Thermodynamic Structure of Atmospheric Boundary Layer over the West Coast of India during Active and Weak Phases of Indian Summer Monsoon

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Introduction

- Understanding the thermodynamics of the atmospheric boundary layer (ABL) is important as they determine the low level atmospheric stability, cloud formation and modulates the weather of a region.
- Structure and thermodynamics of ABL in the southwest monsoon (commonly referred to as the monsoon) are different from that of the trade wind boundary layer. The basic reason for this difference is known to be the presence of monsoon low level jet (Holt and Sethuraman, 1985).
- ABL characteristics vary associated with active and break conditions of the monsoon (Sathyanadh et al., 2017; Sudeepkumar et al., 2018). However, ABL characteristics over the west coast have not been understood.
- The study focuses on the variations in the thermodynamic structure of the west coast of India during active and weak phases of the monsoon.

Data & Methodology

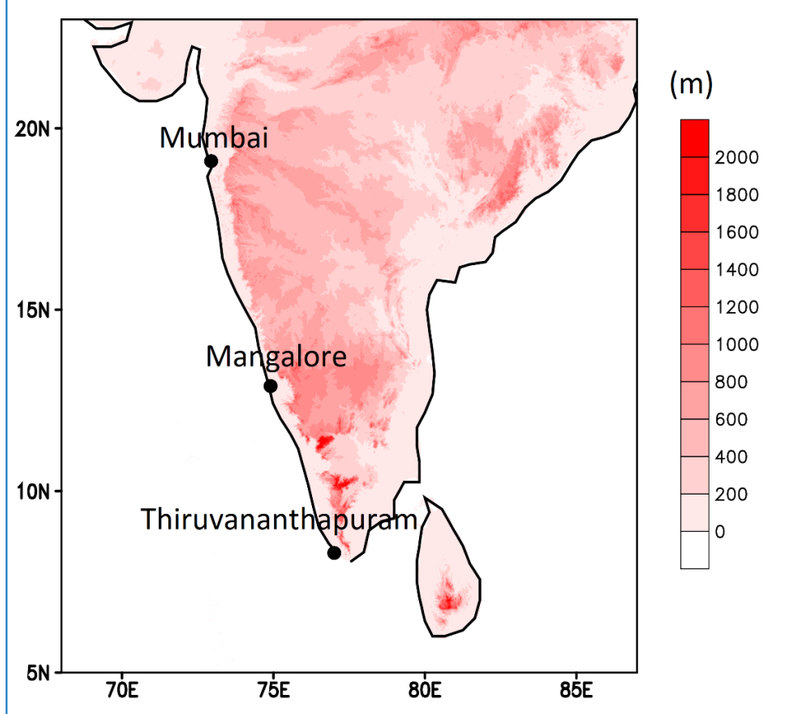

Fig. 1: Map showing the topography of the study region. The stations considered are marked in the figure: Thiruvananthapuram (TVM; 8.3°N, 76.6°E, 63.8 m), Mangalore (MNG; 12.89°N,74.87°E, 79.8 m), Mumbai (MUM; 19.1°N, 72.51°E, 13.0 m).

- Vertical high resolution (~5 m) **Daily GPS Radiosonde** data of TVM, MNG and MUM from India Meteorological Department (IMD) at 05:30 IST (00 UTC) during May-October, 2018.
- Interpolated **daily OLR data** from NOAA (Liebmann and Smith, 1996) with horizontal resolution 2.5° x 2.5° during the same period.
- **Daily rainfall** of TVM, MNG and MUM from IMD.

- Specific humidity, temperature and LCL are calculated based on Babu (1996), and parameters such as θ, θ_v and θ_e are calculated using equations provided in Hess (1979) and Bolton (1980).

Results & Discussion

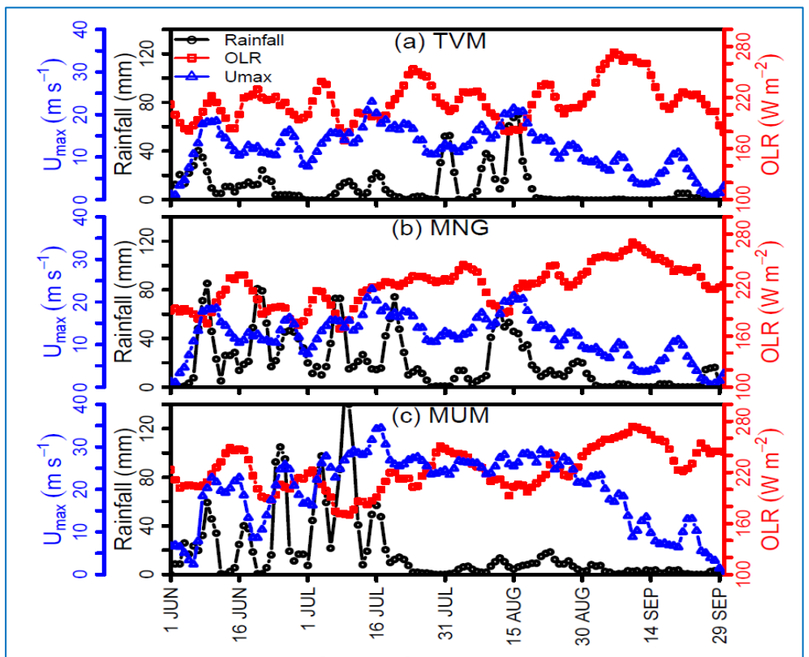

Fig. 2: Variation of rainfall, OLR and maximum zonal wind (below 3500 m) over (a) TVM), (b) MNG, and (c) MUM during the monsoon season, 2018.

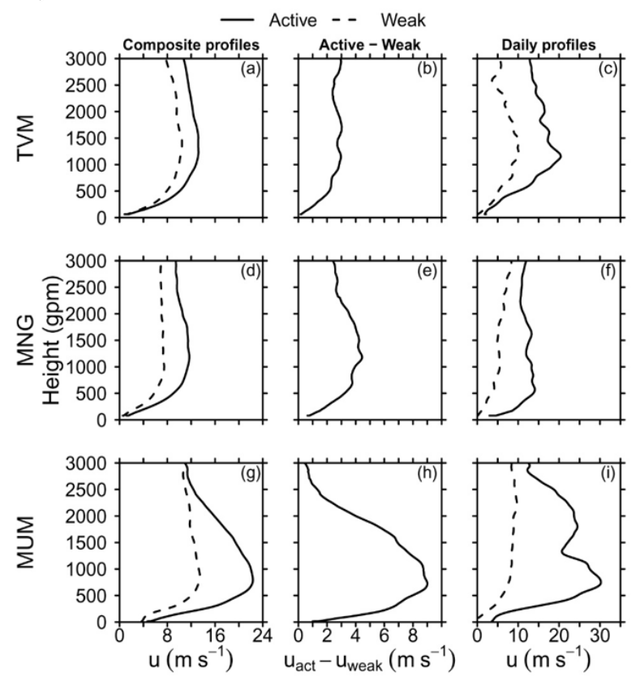

Fig. 3: Zonal wind profiles (u, m s^{-1}) over (a, b, c) TVM, (d, e, f) MNG and (g, h, i) MUM during active and weak monsoon conditions. Composite profiles (a, d, g), difference between active composite and weak composite (b, e, h), and representative daily profiles (c, f, i) are provided.

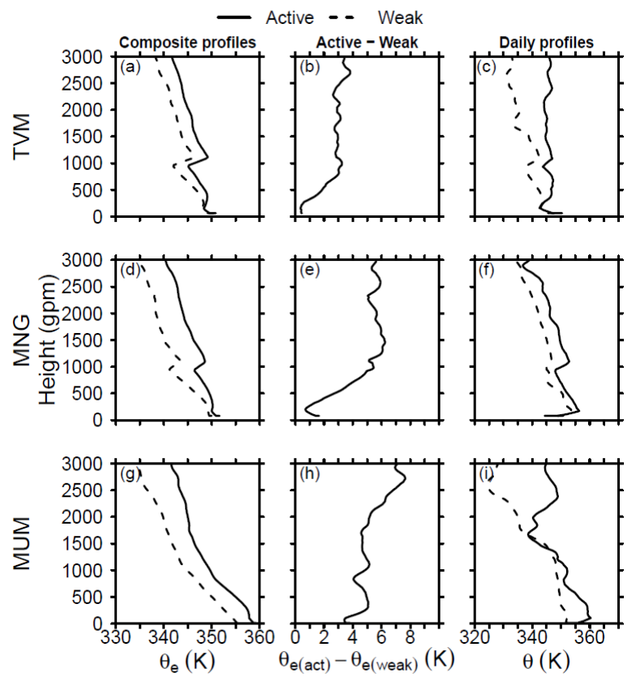

Fig. 4: Same as Fig.3, but for Equivalent potential temperature (θ_e, K).

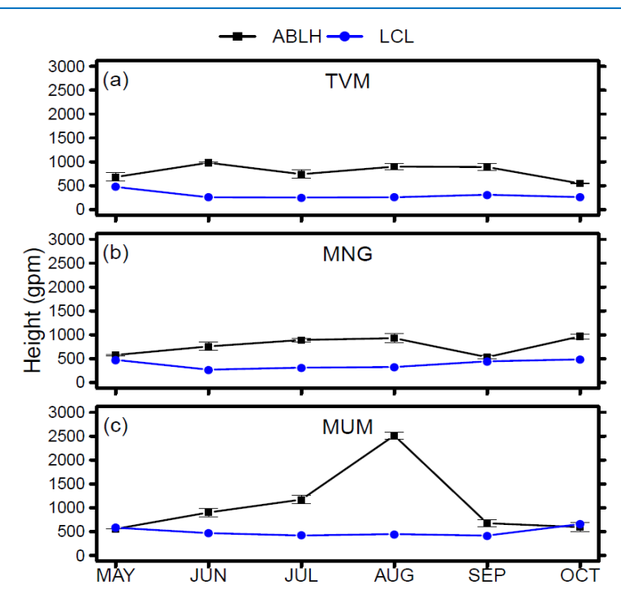

Fig. 5: ABL height and LCL height of representative days of the months over (a) TVM (b) MNG and (c) Mumbai. Mean ABL height estimated from different profiles of the representative days, and their standard deviation are presented.

Summary & Conclusions

- Thermodynamic structure is different over south, central and north parts of the west coast.
- In TVM wind speed has a sharp increase with height up to above the ABL (~1200 m). It develops an absolutely stable or conditionally neutral atmosphere in the ABL. The LCL also lies within the ABL and we expect layered clouds over the region. Although, in weak monsoon conditions ABL becomes conditionally unstable.
- In MNG, the zonal wind in the ABL is comparatively weaker than that of TVM in both active and weak monsoon conditions. Moreover, the increase in zonal wind is prominent up to 600 m, and lies within the ABL.
- In MUM, zonal wind is very strong that increases from the ground up to about 750 m, and the height of zonal wind maximum (> 20 m s^{-1}) lies within the ABL. This dynamic structure develops a conditionally unstable condition above an absolutely stable surface-based inversion during active situations similar to MNG, but with a stronger instability. In weak monsoon, the zonal wind in the ABL considerably decreases especially below 1500 m, however the ABL becomes well mixed due to thermal convection.

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