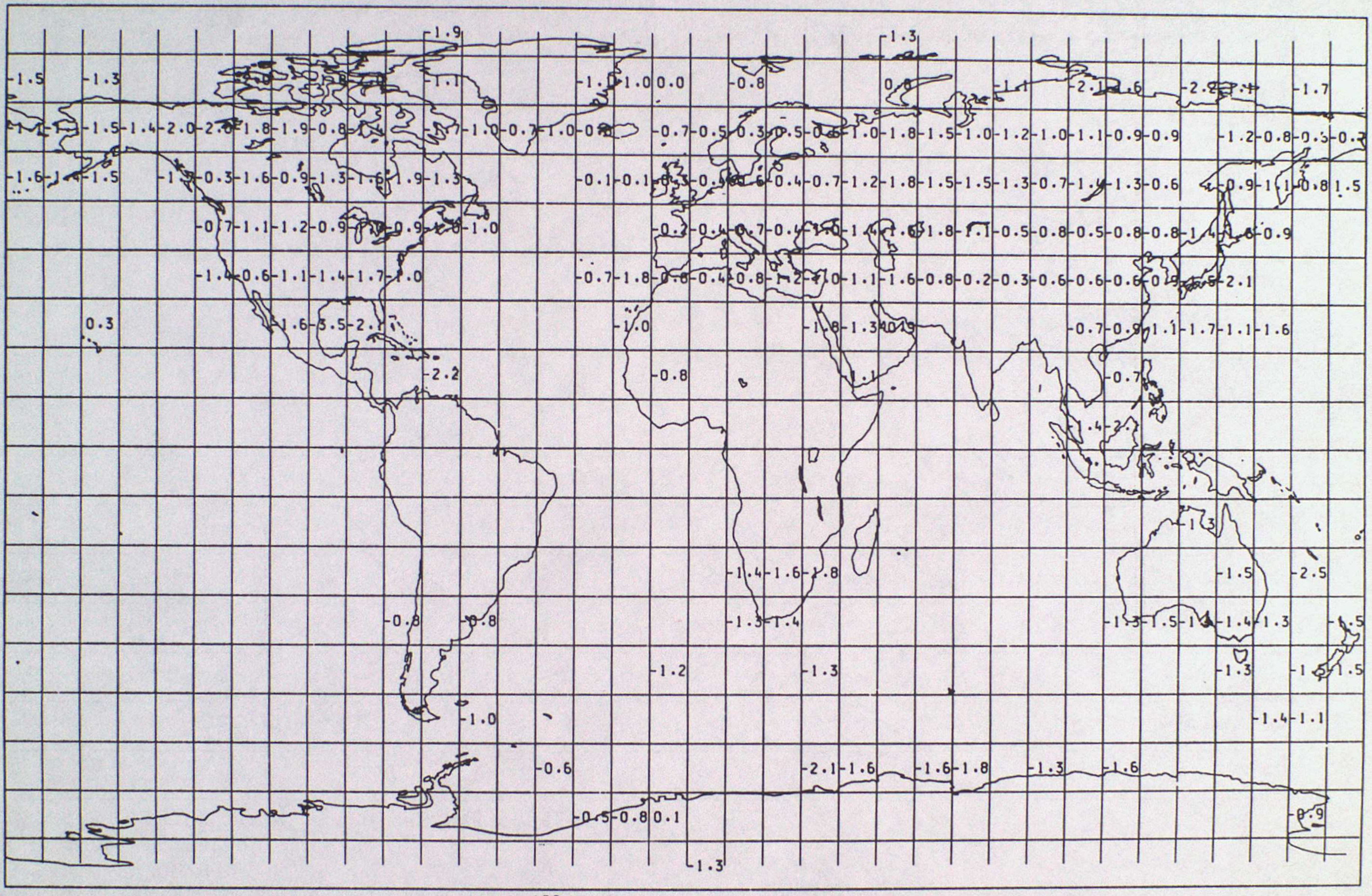

Figure 12

SONDES : RMS O-B TEMPERATURE DIFFERENCES (DEG C)   11 TO 100 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

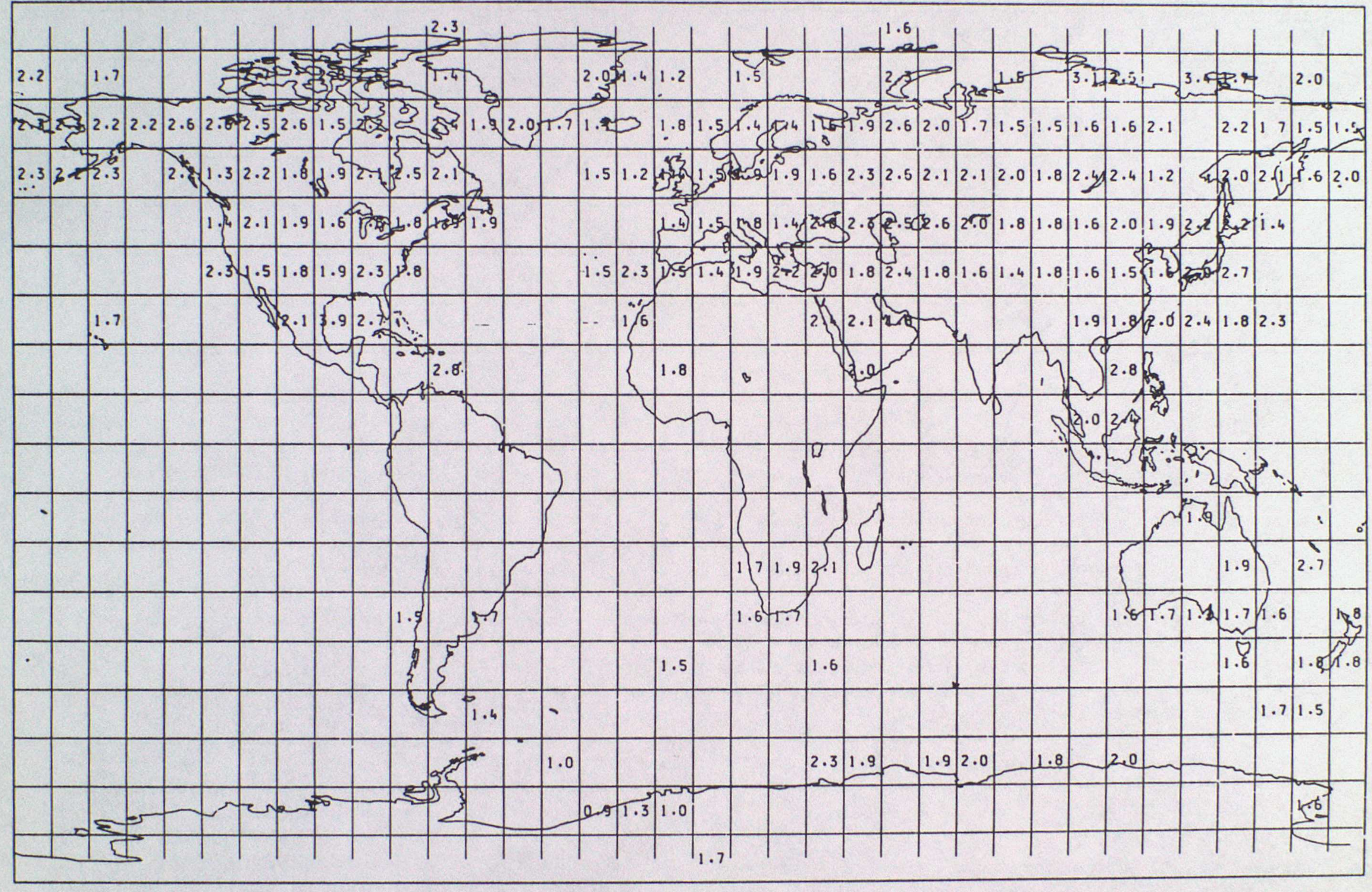

Figure 13

AIREPS : MEAN O-B TEMPERATURES (DEG C) BETWEEN 101 AND 300 HPA
1/12/91 TO 29/02/92
GROSS ERROR CHECK APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

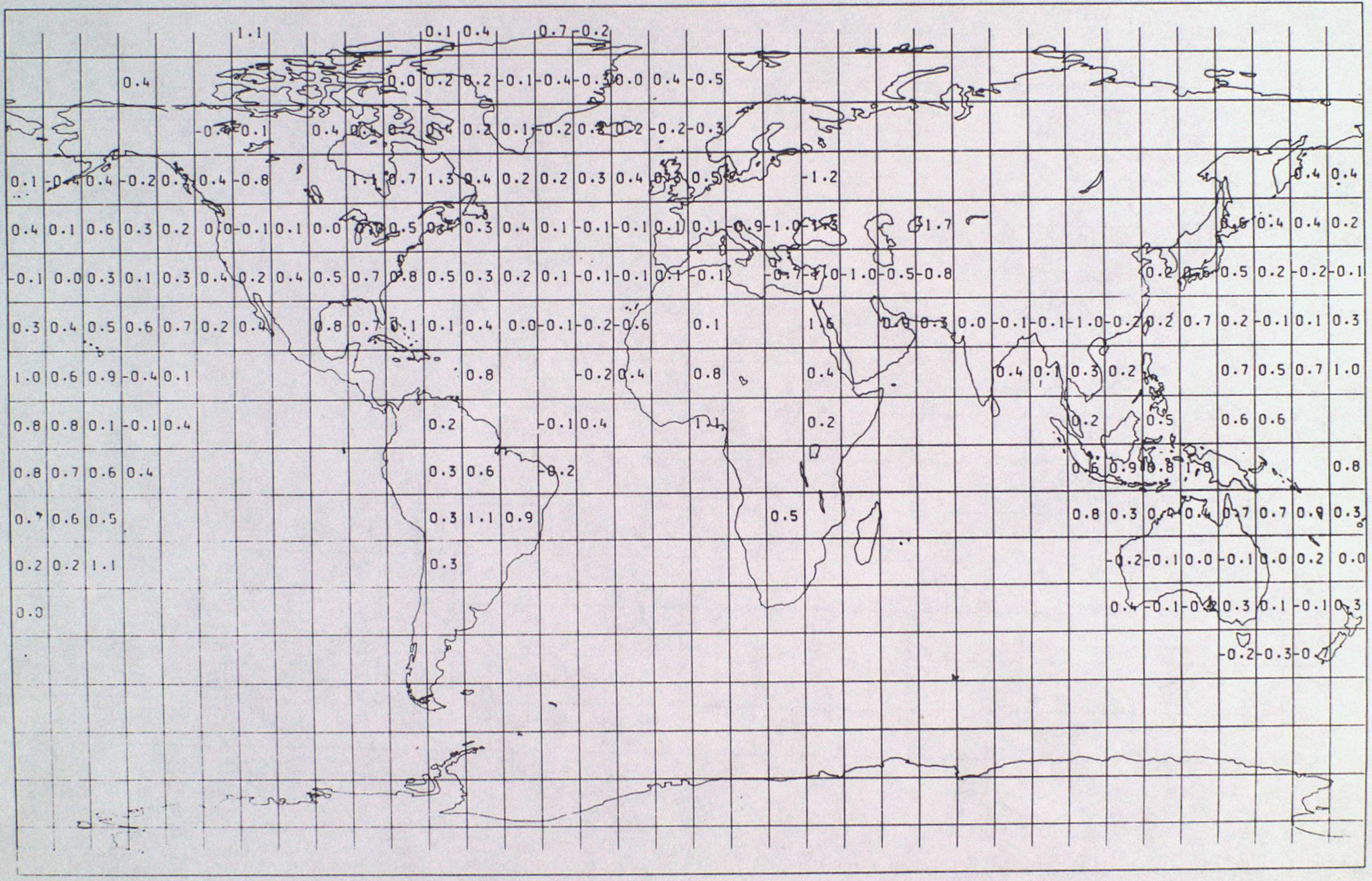

Figure 14

AIREPS : RMS O-B TEMPERATURES (DEG C) BETWEEN 101 AND 300 HPA
1/12/91 TO 29/02/92
GROSS ERROR CHECK APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

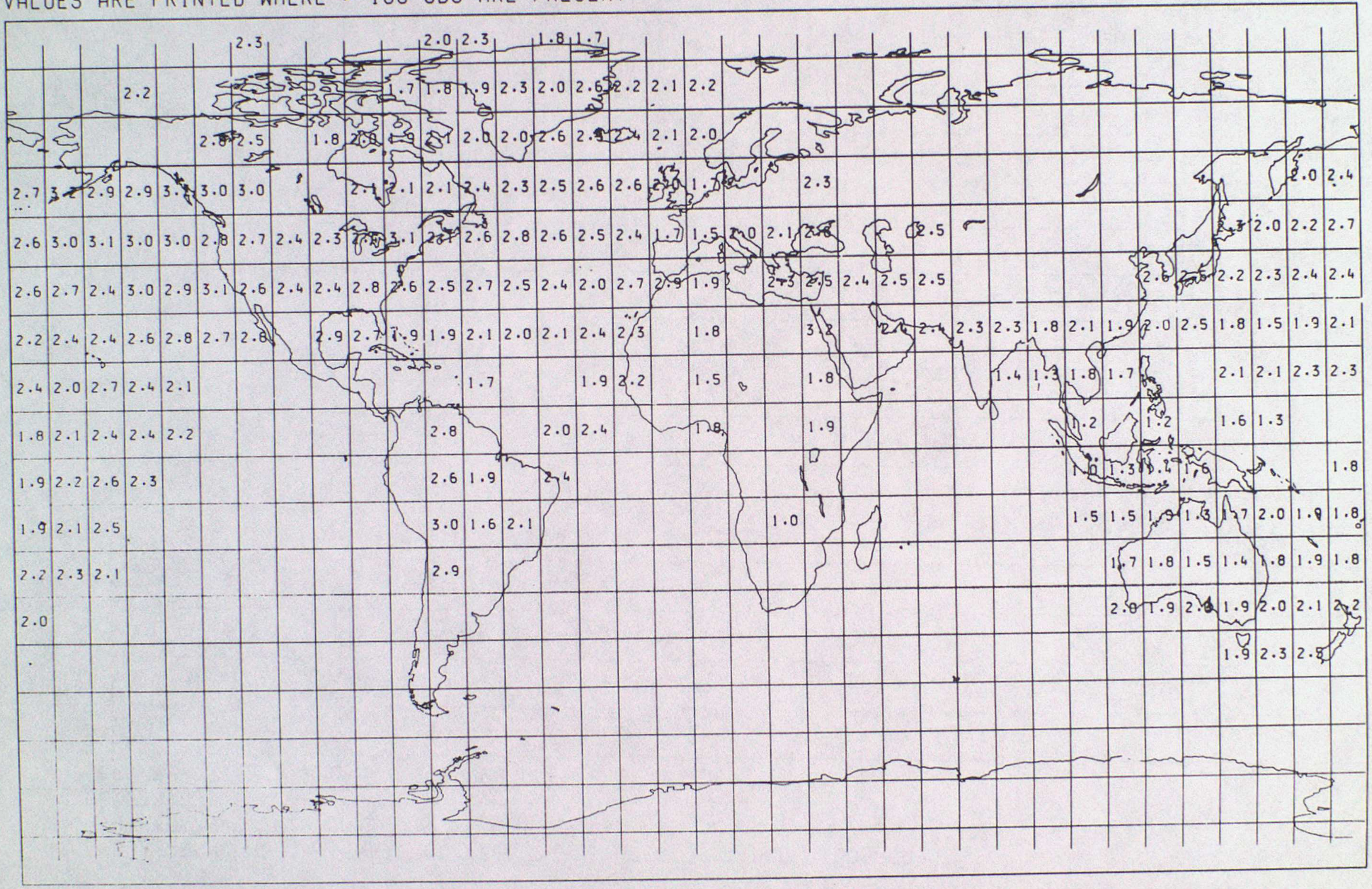

Figure 15

LASS : MEAN O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 500 AND 1000 HPA
1/12/91 TO 29/02/92
DATA FROM NOAA-11
VALUES ARE PRINTED WHERE > 30 OBS ARE PRESENT

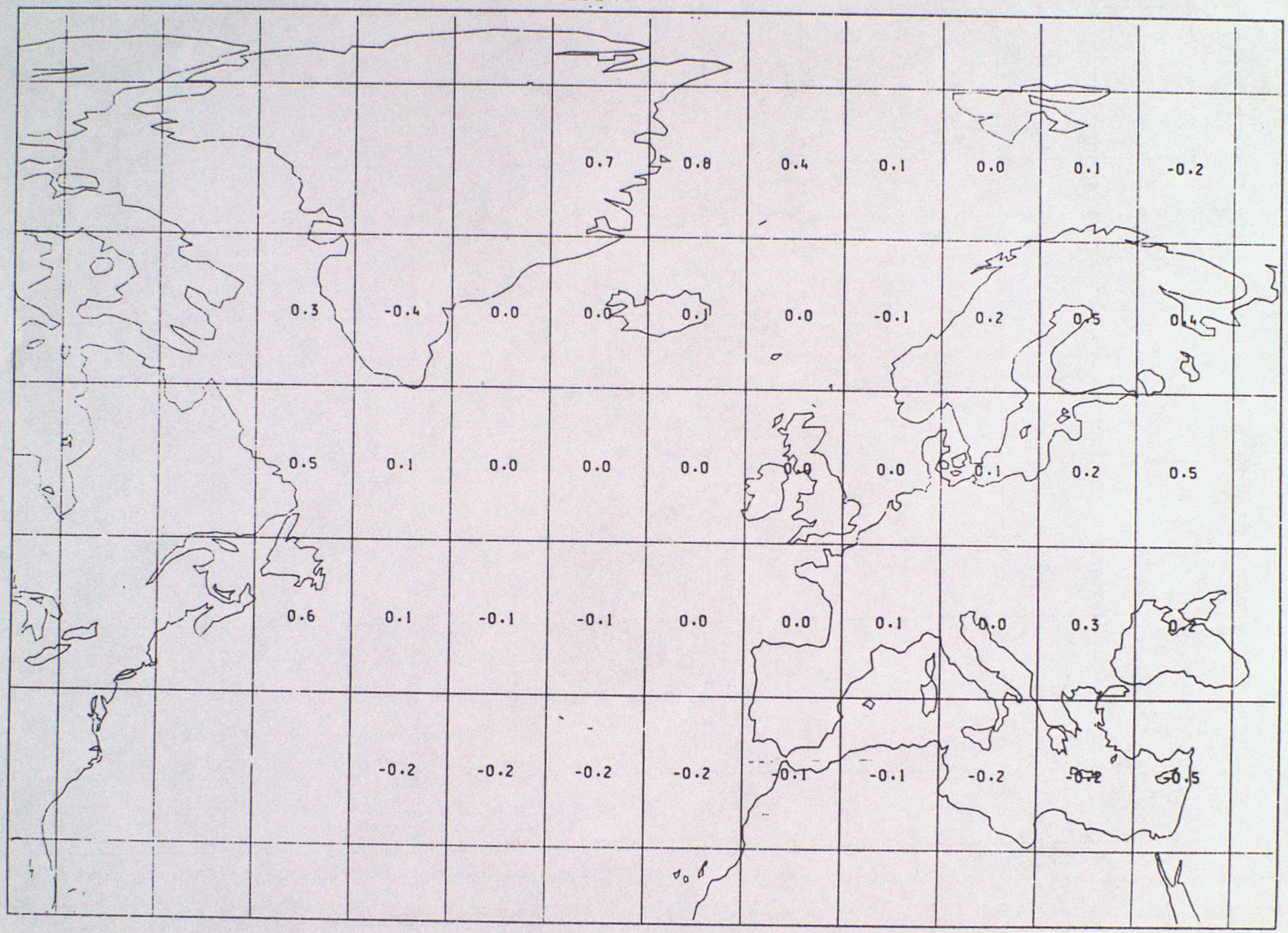

Figure 16

LASS : RMS O-B TEMPERATURE DIFFERENCES (DEG C) BETWEEN 500 AND 1000 HPA
1/12/91 TO 29/02/92
DATA FROM NOAA-11
VALUES ARE USED WHERE > 30 OBS ARE PRESENT

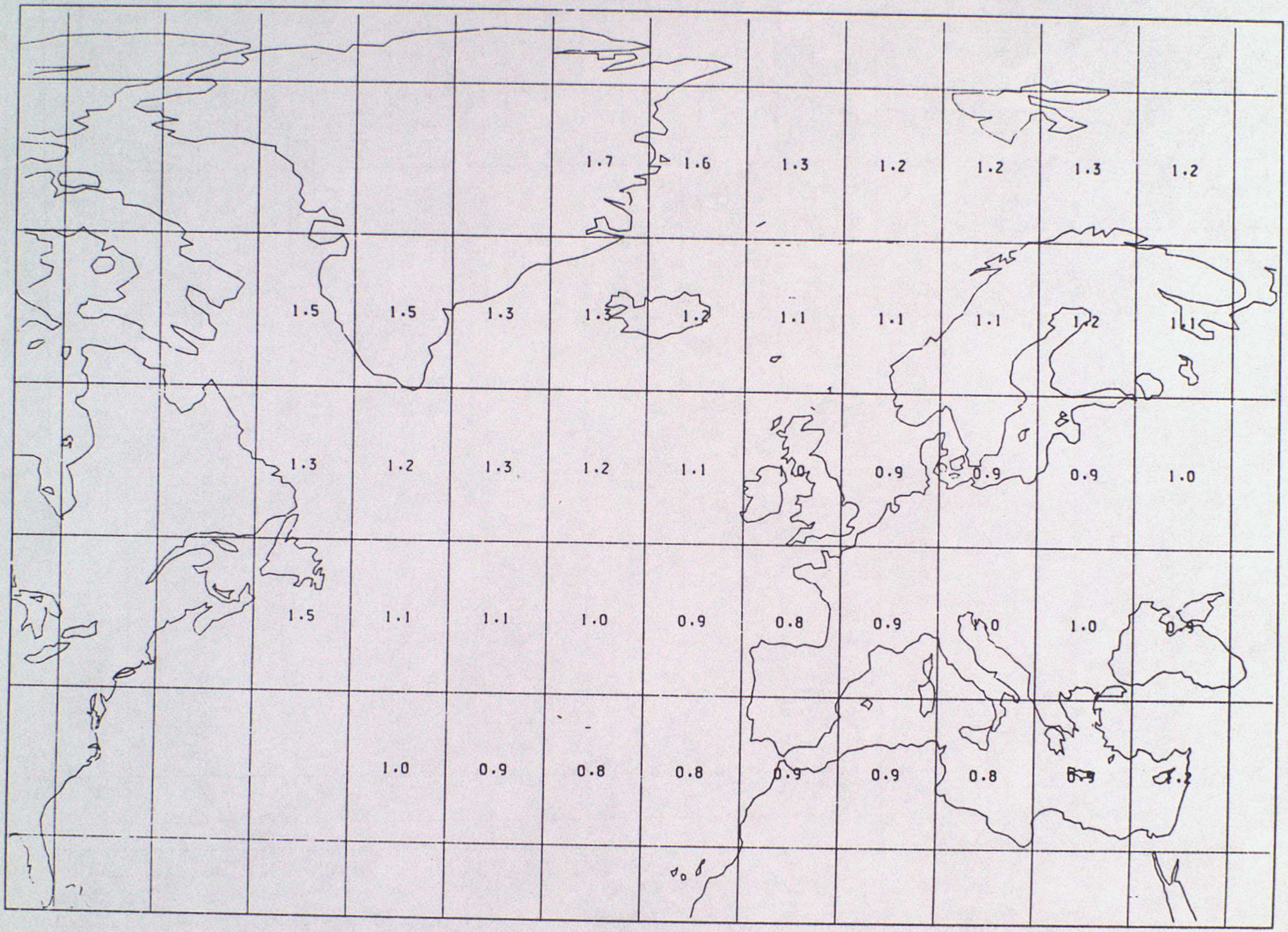

Figure 17

SATOB VECTOR MEAN WINDS BETWEEN 701-1000 HPA
1/12/91 TO 29/02/92
ALL OBSERVATIONS
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

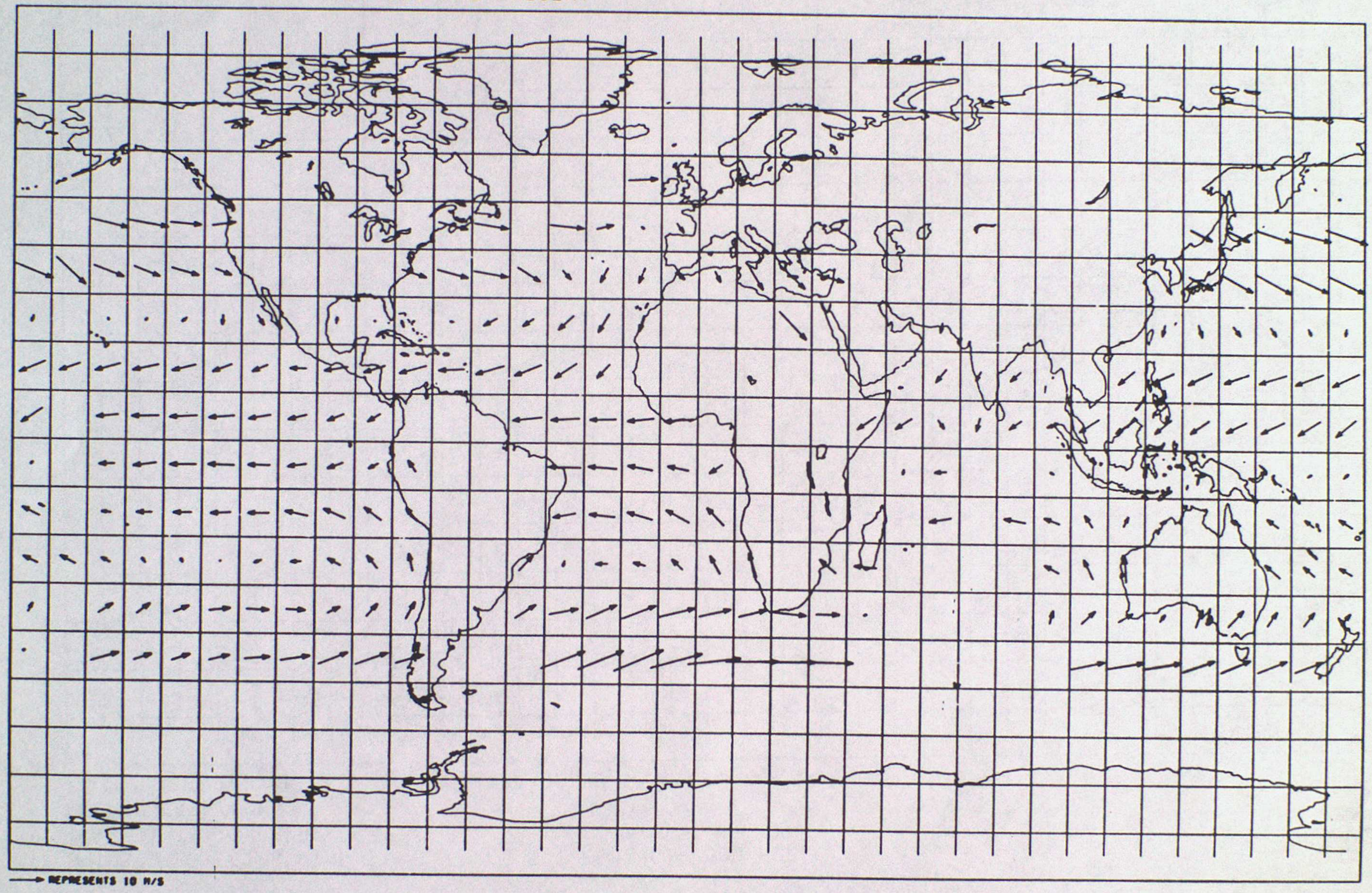

Figure 18

SATOB O-B VECTOR WIND DIFFERENCES BETWEEN 701-1000 HPA
1/12/91 TO 29/02/92
ALL OBSERVATIONS
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

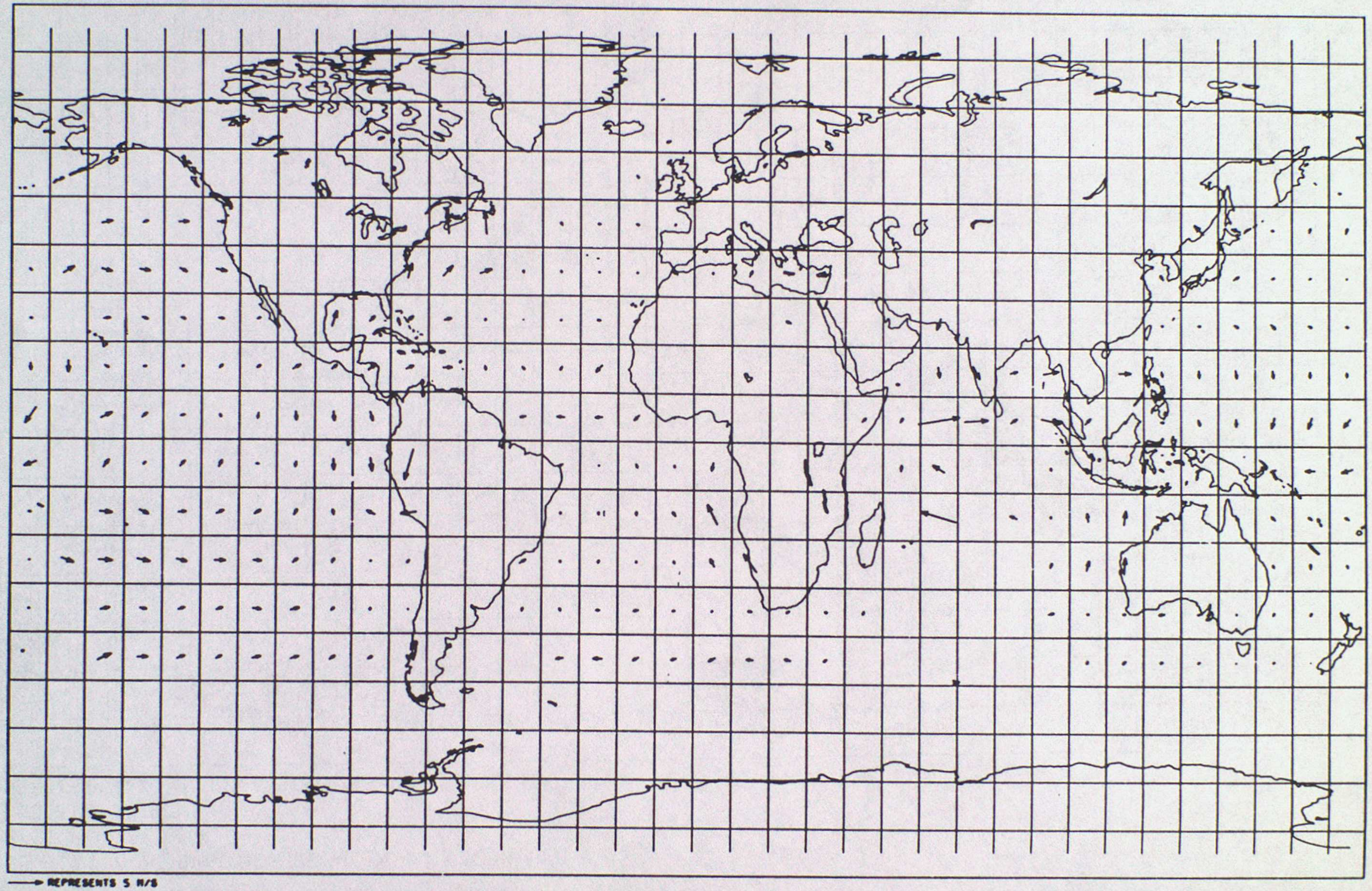

Figure 19

SATOBS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 701 AND 1000 HPA
1/12/91 - 29/2/92
ALL OBSERVATIONS
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

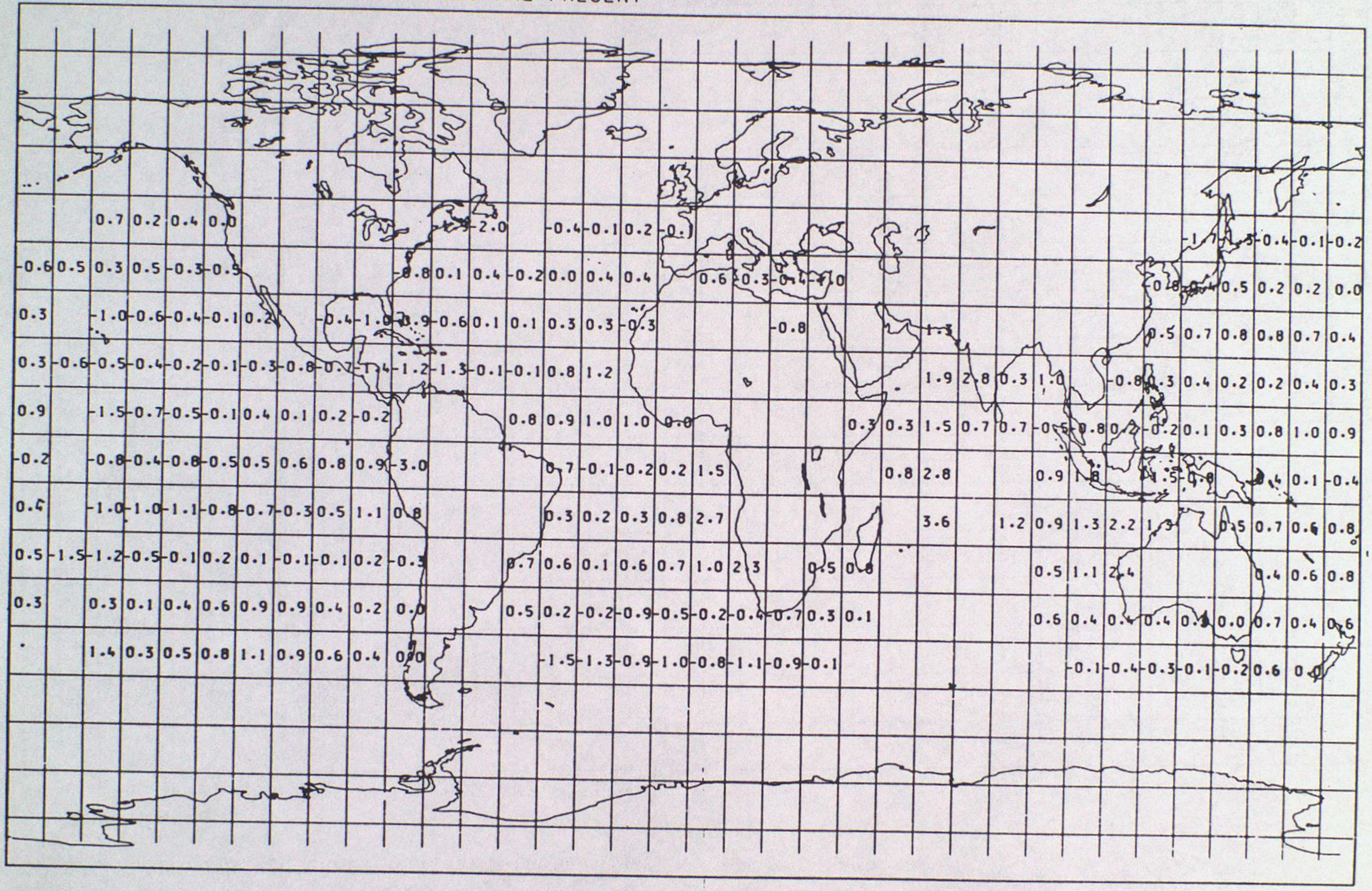

Figure 20

SATOBS : RMS O-B VECTOR DIFFERENCES (M/S) BETWEEN 701 AND 1000 HPA
1/12/91 - 29/2/92
ALL OBSERVATIONS
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

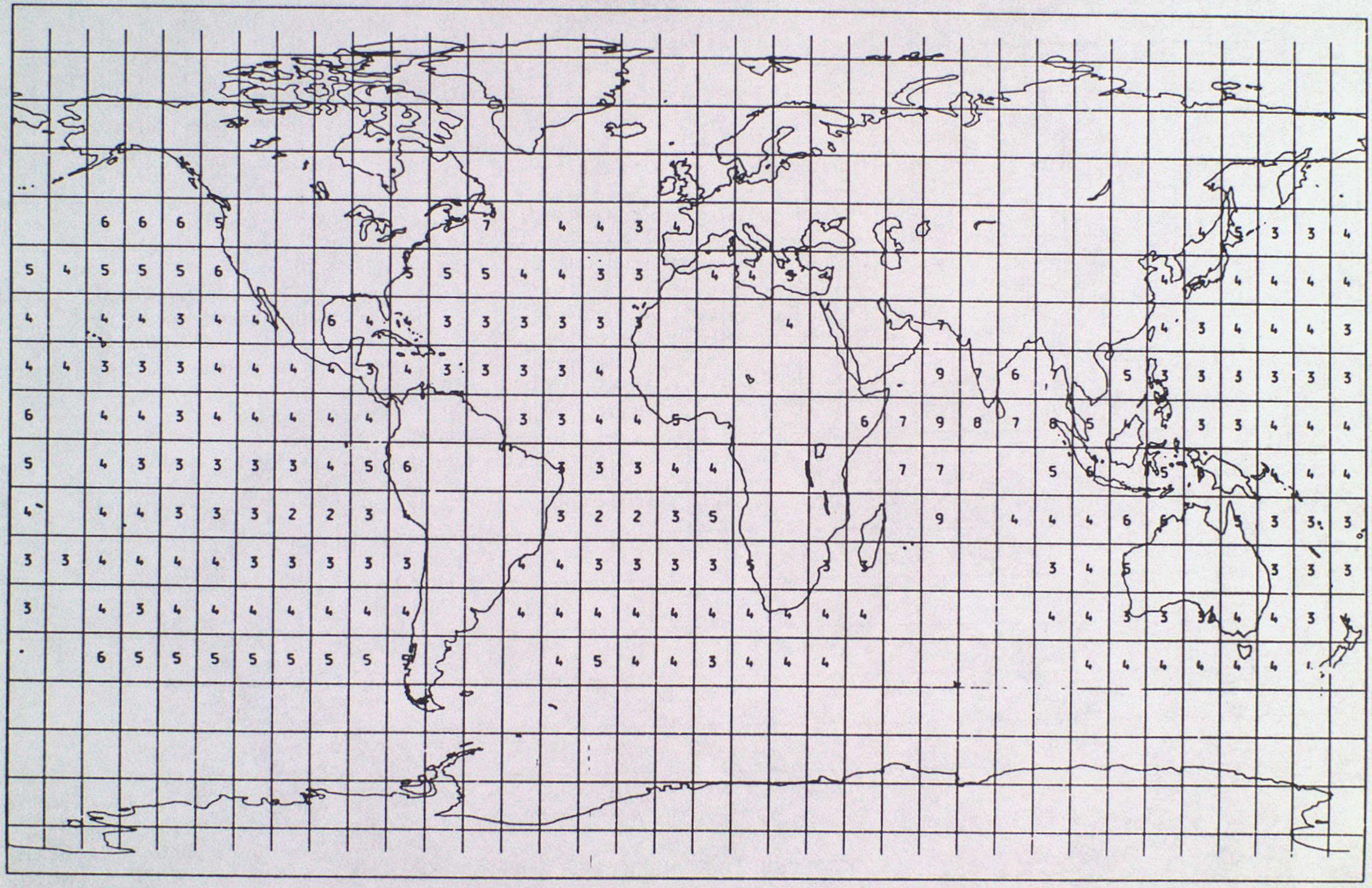

Figure 21

SATOB VECTOR MEAN WINDS BETWEEN 101-400 HPA
1/12/91 TO 29/02/92
ALL OBSERVATIONS
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

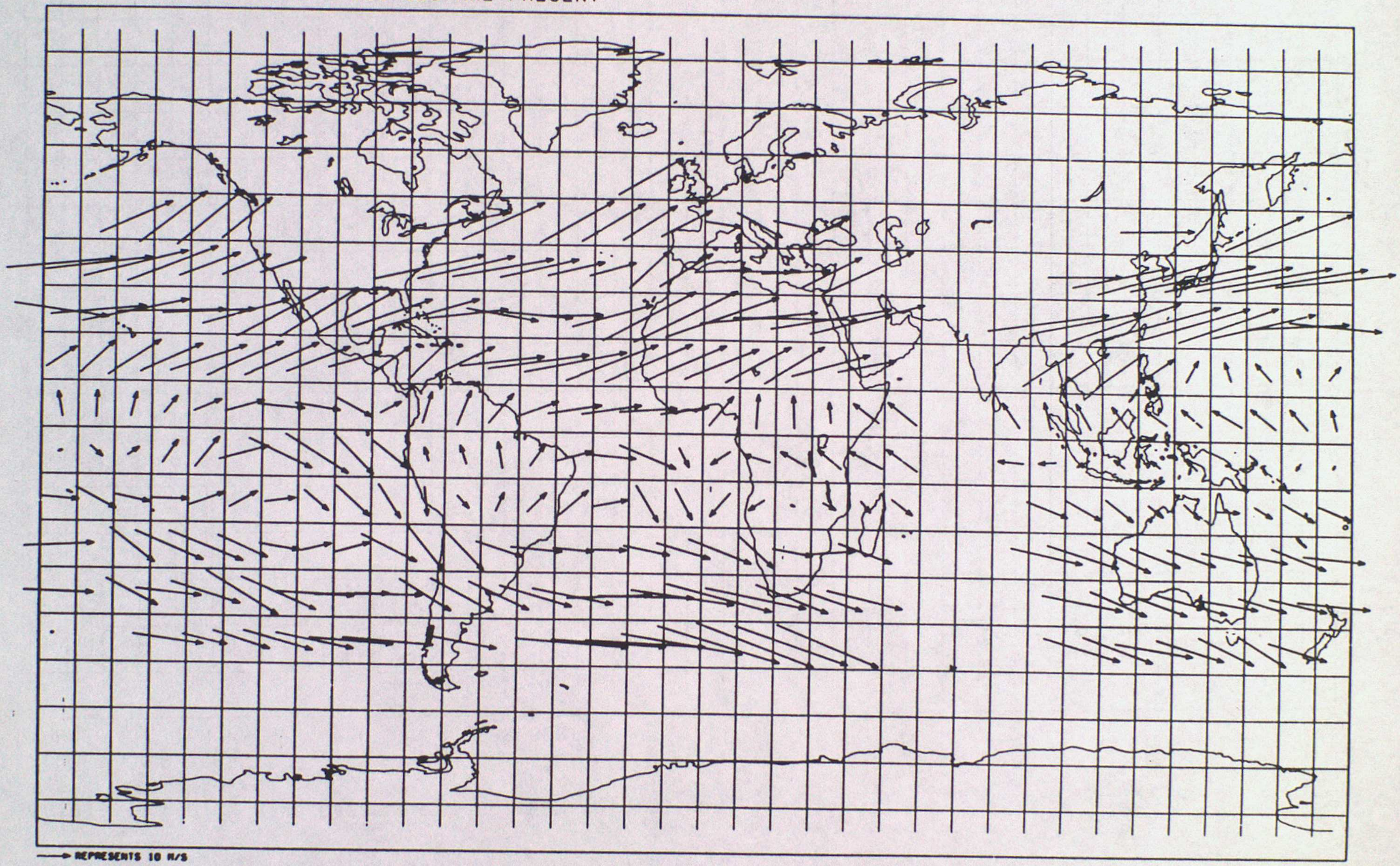

Figure 22

SATOB O-B VECTOR WIND DIFFERENCES BETWEEN 101-400 HPA
1/12/91 TO 29/02/92
ALL OBSERVATIONS
VALUES PLOTTED WHERE > 100 OBS ARE PRESENT

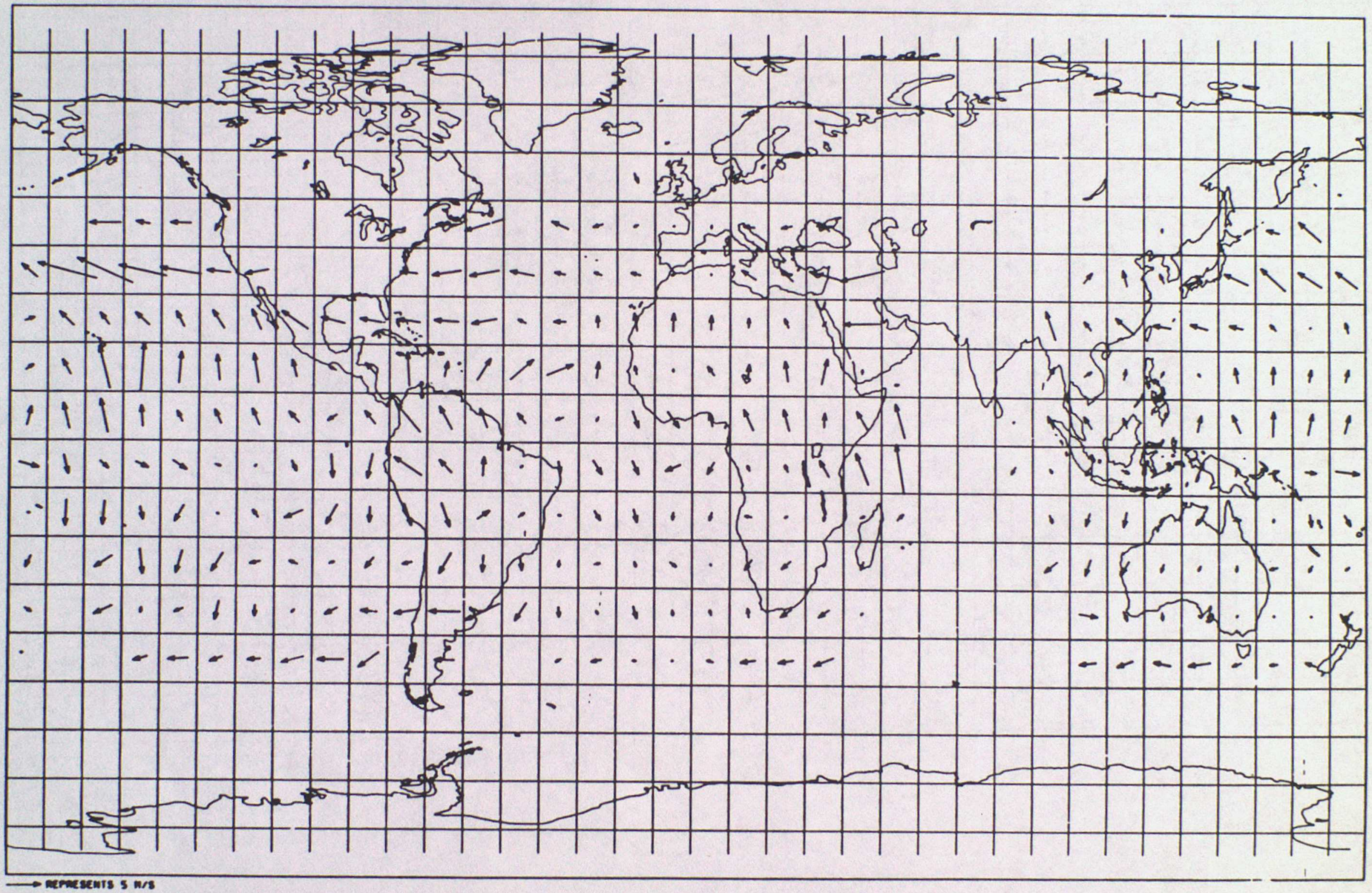

Figure 23

SATOBS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 101 AND 400 HPA
1/12/91 - 29/2/92
ALL OBSERVATIONS
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

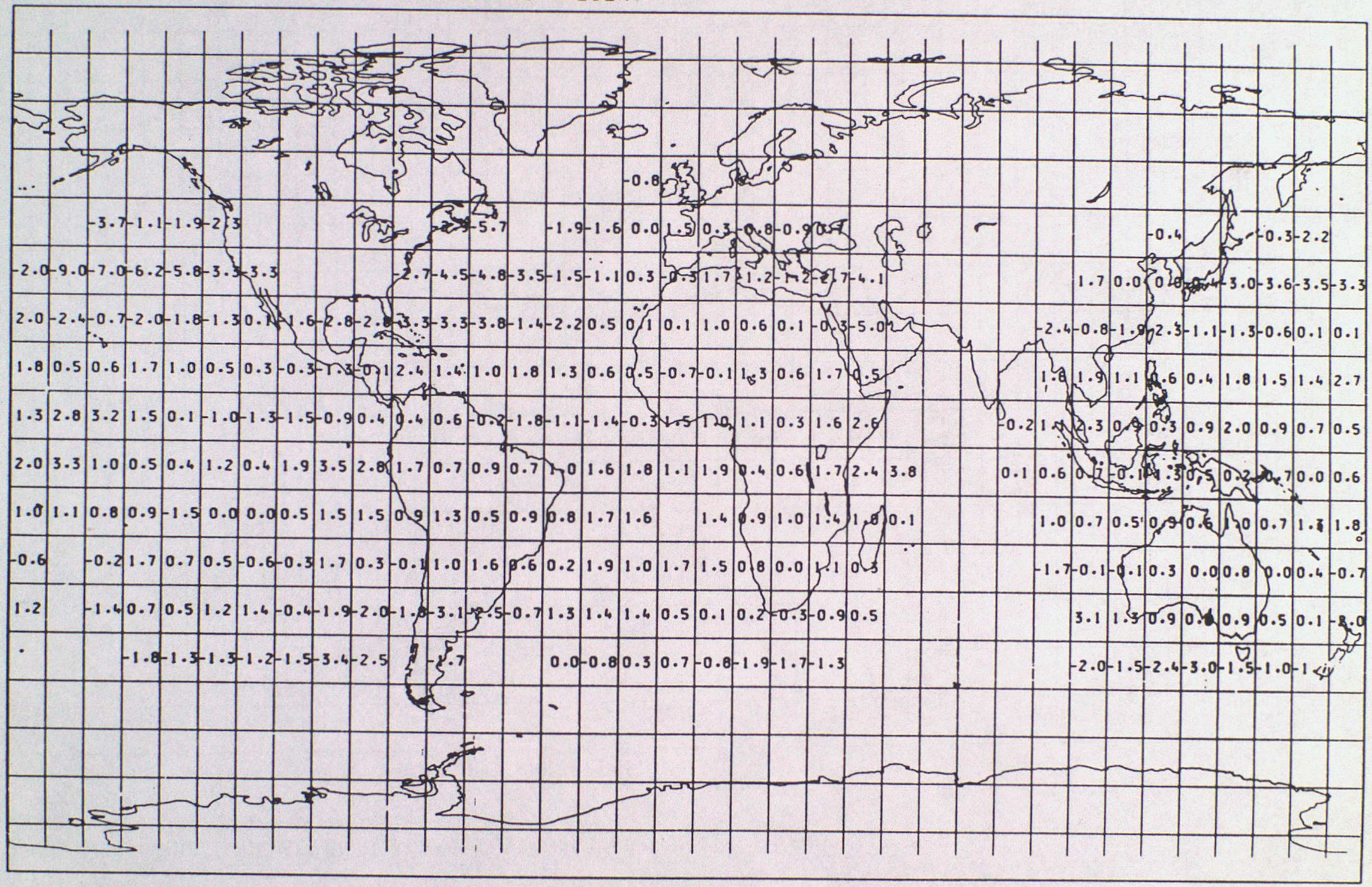

Figure 24

SATOBS : RMS O-B VECTOR DIFFERENCES (M/S) BETWEEN 101 AND 400 HPA
1/12/91 - 29/2/92
ALL OBSERVATIONS
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

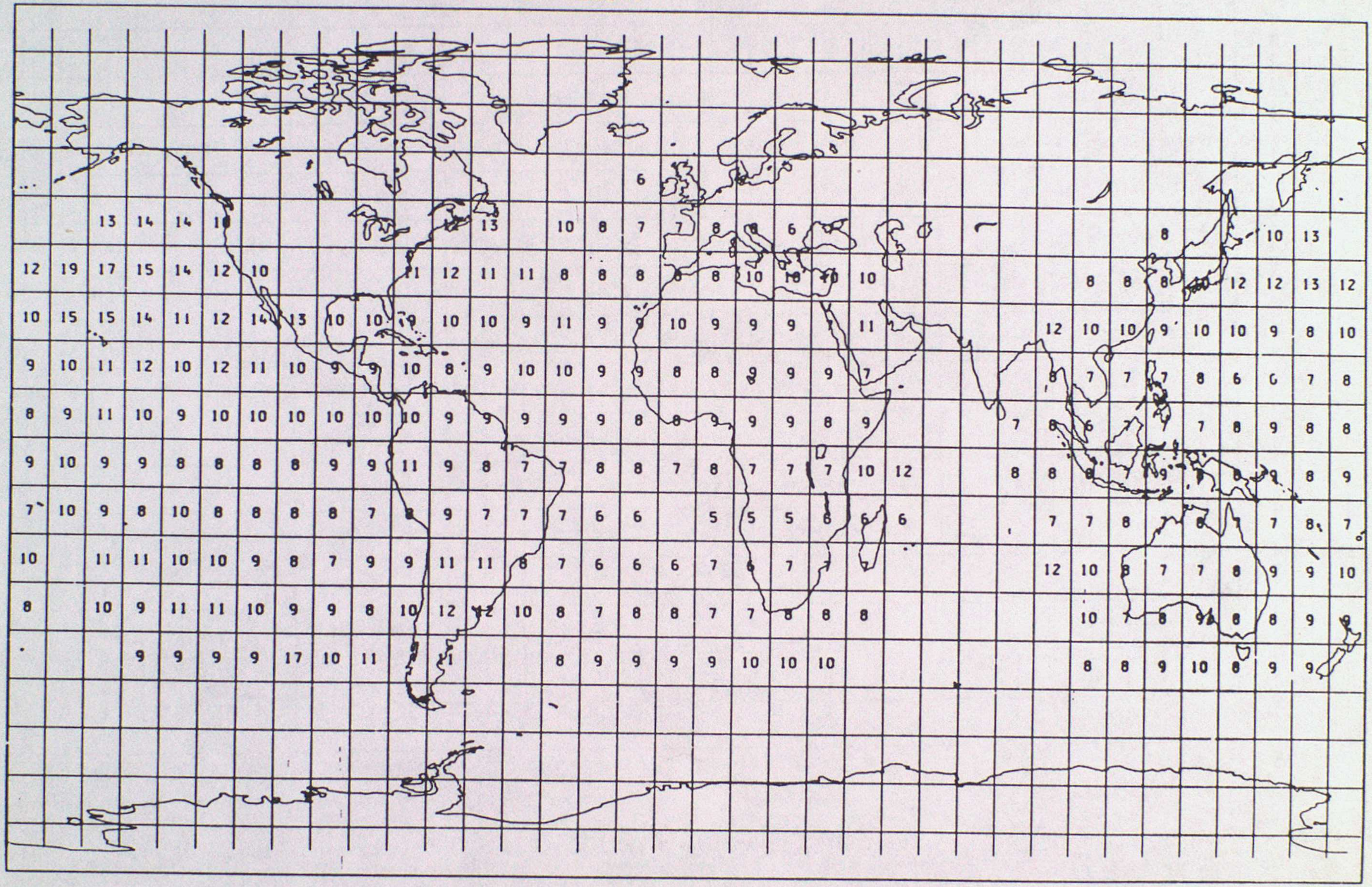

Figure 25

SONDES : O-B SPEED DIFFERENCES (M/S) BETWEEN 701 AND 1000 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

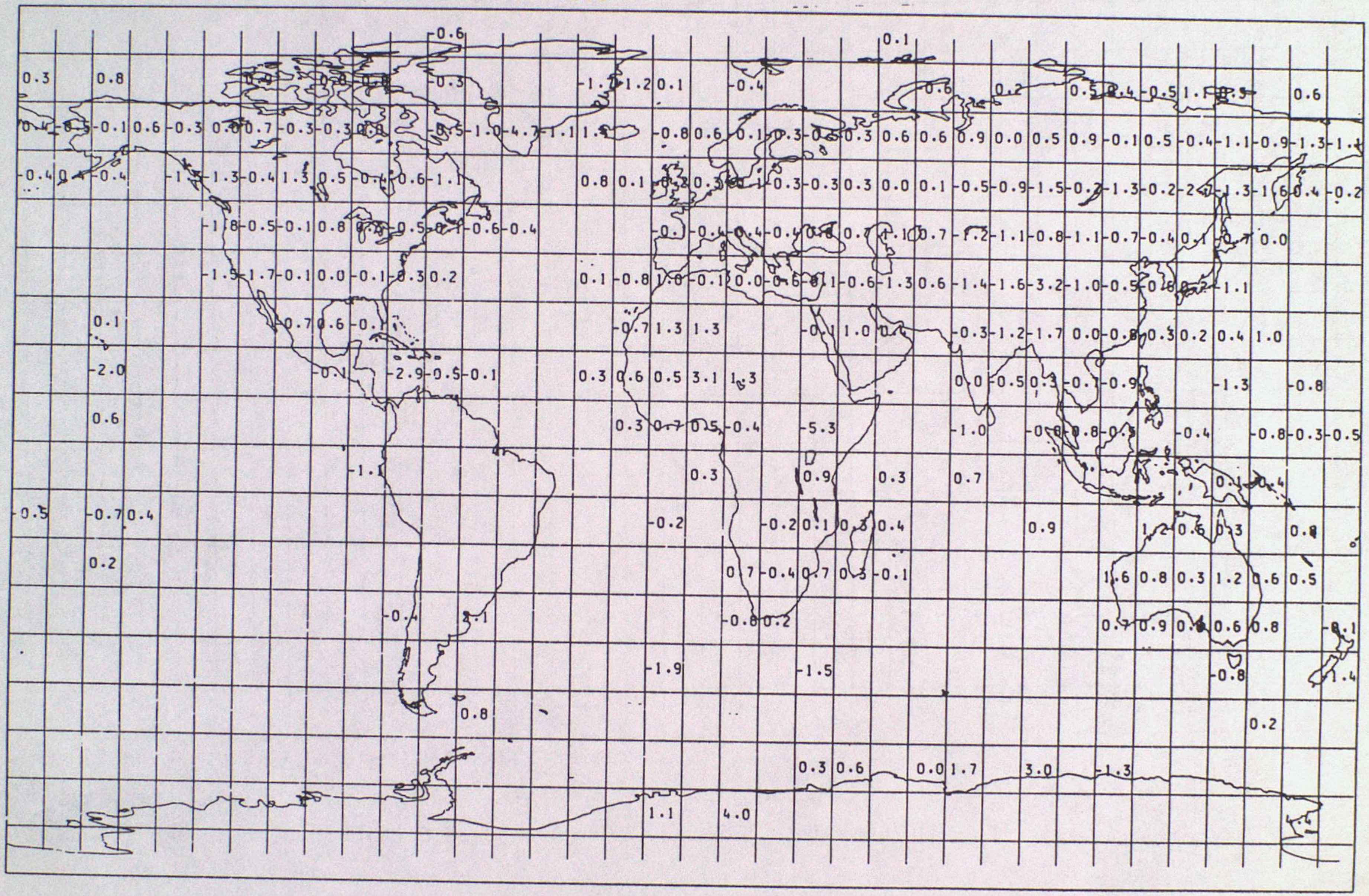

Figure 26

SONDES : RMS O-B VECTOR WIND DIFFERENCES (M/S) BETWEEN 701 AND 1000 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

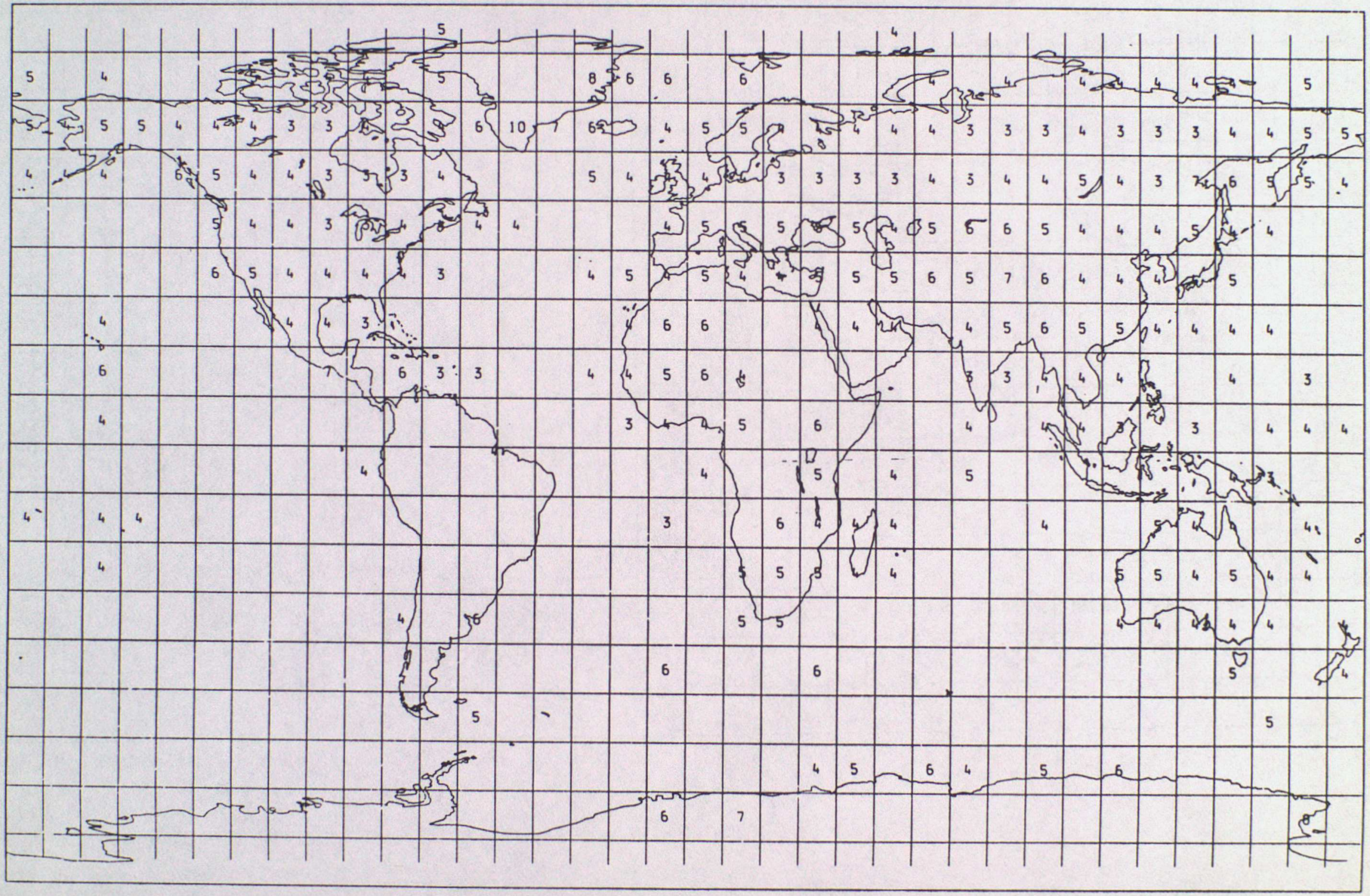

Figure 27

SONDES : O-B SPEED DIFFERENCES (M/S) BETWEEN 101 AND 400 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

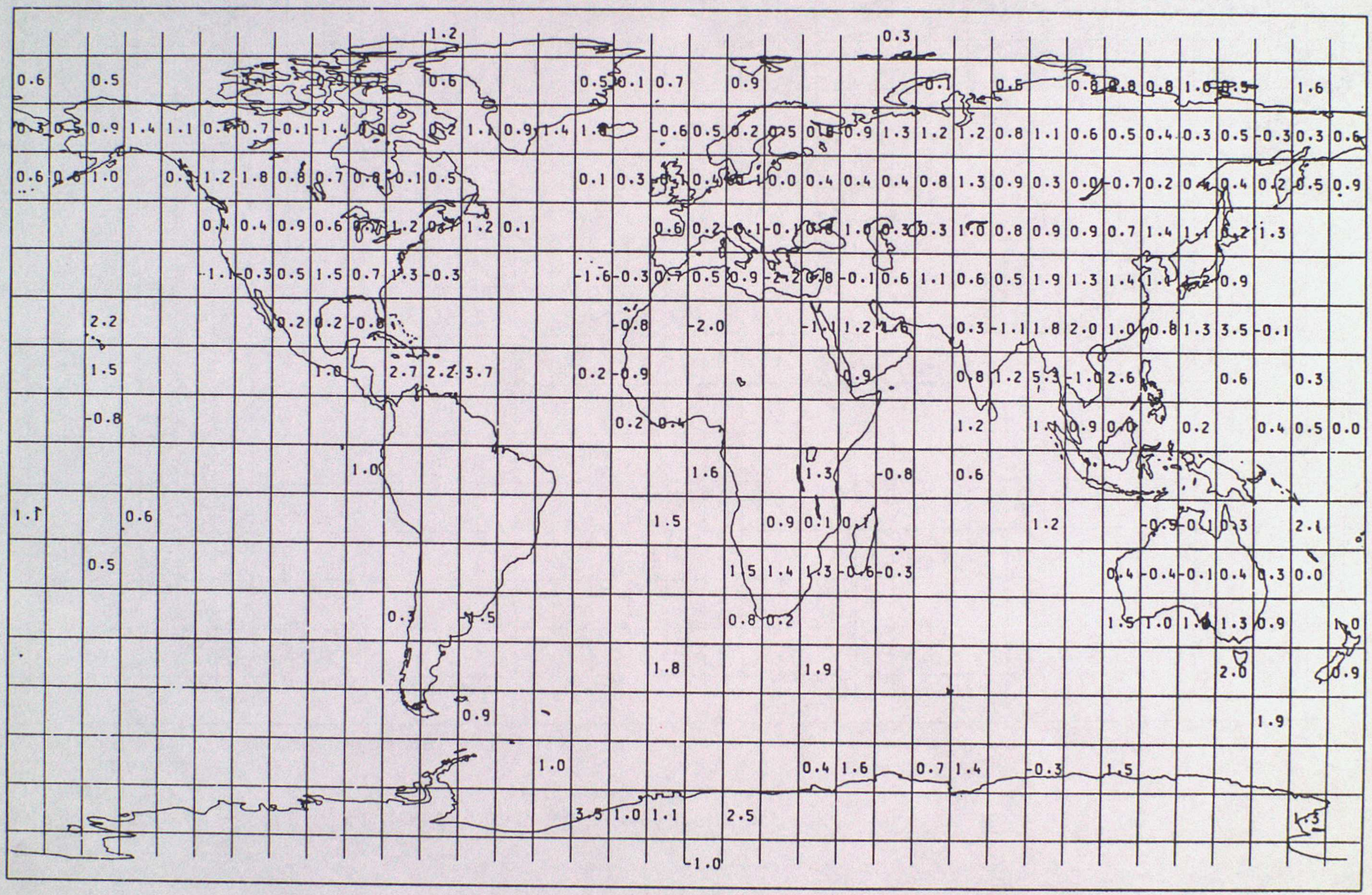

Figure 28

SONDES : RMS O-B VECTOR WIND DIFFERENCES (M/S) BETWEEN 101 AND 400 HPA
1/12/91 TO 29/02/92
QUALITY CONTROL APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

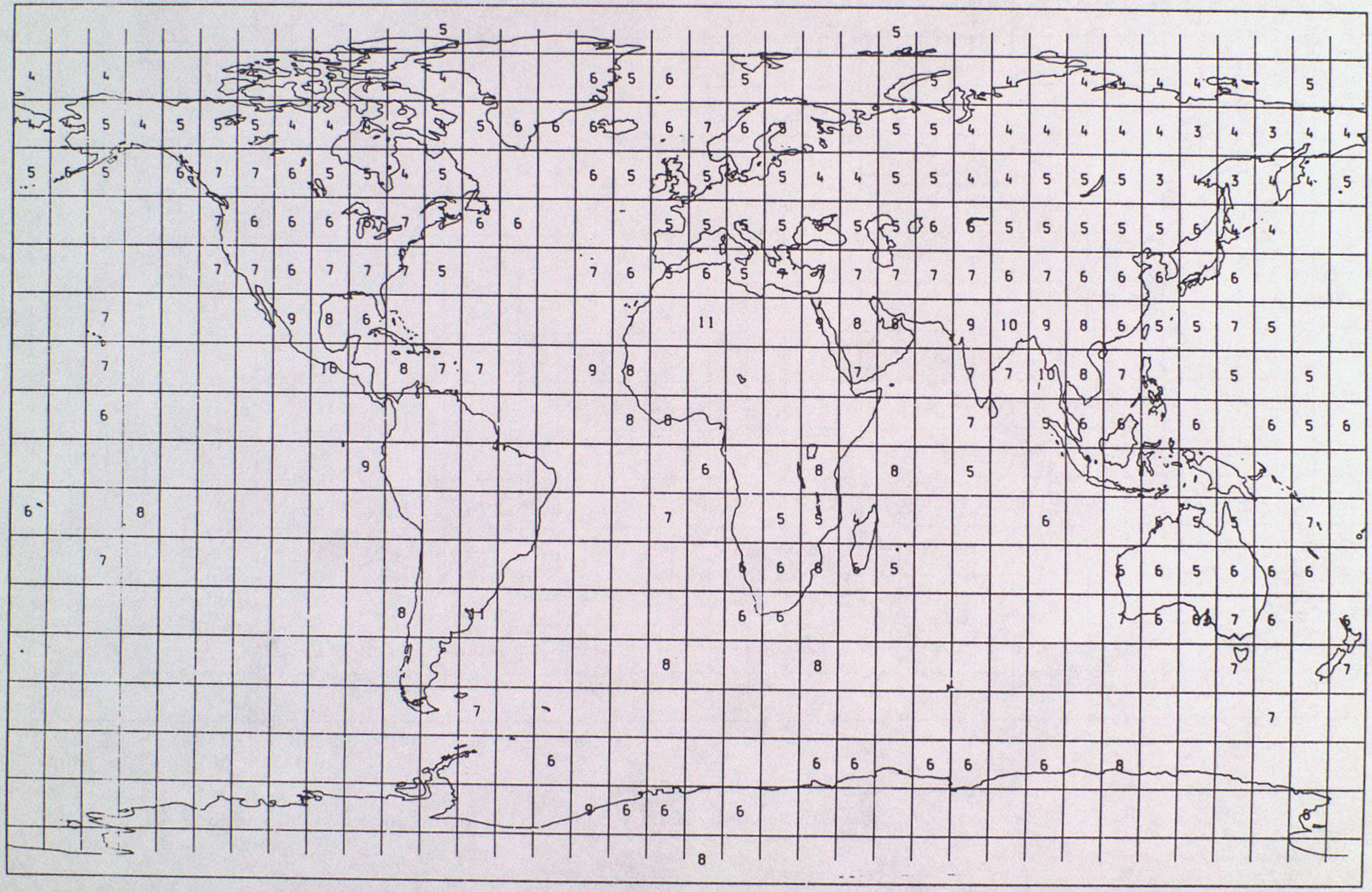

Figure 29

AIREPS : MEAN O-B SPEED DIFFERENCES (M/S) BETWEEN 100 AND 400 HPA
1/12/91 - 29/2/92
GROSS ERROR CHECK APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT

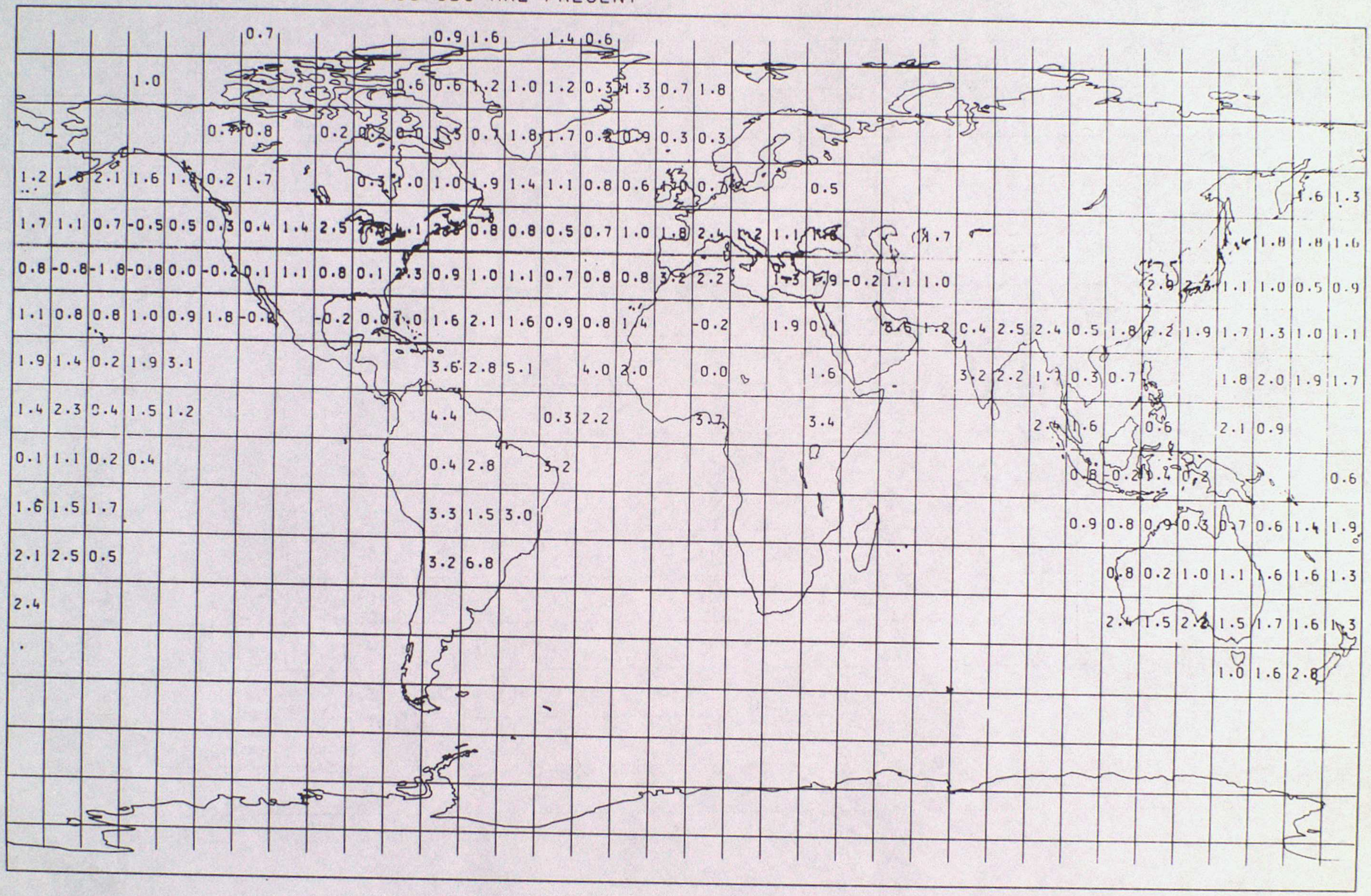

Figure 30

AIREPS : RMS O-B SPEED DIFFERENCES (M/S) BETWEEN 100 AND 400 HPA
1/12/91 - 29/2/92
GROSS ERROR CHECK APPLIED
VALUES ARE PRINTED WHERE > 100 OBS ARE PRESENT