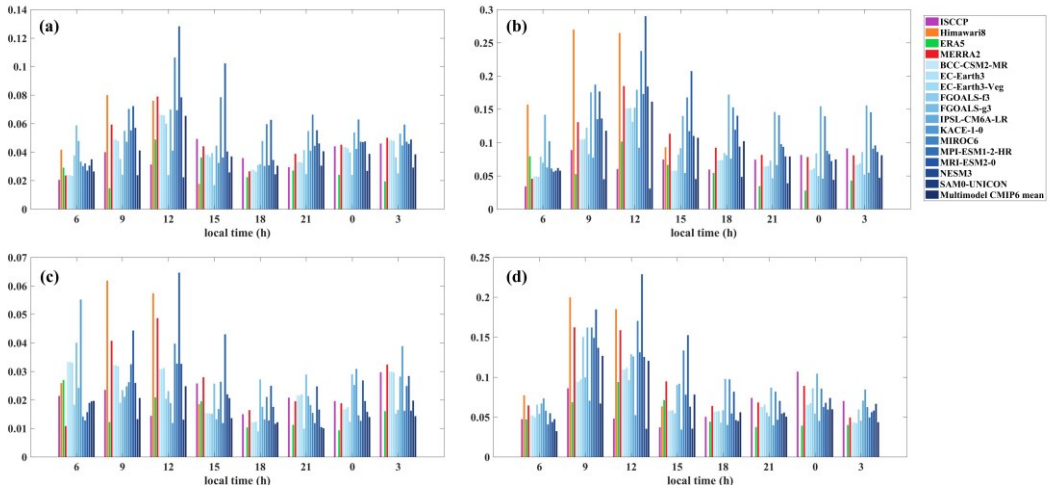

Figure S1: The mean absolute error (MAE) between total cloud cover of spatial distribution based on ISCCP-H, Himawari-8, ERA5, MERRA-2, CMIP6 outputs and CATS of different regions of the TP. (a) The northwestern TP (b) The northeastern TP (c) The southwestern TP (d) The southeastern TP. The regions are divided by latitude and longitude lines of 33°N and 89°E (shown in Fig. 1).

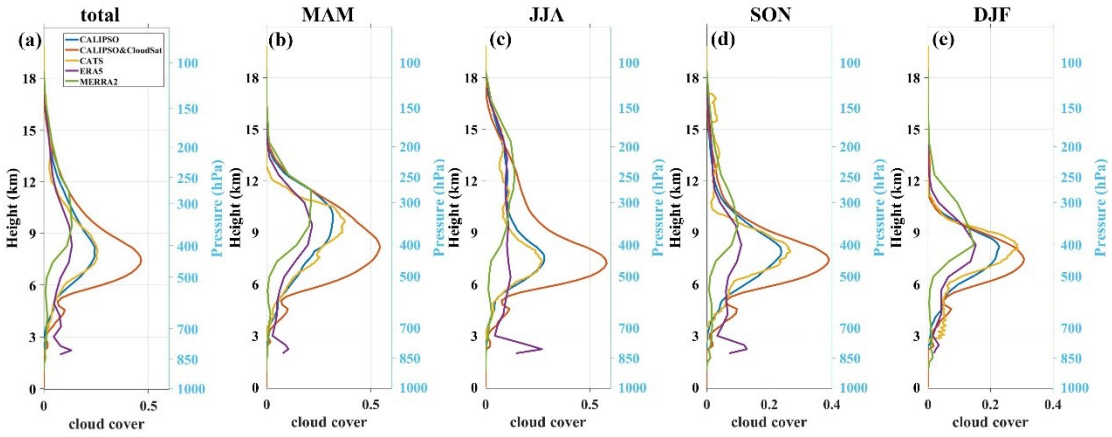

Figure S2: The cloud vertical structure in different seasons of TP based on CALIPSO (blue lines), 2B-GEOPROF-lidar (CALIPSO&CloudSat, red lines), CATS (yellow lines), ERA5 (purple lines), MERRA-2 (green lines) at 13:30 LT. (a) The results of annual average (b) The results of spring (c) The results of summer (d) The results of autumn (e) The results of winter. All seasons here are northern hemisphere seasons.

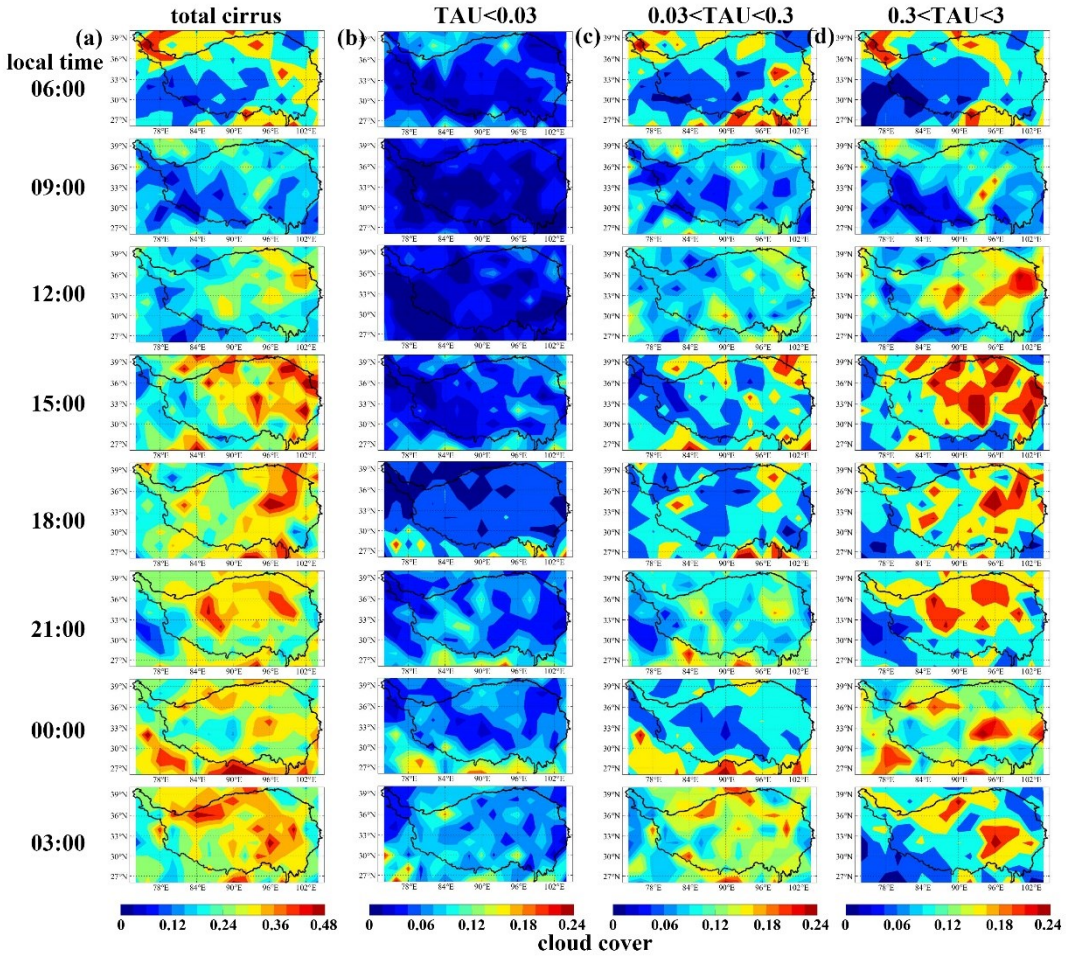

Figure S3: The spatial distribution of 3-hourly cloud cover of cirrus over the TP based on CATS. (a) The cloud cover of all cirrus. (b) The subvisible cirrus (optical thickness less than 0.03). (c) The thin cirrus (optical thickness between 0.03 and 0.3). (d) The opaque cirrus (optical thickness between 0.3 and 3).

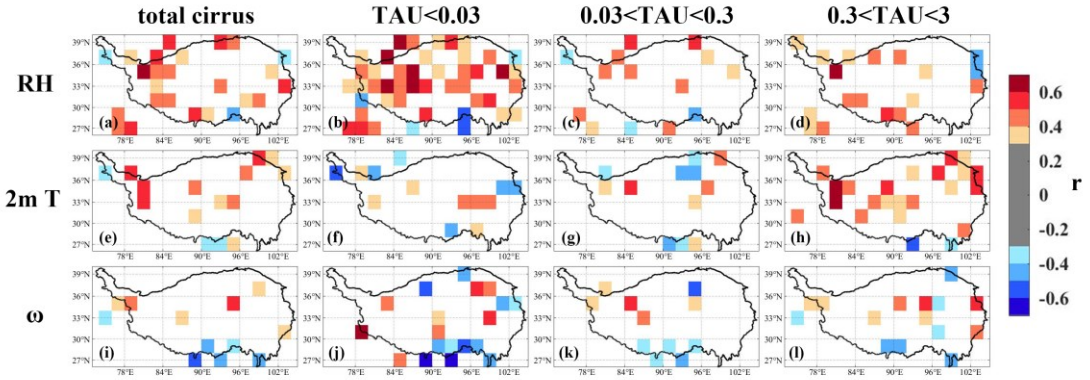

Figure S4: The correlation coefficient between different types of cirrus (first column: all cirrus, second column: the subvisible cirrus (optical thickness less than 0.03), third column: the thin cirrus (optical thickness between 0.03 and 0.3), fourth column: the opaque cirrus (optical thickness between 0.3 and 3)) and 250 hPa relative humidity (%) (first line), 2-m temperature (K) (second line), 250 hPa vertical velocity (Pa/s) (third line) at each 2 degree grid over the TP. The correlation coefficient is shown on the graph only if the correlation passes the significance test by 90%, otherwise it is shown as blank.