Effects of climate changes on Energy Consumption in China

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1 Background

- Energy is one of the key problem over the world
- The research on relationship of climate changes and energy consumption become a hot spots .

The scholars pay more attention to

- How the energy consumption effect climate changes

Pay less attention to

- The anti-influence of climate changes on energy consumption
- With the unceasing enhancement of Chinese economy and people's living standards, weather-sensitive component play an more and more important role in the total load.
- Studying the effects of climate changes on energy consumption can provide scientific basis for the formulation of energy plan and strategy, as well as the energy expend forecast.

2 data and method

2.1 data and origin

- The decade-day temperature data were provided by IGSNRR,CAS. and China Meteorological Administration.
- Energy consumption data were got from Statistical yearbook
- Society economical data were provided by IGSNRR,CAS
- The future scenario data were downloaded from http://www-iam.nies.go.jp/impact/country/.

2.2 The degree-day calculation method

2.2.1 the selection of calculation method:

Comparing the correlation coefficient and the multi-annual mean error between the actual value and the result of following calculation methods, we select the decade-day temperature direct calculation method.

- Wayne's fast monthly degree-day calculation method
- The interpolating method and smoothing method of decade mean temperature which set up by Long Siyu
- Decade-day temperature direct calculation method

2.2 The degree-day calculation method

2.2.2 Steps

- Calculate the year degree-day of the 29 capitals from 1970-1999,
- We found decade-day temperature direct calculation method has the higher precision and is simpler than the others.

The computation expressions :

- $X_m = (T_d - T_b) \times m$

Where X_m is the sum of degree-day, T_d is the mean of decade-day temperature, T_b is the basic temperature, m is the number of the decade-day days. At last sum the results decade-day directly and get the total year degree-days.

2.3 the climate-load abstraction method

The energy consumption is affected by societal economical factors and climatic factors, as they have different change character , we can present the energy consumption by the following expression:

- $y=y_t+y_w+y_c$

y is the actual energy consumption, y_t is the tendency energy consumption,y_w is the fluctuation consumption, y_c is the random variable.

The tendency consumption (y_t) change is gradual and presented as the active function of time. We can use multinomial method to model society economy consumption.The climate consumption (y_w)is the part affected by climatic factors primarily the natural disaster and temperature. Random variable(y_c) occupies a little part in the total and is difficult to distill that is always been omitted. So we can use the difference between actual and society consumption to present the climate consumption

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2.4 The future climate scenarios

- Forecast date source

Adopt the interpolated GCM outputs (0.5º x 0.5º) 2020-2029 and 2050-2059 climate forecast date of Canadian Center for Climate Modeling and Analysis projected by CCCma and CCNI model with assuming the A2 GHGs emission scenario in IS92 edition published by IPCC.

- Material steps of data correct

Compute the difference forecast date between 1990-1999, 2020-2029, 2050-2059 in different area individually.

Use the change value predicted by Chinese scholar for reference and get the revised change value in the areas,

Plus the actual mean monthly temperature in 1990-1999, we concern the result as the mean monthly temperature in 2020-2029 and 2050-2059.(Tab1)

Tab.1 The difference of mean degree-day between 1990—1999 and the future climate scenarios

	2025(1)-1995			2025(2)-1995			2055-1995		
	Total	warm	cool	total	warm	cool	total	warm	cool
Anhui	-105.99	-89.80	-16.19	-124.50	-85.56	-38.94	-28.28	-107.62	79.34
Pekin	-164.19	-200.75	36.56	-152.16	-171.55	19.40	-179.47	-323.39	143.92
Fujian	-8.84	0.00	-8.84	-30.13	0.00	-30.13	80.56	0.00	80.56
Gansu	-4.06	0.57	-4.63	20.91	25.54	-4.63	-148.44	-104.28	-44.15
Guangdong	66.92	0.00	66.92	49.08	0.00	49.08	141.84	0.00	141.84
Guangxi	5.37	0.00	5.37	-12.48	0.00	-12.48	80.37	0.00	80.37
Guizhou	-284.22	-246.12	-38.10	-291.94	-246.12	-45.82	-251.78	-246.12	-5.66
Hainan	-599.03	0.00	-599.03	-615.90	0.00	-615.90	-528.19	0.00	-528.19
Hebei	-456.50	-422.76	-33.74	-449.69	-398.87	-50.81	-468.62	-506.59	37.97
Henan	-147.62	-114.26	-33.37	-148.80	-98.89	-49.90	-107.83	-167.61	59.79
Heilongjiang	-391.71	-365.17	-26.54	-349.76	-314.18	-35.58	-541.23	-579.29	38.06
Hubei	-151.00	-258.45	107.45	-166.65	-254.60	87.94	-76.98	-266.36	189.38
Hunan	-25.85	-18.17	-7.68	-42.35	-18.17	-24.18	43.44	-18.17	61.62
Jilin	-382.16	-304.06	-78.09	-338.07	-252.84	-85.23	-555.21	-519.21	-35.99
Jiangsu	-38.84	-91.96	53.12	-53.93	-87.50	33.57	40.35	-110.68	151.03
Jiangxi	-14.91	-13.41	-1.50	-32.82	-13.41	-19.41	60.32	-13.41	73.73
Liaoning	-310.95	-344.46	33.51	-279.84	-295.04	15.20	-431.58	-541.98	110.41
Mongolia	254.64	273.81	-19.18	-1076.33	-1184.14	107.80	-81.14	-27.04	-54.11
Ningxia	-195.76	-130.42	-65.34	-177.78	-107.00	-70.77	-271.29	-228.80	-42.50
Qinghai	-138.29	-186.12	47.83	-100.96	-155.53	54.57	-295.07	-314.62	19.55
Shandong	-167.53	-125.28	-42.25	-162.99	-104.39	-58.60	-161.04	-213.01	51.97
Shanxi	-10.358	-4.03	-99.55	-165.97	-201.05	35.08	-199.77	-208.73	8.96
Shanxxi	-108.72	-53.26	-55.46	-107.67	-38.17	-69.50	-113.13	-116.64	3.51
Shanghai	-12.89	-35.23	22.34	-30.01	-35.23	5.22	62.47	-35.23	97.70
Sichuan	-262.10	-231.47	-30.62	-249.30	-218.67	-30.62	-309.34	-278.72	-30.62
Tientsin	-187.73	-231.68	43.95	-178.24	-204.67	26.43	-184.36	-345.13	160.77
Sinkiang	-121.72	-183.96	62.24	-118.66	-155.98	37.32	-134.57	-301.46	166.89
Yunnan	-18.46	0.00	-18.46	-18.46	0.00	-18.46	7.52	0.00	7.52
Zhejiang	-103.03	-14.45	-88.58	-107.37	-14.45	-92.91	-66.61	-14.45	-52.15

2.5 forecast model

- Expressions

$$L(t) = N(t) + L(w),$$

$$L(w) = N(t)W(T),$$

$$L(t) = N(t) + N(t)W(T) = N(t)(1+W(T))$$

For computational convenience, this can be rewritten, with $W = 1+W(T)$,then

$$L(t) = N(t)W, \qquad W = L(t) \div N(t)$$

Where $L(t)$ is the total load, $N(t)$ is the tendency consumption, $L(w)$ is the climate consumption, $W(T)$ is the weather sensitive coefficient.

- The calculation of W

This paper use following models respectively to simulate W :

multinomial： $y= b_0+ax +bx^2 +cx^3$

liner： $y=b_0+ax$

exponent： $y=b_0 (a^x)$

Growth： $y=e^{(b0 +a/x)}$

Exponential： $y=b_0*e^{(ax)}$

Where y is weather sensitive coefficient W, x is the year total degree-day, A， b_0， b and c are coefficient.

Investigating those model, we discover that to different province there is different suitable model. Using different models we get the W of 2020-2029, 2050-2059.(Tab 2)

Tab 2. the future W of per-province.

W	2020-2025(1)	2020-2025(2)	2050-2059	W	2020-2025(1)	2020-2025(2)	2050-2059
Anhui	1.025857	0.970238	1.01555	Jiangxi	0.990248	0.62879	1.020986
Pekin	0.9961	1.000253	1.001544	Liaoning	1.007333	1.033235	1.019213
Fujian	1.002092	0.996629	1.000656	Mongolia	1.000169	0.964865	0.991142
Gansu	0.993347	1.004223	0.991521	Ningxia	1.00111	1.028829	1.026901
Guangdong	1.005958	1.027467	1.028504	Qinghai	0.993304	1.012931	0.997727
Guangxi	0.913078	1.034281	0.976268	Shandong	1.001948	0.997913	1.002279
Guizhou	0.992652	1.027643	0.994865	Shanxi	0.999959	0.999771	0.999665
Hainan	1.00136	1.000411	1.001005	Shannxi	0.9902	1.108942	0.990372
Hebei	0.999479	1.003276	1.002523	Shanghai	1.007336	1.006444	1.002593
Henan	0.991433	1.015788	0.991174	Sichuan	0.976747	0.911759	0.984743
Heilongjiang	1.002763	1.008989	1.011663	Tientsin	1.000343	1.001414	1.002391
Hubei	1.006533	0.966603	1.001551	Sinkiang	0.997281	0.985351	0.996037
Hunan	1.053341	0.794394	1.025959	Yunnan	1.01338	0.126312	1.003535
Jilin	1.014605	1.008249	1.07084	Zhejiang	1.000266	0.991412	0.999726
Jiangsu	1.004082	0.982972	0.999687				

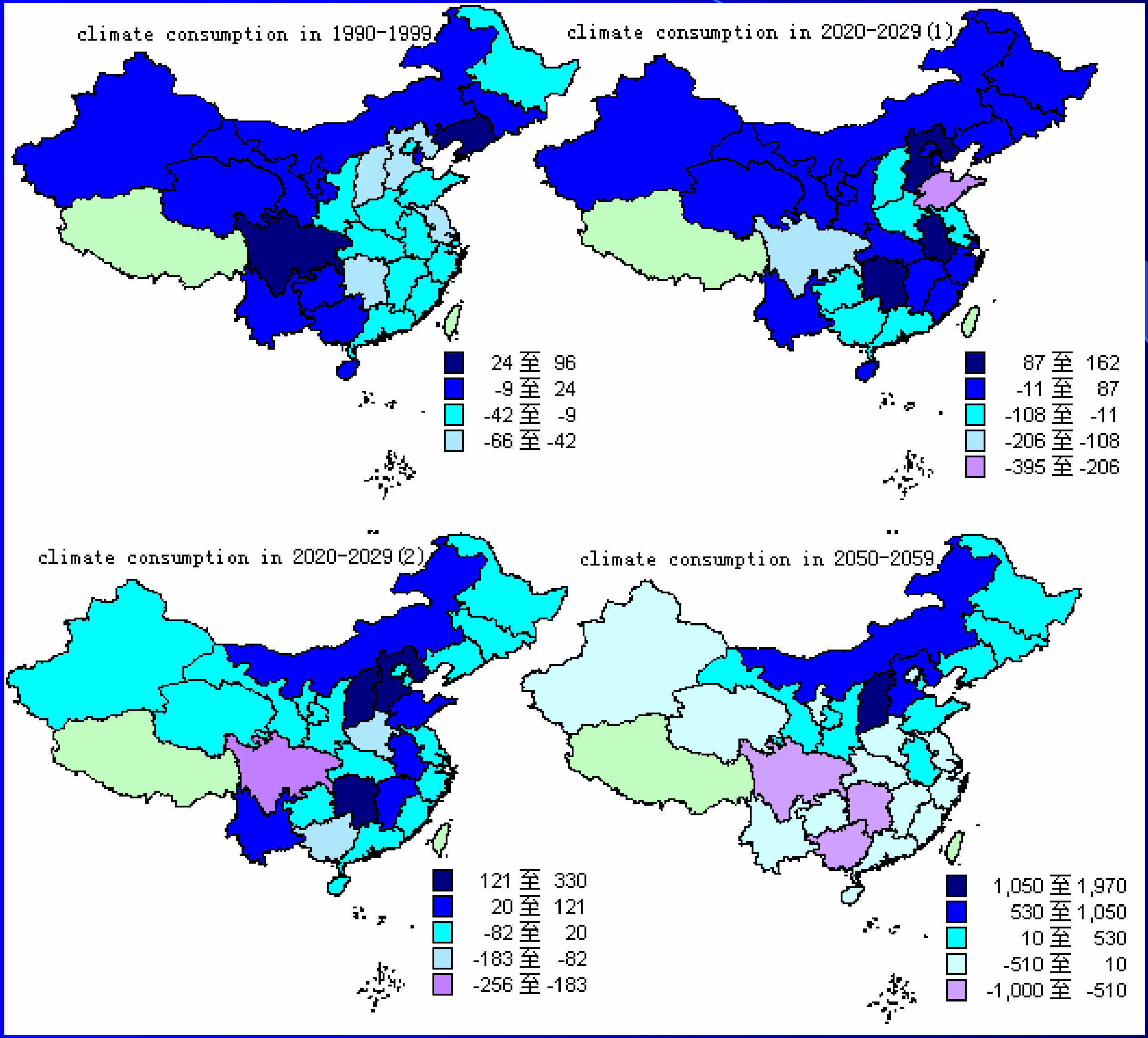
3 The future climate consumption scenario

Basing on the U.S.A.'s energy-consuming situation, we can approximately predict the volume of energy consumption in 2020-2029 in China and then deduce the energy consumption situation of every province.

Using MapInfo software to classify the provinces according to standard deviations of their climate consumption situations and the changes compared with 1990-1999.

The results are presented in chart 1 and chart 2.

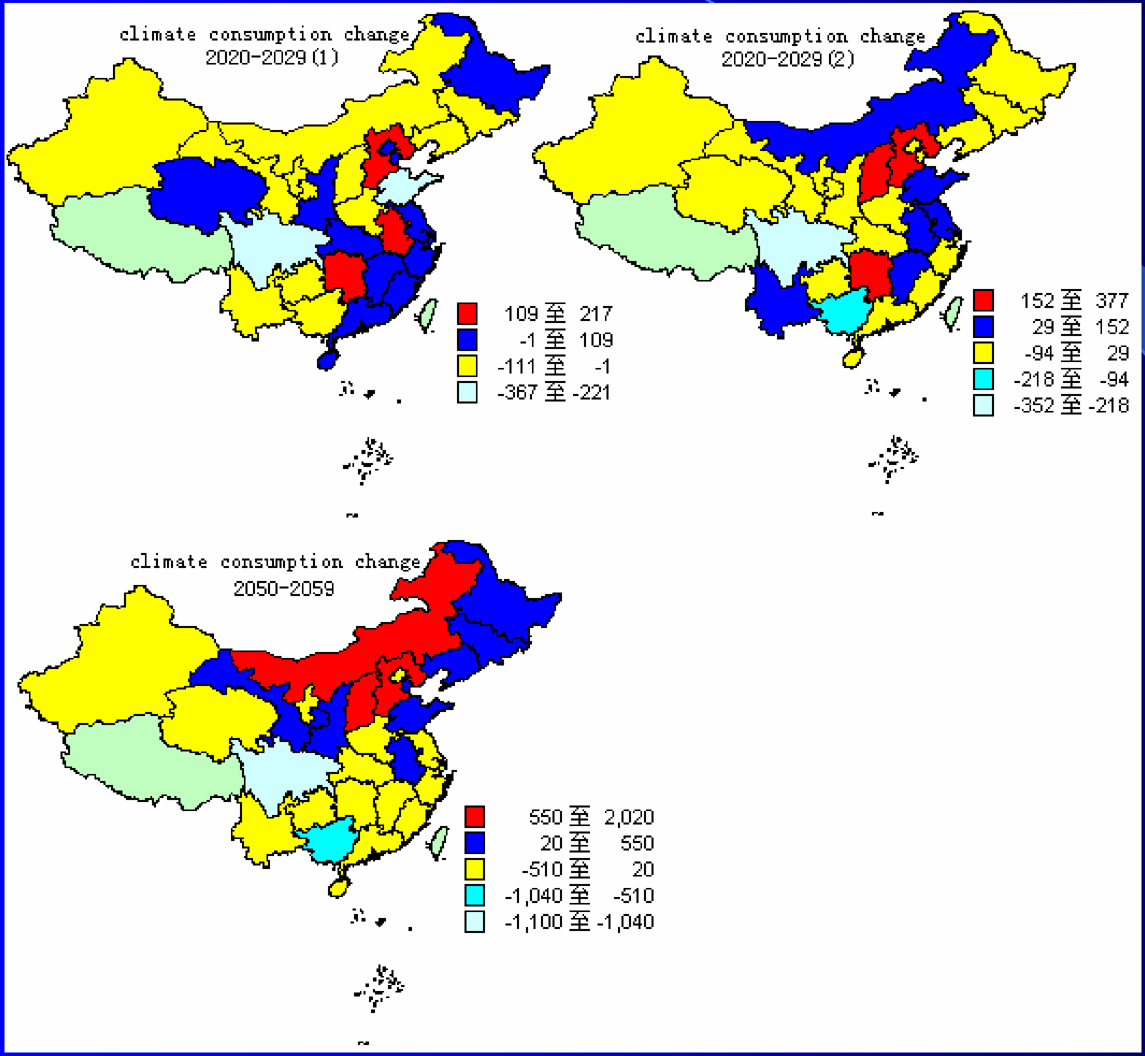
3.1The climate consumption scenario analyse (fig 1)



From the fig 1, we can say that:

- In 2020-2029, if in the first scenario, Anhui, Hebei and Hunan have the largest climate consumption in China, while Shandong and Sichuan is the lowest and Jiangsu, Henan, Shanxi Guangdong and Guizhou, Guangxi in southwest are next to them. If in the second scenario, then Hebei, Shanxi and Hunan belong to the highest climate consumption rank, and the next rank include Mongolia, Shandong, Anhui, Jiangxi and Yunnan, while Sichuan Province is the other extreme, and Guangxi and Henan are next to it.
- In the forecast of 2050-2059 climate consumption scenario, Jiangxi Province has the largest climate consumption forecast, Mongolia and Hebei Province are next to it. Sichuan and Hunan, Guangxi have the largest positive change, Xinjiang, Qinghai, Ningxia, Yunnan, Guizhou, Henan, Hubei, Jiangxi and the coastal province in east China belong to the fourth echelon

3.2 The analyse of climate consumption change (fig 2)



From the chart2, we can say that:

Comparing with 1990 - 1999 situation:

- In 2020 –2029 climate consumption scenario, if in the first scenario, Anhui, Hebei and Hunan have the largest enhancement range in China, the next is Heilongjiang, Qinghai, Shanxi, Hubei, Jiangxi as well as coastal provinces in eastern China, Sichuan and Shandong have the largest drop range. If the second scenario, the provinces belonging to the first rank which have the largest active change scope are Hebei, Shanxi, Hunan, the second rank include Mongolia, Shandong, Jiangsu, Anhui and Jiangxi, at the same time Sichuan has the largest drop change, and the next to Sichuan is Guangxi.
- In 2050-2059 climate consumption scenario, Mongolia and Shanxi and Hebei belong to the highest enhancement rank, the three provinces in Northeast China, Tianjin, Shandong, Anhui, Gansu and Shanxi are the next rank, the last rank which have the largest drop scope contains only Sichuan Province, change scopes of the rest are immediacy.

We can see that the distribution and change situation of China future climate consumption has put up some regional characters:

- The enhanced provinces mainly include those lying in the eastern coastal area and the area close to them in the 2020-2029(1) scenario. When come to the second one, the distribution of enhanced provinces is more disperse than that in the first, but there is still regional character and the distribution areas are the 115-120^{o}N area north to the Changjiang River, Mongolia and the Xianggan area in the Jiangnan region.
- Under 2050-2059 climate scenario, the majority of Chinese north provinces, compared with 1990-1999, have active change in climate consumption, while in the south provinces the scene are just upset, their future energy consumption scenarios drop by varying degree. We consider climate factor as one of the prime influence factors, and the analyze of the degree-day also verify that conclusion.

3.3 The analyse of climate consumption change

- Climate factor is one of the prime influence factors of energy consumption

  In 2020-2029 (1) climate scene, the climate factors of Anhui and Hunan Provinces increase obviously and the factor of Sichuan Province descend markedly, which make the difference of change situations between the three provinces very clear. In 2050-2059 climate scenario, the drops of climate factor in Sichuan and Guangxi Province, compared with 1990-1999, is very significant so is the climate consumption scenario in the two provinces.

- Although change of the climate factor can explain the change of climate consumption partly, we still should pay much attention to the influence of economy factor. So when analyzing the course of energy consumption change , we must discuss the two aspects synthetically.

4 Results and discussion

4.1Results

- Get the mean monthly forecast temperature in 2020-2029 and 2050-2059.
- Get the distribution of Chinese climate consumption in future climate scenarios.
- Get changes of Chinese climate consumption between the three future climate scenarios.

4.2Discussion

Since the lack of energy consumption data, the immaturity of the simulation model and the complexity of the relationship between the two drivers and the climate consumption, there are some defects in this paper to further research.

4.3Annotation

Because of the shortage of energy date in Tibet, Hong Kong, Macao and Taiwan area this article does not involve these areas temporarily.


The end
Thanks