AVAILABILITY, QUALITY AND MONITORING OF METEOROLOGICAL OBSERVATIONS

1. AVAILABILITY OF DATA

Statistics on the availability of meteorological observations and the timeliness of exchange of such data via the Global Telecommunication System (GTS) are prepared by the WMO on the basis of the annual monitoring studies. Various other meteorological centres also carry out regular monitoring tasks, including a survey of the availability of data and the areal coverage, the timeliness of arrival, completeness of reports and adherence to standard coding practices.

The regular exchange of results from the surveys provides feedback to the operators of the observing systems. Also, enhancing the annual WMO monitoring exercise by including information about completeness of reports and adherence to the relevant coding practices will lead to greater benefits. Many countries may be unaware of deficiencies in the distribution of their data, and would be willing to alleviate the problems.

Feedback on the use and usefulness of their data, given by either WMO or the large data processing centres, will lead to a better understanding by the operators of observing systems of the importance of providing good quality observations in a timely fashion. ECMWF, and other large centres, could participate in WMO regional association meetings in order to emphasise the need and importance of meteorological data exchange.

Comprehensive monitoring of the availability and completeness of observation would provide the basis for the selection of reliable stations suitable for providing a base-line network which, if a quality standard is guaranteed, could also serve as a network for reference in comparison with other observation types.

2. REQUIREMENTS FOR DATA

The Global Observing System of the WMO provides a large quantity of observations which are available only within the regions but are not exchanged globally. The major centres have a need for the regular global exchange of all available data at 3 hourly intervals, since the centres with powerful computers have demands for data which are different from smaller meteorological centres which have only limited computer facilities and manual data processing. Satellite wind data from ESA may serve as an example. The operational SATOBS pass a manual (subjective) quality control before being inserted into the GTS for 00 and 12 GMT. Although it would be desirable that SATOBS of corresponding quality be made available at 06 and 18 GMT, satellite wind data produced in a fully automatic mode could possibly be made available with little extra resources. Major analysing centres might be able to handle the data and use them in a sophisticated data assimilation system.

Automated observing systems, e.g. surface data from ships or atmospheric soundings of the ASAP type (giving sounding and possibly drop-sonde type data), will complement the conventional observations. The automation provides the means for obtaining observations at a higher resolution in timely fashion with little extra effort. In particular there is a requirement for data at a higher resolution in time and space from areas where rapid and intense developments of weather systems occur; this could possibly be achieved by automatic means. Fully automatic retrieval of observations from meteorological sensors, e.g. on ships interfaced to a data transmission device, is beneficial although such a system would require a central management for the data collection and re-distribution in certain collection areas on the globe.

The ASDAR system is expected to have a significant impact on the availability of single level wind observations along the world wide flight paths. On take off and landing of the aircraft the ASDARs will provide slanted vertical profiles through the atmosphere complementing the conventional rawinsonde soundings at a high resolution in time. However, the AIREP code will not be the appropriate means of reporting such profiles.

Reporting regulations and practices lead to the unsatisfactory situation that few aircraft observations are made available over land, even from data sparse regions. An enhanced reporting practice, especially from Central and South America, Africa, and parts of Asia is required. Aircraft reports are often given from predefined beacon points, the positions of which are sometimes ambiguous. The location of the measurement should always be reported in latitude/longitude. Checks on the position of aircraft following flight paths should be applied, similar to ship position checks.

3. QUALITY OF DATA

3.1 Methods

The accuracy of the analyses and the first guess fields produced as part of sophisticated data assimilation systems are deemed sufficiently high to allow these fields to be used as reference for the evaluation of the quality of observations when they are compared with these fields. This comparison will provide insight both into the nature of certain error characteristics related to the data and to the forecast model used in the data assimilation. The scales of motion which can be represented in the analysis and by the observations have different space and time characteristics (see Fig. 1). Secondly, all analysis systems have deficiencies, in particular the first guess will have its own systematic error characteristics. It might be possible in limited areas to identify and remove the bias from the first guess fields, thus providing better means for identifying observation errors, e.g. from radiosonde measurements.

The comparison of data quality statistics obtained from various monitoring centres would cross-validate estimates of data error characteristics. This needs to be complemented by the use of the collocation technique, as used in the evaluation of satellite observations, to provide data quality statistics which are independent of analysis systems and dependent only on other data types. However, the collocation technique is limited to those regions where the matches can be achieved.

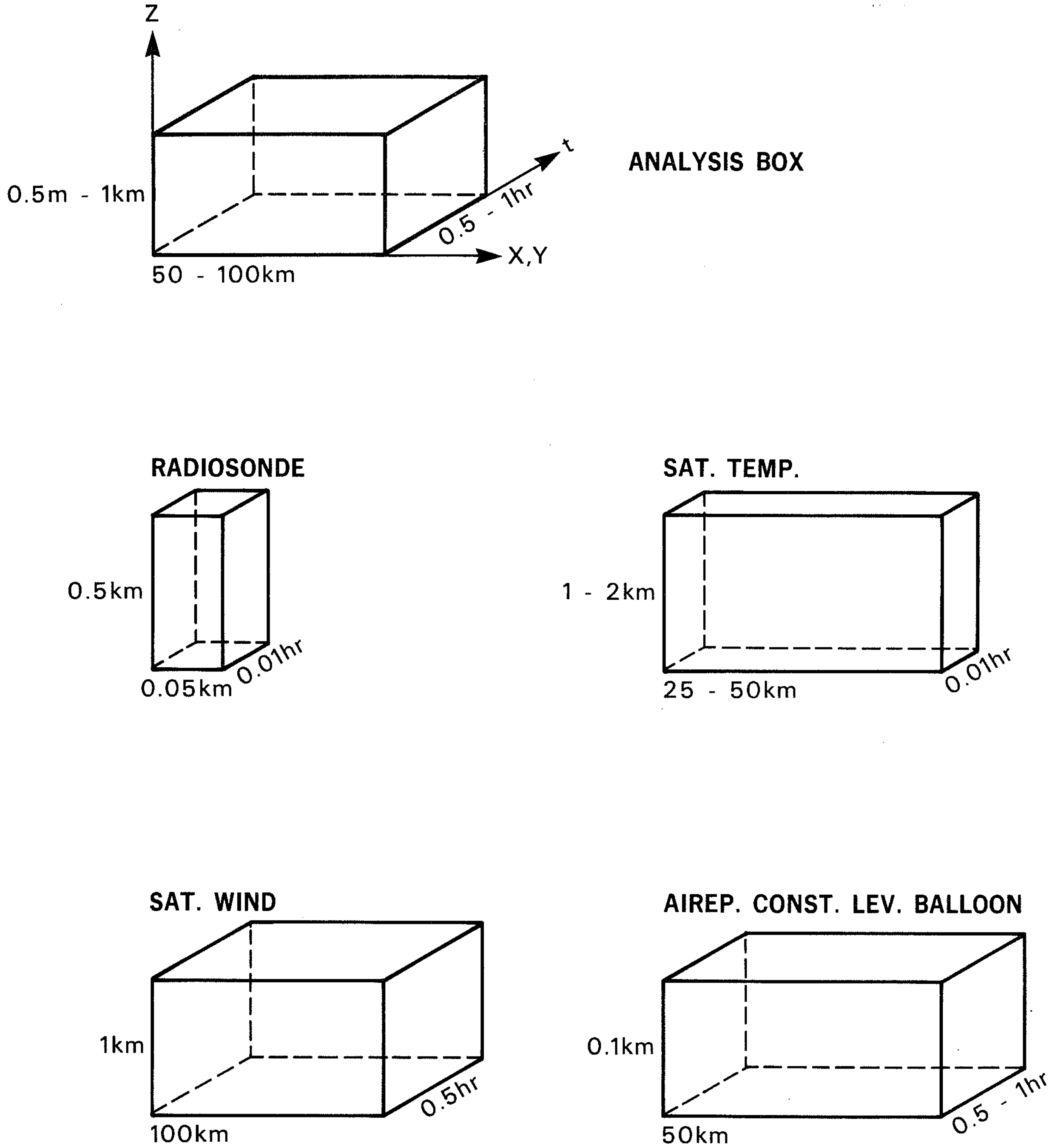

Fig. 1: Sketch of space/time sampling characteristics for some observation types compared to a high resolution model analysis box.

3.2 Rawinsonde data

The quality of rawinsonde temperature and wind observations are found to vary substantially in quality depending on the radiosonde type and the windfinding system. Table 1 gives the differences between area average characteristics of radiosonde observations for homogeneous instrument types.

China	21
France	12
Germany, Fed.Rep.of	12
India	77
Japan	9
Saudi-Arabia	11
USSR	31
USA	11
UK	11

Table 1: Random component of the deviations of the vertically averaged tropospheric geopotential height data from the ECMWF analyses (in metres) for some national radiosonde station networks in September 1984. These deviations depend on the accuracy of both the observations and the analyses.

Pronounced geopotential height errors are often found, particularly in the stratosphere, and so bias corrections for analysis purposes are applied by some centres. For operational purposes bias corrections based on averages over sonde-types are required. The necessary adjustments are then derived from:

- mean day/night differences
- analysis statistics files (observed - first-guess)
- international radiosonde intercomparisons.

The bias correction statistics need to be updated at approximately 3 monthly intervals.

It is necessary that each synoptic upper-air station should inform the WMO Secretariat on a quarterly basis of the types of radiosonde and wind finding systems in use so that all users can be informed. Information on instrumentation error characteristics should also be exchanged, and quality indicators should be included in reports when appropriate.

Solar radiation corrections may soon become mandatory at all WWW radiosonde stations. The diurnal cycle is an essential ingredient in global atmospheric models. Therefore, any correction of radio sounding profiles made at the stations must be applied with care so that the main atmospheric tide components are not accidentally suppressed from the observations. There is also a definite need for accurate quantification of these tide components. The adoption of a standard tide model for use with all radiosondes would make it easier for a global data processing centre to recover the original data if required.

3.3 Vertical temperature sounding data from satellites

Experiments are required to study the information content given by vertical soundings from satellites. The reports in the current SATEM code provide standard pressure layer thicknesses or layer mean temperatures at 14 levels up to 10 mb. Directly measured radiances contain somewhat less vertical information than is actually reported in the SATEM code, but the measurements are available at a much higher horizontal resolution than is generally used by current analysis methods.

If the SATEM message is reduced to about seven layer thicknesses or mean temperatures, then it would be possible to transmit observations with a much larger horizontal coverage on the GTS. In fact, a resolution of 150 km should be practical in the near future.

Most centres carrying out routine analyses could make use of the radiances directly in their data assimilation schemes. The radiance can be recomputed from the information coded in SATEMS but it seems more logical to disseminate the original radiance directly to the users. However, this may cause problems with the current users of GTS SARAD observations unless both data types are disseminated.

Finally, the satellite producer should provide more information about the error characteristics of the satellite to provide, for example, what geographical area the measurement represents and the likely error due to clouds in the field of view of the profiles.

3.4 Winds produced from satellite photographs

Very few quality statistics on the quality of wind vectors derived from cloud motions are available, though the results presented at this workshop are in agreement. Morgan derived the error characteristics of SATOBS in comparison with rawindsonde data, and the results show that the error increases with height or, more appropriately, with the wind speed.

Error statistics stratified according to observed wind speeds are not currently available but are required.

The users of SATOBS produced by the European Space Agency (ESA) have a need for wind data at regular intervals, at least every 6 hours. At present ESA does not produce SATOBS for 06 GMT. A higher frequency of processing the data, such as at 3 hour intervals, would make the production less dependent on model first guess fields. Persistence would then be the more appropriate background. There is, though, the likelihood of introducing features related to the meso-scale wind circulation. On the other hand, it may be desirable to provide more details of the tropical wind fields for the analysis.

The heights of cloud motion vectors as assigned by ESA are at present related to the height of the top of the clouds. Other data producers have a different practice and assign the heights according to height statistics based on climatology. The quality of the heights assigned to the wind vectors produced by ESA should be evaluated.

ECMWF has, in the past, discarded the SATOBS over land since problems have been found with their use over elevated ground and at the jet level. As other data assimilation centres make use of the SATOB data over land, the quality of such data needs to be evaluated and if no adverse effects can be found, they should be re-introduced into the ECMWF analysis.

3.5 Surface observations

The usefulness of surface pressure observations at station level depends crucially on the knowledge of the correct station height. Several analysis centres have identified stations whose height as given in the WMO Volume A is in error. This information is of general interest and should be made available more widely.

For large-scale and meso-scale analyses it is desirable to identify surface stations providing representative wind observations. The relevant information should be obtained from national weather services. The data assimilation systems would also provide the means of identifying representative stations. A first step would be to obtain quality statistics on surface wind measurements both over land and from ships, by comparing the observations with analysed and first guess near-surface wind fields.

4. MONITORING

Global data monitoring, including assessing the quality of observations, should become the task of major centres. The results are useful to enable centres to use the data most efficiently and the WMO Secretariat to initiate remedial action. Therefore:

- information should be exchanged between centres both in near-real time e.g. for blacklisting purposes, and quarterly to provide a more comprehensive assessment of the data;

- quarterly results from the individual centres should be coordinated by one centre and sent to the WMO Secretariat for remedial action.

Note that ECMWF Member States will have direct access to its complete monitoring results.

There should be an agreed format for the presentation of results, including the clarification of results according to the confidence of the monitoring centre as to whether a persistent error is present in the observation.

The parameters presented in the quality monitoring reports should include information about the data reception, systematic and random error compared to first guess and acceptance by the analysis system. Further details will need to be worked out by an expert group.

5. SUMMARY OF RECOMMENDATIONS

5.1 Data requirements

(i) All synoptic data available in the regions at 3 hour intervals should be exchanged globally.

(ii) Automated observations should be made available from weather active areas at a higher resolution in time and space.

(iii) SATOBS should be made available at six hour intervals.

(iv) By reducing the number of layers for which thickness values and mean temperatures are reported in SATEMS the horizontal coverage could be transmitted with a much higher resolution without increasing the GTS load. A 150 km horizontal resolution is considered to be practical in the near future.

(v) Aircraft measurements should be taken also over land in data sparse areas and should be exchanged. Position check procedures similar to those applied to ships should be introduced before using the observations.

5.2 Data quality

(i) The data quality needs to be assessed by comparison with analysis and/or first guess fields. Also the collocation technique should be used to compare different observation types.

(ii) The information on instrumentation error characteristics should be exchanged quarterly. Quality indicators should be included in reports where appropriate.

(iii) Bias correction models should be developed for radiosondes and other relevant observing systems. The adjustment statistics should be exchanged and updated regularly. Similar information should be made available for surface pressure observations from ships.

(iv) Radiation corrections for radiosoundings applied at the station should preserve the atmospheric tides. A tide model should be agreed through WMO for use in connection with radiosoundings.

(v) The use of SATOB data over land in the ECMWF data assimilation should be investigated.

(vi) The use of SATOB data from ESA which are only objectively quality controlled should be evaluated in the ECMWF data assimilation system.

5.3 Data monitoring

(i) The WMO annual monitoring should be enhanced by including information about the timeliness, completeness and coverage of observations. Detailed results should be presented to the operators of the observing systems.

(ii) Data monitoring was considered to be an important task of major meteorological centres. Monitoring results need to be exchanged with the WMO Secretariat and other centres in a standard format.

(iii) There is a need to distinguish between results which should be exchanged in real-time, such as blacklists, and material suitable for exchange in delayed mode, e.g. on a quarterly basis.

(iv) Data monitoring standards and exchange formats should be worked out by an expert group.