Major Changes of CMA Ensembles and its products since 2016

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Acknowledgements to the contributions of NWPC ensemble group members

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Contents

About GRAPES

GRAPES (Global/Regional Assimilation PrEdiction System), project launched since 2001.

What GRAPES' characteristics are?

A Unified NWP system

a common dynamic core with different configurations of physics for different applications

Four main components

Variational DAS

Unified dynamic core

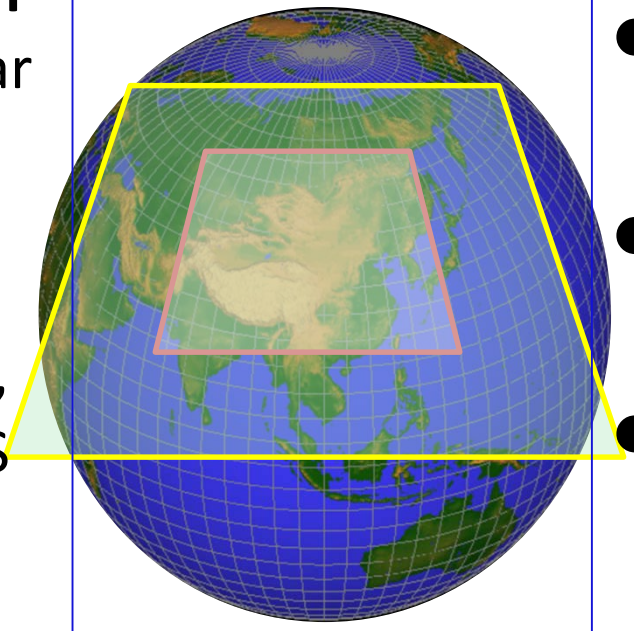
Physical parameterization schemes

Parallel computing

Operational NWP systems in CMA (2019)

Global

- **Data Assimilation**
  - GRAPES-4DVar
- **Global 10d FCST.**
  - GRAPES-GFS
  - 25kmL60
- **Global 15d GEPS,**
  - GRAPES-GEPS
  - 50kmL60,
  - 31mem
  - SVs , SPPT,SKEB

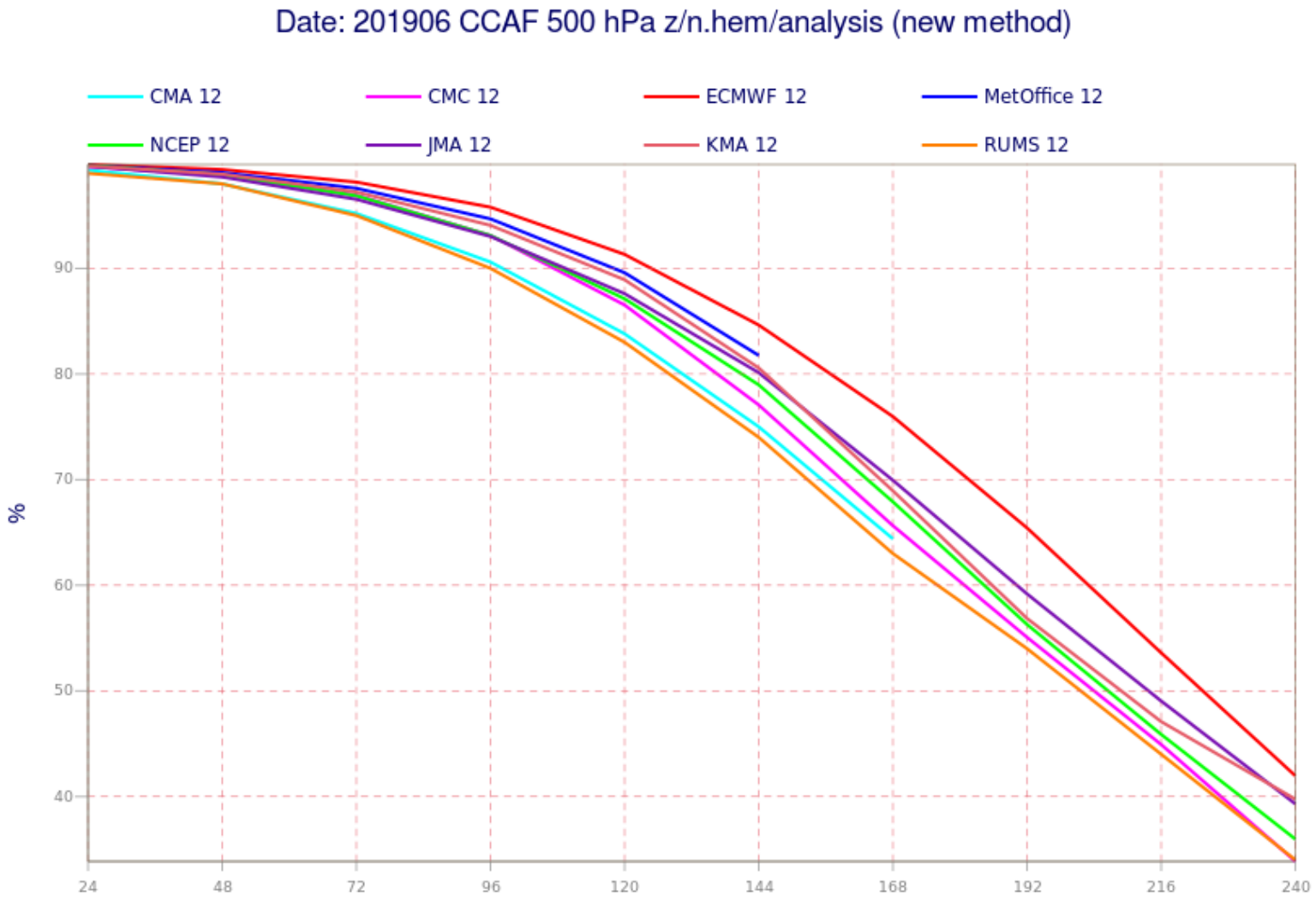


Regional

- **Regional-3km,36h FCST (China)**
  - **36h forecast /4 times**
- **Regional-9km 5d FCST. (Asia and NW Pacific)**
  - **2 times**
- **REPS-10km,3.5d FCST (China)**
  - GRAPES-REPS, **2 times**
  - 15 members
  - ETKF,SPPT

GRAPES 3DVAR and Cloud Analysis

The current performance of GRAPES-GFS in NH



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Major changes of CMA GEPS

(T639-GEPS ⟶ GRAPES-GEPS)

（operationally running since Dec. 26, 2018）

Configurations	T639-GEPS （2014-2018）	GRAPES –GEPS
Resolution	T639L60	50kmL60
Assimilation	T639-GSI + ATOVS	GRAPES-4Dvar
Initial Uncertainty	BGM	SVs
Model Uncertainty	SPPT	SPPT，SKEB
Daily freq.	00 and 12 UTC	00 and 12UTC
Member size	Ctrl + 14 pert	Ctrl + 30 pert.
Forecast Length	15 days	15 days
Typhoon	TC vortex relocation	TC SVs

Major changes of GRAPES-REPS v3.0

System version	GRAPES-REPS v2.0	GRAPES-REPS v3.0
Control model	GRAPES-MESO4.0	GRAPES-MESO4.3
Resolution	0.15° /L50	0.1° /L50
Control IC and BDYs	Same with GRAPES-MESO v4.0	Same with GRAPES-Meso-3km
Data assimilation	none	Cloud Analysis
IC uncertainty	ETKF （12h cycle）+ MSB	ETKF (6h cycle)
Model uncertainty	Multi physics + SPPT	SPPT
BDY uncertainty	T639-GEPS	GRAPES-GEPS
TC uncertainty	none	Conditional TC vortex relocation
Member size	15 （Ctrl+14 pert.)	15 （Ctrl+14 pert.)
Area	70-140E, 15-65N	70-140E, 15-65N
Forecast time	84h（00、12UTC）	84h（00、12UTC）、6h（06、8UTC）
Model output	1h	No change
postprocessing	GRIB2、Images, TC Emergency service	No change

Operationally running since Jul. 2019

REPS	GRAPES-REPS v2.0		GRAPES-REPSv3.0	
Phy.	CP	PBL	CP	PBL
000	new_KF	MRF	new_KF	MRF
001	new_KF	MRF	new_KF	MRF
002	BM	MRF	new_KF	MRF
003	new_KF	MRF	new_KF	MRF
004	new_KF	MRF	new_KF	MRF
005	BM	MRF	new_KF	MRF
006	new_KF	MRF	new_KF	MRF
007	new_KF	MRF	new_KF	MRF
008	SAS	YSU	new_KF	MRF
009	BM	YSU	new_KF	MRF
010	new_KF	YSU	new_KF	MRF
011	SAS	YSU	new_KF	MRF
012	BM	YSU	new_KF	MRF
013	new_KF	YSU	new_KF	MRF
014	SAS	YSU	new_KF	MRF

The conditional TC vortex relocation (1)

The uncertainty of position of TC <15km

Difference of Typhoon position between CMA and JMA (unit: km)

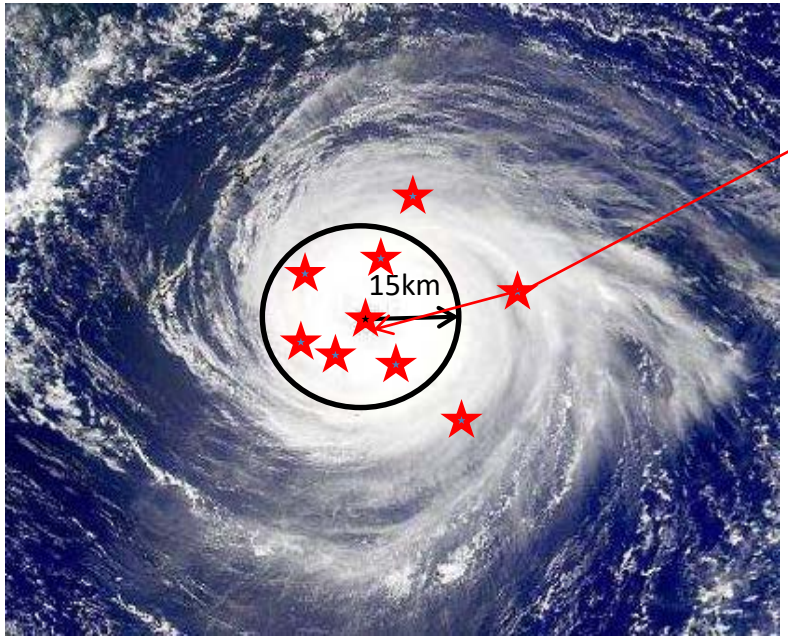
years	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	10-year mean
Diff.	17. 8	12.44	13.24	16.17	13.47	12.96	11.98	13.11	12.56	14.13	13.72

Typhoon best track data set

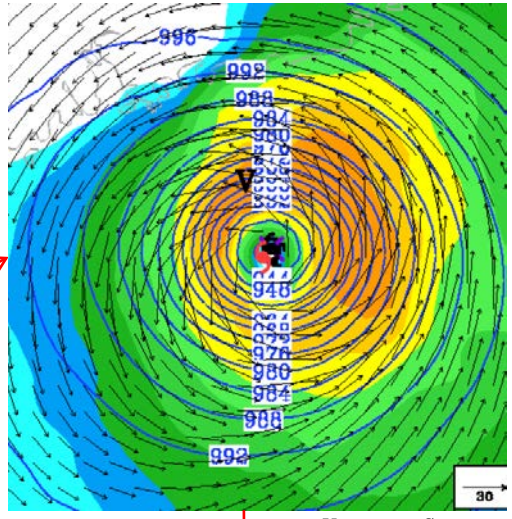
- CMA(Shanghai Typhoon Institute)
- Japan Meteorological Agency

The conditional TC vortex relocation (2)

- The conditional TC **vortex relocation** is applied to ensemble member **only when the difference** of TC position between best track and model analysis is greater than **15km**



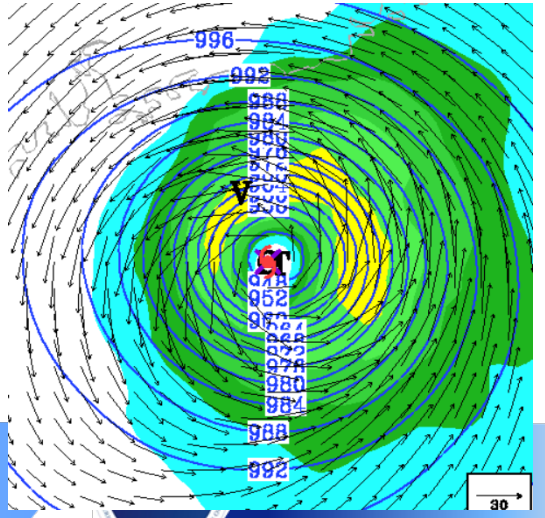
Spatial filtering



Vortex Relocation

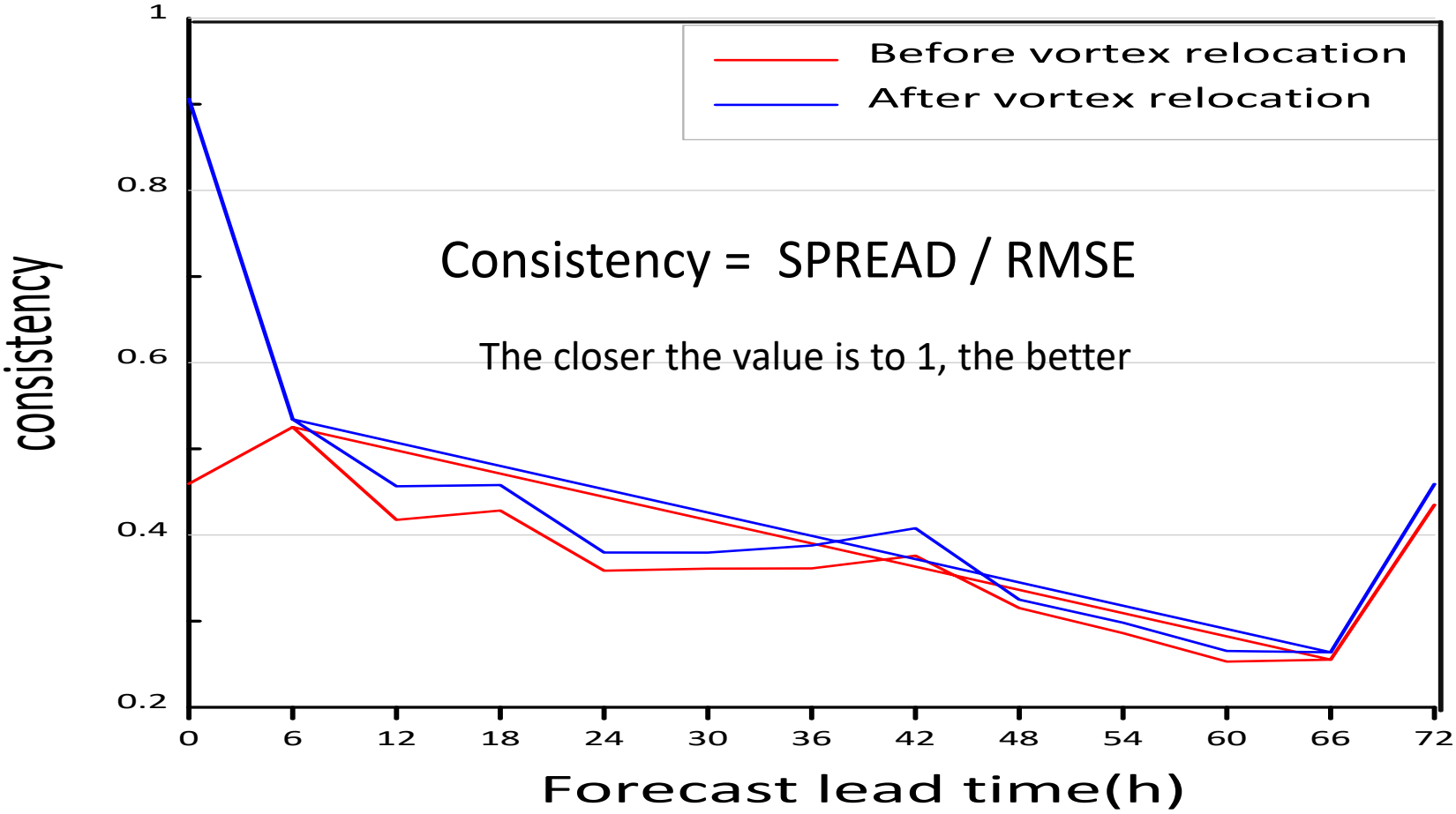
Vortex Center and Boundary Determination and Optimal Interpolation

Synthesis



Yoshio Kurihara，Morris A.Bender,And Rebecca J.Ross.
An Initialization Scheme of Hurricane Models by Vortex Specification.
Mon.Wea.Rev, 1992,2(5),2030-2044

The mean consistency of track positions of 4 Typhoons in 2018(“Maria”, “Mangkhut”, “Trami” and “Kong-Rey”)

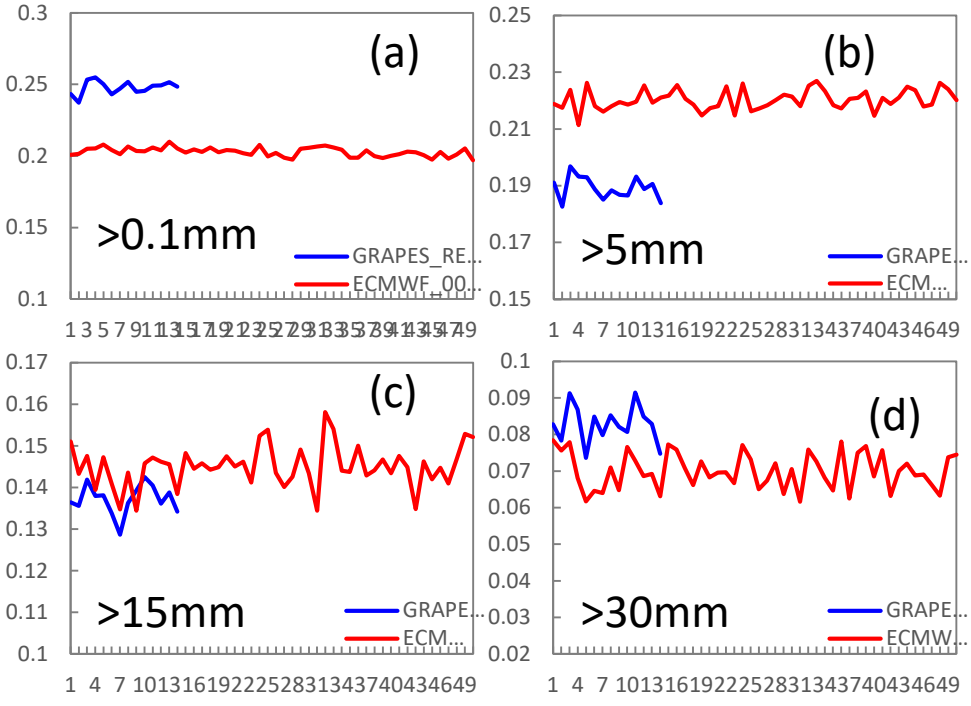


Comparison of GRAPES-REPS with ECMWF-ENS

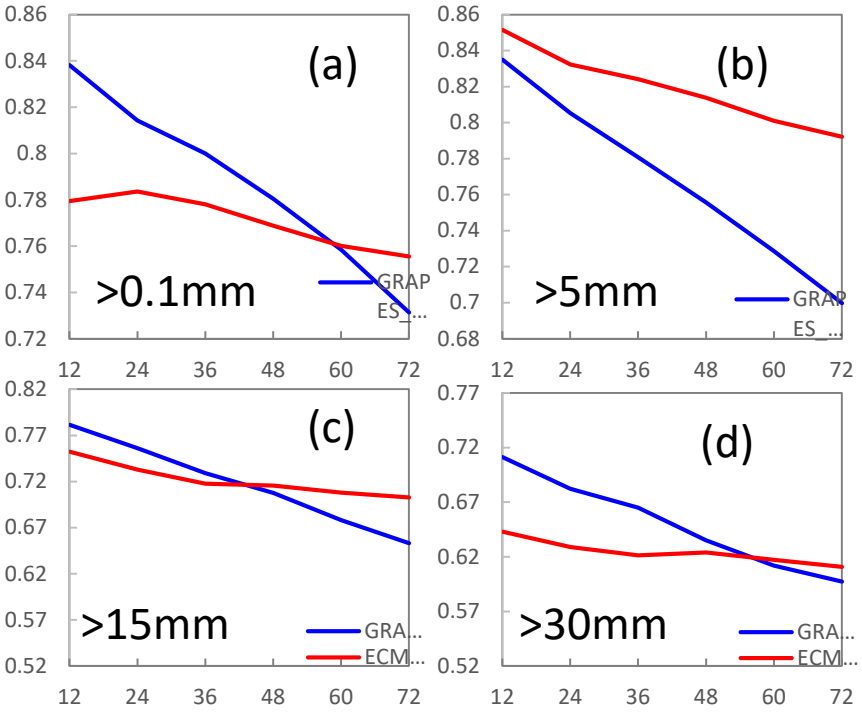
12h accumulated precipitation forecasts over China

ECMWF data : 0.5 degree ENS precipitation **download from ECMWF web**
Period : Jul. 8 – Aug.8, 2019

ETS of ensemble members（12-24h）



AROC



- **It is better for AROC of precip >0.1, 5 and 30mm for 0-48h forecast but is worse for precip > 15mm.**

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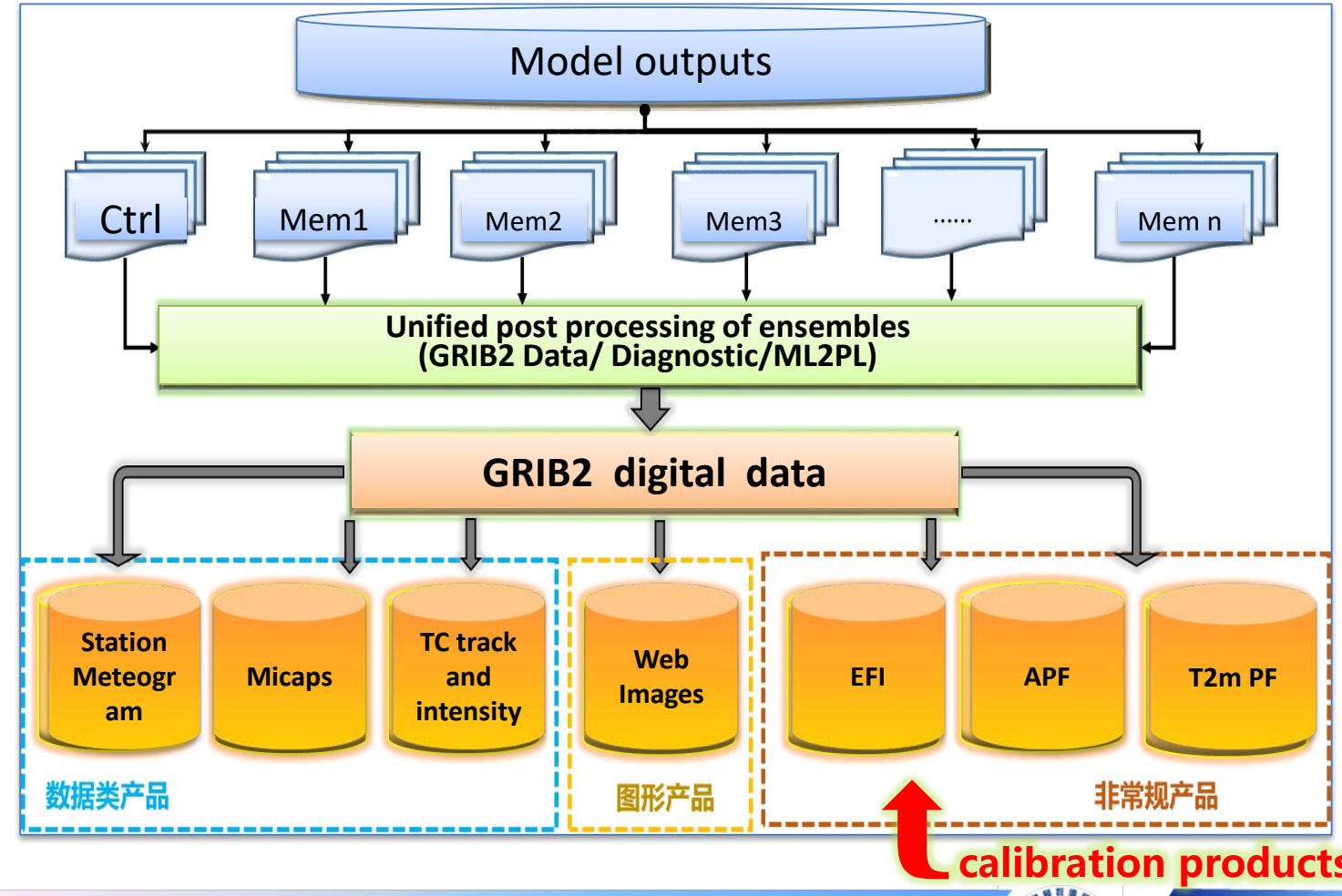
Unified post-process and dissemination of GRAPES-GEPS and -REPS products



List of GRIB2 variables of GRAPES-GEPS and -REPS

No.	Elements	（Categ. / NO.）	Unit	Ini.	Fore.	Level No.	Level	levels
1	位势高度Geoptential height	3 / 5	位势米	00 12	000, 003 006, 009, 012, 015, 018, 021, 024 027 030, 033 036, 039, 042, 045, 048, 051, 054, 057, 060, 063, 066, 069, 072	100	16	100,200,300,400,500,600,650,700,750,800,850,900,925,950,975,1000
2	温度（Temperature）	0 / 0	K					
3	东西风（U component wind）	2 / 2	m/s					
4	南北风V component wind）	2 / 3	m/s					
5	垂直速度（Vertical velocity）	2 / 9	m/s					
6	比湿（Specific humidity）	1 / 0	kg/kg					
7	相对湿度（Relative humidity）	1 / 1	%					
8	涡度(Vorticity)	2 / 12	s^{-1}				7	100,200,500,700,850,925 ，950
9	散度(Divergence)	2 / 13	s^{-1}					
10	温度平流(Temperature advection)	0 / 224	10^{-6}K/s					
11	水汽通量（water vapor flux)	1 / 224	10^{-1}克/hPa.cm^2.s					
12	水汽通量散度(water vapor flux divergence)	1 / 225	10^{-7}克/hPa.cm·cm^{2}s					
13	温度露点差(depression of the dew point)	0 / 7	K					
14	假相当位温(potential pseudo-equivalent temperature)	0 / 3	K					
15	10米U(10m U component wind)	2 / 2	m/s			103	1	10
16	10米V(10m V component wind)	2 / 3	m/s					
17	2米温度(2m temperature)	0 / 0	K					2
18	2米相对湿度(2m relative humidity)	1 / 1	%					
19	海平面气压(sea level pressure)	3 / 1	Pa.			101		0
20	K指数(K index)	7 / 2	K					
21	地面气压(surface pressure)	3 / 0	Pa			1		
22	地表温度(surface temperature)	0 / 0	K					
23	总降水量(total precipitation)	1 / 8	Mm					
24	对流有效位能（convective available potential energy, CAPE）	7 / 6	J/kg					
25	对流抑制能量（Convective Inhibitation）	7 / 7	J/kg					
26	强天气胁迫指数（Severe Weather Threat Index ， SWEAT）	7 / 5	None					
27	抬升指数(Best lifting index)	7 / 0	None					
28	抬升凝结高度(Lifting Condensation Level, LCL)	1 / 228	Pa					

GRAPES_GEPS products for Extreme weather event

(1) Anomaly Probabilistic Forecasts(APF) for 500hPa geopotential height and 850hPa temperature and wind speed based on decaying average bias correction method.

(2) Extreme Forecast Index(EFI) for 2m temperature, 10m wind speed and precipitation with model climate produced by 3 year GRAPES-GFS model 10d forecast data.

(3) Probabilistic Forecasts for 2m Temperature (T2m PF) above or below a threshold with station topography calibration method

GRAPES-GEPS products for extreme weather event

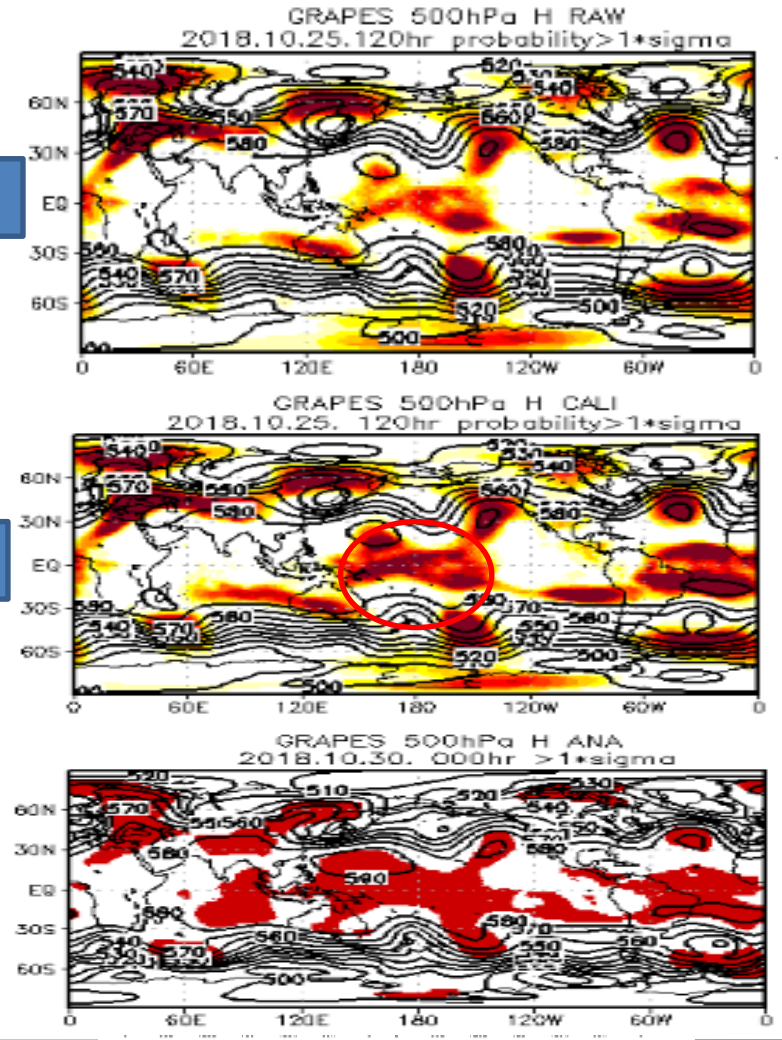
Anomaly Prob. Forecasts of Calibrated GH500

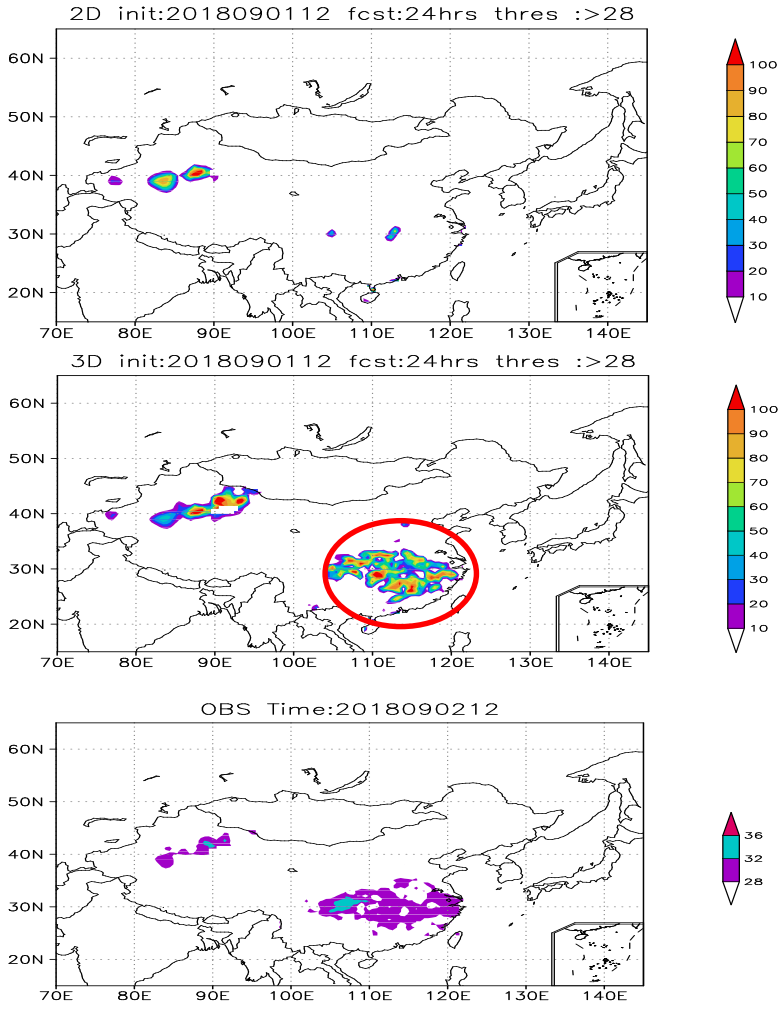
Prob. Forecast of Calibrated T2m> 28 ℃

before

after

Obs.





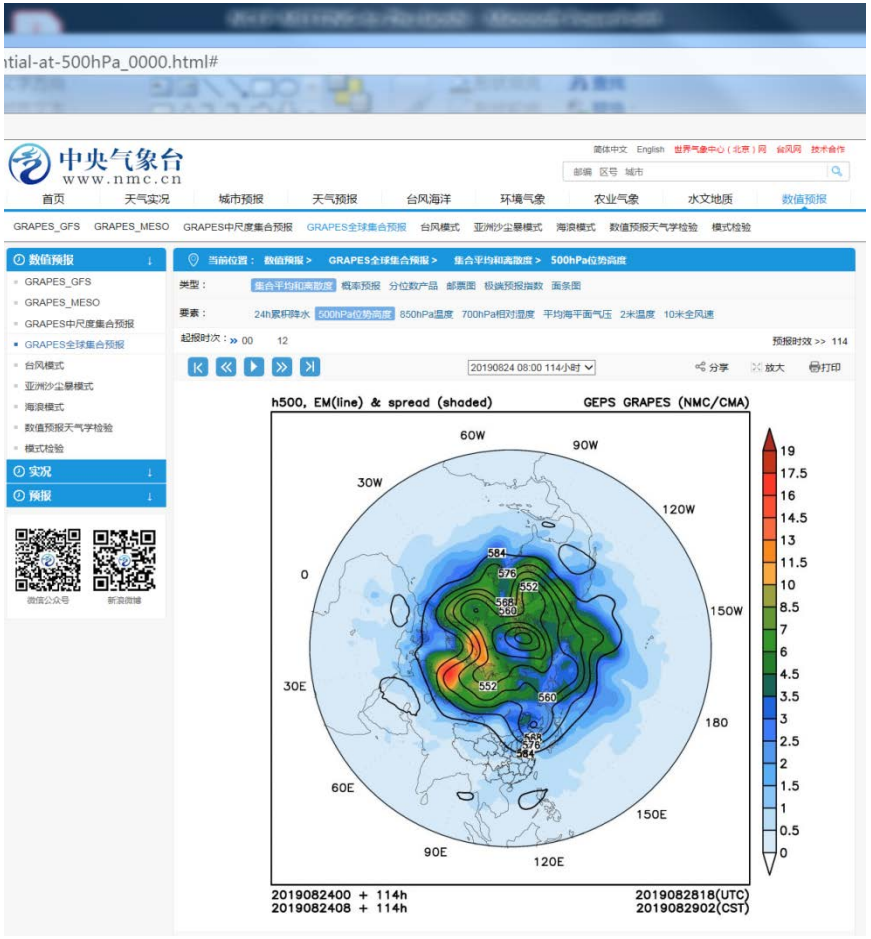
GRAPES-GEPS products on NMC web

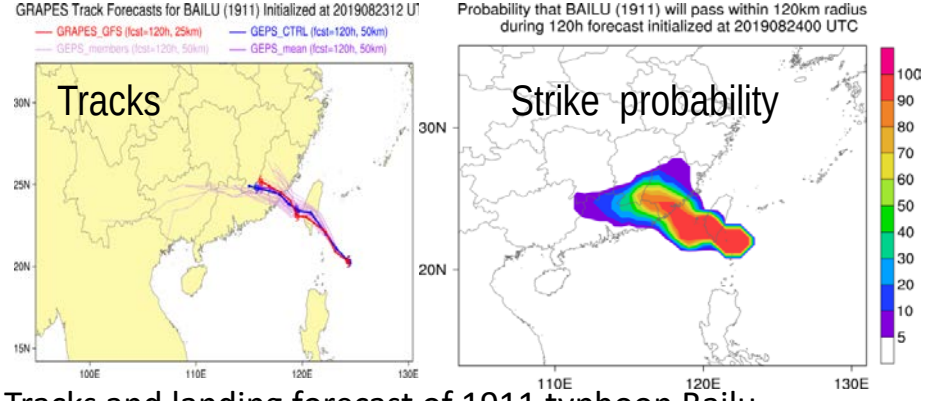
Global ensemble prediction products

- Ensemble-Mean-and-Spread
- Probability
- Mode/Maximum
- Stamps
- EFI
- Spaghetti

products of typhoon forecast

http://www.nmc.cn/publish/grapes-new/Ensemble-Mean-and-Spread/Geopotential-at-500hPa_0000.html





Tracks and landing forecast of 1911 typhoon Bailu （00UTC,24 Aug,2019)

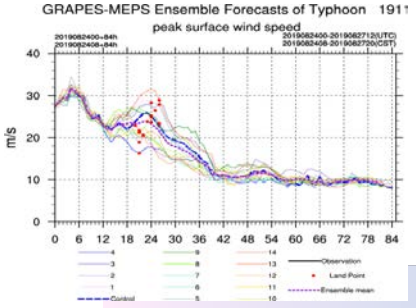
GRAPES-REPS products on NMC web

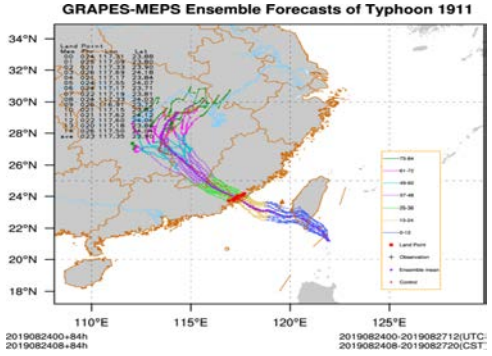
Meso-scale ensemble prediction products

- K index
- Best lifting index
- Vertical wind shear
- Convective Inhabitation
- Convective available potential energy
- Combined radar reflection ratio

landfall typhoon forecast

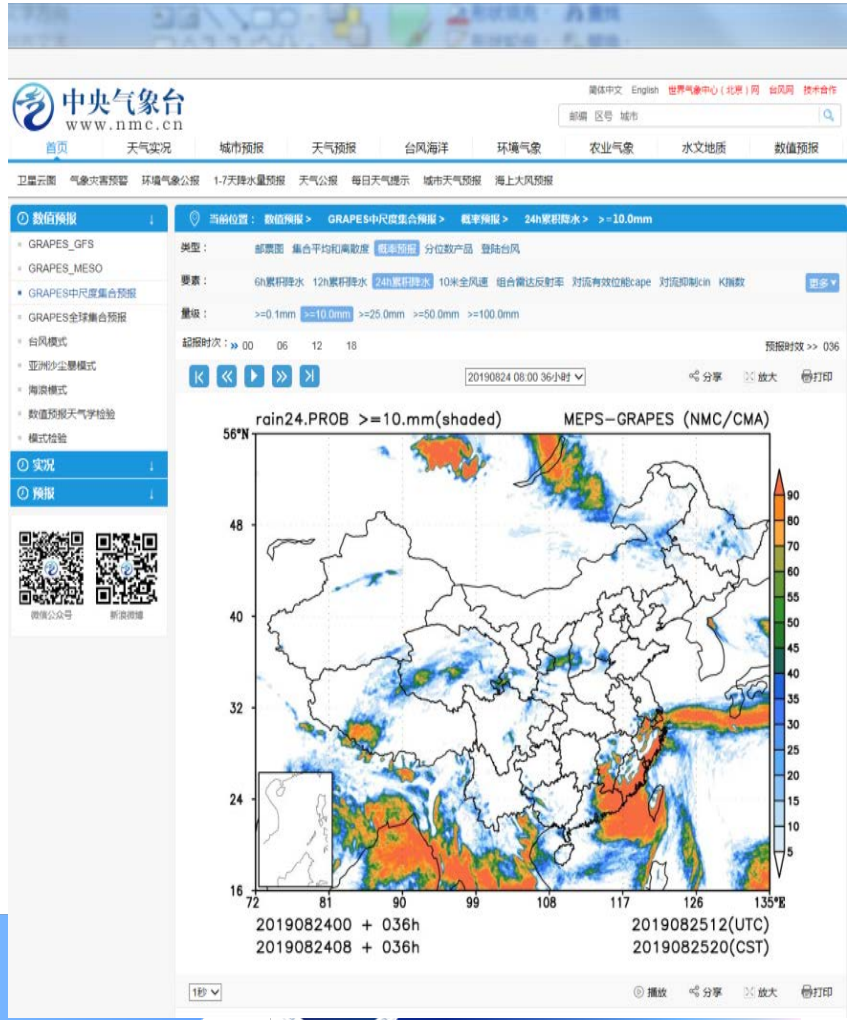
- Landing time
- Landing location
- Landing intensity



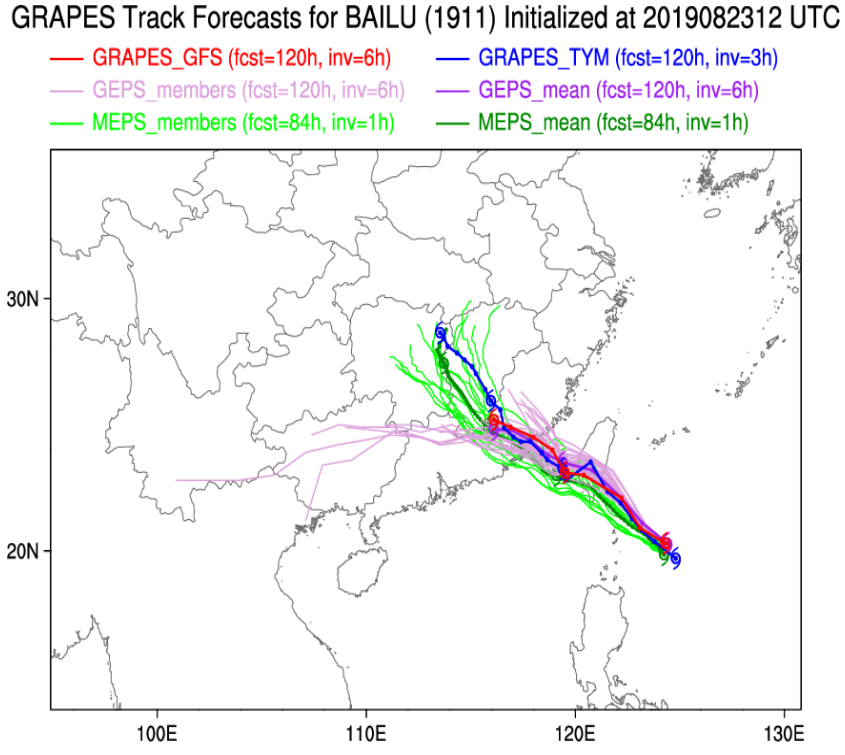


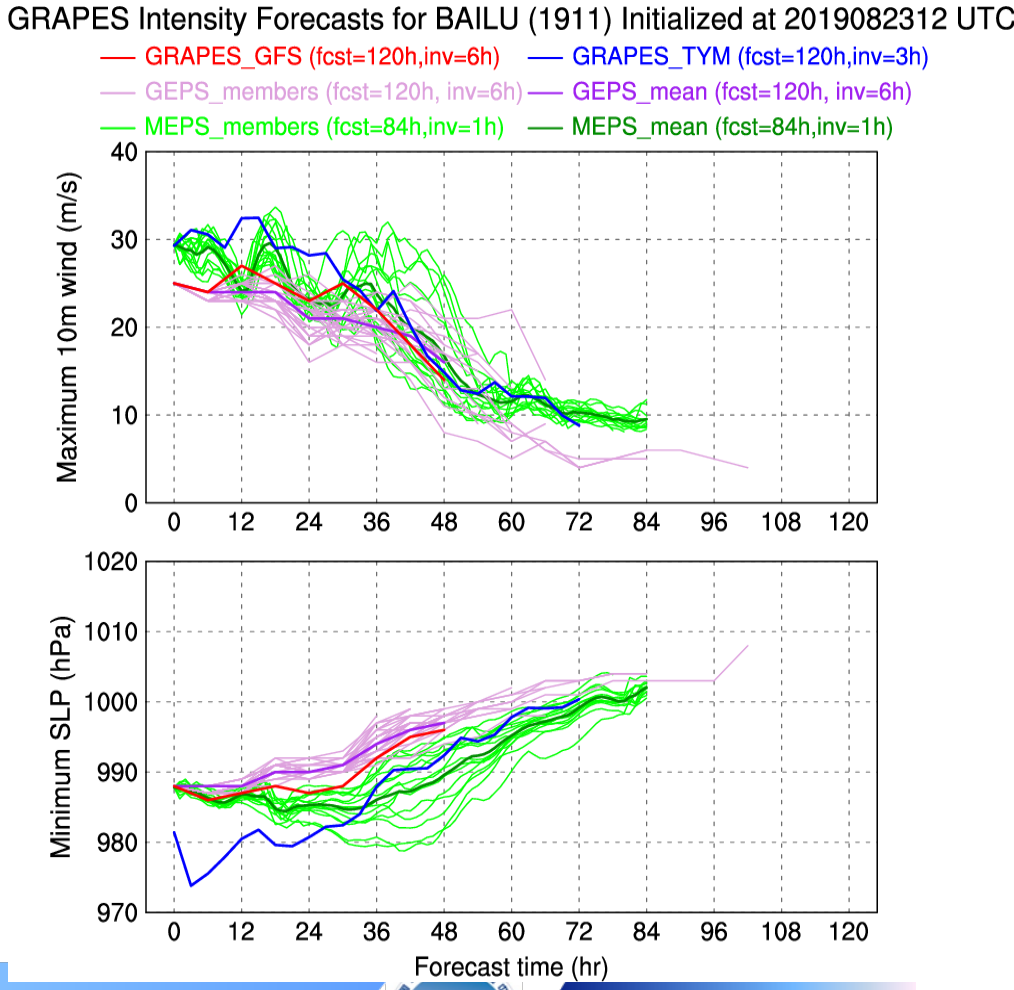
Tracks and landing forecast of 1911 typhoon Bailu（00UTC,24 Aug,2015)

(http://www.nmc.cn/publish/nwpc/grapes-regional/index.html)



Synthesis of GRAPES global and regional ensemble forecasts for TC track and intensity

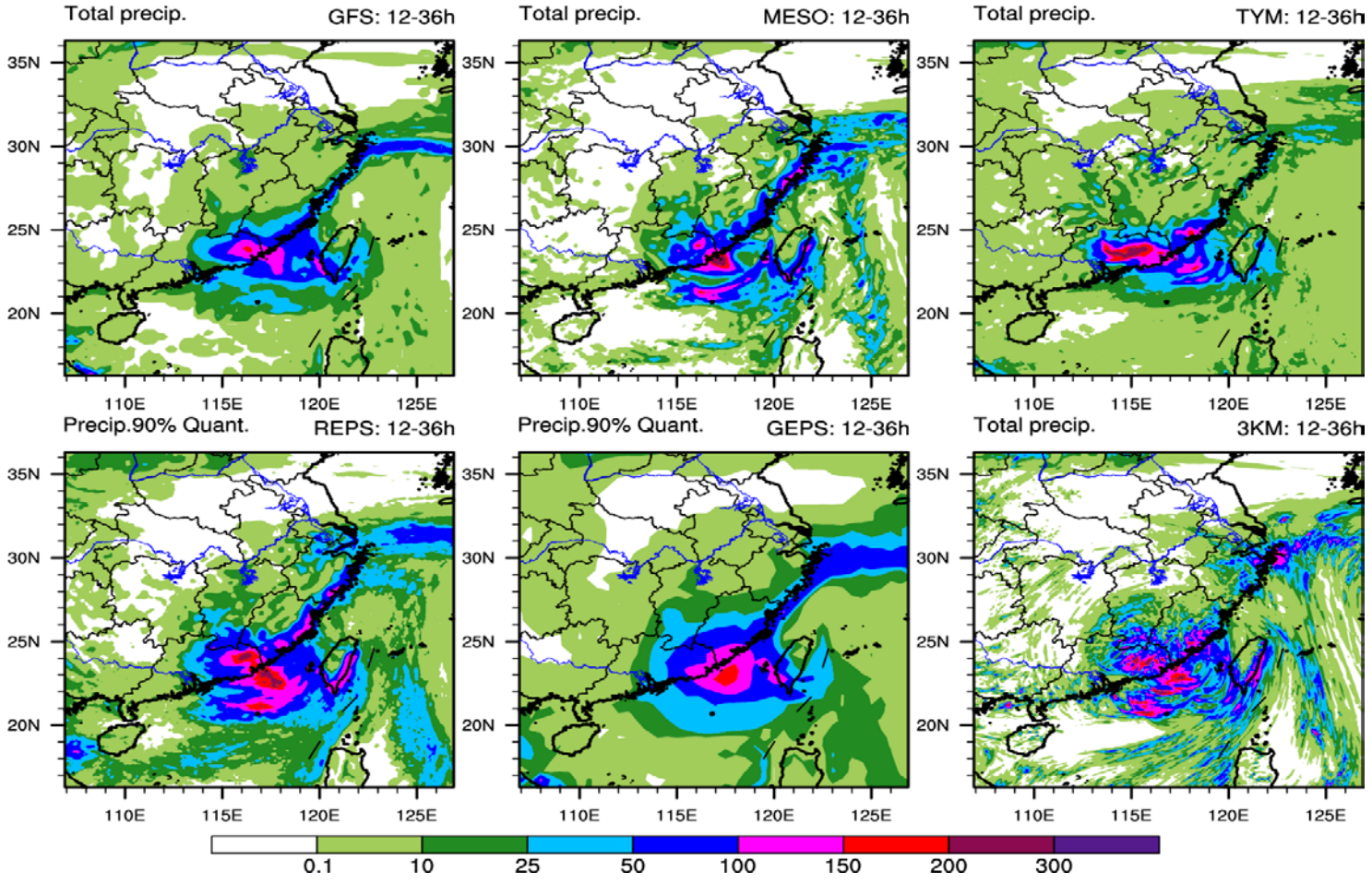




1911 Typhoon Bailu

Ini: 12UTC, 23 Aug, 2019

Synthesis of GRAPES global and regional ensemble forecasts for TC precipitation



1911 Typhoon Bailu Ini: 12UTC, 23 Aug, 2019

4. Future Plan (2019-2021)

- To improve the SVs computing efficiency
- To improve SPPT, SKEB and SPP
- To develop 25km Global EPS
- To develop 3km convective-permitting REPS over China

Thanks!

Questions?

List of GRIB2 digital data of GRAPES-GEPS and -REPS

No.	Elements	（Categ. / NO.）	Unit	Ini.	Fore.	Level No.	Level	levels
1	位势高度Geoptential height	3 / 5	位势米	00 12	000, 003 006, 009, 012, 015, 018, 021, 024 027 030, 033 036, 039, 042, 045, 048, 051, 054, 057, 060, 063, 066, 069, 072	100	16	100,200,300,400,500,600,650,700,750,800,850,900,925,950,975,1000
2	温度（Temperature）	0 / 0	K					
3	东西风（U component wind）	2 / 2	m/s					
4	南北风V component wind）	2 / 3	m/s					
5	垂直速度（Vertical velocity）	2 / 9	m/s					
6	比湿（Specific humidity）	1 / 0	kg/kg					
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20	K指数(K index)	7 / 2	K					
21	地面气压(surface pressure)	3 / 0	Pa			1	1	
22	地表温度(surface temperature)	0 / 0	K					
23	总降水量(total precipitation)	1 / 8	Mm					
24	对流有效位能（convective available potential energy, CAPE）	7 / 6	J/kg					
25	对流抑制能量（Convective Inhibitation）	7 / 7	J/kg					