Team Control Number

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Problem Chosen

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2013 Mathematical Contest in Modeling (MCM) Summary Sheet

summary

Water crisis is a challenge for all of us. Necessarily, Comprehensive plans would be made for the challenge.

Our model contains the predict model and the action model. In the predict mode, we collect enough credible data of the recent years. Follow the rule of water consume and water resource, we classify the consuming water by different usages: Agriculture, Industry, Domestic, Ecology. We do data matching for each term. We use the same method doing data matching for the resource of water in each province and the annual output of desalinize water. In the action mode, we basically di-vide the country by provinces. Each province distribute water resource and doing water transportation individually. In this way shall we deal with the transportation model as an digraph which contains many nodes(the provinces) and lines(the transportation of water). Meanwhile the rate of reproduce water and the amount of desalinized water play important roles in this resource deployment model. We use linear programming to find the best solution.

The mode of water resource is fine and feasible. We consider the terrain and valley and many other key element to the model.

Key Words: Data fitting a nd f orecast; G oal P rogramming; Digraph; Shortest Path;Water Resources; distribution

Water Crisis:searching for a best strategy

February 5, 2013

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Contents

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1 Introduction

The quest title is a reference to the Rime of the Ancient Mariner by Samuel Taylor Coleridge.Now,this short verses has been widely used in many articles related to water problem. As required, we choose China as the picked country and build a mathematical model to meet the water needs in 2025. In order to indicate the strategy clearly,the problem is tackled into four main subproblems:

- Find and deal with the reliable data on the website,
- Build the model to meet the project with the processed data,
- Optimize the model and obtain the best water strategy,
- Provide a non-technical position paper to governmental leadership and explain the approach.

To tackle the first problem, firstly,we get data from the website of National Bureau of Statistics of China,The Ministry of Water Resources,the People's Republic of China.The data we handled is about the water resources,monthly precipitation of major cities, water supply and water use.After a series of calculation, with the help of lingo,we get the variance of major cities' quarterly precipitation ,as well as the distance between the major cities.
For the second problem,build the model to meet the project with the processed data.
As for the third problem,we optimize the model and obtain the best water strategy.
The last problem,we provide a non-technical position paper to governmental leadership and explain the approach

2 background

The background for the lackness of fresh water:Fresh water is the limiting constraint for development in much of the world. As the referenced title from the Rime of the Ancient Mariner by Samuel Taylor Coleridge, "Water, water, every where,And all the boards did shrink",the strength of water is of great importance.Whereas, the current situation is not optimistic.The shortage of fresh water across the world is serious.Thus, build an effective, feasible, and cost-efficient water strategy to meet the projected water needs is urgent and significative.

3 The Description of the Problem

3.1 Problem Restatement

As the limiting constraint for development,fresh water is of great importance. The mathematical model is to determine an effective, feasible, and cost-efficient water strategy for 2013 to meet the projected water needs of in 2025, and identify the best water strategy.In the water strategy, storage,movement,desalination and conservation must addressed. Moreover,the model should discuss the economic, physical, and environmental implications of the strategy. Last, a non-technical position paper should present to governmental leadership and outline the approach, its feasibility and costs, and why it is the "best water strategy choice."

3.2 Problem Analysis

According to the problem statement above,it may reasonably tackle into four subproblems:

1. Build an effective, feasible, and cost-efficient water strategy addressed on storage,movement,de-salinization and conservation to meet the projected water needs,
2. Optimiz the model and identify the best water strategy,
3. Discuss the influence of the model to the economic, physical, and environmental implications,
4. Write a non-technical position paper to governmental leadership and then outline the approach, its feasibility, costs and the reason as well as required.

3.3 Analysis for the Subproblems

In order to solve every subproblem systematically,the analysis for each is showed below:

For subproblem1: Building the model is the key step in solving this problem.Before building the model,we search the internet and find data on the website of National Bureau of Statistics of China and The Ministry of Water Resources. With the processed data ,it is reasonably to forcast the water supply by linear programming and water use by data matching.When forcasting the data of the water supply and water use in 2025,we use the data on the basis of different zones'.In the meantime,the forcasting of the whole area includes the population growth,the cost of the sea water desalinization and quantity demanded of the sea water.

After forcasting the water supply ,water use and other needs,the next step is to compare the data obtained in different areas and find out the areas lacking in fresh water in 2025.When find out the areas, calculate the water shortage and use the model to realize the strategy.
There are four points addressed in the strategy.

- Firstly, the storage. The may data for this point is the monthly precipitation of major cities. The evaluation criterion is the variance of major cities' quarterly precipitation and correlations related to the distance between the major cities.
- Secondly, the movement. Both fresh water and sea water is taken into consideration. According to the geographic position , the transportation cost and other interrelated factor, Different areas will have different movement projects.Here what should be pointed out in advance is the classification. According to the landform, China has three ladders; in terms of the drainage basin, 5 drainage basins are taken into consideration. In this way, the adjacent matrix is structured.
- Thirdly, the desalinization. Take industry, agriculture and water demand in households into consideration. Sea water desalination is used for agriculture and water demand in households as Industry doesn't.
- Fourthly, the conservation. Water demand in households is the mainly conservation of freshwater.

Apart from what has been talked above, some other factors will also affect the final result. In science and technology, with the development, the cost of the

storage, movement, desalinization and conservation will drop obviously.What's more, the population growth and the transfer of industrial structure and humans will also have an effect on the strategy.
Detailed model interpretation will showed in the model parts.

For subproblem2: After building the model, it is to optimiz the model and identify the best water strategy.The optimization will solved with the model setting parts.

For subproblem3: When Discuss the influence of the model to the economic, physical, and environmental implications,

For subproblem4: This part is the summary of the strategy.From the strategy, the approach, the reason for the best water strategy on its feasibility and costs will all concluded reasonably.

4 The Model

4.1 General Assumptions

- There won't be war, natural disasters and other affecting factors from now to 2025.
- There will be neither a wide range of industrial migration and population migration, nor industrial structure reform from now to 2025.
- The road for transportation and the transport form won't change as well.
- The yearly water use of the inhabitants in the same area won't change year by year.
- The yearly population growth of the inhabitants in the same area is a constant.
- The unit cost of the sea water desalinization in different areas is the same.
- The unit cost of the fresh water transportation in different areas is the same.

4.2 Classified Assumptions in Different Aspects

4.2.1 The Hypotheses on Water Price

1. All the cost of the projects, including construction, maintenance, energy dissipation, technology, policy and so on, is contained in the water price.
2. The effectiveness of the various projects, including Economic Efficiency, Eco-Efficiency, flood control and other kinds related, is all contained in the water price as well. It won't talked below.
3. The unit cost of water mentioned above is equal to the own various effectiveness of the water resources.

4.2.2 The Hypotheses on Storage

Take the basic function of water resources storage into consideration, thanks to seasonal variation, water supply changes followed. Consequently, in the model, the hypotheses are as follows:

1. The changing water supply is dealt as precipitation change in different quarters.
2. Water storage capacity of the cities surrounded is taken into account for the water resources storage expansion.

4.2.3 The Hypotheses on movement

1. The pollution and dissipation of water won't considered in water resources movement.
2. Water evaporation is inevitable during the transportation, thus this part of water won't considered as well. The water evaporation is calculated in water price.
3. Water resources movement only implement among neighboring provinces.If required to implement between un-neighboring provinces, it is seen as the implement via the middle node repeatedly (each province is seen as a node) .

4. The cost for water resources movement only related to the distance and the difference in altitude between two provinces. The influence is as follows:
   Define height as a variable ,and its value is the altitude in difference between destination and source areas. The influence is included as followed table:

Height(=destination-source)	Price
>0	distancePrice*waterDistance+heightPrice*height
<0	distancePrice*waterDistance

   Attention: distancePrice and heightPrice were seen as contants.

   It is necessary to account here that the difference of the Price for height that if water transported from low altitude to high altitude, water pump is essential.

5. Terrain has a strong impact on the water resources movement. In China, there are three ladders. The hypotheses here is that the ladder in lower altitude doesn't allowed to transport water to ladder in higher altitude.

6. Drainage basin will affect the water resources movement as well. Take 5 drainage basins into consideration and structure the adjacent matrix, then define waterDistance as Water Affinity to calculate the price.
   WaterDistance is defined as:

$$waterDistance = realDistance * e^{-n} \tag{1}$$

   In definition, n presents correlation degree.For example, Jiangsu Province and Anhu Province are both in two same drainage basins,thus,n=2.

7. In order to calculate conveniently, the distance between different provinces is defined as the distance between two provincial capitals.

4.2.4 The Hypotheses on sea water desalinization

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The location of sea water desalinization is set during the coastal provinces.

2. In terms of transportation, the distance between coastal provinces and sea is defined as 0,the altitude in difference is defined as each province's altitude.
3. Storage difficulty won't take into consideration.
4. The rules for the set of cost is referring to the market.

4.2.5 The Hypotheses on recycle

1. The limiting value is existed.
2. The rules for the set of cost is referring to the market as well.

4.2.6 The Hypotheses on water classification

1. According to usage, water is classified as industrial water, agricultural water, water demand in households and ecological water use.
2. According to quality, water is classified as sea water, fresh water(including surface water ,underground water ,fresh lake water) and recycled water.
3. Sea water used for industry take 20% for the maximum among the water.
4. Recycled water is seen lower than 30%.

4.3 Definitions and Symbols

Symbols	Definitions
X	Years
a,b,c,d	the parameter for each term
Φ	the data matching value
Ψ	The D-value
δ	the variance

4.4 The Foundation of Model for Prediction

4.4.1 The Prediction for the demand of water use

In order to forcast the demand of water use accurately, we get data from the website of National Bureau of Statistics of China. As the data on the website is similar in the years of 2011 and 2010, we use the data of 2010.
The prediction is classified in five sorts, industrial water, agricultural water, water demand in households, ecological water use and total water use.
Emphasis:As there is plenty of data for each sort to predict, we only show the data about industrial water entirely. The sorts left only show pivotal data.

1. Industrial Water

The table below shows the data of industrial water, from the data, we cannot predict the trend clearly. As industrial water affected by other factors easily. Therefore, we predict the data by the way of data matching in high order. Data matching is quite an efficient way for prediction. By the methods of least square method, the result of data matching is listed in the follows.
The final data matching value for each province from year 2004 to 2010 is matched as:

$$\Phi = aX^3 + bX^2 + cX + d \tag{2}$$

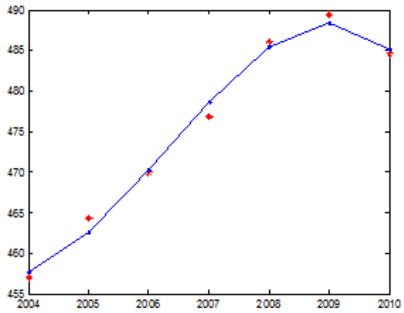
Definition in the formula:

a,b,c,d : the parameter for each term
Φ : the data matching value

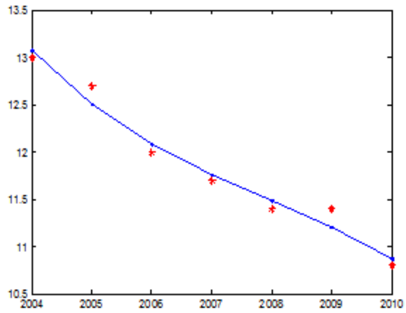
The result of parameter:
The result of data matching values:
In order to observe the data matching value, we calculate the D-value and variance as well. They are defined as:

Ψ: the D-value
δ : the variance

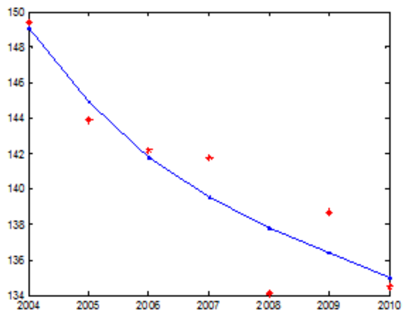
The result of D-value:
The result of variance:
On the other part, figures are also drawn to see the trend. As the variance means the discrepancy between the the data matching value and the original data value, the lower the variance is, the better fitting curve is. The figures below show some of the provinces from 2013 to2025.
According to the calculated parameter for each term ,it is easy to get predicted values from the year 2013 to 2025.The result is showed below:



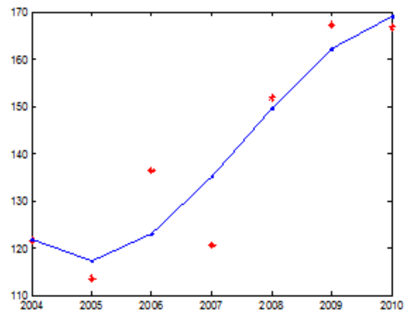
Xinjiang(δ =0.0003)



Beijing(δ =0.0003)



Inner Mongolia(δ =0.0797)

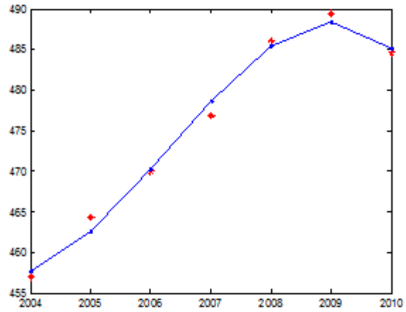


Anhui(δ =1.3586)

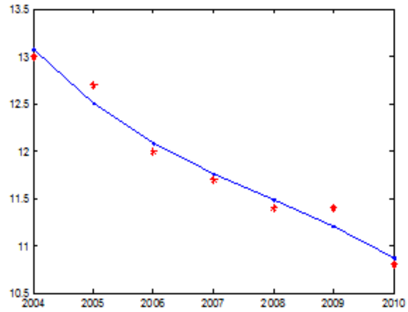
The program of matlab is liseted in appendix.

1. Agriculture Water

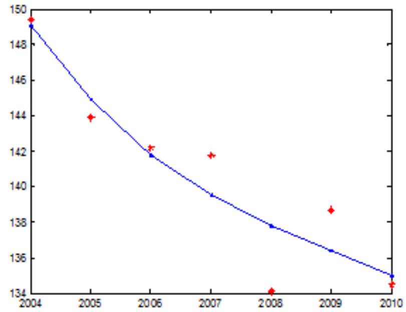
The work done is the same as in industrial water. Here we only list the matching value of parameters and the predicted data for all provinces from 2013 to 2025.
The figure of the data matching values which show some of the provinces from 2013 to2025 is listed as follows:



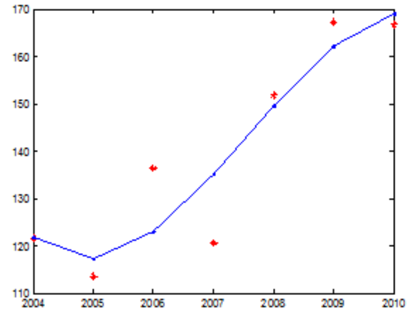
Xinjiang(δ =0.0003)



Beijing(δ =0.0003)



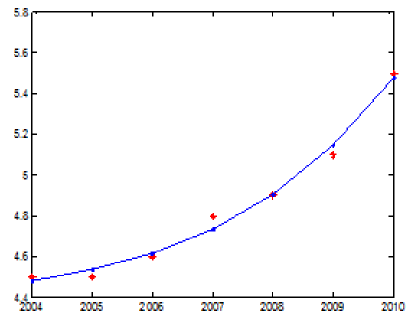
Inner Mongolia(δ =0.0797)



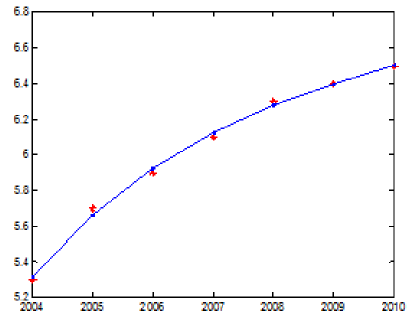
Anhui(δ =1.3586)

1. Water Demand in Households

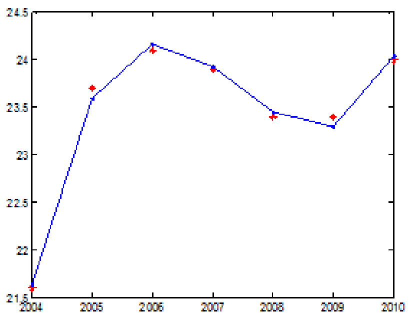
The work done is the same as in industrial water and agriculture water .What listed below is the matching value of parameters ,the predicted data for all provinces from 2013 to 2025 and the figure of the data matching values which show some of the provinces.
The picture of the data matching values which show some of the provinces from 2013 to2025 is listed as follows:
The figures:



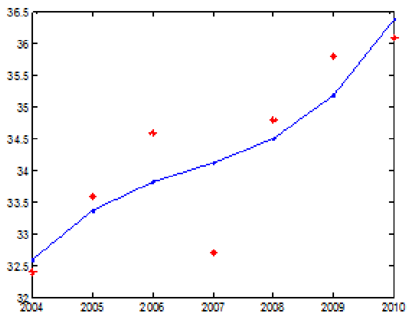
Tianjin (δ =0)



Hebei (δ =0.0001)



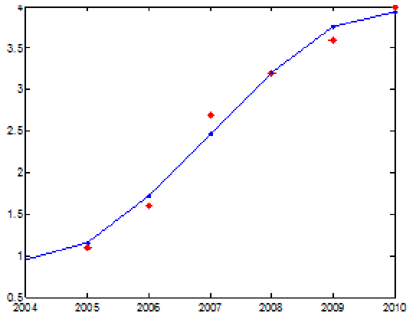
Henan (δ =0.0101)



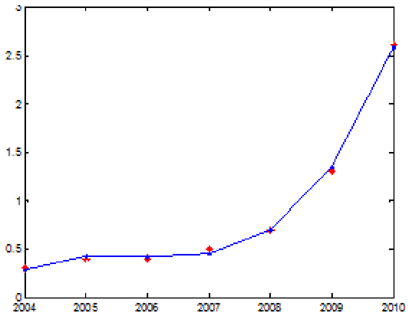
Hainan (δ =0)

1. Ecological Water Use

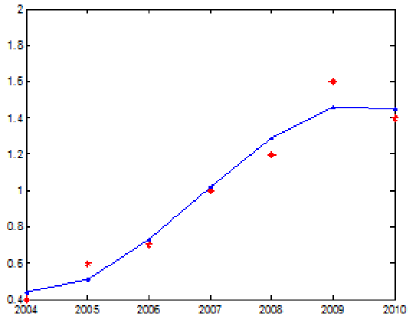
The work done is the same as in industrial water,agriculture water and water demand in households.What listed below is the matching value of parameters,the predicted data for all provinces from 2013 to 2025 and the figure of the data matching values which show some of the provinces.
The figures:



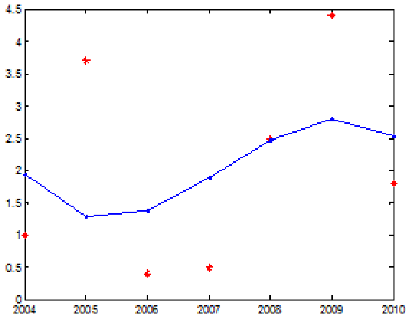
Beijing (δ =0.0003)



Shanxi (δ =0)



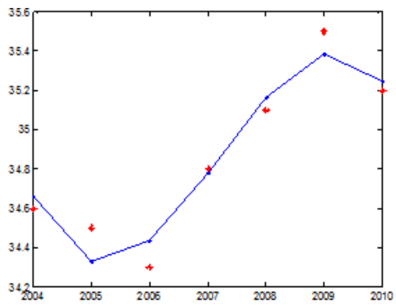
Ningxia (δ =0.0001)



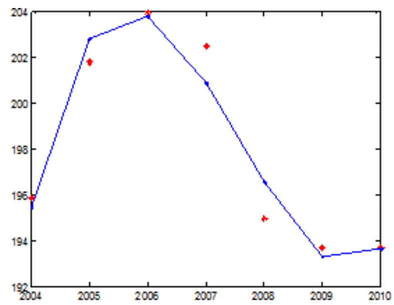
Heilongjiang (δ =0.0392)

1. Total Water Use

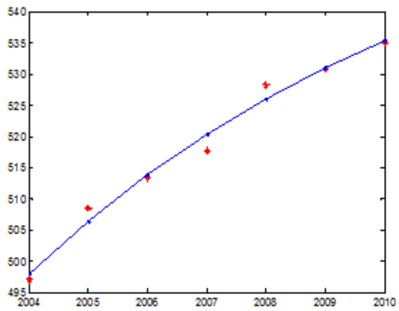
The work done is the same as in industrial water,agriculture water,water demand in households and ecological water use.What listed below is the matching value of parameters,the predicted data for all provinces from 2013 to 2025 and the figure of the data matching values which show some of the provinces.
The figures:



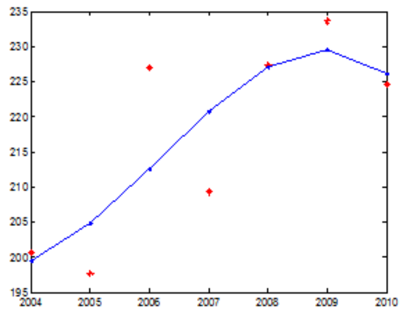
Beijing (δ =0.0002)



Hebei (δ =0.02)



Xinjiang (δ =0.0292)



Henan (δ =1.2442)

4.4.2 The Prediction for the water supply

As to predict the water supply, we get data from the website of National Bureau of Statistics of China as well. Like the part of above, as the data on the website is similar in the years of 2011 and 2010, we use the data of 2010.
In the same way, the prediction is classified in three sorts, surface water, underground water and total water supply.
Compared to the demand of water use, the water supply changes smoothly as it won't affected sharply by natural factor. Human factor doesn't taken into consideration in this model. Consequently, we predict the data by the way of data matching in linear programming. Emphasis:As there is plenty of data for each sort to predict, the basic thought is similar to the demand of water use.Thus, we only show the final data and figures.

1. Surface water

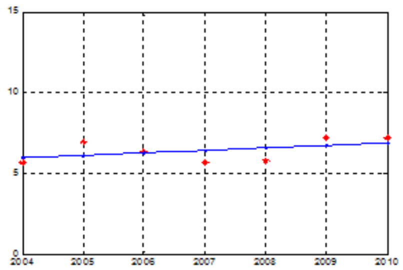
The work done for calculation is similar to the prediction for water supply. The only part changed in the matlab's program is that the parameter of polyfit(a function in matlab)changed from 3 to 1.

$$[p(n,:)s(n,:)] = polyfit(X\_new, A(n,:), 3) \rightarrow [p(n,:)s(n,:)] = polyfit(X\_new, A(n,:), 1) \quad (3)$$

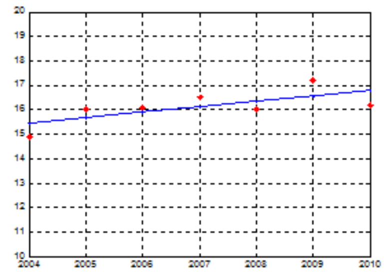
In terms of linear programming, the formula of data matching values is changed into:

$$\Phi = cX + d \quad (4)$$

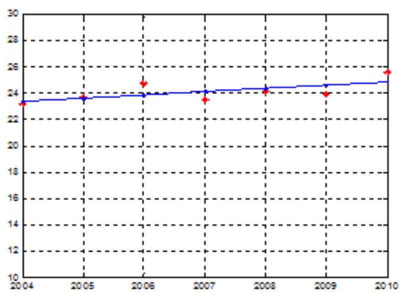
The results are as follows:
The figures are:



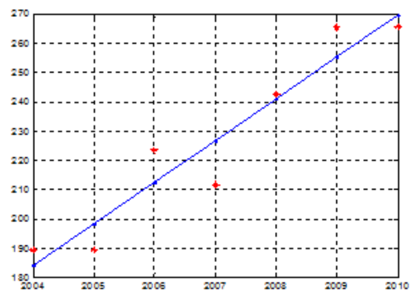
Beijing



Tianjing



Qinghai

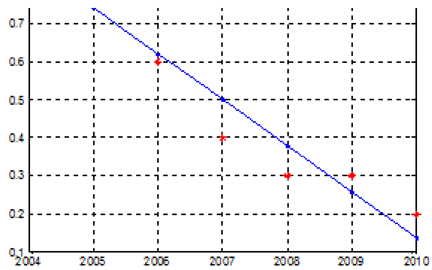


Anhui

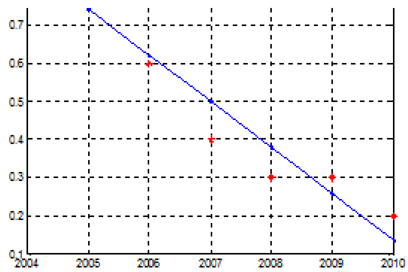
The program of matlab is liseted in appendix.

1. Underground Water

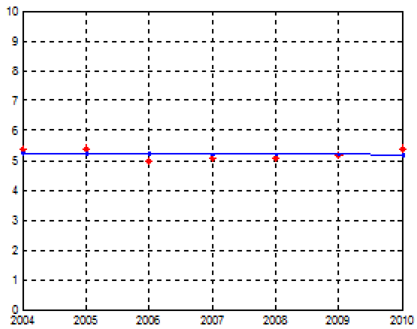
The work done is the same as surface water.What listed below is the matching value of parameters,the predicted data for all provinces from 2013 to 2025 and the figure of the data matching values which show some of the provinces.
The figures are:



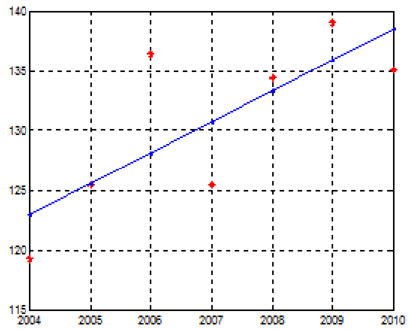
Shanghai



Zhejiang



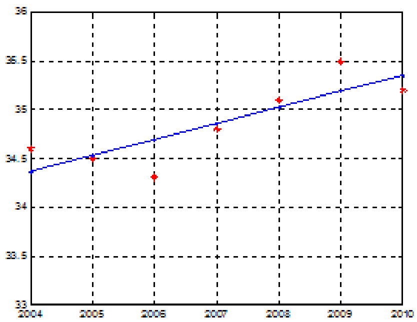
Henan



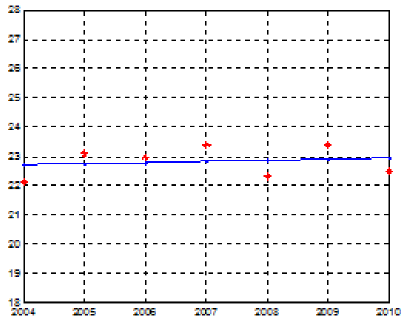
Xinjiang

1. Total Water Supply

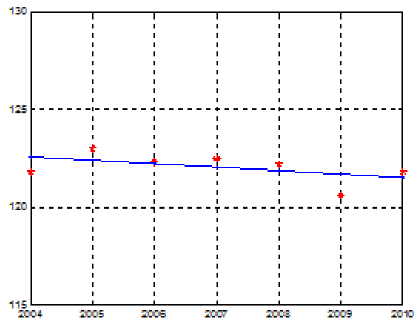
The work done is the same as surface water and underground water .What listed below is the matching value of parameters,the predicted data for all provinces from 2013 to 2025 and the figure of the data matching values which show some of the provinces.
The figures are:



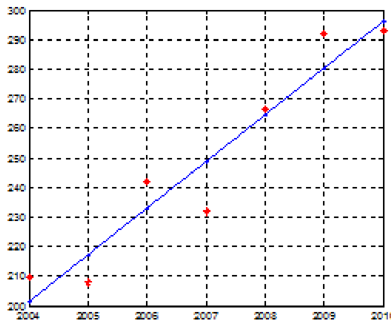
Beijing



Tianjin



Anhui



Gansu

4.5 The Prediction of the cost on Sea Water Desalination

Obviously, sea water desalination is an effective way to relieve the pressure of shortage of fresh water. Therefore, the cost on it has been the most concerned question of everybody. On account of the price of tap-water, the cost of sea water desalination can't be expensive. The cost has many influencing factors like method, technological design, energy consumption, fresh water quality, geography and so on [1]. With the development of technology, the cost has been lower and lower. Normally the cost of SWRO is 5000-6000 Yuan per m3• d, the composite cost is 4.5-5.5 Yuan per m3, when the cost of distillation sea water desalination is 7000-12000 Yuan per m3• d, the composite cost is 5-7 Yuan per m3 [2].So we will choose SWRO to supply more fresh water in the future. From now on to 2025, we can define the cost of sea water desalination as 5 Yuan per m3.

4.6 The Prediction of the throughput of Sea Water Desalination

4.6.1 The throughput of Sea Water Desalination

In this paper, we choose the throughput to be the standard of sea water desalination. The table below shows the throughput of sea water desalination from year 2002 to 2007, then we can use data matching to deal with them and get the law.

year	2002	2003	2004	2005	2006	2007
throughput m^3/d	1750	11660	5650	36480	50304	86420

By data matching, we get the law as follow: y=1666*exp (0.566*x), then we can predict the throughput from 2013 to 2025, here is the prediction table:

year	2008	2009	2010	2011	2012	2013
throughput	154227.0001	271625.8434	478389.6385	842543.7113	1483894.818	2613447.588
year	2014	2015	2016	2017	2018	2019
throughput	4602825.089	8106532.878	14277291.45	25145281.5	44286073.73	77996992.23
year	2020	2021	2022	2023	2024	2025
throughput	137368935.3	241935283	426098382.6	750447927.4	1321694976	2327779912

4.6.2 Water Demand Budget

Sea water desalination can fill the short of fresh water resources, therefore the budget of water demand can be calculated by subtraction formula:

$$\text{Water Demand Budget} = \text{water use-water supply}$$

Here we give the table of the Water Demand Budget:

4.7 The Growth of the Population

In consideration of the population, the total water use can be different. In the coming years till 2025, the population of china will be grown. In this case, we need to revise our model.

4.8 Allocation of Water Recourses Model

1. Node

We define the node as every province and ocean. The attribute of the node includes the follow aspects:

- Available water recourses(limited)
- Recycled water recourses(<40% available fresh water)
- Available seawater recourses(the throughput of seawater recourses in coastal cities is unlimited)
- Desalinated seawater recourses(the total throughput is invariable)
- All the water demand
- The industrial water demand
- Population

Then we can get:

$$Waterstorage = Allthewaterrecourses*(1+utilizationfactor)Availablewaterrecourses = freshw \tag{5}$$

1. Line

The cost of transportation in water recourses and the affinity of water in different provinces.
The attribute of the line includes:

- Relationship between the provinces
- Available seawater recourses
- Available fresh water recourses

1. Complex network

By the means we can get an complex network, and we describe it with adjacent matrix.

- Relationship between the provinces
- Available seawater recourses
- Available fresh water recourses

1. Parameter of water recourses: fresh water recourses (from the model) sea water

1. Model

- Each nodes has two kinds of transportation in water recourses: seawater, fresh water, the price of them is of the same:

$$Price = 0.00083 * waterdistance + 0.0287 * waterheight \tag{6}$$

- The water use of each city can be got from predicted model. Ocean can be a peculiar node. It can supply water to coastal cities without distance but water height. It has its own cost to supply water to coastal cities.

The array for the price of sea water

$$MTsea = \begin{bmatrix} ms_{1,1} & ms_{1,2} & \cdots & ms_{1,32} \\ ms_{2,1} & ms_{2,2} & \cdots & ms_{2,32} \\ \vdots & \vdots & \ddots & \vdots \\ ms_{32,1} & ms_{32,2} & \cdots & ms_{32,32} \end{bmatrix}. \tag{7}$$

The array for the transportation of fresh water

$$PRsea = \begin{bmatrix} ps_{1,1} & ps_{1,2} & \cdots & ps_{1,32} \\ ps_{2,1} & ps_{2,2} & \cdots & ps_{2,32} \\ \vdots & \vdots & \ddots & \vdots \\ ps_{32,1} & ps_{32,2} & \cdots & ps_{32,32} \end{bmatrix}. \tag{8}$$

The array for the price of fresh water

$$MTfresh = \begin{bmatrix} mf_{1,1} & mf_{1,2} & \dots & mf_{1,32} \\ mf_{2,1} & mf_{2,2} & \dots & mf_{2,32} \\ \vdots & \vdots & \ddots & \vdots \\ mf_{32,1} & mf_{32,2} & \dots & mf_{32,32} \end{bmatrix}. \tag{9}$$

The array for the price of fresh water

$$W = \sum_{i=1}^{32}\sum_{j=1}^{32}(ms_{i,j} * ps_{i,j} + mf_{i,j} * pf_{i,j}) \tag{10}$$

The constraints

$$SumFresh = \sum_{i=1}^{32} mf_{32,i} \tag{11}$$

for any k,next two formulas should be coincident

$$\sum_{i=1}^{32} mf_{i,k} - \sum_{j=1}^{32} mf_{k,j} + \sum_{i=1}^{32} ms_{k,j} \geq waterConsume - waterSource * percentage \tag{12}$$

$$\sum_{i=1}^{32} ms_{i,k} - \sum_{j=1}^{32} ms_{k,j} \leq industryWaterConsume \tag{13}$$

5 Strength and Weakness

5.1 The Model for Prediction

5.1.1 Strength

1. For the prediction of water supply, we forcast it from 5 aspects to make the prediction convincing and accurate .As water supply is affected by many factors both in natural factor and human factor, the data matching is set in high order. After testing, we set the order 3. In the order 3, the degree of fitting of the curve is much more higher.

2. For the prediction of water use, since it is regular and won't influenced by other factors, it is predicted in linear programming. The linear first-order algebraic expression is considerable and convincing.

3. In terms of the model of population growth, it is authoritative and uncontroversial and it is useless to make further researching.
4. As the model of sea water desalination prediction, although it is immature, according to the objective laws of the cost of high-tech products, it is set reasonably in some ways.

5.1.2 Weakness

The data calculated in the models is found from the website, and it is quite limited. In this way, the model won't accurate as expected.

5.2 The Model for Water Movement and conservation

5.2.1 Strength

1. Both movement and conservation related closely are considered together, which tally with the actual situation.
2. In the model, the whole country is processed into provinces and sea. On the one hand, it is reasonable in actual situation. On the other hand, it is easy to get the trends of movement, and carried out later on.
3. The model takes the method of linear programming. Therefore, optimal solution will be guaranteed.
4. In the model, the altitude is dealt from the different aspects. Due to the direction of movement, the cost in transportation is different. It is reflected in our actual situation.
5. Take big drainage basins into consideration. China has 7 drainage basins, the area size of the drainage basins is different. Since the price of movement in the same drainage basin is lower than that between different drainage basins, take big drainage basins in consideration and ignore the small ones will make the model and calculation much simpler. In addition, the consequence for neglect won't make a significant impact.

5.2.2 Weakness

1. The area of provinces is different from one to another.

2. The treatment of the drainage basins is too simple in some way.
3. The movement between areas in different altitudes is hard for prediction.

5.3 The Model for Sea Water Desalination

5.3.1 Weakness

1. The places for desalination are unfixed (Set in coastal provinces).
2. The need for sea water desalination is uncertain.
3. Sea Water Desalination affected by natural factors heavily.

6 Model Evaluation

6.1 Evaluation Function of Recycled Water

In the way of sea water desalinization then we get recycled water. However, to make full use of it we need to grading it. In the view of physical truth, we give the classification as follow:

- cities whose water resources is rich(water resources/ water use >2) : utilizable ratio is 10%;
- cities whose water resources is poor(1<water resources/ water use <2) : utilizable ratio is 20%;
- cities whose water resources is seriously poor(water resources/ water use<1): utilizable ratio is 35%;

by means of evaluation function, we can see the condition of each cities clearly, this will do good for our model.

References

[D. E. KNUTH] D. E. KNUTH The TEXbook the American Mathematical Society and AddisonâĂŞWesley Publishing Company , 1984-1986.

[1] Lamport, Leslie, LaTeX: " A Document Preparation System ", Addison-Wesley Publishing Company, 1986.

Appendices

Here are simulation programmes we used in our model as follow.

Appendix A First appendix

Input matlab source:

```
clc
clear
%The source of the data
%Change the filename when running the program
A =load('5.txt');
X=[2004 2005 2006 2007 2008 2009 2010];
X_new = (X-mean(X,2))/std(X);
for n=1:1:31
[p(n,:) s(n,:)]= polyfit(X_new ,A(n,:),1);p,s
[z(n,:) delta(n,:)]=polyval(p(n,:),X_new,s(n,:));z,delta
error(n,:)= var(delta(n,:));error
plot(X,A(n,:),'r+',X,z(n,:),'b*:','Linewidth',3);
%It is used to adjust the  window
%axis([2004 2010 33 37]);
grid on;
end
```

Appendix B Second appendix

Input matlab source:

```
clc
clear
%The source of the data
%Change the filename when running the program
A =load('9.txt');
X=[2004 2005 2006 2007 2008 2009 2010];
X_new = (X-mean(X,2))/std(X);
for n=1:1:29
```

```
[p(n,:) s(n,:)]= polyfit(X_new ,A(n,:),3);p,s
[z(n,:) delta(n,:)]=polyval(p(n,:),X_new,s(n,:));z,delta
error(n,:)= var(delta(n,:));error
plot(X,A(n,:),'r+',X,z(n,:),'b*:','Linewidth',3);
%It is used to adjust the  window
axis([2004 2010 20 30]);
grid on;
end
```