# 第四届“认证杯”数学中国

# 数学建模国际赛

# 承　诺　书

我们仔细阅读了第四届“认证杯”数学中国数学建模国际赛的竞赛规则。

我们完全明白，在竞赛开始后参赛队员不能以任何方式（包括电话、电子邮件、网上咨询等）与队外的任何人（包括指导教师）研究、讨论与赛题有关的问题。

我们知道，抄袭别人的成果是违反竞赛规则的，如果引用别人的成果或其他公开的资料（包括网上查到的资料），必须按照规定的参考文献的表述方式在正文引用处和参考文献中明确列出。

我们郑重承诺，严格遵守竞赛规则，以保证竞赛的公正、公平性。如有违反竞赛规则的行为，我们将受到严肃处理。

我们允许数学中国网站(www.madio.net)公布论文，以供网友之间学习交流，数学中国网站以非商业目的的论文交流不需要提前取得我们的同意。

我们的参赛队号为：2047

我们选择的题目是：B 题

参赛队员　(签名)　：

队员 1：尹修草

队员 2：厉珍珠

队员 3：方晓静

参赛队教练员 (签名)：　房少梅

# 第四届“认证杯”数学中国

# 数学建模国际赛

## 编 号 专 用 页

参赛队伍的参赛队号：2047

竞赛统一编号（由竞赛组委会送至评委团前编号）：

---

竞赛评阅编号（由竞赛评委团评阅前进行编号）：

# The average temperature in Antarctica

**Abstract:** Global warming is a hot issue. The past century, as human activities, a substantial increase in the atmospheric concentrations of carbon dioxide and other greenhouse gases, the earth is growing warm than the greenhouse effect.

Antarctica is the world's changing sensitive areas, due to the special geographical location and the unique natural environment of the Antarctic which, measured data analysis and study of the Antarctic division also has important significance. In this paper, the British Antarctic Survey website get 2000--2015 years of measured temperature data, due to the influence of the Antarctic surface temperature by location and viewing height, so the first use of cluster analysis, mean model established for weather classification, to give The average temperature in the Antarctic, and then study the Antarctic surface temperature variation between the time we applied time series analysis methods. Because the temperature there are seasonal factors at the same time on the subject, according to the decomposition factors and the analysis of auto correlation coefficients were analyzed on four areas, selected suitable AR, MA, ARMA or ARIMA model fitting and predicted that the use of SPSS software model,

as well as in 2016 the average monthly temperature is predicted.

Through the above modeling process, to find a change of temperature of the Antarctic.

Models:

(1)$Y_t = 235.154 + 0.662 Y_{t-1} + 0.827 - 0.38\varepsilon_{t-1} - 0.092\varepsilon_{t-2}$

(2)$Y_t = 44.061 - 0.028\varepsilon_{t-1} + 0.827 + 0.972 X_t$

(3)$Y_t = 0.094 + 0.987\varepsilon_{t-1} + 6.535 + 0.963 X_t$

(4)$Y_t = -1000.239 + 0.078 Y_{t-1} + 15.729 - 0.538\varepsilon_{t-1} - 0.265_{t-2} + 0.927 X_t$

**Keywords:** Time series, Cluster analysis, SPSS,RAIMA, Prediction

**Contents**

# 1、Introduction

## 1.1Global atmospheric change and global warming.

Scientific understanding of global warming is increasing. The Intergovernmental Panel on Climate Change (IPCC) reported in 2014 that scientists were more than 95% certain that global warming is being caused mostly by increasing concentrations green house gases and other human activities.Climate model projections summarized in the report indicated that during the 21st century the global surface temperature is likely to rise a further 0.3 to 1.7 ℃ (0.5 to 3.1 ℉) for their lowest emissions scenario using stringent mitigation and 2.6 to 4.8 ℃ (4.7 to 8.6 ℉) for their highest. These findings have been recognized by the national science academies of the major industrialized nations and are not disputed by any scientific body of national or international standing.

Future climate change and associated impacts will differ from region to region around the globe. Anticipated effects include warming global temperature, rising sea levels, changing precipitation, and expansion of deserts in the subtropics.Warming is expected to be greatest in the Arctic, with the continuing retreat of glaciers, permafrost and sea ice. Other likely changes include more frequent extreme weather events including heat waves, droughts, heavy rainfall, and heavy snowfall;ocean acidification; and species extinctions due to shifting temperature regimes. Effects significant to humans include the threat to food security from decreasing crop yields and the abandonment of populated areas due to flooding.

Possible societal responses to global warming include mitigation by emissions reduction, adaptation to its effects, building systems resilient to its effects, and possible future climate engineering. Most countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC),whose ultimate objective is to prevent dangerous anthropogenic climate change. The UNFCCC have adopted a range of policies designed to reduce greenhouse gas emissions and to assist in adaptation to global warming.Parties to the UNFCCC have agreed that deep cuts in emissions are required, and that future global warming should be limited to below 2.0 ℃ (3.6 ℉) relative to the pre-industrial level.

## 1.2 The purpose and meaning of research Antarctic temperatures

Antarctica is a extreme land: it is the driest, windiest and coldest places on earth . The average thickness of the ice sheet covering Antarctica up to 2000 meters, covering an area of nearly 14 million square kilometers. Antarctica is so remote and so isolated. So, until 2007 even closer, scientists have always thought that Antarctica were not global warming.

This year, the United Nations Intergovernmental Panel on Climate change conclusions in its "Fourth Analysis Report": Antarctica is not unique to humans caused by temperature changes exploratory continent. The report also said that the difference is the Arctic, the Antarctic ice did not experience widespread melting amazing. Some data even hinted that Antarctica is cooling gently. Suspect global warming immediately caught this report as evidence. However, the fact is, scientists on Antarctica was not much understanding of past climate. Long-term ground temperature records almost non-existent, some scientists on hand records dating back to the 20th century, 40 to 50 years. Most of the data collected in this area long-term research stations are located in the surrounding coast, only a few dotted in the vast interior of Antarctica, so that the collected data is clearly beneath reasonable.

Then, over the past six years, scientists have found some clever way to measure the temperature of Antarctica, and thus piece together its complex climate history. Work in this area tells us, whether natural or human-induced climate change are clearly shows Antarctica: Antarctica is not as isolated as we once thought, in fact, in some places in Antarctica is the fastest warming places on Earth . If these warming trends continue, what Antarctica for rest of the world will have great significance occur. Antarctic ice sheet on Earth bears about 70 percent of fresh water, and if it all melted into the sea, the global sea level will rise by more than 60 meters, enough to submerge New York City, London and most other regions of the Netherlands. Fortunately, scientists did not predict the near future there will be a large area of the ice sheet to disappear.

Focus on the future, we need to know in the end how much ice will melt and sea level rise at how block. And in order to make these issues relatively accurate estimate, Antarctica is the biggest unknown.

### 1.3Antarctic temperatures

Australia is almost twice the area of Antarctica is divided into three regions: East, West, and the Antarctic Peninsula. East Antarctica area accounted for two-thirds of the entire Antarctic continent, also with the Indian Ocean and the Atlantic border. Since the altitude is higher than the rest of Antarctica, this area is like a giant Pingdingshan. Scientists so far have not found significant warming here. Recently, scientists use temperature data Beard weather in the past 50 years collected using different methods to calculate the results obtained: West Antarctica warmed almost three times the magnitude of these results. Beard weather stations located near the top of the Antarctic ice sheet is exposed on a flat area, where the weather can represent weather a large area of West Antarctica. Scientists estimate the final: From 1958 to 2010, every 10 years in western Antarctica temperature rise of 0.47 degrees. This means that, regardless of the west Antarctic or the Antarctic Peninsula is the fastest warming places on Earth.

Polar scientists worry that if the warming trend in western Antarctica and the Antarctic Peninsula continues, Antarctica is likely to be more like the Larsen B ice shelf the same disease division. Antarctica's ice shelves surrounding the dam like to maintain the same position Antarctic ice sheets, once they break, to glaciers in Antarctica could influx of internal ocean, raising sea level.

Although scientists have not been able to provide details of the Antarctic climate prediction, but the scientists who work really reveals this continent is not as distant as we once thought isolated, but closely related, and every corner of the world.

## 2.The Description of Problem

### 2.1 Restatement of the problem

The average earth land surface temperature is a key indicator of climate change and global warming.however,in the previous estimates,there are some methodological differences in how land average was defined.for simplicity,we consider Antarctica Only.please develop a mathematical frame work for defining and estimating the average surface temperature form weather station thermometer date,and describe the Antarctica temperature variation with time.

### 2.2 The problem analysis

Now the problem into the following specific analysis, subject to the requirements can be divided into two subsections:

(1) Please give an average surface temperature of the definition of the model.

(2) according to the title of the weather observation data to create a mathematical model to

predict the average surface temperature of Antarctica, and predicted temperature change in Antarctica.

To define the average surface temperature, obtained taking into account the average surface temperature has received all kinds of factors influence the severity, the relationship between the various factors, in order to give a more accurate definition of the relevant formula; only identifies relevant factors and be combined, the resulting mathematical model to predict the average surface temperature of Antarctica, Antarctic temperature changes obtained over time according to forecasts.

The subdivision title question into two parts, in fact, is to use mathematical models to connect the two parts and reach the final prediction purposes.

# 3Models

## 3. 1*Symbols and Assumptions*

| symbol | meaning |
|---|---|
| $x_t$ | the time of $t$ value |
| $B$ | the shift operator |

Assumptions:

The average temperature in Antarctica surface wind speed does not affect the high altitudes.

The average temperature of the surface of Antarctica does not affect the direction of the wind high altitudes.

Weather station data to be used for very high accuracy.

The average surface temperature is determined by the change in Antarctica in 2000 after a significant, 2000 before the change is not significant.

Specific location of the selected weather station is accurate.

## 3.2Data Processing

Antarctica is one of the world's poorest regions meteorological data began Antarctic meteorological observation system at the International Geophysical Year in 1957, though, but because of the Antarctic environment and the huge cost of hungry restrictions, as well as in the British Antarctic Survey website we data are limited, given the paper studies the past 15 years the Antarctic temperature change over time, so we use only the 2000 - 2015 period the cumulative data monthly average temperature of 42 weather stations in 180 months or more.

## 3.3Basic models

### 3.3.1 Cluster analysis model

Cluster analysis based on many observationsbatch of samples, according to certain mathematical formulas specifically some samples or some parameters (indicators) degree of similarity, the similar sample or indicators classified as a class, the dissimilar classified as a class.

Cluster analysis as follows:

Step One: Select a variable

（1）Select is closely related to the purpose of cluster analysis.

（2）Reflect the characteristics of categorical variables.

（3）Values on different subjects have significant differences.

(4)Not highly correlated variables.

Step Two: Calculate similarity

Similarity is a clustering analysis of the basic concepts, he reflects the degree of closeness between the object of study, cluster analysis is based on the similarity between objects to classification. There are many portray similarity measure.

Step Three: Clustering

Selected clustering variables, the degree of similarity is calculated after the sample or between indicators, constitute a similar degree of matrices. At this mainly involves two issues:

(1)Select Clustering

(2)Determine the number of class formation

Step four: the clustering results interpretation and confirmed

Explanation of clustering results is hope for each class features accurate description to each class from a proper name. This step can use a variety of descriptive statistics for analysis, the usual practice is to calculate the average of all types of variables in each cluster, to compare the mean, you can explain all kinds of production for other reasons.

### 3.3.2 Time series model

Time series is a series of observations made in chronological order, and examples of the time series in some areas are very rich, such as economics, business, engineering, natural sciences (particularly geophysics and meteorology), and social sciences, such as concentration reading chemical production process, the stock price, sales of certain goods, sunspot number, which is a kind of depends on the phenomenon of time.

Physical phenomena characteristic of our approach is a mathematical model to describe it, the mathematical model has deterministic model, for example, it can launch a model based on the laws of physics, so we rely on a certain amount of time at any instantaneous pluripotent almost accurately calculate its value; there are uncertainties models, such as in a lot of problems, we have to consider a structure in which there are many unknown factors dependent phenomena in time for these phenomena, we can not write a certainty model, however, possible to derive a model that can calculate the probability of a variable falling between two specific limits. Such a model is called probabilistic models and stochastic models.

Mathematical modeling approach can be roughly divided into two categories, one is the so-called mechanism analysis, one is the so-called test analysis. Usually through the mechanism analysis model of the causal relationship between the various factors analysis of the characteristics of the display object, find the internal mechanism established by the law, but for most practical problems, to understand its internal mechanism is very difficult, even impossible to determine study what factors, only through the system to recognize input test output input output system of law, the establishment of this law as far as possible consistent with the model, which is the test analysis, or call fitting analysis

Time series model is actually required stochastic model, the observed time series was seen as a sample of the generated random process infinite time series overall implementation. Mechanism of variable internal time series are generally not very clear, it is generally used for analytical methods are fitting analysis。

Commonly used time series stochastic model are: Auto regressive moving average model (Auto Regressive Integrated Moving Average, Acronym ARIMA), seasonal model, transfer function model and intervention model. ARIMA model used in this paper, season model and transfer function models. Before they were introduced, first briefly auto regressive model (AR) and moving average model (MA), which is a special form of ARIMA model.

AR model definition:

$$\begin{cases} x_t = \phi_0 + \phi_1 x_{t-1} + \phi_2 x_{t-2} + \cdots + \phi_p x_{t-p} + \varepsilon_t \\ \phi_p \neq 0 \\ E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, s \neq t \\ Ex_s \varepsilon_t = 0, \forall s < t \end{cases}$$

AR $(p)$ Model has three restrictions:

Condition1： $\phi_p \neq 0$ 。 This restriction ensures that the highest order of the model is $p$ 。

Condition2： $E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, s \neq t$ 。 This limitation is actually random noise sequence $\{\varepsilon_t\}$ requirements for zero-mean white noise sequence.

Condition3： $Ex_s \varepsilon_t = 0, \forall s < t$ 。The restrictions described random noise current period regardless of past sequence value.

MA model definition:

$$\begin{cases} x_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - -\theta_q \varepsilon_{t-q} \\ \theta_q \neq 0 \\ E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, s \neq t \end{cases}$$

MA $(q)$ Model has two restrictions:

Condition1： $\phi_q \neq 0$ This restriction ensures that the highest order of the model is.

Condition2： $E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, s \neq t.$ This limitation is actually random noise sequence $\{\varepsilon_t\}$ requirements for zero-mean white noise sequence.

ARMA model definition:

$$\begin{cases} \Phi(B) \nabla^d x_t = \Theta(B) \varepsilon_t \\ E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, s \neq t \\ Ex_s \varepsilon_t = 0, \forall s < t \end{cases}$$

$\nabla^d = (1-B)^d; \Phi(B) = 1 - \phi_1 B - \cdots - \phi_p B^p$ , $\Theta(B) = 1 - \theta_1 B - \cdots - \theta_q B^q$ is ARMA $(p,q)$ smoothing polynomial coefficient 。

ARIMA model is a combination of the essence of the difference computing and ARMA model. This relationship is significant. This shows that if by any non-stationary sequence difference after implementation of appropriate degree difference stationary, it is possible to sequence the difference after the ARMA model fitting. ARMA model and analysis method is very mature, which means that the analysis of difference stationary series will also be very simple and very reliable.

## *3.4Solution and Result of* Cluster analysis Model

*In the Antarctic, the temperature variation is not consistent throughout, in order to temperature changes in the Antarctic and neighboring areas have a more objective spatial distribution of zoning, we all stand on the temperature of temperature with height standardized sequence, latitude and longitude, weather station were clustering analysis.*

*According to the classification of the principles and the existing data, we selected SPSS software to classify meteorological stations.*

*Categories Figure*

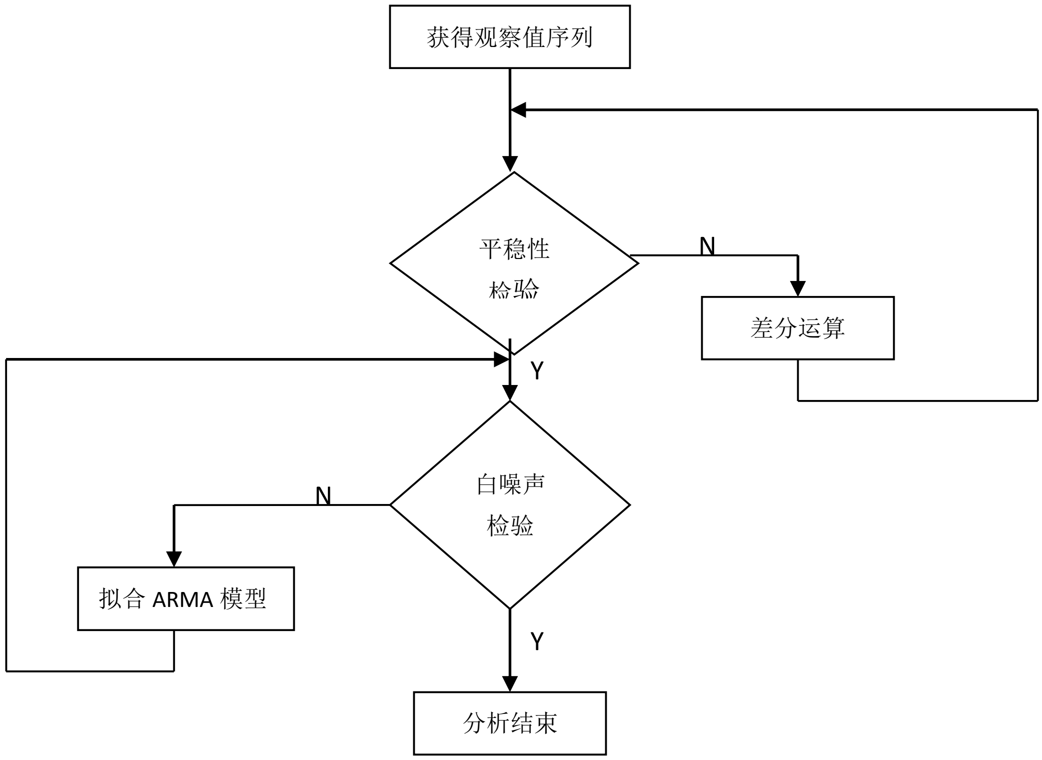
**Cluster Membership**

| Cluster Membership | | | | | |
|---|---|---|---|---|---|
| Case | 站点 ID | 4 Clusters | Case | 站点 ID | 4 Clusters |
| 1 | 68994 | 1 | 22 | 89606 | 4 |
| 2 | 68906 | 1 | 23 | 89611 | 2 |
| 3 | 88903 | 2 | 24 | 89642 | 2 |
| 4 | 88963 | 2 | 25 | 89662 | 3 |
| 5 | 88968 | 2 | 26 | 89664 | 3 |
| 6 | 89002 | 3 | 27 | 94998 | 2 |
| 7 | 89009 | 4 | 28 | 89266 | 3 |
| 8 | 89022 | 3 | 29 | 89661 | 3 |
| 9 | 89050 | 2 | 30 | 89662 | 3 |
| 10 | 89053 | 2 | 31 | 89666 | 3 |
| 11 | 89055 | 2 | 32 | 89667 | 3 |
| 12 | 89056 | 2 | 33 | 89768 | 3 |
| 13 | 89058 | 2 | 34 | 89769 | 3 |
| 14 | 89062 | 2 | 35 | 89799 | 4 |
| 15 | 89063 | 2 | 36 | 89828 | 4 |
| 16 | 89512 | 2 | 37 | 89864 | 3 |
| 17 | 89532 | 2 | 38 | 89866 | 3 |
| 18 | 89564 | 2 | 39 | 89868 | 3 |
| 19 | 89571 | 2 | 40 | 89869 | 3 |
| 20 | 89573 | 2 | 41 | 89872 | 3 |
| 21 | 89592 | 2 | 42 | 89879 | 2 |

*Thus, the selected weather can be divided into four categories for analysis, modeling and forecasting.*

### *3.5Solution and Result of Time series Model.*

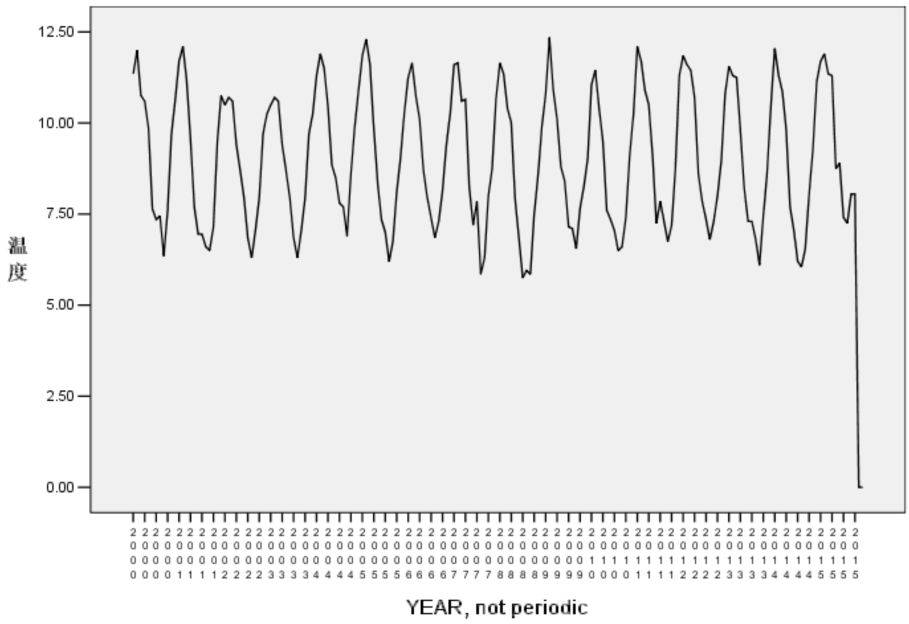
*Mastered the modeling method after ARMA model, try using the ARIMA model to observe the observation series modeling are submitted relatively simple matter. It follows the following process.*




### 3.5.1Model1

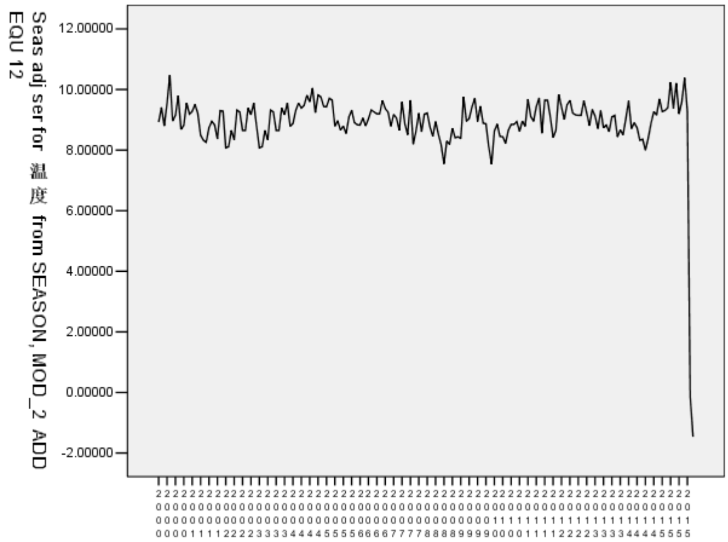
*The first site model and predict:*

*Firstly, a first class site SPSS draw time-series images:*



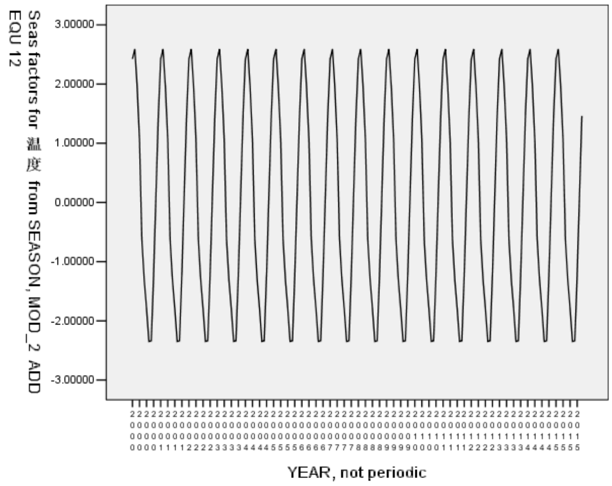

*From the above chart to see a greater degree of temperature fluctuations in Region 1, but change into upper and lower balanced, there could be seasonal factors.*

*So we did waveform data are as follows :( value decomposition see excel1).*

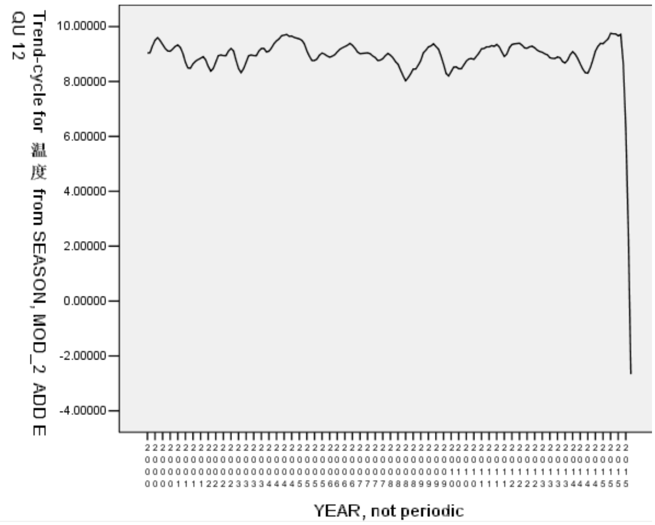



*Seasonal factors fluctuate sequence diagram is obviously fluctuates around a value, and therefore subject to seasonal effects guess.*

*SAF sequence diagram, sequence diagram seasonal temperature changes, the raw data shows seasonal sequence diagram caused fluctuations.*

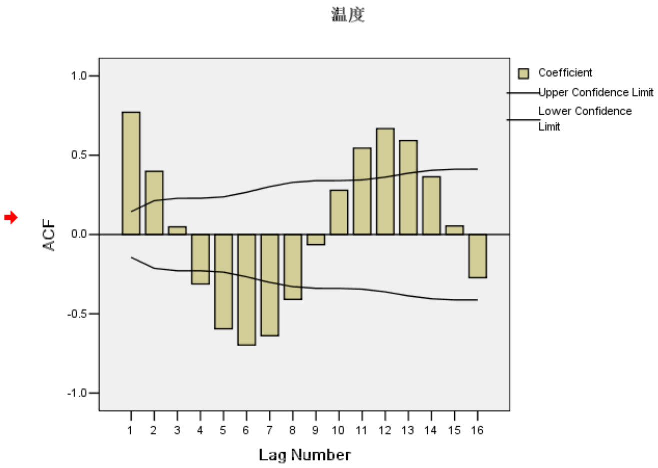



*The following are excluded temperature sequence diagram after season and random toggle interference, obviously there are steady trends.*




*The raw data using SPSS software to do auto-correlation coefficients and partial auto-correlation coefficient analysis:*

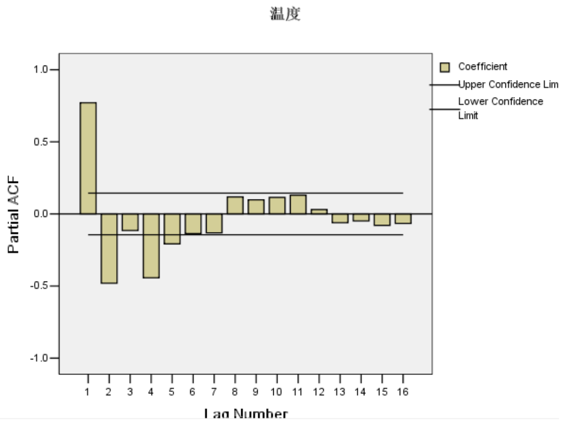
*The results are as follows:*




**Autocorrelations**

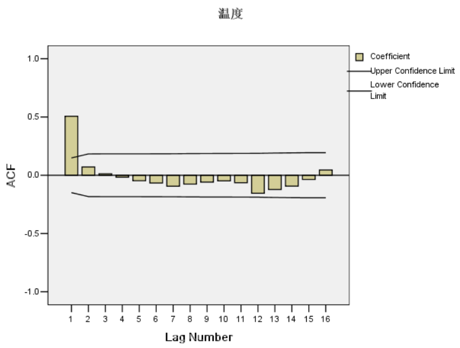
Series: 温度

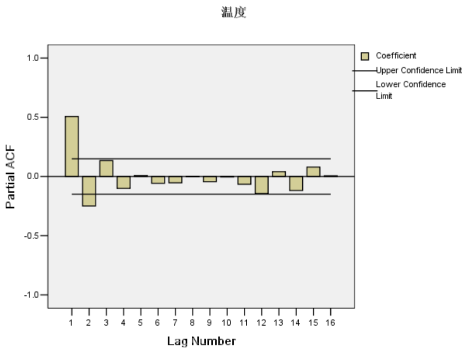
| Lag | Autocorrelation | Std.Error[a] | Box-Ljung Statistic Value | df | Sig.[b] |
|---|---|---|---|---|---|
| 1 | .771 | .072 | 115.792 | 1 | .000 |
| 2 | .399 | .107 | 146.927 | 2 | .000 |
| 3 | .048 | .114 | 147.389 | 3 | .000 |
| 4 | -.312 | .114 | 166.652 | 4 | .000 |
| 5 | -.594 | .119 | 236.934 | 5 | .000 |
| 6 | -.697 | .133 | 334.252 | 6 | .000 |
| 7 | -.638 | .151 | 416.271 | 7 | .000 |
| 8 | -.409 | .165 | 450.161 | 8 | .000 |
| 9 | -.064 | .170 | 450.991 | 9 | .000 |
| 10 | .279 | .170 | 466.920 | 10 | .000 |
| 11 | .545 | .172 | 528.015 | 11 | .000 |
| 12 | .668 | .181 | 620.237 | 12 | .000 |
| 13 | .592 | .193 | 693.247 | 13 | .000 |
| 14 | .364 | .203 | 720.971 | 14 | .000 |
| 15 | .054 | .206 | 721.585 | 15 | .000 |
| 16 | -.272 | .206 | 737.260 | 16 | .000 |




*The figure shows that there is a hangover period auto correlation image rendering, and partial auto correlation image 124 clearly trailing significantly behind gradually showing resistance, the differential data or seasonal difference dimensionality reduction, followed by self-correlation test to determine fit the RAIMA model, specific steps as shown in the flowchart, following results were obtained through the loop experiments using SPSS:*

*The following auto correlation image data when ordinary seasonal difference.*




*ACF evident by the remarkable image of the first order is not 0, after trailing tends to 0, so p= 1, and because the season is to do ordinary differential so P = 1; PACF figure shows the first two significant non-zero, the future tailing tends to 0. so q value of 1 or 2. The test should take two, did not make the difference so that d = 0.*

*Therefore, the establishment RAIMA with SPSS (1,0,2) (1,0,0) made fitting model fitting image using SPSS and results are as follows:*

**Iteration History**

| | Non-Seasonal Lags | | | Seasonal Lags | Regression Coefficients | | | |
|---|---|---|---|---|---|---|---|---|
| | AR1 | MA1 | MA2 | Seasonal AR1 | YEAR, not periodic | Constant | Adjusted Sum of Squares | Marquardt Constant |
| 0 | .117 | -.744 | -.502 | .928 | -.137 | 283.661 | 197.796 | .001 |
| 6 | .624 | -.377 | -.090 | .639 | -.113 | 235.424 | 159.821[a] | .010 |

**Residual Diagnostics**

| | |
|---|---|
| Number of Residuals | 192 |
| Number of Parameters | 4 |
| Residual df | 186 |
| Adjusted Residual Sum of Squares | 159.821 |
| Residual Sum of Squares | 197.796 |
| Residual Variance | .827 |
| Model Std. Error | .909 |
| Log-Likelihood | -254.828 |
| Akaike's Information Criterion (AIC) | 521.656 |
| Schwarz's Bayesian Criterion (BIC) | 541.201 |

*Obviously if replaced by AIC and BIC values for other models will increase, and they small as possible, so this model is relatively optimal model.*

**Parameter Estimates**

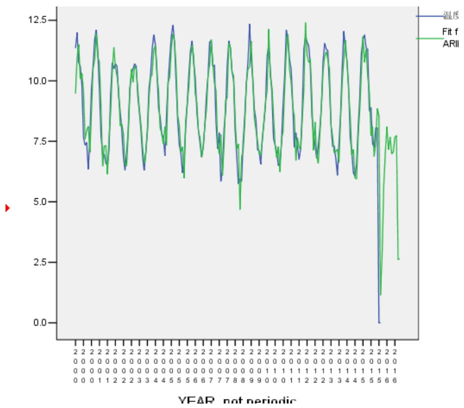
| | | Estimates | Std Error | t | Approx Sig |
|---|---|---|---|---|---|
| Non-Seasonal Lags | AR1 | .622 | .163 | 3.816 | .000 |
| | MA1 | -.380 | .173 | -2.192 | .030 |
| | MA2 | -.092 | .145 | -.636 | .526 |
| Seasonal Lags | Seasonal AR1 | .640 | .074 | 8.663 | .000 |
| Regression Coefficients | YEAR, not periodic | -.113 | .110 | -1.022 | .308 |
| Constant | | 235.154 | 221.719 | 1.061 | .290 |

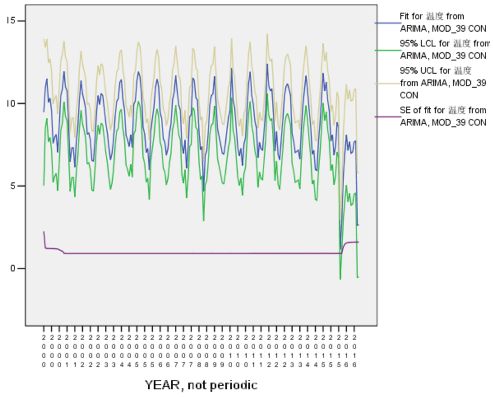
Melard's algorithm was used for estimation.

*According to the table, we can get a first class site fitting model:*

$$Y_t = 235.154 + 0.662 Y_{t-1} + 0.827 - 0.38\varepsilon_{t-1} - 0.092\varepsilon_{t-2}$$

*From the above curve fitting model was fitted with the original curve graph as follows:*




*ARIMA Model prediction*

*ARIMA* $(p,d,q)$ *model representation method as following*：

$$\Phi(B)(1-B)^d x_t = \Theta(B)\varepsilon_t$$

*As ARMA models, may also be a linear function of the random disturbance expressed it:* $x_t = \varepsilon_t + \Psi_1\varepsilon_{t-1} + \Psi_2\varepsilon_{t-2} + \cdots = \Psi(B)\varepsilon_t$

*where*， $\Psi_1, \Psi_2, \cdots$ *the values that satisfy the following recurrence formula:*

$$\begin{cases} \Psi_1 = \phi_1 - \theta_1 \\ \Psi_2 = \phi_1\Psi_1 + \phi_2 - \theta_2 \\ \qquad\vdots \\ \Psi_j = \phi_1\Psi_{j-1} + \cdots + \phi_{p+d}\Psi_{j-p-d} - \theta_j \end{cases}$$

*where*， $\Psi_j = \begin{cases} 0, & j<0 \\ 1, & j=0 \end{cases}$， $\qquad \theta_j = 0,\ j>q$

*then*， $x_{t+l} = (\varepsilon_{t+l} + \Psi_1\varepsilon_{t+l-1} + \cdots + \Psi_{l-1}\varepsilon_{t+1}) + (\Psi_l\varepsilon_t + \Psi_{l+1}\varepsilon_{t-1} + \cdots)$

*Mean square error between the actual value and the predicted value is as follows:*

$$E[x_{t+l} - \hat{x}_t(l)]^2 = (1 + \Psi_1^2 + \cdots + \Psi_{l-1}^2)\sigma_\varepsilon^2 + \sum_{j=0}^{\infty}(\Psi_{l+j} - \Psi_j^*)^2\sigma_\varepsilon^2$$

*only* $\Psi_j^* = \Psi_{l+j}$

*Therefore, under the principle of the minimum mean square error*， $l$ *prediction value*：

$$\hat{x}_t(l) = \Psi_l\varepsilon_t + \Psi_{l+1}\varepsilon_{t-1} + \Psi_{l+2}\varepsilon_{t-2} + \cdots$$

$l$ *Prediction error*： $e_t(l) = \varepsilon_{t+l} + \Psi_1\varepsilon_{t+l-1} + \cdots + \Psi_{l-1}\varepsilon_{t+1}$

*The true value is equal to forecast value plus forecast error:*

$$x_{t+l} = (\varepsilon_{t+l} + \Psi_1\varepsilon_{t+l-1} + \cdots + \Psi_{l-1}\varepsilon_{t+1}) + (\Psi_l\varepsilon_t + \Psi_{l+1}\varepsilon_{t-1} + \cdots) = e_t(l) + \hat{x}_t(l):$$

$l$ *forecast error variance is：* $Var[e_t(l)] = (1 + \Psi_1^2 + \cdots + \Psi_{l-1}^2)\sigma_\varepsilon^2$.

*So fitting the data we get from SPSS software:*

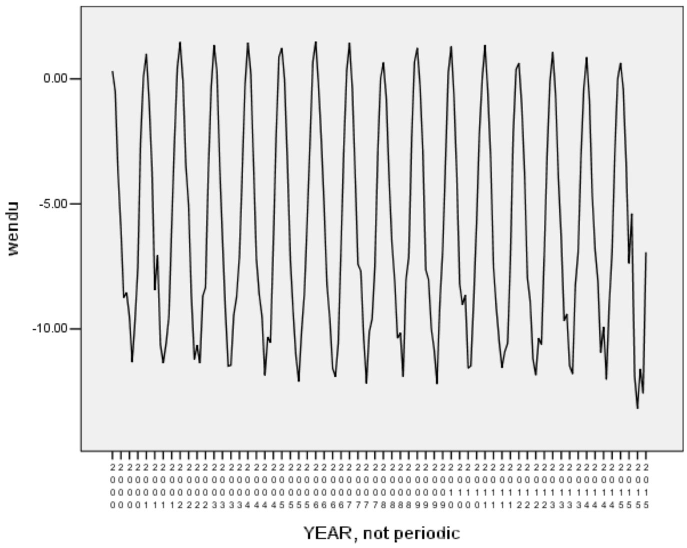
| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.47101 | 10.88286 | 11.3753 | 9.93955 | 10.27822 | 11.37018 | 10.97835 | 10.66711 | 11.54835 | 10.48602 | 9.58295 | 11.25799 | 12.4052 | 10.99543 | 10.87507 | 11.83132 |
| 10.95608 | 11.93729 | 10.55593 | 10.60645 | 11.29598 | 11.92438 | 11.47045 | 11.70257 | 11.38507 | 10.58354 | 12.1287 | 11.92051 | 11.06016 | 11.20132 | 11.67345 | 10.77002 |
| 11.50045 | 10.99311 | 10.17944 | 10.48257 | 11.45019 | 11.64521 | 11.03652 | 10.7089 | 10.34101 | 11.64282 | 10.16717 | 10.46218 | 10.76494 | 10.8893 | 10.74332 | 11.29586 |
| 10.08156 | 10.76042 | 9.6706 | 9.65852 | 10.22454 | 10.52777 | 9.45016 | 9.88585 | 10.22297 | 10.04403 | 9.72769 | 9.95867 | 10.89013 | 10.49557 | 9.59524 | 10.16875 |
| 10.31735 | 8.82556 | 8.14037 | 8.80117 | 9.6167 | 8.55432 | 9.09526 | 9.60629 | 8.32035 | 8.43414 | 8.56355 | 8.95241 | 9.36815 | 8.17151 | 8.57693 | 9.52196 |
| 9.60322 | 6.47175 | 8.21298 | 8.18955 | 8.05946 | 8.15545 | 7.87096 | 7.46582 | 7.1964 | 7.98064 | 7.32113 | 8.53776 | 7.13517 | 7.70968 | 6.92976 | 7.73205 |
| 7.59738 | 7.30556 | 7.80903 | 7.27964 | 7.80343 | 7.04008 | 7.66227 | 6.97786 | 7.38677 | 7.49484 | 6.83407 | 6.71304 | 8.29854 | 7.02867 | 7.16252 | 8.10153 |
| 7.94965 | 7.32011 | 6.56065 | 6.59629 | 7.39651 | 7.27217 | 6.86165 | 7.7818 | 4.68096 | 6.99771 | 7.27542 | 7.64224 | 6.90179 | 7.09402 | 5.9945 | 6.8795 |
| 8.12118 | 6.14361 | 6.49478 | 6.98594 | 8.10869 | 5.98104 | 7.25347 | 6.0845 | 6.87376 | 6.92237 | 6.24211 | 7.24466 | 6.59491 | 7.16982 | 5.93913 | 7.40058 |
| 7.03978 | 7.69409 | 7.79115 | 7.87892 | 7.34231 | 8.33324 | 8.22338 | 7.28613 | 7.11717 | 7.53652 | 7.56597 | 7.18036 | 7.79715 | 6.63647 | 7.69717 | 8.86357 |
| 8.70901 | 8.70173 | 9.48854 | 9.2361 | 9.95848 | 9.1173 | 8.78248 | 9.19219 | 8.26981 | 8.37662 | 7.91521 | 8.41069 | 8.96086 | 8.44913 | 8.81403 | 8.53644 |
| 10.49557 | 10.31238 | 10.47704 | 10.13002 | 10.15008 | 9.8014 | 10.23305 | 9.3121 | 9.93071 | 9.14924 | 9.67855 | 9.65295 | 10.38709 | 9.94205 | 10.32448 | 1.14677 |

*According to the data of fitting to predict we get:*
*Predicted values for 2016 are as follows (annual average temperature: 6.094158)*

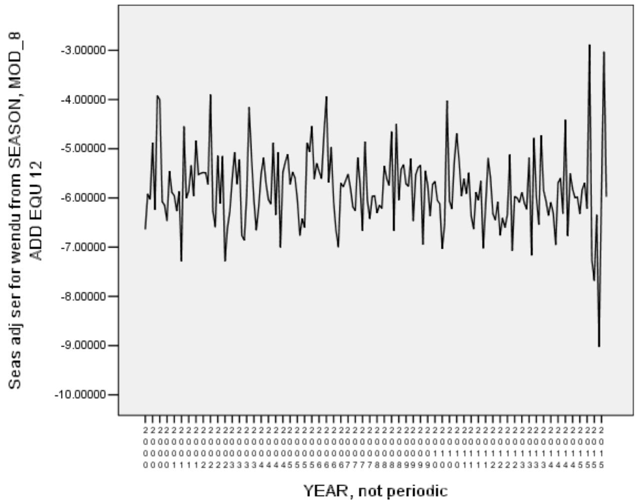
| 月份 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 温度 | 2.81557 | 5.61759 | 7.0353 | 8.10448 | 7.1583 | 7.68066 |
| 月份 | 7 | 8 | 9 | 10 | 11 | 12 |
| 温度 | 6.98635 | 7.0555 | 7.67005 | 7.73399 | 2.62367 | 2.64843 |

### 3.5.2Model2

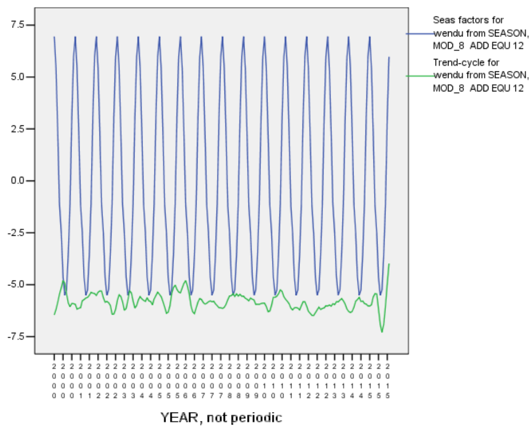
*First, draw a second type of sites using SPSS time-series images*



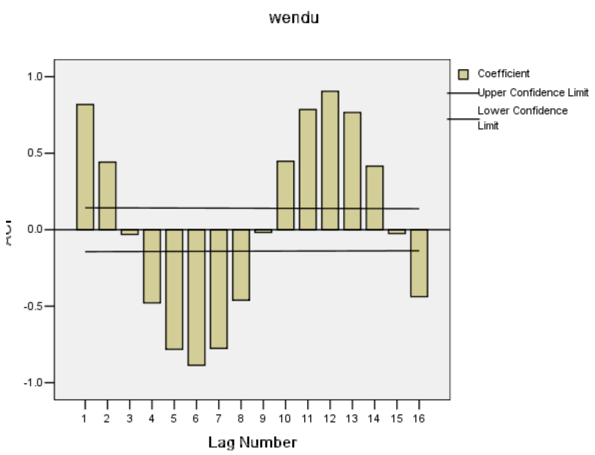

*From the above chart to see a greater degree of temperature fluctuations in Region 1, but change into upper and lower balanced, there could be seasonal factors.So we do decomposed waveform data are as follows:*




*Seasonal factors fluctuate sequence diagram is obviously fluctuates around a value, and therefore subject to seasonal effects guess SAF sequence diagram, sequence diagram seasonal temperature changes the blue line, showing a sequence diagram of the season for the raw data caused fluctuations, the following are excluded seasonal and random interference toggle temperature sequence diagram after the Green Line, Obviously there is a smooth trend.*



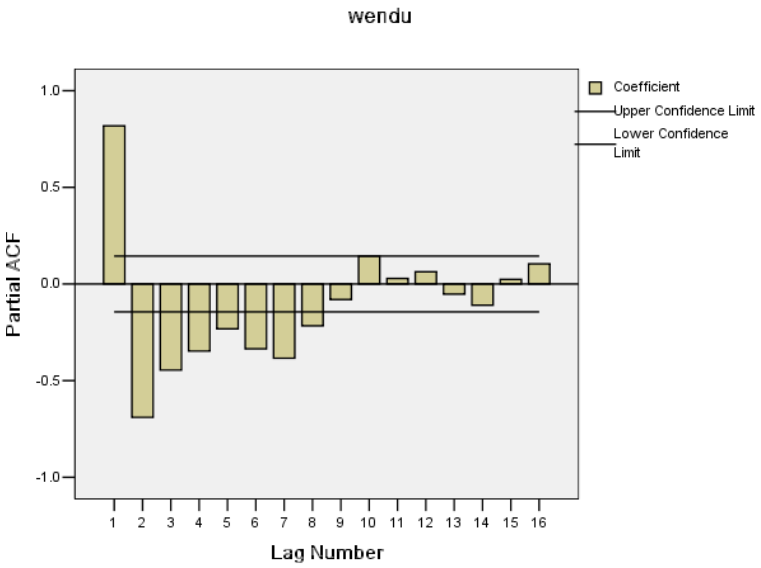

*The raw data using SPSS software to do auto correlation coefficients and partial auto correlation coefficient analysis. The results are as follows:*



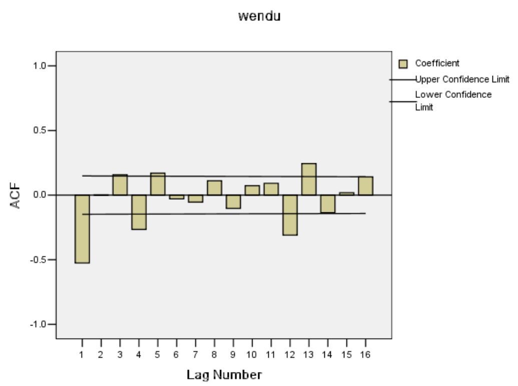
**Autocorrelations**

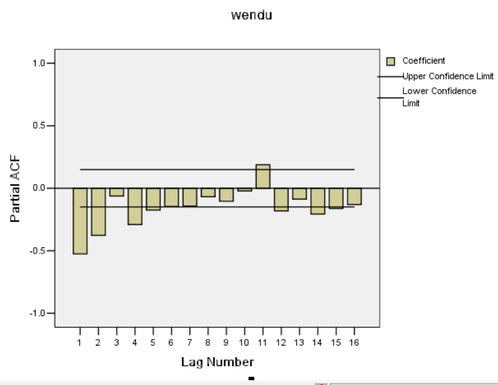
Series: wendu

| Lag | Autocorrelation | Std.Error(a) | Box-Ljung Statistic Value | df | Sig.(b) |
|---|---|---|---|---|---|
| 1 | .818 | .072 | 130.592 | 1 | .000 |
| 2 | .442 | .071 | 168.858 | 2 | .000 |
| 3 | -.031 | .071 | 169.043 | 3 | .000 |
| 4 | -.478 | .071 | 214.358 | 4 | .000 |
| 5 | -.782 | .071 | 336.036 | 5 | .000 |
| 6 | -.886 | .071 | 493.199 | 6 | .000 |
| 7 | -.776 | .070 | 614.295 | 7 | .000 |
| 8 | -.461 | .070 | 657.256 | 8 | .000 |
| 9 | -.018 | .070 | 657.319 | 9 | .000 |
| 10 | .447 | .070 | 698.293 | 10 | .000 |
| 11 | .785 | .070 | 825.227 | 11 | .000 |
| 12 | .905 | .070 | 994.568 | 12 | .000 |
| 13 | .766 | .069 | 1116.683 | 13 | .000 |
| 14 | .416 | .069 | 1152.858 | 14 | .000 |
| 15 | -.025 | .069 | 1152.989 | 15 | .000 |
| 16 | -.437 | .069 | 1193.424 | 16 | .000 |




*From the above chart shows auto correlation image showing a trailing period, and partial auto correlation image 123 clearly trailing significantly behind gradually showing resistance, the differential data or seasonal difference dimension reduction, followed by self-correlation test to determine fit the RAIMA model, specific steps as shown in the flowchart, following results were obtained through the loop experiments using SPSS.The following auto correlation image data when ordinary seasonal difference and time difference.*




*ACF evident by the remarkable image of the first order is not 0, the second truncated, so p = 0, and because doing so ordinary seasonal differentiating P =1; Fig approximation by the PACF index tends to 0, so q = 1, do ordinary differential so d = 1.*
*Therefore, the use SPSS establish ARIMA (0,1,1) (1,0,0) made fitting model fitting image using SPSS and results are as follows:*

**Iteration History**

| | Non-Seasonal Lags | Seasonal Lags | Regression Coefficients | | | |
|---|---|---|---|---|---|---|
| | MA1 | Seasonal AR1 | YEAR, not periodic | Constant | Adjusted Sum of Squares | Marquardt Constant |
| 0 | -.958 | .925 | .083 | -172.593 | 1055.728 | .001 |
| 1 | -.897 | .722 | .025 | -55.787 | 709.217 | .001 |
| 2 | -.807 | .768 | -.006 | 6.333 | 518.700 | .000 |
| 3 | -.659 | .877 | -.019 | 31.659 | 387.618 | .000 |
| 4 | -.444 | .932 | -.024 | 42.522 | 310.243 | .000 |
| 5 | -.202 | .959 | -.025 | 43.587 | 272.235 | .000 |
| 6 | -.048 | .970 | -.025 | 43.931 | 264.646 | .000 |
| 7 | -.028 | .970 | -.025 | 44.062 | 264.539[a] | .000 |

**Residual Diagnostics**

| | |
|---|---|
| Number of Residuals | 192 |
| Number of Parameters | 4 |
| Residual df | 186 |
| Adjusted Residual Sum of Squares | 159.821 |
| Residual Sum of Squares | 197.796 |
| Residual Variance | .827 |
| Model Std. Error | .909 |
| Log-Likelihood | -254.828 |
| Akaike's Information Criterion (AIC) | 521.656 |
| Schwarz's Bayesian Criterion (BIC) | 541.201 |

Obviously if replaced by AIC and BIC values for other models will increase, and they small as possible, so this model is relatively optimal model.

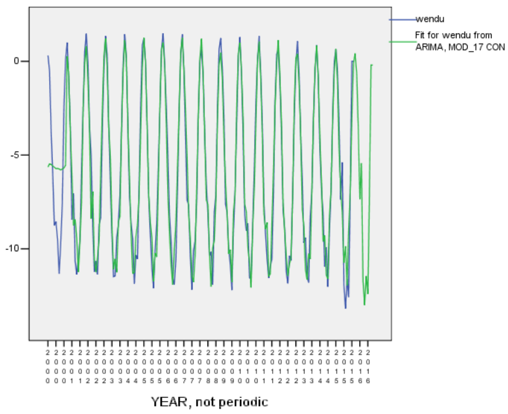
**Parameter Estimates**

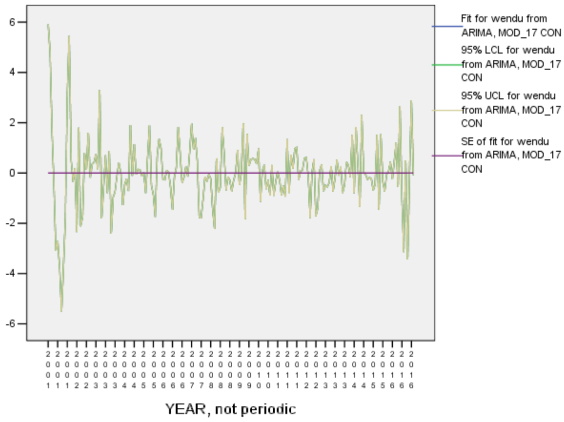
| | | Estimates | Std Error | t | Approx Sig |
|---|---|---|---|---|---|
| Non-Seasonal Lags | MA1 | -.028 | .068 | -.408 | .683 |
| Seasonal Lags | Seasonal AR1 | .971 | .013 | 74.205 | .000 |
| Regression Coefficients | YEAR, not periodic | -.025 | .076 | -.328 | .743 |
| Constant | | 44.061 | 152.071 | .290 | .772 |

According to the table, we can get the second category sites fit model is:

$$Y_t = 44.061 - 0.028\varepsilon_{t-1} + 0.827 + 0.972X_t$$

From the above the fit curve and the original curve model obtained graph below:




So fitting the data we get from SPSS software:

| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -5.63752 | 0.27216 | 0.79556 | 1.21934 | 1.12088 | 1.24751 | 1.00077 | 1.25249 | 1.19898 | 0.45714 | 0.99709 | 1.05232 | 1.12253 | 0.40461 | 0.83654 | 0.65436 |
| -5.47176 | -0.67015 | -1.01208 | -0.27101 | 0.13672 | 0.01957 | -0.24838 | -0.38869 | -0.6089 | -0.89784 | -0.53839 | -0.8206 | -0.70731 | -1.19507 | -0.87868 | -1.08457 |
| -5.49949 | -3.82605 | -3.64024 | -3.51416 | -3.51961 | -3.50574 | -3.396 | -2.5541 | -3.98 | -3.99105 | -3.0247 | -3.90663 | -3.31393 | -3.86413 | -4.02511 | -4.71029 |
| -5.58853 | -6.04131 | -8.38478 | -5.0989 | -6.37731 | -7.17126 | -7.14597 | -5.17752 | -7.396 | -6.48494 | -7.62043 | -8.12745 | -7.51081 | -7.88864 | -6.37152 | -6.81309 |
| -5.64996 | -8.74552 | -6.94627 | -8.74463 | -9.21304 | -8.57034 | -9.13462 | -8.21151 | -7.6301 | -8.09977 | -8.01182 | -8.95038 | -9.08133 | -8.80915 | -9.604 | -8.0832 |
| -5.72371 | -8.43731 | -10.5549 | -11.092 | -11.3239 | -9.43373 | -10.8907 | -9.49325 | -10.269 | -10.2598 | -9.93654 | -8.59404 | -10.39018 | -11.1185 | -9.28686 | -10.7442 |
| -5.71609 | -9.48195 | -11.2406 | -10.5399 | -11.2506 | -11.7401 | -11.9076 | -11.4491 | -12.016 | -10.0507 | -10.6874 | -11.4761 | -11.4372 | -11.6436 | -11.3979 | -9.86227 |
| -5.74318 | -11.24 | -10.4536 | -11.2482 | -9.34285 | -10.2252 | -10.0135 | -11.7751 | -9.952 | -11.7833 | -12.063 | -11.3378 | -10.79428 | -10.2602 | -11.6072 | -11.9601 |
| -5.7931 | -9.57764 | -9.44254 | -8.5754 | -8.68379 | -10.4258 | -8.59935 | -10.3786 | -9.5585 | -8.01168 | -8.90651 | -8.72715 | -10.44124 | -10.5451 | -8.23846 | -8.9649 |
| -5.74604 | -7.4875 | -5.8872 | -8.2909 | -7.14559 | -6.48569 | -5.68365 | -6.72942 | -7.4135 | -7.11495 | -6.79914 | -5.82517 | -7.19665 | -6.95448 | -6.92441 | -6.9741 |
| -5.68692 | -2.49979 | -2.68125 | -3.6431 | -3.69419 | -2.34297 | -2.73229 | -2.88015 | -3.0357 | -2.50266 | -3.40475 | -2.38618 | -2.29032 | -3.08064 | -3.14446 | -3.07754 |
| -5.54669 | -0.10306 | 0.24932 | -0.4878 | -0.34152 | 0.63938 | 0.46546 | 0.12869 | -0.1581 | 0.41617 | 0.08351 | -0.177 | 0.15617 | -0.30967 | -0.56388 | -0.11993 |

According to fitting the data to predict we get:

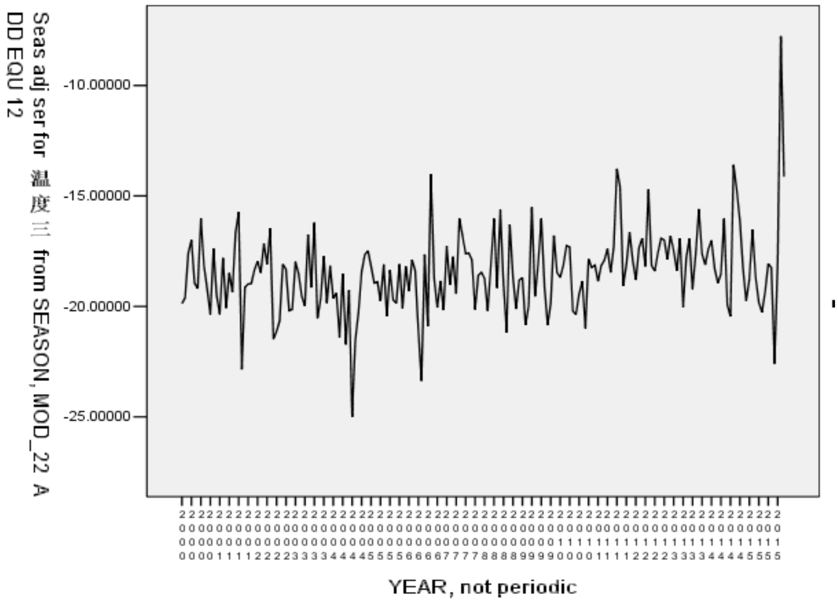
Predicted values for 2016 were as follows (annual average temperature: -6.03656)

| 月份 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 温度 | 0.41817 | -0.61402 | -3.50643 | -7.35974 | -5.43308 | -11.7469 |
| 月份 | 7 | 8 | 9 | 10 | 11 | 12 |
| 温度 | -13.0033 | -11.4557 | -12.402 | -6.93267 | -0.20151 | -0.20151 |

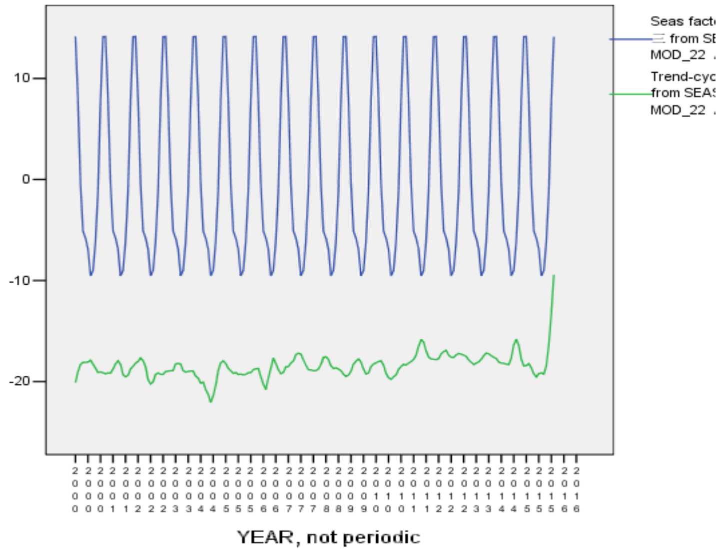
### 3.5.3Model3

First, draw a third category of sites using SPSS time-series images:


From the above chart to see a greater degree of temperature fluctuations in Region 1, but change into upper and lower balanced, there could be seasonal factors.So we do decomposed waveform data are as follows:

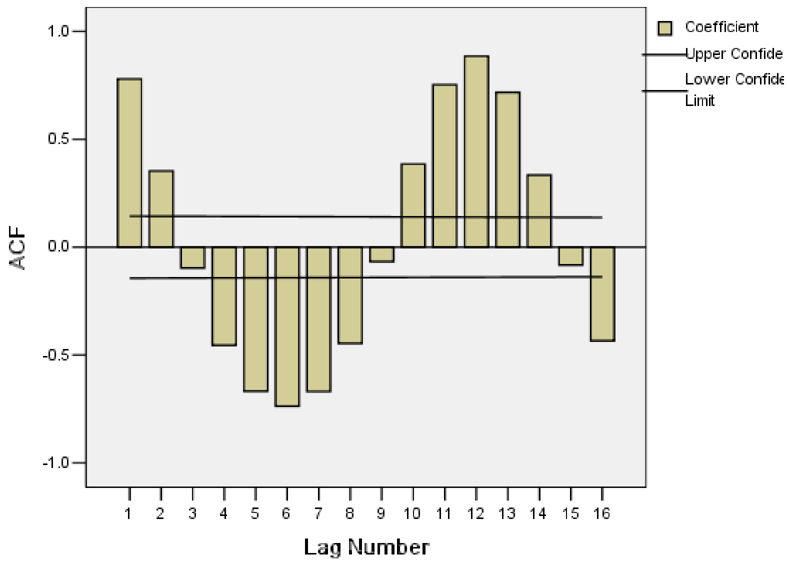



Seasonal factors fluctuate sequence diagram is obviously fluctuates around a value, and therefore subject to seasonal effects guess SAF sequence diagrams, seasonal temperature variation sequence diagram blue line, showing the raw data seasons sequence diagram caused fluctuations, the following are excluded seasonal and random interference toggle temperature sequence diagram after the Green Line,Obviously there is a smooth trend.




Of the raw data the auto correlation coefficients and partial auto correlation coefficient analysis: (SPSS)

温度三

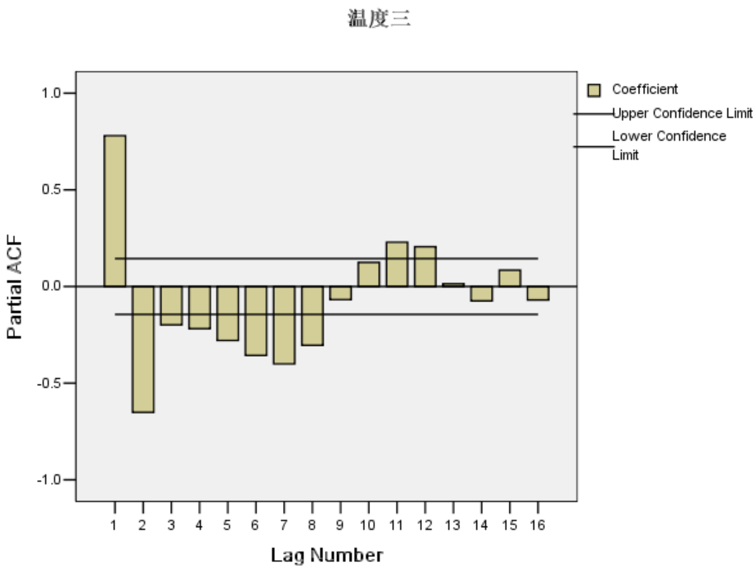



**Autocorrelations**

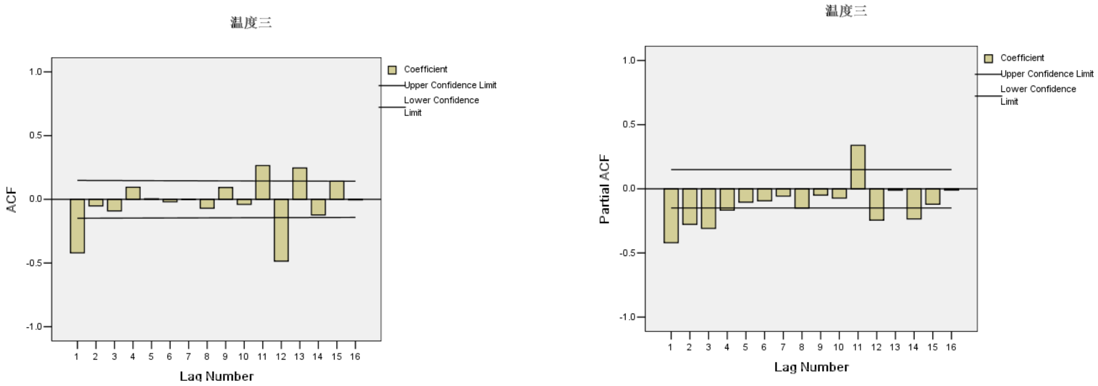
Series: 温度三

| Lag | Autocorrelation | Std.Error[a] | Box-Ljung Statistic Value | df | Sig.[b] |
|---|---|---|---|---|---|
| 1 | .780 | .072 | 118.683 | 1 | .000 |
| 2 | .354 | .071 | 143.225 | 2 | .000 |
| 3 | -.097 | .071 | 145.071 | 3 | .000 |
| 4 | -.454 | .071 | 185.896 | 4 | .000 |
| 5 | -.668 | .071 | 274.831 | 5 | .000 |
| 6 | -.738 | .071 | 383.844 | 6 | .000 |
| 7 | -.669 | .070 | 474.035 | 7 | .000 |
| 8 | -.446 | .070 | 514.307 | 8 | .000 |
| 9 | -.066 | .070 | 515.200 | 9 | .000 |
| 10 | .386 | .070 | 545.623 | 10 | .000 |
| 11 | .753 | .070 | 662.297 | 11 | .000 |
| 12 | .885 | .070 | 824.456 | 12 | .000 |
| 13 | .717 | .069 | 931.578 | 13 | .000 |
| 14 | .334 | .069 | 954.865 | 14 | .000 |
| 15 | -.084 | .069 | 956.342 | 15 | .000 |
| 16 | -.434 | .069 | 996.224 | 16 | .000 |

a. The underlying process assumed is independence (white noise)




The figure shows that there is a hangover period auto correlation image presentation, and partial auto correlation image 12 gradually showing obvious trailing significantly behind resistance, differential data or seasonal difference dimensionality reduction, followed by self-correlation test to determine fit the RAIMA model, specific steps as shown in the flowchart, following results were obtained through the loop experiments using SPSS. The following auto correlation image data when ordinary seasonal difference and time difference.




ACF evident by the remarkable image of the first order is not 0, the second truncated, so p = 1, and because the season is to do ordinary differential so P=1; Fig approximation by the PACF index tends to 0, so q = 0, Under the inspection should take two, so do ordinary differential d = 1. Therefore, the establishment by SPSS RAIMA (0,1,1) (1,0,0) made fitting model fitting image using SPSS and results are as follows:

**Iteration History**

| | Non-Seasonal Lags | Seasonal Lags | Regression Coefficients | | | |
|---|---|---|---|---|---|---|
| | MA1 | Seasonal AR1 | YEAR, not periodic | Constant | Adjusted Sum of Squares | Marquardt Constant |
| 0 | -.719 | .747 | -.004 | -.082 | 5702.319 | .001 |
| 1 | -.532 | .427 | .116 | -.018 | 3399.419 | .001 |
| 2 | -.219 | .638 | -.029 | .040 | 2510.174 | .000 |
| 3 | .114 | .835 | -.060 | .118 | 2038.694 | .000 |
| 4 | .382 | .912 | -.163 | .153 | 1828.782 | .000 |
| 5 | .583 | .945 | -.380 | .141 | 1713.171 | .000 |
| 6 | .743 | .958 | -.712 | .116 | 1629.084 | .000 |
| 7 | .871 | .962 | -1.021 | .100 | 1552.637 | .000 |
| 8 | .981 | .963 | -1.098 | .094 | 1450.380 | .000 |
| 9 | .987[a] | .963[a] | -1.083[a] | .094[a] | 1442.104 | 10.000 |

**Residual Diagnostics**

| | |
|---|---|
| Number of Residuals | 191 |
| Number of Parameters | 2 |
| Residual df | 187 |
| Adjusted Residual Sum of Squares | 1441.385 |
| Residual Sum of Squares | 5702.319 |
| Residual Variance | 6.535 |
| Model Std. Error | 2.556 |
| Log-Likelihood | -465.070 |
| Akaike's Information Criterion (AIC) | 938.139 |
| Schwarz's Bayesian Criterion (BIC) | 951.148 |

Obviously if replaced by AIC and BIC values for other models will increase, and they small as possible, so this model is relatively optimal model.

**Parameter Estimates**

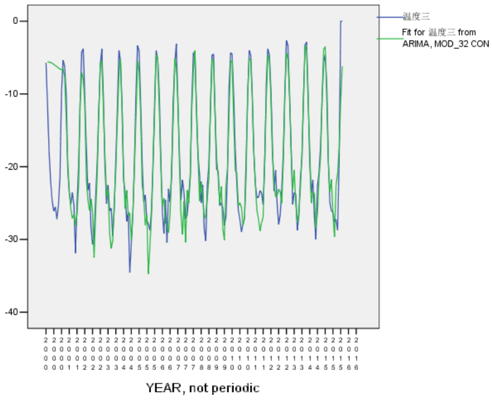
| | | Estimates | Std Error | t | Approx Sig |
|---|---|---|---|---|---|
| Non-Seasonal Lags | MA1 | .987 | .021 | 47.489 | .000 |
| Seasonal Lags | Seasonal AR1 | .963 | .016 | 60.681 | .000 |
| Regression Coefficients | YEAR, not periodic | -1.082 | 8.305 | -.130 | .896 |
| Constant | | .094 | .693 | .136 | .892 |

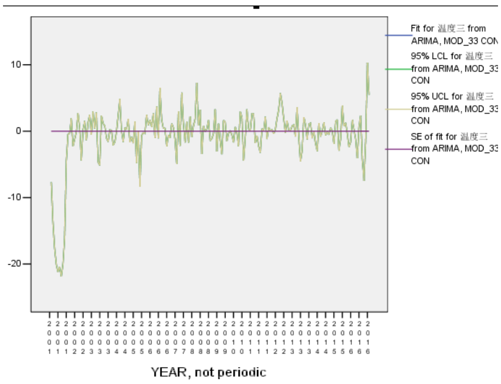
Melard's algorithm was used for estimation.

According to the table, we can get a third class of these sites fit model is:

$$Y_t = 0.094 + 0.987\varepsilon_{t-1} + 6.535 + 0.963X_t$$

From the above curve fitting model was fitted with the original curve graph as follows:




So fitting the data we get from SPSS software:

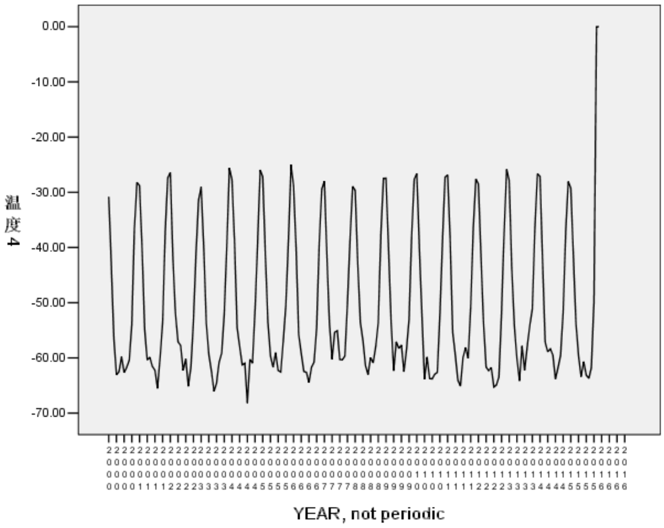
| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | -7.58429 | 0.79556 | -7.90048 | -7.90048 | -5.44397 | -5.25257 | -6.91087 | -5.25341 | -6.27069 | -4.04401 | -5.4791 | -5.4046 | -5.373 | -5.2831 | -5.22062 |
| -5.62034 | -13.295 | -1.01208 | -11.3789 | -11.3789 | -11.8994 | -11.7593 | -12.6342 | -11.9691 | -10.8393 | -11.73637 | -12.8578 | -13.4435 | -10.8058 | -10.578 | -9.77875 |
| -5.60368 | -19.3244 | -3.64024 | -21.5616 | -21.5616 | -18.6175 | -20.7558 | -22.5551 | -19.8995 | -19.3325 | -18.53215 | -18.8774 | -20.558 | -17.9663 | -18.351 | -17.3885 |
| -5.66788 | -23.3131 | -8.38478 | -24.5321 | -24.5321 | -24.0997 | -25.7323 | -24.2845 | -25.2783 | -26.4886 | -24.69531 | -21.4195 | -20.7999 | -22.5817 | -22.377 | -23.1662 |
| -5.78407 | -25.8483 | -6.94627 | -25.997 | -25.997 | -23.1944 | -23.2509 | -28.0309 | -24.3424 | -29.2969 | -22.02326 | -25.082 | -25.3476 | -26.0307 | -24.074 | -20.4801 |
| -5.93242 | -27.1258 | -10.5549 | -24.4263 | -24.4263 | -29.0607 | -26.6648 | -26.657 | -27.7156 | -24.7377 | -23.85622 | -22.7294 | -24.9737 | -27.2018 | -23.947 | -24.8999 |
| -6.096 | -26.5506 | -11.2406 | -26.0987 | -26.0987 | -31.2266 | -26.366 | -34.7363 | -28.195 | -30.392 | -27.16271 | -28.5181 | -25.589 | -28.8082 | -23.111 | -27.6522 |
| -6.2505 | -28.1222 | -10.4536 | -32.5198 | -32.5198 | -30.1964 | -30.1346 | -30.8068 | -29.0323 | -23.2296 | -26.65293 | -30.1132 | -28.0534 | -27.6814 | -23.483 | -26.389 |
| -6.42415 | -26.3715 | -9.44254 | -26.0945 | -26.0945 | -24.9202 | -26.5138 | -26.7337 | -26.2929 | -25.002 | -24.20402 | -22.5692 | -26.9707 | -26.8801 | -25.022 | -22.9451 |
| -6.57176 | -22.6606 | -5.8872 | -21.1318 | -21.1318 | -20.3493 | -19.8405 | -20.1866 | -19.773 | -21.4663 | -21.53624 | -20.1383 | -21.1992 | -19.0396 | -19.262 | -18.2015 |
| -6.66846 | -11.1841 | -2.68125 | -12.5205 | -12.5205 | -13.5594 | -13.2986 | -10.8452 | -13.1411 | -11.7317 | -11.44008 | -12.9449 | -9.66519 | -10.8381 | -9.2621 | -10.4818 |
| -6.61207 | -7.08581 | 0.24932 | -5.78931 | -5.78931 | -7.36323 | -5.50729 | -4.57329 | -5.16372 | -6.86553 | -5.20381 | -5.51612 | -5.16443 | -4.58238 | -4.3874 | -3.32551 |

According to fitting the data to predict we get:Predicted values for 2016 were as follows (annual average temperature: -17.7387)

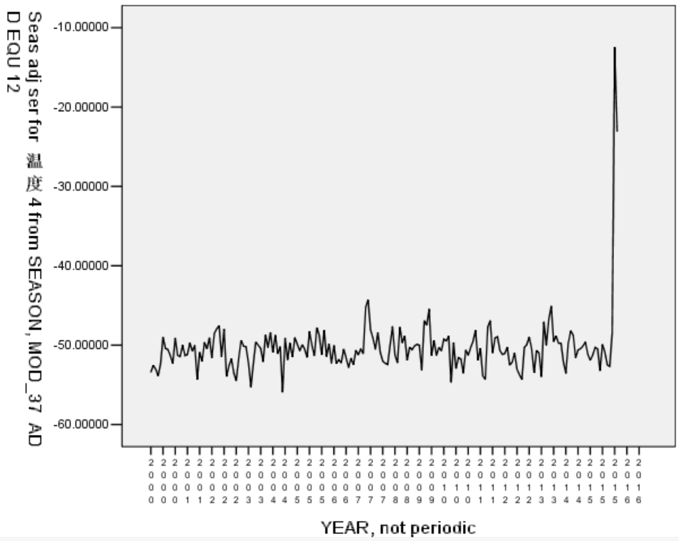
| 月份 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 温度 | −5.18127 | −8.99619 | −19.0939 | −24.7289 | −25.8213 | −25.9918 |
| 月份 | 7 | 8 | 9 | 10 | 11 | 12 |
| 温度 | −27.2879 | −26.9659 | −28.3466 | −19.0436 | −0.70522 | −0.70171 |

### 3.5.1Model4

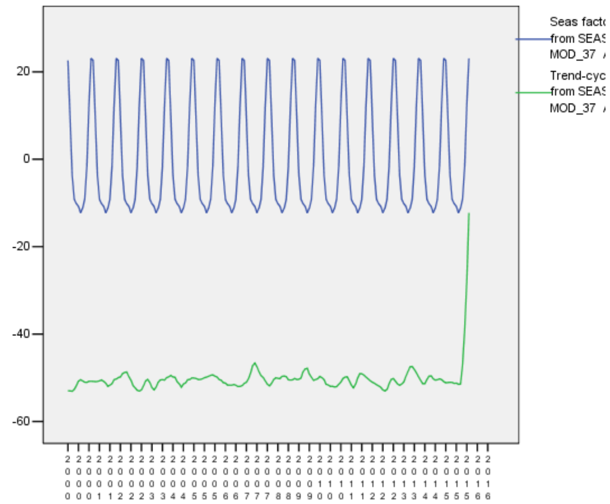
First, draw a fourth category of sites using SPSS time-series images:



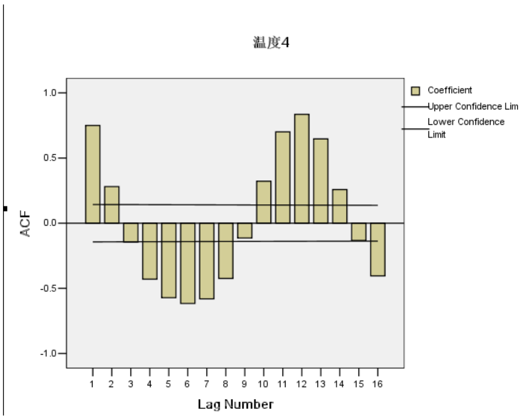

From the above chart to see a greater degree of temperature fluctuations in Region 1, but change into upper and lower balanced, there could be seasonal factors.So we do decomposed waveform data are as follows:




Seasonal factors fluctuate sequence diagram is obviously fluctuates around a value, and therefore subject to seasonal effects guess weak SAF sequence diagrams, seasonal temperature variation sequence diagram blue line, showing the raw data seasons sequence diagram caused fluctuations, the following are excluded temperature season toggle interference and random sequence diagram after the Green Line,Obviously there is a smooth trend.




SPSS software from the original data do auto correlation coefficients and partial auto correlation coefficient analysis:

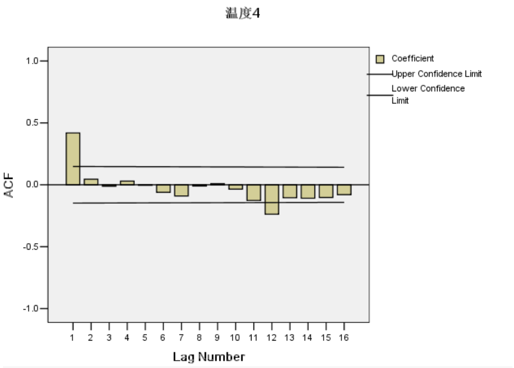


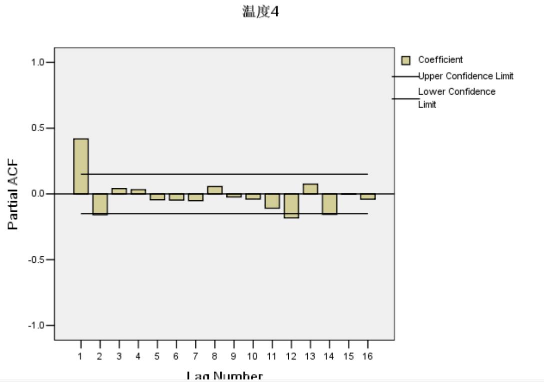

**Autocorrelations**

Series:温度4

| Lag | Autocorrelation | Std.Error[a] | Box-Ljung Statistic Value | df | Sig.[b] |
|---|---|---|---|---|---|
| 1 | .750 | .072 | 109.714 | 1 | .000 |
| 2 | .281 | .071 | 125.173 | 2 | .000 |
| 3 | -.144 | .071 | 129.288 | 3 | .000 |
| 4 | -.429 | .071 | 165.791 | 4 | .000 |
| 5 | -.572 | .071 | 230.900 | 5 | .000 |
| 6 | -.616 | .071 | 306.877 | 6 | .000 |
| 7 | -.581 | .070 | 374.744 | 7 | .000 |
| 8 | -.423 | .070 | 411.042 | 8 | .000 |
| 9 | -.113 | .070 | 413.658 | 9 | .000 |
| 10 | .322 | .070 | 434.933 | 10 | .000 |
| 11 | .701 | .070 | 536.096 | 11 | .000 |
| 12 | .835 | .070 | 680.398 | 12 | .000 |
| 13 | .647 | .069 | 767.473 | 13 | .000 |
| 14 | .258 | .069 | 781.452 | 14 | .000 |
| 15 | -.133 | .069 | 785.151 | 15 | .000 |
| 16 | -.404 | .069 | 819.691 | 16 | .000 |

The figure shows that there is a hangover period auto correlation image presentation, and partial auto correlation image 12 gradually showing obvious trailing significantly behind resistance, differential data or seasonal difference dimension reduction, followed by self-correlation test to determine fit the RAIMA model, specific steps as shown in the flowchart, following results were obtained through the loop experiments using SPSS.When the data from ordinary seasonal difference following Related Image.




ACF evident by the remarkable image of the first order is not 0, the second truncated, so p=1, and because the season is to do ordinary differential so P=1; Fig PACF by the former two is not significant to 0, q = 2. The test should take two, so do ordinary differential d = 1.Therefore, the establishment RAIMA with SPSS (1,0,2) (1,0,0) made fitting model fitting image using SPSS and results are as follows:

**Iteration History**

| | Non-Seasonal Lags | | | Seasonal Lags | Regression Coefficients | | | |
|---|---|---|---|---|---|---|---|---|
| | AR1 | MA1 | MA2 | Seasonal AR1 | YEAR, not periodic | Constant | Adjusted Sum of Squares | Marquardt Constant |
| 0 | -.518 | -1.037 | -.949 | .934 | .533 | -1119.073 | 5549.251 | .001 |
| 1 | -.306 | -.959 | -.905 | .891 | .469 | -990.086 | 4388.074 | .001 |
| 2 | -.244 | -.901 | -.852 | .842 | .447 | -946.172 | 4241.054 | .000 |
| 3 | -.269 | -.917 | -.782 | .877 | .463 | -979.089 | 3948.258 | .000 |
| 4 | -.169 | -.816 | -.657 | .892 | .472 | -997.246 | 3625.915 | .000 |
| 5 | -.124 | -.750 | -.498 | .919 | .475 | -1001.879 | 3394.188 | .000 |
| 6 | .012 | -.608 | -.341 | .925 | .474 | -1000.894 | 3321.656 | .000 |
| 7 | .083 | -.534 | -.269 | .927 | .476 | -1003.506 | 3314.852 | .000 |
| 8 | .077 | -.539 | -.266 | .927 | .474 | -999.704 | 3314.767a | .000 |

**Residual Diagnostics**

| | |
|---|---|
| Number of Residuals | 192 |
| Number of Parameters | 4 |
| Residual df | 186 |
| Adjusted Residual Sum of Squares | 3314.767 |
| Residual Sum of Squares | 5549.251 |
| Residual Variance | 15.729 |
| Model Std. Error | 3.966 |
| Log-Likelihood | -546.336 |
| Akaike's Information Criterion (AIC) | 1104.672 |
| Schwarz's Bayesian Criterion (BIC) | 1124.217 |

Obviously if replaced by AIC and BIC values for other models will increase, and they small as possible, so this model is relatively optimal model.

**Parameter Estimates**

| | | Estimates | Std Error | t | Approx Sig |
|---|---|---|---|---|---|
| Non-Seasonal Lags | AR1 | .078 | .313 | .250 | .803 |
| | MA1 | -.538 | .300 | -1.791 | .075 |
| | MA2 | -.265 | .155 | -1.714 | .088 |
| Seasonal Lags | Seasonal AR1 | .927 | .032 | 29.159 | .000 |
| Regression Coefficients | YEAR, not periodic | .474 | .461 | 1.028 | .305 |
| Constant | | -1000.239 | 925.243 | -1.081 | .281 |

Melard's algorithm was used for estimation.

**Parameter Estimates**

| | | Estimates | Std Error | t | Approx Sig |
|---|---|---|---|---|---|
| Non-Seasonal Lags | AR1 | .078 | .313 | .250 | .803 |
| | MA1 | -.538 | .300 | -1.791 | .075 |
| | MA2 | -.265 | .155 | -1.714 | .088 |
| Seasonal Lags | Seasonal AR1 | .927 | .032 | 29.159 | .000 |
| Regression Coefficients | YEAR, not periodic | .474 | .461 | 1.028 | .305 |
| Constant | | -1000.239 | 925.243 | -1.081 | .281 |

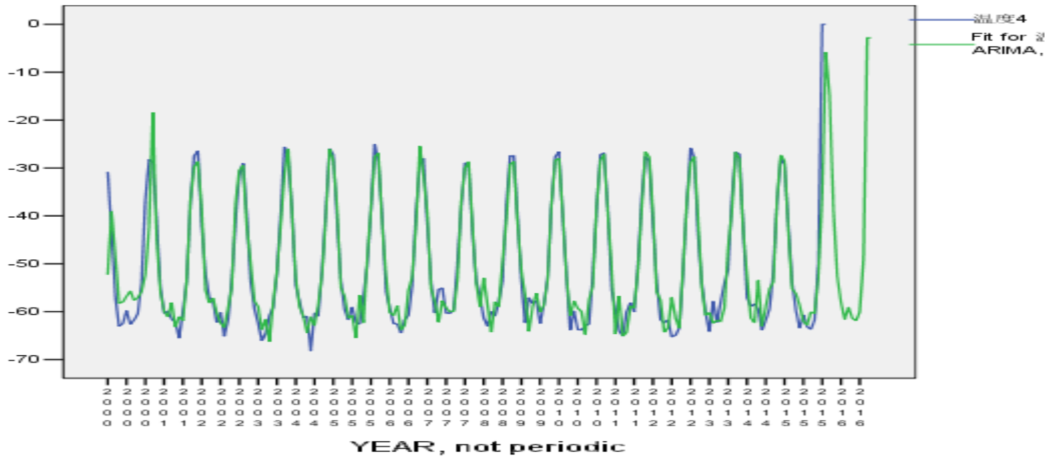
Melard's algorithm was used for estimation.

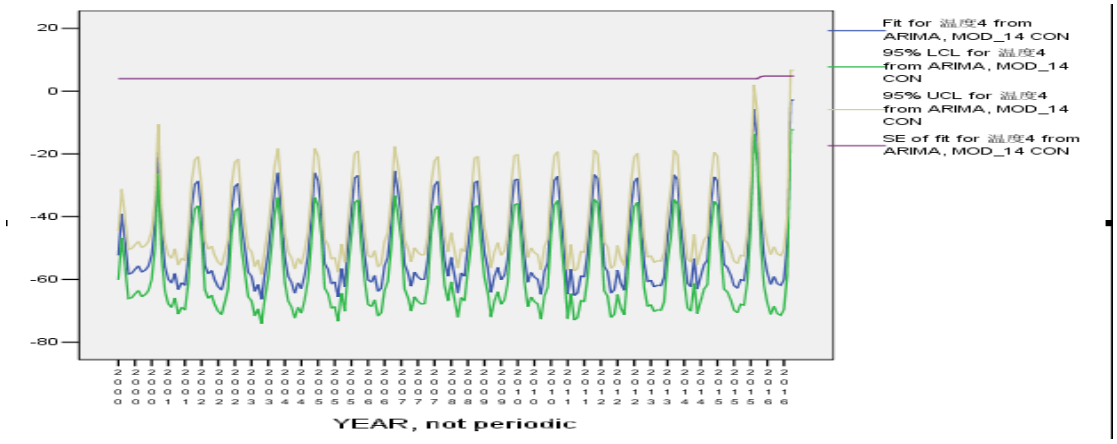
According to the table, we can get the fourth category of these sites fit model is:

$$Y_t = -1000.239 + 0.078Y_{t-1} + 15.729 - 0.538\varepsilon_{t-1} - 0.265_{t-2} + 0.927X_t$$

Where x is the seasonal effects of temperature SAF

From the above the fit curve and the original curve model obtained graph below




So fitting the data we get from SPSS software:

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| 1 | -5.22062 | -55.7974 | -53.517 | -54.9647 | -51.6734 | -52.2575 | -49.2156 | -52.7549 |
| 2 | -9.77875 | -52.2786 | -36.87 | -37.5097 | -41.7341 | -40.1172 | -38.5261 | -41.7538 |
| 3 | -17.3885 | -42.1461 | -29.666 | -30.4133 | -31.2137 | -26.0586 | -27.6524 | -25.4266 |
| 4 | -52.292 | -18.3642 | -28.688 | -29.4532 | -26.0507 | -28.4229 | -26.8844 | -31.492 |
| 5 | -39.0535 | -44.835 | -38.655 | -42.3649 | -39.3215 | -38.3716 | -41.6577 | -39.4415 |
| 6 | -47.9656 | -55.929 | -55.467 | -49.8439 | -53.0168 | -54.9967 | -52.3722 | -55.2216 |
| 7 | -58.2741 | -59.9649 | -58.144 | -57.7401 | -59.0058 | -56.7582 | -60.1715 | -57.8601 |
| 8 | -57.9747 | -61.0905 | -57.179 | -58.9053 | -60.8422 | -61.3467 | -60.8098 | -62.1732 |
| 9 | -56.7882 | -58.0938 | -60.299 | -63.7485 | -64.4084 | -60.7964 | -58.7082 | -57.6853 |
| 10 | -55.6815 | -63.1761 | -62.372 | -61.607 | -61.0515 | -65.4998 | -63.7987 | -59.2104 |
| 11 | -57.6402 | -61.0453 | -63.322 | -66.276 | -62.9104 | -56.5539 | -62.8238 | -60.0013 |
| 12 | -57.0715 | -61.8865 | -59.381 | -58.0821 | -58.5405 | -62.3336 | -55.4936 | -59.9081 |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| 1 | -53.5435 | -49.6385 | -53.3286 | -54.7673 | -51.5618 | -51.274 | -46.5859 | -53.8759 |
| 2 | -37.189 | -40.8851 | -37.8252 | -38.1011 | -38.6707 | -37.242 | -38.7985 | -36.6904 |
| 3 | -30.0186 | -29.2009 | -28.392 | -28.405 | -26.6212 | -28.871 | -26.6922 | -27.3094 |
| 4 | -28.6973 | -28.6147 | -27.9929 | -27.1005 | -27.7312 | -27.604 | -28.0489 | -28.5579 |
| 5 | -41.9793 | -41.4623 | -39.2905 | -39.4508 | -39.407 | -40.604 | -42.9551 | -42.9375 |
| 6 | -53.9461 | -51.5335 | -52.5553 | -50.8729 | -55.8837 | -54.82 | -52.5399 | -55.2185 |
| 7 | -58.9729 | -56.5516 | -60.8447 | -64.6935 | -57.5358 | -60.737 | -61.2818 | -56.2026 |
| 8 | -52.956 | -64.1109 | -57.7475 | -56.7124 | -64.2803 | -60.222 | -62.3014 | -58.5846 |
| 9 | -58.6529 | -58.988 | -59.2859 | -65.0911 | -63.3555 | -62.375 | -53.4287 | -62.0169 |
| 10 | -64.259 | -56.1445 | -59.963 | -64.3261 | -57.0185 | -61.851 | -63.0309 | -62.7823 |
| 11 | -57.9543 | -60.0808 | -64.7805 | -58.8074 | -61.3576 | -62.016 | -58.9726 | -60.0664 |
| 12 | -58.9621 | -58.703 | -57.4331 | -59.26 | -63.3919 | -59.279 | -55.2219 | -60.3645 |

According to fitting the data to predict we get:Predicted values for 2016 were as follows (annual average temperature: -43.5851)

| 月份 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 温度 | -15.0423 | -38.7334 | -52.4868 | -58.0814 | -61.5963 | -59.0635 |
| 月份 | 7 | 8 | 9 | 10 | 11 | 12 |
| 温度 | -61.3504 | -61.8757 | -60.0679 | -49.082 | -2.82078 | -2.82078 |

Above the model used by the autocorrelation test modeling success.

## 4. Conclusions.

The model will be combined with clustering analysis Time series of surface temperatures in Antarctica were conducted subregional seminars and fitting conclusion can be seen from the above fitting out of the temperature and the actual temperature fluctuations sequence diagram is very close, so the model is valid . And the time series can be more accurately predict the short-term temperature changes in the value of the Antarctic surface temperature is divided into four areas to discuss, excluding the impact of a high degree of latitude and objective observation point on the earth's surface temperature caused, while Time series model Join the seasonal factors and the impact of stochastic volatility factor, so that more accurate prediction value, it can be seen from the above model of global warming on the Antarctic surface temperature is seasonal impact, if and to the annual average temperature words, the impact of global warming on the Antarctic surface temperature variations are also volatility. The model is a clustering analysis and Time series, the effective integration of SPSS.

## 5.Future Work

Plans for the future:

1, the more weather measurement data superimposition processing to obtain a more accurate prediction value;

2, the Year of the measured data more weather overlay process, makes the model closer to the exact value;

3, will consider more factors to build the model, such as the effect of pressure, wind speed, etc.;

4, looking more optimized models, making more accurate predictive value;

## 6. References.

[1] Tang Guoli, Ding Yihui analysis of nearly 44 years of Nanjing temperature characteris
[2] efficiency Cunde change in Antatics and possible causes of the [A] Laboratory for Climate Studies, China Meteorological Administration, Beijing: National Climate Center, 100 081 30 1 2006 Volume 1 463 month.rctic climate system: past, present and future [A] State Key Laboratory of Cold and Arid Regions Environmental and Engineering Research Institute of Cryosphere Sciences, Lanzhou 730000, China; Chinese Academy of Meteorological Sciences. Beijing 10008 volume 4, No. 1 January 2008 532.
[3] LU Long Wow, Bian Lingen, Jia Peng group temporal changes in temperature characteristics of the Antarctic and adjacent areas [D] Chinese Academy of Meteorological Sciences, Beijing 100081, China Science Daily: 1997.6 27 Volume III.
[4] Wang Yan Application of Sequence Analysis (Third Edition) [M] Beijing: China Renmin University Press .2012,12.

**7. Appendix**

| Stage | Cluster Combined | | Coefficients | Stage Cluster First Appears | | Next Stage |
|---|---|---|---|---|---|---|
| | Cluster 1 | Cluster 2 | | Cluster 1 | Cluster 2 | |
| 1 | 25 | 30 | .000 | 0 | 0 | 23 |
| 2 | 33 | 34 | .000 | 0 | 0 | 7 |
| 3 | 12 | 13 | .000 | 0 | 0 | 5 |
| 4 | 21 | 24 | .001 | 0 | 0 | 10 |
| 5 | 10 | 12 | .001 | 0 | 3 | 26 |
| 6 | 17 | 19 | .004 | 0 | 0 | 8 |
| 7 | 33 | 41 | .006 | 2 | 0 | 13 |
| 8 | 17 | 20 | .006 | 6 | 0 | 20 |
| 9 | 8 | 37 | .009 | 0 | 0 | 22 |
| 10 | 18 | 21 | .011 | 0 | 4 | 12 |
| 11 | 26 | 38 | .013 | 0 | 0 | 17 |
| 12 | 18 | 23 | .022 | 10 | 0 | 20 |
| 13 | 32 | 33 | .023 | 0 | 7 | 18 |
| 14 | 6 | 28 | .026 | 0 | 0 | 24 |
| 15 | 5 | 9 | .027 | 0 | 0 | 19 |
| 16 | 16 | 42 | .029 | 0 | 0 | 27 |
| 17 | 26 | 31 | .033 | 11 | 0 | 22 |
| 18 | 32 | 40 | .041 | 13 | 0 | 25 |
| 19 | 4 | 5 | .057 | 0 | 15 | 28 |
| 20 | 17 | 18 | .060 | 8 | 12 | 27 |
| 21 | 7 | 35 | .085 | 0 | 0 | 38 |
| 22 | 8 | 26 | .089 | 9 | 17 | 23 |
| 23 | 8 | 25 | .098 | 22 | 1 | 29 |
| 24 | 6 | 29 | .105 | 14 | 0 | 29 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 25 | 32 | 39 | .105 | 18 | 0 | 34 |
| 26 | 10 | 15 | .107 | 5 | 0 | 28 |
| 27 | 16 | 17 | .163 | 16 | 20 | 31 |
| 28 | 4 | 10 | .170 | 19 | 26 | 33 |
| 29 | 6 | 8 | .225 | 24 | 23 | 34 |
| 30 | 22 | 36 | .231 | 0 | 0 | 38 |
| 31 | 11 | 16 | .286 | 0 | 27 | 36 |
| 32 | 3 | 27 | .289 | 0 | 0 | 37 |
| 33 | 4 | 14 | .315 | 28 | 0 | 36 |
| 34 | 6 | 32 | .439 | 29 | 25 | 39 |
| 35 | 1 | 2 | .610 | 0 | 0 | 40 |
| 36 | 4 | 11 | .878 | 33 | 31 | 37 |
| 37 | 3 | 4 | 1.785 | 32 | 36 | 39 |
| 38 | 7 | 22 | 2.048 | 21 | 30 | 41 |
| 39 | 3 | 6 | 2.704 | 37 | 34 | 40 |
| 40 | 1 | 3 | 9.938 | 35 | 39 | 41 |
| 41 | 1 | 7 | 22.350 | 40 | 38 | 0 |