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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Precipitation** | **Average temperature** | **Maximum temperature** | **Minimum temperature** |
| **Model1** | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) |
| **Model2** | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast |
| **Model3** | F(Lat,Lon,Elev,Coast,Trmm\_m) | F(Lat,Lon,Elev,Coast,LST\_am) | F(Lat,Lon,Elev,Coast,LST\_dm) | F(Lat,Lon,Elev,Coast,LST\_nm) |
| **Model4** | F(Lat,Lon,Elev,Coast)+Trmm\_m | F(Lat,Lon,Elev,Coast)+LST\_am | F(Lat,Lon,Elev,Coast)+LST\_dm | F(Lat,Lon,Elev,Coast)+LST\_nm |
| **Model5** | F(Lat,Lon,Elev,Trmm\_m)+Coast | F(Lat,Lon,Elev,LST\_am)+Coast | F(Lat,Lon,Elev,LST\_dm)+Coast | F(Lat,Lon,Elev,LST\_nm)+Coast |
| **Model6** | F(Lat,Lon,Elev)+Coast+Trmm\_m | F(Lat,Lon,Elev)+Coast+LST\_am | F(Lat,Lon,Elev)+Coast+LST\_dm | F(Lat,Lon,Elev)+Coast+LST\_nm |
| **Model7** | F(Lat,Lon,Elev,Coast,Trmm\_m,Trmm\_y) | F(Lat,Lon,Elev,Coast,LST\_am,LST\_ay) | F(Lat,Lon,Elev,Coast,LST\_dm,LST\_dy) | F(Lat,Lon,Elev,Coast,LST\_nm,LST\_ny) |
| **Model8** | F(Lat,Lon,Elev,Coast,Trmm\_y)+Trmm\_m | F(Lat,Lon,Elev,Coast,LST\_ay)+LST\_am | F(Lat,Lon,Elev,Coast,LST\_dy)+LST\_dm | F(Lat,Lon,Elev,Coast,LST\_ny)+LST\_nm |
| **Model9** | F(Lat,Lon,Elev,Coast,Trmm\_m)+Trmm\_y | F(Lat,Lon,Elev,Coast,LST\_am)+LST\_ay | F(Lat,Lon,Elev,Coast,LST\_dm)+LST\_dy | F(Lat,Lon,Elev,Coast,LST\_nm)+LST\_ny |
| **Model10** | F(Lat,Lon,Elev,Trmm\_m,Trmm\_y)+Coast | F(Lat,Lon,Elev,LST\_am,LST\_ay)+Coast | F(Lat,Lon,Elev,LST\_dm,LST\_dy)+Coast | F(Lat,Lon,Elev,LST\_nm,LST\_ny)+Coast |
| **Model11** | F(Lat,Lon,Elev,Trmm\_y)+Coast+Trmm\_m | F(Lat,Lon,Elev,LST\_ay)+Coast+LST\_am | F(Lat,Lon,Elev,LST\_dy)+Coast+LST\_dm | F(Lat,Lon,Elev,LST\_ny)+Coast+LST\_nm |
| **Model12** | F(Lat,Lon,Elev,Coast)+Trmm\_m+Trmm\_y | F(Lat,Lon,Elev,Coast)+LST\_am+LST\_ay | F(Lat,Lon,Elev,Coast)+LST\_dm+LST\_dy | F(Lat,Lon,Elev,Coast)+LST\_nm+LST\_ny |
| **Model13** | F(Lat,Lon,Elev,Trmm\_m)+coast+Trmm\_y | F(Lat,Lon,Elev,LST\_am)+coast+LST\_ay | F(Lat,Lon,Elev,LST\_dm)+coast+LST\_dy | F(Lat,Lon,Elev,LST\_nm)+coast+LST\_ny |
| **Model14** | F(Lat,Lon,Elev)+Coast+Trmm\_m+Trmm\_y | F(Lat,Lon,Elev)+Coast+LST\_am+LST\_ay | F(Lat,Lon,Elev)+Coast+LST\_dm+LST\_dy | F(Lat,Lon,Elev)+Coast+LST\_nm+LST\_ny |

Table S2. Tenfold cross-validation coefficients of determination (*R2*) between observed and 14 models prediction over independent weather stations (precipitation).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model  formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Model1** | 0.870 | 0.926 | 0.967 | 0.974 | 0.959 | 0.936 | 0.891 | 0.870 | 0.924 | 0.890 | 0.898 | 0.834 |
| **Model2** | 0.903 | 0.933 | 0.962 | 0.970 | 0.953 | 0.928 | 0.834 | 0.837 | 0.898 | 0.844 | 0.832 | 0.807 |
| **Model3** | 0.902 | 0.939 | 0.969 | 0.975 | 0.959 | 0.943 | 0.876 | 0.875 | 0.910 | 0.868 | 0.838 | 0.807 |
| **Model4** | 0.882 | 0.945 | 0.971 | 0.976 | 0.965 | 0.953 | 0.897 | 0.886 | 0.901 | 0.881 | 0.840 | 0.832 |
| **Model5** | 0.896 | 0.936 | 0.960 | 0.968 | 0.957 | 0.935 | 0.864 | 0.853 | 0.884 | 0.844 | 0.825 | 0.849 |
| **Model6** | 0.911 | 0.949 | 0.973 | 0.978 | **0.966** | 0.948 | 0.896 | 0.891 | 0.919 | 0.900 | 0.883 | **0.860** |
| **Model7** | 0.899 | **0.950** | 0.974 | **0.978** | 0.964 | 0.950 | 0.901 | 0.895 | 0.917 | 0.903 | 0.878 | 0.816 |
| **Model8** | 0.866 | 0.932 | 0.972 | 0.978 | 0.960 | 0.938 | 0.898 | 0.885 | 0.910 | 0.892 | 0.809 | 0.802 |
| **Model9** | 0.887 | 0.939 | 0.968 | 0.975 | 0.963 | 0.949 | 0.889 | 0.882 | 0.913 | 0.879 | 0.818 | 0.805 |
| **Model10** | 0.908 | 0.948 | 0.974 | 0.978 | 0.965 | 0.948 | 0.900 | 0.894 | 0.922 | **0.914** | **0.899** | 0.824 |
| **Model11** | 0.881 | 0.945 | 0.968 | 0.976 | 0.962 | 0.950 | 0.890 | 0.882 | 0.913 | 0.875 | 0.864 | 0.816 |
| **Model12** | 0.868 | 0.940 | 0.971 | 0.976 | 0.960 | 0.940 | 0.894 | 0.885 | 0.923 | 0.902 | 0.856 | 0.770 |
| **Model13** | **0.920** | 0.940 | **0.975** | 0.978 | 0.961 | 0.948 | **0.905** | **0.899** | **0.928** | 0.904 | 0.869 | 0.830 |
| **Model14** | 0.890 | 0.937 | 0.971 | 0.977 | 0.965 | **0.953** | 0.899 | 0.894 | 0.915 | 0.883 | 0.859 | 0.835 |

Table S3. Tenfold cross-validation coefficients of determination (*R2*) between observed and 14 models prediction over independent weather stations (average temperature).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| formulations |
| **Model1** | 0.988 | 0.988 | 0.988 | 0.985 | 0.983 | 0.980 | 0.984 | 0.985 | 0.986 | 0.990 | 0.992 | 0.990 |
| **Model2** | **0.990** | **0.989** | **0.989** | 0.987 | 0.982 | 0.981 | 0.984 | 0.985 | 0.987 | **0.990** | **0.993** | **0.991** |
| **Model3** | 0.990 | 0.989 | 0.987 | 0.985 | 0.980 | 0.980 | 0.984 | 0.986 | 0.987 | 0.989 | 0.992 | 0.990 |
| **Model4** | 0.988 | 0.988 | 0.988 | 0.986 | 0.983 | 0.981 | 0.984 | 0.985 | 0.987 | 0.989 | 0.991 | 0.989 |
| **Model5** | 0.988 | 0.987 | 0.986 | 0.984 | 0.980 | 0.976 | 0.981 | 0.984 | 0.985 | 0.988 | 0.991 | 0.989 |
| **Model6** | 0.990 | 0.989 | 0.989 | 0.987 | 0.983 | 0.982 | 0.985 | 0.986 | 0.988 | 0.990 | 0.992 | 0.991 |
| **Model7** | 0.989 | 0.988 | 0.988 | 0.986 | 0.982 | 0.980 | 0.984 | 0.985 | 0.987 | 0.989 | 0.992 | 0.990 |
| **Model8** | 0.988 | 0.988 | 0.987 | 0.985 | 0.981 | 0.980 | 0.983 | 0.986 | 0.986 | 0.989 | 0.992 | 0.990 |
| **Model9** | 0.990 | 0.989 | 0.987 | 0.985 | 0.982 | 0.981 | 0.983 | 0.986 | 0.986 | 0.990 | 0.992 | 0.990 |
| **Model10** | 0.989 | 0.988 | 0.987 | 0.983 | 0.980 | 0.977 | 0.982 | 0.985 | 0.986 | 0.989 | 0.991 | 0.990 |
| **Model11** | 0.986 | 0.985 | 0.985 | 0.983 | 0.979 | 0.977 | 0.980 | 0.983 | 0.984 | 0.987 | 0.990 | 0.988 |
| **Model12** | 0.988 | 0.988 | 0.988 | 0.986 | 0.983 | 0.981 | 0.984 | 0.986 | 0.986 | 0.989 | 0.991 | 0.989 |
| **Model13** | 0.989 | 0.987 | 0.986 | 0.983 | 0.979 | 0.977 | 0.982 | 0.984 | 0.985 | 0.988 | 0.992 | 0.989 |
| **Model14** | 0.990 | 0.989 | 0.989 | **0.987** | **0.984** | **0.982** | **0.985** | **0.986** | **0.988** | 0.990 | 0.992 | 0.991 |

Table S4. Tenfold cross-validation coefficients of determination (*R2*) between observed and 14 models prediction over independent weather stations (maximum temperature).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| formulations |
| **Model1** | 0.987 | 0.985 | 0.980 | 0.971 | 0.964 | 0.965 | 0.969 | 0.972 | 0.978 | 0.985 | 0.991 | 0.988 |
| **Model2** | **0.990** | 0.986 | 0.980 | 0.973 | 0.963 | 0.965 | 0.971 | 0.977 | 0.979 | 0.985 | 0.992 | **0.992** |
| **Model3** | 0.989 | 0.985 | 0.979 | 0.971 | 0.965 | 0.964 | 0.972 | 0.977 | 0.975 | 0.983 | 0.991 | 0.991 |
| **Model4** | 0.986 | 0.984 | 0.980 | 0.972 | 0.959 | 0.963 | 0.971 | 0.975 | 0.979 | 0.984 | 0.991 | 0.990 |
| **Model5** | 0.987 | 0.980 | 0.978 | 0.970 | 0.960 | 0.962 | 0.967 | 0.973 | 0.974 | 0.982 | 0.988 | 0.989 |
| **Model6** | 0.989 | **0.986** | 0.981 | 0.973 | 0.967 | 0.966 | **0.974** | **0.979** | 0.980 | 0.985 | **0.992** | 0.991 |
| **Model7** | 0.986 | 0.979 | 0.978 | 0.970 | 0.952 | 0.948 | 0.950 | 0.962 | 0.972 | 0.977 | 0.989 | 0.989 |
| **Model8** | 0.988 | 0.984 | 0.980 | 0.971 | 0.964 | 0.964 | 0.969 | 0.976 | 0.977 | 0.984 | 0.991 | 0.990 |
| **Model9** | 0.989 | 0.985 | 0.980 | 0.972 | 0.965 | **0.967** | 0.972 | 0.975 | 0.977 | 0.984 | 0.991 | 0.991 |
| **Model10** | 0.988 | 0.983 | 0.979 | 0.970 | 0.963 | 0.960 | 0.967 | 0.973 | 0.976 | 0.982 | 0.989 | 0.990 |
| **Model11** | 0.984 | 0.981 | 0.977 | 0.968 | 0.959 | 0.959 | 0.964 | 0.971 | 0.973 | 0.979 | 0.989 | 0.988 |
| **Model12** | 0.987 | 0.984 | 0.980 | **0.974** | 0.965 | 0.967 | 0.973 | 0.976 | 0.978 | 0.984 | 0.990 | 0.990 |
| **Model13** | 0.987 | 0.980 | 0.977 | 0.970 | 0.960 | 0.958 | 0.967 | 0.972 | 0.975 | 0.982 | 0.989 | 0.989 |
| **Model14** | 0.990 | 0.986 | **0.982** | 0.972 | **0.968** | 0.967 | 0.971 | 0.978 | **0.981** | **0.986** | 0.992 | 0.991 |

Table S5. Tenfold cross-validation coefficients of determination (*R2*) between observed and 14 models prediction over independent weather stations (minimum temperature).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| formulations |
| **Model1** | 0.982 | 0.983 | 0.984 | 0.983 | 0.982 | 0.979 | 0.980 | 0.982 | 0.982 | 0.985 | 0.986 | 0.984 |
| **Model2** | **0.985** | **0.985** | **0.986** | **0.984** | 0.981 | 0.979 | 0.982 | 0.983 | 0.983 | 0.986 | 0.987 | **0.985** |
| **Model3** | 0.985 | 0.983 | 0.984 | 0.983 | 0.981 | 0.980 | 0.982 | 0.982 | 0.983 | 0.986 | 0.987 | 0.985 |
| **Model4** | 0.982 | 0.983 | 0.984 | 0.982 | 0.981 | 0.979 | 0.981 | 0.982 | 0.982 | 0.985 | 0.986 | 0.983 |
| **Model5** | 0.982 | 0.981 | 0.983 | 0.981 | 0.980 | 0.977 | 0.979 | 0.979 | 0.980 | 0.984 | 0.985 | 0.983 |
| **Model6** | 0.984 | 0.985 | 0.985 | 0.984 | 0.981 | **0.980** | 0.983 | 0.983 | 0.983 | 0.986 | **0.987** | 0.985 |
| **Model7** | 0.981 | 0.979 | 0.977 | 0.977 | 0.975 | 0.970 | 0.976 | 0.978 | 0.980 | 0.982 | 0.983 | 0.977 |
| **Model8** | 0.983 | 0.983 | 0.984 | 0.982 | 0.981 | 0.980 | 0.982 | 0.983 | 0.983 | 0.986 | 0.987 | 0.985 |
| **Model9** | 0.984 | 0.983 | 0.984 | 0.983 | 0.981 | 0.979 | 0.981 | 0.983 | 0.983 | 0.985 | 0.986 | 0.984 |
| **Model10** | 0.983 | 0.984 | 0.984 | 0.982 | 0.980 | 0.978 | 0.980 | 0.982 | 0.982 | 0.985 | 0.987 | 0.984 |
| **Model11** | 0.981 | 0.981 | 0.983 | 0.981 | 0.979 | 0.976 | 0.979 | 0.980 | 0.980 | 0.985 | 0.986 | 0.982 |
| **Model12** | 0.981 | 0.984 | 0.984 | 0.983 | 0.980 | 0.979 | 0.981 | 0.983 | 0.983 | 0.985 | 0.986 | 0.983 |
| **Model13** | 0.982 | 0.981 | 0.982 | 0.981 | 0.980 | 0.977 | 0.979 | 0.980 | 0.981 | 0.984 | 0.986 | 0.982 |
| **Model14** | 0.984 | 0.985 | 0.985 | 0.984 | **0.982** | 0.979 | **0.983** | **0.984** | **0.983** | **0.986** | 0.987 | 0.985 |

Table S6. The optimal model formulations for estimating ChinaClim\_baseline for each month.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Precipitation | Model13 | Model7 | Model13 | Model7 | Model6 | Model14 | Model13 | Model13 | Model13 | Model10 | Model10 | Model6 |
| Average temperature | Model2 | Model2 | Model2 | Model14 | Model14 | Model4 | Model4 | Model14 | Model14 | Model2 | Model2 | Model2 |
| Maximum temperature | Model2 | Model6 | Model14 | Model12 | Model14 | Model9 | Model6 | Model6 | Model14 | Model14 | Model6 | Model2 |
| Minimum temperature | Model2 | Model2 | Model2 | Model2 | Model14 | Model6 | Model14 | Model14 | Model14 | Model14 | Model6 | Model2 |

Note: Model4: F(Lat,Lon,Elev,Coast)+Trmm\_m/LST\_am/LST\_dm/LST\_nm,

Model6: F(Lat,Lon,Elev)+Coast+Trmm\_m/LST\_am/LST\_dm/LST\_nm ,

Model7: F(Lat,Lon,Elev,Coast,Trmm\_m/LST\_am/LST\_dm/LST\_nm,Trmm\_y/LST\_ay/LST\_dy/LST\_ny),

Model 9: F(Lat,Lon,Elev,Coast,Trmm\_m/LST\_am/LST\_dm/LST\_nm)+Trmm\_y/LST\_ay/LST\_dy/LST\_ny,

Model 10: F(Lat,Lon,Elev,Trmm\_m/LST\_am/LST\_dm/LST\_nm,Trmm\_y/LST\_ay/LST\_dy/LST\_ny)+Coast,

Model13: F(Lat,Lon,Elev,Trmm\_m/LST\_am/LST\_dm/LST\_nm)+coast+Trmm\_y/LST\_ay/LST\_dy/LST\_ny and

Model14: F(Lat,Lon,Elev)+Coast+Trmm\_m/LST\_am/LST\_dm/LST\_nm +Trmm\_y/LST\_ay/LST\_dy/LST\_nyAll model considered satellite-driven data as either independent spline variables or linear covariates.

Table S7. The different model combinations were test to choose the optimal TPS model of ChinaClim\_timeseries

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Precipitation** | **Average temperature** | **Maximum temperature** | **Minimum temperature** |
| **Model1** | F(Lat,Lon,Elev) | F(Lat,Lon,Elev) | F(Lat,Lon,Elev) | F(Lat,Lon,Elev) |
| **Model2** | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) | F(Lat,Lon,Elev,Coast) |
| **Model3** | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast | F(Lat,Lon,Elev)+Coast |
| **Model4** | F(Lat,Lon,Elev)+Coast+Base\_prep | F(Lat,Lon,Elev)+Coast+Base\_tavg | F(Lat,Lon,Elev)+Coast+Base\_tmax | F(Lat,Lon,Elev)+Coast+Base\_tmin |
| **Model5** | F(Lat,Lon,Elev,Coast)+Base\_prep | F(X,Y,Z,Coast)+Base\_tavg | F(Lat,Lon,Elev,Coast)+Base\_tmax | F(Lat,Lon,Elev,Coast)+Base\_tmin |
| **Model6** | F(Lat,Lon,Elev,Base\_prep)+Coast | F(Lat,Lon,Elev,Base\_tavg)+Coast | F(Lat,Lon,Elev,Base\_tmax)+Coast | F(Lat,Lon,Elev,Base\_tmin)+Coast |
| **Model7** | F(Lat,Lon,Elev,Coast,Base\_prep) | F(Lat,Lon,Elev,Coast,Base\_tavg) | F(Lat,Lon,Elev,Coast,Base\_tmax) | F(Lat,Lon,Elev,Coast,Base\_tmin) |
| **Model8** | F(Lat,Lon,Elev,Base\_prep,Coast)+Trmm\_a | F(Lat,Lon,Elev,Base\_tavg,Coast)+Lst\_aa | F(Lat,Lon,Elev,Base\_tmax,Coast)+Lst\_da | F(Lat,Lon,Elev,Base\_tmin,Coast)+Lst\_na |
| **Model9** | F(Lat,Lon,Elev,Base\_prep,Trmm\_a)+Coast | F(Lat,Lon,Elev,Base\_tavg,Lst\_aa)+Coast | F(Lat,Lon,Elev,Base\_tmax,Lst\_da)+Coast | F(Lat,Lon,Elev,Base\_tmin,Lst\_na)+Coast |
| **Model10** | F(Lat,Lon,Elev,Coast,Trmm\_a)+Base\_prep | F(Lat,Lon,Elev,Coast,Lst\_aa)+Base\_tavg | F(Lat,Lon,Elev,Coast,Lst\_da)+Base\_tmax | F(Lat,Lon,Elev,Coast,Lst\_na)+Base\_tmin |
| **Model11** | F(Lat,Lon,Elev,Base\_prep)+Coast+Trmm\_a | F(Lat,Lon,Elev,Base\_tavg)+Coast+Lst\_aa | F(Lat,Lon,Elev,Base\_tmax)+Coast+Lst\_da | F(Lat,Lon,Elev,Base\_tmin)+Coast+Lst\_na |
| **Model12** | F(Lat,Lon,Elev,Coast)+Trmm\_a+Base\_prep | F(Lat,Lon,Elev,Coast)+Lst\_aa+Base\_tavg | F(Lat,Lon,Elev,Coast)+Lst\_da+Base\_tmax | F(Lat,Lon,Elev,Coast)+Lst\_na+Base\_tmin |
| **Model13** | F(Lat,Lon,Elev,Trmm\_a)+Base\_prep+Coast | F(Lat,Lon,Elev,Lst\_aa)+Base\_tavg+Coast | F(Lat,Lon,Elev,Lst\_da)+Base\_tmax+Coast | F(Lat,Lon,Elev,Lst\_na)+Base\_tmin+Coast |
| **Model14** | F(Lat,Lon,Elev)+Trmm\_a+Base\_prep+Coast | F(Lat,Lon,Elev)+Lst\_aa+Base\_tavg+Coast | F(Lat,Lon,Elev)+Lst\_da+Base\_tmax+Coast | F(Lat,Lon,Elev)+Lst\_na+Base\_tmin+Coast |
| **Model15** | F(Lat,Lon,Elev,Base\_prep,coast,Trmm\_a) | F(Lat,Lon,Elev,Base\_tavg,coast,Lst\_aa) | F(Lat,Lon,Elev,Base\_tmax,coast,Lst\_da) | F(Lat,Lon,Elev,Base\_tmin,coast,Lst\_na) |

Table S8. Tenfold cross-validation coefficients of determination (*R2*) between observed and 7 models prediction over independent weather stations (precipitation: 1952-1997).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.881 | 0.907 | 0.914 | 0.876 | 0.842 | 0.774 | 0.674 | 0.665 | 0.715 | 0.787 | 0.824 | 0.824 |
| **Model2** | 0.874 | 0.900 | 0.907 | 0.865 | 0.831 | 0.759 | 0.654 | 0.649 | 0.702 | 0.771 | 0.810 | 0.821 |
| **Model3** | 0.880 | 0.907 | 0.913 | 0.876 | 0.842 | 0.777 | 0.675 | 0.663 | 0.719 | 0.788 | 0.826 | 0.825 |
| **Model4** | **0.894** | **0.911** | **0.917** | **0.884** | **0.843** | **0.779** | **0.680** | **0.671** | **0.726** | **0.793** | **0.828** | **0.838** |
| **Model5** | 0.884 | 0.903 | 0.911 | 0.868 | 0.830 | 0.763 | 0.658 | 0.658 | 0.705 | 0.773 | 0.813 | 0.832 |
| **Model6** | 0.865 | 0.889 | 0.892 | 0.850 | 0.802 | 0.737 | 0.627 | 0.632 | 0.669 | 0.769 | 0.793 | 0.793 |
| **Model7** | 0.884 | 0.904 | 0.906 | 0.864 | 0.824 | 0.759 | 0.641 | 0.638 | 0.689 | 0.783 | 0.811 | 0.820 |

Table S9. Tenfold cross-validation coefficients of determination (*R2*) between observed and 7 models prediction over independent weather stations (average temperature: 1952-2000).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.946 | 0.931 | 0.899 | 0.841 | 0.798 | 0.785 | 0.800 | 0.811 | 0.843 | 0.889 | 0.931 | 0.948 |
| **Model2** | 0.928 | 0.909 | 0.867 | 0.794 | 0.742 | 0.729 | 0.749 | 0.759 | 0.795 | 0.853 | 0.907 | 0.931 |
| **Model3** | 0.945 | 0.931 | 0.899 | 0.842 | 0.800 | 0.786 | 0.802 | 0.812 | 0.844 | 0.889 | 0.931 | 0.948 |
| **Model4** | **0.980** | 0.978 | 0.977 | **0.974** | **0.967** | **0.966** | **0.972** | **0.974** | **0.976** | 0.980 | **0.985** | 0.983 |
| **Model5** | 0.977 | 0.976 | 0.974 | 0.971 | 0.965 | 0.965 | 0.970 | 0.973 | 0.975 | 0.978 | 0.984 | 0.981 |
| **Model6** | 0.976 | 0.976 | 0.975 | 0.972 | 0.964 | 0.960 | 0.967 | 0.969 | 0.972 | 0.978 | 0.983 | 0.980 |
| **Model7** | 0.980 | **0.980** | **0.978** | 0.974 | 0.967 | 0.965 | 0.970 | 0.973 | 0.975 | **0.980** | 0.985 | **0.983** |

Table S10. Tenfold cross-validation coefficients of determination (*R2*) between observed and 7 models prediction over independent weather stations (maximum temperature: 1952-2000).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.936 | 0.907 | 0.852 | 0.757 | 0.707 | 0.723 | 0.736 | 0.747 | 0.779 | 0.840 | 0.913 | 0.943 |
| **Model2** | 0.915 | 0.876 | 0.809 | 0.703 | 0.653 | 0.666 | 0.679 | 0.692 | 0.726 | 0.791 | 0.884 | 0.924 |
| **Model3** | 0.936 | 0.906 | 0.853 | 0.761 | 0.715 | 0.726 | 0.736 | 0.748 | 0.781 | 0.839 | 0.913 | 0.942 |
| **Model4** | 0.973 | 0.967 | 0.959 | 0.946 | 0.934 | 0.939 | 0.950 | 0.957 | **0.960** | 0.966 | 0.978 | 0.979 |
| **Model5** | 0.971 | 0.966 | 0.957 | 0.944 | 0.935 | **0.941** | **0.951** | **0.958** | 0.960 | 0.962 | 0.976 | 0.976 |
| **Model6** | 0.971 | 0.968 | 0.963 | 0.953 | 0.938 | 0.937 | 0.944 | 0.953 | 0.956 | 0.962 | 0.978 | 0.977 |
| **Model7** | **0.977** | **0.973** | **0.966** | **0.953** | **0.939** | 0.941 | 0.947 | 0.955 | 0.959 | **0.967** | **0.980** | **0.981** |

Table S11. Tenfold cross-validation coefficients of determination (*R2*) between observed and 7 models prediction over independent weather stations (minimum temperature: 1952-2000).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.943 | 0.938 | 0.921 | 0.894 | 0.868 | 0.843 | 0.846 | 0.854 | 0.881 | 0.908 | 0.932 | 0.943 |
| **Model2** | 0.924 | 0.916 | 0.895 | 0.860 | 0.827 | 0.795 | 0.799 | 0.810 | 0.846 | 0.880 | 0.910 | 0.925 |
| **Model3** | 0.943 | 0.937 | 0.921 | 0.895 | 0.868 | 0.844 | 0.847 | 0.855 | 0.881 | 0.908 | 0.932 | 0.943 |
| **Model4** | 0.974 | 0.975 | 0.976 | **0.975** | **0.971** | **0.968** | **0.972** | **0.973** | **0.973** | 0.976 | 0.979 | 0.976 |
| **Model5** | 0.971 | 0.972 | 0.973 | 0.972 | 0.968 | 0.965 | 0.970 | 0.971 | 0.971 | 0.974 | 0.977 | 0.973 |
| **Model6** | 0.972 | 0.974 | 0.973 | 0.972 | 0.969 | 0.963 | 0.967 | 0.968 | 0.972 | 0.975 | 0.978 | 0.974 |
| **Model7** | **0.975** | **0.977** | **0.976** | 0.974 | 0.970 | 0.968 | 0.972 | 0.972 | 0.973 | **0.976** | **0.979** | **0.976** |

Table S12. The optimal model formulations for ChinaClim\_timeseries. (Precipitation: 1952-1997; Temperature: 1952-2000)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Precipitation anomaly | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 |
| Average temperature anomaly | Model7 | Model7 | Model7 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model7 | Model7 | Model7 |
| Maximum temperature anomaly | Model7 | Model7 | Model7 | Model7 | Model7 | Model5 | Model5 | Model5 | Model4 | Model7 | Model7 | Model7 |
| Minimum temperature anomaly | Model7 | Model7 | Model7 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model7 | Model7 | Model7 |

Note: Model4: F(Lat,Lon,Elev)+Coast+Base\_prep/Base\_tavg/Base\_tmax/Base\_tmin,

Model5: F(Lat,Lon,Elev,Coast)+Base\_prep/Base\_tavg/Base\_tmax/Base\_tmin and

Model7: F(Lat,Lon,Elev,Coast,Base\_prep/Base\_tavg/Base\_tmax/Base\_tmin)

All model considered ChinaClim\_baseline as either independent spline variables or linear covariates.

Table S13. Tenfold cross-validation coefficients of determination (*R2*) between observed and 15 models prediction over independent weather stations (precipitation: 1998-2019).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.901 | 0.893 | 0.920 | 0.859 | 0.827 | 0.786 | 0.683 | 0.669 | 0.695 | 0.781 | 0.837 | 0.852 |
| **Model2** | 0.896 | 0.884 | 0.913 | 0.849 | 0.820 | 0.772 | 0.659 | 0.659 | 0.686 | 0.764 | 0.824 | 0.854 |
| **Model3** | 0.902 | 0.892 | 0.917 | 0.860 | 0.831 | 0.790 | 0.682 | 0.675 | 0.702 | 0.780 | 0.837 | 0.850 |
| **Model4** | 0.906 | 0.900 | 0.920 | 0.862 | 0.829 | 0.790 | 0.688 | 0.680 | 0.702 | 0.787 | 0.836 | 0.861 |
| **Model5** | 0.900 | 0.893 | 0.914 | 0.853 | 0.820 | 0.775 | 0.666 | 0.670 | 0.691 | 0.769 | 0.826 | 0.858 |
| **Model6** | 0.878 | 0.880 | 0.898 | 0.837 | 0.786 | 0.752 | 0.626 | 0.644 | 0.661 | 0.755 | 0.797 | 0.819 |
| **Model7** | 0.898 | 0.895 | 0.910 | 0.849 | 0.809 | 0.772 | 0.646 | 0.652 | 0.674 | 0.782 | 0.820 | 0.846 |
| **Model8** | 0.918 | 0.917 | 0.935 | 0.887 | 0.863 | 0.844 | 0.778 | 0.768 | 0.786 | 0.848 | 0.871 | 0.877 |
| **Model9** | 0.920 | 0.915 | 0.932 | 0.882 | 0.855 | 0.835 | 0.770 | 0.764 | 0.771 | 0.831 | 0.870 | 0.880 |
| **Model10** | 0.919 | 0.914 | 0.929 | 0.887 | 0.864 | 0.845 | 0.777 | 0.770 | 0.782 | 0.834 | 0.871 | 0.882 |
| **Model11** | 0.903 | 0.904 | 0.921 | 0.876 | 0.850 | 0.840 | 0.774 | 0.768 | 0.777 | 0.835 | 0.864 | 0.852 |
| **Model12** | 0.923 | 0.920 | 0.936 | 0.893 | 0.872 | 0.848 | 0.781 | 0.774 | 0.792 | 0.841 | 0.869 | 0.889 |
| **Model13** | 0.907 | 0.897 | 0.917 | 0.875 | 0.850 | 0.838 | 0.777 | 0.769 | 0.768 | 0.820 | 0.853 | 0.867 |
| **Model14** | **0.927** | **0.925** | **0.938** | **0.896** | **0.875** | **0.856** | **0.785** | **0.777** | **0.795** | **0.850** | **0.877** | **0.891** |
| **Model15** | 0.861 | 0.845 | 0.885 | 0.820 | 0.800 | 0.773 | 0.724 | 0.694 | 0.690 | 0.715 | 0.804 | 0.795 |

Table S14. Tenfold cross-validation coefficients of determination (*R2*) between observed and 15 models prediction over independent weather stations (average temperature: 2001-2019).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.944 | 0.930 | 0.899 | 0.846 | 0.802 | 0.785 | 0.802 | 0.807 | 0.837 | 0.890 | 0.931 | 0.947 |
| **Model2** | 0.926 | 0.906 | 0.866 | 0.795 | 0.750 | 0.725 | 0.753 | 0.753 | 0.787 | 0.849 | 0.907 | 0.931 |
| **Model3** | 0.944 | 0.930 | 0.899 | 0.846 | 0.803 | 0.787 | 0.803 | 0.808 | 0.837 | 0.889 | 0.930 | 0.947 |
| **Model4** | 0.980 | 0.980 | 0.979 | **0.976** | **0.970** | **0.968** | **0.976** | **0.975** | **0.977** | 0.982 | 0.986 | 0.983 |
| **Model5** | 0.978 | 0.978 | 0.976 | 0.975 | 0.969 | 0.968 | 0.975 | 0.974 | 0.976 | 0.980 | 0.985 | 0.982 |
| **Model6** | 0.977 | 0.978 | 0.977 | 0.976 | 0.969 | 0.963 | 0.971 | 0.971 | 0.973 | 0.980 | 0.985 | 0.982 |
| **Model7** | **0.981** | **0.981** | **0.979** | 0.975 | 0.971 | 0.967 | 0.973 | 0.973 | 0.976 | **0.982** | **0.986** | **0.984** |
| **Model8** | 0.980 | 0.981 | 0.978 | 0.975 | 0.971 | 0.967 | 0.973 | 0.973 | 0.976 | 0.982 | 0.986 | 0.984 |
| **Model9** | 0.979 | 0.979 | 0.978 | 0.974 | 0.965 | 0.962 | 0.969 | 0.971 | 0.975 | 0.981 | 0.986 | 0.983 |
| **Model10** | 0.978 | 0.979 | 0.978 | 0.973 | 0.967 | 0.965 | 0.972 | 0.974 | 0.975 | 0.980 | 0.986 | 0.982 |
| **Model11** | 0.977 | 0.978 | 0.977 | 0.976 | 0.969 | 0.963 | 0.970 | 0.971 | 0.973 | 0.980 | 0.985 | 0.982 |
| **Model12** | 0.978 | 0.979 | 0.976 | 0.975 | 0.970 | 0.968 | 0.976 | 0.975 | 0.976 | 0.981 | 0.985 | 0.982 |
| **Model13** | 0.975 | 0.976 | 0.974 | 0.970 | 0.964 | 0.962 | 0.968 | 0.971 | 0.975 | 0.980 | 0.984 | 0.981 |
| **Model14** | 0.980 | 0.980 | 0.978 | 0.976 | 0.971 | 0.968 | 0.975 | 0.975 | 0.977 | 0.982 | 0.986 | 0.984 |
| **Model15** | 0.971 | 0.965 | 0.961 | 0.959 | 0.952 | 0.951 | 0.958 | 0.957 | 0.966 | 0.972 | 0.980 | 0.975 |

Table S15. Tenfold cross-validation coefficients of determination (*R2*) between observed and 15 models prediction over independent weather stations (maximum temperature: 2001-2019).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.936 | 0.911 | 0.856 | 0.766 | 0.724 | 0.727 | 0.740 | 0.740 | 0.775 | 0.842 | 0.916 | 0.944 |
| **Model2** | 0.914 | 0.879 | 0.813 | 0.715 | 0.663 | 0.670 | 0.685 | 0.682 | 0.715 | 0.791 | 0.886 | 0.923 |
| **Model3** | 0.936 | 0.910 | 0.857 | 0.773 | 0.727 | 0.731 | 0.739 | 0.741 | 0.773 | 0.842 | 0.917 | 0.943 |
| **Model4** | 0.975 | 0.972 | 0.966 | 0.958 | 0.947 | 0.947 | 0.957 | 0.960 | **0.965** | 0.972 | 0.983 | 0.981 |
| **Model5** | 0.973 | 0.971 | 0.966 | 0.958 | 0.950 | **0.951** | **0.961** | **0.962** | 0.963 | 0.970 | 0.981 | 0.979 |
| **Model6** | 0.972 | 0.972 | 0.967 | 0.958 | 0.948 | 0.942 | 0.951 | 0.954 | 0.956 | 0.967 | 0.980 | 0.978 |
| **Model7** | **0.978** | **0.977** | **0.971** | **0.962** | **0.951** | 0.947 | 0.955 | 0.957 | 0.962 | **0.973** | **0.984** | **0.983** |
| **Model8** | 0.978 | 0.976 | 0.971 | 0.962 | 0.950 | 0.947 | 0.956 | 0.957 | 0.961 | 0.973 | 0.984 | 0.982 |
| **Model9** | 0.975 | 0.973 | 0.966 | 0.953 | 0.936 | 0.932 | 0.942 | 0.947 | 0.951 | 0.968 | 0.982 | 0.980 |
| **Model10** | 0.974 | 0.971 | 0.965 | 0.954 | 0.940 | 0.940 | 0.950 | 0.954 | 0.958 | 0.969 | 0.982 | 0.980 |
| **Model11** | 0.972 | 0.973 | 0.967 | 0.959 | 0.947 | 0.941 | 0.951 | 0.954 | 0.957 | 0.967 | 0.981 | 0.978 |
| **Model12** | 0.973 | 0.972 | 0.965 | 0.957 | 0.950 | 0.951 | 0.961 | 0.962 | 0.965 | 0.970 | 0.981 | 0.979 |
| **Model13** | 0.969 | 0.966 | 0.960 | 0.948 | 0.931 | 0.931 | 0.945 | 0.949 | 0.951 | 0.965 | 0.977 | 0.976 |
| **Model14** | 0.975 | 0.972 | 0.966 | 0.957 | 0.946 | 0.947 | 0.956 | 0.960 | 0.963 | 0.972 | 0.983 | 0.981 |
| **Model15** | 0.966 | 0.965 | 0.954 | 0.944 | 0.927 | 0.920 | 0.936 | 0.937 | 0.942 | 0.954 | 0.973 | 0.974 |

Table S16. Tenfold cross-validation coefficients of determination (*R2*) between observed and 15 models prediction over independent weather stations (minimum temperature: 2001-2019).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Multiple model formulations | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|
| **Model1** | 0.941 | 0.936 | 0.919 | 0.894 | 0.863 | 0.839 | 0.845 | 0.852 | 0.877 | 0.909 | 0.931 | 0.942 |
| **Model2** | 0.923 | 0.914 | 0.892 | 0.860 | 0.820 | 0.791 | 0.801 | 0.807 | 0.839 | 0.879 | 0.907 | 0.923 |
| **Model3** | 0.941 | 0.936 | 0.919 | 0.893 | 0.863 | 0.839 | 0.845 | 0.852 | 0.877 | 0.908 | 0.931 | 0.941 |
| **Model4** | 0.974 | 0.976 | 0.976 | **0.974** | **0.972** | **0.969** | **0.974** | **0.974** | **0.974** | 0.976 | 0.979 | 0.977 |
| **Model5** | 0.972 | 0.973 | 0.973 | 0.972 | 0.969 | 0.968 | 0.973 | 0.973 | 0.973 | 0.975 | 0.978 | 0.975 |
| **Model6** | 0.972 | 0.975 | 0.974 | 0.973 | 0.971 | 0.968 | 0.972 | 0.973 | 0.974 | 0.977 | 0.980 | 0.977 |
| **Model7** | **0.975** | **0.977** | **0.976** | 0.974 | 0.971 | 0.969 | 0.973 | 0.974 | 0.973 | **0.977** | **0.980** | **0.978** |
| **Model8** | 0.975 | 0.977 | 0.976 | 0.974 | 0.971 | 0.969 | 0.973 | 0.974 | 0.974 | 0.977 | 0.980 | 0.978 |
| **Model9** | 0.974 | 0.976 | 0.976 | 0.973 | 0.969 | 0.968 | 0.972 | 0.973 | 0.974 | 0.977 | 0.979 | 0.977 |
| **Model10** | 0.972 | 0.974 | 0.975 | 0.972 | 0.969 | 0.968 | 0.973 | 0.974 | 0.973 | 0.975 | 0.978 | 0.975 |
| **Model11** | 0.973 | 0.975 | 0.974 | 0.973 | 0.970 | 0.968 | 0.972 | 0.973 | 0.974 | 0.977 | 0.980 | 0.977 |
| **Model12** | 0.972 | 0.974 | 0.973 | 0.972 | 0.969 | 0.967 | 0.973 | 0.973 | 0.973 | 0.975 | 0.978 | 0.975 |
| **Model13** | 0.970 | 0.973 | 0.973 | 0.972 | 0.968 | 0.966 | 0.972 | 0.973 | 0.972 | 0.974 | 0.977 | 0.974 |
| **Model14** | 0.974 | 0.976 | 0.976 | 0.974 | 0.970 | 0.969 | 0.973 | 0.974 | 0.974 | 0.976 | 0.979 | 0.977 |
| **Model15** | 0.962 | 0.963 | 0.958 | 0.948 | 0.947 | 0.949 | 0.958 | 0.952 | 0.961 | 0.963 | 0.968 | 0.968 |

Table S17. 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 |
| Precipitation anomaly | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 | Model14 |
| Average temperature anomaly | Model7 | Model7 | Model7 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model7 | Model7 | Model7 |
| Maximum temperature anomaly | Model7 | Model7 | Model7 | Model7 | Model7 | Model5 | Model5 | Model5 | Model4 | Model7 | Model7 | Model7 |
| Minimum temperature anomaly | Model7 | Model7 | Model7 | Model4 | Model4 | Model4 | Model4 | Model4 | Model4 | Model7 | Model7 | Model7 |

Note: Model8: F(Lat,Lon,Elev,Base\_prep/Base\_tavg/Base\_tmax/ Base\_tmin ,Coast)+Trmm\_a/Lst\_aa/Lst\_da/Lst\_na,

Model12: F(Lat,Lon,Elev,Coast)+Trmm\_a/Lst\_aa/Lst\_da/Lst\_na +Base\_prep/Base\_tavg/Base\_tmax/Base\_tmin,

Model14: F(Lat,Lon,Elev)+Coast +Trmm\_a/Lst\_aa/Lst\_da/Lst\_na +Base\_prep/Base\_tavg/Base\_tmax/Base\_tmin,

Both model12 and model14 considered satellite-driven anomaly as either independent spline variables or linear covariates.