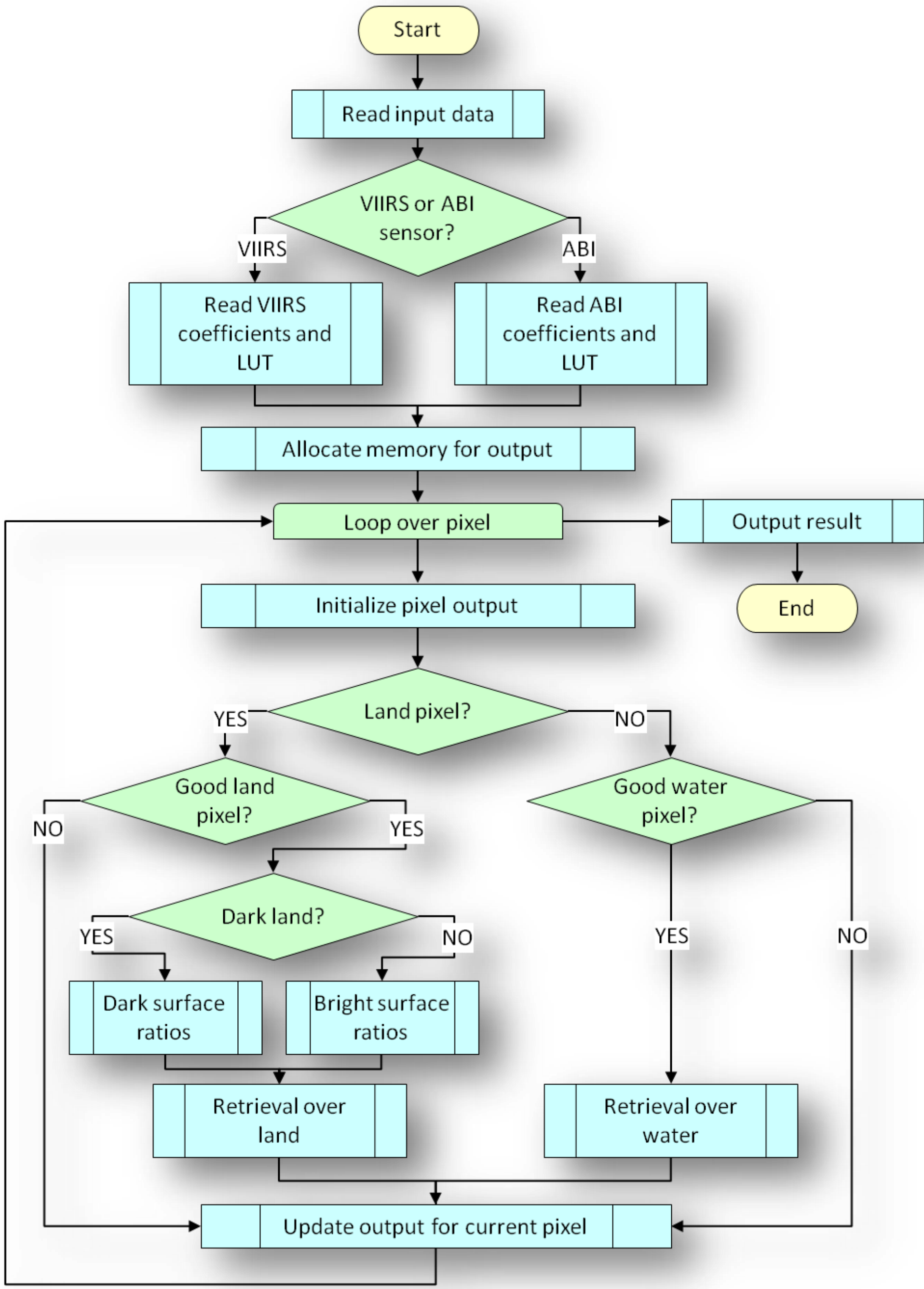
EPS
Aerosol Optical Depth and Aerosol Particle Size Parameter Products

EPS AOD & APSP Products

- **Products:**
  - **Aerosol optical depth (AOD) over land and ocean**: optical measure of amount of aerosol in vertical column of atmosphere.
  - **Aerosol Particle Size Parameter (APSP) over ocean only**: reported as Angstrom Exponent (proxy of APSP)
- **Team members**
  - P. Ciren, J. Huang, S. Kondragunta, I, Laszlo, H, Liu, S. Superczynski, L. Remer, H. Zhang
  - Algorithm (v1) developers: H. Liu, H. Zhang and I. Laszlo
- **Users**
  - air quality (NWS), research, applied science, private, and governmental communities
  - Downstream products (surface reflectance, NDVI)

EPS AOD & APSP Algorithm

High level flowchart



- **Designed to handle VIIRS and ABI**

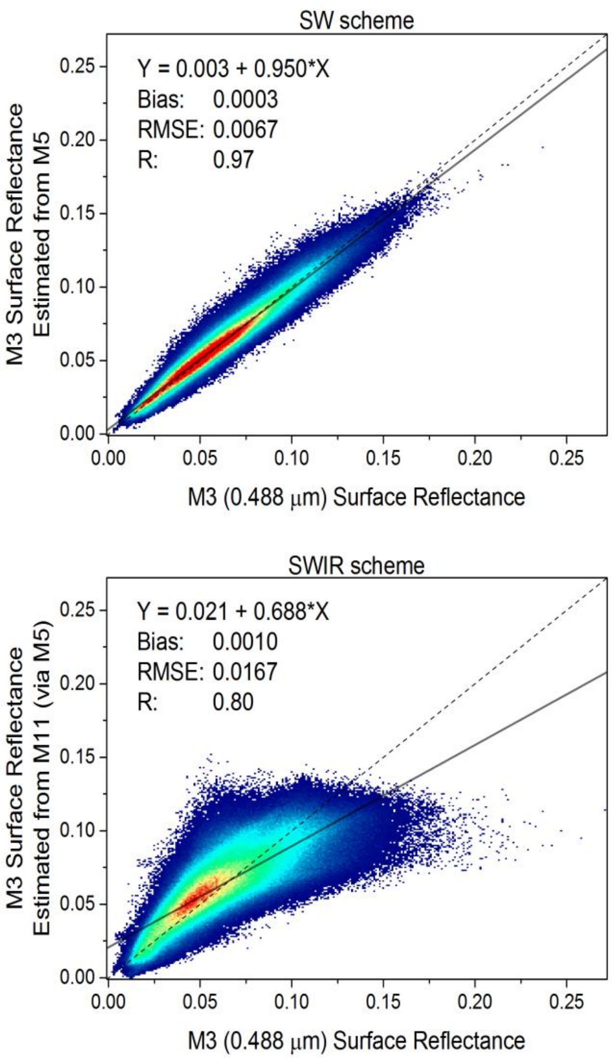
Band name	Central Wavelength (μm)		Use in aerosol algorithm
	VIIRS	ABI	
M1	0.412		IL+TL
M2	0.445		IL+TL
M3	0.488	0.470	IL+TL
M4	0.555		IO+TO
M5	0.672	0.640	IL+TL+IO+TO
M6	0.746		IO (if unsaturated)
M7	0.865	0.865	IO+TO+TL
M8	1.240		IO+TO+TL
M9	1.378	1.378	TL+TO
M10	1.610	1.610	IO+TO
M11	2.250	2.250	IL+IO+TO
M15	10.763	11.2	TL
M16	12.013	12.3	TL

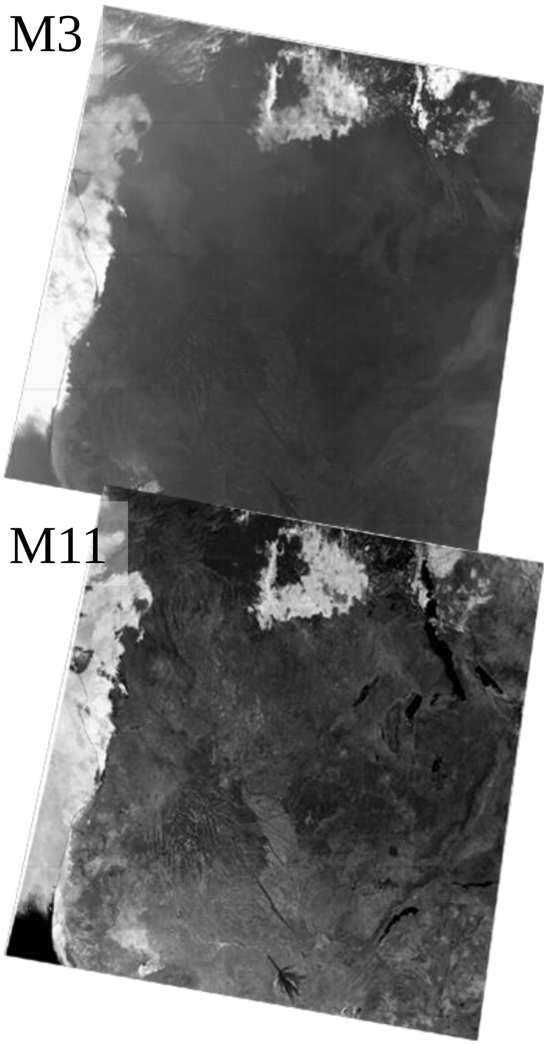
IL: inversion over land; IO: inversion over ocean; TL: internal test over land; TO: internal test over ocean

- EPS over-ocean algorithm is almost identical to that in IDPS
- **EPS over-land algorithm:**
  - **improved version of the dark-target one in IDPS**
  - **also retrieves AOD over bright surface**

EPS AOD Algorithm – dark land

- Combines IDPS and MODIS/GOES-R:
  - **SW-scheme (IDPS)**: more accurate estimation of M3 surface reflectance from M5 for low AOT
  - **SWIR-scheme (MODIS)**: more transparent M11 allows more accurate estimation of M3 (from M11) surface reflectance for high AOT
- **AOT range: -0.05 – 5.0**
- Non-constant surface reflectance ratios
- Less reliance on VCM – extensive internal tests
- Spatial variability test to better detect snow and cloud (M1 std in 3x3 pixels > threshold)



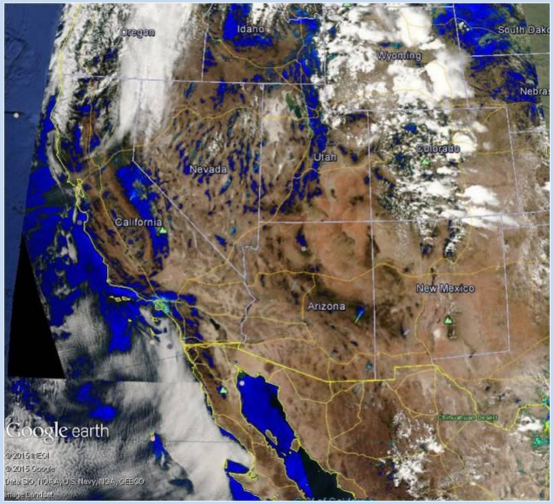


EPS AOD Algorithm – bright land

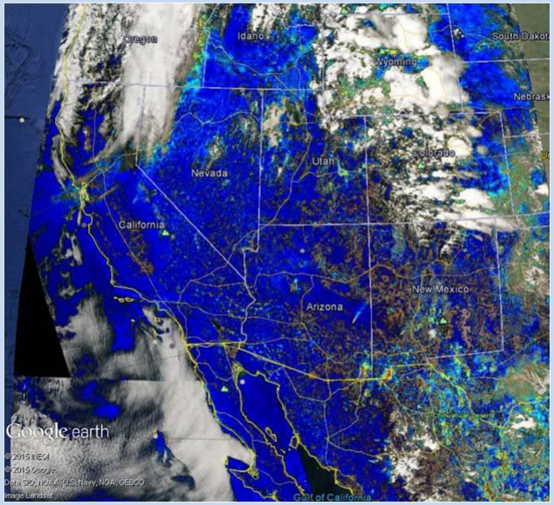
- Works as IDPS but uses regional (0.1°x0.1°) database of surface reflectance ratios for bright surface (M11 ≥0.25)
  - M3/M5 for North Africa/Arabian Peninsula
  - M1/M5 for the other regions
- Aerosol model:
  - dust for North Africa/Arabian Peninsula
  - selects IDPS models for other regions

IDPS vs. EPS AOD spatial coverage

IDPS



EPS



IDPS vs. EPS Algorithm

	IDPS	EPS
Algorithm (general)		
Data screening	External VCM + internal tests	Internal tests + external CM
Residual calculated as	Absolute difference	Relative difference
Over-land algorithm		
Channel used	0.41, 0.44, 0.48, 0.67, 2.25 µm	Same
Retrieve over	Dark surface only	Dark + bright surface
Aerosol model	five models from AERONET	MODIS C5
Spectral surface reflectance relationship	Constant Ratio	*Dark surface*: linear function of TOA SWIR-NDVI, redness and glint *Bright surface*: ratio as a function of location and scattering angle
Reference channels	0.48 and 0.67µm (SW scheme)	*Dark surface*: Same + 0.48 and 2.25µm (SWIR scheme) *Bright surface*: Same (Africa); 0.41 and 0.67µm (elsewhere)
Matching	Surface reflectances	TOA reflectances
Over-ocean algorithm		
Channel used	0.67, 0.74, 0.86, 1.24, 1.61, 2.25 µm	Same + 0.55 µm
Surface reflection	Non-Lambertian, function of wind speed and direction	Same + weighting with foam fraction
Aerosol model	Combination of fine and coarse modes (MODIS C4)	Same , but MODIS C5
Matching	TOA reflectances	Same
Retrieval over inland water	No	Yes

IDPS vs. EPS Inputs

	Inputs	IDPS	EPS
Reflectance	M1-M11	X	X
Brightness Temperature	M12	X	
	M15	X	X
	M16	X	X
Geolocation	Longitude	X	X
	Latitude	X	X
Geometry	Solar Zenith	X	X
	Solar Azimuth	X	X
	Satellite Zenith	X	X
	Satellite Azimuth	X	X
Ancillary Data	Wind Speed and Direction	X	X
	Precipitable Water	X	X
	Ozone	X	X
	Surface Pressure	X	X
VCM	Cloud Mask	X	X
	Cloud Mask Quality	X	
	Snow/Ice	X	X
	Fire	X	X
	Cloud Shadow	X	X
	Sunglint	X	X
	Ash	X	
	Heavy Aerosol	X	X
	Land/Water	X	X
	Cirrus	X	

IDPS vs. EPS Internal Tests

Internal Tests	IDPS	EPS
Over Ocean		
Cloud		X
Cirrus		X
Thin Cirrus		X
Spatial Variability		X
Sea Ice	X	X
Turbid/Shallow Water	X	X
Sunglint	X	X
Heavy Aerosol		X
Over Land		
Cloud		X
Cirrus	X	X
Thin Cirrus		X
Spatial Variability		X
Snow/ice	X	X
Fire	X	
Ephemeral Water		X
Sunglint	X	
Heavy Aerosol		X

IDPS vs. EPS Products

Outputs	IDPS		EPS
	EDR	IP	
Nominal spatial resolution	6 km	0.75 km	0.75 km
Granule size	86 seconds	86 seconds	86 seconds
AOT at 550-nm	[0, 2] range	[0, 2] range	[-0.05, 5] range
AOT at M-bands	M1 –M11 except M9	M1 –M11 except M9	M1 –M11
Slant Path AOT at 550-nm		X	
Ångström Exponent	Land: 445 vs. 672-nm Ocean: 865 vs. 1610-nm		Land: N/A Ocean : 555 vs. 672-nm 865 vs. 1610-nm
Fine Mode Fraction	Mean Value	X	X
Ocean Fine Mode	Dominant Type	X	X
Ocean Coarse Mode	Dominant Type	X	X
Land Aerosol Model	Dominant Type	X	X
Surface Reflectance			X
Retrieval Residual			X
Spatial Variability			X
AOT at 550-nm for Each Candidate Land Aerosol Model			X
Retrieval Residual for Each Candidate Land Aerosol Model			X

IDPS vs. EPS Quality Flags

Quality Flags	IDPS		EPS
	EDR	IP	
AOT Quality	X	X	X
AE Quality	X	X	
Land/Water Mask	X	X	X
AOT Out-of-Range	X	X	
AE Out-of-Range	X	X	
Cloud Contamination	X	X	X
Cloud Adjacency	X	X	X
Cirrus Contamination	X	X	X
Bad SDR	X	X	X
Sunglint	X	X	X
Cloud Shadow	X	X	X
Snow/Ice	X	X	X
Fire	X	X	X
Low Sun (65°<solzen≤80°)	X	X	
Low Sun (solzen>80°)	X	X	X
Bright Land	X	X	X
Turbid/Shallow Water	X	X	X
AE Excluded	X	X	
Cloud Mask Quality		X	
Interpolation/Climatology		X	
Ash		X	
Residual Out-of-Range		X	X

IDPS vs. EPS Quality Flags (Cont.)

Quality Flags	IDPS EDR	IDPS IP	EPS
Invalid Geolocation			X
Invalid Geometry			X
Invalid Ancillary Data			X
Internal Test Cloudy			X
Internal Test Thin Cirrus			X
Internal Test Inhomogeneity			X
Heavy Aerosol			X
SW Scheme over Land			X
SWIR Scheme over Land			X
Bright Surface Scheme over Land			X
Failed Retrieval			X
Extrapolation			X
NDVI Out-of-Range			X
Redness Ratio Out-of-Range			X
Snow Adjacency			X
Barren Land Cover Type over Dark Surface			X

Pixel Selection & Quality Levels EPS

Condition	Quality Level			Applies to		Detected by	
	No Retrieval	Low	Medium	Land	Ocean	VCM	Internal Tests
Invalid input data	X			X	X		X
Cloud Contamination	X			X	X	X	X
Snow/Ice	X			X	X	X	X
Fire	X			X		X	
Ephemeral Water	X			X			X
Sun Glint	X				X	X	X
Shallow Water	X				X		X
AOT Out-of-Range		X		X	X		X
Coastal		X		X		X	
Low Sun (solzen > 80°)		X		X	X		X
Extrapolation		X		X	X		X
High Inhomogeneity		X		X	X		X
High Residual		X		X	X		X
Cloud Shadow			X	X	X	X	
Thin Cirrus			X	X	X		X
Cloud Adjacency			X	X	X		X
Snow Adjacency			X	X	X		X
Medium Inhomogeneity			X	X	X		X
Medium Residual			X	X	X		X
NDVI Out-of-Range			X	X			X
Redness Out-of-Range			X	X			X

Lessons Learned

- Careful analysis of IDPS vs. EPS inputs (SDR, masks, quality flags, ancillary data) is needed in developing the AOD algorithm.
- Coordination with upstream and downstream product teams should be done early on, but to be effective upstream algorithm should already be mature enough.
  - Provided sample data, description of new file format and content, information on aerosol models used, and new LUT to surface reflectance team.
- Users should be made aware of any changes, and science teams should be made aware of “new” user requirements. (EPS AOD product is “only” at pixel level, but some users now prefer aggregated, lower-resolution product.)
- Should maintain format and content of output file similar to IDPS output as much as possible. Reprocessing of past record of NPP data with EPS algorithm may lessen this requirement.

Lessons Learned (contd.)

- Common ancillary data (e.g., surface type map) should be identified early on, and science teams should be made aware of them.
- Common procedures and/or inputs (e.g., model pressure corrected for actual surface elevation) should be identified and implemented in the framework to provide consistent inputs.
- Provide an opportunity for the science team to review code implemented in framework, especially if science code was changed in any way.
- When testing framework implementation of an algorithm that requires the framework to prepare (e.g., grid, aggregate) inputs original inputs (and perhaps code used) should also be provided to science teams so that the processed input could also be checked.

Path Forward

- **Anticipated developments**
  - Test/refine internal test implemented for detection of heavy aerosols.
  - Update ATBD.
  - Provide test data (of sufficient spatial and temporal coverage) to downstream algorithm teams and users.
  - Consider/evaluate feedback from downstream algorithm teams and users, and make algorithm/code changes if appropriate.
  - Update spectral reflectance-ratio database using actual VIIRS/J1 observations.
  - Update thresholds in internal tests based on actual VIIRS/J1 AOD data.
  - Generate spectral reflectance-ratio database using actual ABI observations.
  - Update thresholds in internal tests based on actual ABI AOD data.
  - Perform cal/val work of AOD from JPSS (repeat work done for NPP).

Summary

- **Reviews:**
  - √ CDR: April, 2013
  - √ UTR: November, 2014
  - √ ARR: December, 2015
  - – **Operational Readiness Review: July 2016**
- EPS AOD algorithm and ATBD were delivered to ASSISTT in January 2016.
- Updates to run the algorithm with AHI data, and other small updates were delivered in mid-March.
- Not aware of any J1 product change negatively impacting EPS AOD product; no outstanding issues at this time.