iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53925

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Wind Profiler for Understanding of Meiyu at Dongshan

D. Kothandan[1], P.V. Ramana Moorthy[2], V. Adinarayna[3]
[1]Department of Physics, Sreenivasa Institute of Technology and Management Studies, Chittoor, Andhra Pradesh, India
[2] Department of Physics, Sreenivasa Institute of Technology and Management Studies, Chittoor, Andhra Pradesh, India
[3]Department of Physics, Rayalaseema University, Kurnool, Andhra Pradesh, India

Abstract: To understand the Meiyu Boundary layer evolutionand vertical structure of precipitating cloud systems over Dongshan, special observational campaigns have been conducted downstream of the Yangtze River during June and July in the years 2001 and 2002. We deployed a Lower Atmospheric Wind Profiler (LAWP) with Radio Acoustic Sounding System (RASS) at the Meteorological Observatory, Dongshan within a mesoscale network that consists of three X-band Doppler radars, three AWS, and Micro rain radar to observe the inner structure of precipitating cloud systems seen frequently in the observational area. The LAWP provides vertical profiles of three-dimensional wind, vertical structure of the precipitating cloud system, convective boundary layer (CBL), and temperature from the (RASS) lower atmosphere with a height resolution of 60 m to 200 m and a time resolution of about 1 to 60 minutes. LAWP had been operated in two modes: low mode and high mode up to 4 km and 11 km height during non-rainy and rain conditions, respectively. A study was carried out during an intensive observational period (IOP-2001 and IOP-2002) to understand the pre-convective environments in the boundary layer during pre-Meiyu and Meiyu convective days to find out whether there is any precursor before the convection triggering. Further in Meiyu precipitating cloud systems, the reflectivity vertical structure can be used to identify the range of precipitation processes from the young, dynamically vigorous cells to the mature, bright band resolved stratiform rain.

I. INTRODUCTION

The improvement of short-term synoptic weather forecasts as well as numerical weather predictions requires a new type of data concerning information on the mesoscale kinematic and thermodynamic structure in time and spatial (vertical). The standard method for sounding the planetary boundary layer (PBL) and free atmosphere using radiosondes is not able to provide data with the necessary temporal and spatial resolution for mesoscale analyses given an acceptable economic effort [Stull, 1988]. The application of remote sensing techniques to the PBL has started to realize some of its promise. Even the fair-weather boundary layer responds well to remote sensing because radars ``see'' refractive-index fluctuations. Ground-based L-band wind profilers employing three or five stationary beams looking at angles close to vertical have been proven useful in obtaining mean winds for several years [Reddy et al., 2001].

The atmospheric thermodynamic structure can be determined by exploiting the refractive index dependence on temperature and humidity, and through the use of radio-acoustic sounding (RASS) technique [May et al., 1988]. The vertical structure of the cloud systems leads straightforwardly to the identification of the bright band and stratiform precipitation. Mesoscale convective systems can be identified by disturbances above the melting level [Gage et al., 1994].

II. BRIEF DESCRIPTION OF EXPERIMENTAL SITES AND DATA-BASE

The wind profiler was installed along with an automatic weather station, the Institute of Low-Temperature Sciences, Hokkaido University X-band Doppler radar, and micro rain radar in the premises of the Dongshan Meteorological Observatory, in Suzhou prefecture, about 120 km west of Shanghai, PR China. The Dongshan site is ideal because of thesurrounding vegetation and some rural houses.

The site is on the peninsula of Taihu Lake, which is the largest in China about 2425 sq km. About 3 km on the west side of the site there are hills about 400 m high. The LAP has been operated continuously from 4 June to 16 July 2001 during the campaign and revealed several interesting meteorological phenomena during the intensive field experiments on the Meiyu frontal precipitation systems the downstream of Yangtze River in 2001. In this paper, we will briefly describe the 1290 MHz wind profiler with RASS and present an overview of its performance.

III. BRIEF DESCRIPTION OF LOWER ATMOSPHERIC WIND PROFILER RADIO ACOUSTIC SOUNDING SYSTEM

The lower atmospheric wind profiler (LAWP) operates on a radio frequency of 1290 MHz. The LAP has an electronically steered phased array antenna capable of producing five beams. Normally, the five beam directions are north, south, east, west, and vertical. The off-vertical beams are at an elevation of 74.5 degrees (15.5 degrees down from vertical). The effective antenna area amounts to 6.8 m^2 (9x 0.87 m x 0.87 m) by the symmetric arrangement of 3 x 3 antenna panels. Thus, using a pulse peak power of 800 W with a power-aperture product of 340 Wm^2. The LAP antenna is enclosed in a cluttered screen and covered by a radome. Figure 1 shows the wind profiler antenna with 4-Radio acoustic sounding system (RASS) speakers around it. The transmitter is capable of producing pulses of four lengths: 400, 700, 1400, or 2800 ns. These correspond to vertical resolutions of 58, 101, 202, or 410 meters. The inter-pulse period (pulse repetition frequency) is fully controllable, so the maximum range is limited only by the strength of the returned signals. A sampling of the returned signal (i.e. the range gates) can be done at intervals that are multiples of the pulse lengths. There is a reasonable level of control on all periods of intermediate processing. The transmit/receive unit is installed below the wind profiler antenna and converts the 1290 MHz signal, both transmitted and received signal to an intermediate frequency of 60 MHz. Furthermore, a special pulse shaping technique is used in the transmitter to achieve a low-frequency bandwidth (e.g. 2 MHz at 400 m resolution). The T/R interface is controlled by the radar processor, which also prepares the acoustic signals for the audio amplifier. The radar processor calculates the spectra, moments, wind, and temperature data and stores them in the radar computer.

The RASS system composed of four acoustic sources, one on each side of the profiler antenna (see Fig.1), transmits an acoustic wave directed vertically. For most of the experiment, the LAWP operated in RASS mode for 3 min every hour and the rest of the time in the normal wind mode described above. Generally, the speed of sound and the vertical velocity is measured simultaneously by a power spectral analysis with 2048 complex time series points using a Nyquist velocity of about 350 m/s. Thus, the clear-air signal near zero velocity as well as the RASS signal near the speed of sound (330 m/s) is measured simultaneously. Hence, a correction of the influence of vertical wind on the speed of sound is possible. This joint radio-acoustic sounding system usually estimates virtual temperature profiles with lower height coverage than the wind, due to the smaller height coverage of the acoustic emission, which also depends on the atmospheric conditions.

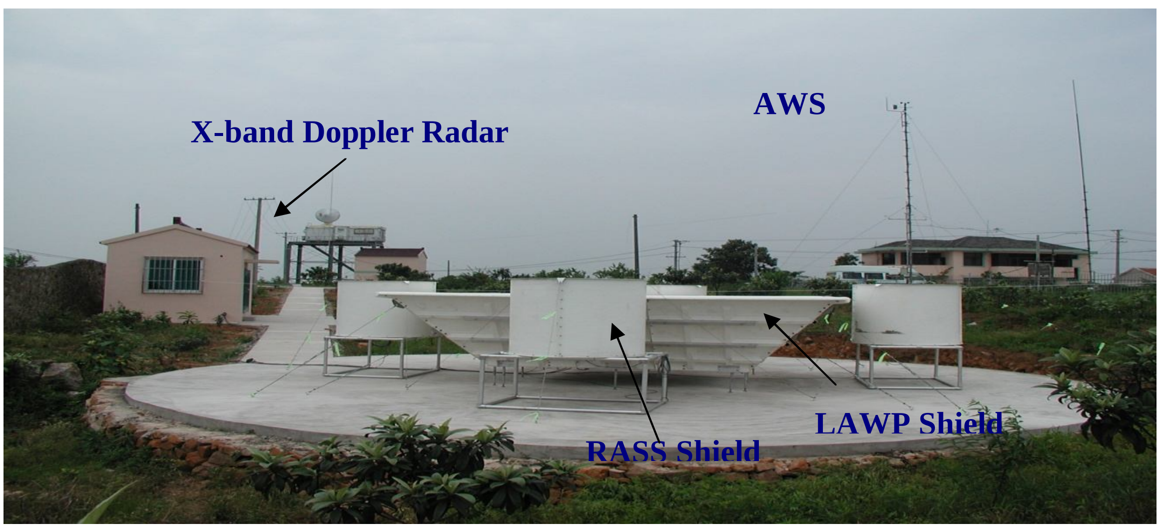


Fig.1 Wind profiler Antenna assembly

IV. OBSERVATIONAL RESULTS

Observations of the atmospheric wind profilers are useful to delineate the diurnal evolution of the PBL structure. Convective boundary layer (CBL) observations using wind profiler in this region are very few compared to other mid-latitude regions. The intensity of the signal-to-noise ratio (SNR) is determined by the refractivity turbulence seen by the LAWP, which depends on the strength of mechanical turbulence and the background refractive index gradient. Figure 2 shows a time-height cross-section of reflectivity (SNR) observed on 4 July 2001 (clear, sunny days). Two-day observations show that a thin enhanced reflectivity layer appeared in the morning (~0700 LT=local time) at about 200 m and ascended to about 1.0 km in the afternoon (~1300 LT).

After 1600 LT, the enhanced layer gradually disappeared. The boundary layer top as shown by the reflectivity plot on 4 July 2001, grew rapidly into the residual layer between 0930 and 1200 LT and then prevented from significant further growth by the strong and sharp capping inversion. At night, the CBL was replaced by a stable or nocturnal boundary layer. The LAWP cannot measure the height of the nocturnal boundary layer because it is at or below the minimum height of the profiler. It must be noted that such remarkable diurnal PBL variations on other clear days during the Meiyu season. Were observed. On cloudy days such features were weak or disappeared. On rainy days strong echoes caused by rainfall appeared, but are entirely different and distinguished from the typical behavior of clear-air echoes mentioned above. The top of a convective boundary layer is present as a distinctive signature in a time-height plot of reflectivity. Generally, a strong peak of reflectivity is seen at the boundary layer top, though the strength of this peak depends on a variety of factors. The reflectivity peak is the result of strong gradients of temperature and especially humidity. Such gradients, although not usually as strong, may also be present at the boundaries of other atmospheric layers.

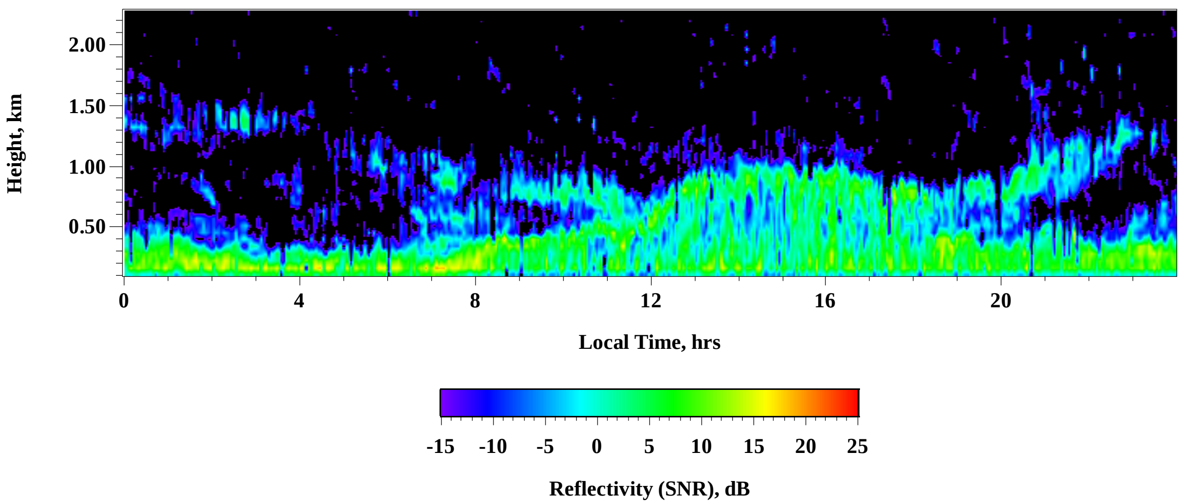


Fig.2 Time-height cross-section of the Reflectivity (SNR) for the vertical beam on 04 July 2001 (a clear sunny day)

The vertical coverage of the wind profiler and the RASS system depended on the meteorologicalconditionsasobserved in Figure 3, which shows a temporal sequence of the wind profiles on 04 July 2001 and varied throughout the day. The signal was lost on several occasions when the relative humidity was very low, and the above subsidence inversions occurred, the wind profiler did not encounter targets and the SNR degraded rapidly.

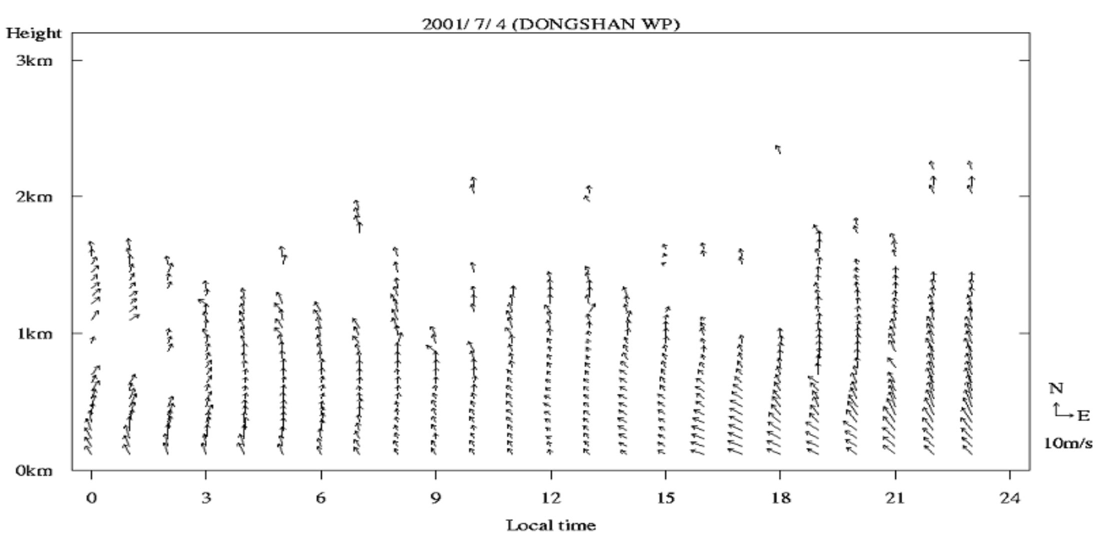


Fig. 3 Time-Height cross-section of wind vector measurement on 04 July 2001

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

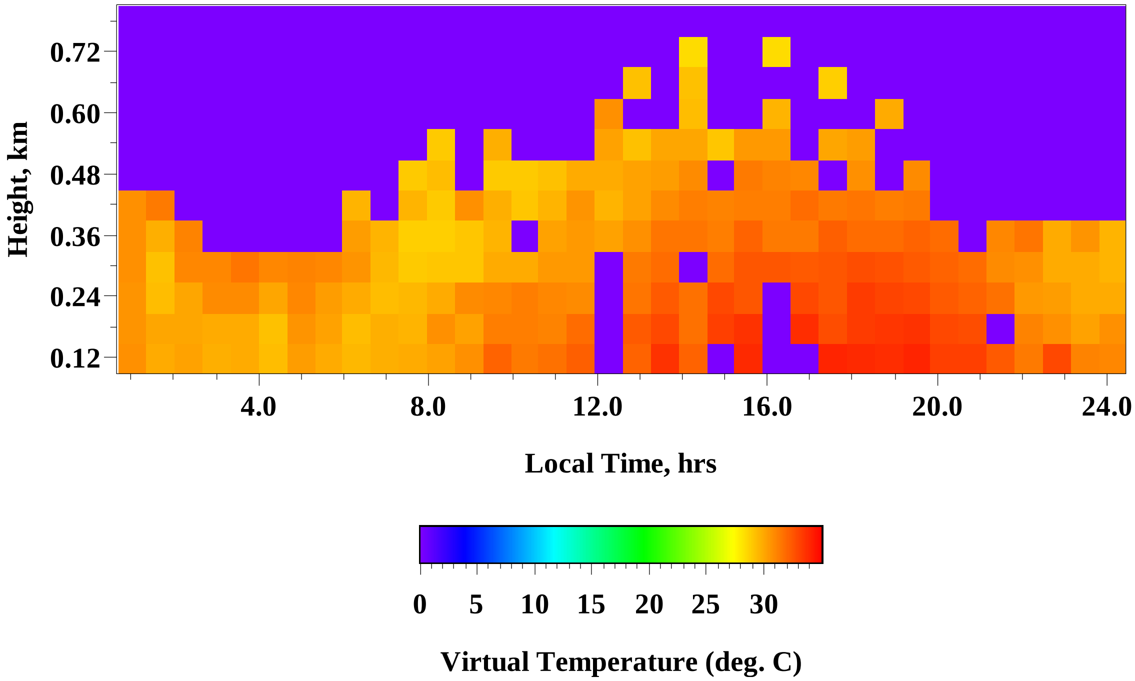


Fig.4 Time-Height cross-section of virtual temperatures on 04 July 2001

In Figure 4, the time heights cross-section of virtual temperatures for the clear day on 4 July 2001 is shown. A well-defined daily cycle of temperature, caused by a dry continental air mass can be seen. Thus, looking at the vertical temperature gradient, a surface inversion and its gradual decrease with time after sunrise (about 06:00 LT) can be noticed. Therefore, the LAWP/RASS can provide information on the mesoscale variations of the thermal structure of the boundary layer [Rogers et al. 1994; Angevine et al. 1994]. Another parameter, derivable by the LAWP system is the vertical movement of inversions i.e. Entrainment velocity.

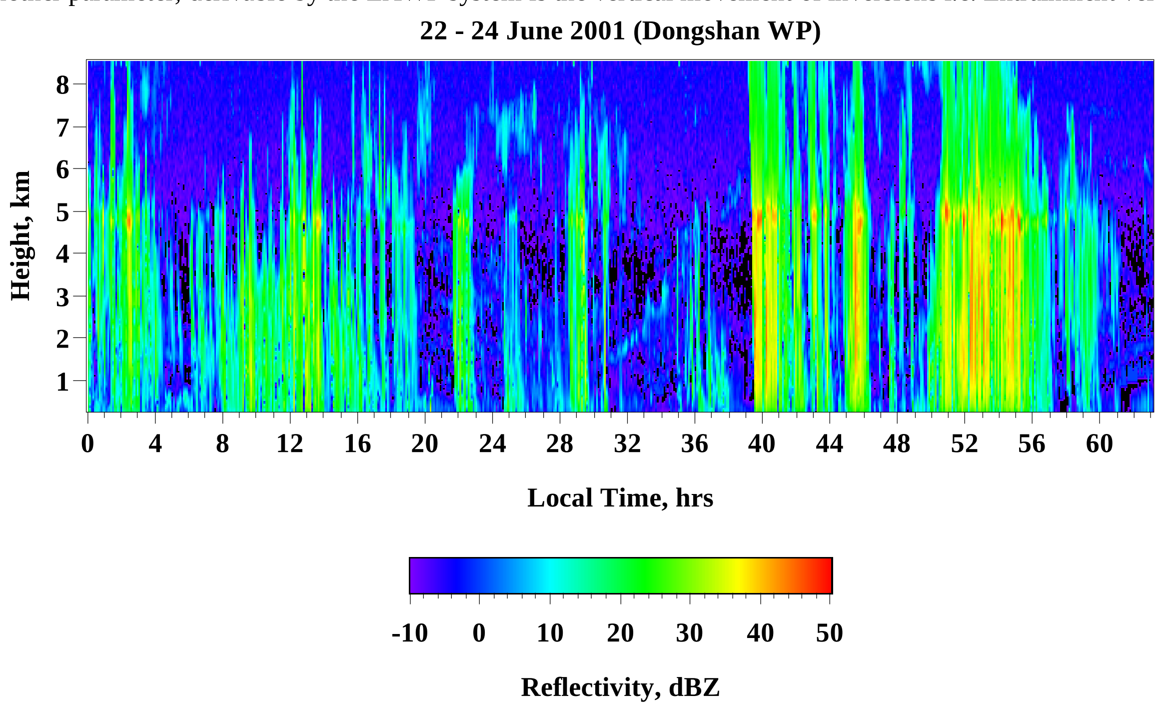


Fig.5 Time-height cross-section of reflectivity observed by the vertical beam of the LAWP on 22 and 24 June 2001

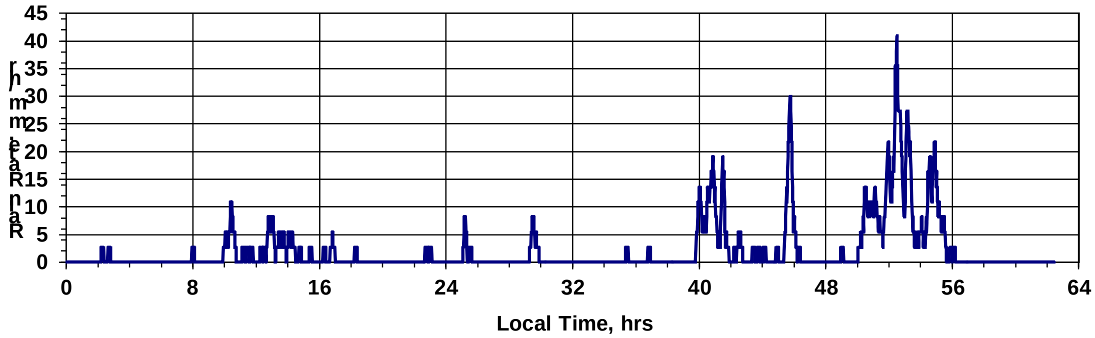


Fig.6 Time series of rain rate observed using AWS on 22 and 24 June 2001

The shape of the Doppler spectra is characterized by the first three spectral moment information about the hydrometeors in the precipitating cloud systems. The moments yield the reflectivity of the hydrometeors, the reflectivity-weighted fall speed of the hydrometeors, and the variance of the hydrometeor fall speeds within the observing volume. A time-height cross-section of equivalent reflectivity obtained from 22-24 June 2001 during the passage of the Meiyu frontal system is shown in Figure 5. This figure illustrates the LAWPs' potential for diagnosing the vertical structure of precipitating cloud systems. Several different types of vertical structures are evident in this figure during periods of rainfall observed at the surface [as shown in Figure 6], as the Stratiform/convective cloud systems pass over the profiler. On 22 to 24 June 2001 several times a bright band in the reflectivity and a melting layer signature of rapidly accelerating hydrometeor fall speeds below 4.6 km provides a clear example of stratiform rain. A heavier rain episode occurred between 15:30 LT and 17:00 LT on 23 June illustrating deep convection without a melting layer signature.

V. ACKNOWLEDGMENT

The authors are thankful to the China Meteorological Administration for their activity support for the intensive field experiments on the Meiyu frontal precipitation systems the downstream of Yangtze River in 2001. We greatly acknowledge the participation of the Doppler radar group of the Hydrospheric Atmospheric Research Center, Nagoya University, and the Institute of Low-Temperature Sciences, Hokkaido University for this campaign. We are also thankful to Frontier Observational System for Global Change, Yokohama for providing the necessary facilities to carry out the research work at PR China.

REFERENCES

[1] Angevine, W. M., A.B. White, and S.K. Avery, Boundary-layer depth and entrainment zone characterization with a boundary-layer profiler, Boundary-LayerMeteorol., **68**, 375-385, 1994.

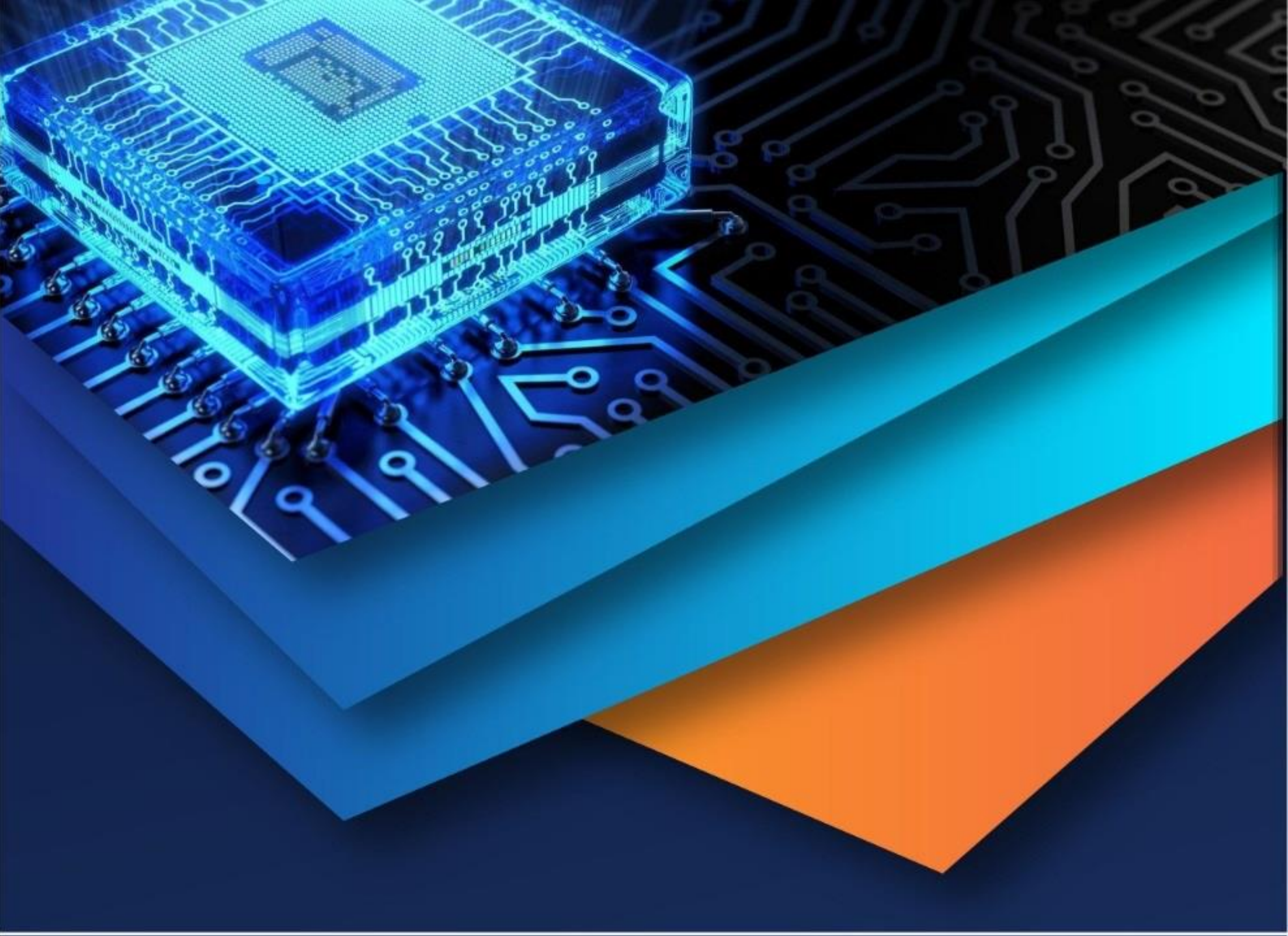
[2] Gage, K.S., C.R.Williams, and W.L.Ecklund, UHF wind profilers: A new tool for diagnosing tropical convective cloud systems, Bull. Amer. Meteorol. Soc., **75**, 2289-2294, 1994.

[3] Krishna Reddy.K.,T.Kozu, K.Nakamura, Y.Ohno, P.Srinivasulu, V.K.Anandan, A.R.Jain, P.B.Rao, R.Ranga Rao, G.Viswanthan and D.N.Rao, Lower atmospheric wind profiler at Gadanki, Tropical India: Initial results, MeteorologischeZeitschrift, **10**, 457-466, 2001.

[4] May, P.T., R.G.Strauch and K.P.Moran, The altitude coverage of temperature measurements using RASS with wind profiler radars, Geophys. Res. Lett., **15**, 1381-1384,1988.

[5] Rogers, R.R., W.L.Ecklund, D.A.Carter, K.S.Gage and S.A. Ethier, Research Applications of a boundary-layer wind profiler, Bull. Amer. Meteorol. Soc., **74**, 567-580, 1993.

[6] Stull, R.B., An Introduction to Boundary Layer Meteorology, 666 pp., Kluwer Academic, Norwell, Mass., 1988.



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY