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Letters to the Editor

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COMPARATIVE STUDY OF INDIAN RADIOSONDE AND RADAR GEOPOTENTIAL HEIGHTS

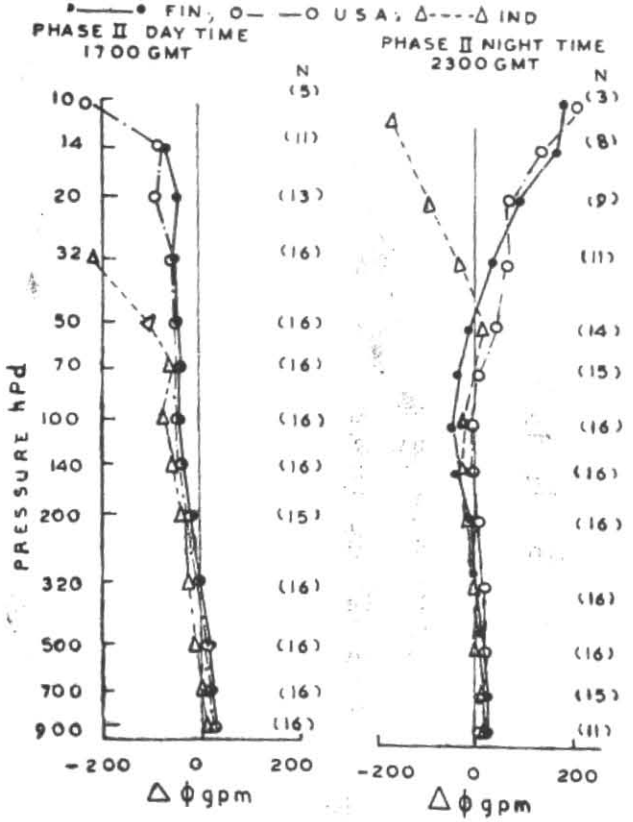
1. In the International Intercomparison Experiment of Radiosonde organised by World Meteorological Organization during 1984-85, India, being one of the major developing countries which make the entire requirement of radiosondes within the country, qualified for participation in the experiment. India took part in the Phase II experiment in USA, during 4 February to 15 March 1985 alongwith other countries, USA, 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 need for information on the accuracy of upper air observations is increasing with the development of more sophisticated meteorological analysis methods, such as optimum interpolation, which operate best with pre-knowledge of the error estimates of each radiosonde types. The radiosonde intercomparisons are aimed to provide usable information on the relative differences of instruments. The primary concern of analysis is, however, the accuracy of radiosonde heights. With proper experimental design and the availability of independent height measurements, such as from radar, it may be possible to establish methods to determine absolute height, in the absence of a reference radiosonde "standard" instrument.

The WMO intercomparison experiment was held at NASA Wallops Flight Facility which had high-precision tracking radars available. The large number of 95 balloon flights provided a significantly large data sample for analysis, as daily 4 flights were taken at 4 hourly intervals.

2. *Use of precision radar* — All the joint radiosonde ascents during the intercomparison experiment were tracked by C-band high *precision* radars (FPQ-6 and *FPS-16*) by attaching a suitable target to the balloon. These radars which were available at Wallops Island Flight Facility tracked 95% of the flights independently. The radars which are in operational use are very accurate as they are subject to frequent routine calibration procedures using boresights and satellite. The FPQ-6 radar system is a long range high precision tracking radar having a range capability of 32,000 miles and is capable of measuring range with an accuracy of ± 5 yd (4.57 m) and range rate to an accuracy of ± 0.1 yd/sec (8.5 cm/sec). This radar has a peak transmitting power of 3 megawatts with a 29 ft (8.84 m) antenna dish. The beam width is 0.39° and it provides an angular measurement precision of $\pm 0.0028°$. Thus, it is estimated that this radar is capable of providing height measurements to better than ± 6 metres r.m.s. The other radar FPS-16 also has got similar capabilities. To obtain altitude compatibility between the radar and the radiosonde data, radar angles and slant ranges have to be corrected for atmospheric refractivity and the earth's curvature. The radar heights which is usually presented in the form of geometrical heights had to be converted into gpm units for comparison with the radiosonde heights using standard procedures. Direct comparison is possible only for measurements made simultaneously, as was done during the experiment. The radiosonde and radar measurements were averaged over unique pressure layers and also the average gpm within the layer was assigned to the middle of the layers. The mean profiles were obtained average over time representative of the data set. The mean differences between the radar measured height and the radiosonde calculated heights are presented in respect of the Indian radiosonde measurements alongwith that of USA and Finnish radiosondes. The preliminary results of a comparison of the calculated radiosonde geopotential heights with the precise height information obtained from radar track data are discussed.

3. *Analysis of results* — The results from the simultaneously sampled measurements of radiosonde and radar geopotential heights during day and night conditions in respect of the radiosondes of USA/Finland/India are shown in Fig. 1. At levels below 100 hPa the radar heights are higher than radiosonde heights. During night time, however, above 100 hPa there is a reversal making the radar heights lower than radiosonde heights (Fig. 1 b). Comparison of radar heights with the radiosonde heights of Finland/USA/India reveals that up to 70 hPa these radiosondes agree closest to radar. During day time, at 100 hPa the radiosonde measurements of



Figs. 1 (a&b). Differences in radar-radiosonde heights (gpm)

gpm heights of these three radiosondes were on an average 50 ± 20 m higher than radar heights (Fig. 1 a). The difference between day time and night time comparison of radiosonde geopotentials with radar heights were at 100 hPa from $+3$ to -17 m for Finnish radiosonde and 44 ± 20 m for US radiosonde. At levels above 70 hPa the differences between radar and Indian radiosonde geopotentials become larger.

At night time (Fig. 1 b), the average difference obtained between radiosonde geopotentials of Finland, India and USA *versus* radar geopotentials is about 25 m at 500 hPa. The radiosonde heights of all the three sondes were lower than the radar heights. Between 200 and 70 hPa, however, the difference increases to about 5-10 m for the Indian radiosonde making it higher than the radar heights. The Finnish radiosonde heights also show similar trend. At levels above 70 hPa up to 20 hPa the heights show further increase up to 70 m for the Indian radiosonde, the heights being higher than the radar heights. Whereas the US radiosonde heights are lower than radar heights by 75 m between the same two levels. However, the differences between Indian, Finnish and US radiosonde heights relative to radar heights follow the same shape vertically up to 50 hPa and thereafter the heights tend to diverge (Fig. 1 b). The cause for this divergence is being examined.

4. *Conclusion* — (*i*) The differences between the radiosonde geopotential heights obtained by the Indian radiosonde measurements and the radar heights for both day and night time in the Intercomparison Experiment followed the same trend from 900 to 50 hPa level as that of Finnish and US sondes.

(*ii*) During day time, the Indian radiosonde heights were throughout higher than the radar heights, whereas during night time from 900 hPa to 70 hPa the heights were close within ± 20 m.

(*iii*) The differences of Indian radiosonde heights relative to radar heights closely followed the same trend as that of US/Finnish heights up to 50 hPa, thereafter tending to diverge, which is under investigation.

Reference

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