Application of Ensemble Forecasts on Severe Convective Weather Forecasting in SWPC in China

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National Meteorological Center (NMC), CMA

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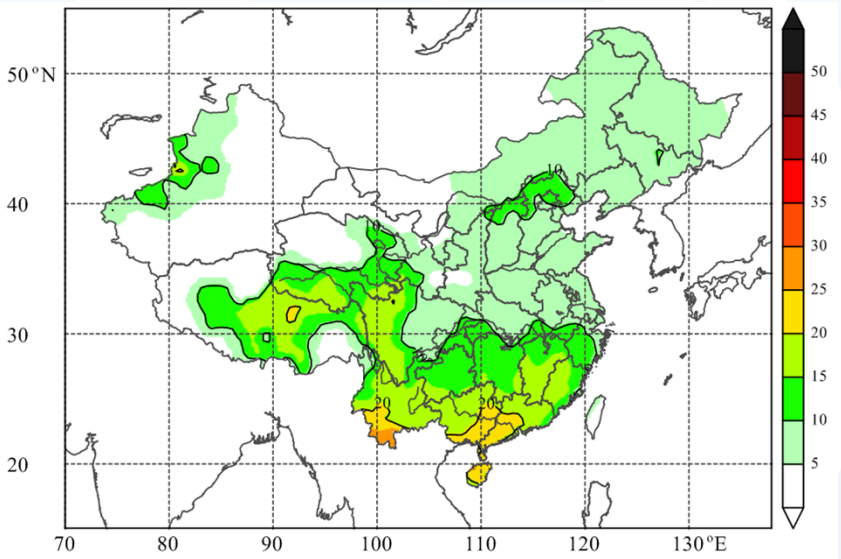
国家气象中心
NATIONAL METEOROLOGICAL CENTER

Outline

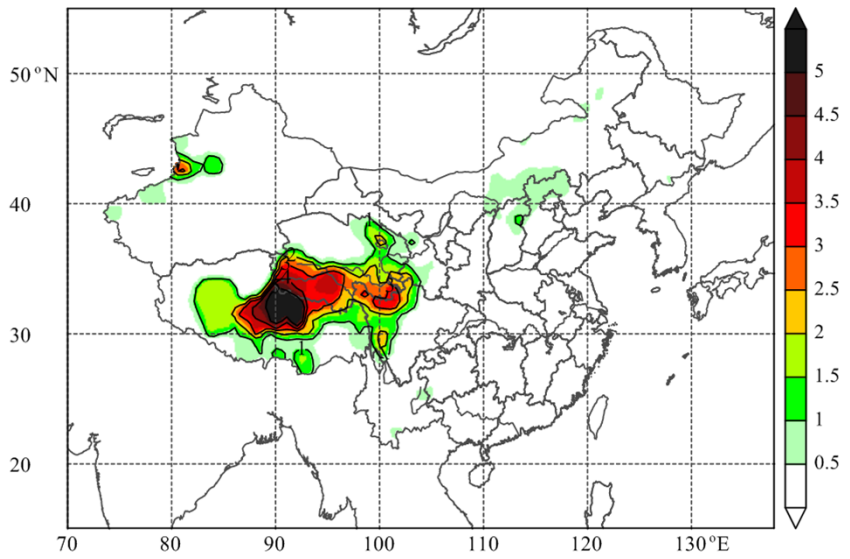
- The main characteristics of Severe Convective Weather（SCW） in China
- The Operational Forecasting on SCW in Severe Weather Prediction Center（SWPC） in NMC
- Ensemble Forecast Products on SCW in NMC
- Primary application of ensemble forecasts on SCW in SWPC
- Summary

The Definition of SCW in SWPC

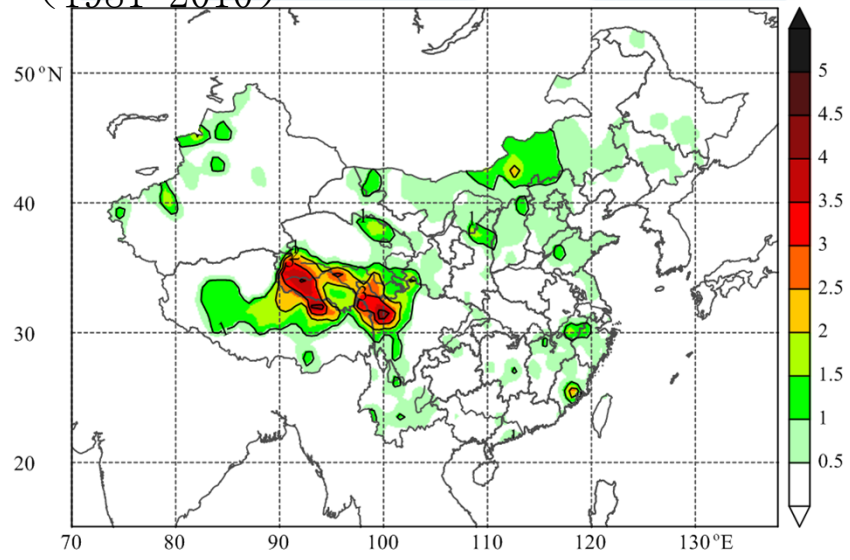
- Thunderstorm Gust 17 m/s or more
- Hail
- Short Range Heavy Rainfall 20mm/h or more
- Tornado
- Severe Lightning



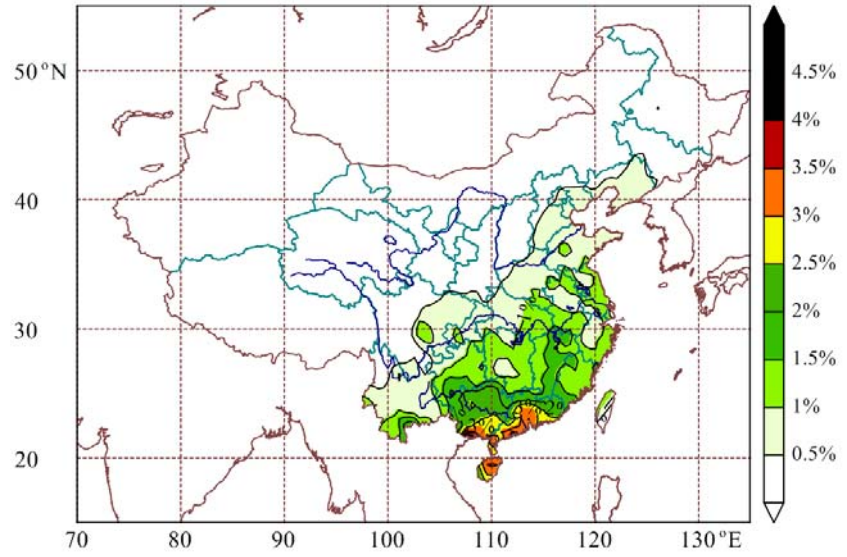
Annual mean probability of thunderstorm (1981-2010)



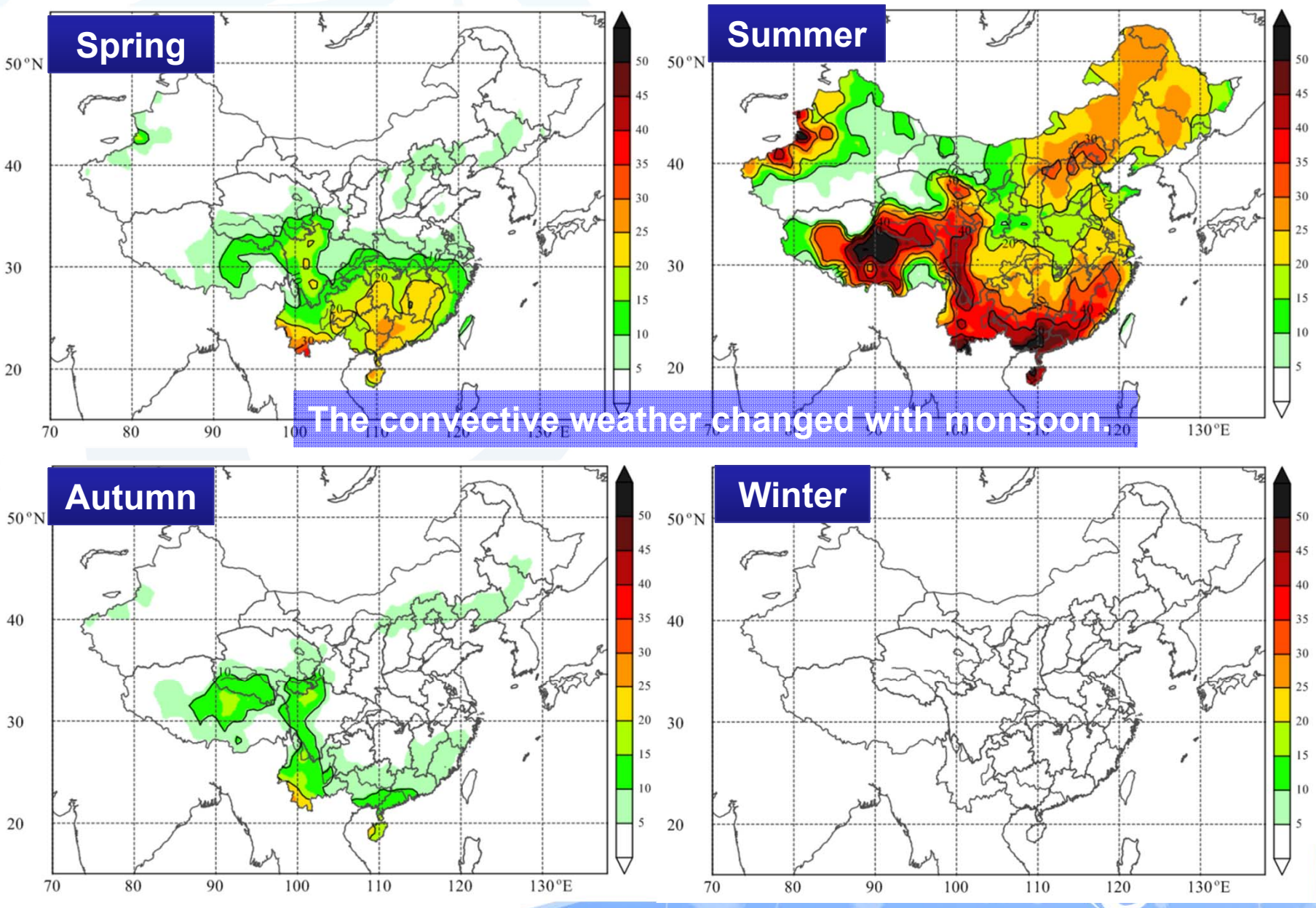
Annual mean probability of hail (1981-2010)



Annual mean probability of thunderstorm gust (1981-2010)

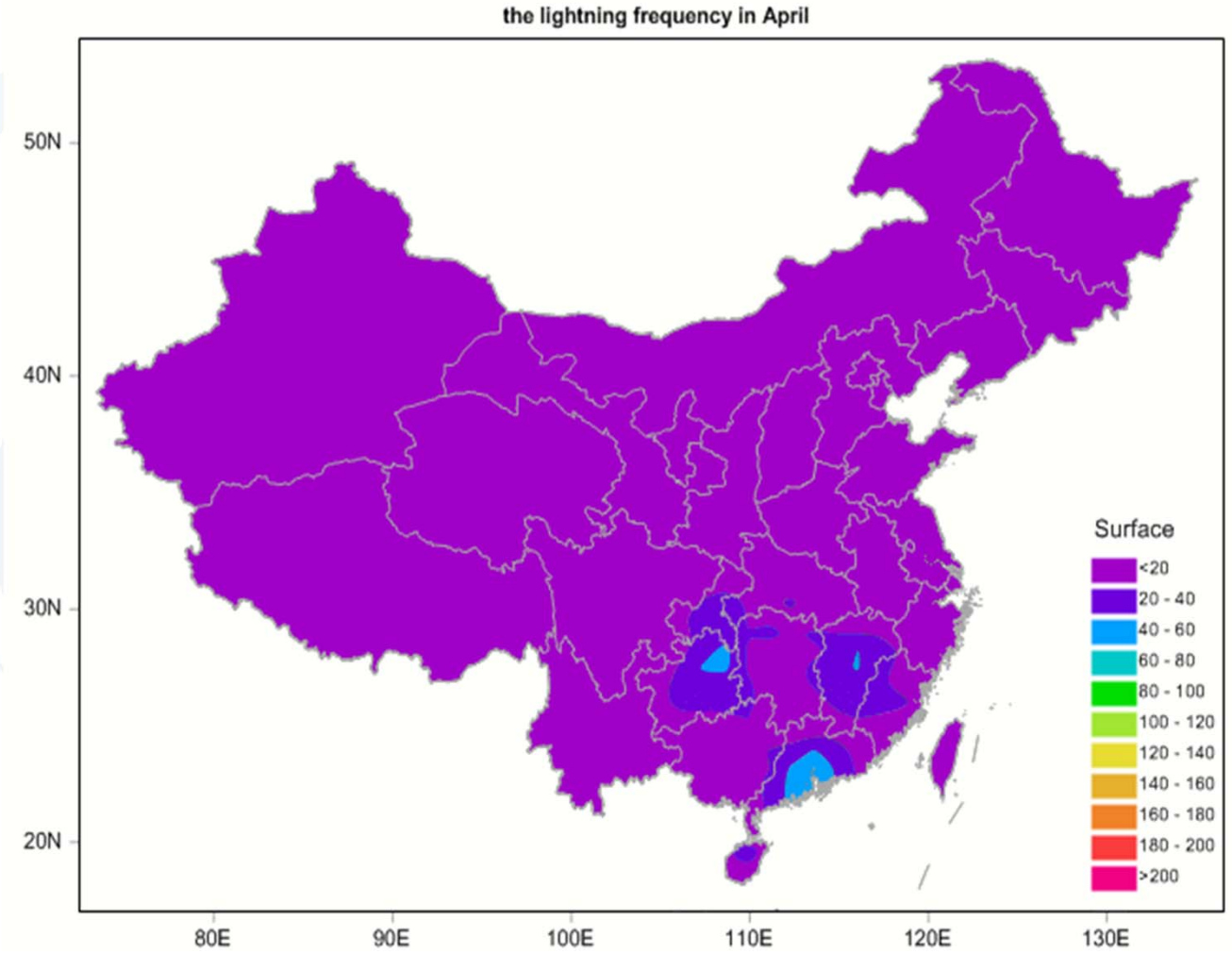


Annual mean probability of short range heavy rainfall



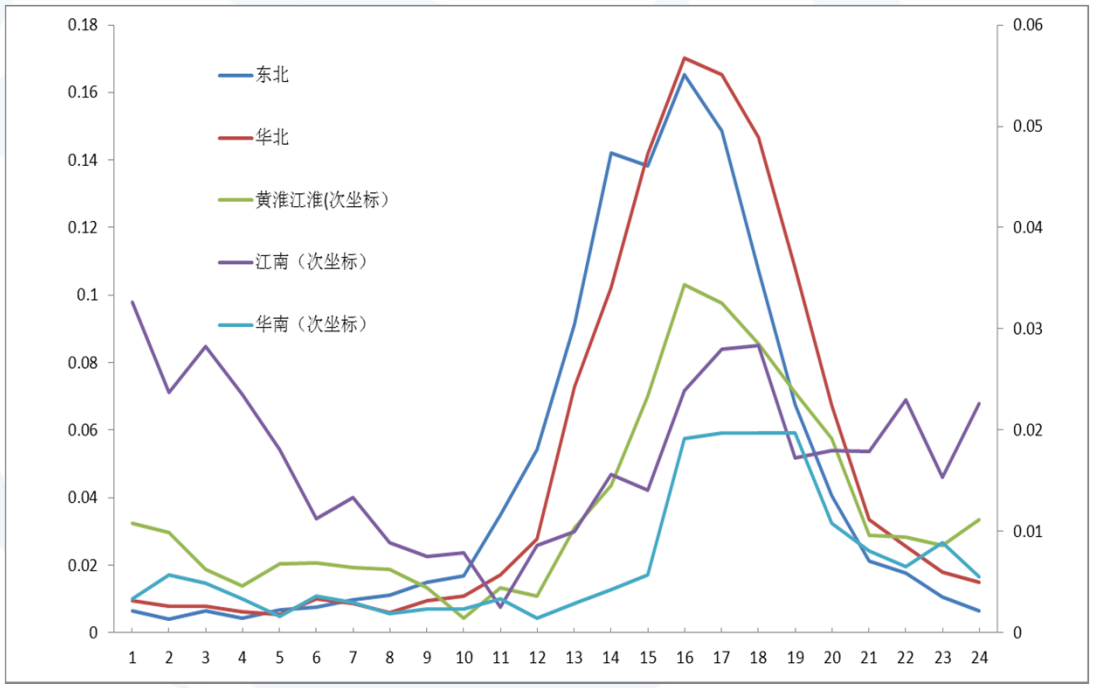
The convective weather changed with monsoon.

Thunderstorm probability distribution in different season.

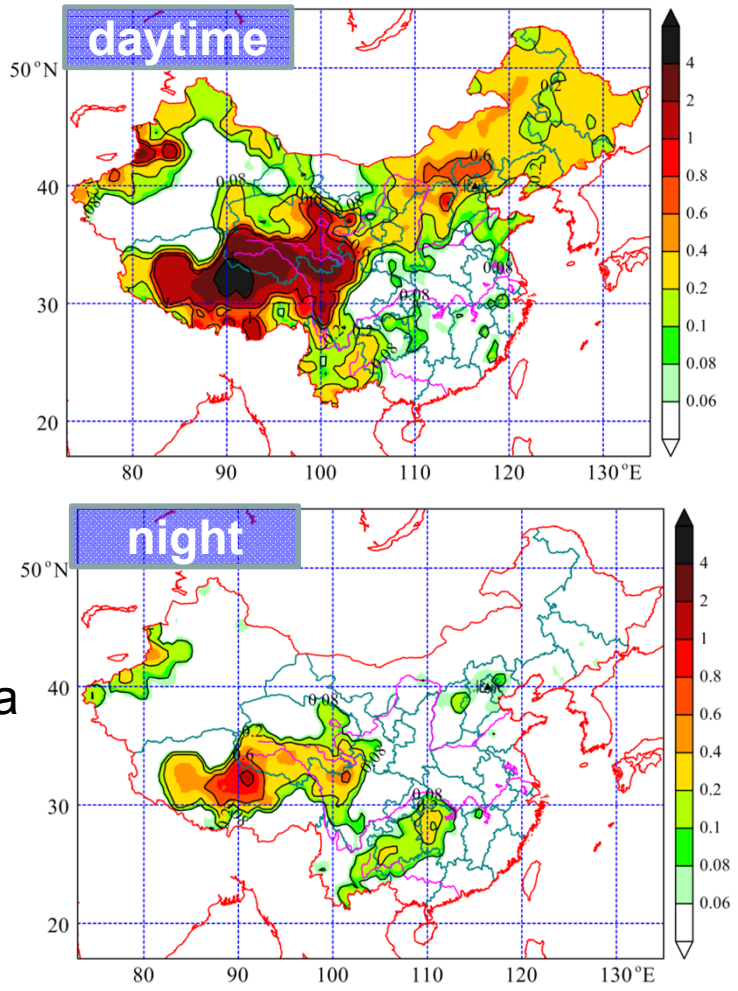


Lightning Distribution from April to September in 2009-012

The convective region changed by advancing of monsoon from south to north

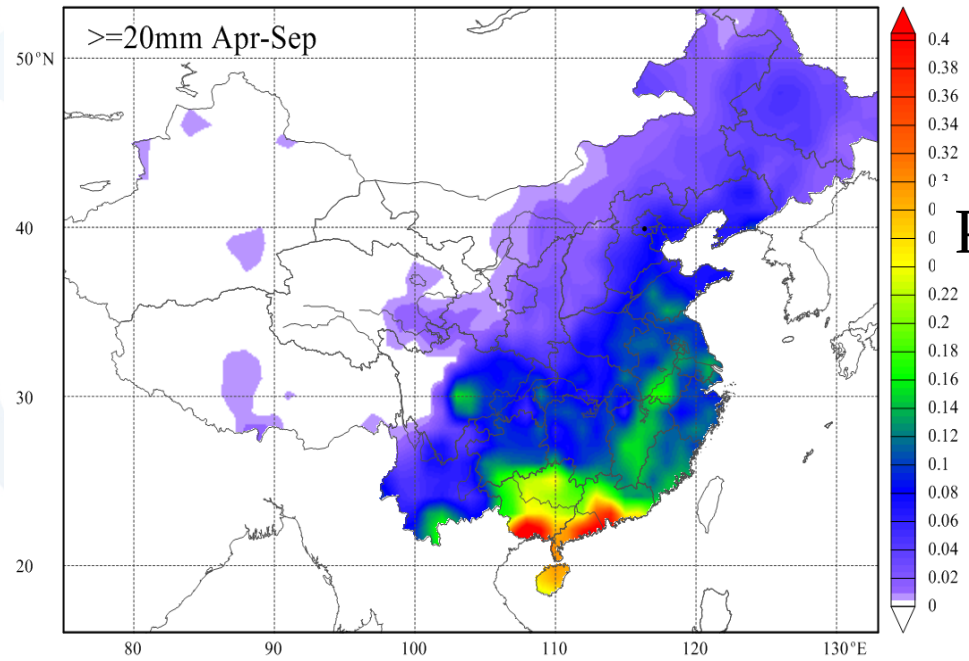


The diurnal variation of hail in middle and east China



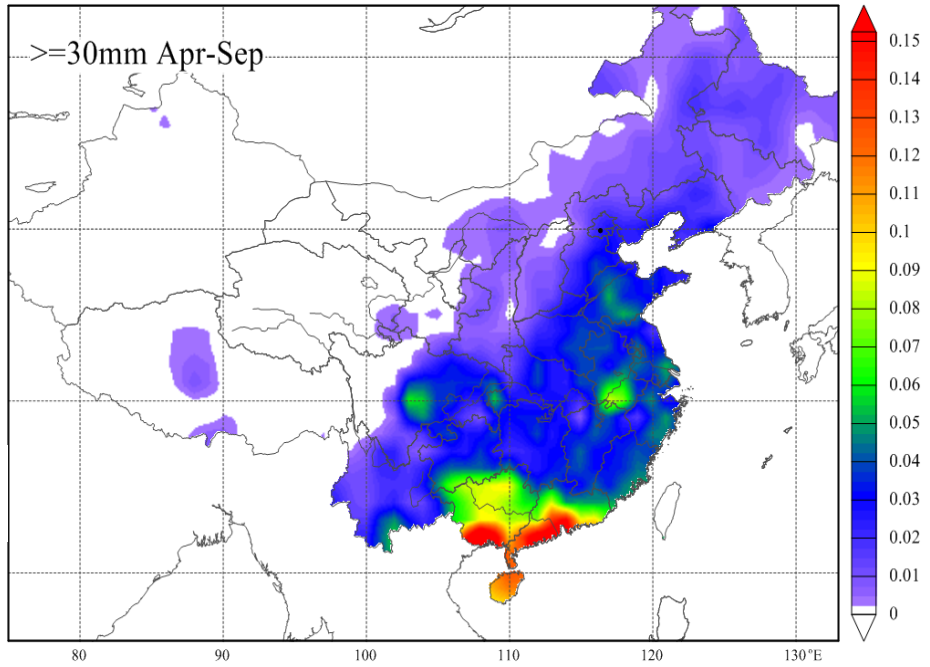
Obvious diurnal variation

The climate probability of hail in 12 interval in middle and east China



Probability more than 20mm/h (%)

Probability more than 30mm/h (%)



Probability of short range heavy rainfall （≥20mm/h and ≥30mm/h） （Apr.-Sep.）

The main SCW in China is short range heavy rainfall.

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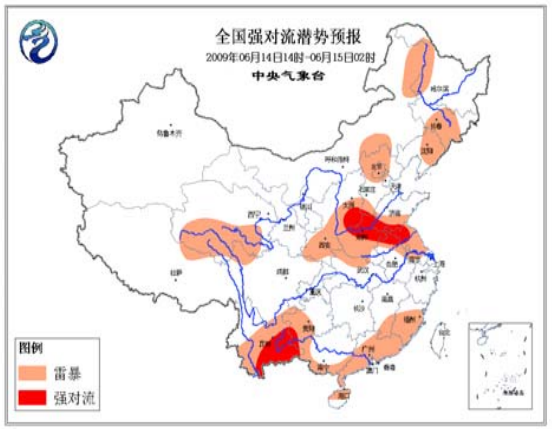
The main characteristics of SCW in China

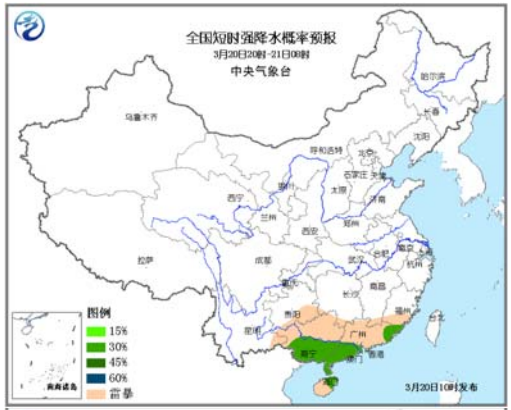
- There are many types of SCW in SWPC
- The convective weather changed with monsoon
- Obvious diurnal variation
- Short range heavy rainfall is one of main SCW in China

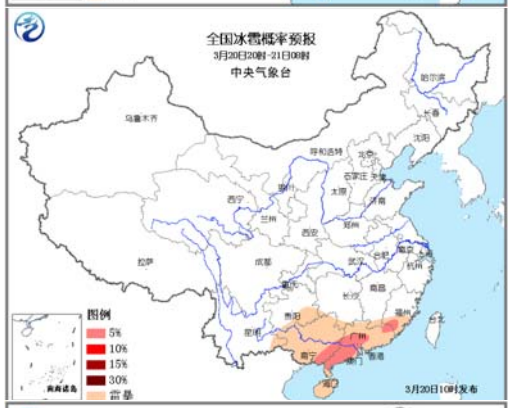
The Operational Forecasting on Severe Convective Weather in SWPC

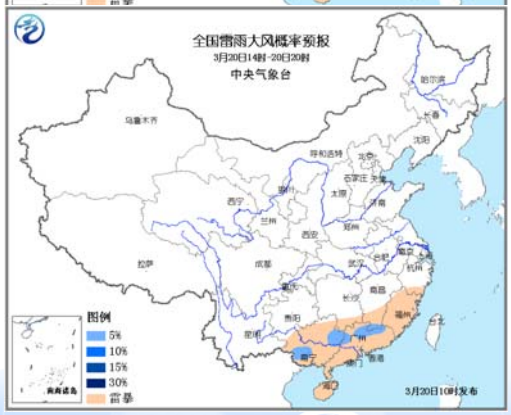


2009

2010







now

Severe Convective Weather

Deterministic Forecast

Short Range Heavy rainfall Thunderstorm gust and hail

Probability forecast

Short Range Heavy rainfall Thunderstorm gust Hail

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  - 强对流天气分析
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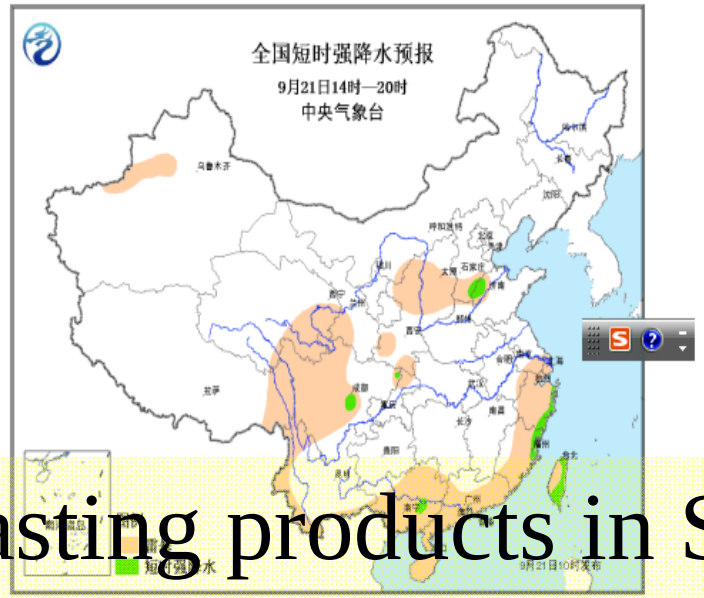
强对流天气预报

预报：丛春华 蔡雪薇 2013 年 09 月 21 日 10 时

华东沿海江南等地的局部有强对流天气

预计9月21日14时至9月22日08时，浙江东部、福建东部、台湾大部、广东东南部、江西中部等地的部分地区有短时强降水，山东西北部、四川盆地东部、广西中部等地的局部地区有短时强降水天气；内蒙古中南部、宁夏北部、甘肃西南部和青海东南部等地的局地有雷雨大风或冰雹天气。

Monitor
Diagnosis
Analysis
forecast



Guidance forecasting products in SWPC, CMA

http://www.weather.gov.cn

Ensemble Forecast Products in NMC

- T213： Global Ensemble Forecast System（GEFS）（T639（2014））
- NCEP ： Products of NCEP Ensemble Forecast System
- EC： Products of EC Ensemble Forecast System
- WRF：Regional Ensemble Forecast System（REFS）
- GRAPES：Regional Ensemble Forecast System（REFS）

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Ensemble Forecast Products on SCW in SWPC

- Ensemble Forecast Products on SCW in SWPC Based on GEFS
- Ensemble Forecast Products on SCW in SWPC Based on REFS
- Ensemble Forecast Products on SCW in SWPC Display

➢Ingredients-Based Forecasting

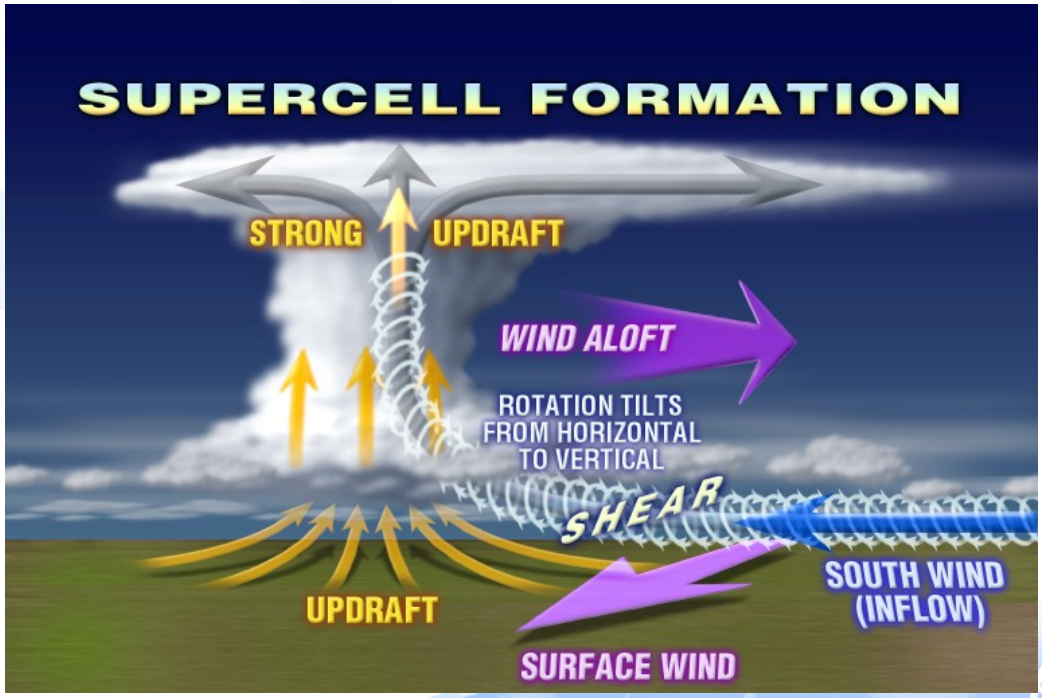
Fundamental Severe Storm Ingredients:

Moisture

Instability

Wind Shear

Localizing Trigger



Dowswell

Storm Mode

Ensemble Forecast Products on Severe Convective Weather in SWPC Based on GEFS（EC、NCEP）

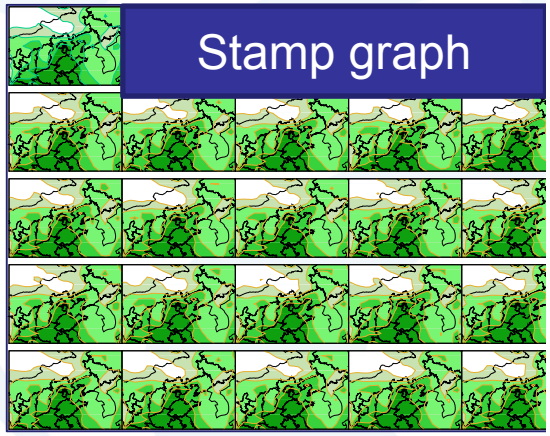
NCEP √
EC √

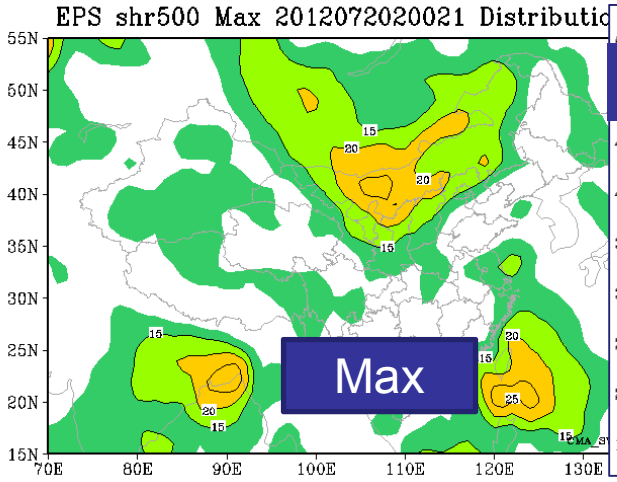
		Mean Spread	Max/min /medain	Stamp graph	Threshold Probability	Box plot	mode	Probability matching	Spaghetti diagram
Moisture	relative humidity 850,700,500hPa	√	√		√		√	√	
	Pwat			√					
Instability	CAPE	√√	√√		√√	√	√√	√√	
	T850-500	√	√		√		√	√	
	K Index	√	√		√		√	√	
	BLI	√	√		√		√	√	
Dynamic and Lifting etc.	wind shear（0-500hPa）	√	√		√		√	√	
	wind shear（0-700hPa）	√	√		√		√	√	
	Z0 level								√
Composite index	CS Index				√		√	√	
	Ship Index	√	√		√		√	√	
Propability	Short-range heavy rainfall				√				

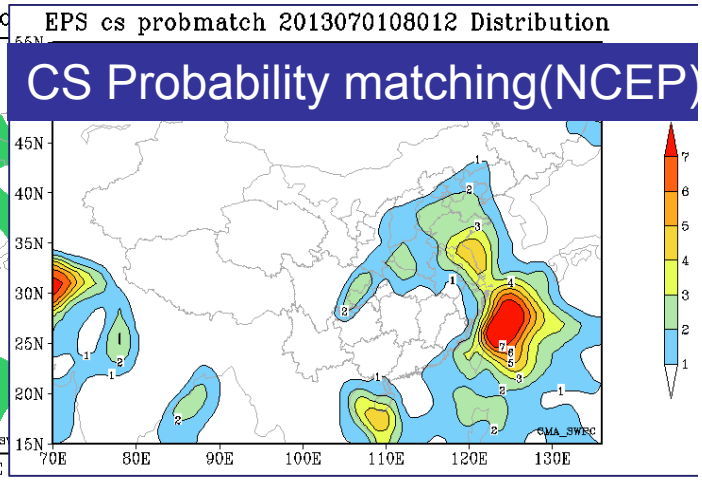
Ensemble Forecast Products on SCW in SWPC Based on GEFS（EC、NCEP）

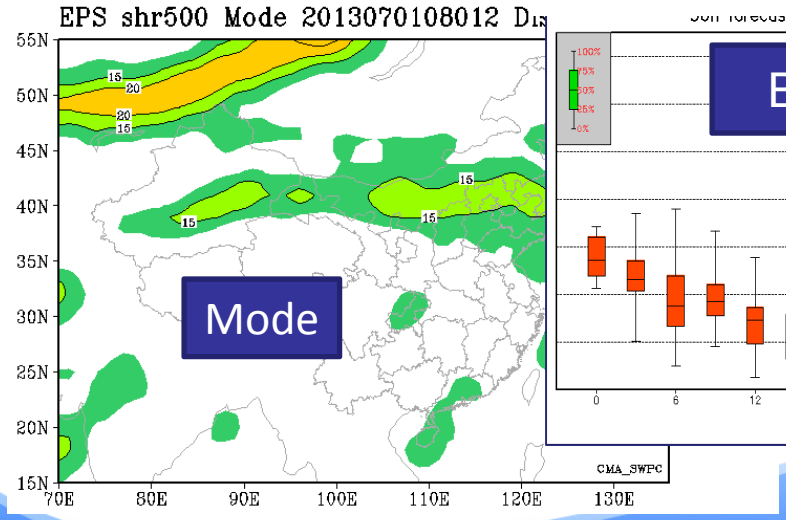
- Products of statistics
- Classification of convective weather index -hail
- Objective Product of Probability of Short Range Heavy rainfall (testing)

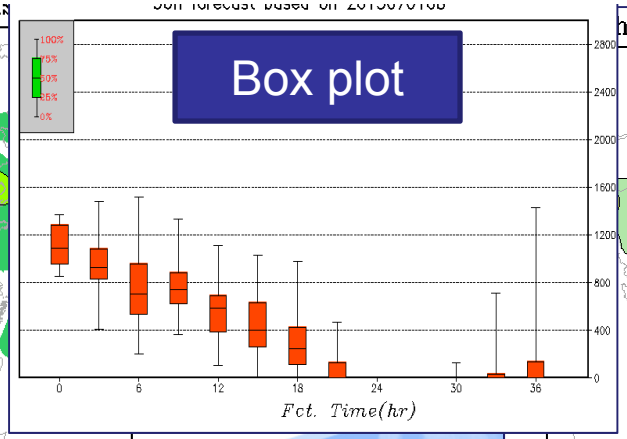
Products of statistics

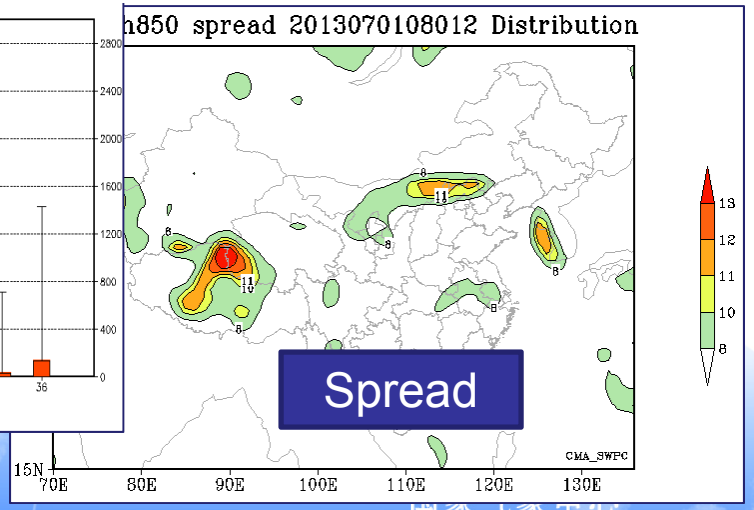












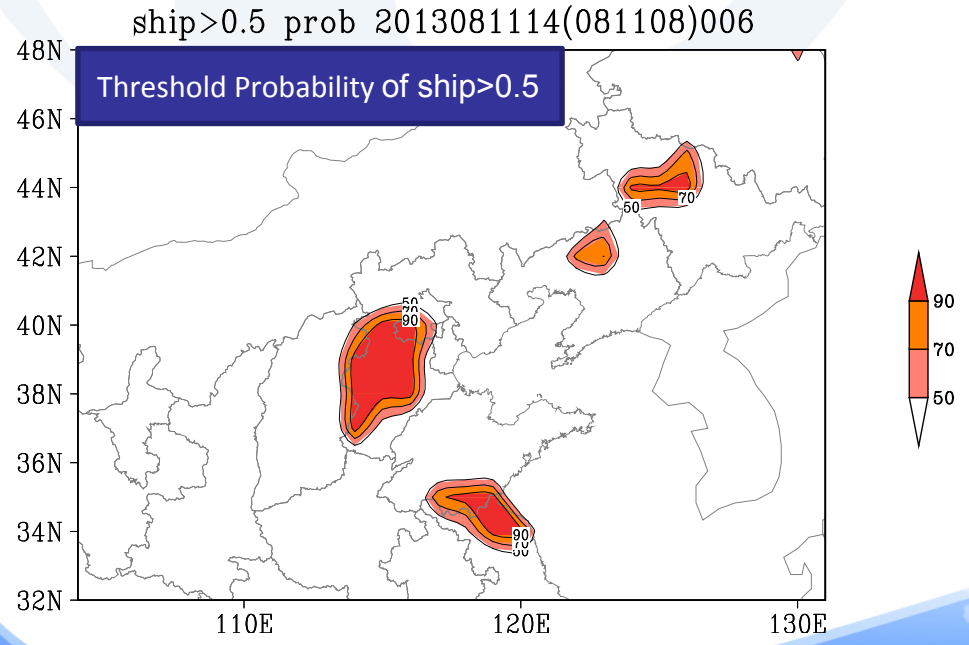
Classification of Convective weather index -hail

1、SHIP(SPC):

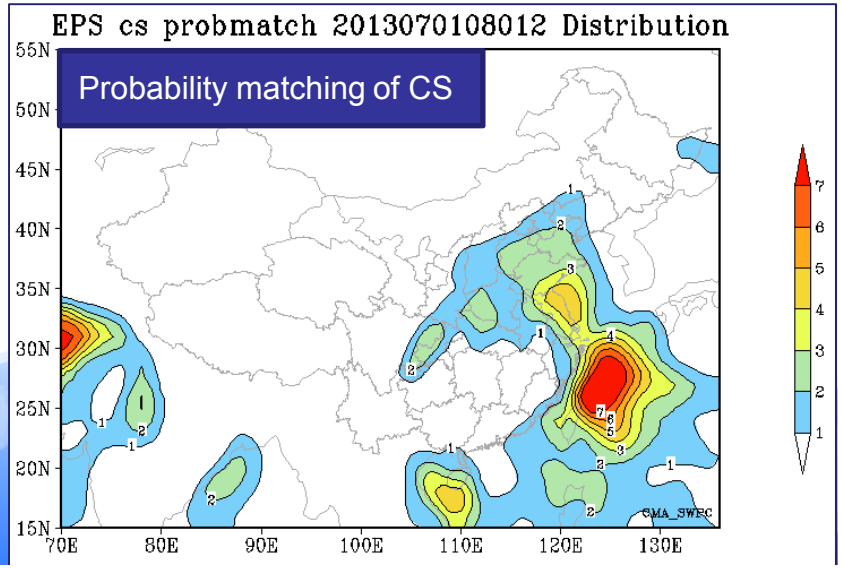
$$SHIP = \frac{\text{MUCAPE} \times \text{MR of MU parcel} \times \text{700-500mb lapse rate} \times (-1 \times \text{500mb T}) \times \text{0-6km Shear}}{44{,}000{,}000}$$

units: J/kg | *Mixing Ratio units: g/kg* | *units: °C/km* | *units: °C* | *units: m/s*

最优抬升能量 最优抬升高度层比湿 温度递减率 500mb温度 0-6km切变



2、CS： Uses a CAPE * 0-6 km shear parameter (normalized) to estimate duration of updrafts (Energy Shear Index), based on 5 previous studies of supercell updrafts:

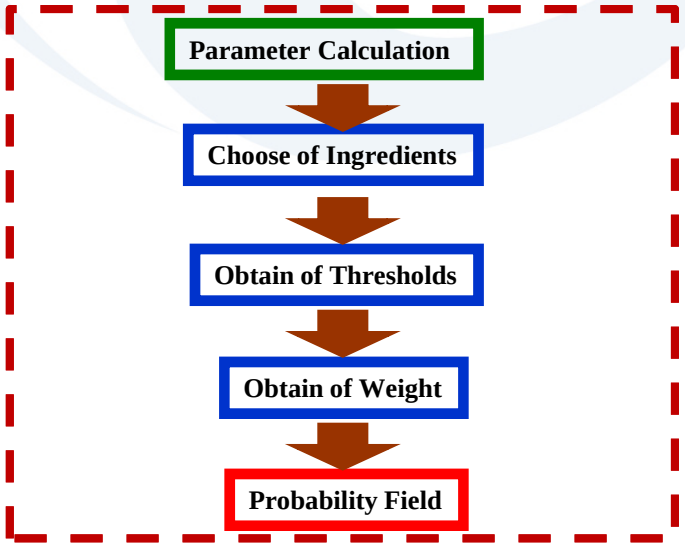


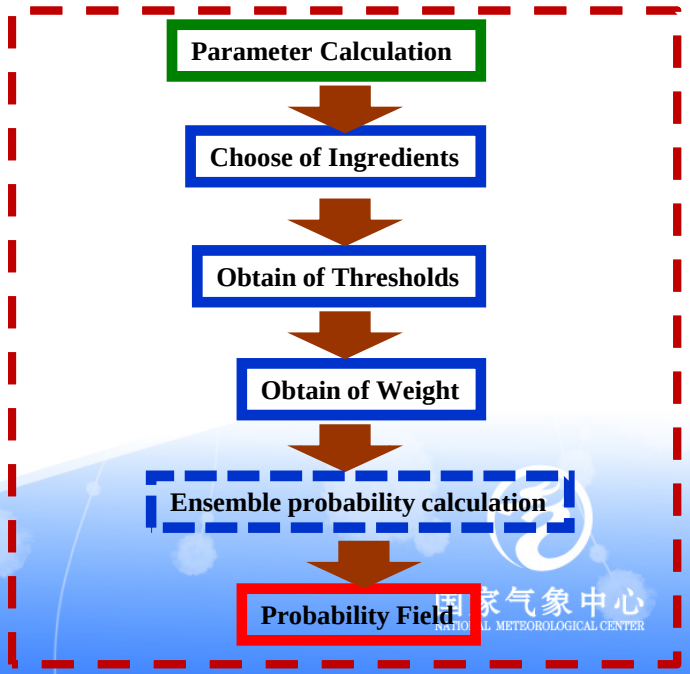
Objective Product of Probability of Short Range Heavy rainfall (testing,2013)

Ingredients-Based Forecasting→ Probability forecast

Ingredients-Based Forecasting +Ensemble→ Probability forecast

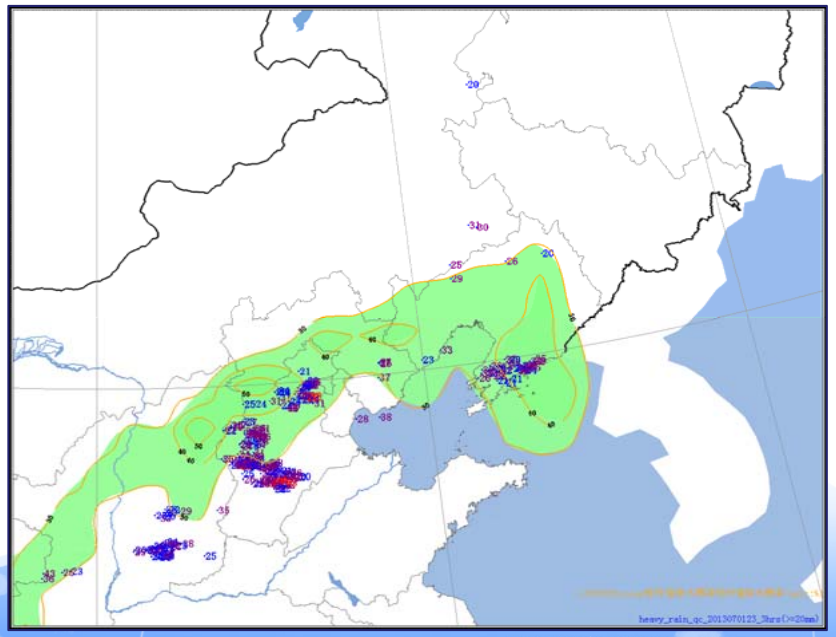
Put the uncertain information into Probability forecast





Objective Product of Probability of Short Range Heavy rainfall (testing,2013)

- Instability：lapse rate（850-500hPa）
- Moisture：dew point（850、700hPa）
- Dynamic and Lifting：divergence（850、700hPa）
- Topography revise



Regional Ensemble Forecast System （REFS）in China（WRF）

- 2006-2008: Start work on REPS based on the WMO BO8RDP project.
  - East China based on WRF model, 15km(234×200 grids),
  - 15 members
  - 36h forecast, twice/day
  - Support Beijing Olympic game

- 2009-2010: Start work on REPS over China based on the B08RDP REPS system

- **18 Jun 2010: Real time running.**
  - China, 15km(434×267 grids),
  - 15members
  - 60h forecast, twice/day
  - Running at IBM computer at Meteorological Bureau of Beijing

Product list of REPS at CNWP, CMA

Name	Variables	Products	Probability
3D variables			
HGT	Height	*Layers：200 ,250,500,700,850,925, 1000hPa* Mean,Spread	*Forecast hours：* *000,003,006,012,018,021,024，* *027,030,036，039，42，045，048，051，054，057，060*
QVAPOR	Specific humidity		
RH	Relative humidity		
UV	U and V component Wind		
TCTD	Temperature and Dew-point temperature		
THETASE	Pseudo-wet-bulb potential temperature		
DBZ	Radar reflectively	Mean, Spread, Probability	*>10,>30,>50*
SOIL	4 level Soil huimidity	Mean, Spread	
2D variables			
RAIN_3HR	3h accumulated precipitation	Mean, Spread, Mean,Spread	>0.25, >5, >15, >25, >50(mm)
RAIN_6HR	6h accumulated precipitation		
RAIN_12HR	12h accumulated precipitation		
RAIN_24HR	24h accumulated precipitation		
RAINC_3HR	3h accumulated convective precipitation		
RH2M	2m Relative humidity	Mean, Spread, Probability	
SAUN	Sangla Index		
CIN	Convecitve inhabition		
SLP	Sea Level Pressure		
T2M	2m Temperature	Mean, Spread, Probability	>35,>38（J/kg）
CAPE	Convective Available Potential Energy	Mean, Spread, Probability	*>500,>1000，>1500,>2000 （J/kg）*
UV10M	10m Wind	Mean, Spread, Probability	>8m/s, >12m/s, >16 (m/s)
Syntesizing Convective Risk Index			
RISK_PRB1	Convective Risk Index	Probability	
RISK_PRB2	Convective Risk Index	Probability	

All in the Format of MICAPS and images , 8.8G/day

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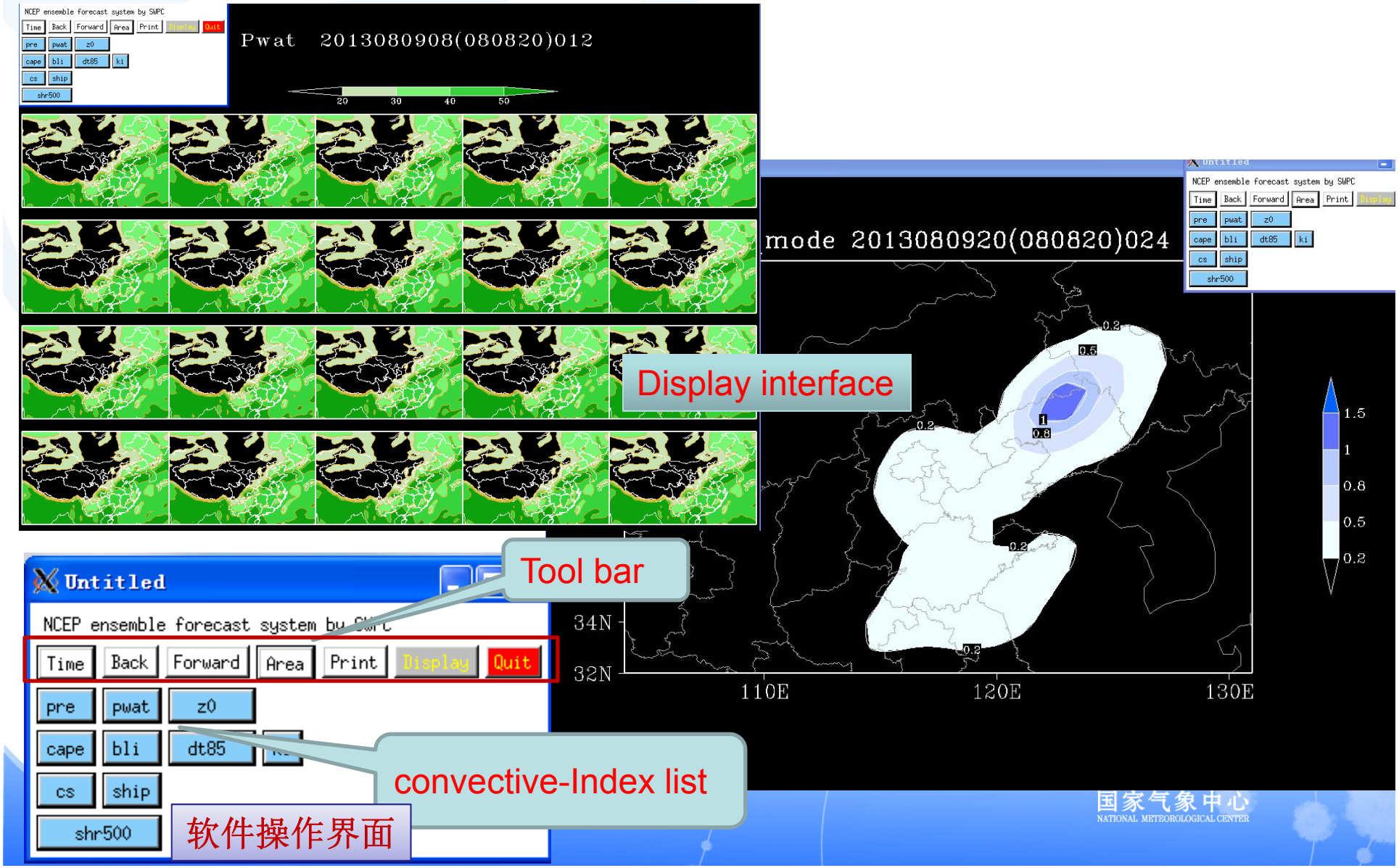
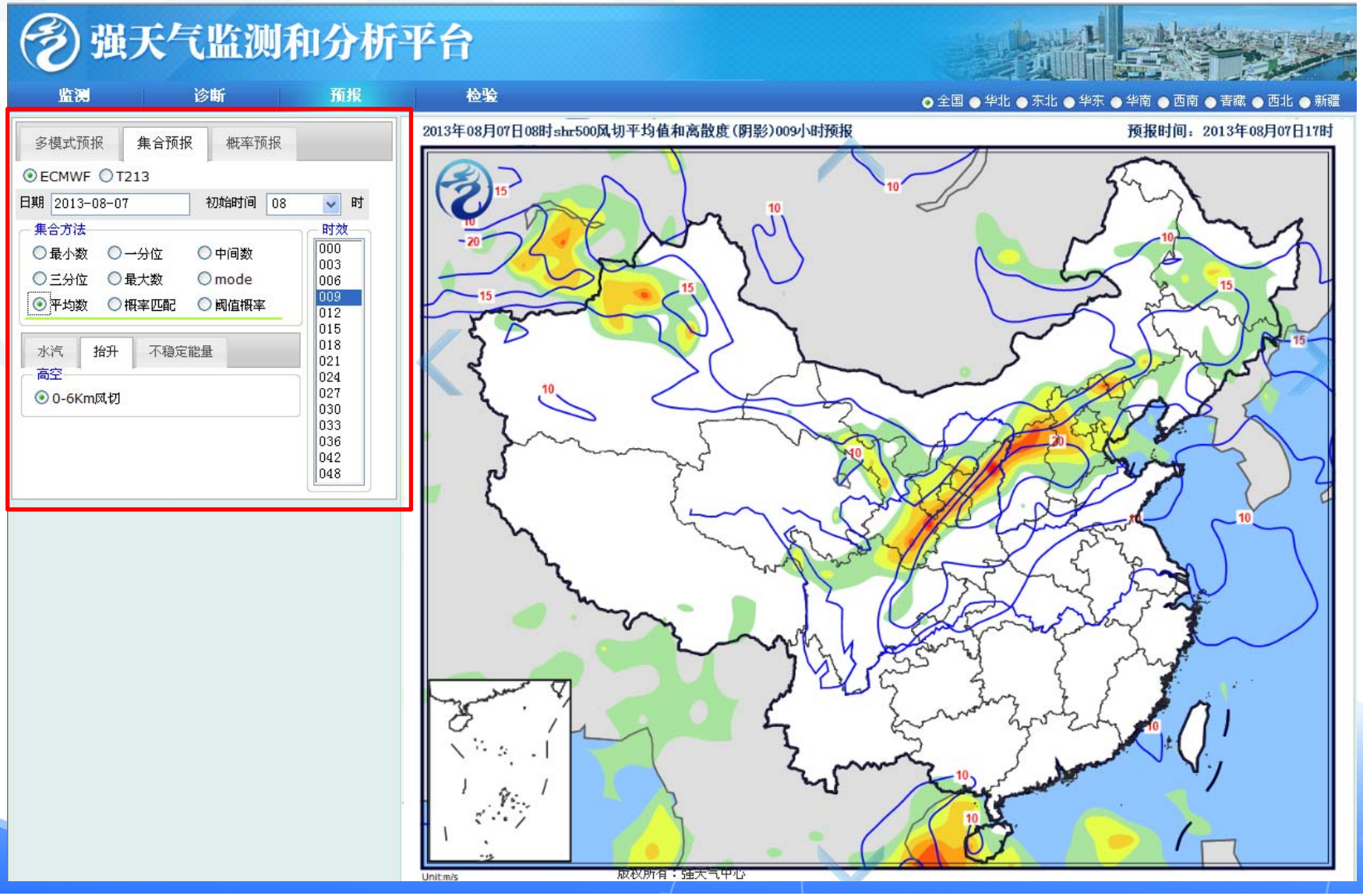
Ensemble Forecast Products on SCW in SWPC Display



Display Platform on the webset



Primary application of ensemble forecasts on SCW

Classification of SCW

- Short Range Heavy rainfall： Torrential Rain in Beijing on 21 July，2012
- SCW caused by different synoptic systems
- Hail

Multiple types of SCW

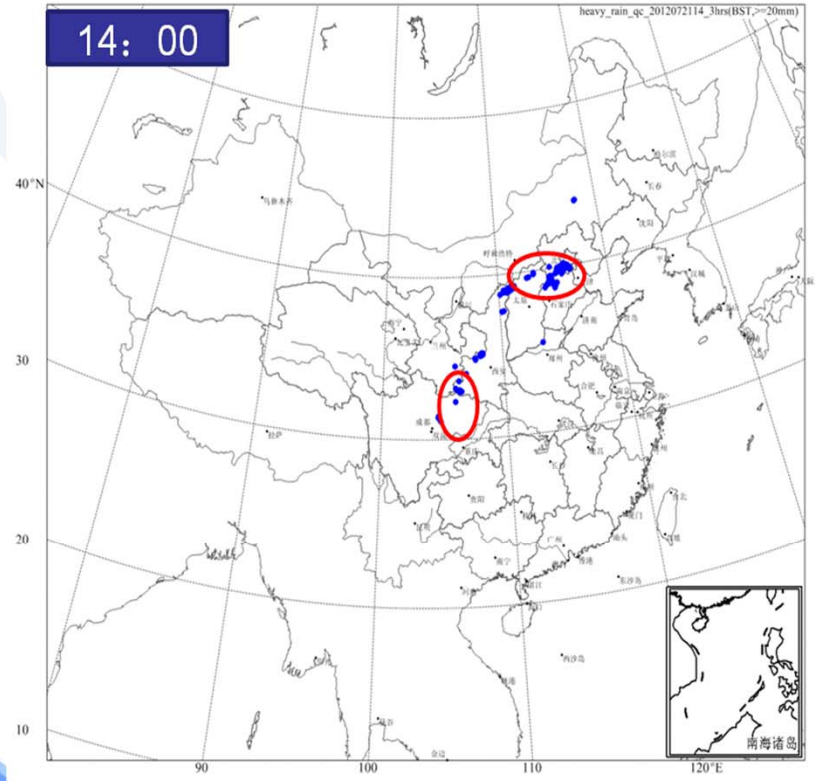
- Two case for SCW(4.10 ,3.19)

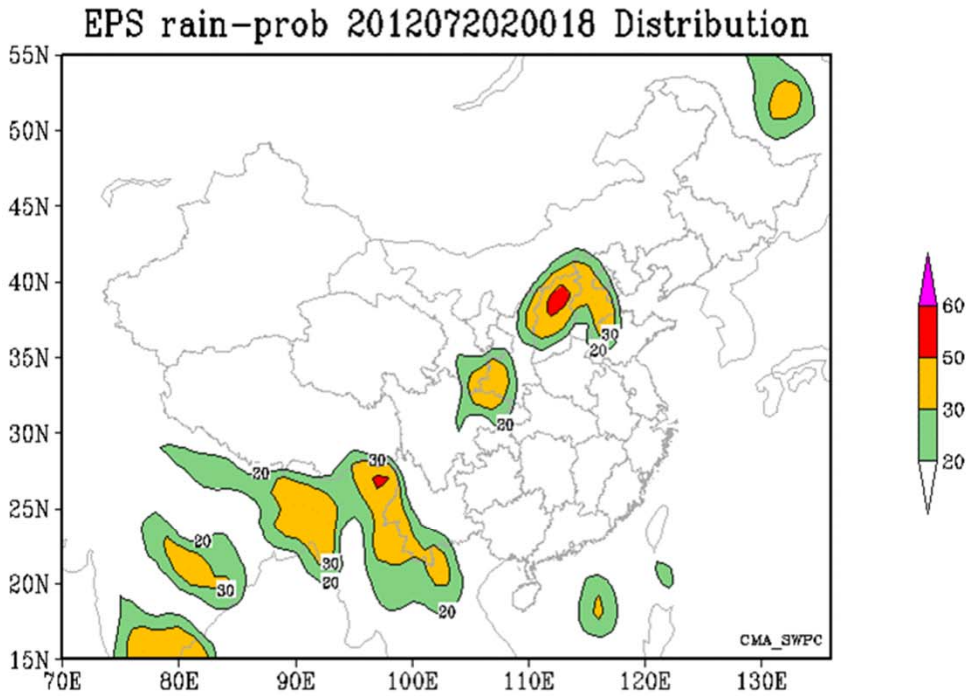
Primary application of ensemble forecasts on SCW

Classification of SCW

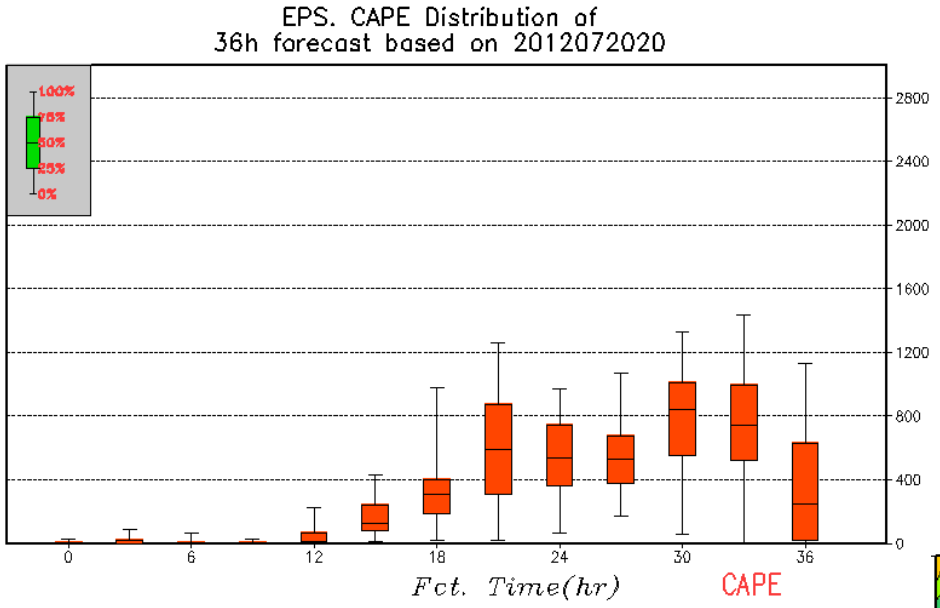
Short Range Heavy rainfall：

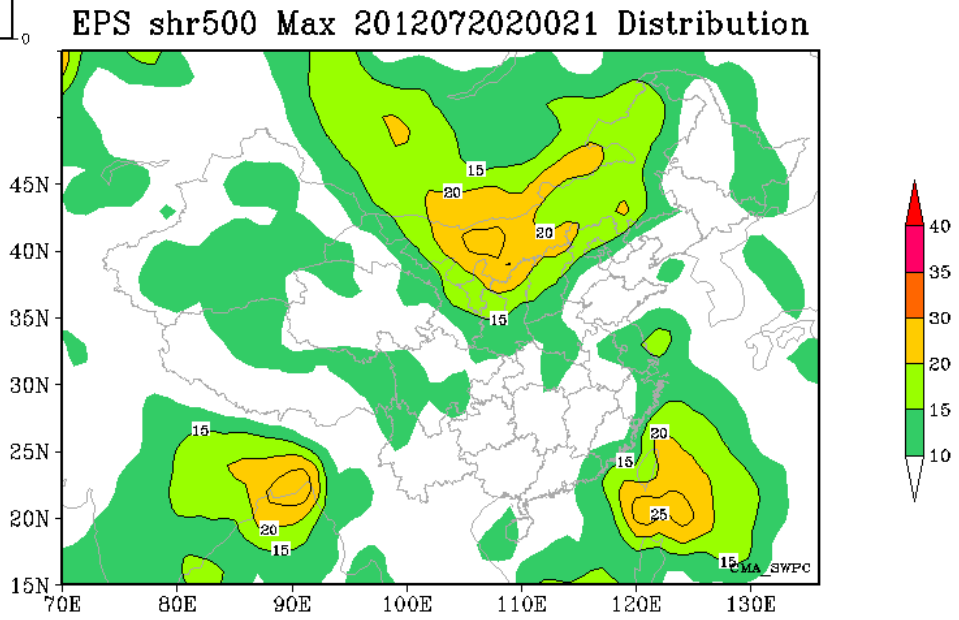
Torrential Rain in Beijing on 21 July， 2012





Cape and wind shear

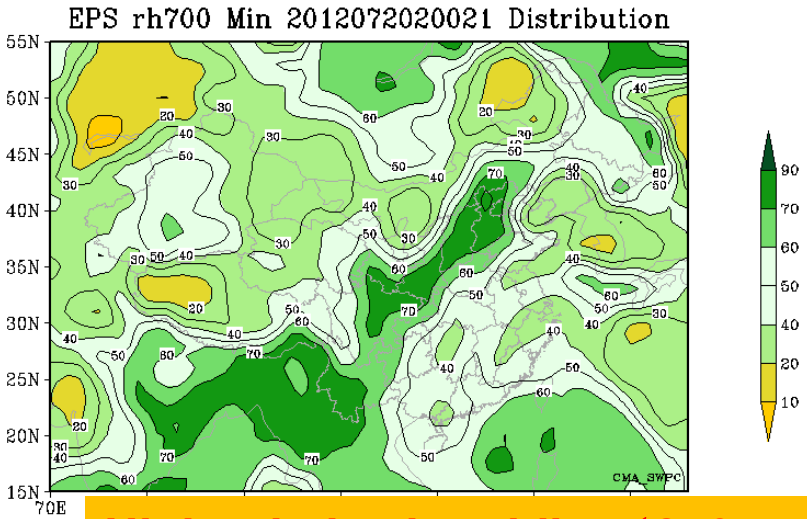


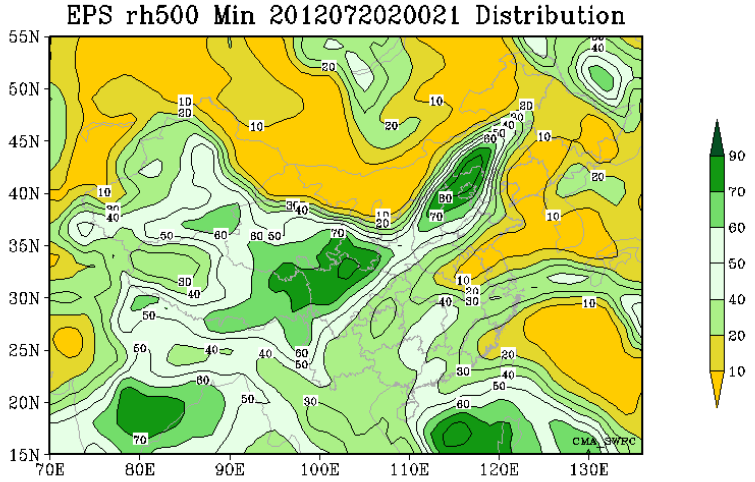


Short Range Heavy rainfall advantageous condition：

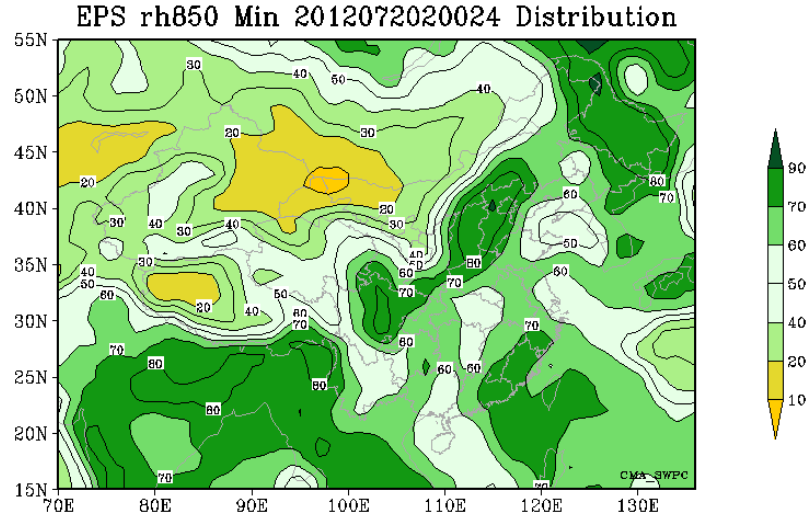
- **Instability energy**
- **Weaker wind shaear**

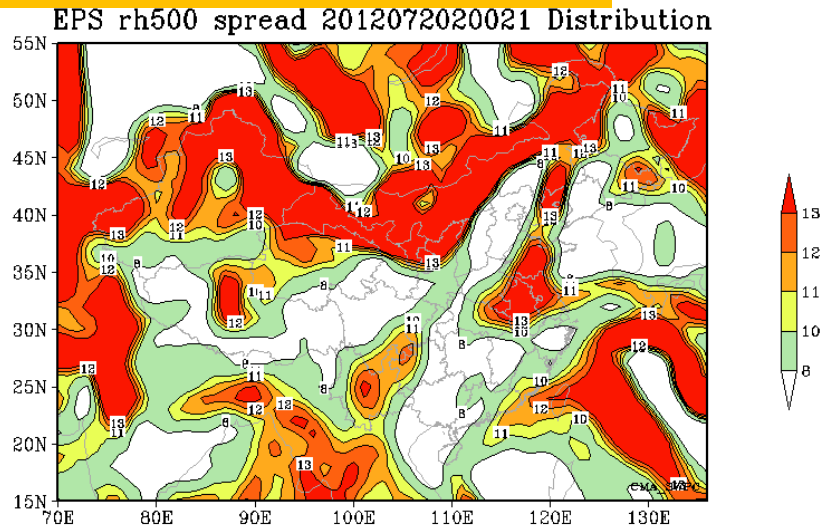
Moisture





High relative humidity（850、700、500）；Small spread





Summary

- The main characteristics of SCW in China
  - The convective weather changed with monsoon
  - Short range heavy rainfall is one of main SCW in China
- The trend of operational forecasting on SCW in NMC is Probability
- SWPC operations are critically dependent on ensemble data
  - Building ensemble-based guidance products to support SCW Forecasting
- Skillful and reliable ensemble system：GEFS? REFS?
- Forecast tools integrated into MICAPS

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Thanks for your attention!

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