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METHOD FOR DEMARCATING A GEOGRAPHICAL TRANSITION ZONE

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ABSTRACT

The present invention discloses a method for demarcating a geographical transition zone, and relates to the technical field of geography. The method includes: selecting a climate index for demarcating a transition zone; performing spatial interpolation of the climate index by a geostatistical analysis method in geography; then finding an average position of a changing isoline of each climate index by an average - standard deviation method in statistics; and finally obtaining a dividing line of the transition zone and a range of a climate stable region, a sensitive region and an anomalous region in the transition zone. The present invention finds an overall change in the climate indexes over the years from a year-by-year change based on a long-term series of historical meteorological observation data. The method overcomes the deficiency that conventional calculations using a multi-year average miss an extreme year, and the method is more comprehensive and objective.

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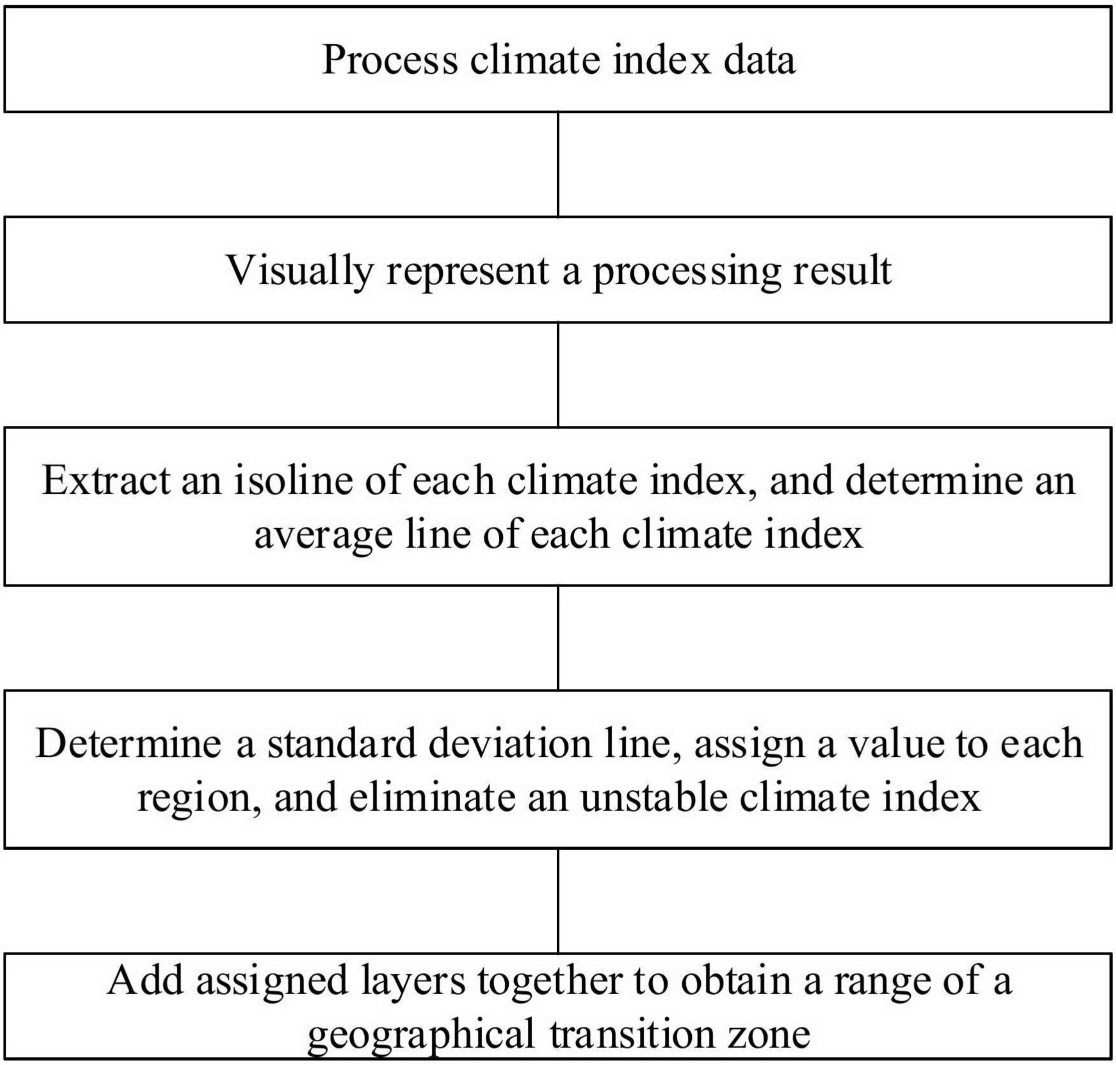

FIG. 1

METHOD FOR DEMARCATING A GEOGRAPHICAL TRANSITION ZONE

TECHNICAL FIELD

[0001] The present invention relates generally to the technical field of geography, and in particular embodiments shows effective application to demarcating a geographical transition zone.

BACKGROUND

[0002] Geographical transition zones, also called regional boundary or boundary lines, separate nations, form social distinctions and divide political areas under climate and other indices, for example, the North-South dividing line of China.

[0003] Since ancient times, China has been divided into North and South. It is believed that Northern and Southern China have obvious differences in climatic characteristics, agricultural production and living habits, etc. However, the specific location of the North-South dividing line of China is not clear. In 1908, the founder of the Geographical Society of China, Mr. Zhang Xiangwen, first proposed the idea of dividing the north and south of China by "Qinling-Huaihe River". However, as the landscape on the ground is continuous and stable, it is difficult to find a line with two sides completely different in terms of natural landscapes such as geography and climate and cultural landscapes. Therefore, some scholars have further proposed that the differences between the north and south of the dividing line are achieved through a fairly wide zone, but there is no unified understanding of where and how wide the zone is.

[0004] Limited by data and technical conditions, the early studies of the North-South dividing line and the North-South transition zone were mostly based on qualitative and expert integration methods. With the rise of quantitative geography in the 1970s and the development of remote sensing, geographic information system and global positioning system (3S) in the mid-1990s, the method of demarcation has gradually become more quantitative and comprehensive. Compared with traditional overlay methods and geographical correlation analysis methods, the quantitative methods such as cluster analysis and fuzzy comprehensive evaluation improve the objectivity and mathematical verification of demarcation results. However, they have problems such as difficult parameter obtaining of different regions, complicated calculations and inconsistent precision verification standards. Mathematical statistical methods are simple to calculate, but they usually select the multi-year average of meteorological indexes for calculation and analysis. As a result, they often miss the change of meteorological indices in extreme years, and cannot comprehensively and objectively reflect the actual conditions.

[0005] The present invention seeks to provide a method for demarcating a geographical transition zone, which substantially ameliorates one or more of the abovementioned issues, or at least provides a new and useful alternative.

SUMMARY

[0006] In accordance with one aspect of the present invention, there is provided a method for demarcating a geographical transition zone, where the method includes the following steps:

selecting a climate index, and interpolating daily climate index data observed for a plurality of years in the past based on a structured query language (SQL) server database to obtain a spatial distribution map of the climate index;

extracting an isoline in the spatial distribution map of each climate index, and determining an average line of each climate index according to the isoline and a fishnet line;

determining a plurality of standard deviation lines for the average line of each climate index, the standard deviation lines dividing a swing range of respective climate indexes into a plurality of belt regions, assigning a value to each region, and eliminating an unstable climate index according to the stability of each region; and

adding assigned layers together by a raster calculator to obtain a range of a geographical transition zone, and performing natural breaks classification to obtain a range of a stable region, a sensitive region and an anomalous region of the geographical transition zone.

[0007] In one embodiment the method further includes the step of verifying an interpolation accuracy before obtaining the spatial distribution map of each climate index, and obtaining the spatial distribution map after the verification passes.

[0008] In one embodiment, the selected climate indices are annual precipitation, aridity index, average temperature in January, accumulated ≥ 10°C daily average temperature and days with ≥ 10°C daily average temperature.

[0009] In one embodiment the method further includes the steps of: after the interpolation is completed, using the raster calculator in ArcGIS to subtract a cutoff value of each climate index from an annual interpolation surface of the climate index to obtain a raster surface; solving an absolute value of an annual average value, and visually representing an absolute value raster surface of each climate index.

[0010] In one embodiment the step of determining an average line of each climate index according to the isoline and a fishnet line specifically includes the steps of:

drawing a 5 km × 5 km fishnet, deleting a horizontal fishnet line, and intersecting a vertical fishnet line with the isoline of each climate index to find a point of intersection; extracting a longitude and a latitude of points of intersection on the same vertical fishnet line, calculating an average of the longitude and the latitude, generating a point from the average of the longitude and the latitude of all vertical fishnet lines, and turning a point set into a line, which is a changing average line of the climate index.

[0011] Compared with the prior art, embodiments of the present invention draw on an average - standard deviation method in the principle of statistics. The present invention combines the averages of the isolines of the various climate indices over a plurality of years with different multiples of standard deviations to determine the boundary of the geographical transition zone. In this way, embodiments of the present invention achieve the effective demarcation of the geographical transition zone. The method of embodiments of the present invention have the following advantages:

1. The method finds an overall change in the climate indexes over a plurality of years from a year-by-year change based on a long-term series of historical meteorological observation data. The method overcomes the deficiency of conventional calculations, which, using a multi-year average, miss an extreme year, and the method is more comprehensive and objective. In addition, the method is logically rigorous by referring to a statistical method to determine the boundary.

2. The method for demarcating a geographical transition zone of embodiments of the present invention can be used for determining other types of transition zones in geography, and has universality and reference significance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] To facilitate understanding of the inventive concept, the following is a description of an embodiment shown in the accompanying drawings. The accompanying drawings in the following description show some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

[0013] FIG. 1 is a flowchart of a method for demarcating a geographical transition zone according to an embodiment of the present invention;

[0014] FIG. 2 shows a visual representation;

[0015] FIG. 3 shows an average line;

[0016] FIGS. 4a to 4 shows a changing inter-decadal average of a climate index;

[0017] FIG. 5 is a belt region demarcated by a standard deviation line; and

[0018] FIG. 6 shows a range of a North-South transition zone of China.

DETAILED DESCRIPTION

[0019] The following describes the technical solutions in the embodiments of the present invention with reference to accompanying drawings in the embodiments of the present invention. The description is clear and complete enough for a person of ordinary skill to work the invention. The described embodiments are merely a part rather than all of the embodiments which could fall within the scope of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0020] Referring to FIG. 1, the embodiment shown of the present invention provides a method for demarcating a geographical transition zone, where the method includes the following steps:

[0021] Step 1, process climate index data.

[0022] Select multiple representative climate indexes, and use an ordinary Kriging method to interpolate daily climate index data observed for a plurality of years in the past based on a structured query language (SQL) server database to obtain a spatial distribution map of the climate indices. In this embodiment, it is necessary to verify an interpolation accuracy before obtaining the spatial distribution map of each climate index. The spatial distribution map is obtained after the verification passes. The selected climate index data spans 68 years, that is, from 1951 to 2018. The climate indices are specifically annual precipitation, aridity index, average temperature in January, accumulated ≥ 10°C daily average temperature and days with ≥ 10°C daily average temperature. The annual precipitation, the average temperature in January, the accumulated ≥ 10°C daily average temperature and the days with ≥ 10°C daily average temperature are directly obtained through statistics. The aridity index is calculated from the annual precipitation and potential evapotranspiration according to the following formula:

$$K = \frac{ET_0}{P}$$

[0023] In the formula, K is the aridity index, ET_0 is the potential evapotranspiration (mm), and P is the annual precipitation (mm).

[0024] Step 2, visually represent a processing result.

[0025] In ArcGIS, use a raster calculator to subtract a cutoff value of each climate index from an annual interpolation surface x_i of the climate index to obtain a raster surface y_i; solve an absolute value p_i of an annual average value z_i, and visually represent an absolute value raster surface p_i of each climate index. In this embodiment, the cutoff values of the annual precipitation, the aridity index, the average temperature in January, the accumulated ≥ 10°C daily average temperature and the days with ≥ 10°C daily average temperature are 800 mm, 0.5, 0°C, 4,500°C and 219 days, respectively.

[0026] Step 3, extract an isoline in the spatial distribution map of each climate index obtained in step 1, and determine an average line of each climate index according to the isoline and a fishnet line.

[0027] Extract an 800 mm isohyet, a 0°C January isotherm, a 4,500°C isoline of accumulated ≥ 10°C daily average temperature, a 219-day isoline of days with ≥ 10°C daily average temperature and a 0.5 isoline of aridity index from the spatial distribution maps of the climate indexes over the years, where for the sake of comparability, the isolines of the climate indexes are respectively extracted by excluding the shortest arc and remaining only the longest arc that is fully connected. Then draw a 5 km × 5 km fishnet; delete a horizontal fishnet line, and intersect a vertical fishnet line with the isoline of each climate index to find a point of intersection. Extract a longitude and a latitude of points of intersection on the same vertical fishnet line, calculate an average of the longitude and the latitude, generate a point from the average of the longitude and the latitude of all vertical fishnet lines, and turn a point set into a line, which is a changing average line μ of the climate index.

[0028] Step 4, determine a plurality of standard deviation lines for the average line of each climate index, the standard deviation lines dividing a swing range of respective climate indexes into a plurality of belt regions, assign a value to each region, and eliminate an unstable climate index according to the stability of each region.

[0029] Find standard deviation lines of different multiples for the average line μ of each climate index, which are μ + 1std (standard deviation), μ - 1std (standard deviation), μ + 2std (standard deviation), μ - 2std (standard deviation), μ + 3std (standard deviation), and μ - 3std (standard deviation). Use μ, μ ± 1std, μ ± 2std and μ ± 3std as dividing lines to divide the swing range of the 5 climate indexes into 6 belt regions, and assign a value to each region, that is, assign a value of 1 to a range of μ ± 1std (standard deviation), a value of 2 to a range of μ ± 2std (standard deviation), and a value of 3 to a range of μ ± 3std (standard deviation). The inter-decadal changes of the climate indexes in the 68 years show that: the 800 mm isohyet, the 0°C January isotherm and the 0.5 isoline of aridity index are more stable than the 4,500°C isoline of accumulated ≥ 10°C daily average temperature and the 219-day isoline of days with ≥ 10°C daily average temperature, and the 219-day isoline of days with ≥ 10°C daily average temperature is more stable than the 4,500°C isoline of accumulated ≥ 10°C daily average temperature. Therefore, the 4,500°C isoline of accumulated ≥ 10°C daily average temperature is excluded, and the other 4 climate indexes are remained for comprehensive calculation.

[0030] Step 5, add assigned layers together by the raster calculator to obtain a range of a geographical transition zone with a value between 4 and 12, and perform natural breaks classification to obtain a range of a stable region, a sensitive region and an anomalous region of the geographical transition zone.

Description of Experiment

[0031] Taking the North-South transition zone of China as an example, the visual representation of the processing result in step 2 is shown in FIG. 2. In FIG. 2, a is the 800 mm isohyet, b is the 0°C January isotherm, c is the 4,500°C isoline of accumulated ≥ 10°C daily average temperature, d is the isoline of days with ≥ 10°C daily average temperature, and e is the 0.5 isoline of aridity index.

[0032] The isolines obtained in step 3 are shown in FIG. 3, and the inter-decadal changing averages of the various climate indexes obtained in step 4 are shown in FIG. 4. In FIG. 4, a shows a changing average of the 800 mm isohyet, b shows a changing average of the 0°C January isotherm, c shows a changing average of the 4,500°C isoline of accumulated ≥ 10°C daily average temperature, d shows a changing average of the 219-day isoline of days with ≥ 10°C daily average temperature, and e shows a changing average of the 0.5 isoline of aridity index. The belt regions demarcated by the standard deviation lines in step 4 are shown in FIG. 5. In FIG. 5, a shows a belt region demarcated by the 800 mm isohyet, b shows a belt region demarcated by the 0°C January isotherm, c shows a belt region demarcated by the 219-day isoline of days with ≥ 10°C daily average temperature, and d shows a belt region demarcated by the 0.5 isoline of aridity index.

[0033] The range of the North-South transition zone of China demarcated in step 5 is shown in FIG. 6, where the regions from light to dark represent the stable region, the sensitive region and the anomalous region in order.

[00034] Although some preferred embodiments of the present invention have been described, persons skilled in the art can make changes and modifications to these embodiments once they learn the basic inventive concept. Therefore, the following claims are intended to be construed as to cover the preferred embodiments and all changes and modifications falling within the scope of the present invention.

[0035] Obviously, a person skilled in the art can make various modifications and variations to the present invention without departing from the spirit and scope of the present invention. The present invention is intended to cover these modifications and variations provided that they fall within the scope of protection defined by the following claims and their equivalent technologies.

The claims defining the present invention are as set out below:

1. A method for demarcating a geographical transition zone, wherein the method includes the following steps:

selecting a climate index, and interpolating daily climate index data observed for a plurality of years in the past based on a structured query language (SQL) server database to obtain a spatial distribution map of the climate index;

extracting an isoline in the spatial distribution map of each climate index, and determining an average line of each climate index according to the isoline and a fishnet line;

determining a plurality of standard deviation lines for the average line of each climate index, the standard deviation lines dividing a swing range of respective climate indexes into a plurality of belt regions, assigning a value to each region, and eliminating an unstable climate index according to the stability of each region; and

adding assigned layers together by a raster calculator to obtain a range of a geographical transition zone, and performing natural breaks classification to obtain a range of a stable region, a sensitive region and an anomalous region of the geographical transition zone.

2. The method for demarcating a geographical transition zone according to claim 1, wherein the method further includes verifying an interpolation accuracy before obtaining the spatial distribution map of each climate index, and obtaining the spatial distribution map after the verification passes.

3. The method for demarcating a geographical transition zone according to claim 1 or 2, wherein the selected climate indices are annual precipitation, aridity index, average temperature in January, accumulated ≥ 10°C daily average temperature and days with ≥ 10°C daily average temperature.

4. The method for demarcating a geographical transition zone according to any one of claims 1 to 3, wherein the method further includes the steps of: after the interpolation is completed, using the raster calculator in ArcGIS to subtract a cutoff value of each climate index from an annual interpolation surface of the climate index to obtain a raster surface; solving an absolute value of an annual average value, and visually representing an absolute value raster surface of each climate index.

5. The method for demarcating a geographical transition zone according to any one of claims 1 to 4, wherein the step of determining an average line of each climate index according to the isoline and a fishnet line specifically includes the steps of:

drawing a 5 km × 5 km fishnet, deleting a horizontal fishnet line, and intersecting a vertical fishnet line with the isoline of each climate index to find a point of intersection; extracting a longitude and a latitude of points of intersection on the same vertical fishnet line, calculating an

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average of the longitude and the latitude, generating a point from the average of the longitude and the latitude of all vertical fishnet lines, and turning a point set into a line, which is a changing average line of the climate index.

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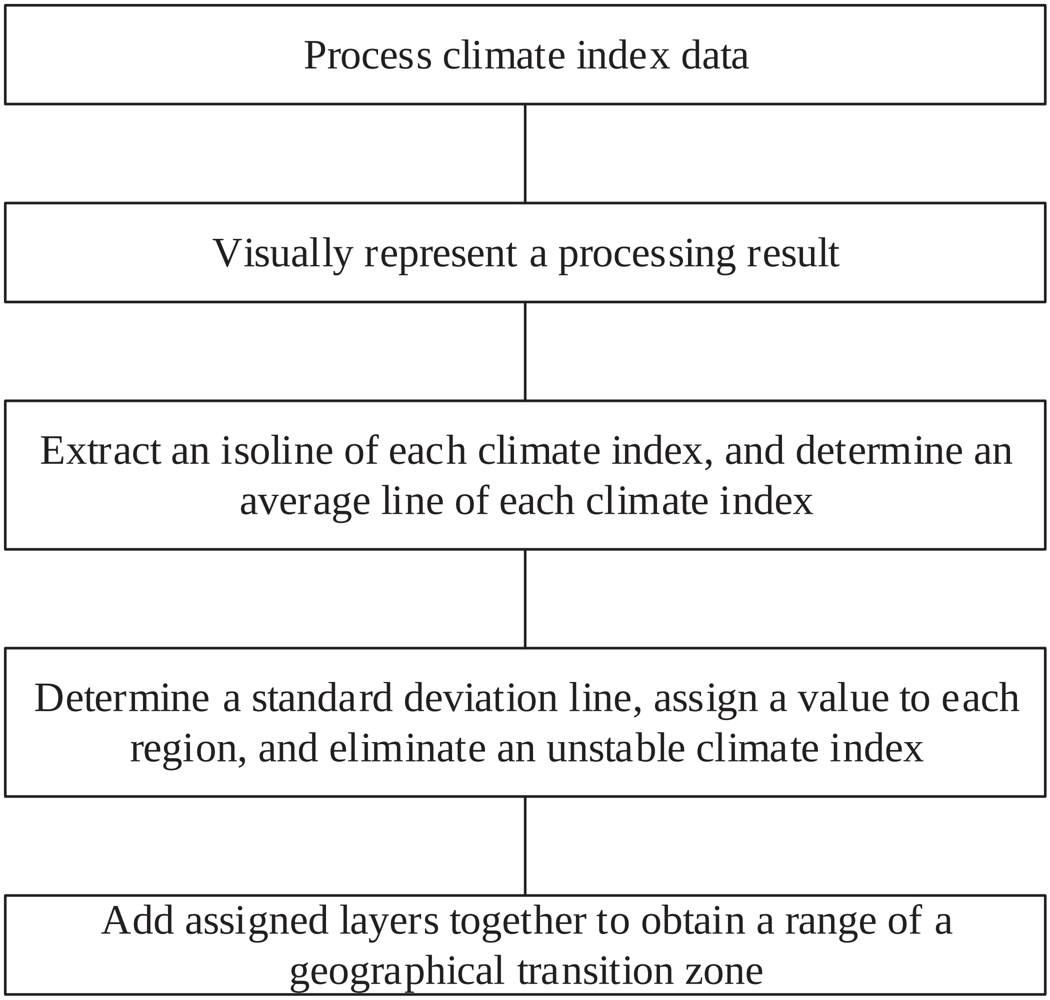

FIG. 1

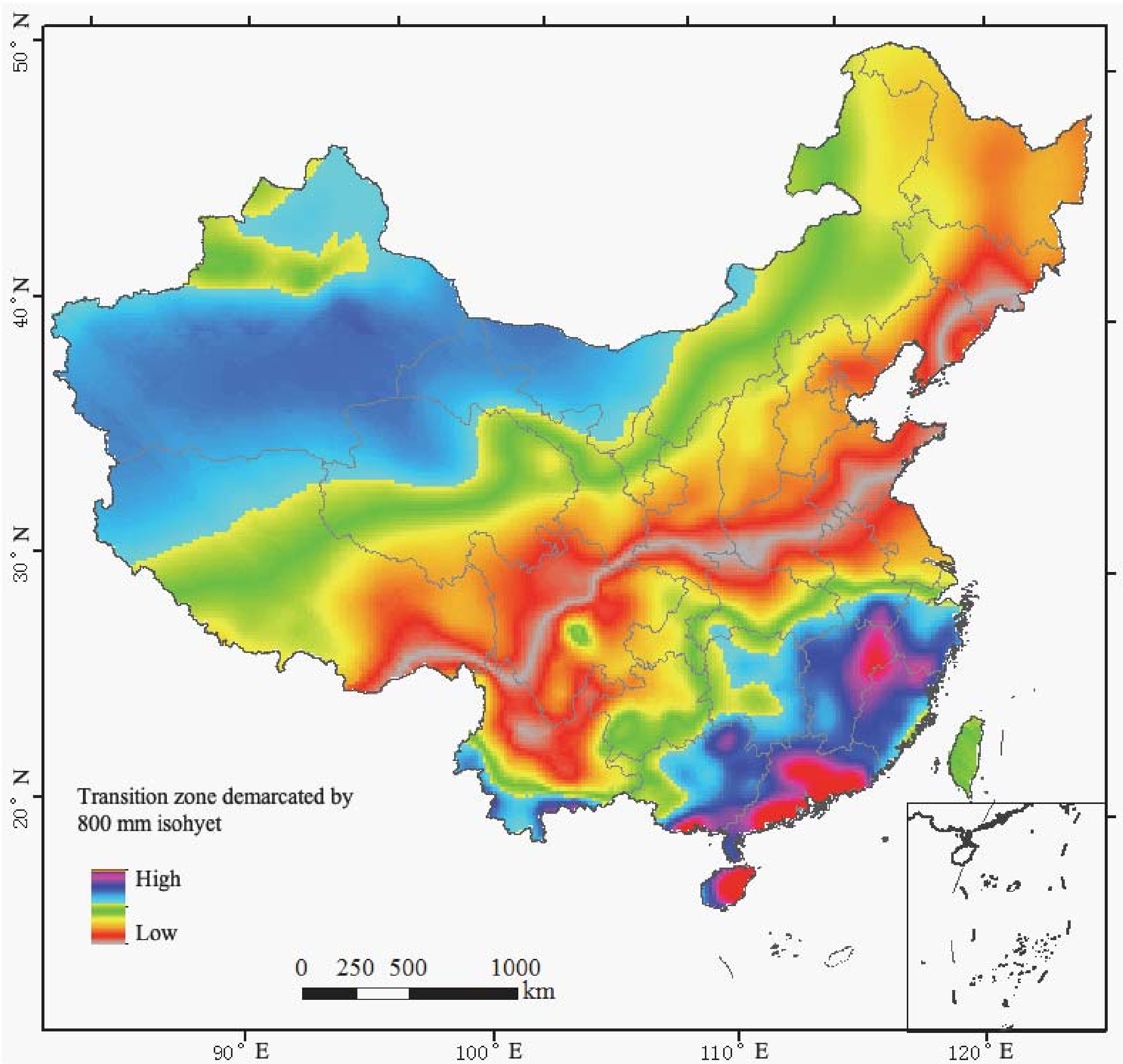
50° N
40° N
30° N
20° N
90° E
100° E
110° E
120° E
Transition zone demarcated by
800 mm isohyet
High
Low
0 250 500 1000
km

Fig 2a

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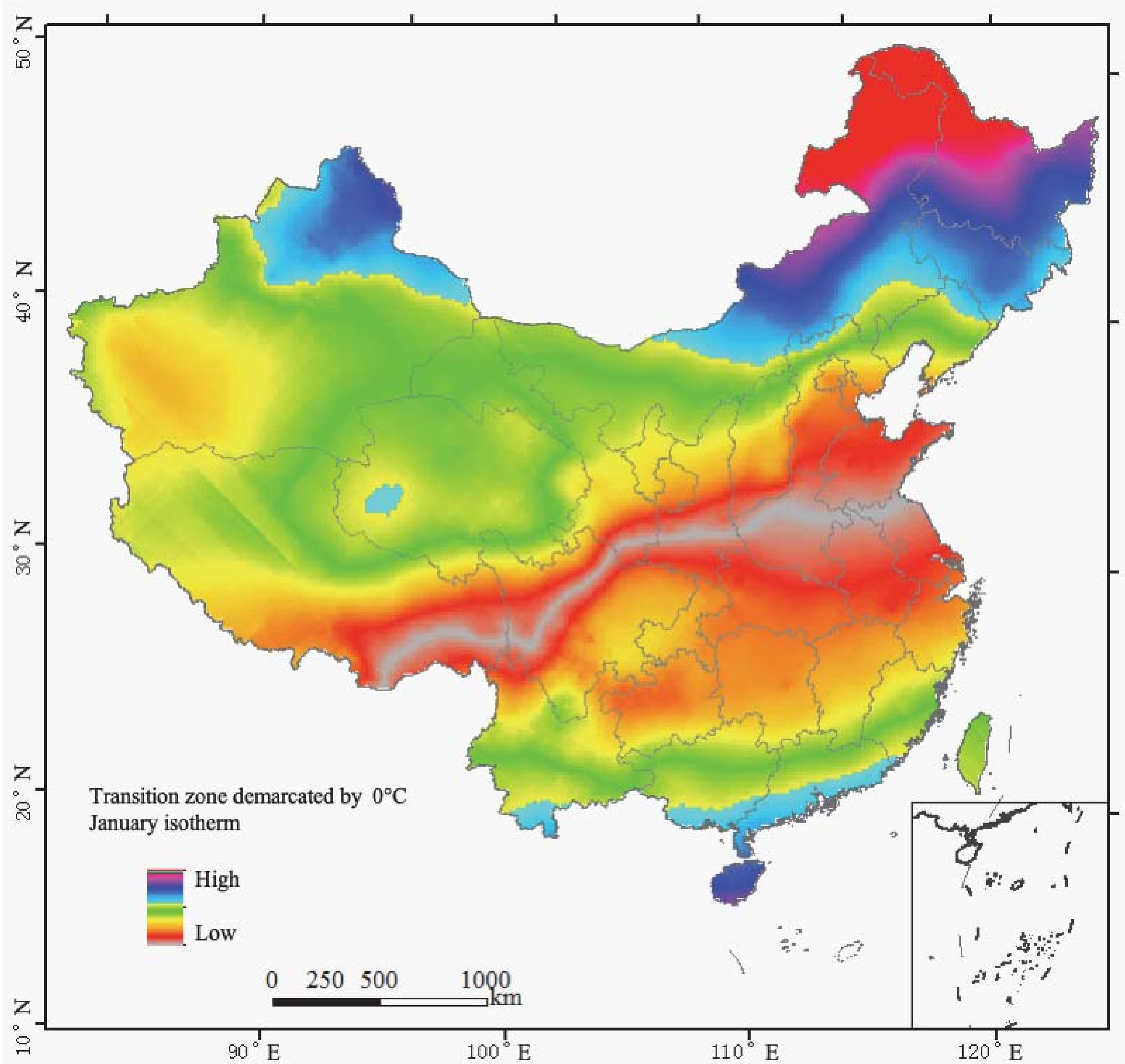

Fig 2b

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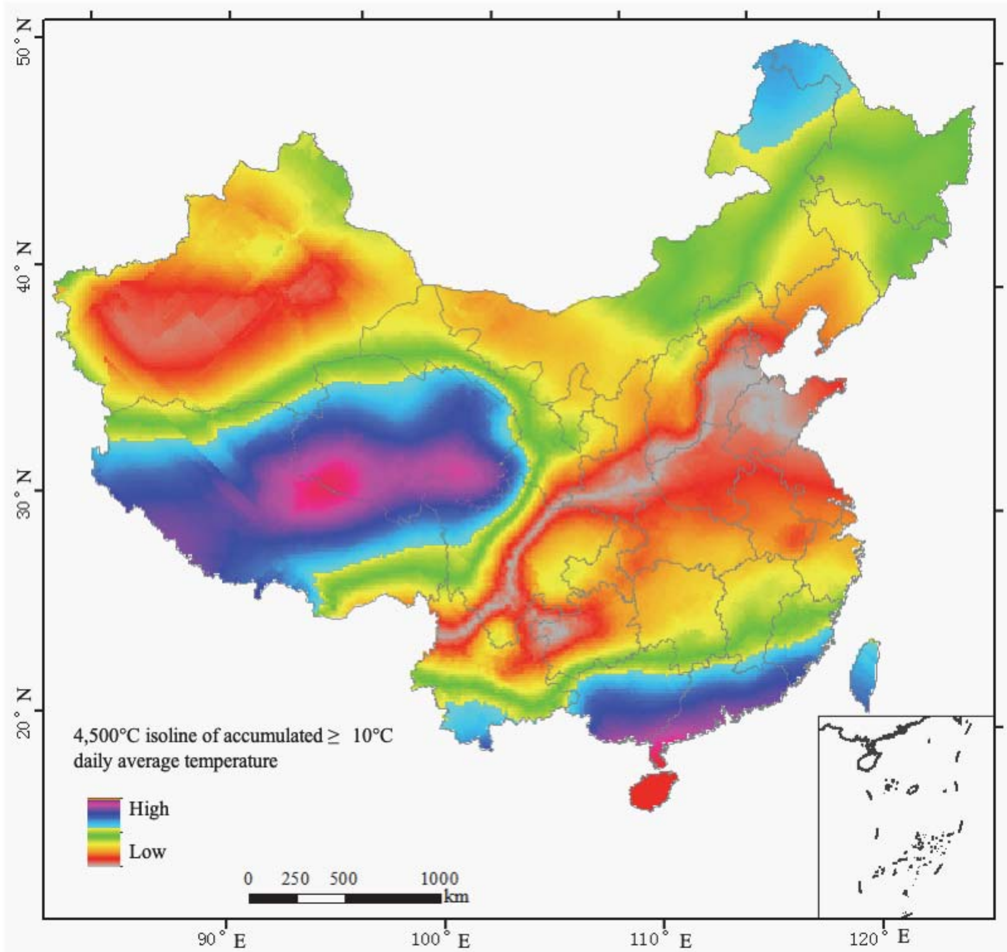

Fig 2c

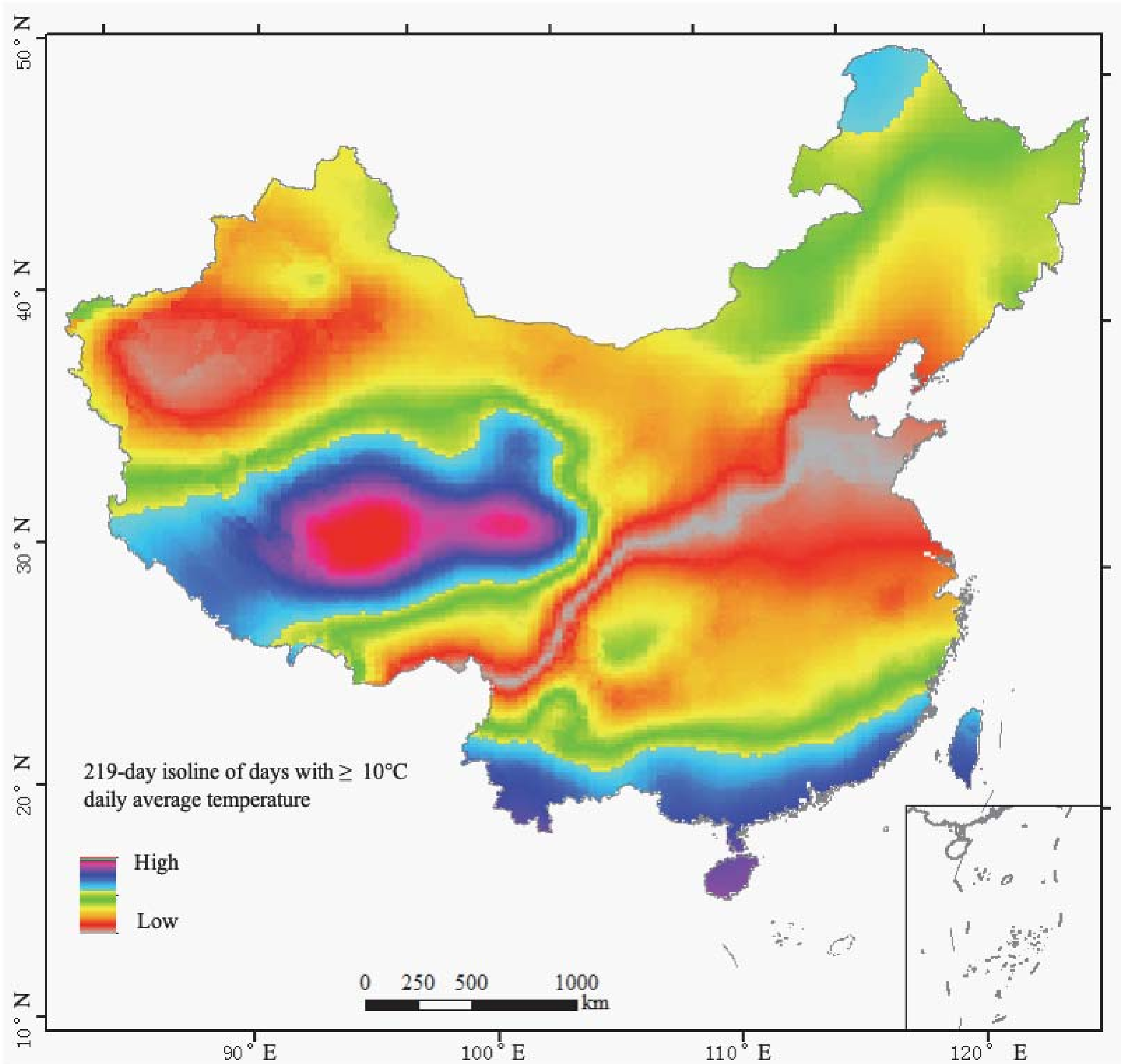
50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
219-day isoline of days with ≥ 10°C
daily average temperature
High
Low
0 250 500 1000
km

Fig 2d

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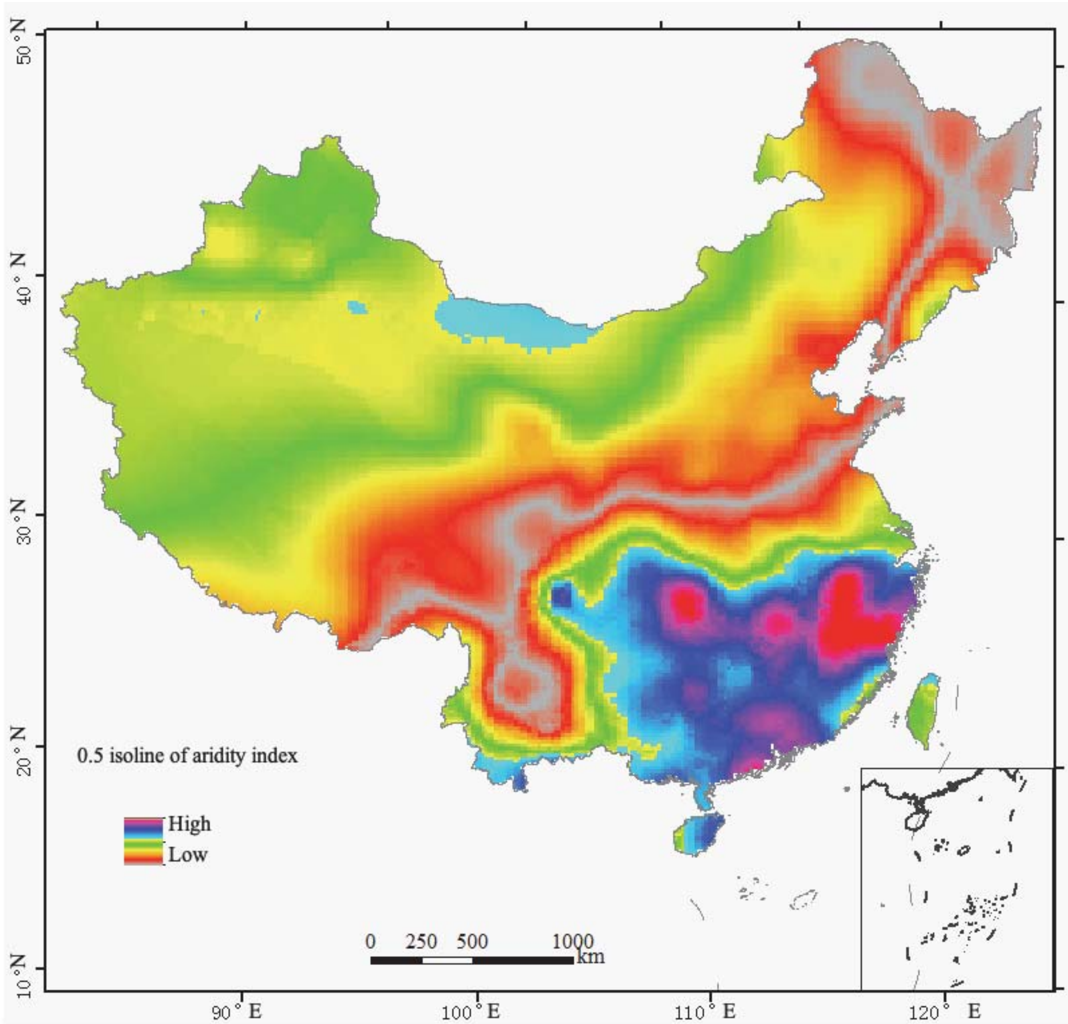

FIG. 2e

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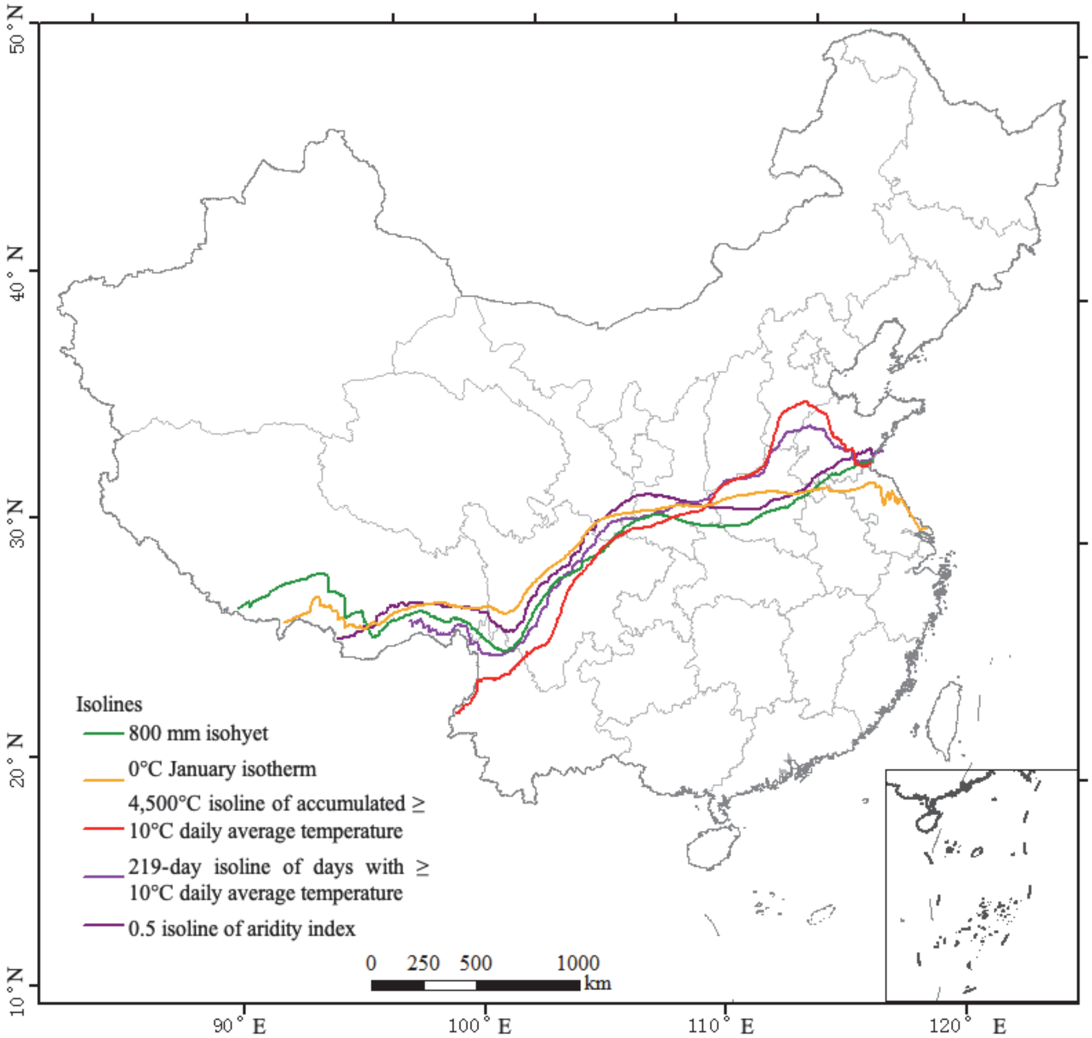

FIG. 3

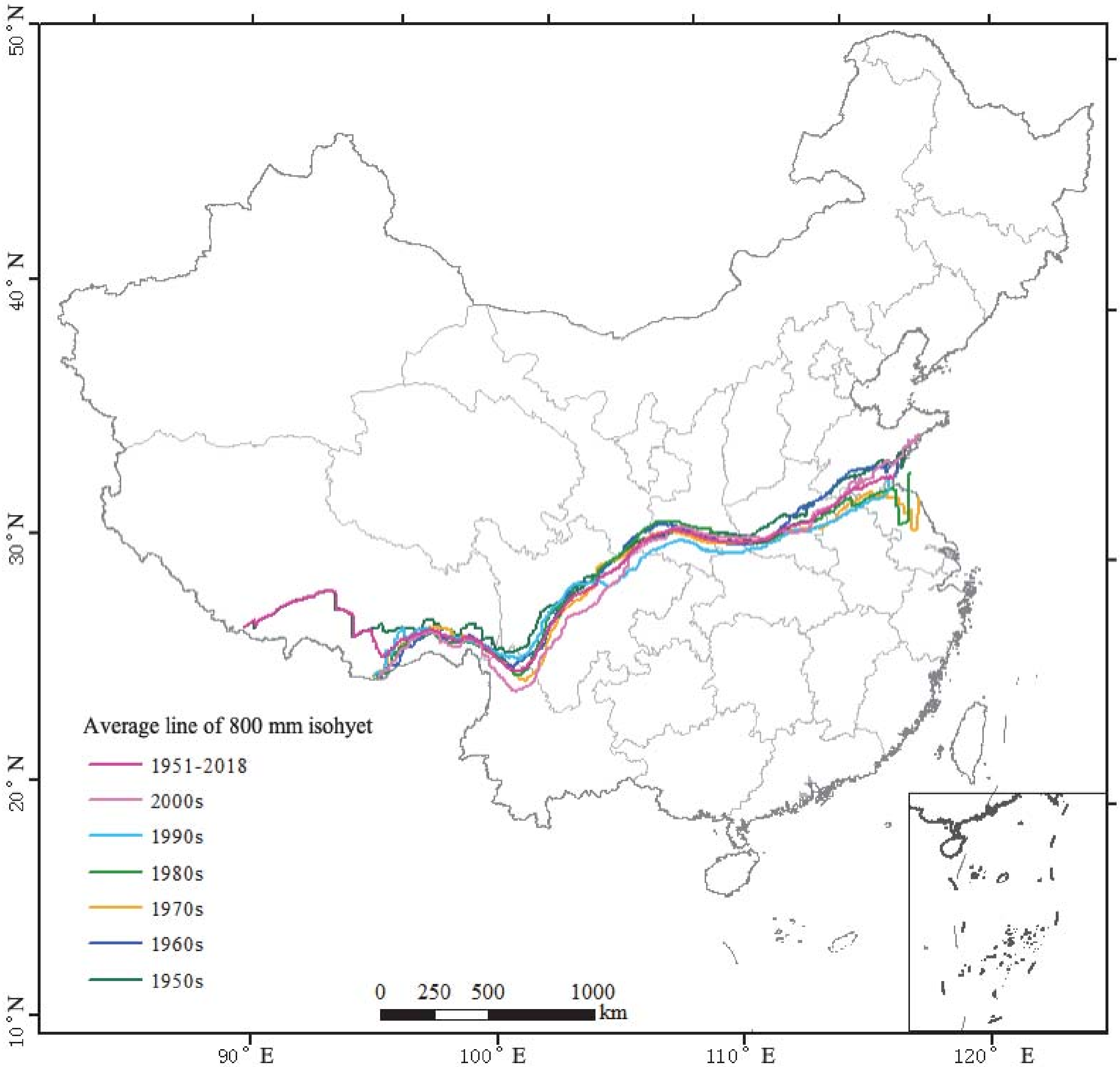
50°N
40°N
30°N
20°N
10°N
90° E
100° E
110° E
120° E
Average line of 800 mm isohyet
1951-2018
2000s
1990s
1980s
1970s
1960s
1950s
0 250 500 1000
km

Fig 4a

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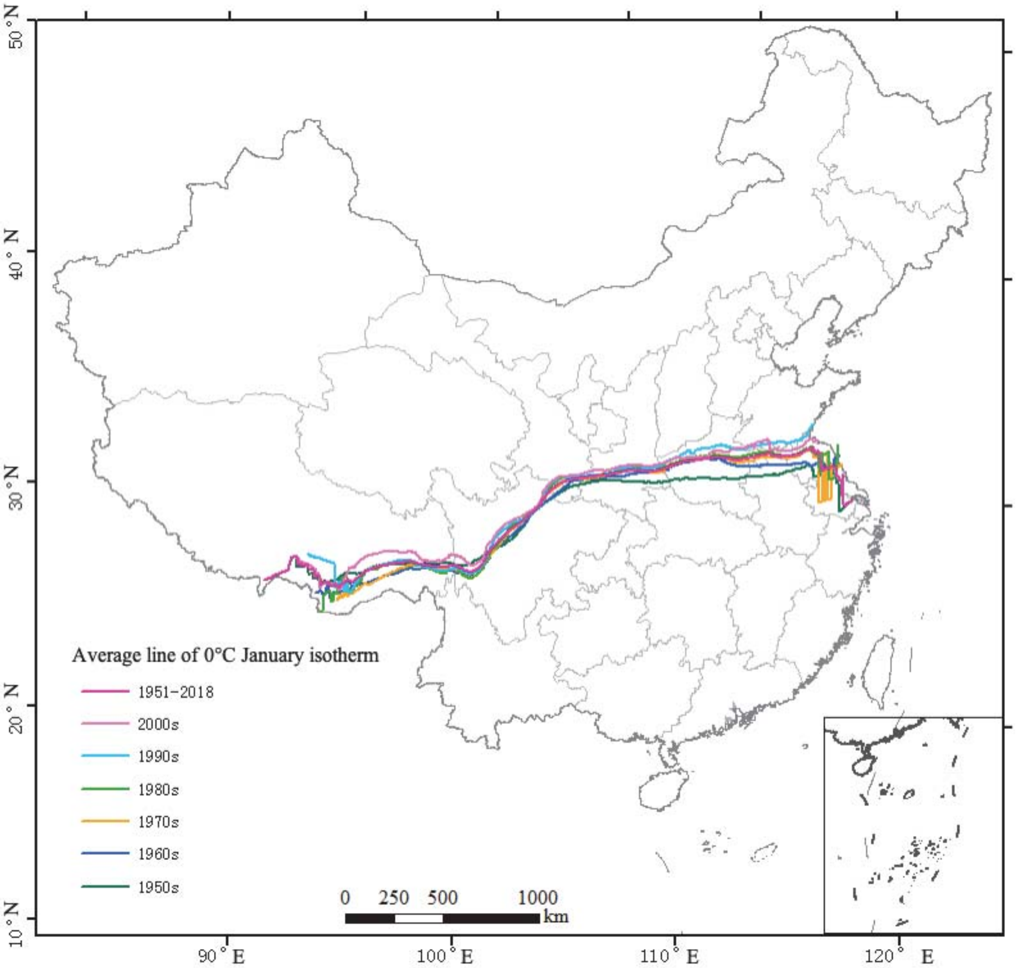


Fig 4b

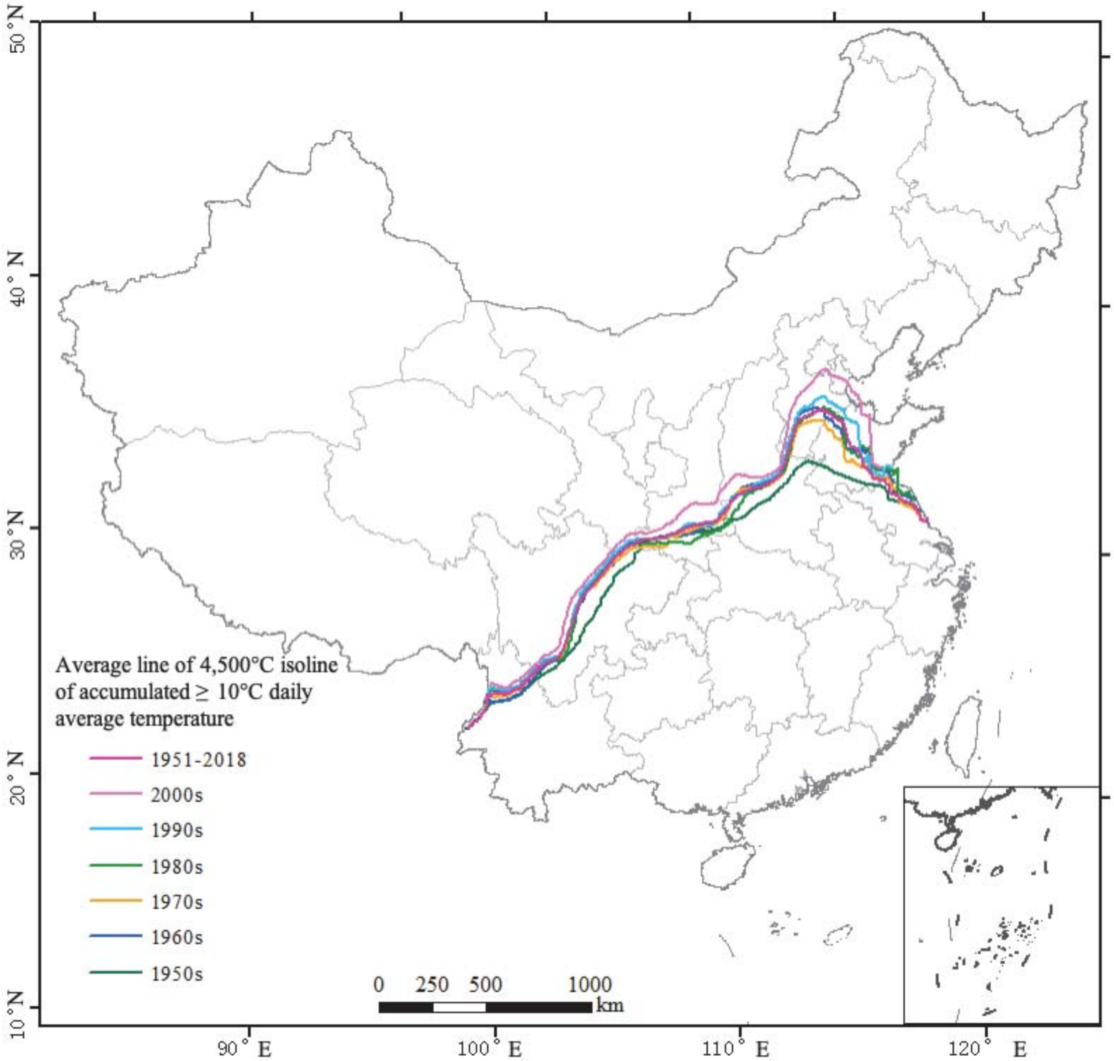

50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
Average line of 4,500°C isoline of accumulated ≥ 10°C daily average temperature
1951-2018
2000s
1990s
1980s
1970s
1960s
1950s
0 250 500 1000
km

Fig 4c

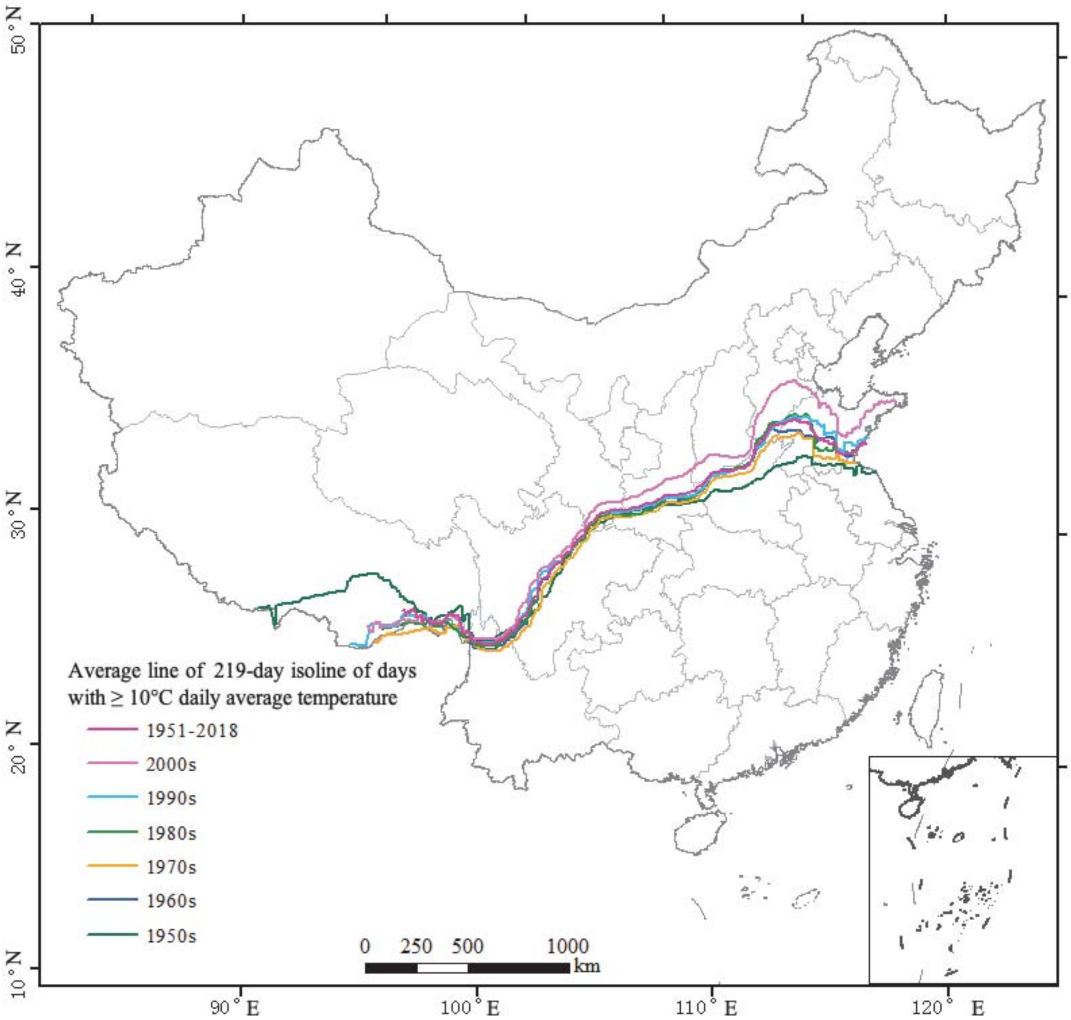

50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
Average line of 219-day isoline of days with ≥ 10°C daily average temperature
1951-2018
2000s
1990s
1980s
1970s
1960s
1950s
0 250 500 1000
km

Fig 4d

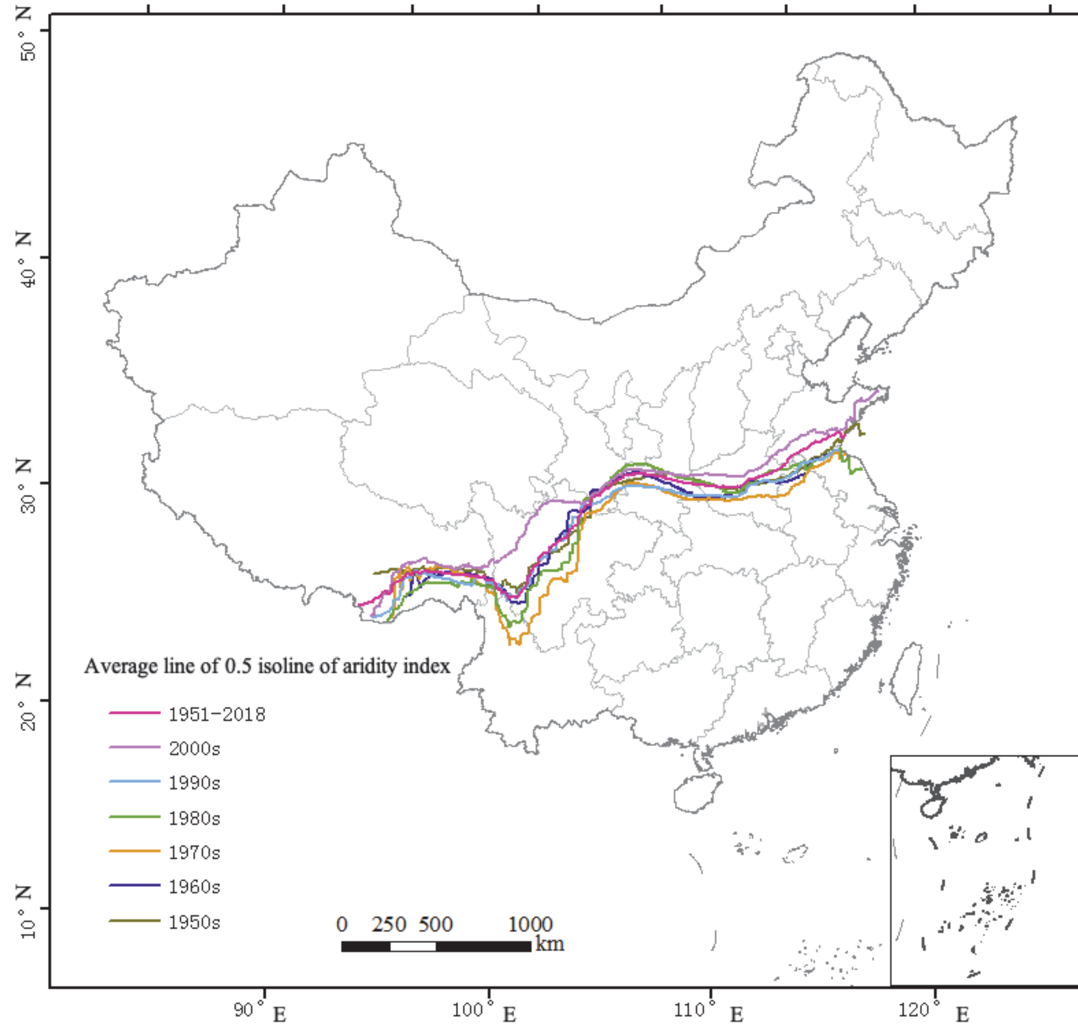
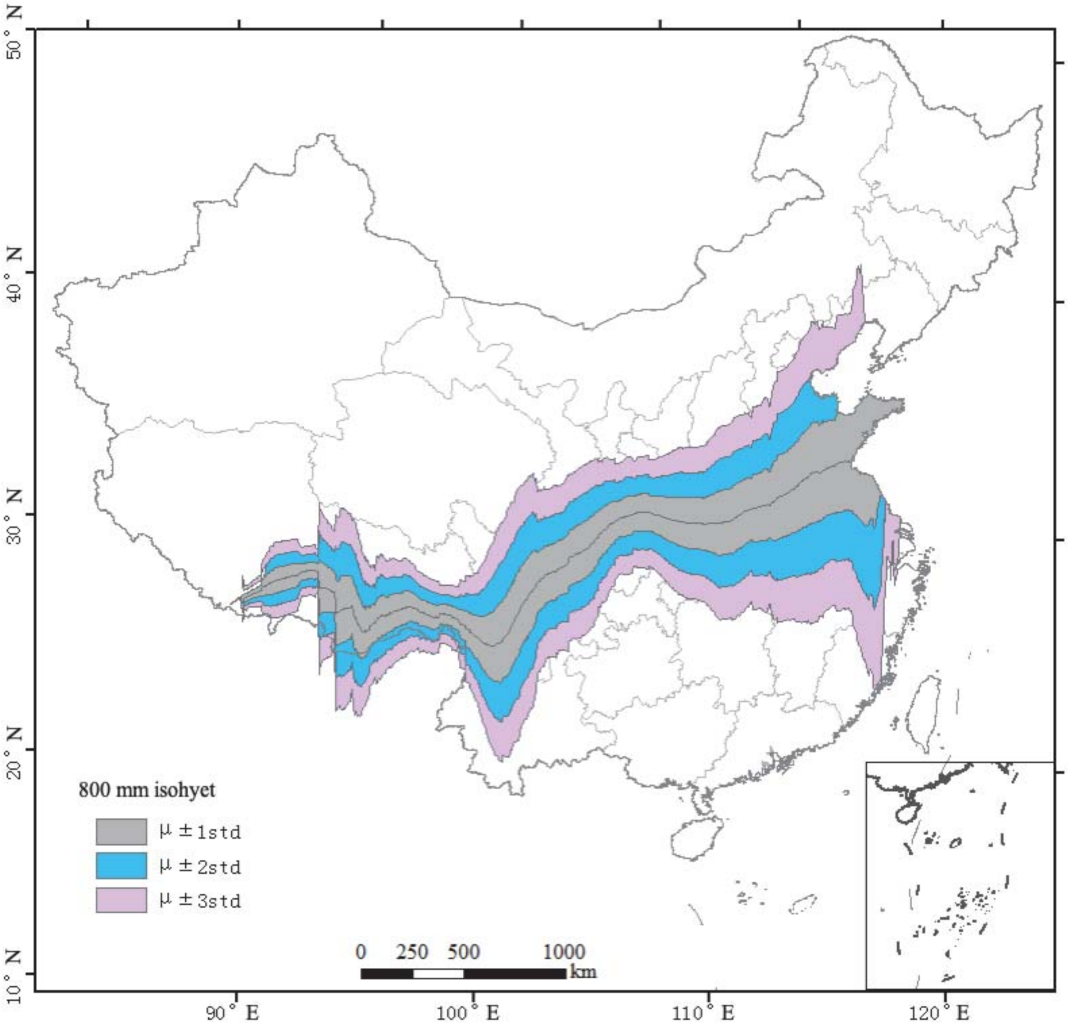

50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
Average line of 0.5 isoline of aridity index
1951-2018
2000s
1990s
1980s
1970s
1960s
1950s
0 250 500 1000
km

FIG. 4e



50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
800 mm isohyet
μ ± 1std
μ ± 2std
μ ± 3std
0 250 500 1000
km

Fig 5a

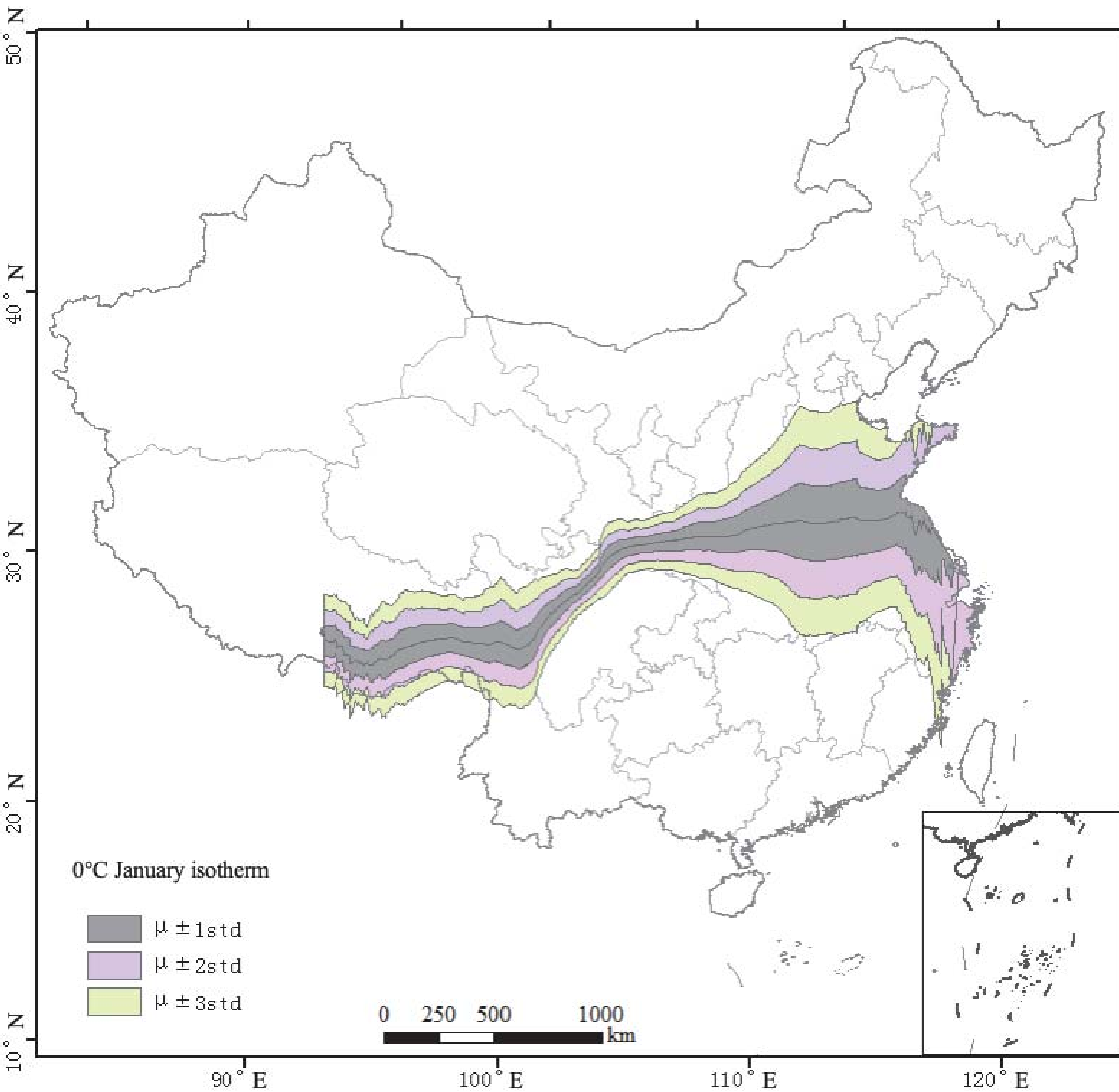

50° N
40° N
30° N
20° N
10° N
90° E
100° E
110° E
120° E
0°C January isotherm
μ ± 1std
μ ± 2std
μ ± 3std
0 250 500 1000
km

Fig 5b

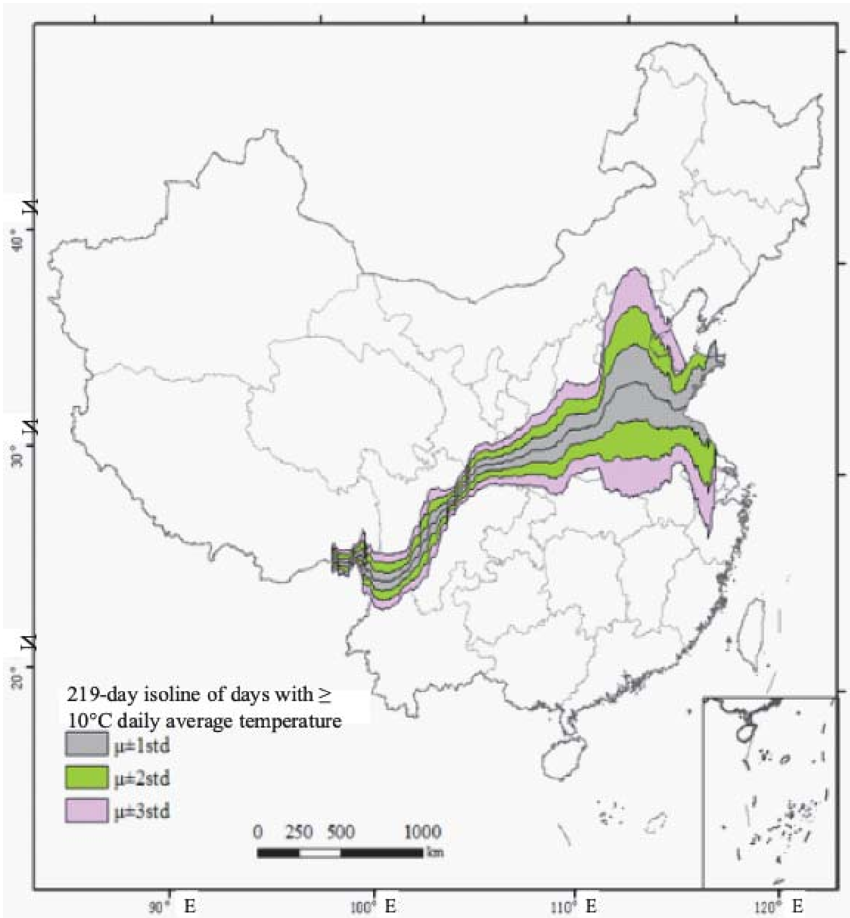

219-day isoline of days with ≥ 10°C daily average temperature
μ±1std
μ±2std
μ±3std
0 250 500 1000
km
90° E
100° E
110° E
120° E
40° N
30° N
20° N

Fig 5c

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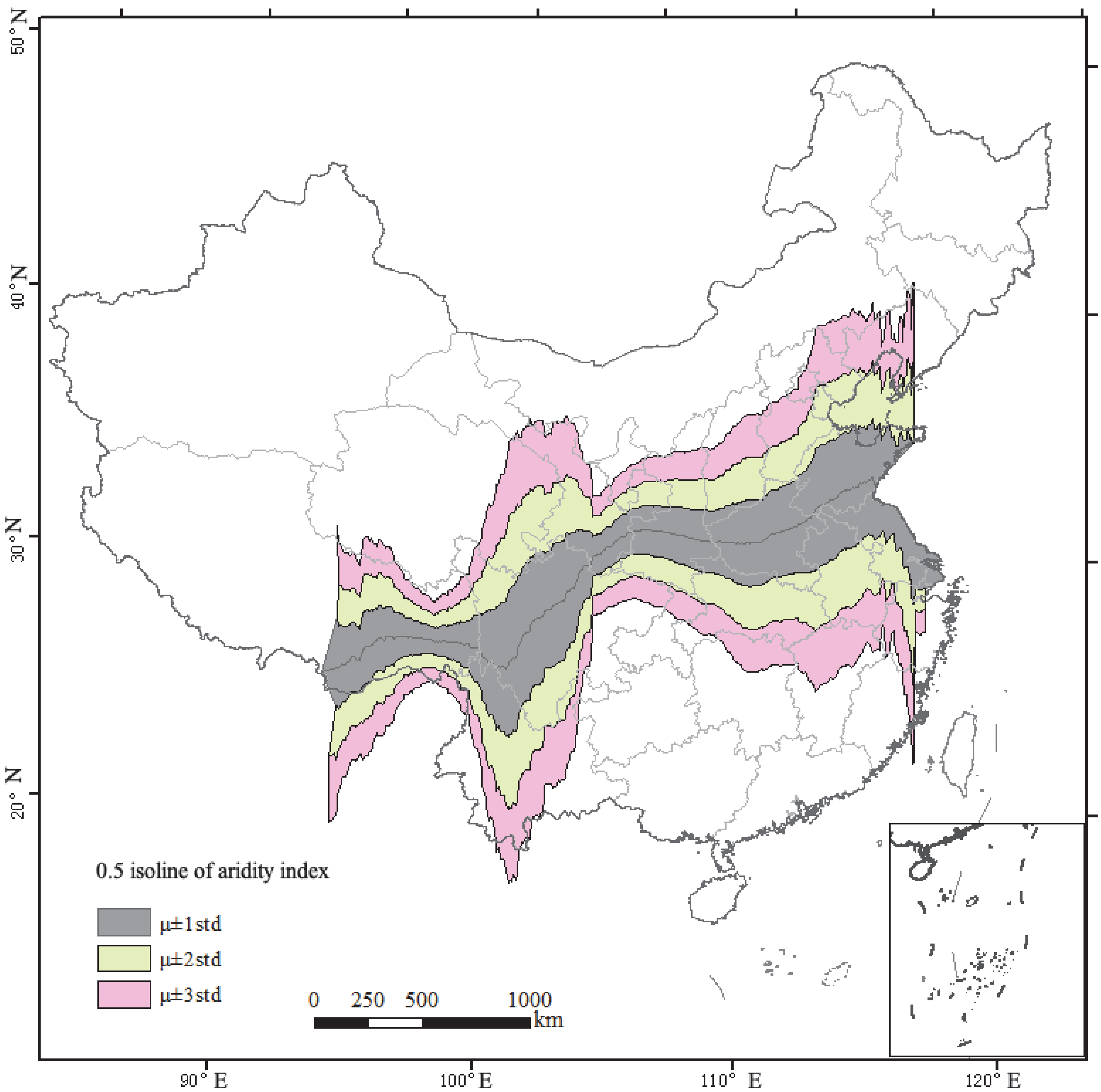

FIG. 5d

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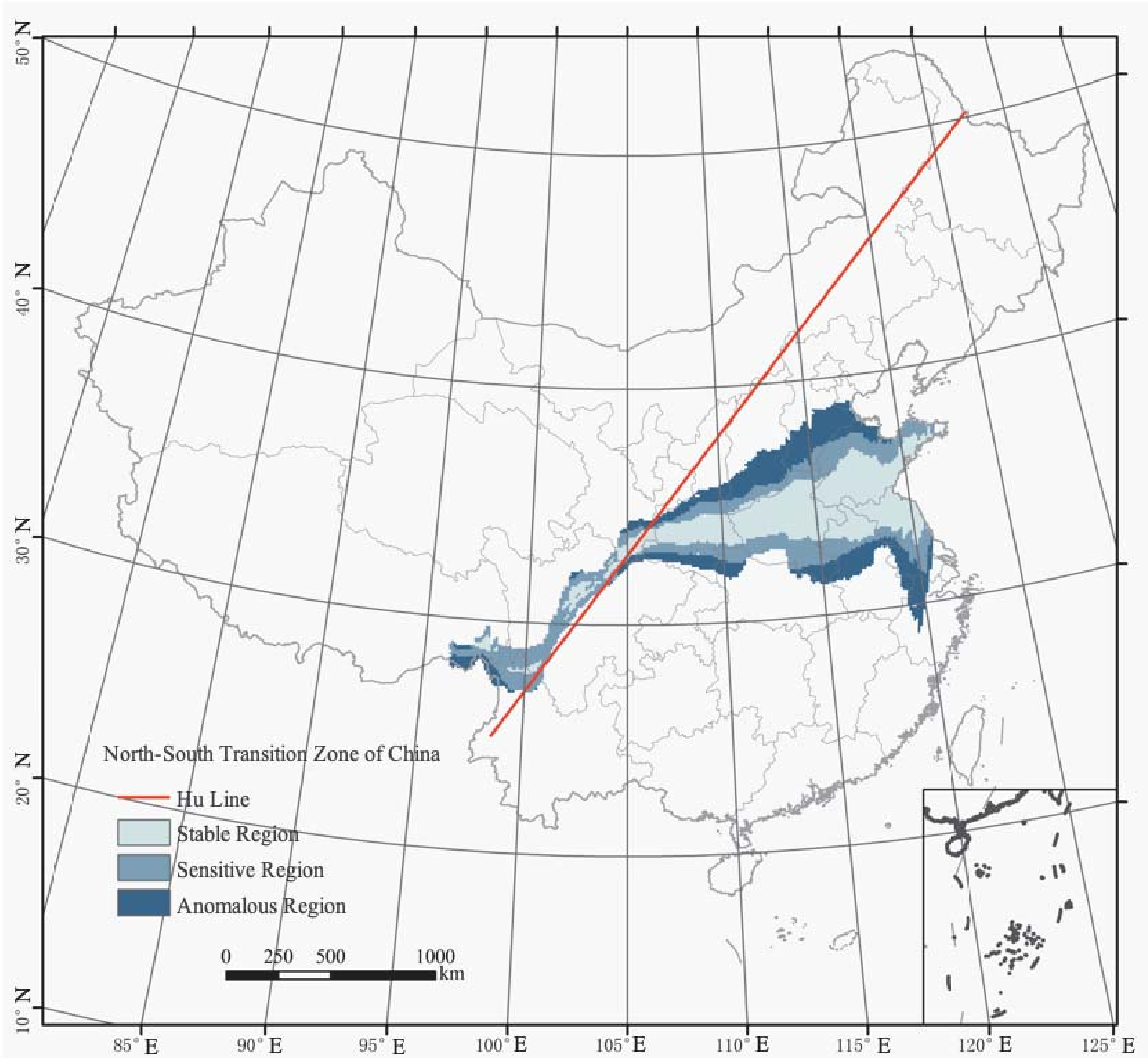

FIG. 6