



*Supplement of*

## **Evaluation of annual trends in carbon cycle variables simulated by CMIP6 Earth system models in China**

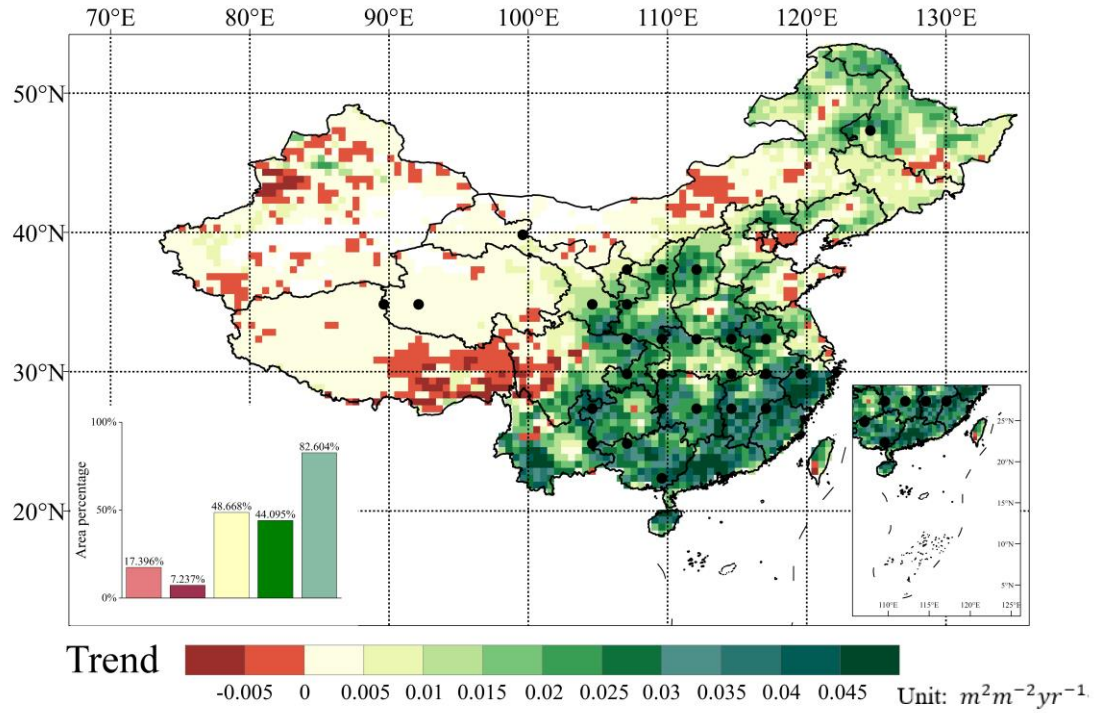
**Ziyang Li et al.**

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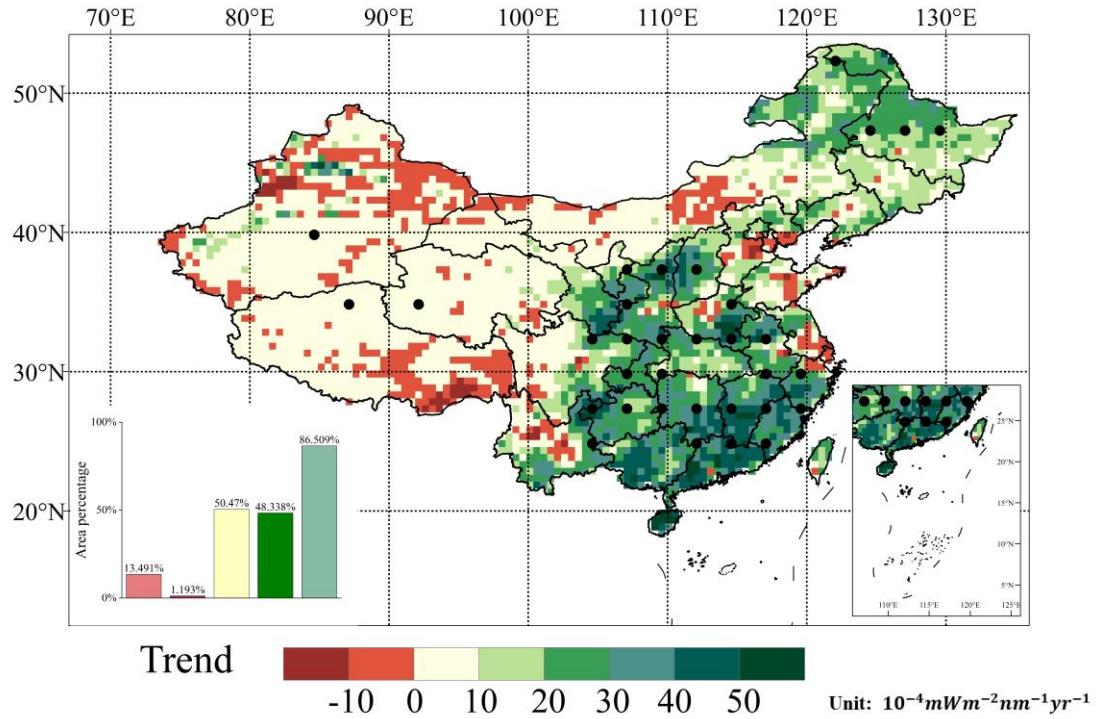
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**Table S1: Summary of the classification of vegetation and land use types in China.**

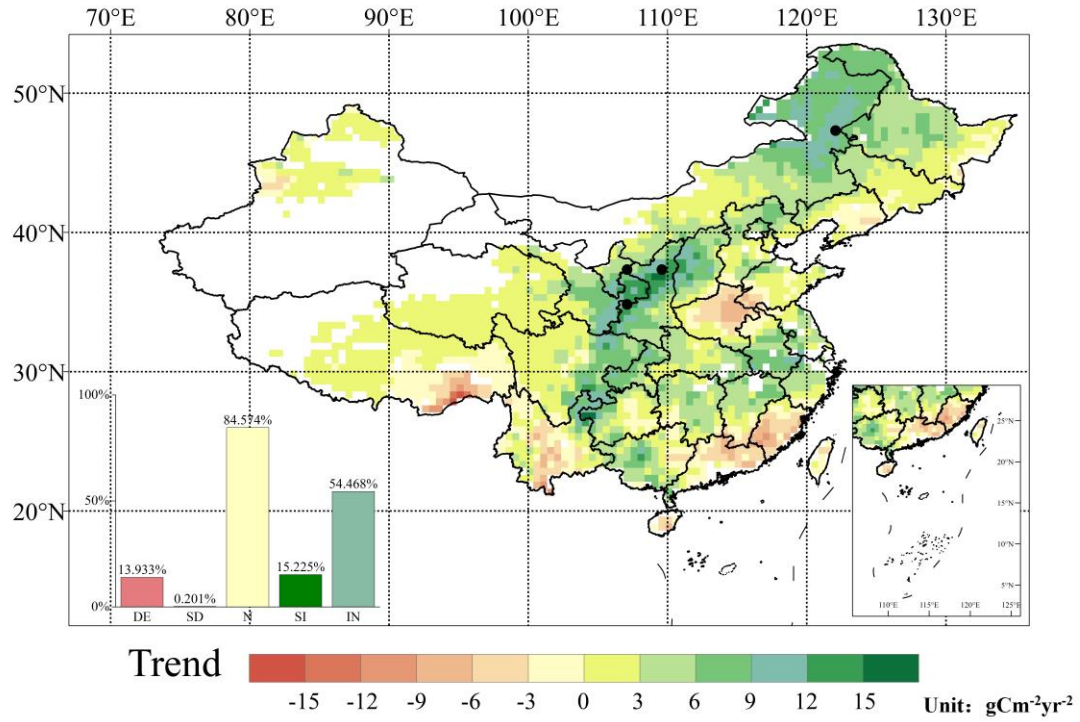
| Name  | Vegetation or land use type         | Classification type | area proportion (%) |
|-------|-------------------------------------|---------------------|---------------------|
| ENF   | Evergreen Needleleaf Forests        | Tree Cover          | 0.77                |
| EBF   | Evergreen Broadleaf Forests         | Tree Cover          | 2.37                |
| DNF   | Deciduous Needleleaf Forests        | Tree Cover          | 0.15                |
| DBF   | Deciduous Broadleaf Forests         | Tree Cover          | 3.29                |
| MF    | Mixed Forests                       | Tree Cover          | 2.75                |
| CS    | Closed Shrublands                   | Grassland           | 0.04                |
| OS    | Open Shrublands                     | Grassland           | 0.08                |
| WS    | Woody Savannas                      | Tree Cover          | 10.01               |
| Sa    | Savannas                            | Tree Cover          | 7.96                |
| Gr    | Grasslands                          | Grassland           | 30.04               |
| PW    | Permanent Wetlands                  | Grassland           | 0.21                |
| Cr    | Croplands                           | Crop                | 12.92               |
| UBL   | Urban and Built-up Lands            | Non Vegetable       | 1.25                |
| C/NVM | Cropland/Natural Vegetation Mosaics | Crop                | 2.02                |
| PSI   | Permanent Snow and Ice              | Non Vegetable       | 0.33                |
| Ba    | Barren                              | Non Vegetable       | 24.82               |
| WB    | Water Bodies                        | Non Vegetable       | 0.99                |



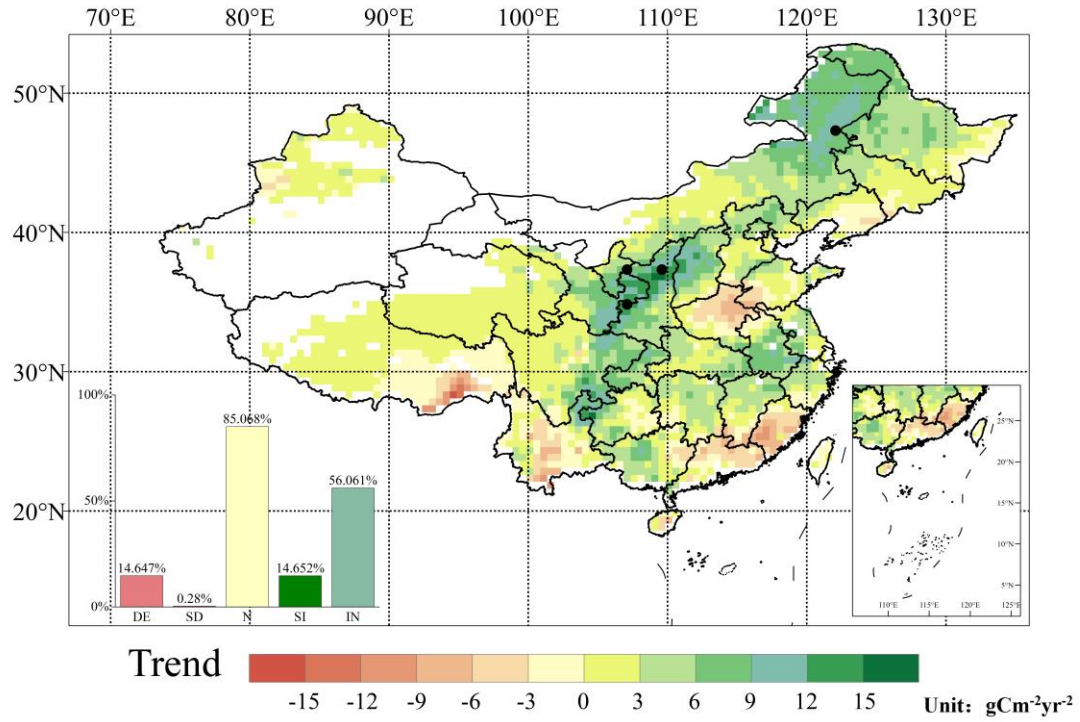
**Figure S1: The observed annual MODIS LAI trend during 2003~2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).**



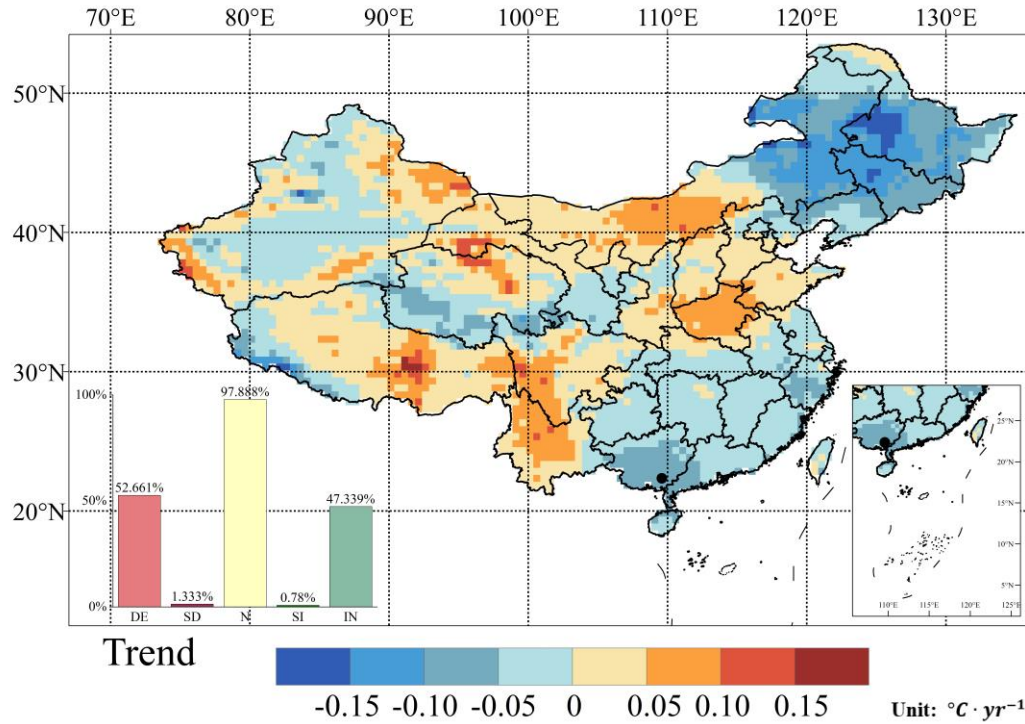
**Figure S2:** The observed annual CSIF trend during 2003~2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).



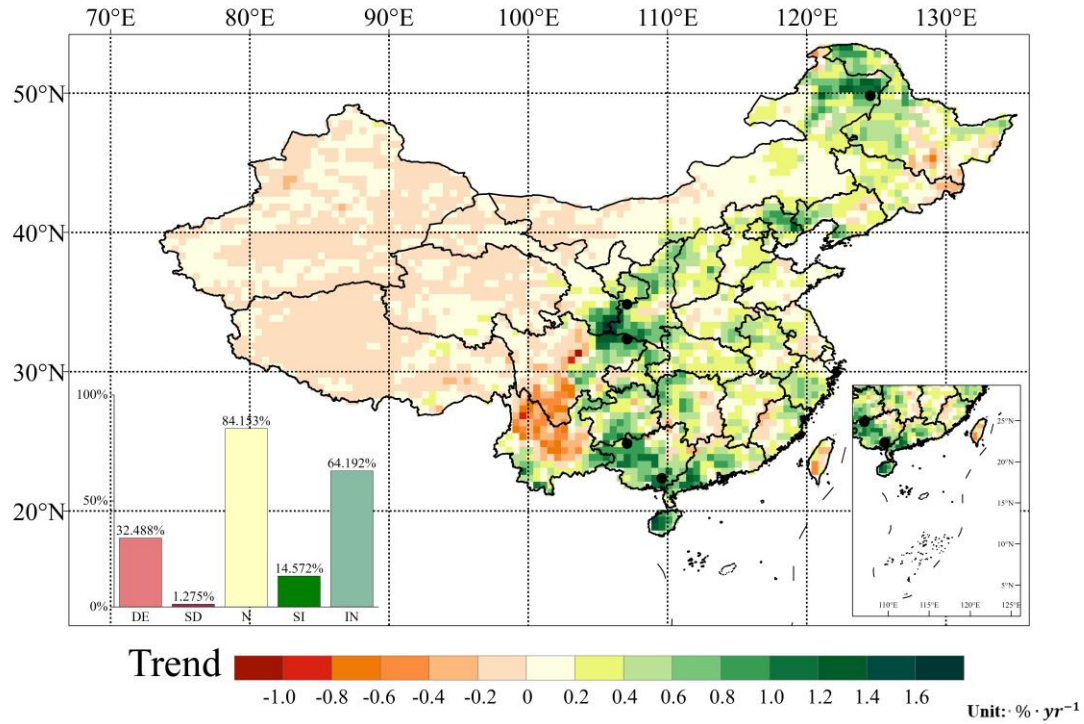
**Figure S3: The observed annual MODIS NPP trend during 2003~2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).**



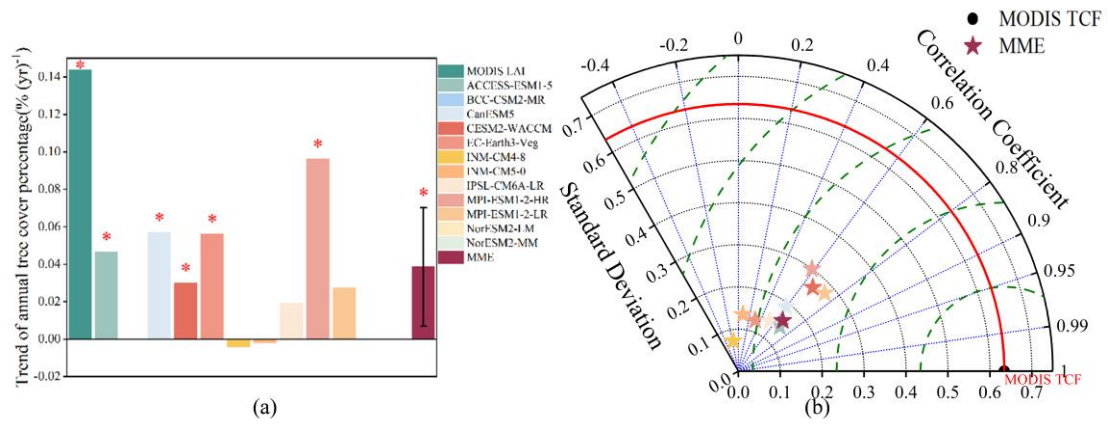
**Figure S4: The observed annual MODIS NPP trend during 2003~2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).**



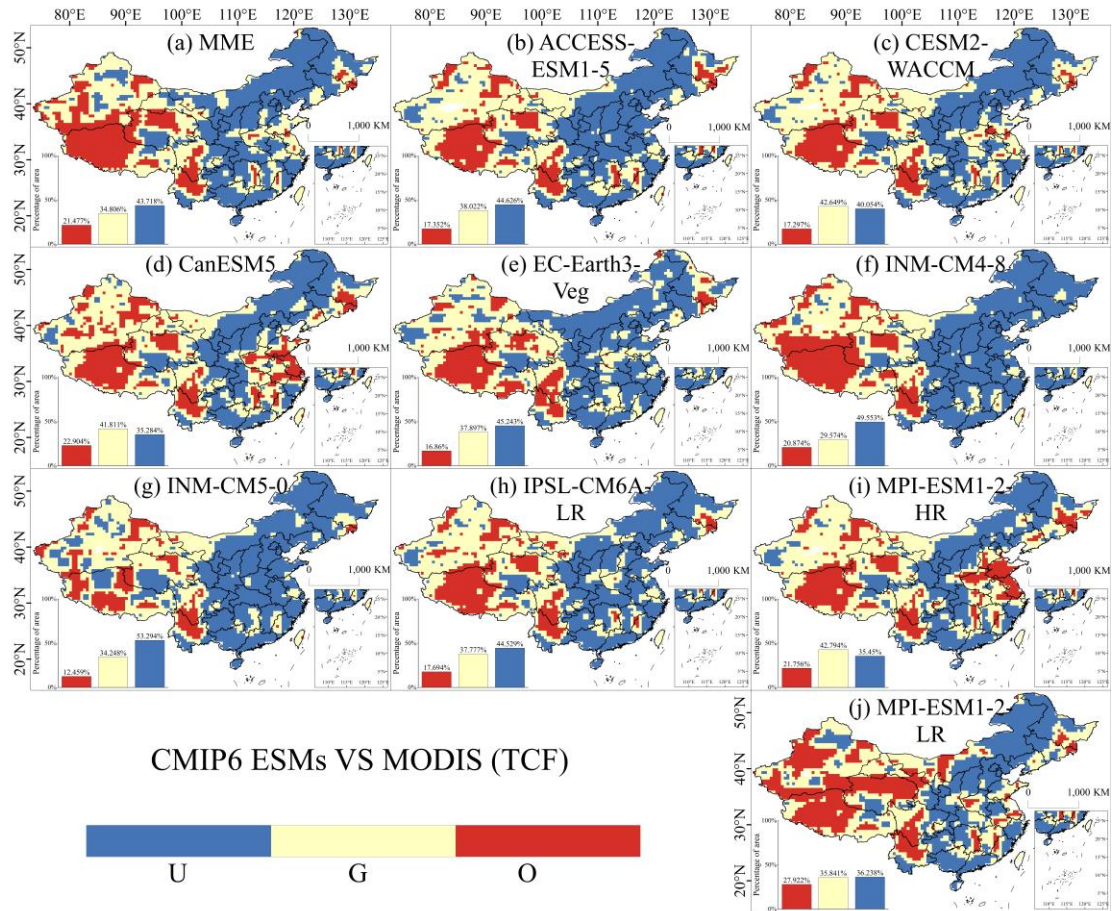
**Figure S5: The observed annual MODIS LST trend during 2003~2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).**



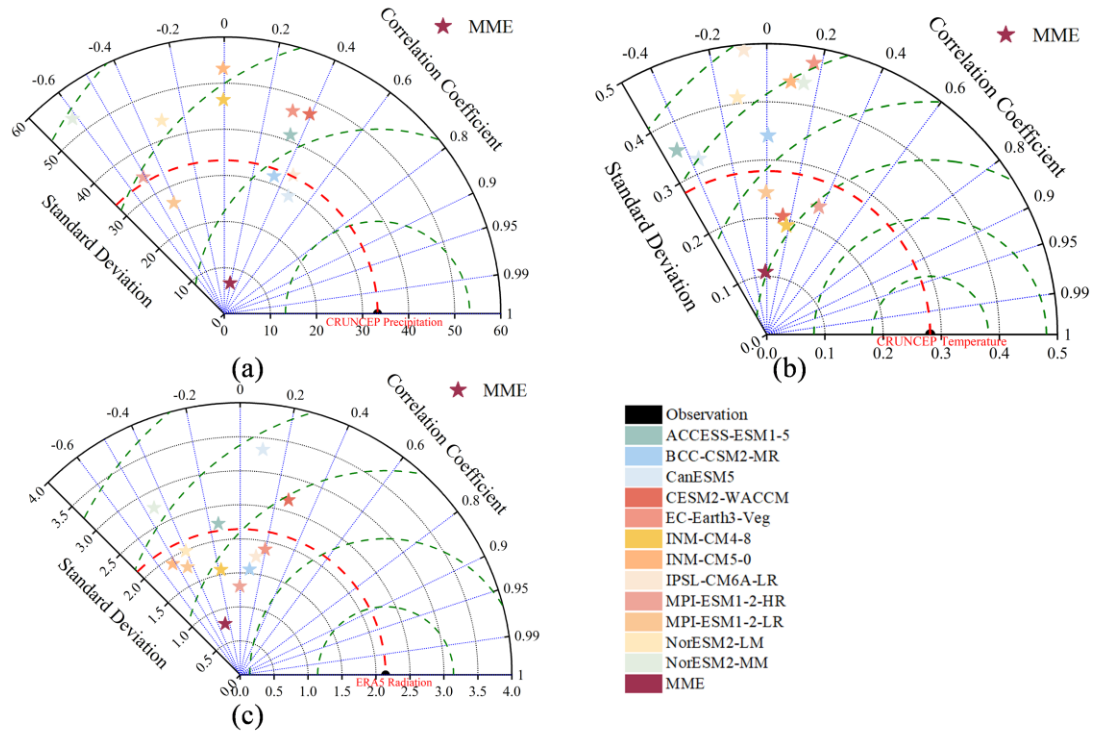
**Figure S6:** The observed annual CSIF, (c) MODIS NPP, (d) MODIS NEP, (e) MODIS LST and (f) MODIS TCF trend during 2003–2014 in China. Pink color represents the percentage of area of decreasing regions (DE), red color represents the percentage of area of significantly decreasing regions (SD), yellow color represents the percentage of area of regions with no significant change (N), green color represents the percentage of area of significantly increasing regions (SI), and light green color represents the percentage of area of increasing regions (IN). The dot indicated the significant trend ( $p < 0.05$ ).



**Figure S7: (a) Overall annual average TCF trends in China during 2003-2014. The asterisk (\*) indicated the significant trend ( $p < 0.05$ ). (b) The Taylor diagrams compare the remotely-sensed and model-simulated global annual mean TCF for the historical period (2003-2014). The standard deviation shows the interannual variability of the observed and simulated LAI. The dashed green lines show centered root mean square difference (RMSD) between model simulations and satellite observations.**



**Figure S8: Evaluation of the tree cover percentage trend performance of the CMIP6 ESM from 2003 to 2014 in China.** A paired t-test with a sample size of 9 was conducted using a 3×3 sliding window to determine whether the model simulated a trend that was not significantly different from the observed data (Good), significantly smaller than the observed data (Underestimate), or significantly larger than the observed data (Overestimate). U, G, and O represent 'Underestimate ', 'Good', and 'Overestimate', respectively.



**Figure S9:** The Taylor diagram compares the observed and model-simulated annual means of climate factors (a) precipitation, (b) temperature, and (c) solar radiation for the historical period (2003-2014). The standard deviation shows the interannual variability of the observed and simulated LAI. The dashed green lines show centered root mean square difference (RMSD) between model simulations and satellite observations.

**Table S2: Summary of Statistical Metrics (Mean, SD, RMSD) for Observed and Model-Simulated Annual Mean Precipitation, Temperature, and Radiation**

|                            | Precipitation(mm) |          |          | Temperature(°C) |         |         | Radiation(W/m <sup>2</sup> ) |         |         |
|----------------------------|-------------------|----------|----------|-----------------|---------|---------|------------------------------|---------|---------|
|                            | Mean              | SD       | RMSD     | Mean            | SD      | RMSD    | Mean                         | SD      | RMSD    |
| Remote sensing observation | 613.64806         | 33.26141 | /        | 7.63093         | 0.28095 | /       | 178.18524                    | 2.14209 | /       |
| MME                        | 867.4114          | 6.73035  | 31.29347 | 6.52192         | 0.10744 | 0.29024 | 194.01037                    | 0.78118 | 2.3726  |
| ACCESS-ESM1-5              | 1040.18351        | 41.31607 | 41.28819 | 7.16172         | 0.35231 | 0.51566 | 184.97961                    | 2.2438  | 3.17482 |
| BCC-CSM2-MR                | 727.37508         | 31.7226  | 35.76094 | 4.82402         | 0.34208 | 0.42253 | 183.79863                    | 1.55593 | 2.42488 |
| CanESM5                    | 747.40222         | 29.02126 | 30.65384 | 3.78862         | 0.32382 | 0.47857 | 188.30924                    | 3.32677 | 3.61066 |
| CESM2-WACCM                | 931.57702         | 47.06833 | 43.754   | 8.61381         | 0.20517 | 0.31106 | 191.1325                     | 2.66486 | 2.81495 |
| EC-Earth3-Veg              | 697.68418         | 46.3696  | 45.6074  | 5.62987         | 0.4737  | 0.48608 | 190.16296                    | 1.87844 | 2.44838 |
| INM-CM4-8                  | 1116.61609        | 46.36924 | 54.74785 | 7.04681         | 0.19034 | 0.29721 | 210.0205                     | 1.56934 | 2.75106 |
| INM-CM5-0                  | 1082.96623        | 53.14569 | 60.16718 | 6.52697         | 0.4369  | 0.47534 | 210.44639                    | 1.90865 | 3.38243 |
| IPSL-CM6A-LR               | 738.0079          | 33.52197 | 33.67346 | 3.04972         | 0.49094 | 0.56015 | 201.9655                     | 1.75335 | 2.47112 |
| MPI-ESM1-2-HR              | 733.44302         | 34.4346  | 56.33748 | 7.25265         | 0.23723 | 0.27916 | 194.34585                    | 1.30037 | 2.40424 |
| MPI-ESM1-2-LR              | 794.64687         | 26.41971 | 48.19112 | 6.4484          | 0.24422 | 0.35745 | 186.96089                    | 1.76221 | 3.17683 |
| NorESM2-LM                 | 851.89759         | 44.01298 | 60.15218 | 8.31717         | 0.41054 | 0.50303 | 193.13471                    | 1.98927 | 3.31409 |
| NorESM2-MM                 | 834.14687         | 53.5992  | 75.2135  | 7.8185          | 0.43701 | 0.46347 | 197.56405                    | 2.76213 | 4.02235 |

**Table S3: Summary of key land surface components and related parameters for selected ESMs**

| ESM name      | Modelling group | Land surface model    | Fire/N cycle/Dynamic vegetation | Prognostic LAI/leaf phenology | Number of live&dead carbon pools | Number of PFTs |
|---------------|-----------------|-----------------------|---------------------------------|-------------------------------|----------------------------------|----------------|
| ACCESS-ESM1-5 | CSIRO           | CABLE2.4              | No/Yes/No                       | Yes/No                        | 3 & 6                            | 13             |
| BCC-CSM2-MR   | BCC             | BCC-AVIM2             | No/No/No                        | Yes/Yes(for deciduous)        | 3 & 8                            | 16             |
| CanESM5       | CCCma           | CLASS-CTEM            | No/No/No                        | Yes/Yes                       | 3 & 2                            | 9              |
| CESM2-WACCM   | CESM            | CLM5                  | -/Yes/No                        | Yes/Yes                       | 22 & 7                           | 22             |
| EC-Earth3-Veg | EC-Earth        | H-TESESEL & LPJ-GUESS | -                               | -                             | -                                | -              |
| INM-CM4-8     | INM             | -                     | -                               | -                             | -                                | -              |
| INM-CM5-0     | INM             | -                     | -                               | -                             | -                                | -              |
| IPSL-CM6A-LR  | IPSL            | ORCHIDEE v2.0         | No/No/No                        | Yes/Yes                       | 8 & 3                            | 15             |
| MPI-ESM1-2-HR | MPI             | JSBACH3.2             | Yes/Yes/Yes                     | Yes/Yes                       | 3 & 18                           | 13             |
| MPI-ESM1-2-LR | MPI             | JSBACH3.2             | Yes/Yes/Yes                     | Yes/Yes                       | 3 & 18                           | 13             |
| NorESM2-LM    | NorESM          | CLM5                  | Yes/Yes/No                      | Yes/Yes                       | 22 & 7                           | 22             |
| NorESM2-MM    | NorESM          | CLM5                  | Yes/Yes/No                      | Yes/Yes                       | 22 & 7                           | 22             |