

CMA future prospects for radio occultation

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Presented to CGMS-[43] [Plenary & Working Group II] session, agenda item [05]

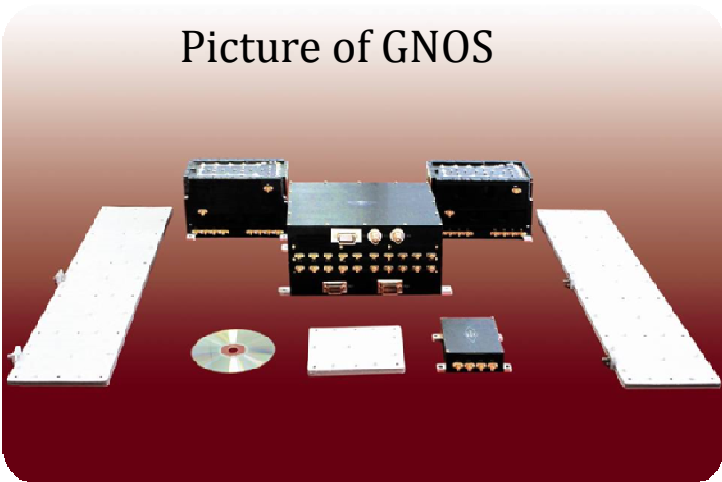
1. FY3C/GNOS overview

GNOS--Global Navigation Satellite System Occultation Sounder

First Launched on Sep.23rd, 2013



Picture of GNOS



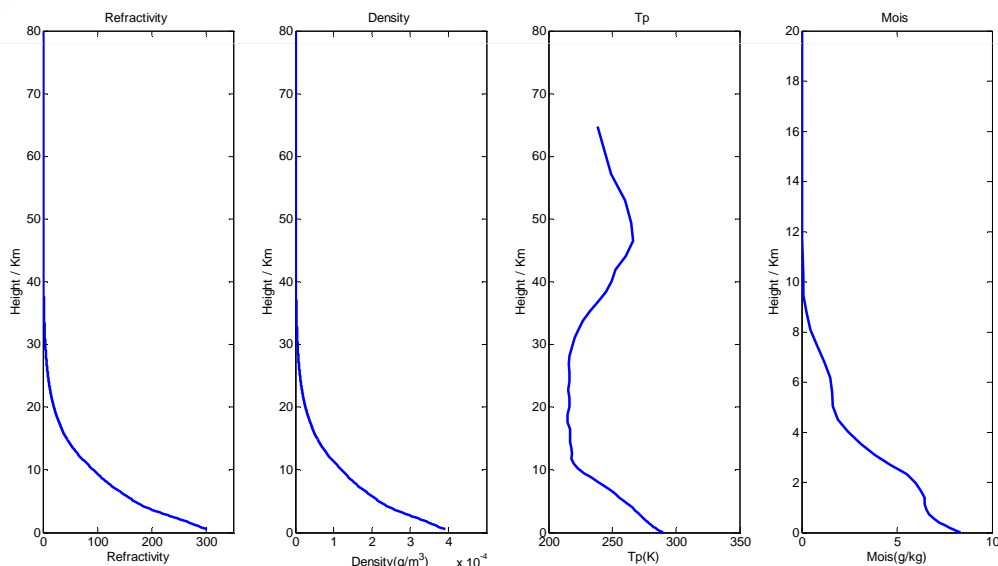
GNOS instrument parameters

Parameters	Content
Instrument mass	7.5kg
Constellation	GPS L1、L2 Beidou B1、B2
Channel number	Positioning: 8 Occultation: GPS 6 Beidou 4
Sampling rate	Positioning & Ionosphere occultation: 1Hz Atmosphere occultation: CL 50Hz OL 100Hz
Clock stability	1×10^{-12} (1secAllan)
Antenna specification	Atmosphere occultation antenna: Gain: >10dBi Antenna field of view: (El $\pm 7.5^\circ$ Az $\pm 35^\circ$) Positioning & Ionosphere occultation antenna: Gain: -1dBi Antenna field of view: $\pm 60^\circ$
Pseudorange precision	$\leq 30\text{cm}$
Carrier phase precision	$\leq 2\text{mm}$

2. GNOS Operational Products

- **Products category**
 - L1 Excess phase, POD
 - L2a Banding angle, Refractivity, Electron density
 - L2b Temperature, Humidity

GNOS data start from June 1st,2014



Occultation date is 2 Oct.2013, and the time is 03:22(UTC).Occultation located at 136.43E,49.18N, which received signal from GPS14 by GNOS/FY3C.

The screenshot shows the 'FENGYUN Satellite Data Center' website. The header includes the NSMC logo and navigation links for 'SATELLITES', 'DATA', 'IMAGES', 'PRODUCTS', 'DOCUMENTS', and 'TOOLS'. A search bar is present on the right. Below the header, there are sections for 'Archive' (listing satellites like FY-3C, FY-3B, etc.), 'FY-LEO' and 'FY-GEO' data filters, a 'Sign In' form, and a 'Statistics' section showing download statistics since 2005 (2,204,126,656 MB). A 'SATELLITE TRACK' map is visible, along with 'Orbit Parameters' for various satellites.

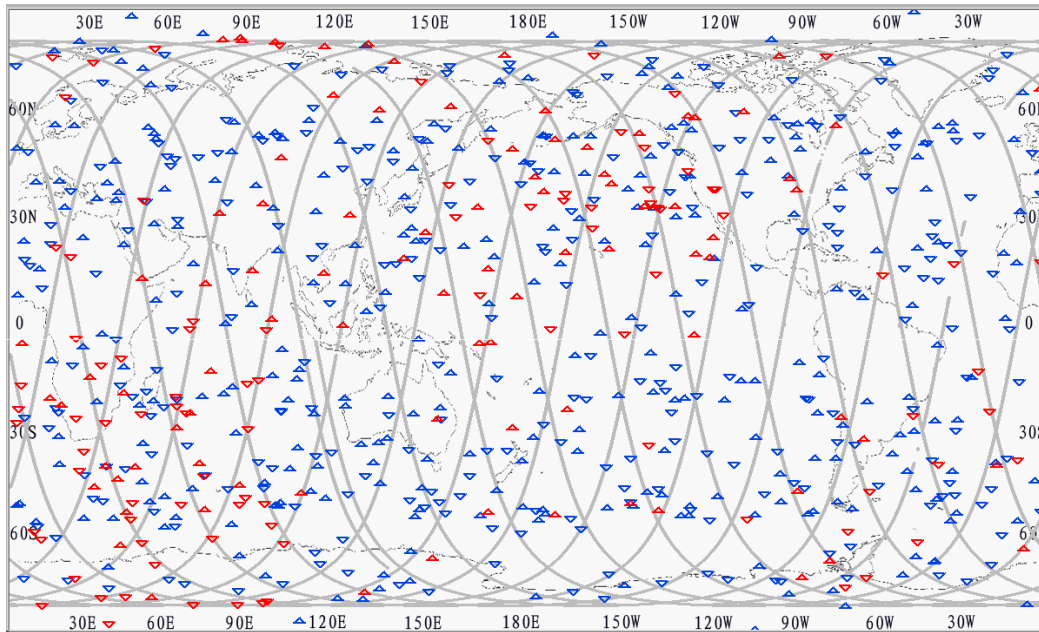
<http://satellite.cma.gov.cn/portalsite/default.aspx>

Dissemination ways

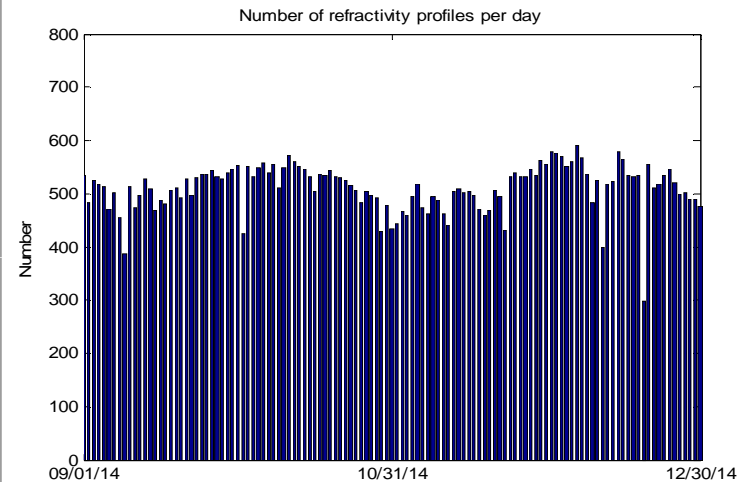
- Web-based service
- CMACAST
- GTS



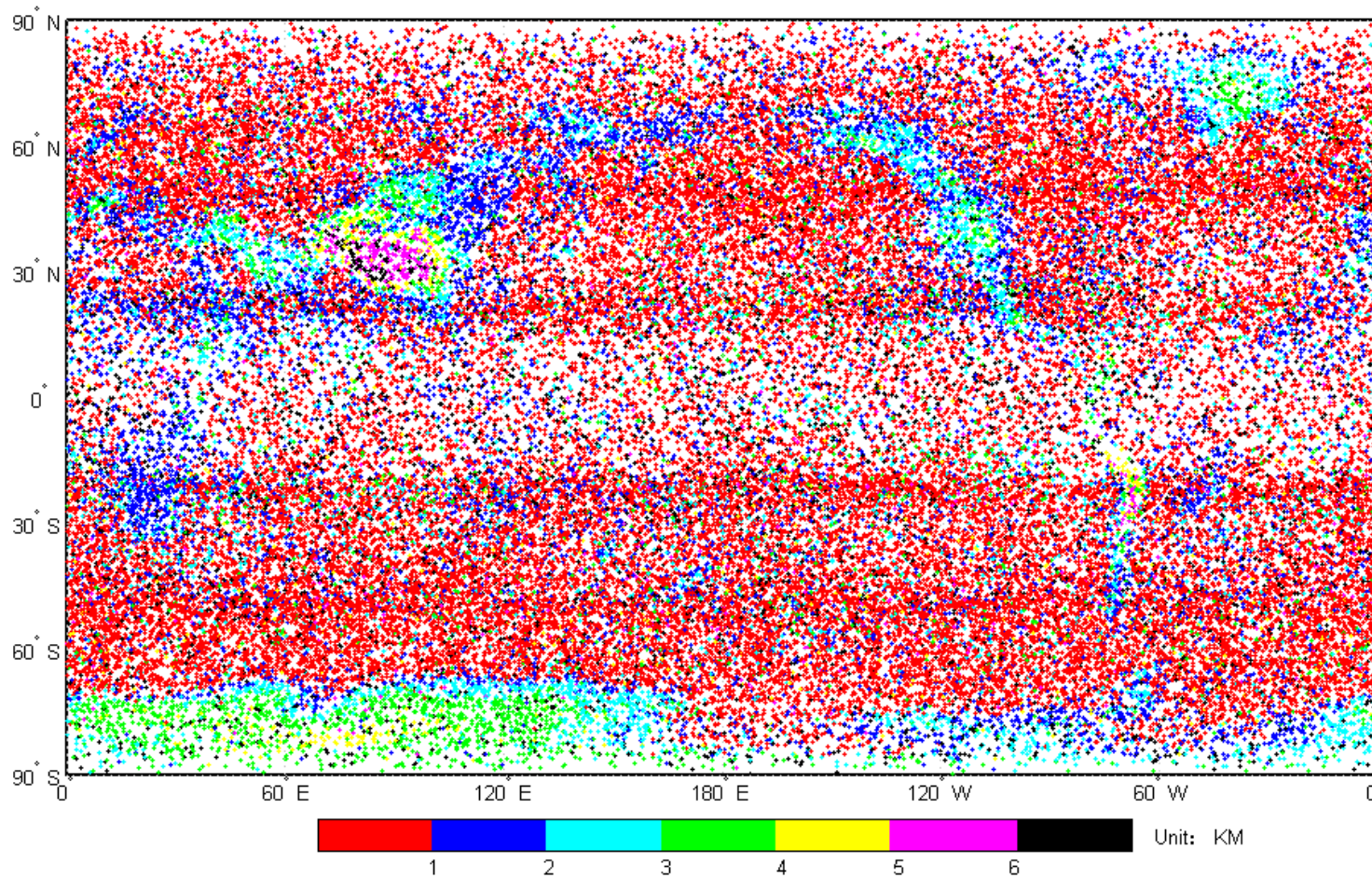
Daily Occultation events



➤ Blue is GPS (552 times), Red is BDS(184 times)



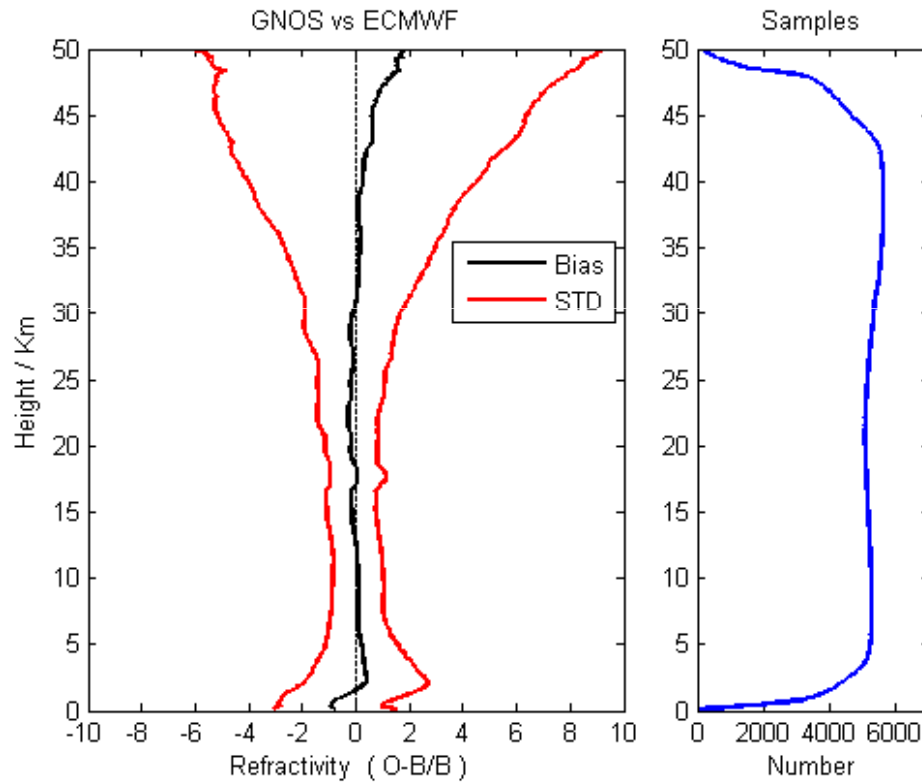
- Only shows GNOS/GPS processing stream in operation (GPS parameters from IGS web)
- About 500 refractivity profiles per day



**the distribution of radio occultation spots from January 1, 2014 to
June 30, 2014**

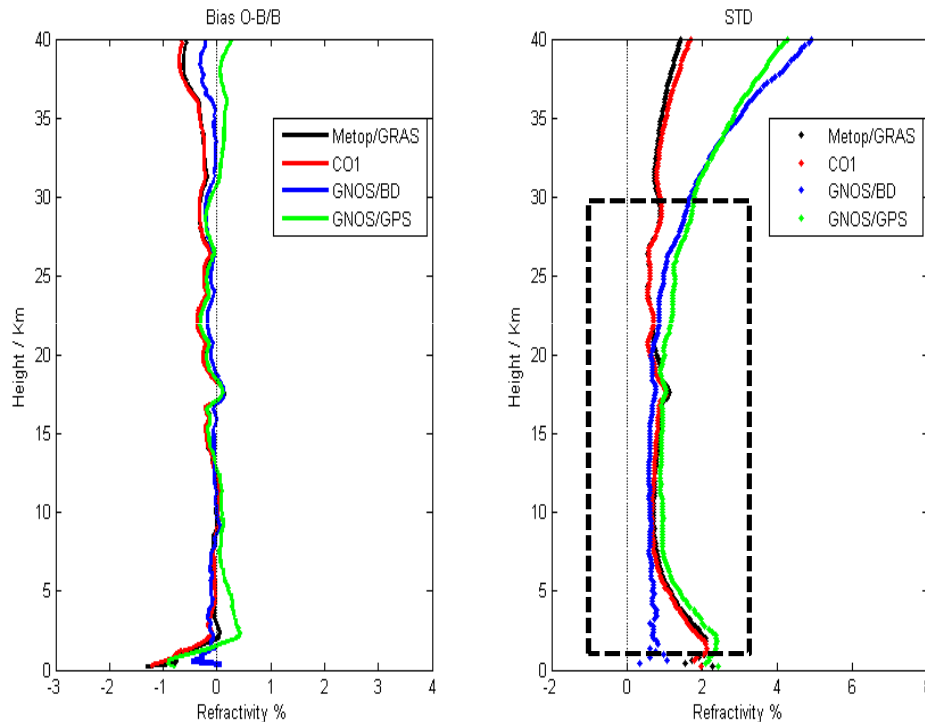
3. Results Validation

➤ GNOS/GPS Compare with ECMWF reanalysis



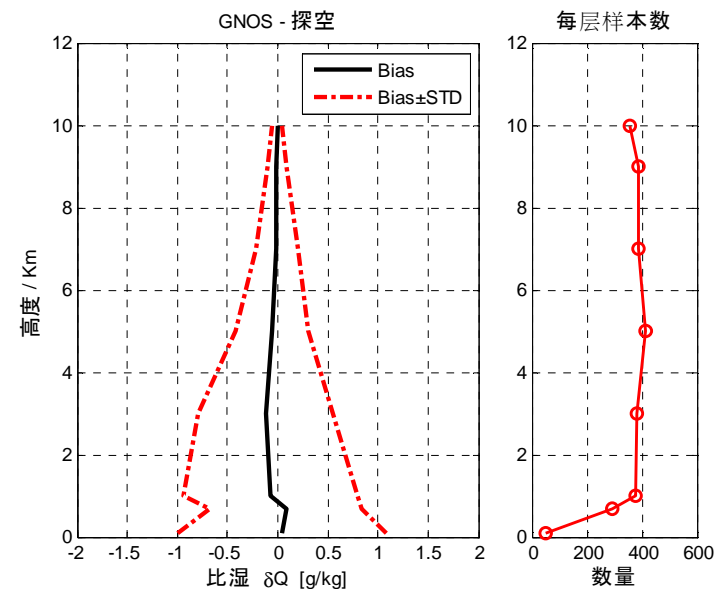
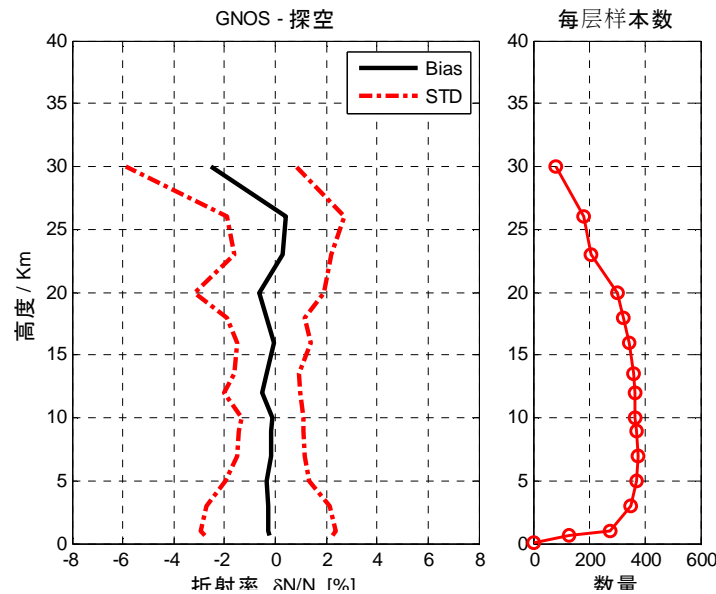
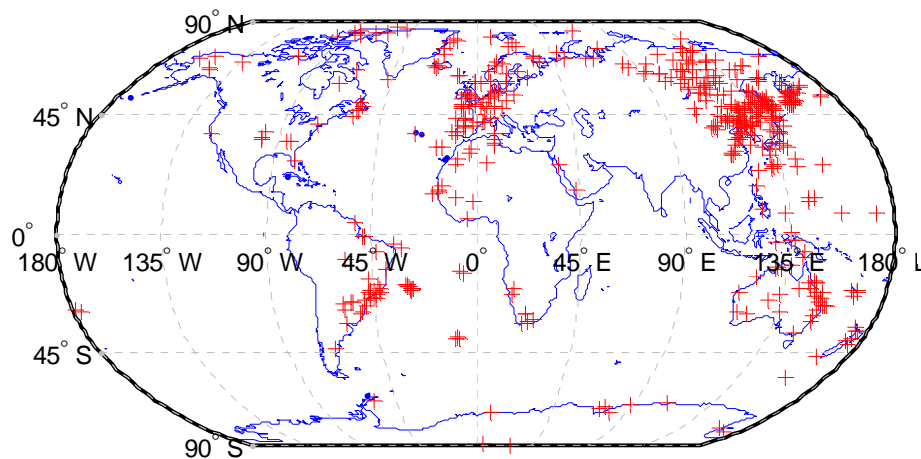
- GNOS meets the requirement of 2% (STD) below 35km

- Compare with ECMWF reanalysis
- Including GNOS/GPS, GNOS/BDS, COSMIC and METOPA/GRAS



- Exhibiting good agreement with ECMWF in terms of bias
- Reconfirming the characteristic of non-bias of radio occultation
- The most excellent sounding height of GNOS is from 5 to 30 kilometers, standard deviation is within 1%

- GNOS/GPS Temperature/Moisture validated with Radiosonde



4. Data Assimilation into NWP

Unified framework for global and regional system, the global version operation since 2009.

GRAPES forecast model

- Non-hydrostatic equations
- Terrain-following coordinate
- Arakawa-C(horizontal) and Charney Phillips(vertical) grid
- Model top at 32.5km
- Resolution $0.5^\circ \times 0.5^\circ$.

GRAPES-DVar

- Observations assimilated : conventional data (radiosondes, synops, ships, AMV and aircraft), GNSS RO, MODIS wind, ASCAT wind, radiances(NOAA15,16,17,18,19,METOP and FY)
- Incremental digital filter initialization

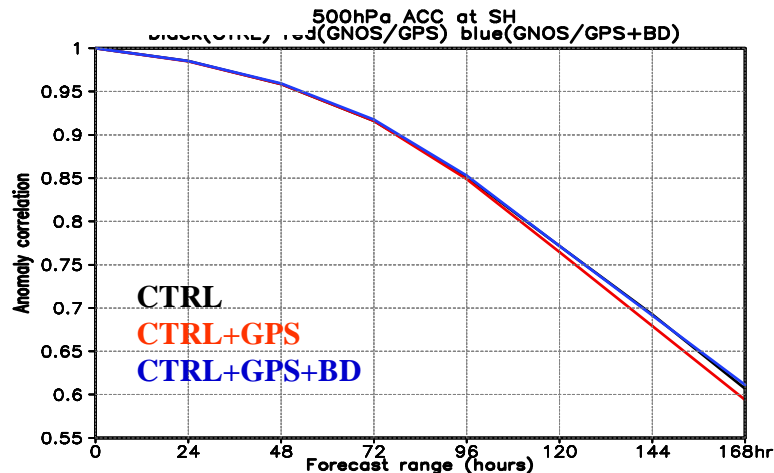
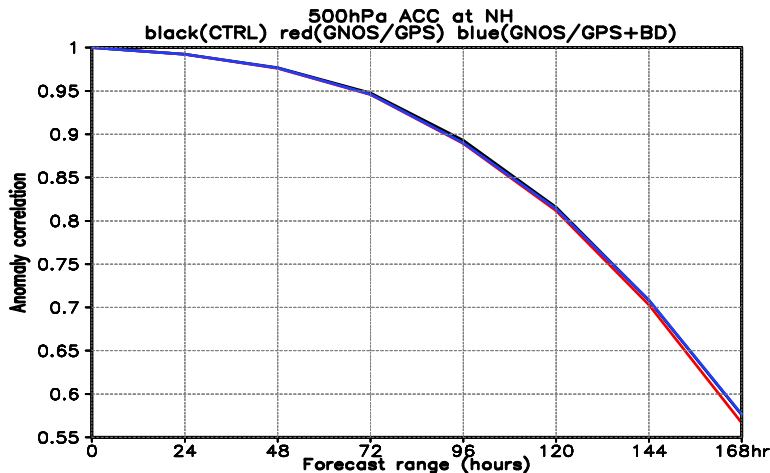
Experiment Setup

- Control experiment (configuration of global operational system)
- impact experiments (ctrl+gnos/gps, ctrl+gnos/gps+gnos/bd)
- Cycling time: 1st - 30th, Nonvember, 2013



Preliminary Forecast Impact Experiment

Impact on GRAPES Forecast Accuracy

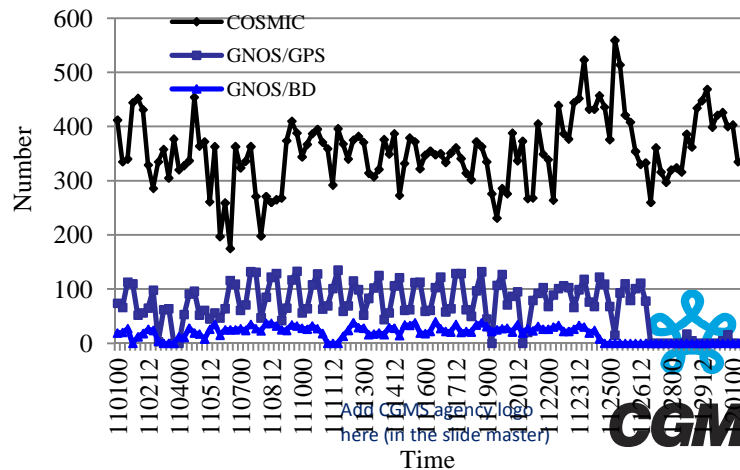


ACC scores (the higher the better) for forecast days.

GNOS data has an **neutral and positive** impacts on GRAPES analysis and forecast skill.

Courtesy of Liu yan (NWPC/CMA)

Number of CS RO data Assimilated per 6 hours in November



5. GNOS on FY-3 follow-on

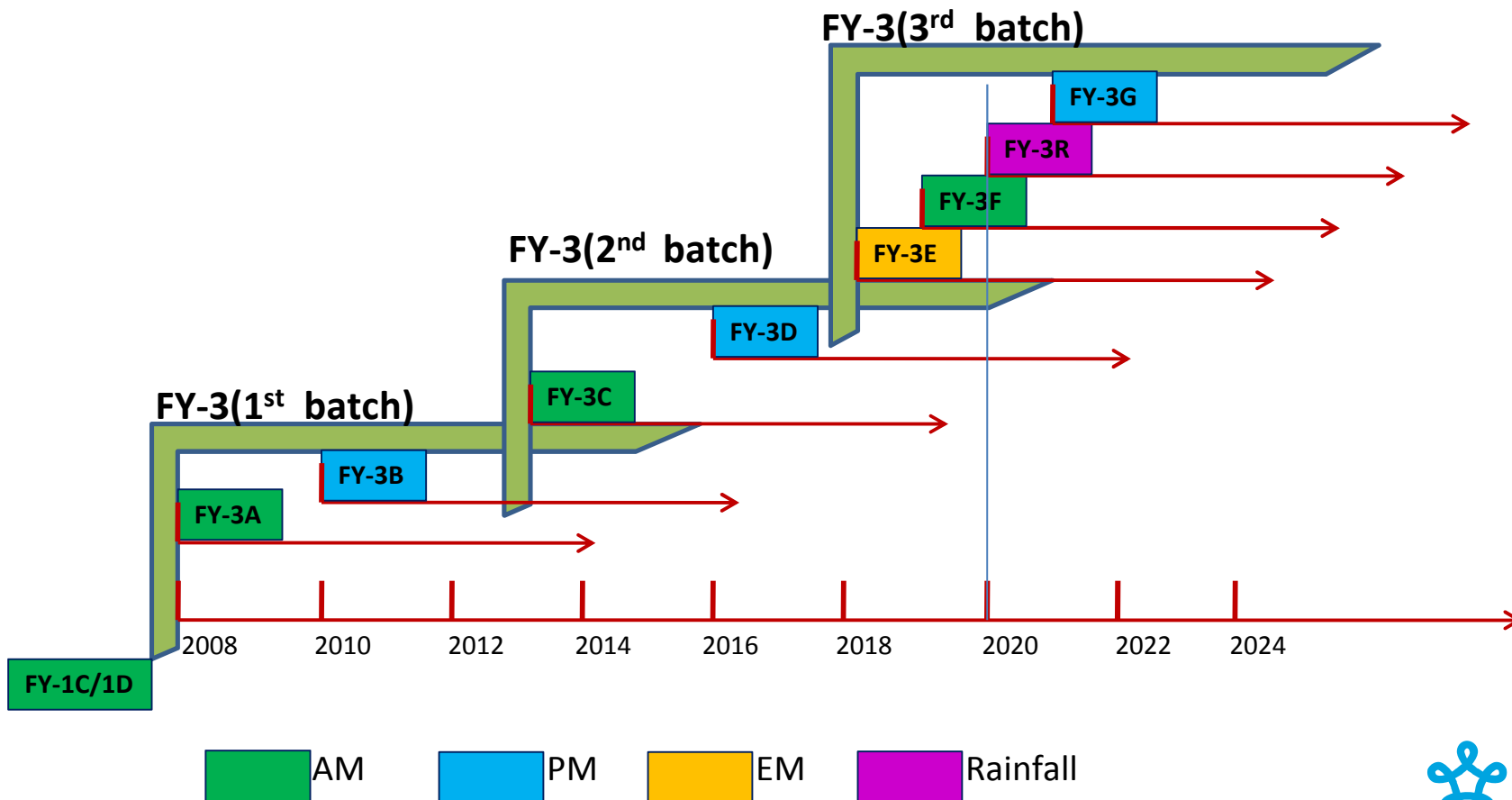
FY-3 02 batch to 03 batch Transition

3 yrs

5 yrs

8 yrs

Designing lifetime



GNOS Improvement

- **Atmosphere occultation antenna**
 - Gain will be improved
- **More RO channels**
 - GPS: 6 → 8
 - BDS: 4 → 8
- **Open loop tracking for B1**

6. Summary

- **Daily profiles can up to ~500 for GNOS/GPS**
- **GNOS/FY-3C shows good data quality during 5 – 30 km**
- **GNOS/F-3C data has an neutral and positive impacts on GRAPES forecast skill.**
- **The next instrument of GNOS on FY-3D and follow-on will be improved on antenna gain, channel number and B1 open loop tracking ability**

Future Work

- More elaborated experiments on the assimilation of GNOS
- Promote operation of the occultation data from BDS
- International Cooperation