

TWO APPLICATIONS OF
IMPROVEMENTS FOR AMVS OF
NSMC/CMA

Zhang Xiaohu, Xu Jianmin

National Satellite Meteorological
Center, Beijing 100081, CHINA

- RE-NAVIGATION BASED ON FULL EARTH DISC IMAGE
- CALCULATION OF RADIATION TRANSFER USING NWP DATA

RE-NAVIGATION BASED ON FULL EARTH DISC IMAGE

Image navigation status in NSMC/CMA

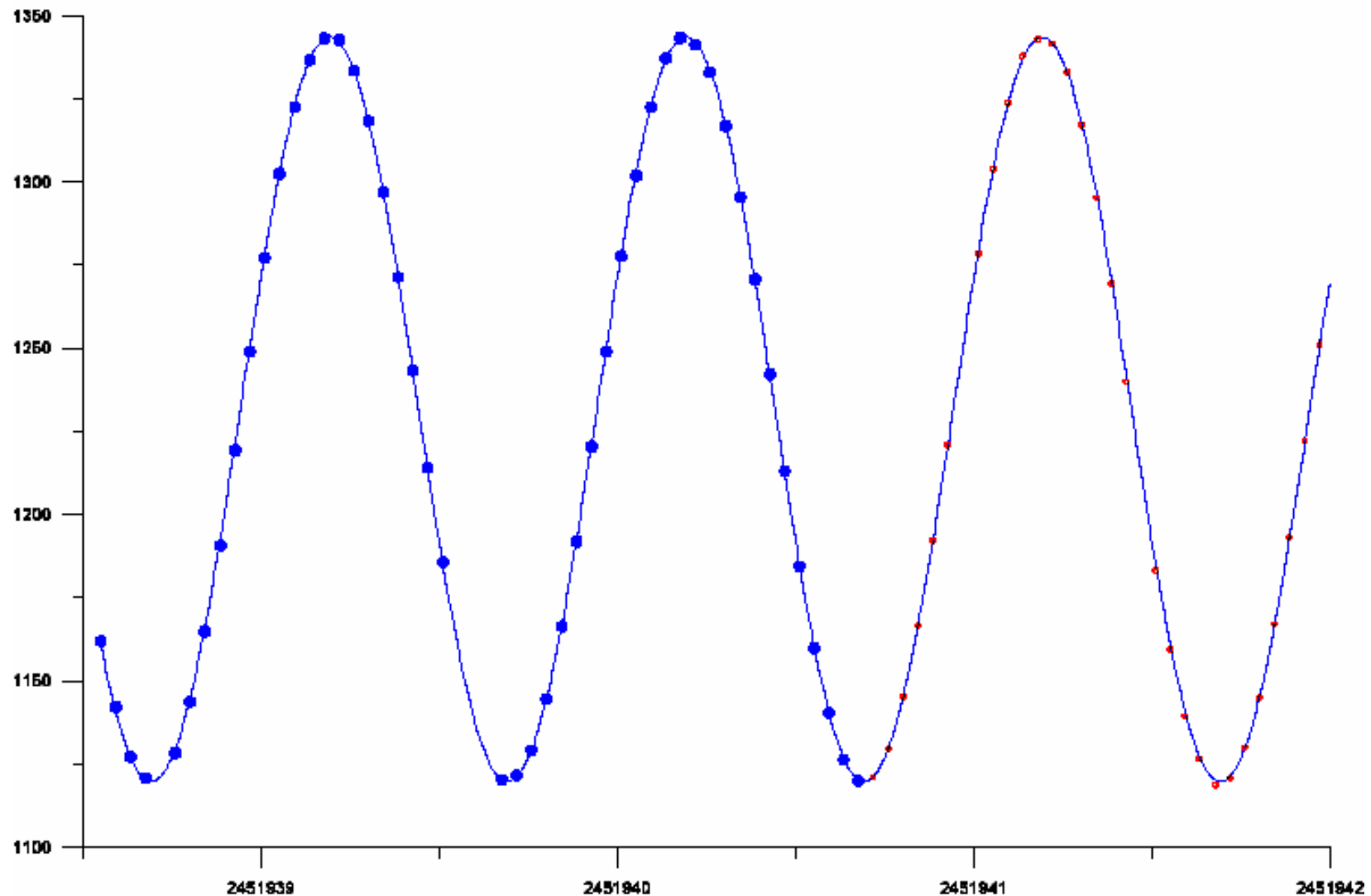
- An automatic image navigation model for FY2 geosynchronous meteorological satellites has been realized in NSMC.
- The model uses **time series of satellite positions and observation vectors toward earth centre** as input, to solve satellite attitude.
- Satellite attitude parameters consist of satellite spin axis vector and misalignment in three orientations(roll, pitch, yaw)

Full disk image center is predictable

sin fitter of image center line position

point: real position

blue point: point used by sinfitter



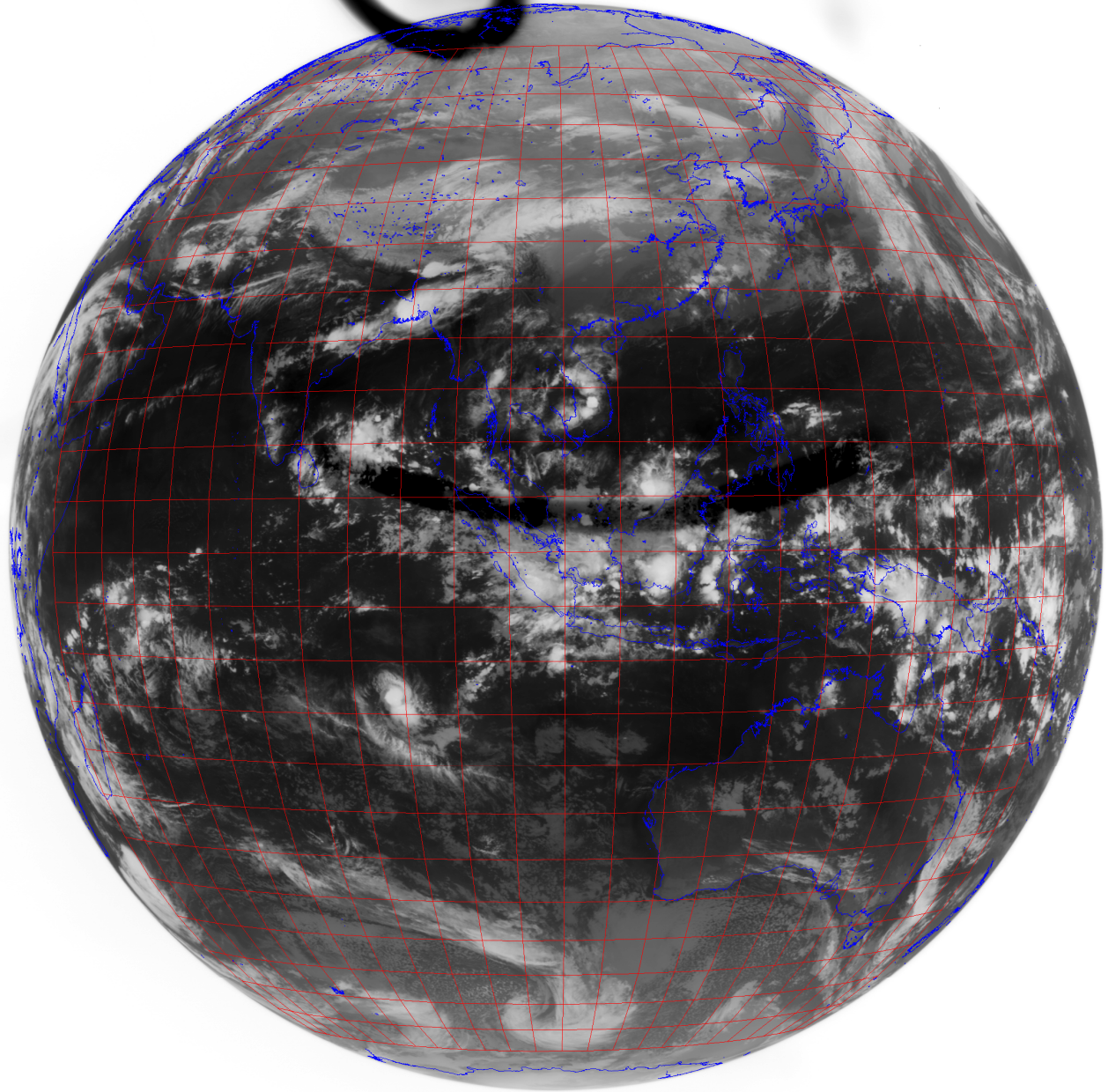
- In the time series of earth disk center line count, there is information of the attitude (orientation of the satellite spin axis) and the roll component of the misalignment.
- With this information, the attitude and the roll component of the misalignment can be solved simultaneously.
- Image grids in the future 24 hours are predicted automatically.
- FY-2 image navigation accuracy approaches **1 IR pixel or 2 visible pixels.**

But, in some special periods...

- **During eclipse periods**, two midnight images are not taken everyday. The navigation accuracy (around 2 IR pixel) is lower than usual.
- **In 24 hours after orbit and attitude control**, the image navigation accuracy is poor.
- **Sun or moon entered the view of satellite**. The image navigation accuracy is affected.
- Nutation and Precession of the Spining Satellite will cause a minor bias between predicted attitude and real attitude.

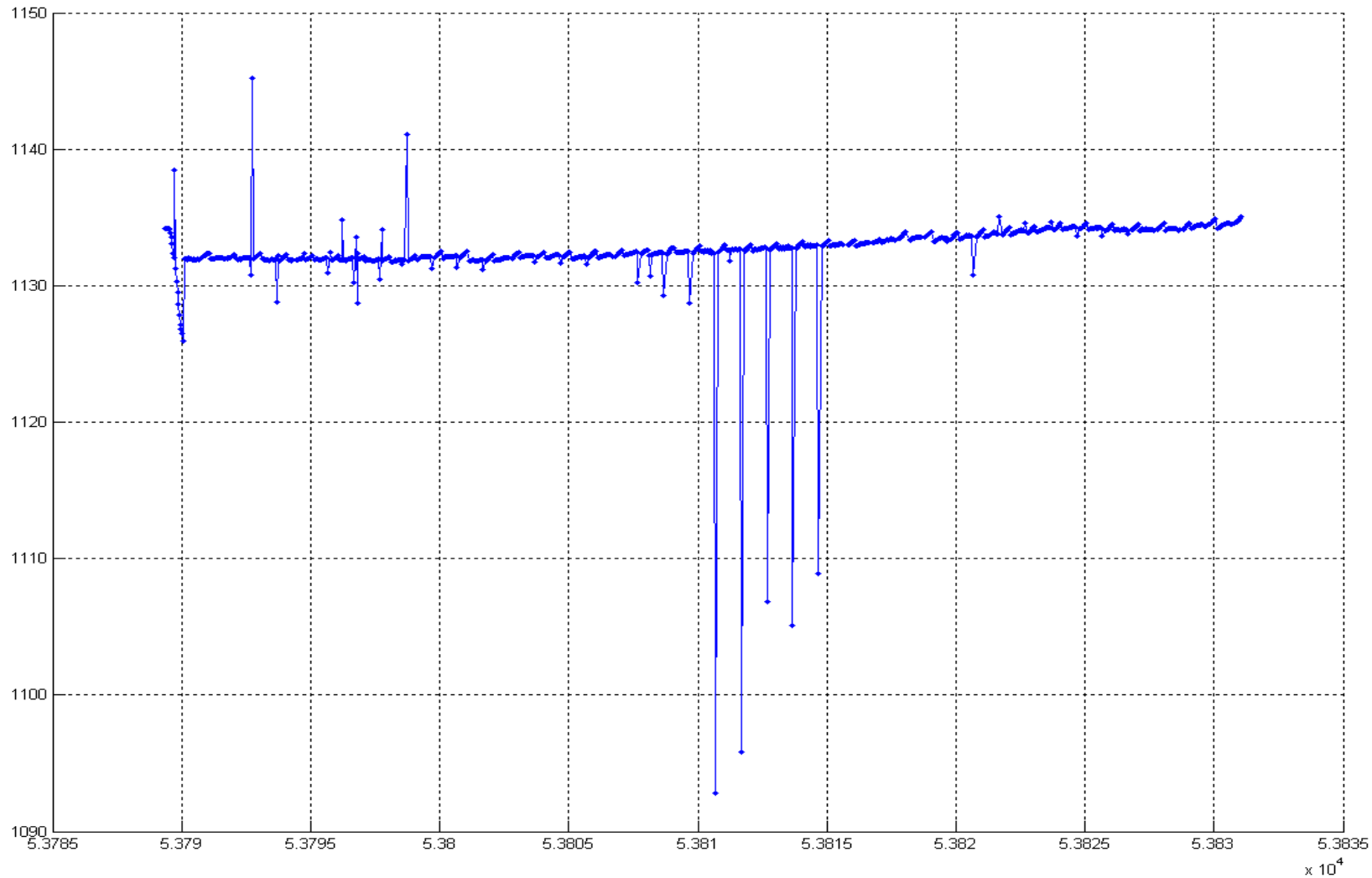
Sun entered the
view of satellite

It will cause a
wrong result in
earth detecting



2006/2/23~2006/4/6 earth disc center line count

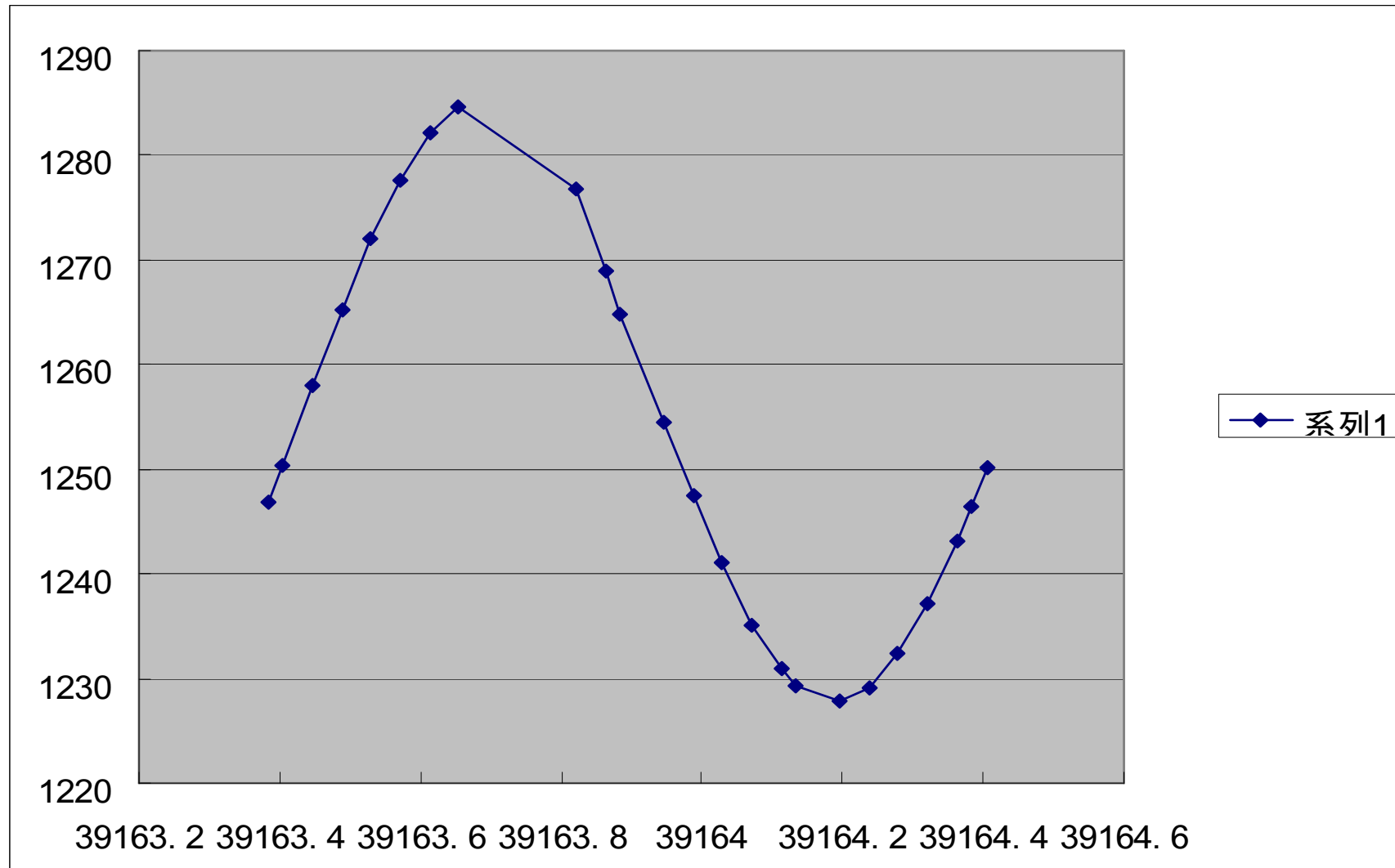
There are many error values. Which will affect the attitude solving.



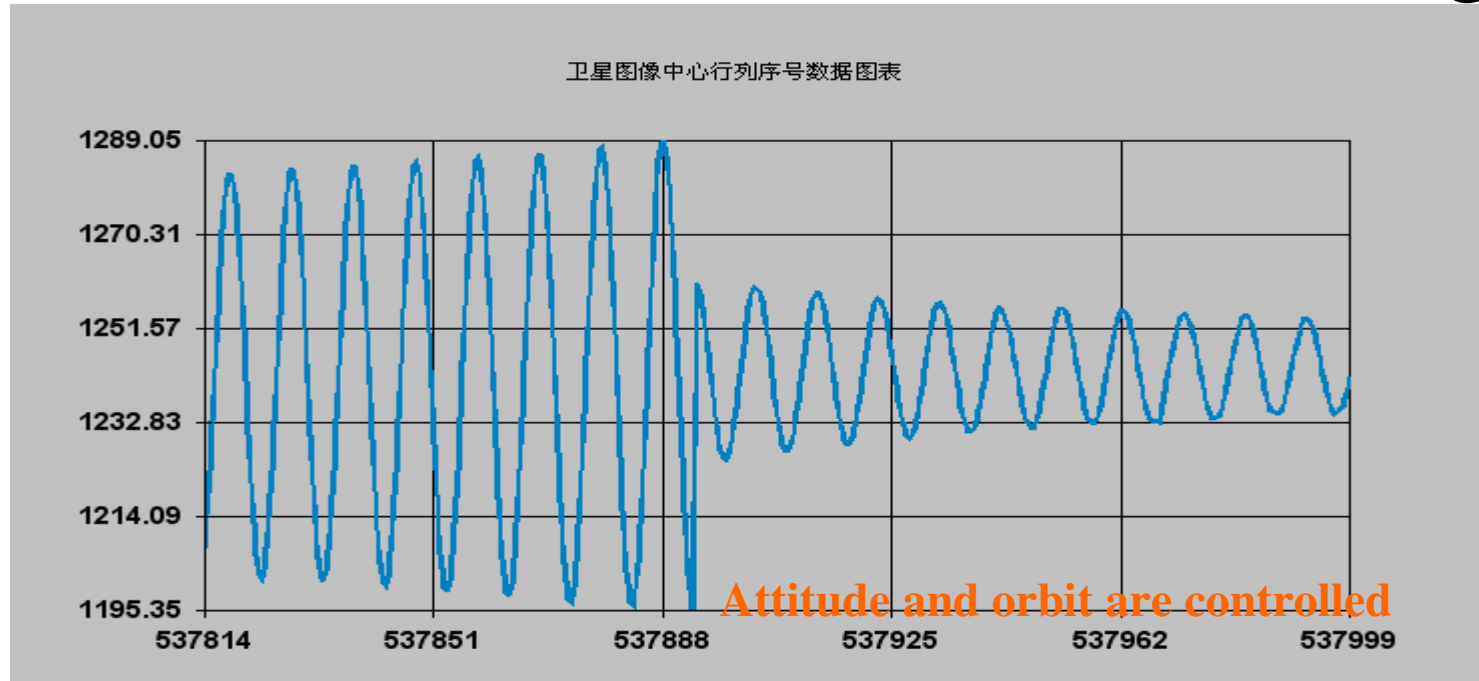
During eclipse periods,

two midnight images are not taken everyday.

The lack of sample will affect the accuracy of attitude solving.



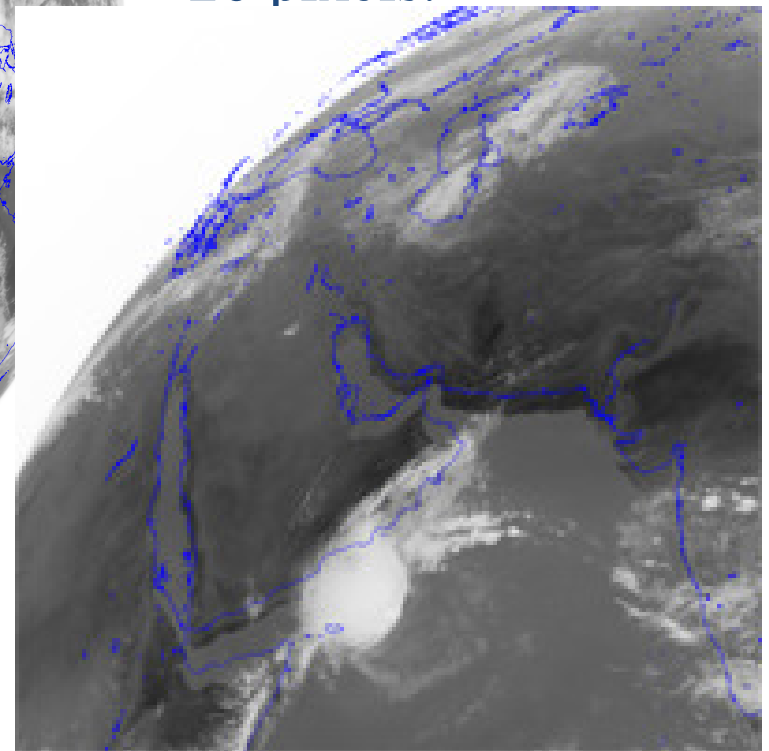
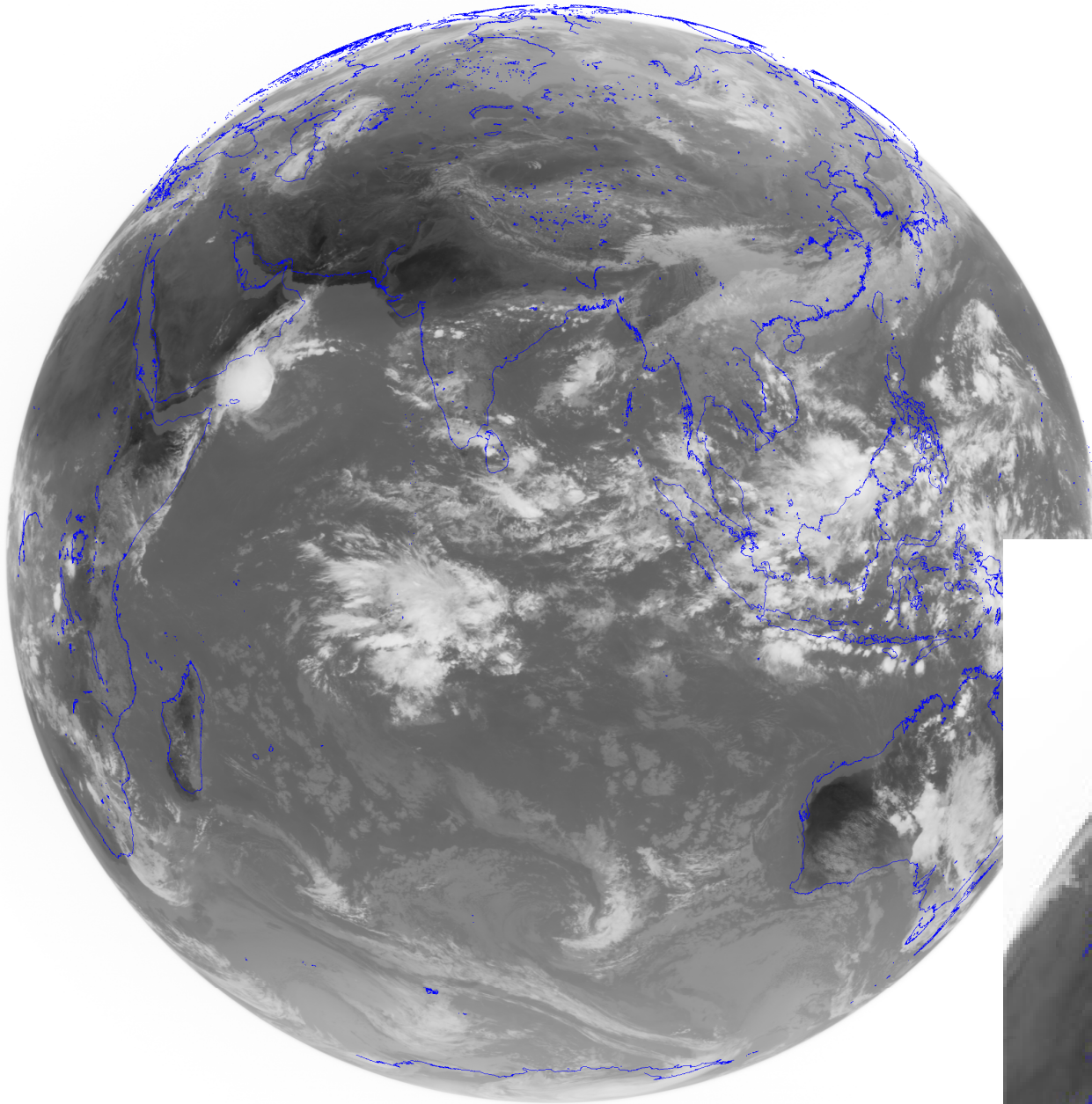
Line count series of earth disc image



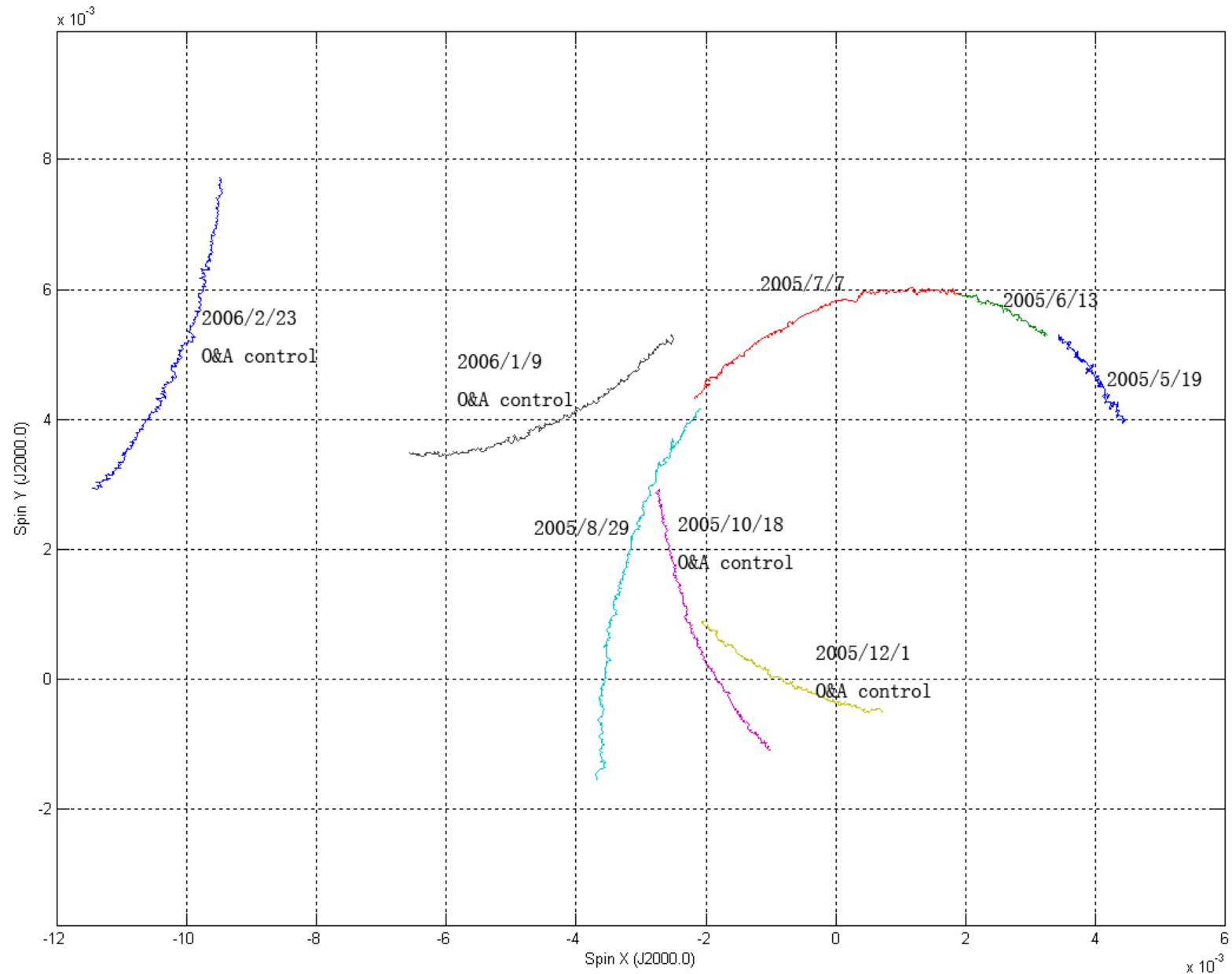
- It reflects that the attitude changed.
- In 24 hours after orbit and attitude control, the line count series of earth disc image are not continuous.
- The data of past 24 hours can not be used to solve the attitude.
- The image navigation accuracy is poor.

2007-11-1
07:30UTC
FY2D first S-VISSR
image after satellite
control

It has a bias of
navigation more than
20 pixels.



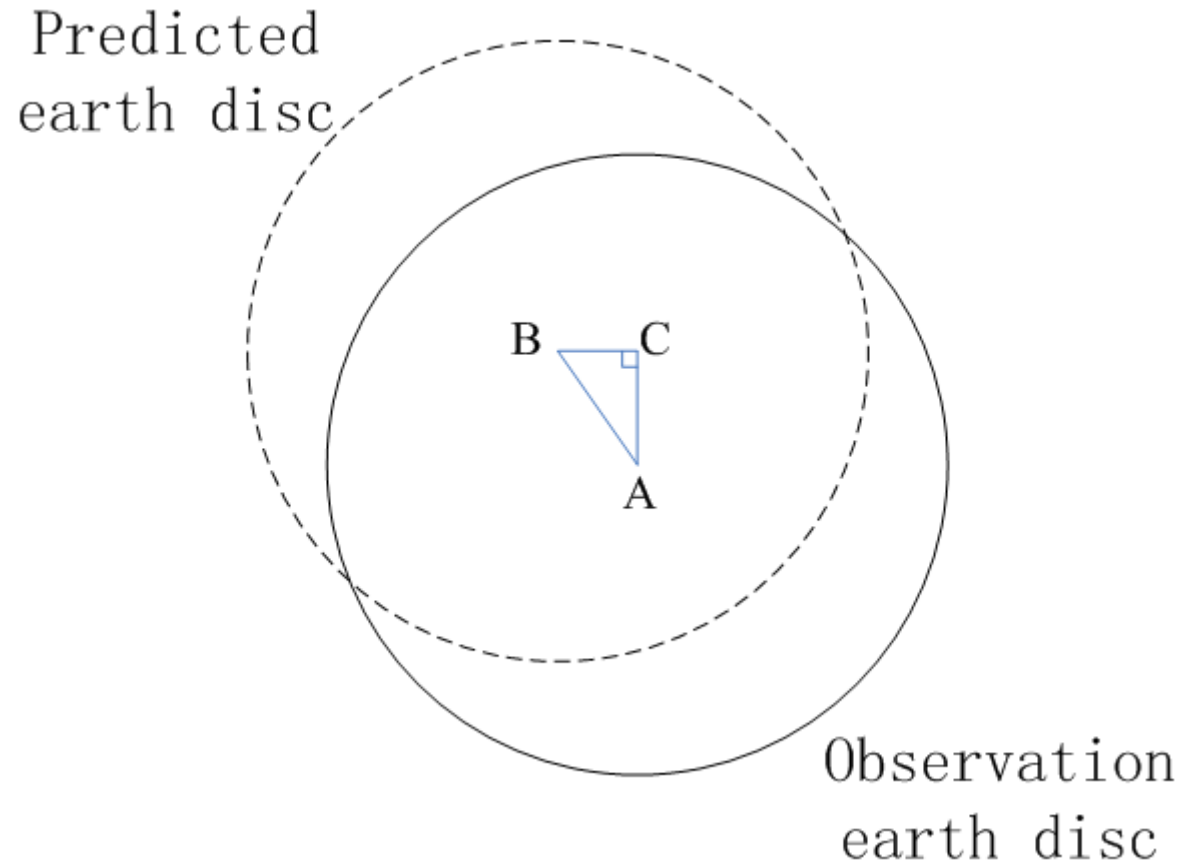
FY-2C Spin Axis Projection on J2000.0 Equatorial Plane Showing Nutation and Precession of the Spinning Satellite



Re-navigation method

- After one observation, the earth disc center in the image can be determined by earth detecting.
- Using the predicted orbit and altitude parameters, the predicted earth disc center in the image can be calculated.
- Compared the two center positions, the roll and pitch misalignment can be calculated.

- Re-navigation method can solve problems above except **Sun or moon entered the view of satellite**, because it will cause earth edge detecting failed.



A ----- the center of **observation** earth disc (in pixels)

B ----- the center of **predicted** earth disc (in pixels)

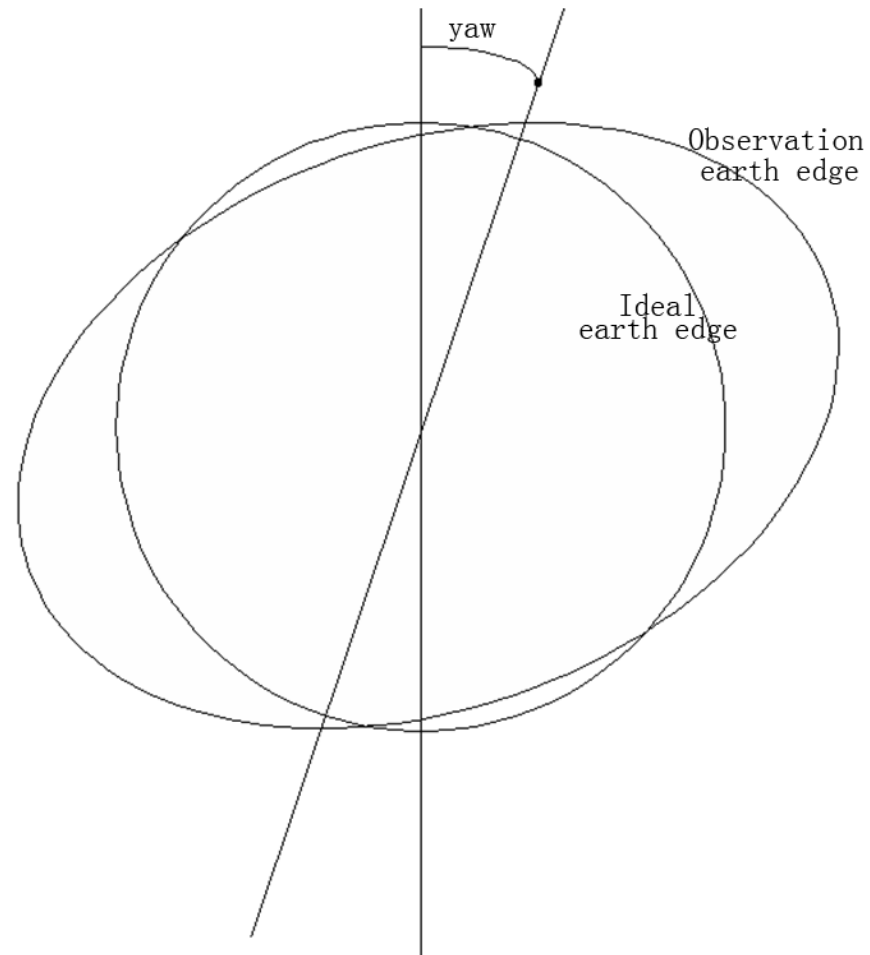
AC ----- the bias of roll misalignment (in pixels)

CB ----- the bias of pitch misalignment (in pixels)

$\Delta\text{Roll} = \text{AC} * \text{Stepping-angle}$

$\Delta\text{Pitch} = \text{CB} * \text{Sampling-angle}$

Yaw misalignment can be determined by the vertical axis of observation earth disc



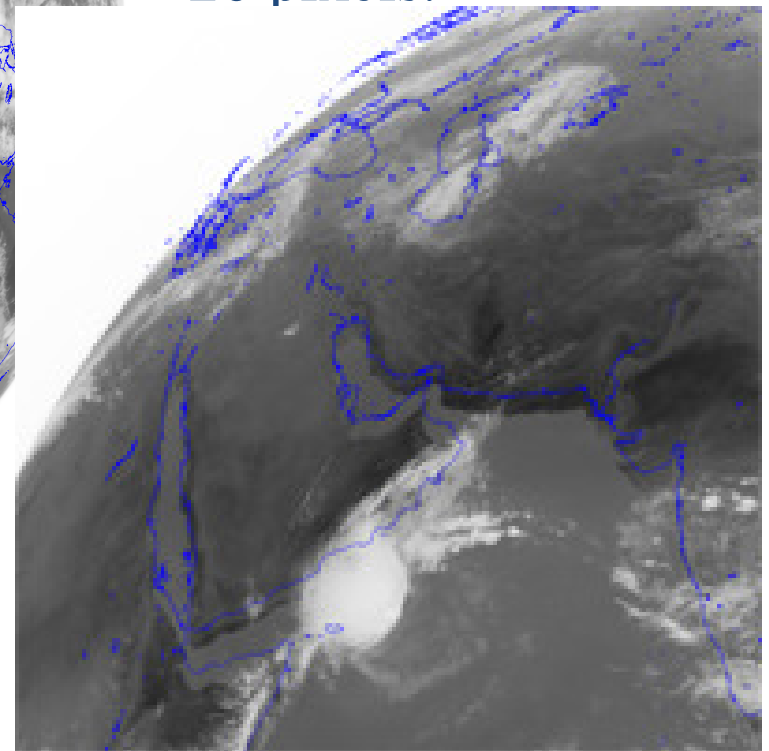
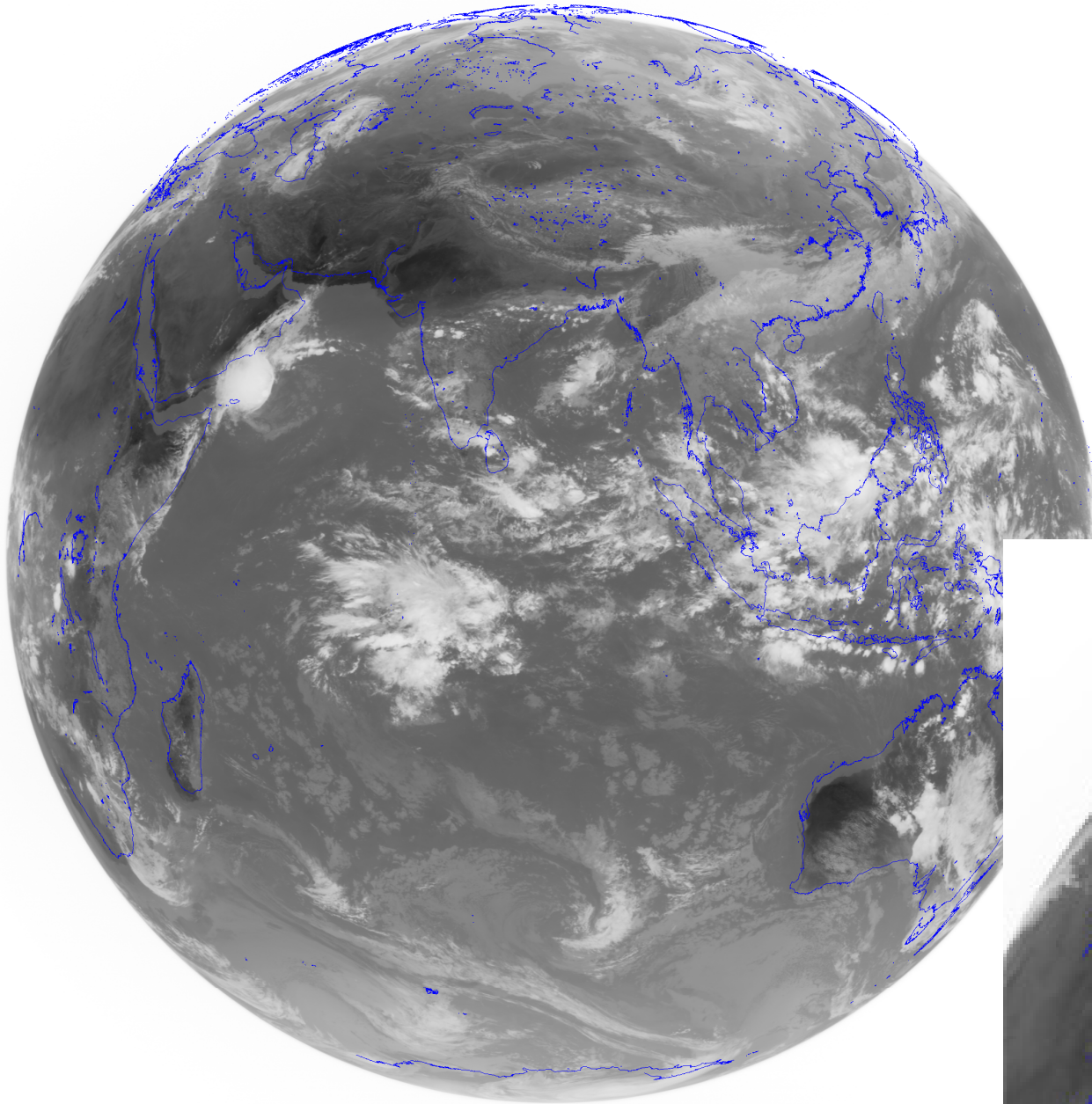
Re-navigation misalignment set

- $\text{Roll} = \text{Roll}(\text{predict}) + \Delta\text{Roll}$
- $\text{Pitch} = \text{Pitch}(\text{predict}) + \Delta\text{Pitch}$
- $\text{Yaw} = \text{yaw}$

- Using these misalignment parameters and the predicted orbit and attitude parameters, we can obtain accurate navigation result .

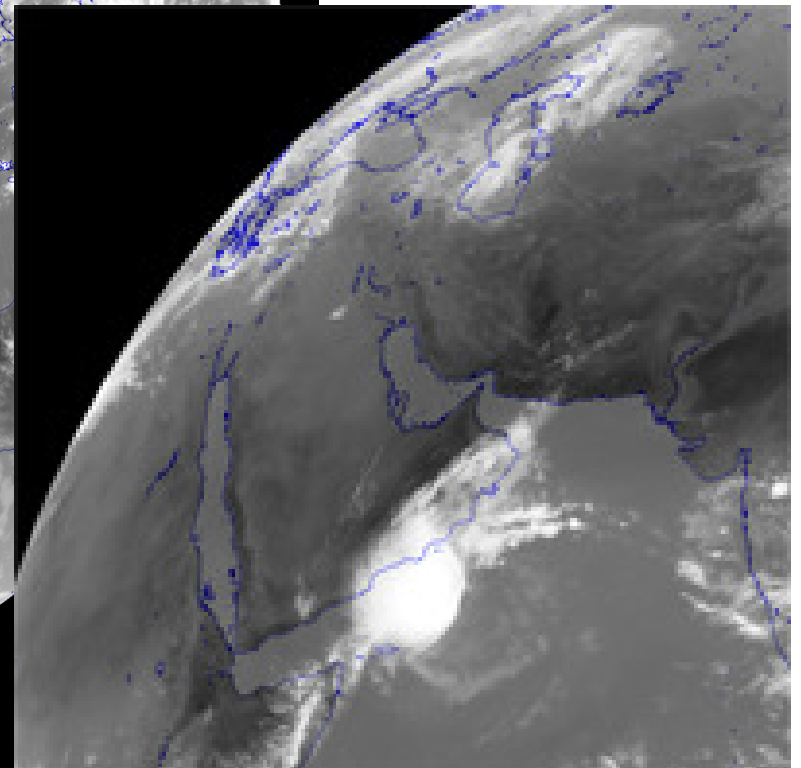
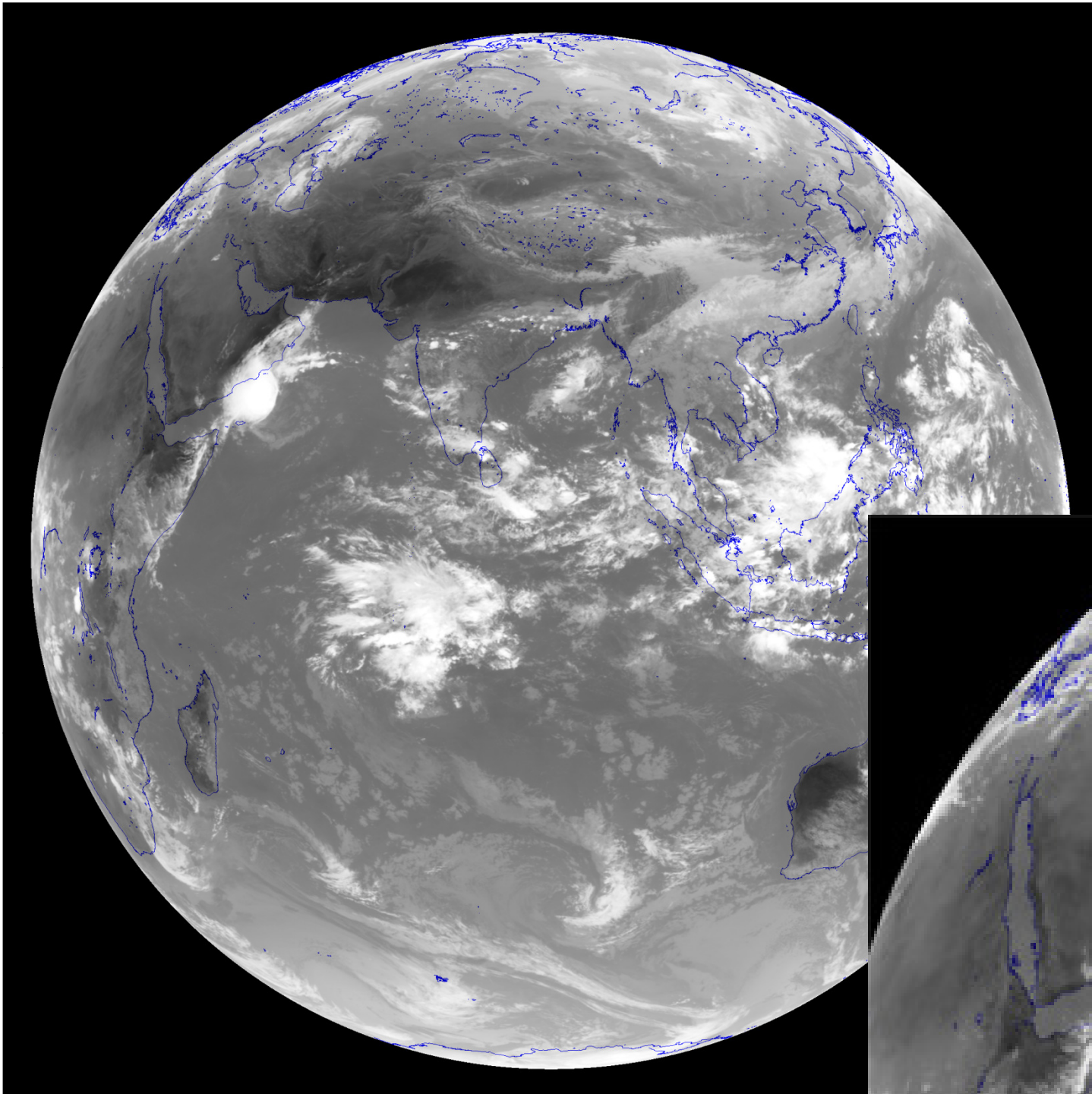
2007-11-1
07:30UTC
FY2D first S-VISSR
image after satellite
control

It has a bias of
navigation more than
20 pixels.



FY2D first
image after
satellite control

After re-
navigation, the
navigation result
is perfect

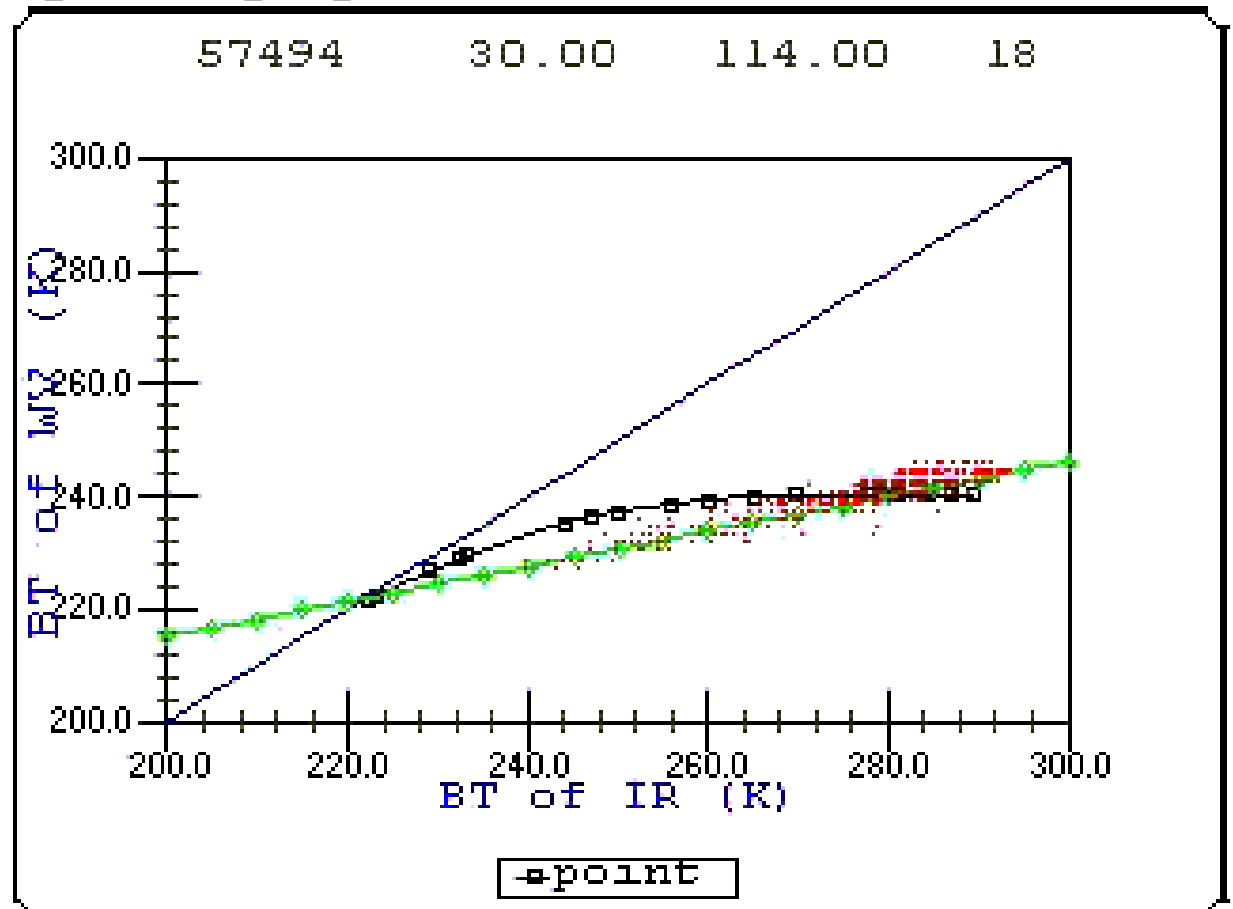


CALCULATION OF
RADIATION TRANSFER
USING NWP DATA

Improvements in calculation of semi-transparency correction tables

- The semi-transparency correction tables are used to perform a correction to the IR radiance to take account of semi-transparent cloud or small scale cloud which does not completely fill the field of view.
- The semi-transparency correction relates the IR radiance to the WV radiance which would occur in the presence of fully opaque cloud at a given level in the atmosphere.

- In AMVs operation, the semi-transparency correction tables are used in height assignment.
- The mission of this application is to improve the accuracy of the curve which shows the theoretical IR/WV relationship for opaque clouds.



SIX change in this application

- ① The NWP parameter fields are improved:
 - At present, T639 data is used rather than original T213.
 - T639 resolution: 0.28125 degree
 - T213 resolution: 0.5625 degree

- ② The vertical extension of the NWP parameter fields is expanded from the original surface-100hPa to the present surface-10hPa.

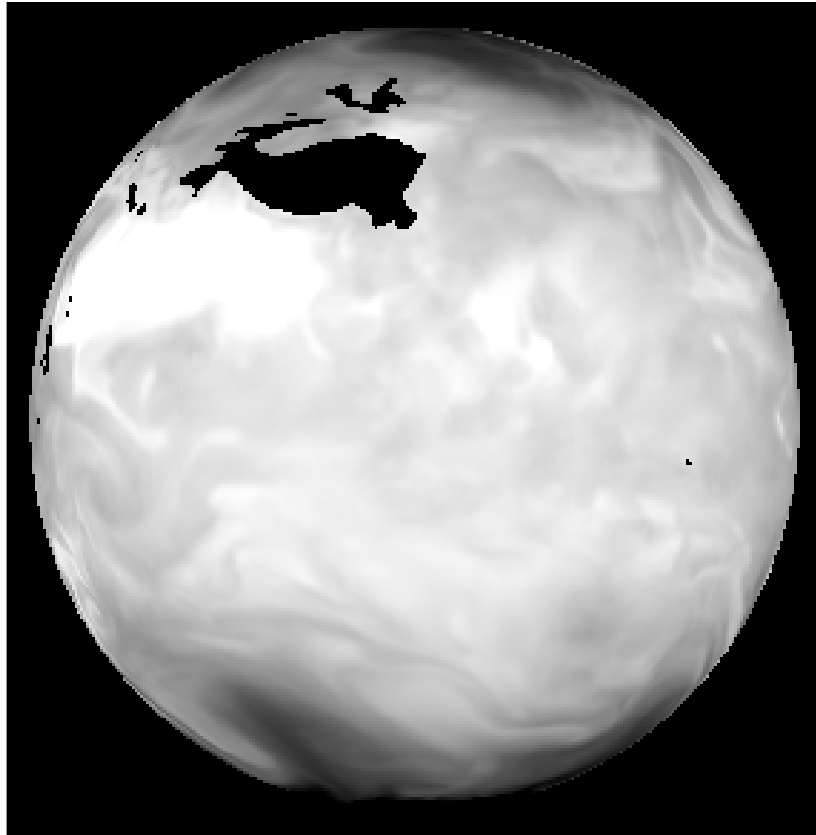
By doing so, high level atmospheric status is considered.

③ For atmospheric compositions other than water vapour, originally, one set of climate values from American standard Atmosphere was used to represent the whole earth disk area; while At present, climate values from 5 regions are used: tropical, mid-latitude summer, mid-latitude winter, high-latitude summer, high-latitude winter.

By doing so, radiation contributions from other radiation active gases are better considered.

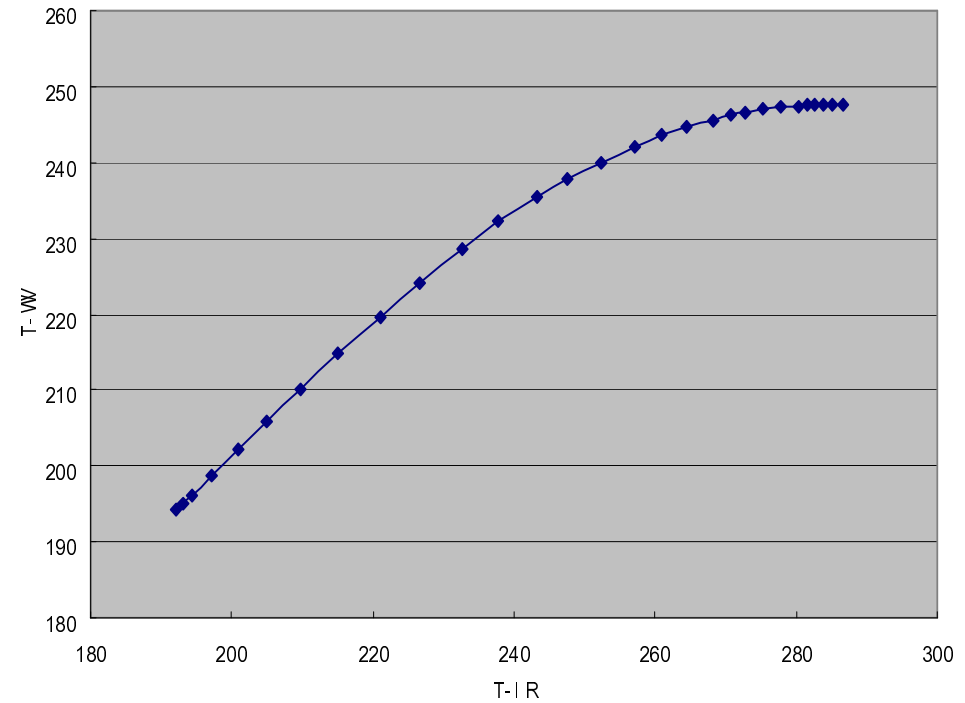
- ④ NWP parameter layers are increased.
 - Originally, data from 38 layers are used.
 - At present, data from 120 layers are used. From 10 to 1200 hPa, a 10 hPa interval is a layer.
- ⑤ For temperature profile data resolution
 - originally the data interval is 10 degree.
 - At present, the data interval is 5 degree.
- ⑥ For humidity profile data resolution
 - originally, there are 10 humidity status.
 - At present, there are 20 humidity status:
0.1, 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95%.

A result of semi-transparency correction tables



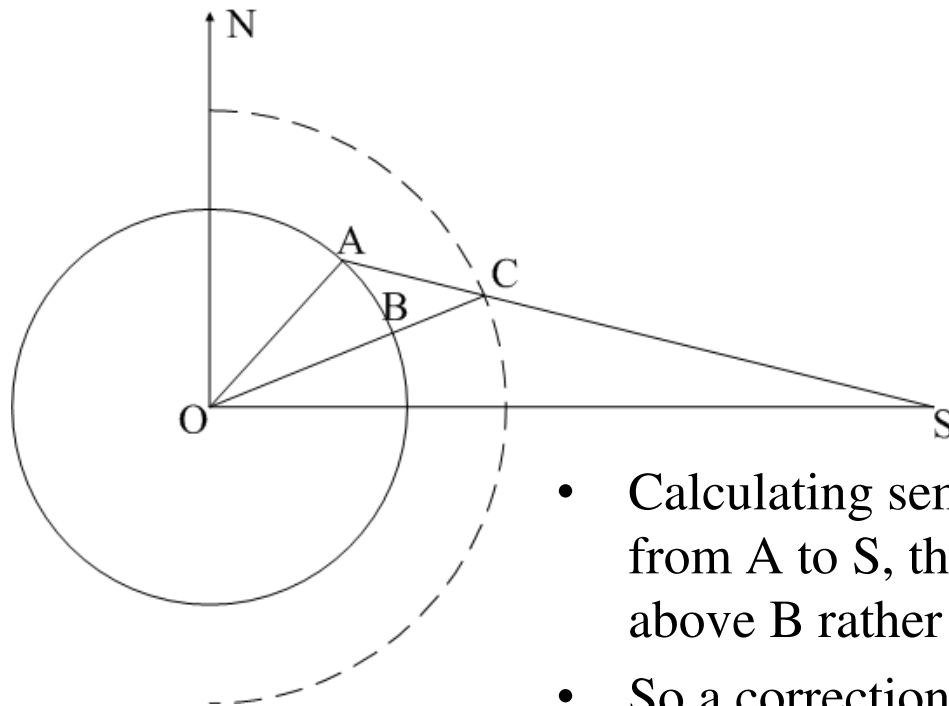
800hPa blackbody radiation temperature

红外、水汽入瞳辐射对照表示意



Opaque cloud IR and WV channel
Brightness temperature relationship

A new improvement in progress



O: earth center

S: satellite position

A: one position on earth surface

C: point of intersection that line AS
cross a certain NWP layer

B: projection of point C on earth surface

$$\angle AOC = \angle AOS - \angle COS$$

- Calculating semi-transparency correction tables in the path from A to S, the NWP data of C will be the certain height above B rather than A.
- So a correction occurs when the radiation from A to S is calculated.
- The correction varies along with height of C and satellite zenith.
- The correction is $\angle AOC$.

Correction value(degree) of various height and satellite zenith

Satellite zenith(degree)

Height(km)

	35	40	45	50	55	60	65	70
1	0.00629	0.00754	0.00898	0.0107	0.01283	0.01555	0.01925	0.02466
2	0.01258	0.01507	0.01796	0.0214	0.02564	0.03109	0.03849	0.04929
3	0.01886	0.0226	0.02693	0.03209	0.03845	0.04662	0.0577	0.07388
4	0.02514	0.03013	0.0359	0.04278	0.05125	0.06214	0.0769	0.09843
5	0.03142	0.03765	0.04486	0.05346	0.06405	0.07764	0.09607	0.12295
6	0.0377	0.04517	0.05382	0.06413	0.07683	0.09314	0.11523	0.14743
7	0.04397	0.05269	0.06278	0.0748	0.08961	0.10862	0.13437	0.17187
8	0.05024	0.0602	0.07173	0.08546	0.10238	0.12409	0.15348	0.19628
9	0.05651	0.06771	0.08068	0.09612	0.11514	0.13954	0.17258	0.22065
10	0.06278	0.07522	0.08962	0.10677	0.12789	0.15499	0.19166	0.24499
11	0.06904	0.08272	0.09856	0.11742	0.14063	0.17042	0.21071	0.26929
12	0.0753	0.09022	0.10749	0.12806	0.15337	0.18584	0.22975	0.29355
13	0.08156	0.09772	0.11643	0.13869	0.1661	0.20125	0.24877	0.31778
14	0.08782	0.10522	0.12535	0.14932	0.17882	0.21664	0.26777	0.34198
15	0.09408	0.11271	0.13427	0.15994	0.19153	0.23203	0.28675	0.36613
16	0.10033	0.1202	0.14319	0.17056	0.20424	0.2474	0.30571	0.39026
17	0.10658	0.12768	0.15211	0.18117	0.21693	0.26276	0.32465	0.41435
18	0.11282	0.13516	0.16102	0.19178	0.22962	0.27811	0.34358	0.4384
19	0.11907	0.14264	0.16992	0.20238	0.2423	0.29345	0.36248	0.46242
20	0.12531	0.15012	0.17882	0.21297	0.25497	0.30877	0.38137	0.48641

T213 half grid:0.28125degree

T639 half grid:0.14062degree

red value: > T213 half grid

blue value + red value : >T639 half grid

END

Thank for your attention!