MONITORING OF TOVS AND DMSP DATA

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1. INTRODUCTION

As part of its data monitoring activities, ECMWF undertakes regular monitoring of the availability and quality of temperature profile data derived from TOVS and DMSP measurements. This paper shows the main tools currently in use at ECMWF for this monitoring and gives results on the typical quality of the data. The importance of being well aware of their characteristics, either qualities or deficiencies, in order to optimize their use in the data assimilation is demonstrated by Andersson et al. (1989). The aspects related to their quality control before and during the analysis are described in the papers by Lönnberg and Kelly et al. (1989).

2. OPERATIONAL ASPECTS

At the moment, ECMWF receives data from four satellites, NOAA-10, NOAA-11, DMSP-8 and DMSP-9. Data from NOAA satellites are received on the GTS in 500 km resolution, and in binary code through a special link between NMC and UKMO in 250 km resolution (the 250 km data are considered in the following).

The data coverage is plotted for every analysis time (6 hour intervals), which allows a quick detection of most telecommunication problems. Table 1 gives the list of such problems since January 1987.

Table 1: Data problems due to communication or encoding

1 - 2 January 1987	Earth location error
16 Sep - 8 Oct 1987	Following protocol changes on the NMC-UKMO link, 250 km TOVS data not available
1 - 4 January 1988	Earth location error (shifted 1 deg. east)
7 - 10 February 1989	Communication problem in US, no DMSP data
18 - 27 April 1989	Occasional corruption of all incoming data

Concerning the quality of the data, from time to time part or all of the data become suddenly affected by some problem which also requires a prompt detection to suppress the data from the assimilation and inform the data producer (table 2).

Table 2: Quality problems

January 1987	NOAA-9 and NOAA-10 soundings incompatible; retrieval problems over Asia and Europe
February 1987	NOAA-9 MSU channel 3 erratic
9 March 1987	NOAA-9 soundings production halted (channel 2 lost)
3 - 11 August 1987	NOAA-10 had warm 50-30 hPa bias over Antarctica (problem resolved by update of coefficients at NESDIS)
August 1988	Occasional random errors in DMSP-8 data

3. QUALITY MONITORING

Besides the detection of occasional problems as listed above, the data quality is assessed regularly by cross-comparisons with radiosonde observations and with the ECMWF analysis and 6-hour forecast (first-guess). Obviously none of these comparisons involve completely independent data, but nevertheless they have proved valuable for both trouble shooting and assessing the typical characteristics of the data (Hollingsworth et al. 1986).

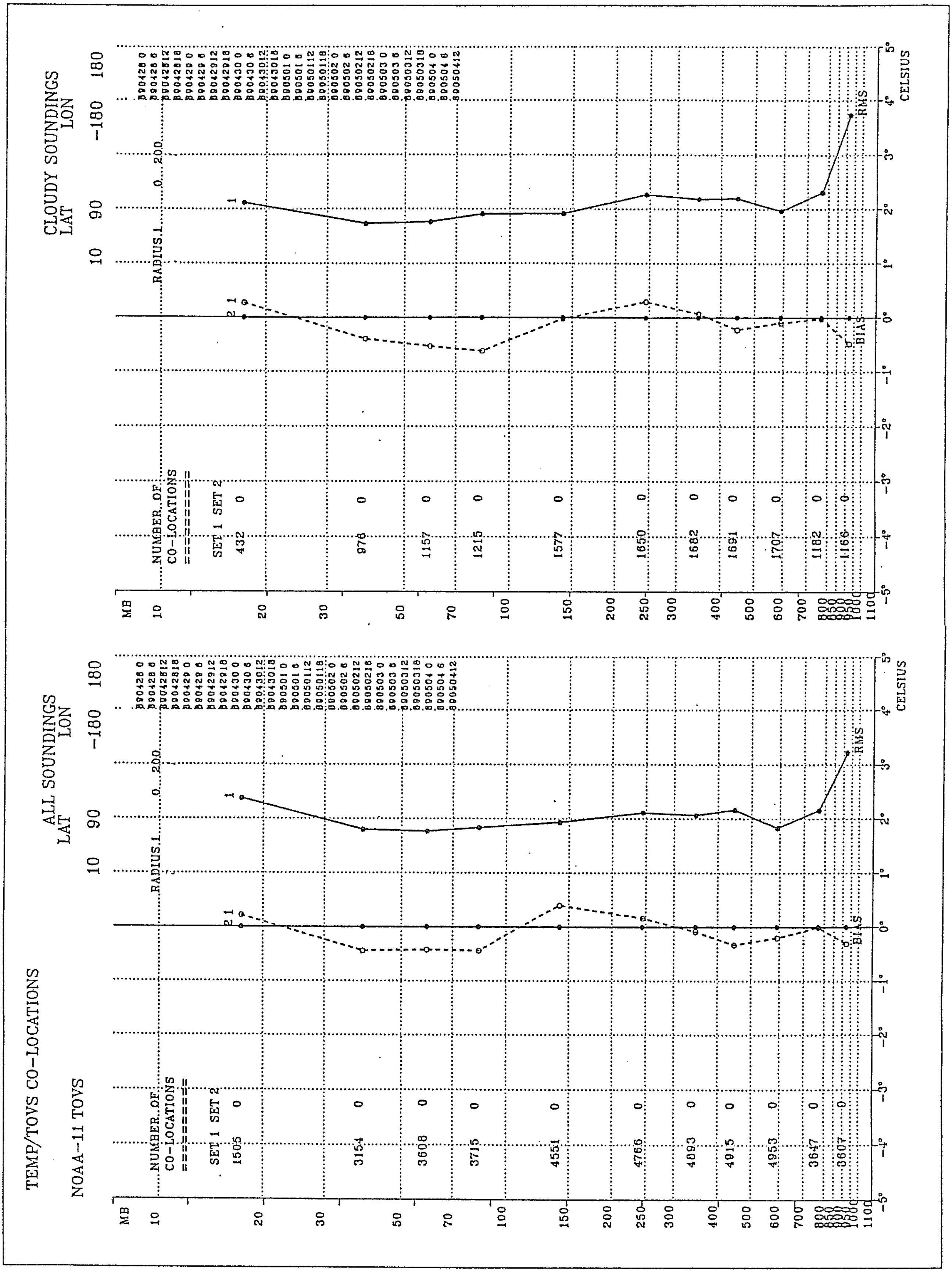

Fig. 1a: NOAA-11, all soundings

Fig. 1b: NOAA-11, MSU soundings

Fig. 1: TEMP/TOVS collocation statistics of mean layer temperatures for the week 28 April to 4 May 1989

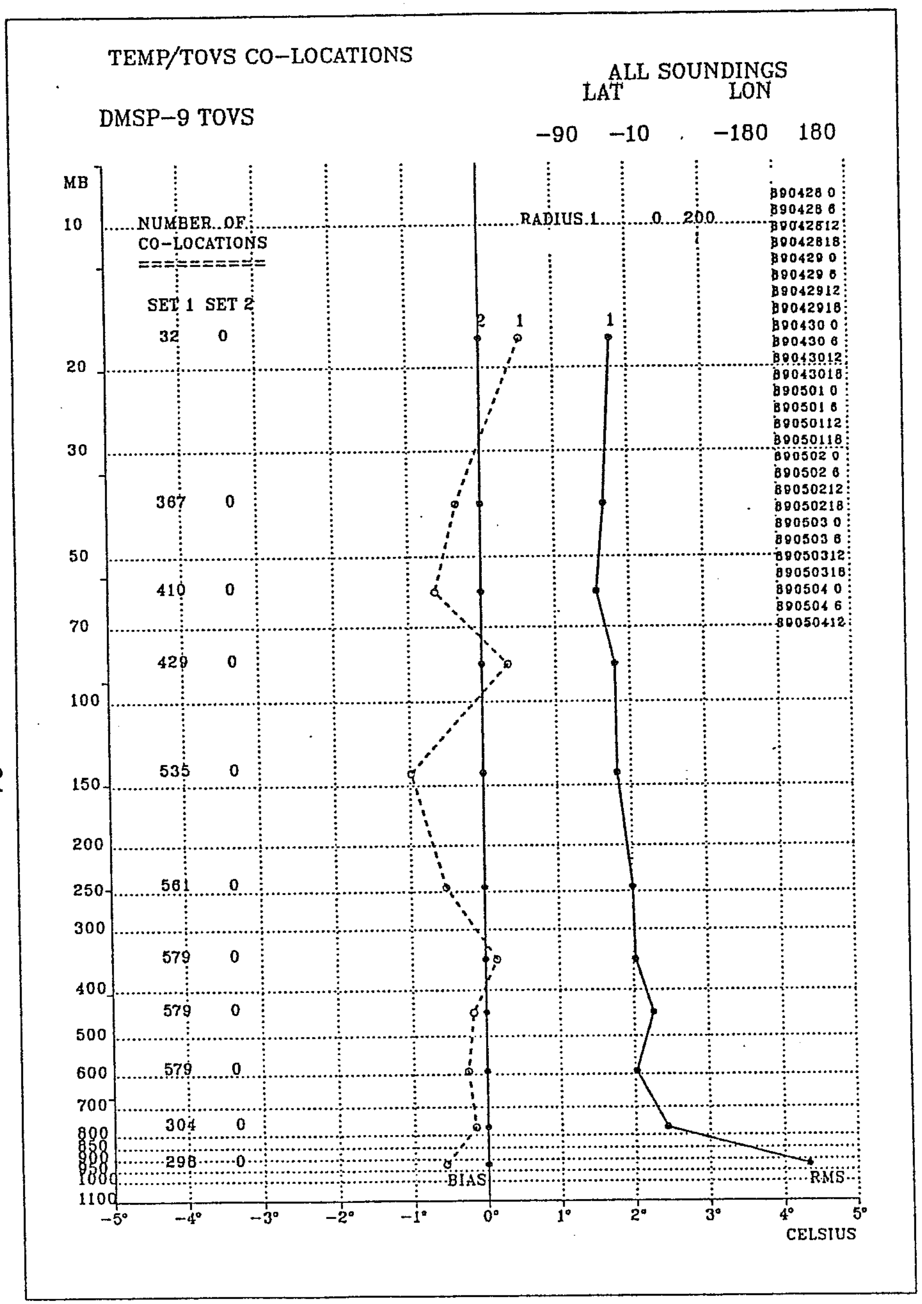

Fig. 1c: DMSP-9

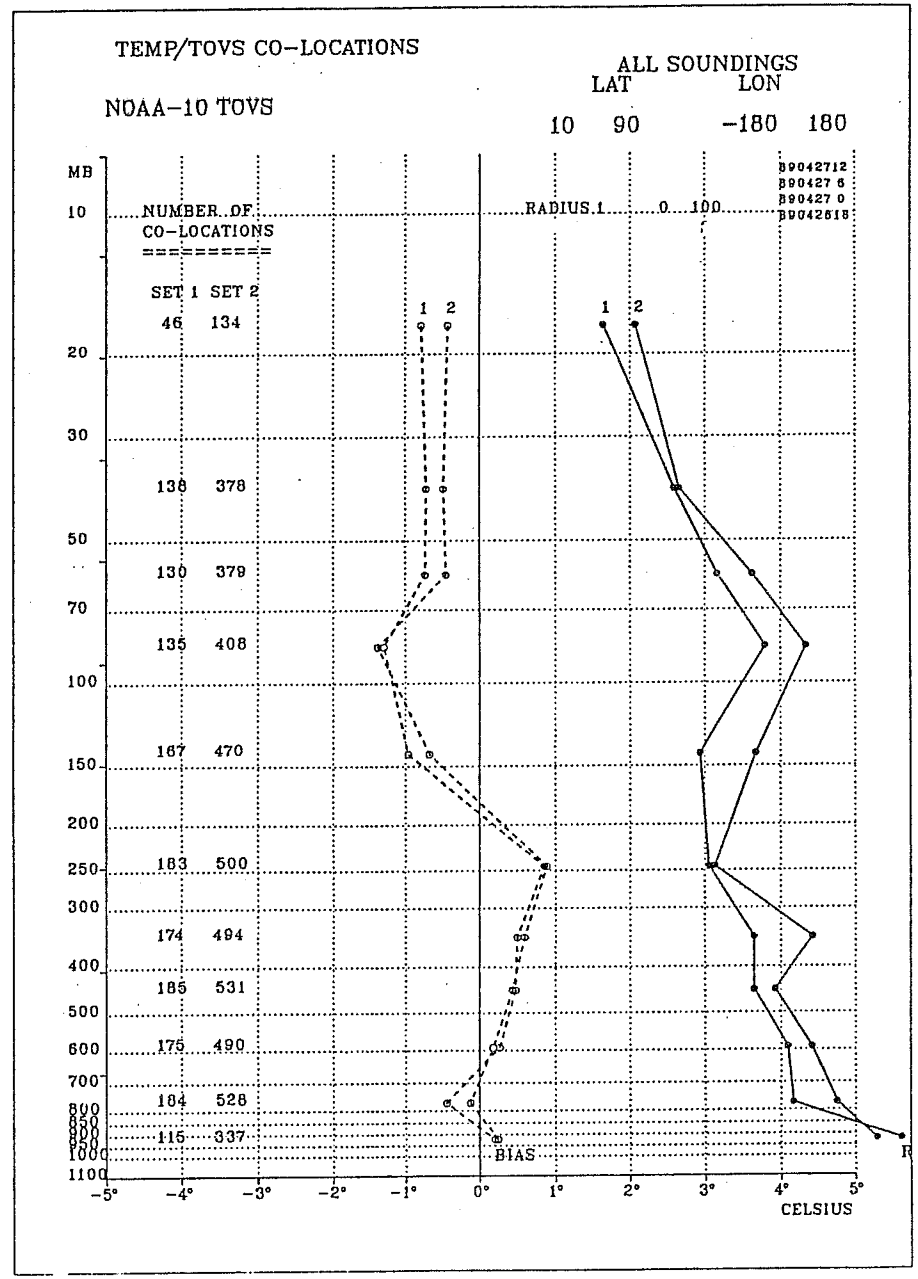

Fig. 2: As Fig. 1 for NOAA-10, 26 April, 18 UTC, to

3.1. COLLOCATIONS WITH RADIOSONDE DATA

Fig. 1 shows 3 typical plots of vertical profile of collocation statistics between radiosondes and satellite data, for the week 28/4 - 4/5/1989. The data are collected within 200 km around the location of each radiosonde station, sample sizes are given on the left. For the NOAA satellites, all sounding types together (fig. 1a), the bias is very small, below 0.5 K, and the RMS error is around 2 K in the mid-troposphere and 3.5 near the surface; for cloudy soundings (fig 1b), the values are generally larger near the surface. For DMSP satellites, fig. 1c shows a much larger RMS in the lowest layer, up to 4.5 K; also in the mid troposphere the bias is often larger. In contrast, fig. 2 is an example of a collocation profile very different from normal. It is for NOAA-10 on one day during the period in April 1989 when the data were corrupted by telecommunication problems in the US (cf table 1 above).

A complete set of profiles for the 4 satellites currently received is produced every day. When an unusually large value is found, the problem is looked into with geogaphical charts showing the collocated data and the analysed field at the corresponding levels.

3.2. COMPARISONS WITH THE FIRST-GUESS

At the moment, the TOVS and DMSP data are compared routinely to the ECMWF first-guess in two different ways: monthly, to assess the systematic deficiencies in the quality of the data, and over other time scales to monitor the stability check recently put in operations.

3.2.1. Monthly statistics, mean departure from first-guess.
Figures 3 to 6 show the monthly mean values for April 1989 of the observation departures from the first-guess, averaged over 5-degree squares, for selected levels and sounding types (the values are in tenths of degree; corrupt data received after 18 April are excluded). The satellite presented here is NOAA-11, but the results for NOAA-10 are very similar. The main features are:

(i) in the upper troposphere (fig. 3), the bias is generally very small, less than 1 degree in absolute value;

(ii) in the lowest layer (1000/850 hPa, fig. 4 and 5), the bias is much larger. It shows a strong regional dependence, with characteristic maxima in the subtropical highs. It is largest for the cloudy soundings,

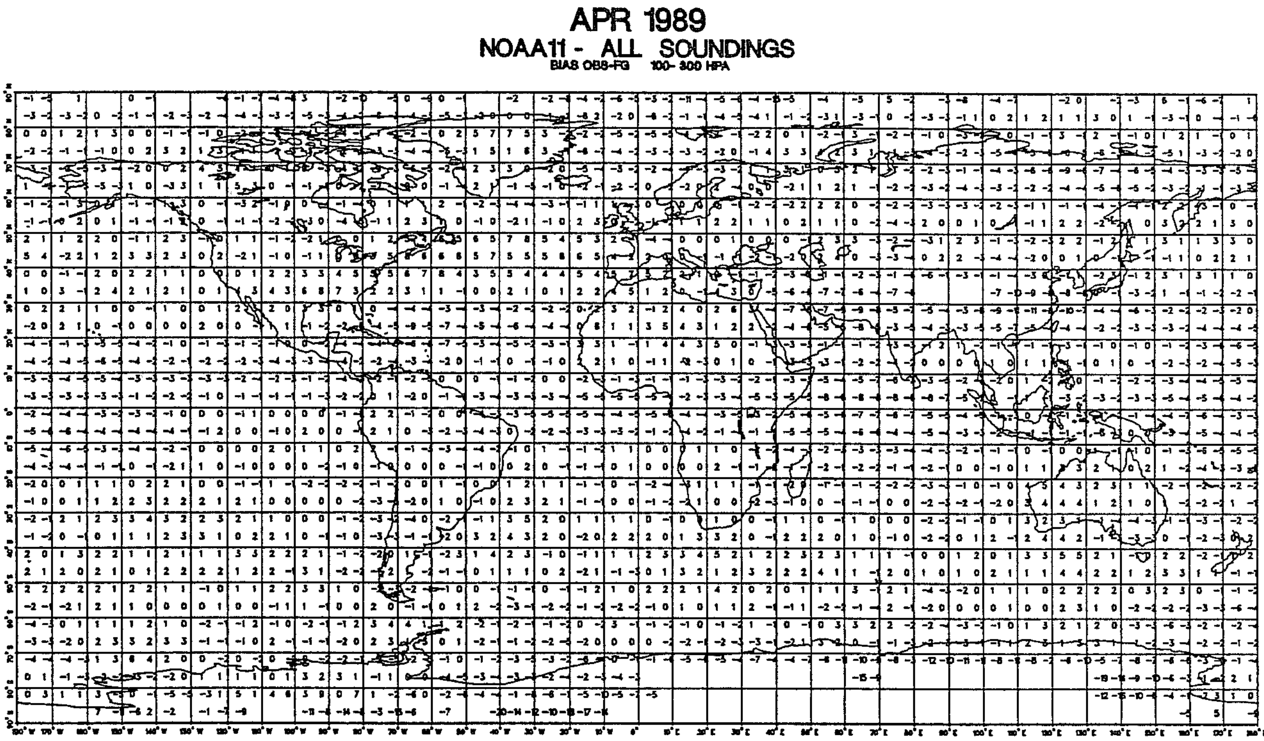

Fig. 3: Mean observed minus first-guess differences of mean 300/100 hPa layer temperatures from NOAA-11 for April 1989. Statistics are averaged over latitude/longitude boxes of 5 x 5 degrees; unit: degree/10

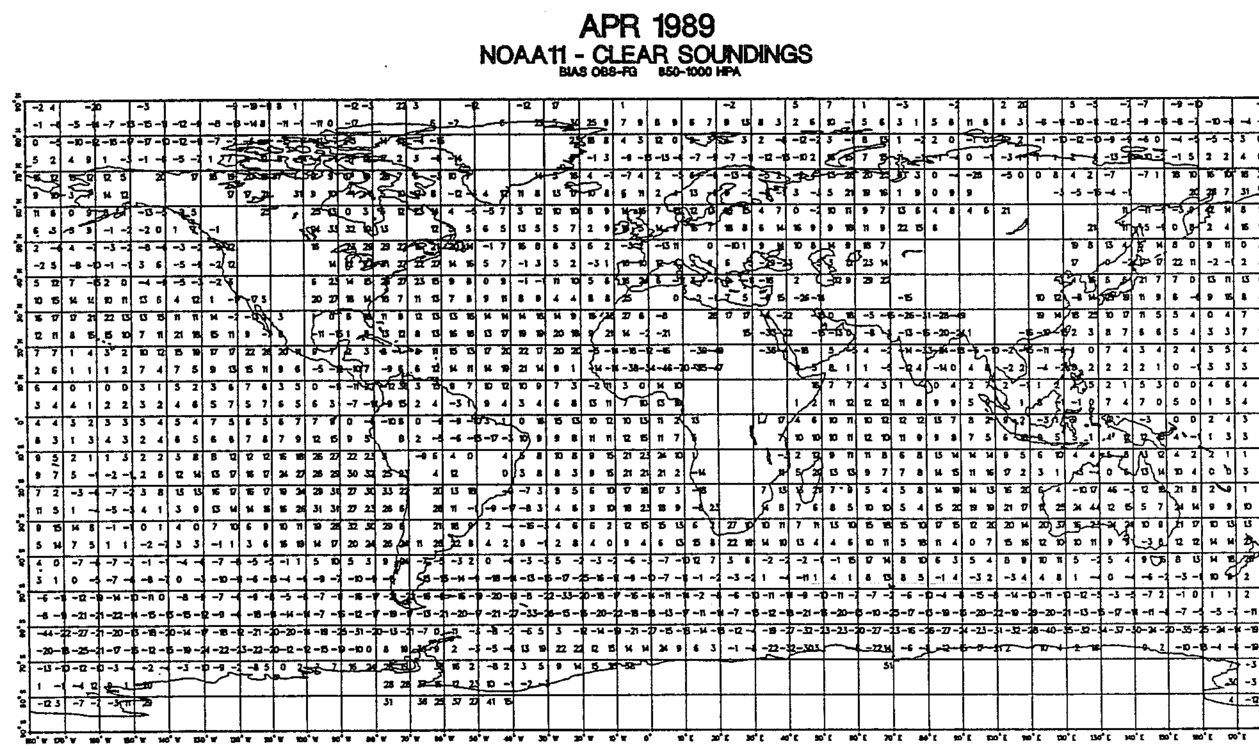

Fig. 4: As Fig. 3 for layer 1000/850 hPa, clear soundings

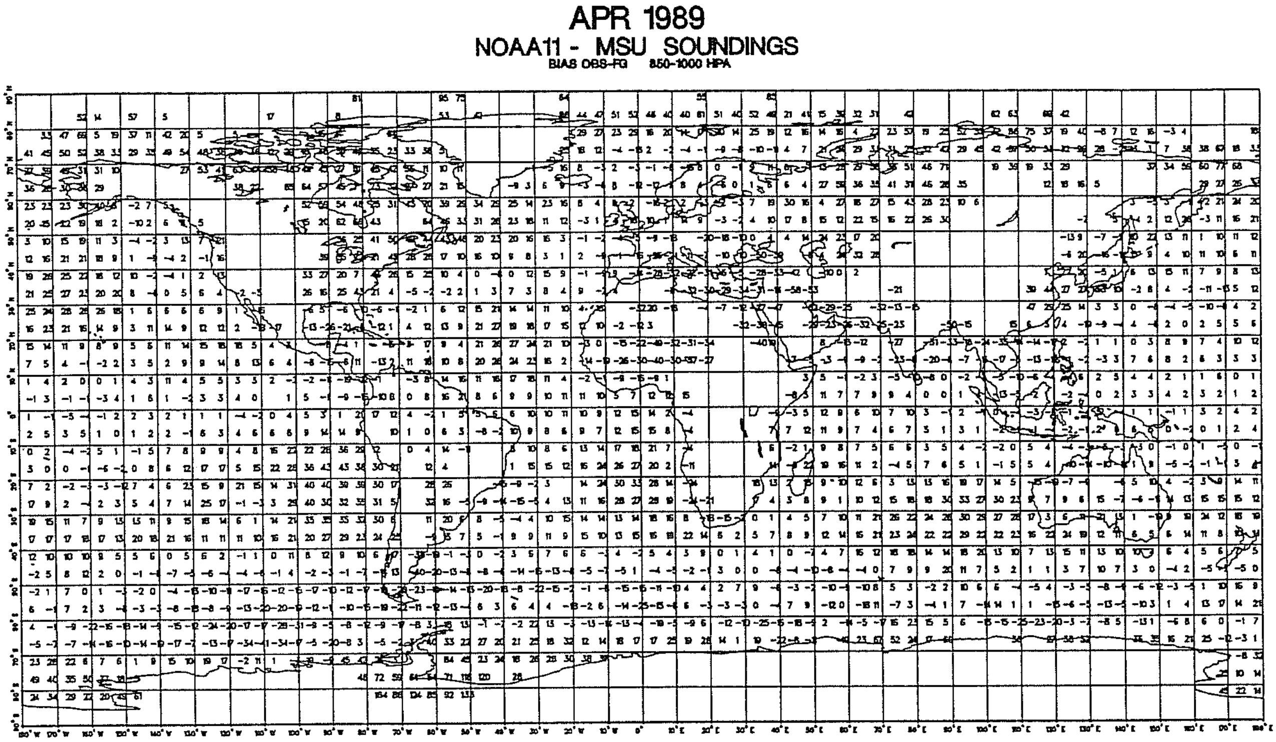

Fig. 5: As Fig. 3 for layer 1000/850 hPa, MSU soundings

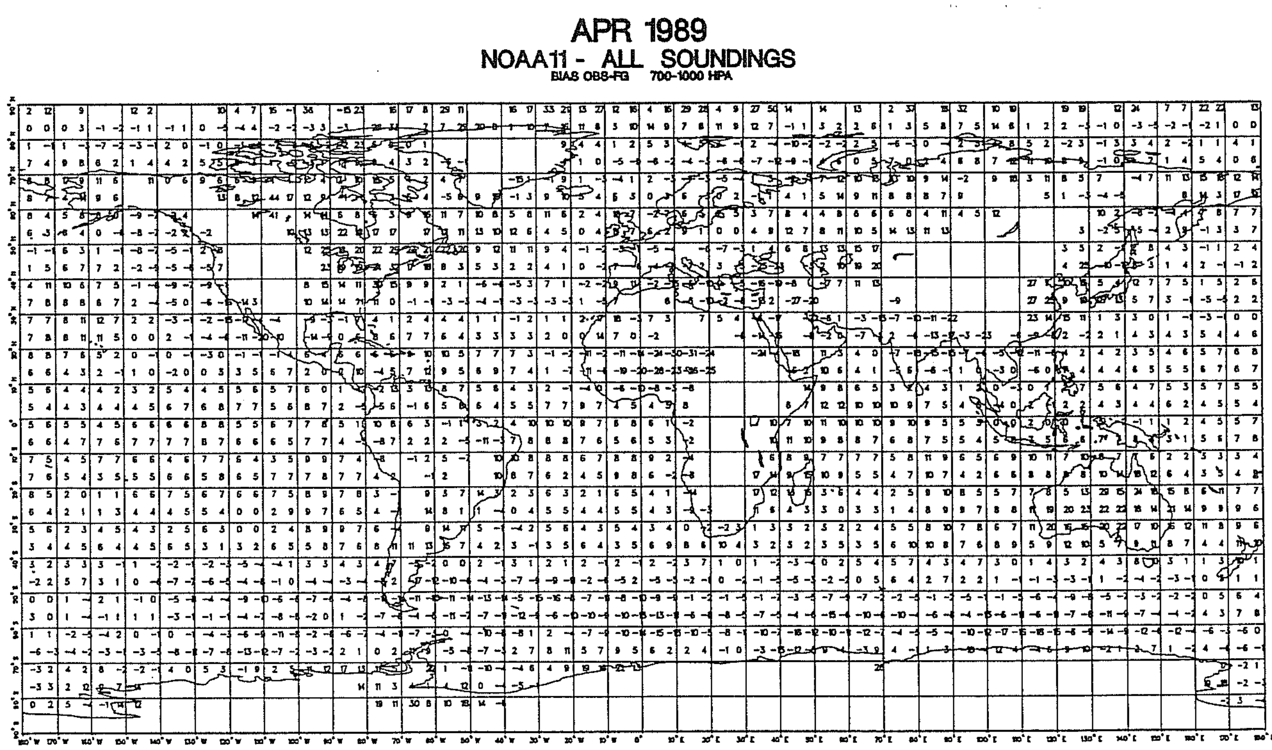

Fig. 6: As Fig. 3 for layer 1000/700 hPa, all soundings

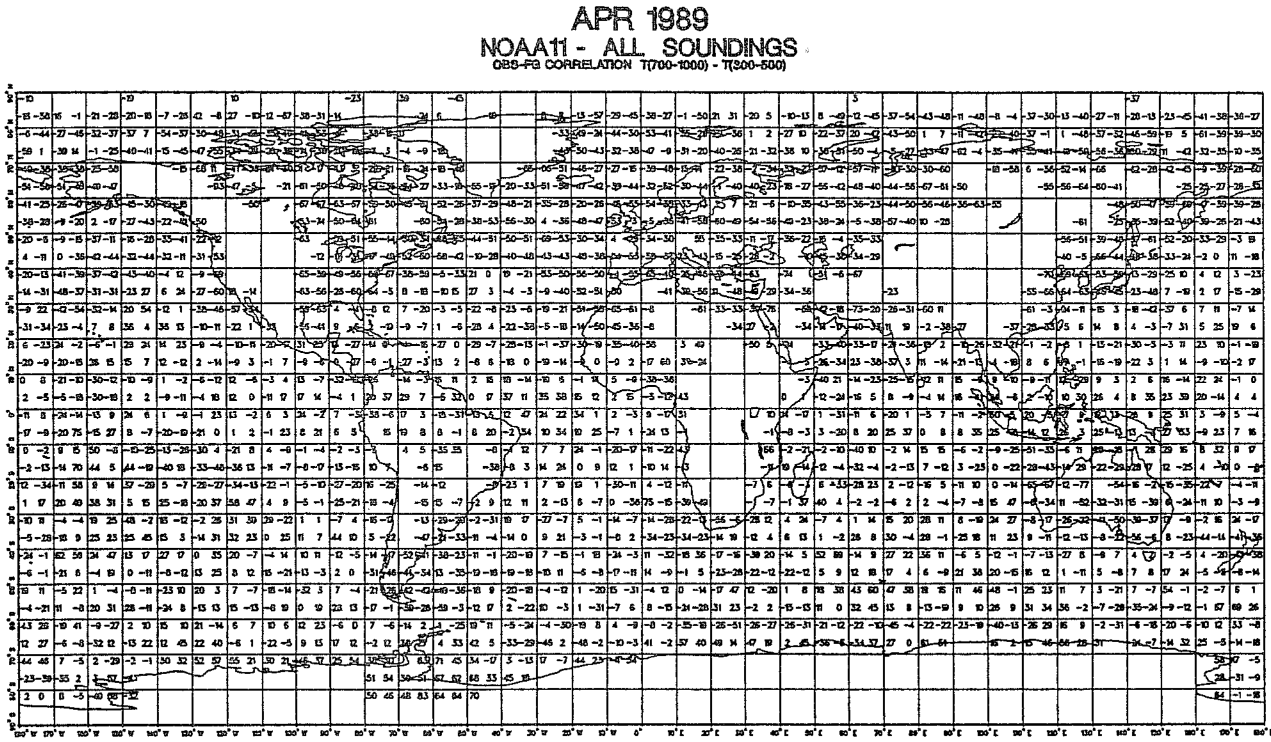

Fig. 7: Correlation coefficient between the observed minus first-guess differences for the layers 1000/700 hPa and 500/300 hPa from NOAA-11 for April 1989. Unit: %

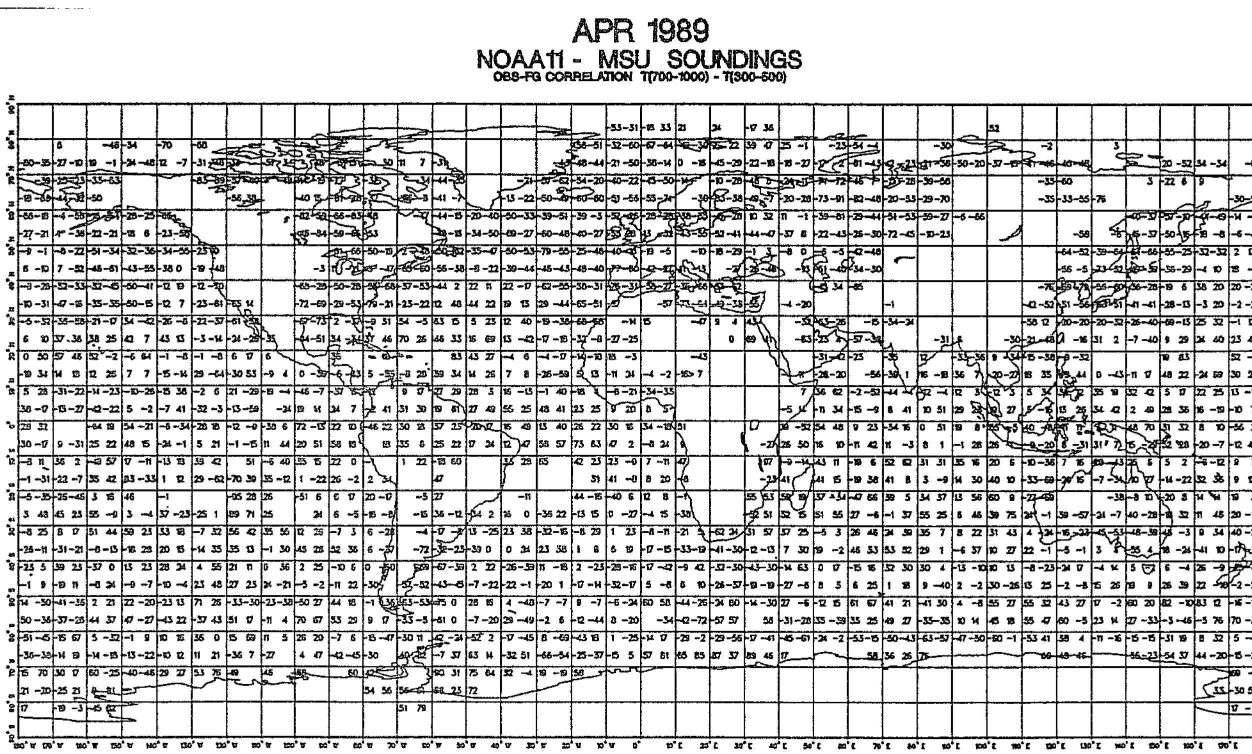

Fig. 8: As Fig. 7, for MSU soundings

19/ 2/89 6 UTC
Field : Mean Layer Temperature (First-Guess), Layer 700 / 500 hPa
Symbols : TOVS Stability Departure from FG, circle = clear, triangle = partly cloudy, square = MSU
Departures (degrees): (< -3.5) (-3.5 to -1.5) (-1.5 to +1.5) (+1.5 to +3.5) (> +3.5)

Reports received/rejected NH: 1056/388 Tropics: 979/ 17 SH: 1628/110 (land excluded)

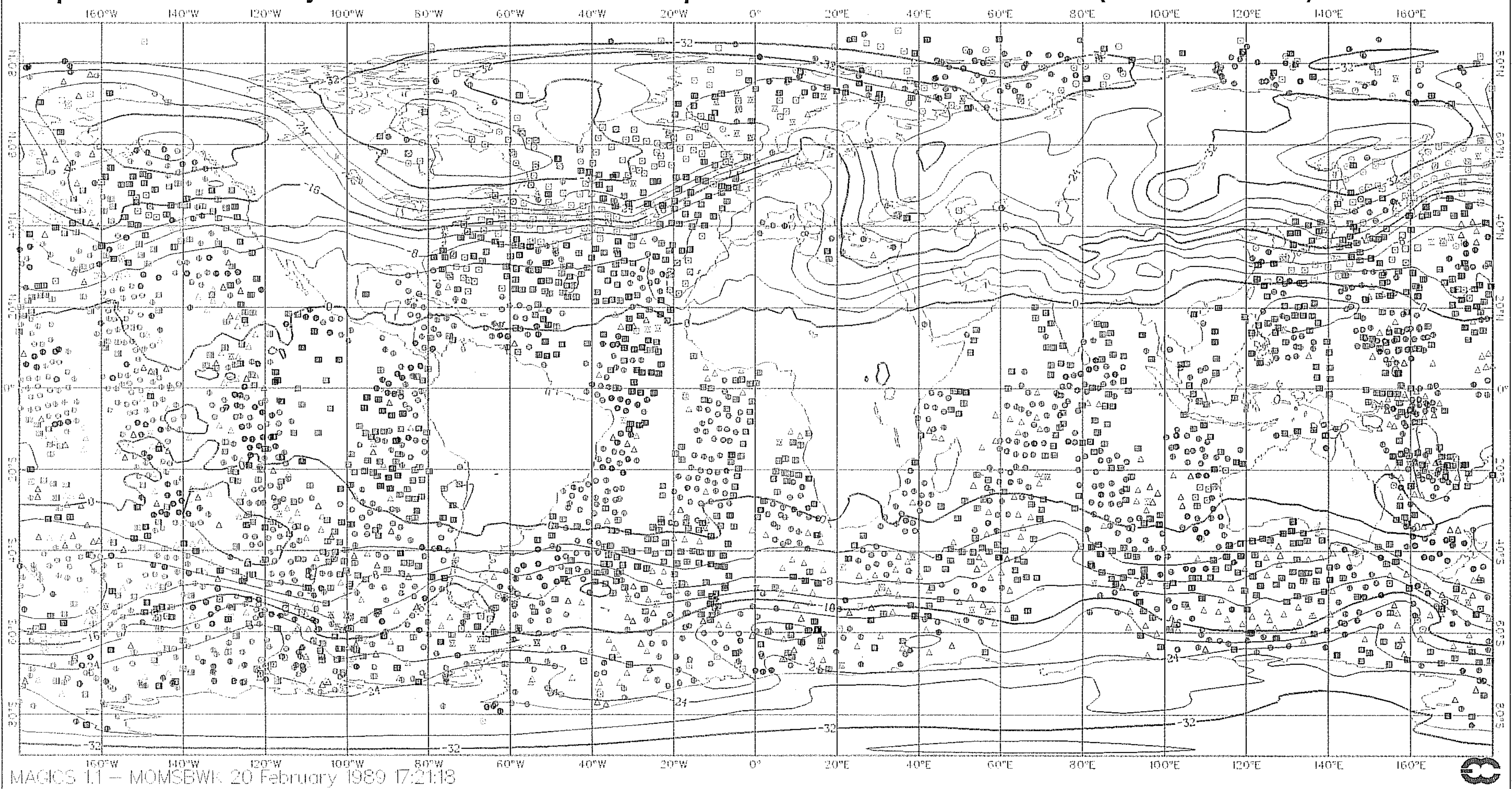

Fig. 9

exceeding 4.0 degrees in places. There is also a large positive bias east of the continent in the Northern Hemisphere; this is a reflexion of a systematic under-estimation of the vertical temperature gradient in cold-air outbreaks (cf below). It is noticeable that the bias in the layer 1000/700 hPa, which is the first layer actually used in the analysis, is generally smaller (fig. 6): there is a compensation within the analysis layer in some areas. But there is still a large positive bias in some places.

3.2.2. Monthly statistics, correlation between layers.

To illustrate to what extent errors in the lowest layer are compensated by opposite errors aloft, the correlation coefficients between the bias in the layer 1000/700 hPa and the bias in the layer 500/300 hPa, averaged over 5 degree squares, are plotted on figure 7. A negative correlation coefficient is found in most places where the mean bias in the lowest layer is large. For this particular month, the largest problems are along the Northern Hemisphere storm tracks, where the statistics for MSU soundings (fig. 8) show several correlations less than -0.6.

3.2.3. Monitoring of the stability check.

To cope with this compensation of errors within the troposphere, a quality-control check of the tropospheric stability, T(500/300)-T(1000/700), was introduced in operations on 31/1/1989 (cf paper by Kelly). Since then, a chart showing the effect of this check is produced for every analysis cycle. Fig. 9 is an example for 19 February 1989 06 UTC. The data marked with a cross are the data having failed the check; the negative values of stability departure (blue and dark blue) correspond to observed data more unstable than the first-guess. The contour lines are the mean temperature of the layer 700/500 hPa as given by the first-guess. A typical situation on this chart is seen in the North Atlantic: almost all the data were rejected around 45 N in an area with a sharp horizontal temperature gradient; it is worth noting that the collocated radiosondes on the east coast of North America and in Ireland and Iceland gave exactly the same indication as the first-guess.

The effect of the stability check is well illustrated by comparing the fig. 7 and 10. On fig. 10, the profiles which failed the check have been excluded from the statistics. The resulting correlation coefficients in the North Atlantic are small and distributed at random. In the Pacific and the Southern Hemisphere, they are positive, and rather large from place to place. This

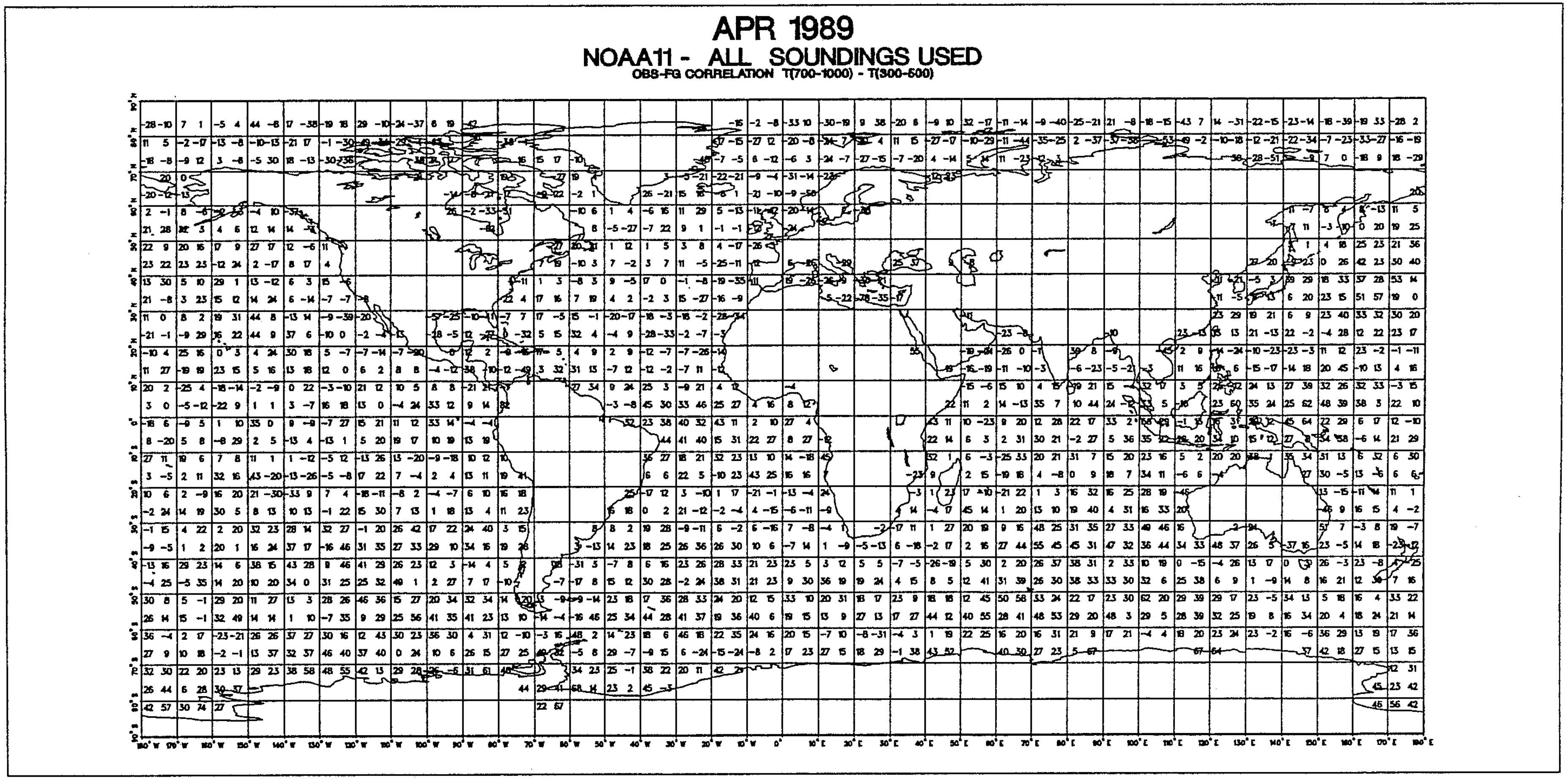

Fig. 10: As Fig. 7, soundings rejected by the analysis excluded

NA11 - Clear soundings

18 March 1989 to 31 March 1989

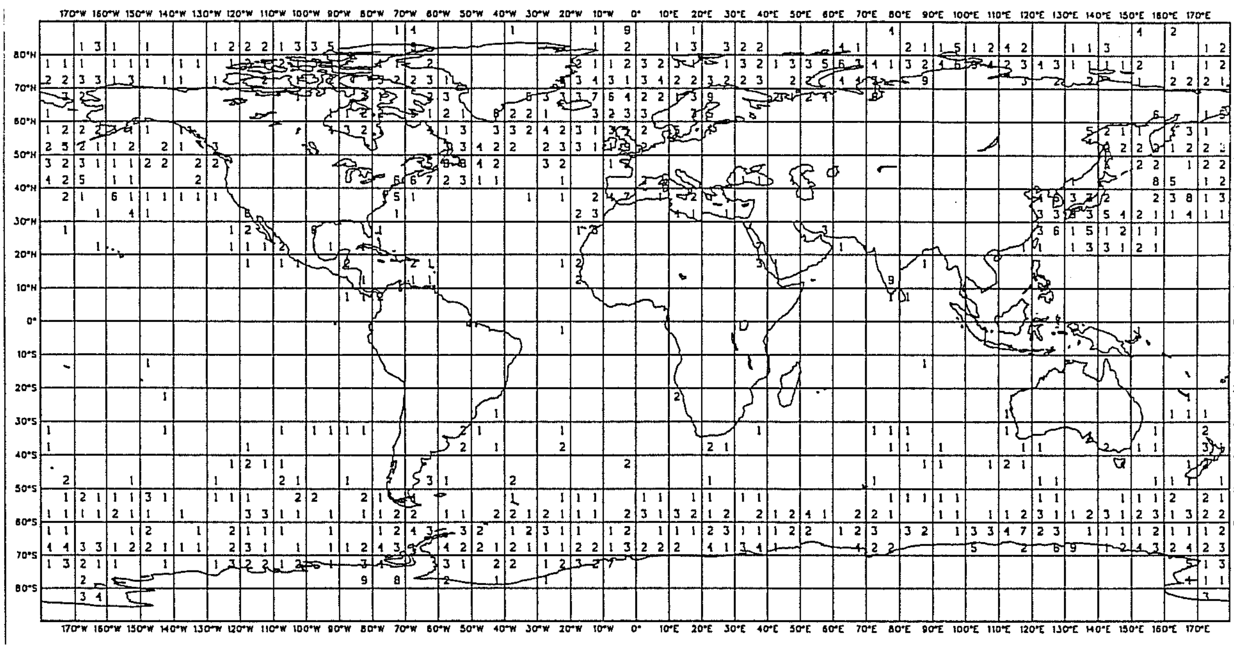

Fig. 11: Percentage of clear NOAA-11 soundings rejected by the analysis between 18 and 31 March 1989. Unit: percentage divided by 10. Blank means less than 4% of the data rejected.

NA11 - N* soundings

18 March 1989 to 31 March 1989

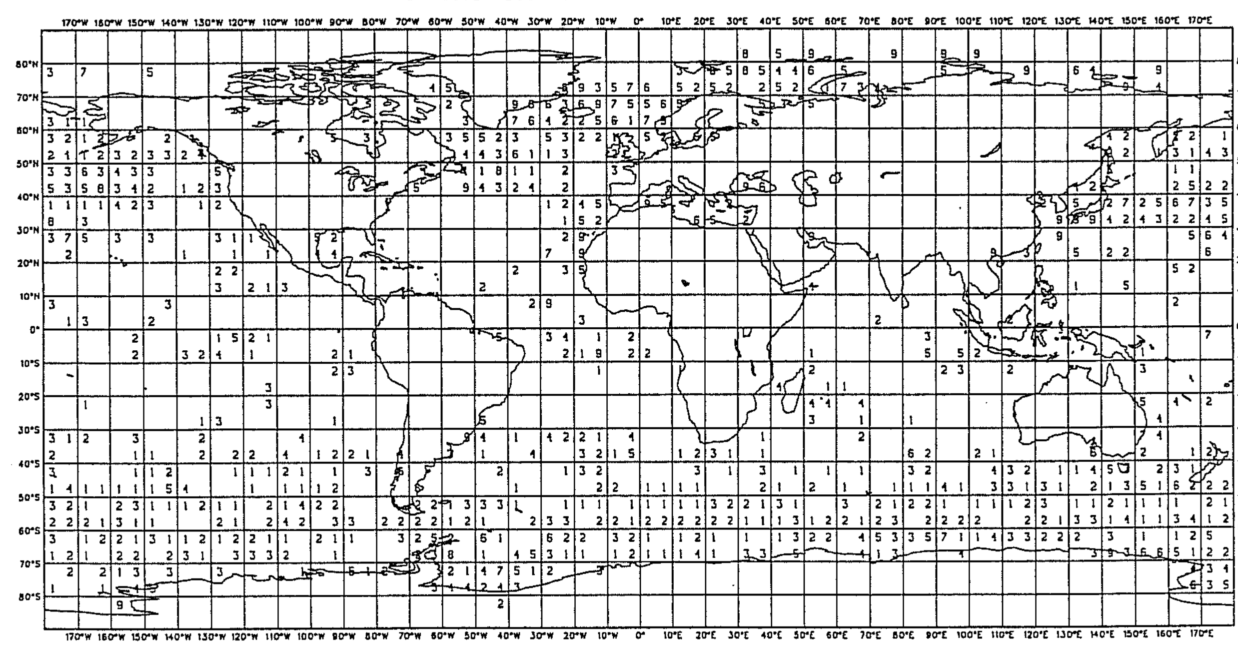

Fig. 12: As Fig. 11 for N* soundings

NA11 - Cloudy soundings

18 March 1989 to 31 March 1989

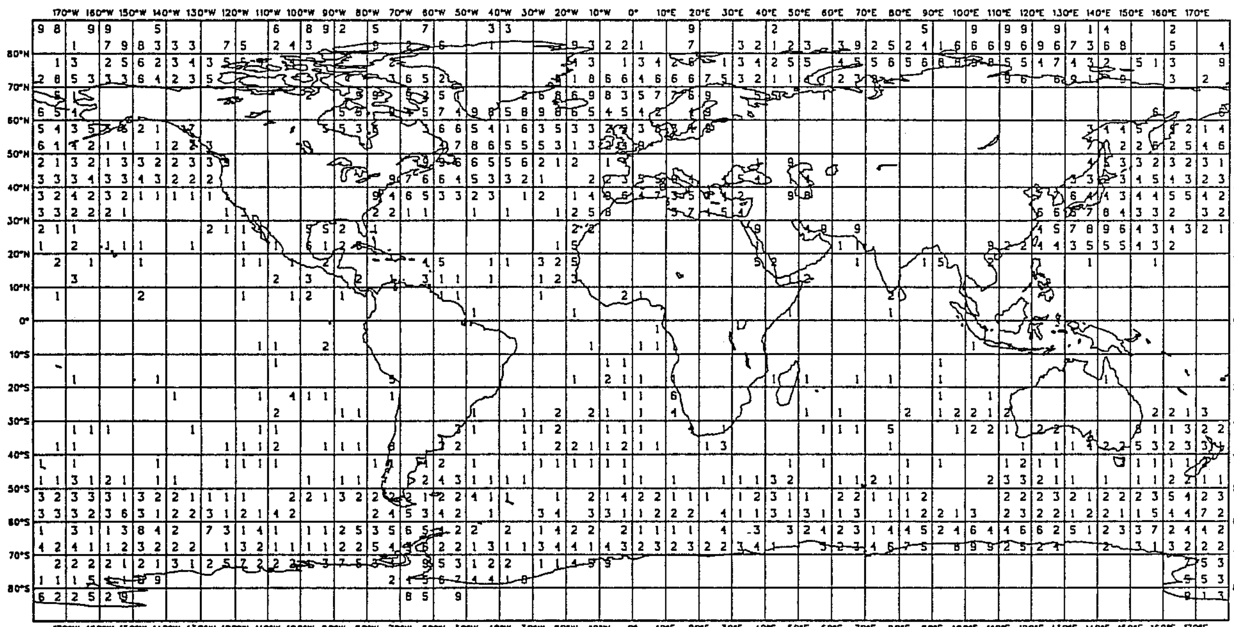

Fig. 13: As Fig. 11 for MSU soundings

DM08 - Cloudy soundings

18 March 1989 to 31 March 1989

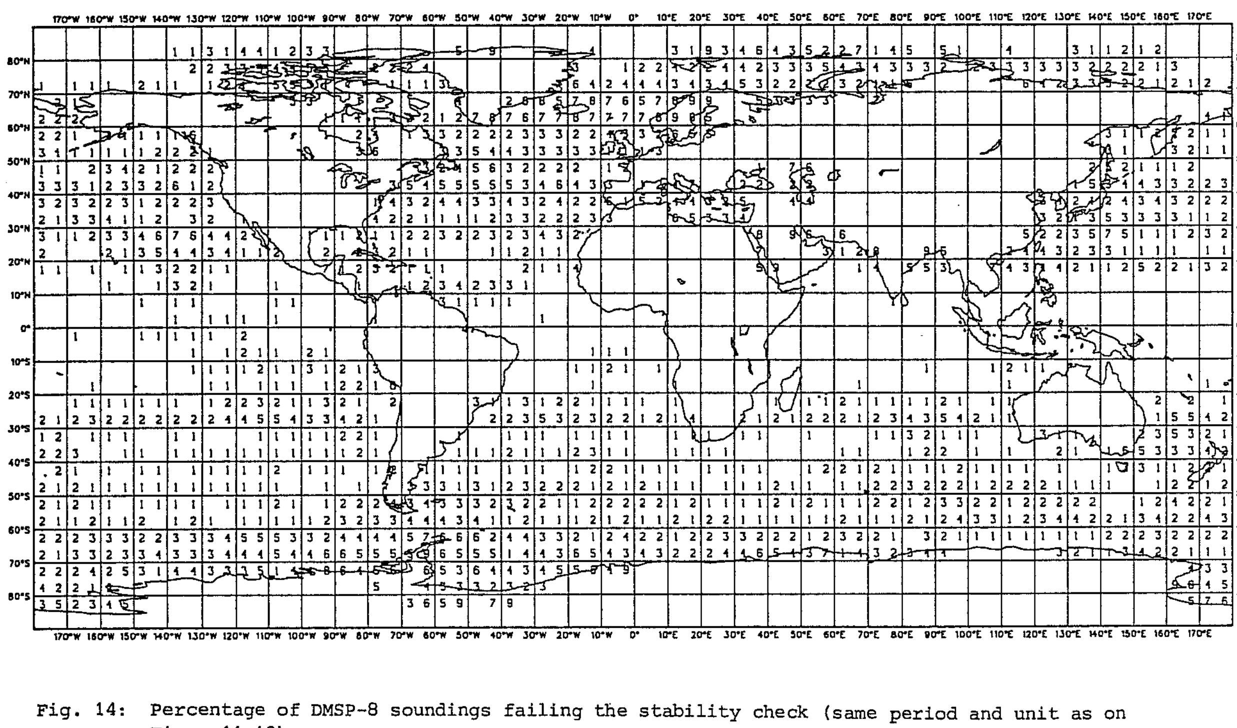

Fig. 14: Percentage of DMSP-8 soundings failing the stability check (same period and unit as on Figs. 11-13)

probably means that in these areas where the first-guess errors can be relatively large the satellite data have a consistent corrective action on the first-guess, which is not the case in the North Atlantic where the quality of the first-guess is better than the quality of the data.

4. CONCLUSION

This paper concentrated mainly on data quality problems in the troposphere. Of course the usefulness of the TOVS data in the stratosphere and upper troposphere is well established and should also be kept in mind. For the troposphere, fig. 11 to 14 provide a pictorial summary of what has been said: among the data received from NOAA-11 and DMSP-8 during a two week period, they show the percentage of data which were not used by the analysis for one reason or another (for NOAA-11), or which failed the stability check (for DMSP-8, as DMSP data are not used anyway at the moment). The numbers are percentages divided by 10. These figures clearly show the current limits of TOVS and DMSP data as far as numerical weather prediction is concerned. For example, for this North Hemisphere winter period about 50 % of the MSU soundings could not be used in the North Atlantic and North-West Pacific, in areas where most mid-latitude cyclones develop. Taking all sounding types together, on average from February to April 1989 the percentage of rejected data in the troposphere was about 20 % in the Northern Hemisphere and 10 % in the Southern Hemisphere.

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