

GOESR3 Periodic Reporting

Reporting Period: January 2018 – June 2018 (2nd half of FY17 funding cycle)

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Project Title: Improving the ABI Cloud Layers Product for Multiple Layer Cloud Systems and Aviation Forecast Applications

Project Number: 479

Executive Summary

This project seeks to improve the classification and categorization of multilayer cloud scenes by the GOES-16 ABI, while simultaneously improving the Cloud Cover Layers product that identifies the height category of clouds in any given ABI pixel. The general methodology is threefold: (1) To investigate the usefulness of certain cloud proxies, such as layer relative humidity, by training on actively-sensed cloud layer boundaries; (2) To develop a new multispectral retrieval that uses ABI radiances to determine separation between cloud layers in known multilayer situations; and (3) To fuse this information together with our own statistical cloud base algorithm, which has been trained on radar and lidar-observed cloud boundaries.

In the second half of FY17, we have continued the progress reported in the first half, which included the public release of an improved cloud covers layers product available in near-real time via the CIRA SLIDER tool. The algorithm was also submitted for implementation in the NOAA Enterprise Cloud Processing System, which provides a direct pathway for inclusion in official NOAA products. In the second half of FY17, we have explored the potential use of NWP moisture as a proxy for cloud cover in ABI-ambiguous situations, and have begun developing the daytime portion of our proposed multi-spectral algorithm to aid in cloud boundary determination when cirrus occur over thicker low clouds.

Progress toward FY17 Milestones

This section will address overall progress toward FY17 milestones achieved during January to July 2018 reporting period (new progress). Progress reported in the previous FY17 report will not be repeated. Milestones, bulleted and in italics, will be referenced as required.

- *Collect six years of CloudSat and CALIPSO cloud mask data, and co-located relative humidity data from NWP analysis*
- *Build database of actively sensed cloud occurrence and corresponding probability of hydrometeor presence; determine best ways to segregate the data.*

Co-location efforts between CloudSat, CALIPSO, and NWP estimates of relative humidity (RH) data have been successful, and an initial analysis performed. The goal of this portion of the work was to determine if RH can be used as a proxy for cloud cover in situations where cloud height from the ABI is completely ambiguous. For example, areas where ABI detects a relatively high cloud of high optical thickness should be flagged as potentially containing an unresolved cloud. If we know the RH in the lowest layers from NWP, can we determine whether the cloud cover layers product should be assigned as containing a cloud in that layer? Results

from our joint analysis of actively-sensed cloud boundaries and NWP data are beginning to answer this question.

Figure 1(a) shows the near-global probability of detection (POD) and false alarm rate (FAR) for a multi-month period obtained when using a RH threshold of 70% in the 1-3 km layer as a predictor of cloud within that layer. It is seen that the POD of a cloud using this threshold is particularly high in both the tropics and mid-latitude storm tracks. In the former case, this is because the low-level RH is almost always 70% or greater, and the higher FAR in the tropics reveals that RH is a poor predictor of cloudiness for this reason. In the mid-latitudes, however, the FAR is relatively small. Figure 1(b) masks as red locations where $POD > 50\%$ and $FAR < 50\%$, indicating that this RH threshold may be a useful predictor of low-level cloudiness *outside the tropics*, and specifically may be useful over the continental U.S. (CONUS). Our current work includes finding the most useful RH threshold as a function of both space and time.

- *Create lookup tables of 0.64 and 1.38 μm reflectance using radiative transfer code. Determine physically realistic cloud scenarios (combinations of microphysical properties and heights) that will form the basis of this database.*

To build multispectral lookup tables (0.64 and 1.38 μm for daytime), radiative transfer simulations have been performed using the Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART). For more realistic cloud simulation scenarios, we used input profiles obtained from co-locations between CloudSat/CALIPSO, ECMWF, and GOES-16 ABI as a baseline. Variations such as solar/sensor geometry angles and optical thickness of cloud layers have been added to enrich the lookup table. Figure 2 shows sample radiative transfer simulations (with varying optical thickness of the top ice cloud layer) and the CloudSat/CALIPSO vertical cross-section for a multi-layer case. The reflectance ratio observed from ABI are present around 0.120–0.238 with a mean value of 0.167, which corresponds to the simulated results with the top ice layer optical thickness of 1–2. We will continue to extend the lookup table using observational values from multi-layer cloud scenes as guidance for the radiative transfer simulations.

- *Begin translational work to bring statistical cloud base algorithm from the world of VIIRS and AHI into the ABI framework.*

Progress on this milestone was detailed in the last reporting period; in summary, we have made the algorithm operational and available in near-real time via the SLIDER interface. As an update, we are currently implementing an expansion from a three layer, pressure-based product to a five layer, flight-level based product (at the request of our NOAA operational partners).

- *Present early results at GOES-R meeting and at AMS or AGU.*

Our initial work was presented at the 14th Annual Symposium on New Generation Operational Environmental Satellite Systems at the American Meteorological Society 2018 Annual meeting.

Plans for Next Reporting Period

- *Begin testing of daytime/nighttime lookup tables for determination of lower cloud boundaries (including high/low separation distance) in multilayer situations. Compare this physically based method to a statistically based method based on existing CloudSat/CALIPSO cloud boundaries.*

Most of the next reporting period will be dedicated toward finishing implementation of the daytime lookup tables that are being developed to determine high/low cloud separation distance in multiple layer situations. This will involve completing the construction of lookup tables, honing assumptions required for the method (such as that on upper-layer cloud optical depth, which will be derived in a statistical sense from CALIPSO data), and determining where and when to apply the retrieval. We will then begin testing on a selection of cases where we have ABI data overlapping with CloudSat and CALIPSO, and then will begin applying this methodology to wider areas as part of the goal of later moving into real-time predictions.

- *Complete a daytime lookup table and start building a lookup table of nocturnal 3.9 and 11.2 μm BTD using radiative transfer code.*

Progress in the above goal will lead directly into implementing the second half of our proposed multispectral retrieval, which operates during the nighttime. The workflow required to meet this milestone is actually quite similar to that required for the daytime portion of the retrieval. The same radiative transfer code, SBDART, will be used to generate tables at these two infrared frequencies. We will then explore how the difference in brightness temperature relates to the separation distance between cloud layers in the active sensor observations.

- *Present results at GOES-R meeting and at AMS or AGU.*

We will present our latest work at the 15th Annual Symposium on New Generation Operational Environmental Satellite Systems during the 99th American Meteorological Society Annual Meeting in January of 2019.

Additional Information

1. Interaction with operational partners – As planned, we are still in the developmental stages of our algorithm improvements, and as such have not yet begun interacting with operational partners. The second half of Year 2 will see interactions with the Aviation Weather Center, including visits with potential product users.

2. Conference/workshop participation – See above; we will present our work at the 99th American Meteorological Society Annual Meeting in January of 2019.

3. Outside project publicity – None.

4. Journal articles – None prepared or anticipated in this reporting period. We plan our first publication in the second half of Year 2.

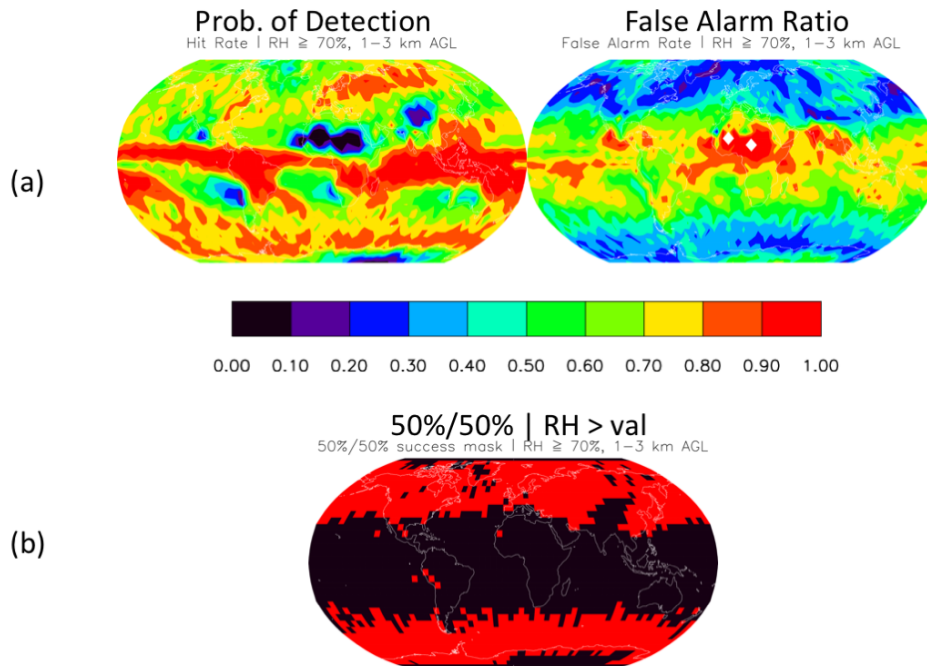


Figure 1. (a) The probability of correctly predicting (probability of detection; POD) a 1-3 km cloud layer when relative humidity in that layer exceeds a threshold of 70%; and the probability of incorrectly predicting (false alarm ratio; FAR) a 1-3 km cloud under the same conditions, when no cloud is actually observed. (b) A mask showing red where POD exceeds 50%, and FAR is less than 50%; using the same relative humidity threshold of 70%.

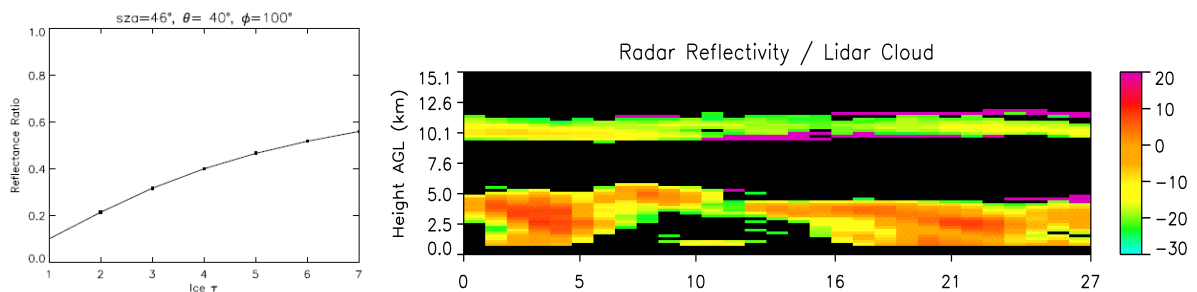


Figure 2. Sample radiative transfer simulations of the reflectance ratio between 1.38 μm and 0.64 μm channels and the vertical cross-section of CloudSat/CALIPSO for a multi-layer cloud scene (11:15:20 to 11:15:25 UTC 2017/09/27).