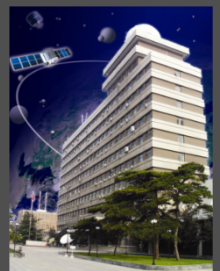
The Use of Feng-Yun Satellite data in short-range Precipitation forecasting in China



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4th Asia-Oceania Meteorological Satellite Users Conference

Oct 9-11, 2013, Melbourn, Australia

Outline

- Introduction
- Application of FY-2 Data in 3D cloud analysis
- Short-Range Forecast Impact Tests of FY-2 Satellite data
- Summary

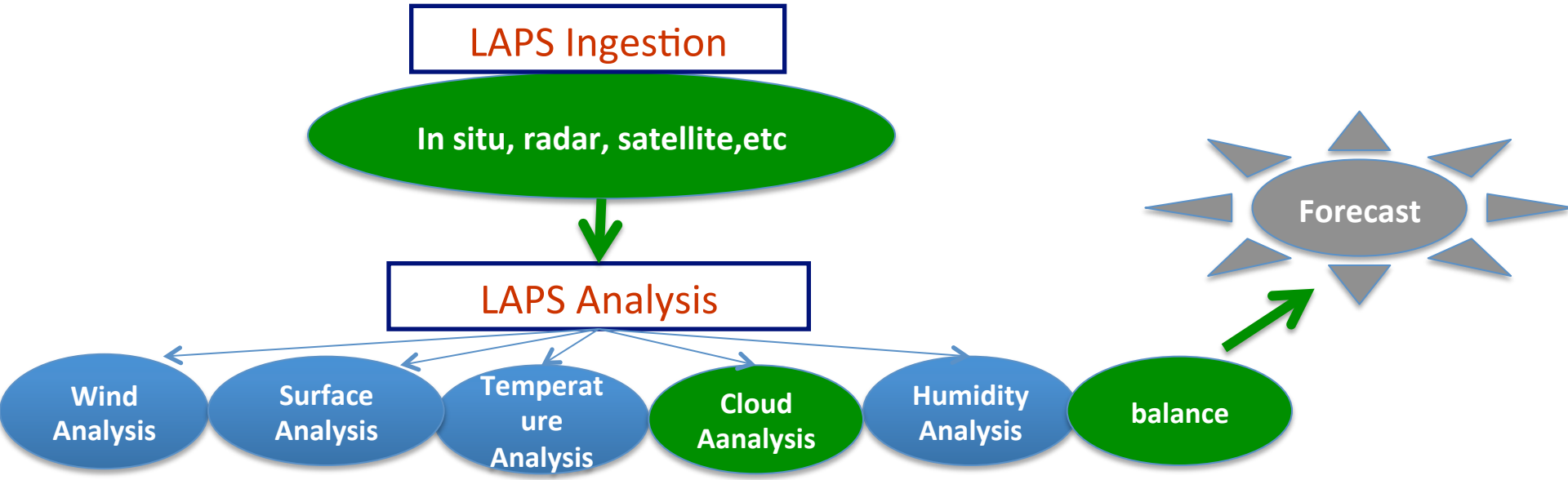
Introduction- Background

- Absence or improper initialization of the cloud and precipitation in the initial condition of NWP model will cause the Spin-Up problem, which shows as the significant delay in the development of cloud and precipitation at the early stage of a model forecast. By solving the Spin-Up problem, short-range weather forecast can be improved.
- How? “Hot-start” – improve initial condition of NWP model ,especially cloud .
- 3D Cloud information is needed in NWP model . Three dimensional analysis systems is developed.

LAPS/STMAS; GSI; WRFVAR; MESAN; ACAPS …….

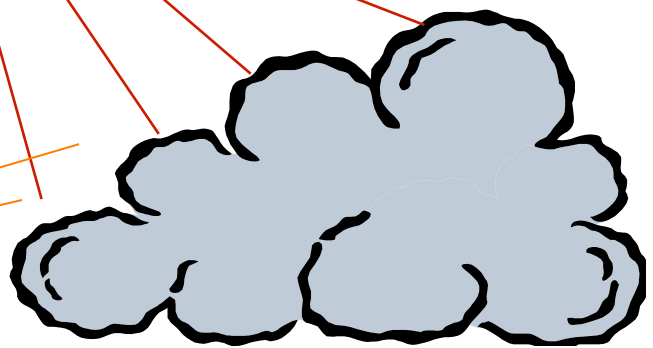
Introduction of LAPS (Local Analysis and Prediction System)

- Developed by NOAA ESRL/GSD (FSL)
- LAPS blends a wide variety of global, national, and local datasets (e.g. surface observing systems, Doppler radars, satellites, wind and temperature (RASS) profilers, radiometric profilers, as well as aircraft) into analyzed grids.
- LAPS hotstart is used to initialize mesoscale forecast models (e.g. WRF, MM5, RAMS) to eliminate the Spin-up problem of NWP


LAPS Ingestion
In situ, radar, satellite,etc
LAPS Analysis
Wind Analysis
Surface Analysis
Temperature Analysis
Cloud Aanalysis
Humidity Analysis
balance
Forecast

LAPS Cloud Analysis

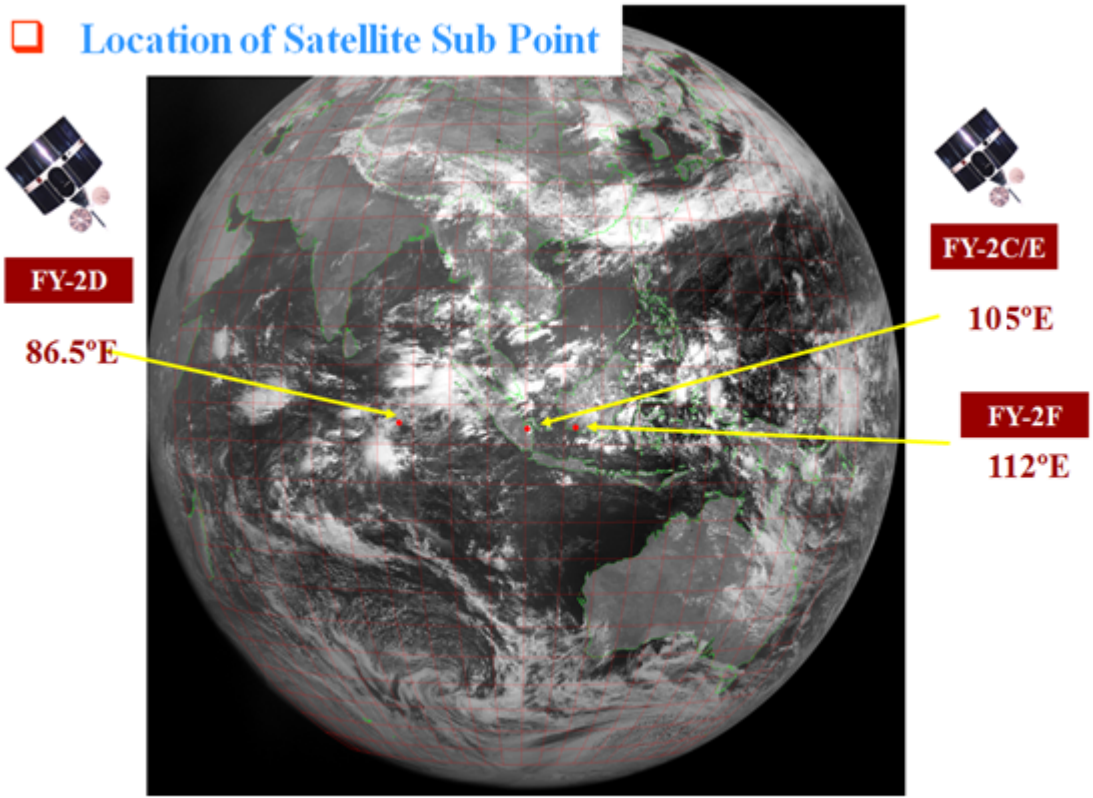
Different data can be combined (including ground-based observation, radar, satellite, airplane etc.) to produce high-resolution three dimensional clouds centered on a domain of the users choosing.



METAR METAR METAR

Application of FY-2 Data in 3D cloud analysis

Geostationary Meteorological Satellite



Sensor on FY-2 Satellite

VISSR

Channels	Wavelength (μm)
1	0.55-0.7
2	3.5-4.0
3	6.3-7.6
4	10.3-11.3
5	11.5-12.5

Input

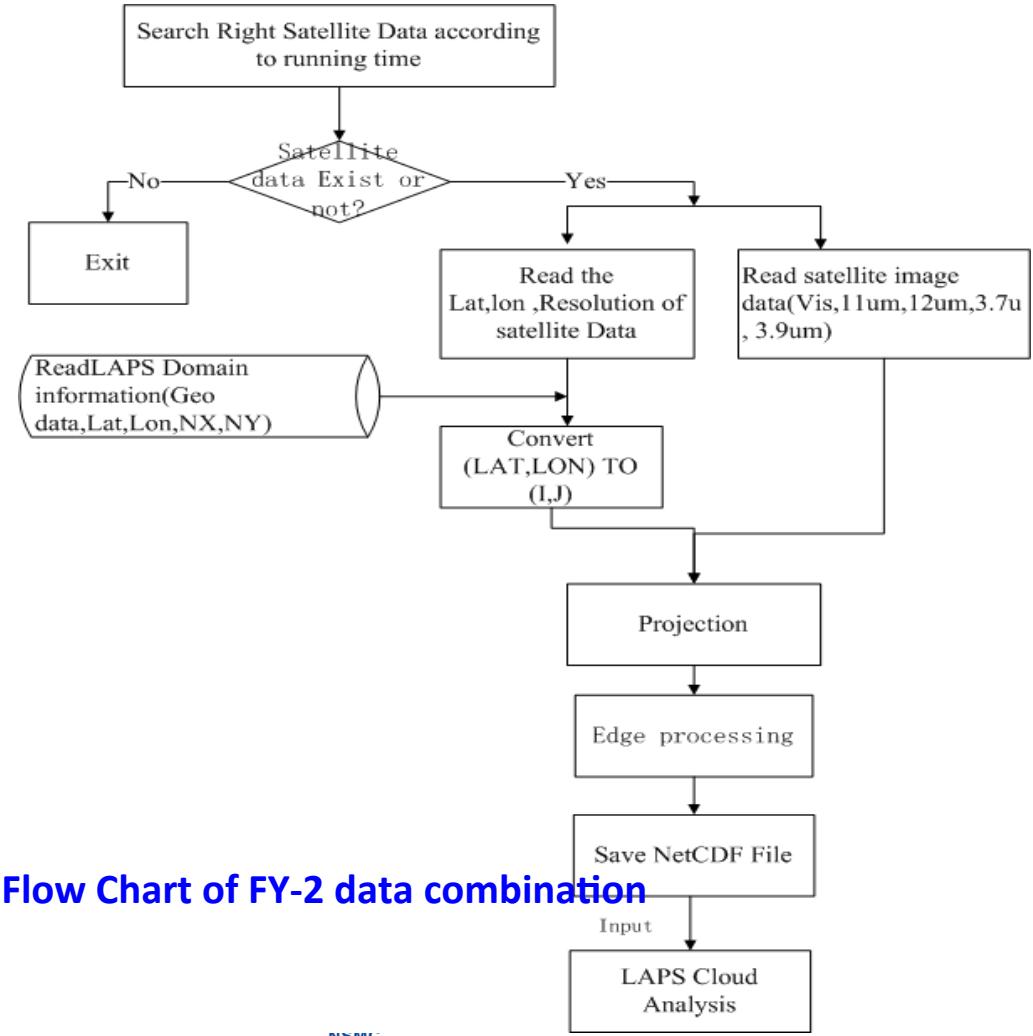
- GFS forecast data
- Ground-base data
- Radar Base data
- 11 μm、3.9 μm and visible data of FY-2
- Cloud top Pressure ,
- Cloud top Temperature
- Cloud Amount

Output

- 3D Cloud Amount
- Cloud Base height,Cloud Top Height
- Column Cloud
- 3D cloud water
- 3D Cloud ICE
- 3D cloud type
- Rain and Snow

FY-2 Satellite data combination

- **Ingest the FY-2 satellite data into LAPS, Obtain the 3D cloud analysis utilizing Satellite data, Radar data and surface observations of LAPS in China**

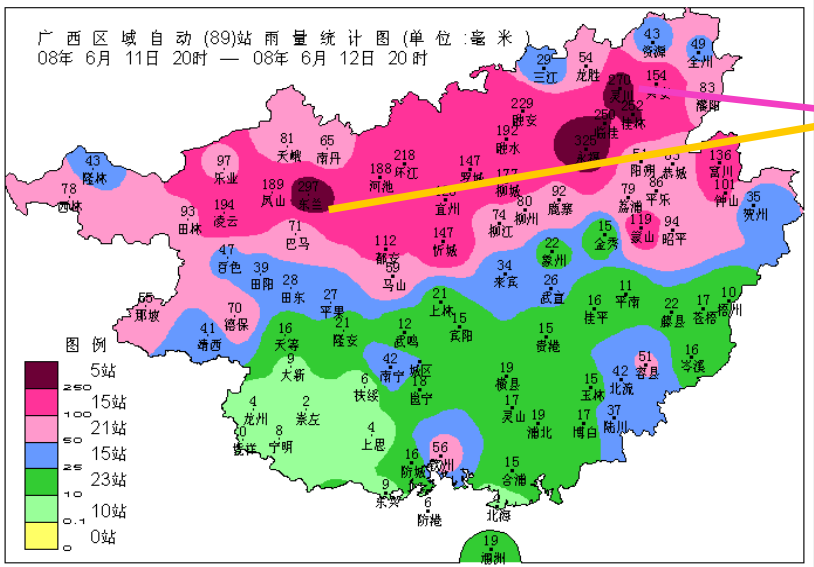


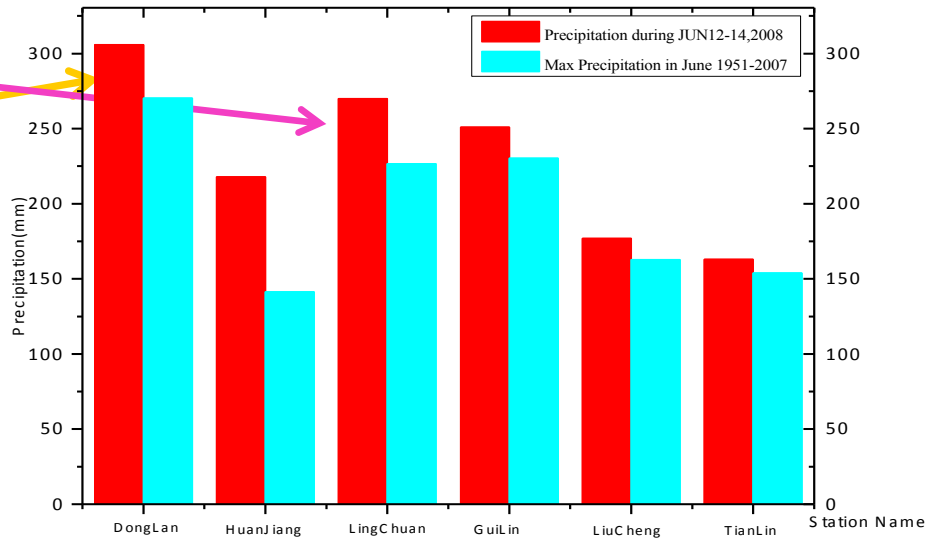
Flow Chart of FY-2 data combination

3D cloud Analysis results

Case：Rainstorm Case occurred June 13,2008

Domain：South China,14 ºN -32ºN, 102 ºE -123ºE





Rainfall exceed the extreme value

Input Data:

- Background Data：

  NCEP GFS Forecast, 1º*1º,

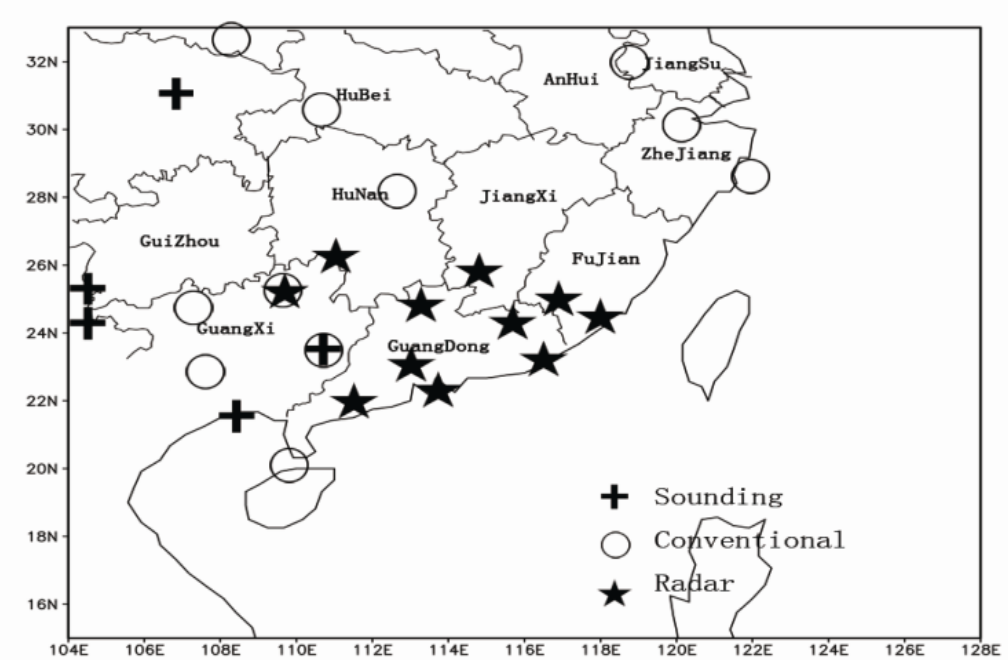
- 10 surface-based station Observations

- 12 weather Radar station Data

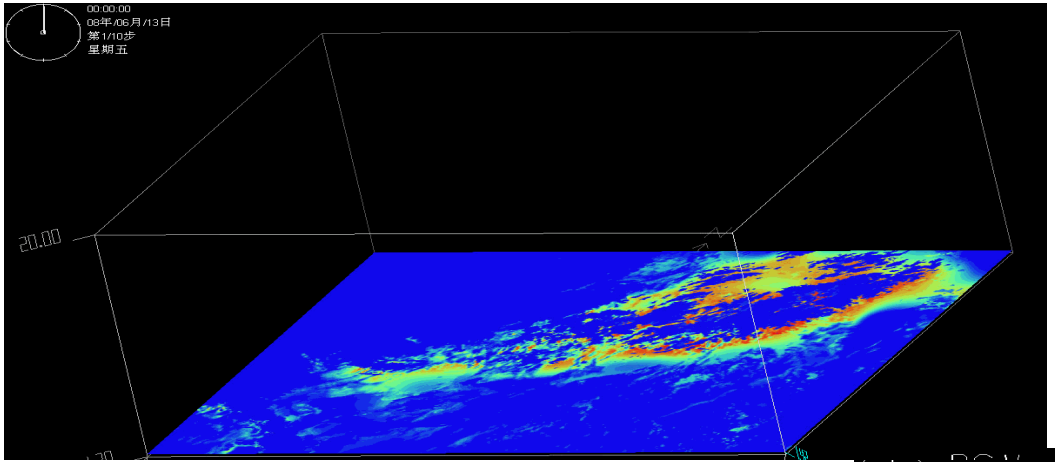
- Satellite Data:

  China FY-2C Data

  Resolution:5km



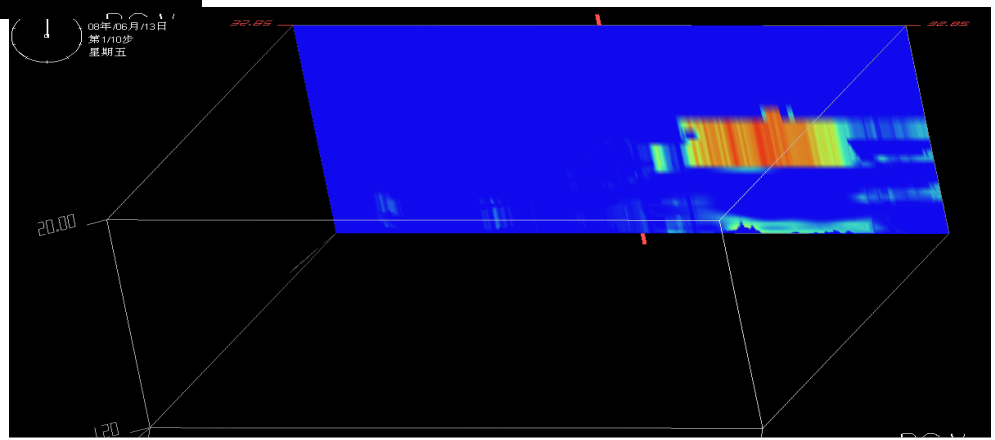
Cloud Analysis Results



3D Cloud Amount

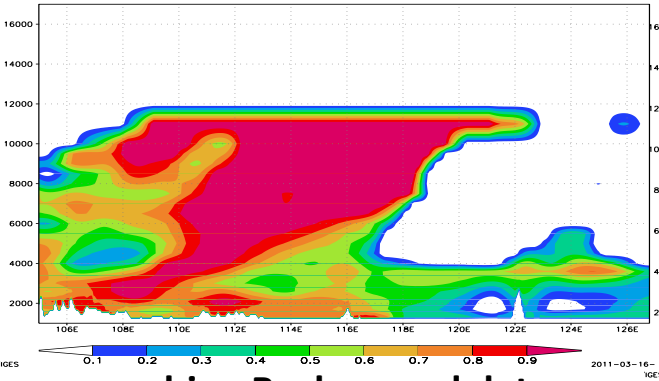
Cross-section of 3D cloud amount

08 June 13,2008

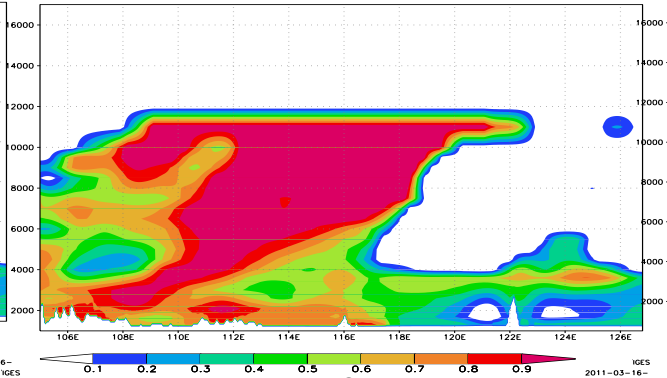


Cloud Analysis Results

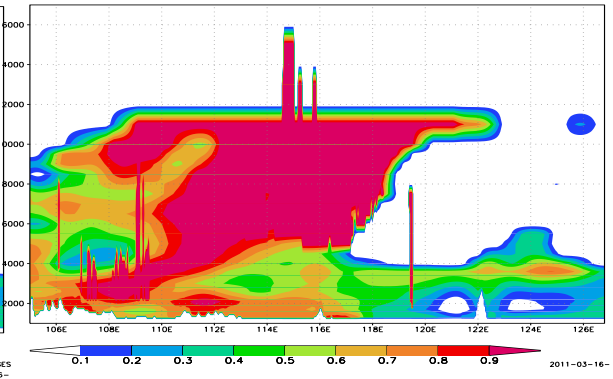
3D Cloud Amount



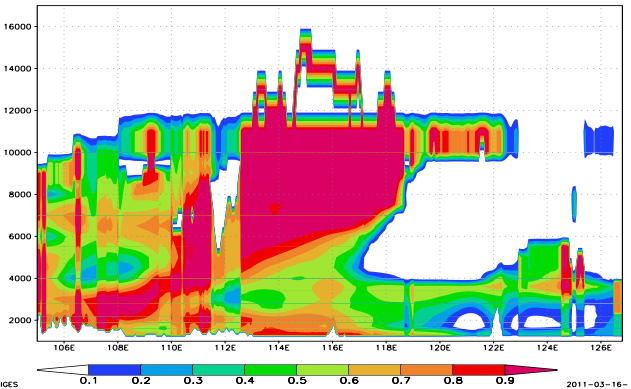
combine Background data



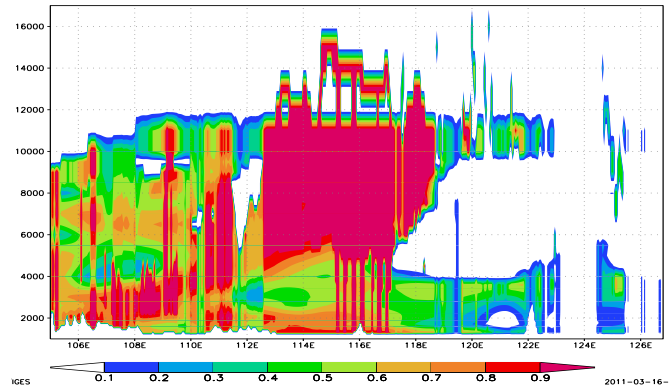
combine surface data



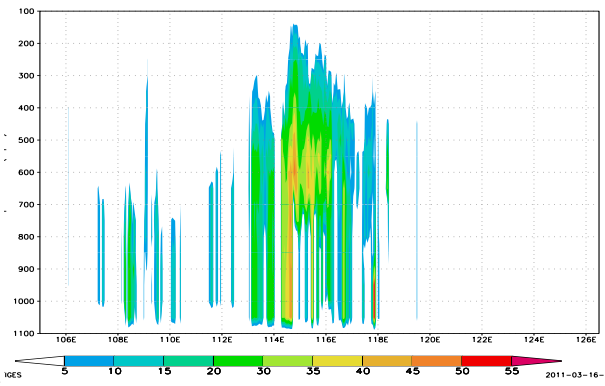
combine Radar data



combine satellite data



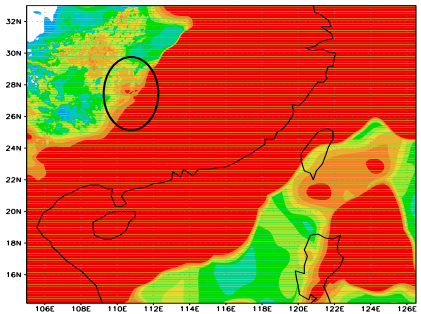
combine satellite+radar+surface data



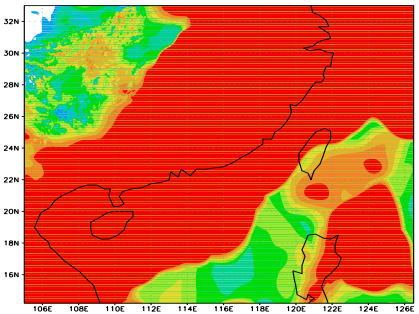
Radar Reflectivity

Cloud Analysis Results

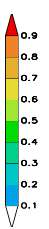
Column cloud Amount

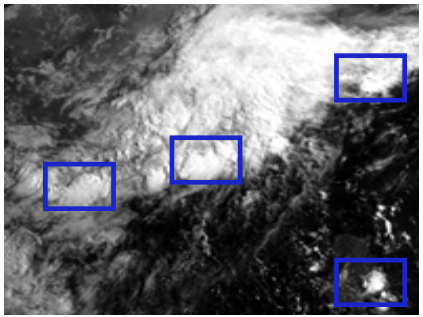


combine Background data

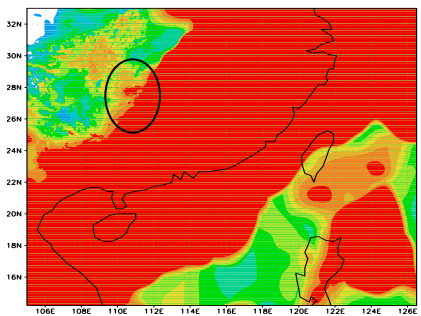


combine surface data

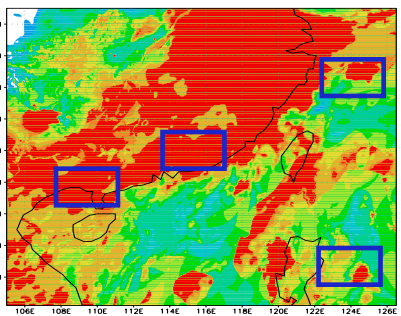




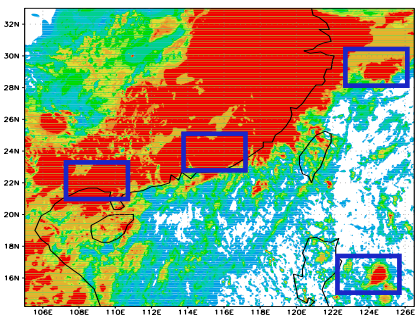
SatelliteVisible image



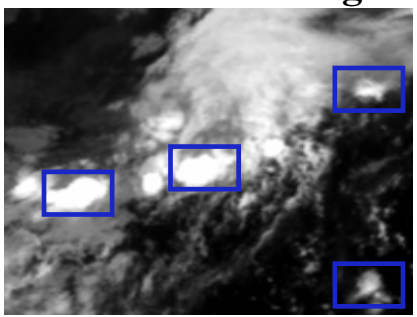
combine Radar data



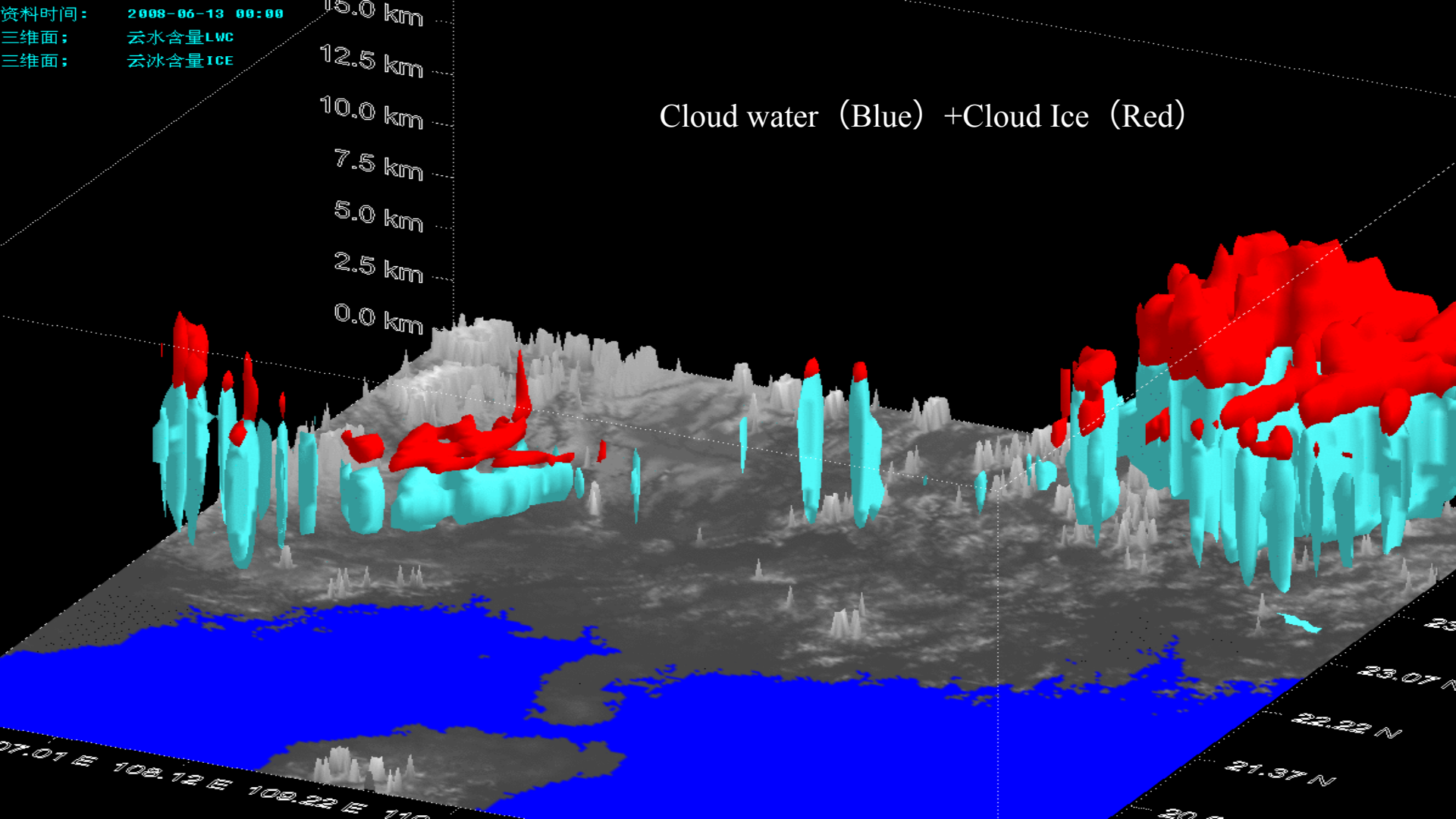
combine satellite data



combine satellite+radar+surface data



Satellite IR image


资料时间： 2008-06-13 00:00
三维面： 云水含量LWC
三维面： 云冰含量ICE
15.0 km
12.5 km
10.0 km
7.5 km
5.0 km
2.5 km
0.0 km
Cloud water（Blue）+Cloud Ice（Red）
107.01 E
108.12 E
109.22 E
23.07 N
22.22 N
21.37 N

Short-Range Forecast Impact Tests of FY-2 Satellite data

Forecast Model：GRAPES(Global/Regional Assimilation and Prediction System) ,

Resolution: 15km, 32 Level in vertical

Background Data: NCEP GFS data

all experiments were performed over 24h and began at 00UTC 13 June 2008, time step is 1 hour

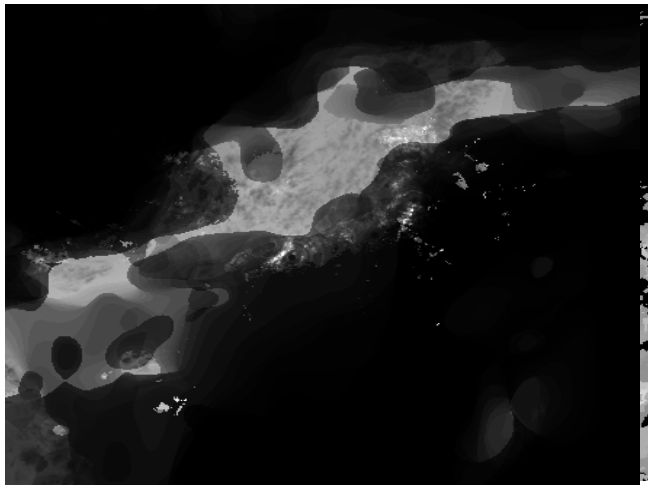
Experiments：

Experiment 1: With 0 initial values of cloud and rain – “Cold-Start”.

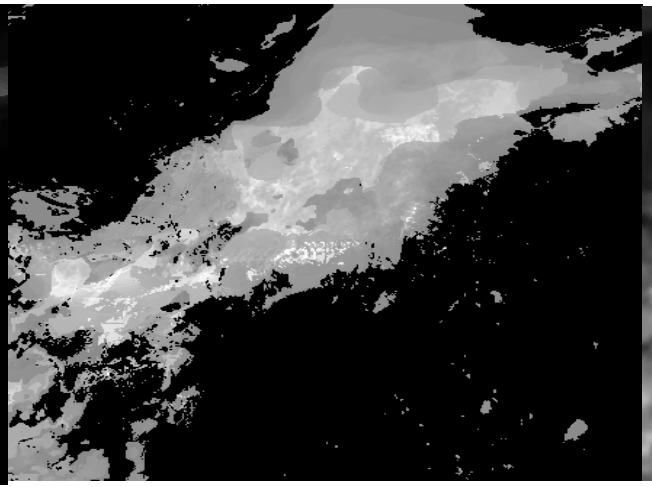
Experiment 2: The data of cloud water, cloud ice and rainwater analyzed by LAPS used as the initial field for GRAPES ,LAPS not combined satellite data, but with radar and conventional observation data, --”Hot-nosat”.

Experiment 3: The data of cloud water, cloud ice and rainwater analyzed by LAPS used as the initial field for GRAPES, LAPS combined both FY satellite data and radar, surface observations etc. ---”Hot-sat"

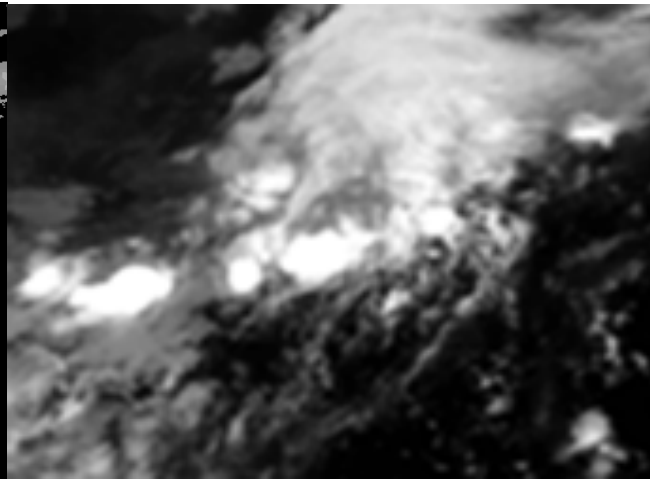
Hydrometeors distribution obtained from LAPS analysis



Hot-nosat experiment



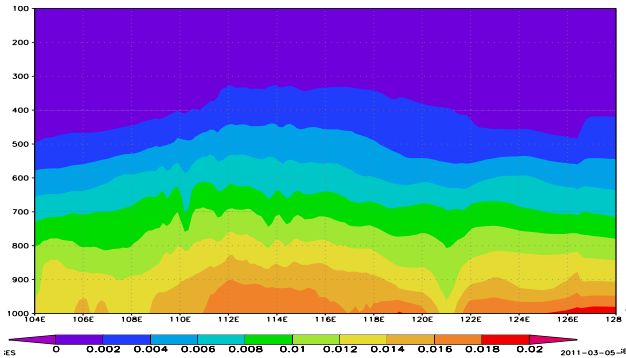
Hot-sat experiment



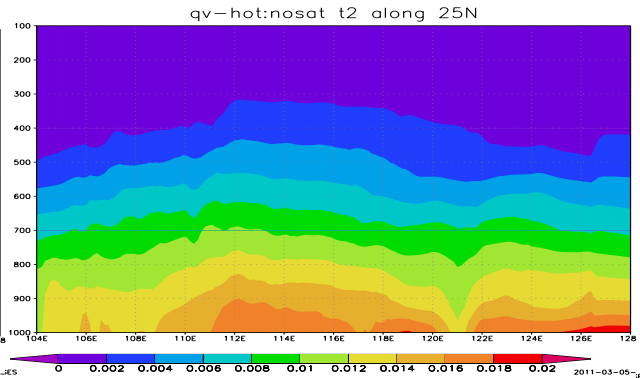
satellite infrared image

FY satellite data gave more accurate initial cloud condition to NWP model.

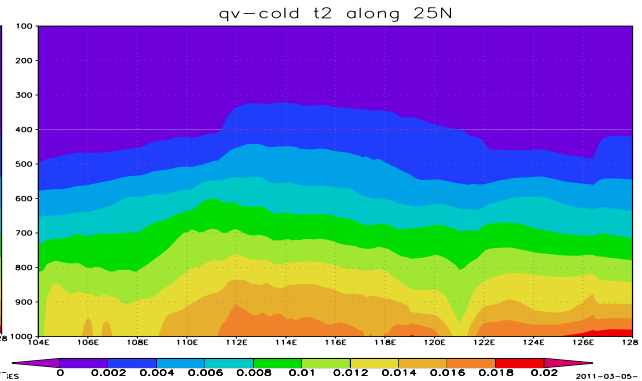
Hydrometeors Forecast 1h-Water Vapor (25ºN Cross-section)



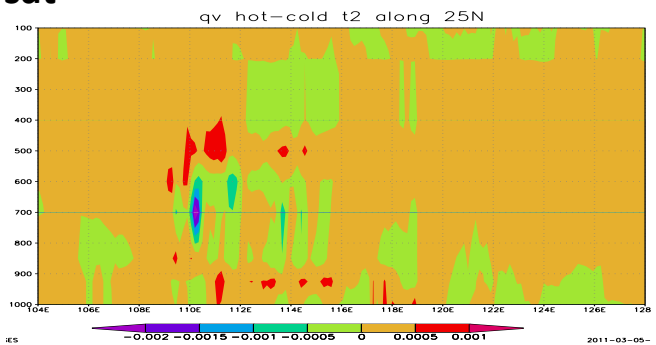
Hot-sat



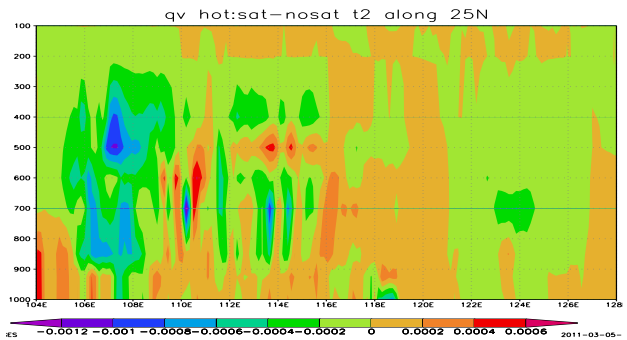
Hot-nosat



Cold start

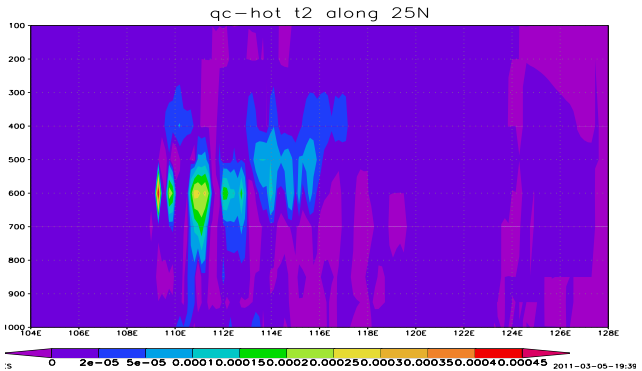


Difference of Hot-sat and cold-start

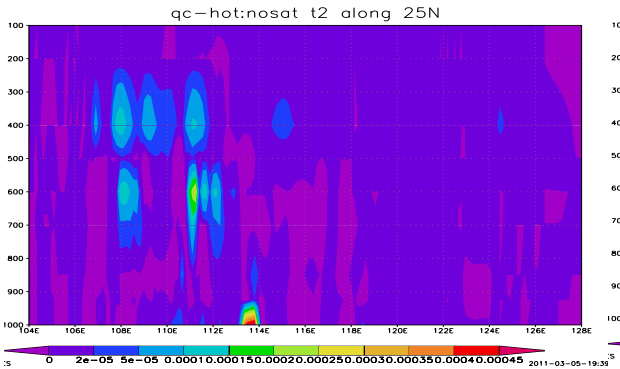


Difference of Hot-sat and Hot-nosat

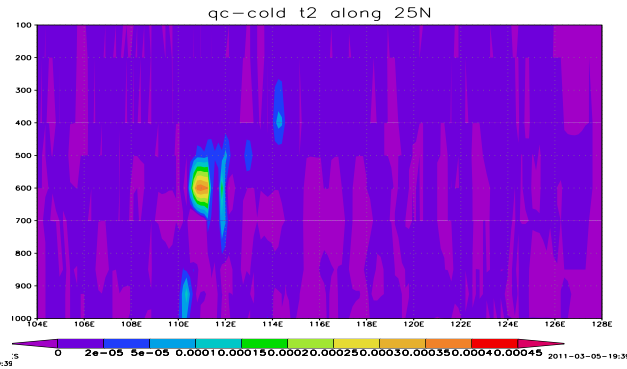
Hydrometeors Forecast 1h-cloud water(25ºN Cross-section)



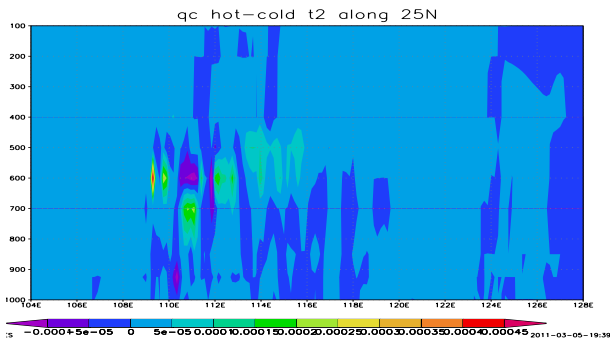
Hot-sat



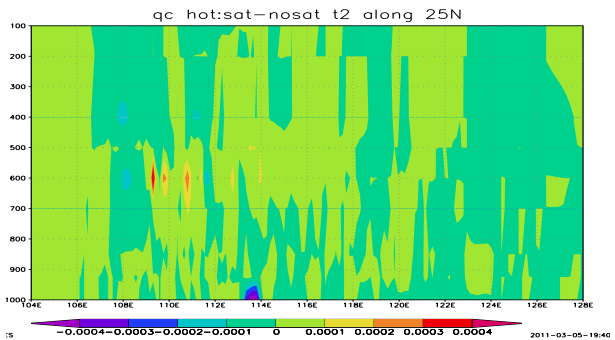
Hot-nosat



Cold Start

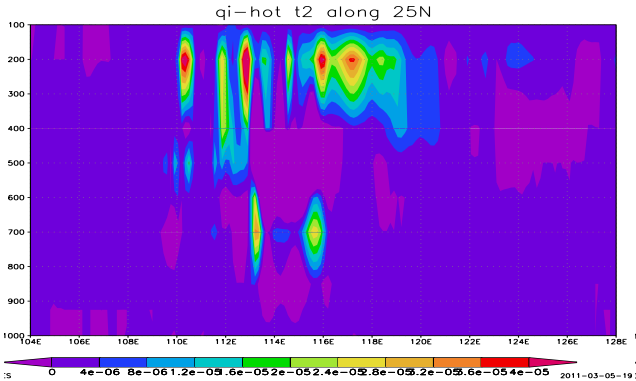


Difference of Hot-sat and cold-start

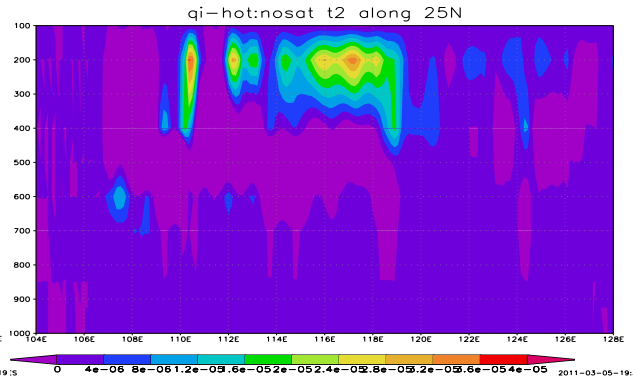


Difference of Hot-sat and Hot-nosat

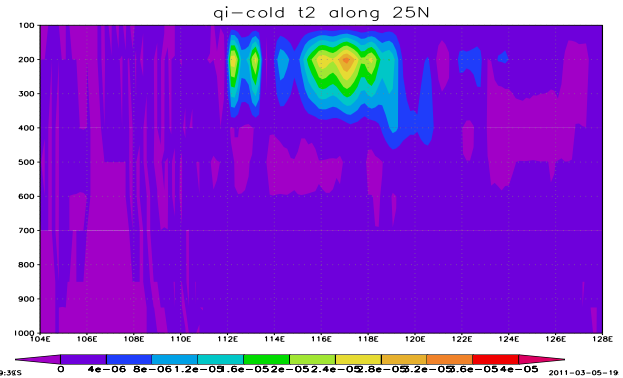
Hydrometeors Forecast 1h-cloud ice(25ºN Cross-section)



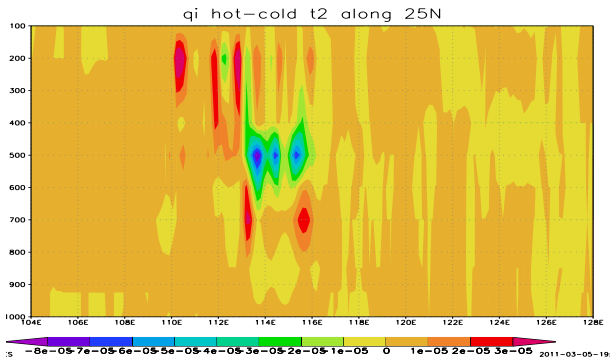
Hot-sat



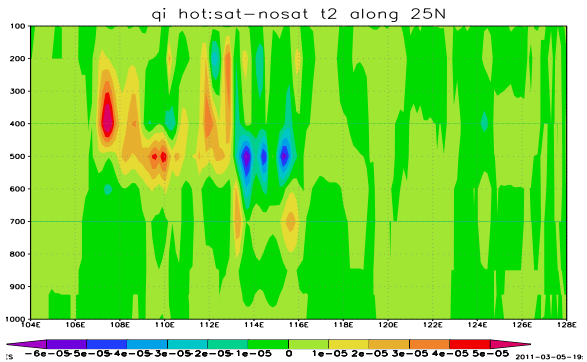
Hot-nosat



Cold start

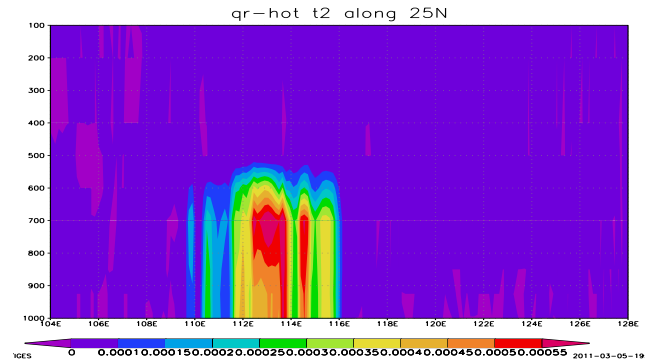


Difference of Hot-sat and cold-start

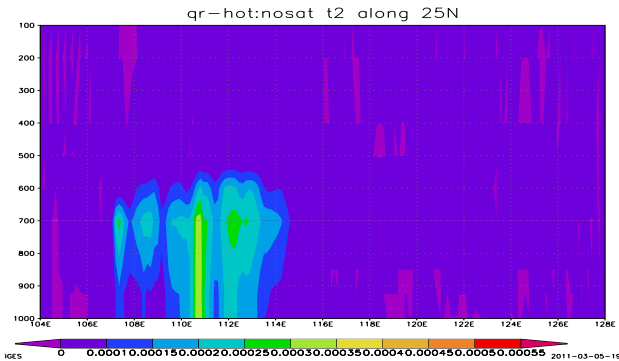


Difference of Hot-sat and Hot-nosat

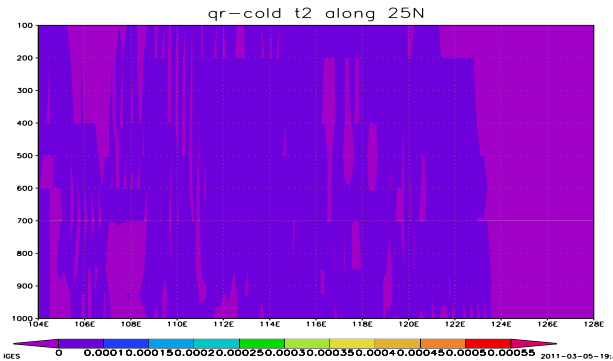
Hydrometeors Forecast 1h-rain water(25ºN Cross-section)



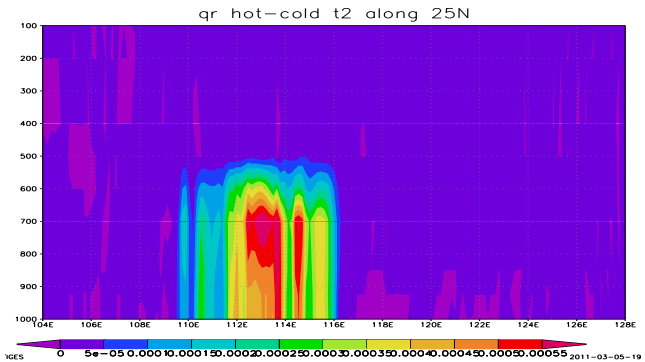
Hot-sat



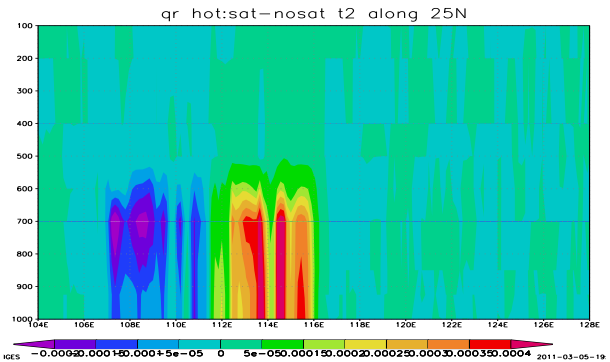
Hot-nosat



Cold start

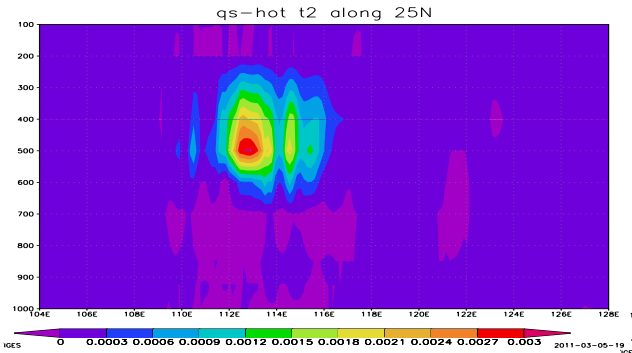


Difference of Hot-sat and cold-start

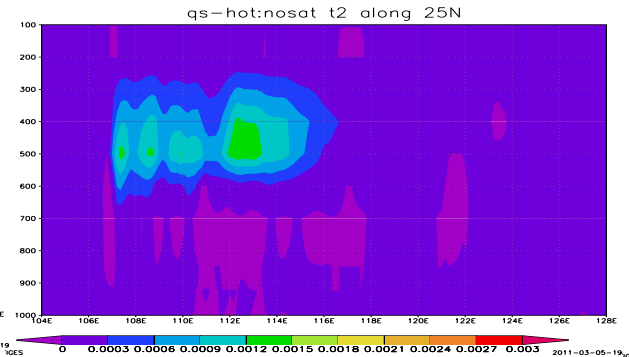


Difference of Hot-sat and Hot-nosat

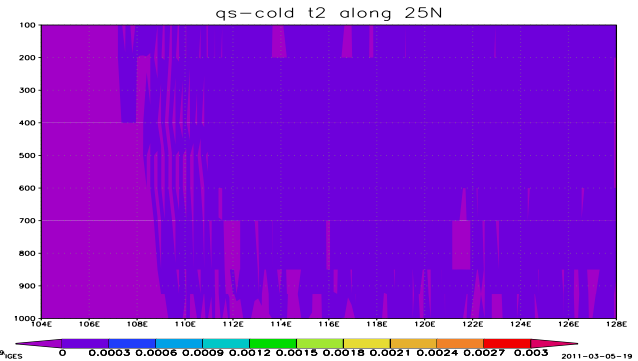
Hydrometeors Forecast 1h-Snow(25ºN Cross-section)



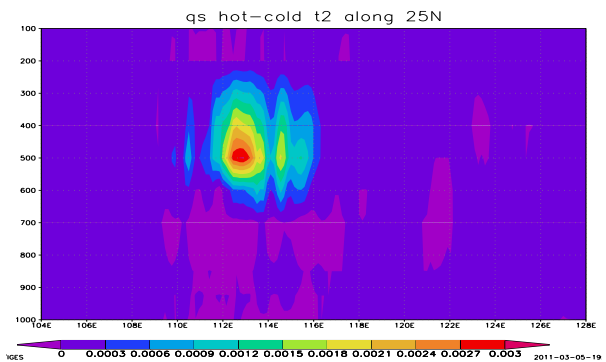
Hot-sat



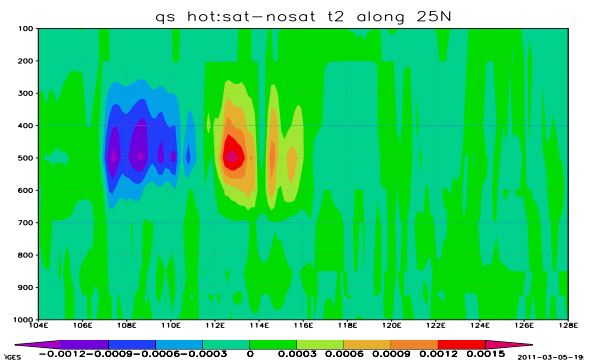
Hot-nosat



Cold-start



Difference of Hot-sat and cold-start

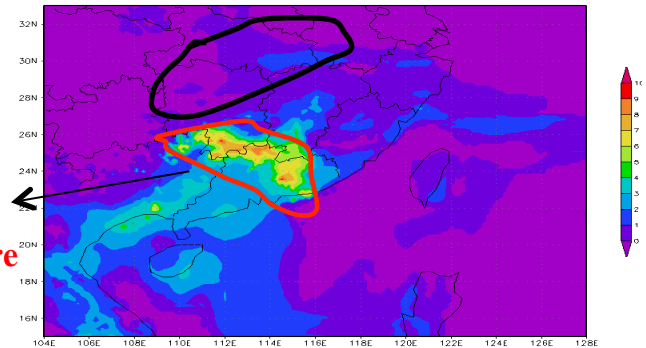


Difference of Hot-sat and Hot-nosat

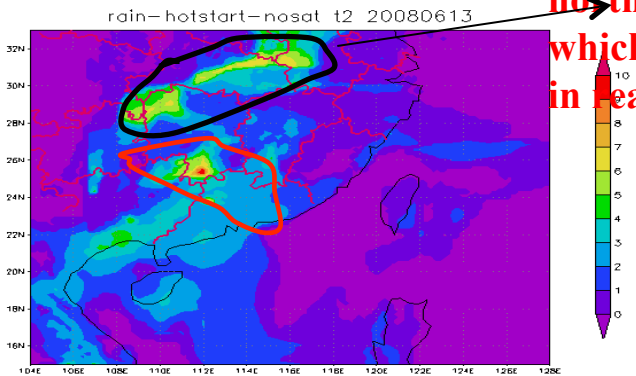
Precipitation forecast-1h

High precipitation value center in the north of domain which is not showed in real observations

About10mm，Distribution of precipitation is more consistent with real Observations

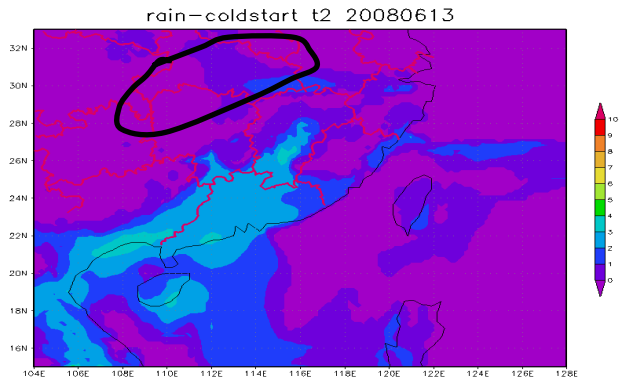


Hot-sat

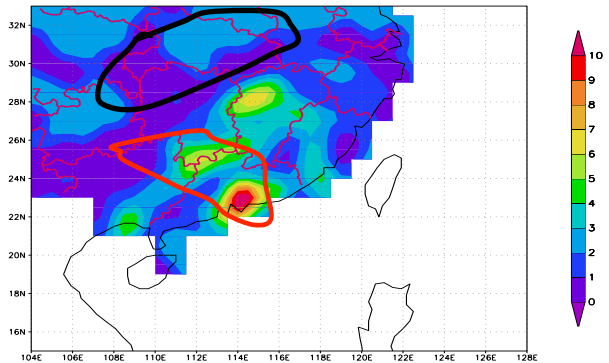


Hot-nosat

Less than 5mm what is caused by “Spin-Up” problem of NWP model

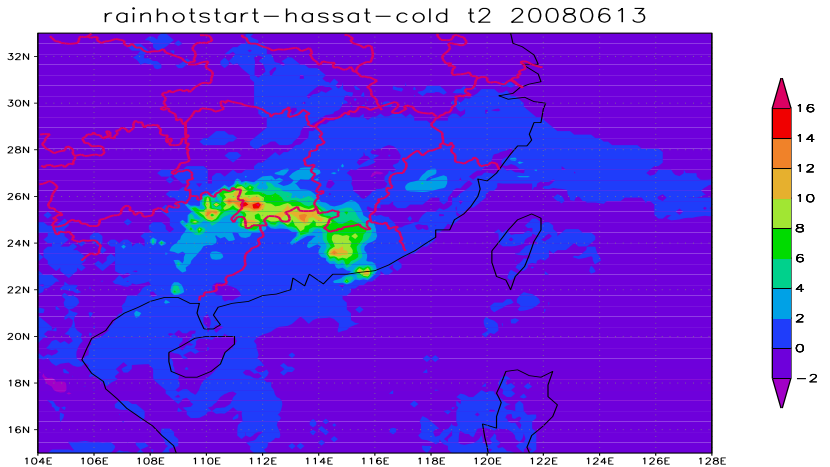


Cold Start

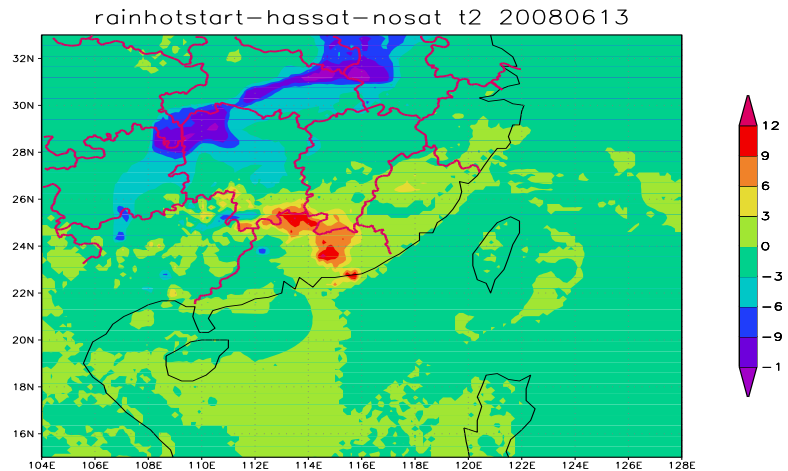


Observations from rain-gauge data

Precipitation forecast-1h



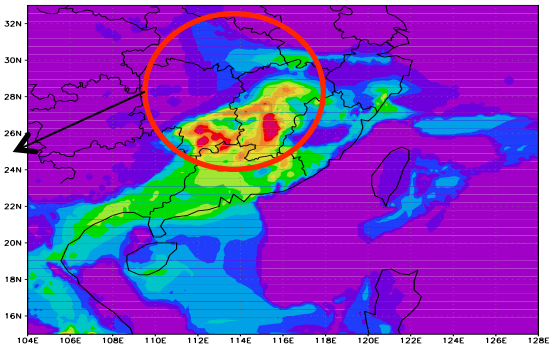
Difference of Hot-sat and Cold start



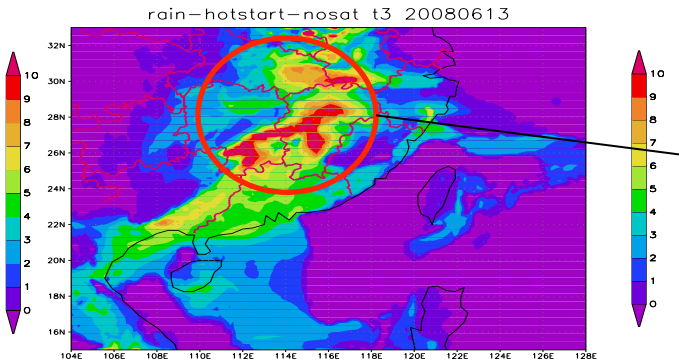
Difference of Hot-sat and Hot-nosat

Precipitation forecast-2h

Distribution of precipitation intensity is closer to real observations



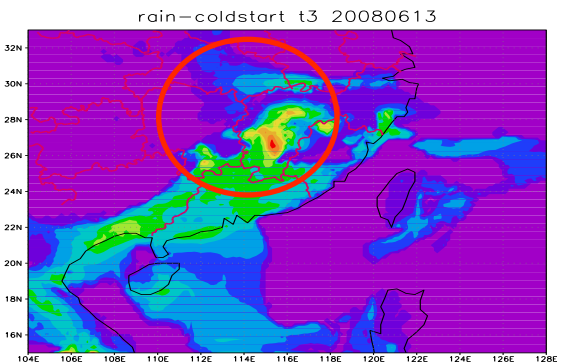
Hot-sat



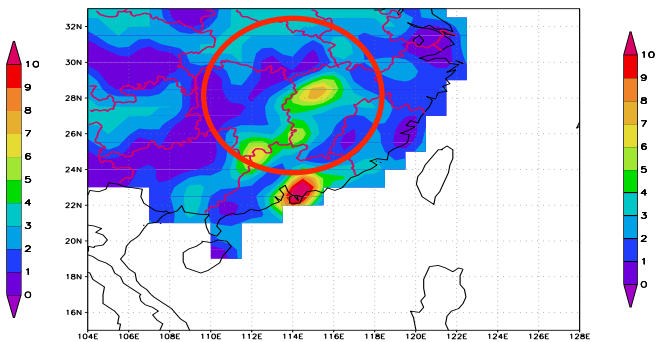
Hot-nosat

Precipitation intensity is more than observations, precipitation region is larger than observations

Precipitation is still less than real observations



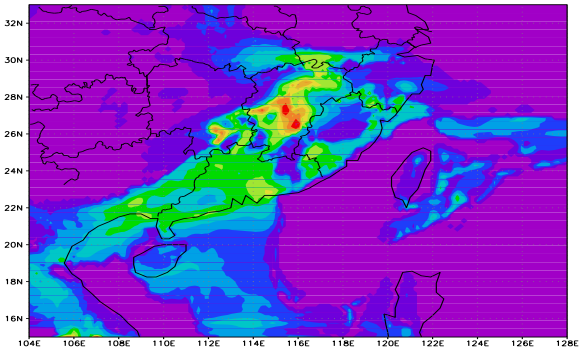
Cold start



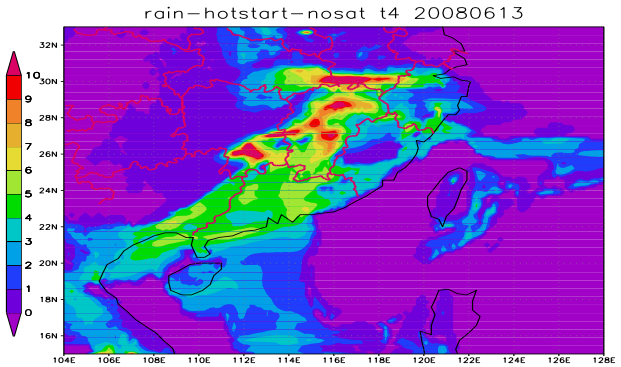
Observation from rain-gauge data

Precipitation forecast-3h

Precipitation with Hot-sat experiment is more consistent with real observation



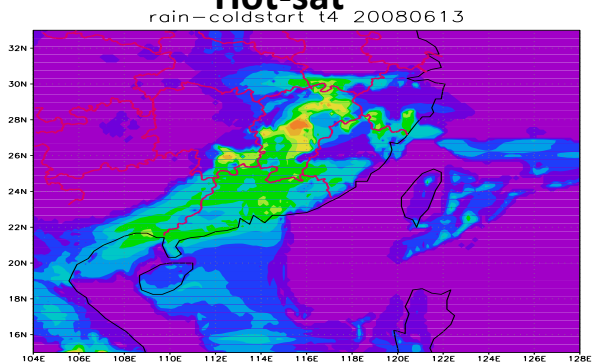
Hot-sat



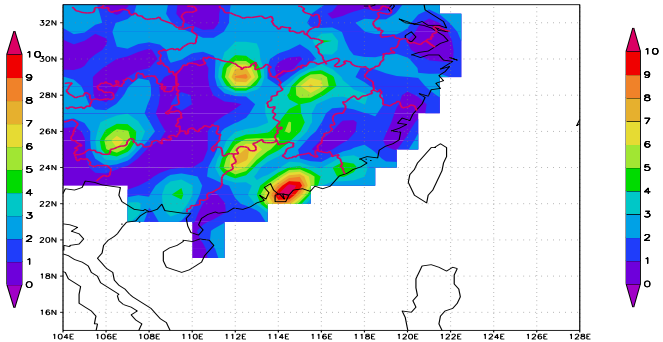
Hot-nosat

precipitation intensity is still more

Precipitation intensity in cold-start experiment increased

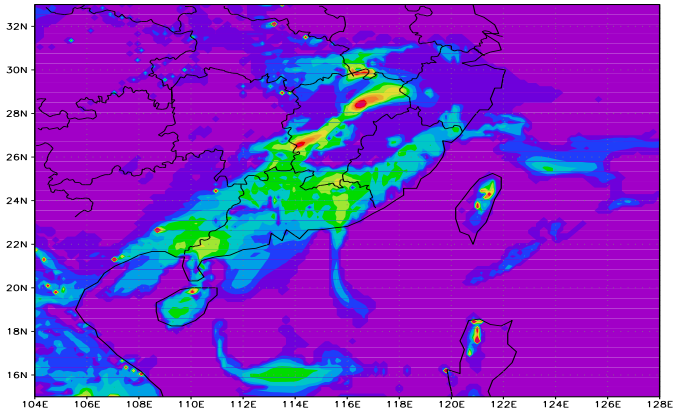


Cold start

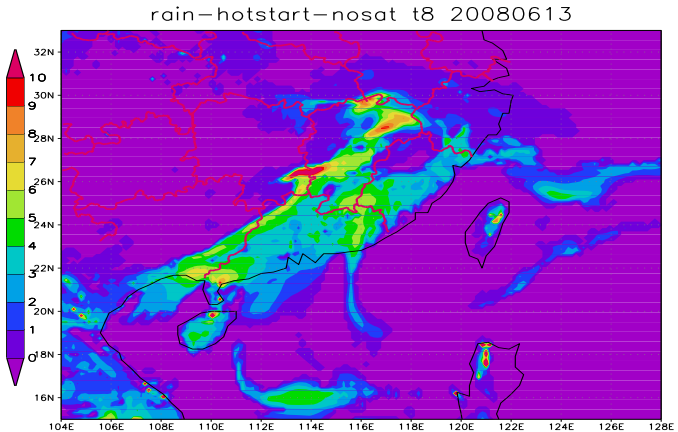


Observation from rain-gauge data

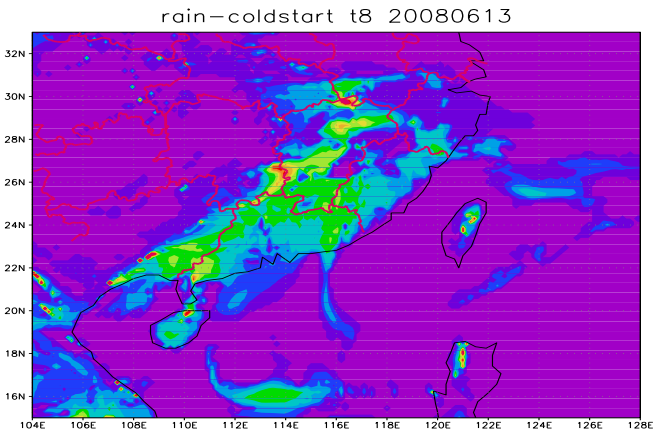
Precipitation forecast-4~7h



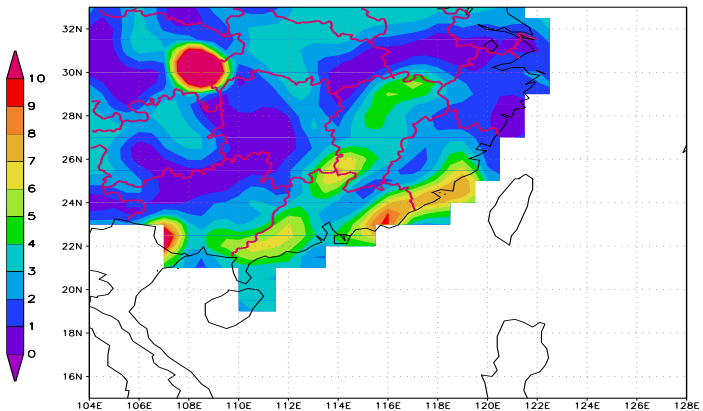
Hot-sat



Hot-nosat



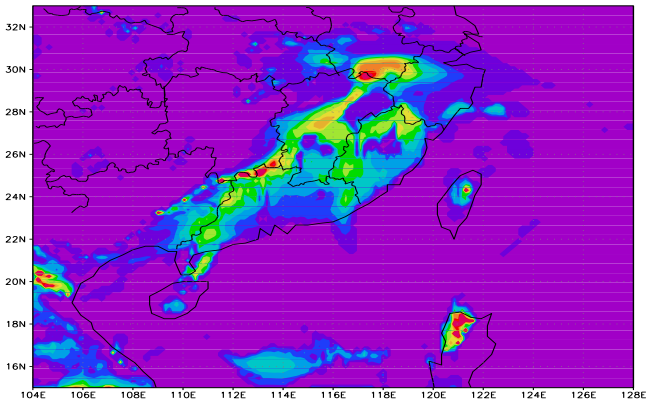
Cold start



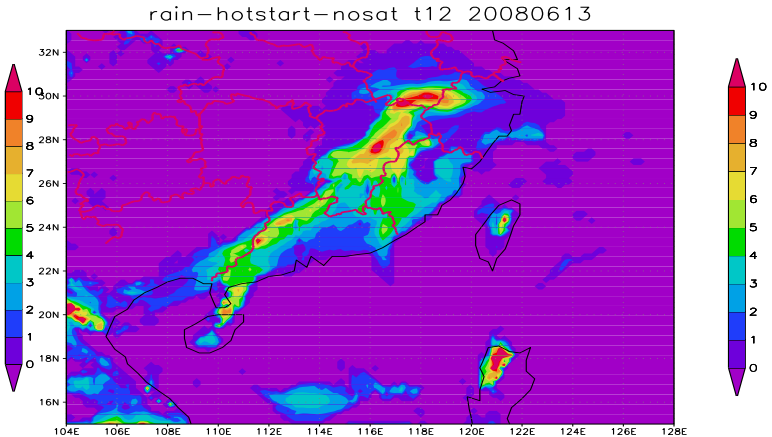
Observation from rain-gauge data

From 4 to 7h, the intensity and regions of precipitation are closer in three experiments

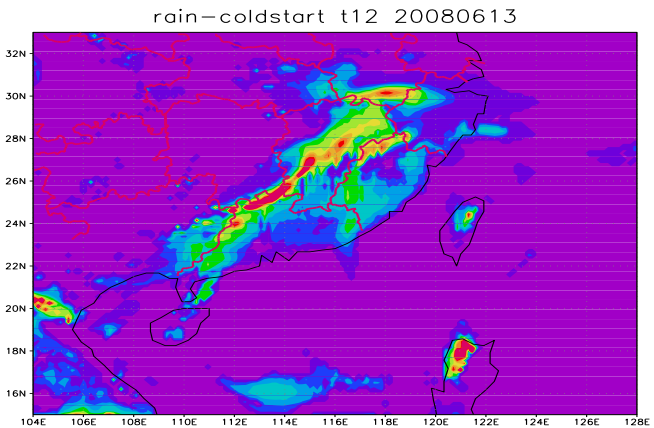
Precipitation forecast-8~24h



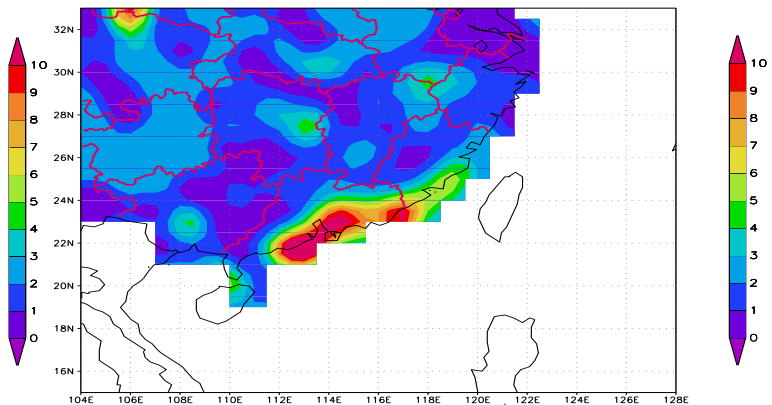
Hot-sat



Hot-nosat



Cold start

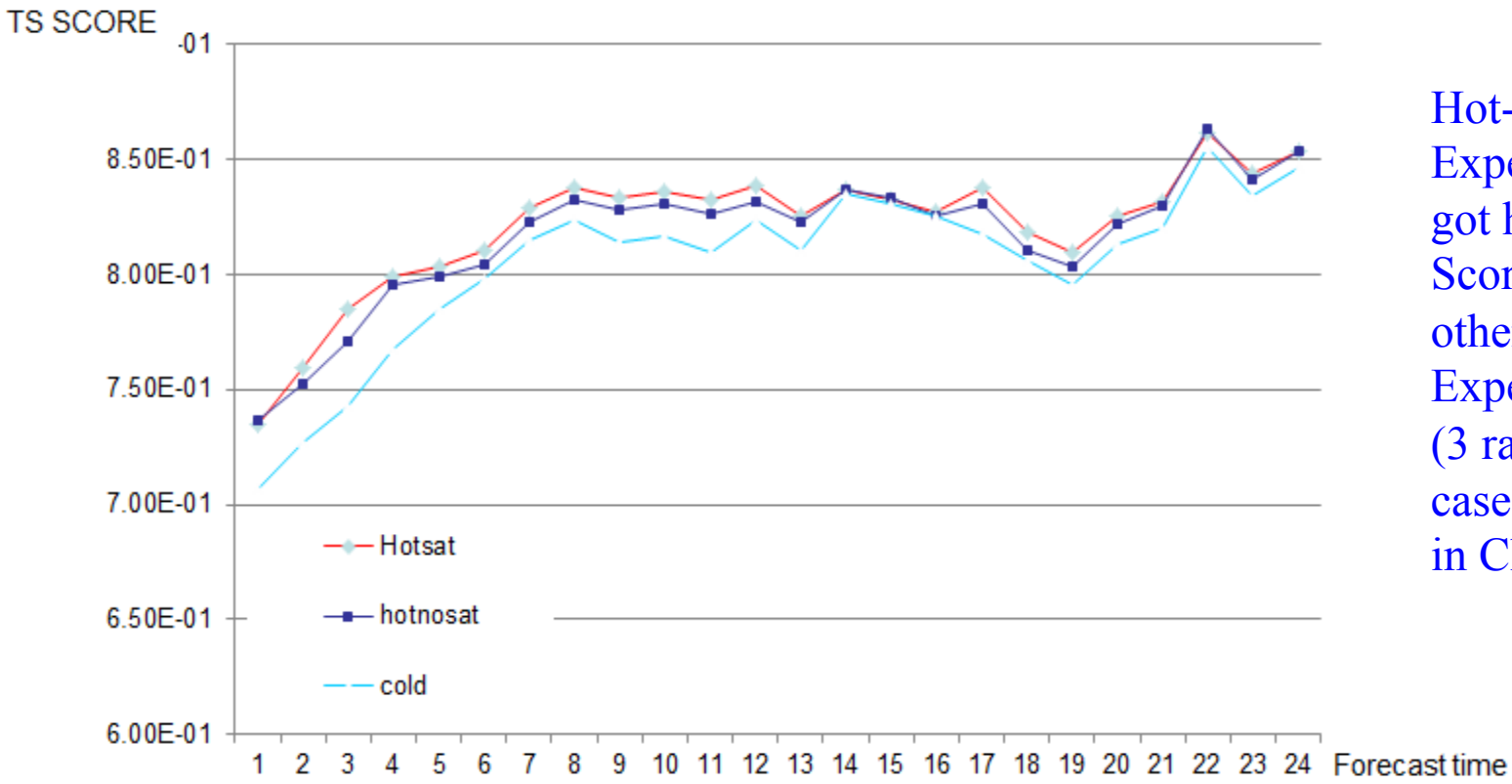


Observation from rain-gauge data

Up to 8h,the spatial distribution of precipitation are almost same

From 1-24h forecast:

- ✓ The period that hot start affects is mainly in the first 6 hours of forecast. This period is matched with model integration time with cold start scheme.
- ✓ hot start is the effective way to eliminate Spin-Up problem of model and improve precision of forecast in 0-6h.
- ✓ With no satellite data combined , forecasted precipitation is more ,but Satellite data combination relieved this hot start problem in this case.



Hot-sat Experiment got higher TS Score than other two Experiments (3 rainstorm cases in 2008 in China)

Summary

- Three Dimensional Cloud Information can be got utilizing China FY-2 data and other data ,and used to “hotstart” NWP model.
- Analysis indicates that the positive impact of satellite data at the early stage of precipitation simulation can be better discerned by comparing the precipitation distribution from three experiments.
- "hot start" can eliminate "Spin-Up" problem and shorten the integration time of model to some extent, and satellite data can improve precipitation forecast within the first 6 hours.
- The Hot-start experiment with no satellite data combined produces more precipitation, satellite data can reduce this phenomenon to some extent.

Thanks for your attention!