探索未来气候发展趋势项目

概览

在这个项目中,我将分析广州和全球的气温数据,并比较广州气温走向与全球气温走向,形成可视化的分析报告。

说明

本次分析将按照:

- 采集数据
- 整理数据
- 创建图像
- 观察分析
- 得出结论

的步骤进行研究分析,试用SQL语言和r语言画图工具进行数据可视化。

步骤详解

1.采集数据(SQL)

• 确认城市 查询数据库中的中国城市。试用如下代码在网页中查询相关数据:

```
SELECT *
FROM city_list
WHERE country = 'China'
```

由于答主所在城市为深圳,纵观全表,广州为表中距离最近城市,所以将广州选为全球气候的对比城市。

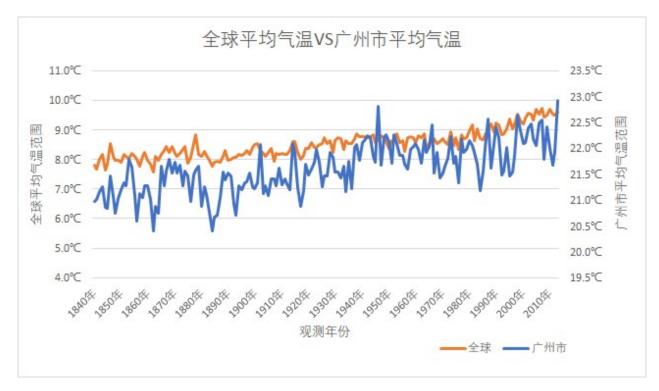
• 提取广州市和全球相同年份平均气温值

```
SELECT c.year, c.avg_temp as city_temp, g.avg_temp as global_temp
FROM city_data c, global_data g
WHERE c.year = g.year
AND c.city = 'Guangzhou'
```

保存数据到result.xls文件。

2. 整理数据(excel)

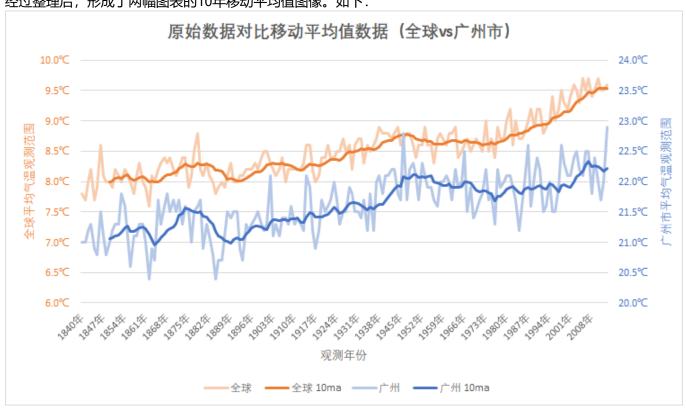
我们将生成的xls文件通过excel形成初步的观测图像,如下(为突出两组数据的走向,右侧增加了次坐标轴作为参考):



由图中可观测到,两组数据在未经过处理前,形成的曲线波动较大,难以看出明显的运动趋势; 这里我们选择使用移动平均法对两组数据的曲线进行平滑处理,以使曲线运动趋势更加明显,更易观测; 我们知道,移动平均数的N值越大,曲线越平滑,但也使折线图的一些细节被埋没。根据经验,我们取N=10,作为移动平均值的处理周期,既保证观察到更多局部的波动,又突出长远趋势。 通过excel中的average函数对两组原始数据进行处理。

3. 形成图表(excel)

经过整理后,形成了两幅图表的10年移动平均值图像。如下:



4. 观察分析

观测平滑处理后的折线图, 我可以初步得出以下结论:

• 整体而言,全球平均气温逐年递增,世界是越来越热的;

- 整体而言,广州市平均气温逐年递增,广州市也是越来越热的;
- 广州市的平均气温高于同期全球平均气温;

同时我又产生了以下几个问题,它们是:

- 广州市平均气温与全球气温变动有一定的相关性吗? (从移动平均值曲线基本平行推断得出);
- 在2019年,广州市平均气温大约会达到多少?

5.进一步验证 (excel)

• 针对第一个问题,我使用excel中的【数据分析】加载项中的【相关系数】,对全球平均气温和广州市平均气温原始数据进行分析,得到以下内容:

	广州	全球
广州	1	000 000 00 00 00 00 00 00 00 00 00 00 0
全球	0.758083	1

可知,两组原始数据的相关系数约为0.758,证明两组数据具有较高的相关性。

• 针对第二个问题:通过之前的观测发现,数据具有明显的上升趋势,明显的趋势变动的时间序列,于是 我选择通过holt指数平滑法进行分析,主要使用excel的【数据分析-回归】和【规划求解】功能进行。涉 及到公式为:

$$\begin{array}{ll} L_{t+1} = \alpha D_{t+1} + (1-\alpha)(L_t + Tt) & \text{其中:} \\ T_{t+1} = \beta(L_{t+1} - L_t) + (1-\beta)T_t & \text{F代表预测值}, L 代表截距(level), \\ & T 代表斜率 \ (trend), \ D 表示实 \\ \hline F_{t+1} = L_t + T_t & \text{际值;} \\ \hline F_{t+n} = L_t + nT_t & \alpha n\beta 表示两个参数。 \end{array}$$

1) 整理数据,将日期栏按照序列加工为"1、2、3、4、……174",通过回归计算得以下内容:

SUMMARY	OUTPUT							
	回归统计							
Multiple R	0.70251685							
R Square	0.493529924							
Adjusted R	0.490585331							
标准误差	0.343997199							
观测值	174							
方差分析								
	df	SS	MS	F	ignificance	F		
回归分析	1	19.83344	19.83344	167.6055	3.36E-27			
残差	172	20.35346	0.118334					
总计	173	40.1869						
	Coefficients	标准误差	t Stat	P-value	Lower 95%	Upper 95%	下限 95.0%	上限 95.0%
Intercept	21.02565278	0.052382	401.3881	1.5E-257	20.92226	21.12905	20.92226	21.12905
X Variable	0.006721604	0.000519	12.94625	3.36E-27	0.005697	0.007746	0.005697	0.007746

2) 确认初始trend和level(分别对应Coefficients的1、2行),然后根据以上公式计算出forcast.ft值,如图:

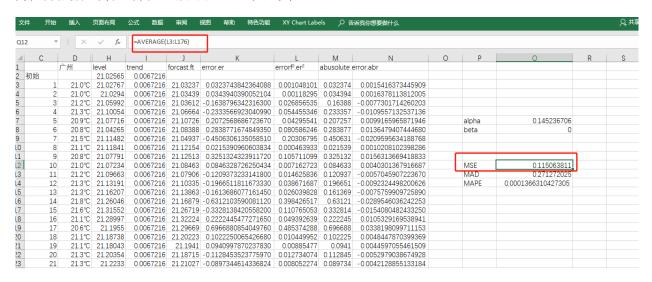
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5 20.9°C 21.07716 0.0067216 21.1073 6 20.8°C 21.04265 0.0067216 21.0836 7 21.5°C 21.11482 0.0067216 21.0493 8 21.1°C 21.11841 0.0067216 21.1219 9 20.8°C 21.07791 0.0067216 21.1253 10 21.0°C 21.07234 0.0067216 21.0844 11 21.2°C 21.09663 0.0067216 21.0794 11 21.2°C 21.09663 0.0067216 21.0794 12 21.3°C 21.13191 0.0067216 21.0794 13 21.3°C 21.13191 0.0067216 21.1386 14 21.8°C 21.26046 0.0067216 21.1386 15 21.6°C 21.31552 0.0067216 21.2673 16 21.1°C 21.28997 0.0067216 21.2963 18 21.1°C 21.1955 0.0067216 21.2963 18 21.1°C 21.1953 0.0067216 21.2963 19 21.1°C 21.18738 0.0067216 21.2923 19 21.1°C 21.20354 0.0067216 21.2923 20 21.3°C 21.20354 0.0067216 21.2933 20 4°C 21.08666 0.0067216 21.2033 23 20 4°C 21.08666 0.0067216 21.2033 24 20.9°C 21.0653 0.0067216 21.2033 25 20.7°C 21.01799 0.0067216 21.0933 25 20.7°C 21.01799 0.0067216 21.0943 30 21.5°C 21.124279 0.0067216 21.0244 27 21.3°C 21.22475 0.0067216 21.2943 30 21.5°C 21.24275 0.0067216 21.2943 30 21.5°C 21.42355 0.0067216 21.2943 31 21.7°C 21.40384 0.0067216 21.234 33 21.5°C 21.43968 0.0067216 21.393 34 21.3°C 21.43968 0.0067216 21.393 35 21.5°C 21.44395 0.0067216 21.493 36 21.5°C 21.44395 0.0067216 21.493 37 21.0°C 21.42199 0.0067216 21.493 38 21.5°C 21.44396 0.0067216 21.493 39 21.6°C 21.42199 0.0067216 21.493 40 21.7°C 21.46945 0.0067216 21.493 41 21.3°C 21.46945 0.0067216 21.493 42 21.3°C 21.46945 0.0067216 21.493 43 21.5°C 21.44697 0.0067216 21.493 44 20.8°C 21.2953 0.0067216 21.493 45 21.5°C 21.445058 0.0067216 21.493 46 20.7°C 21.45058 0.0067216 21.493 47 21.3°C 21.45058 0.0067216 21.493 48 21.1°C 21.45058 0.0067216 21.493 49 21.5°C 21.45058 0.0067216 21.493 40 21.7°C 21.5076 0.0067216 21.493 41 20.9°C 21.45058 0.0067216 21.493 42 21.3°C 21.45058 0.0067216 21.493 43 21.1°C 21.45058 0.0067216 21.493 44 20.8°C 21.25073 0.0067216 21.493 45 21.4°C 21.47994 0.0067216 21.493 46 20.7°C 21.42199 0.0067216 21.493 47 20.7°C 21.05493 0.0067216 21.493 48 21.1°C 21.07072 0.0067216 21.493 49 21.5°C 21.27681 0.0067216 21.1935 50 21.4°C 21.27681 0.0067216 21.1935 51 21.5°C 21			21.10054		21.06664
6 20.8°C 21.04265 0.0067216 21.0838 7 21.5°C 21.11482 0.0067216 21.0493 8 21.1°C 21.11841 0.0067216 21.1218 9 20.8°C 21.07791 0.0067216 21.1218 10 21.0°C 21.07234 0.0067216 21.0844 11 21.2°C 21.09663 0.0067216 21.0794 12 21.3°C 21.13191 0.0067216 21.1033 13 21.3°C 21.16207 0.0067216 21.1386 14 21.8°C 21.26046 0.0067216 21.1386 15 21.6°C 21.31552 0.0067216 21.2673 16 21.1°C 21.28997 0.0067216 21.2267 17 20.6°C 21.1955 0.0067216 21.2902 18 21.1°C 21.18738 0.0067216 21.2902 19 21.1°C 21.18043 0.0067216 21.2902 19 21.1°C 21.18043 0.0067216 21.193 20 21.3°C 21.2233 0.0067216 21.2902 21.3°C 21.29354 0.0067216 21.2902 22 21.0°C 21.19661 0.0067216 21.2103 23 20.4°C 21.08666 0.0067216 21.203 24 20.9°C 21.0653 0.0067216 21.203 24 20.9°C 21.0653 0.0067216 21.093 25 20.7°C 21.01799 0.0067216 21.024 27 21.3°C 21.22475 0.0067216 21.024 27 21.3°C 21.2475 0.0067216 21.230 28 21.6°C 21.2475 0.0067216 21.230 31 21.7°C 21.40384 0.0067216 21.231 30 21.5°C 21.43868 0.0067216 21.231 31 21.7°C 21.40384 0.0067216 21.353 32 21.5°C 21.43869 0.0067216 21.3403 31 21.7°C 21.40384 0.0067216 21.3403 32 21.5°C 21.44697 0.0067216 21.476 35 21.6°C 21.47803 0.0067216 21.476 36 21.5°C 21.44869 0.0067216 21.476 37 21.0°C 21.4199 0.0067216 21.493 38 21.5°C 21.44869 0.0067216 21.493 39 21.6°C 21.44869 0.0067216 21.446 40 21.7°C 21.4558 0.0067216 21.476 41 20.9°C 21.4558 0.0067216 21.476 42 21.3°C 21.45058 0.0067216 21.476 43 21.1°C 21.47803 0.0067216 21.476 44 20.8°C 21.2455 0.0067216 21.476 45 21.47803 0.0067216 21.476 46 20.7°C 21.4919 0.0067216 21.493 47 21.0°C 21.4199 0.0067216 21.493 48 21.1°C 21.45089 0.0067216 21.493 49 21.5°C 21.4955 0.0067216 21.476 41 20.9°C 21.4955 0.0067216 21.476 41 20.9°C 21.4950 0.0067216 21.476 42 21.3°C 21.49697 0.0067216 21.476 43 21.1°C 21.49890 0.0067216 21.476 44 20.8°C 21.29553 0.0067216 21.476 45 20.4°C 21.7121 0.0067216 21.431 46 20.7°C 21.05493 0.0067216 21.431 47 20.7°C 21.05493 0.0067216 21.431 48 21.1°C 21.7784 0.0067216 21.315 50 21.4°C 21.7784 0.0067216 21.338 51 21.5°C 21.27681 0.0067216 21.338 51 21.5					21.10726
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31					21.23147
32 21.5°C 21.42355 0.0067216 21.4109 33 21.7°C 21.46945 0.0067216 21.4302 34 21.3°C 21.45058 0.0067216 21.4762 35 21.6°C 21.47803 0.0067216 21.4457 36 21.5°C 21.48697 0.0067216 21.4847 37 21.0°C 21.42199 0.0067216 21.4287 38 21.5°C 21.43906 0.0067216 21.4287 39 21.6°C 21.46818 0.0067216 21.4457 40 21.7°C 21.5076 0.0067216 21.4457 41 20.9°C 21.4251 0.0067216 21.4318 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4318 44 20.8°C 21.29553 0.0067216 21.3797 45 20.4°C 21.17121 0.0067216 21.3797 46 20.7°C 21.0852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.1152 48 21.1°C 21.37382 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0616 50 21.4°C 21.17994 0.0067216 21.1428 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388					21.32077
33 21.7°C 21.46945 0.0067216 21.4302 34 21.3°C 21.45058 0.0067216 21.4761 35 21.6°C 21.47803 0.0067216 21.4847 36 21.5°C 21.48697 0.0067216 21.4847 37 21.0°C 21.42199 0.0067216 21.4287 38 21.5°C 21.43906 0.0067216 21.4287 39 21.6°C 21.46818 0.0067216 21.4457 40 21.7°C 21.5076 0.0067216 21.4457 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.3797 45 20.4°C 21.17121 0.0067216 21.3797 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1779 48 21.1°C 21.06722 0.0067216 21.1153 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1428 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388	31		21.40384	0.0067216	21.35352
34 21.3°C 21.45058 0.0067216 21.4761 35 21.6°C 21.47803 0.0067216 21.4847 36 21.5°C 21.48697 0.0067216 21.4847 37 21.0°C 21.42199 0.0067216 21.4936 38 21.5°C 21.43906 0.0067216 21.4287 39 21.6°C 21.46818 0.0067216 21.4457 40 21.7°C 21.5076 0.0067216 21.4457 41 20.9°C 21.4251 0.0067216 21.4318 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4318 44 20.8°C 21.29553 0.0067216 21.3797 45 20.4°C 21.17121 0.0067216 21.3797 46 20.7°C 21.10852 0.0067216 21.3797 47 20.7°C 21.05493 0.0067216 21.1779 48 21.1°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.1152 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388	32	21.5℃	21.42355		21.41056
35	33	21.7℃	21.46945	0.0067216	21.43027
36 21.5°C 21.48697 0.0067216 21.4847 37 21.0°C 21.42199 0.0067216 21.4936 38 21.5°C 21.43906 0.0067216 21.4287 39 21.6°C 21.46818 0.0067216 21.4457 40 21.7°C 21.5076 0.0067216 21.474 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.3797 45 20.4°C 21.17121 0.0067216 21.3797 46 20.7°C 21.10852 0.0067216 21.3797 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388	34	21.3℃	21.45058	0.0067216	21.47617
37 21.0°C 21.42199 0.0067216 21.4936 38 21.5°C 21.43906 0.0067216 21.428 39 21.6°C 21.46818 0.0067216 21.445 40 21.7°C 21.5076 0.0067216 21.474 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.379 45 20.4°C 21.17121 0.0067216 21.379 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1779 48 21.1°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0733 50 21.4°C 21.17994 0.0067216 21.1428 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388	35	21.6°C	21.47803	0.0067216	21.4573
37 21.0°C 21.42199 0.0067216 21.4936 38 21.5°C 21.43906 0.0067216 21.428 39 21.6°C 21.46818 0.0067216 21.445 40 21.7°C 21.5076 0.0067216 21.474 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.379 45 20.4°C 21.17121 0.0067216 21.379 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1779 48 21.1°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0733 50 21.4°C 21.17994 0.0067216 21.1428 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388	36	21.5℃	21.48697	0.0067216	21.48475
38				0.0067216	21.49369
39 21.6°C 21.46818 0.0067216 21.4457 40 21.7°C 21.5076 0.0067216 21.477 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.3793 45 20.4°C 21.17121 0.0067216 21.3793 46 20.7°C 21.10852 0.0067216 21.1773 47 20.7°C 21.05493 0.0067216 21.1153 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0616 49 21.5°C 21.17994 0.0067216 21.1423 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2383 53 20.9°C 21.22783 0.0067216 21.2383					21.42871
40 21.7°C 21.5076 0.0067216 21.474 41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.379 45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2383 53 20.9°C 21.22783 0.0067216 21.2838					21.44578
41 20.9°C 21.4251 0.0067216 21.5143 42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.3793 45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0618 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1868 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2388					21.4749
42 21.3°C 21.41267 0.0067216 21.4318 43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.379 45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0733 50 21.4°C 21.17994 0.0067216 21.1425 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2385 53 20.9°C 21.22783 0.0067216 21.2835					21.51432
43 21.1°C 21.37301 0.0067216 21.4193 44 20.8°C 21.29553 0.0067216 21.379 45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					21.43182
44 20.8°C 21.29553 0.0067216 21.3797 45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
45 20.4°C 21.17121 0.0067216 21.3022 46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
46 20.7°C 21.10852 0.0067216 21.1779 47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
47 20.7°C 21.05493 0.0067216 21.1152 48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
48 21.1°C 21.06722 0.0067216 21.0616 49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
49 21.5°C 21.13582 0.0067216 21.0739 50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2889					
50 21.4°C 21.17994 0.0067216 21.1429 51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2839					
51 21.5°C 21.23217 0.0067216 21.1866 52 21.5°C 21.27681 0.0067216 21.2388 53 20.9°C 21.22783 0.0067216 21.2838					
52 21.5℃ 21.27681 0.0067216 21.2388 53 20.9℃ 21.22783 0.0067216 21.2838					
53 20.9°C 21.22783 0.0067216 21.2835					21.18666
					21.23889
54 20.7°C 21.15692 0.0067216 21.2345					
	54	20.7℃	21.15692	0.0067216	21.23455

55	21.3℃	21.18344	0.0067216	21.16364
56	21.2℃	21.19159	0.0067216	21.19016
57	21.3℃	21.21308	0.0067216	21.19831
58	21.4℃	21.24598	0.0067216	21.2198
59	21.5℃	21.28861	0.0067216	21.2527
60	21.3℃	21.29601	0.0067216	21.29534
61	21.2℃	21.28781	0.0067216	21.30273
62	21.3℃	21.29533	0.0067216	21.29454
63	22.1°C	21.41794	0.0067216	21.30205
64	21.1℃	21.37751	0.0067216	21.42466
65	21.3℃	21.372	0.0067216	21.38423
66	21.1°C	21.33824	0.0067216	21.37872
67	21.4℃	21.35296	0.0067216	21.34496
68	21.4℃	21.36553	0.0067216	21.35968
69	21.3℃	21.36176	0.0067216	21.37225
70	21.6°C	21.40211	0.0067216	21.36848
71	21.3℃	21.39302	0.0067216	21.40883
72	21.4℃	21.39978	0.0067216	21.39974
73	21.3℃	21.39104	0.0067216	21.4065
74	21.2℃	21.36904	0.0067216	21.39776
75	22.1℃	21.48094	0.0067216	21.37576
76	21.9℃	21.54755	0.0067216	21.48767
77	21.2℃	21.50282	0.0067216	21.55427
78	20.9℃	21.42101	0.0067216	21.50954
79	21.2℃	21.39466	0.0067216	21.42773
80	21.7℃	21.44475	0.0067216	21.40138
81	21.5℃	21.45852	0.0067216	21.45147
82	21.6℃	21.48481	0.0067216	21.46524
83	21.7℃	21.52181	0.0067216	21.49154
84	22.0°C	21.59701	0.0067216	21.52853
85	21.7℃	21.61771	0.0067216	21.60373
86	21.3℃	21.57731	0.0067216	21.62443
87	21.5°C	21.57183	0.0067216	21.58404
88	21.5°C	21.56714	0.0067216	21.57855
89	21.9℃	21.62123	0.0067216	21.57386
90	21.8℃	21.65294	0.0067216	21.62795
91	21.5℃	21.63647	0.0067216	21.65966
92	21.5℃	21.6224	0.0067216	21.6432
93	21.4℃	21.59584	0.0067216	21.62912
94	21.7℃	21.61672	0.0067216	21.60256
95	21.2℃	21.56194	0.0067216	21.62344
96	21.8℃	21.60226	0.0067216	21.56866
97	21.2℃	21.54958	0.0067216	21.60898
98	22.0°C	21.62074	0.0067216	21.5563
99	22.1℃	21.6961	0.0067216	21.62747
100	21.8℃	21.71693	0.0067216	21.70282
101	22.1℃	21.77831	0.0067216	21.72365
102	22.1℃	21.83078	0.0067216	21.78503
103	22.2℃	21.89015	0.0067216	21.8375
104	22.2℃	21.9409	0.0067216	21.89687
105	21.8℃	21.92618	0.0067216	21.94762
106	21.7℃	21.89907	0.0067216	21.9329
107	22.8℃	22.03567	0.0067216	21.9058
108	21.7℃	21.99266	0.0067216	22.04239
109	22.2℃	22.02852	0.0067216	21.99938
110	22.3℃	22.07369	0.0067216	22.03524

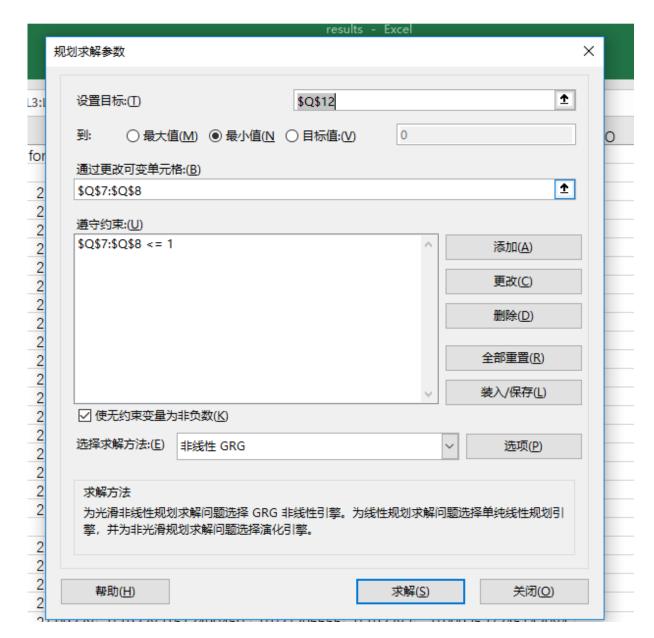
111	22.1℃	22.08326	0.0067216	22.08042
112	21.7℃	22.03334	0.0067216	22.08998
113	22.3℃	22.07782	0.0067216	22.04006
114	22.1℃	22.08678	0.0067216	22.08454
115	21.9℃	22.0654	0.0067216	22.0935
116	21.9℃	22.04712	0.0067216	22.07212
117	21.7℃	22.00245	0.0067216	22.05385
118	21.6°C	21.94975	0.0067216	22.00918
119	22.0°C	21.96279	0.0067216	21.95647
120	22.0°C	21.97394	0.0067216	21.96951
121	22.1℃	21.998	0.0067216	21.98066
122	22.0°C	22.00403	0.0067216	22.00472
123	21.7℃	21.96562	0.0067216	22.01075
124	22.2°C	22.00541	0.0067216	21.97234
125	21.9℃	21.99584	0.0067216	22.01213
126	22.0°C	22.00219	0.0067216	22.00256
127	22.5℃	22.08024	0.0067216	22.00230
128	21.5℃	22.00024	0.0067216	22.08696
129	21.9℃	21.99268	0.0067216	22.00843
130	21.4℃	21.91235	0.0067216	21.99941
131	21.5℃	21.85821	0.0067216	21.91907
132	21.7℃	21.84098	0.0067216	21.86493
133	21.8℃	21.84077	0.0067216	21.8477
134	22.2°C	21.89869	0.0067216	21.84749
135	21.7℃	21.87558	0.0067216	21.90541
136	21.8℃	21.87035	0.0067216	21.8823
137	21.3℃	21.79326	0.0067216	21.87707
138	22.2℃	21.85808	0.0067216	21.79998
139	21.9℃	21.86991	0.0067216	21.8648
140	22.0°C	21.89455	0.0067216	21.87663
141	22.1℃	21.93013	0.0067216	21.90127
142	22.1℃	21.96055	0.0067216	21.93686
143	21.9℃	21.9575	0.0067216	21.96727
144	21.7℃	21.92585	0.0067216	21.96422
145	21.2℃	21.82617	0.0067216	21.93257
146	21.6°C	21.79907	0.0067216	21.8329
147	22.0°C	21.834	0.0067216	21.80579
148	22.6°C	21.95099	0.0067216	21.84072
149	21.6°C	21.90576	0.0067216	21.95772
150	22.1°C	21.93972	0.0067216	21.91248
151	22.4°C	22.01231	0.0067216	21.94644
152	22.2℃	22.04532	0.0067216	22.01904
153	21.5℃	21.97186	0.0067216	22.05204
154	21.6℃	21.9236	0.0067216	21.97858
155	22.0°C	21.9230	0.0067216	21.93032
156	21.5℃	21.88222	0.0067216	21.93032
157	21.5℃ 21.5℃	21.83245	0.0067216	21.88894
158	21.9℃	21.84801	0.0067216	21.83917
159	22.6℃	21.96297	0.0067216	21.85473
160	22.3℃	22.01766	0.0067216	21.96969
161	22.1℃	22.03537	0.0067216	22.02439
162	22.1℃	22.0505	0.0067216	22.04209
163	22.4℃	22.10701	0.0067216	22.05722
164	22.5°C	22.16983	0.0067216	22.11373
165	22.2℃	22.17996	0.0067216	22.17655
166	22.1℃	22.17409	0.0067216	22.18668

167	22.5℃	22.22717	0.0067216	22.18081
168	22.5℃	22.27254	0.0067216	22.23389
169	21.8℃	22.20965	0.0067216	22.27926
170	22.4℃	22.24304	0.0067216	22.21638
171	22.0°C	22.21349	0.0067216	22.24977
172	21.7℃	22.14466	0.0067216	22.22021
173	22.0°C	22.12939	0.0067216	22.15138
174	22.9℃	22.24706	0.0067216	22.13612
				22.25378
				22.2605
				22.26722
				22.27395
				22.28067
				22.28739

3) 根据结果计算出,计算预测值与实际值差异error.er,差异平方error².er²,绝对差异,以及平均绝对差异,再根据差异值计算出均方误差MSE,如图:



4) 最后通过规划求解,求得MSE最小时的α和β组合,注意,这里设定α和β<=1,如图:



得到在MSE最小时, α≈0.1452, β= 0, 此时预测到的2019年广州市平均气温为22.29℃。如图

TOO	22.1 U	ZZ.174U9	U.UU0/210	ZZ.18008	U.U800774995114348	U.UU / DIZ989	U.U800//	U.UU39ZZU388U14ZZ4	
167	22.5°C		0.0067216		-0.3191896513015320	0.101882033	0.31919	-0.0141862067245125	
168	22.5℃	22.27254	0.0067216	22.23389	-0.2661099941040350	0.070814529	0.26611	-0.0118271108490682	
169	21.8℃	22.20965	0.0067216	22.27926	0.4792605485326650	0.229690673	0.479261	0.0219844288317736	
170	22.4℃	22.24304	0.0067216	22.21638	-0.1836240711059070	0.033717799	0.183624	-0.0081975031743709	
171	22.0°C	22.21349	0.0067216	22.24977	0.2497664877927690	0.062383298	0.249766	0.0113530221723986	
172	21.7℃	22.14466	0.0067216	22.22021	0.5202128295559270	0.270621388	0.520213	0.0239729414541902	
173	22.0°C	22.12939	0.0067216	22.15138	0.1513804355231090	0.022916036	0.15138	0.0068809288874140	
174	22.9℃	22.24706	0.0067216	22.13612	-0.7638839565771890	0.583518699	0.763884	-0.0333573780164711	
175				22.25378					
176				22.2605					
177				22.26722					
178				22.27395					
170				22.28067	1				
.80 (2019年))			22.28739					
					_				

6. 得出结论

- 整体而言,全球平均气温逐年递增,世界是越来越热的;
- 整体而言,广州市平均气温逐年递增,广州市也是越来越热的;
- 广州市的平均气温高于同期全球平均气温;
- 广州市平均气温与全球气温变动有一定的相关性, 相关系数约为0.758;