ECMWF MONITORING SYSTEM

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1. INTRODUCTION

Much progress has been made in recent years in numerical weather forecasting. Models and analysis techniques have been developed and refined while the rapidly increasing power of supercomputers has actually enabled the scientists to implement their schemes. However, numerical forecasting is not only a modelling but also an initial data problem. Much can be gained from improvements in the Global Observing System (GOS), resulting in better quality data and an improved data coverage. However, very little has happened over the last few years. Instead of an improvement there are signs of a degradation of the system, in particular in the conventional surface based observations.

In order to manifest the deficiencies in the availability and quality of the observations, ECMWF undertakes regular data monitoring of all observation types. The system was first described by F. Delsol, 1984, and has since been developed further. The main components are

(i) Real time monitoring
(ii) Monthly statistics and summaries
(iii) Long-term trends in the performance

While most of the real-time monitoring tools have been in operational use at ECMWF for several years, new tools were developed to assess the long-term trend of data availability and quality at individual stations and to display the results in geographical maps to facilitate a cross-reference between stations. Although the ECMWF monitoring is general and is applicable to any data type, it is acknowledged that the global radiosonde network is of primary importance not only for numerical weather analysis, but also for the calibration of other observing systems such as the satellite sounding measurements (see paper by J. Neilon elsewhere in these proceedings).

The purpose of this paper is to describe the present ECMWF monitoring system. As it is closely related to the data assimilation and the first guess produced by the model, first an overview of the operational forecast system and the schedule is given. Then the monitoring activities are summarised. The results of the radiosonde monitoring are shown in papers by A. Radford, and H. Böttger and A. Radford in these proceedings. The final paragraph looks at the action to be taken based on the monitoring results and presents the ECMWF plans for the distribution of monitoring results.

2. ECMWF OPERATIONAL ANALYSIS AND FORECAST SYSTEM

2.1 Schedule

ECMWF produces routine global analyses for the four main synoptic hours 00, 06, 12 and 18 UTC and global 10-day forecasts based on 12 UTC data. The operational schedule with the approximate running times of the analysis and forecast suite is shown in Fig. 1. As a forecasting centre with the emphasis on the medium-range, ECMWF operates with long data collection times of between 18 hours for the 18 UTC analysis and 8 hours for the 12 UTC final analysis. This schedule ensures the most comprehensive global data coverage including the Southern Hemisphere surface data and global satellite sounding data, thus obtaining the best possible description of the initial state of the atmosphere.

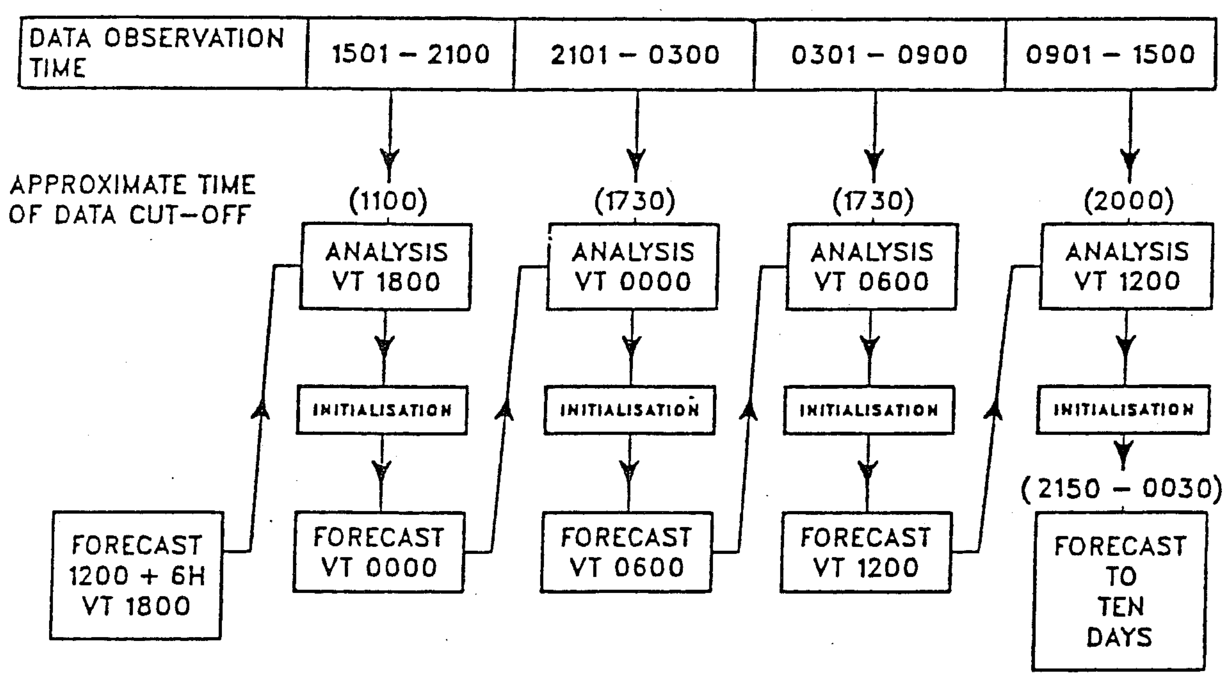

Fig. 1: The ECMWF operational schedule in late 1987, all times shown in UTC

2.2 Data assimilation system

ECMWF operates a full data assimilation system with intermittent data insertion and three main steps: analysis, initialisation and 6-hour forecast to provide the first-guess for the next analysis. The system is described by Lorenc (1981) and the recent revisions of the analysis were documented by Shaw, Lönnberg and Hollingsworth (1984), and Lönnberg, Pailleux and Hollingsworth (1986). A comprehensive quality control scheme for the data is included in the analysis (Lönnberg and Shaw, 1985). Prior to the use of the data in the analysis the incoming bulletins undergo telecommunications checks, decoding and simple checks on departure from rather wide climatological limits. The internal consistency of radiosonde data is controlled by applying the hydrostatic check.

2.3 The forecast model

The first-guess field is produced with the same operational forecast model that provides the main 10-day forecast. The resolution of the model is given by spectral representation which at present is truncated at wave number 106. Therefore features with a half wavelength for approximately 190 km can at best be expected to be resolved. Physical processes are calculated on the surface grid of the model which has a near regular resolution of 1.125 degrees in latitude and longitude. For a more comprehensive description of the model and the physical parameterisation reference is made to Tiedtke et al. (1979), Simmons and Jarraud (1983), Jarraud et al. (1985), Tiedtke and Slingo (1985).

3. REAL-TIME MONITORING

3.1 Data availability at ECMWF

The availability of the observations is closely monitored by daily updated time graphs of received data volumes for each observation type. Transmission problems or deficiencies in the data generation for the GTS, e.g. for AIREP or DRIBUS, would easily be detected. The geographical distribution of the observations is given by data coverage charts which allow comprehensive availability monitoring of all data types.

3.2 Data quality

For each data assimilation cycle summary statistics on the

(i) data rejection

(ii) differences between the observations and the first guess and the analysis

(iii) analysis increments

are produced and displayed graphically for inspection.

Clustering of data rejections in particular regions, recurring rejection of the same observation, unusually large differences between the observations and the first guess and/or large analysis increments in a particular region are all signals which will alert the analyst who monitors the performance of the analysis and forecast system. Most data problems are identified by these means without delay.

Additional tools are available in the form of collocation statistics comparing the observations from different data types, such as satellite and radiosonde soundings. An example for the NOAA-10 and NOAA-9 soundings compared with collocated radiosonde soundings in the Northern Hemisphere is shown in Figs. 2 and 3.

NOAA-10 soundings compare well with the radiosondes while the NOAA-9 soundings are of limited use and are heavily biased. NOAA-9 soundings are based on the HIRS instruments only after the failure of the MSU unit early in 1987.

Collocation statistics can also be produced for other observation types, such as wind data; they can be produced selectively, e.g. for a list of stations or for regions. As the collocation statistics are independent of the numerical model, they are a powerful tool for exploring data problems and can be used as supporting evidence for the problems identified by comparison with the model's first guess.

4. MONTHLY STATISTICS

The daily monitoring results are accumulated and summarised in monthly statistics, which for several data types, such as TEMP, PILOT, DRIBUS, are readily accessible by the ECMWF Member States.

The monthly statistics files contain information on

(i) Data reception at ECMWF via the GTS

(ii) Average differences between the observations and the first guess the analysis and the initialised analysis at the location of each observation

The latter allows some judgement on the quality of the observations.

Hollingsworth et al. (1986) provided the rationale for using modern data assimilation systems as the appropriate tools for monitoring the quality of observations. Especially in mid-latitude areas, where an adequate observational network ensures a sufficient data coverage, the 6-hour forecast error (first-guess error) is quite low and allows the evaluation of the data quality by comparison with the first-guess. North America, Europe and most parts of Asia are suitable areas for such evaluations. In data sparse areas, however, a more cautious approach is required, before any conclusions on the data quality are drawn from the comparison with the first-guess alone, as the model errors might be dominating. Only if additional independent comparisons, such as results from collocation statistics of radiosonde ascents and atmospheric soundings derived from satellite radiance measurements corroborate, the data versus first-guess findings may then be accepted with confidence. ECMWF has developed such additional tools and applies them whenever possible to confirm monitoring results for radiosondes in data sparse areas, e.g. the Southern Hemisphere and mid-Pacific Islands.

For radiosonde observations the vertical difference profiles for the u and v component of the wind and the geopotential height displayed as mean differences (bias) and standard deviation of the differences give the most comprehensive monthly summary of the station performance. Examples can be found in the paper by A. Radford in these proceedings. For further investigations of data problems, plots of daily wind and height departures are available.

5. LONG TERM TREND STATISTICS

The long term trends in the performance of radiosonde (TEMP) and PILOT stations is best summarised in 13 month time graphs based on monthly performance statistics. Several examples are given in the papers by A. Radford and

H. Böttger and A. Radford in these proceedings. They demonstrate the usefulness of the monitoring tool to identify any problems with the performance of any station in the global network.

ECMWF updates the time-graphs of the global radiosonde network every 6 months. On several occasions the results have been communicated to the WMO Secretariat and national weather services, with noticeable success when corrective action was taken at a station with a poor performance record.

6. ACTIONS BASED ON MONITORING RESULTS

ECMWF summarises the monitoring results in internal monthly reports. Internal decisions on the use of the data are based on these results. According to the WMO recommendations concerning the exchange of information on suspect stations, ECMWF plans to participate and make such information available efficiently via electronic bulletin boards.

There are also plans to start a new global data monitoring report to be published monthly and distributed to interested parties. The planned specification is given in tables 1 and 2. Both the data availability and the quality will be covered for the data types which are of prime interest.

The long-term trend evaluation, in particular, of TEMP and PILOT stations will continue. "Country packages" will be produced as required and problems will be brought to the attention of data producers and interested weather services.

7. REFERENCES

Böttger, H. and Radford, A.M., 1987: Monitoring the Baseline Upper Air Network (BUAN), ECMWF/WMO Workshop on Radiosonde Data Quality and Monitoring.

Hollingsworth, A., Shaw, D.B., Lönnberg, P., Illari, L., Arpe, K., and Simmons, A.J., 1986: Monitoring of Observation and Analysis Quality by a Data Assimilation System. Mon.Wea.Rev. 114, 861-879.

Jarraud, M., Simmons, A.J., Kanamitsu, M., 1985: Development of the high resolution model. ECMWF Technical Memorandum No. 107 (available from ECMWF).

Lönnberg, P., Pailleux, J., and Hollingsworth, A., 1986: The new analysis system. ECMWF Technical Memorandum No. 125 (available from ECMWF).

Lorenc, A.C., 1981: A Global Three-dimensional Multivariate Statistical Interpretation Scheme. Mon.Wea.Rev., 109, 701-721.

Neilon, J.R., 1987: Baseline Upper Air Network (BUAN) Feasibility Study, ECMWF/WMO Workshop on Radiosonde Data Quality and Monitoring.

Radford, A.M., 1987: ECMWF Radiosonde Monitoring Results, ECMWF/WMO Workshop on Radiosonde Data Quality and Monitoring.

Shaw, D.B., Lönnberg, P., Hollingsworth, A., 1984: The 1984 revision of the ECMWF analysis system. Technical Memorandum No. 92 (available from ECMWF).

Simmons, A.J., and Jarraud, M., 1983: The design and performance of the new ECMWF operational model. Proceedings of the 1983 ECMWF Seminar.

Tiedtke, M., Geleyn, J.-F., Hollingsworth, A., and Louis, J.-F., 1979: ECMWF model parameterisation of sub grid scale processes. ECMWF Techn. Rep. 10 (available from ECMWF).

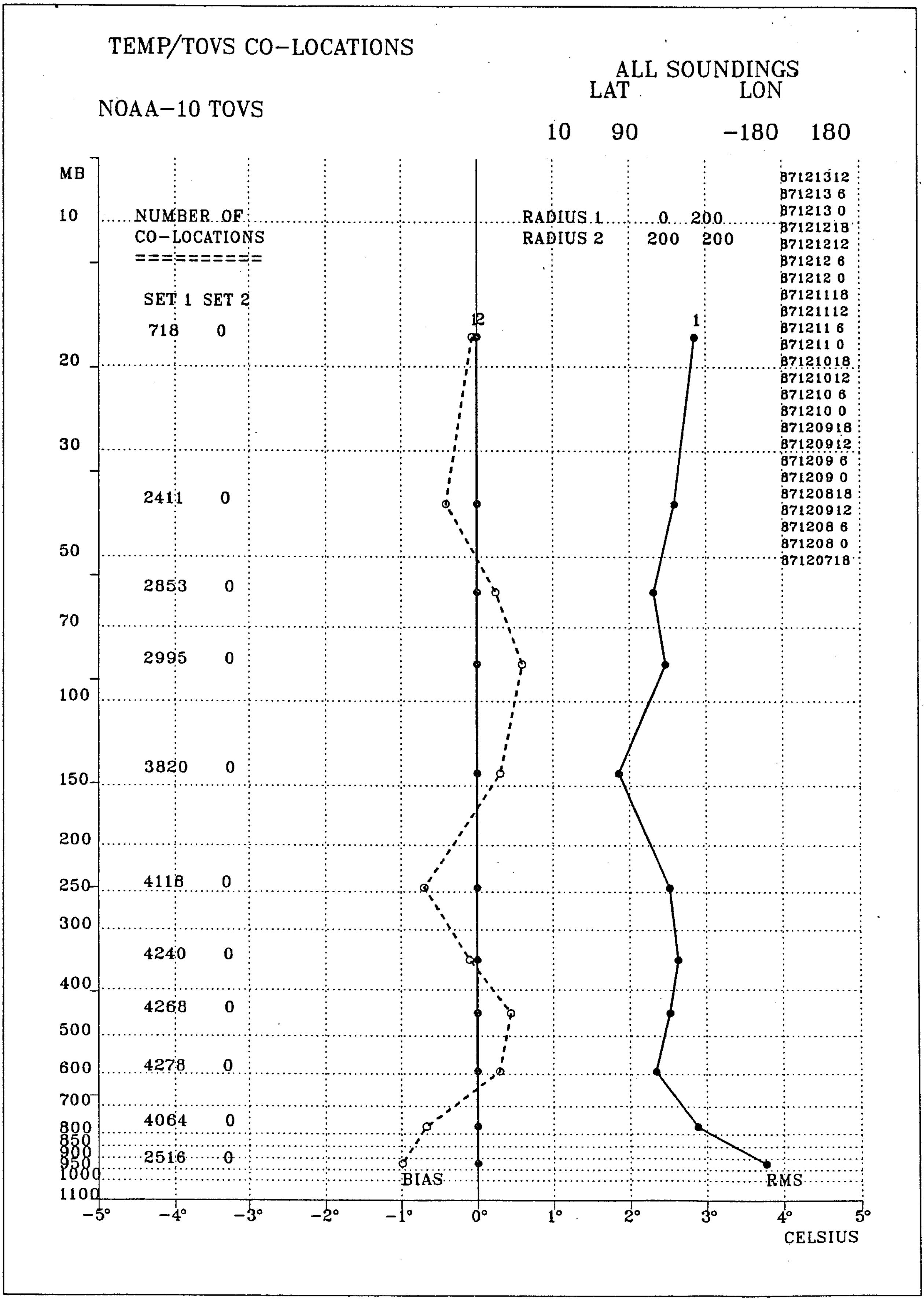

Fig. 2: Collocation statistics of Northern Hemisphere radiosonde and NOAA10 satellite temperature soundings for the six-day period 7 December (18UTC) to 13 December 1987 (12UTC), mean temperature differences (dotted line), rms-differences (full line). The number of collocations within a radius of 200 km in each thickness layer is indicated on the left.

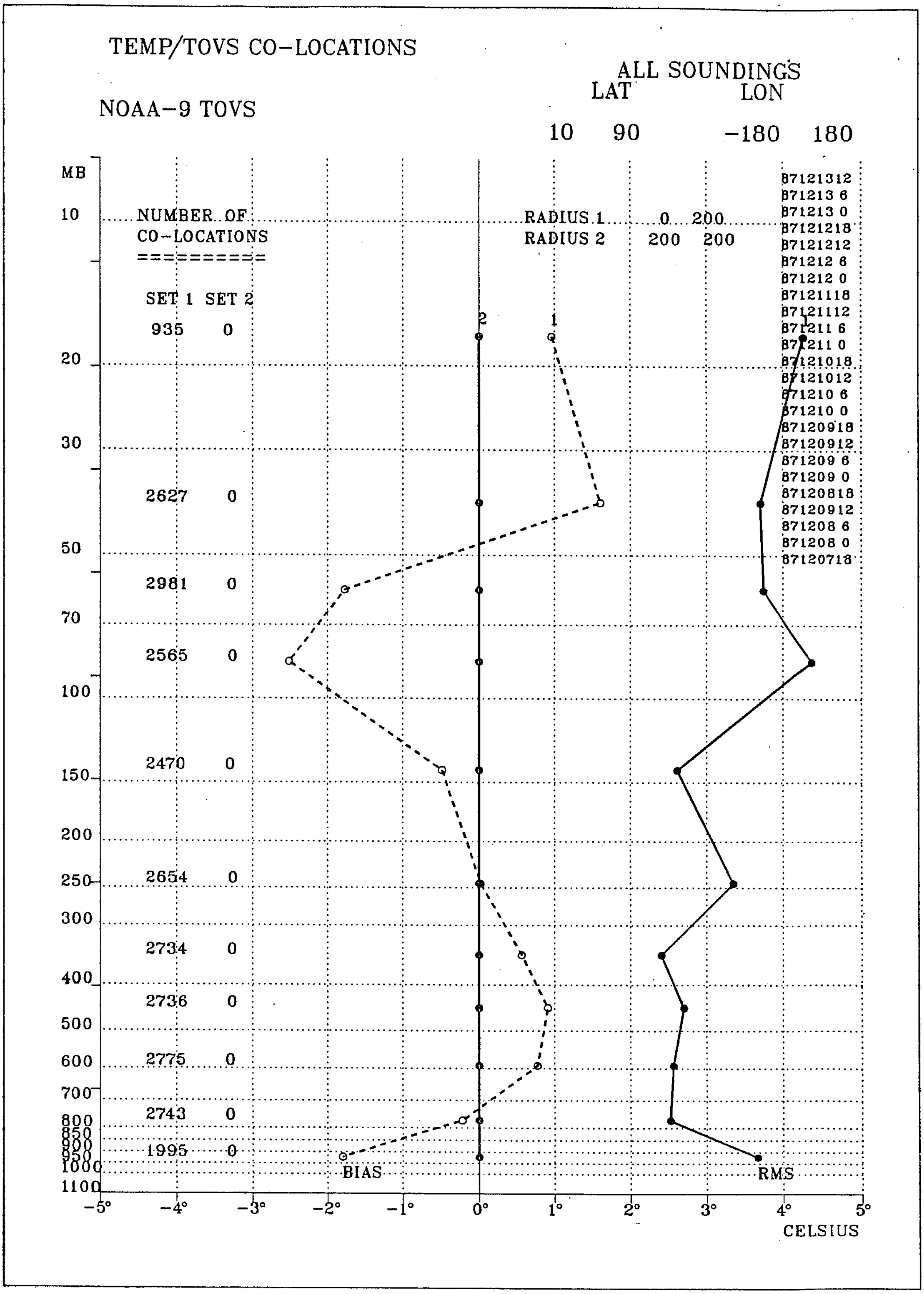

Fig. 3: Collocation statistics of Northern Hemisphere radiosonde and NOAA9 satellite sounding collocations for the six-day period 7 December (18UTC) to 13 December 1987 (12UTC), mean temperature differences (dotted line), rms-differences (full line). The number of collocations within a radius of 200 km in each thickness layer is indicated on the left.

Observation type	Parameter	Level/Layer	No. of charts
(a) Surface			
SYNOP/SHIP	MSLP	Surface	1
DRIBU	MSLP	Surface	1
(b) Upper Air			
TEMP/TEMPSHIP	Geopotential	500 hPa	1
TEMP/TEMPSHIP) PILOT/PILOTSHIP)	Wind	300 hPa	1
AIREP	Wind	350 - 150 hPa	1
(c) Satellite Wind			
SATOB	Wind	1000 - 700 hPa	1
SATOB	Wind	350 - 150 hPa	1
(d) Satellite Temperature			
SATEM (n_1 satellites)	Thickness	300 - 100 hPa	n_1
TOVS (n_2 satellites)	Thickness	300 - 100 hPa	n_2

Table 1: Specification of a planned monthly ECMWF data monitoring publication, part I: Data availability

(a) Surface	No. of tables/charts
Lists of suspect stations for SHIP (surface pressure) and DRIBU (surface pressure) in the format according to Recommendation 3 CBS-Ext(85).	2 tables
(b) Upper Air	
i) Lists of suspect stations for TEMP (geopotential), TEMP/PILOT (wind) in the format according to Recommendation 3 CBS-Ext(85).	2 tables
ii) Global maps showing the locations of the suspect TEMP (geopotential) and TEMP/PILOT (wind) stations together with plotted station number, RMS and bias values.	2 charts
iii) Tables of vertically averaged statistics (geopotential and wind) for all TEMPSHIPS plus selected island TEMPs.	2 tables
(c) Satellite Wind Data - SATOB	
Global charts of	
i) mean observed minus first-guess vector wind	2 charts
ii) mean observed vector wind	2 charts
averaged over 5 degree boxes for 350-150 hPa and 1000-700 hPa. All four analysis cycles combined.	
(d) Satellite Temperature Data - TOVS	
Vertical profiles of co-location statistics against selected radiosondes for each hemisphere and for each of n_2 satellites.	2 n_2 charts

Table 2: Specification of a planned monthly ECMWF monitoring publication, part II: Data quality