Presentations about NWP in CMA

- Numerical Weather Prediction Systems
- GRAPES_meso and its applications
- NWP products and service
- Research activities and future plan

- *How to use GRAPES_meso*

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Numerical Weather Prediction Systems in CMA

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Numerical Weather Prediction Center
Chinese Meteorological Administration
12/2012

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CONTENTS

- Overview NWPC
- Operational NWP systems
- Products and service
- Suggestion for using NWP products

CMA Numerical Weather Prediction Center

- **The Numerical Prediction Center (NPC) at CMA, founded on 28th April,2010.**
- **Director: Dr. WANG Jianjie**
- **Deputy-director: Dr. GONG Jiandong and Dr. SHEN Xueshun**
- **Engineer general: Dr. CHEN Dehui**
- **77 staffs**

Major Responsibilities

- **Develop and improve numerical prediction systems**
- **Maintenance of operational numerical weather prediction systems**

Numerical Weather Prediction Center at CMA (NWPC)

R&D Division

Dynamic process group

Data assimilation group

Observation data quality control group

Physical process group

Parallel computing group

Regional model group

System & Operation Division

Ensemble prediction Group

Typhoon prediction group

Model verification group

Post process and products development group

System pre-operational test group

Model version manage and information technology group

General Office

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NWPC stuffs

Total FTEs: 77
(by 30 July 2012)

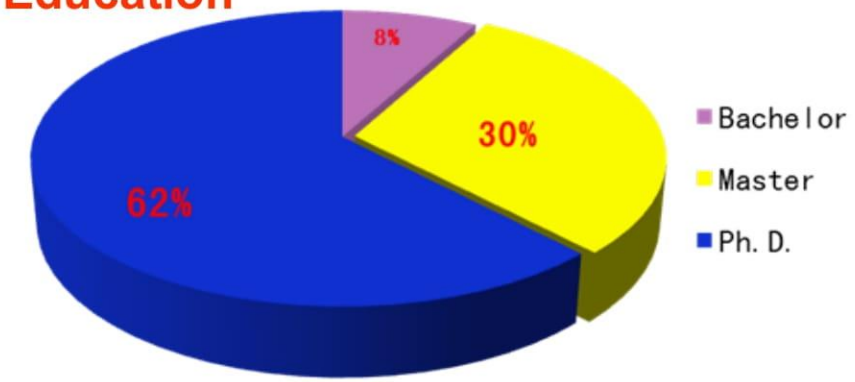
EDUCATION:
47 with Doctor Degree, 23 with Master Degree and 7 with Bachelor, > 95% staffs are undertaking the research and operation tasks.

Age Distribution

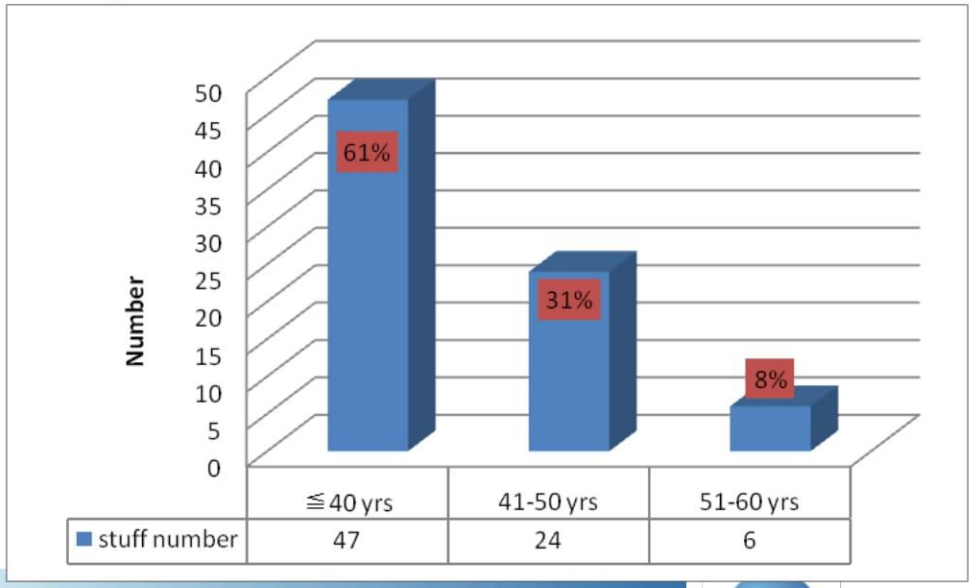
Over 60% of stuff are below 40 years age

20+ Senior scientists

Education



Age distribution



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CONTENTS

- Overview NWPC
- Operational NWP systems
- Products and service
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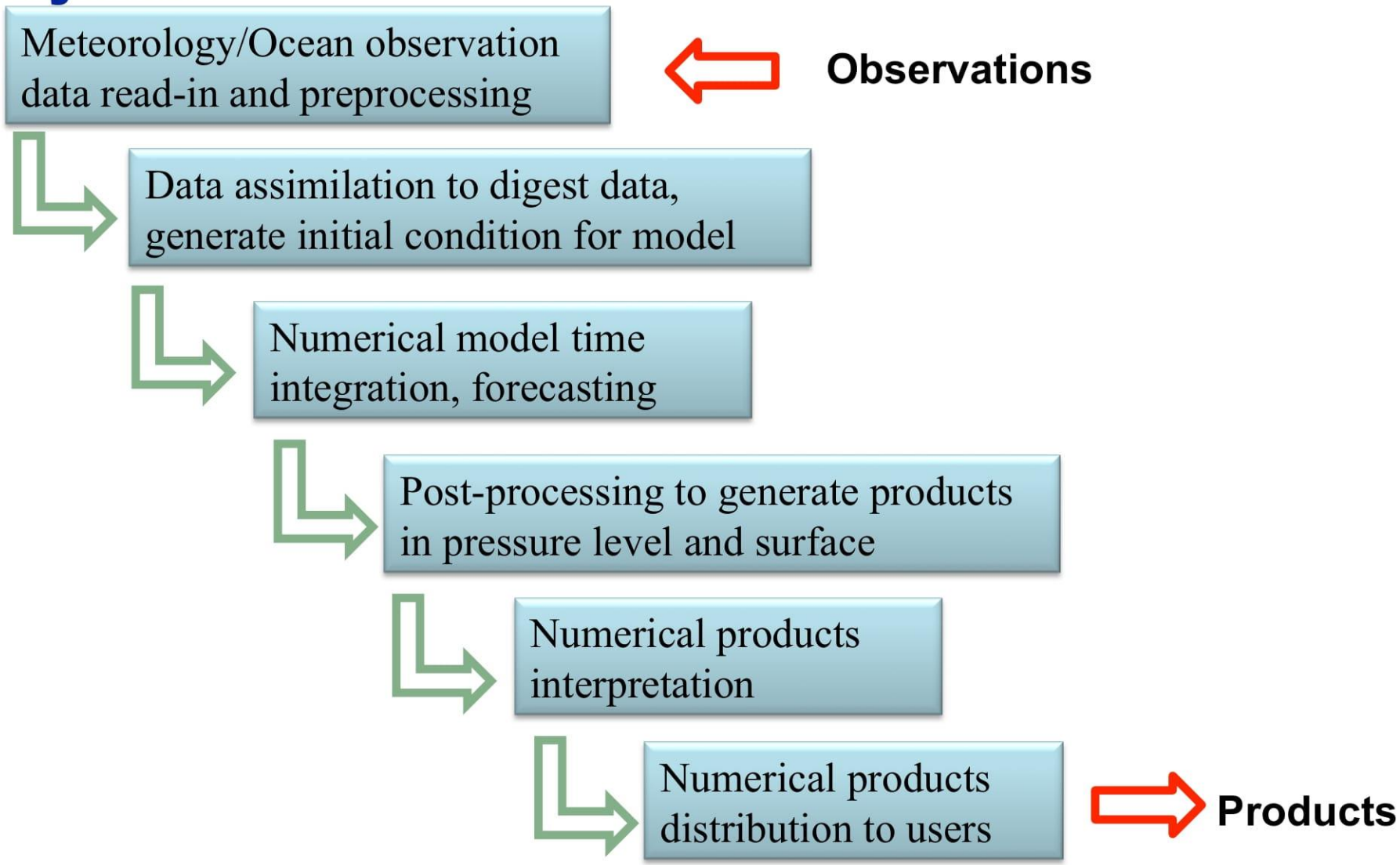
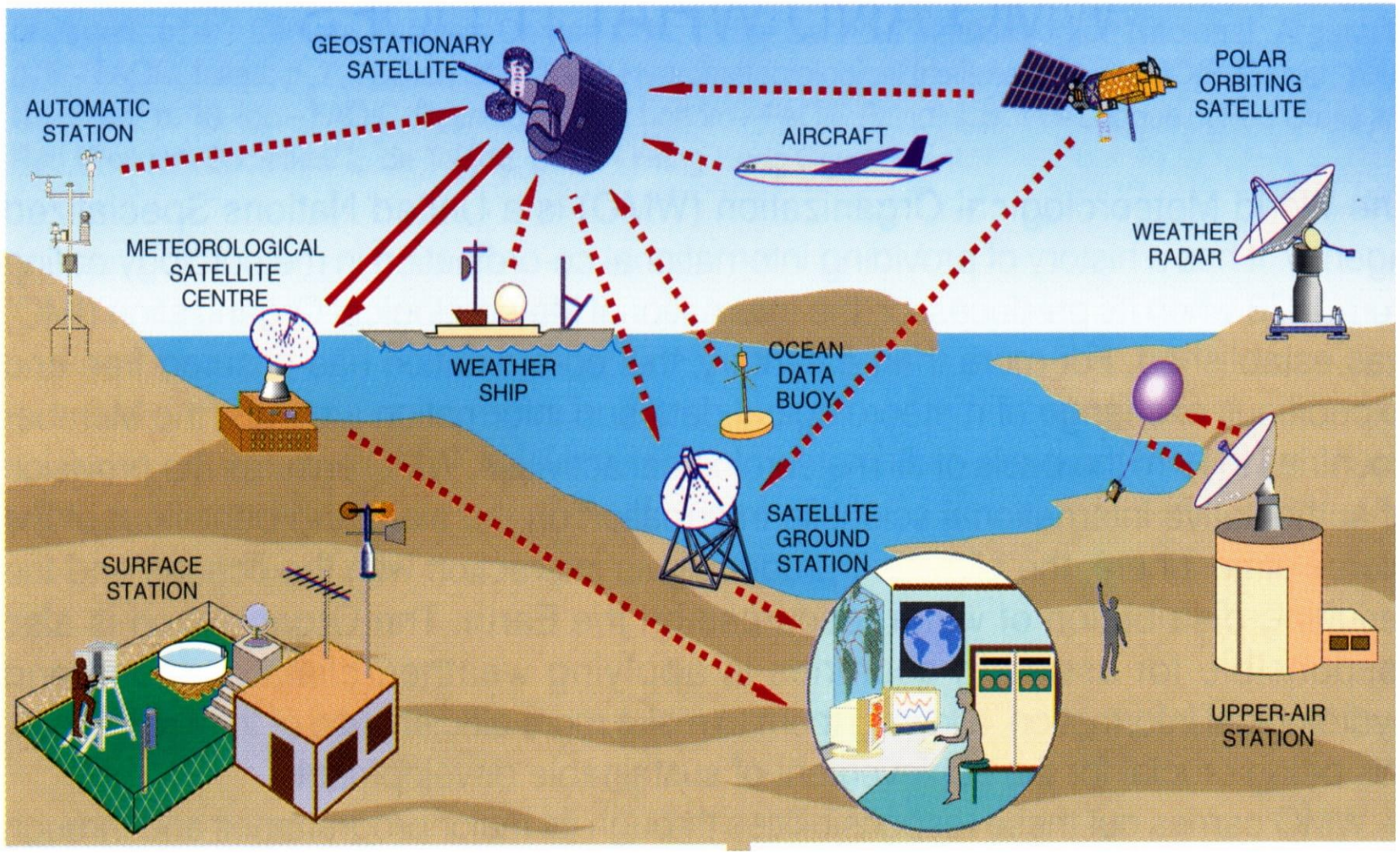
Operational NWP systems

- Overview of the NWP systems
- Global
- Regional
- TC track and intensity
- EPS
- Supercomputer

Components of an operational numerical model system



Meteorology comprehensive observation systems



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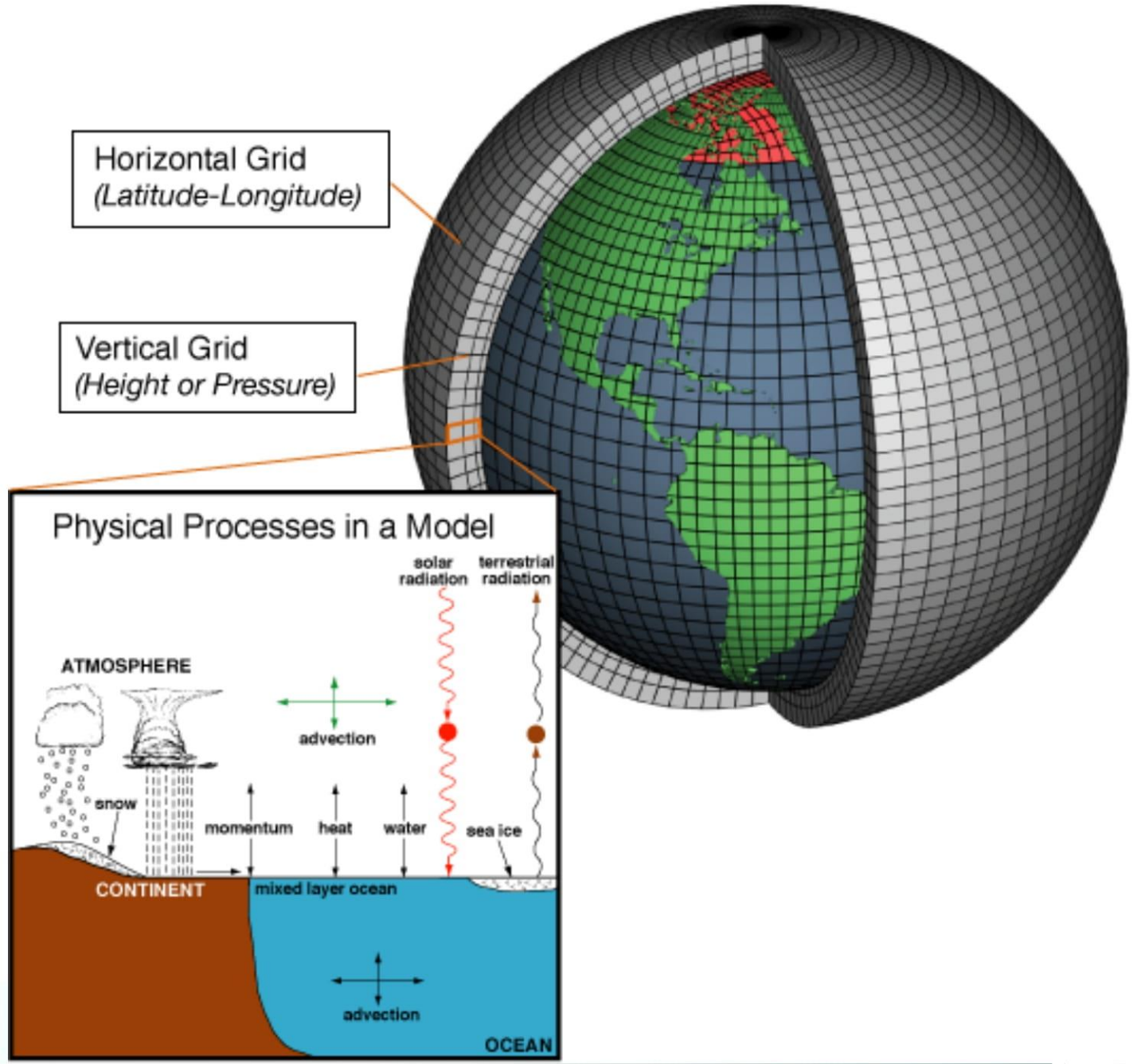
Horizontal Grid
(Latitude-Longitude)
Vertical Grid
(Height or Pressure)
Physical Processes in a Model
solar radiation
terrestrial radiation
ATMOSPHERE
advection
snow
momentum
heat
water
sea ice
CONTINENT
mixed layer ocean
advection
OCEAN

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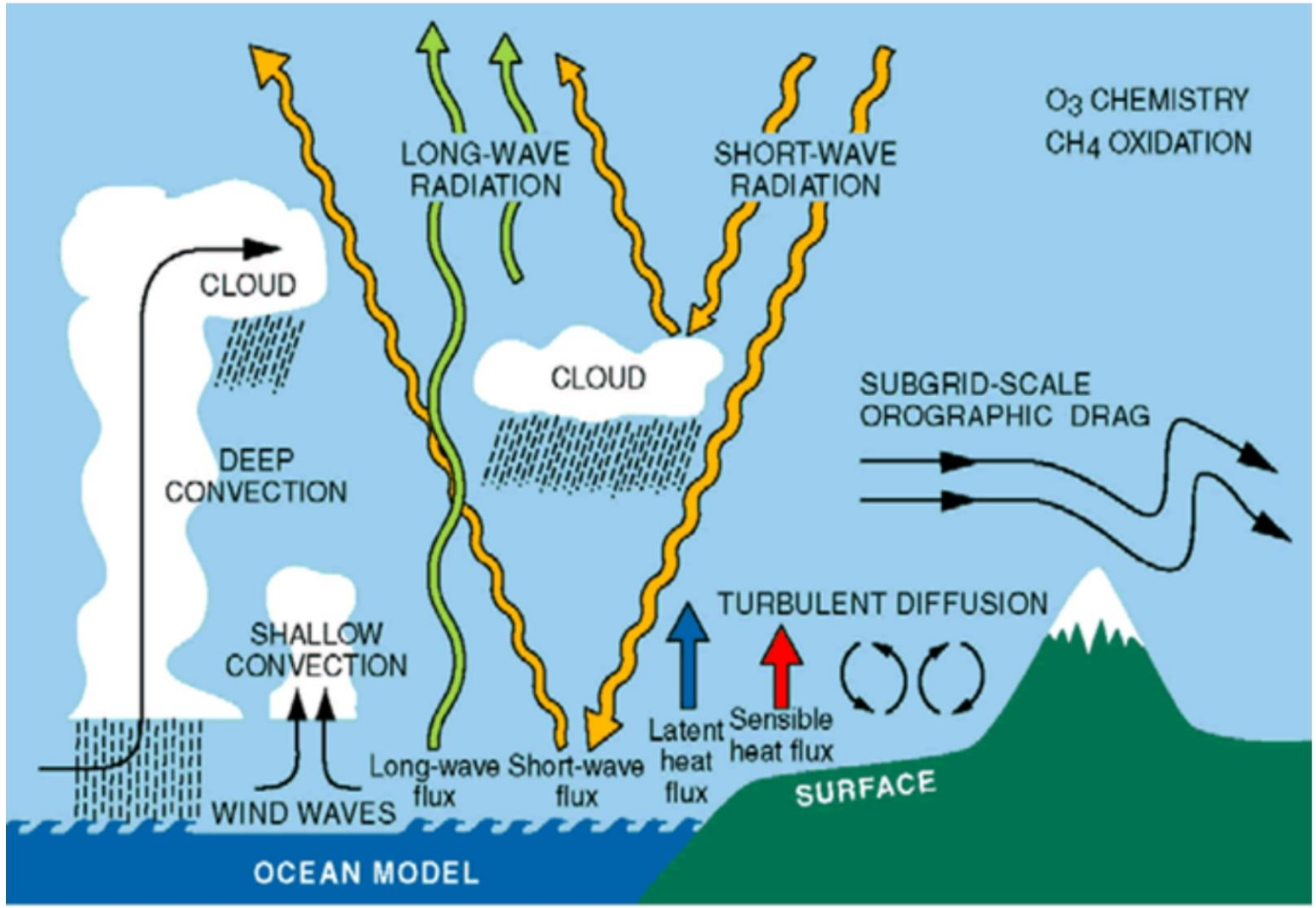
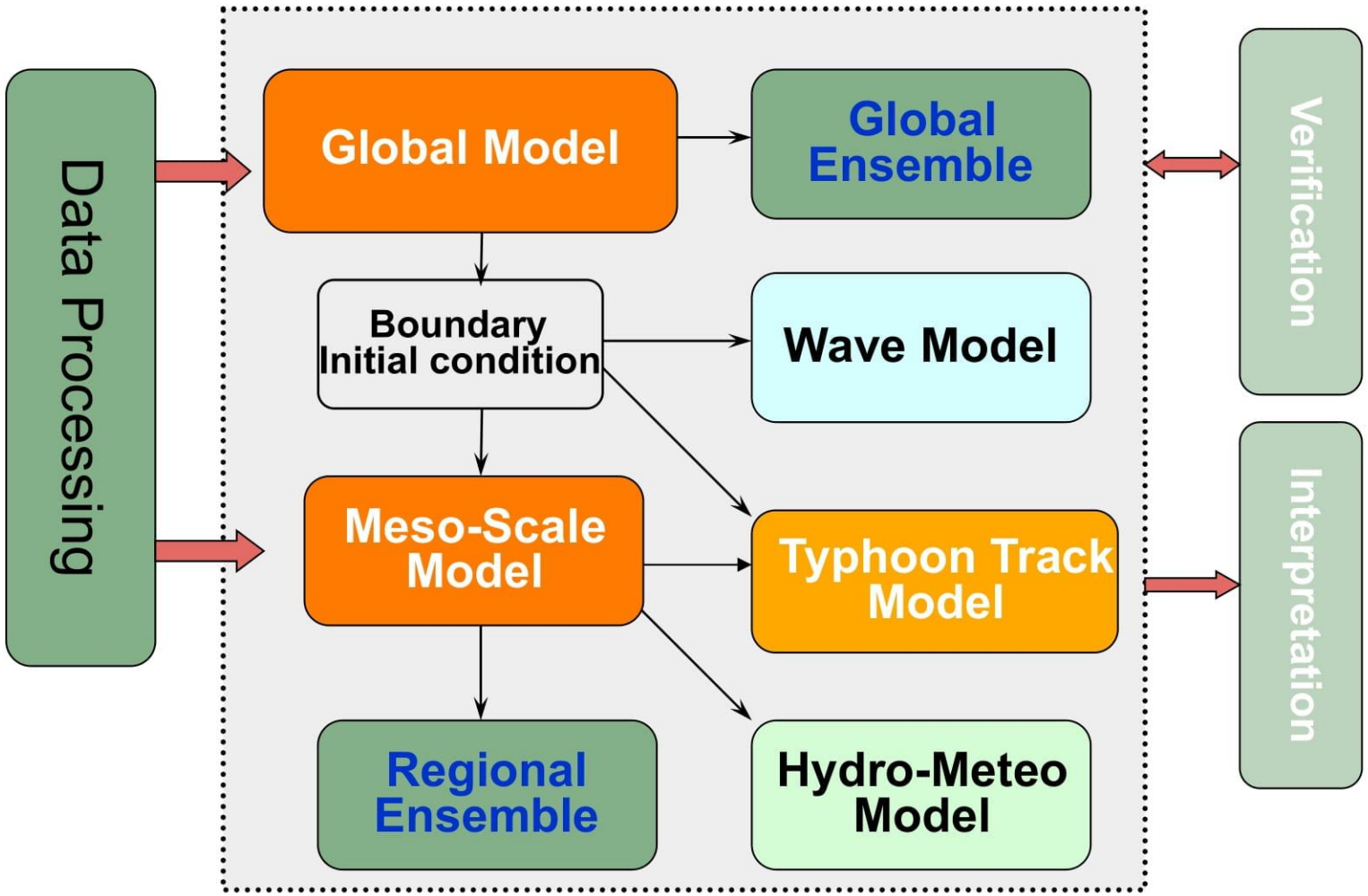
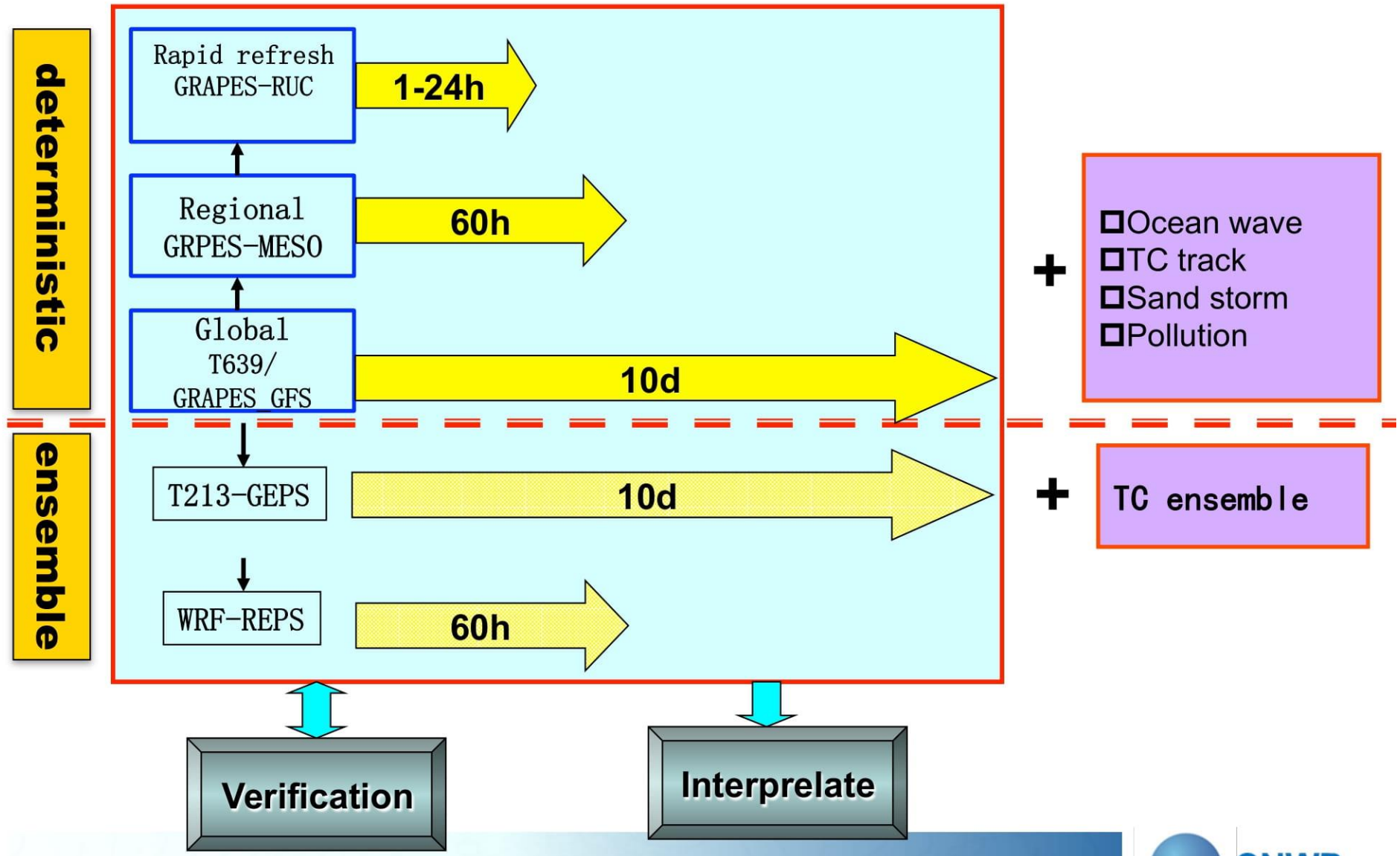

LONG-WAVE RADIATION
SHORT-WAVE RADIATION
O_3 CHEMISTRY
CH_4 OXIDATION
CLOUD
CLOUD
DEEP CONVECTION
SUBGRID-SCALE OROGRAPHIC DRAG
TURBULENT DIFFUSION
SHALLOW CONVECTION
Latent heat flux
Sensible heat flux
Long-wave flux
Short-wave flux
WIND WAVES
SURFACE
OCEAN MODEL

Structure of NWP Systems



NWP systems in CMA



Operational NWP Systems in CMA

- **Basic Operational Systems：(operational date)**
  - Global -3DVAR & Global Medium Range Forecast System（T639L60, 3DVAR,2008.5，ATOVS>30%）
  - Meso-scale Forecast System（GRAPES-MESO v3.0 2010.6）
  - Regional Rapid Analysis and Forecast System (GRAPES_RAFS,2010.5)
  - Global Ensemble Prediction System（T213L31-GEPS, 60km，2006.12）
  - Regional Ensemble Prediction System (WRF-REPS,15km,2011.5)
  - Global Typhoon Track Prediction System（T213-GTTP, 2006.1）
  - Regional Typhoon wind-rain prediction system (GRAPES_TYM,2012.7)
  - Numerical Model Verification System（198x,199x）
  - Numerical Model Operation Support System（SMS，2006.1,MARS, 2009)

- **Basic Environment Prediction Systems：**
  - Global/Regional/EPS Wave Forecast System（NMC-WAV,2005.8）
  - Regional Dust-Storm Prediction System（MM5/GRAPES,2006.12)
  - pollution transport and dispersion system （T213/WRF-HYSPLIT4,2001.9, 2008.4）
  - UVI prediction System （T213-SUV，2004.6）
  - Forest-Fire Alert System（T213-FIRE,2004.6)
  - Weather Modification Supporting System (GRAPES,2007)

Current major operational NWP systems

	Global Spectral Model (T_L639L60)	Meso Scale Model (GRAPES_Meso)	10day Ensemble (T213L31)	Typhoon deterministic & Ensemble forecast
Forecast range	Medium-range (10day)	Rainfall forecast Short-range forecast	10day forecast	Typhoon forecast
Forecast domain	Global	East Asia (8340km x 5480km)	Global	
Horizontal resolution	T_L639(0.28125 deg)	15km	T213(0.5625 deg)	
Vertical levels / Top	60 0.1 hPa	31 10hPa	31 10 hPa	
Forecast Hours (Initial time)	240 hours (00, 12 UTC) 84 hours (06, 18UTC)	72 hours (00, 12UTC)	240 hours (00、12 UTC) 15 members	120 hours (00, 06, 12, 18 UTC) 120 hours (00、12 UTC) 15 members
Initial Condition	Global Analysis (NCEP GSI)	GRAPES 3DVAR	NCEP SSI + Vortex relocation and Intensity adjustment with ensemble perturbations Perturbations are produced by Breeding-method	

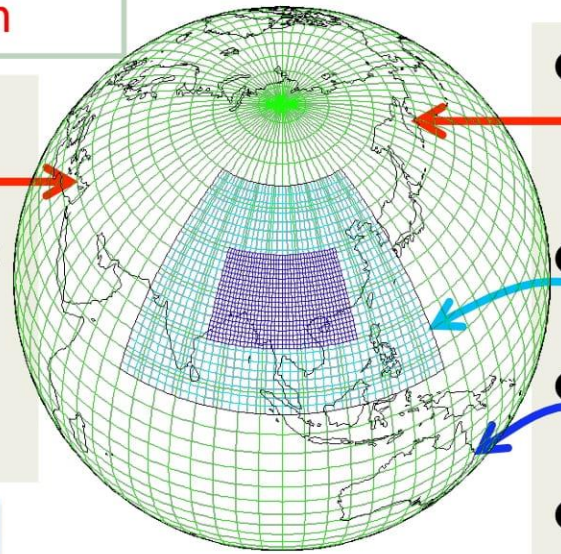
Current Operational NWP System

Introduced spectral model

Main production system

- GLB 10-day deterministic:
  - T639L60
- Global ensemble forecast:
  - T213L31
- Global Typhoon forecast:
  - T213L31

Data assimilation: GSI



CMA-developed GRAPES

- GLB 10-day deterministic:
  - GRAPES_GFS 50km

  Parallel run vs. T639
- Meso-scale :
  - GRAPES_Meso 15km
- WP Typhoon forecast:
  - GRAPES_TYM 15km
- Rapid update:
  - GRAPES_RAFS 15km

Data assimilation: GRAPES_3DVAR

Thanks ECMWF & NCEP !

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T639 — CMA's GFS

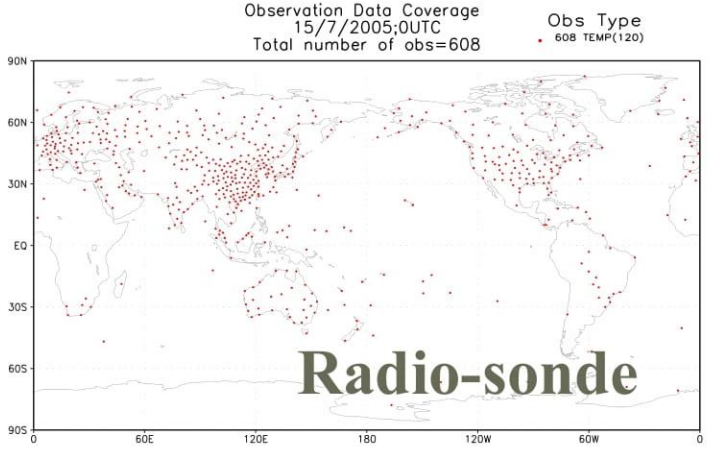
- Forecasting of large-scale circulation situation for 1 to 10 days ahead, such as large-scale rainfall , upper trough, Subtropical high pressure, surface high- and low- pressure, cold and warm frontal, large area of rain etc.
- Provide 3hr interval forecasting products to 120hrs
- Provide most products according to the requirement of forecasting and serving
- Provide products for driving meso/regional model in NWPC and 8 regional meteorological centers of CMA
- Provide products for driving environment prediction systems in NWPC
  - → Global Wave (NCEP WAVEWATCH Ⅲ)
  - → Nuclear Pollution transport and dispersion model system(HYSPLIT4)
  - → Regional Dust-Storm Prediction System
  - → UV-I ,Forest fire-Alert etc. special systems

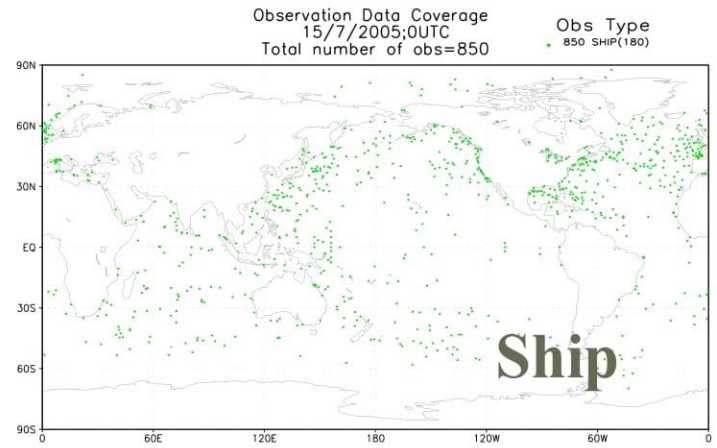
DA

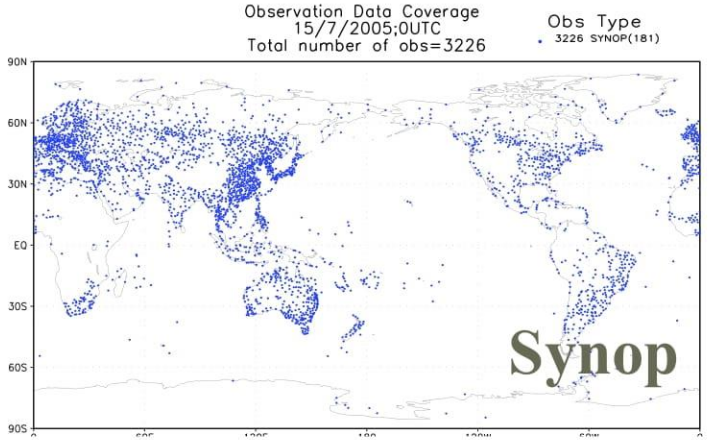
- NCEP-GSI
- Background error tuning
- NOAA 15/16/18 ATOVS 1b data

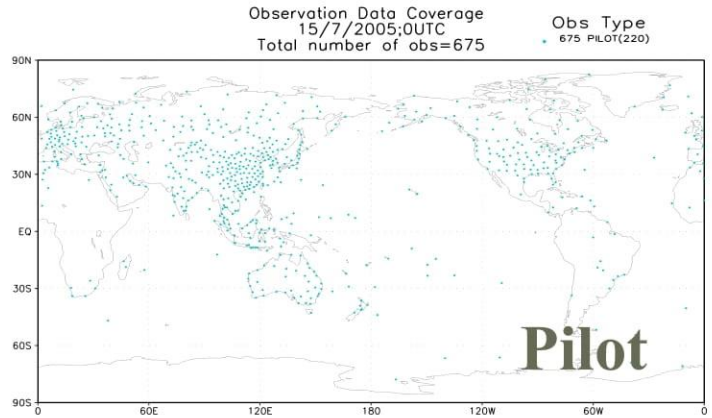
Model

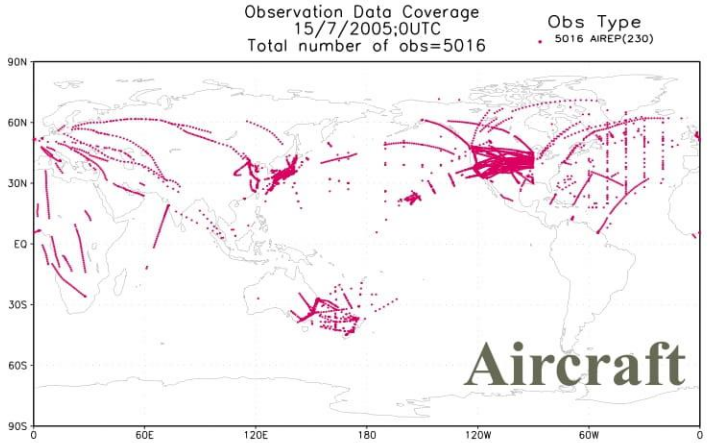
- triangular truncation, resolving 639 waves around a great circle on the globe;60 levels (up to 0.1 hPa).
- Semi-lagrangian, semi-implicit temporal integration, time step 10minutes.
- use of a reduced Gaussian grid.
- Hydrostatic.
- Forth order linear horizontal diffusion
- Full physics package











Conventional observations

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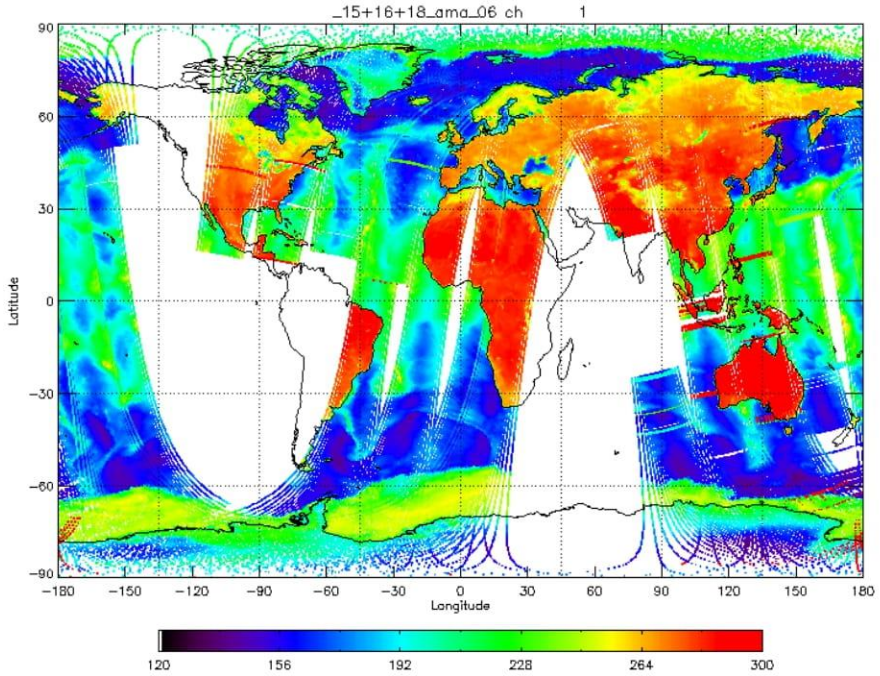
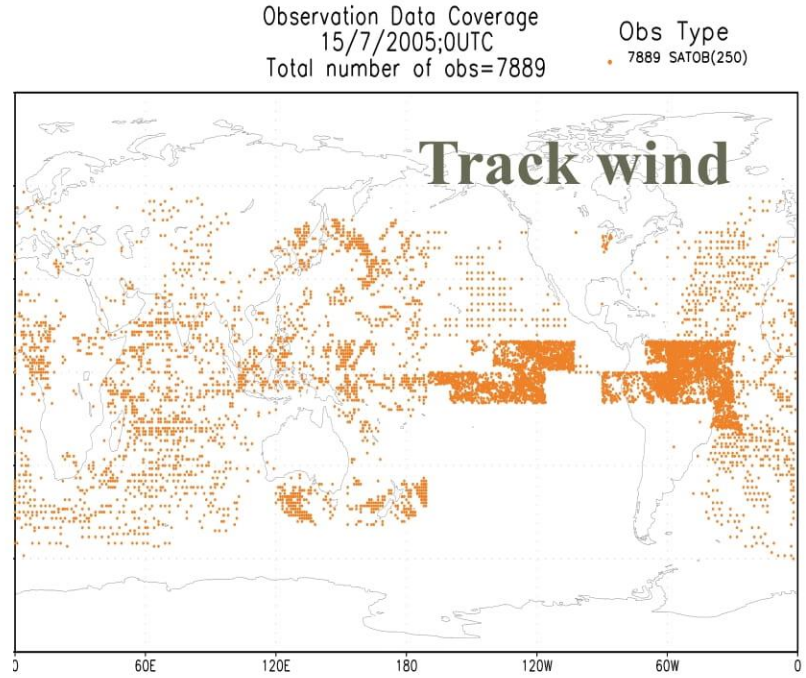
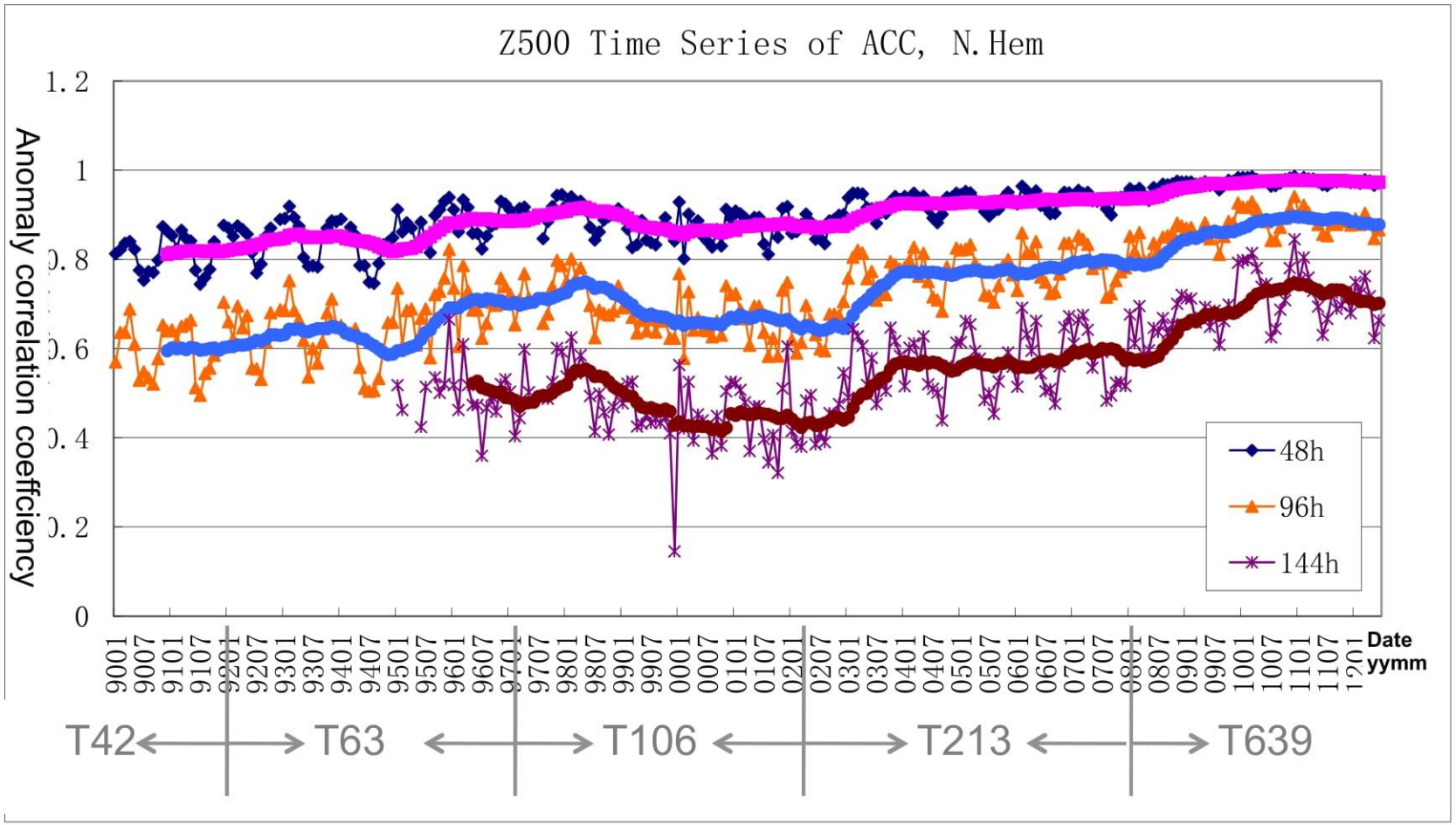
AMSU-A n15,16,18





Performance of NWP in history: Global Model



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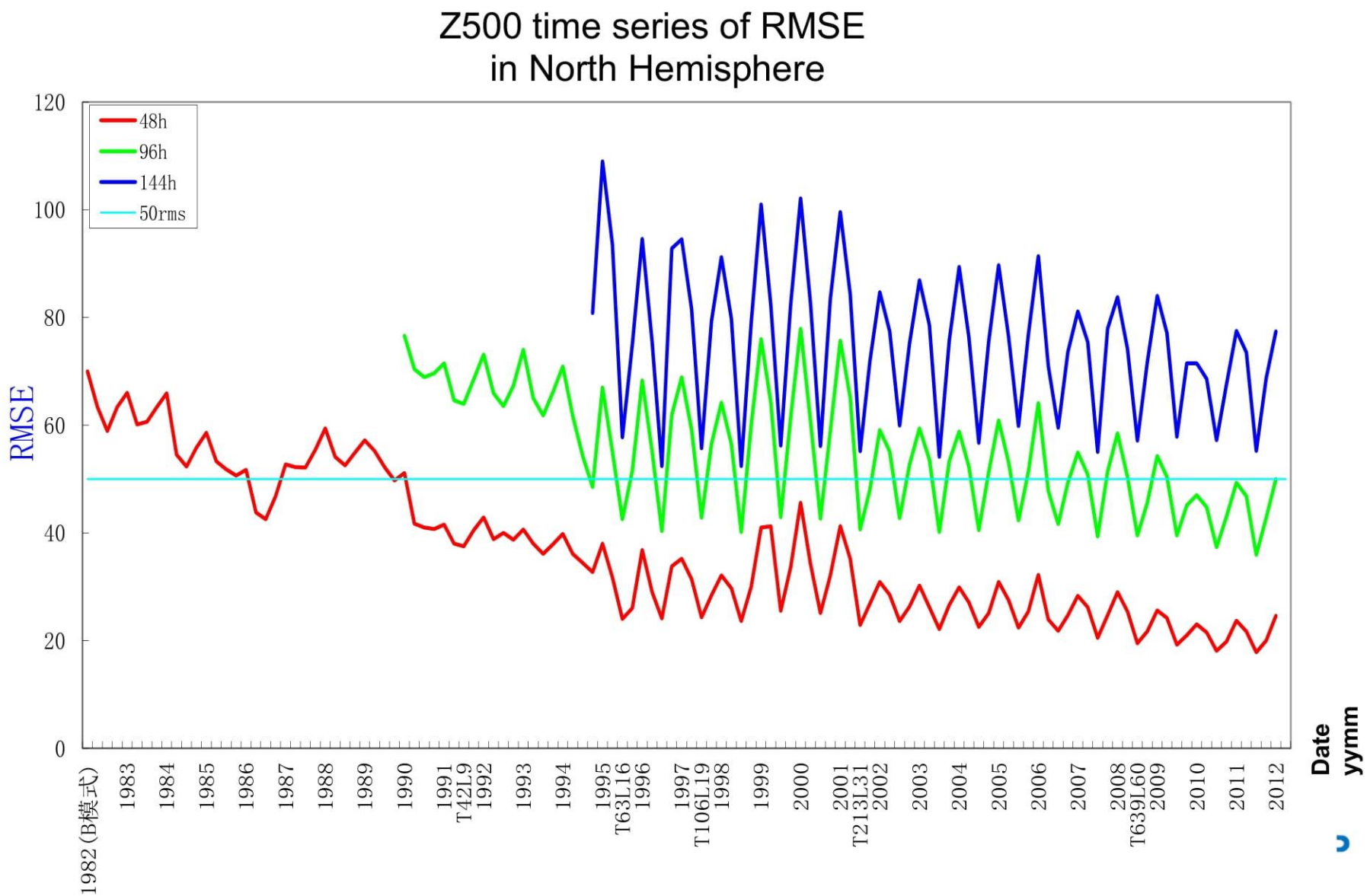
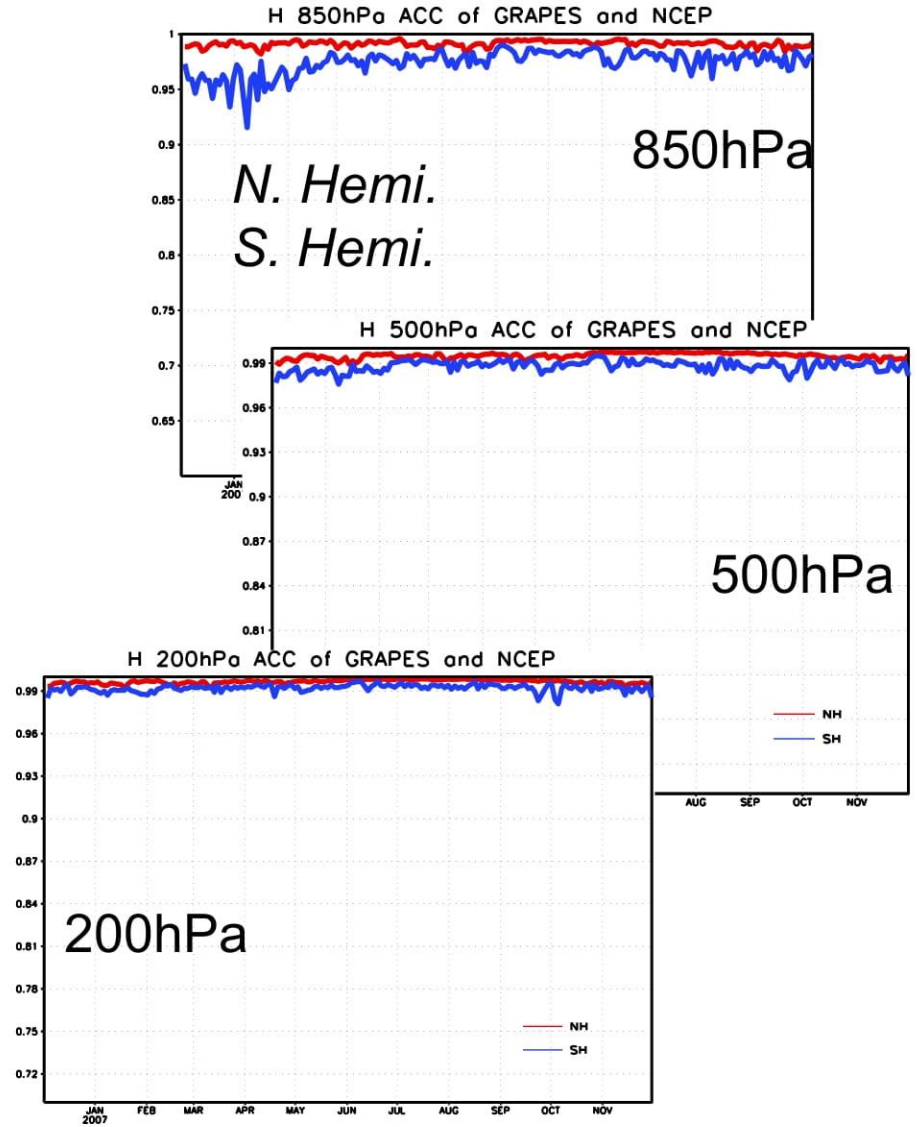
Performance of NWP in history: Global model



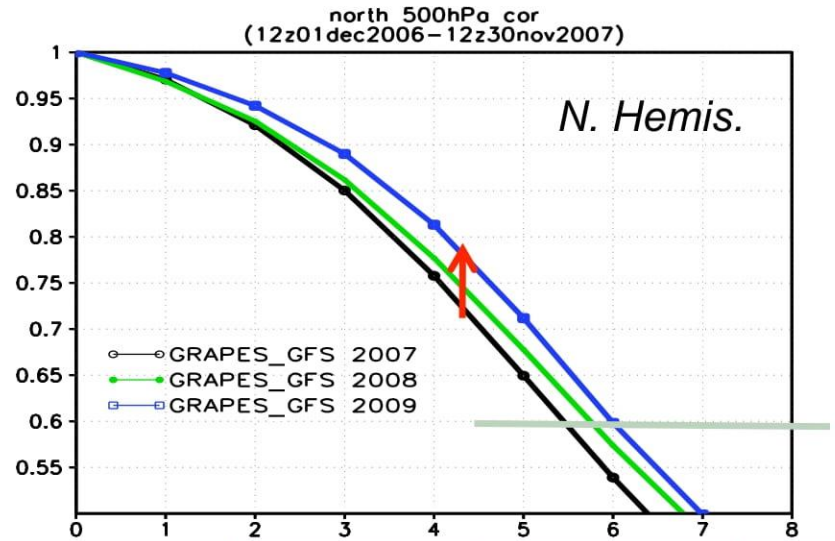
GRAPES_GFS

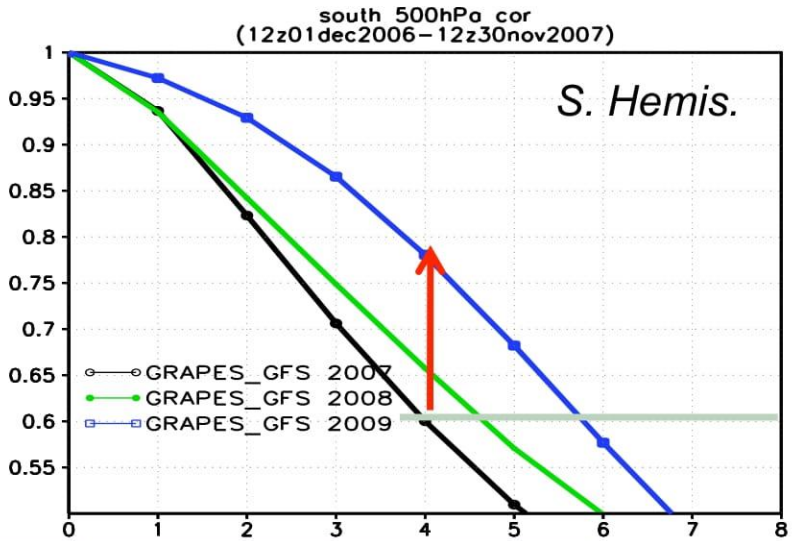
- **GRAPES_Global**
  - ➔ ***0.5x0.5 Degree***
  - ➔ ***L36 with model top at 10hPa***
  - ➔ ***240 hour forecast***
- **GRAPES_3DVAR**
  - ➔ ***1.125x1.125 degree***
  - ➔ ***6-hourly cycle***
  - ➔ ***Assimilated Obs.***
    - *GTS conventional data*
    - *NOAA15、16、17、18、19*
    - *FY-3 radiance*
    - *METEOSAT-9 & MTSAT AMV*
    - *MODIS polar AMV*
    - *COSMIC Refraction*



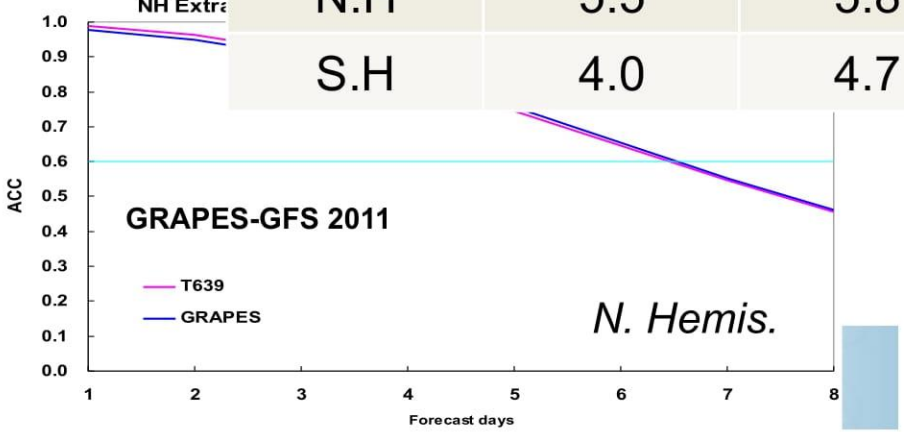
Comparison between GRAPES and NCEP analysis

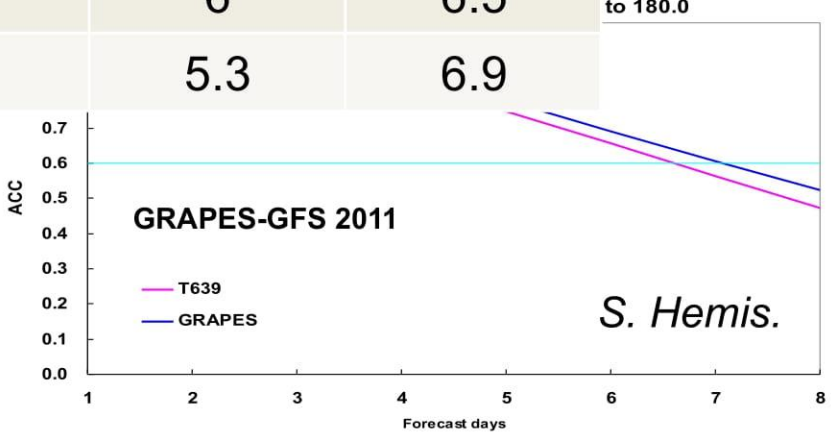
ACC (500 hPa HGT)

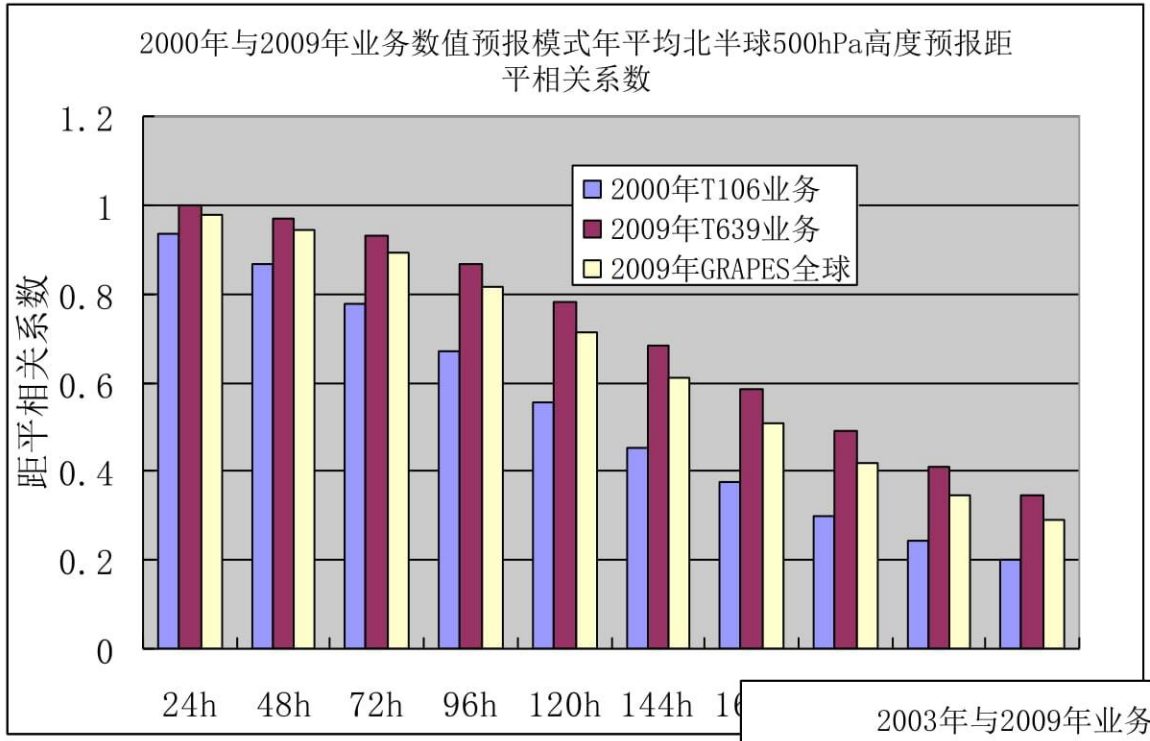




Exp. Year	2007	2008	2009	2011
N.H	5.5	5.8	6	6.5
S.H	4.0	4.7	5.3	6.9

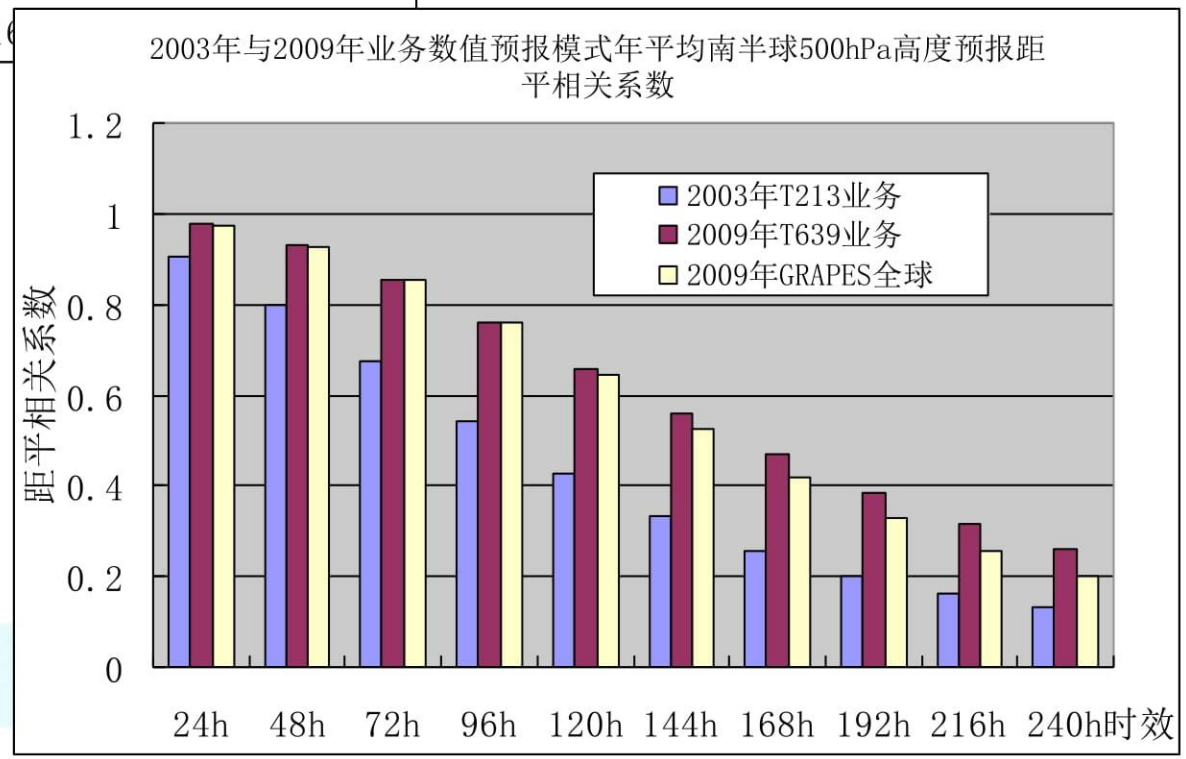




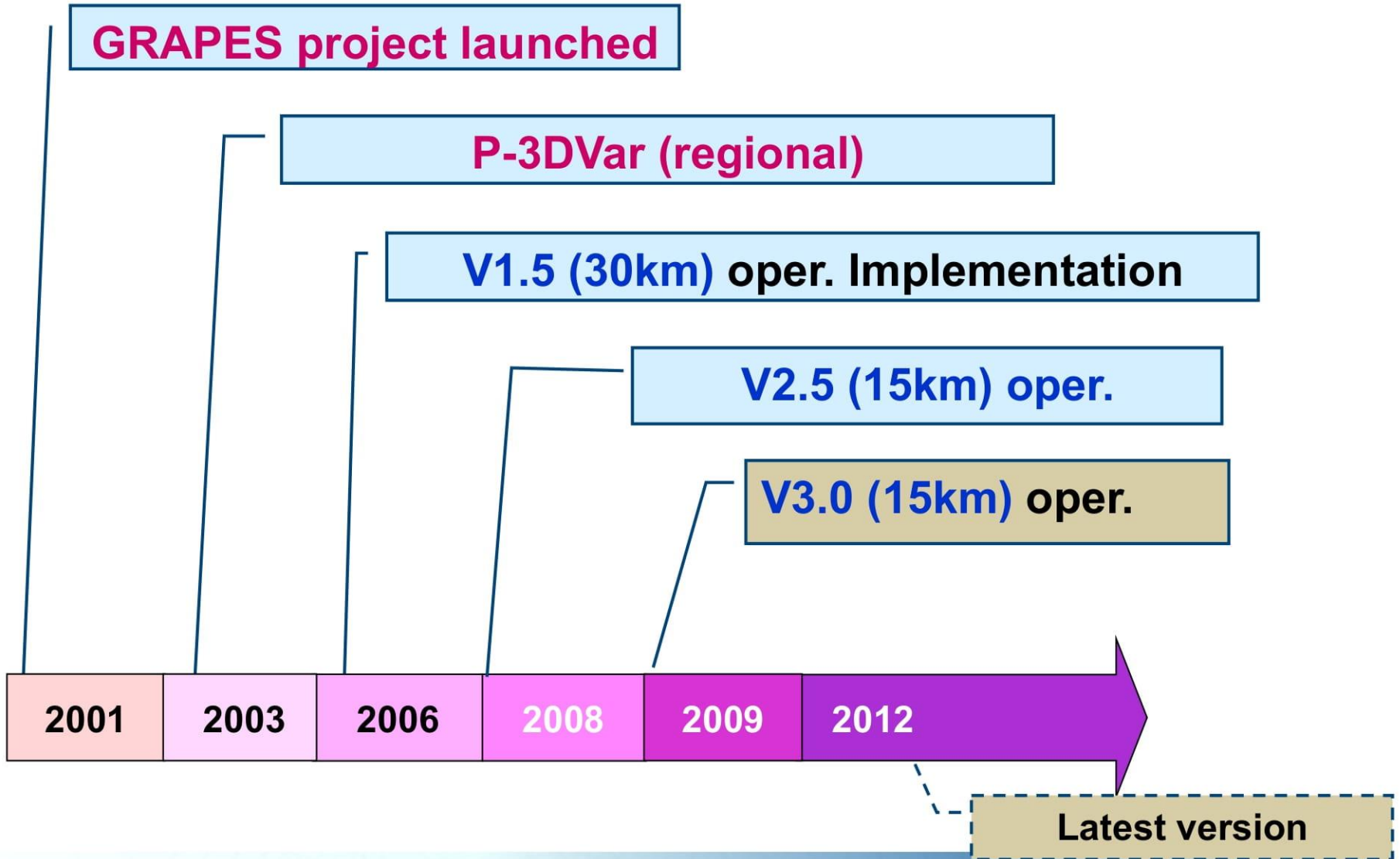


NH 500hPa ACC

SH 500hPa ACC

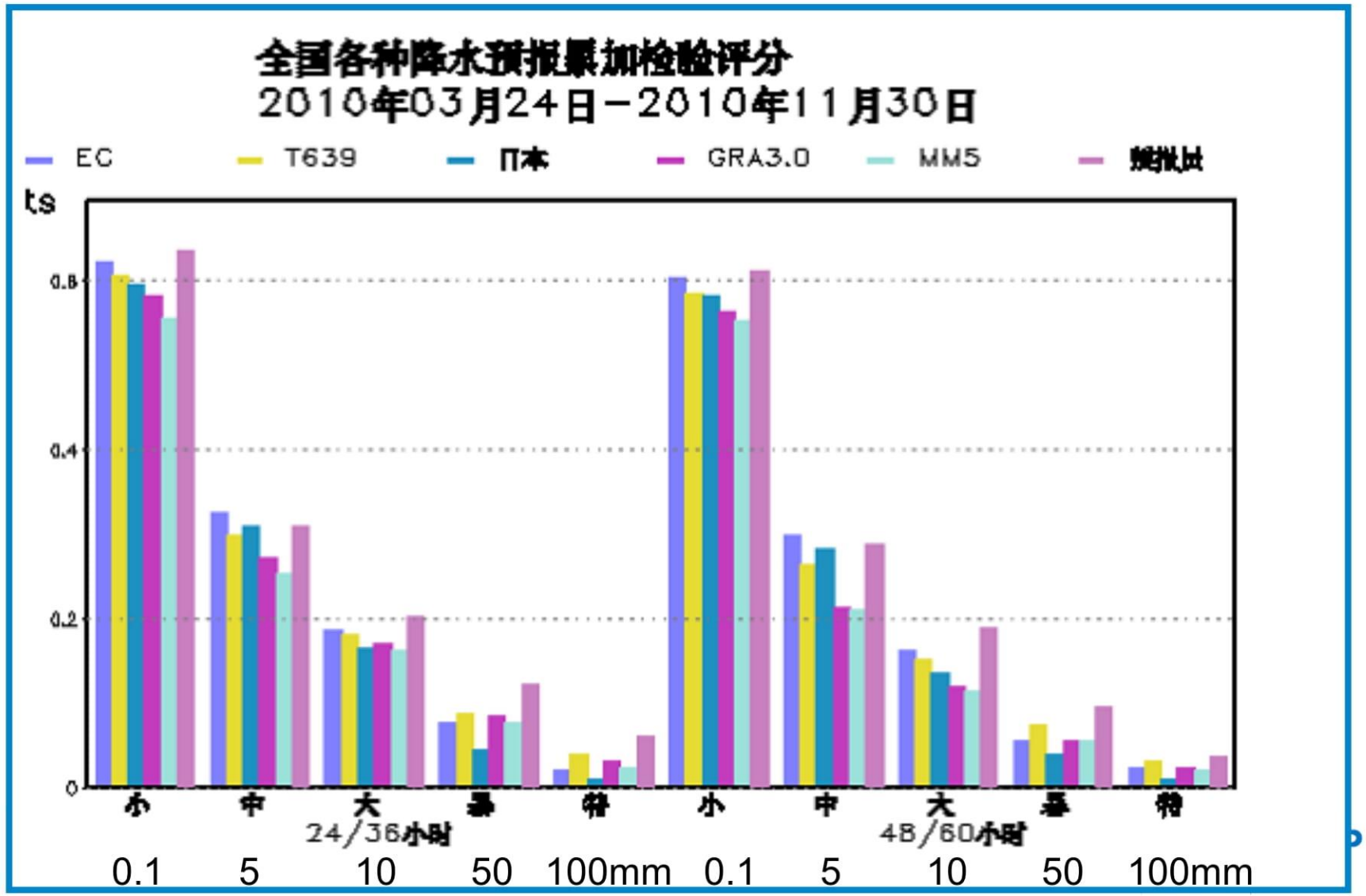


GRAPES_meso - regional prediction



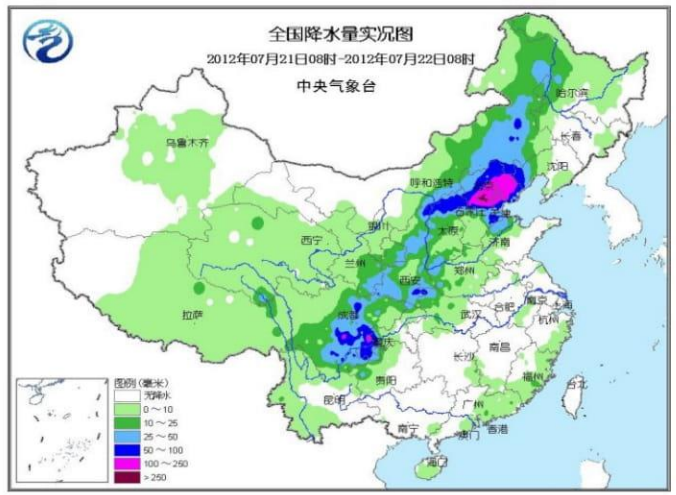
Precipitation forecast of GRAPES_Meso

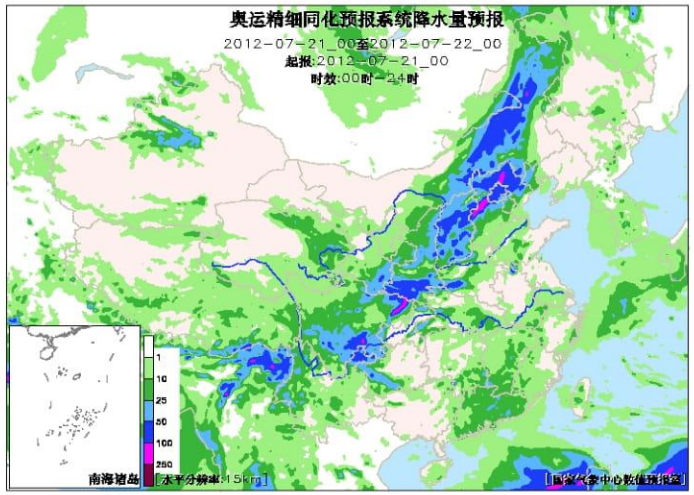
Threat Score



HR GRAPES_meso

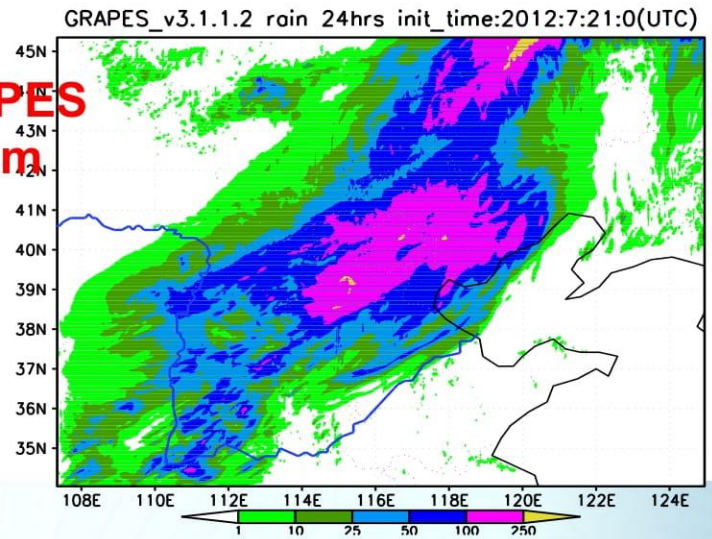
Obs

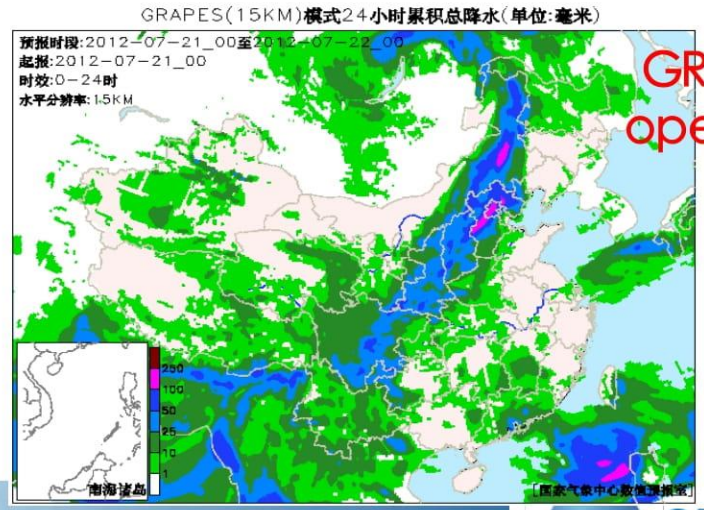




WRF

GRAPES
-3km





GRAPES-
operation

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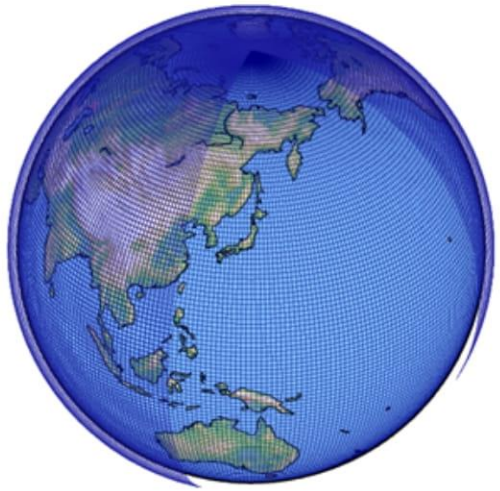
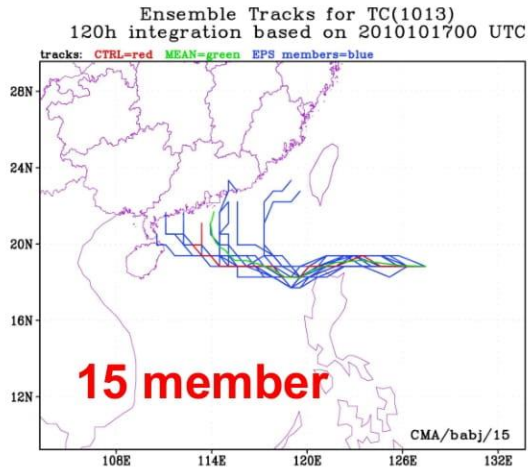
TC prediction system - History

Date	Model	resolution	Data assimilation	Votex initialization	Forecasting length
1996	Regional grid	50KM/L16 **IC/ BC (T106L19)**	no	BOGUS Symmetric	48h
2002	Regional grid	50KM/L16 **IC/ BC (T213L31)**	no	BOGUS Symmetric	48h
2004	Global spectral (GMTTP)	T213L31	OI	BOGUS asymmetry	120h
2006	Global spectral (GMTTP)	T213L31	3DVAR	BOGUS+ Relocation+ intensity modification	120h

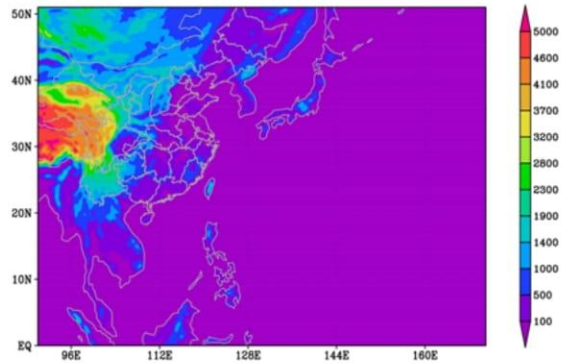
TC prediction



2006
GMTTP-T213L31
FT=120h
(00,06,12,18UTC)



2007
TC-EPS:T213L31
FT=120h (00,12UTC)



2011
GRAPES_TYM(0.15/31/
NMC)

2006
GRAPES_TCM (0.15/31/STI)

2006
GRAPES-TMM (0.36/31/
GZH)

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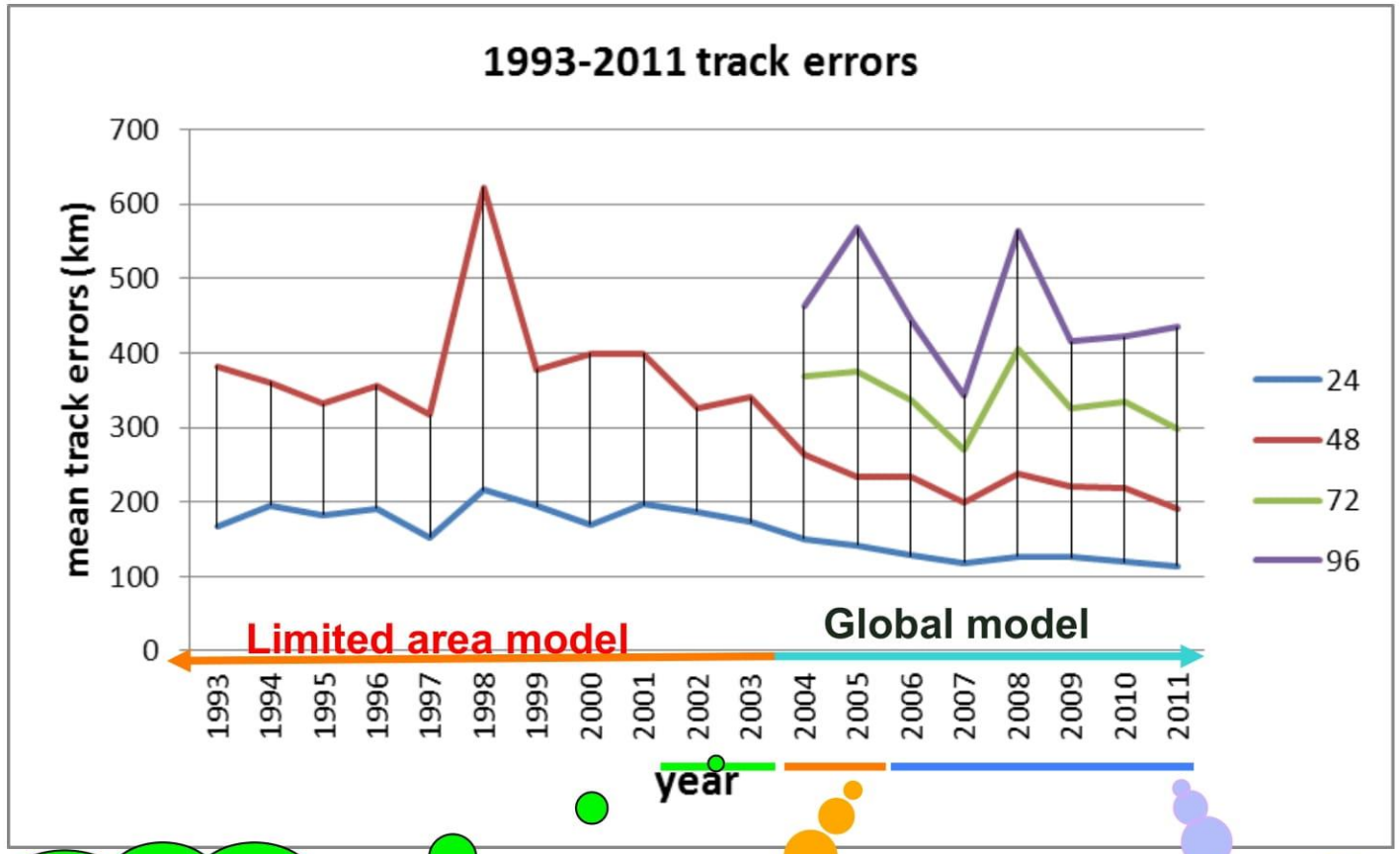
Performance of NWP in history: Typhoon track



Upgrading initial and Boundary condition

Global model and asymmetric vortex

3DVAR and new vortex initialization scheme

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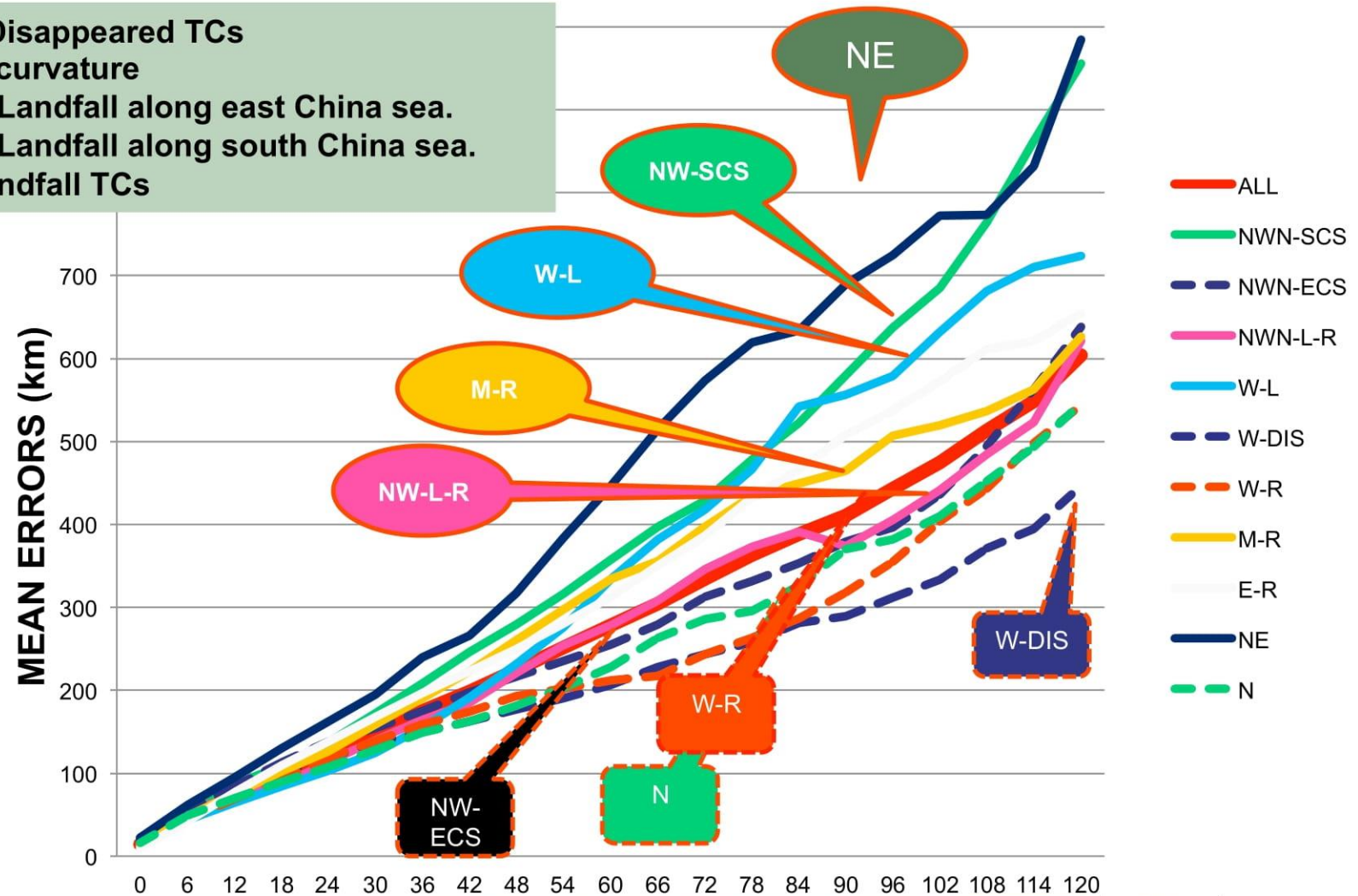
Mean track errors for different types of TC

-DIS: Disappeared TCs
-R: Recurvature
-ECS: Landfall along east China sea.
-SCS: Landfall along south China sea.
-L: Landfall TCs



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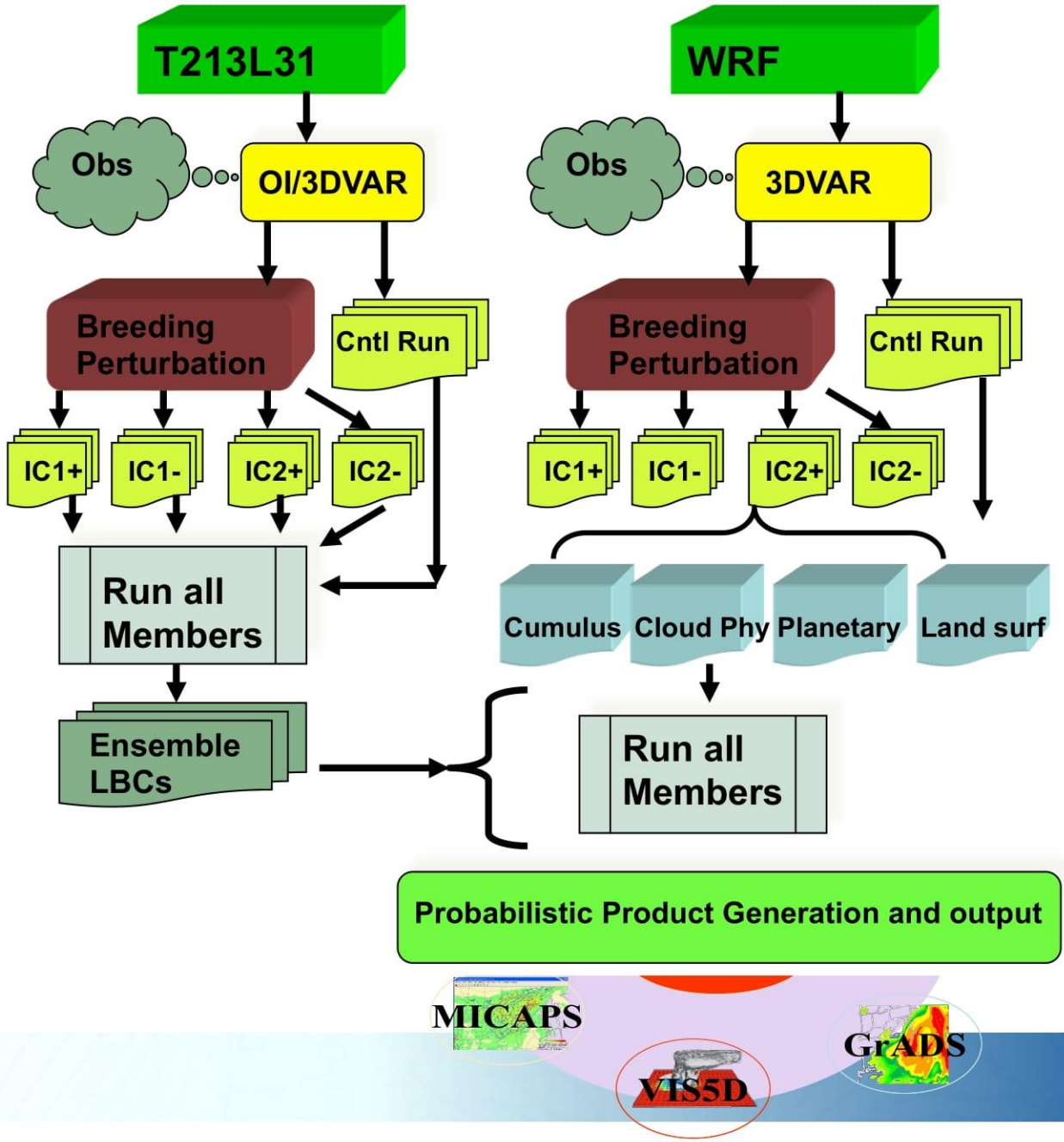
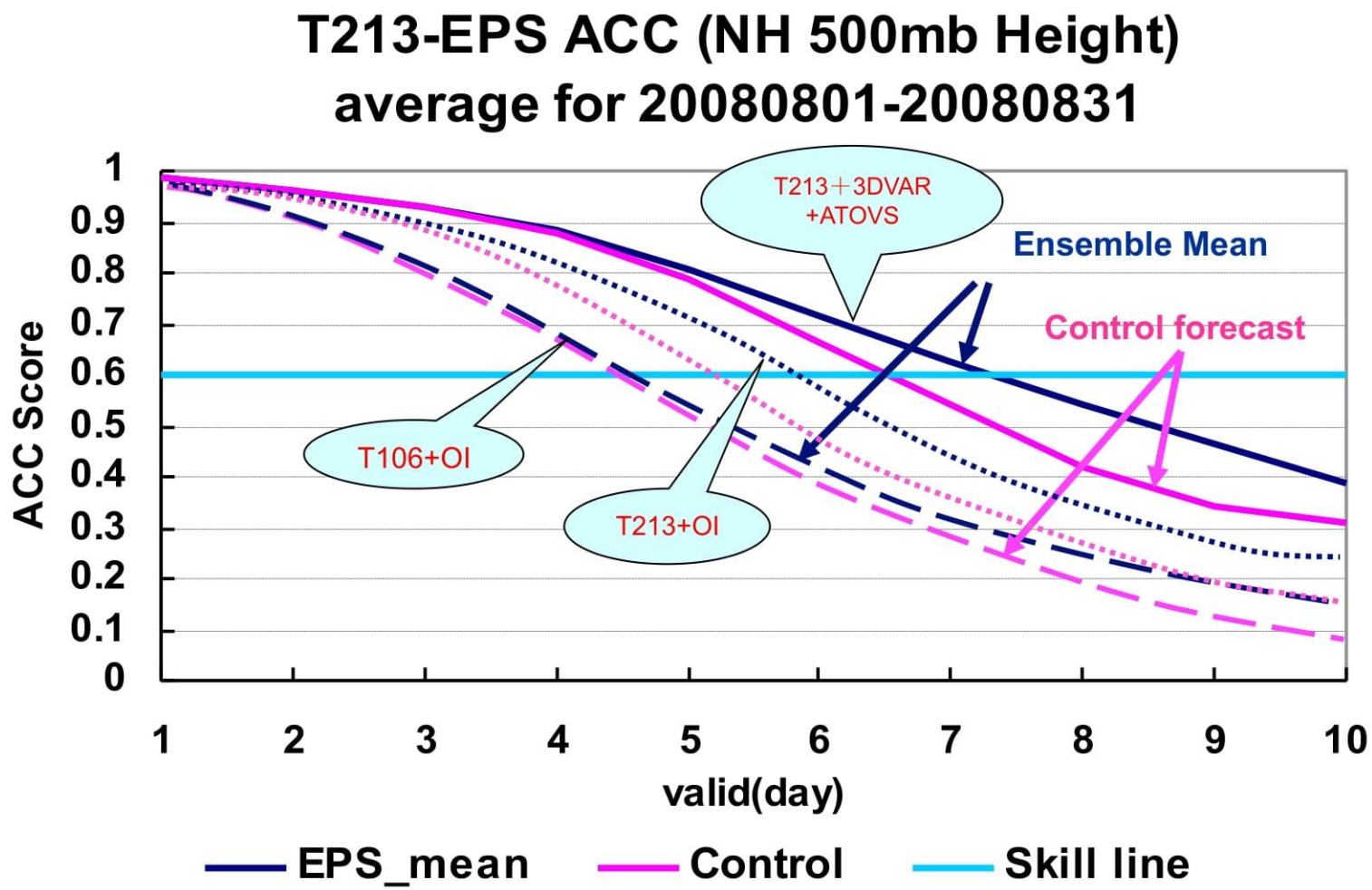
EPS - History

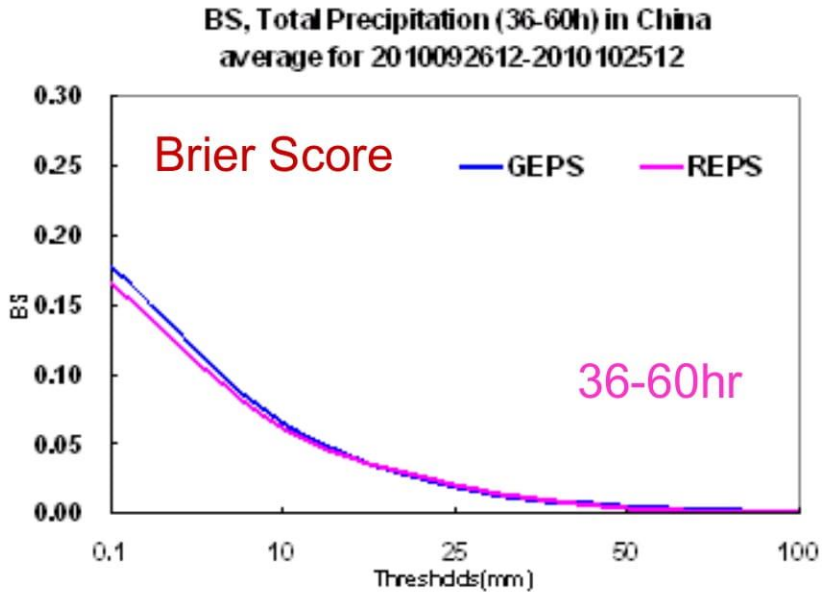
- Jun. 1998 : Researches on T106L19 GEPS
- Feb. 1999: T106L19 GEPS operational test
- Mar. 2001: T106L19 GEPS implementation
- Dec. 2005: T213L31 GEPS operational test
- Dec. 2006: T213L31 GEPS implementation
- Jun. 2007: T213L31 Typhoon Track EPS test
- May.2008: T213L31 Typhoon Track EPS implementation

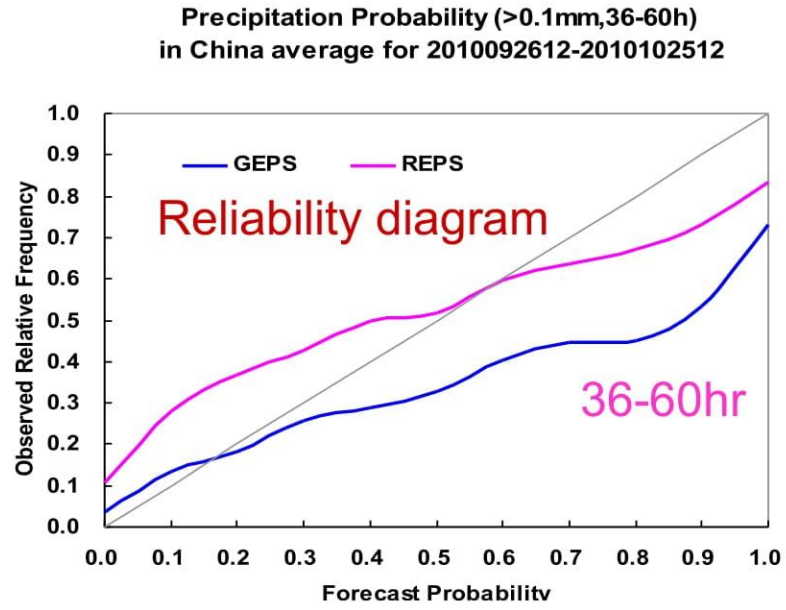

T213L31
Obs
OI/3DVAR
Breeding Perturbation
Cntl Run
IC1+
IC1-
IC2+
IC2-
Run all Members
Ensemble LBCs
WRF
Obs
3DVAR
Breeding Perturbation
Cntl Run
IC1+
IC1-
IC2+
IC2-
Cumulus
Cloud Phy
Planetary
Land surf
Run all Members
Probabilistic Product Generation and output
MICAPS
VIS5D
GrADS
CNWP

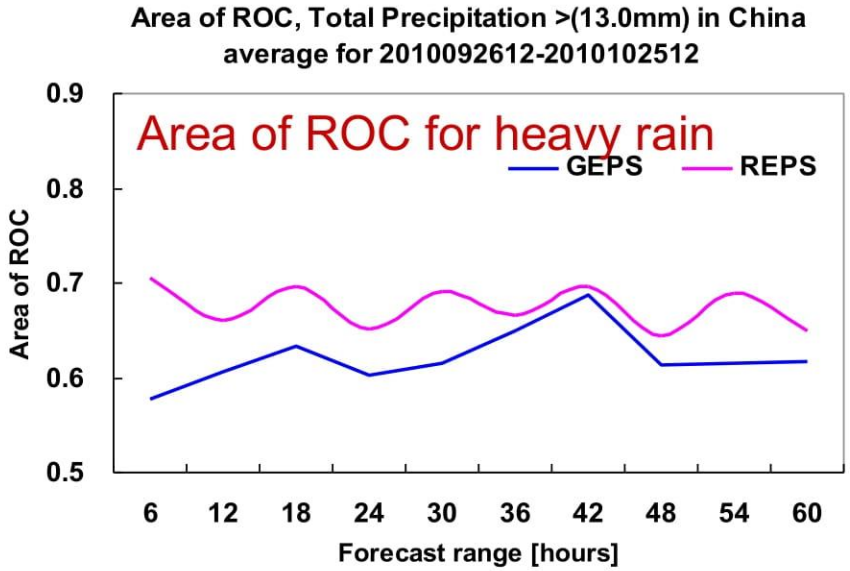
Performance of NWP in history : Global EPS

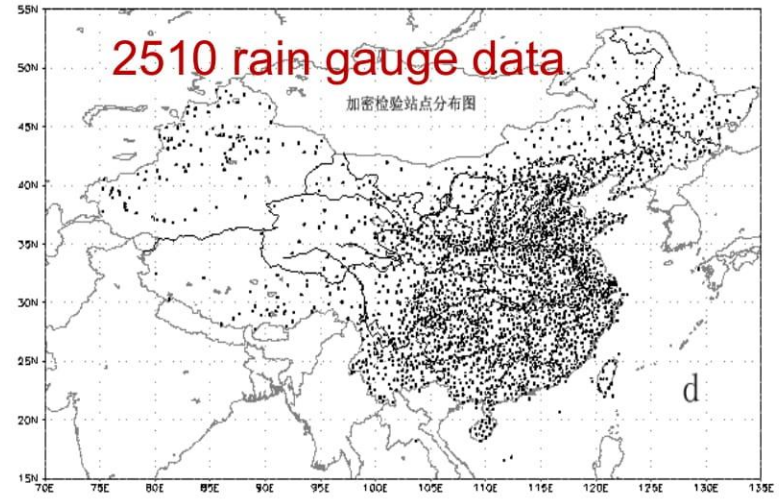


Comparison of GEPS and REPS for precipitation



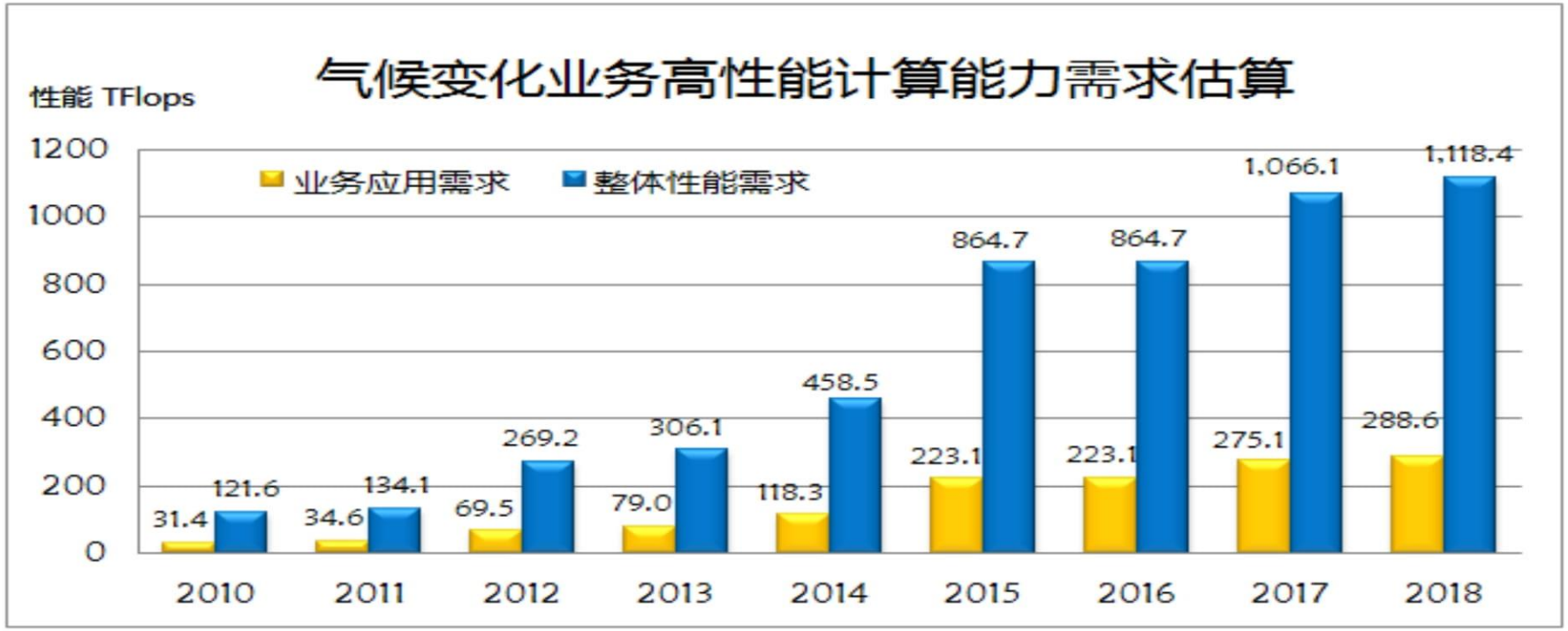






CNWP

CMA supercomputer and future update plan



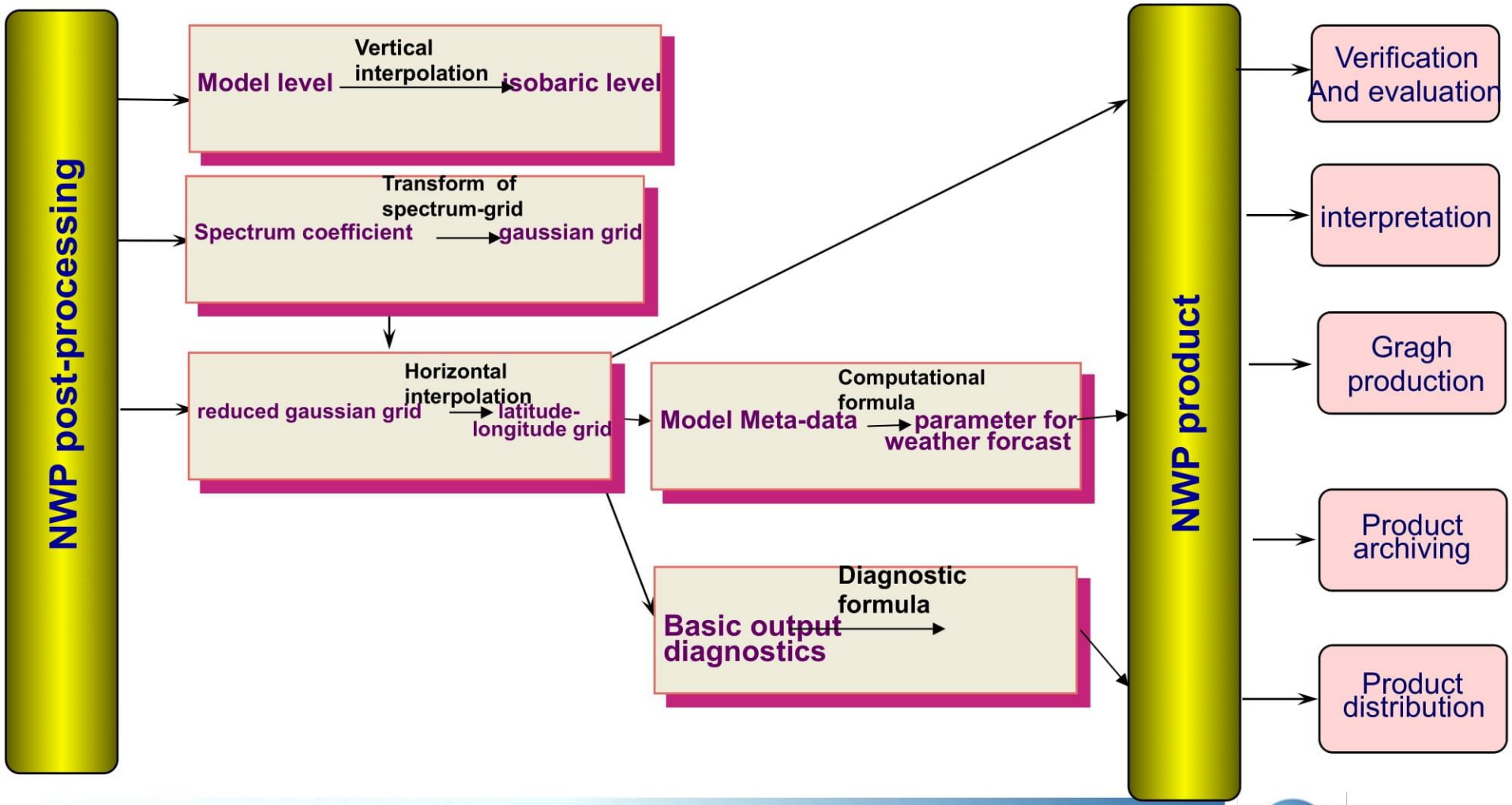
2012: (imported machine, peak-300TFlops , storage 1PB , sustained speed 15TFlops)

2014 (domestic made, peak-800TFlops , storage 2PB , sustained speed 50TFlops)

CONTENTS

- Overview NWPC
- Operational NWP systems
- Products and service
- Suggestion for using NWP products

NWP post-processing and product (e.g.T639)

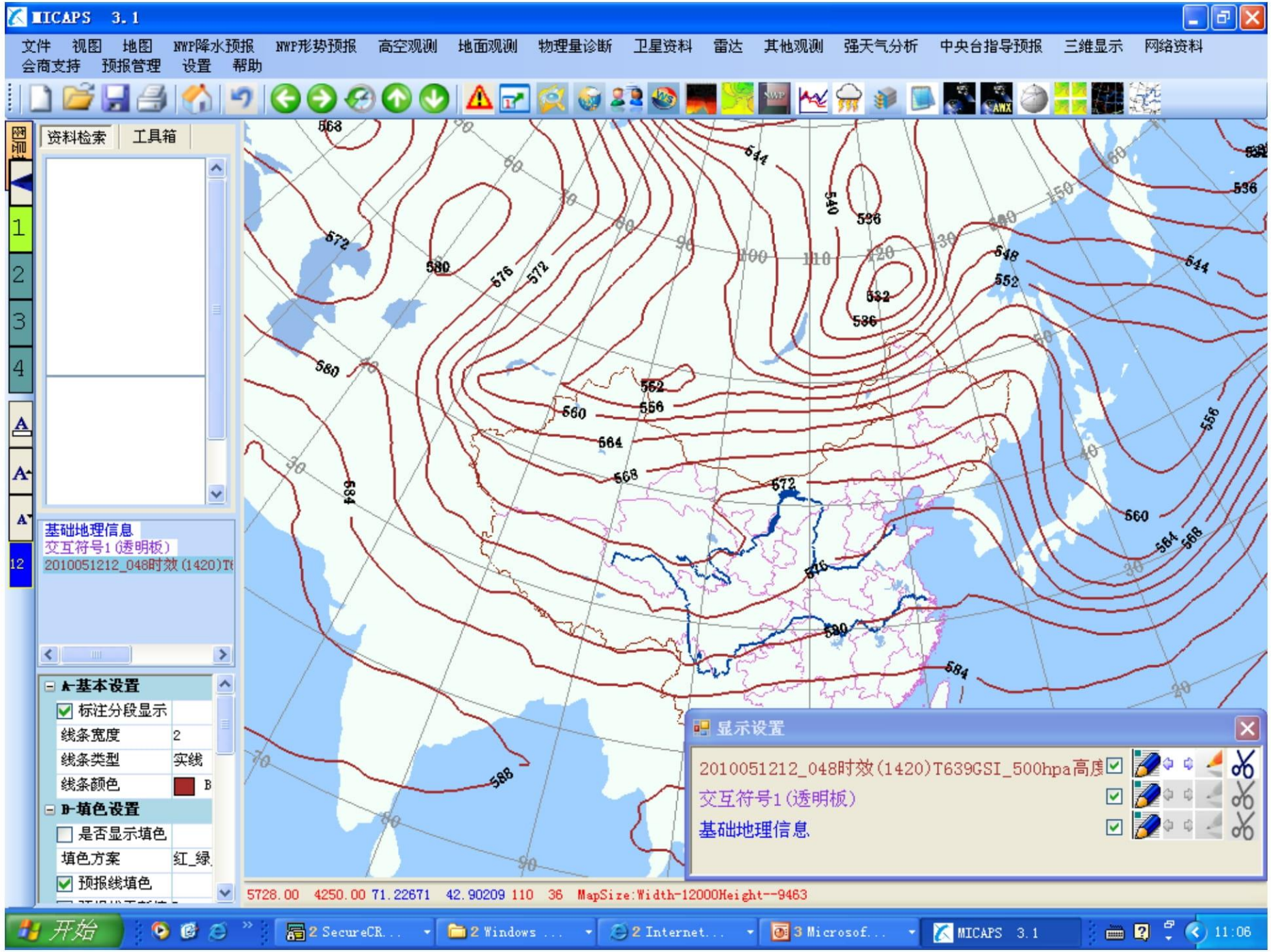


MICAPS Products of T639 GFS

Run 4 times per day

Run T+240 hr forecast at 00 and 12UTC
Run T+084 hr forecast at 06 and 18 UTC

element	level	Valid time	acquisition
H,T,W,Vor,Div,RH,Td,U,V	10,20,30,50,70,100, 150,200,250,300, 400,500,600,700, 850,925,1000 (17levs)	T+120hr VT: 3hrs interval T+120~168 VT: 6hrs interval T+168-240 VT: 12hrs interval	DMO(directly model output)
T_adv,Vor_adv	200,500, 700,850,925,1000		Processed
T-Td,Q_flux,MPV,Qflux_div,PTE	500,700,850,925		Processed
Elements after bias correction: H_500,T_850,U_850,V_850			Processed
Accumulated total precipitation: 3-hour,6-hour,12-hour,24-hour			Processed
Accumulated convective precipitation: 3-hour,6-hour,12-hour,24-hour			Processed
Accumulated snow fall: 3,6,12,24-hour			Processed
10m Wind field, K-index, 10m stream field			Processed
Slp,2T,2RH,Snowdepth,Totalcloud, 4layers soil humidity etc. total over 40 variables			DMO
anomaly of 10-day accumulated Precipitation, Days of ten-day forecast that 3-continuous day daily maximum temperature >35 degree;37 degree;40 degree, respectively. Minimum temperature			Processed


MICAPS 3.1
文件 视图 地图 NWP降水预报 NWP形势预报 高空观测 地面观测 物理量诊断 卫星资料 雷达 其他观测 强天气分析 中央台指导预报 三维显示 网络资料
会商支持 预报管理 设置 帮助
资料检索 工具箱
基础地理信息
交互符号1(透明板)
2010051212_048时效(1420)T
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线条类型 实线
线条颜色
B-填色设置
是否显示填色
填色方案 红_绿
预报线填色
显示设置
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交互符号1(透明板)
基础地理信息
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开始
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2 Windows ...
2 Internet...
3 Microsof...
MICAPS 3.1
11:06

Graphic products on web

area		Output time			Output time
North hemisphere	200hpa height	0, 12, 24, 36,48,60, 72,84,96, 108,120, 144,168, 192,216, 240	Eastern Asia（10N－60N, 60E－140E）	500hpa height＋850hpa wind	（000,003, 006,009,012,015,018,021,024,027, 030,033,036,039,042,045,048,051, 054,057,060,072,084,096,108,120, 132,144,156,168,192,216,240)
	850hpa temperature			850hpa relative humidity＋850hpa wind	
	200hpa specific humidity＋200hpa wind field			700hpa streamline	
	Sea level pressure			K-index	
Asia Europe(20E-170E, 0N-70N)	500hpa height＋slp	0, 6,12, 18,24, 30,36,42,48,54,60, 66,72,84,96,108,120, 132,144156,168,		700hpa、 850hpa relative humidity	
	500hpa height＋500hpa temperature			500hpa、 850hpa temperature advection	
	500hpa height＋850hpa wind			500hpa vorticity advection	
	700hpa specific humidity＋700hpa wind			500hpa、 850hpa vorticity	
	850hpa specific humidity＋850hpa wind			700hpa、850hpa Θse	
				700hpa、850hpa moisture flux	
	500hpa height＋slp			700hpa、850hpa moisture flux divergence	
	Sea level pressure			500、700、850hpavertical velocity	
	700hpa、 850hpa wind field				

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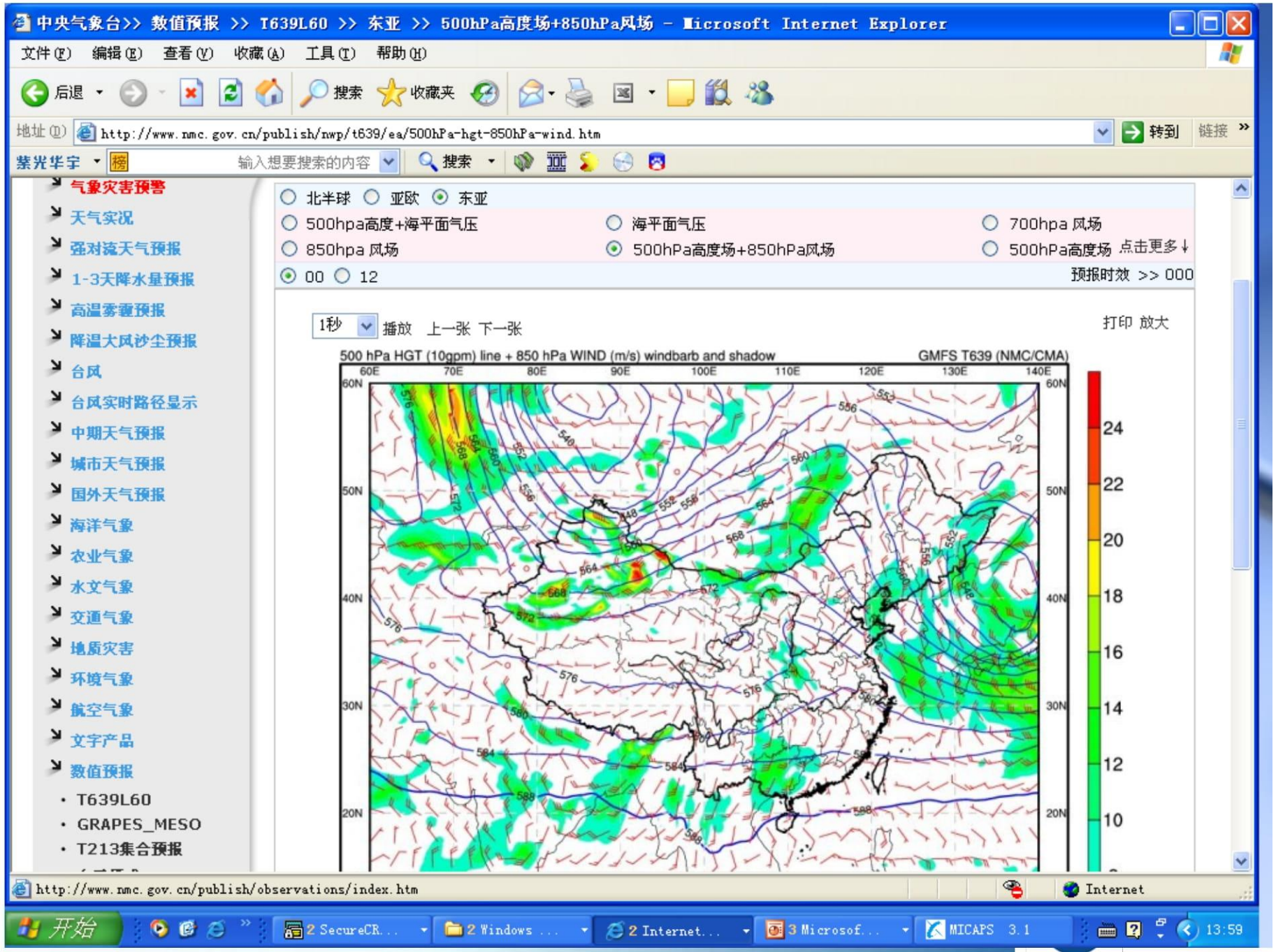
中央气象台>> 数值预报 >> T639L60 >> 东亚 >> 500hPa高度场+850hPa风场 - Microsoft Internet Explorer
文件(F) 编辑(E) 查看(V) 收藏(A) 工具(T) 帮助(H)
后退 搜索 收藏夹
地址(D) http://www.nmc.gov.cn/publish/nwp/t639/ea/500hPa-hgt-850hPa-wind.htm
转到 链接
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天气实况
强对流天气预报
1-3天降水量预报
高温雾霾预报
降温大风沙尘预报
台风
台风实时路径显示
中期天气预报
城市天气预报
国外天气预报
海洋气象
农业气象
水文气象
交通气象
地质灾害
环境气象
航空气象
文字产品
数值预报
T639L60
GRAPES_MESO
T213集合预报
北半球 亚欧 东亚
500hpa高度+海平面气压 海平面气压 700hpa 风场
850hpa 风场 500hPa高度场+850hPa风场 500hPa高度场 点击更多↓
00 12 预报时效 >> 000
1秒 播放 上一张 下一张 打印 放大
500 hPa HGT (10gpm) line + 850 hPa WIND (m/s) windbarb and shadow
GMFS T639 (NMC/CMA)
60E 70E 80E 90E 100E 110E 120E 130E 140E
60N 50N 40N 30N 20N
24 22 20 18 16 14 12 10
http://www.nmc.gov.cn/publish/observations/index.htm
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3 Microsof...
MICAPS 3.1
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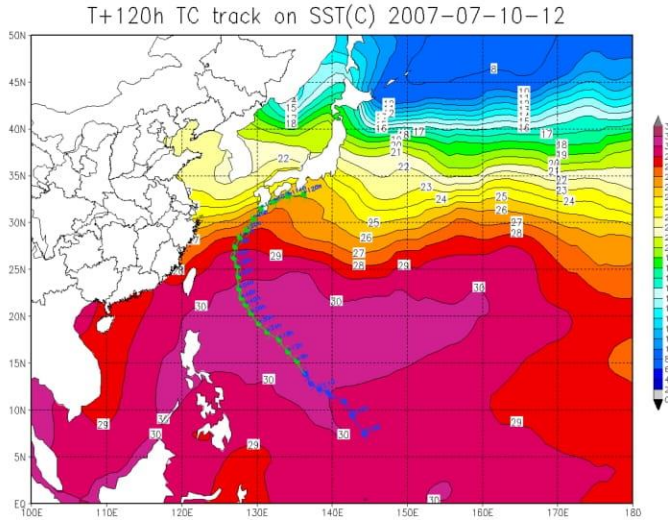
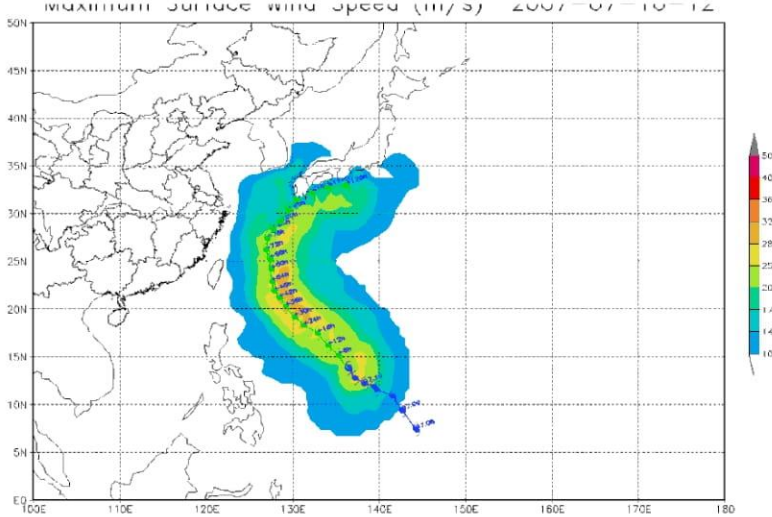
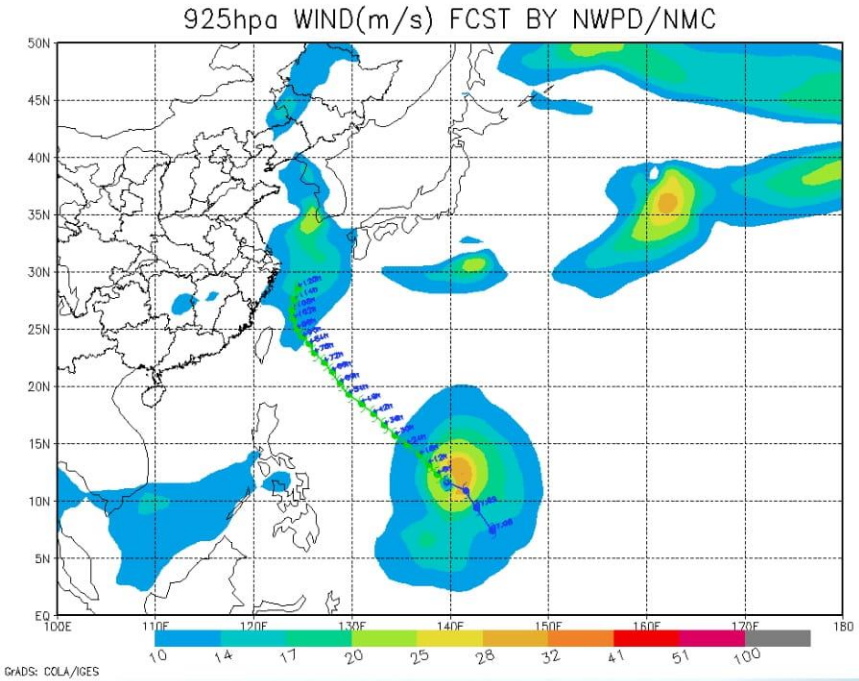
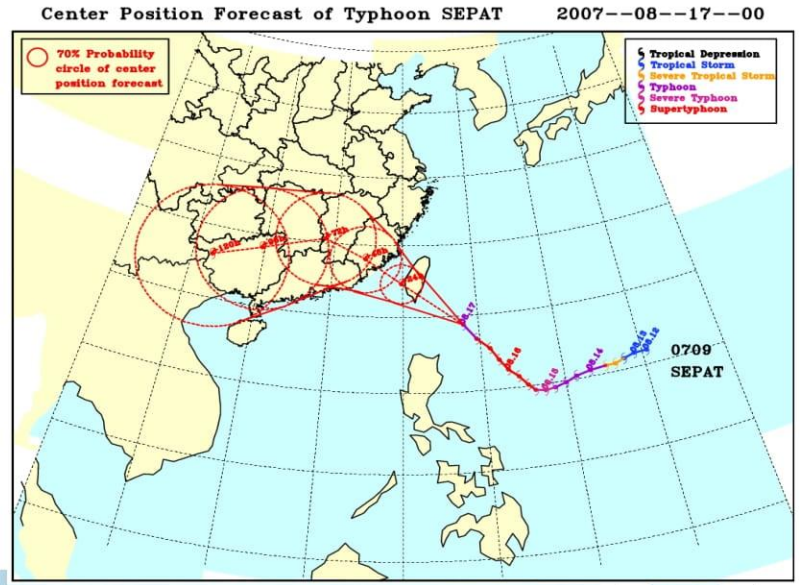
Typhoon products









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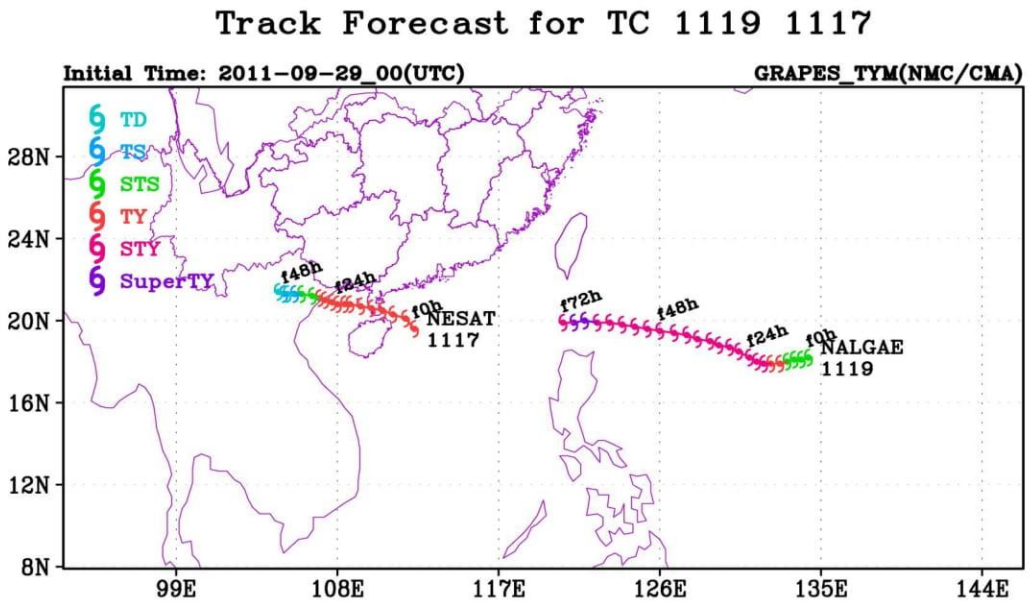
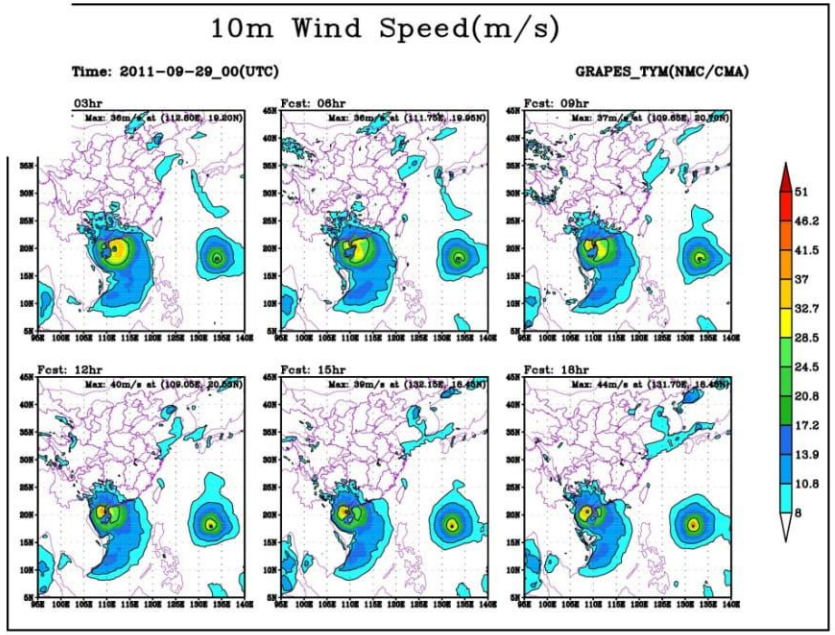
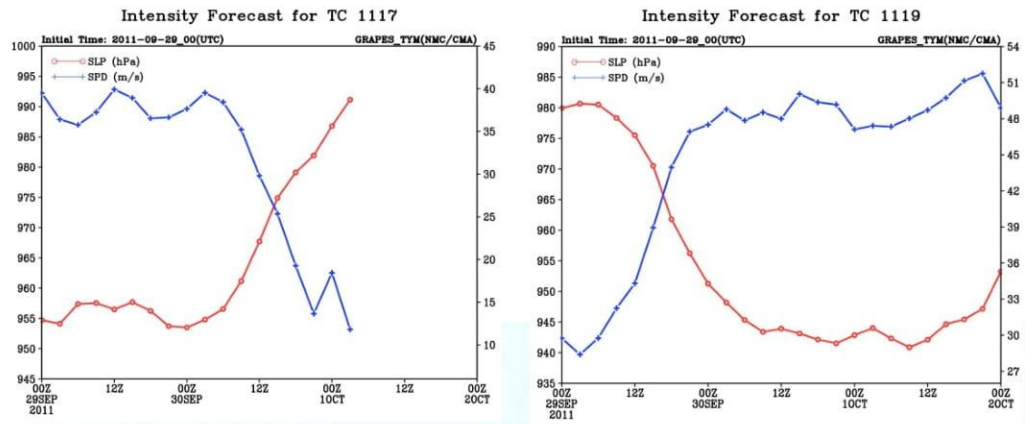
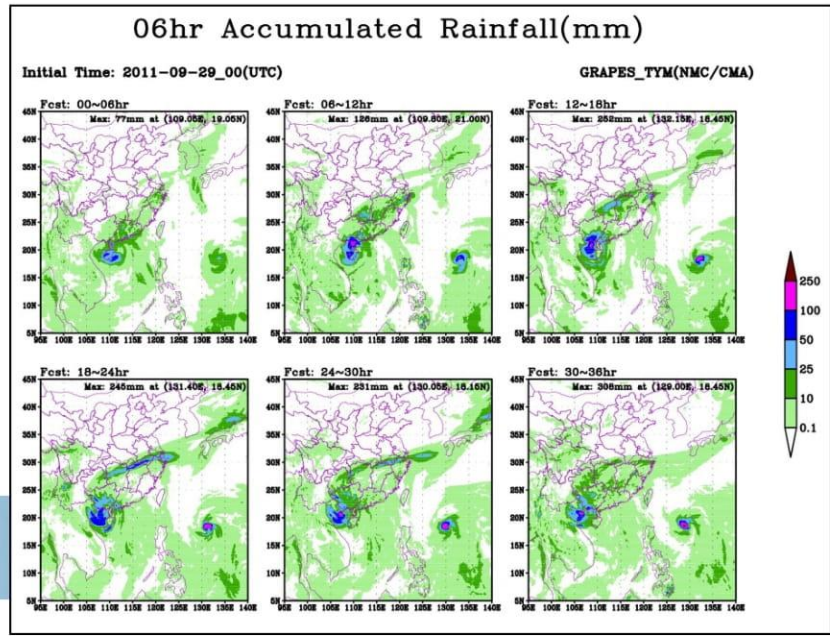
Typhoon Products

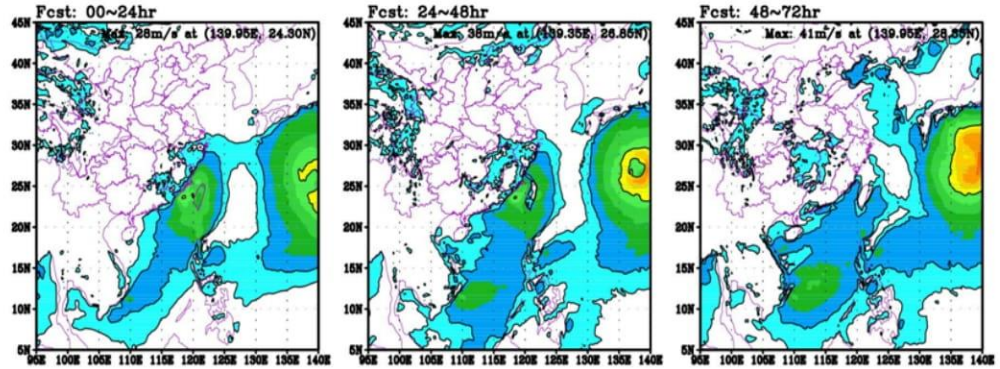


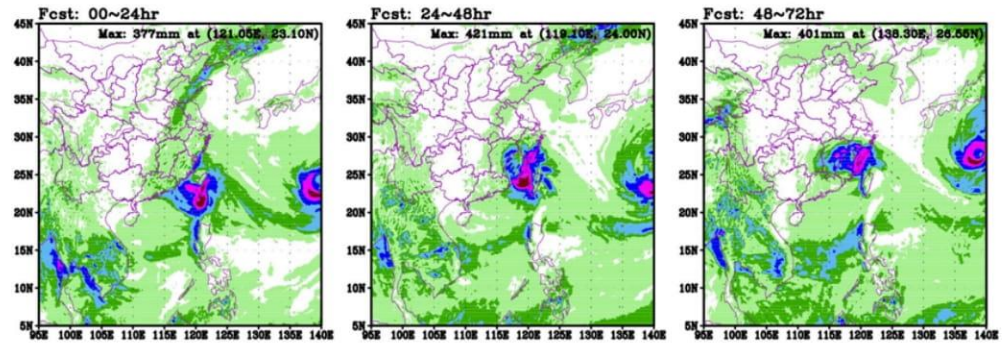


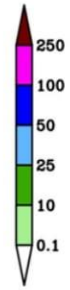


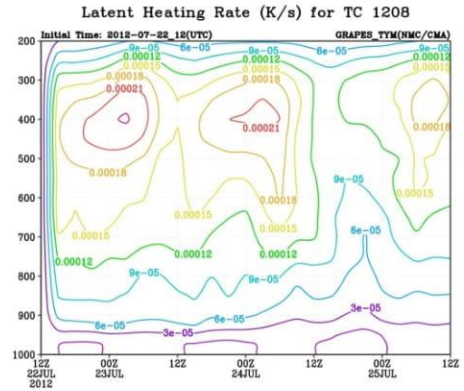


Typhoon products

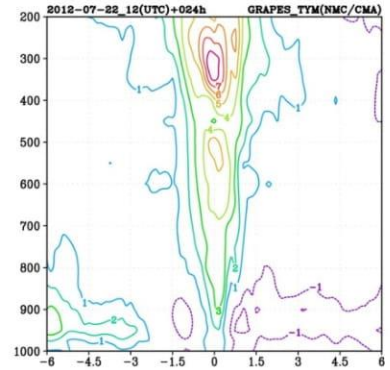


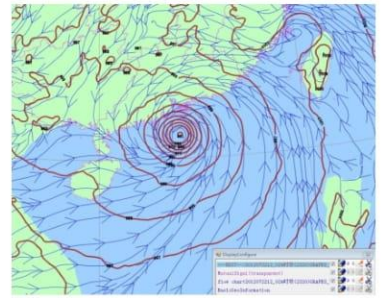






Anomaly of Temperature (K) at Lat. Sec. cross 1208 center (21.15N)





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elements

length

Information of TC

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- 1-3天降水量预报
- 高温雾霾预报
- 强温大风沙尘预报
- 台风
- 台风实时路径显示
- 中期天气预报
- 城市天气预报
- 国外天气预报
- 海洋气象
- 农业气象
- 水文气象
- 交通气象
- 地质灾害
- 环境气象
- 航空气象
- 文字产品
- 数值预报
  - T639L60
  - GRAPES_MESO
  - T213集合预报
  - 台风模式
  - 海浪模式
  - 亚洲沙尘暴模式
  - 人工增雨模式产品
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2009年10月21日18时发布热带气旋公报 更多预警

当前位置>>首页>>数值预报>>台风模式>>引导气流>>500-850hPa引导气流

台风路径 大风范围 引导气流 垂直切变 散度 涡度 位势高度 台风袭击概率 集合预报台风路径

500-850hPa引导气流 200-850hPa引导气流 700hPa引导气流

500hPa引导气流

00 06 12 18 预报时效 >> 000

1秒 播放 上一张 下一张

000 006 012 018
024 030 036 042
048 054 060 066
072 078 084 090
096 102 108 114
120

500-850hPa引导气流(GMTTP模式资料)2009年10月21日00

60N 55N 50N 45N 40N 35N 30N 25N 20N 15N 10N 5N EQ

60E 70E 80E 90E 100E 110E 120E 130E 140E 150E 160E 170E 180

37 33 28 25 23 21 19 17 15 13 11 9 7 5 4 3 2 1

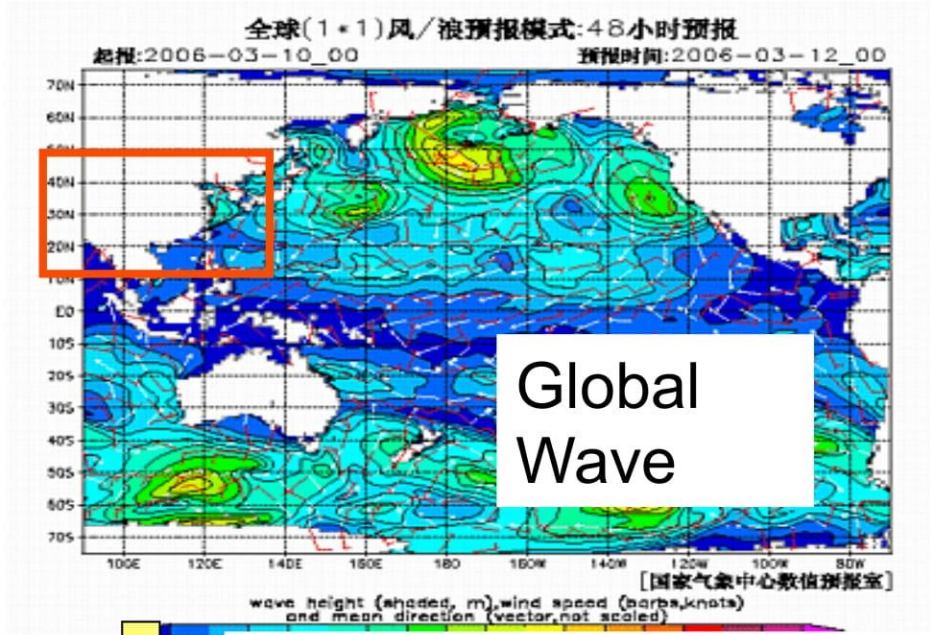
LUPIT: 中心位置::(20.1N,127.1E),移向::WSW 移速::15KM/H

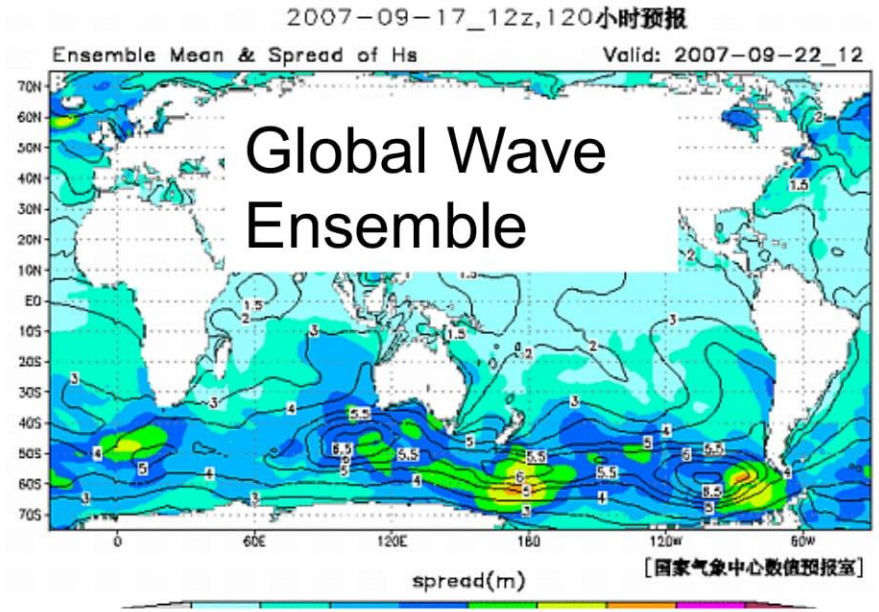
20091021 00:00 20091021 00:00 06小时 20091021 00:00 12小时 20091021 00:00 18小时

相关产品

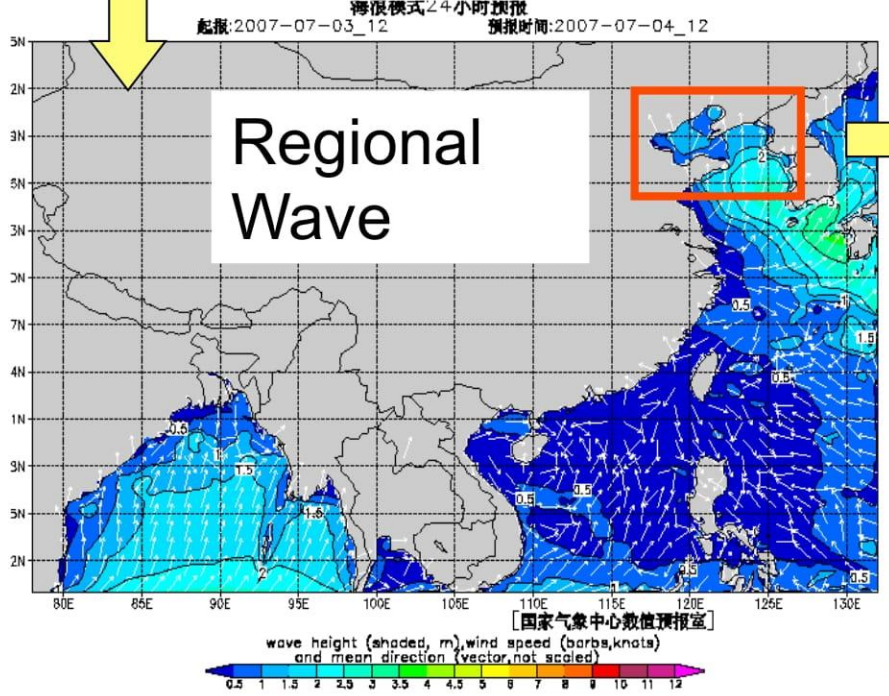
定量降水预报-24小时降水量	文字预报-短期天气预报
天气图分析-亚欧地面分析	全国雷达
卫星云图	实况观测-地面观测

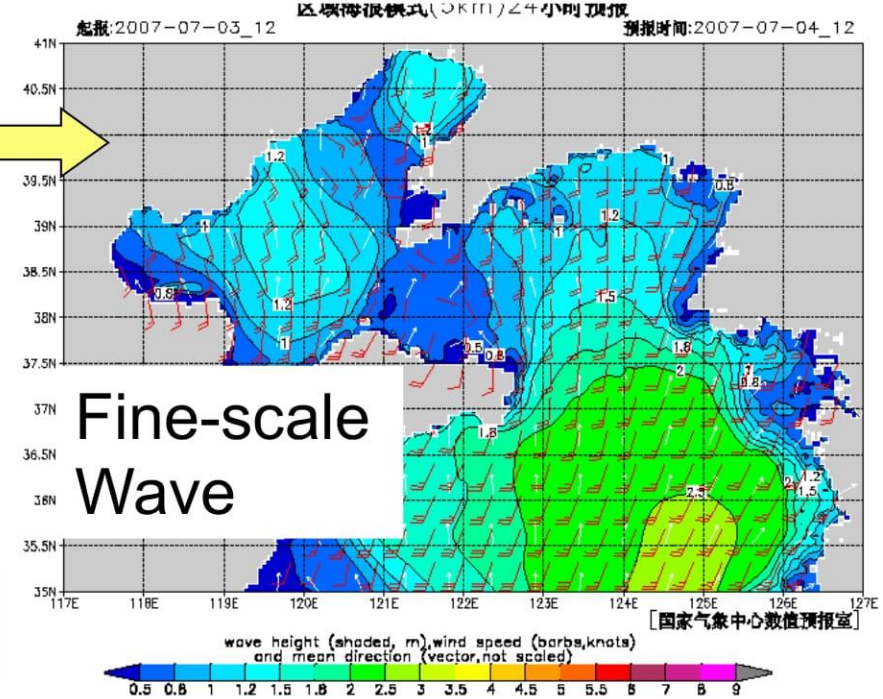
Internet 100%

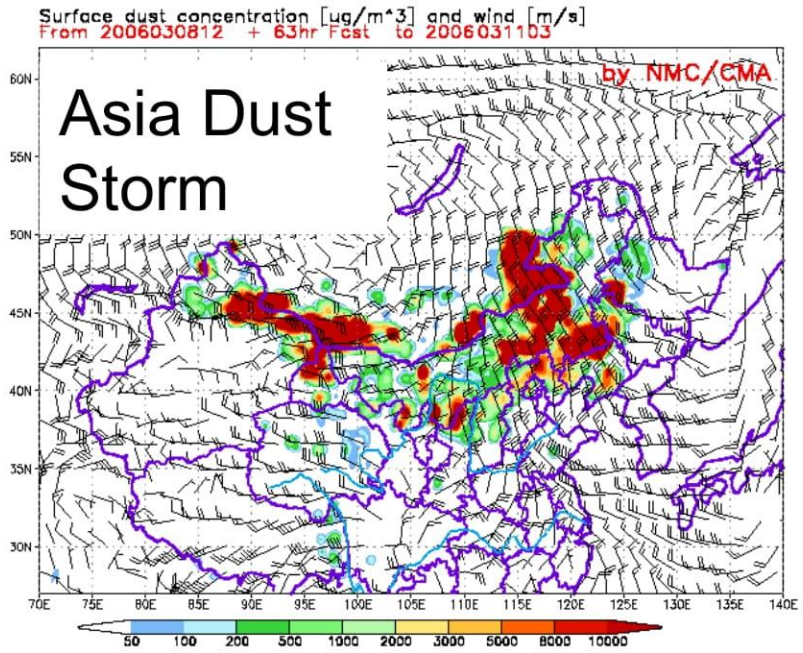


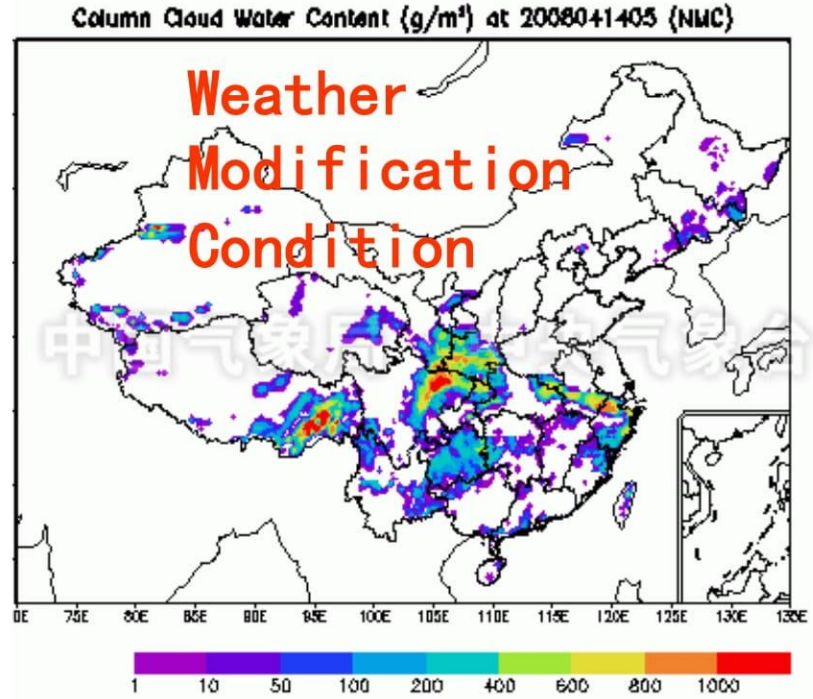


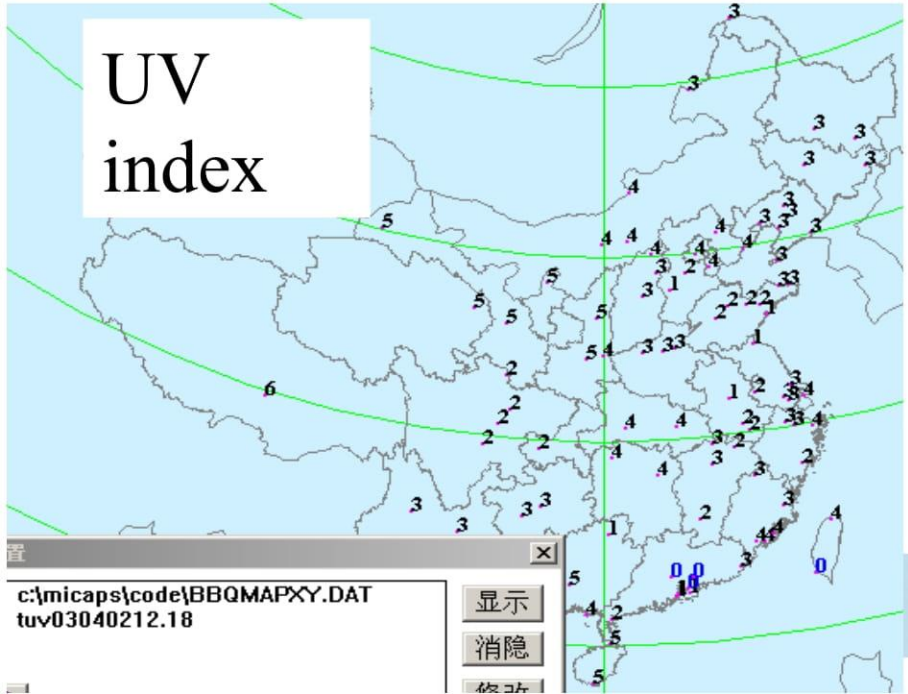
environment prediction systems products-Sea Wave






Surface dust concentration [ug/m^3] and wind [m/s]
From 2006030812 + 63hr Fcst to 2006031103
by NMC/CMA
Asia Dust Storm


Column Cloud Water Content (g/m²) at 2006041405 (NMC)
Weather Modification Condition


UV index
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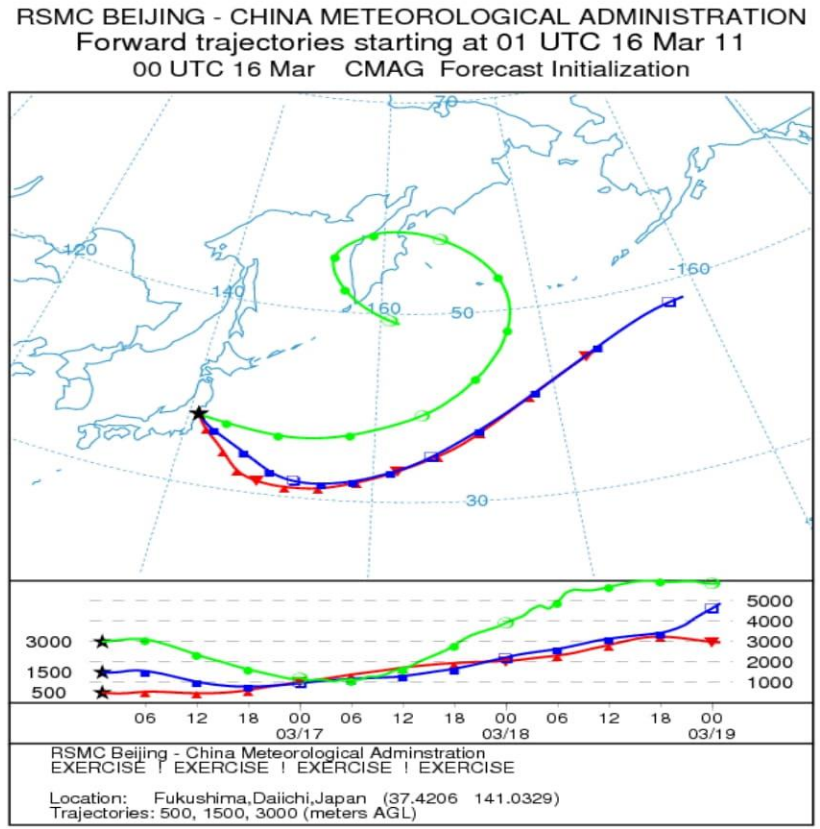
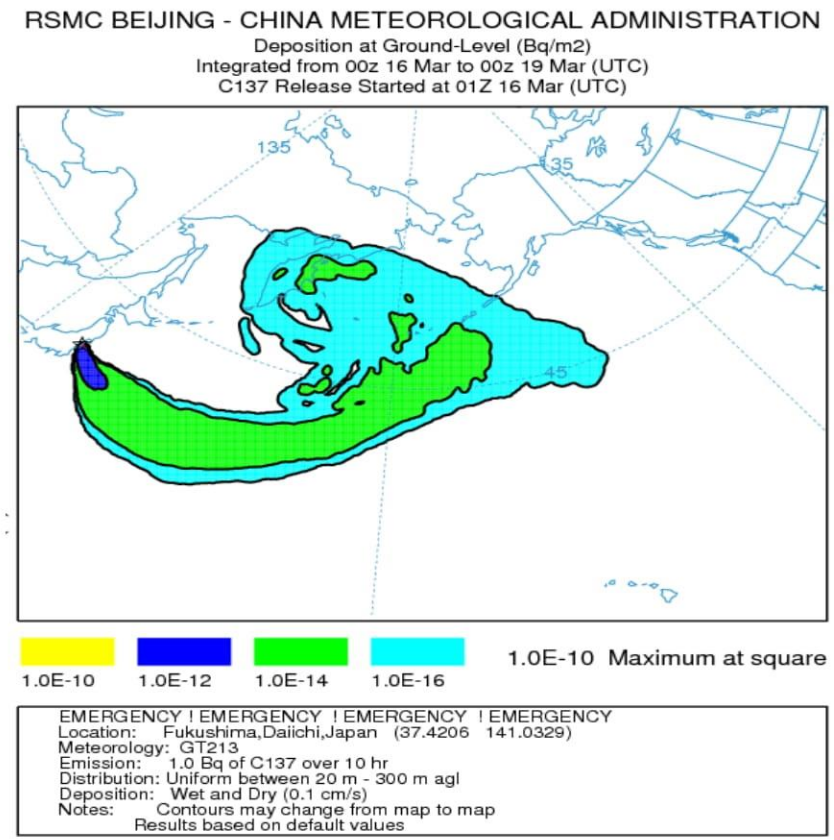
显示
消隐


Forest fire alarm

Global pollution transport and dispersion model system





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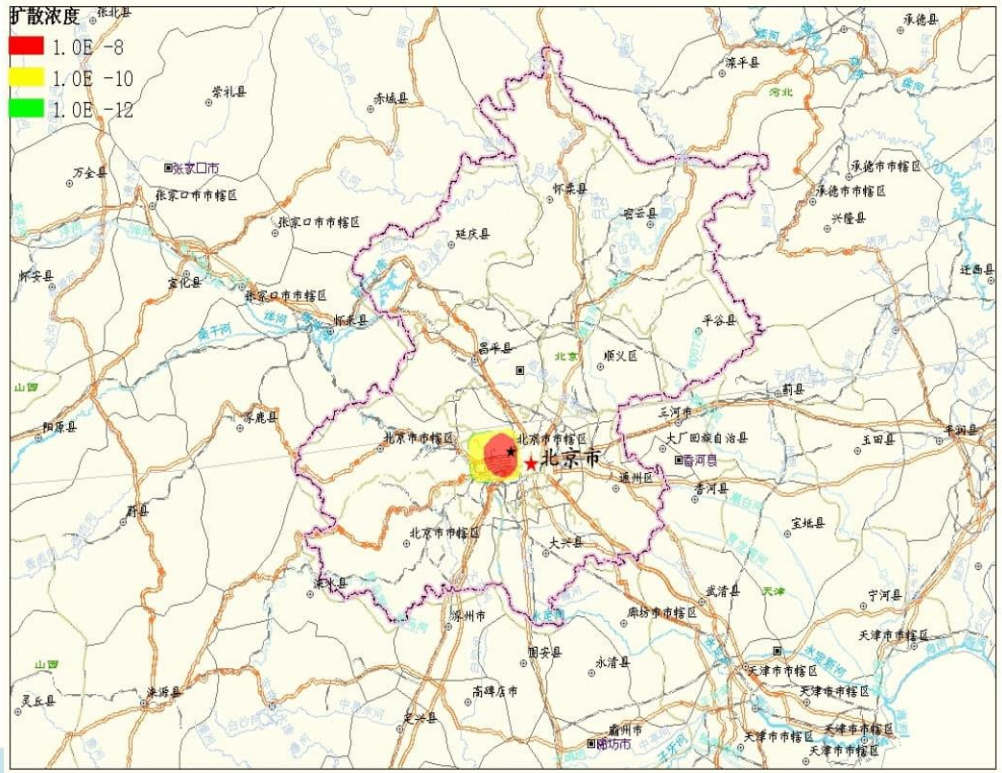
5km regional pollution transport and dispersion model system

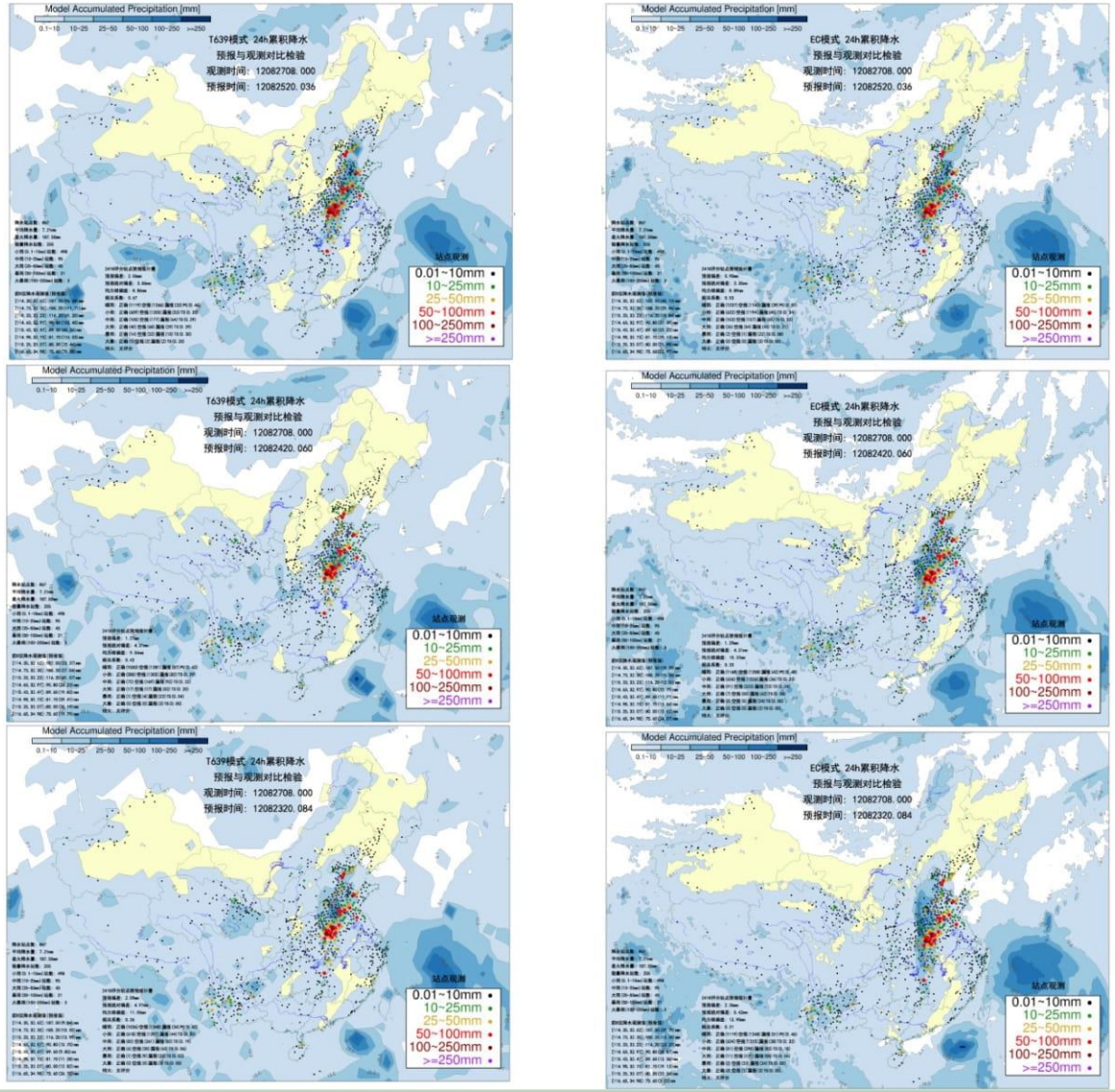
After started，can provide 1~5km, 1hour interval noxious gas transport and dispersion products within 30 minutes

Various height transport height



Surface to 100m noxious gas dispersion (1hour interval)

Forecaster evaluation products
-model products synoptic verification and assessments(NMC)



T639（left column）、EC（right column）36h（top row）、60h（middle row）、84h（bottom row）8.26.08～8.27.08 daily accumulated precipitation forecasts(mm)。shaded line is for forecasting, dot is for station observation

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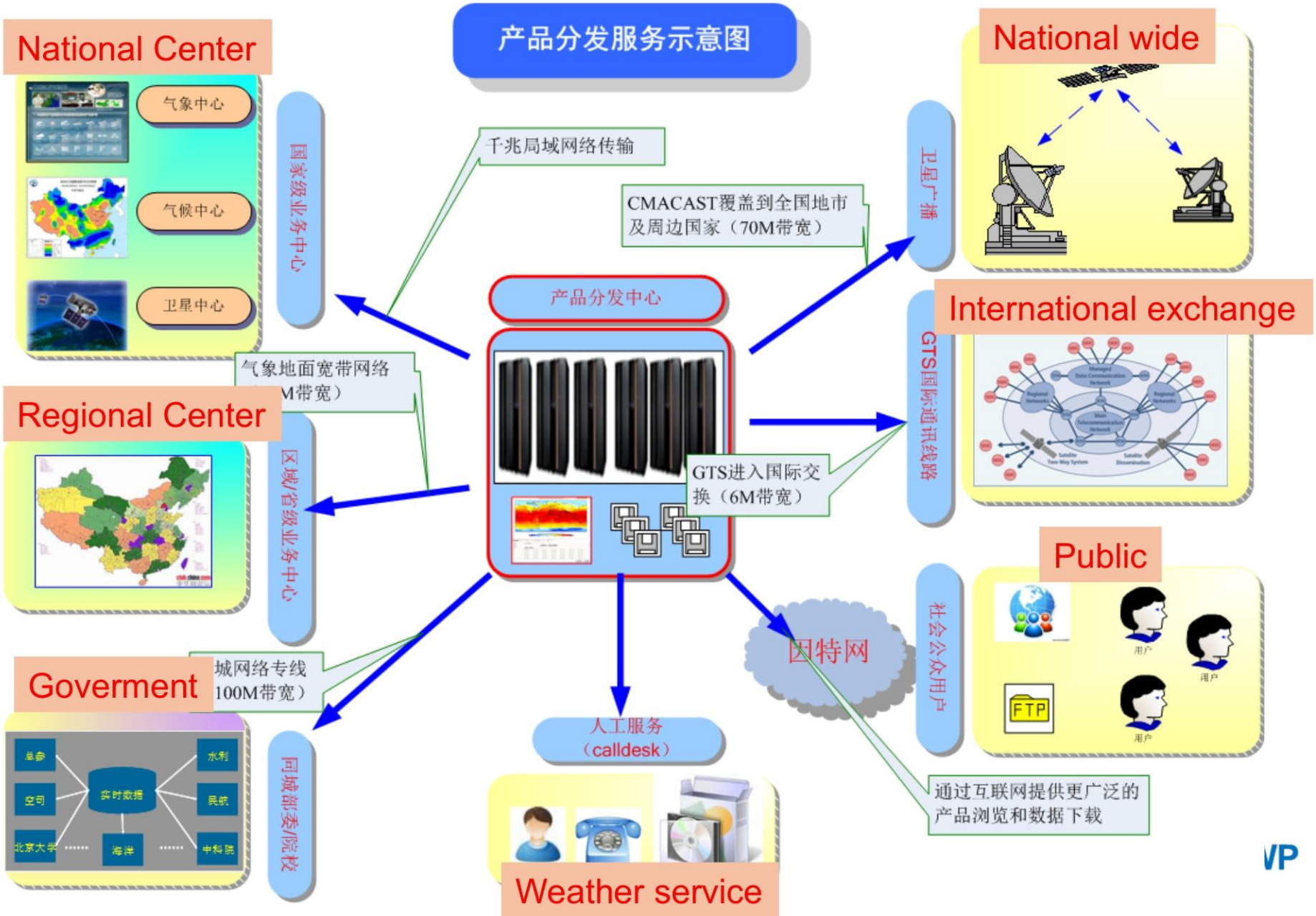
Diagram of NWP products distribution



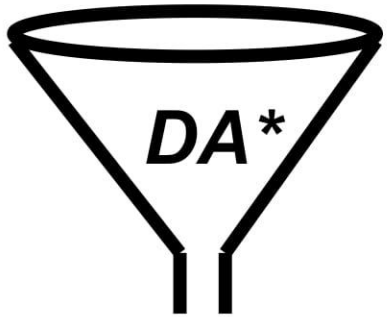
The forecaster feedback for T639 Products

CONTENTS

- Overview NWPC
- Operational NWP systems
- Products and service
- Suggestion for using NWP products

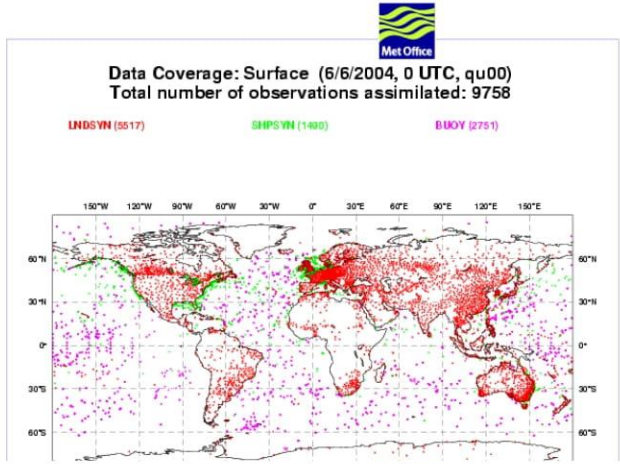
Uncertainty in the initial condition

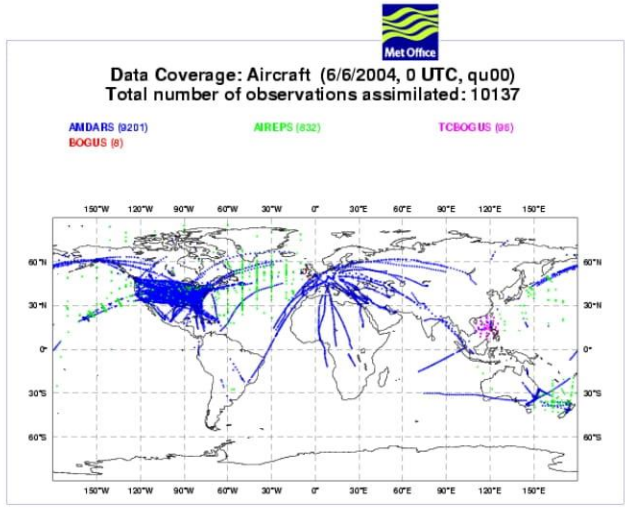
How do we create the IC?

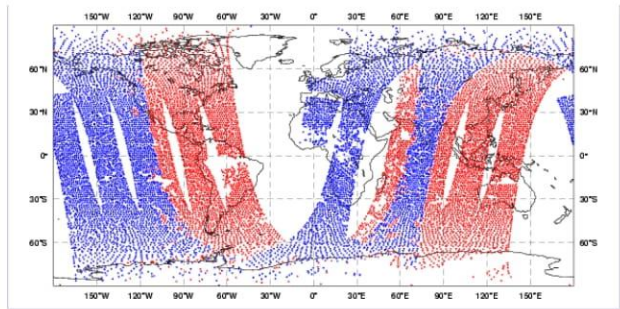


IC

(*) *DATA ASSIMILATION SYSTEM*

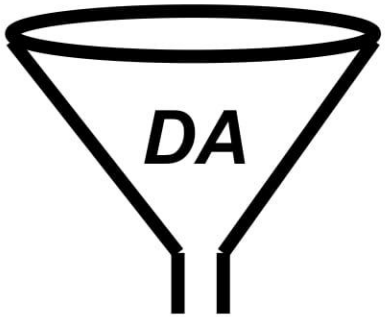






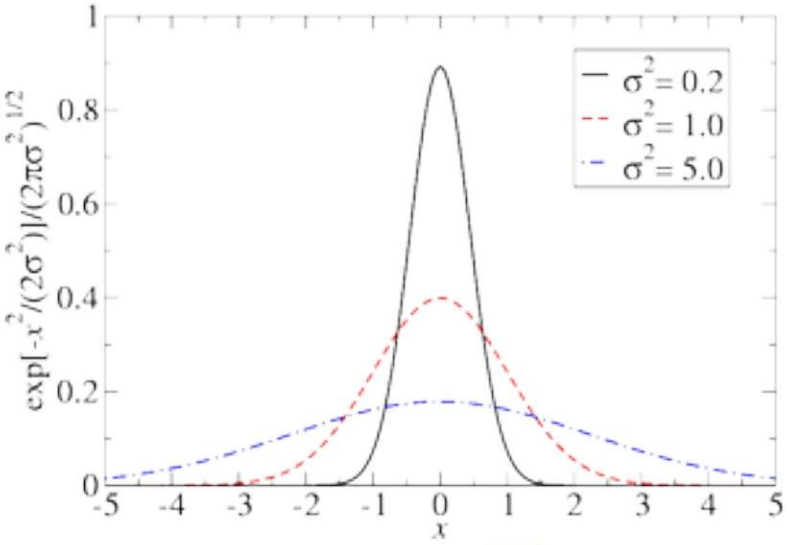
Uncertainty in the initial condition

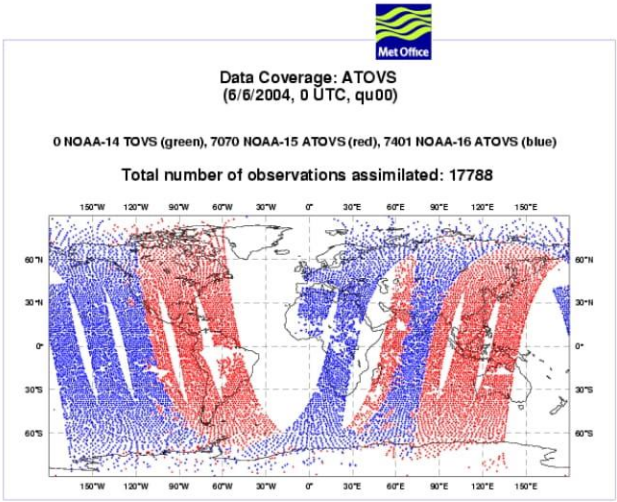
But, observations are subject to errors!



IC 1 IC 2

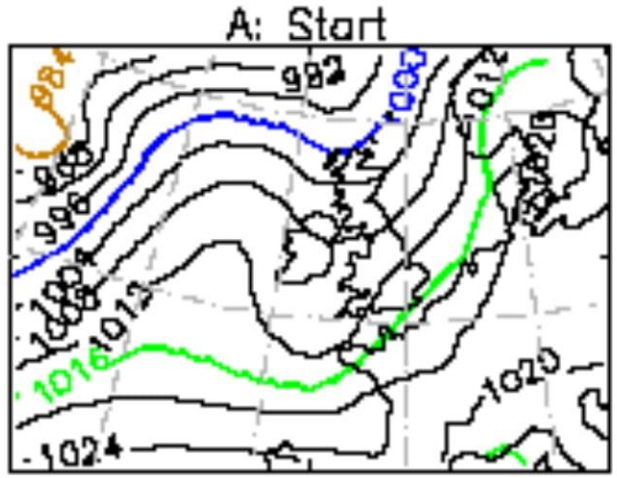
- **We get a different IC!**

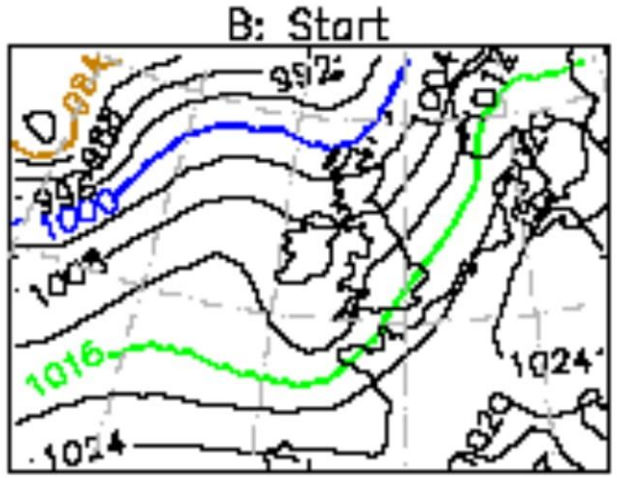


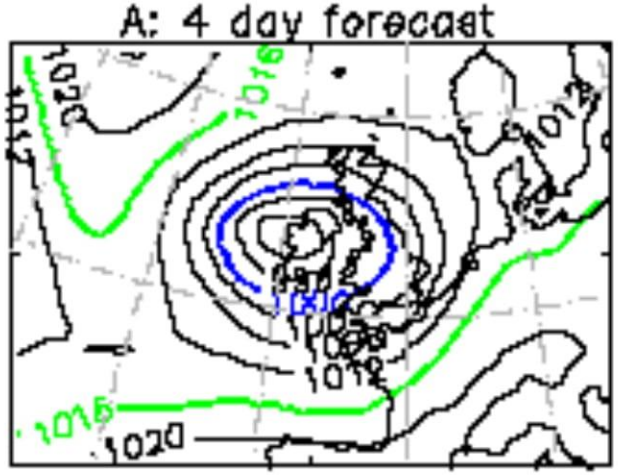


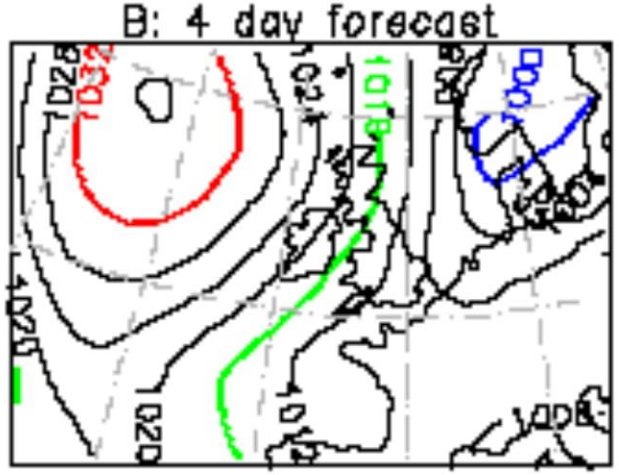
ECMWF

Small errors in the IC grow rapidly and affect predictability









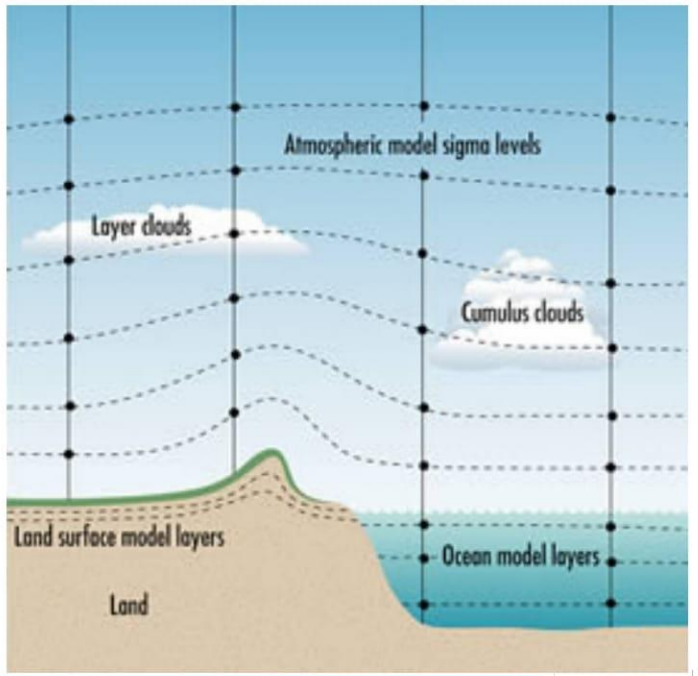
CNWP

Model uncertainties

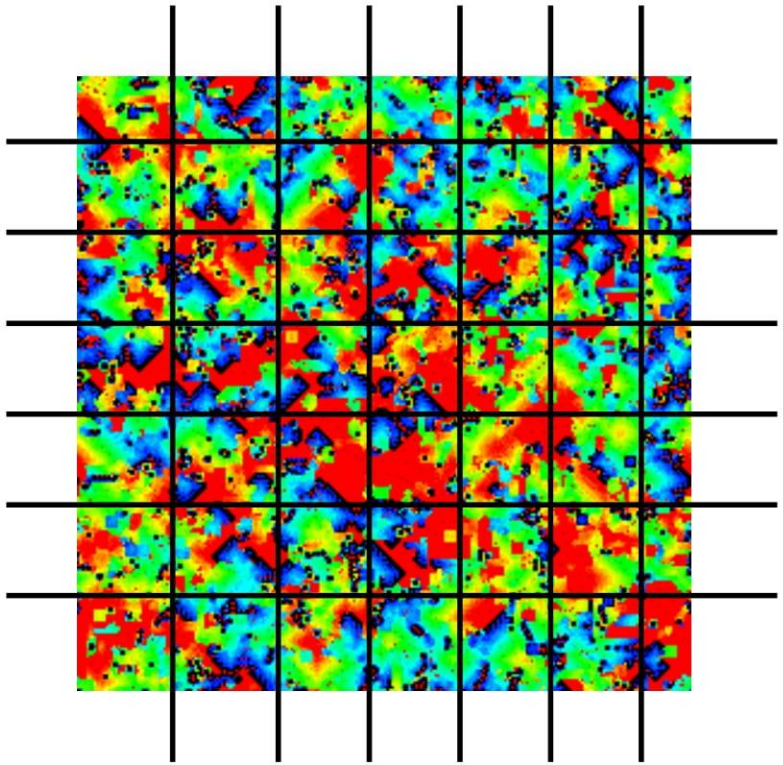
All models are imperfect!

Incomplete knowledge of the atmosphere

Limited resolution of the models (i.e. some scales cannot be resolved!)

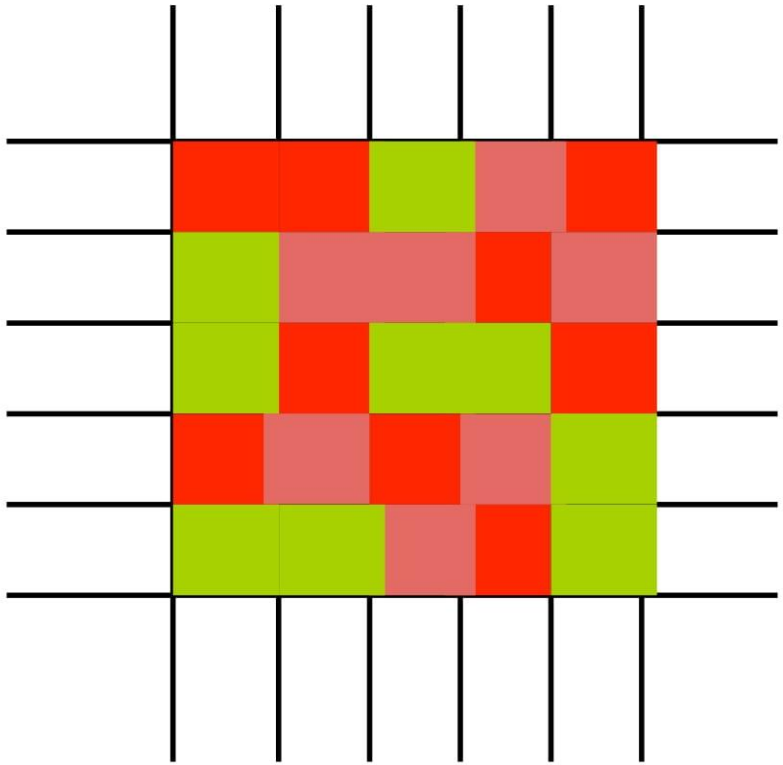


Model uncertainty: Subgrid variability



Small scale

Global model



Suggestion

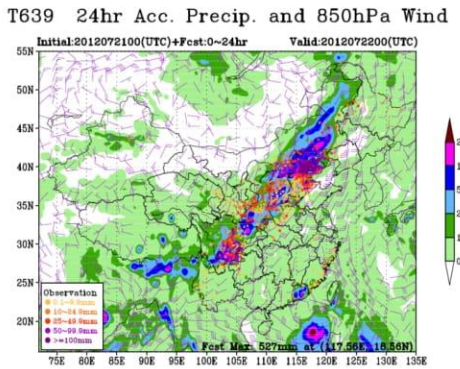
- Even NWP systems are more accuracy than ever before, systems always have uncertainties in initial condition and model. The more forecaster understand how the products are generated, the better forecaster can use them.

- Forecaster could find the merit and weakness of a model. To use the numerical products by a reasonable way, forecaster could add a value to weather prediction, to provide more accuracy and more usefully weather prediction.

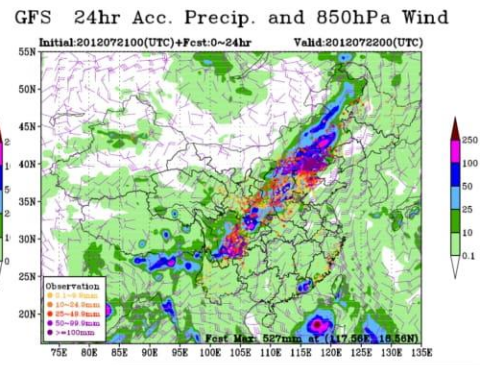
- But, it is really a challenge to find the merit and weakness of a model. Forecaster must work very hard to find out. Extra knowledge and experiences, like understand local weather climate, or historic weather cases analysis, will help forecaster to use/control numerical products.

Too much model and too much information!

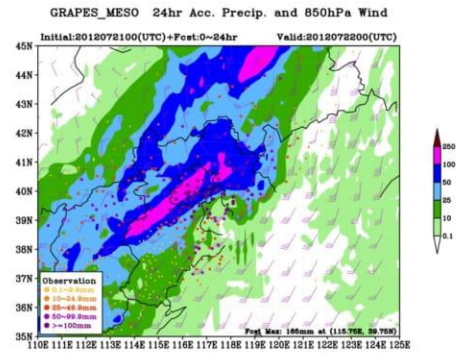
CMA T639



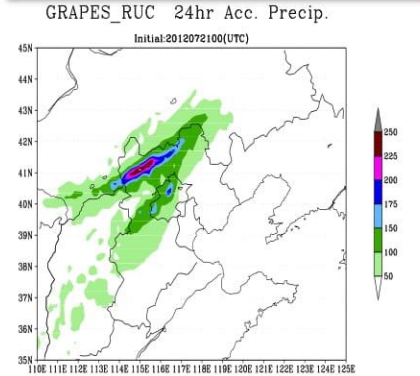
CMA GRAPES-GFS



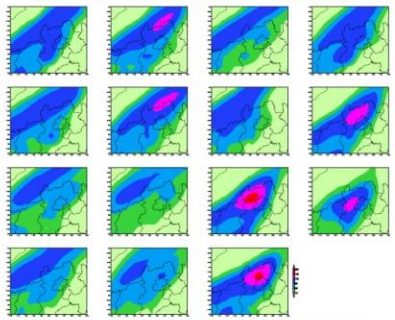
CMA GRAPES-MESO



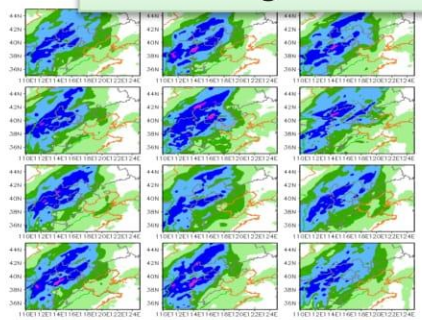
CMA GRAPES-RUC

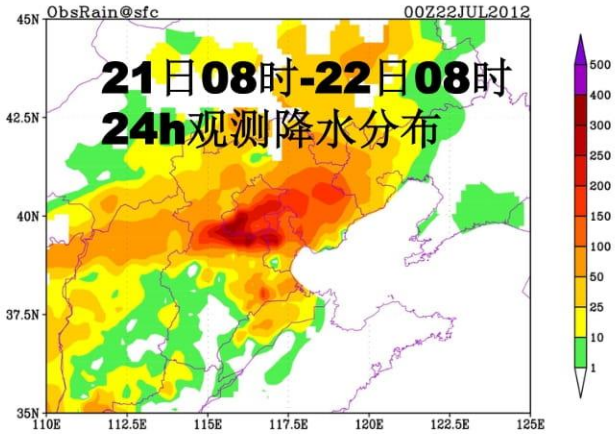


CMA T213 EPS

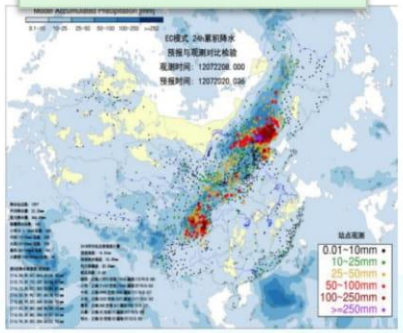


CMA Reg EPS

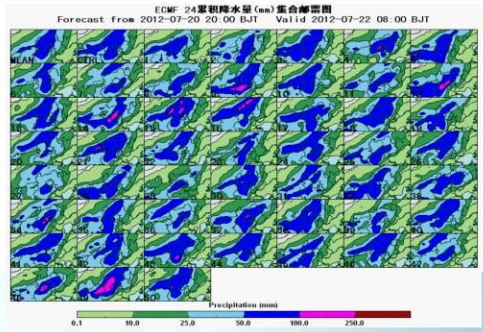




ECMWF T1279



ECMWF T799 EPS



How does a forecaster can digest so many information!

CNWP

THANKS FOR YOUR ATTENTION!