Climatology of Lower Tropospheric Turbulence at Kochi using S-T radar

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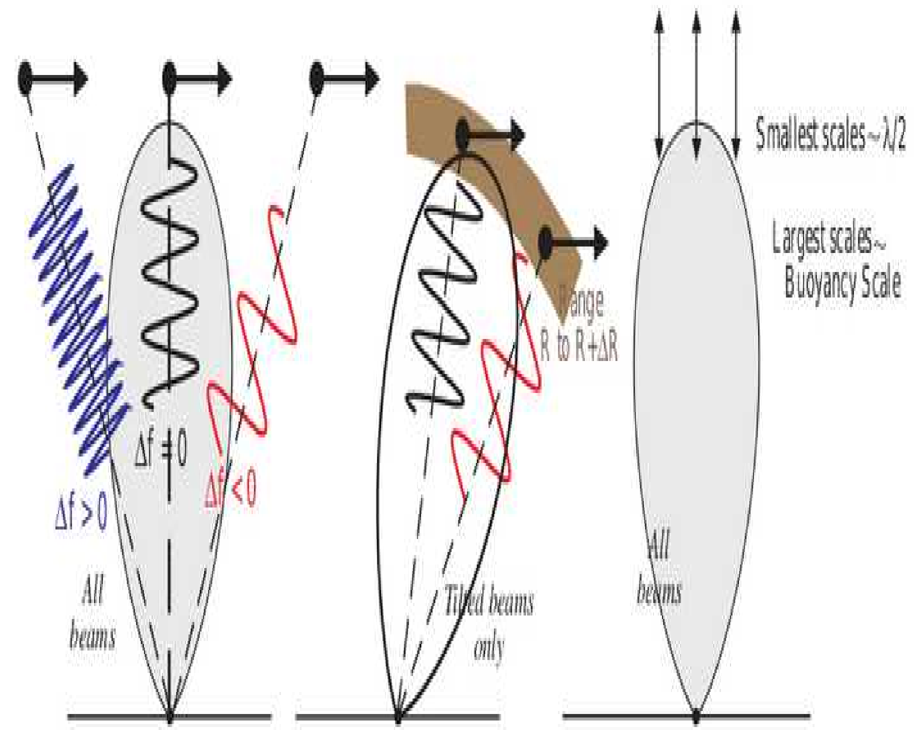
Methodology

- We use espectral width method of turbulent kinetic energy disssipation rate (ε) estimation.
- One of the method of determining turbulence intensity from VHF radar (Satheesan and Krishnamurty).
- In order to suppress the unrealistic data due to precipitation, air- craft, etc., the data is first filtered by discarding all the data points corresponding to vertical wind speed greater than ±5 m s−1 and above 95th percentile of each day.
- $\sigma_{obs} = \sigma_{turbulent} + \sigma_{non\_turbulent}$
- $\sigma_{tubulent} = \sigma_{obs} - \sigma_{non\_turbulent}$
- $\sigma_{non\_turbulent} = \sigma_{beam+Shear\ broadening+gravity\ waves}$

- $\sigma_{beam\ broadening}$-> due to different radial Doppler velocities in different parts of a finite beam.
- Always broadens the spectrum and occurs for all beams
- $\sigma_{shear\ broadening}$ → horizontal wind velocity varies with height.`
- Either broaden or reduce the spectrum.
- Occurs for only oblique beams
- Gravity→ vertical oscillatory motions of the scatterers
- Negligible in lower troposphere



(a) Beam-broadening (b) Shear effects (c) Vertical motions

- The corrections are applied using equations given in Nastrom and Eaton (1997).
- $\sigma_{obs} < \sigma_{non\text{-}turbulent}$ leads to negative turbulence values.
- Studies shows that if the percentage negative values is less than 30%, studies using only positive values are still valid (Dehghan and Hocking, 2011)
- From this corrected spectral width, ε is estimated based on the relation in Hocking (1985):

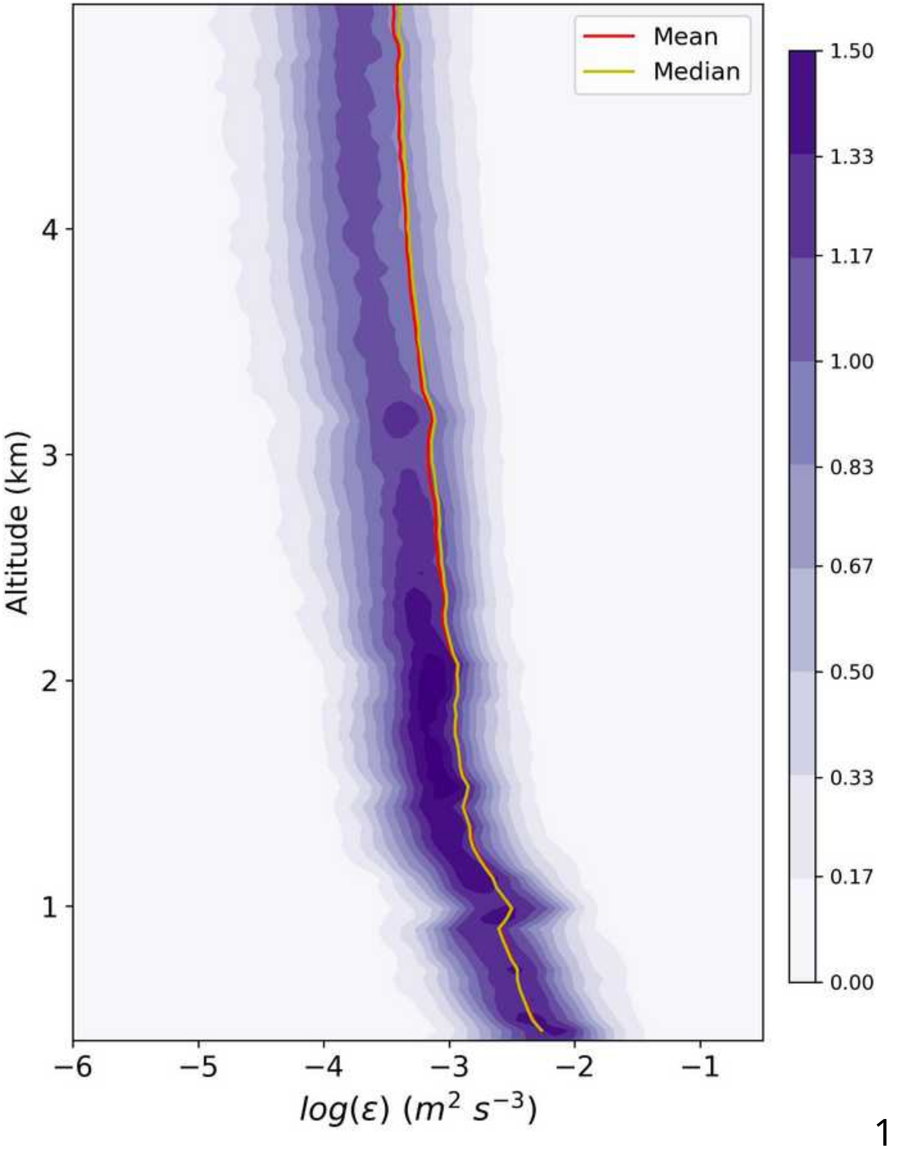
$$\varepsilon = 0.49(\sigma^2_{turb})\,N$$

where N is the Brunt-Vaisala frequency

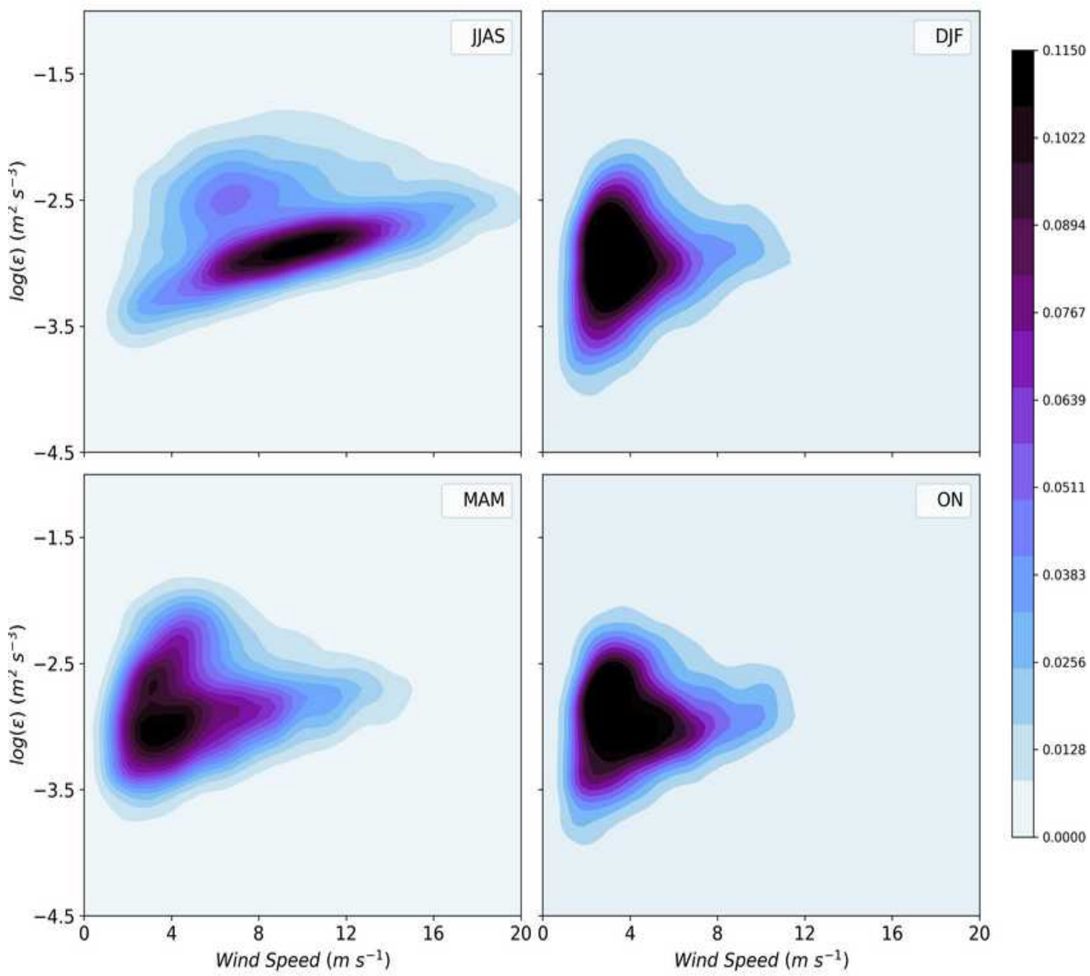
Additional Results

Vertical distribution

- Generally ε decreases with height.
- Median and Mean values of turbulence does not show much differences.
- Majority of the data falls between -4.5 to -2.9 $m^2\ s^{-1}$.
- The decrease in ε is faster in the lowest layer up to 1 km which is the boundary layer, the most turbulent layer where most of the mixing of heat mass, momentum, and energy takes place.

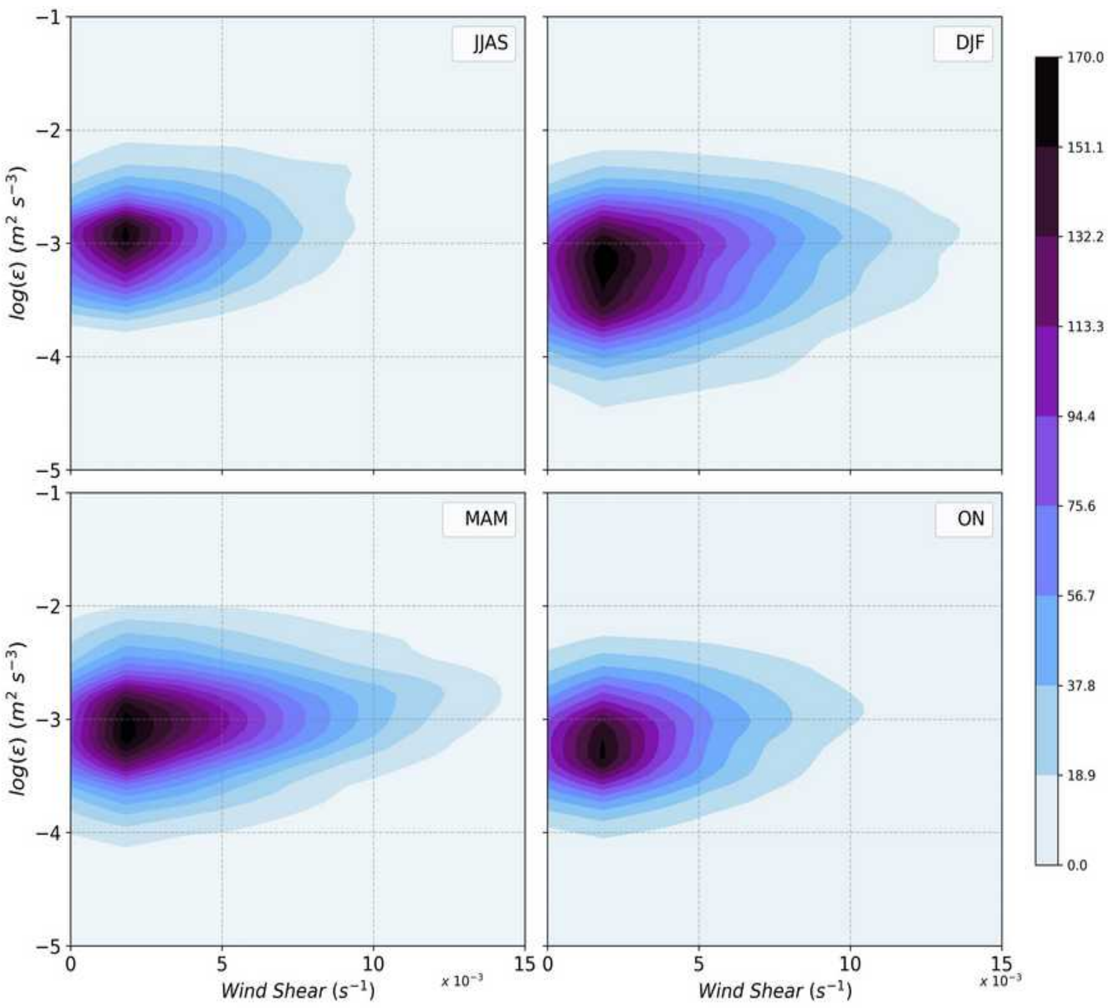


Seasonal 2D density of ε vs wind speed



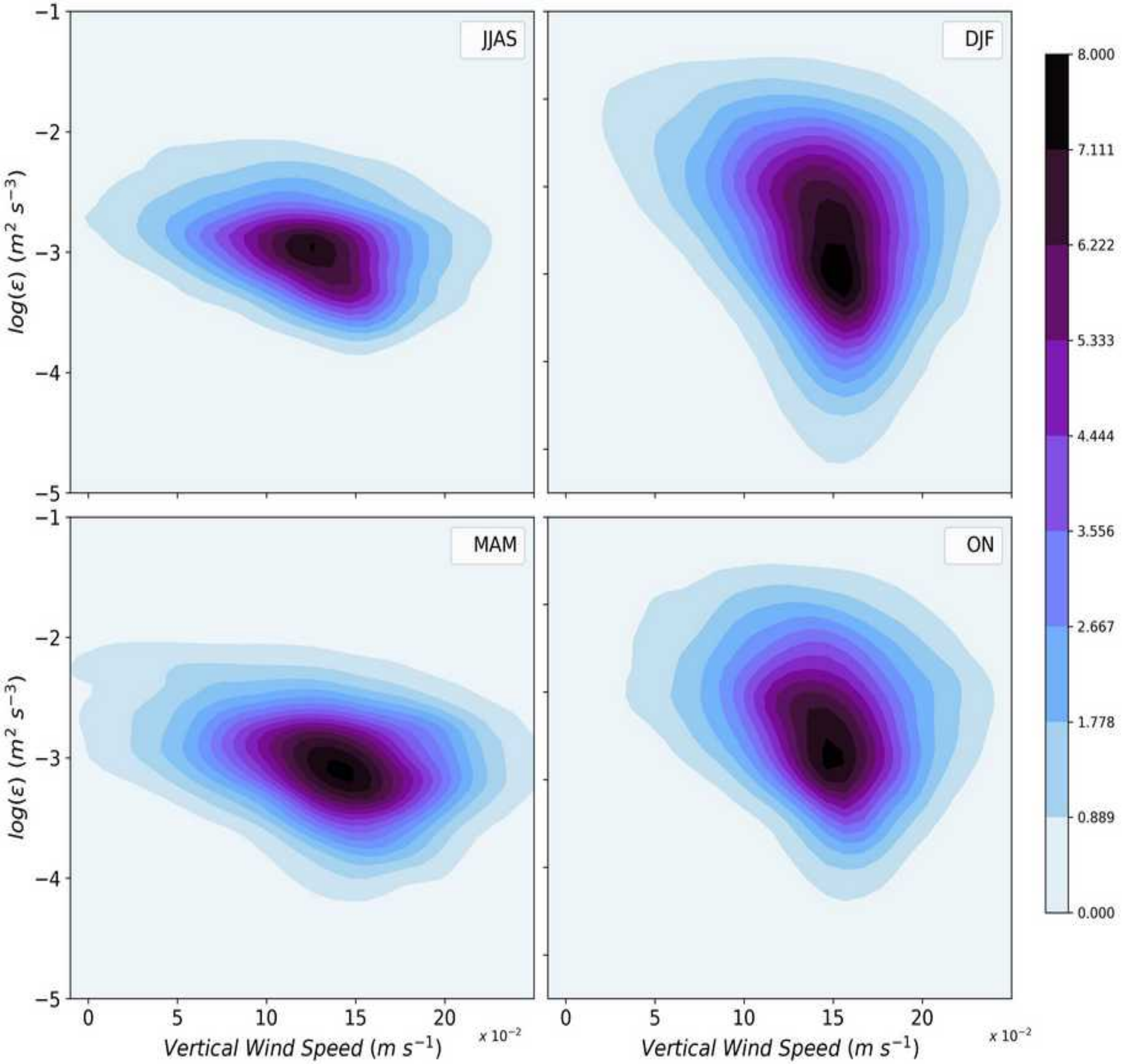
- The density shows almost a linear relationship between ε and wind speed in monsoon season.
- ε increases with increasing wind speed.
- Maximum density obseved at wind speeds between 6-12 ms^{-1}
- Stronger turbulence occurs at higher wind speed.
- Turbulence of all values occurs in low wind speeds and converges to a value at higher wind speeds in all other seasons.
- Low wind speed in winter season.
- Shows the lowest range of ε .
- Maximum density between 2-5 ms^{-1}.
- In the pre-monsoon season, the density in the lower troposphere retains the shape of 2D density of all datasets.
- 2D density shows similar pattern as winter season but at a slightly shorter range of ε values in the lower troposphere.

Seasonal 2D density of ε vs wind shear



- All the densities exhibit an oval shape and all of them have good symmetry.
- Higher shear in winter and pre-monsoon season.
- Range of ε smaller in pre-monsoon season
- Lower shear values were observed in monsoon season.
- Wide range of occurs at lower wind shear between 1 x 10^{-3} to 3 x10^{-3}.
- In the monsoon season, this range is observed to be the lowest
- Turbulence does not increase with wind shear but it converges to −3 m^2 s^{-3} at higher wind shear.
- Similar pattern of 2D density in winter and post-monsoon season with slightly lower shear in post monsoon season

Seasonal 2D density of ε vs vertical wind speed



- 2D densities show distinct patterns in every season.
- Density is observed maximum at vertical wind speeds between 0.10 to 0.15 m s^{-1}.
- Range of ε smaller in pre-monsoon season
- Lower shear values were observed in monsoon season.
- Wide range of occurs at lower wind shear between 1 x 10^{-3} to 3 x10^{-3}.
- Winter and post-monsoon seasons show a similar pattern of density with a slightly lower extent of both variables in the post-monsoon season.
- Range of both ε and vertical wind speed observed is minimum in monsoon season.
- Higher range of vertical wind speed in pre-monsoon season.

Thank you