DETERMINATION OF USER DISTRIBUTION IMAGE SIZE AND POSITION OF EACH OBSERVATION AREA OF METEOROLOGICAL IMAGER IN COMS

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ABSTRACT :

In this paper, requirements of Meteorological Administration about Meteorological Imager (MI) of Communications, Ocean and Meteorological Satellite (COMS) is analyzed for the design of COMS ground station and according to the analysis results, the distribution image size of each observation area suitable for satellite Field Of View (FOV) stated at the requirements of meteorological administration is determined and the precise satellite FOV and the size of distribution image is calculated on the basis of the image size of the determined observation area. The results in this paper were applied to the detailed design for COMS ground station and also are expected to be used for the future observation scheduling and the scheduling of distribution of user data.

KEY WORDS : COMS, Meteorological Imager, Field Of View, the GEOStationary projection, observation area, observation scheduling

1. INTRODUCTION

Communications, Ocean and Meteorological Satellite (COMS) for the hybrid mission of meteorological observation, ocean monitoring, and telecommunication service is planned to be launched onto Geostationary Earth Orbit in 2008.

Meteological Imager(MI) observation mode can be divided into three modes, Global, Regional and Local area. Regional Mode can be divided into 4 observation modes such as APNH (Asia Pacific in Northern Hemisphere, ENH (Extended Northern Hemisphere), LSH (Limited Southern Hemisphere, LFD (Limited Full Disk). Information observed at MI is distributed to users through a satellite after received and reprocessed at a ground station. The method for this is to use LRIT / HRIT (Low Rate Information Transmission / High Rate Information Transmission) format recommended from CGMS (Coordination Group for Meteorological Satellites).

2. IMAGE PROJECTION

LRIT / HRIT Format recommends using one of these three, GEOS projection, Polar stereographic projection and Mercator projecion for image distribution and this paper uses GEOS projection.

Each projection is able to convert mutually and the method is explained in the document of CGMS LRIT/LRIT.

2.1 Projection coordinates

GEOS projection is a extensively used method for a normal geostationary orbit weather satellite and user distribution image of MI on CMOS is supposed to observe it. First of all, the equation on earth elliptical and the distance from geostationary Earth orbit satellite to Earth nadir point is required for GEOS Projection. These constant values are used in the transformation formulas :

- h = Distance from satellite to Earth center 42164 km
- r_{eq} = Equatorial Earth radius 6378.1690 km
- r_{pol} = Polar Earth radius 6356.5838 km

Earth projection image can be represented by (x, y) on the plane coordinates and the transformation

formula from satellite-oriented cartesian into plane coordinates is to Equation (1). By transforming this inverse, the transformation formula from Satellite-oriented cartesian into plane coordinates is obtained like equation (2).

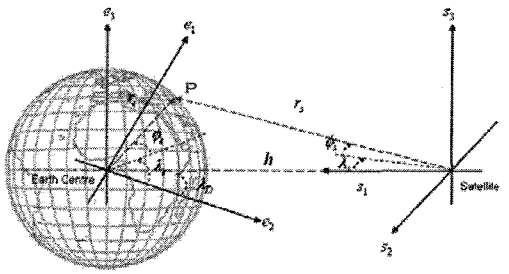


Figure 1. Process to decide coordinates on earth projection point.

$$x = tan^{-1}\left(\frac{-s_2}{s_1}\right)$$

$$y = sin^{-1}\left(\frac{-s_3}{\sqrt{s_1^2+s_2^2+s_3^2}}\right) \quad (1)$$

The geographical coordinates (λ, ϕ) are :

$$\lambda = tan^{-1}\left(\frac{s_2}{s_1}\right) + \lambda_D$$

$$\phi = tan^{-1}\left(\frac{r_{eq}^2}{r_{pol}^2} \cdot \frac{s_3}{\sqrt{s_1^2+s_2^2}}\right) \quad (2)$$

3. DETERMINATION OF IMAGE SIZE

3. 1 FOV angle for Full Disk observation

When using GEOS projection method at COMS, the satellite sub point is 128.2° East. Figure 1 illustrates the calculation method of minimal Field of View angle in order that COMS can observe Full Disk. By evaluating the angle between tangent lines toward Earth elliptical at the satellite h distance away from earth, Minimal Field of View angle can be evaluated. Horizontal Field of View angle of satellite is the angle of tangent lines toward long radius of earth elliptical and Vertical Field of View angle of satellite is the angle of tangent lines toward short radius of earth elliptical. and the equation to evaluate the two angles is as below.

Minimal Value of horizontal FOV angle of satellite :

$$\tan^{-1}\left(\frac{x}{h-y}\right) \times 2 \quad (3)$$

where, x = tangent lines toward long radius of earth elliptical

y = tangent lines toward short radius of earth elliptical.

- Minimal Value of vertical FOV angle of satellite can be evaluated by replacing the value of r_{eq} with value of r_{pol}
- Horizontal / Vertical minimum Field of View angles of satellite are evaluated by the equation obtained above.
  - Horizontal minimum Field of View angle of satellite = 17.3998°
  - Vertical minimum Field of View angle of satellite = 17.3431°

3. 2 Imgae size of MI for Full Disk Observation and GEOS Projection.

Visible Channel of MI on COMS is Field of View angle of 28 μrad on the basis of Nadir and observes a radius of 1 km above ground. Image size of Visible Chanel including Full Disk can be obtained by using Horizontal/Vertical minimum Field of View angles for Full Disk Observation obtained above and minimum horizontal image size for Full Disk Observation is 10,845.8285 pixel and Vertical one is 10,810.5247 pixel. The size of Distribution image of Full Disk observation is decided as 1,000 × 11,000 pixel. We created the image size of 11000 × 11,000 pixel and satellite nadir at 128.2° East by using the GEOS projection coordinates. Figure 2 results from representing Global Self-consistent Hierarchical High-resolution Shoreline, Landmark database of 1km sea map on the created projection coordinates for verification of GEOS projection coordinates of CMOS. Figure 2 indicates that projection results can be verified at 128.2° East and the size of distribution image is larger than that of minimum horizontal/vertical distribution image.

Accordingly, we can see that a part of space area is involved in up and down, left and right of the image

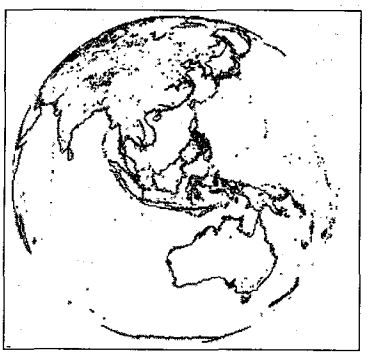


Figure 2. GEOS Projection results of visible channel image of COMS

3. 3 Calculation of FOV angle and image size of each observation area

In the COMS user's requirement list, Satellite FOV angle of each observation area (FD, APNH, ENH and LSH)of MI is to Table 2. The size of observed image is the value obtained on the basis of Satellite FOV angle of user's requirement. Distribution image sizes of each observation area are decided as those in Table 3, based on evaluated angles in Table 2

Table 2. FOV angle of each observation area

Observ -ation Area	User's requirement		
	Observation Cycle	Time required (including black body)	FOV
FD	180	within about 25min	EW : ≥19° NS : ≥ 17.6°
APNH	30	within about 4min	EW : -2.2° ~ +4.3 NS : +8.1 ~ +3.2
ENH	30	within about 11min	EW : -6.2° ~ +6.2 NS : +8.1 ~ -1.8
LSH	30	within about 6min	EW : -6.2° ~ +6.2 NS : -1.8 ~ +6.9
LFD	Limited Full Disk (Combination of ENH and LSH)		
LA	Local area (EW : 1000km, NS : 1000km) Randomly selectable in the area		

Table 3. Decided Size of distribution image

Observation Area	Size of Image	
	VIS (pixel)	IR (pixel)
FD	11,000×11,000	2,750×2,750
APNH	4,800×3,400	1,200×850
ENH	8,900×6,200	2,225×1,550
LSH	8,900×3,800	2,225×950

3. 4 Location Determination of Each observation area image and Calculation of accurate FOV angle

The resolution of the image of 11,000 × 11,000 Pixel of MI on COMS is 1km.

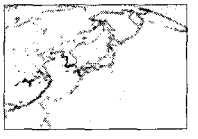
Accordingly, by calculating the location within 11,000 × 11,000 Pixel image as to each observation image, the latitude/longitude values of 4 vertexes of each observation image can be decided and also accurate satellite FOV angles are evaluated. The Definition of the location within the Full Disk image is the horizontal and vertical pixel distance from the end of 11,000 × 11,000 Pixel image. This information is delivered to users for when the image of the foreign weather satellite is handled and used for several further handlings such as the image overlapping using handled images effectively. The latitude/longitude values of 4 vertexes of each observation image explained above and the accurate satellite FOV angle are shown at Table 4.

Figure 3 is the simulated result of the image of each observation area of COMS and represents the shoreline by using GSHHS landmark of 1km resolution as does Figure 4.

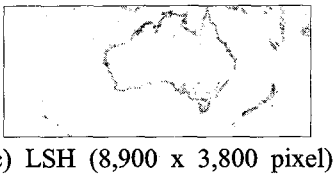
Table 4. Determination of Each Observation Image Latitude and Longitude

Observation area	Image Start point within FD	Latitude and Longitude.	FOV angle of each image size
FD (11,000X11,000)	EW : - NS : -	All space area	EW : -8.82355~8.82355 NS : -8.82355~8.82355
APNH 4,800X3,400	EW : 3,719 NS : 344	Upper left and right : space area Lower left : 17.619913, 109.583084 Lower right :17.896444, 157.806305	EW : -2.85723~4.84333 NS : 8.27168~2.81712
ENH 8,900X6,200	EW : 1,138 NS : 344	Upper left and right : space area Lower left : -9.008526, 78.452911 Lower right : -8.982827, 176.762054	EW : -6.99788~7.28023 NS :8.27168~ -1.67356
LSH 8,900X3,800	EW : 1,138 NS : 6,545	Upper left : -9.018450, 78.450508 Lower left and right : space area Upper right : -8.992720, 176.764328	EW :-6.99788~7.28023 NS : -1.67647~-7.77275

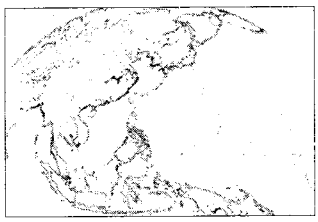
(a) FD (11,000 x 11,000 pixel)



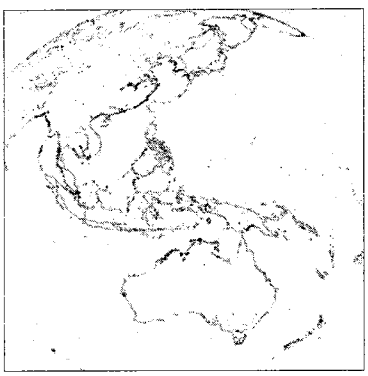
(b) APNH (4,800 x 3,400 pixel)



(c) LSH (8,900 x 3,800 pixel)



(d) ENH (8,900 x 6,200 pixel)



(c) LFH (8,900 x 10,000 pixel)

Figure 3. Simulation result of projection image od each observation area

3. 5 Determination of User distribution image size

We can estimate the amount of user's distribution image created a day by using the size of decided image and distribution schedule being considered at Meteorological Administration. The number of observations of each area per day and the amount of user's distribution image of each observation area are estimated and shown in Table 5. The amount of user's distribution image created a day at MI on COMS is 12.064 Gbyte and provided for the design of detailed ground station of COMS and Meteorological Satellite Center.

Table 5. Pixel file Size of MI Level 1B

Observation area		File size [pixel]	File size (one observation) [byte]	Observation number a day	File size (a day observation) [Gbyte]		Total File size (a day) [Gbyte]
FD	VIS	11,000 x 11,000	242,000,000	8	1.936	2.42	
	IR	2,750 x 2,750	15,125,000		0.484		
APNH	VIS	4,800 x 3,400	32,640,000	12	0.3056	1.632	
	IR	1,200 x 850	2,040,000		0. 3264		
ENH	VIS	8,900 x 6,200	110,360,000	12	4. 4144	5.518	12.952
	IR	2,225 x 1,550	6,897,500		1.1036		
LSH	VIS	8,900 x 3,800	67,640,000	12	2.7056	3.382	
	IR	2,225 x 950	4,227,500		0.6764		

4. CONCLUSIONS

In this paper, the image size is decided on the basis of satellite FOV angles requested by users and accordingly the accurate satellite FOV angle and the size of user's distribution image are estimated.

On behalf of this, first , the concept of GEOStationary Projection is explained and the minimum satellite FOV angle for observation of Full Disk is calculated.

Second, based on the user's requirement and the evaluated minimum FOV angle of the satellite , the size of the user distribution image of each observation area is decided and the accurate FOV angle of a satellite as well as the amount of user distribution image created a day is estimated accordingly. The results of this paper influence the detailed design of the COMS ground station development on the way and are expected to be used for the further scheduling of the satellite observation and the distribution of user data.

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