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Atmospheric Measurement Techniques Discussions

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Interactive comment

Interactive comment on "Global Cloud Property Models for Real Time Triage Onboard Visible-Shortwave Infrared Spectrometers" *by* Macey W. Sandford et al.

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Response to RC1:

We would like to thank the reviewer for closely reading the article and providing helpful feedback while finding aspects of the discussion that can be expanded further on to clarify our work.

l. 87: The reader could wonder where these labels are coming from. The Authors could put a brief link to Sec. 2.2 in anticipation of this question.

Great idea! I can add that in.

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Sec. 2.1: Please list the pixel size and the orbit of the satellite. Can sun-glint be expected?

The pixel size of the Hyperion instrument is 30 m per pixel and 7.5 km by 100 km land area per image. It followed a polar orbit.

l. 100: Please briefly mention the selection process of 102 sample maps. How important is coverage across solar geometries versus surface types?

To ensure that we sampled the entire globe, we collected approximately 25 images from each section of the globe. Namely the Arctic, Northern Midlatitude, Tropics, Southern Midlatitude, and Antarctic. We found that there were many less applicable images from both of the polar regions so combining them we included 21 images. We found that there were many Tropic images so that sample set ending up being 30 images and the Midlatitudes add up to 51. These number are not round because of the issue of resampling when including the Ocean subset. The 19 in the ocean category can be found in the other latitudinal zones, so any cross over between the two subsets were eliminated to ensure the entire sample set was unique.

Since we worked with TOA brightness, we did not need to consider solar geometries. According to our study of cloud brightness by latitude, surface type does play a role in apparent cloud brightness so it was important for us to include a variety of latitudinal ranges.

ll. 106-109: The purpose of this sentence is not apparent. Please rephrase or exclude if irrelevant.

The purpose of these sentences is to inform readers about the selection of three bands to classify cloudy pixels. It gives background to the radiation sources that the instrument measures. These sentences will be written as: In order to detect cloudy pixels with confidence, we selected three specific spectral bands that can distinguish clouds from other surface types. It is important to note that Earth's total TOA energy flux con-

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stitutes the total incoming solar radiation, the consequential outgoing reflected shortwave radiation from the clouds and surface, and the outgoing emitted longwave radiation from Earth's surface, atmosphere, and clouds (e.g., Trenberth et al. 2009).

ll. 117-119: I understand the satellite hardware limits the complexity of a cloud screening algorithm. How much more complex (than decision trees) could a potential algorithm be? What exactly are the limitation: RAM or CPU power? Perhaps these answers could extent the discussion in Sec. 4.

The algorithm that we propose uses pre-calculated thresholds to screen data onboard. This method is of similar complexity to decision trees such that decision trees have N thresholds, where N is the maximum height of the tree, and our process uses 3 thresholds.

Hyperspectral instruments produce data rates of Gb/s and with relatively simple hardware (FPGA), or with hardware that people are starting to fly now (see below) you could keep up. Current efforts to fly more powerful computation include flight of the Qualcomm Snapdragon on the Mars Helicopter [Grip et al. 2019] and flight of the Intel Myriad Chip on FSSCCAT [ESA 2020], however future computing needs for onboard AI will continue to grow [Dally et al. 2020].

Dally, William J., Yatish Turakhia, and Song Han. "Domain-specific hardware accelerators." Communications of the ACM 63.7 (2020): 48-57.

Grip HF, Lam J, Bayard DS, Conway DT, Singh G, Brockers R, Delaune JH, Matthies LH, Malpica C, Brown TL, Jain A. Flight Control System for NASA's Mars Helicopter. In AIAA Scitech 2019 Forum 2019 (p. 1289).

European Space Agency (ESA), FSSCCAT-1 Ready for Launch, https://www.esa.int/Applications/Observing_the_Earth/Ph-sat/FSSCat_F-sat-1_ready_for_launch , retrieved 6 August 2020

For example, EO-1 had a Mongoose M5 which is a variant of a RAD 3000 (PowerPC family) CPU. It had a 6 MHz clock speed so around 6 MIPS processing power. The challenge is that it had no hardware floating point support. If the computation was all performed fixed point it would be much more efficient, but all onboard classification was performed on top of the atmosphere reflectance data which was in floating point. Additionally, it had most but not all of the CPU for image processing. Therefore scenes required 10's of minutes to load into RAM and process, during which time another scene could not be acquired (as the Solid State Recorder could not simultaneously read and write). Current spacecraft have more computing capability but still fall far below laptop like computing power. A typical flight CPU would be a Rad 750 (about 200 MIPS) with 128 MB RAM. In comparison a typical laptop in 2020 has 400K MIPS or 2000x the compute power and 16 GB RAM. Future spacecraft are likely to have special purpose processors to handle instrument processing that would enable more sophisticated processing onboard. For example, the Mars 2020 Helicopter uses a Qualcomm Snapdragon processor.

ll. 145-146: Should the 'historical average' be determined from the same pixel size as the future samples? (or in other words: does cloud fraction change when using larger or smaller pixels?) And what cloud optical thickness threshold was used for MODIS cloud detection? Perhaps the Authors could discuss these answers in the Sec. 4.

We actually did not experiment with how our historical averages change with pixel size. The best I can do to address this concern is point the reviewers to the method we used to label our ground truth pixels. The pixels surrounding areas of a certain surface type were labeled as ambiguous and not used in our cloud fractions so that any pixels that may include two classification types were not misclassified either way, thus not included in the historical average. This method helps to mitigate any change in cloud fraction where pixel size varies, for example if more than one surface type is present due to the large pixel size. Although, we could complete a study using data with smaller and larger pixels to definitively say that the pixel size is not a large concern, but it fell outside the scope of the study we conducted.

ll. 193-203: Perhaps these paragraphs are better suited for the discussion in Sec. 4.

Thank you for the suggestion, I agree!

ll. 259-262: Perhaps this paragraph is better suited for the discussion in Sec. 4.

Thank you for the suggestion, I agree!

Fig. 2: Please explain the colors in this figure.

Thank you for the suggestion, that would be helpful!

Fig. 5: Which wavelength was used to capture this image? Please add the fraction of excluded pixels in b, c, and d to the caption.

This Hyperion image is named EO1H1940712011304110T1. The image was created using the default RGB wavelengths in the ENVI program, although the algorithm to create the image in this figure only considers the three wavelengths used in our thresholds. The RGB image is used for visualization. The images in b, c and d show the pixels excised based on our calculated thresholds using a false positive of 1000, 100 and 10, respectively. Figure 5b has 8.5% of the total pixels excised, figure 5c has 16.4%, and figure 5d has 25%. I plan to revise the figure caption to include the filename and the percentage of excised pixels.

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