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205 MHz Stratosphere-Troposphere Radar at Cochin, India: Scientific Applications and Accomplishments

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Abstract

The Stratosphere-Troposphere (ST) wind profiler radar at 205 MHz has been operational at the Advanced Centre for Atmospheric Radar Research (ACARR) in Cochin (10ºN, 76ºE) since 2017. This radar provides high-quality three-dimensional wind measurements from the lower troposphere (315 m) to the lower stratosphere (19 km). The exceptional data collected by this radar is being utilized for a wide range of atmospheric studies, and many signal processing algorithms have been developed for data classification and noise elimination. This paper presents the technical details of the ACARR ST radar and highlights a few notable scientific applications made since its inception. The paper will cover the radar's applications, including studies on inertial gravity waves, monsoon dynamics, stratosphere-troposphere interactions, estimation of turbulence and tropopause height, validation of satellite Aeolus wind data, application of artificial intelligence for radar data classification, novel algorithms for separating ambient air and precipitation echoes, and ground clutter removal etc.

1. Introduction

Radars first demonstrated their wind profiling capabilities in the late 1960s. Since then, they have been extensively used in regional weather prediction models, studying the evolution of convective events and gravity waves, monitoring turbulence, and forecasting rainstorms, among many other applications.

The Stratosphere-Troposphere (ST) wind profiler radar at 205 MHz is operational at Cochin University of Science and Technology since 2017. The use of radar frequencies around 205 MHz for wind profiling offers several advantages over frequencies at 50 or 400 MHz. Compared to a 50 MHz radar, a 205 MHz radar requires a much smaller antenna. Additionally, it uses more compact and modest modules and hardware while providing the same height coverage but with improved vertical resolution (45–300 m). In comparison to a 400 MHz radar, the 205 MHz radar offers better height coverage and vertical resolution. The vertical resolution of wind profiling radars is limited by their bandwidth; a larger bandwidth results in finer vertical resolution. The 205 MHz wind profiler has a bandwidth of 5 MHz, whereas radars operating around 50 or 400 MHz typically have bandwidths at or below 2 MHz.

This paper presents several scientific results related to the applications of this radar in the troposphere and lower stratosphere.

2. Results

The 205 MHz ST radar has been used in studying various atmospheric processes within the troposphere and lower stratosphere. The radar has also been instrumental in several other

applications pertaining to monsoon, turbulence, inertial gravity waves etc. Here we present a few of the results from some of the applications.

Radar Validation

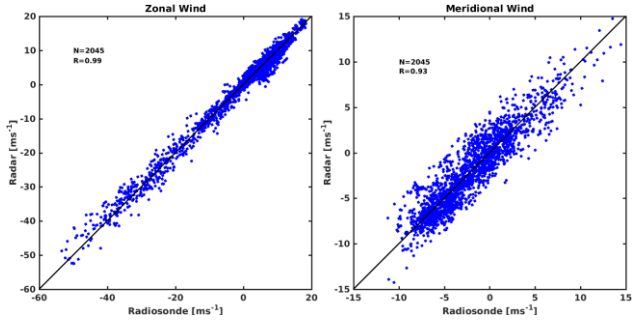

Figure 1: Scatterplots of radar vs radiosonde zonal and meridional winds (Kottayil et. al. 2016, Samson et. al. 2016, Mohankumar et, al. 2027).

Tropopause height determination

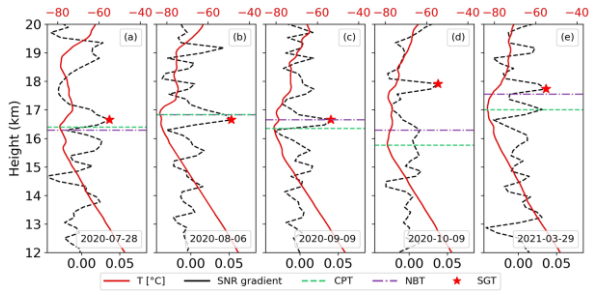

Figure 2: Comparison of different methods for determining the tropopause height; NBT= natural breakpoint, SGT= SNR gradient tropopause (Sujithlal et. al. 2024)

Satellite data validation

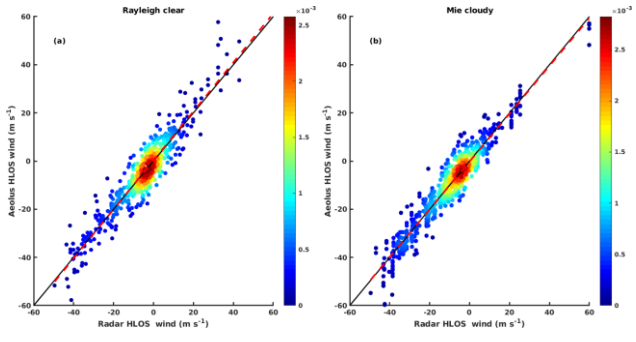

Figure 3: Scatter plot between radar and Aeolus wind for (a) Rayleigh clear and (b) Mie cloudy. The black line is the diagonal line and the dotted red line is the linear regression line. Colour bar shows the probability density (Kottayil et. al. 2022).

Estimation of Turbulence

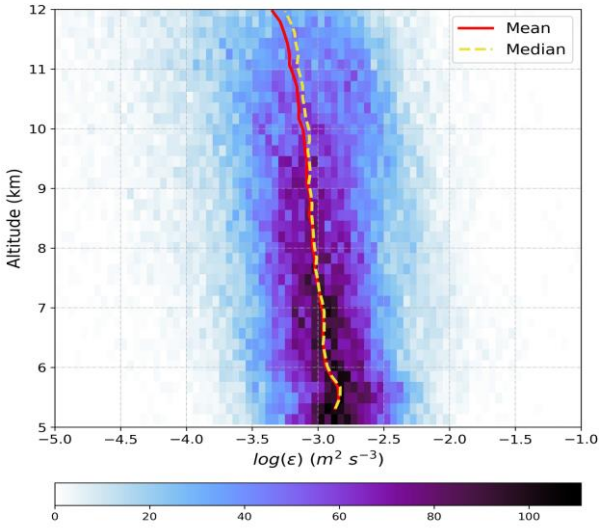

Figure 4: Vertical variation of turbulent kinetic energy dissipation rate within 5-12 km observed from 205 MHz radar (Ahana et. al. 2024).

Gravity waves

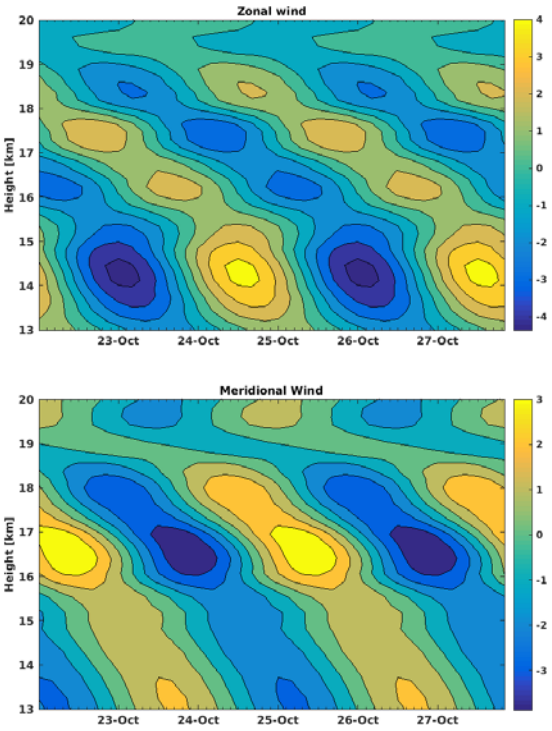

Figure 5: Height-time variations in zonal (c) and meridional (d) wind for a monochromatic

frequency with a period of 72 hours (Kottayil et. al. 2018).

3. Conclusions

A novel stratosphere–troposphere wind profiler radar operating at 205 MHz, the first of its kind in the world, was established in Cochin to measure wind profiles at altitudes ranging from 315 meters to 20 kilometers. This radar comprises 619 three-element Yagi–Uda antennas and boasts a peak power aperture product of 1.6 $\times 10^8$ $Wm^{2\cdot}$ In this paper, some of the key results from the radar's diverse scientific applications are presented. The installation of this radar in Cochin, a region critical for the onset of the southwest monsoon, is highly significant in the meteorological context. Numerous scientific outcomes are anticipated from this facility in the future.

4. Acknowledgements

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