



Read-me for Data Users

MEMORANDUM FOR: The JPSS Program Record
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SUBJECT: NOAA-20 Snow Product Provisional maturity status
DATE: 06/10/2020
Validated maturity status declaration for Binary and Fractional Snow Cover Product
Maturity Review Date: 06/18/2020
Effective Date: TBD
Operational System: NDE, Version 3.0

The JPSS Algorithm Maturity Readiness Review Board approved the release of the NOAA-20 Snow Product to the public with a Validated maturity level quality as of TBD (effective date), based on JPSS Validation Maturity Review held on 06/18/2020 (link to review artifacts).

Validated Maturity Definition

Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal). Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level. Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose. Product is ready for operational use based on documented validation findings and user feedback. Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

<http://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php>

Snow Product and Algorithm Description

The NOAA-20 Spacecraft with the Visible Infrared Imaging Radiometer Suite (VIIRS) was successfully launched on November 10, 2017. With 22 spectral bands covering wavelengths from 0.41 to 12.5 μm , VIIRS provides operational information on the land surface, atmosphere, and ocean for weather, climate and other environmental applications. The Snow Cover EDR is among a number of cryosphere products generated with VIIRS data. The Snow Cover EDR (JPSSRR-SNOWCOVER) includes two products, the Binary Snow Map and the Snow Fraction.

The binary snow map is generated with reflectances and brightness temperatures observed in VIIRS bands I1, I2, I3 and I5. The algorithm to identify snow cover in VIIRS pixels utilizes a decision-tree threshold-based technique, which generally follows the logic of the MODIS SnowMap algorithm. The

results of preliminary spectral-based snow identification are further subjected to a series of consistency tests to eliminate spurious snow and no-snow identifications and mask out scenes where snow identifications may not be sufficiently reliable. An externally generated cloud mask is applied to limit snow identifications to clear sky pixels. Snow retrievals are performed only in daytime conditions.

The snow fraction is derived in VIIRS pixels which were identified as snow-covered in the binary snow map. The snow fraction retrieval algorithm implements a linear unmixture technique. It incorporates VIIRS observations in one, visible spectral band I1 and two endmembers representing the reflectance of a completely snow free land surface and the reflectance of snow. The values of both endmembers have been established empirically and are adjusted with changing viewing and illumination geometry of observations. The derived snow cover fraction is a “viewable” snow cover fraction characterizing the fraction of snow covered land “seen” by the instrument as snow covered. In other words it does not include and account for the snow cover masked by the forest cover or any other natural or artificial obstacles.

Both binary and fractional snow cover are derived at the VIIRS imagery (375m) spatial resolution. The snow product EDR contains two data objects (binary snow and fractional snow) and corresponding two 8-bit quality flags. The Snow Cover EDR output file format is NetCDF4.

VIIRS Snow Cover product requirements and exclusions are documented in the Joint Polar Satellite System (JPSS) Ground Segment Data Product Specification (GSegDPS), Dec 2019,

https://www.jpss.noaa.gov/assets/pdfs/technical_documents/474-01543_JPSS-GSegDPS_A.pdf

The documents require that the binary snow algorithm ensures at least 90% probability of correct snow/no-snow classification and the fractional snow cover algorithm produces the snow fraction with the maximum uncertainty of 20%. The documents require the refresh rate of at least 90% coverage of the globe every 24 hours.

Product evaluation/validation

For the Validation Maturity Review we evaluated the quality of the NOAA-20 VIIRS Snow Cover EDR generated with v3r0 VIIRS product retrieval system. Snow products were generated offline by the STAR Algorithm Software Integration (ASSISTT) team. Retrievals that were made available to the Cryosphere Team covered one week in October 2019, four weeks in February 2020 and two weeks in the second half of May 2020. The collected dataset covers the fall, winter and spring-summer season in the Northern Hemisphere and therefore is sufficient for a full-scale validation of the product.

For qualitative evaluation and accuracy assessment daily snow product granules were aggregated and gridded into global binary snow cover and snow fraction maps. Maps were produced on a latitude-longitude grid with 0.01 degree grid cell size. Qualitative evaluation of the snow products was conducted through comparison of the derived products with corresponding true color imagery and other similar snow products from other satellite sensors. For quantitative assessment of the accuracy of the binary snow map we performed a point-by-point comparison of daily gridded snow cover maps with Northern Hemisphere snow maps generated within NOAA Interactive Multisensor Snow and Ice Mapping System, IMS and with in situ data. Estimates of the snow mapping accuracy were produced



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for regions with “climatologically variable” snow cover, in other words, the comparison excluded the areas where on the given day of the year the snow cover was either always present or always absent in the past. For the quantitative comparison with in situ data we have selected stations located in the Continental US (CONUS) and Southern Canada. Station snow depth data were acquired from the Global Historical Climatology Network Daily (GHCN-D) dataset maintained by National Centers for Environmental Information (NCEI). Only qualitative assessment of the snow product validity has been performed over the Southern Hemisphere.

Inasmuch the snow fraction is a remote sensing parameter and is not observed in situ, direct assessment of its retrieval accuracy is impossible. The quality of the NOAA-20 VIIRS snow fraction product was evaluated by comparing it with the snow fraction derived from SNPP satellite and through a number of consistency tests.

Our analysis has shown that the NOAA-20 VIIRS Binary Snow Cover Map product realistically reproduces the global distribution of the snow cover. It is consistent with other available remote sensing based products and with in situ snow cover observations. For the time periods involved in the analysis the daily agreement of the VIIRS Binary Snow Maps to IMS interactive charts over the Northern Hemisphere ranged mostly within 90 to 95%. The mean daily agreement of VIIRS snow maps to in situ data during this time period ranged from 91% in February 2020 to 96% in May 2020. The estimated agreement matches or exceeds the VIIRS snow correct typing requirement of 90%. Most errors in the VIIRS snow cover map were snow omission errors.

The analysis of the snow fraction product has demonstrated its robust positive correlation (and, hence, consistency) with the observed snow depth over plain non-forested areas. Theoretically estimated accuracy of the snow fraction with the developed algorithm ranges within 0.15-0.20. The comparison of snow fraction derived from NOAA-20 with SNPP retrievals has shown their strong positive correlation of over 0.94 and the mean difference of less than 0.2. Based on these estimates it is concluded that the snow fraction product meets the requirement of 20% retrieval accuracy.

Product Availability/Reliability

NOAA-20 VIIRS Snow Product generated within the algorithm version 3.0 will become available to the users tentatively in late fall 2020 with the implementation of the new system within NDE.

Algorithm Performance Dependence

The quality of the NOAA-20 VIIRS Snow Product is critically dependent on the quality of the input VIIRS SDR data (reflectance and brightness temperature) as well as on the accuracy of geolocation information and of the cloud mask.

Known errors/issues/limitations



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In the current version of the binary snow and fractional snow cover product the cloud mask incorporates “confidently cloudy”, “probably cloudy” and “probably clear” categories of the VIIRS cloud mask. It has been determined that this cloud mask tends to miss low-level clouds and fog over snow-covered land. These clouds are often not identified as “snow” and therefore cause snow cover misses in the snow cover product. Additional cloud-identification tests incorporated in the snow algorithm may help to improve cloud screening and, hence reduce snow misses.

Changes since last maturity stage

The binary and fractional snow algorithms have not changed since the last maturity stage. Considerable changes have been introduced to the cloud mask algorithm (v2r3 vs v3r0). These changes helped to correct a gross overestimation of the cloud amount over snow-covered land inherent to the cloud mask generated with the previous v2r2-3 versions of the algorithm.

Review board recommendations

Based on our evaluation, the Binary and the Fractional Snow Cover Products of NOAA-20 VIIRS Snow Cover EDR meet all the criteria of the validated level of maturity. Although some issues still exist, our evaluation shows that both products are reasonably accurate and well agree to other remote-sensing based products and *in situ* measurements. Therefore we conclude that NOAA-20 VIIRS Binary and Fractional Snow Cover Map Products generated with v3r0 of the system build have reached the validated maturity level. They can be made publically available once the new version of the algorithm becomes operational. The validated maturity effectivity date is TBD and depends upon the successful implementation of the NDE v3.0 system build.

Path Forward/Future Plans

Routine monitoring of the product accuracy and performance will continue. More detailed quantitative estimates of the snow product accuracy over various land surface cover types and topography will be established over the Northern Hemisphere using the operational data.

Additional Items to note

Additional information is available in the JPSS Snow Cover Product algorithm theoretical basis documents (ATBD) and validation maturity review briefing, which can be accessed at:

<http://www.star.nesdis.noaa.gov/jpss/Docs.php>

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