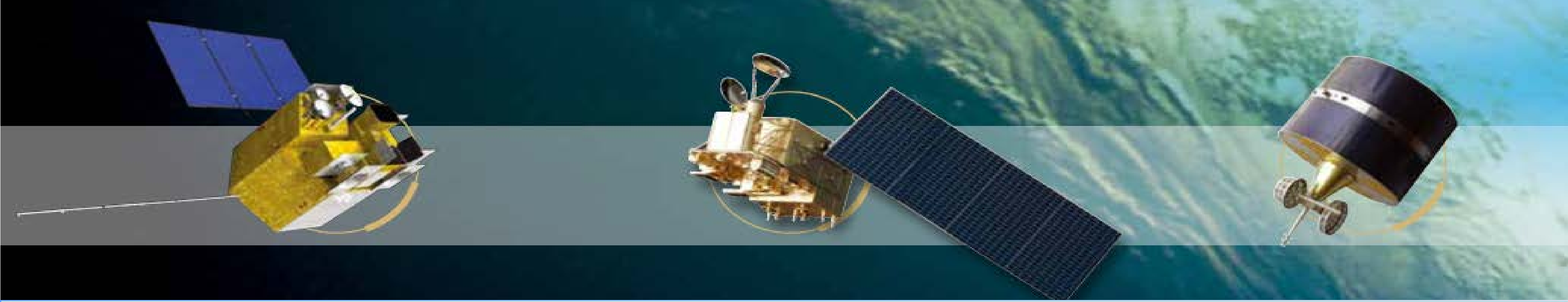


Status of investigations on using early morning orbit by FY-3 satellite

Peng ZHANG

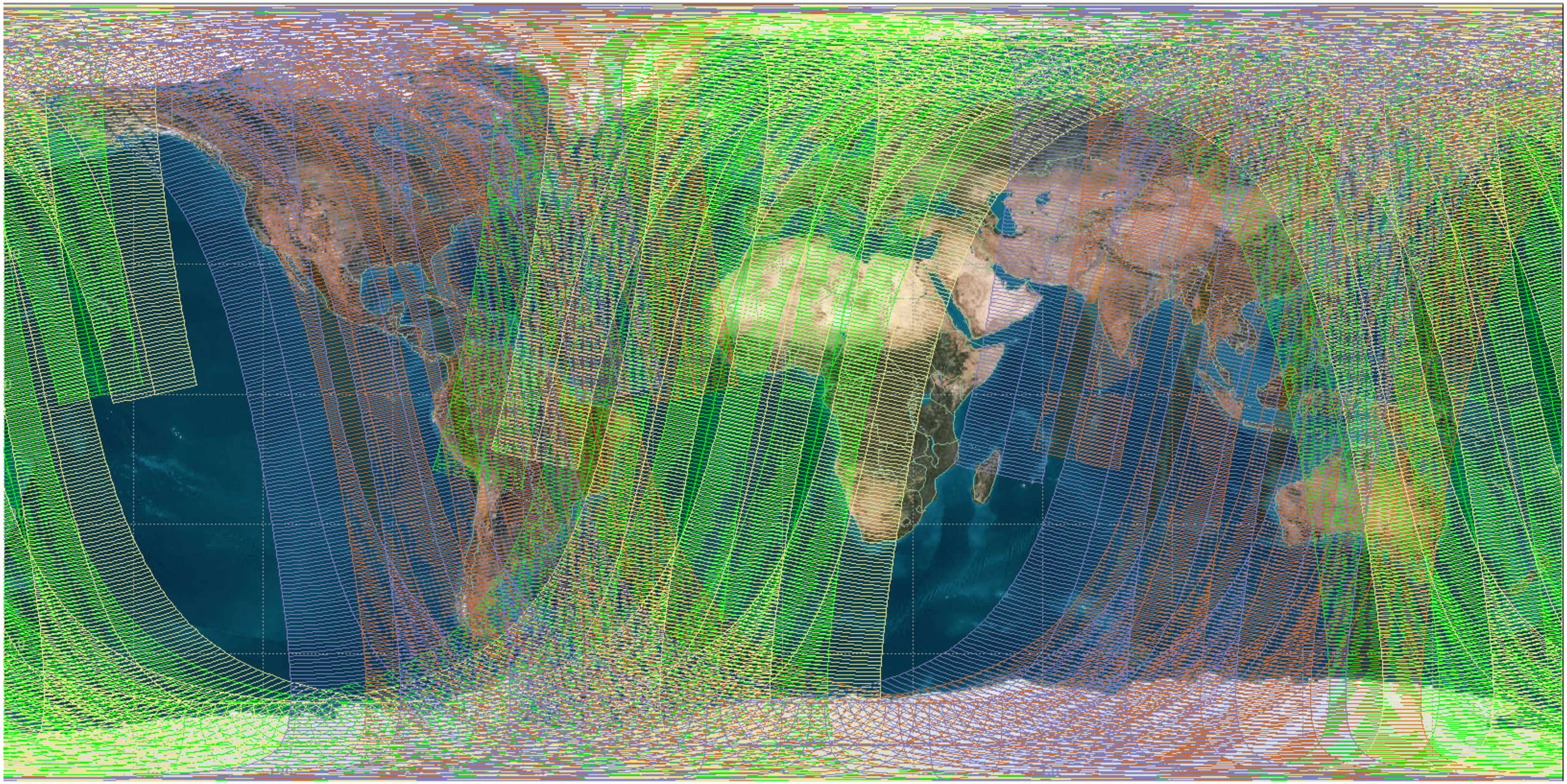
National Satellite Meteorological Center ,CMA

July 8-12, Tsukuba, Japan

Outline

- Recalling the Former Discussions
- Latest Progress
- Payloads and Orbit Engineering Reconfiguration
- Summarization and Conclusion

Gap obviously exists in current operational polar- orbiting constellation



FY-3A 10:00 AM

FY-3B 13:40 PM

Metop-A 9:30 AM

SNPP 13:30 PM

1. Recalling the Former Discussions

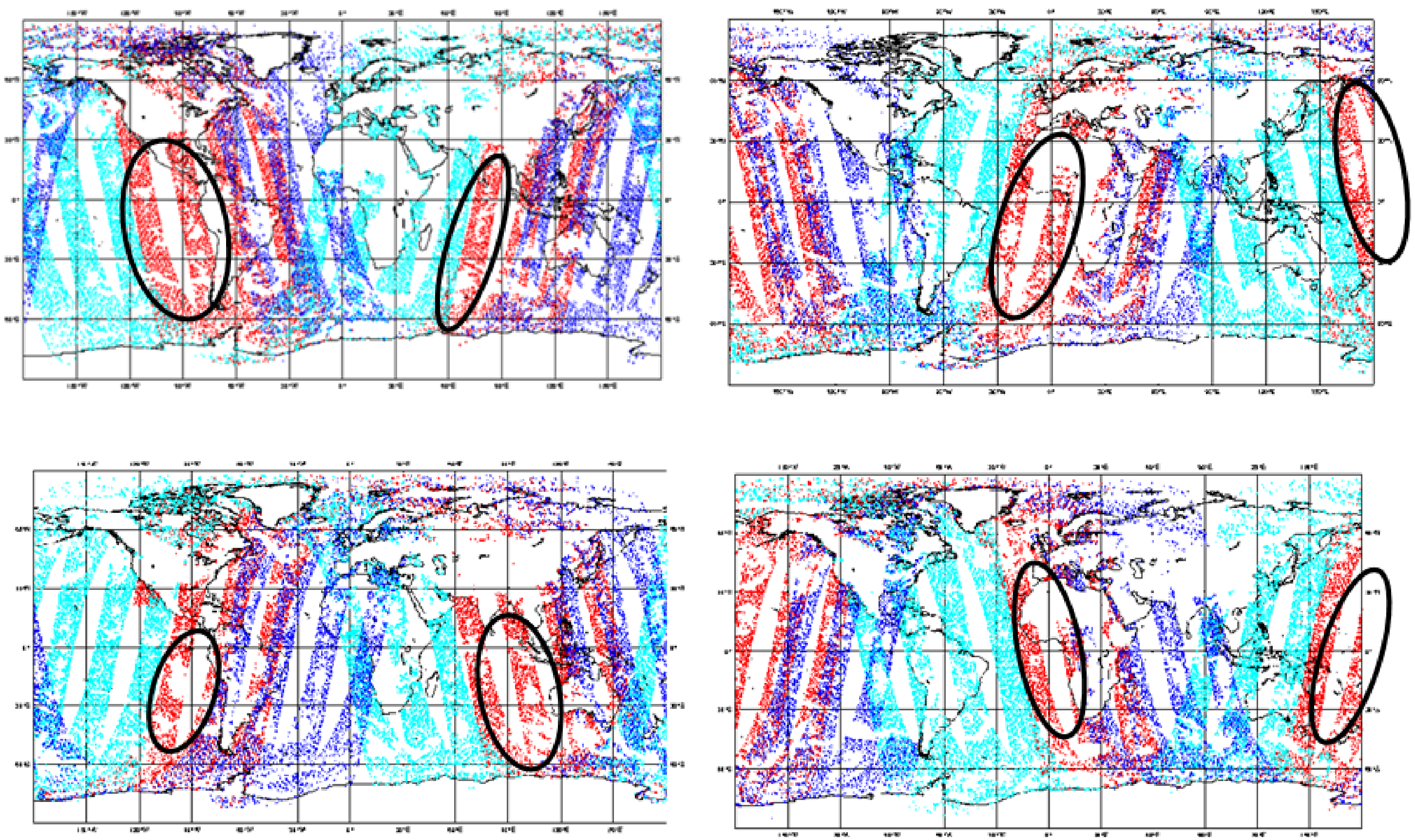
"WMO VISION FOR THE GOS IN 2025"

-- Optimizing the current operational polar-orbiting system

- **Recommendation 39.01**: CGMS agencies are invited to assess the possibility of implementing the mission with sounding capabilities in early morning orbit.
- Relative actions and recommendations are also from ET-SAT-7 and CBS-15.
- CMA indicated its willingness to investigate the possibility of flying the mission with sounding capabilities in the early-morning orbit in order to have a better distribution of atmospheric sounding system over the planned 3 orbits.

Courtesy to CGMS and WMO
Special Courtesy to Mitch Goldberg, NESDIS/NOAA

The assessment study is benefited with NOAA-15, 16, and 17 orbital data. As the figures below, the early morning data fill the gaps (ellipses) during 4 time windows of assimilation.



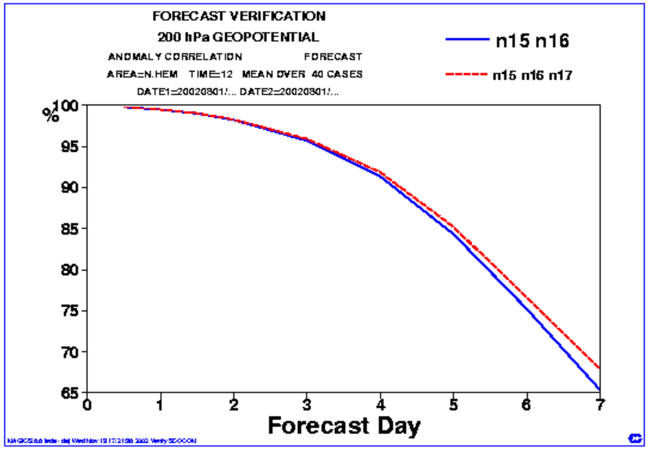
NOAA -15 (07:30 am)- red,NOAA-16 (13:30 pm) light blue,,NOAA-17 (10:00 am) dark blue

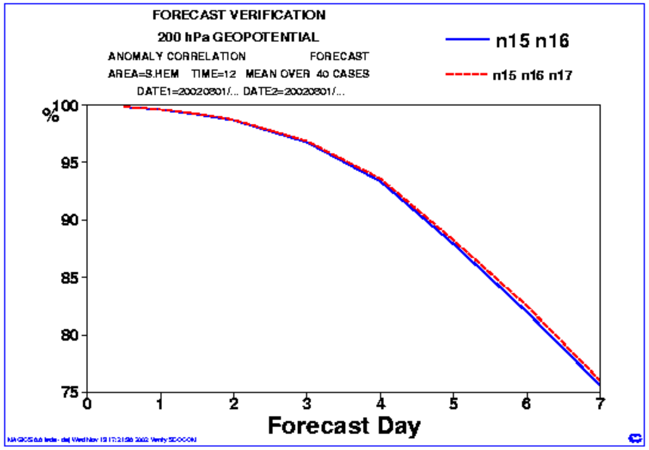
Outcome of the assimilation studies (3SAT versus 2SAT)

Courtesy to ECMWF

Z200 scores averaged over 40 cases

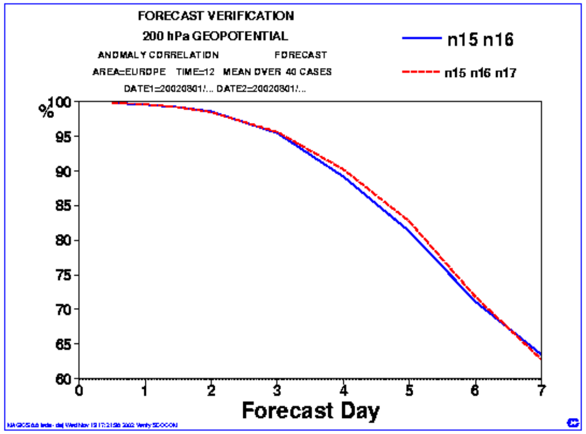
Half hemispheric

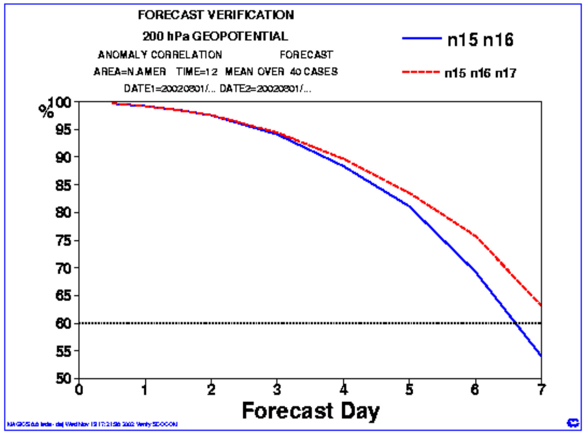




- **3SAT is better than 2SAT for hemispheric scores**
- **3SAT is neutral or better than 2SAT up over Europe**
- **3SAT is impressively better than 2SAT over North-America!**

Regional





CGMS 40: CMA presents the report 'CMA Consideration on early-morning orbit satellite' by Yang Jun in Lugano.

- Impossible for CMA to fly three orbits (AM, PM, and Early Morning) at the same time
- FY-3C & 3D are being manufactured now, no chance to make them changed for Early Morning orbit
- **FY-3E is the only possible opportunity for CMA to fly early morning orbit before 2020**

FY-3 OPERATIONAL SATELLITE INSTRUMENTS	FY-3C	FY-3D	FY-3E	FY-3F
MERSI – Medium Resolution Spectral Imager (I, II)	√(I)	√(II)	√(II)	√(II)
MWTS – Microwave Temperature Sounder (II)	√	√	√	√
MWHS – Microwave Humidity Sounder (II)	√	√	√	√
MWRI – Microwave Radiation Imager	√	√		√
WindRAD - Wind Radar			√	
GAS - Greenhouse Gases Absorption Spectrometer		√		√
HIRAS – Hyper spectral Infrared Atmospheric Sounder		√	√	√
OMS – Ozone Mapping Spectrometer			√	
GNOS – GNSS Occultation Sounder	√	√	√	√
ERM – Earth Radiation Measurement (I, II)	√(I)		√(II)	
SIM – Solar irritation Monitor (I, II)	√(I)		√(II)	
SES – Space Environment Suite	√	√	√	√
IRAS – Infrared Atmospheric Sounder	√			
VIRR – visible and Infrared Radiometer	√			
SBUS – Solar Backscattered Ultraviolet Sounder	√			
TOU – Total Ozone Unit	√			

↑ *2016*

Some Issues are still unclear before Tiger Team's report

Sounding Capability:
Some Questions for the Present NWP Assessment

The assessment is made for the Global, Europe, and North America, however,

1. Less assessment on the East Asia region
2. Less inter-comparison among the NWP centers

Imaging Capability:

1. Less demonstrations on the usage of the direct image or the derived products from the optical imager on the E.M. Orbit

After CGMS 40

CMA: the engineering practicability of platform and payloads;
Tiger Team: Benefits assessment from E.M. Orbit

2. Latest Progress

1. Potential User Workshop
    - Beijing, March 11, 2013
    - CMA Headquarter, NWPC, NNWPC, NCC, CAMS

2. Engineering Feasibility Seminar
    - Shanghai, Nov. 8, 2012
    - Shanghai, Jan. 10, 2013
    - Beijing, March 12, 2013
    - SAST/CAST

3. Financial Support Discussion
    - Jan., 2013
    - CMA, CNSA, NDRC

4. Tiger Team Meeting

5. 65th WMO EC: Dr. Zheng's statement on E.M

Tiger Team Meeting

April 25 ~ 26, Beijing

Assessment of the benefits of a satellite mission in an early morning orbit

Report from the WMO-CGMS Tiger Team

April 2013

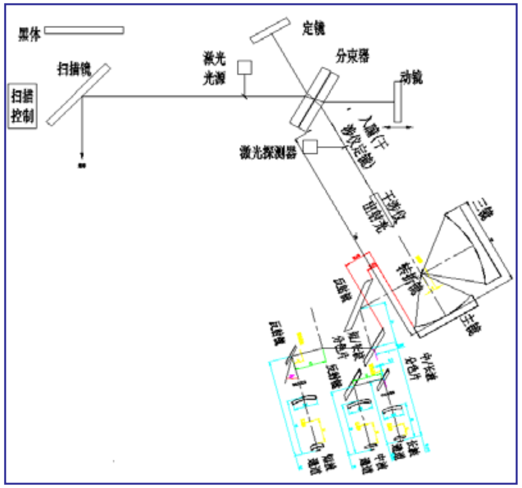
1. **BENEFITS OF AN EARLY MORNING MISSION FOR NWP**
2. **BENEFITS FOR OTHER APPLICATIONS**
   - **Diurnal cycle and daily operations schedule**
   - **Tropical cyclones and other severe events**
   - **Climate monitoring**
   - **Air quality**
   - **Solar observations**

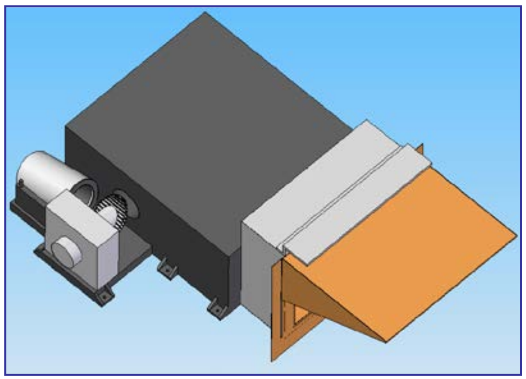
3. Payloads and Orbit Engineering Reconfiguration

NSMC

FY-3 OPERATIONAL SATELLITE INSTRUMENTS	FY-3C	FY-3D	FY-3E	FY-3F
MERSI – Medium Resolution Spectral Imager (I, II)	√(I)	√(II)	TBD	√(II)
MWTS – Microwave Temperature Sounder (II)	√	√	√	√
MWHS – Microwave Humidity Sounder (II)	√	√	√	√
MWRI – Microwave Radiation Imager	√	√		√
WindRAD - Wind Radar			√	
GAS - Greenhouse Gases Absorption Spectromete		√		√
HIRAS – Hyperspectral Infrared Atmospheric Sounder		√	√	√
OMS – Ozone Mapping Spectrometer				
GNOS – GNSS Occultation Sounder	√	√	√	√
ERM – Earth Radiation Measurement (I, II)	√(I)			
SIM – Solar irritation Monitor (II)	√			
SES – Space Environment Suite	√	√	√	√
IRAS – Infrared Atmospheric Sounder	√			
VIRR – visible and Infrared Radiometer	√			
SBUS – Solar Backscattered Ultraviolet Sounder	√			
TOU – Total Ozone Unit	√			

- **First Priority:** HIRAS, MWTSⅡ, MWHSⅡ, GNOS, WindRAD, DNB Imager
- **Second Priority:** SIMⅡ, SES (IP, WAI, SEM)
- **Opportunity:** MWRI, MERSIⅡ





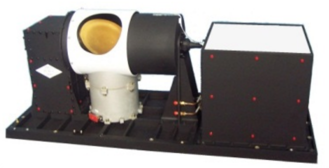
HIRAS

Specification	LWIR Band	MWIR Band	SWIR Band
Spectral Range	650 – 1136 cm-1	1210 – 1750 cm-1	2155-2550 cm-1
Spectral Res	0.625 cm-1	1.25 cm-1	2.5 cm-1
NEΔT @250K	0.15~0.4K	0.1~0.7K	0.3~1.2K
pixes per scan line	58		
Scan Angle	±50.4° around nadir		
Spatial Res	1.1 degrees (16.0km) IFOV at arranged in 2×2 array		
Power/Mass	129watts/120kg		

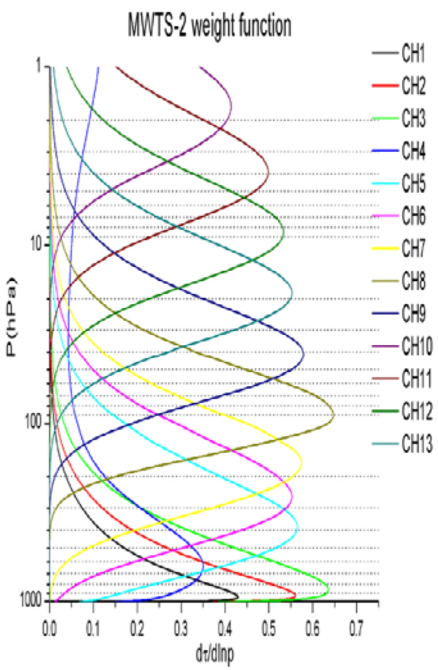
HIRAS/FY-3: Michelson interferometer
Aims: global temperature and moisture sounding from the infrared spectrum from 650 to 2550 cm−1

1) **retrieving atmospheric temperature and humidity profiles with high accuracies for numerical weather prediction and climate research at high vertical resolution.**
2) **Trace gases to be derived from HIRAS include ozone columnar amounts in deep layers and columnar amounts of carbon monoxide, nitrous oxide, methane, and carbon dioxide.**
3) **Cloud parameters .**

WMTS II



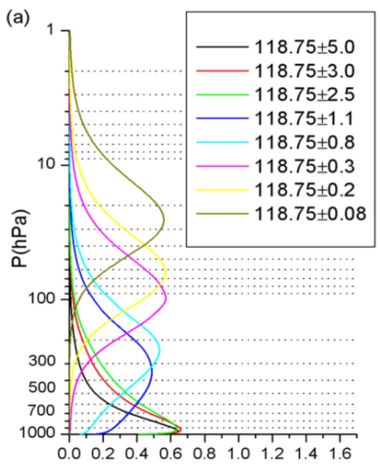
Parameter	Specification
Scan Angle	±49.5°
Pixels Per Scan Line	90
Quantization	13 bits

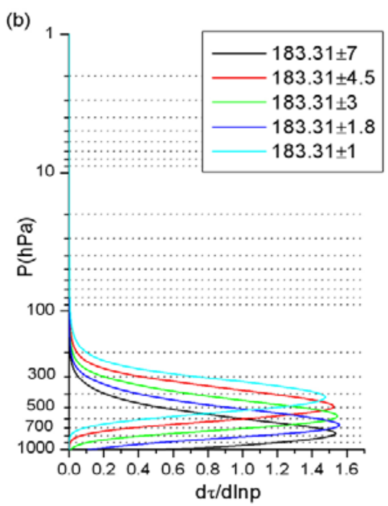


Ch No.	Central Frequency （GHz）	3dB Bandwidth （MHz）	NEΔT （K）	Main Beam Eff.	Dynamic Range （K）	Cal. Acc. （K）	Purpose
1	50. 3	180	1. 20	>90%	3～340	1. 5	Surface Emiss.
2	51. 76	400	0. 75	>90%	3～340	1. 5	Atmospheric Temperature Profile
3	52. 8	400	0. 75	>90%	3～340	1. 5	
4	53. 596	400	0. 75	>90%	3～340	1. 5	
5	54. 40	400	0. 75	>90%	3～340	1. 5	
6	54. 94	400	0. 75	>90%	3～340	1. 5	
7	55. 50	330	0. 75	>90%	3～340	1. 5	
8	57. 290344(fo)	330	0. 75	>90%	3～340	1. 5	
9	fo±0. 217	78	1. 20	>90%	3～340	1. 5	
10	fo±0. 3222±0. 048	36	1. 20	>90%	3～340	1. 5	
11	fo±0. 3222±0. 022	16	1. 70	>90%	3～340	1. 5	
12	fo±0. 3222±0. 010	8	2. 40	>90%	3～340	1. 5	
13	fo±0. 3222±0. 0045	3	3. 60	>90%	3～340	1. 5	

WMHS II

Parameter	Specification
Scan Angle	±53.35°
Pixels Per Scan Line	98
Quantization	14 bits

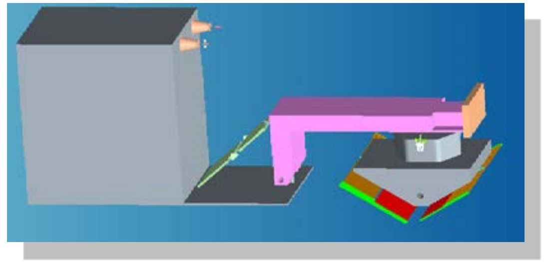




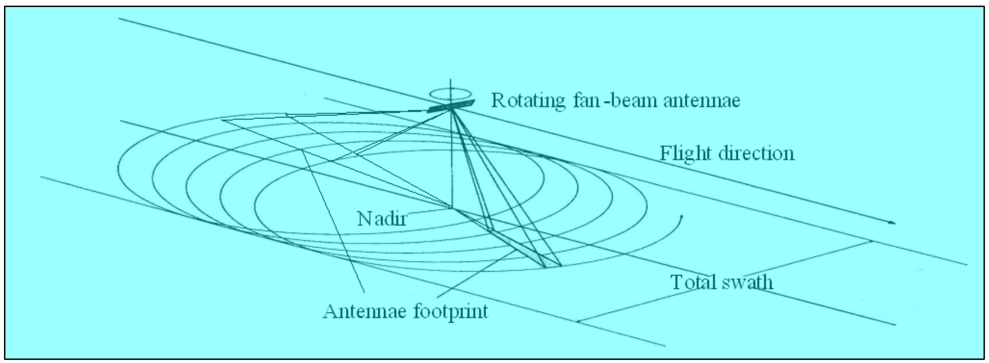
Ch No.	Central Frequency (GHz)	Polarization	Bandwidth (MHz)	Freq. Stability (MHz)	Dynamic Range (K)	NEΔT (K)	Cal. Acc. (K)	Main Beam Width	Main Beam Eff.	Purpose
1	89.0	V	1500	50	3—340	1.0	1.3	2.0°	>92%	Surface and Precipitation
2	118.75±0.08	H	20	30	3—340	3.6	2.0	2.0°	>92%	Atmospheric Temperature Profile
3	118.75±0.2	H	100	30	3—340	2.0	2.0	2.0°	>92%	
4	118.75±0.3	H	165	30	3—340	1.6	2.0	2.0°	>92%	
5	118.75±0.8	H	200	30	3—340	1.6	2.0	2.0°	>92%	
6	118.75±1.1	H	200	30	3—340	1.6	2.0	2.0°	>92%	
7	118.75±2.5	H	200	30	3—340	1.6	2.0	2.0°	>92%	
8	118.75±3.0	H	1000	30	3—340	1.0	2.0	2.0°	>92%	
9	118.75±5.0	H	2000	30	3—340	1.0	2.0	2.0°	>92%	
10	150.0	V	1500	50	3—340	1.0	1.3	1.1°	>95%	Surface and Precipitation
11	183.31±1	H	500	30	3—340	1.0	1.3	1.1°	>95%	Atmospheric Moisture Profile
12	183.31±1.8	H	700	30	3—340	1.0	1.3	1.1°	>95%	
13	183.31±3	H	1000	30	3—340	1.0	1.3	1.1°	>95%	
14	183.31±4.5	H	2000	30	3—340	1.0	1.3	1.1°	>95%	
15	183.31±7	H	2000	30	3—340	1.0	1.3	1.1°	>95%	

WindRAD

The Wind Radar monitors Global ocean surface wind field (OSWF) from space. The wind radar will measure the radar backscattering of sea surface from different azimuth and then retrieve wind vector with the geophysical model function (GMF). The OSWF data will significantly contribute to improve weather forecast, especially numerical model prediction of typhoon tracks and landfalls.

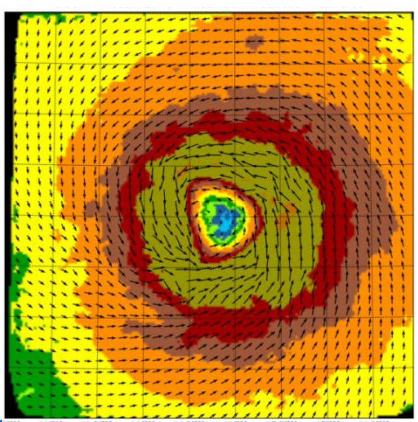


Wind Radar

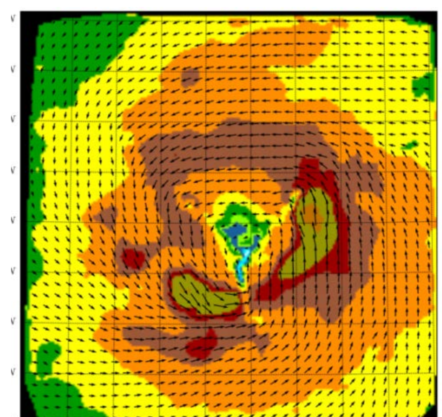


Measurement geometry of Wind Radar

The four antennae (two polarization of each frequency) of Wind Radar rotate slowly around the vertical axis of spin platform, and each pixel within the swath will be illuminated from more azimuth directions than the existing spaceborne sactterometers due to the low rotation rate .



Wind Radar



SeaWinds

Wave band		C	Ku
Centre frequency		5.3GHz	13.256GHz
Polarization		HH,VV	HH,VV
Spatial resolution	azimuth direction	≈25 km	≈10 km
	range direction	≤ 10 km	≤ 5 km
Swath width		> 1200 km	
Incidence angle		36° ~ 45°	37° ~ 43°
Peak Gain		31 dBi	37.5 dBi
Transmitted power		124 W	141 W
Rotation rate		0.4 ~ 0.7 rad/s	
Radiometric accuracy		1dB（≤ 5m/s）; 0.5dB（others）	
Wind speed range		3 ~ 50 m/s	
Wind speed accuracy		1.5 m/s（≤ 20m/s）; 10%（others）	
Wind speed range		0 ~ 360°	
Wind direction accuracy		< 20°	

Expected performance of the Wind Radar

- Better spatial resolution than the current spaceborne scatterometers;
- High wind retrieval capability ;
- Nearly all-weather capability .

GNOS

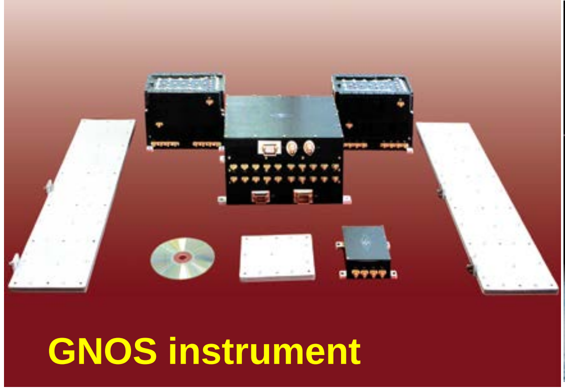
GNOS will receive two types of signal from GPS and China BeiDou-2. GNOS will observe over 1000 occultations per day with GPS and BD satellites,

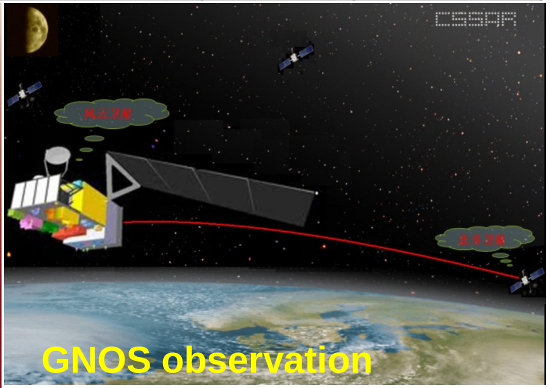
Expected Products

- Temperature profiles
- Humidity profiles
- Refractivity profiles
- Electronic content profiles

Frequency	GPS L1/L2; BD2
Receiver Channels	8 (Navigation) 4 (Occultation)
Sampling rate	1 ~ 50 Hz
Crystal oscillator	1e-11 (100s)
Real-time position	10m（RMS）
Real-time velocity	0.1m/s(RMS)
Phase center accuracy	2 mm (RMS)
Antenna number	1 (Navigation) 2 (Occultation)

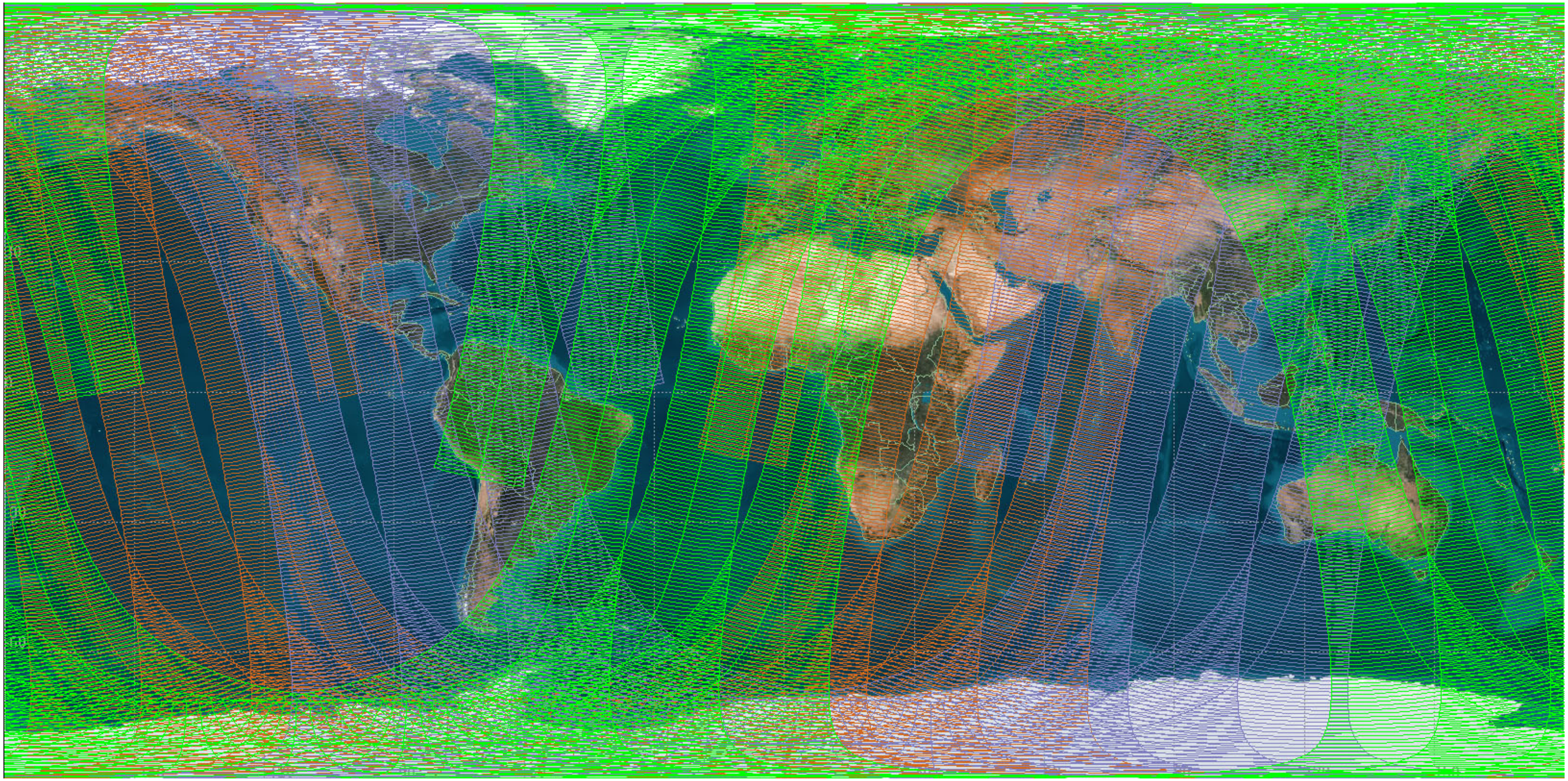
		Temperature	**Humidity**	**Refractivity**	**Electronic Content**
RMS Accuracy	Low Tropos.	0.5-3 k	0.25-1.0 g/kg	0.1-0.5%	(100-600 km) < 20%
	High Tropos.	0.5-3 k	0.05-0.2 g/kg	0.1-0.2%	
	Low Stratos.	0.5-3 k	--------	0.1-0.2%	
	High Stratos.	0.5-5 k	--------	0.2-2.0%	





Orbit Option: FY-3 Early Morning + NPP + Metop

Recognizing that global even distribution of sounding data is of great significance for the 6 hour NWP assimilation window, one approach is to constitute a three orbital fleet including Metop（Mid. Morning） + NPP(Afternoon) +FY-3(Early Morning).



FY-3 Early Morning 6:00 AM

Metop-A 9:30 AM

NPP 13:30 PM

Plan in this year

- Completing the payloads configures of FY-3 E.M
- Completing the specification of the each payloads
- Completing the redesign of the calibration system for the sounding instruments
- Starting the procedure for redeploying FY3 to an early morning orbit

Summarization

1. **Payloads:**
   - Most payloads (first priority) in readiness, the optical imager is to be determined
   - Onboard calibration system should be redesigned

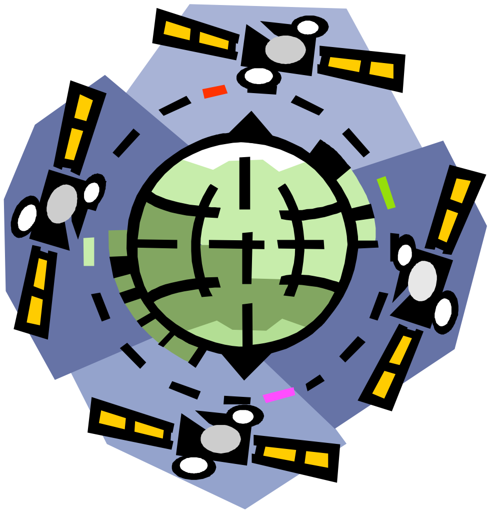
2. **Imagery Usage**:
   - The optical imager is different from the DNB on the SNPP
   - The usage of the optical imagery and the derived products will decided the specification of the DNB imager

3. **Platform:** Modified lightly from original FY-3A/B platform

4. **Financial Support:** 15-20% budget increment

Conclusion

- CMA do appreciate the supports from CGMS and WMO, especially the Tiger Team, on the benefit assessment of the E.M. orbit;
- CMA is considering starting the procedure for redeploying FY3 to an early morning orbit and calls on support from WMO, CGMS members and satellite operators to reach this objective
- International efforts are expected in the course of the development phase of the FY-3 early morning mission.
- CMA will continue to investigate the possibility of flying the mission with sounding capabilities in the early-morning orbit in order to have a better distribution of atmospheric sounding system over the planned 3 orbits and to improve the global numerical weather prediction.



Thank you !