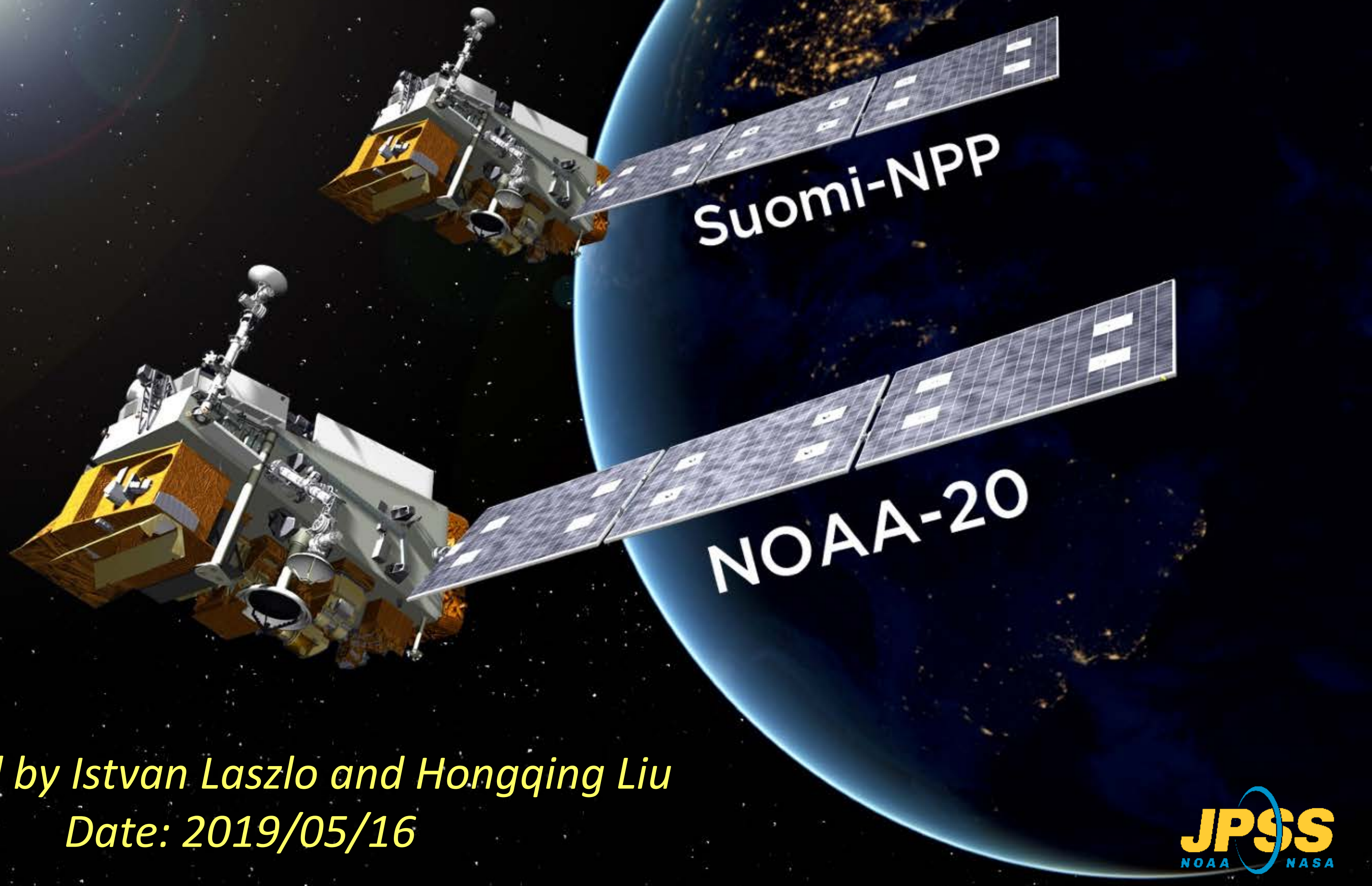
# Validated Maturity Science Review For Aerosol Optical Depth and Aerosol Particle Size




*Presented by Istvan Laszlo and Hongqing Liu*

*Date: 2019/05/16*

JPSS
NOAA NASA

# JPSS Data Products Maturity Definition

## 1. Beta

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

## 2. Provisional

- o 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.
- o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- o Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

## 3. Validated

- o Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- o 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.
- o Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- o Product is ready for operational use based on documented validation findings and user feedback.
- o Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

# Validated Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Validated Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward
- Summary

# Validated Maturity Review - Exit Criteria

- Validated Maturity Performance is well characterized and meets/exceeds the requirements:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Validated Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Validated Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward

# VALIDATED MATURITY REVIEW MATERIAL

# Outline

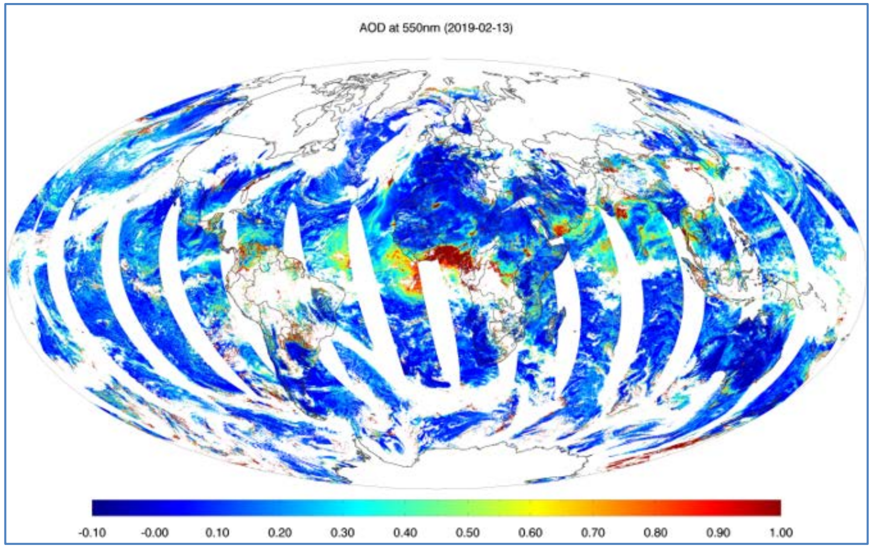
- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

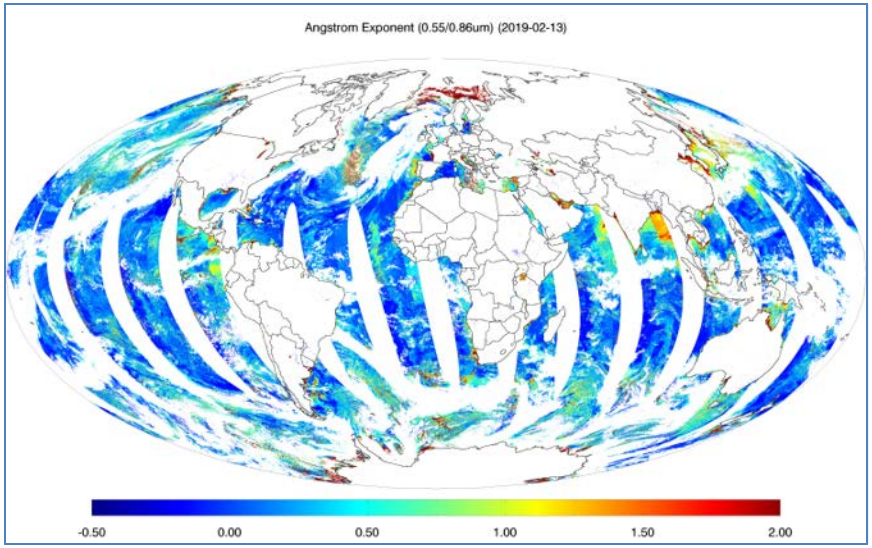
## Algorithm Cal/Val Team Members

| Name | Organization | Major Task |
|---|---|---|
| Pubu Ciren | IMSG | Aerosol detection product development and validation, liaison to Cloud Team and pIPT |
| Amy Huff | PSU | User (forecasters) feedback, outreach |
| Edward J. Hyer | NRL | Product validation, assimilation activities |
| Shobha Kondragunta | NOAA | Co-lead (detection) |
| Istvan Laszlo | NOAA | Co-lead (optical depth) |
| Hongqing Liu | IMSG | Algorithm development, validation, visualization |
| Lorraine A. Remer | UMBC | Documentation, liaison to Cloud Team |
| Shuang Qiu | NOAA | OSPO PAL for AOD and ADP |
| Arthur Russakoff | IMSG | Algorithm integration |
| Ivan Valerio | IMSG | Data management and monitoring |
| Hai Zhang | IMSG | Algorithm coding for and maintenance of eIDEA, AerosolWatch websites |

# Product Overview/Requirements (1/2)

- **Aerosol Optical Depth (AOD)**
  - Unitless measure of extinction of radiation by particles suspended in air (aerosol). Depends on the amount and microphysical and chemical properties of particles.
- **Aerosol Particle Size (APS)**
  - Measure of the size distribution in terms of an effective radius.
  - Reported as the unitless Ångström Exponent (AE).
    - Small/large AE represents large/small particles.
    - Derived from AOD.
  - Only over water.



# Product Overview/Requirements (2/2)

| Attribute | AOD | | APS | |
|---|---|---|---|---|
| *Applicable Conditions* | Clear sky, daytime only, zenith angles ≤80$^o$ | | | |
| *Geographical Coverage* | Global | | | |
| *Vertical Coverage* | Total column | | | |
| *Vertical Cell Size* | Total column | | | |
| *Horizontal Cell Size* | 0.75 km at nadir, 1.6 km at edge of scan | | | |
| *Mapping Uncertainty, 3σ* | 4 km | | | |
| *Measurement Range* | -0.05 to +5 | | -1 to +3 | |
| *Measurement* | *Accuracy* | *Precision* | *Accuracy* | *Precision* |
| *Over Ocean* | 0.08 (AOD< 0.3)<br>0.15 (AOD≥ 0.3) | 0.15 (AOD≤ 0.3)<br>0.35 (AOD≥ 0.3) | 0.3 | 0.6 |
| *Over Land* | 0.06 (AOD< 0.1);<br>0.05 (0.1≤AOD≤0.8)<br>0.20 (AOD>0.8) | 0.15 (AOD< 0.1)<br>0.25 (0.1≤AOD≤0.8)<br>0.45 (AOD>0.8) | n/a | n/a |
| *Refresh Rate* | 90 minutes (~100 minutes) | | | |

Source: JPSS L1RD supplement, JERD

# Processing Environment and Algorithms

- Algorithm version:
  - JRR-AOD v2r0
- Version of LUTs used:
  - V1 LUT (created with NOAA-20 VIIRS RSRs on Feb. 2018)
- Version of PCTs used:
  - V1 PCT (created with NOAA-20 VIIRS RSRs on Feb. 2018)
- Effective date:
  - September 28, 2018 from NDE I&T string;
  - March 7, 2019 from NDE operational string.

- Findings/Issues from Beta/Provisional Review
  - Global fields of AOD and AE from NOAA-20 are similar to those from S-NPP.
  - Preliminary evaluation with AERONET data indicates requirements are met.
  - NOAA-20 retrievals use NPP VIIRS LUT/PCT leading to an overestimation of AOD and underestimation of AE.
- Improvements since Provisional Review
  - Algorithm Improvements
    - No changes.
  - LUT / PCT updates
    - Updated LUT/PCT for NOAA-20 VIIRS RSRs.

# Validation Datasets

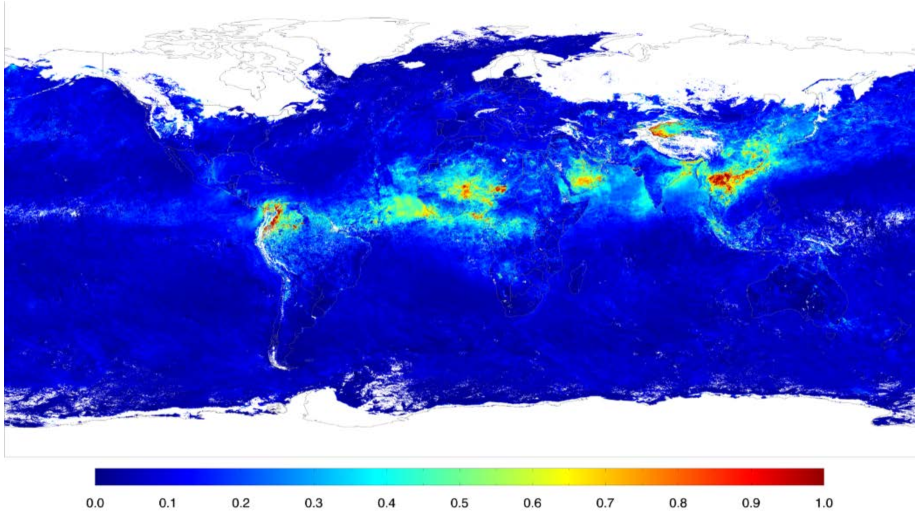
| Data Source | | Period | Coverage | Comment |
|---|---|---|---|---|
| **NOAA-20 NDE** | | 09/28/2018 – 04/11/2019 | Global | |
| | Integration and Testing String (I&T) | 09/28/2018 – 03/07/2019 | | Frequent missing data (granules, days). |
| | Operational String (Opr) | 03/08/2019 – 04/11/2019 | | Complete spatial and temporal coverage. |
| **NOAA-20 Offline (Local) Retrievals** | | 01/07/2018 – 04/11/2019 | Over AERONET stations | NOAA-20 data over AERONET stations; offline retrievals; covers a full annual cycle. |
| **S-NPP NDE** | | 01/07/2018 – 04/11/2019 | Global | For comparison with NOAA-20 VIIRS EPS AOD products. |
| **AERONET** | | 01/07/2018 – 04/11/2019 | Stations | Reference (ground “truth”) for quantitative evaluation of quality. |

# Validation Strategies/Methods

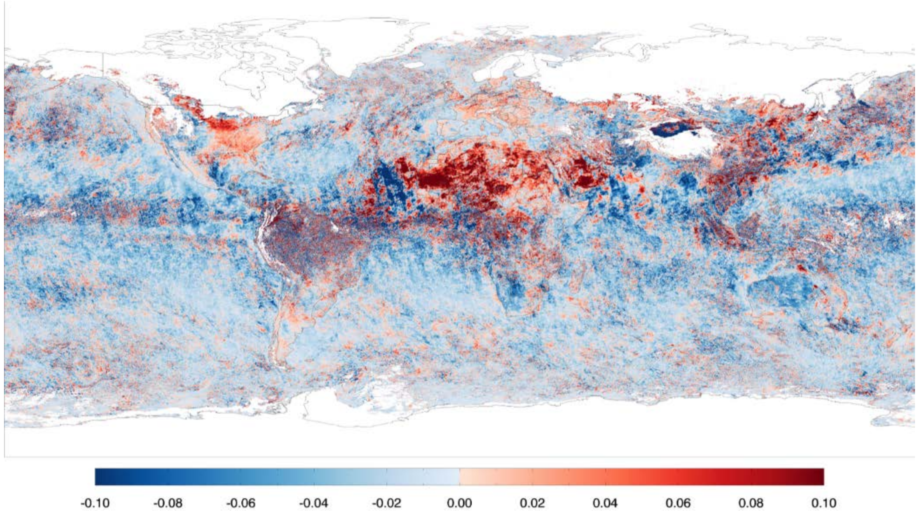
- **Comparison with S-NPP VIIRS AOD product**
  - Global images of monthly averages
  - Daily average of global AOD over land and water
  - Collocated retrievals over AERONET stations
    - Retrievals over all and same AERONET stations
    - Time difference is less than 1 hour
- **Comparison with ground measurements**
  - Take AERONET V3 L1.5 direct-sun measurements as “ground truth”
  - Match VIIRS retrievals with AERONET measurements
    - High-quality VIIRS EPS AOD is used only
    - Spatial domain: circle of 27.5 km in radius centered on AERONET stations
    - Temporal domain: one-hour centered on satellite overpass time
    - At least 2 AERONET measurements within temporal domain
    - At least 750 VIIRS retrievals within spatial domain
    - AE is evaluated only if 550-nm AOD is larger than 0.15 over water

# Monthly Mean (March 2019) AOD550 Images

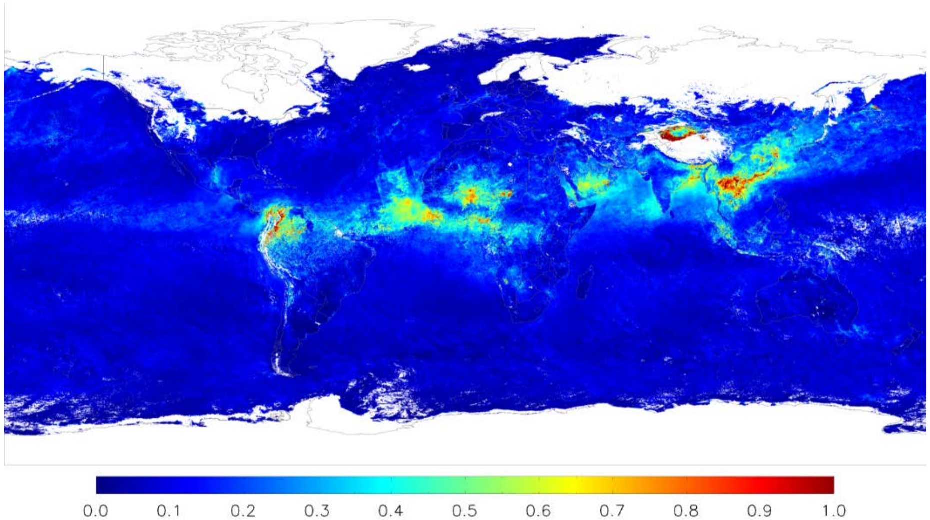
**NOAA-20**




**Difference (NOAA-20 – S-NPP)**



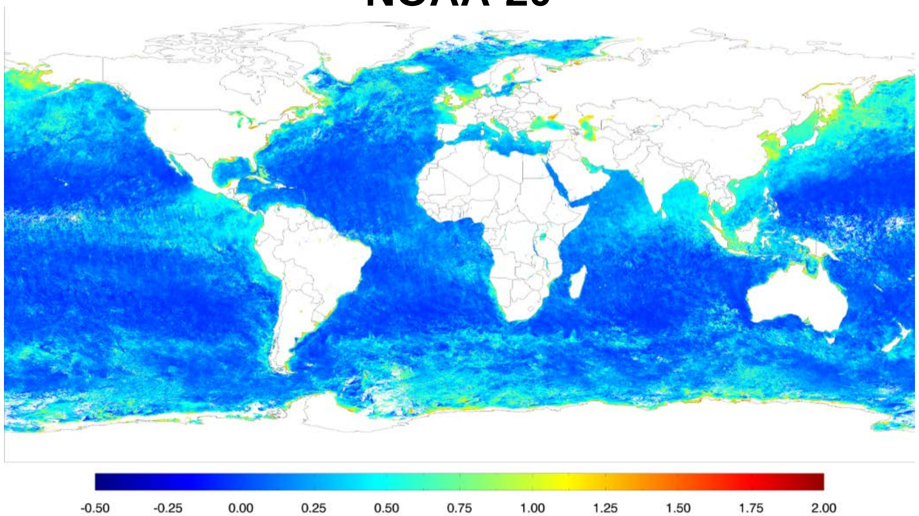

**S-NPP**



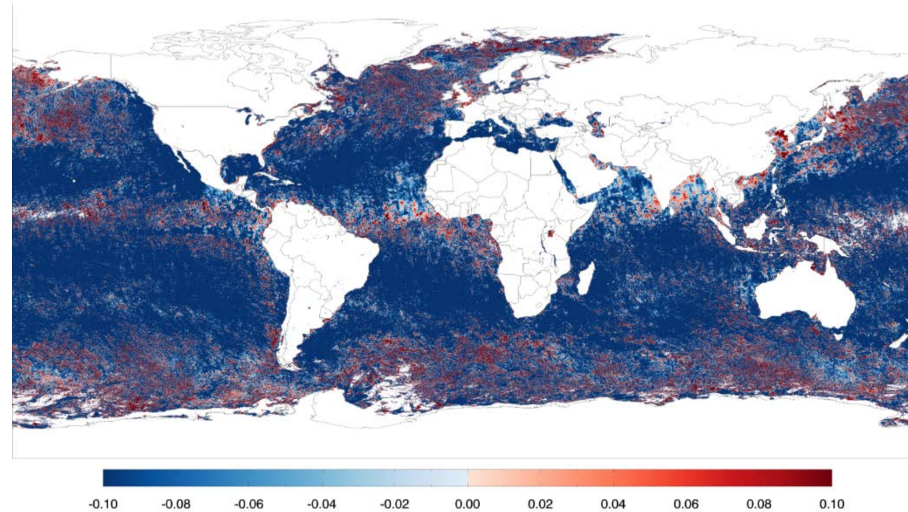

- NOAA-20 and S-NPP AOD have similar spatial patterns.
- The difference varies by region:
  - NOAA-20 AOD is higher over land, especially over bright land;
  - NOAA-20 AOD is lower over much of the ocean.

# Monthly Mean (March 2019) Angstrom Exponent (0.55 vs 0.86 µm) Images

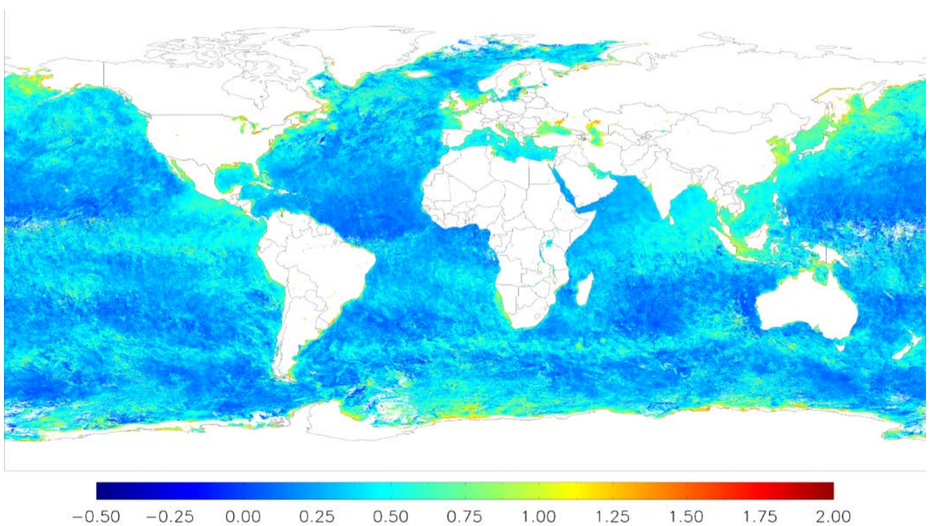
### NOAA-20




### Difference (NOAA-20 – S-NPP)



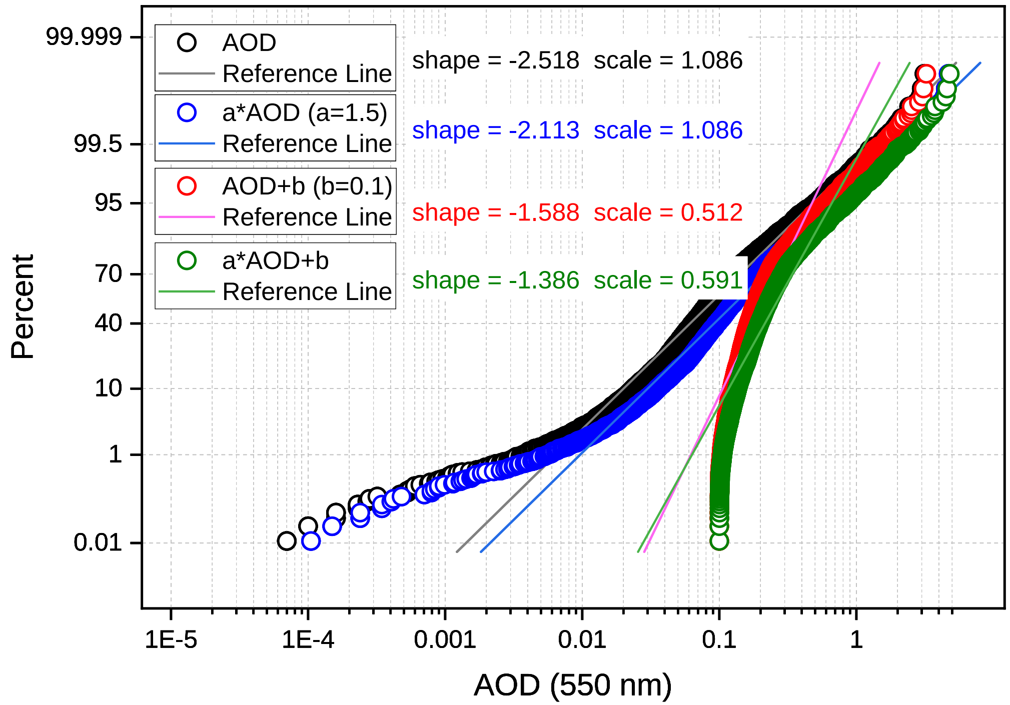

### S-NPP




- NOAA-20 and S-NPP AE have similar spatial patterns but differences are clearly visible.
- Relative to S-NPP, NOAA-20 AE is
  - smaller at mid-latitudes (larger particles),
  - higher at high-latitudes and in the tropics (smaller particles).
- Features are similar for 0.86 vs 1.61 µm AE. (Not shown.)

# NOAA-20 vs. S-NPP – Probability Plots

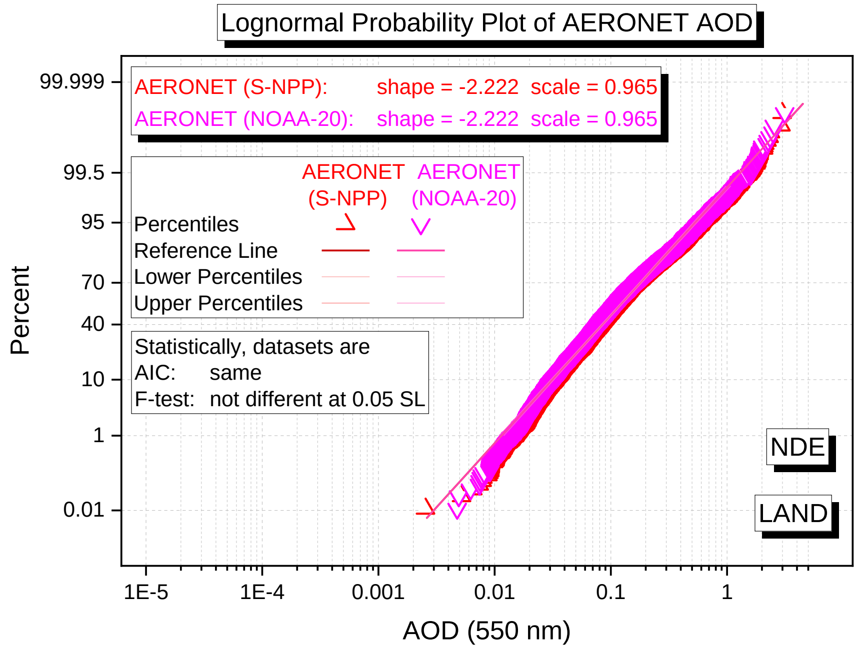
- Using probability plots to compare NOAA-20 and S-NPP AOD.
- Data: high-quality NOAA-20 AOD over land in NDE over AERONET sites: 09/28/2018 – 04/11/2019.
- Lognormal distribution is assumed.
- Reference line, fit parameters shape [mean of ln(AOD)] and scale [std. of ln(AOD)] are compared.

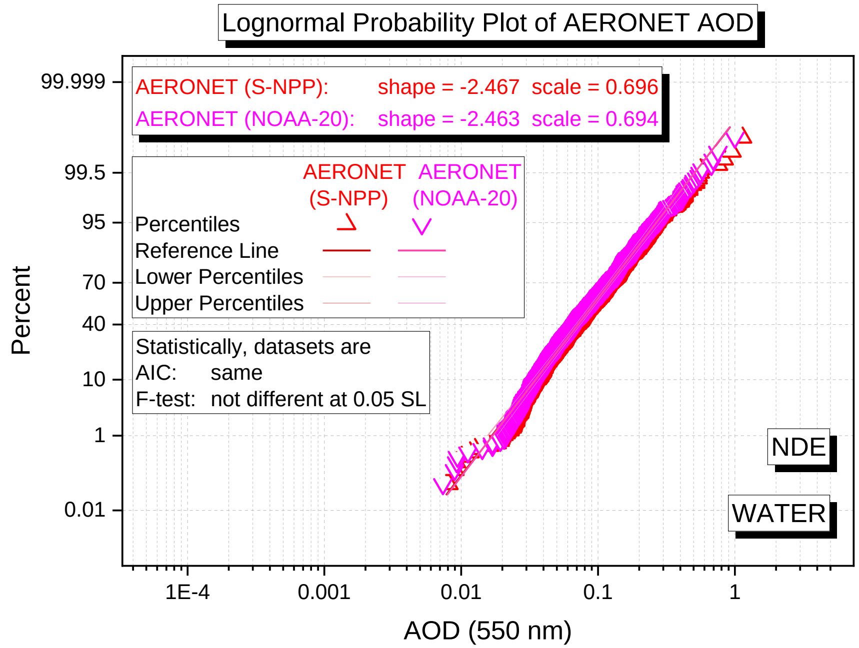



Reference line, shape and scale of fit reflects transformation of data. A bias has a large impact.

- Tests for measuring whether NOAA-20 and S-NPP data are statistically same or different:
  - Akaike Information Criteria (AIC)
  - F-test

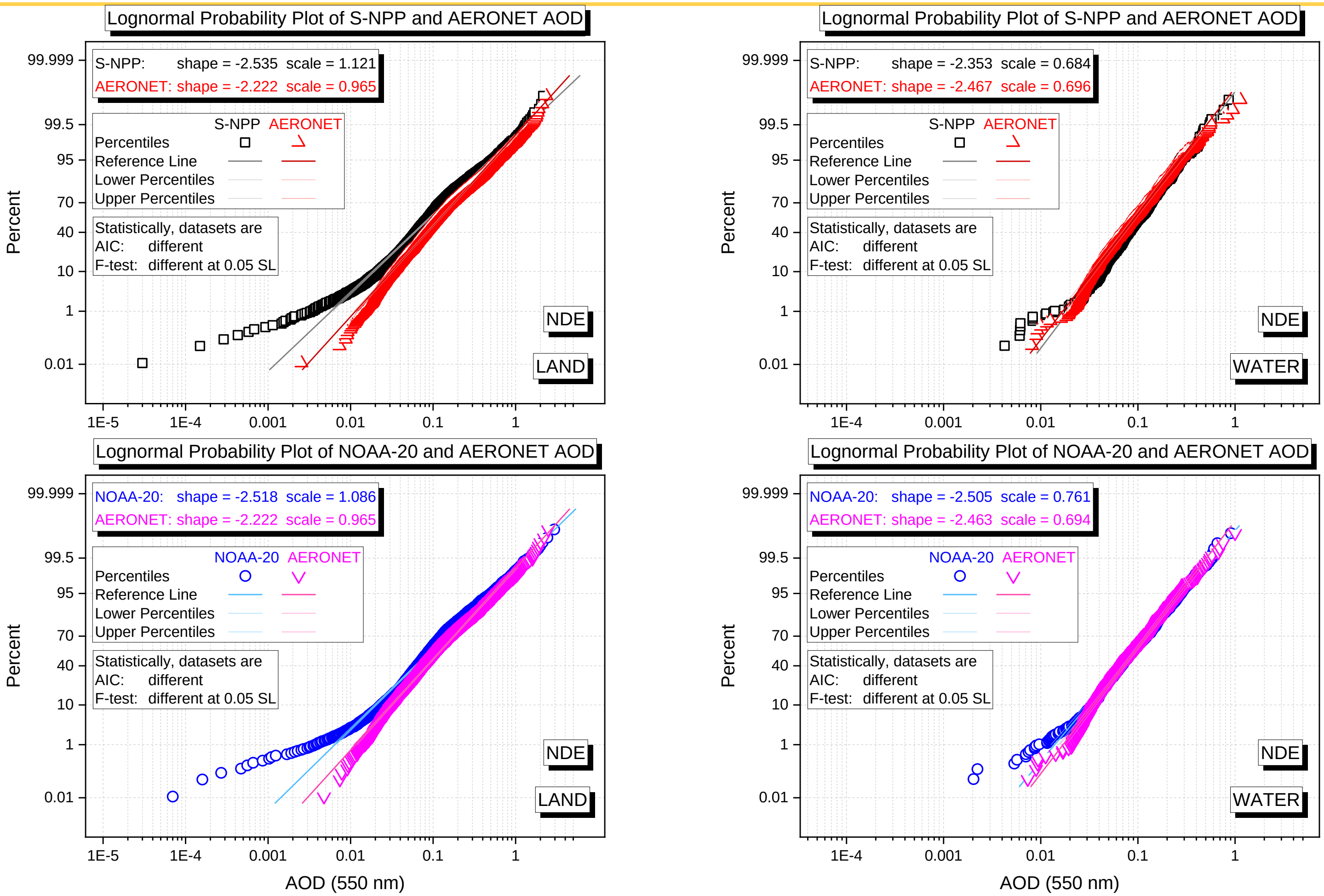
# Probability Plot of AERONET AOD



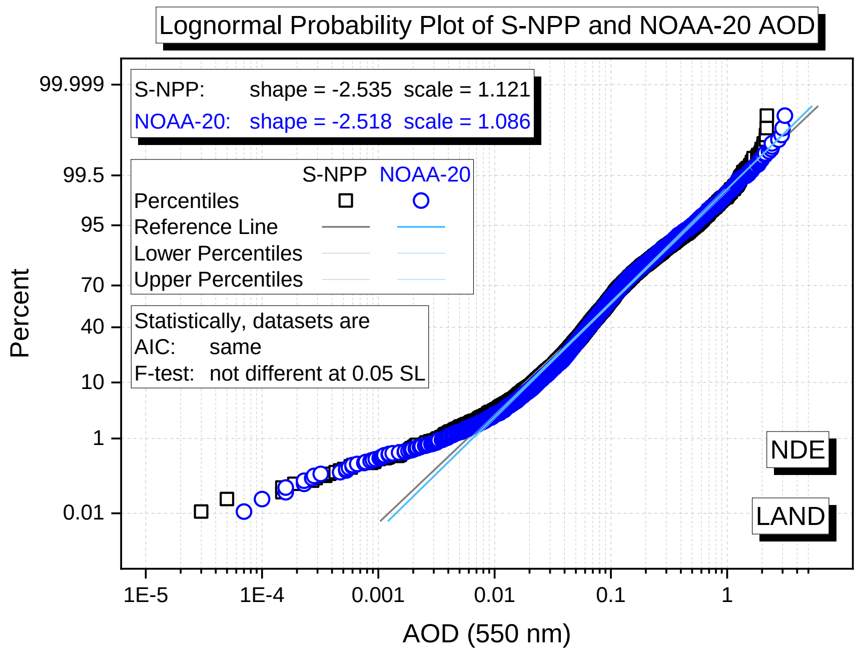

- Lower and upper percentiles represent boundaries of the 95% confidence interval.
- AERONET matchups with NOAA-20 and S-NPP are statistically not different:
  - Indicates AODs sampled at 50 minutes apart are coming from the same (or at least statistically very similar) population(s).
    - Caveat: AERONET data matched with NOAA-20 and S-NPP may not be totally independent; there could be about 10-minute overlap between them.
  - Suggests similar CDFs of NOAA-20 and S-NPP AODs should be expected (does not necessarily mean they have to agree with AERONET CDFs).

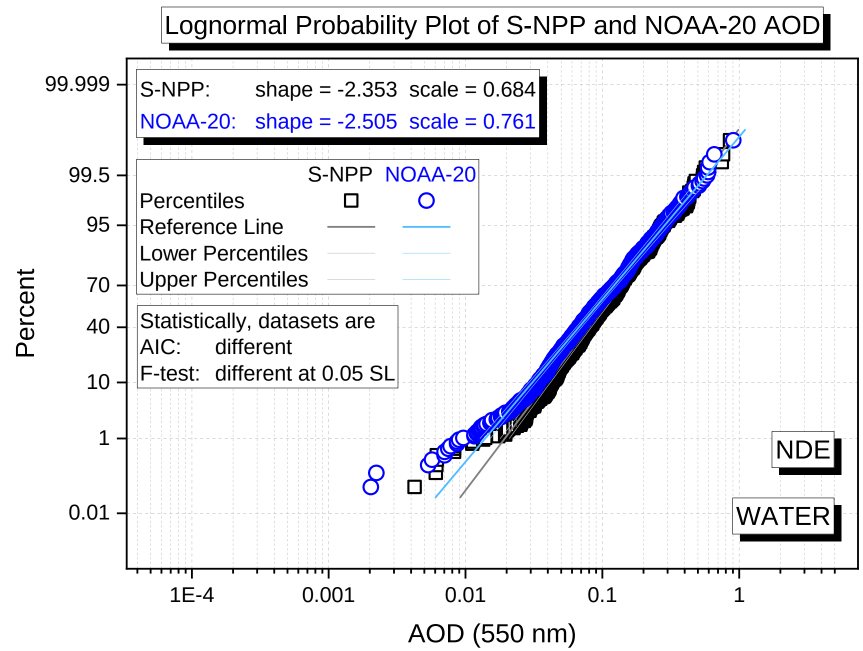
# Probability Plots of VIIRS and AERONET AOD




- AIC and F-test indicate NOAA-20 and S-NPP AOD products are statistically different from AERONET. However, …
- Probability plots suggest similar qualities of both relative to AERONET.

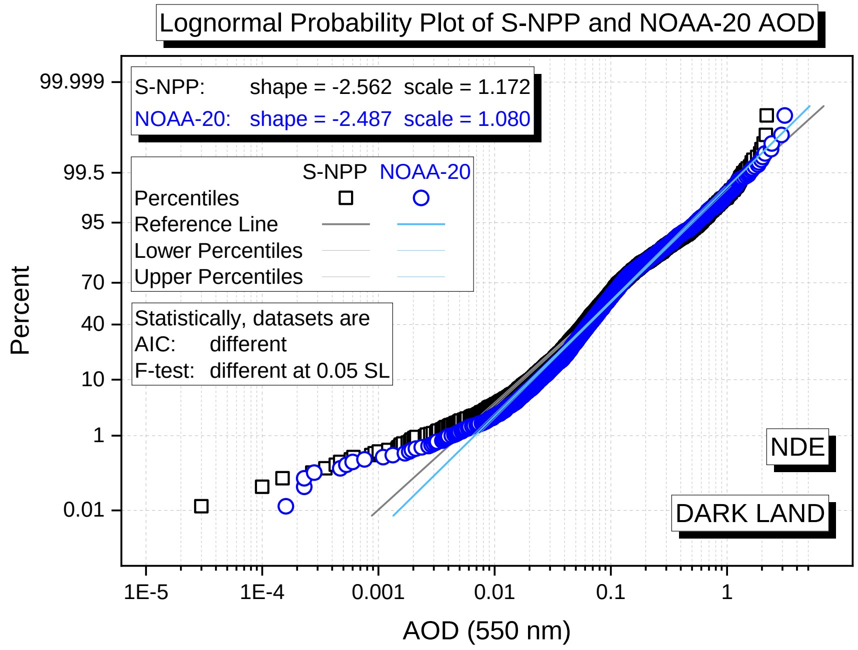
# Probability Plot of AERONET AOD

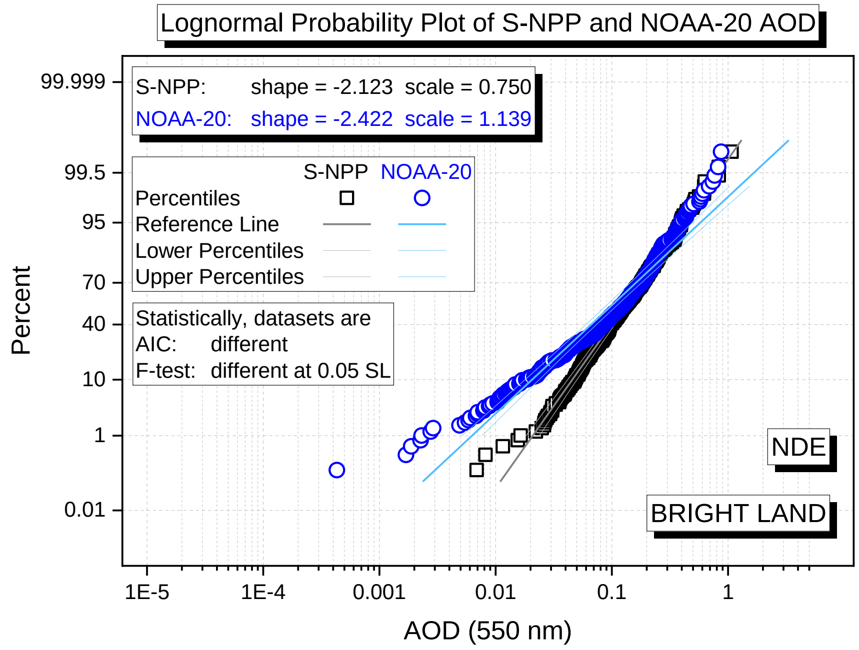



- Over-land NOAA-20 and S-NPP AOD CDFs are statistically not different (but see next slide).
- Over-water NOAA-20 and S-NPP AOD CDFs are statistically different.
  - Fit lines are different, especially at low AOD, and indicate a possible (negative) “bias” in NOAA-20 wrt S-NPP.
  - NOAA-20 shape value indicates smaller mean NOAA-20 AOD than that from S-NPP.

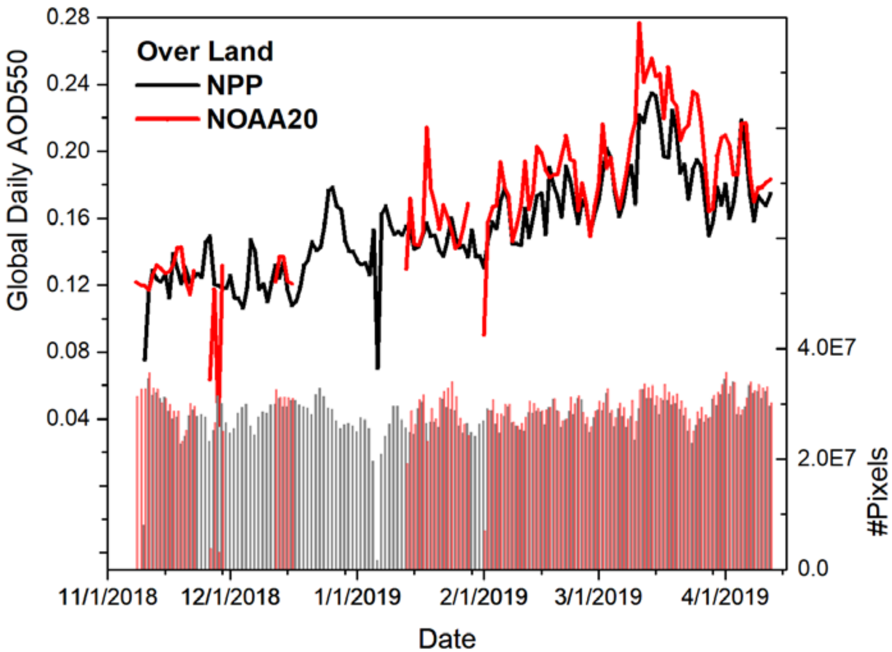
# Dark Land vs. Bright Land

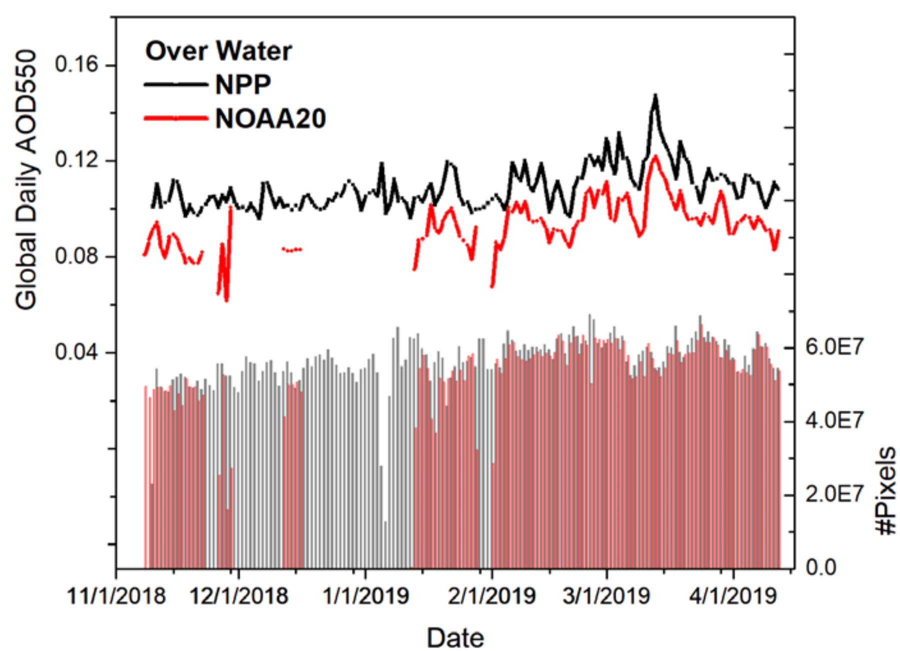



- S-NPP and NOAA-20 AOD over dark and bright land are statistically different.
- Difference over bright land is significantly larger.
- Currently, S-NPP spectral land-surface reflectance relationships between blue/red/nir VIIRS channels are used in NOAA-20 AOD retrievals. They must be updated for NOAA-20. Need one year of NOAA-20 stable, well-calibrated reflectance data.
- Bright land surface reflectance retrieval is more sensitive to S-NPP vs. NOAA-20 reflectance difference.

# Global Daily Average of NOAA-20 and S-NPP AOD in NDE

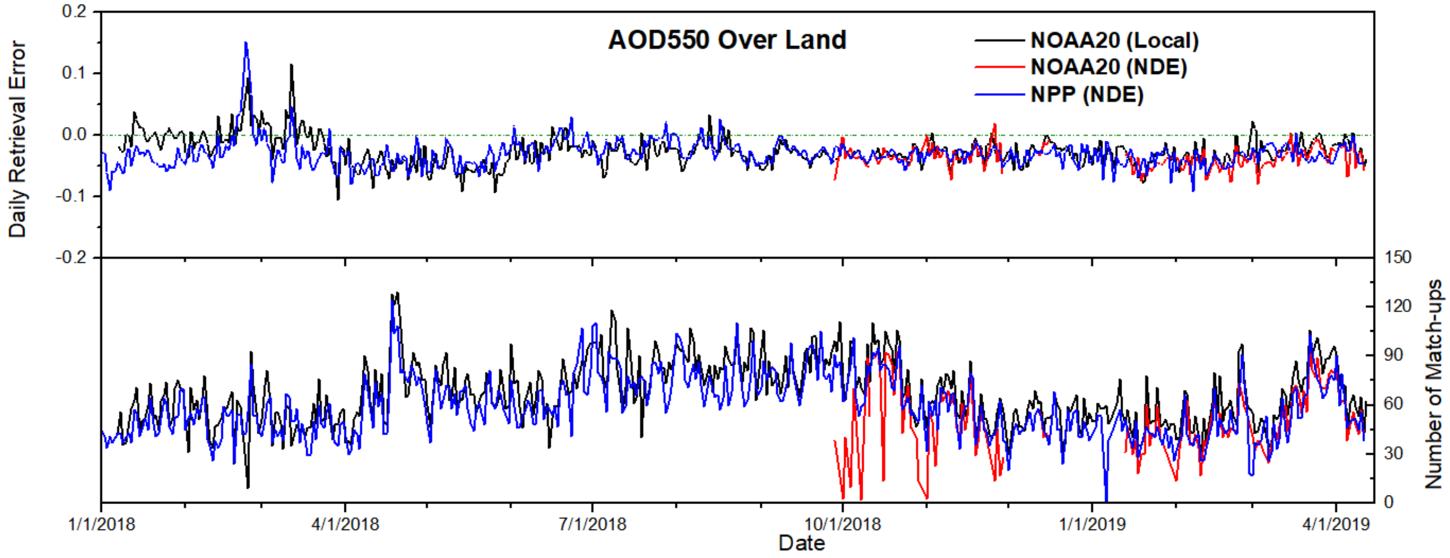


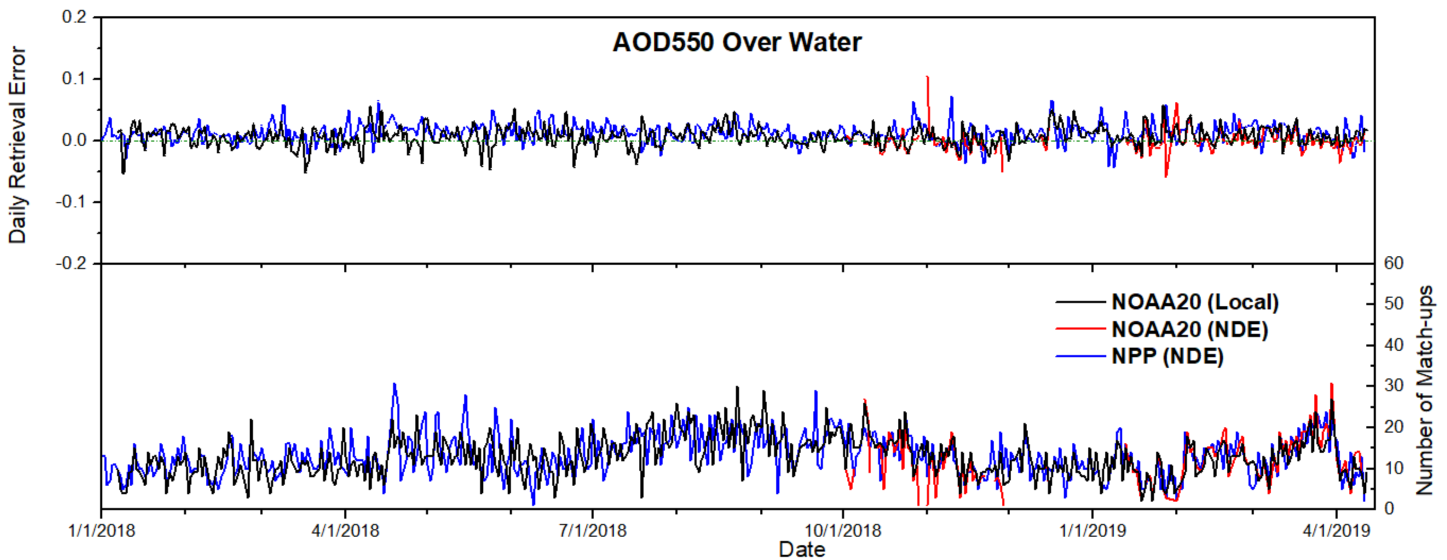




Difference (NOAA-20 – S-NPP) of global-average 550-nm AOD (after 2/1/2019 when the NDE NOAA-20 data have complete spatial coverage) is

- +0.017 over land,
- -0.016 over water.

# Time Series of Daily AOD Error wrt AERONET

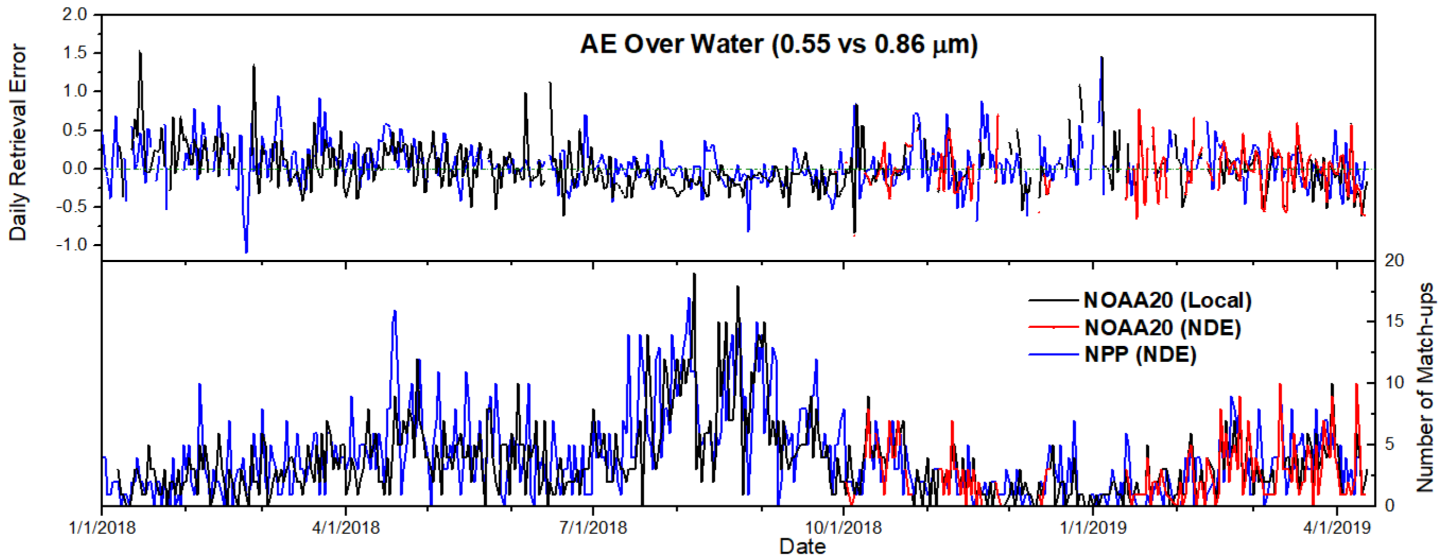


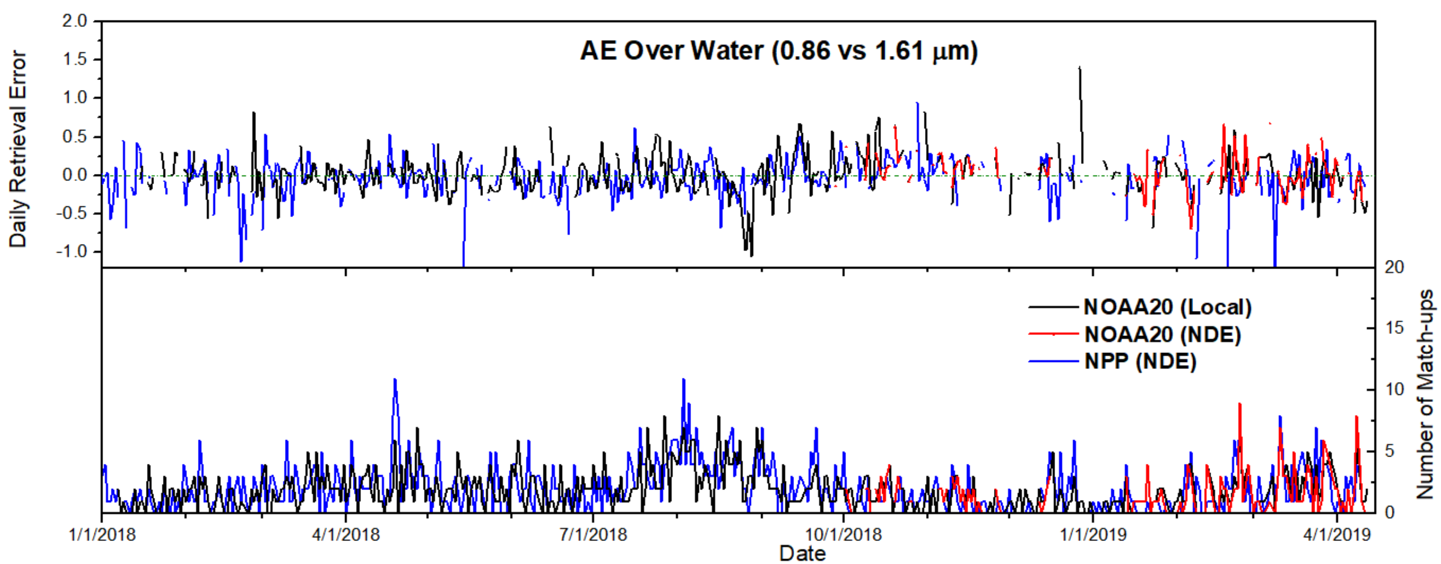




Daily averages over AERONET sites.

**Time series (trends in day-to-day variability) of the three VIIRS EPS AODs are similar.**

# Time Series of Daily APS Error



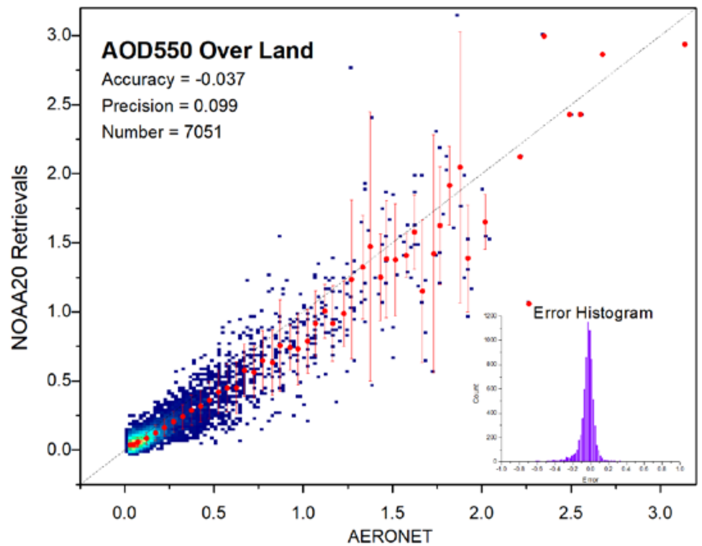



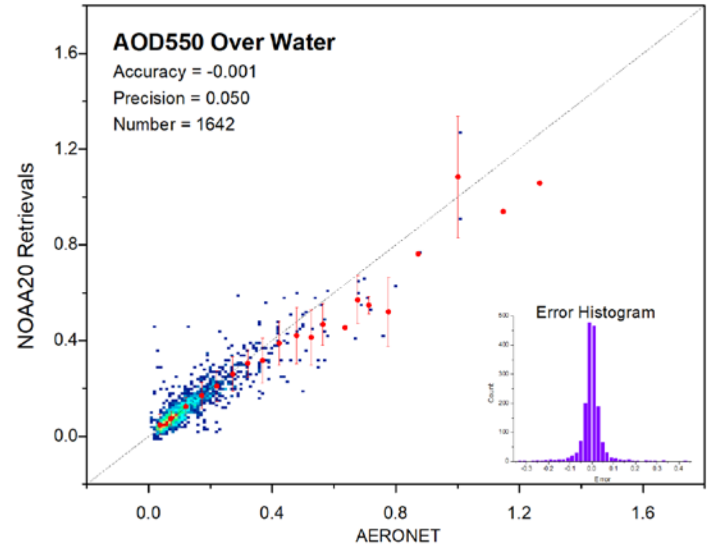

APS (AE) from daily average AODs over AERONET sites.

**Time series (trends in day-to-day variability) of biases of the three VIIRS EPS APSs are similar.**

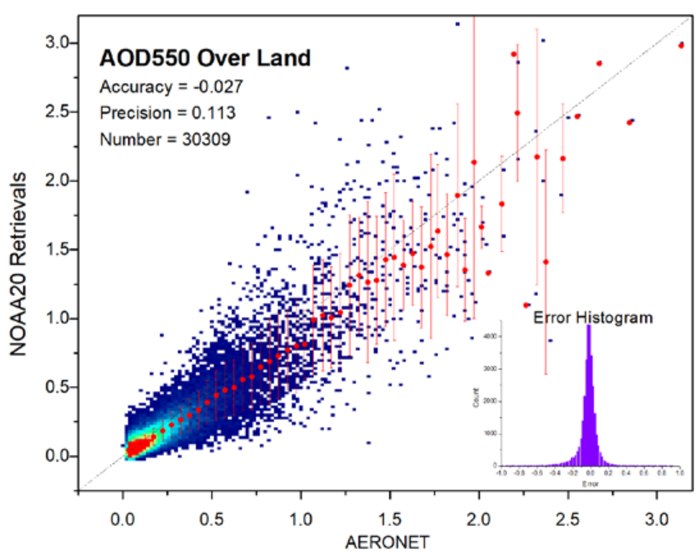
# Validation of NOAA-20 550-nm AOD

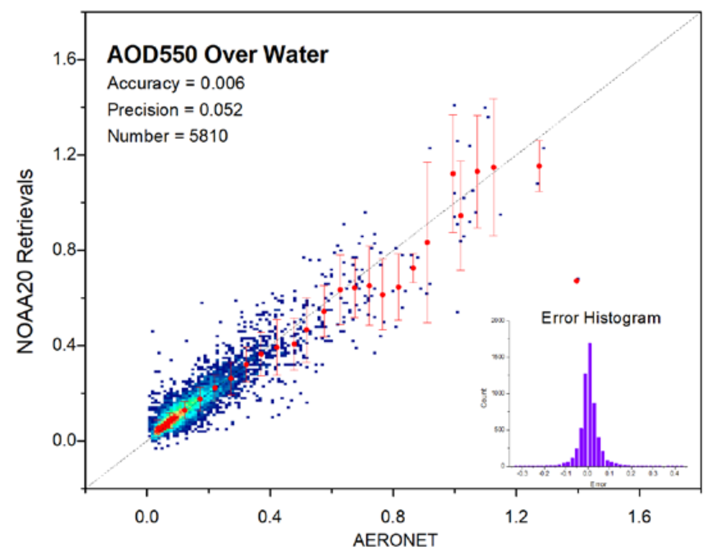
NOAA-20 (NDE)



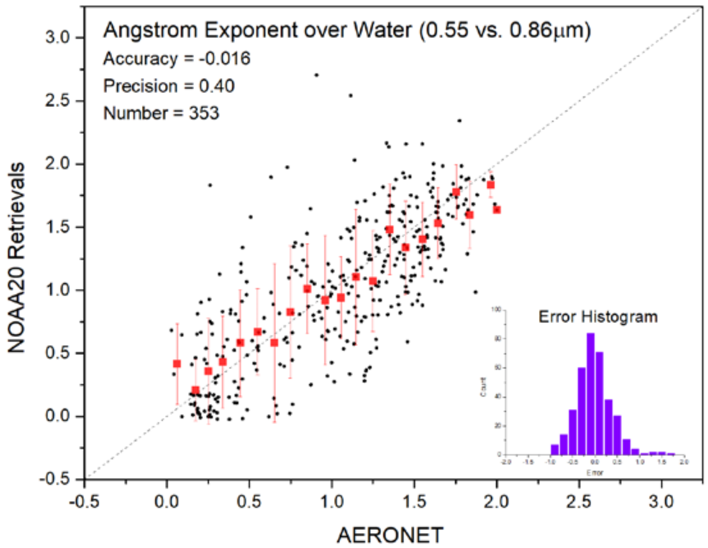

NOAA-20 (Offline)

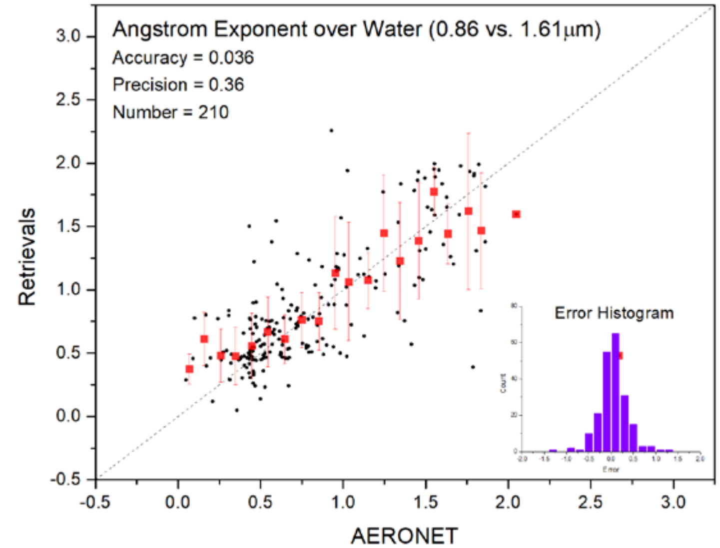


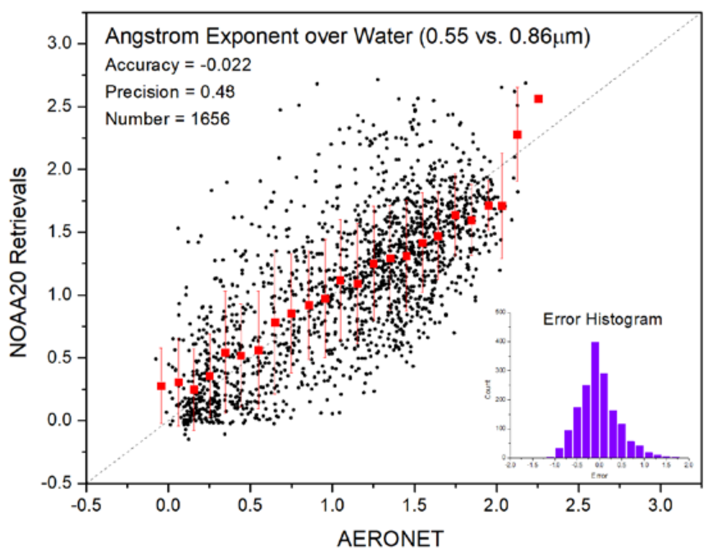
# Validation of NOAA-20 Angstrom Exponents

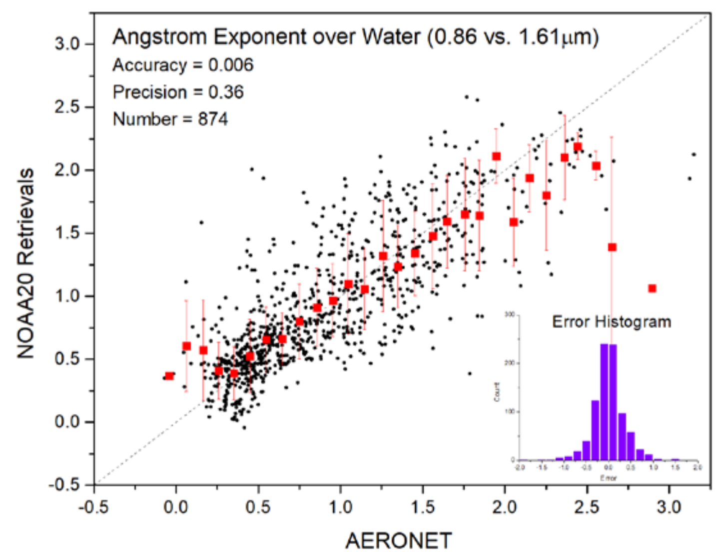
NOAA-20 (NDE)




NOAA-20 (Offline)



# Accuracy and Precision

| Land | L1RD | N20 (NDE) | N20 (Offline) | Matched* N20 (NDE) | Matched* SNPP (NDE) |
|---|---|---|---|---|---|
| **AOD550 < 0.1** | | | | | |
| **A** | 0.06 | -0.006 | 0.002 | -0.005 | -0.006 |
| **P** | 0.15 | 0.04 | 0.05 | 0.04 | 0.004 |
| **N** | | 3,676 | 13,661 | 3,556 | 3561 |
| **0.1 ≤ AOD550 ≤ 0.8** | | | | | |
| **A** | 0.05 | ***-0.06*** | **-0.04** | ***-0.07*** | ***-0.06*** |
| **P** | 0.25 | 0.09 | 0.11 | 0.09 | 0.09 |
| **N** | | 3,150 | 15,698 | 2,962 | 2953 |
| **AOD550 > 0.8** | | | | | |
| **A** | 0.20 | -0.17 | -0.14 | -0.16 | -0.18 |
| **P** | 0.45 | 0.35 | 0.40 | 0.36 | 0.27 |
| **N** | | 225 | 8941 | 168 | 172 |

| Water | L1RD | N20 (NDE) | N20 (Offline) | Matched* N20 (NDE) | Matched* SNPP (NDE) |
|---|---|---|---|---|---|
| **AOD550 < 0.3** | | | | | |
| **A** | 0.08 | 0.003 | 0.009 | -0.0002 | 0.01 |
| **P** | 0.15 | 0.04 | 0.04 | 0.04 | 0.03 |
| **N** | | 1,532 | 5,296 | 1,095 | 1,095 |
| **AOD550 ≥ 0.3** | | | | | |
| **A** | 0.15 | -0.05 | -0.02 | -0.04 | -0.04 |
| **P** | 0.35 | 0.11 | 0.12 | 0.09 | 0.10 |
| **N** | | 110 | 514 | 43 | 43 |
| **APS (Ångström Exponent, 0.55 vs. 0.86 µm)** | | | | | |
| **A** | 0.3 | -0.016 | -0.022 | -0.001 | 0.025 |
| **P** | 0.6 | 0.40 | 0.43 | 0.33 | 0.33 |
| **N** | | 353 | 1,656 | 216 | 258 |
| **APS (Ångström Exponent, 0.86 vs. 1.61 µm)** | | | | | |
| **A** | 0.3 | 0.036 | 0.006 | 0.052 | -0.060 |
| **P** | 0.6 | 0.36 | 0.36 | 0.36 | 0.38 |
| **N** | | 210 | 874 | 93 | 112 |

NOAA-20 EPS products meet requirements,

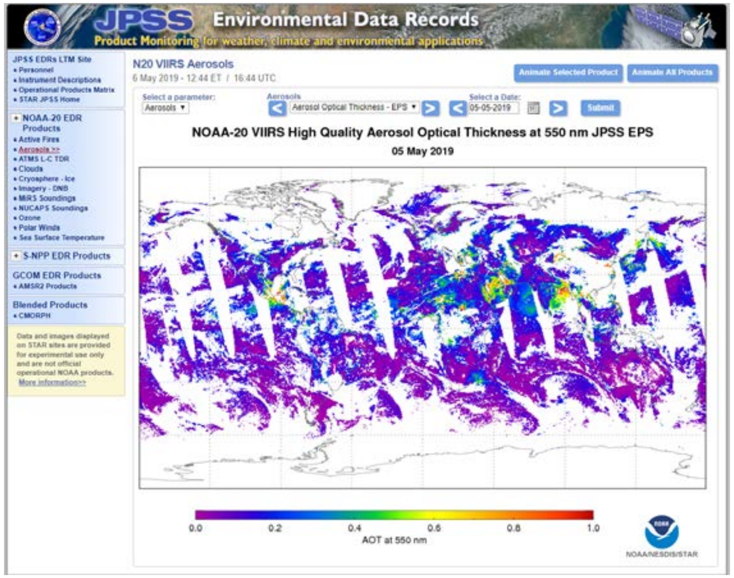
- except for over-land AOD in NDE at mid-value range,
- but, the offline, longer time period product meets the requirement at the mid-value range.

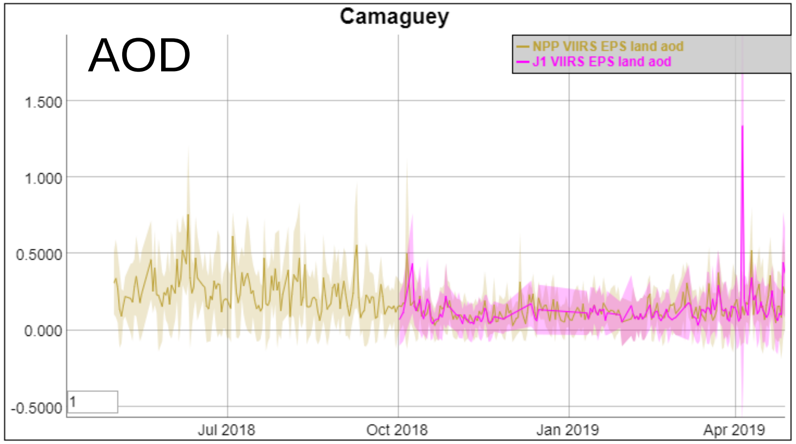
**A**: accuracy; **P**: precision; **N**: number

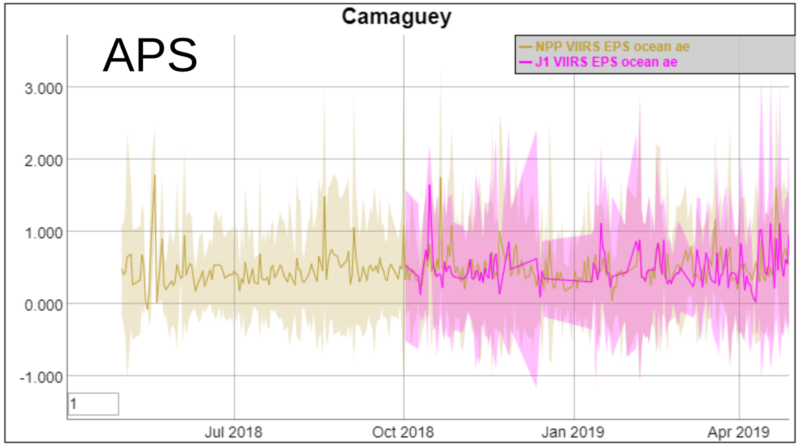
*Only common sites are used

# Long-term Monitoring Readiness

- **OSPO:**
  - Monitors meta data.
- **STAR LTM**:
  - Plots NOAA-20 (and S-NPP) VIIRS high-quality 550-nm AOD (EPS).
- **STAR Aerosol Cal/Val Team:**
  - Interactively displays S-NPP and NOAA-20 VIIRS, MODIS and AERONET AOD, AE, geometry, cloud fraction, reflectance and bias for six sites.



# Evaluation of the effect of required algorithm inputs (2-5 slides)

- Required Algorithm Inputs
  - Primary Sensor Data
    - NOAA-20 VIIRS M-band SDR and GEO.
  - Ancillary Data
    - GFS TPW, ozone, wind, surface pressure,
    - Global land surface type.
  - Upstream algorithms
    - Cloud mask, cloud shadow mask, land/water mask, fire mask, snow/ice mask, glint mask, heavy aerosol mask.
  - LUTs / PCTs
    - Aerosol LUT and sunglint reflectance LUT.
    - Coefficients used for calculating gaseous absorption, molecular and water spectral reflection, valid input value ranges, thresholds for internal test and quality control, spectral relationship of dark land reflectance, and ratio of bright surface reflectances.

# Evaluation of the effect of required algorithm inputs

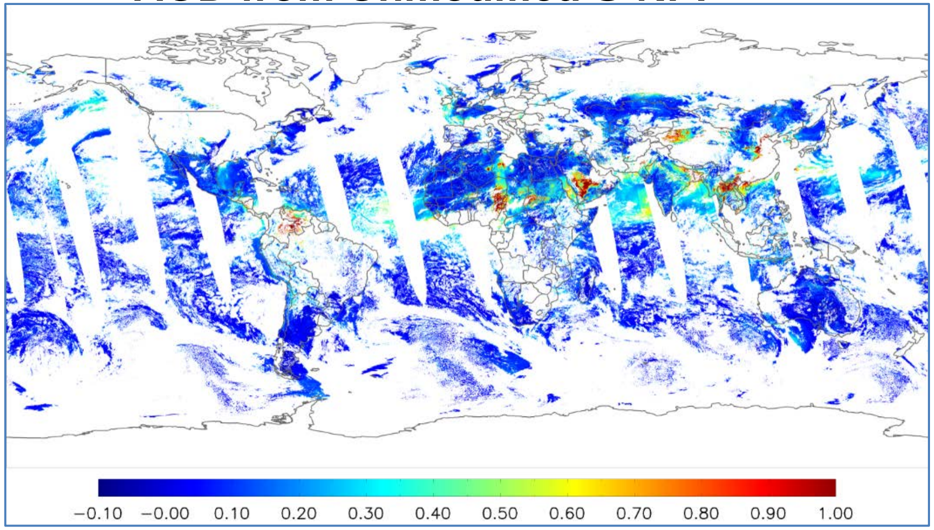
- VIIRS SDR Team: “NOAA-20 VIIRS observed reflectance is consistently lower than S-NPP for all RSBs.”

| M1 | M2 | M3 | M4 | M5 | M7 | M8 | M9 | M10 | M11 |
|---|---|---|---|---|---|---|---|---|---|
| -3% | -1.7% | -2.6% | -3.2% | -5% | -3.8% | -2.7% | -1.2% | -1.9% | -2.2% |

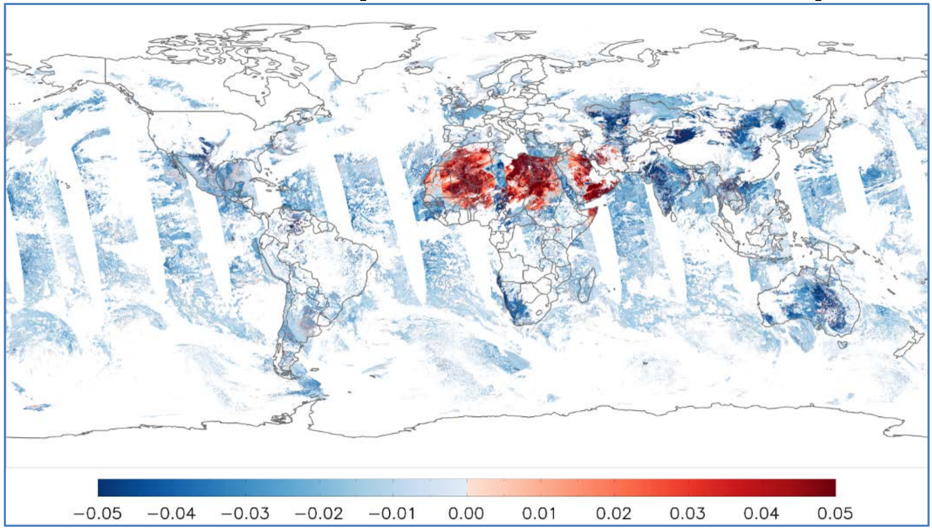
- Evaluation of the effect of NOAA-20 and S-NPP reflectance difference on AOD:
  - Selected one day (4/11/2019) S-NPP VIIRS measurements.
  - Changed S-NPP SDRs by suggested values.
  - Performed AOD retrievals with the original and modified reflectances.

# Calibration Effect on 550-nm AOD

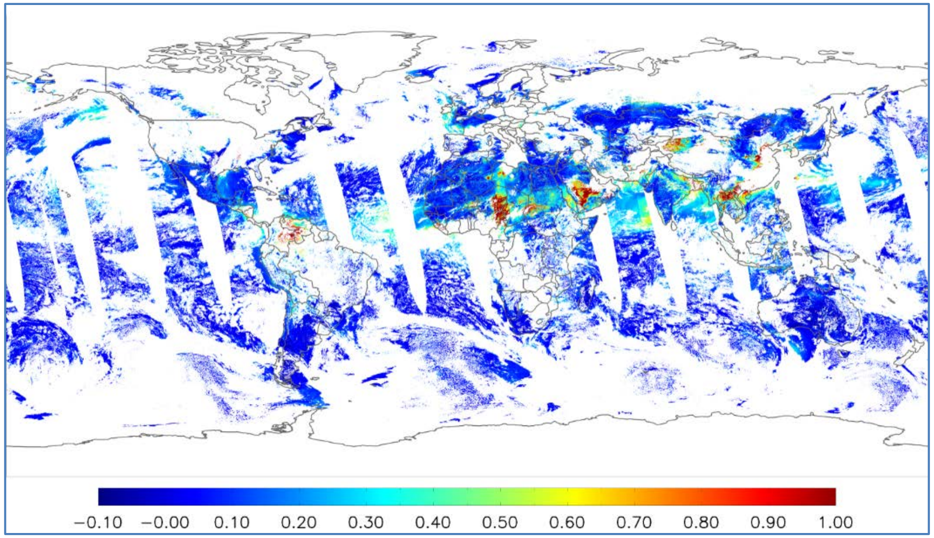
**AOD from Unmodified S-NPP**




**AOD Difference (Modified - Unmodified)**



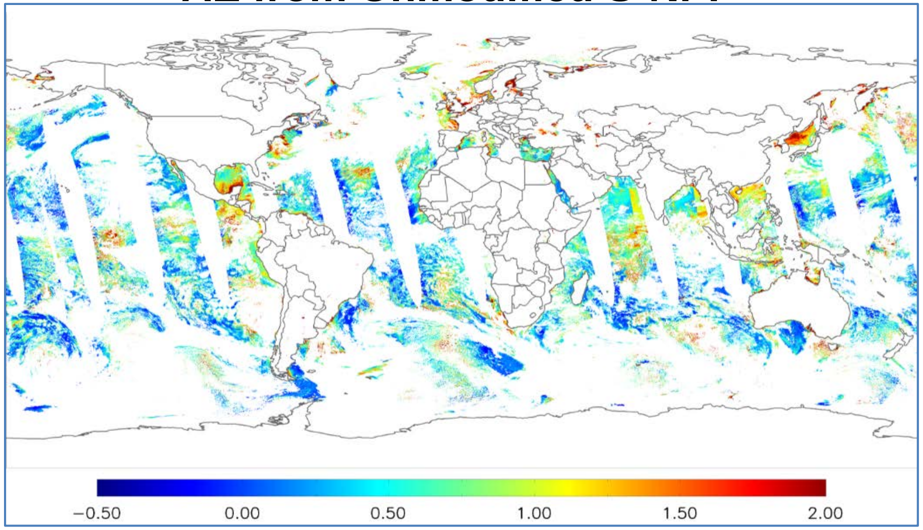

**AOD from Modified S-NPP**



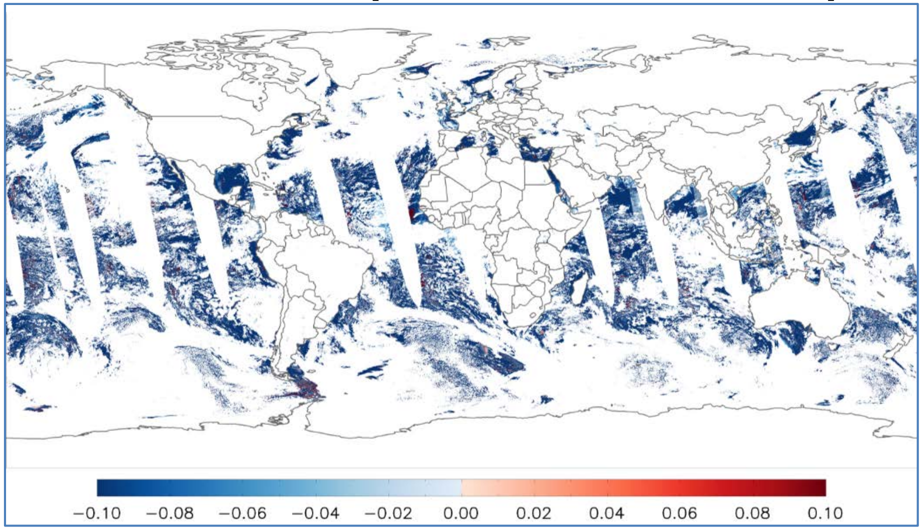

- Reduced spectral TOA reflectance leads to change in AOD:
  - -0.005 over land (but increase over bright surface)
  - -0.014 over water (consistent with the -0.016 global difference between NOAA-20 and S-NPP shown on slide 21)

# Calibration Effect on Angstrom Exponent AE (SW: 0.55 vs 0.86 µm)

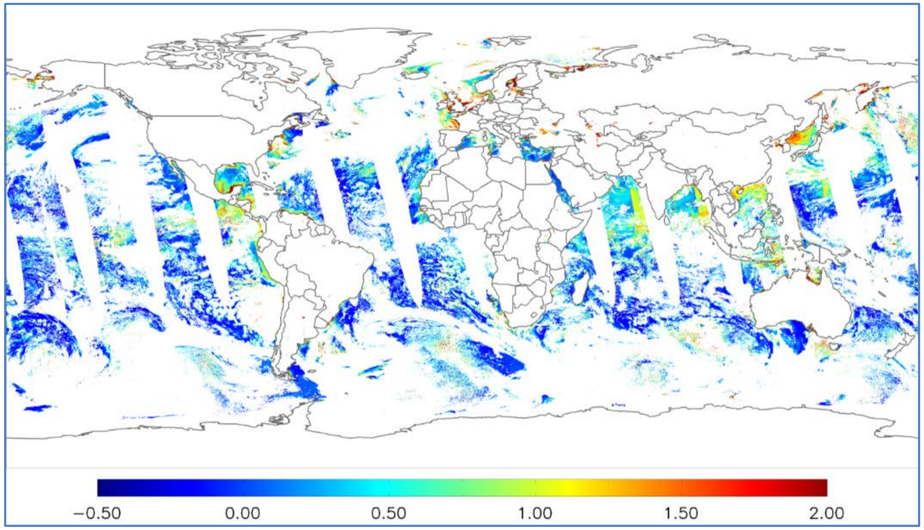
AE from Unmodified S-NPP




AE Difference (Modified - Unmodified)




AE from Modified S-NPP

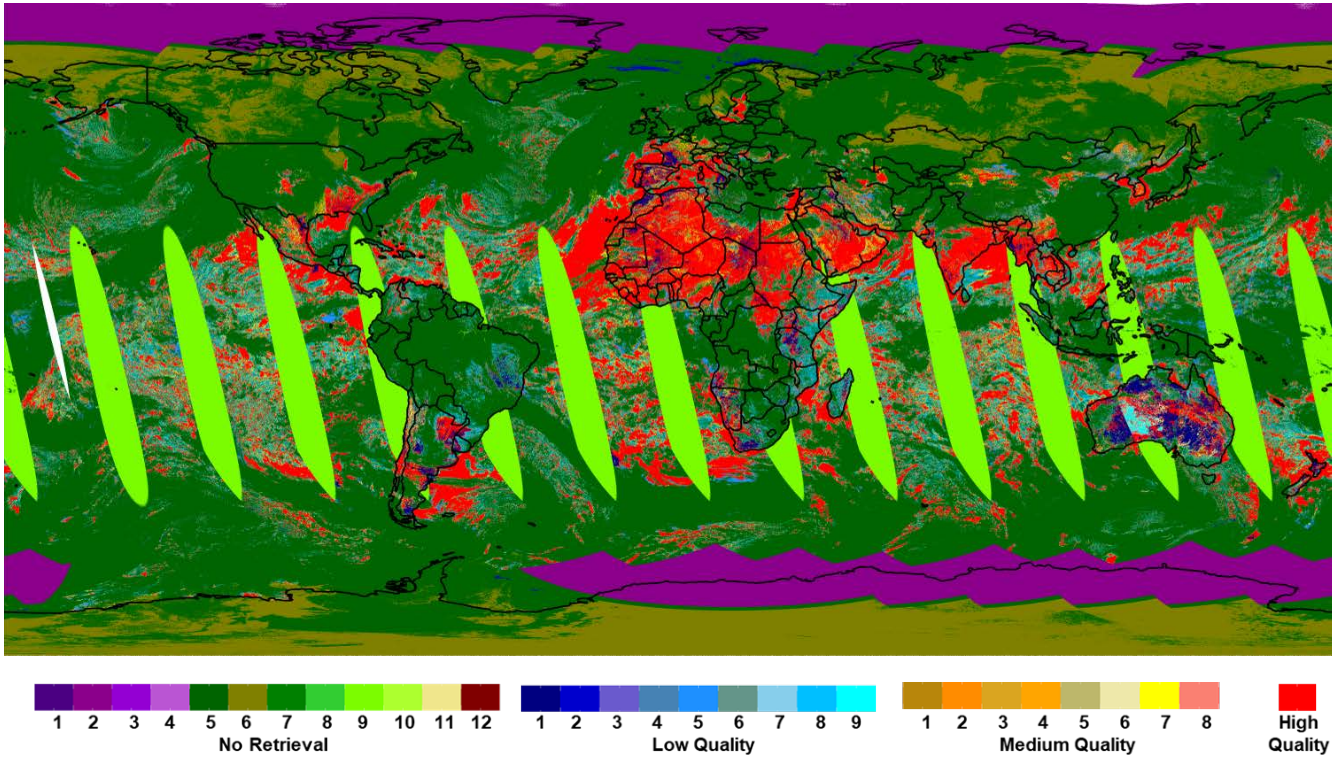



- Reduced spectral TOA reflectance leads to change in AE:
  - AE is very sensitive to spectral reflectance contrast leading to
  - -0.28 (global average) change in SW (0.55 vs 0.86 µm) AE.
  - -0.18 (global average) change in LW (0.86 vs 1.61 µm) AE. (Not shown.)

# Quality flag analysis/validation

- Defined Quality Flags
  - Five categories:
    - **QCExtn**: values of external input masks (cloud, cloud shadow, snow, fire, glint, heavy aerosol).
    - **QCInput**: quality of coordinates, geometry, ancillary data, reflectance and brightness temperature.
    - **QCTest**: results of internal tests for cloud, cirrus, thin cirrus, spatial variability, snow/ice, ephemeral and shallow water, and heavy aerosol.
    - **QCPath**: indicates retrieval is over water, over dark or bright land, SW or SWIR path is used.
    - **QCRet**: indicates quality of retrieval and associated condition (failed, large residual, extrapolation is used, adjacent to cloud or snow, SWIR NDVI and/or redness ratio is out of range).
- Detailed descriptions of QFs are in the "*EPS Aerosol Optical Depth (AOD) Algorithm Theoretical Basis Document*".

# Quality flags – Example for 2/13/2019




| No Retrieval | |
|---|---|
| 1 | Invalid longitude/latitude |
| 2 | Geometry not applicable |
| 3 | Missing model data |
| 4 | Missing reflectance |
| 5 | Cloudy |
| 6 | Snow/ice |
| 7 | Shallow water |
| 8 | Ephemeral water |
| 9 | Glint over water |
| 10 | Fire |
| 11 | No surface data over bright surface |
| 12 | Failed retrieval |

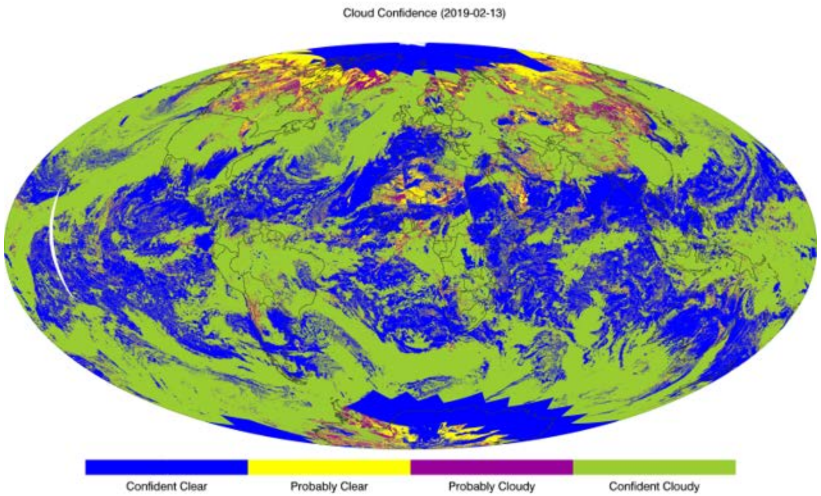
- **No retrievals**: majority is due to the presence of clouds.
- **Low/Medium quality**: high spatial variability of scenes is the main cause of degraded quality.

| Medium Quality | |
|---|---|
| 1 | Cloud shadow |
| 2 | Thin cirrus |
| 3 | Adjacent to cloud/snow |
| 4 | Barren dark land surface |
| 5 | NDVI out of range |
| 6 | Redness ratio out of range |
| 7 | Inhomogeneous scene |
| 8 | Large retrieval residual |

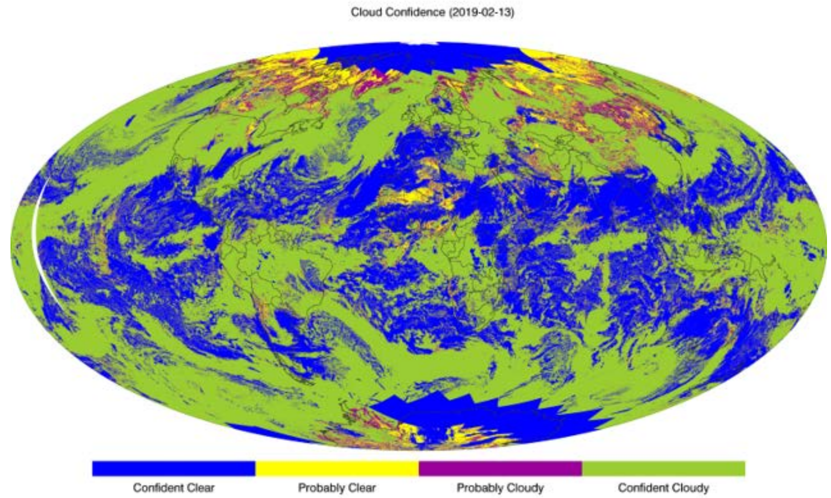
| Low Quality | |
|---|---|
| 1 | AOD out of range |
| 2 | Large solar zenith angle |
| 3 | Cloudy (internal test) |
| 4 | Cirrus (internal test) |
| 5 | Cloudy (ECM) |
| 6 | Coastal pixel |
| 7 | Extrapolation |
| 8 | Spatial inhomogeneous |
| 9 | Large retrieval residual |

# Quality flags – External Cloud Mask for 2/13/2019

**S-NPP**



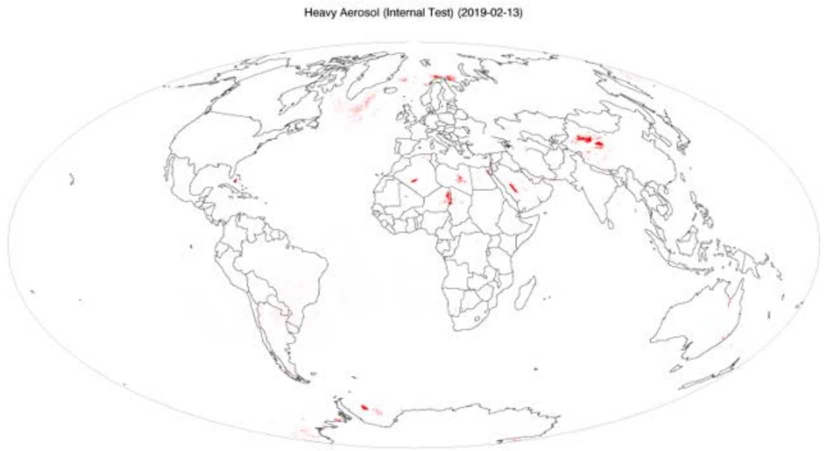

**NOAA-20**



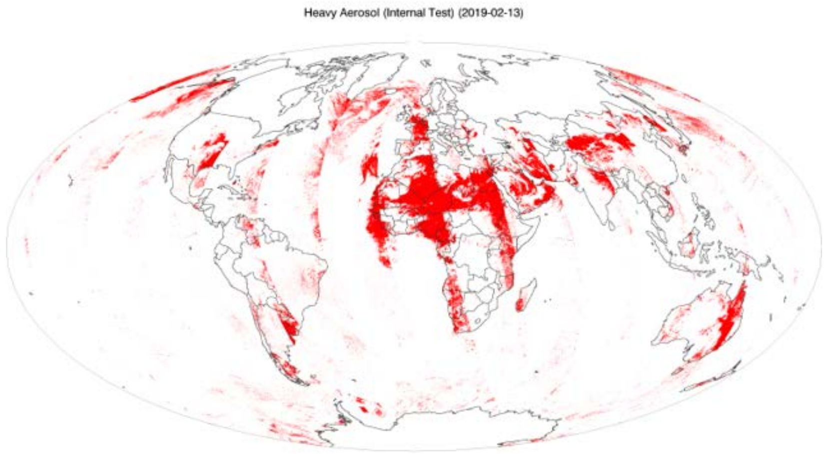

All NOAA-20 and S-NPP QFs are similar, except …

# Quality flags – Internal Heavy Aerosol for 2/13/2019

**S-NPP**



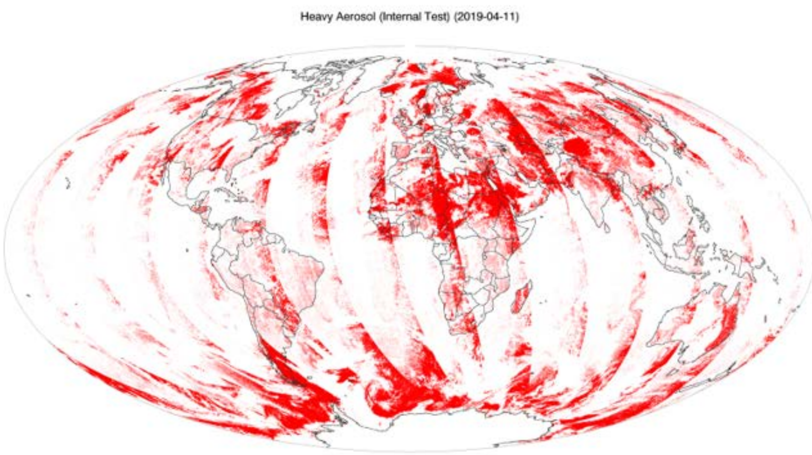

**NOAA-20**



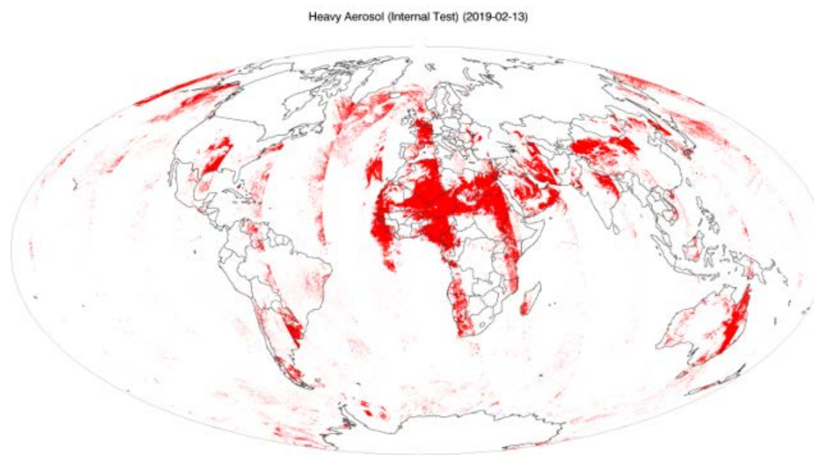

… flags of heavy aerosol indicated by internal tests are different. NOAA-20 heavy aerosol flag is incorrect.

# Quality flags – Internal Heavy Aerosol for 2/13/2019

## Reduced S-NPP




## NOAA-20




- Result of heavy-aerosol internal test with reduced S-NPP reflectances is similar to that from NOAA-20.
- Threshold in NOAA-20 heavy aerosol test must be revised.

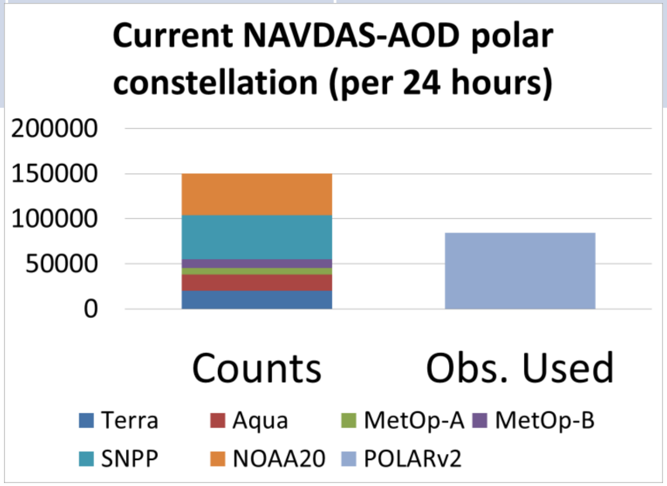
# Error Budget (available NOAA-20 NDE products)

| Attribute Analyzed - Accuracy | | L1RD Threshold | On-orbit Performance | Meet Requirement? | Additional Comments |
|---|---|---|---|---|---|
| AOD550 over Land | AOD550 <0.1 | 0.06 | -0.006 | Yes | |
| | 0.1 ≤ AOD550 ≤ 0.8 | 0.05 | -0.06<br>-0.04 | No (NDE)<br>Yes (offline) | Data of longer time period offline retrievals meet the requirement |
| | AOD550 > 0.8 | 0.20 | -0.17 | Yes | |
| AOD550 over Water | AOD550 < 0.3 | 0.08 | 0.003 | Yes | |
| | AOD550 ≥ 0.3 | 0.15 | -0.15 | Yes | |
| APS over water (0.55 vs 0.86 µm AE) | | 0.3 | -0.016 | Yes | |
| APS over water (0.86 vs 1.61 µm AE) | | 0.3 | 0.036 | Yes | |

| Attribute Analyzed - Precision | | L1RD Threshold | On-orbit Performance | Meet Requirement? | Additional Comments |
|---|---|---|---|---|---|
| AOD550 over Land | AOD550 <0.1 | 0.15 | 0.04 | Yes | |
| | 0.1 ≤ AOD550 ≤ 0.8 | 0.25 | 0.09 | Yes | |
| | AOD550 > 0.8 | 0.45 | 0.35 | Yes | |
| AOD550 over Water | AOD550 < 0.3 | 0.15 | 0.04 | Yes | |
| | AOD550 ≥ 0.3 | 0.35 | 0.11 | Yes | |
| APS over water (0.55 vs 0.86 µm AE) | | 0.6 | 0.40 | Yes | |
| APS over water (0.86 vs 1.61 µm AE) | | 0.6 | 0.36 | Yes | |

# User Feedback

| Name | Organization | Application | User Feedback<br>- User readiness dates for ingest of data and bringing data to operations |
|---|---|---|---|
| Edward J. Hyer | NRL | Assimilation of satellite-derived AOD in the Navy model (NAVDAS-AOD) for initialization. | Added NOAA-20 AOD to NRL system starting 04/08/2019.<br><br>Adding NOAA-20 on top of a 5-sensor constellation (2x MODIS + 2x AVHRR + SNPP VIIRS) increases the observation counts by 15%.<br><br>Qualitatively, the data look good.<br><br>Quantitative evaluation is pending. |



# Downstream Product Feedback

| Algorithm | Product | Downstream Product Feedback<br>- Reports from downstream product teams on the dependencies and impacts |
|---|---|---|
| Surface Reflectance | Surface Reflectance | Too few good-quality AOD retrievals available from the AOD algorithm. This “forces” the surface reflectance algorithm to use AOD climatology.<br>Overall, however, there are no major issues with AOD. |

*February 13, 2019*

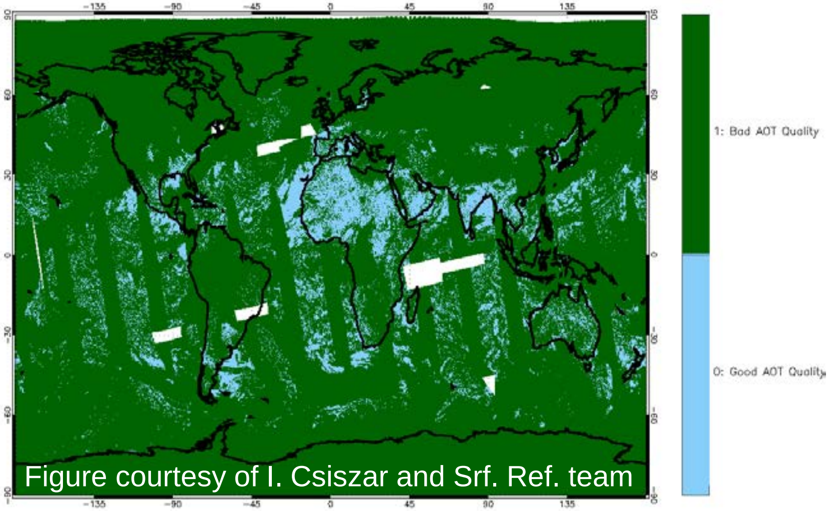


Figure courtesy of I. Csiszar and Srf. Ref. team

- VIIRS AOD product has 4 quality levels based on conditions that negatively impact or violate assumptions in AOD retrieval: no retrieval, low, medium and high quality.
- Surface Reflectance algorithm uses high-quality AOD as good.
- Aerosol team may revisit QF assignment to increase number of high-quality AOD.

# Risks, Actions, and Mitigations

- Risks/actions identified during the previous maturity review

| Identified Risk | Description | Impact | Action/Mitigation and Schedule |
|---|---|---|---|
| LUT | S-NPP LUT is used | Degraded accuracy. | CLOSED: NOAA-20 LUT had been implemented. |
| Metadata | Incorrect metadata averages | Incorrect mean values. | CLOSED: Calculation of metadata averages are corrected. |
| Missing granules | Frequent missing granules in NDE I&T | Missing product. | CLOSED: Starting around 2/1/2019 number of missing granules is greatly reduced. |
| Channel saturation | Saturation of channels (e.g., M6) is not properly indicated. | Degraded quality. | CLOSED (?) |
| Versioning | Version of algorithm, LUT, PCT, ancillary data, etc. are not captured in product file. | Hinders traceability of changes. | OPEN: Add version numbers to product file as metadata. |
| QC flags | QC flags are not grouped to indicate what conditions/tests contribute to quality levels. | Cannot easily identify conditions resulting in a given quality level. | OPEN: Re-group QC. On hold because it would require changes in AOD BUFR code. |

# Risks, Actions, and Mitigations

- New open risks/actions identified during preparation for validated maturity review

| Identified Risk | Description | Impact | Action/Mitigation and Schedule |
|---|---|---|---|
| PCT | AOD retrieval uses land-surface spectral reflectance relationships that were generated for S-NPP. | Errors in over-land AOD and APS. | Collect at least one-year of NOAA-20 TOA reflectances, and re-derive surface reflectance relationships. Dec 2019/Feb 2020. |
| Internal Test | AOD retrieval uses thresholds in internal tests of sea ice and heavy aerosol over water that were generated for S-NPP. | Misidentification. | Update thresholds in internal tests of sea ice and heavy aerosol over water. Mar 2020. |
| Bright-surface misidentification | When heavy aerosol is present over a dark pixel the internal test may incorrectly indicate bright surface but bright-surface relationship is not available for that pixel. | No retrieval. | Retrieve AOD using dark-surface relationship.<br>Next DAP (Jan 2020) |
| QF | Quality flag is needed to indicate when dark surface is misidentified as bright surface and dark-target retrieval is performed. | Incorrect retrieval path indicated. | Add flag to indicate dark-target retrieval is used for misidentified bright pixel.<br>Next DAP (Jan 2020) |

# Documentations (Check List)

| Science Maturity Check List | Yes ? |
|---|---|
| ReadMe for Data Product Users | Yes |
| Algorithm Theoretical Basis Document (ATBD) | Yes |
| Algorithm Calibration/Validation Plan | Yes |
| (External/Internal) Users Manual | Yes |
| System Maintenance Manual (for ESPC products) | Yes |
| Peer Reviewed Publications<br>(Demonstrates algorithm is independently reviewed) | Yes (S-NPP) |
| Regular  Validation Reports  (at least annually)<br>(Demonstrates long-term performance of the algorithm) | JPSS Annual Meeting |

# Check List - Validated Maturity

| Validated Maturity End State | Assessment |
|---|---|
| Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal). | Performance has been demonstrated globally, but for now only offline data covers all seasons. |
| 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. | Yes |
| Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose. | Yes (from offline results) |
| Product is ready for operational use based on documented validation findings and user feedback. | Yes, but only limited user feedback is available for now. |
| Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument. | Yes |

# Conclusion

- Cal/Val results summary:
  - NOAA-20 EPS AOD and AE meet requirements.
  - Quality of NOAA-20 EPS AOD and AE products wrt AERONET are similar to that from S-NPP.
  - The systematic difference between NOAA-20 and S-NPP global daily AOD over water can largely be attributed to differences in NOAA-20 and S-NPP SDRs.
  - Team recommends algorithm validated maturity
    - Caveats
      - Land surface spectral reflectance relationships and thresholds of internal tests must be updated based on NOAA-20 observations.

# Path Forward

- Planned improvements
  - Derive dark- and bright-land spectral surface relationships based on NOAA-20 measurements.
  - Update thresholds of internal tests (especially for detecting heavy aerosol) for NOAA-20.
  - Explore improving retrieval for urban surfaces if needed.
  - Explore improving seasonal and geometry dependence of surface reflectance relationships.
- Future Cal/Val activities / milestones
  - The team will continue assessing the performance of the NOAA-20 AOD product.
  - Prepare/test/evaluate first version of surface reflectance relationships updated for NOAA 20 (Dec 2019/Feb 2020).
  - Prepare/test/evaluate first version of internal test thresholds updated for NOAA-20 (Mar 2020).
  - Prepare LUTs, PCTs for J2 when J2 SRS available. (Lesson learned from NOAA-20 cal/val.)

# EXTRA SLIDES

# Accuracy and Precision

| Land | Req | N20 (NDE) | N20 (Local) | Matched | |
|---|---|---|---|---|---|
| | | | | N20 | NPP |
| **AOD550 < 0.1** | | | | | |
| **Accuracy** | 0.06 | -0.006 | 0.002 | -0.005 | -0.006 |
| **Precision** | 0.15 | 0.04 | 0.05 | 0.04 | 0.004 |
| **Number** | / | 3,676 | 13,661 | 3,556 | 3561 |
| **0.1 ≤ AOD550 ≤ 0.8** | | | | | |
| **Accuracy** | 0.05 | ***-0.06*** | -0.04 | ***-0.07*** | ***-0.06*** |
| **Precision** | 0.25 | 0.09 | 0.11 | 0.09 | 0.09 |
| **Number** | / | 3,150 | 15,698 | 2,962 | 2953 |
| **AOD550 > 0.8** | | | | | |
| **Accuracy** | 0.20 | -0.17 | -0.14 | -0.16 | -0.18 |
| **Precision** | 0.45 | 0.35 | 0.40 | 0.36 | 0.27 |
| **Number** | / | 225 | 8941 | 168 | 172 |
| **All** | | | | | |
| **Accuracy** | N/A | -0.04 | -0.03 | -0.04 | -0.03 |
| **Precision** | N/A | 0.10 | 0.11 | 0.09 | 0.09 |
| **Number** | / | 7,051 | 30,309 | 6,686 | 6,686 |

NOAA-20 EPS products meet the requirements

- Except the NDE land AOD at mid-value range
- Longer time period product (local retrievals) meet the requirement at the mid-value range

| Water | Req | N20 (NDE) | N20 (Local) | Matched | |
|---|---|---|---|---|---|
| | | | | N20 | NPP |
| **AOD550 < 0.3** | | | | | |
| **Accuracy** | 0.08 | 0.003 | 0.009 | -0.0002 | 0.01 |
| **Precision** | 0.15 | 0.04 | 0.04 | 0.04 | 0.03 |
| **Number** | | 1,532 | 5,296 | 1,095 | 1,095 |
| **AOD550 ≥ 0.3** | | | | | |
| **Accuracy** | 0.15 | -0.05 | -0.02 | -0.04 | -0.04 |
| **Precision** | 0.35 | 0.11 | 0.12 | 0.09 | 0.10 |
| **Number** | | 110 | 514 | 43 | 43 |
| **All** | | | | | |
| **Accuracy** | | -0.001 | 0.006 | -0.002 | 0.01 |
| **Precision** | | 0.05 | 0.05 | 0.04 | 0.04 |
| **Number** | | 1,642 | 5,810 | 1,138 | 1,138 |
| **Ångström Exponent (0.55 vs 0.86 μm)** | | | | | |
| **Accuracy** | 0.3 | -0.016 | -0.022 | -0.001 | 0.025 |
| **Precision** | 0.6 | 0.40 | 0.43 | 0.33 | 0.33 |
| **Number** | | 353 | 1,656 | 216 | 258 |
| **Ångström Exponent (0.86 vs 1.61 μm)** | | | | | |
| **Accuracy** | 0.3 | 0.036 | 0.006 | 0.052 | -0.060 |
| **Precision** | 0.6 | 0.36 | 0.36 | 0.36 | 0.38 |
| **Number** | | 210 | 874 | 93 | 112 |