Comparison of Histogram Matching Preprocessing Methods for Generating Natural GOCI-II Full Disk Images

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Abstract: Full-disk satellite imagery is essential for monitoring atmospheric and oceanic changes on a global scale and supports applications such as cloud tracking and ocean current analysis through time-series observations. However, sequential acquisition of full-disk images introduces temporal differences between slots, leading to brightness inconsistencies and visually unnatural mosaics. To address this issue, we propose a methodology that combines preprocessing with histogram matching to generate visually consistent full-disk images. In the proposed approach, three preprocessing steps were applied prior to histogram matching: adjusting the matching order, removing cloud regions, and applying image offset shifting. Results show that aligning histogram offsets relative to a reference image and matching images in slot-number order produced the most visually consistent mosaics. The methodology provides a practical framework for integrating multitemporal imagery and serves as a basis for applications in global monitoring and time-series pattern analysis. Furthermore, future work incorporating deep learning or GAN-based shifting of cloud gaps is expected to further enhance mosaic quality and accuracy.

Keywords: GOCI-II, Full disk mosaicking, Histogram matching, Ocean satellite, Image processing

1. Introduction

Full disk imagery is significant in that it enables observation of atmospheric and oceanic changes on a global scale. It is particularly important for time-series analysis, which supports various applications such as cloud motion estimation and ocean current monitoring through continuous image acquisition. Accordingly, satellites such as the GOES series (USA), Himawari series (Japan), and Meteosat series (EU) continuously provide full disk imagery and derived products. Korea also contributes with its GEO-KOMPSAT-2A and 2B satellites, which provide global coverage for atmospheric and oceanic monitoring. As with conventional full disk systems, the GOCI-II payload aboard the GK-2B satellite captures slot-by-slot images that must be mosaicked into a single full disk image. However, this sequential acquisition introduces time differences between slots, resulting in pixel value imbalances that can degrade analytical accuracy. Additional rightness range inconsistencies between slots can lead to visually unnatural mosaicked images. In this paper, we aimed to generate visually natural full disk images by using histogram matching in the image matching process.

2. Methodology

For rapid normalization and mosaicking of large numbers of scenes, histogram matching was adopted to generate full-disk images. In the GOCI-II full-disk mode, 235 scenes are acquired over a 12-hour period. To enhance operational efficiency and prolong satellite lifetime, the current strategy limits acquisitions to 45 scenes over Indonesia. Despite this reduction, the histogram ranges of adjacent scenes continue to differ markedly due to significant changes in illumination conditions throughout the observation period. As a result, the final mosaic produced through histogram matching exhibits severe brightness inconsistencies, as shown in Fig. 1.

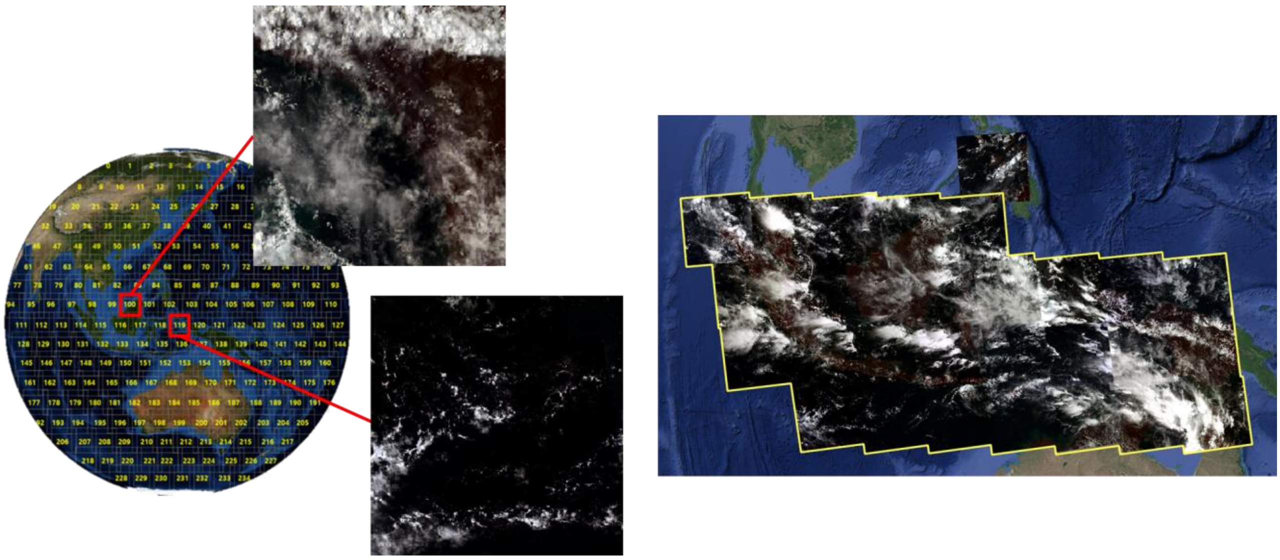

Figure 1: Brightness Variations Between Slot Images (Left) and Histogram Matching Results (Right)

To improve the naturalness of histogram matching results, even in cases where image contrast varies considerably, three preprocessing procedures were introduced: (1) adjusting the matching order, (2) removing cloud regions, and (3) shifting image histogram offset. The matching order refers to the sequence in which image pairs are matched; two strategies were tested—slot-based order, where adjacent images are matched according to their slot numbers, and acquisition-based order, which follows the temporal sequence of image capture. Cloud removal involves excluding regions with abnormally high reflectance values caused by clouds, thereby enabling more consistent histogram matching across land and ocean surfaces. Image offset shifting is performed by computing the mean pixel values of each image and adjusting them to align histogram ranges before matching. Two approaches were compared: applying pairwise offset shifting between matching images and applying global offset shifting with respect to a single reference image. The reference image was selected based on visual inspection to ensure minimal cloud coverage and balanced proportions of land and ocean. The performance of each preprocessing step was evaluated by comparing histogram matching results with and without preprocessing, and the approach yielding the most visually consistent full-disk image was identified.

3. Results/Findings

Figure 2 shows full-disk mosaics produced with different preprocessing steps prior to histogram matching: matching order, cloud removal, and offset shifting. Images matched in acquisition order were initially visually natural; However, subsequent illumination changes led to reduced pixel ranges and obscured features. In contrast, slot-order matching yielded images that were darker on average, while maintaining more uniform illumination across the sequence.

Time-Series Matching — Slot-Series Matching

Figure 2: Results of the histogram matching by matching order

Removing clouds without adjustment created abrupt changes, while histogram matching after cloud removal yielded smoother brightness transitions. Pairwise offset shifting caused extreme variations, whereas global shifting using a single reference image produced the most consistent and natural mosaic.

Without Offset Shifting — With Offset Shifting

Cloud filtered

Cloud unfiltered

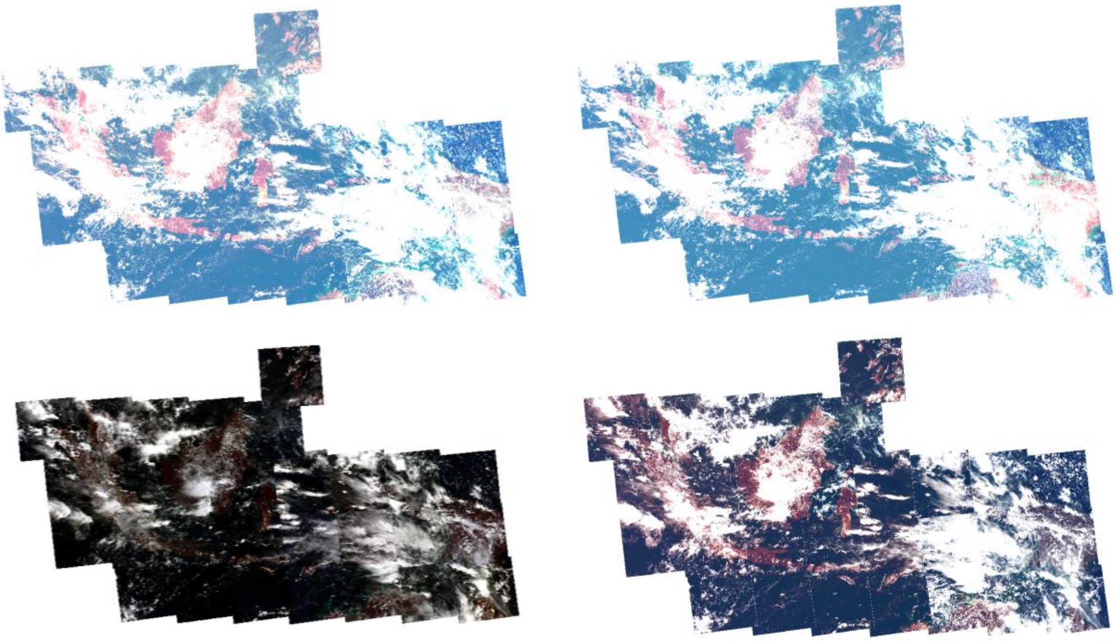

Figure 3: Results of the histogram matching by removing cloud regions and shifting image histogram offset

4. Conclusion

This study demonstrated a fast and effective approach for full-disk mosaicking. The method applies preprocessing and histogram matching to large volumes of imagery acquired under varying illumination conditions. Adjusting histogram offsets relative to a reference image and matching in slot-number order produced the most visually consistent mosaics. This provides a practical methodology for integrating multi-temporal scenes and offers a basis for applications such as global monitoring and time-series pattern analysis. However, histogram matching directly alters pixel values, requiring additional validation when applied to quantitative time-series analysis. In this study, cloud-covered pixels were simply removed and treated as gaps, which sometimes reduced the continuity of the mosaics. Future work will explore deep learning–based shifting and GAN-based synthesis techniques to reconstruct missing cloud regions prior to histogram matching. Such approaches are expected to produce more seamless and accurate full-disk mosaics. Overall, this work presents not only an efficient baseline methodology for global image mosaicking but also highlights the need and potential for AI-based extensions in subsequent research.

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