

Study of GPS Radiosonde observation system in Goa

S. M. METRI

India Meteorological Department, AMO Mohanbari, India

(Received 4 August 2009, Modified 17 February 2011)

e mail : metrisunder@yahoo.com

सार – मौसम विज्ञानिक रेडियो सॉंदे का उपयोग पहले जहाजरानी प्रणाली में उपरितन वायुदाब, तापमान, आर्द्रता और पवन आँकड़ों को रेडार के माध्यम से प्राप्त करने के लिए किया जाता रहा है। इस शोध पत्र में अभी हाल ही में भारत मौसम विज्ञान विभाग में लगाए गए जी. पी. एस. रेडियो सॉंदे परीक्षण के बारे में बताया गया है। एम.2के.2 रेडियो सॉंदे से लिए गए प्रेक्षणों की इसमें चर्चा की गई है। जी. पी. एस. रेडियो सॉंदे से पवन आँकड़े भी प्राप्त होते हैं।

ABSTRACT. Meteorological Radiosonde in the past used to apply navigation system to route to determine the upper air pressure, temperature, humidity and the wind data through Radars. In this paper GPS Radiosonde test has been recently introduced in IMD is studied. The observations taken from M2K2 Radiosonde have been discussed. GPS Radiosonde obtains wind data as well.

Key words – GPS Radiosonde, T-Phigram, Heavy rainfall.

1. Introduction

India Meteorological Department (IMD) adopted to take upper air observations atmospheric pressure, temperature and relative humidity with Radiosonde MK-III pressure sequencing device. The expansion of aneroid barometer makes mechanical attached pen to slide over the commutator plate thereby connecting sensors of pressure, temperature and humidity. Later on IMD introduced modified Radiosonde MK-IV using Society for Applied Microwave Electronic Engineering Research (SMEER) ground equipment. This uses time sequencing of sensors and reference value in predetermined way using time circuit. It transmits sequential frequencies in a two second cycle showing pressure, temperature and humidity in four equal space of time segment. The signals received are computed at SMEER ground equipment.

Recently, the M2K2 Radiosonde of 403 MHz frequency based on GPS receiving device is introduced for upper air observation at some of the stations of IMD. This GPS receiving device in Radiosonde allows accurate observation in wide range of altitude from the near ground to the stratosphere resulting in improvement in the defectiveness of the pressure sensor and total elimination of pressure sensor from M2K2 Radiosonde.

2. GPS Radiosonde System

The block diagram of GPS Radiosonde is shown in the Fig. 1. This GPS positioning system with M2K2 Radiosonde is used to transmit observation data to the ground station SR2K2. The instrument consists of no pressure sensor and weight of about 200 grams.

M2K2 Radiosonde is activated by alkaline cell instead of water activated battery, capable of operating up to three hours; it operates in the frequency range of 400-406 MHz. The desired frequency can be set at the ground automatically due to built in barometer. The GPS receiver of Radiosonde measures the satellite carrier Doppler shifts and transmits this GPS information along with Pressure, Temperature and Humidity (PTU) data to ground SR2K2. The atmospheric pressure data is determined by calculating from GPS altitude, temperature and humidity parameters according to Laplace Law, wind finding is based on differential calculation providing position and speed components. GPS Radiosonde will acquire wind finding data in most, if not all, thunderstorm and non-thunderstorm cloud, was studied by Rust. (1999). The wind speed is determined from GPS position using Geometric calculation and Doppler measurement is performed on instant speed. The receiving antenna is used either Omni directional or turnstile antenna for receiving Radiosonde signals from GPS Satellite.

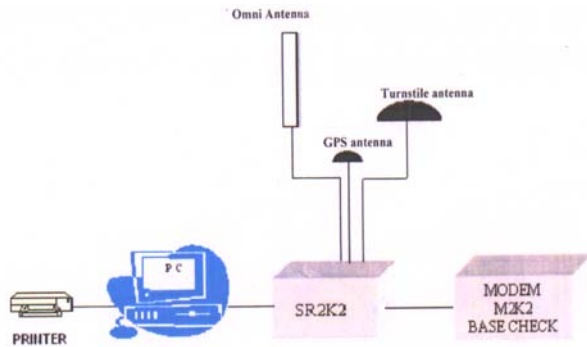


Fig 1. System Block diagram of GPS Sonde

3. Ground Station SR2K2 System

The system has built in barometer board provides automatically launch area ground pressure to the software. Ground check system allows a calibration of temperature and humidity sensors prior launch and secondly the GPS initialization of the Radiosonde is performed from indoor due to built in GPS repeater antenna.

SR2K2 upper air sounding system primary function consists in collecting PTU and wind data measured are transmitted by Radiosonde through a 403 MHz link during its ascents to the upper air atmosphere. The signal sent are demodulated and coded. The PTU data, Radiosonde calibration and GPS positioning data are then transmitted to the computer system. Interface of Calculation and Analysis of Radiosonde (ICAR) is the software module used for edition of World Meteorological Organisation (WMO) messages, aeronautical report (significant points, standard level and additional level etc.) and sounding analysis. System allows display of thermodynamic diagrams, storage of data replay and modification of flights.

4. Feature of M2K2 GPS Radiosonde

- The GPS Sonde calculates the pressure from the GPS altitude, temperature and humidity parameters according to Laplace Law, considered as most accurate and reliable.
- Ground checks facility available, with built in GPS repeater for indoor initialization.
- Ground station SR2K2 has built in barometer, providing launch area ground pressure to the software.
- GPS receiver provides latitude, longitude and altitude during the flight.

- Wind data finding is based on differential calculation for providing position and speed.
- The parameter of sensors for observation are calculated automatically in receiving station SR2K2 and are stored in personal computer thereby skill manpower is reduced to automatic operation.
- The final message is sent to users in coded form with a click if internet facility available.

5. Technical specification of sensors

Temperature

Sensors Type	: Thermistor
Measuring range	: 60° C to 90° C
Resolution	: 0.1° C
Accuracy	: +/- 0.5° C

Humidity

Sensors Type	: Capacitor
Measuring range	: 0 to 100 %
Resolution	: 1%
Accuracy	: +/- 0.5 %

Pressure

Range	: 1100 to 3 hPa
Accuracy	: +/- 1.0 hPa of surface +/- .1 hPa at 60 hPa

Wind measurement

General	: DGPS with c/a code altitude
Wind direction accuracy	: 2°
Position accuracy	: 10 meters

Batteries : 1.5V alkaline, 4 batteries

Transmitter

Frequency range	: 400 to 406 MHz
Output power	: 200mW

SR2K2 Ground Station

Weight	: 3.5kg
Power consumption	: 15 W
GPS	: 14 channel receiver

Work station can be operated either Laptop or Desktop

TABLE 1

Comparison of altitudes between Radiosonde MK IV and GPS Sonde

Pressure level	Altitude	
	MK-IV	GPS Sonde
950	511	510
925	746	740
900	984	978
850	1478	1473
700	3087	3132
650	3996	3748
600	4351	4402
550	5050	5101
450	6623	6677
400	7528	7580
350	8531	8581
300	9666	9694
250	10957	10977
200	12484	12463

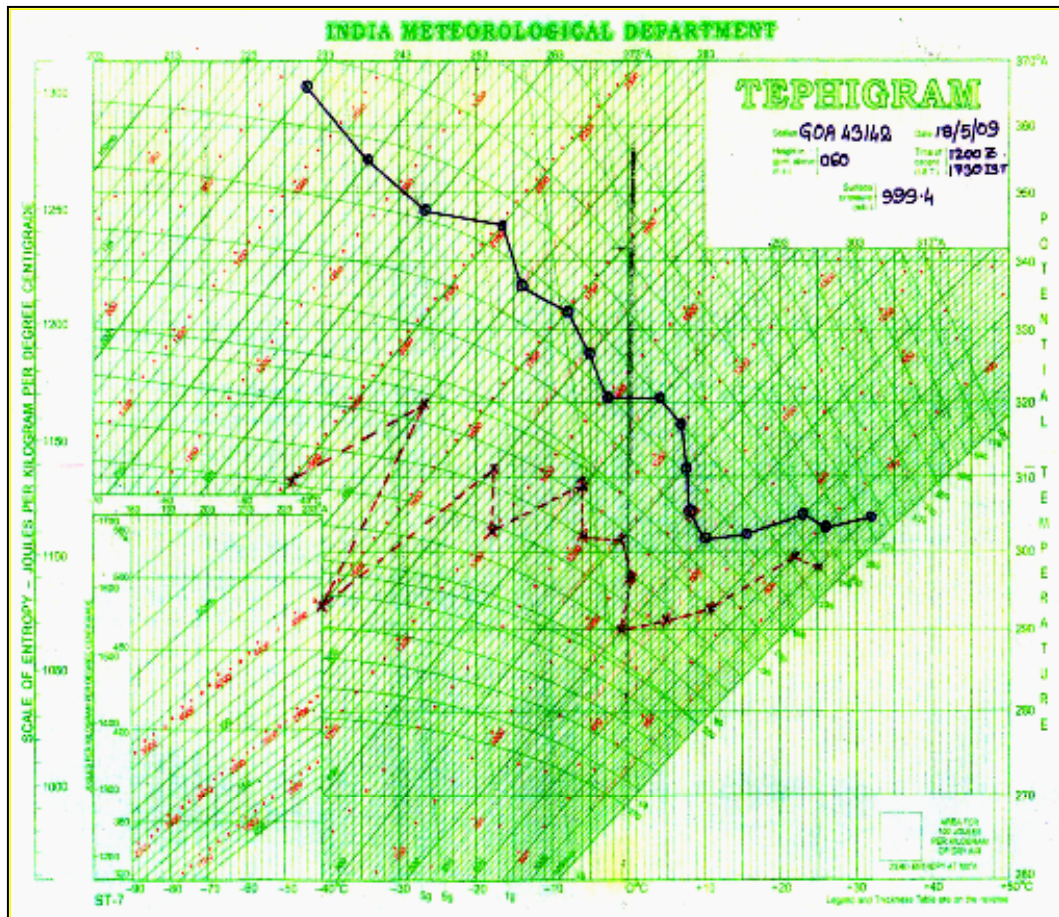


Fig. 2 (a). T-Phigram of Radiosonde MK IV is obtained from the test ascent taken on 18th May 2009 1200 UTC at RS/RW Goa for comparing with GPS M2K2 data

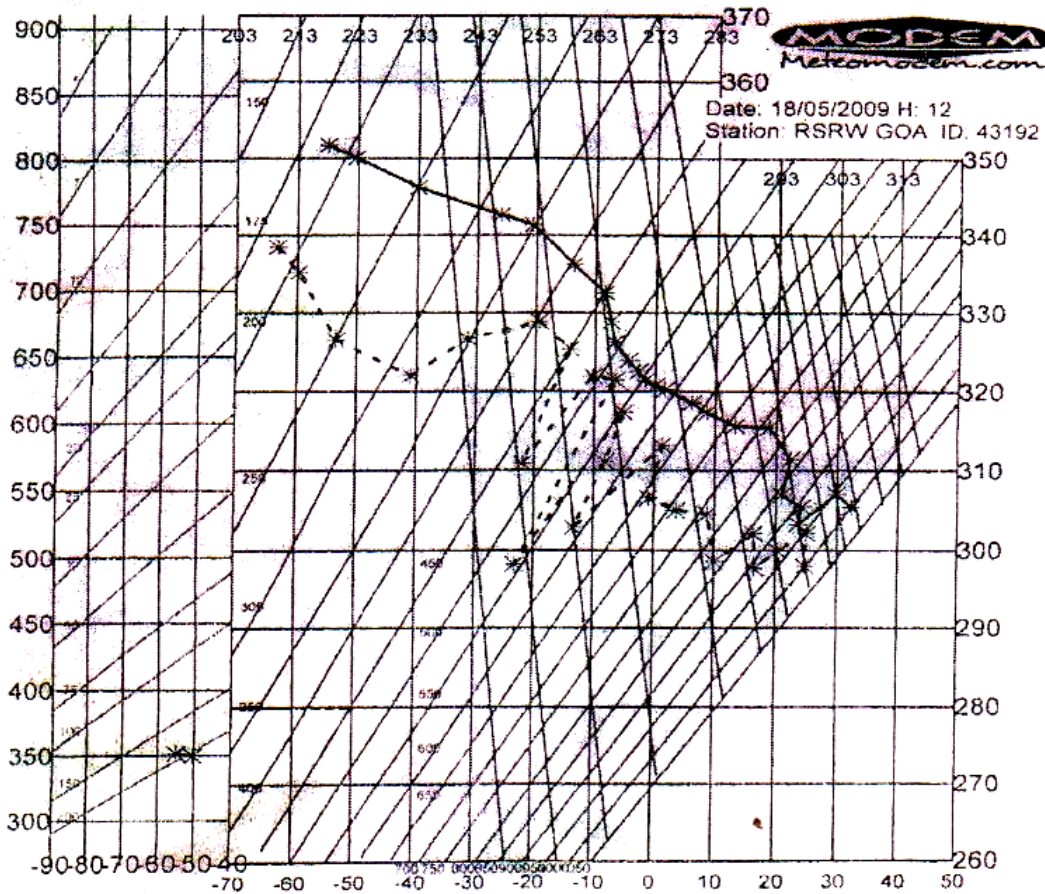


Fig. 2(b). T-Phigram of GPS Sounding on 18th May 2009 1200 UTC at RS/RW, Goa for comparing with Radiosonde MK IV data

TABLE 2

Exceptional heavy rainfall recorded in millimeters on 7th June 2009, 2nd July 2009 and 4th July 2009

Date	Cancona	Dabolim	Mapusa	Margao	Mormugao	Pernem	Ponda	Quepem	Sangeum	Valpoi	Panaji
07 June 2009	168.4	115.9	220.6	113.0	136.6	268.0	242.2	100.6	432.6	237.4	199.2
02 July 2009	80.2	150.8	301.4	77.2	173.0	282.4	188.4	89.4	135.6	150.4	158.7
04 July 2009	164.4	171.6	142.4	116.3	138.4	150.2	135.4	135.6	173.6	100.0	136.4

6. Balloon borne flight test

The flight test was carried out on 18th May 2009 1200 UTC at IMD Goa, both Radiosonde Mark IV and GPS M2K2 were released with a single balloon at distance of two meters apart and ascent was carried out. A target was also tied with the balloon for receiving radar wind

data. The PTU data collected from the both receiver were processed. The flight has taken up to the level of 200 hPa. The altitude and pressure obtained are shown in the Table 1.

The altitude difference between RS Mark IV and GPS Radiosonde M2K2 measurements are verified. The

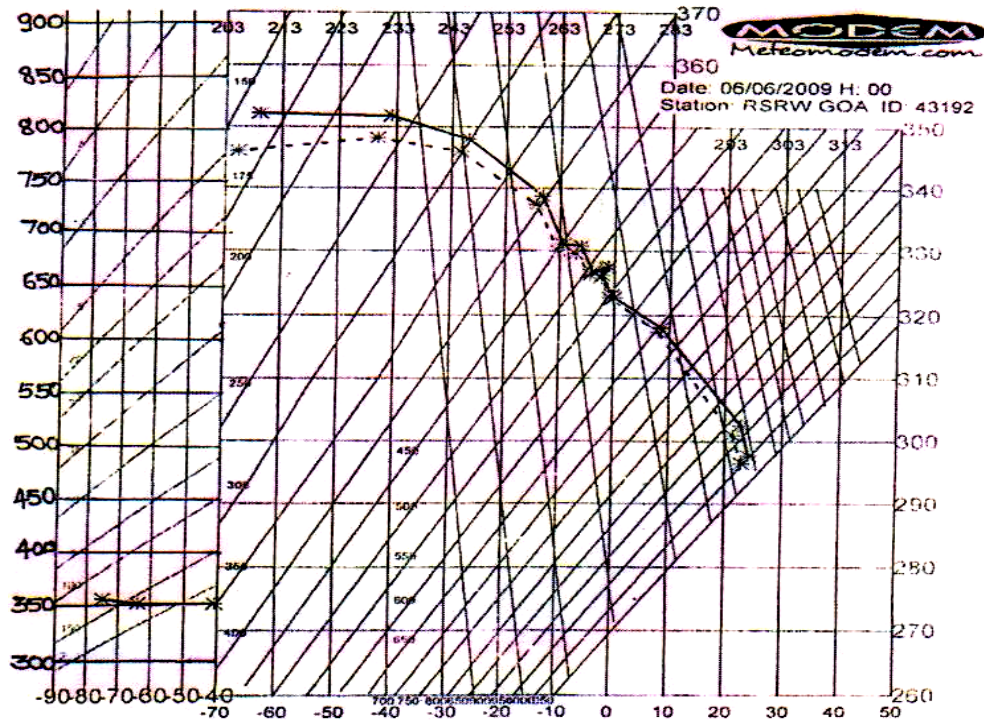


Fig. 3(a). T-Phigram of GPS ascent on 6th June 2009, 0000 UTC shows the freezing level at 550 hPa before the heavy rainfall day on 7th June 2009

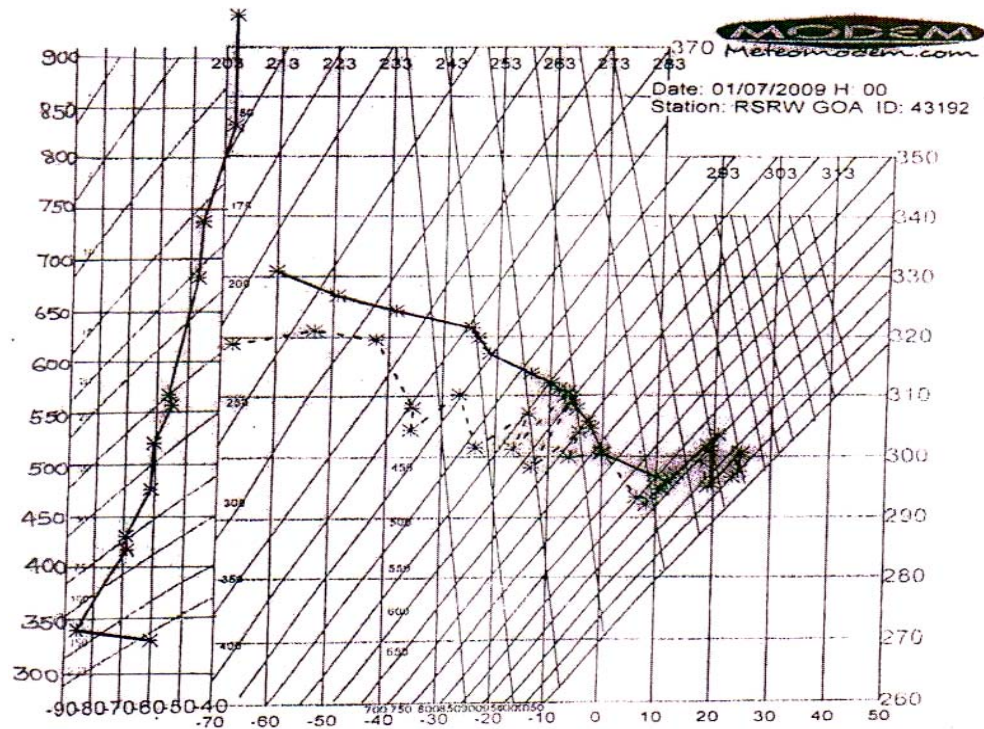


Fig. 3(b). T-Phigram of GPS on 1st July 2009, 0000 UTC shows the freezing level at 550 hPa before the heavy rainfall day on 2nd July 2009

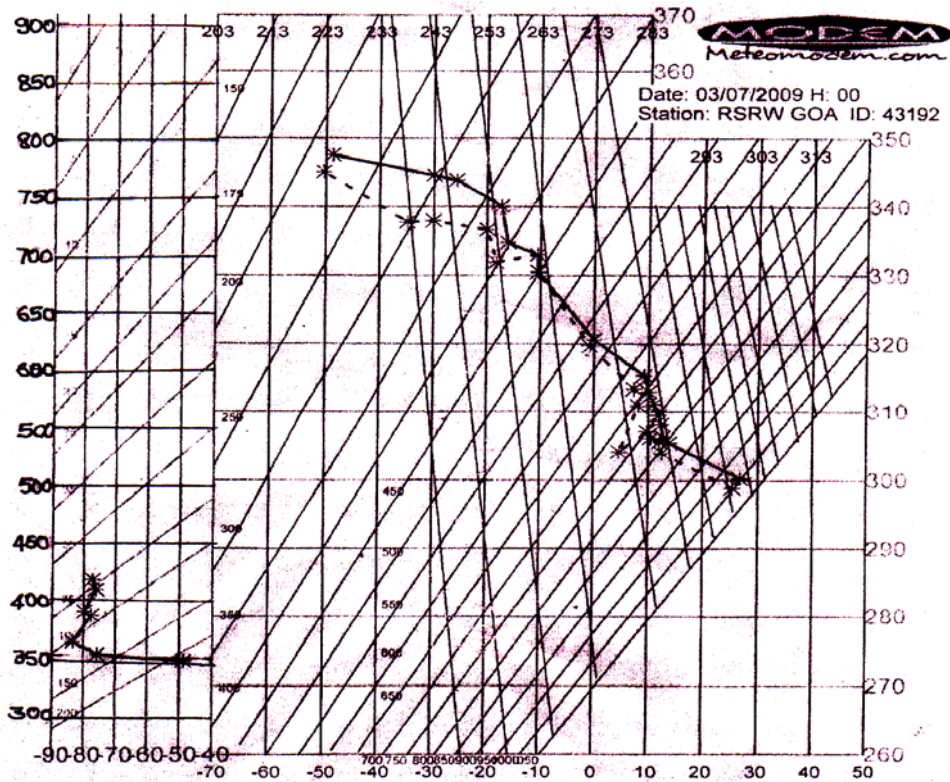


Fig. 3 (c). T-Phigram of GPS ascent on 3rd July 2009, 0000 UTC shows the freezing level at 450 hPa before the heavy rainfall day on 4th July 2009

results observed shows that accuracy in M2K2 is smaller than the Mark IV Radiosonde. The atmospheric pressure values calculated from the geometric altitude from GPS data, air temperature and humidity obtained from Radiosonde sensors. The related T-Phigrams are shown in the Figs. 2 (a&b). It is found that there are no significant changes and almost resembles each other for both sondes.

7. Heavy rainfall events

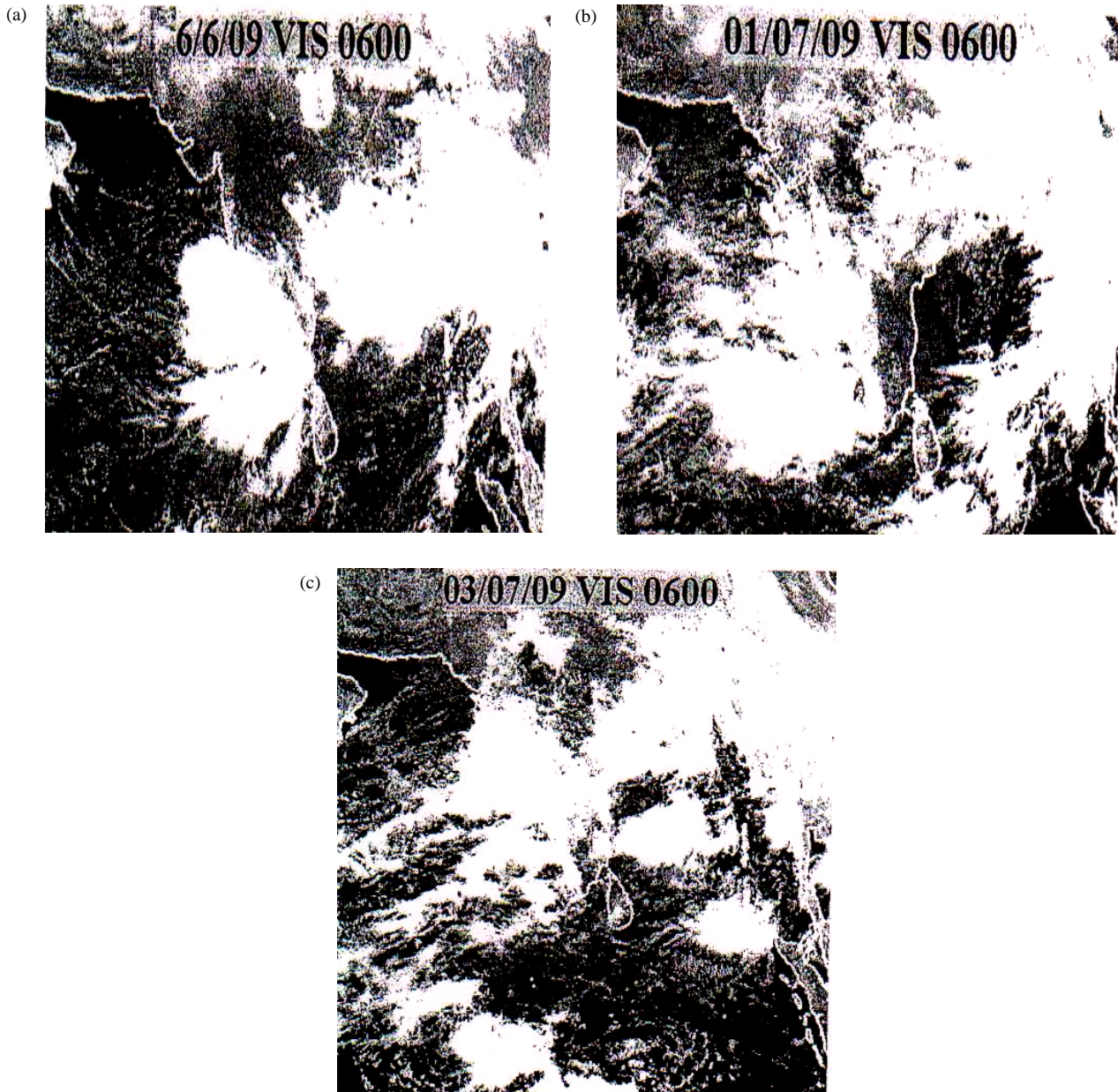
Some of the heavy rainfall cases occurred over 11 stations in Goa has studied for the days 6th June 2009, 1st July 2009 and 3rd July 2009. Exceptionally heavy rainfall recorded on 7th June 2009, 2nd July 2009 and 4th July 2009 at some stations in Goa. The highest rainfall of 432.6 mm during 24 hrs was recorded at Sanguem on 4th July is shown in the Table 2.

The 0000 UTC GPS Sonde ascents on 06 July 2009 and 01 July 2009 shows the freezing level appeared at 550 hPa. The freezing level on 03 July 2009 0000 UTC GPS Sonde ascents shows at 450 hPa.

The temperature difference between the surface and the level 850 hPa during the days was 5.3° C, 6.3° C and 8.4° C respectively. The wind available at 850 hPa in these events was 10.3 knots, 10.9 knots and 21.9 knots. This indicates that during heavy rainfall events the wind speed was less than 22 knots at the level 850 hPa.

Shymala *et al.*, (2001) had explained on the event of heavy rainfall on 13th July 2001 in North Konkan region and Kumar *et al.*, (2007) observed impact of low level Jet on heavy rainfall events over Mumbai. They mentioned in the earlier studies that effect of offshore trough, low level circulation etc. along west coast may not always results in very rains over Konkan region.

The T-Phigrams of GPS Sonde ascents taken on 6th June 2009, 1st July 2009 and 3rd July 2009 over Goa are shown in the Figs. 3 (a-c). The NOAA Satellite pictures obtained during the period are shown in the Figs. 4 (a-c). The T-Phigram presents in the Fig. 2(a) shows the availability of moisture from surface to 120 hPa and existence of 90% humidity up to 400 hPa. In the region



Figs. 4(a-c). Shows the NOAA satellite cloud picture on (a) 6th June 2009 at 0600 UTC, (b) 1st July 2009 at 0600 UTC and (c) 3rd July 2009 at 0600 UTC passing over Konkan and Goa

between 500 hPa and 600 hPa level the temperature and dew point temperature are equal and indicates where the GPS Sonde has passed through saturated air cloud as shown in Fig. 2(a). The NOAA satellite cloud pictures obtained on the same day clearly indicates the convective cloud passing over Konkan and Goa coast. An average of 172.0 mm rainfall recorded for the next above mentioned days at all 11 raingauge stations in Goa. Some exceptional heavy rainfall also recorded on 7th June 2009, 2nd July

2009 and 4th July 2009 with highest rainfall of 432.06 mm at Sanguem on 4th July 2009.

8. Conclusions

(i) M2K2 GPS Sonde provides automatically launch ground pressure to the software. Due to built in barometer in the ground station SR2K2. No risk to forget updating of pressure value at ground level before launch.

(ii) Indoor initialization of Radiosonde is possible and no longer necessary to place it in outdoor.

(iii) No pressure sensor is required in GPS Sonde. Pressure is calculated from GPS altitude and temperature and humidity parameters according to Laplace Law. No need of Radar for the upper air wind. GPS wind finding is based on differential calculation which provides position and speed component.

(iv) T-Phigrams obtained from Goa ascents show that before the heavy rainfall day more than 90% humidity exists between the levels of 700 hPa to 500 hPa.

(v) The T-Phigrams obtained from the observations of M2K2 GPS Sonde show reliable thermodynamic characteristics. The T-Phigram is useful in forecasting of heavy rainfall over Goa. The wind at levels 850 hPa for all heavy rainfall occasions studied and found weak (less than 22 knots) over Goa.

(vi) The atmospheric upper air data from M2K2 allows higher vertical atmospheric observation with smaller accuracy in comparison with Radiosonde Mark IV.

(vii) The GPS Sonde will acquire reliable wind finding data in most.

Acknowledgements

The author is thankful to the Director General of Meteorology, New Delhi for introducing GPS Sonde system in IMD and providing facilities for the research work. The author is also thankful to Shri A. B. Halki, S A for his assistance.

References

- Kumar, Vinod, Bhagat, D. K. U. Kumar, M. Satya and Ganesh, Shiv, 2007, "Impact of low level jet on heavy rainfall events over Mumbai", *Mausam*, **58**, 2, 229-2490.
- Rust., W. David, 1999, "Test of GPS Sonde in thunderstorm Electrical Environments", *Journal of Atmospheric and Oceanic Technology*, **16**, 550-559.
- Shymala, B. Iyer, Shinde, B. G., Naire, G. N., Sushama and Burte M., 2001, "A satellite synoptic statistical study of very heavy rainfall in Konkan and Gujarat", *TROPMET* 2001, 137-142.
-