NOAA ROSES Semi-Annual Report

Reporting Period: September 2020 – February 2021 (1st report)

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Project Title: Development and implementation of a new set of enhanced GOES-R ABI snow cover products

Executive Summary (1 paragraph max)

With this 3-year project we are planning to develop and implement into operations a set of new GOES-R series ABI snow retrieval algorithms and a corresponding set of improved snow cover products. The new set of ABI snow products will provide an enhanced characterization of the snow cover properties over Western Hemisphere and will include information on the presence or absence of the snow cover (binary snow mask), the snow cover fraction and the snow depth. Using the full potential of frequent observations of GOES-R and –S, the proposed system will provide intraday updates on the state of the snow cover. There are no other similar products produced by NESDIS or other national or international space and weather agencies. The work will rely on the use of existing VIIRS Enterprise snow algorithms that will be modified and adapted to ABI data. Application of the same snow retrieval algorithms with both VIIRS and ABI will lower the efforts and the cost of maintaining and upgrading of the two NOAA product generation systems.

Progress toward FY20 Milestones and Relevant Findings (with any Figs)

- We have developed support software to acquire, ingest, decode, calibrate, navigate and reproject GOES-R and –S ABI imagery and prepare the ABI data for further snow cover retrievals.

- The operational VIIRS Enterprise snow algorithms were adopted to ABI and were applied to a series of ABI images to assess their performance with geostationary satellite data.

- Preliminary snow retrieval results have been examined and their accuracy has been quantitatively evaluated.

- It was found that adjustments and modifications to the Enterprise algorithms are needed to achieve high accuracy snow retrievals with ABI data. The need for modifications is explained by the difference in the spectral response functions of matching spectral bands of VIIRS and ABI and, more importantly, by the difference in the viewing and illumination geometry of VIIRS and ABI.

More detail on the results of the work are provided below:

<u>Improved ABI GOES-16/17 snow masking with adjusted VIIRS algorithm</u>

VIIRS Enterprise snow identification algorithm has been modified to fit GOES ABI. Modifications included adjusted threshold values for spectral tests involving reflectance in ABI bands 2(visible), 3 (near IR) and 5 (shortwave IR), NDVI and NDSI. No changes were made to consistency tests which are identical to tests implemented with VIIRS data. The developed algorithm identifies snow and ice cover first and then discriminates the remaining pixels between cloudy and clear-sky land surface (or open water). Algorithm adjustment resulted in a noticeable improvement of snow masking with ABI as compared to our earlier tests where the original (unchanged) VIIRS algorithm was used. Improvements include a better identification of snow in forested areas and a better discrimination between snow and clouds.

Analysis of snow retrievals has shown that over non-vegetated (bright) land surfaces, particularly in the mountains, cloud shadows may confuse the snow detection algorithm and cause false snow identifications. Similar effect may have topographic shadows. Calculations of cloud shadows and topographic shadows should be considered in the development of an advanced version of the algorithm.

No adjustments have yet been made to the snow fraction algorithm: The original VIIRS visible reflectance-based snow fraction algorithm is applied to ABI data. GOES-data are being collected to build ABI specific kernel driven BRDF models for snow cover and snow-free land surface.

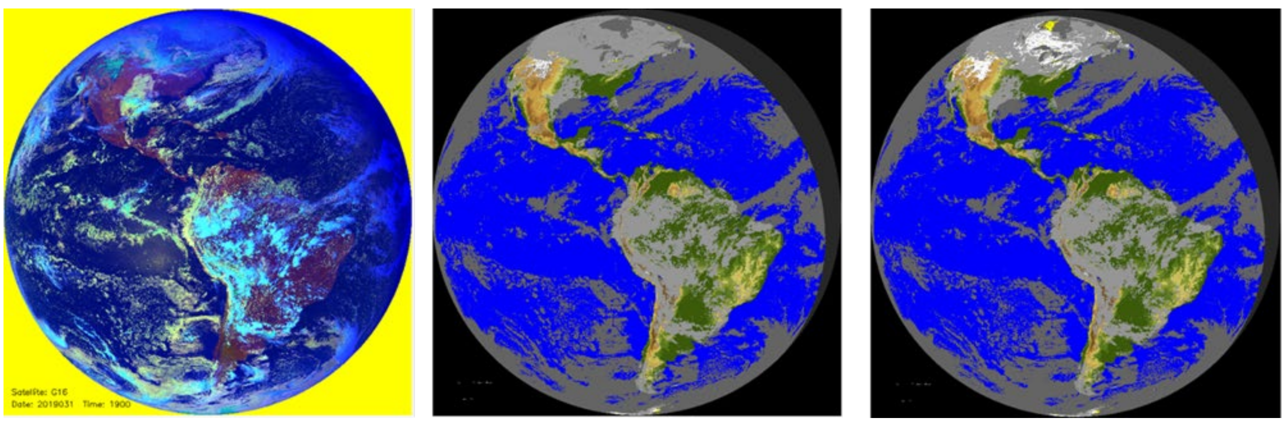
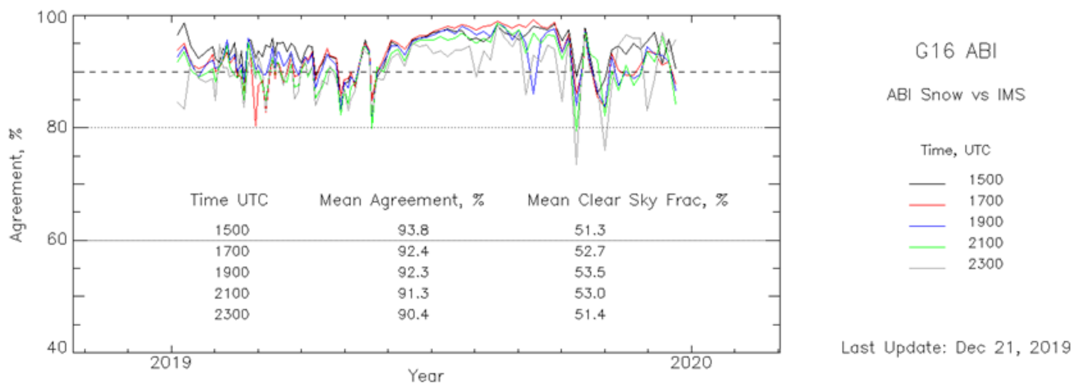


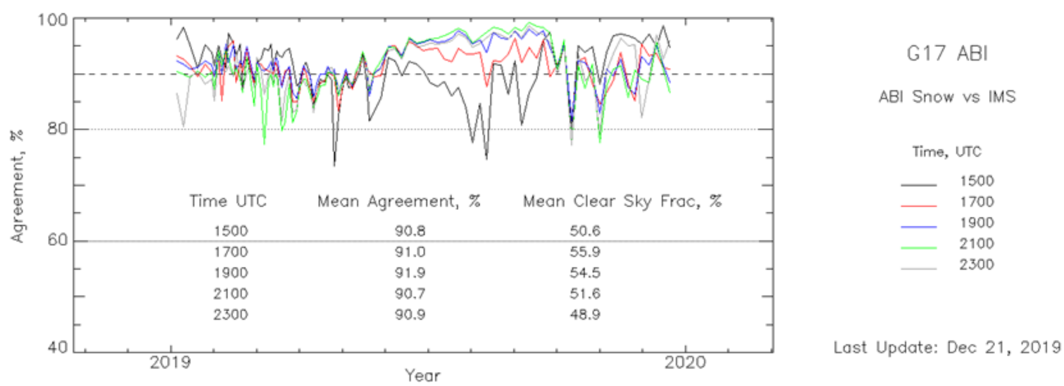
Figure 1. Example of RGB false color full disk ABI images (left) and ABI GOES-16 snow cover mask produced with the original VIIRS algorithm (center) and with adjusted threshold values (right). Note a considerable improvement of the snow/cloud discrimination with the adjusted algorithm which results in a better characterization of the snow extent (shown in white) in North America.

<u>Validation of ABI snow retrievals with IMS data</u>

Daily snow maps derived from ABI sensor data onboard G16 and G17 have been quantitatively compared to daily IMS product to estimate the accuracy of ABI product. ABI snow maps were derived using the VIIRS snow identification algorithm which was adjusted to ABI and complemented with simple cloud identification tests. ABI maps were produced every 2-5 days over the year 2019. To compare with IMS we have used ABI snow maps derived at 1500, 1700, 1900, 2100 and 2300 UTC. The comparison included only ABI pixels over the land surface that were identified as “cloud clear”. Accuracy estimates accounted for the snow cover climatology: Areas where the probability of snow cover occurrence for a given day of the year was either 0 or 1 (i.e., where snow cover was always observed or never observed before) were excluded from the comparison.

Figure 1 shows time series of the daily agreement rate between ABI snow maps and IMS over the Northern Hemisphere in 2019. The agreement rate generally ranges within 80 to 95% with the average value of around 90% in the fall, winter and spring season. The yearly mean agreement doesn't change much from GOES-16 (East) to GOES-17 (West) and generally ranges within 90 to 93%. This accuracy level fits a typical requirement of 90% correct snow/no-snow discrimination for binary snow cover products derived from satellite observations in the visible and infrared.





Plans for Next Reporting Period

- Continue adjustment of VIIRS Enterprise snow algorithms to ABI. This includes:
    - Adjustment and tuning of spectral thresholds for the classification algorithm
    - Adjustment of a built-in cloud identification algorithm
    - Modification of the algorithm to include observation geometry-dependent thresholds
- Develop physically-based parameterization for snow cover and snow-free land surface BRDF
    - Utilize in situ observed reflectance of snow and different vegetation cover types
    - Incorporate physically-based model to predict top-of-the-atmosphere reflectance values for observations geometries inherent to geostationary satellites
- Validate binary snow cover and snow cover fraction retrievals using in situ observations, IMS analysis and higher spatial resolution satellite imagery