

Radar Data Quality Control, 3D Mosaic System and its Application with Cloud Analysis

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National Meteorological Center of CMA

2016-07-28



Key Components

1.

Radar data status and applications

2.

Radar data quality control

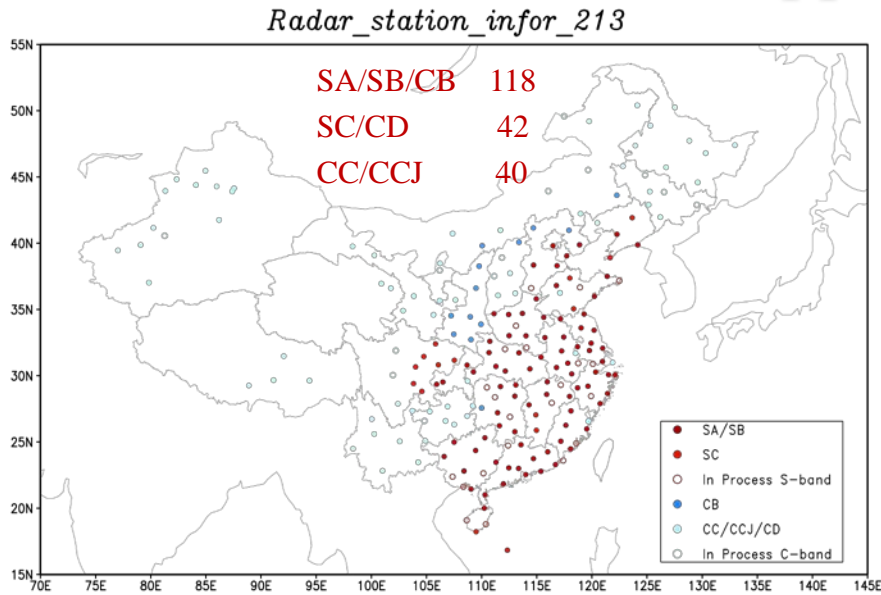
3.

3D mosaic operational system

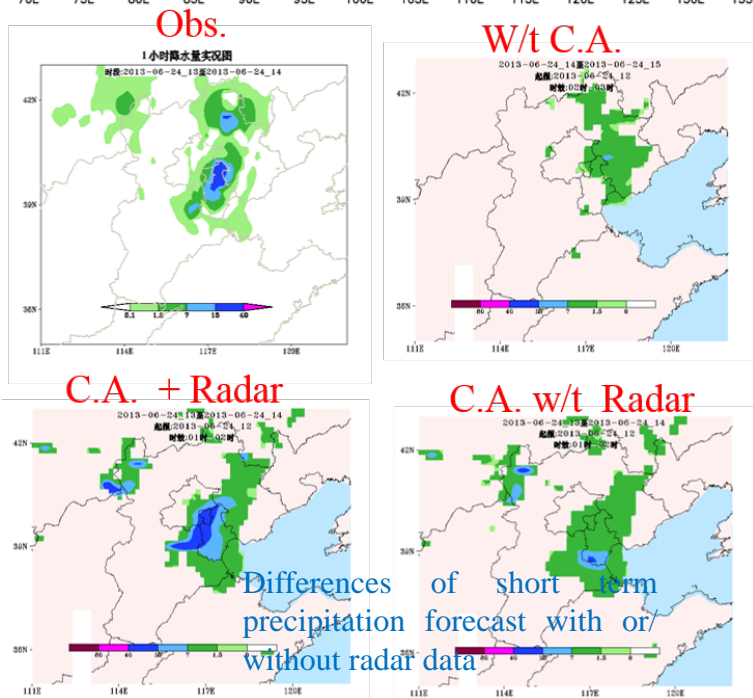
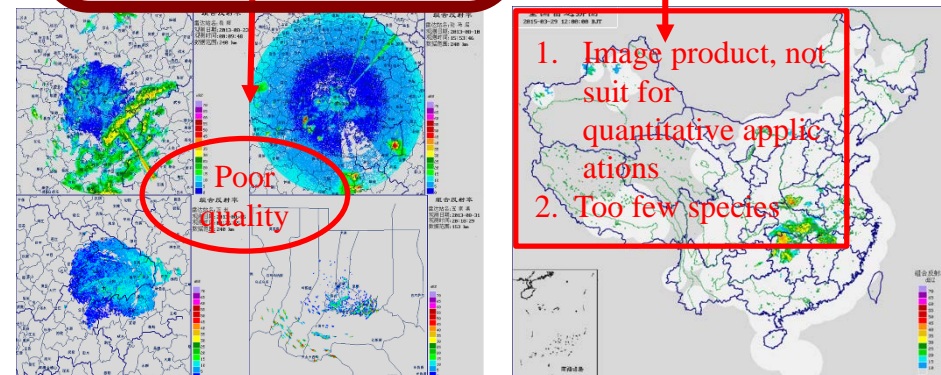
4.

Application with Cloud-Analysis

1. Radar data status and applications

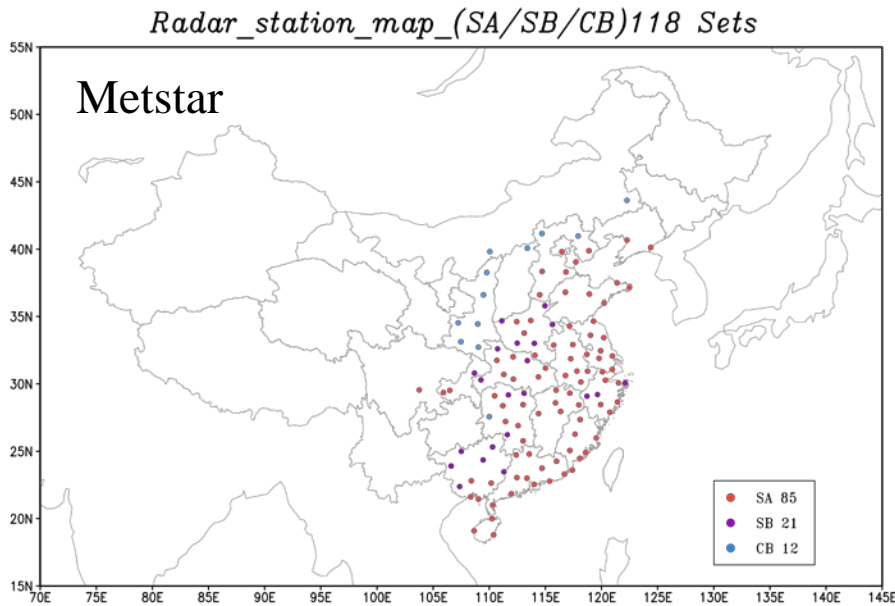


Radar Data



- ✓ Lots of radar data, but poor quality of base data makes quantitative applications impossible
- ✓ The existing products are difficult to meet the operational need of national numerical prediction system
- ✓ Without using radar reflectivity data in regional assimilation, small range and weak structure of precipitation appears in the short term forecast

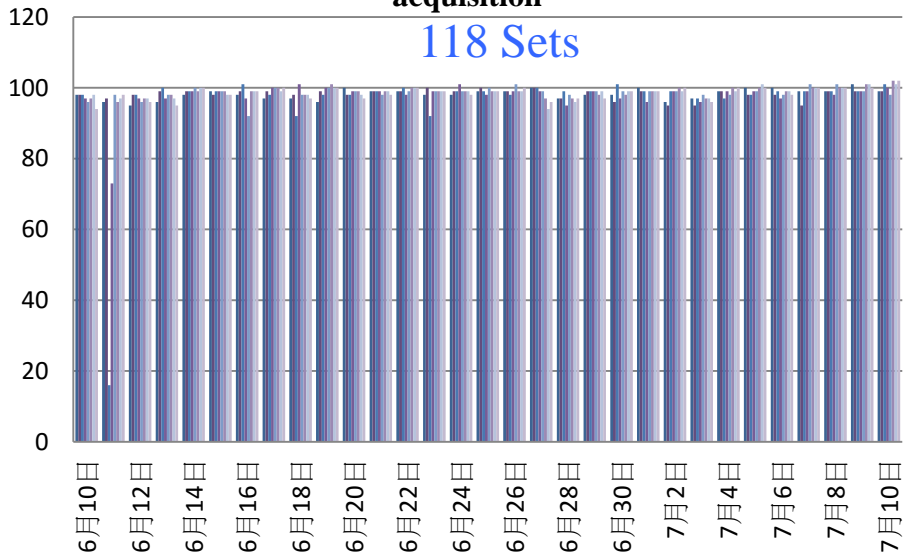
Radar base data acquisition and quality issues



20150610-20150710

Radar base data (SA/SB/CB) real-time (45min) acquisition

118 Sets



Radar reflectivity quality issue cases summary

- Statistical time :
July, Oct., Sept. 2013
- Thousands of EMI
- Hundreds of AP clutter
- Hundreds of TP

Courtesy of CMA Meteorological Observation Center



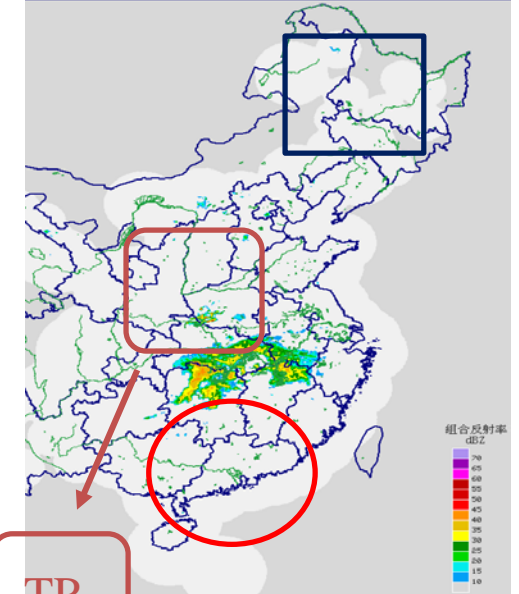
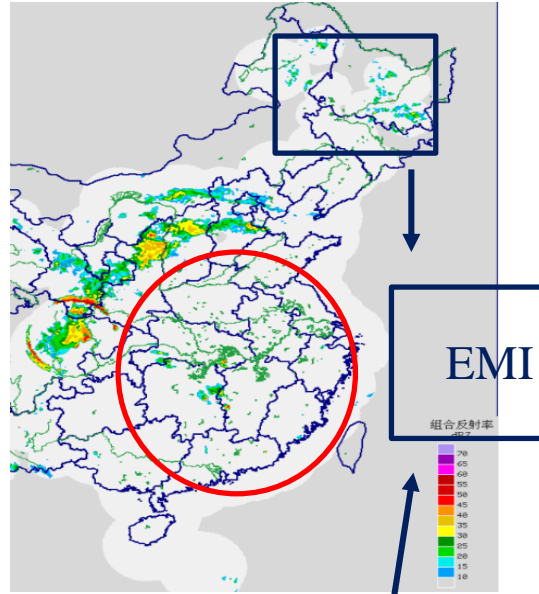
2013

National radar mosaic/118 (SA/SB/CB) 2014/12

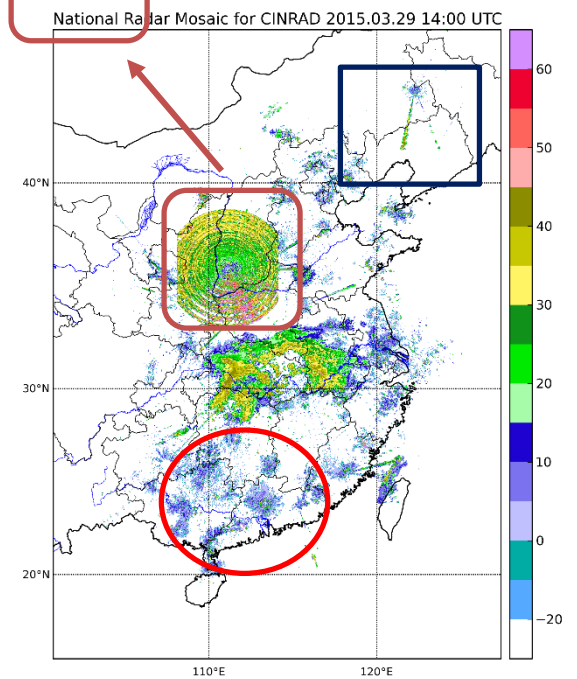
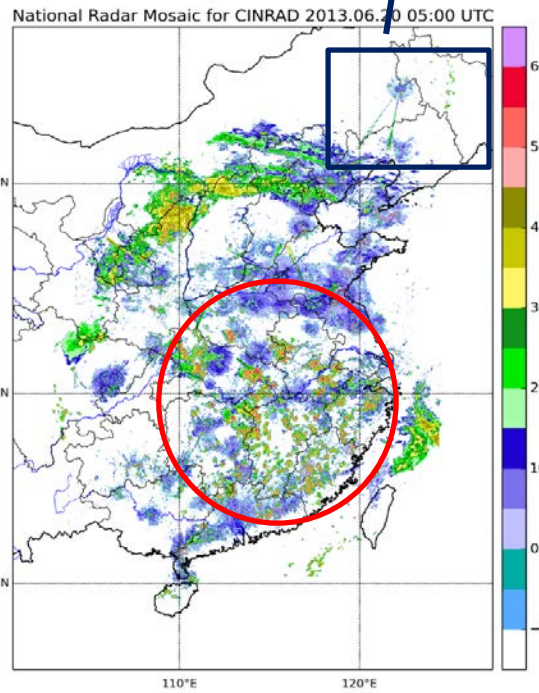
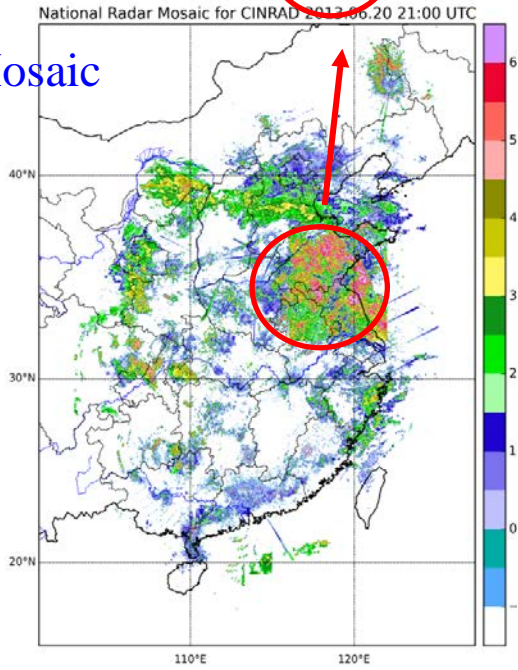
Linux Workstation

Radar data quality issues

Observation



3D Mosaic

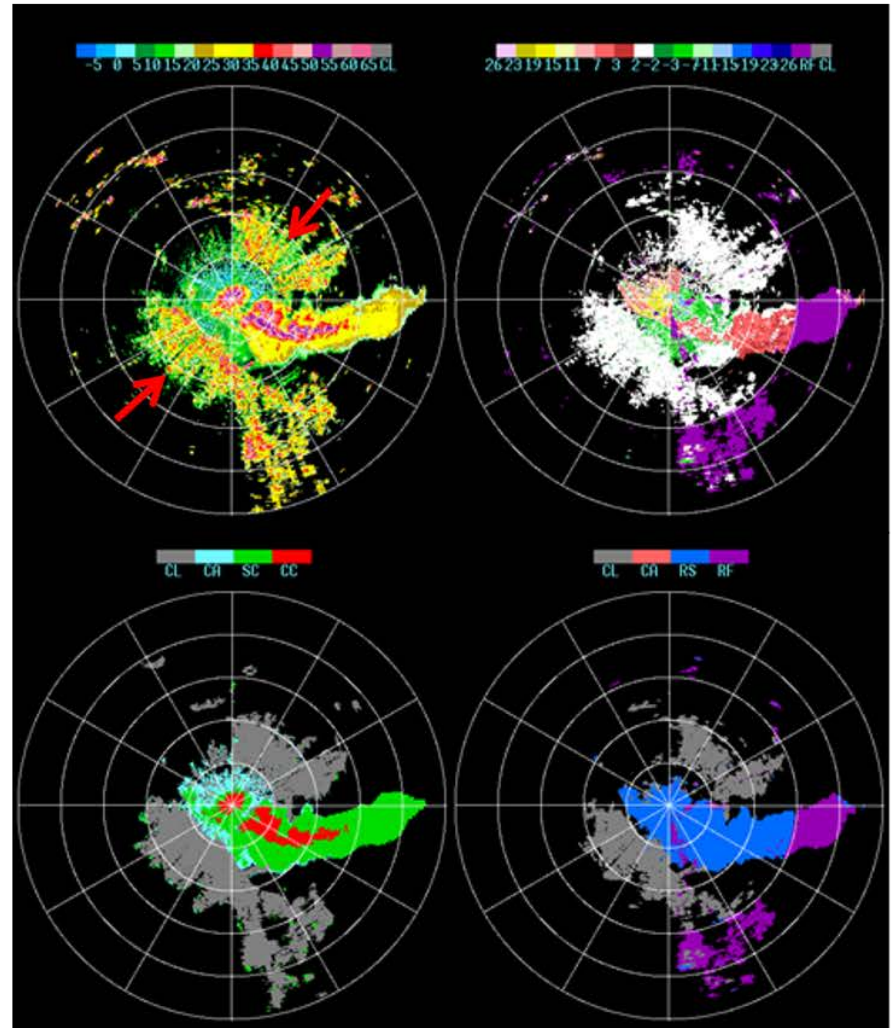
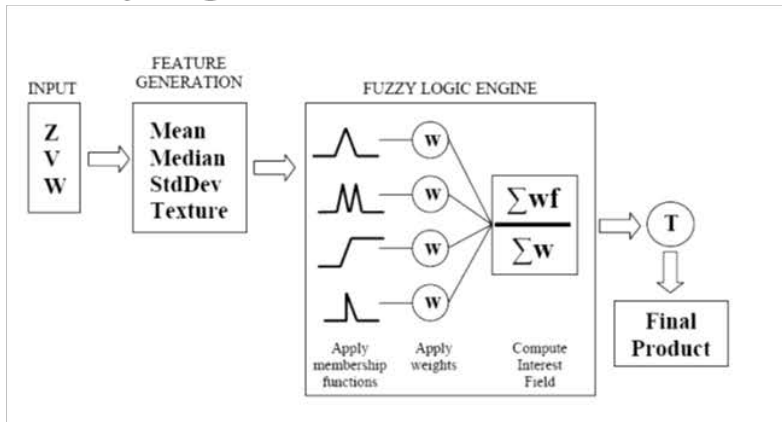


2. Radar data quality control system (2014)

a. Abnormal Propagation Clutter

Tianjin
2005/6/21 12:13UTC
0.5 tilt

Fuzzy logic method



Characteristic Parameters

雷达测高
测风测速

$$GDBZ = w(R)(Z_{up} - Z_{low})$$

$$TDBZ = \frac{\sum_{i=1}^{NA} \sum_{j=1}^{NR} (Z_{i,j} - Z_{i,j+1})^2}{NA \times NR}$$

雷达中心
区域测高

$$SDVE = \left[\frac{\sum_{i=1}^{NA} \sum_{j=1}^{NR} (MDVE_{i,j} - \overline{MDVE})^2}{NA \times NR} \right]^{1/2}$$

$$SIGN = \frac{\sum_{i=1}^{NA} \sum_{j=1}^{NR} M_{zdv}}{NA \times NR}$$

$$M_{zdv} = \begin{cases} 1 & Z_j - Z_{j-1} > 0 \\ 0 & Z_j - Z_{j-1} \leq 0 \end{cases}$$

风向已反转
或变化异常

$$SPIN = \frac{\sum_{i=1}^{NA} \sum_{j=1}^{NR} M_{spin}}{NA \times NR}$$

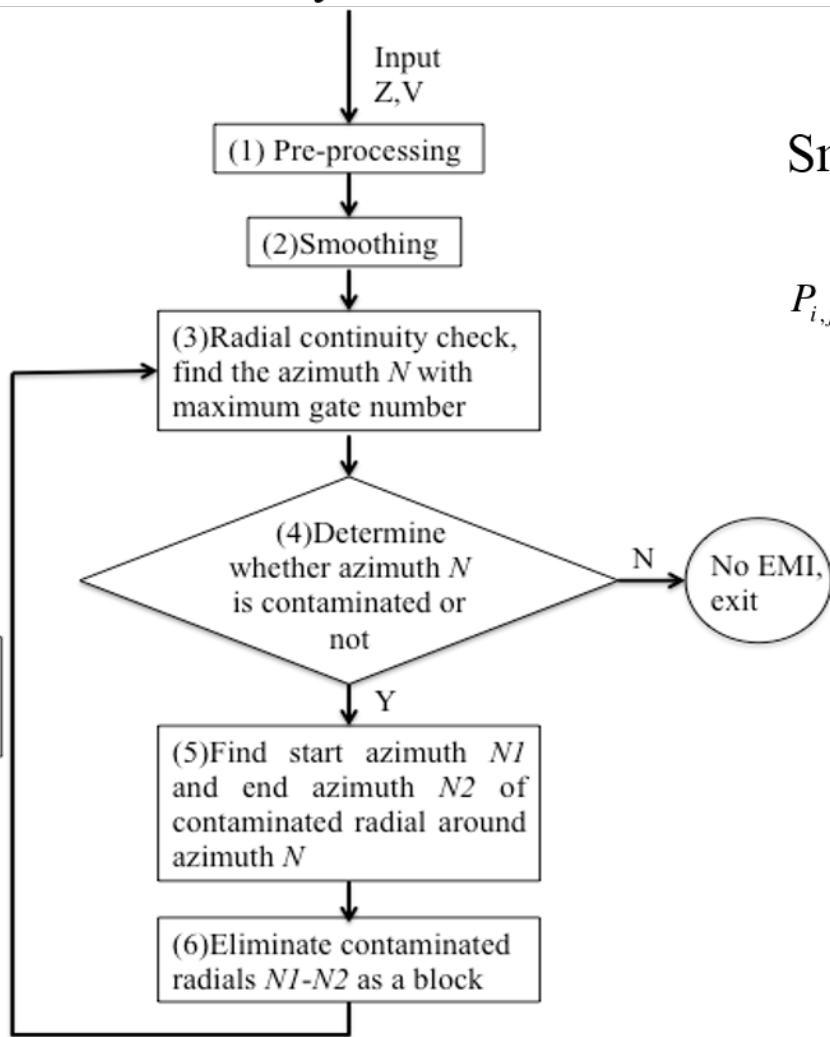
$$M_{spin} = \begin{cases} 1 & |Z_j - Z_{j-1}| > Z_{max} \\ 0 & |Z_j - Z_{j-1}| \leq Z_{max} \end{cases}$$

Z: NA*NR
5*5
V: NA*NR
5*9

(Y. Jiang, L. Liu et.al, 2009)

b. Electromagnetic Interference (EMI)

Radial continuity check



The EMI echo refers to the radar echo caused by outside equipment working in the same frequency or near frequency, which generally appears as spiral shape or full of dots all over PPI, or radial shape.

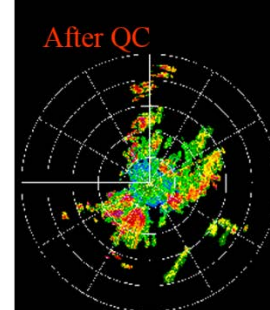
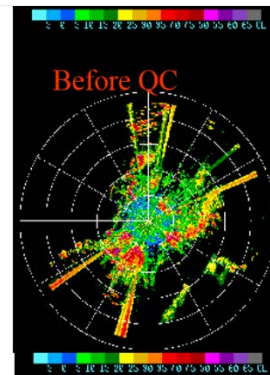
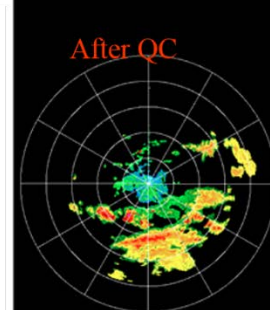
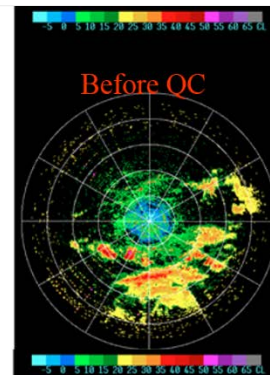
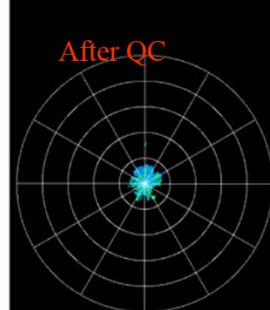
Smoothing

$$P_{i,j} = \frac{\sum_{i-2}^{i+2} \sum_{j-2}^{j+2} N_z \times 100}{5 \times 5} \% < 55\% \quad N_z = \begin{cases} 1 & Z_{i,j} \neq spval \\ 0 & Z_{i,j} = spval \end{cases}$$

Qingdao
2008/10/24 0351UTC
0.5 tilt

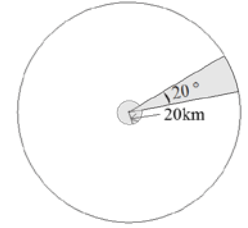
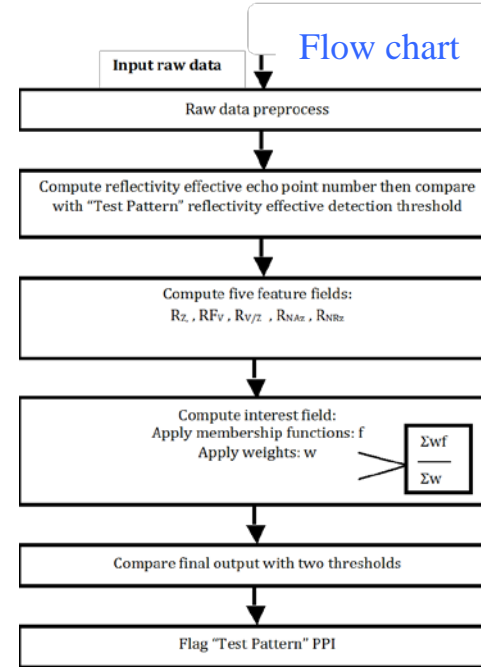
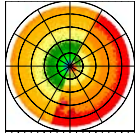
Qinddao
2008/07/30 0103UTC
0.5 tilt

Puyang
2008/07/15 1154UTC
0.5 tilt



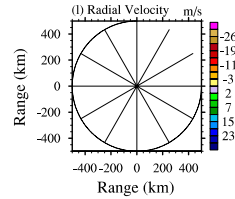
(Y. Jiang, L. Liu, et.al, accepted)

c. Test Pattern



W:
3, 1, 1, 1, 1

T:
0.48
0.28, when $Rv/z > 55\%$

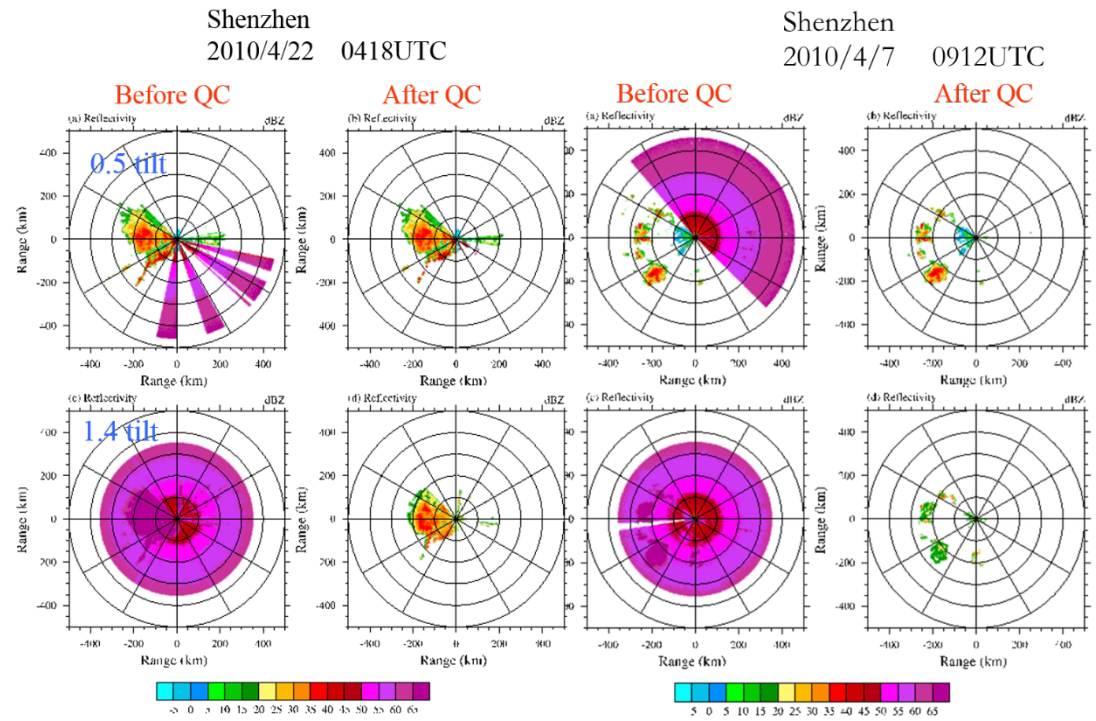


Test pattern caused by various factors, such as test signal or unclear radar hardware failures in CINRAD.

Features:

1. Contaminated reflectivity with not-contaminated velocity.
2. Contaminated reflectivity and velocity with Range Fold value.
3. Appear at lower tilts, and sometimes at higher tilts.
4. Covers full of PPI, or semicircular, or fan-shaped, or radial shaped.
5. Reflectivity does not change much azimuthally, but increases with range.

(Y. Jiang & L. Liu, 2014, *Adv. Atmos. Sci.*)



Radar Data Quality Control Scheme - IBM

Step 1

Retrieve radar
base data
(SA/SB/CB)

Step 2

Input Z, V,
SW

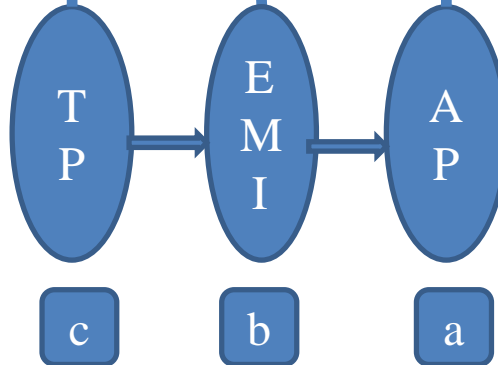
Pre-
processing

Quality
control
check

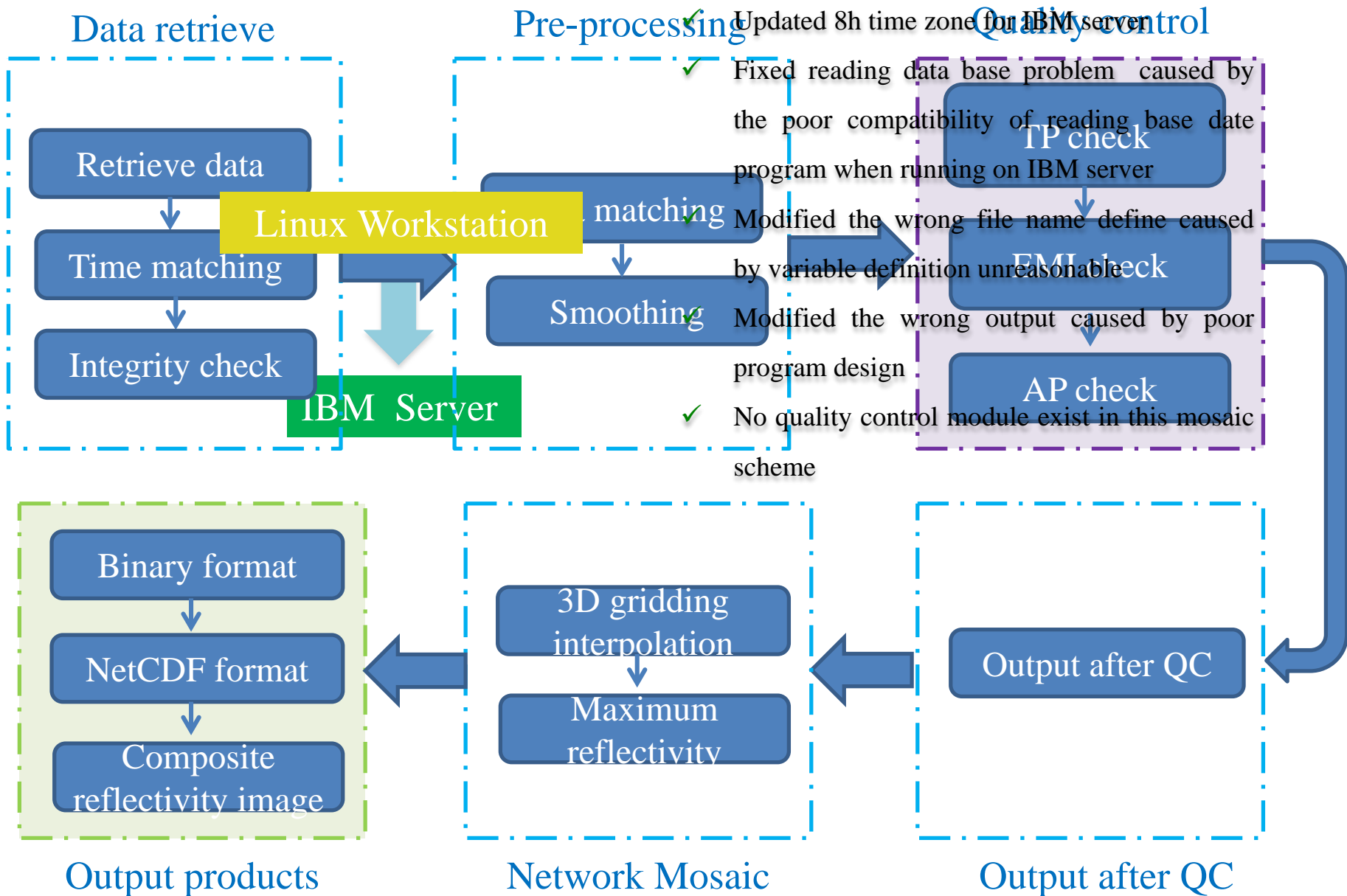
Step 3

Output base
data format

- ✓ Follow a certain order
- ✓ Quality over quantity



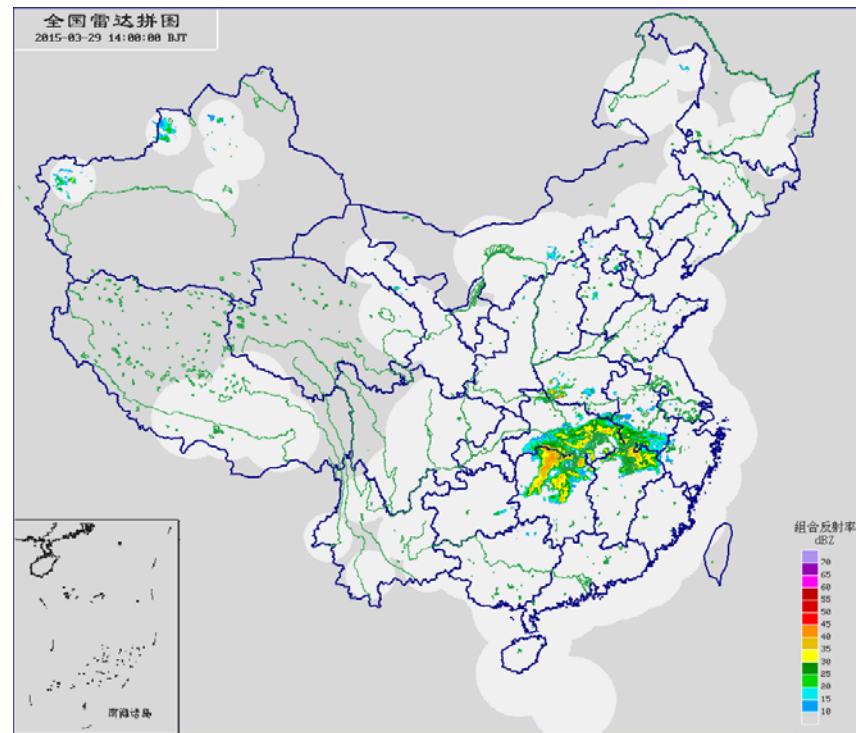
3. Radar quality control & network mosaic scheme



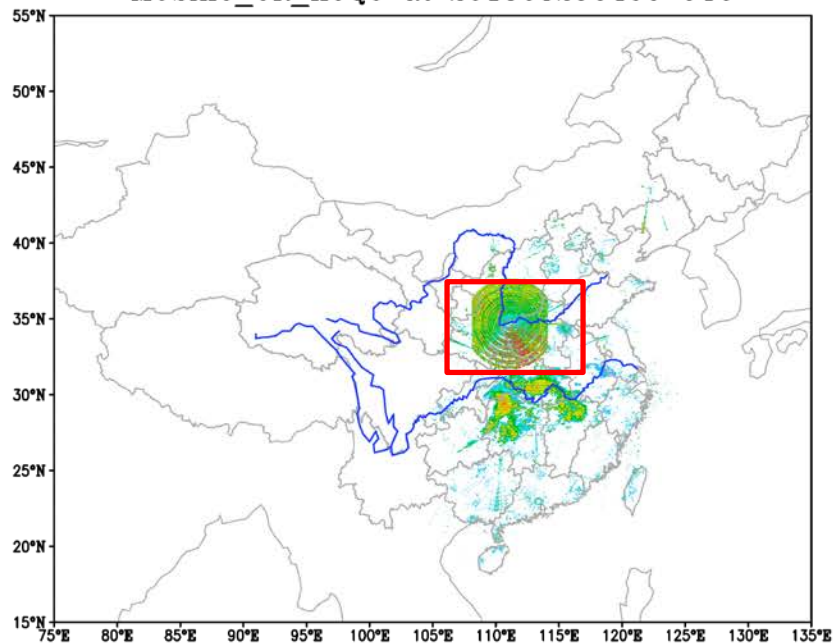
Composite reflectivity:

2015/03/29 0600UTC

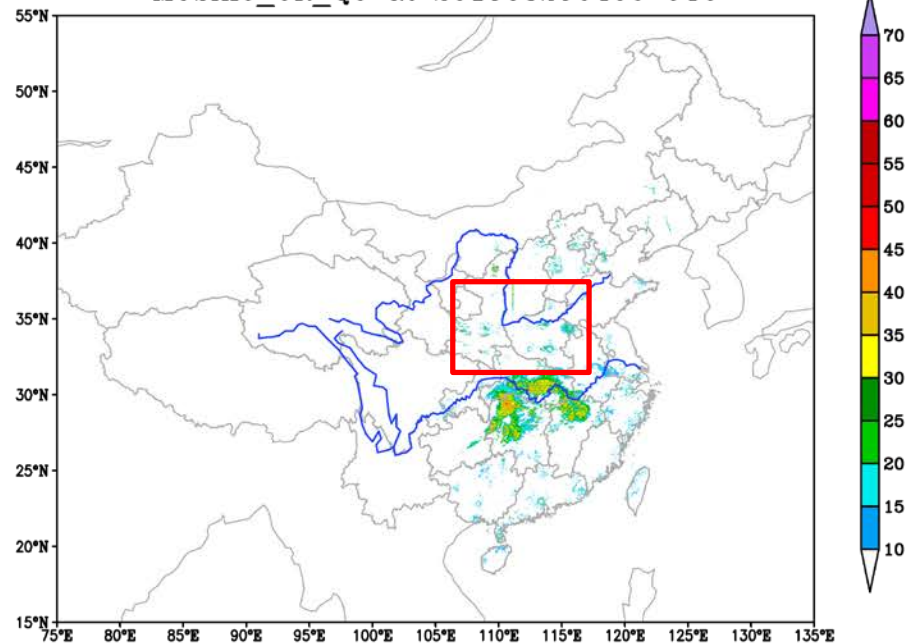
- 1) Radar Obs. (upper right)
- 2) Mosaic w/t radar QC (lower left)
- 3) Mosaic after radar QC (lower right)



MOSAIC_CR_noQC at 201503290400 UTC



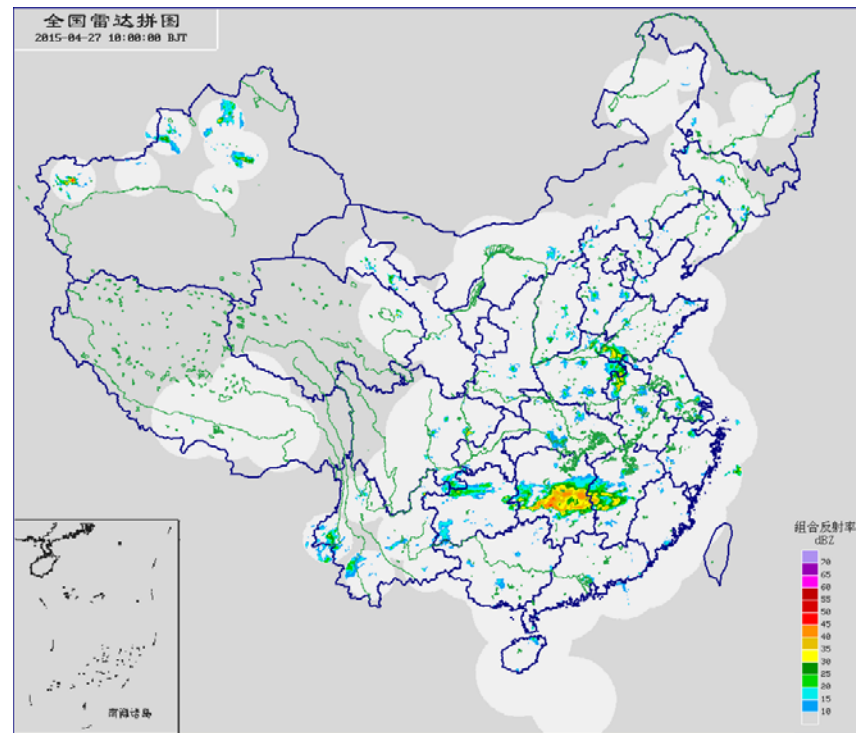
MOSAIC_CR_QC at 201503290400 UTC



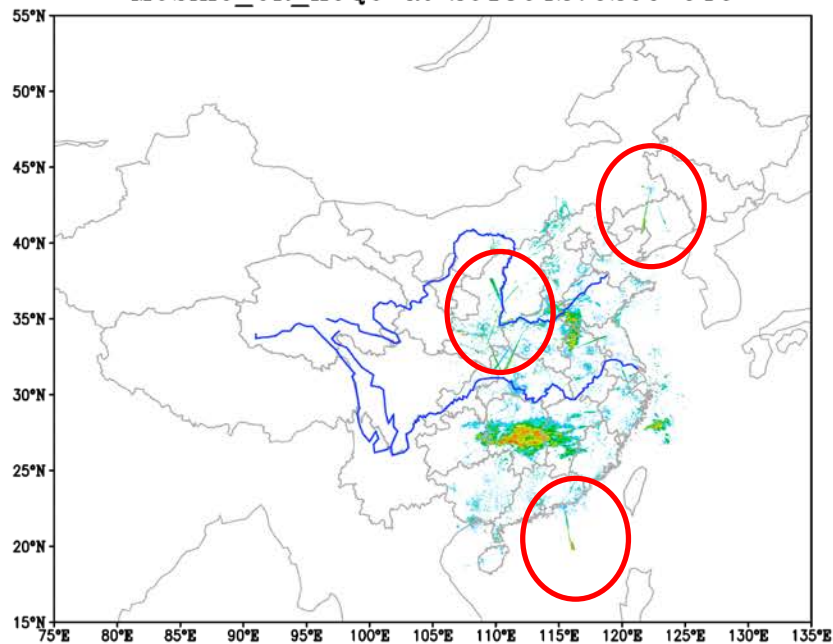
Composite reflectivity:

2015/04/27 0200UTC

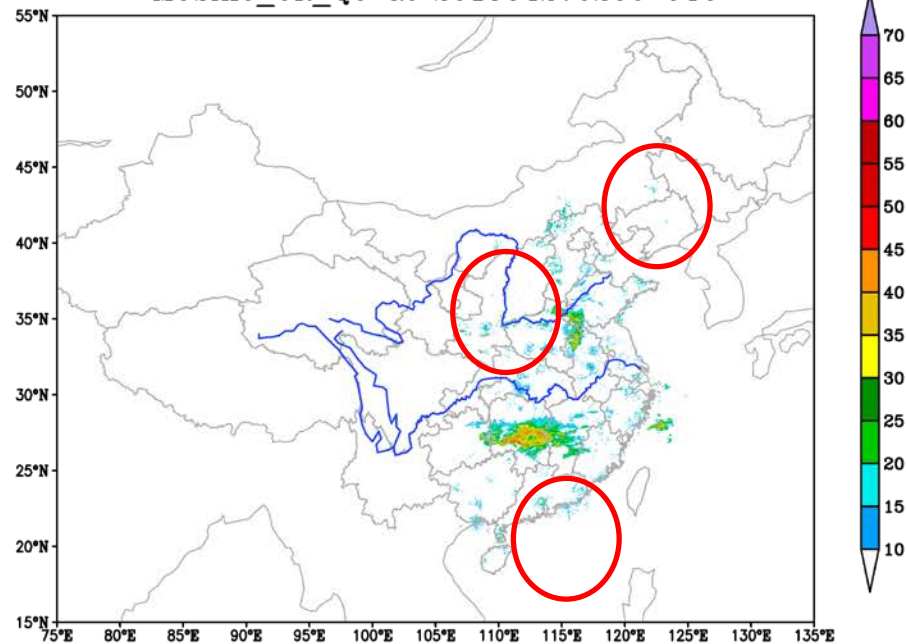
- 1) Radar Obs. (upper right)
- 2) Mosaic w/t radar QC (lower left)
- 3) Mosaic after radar QC (lower right)



MOSAIC_CR_noQC at 201504270200 UTC

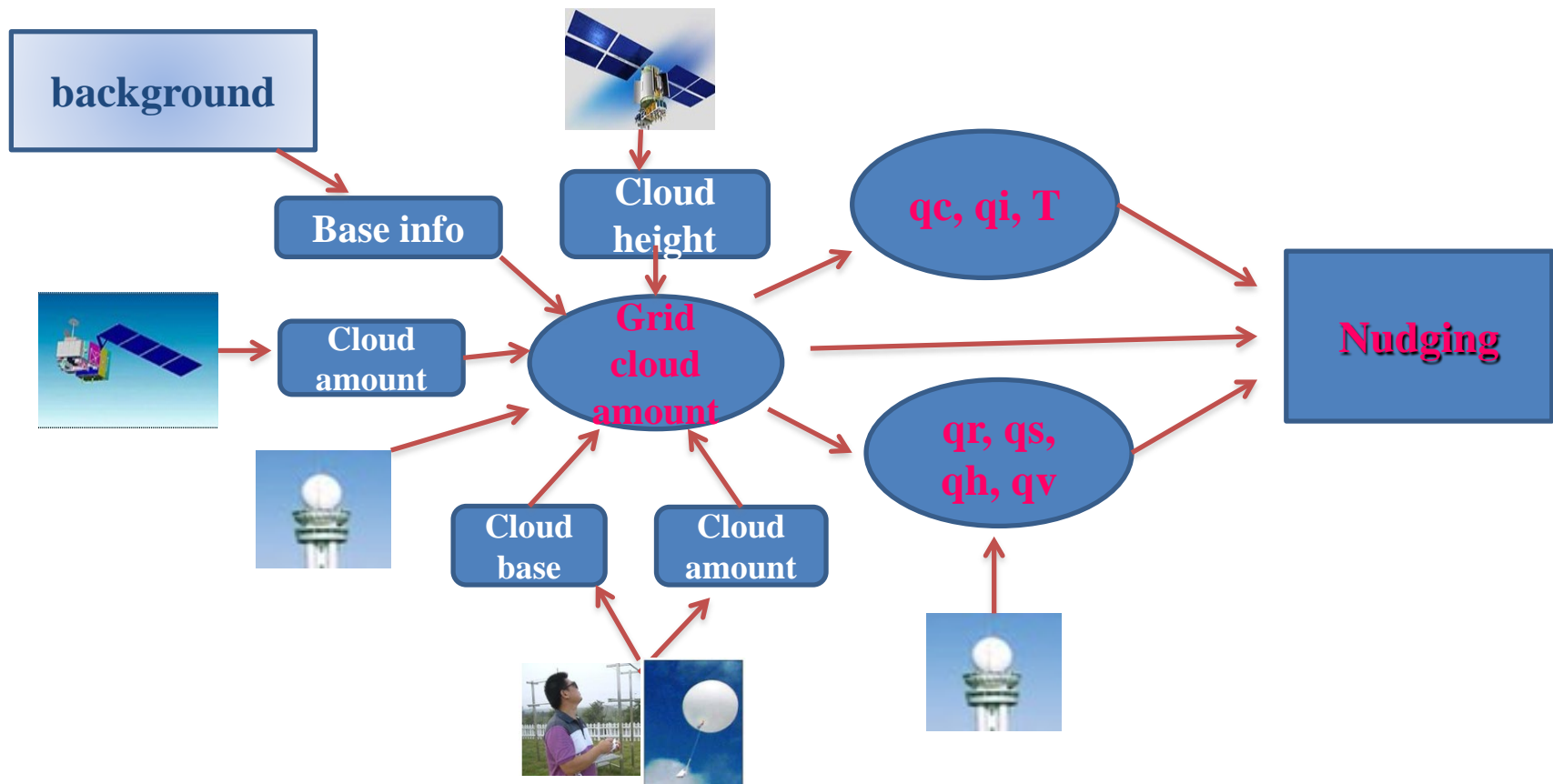


MOSAIC_CR_QC at 201504270200 UTC



4. Introduction of Cloud Analysis

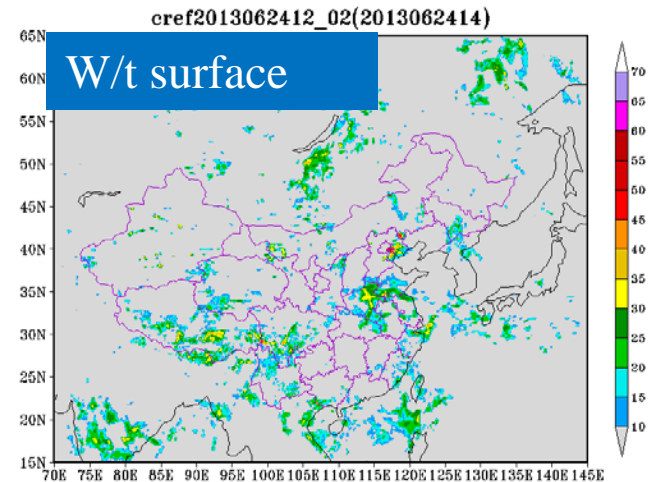
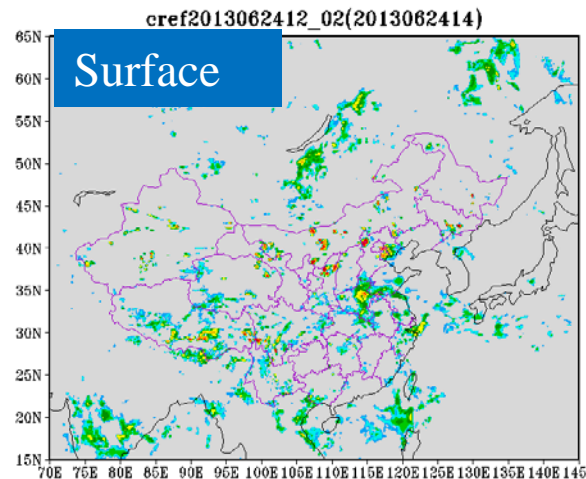
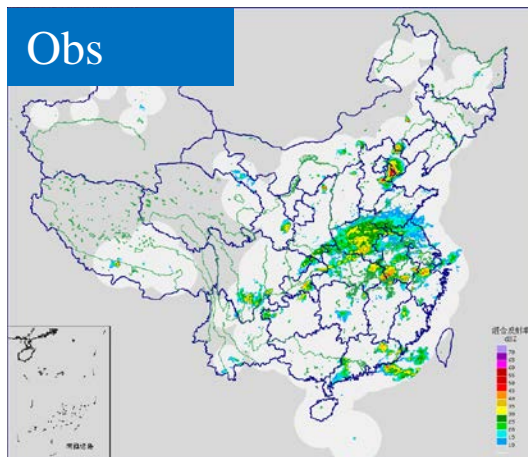
Base scheme: ARPS cloud analysis (OU)



Cloud analysis variables: $qv, qc, qi, qs, qr, qg, t$
Applying scheme in model: Nudging

Observations used in C.A.

- Observations that can be used :
- 3D Mosaic reflectivity
- FY sat. TBB, FY sat. CTA
- Surface: sounding, manual obs.



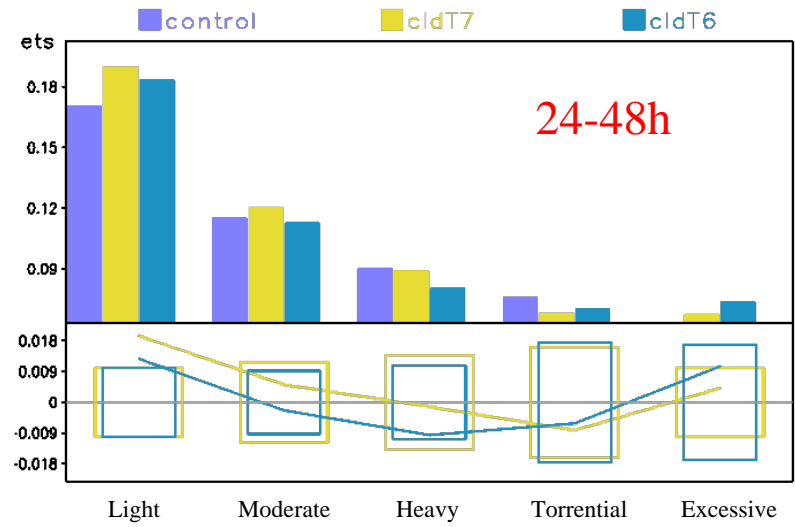
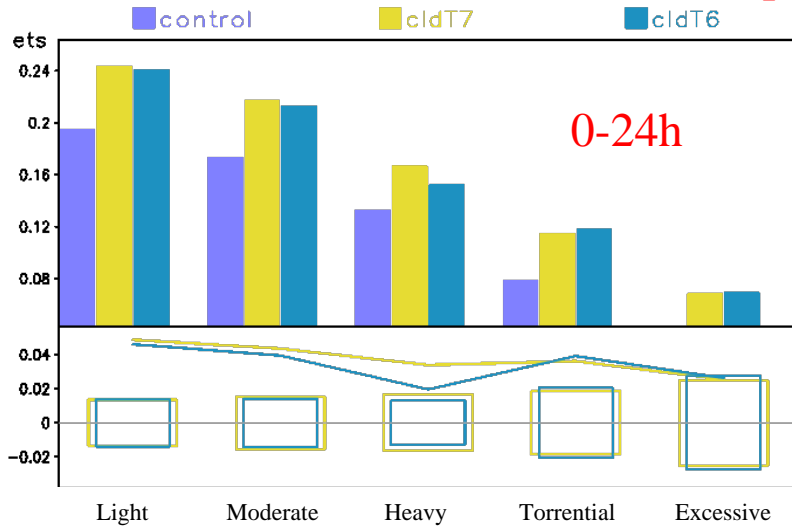
False convection
No surface observation at night

3D Mosaic reflectivity
FY sat product

ETS verification of precipitation GRAPES-Meso(3km)

(July 15th-Aug. 14th 2014)

24h precipitation ETS



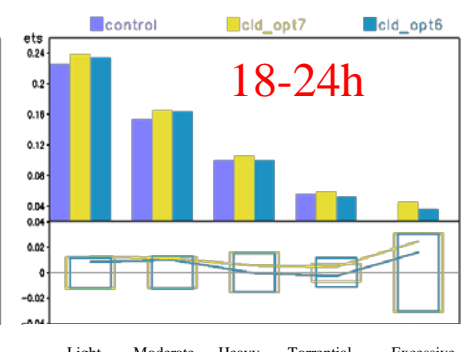
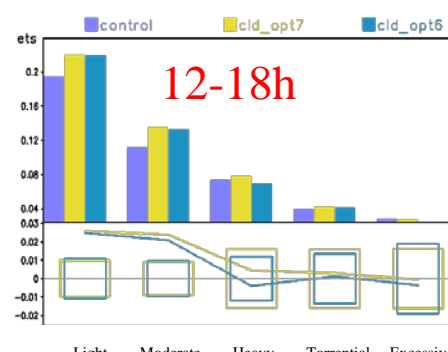
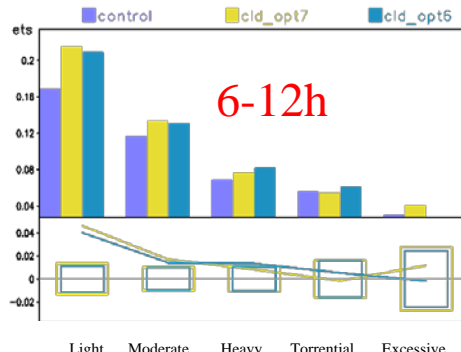
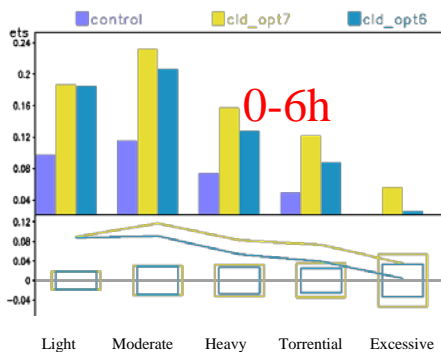
Control : W/t CA

Cld7 : CA, NCEP latent scheme

Cld6 : CA,
wet adiabatic profile

$$tten = \alpha * ref$$

6h precipitation ETS



Influence of high quality radar data

24h precipitation ETS verification

2013

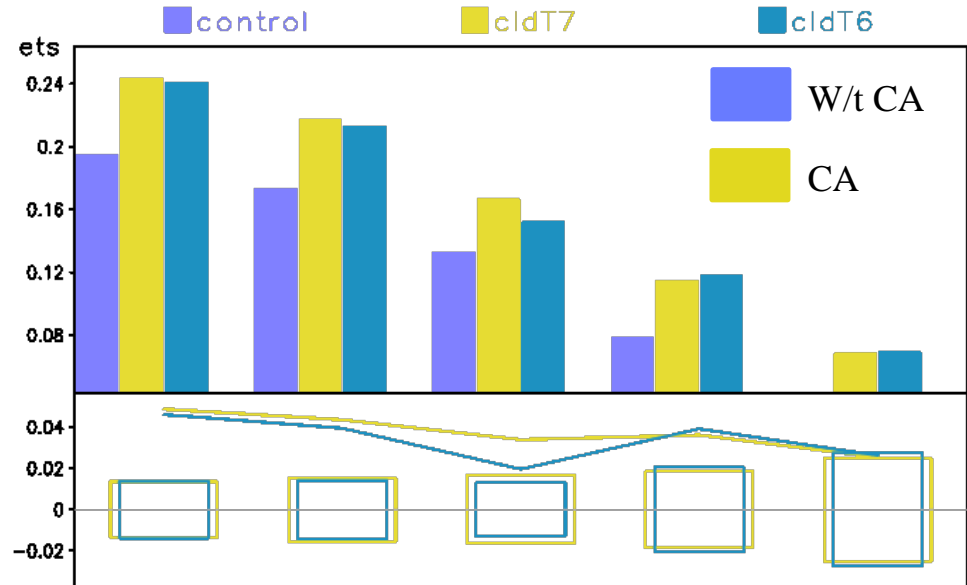
15km MESOv3.3

GFS/aob

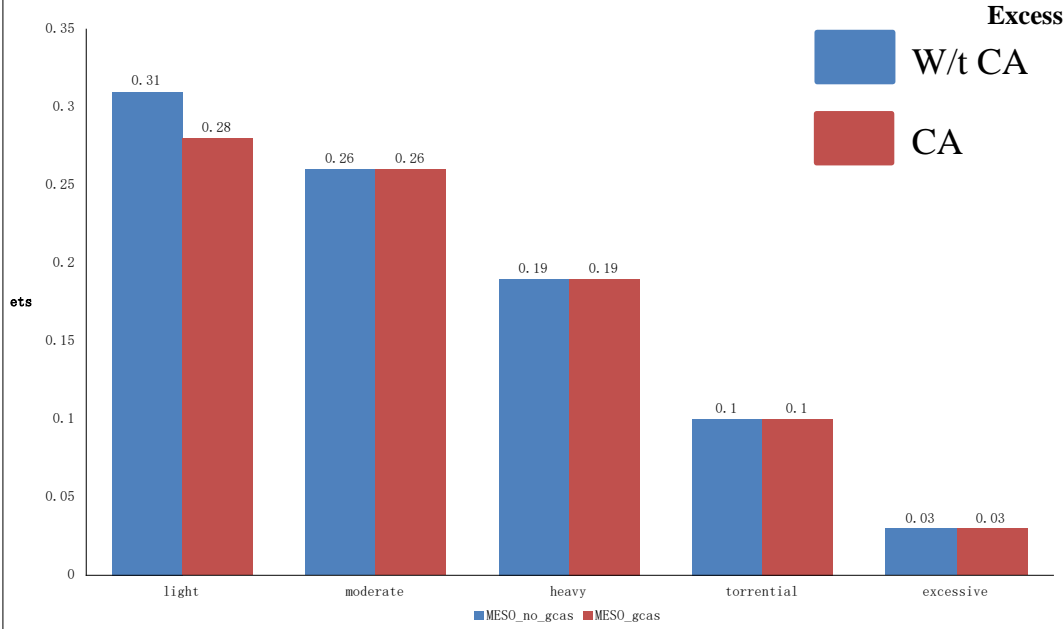
Radar mosaic (6 sets) of northern

China / W/t QC

20130601-20130630



201306 024h rain forecast accumulation test score



2015

3km MESOv4.0

T639_an

National radar mosaic

(SA/SB/CB,118 sets) / QC

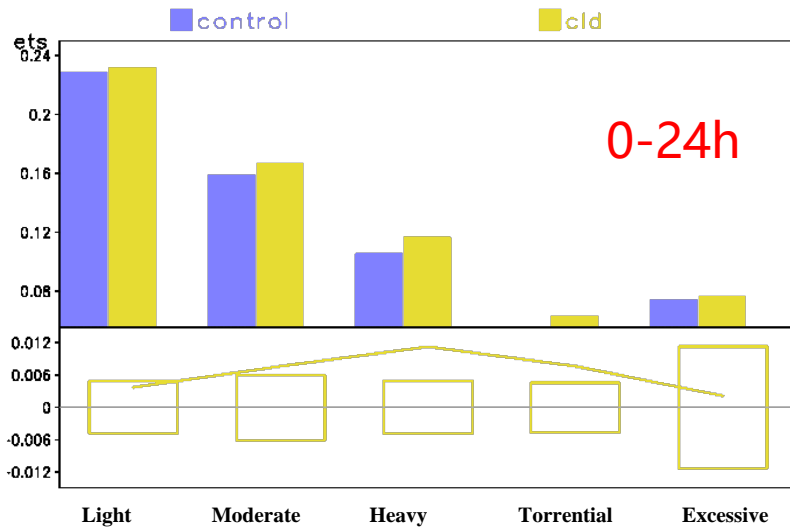
20140715-20140814

Significant improvement with assimilating high quality radar data.

Performance in different resolution

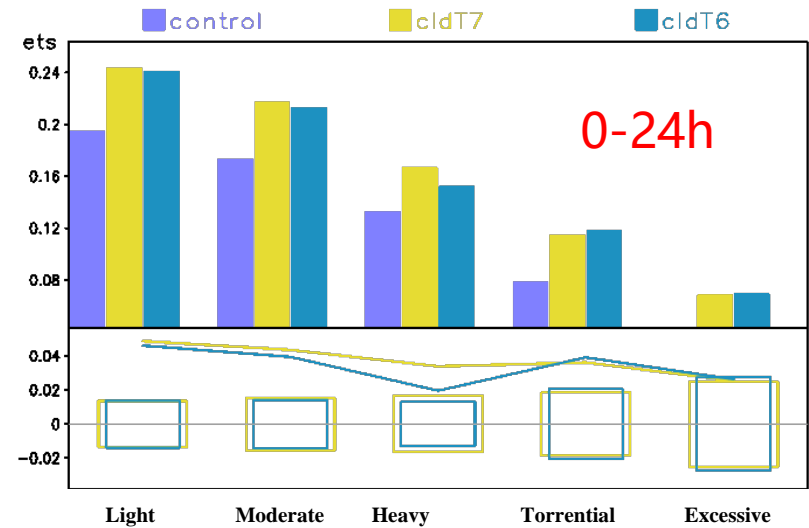
24h precipitation ETS verification

GRAPES-Meso 10km National



Control : W/t CA

GRAPES-Meso 3km South China



Cld7 : CA, NCEP latent scheme

Better performance in high resolution version, especially in heavy scale precipitation

Squall line -- July 18th 2014

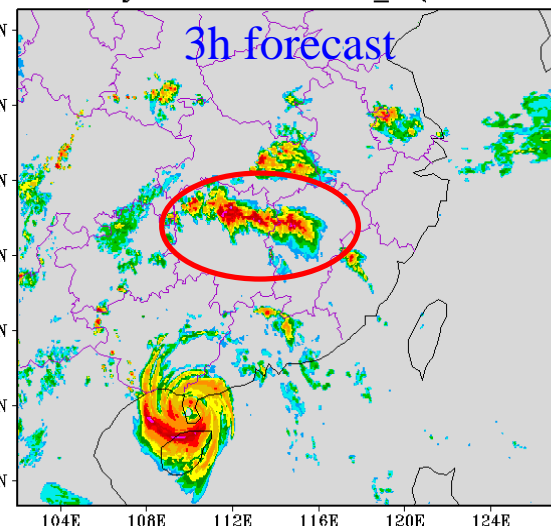
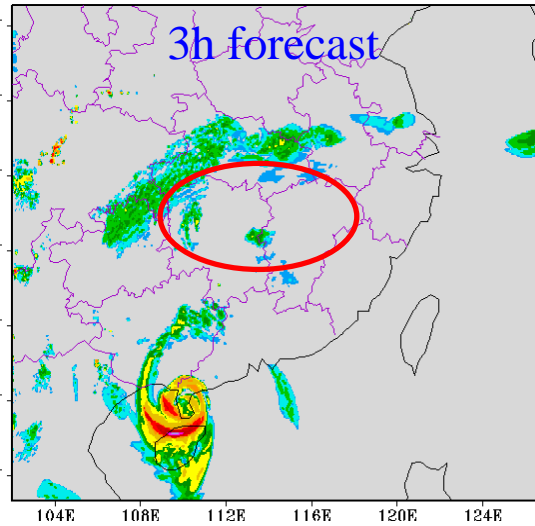
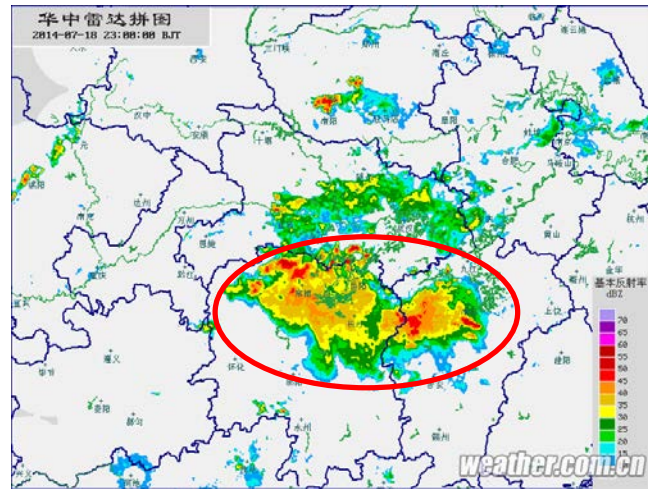
Obs

W/t CA

CA

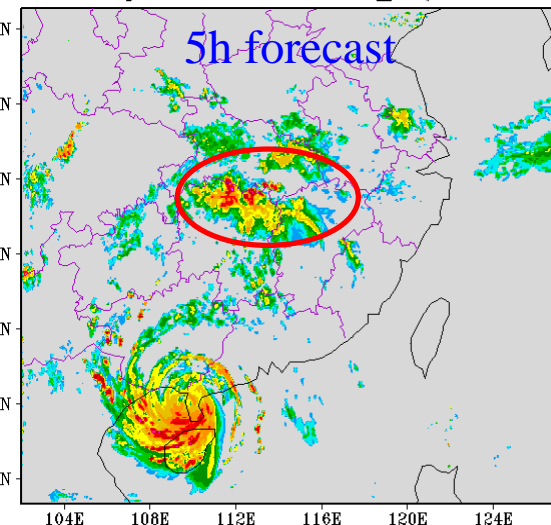
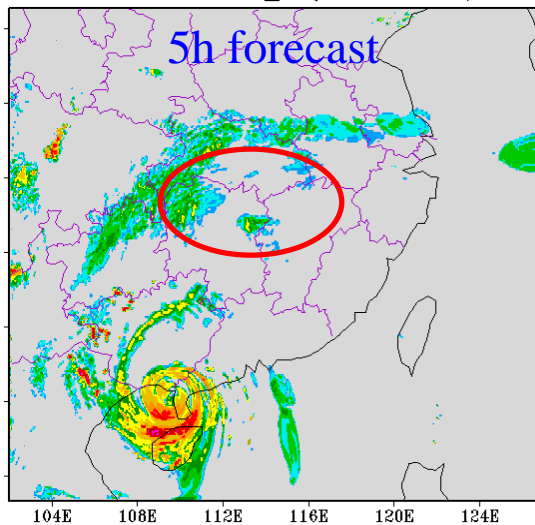
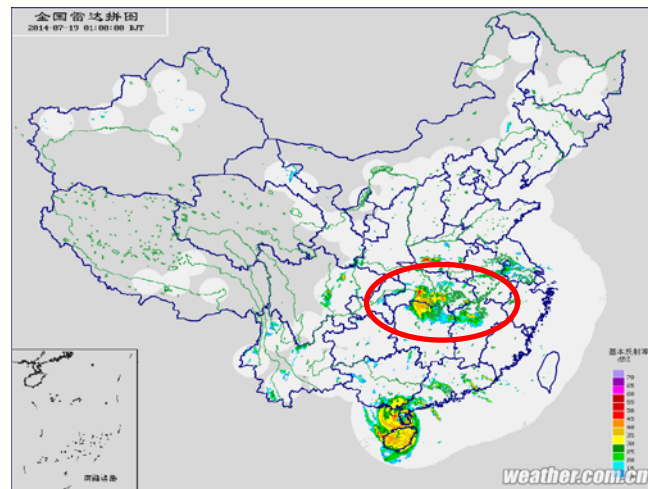
CR 2014071812_03(2014071815)

cloud analysis CR 2014071812_03(2014071815)



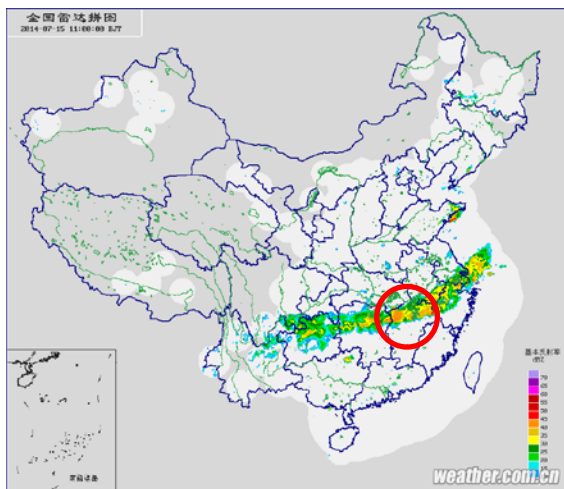
CR 2014071812_05(2014071817)

cloud analysis CR 2014071812_05(2014071817)

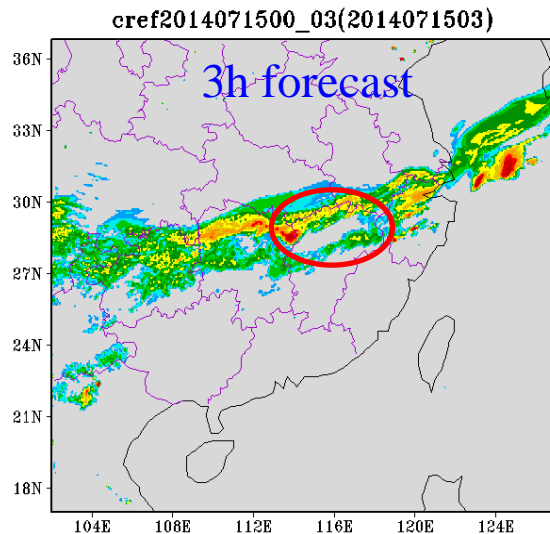


Meiyu front -- July 15th 2014

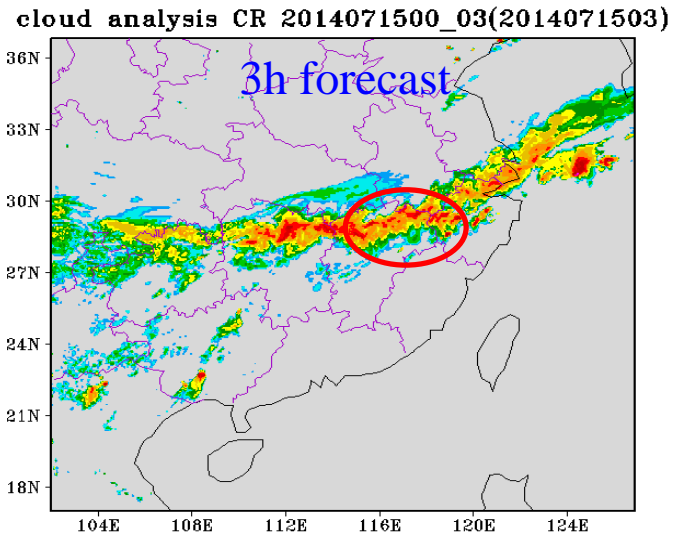
Obs



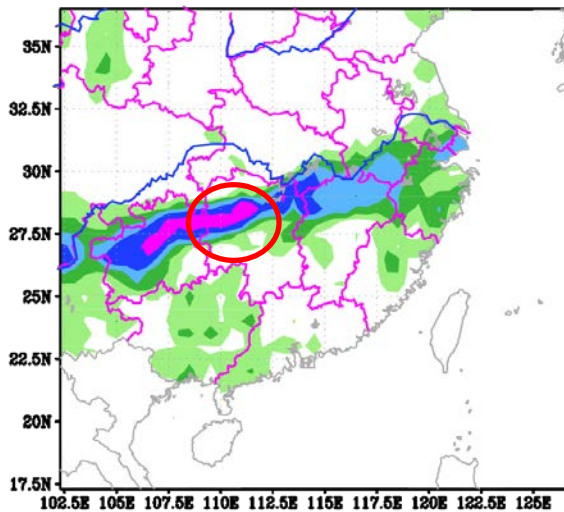
W/t CA



CA

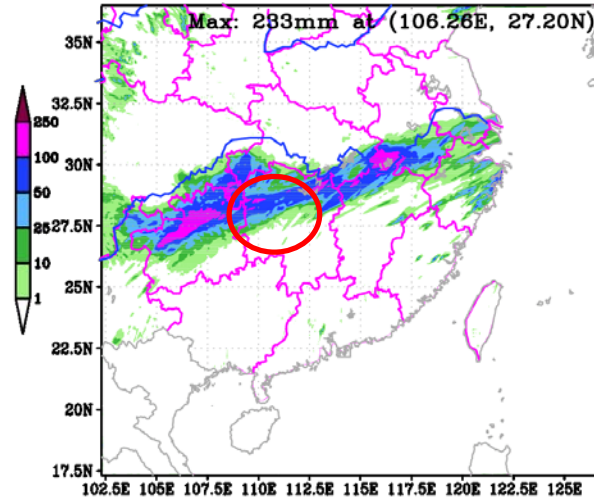


Observed-Precipitation
period:2014:7:15:0-2014:7:16:0UTC



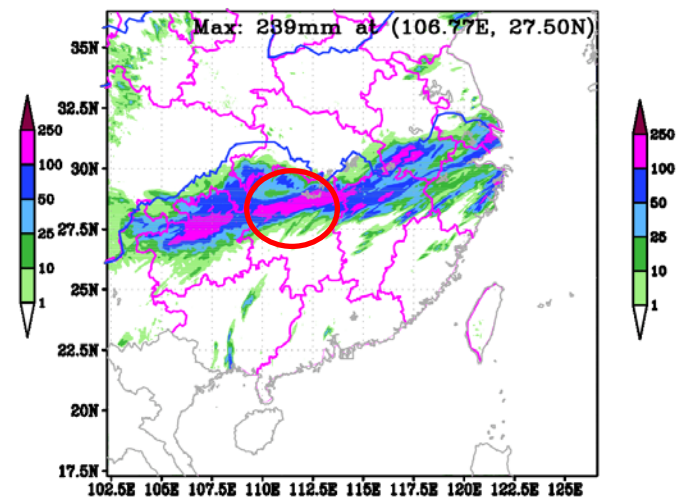
CMA_GRAPES-V4.0_3km降水预报(0-24小时)

模式起始时间:2014:7:15:0(UTC)
预报时间:2014:7:15:0-2014:7:16:0(UTC)



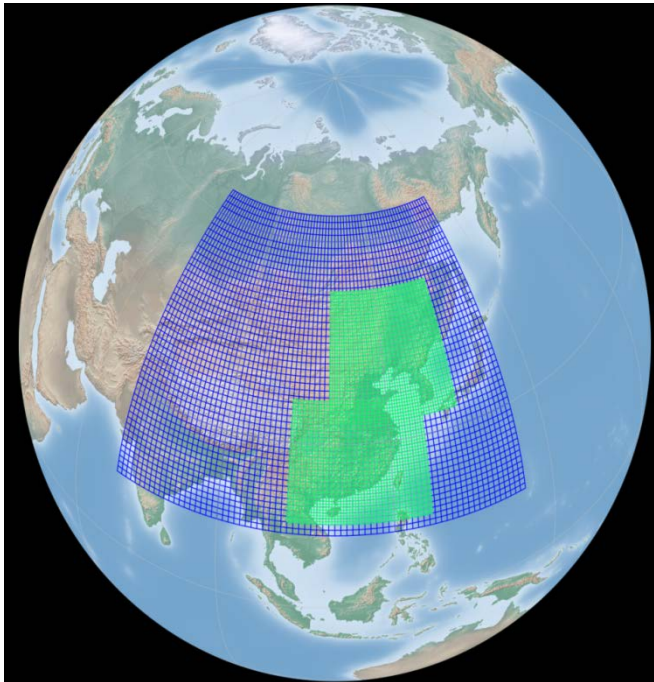
CMA_GRAPES-V4.0_3km降水预报(0-24小时)

模式起始时间:2014:7:15:0(UTC)
预报时间:2014:7:15:0-2014:7:16:0(UTC)



Real time application

- Radar QC & mosaic system went online since June 9th 2015
- Accomplished Cloud analysis running in GRAPES-MESO 3km system
- Stable online running since July 1st 2015

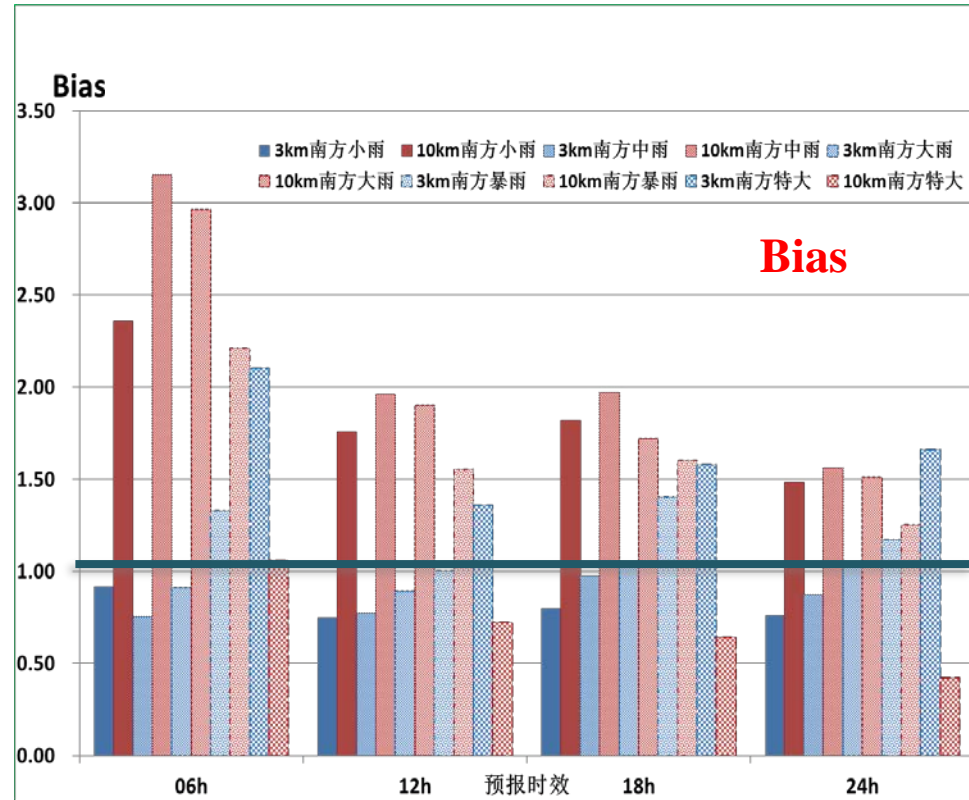
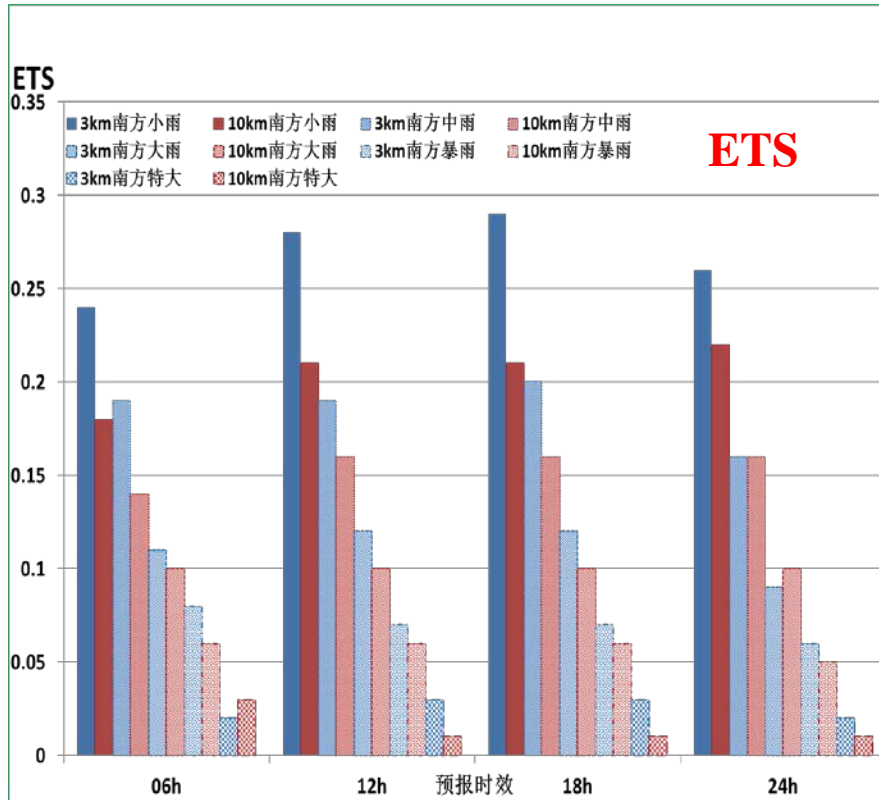


Date	Total Rads.	North	South
2015072900	102	30	85
2015072912	101	31	83
2015073000	98	30	80
2015073012	4	1	3
2015073100	101	30	83

Comparison between 3km real time system and 10km operational system

---Southern China June-Aug., 2015

6h precipitation ETS/Bias verification



3km performs better than 10km

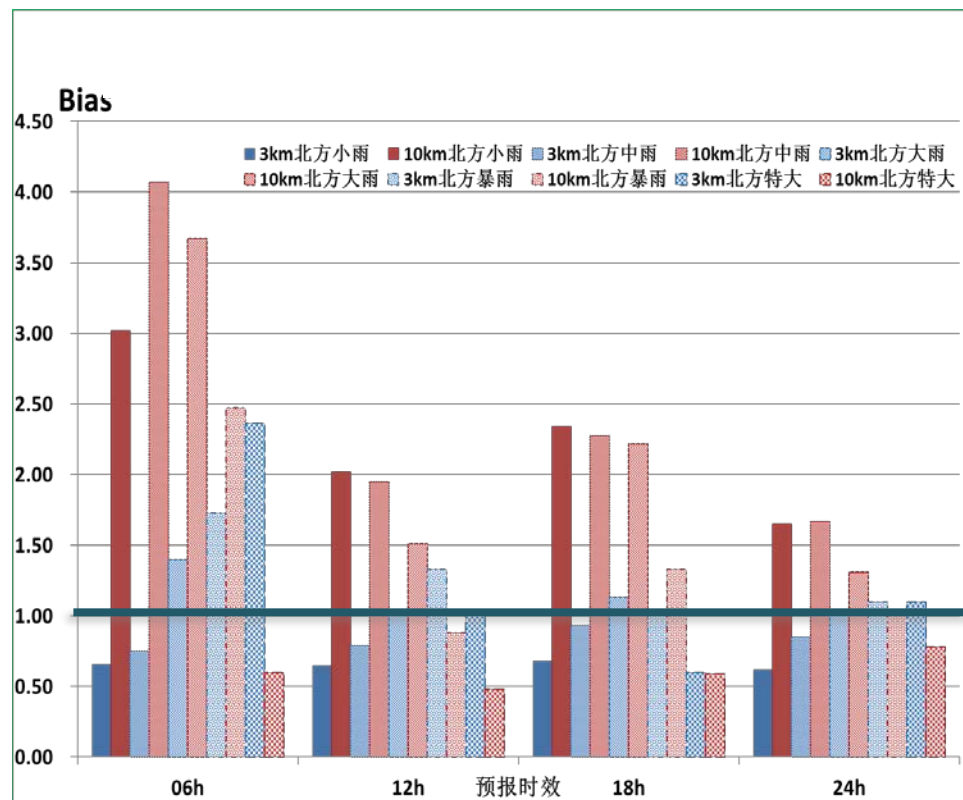
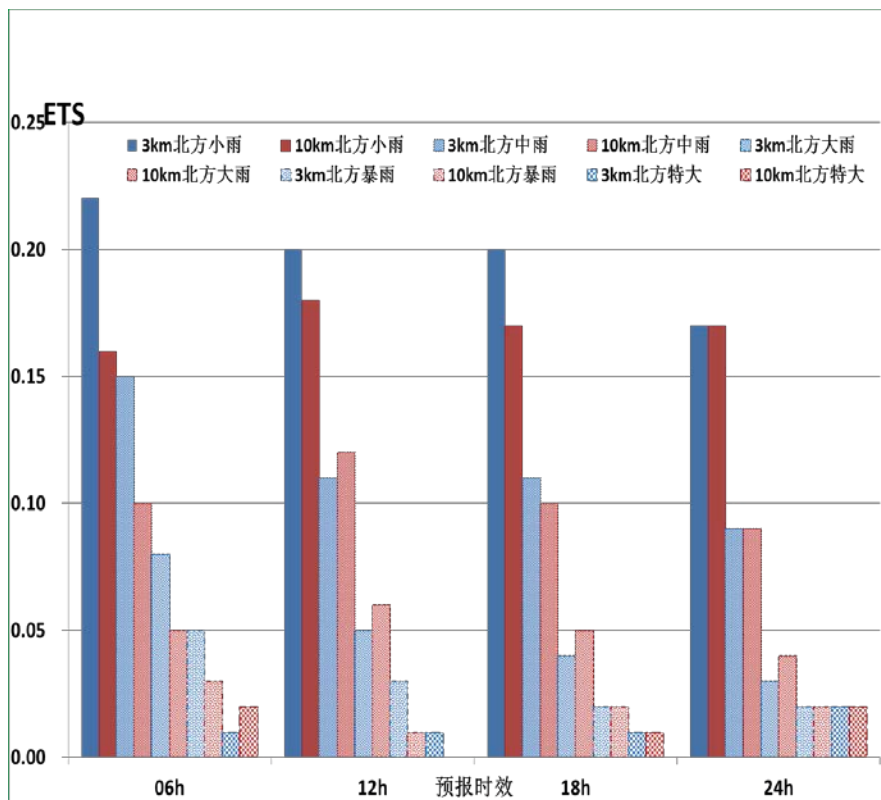
3km

10km

Comparison between 3km real time system and 10km operational system

---Northern China, July-Sept., 2015

6h precipitation ETS/Bias verification

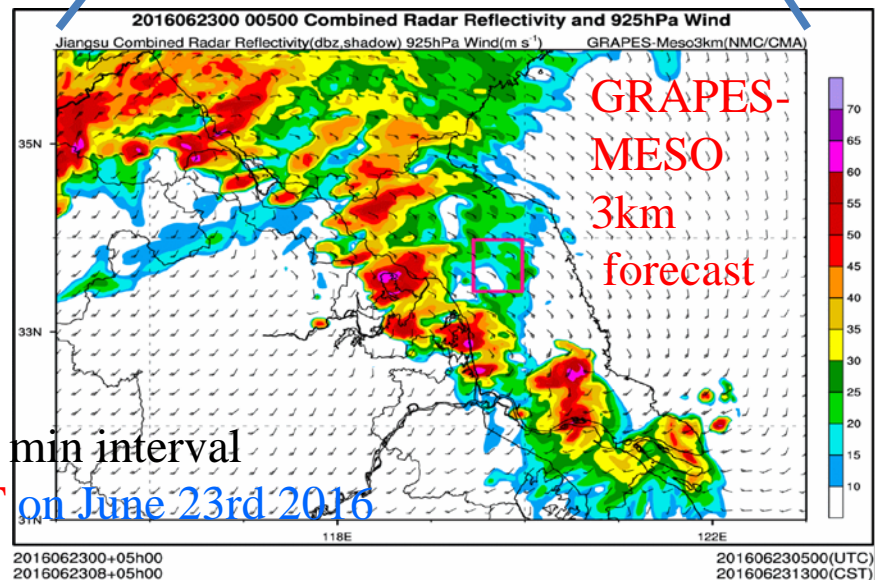
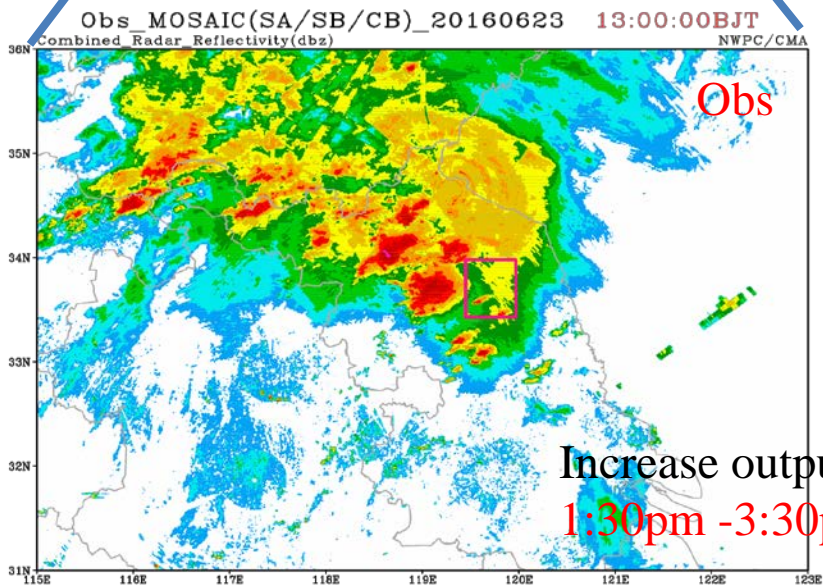
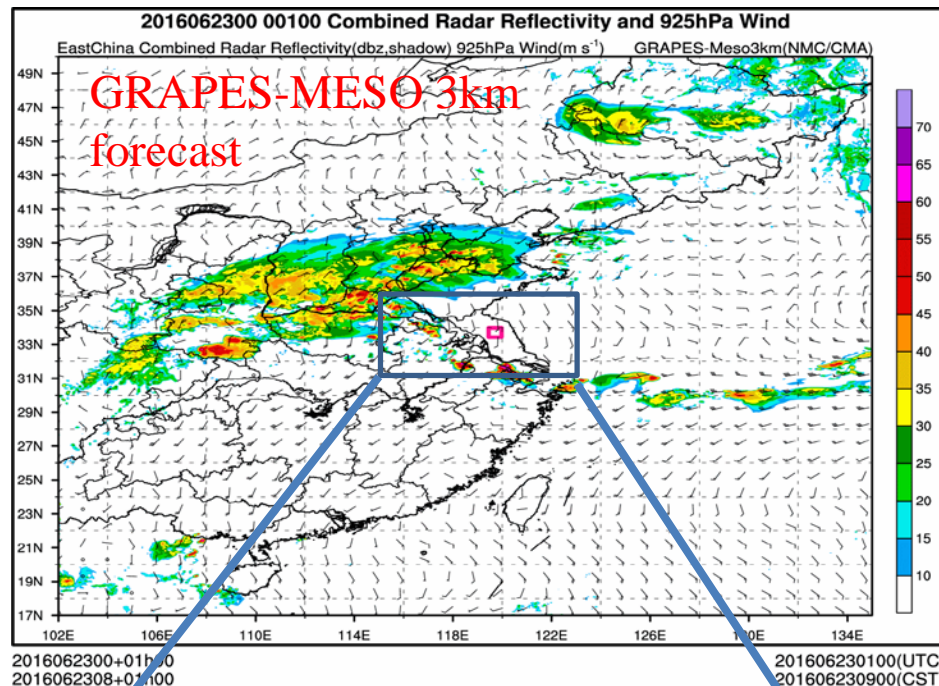
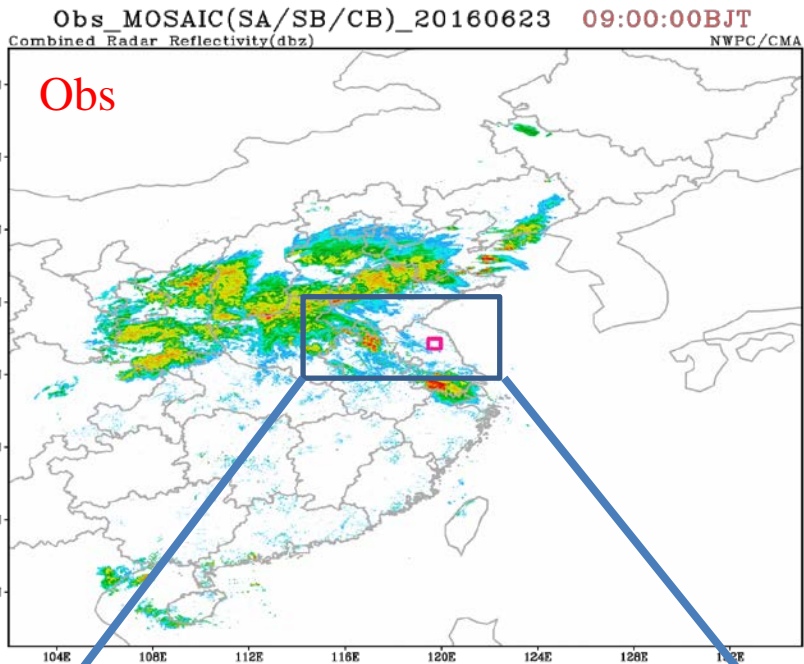


3km performs better than 10km

3km

10km

Key case--- Funing Tornado on June 23rd 2016



Increase output to 10 min interval
1:30pm -3:30pm BJT on June 23rd 2016

Conclusions

- Successfully provided national radar 3D digital mosaic data (SA/SB/CB, 118 sets) for the national NWP model.
- The radar QC module is proved to be efficient as it solves the radar quality issues, such as TP, EMI and AP clutter. And radar QC is a continuous work, should keep working on it.
- Significant positive performance when assimilating radar data with cloud-analysis system.
- Better precipitation verification in 3km real-time system than 10km operational system.
- Other departments already show their interests in mosaic data and the QC performance.

Future plans

- Only SA/SB/CB radars are used by now, still needs working on SC/CC/CD/CCJ radars.
- Lacking of radial winds, lighting.....
- Quality control for radial winds.
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THANKS

The word "THANKS" is rendered in a bold, blue, sans-serif font. The letters have a slight 3D effect with a dark blue shadow on the bottom edge. Below the text is a soft, light blue reflection that fades out towards the bottom of the frame.