Representativeness Evaluation of China's National Baseline Climate Station Network

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Abstract

The spatial distribution and representativeness of the current national baseline climate station network have been evaluated through analyzing their geographic locations, land-use types, elevations and temperature records. The results show that China mainland still has 1 climatic zone, 4 climatic sub-zones and 18 third-order climatic regions with no baseline climate stations. Furthermore, 20% of the stations were distributed around build-up land which only comprises 0.3% of the country. Few baseline climate stations exist in high altitude region, wasteland, as well as ocean area, which is not enough to monitor the state and the changes of climate over these regions. Recent 10 years' temperature records indicate that 19 out of 143 stations have not kept the climatic characteristics of which climate zone they stay. So, it is urgent to optimize the distribution of current baseline climate station network in China.

Keywords: baseline climate stations network, spatial distribution, representativeness

Text

1. Introduction

Humans are bewildered by a climate featured with global warming. The raised occurrence of abnormal climate events has imposed increasingly enhanced impacts on the survival of humans and on the socioeconomic development of human society as well. Climate change is not only a hot issue that may hamper a nation's economic development, but has also become a political and diplomatic concern (IPCC 2007). Accurate and reliable monitoring information makes a scientific basis for adapting to climate change impacts. The acquisition of monitoring information and associated applications depends on the configuration of an observing network (WMO No.488; No.544). Climate observation is meant to collect spatial information across a vast area and at a large scale. In this context, the spatial distribution of baseline stations, and the representativeness of the ambient environment are extremely important in obtaining accurate monitoring information. This paper evaluates the spatial distribution of China's national baseline climate station network and associated representativeness, in the context of the evenness of spatial distribution, climate representativeness, land use type, and elevation, using Geographic Information System (GIS) technology, in an attempt to provide scientific evidences for further optimizing the baseline climate station network in the country.

2. Data and methodology

The following data were employed in the study: China climate zoning map (Yan Hong et al, 2002), land use type (1-km resolution), geographical elevation (1-km resolution), and daily temperature data collected by the national baseline climate stations.

In the study, a geographic information system was applied to make an integrated analysis of a range of spatial information, including climate zoning, land use, elevation, and the data collected by the baseline climate stations. Meanwhile, climate belts were calculated as a proportion of area using statistical means. Additionally, the temperature series in the vicinity of the baseline climate stations were analyzed statistically, based on the indicators of climate zoning, so as to judge the representativeness of the temperature data collected by the baseline stations for a given climate zone.

3. Results

3.1 Spatial distribution

Global Climate Model (GCM) is configured at a resolution of 2.5°×2.5°. Fig. 1 shows the density of baseline climate stations across China (2.5°×2.5°). The continental part of China has been covered by 207 grids, including the grids with incomplete rims. Of them, 100 inland grids are not covered by baseline stations, with 74 grids being covered by one baseline station, 25 grids by 2 baseline stations, and 6 grids by 3 baseline stations. Apparently, China’s baseline climate station network has covered the most part of the southeast inland region. Unfortunately, the west part of the country has mostly not been covered by baseline stations, and hence is not in a position to provide any baseline information to climate models.

Fig.1 The distribution of National baseline climate stations in 2.5°×2.5° grids

3.2 Climate zoning

In China, climate zoning was made at three levels: climate zone as level I, climate sub-zone level II, and climate region level III. The distribution of baseline climate stations at different levels was given in Fig. 2.

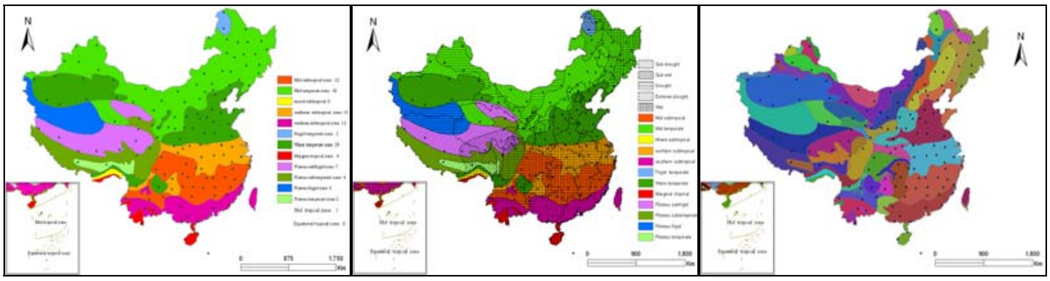

Fig.2 The distribution of National baseline climate stations in climatic zone

From climate zones to climate sub-zones, six major climatic zones (Frigid temperate, Plateau frigid, Northern subtropical, Mid subtropical, Mid tropical, and Equatorial tropical) has only one climate sub-zone for each. Of the 28 climate sub-zones in the country, 4 (Plateau frigid dry, Plateau sub-frigid wet, North-middle-south mixed subtropical wet, and Equatorial tropical wet) have not yet been covered by any baseline station. 10 climate sub-zones, including the Warm-temperate wet sub-zone, have only one national baseline climate station. The Mid subtropical wet sub-zone enjoys an extensive coverage of 22 baseline stations, and 18 baseline stations cover the Northern subtropical wet sub-zone. In a whole, 103 baseline stations work for the wet and sub-wet climate sub-zones, taking up 72% of the total baseline stations in the country. Only 40 baseline stations possessed by the dry, sub-dry, and extremely dry climate sub-zones.

From climate sub-zones to climate regions, 18 climate regions, including the Altai Mountains region, or 28% of the total climate regions, have not yet been covered by baseline climate stations. 19 climate regions, including East Tibet region, have only one baseline station. The middle reaches of the Yangtze River region and South of Yangtze River region enjoy the largest number of baseline stations with 11 for each.

To understand the proportional agreement between the distribution of baseline stations and the area of climatic zones, the area of individual climatic zones and the number of baseline stations possessed by the climatic zones were calculated separately (Fig. 3). It is apparent that the Mid temperate zone enjoys the largest area, or 28.5% of China's total homeland, covered by 29.4% of the nation's baseline climate stations. However, the Plateau Frigid zone, occupying 5.7% of the nation's territories, has no baseline stations at all. The equatorial tropical belt, taking up 9.4% of the homeland, has no baseline stations either. Apparently, China's national baseline climate station network has not been configured to match the area a climate zone occupies, with excessively low numbers of baseline stations for some climate zones (Plateau Frigid, Mid tropical, and equatorial tropical), but high numbers for others (Northern subtropical and Mid subtropical). The scarce distribution of baseline climate stations in Plateau and tropical marine regions has made poor monitoring of the climate changes occurred there. One can also see that the west part of the country failed to see a more detailed climate zoning structure, due to the scarcity of baseline climate stations in the region.

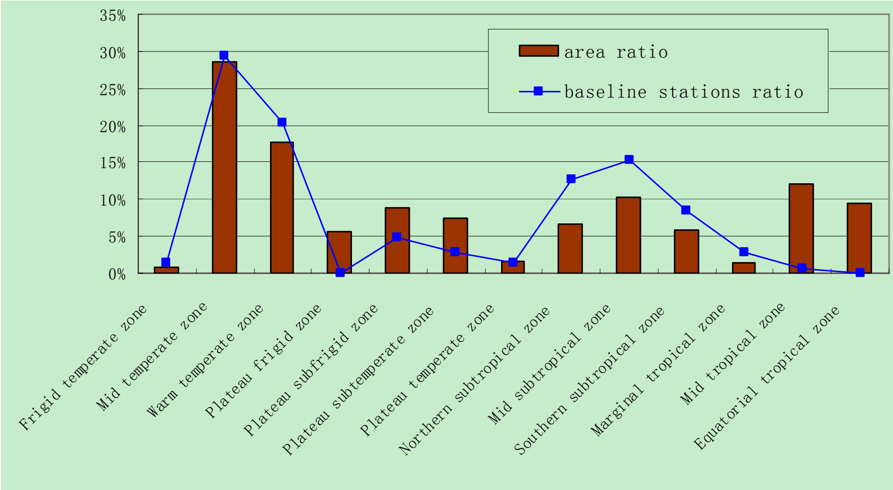

Fig. 3 Area proportion of individual climate zones and associated baseline stations

3.3 Land use type

Table 1 presents the area taken by 6 major land surface types and associated proportions in 13 climate zones, calculated on the retrieved satellite data (1-km resolution), and the numbers of baseline climate stations possessed by them. The red number shows the dominant and sub dominant underlying surface types in one climate zone. Gray shadow represents the underlying surface type with the largest number (first two) of baseline stations.

Table 1 Surface type in climate zones (area proportion) and associated baseline stations

	Crop land		Forest land		Grass land		Water area		Building area		Waste land	
	Area proportion	Number of stations	Area proportion	Number of stations	Area proportion	Number of stations	Area proportion	Number of stations	Area proportion	Number of stations	Area proportion	Number of stations
Frigid Temperate zone	1.5%	0	80.3%	1	14.2%	1	0.0%	0	0.0%	0	4.0%	0
Mid Temperate zone	18.0%	15	17.4%	1	40.1%	12	1.0%	0	0.2%	12	23.2%	2
Warm Temperate zone	32.4%	14	15.1%	2	15.4%	2	1.1%	0	0.6%	9	35.4%	1
Northern Subtropical zone	47.2%	13	42.9%	2	4.7%	0	4.7%	1	0.4%	2	0.0%	0
Mid subtropical zone	32.1%	11	60.5%	4	6.5%	1	0.8%	2	0.1%	4	0.0%	0
Southern subtropical zone	24.5%	8	67.7%	3	5.9%	0	0.6%	0	0.6%	1	0.1%	0
Marginal Tropical zone	21.2%	2	67.8%	0	9.8%	0	0.6%	0	0.2%	1	0.4%	0
Plateau Frigid zone	0.0%	0	0.0%	0	51.3%	0	5.1%	0	0.0%	0	43.6%	0
Plateau sub-frigid zone	0.5%	0	1.4%	0	83.4%	7	2.5%	0	0.0%	0	12.2%	0
Plateau sub-temperate zone	1.6%	2	15.7%	0	62.0%	2	3.4%	0	0.0%	0	17.3%	0
Plateau temperate zone	1.1%	0	25.6%	1	53.7%	1	2.9%	0	0.0%	0	16.6%	0
Mid tropical zone	0.0%	0	0.0%	0	0.0%	0	100%	1	0.0%	0	0.0%	0
Equatorial tropical zone	0.0%	0	0.0%	0	0.0%	0	100%	0	0.0%	0	0.0%	0
total	20.2%	65	25.6%	14	33.2%	26	1.8%	4	0.3%	29	19%	3
note: land types of 2 stations are unknowing												

It won’t be difficult to see from Table 1 that cropland makes a dominant or sub dominant underlying surface type over 5 climate zones, enjoying relatively more baseline stations in number. Forested area is a dominant or sub dominant underlying surface type across 6 climate zones, though only 4 of them have relatively more baseline stations. Of said zones, the marginal tropical are not covered by baseline stations, though they are large in forested area. Grassland constitutes a dominant or sub dominant underlying surface type over 6 climate zones. 5 of them possess relatively more baseline stations. However, the Plateau Frigid zone has no baseline stations, though 51.3% of the belt is covered by grasslands. The Mid and equatorial tropical zones, entirely covered by water bodies, have only one baseline station (Mid tropical zone). The urban area, though never a dominant or sub dominant underlying surface type across all climate belts, enjoys relatively more baseline stations in 4 climate zones. On the contrary, desert, a dominant or sub dominant underlying surface type sitting in 5 climate belts, has only 3 baseline climate stations in the Mid temperate and warm-temperate climate zones. Viewing the country as a whole, grasslands and forested area makes a major surface type. However, the cropland, occupying 20% of the homeland, has attracted the attention of 65 baseline climate stations, or 45% of the total. Furthermore, the urban area, taking up only 0.3% of the homeland, is taken care of by 29 baseline stations, or 20% of the total. Unluckily, desert, covering 19% of the homeland, is monitored by only 2% of the nation’s baseline stations. China’s baseline climate station network is apparently not evenly distributed by surface type, which noticeably weakens the capability of monitoring the climates over certain surface type.

3.4 Elevation

Elevation plays an important role in shaping up climate belts and associated distribution. Fig. 4 depicts the distribution of climate zones and associated baseline stations at different elevations. It is easy to see that climate belts are divided in line with elevations.

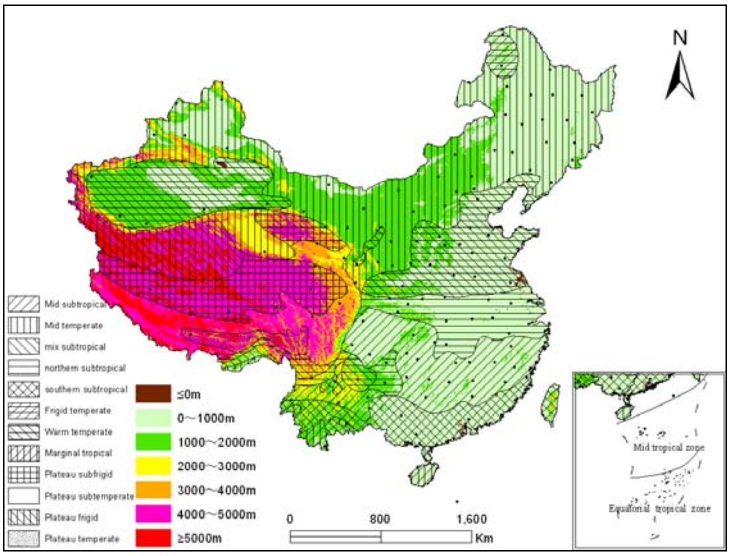

Fig.4 The distribution of climate zones and associated baseline stations at different elevations

Statistics show that 53.4% of China’s homeland sits at an elevation ranging from 0 to 1000m, crossing 9 climate zones. The Mid temperate zone takes the lion’s share by 34%, followed by the Warm-temperate zone (21%). The elevation range has been covered by 97 baseline stations, or

67.8% of the total, proportionally sat in the Mid temperate zone (25), the Warm-temperate zone (20), and the Mid subtropical zone (20).

20.2% of the homeland has reached the range of 1000-2000m, across 6 climate belts. The Mid temperate zone similarly takes up the lion's share by 49%, followed by the Warm-temperate zone (31%). The range is monitored by 30 baseline stations, mainly in the Mid temperate zone (15), and the Warm-temperate zone (8).

5% of China's territories falls under the range of 2000-3000m, across 7 climate zones. The Mid temperate zone hits the largest in area by 45%, followed by the warm-temperate zone (16%). The range has only 5 baseline stations, with 2 in the Mid temperate zone, 1 in the Warm-temperate zone, 1 in the northern subtropical zone, and 1 in the Plateau temperate zone.

The part of territories that reaches the range between 3000m and 4000m is 4.9 in percentage, across 8 climate belts. The Plateau sub-temperate zone is the largest in area (29%), followed by the Plateau sub-frigid zone (23%) and the Mid temperate zone (23%). The range is monitored by 7 baseline stations, with 3 in the Plateau sub-temperate, 3 in the Plateau sub-frigid, and 1 in the Plateau temperate.

11.1% of the homeland hits the category of 4000-5000m, across 6 climate belts. The Plateau frigid zone occupies the largest area by 45%, with the Plateau sub-frigid and the Plateau sub-temperate being the next at 25% and 19% respectively. This part of homeland is taken care of by 4 baseline stations, all sitting in the Plateau sub-frigid zone.

China has 6.3% of the territories up to an elevation of 5000m or above, across 4 climate belts. The Plateau frigid zone makes the dominant type by 42% in area, followed by the Plateau subtemperate (29%) and Plateau sub-frigid (24%). There is no observing station at this height.

In summary, 68% of Chinese territories sits at an elevation of 2000m or under, monitored by 127 baseline climate stations, or 89% of the total. 32% of the homeland rides an elevation of 2000m or above, with 16 baseline stations, or 11% of the total. Apparently, the higher the elevation, the fewer the baseline stations in number, suggesting that the raised elevation has noticeably poor climate representativeness.

In addition, the Mid temperate zone and the warm-temperate zone saw the largest elevation difference from 0m to 5000m in distribution.

3.5 Climate features observed

Climate belts were divided based on temperature data (Yan et al, 2002), including the number of days that passed ≥10℃ in the 5-day sliding means, accumulative temperature ≥10℃, mean temperature in January, and mean temperature in July. Calculation was made to analyze the data collected by 143 baseline stations. The one that failed to agree with all the indicators was deemed as having changed climatic features. Results indicate that 19 stations have shown changed climate representativeness in the past decade. Of them, 16 stations were shifting towards the warmer climate belts in the neighborhood, and 3 stations towards the colder belts. Fig. 5 illustrates the positions of these stations. It is obvious that the baseline stations that have registered changed climate features are mostly sitting on the rims of a climate belt, with only 7 stations being the exception, which is noticeably the result of local human activities.

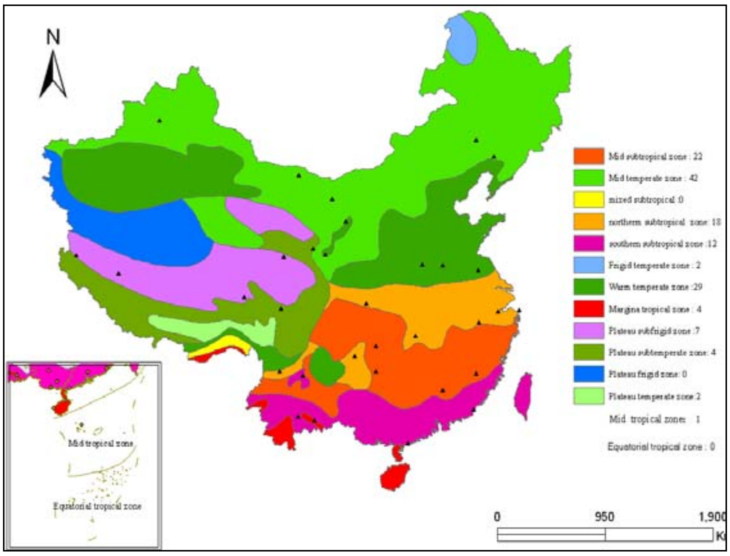

Fig.5 the distribution of national baseline climate stations which have not hold their original climatic features.

4. Discussion

The paper analyzed the distribution of baseline climate stations in the context of both surface type and elevation, in an attempt to exhibit the impact of human activities on site selections. Cropland and urban areas are the sites having frequent human activities. As a result, the areas dominated by the aforesaid two underlying surface types have the largest number of baseline climate stations. However, desert, water bodies, and highland had fewer baseline stations, as they are less accessible to human activities. The distribution pattern compromises the zonal representativeness of the data collected by the baseline stations on the one hand, and makes the observed data subject more to the implications of human activities on the other, suggesting that the baseline data collected in such manner is not in a position to show climate change trends across the country.

When judging the climate representativeness of a baseline station, author did not rigidly use the number of days ≥10℃ in the 5-day sliding means as the sole indicator. A station is only asked to satisfy one of the four indicators to be qualified for possessing the characteristics of a climate belt. This results in a somewhat loosened grip on the climate belt representativeness. Even under the loosened criteria, most baseline stations sitting on the border of a climate belt tend to move towards the adjacent climate belts, which makes an evidence showing the northbound shift of climate belts caused by climate warming. When using the number of days ≥10℃ as the only indicator, more than half of the baseline stations (81) have shown a changed climate representativeness. Some baseline stations that are physically located in the center of a climate zone have showed a changed representativeness that could only be explained by the implications of local human activities. Apparently, these stations have no longer had the representativeness they are supposed to have.

5. Conclusions

The paper evaluates the spatial distribution of China's national baseline climate station network and associated representativeness, in the context of spatial distribution, climate representativeness, land use type, and elevations, and has reached the following conclusions and suggestions:

1) The existing baseline climate station network is poor in monitoring climate changes across high

elevation areas, desert areas, and marine areas. In this context, more baseline stations have to be built in the areas to enhance the capability of monitoring climate change;

2) Baseline stations are apparently insufficient in number across the climate belts having a natural underlying surface, though they are proportionally large by area. The poor representativeness of natural underlying surface can be remedied by building more baseline stations in the areas;

3) Some baseline stations have demonstrated changed climate representativeness, while some others are no longer in a position to represent the climate across their own belts. In this context, their functions and operations shall be readjusted accordingly. New initiatives shall be staged to reclassify climate belts, so as to produce accurate descriptions of climate belt shifts under climate warming.

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