Assessment of geometric errors of Advanced Himawari-8 Imager (AHI) over one year operation

○Wataru Takeuchi[1)]

1) Institute of Industrial Science, The University of Tokyo, Japan

Abstract: This paper presents an approach to check a geometric performance of Advanced Himawari-8 imager (AHI) and demonstrate and evaluate a new approach to ensure more geometric accurately focusing on visible imagery in 500 meters. A series of processing is supplemented by ground control points of shore lines, land mark locations and digital elevation model. Firstly, a template matching technique is conducted to find a best matching point by simply moving the center of AHI sub-image over each point in a reference image of shore lines and calculating the sum of products between the coefficients and the corresponding neighbourhood pixels in the area spanned by the filter mask. Secondly, ortho-rectification processing is carried out to compensate for the geodetical distortions with respect to the acquisition condition including viewing geometry and so on. As a result, an average of root mean square sum of residual errors with system correction and that of precise geometric correction are shown. Overall geometric accuracy is about 1 to 1.5 pixels from 2015 March to July and it also gradually decreased down to 0.2 to 0.8 from 2015 September to 2016 February. AHI is officially open to public for operational use as of July 1, 2015 and after that operation date geometric errors are reasonably satisfied within one pixels of errors.

Introduction

Advanced Himawari-8 Imager (AHI) is a Japanese weather satellite for geosynchronous with a three-axis stabilized spacecraft with a meteorological mission. The Japan Meteorological Agency (JMA) contracted for AHI as a successor to MTSAT and GMS series, in cooperation with the Civil Aviation Bureau (CAB), of the Ministry of Transport of Japan (JMA, 2003). AHI breaks through limitations of earlier three-axis stabilized GEO instruments with significant improvements in many areas, including spatial sampling, radiometric sensitivity, calibration and performance around local midnight.

The objective of this study is to check a geometric performance of AHI imagery and demonstrate and evaluate a new approach to ensure more geometric accuracy focusing on visible imagery in 500 meters from 2015 March to 2016 February.

Methodology

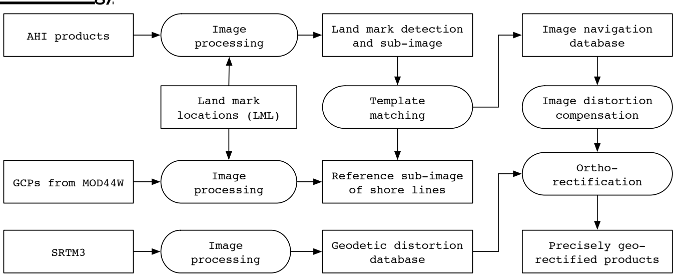


Figure 1 Flowchart of a precise geometric correction of AHI using a template matching technique.

- A AHI visible image is clipped out into 64 × 64 sub-images centered on 792 LMLs.
- A suit of sub-images is digitized into a land-sea mask image using a discriminant analysis which enables a dynamic thresholding (Kittler et al., 1985).
- Shore lines are extracted from GSHHS database and they were digitized into 128 × 128 subimages centered on 792 LMLs used as a reference.

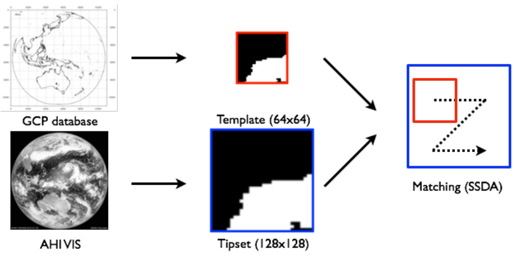
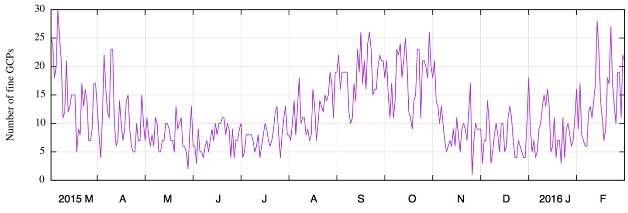


Figure 2. A template matching technique with sequential similarity detection algorithm (SSDA)

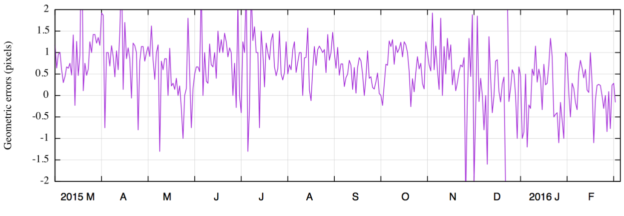
- A template matching technique is conducted to find a best matching point with sequential similarity detection algorithm (SSDA) by simply moving the center of 64 × 64 sub-image over each point in a reference image and calculating the sum of products.
- Image distortion compensation is conducted by an affine transformation shown as following formula;

$$\begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b_1 \\ b_2 \end{pmatrix}$$

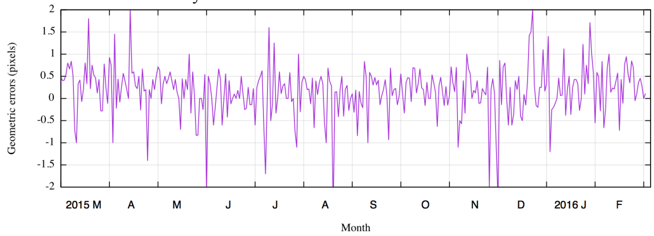
Results and discussions



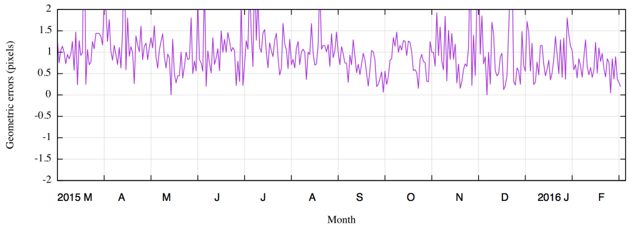
- Figure 3-(a) shows the number of fine pixels among 796 LSLs which are identified as cloud free and used to detect land mark and generate sub-image from Band 3. It ranges from 5 to 25 LSLs from 2015 March to 2016 February. The number of fine pixels are relatively lower from May to August because of rainy season in monsoon Asian region whereas 20 to 25 LSLs are available from September to October which guarantees higher geometric error compensation reliability. A series of template processing is carried out by using those fine LSLs for the further analysis.



- Figure3-(b) shows geometric errors in east-west direction which is obtained from template matching results. Overall geometric accuracy is about 0.7 to 1.2 pixels from 2015 March to July and it gradually decreased down to 0.2 to 0.5 from 2015 September to 2016 February. In July and November, a relatively higher errors more than 2.0 pixels are often found because of less fine GCP's are available for processing as shown in Figure3-(a).



- Figure3-(c) shows geometric errors in north-south direction which is obtained from template matching results. Overall geometric accuracy is about 0.2 to 0.5 pixels from 2015 March to July and it also gradually decreased down to -0.2 to 0.2 from 2015 September to 2016 February. In July and November, a relatively higher errors more than 2.0 pixels are often found like those in east-west direction because of less fine GCP's are available for processing as shown in Figure3- (a).



- Figure3-(d) shows overall geometric errors which is obtained from root mean square errors from east-west and north-south directions. Overall geometric accuracy is about 1 to 1.5 pixels from 2015 March to July and it also gradually decreased down to 0.2 to 0.8 from 2015 September to 2016 February. AHI is officially open to public for operational use as of July 1, 2015 and after that operation date geometric errors are reasonably satisfied within one pixels of errors.

Figure 3 The number of fine GCPs selected for template matching and geometric errors.

Key publications

[1] Japan Meteorological Agency, 2003. JMA HRIT Mission Specific Implementation, Ver. 1.2.
[2] Takeuchi, W., K. Oyoshi and S. Akatsuka, 2015. Assessment of geometric accuracy with Advanced Himawari-8 Imager (AHI). Proceed. Int. symp. remote sens. (ISRS 2015), Tainan, Taiwan.
[3] Yasukawa, M. and M. Takagi, 2003. Geometric correction of GMS S-VISSR using elevation distortion compensation. Japanese journal of photogrammetry and remote sensing, 42(6), 33-41.
[4] Takagi, M., 2004. Precise geometric correction for NOAA and GMS images considering elevation effects using GCP template matching and affine transform. Proceedings of the SPIE, 5238, 132-141.
[5] Kittler, J. and M. J. Duff, 1985. Image Processing System Architectures. John Wiley & Sons, Inc., New York, USA.
[6] Takeuchi, W., T. Nemoto, T. Kaneko and Y. Yasuoka, 2010. Development of MTSAT data processing, distribution and visualization system on WWW. Asian Journal of Geoinformatics, 10(3), 29-33.

Further details, contact: Dr. Wataru Takeuchi , Ce-505, 6-1, Komaba 4-chome, Meguro, Tokyo 153-8505 JAPAN (URL: http://wtlab.iis.u-tokyo.ac.jp/ E-mail: wataru@iis.u-tokyo.ac.jp)