COMS METEOROLOGICAL IMAGER SPACE LOOK SIDE SELECTION ALGORITHM

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ABSTRACT: COMS(Communication, Ocean and Meteorological Satellite) has multiple payloads; Meteorological Image(MI), Ocean Color Imager(GOCI) and Ka-band communication payloads. MI has 4 IR and 1 visible channel. In order to improve the quality of IR image, two calibration sources are used; black body image and cold space look data. In case of COMS, the space look is performed at 10.4 degree away from the nadir in east/west direction. During space look, SUN or moon intrusions are strictly forbidden, because it would degrade the quality of collected IR channel calibration data. Therefore we shall pay attention to select space look side depending on SUN and moon location. This paper proposes and discusses a simple and complete space look side selection logic based on SUN and moon intrusion event file. Computer simulation has been performed to analyze the performance of the proposed algorithm in term of east/west angular distance between space look position and hazardous intrusion sources; SUN and moon.

KEY WORDS: COMS, Geostationary Satellite, Meteorological Imager, Space Look

1. INTRODUCTION

Communication, Ocean and Meteorological Satellite (COMS) satellite is in schedule to be launched in the mid of 2009. It has multiple payloads; Meteorological Image(MI), Ocean Color Imager(GOCI) and Ka-band communication payloads. In case of MI, it has 4 IR and 1 visible channel and will scan the areas shown in Figure 1. The scan area consist of FD(Full Disk), APNH(Asia Pecific Norhtern Hemisphere) ENH(Extended Northern Hemisphere), LSH(Limited Southern Hemisphere) and LA(Local Area)

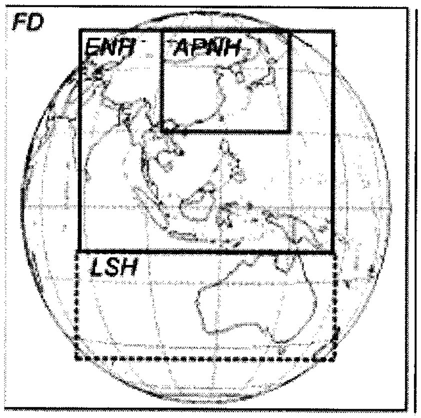

Figure 1 MI Scan Area of the COMS

In order to improve the quality of IR image, two calibration sources are used; black body image and cold space look data. The black body calibration is performed every 30 minutes and it is implemented by starring internal black body target for given time. And space look is performed every 36.6 seconds in low rate mode and every 9.2 second in high rate mode. In case of COMS, the space look is performed at 10.4 degree away from the nadir in east/west direction to look cold space which has constant temperature.

During space look, SUN or moon intrusions are strictly forbidden, because it would degrade the quality of collected IR channel calibration data. Therefore we need to pay attention to select space look side depending on the SUN and moon location. The SUN intrusion can be easily avoided by changing space look side at given time. For example, we can change space look side at midnight (east to west) and at noon (west to east) twice a day. However, the moon intrusion is not easy to consider because its ephemeris is much more complex than the SUN. Even worse, we need to consider SUN and moon intrusion together to reflect real situation

This paper proposes and discusses a simple but a complete space look side selection logic based on the SUN and moon intrusion event file. Computer simulation has been performed to analyze the performance of the proposed algorithm in term of east/west angular distance between space look position and hazardous intrusion sources; SUN and moon.

2. MI SPACE LOOK AND SIDE SELECTION

MI is scanning type sensor scanning east/west in 20 degree/seconds. MI shall perform the space look at location 10.4 degree east or 10.4 degree west cyclically to get IR channel calibration data. The frequency of space look is 36.6 seconds in low rate mode and 9.2 second in high rate mode. The space look data shall not include SUN and moon illumination to obtain high quality calibration data. For that, we need to select space look side very carefully depending on the SUN and moon location.

Figure 2 shows basic concept to be used for COMS to select space look side. When SUN/moon is position at left side of the earth, the space look shall be performed in the east. And when SUN/moon is positioned in the east of the earth, space look shall be performed in the west. This means that the space look side shall be changed from the east to the west while SUN/moon across the earth behind from the west to east. For this reason, to avoid SUN intrusion, we need to change the space look side from the east to the west in midnight. And the side shall be changed from the west to the east somewhere from the end of intrusion and before start of next intrusion. The noon can be a good choice to give maximum extent of margin.

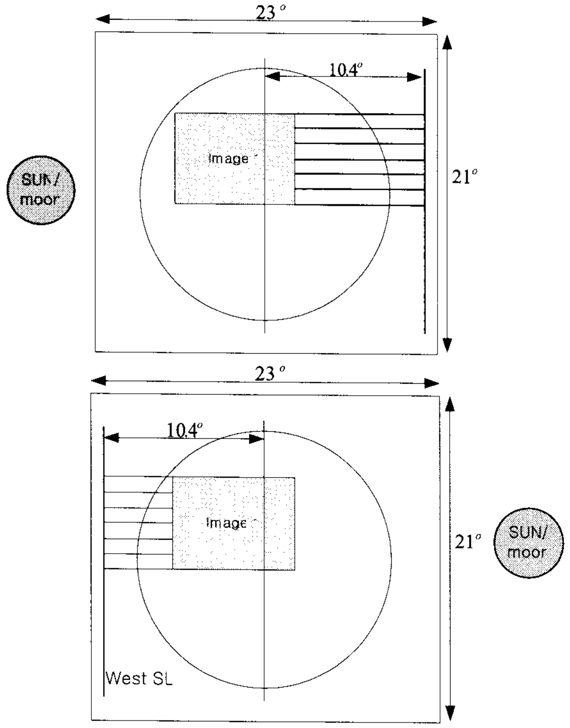

Figure 2 Space Look side depending on SUN/moon location

When moon intrusion is included, the concept should be much more complex as the moon motion is very complex and it is not possible to assign fixed time of a day for side change. Therefore, this paper proposes following principal based algorithm for space look side selection as shown in Figure 3. The basic principal is as follows;

- The SUN and moon intrusions are defined when the SUN or moon is positioned inside of MI field of view shown in Figure 2. And the intrusion event file including intrusion start/end time and origin of intrusion shall be prepared for whole mission life.
- As a minimum 30 minutes before, the start of SUN/moon intrusion, the space look side should be in east side.
- Space look side shall be changed from the east to the west at center of SUN/moon intrusion
- Space look side shall be changed from the west to the east at center of two intrusions
- When the SUN and moon intrusions (including 30 minutes margin on both end) are partially or fully overlapped, the moon intrusion shall be ignored, and next intrusion should be considered to determine next SL side selection and selection time.

As the moon intrusion has less impact than the SUN in calibration quality point of view, when SUN and moon are located near the earth in MI field of view, the intrusion by the moon is neglected. This selection is recommendation by MI manufacturer.

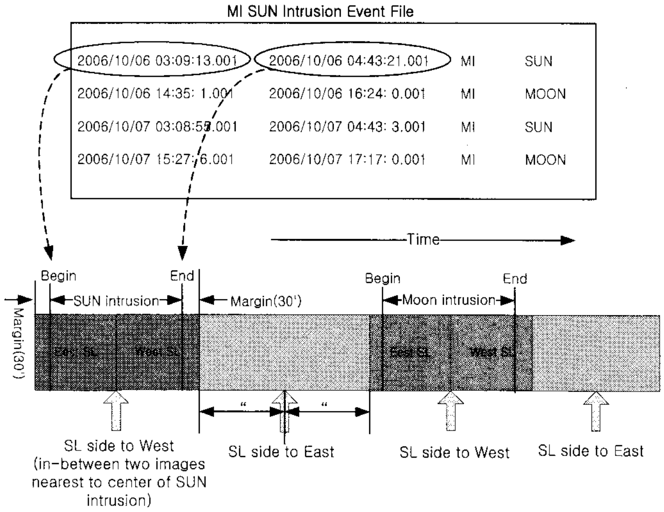

Figure 3 Concept of proposed space look side selection algorithm

3. COMPUTATION OF SUN/MOON INTRUSION

To implement the algorithm described in previous section, computation of the SUM/moon intrusion shall be performed. The intrusion is declared when the SUN or moon appears in the MI field of view defined in Figure 2 of previous section. MI field of view is 21 degree in north/south and 23 degree in east/west.

The coordinate definition for computation of the SUN/moon intrusion into MI field of view is show in Figure 4.

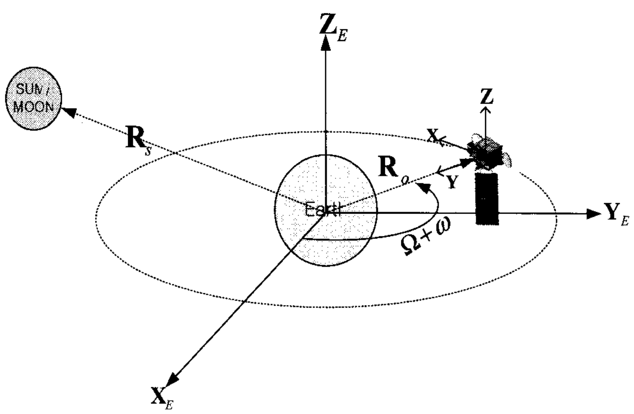

Figure 4 Coordinate definition

If we assume that the inclination is very small, the location of SUN/moon $\mathbf{R}_{SL}$ in spacecraft body coordinate can be described as follows;

$$\mathbf{R}_{SL} = TF_Z(\Omega + \omega + \pi)(\mathbf{R}_s - \mathbf{R}_\circ) \qquad (1)$$

Here, Ω means the right ascension ascending node. ω is the argument of peerage. $\mathbf{R}_s$ and $\mathbf{R}_\circ$ are the SUN and satellite position vectors in earth centered inertial coordinate respectively. TF_Z indicates Eular coordinate transformation in Z-axis, and it can be described as follows;

$$TF_z(\theta) = \begin{bmatrix} \cos(\theta) & \sin(\theta) & 0 \\ -\sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (2)$$

The elevation (El) and azimuth (Az) of the SUN or moon can be obtained as follows;

$$El = \tan^{-1}\left(\frac{Z_{SL}}{Y_{SL}}\right) \qquad (3)$$

$$Az = \tan^{-1}\left(\frac{Y_{SL}}{Y_{SL}}\right) \qquad (4)$$

Intrusion is detected when following condition is met.

$$|El| \le 10.5^\circ \ \& \ |Az| \le 11.5^\circ \qquad (5)$$

Using the equations from (1) to (5), we can easily prepare intrusion event file which is input to space look side computation.

4. SIMULATION AND DISCUSSION

In this simulation, instead of using complicated orbit propagation taking into account station-keeping, it has been assumed that the spacecraft is constantly positioned at 128.2 deg.E. This is reasonable assumption because station-keeping box size is very small (0.1 degree for north/south and east/west direction), and it is guaranteed by performing station-keeping maneuvers every 7 days. Simulation has been done for year 2010. For the preparation of intrusion event file, the intrusions are computed every 300 seconds. Ephemeris of the SUN, moon and earth are computed using the equations described in reference [Sue].

Table 1 shows the annual number of intrusions expected from 2010 to 2019. The SUN intrusion happens 110 to 111 times annually and it appears around equinox season. In case of the moon, the number of intrusions varies depending on years. The maximum number of moon intrusions is 155/year and it happens from 2015 to 2016. It is significant number of intrusions and it can not be neglected.

Table 2 shows the total number intrusions and discarded number of intrusions by overlapping for year 2010. There are 14 events in which SUN and moon intrusions are overlapped taking into account 30 minutes margin. Consequently, 14 moon intrusions are discarded because the SUN intrusions have higher priority than the moon intrusions. This means the moon intrusion can not be avoided during these days.

Table 1 Number of Intrusions Expected

Year	No. SUN intrusion	No. moon intrusion
2010	111	115
2011	110	121
2012	111	126
2013	110	145
2014	111	155
2015	110	155
2016	111	153
2017	110	146
2018	111	141
2019	110	124

Table 2 Number of Intrusions in 2010

Origin	SUN	moon
Number of intrusions	111	115
Overlapped intrusion	14	
Discarded intrusion	0	14

Figure 5 shows the resulted east/west delta angle between the SUN/moon and space look location when we apply proposed space look side selection algorithm. To show data effectively, the plot includes only the data whose elevation are within intrusion range. In this simulation, 30 minutes margin has been considered. According to this plot, for the SUN, the delta angle is larger than 10 degree all the year round and it is safe in SUN intrusion point of view. But in moon case, its angle approaches to zero from time to time because of discarded moon intrusions.

Figure 6 shows the result for the same case except for absence of 30 minutes margin. From this figure, we can notice that 3 cases of SUN intrusions approach to zero. It is certain that 30 minutes margin is necessary to avoid SUN in space look location.

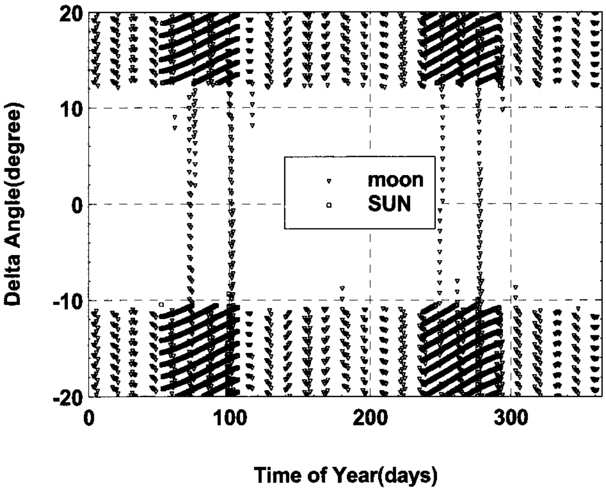

Figure 5 Delta Angle(with 30 minutes margin)

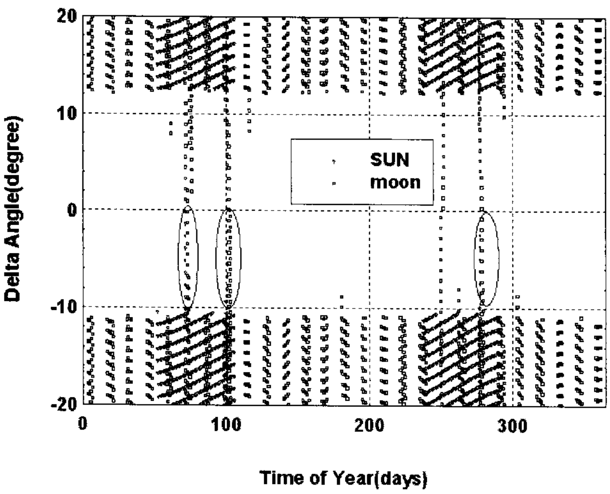

Figure 6 Delta Angle (without 30 minutes margin)

5. CONCLUSIONS

This paper analysed the SUN and intrusion into MI(Meteorological Imager) field of view, and proposed a simple but complete MI space look side selection algorithm of the COMS satellite taking into account intrusion by the SUN and moon. Through the computer simulations, it was proved that the proposed algorithm can avoid SUN and moon intrusion during space look effectively. It is concluded that 30 minutes margin in east/west intrusion is necessary to guarantee complete SUN intrusion avoidance. The algorithm proposed in this paper can be applicable to COMS operation effectively.

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