A significant increasing trend of fine-mode AOD is observed and high CF (~0.4-0.5) from warm clouds is also observed over AS and BOB

Supplementary Result 1

A significant increasing trend of warm cloud CF is also observed over NIO, and the percentage of warm clouds to the total cloud cover is higher over AS as compared to BOB

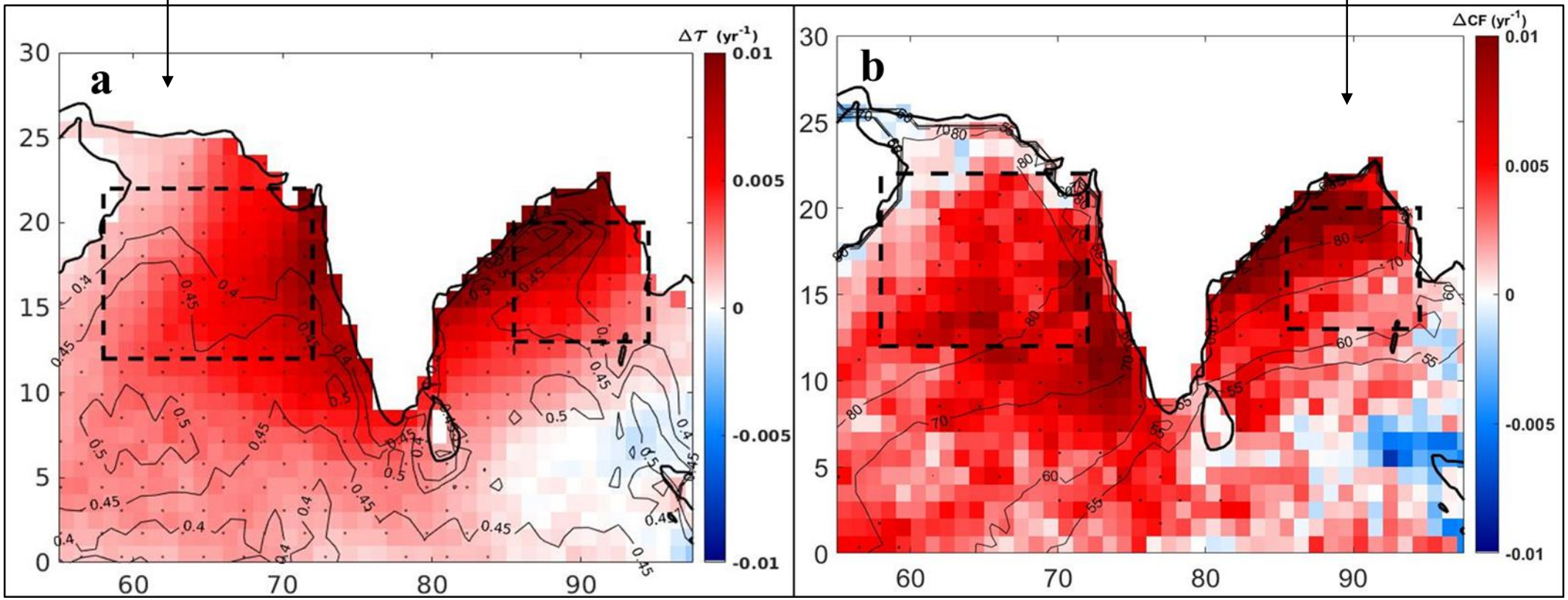
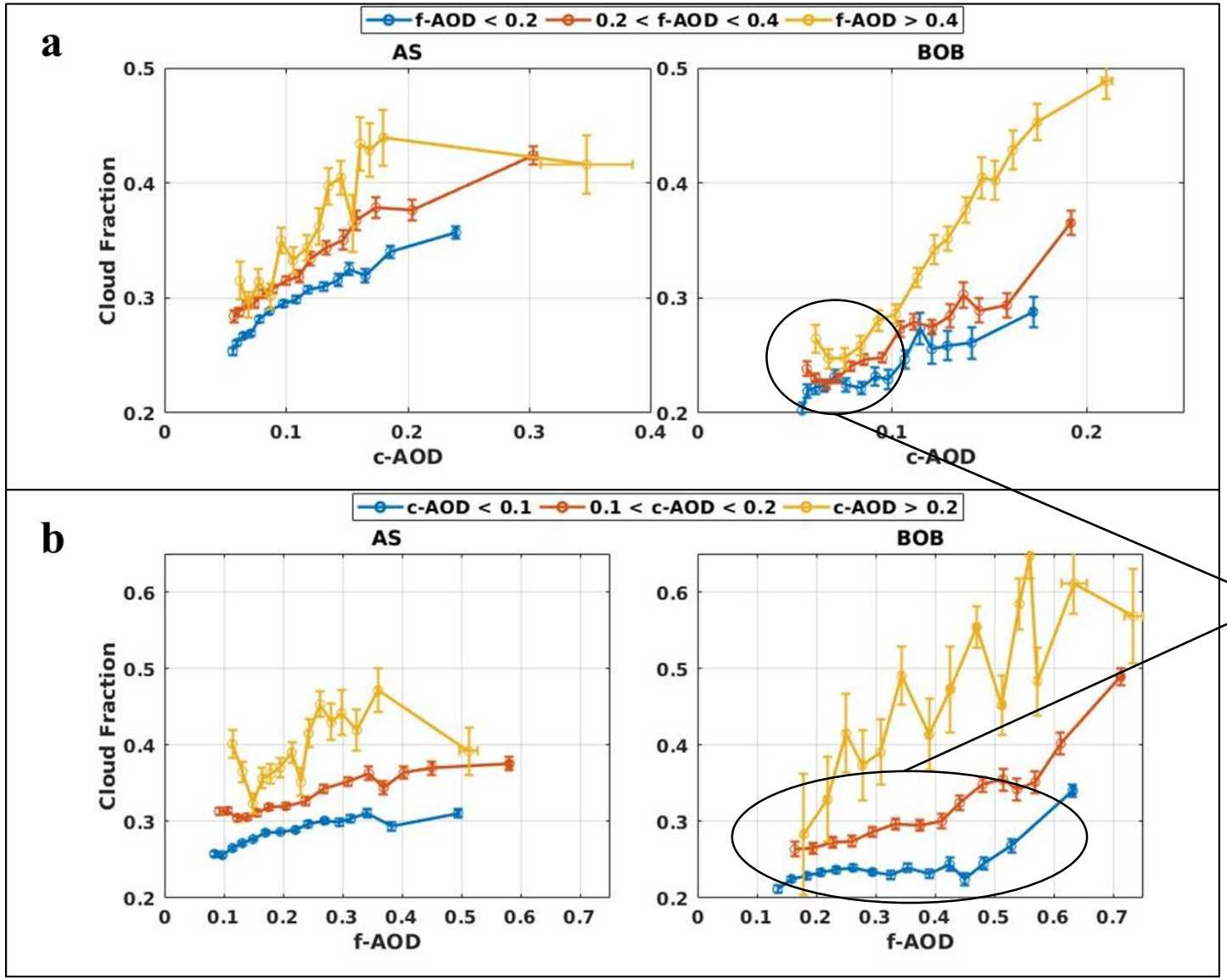


Figure S1| Pixel-wise trend of (a) fine-mode AOD with contours representing the cloud fraction (CF) of warm clouds (Cloud Top Temperature, CTT > 273K) and (b) warm cloud CF with contours representing the percentage contribution of warm clouds to the total cloud cover over the Northern Indian Ocean during the winter season (DJF) for the period 2000–2021.

Supplementary Result 2

The average increase in CF is much more with c-aod as compared with f-aod, however it should be noted that the average CF increase when both the fine and coarse mode aerosols are abundant

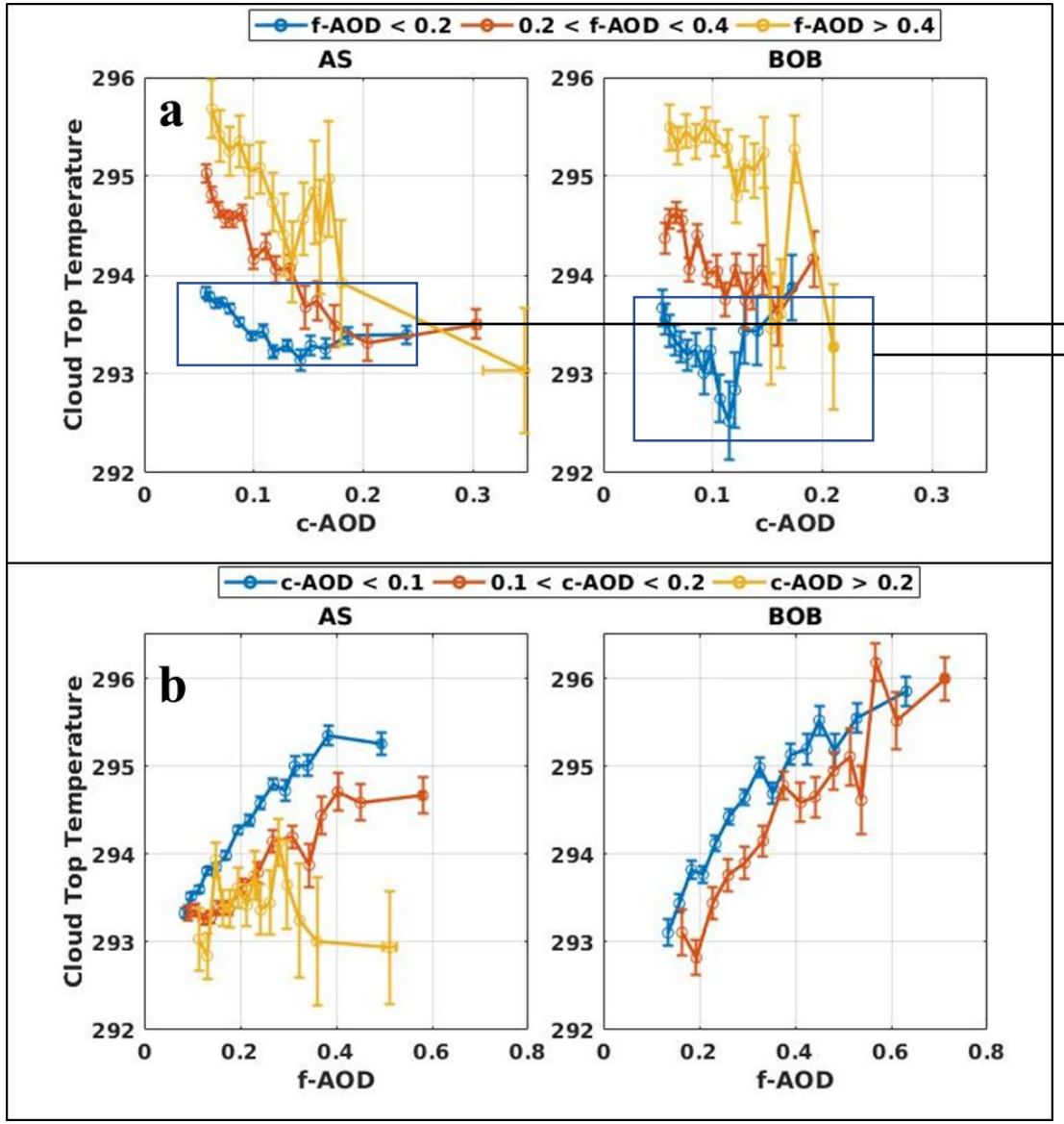


Over BOB, a decline in CF is observed at very low c-AOD and can be attributed to the cloud dissipation due to fine mode-aerosol induced changes in cloud microphysical properties

Figure S2| Warm cloud fraction as a function of a) coarse mode AOD at fixed fine mode AOD and b) fine mode AOD at fixed coarse mode AOD over Arabian Sea and Bay of Bengal. The different colors correspond to the values of f-AOD and c-AOD fixed and is shown in the legends at the top of each plot.

Supplementary Result 3

There is an average decrease in the CTT with increase in c-AOD, however the effects varies at diff f-AOD. At high f-AOD the initial CTT is relatively high as compared to when the f-AOD is lower. This indicates the semi-direct effect is notably higher due to f-AOD.



The reversal in the decrease in CTT with increase in c-AOD is also observed at very low f-AOD values and is prominent over BOB as compared to AS. This observation indicates that the microphysical effect is also playing a major role along with semi-direct effects and it depends on the relative concentration of the different sized particles.

Figure S3| Cloud Top Temperature (Warm clouds) as a function of a) coarse mode AOD at fixed fine mode AOD and b) fine mode AOD at fixed coarse mode AOD over Arabian Sea and Bay of Bengal. The different colors correspond to the values of f-AOD and c-AOD fixed and is shown in the legends at the top of each plot.