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Radiosonde: A tool to monitor atmospheric profiles

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Monitoring with an instrument is important to enhance the knowledge of the atmosphere. An instrument consists of sensors and other important elements to measure and process the data of different kinds of meteorological parameters. Sensor is an essential part of the instrument because it records the information about the atmosphere and supplies the corresponding output in the data displayed for the users.This paper introduces the radiosonde observations to measure the vertical profiles of meteorological parameters (temperature, relative humidity, mixing ratio and wind speed) profilesover three stations i.e., Srinagar (J&K), Delhi, and Mumbai on 09 Aug 2018 (a monsoon day) and 15 Feb 2019 (a winter day) at 0000 GMT and 1200 GMT.

Keywords: Meteorological parameters, Radiosonde, Troposphere

1 Introduction

The availability of meteorological data for a particular location is very crucial for the scientific study of atmospheric phenomena. At present, a number of techniques such as Automatic weather station (AWS), satellites, weather radar, radiosonde and microwave radiometers, etc. are available to observe the meteorological parameters directly.

In the seventeenth century, instruments were developed to measure atmospheric parameters for the scientific study of atmospheric dynamics. Later on, kites were being used to measure the temperature above the Earth's surface. In the late eighteenth century, balloons were used for the observation of upper atmospheric properties. Since then the balloons plays a key role in the investigation of upper as well as near Earth's surface[1]. A package of meteorological instruments for measuring different parameters of the atmosphere is attached to these balloons. This lightweight package is called radiosonde, as shown in Fig. 1. It contains instruments capable of making direct measurements of different parameters, such as atmospheric pressure, temperature, relative humidity, wind speed and wind direction. Since the late 1920s, these Helium-filled; teardrop-shaped rubber balloons are aloft with a lightweight package of instruments, measure the weather parameters and provide significant data of each second to the receiver[1]. The diameter of the majority of these balloons is kept about two meters. Their sizes increase with the decrease in pressure at higher altitudes. These balloons work as inflatable bags which can reach higher altitudes and can even penetrate the troposphere. In ideal conditions, the weather balloon cans ascent up to 35 km, or where the pressure drops to about 10 millibars. Some radiosondes are not suitable for observing parameters at very low pressure because the error in the measurements increases at low pressures.

The accuracy requirements of the meteorological parameters in the range from 100 hPa to 5 or 10 hPa

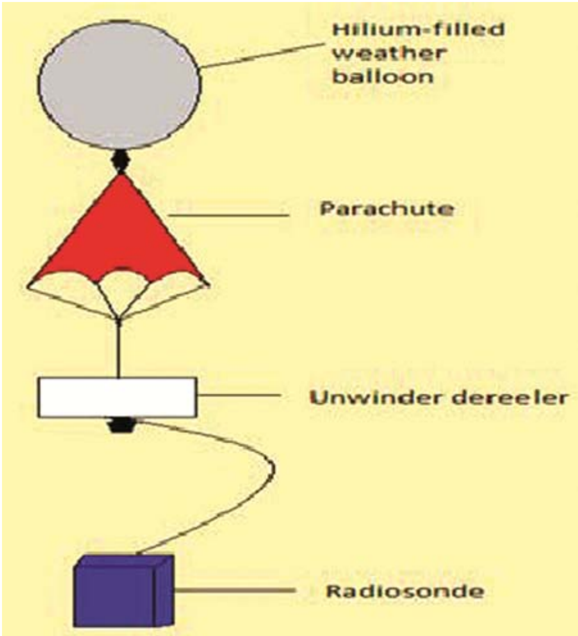

Fig. 1 — Schematic representation of radiosonde flight[3].

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for upper- air observations are presented in the tabular form (Table 1).

Upper air data defined as above three meters from the Earth's surface can be obtained from the radiosonde with short time intervals of every second at a suitable level. The position of the balloon is tracked with the help of Radar or GPS system. Some weather balloons have also been used to observe ozone levels in the atmosphere and also track the patterns of ozone depletion. Balloon carry a parachute attached between the balloon and radiosonde which helps in bringing back the radiosonde to the Earth after the balloonburst. Some weather balloons are designed to travel higher altitudes, up to 35 to 40 km, while others burst at sufficient altitude releasing their radiosonde package back to Earth via parachute. Well guided instructions regarding address and a return request are printed on the instrument so that the finder could send it back to the written address.

At present, approximately, 1000 radiosonde stations are being operated across the globe (http://www.wmo.int/pages/prog/www/OSY/Gos-components.html), which conduct the observations twice a day, one at 0000 GMT (0530 AM IST) and other at 1200 GMT (0530 PM IST)). Every day, approx. 2-4 radiosondes are sent from a radiosonde station. This means that, across the globe, more than 2000 radiosondes send weather data to Earthper day. This collected data is then shared around the world to prepare an international pool of radiosonde data and is also made freely available to all countries for analysis. The radiosonde data can be easily obtained from the University of Wyoming website: http://weather.uwyo.edu/upperair/sounding.html. In India, 39 radiosondes/ radio wind stations are working under Indian Meteorological Department (IMD), which include two stations only for radiosonde data and three stations for mountain meteorology project[4].

Several studies have been done on the basis of radiosonde observations all over the world[5-7]. On the basis of these studies, the meteorological data obtained from radiosonde can be used for the following purposes:

Table 1 — Accuracy requirements for upper-air observations[2].

Range	Parameters	Accuracy
Troposphere (From surface to 5 or 10 hPa)	Pressure	~ ±1 or ±2 hPa
	Temperature	~ ±0.5 or ±1 K
	Relative humidity	~ ±5%
	Wind speed	~ ±1 or 2 m/s
	Wind direction	~ 5° for <15 m/s
		~ 2.5° for >15 m/s

(i) Input data for computer-based weather prediction models
(ii) Local severe storm, aviation, fire weather, hurricane movements and marine forecasts
(iii) Weather and climate change research
(iv) Input for air pollution models
(v) Defence applications
(vi) Propagation conditions for electromagnetic waves or sound waves in the atmosphere

2 Data and Sites Description

In the present study, the data provided by radiosonde observation is utilized to obtain the vertical profiles of atmospheric parameters over three stations i.e., Srinagar (J&K), Delhi, and Mumbai on 09 Aug 2018 (a monsoon day) and 15 Feb 2019 (a winter day) at 0000 GMT and 1200 GMT. Srinagar is a hill station, situated at about 1500 m amsl, Delhi is an inland station, situated at about 216 m amsl whereas Mumbai is a coastal station located at about 14 m amsl. The data for the selected days were obtained from the link mentioned above.

3 Results and Discussion

3.1 Temperature profiles

Generally, the temperature is decreased with altitude in the troposphere (bottom layer of the atmosphere) at all the stations as shown in Fig. 2. The maximum temperature was found near the Earth surface because the Earth surface radiates energy to the atmosphere. The troposphere is an important layer for the study of atmospheric phenomena because all the important weather phenomena occur in this region. In the stratosphere, temperature decreases with altitude because here the ultraviolet rays are absorbed by the ozone layer. On a winter day (15 Feb 2019), more than one tropopause is observed over all the selected stations. The trend of temperature is almost the same for all the three stations and at both times (0000 GMT and 1200 GMT).

3.2 Relative humidity profiles

The relative humidity was found to be maximum near the surface for all the stations except Mumbai. Srinagar shows high humidity values of about 90 % near the surface of the Earth. All the stations show very high relative humidity values during the morning hours and the maximum part is found in the lower troposphere. For all stations, the relative humidity decreases with altitude and goes almost negligible after around 18 km for all times as shown in Fig. 3. On the monsoon day, troposphere shows the humid atmosphere.

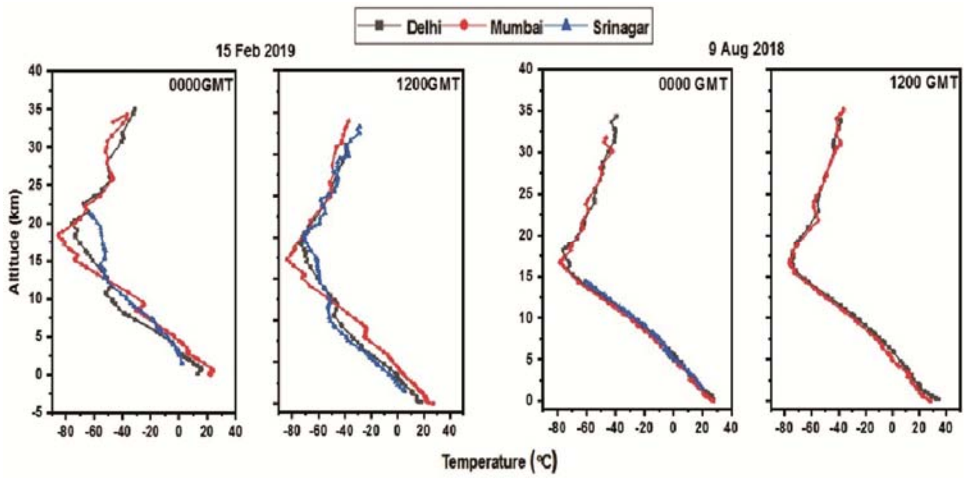

Fig. 2 — Vertical profiles of temperature for Delhi, Mumbai and Srinagar at 0000 GMT and 1200 GMT

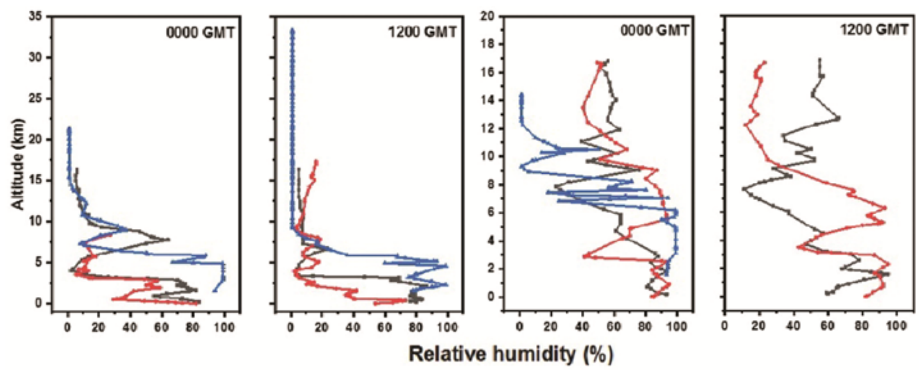

Fig. 3 — Vertical profiles of relative humidity for Delhi, Mumbai and Srinagar at 0000 GMT and 1200 GMT

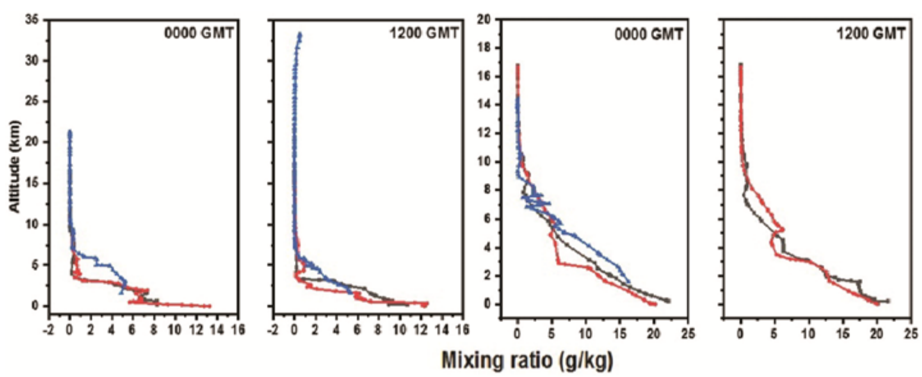

Fig. 4 — Vertical profiles of mixing ratio for Delhi, Mumbai and Srinagar at 0000 GMT and 1200 GMT

3.3 Mixing ratio profiles

The mixing ratio is the ratio of the mass of water vapor to the mass of dry air. It does not depend on pressure or temperature changes. The mixing ratio is decreased with altitude and is negligible above 18 km of altitude, similar to the relative humidity (Fig. 4). The maximum value of about 20 g/kg is observed on the monsoon day at all stations. It may be because of this reason the air is moist in the monsoon.

3.4 Wind speed profiles

Figure 5 shows that the wind speed near the surface is about 0 to 5 m/s for all the selected stations and at all times. On a winter day, a peak is found at nearly 10 to 15 km of height with maximum wind speed values of about 60 to 100 m/s due to the subtropical jet stream. After that height the wind is calm and the speed decreases to about 40 km of height. In monsoon, the speed shows an increasing pattern at all

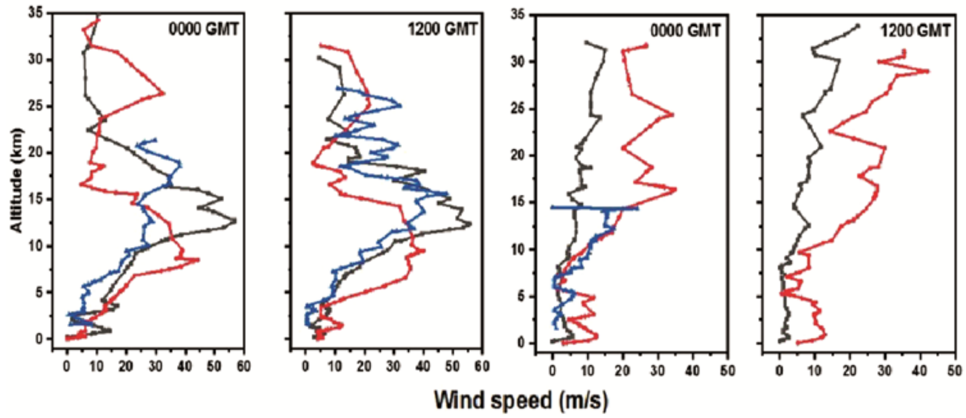

Fig. 5 — Vertical profiles of wind speed for Delhi, Mumbai and Srinagar at 0000 GMT and 1200 GMT

times for all the stations. For Delhi and Srinagar stations, the wind speed is ranging from 1 to 50 m/s from the surface to 14 km altitude whereas for Mumbai, wind speed is maximum (~ 90 m/s) in the evening hours.

4 Conclusions

Thevertical structure of meteorological parameters in the troposphere are essential in the field of weather nowcasting and forecasting, particularly regional and local forecasting. According to our analysis for few stations of India, radiosonde gives the temperature and wind profiles up to 35 km of altitude whereas the relative humidity and mixing ratio profiles are almost negligible after 18 km. On a winter day, temperature profiles show more than one tropopause and are observed over all the selected stations. The radiosonde data is also used for the validation of data from other instruments.

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