Monitoring, Assessment, Prediction and Meteorological service of Agricultural Drought in China

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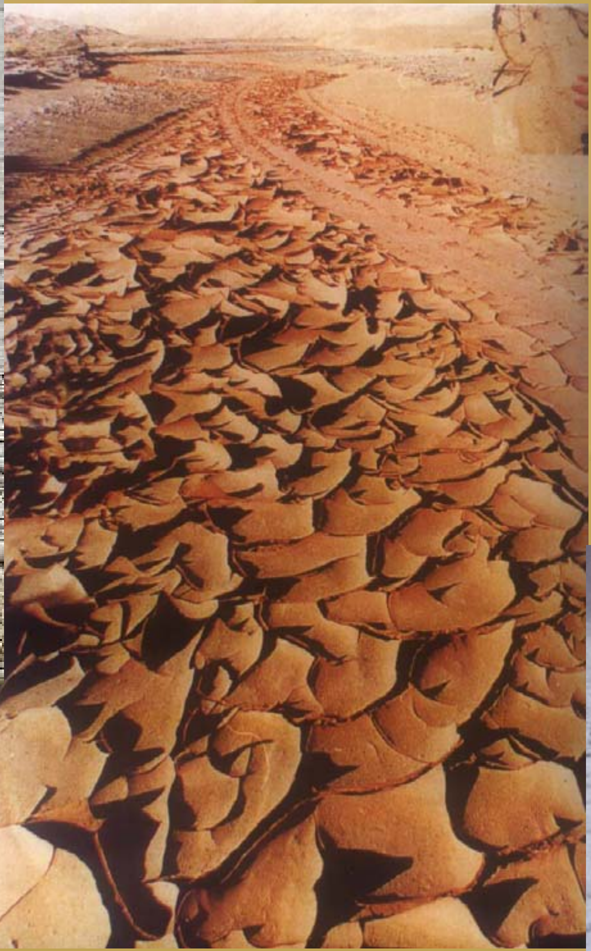
Content

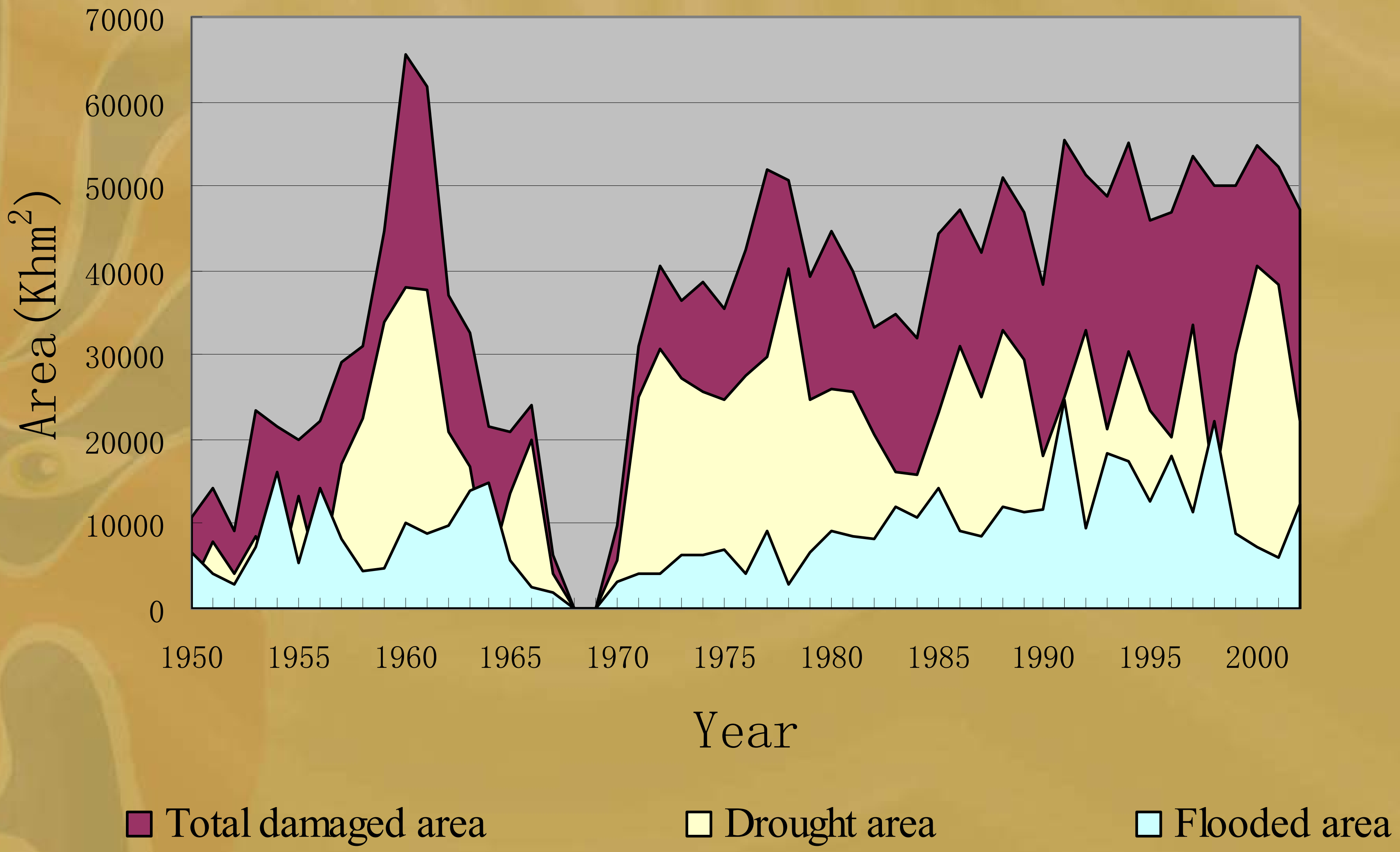
- Characteristics of agrometerological Drought
- Monitoring of Drought
- Risk Assessment of Agricultural Drought
- Prediction of Agricultural Drought
- Meteorological Service for *Mitigating* Agricultural Drought
- Conclusions

Drought is one of the most severe meteorological disasters



With characteristic of slow development, long duration, wide *stricken* area and severity.

Significant impact on hydrology, agriculture, eco-environment, economy and society



Compared with average in 1950-1990, drought damaged areas increased 33%, flood damaged areas increased 89% in 1990-2000

(1) Characteristics of Agro-meteorological Drought in China

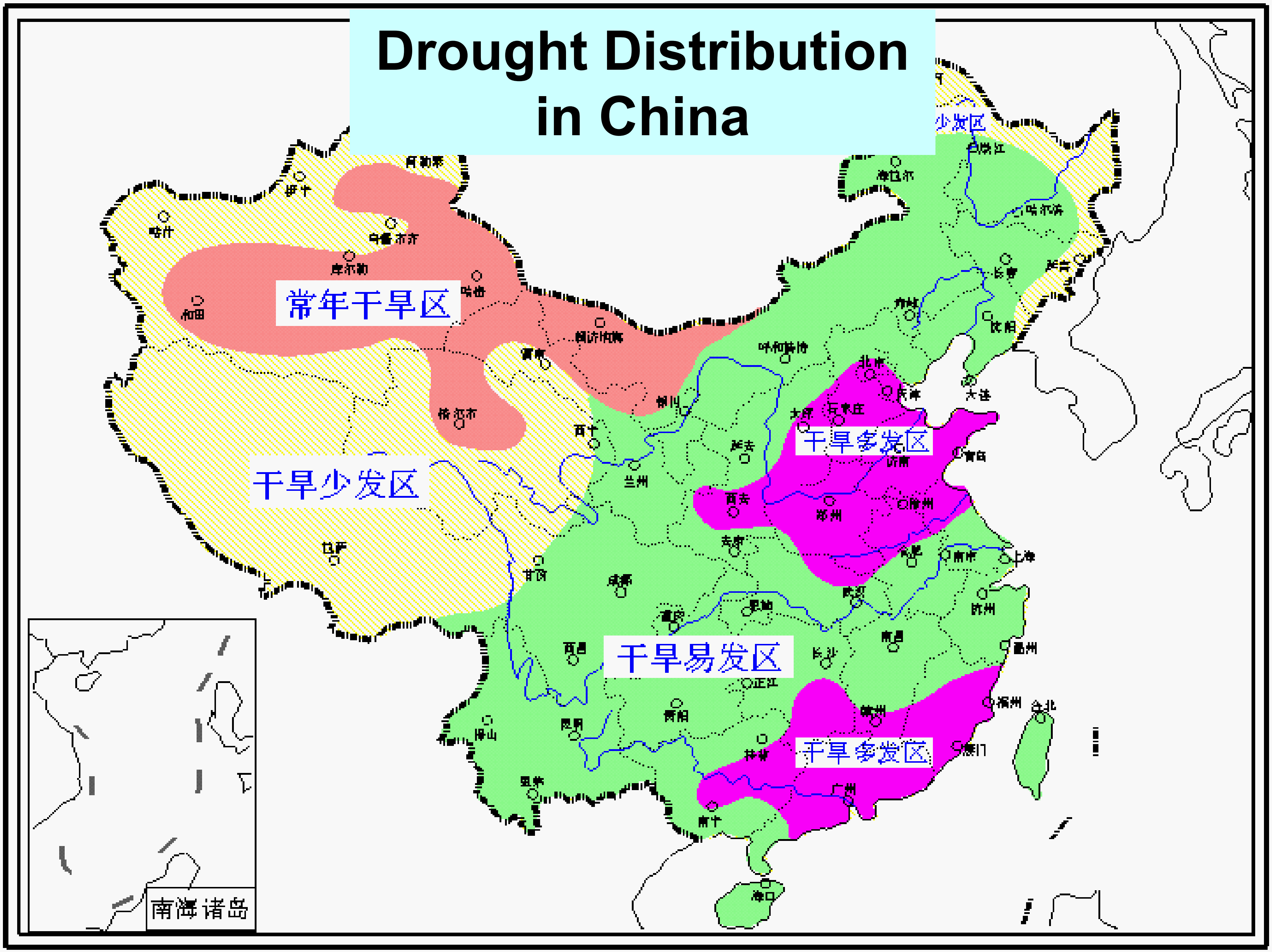
Seasonal and Regional Feature:

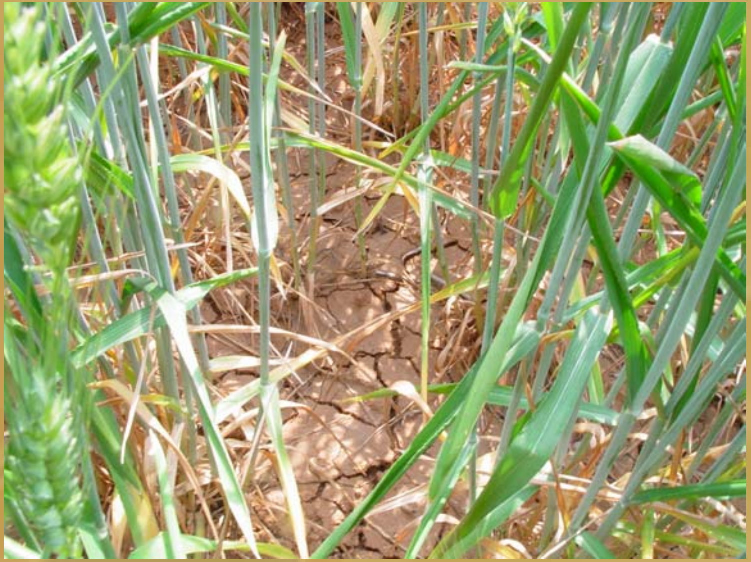
- Large territory
- Different climate type (spatial and temporal distribution of precipitation, variability)
- Various agriculture style (crop varieties, cropping system, water requirement)
- Different water supply conditions for agricultural crops

Type of agricultural drought

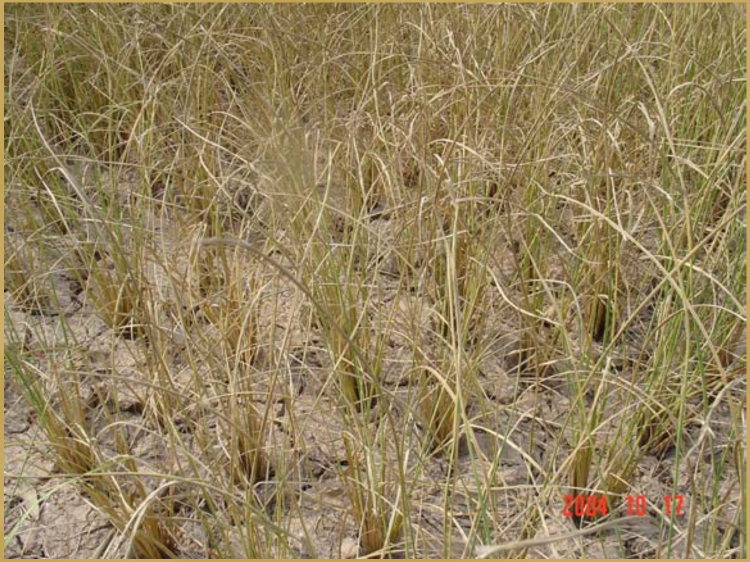
- **Spring drought of winter wheat in North China**
- **Summer drought of rice in southern China**
- **Summer drought of autumn-matured crops**
- **Autumn drought of rice in southern China and drought in sowing period of winter wheat in North China**
- **Winter drought of over-winter crops in South China**

Drought Distribution in China

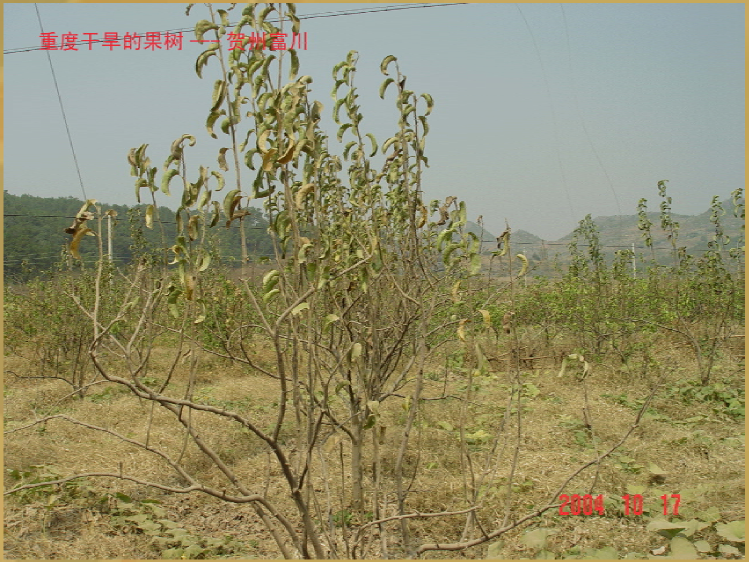

常年干旱区
干旱少发区
干旱易发区
干旱多发区
干旱多发区
少发区
南海诸岛
阿勒泰
伊宁
喀什
乌鲁木齐
库尔勒
和田
哈密
格尔木
西宁
兰州
拉萨
甘孜
成都
银川
延安
呼和浩特
海拉尔
嫩江
哈尔滨
长春
延吉
沈阳
大连
北京
天津
石家庄
太原
济南
青岛
西安
郑州
徐州
南京
上海
合肥
武汉
杭州
南昌
长沙
温州
福州
台北
厦门
赣州
广州
南宁
桂林
海口
重庆
宜昌
西昌
贵阳
昆明
保山
思茅
芷江



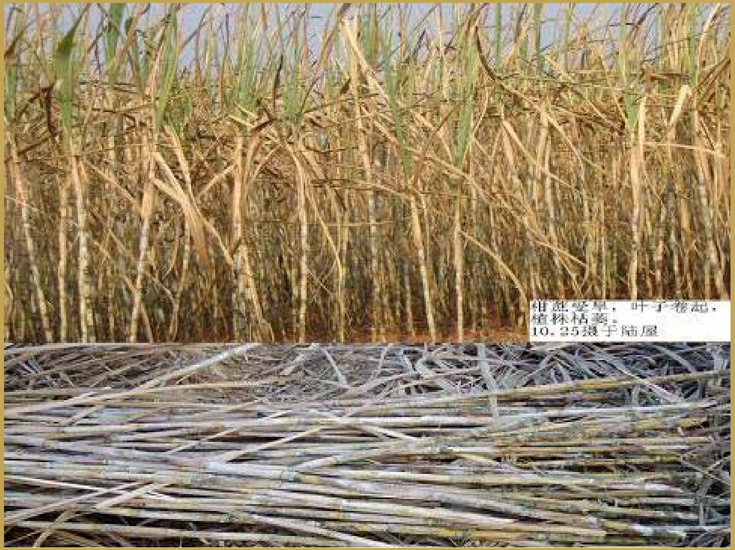
Wheat, MAY. 2004 Henan



Rice, 17,Oct. 2004 Guangxi


重度干旱的果树 —— 贺州富川
2004 10 17

Fruit trees, Oct. 2004 Guangxi

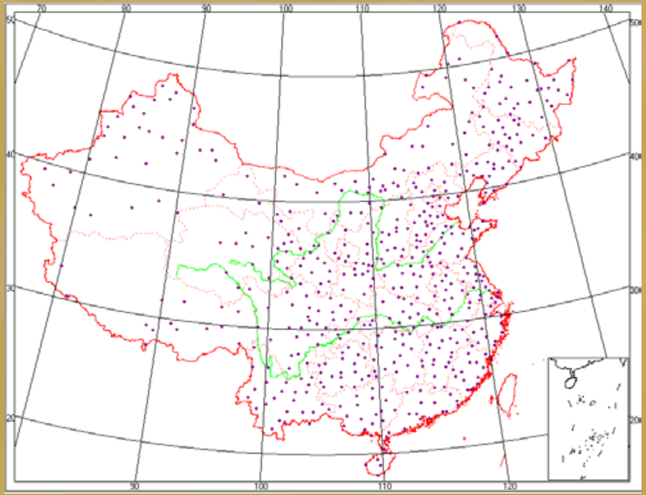

甘蔗受旱，叶子卷起，
植株枯萎。
10.25摄于陆屋

Sugar cane, 25,Oct. 2004 Guangxi

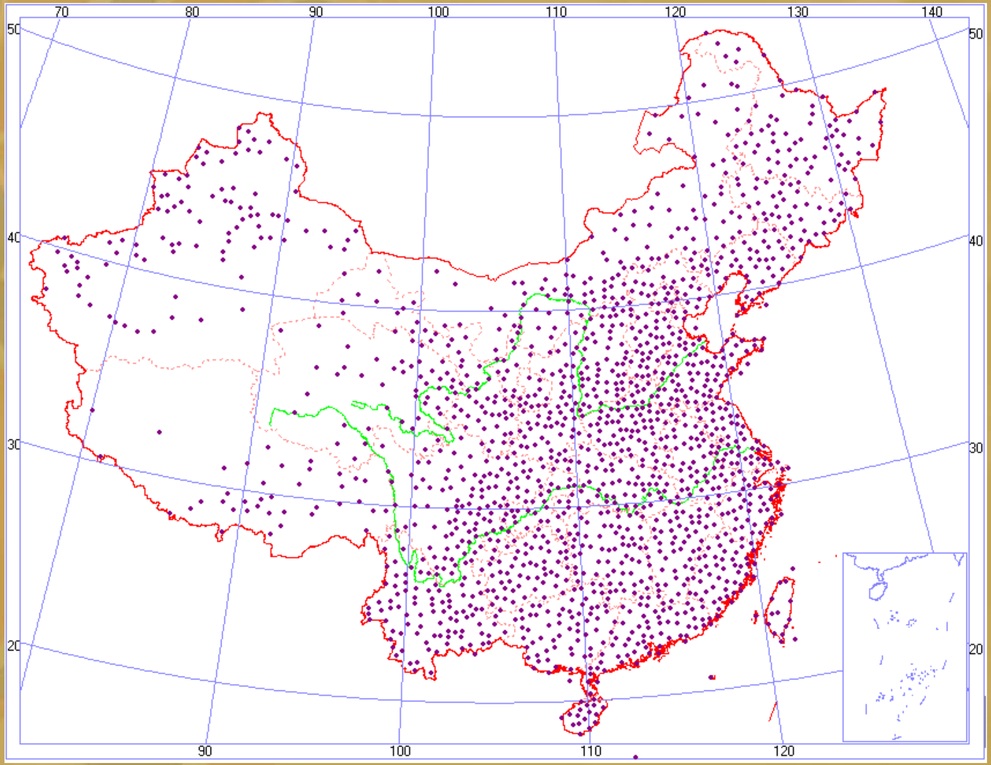
(2) Monitoring of Drought

- Drought Monitoring based on Station Network
- Drought Monitoring Using Remote Sensing Technique
- Experimental site aiming at agricultural drought

Drought Monitoring based on Station Network


70
80
90
100
110
120
130
140
50
40
30
20

Agro-meteorological Stations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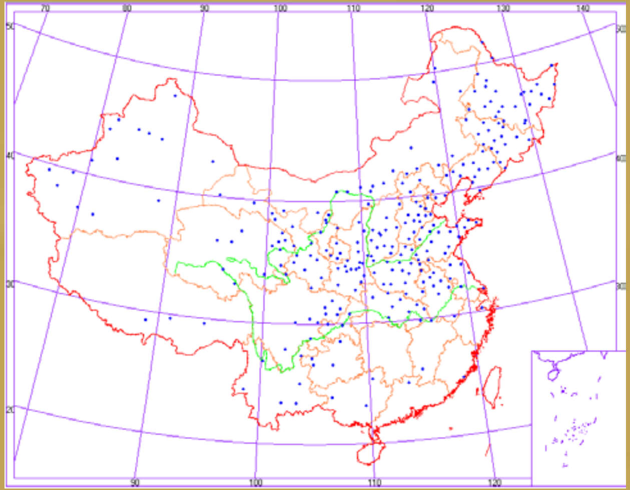
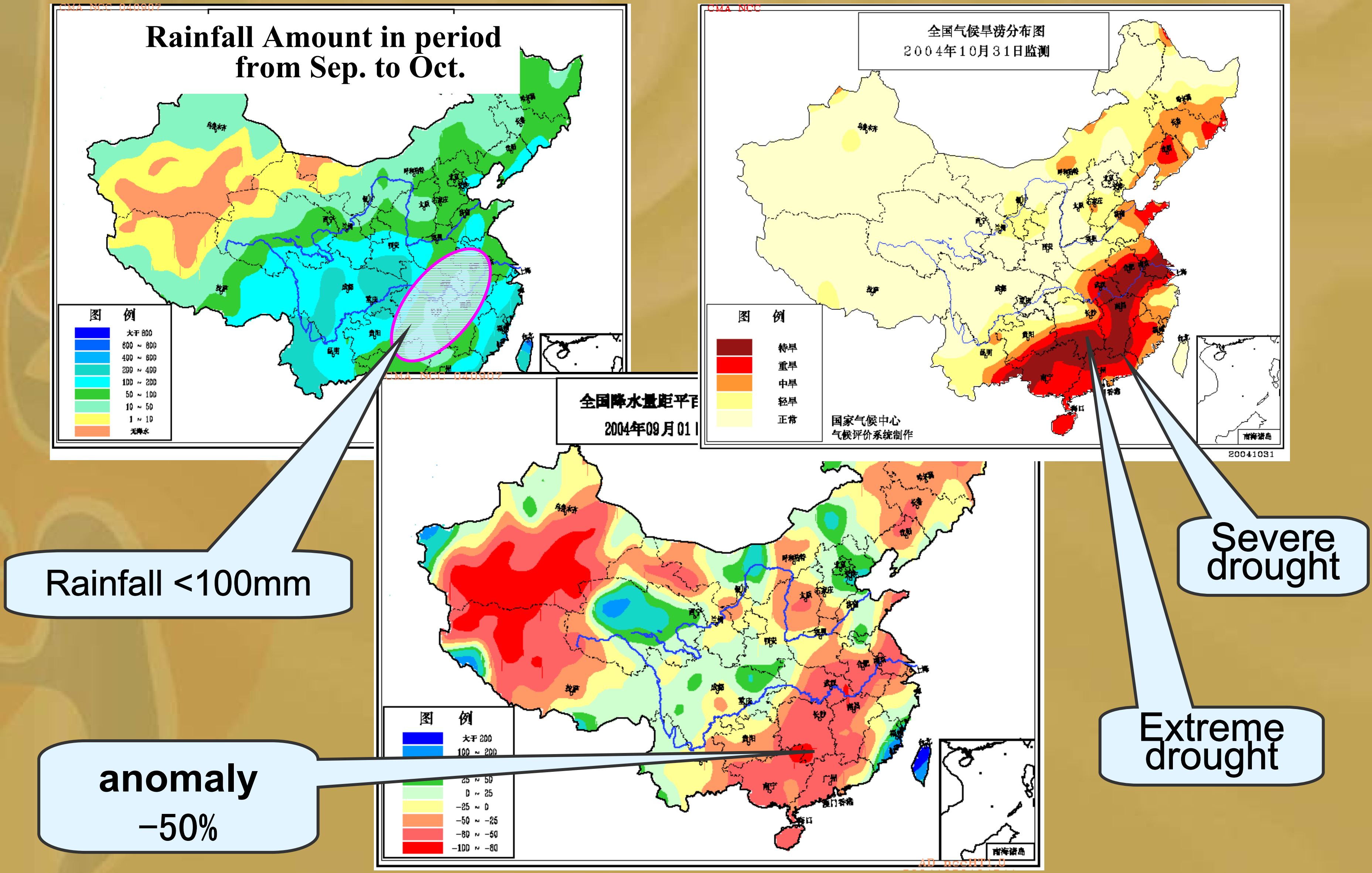
90
100
110
120

Weather Stations in China


70
80
90
100
110
120
130
140
50
40
30
20

Soil Moisture Observation Stations

Precipitation, abnormality, drought index from Sep. to Oct. 2004


Rainfall Amount in period from Sep. to Oct.
CMA NCC 040907
图 例
大于800
600 ~ 800
400 ~ 600
200 ~ 400
100 ~ 200
50 ~ 100
10 ~ 50
1 ~ 10
无降水
CMA NCC
全国气候旱涝分布图
2004年10月31日监测
图 例
特旱
重旱
中旱
轻旱
正常
国家气候中心
气候评价系统制作
南海诸岛
20041031
全国降水量距平百
2004年09月01
图 例
大于200
100 ~ 200
25 ~ 50
0 ~ 25
−25 ~ 0
−50 ~ −25
−80 ~ −50
−100 ~ −80
南海诸岛

Rainfall <100mm

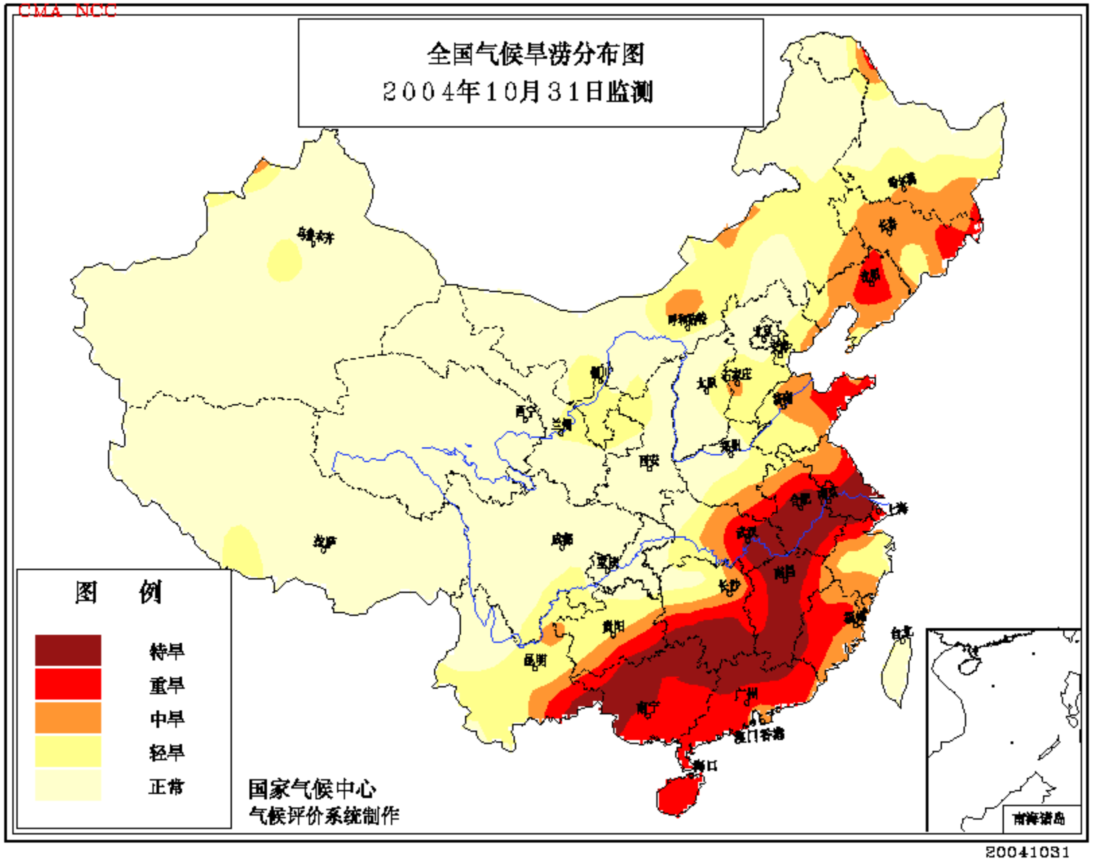
anomaly

−50%

Severe drought

Extreme drought

Drought Evolution in October, 2004



CMA NCC

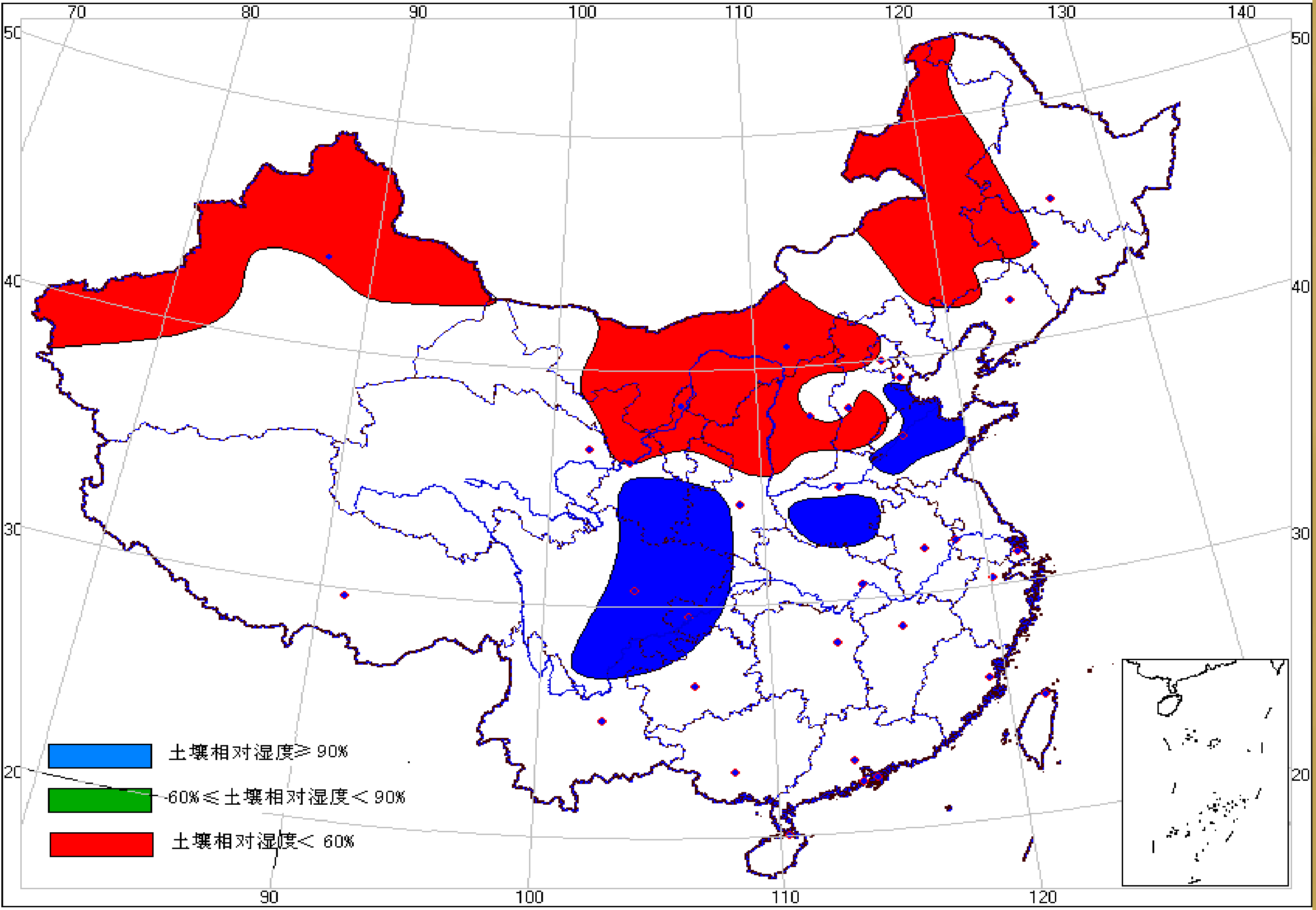
全国气候旱涝分布图
2004年10月31日监测

图 例
🟥 特旱
🟥 重旱
🟧 中旱
🟨 轻旱
⬜ 正常
乌鲁木齐
哈尔滨
长春
沈阳
呼和浩特
北京
天津
石家庄
太原
济南
银川
西宁
兰州
郑州
西安
拉萨
成都
重庆
武汉
合肥
南京
上海
杭州
长沙
南昌
福州
台北
贵阳
昆明
南宁
广州
澳门
香港
海口
南海诸岛

国家气候中心
气候评价系统制作

20041031

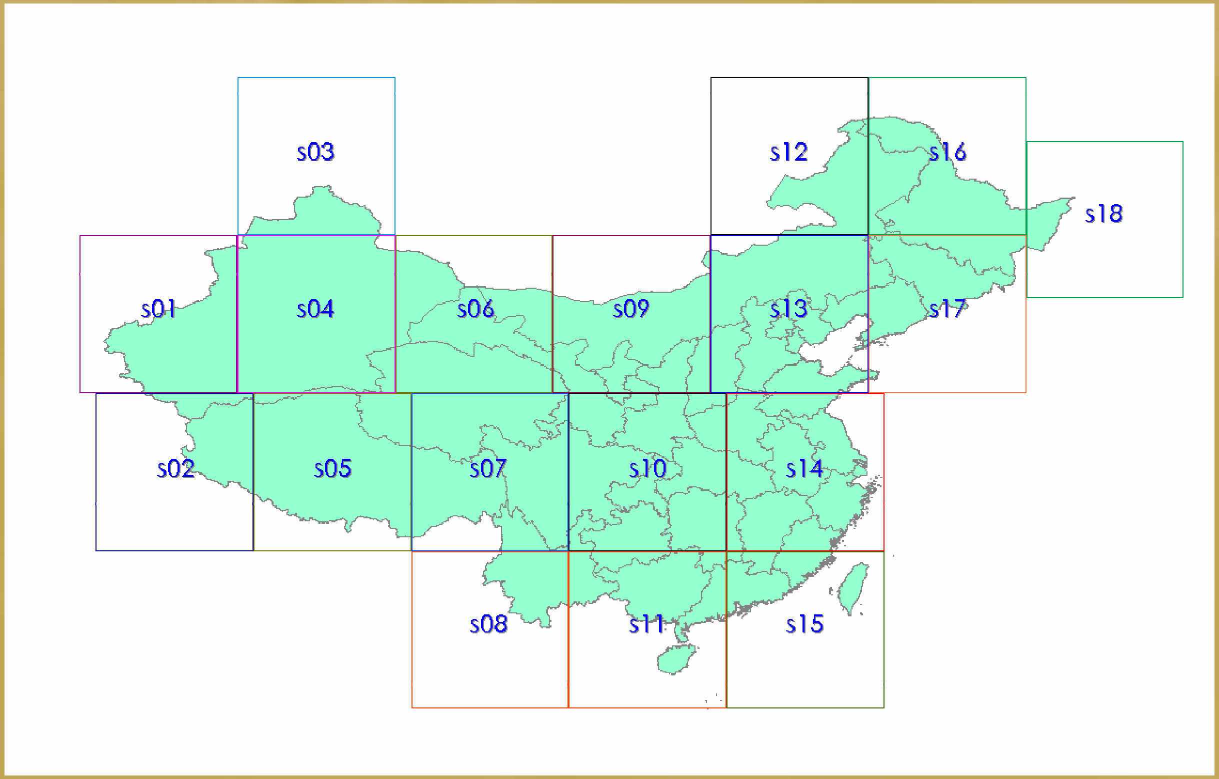
Drought Monitoring according to Soil Moisture Observation on 1, October, 2004


70
80
90
100
110
120
130
140
50
40
30
20
🟦 土壤相对湿度≥ 90%
🟩 60%≤土壤相对湿度< 90%
🟥 土壤相对湿度< 60%
90
100
110
120

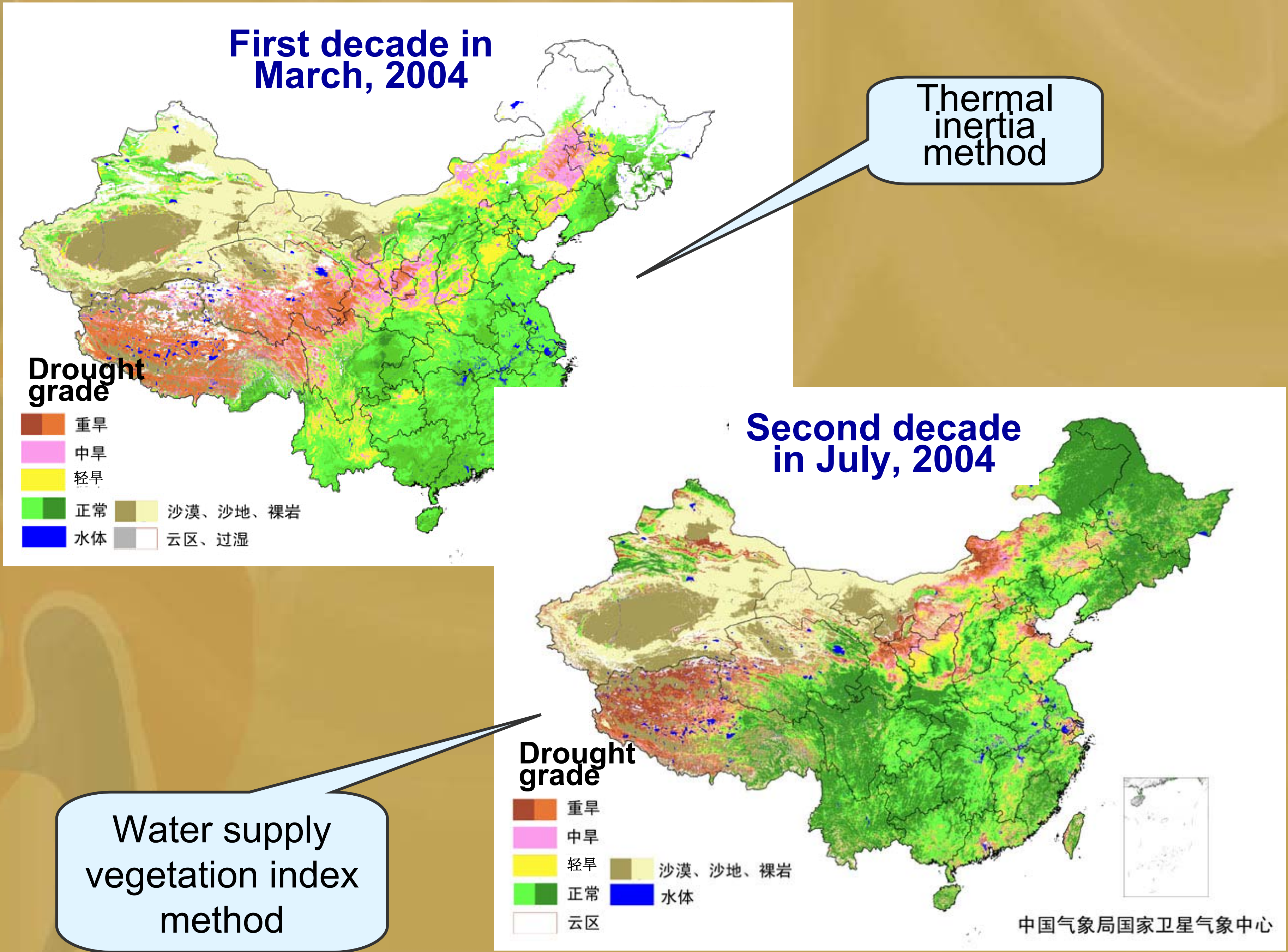
Relative soil moisture >90%, 60%-90%, <60%

Drought Monitoring Using Remote Sensing Technique

Drought Monitoring in nationwide using polar orbit satellite data has been put into routine operation in CMA since 2002.


s03
s12
s16
s18
s01
s04
s06
s09
s13
s17
s02
s05
s07
s10
s14
s08
s11
s15

Data source: NOAA-16
polar orbit meteorological satellite
Coverage: nationwide,18 areas
Period: every 10 days



First decade in March, 2004

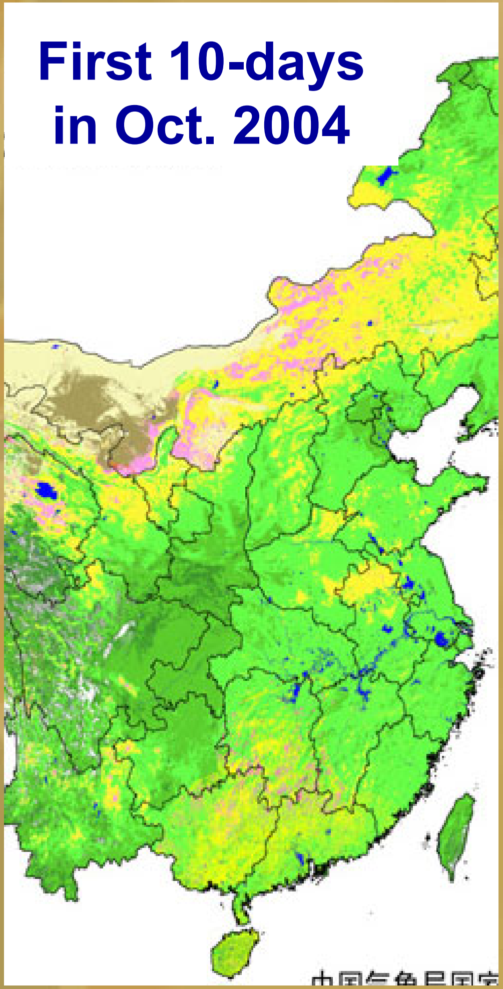
Second decade in July, 2004

Drought grade
重旱
中旱
轻旱
正常
沙漠、沙地、裸岩
水体
云区、过湿
Drought grade
重旱
中旱
轻旱
沙漠、沙地、裸岩
正常
水体
云区
中国气象局国家卫星气象中心

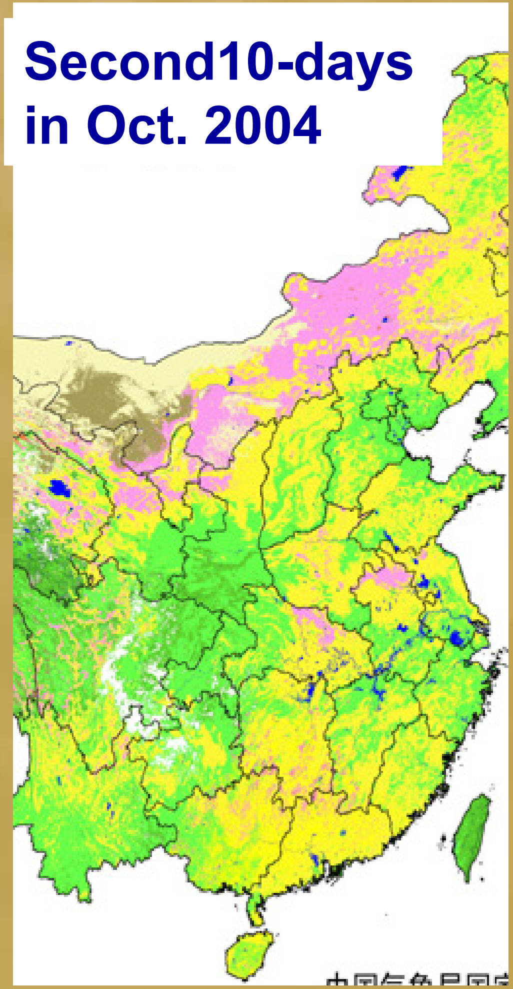
Thermal inertia method

Water supply vegetation index method

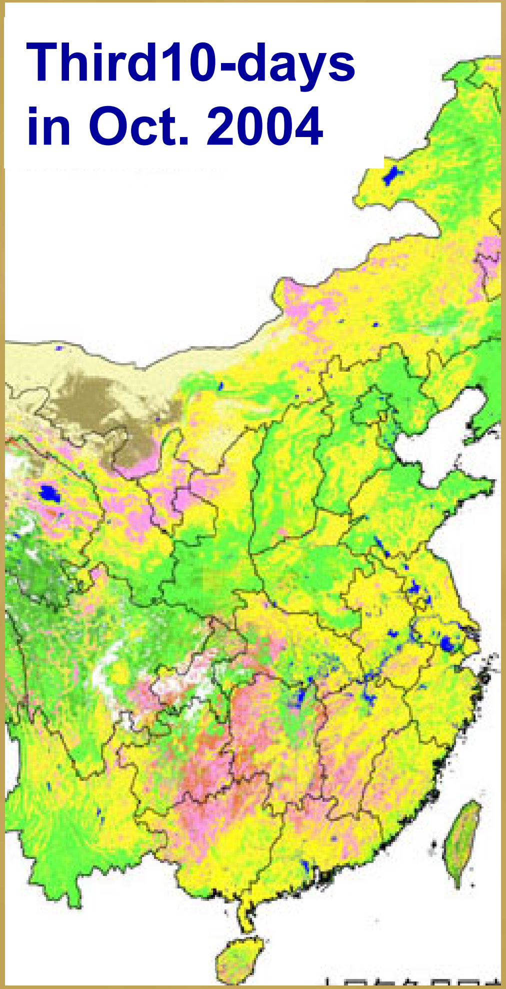
Dynamic monitoring of drought in October, 2004



First 10-days
in Oct. 2004



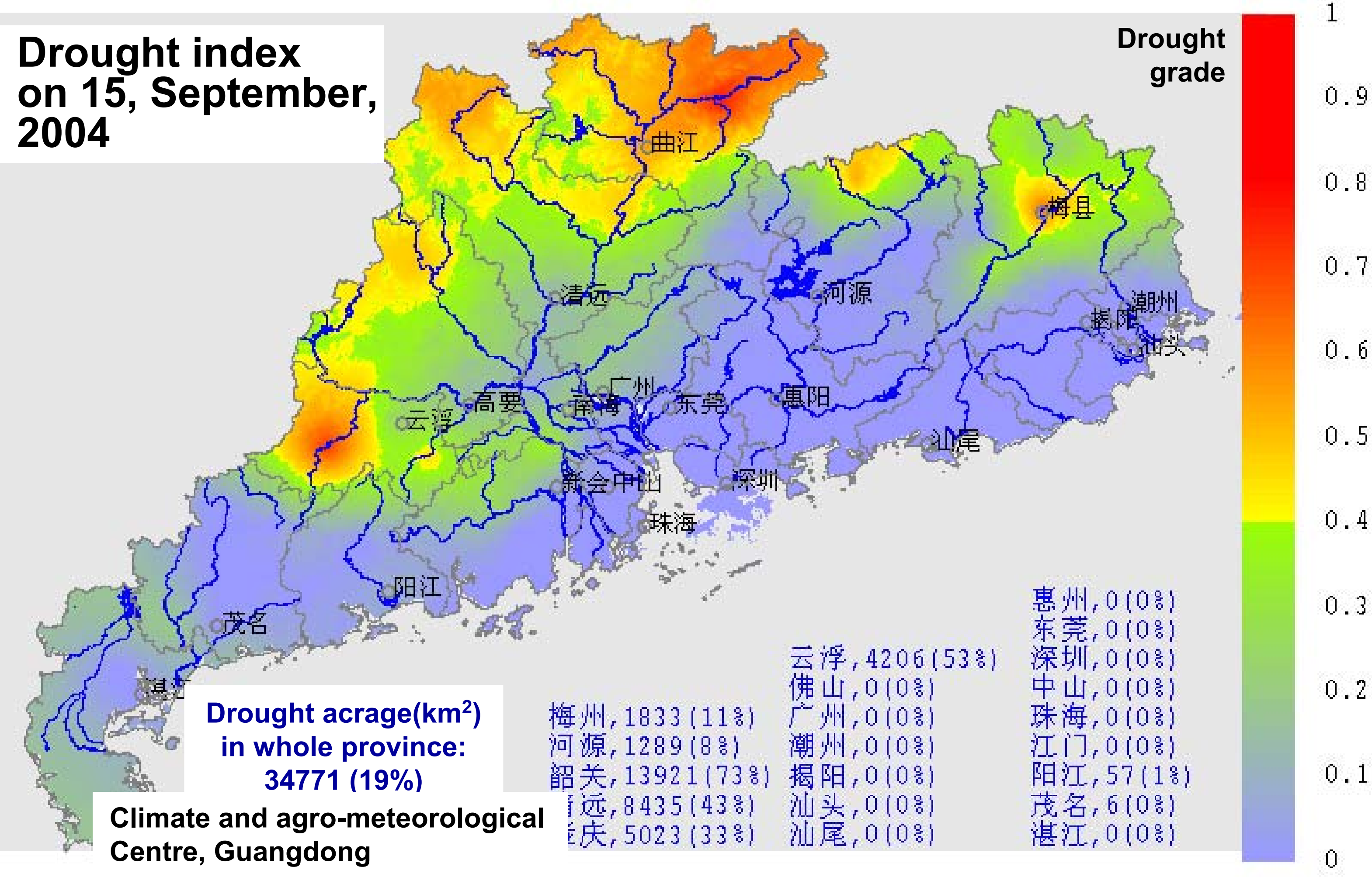
Second10-days
in Oct. 2004



Third10-days
in Oct. 2004

The drought in southern China developed and expanded quickly since October.

Drought Monitoring and Assessment using GIS



Drought index on 15, September, 2004

Drought grade
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
曲江
梅县
清远
河源
潮州
揭阳
汕头
高要
广州
云浮
南海
东莞
惠阳
汕尾
新会
中山
深圳
珠海
阳江
茂名
湛江

梅州,1833(11%)
河源,1289(8%)
韶关,13921(73%)
远,8435(43%)
庆,5023(33%)

云浮,4206(53%)
佛山,0(0%)
广州,0(0%)
潮州,0(0%)
揭阳,0(0%)
汕头,0(0%)
汕尾,0(0%)

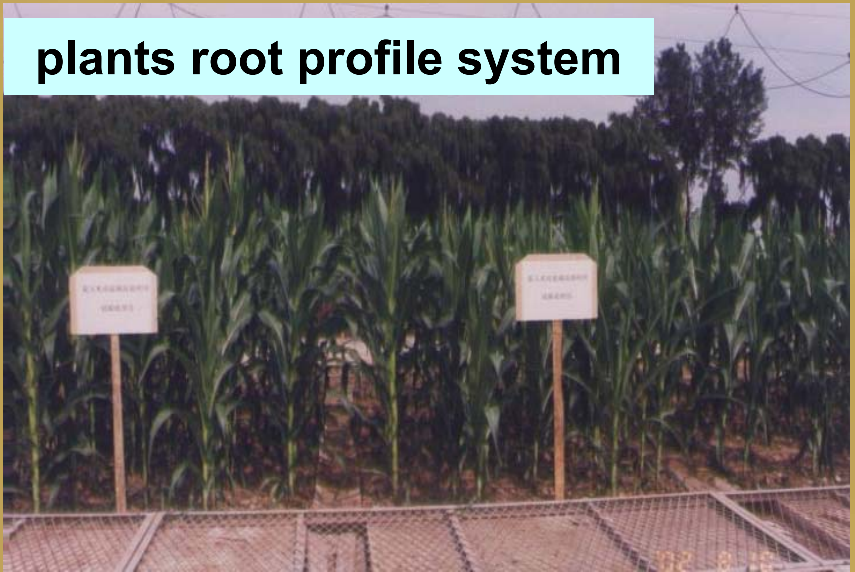
惠州,0(0%)
东莞,0(0%)
深圳,0(0%)
中山,0(0%)
珠海,0(0%)
江门,0(0%)
阳江,57(1%)
茂名,6(0%)
湛江,0(0%)

Drought acrage(km^2) in whole province: 34771 (19%)

Climate and agro-meteorological Centre, Guangdong

Comprehensive experimental site of soil-plant-atmosphere continuum

Rainproof Shed



plants root profile system

(3) Risk Assessment of Agricultural Drought

- Risk identification of drought in North China
- Risk assessment of drought in North China
- Comprehensive risk zoning of drought in North China

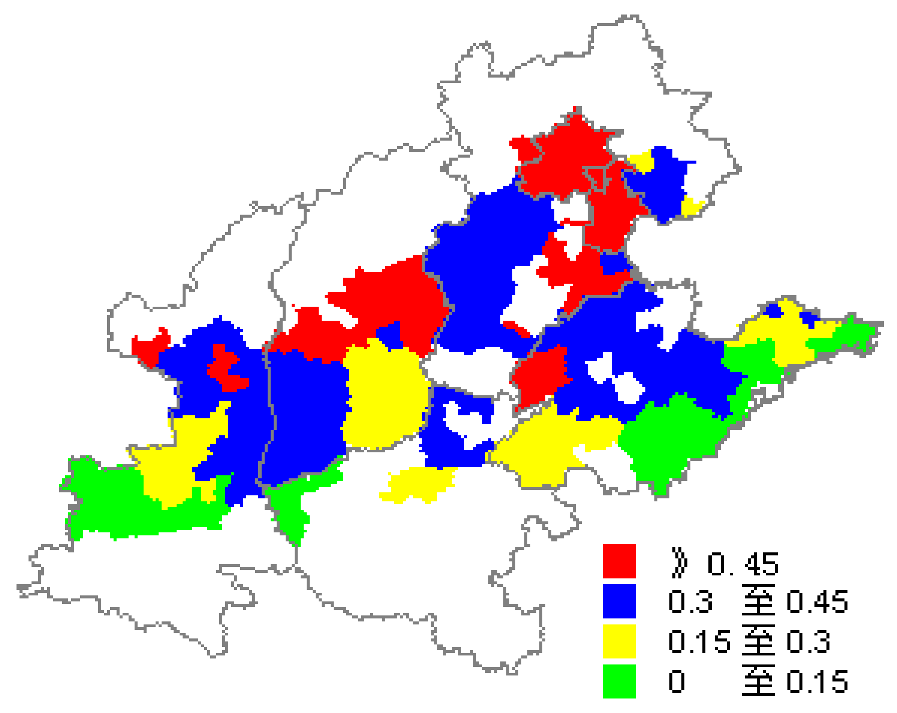
Risk identification：to determine index of risk and damage losses, fit the probabilities distribution functions of disaster indexes and losses

Quantitative index of wheat drought risk

Disaster-Inducing factors	①water stress percent during growing season of wheat(%)；②negative abnormality of precipitation during growing season of wheat(%，leading index) and abnormality during jointing stage (%，secondary index)				
Grade	**Light drought**	**Moderate drought**	**Drought**	**Severe drought**	**Extreme drought**
Index①	＜20	20～30	30～40	40～70	＞70
Yield reduction (A，%)	＜9	9～12	12～14	14～21	＞21
Yield reduction (A，%)	＜9	9～15	15～21	21～40	＞40
Index②（leading/secondary,%）	＜15/ ＜30	15～35/ 30～65	35～55/ 65～100	＞55/	
Yield reduction（leading/secondary,%）	＜10/ ＜10	10～20/ 10～20	20～30/ 20～30	＞30/	

Risk assessment

intensity



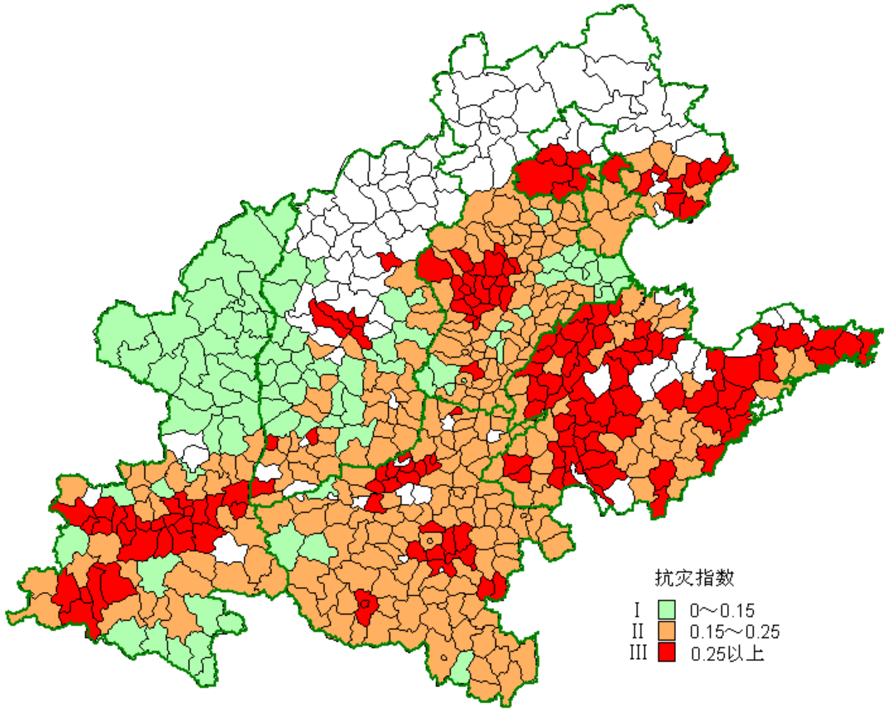
》0. 45
0.3 至 0.45
0.15 至 0.3
0 至 0.15

Risk index of water stress

$$I = \sum_{i=1}^{n} D_i P_i$$

Water stress and their probability

capacity



抗灾指数
I 0~0.15
II 0.15~0.25
III 0.25以上

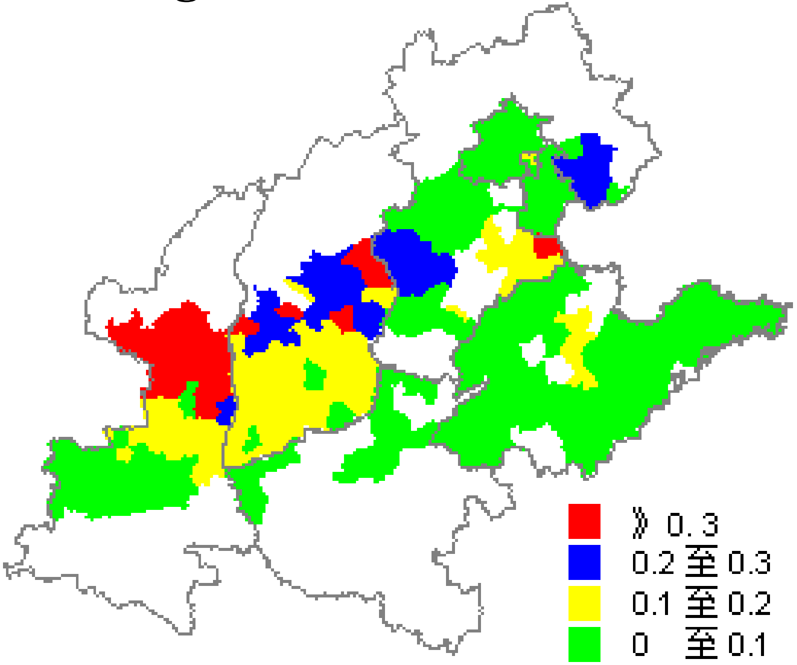
Index of drought-resisting of winter wheat in North China

$$k = \frac{1}{n} \sum \frac{Y_i}{Y_{mi}}$$

Actual yield and potential productivity

Comprehensive risk zoning

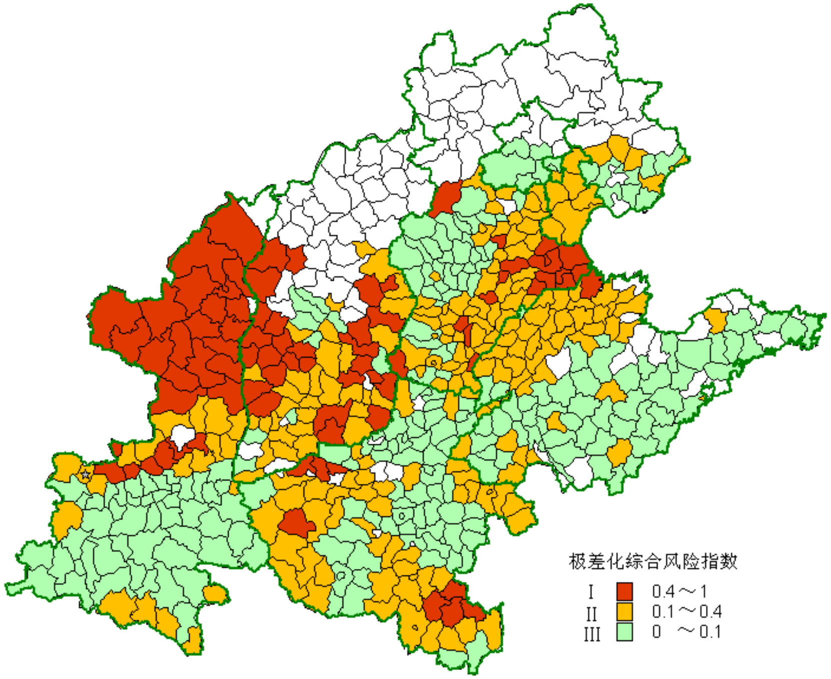
Comprehensive drought risk zoning of wheat in North China



$$M = \frac{1}{a}\sum_{i=1}^{n}(f_i \times P_i + R_i \times D_i)$$

F, P: water stress and their probability; R,D: yield reduction percent and probability; a: time trend coefficients of drought-resisting capacity

Risk zoning of drought loss of wheat in North China



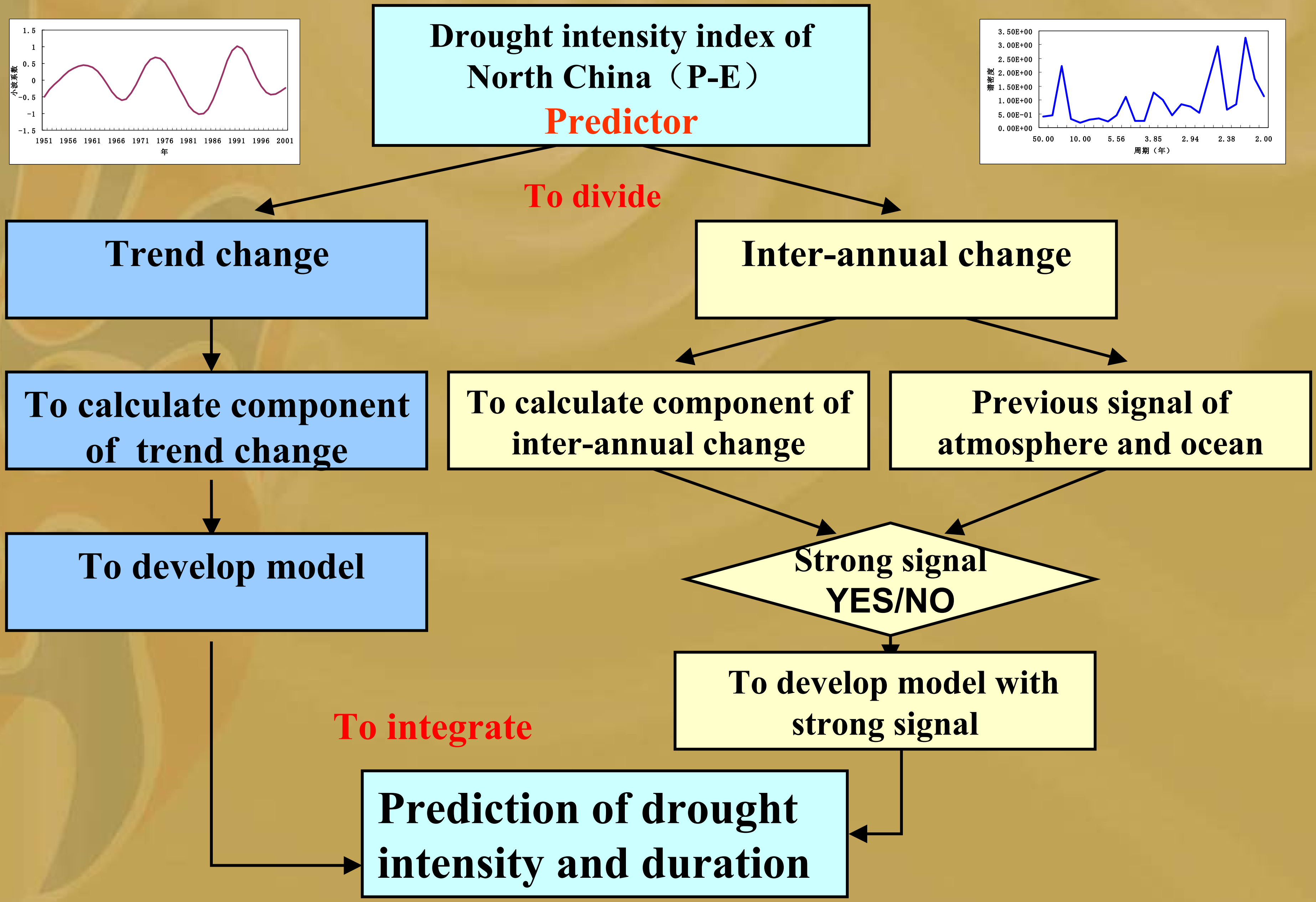
$$M = \frac{1}{k}\times Y \times C \times \sum_{i=1}^{n} R_i P_i$$

R: yield reduction percent; P: average yield reduction percent; C: variance coefficient of yield reduction; k: index of disaster-resisting

(4) Prediction of Agricultural Drought in North China

- long term prediction of agricultural drought in North China
- Irrigation scheme for wheat
- wheat drought prediction based on crop model

Long term prediction of drought in North China


1.5
1
0.5
0
-0.5
-1
-1.5
小波系数
1951
1956
1961
1966
1971
1976
1981
1986
1991
1996
2001
年
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
谱密度
50.00
10.00
5.56
3.85
2.94
2.38
2.00
周期（年）

Drought intensity index of North China（P-E）

Predictor

To divide

Trend change

To calculate component of trend change

To develop model

Inter-annual change

To calculate component of inter-annual change

Previous signal of atmosphere and ocean

Strong signal
YES/NO

To develop model with strong signal

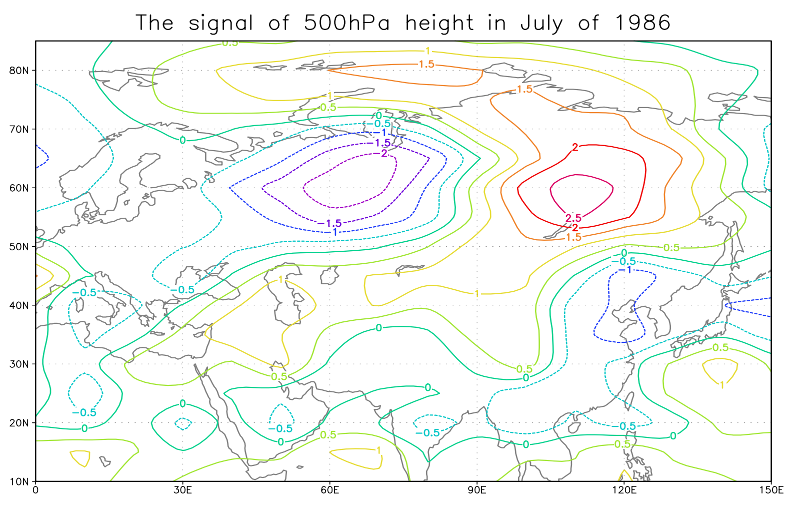
To integrate

Prediction of drought intensity and duration

Previous signal of severe drought in North China

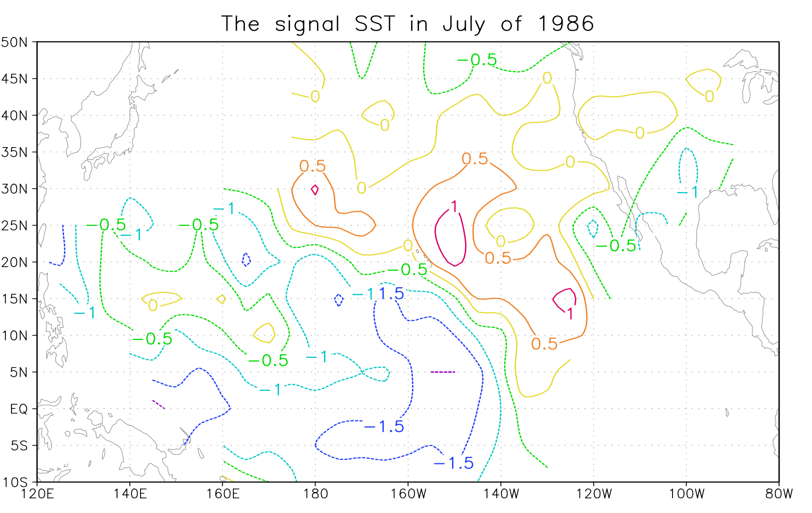
Height

SST



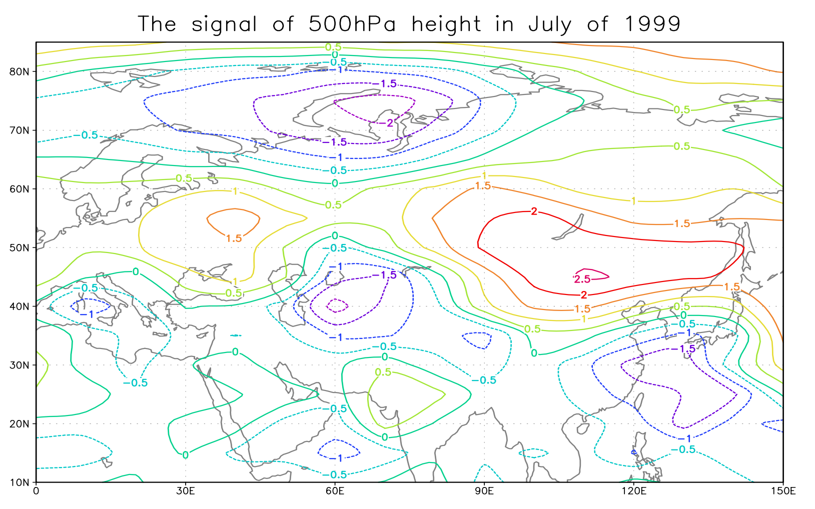
The signal of 500hPa height in July of 1986

80N
70N
60N
50N
40N
30N
20N
10N
0
30E
60E
90E
120E
150E



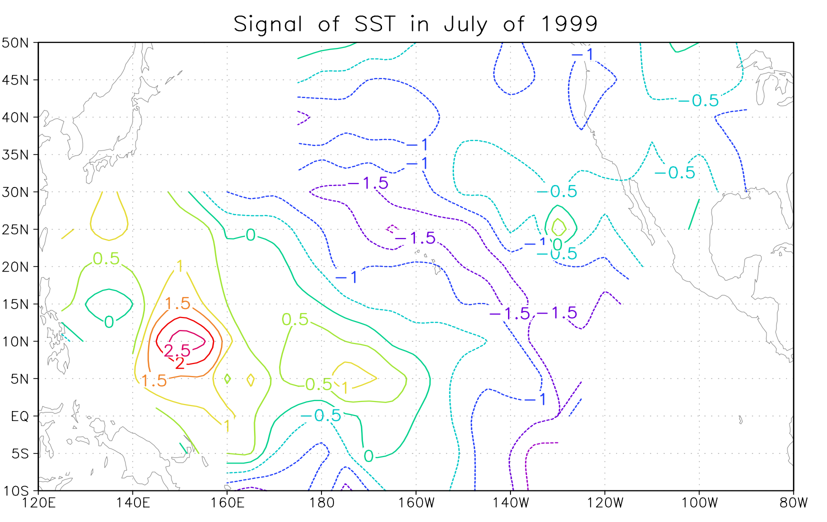
The signal SST in July of 1986

50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
5S
10S
120E
140E
160E
180
160W
140W
120W
100W
80W



The signal of 500hPa height in July of 1999

80N
70N
60N
50N
40N
30N
20N
10N
0
30E
60E
90E
120E
150E



Signal of SST in July of 1999

50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
5S
10S
120E
140E
160E
180
160W
140W
120W
100W
80W

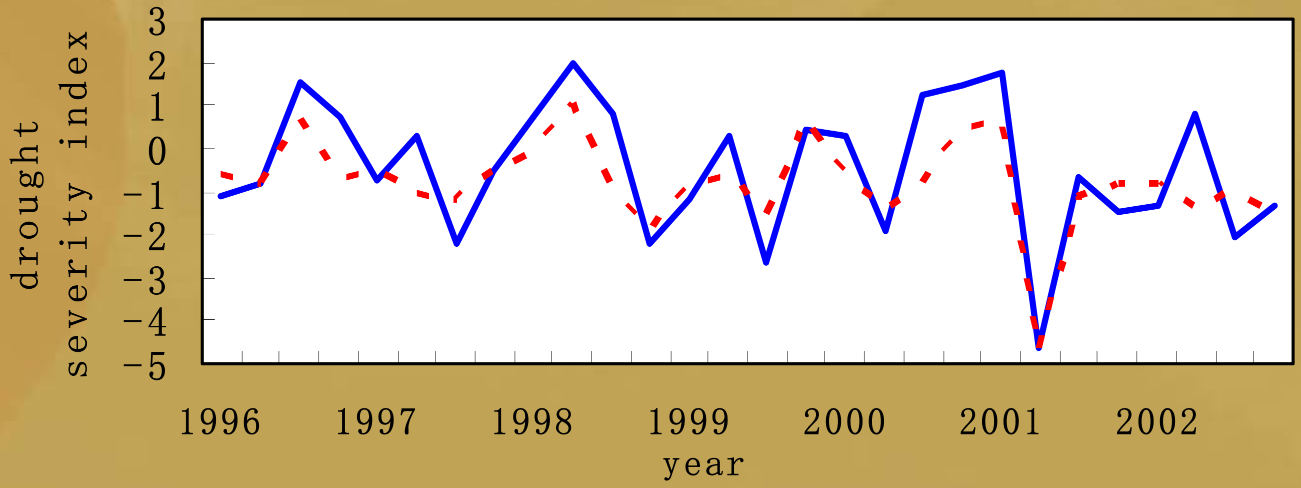
Abnormality in height of the Urals and Lake Baikal

Abnormality in Kuroshio, warming Pool and Nino 4

Fitted accuracies (%)

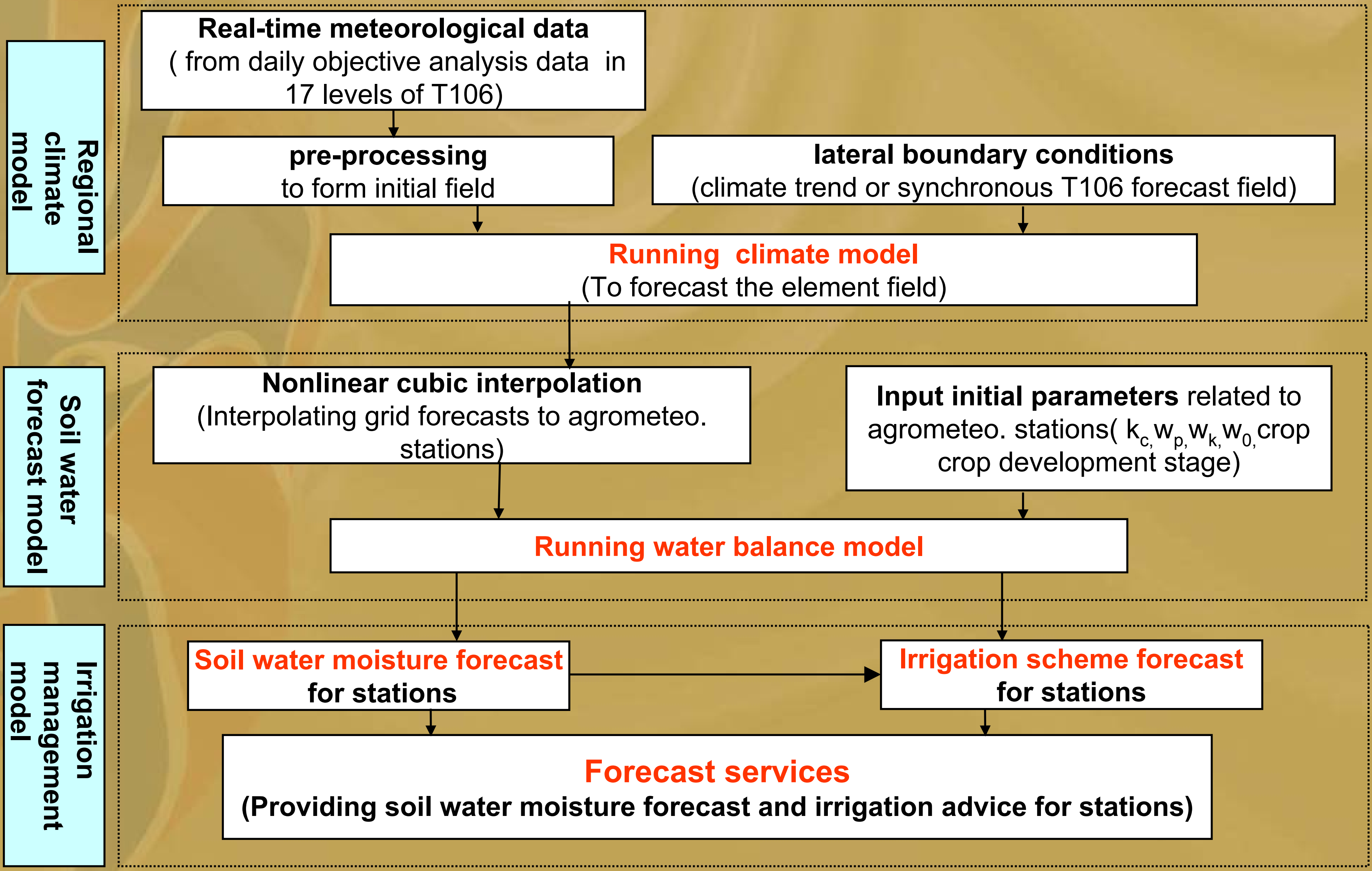
	winter	spring	summer	autumn	average
Advance by 3 months	82	75	90	94	85.2
Advance by 3 months	82	75	87	90	83.5

Validation in 1996-2002 (3 months in advance)



averaged accuracy 71%

Predicted irrigation scheme for wheat in North China



Regional climate model

Real-time meteorological data
(from daily objective analysis data in 17 levels of T106)

pre-processing
to form initial field

lateral boundary conditions
(climate trend or synchronous T106 forecast field)

Running climate model
(To forecast the element field)

Soil water forecast model

Nonlinear cubic interpolation
(Interpolating grid forecasts to agrometeo. stations)

Input initial parameters related to agrometeo. stations(k_c, w_p, w_k, w_0, crop crop development stage)

Running water balance model

Irrigation management model

Soil water moisture forecast for stations

Irrigation scheme forecast for stations

Forecast services
(Providing soil water moisture forecast and irrigation advice for stations)

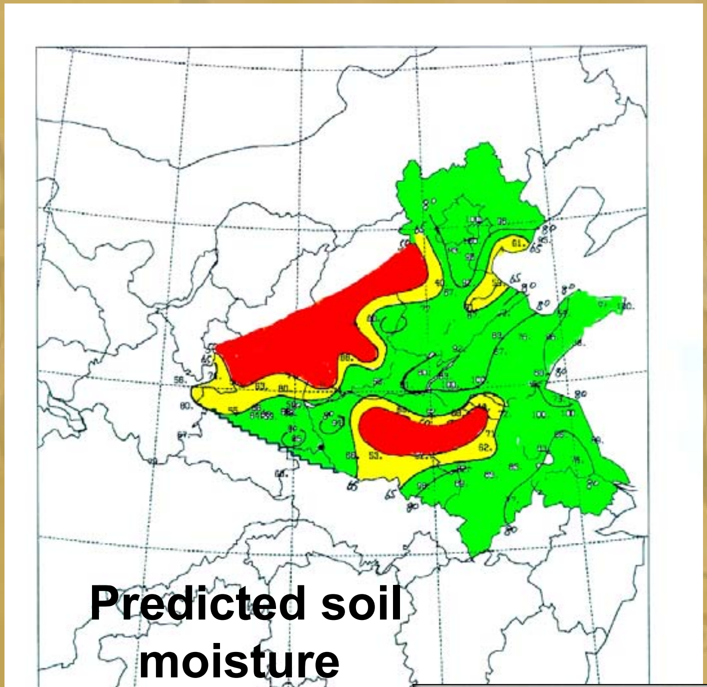
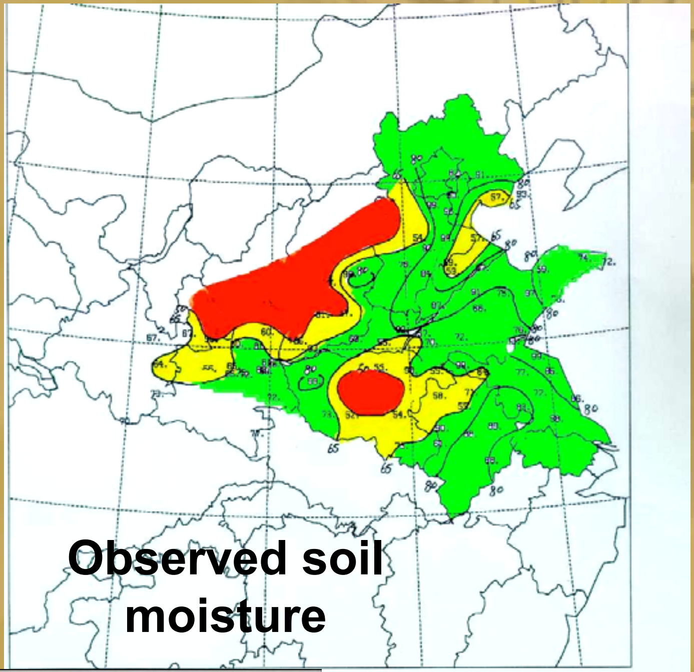
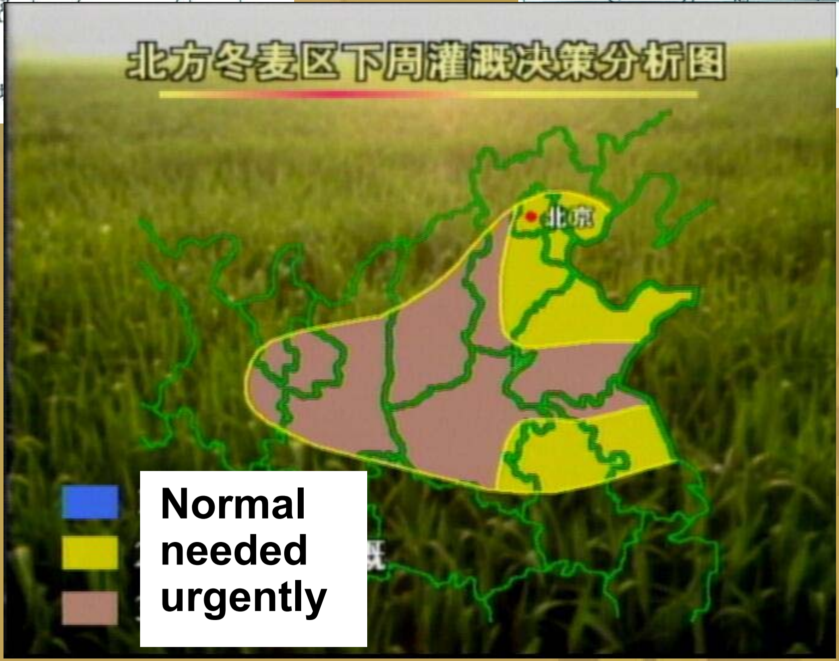

Predicted soil moisture

图 3　2000 年 4 月 8 日 0～100 厘米土

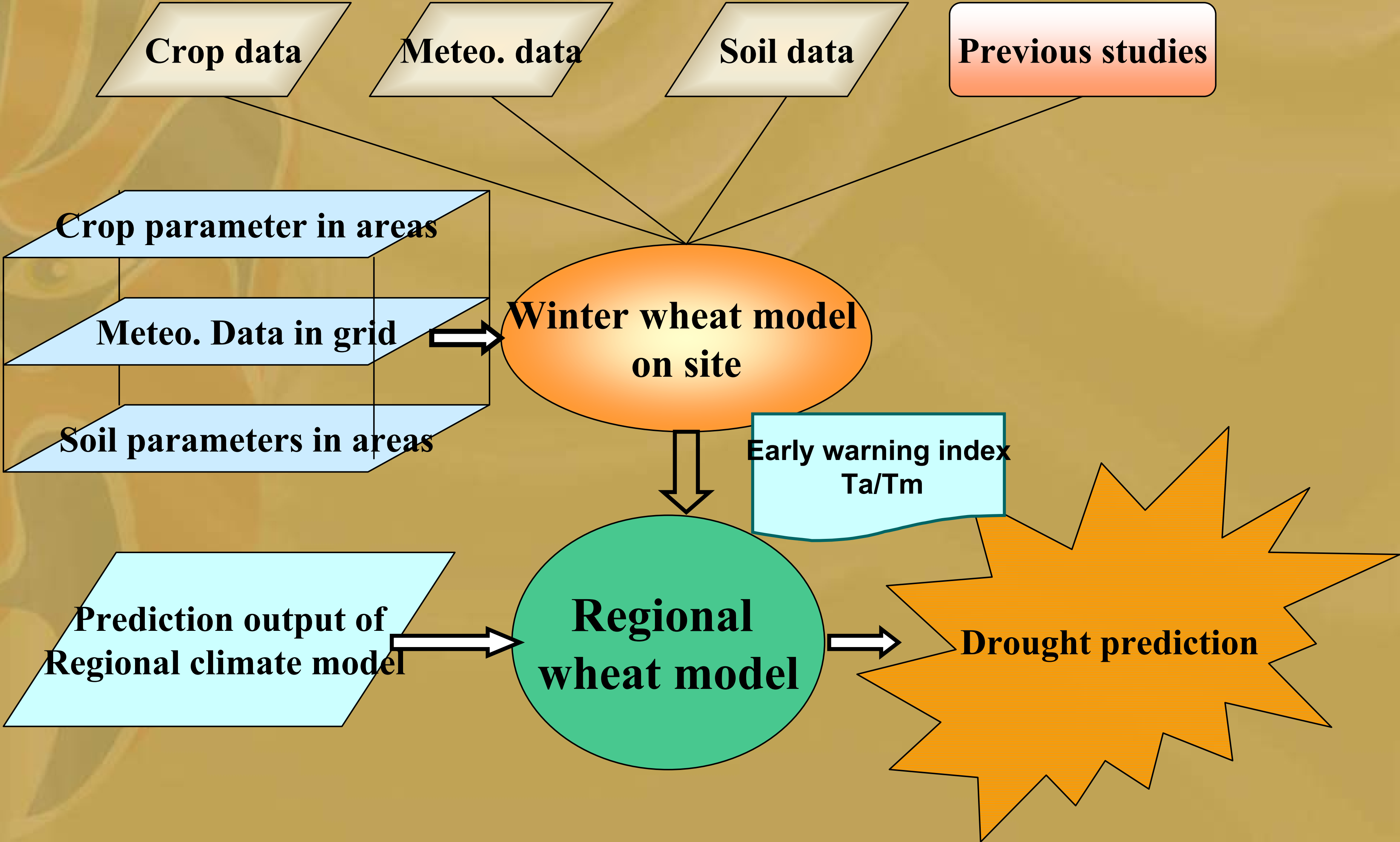

Observed soil moisture

厘米土壤湿度（%）实况图


北方冬麦区下周灌溉决策分析图
北京
🟦 Normal
🟨 needed
🟫 urgently

Irrigation scheme service shown on TV channel

wheat drought prediction based on crop model



Crop data

Meteo. data

Soil data

Previous studies

Crop parameter in areas

Meteo. Data in grid

Soil parameters in areas

Winter wheat model on site

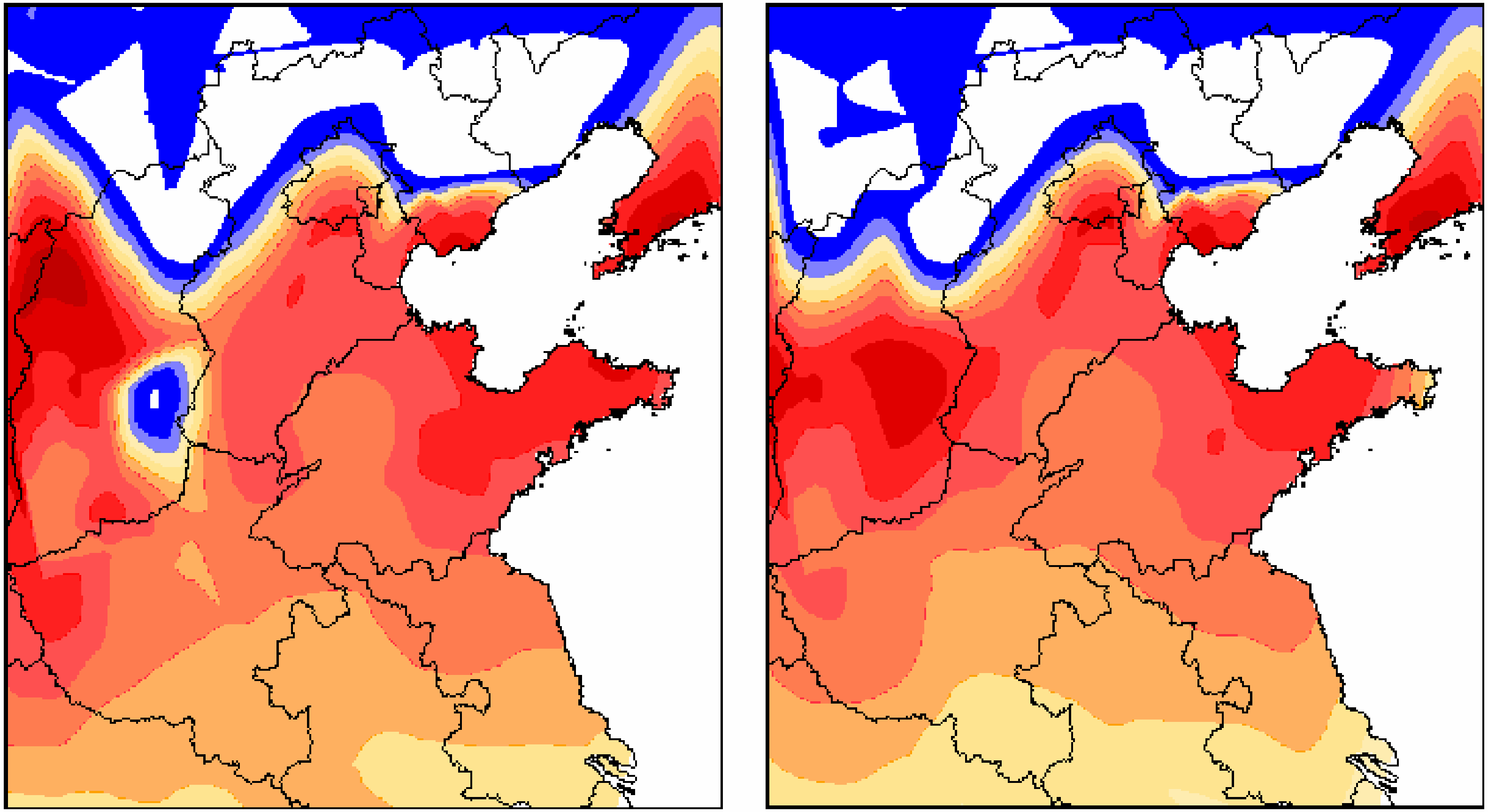
Early warning index Ta/Tm

Prediction output of Regional climate model

Regional wheat model

Drought prediction

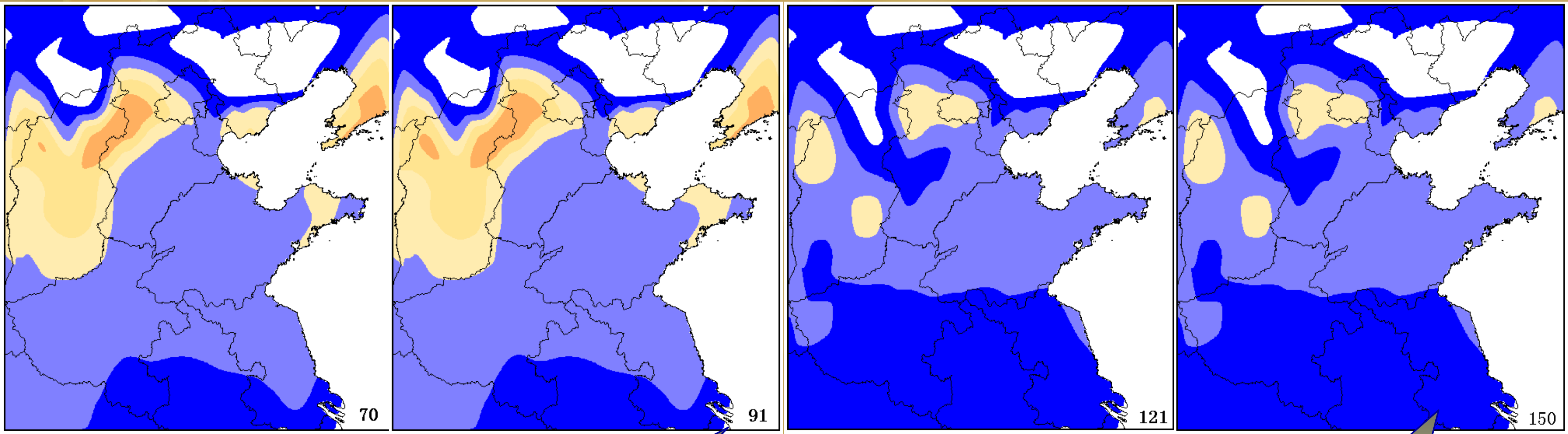
Predicted 10-days early warning of wheat drought



3 Medium,180

3 Medium,70

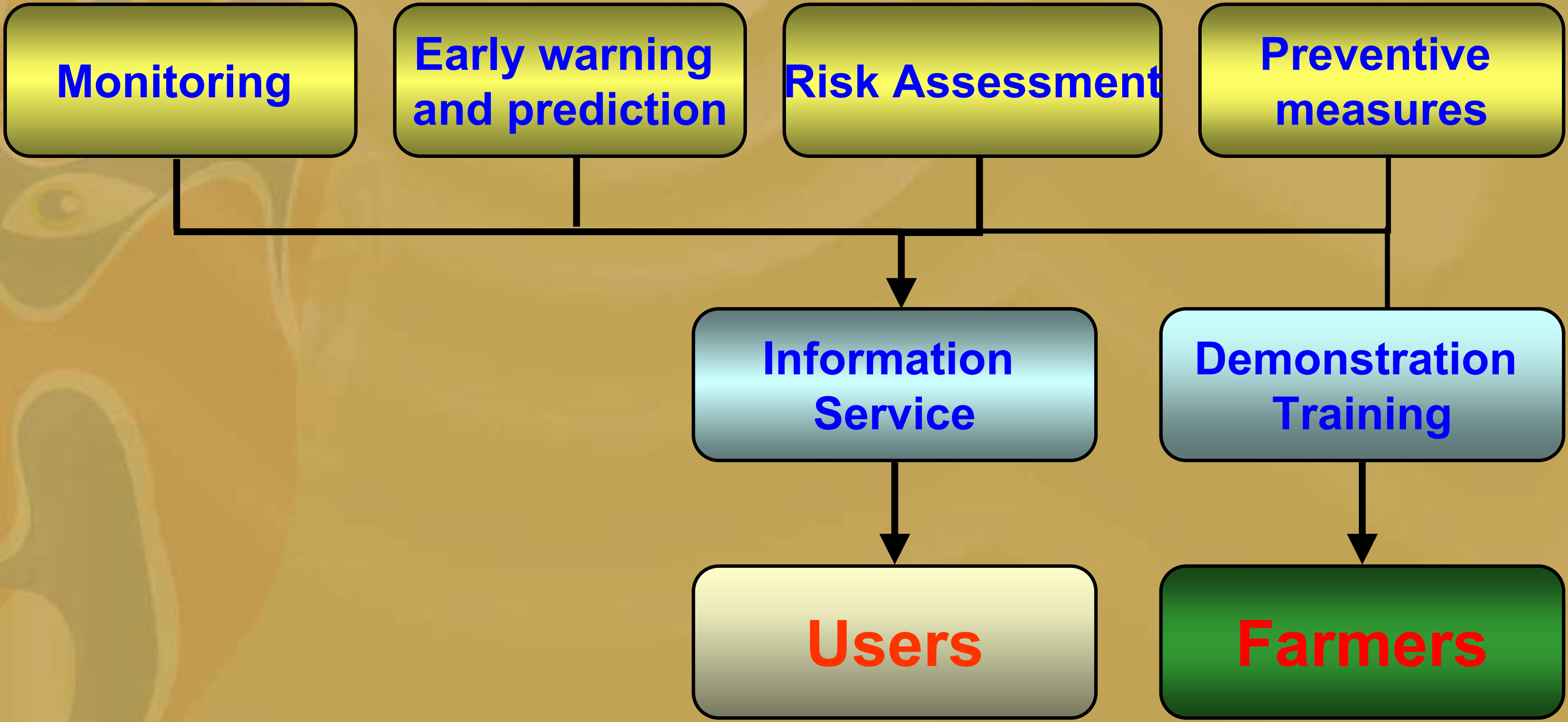
Comparison



Drought prediction according to forecasted weather elements started on DOY 70,91,121,respectively

Drought prediction according to real data on DOY 150

(5) Meteorological Service for *Mitigating* Agricultural Drought



Monitoring

Early warning and prediction

Risk Assessment

Preventive measures

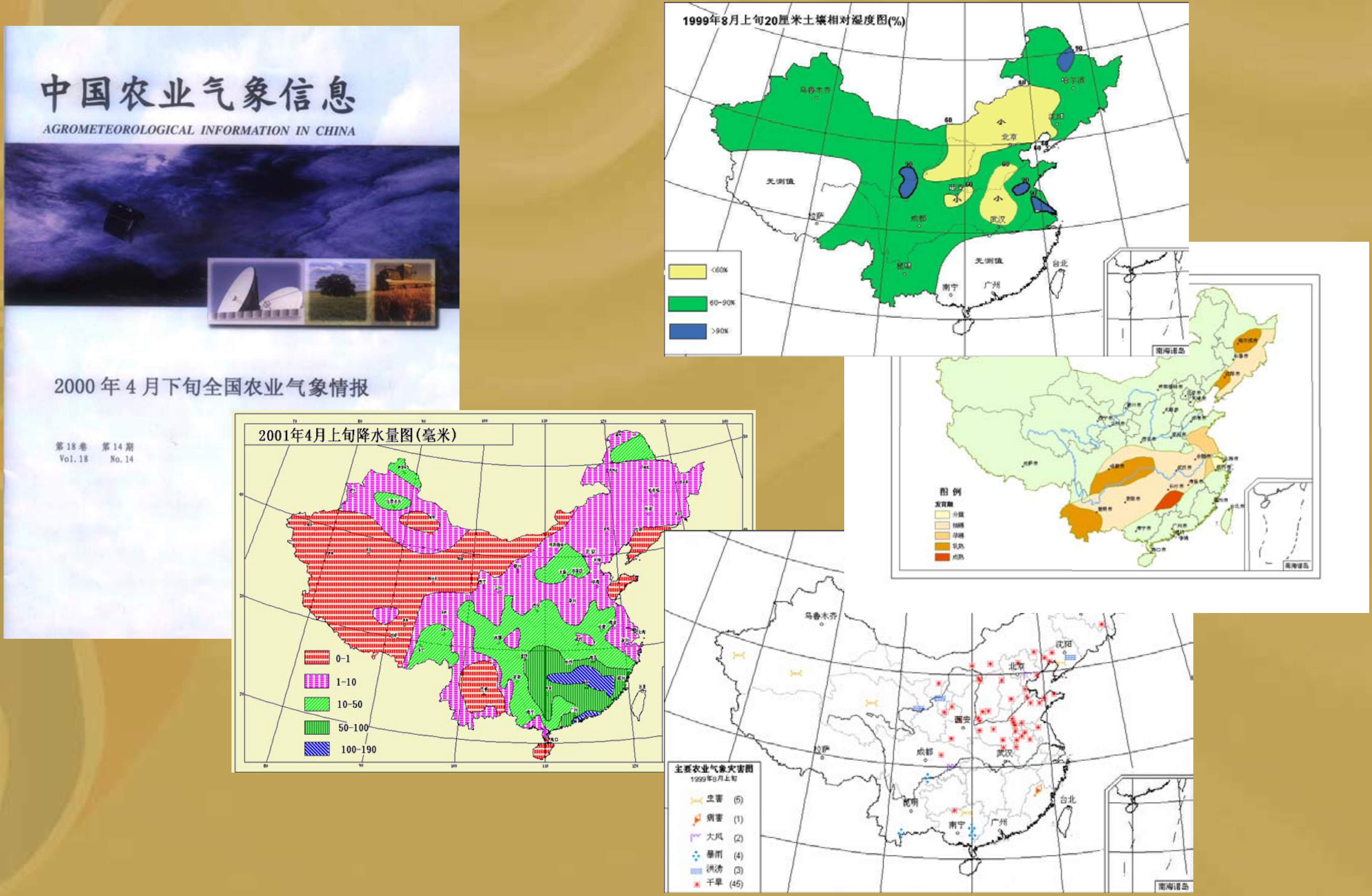
Information Service

Demonstration Training

Users

Farmers

Providing agrometeorological information services



中国农业气象信息
AGROMETEOROLOGICAL INFORMATION IN CHINA

2000 年 4 月下旬全国农业气象情报

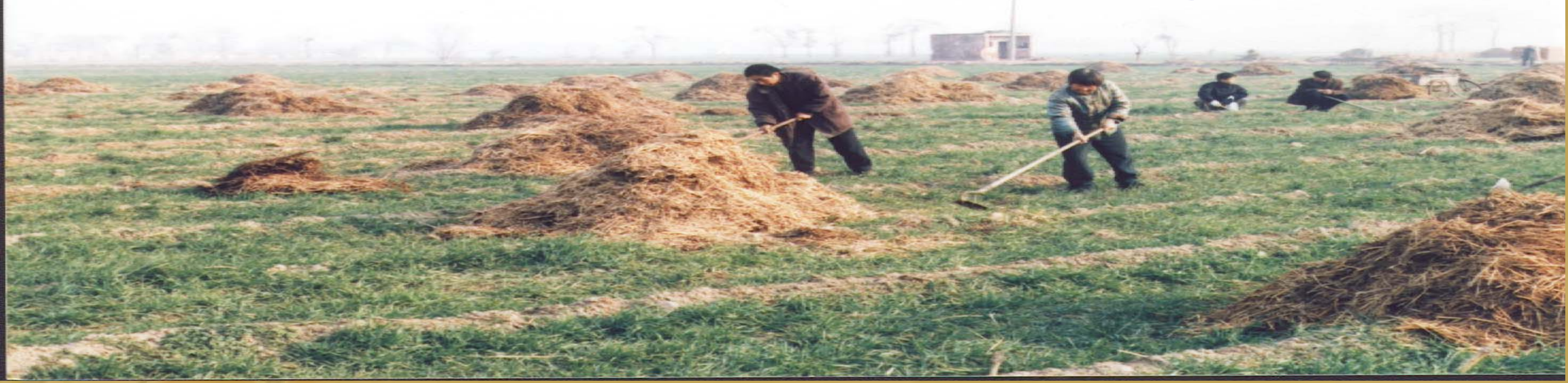
第 18 卷　第 14 期
Vol. 18　No. 14

1999年8月上旬20厘米土壤相对湿度图(%)
<60%
60-90%
>90%
无测值
2001年4月上旬降水量图(毫米)
0-1
1-10
10-50
50-100
100-190
图 例
发育期
分蘖
抽穗
孕穗
乳熟
成熟
主要农业气象灾害图
1999年8月上旬
虫害 (5)
病害 (1)
大风 (2)
暴雨 (4)
洪涝 (3)
干旱 (45)
乌鲁木齐
北京
沈阳
拉萨
成都
西安
武汉
昆明
南宁
广州
台北
南海诸岛

Propose and popularize practical measures in drought-combating and reducing drought damage loss

- rationally use of stored soil moisture before sowing
- deep plough
- straw mulching
- optimum irrigation
- Prepare multi-functional drought preventing reagents

straw mulching



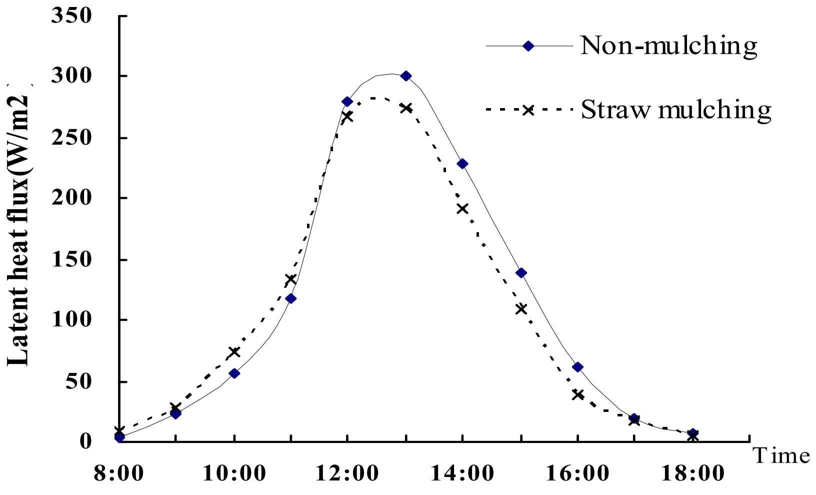


Fig. 3. Diurnal change of latent heat flux in wheat field

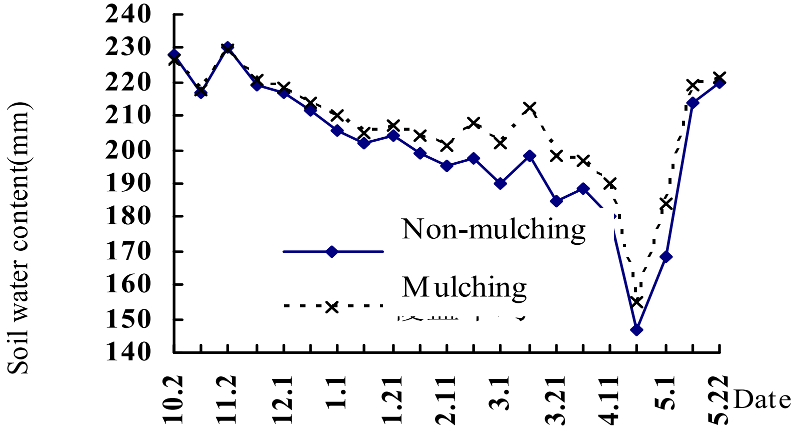


Fig.5. Soil water content in 0-100cm layer under mulching and non-mulching treatment in 1998

Latent heat flux is reduced

Wheat yield increased by 18.5%, water use efficiency was improved by 22.1%.

Preparing and spraying multi-functional drought preventing reagents

多功能防旱剂
河南省气象科研所研制
多功能防旱剂
河南省气象科研所研制

To restrain evaporation and promote crop growth

To spray on plant leaves during ear sprouting and grain filling with 1：1000

popularize agricultural drought mitigation techniques through demonstration, education and training

Handbook are published and issued to farmers.
The training courses are hold.
The drought mitigation techniques are shown on TV station.
The comprehensive techniques of drought mitigation of winter wheat has been popularized about 50000 hectare.

冬小麦干旱防御试验田
技术措施
深州市气象局
2003 4 9

Demonstration field

Training

(6) Conclusions

1. Important role of drought reduction

It is very important to monitor, assess, predict agricultural drought and provide meteorological service on drought information and techniques for mitigating drought in sustainable development.

2. Further improvement is necessary

- Standardization of monitoring
- Data collection and transmission
- Information and products deliver
- Research on drought index, cause and formation of drought, drought prediction, new technique application
- More cooperation

Thank You