Introduction of Medium and Extended-range Weather Forecast Services in CMA

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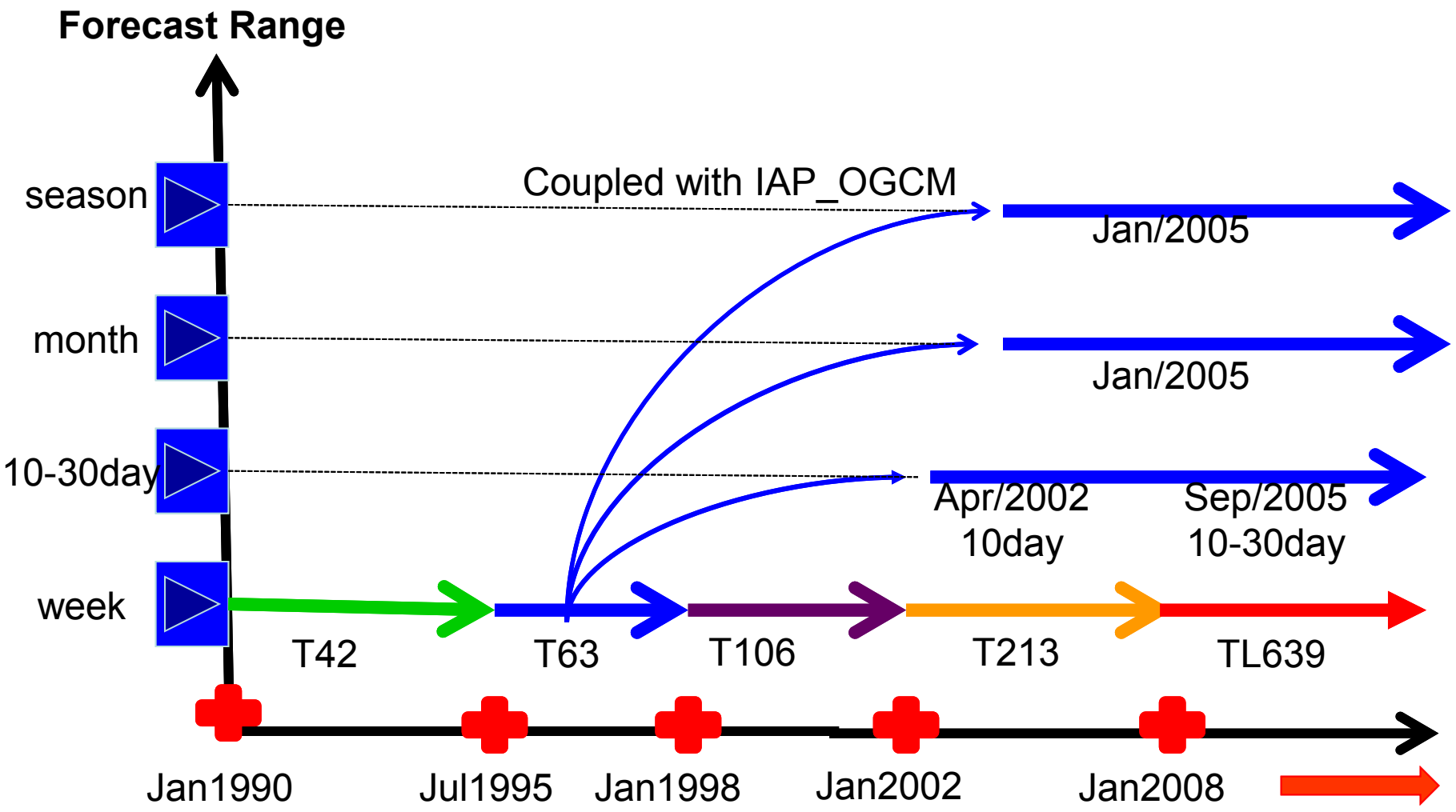
History of CMA global medium to long range forecast systems



Medium and Extended Range Forecast Services

Kind of Forecast	Date of Issue	Forecast Model
1-week	00UTC & 12UTC, every day	• T_L639L60 • T213L31ensemble with fixed SST（since 2006）
10-30day forecast	• End of every pentad:10day fcst. • End of every 10-day: 20-day fcst.	T63L16ensemble with persistent SSTA
1-month forecast	• 28th of each month: monthly forecast • 1st、6th、11th、16th、21th、26th of each month: 30-day forecast	T63L16ensemble with persistent SSTA
3-month forecast	28th of the month	CGCM
Flood season forecast (JJA)	1 April	CGCM
Annual forecast (DJF, MAM)	1 November	CGCM

Operational dissemination

NMC

NCC

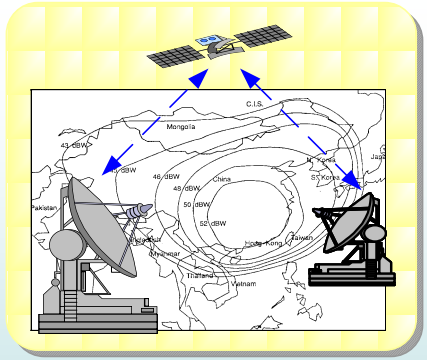
NSMC

National Operational Cneter

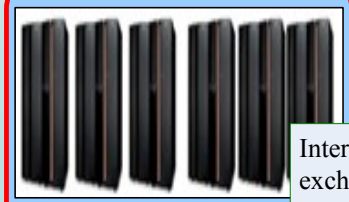
Local net with 1000Mbps

CMACAST covers China and surroundings with 70Mbps

Satellite cast

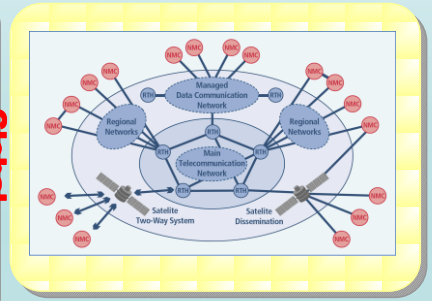


Numerical Prediction Center



CMA PRIVATE NET with about 10Mbps

Global Telecommunication System



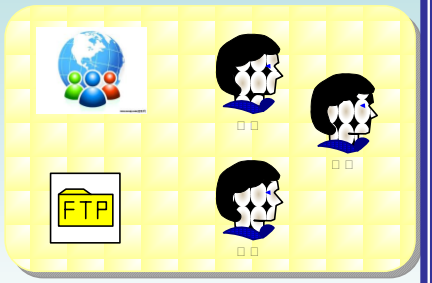
International exchange with GTS□ 6Mbps totally□

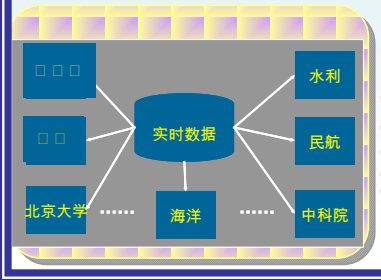
Regional/Province Operation Center

Leased line with 100Mbps

Internet

Global public





National ministries/universities

Human services □ calldesk□

Web browse and FTP download by internet

Medium range forecast system

1-week forecast

Based on T639 deterministic forecast

	Global Spectral Model (T_L639L60)
Forecast range	Short- and Medium-range forecast
Forecast domain	Global
Horizontal resolution	T_L639(0.28125 deg)
Vertical levels / Top	60 0.1 hPa
Forecast Hours (Initial time)	240 hours(00、12 UTC) 84 hours (06、18 UTC)
Initial Condition	Global Analysis (NCEP GSI)

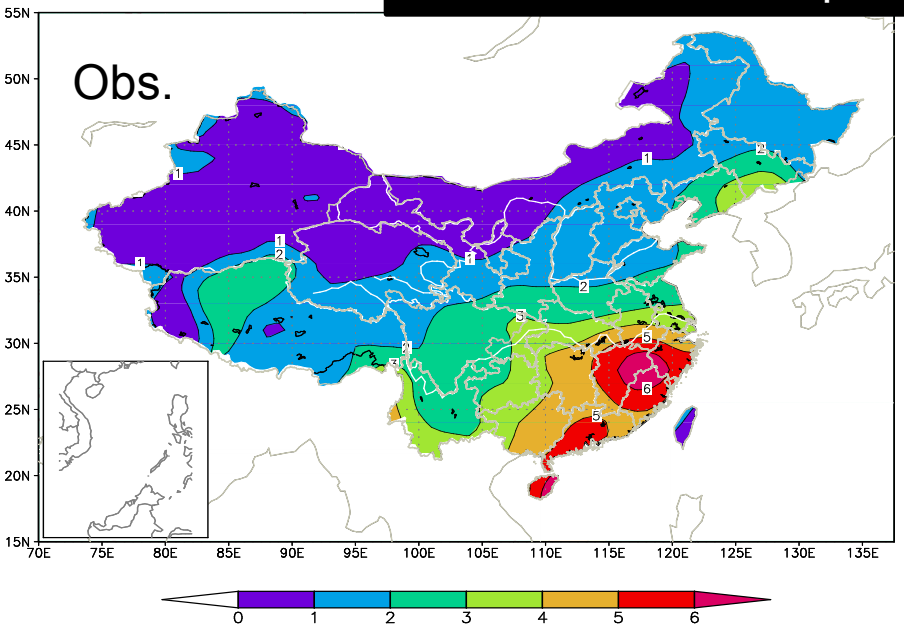
T639 DA: GSI/NCEP

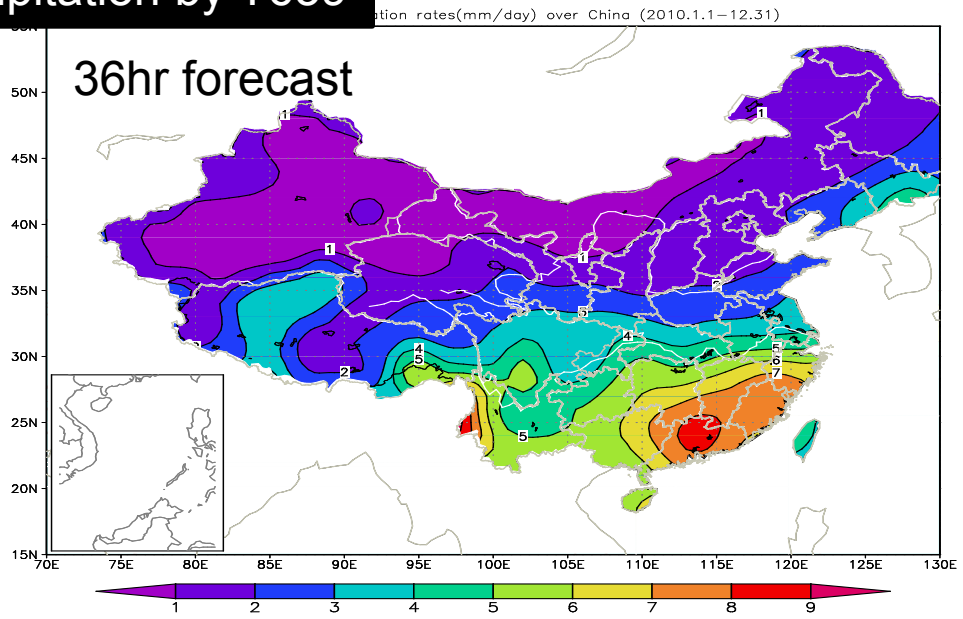
(grid-point statistical interpolation: *Wan-Shu Wu, R. James Purser and David F. Parrish, 2002*)

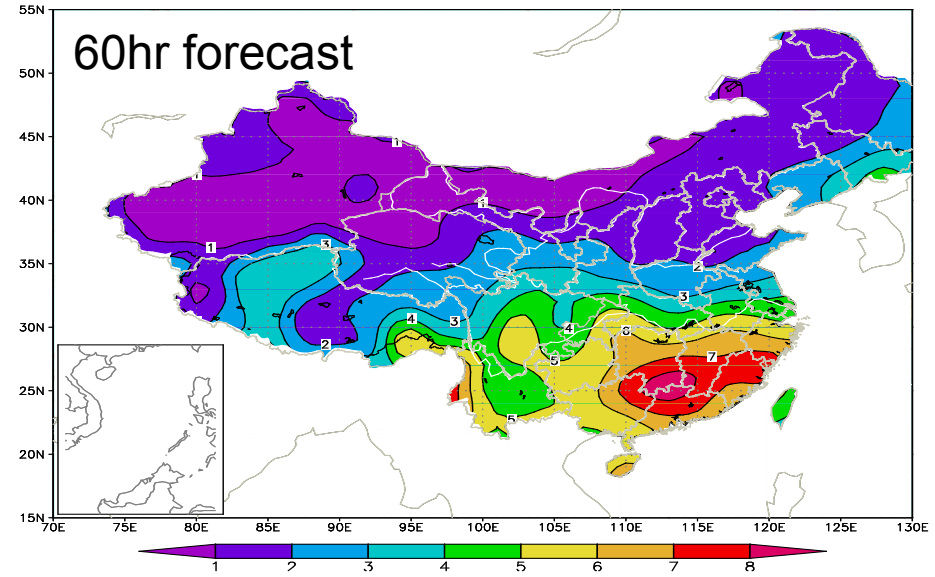
	Global Analysis
Analysis scheme	**GSI 3DVAR**
Analysis time	**00, 06, 12, 18 UTC**
Data cut-off time	**3 hours 29 minutes(00, 12 UTC)** **5 hours 45 minutes (06, 18 UTC)** **[Early Analysis]** **10 hours (00, 12 UTC)** **7 hours 40 minuts (06, 18 UTC)** **[Cycle Analysis]**
Resolution	**TL639L60**
Assimilation window	**-3 hours to +3 hours of analysis time**

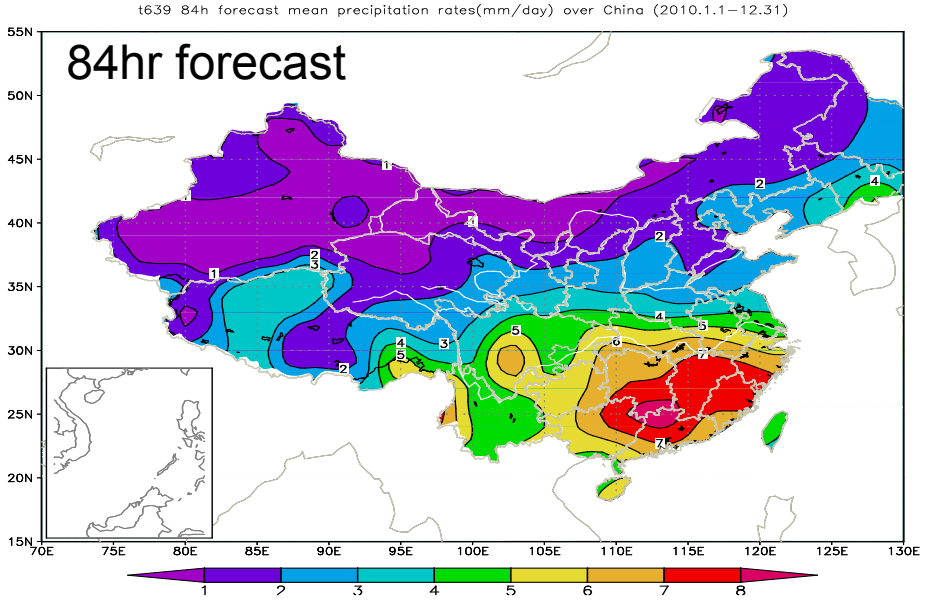
Conventional data
radiosondes,
aircraft,
synop,
ship,
buoy,
AMVs-Infrared
Satellite data
NOAA-15,-18 AMSUA
NOAA-15, AMSUB
NOAA-18, MHS

2010 annual mean precipitation by T639

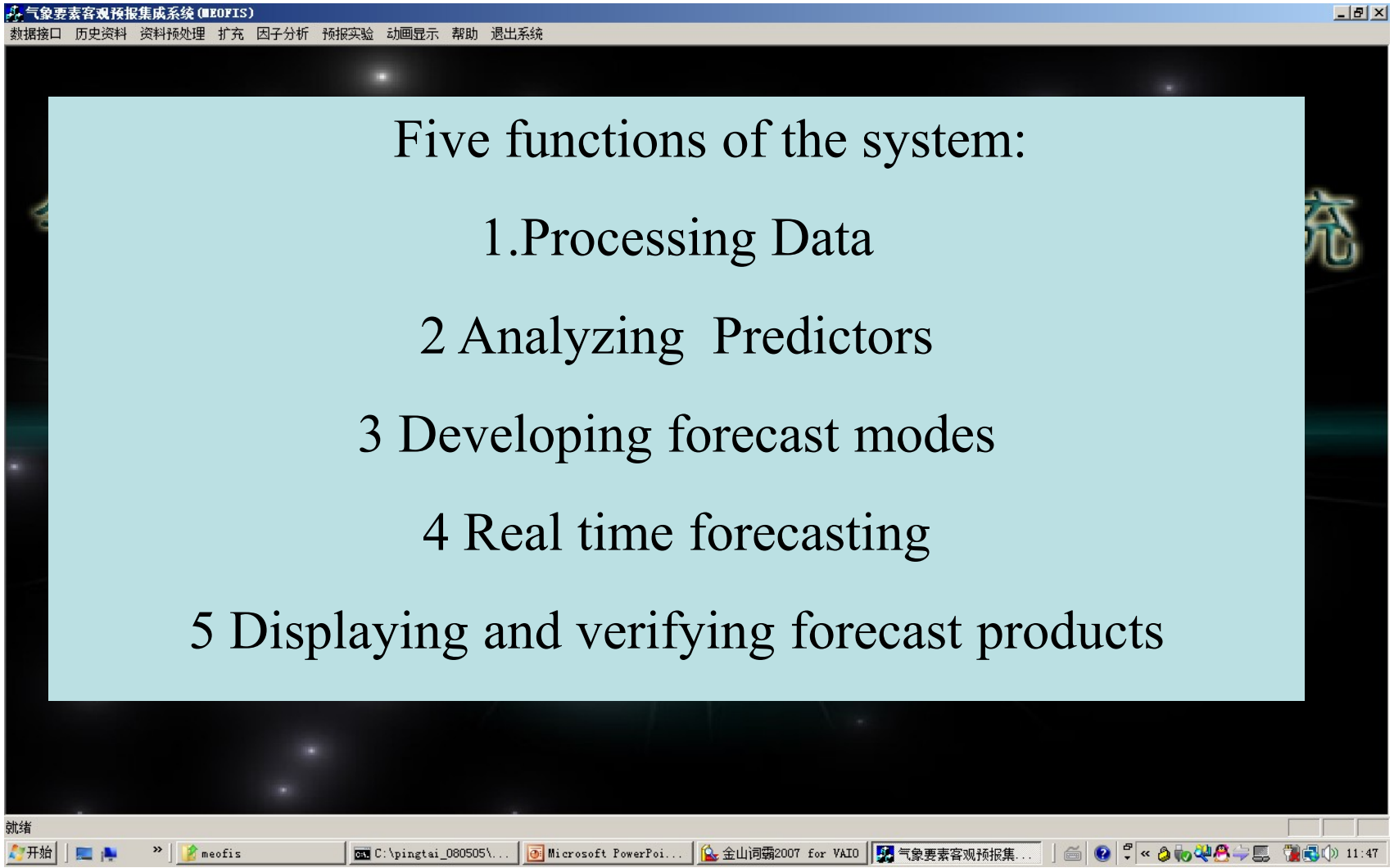








The CMA
Objective Meteorological Forecast System



Medium-range forecast
examples of guidance used in CMA

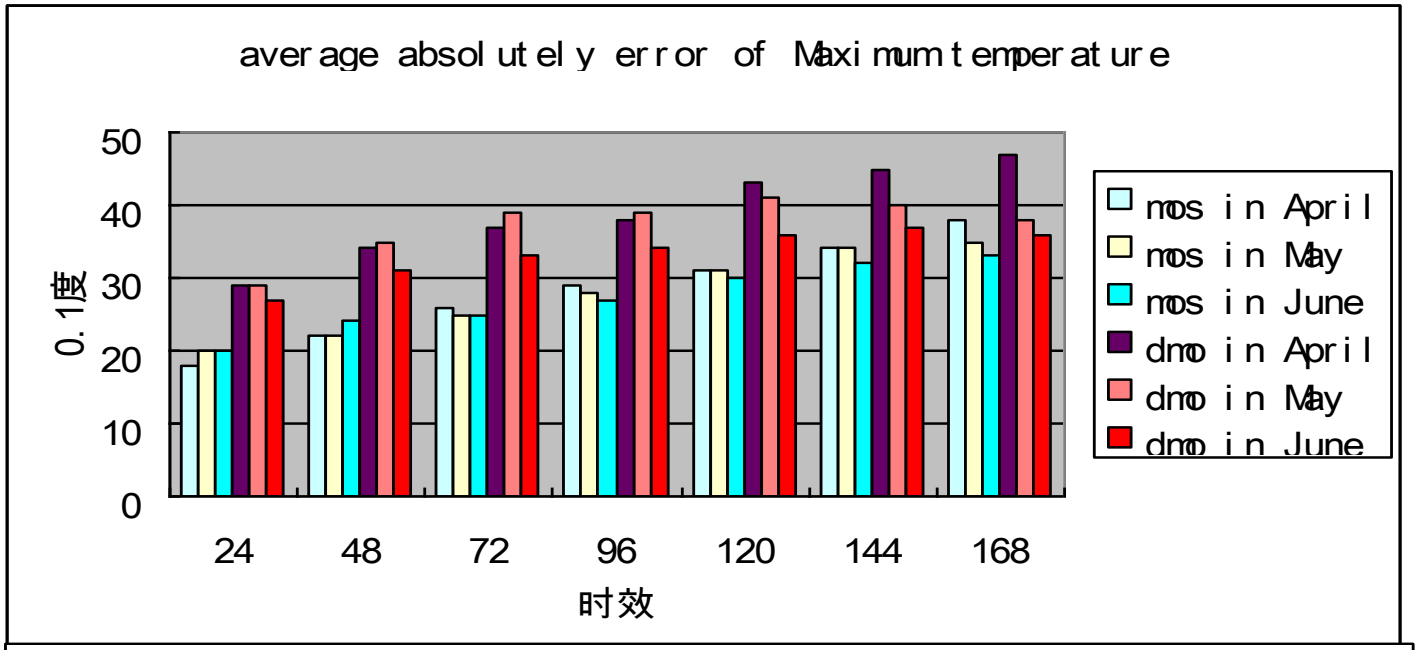
- **Algorithm**
  - Neural network
  - Kalman filter

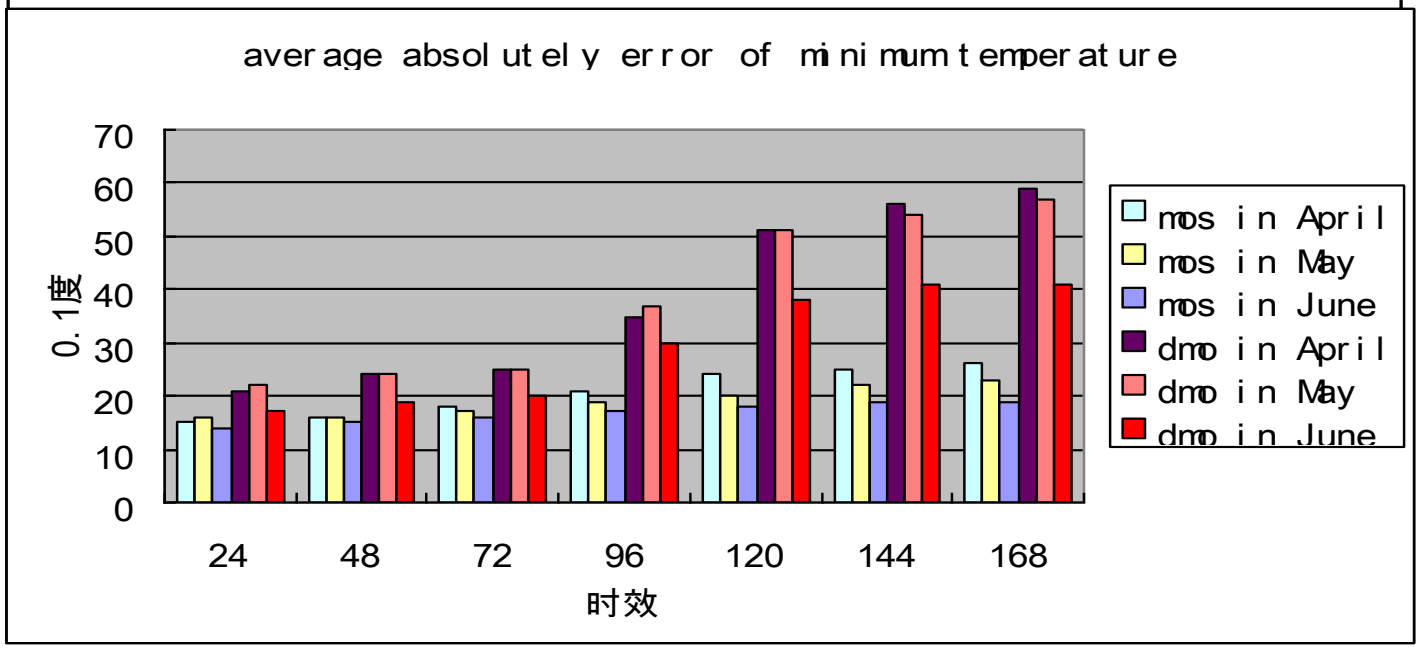
About 2600 stations
Valid at 00 & 12 UTC

- 12-h precipitation
- wind speed and wind direction ***(prevailing during 12 hours)***
- cloud cover ***(averaged during 12 hours)***
- max/min temperature
- max/min relative humidity
- Categorized weather

from 24 to 168-h projection with 12-h interval

Error of Max/Min temperature of MOS and DMO in Apr.~Jun. 2008

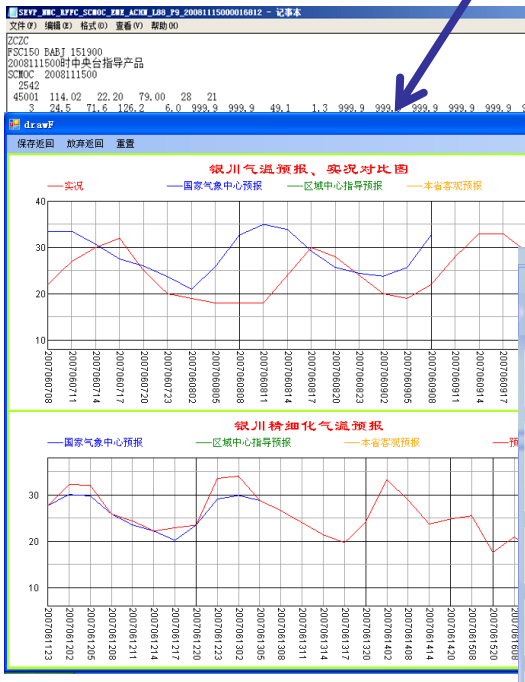


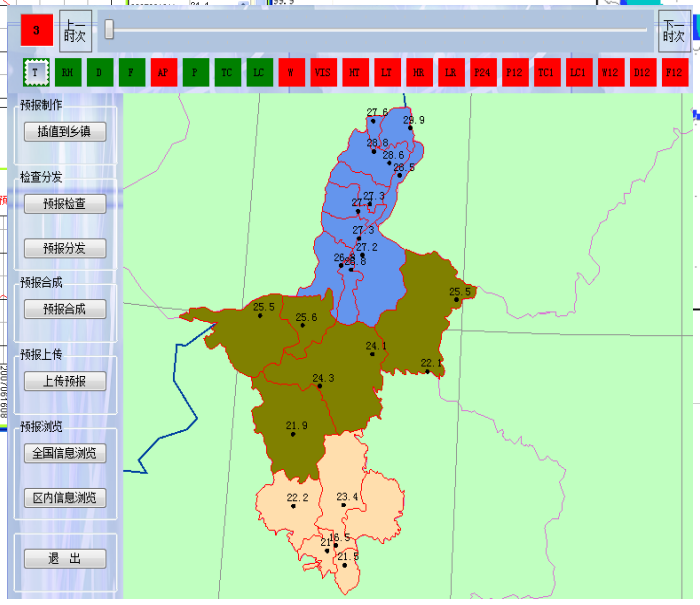


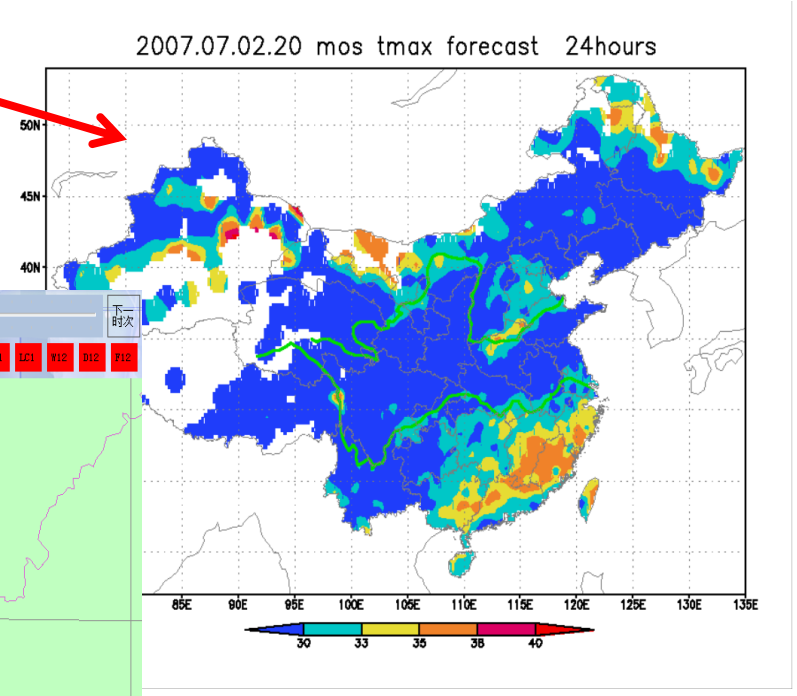
Guidance issuance

- Data with MICAPS format
- Graphic form

Meteorological Information Comprehensive Analysis and Process System







Application case

10 and 10-30 day forecast model

Horizontal resolution	T63 (~1.875º Gaussian grid)
Vertical levels	16 (Top Layer Pressure:25hPa)
Time integration range	45 days
Executing frequency	Once every pentad
Ensemble size	40 members
Initial values & perturbation method	CMA global analysis SV & Lagged Average Forecast (LAF) method
SST	Persisted anomaly
Land surface Parameters	Initial conditions of land parameters are provided by climatology

forecast products
by T63L16 40m ensemble with persistent SSTA

(1) 10-day mean precipitation anomaly percentage
(2) 10-day mean precipitation most likely categories
(3) 10-day mean temperature anomaly
(4) 10-day mean temperature most likely categories
(5) 10-day mean 500hPa height anomaly
(6) 10-day mean sea level pressure anomaly
(7) 10-day mean 200hPa wind anomaly
(8) 10-day mean 700hPa wind anomaly

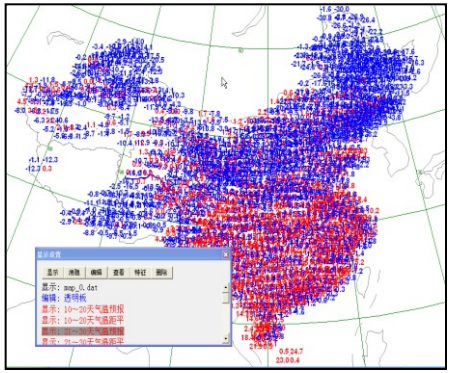
10 and 10-30day forecast guidance

Methods:

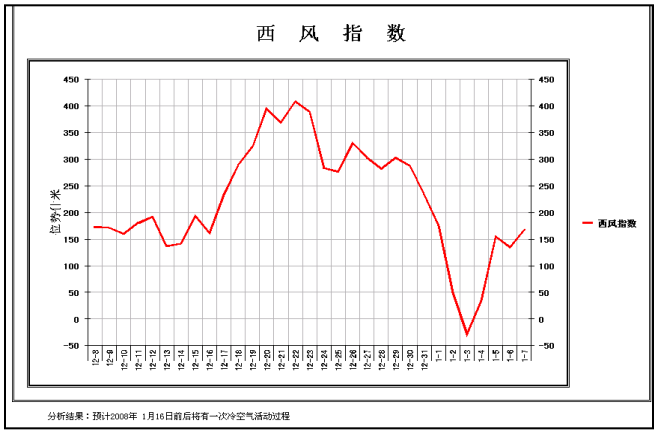
- T63L16 ensemble forecast (40members) with persistent SSTA
- Synoptic theory: westerly index & MJO index
- Statistics: pattern similarity

$$I_{ij} = r_{ij}(1 - \frac{E_{ij}}{n\sigma})$$

基于统计方法的综合相似预报

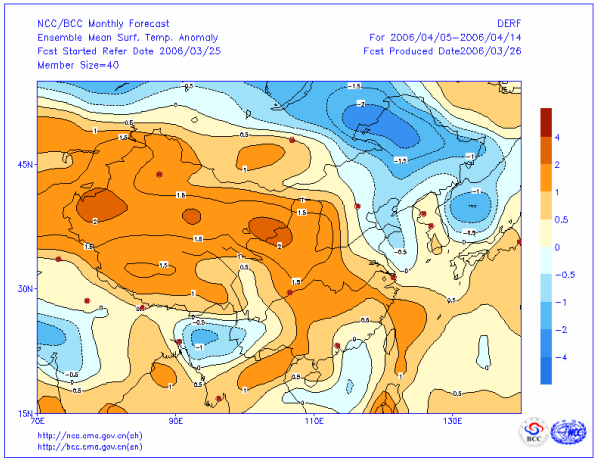


利用天气气候学方法，建立的基于西风指数循环理论的寒潮天气过程延伸期预报方法

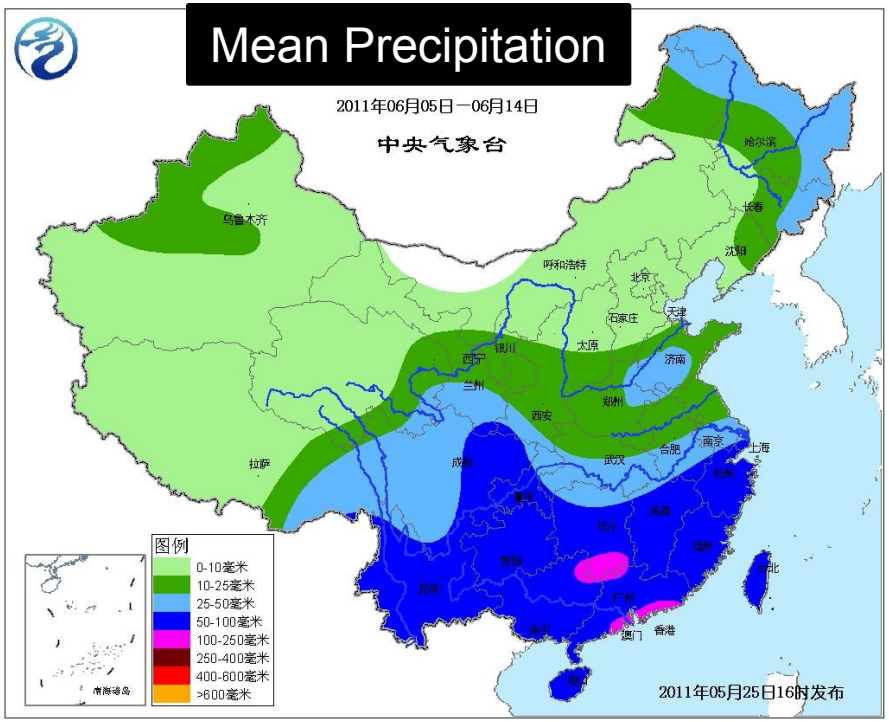


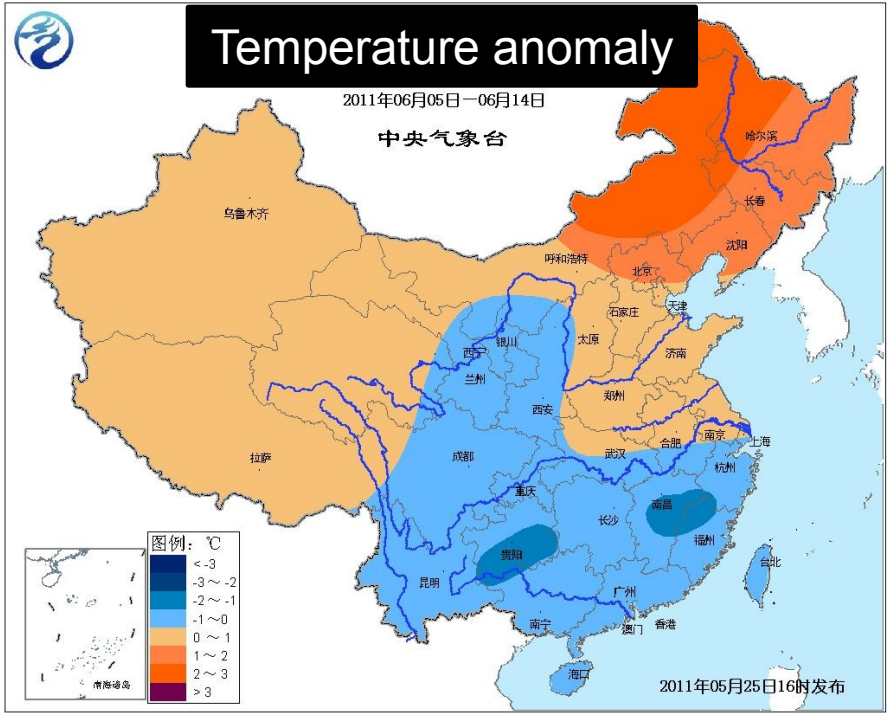
基于西风指数循环理论的强冷空气过程延伸期预报模型

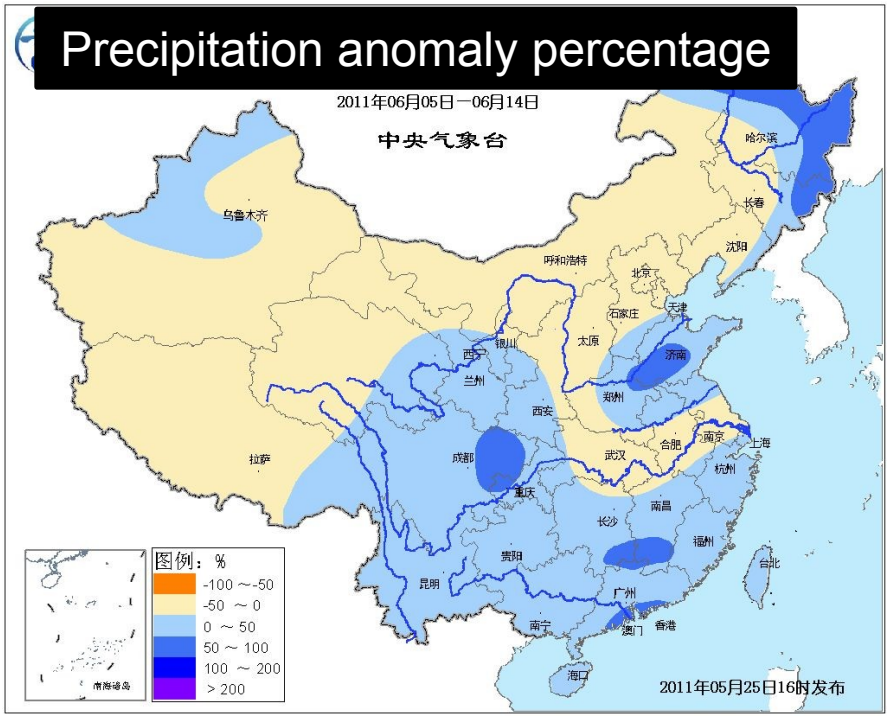
国家气候中心月动力延伸集合预报产品



Example of 10-day forecast guidance







每候末发布：第2旬降水量预报、降水量距平和气温距平预报。

每旬末发布未来第2、3旬降水量预报（夏半年）、未来第2、3旬气温距平预报（冬半年）。

Successful example of 10-day forecast service flood in Huai River in July,2007

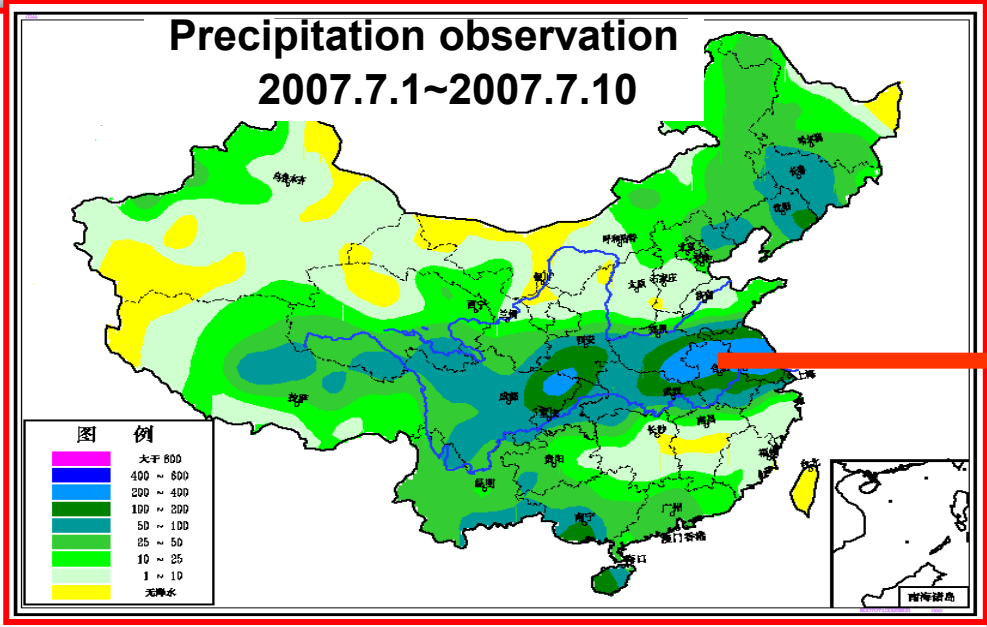
中 期 旬 报

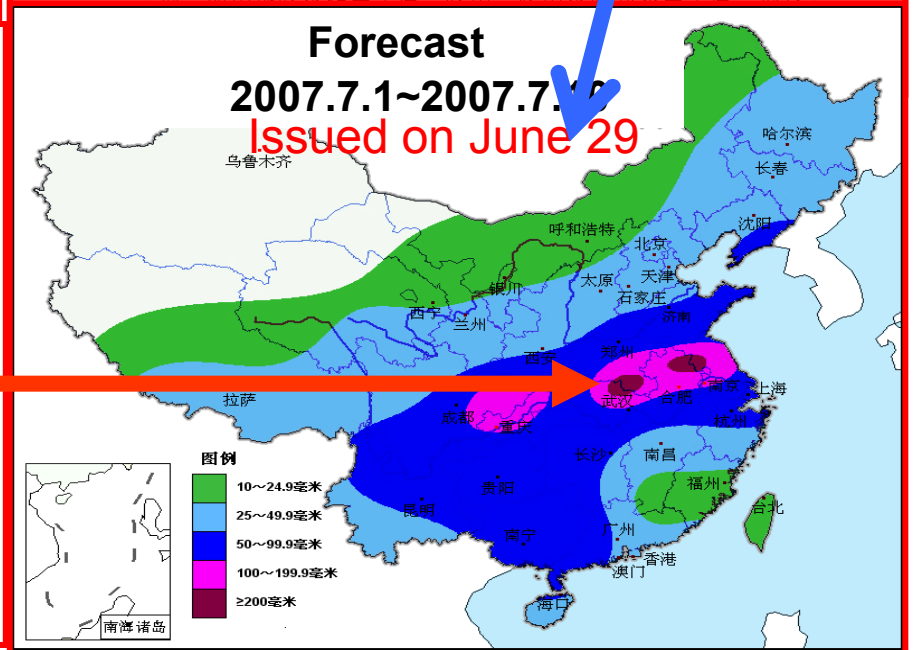
中国气象局中央气象台 预 报：牛若芸 签 发：王秀文 2007 年 06 月 29 日

7月上旬天气趋势预报

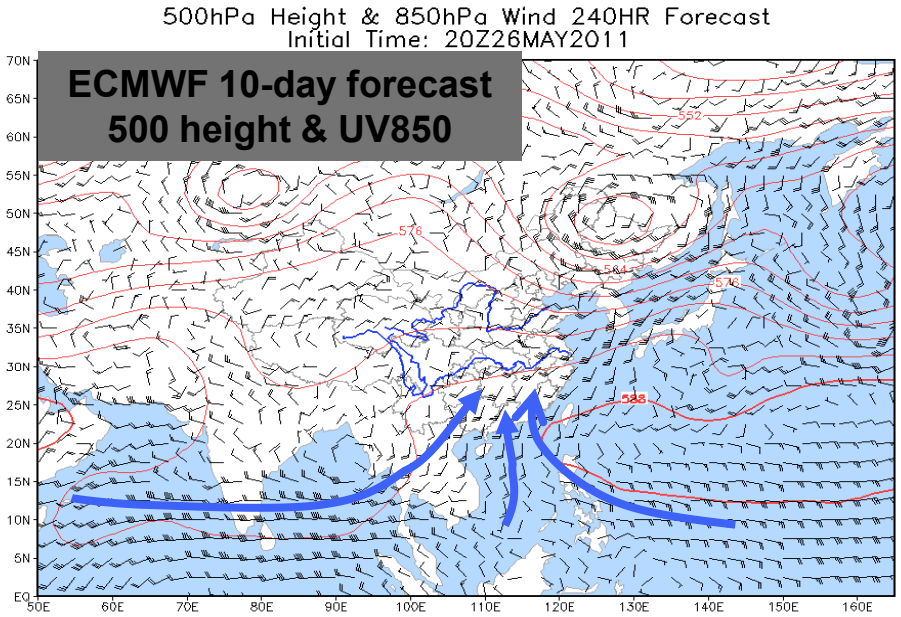
一、上旬天气趋势

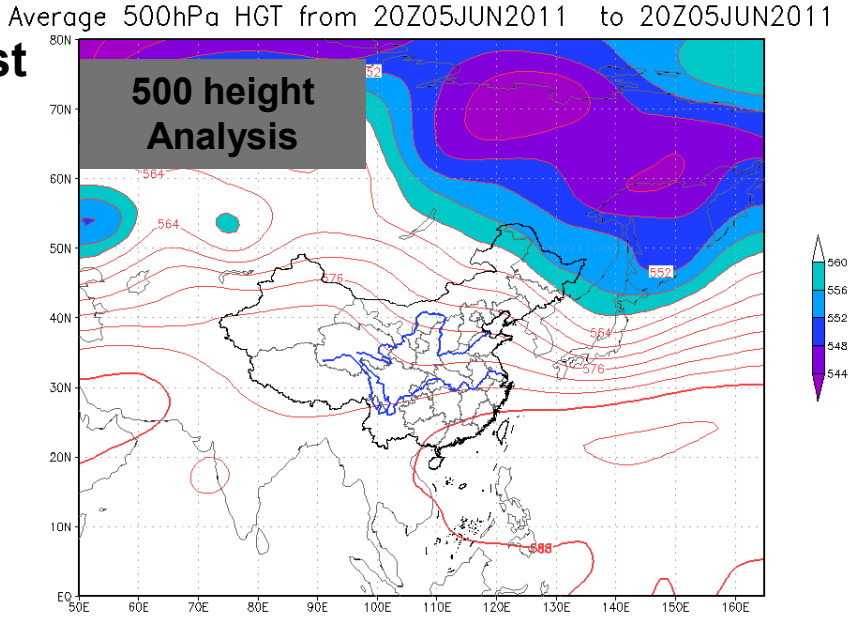
预计 7 月上旬，主要雨带将位于四川盆地东部至淮河流域一带，旬雨量一般有 60-90 毫米，部分地区有 100-180 毫米，局部可超过 200 毫米；降雨量较常年同期偏多 6 成至 1 倍，局部地区偏多 2 倍以上。华北地区东部、东北地区多阵性降雨，降雨量一般有 10－25 毫米，其中东北地区南部的局部地区有 30－50 毫米；大部分地区雨量基本与常年同期持平。西北地区东

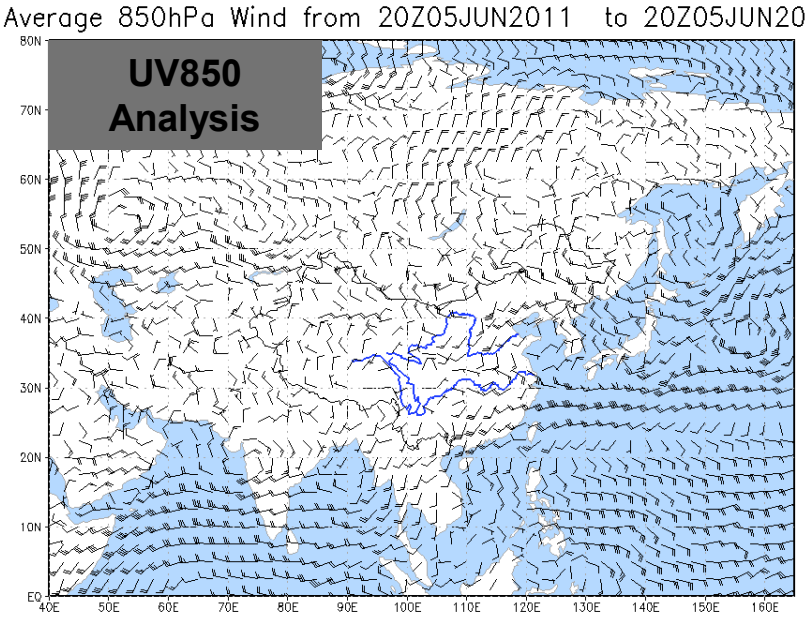




Application of ECMWF medium-range forecast







Successfully predict the transition of weather regime from draught to wet.

- Severe draught over the southern China during April-May,2011.
- The EC 10-day forecast from May 26 showed the transition: southerly wind will become dominant & subtropical high will move westward.

Outline of CMA's Long-range Forecasts

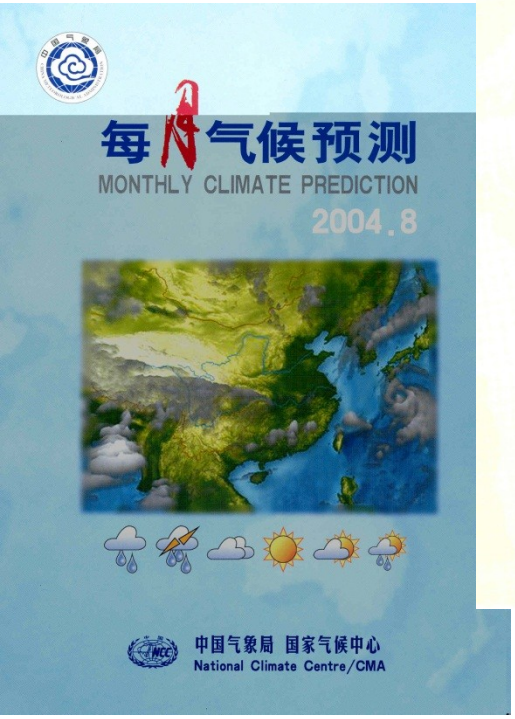
3-month and 1-month forecast

Kind of Forecast	Three-month/flood season/annual forecast	One-month forecast
Date of issue	Model: 22th of the month Official issue: 28th of each month	Model: 21th of the month Official issue: 28th of each month
Products	· precipitation and its anomaly percentage · surface temperature anomaly · most likely precipitation categories · most likely temperature categories · 200hPa wind anomaly · 850hPa wind anomaly · 500hPa height and its anomaly	• precipitation anomaly percentage • mean precipitation most likely categories • temperature anomaly • mean temperature most likely categories • 500hPa height anomaly • sea level pressure anomaly • 200hPa wind anomaly • 700hPa wind anomaly
Forecast Method	CGCM Statistical methods	T63L16 Statistical methods

Other Guidance Products for long-range forecast based on the CGCM ensemble

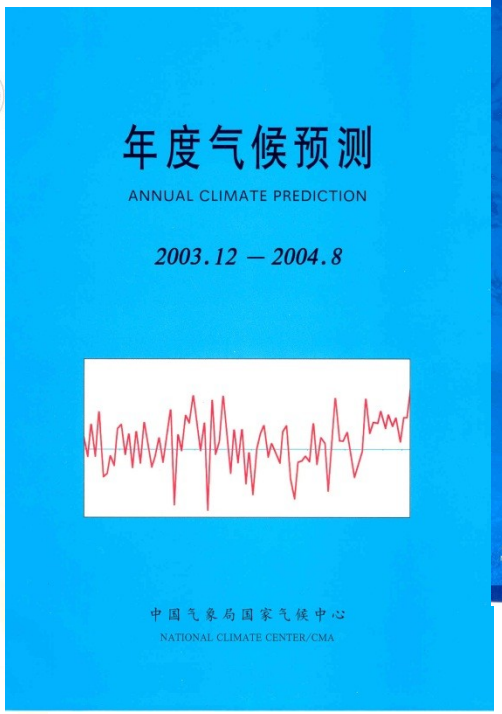
- Monthly/Seasonal precipitation and temperature
- Tropical cyclone frequency
- Cold air activities
- Climate condition of crop seeding
- First frost date
- Monsoon onset and withdraw date and its intensity
- Forest and grassland fireproofing
- Sand storm frequency
- and ……

Issuance of Climate Prediction Products



Monthly

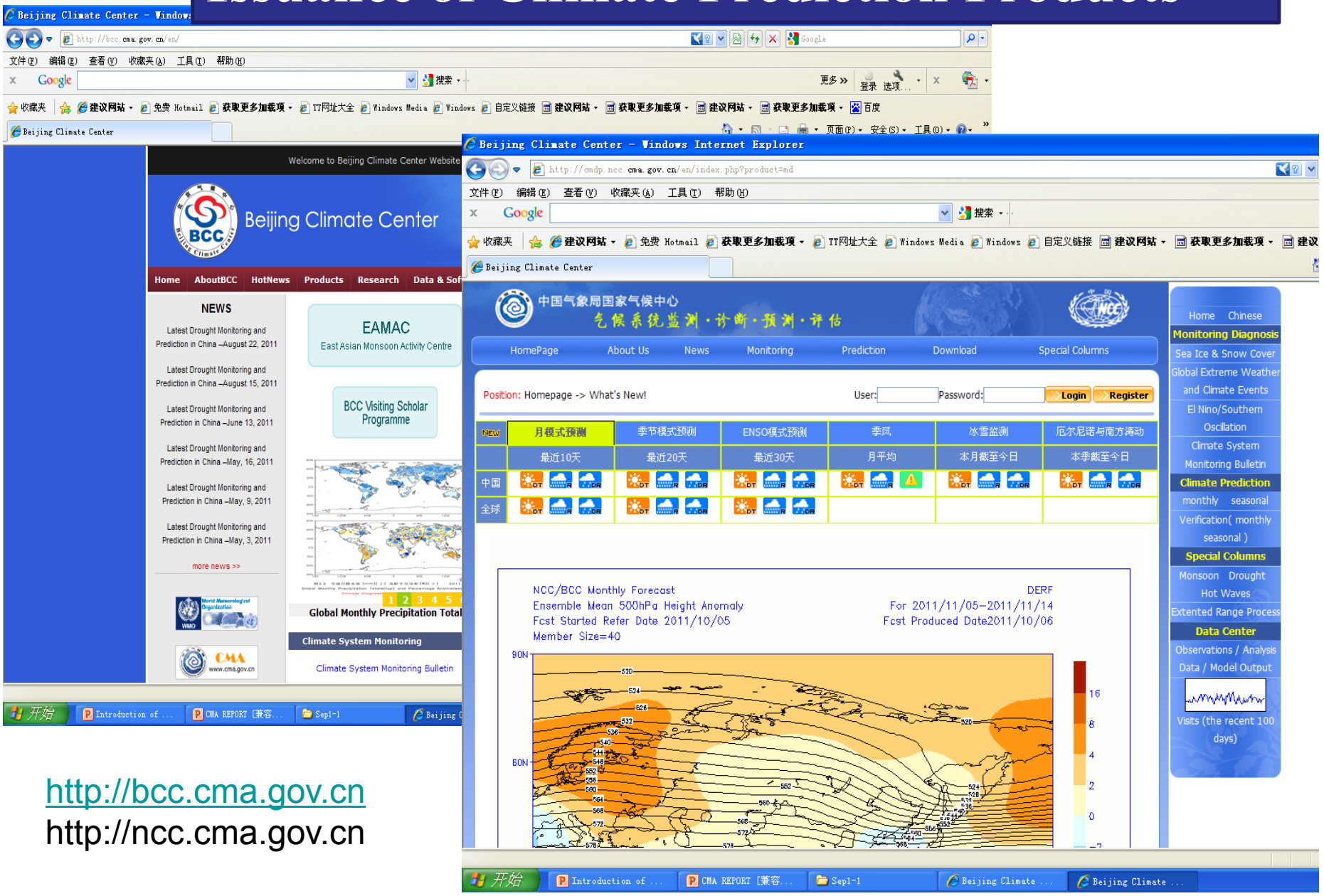
July and August



Annual

Summer

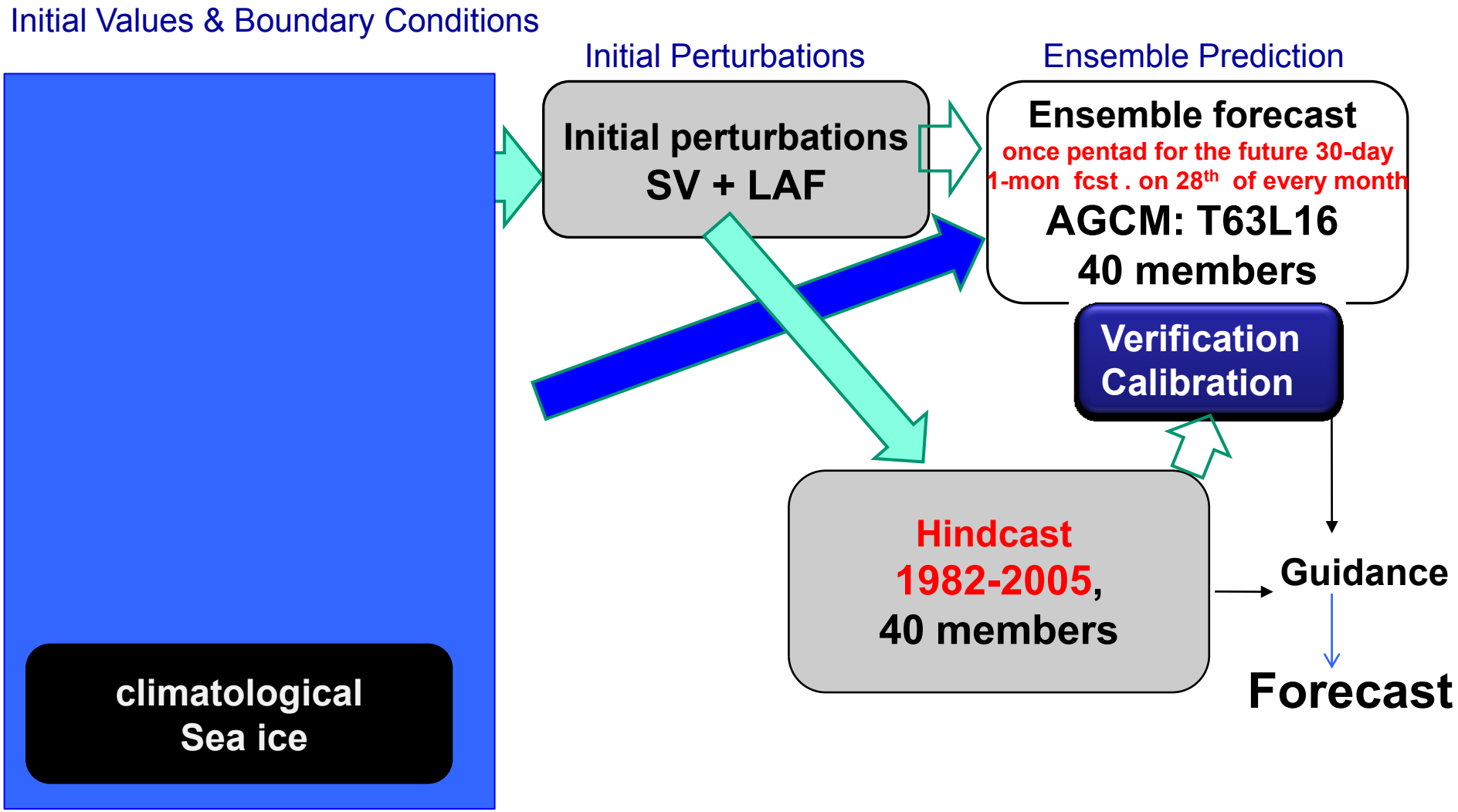
Issuance of Climate Prediction Products



http://bcc.cma.gov.cn

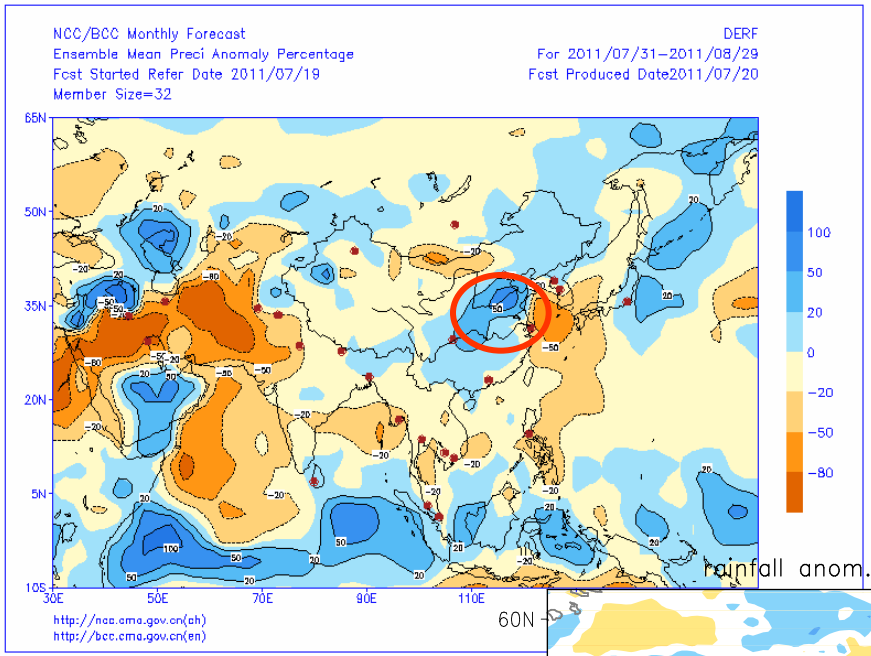
http://ncc.cma.gov.cn

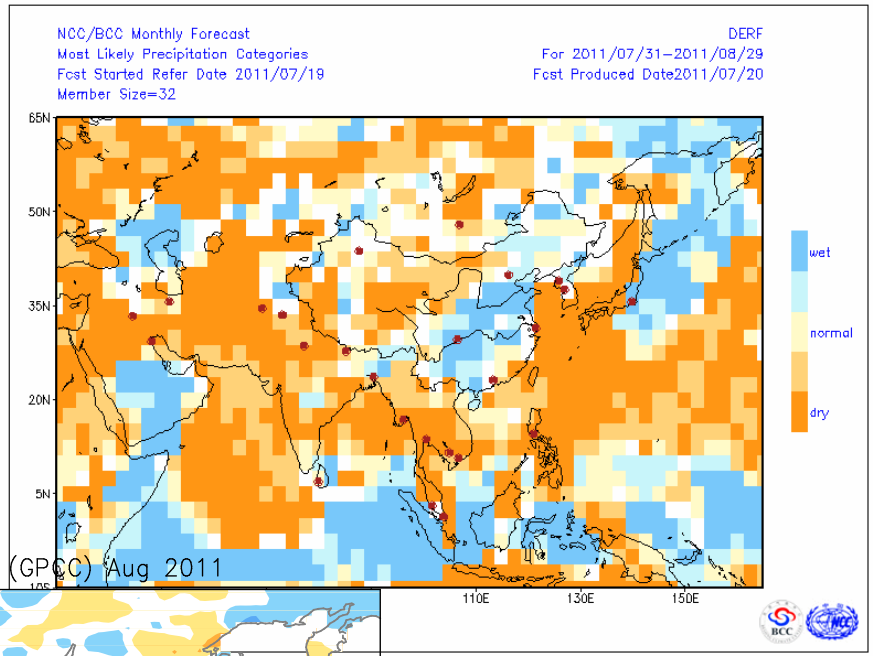
One-month Forecast System



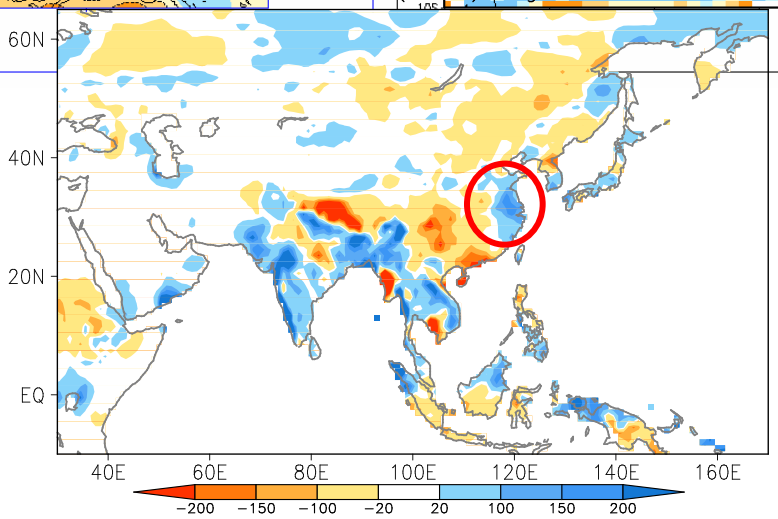
26

An example: 30-day mean precipitation anomaly percentage (left) and the most likely categories (right) August. 2011



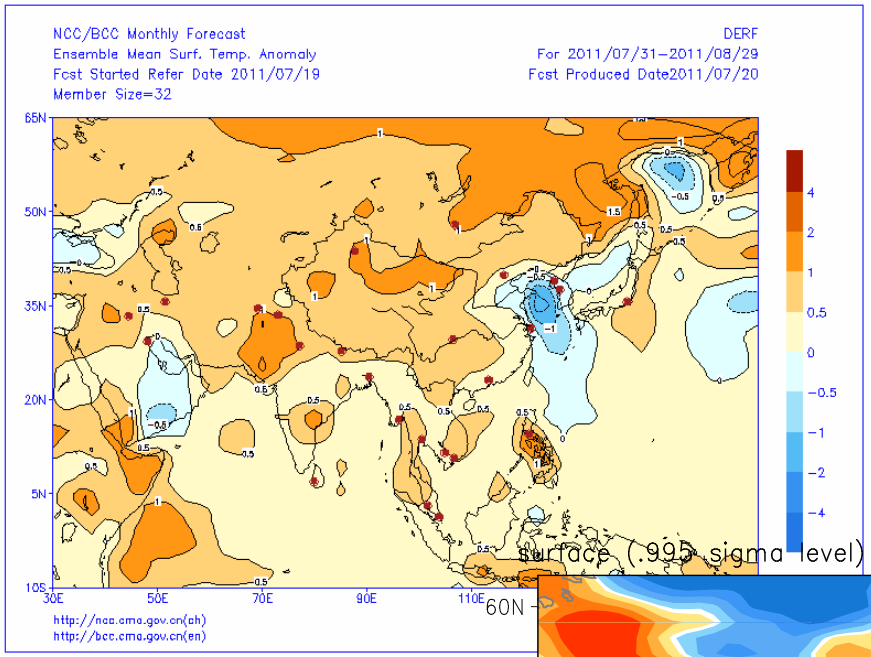


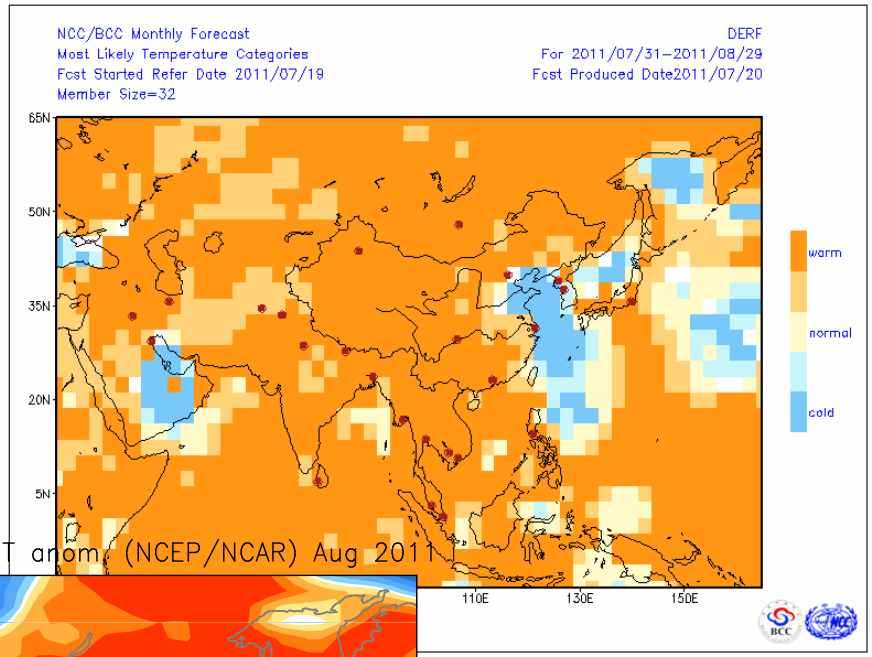
rainfall anom. (GPCC) Aug 2011

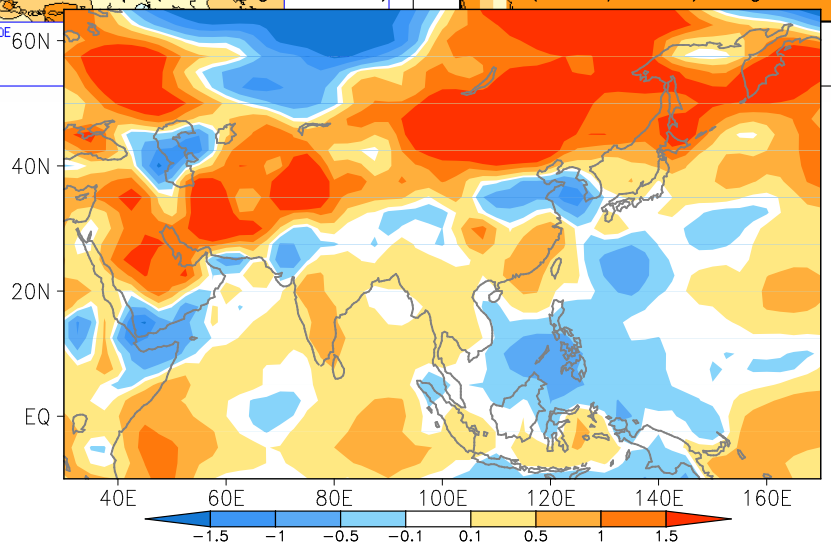


GPCP rainfall anomaly

30-day mean temperature anomaly (left, unit:°C) and the most likely categories (right)
August. 2011

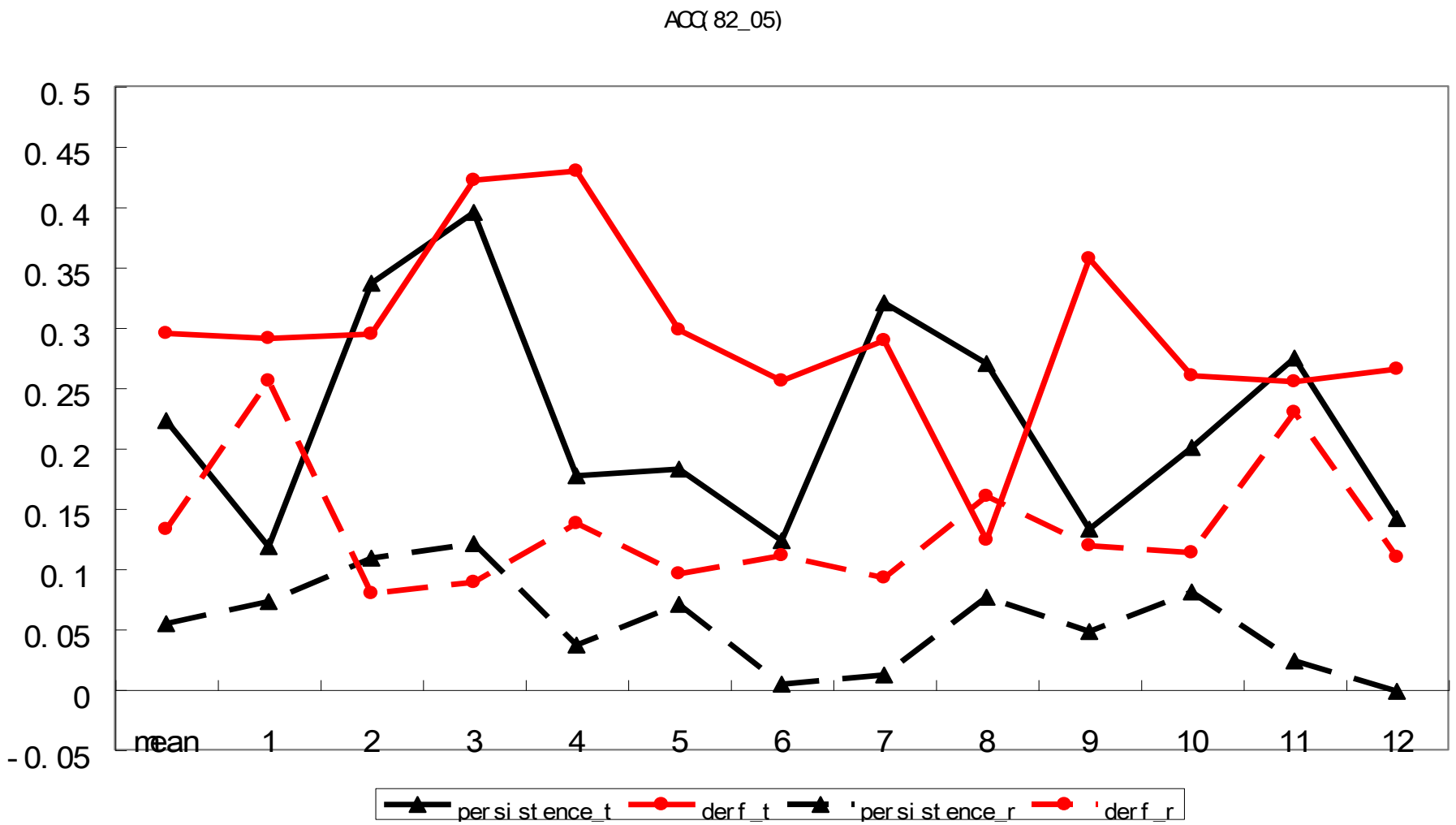




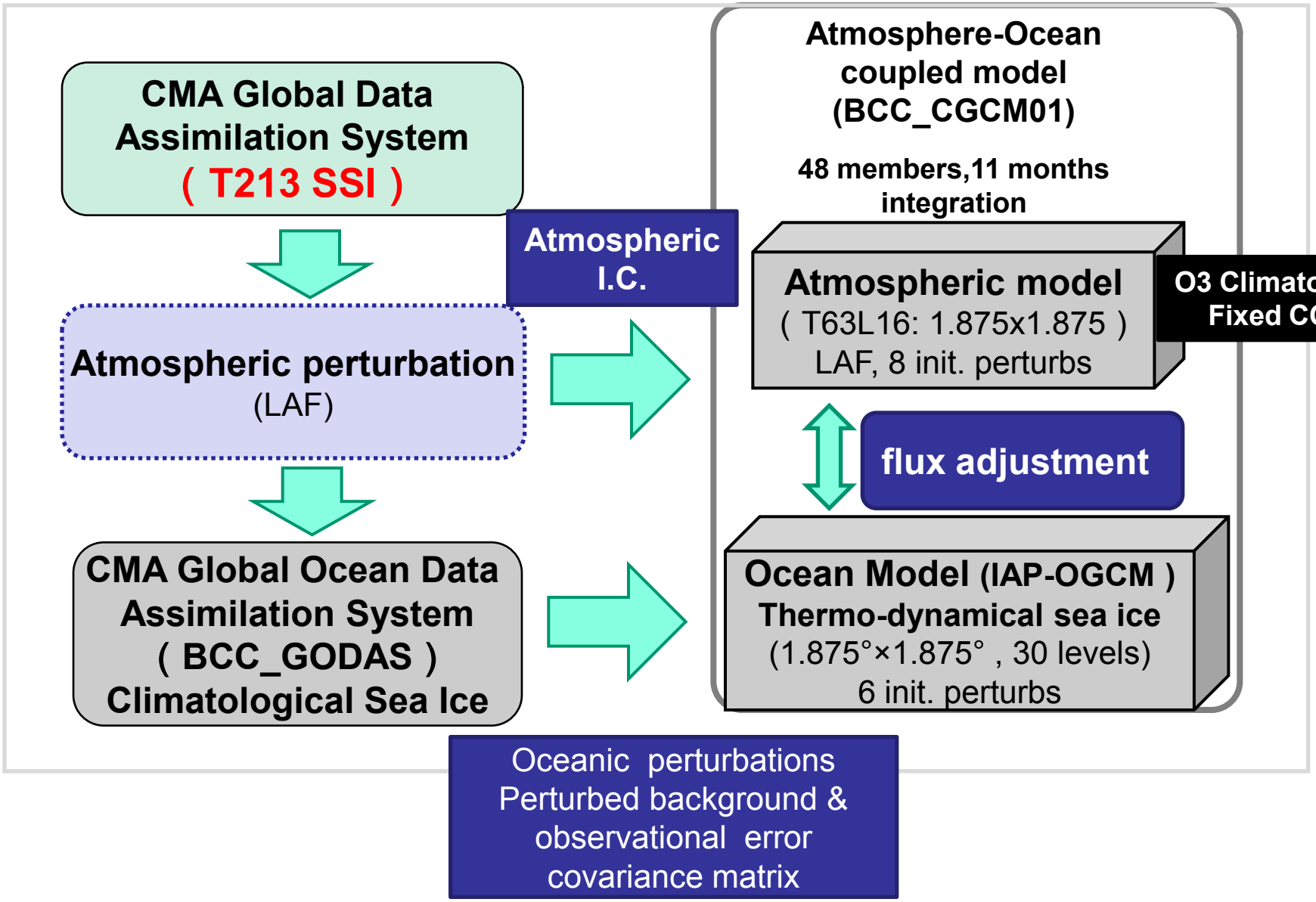


NCEP/NCAR analysis
T at sigma=0.995

Skill of precipitation and temperature in China
(verification method: ACC)



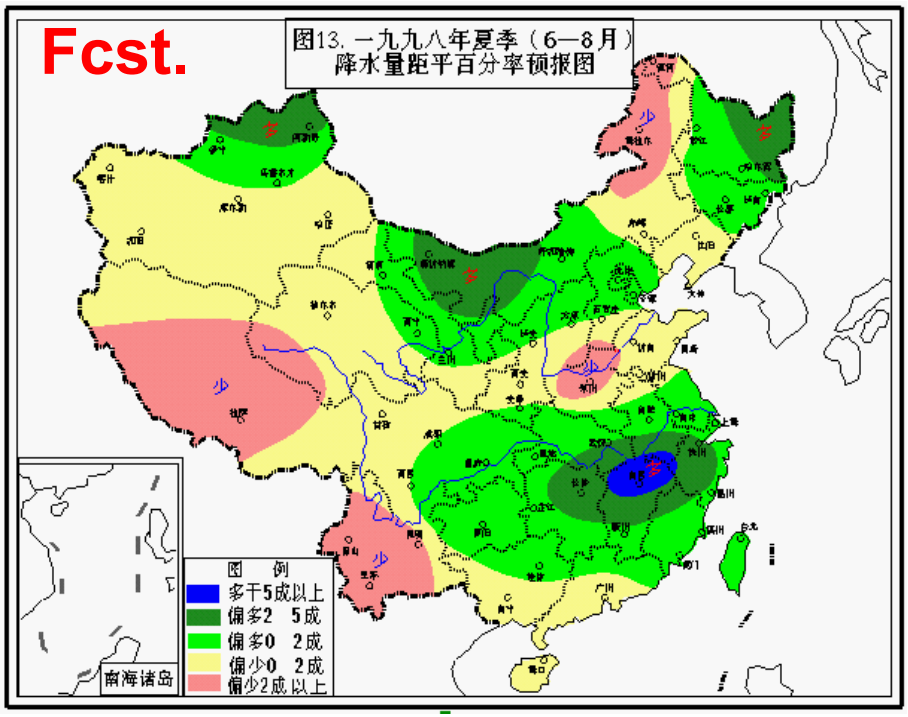
Seasonal Forecast Model System

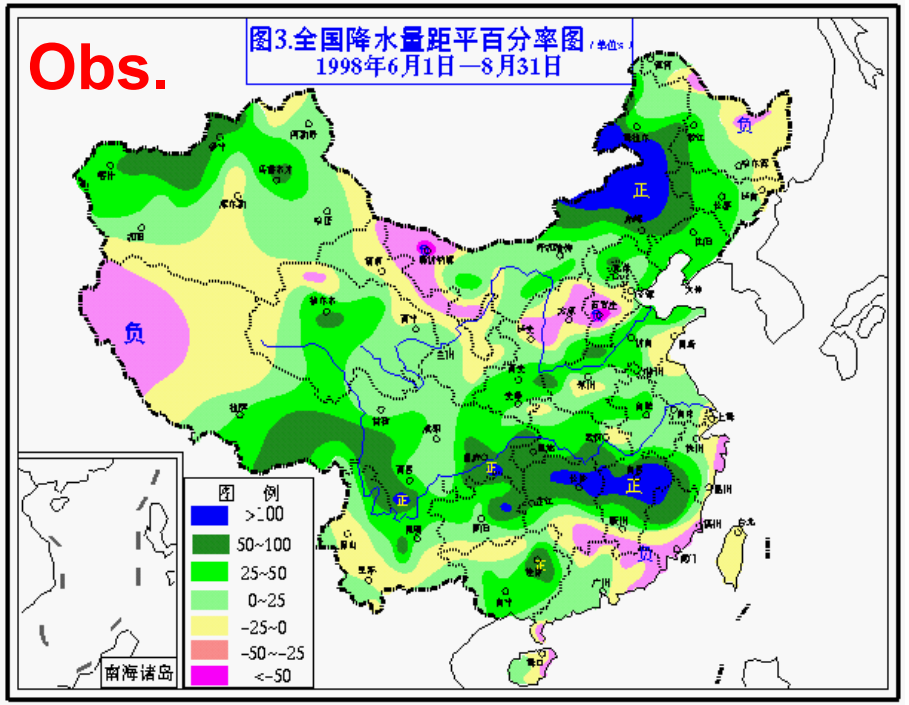


Successful prediction case

Issued in April

The summer rainfall anomaly percentage forecast (left) and observation (right) in 1998

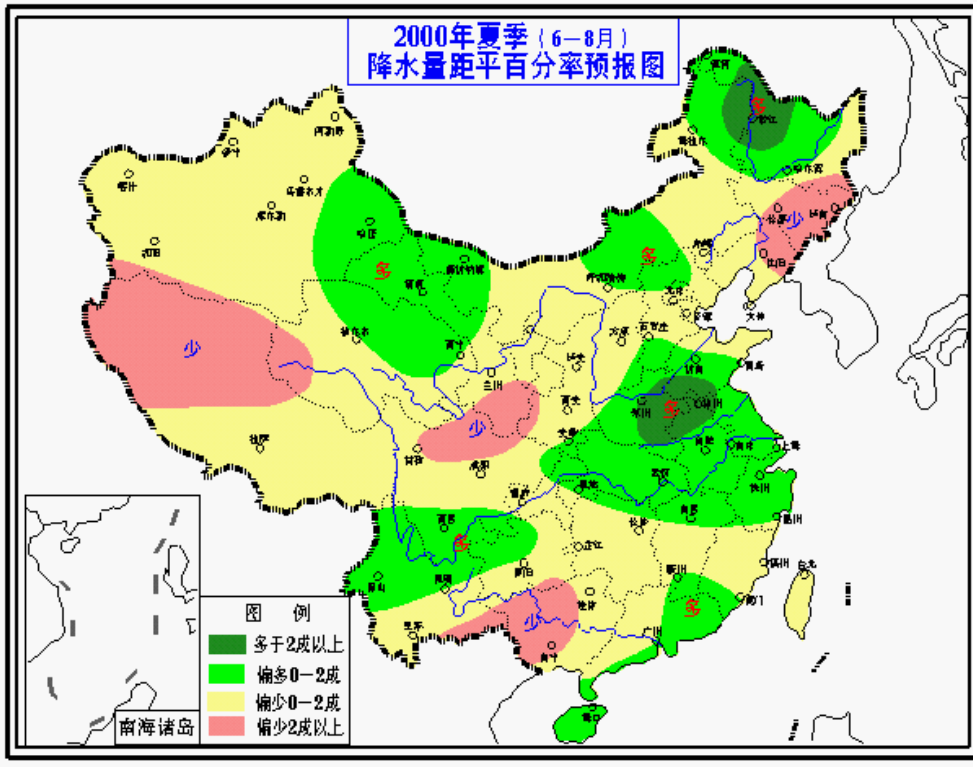


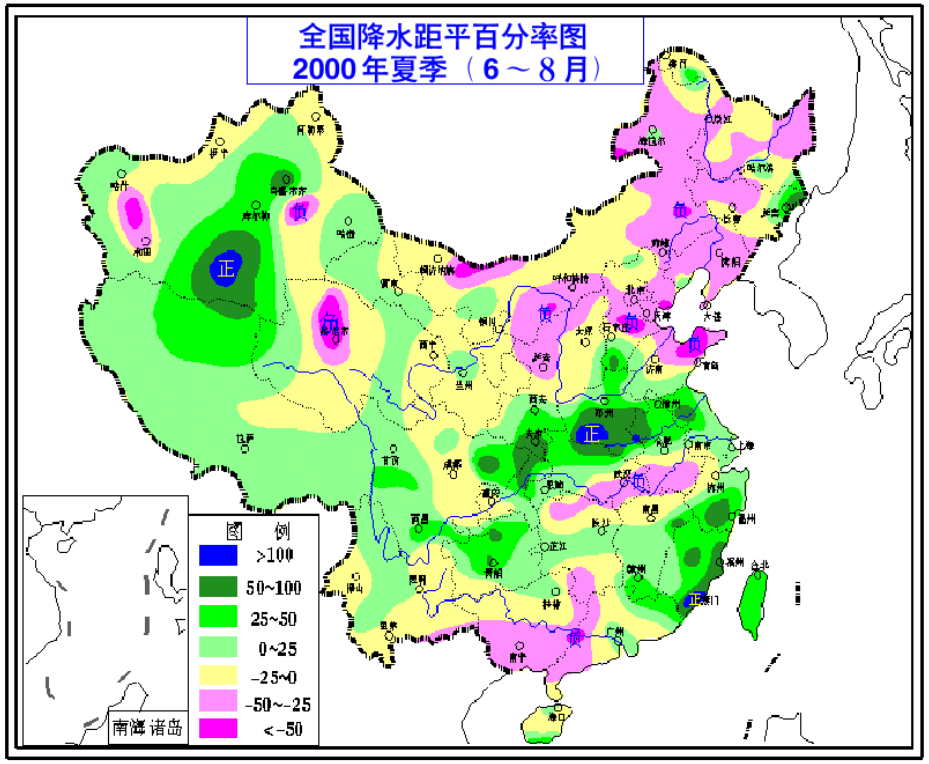


Successful prediction case

Issued in April

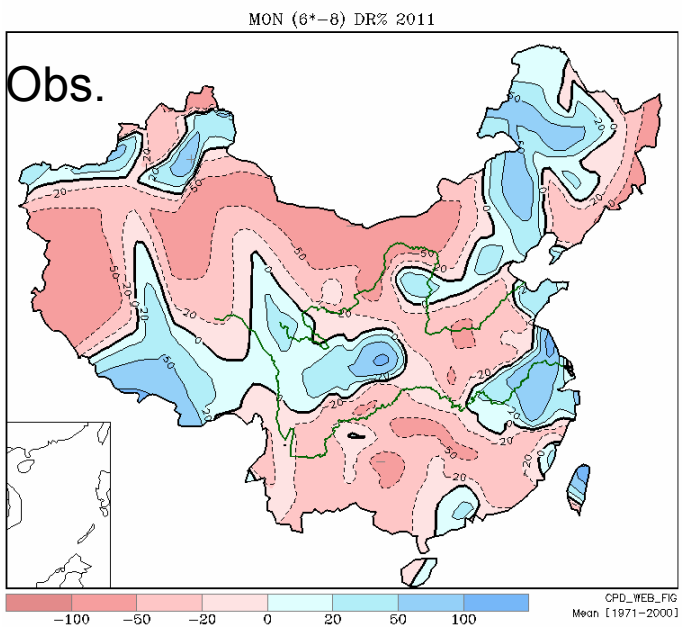
The summer rainfall anomaly percentage forecast (left) and observation (right) in 2000





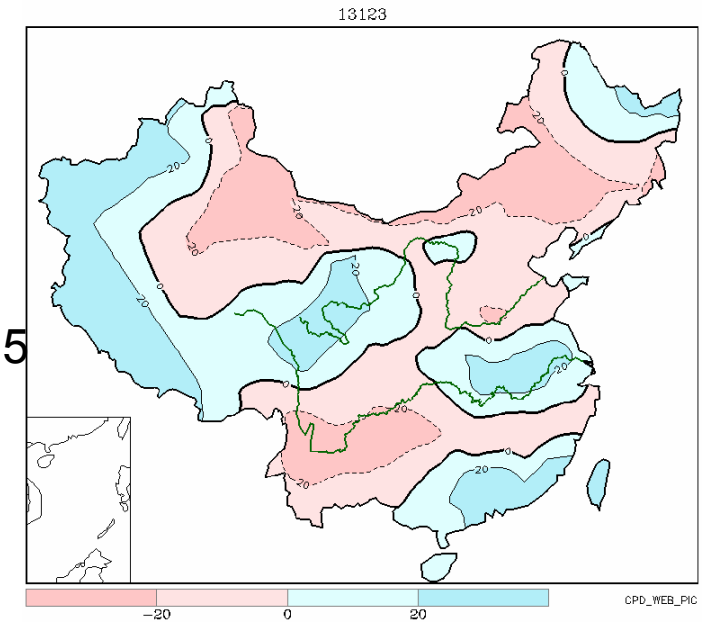
Flood season forecast in 2011

Precipitation anomaly percentage JJA/2011



ACC=0.25

Seasonal forecast guidance (Issued on 26th March,2011)



CGCM performance

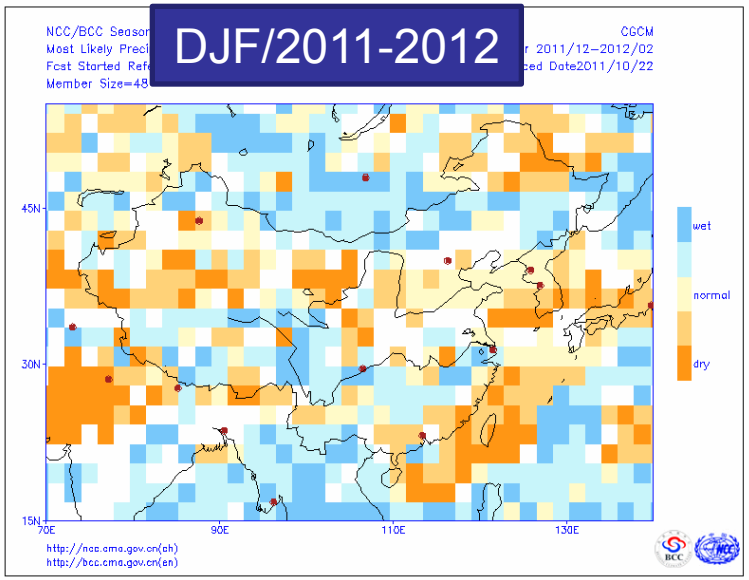
Anomaly Correlation coefficients

(Initial Condition : Mar, Period of Forecast: JJA)

Averaged period:1983-2002

	Global	N. H.	E. Asia
Z_{500}	0.20	0.18	0.21
T_{850}	0.07	0.07	0.15

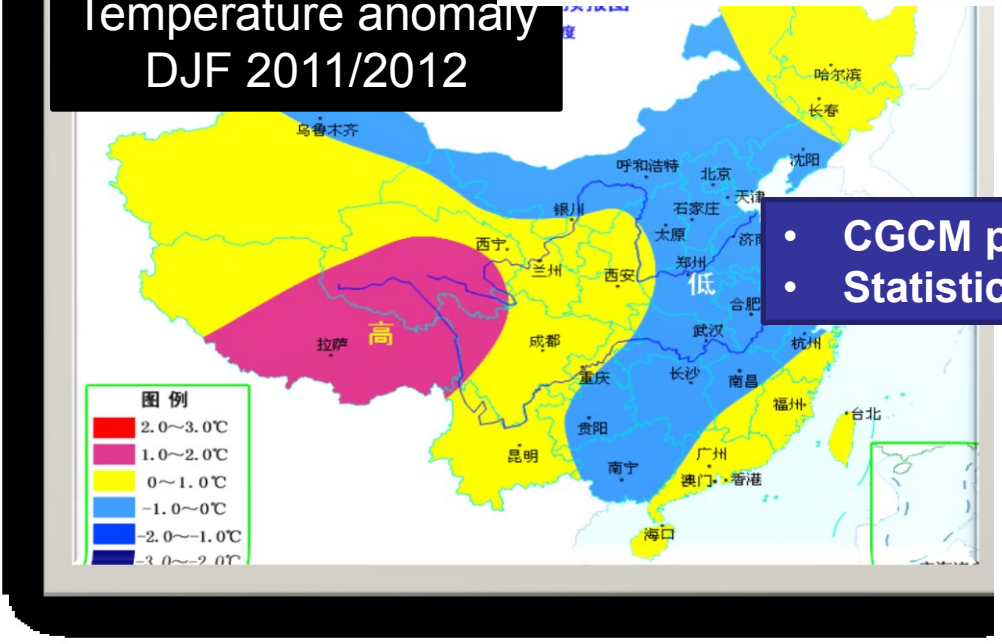
Planned forecast guidance for this winter



CGCM prediction

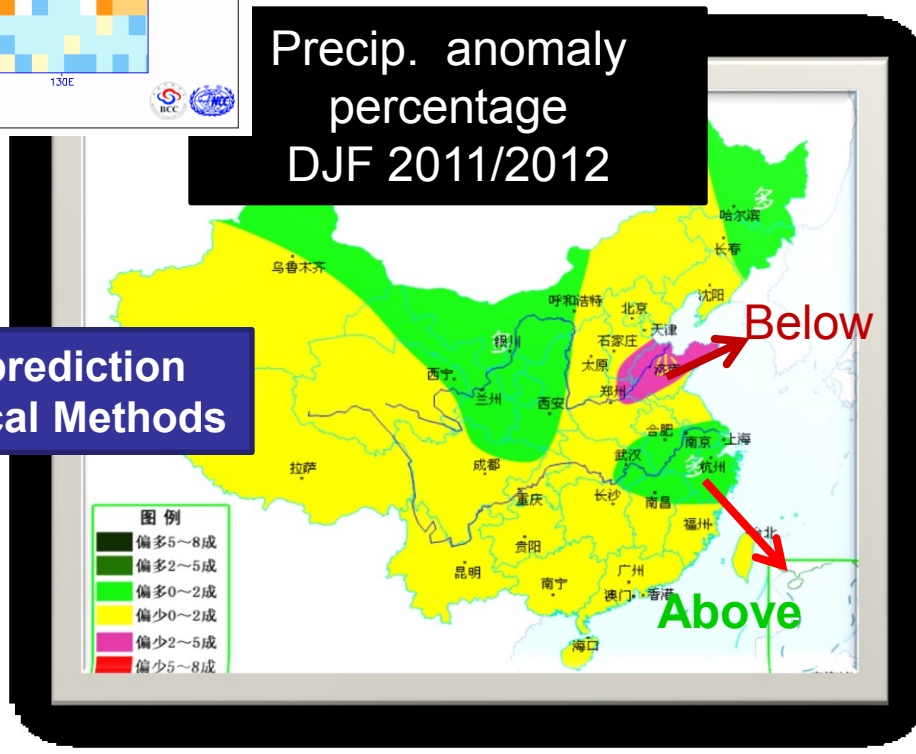
Preci. anomaly percentage

Temperature anomaly
DJF 2011/2012

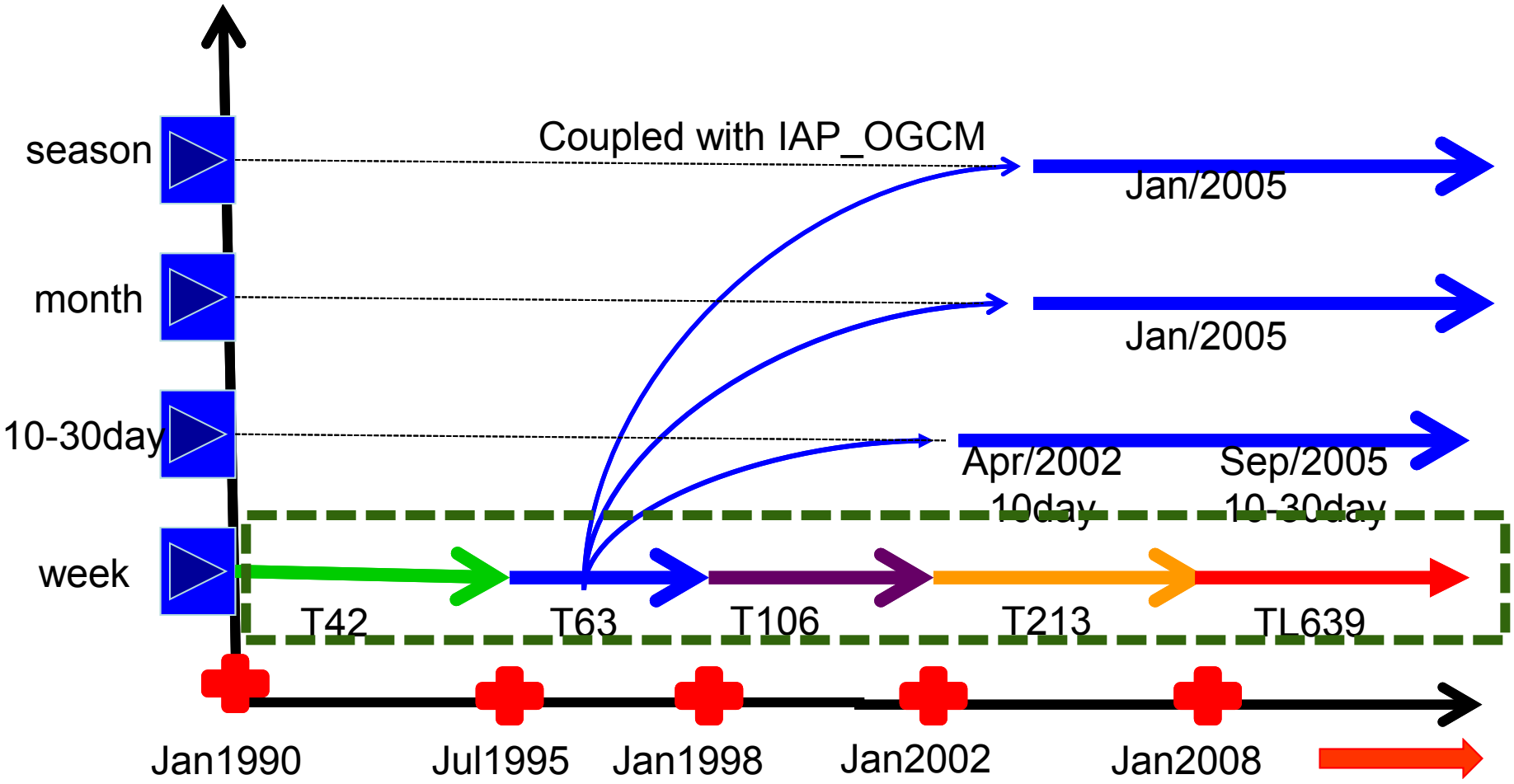


- **CGCM prediction**
- **Statistical Methods**

Precip. anomaly
percentage
DJF 2011/2012



History of CMA global medium to long range forecast systems



GRAPES: Global and Regional Assimilation & Prediction System

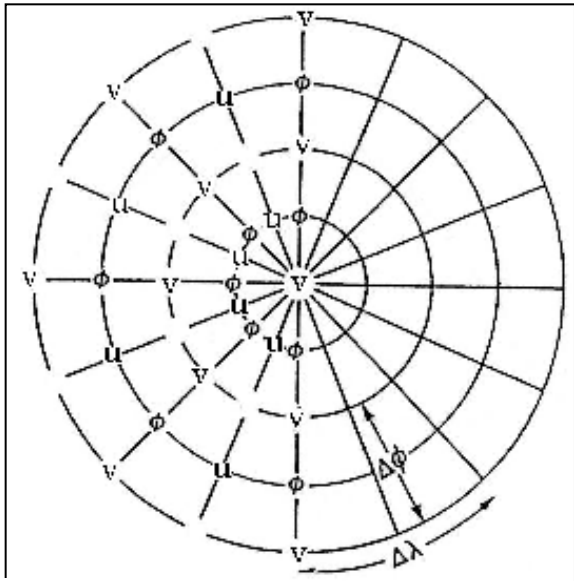
since 2001

A Unified Global and Regional NWP System

- Global model
- Meso-scale model
- Global VAR
- Regional VAR

Unified
GRAPES Model Dynamic Core

- Fully compressible equations with shallow atmosphere approximation
- 2-time-level semi-implicit semi-Lagrangian (SISL) time-stepping
- QMSL or CSLR for scalar advection
- 3D vector form for momentum equations
- Height-based terrain-following coordinate
- Option of hydrostatic and non-hydrostatic
- Arakawa-C grid but V at poles
- Charney-Phillips vertical grid
- GCR for Helmholtz Eq.
- Spherical & polar effects of trajectory calculation
- Quasi-cubic interpolation
- Mass fixer $\longrightarrow \int \frac{(\pi+\Delta\pi)^{C_p/R-1}\,dV}{\theta} = M_{initial}$
- Polar filter



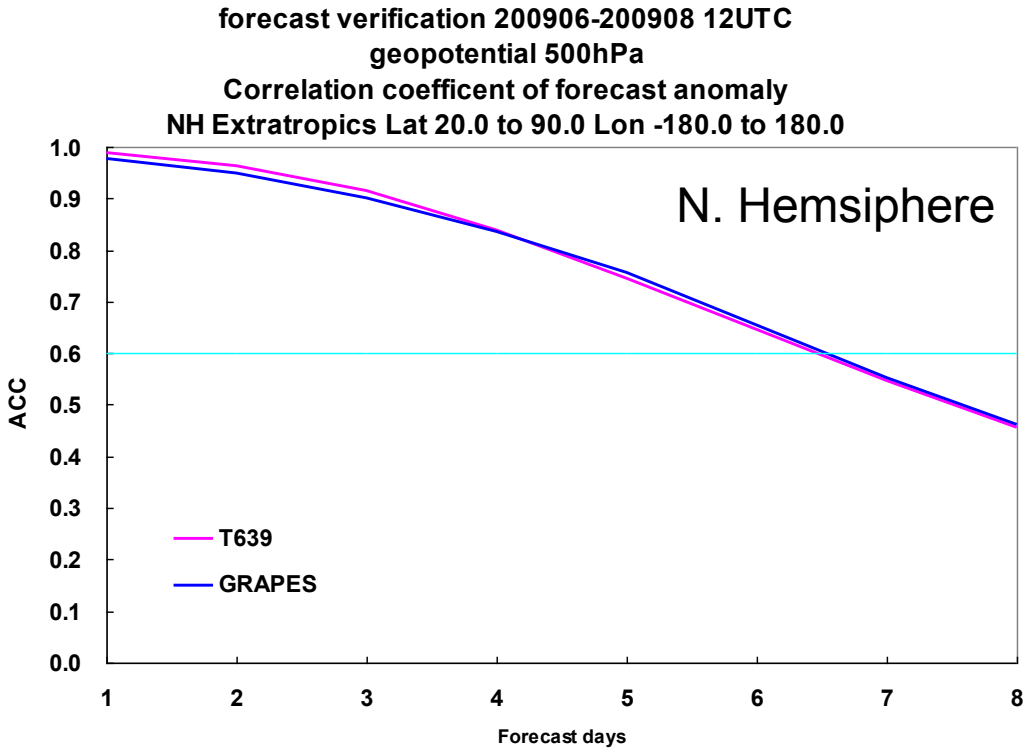
Model top

$z, \hat{z}, \theta, w, \hat{w}$
$z, \hat{z}, \rho, P, u, v$
$z, \hat{z}, \theta, w, \hat{w}$
$z, \hat{z}, \rho, P, u, v$
•
•
•
$z, \hat{z}, \theta, w, \hat{w}$
$z, \hat{z}, \rho, P, u, v$
$z, \hat{z}, \theta, w, \hat{w}$
$z, \hat{z}, \rho, P, u, v$
$z, \hat{z}, w, \hat{w}$

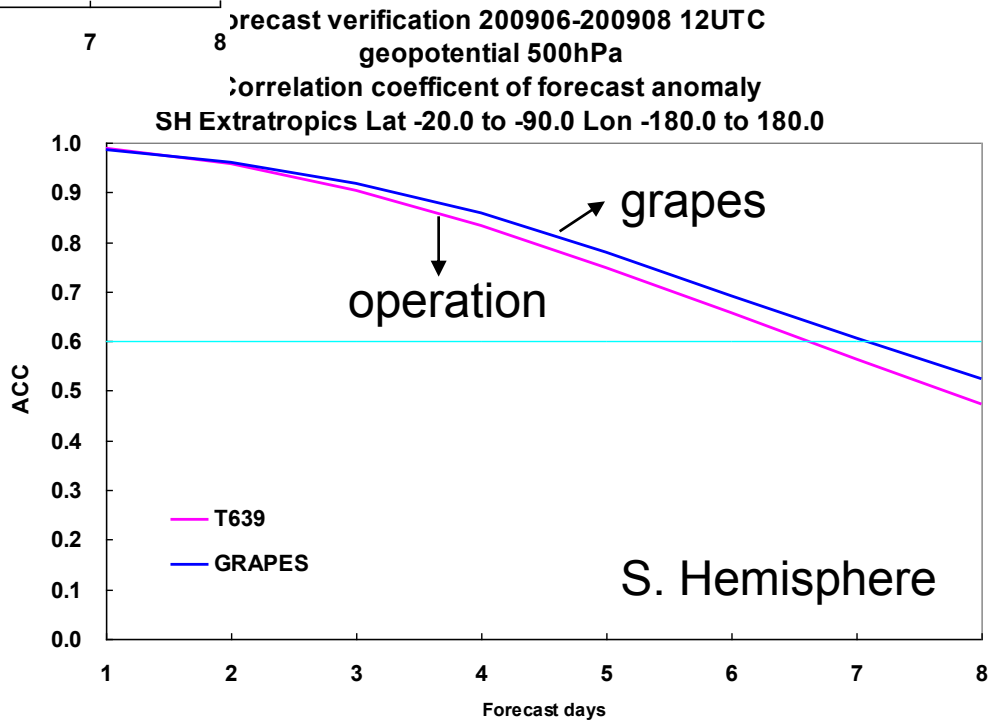
Surface

Configuration of GRAPES_GFS

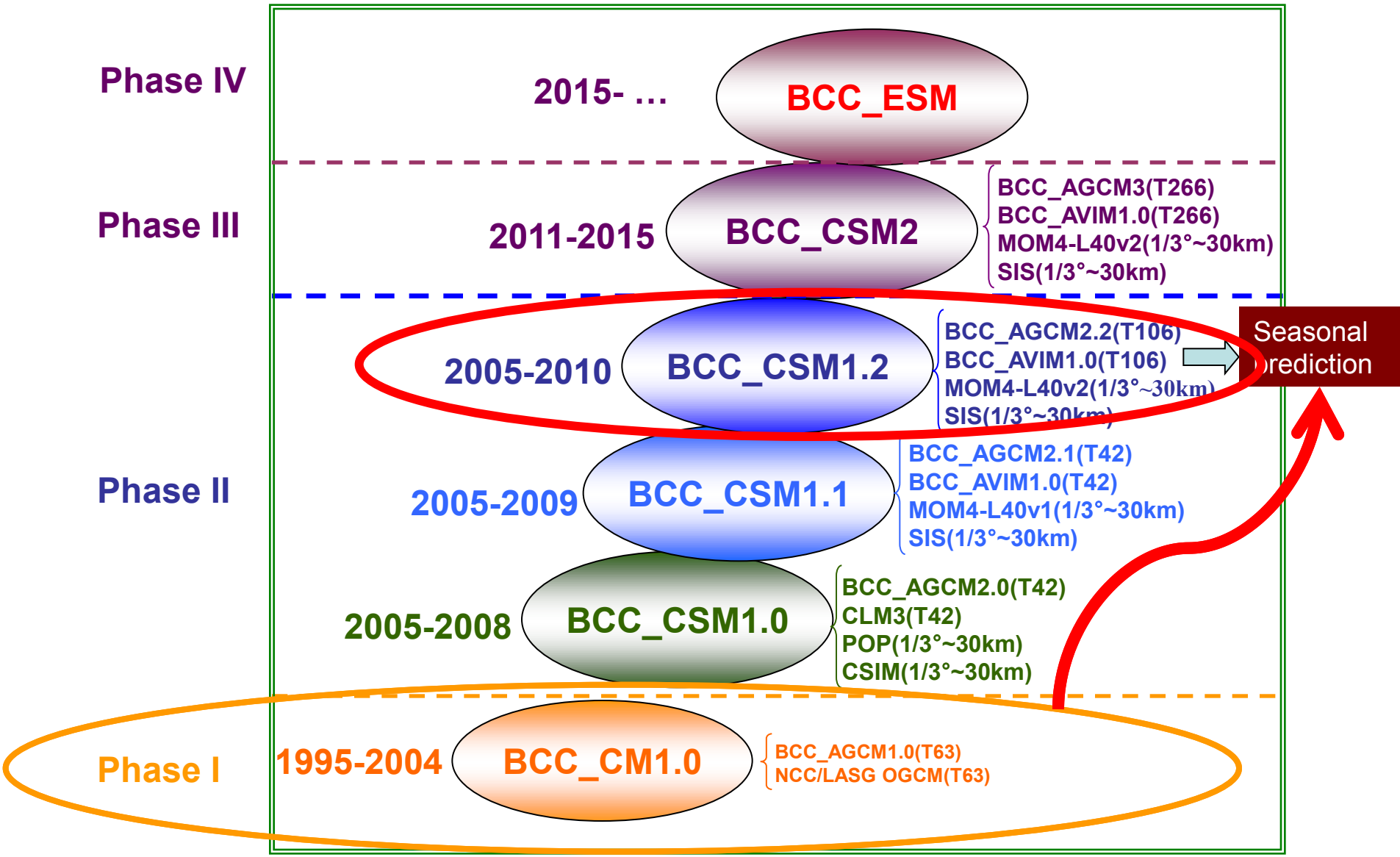
- **GRAPES_GFS** : medium-range global forecast
  - **GRAPES_Global 50km L36 with model top at 10 hPa**
  - **GRAPES_3DVAR at 1.125 degree**
  - **6-hourly cycle**
  - **240 hour forecast (00,12UTC)**
  - **Assimilated Obs.**
    - **GTS conventional data**
    - **NOAA15、16、18、19**
    - **METOP-2 amsu**
    - **COSMIC Refraction**
    - **AIRS**
    - **FY-3 radiance**
    - **METEOSAT-9 & MTSAT AMV**
    - **MODIS polar AMV**



ACC 500hPa Z
JJA 2009



Future development of long-range forecast system



THANK YOU