CMA Consideration on early-morning orbit satellite

National Satellite Meteorological Center, CMA

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CGMS 40 in Lugano: 5-9 Nov., 2012

Outline

- Background
- Gap analysis on the sounding data coverage
- Feasibility study on FY-3 use of early morning orbit
- Conclusions

Background

"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 an IR Sounding in early morning orbit.

- Relative actions and recommendations are also from ET-SAT-7 and CBS-15

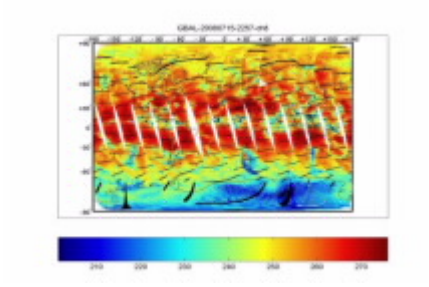
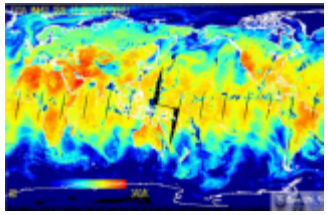
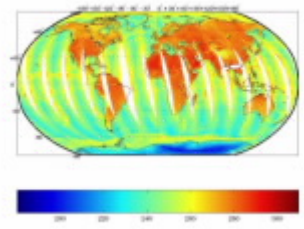
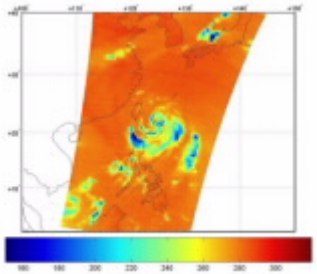
- CMA indicated its willingness to investigate the possibility of flying an IR Sounder in the early-morning orbit in order to have a better distribution of IR sounding over the planned 3 orbits.

Investigation based on the following operational polar-orbiting missions with sounding capabilities

- METOP-A/B, AM, by EUMETSAT
- Suomi-NPP(JPSS), PM, by NOAA
- FY-3A/B, AM+PM, by CMA

VASS：Vertical Atmosphere Sounding Suite onboard FY-3A/B

SOUNDING INSTRUMENTS		
Infrared Atmospheric Sounder (IRAS)	Spectral range: 0.69～15.5μm Channel numbers: 26 Cross track scanning: ±49.5° Spatial resolution: 17.0 KM	Atmospheric temperature profile, atmospheric humidity profile, total ozone content, cirrus, aerosol, etc
Microwave Atmospheric Temperature Sounder (MWTS)	Frequency range: 50～57GHz Channel numbers: 4 Cross track scanning: ±48.6° Spatial resolution : 50～75 KM	Atmospheric temperature profile, rainfall, cloud liquid water, surface parameters, etc.
Microwave Atmospheric Humidity Sounder (MWHS)	Frequency range: 150～183GHz Channel numbers: 5 Cross track scanning: ±48.95° Spatial resolution (SSP): 15 KM	Atmospheric humidity profile, water vapour, rainfall, cloud liquid water, etc.

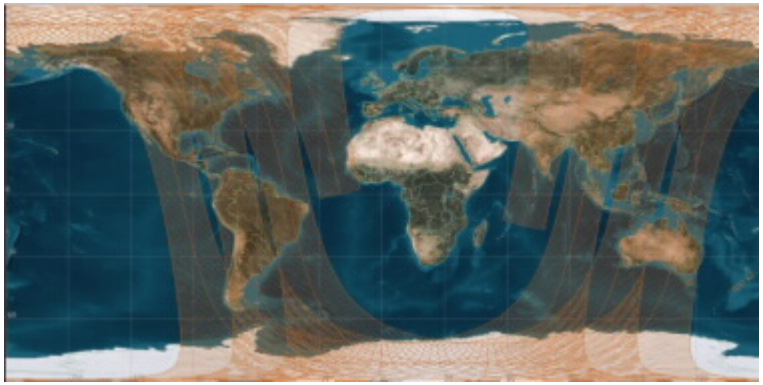





VASS improvements in FY-3 follow-ons

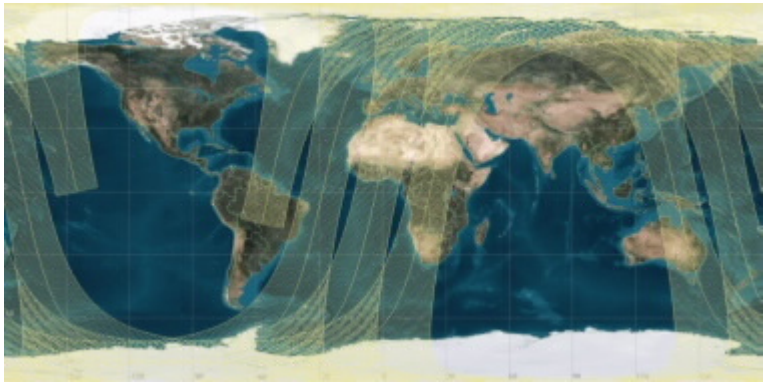
(FY-3C/D/E/F already approved)

- IRAS → HIRAS (filters to hyper-spectral)
- MWTS → MWTS II (4 channels to 13 channels)
- MWHS → MWHS II (add 89GHz,118Ghz)

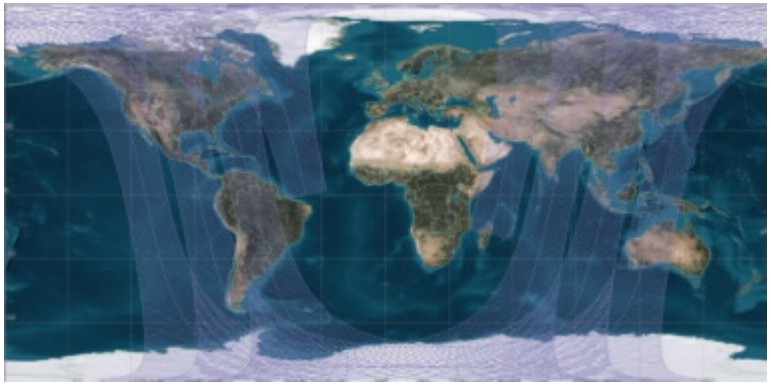
Gap analysis on the 6 hr. period sounding data coverage



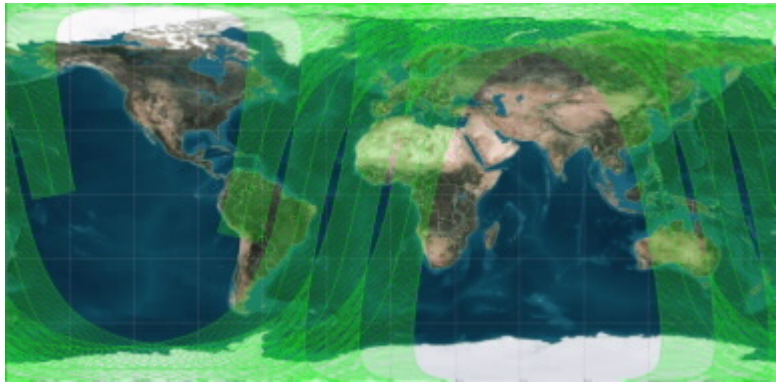
FY-3A 10:00 AM



FY-3B 13:40 PM



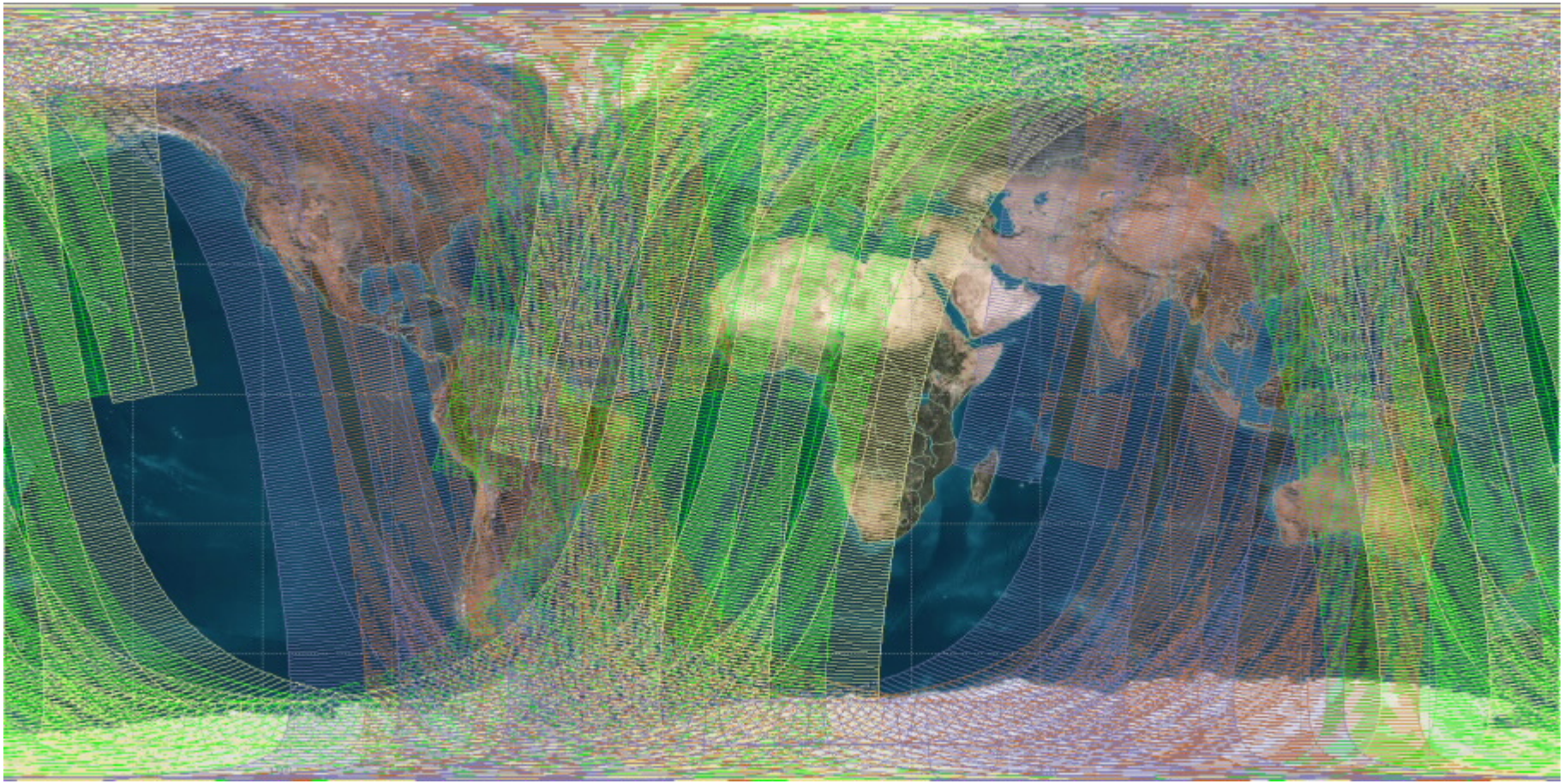
Metop-A 9:30 AM



NPP 13:30 PM

Data coverage is overlapped in most region with FY-3A and Metop-A, and with FY-3B and Soumi-NPP

Gap obviously exists in current operational polar- orbiting constellation



FY-3A 10:00 AM

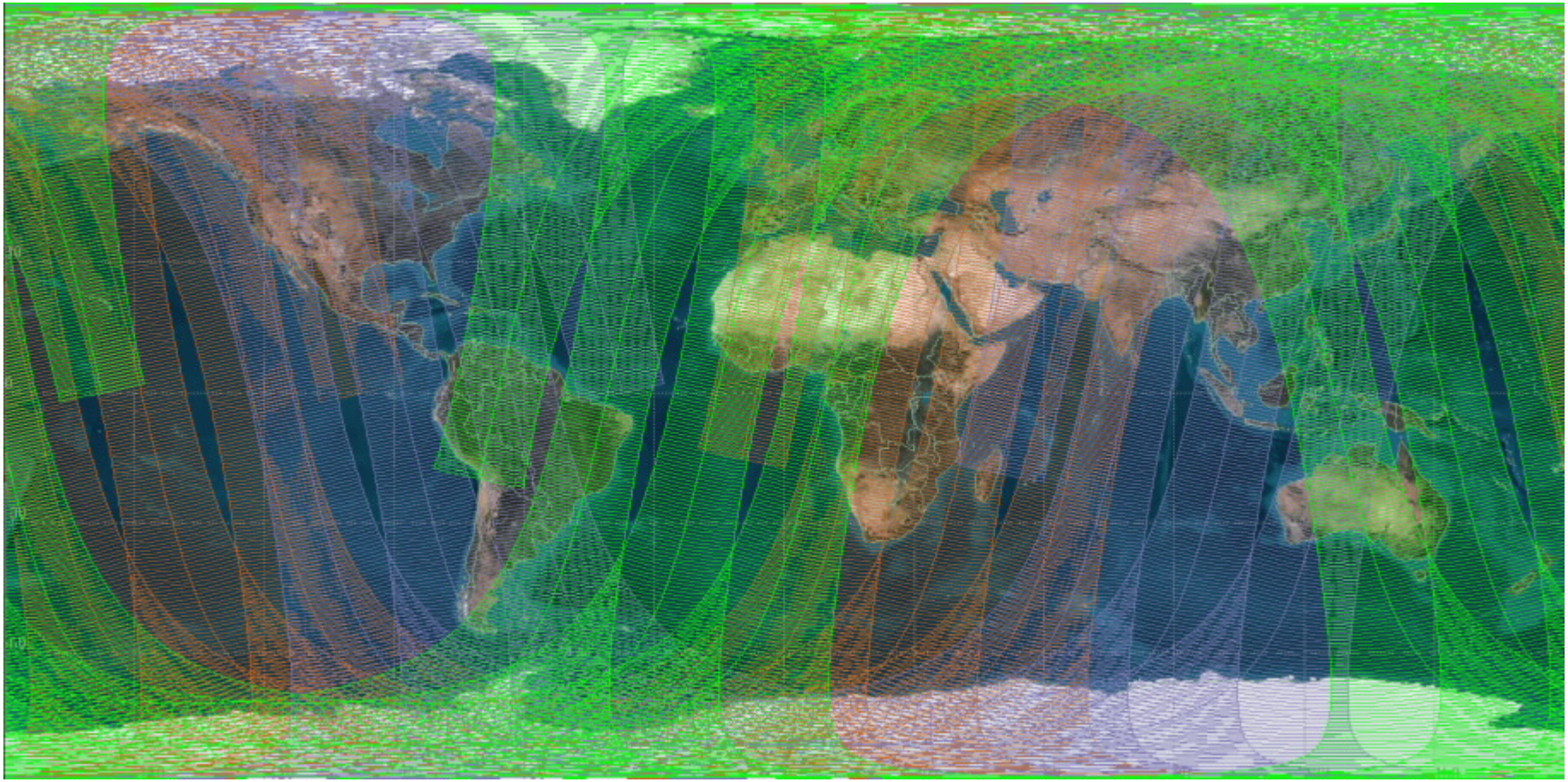
Metop-A 9:30 AM

FY-3B 13:40 PM

NPP 13:30 PM

Assumption: Metop-A + NPP+FY-3 Early Morning

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

Feasibility Study on FY-3 Use of Early Morning Orbit

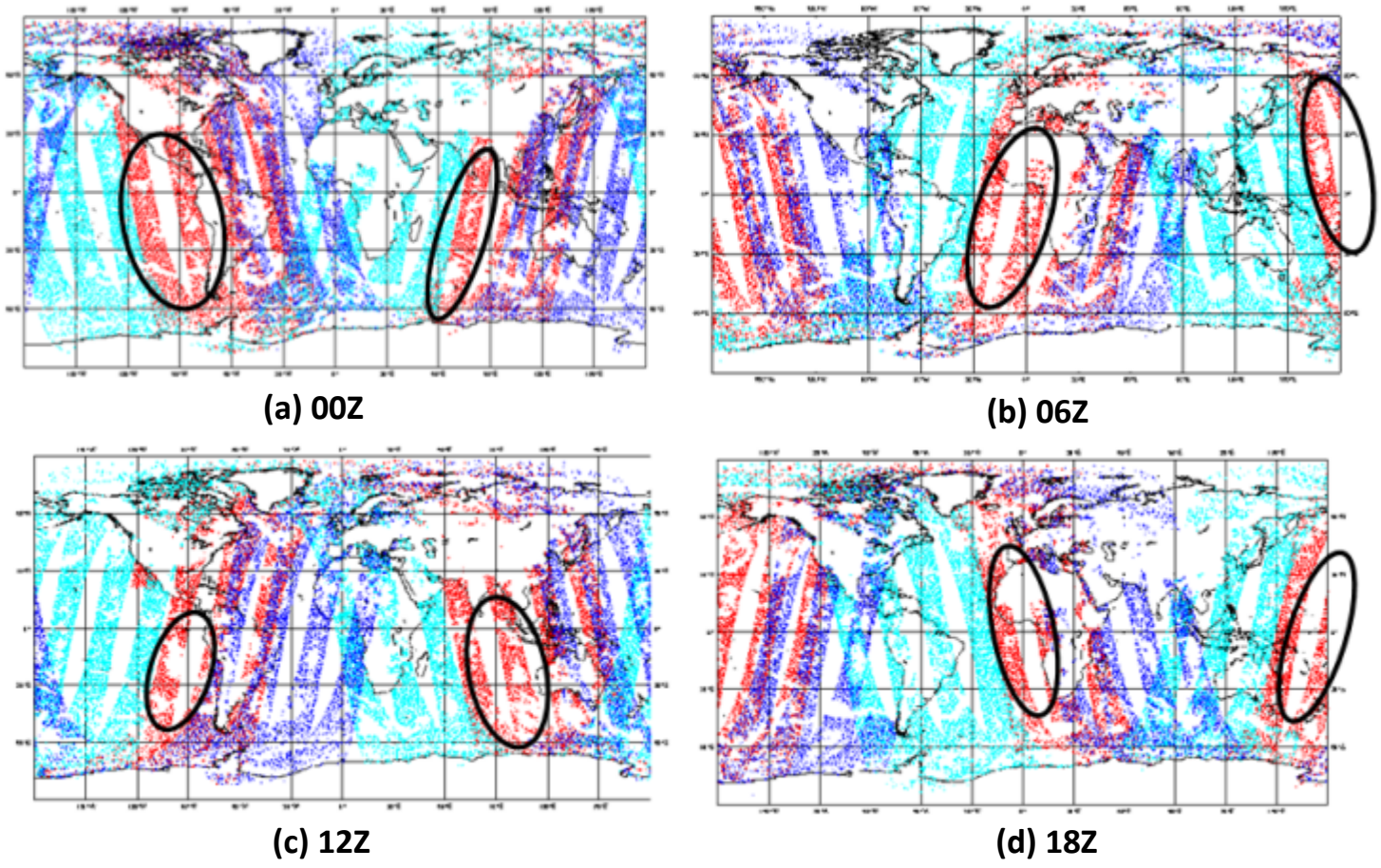
FY-3 OPERATIONAL SATELLITE INSTRUMENTS	FY-3C	FY-3D	FY-3E	FY-3F
MERSI – Medium Resolution Spectral Imager (I, II)	√(I)	√(II)	√(II)	√(II)
MWTS – Microwave Temperature Sounder (II)	√	√	√	√
MWHS – Microwave Humidity Sounder (II)	√	√	√	√
MWRI – Microwave Radiation Imager	√	√		√
WindRAD - Wind Radar			√	
GAS - 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	√			

FY-3C/D/E/F Payload Deployment 1 ***2016***

- 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

Assessment for the Impact on NWP

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.



(a) 00Z (b) 06Z

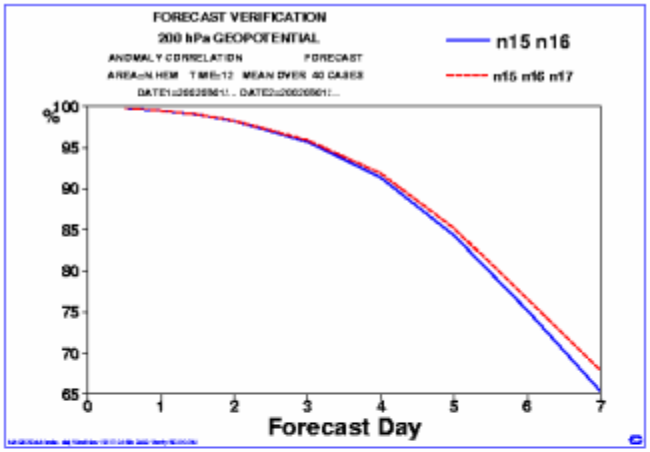
(c) 12Z (d) 18Z

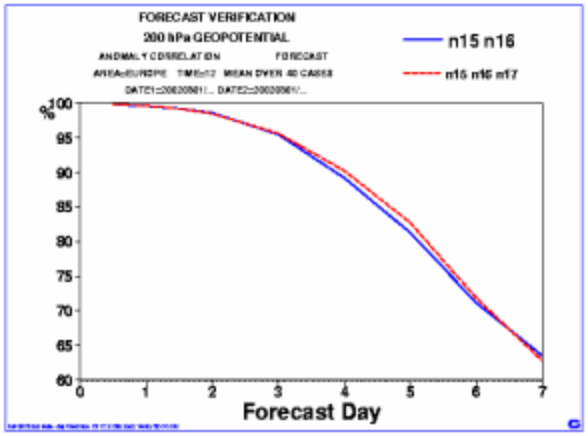
NOAA -15 (07:30 am)- red,NOAA-16 (13:30 pm) light blue,,NOAA-17 (10:00 am) dark blue

Courtesy to
Mitch Goldberg, NESDIS/NOAA
Jean-Noël Thépaut and, ECMWF

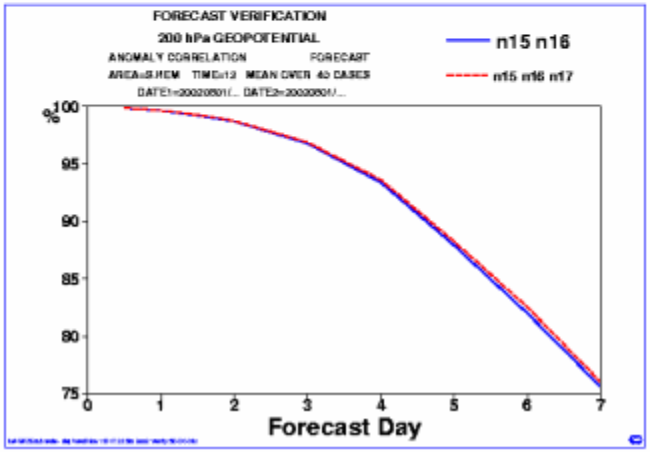
Outcome of the assimilation studies (3SAT versus 2SAT)

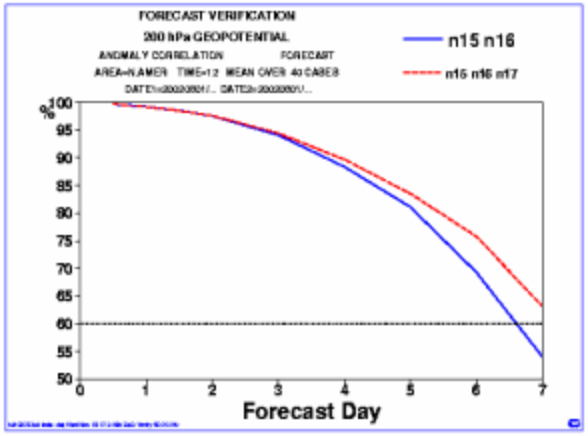
Z200 scores averaged over 40 cases





- **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!**





Half hemispheric

Courtesy to

Mitch Goldberg, NESDIS/NOAA

Jean-Noël Thépaut and Graeme Kelly, ECMWF

Regional

Some Questions for the Present Assessment

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

1, No assessment was seen for Asia, particularly the East Asia,

2, No explanation for the much more improvement in the northern hemisphere than the southern hemisphere,

3, No explanation for the apparent difference of the impact in Europe against that in North America

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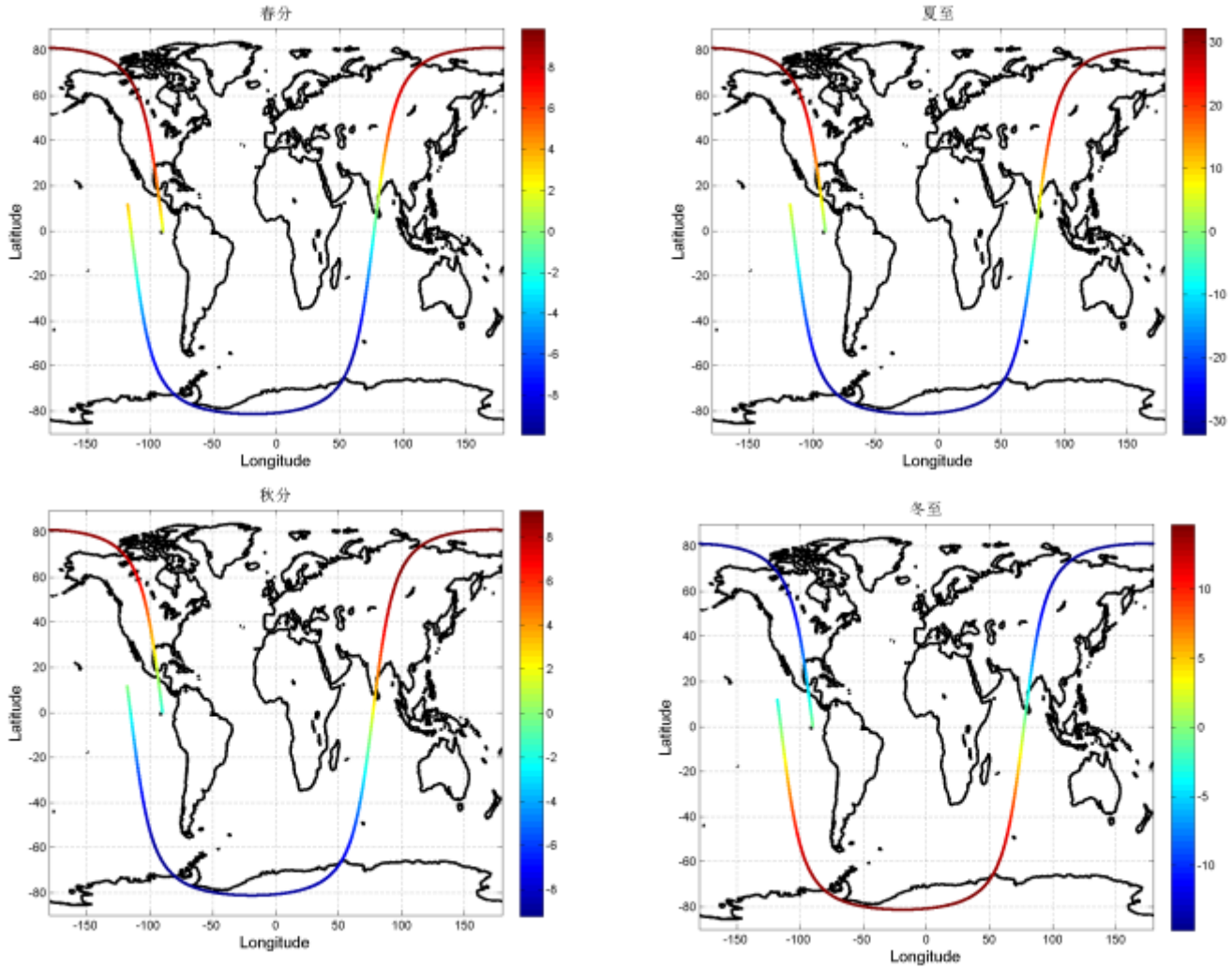
Solar height angle for the early morning orbit



For the 6am orbit, the maximun angle of solar height in the northern hemisphere is 32 degree on the Summer Solstice near the south most of the orbit; For the South, the highest solar angle is 15 degree on the Winter Solstice near the north most of the orbit.

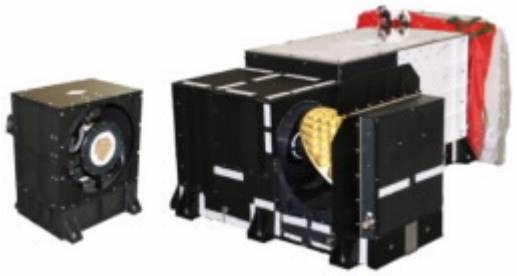
Assessment of Impact on FY-3E Spacecraft and Payloads

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	√			

- Sounding instruments including
  MWTS，MWHS，HIRAS and
  GNOS、WindRAD、SES are not impacted
- The influence to VIS, near-IR channels of MERSI is striking
- OMS and ERM shall be basically useless

MERSI：

MEdium Resolution Spectral Imager



MERSI channel characteristics

use	Ch No.	wave length (um)	Band width (nm)	Spatial resolution (m)	Ltyp/Ttyp W/m^2- m-sr	SNR NEΔT(K)	Dynamic range (Max ρ、Max K)
land、cloud	1	0.470	50	250m	35.3	100	90%
	2	0.550	50	250m	29.0	100	90%
	3	0.650	50	250m	22	100	90%
	4	0.865	50	250m	25	100	90%
	5	1.24/1.03	20	1000m	5.4	100	90%
	6	1.64	50	1000m	7.3	200	90%
	7	2.13	50	1000m	1.2	100	90%
Ocean colour,bio-cycle, earth chemistry	8	0.412	20	1000m	44.9	300	0~30%, 30%~100%
	9	0.443	20	1000m	41.9	300	0~30%, 30%~100%
	10	0.490	20	1000m	32.1	300	0~30%, 30%~100%
	11	0.555	20	1000m	21	500	0~30%, 30%~100%
	12	0.670	20	1000m	10	500	0~30%, 30%~100%
	13	0.709	20	1000m	6.9	500	0~30%, 30%~100%
	14	0.746	20	1000m	9.6	500	0~30%, 30%~100%
	15	0.865	20	1000m	6.4	500	0~30%, 30%~100%
Water vapor	16	0.905	20	1000m	10.0	200	100%
	17	0.936	20	1000m	3.6	100	100%
	18	0.940	50	1000m	15.0	200	100%
plums	19	1.38	20/30	1000m	6	60/100	100%
Temp-land, cloud	20	3.8	180	1000m	270K	0.25K	200-350k
	21	4.050	155	1000m	300/380K	0.25K	200-380k
Water vapor	22	7.2	500	1000m	270K	0.30K	180-270k
	23	8.550	300	1000m	270K	0.25K	180-300k
Temp-land, cloud	24	10.8	1000	250m	300K	0.4K	180-330k
	25	12.0	1000	250m	300K	0.4K	180-330k

OMS: Ozone Monitor Suite

OMS/FY-3:

- **total column ozone mapping**
- **ozone profiler which includes nadir ozone profiler and limb ozone profiler**
- **the high spectral resolution OMS will replace the former UV ozone instruments TOU and SBUS flown on FY-3A/B/C**

Aims: global total column ozone and profile, global total amount of SO2, NO2 and aerosol optical properties such as aerosol index, optical depth

	Nadir detection		Limb detection
	Total column amount	**Vertical profile**	
Spectral range	300~500nm	250~310nm	290-500nm
Scientific purpose	O_3、NO_2、SO_2、HCHO、BrO、OClO、aerosol	O_3 profile	O_3、NO_2、SO_2、HCHO、BrO、OClO、stratospheric aerosol profiles
Spectral resolution	300~365nm 0.4nm 365~500nm 0.6nm	250~310nm 0.4nm	290-500nm 0.6nm
Spatial resolution	15（along track） 25（cross track）km	34（along track） 60（cross track）km	3km
Field of view	112°	2.3°（along track）×0.045°（cross track）	2.3°（along track）×0.045°（cross track）
Dynamic range	10^4	10^5	10^5

Other benefits of early morning observation

- ✓ In CMA, nation-wide weather briefing is held at 8:00 am every morning. The early morning observation can provide valuable measurements supplementary to GEO imagery, especially with more information on typhoon and severe convective weather monitoring for forecasters.

- ✓ It will bring some advantage for monitoring certain weather phenomena and disaster events, for example, fogs in early morning, city lights…..

Risk Analysis

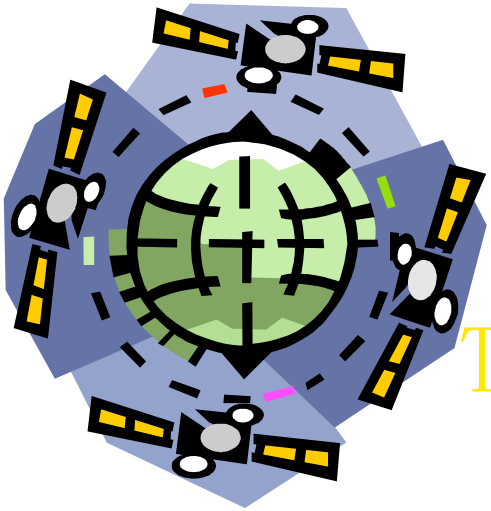
1.The payloads deployment for both FY-3E and FY-3F needs to be re-considered, the specifications of optical instruments need to be adjusted and re-designed.

2.In early morning orbit, the temperature varies dramatically from one side to the other of the spacecraft, this will have big impact on the working environment of instruments, especially the onboard calibration system. So that the thermal control system of the spacecraft as well as instruments need to be reviewed and re-designed.

3.The current development plan has been already approved by government，the change in the plan needs a complicated and long process to assess the technical and financial feasibility.

Conclusions

1. It has been well recognized that a satellite in the operational early morning orbit will help improve NWP by filling up the existing data gaps;
2. CGMS members are encouraged to further contribute to requirement definition and assessment of impact on NWP and other uses of early morning orbit satellites,
3. Change on FY-3 satellite plan will bring technical and financial risks; risk analysis needs to be refined;
4. In view of the influence of orbital adjustment on the CMA daily operation and long-term continuity in weather, environment, and climate monitoring, so that approaches to effectively reduce these impact must be considered.
5. CMA will continue to explore the possibility of using early morning orbit with FY-3 follow-ons.



Thank you!