Prediction of the First Frost Dates in Northern China

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Oct.8-10, Russia

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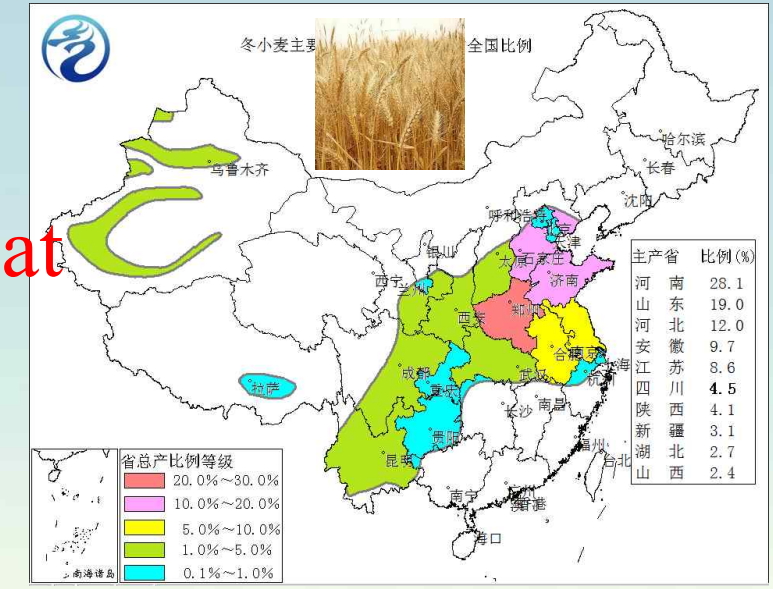
Outline

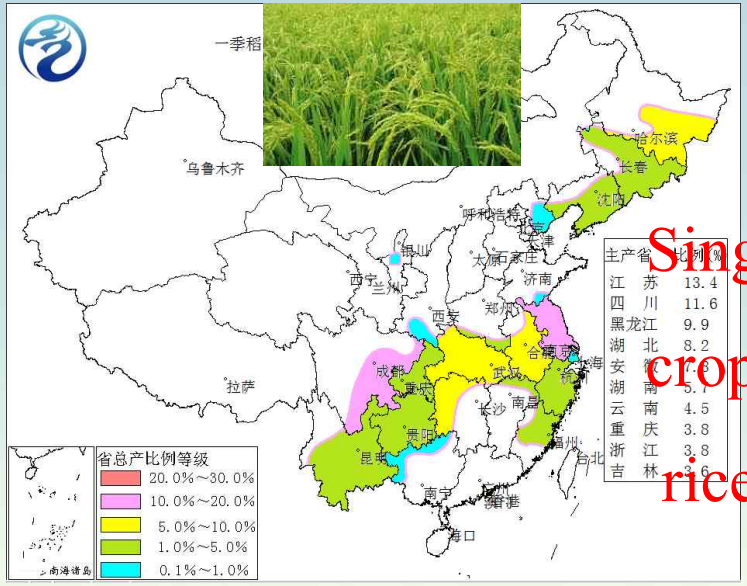
- Service and system
- Data and definition
- Climatic variability
- Prediction method
- Verification and application
- Conclusion and discussion

Distribution of main crops

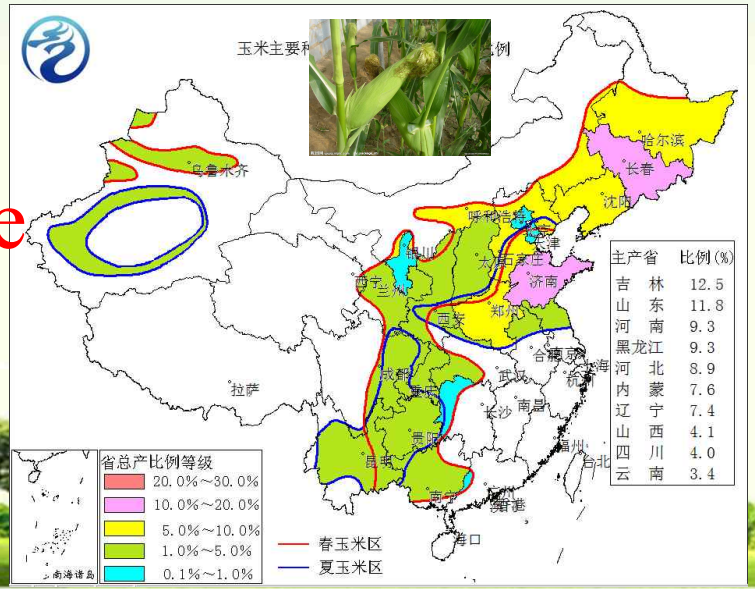
wheat



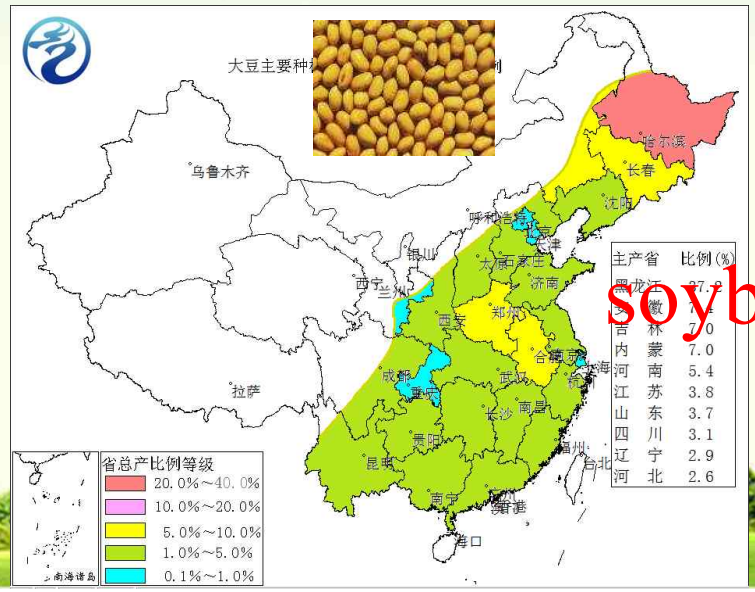
Single cropping rice



maize



soybean

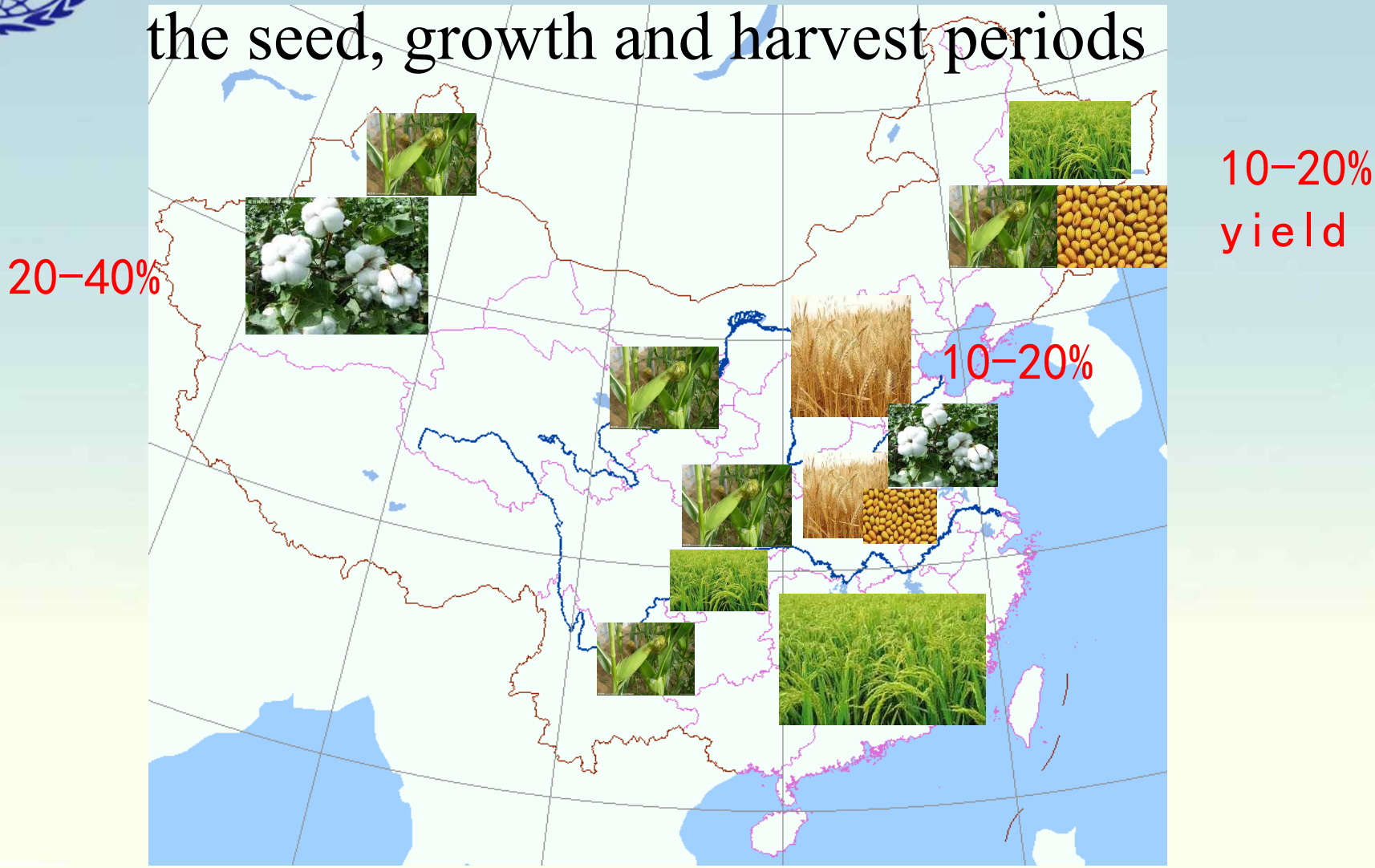


Climate prediction service for agriculture

- **Jan.-Feb.: Meteorological conditions for spring sowing in South China and the middle-low reaches of Yangtze River;**
- **Mar. : tendency of summer temperature in Northeast China;**
- **Aug.-Oct. : the first frost date in Northern China;**
- **Sep.-Oct. : strength of cold dew wind in Southern China;**
- **Winter half-year: frequency and intensity of cold wave ;**

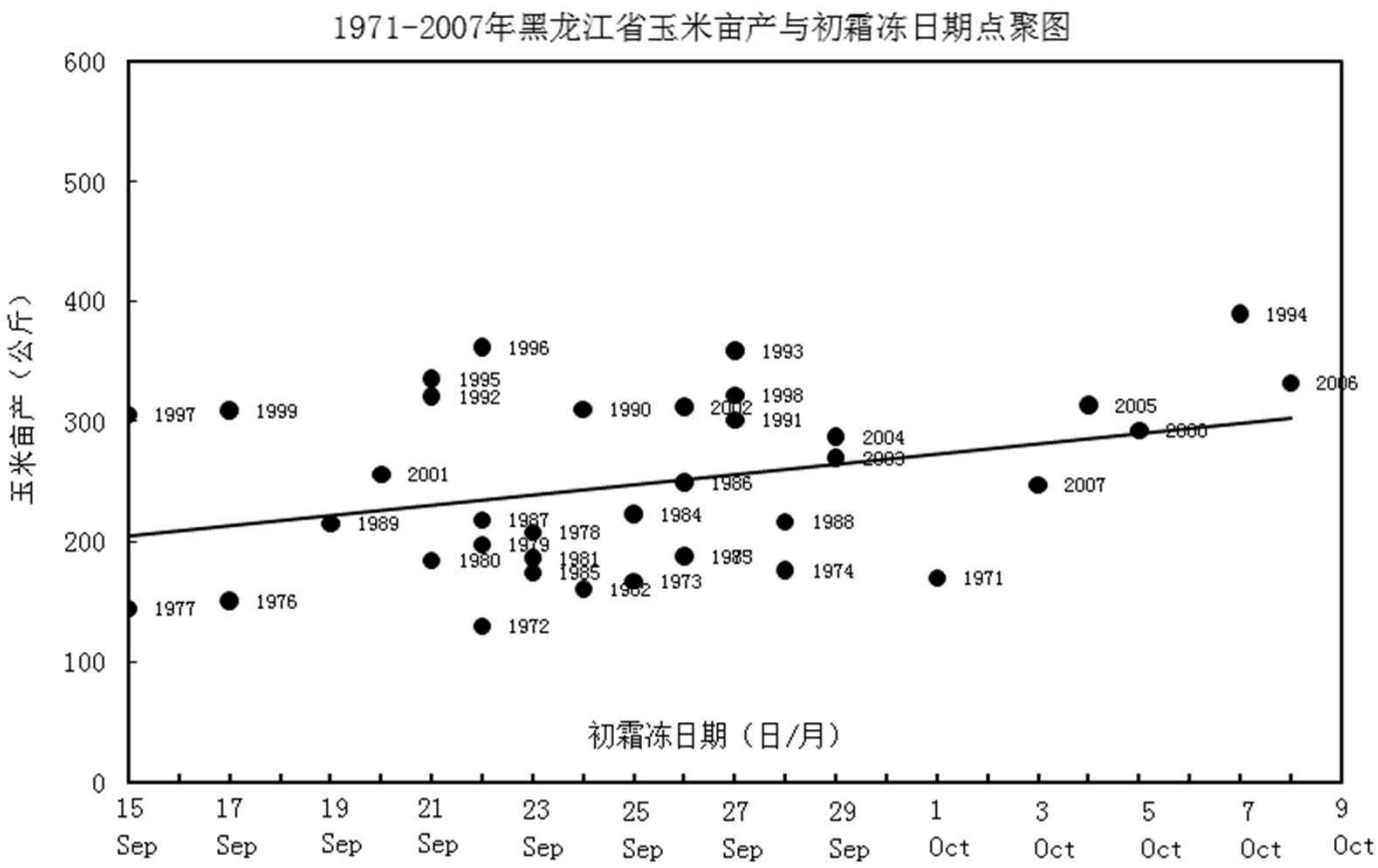
Provide Climate conditions during the seed, growth and harvest periods

Climate condition during the seed, growth and harvest periods



$$yield = f(T, Rain, sunshine, \ldots)$$

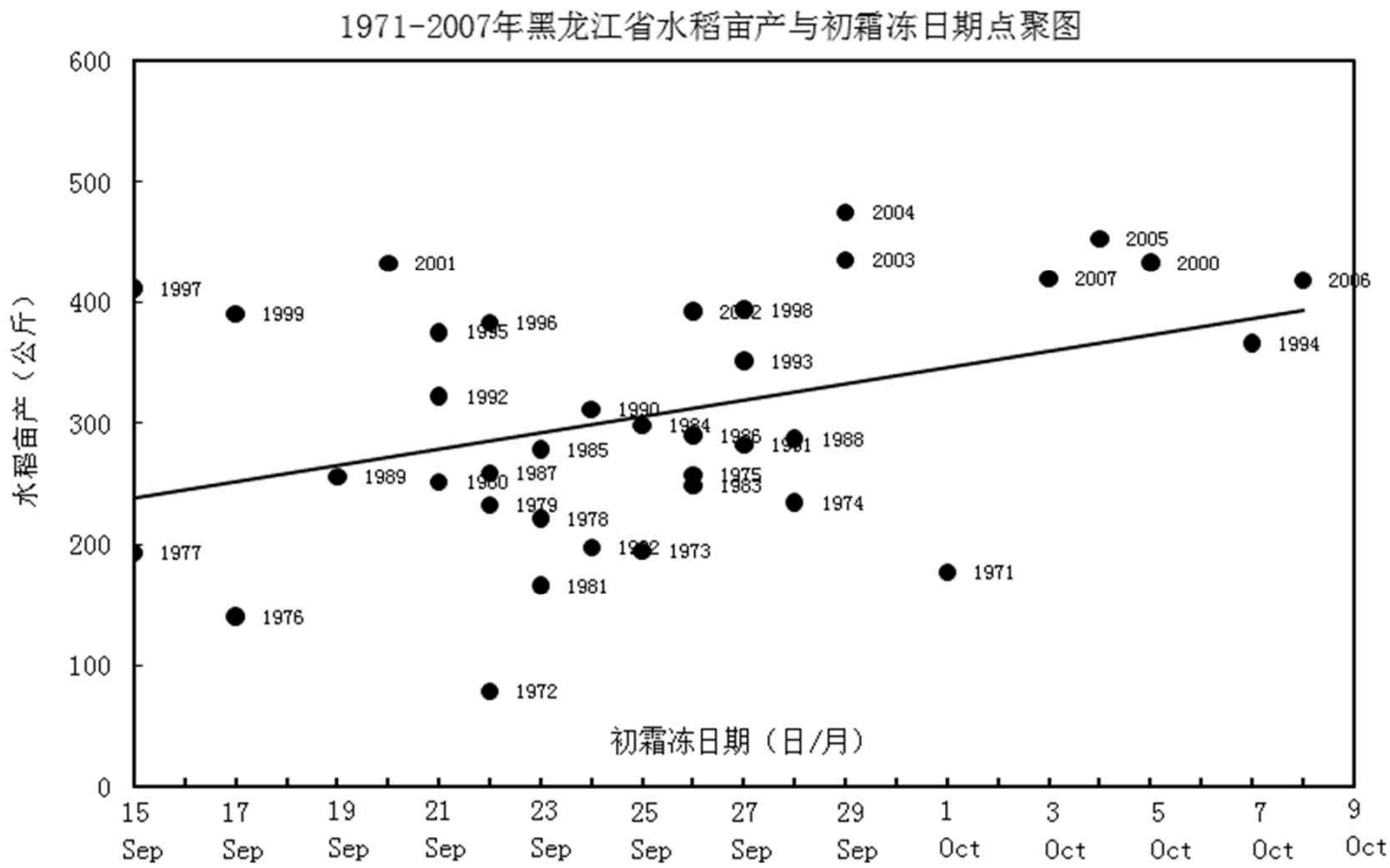
The relationship between the first frost date and corn yield in Heilongjiang Province



Acre yield (Corn)

The first frost date

The relationship between the first frost date and rice yield in Heilongjiang Province



Acre Yield (Rice)

The first frost date

Sub-system of operational prediction and service of the first frost date in Northern China

System introduction

Station data and analysis

Frost date monitoring

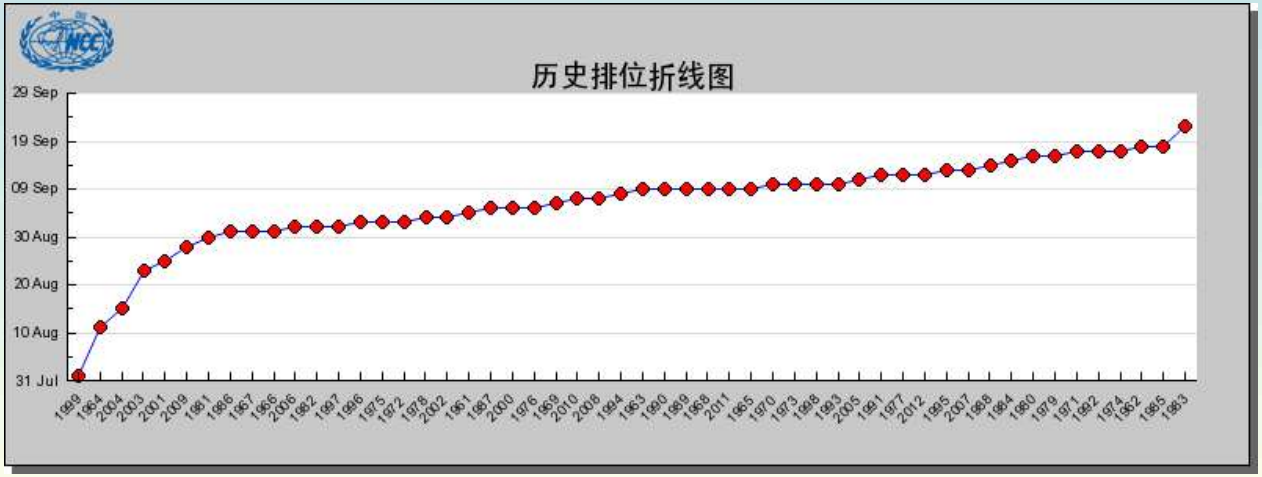
Objective prediction model

Frost date archive

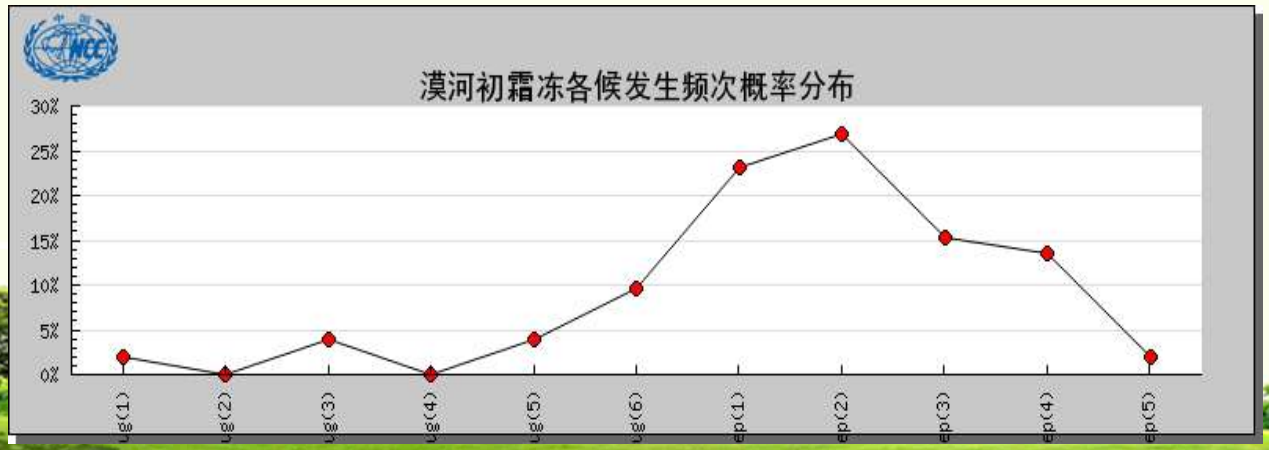
Climate features

Station data and analysis

Station number：50136　station name：Mohe
province：Heilongjiang　city：Daxinganling　county：Mohe



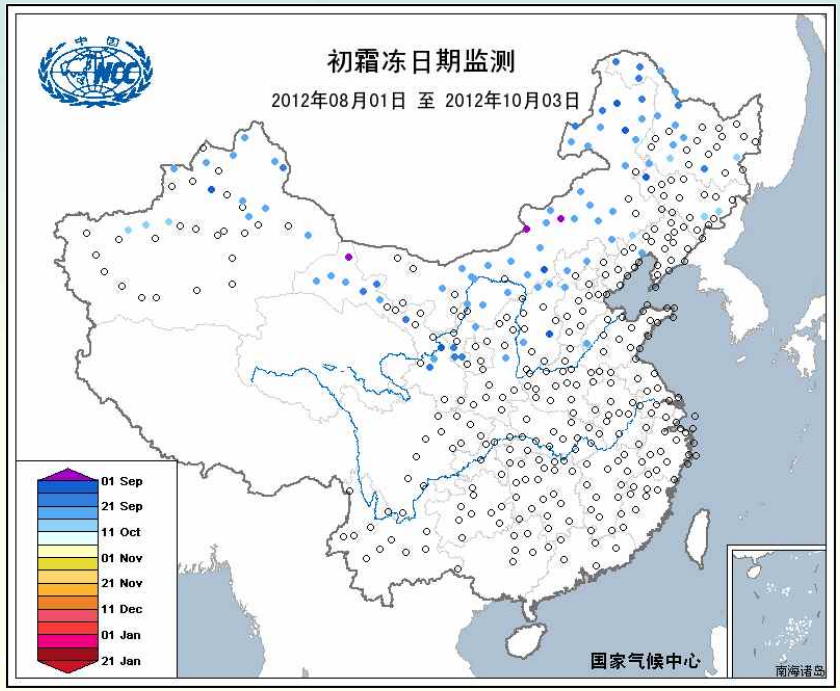
ranking of the first frost date every year



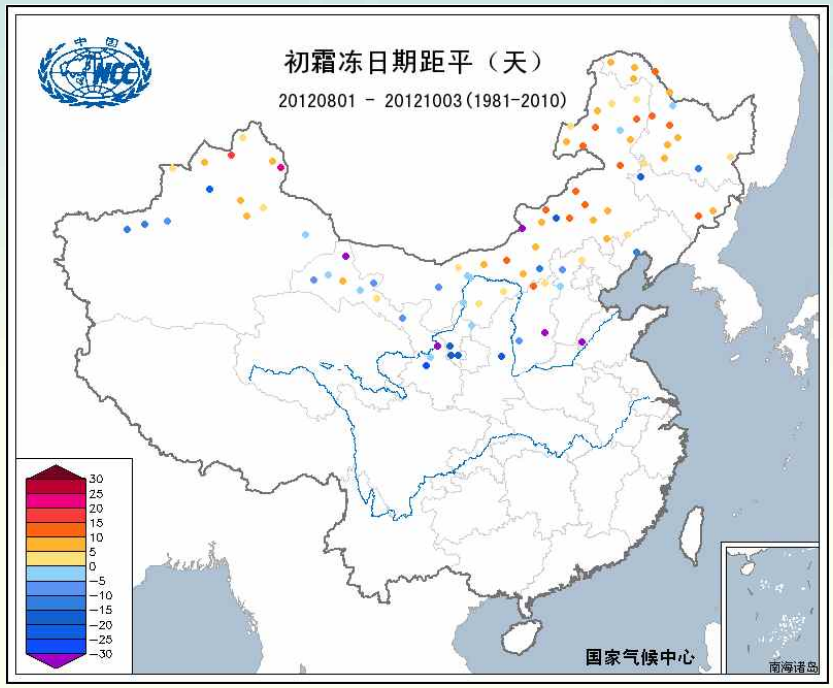
Frequency of the first frost date on each dekad

Real-time frost date monitoring

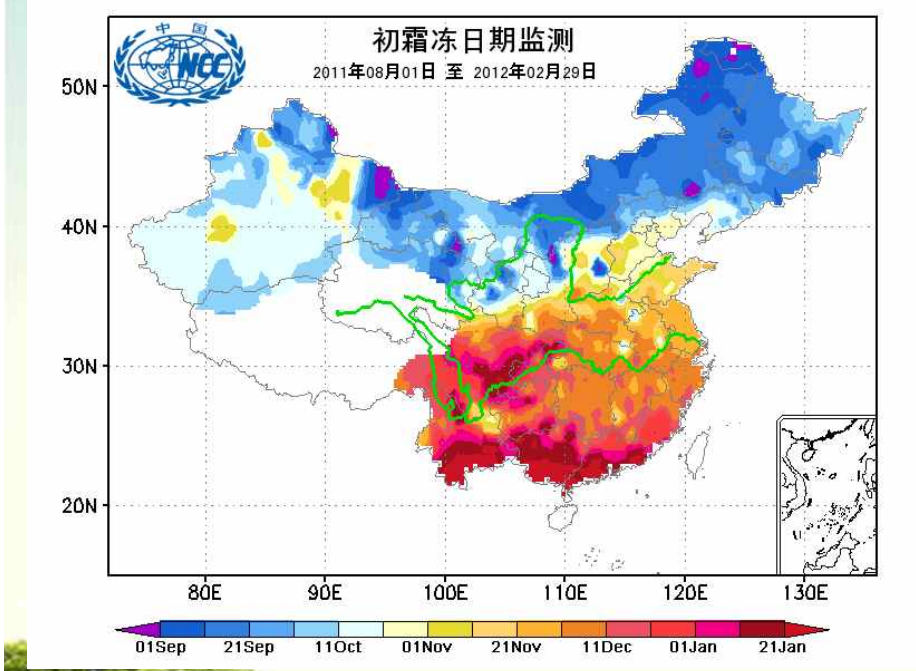
date

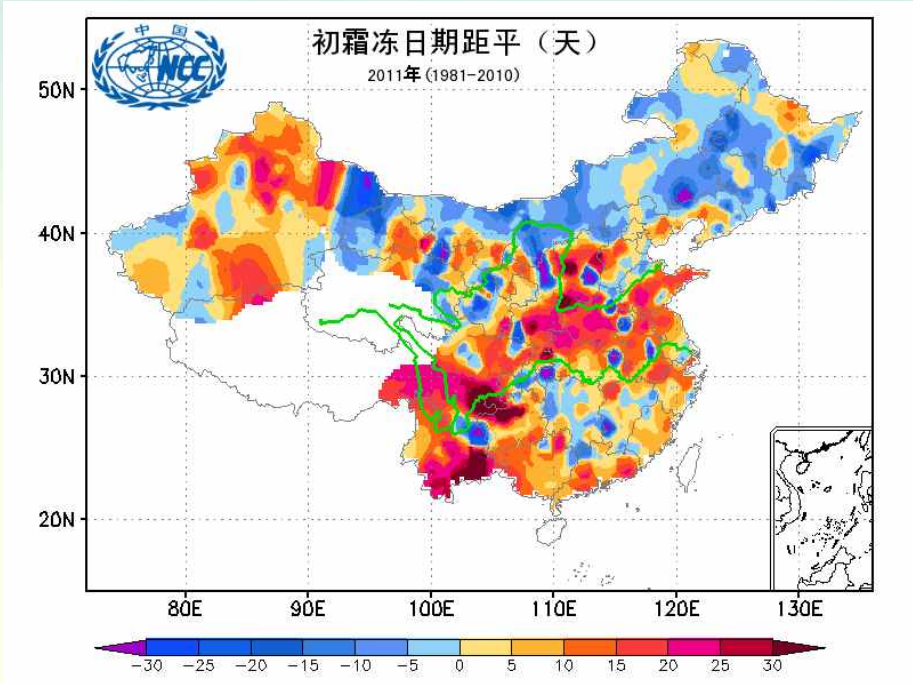


date anomaly

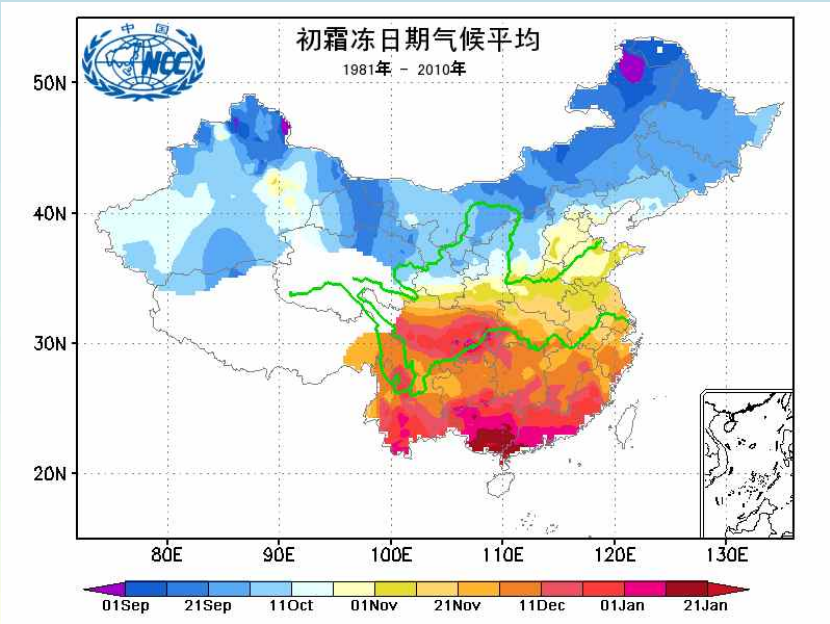


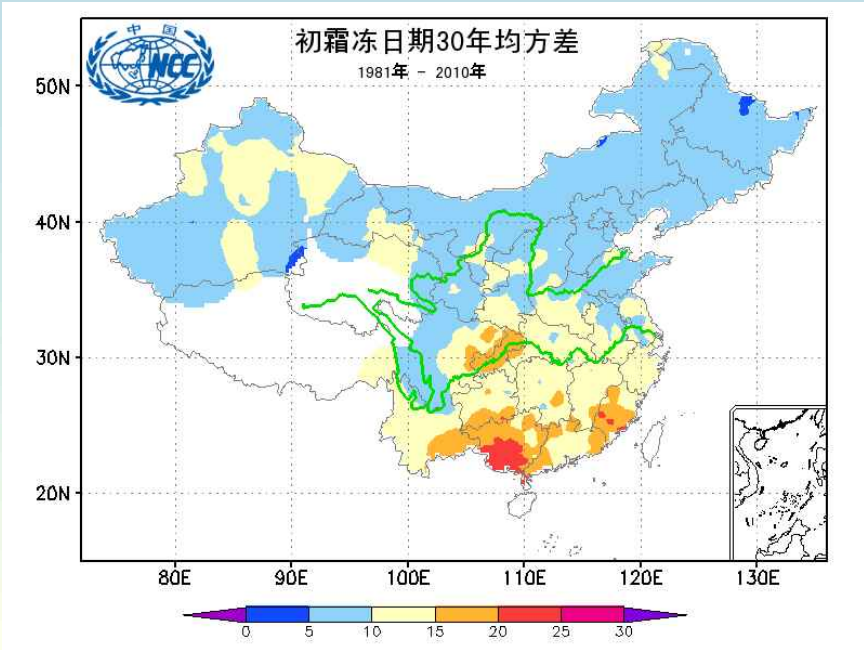
Frost date archive: date and date anomaly information in the past years





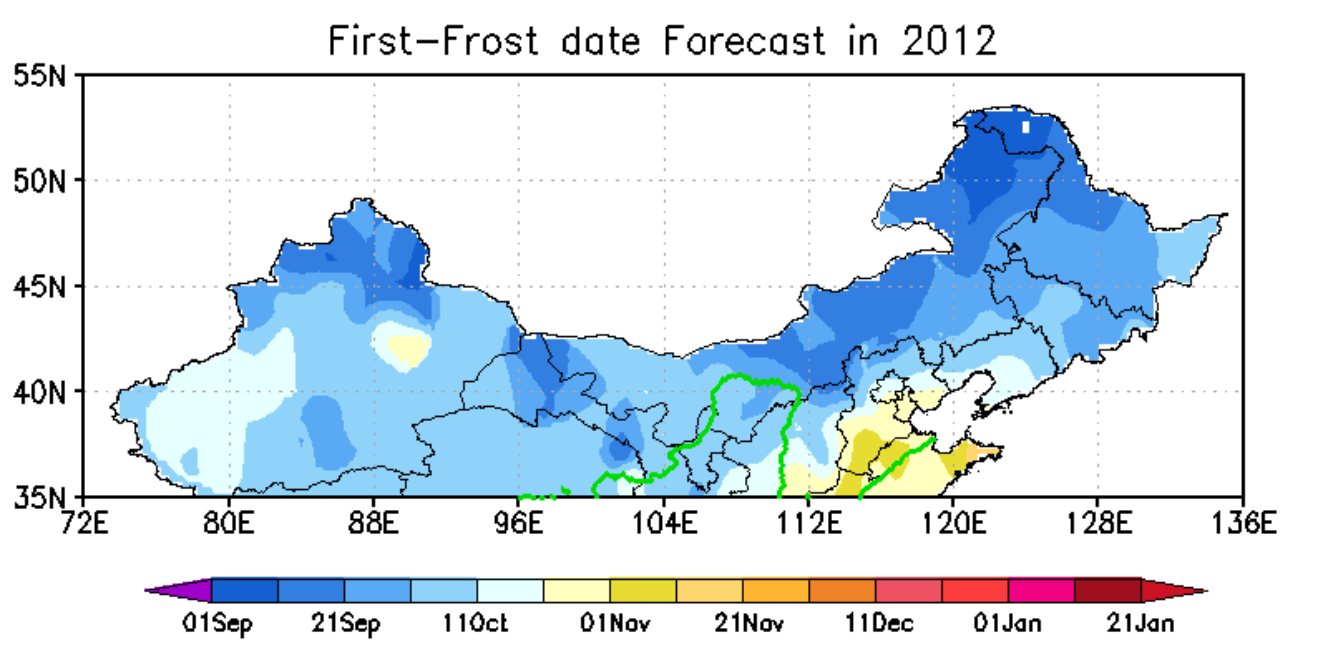
Climate features





Climate Features of 10 years, 30 years moved average , root mean square, etc

Objective prediction model



Provide the prediction of first frost date in the end of August

Data and definition

Three definitions for the first frost date：

D1: The first date is confirmed when the lowest daily station ground surface temperature ≤0℃ (Chen & Zhang, 1995;Huang et al.,1997)

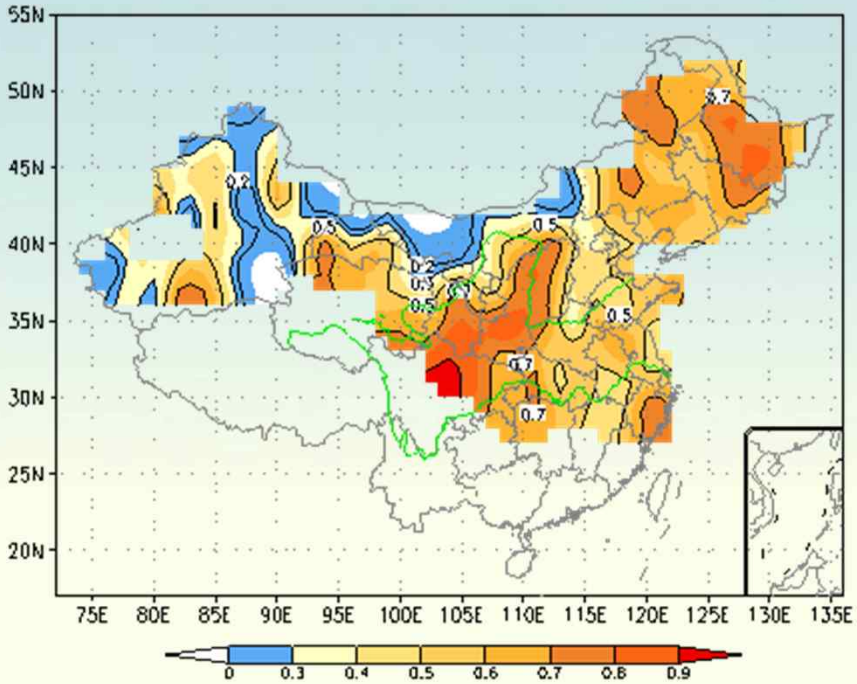
D2: The first date is confirmed when the lowest daily station air temperature (1.5 m high) ≤2℃ (Ye & Zhang,2008)

D3: The first date is confirmed when the frost phenomenon is observed.

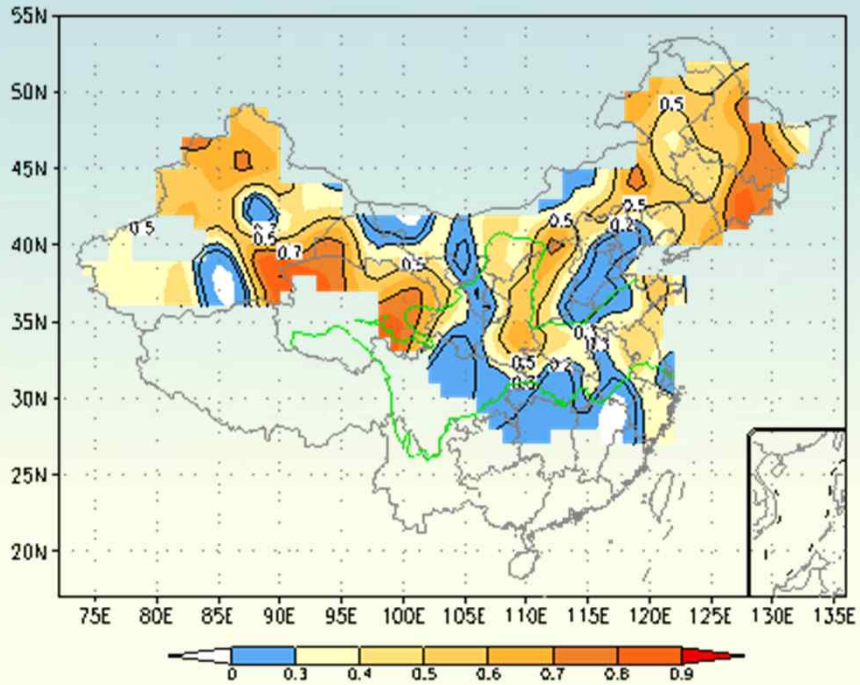
The first two definition can be supported by real-time meteorological data, while the third can't get in time and short of history data.

The ACC of D1&D3, D2&D3

D1 & D3

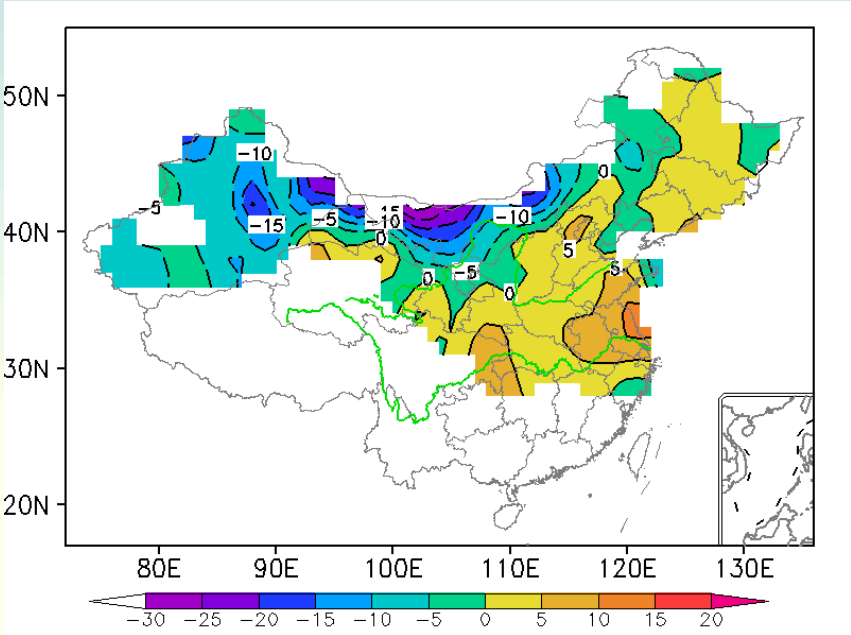


D2 & D3

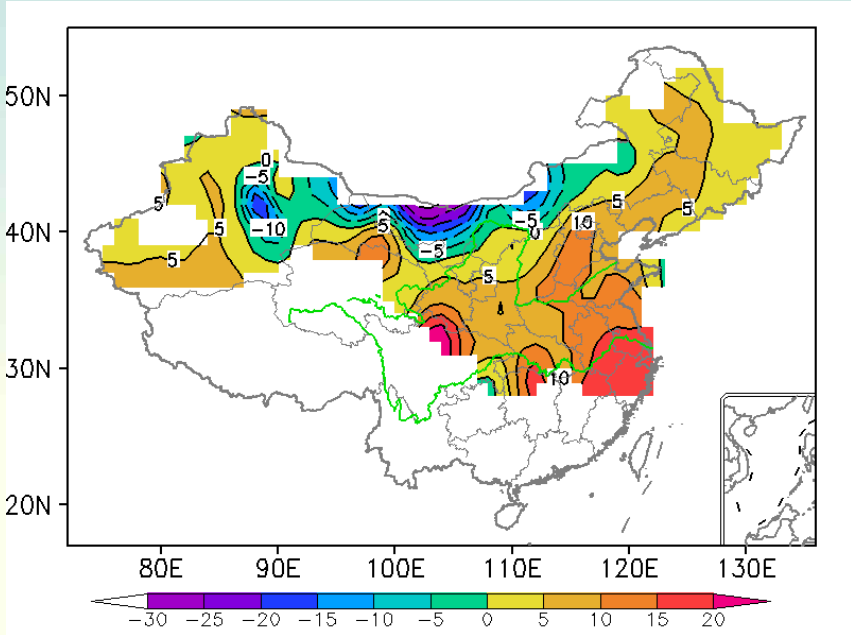


The difference of D1&D3, D2&D3

D1 & D3



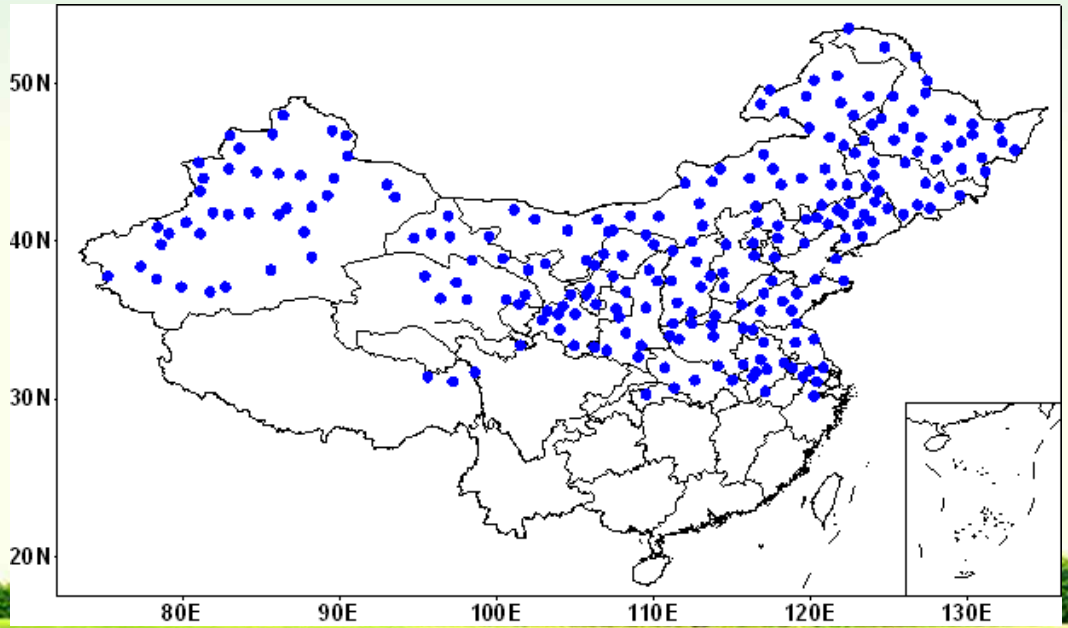
D2 & D3



D1: The first frost date is defined as the lowest daily ground surface temperature ≤0℃

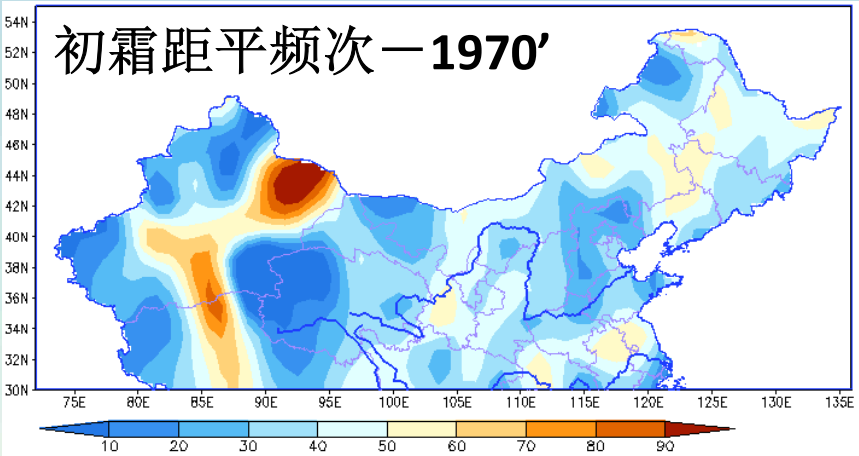
predictand: Northern China (≥30°N),

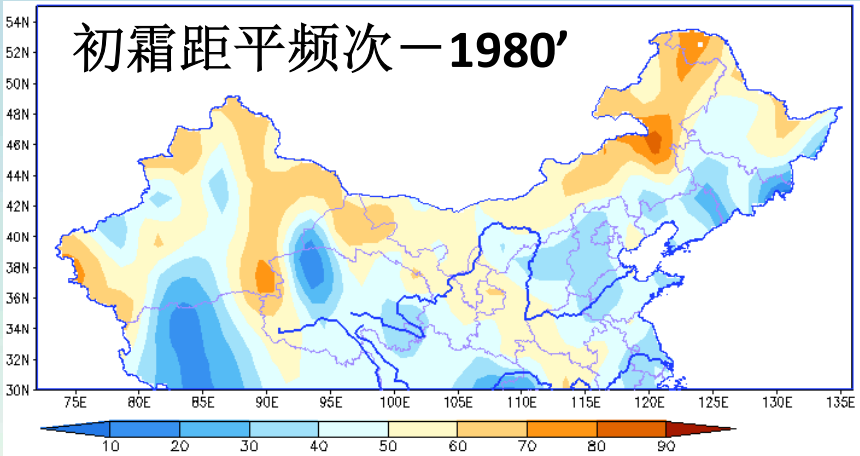
total 233 stations

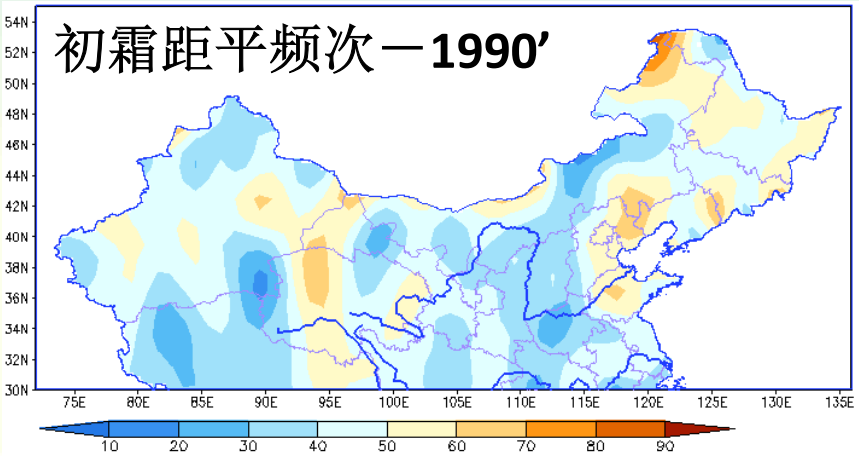


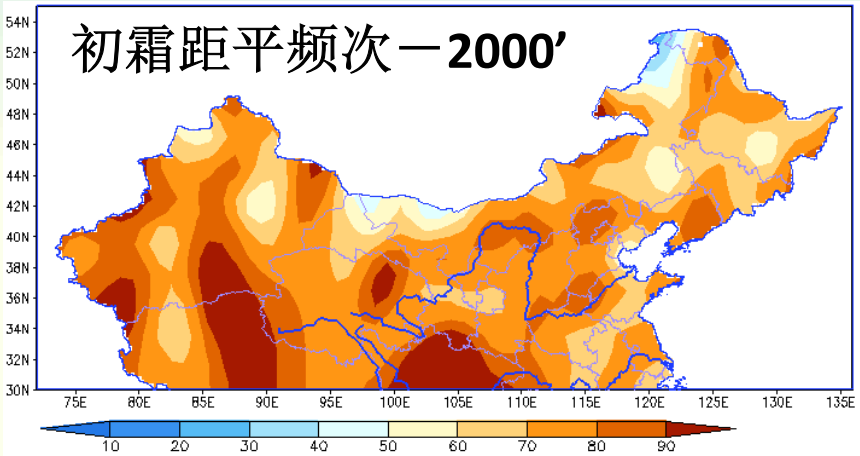
Decadal climate features

(frequencies of later than normal years)



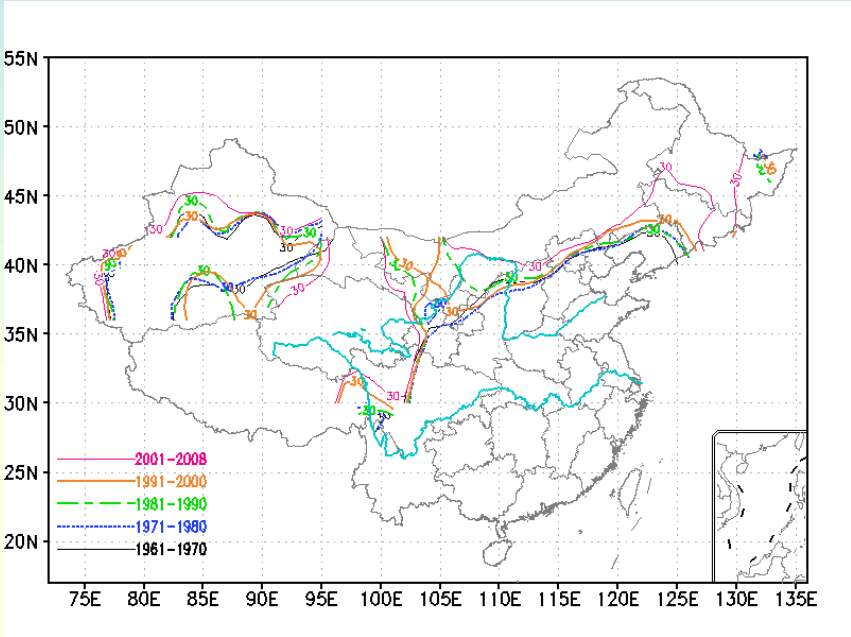




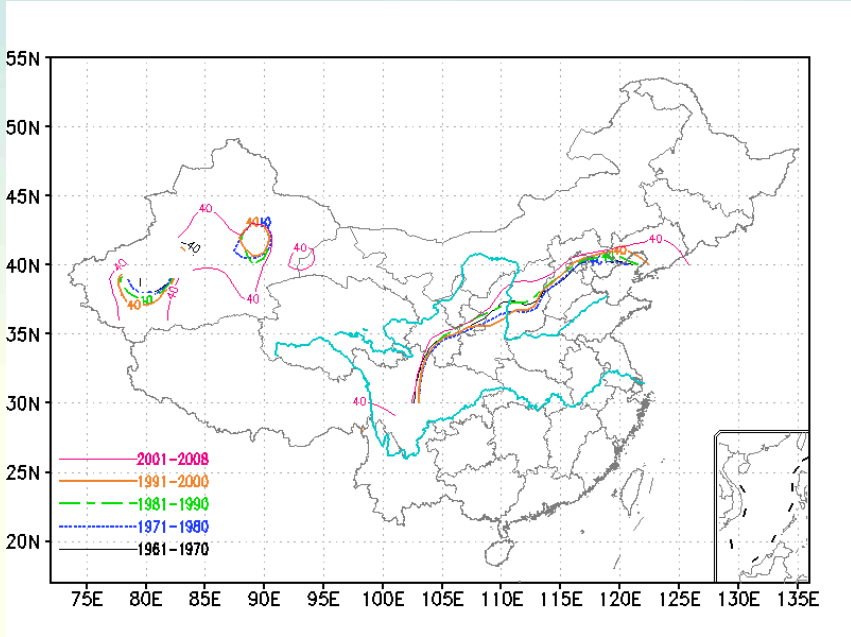


Decadal climate features

The average date line when the first frost date begin from Sept.30th

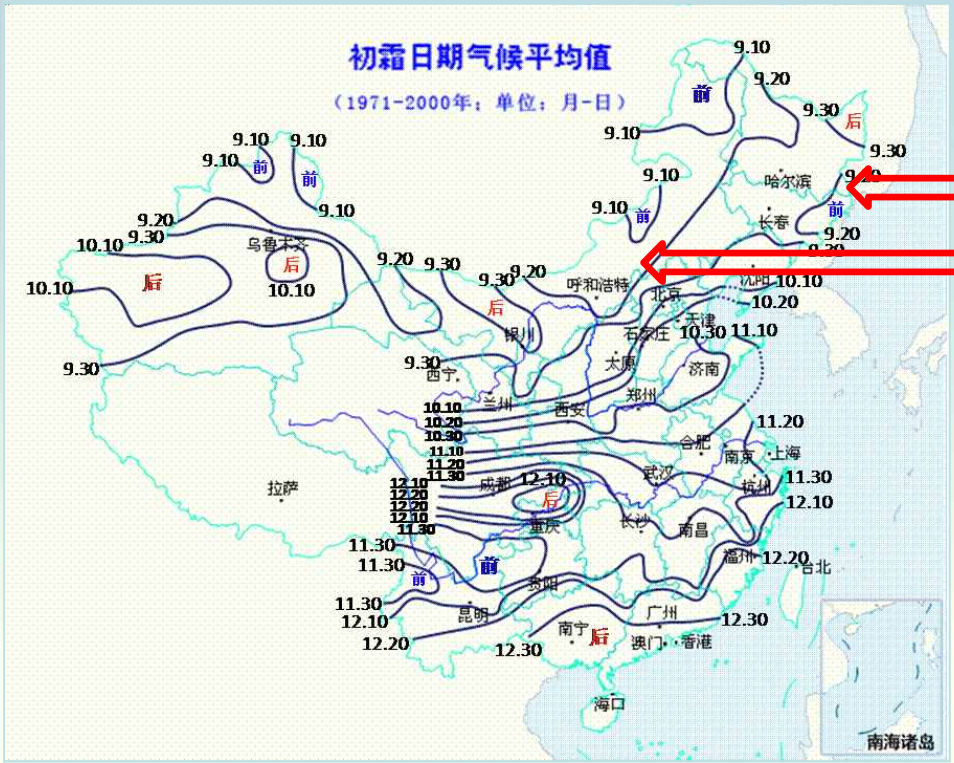


The average date line when the first frost date begin from Oct.10th

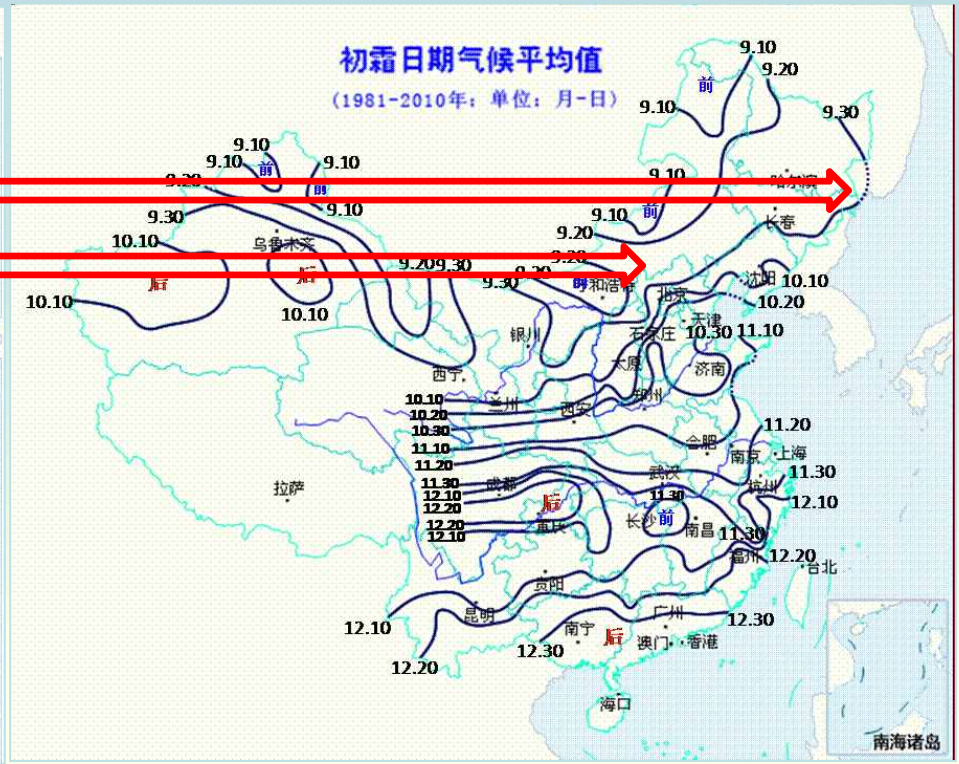


Change of climate average

1971-2000

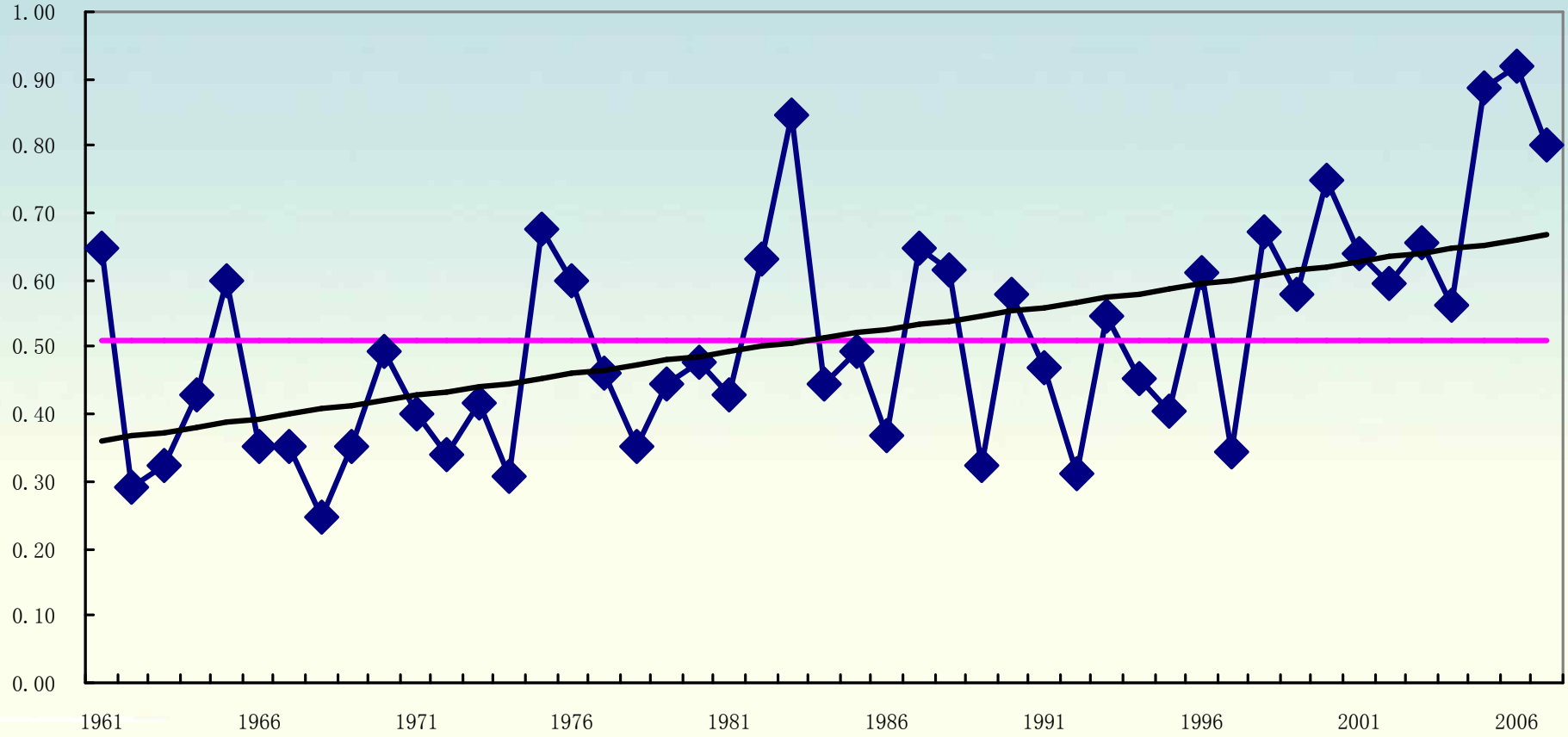


1981-2010

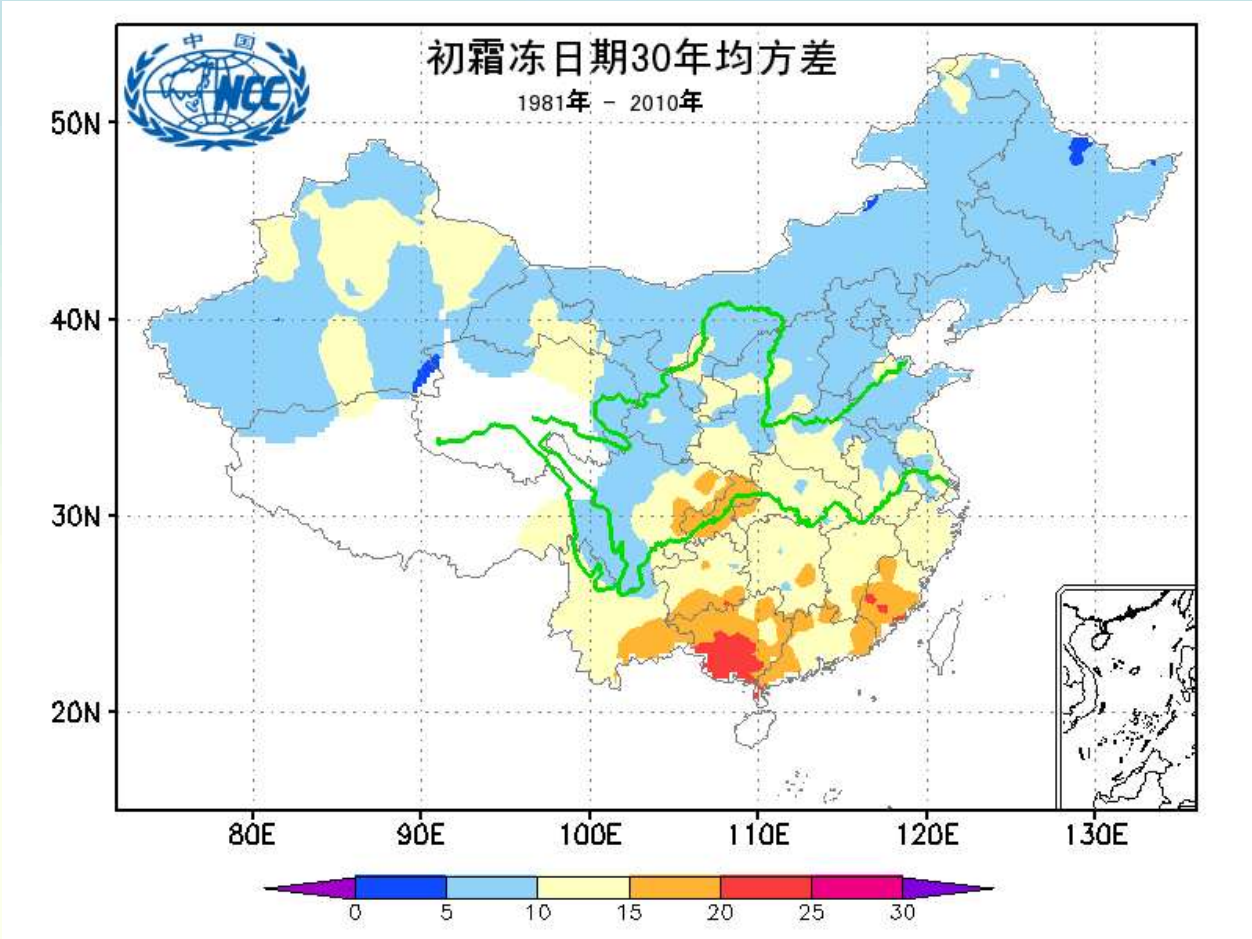


- The earliest region: Northern Northeast China, eastern Inner Mongolia(before Sept.20th)
- The later region: Jiang-Huai region (after the third dekad of Nov.)
- Change of average: in part of Northern China

Ratio of later than normal stations to total stations



Root mean square in 1981-2010 (unit: day)

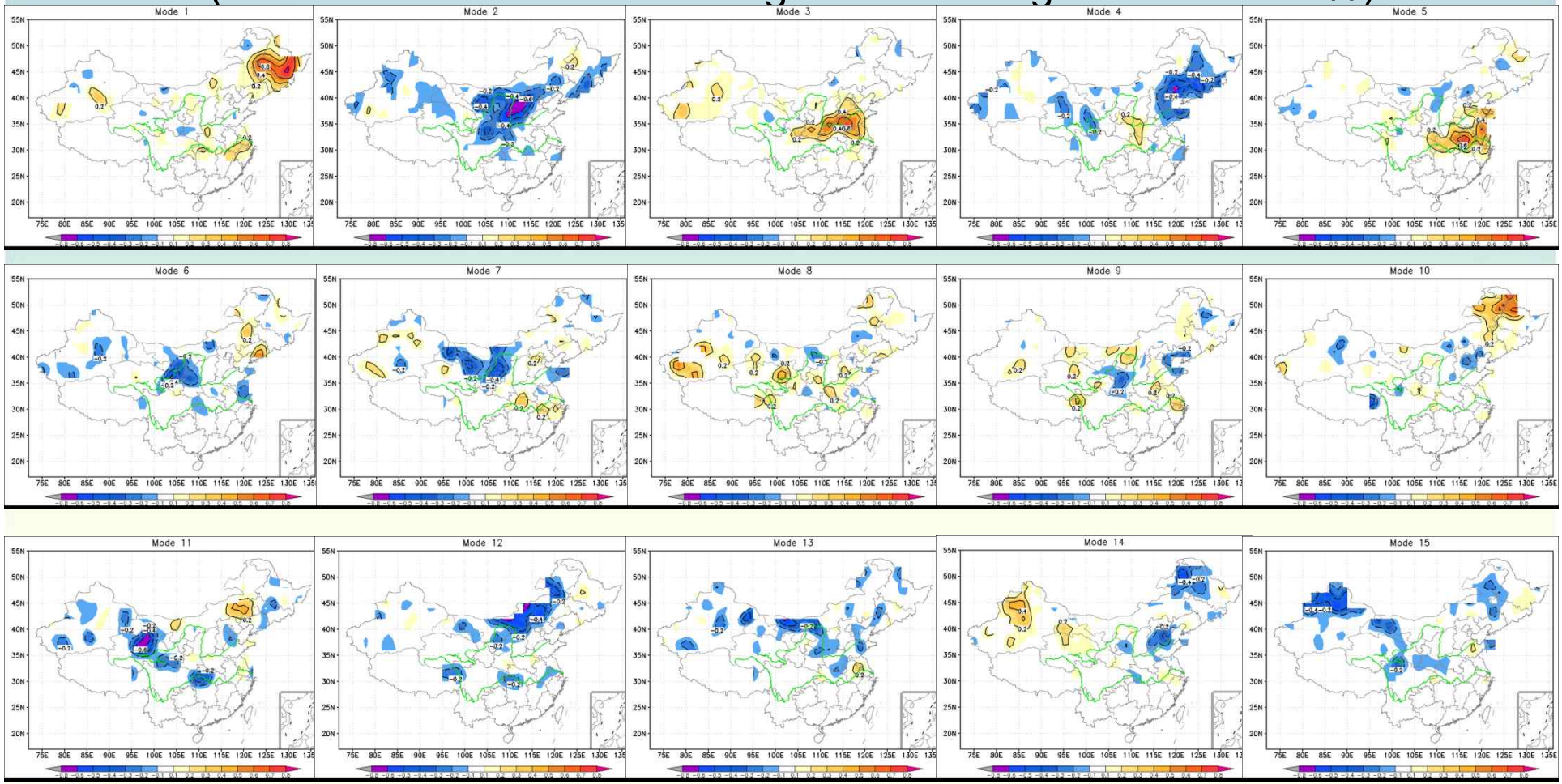


Prediction methods

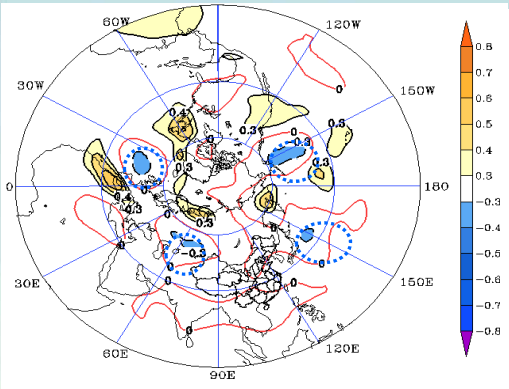
- Statistical method
- Dynamic-statistic method

REOF of the first frost dates

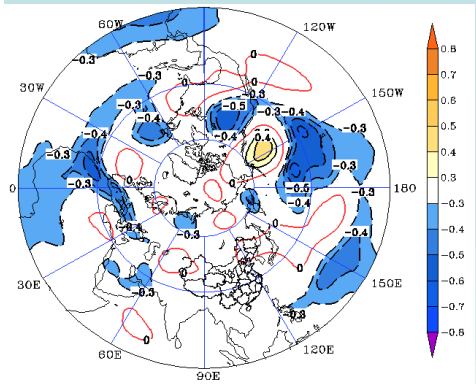
(the total variance of the 5 eigenvectors is greater than 80%)



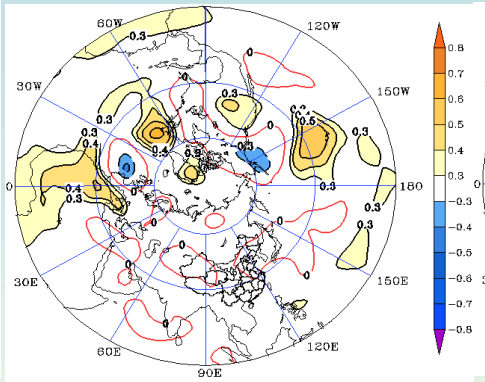
REOF of the first frost dates corresponding circulation and SSTA pattern



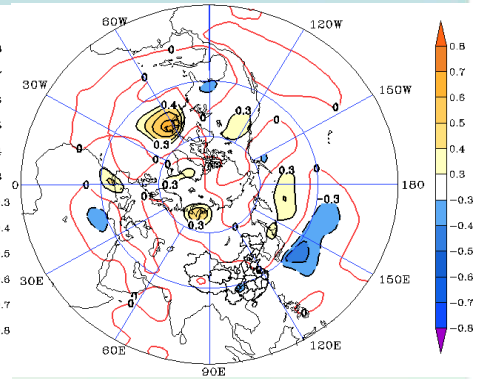
Mode 1



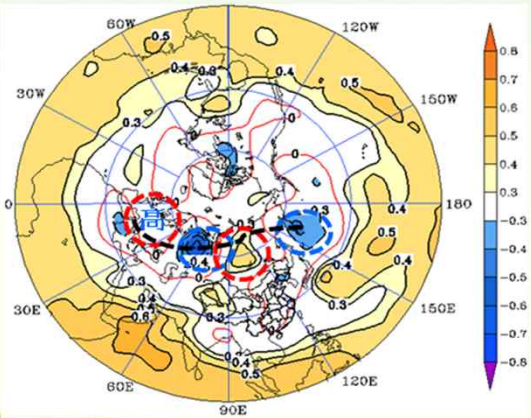
Mode 2



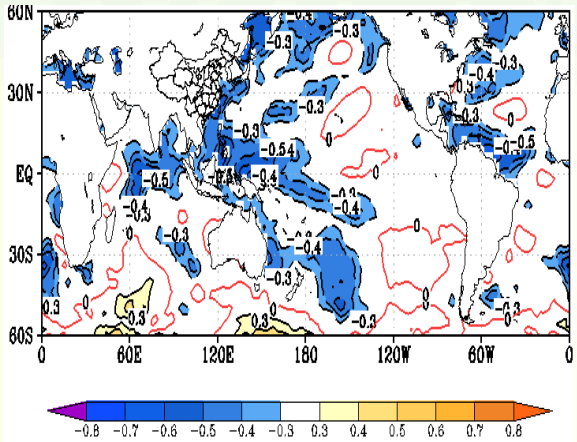
Mode 3



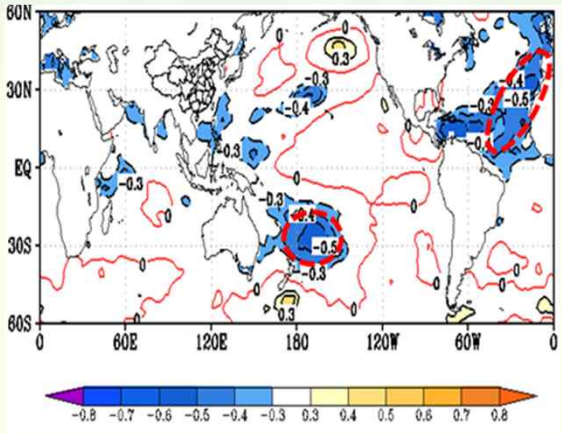
Mode 5



Mode 7

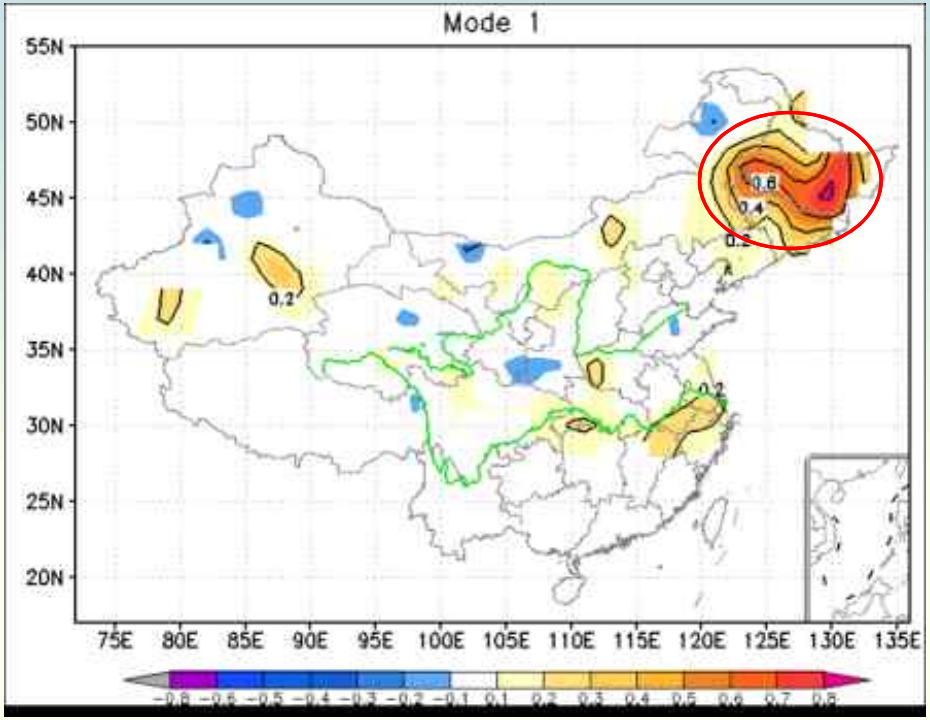


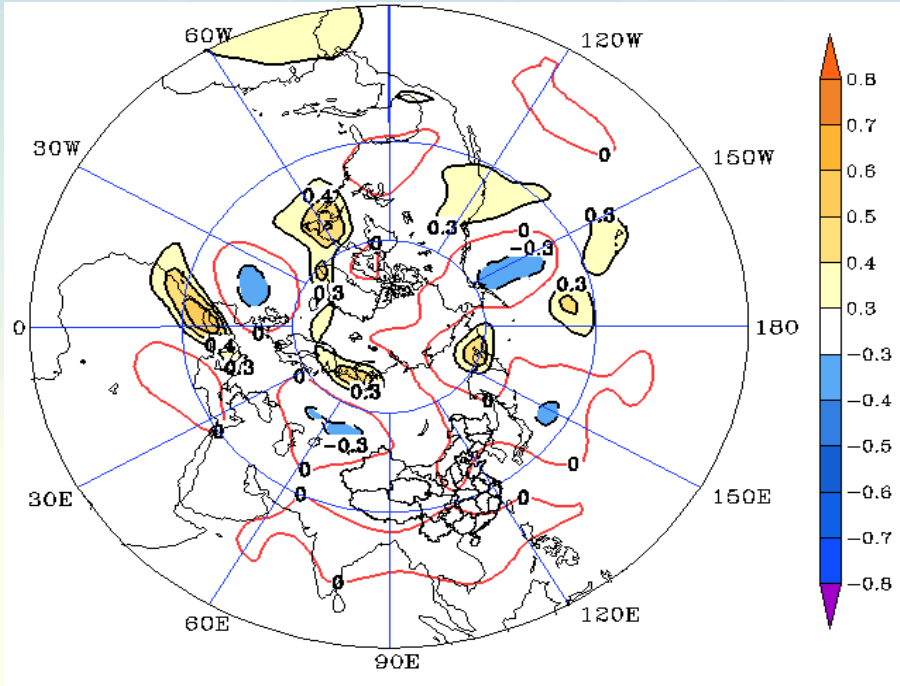
Mode 4



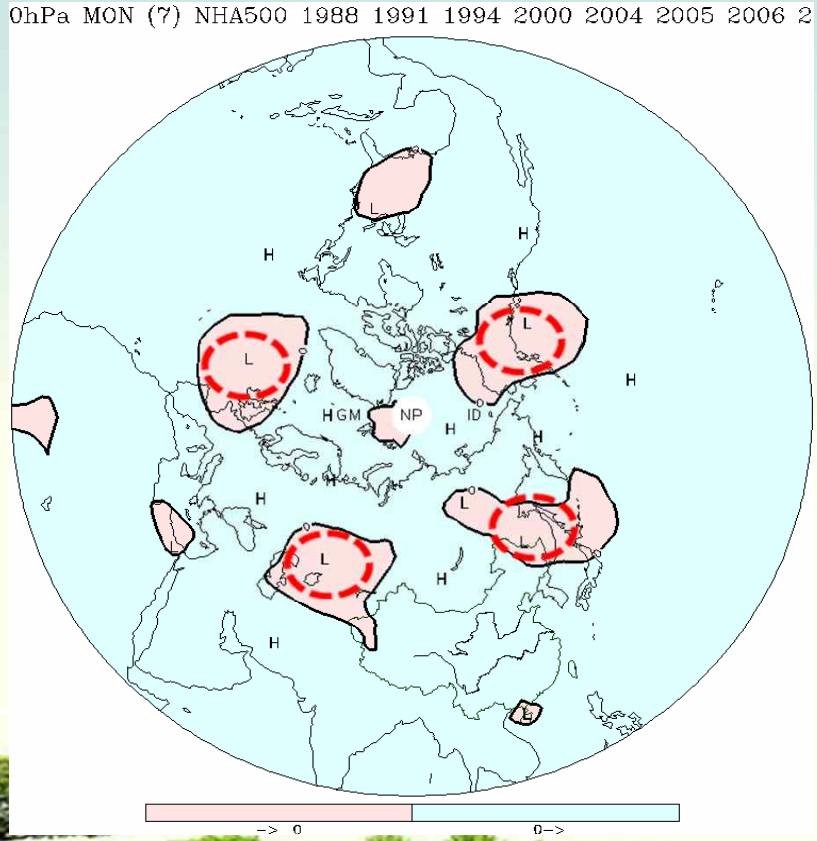
Mode 15

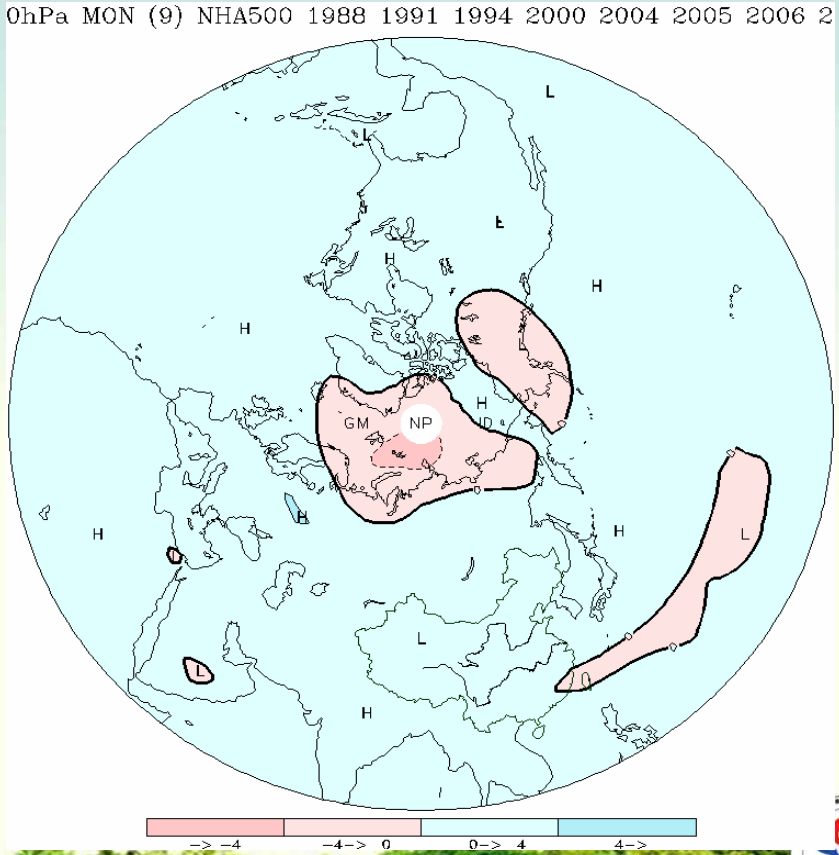
Mode 1 of REOF (the first frost date) and corresponded circulation pattern in June



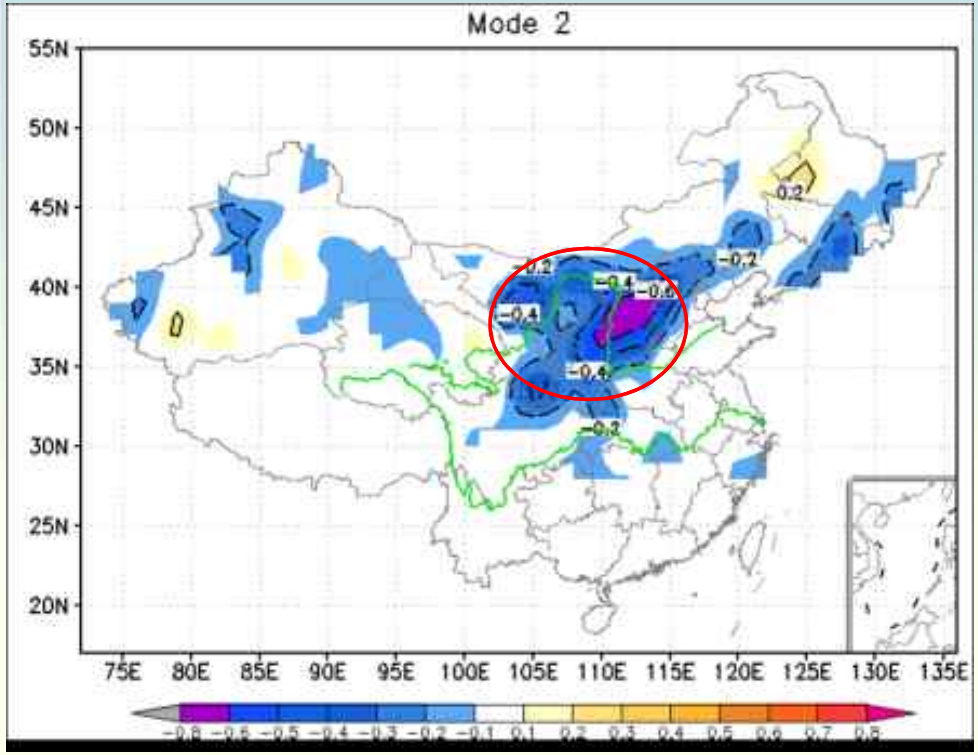


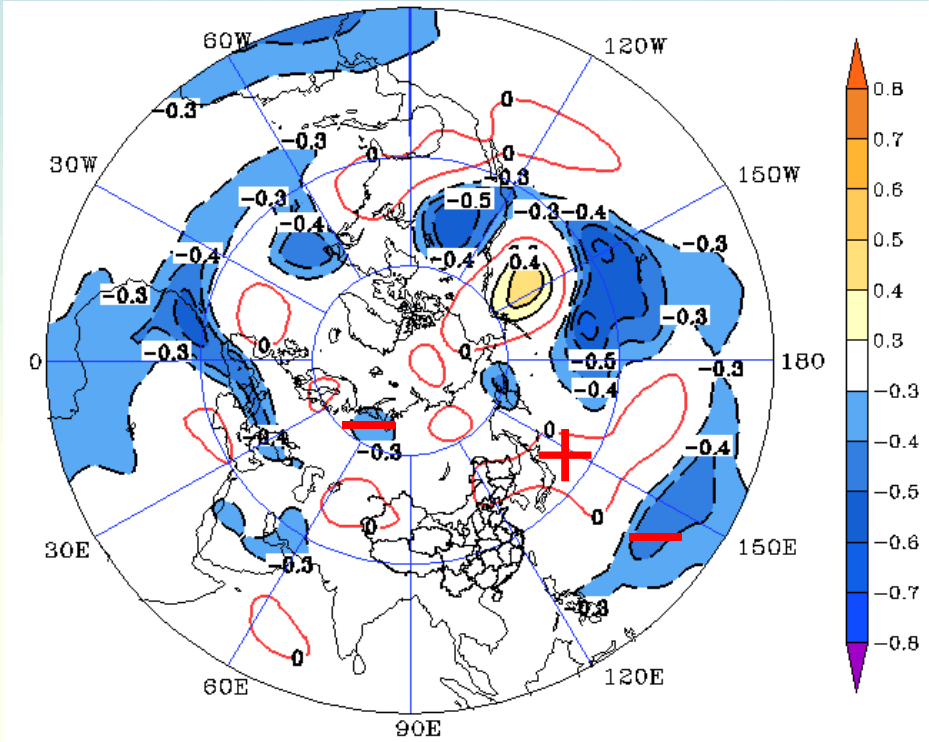
Composition field of 500-hPa height anomaly in July and September respectively during late first-frost date years



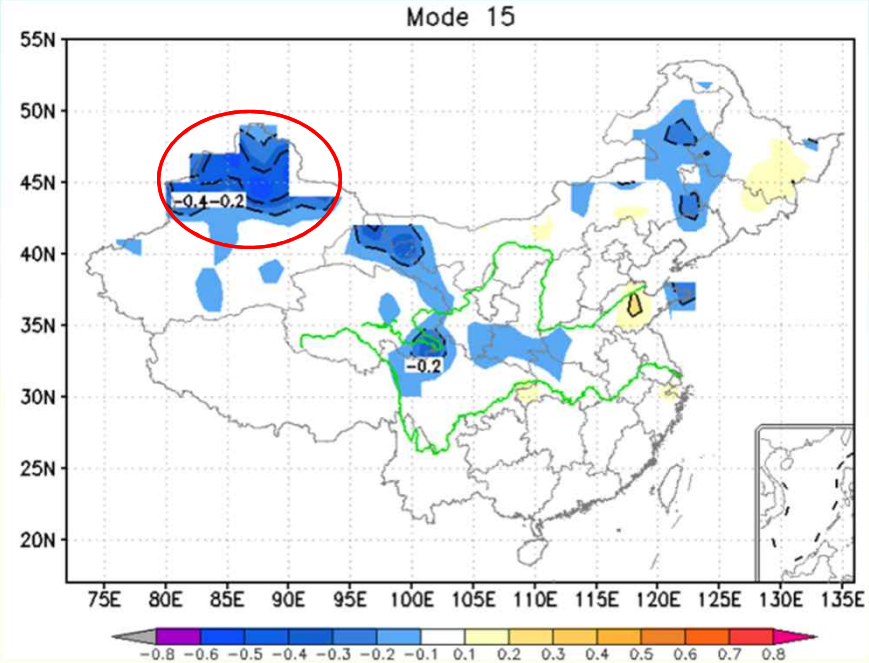


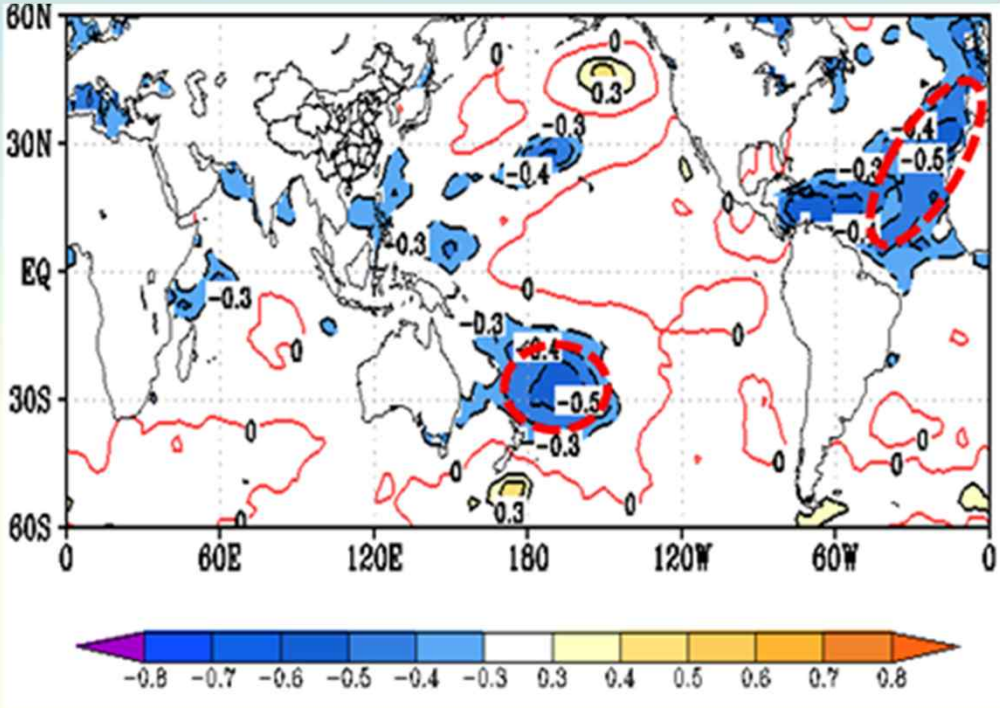
Mode 2 of REOF (the first frost date) and corresponded circulation pattern in June





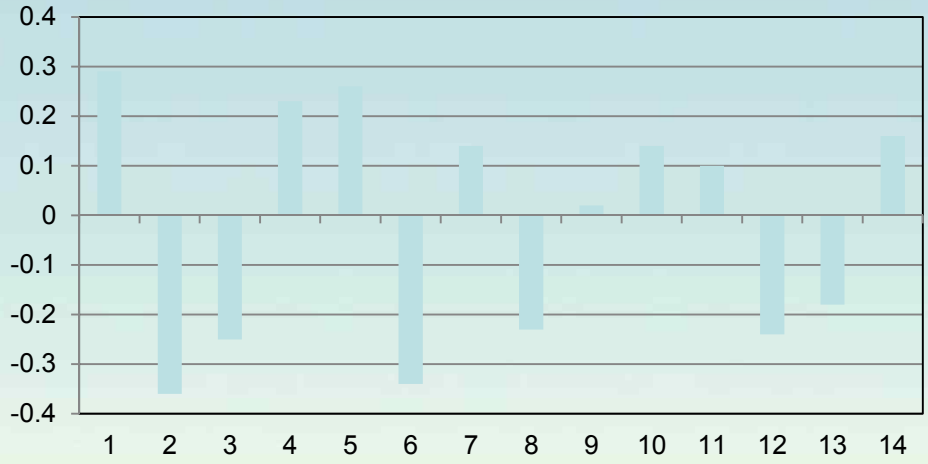
Mode 15 of REOF (the first frost date) and corresponded SSTA field in June





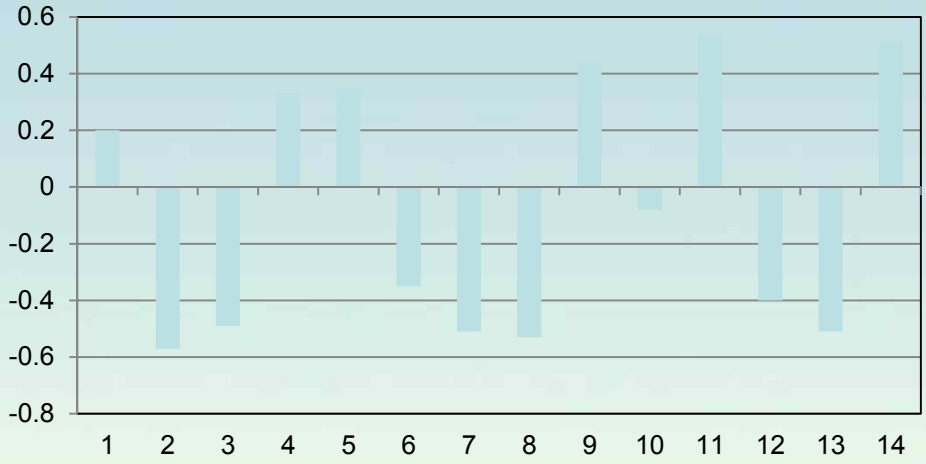
Significant predictors

大气影响因子



From atmospheric fields

海温影响因子



From SST fields

- Calculate the spatial ACC of 500hPa/SST in June and 15 projected 500hPa /SST fields corresponded with 15 REOF mode. All the predictors can be selected from the ACC value which get to 5% significant test. Analysis show that there are 7 predictors from 500hPa potential height and 4 predictors from SSTA play important role in 1979-2006.

Linear regression equation

$$[y]_t = [\beta]_0 + \sum_{i=1}^{11} [\beta]_i [x]_{i,t} + [\varepsilon]_t$$

$$[x]_{i,t} = S_{i,t} [V]_i$$

y: predictant (the first frost date of 233 stations)

[ ]: matrix

β: regression coefficient

ε: prediction error

x: predictors (the correlation value of analogue year times corresponding eigenvectors of REOF mode)

S: spatial ACC， (significant test :0.01)

i: from 1 to 11 (11 predictors)

t: time (year)

The flowchart of statistical prediction model for the first frost dates (R: correlation coefficient)

REOF of the first frost dates
Choose the 15 eigenvectors as orthogonal basis

Select predictors

Predictors from atmospheric fields

(1)Calculate the R between each eigenvectors and atmospheric fields

(2)Calculate the R between predictand and analogue year in circulation fields

(3)The correlation value of analogue year times corresponding eigenvectors of REOF to be a predictor

Predictors from ocean fields

(1)Calculate the R between each eigenvectors and SST fields

(2)Calculate the R between predictand and analogue year in SST fields

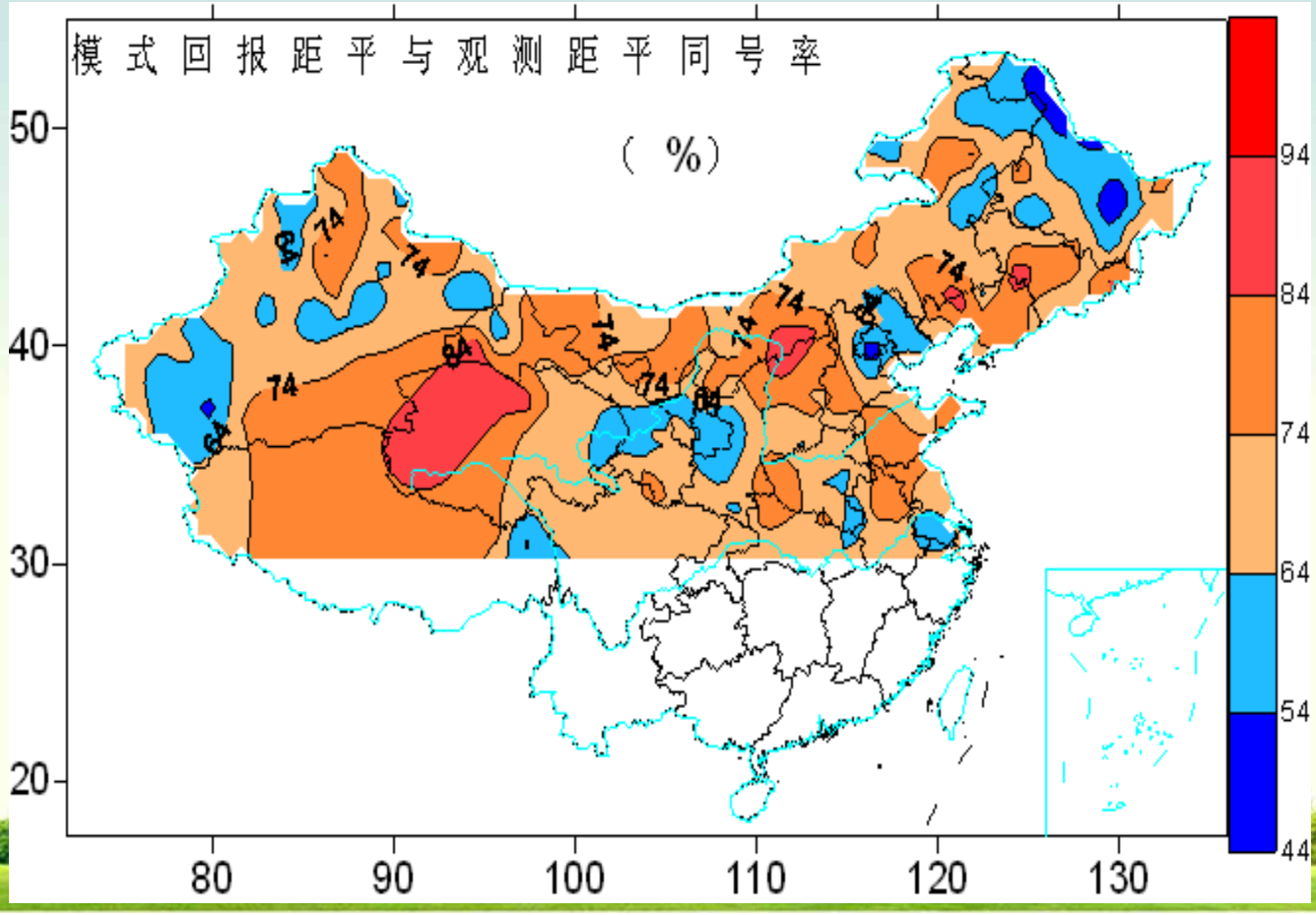
(3)The correlation value of analogue year times corresponding eigenvectors of REOF to be a predictor

Total 11 predictors
（7 in atmospheric field, 4 in SST fields）

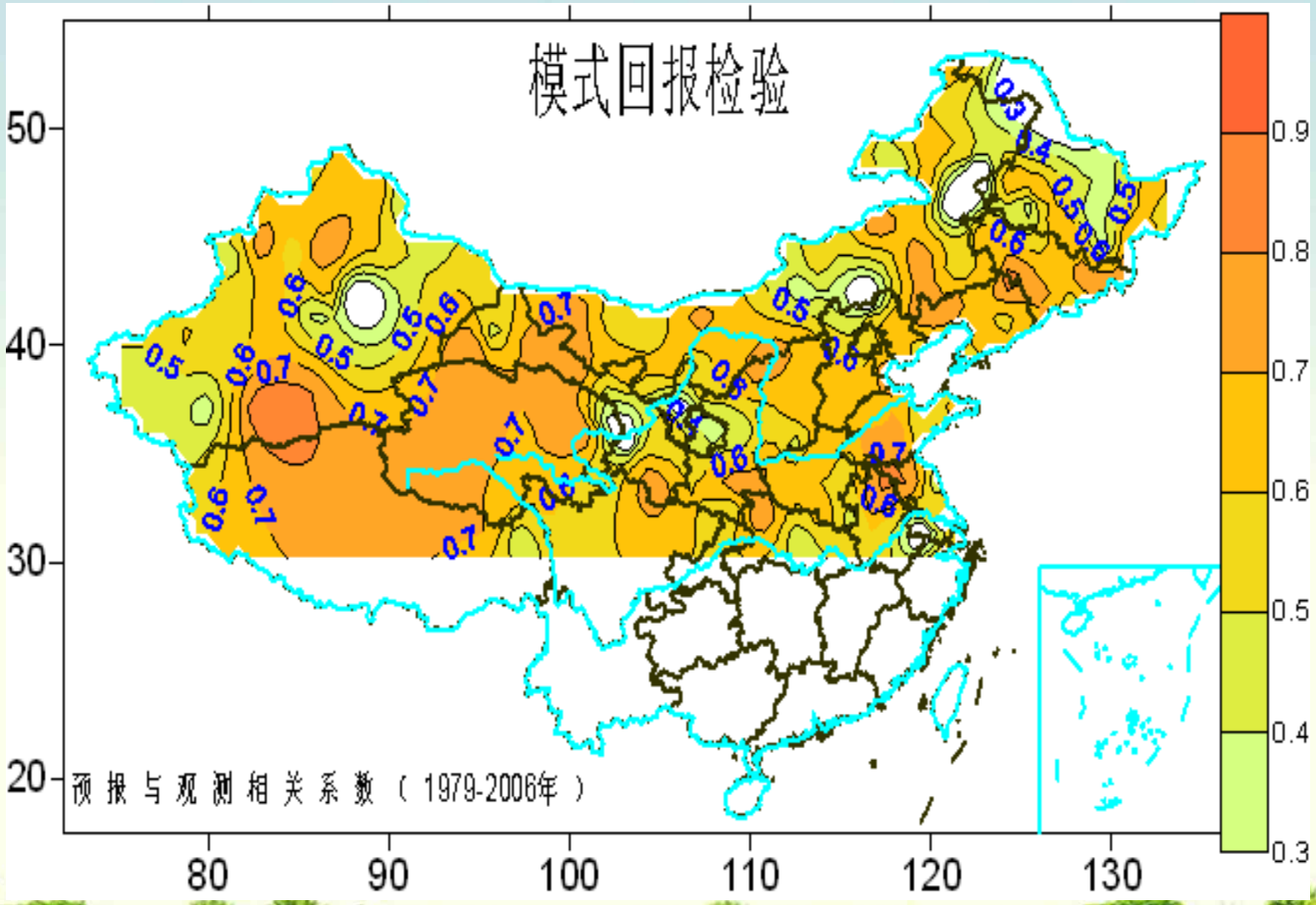
Stepwise linear regression prediction model

Verification and application :

Hindcast test：same sigh percentage of the prediction and observation (1979-2006)

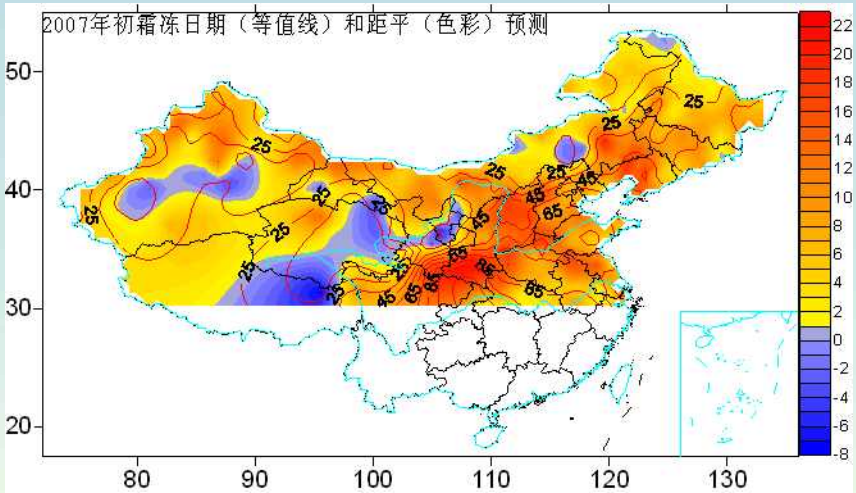


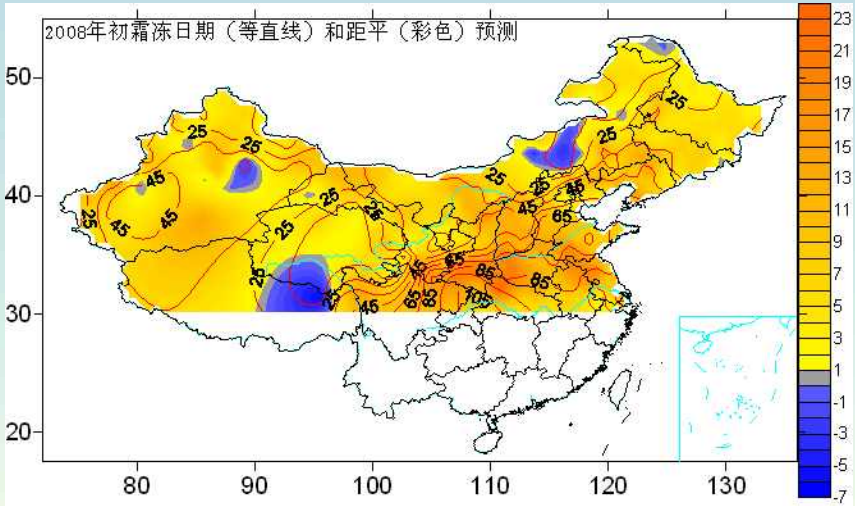
Hindcast test： ACC between the prediction and observation (1979-2006)

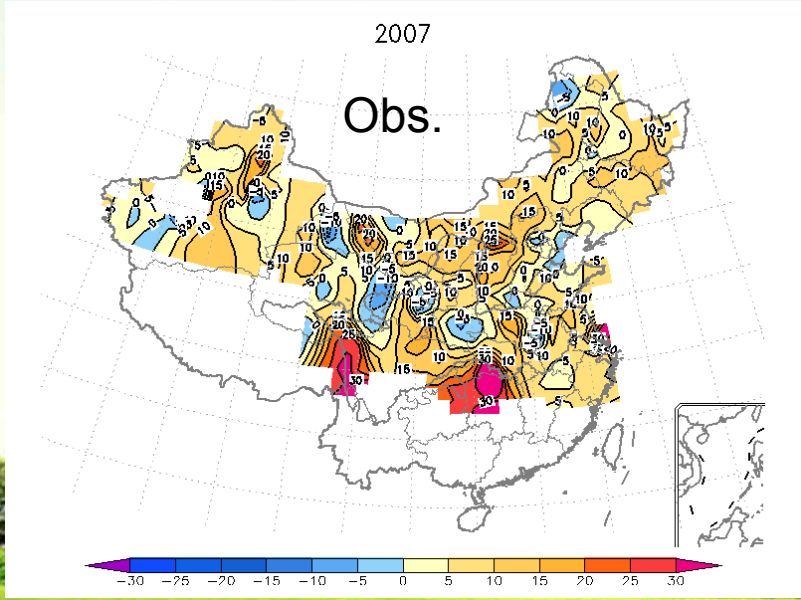


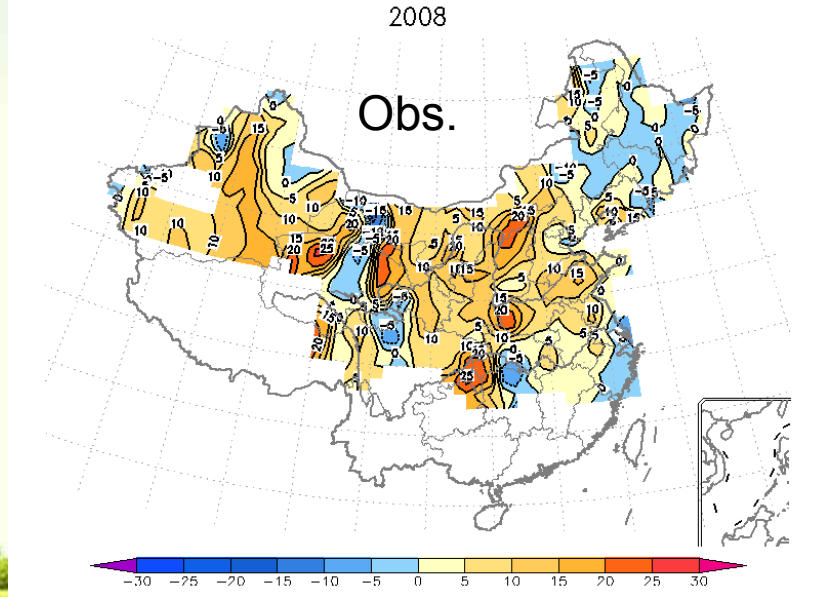
Verification and application :

Independent prediction：2007、2008



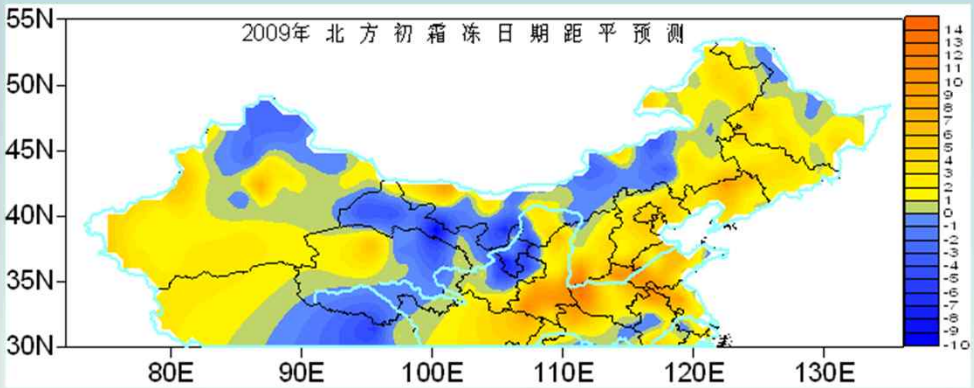


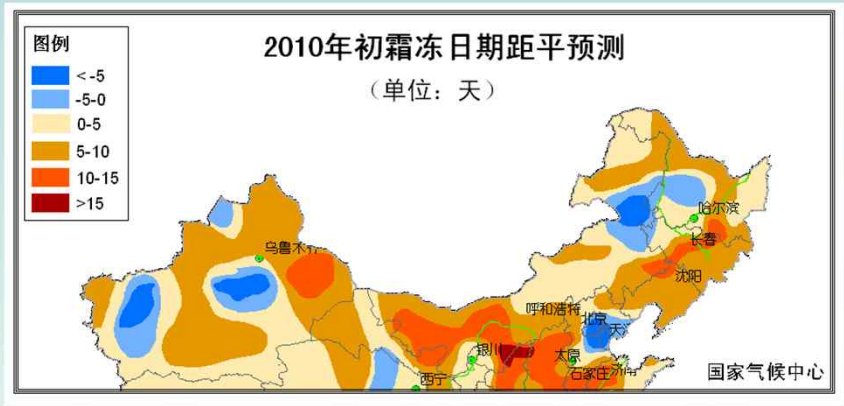


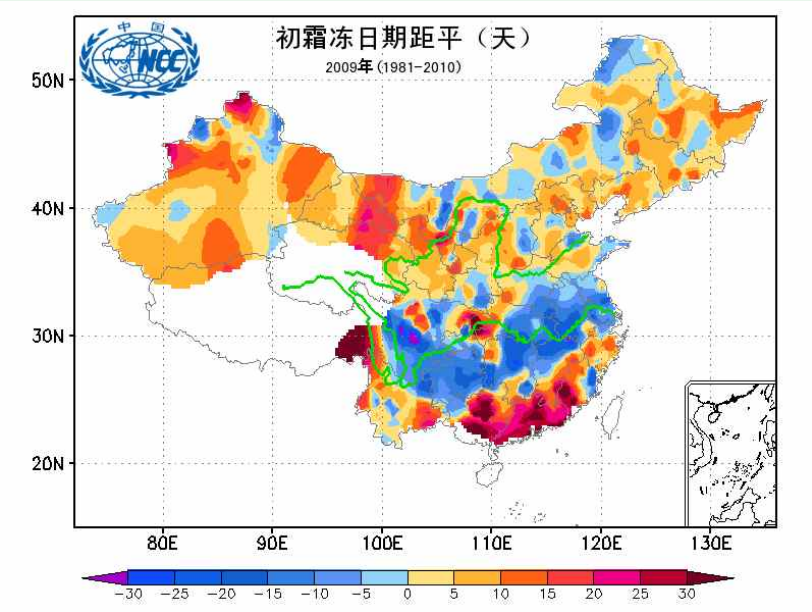


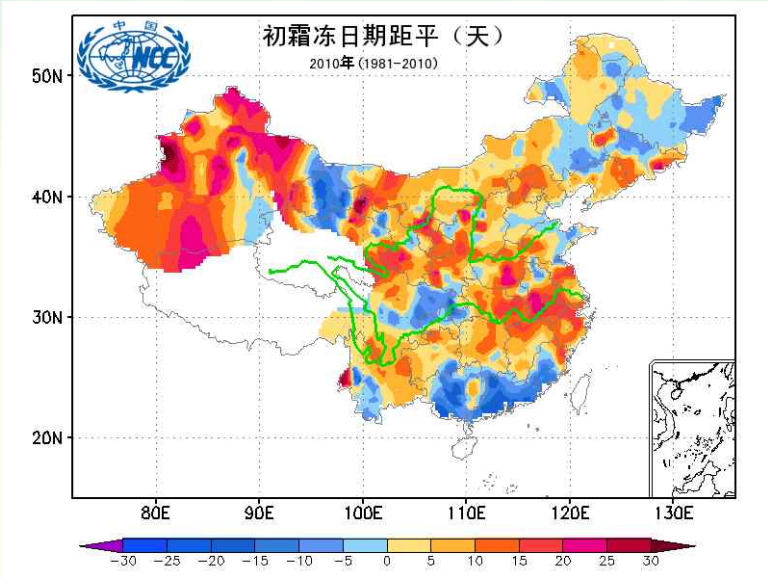
Verification and application :

Realtime prediction：2009,2010



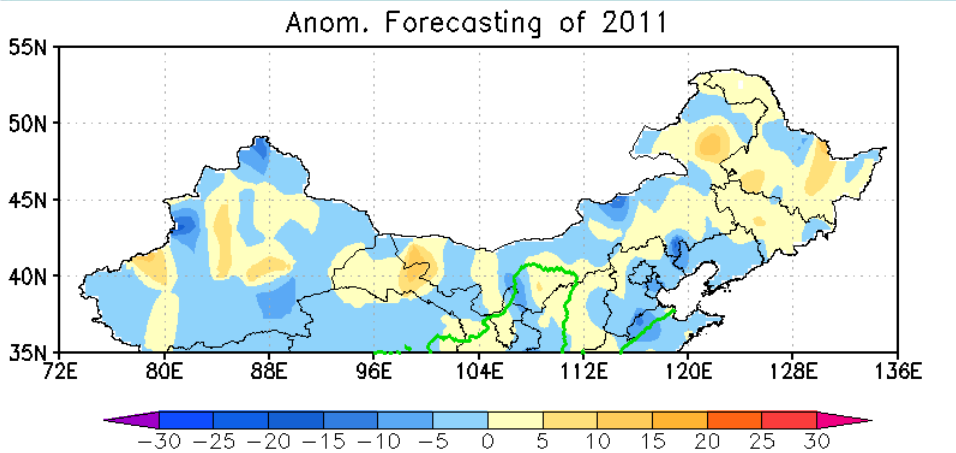


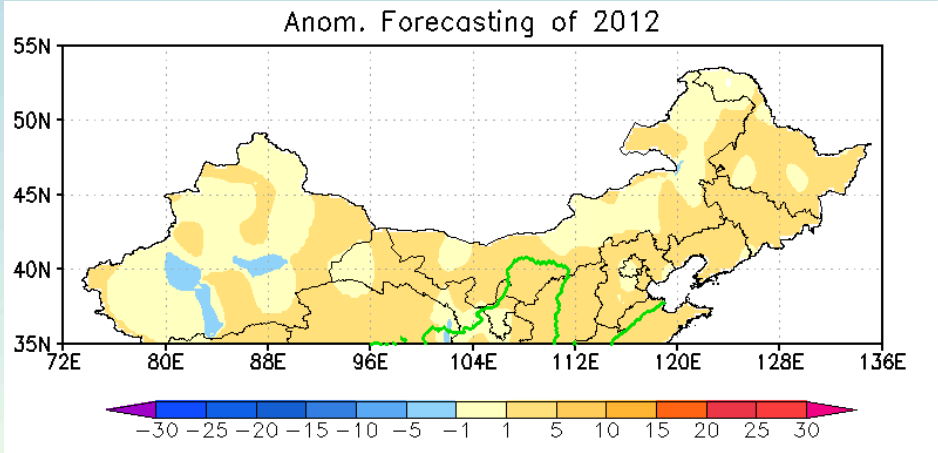


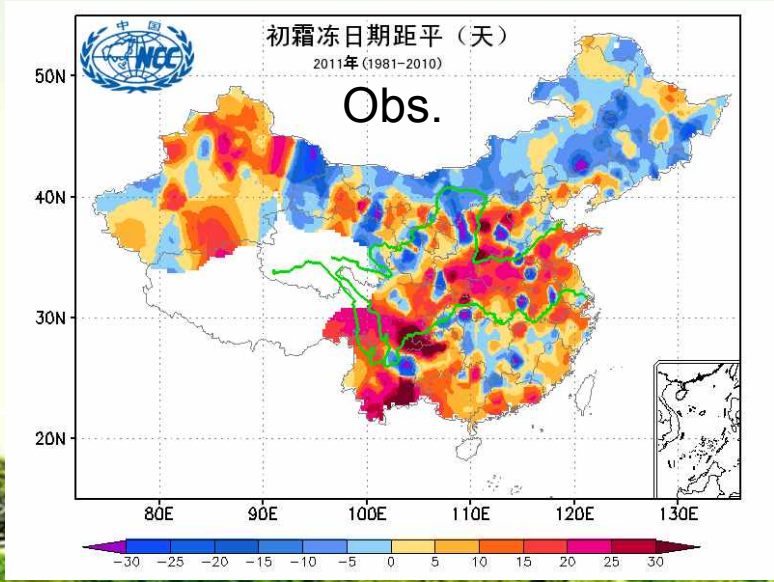


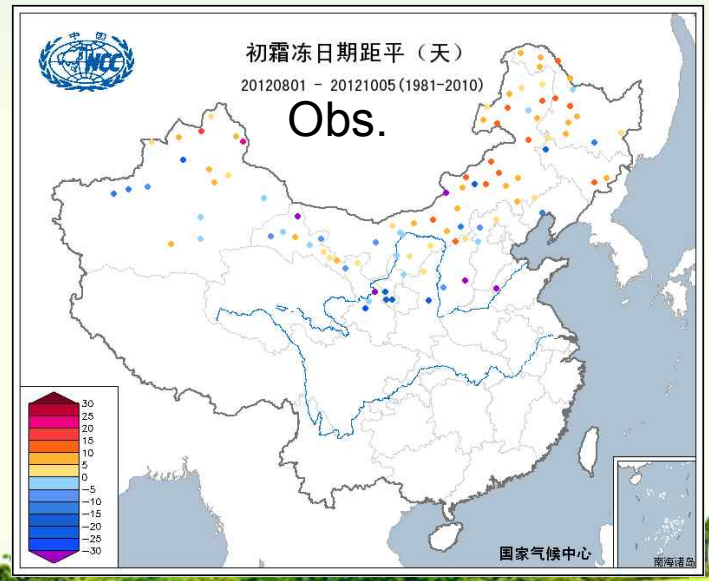
Verification and application :

Realtime prediction：2011,2012









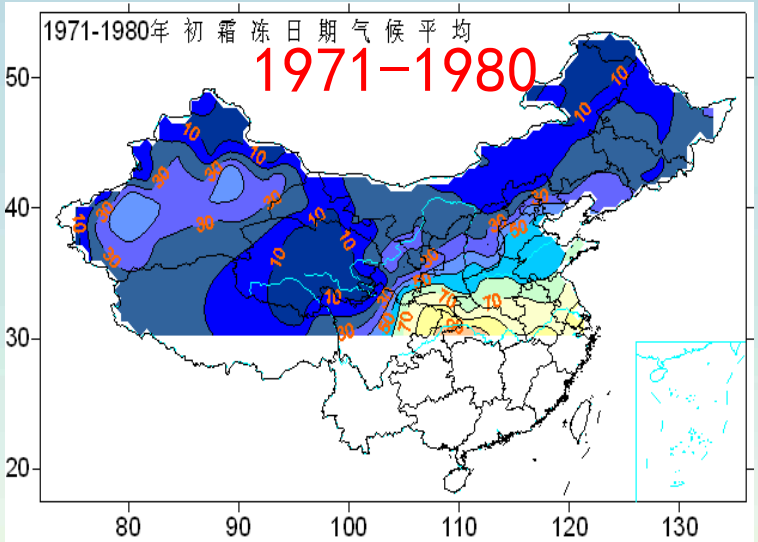
Conclusion and discussion

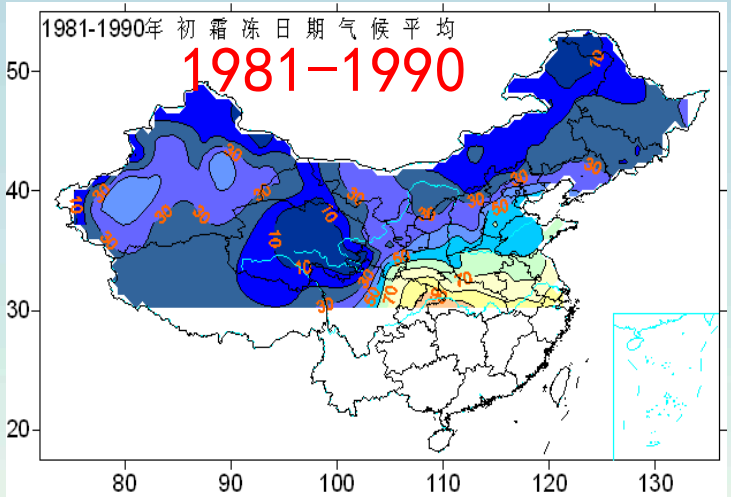
- Based on monitoring and prediction of the first frost date, we have developed an operational sub-system which can provide the climatic features and outlook of the first frost date for more than 200 representative stations in Northern China.
- Evaluation of the statistical model performance shows that the skill is higher in most of Northern China.
- The model needs to be improved and modified predictions of the first frost date need providing in order to satisfy the users' demands.

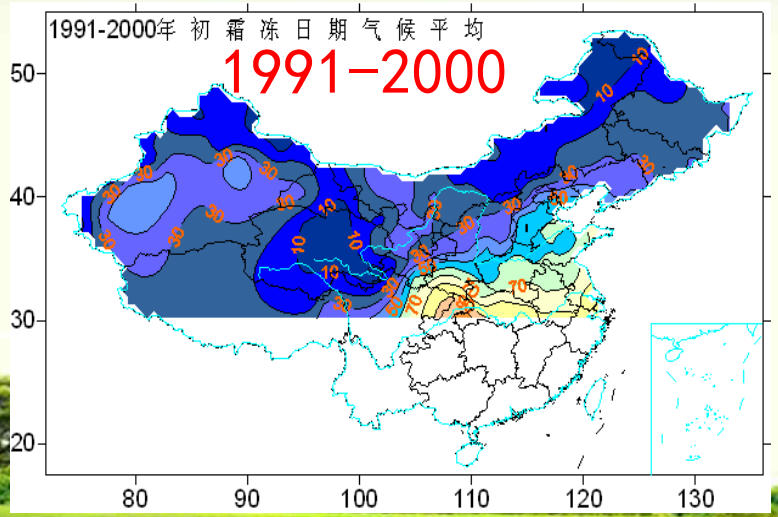

谢谢！
Thank you!

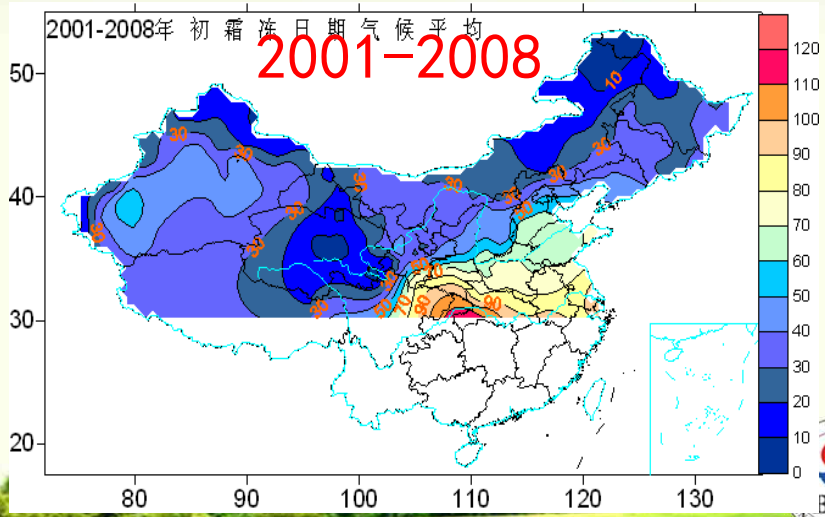
Climatic variability：

Decadal climate features

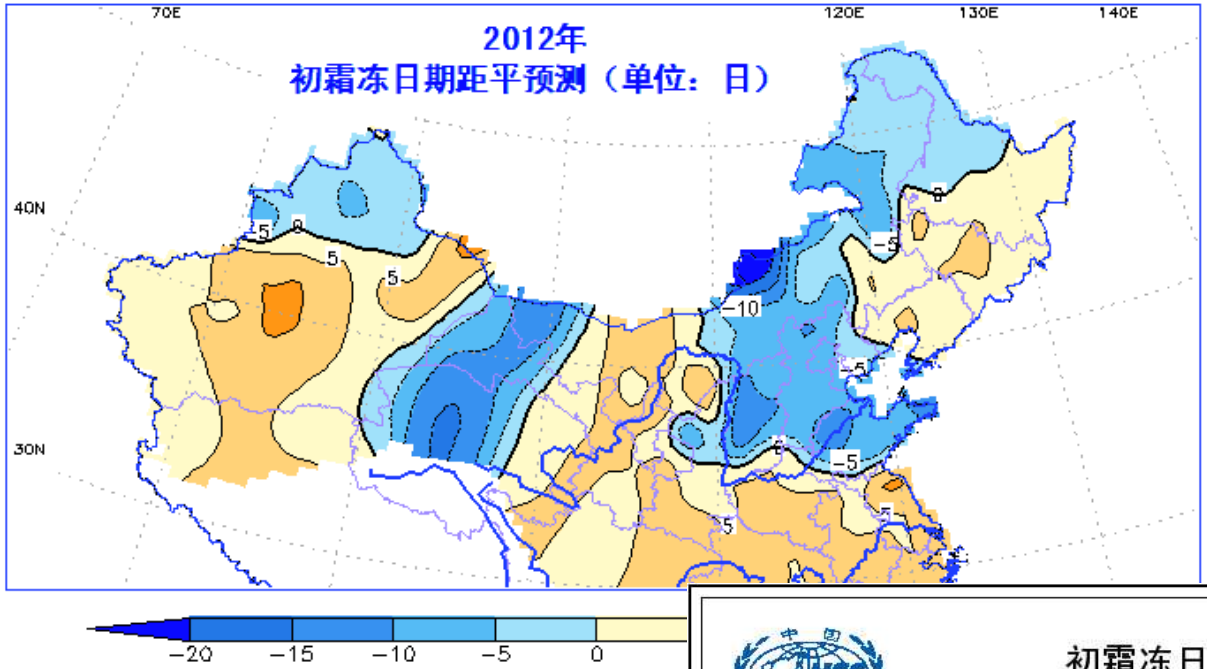


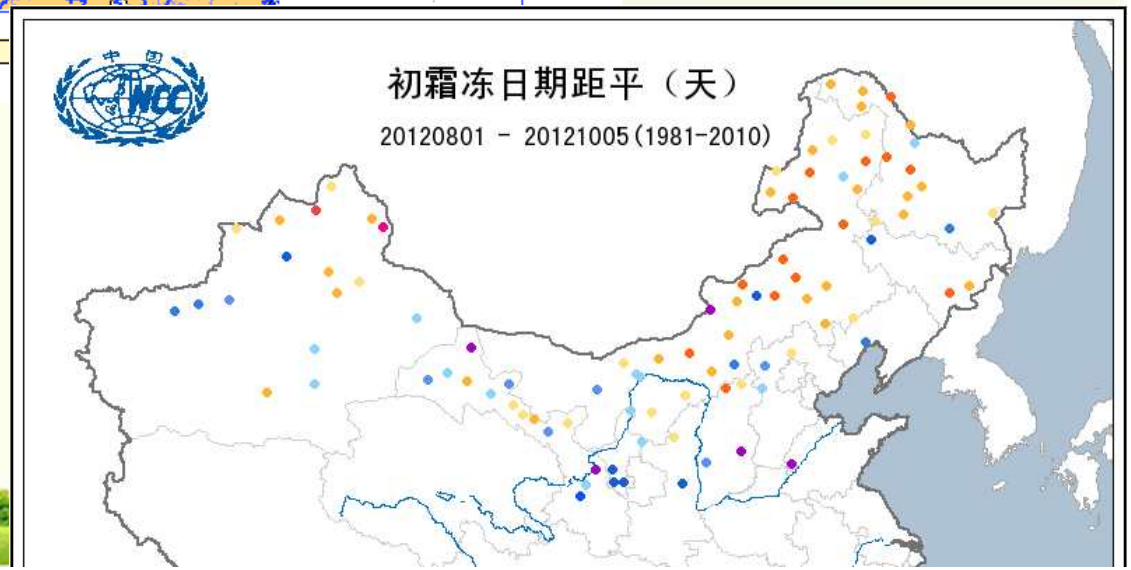




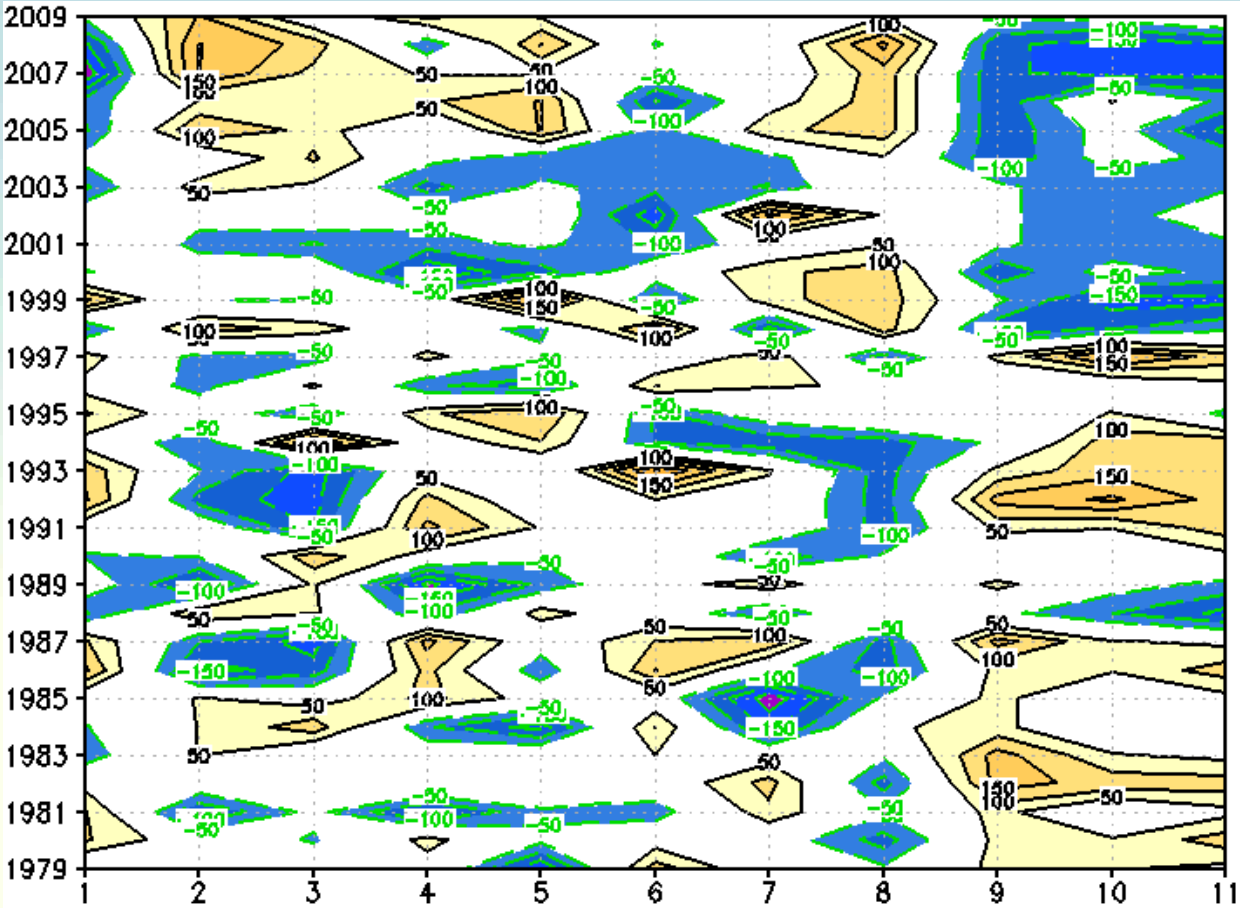


issued prediction in 2012





11 predictors changed with years in the regression equations



Predictors from circultion

Predictiors from SST