GOCI Level-2 Processing Improvements and Cloud Motion Analysis

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Introduction.

The Ocean Biology Processing Group has been working with the Korean Institute of Ocean Science and Technology (KIOST) to process geosynchronous ocean color data from the GOCI (Geostationary Ocean Color Instrument) aboard the COMS (Communications, Ocean and Meteorological Satellite). The level-2 processing program, l2gen has GOCI processing as an option. Improvements made to that processing are discussed here as well as a discussion about cloud motion effects.

Level-2 processing improvements: Metadata interpretation – The GOCI L1B metadata was not being interpreted correctly and was repaired.

Slot times were used to generate solar geometry – this improved atmospheric correction and stabilized many ocean color parameters through the day (see Rrs plots, Fig 2).

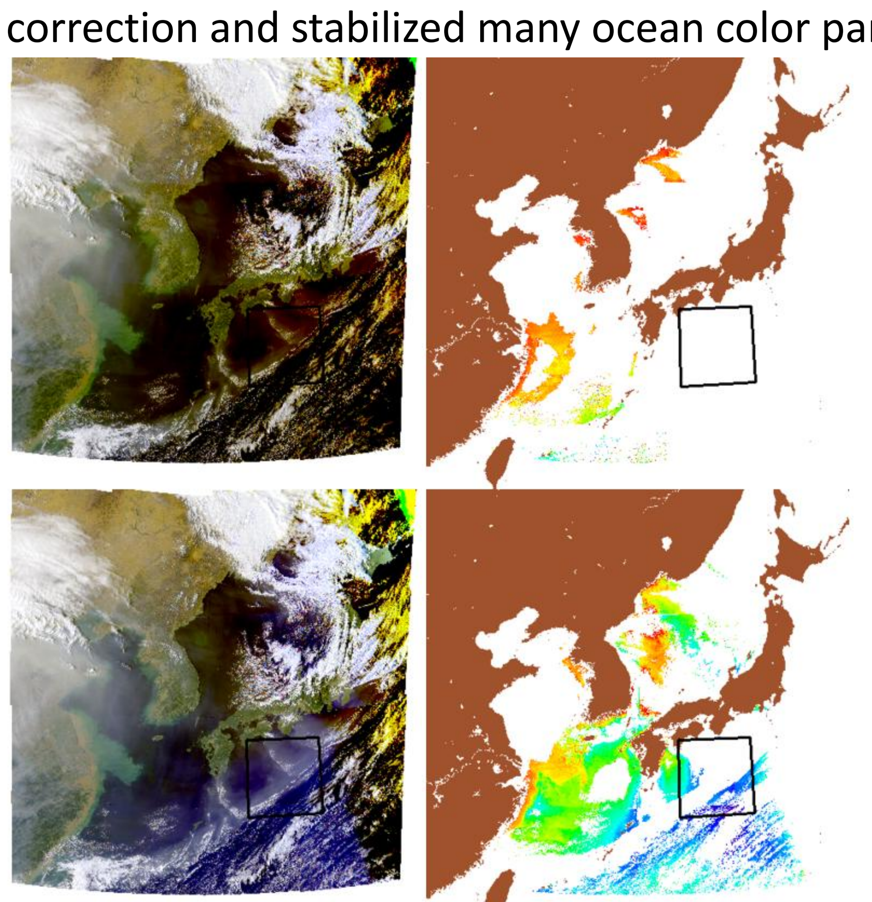

Figure 1. True color (left column) and chlorophyll-a (right column) for the 1600 local time GOCI scene on 12 Oct 2013. The top row was generated using one time for the entire scene while the bottom row uses the slot-based times. The 1600 time is affected the most by low solar zenith angles.

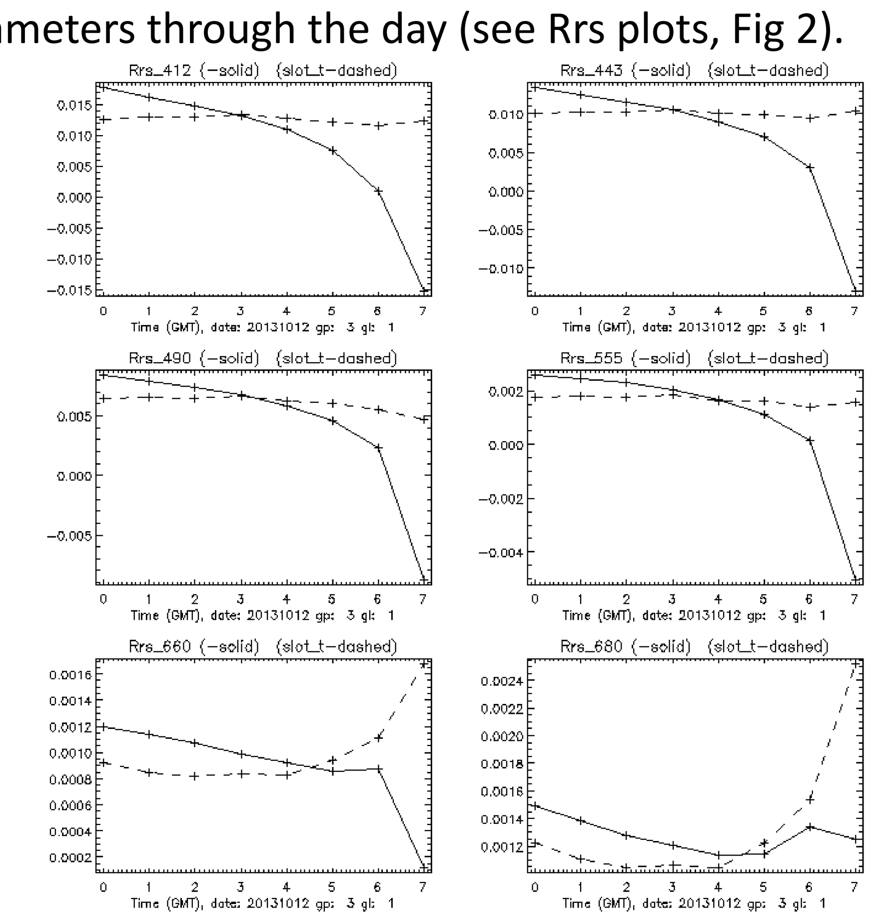

Figure 2. These 6 plots show the Rrs (remote-sensed reflectance) for the 6 GOCI visible bands as a function of time of day. Each point is the average of the non-cloud portion in the box shown in Fig 1. Rrs before (solid lines) and after (dashed) slot time use are plotted.

Residual gradients were seen and characterized in the GOCI 'Slots'

Current GOCI images contain a residual uncorrected gradient in the slots used to make up a complete scene. The gradient is shown in Figure 3 by binning the aerosol optical thickness at 865 nm (AOT) in slot coordinates for all the slots in the for 14 Aug 2012 scene (16 slots per scene/time and 8 scenes, 128 slots total). Figure 4 shows the AOT gradient clearly, rising toward the bottom of the slot. KIOST is developing a correction for this gradient (Kim et. al., 2015).

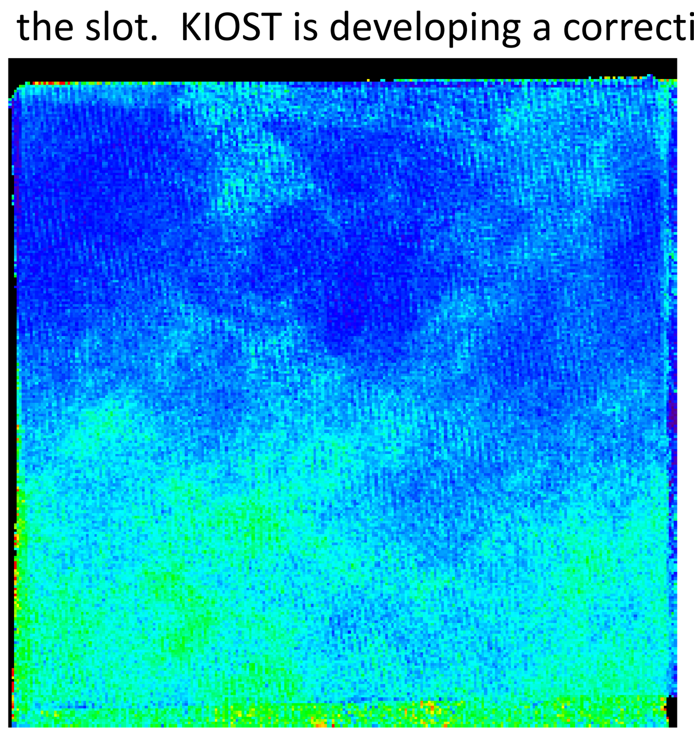

Figure 3. Image of 865 nm AOT slot-binned for 14 Aug 2012. The higher AOT (greens) consistently occur at the South end (bottom) of the slots.

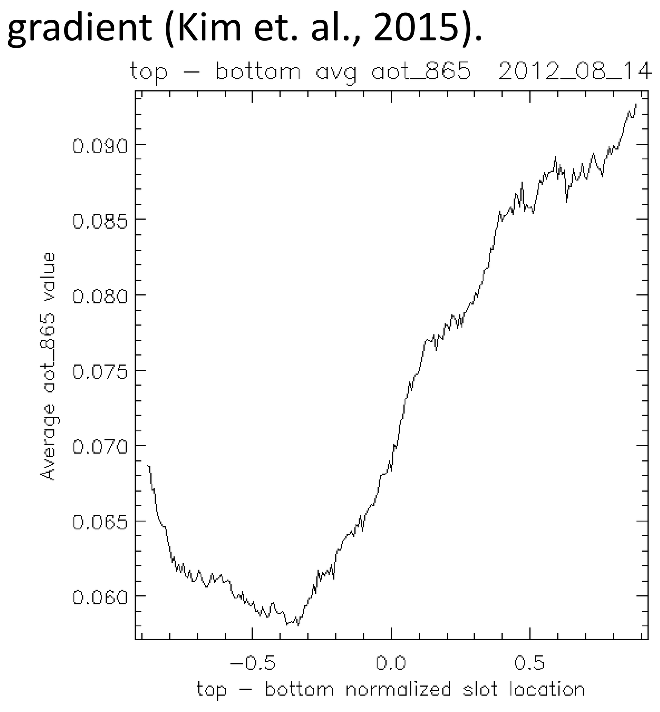

Figure 4. Average of all rows of aot_865, omitting row and column data < 0.12 units from the edge (15 pixels) to avoid edge effects (lack of data and data from scene bottom only due to slot stitching).

Cloud motion Effects in GOCI

In the time it takes for the GOCI instrument to step through all the filter positions for the 8 bands, clouds in the scene can move by more than the detector size of 500 m. This was also noted by Fukushima et. al., 2015. Table 1 shows the relative times that bands are acquired for the 4 June, 2015 scene examined here (note that time delays may be adjusted through the mission to compensate for detector degradation).

Band	Wavelength (nm)	Time offset from 1st band (sec)	Approximate color	Comments
1	412	36	Violet	TC-Blue
2	443	20	Blue	
3	490	52	Blue	Largest shift
4	555	6	Green	TC-Green
5	660	0	Red	TC-Red
6	680	28	Red	
7	745	14	NIR	
8	865	44	NIR	

Table 1. Relative times when GOCI bands are acquired.

References

F. Faure, P. Coste, and G. Kang, "The GOCI instrument on COMS mission—The first geostationary ocean color imager," in Proc. ICSO, Oct. 2008, pp. 1–6.

H. Fukushima, K. Ogata, M. Toratani, J. Ahn, W. Kim, Y. Park, "Cloud-affected pixel identification on COMS/GOCI Ocean Color Imagery in Consideration to Fast-moving Cloud Fragments" in Proc. Int. Sym. Remote Sens. (ISRS), April, 2015.

W. Kim, J. Ahn, and Y. Park, Correction of Stray-light Driven Interslot Radiometric Discrepancy (ISRD) Present in Radiometric Products of Geostationary Ocean Color Imager (GOCI), 2015, IEEE Trans Geo and Rem. Sens., 53, pp5458-5472.

Cloud Motion – 4 June 2015 case

The true color image of the noon (0300) time (Figure 5), if looked at in detail at point A (Figure 6), shows the effect of cloud motion. The bands used traditionally to make the true color (Fig 6) have a maximum 36 second delay between the bands used. Only a slight ghosting effect is seen. However, if the green portion of the true color image was made instead with the 490 nm band, the cloud shift caused by a 52 second delay is quite evident (Figure 7)

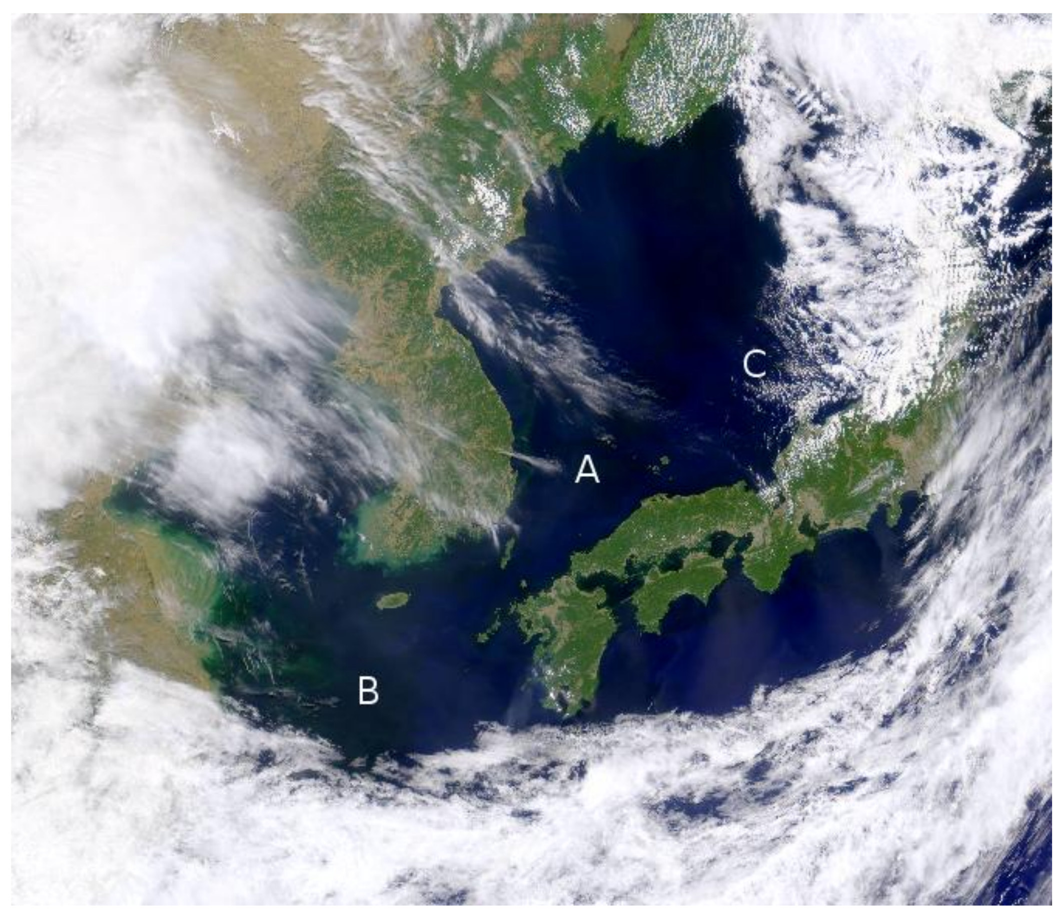

Figure 5. True color image of a portion of the GOCI scene on 4 June 2015. 3 regions with clouds are indicated with the letters A, B, and C

Figures 6. A close up view of the region A from Fig 5 showing a cirrus cloud moving off the Korean coast

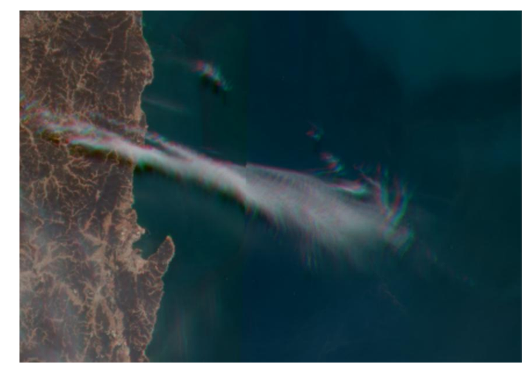

Figure 7. Same region as Fig 6, but made using the 490 nm band for the green channel. The 52 second time difference between the red and green bands is very noticeable.

Per-band pixel shift determination

The cloud mask for ocean regions is determined using band 8 at 865 nm. The cloud shift relative to band 8 should be taken into account for cloud masking with at least an enlargement of the cloud mask. **Using cloud tracking techniques, the shift of each band relative to band 8 can be determined automatically by finding the shift that maximizes the correlation to band 8.** This technique would reduce the amount of masking required to remove cloud-contaminated pixels. The plots in figure 8, were generated for the points A, B, and C in Fig 5 to show the technique. The tracking not only shows the amount of shift, **but it also shows that GOCI has little jitter** – the only source of the shift appears to be the cloud motion. **This technique can also be used to determine cloud winds** in the sub-minute realm – something only coming on-line with GOES-R.

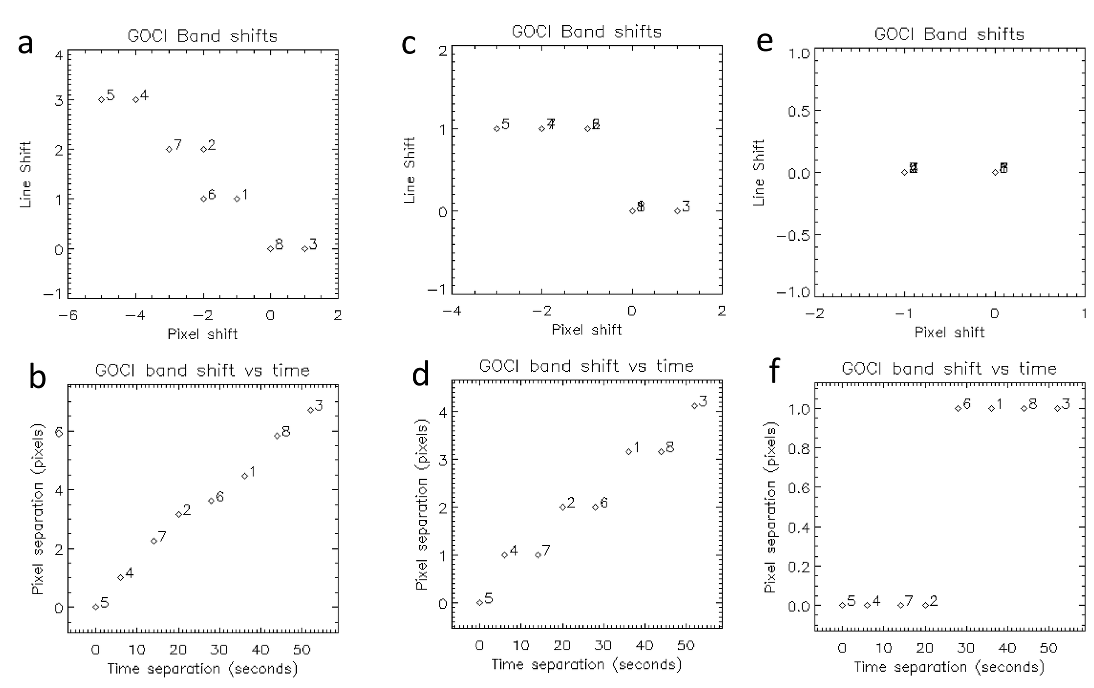

Figure 8. a, c, and e: Cloud shift in pixel and line relative to band 8 derived at points A, B, and C for the scene in Fig 5. Plots b, d, and f are the displacement of the cloud from band 5 (first acquired band) versus time. Bands are labeled with their band number. The shift at point A (plot b) indicates a wind speed of 127 kt, which is close to what was reported in the 250 mb upper air analysis. Point B had lower winds while point C, a group of cumulus clouds, had only a 1 pixel shift. Even so, the shift as a function of time remains monotonic (plot f).

Impact of moving features on satellite measurements

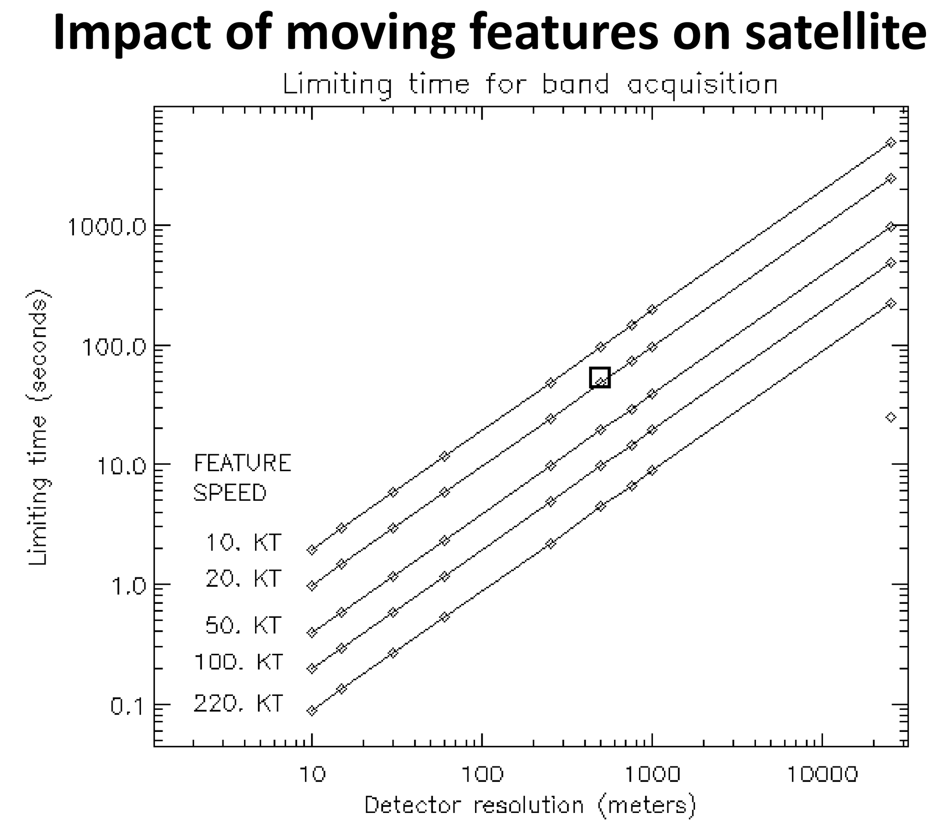

Figure 9. The maximum time allowed to acquire all bands for a pixel so that the feature, clouds in this case, will move by less than the detector size. GOCI is indicated by the square on the plot.

Any instrument that sequentially acquires band data can be examined to determine the maximum time allowable before the motion of a feature will need to be considered. For GOCI, with a detector size of 500 meters and which takes 52 seconds to acquire all 8 bands, cloud motion of less than the detector size will happen only for clouds moving at 20 kt or less. As the maximum wind speed seen in the atmosphere is 220 kt, GOCI would have to acquire all 8 bands in under 4.5 seconds to keep cloud motion to under 1 pixel. The plot in Fig 9 graphically shows this relationship for a range of detector sizes and feature speeds.

Summary

- Metadata use in level-2 processing was improved.
- Slot times were introduced into processing with greatly improved diurnal stability of ocean color parameters.
- An uncorrected gradient in slots was found.
- Cloud motion needs to be considered for GOCI, possibly other ocean color instruments.
  - Time to acquire all bands for a location needs to be short enough to avoid cloud motion between bands.
  - If time is large, inter-band correlations and cloud mask shifting can be used to properly mask other bands.
  - Cloud wind speeds can be determined from band shifts if the time is large enough.
  - GOCI appears to have little jitter (detector motion) between bands.