TECHNICAL MEMORANDUM

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On the use of cloud track wind data from FGGE in the upper troposphere

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November 1985

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1. INTRODUCTION

Cloud track wind data collected from five geostationary satellites during FGGE gave, for the first time, a good coverage of tropical and subtropical wind observations at all longitudes. When the ECMWF assimilation of the so called Main FGGE level II-b data started in 1979, our knowledge of the quality and performance of the cloudwind data was very limited. It was recognized, however, that a possible source of error in the data was the assigned height. The methods of height assignment varied between different producers, some giving a cloud (top) temperature with a corresponding pressure determined from some (climatological) temperature profile, while others just gave a pressure level. Assuming that temperature measurements, when available, were more reliable than given pressure levels, ECMWF adopted a scheme for reassignment of cloud wind heights to the level of best fit between observed cloud temperature and the 6 hour first guess forecast temperature. A small collocation study by P. Julian and M. Kanamitsu at ECMWF (not published) showed some improvement in rms differences between collocated radiosonde and SATOB (i.e. cloud wind) data after the height reassignment. During the level III-b assimilation, the effect of the height reassignment was not studied further, although statistics from each analysis showed that the height changes were usually of the order 30-40 mb or less.

The vertical structure function used for the ECMWF Main level III-b assimilation was very wide, making the net effect of the height reassignment small. In Baede et al. (1985) the consequences of the use of such a broad vertical structure function is discussed in connection with an observing system experiment concerned with aircraft data. Julian (1980) also pointed out the difficulties in analyzing sharp vertical gradients of the horizontal wind in divergent areas near cloud tops in the tropical convergence zone with these structure functions.

An observing system experiment specifically studying the impact of the FGGE SATOB data was carried out at ECMWF by Kållberg et al. (1982). It was shown that the cloud wind data had a positive impact on the analyzed tropical motion, while their impact at higher latitudes was rather questionable and sometimes clearly negative, particularly in the subtropical jetstream. Large negative biases were found in the reported zonal wind component, especially over the Mediterranean-Western Asian region.

The problems were assumed to be connected with high level cirrus over mountaineous regions not being representative of the flow. High level SATOB winds over land have subsequently been eliminated in OSEs and the ECMWF operational system.

An enhanced set of FGGE observations, the final II-b set, has recently become available. In this set, several subsets of SATOB data have been added or replaced. The coverage over the western Pacific ocean is particularly upgraded due to a large set of vectors extracted from Himawari imagery by the SSEC, University of Wisconsin. ECMWF has recently started analysing the final II-b data. In addition to the enhanced observational data base, the assimilation system has been upgraded in many respects, and is identical to that used in ECMWF operations, except that a T63 resolution is used for the forecast step. The major changes in the assimilation compared to that used for the main III-b analyses are

(a) improved vertical interpolations between the vertical grids used in the analysis and forecast model

(b) improved data selection and quality control algorithms (see Shaw et al. 1984)

(c) improved statistical structure functions for the optimum interpolation (see Hollingsworth and Lönnberg, and Lönnberg and Hollingsworth, 1986).

2. DECEMBER 1978 ASSIMILATION

As a preliminary to the reassimilation of the two FGGE Special Observing Periods, the final II-b data for December 1978 have recently been analyzed. The assimilation system was that planned to be used for the final analysis of the SOPs. SATOB data were thus excluded over land areas. However, due to a programming error, the height reassignment code was not activated during the first few days of the assimilation. When the error was discovered, it was decided to continue the assimilation without reintroduction of the height modification since otherwise statistics already accumulated would be useless. The use of the SATOB data, exactly as given by the producers, in hindsight also gave us the opportunity to study the quality of the data when unaffected by our modifications. Indeed, after the conclusion of the December analyses we were informed by SSEC* (D. Wylie, personal communication) that, for the University of Wisconsin data, the pressure level assignments should be considered as more reliable than the temperatures. Contrary to our assumptions for the main III-b assimilation, the data producers at SSEC often concentrated their efforts on the height specification and subsequently used standard atmosphere soundings for temperature assignments.

Due to the importance of the Indian Ocean and Western Pacific Ocean SATOB data for the FGGE analyses, the best possible use of the University of Wisconsin data is particularly important, and during the assimilation the monitoring was concentrated on those areas. Only upper troposphere SATOB data are discussed in the present study.

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*SSEC - Space Science and Engineering Center

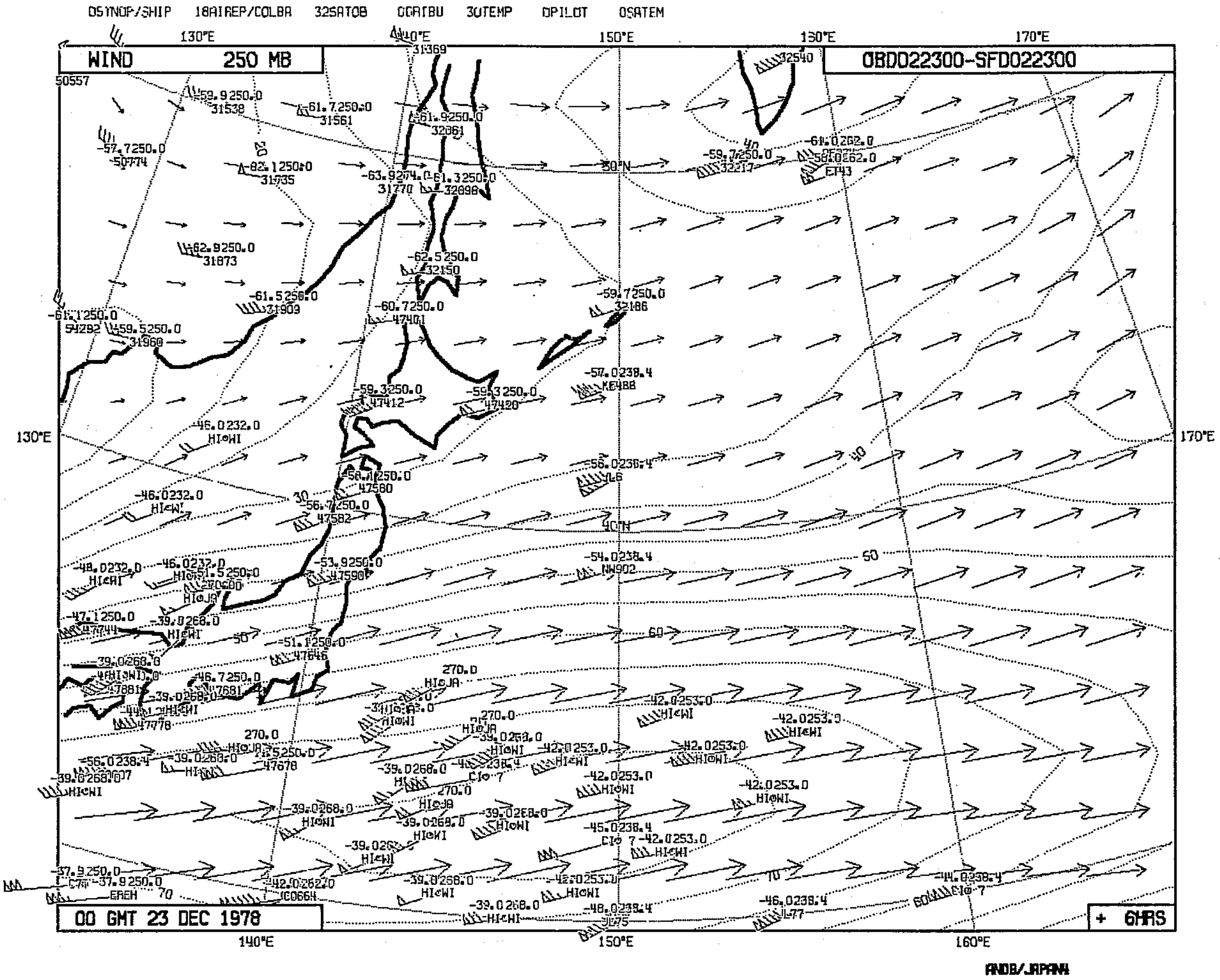


Fig. 1 First guess forecast of 250 mb winds at 00GMT, 23 Dec 1978. Isotachs (dotted) are in ms^{-1}. Observations from a ±50 mb interval are plotted. HI WI and HI JA are Himawari SATOB data, 5-digit numbers (and EREH) indicate TEMP data. Other data are AIREPs. Observed (or assigned) temperatures, in °C, and pressures, in mb, are plotted at each observation.

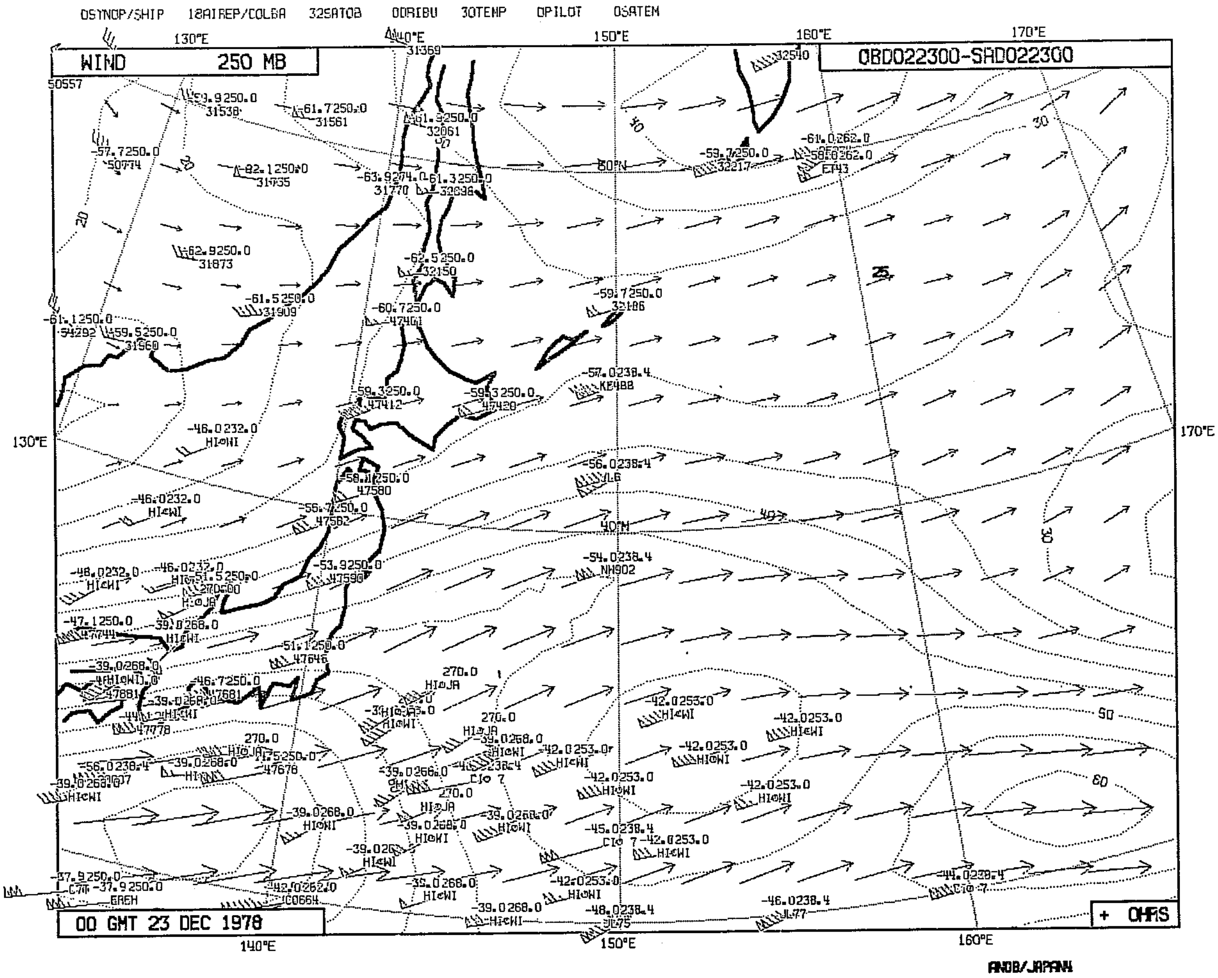


Fig. 2 As Fig. 1, but uninitialized analysis.

2.1 Example of SATOB discrepancy

On December 23, 00GMT, large analysis increments were noted in the 250 mb wind analyses west of Japan. The first guess forecast showed a jet stream maximum with a smooth elongated shape and a maximum windspeed exceeding 75 ms^{-1} between 138°E and 155°E (Fig. 1); the analysis has a wind speed minimum less than 45 ms^{-1} around 152°E (Fig. 2). The area is well covered by SATOB data from Himawari produced by the Japanese Centre (HI JA) and SSEC, University of Wisconsin (HI WI). Aircraft data (CI 7, CO664, JL77, JL75) and radiosonde data (C7T, EREH, 47678) both give observed windspeeds that agree well with the first guess, while the SATOB data underestimate the windspeed. Compare, for instance the AIREP from CI 7 at (150°E, 32°N) which gives 75 ms^{-1} with the HI WI SATOB at (152°E, 32°N) giving 35 ms^{-1}. Both cannot be right, even allowing for the differences in given pressures and temperatures. Many cases of similar discrepancies between SATOB data and other data were noted during the assimilation. The areas most affected were in the western Pacific jetstream and the subtropical jet over western and central Asia.

2.2 The average analysis increments

During the data assimilation, the fit of all accepted observations to the first guess forecast, the analysis and the initialized analysis is calculated and archived. These data provide a valuable source of information on the behaviour of the data assimilation system as well as on the quality of the observations. In particular the differences between observations and the first guess forecast, when averaged over a month, can reveal otherwise hard-to-discover observation problems. This is so since the quality of the first guess forecast is well known after several years of operations at ECMWF. Hollingsworth et al., 1985 discuss the value and the use of the first guess fit statistics in some detail.

For fixed stations, such as radiosondes, the observed minus first guess statistics can be displayed for each station. In this way serious biases were discovered for several stations in the December 1978 FGGE data.

The average analysis increment (analysis minus first guess) for 26 days in December 1978 is shown in Fig. 3.

Several radiosonde stations show large biases in their observations, the most obvious are Gough Island (40°S, 10°W), Marion Island (50°S, 37°E), Isla Socorro (18°N, 110°W), a Brazilian station at 30°S, 50°W and a few stations in western Asia. Another area with large analysis increments is found east of Japan, where a monthly mean easterly analysis increment of 5 ms^{-1} stretches from 180°E to 150°E between 35°N and 40°N. This is the area examined in the example above, where biased SATOB data were frequently found. The standard deviation over the month of the analysis increment exceeds 12 ms^{-1} in this area. The observed wind data are thus very far off the first guess, and have a large impact on the wind analyses.

2.3 Some SATOB diagnostics

When evaluating the performance of data with varying positions, such as SATOB and aircraft data, they are averaged geographically using the methods of Delsol (1985). All SATOB data used for the analysis at 200 mb and 250 mb have been averaged for the month into 5°x5° boxes. The averaged SATOBs within a box, the number of SATOBs in each box, and the mean monthly box difference between the SATOBs and the first guess forecast are shown in Fig. 4 for the Meteosat area. Large easterly biases, more than 10 ms^{-1} are found over the Mediterranean and over the South Atlantic. Corresponding plots for aircraft observations, Fig. 5, show no zonal biases.

SATOB data from the University of Wisconsin (both Himawari and GOES-IO) and the Japanese Himawari producer show very similar biases in their zonal speeds. Data produced by NESS, from GOES-E and GOES-W, on the other hand are much less biased. It should be pointed out, however, that the NESS data cover areas with very few aircraft or TEMP/PILOT data. This makes first guess comparisons somewhat dangerous, since the forecast is to a larger extent based on the same kind of SATOB data that are being checked. The Meteosat, GOES-IO and Himawari areas on the other hand are well covered with aircraft and TEMP/PILOT observations, making the first guess less dependent on the SATOB data.

Routine monitoring of SATOB data in the ECMWF operations shows a similar behaviour in this type of diagnostics (F. Delsol, pers.comm.).

Aggregate statistics of observed minus first guess wind speed differences for observations between 100 mb and 300 mb are shown in Table 1 for all the SATOB producers available in December 1978. Statistics for ASDAR and conventional AIREP data are also included. In the extratropics, all SATOB data show a negative bias in the u-component, varying between -7.0 ms^{-1} for Himawari/SSEC and -1.6 ms^{-1} for GOES-E/NESS. The aircraft data on the other hand show positive u-biases of 0.6 ms^{-1} for ASDAR and 0.8 ms^{-1} for conventional AIREPs. The aircraft biases are probably due to the use of negatively biased SATOB data for the first guess forecasts. No appreciable systematic biases can be found in the extratropical v-components.

The standard deviations of the u- and v-components in the extratropics show significant differences between the datasets. The aircraft data, and particularly the ASDAR winds, seem to have an excellent quality, with standard deviations of 6.0 ms^{-1} and 7.5 ms^{-1} for the conventional AIREPs. For the

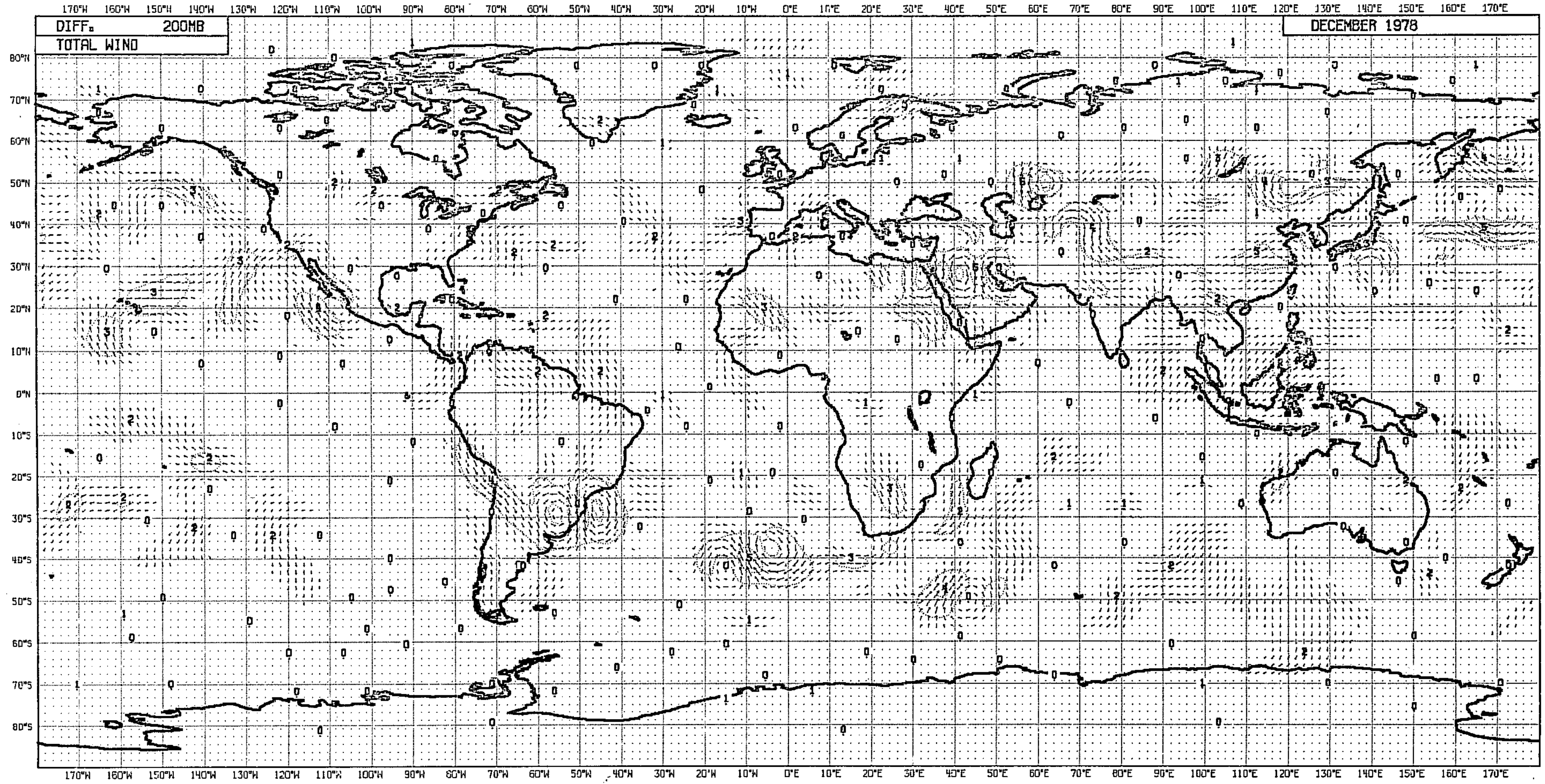


Fig. 3 Average analysis increment (analysis minus first guess) for 26 days in December 1978. Isotachs (dotted) for every 2.5 ms^{-1}.

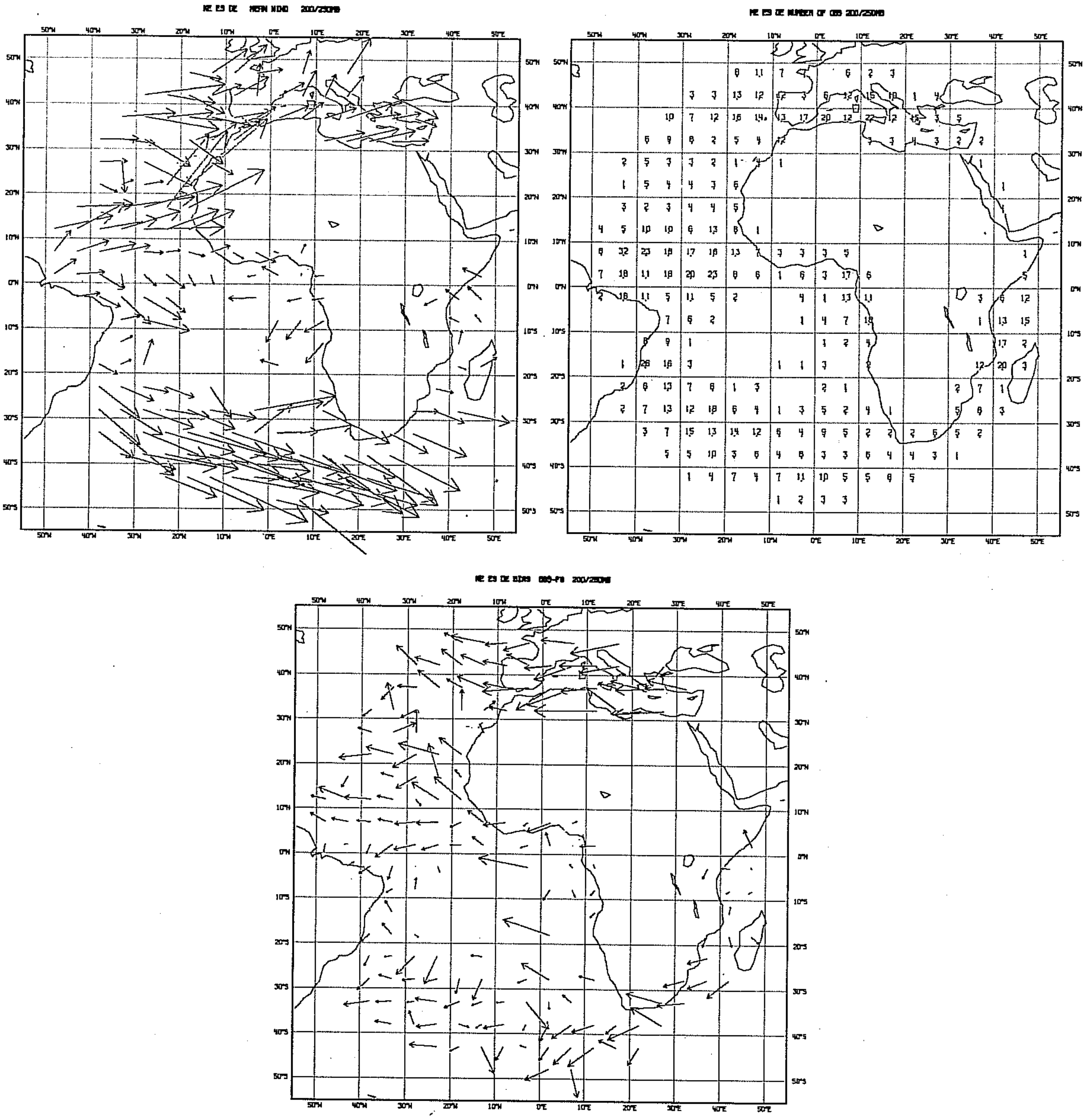
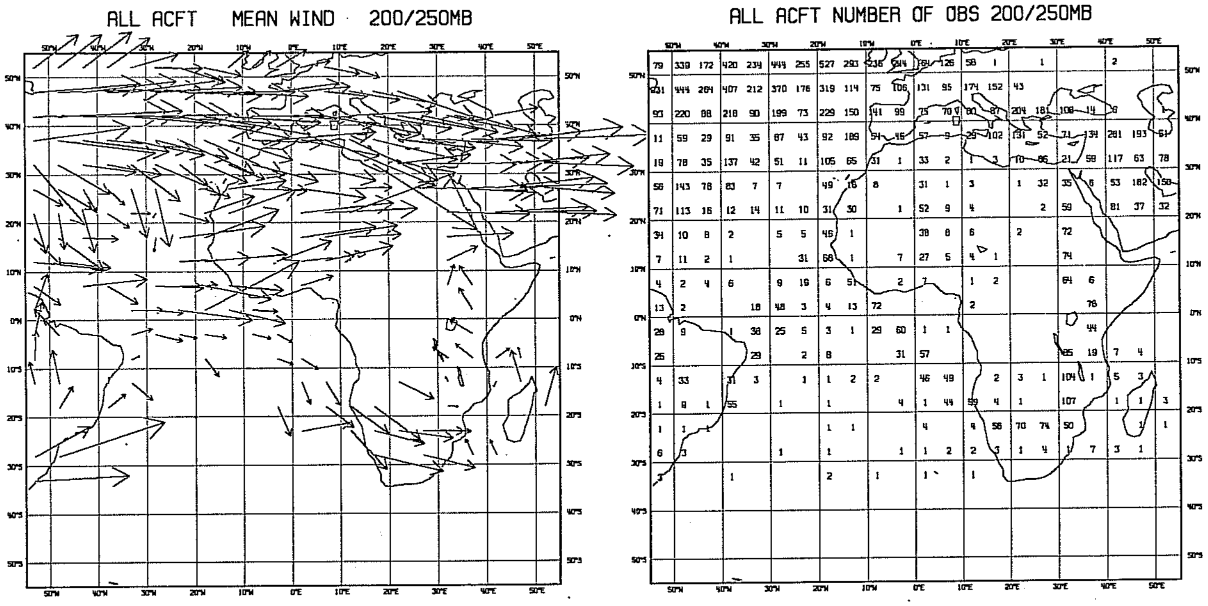


Fig. 4 Average of all SATOB data for December 1978 in 5°x5° boxes (top left). Number of data in each box (top right). Box average of observed minus first guess differences (bottom). The scale of the arrows is such that 10° of longitude on the map corresponds to about 18 ms^{-1}.



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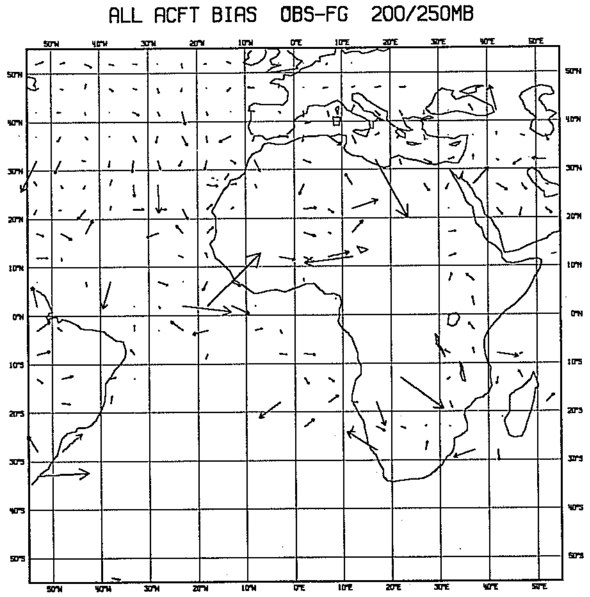

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Fig. 5 As Fig. 4, but for aircraft data.

	ASDAR		AIREP		Meteosat ESA		GOES-I SSEC		Himawari Japan		Himawari SSEC		GOES-W SSEC		GOES-W NESS		GOES-E SSEC		GOES-E NESS	
	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
u-component extratropics	+0.6	5.9	+0.8	7.4	-3.0	10.5	-2.7	8.3	-3.5	11.4	-7.0	11.2	-		-1.9	8.2	-		-1.6	8.1
v-component extratropics	-0.1	6.0	-0.2	7.7	-1.3	9.6	-1.6	7.3	-1.2	7.9	-0.5	9.5	-		+0.6	8.5	-		0.3	8.3
u-component tropics	+1.0	5.0	+1.0	6.0	-2.2	8.2	0.0	5.8	+2.1	7.5	+0.6	5.4	-2.8	7.	+0.2	6.9	-0.9	7.2	+1.4	7.9
v-component tropics	+0.7	5.1	+0.7	5.7	+0.1	6.2	+0.4	5.5	-1.4	7.3	-0.5	5.1	-0.9	5.	+1.4	7.1	-0.4	6.2	+2.2	6.6.

Table 1 Observed minus first guess differences in u- and v-components of the wind in msec^{-1}. Data between 100 mb and 300 mb only. Tropics defined to be between 20°N and 20°S. SSEC did not produce extratropical winds from GOES-E and GOES-W.

SATOB producers, the standard deviation in the u-component varies between about 8 ms^{-1} for NESS and 10-11 ms^{-1} for ESA, and the two Himawari producers. Similar differences are seen in standard deviation of the v-component.

In the tropics the biases are all very small and, probably, not significant. The standard deviations are of the order 5-8 ms^{-1} for all datasets, again the ASDAR data are clearly the best.

Judging from comparisons with the first guess forecasts, the NESS derived SATOB winds from GOES-E and GOES-W are significantly better than other SATOB data. As already pointed out however, the two western hemisphere GOES satellites, cover areas with very few other wind data. Thus the first guess forecasts are to a higher degree determined by the GOES SATOB data, and the comparison may thus be "unfair".

As shown, clear negative biases are found in the zonal component of upper troposphere, midlatitude SATOB data when compared with the first guess forecast in the data assimilation. Considering the accuracy of the ECMWF 6 hour forecast, as shown by Hollingsworth et al., 1985, these biases are most likely due to the observations.

2.4 A collocation study

As an independent check, a collocation study not affected by the processing in the data assimilation was carried out. All final II-b SATOB data for 10 days in December were compared with collocated aircraft and TEMP/PILOT observations. The SATOB data were used at the pressure level assigned by the producer.

All collocated pairs with great circle distances from each other less than a cut-off separation were extracted from the II-b database. The pairs could then, in the statistical treatment, be stratified depending on time separation, latitude, pressure interval and pressure separation. Scatterograms were produced for reported windspeed (disregarding direction), reported direction, as well as SATOB wind component parallel and normal to that of the aircraft or TEMP/PILOT. The results for the total windspeed of SATOB/TEMP/PILOT data poleward of 20°N/S are shown in Fig. 6 for the different producers. In each scatterogram the mean and standard deviations are shown, as well as in the correlation; a linear regression line is also shown. The time window was ±3 hours from the synoptic times, the horizontal separation 100 km and the vertical separation 20 mb. Pairs differing more than 40 ms^{-1} in the windvector were excluded from the scatterogram and the statistics. Only SATOBs assigned between 100 mb and 300 mb were included.

All the subsets show large negative biases, although the sample sizes are too small for definite conclusions about the NESS produced winds. Similar results have been obtained by M.-C. Pierrard (1985) at Meteorologie Nationale in Paris who has collected collocation statistics during 18 months between August 1983 and March 1985.

No significant biases were seen in the directions, although as for the speeds, the standard deviation was large.

Collocated SATOB and aircraft data show a similar behaviour, Fig. 7 (top). Here the time window is only 1 hour. Due to the small sample size, the statistics are not shown for the individual producers.

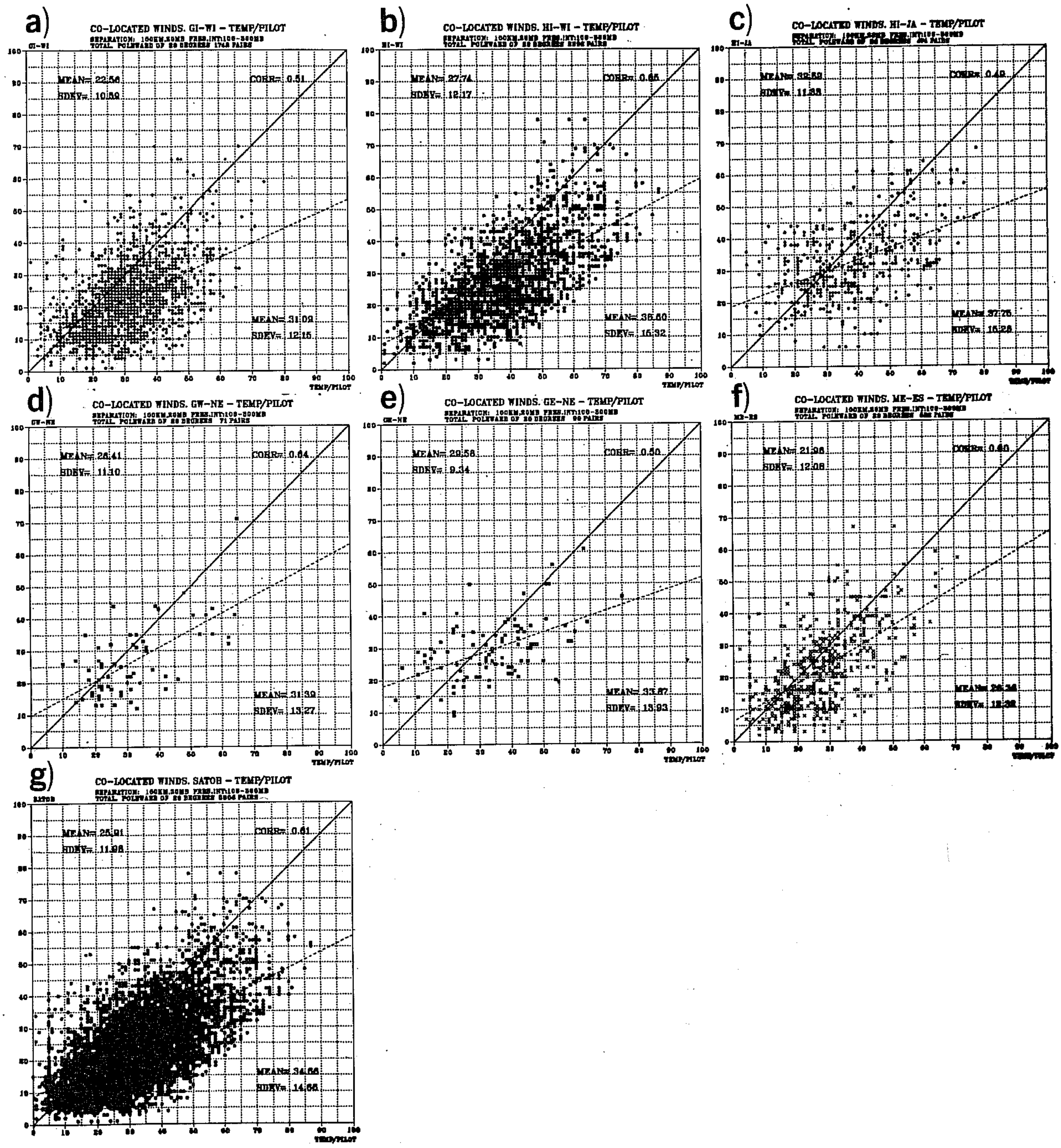

Fig. 6 Scatterograms of collocated SATOB data and TEMP/PILOT data for different producers. a) GOES-IO/SSEC, b) Himawari/SSEC, c) Himawari/Japan, d) GOES-W/NESS, e) GOES-E/NESS, f) Meteosat/ESA, g) all producers combined.

The dashed line is the linear regression. The time window is ± 3 hours, separation 100 km and 20 mb. Only data between 100 mb and 300 mb, poleward of 20°N/S are included. Pairs differing more than 40 ms^{-1} are excluded.

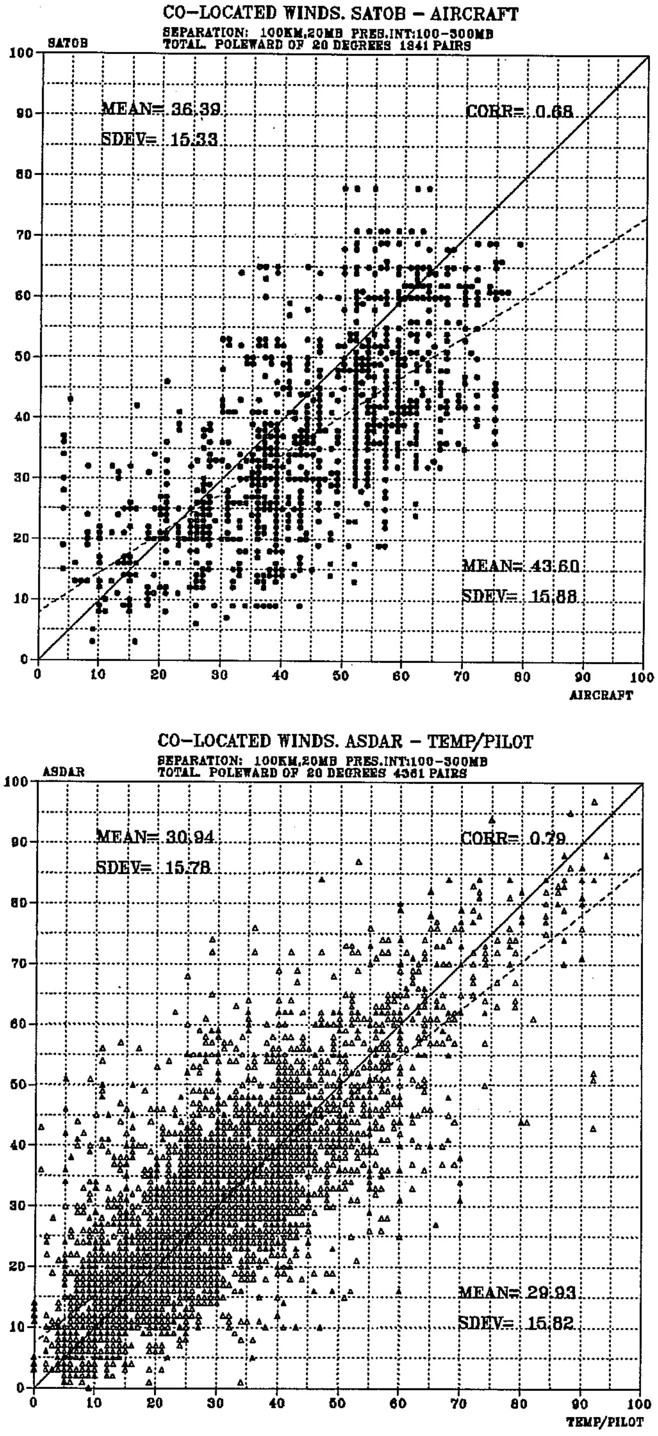

Fig. 7 As Fig. 6, but for all collocated SATOB versus aircraft data (top), and collocated ASDAR and TEMP/PILOT data (bottom). The time window is 1 hour.

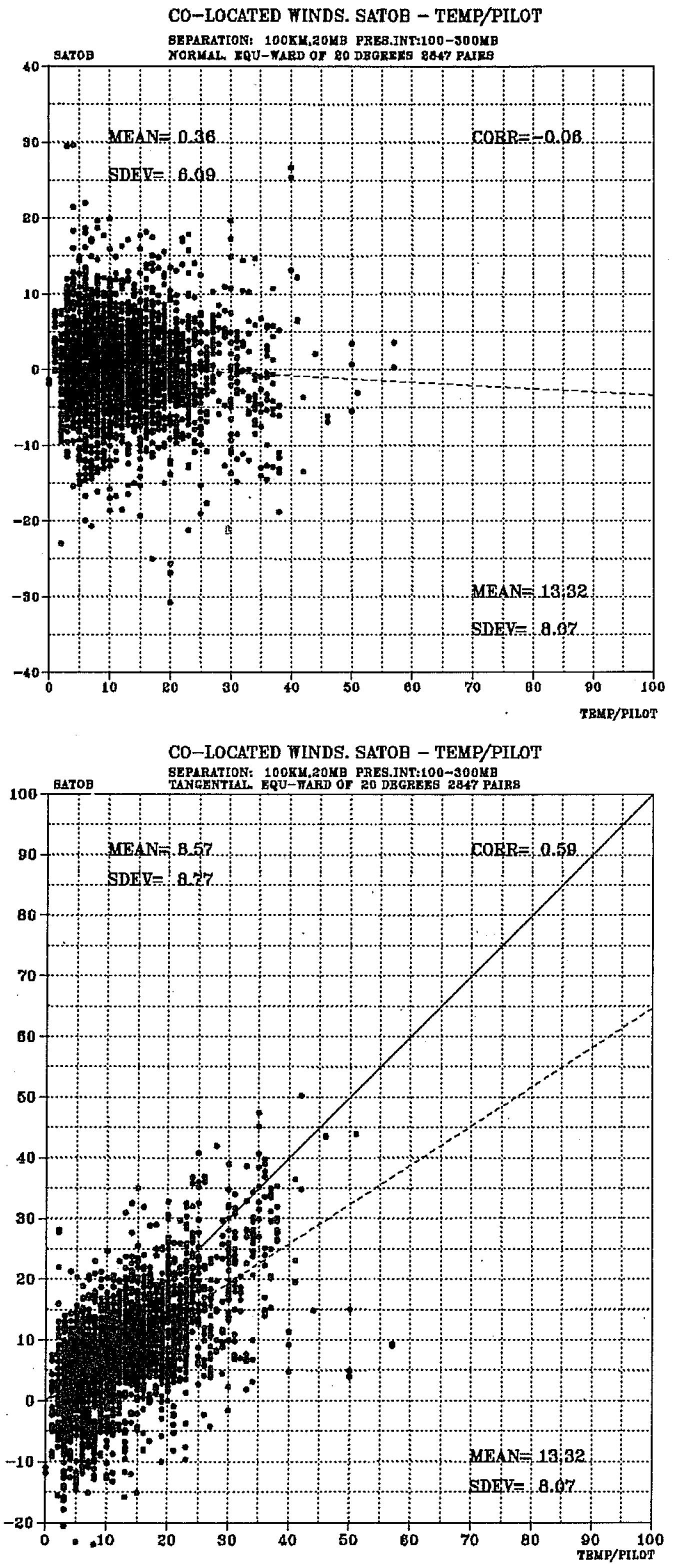

Fig. 8 Scatter of normal (top) and tangential (bottom) wind components from collocated pairs of SATOB and TEMP/PILOT in the tropics (20°S-20°N).

Fig. 7 (bottom) shows the scatter of collocated ASDAR-TEMP/PILOT data. ASDAR data are high quality automated wind data determined from the inertia navigation systems of wide bodied jet aircraft. The ASDAR speeds, and also manually observed Airep speeds, show hardly any bias to the TEMP/PILOT data. This is also true for direction.

In the deep tropics, where observed windspeeds are much weaker, no significant biases are found. This is illustrated in Fig. 8 where the tangential and normal components of the SATOB observation when projected on the TEMP/PILOT vector are shown.

It should be pointed out that the collocation statistics were derived using the SATOB heights as assigned by the producer. The biases may thus be due either to actual underestimates of the wind speed, or systematically erroneous height assignments, or both.

2.5 Overview of the results

Although each separate type of diagnostic shown in this section may raise questions on the representativeness and significance of the biases found, the combined results, in our opinion, leaves little doubt that the midlatitude, upper troposphere SATOB data severely underestimates the zonal windspeed. A systematic acceptance of biased wind data is obviously serious for the climatology of the analyses, as well as on forecasts run from individual analyses. This is particularly critical in the Southern Hemisphere where very few independent sources of upper air wind data exists.

Operational experience from ECMWF does indicate a systematic underestimate of the Southern Hemisphere jetstream. Due to the work schedules of SATOB producers, and timetables of international airlines, diurnal variations in data coverage are found in many areas of the globe. Local oscillations in zonal wind speeds between a 12Z analysis primarily determined by, say, SATOB data and an 18Z analysis primarily determined by aircraft data have been noted in operational practice at ECMWF.

A comparison of calibrated SATOB speeds with collocated aircraft data for the 10 days in December is shown in Fig. 9. Observation pairs differing more than 40 ms^{-1} in windvector are not plotted or used for the regression calculation. The linear regression line is very close to that of completely unbiased observations.

The standard deviation of the SATOB speeds increases in this sample from 15 ms^{-1} to 22 ms^{-1} when the calibration is applied. This consequence of the calibration is expected, since the amount of modification is proportional to the reported windspeed.

The calibration relation was based on assembled collocation statistics for all satellites and all producers. Due to the number and distribution of pairs, the University of Wisconsin Himawari data were heavily overrepresented in the material. Since that dataset seems to suffer from the largest biases, the selected regression line may overdo the calibration for other data. Indeed, some examples of overcalibration were seen.

3.2 The analyses

The mean difference between all CALIB and all CNTRL analyses, Fig. 10, shows the areas where the calibration has the largest effects. The impact is pronounced in areas with few other data, while the analyses are more similar in regions with ample aircraft data, for instance between the west coast of the USA and Hawaii.

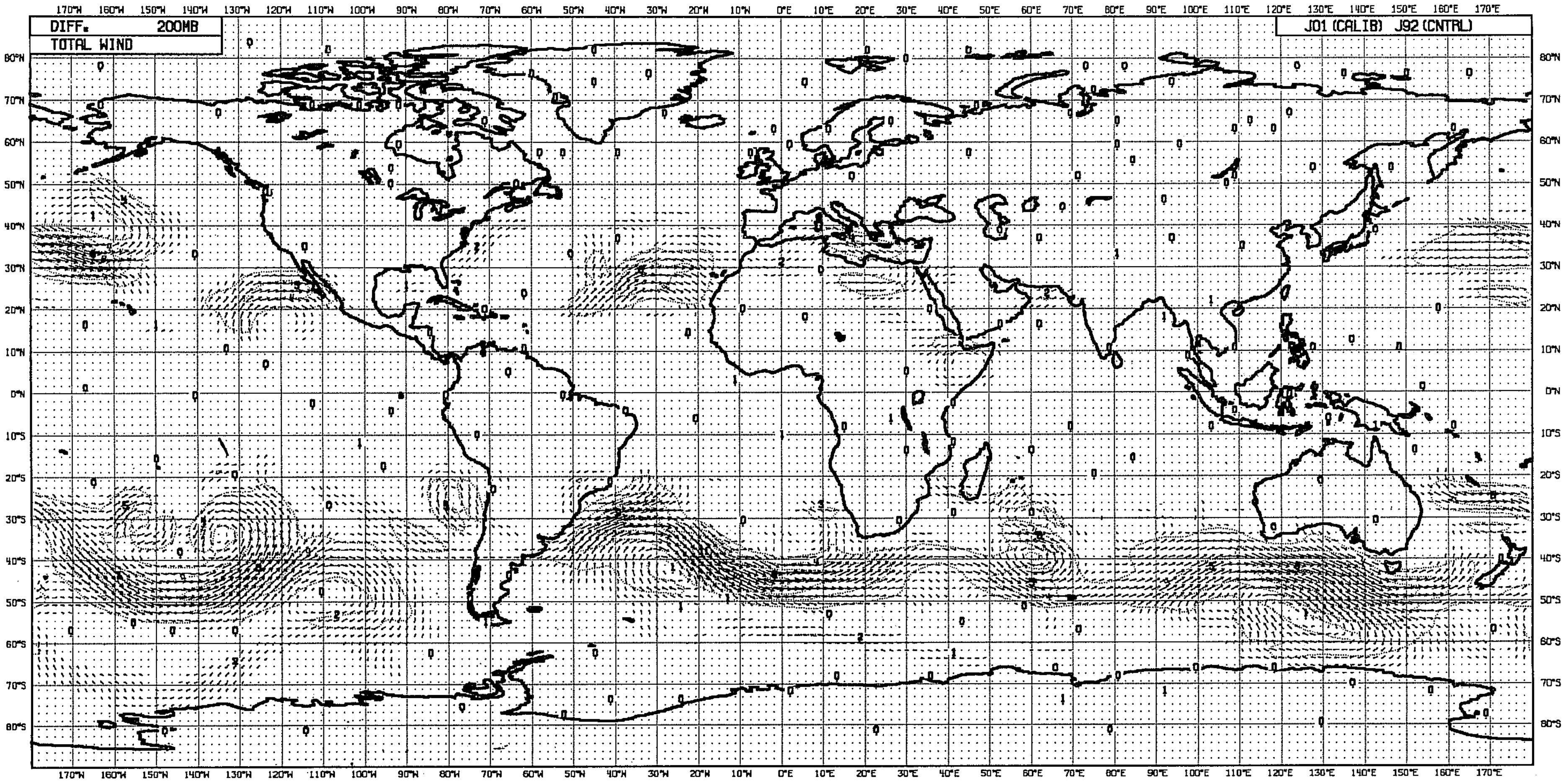

Fig. 10 Mean difference, CALIB minus CNTRL, for five days. Isotachs (dotted) for every 2.5 ms^{-1}.

The calibration reduces the bias in the observed minus first guess statistics, shown in Fig. 11 for the u-component in areas poleward of 20° N/S and between 100 mb and 300 mb. The mean bias in the University of Wisconsin Himawari data is reduced from -9.8 ms^{-1} to -5.9 ms^{-1}. For Meteosat, the bias is changed from -3.7 ms^{-1} to +5.1 ms^{-1}, thus clearly overcalibrating. This is also the case for the GOES-E and GOES-W winds from NESS.

The positive zonal bias in aircraft data found in the December assimilation, and also seen in the CNTRL statistics is reduced to some extent by the modification. The first guess forecasts in the CALIB assimilation are thus slightly closer to the aircraft data than the uncalibrated forecasts.

Although negative biases in the u-component of the SATOB data are reduced by the calibration, the standard deviation of the observed minus first guess is increased by a considerable amount, up to 7 ms^{-1} for one producer. As mentioned above, this is an unavoidable effect of the chosen calibration equation. Large standard deviations imply noisy and less reliable data.

Hardly any differences were found between the two assimilations in the bias of the v-component. The standard deviation, on the other hand, increased in a similar fashion to that of the u-component.

3.3 The forecasts

One pair of forecasts, from CALIB and CNTRL, was made, both starting at 00GMT, January 5, and run up to 96 hours. Experience from observing system experiments at ECMWF indicates that, due to large variations from case to case, conclusions drawn from a single forecast pair may not be typical for a larger sample of forecast experiments. This is particularly evident in the

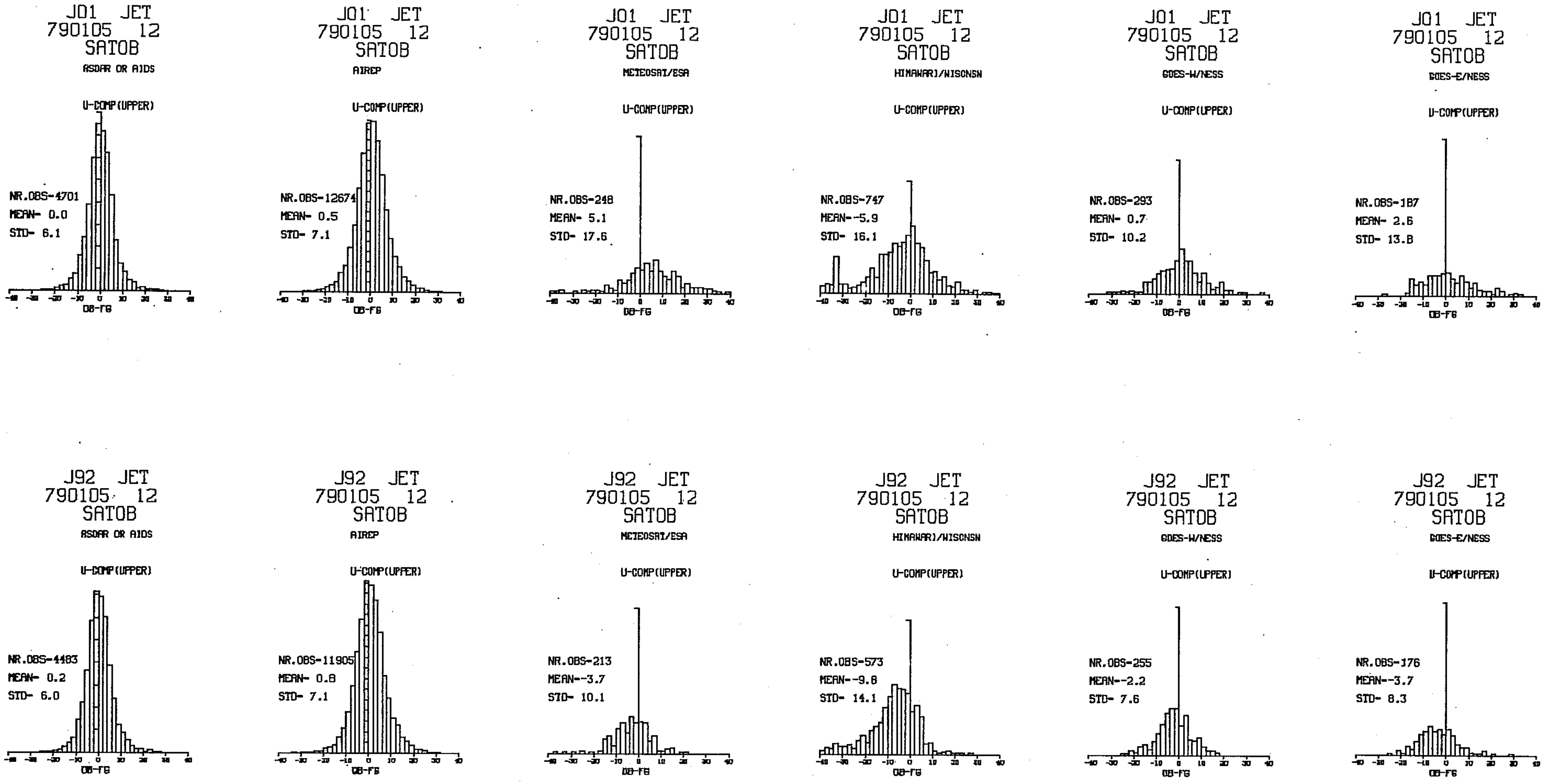

Fig. 11 Observed minus first guess windspeeds, poleward of 20°N and between 100 mb and 300 mb. The vertical scale is shown on the central (zero) bar, in units of 100 observations. Mean and standard deviation as plotted on the graph. Top row for CALIB, bottom for CNTRL.

medium range, i.e. beyond about day 4. It is believed, however, that for the first few days, clear differences between the forecasts should reflect a real impact of the modified observations, even if only one case is studied.

The verifying analyses were taken from the main ECMWF level III-b dataset. There were fairly large differences in the assimilation system used for the main analyses and that used for the experiment; of particular relevance for the wind verification are changes in the optimum interpolation structure functions, and the introduction of diabatic initialization in the experiment. Also, the final level II-b data containing additional observations were used for the experiment analyses. Still the main III-b analyses provide the best approximation of the true state of the atmosphere between 5 and 9 January 1979 available to us for verification purposes.

The root mean square (rms) vector difference between the forecast and verification winds is shown in Fig. 12 for the latitude bands 50°-20°S, 20°S-20°N and 20°-50°N.

The initial differences between both the experiment analyses and the verification are large in all areas and at all levels. As pointed out above, this is due to the changes in assimilation systems and data coverages between experiment and verification analyses. The initial CNTRL analysis is closer to the verification in all areas and at all levels shown, which is expected since no calibration was applied to the III-b analyses. Very soon however, the CALIB forecast fits the verification better in both midlatitude bands.

This is evident not only at 200 mb and 500 mb but also at 850 mb, below the lower limit of the calibration. The impact of the calibration is larger in the Southern than in the Northern Hemisphere analyses. The differences between the cases in the tropics are too small to be significant.

A similar behaviour is seen in the anomaly correlation plots, in Fig. 13. The positive impact of the calibration is largest in the Southern Hemisphere, but not insignificant north of 20°N either.

Root mean square fit and anomaly correlation of geopotential heights at 200 mb are shown in Fig. 14. Also here the CALIB forecast is closer to the verification, except during the first day in the Southern Hemisphere, where again the CNTRL analysis is more similar to the uncalibrated verification. The improvement in anomaly correlation from 75% to 82% at day four in the Southern Hemisphere is quite dramatic.

The good agreement between the impacts on the wind and the height fields at midlatitudes demonstrates the ability of the ECMWF data assimilation system to make use of single level wind data in a meteorologically consistent way.

The upper map in Fig. 15 shows the 200 mb wind difference between the CALIB and CNTRL forecasts at 48 hours. In the Northern Hemisphere the differences are localized to a few areas, i.e. a few weather systems, while in the Southern Hemisphere marked forecast differences are seen at most longitudes. The verification analysis is shown in the lower map of Fig. 15. The rms difference of forecast winds to verification showed that the CALIB forecast fitted the verifying analysis better than CNTRL in both hemispheres. This is confirmed by maps of the forecast error vector (Fig. 16).

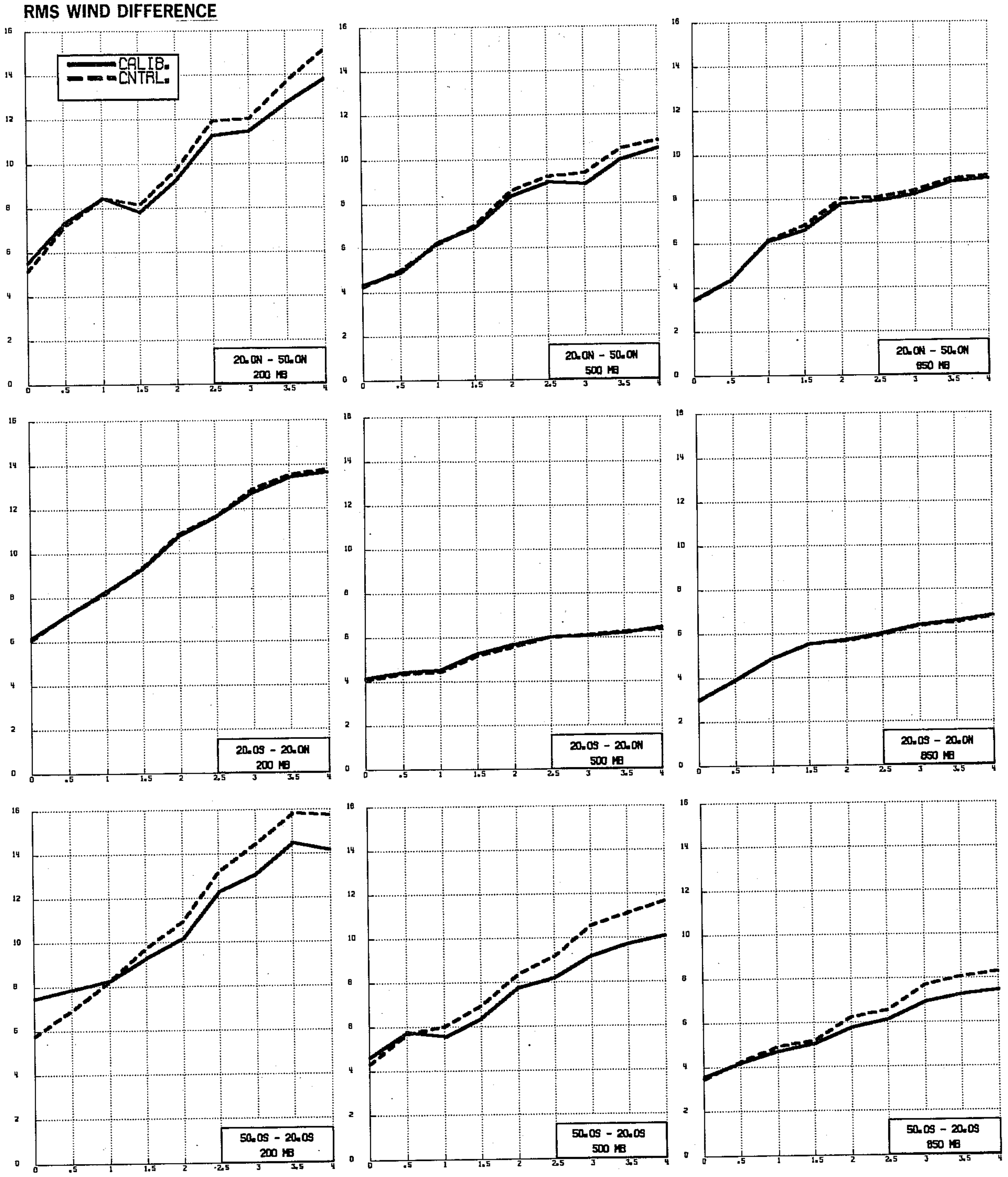

Fig. 12 Root mean square vector wind differences (absolute values in ms^{-1}) between forecast and main III-b analysis at 200 mb (left) 500 mb (central) and 850 mb (right). Full lines for CALIB, dashed for CNTRL. Top row 20°N to 50°N, middle row 20°N to 20°S and bottom row 20°S to 50°S.

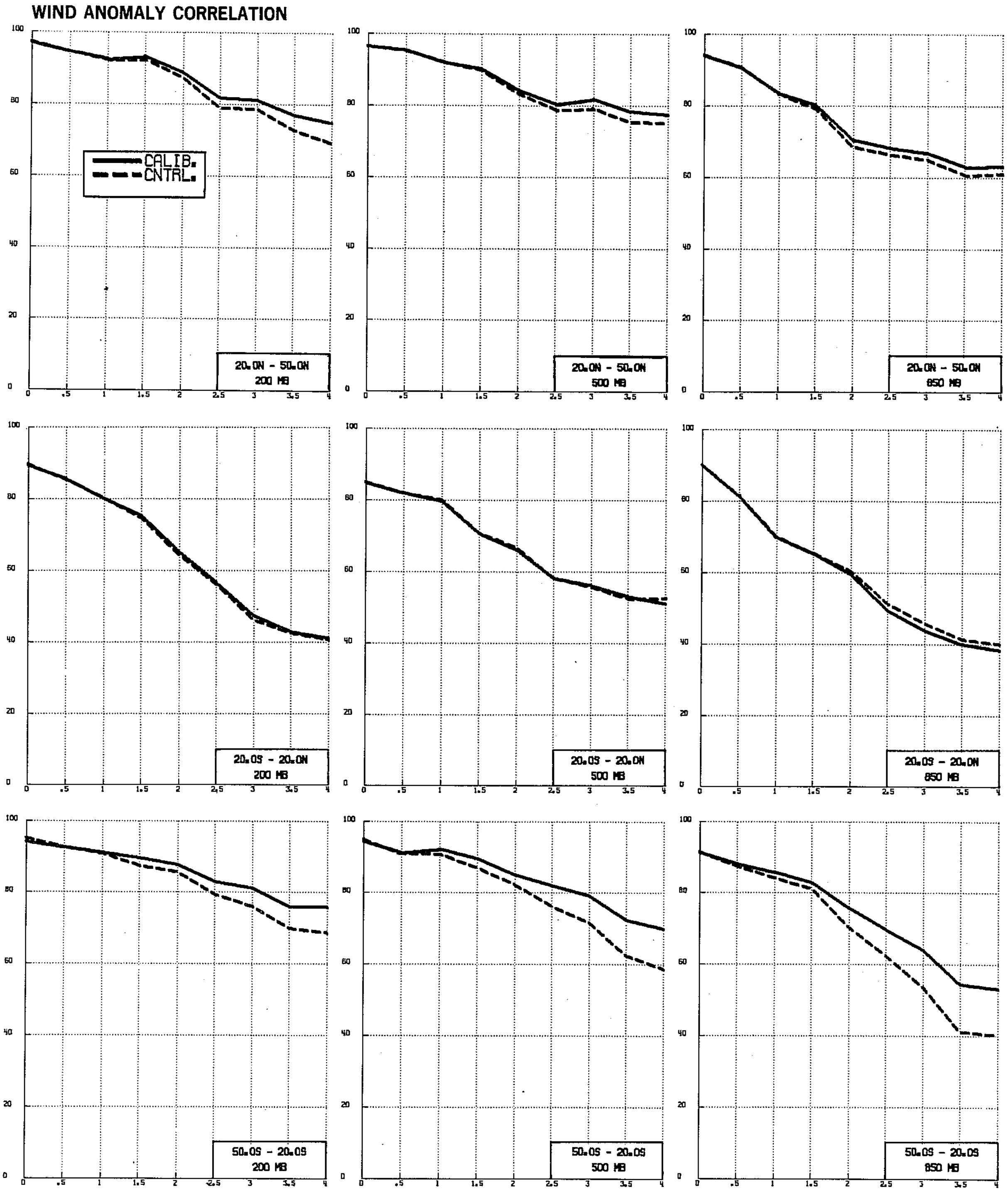

Fig. 13 As Fig. 12, but anomaly correlation

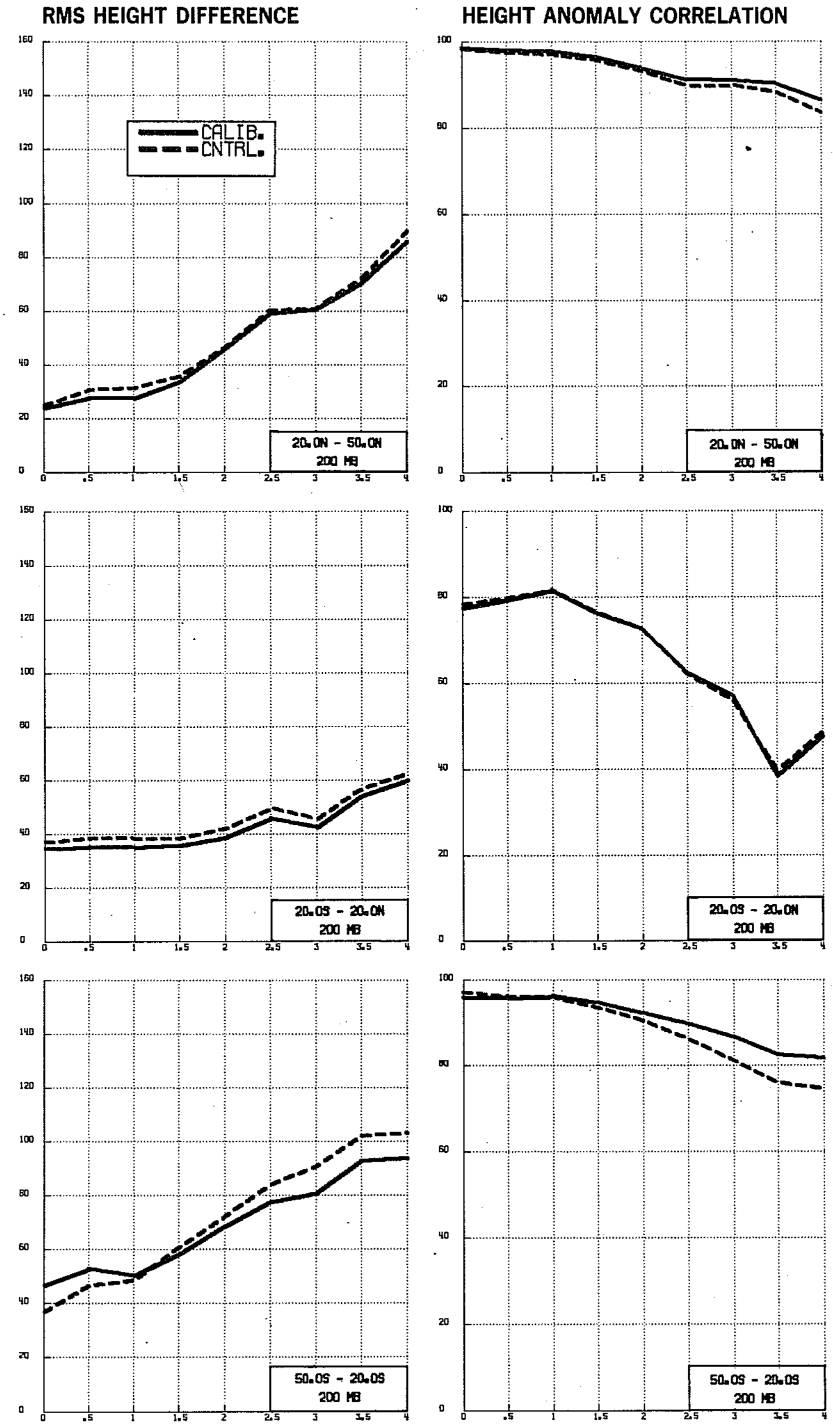

Fig. 14 Root mean square difference (left) and anomaly correlation (right) of 200 mb geopotential. Otherwise as Figs. 12 and 13.

In areas where substantial differences between the forecasts are found, the CALIB error is almost always smaller, for instance north of Hawaii, in Sudan, off Natal and in the vicinity of Tasmania-Campbell Island. An exception is the midwest of the United States where the CNTRL errors are smaller. The error vectors are usually more or less antiparallel to the observed flow, see Fig. 15 (bottom), indicating that the forecasts underestimate jet windspeeds and wave amplitudes. The forecast difference vectors, CALIB minus CNTRL, on the other hand are more often than not quasi-parallel to the observed flow. The calibrated initial state reduces the underestimation of the forecast 200 mb wind speed and wave amplitudes.

In the 96 hour forecasts, Fig. 17, the differences between CALIB and CNTRL have grown further. The amplification of the north Pacific ridge observed around 137°W is underestimated by both forecasts, CALIB is however clearly better. The forecast difference vector field, Fig. 18 (top), has an anticyclonic shape, in phase with the observed field, i.e. the calibration enhances the development of the forecast ridge. A similar improvement is seen in the deep trough south of Madagascar. Again its amplitude is underestimated by both forecasts, but much less so in CALIB. Note in particular the forecast positions of the jet observed over northern Mosambique-Madagascar.

3.4 Conclusion

The experiment clearly demonstrates the sensitivity of the data assimilation system to problems in SATOB wind speed measurements. A simple calibration of observed windspeeds in critical regions has a profound impact on forecast wind and geopotential patterns already after 2 days. Confidence in the general approach is given by the fact that the problems of underestimation of extreme

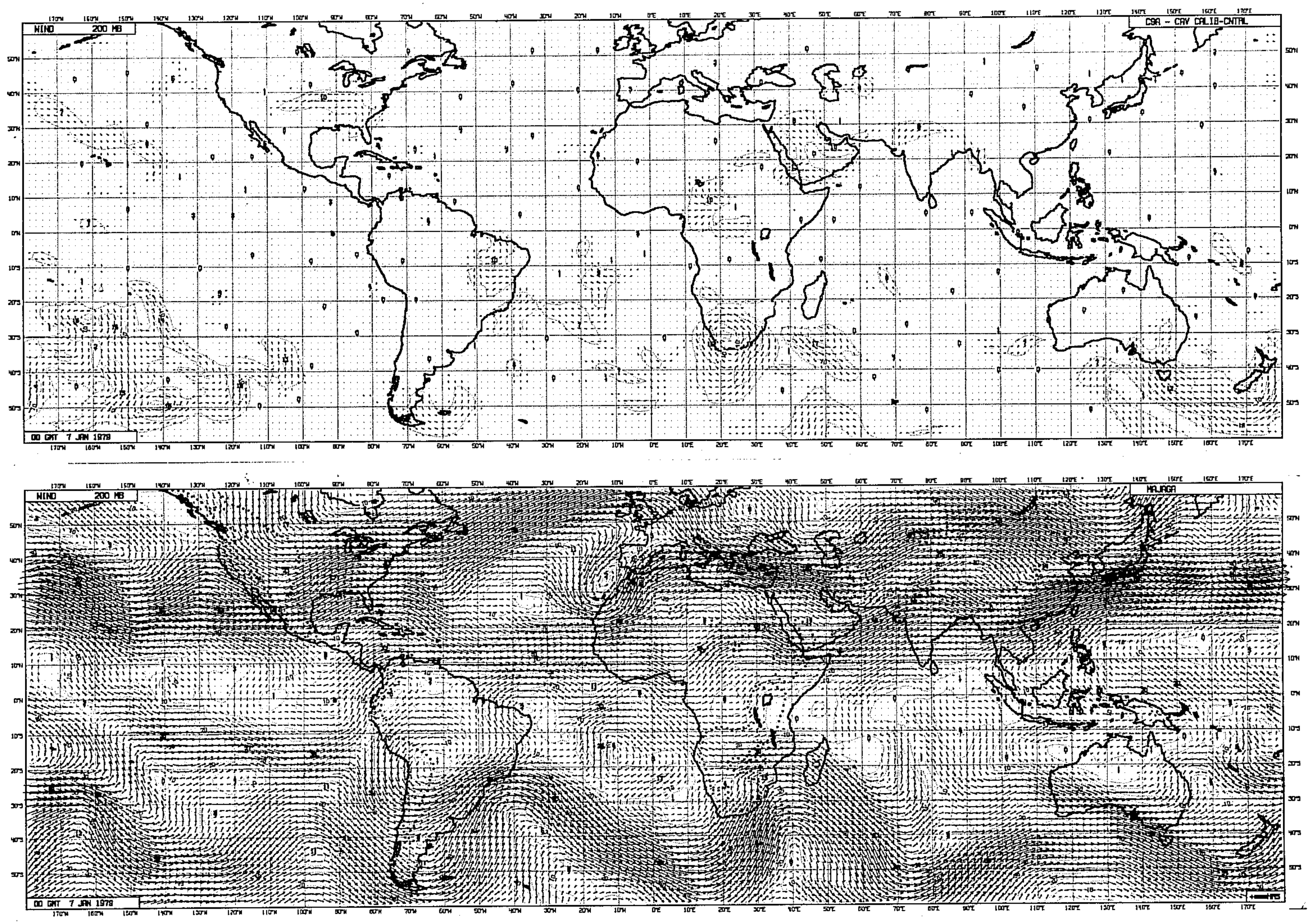

Fig. 15 Top: 200 mb wind difference between CALIB and CNTRL forecasts at +48 hours. Isotachs for every 5 ms^{-1}. Bottom: verification map, valid 00GMT, Jan 7 1979.

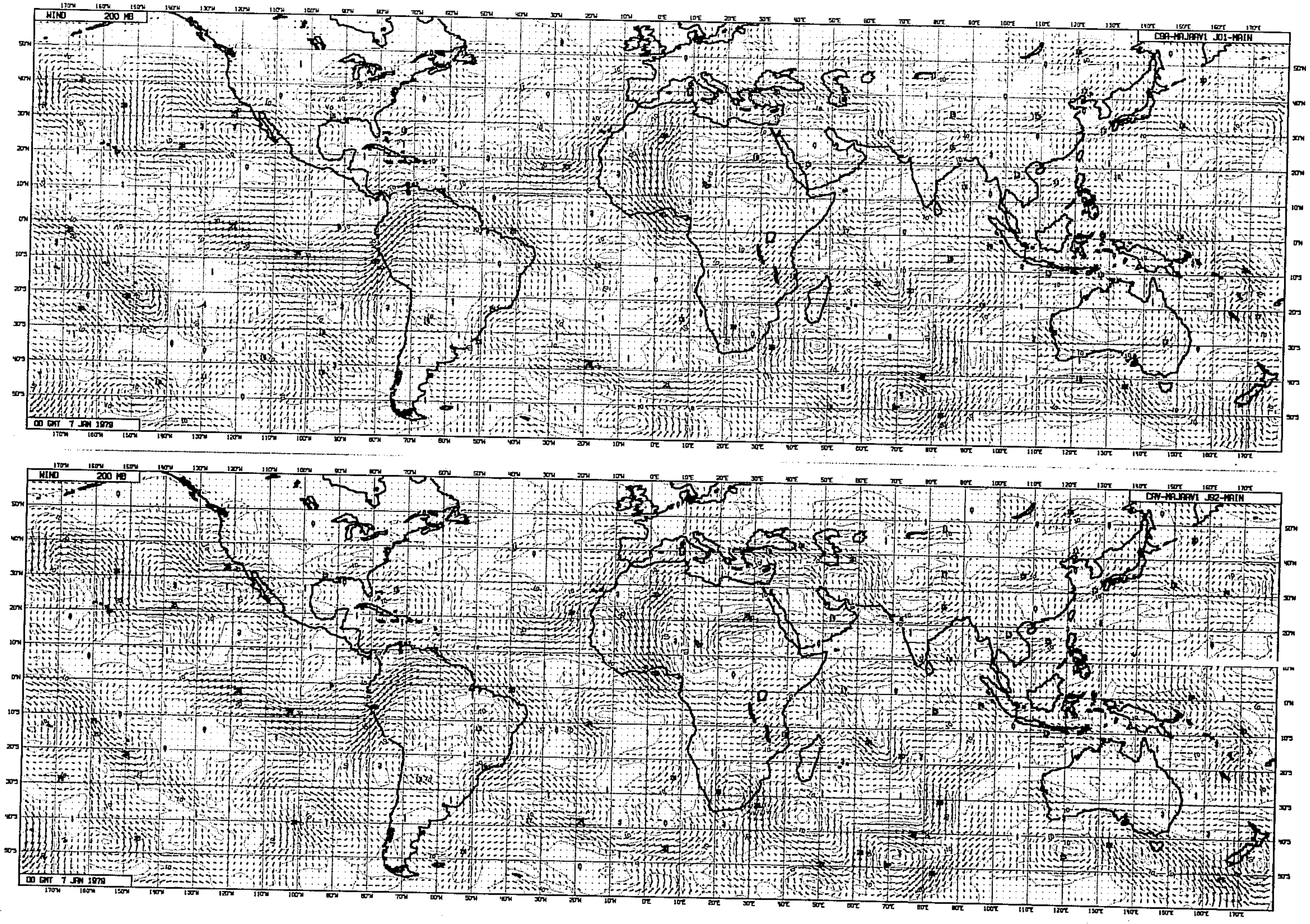

Fig. 16 Forecast error vector, i.e. forecast minus verification, of 200 mb winds for CALIB (top) and CNTRL (bottom). Isotachs for every 5 ms^{-1}.

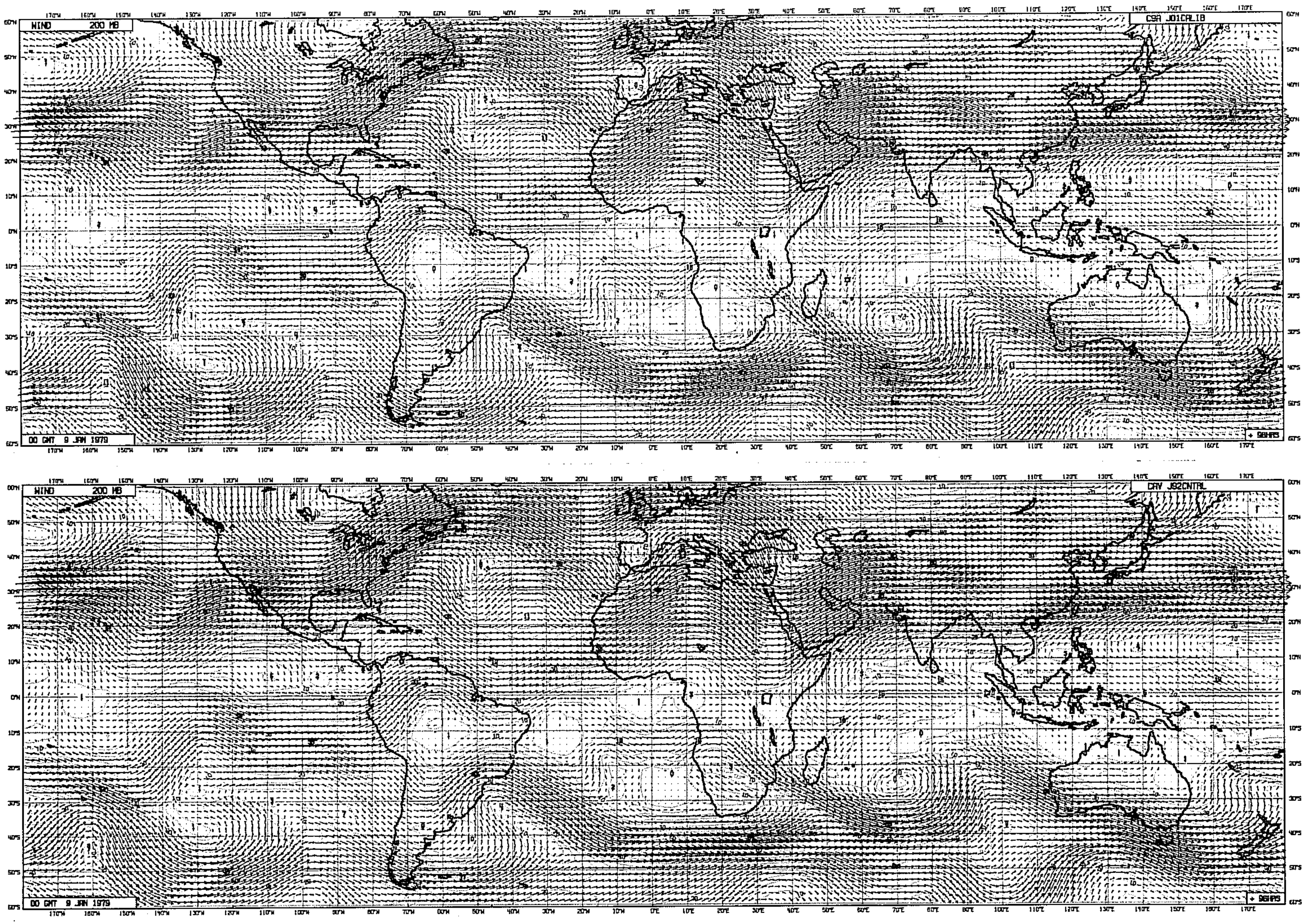

Fig. 17 200 mb wind forecasts at +96 hours from CALIB (top) and CNTRL (bottom). Isotachs every 5 ms^{-1}.

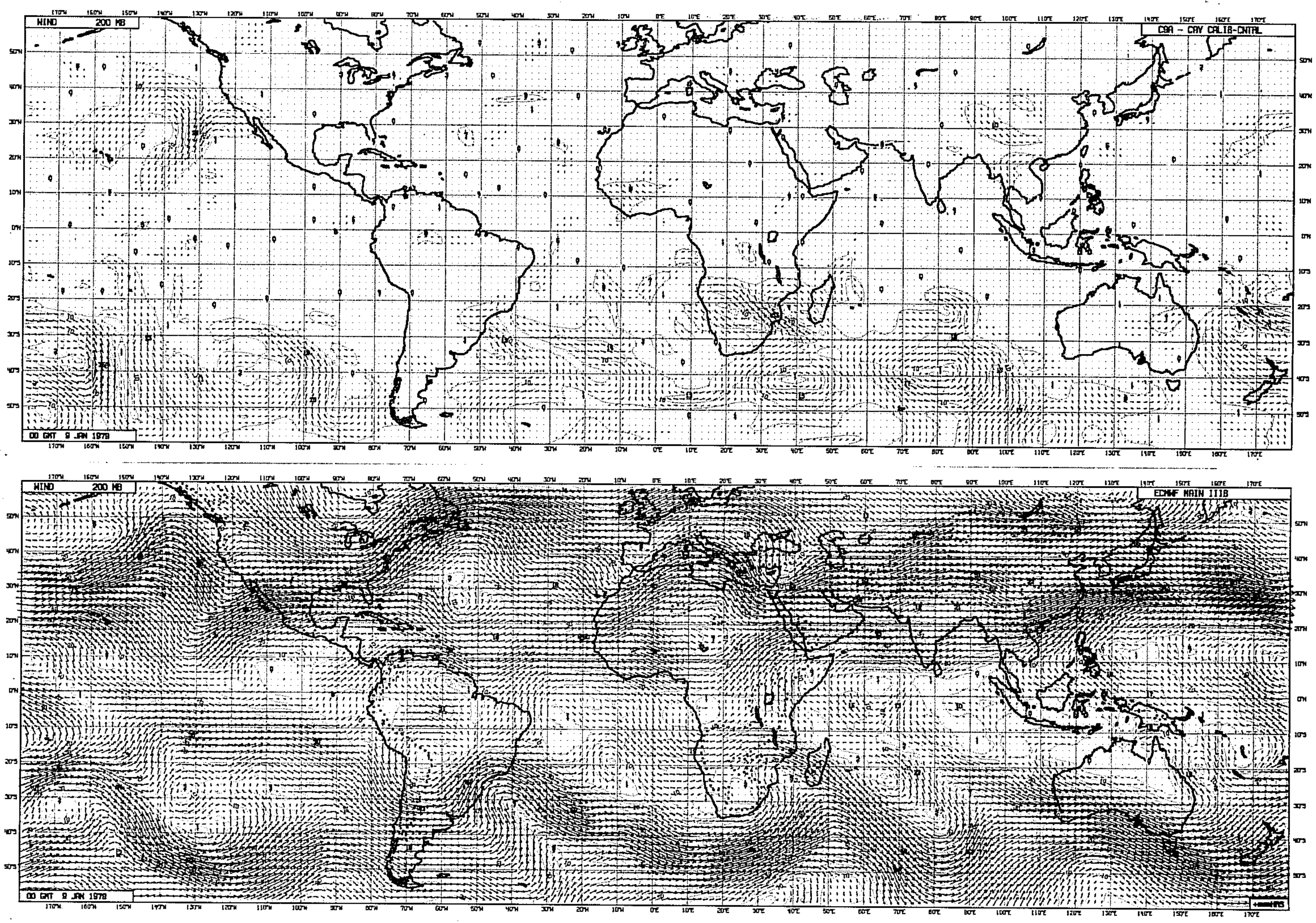

Fig. 18 Top: Forecast difference, 200 mb wind, CALIB minus CNTRL, at +96 hours (top). Bottom: verification, valid 00GMT 9 Jan. Isotachs every 5 ms^{-1}.

winds by SATOBs have been evident in operational practice for several years (Delsol, 1985). Admittedly the calibration was crude and rather drastic, but the large positive impact is somewhat surprising and disturbing. It is well known, however, that the correct analysis of jet stream speeds and positions is crucial for the correct prediction of the development of midlatitude disturbances. The erroneous SATOB observations may corrupt the analyses in particularly sensitive areas.

4. SUMMARY

Cloud track wind data (SATOB) from December 1978 of the final FGGE level II-b data have been evaluated during a reassimilation at ECMWF, using a much upgraded data assimilation system. In midlatitude upper troposphere high wind speed areas, the SATOB data were found to suffer from rather large negative biases in their observed wind speed. This was seen in individual synoptic cases, in monthly mean analysis increments, in monthly averages of differences between observation and first guess forecast, and in comparisons with collocated TEMP/PILOT and Aircraft data.

All SATOB data were used, and evaluated at the pressure level assigned by the producer. Due to the difficulties in determination of representative heights of drifting cirrus clouds, whether by measured cloud top infra-red temperatures or by any other method, the given heights must be considered uncertain. According to SSEC, University of Wisconsin (D. Wylie, pers.comm.), the upper level SATOB data should be considered as "indicators of mean layer flow", and ought not be used for high vertical resolution analyses of strongly sheared flow.

The negative biases found in upper level, midlatitude windspeeds may be associated with the difficulties in the height assignment. Several examples were found where jet stream SATOB data were more representative for the flow 50-100 mb lower down, judged both from given SATOB temperatures and windspeeds when compared with the first guess forecast. Other examples, however, showed the opposite - the SATOB pressure seemed more consistent with the first guess than the SATOB temperature.

Another possible reason for the biases may be unrepresentativeness of the cirrus clouds as tracers of the flow. If the clouds systematically occur on the equatorward side of the jet core, as is observed, the horizontal distribution of the SATOB data may generate biases to the first guess. The collocation results however contradict such a proposal.

Although providing invaluable information from otherwise very sparsely observed parts of the atmosphere, the SATOB data do suffer from quality problems not encountered in other data sources. The use of these data in data assimilation systems requires close monitoring and strict quality control to give maximum positive impact. Preferably some of the meteorological quality control should be made at the time of wind extraction, using information from a high quality global forecasting system. This study is concerned only with the FGGE data from 1978 and 1979. The problems described are well known to SATOB producers, and continuous efforts are being made to reduce the biases. Experience from recent operations at ECMWF indicates that the quality of the SATOB data has increased.

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