Table S1. The different model combinations were test to choose the optimal TPS model for ChinaClim\_baseline.

|  |  |  |
| --- | --- | --- |
|  | **Precipitation** | **Temperature elements** |
| Model **1** | F(x,y,z)+coast | F(x,y,z)+coast |
| Model **2** | F(x,y,z,coast)+trmm\_m | F(x,y,z,coast)+lst\_m |
| Model **3** | F(x,y,z,trmm\_m)+coast | F(x,y,z, lst\_m)+coast |
| Model **4** | F(x,y,z)+coast+trmm\_m | F(x,y,z)+coast+ lst\_m |
| Model **5** | F(x,y,z,coast,trmm\_y)+trmm\_m | F(x,y,z,coast, lst\_y)+ lst\_m |
| Model **6** | F(x,y,z,coast,trmm\_m)+Trmm\_y | F(x,y,z,coast, lst\_m)+ lst\_y |
| Model **7** | F(x,y,z,trmm\_m,trmm\_y)+coast | F(x,y,z, lst\_m, lst \_y)+coast |
| Model **8** | F(x,y,z,trmm\_y)+coast+Trmm\_m | F(x,y,z lst\_y)+coast+ lst\_m |
| Model **9** | F(x,y,z,coast)+trmm\_m+trmm\_y | F(x,y,z,coast)+ lst \_m+ lst\_y |
| Model **10** | F(x,y,z,Trmm\_m)+coast+trmm\_y | F(x,y,z, lst\_m)+coast+ lst\_y |
| Model **11** | F(x,y,z)+coast+trmm\_m+trmm\_y | F(x,y,z)+coast+ lst\_m+ lst\_y |

Note：lst\_m and lst\_y represented the average of the day and night LST) during 2001-2019 averaged by month (lst\_dm, lst\_nm, lst\_am) and year (lst\_dy, lst\_ny, lst\_ay), respectively.

Table S2. Tenfold spatially stratified cross-validation statistics for selected models in different months over Temperate continental region.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Precipitation | Model **5** | Model **5** | Model **2** | Model **6** | Model **5** | Model **7** | Model **7** | Model **6** | Model **7** | Model **7** | Model **1** | Model **5** |
| Average temperature | Model **1** | Model **11** | Model **4** | Model **4** | Model **11** | Model **11** | Model **1** | Model **11** | Model **1** | Model **4** | Model **4** | Model **4** |
| Maximum temperature | Model **4** | Model **4** | Model **4** | Model **11** | Model **4** | Model **6** | Model **1** | Model **4** | Model **1** | Model **1** | Model **1** | Model **1** |
| Minimum temperature | Model **7** | Model **11** | Model **6** | Model **4** | Model **4** | Model **6** | Model **11** | Model **11** | Model **1** | Model **6** | Model **11** | Model **1** |

Table S3. Tenfold spatially stratified cross-validation statistics for selected models in different months over High cold Tibetan Plateau.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Precipitation | Model **11** | Model **5** | Model **5** | Model **5** | Model **5** | Model **6** | Model **7** | Model **5** | Model **5** | Model **7** | Model **5** | Model **11** |
| Average temperature | Model **1** | Model **1** | Model **4** | Model **4** | Model **9** | Model **1** | Model **6** | Model **6** | Model 4 | Model **1** | Model **1** | Model **11** |
| Maximum temperature | Model **1** | Model **4** | Model **9** | Model **6** | Model **9** | Model **9** | Model **1** | Model **9** | Model **2** | Model **4** | Model **1** | Model **6** |
| Minimum temperature | Model **1** | Model **1** | Model **11** | Model **1** | Model **1** | Model **6** | Model **6** | Model **9** | Model **1** | Model **1** | Model **11** | Model **4** |

Table S4. Tenfold spatially stratified cross-validation statistics for selected models in different months over Temperate monsoonal region.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Prep | Model **4** | Model **4** | Model **4** | Model **7** | Model **7** | Model **6** | Model **9** | Model **4** | Model **11** | Model **11** | Model **7** | Model **6** |
| Tavg | Model **4** | Model **1** | Model **4** | Model **4** | Model **4** | Model **1** | Model **4** | Model **4** | Model **4** | Model **1** | Model **6** | Model **4** |
| Tmax | Model **11** | Model **11** | Model **5** | Model **9** | Model **1** | Model **1** | Model **4** | Model **1** | Model **1** | Model **4** | Model **6** | Model **6** |
| Tmin | Model **11** | Model **4** | Model **2** | Model **11** | Model **11** | Model **11** | Model **9** | Model **9** | Model **9** | Model **4** | Model **11** | Model **1** |

Table S5. Tenfold spatially stratified cross-validation statistics for selected models in different months over Subtropical-tropical monsoonal region.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Prep | Model **8** | Model **6** | Model **7** | Model **5** | Model **5** | Model **11** | Model **6** | Model **4** | Model **6** | Model **7** | Model **6** | Model **9** |
| Tavg | Model **1** | Model **1** | Model **1** | Model **11** | Model **9** | Model **4** | Model **1** | Model **1** | Model **11** | Model **9** | Model **1** | Model **1** |
| Tmax | Model **11** | Model **4** | Model **1** | Model **4** | Model **9** | Model **1** | Model **4** | Model **11** | Model **4** | Model **1** | Model **4** | Model **1** |
| Tmin | Model **11** | Model **1** | Model **1** | Model **4** | Model **4** | Model **2** | Model **9** | Model **2** | Model **9** | Model **11** | Model **1** | Model **4** |

Table S6. The different model combinations were test to choose the optimal TPS model for ChinaClim\_time-series

|  |  |  |
| --- | --- | --- |
|  | **Precipitation** | **Temperature elements** |
| Model **1** | F(x,y,z,base,coast)+cru\_r | F(x,y,z,base,coast)+cru\_a |
| Model **2** | F(x,y,z,base,cru\_r)+coast | F(x,y,z,base,cru\_a)+coast |
| Model **3** | F(x,y,z,coast,cru\_r)+base | F(x,y,z,coast,cru\_a)+base |
| Model **4** | F(x,y,z,base)+coast+cru\_r | F(x,y,z,base)+coast+cru\_a |
| Model **5** | F(x,y,z,coast)+cru\_r+base | F(x,y,z,coast)+cru\_a+base |
| Model **6** | F(x,y,z,base)+base +coast | F(x,y,z, cru\_a)+base+coast |
| Model **7** | F(x,y,z)+cru\_r+base+coast | F(x,y,z)+cru\_a+base+coast |
| Model **1a** | F(x,y,z,base,coast)+cru\_r+trmm\_r | F(x,y,z,base,coast)+cru\_a+lst\_a |
| Model **1b** | F(x,y,z,base,coast,trmm\_r)+cru\_r | F(x,y,z,base,coast,lst\_a)+cru\_a |
| Model **7a** | F(x,y,z,trmm\_r)+cru\_r+base+coast | F(x,y,z,lst\_a)+cru\_a+base+coast |
| Model **7b** | F(x,y,z)+cru\_r+base+coast+trmm\_r | F(x,y,z)+cru\_a+base+coast+lst\_a |

Note：base was the 30-Year Normals; trmm\_r was monthly precipitation ratio from TRMM 3B43; lst\_a was monthly temperature anomaly from Modis LST; cru\_r and cru\_a represented monthly precipitation ratio and temperature anomaly from CRU, respectively.

Table S7. The optimal model formulations for ChinaClim\_timeseries.during 1952-2019

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Prep | Model **7** | Model 1 | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** |
| Tavg | Model **1** | Model **1** | Model **1** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **1** |
| Tmax | Model **1** | Model **1** | Model **1** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **1** | Model **1** |
| Tmin | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** | Model **7** |

Table S8. The optimal model formulations for ChinaClim\_timeseries. (Precipitation: 1998-2019; Temperature: 2001-2019)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Prep | Model **7b** | Model **1a** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** |
| Tavg | Model **1a** | Model **1a** | Model **1a** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **1a** |
| Tmax | Model **1a** | Model **1a** | Model **1a** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **1a** | Model **1a** |
| Tmin | Model **7b** | Model **7b** | Model **7** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** | Model **7b** |



Figure S1. Density scatter plots of precipitation in Temperate continental region (a, b), High cold Tibetan Plateau (c, d), Temperate monsoonal region (e, f), Subtropical-tropical monsoonal region (g, h). The first row represented precipitation model with satellite-driven data; the second row represented precipitation model without satellite-driven data.



Figure S2. Density scatter plots of average temperature in Temperate continental region (a, b), High cold Tibetan Plateau (c, d), Temperate monsoonal region (e, f), Subtropical-tropical monsoonal region (g, h). The first row represented average temperature model with satellite-driven data; the second row represented average temperature model without satellite-driven data.



Figure S3. Density scatter plots of maximum temperature in Temperate continental region (a, b), High cold Tibetan Plateau (c, d), Temperate monsoonal region (e, f), Subtropical-tropical monsoonal region (g, h). The first row represented maximum temperature model with satellite-driven data; the second row represented maximum temperature model without satellite-driven data.



Figure S4. Density scatter plots of minimum temperature in Temperate continental region (a, b), High cold Tibetan Plateau (c, d), Temperate monsoonal region (e, f), Subtropical-tropical monsoonal region (g, h). The first row represented minimum temperature model with satellite-driven data; the second row represented minimum temperature model without satellite-driven data.