Read-me for Data Users

MEMORANDUM FOR:	The JPSS Program Record
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CONCURRED BY:	JPSS Algorithm Management Project Lead Arron Layns
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APPROVED BY:	JPSS Program Scientist Mitch Goldberg
SUBJECT:	NOAA-20 Product Beta maturity status
DATE:	April 18, 2018

Provisional maturity status declaration for NOAA-20 Aerosol Detection Product

Maturity Review Date:	**04/18/2018**
Effective Date:	**04/18/2018**
Operational System:	**NDE, Version v1r1**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the NOAA-20 Aerosol Detection Product to the public with a Provisional maturity level quality as of 04/18/2018 (effective date), based on JPSS Validation Maturity Review held on 04/18/2018 (link to review artifacts).

1. Definition of Provisional:
    - Product is minimally validated, and may contain significant identified and unidentified errors.
    - Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
    - Documentation of product performance and identified product performance anomalies, including recommended strategies, exists.
2. Algorithm Description:

    The Collection Short Name for the ADP from N20 is:
    JRR-ADP_j01_sYYYYMMDDSSSSSSS_eYYYYMMDDSSSSSSS_cYYYYMMDDSSSSSS where YYYY is the year in 4 digits, MM the month, DD the day, and SS the seconds down to the sixth or seventh significant digit depending on whether the reference is to the start time of the granule (s), the end time of the granule (e), or the time it was created (c).

    Product requirements for the ECM are now specified in the JPSS National Environmental Satellite, Data, and Information Service (NESDIS) Environmental Satellite Processing Center (ESPC) Requirements Document (JERD) Volume 2: Science Requirements. These requirements are:

Applicable Conditions:
1. Aerosol Detection includes dust/sand, and smoke at any altitude.
2. Clear, for Aerosol Optical Depth (AOD) greater than 0.15, daytime only.

JERD-2424 The algorithm shall produce an aerosol detection product that has a horizontal cell size of 0.8 km at Nadir (Note 2).

JERD-2455 The algorithm shall produce an aerosol detection product that has a vertical cell size of the total column.

JERD-2456 The algorithm shall produce an aerosol detection product that has a mapping uncertainty (3 sigma) of 3 km.

JERD-2457 The algorithm shall produce an aerosol detection product that has a measurement range of:
Detect suspended matter (dust/sand and smoke) (Note 1) of dust/sand and smoke and Smoke plume column concentration of 0 to 2000 $\mu g/m^2$.

JERD-2458 The algorithm shall produce an aerosol detection product that has a probability of correct typing (Note 2) of:
80% for suspended matter,
80% for Dust, and
70% for Smoke

Notes:
1. DOC has a responsibility for analyzing areas of volcanic ash, blowing dust, and smoke. There is therefore a requirement that the AOD algorithm identify instances of multiple types of aerosols at the same location and not to merely provide a single aerosol type with the highest concentration or probability.
2. Probability of correct typing performance will be verified and validated for an aggregated 3 km horizontal cell to provide for adequate comparability of performance across the scan.
3. Volcanic ash detection will be reported in SM output file but information will come from a separate volcanic ash algorithm and refer to volcanic ash requirement table.

The key product outputs in the ADP (Aerosol Detection Product) are:

- Dust
- Smoke
- Ash

Table 2: ADP output file parameters

Variable	Type	Description	Dim	Units	Range
Ash	Byte	Volcanic Ash Flag: 1 = yes, 0 = No	2	1	0,1
AshConfidHighPct	Float	Percent of high confidence ash	0	Percent	0, 100
AshConfidLowPct	Float	Percent of low confidence ash	0	Percent	0, 100

AshConfidMediumPct	Float	Percent of medium confidence ash	0	Percent	0, 100
AshPct	Float	Percent of good ash retrieval	0	Percent	0, 100
QC_Flag	Byte	Quality Flag for Ash, Smoke, Dust and NUC(see Table 3)	2	1	-128,127
PQI1	Byte	Product Quality Information (Byte 2 in Table 4)	2	1	-128,127
PQI2	Byte	Product Quality Information (Byte 3 in Table 4)	2	1	-128,127
PQI3	Byte	Product Quality Information (Byte 4 in Table 4)	2	1	-128,127
PQI4	Byte	Product Quality Information (Byte 5 in Table 4)	2	1	-128,127
Cloud	Byte	Cloud Flag: 1 yes, 0 no	2	1	0,1
SAAI	Float	Scaled Absorbing Aerosol Index	2	1	
Dust	Byte	Dust flag: 1 yes, 0 no	2	1	0,1
DustConfidHighPct	Float	Percent of high confidence dust	0	Percent	0, 100
DustConfidLowPct	Float	Percent of low confidence dust	0	Percent	0, 100
DustConfidMediumPct	Float	Percent of medium confidence dust	0	Percent	0, 100
DustPct	Float	Percent of good dust retrieval	0	Percent	0, 100
Latitude	Float	Pixel latitude in field latitude	2	Degrees north	-90., 90.
Longitude	Float	Pixel longitude in field longitude	2	Degrees east	-180., 180.
DSDI	Float	Dust Smoke Discrimination Index	2	1	
NUC	Byte	None, Unknown, Clear_sky Flag: 1 Yes, 0 No	2	1	0, 1
NUCConfidHighPct	Float	Percent of high confidence NUC	0	Percent	0, 100
NUCConfidLowPct	Float	Percent of low confidence NUC	0	Percent	0, 100
NUCConfidMediumPct	Float	Percent of medium confidence NUC	0	Percent	0, 100
NUCPct	Float	Percent of good NUC retrieval	0	Percent	0, 100
NoAshPct	Float	Percent of ash not determined (bad)	0	Percent	0, 100
NoDustPct	Float	Percent of dust not determined (bad)	0	Percent	0, 100
NoNUCPct	Float	Percent of NUC not determined (bad)	0	Percent	0, 100
NoSmokePct	Float	Percent of smoke	0	Percent	0, 100

		not determined (bad)			
NumOfGoodAshRetrieval	Long	Number of Good Ash Retrievals	0	1	
NumOfGoodDustRetrieval	Long	Number of Good Dust Retrievals	0	1	
NumOfGoodNUCRetrieval	Long	Number of Good NUC Retrievals	0	1	
NumOfGoodSmokeRetrieval	Long	Number of Good Smoke Retrievals	0	1	
NumOfQualityFlag	Long	Number of quality flag	0	1	
NumOfSatZenAngLess60	Long	Number of pixel with satellite zenith angle less 60 degree	0	1	
NumOfSolZenAngLess60	Long	Number of pixel with solar zenith angle less 60 degree	0	1	
Smoke	Byte	Smoke Flag: 1 Yes, 0 No	2	1	0, 1
SmokeCon	Float	Smoke Concentration	2	ug/m^3	
SmokeConfidHighPct	Float	Percent of high confidence smoke	0	Percent	0, 100
SmokeConfidLowPct	Float	Percent of low confidence smoke	0	Percent	0, 100
SmokeConfidMediumPct	Float	Percent of medium confidence smoke	0	Percent	0, 100
SmokePct	Float	Percent of good smoke retrieval	0	Percent	0, 100
SnowIce	Byte	Snow Ice Flag: 1 Yes, 0 No	2	1	0, 1
StartColumn	Long	Start column index	0		
StartRow	Long	Start row index	0		
TotalPixel	Long	Total number of pixels where retrievals are attempted	0	1	

Table3. Quality flags for JPSS ADP product (QC_Flag)

Byte/Bit*		Quality Flag Name	Meaning		
			2bit: 11	01	00 (default:00)
1	0-1	QC_ASH_DETECTION	Low	Medium	High
	2-3	QC_SMOKE_DETECTION	Low	Medium	High
	4-5	QC_DUST_CONFIDENCE	Low	Medium	High
	6-7	QC_NUC_CONFIDENCE	Low	Medium	High

Table 4. Product quality information (PQI) flags for JPSS ADP product

Byte/Bit*		Diagnostic Flag Name	Meaning		
			1bit: 0 (default)	1	
			2bit: 00 (default)	01	11
2	0	QC_INPUT_LON	valid longitude	Invalid longitude 180<longitude or longitude <-180	
	1	QC_INPUT_LAT	valid latitude	Invalid latitude 90<latitude or latitude <-90	
	2-3	QC_INPUT_SOLZEN	Valid solar zenith angle (SZA) 0≤SZA≤90	invalid solar zenith angle(SZA) 90<SZA or SZA <0	90≥Solar zenith angle >60
	4-5	QC_INPUT_SATZEN	Valid local zenith angle(VZA) 0≤VZA≤90	invalid local zenith angle(VZA) 90<VZA or VZA <0	90≥Local zenith angle >60
	6-7	QC_INPUT_SNOW/ICE_SOURCE	Snow/ice Mask from VIIRS retrieval	Snow/ice Mask from IMS	Snow/ice Mask from Internal test
3	8	QC_INPUT_SUNGLINT_SOURCE	VIIRS sun glint Mask (from Cloud Mask product)	Internal sun glint Mask	
	9	QC_INPUT_SUNGLINT	outside of sun glint	within sun glint	
	10	QC_INPUT_LAND/WATER	Water	Land	
	11	QC_INPUT_DAY/NIGHT	Day	Night	
	12	QC_WATER_SMOKE_INPUT	Valid VIIRS inputs	invalid VIIRS inputs	
	13	QC_WATER_SMOKE_CLOUD	Cloud-free	Obscured by clouds	
	14	QC_WATER_SMOKE_SNOW/ICE	Snow/ice free	With snow/ice	
	15	QC_WATER_SMOKE_TYPE	Thin Smoke	Thick Smoke	
4	16	QC_WATER_DUST_INPUT	Valid VIIRS inputs	Invalid VIIRS inputs	
	17	QC_WATER_DUST_CLOUD	Cloud-free	Obscured by clouds	
	18	QC_WATER_DUST_SNOW/ICE	Snow/ice free	With snow/ice	
	19	QC_WATER_DUST_TYPE	Thin dust	Thick dust	
	20	QC_LAND_SMOKE_INPUT	Invalid VIIRS inputs	Valid VIIRS inputs	
	21	QC_LAND_SMOKE_CLOUD	Cloud-free	Obscured by clouds	
	22	QC_LAND_SMOKE_SNOW/ICE	Snow/ice free	With snow/ice	
	23	QC_LAND_SMOKE_TYPE	fire	Thick smoke	
5	24	QC_LAND_DUST_INPUT	Valid VIIRS inputs	Invalid VIIRS inputs	
	25	QC_LAND_DUST_CLOUD	Cloud-free	Obscured by clouds	
	26	QC_LAND_DUST_SNOW/ICE	Snow/ice free	With snow/ice	
	27	QC_LAND_DUST_TYPE	Thin dust	Thick dust	

	28-29	Smoke_Detection_Algorithm_Path	Deep-blue based algorithm	IR-Visible based algorithm	Both
	30-31	Dust_Detection_Algorithm_Path	Deep-blue based algorithm	IR-Visible based algorithm	Both

Product evaluation/validation

- EPS aerosol detection algorithm was run offline by downloading SDRs from SCDR and VIIRS cloud mask from IDPS. The algorithm was also run on SNPP VIIRS using IDPS cloud mask. This was done to allow for comparisons between the two satellite products. It should be noted that operational processing of SNPP VIIRS in the NDE uses Enterprise Cloud Mask algorithm which is not yet available for NOAA-20. IDPS is Integrated Data Processing Segment.
- The aerosol detection product between NOAA-20 and SNPP VIIRS were compared by generating monthly dust and smoke fractions. The time period for these comparisons was January 9 – March 31, 2018. Comparisons of each sensor data were also made to other correlative measurements such as CALIPSO Vertical Feature Mask and AERONET dust and smoke flags generated from Angstrom Exponent classification.

Product availability/reliability

- NOAA-20 aerosol detection data were being produced on the NDE (NOAA Data Exploitation) Integration and Testing (I&T) string since 03/26/2018. Test data were processed offline and compared to show that offline runs agree with data obtained from I&T.
- The product is not available from NDE and will become available when the algorithm reaches provisional maturity status.

Algorithm performance dependence

- NOAA-20 ADP product meets requirements for dust (80% correct detection) and smoke (80% over land and 70$ over ocean correct detection), based on CALIPSO comparisons. CALIPSO is NASA's Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observatory which provides daytime and nighttime vertical profiles of clouds and aerosols.
- NOAA-20 ADP product does not meet requirements (NOT EXPECTED) based on AERONET comparisons. Reasons: (1) AERONET dust/smoke identification is also based on classification and thus not as accurate as CALIPSO, (2) Number of matchups with AERONET are limited, (3) matchup criteria too strict. AERONET is AERosol Robotic NETwork which is a network of ground-based sunphotometers that measure aerosol optical depth and angstrom exponent.

Known errors/issues/limitations

- False dust detections have been identified over bright surfaces when satellite observes the Earth in nadir view
- Algorithm updates to minimize false detections are forthcoming
- Updates will be implemented for both SNPP and NOAA-20
- Although ADP is provisional, it should be noted that cloud mask is still beta but the

ADP algorithm uses several internal tests to screen for clouds so the product is minimally impacted.

3. Changes since last maturity stage
    - A new Delivery of Algorithm Package (DAP) will be made prior to validated maturity review
4. Review board recommendations
    - Reached provisional
5. Path Forward/Future Plan
    - Delivery of a new DAP
6. Additional Items to note

The aerosol detection algorithm theoretical basis document can be obtained at https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_EPS_Aerosol_ADP_v1.1.pdf

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Example of IDL reader for ADP :

```
pro read_JPSS_ADP, filename, Dust_AAI, Smoke_AAI

   MISVAL=-999.9

   print, filename
   fid=ncdf_open(fname)
   vid=ncdf_varid(fid, 'Latitude')
   ncdf_varget,fid, vid, lat

   vid=ncdf_varid(fid, 'Longitude')
   ncdf_varget,fid, vid, lon

   vid=ncdf_varid(fid, 'Ash')
   ncdf_varget,fid, vid, Ash

   vid=ncdf_varid(fid, 'Smoke')
   ncdf_varget,fid, vid, Smoke

   vid=ncdf_varid(fid, 'Dust')
   ncdf_varget,fid, vid, Dust

   vid=ncdf_varid(fid, 'Cloud')
   ncdf_varget,fid, vid, cld

   vid=ncdf_varid(fid, 'NUC')
   ncdf_varget,fid, vid, Nuc

   vid=ncdf_varid(fid, 'SAAI')
   ncdf_varget,fid, vid, AAI
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```
   vid=ncdf_varid(fid, 'DSDI')
   ncdf_varget,fid, vid, DSDI

   vid=ncdf_varid(fid, 'QC_Flag')
   ncdf_varget,fid, vid, Qual_B1

   vid=ncdf_varid(fid, 'PQI1')
   ncdf_varget,fid, vid, Qual_B2

   vid=ncdf_varid(fid, 'PQI2')
   ncdf_varget,fid, vid, Qual_B3

   vid=ncdf_varid(fid, 'PQI3')
   ncdf_varget,fid, vid, Qual_B4

   vid=ncdf_varid(fid, 'PQI4')
   ncdf_varget,fid, vid, Qual_B5

   ncdf_close,fid




;;;;smoke/dust detection algorithm path
;smoke
;bytet5, bit5-6 (smoke detection algorithm source): 00: deep-blue 01:ir_visible
11: both

tmp_mask=Qual_B5

    idx=where(((ishft(tmp_mask,-4) and 3) eq 2),COMPLEMENT=cidx,n)
    if ( n gt 0) then smoke(idx)=0
;dust
;bytet5, bit7-8 (smoke detection algorithm source): 00: deep-blue 01:ir_visible
11: both

tmp_mask=Qual_B5

    idx=where(((ishft(tmp_mask,-6) and 3) eq 2), n)

     if (n gt 0) then dust(idx)=0

  sugln=smoke
  sugln(*,*)=0
  lndwat=smoke
  lndwat(*,*)=0
  lndwat=smoke
  lndwat(*,*)=0

; Byte 3 bit 2 (sun glint)
tmp_mask=Qual_B3
   idx = WHERE((tmp_mask AND 2) EQ 2, COMPLEMENT=cidx, nc)
;print, nc
   IF nc GT 0 THEN sugln[idx] = 1
; Byte 3 bit 3 (land/water)
tmp_mask=Qual_B3
   idx = WHERE((tmp_mask AND 4) EQ 4, COMPLEMENT=cidx, nc)
;print, nc
   IF nc GT 0 THEN lndwat[idx] = 1

;no glint on land
```

```
   idx=where(lndwat eq 1 and sugln eq 1,nn)
   if ( nn gt 0) then sugln(idx)=0

;dust (no dust detection in the sunglint region)
   idx=where(dust eq 1 and lndwat eq 0 and sugln eq 1, nn)
   if (nn gt 0) then begin
      dust(idx)=0
   endif


; scaled Absorbing Aerosol Index for dust - show dust internsity
   Dust_AAI=AAI
   Dust_AAI(*,*)=MISVAL
   idx=where(dust eq 1,n)
   if (n gt 0) then Dust_AAI(idx)=AAI(idx)
; scaled Absorbing Aerosol Index for smoke - show smoke internsity
; I believe this is what you want to display if you want to display smoke/mask
; you can color-scaled this value from 0 to 5 (or up to any value make color-
stretch nice)
   Smoke_AAI=AAI
   Smoke_AAI(*,*)=MISVAL
   idx=where(smoke eq 1,n)
   if (n gt 0) then Smoke_AAI(idx)=AAI(idx)
   print, max(Smoke_AAI),min(Smoke_AAI)

end
```