Diurnal Variation of Turbulent Eddy Dissipation Rate Studied Using 205 MHz Wind Profiler Radar

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Introduction

- **205 MHz stratosphere-troposphere (ST) wind profiler radar:** A unique and novel radar set up at Cochin (10.04˚N;76.33˚ E) India.
- The radar provides accurate three-dimensional wind profiles for an altitude range of 315 m to 20 km.
- This work looks into the diurnal variation of turbulent eddy dissipation rate derived from 205 MHz radar observations.
- Factors which affect diurnal variation of eddy dissipation rates at boundary layer are explored.
- Eddy dissipation rates have been derived using spectral width method.
- The profiles of spectral width and horizontal wind observed throughout a 6 day period during October 22-27,2016 have been used in the present study. The vertical resolution of the data used in the present study is 45 m.

Measurements

Fig. 1: An aerial view of the 619 element 205 MHz Wind profiler Radar atop the ACARR institute at Cochin.

Methodology

Observed Doppler width from the radar is corrected for beam and shear broadening using the following formula

$$\sigma^2_{beam+shear} = \frac{\theta^2}{3}V^2\cos^2\alpha - \frac{2\theta^2}{3}\sin^2\alpha\left(V\frac{\partial V}{\partial Z}R\cos\alpha\right)$$
$$+\frac{\theta^2}{24}\,(3+\cos 4\alpha - 4\cos 2\alpha)\left(\frac{\partial V}{\partial Z}\right)^2 R^2$$
$$+\left(\frac{\theta^2}{3}\cos 4\alpha + \sin^2\alpha\cos^2\alpha\right)\left(\frac{\delta V}{\delta Z}\right)^2\frac{\Delta R^2}{12}$$

where θ = half Power beam width , α= Zenith angle , ΔR= range resolution , V= horizontal wind speed , $\frac{\delta V}{\delta Z}$= Vertical wind shear.

From the corrected Doppler width Eddy dissipation is calculated using

$$\in = A^{-3/2}N\sigma^2_{turbc}$$

Where A = 1.6, Kolmogorov constant, N = 0.018 rad/s, Brunt Vaisala frequency

Results

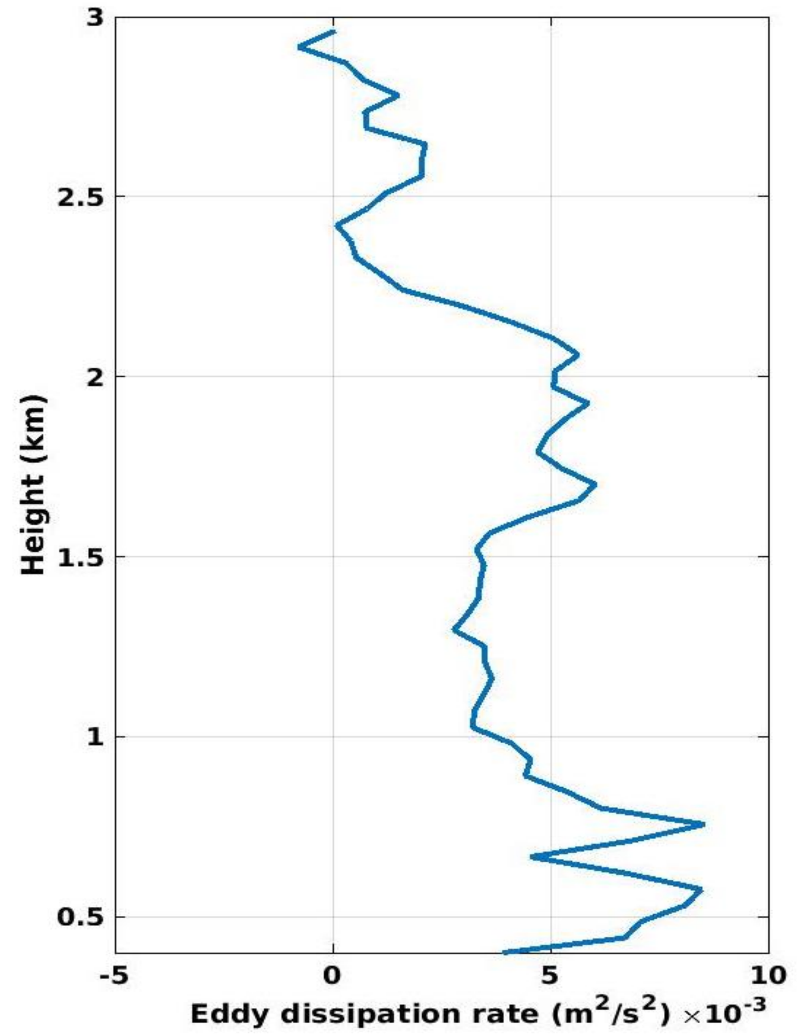

Fig 2. Vertical profile of eddy dissipation rate.

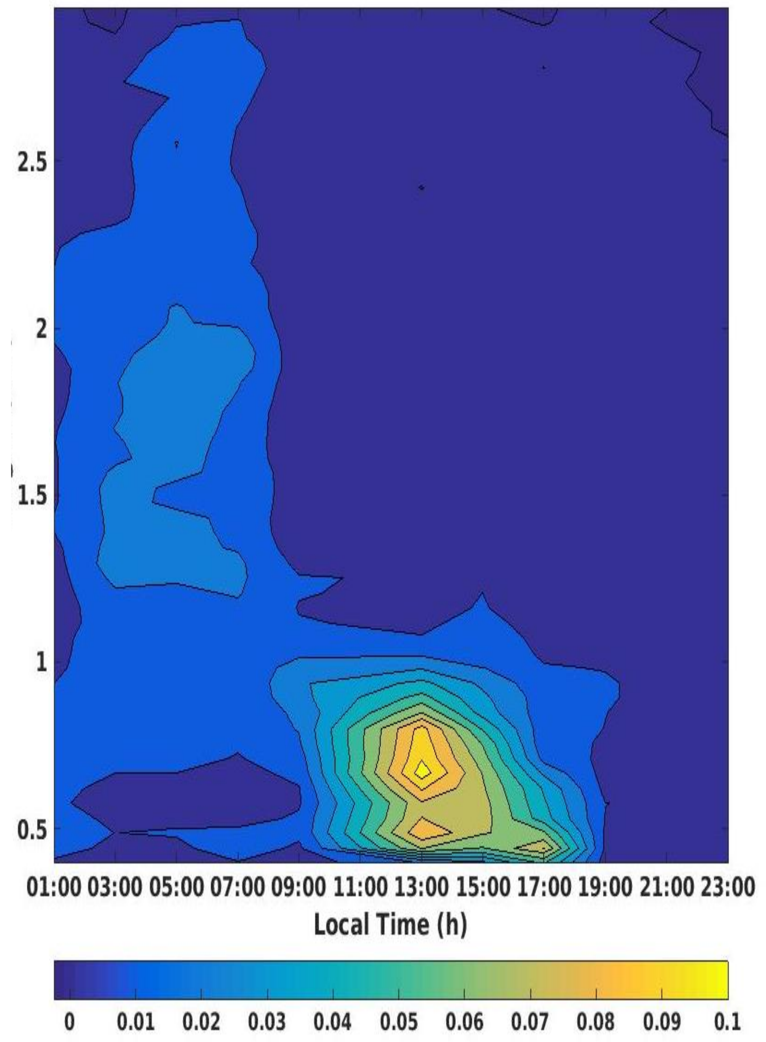

Fig 3. Diurnal variation of Eddy dissipation rate observed on 24th October 2017.

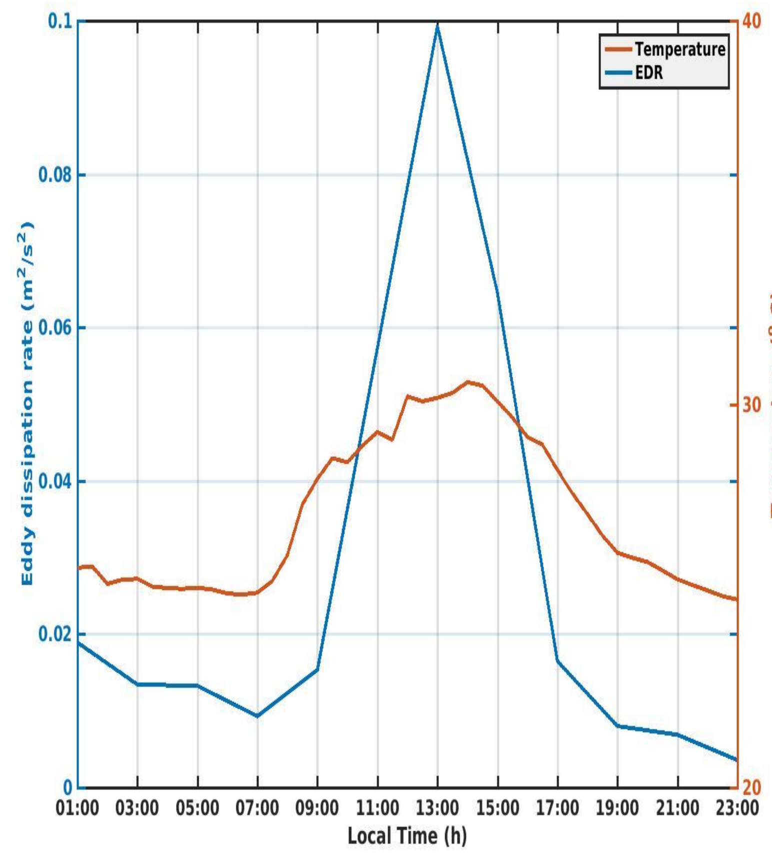

Fig 4 . Diurnal variation of surface temperature and eddy dissipation rate (observed at 900 m).

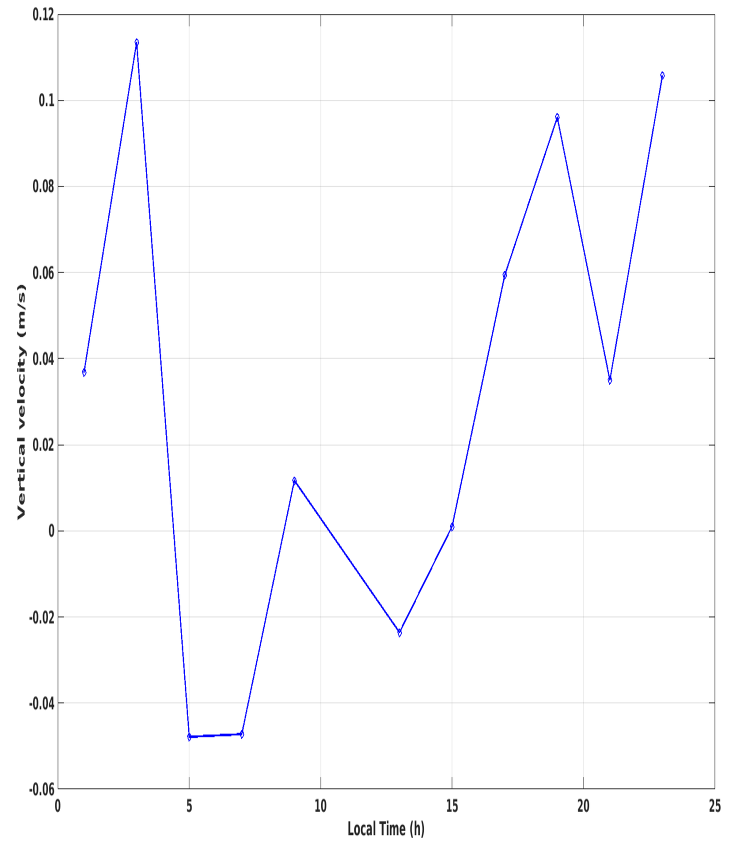

Fig 5. Diurnal variation of vertical velocity at 1 km, positive (negative) values refer to the ascending (descending) motion.

- The maximum values of eddy dissipation rate are observed in the Planetary boundary layer below 1 km (Fig.2).
- Eddy dissipation rate shows diurnal variation the value of which peaks during afternoon hours in the tropical boundary layer (Fig.3).
- A positive correlation is seen between temperature and Eddy dissipation rate (Fig.4).
- The surface temperature and eddy dissipation rates show coherent fluctuations.

Conclusions

- High vertical resolution (45m) measurements of spectral width and wind are used to study the diurnal variation of eddy dissipation rate.
- The eddy dissipation rate shows a strong diurnal variation the value of which peaks during afternoon hours.
- An association among surface temperature , eddy dissipation rate and vertical velocity shows that convection increases the value of dissipation rate at the boundary layer.
- Subsequent studies of this nature from this radar facility are expected to provide deeper insights into turbulence observed over tropics in the future.

Reference

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