MEMORANDUM FOR:	The JPSS Program Record
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CONCURRED BY:	JPSS Algorithm Management Project Lead Lihang Zhou
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SUBJECT:	NOAA-21 Surface Albedo Product Provisional maturity status
DATE:	01/25/2024

Provisional maturity status declaration for JPSS NOAA-21 Surface Albedo

Maturity Review Date:	**01/25/2024**
Effective Date:	**01/25/2024**
Operational System:	**NDE, Version v2r2**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the JPSS VIIRS Surface Albedo to the public with a Provisional maturity level quality as of 01/25/2024 (effective date), based on the JPSS Validation Maturity Review held on 01/25/2024.

1. Provisional maturity stage definition
   - Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
   - Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
   - Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
   - Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.
   (reference to the AMM webpage for maturity definition:
   http://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php)

2. Algorithm Description:

   2.1 List of Products (Collection Short Name (CSN))

   The official VIIRS Surface Albedo (LSA) products consist of two levels of data: L2 granule Surface Albedo and L3 daily gridded Surface Albedo. The L2 Surface Albedo is generated using the enterprise algorithm designed to derive accurate albedo values, while the L3 Surface Albedo is derived from the composite data of L2 Surface Albedo. Access to both products can be obtained from Comprehensive Large Array-data Stewardship System (CLASS) under the categories JPSS_GRAN and JPSS_NGRN, respectively.

   L2 granule LSA product: VIIRS-SURFALB

Table 1. Layers contained in NOAA-21 Albedo EDR file.

Output Data	Description
VIIRS_Albedo_EDR	**VIIRS Improved Surface Albedo EDR**
DataQualityFlag (DQF)	VIIRS Surface Albedo 2-bit High-level Data Quality Flag
ProductQualityInformation (PQI)	VIIRS Surface Albedo 2-byte Product Quality Information
AlbScl	VIIRS LSA Albedo Scale Factor
AlbOff	VIIRS LSA Albedo Offset
Latitude	Latitude
Longitude	Longitude
Metadata Variables	Details in metadata list in ATBD

In the table, AlbScl, AlbOff and Metadata Variables are scalars; others are data array.

L3 gridded LSA product: GRIDDED_VIIRS_LSA_DLY

Table 2. Layers contained in NOAA-21 Gridded Albedo file.

Output Data	Description
VIIRS_Albedo_1km	VIIRS Improved Surface Albedo EDR
DQF	VIIRS Surface Albedo 1-byte High-level Data Quality Flag
QualityFlag	VIIRS Surface Albedo 2-byte Product Quality Information

The L2 LSA algorithm comprises two main components. In the online component, the final granule albedo is estimated through a combination of two datasets: the directly estimated albedo and a historical temporally-filtered gap-free albedo. The latter is derived offline using historical granule albedo data. The directly-estimated albedo is computed based on a linear relationship established between the albedo and the TOA reflectance sensed by the satellite's multichannel sensors.

2.2 Product requirements/Exclusions (DPS)

Surface albedo is the measure of solar radiation, ranging from 0.4 to 4.0 microns, that is reflected by the Earth's surface into the upward hemisphere (sky dome). This measurement encompasses both the diffuse and direct components of reflected radiation, divided by the total incident energy received from this hemisphere, which includes both direct and diffuse components. Surface albedo plays a crucial role in determining the radiative balance at the surface, influencing the distribution of incident energy between surface heating and reflected energy back to space. Moreover, albedo serves as a valuable indicator of surface type and provides a backdrop against which clouds can be detected and analyzed.

Table 3. Surface Albedo product requirement

Attribute	Threshold
Geographic coverage	global, including land ocean and ice surface conditions
Horizontal Cell Size	0.80 km
Mapping Uncertainty	1 km at Nadir
Measurement Range	0 to 1.0 (albedo units)
Measurement Accuracy	0.05 (albedo units)
Measurement Precision	0.08 (albedo units)

2.3 Quality flags (Table)

Two quality flag arrays are provided with the Earth Data Records (EDR) product. These include the Product Quality Information (PQI) flags, which offer data quality information, and the Data Quality Flag (DQF) used for product monitoring purposes.

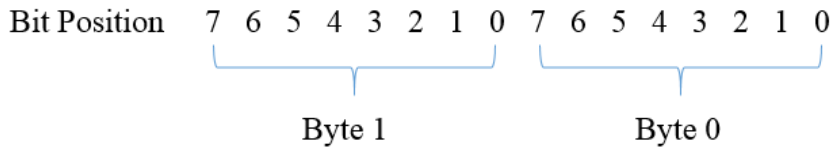### (a) Product Quality Information flags

Bit Position   7 6 5 4 3 2 1 0   7 6 5 4 3 2 1 0

Byte 1   Byte 0

Table 4. *Product Quality Information (PQI) of L2 LSA*

Byte	Bit	Flag	Source	Description
0	0-1	Overall quality	LSA	00: high-quality retrieval, 01: retrieval, 10:no retrieval
	2-3	Cloud condition	Cloud mask	00=confidently clear, 01=probably clear,10=probably cloudy,11=confidently cloudy
	4	SDR quality	SDR	0 = normal, 1 = bad data
	5	Solar zenith angle flag	SDR	0: favorable SZA, 1: very large SZA (>60)
	6	View zenith angle flag	SDR	0: favorable VZA, 1: very large VZA (>60)
	7	Spare		
1	0-2	Retrieval Path	LSA	000: generic, 001: desert, 010: snow, 011: sea-ice, 100: no retrieval

	3-4	Temporal filter quality flag	LSA	00: high-quality retrieval, 01: degraded retrieval, 10:no retrieval
	5	Online filter flag	Online filter	0: no filter, 1: filtered
	6-7	Spare		

Table 5. *Product Quality Information (PQI) of L3 LSA*

Byte	Bit	Flag	Source	Description
0	0-1	Overall quality	LSA	00: high-quality retrieval, 01: retrieval, 10:no retrieval
	2-3	Cloud condition	Cloud mask	00=confidently clear, 01=probably clear,10=probably cloudy,11=confidently cloudy
	4-6	Retrieval Path	LSA	000: generic, 001: desert, 010: snow, 011: sea-ice, 100: no retrieval
	7	Spare		

(b) Data Quality Flag

Bit Position   7 6 5 4 3 2 1 0

Table 6. *Data Quality Flag (DQF)*

Byte	Bit	Flag	Source	Description
0	0-1	Overall quality	LSA	00: high-quality retrieval, 01: retrieval, 10:no retrieval

* Note: The left-most bit, also known as the high-order bit, holds the highest significance in the definition and description of both PQI and DQF.

2.4 Product evaluation/validation

The NOAA-21 albedo product Evaluation/Validation is performed preliminarily through,
- Visual inspection of the albedo data.
- Albedo data validation
  - i. Direct comparison with ground albedo estimates
  - ii. Cross-satellite comparisons with S-NPP and NOAA-20 VIIRS albedo data
- Understanding the influence of input data through analyzing quality flags

2.5 Product availability/reliability

The NOAA-21 LSA EDR data have been produced since February 2023. Data from after August 30, 2023, exhibit optimal quality across all pixels. However, the data leading up to

August 30, 2023, were not of optimal quality; only clear-sky pixels met the quality standards, while cloudy pixels had no values.

2.6 Algorithm performance dependence

The selection of the albedo retrieving method is based on whether clouds are present and the kind of ground surface. We have observed that the albedo difference between NOAA-21 and NOAA-20 is directly correlated with inconsistencies in the cloud mask. This correlation is expected, considering the time elapsed between their observations.

2.7 Known errors/issues/limitations
- Some missing granules in NDE

3. Changes in version v2r2 since last version v1r4

1. L2-online code update

We will be using the IMS snow/ice mask as input instead of the VIIRS Snow mask and ice concentration. This decision is because albedo is an all-sky product that requires snow/ice information even under cloudy conditions, which is included in the IMS dataset. The VIIRS snow/ice mask only offers clear-sky information, which is inadequate for maintaining the continuity of the VIIRS albedo requirement.

2. L2-offline code update

1) Snow/Snow-free observations separation in offline temporal filtering

-- Mark snow/snow-free flags for each L2 albedo layers within the filtering window

-- Use snow (snow-free) only observations in temporal filtering for snow (snow-free) pixels in the current day

-- If there are no historical snow (or snow-free) observations on a current day that is classified as snow (or snow-free), the temporal filtering process will utilize all valid observations within the filtering window, following the same approach as in the original algorithm

2) Handling the updated netCDF format climatology

2. L2-offline ancillary data (climatology) update

1) Climatology of Version 5 with upgraded quality to replace the previous one (V4:mod_alb_clm_20200413.tar.gz)

2) Using netCDF format to replace the previous binary (img) format

3. L2-online ancillary data (LUTs) update

1) NAN values in the previous NPP and J01 LUTs are filled

2) The latest J02 VIIRS SRFs were considered in the improved J02 LUTs

4. L3 code update

1) Handling the netCDF version gridding index (tiles_info)

4. Review board recommendations
5. Path Forward/Future Plan
- Future Cal/Val activities
  - Implement the LTM adaptations with routine NOAA-21 albedo data
  - Routine cross-comparisons
  - Validated maturity Review

- – Climatology update
- User engagement
  - – Application in NOAA climate models
- Improved albedo products
  - – Blended Albedo product with S-NPP and NOAA-20 VIIRS Albedo
  - – Apply NOAA-21 data into BRDF/BSA/WSA/NBAR algorithm

6. Additional Items to note
   None

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

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

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