Referee #4

At the outset, we thank the reviewer for positive and constructive comments that improved the quality of the manuscript.

Comment: This study investigated the variability in the vertical structure of precipitation as a function of sea surface temperature using TRMM precipitation radar measurements. I think the paper lacks focus, inadequate analysis, and insufficient literature review. The intent of the paper digresses at some point by incorporating the aerosol/cloud radiation analysis without a context jumbling both convective dynamics and radiative impacts of aerosols on clouds. Given the scope, the section with aerosol and radiation properties is redundant. Most of the analysis lacks context. Overall, the quality and the content of the present paper are poor.

Reply: *The aim of the present study is to understand differences in the variation of vertical structure of precipitation with SST over the Arabian Sea and Bay of Bengal. SST being the main driving force to trigger precipitating systems through air-sea interactions, the occurrence of precipitation top height and intensity profiles (reflectivity) as a function of SST are studied. Besides SST, the vertical structure can be modified by aerosols (or CCN, mostly at the cloud formation stage) and thermodynamics of the ambient atmosphere. In the revised manuscript, all these parameters are considered to explain the differences in the vertical structure. Aerosols are considered only for understanding variation in cloud effective radius, nevertheless their radiative effects (direct, indirect, etc.) are not considered in the present study. Recent studies, indeed, have shown the impact of aerosols (PM_{10}) on the vertical structure of precipitation (Gao et al., 2018 and references therein).*

We have rewritten the introduction with more focus on the above aspects and highlighting the known differences in various aspects/parameters over AS and BOB. The literature survey is also improved considerably in the revised manuscript by adding appropriate references (Guo et al. 2018; Nuijens et al. 2017; Weller et al. 2016; Sathiyamoorthy et al. 2013; Takayabu et al. 2010; Bhat et al. 2001; Ramanathan et al. 2001; Gadgil 2000; Krishnamurti 1981; Narayanan and Rao 1981;).

Comment: Introduction lacks discussion on how Arabian Sea and Bay of Bengal regions are distinctly different in its background state, which would help them explain the further analysis on convective profiles. Though the authors have claimed to have studied the “causative mechanisms” of SST with the vertical structure of precipitation in the introduction, no suggestions based on the analysis performed have been discussed in the later sections. Mere correlation doesn’t explain the causality, which needs carefully controlled model experiments with a rigor to assess the confounding factors controlling the SST and precipitation relationship.

Reply: *The introduction of the revised manuscript is modified by considering all the suggestion of the reviewer. The role of the surrounding seas on the rainfall over the Indian landmass is stated and the differences between the two seas are clearly mentioned with proper references in the revised manuscript as follows:*

Indian summer monsoon (ISM) is one of the most complex weather phenomena, involving coupling between the atmosphere, land and ocean. At the boundary of the ocean and atmosphere air-sea interactions play a key role for the coupled Earth system (Wu and Kirtman 2005; Feng et al. 2018). SST – precipitation relations are the important measures for the air-sea interactions on different temporal scales (Woolnough et al., 2000; Rajendran et al. 2012). Recent studies (Wang et al. 2005; Rajeevan et al. 2012; Chaudhari et al. 2013; 2016; Weller et al. 2016; Feng et al. 2018) have shown that the simulation of ISM can be improved with the exact representation of sea surface temperature (SST) - precipitation relationship. SST modulates the meteorological factors that influence the formation and evolution of different kinds of precipitating systems over tropical oceans (Gadgil et al. 1984; Schumacher and Houze, 2003; Takayabu et al. 2010; Oueslati and Bellon 2015).

The studies dealing with SST and cloud/precipitation population considered whole Indian Ocean as a single entity (Gadgil et al. 1984; Woolnough et al., 2000; Rajendran et al. 2012; Sabin et al. 2012; Meenu et al. 2012; Nair and Rajeev 2014; Roxy 2014; Nair et al. 2017). But in reality the BOB and the AS of Indian Ocean possesses distinctly different features. The summer monsoon experiment (MONEX) showed the influence of the AS and the BOB on the rainfall produced over the Indian sub-continent (Krishnamurti 1985; Houze and Churchill 1987; Gadgil 2000; Bhat et al.2001) and also proved how these two seas are different with respect to the other, in terms of SST, back ground atmosphere and the occurrence of precipitating systems. The SST in the AS cools between 10 °N and 20 °N during the monsoon season whereas warming is seen in other Oceans between the same latitudes (Krishnamurthi 1981). SST variability is large over the AS than the BOB at seasonal and intraseasonal scales (Sengupta et al. 2001; Roxy et al. 2013). The monsoonal winds are stronger over the AS than BOB (Findlater 1969). Also, lower-tropospheric thermal inversions are more frequent and stronger over the AS than BOB (Narayanan and Rao 1981; Sathiyamoorthy et al. 2013). Thus, the atmospheric and sea surface conditions and in turn the occurrence of different kinds of precipitating systems are quite different over the BOB and the AS during the ISM period (June to September - JJAS). For instance, long-term measurements of tropical rainfall measuring mission (TRMM) precipitation radar (PR) have shown that shallow systems are more prevalent over the AS, while deeper systems occur frequently over the BOB (Liu et al. 2007; Romatschke et al. 2010; Saikranthi et al. 2014; Houze et al. 2015).

The aforementioned studies mainly focused on the morphology of vertical structure of precipitation, but, none of them studied the variation of vertical structure of precipitation (in terms of occurrence and intensity) with SST and the differences in the vertical structure over AS and BOB. On the other hand, information on the vertical structure of precipitation is essential for improving the accuracy of rainfall estimation (Fu and Liu 2001; Sunilkumar et al. 2015), understanding the dynamical and microphysical processes of hydrometeor growth/decay mechanisms (Houze 2004; Greets and Dejene 2005; Saikranthi et al. 2014; Rao et al. 2016) and for improving the latent heating retrievals (Tao et al. 2006). SST being the main driving force to trigger precipitating systems through air-sea interactions (Sabin et al. 2012; Nuijens et al. 2017), can alter the vertical structure of precipitation (Oueslati and Bellon 2015). Therefore, the present study aims to understand the variation of vertical structure of precipitation (in terms of precipitation top height and intensity) with SST over the AS and BOB. Besides the SST, vertical structure can be modified by aerosols (or CCN, mostly at the cloud formation stage) and thermodynamics of the ambient atmosphere. For instance, recent studies have shown the impact of surface aerosols (PM_{10}) in altering the vertical structure of precipitation (Gao et al., 2018). All these parameters, therefore, are considered in the present study to explain the differences in the vertical structure.

Comment: Given the non-linear influence of sea surface temperature on the variability of precipitation structure, it would be an oversimplification to look at the influence of SST on the mean structure of radar echoes. It would have been interesting to classify the mean structure further into different cloud types (e.g., shallow/congestus/deep/) and assess the variability of these populations in terms of factors (e.g., winds, stability) that are co-associated with SSTs. There are no insights been provided on why the differences in the variabilities of vertical structure exist between AS and BOB. It is important to investigate if more variability over the AS is due to fluctuations in the winds/SSTs or both. From figure 2, it is evident that AS region has more seasonality in term of air-sea variables compared to BOB. Given the influence of more variables, merely analyzing indirect relationships of precipitation structure with SSTs would be futile. One way to analyze is to look at the variability of large-scale parameters (e.g., stability, vertical velocity, wind speed) for a given SST, and look at the cloud population in terms of these co-associated variables. By doing so, one would prioritize the combination of factors that lead to different convection type. SST influence on the clouds is of the first order; however, it is also important to show the temporal variation, highlighting the seasonal evolution of cloud types collocated with SSTs and other variables.

Reply: *We agree with the reviewer that all the forcing/controlling parameters (SST, winds, vertical wind velocity, stability, etc.) need to be considered for understanding the vertical structure of precipitation. We did the same in the revised version of the manuscript. Also, we studied the vertical structure of two types of precipitation (deep and shallow) as suggested by the reviewer. Since, stratiform rain is the trailing portions of convective complexes (Houze et al. 2015) and is not directly driven by the SST, it's relation with SST is not dealt separately.*

Comment: The stability measure (LTS) used here is appropriate for stratiform clouds, which may not be appropriate for convective clouds in these regions. One may use static stability profiles instead.

Reply: *As suggested by the reviewer instead of LTS the static stability (profiles of θ_e) is used in the revised manuscript to explain the convective strength as a function of SST.*