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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The vertical structure of cloud radiative heating over the Indian subcontinent during summer monsoon" *by* E. Johansson et al.

Anonymous Referee #2

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Comments on the manuscript "The vertical structure of cloud radiative heating over the Indian subcontinent during summer monsoon" – by E. Johansson, A. Devasthale, T.L'Ecuyer, A.M.L. Ekman and M. Tjernstrom (Atmos. Chem. Phys. Discuss., 15, 5423-5429, 2015).

General comments: The present study provides various cloud radiative parameters over the Indian summer monsoon region (eg., cloud radiative heating (CRH), contribution of different cloud types to total CRH, distribution of CRH during active and break monsoon conditions and radiative effects of different cloud types, etc) based on measurements from CloudSat and CALIPSO satellites which carry active radar and

lidar sensors. Discussions on the role of CRH with regard to monsoon circulation are mostly descriptive. For example, the authors mention that the net radiative warming of clouds together with latent heating sustains the monsoon circulation. However, individual contributions of latent heating and net radiative warming of clouds on the monsoon circulation are unclear; and therefore deriving this information from satellites would be valuable for understanding monsoons. While some of the results are interesting, the present work needs to be substantially improved and greatly strengthened. This is essential to bring out important value additions about CRH over the Indian monsoon region. As such, this manuscript is not acceptable for publication in ACP in the present form.

Specific comments: (1) The authors suggest that deep convection produces strong cooling at the surface during active periods of monsoon; whereas stratiform clouds are important during break periods. These results are somewhat different from earlier studies. During active monsoon conditions and periods associated with monsoon synoptic systems like the Bay of Bengal depressions, measurements from the TRMM Precipitation Radar (PR) indicate preponderance of stratiform rain and the coverage of fewer deep convective elements (Ref: Stano et al. 2002, Houze et al., 2007, Krishnan et al., 2011, Romatschke and Houze, 2012). The dominance of nimbostratus clouds during monsoon depressions was noted by Stano et al. (2002). The latent heating due to stratiform precipitation during active monsoon conditions drives continental scale circulation in the mid-tropospheric levels extending vertically up to 300 hPa (Choudhury and Krishnan, 2011). According to these studies, stratiform clouds are very important for large scale organization of monsoon convective activity. This is something that the authors need to carefully address in the context of their analysis.

(2) The issue of cloud radiative effects during monsoon breaks over the Tropical Indian Ocean has been examined using satellite data – CERES, SRB, ISCCP (Ref: Basanta Samala and Krishnan, 2007). It will be useful to highlight further value additions from the CloudSat and CALIPSO measurements, especially in the context of monsoon

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breaks.

(3) The tropical tropopause layer (TTL) cooling during the monsoon season is an interesting result. The authors further note that the TTL cooling is stronger during active monsoon conditions (-1.23 K day-1) as compared to break periods (-0.36 K day-1), since high clouds, associated with deep convection, emit at much colder temperature. The link between the vertical temperature gradients and strength of the monsoon circulation is an interesting problem for further investigations.

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