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COMPARISON OF TEMPERATURE AND HUMIDITY PROFILES OBTAINED FROM RADIOSONDE AND SATELLITE OVER DELHI

1. Upper air atmospheric profiles of temperature and humidity are crucial parameters for meteorology and climate research [Buehler *et al*., 2004]. Reliable and accurate measurement of upper air Meteorological data is a basic requirement for defining current weather, weather forecasting, NWP and disaster management (Zapotoncy *et al*., 2008). Radiosonde provides the vertical profile of temperature and humidity at a place and these data are also used for calibrating the satellite observations. The meteorological data collected all over the country are used on real time basis for operational forecasting. These data are basis for the preparation of short period averages and climatological normals of data. These are required for defining the initial conditions of NWP models, hence the backbone of the weather forecasting system. Earlier, attempts have been made (Singh *et al*., 2005) for using temperature and moisture profiles retrieved from NOAA-16 ATOVS [Advanced TIROS (Television Infra-Red Observation Satellite] Operational Vertical Sounder) data over Indian region into the regional NWP model for the impact study. Using this data several experiments were undertaken to examine the impact of these data sets on some of the important weather systems such as monsoon depression, active monsoon conditions during monsoon 2003. The preliminary studies revealed that these additional data have a positive impact on rainfall prediction of the limited area model.

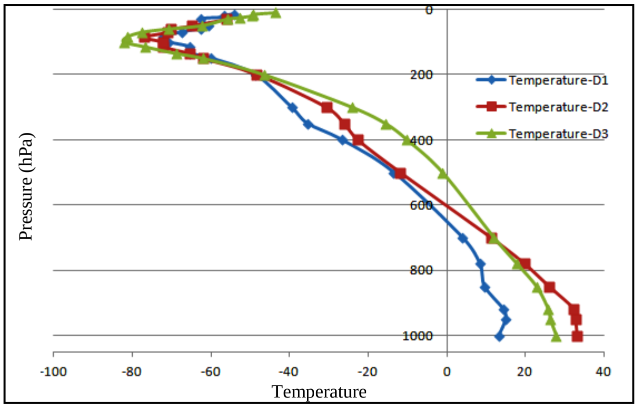

Fig. 1. Temperature profiles on 21 May 2012 (D1), 20 Aug 2012 (D2) & 14 Jan 2013 (D3)

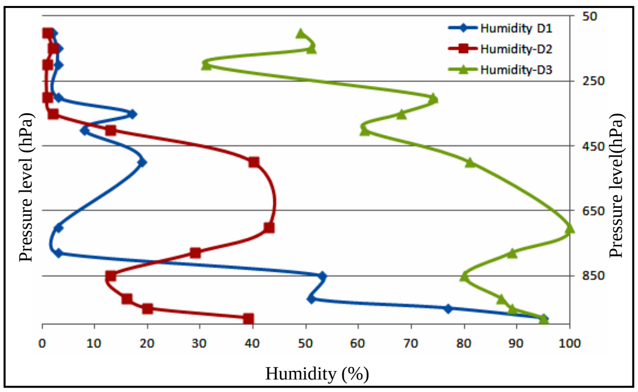

Fig. 2. Humidity profiles on 21 May, 2012 (D1), 20 Aug 2012 (D2) & 14 Jan 2013 (D3)

The upper air profile is obtained twice a day at more than 700 sites and four times a day at more than 300 sites across the globe, under the co-ordination of World Meteorological Organization (WMO), as part of the global meteorological network generally carried out at synoptic times (0000, 0600, 1200 and 1800 UTC). India Meteorological Department has 39 operational Radiosonde radiowind stations in their upper air network. Recently 16 stations in the network have been upgraded by employing GPS based radiosounding systems. After introduction of GPS based radiosounding system in the upper air network of IMD, data quality has improved substantially which has been validated by NCMRWF and ECMWF, ultimately resulted in removal of black list tag from ECMWF for these up-graded radiosonde stations (Kumar *et al.*, 2011).

Two different data sets for these parameters, one from polar-orbiting meteorological sensors of METOP satellite and the other from synoptic meteorological radiosondes RS 92 with Vaisala MW-31 radiosounding system have been compared in this study. The study is related to the comparison of both the data sets for New Delhi station.

TABLE 1

Datasets used for comparison

S. No.	Date	Scheduled time of observation	Radiosonde actual time of release	METOP time of profile	Remarks
1	21 May 2012	0000 UTC	20120520**2301**	2012**0520**2238	Hot & Dry
2	20 Aug 2012	0000 UTC	20120819**2305**	2012**0819**1956	Hot & Humid
3	14 Jan 2013	0000 UTC	20130113**2309**	2013**0113**2035	Cold & Humid

2(a). *Radisonde Data* - Radio Meteorological Observatory at New Delhi is one of best radisounding stations in the upper air network of India Meteorological department. The station is equipped with Vaisala MW-31 radiosounding system and uses RS 92 radisondes. Fig. 1 shows radiosonde temperature profiles and Fig. 2 shows humidity profiles of 0000 UTC observations on 21st May 2012 (D-1), 20th Aug 2012 (D-2) and 14th Jan 2013 (D-3), which have been used for comparison with the satellite derived upper air profiles. Three different days, representative of hot & humid, dry hot and cold & humid conditions have been chosen for comparison.

2(b). *Satellite Data* - India Meteorological Department started using satellite derived upper air profiles of temperature and humidity from May 2012 from METOP satellite. Almost daily profiles are available corresponding to the passage of the satellite over the Indian region. METOP is equipped with Infrared Atmospheric Sounder Interferometer (IASI) which is designed for operational meteorological temperature and moisture soundings with a very high level of accuracy in addition to monitoring trace gases for atmospheric chemistry applications. It measures scene radiance in 8400 infrared channels to derive temperature and moisture profiles to an accuracy of 1° per 1 km of atmosphere.

The main difficulty in using the data is that, the satellite data availability depends upon time of passage of the satellite over the region of study whereas radiosounding observations are scheduled at fixed timings *i.e.*, 0000 & 1200 UTC. Hence, the nearest available time profiles corresponding to radiosounding observation have been used. The details of datasets used for comparison are given in the Table 1.

3(a). The temperature (T) profiles comparisons on 21st May 2012 have been plotted in Fig. 3, which indicate an overall coefficient of correlation r = 0.998. It shows that the temperature profiles observed by Satellite and radiosonde, from surface to 400 hPa level are perfectly matching with difference in corresponding values are <1 °C which is the order of accuracy and having a

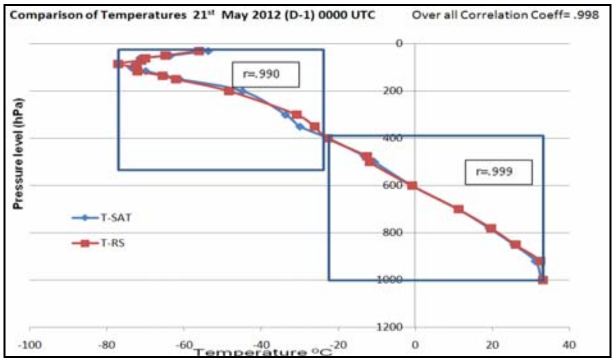

Fig. 3. Comparison of temperatures 21st May 2012 (D-1) 0000 UTC

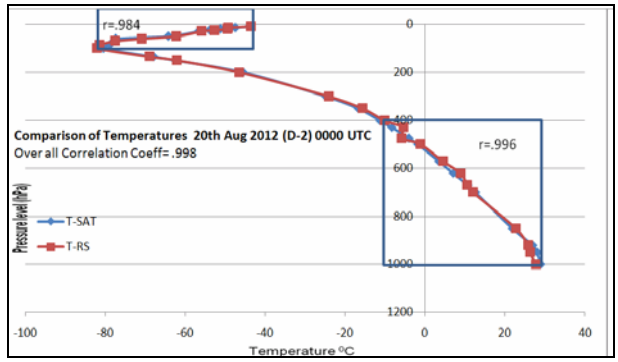

Fig. 5. Comparison of temperatures 20th Aug 2012 (D-2) 0000 UTC

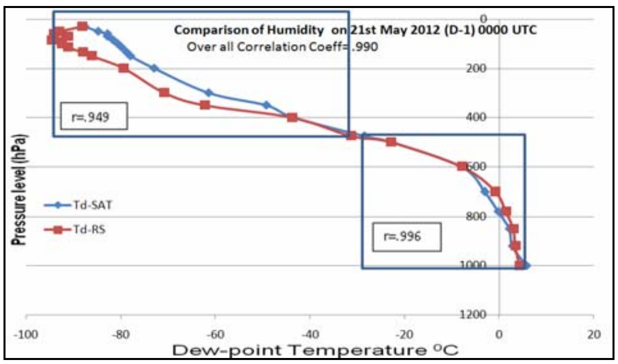

Fig. 4. Comparison of humidity (Dew point temperature) 21st May 2012 (D-1) 0000 UTC

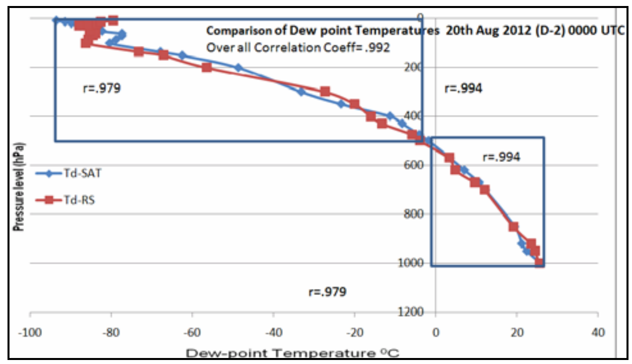

Fig. 6. Comparison of humidity (Dew point temperature) on 20th Aug 2012 (D-2)-0000 UTC

correlation coefficient of 0.999, but the difference increases with height beyond 400 hPa. Above 400 hPa level the difference between individual corresponding values vary from 0.01 ºC to 4.49 ºC, but the profiles are in good agreement with a coefficient of correlation r = .990.

3(b). The dew point temperature (T_d) profiles (Humidity profiles) comparisons on 21st May 2012 have been plotted in Fig. 4. It shows overall correlation coefficient r = 0.990 and indicates that the profiles observed by Satellite and Radiosonde, from surface to 400 hPa level are in good agreement with each other and the difference in corresponding values are varying between 0.22 ºC and -2.1 ºC and having a correlation coefficient of 0.996, but the difference increases with height beyond 400 hPa. Above 400 hPa level, the difference between individual corresponding values vary from 0.26 ºC to 13.0 ºC, but the profiles are in good agreement and have coefficient of correlation r = 0.949.

3(c). The temperature (T) profiles comparisons on 20th August 2012 have been plotted in Fig. 5, which indicate an overall coefficient of correlation r = 0.998. It shows that the temperature profiles observed by Satellite and radiosonde, from surface to 400 hPa level are having a varying difference from 0.05 ºC to 3.01 ºC and having coefficient of correlation r = 0.996, but the profiles are perfectly matching between 400 hPa level to 100 hPa level with difference in corresponding values < 1 ºC which is the order of accuracy and having a correlation coefficient of 0.999, but the difference increases with height beyond 100 hPa varying from 0.10 ºC to 6.51 ºC, but the profiles are in good agreement with a coefficient of correlation r = 0.984.

3(d). The dew point temperature (T_d) profiles (Humidity profiles) comparisons on 20th Aug 2012 have been plotted in Fig. 6, and have coefficient of correlation r = 0.992. It shows that the profiles observed by Satellite and radiosonde, from surface to 500 hPa level are in good agreement with each other and the difference in corresponding values are varying between 0.22 ºC & 2.19 ºC and having a correlation coefficient of 0.994, but the difference increases with height beyond 500 hPa level and the difference between individual corresponding values vary from 0.28 ºC to 14.09 ºC, but the profiles are in good agreement and have coefficient of correlation r = 0.979.

3(e). The temperature (T) profiles comparisons on 14th January, 2013 have been plotted in Fig. 7, which indicate an overall coefficient of correlation r = 0.998. It shows that the temperature profiles observed by Satellite and radiosonde, from surface to 700 hPa level are having corresponding difference in values from 0.02 to 2.22 ºC

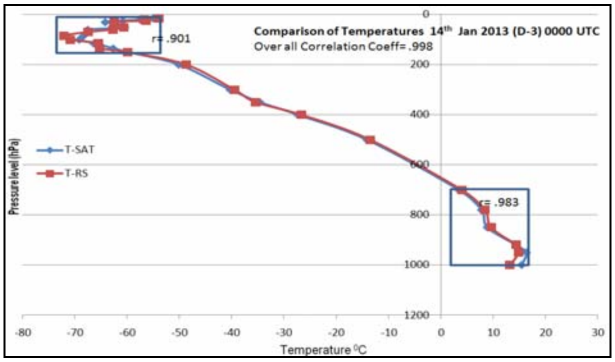

Fig. 7. Comparison of temperatures on 14th Jan 2013 (D-3)-0000 UTC

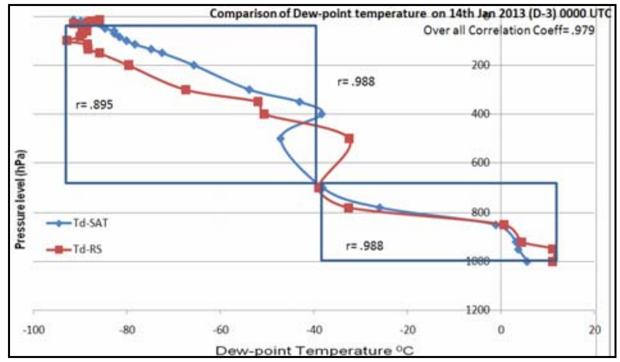

Fig. 8. Comparison of humidity (Dew-point temperatures on 14th Jan 2013 (D-3)-0000 UTC

having coefficient of correlation r = 0.983. From 700 hPa level to 150 hPa level, the profiles are perfectly matching with difference in corresponding values are <1 ºC which is the order of accuracy and having a correlation coefficient of 0.999, but the difference increases with height beyond 150 hPa. Above 150 hPa level the difference between individual corresponding values vary from 0.02 ºC to 4.85 ºC, but the profiles are in good agreement with a coefficient of correlation r = 0.901.

3(f). The dew point temperature (T_d) profiles (Humidity profiles) comparisons on 14th January 2013 have been plotted in Fig. 8 and have overall coefficient of correlation r = 0.979. It shows that the profiles observed by Satellite and radiosonde, from surface to 700 hPa level are much closer in values with each other and the difference in corresponding values are varying between 0.79 ºC and 7.33 ºC and having a correlation coefficient of 0.988, but the difference increases with height beyond 700 hPa level and the difference between individual corresponding values vary from 0.34 ºC to 14.67 ºC, but the profiles are in good agreement and have coefficient of correlation r = 0.895.

4. The comparison of profiles reveal that temperature profiles derived from satellite are perfectly matching with that of radiosounding in most of the cases, hence can be utilized whenever / wherever radiosounding profiles are not available. Satellite derived temperature profiles are very much useful for the timings of availability other than the scheduled radiosounding timings of 0000 and 1200 UTC and the places wherever radio soundings are not possible like hilly terrain, sea surface etc.

The difference in humidity values of satellite derived and obtained from radiosounding are much larger than the order of its accuracy. So, satellite derived humidity profiles cannot be used directly in place of radiosounding profiles, however biases can be calculated based on a larger data set averages and the profiles may be corrected accordingly.

Due to humidity profile mismatches and non availability of satellite derived profiles at the standard radiosounding timings of 0000 & 1200 UTC, satellite derived profiles cannot be direct replacement of radiosounding profiles at present.

5. The authors are thankful to Dr. L. S. Rathore, Director General of Meteorology, IMD, New Delhi, for constant encouragement, invaluable suggestions and expert guidance.

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