PERFORMANCE OF INDIAN RADIOSONDE IN THE INTERNATIONAL RADIOSONDE INTERCOMPARISON EXPERIMENT PHASE II (1985)

N. Seshadri
India Meteorological Department
New Delhi

1. INTRODUCTION

In the International Intercomparison Experiment of Radiosonde organised by WMO during 1984-85, India, being one of the major developing countries which make the entire requirement of radiosondes within the country, qualified for participation in the experiment. India took part in the Phase II experiment in USA at Wallops Island during 4 February to 15 March 1985 along with other countries : U.S.A., Finland, and Australia. The Indian Radiosonde system which is being manufactured within the country is being used in the 35 upper air stations in the Indian National network, taking observations twice daily, at the standard synoptic hours.

The Indian radiosonde which was used in the intercomparison experiment is an audiomodulated instrument in which the frequency is varied by the change of resistances of the meteorological sensors. The radiosonde has aneroid capsule made of Nispan-C, rod thermistor and humidity sensor for measuring the P,T,U elements. All the components of the radiosonde are manufactured in the India Meteorological Department and the instruments are calibrated for a range of 5 hPa to 1020 hPa required for an operational instrument in the Indian sub-continent. The rod thermistor is capable of operating between temperatures of $50^{\circ}C$ to $-80^{\circ}C$ and the humidity sensor is capable of measuring in the range of 10-90%. The ground equipment which operates in a frequency of 401 MHz along with the recorder is fabricated in the country. In addition, a small microcomputer is also used at certain locations for computations after selecting the data manually and entering it into computer. This set up was taken for the intercomparison experiment during 1985. The other countries which participated, like Finland, had a fully automated radiosonde computing system, and USA had also equally sophisticated arrangements for automatic computation of the radiosonde data. India participated only in the P,T,U comparison whereas the other 3 countries took part in the wind comparison also. India could get the benefit of getting very accurate radar heights tracked by a high precision radar operating at the experiment site and participated in 95 successful radiosonde ascents in the experiment along with three other countries.

2. ANALYSIS OF THE PERFORMANCE OF INDIAN RADIOSONDE DURING THE INTERCOMPARISON

The results of the analysis of the performance of Indian radiosonde based on the homogenous data sets for the duration of the experiment are discussed below:

2.1 Maximum pressure levels

The quantitative analysis of the maximum pressure levels (hPa) reached by Indian radiosonde as compared to the other three radiosondes of USA, Finland, and Australia in 95 ascents was made. The percentage frequency distribution of maximum hPa level reached by the 4 participating countries at 10 hPa interval was examined. It is seen that a maximum of 98% occasions data were collected above 50 hPa by USA, Finland and Australia with India at 90%. The instruments from USA, Finland and Australia reached above 20 hPa levels on 80% of occasions as compared to 70% reached by the Indian radiosondes. The performance of the Indian radiosonde instruments has been comparable with that of other participating countries.

2.2 Ascent durations

Even though all the instruments were attached to the same instrument rig carried by a single balloon, the maximum duration of ascents of useful data was dependent on the quality of performance of the sensors and telemetry of the individual instruments. The percentage frequency distribution of the maximum radiosonde ascent durations of USA, Finland, Australia and India were examined. The percentage number of occasions of ascent durations above 60 minutes were USA-98%, Finland-99%, Australia-98%, and India-90%.

The percentage number of occasions of durations above 80 minutes were USA-79%, Finland-81%, Australia-79%, and India-53%. There has been a reduction of 17 to 21% of number of ascents in durations between 60 to 80 minutes in respect of USA-Finland-Australia whereas the reduction is 26% in case of India. The main reason was that Indian radiosonde telemetry was experiencing severe signal interference from local powerful transmissions in 394-400 MHz range after 70-80 minutes, even though the sensors were still functioning satisfactorily.

2.3 Maximum heights

The analysis of the maximum heights (in kms) reached by the Indian Radiosonde in 95 ascents showed that out of these, 75% ascents were followed till balloon burst and remaining 25% ascents could be followed only upto such heights till the signals were strong without interference. The average maximum height upto which the Indian Radiosonde instrument functioned during the entire experiment was 27.6 km as against average balloon burst height of 28.6 km. The percentage performance of Indian instruments was 96% as far as the heights are concerned.

3. COMPARISON OF SIMULTANEOUS MEASUREMENTS

3.1 Temperature

The Indian Radiosonde used for temperature measurement a rod thermistor made in India, as temperature sensor, coated with titanium oxide. This is similar to the one used by USA, except for the Lead Carbonate coating. The sensor is exposed by an external mounting on outrigger. The response time is 2-3 seconds and no radiation correction is applied.

The relative performance of the various temperature sensors in night time conditions (2300 GMT) in Phase II shown in Fig. 1(b) is relative to the mean of the values of sondes of Finland and USA which were designated as link sondes between the two phases of the intercomparison experiment. The reproducibility of Indian Radiosonde temperatures below 100 hPa levels was at best $0.4^{o}C$ as against $0.2^{o}C$ for the link sondes. At levels between 200 and 100 hPa where the vertical lapse rates were very small, the Indian radiosonde tended to be in close agreement with the U.S. sonde. At levels above 100 hPa the measurements of the radiosonde types diverge. The divergence is too large to be attributed to the thermal lag of the sensor alone. The Indian rod thermistor which uses a different coating from the US thermistor suffered less serious radiative cooling errors than the US thermistor. This suggests that the day time measurements of Indian Radiosonde may tend to be somewhat higher than similar sensors used by USA.

The relative performance of the various temperature sensors in day time conditions (1700 GMT) may be seen in Fig. 1(a). The most striking feature is the manner in which the USA and Finnish measurements have changed relative positions between 2300 GMT and 1700 GMT measurements. At levels between 200 and 100 hPa the Indian and US sondes showed warmer values as against the Finnish sonde. This may be due to the Finnish measurements being compensated for solar heating errors. The Indian and U.S. sondes which do not have solar correction were in agreement in temperatures spread not more than 0.6°C. At levels higher than 100 hPa the relative performance diverges. The maximum temperature differences between the US and Indian sondes at levels from 100 hPa to 10 hPa was 0.7°C to 1.0°C.

3.2 Pressure

The differences in pressure measurements of the radiosondes (ΔP) relative to the mean pressure measurements of the link sondes for day and night were examined at the various pressure levels and shown in Fig. 2. The pressures measured by Indian Radiosonde are also quite comparable to the mean value in the troposphere and lower stratosphere. However, this difference increased appreciably above 50 hPa level. The night time results of the Indian radiosondes are very similar to the day time results but showed larger variability as compared to the USA/Finland measurements which exhibited more stability and better reproducibility than the other sondes.

3.3 Mean Geopotential heights

Comparison of mean geopotential heights derived at simultaneous times for all the radiosonde ascents of the participating countries at various pressure levels during day (1700 GMT) and night (2300 GMT) was made. During day time, the spread of heights of USA, Finland and Indian radiosondes were in close range of 9 metres till 400 hPa and 30 metres at 100 hPa. In the middle atmosphere, the differences between each radiosonde height and radar height have considerable range. However, during night time all the geopotential radiosonde heights of USA/Finland/India are mainly close together except for Australia. The spread of heights till 400 hPa was 14 metres increasing to 54 metres at 100 hPa which tended to further increase at higher altitudes to reach a few hundred metres. The reproducibility of gpm height measurements by Indian Radiosonde was found to be much better than obtained operationally due to elimination of observer and telecommunication errors which normally can compromise the operational measurements.

The comparison of geopotential heights at standard pressure levels of the mean differences of gpm heights obtained from the data sets of intercomparison of the radiosondes for day and night time ascents (Fig. 3) showed differences in night time gpm measurements between Indian and US instruments upto 250 hPa level were within 10 metres, but the differences above this level were larger than 22 metres at 100 hPa level. From 100 hPa to 20 hPa the differences progressively increased to a maximum of 60 metres. But the Indian instrument was in close agreement to Finnish radiosonde in gpm values within 10 metres right from ground to 20 hPa levels.

The day time gpm differences between Indian and US sondes upto 250 hPa levels are almost negligible and above this level upto 20 hPa the two instruments closely follow the same trend with a maximum difference of 20 metres. The overall differences in gpm at standard level surfaces during both day and night time in respect of Finland/USA/Indian instruments in Phase II were well within ± 15 metres. The largest mean day time differences between the instruments is smaller than the night time values.

4. COMPARISON OF RADIOSONDE GEOPOTENTIAL HEIGHTS WITH RADAR HEIGHTS

All the joint radiosonde ascents during the intercomparison experiment were tracked by C-band high precision radars by attaching a suitable radar target to the balloon. The radar tracking provided independent height information which could be used to compare with the radiosonde computed heights to obtain altitude compatibility of the radar data. The radar angles and slant ranges were corrected for atmospheric refractivity and also for earth curvature. The radar geometric heights were converted into geopotential height units. The results of the comparison of simultaneously sampled radiosonde and radar measurements of geopotential heights are shown in Fig. 4(a) and 4(b) for day time and night time conditions respectively. The measurements of the USA instrument agreed more closely with the radar measured heights. At 100 hPa, the geopotential height observations of the radiosondes of India and USA were on an average about 50 $\pm$ 20 metres higher than the radar heights. The spread values of heights of USA, Finland and Indian radiosonde group, close from the surface to near about 70 hPa were not exceeding 40 metres. During night time, the radiosonde geopotentials from surface to 100 hPa were all grouped together and showed similar trend relative to the radar values. However, the spread of the height at 100 hPa reached about 70 metres. The night and day time comparisons showed that the radiosonde gpm heights are lower than the radar height gpm. As the tracking radars at Wallops are well maintained and calibrated routinely the differences are believed to be caused by the errors in the pressure/temperature measurements rather than in the radar measurements.

5. CONCLUSIONS

5.1 The performance of the Indian radiosonde as an operational instrument of a major developing country has been comparable with the radiosondes of other countries during the Phase II Intercomparison Experiment. The Indian radiosonde appears to be adequate as an instrument.

5.2 The Indian radiosondes' real capability was disguised to some extent by the operational techniques employed in reading the pressure values and deep layer interpolations in the vertical for computing the data.

5.3 The measurements of the Indian radiosondes showed greater compatibility with the measurements of US instruments which were used as one of the link sondes in the experiment.

5.4 As a result of the experiment it was realised that the radiosonde systems should have automatic conversion of incoming signals into a data stream of meteorological variables to avoid mistakes in reading data from chart records.

5.5 The use of low cost computers for automatic computation and data reduction will help eliminating the operator errors and produce measurements with consistency in reproducibility. This will bring out the real capability of the radiosonde.

ACKNOWLEDGEMENT

The author is grateful to the WMO and the Project Coordinator of Phase II Intercomparison Experiment for the valuable material provided in the Final Report of the WMO international Radiosonde Intercomparison.

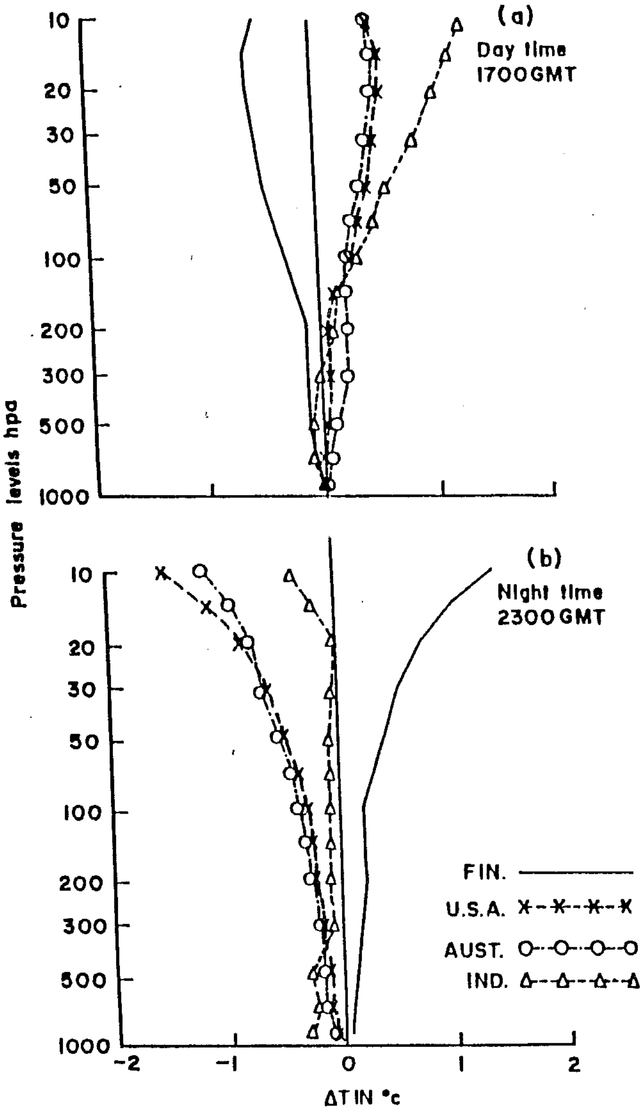

Fig.- I

Temperature differences (ΔT) between mean values of link sondes (FIN/U.S.A.) and other sondes.

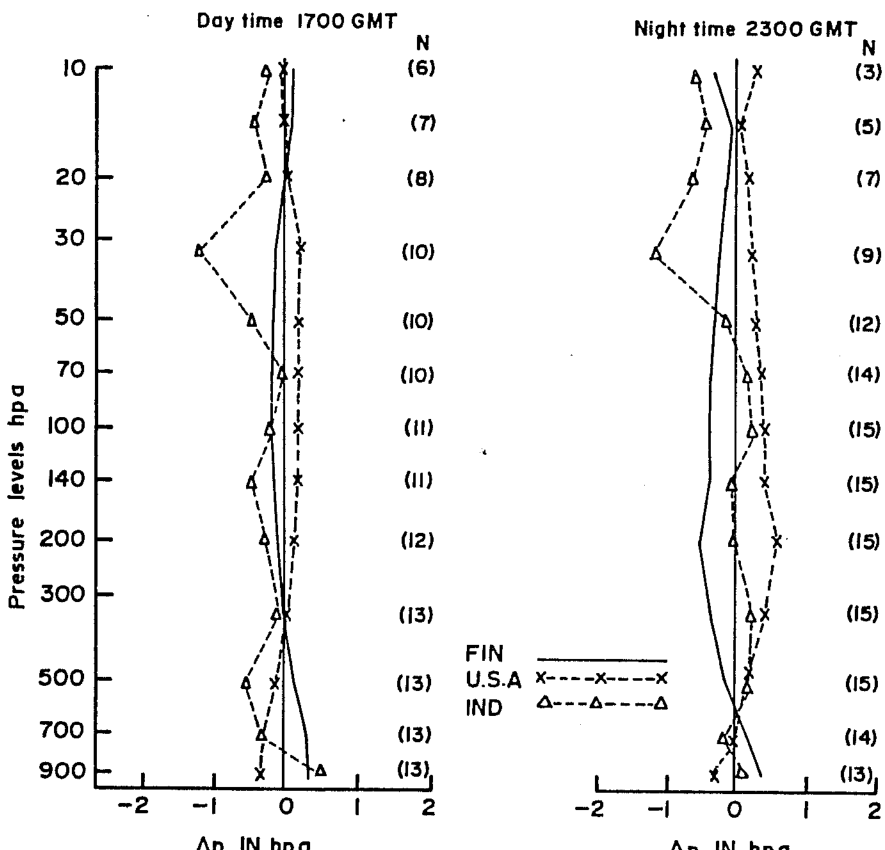

Fig.— 2

Pressure comparison data between mean values of link sondes (FIN/USA) and other sondes.

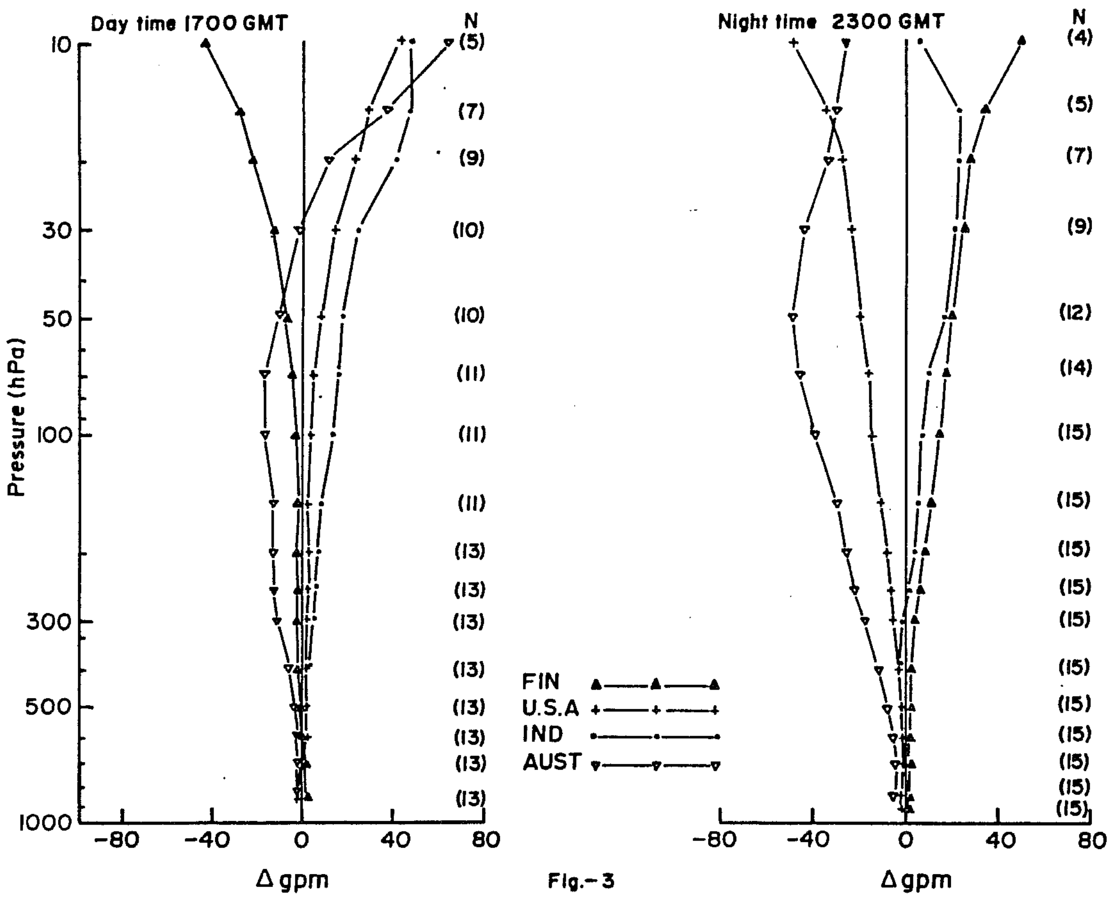

Fig.-3

Geopotential comparison at standard levels (Phase II)

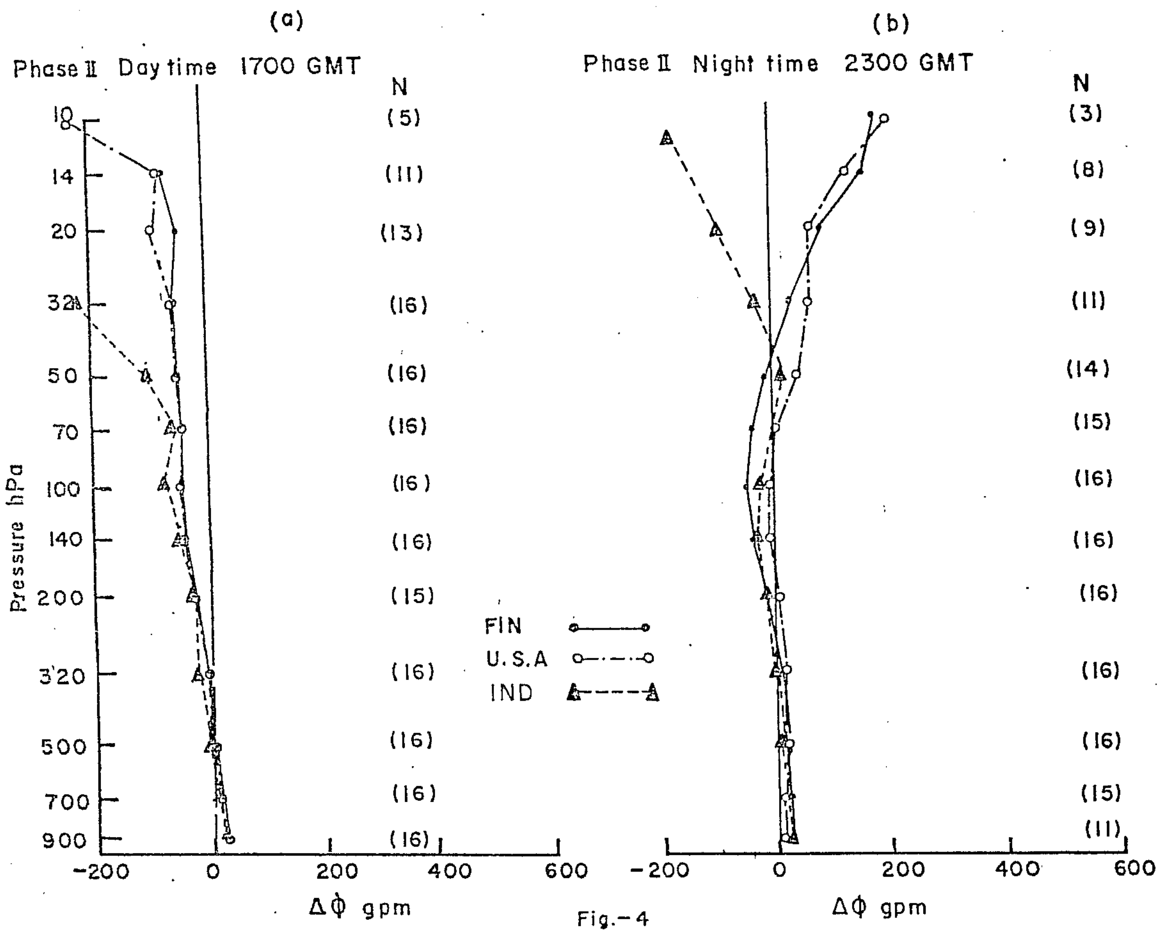

Fig.-4

DIFFERENCES IN RADAR-RADIO SONDE HEIGHTS (GPM).