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Forecasting Products ~~Branch~~ Monitoring Note No. 1

Statistics derived from the OPD archives for the year 1987

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September 1988

Contents

Glossary and Abbreviations

sd	:	standard deviation
o-b	:	observations minus background
O-a	:	observation minus analysis
CM	:	Coarse Mesh
FM	:	Fine Mesh

TEMP — upper air temperature, wind and humidity soundings from land and sea based stations

PILOT — upper air wind soundings from land and sea based stations

SHIP — reports from surface ships

AIREP — aircraft reports

SATOB — satellite cloud vector winds

C C SATEM — 250 km resolution satellite temperature soundings

LASS — local area satellite soundings

OWS — Ocean Weather Ship

1. Introduction

In January 1987 the Observations Processing Database (OPD) was considered fully operational and during the year studies of the quality of observations began. The OPD contains the value of the observation (after processing in a form suitable for the model), and values of background and analysis fields and any quality control flags raised on the observation. The software which has been written to process the information in the OPD can produce statistics for individual stations or by model data type(s), for areas specified by the user. For the purpose of this report no reference is made to any study of the observation quality from individual stations, rather the data is analysed by model data type e.g. AIREP, SATOB. Statistics are generated for most of these data types for the CM model in 10° latitude bands, except for TEMP and PILOT reports which are analysed in 30° latitude bands. The majority of the information refers to the CM model; where information is presented for the FM model, it covers the entire FM area.

Statistics can be generated for each month or for shorter or longer periods using the OPD software, but in the present report, any seasonal variation in the statistics is presented using July and December data, ie summer and winter data. In the case of TEMP and PILOT data, problems with the OPD archives prevented the presentation of statistics for July 1987, consequently, data are presented for the month of August 1987. In the presentation of statistics for LASS data and C.C. SATEM data over the FM area a more detailed look is taken at the variation in statistics over the year. Data are presented for March, July and October 1987. Unfortunately, because of an error introduced into the processing of LASS data at the beginning of November 1987, it is not possible to present any LASS statistics for December 1987 in this report.

Statistics for data types such as SATOB (each satellite is presented separately) and AIREP are presented for data grouped into 100 mb bands covering an appropriate range of pressures for the data type under consideration. For C.C. SATEM and LASS data the statistics are presented for the pressure levels appropriate to the data type. The processed data for TEMPS and PILOTS in the OPD contain the value of the pressure at each model sigma level for which any data are present. When processing this data, the statistics are assigned to the mean of all the pressure levels from the individual observations.

The OPD stores differences of observations from the model background and analysis fields for variables and data types which are not passed to the analysis, unlike the FLAGOB archive (see Met O 2b Technical Note No. 114). This means that information can be presented on the quality of LASS data and SATOBS from the Indian satellite, for example. In order to present all statistics on the same basis, all observations have been used for all the variables appropriate to the data type, whether or not the data have been flagged by the SDB, CFO or the model quality control scheme. Similarly, CFO corrections to SHIPS and AIREPS have been excluded from the analysis, and the original reports used instead. The mean and standard deviation of observation minus background (o-b) and differences may be significantly influenced by the presence of erroneous observations where the sample size is small, for example at upper levels in the atmosphere or in parts of the southern hemisphere.

2. Results

2.1 Upper air soundings

These combine all TEMP and PILOT reports (excluding any duplicates of the TEMP message in a subsequent PILOT report) but include flagged data at all levels. The data were organized into 30° latitude bands and the seasonal variation is represented by the statistics for August and December 1987.

Figures 2.1.1 and 2.1.2 present the statistics for August and December 1987 respectively for the latitude band 60-90S. These figures reveal a number of interesting features. In the temperature statistics there is a large positive bias of the grouped observations against the background field at the lowest model sigma level. This bias extends to the seventh model level in winter and is greater in the Antarctic winter than in summer. There is a corresponding bias in relative humidity of the opposite sense (observed humidities lower than background field). The observed wind speed at the lowest sigma level is, on average, greater than the background speed and the wind direction is backed, on average, against the background field, but the standard deviation of o- b wind direction differences is very large.

In the upper atmosphere there is a noticeable cold bias of the observations relative to the background field in the tropopause region (around 300 mb) but a warm bias in the stratosphere, in both winter and summer. The observed wind speed on sigma levels shows a small positive bias against the background field from levels above the boundary layer to the stratosphere.

The most severe problems in this region appear to be related to the modelling of the boundary layer over the Antarctic continent where the radiosonde stations are located. In general there is only a difference of +200-300 m between the model height and the station height for the majority of stations which are situated on the edge of the Antarctic continent. In the centre of the continent, model and station heights are in good agreement. A contributory factor in the bias of o-b temperature may be errors in the calculation of radiative cooling (note the greater bias of o-b values in winter than in summer). It is interesting to note that the proportion of temperature observations with a final flag is 7% at the lowest model sigma level in winter. This percentage is rather higher than normally found with sonde data. It is believed that there may be erroneous flagging of low levels in the TEMP reports due to a bias in the background field.

In the latitude band from 30S to 60S the statistics show little seasonal variation, apart from a slight increase in the standard deviation of o-b differences from summer to winter, reflecting an increase in the variability of the background field from summer to winter. The statistics for August 1987 are presented in figure 2.1.3. These data are, of course, representative of continental conditions as the vast majority of the TEMP and PILOT reports come from land areas. This figure shows that the total grouped TEMP and PILOT reports show a negligible bias of u,v and wind components against the first guess field except in the boundary layer. The relative humidity plot suggests that in this latitude band, the CM model humidities are a few per cent below the sigma level values derived from the original observations but between 750 mb and 300 mb there is an increasing negative bias i.e. the background field is more moist than the observations. Above 300 mb there is too little humidity data to draw any definite conclusions on the characteristics of the background field relative to the observations.

The most interesting profile is that for the mean o-b temperature data which show a somewhat irregular bias of the layer mean values, derived from the standard level and special level reports against the background field itself. There is a cold bias in the boundary layer then a variable warm bias from 850 to 400 mb, then a cold bias around the tropopause. In the stratosphere there is warm bias against the first-guess. This particular structure is also found in the summer period at these latitudes and a pattern of cold and warm biases may be seen in the statistics for individual stations. The reasons for this particular structure are not yet known.

Statistics were also generated for the latitude bands from 30S to 0°S and 0° to 30°N. As the data show little variation over those latitude bands only the data for 0-30°N for December 1987 are presented, in figure 2.1.4.

The vertical profile of the temperature bias shows a somewhat similar profile to that in Figure 2.1.3 but with the magnitude of the cold bias around 250 mb somewhat reduced.

The humidity bias in the upper troposphere is reduced from that at 30-60S. There is a negative bias of the u component of wind speed in the tropical boundary layer and on average a backing of the observed wind direction relative to the first guess field, i.e. the values of the o-b bias are negative. Above the boundary layer there is a negligible bias of the u and v wind components, except in the stratosphere around 50 mb where the sigma level mean values show a negative bias against the background field.

The latitude band from 30 to 60N contains the great majority of the upper air soundings and in this region the analysis is completely dominated over land by the upper air soundings (satellite temperature data over land are not passed to the analysis). In the southern hemisphere the satellite soundings over model land points are again not passed to the analysis but there are far fewer radiosonde data available over the continents. It is noticeable from figure 2.1.5 that the irregular pattern of warm and cold bias of observed temperatures minus background temperatures has been much reduced in the grouped radiosonde and pilot data, though the statistics for individual stations can still show a structure similar to that seen in fig 2.1.3, for example. The relative humidity statistics still show a negative bias in the upper troposphere. This characteristic is apparent from latitudes 60S to 60N and may reflect a particular tendency of the CM model to overestimate the absolute humidity, but the any bias in temperature is important also, of course. The background field shows a negligible bias against the obseved wind data on sigma levels except again in the boundary layer where there is also again a direction and speed bias.

Finally, the statistics for upper air ascents in the latitude band 60-90N were generated for summer and winter periods, represented by August and December data. The December statistics are presented here as fig. 2.1.6. In summer there is a very small bias of observed temperature against the background field at the lowest model sigma level but in winter near the surface it is apparent that there is a very marked warm bias (background far too cold relative to the observations). This may be due to the model specification of snow and ice cover, moisture content of the ground, and errors in the surface radiation balance and heat fluxes. These data suggest that the model builds up a strong inversion near the surface which is not represented by the observations. The bias of wind speed and direction increases from summer to winter and might be influenced by the bias in the temperature field of the model, though even in summer there is a small negative bias of wind speed and wind direction in the boundary layer, similar to that shown in the tropics where temperature errors are probably not a controlling factor.

2.2 Satellite Cloud Track Winds: SATOBS

Satellite cloud track wind data are available from five satellites, with four unique identifiers, as given in table 2.2.1.

Table 2.2.1. Satellite identifiers for SATOB data and area of coverage for each satellite.

Satellite	Identifier	Area of Coverage
METEOSAT	00000001	50S to 50N, 60W to 40E
GMS	00000103	50S to 50N, 100E to 180E
GOES W + E	00000200	50S to 50N, 180W to 20W
INSAT	00000420	10S to 30N, 60E to 100E

Data from the INSAT satellite are valid at 6Z and are only received somewhat irregularly throughout any month and the number of observations received varies also from month to month.

The statistics for SATOBS are given separately for each satellite using data for all analysis hours combined and all available observations are used, irrespecitve of flagging. Because the model surface type is not indicated for SATOB observation stored in the OPD all observations, whether over sea or land, are used in the analysis of the data.

2.2.1 METEOSAT SATOBS

Figs 2.2.1 and 2.2.2 present the statistics for Meteosat for 50S to 40S for the months of July (winter) and December (summer). The wind speed observations are in the mean, rather weaker than the background fields at pressure levels above 500 mb by up to 15 kts, this being due essentially to the bias in the u component of the wind speed. There is a noticeable seasonal variation in the magnitude of the bias in wind speed, which decreases in summer to around 5 kts. The information on the direction of the wind speed agrees very well in the mean with the background field and the standard deviation of the differences of wind direction from the background field is rather less than that for TEMPS and PILOTS in the latitude band 30-60S. It is difficult however to make any comparison of TEMPS and PILOTS and SATOBS because the TEMP and PILOT data are mainly over land and the SATOBS mainly over the sea and the grouped results for TEMPS and PILOTS include some variability because of the different characteristics of different wind finding systems used in different countries. Also SATOBS only exist where there is cloud which is correlated with synoptic type and probably correlated with background error. In the tropics the bias of METEOSAT SATOB observations decreases and becomes slightly positive, the wind direciton bias increases somewhat and there is a noticeable increase in the standard deviation of the o-bwind directions (see figs 2.2.3 and 2.2.4). From 10°S to 10°N, where the tropical air streams converge and wind speeds and directions are more variable the bias of wind speed against background is small but below 750 mb there is a very marked bias in the SATOB wind direction against the background field.

From the tropics to 50°N the METEOSAT data show an increasing negative bias of wind speed at high levels against the background field but the bias of wind direction is very small. An example is shown in Fig. 2.2.5 for data from 30 to 40N for December 1987. There is only a small seasonal variation in the wind speed bias, this being slightly greater in winter than summer.

2.2.2 GOES W, GOES E SATOBS

SATOB data from the GOES W and GOES E satellites were analysed in a similar way to the METEOSAT data. These observations are concentrated in pressure levels from 1000-800 mb and 300-100 mb with very little data in the mid-atmosphere, unlike METEOSAT data which are rather more uniformly distributed in the vertical. Figs 2.2.6 and 2.2.7 show that in the latitude band 40 to 50S, there is a negligible bias in the wind speed at lowest levels and a small negative bias in the upper troposphere when compared with the model background field. This is in marked contrast to the METEOSAT data for the winter season. The bias of wind direction is small, except in summer at low levels where it is rather greater than that of METEOSAT data. The statistics for GOES data for the 900 mb level show a rather greater standard deviation of o-b differences of wind direction than METEOSAT SATOBS. From 40-50S to the tropics the GOES data shows similar characteristics to the METEOSAT data, viz:

i) a reduction in the wind speed bias at high levels

ii) a reduction in the standard deviation of u, v and wind speed differences against the background field, in line with a likely reduction in background field errors

iii) an increase in the standard deviation of wind direction differences from the background field in the tropics at low levels and especially at high levels.

Figures 2.2.8 and 2.2.9 present the statistics for GOES for the equatorial regions. GOES data like METEOSAT data show a negligible speed bias but bias of the opposite sense in wind direction at low levels. The standard deviation of differences of wind directions in the upper troposphere is large, larger even than that for METEOSAT data. It is possible that these SATOB winds are deduced from the development of Cb anvils or cirrus clouds at high levels, which may not reflect the mean wind direction of the model at any given time, though there is no large consistent bias in wind directions.

Moving from the equatorial region to the tropics and extra tropical regions GOES data, like METEOSAT data, show an increasing tendency to underestimate the wind speed at jet stream level when compared with the model wind field but there is a reduction in the bias and the standard deviation of wind direction differences from the first guess field. GOES data exhibit a marked seasonal variation in the bias of wind speed from summer to winter at latitudes 40 to 50N at jet stream levels. In summer, there is a negligible bias of wind speed (see Fig 2.2.10) from 300 to 200 mb but this completely changes in winter (Fig. 2.2.10) when a marked negative bias, around 10 kts, appears at jet stream level. This behaviour is in marked contrast to that of the Meteosat data, which show a negative bias in both seasons.

2.2.3 GMS SATOBS

SATOB data are also received from the GMS satellite over the W. Pacific. This data is allocated a designated set of fixed pressure levels according to season and latitude, unlike the METEOSAT and GOES data. The OPD archives for July and December 1987 suggest that the data is available on the following pressure levels:

Table 2.2.2. Assignment of pressure levels in GMS SATOBS

	July	Dec
Area:		
50S-40S	850,400	850,300,250
40S-30S	850,400	850,300,200
30S-20S	850,400,200	850,300,200
20S-20N	850,200	850,200
20N-30N	850,200	850,400,300,200
30N-40N	850,200	850,400,300
40N-50N	850,250	850,400,300

The majority of the data are concentrated at the 850 mb level in both months, with other data at near tropopause or jet stream levels. This data was analysed and plotted in a similar way to other SATOB data, but because of the very limited number of levels of data available the plotted statistics can only be strictly compared with other data types at the above pressure levels.

Figs 2.2.11 and 2.2.12 present the data for the latitude band 50S to 40S for July and December 1987. These results might be compared with the data for METEOSAT and GOES W and GOES E. Between summer and winter there is very little change in the bias and standard deviation of the wind speed differences from the first guess field (unlike the data from METEOSAT and GOES). At jet stream level in summer the wind speed is biased too low relative to the background field. The magnitude of this bias is very comparable to the bias for the other SATOB data in this latitude band.

In the equatorial regions and most of the tropics the bias of wind speed and direction against the background field at 850 mb and 200 mb is small but between 20 and 30N, where there is a seasonal change in the assignment of the SATOB pressure levels, there is a noticeable change in the statistics. In summer the wind speed at 200 mb is very close to the background field on average but with considerable variability in observed-background wind directions perhaps because the deduced direction of the clouds (cirrus elements?) are not representative of the overall airflow. From summer to winter two additional pressure levels are assigned to the data but a negative bias of wind speed appears (Fig. 2.2.14) and the standard deviation of the o-b values greatly increases. Perhaps this is due in part to a misassignment of the pressure levels given to the SATOB data. The data for December for latitudes 40 to 50N are also presented in figure 2.2.15. In summer the wind speed at 850 mb shows a bias of roughly -2 kts against the background field and roughly -7 kts at 250 mb. This is slightly worse than GOES data but rather better than METEOSAT data in the extratropics. In winter, there is a noted deterioration in the statistics due to the bias of the u component of the wind which reaches -25 kts at 300 mb. This is considerably greater than that for METEOSAT or GOES data at these latitudes but it must be remembered that wind speeds in the Pacific jet are higher than in the Atlantic jet. These data were heavily flagged at both 400 mb (34% final flag) and 300 mb (44%) final flag due to CFO rejections. The standard deviation of both wind speed and direction differences are both large and may reflect, in part the fact that the wind observations are assigned to a fixed pressure level.

2.2.4 INSAT SATOBS

This data are available for the latitude bands 10S to 30°N but the data volume varies from month to month. Because of a lack of data in July 1987 only a selection of the statistics for December 1987 are presented. Most of the observations are concentrated at latitudes from 0° to 20°N. These SATOB wind observations are concentrated at 850 mb with a quite even distribution of the remaining observations at higher levels. The available data for latitudes 0-20N are presented in Figs 2.2.16 and 2.2.17. The wind speed in general shows a strong positive bias against the background field which is unique amongst SATOB data. The direction statistics are very poor, showing a tendency to oscillate between positive and negative bias from level to level, with a very large standard deviation, so large in many cases that it cannot be plotted (ie > 50 degrees). The standard deviation of wind speed and u and v wind component differences from the background field are also large, roughly double that of METEOSAT data in the equivalent latitudes in the Atlantic. Part of this increased variability could be due to the greater variability in background field over the Indian Ocean and N. India compared to that over the Atlantic but subjective assessments of the data reveal a large number to be mutually inconsistent. In the Indian Ocean itself there is very little wind data which are used in the analysis which might be compared with this SATOB data apart from isolated TEMP and PILOT reports from island stations and there are virtually no AIREP data. Unfortunately the model surface type is not at present correctly indicated for SATOB data in the OPD so SATOBS over the India continent cannot be compared with TEMP and PILOT wind statistics using a selection by surface type. In the absence of any other data the only comparison that can be made is with longitudinal average statistics for combined TEMP and PILOT reports (see statistics for the latitude baud 0-30N). It is believed that the major contributor to the observation minus background differences is due to the poor quality of the observations and therefore they should continue to be rejected and not passed to the analysis.

2.3 Compressed Code SATEM data in the CM Model

2.3.1 Data over the open sea

Statistics from NOAA 10 were generated from the OPD data at model sea points on the pressure levels appropriate to the data. All available data were used, irrespective of the number of levels in an individual record. Fig 2.3.1 present the statistics for temperature (derived from the potential temperature difference held in the OPD) for summer and winter in the southern hemisphere at latitudes 60-70S. These data might be compared with the statistics for TEMP reports for the latitude band 60-90S (these data are concentrated over the Antarctic continent at latitudes 60-70S). The satellite data show a negligible bias against the background field in summer and winter from 450 to 850 mb but a cold bias at 922 mb in both seasons. There is a warm bias just above the tropopause and a strong cold bias at 38.7 mb, but only in the summer season. TEMP data show an opposite bias at the tropopause and in the stratosphere. The standard deviation of satellite temperature observations from the background field is slightly less than that for TEMPS (latitudes 60-90S) but the TEMP data are a combination of observations from different sonde types and grouped TEMP data might be expected to show greater variability from the background field.

In mid-latitudes, (fig. 2.3.2) the low level bias of C.C. SATEMS relative to the background field has changed sign and is slightly positive. At 87.2 mb a negative bias (observations cold relative to background) has appeared. The cold bias at 38.7 mb remains and is much more marked in summer than in winter. The statistics derived from the OPD show that as we move towards the tropics and equatorial regions, the cold bias at 87.2 mb becomes stronger, reaching a maximum over the equator and decreasing again in the northern hemisphere towards the sub-tropical highs and mid-latitudes. Fig. 2.3.3 shows an example, for the latitude band 0-10N for July (there is negligible seasonal variation in the statistics). This behaviour may be connected in some way with the greater height of the tropopause in the tropics and equatorial regions and the representation by the satellite data and the model of the tropopause, and the interpolation of the model background fields to the pressure level of the observation. This particular question requires further study.

Fig 2.3.4 presents data for the latitude band 30-40N for the summer and winter seasons. The general profile is very similar to that for the equivalent latitudes in the southern hemisphere with a stronger cold bias at 38.7 mb in summer than in winter. In the lower tropopause the warm bias in winter is slightly greater than that in equivalent latitudes in the southern hemisphere. Grouped TEMP data also show a slight warm bias in the lower troposphere but show the opposite bias to C.C. SATEM data in the stratosphere.

At higher latitudes, 60 to 70N, C.C. SATEM over the sea (Fig. 2.3.5) show a warm bias against the background field in winter in most of the troposphere and a more marked warm bias in the lower stratosphere. TEMP data in the latitude band 60-90N show no such bias, therefore this is deduced to be a characteristic of the satellite data itself at these latitudes. In the southern hemisphere the C.C. SATEM data do not show this characteristic to the same extent. A latitudes 60-70S there are far fewer TEMPS and the data available to the analysis is dominated by satellite temperatures soundings so a closer fit of satellite data to the background temperature field might be expected. The cold bias at the uppermost level of C.C. SATEM data, viz at 38.7 mb remains and is intensified from that at middle latitudes. This bias shows a seasonal trend being most severe in winter. As in other latitude bands this bias is in the opposite sense to that of grouped TEMP data, which show a small positive or warm bias against the background field, though the observations from individual TEMP stations can show a much greater warm bias.

2.3.2 Data over sea ice and ice covered land

In the CM model C.C. SATEM data are at present only used in the analysis over sea and sea ice surfaces though data covering all model surface types is contained in the OPD. For the purposes of comparison of C.C. SATEM statistics with TEMP data which are concentrated over land and for a comparison with C.C. SATEM data over the sea, statistics were generated for sea ice and land ice surface types for latitudes 60-90N and 60-90S. Figure 2.3.6 presents the data for the latitude band covering the Antarctic continent. These data should be compared with satellite data over the sea in the latitude band 60-70S and TEMP and PILOT data from 60-90S. A comparison with these data shows that at 922 mb the C.C. SATEM data over land ice have the opposite bias, i.e. a warm bias relative to the background field compared to C.C. SATEM data over the sea, but radiosonde data also show an even stronger warmer bias. It has already been suggested that the background field temperatures may be too low in this region in the boundary layer over the antarctic continent. Above this level the bias profile is very similar to that obtained for C.C. SATEM data over the sea, but with a stronger cold bias in the stratosphere. The C.C. SATEM data over the sea in these latitudes at pressure levels of 83.7, 59.2 and 38.7 mb are, however, not passed to the analysis. The standard deviation of o-b values is very similar to that of TEMPS and C.C. SATEM data over the sea, except at 922 mb where it is considerably greater.

In the southern hemisphere summer the warm bias of C.C. SATEM data (and TEMP data) relative to the background at 922 mb is notably reduced, perhaps because of a seasonal change in the bias of the background field, as was previously suggested. The bias in the troposphere shows little seasonal change but there is a similar seasonal change in the stratosphere as there is for satellite soundings over the sea.

The statistics for the latitude band 60-90N for summer and winter 1987 are given in figure 2.3.7. This data is inevitably concentrated near the poles whereas the TEMP and PILOT data within this large latitude band is concentrated in lower latitudes as is the C.C. SATEM data over the sea.

The data itself show a very small bias against background except in the stratosphere, where it is again apparent that the satellite temperature soundings show a cold bias against the background field,in this case at the 38.7 mb level. There is negligible seasonal change in the bias, but a significant increase in the standard deviation of o-b differences from summer to winter at the 922 mb level. This is also apparent with TEMP data and it is likely that this reflects a seasonal variation in the quality of the first guess temperature field at low levels.

2.3.3 Data over Arid and Temperate Land

These data were analysed in 30° bands from 60°S to 90N and form a useful comparison with averaged TEMP data. Figure 2.3.8 presents the results for the latitude band 30-60S for the winter and summer seasons. The vertical profiles show a cold stratospheric bias and a cold bias relative to background at 922 mb, which is in the same sense and similar magnitude to that for TEMP data but C.C. SATEM data over the sea in these latitudes show a slight warm bias at this pressure level. There is a small seasonal increase in the cold bias from summer to winter at 922 mb. These figures show that the analysis has a larger bias than the background field (larger in winter than in summer) probably because the analysis does not use C.C. SATEM data over land surfaces. A noticeable point is the increase in the standard deviation of o-b differences from winter to summer at the 922 mb level and the fact that this is rather greater than that for data over the sea, but is comparable to that for TEMP data.

Data for the latitude band 0-30S and 0-30N show many of the tendencies noted above in both seasons viz, a cold bias of approx -1°K at the 922 mb level relative to the background field and a sharp increase in the standard deviation of o-b differences at the 922 mb level from sea to land surfaces, possibly due to greater retrieval problems for near surface radiances over land surfaces and greater variability in the first guess field. The stratospheric temperature bias is as severe over land surfaces as over the sea and is again in the opposite sign to that of TEMP data. Note that in moving from latitudes 60S to 30S to 30N a warm bias has developed in the mid-troposphere, ie the SATEM profile at pressure levels below below 500 mb is more stable than the background profile. This warm bias extends to the lower troposphere at latitudes 30-60N in winter (Fig. 2.3.11) but almost disappears in summer. In addition, a warm bias has developed around the tropopause level. C.C. SATEM data over the sea at these latitudes show this characteristic also. These data show a rather greater standard deviation of o-b temperature values over land surfaces compared to soundings over the sea. Fig. 2.3.12 presents the statistics for the latitude band 60-90N. There is a marked seasonal change in the o-b temperature biaswith a mid-tropospheric warm bias in December to which is much reduced in the summer and a very marked warm bias appearing around 250 mb in winter. It is remarkable that the stratospheric bias in winter is so small, roughly -1°K, whereas in summer the much greater atmospheric bias is more typical of C.C. SATEM soundings. As a comparison, the background field fits the grouped TEMP data in the latitude band 30-60N very well, even in the stratosphere. The TEMP data show is a small warm bias against the background field in the summer stratosphere and this again is of opposite sign to the bias of C.C. SATEM data over the sea.

2.4 LASS and Compressed Code SATEM data in the FM model

There have been various changes to the LASS data over the year, for example on 23 June a significant change was made to the cloud clearing scheme. Because of this it is instructive to compare the statistics throughout the year. Fig. 2.4.1 presents the results for March 1987 for LASS and C.C. SATEM data. Both exhibit a very small bias against the background field, increasing slightly at tropopause level. The most significant bias is at the 38.7 mb level in the stratosphere where there is a strong cold bias relative to the background field. LASS data show a similarly small absolute bias in the middle atmosphere but an increasing tendency to a cold bias in the lower atmosphere and again a very marked cold bias at the topmost level, in this case 30 mb. Above the tropopause the bias oscillates in sign from level to level. The standard deviation of o-b differences is scarcely different at levels from 300 to 850 mb, but LASS data show noticeably greater variability at tropopause levels. Note that the standard deviation of the o-b differences at 38.7 mb (C.C. SATEM) and 30 mb (LASS) is quite small, showing that the marked bias against the background field is consistent within the data.

Following the change to the cloud clearing scheme on 23 June there was a marked change in the structure of the LASS bias (Fig. 2.4.2) with a warm bias from 850 to 550 mb and a cold bias to 200 mb, with a maximum at tropopause level. The stratospheric biases increased in magnitude also. Figure 2.4.2 shows that there was negligible change in the quality of C.C. SATEM data (NOAA 10 data). This figure shows a marked increase in the standard deviation of the o-b differences for LASS data, ie the data have become more variable when judged against the background field. The standard deviation for C.C. SATEM data show a slight decrease, reflecting perhaps lower background field errors in summer. By October 1987 some adjustment of the LASS data had taken place (Fig. 2.4.3) as the upper tropospheric bias had decreased and the warm bias of the lower troposphere reduced. However, the data still show an irregular bias in comparison to the background field. The standard deviation of o-b temperature differences is also larger than that for C.C. SATEM data which shows only a small seasonal increase.

A comparison of the bias and standard deviation of satellite temperature soundings over the FM area with radiosonde data is made here using data from Ocean Weather Ships and selected coastal stations viz: 03953, 04018, 08001, 08509, 71399 and 72304 for March and August 1987 (Fig. 2.4.4). The data for TEMPS shows a very small absolute temperature bias, which changes sign slightly from season to season (at a given pressure level). The bias at the tropopause is positive (i.e. observations greater than background) as it is for C.C. SATEM data, but the bias at this level is of the opposite sign for LASS data, see for example the data for July 1987. In the upper stratosphere, the bias of TEMPS is positive but negative for C.C. SATEMS and LASS. The standard deviation of o-b temperature of differences for TEMPS is very slightly less than that for C.C. SATEM and LASS at mid-tropospheric levels and noticeably less at the tropopause level and near the surface. The standard deviation of o-b differences for TEMPS also shows a small decrease from summer to winter, as would be expected.

2.5 Aircraft Data : AIREPS

AIREP observations were grouped into 100 mb pressure bands from 500 to 100 mb only, though in fact most of the data lie in the pressure bands 300-200 mb and 200-100 mb. There is a much smaller sample of observations from the pressures above and below these two bauds and this should be borne in mind when studying the statistics. The data were organised into 10° latitude bands from latitudes 70S to 70N and statistics calculated for temperature, wind speed and wind direction. Because of the small numbers of AIREPS currently received from latitudes south of 40S the first latitude band for which a significant number of observations are available is 30 to 40S. Data are presented in Figs 2.5.1 and 2.5.2 for this latitude baud for July and December 1987 respectively. These figures show a little seasonal variation, perhaps because of the seasonal variation in the quality of the background field. In both seasons the AIREP data show a warm bias against the background field of the order of +1°K at jet stream level and a bias in wind speed of +5 to +10 kts at pressures from 300 to 200 mb. The bias of wind direction is very small in this pressure band. TEMP data for 30 to 60S show an opposite bias in temperature at jet stream level and negligible speed and direction biases, but the TEMP data is concentrated over land whereas the AIREP data is concentrated over the sea at jet stream level. More noticeable is the much greater standard deviation of o-b temperature differences for AIREP data than for TEMPS or C.C. SATEMS. The standard deviation of o-b temperatures is roughly 1°K greater for AIREPS than for TEMP data in the latitude band 30-60S, in both seasons, though the standard deviation of wind speed differences is very comparable to that for TEMP data. From latitudes 40 to 30S to 10 to 0°S there is no great change in the magnitude of the bias of AIREP temperature or wind speed observations against the background field at pressure levels from 200-300 mb. Because there is no significant seasonal variation in the statistics at these latitudes, only the data for December 1987 are presented (Fig. 2.5.3). The warm bias against the background temperature field has decreased somewhat but the bias of wind speed has increased. SATOB data from the METEOSAT and GOES satellites show a small positive bias of wind speed against the background field in the tropics at these levels; TEMP and PILOT reports are on average very close to the first guess field. Again, the standard deviation of o-b temperature differences are considerably greater than for TEMP or C.C. SATEM data at similar levels and the standard deviation of o-b wind speed differences is considerably higher than SATOB data and TEMP and PILOT data (using all original observations in all cases).

AIREP data for the latitude bands 50 to 60N are presented in Figs. 2.5.4 and 2.5.5 and show that the warm temperature bias at pressures between 200-300 mb has been reduced considerably. The small positive bias in wind speed remains at much the same valueas at other latitudes. A comparison of the standard deviation of temperature and wind speed differences from the background with TEMP data within the latitude band 60 to 90N in winter and summer again shows that the standard deviation of temperature differences is about 1°K greater and wind speed about 5 kts greater at jet stream level but the positions of AIREP observations at these latitudes are biased towards jet cores where background errors and errors of representativeness are larger than elsewhere.

2.6 Surface SHIP data

Surface ship observations were grouped together and sorted into 10° latitude bands. The statistics for pressure at the model surface (p*) and wind speed for July and December 1987 are given in tabnles 2.3 to 2.6. CFO corrections and duplicates and observations with an SDB position flag were excluded. It can be seen that there is a general tendency for the pressure observations to have a positive bias against the background field (or the background fiela to be too low). This can be seen at most latitudes and in both seasons. The standard deviation of o-b pressure differences is smallest in the latitudes dominated by the sub-tropical highs, as would be expected, and increases to the north and south, with lower values in the summer season than in the winter. These results may well be influenced by the presence of erroneous observations (between 5 and 10% of all ship pressure observations have a final flag). If these data are omitted then the statistics do change noticeably as Tables 2.3 to 2.6 show. The exclusion of flagged data has, in the southern hemisphere, reduced the positive bias significantly in July, in fact it now becomes negative, but a much smaller change is seen in the summer season. There is a general tendency for heavily flagged ships to show a positive bias against the background field, for example ships of the USSR, but of course there could be a deficiency in the first guess field in the data sparse regions of the southern hemisphere, which may be worse in winter than in summer.

In the tropics and northern hemisphere the exclusion of flagged data has led to a small reduction in the positive bias of pressure data against the background field, but this still remains, and is maintained by the analysis field.

The comparison of ship wind data against the background field is complicated because of a change in the practice whereby CFO have rejected ship observations. From the end of September 1987 CFO have rejected the individual elements in a ship report, such as the wind or pressure. Prior to this it was common that all of a ship report was rejected, usually because of objections to the pressure observation. However, a study of these rejected wind observations made in the north Atlantic showed that their quality (judged against the background field) was little inferior to the quality of wind data actually used in the analysis, i.e. the winds need not have been rejected. Looking at the statistics for data without a final flag it can be seen that there is a consistent positive bias of ship winds against both the surface background and analysis wind fields. This may be dependent on the observed wind speed itself as the bias is very slightly greater in the N. hemisphere winter than the northern hemisphere summer. In the southern hemisphere the situation is not as clear because of the much reduced volume of data. It has been known for some time that visual observations of the sea state lead to wind speed estimates which are slightly greater than that from a good adjacent instrumental observation at Beaufort force 7 or above. This may be a contributory factor in the above bias. However, it may be that there is a bias in the surface wind field of the model. Because ship wind observations are a combination of visual and instrumental observations it will be necessary to derive statistics separately for areas where visual or instrumental observations dominate before any further conclusions can be drawn. The exclusion of flagged data (Dec 1987 only considered) does lead to a small reduction in the bias but this still remains at about +2 to 4 kts over the globe, showing this to be a real characteristic of the data and/or the surface background wind field in the OPD. The standard deviation of the differences from the background field does decrease significantly, as would be expected, if erroneous observations are excluded.

TABLE 2.3. ALL SHIP DATA : 10°latitude bands. Month: JULY 1987

	p* (mb)					wind speed (kts)				
AREA	n. obs	o-b	o-a	sd o-b	sd o-a	n. obs	o-b	o-a	sd o-b	sd o-b
70S-60S	5	3.2	-1.3	5.6	5.6	5	4.1	1.8	3.4	3.8
60S-50S	219	-0.3	0.5	7.9	7.0	216	1.6	0.9	9.4	7.8
50S-40S	781	0.3	0.5	6.2	5.9	771	0.9	0.8	10.8	8.8
40S-30S	2471	0.3	0.1	2.6	2.0	2402	4.1	2.7	8.7	7.5
30S-20S	2312	-0.2	0.0	4.1	3.9	2237	2.0	1.4	7.3	5.8
20S-10S	2481	0.6	0.3	3.3	3.1	2455	1.1	0.7	8.9	7.7
10S-0	1893	0.6	0.2	3.7	3.7	1862	1.4	1.1	7.5	6.3
0-10N	3906	0.6	0.5	4.8	4.8	3776	2.8	2.1	9.9	8.9
10-20N	5723	0.4	0.4	4.1	3.9	5567	3.0	2.1	9.4	8.2
20-30N	7320	0.3	0.2	3.9	3.7	7170	2.5	2.0	10.0	9.3
30-40N	12104	0.3	0.2	3.9	3.7	11719	3.5	2.7	9.3	8.7
40-50N	19079	0.1	0.2	5.8	5.7	18061	3.5	3.0	10.5	10.2
50-60N	12459	0.4	0.4	6.0	5.8	12259	3.1	2.8	9.5	9.1
60-70N	6628	0.4	0.4	4.4	4.3	6430	2.5	2.2	11.4	11.1
70-80N	2652	0.7	0.4	6.9	6.8	1999	3.7	3.3	13.5	13.3
80-90N	244	0.4	0.6	7.1	7.1	241	5.6	4.8	8.3	7.0

TABLE 2.4. ALL SHIP DATA : 10°latitude bands. Month: DEC. 1987

	p* (mb)					wind speed (kts)				
AREA	n. obs	o-b	o-a	sd o-b	sd o-a	n. obs	o-b	o-a	sd o-b	sd o-b
70S-60S	282	-0.4	0.0	6.1	5.6	280	3.9	2.6	8.2	6.6
60S-50S	937	0.5	8.3	8.3	7.7	931	1.0	1.0	11.0	9.8
50S-40S	975	-0.2	0.1	6.7	6.5	952	2.6	2.1	10.9	9.8
40S-30S	2500	0.3	0.4	5.2	5.0	2396	4.1	2.8	9.2	8.1
30S-20S	2076	0.1	0.3	3.0	2.7	2018	2.5	1.7	9.3	8.2
20S-10S	2478	0.5	0.3	2.8	2.6	2423	1.8	1.2	9.0	7.9
10S-0	2205	0.7	0.4	3.2	3.1	2133	2.3	1.5	10.0	9.1
0-10N	4163	0.8	0.4	4.1	4.0	3975	2.5	1.9	10.2	9.0
10-20N	6433	0.4	0.3	3.6	3.3	6313	1.8	1.2	10.5	9.4
20-30N	8596	0.0	0.1	3.9	3.7	8413	2.5	1.9	11.1	10.3
30-40N	14463	-0.2	0.3	6.8	6.6	14146	3.8	2.7	10.0	9.2
40-50N	14189	0.1	0.4	9.0	8.8	13992	3.3	2.6	11.0	10.2
50-60N	9815	0.7	0.7	8.0	7.8	9697	3.9	3.4	12.6	12.0
60-70N	4086	1.5	1.4	12.7	12.5	3999	4.4	4.0	13.0	10.0
70-80N	2237	1.4	0.8	9.5	9.4	2184	3.3	3.4	14.7	14.3
80-90N	102	-0.8	-0.6	4.4	3.8	103	6.4	6.0	12.7	10.9

TABLE 2.5. SHIP DATA WITHOUT FINAL FLAG : 10° latitude bands Month: JULY 1987

	p* (mb)					wind speed (kts)				
AREA	n. obs	o-b	o-a	sd o-b	sd o-a	n. obs	o-b	o-a	sd o-b	sd o-b
70S-60S	4	5.9	1.5	1.7	0.5	4	4.9	3.4	3.2	2.1
60S-50S	194	-0.7	0.1	3.7	2.2	190	1.4	0.8	8.5	5.7
50S-40S	727	-0.2	0.1	2.8	1.6	728	0.7	0.5	9.5	6.2
40S-30S	2320	-0.3	0.1	1.9	1.2	2276	3.8	2.5	7.8	6.3
30S-20S	2177	-0.2	0.0	1.8	1.4	2131	1.9	1.3	6.5	4.6
20S-10S	2320	0.4	0.1	2.6	2.4	2338	0.8	0.4	7.0	5.4
10S-0	1781	0.5	0.1	1.7	1.6	1786	1.1	0.8	5.6	3.6
0-10N	3669	0.4	0.2	2.5	2.5	3581	2.1	1.4	5.8	3.9
10-20N	5391	0.3	0.3	2.4	2.2	5308	2.5	1.6	6.6	4.5
20-30N	0691	0.2	0.1	2.4	2.1	6675	2.0	1.4	6.2	4.9
30-40N	10924	0.1	0.0	2.3	1.9	10734	2.9	2.2	6.0	4.8
40-50N	16696	-0.1	0.1	3.5	3.3	16576	2.9	2.4	6.1	5.4
50-60N	11420	0.2	0.2	4.5	4.3	11342	2.7	2.3	5.9	5.1
60-70N	5919	0.1	0.1	2.0	1.6	5873	1.8	1.5	5.5	4.9
70-80N	2374	0.3	-0.1	3.4	3.2	2423	2.7	2.4	5.7	4.9
80-90N	234	-0.2	0.0	1.5	1.0	234	6.1	5.2	4.1	3.4

TABLE 2.6. SHIP DATA WITHOUT FINAL FLAG : 10° latitude bands Month: DEC. 1987

	p* (mb)					wind speed (kts)				
AREA	n. obs	o-b	o-a	sd o-b	sd o-a	n. obs	o-b	o-a	sd o-b	sd o-b
70S-60S	262	-0.2	0.2	3.6	2.5	273	3.8	2.5	8.1	6.4
60S-50S	837	0.1	0.2	6.3	5.6	881	0.8	0.8	9.4	8.1
50S-40S	898	0.0	0.3	6.4	6.2	919	2.1	1.6	7.5	5.7
40S-30S	2425	0.2	0.3	4.3	4.0	2361	3.7	2.4	7.0	5.3
30S-20S	2009	0.1	0.2	2.0	1.6	1987	2.1	1.2	6.3	4.3
20S-10S	2376	0.3	0.1	1.9	1.5	2363	1.3	0.8	6.2	6.5
10S-0	2065	0.5	0.3	2.6	2.6	2078	1.9	1.1	7.3	6.1
0-10N	3880	0.6	0.2	2.5	2.3	3847	1.9	1.2	6.7	4.4
10-20N	5945	0.2	0.1	2.1	1.8	6148	1.3	0.7	6.8	4.8
20-30N	7807	-0.2	0.0	2.5	2.2	8154	1.8	1.1	6.4	4.8
30-40N	12906	-0.4	0.1	5.4	5.2	13564	3.2	2.2	7.2	5.8
40-50N	12558	-0.1	0.2	6.9	6.8	13329	2.7	2.0	8.1	6.8
50-60N	8746	0.2	0.2	5.8	5.6	9235	3.0	2.5	8.3	7.1
60-70N	3621	1.0	0.9	10.3	10.2	3821	3.6	3.3	8.9	7.5
70-80N	2015	0.7	0.2	6.5	6.3	2092	2.1	2.2	6.8	5.7

3. Conclusions

This study of the OPD statistics for 1987 reveals a large number of interesting facts on the differences between observations and first guess fields for a range of data types. A comparison of sigma level mean values derived from TEMP and PILOT reports reveals noticeable biases in temperature in the boundary layer over Antarctica, especially in winter, and over the continental areas in the latitude band 60 to 90°N in winter. Biases of wind speed and wind direction in the boundary layer are also seen at many latitudes. An alternating cold and warm bias in o-b temperatures is seen in the grouped upper air statistics at some latitudes.

SATOB data show a negative bias of wind speed against the background field (observed wind speeds too low) at extratropical latitudes at jet stream level, especially in the region of the Pacific jet. The o-b wind direction bias for SATOB data is very small in the extratropics but increases in the tropics and equatorial regions as does the standard deviation of o-b wind direction differences. The high level wind speed bias of SATOB data decreases from the extratropics to the equator. The SATOB data from each satellite's data shows it own characteristics. The quality of the wind data from the Indian satellite is very poor, when judged solely against the background field over the Indian ocean.

SATEM data over the sea is biased against the first guess temperature field at the 922 mb level but more noticeably so at tropopause or near tropopause level and in the stratosphere. A very marked cold bias exists at the 78.7 mb level in the tropics and equatorial regions; in high latitudes the strong cold bias is found at the 38.7 mb level. Statistics generated for SATEM data over ice and sea ice surfaces show a warm bias at the 922 mb level, especially in winter when the background field appears too cold and there is a significantly greater standard deviation of o-b temperature differences at this level, probably reflecting increased errors in the retrieval of near surface virtual temperatures from the original radiances. SATEM mean o-b temperature profiles over land surfaces in the tropics and at high latitudes (60° to 90°N) show a more stable temperature profile than the background field in the mid-troposphere. At the 922 mb level at all latitudes, SATEM data over land and ice show a greater standard deviation of o-b temperature differences compared to data over the sea. levels above. This standard deviation is comparable to that of SATEM data over ice and sea ice and rather greater than that over the sea.

LASS and C.C. SATEM data statistics for March, July and October 1987 show that while LASS data deteriorated in quality compared with the first guess field, with an increasing bias in both the troposphere and stratosphere, C.C. SATEM data showed only a small seasonal change in o-b statistics and had much smaller biases and standard deviation of o-b temperature differences in July and October 1987. FM TEMP data from the OWS stations and selected coastal stations show a similar standard deviation of o-b temperature differences to C.C. SATEM data, but with their own particular temperature bias profile, as seen in certain of the CM TEMP profiles.

AIREP temperature observations in the pressure bands 300-200 mb and 200-100 mb show a warm bias relative to the background field in the southern hemisphere summer and winter, in the tropics and northern hemisphere. AIREP wind speed observations are biased against the background field by approximately + 5 kts in these same pressure bands at all latitudes and seasons. The standard deviation of temperature differences and wind speed differences of AIREP data at jet stream level are somewhat greater than that for grouped TEMP and PILOT data.

A study of SHIP data grouped into 10° latitude bands from 70°S to 90°N reveals that SHIP wind reports are, in the mean, biased against the surface background wind field by +2 to +4 kts. This bias is not noticeably reduced by the exclusion of flagged ship data. SHIP pressure observations show, in general, a small positive bias against the background field and a smaller, but not zero bias against the analysis field. These biases are reduced by the exclusion of flagged data.

MET O8

MONITORING NOTE NO. 1. : FIGURES.

FIG. 2.1.1 TEMP + PILOT

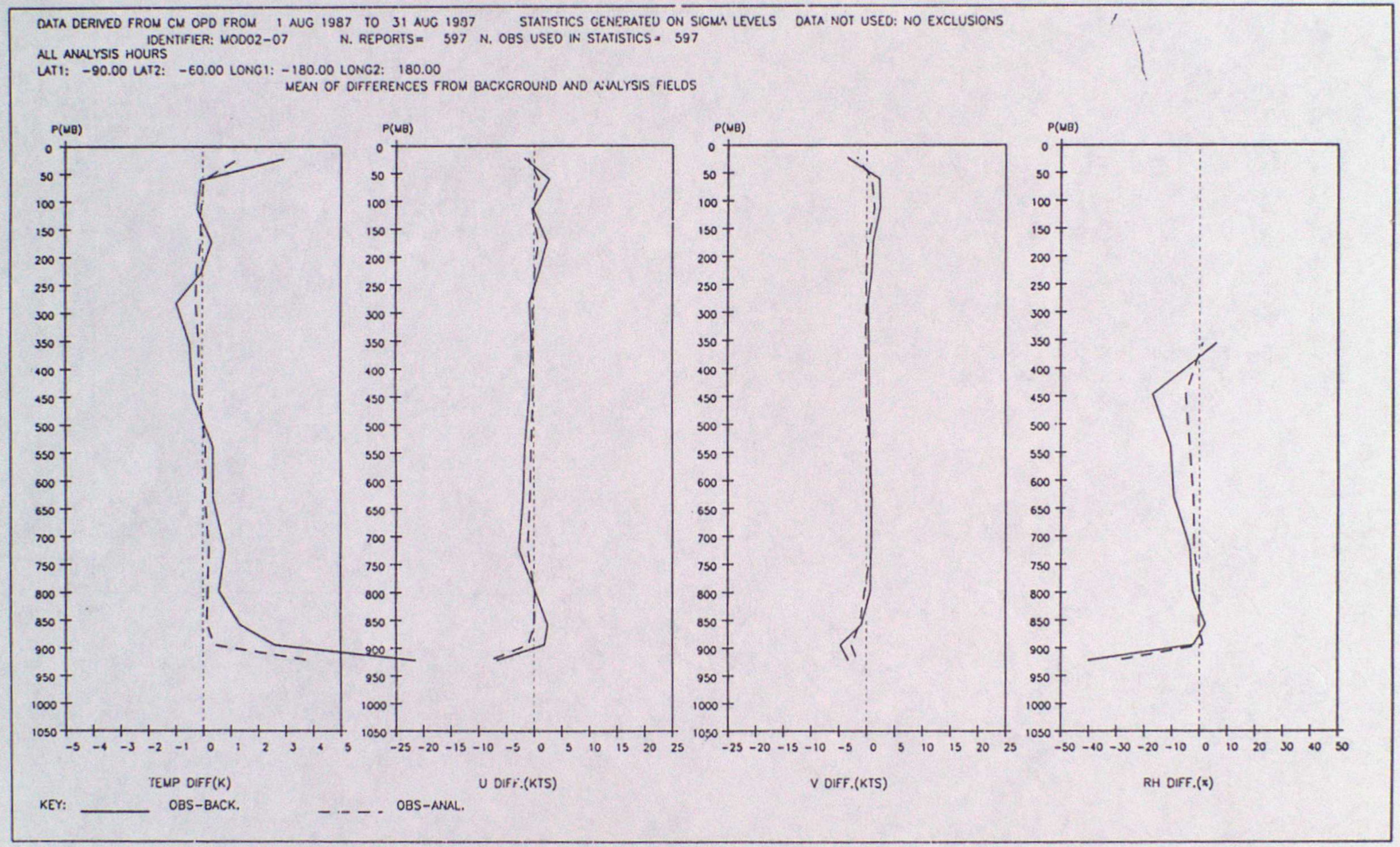
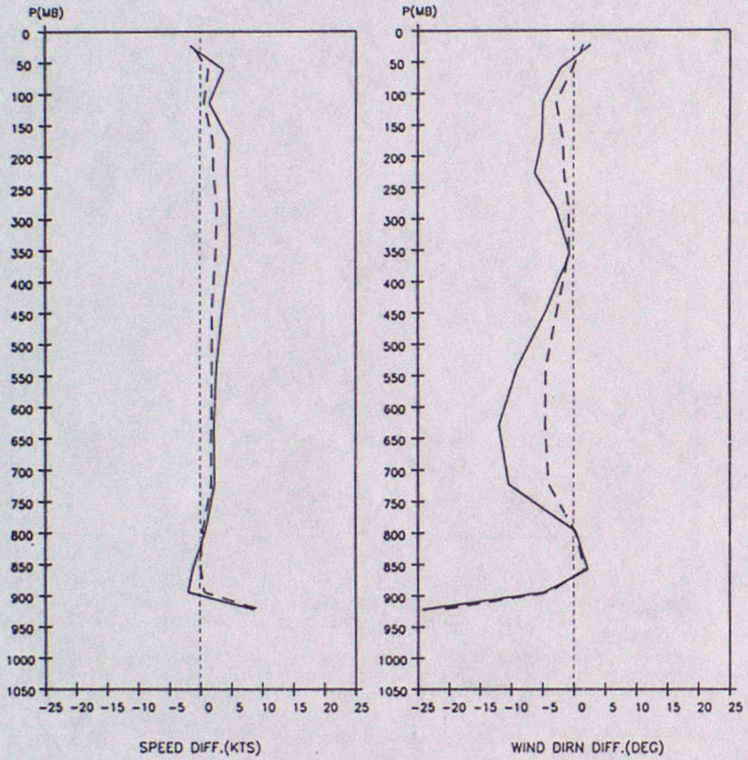


FIG. 2.1.1 CONT. TEMP + PILOT.

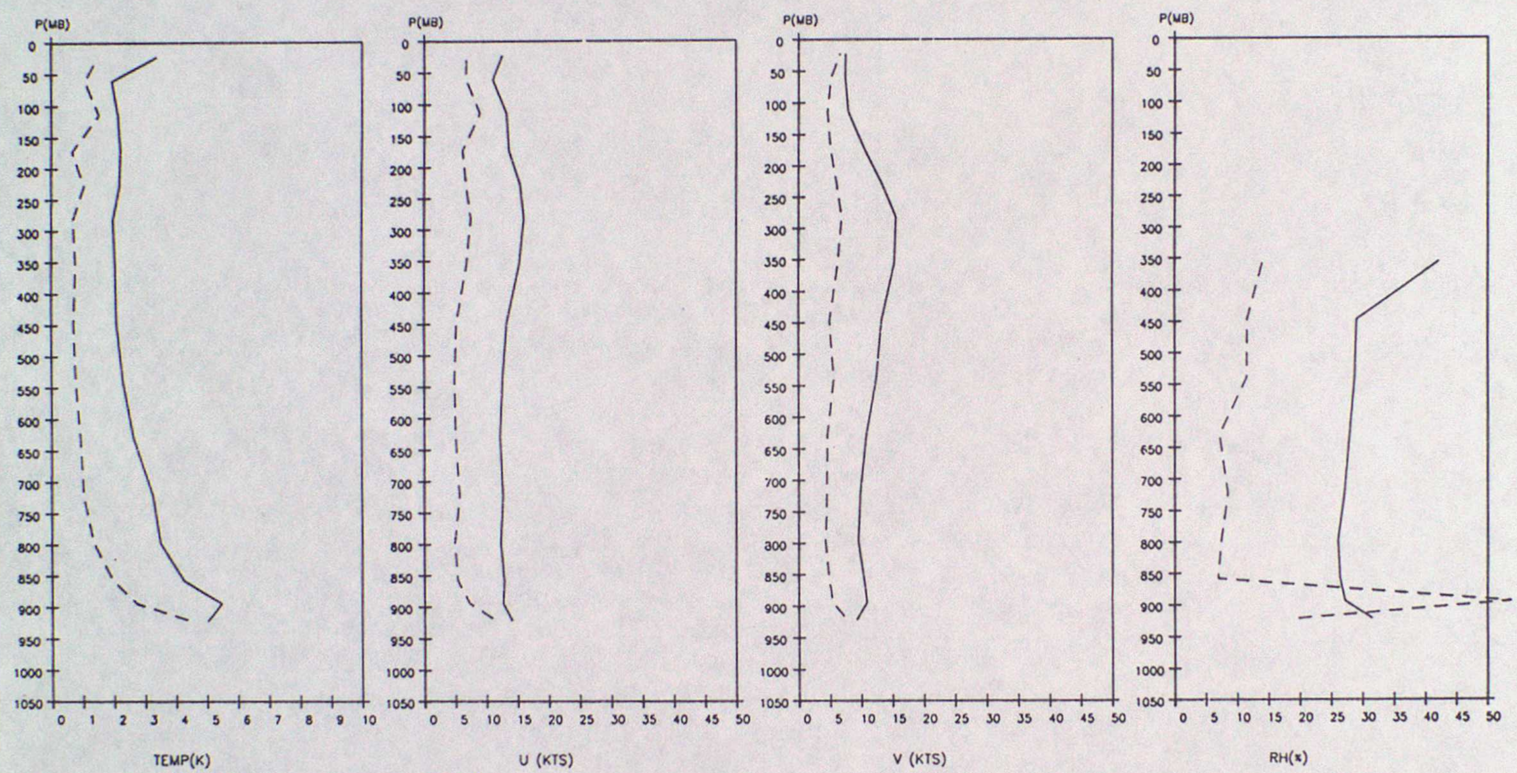
DATA DERIVED FROM CM OPD FROM 1 AUG 1987 TO 31 AUG 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 597 N. OBS USED IN STATISTICS= 597
ALL ANALYSIS HOURS
LAT1: -90.00 LAT2: -60.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ———— OBS-BACK. – – – – OBS-ANAL.

FIG. 2.1.1 CONT.   TEMP+ PILOT

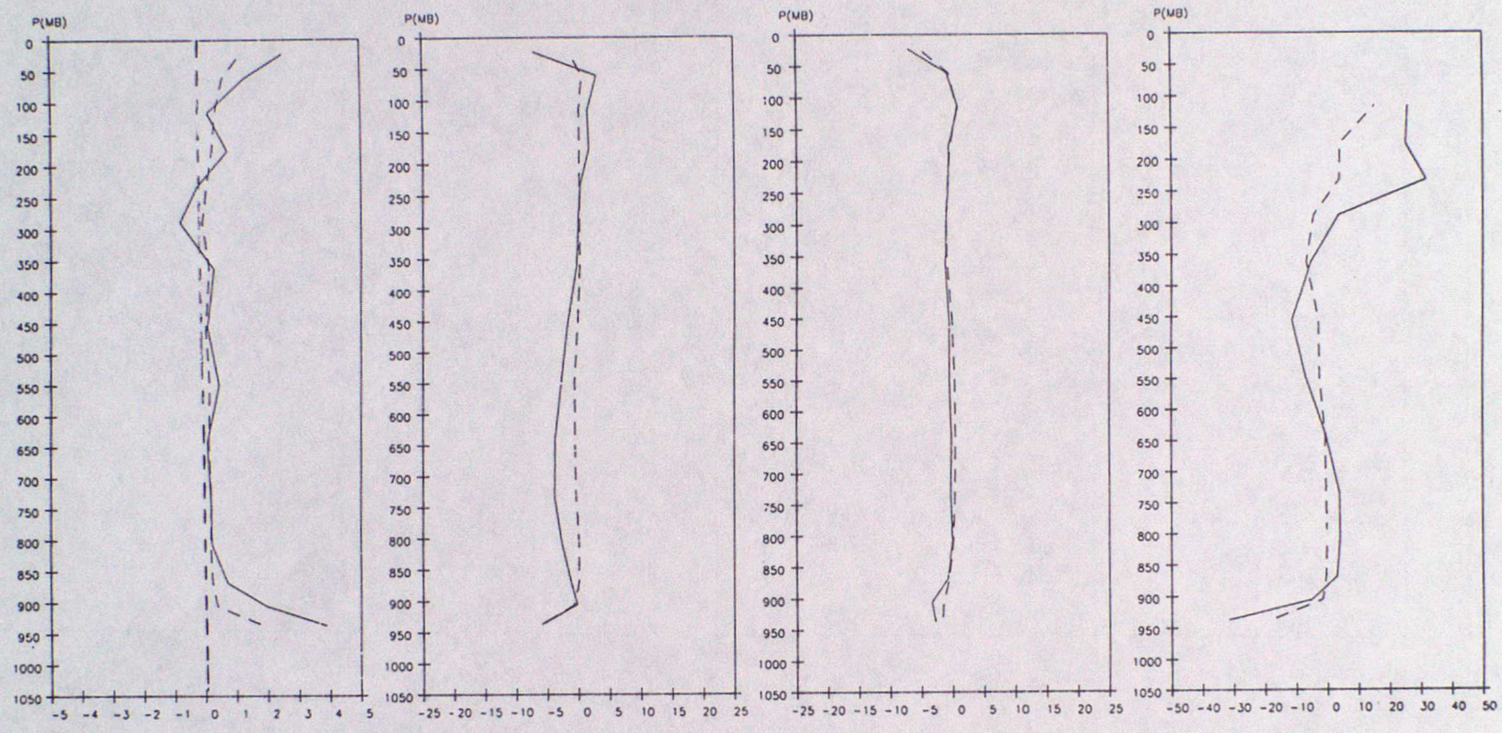
DATA DERIVED FROM CM OPD FROM 1 AUG 1987 TO 31 AUG 1987   STATISTICS GENERATED ON SIGMA LEVELS   DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07   N. REPORTS= 597 N. OBS USED IN STATISTICS= 597
ALL ANALYSIS HOURS
LAT1: -90.00 LAT2: -60.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ———— OBS-BACK.   – – – – OBS-ANAL.

FIG. 2.1.2. TEMP + PILOT.

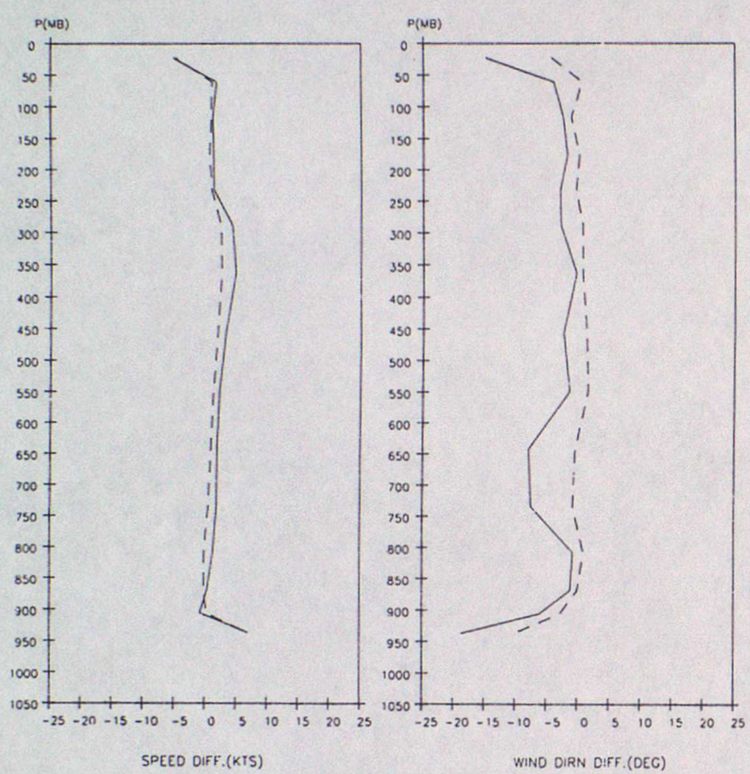
DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 670 N. OBS USED IN STATISTICS= 670
ALL ANALYSIS HOURS
LAT1: -90.00 LAT2: -60.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. - - - OBS-ANAL.

FIG. 2.1.2. CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 670 N. OBS USED IN STATISTICS= 670
ALL ANALYSIS HOURS
LAT1: -90.00 LAT2: -60.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYS'S FIELDS



KEY: ———— OBS-BACK. – – – . OBS-ANAL.

Fig. 2.1.2. cont. Temp + Pilot.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 670 N. OBS USED IN STATISTICS= 670
ALL ANALYSIS HOURS
LAT1: -90.00 LAT2: -60.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

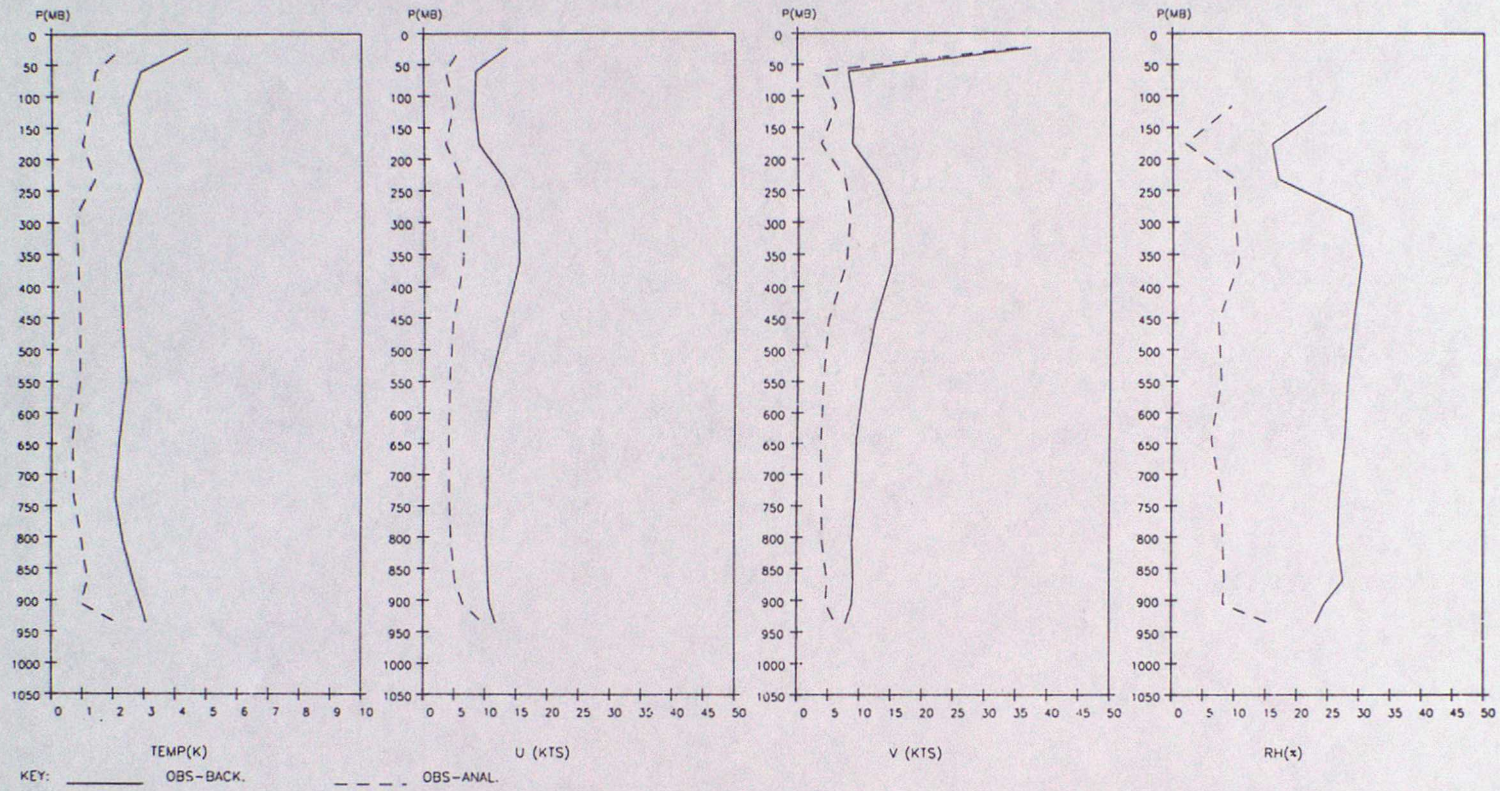


FIG. 2.1.3. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 AUG 1987 TO 31 AUG 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 4230 N. OBS USED IN STATISTICS= 4230
ALL ANALYSIS HOURS
LAT1: -60.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

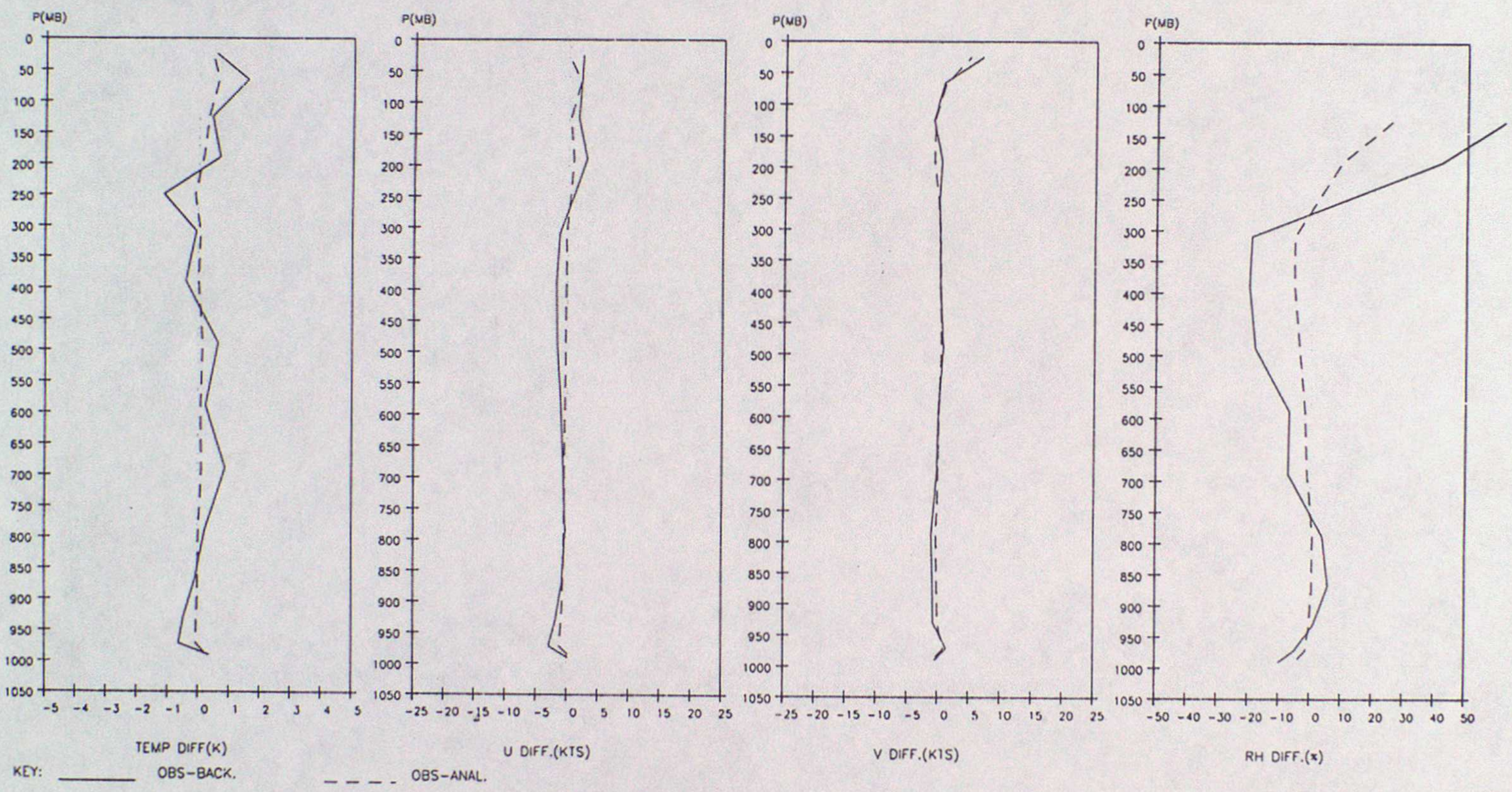
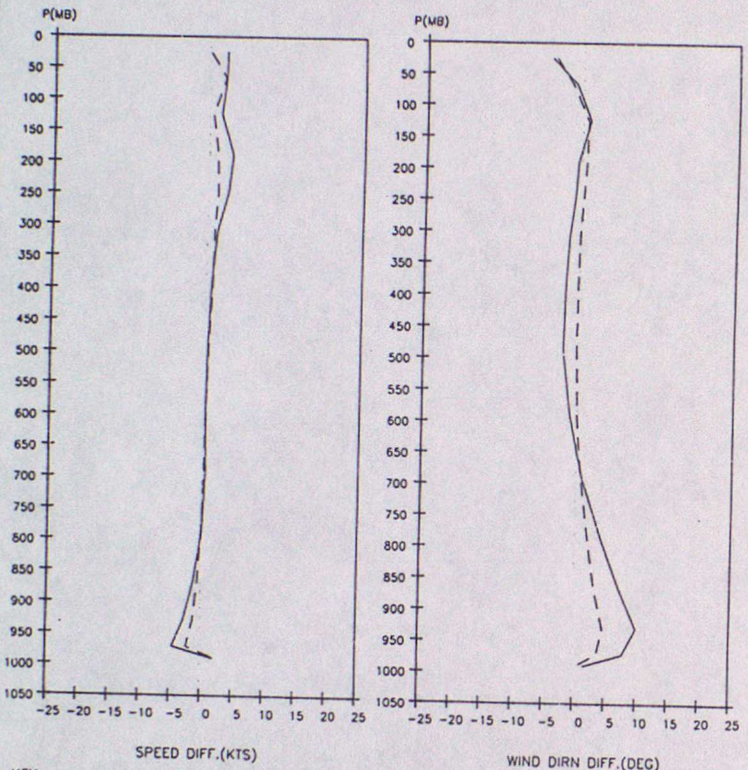


FIG 2.1.3. CONT. TEMP + PILOT.

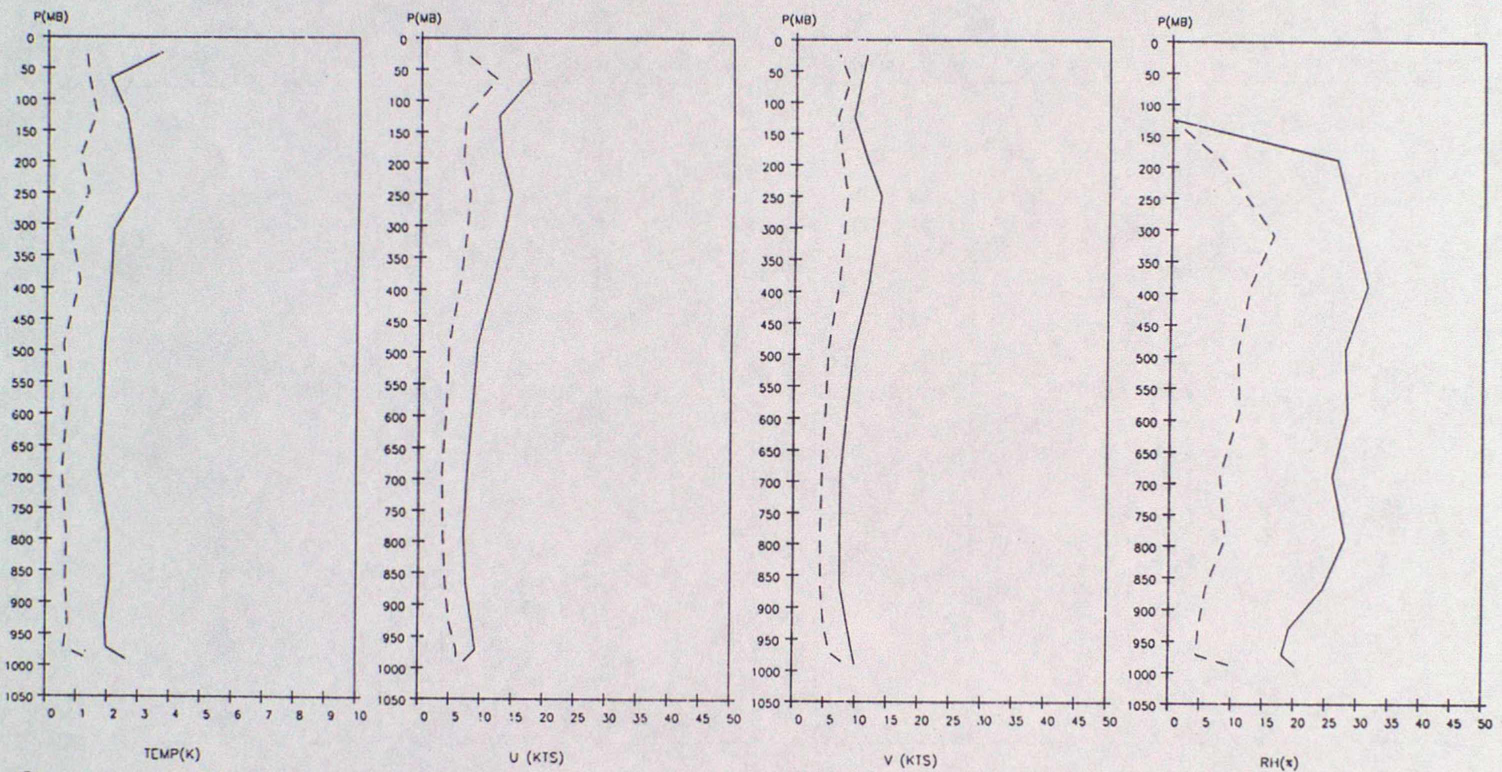
DATA DERIVED FROM CM OPD FROM 1 AUG 1987 TO 31 AUG 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 4230 N. OBS USED IN STATISTICS= 4230
ALL ANALYSIS HOURS
LAT1: -60.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. – – – – OBS-ANAL.

FIG 2.1.3 CONT. TEMP + PILOT

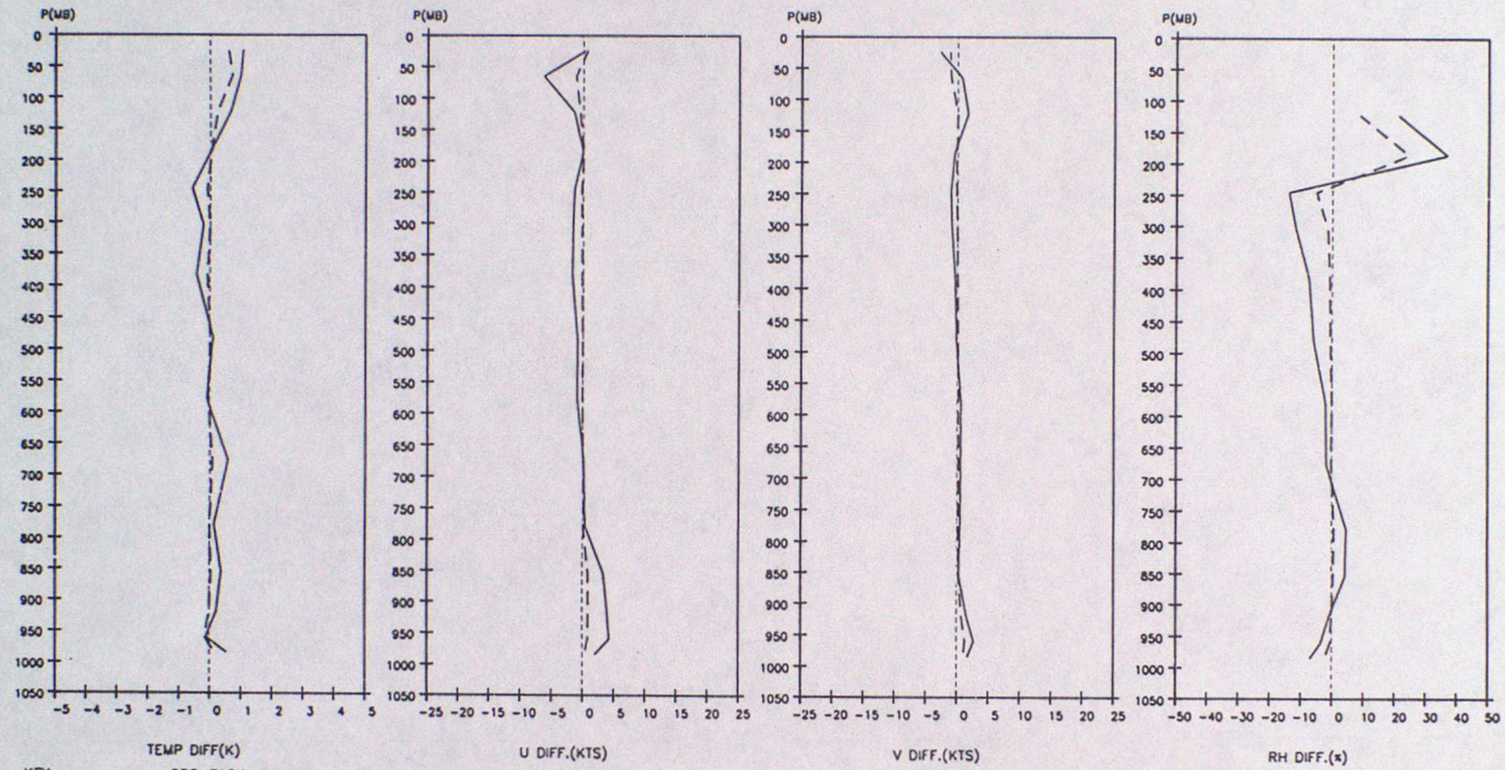
DATA DERIVED FROM CM OPD FROM 1 AUG 1987 TO 31 AUG 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 4230 N. OBS USED IN STATISTICS= 230
ALL ANALYSIS HOURS
LAT1: -60.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. -- — — OBS-ANAL.

FIG. 2.1.4. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 13486 N. OBS USED IN STATISTICS=13486
ALL ANALYSIS HOURS
LAT1: 0.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. – – – – OBS-ANAL.

FIG. 2.1.4 CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 13486 N. OBS USED IN STATISTICS=13486
ALL ANALYSIS HOURS
LAT1: 0.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

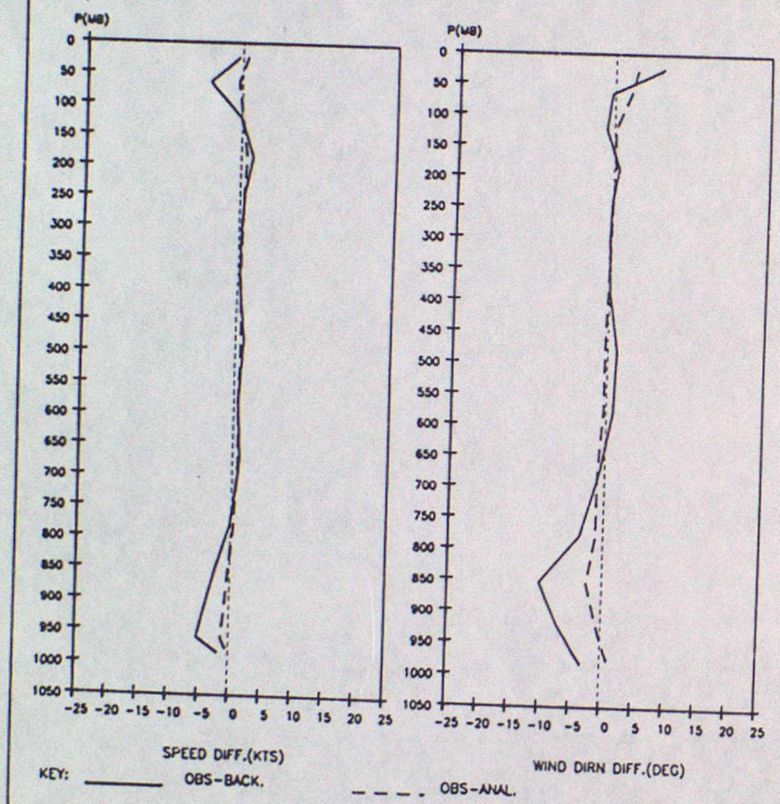


FIG. 2.1.4 CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 13486 N. OBS USED IN STATISTICS=13486
ALL ANALYSIS HOURS
LAT1: 0.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

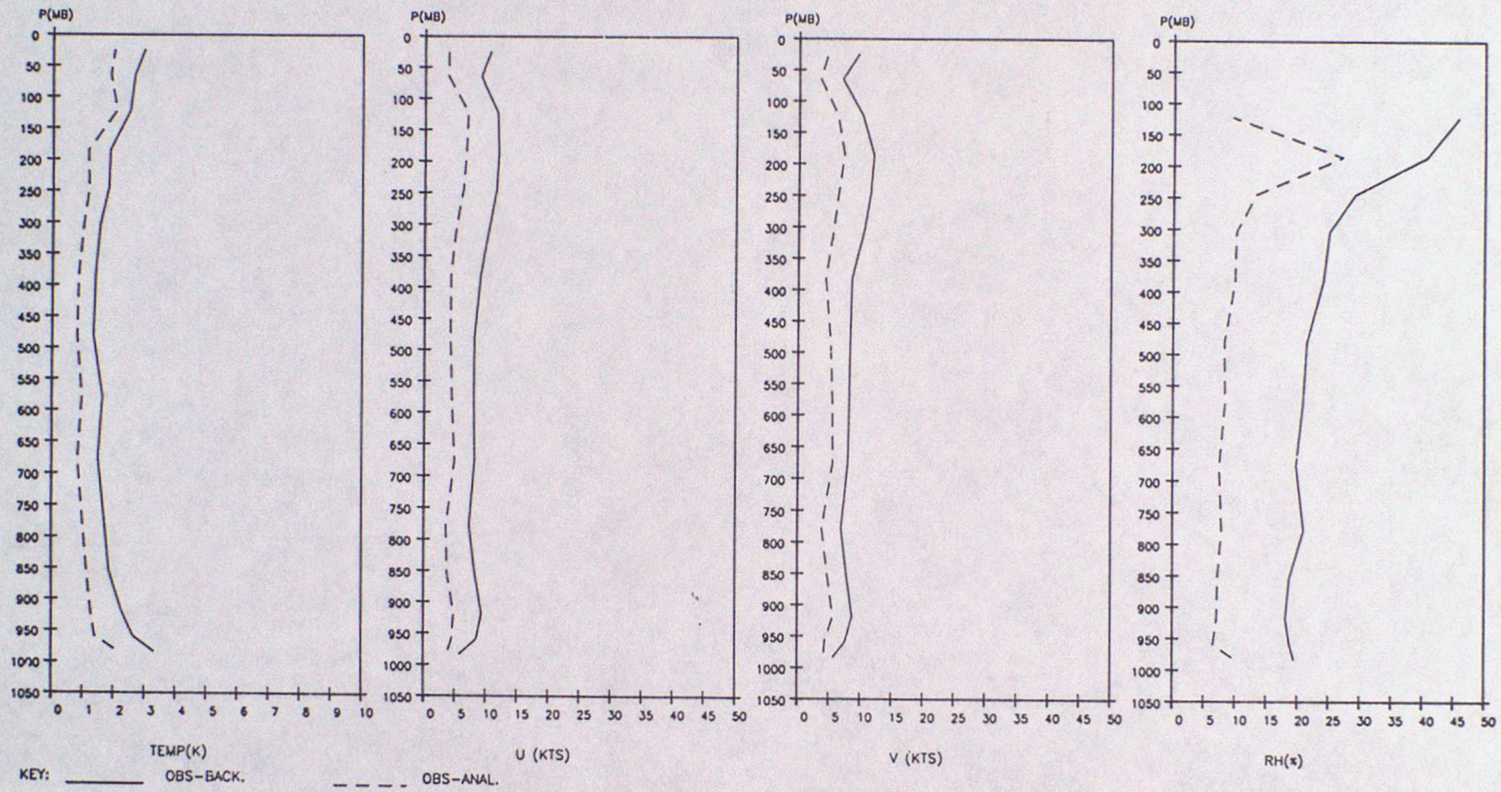
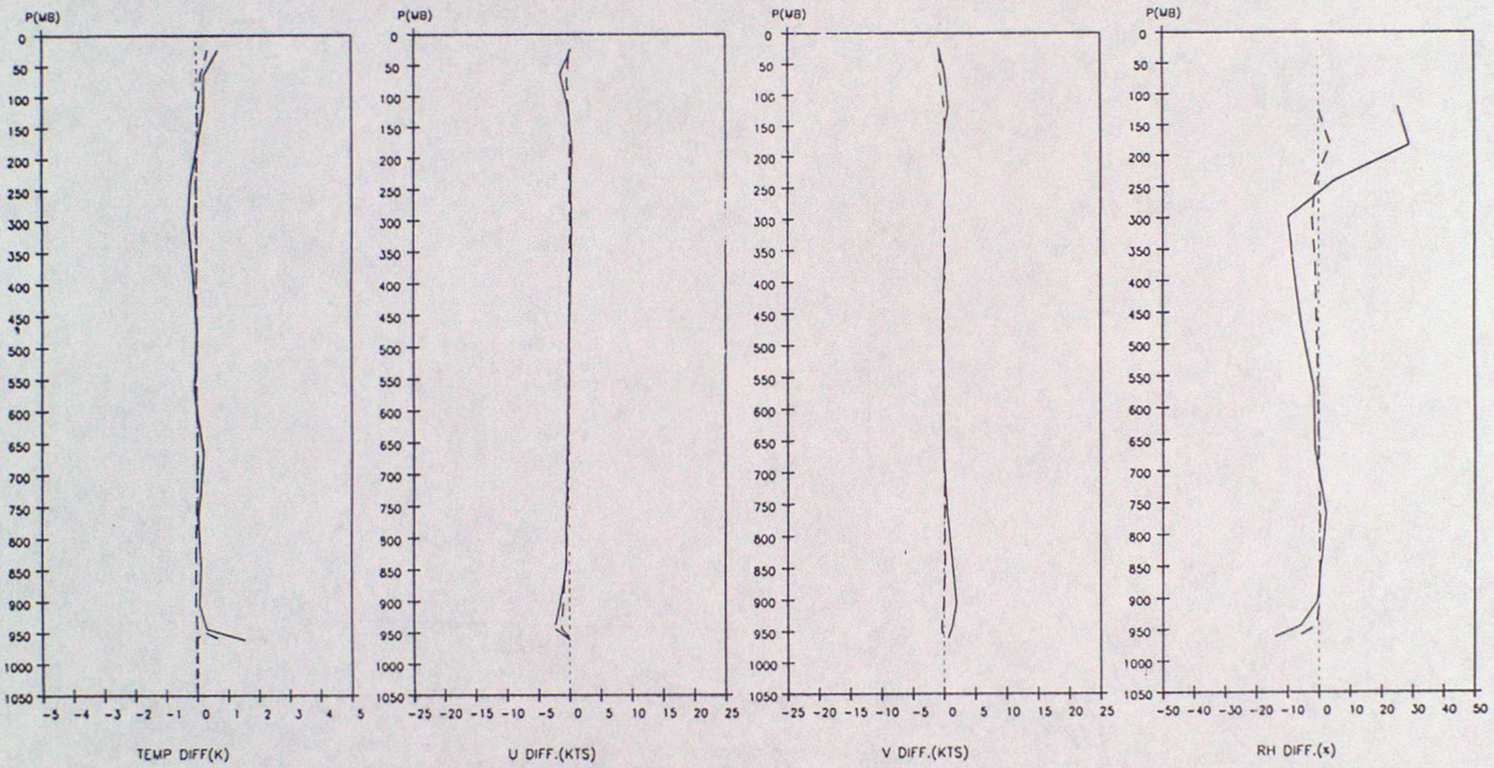


FIG. 2.1.5. TEMP + PILOT.

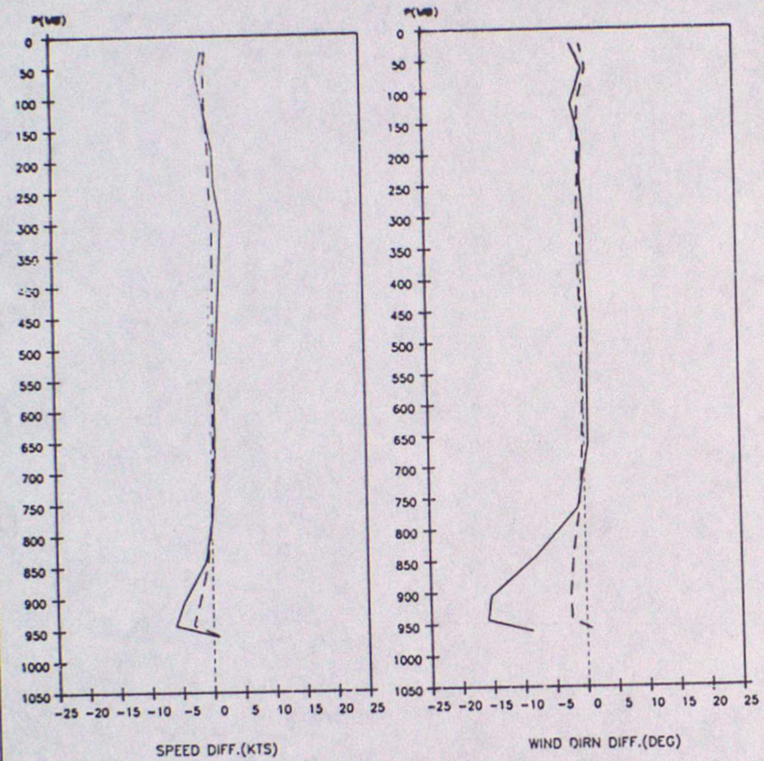
DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 33597 N. OBS USED IN STATISTICS= 33597
ALL ANALYSIS HOURS
LAT1: 30.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. — — — OBS-ANAL.

FIG 2.1.5. CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS=33597 N. OBS USED IN STATISTICS=33597
ALL ANALYSIS HOURS
LAT1: 30.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. – – – OBS-ANAL.

FIG. 2.1.5 CONT. TEMP + PILOT

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS-33597 N. OBS USED IN STATISTICS-33597
ALL ANALYSIS HOURS
LAT1: 30 .00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

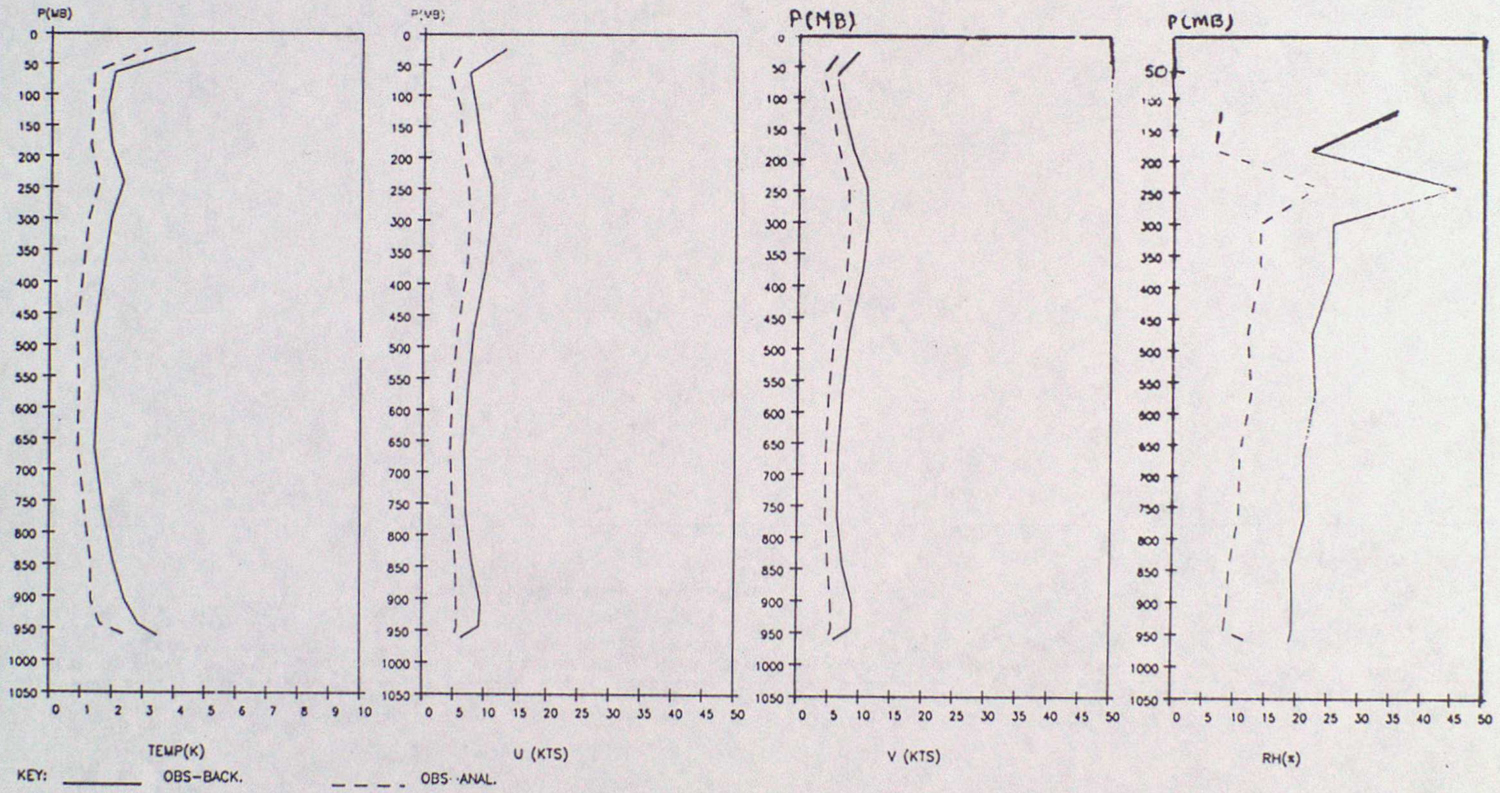


FIG. 2.1.6. TEMP + PILOT

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-87 N. REPORTS= 8003 N. OBS USED IN STATISTICS= 8003
ALL ANALYSIS HOURS
LAT1: 60.00 LAT2: 90.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

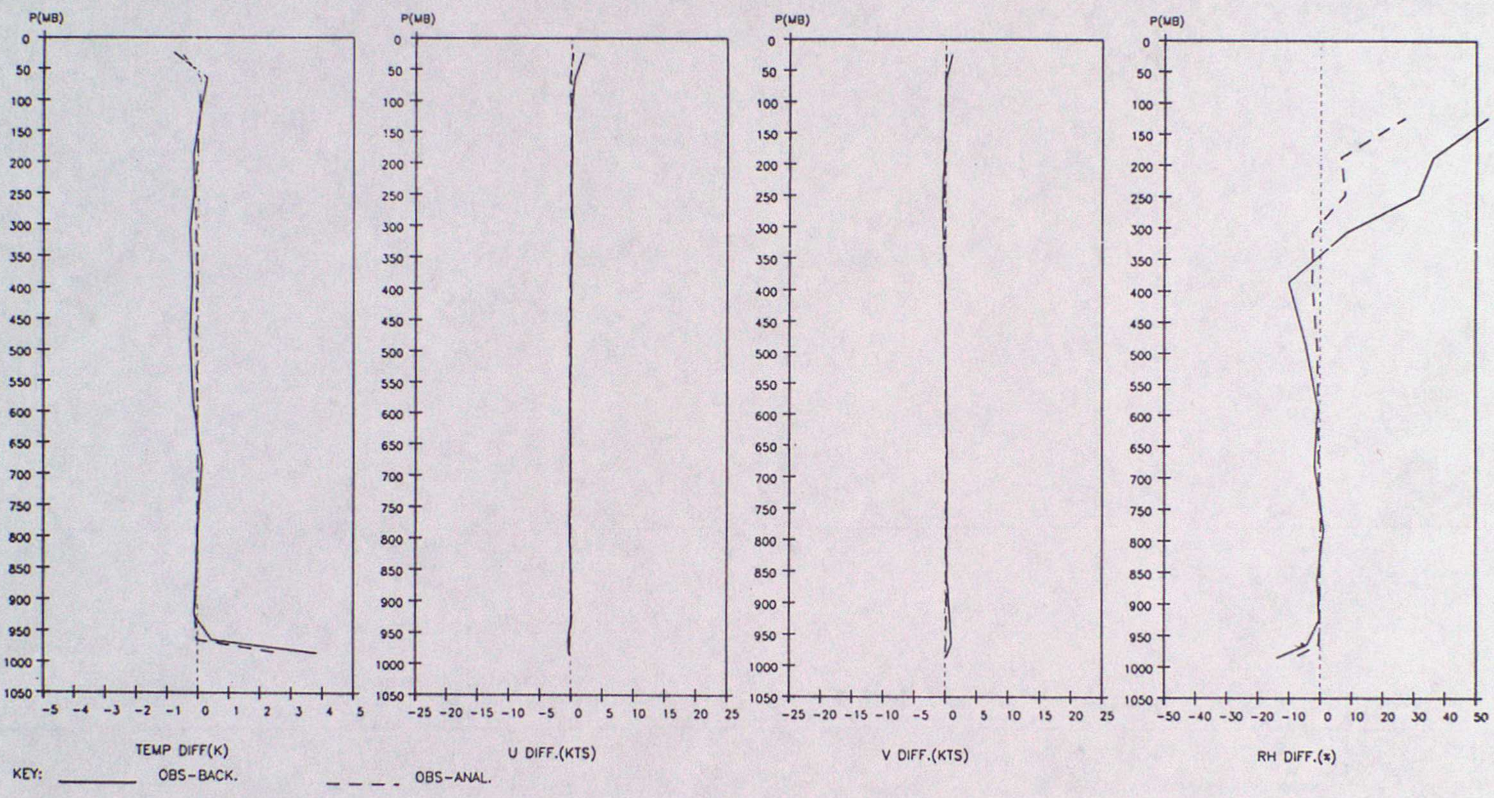
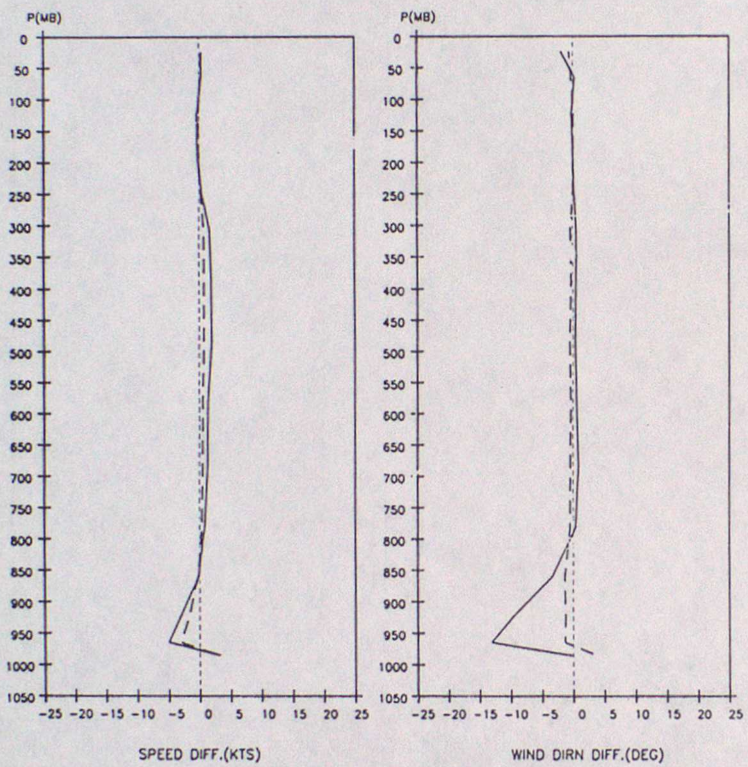


FIG. 2.1.6 CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: MOD02-07 N. REPORTS= 8003 N. OBS USED IN STATISTICS= 8003
ALL ANALYSIS HOURS
LAT1: 60.00 LAT2: 90.00 LONG1: -180.00 LONG2: 180.00
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ———— OBS-BACK. — — — OBS-ANAL.

FIG. 2.1.6. CONT. TEMP + PILOT.

DATA DERIVED FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS
IDENTIFIER: W0002-07 N. REPORTS= 8003 N. OBS USED IN STATISTICS= 8003
ALL ANALYSIS HOURS
LAT1: 60.00 LAT2: 90.00 LONG1: -180.00 LONG2: 180.00
SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

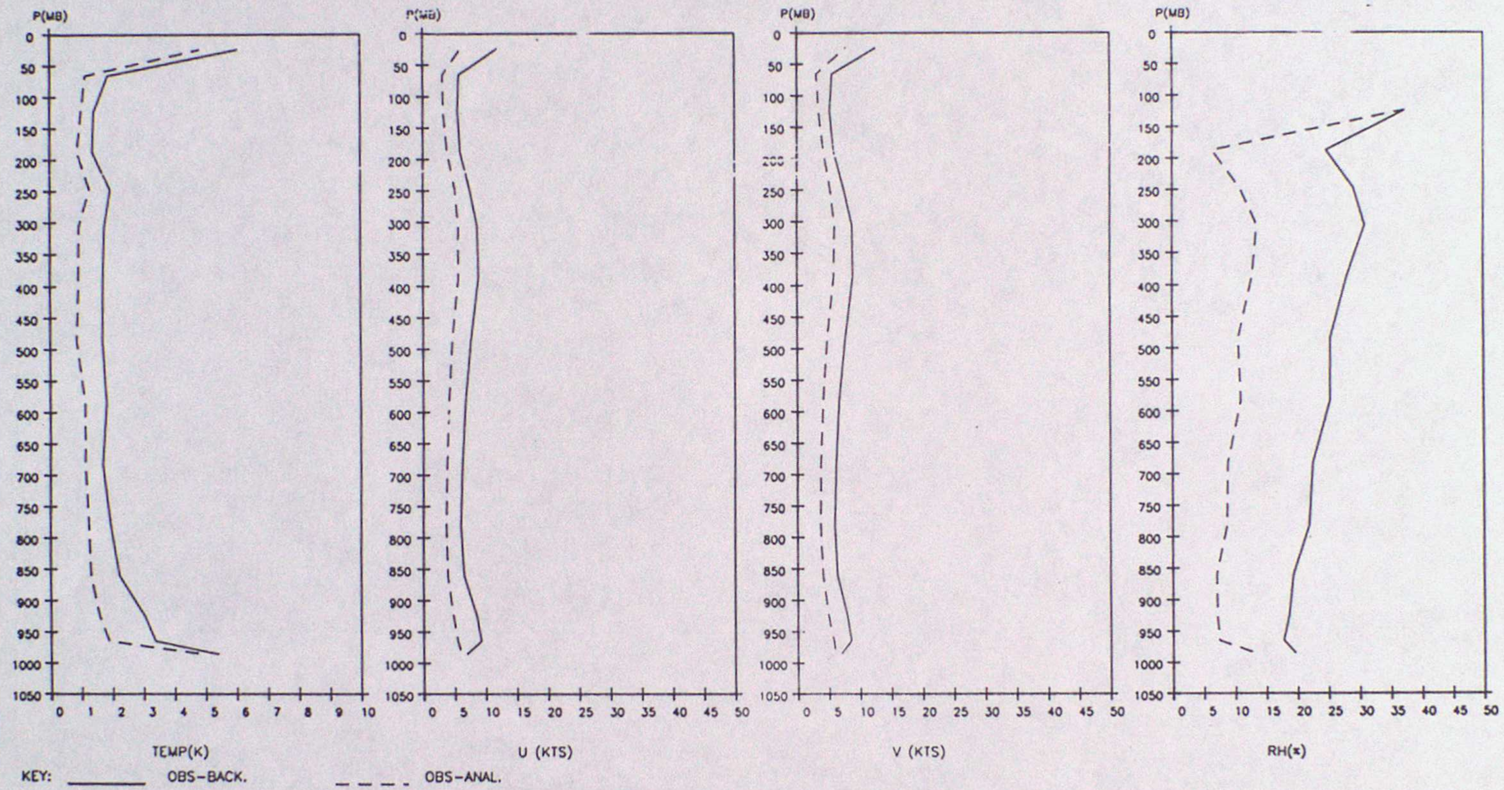


FIG. 2.2.1. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 3003 N. OBS USED: 3003
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

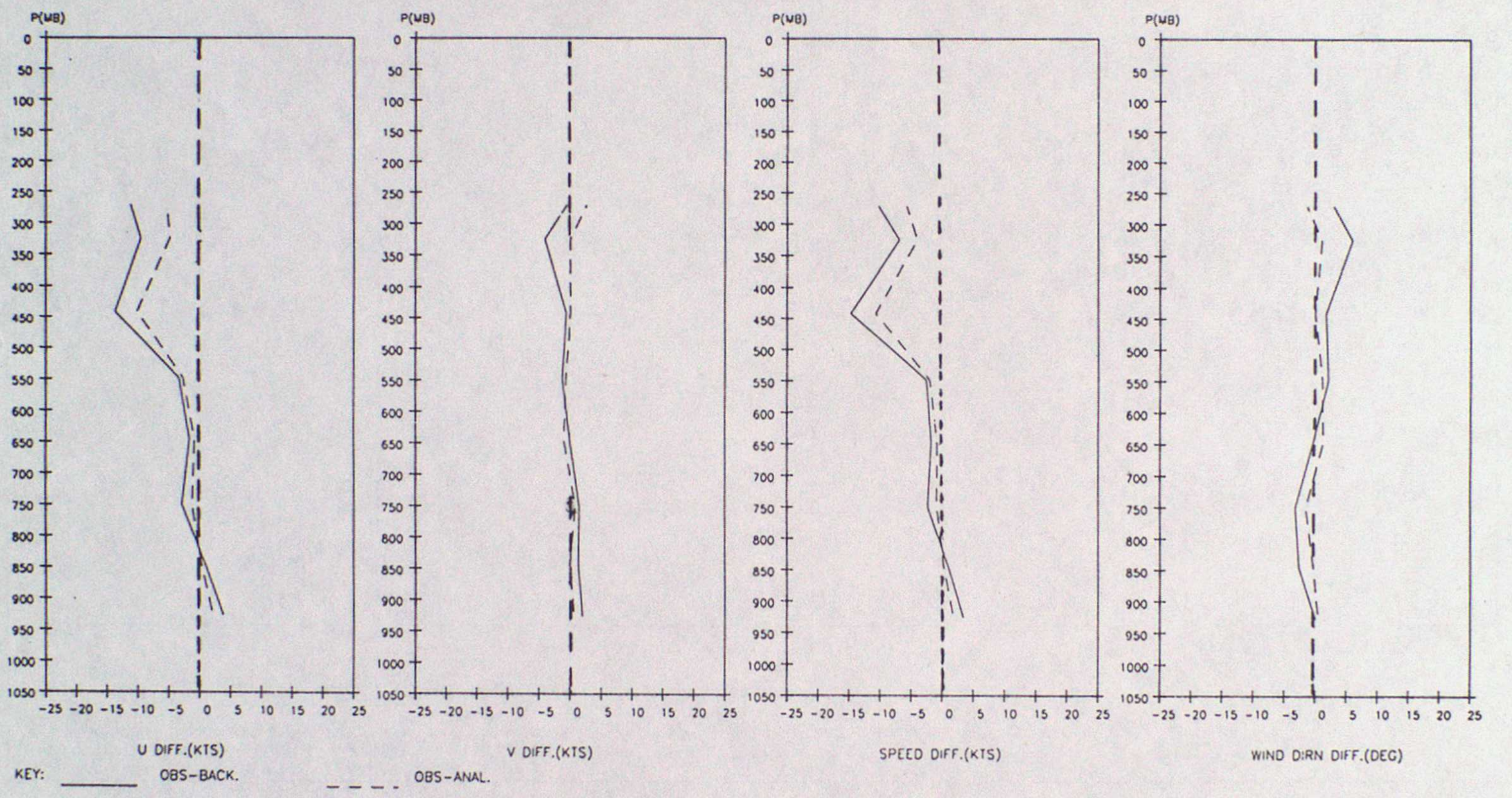


FIG. 2.2.1 CONT. METEOSAT.

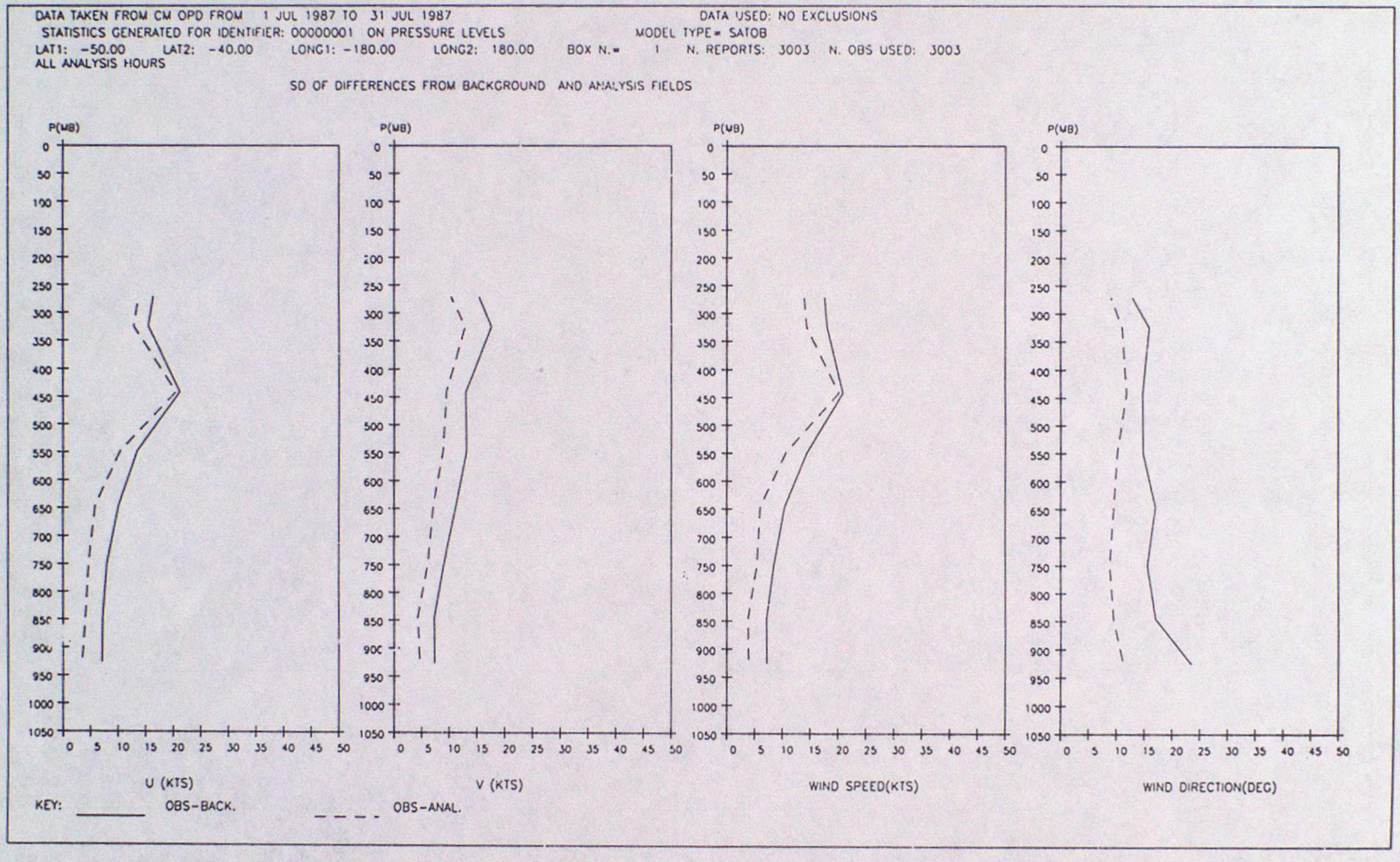


FIG. 2.2.2. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE = SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N. = 1 N. REPORTS: 4424 N. OBS USED: 4424
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

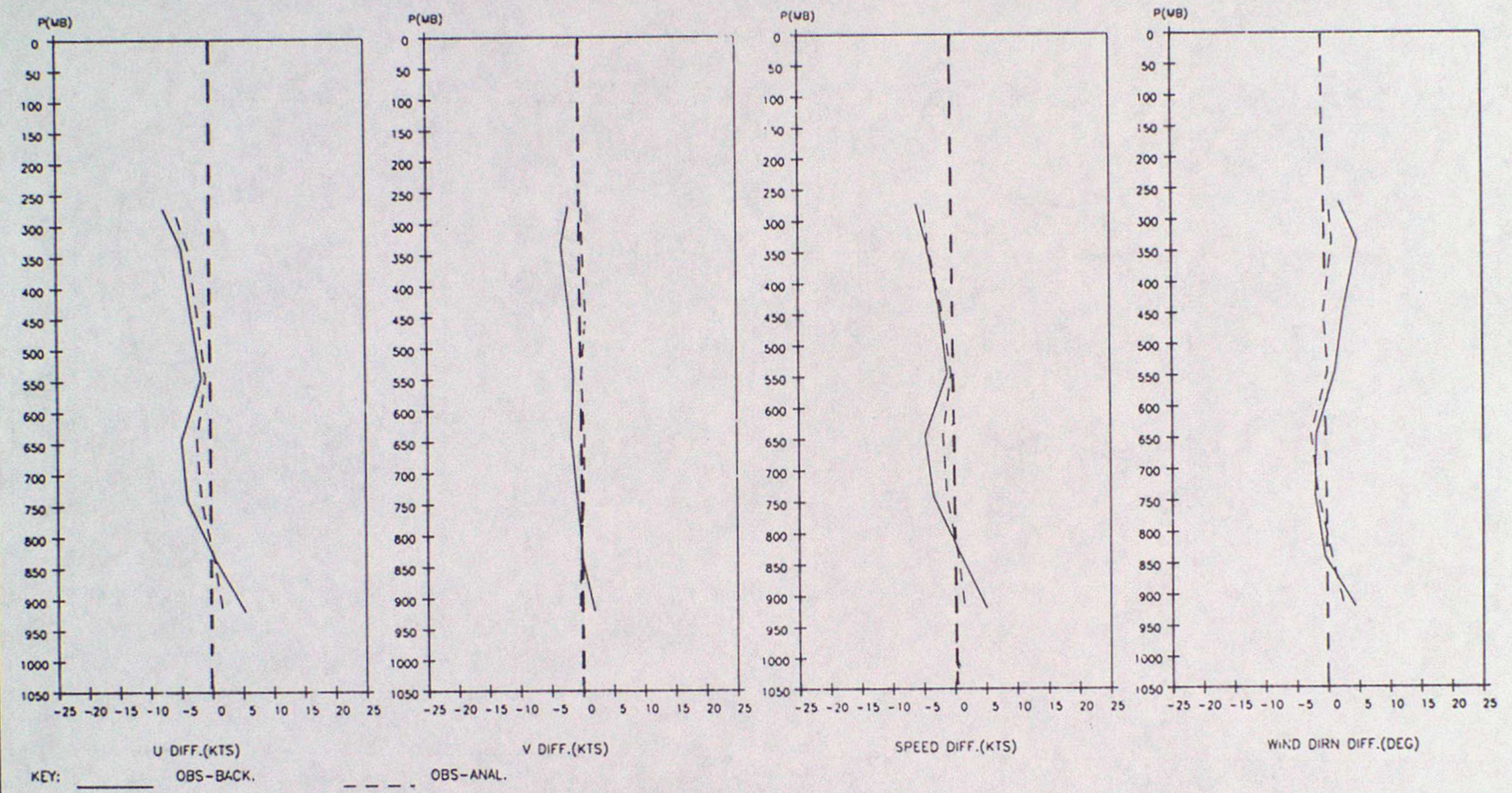
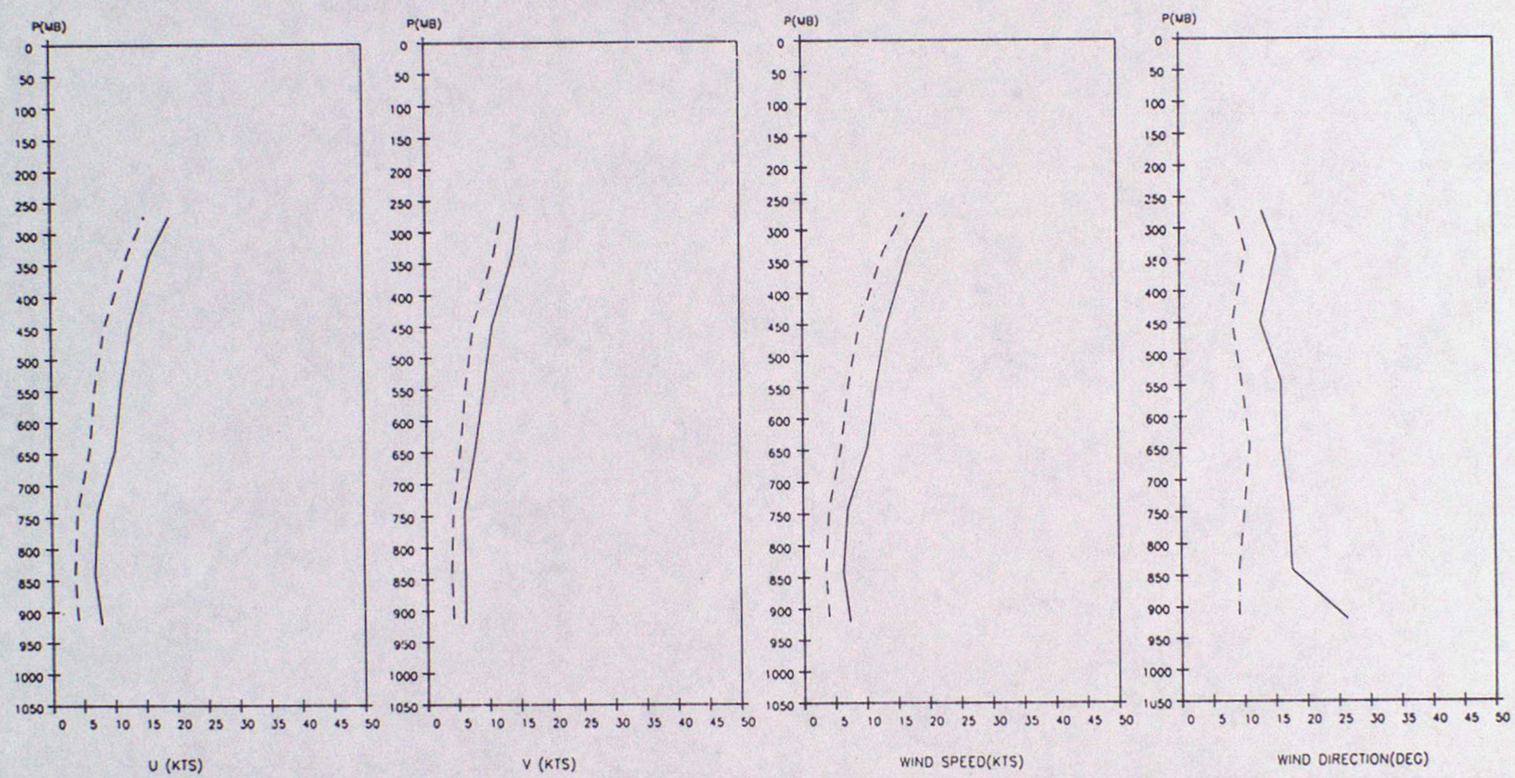


FIG. 2.2.2. CONT. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 4424 N. OBS USED: 4424
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ———— OBS-BACK. – – – – OBS-ANAL.

FIG 2.2.3 METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 5 N. REPORTS: 5421 N. OBS USED: 5421
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

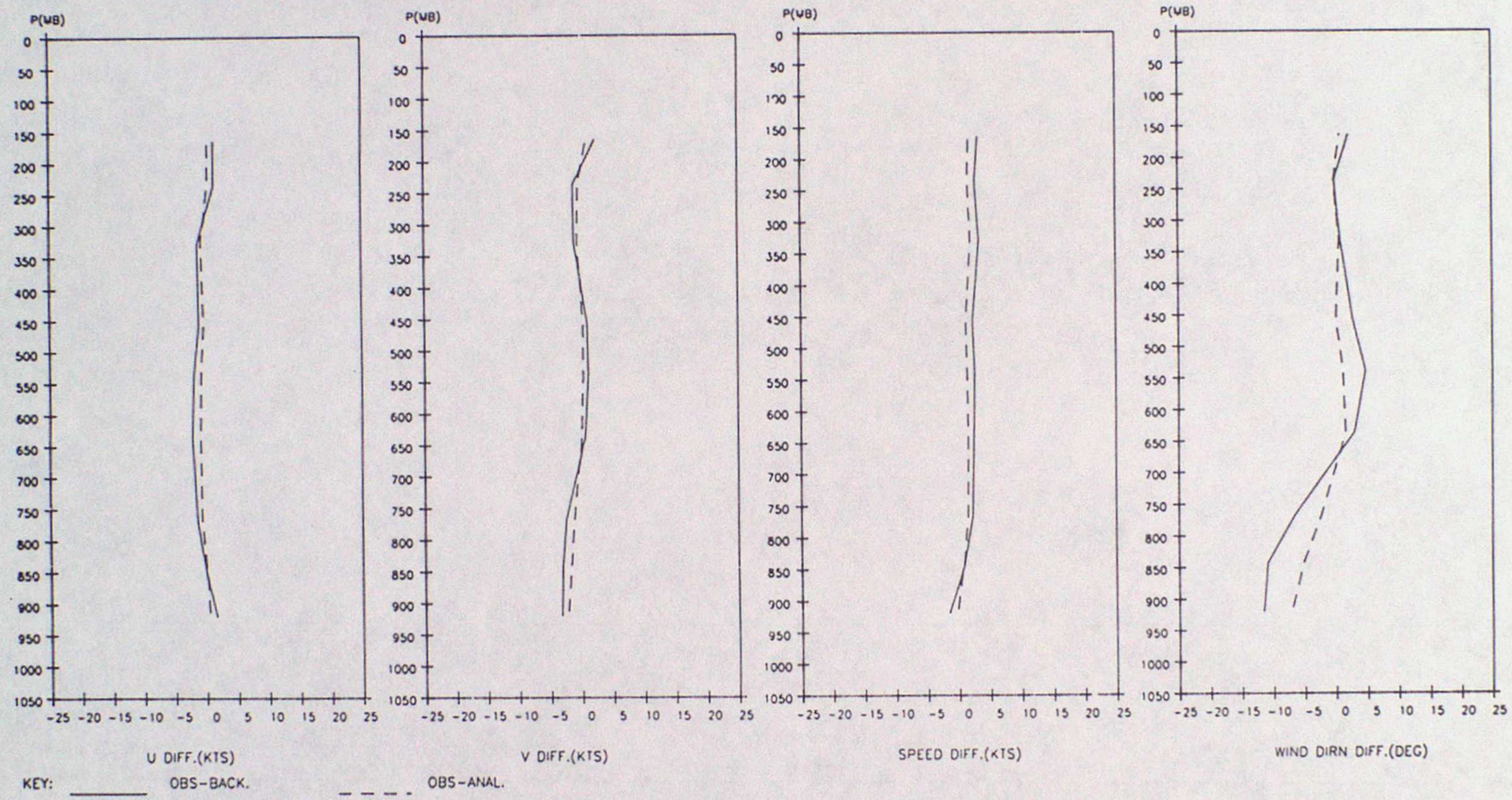


FIG. 2.2.3. CONT. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE = SATOB
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 5 N. REPORTS: 5421 N. OBS USED: 5421
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

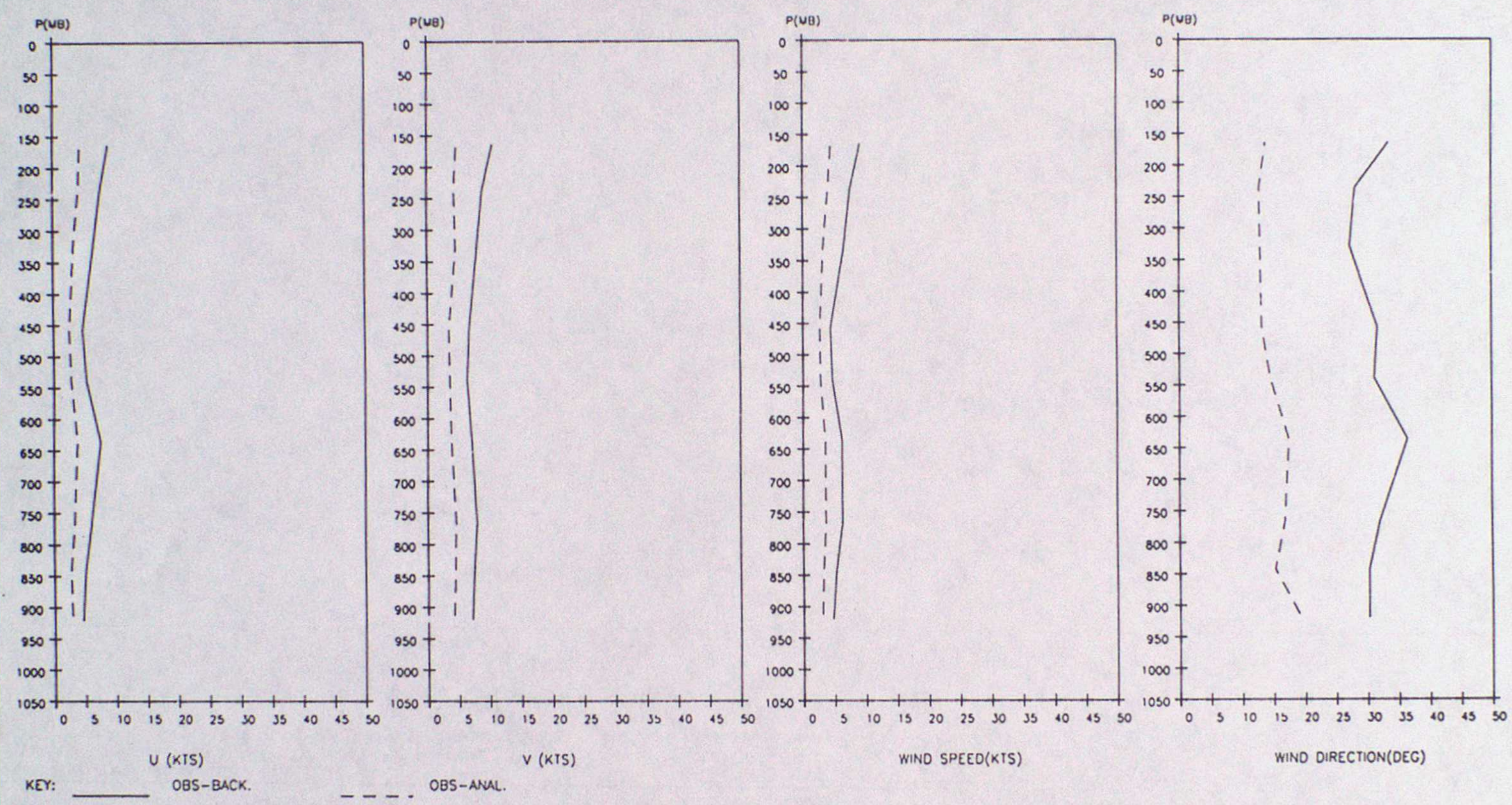


FIG. 2.2.4 METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 0000G001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 8505 N. OBS USED: 8505
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

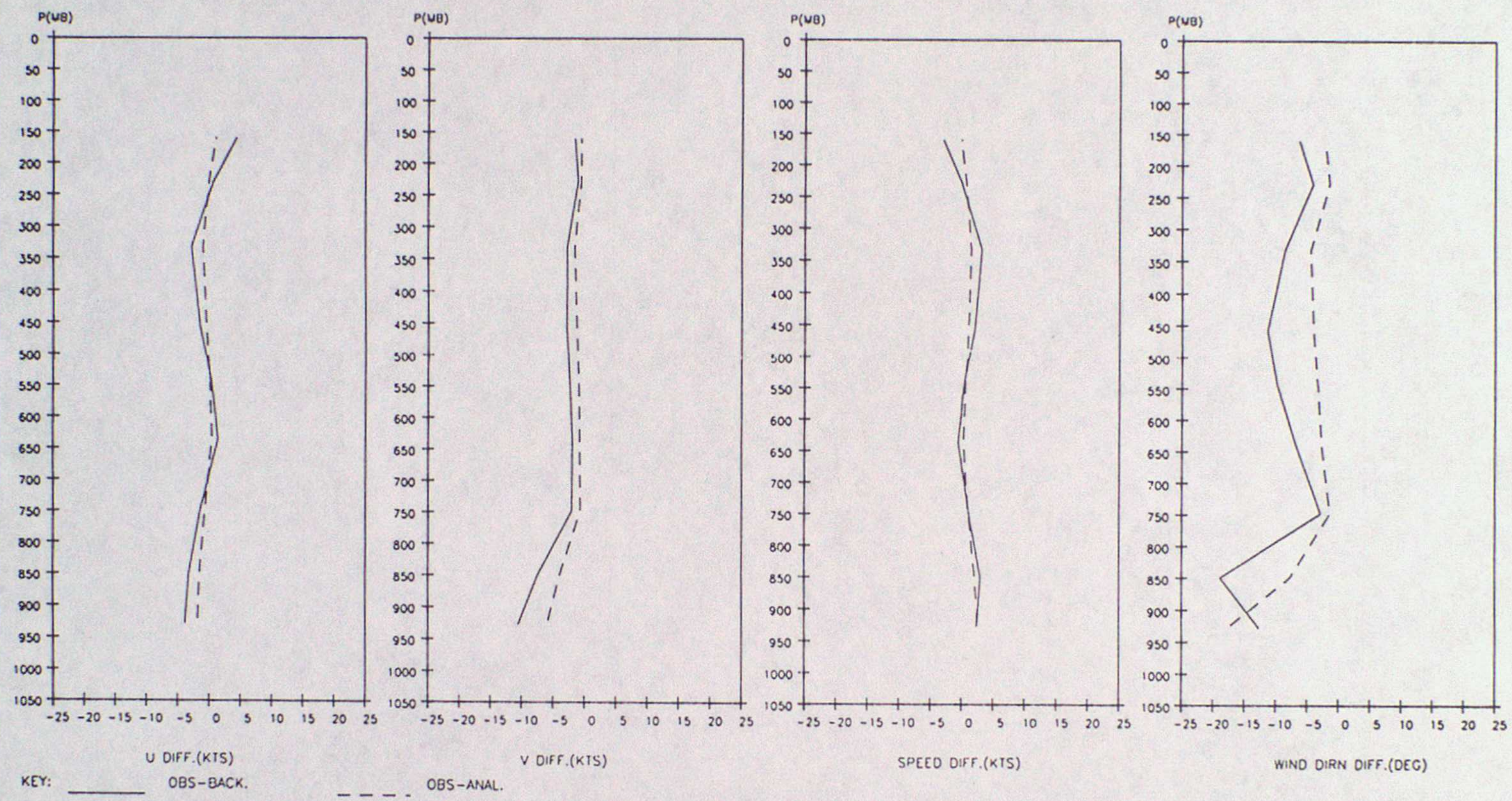
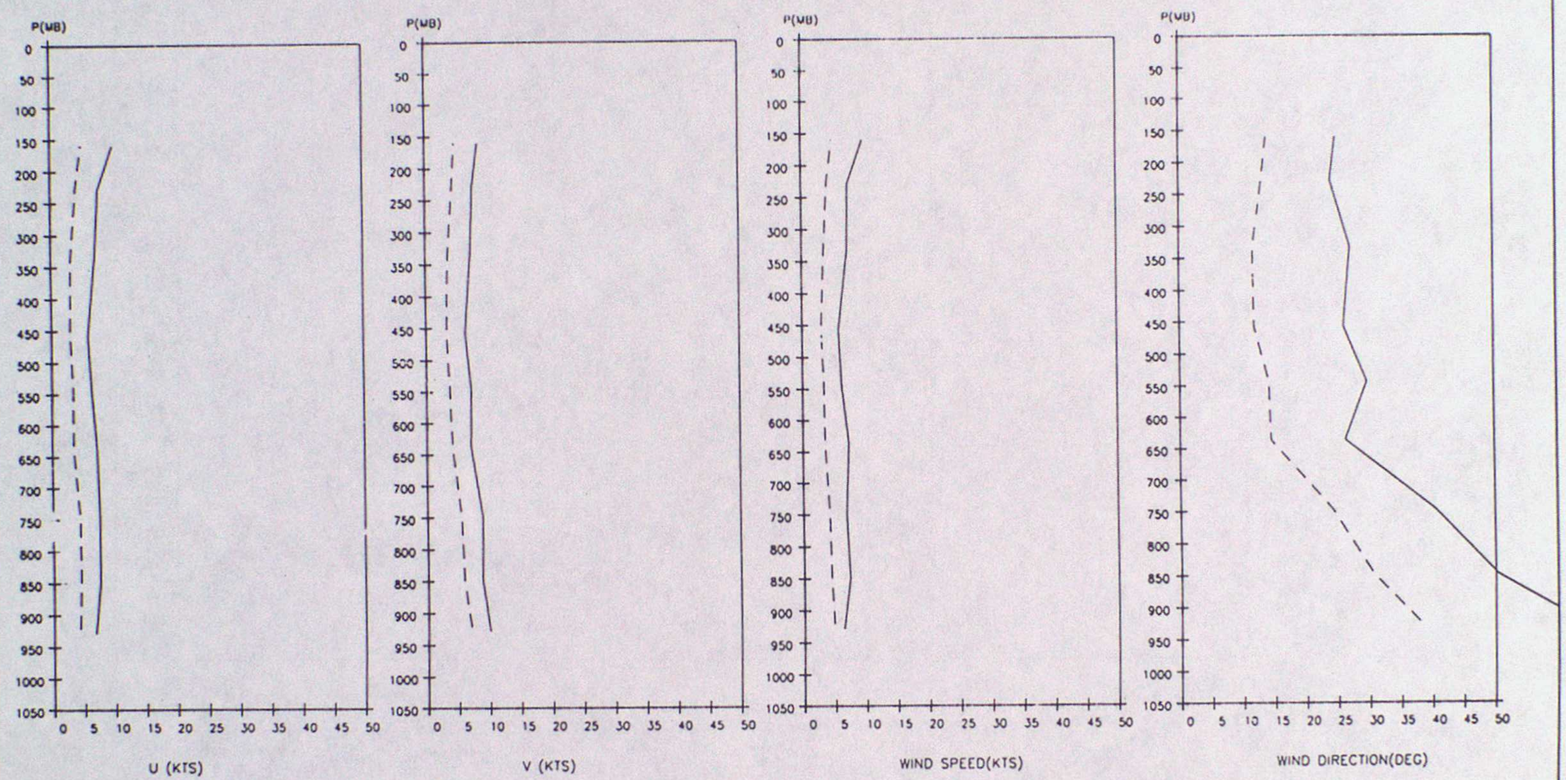


FIG. 2.2.4. CONT. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 8505 N. OBS USED: 8505
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



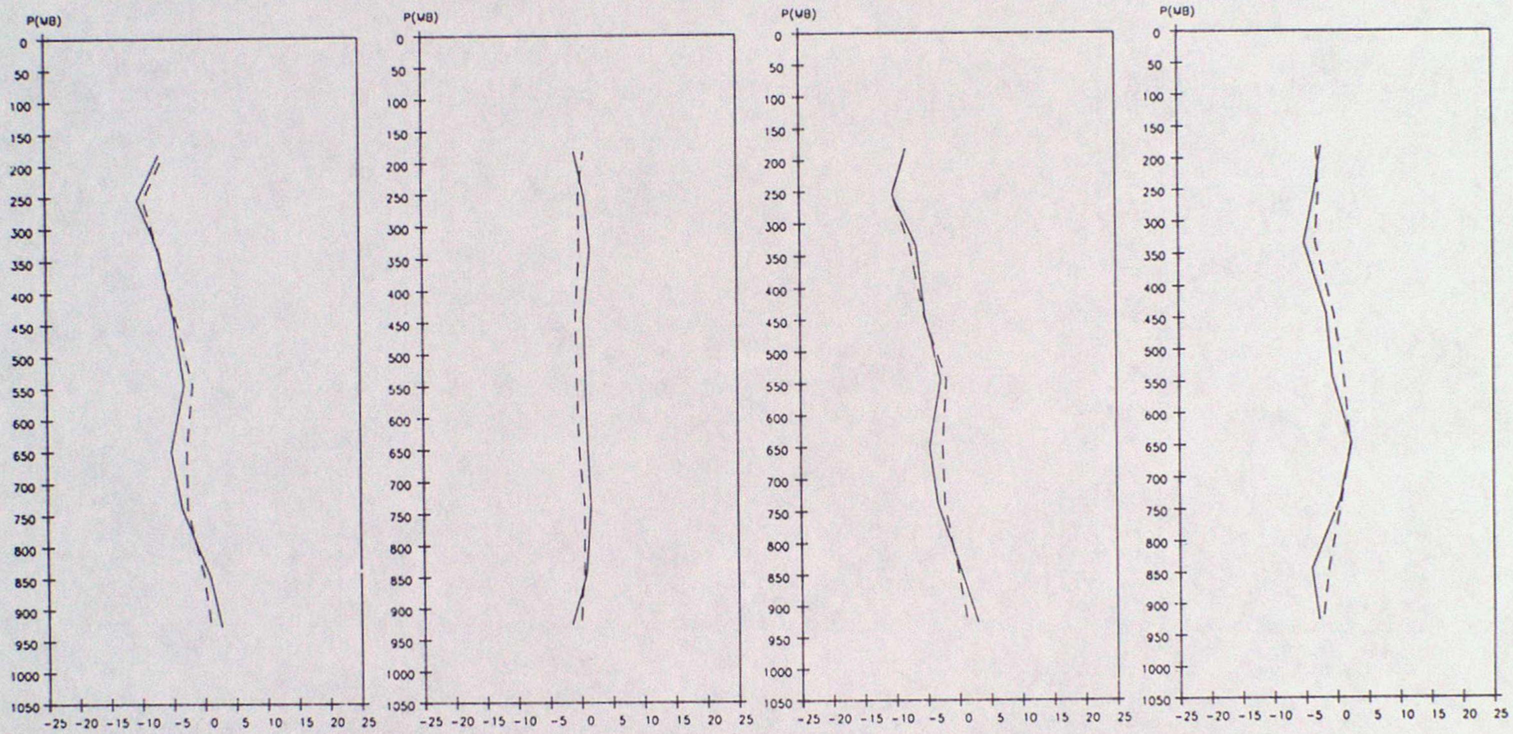
KEY: ——— OBS-BACK. - - - - OBS-ANAL.

FIG. 2.2.5. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS
LAT1: 30.00 LAT2: 40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 9
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= SATOB
N. REPORTS: 5216 N. OBS USED: 5216

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

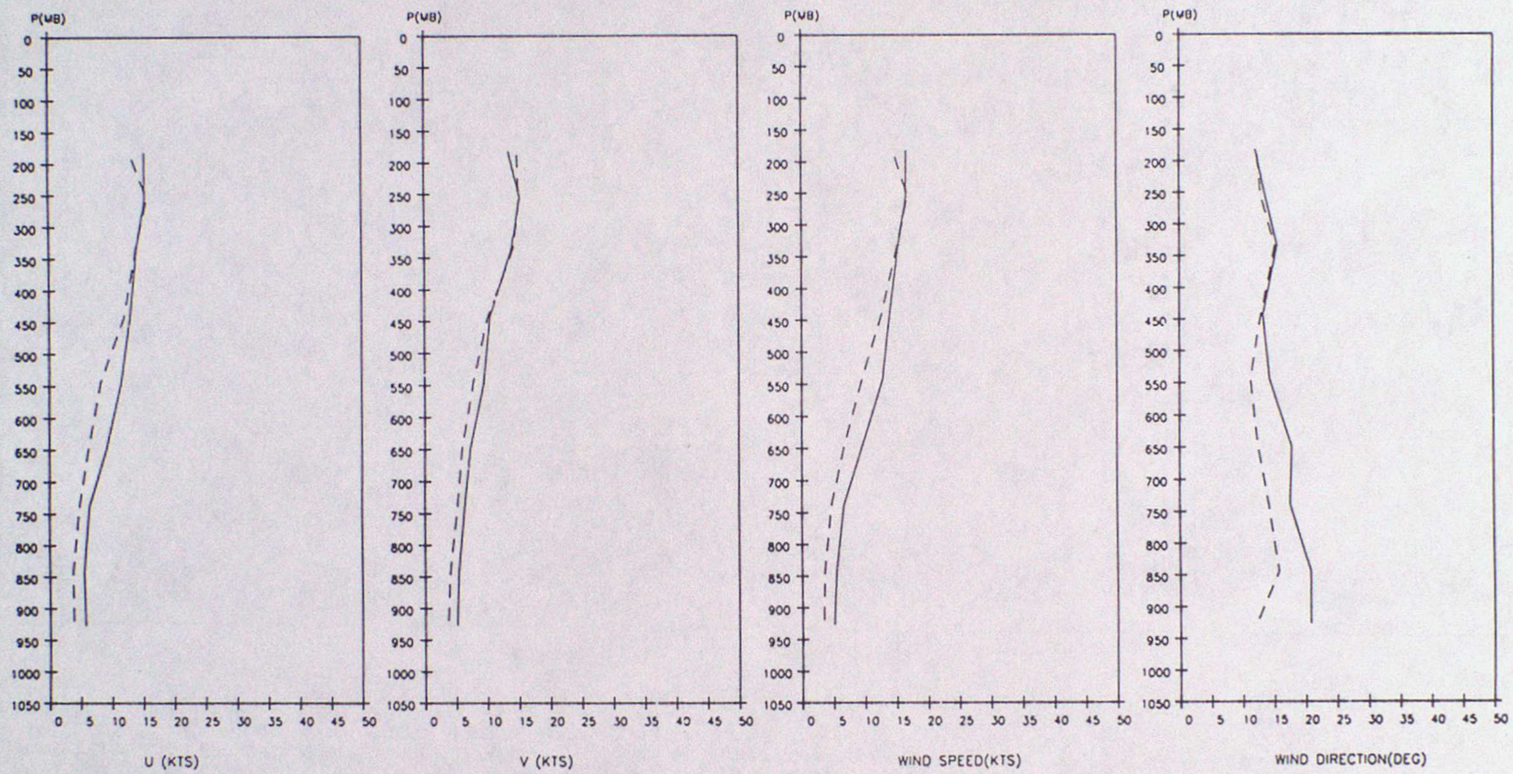


KEY: ——— OBS-BACK. - - - - OBS-ANAL.

FIG. 2.2.5 CONT. METEOSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000001 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 30.00 LAT2: 40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 9 N. REPORTS: 5216 N. OBS USED: 5216
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. - - - - OBS-ANAL.

FIG. 2.2.6. GOES.

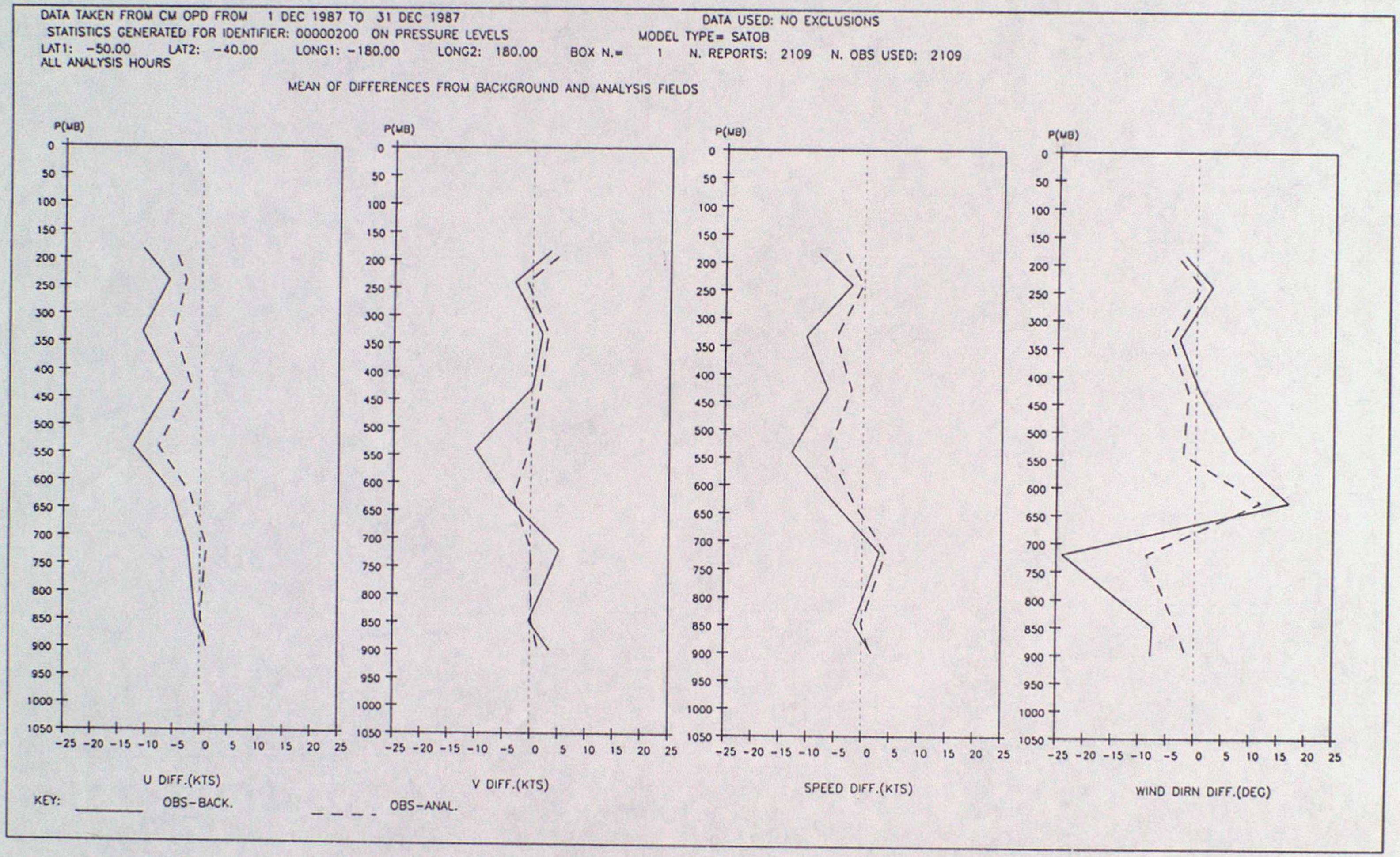

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987
DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS
MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 2109 N. OBS USED: 2109
ALL ANALYSIS HOURS
MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS
P(MB)
U DIFF.(KTS)
V DIFF.(KTS)
SPEED DIFF.(KTS)
WIND DIRN DIFF.(DEG)
KEY: OBS-BACK. OBS-ANAL.

FIG. 2.2.6 CONT. GOES

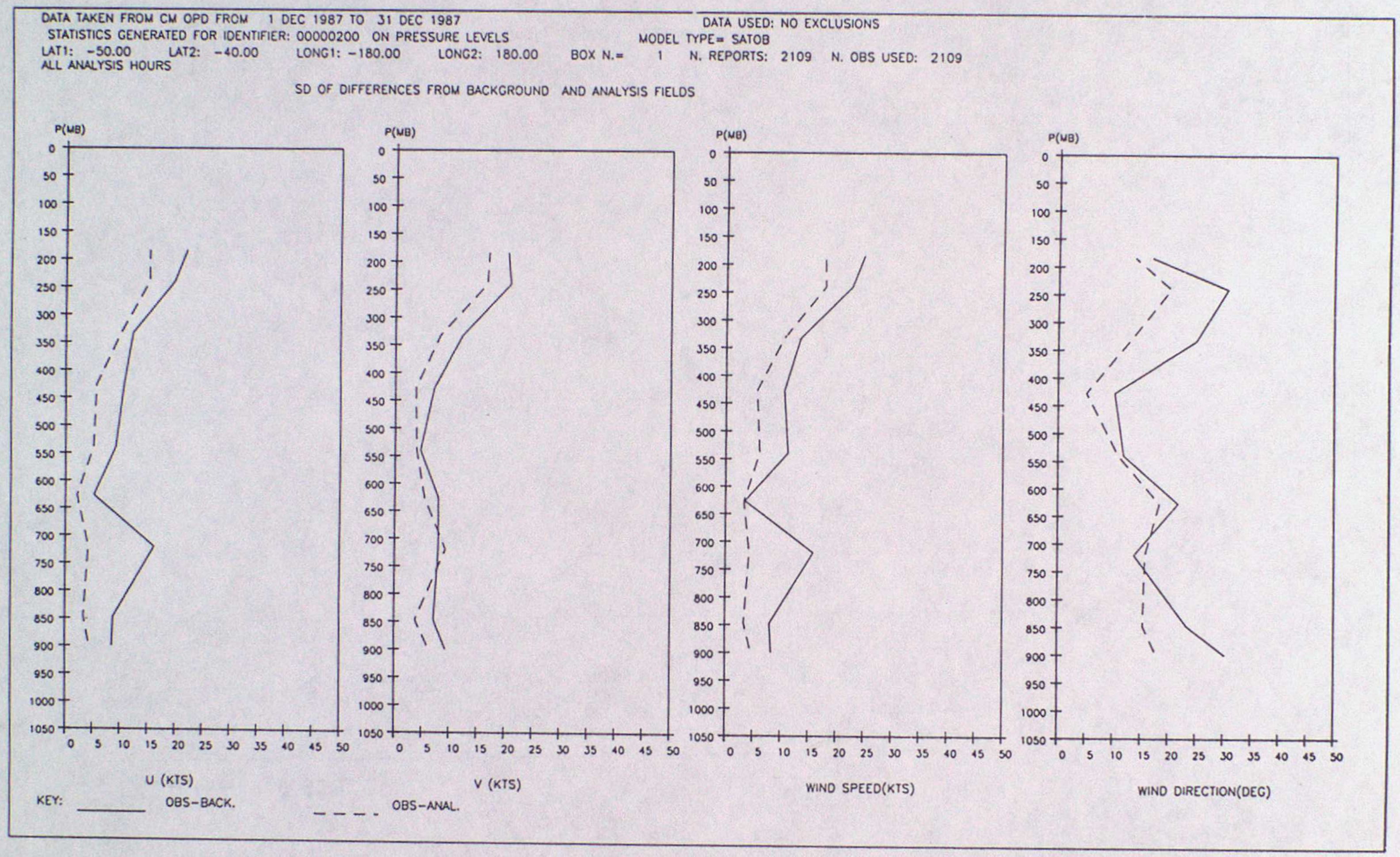


FIG. 2.2.7. GOES.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 — DATA USED: NO EXCLUSIONS

STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS — MODEL TYPE= SATOB

LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 2623 N. OBS USED: 2623

ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

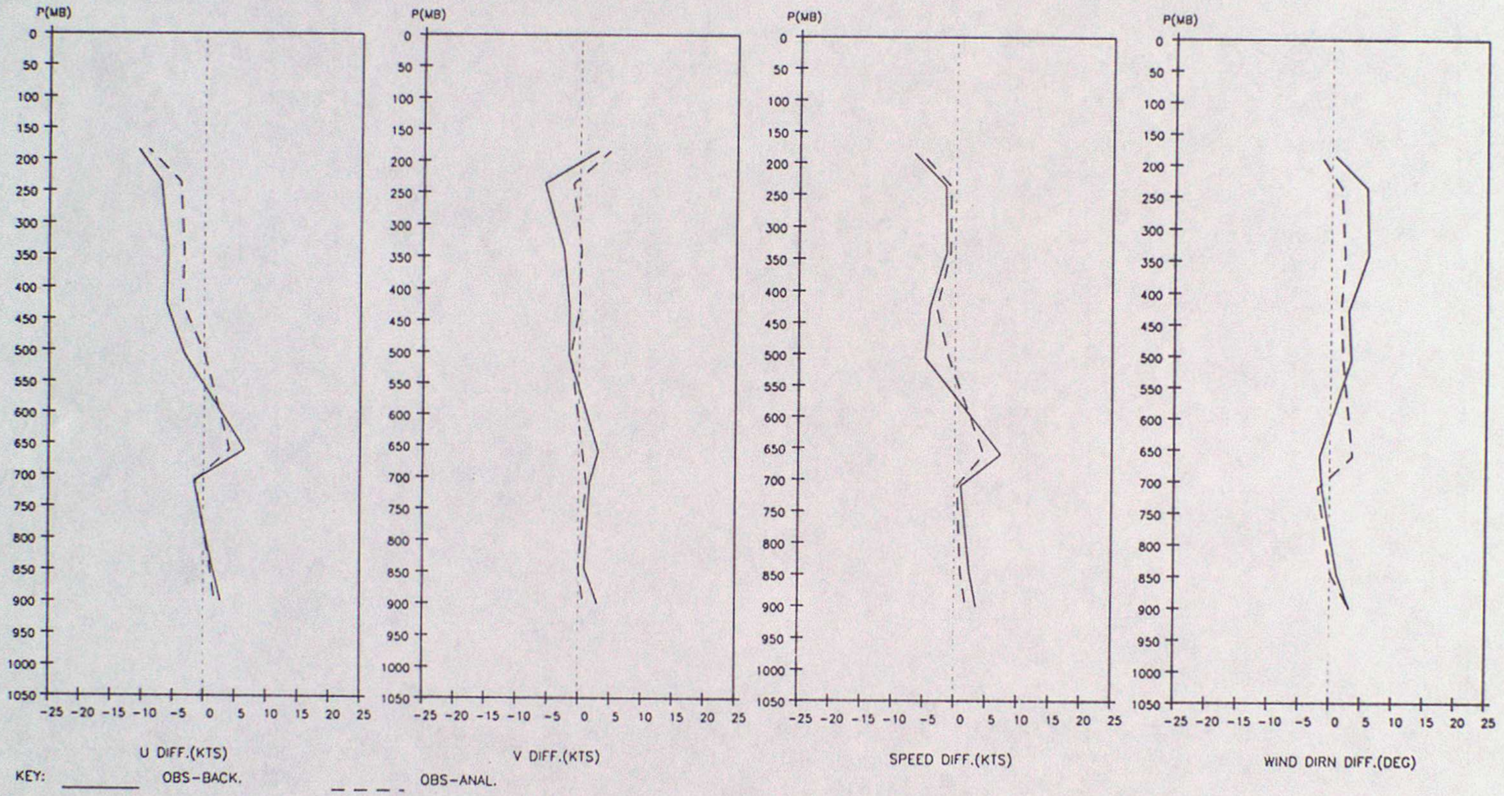


FIG. 2.2.7. CONT. GOES.

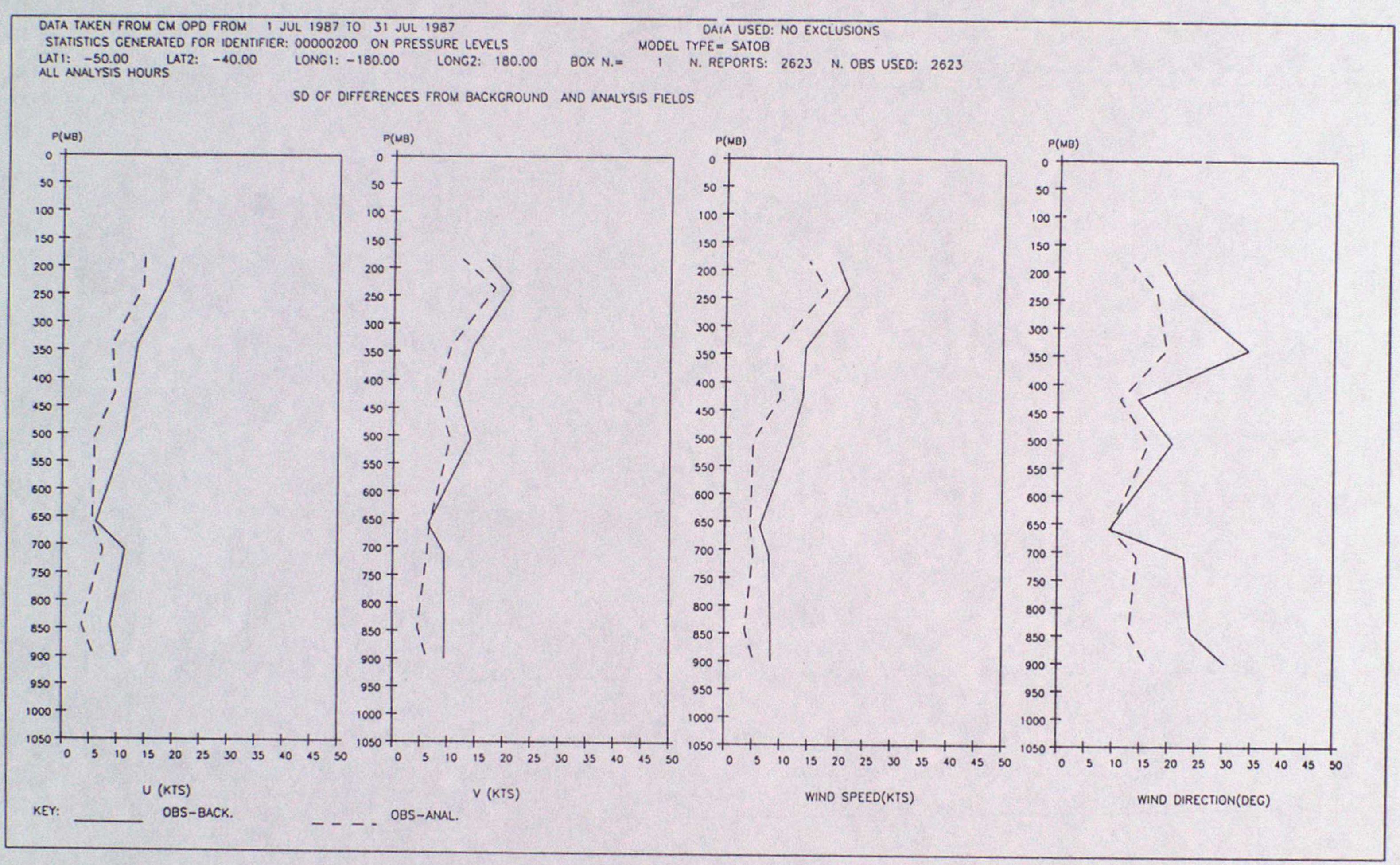


FIG. 2.2.8. GOES.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 5 N. REPORTS: 6979 N. OBS USED: 6979
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

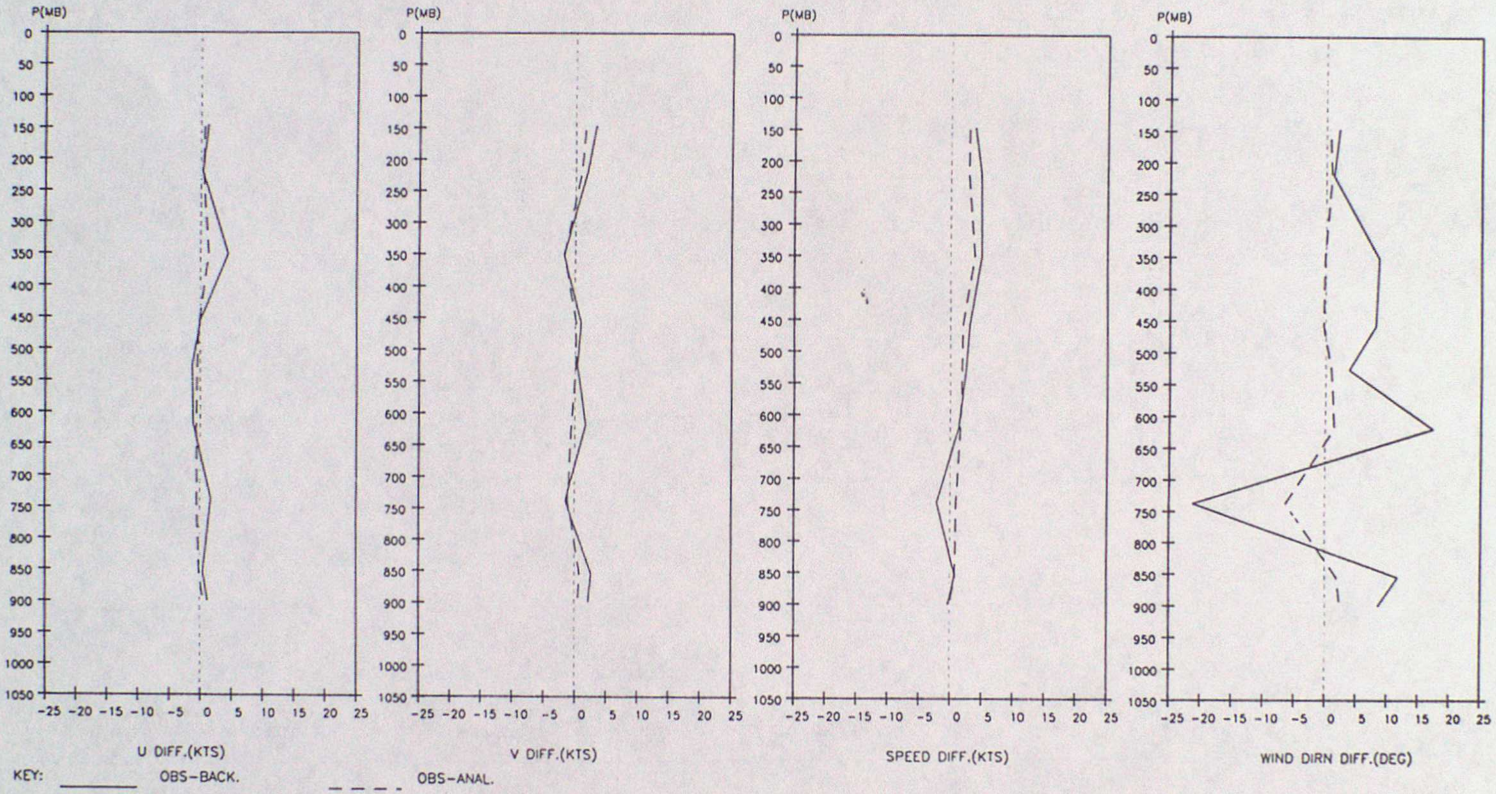


FIG 2.2.8. CONT. GOES.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 5 N. REPORTS: 6979 N. OBS USED: 6979
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

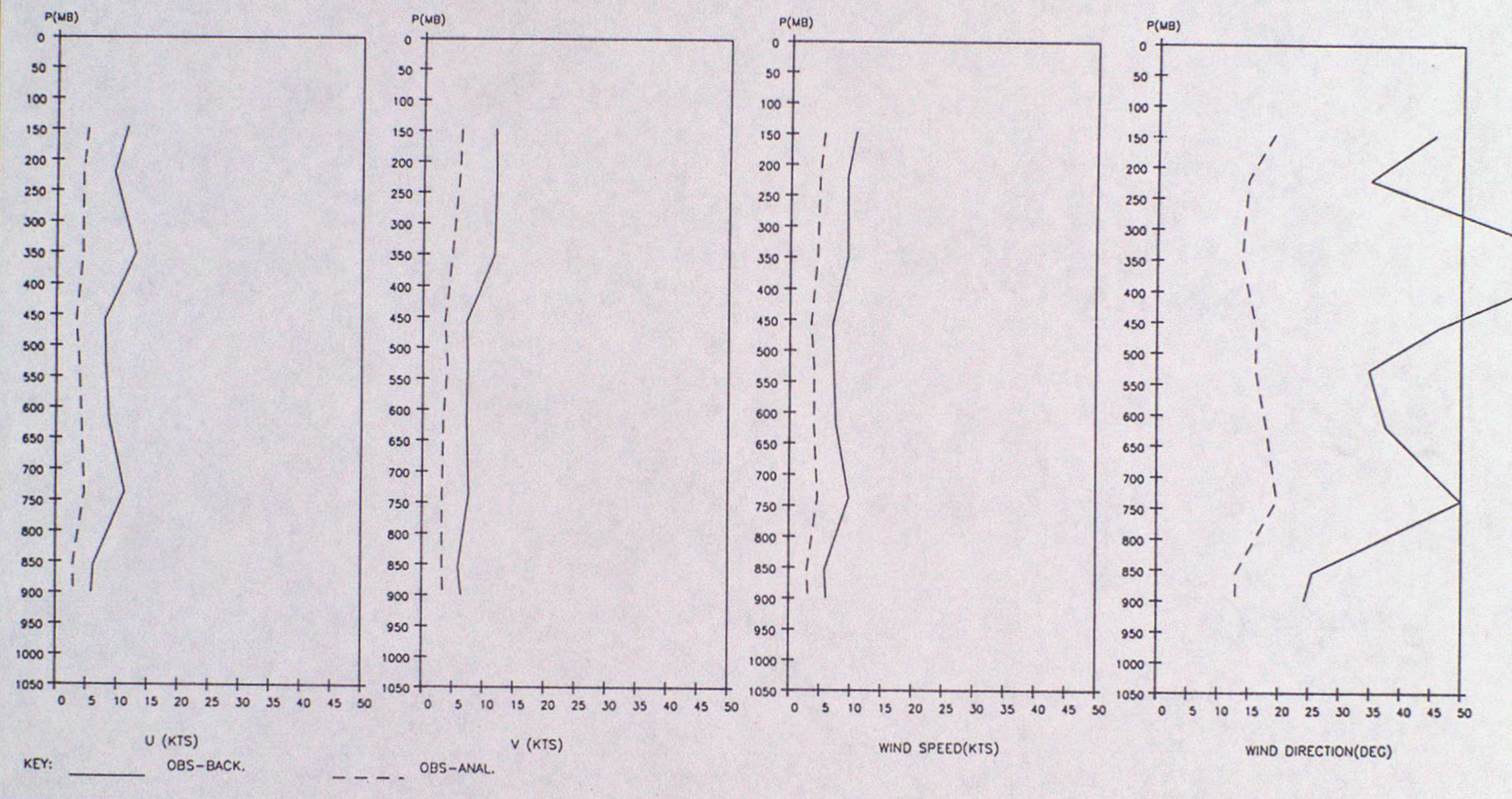


FIG. 2.2.9. GOES

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 5052 N. OBS USED: 5052
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

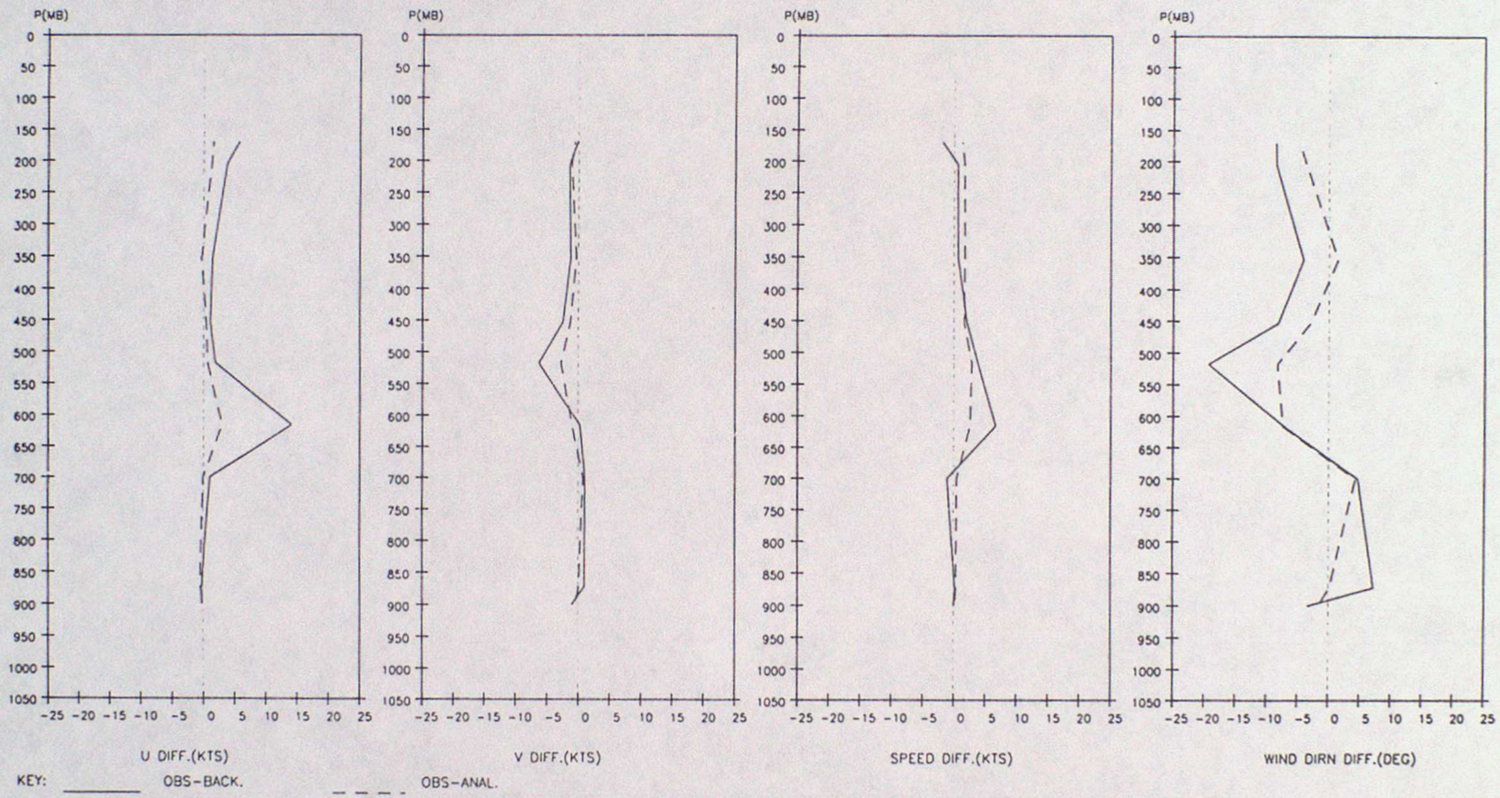


Fig. 2.2.9. CONT. GOES.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 5052 N. OBS USED: 5052
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

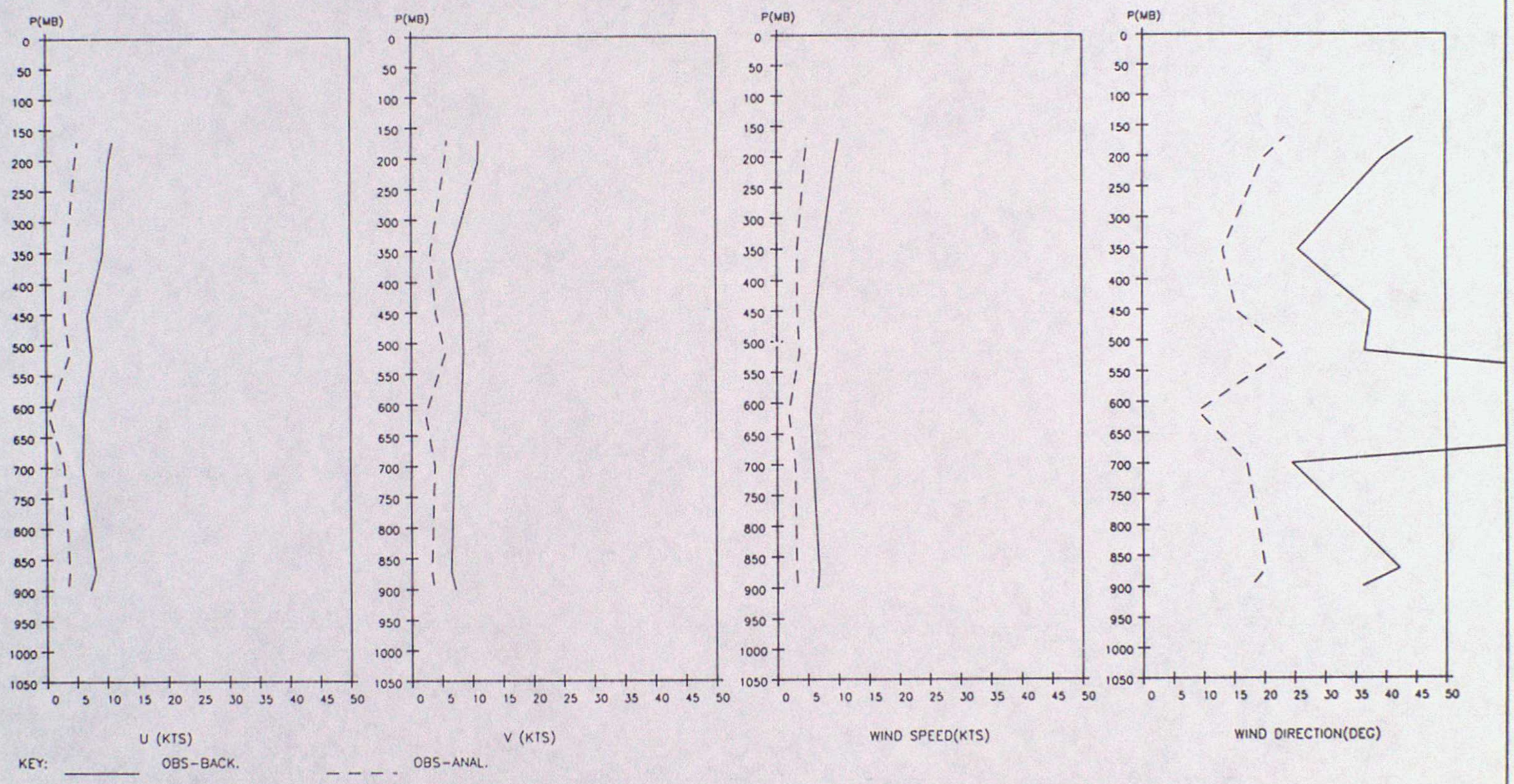
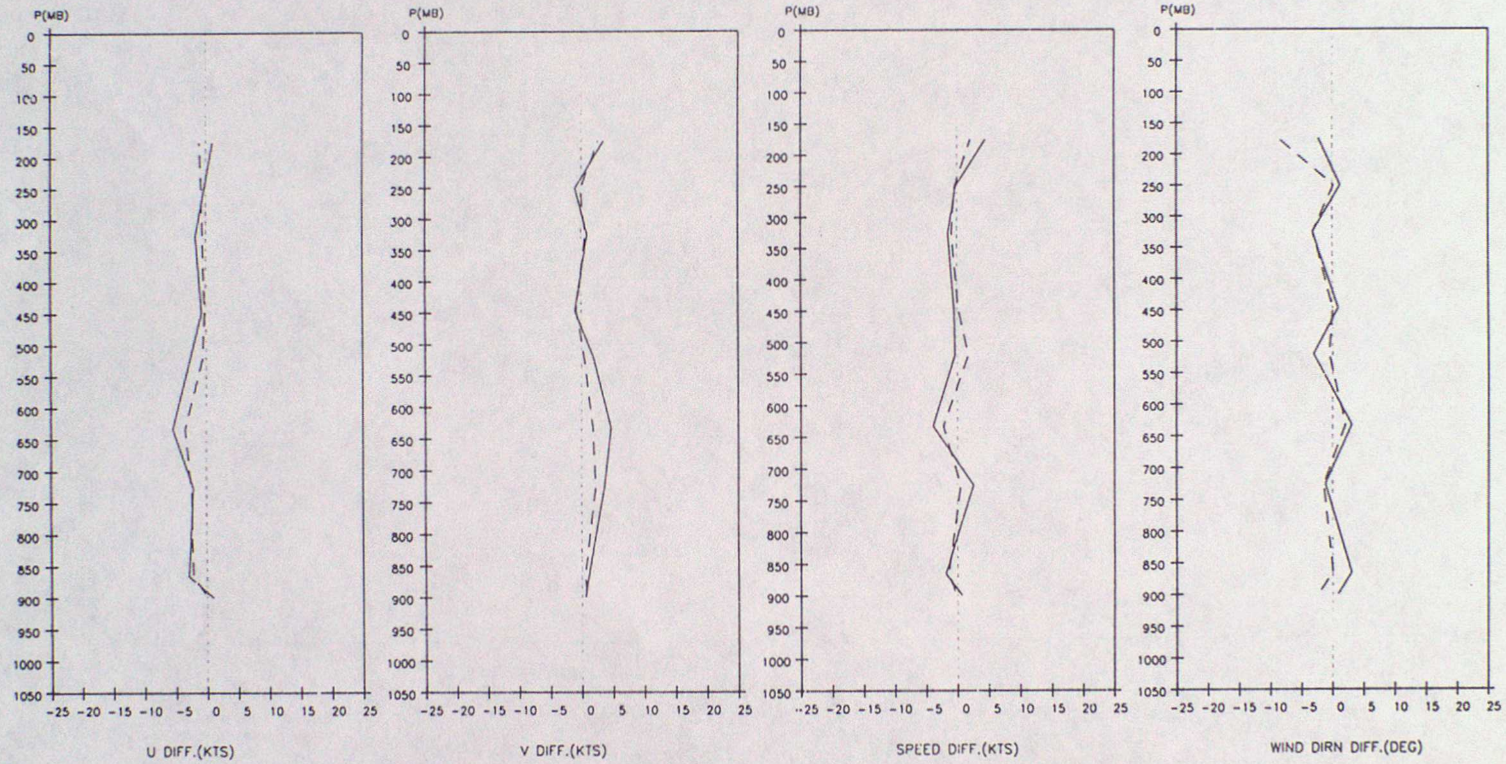


FIG. 2.2.10. GOES.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 40.00 LAT2: 50.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 10 N. REPORTS: 2026 N. OBS USED: 2026
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ———— OBS-BACK. - - - - OBS-ANAL.

FIG 2.2.10 CONT. GOES.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000200 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 40.00 LAT2: 50.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 10 N. REPORTS: 1945 N. OBS USED: 1945
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

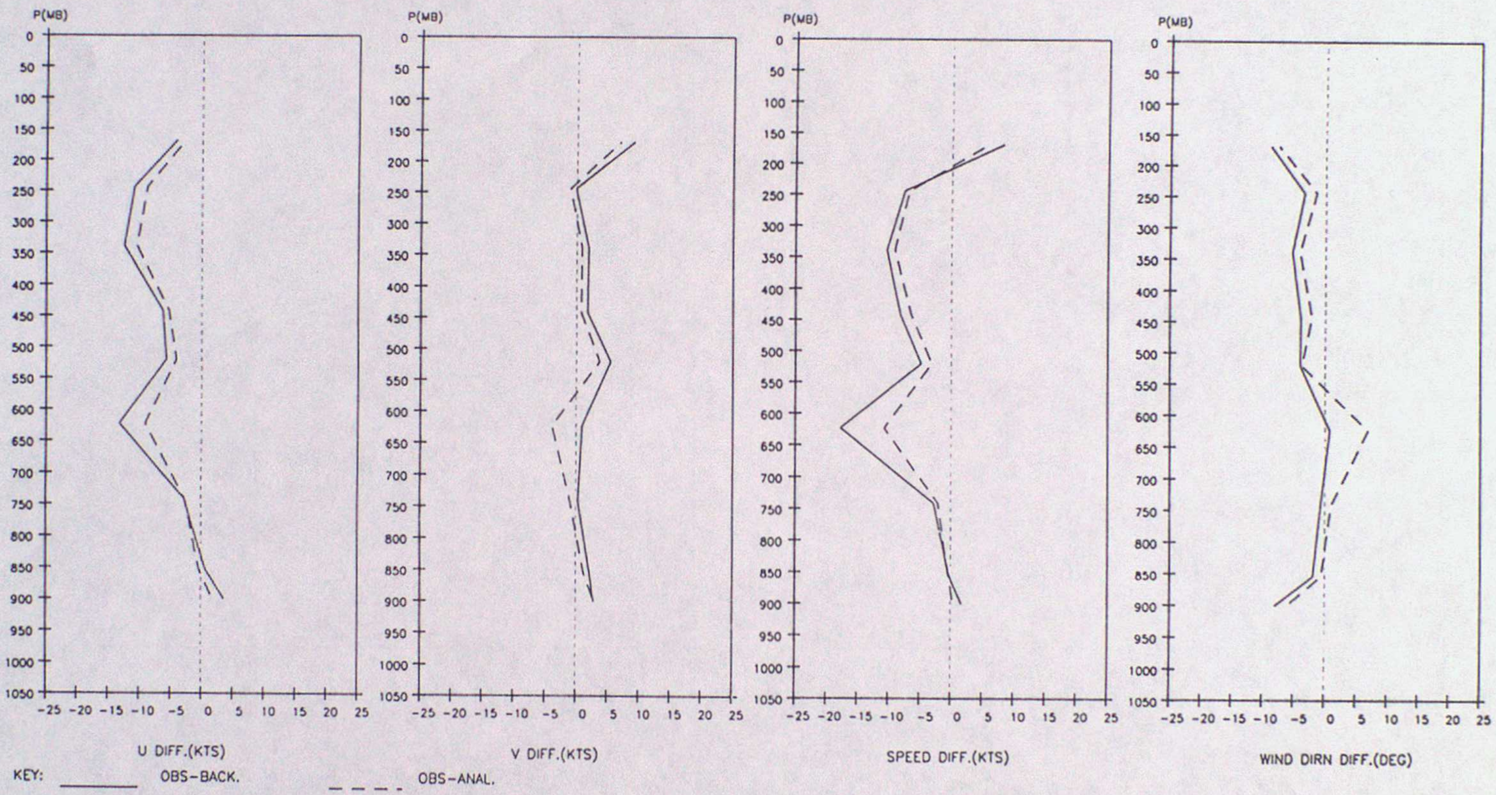


FIG. 2.2.11. GMS

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 3025 N. OBS USED: 3025
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

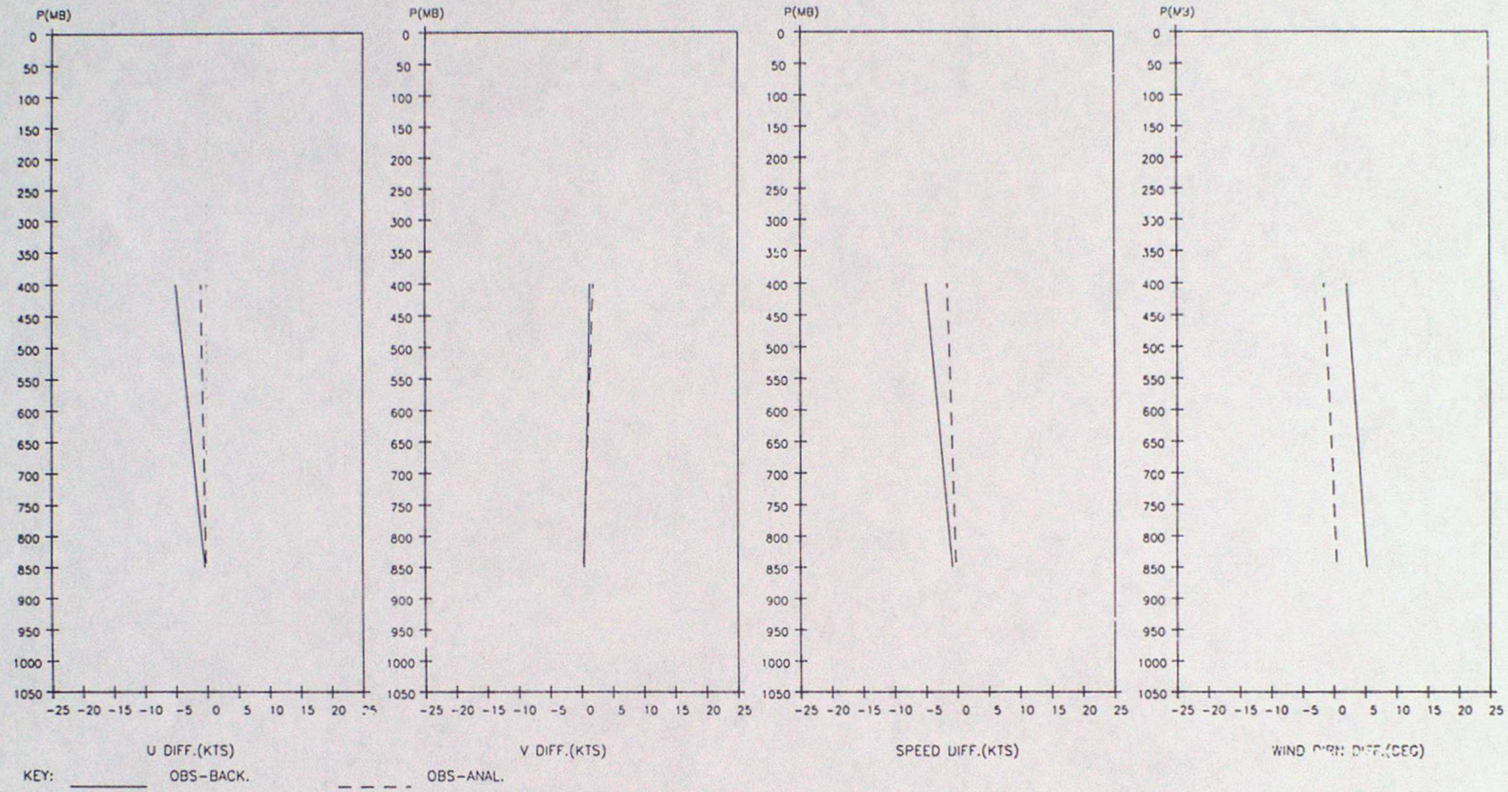


FIG. 2.2.11. CONT. GMS

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 3025 N. OBS USED: 3025
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

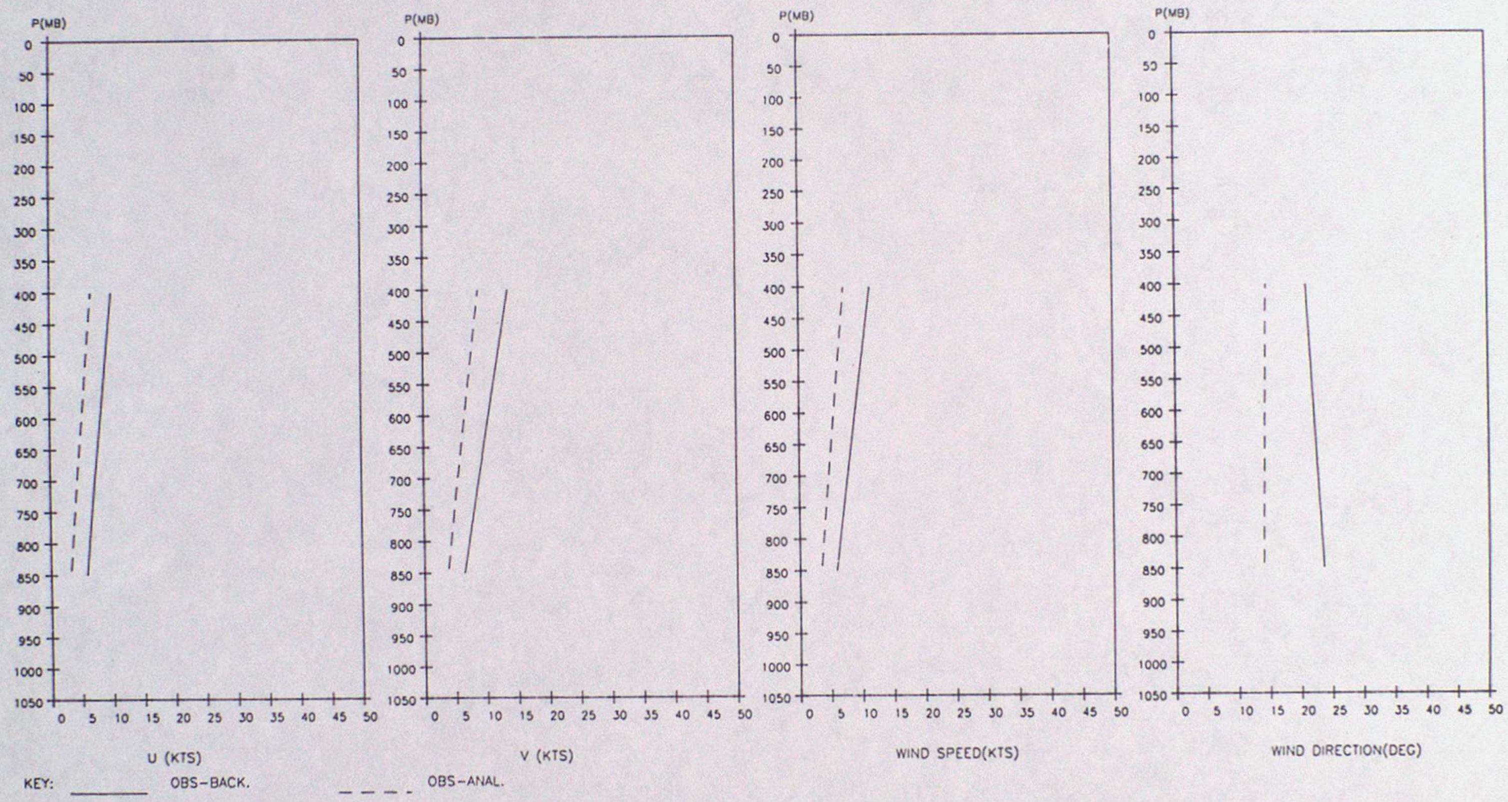


FIG. 2.2.12. GMS

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 3578 N. OBS USED: 3578
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

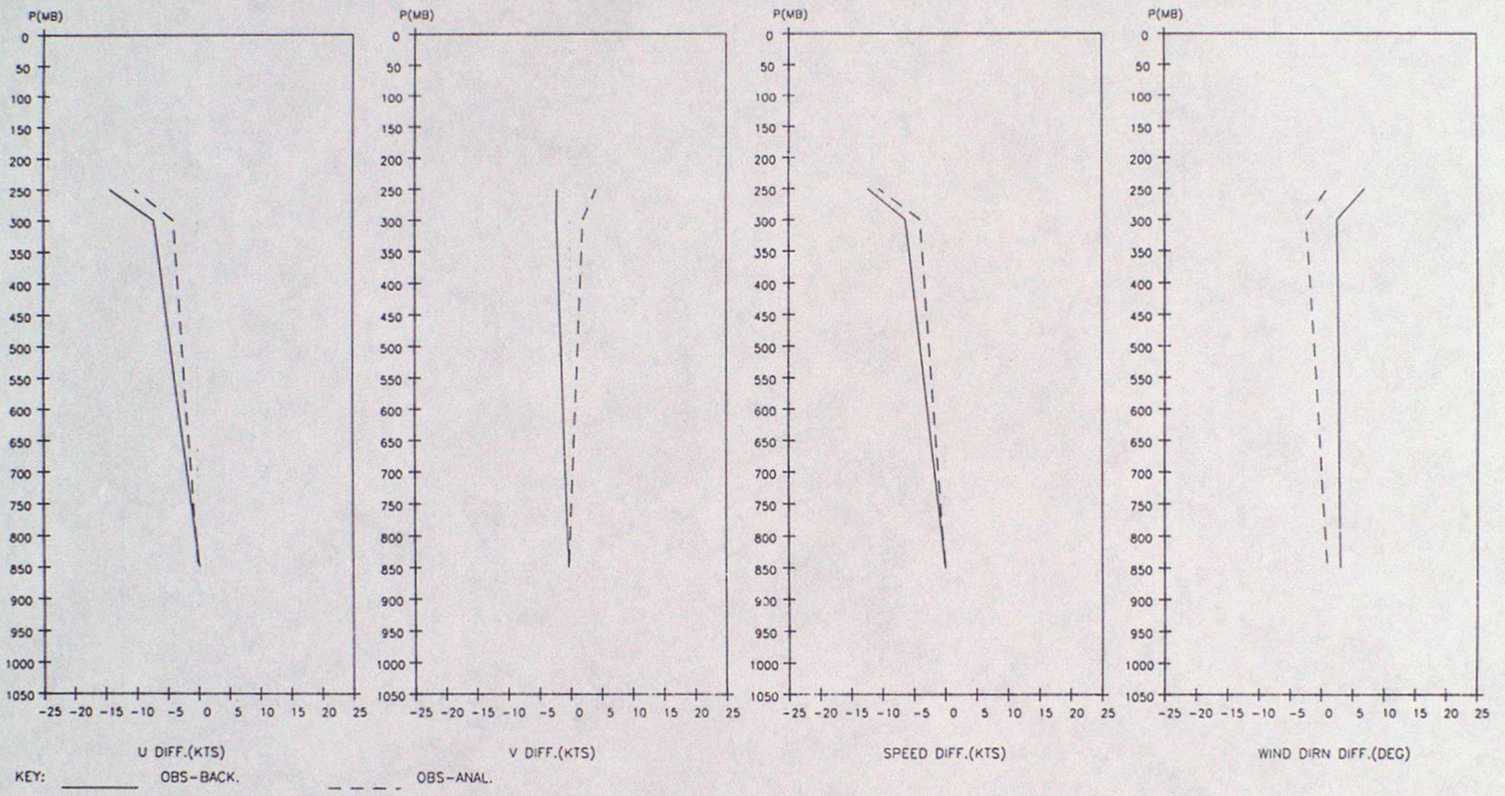


FIG. 2.2.12. CONT. GMS

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: -50.00 LAT2: -40.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 3578 N. OBS USED: 3578
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

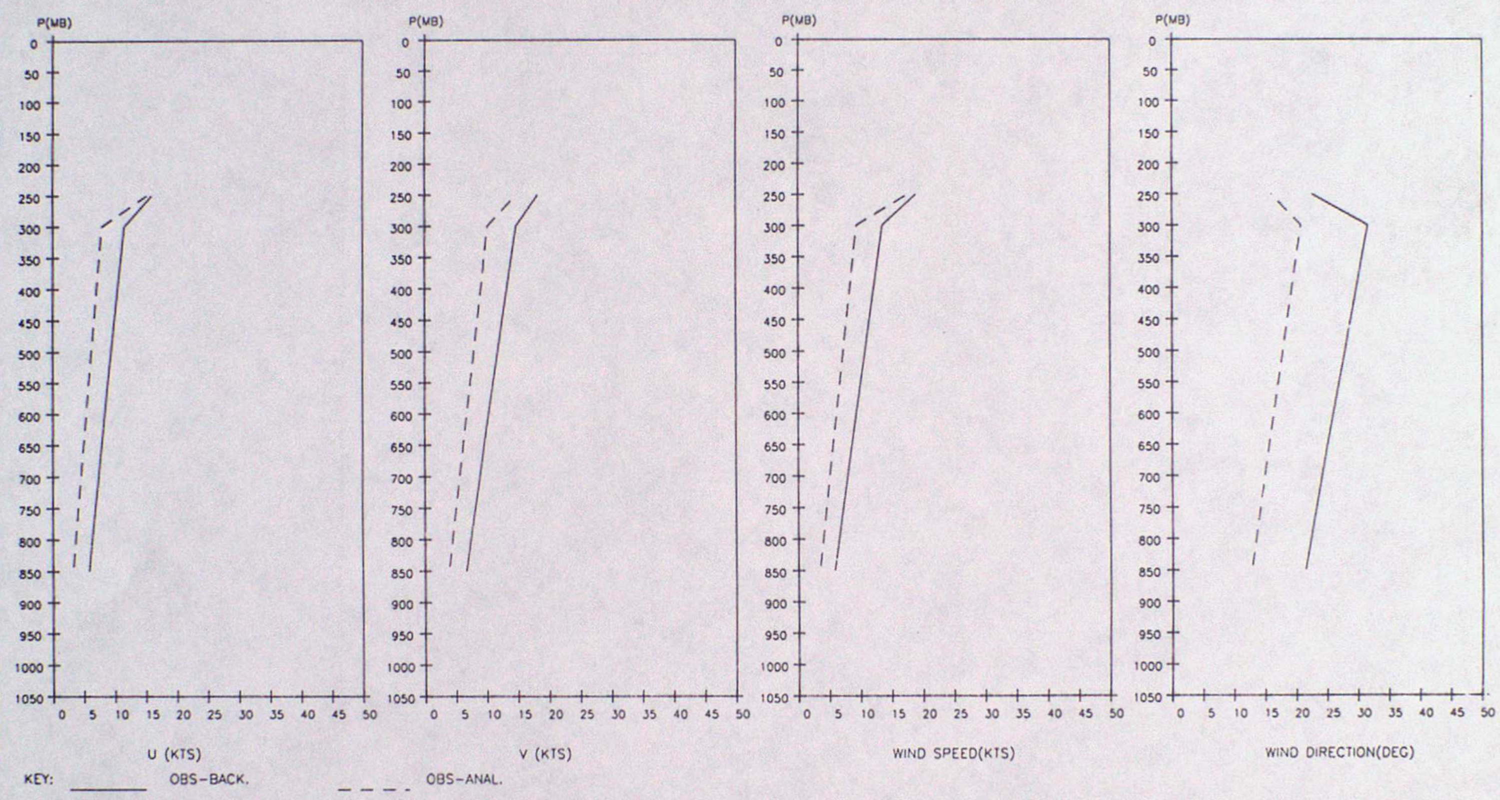


FIG. 2.2.13. GMS

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 20.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1 N. REPORTS: 4060 N. OBS USED: 4060
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

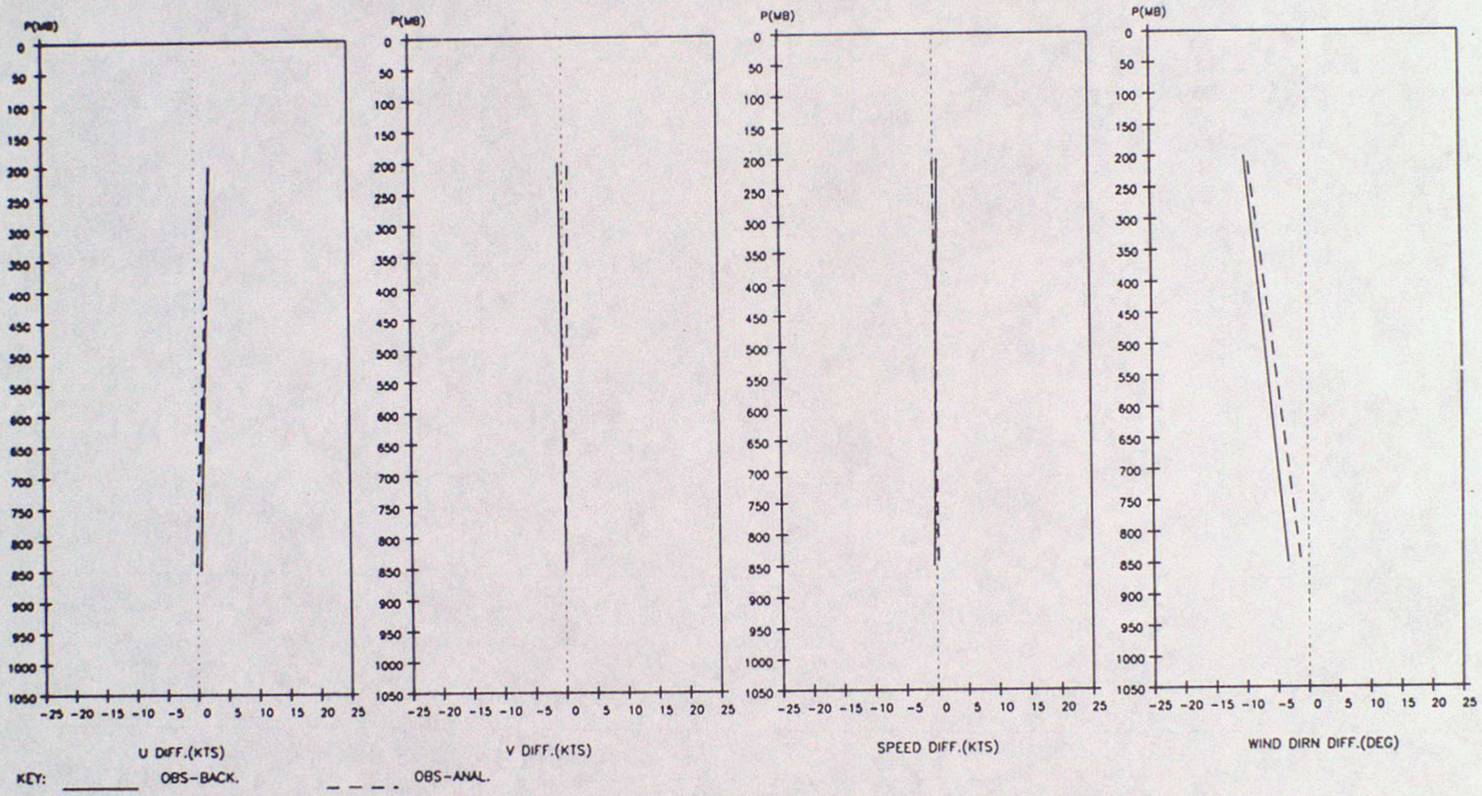


FIG. 2.2.13 CONT. GMS

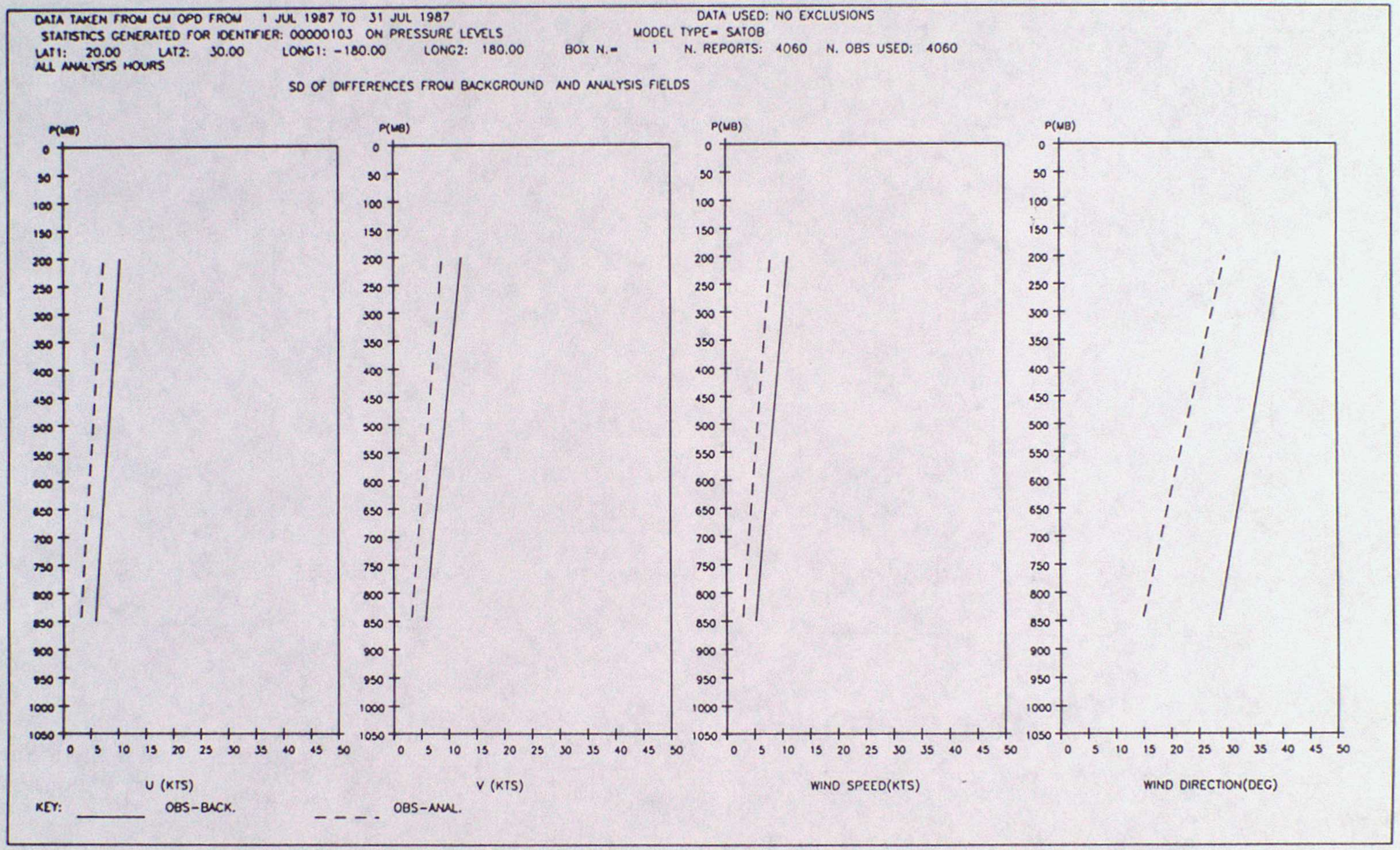


FIG. 2.2.14 GMS

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS
LAT1: 20.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= SATOB
N. REPORTS: 6368 N. OBS USED: 6368

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

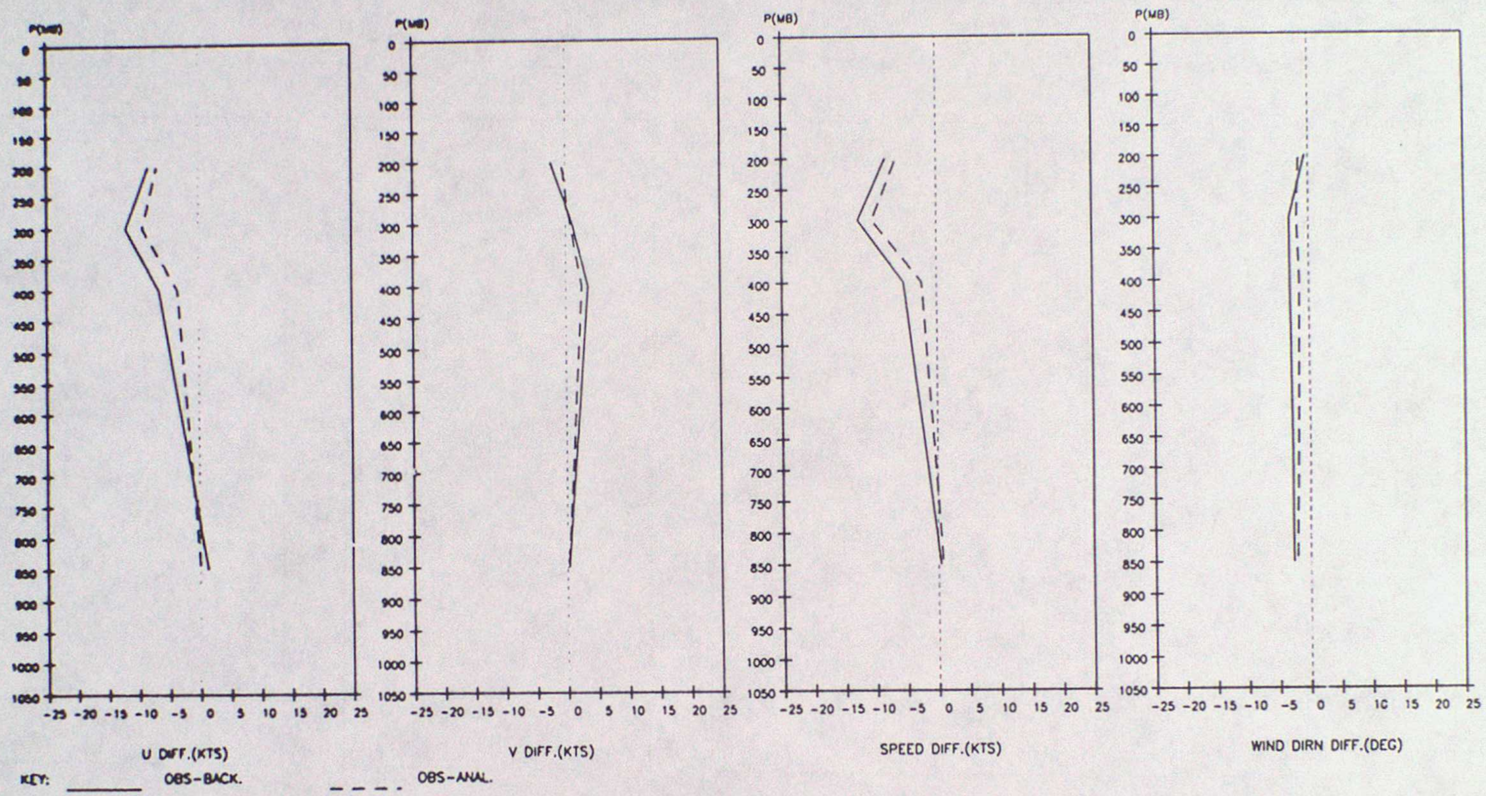


FIG. 2.2.14 CONT. GMS

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS
LAT1: 20.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 1
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= SATOB
N. REPORTS: 6368 N. OBS USED: 6368

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

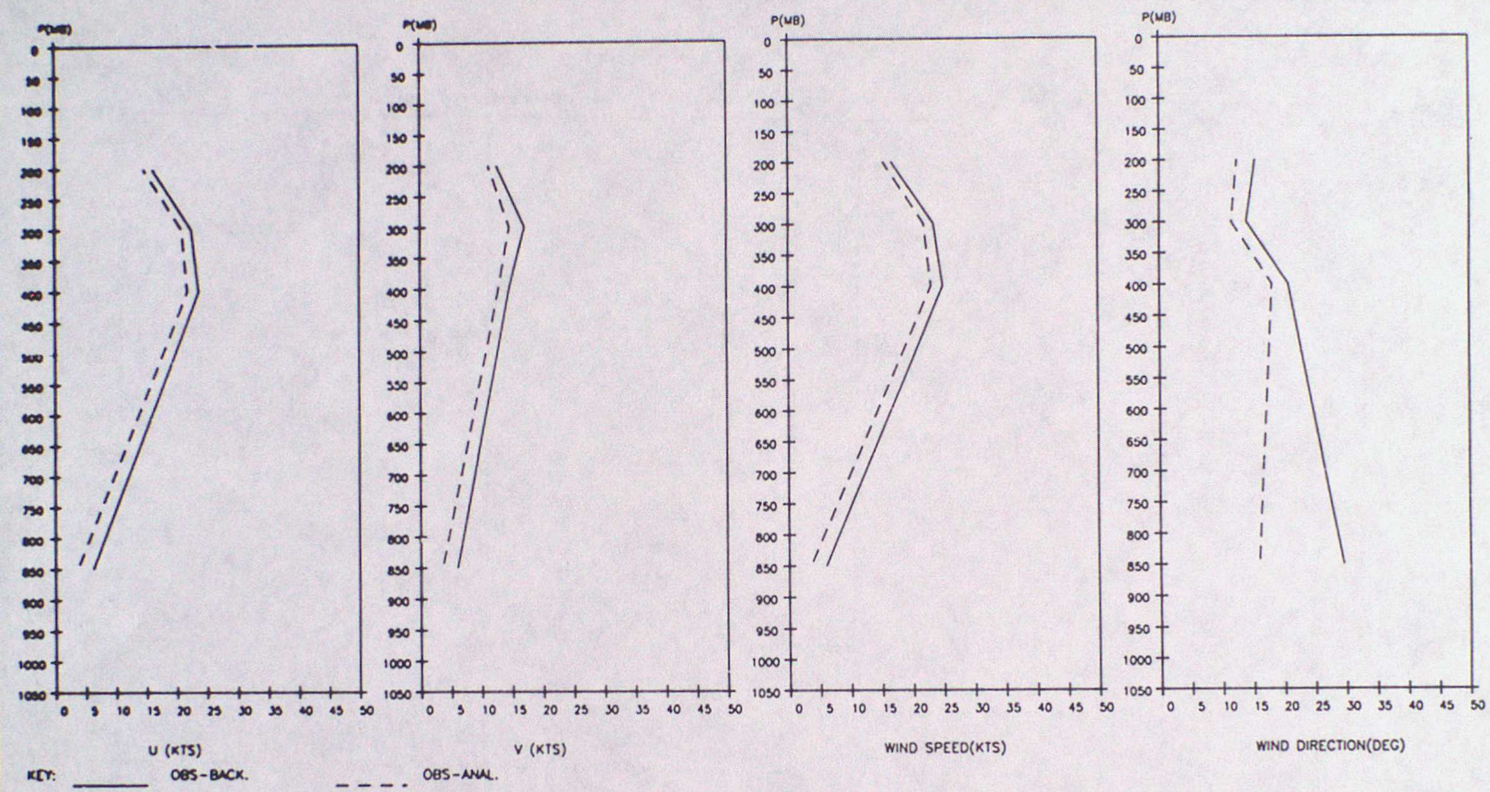
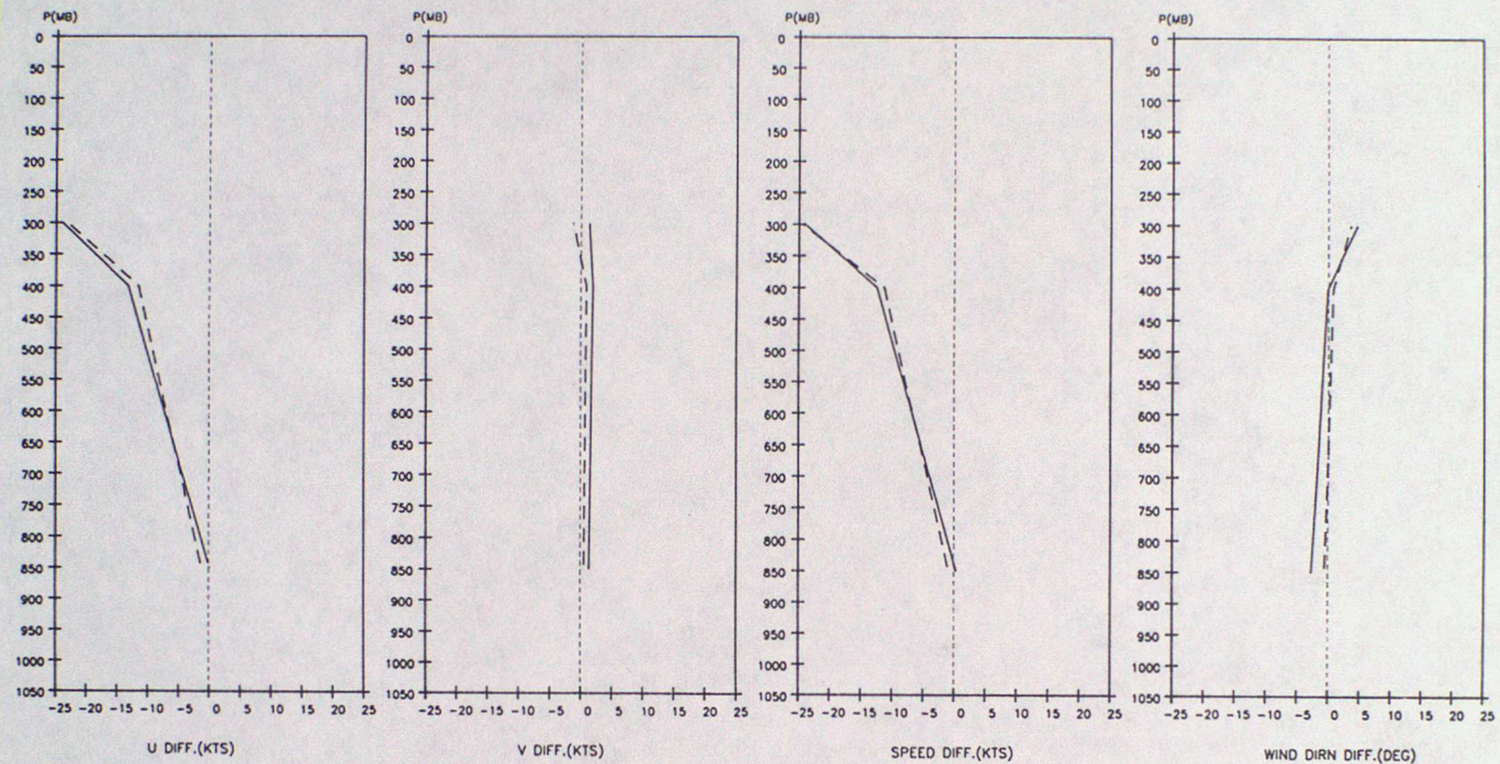


FIG. 2.2.15 GMS.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 40.00 LAT2: 50.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 2780 N. OBS USED: 2780
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. — — — OBS-ANAL.

FIG. 2.2.15 CONT. GMS

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000103 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 40.00 LAT2: 50.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 2780 N. OBS USED: 2780
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

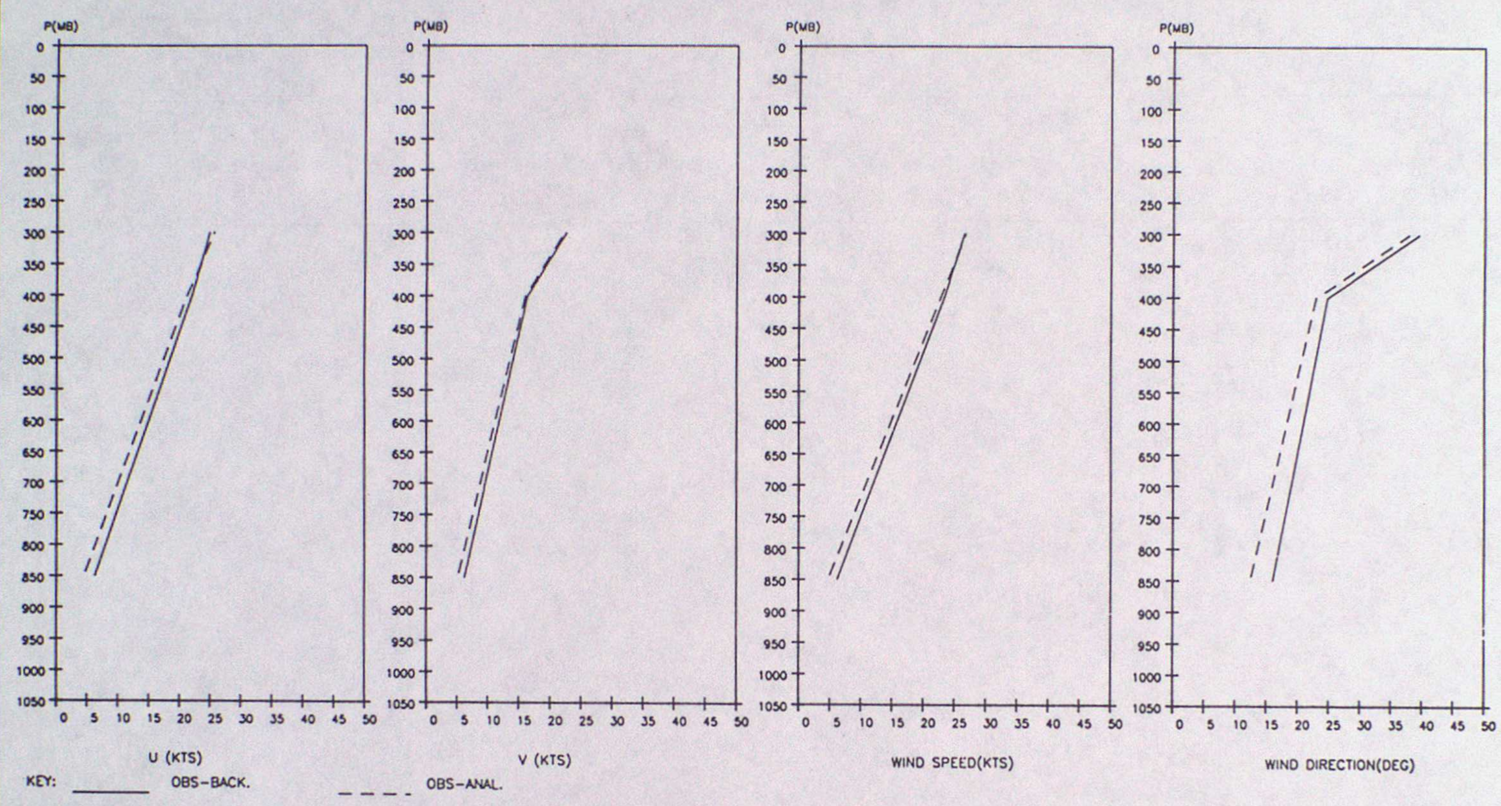


FIG. 2.2.16 INSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000420 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 863 N. OBS USED: 863
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

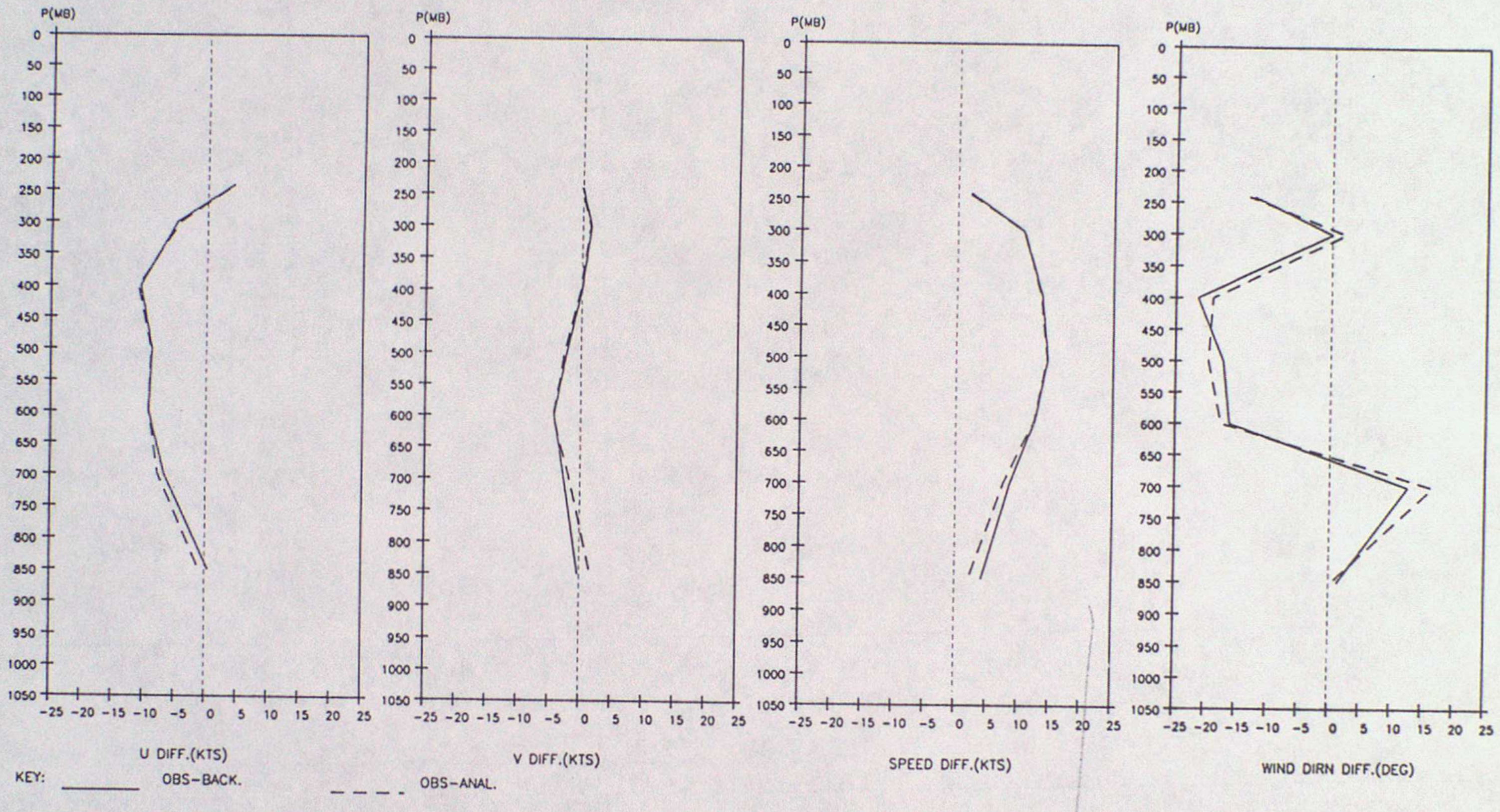


FIG. 2.2.16. CONT. INSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000420 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 863 N. OBS USED: 863
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

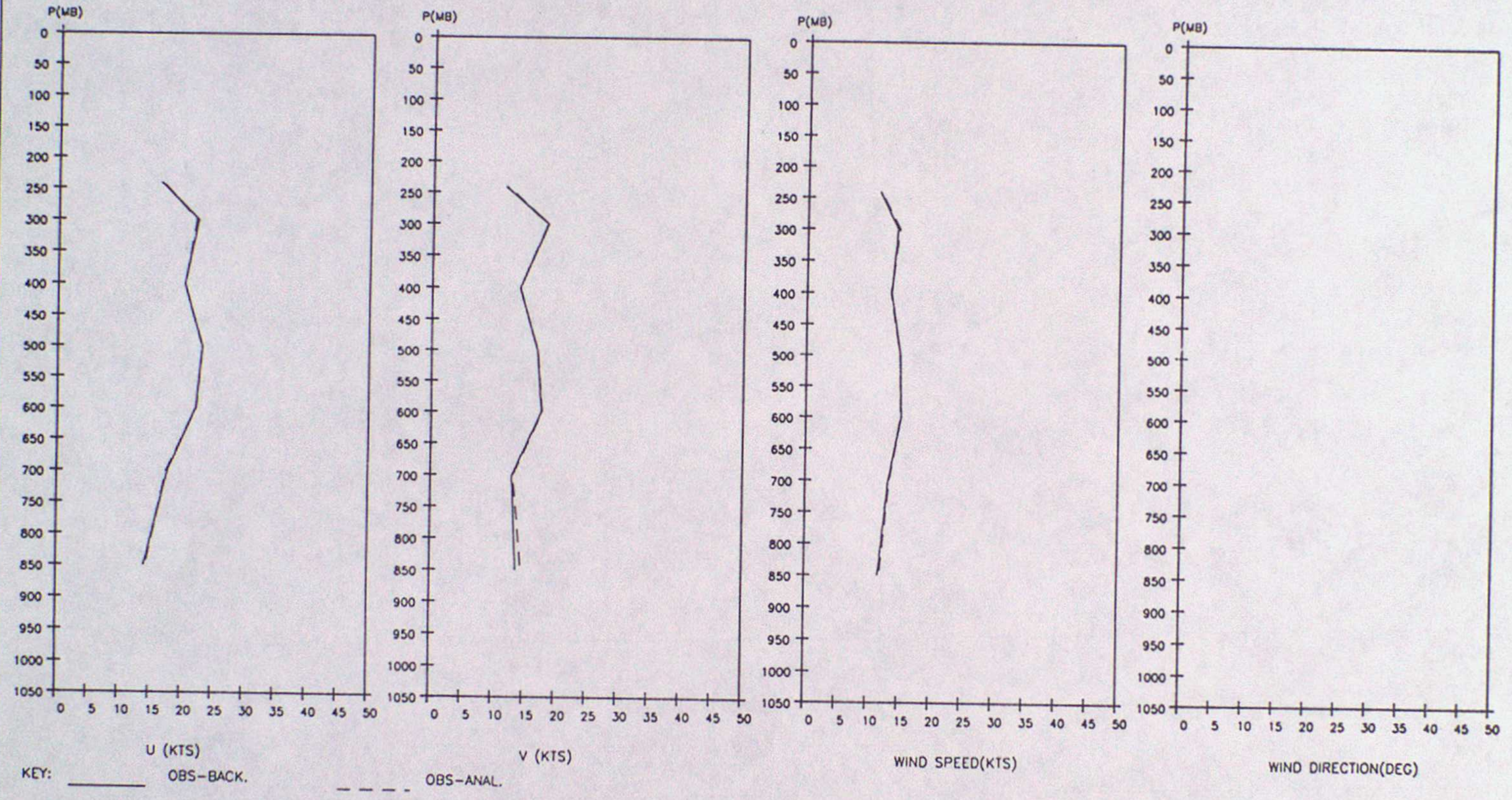


FIG. 2.2.17 INSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000420 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 10.00 LAT2: 20.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 7 N. REPORTS: 1257 N. OBS USED: 1257
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

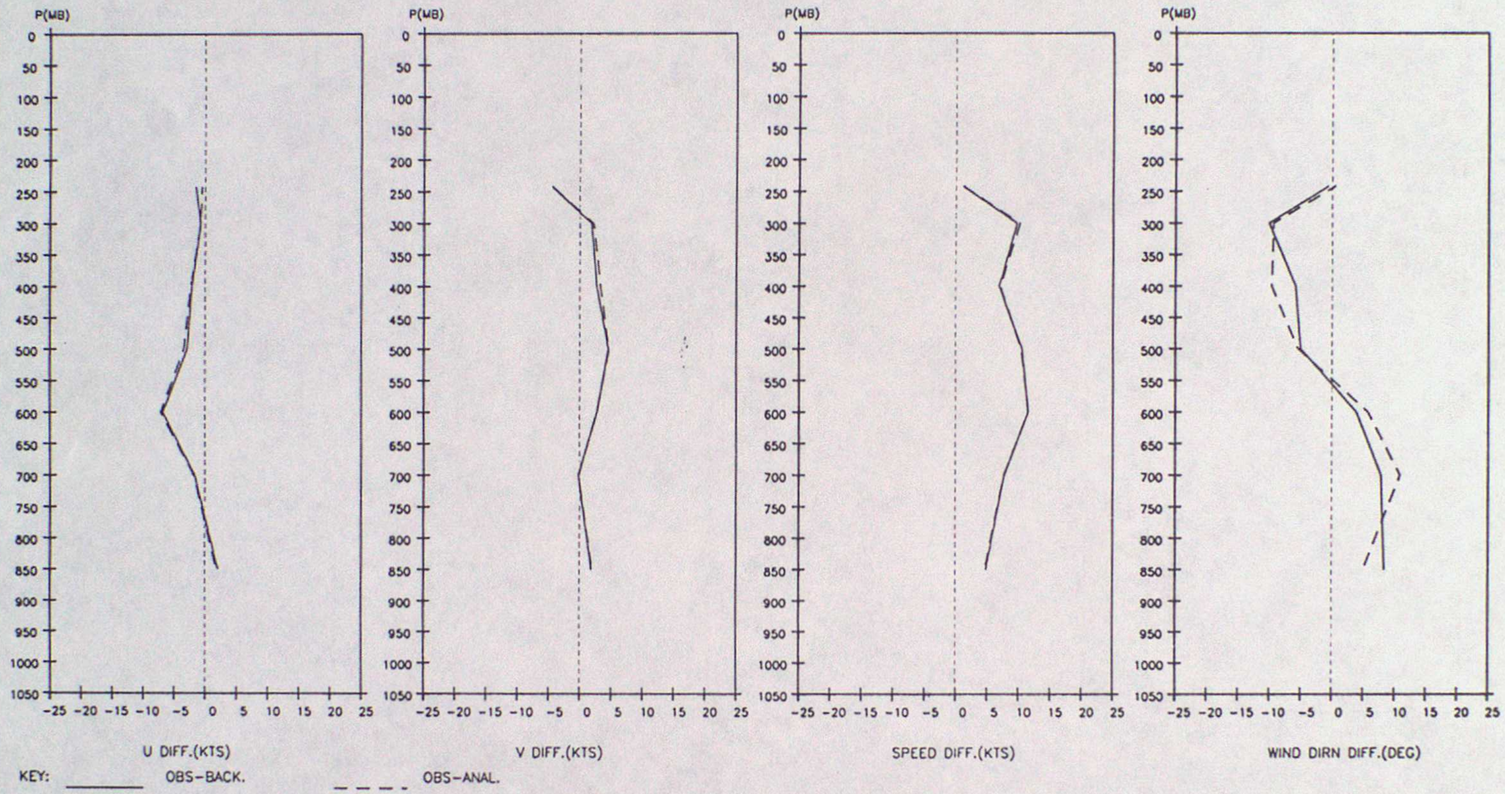


FIG. 2.2.17 CONT. INSAT.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: 00000420 ON PRESSURE LEVELS MODEL TYPE= SATOB
LAT1: 10.00 LAT2: 20.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 7 N. REPORTS: 1257 N. OBS USED: 1257
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

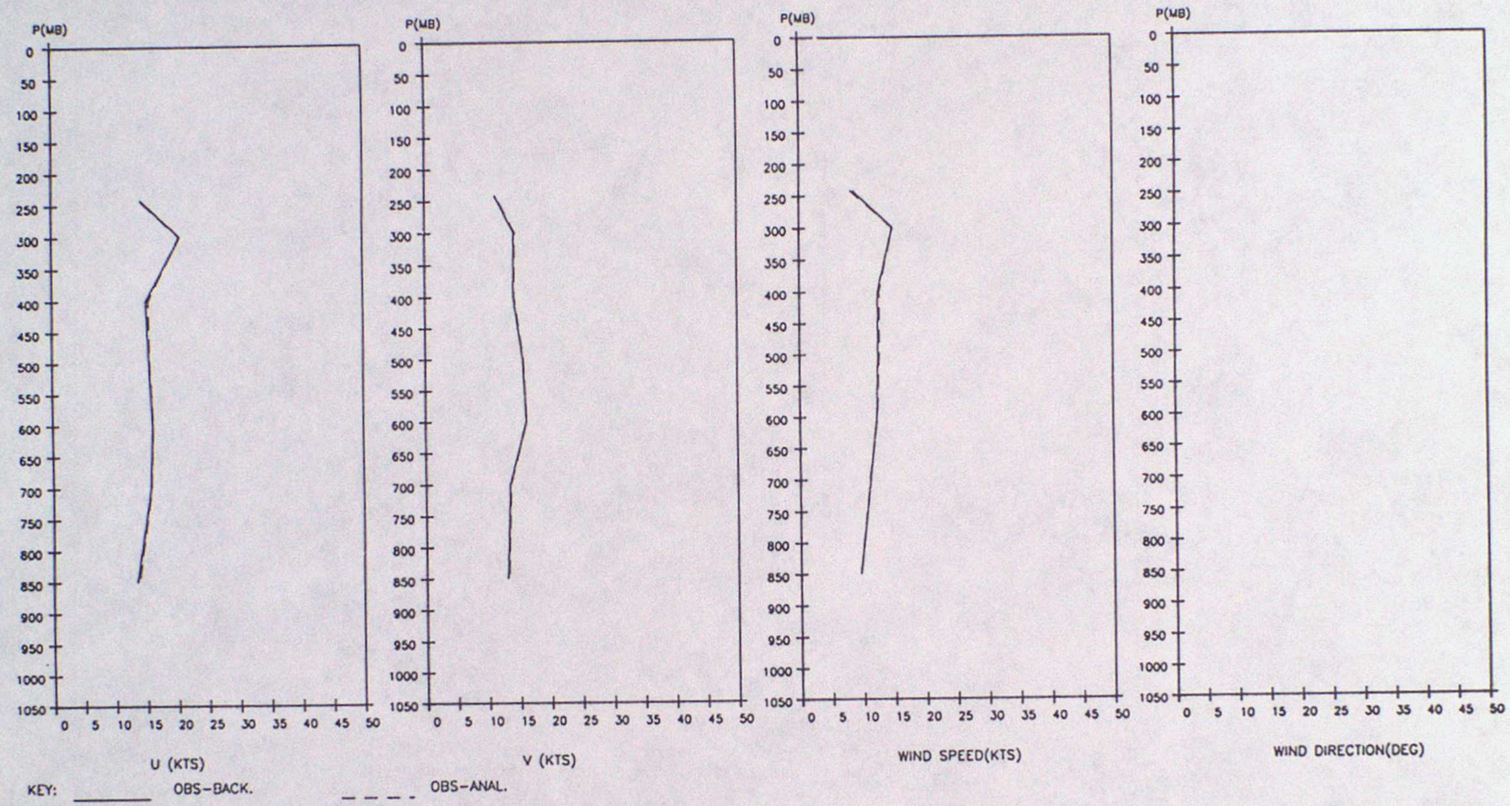


FIG. 2.3.1. C.C. SATEM. OVER SEA

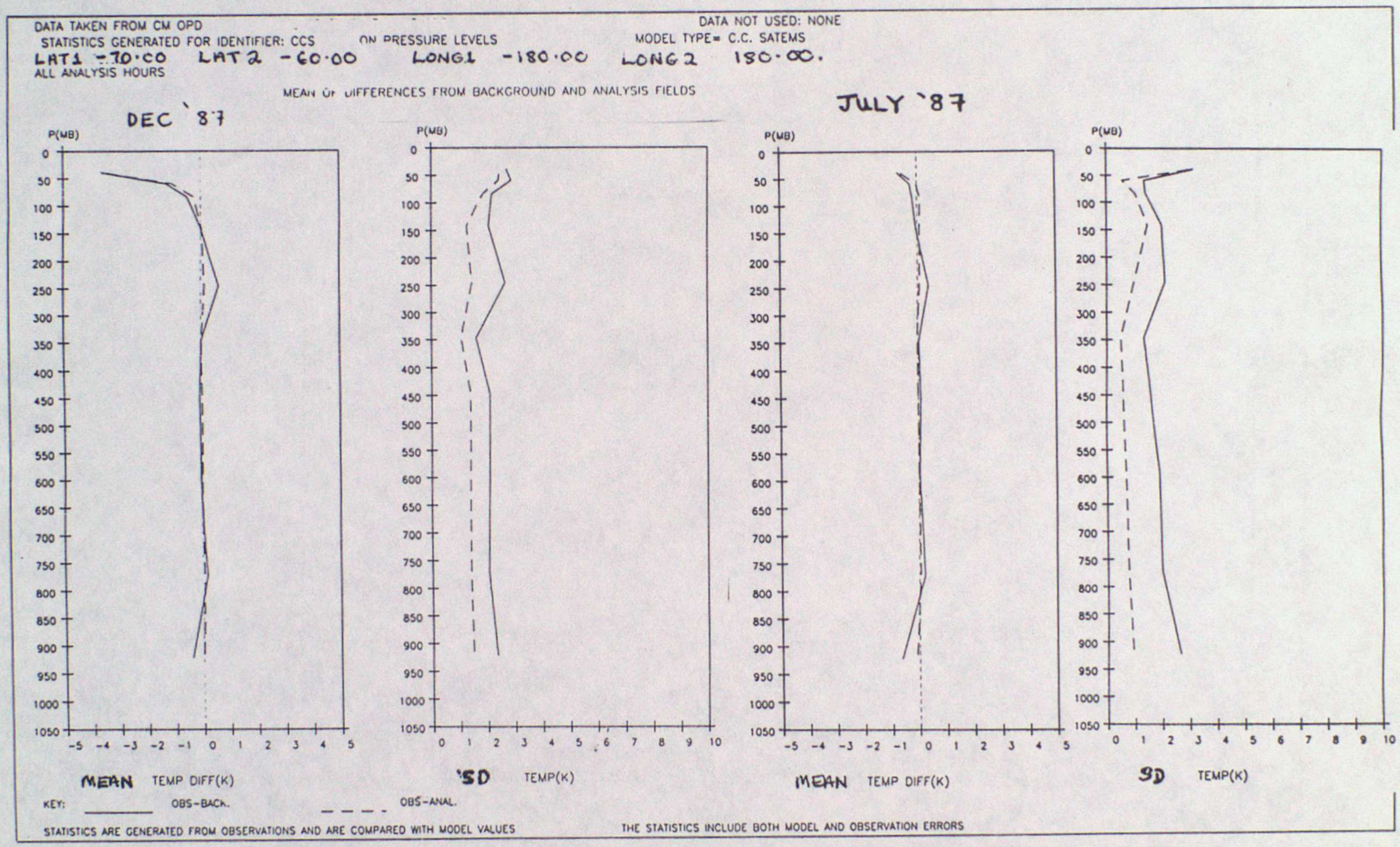


FIG. 2.3.2. G.C. SATEM. OVER SEA.

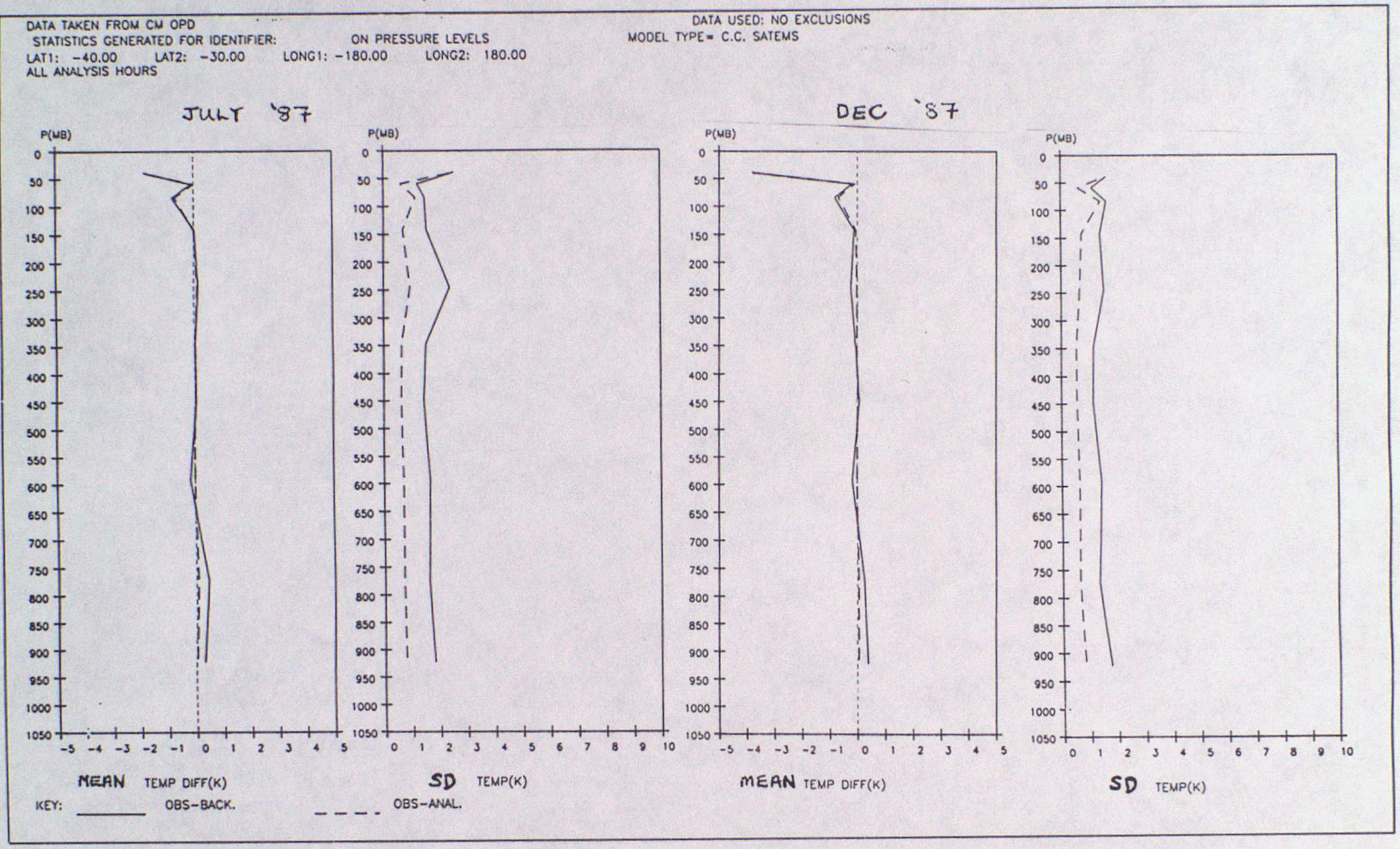
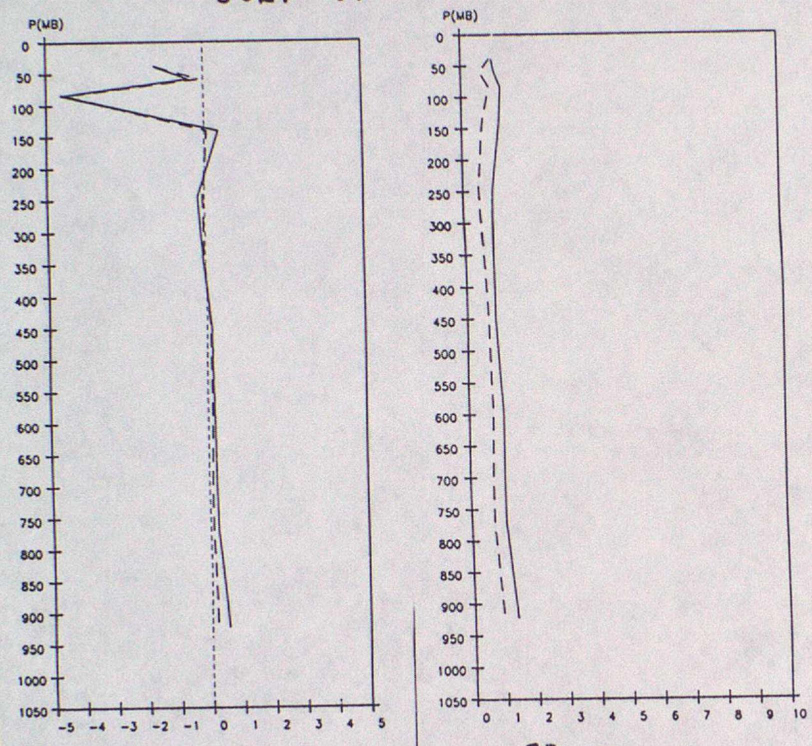


FIG. 2.3.3. C.C. SATEM. OVER SEA.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS MODEL TYPE= C.C. SATEMS
LAT1: 0.00 LAT2: 10.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 8 N. REPORTS: 8293 N. OBS USED: 8293
ALL ANALYSIS HOURS

JULY '87



KEY: ______ OBS-BACK. - - - - OBS-ANAL.

FIG. 2.3.4. C.C. SATEM. OVER SEA.

DATA TAKEN FROM CM OPD
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS
LAT1: 30.00 LAT2: 40.00 LONG1: -180.00 LONG2: 180.00
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= C.C. SATEMS

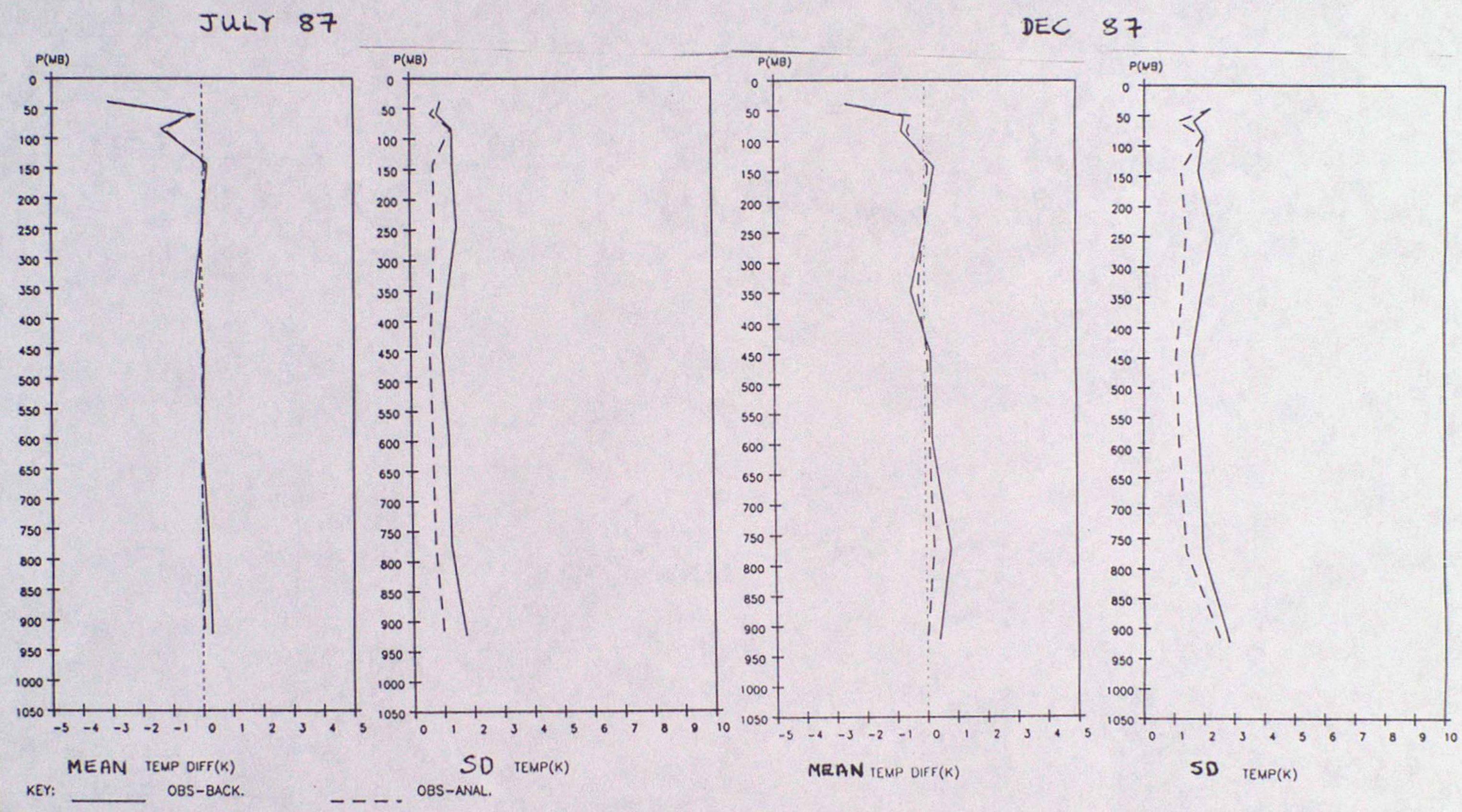
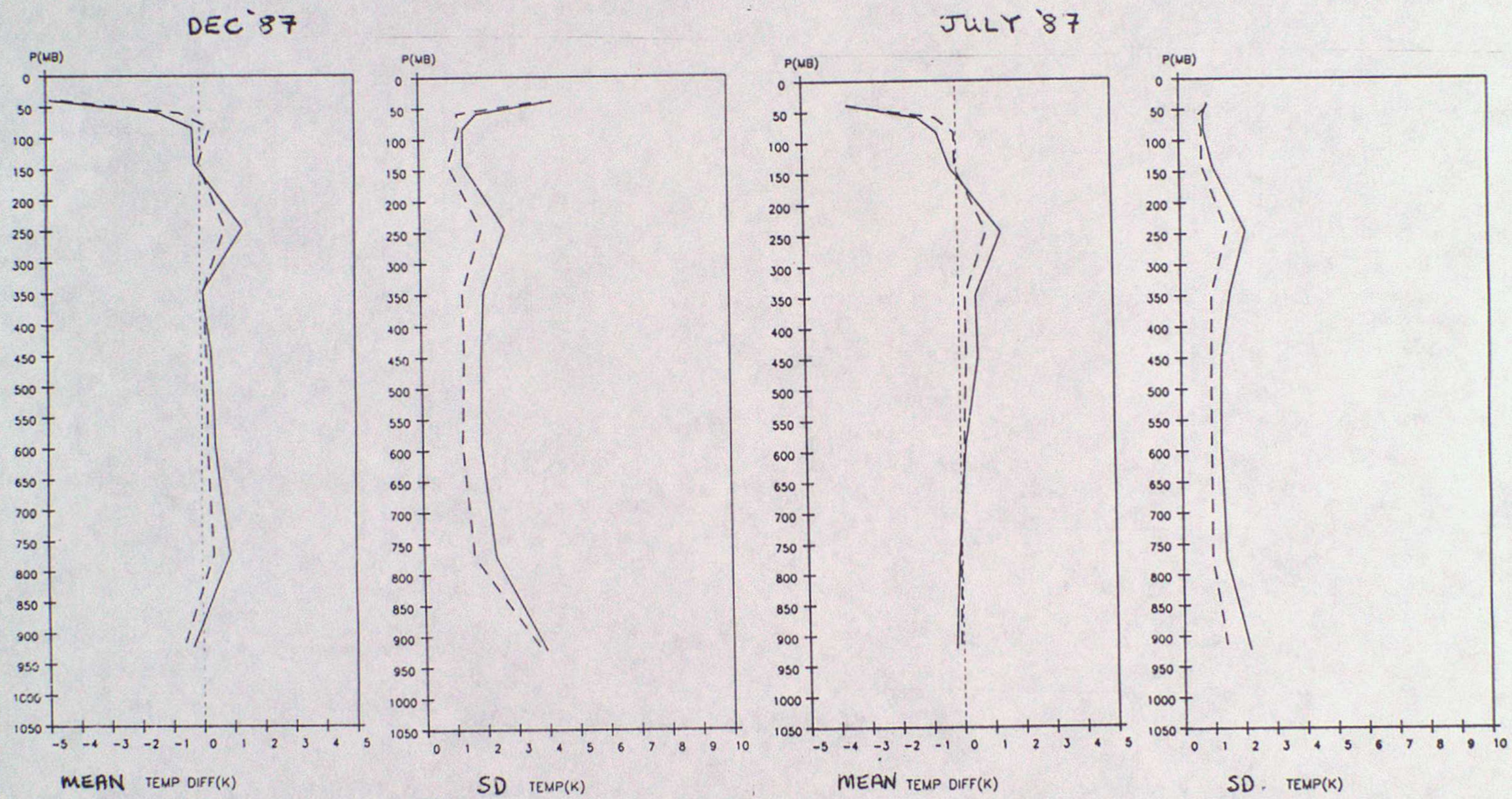


FIG. 2.3.5. C.C. SATEM. OVER SEA.

DATA TAKEN FROM CM OPD
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS
LAT1: 60.00 LAT2: 70.00 LONG1: -180.00 LONG2: 180.00
ALL ANALYSIS HOURS

DATA NOT USED: NONE
MODEL TYPE= C.C. SATEMS



KEY: ——— OBS-BACK. – – – OBS-ANAL.

STATISTICS ARE GENERATED FROM OBSERVATIONS AND ARE COMPARED WITH MODEL VALUES

THE STATISTICS INCLUDE BOTH MODEL AND OBSERVATION ERRORS

FIG. 2.3.6. C.C. SATEM OVER ICE / SEA ICE.

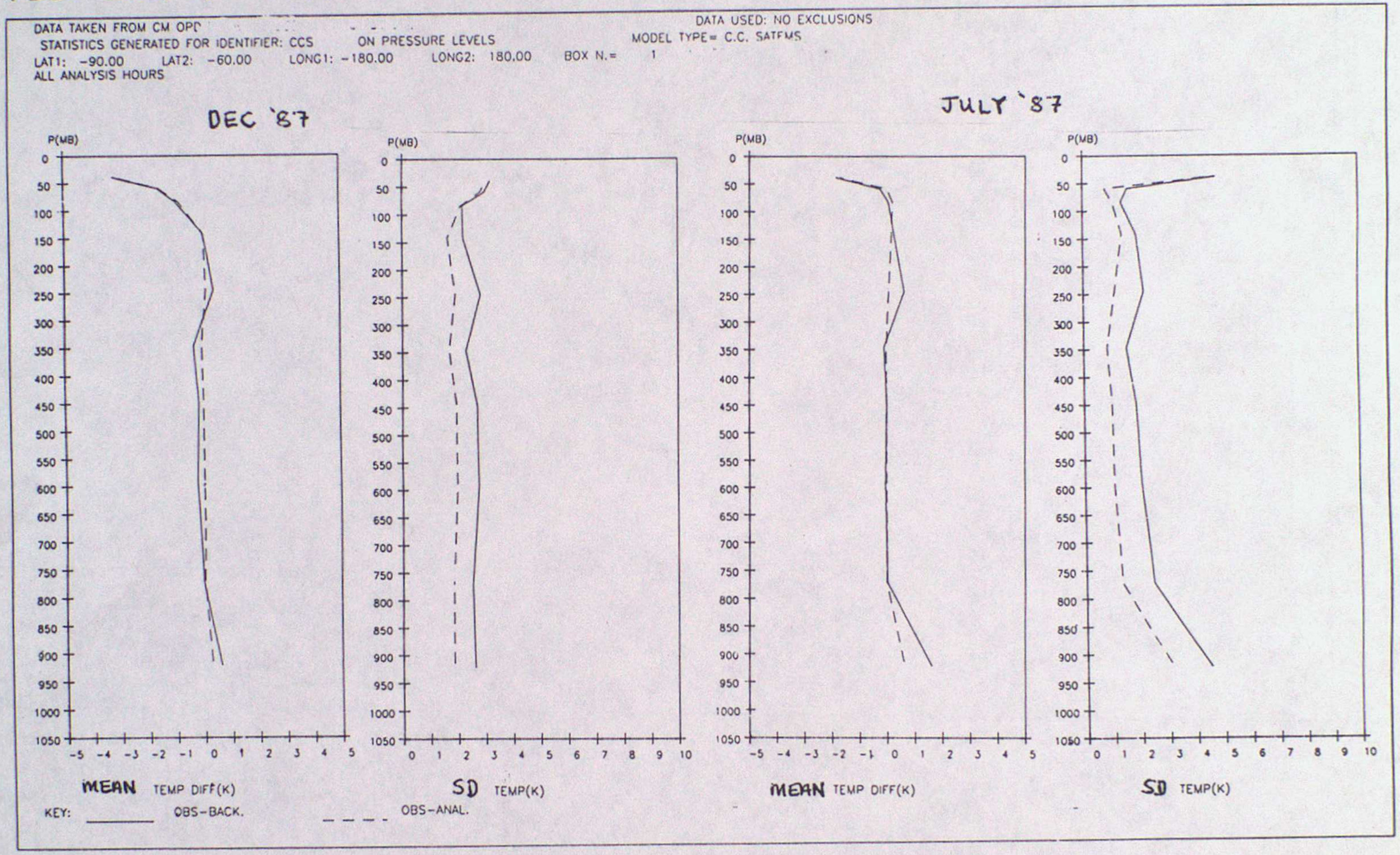


FIG. 2.3.7. C.C. SATEM OVER ICE/SEA ICE.

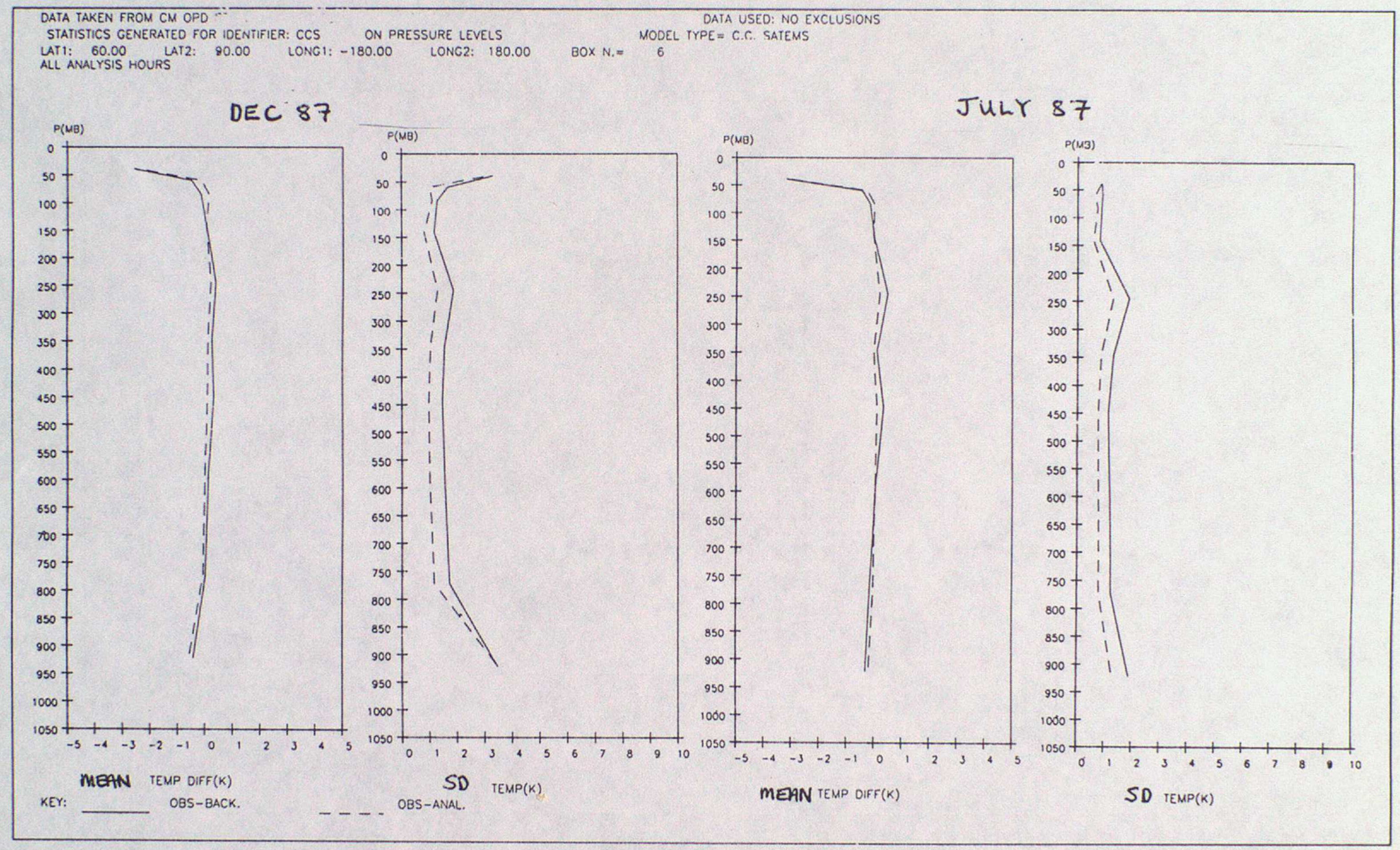


FIG. 2.3.8. C.C. SATEM OVER LAND

DATA TAKEN FROM CM OPD
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS
LAT1: -60.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 2
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= C.C. SATEMS

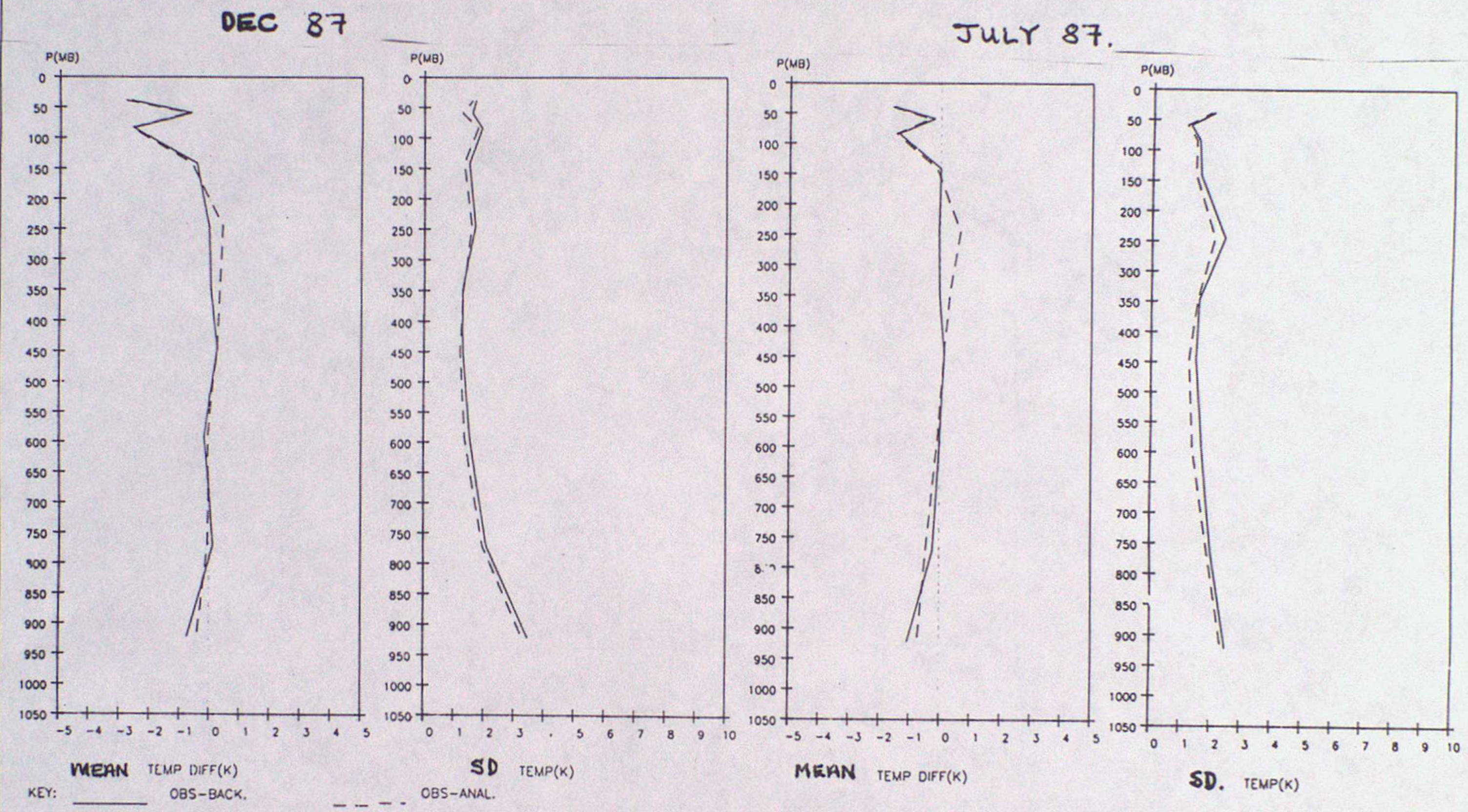


FIG. 2.3.9. C.C. SATEM OVER LAND

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 — DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS — MODEL TYPE= C.C. SATEMS
LAT1: -30.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 3789 N. OBS USED: 3789
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

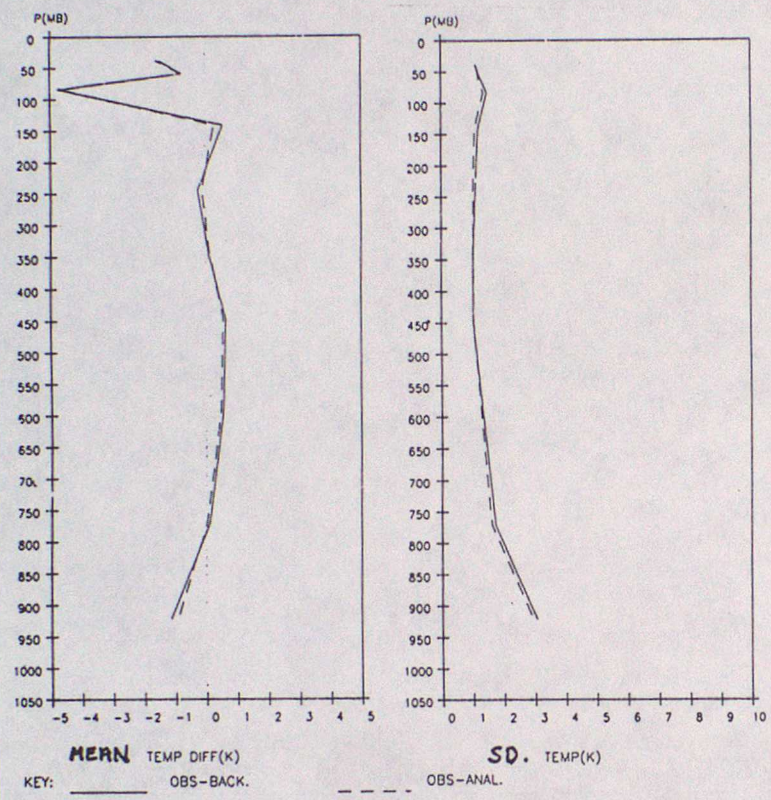


FIG. 2.3.10 C.C. SATEM OVER LAND.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NO EXCLUSIONS
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS MODEL TYPE= C.C. SATEMS
LAT1: 0.00 LAT2: 30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 4 N. REPORTS: 3943 N. OBS USED: 3943
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

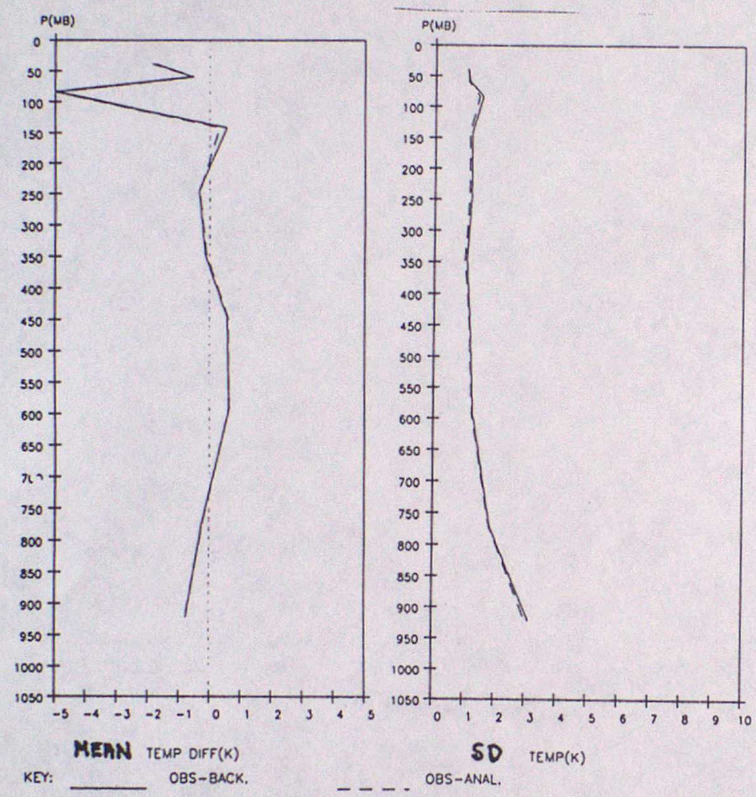


FIG. 2. 3. 11. C.C. SATEM OVER LAND.

DATA TAKEN FROM CM OPC
STATISTICS GENERATED FOR IDENTIFIER: CCS ON PRESSURE LEVELS
LAT1: 30.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 5
ALL ANALYSIS HOURS

DATA USED: NO EXCLUSIONS
MODEL TYPE= C.C. SATEMS

DEC 87

JULY 87

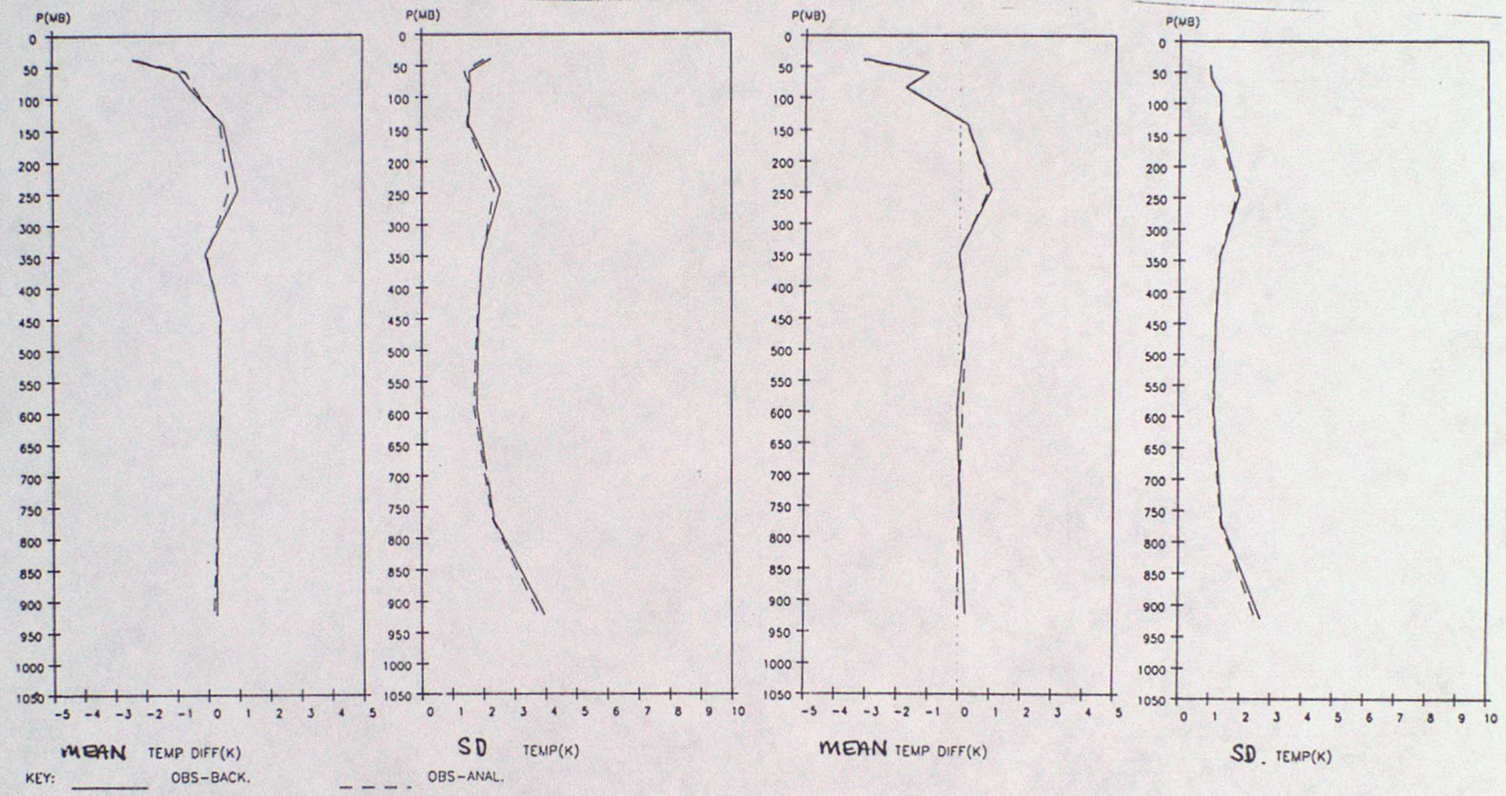


FIG. 2.3.12 C.C. SATEM OVER LAND

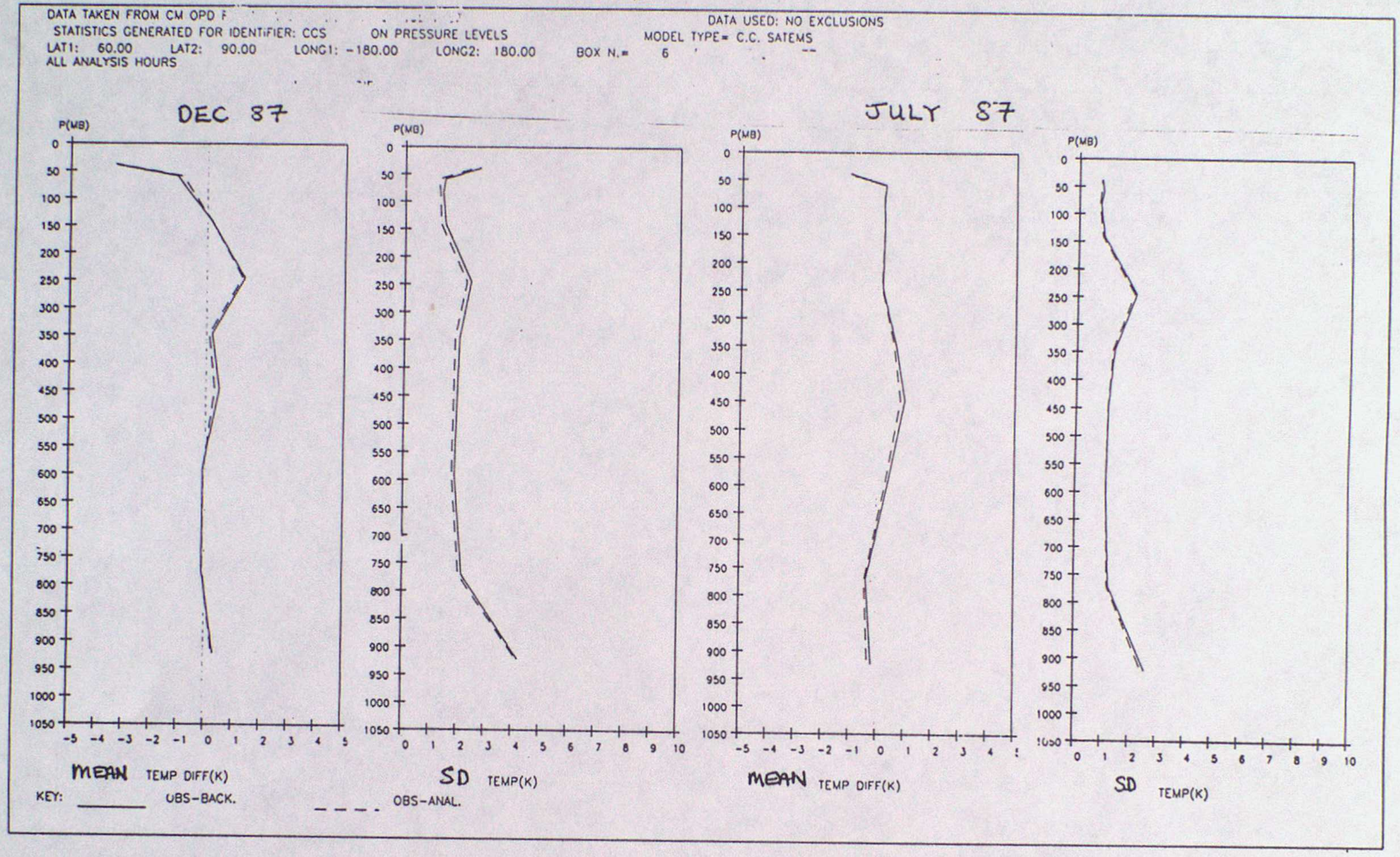


FIG. 2.4.1. LASS AND C.C. SATEM OVER FM AREA. MAR '87

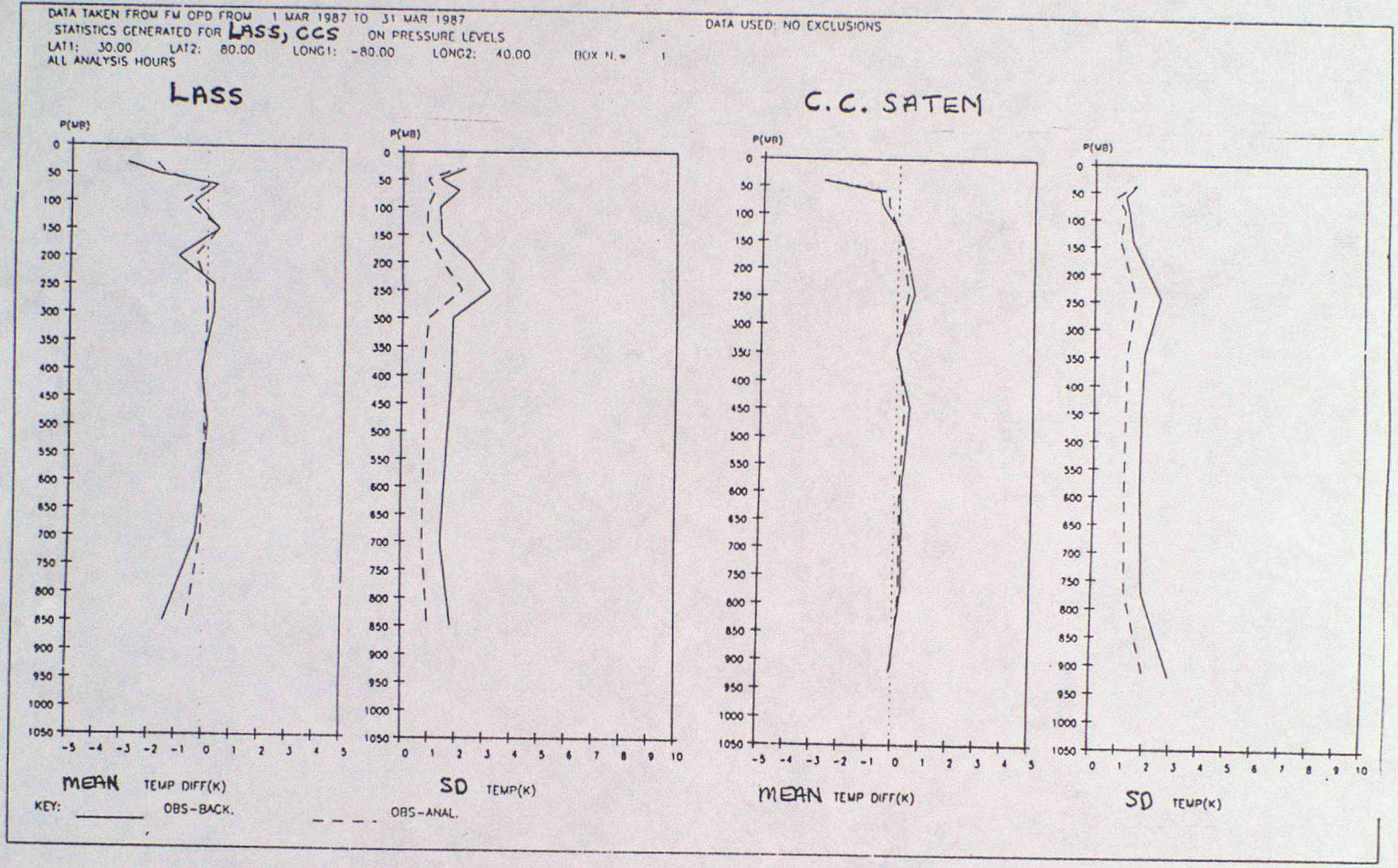


FIG. 2.4.2. LASS AND C.C.SATEM OVER FM AREA. JULY '87

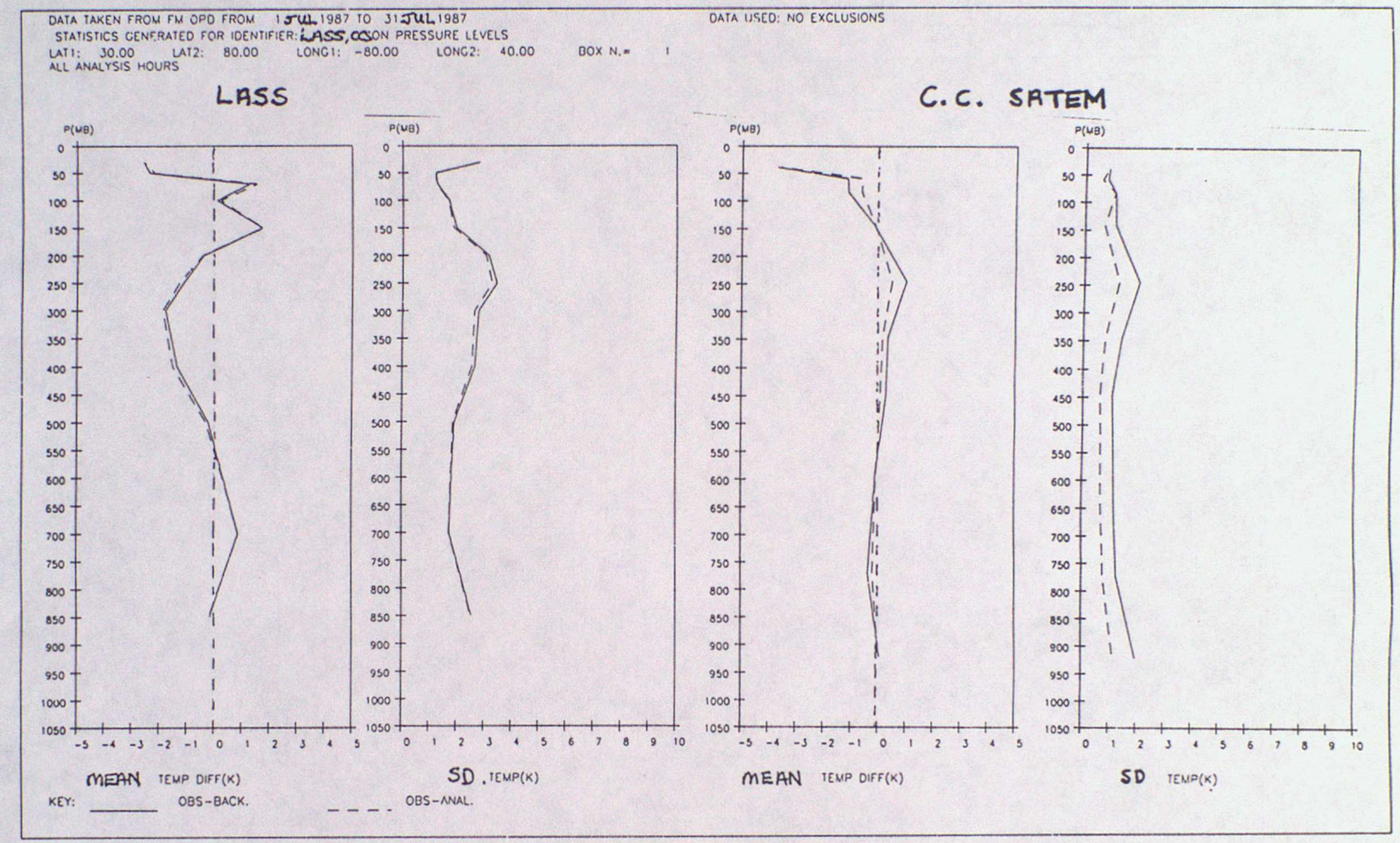


FIG. 2.4.3. LASS AND C.C. SATEM OVER THE FM AREA. OCT '87

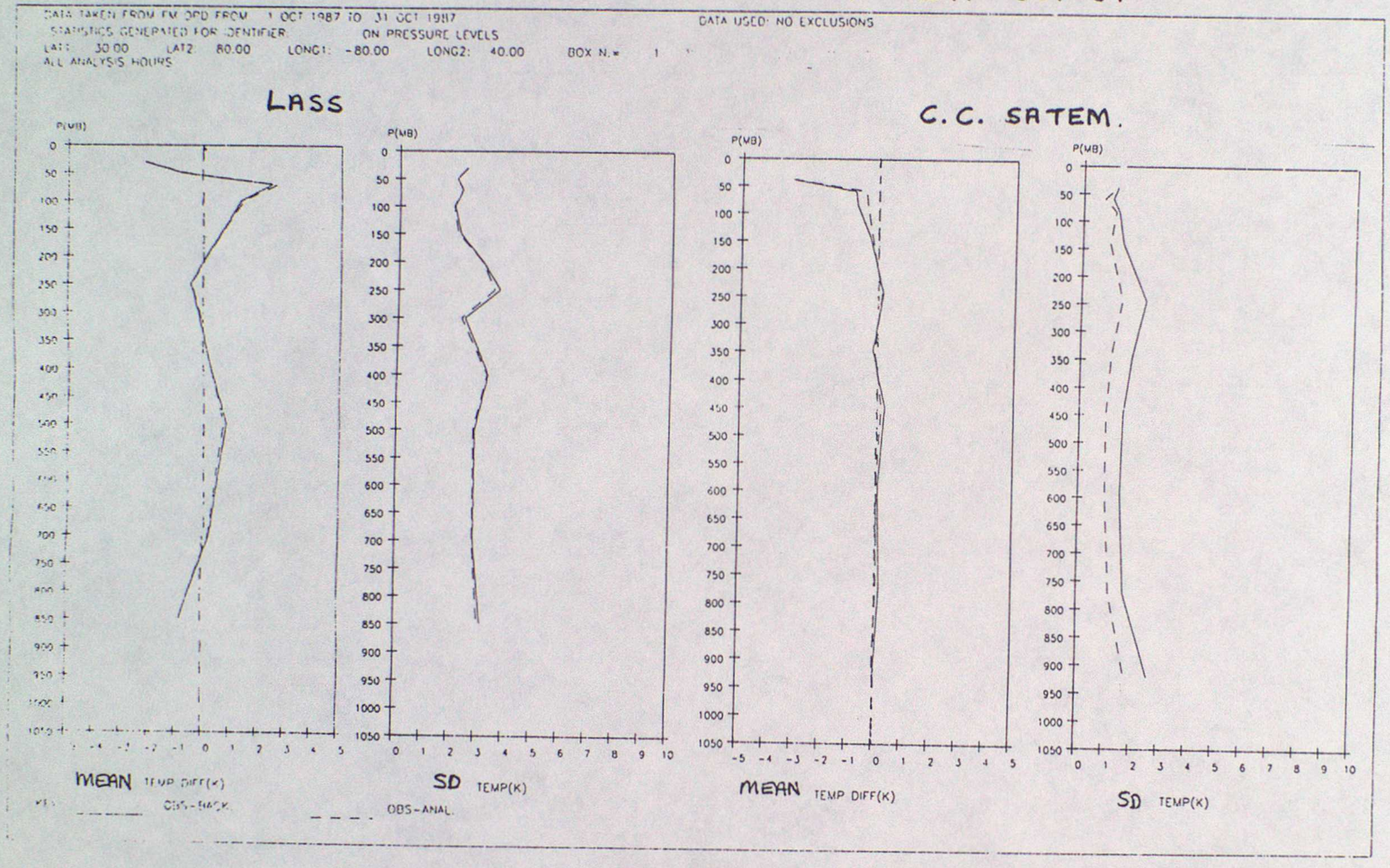
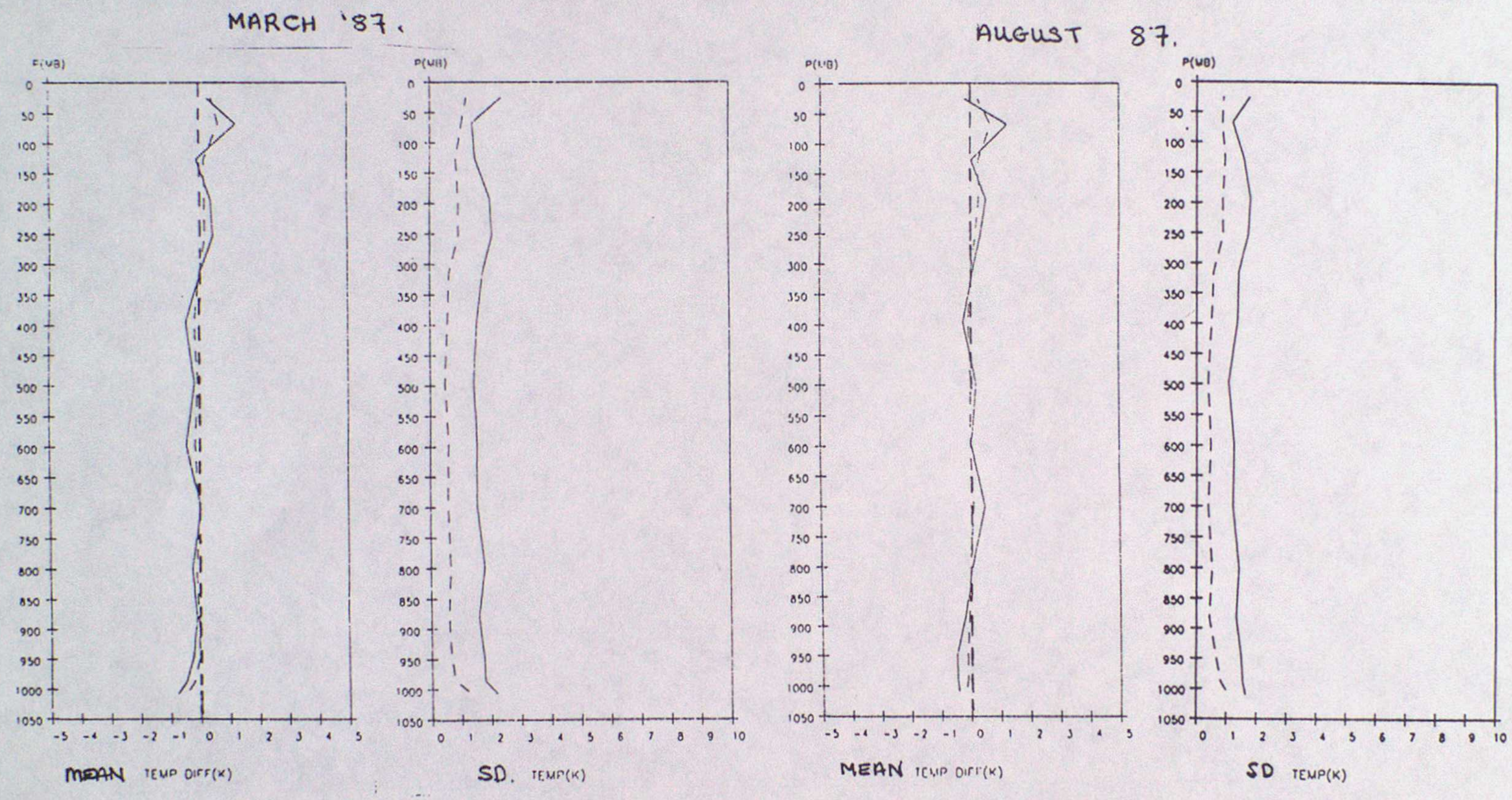


FIG 2.4.4 OWS AND COASTAL VAR STATIONS IN FM AREA.

OWS 'C', 'L', 'M', 03953, 04018, 08001, 08509, 71399, 72304.

DATA DERIVED FROM FM OPD
IDENTIFIER: MOD02-07
ALL ANALYSIS HOURS
LAT1: 30.00 LAT2: 80.00 LONG1: -80.00 LONG2: 40.00

STATISTICS GENERATED ON SIGMA LEVELS DATA NOT USED: NO EXCLUSIONS



KEY: OB-BACK ——— OB-ANAL - - - -

FIG. 2.5.1 AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: -40.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 2483 N. OBS USED: 2483
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

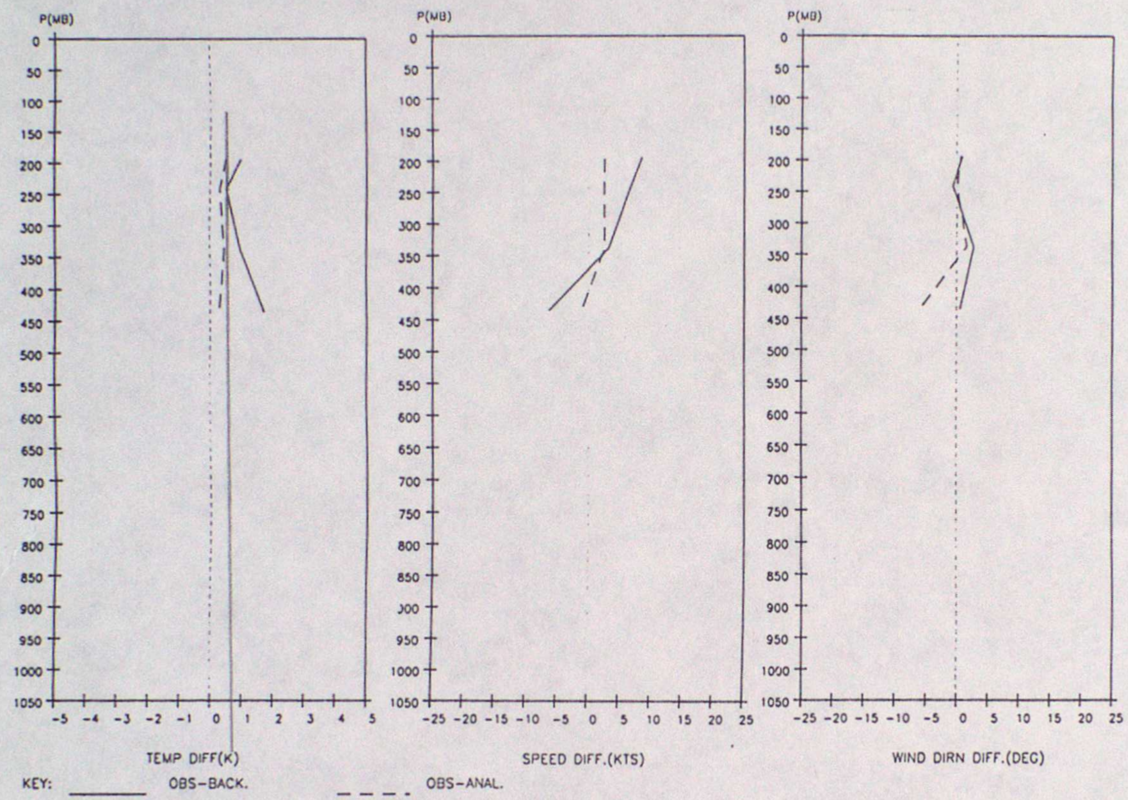
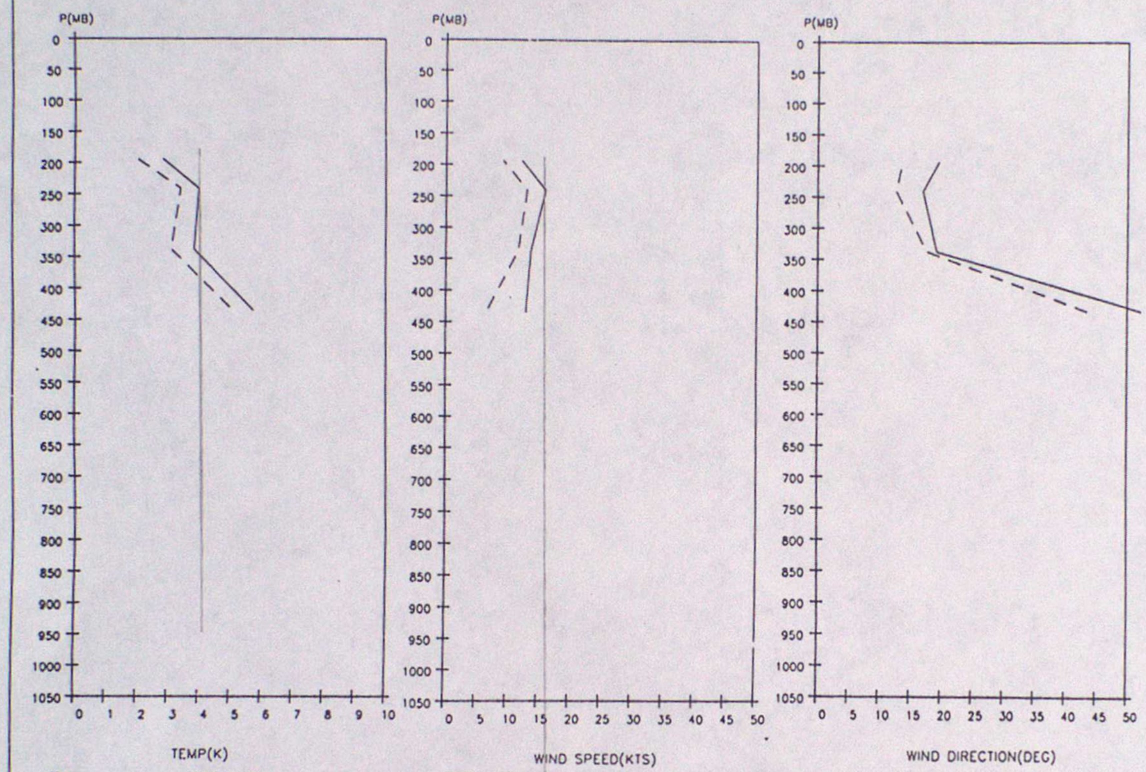


FIG. 2.5.1 CONT. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: -40.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 2483 N. OBS USED: 2483
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

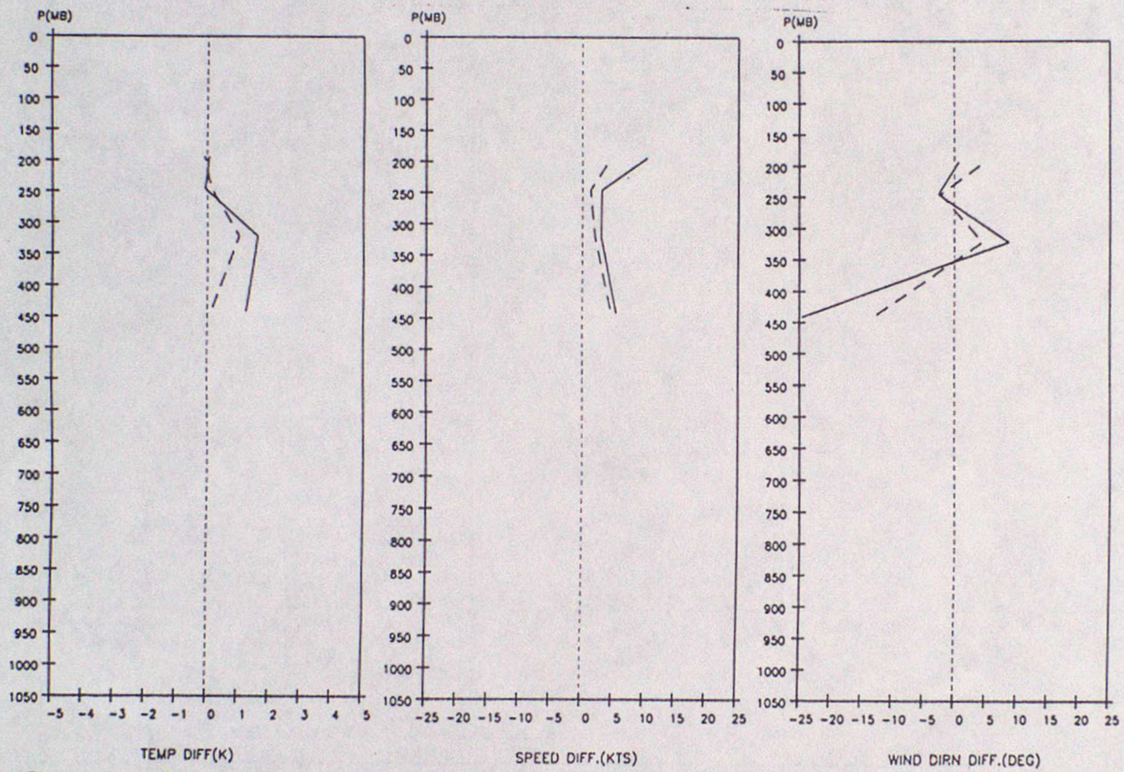


KEY: ——— OBS-BACK. - - - - OBS-ANAL.

Fig. 2.5.2. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: −40.00 LAT2: −30.00 LONG1: −180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 676 N. OBS USED: 676
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

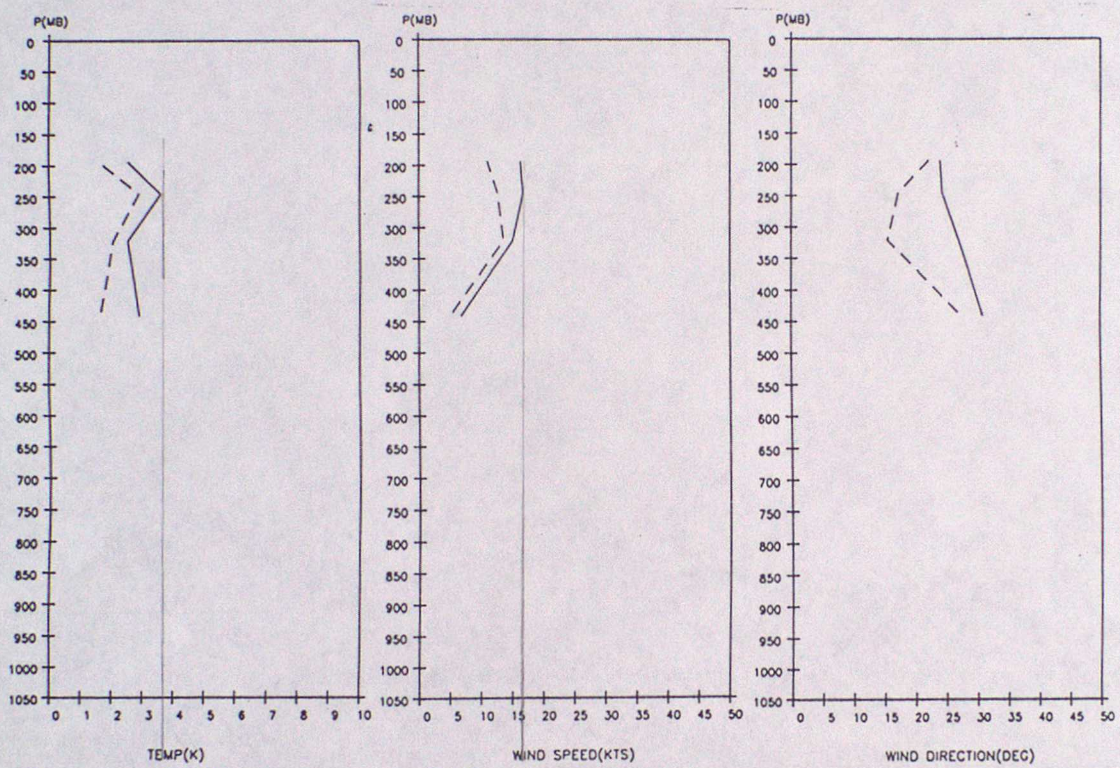


KEY: ——— OBS-BACK. – – – – OBS-ANAL.

FIG. 2.5.2. CONT. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: -40.00 LAT2: -30.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 3 N. REPORTS: 676 N. OBS USED: 676
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

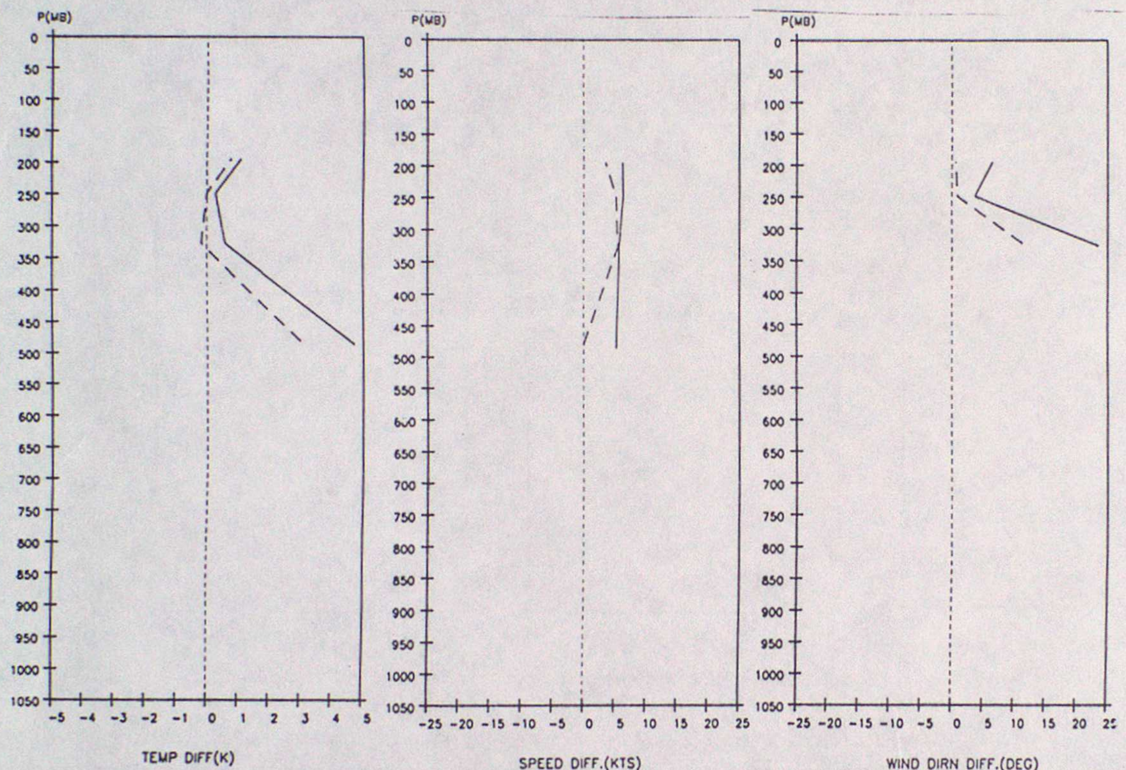


KEY: ——— OBS-BACK. - - - - OBS-ANAL.

FIG. 2.5.3. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 1758 N. OBS USED: 1758
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

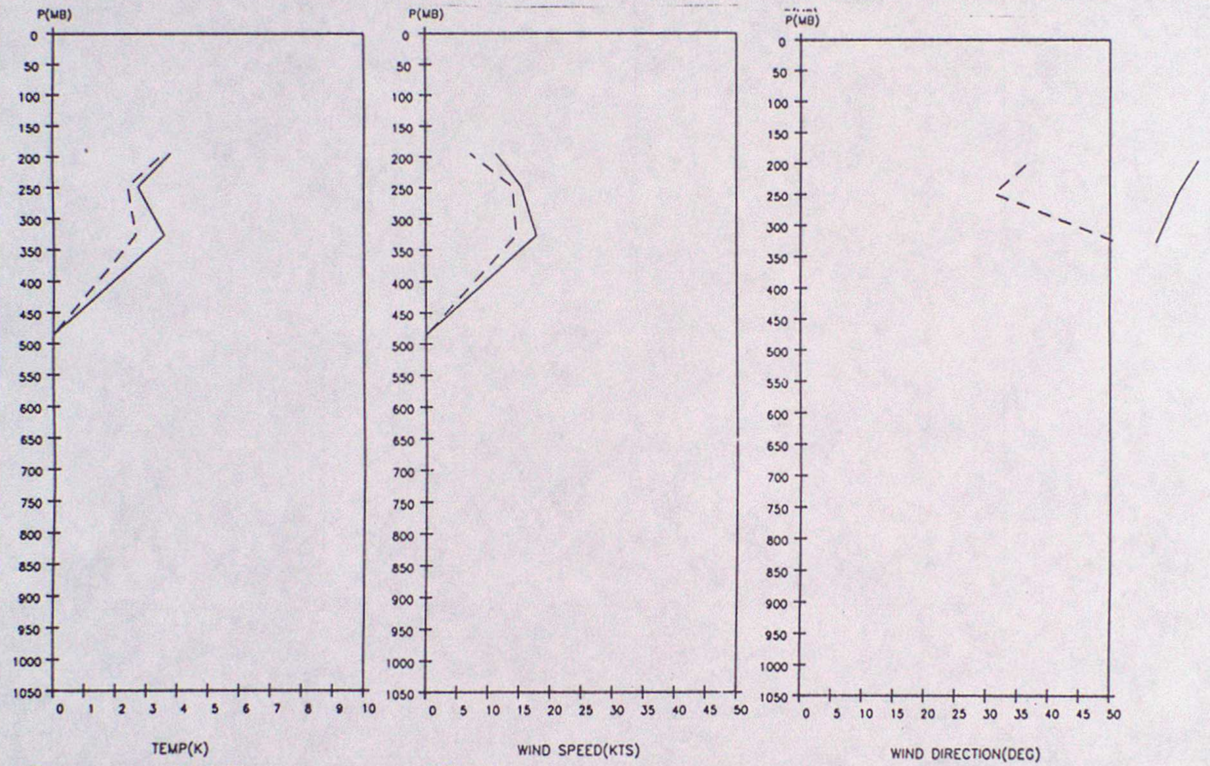


KEY: ———— OBS-BACK. – – – – OBS-ANAL.

FIG. 2.5.3. CONT. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: -10.00 LAT2: 0.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 6 N. REPORTS: 1758 N. OBS USED: 1758
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. - - - - OBS-ANAL.

FIG. 2.5.4. AIREP DATA.

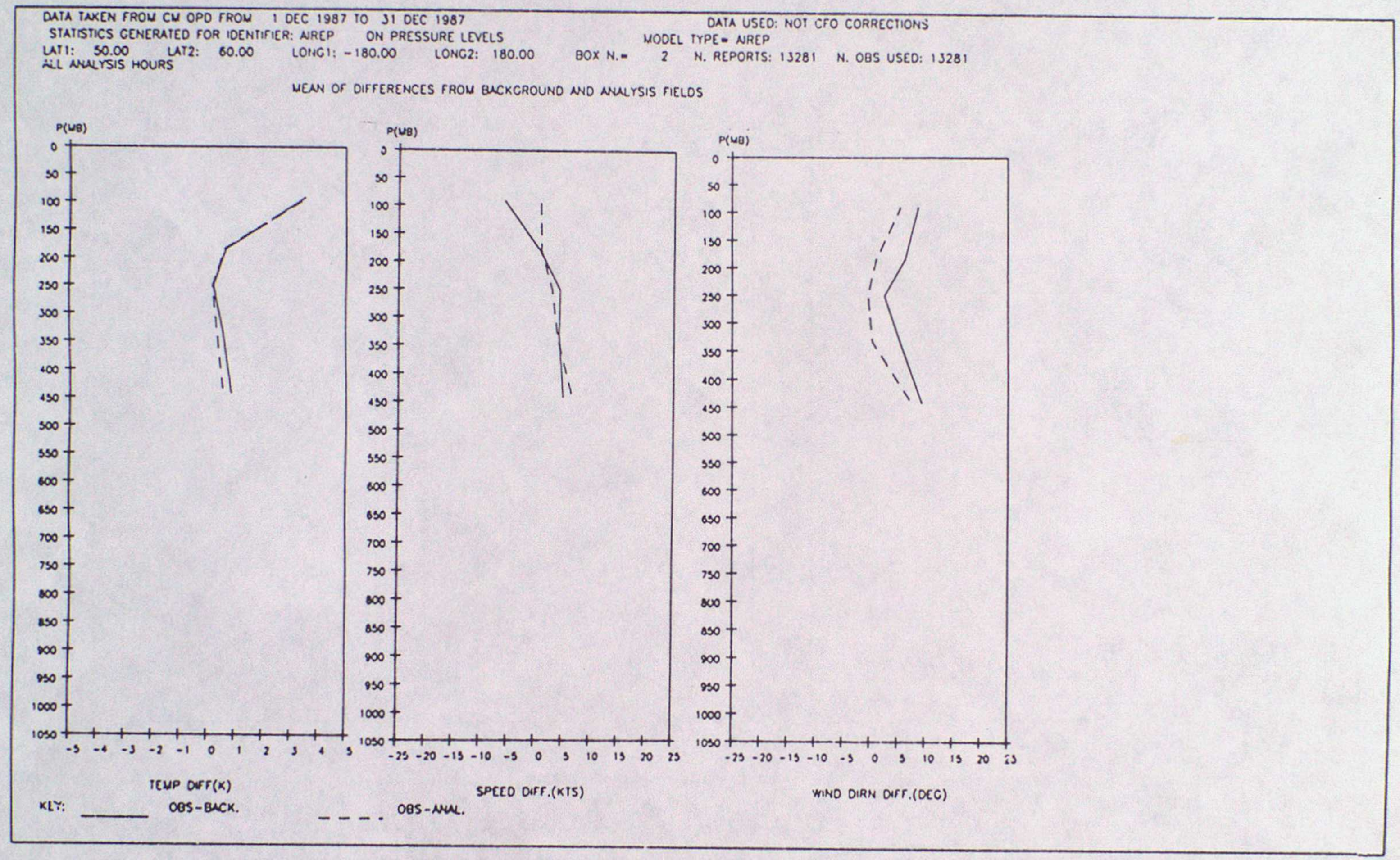


FIG. 25.4. CONT. AIREP DATA.

DATA TAKEN FROM CM GPD FROM 1 DEC 1987 TO 31 DEC 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: 50.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 2 N. REPORTS: 13281 N. OBS USED: 13281
ALL ANALYSIS HOURS

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

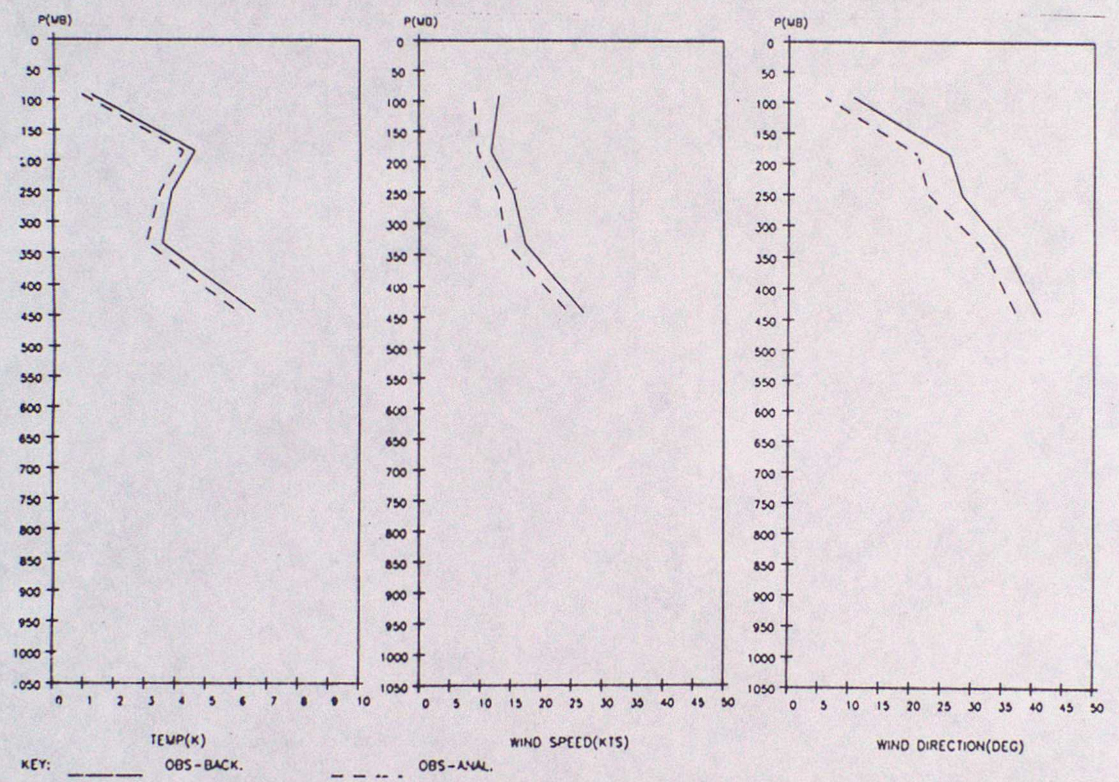


FIG. 2.5.5. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987 DATA USED: NOT CFO CORRECTIONS
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS MODEL TYPE= AIREP
LAT1: 50.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 2 N. REPORTS: 16229 N. OBS USED: 16229
ALL ANALYSIS HOURS

MEAN OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS

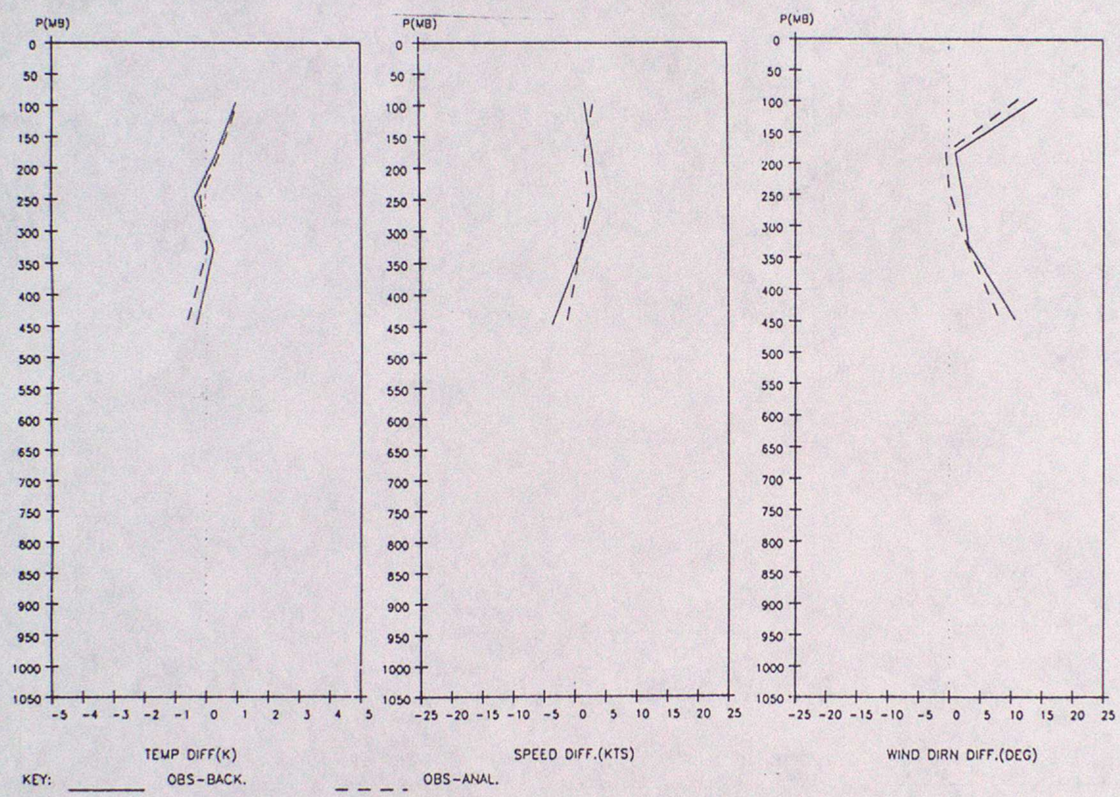
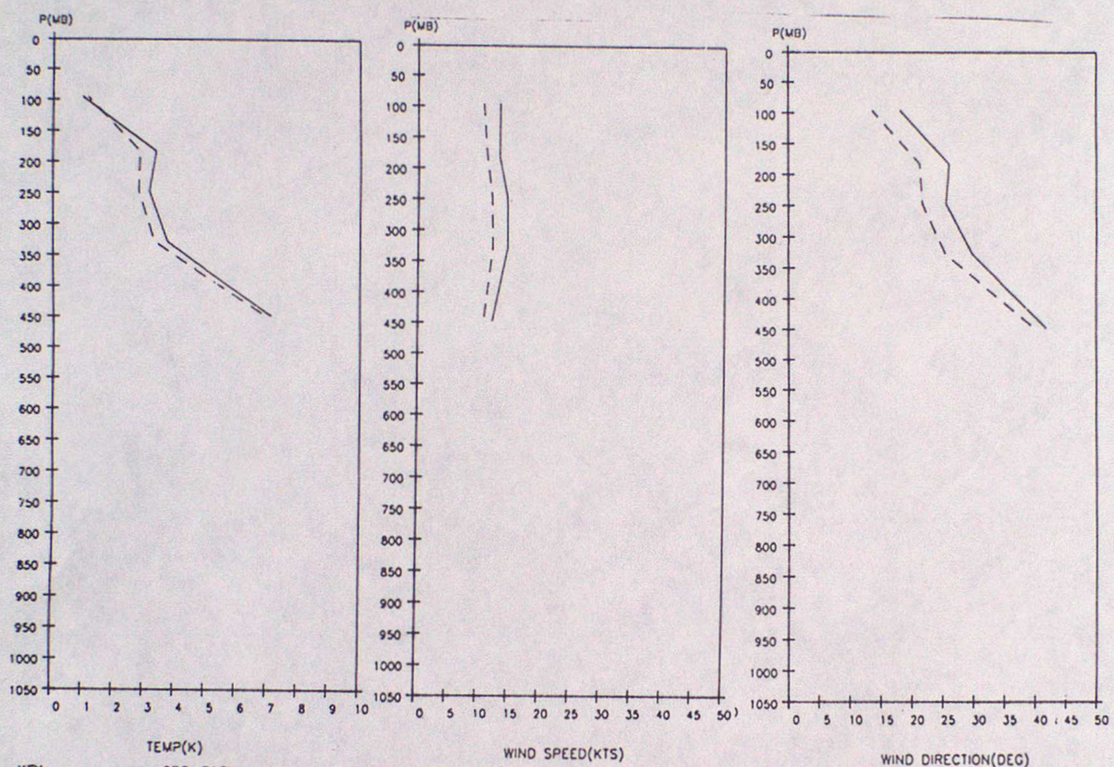


FIG. 2.55. CONT. AIREP DATA.

DATA TAKEN FROM CM OPD FROM 1 JUL 1987 TO 31 JUL 1987
STATISTICS GENERATED FOR IDENTIFIER: AIREP ON PRESSURE LEVELS
LAT1: 50.00 LAT2: 60.00 LONG1: -180.00 LONG2: 180.00 BOX N.= 2
ALL ANALYSIS HOURS

DATA USED: NOT CFO CORRECTIONS
MODEL TYPE= AIREP
N. REPORTS: 16229 N. OBS USED: 16229

SD OF DIFFERENCES FROM BACKGROUND AND ANALYSIS FIELDS



KEY: ——— OBS-BACK. – – – OBS-ANAL.