Comparison of Wind data of Ultrasonic wind sensor with Dyne Tube Pressure Anemograph wind sensor and its performances in Indian Subcontinent

Anjit Anjan, Manish Ranalkar, B.Amudha, Rudra Pratap & Dr. R.D.Vashistha

O/o Dy. Director General of Meteorology (Surface Instruments),
India Meteorological Deaprtment, Shivaji Nagar, Pune-411 005
INDIA
Telephone: +91-20-25535411, Telefax: +91-20-25521529 E-mail: anjit_anjan@yahoo.com

Abstract

India Meteorological Department has established a network of 125 state-of-art Automatic Weather Stations during 2006-2007. In earlier IMD network of Automatic weather station, conventional mechanical wind sensors (IMD make) have provided adequate wind data. Cup and vane or propeller and vane anemometers sense the force of the wind through mechanical means. It has serviceable parts and always requires maintenance. In view of this problem, Ultrasonic wind sensor (Gill make) has been used in the expanded 125 network of Automatic Weather Station. It is robust, lightweight unit with no moving parts. It has no serviceable parts, requires no calibration at field site and maintenance free. Its performance and calibration has been also verified in IMD wind tunnel. Its performances have been monitored since installation and data have been compared with collocated IMD's Dyne Pressure Tube Anemograph(DPTA) wind sensor. The Ultrasonic wind sensor data have been compared with Dyne Pressure Tube Anemograph at Pune and Kolkata. The comparison of wind data is being done where both sensors are kept at same height (10 meters above ground as per WMO guidelines).The 3 minutes vector averaging of Wind data in Ultra Sonic wind sensor has been done as per Synoptic observation. The performances of Ultra Sonic wind sensor in expanded network of Automatic Weather Station are very encouraging since their installation.

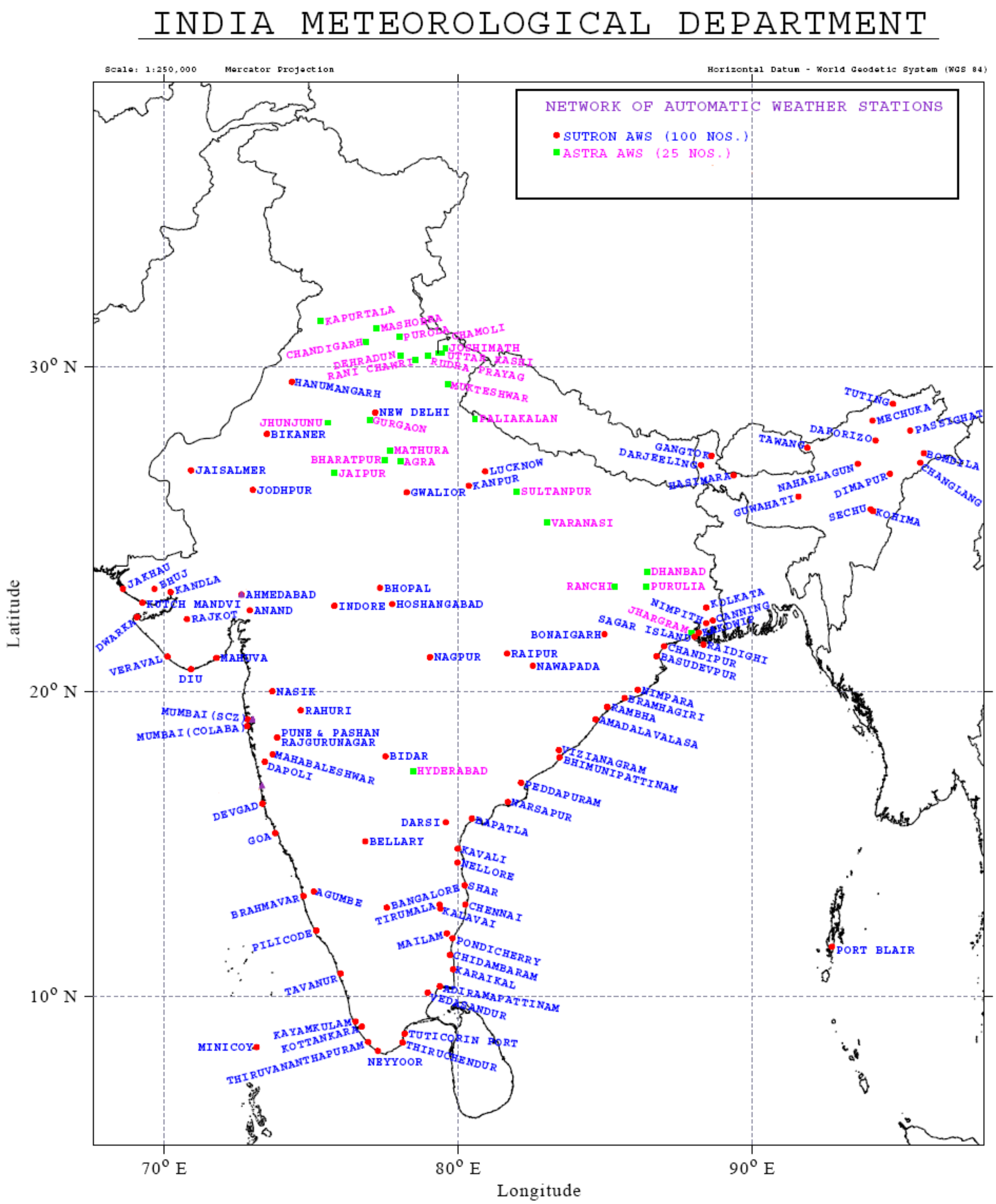

INDIA METEOROLOGICAL DEPARTMENT
Scale: 1:250,000
Mercator Projection
Horizontal Datum - World Geodetic System (WGS 84)
NETWORK OF AUTOMATIC WEATHER STATIONS
SUTRON AWS (100 NOS.)
ASTRA AWS (25 NOS.)
30° N
20° N
10° N
70° E
80° E
90° E
Latitude
Longitude
KAPURTALA
CHANDIGARH
CHAMOLI
JOSHIMATH
HANUMANGARH
MUKTESHWAR
NEW DELHI
GURGAON
JHUNJUNU
BIKANER
PALIAKALAN
MATHURA
BHARATPUR
AGRA
JAIPUR
JAISALMER
JODHPUR
LUCKNOW
KANPUR
GWALIOR
SULTANPUR
VARANASI
TUTING
MECHUKA
PASSIGHAT
DAPORIZO
TAWANG
GANGTOK
DARJEELING
BOMDILA
NAHARLAGUN
DIMAPUR
CHANGLANG
GUWAHATI
SECHU
KOHIMA
JAKHAU
BHUJ
KANDLA
AHMEDABAD
BHOPAL
DHANBAD
RANCHI
PURULIA
KUTCH MANDVI
ANAND
INDORE
HOSHANGABAD
KOLKATA
NIMPITH
CANNING
JHARGRAM
SAGAR ISLAND
DWARKA
RAJKOT
BONAIGARH
VERAVAL
MAHUVA
NAGPUR
RAIPUR
CHANDIPUR
RAIDIGHI
BASUDEVPUR
NAWAPADA
DIU
NASIK
NIMPARA
BRAMHAGIRI
RAHURI
RAMBHA
MUMBAI (SCZ)
MUMBAI (COLABA)
PUNE & PASHAN
RAJGURUNAGAR
AMADALAVALASA
BIDAR
VIZIANAGRAM
BHIMUNIPATTINAM
MAHABALESHWAR
DAPOLI
HYDERABAD
PEDDAPURAM
NARSAPUR
DEVGAD
DARSI
BAPATLA
GOA
BELLARY
KAVALI
NELLORE
SHAR
AGUMBE
BANGALORE
BRAHMAVAR
TIRUMALA
CHENNAI
KALAVAI
PILICODE
MAILAM
PONDICHERRY
CHIDAMBARAM
KARAIKAL
PORT BLAIR
TAVANUR
ADIRAMAPATTINAM
VEDARANYAM
KAYAMKULAM
KOTTANKARA
TUTICORIN PORT
MINICOY
THIRUCHENDUR
THIRUVANANTHAPURAM
NEYYOOR

Fig. 1

1. Ultrasonic Wind Sensor

1.1. Introduction:

Ultra sonic wind sensors had been in use since the 1950's, but in the early days were very expensive to produce, were fragile and prone to failure and required a lot of maintenance. Sonic anemometers as replacements for conventional mechanical anemometers have been in production since the early1990's and have to date gained acceptance by the user community. As new materials, solid-state electronics and the proliferation of the microprocessor became a reality, the cost to produce a sonic anemometer started rivaling the conventional wind sensors. This new generation of sonic anemometers does not have the response, maintenance and icing problems associated with conventional, mechanical wind sensors.

1.2. Principle and sensor details:

Sonic anemometers operate on the principle that the time required for a sound wave to travel from point A to point B is affected by the speed of the wind in a predictable and repeatable way. It is easy to install and maintain because of lightweight and compact, and has no moving parts. For operation in areas where frequent extreme icing conditions will be encountered, built-in, thermostatically controlled heaters are available. Sonic anemometers are provided with a built-in, flux-gate compass, which automatically references the wind direction output to magnetic north, regardless of the sensors orientation. This compass feature, combined with our sensors small size, low weight and low power requirements makes it very easy to transport and deploy for short-term studies. These features also make it the ideal sensor for providing meteorological data input to a computer that performs real time dispersion calculations at an accidental spill or release of hazardous materials. A sonic anemometer measures the wind using the principles described above without any moving mechanical devices, i.e. there are no physical constraints on the sensor response due to mechanical friction, aerodynamic drag, lift or transducer mass. A sonic anemometer is an instrument that exhibits an instantaneous response, has zero threshold, no delay distance and is critically damped. The accuracy of the wind speed measurement is the same as the resolution (0.1 m/s) and is only limited by the electronics of the sensor.

It is easy to install and maintain because of lightweight and compact, and has no moving parts. For operation in areas where frequent extreme icing conditions will be encountered, built-in, thermostatically controlled heaters are available. Sonic anemometers are provided with a built-in, flux-gate compass, which automatically references the wind direction output to magnetic north, regardless of the sensors orientation. This compass feature, combined with our sensors small size, low weight and low power requirements makes it very easy to transport and deploy for short-term studies. These features also make it the ideal sensor for providing meteorological data input to a computer that performs real time dispersion calculations at an accidental spill or release of hazardous materials. A sonic anemometer measures the wind using the principles described above without any moving mechanical devices, i.e. there are no physical constraints on the sensor response due to mechanical friction, aerodynamic drag, lift or transducer mass. A sonic anemometer is an instrument that exhibits an instantaneous response, has zero threshold, no delay distance and is critically damped. The accuracy of the wind speed measurement is the same as the resolution (0.1 m/s) and is only limited by the electronics of the sensor.

This type of sensor likely to become a natural roosting or nesting spot for birds. In addition, misalignment of the transducers due to bent support arms is another potential problem. Ice build-up on the transducer will degrade the sensor performance and often damage the transducer(s) to the point where the data produced by the sensor is no longer meaningful.

At low wind speeds, a small error in the measurement along one axis may lead to a relatively large error in the calculated wind direction. Therefore most sonic anemometers do not define wind direction accuracy below a minimum wind speed. This threshold speed varies by manufacturer and configuration.

2. Wind sensor in IMD network of Automatic weather station:

2.1 Gill wind sensor

The Gill Wind sonic sensor has been installed in 125 network of Automatic Weather Station in India and is shown in Fig.1 It is robust, lightweight unit with no moving parts. It has no serviceable parts, requires no calibration at field site and maintenance free. Their performance and calibration was evaluated in IMD wind tunnel before they deployed in field site. Authors have evaluated the performance of these sensors with collocated Dyne Pressure Tube Anemograph (DPTA).The study shows that the performance of Ultrasonic wind sensor is found satisfactory and they could be used for operational use as a replacement of conventional wind sensor. The performance of Wind sonic sensor was found to be accurate and comparable. Its principle of operation is as follows:

2.2. Principle of Wind sonic sensor

The principle of wind sonic is based on Doppler shift principle. It has four transducers which are in all four directions-North, South, East and West. The wind sonic measures the time taken for an ultrasonic pulse to travel from one transducer (North Direction) to another transducer (South direction) and compares it with the time for a pulse to travel from transducer (South direction) to transducer (North Direction).Similarly same case is repeated for East and West transducers.

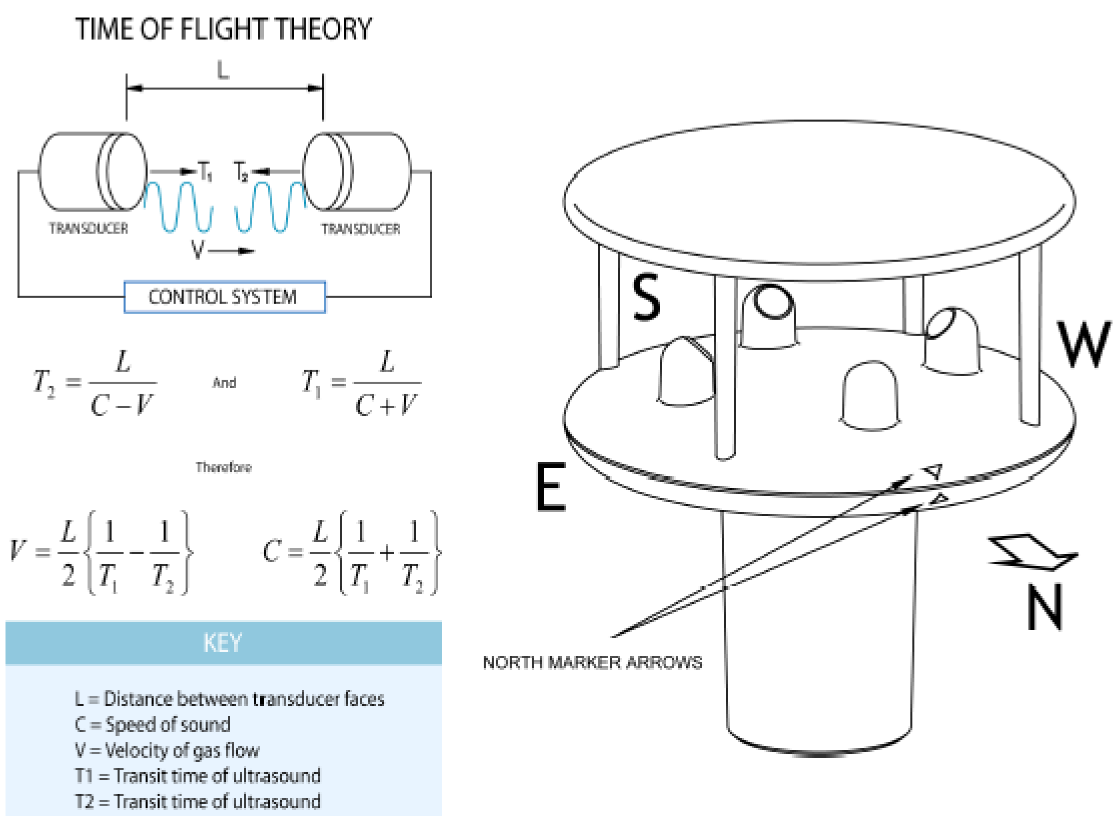


Fig 2

3. Dynes Pressure Tube Anemograph*:*

The Dyne Pressure Tube Anemograph is an instrument for the continuous recording of the instantaneous value of wind speed and wind direction on a single chart so that the wind is completely described as vector quantity. Wind direction is measured and recorded by means of a wind vane and a mechanical twin pen recorder. Wind speed is measured by means of a pitot static tube and recorded by a sensitive float manometer. The pitot-head is kept facing the wind by means of the vane and as the wind blows into the mouth of the tube, it produces an increase in pressure in it proportional to the square of the wind speed (called pressure tube).The wind blowing the suction holes below the arm of the vane produces a decrease of pressure inside the suction tube.The difference in pressure in the pressure tube and suction tube is directly proportional to the square of the wind and is recorded by the float manometer on chart wound on a clockdrum.

4. Comparison of Wind data of Ultrasonic Wind Sensor and Dynes Pressure Tube Anemograph:

The principle of operation of Ultrasonic Wind Sensor and Dyne Pressure Tube Anemograph (DPTA) are different. The DTPA wind has threshold of 1 knot whereas Ultrasonic Wind Sensor has zero threshold. The accuracy of Wind speed and wind direction of Ultrasonic Wind Sensor are as +/- 2% and +/-3%.The error in DPTA is not more than 1 knot in a steady wind and 2-3 knots at all speeds. The sensor of both method are kept at a same height (10 metre above as WMO recommendation).As per WMO, an accuracy for horizontal wind speed of 0.5 m/s below 5 m/s and better than 10% above 5 m/s is sufficient for weather monitoring and forecasting, wind load climatology, wind energy, estimation of surface fluxes-evaporation, air pollution dispersion and agriculture applications and probability of wind damage. Wind direction should measure an accuracy of 5 degree.

4.1 Comparisons of Wind data of AWS and DPTA at CAGMO, Pune is shown below (Fig 3).

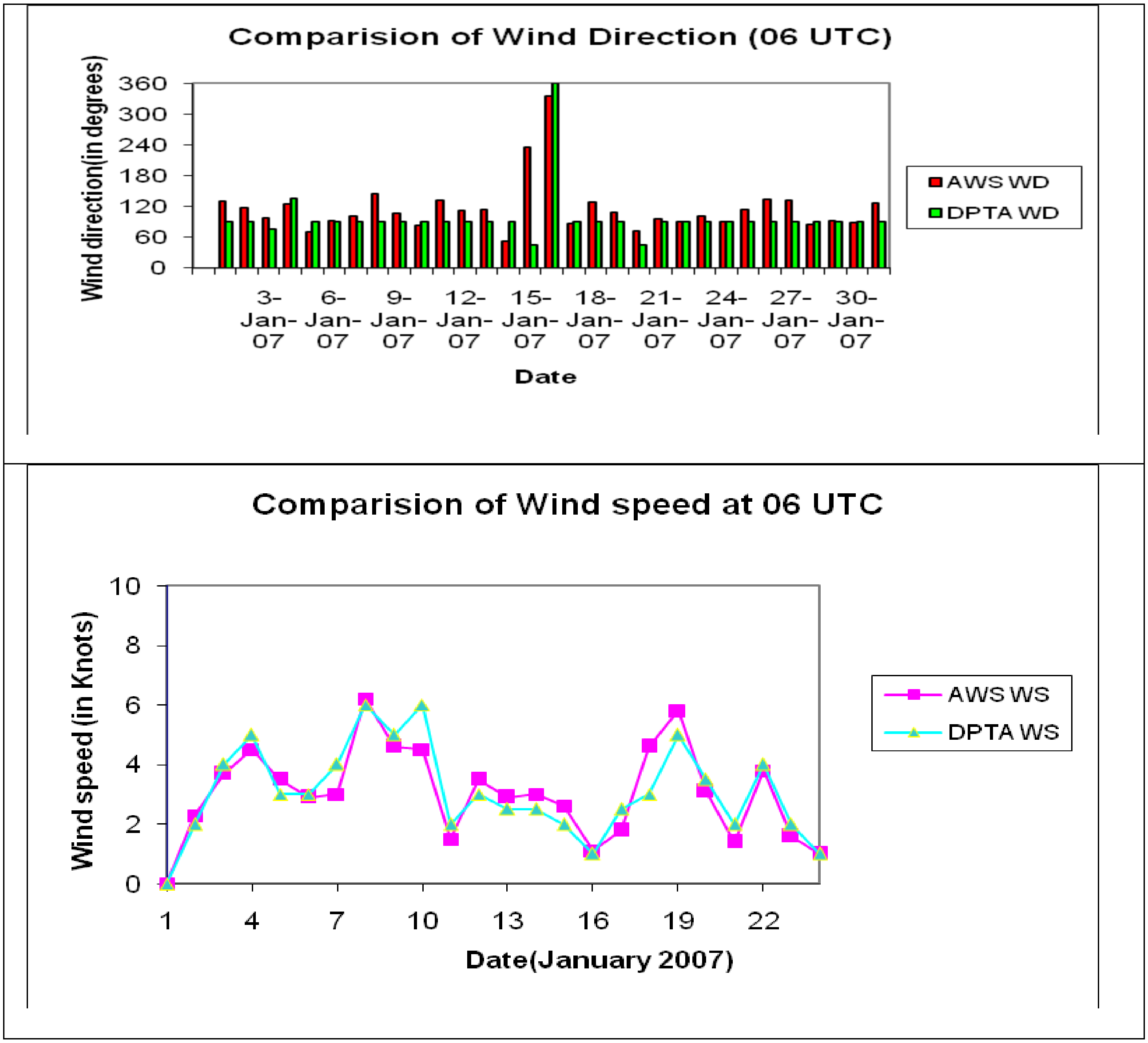
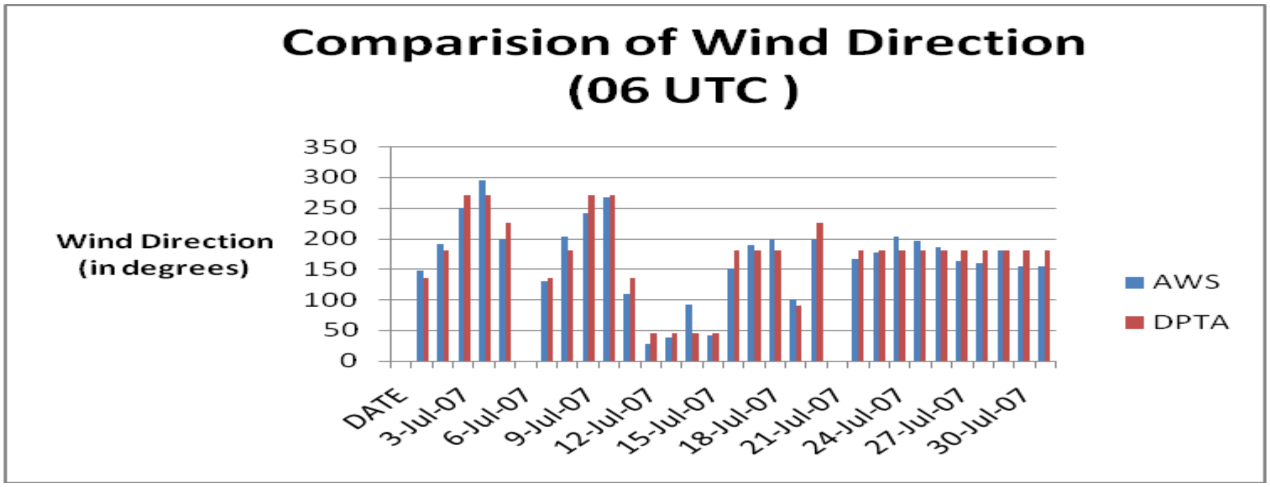


Fig.3

4.2 Comparisons of Wind data of AWS and DPTA at M.O. Kolkata is shown below Fig.4:



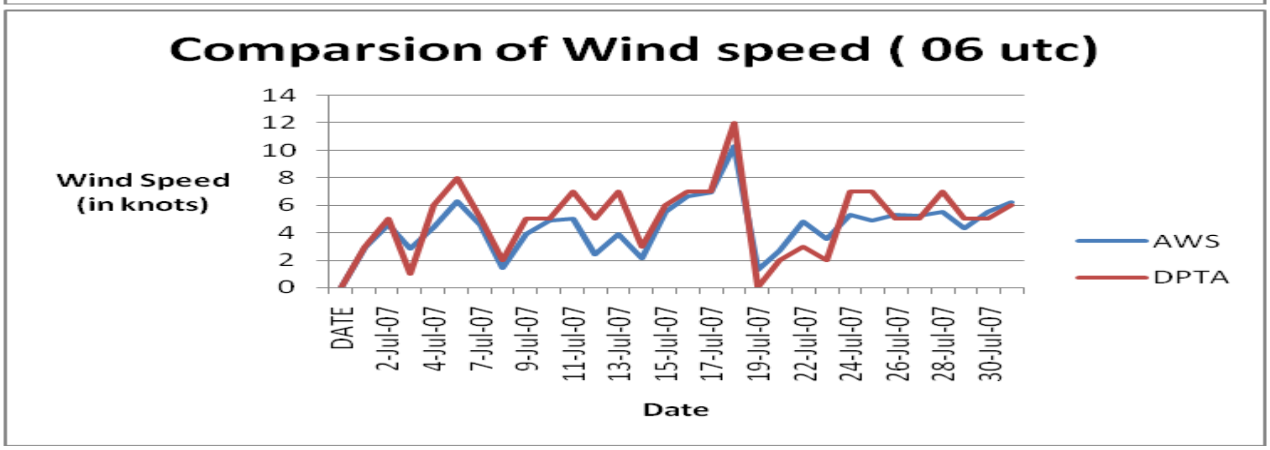


Fig.4

4.3. Performances of Ultra wind sonic sensor in Indian Subcontinent:

The wind data during June, 2007(SW Monsoon period) of Ultra sonic wind sensor in East coasts and West coasts of India have been analyzed and graphs are drawn.

The wind data of four AWS stations along east coast have been analyzed and are Shown (Fig 5 and 6). The locations of automatic weather stations are Sagar Island (Lat. 21.7˚ E, Long. 88.1˚ N), Vizianagaram (Lat. 18.1˚E, Long. 83.4˚ N), Chennai (Lat. 13.1˚ E, Long 80.2˚ N) and Karaikal (Lat. 10.9˚ E, Long. 79.8˚ N).

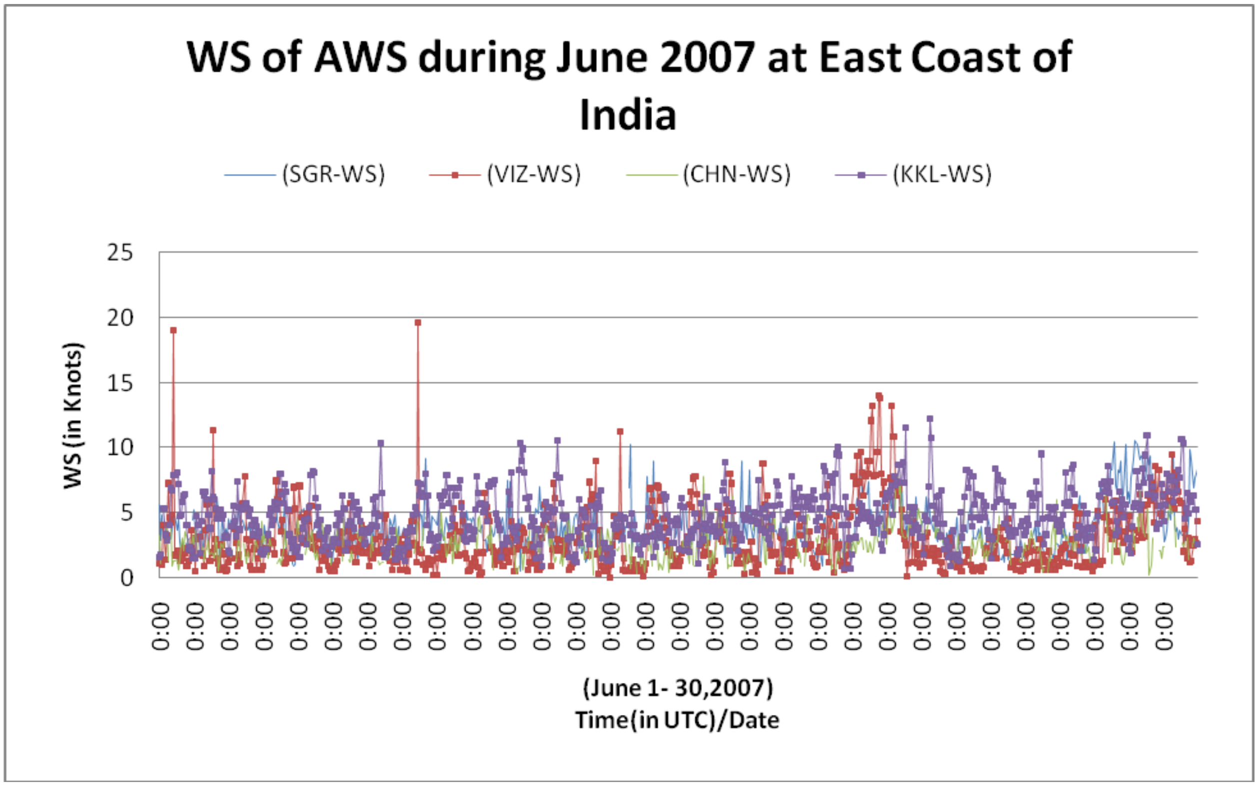

WS of AWS during June 2007 at East Coast of India
(SGR-WS)
(VIZ-WS)
(CHN-WS)
(KKL-WS)
WS (in Knots)
25
20
15
10
5
0
0:00
(June 1- 30,2007)
Time(in UTC)/Date

Fig. 5

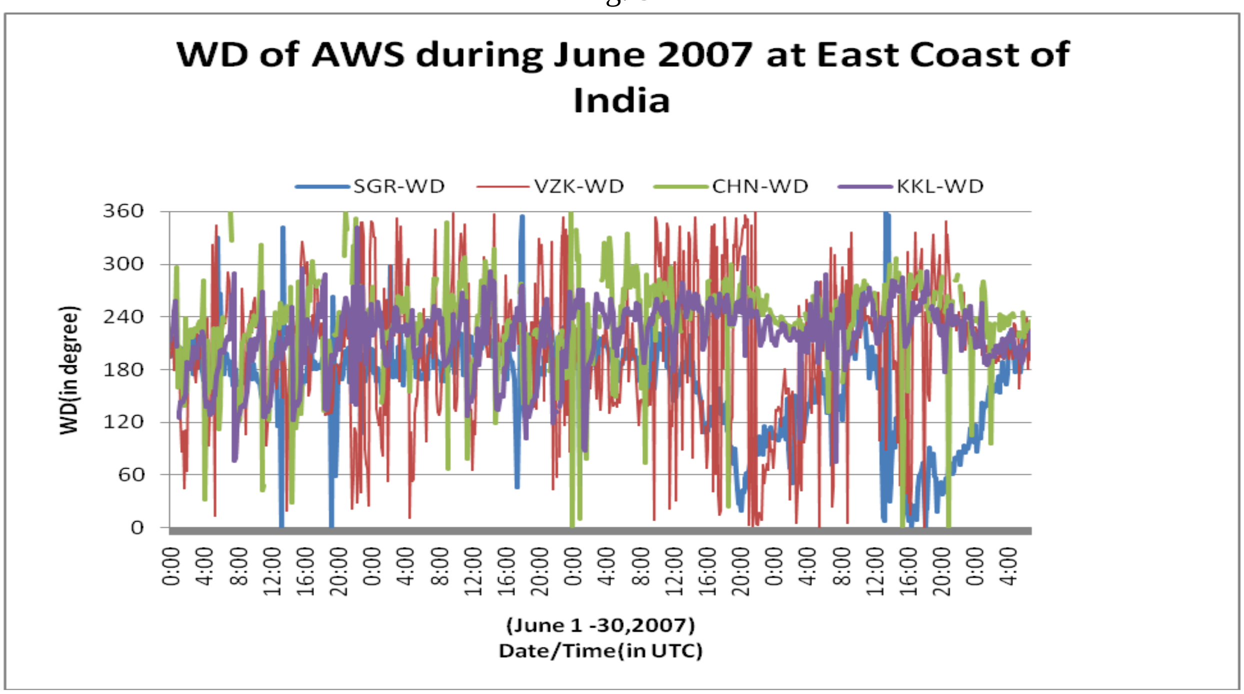

WD of AWS during June 2007 at East Coast of India
SGR-WD
VZK-WD
CHN-WD
KKL-WD
WD(in degree)
360
300
240
180
120
60
0
0:00
4:00
8:00
12:00
16:00
20:00
(June 1 -30,2007)
Date/Time(in UTC)

Fig.6

The wind data of four AWS stations along west coast have been analyzed and are shown (Figs 7 and 8). The locations of automatic weather stations are Thiruvananthapuram (Lat. 08.3˚ E, Long. 76.9˚ N), Goa (Lat. 15.4˚E, Long. 73.8˚ N), Mumbai Santa Cruz(Lat. 19.1˚ E,Long 72.8˚ N) and Dwarka(Lat. 22.4˚ E, Long. 69.1˚ N).

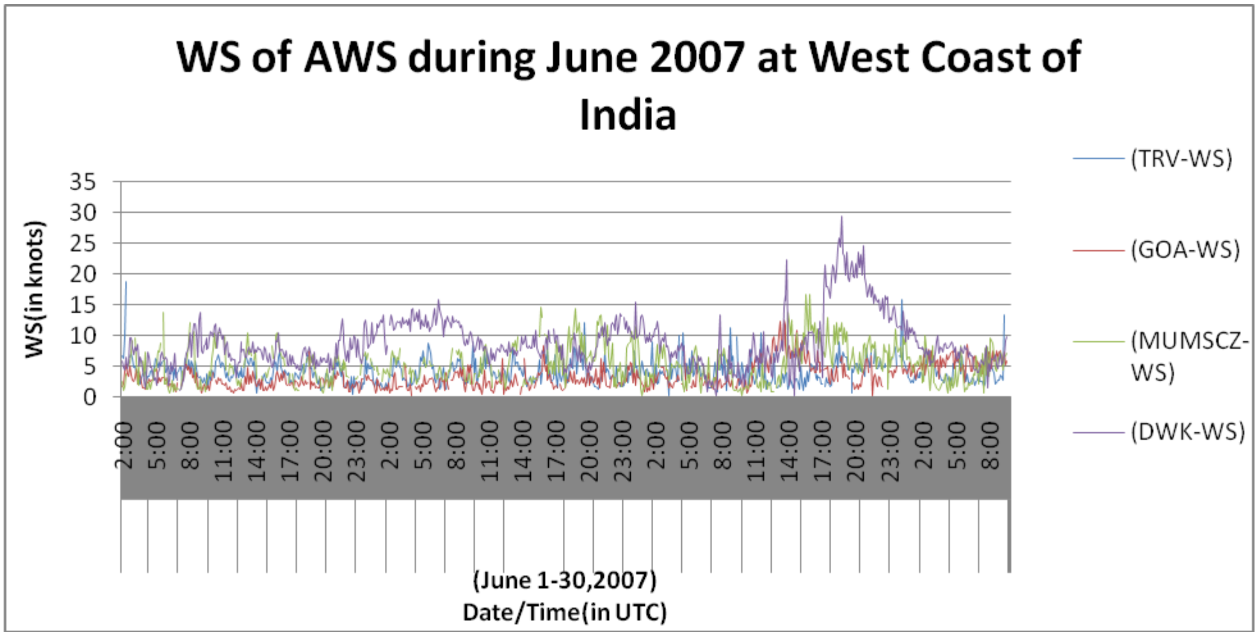


Fig.7

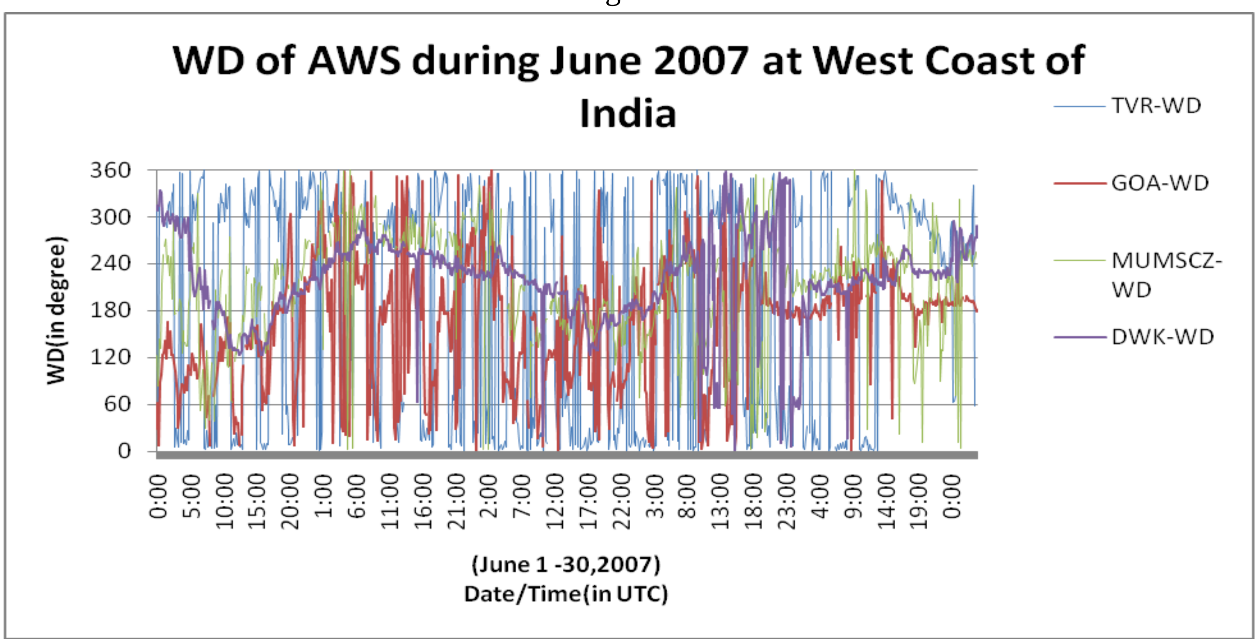


Fig. 8

5. Conclusions:

Comparisons of AWS wind data for M.O., Kolkata and CAGMO, Pune has been done. The wind data are comparable and useful for weather monitoring and forecasting, wind load climatology, wind energy, estimation of surface fluxes-evaporation, air pollution dispersion and agriculture applications and probability of wind damage.

The wind data of east coast and west coast of India during SW Monsoon period (June,2007) has been analyzed and found useful for weather monitoring and forecasting. Studies should that the wind measured by ultrasonic wind sensor on the coastal status of India compared well within the wind recorded manual wind measuring equipment of IMD at these stations.

6. Acknowledgement*:*

The authors are thankful to the Director General of Meteorology, New Delhi for continuous encouragement and guidance during establishment of the Network of 125 AWS.

7. References:

1. Vashistha R.D., S. Balachandran, R. Pratap and S.K. Dikshit, "Data Comparison between AWS and Conventional Method of Observations". Proceedings of TROPMET-2000.
2. Vashishtha R.D., B. Amudha and Rudra Pratap, 2005: "Present Status of Surface Meteorological Observations in India", WMO Technical Conference on Instruments and Methods of Observation (TECO 2005).
3. Manual of Gill Wind Sonic Sensor.
4. Instructions for the use and care of Dyne Pressure Tube Anemograph, Instrument section, Meteorological office, Pune.
5. WMO Guide (Chapter 5 ,Measurement of surface wind)

***************** ************** *****************