Indian summer monsoon onset signatures on the tropical tropopause layer

S. Ravindra Babu[1] , M. Venkat Ratnam[2], Ghouse Basha[2] and B.V. Krishnamurthy [3]

[1]National Central University, Zhongli, Taiwan.

[2]National Atmospheric Research Laboratory (NARL), Gadanki, India.

[3]CEBROSS, Chennai, India.

Abstract: Over the Indian region, changes in the tropopause parameters during pre-monsoon to monsoon seasons have been reported. However, no study exists to date dealing with the Indian summer monsoon (ISM) onset signatures on the tropopause parameters. In the present study, the climatological structure of the tropical tropopause layer during the onset phase of ISM is delineated by using long-term (2006–2017) radiosonde observations over Gadanki (13.5°N, 79.2°E). A prominent transition in the tropopause parameters from pre-monsoon to monsoon is noticed and the transition is initiated from the day of ISM onset. Continuous decrease (increase) of tropopause altitude (temperature) is perceived after the ISM onset. The ozonesonde observations clearly show the strong enhancement in the ozone mixing ratio in the lower stratosphere (~16–20 km) after the ISM onset. This clearly demonstrates the instantaneous warming of the tropopause region after the ISM onset in addition to the latent heat release due to the precipitation. Transitions from pre-monsoon to monsoon in the tropopause parameters are influenced strongly by onset of ISM which was attributed as seasonal changes earlier. These results provide strong evidence on the ISM onset signatures on the tropical tropopause parameters.

1. Introduction

❖ Indian summer monsoon (ISM), the seasonal reversal of the wind occurring in May–June, brings a huge amount of moisture from the Arabian Sea to the Indian subcontinent through south westerlies.

❖One of the important and characteristic features of the ISM is its sudden onset which occurs over southern tip of India generally known as monsoon onset over Kerala (MOK).

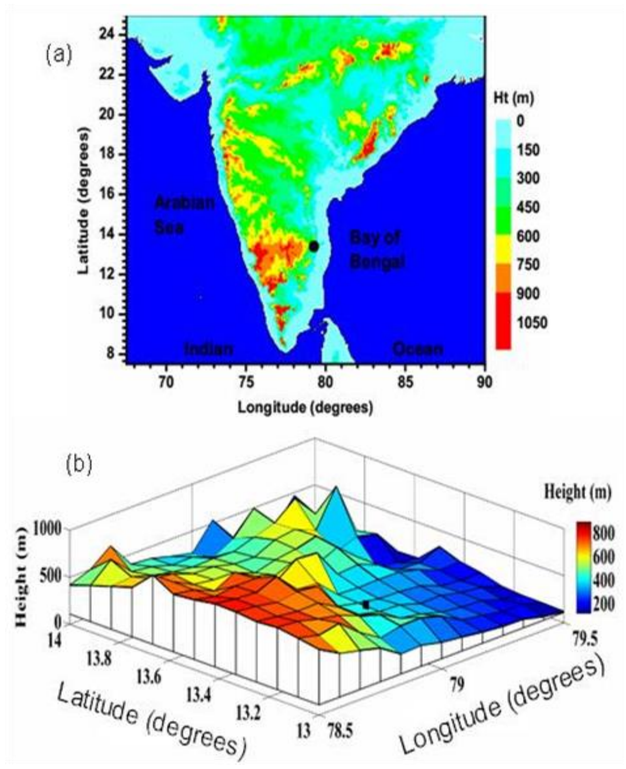
❖During monsoon onset, large convective activity and rainfall is expected to occur.

❖Large latent heat will be released in the troposphere which will affect the background temperature structure including the tropopause characteristics.

❖Also will leads to water vapor transport from UT to the LS and at the same time ozone rich air from stratosphere is expected to reach UT through tropopause leading to the STE processes.

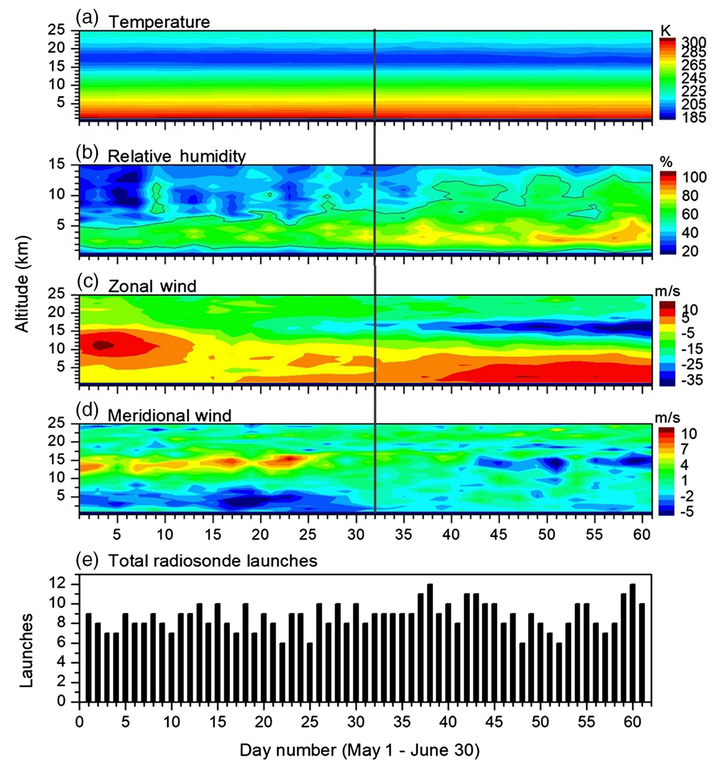
❖ Though the seasonal variations are well documented in the literature, to the best of our knowledge no systematic study exists to date which deals with the changes in the tropopause parameters during the onset of ISM.

2. Study location



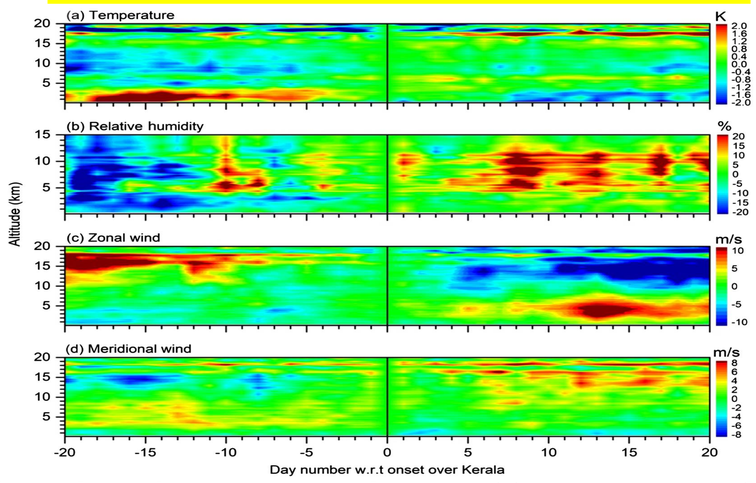
(a) Topography of Indian subcontinent plotted using global 30 arc sec elevation data provided by the EROS Data Center, National Mapping Division, U.S. Geological Survey. The location of Gadanki is shown with a circle. (b) High-resolution topography mapping within a 50-km radius from Gadanki.

2.1. Climatological thermo-dynamical parameters during ISM onset



Climatological mean (2006–2017) contours of (a) temperature, (b) relative humidity, (c) zonal wind (d) meridional wind during May 1 to June 30 over Gadanki. Vertical line shows the climatological onset day over Kerala based on IMD reports. (e) Number of available radiosonde profiles on each day the same period.

3. Climatological mean anomalies with respect to ISM onset

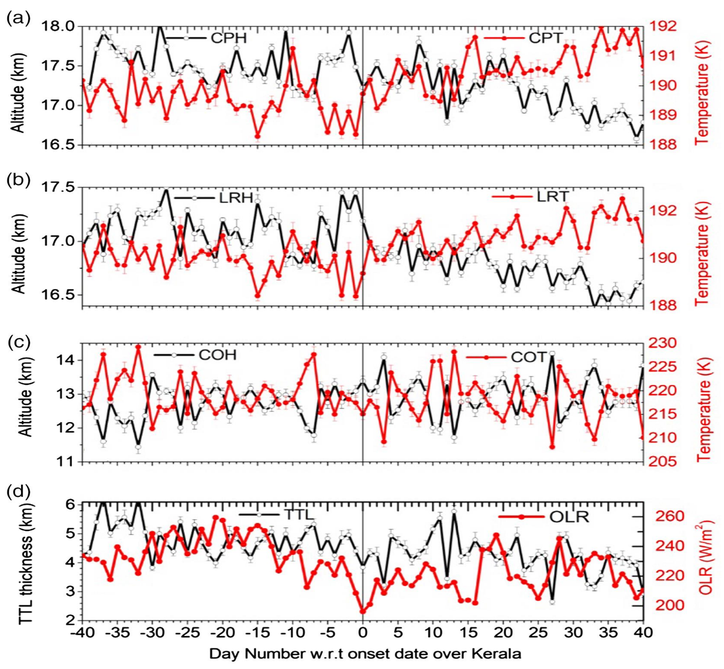


Climatological mean anomalies in (a) temperature, (b) relative humidity, (c) zonal wind and (d) meridional wind observed over Gadanki with respect to onset day over Kerala (onset day over Kerala as zero)

Parameter	Pre-Monsoon	Monsoon
CPH	17.5± 0.5	16.8 ± 0.5
CPT	189.9± 1.7	191.3 ± 2
LRH	17 ± 0.5	16.5 ± 0.5
LRT	190.5 ± 2.2	191.6 ± 2.2
COH	12.4 ± 1.4	12.9 ± 1.6
TTL thickness	5.1 ± 1.6	3.8 ± 1.6
OLR	241.5 ± 3.9	215.2 ± 3.3

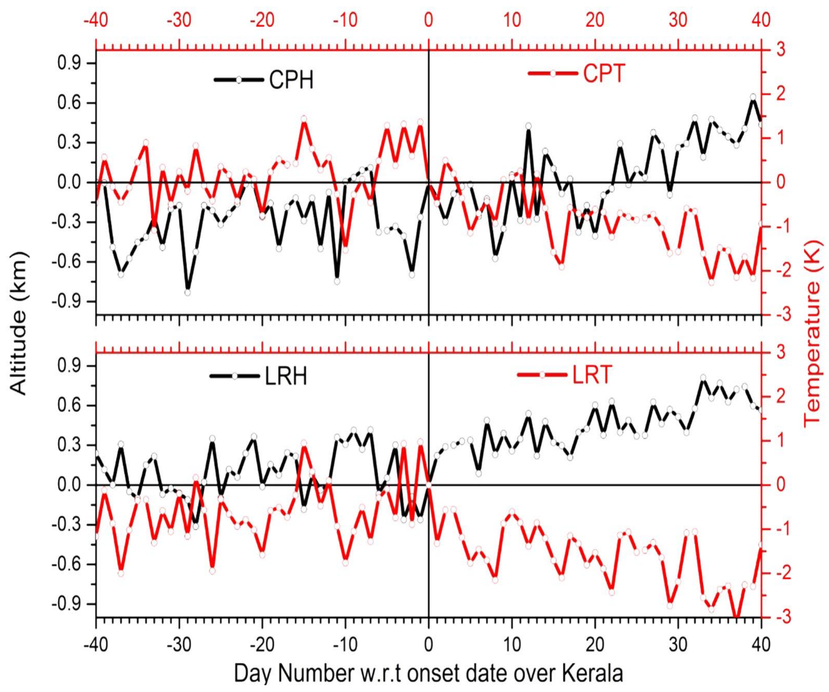
The 12-year mean tropopause parameters

3.1. Climatological mean tropopause parameters with respect to ISM onset



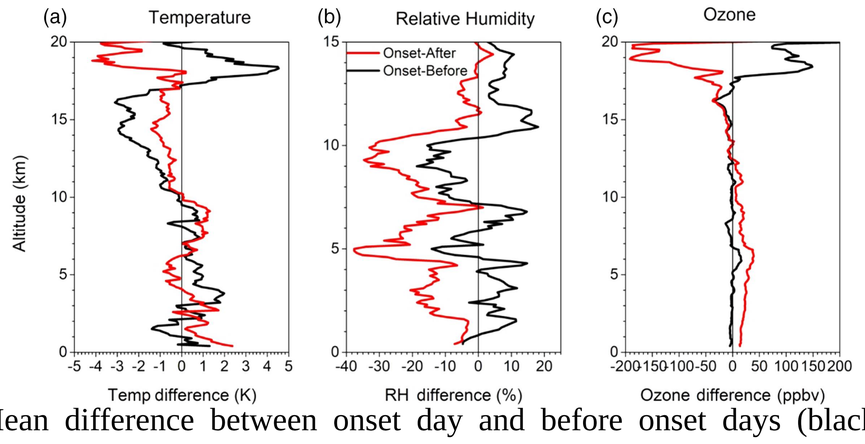
Climatological mean variability in the (a) cold point tropopause altitude (black) and corresponding temperature (red), (b) lapse rate tropopause altitude (black) and corresponding temperature (red), (c) convective outflow level altitude (black) and corresponding temperature (red) and (d) TTL thickness (black) and outgoing longwave radiation (red) observed over Gadanki with respect to monsoon onset over Kerala

3.2.Climatological mean tropopause anomalies with respect to ISM onset



Climatological mean anomalies observed in the (a) cold point tropopause altitude (black) and corresponding temperature (red), (b) lapse rate tropopause altitude (black) and corresponding temperature (red) with respect to monsoon onset day (as zero) over Kerala

3.3. Water vapor and ozone variations around ISM onset



Mean difference between onset day and before onset days (black) and onset day and after onset days (red) observed in (a) temperature, (b) RH and (c) ozone mixing ratio.

4.Summary and Conclusions

- The effect of ISM onset/arrival is observed on the tropopause parameters with decrease in the tropopause altitudes (CPH/LRH) and increase in the tropopause temperatures (CPT/LRT) and minimum in the TTL thickness.
- There exits distinct patterns in all the tropopause parameters before and after the onset. Transitions from pre-monsoon to monsoon in the tropopause parameters are influenced strongly by onset of ISM which was attributed as seasonal change in the tropopause parameters earlier.
- Significant increase in the ozone between 16 and 20 km and water vapor in mid and upper troposphere is noticed that contributed to the observed changes in UTLS thermal structure in addition to the latent heat release due to precipitation after the onset.

5. References

S.RavindraBabu, M. VenkataRatnam, G. Basha and B.V. Krishnamurthy: Indian Summer Monsoon Onset signatures on the Tropical Tropopause Layer (**2019**) ***Atmospheric Science Letters***, **https://doi.org/10.1002/asl.884**

Email : baburavindra595@gmail.com