

On the nature and origin of the post sunset turbulence over complex terrain

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Abstract:

The nocturnal boundary layer is known to be stable with occasional weak and sporadic turbulence due to dynamic instability. The behaviour of the turbulence after sunset is chaotic and anomalous i.e. sudden enhancement in signal-to-noise ratio (SNR) and spectral width (σ) is seen up to greater altitudes after the sunset; defined one such episodic process as (post sunset turbulence-PST). Thus, the present study focussed on the PST's nature and origin making use of an integrated approach viz., in-situ and remote sensing instruments at tropical continental site Gadanki. PSTs are not rare, rather present ubiquitous nature and persist for longer period. This paper resolves the answers to some important issues 1) how often turbulence episodes (enhanced turbulence) occur during the night? 2) If so, how to identify the onset and offset such PST and how long it persists? 3) Does the PST's (occurrence, onset and duration) show any seasonal and height dependency? 4) Which physical mechanism is responsible for its occurrence?

The PSTs are not rare, rather present on many fair weather nights in nature. On average, PST's are occurred ~45% at all levels, indicating that there is a possibility of one PST on any two fair weather nights. About ~60% of the time PST's are captured in the height region (900-1500) m, and relatively less in the height region (300-450) m (~50%), further reduced at the surface (48 %). On average, PSTs occur at the surface, ~1 h 10 min after sunset, whereas they are seen at ~1 h 40 min and ~2 h 10 min after sunset in the height region of 300-450 m and 900-1500 m, respectively. The PST's are not an instantaneous process; once it occurs, they sustained for longer time i.e. varies from few minutes to several hours involved interplay of weak forcings including the radiation, advection and entrainment. On average the duration of PST is ~2 h at the surface, ~2 h 10 min in the height region (300-450) m and it persist 2-6 h at upper levels (≥ 900 m). The PSTs (occurrence, onset, duration) are first observed at the surface and then in sodar data and finally in radar data (like bottom-to-top evolution with sloped structure). The onset of PST and duration clearly show vertical variation in all seasons. Delayed occurrence and persists for longer time at higher altitudes. However, mechanisms that could explain this unexpected behavior of turbulence in the

absence of solar forcing is primarily associated with background conditions i.e. during the PST night the surface conditions are hotter (4-6 °C larger than normal night), winds accelerates (1-2 m s⁻¹ higher), and enhancement in surface moisture (0.5-1 g kg⁻¹).