Regional distribution of the high altitude clouds over the Indian Subcontinent and surrounding oceanic areas based on 7-years of satellite observations

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Role of high altitude clouds on the hydrological cycle, energetics and radiation budget of the earth-atmosphere system are considerably different from that of the other clouds. The high altitude clouds can be formed either through deep convection or through insitu condensation. Because of this, these clouds can be used as tracers of the deep convention, which has significant importance in the generation of atmospheric waves and vertical coupling of the atmosphere. The spatio-temporal variations of deep convective events and cloud cover over the Indian subcontinent are unique mainly because the Inter Tropical Convergence Zone (ITCZ) has largest annual migration in this region. Satellite observations of the cloud top temperature provide a unique opportunity to study the regional distribution of high altitude clouds. Detailed quantitative estimates of the spatio-temporal variations of deep convective events over the Indian subcontinent and the surrounding oceanic areas in the geographical region between 40˚E-100˚E and 25˚S-25˚N are reported here. This study is based on the daytime observations made by the Advanced Very High Resolution Radiometer (AVHRR) onboard NOAA-14 and NOAA-16 during the period of 1996-2003. All the daytime passes of NOAA14/16 satellites over the study region during this period are used in the present study. Those pixels having brightness temperature (BT) in thermal IR bands (viz. Channels 4 and 5) $<$245K are considered as high altitude clouds and those having BT$<$220 K are considered as very high altitude clouds. The present study shows that the spatial distribution of high and very high altitude clouds show large spatial and temporal heterogeneity. During the January to April period, the monthly mean fractional area covered by high altitude clouds (FRHC, the value of which can range from 0 to 1) is $<$0.1 over the Indian subcontinent while it is 0.3 to 0.4 over the Inter Tropical Convergence Zone, located in the equatorial Indian Ocean during this period. Highest values of FRHC are observed during June to August period over the North Bay of Bengal (NBoB). In this region, the monthly mean values of FRHC are between 0.4 to 0.6 over a large geographical region extending more than 10^6 km^2. Though the monthly mean FRHC over the Southeast Arabian Sea (SEAS) is also very large ($\sim$0.4) during June-July, its areal extent is limited to $<10^5$ km^2. Regions of high FRHC are mostly located over the oceanic regions adjacent to continents. In those regions where FRHC is large, it shows significant temporal variations. Over the NBoB and SEAS, daily values of regional mean FRHC ranges from 0 to 0.9, and generally varies over

periods of 5-15 days and 30-40days. The corresponding regional mean cloud top temperature of the high altitude clouds (HCTT) over these regions also shows large short period oscillations and seasonal variations. The regional mean values of HCTT over NBoB is generally in the range of 245 to 235 K during January-April, and in the range of 240 to 210 K during June-July, indicating a change of more than 3 km in the mean cloud top altitude between January and July. The corresponding values of HCTT over SEAS are in the range of 245 to 235 K during January-April, and in the range of 240 to 220 K during June-July, indicating a relatively smaller seasonal change.