GOES-R
Advanced Baseline Imager (ABI) Aerosol Optical Depth (AOD) algorithm and product status

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Outline

- ABI aerosol optical depth (AOD) algorithm

- ABI AOD product file

- ABI Scenes, Modes and Fixed Grid

- Beta results

- Path forward

- Summary

- Useful documents

Aerosol Optical Depth

- A measure of extinction of radiation due to aerosols in a vertical column of air from surface to top of atmosphere

- Depends on
  - amount (number/volume concentration)
  - size (size distribution) and shape
  - chemical makeup (complex refractive index)
  - wavelength of radiation

- For same concentration and layer thickness AODs of different aerosol types differ
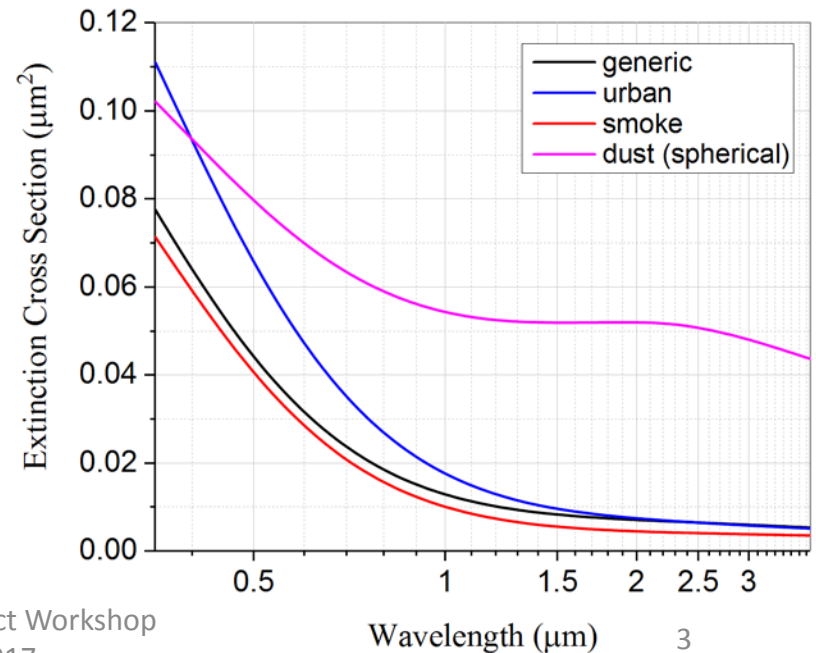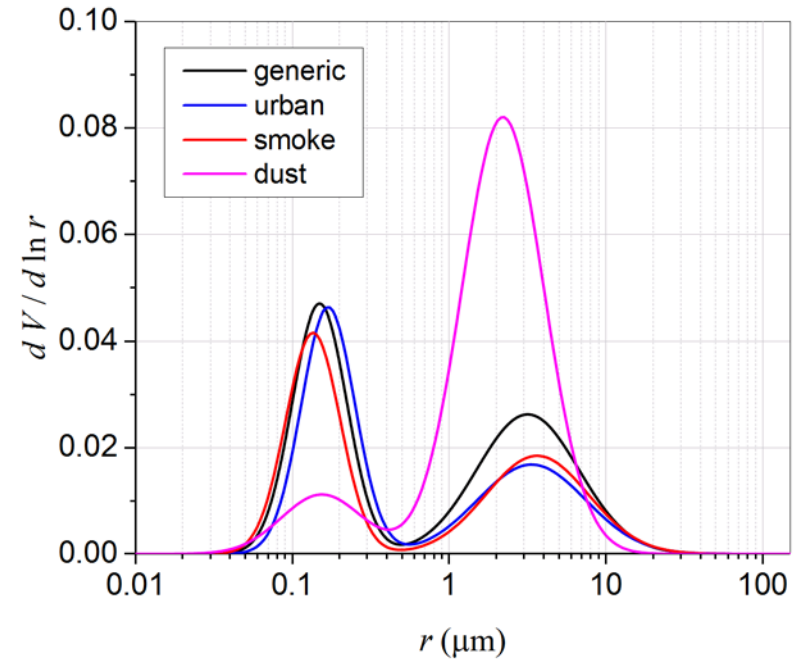
GOES-R AOD Algorithm (1)

- MODIS and early VIIRS heritage.

- **Retrieves AOD and aerosol type simultaneously by comparing reflectances calculated for varying AOD and set of discrete aerosol models with reflectances observed at multiple wavelengths.**

  - Water: 4 fine and 5 coarse mode models; surface contribution is calculated.

  - Land: generic, dust, smoke and urban models; surface contribution (reflectance) is retrieved using the MODIS dark-target approach.

  - Surface reflectance relationships for vegetation and soil.

- **No retrieval for bright land or sun glint (specular reflection).**

OBSERVATION

Solution with residual

Candidate Solutions

- Developed with MODIS proxy

  - *LUT, gas absorption parameterization, NIR-to-red/blue surface reflectances are for MODIS not ABI !*

  - *No internal tests for "bad" pixels*

- Delivered to GOES-R prime contractor (Harris) in 2008-2010 (!)

- Currently implemented in GOES-R Ground System (GS)

Scenes and Scan Modes

- **Full Disk** (near hemispheric coverage)
- **CONUS** (~3000 km x 5000 km region covering the contagious US)
- **Mesoscale*** (1000 km x 1000 km dynamically centered)

Approximate Pixel Area (Nominally 1km at Nadir) from -75.0 West

Mesoscale box locations are movable

Flex Mode (mode 3)

Courtesy of Tim Schmit and Mat Gunshor

Scan Mode 3 (Flex Mode)
- In 15 min:
  - 1 FD +
  - 3 CONUS (every 5 min) +
  - 30 Mesoscale (every 30 sec)

Scan Mode 4 (Continuous Full Disk mode)
- In 5 min:
  - 1 Full Disk

Scan Mode 6
- In 10 min:
  - 1 Full Disk +
 - 2 CONUS +
  - 20 Mesoscale
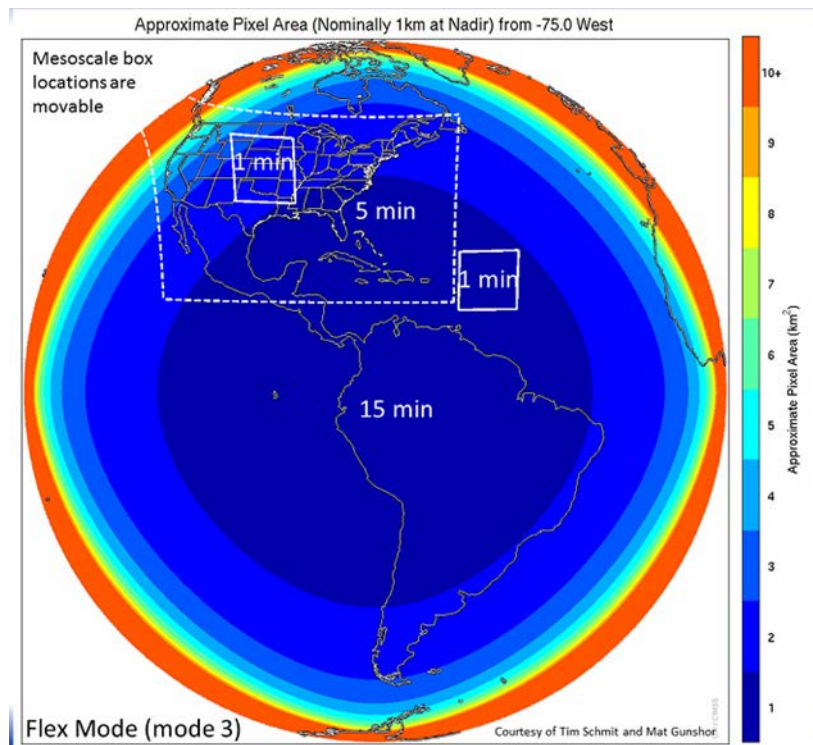
*No AOD product

ABI Fixed Grid

- Projection is based on the viewing perspective of an idealized location of the satellite.

- Data points have the same angular separation from the satellite's sub-point in both east to west and north to south directions: 14 µrad=0.5 km , 28 µrad=1 km , **56 µrad= 2 km**.

- Cartesian coordinate system: x axis = E/W scan angle, y axis = N/S scan angle, origin = satellite sub-point (y = 0, x = 0).
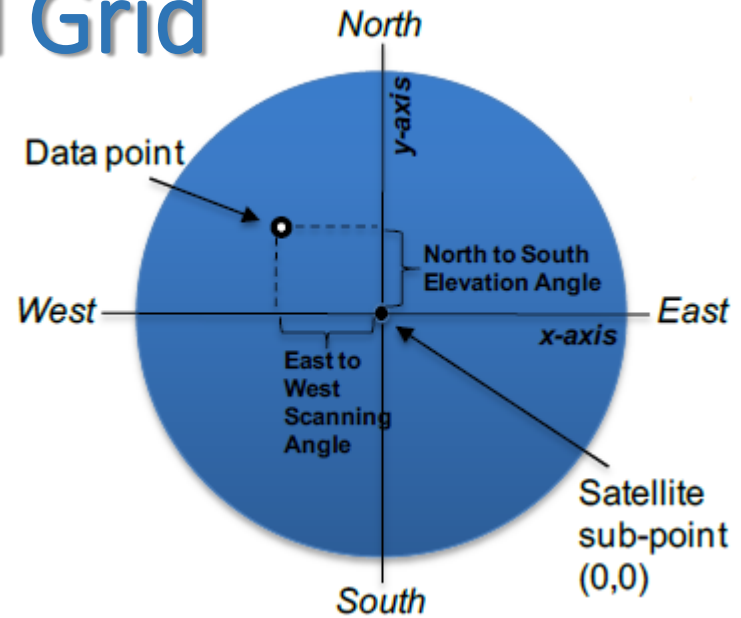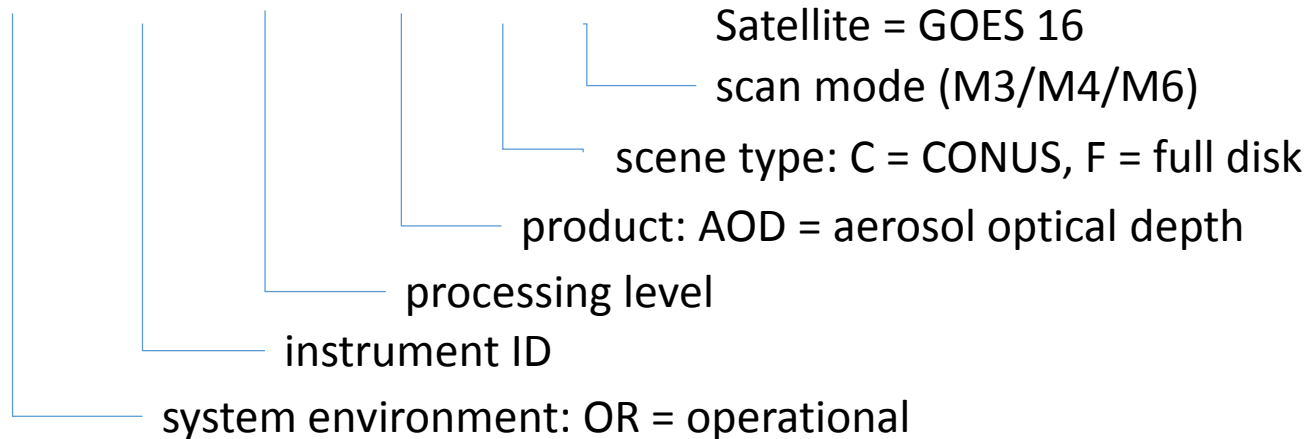

ABI L1b Radiances (Ch 3)
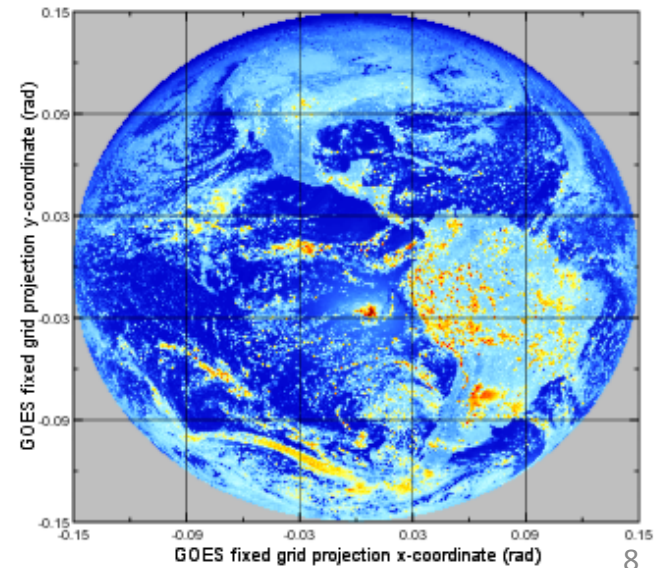
AOD File Naming Convention

- File name: OR_ABI-L2-AODC-M3_G16_ sYYYYDDDHHMMSST_eYYYYDDDHHMMSST_ cYYYYDDDHHMMSST.nc

- OR_ABI-L2- AODC-M3_G16_...

Satellite = GOES 16

scan mode (M3/M4/M6)

scene type: C = CONUS, F = full disk

product: AOD = aerosol optical depth

processing level

instrument ID

system environment: OR = operational

s = start date and time, **e** = end date and time, **c** = creation date and time
YYYY = year, **DDD** = day of year, **HH** = hour, **MM** = minute, **SS** = second, **T** = tenth od second

AOD Product

- **Spatial resolution: 2 km (nominal)**
- **Temporal resolution: M3: 15 min FD, 5 min CONUS; M4: 5 min FD (CONUS extracted from FD); M6: 10 min FD, 5 min CONUS**
- **AOD file content:**
  - 550-nm Aerosol Optical Depth for Full Disk and CONUS in range -1 to +5 over land and sea
  - Quality flag (0=good; 1=bad)
  - Mean, max and min of 550-nm AOD over land and sea
  - Mean, max and min of spectral AOD over land and sea (for bands used in the retrieval)
  - Standard deviation of 550-nm AOD over land and sea
  - 10-deg zonal mean values
- **Products are in netCDF 4 files. Most data are packed; use scale factor and offset to unpack.**
- **No lat/lon data in file.**

AOD Product Status

- **In Beta maturity status since May 24, 2017**
  - Beta product is minimally validated and may still contain significant errors; not recommended for operational use.

- Will be available from NOAA's Comprehensive Large Array-Data Stewardship System (CLASS) at https://www.class.ncdc.noaa.gov (access is restricted as of now)

- Look for "GOES-R Series ABI Products GRABIPRD (partially restricted L1b and L2+ Data Products)" - GOES-R ABI Products and Product type AOD

AOD M3 Full Disk May 1, 2017 17:30 UTC (Test position 89.5 W)

Aerosol Optical Depth at 550nm

2017121 1730

−0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Aerosol Optical Depth at 550nm

# of Retrievals	3840527
MAX	4.999
MIN	−0.724
MEAN	0.193
STD	0.240
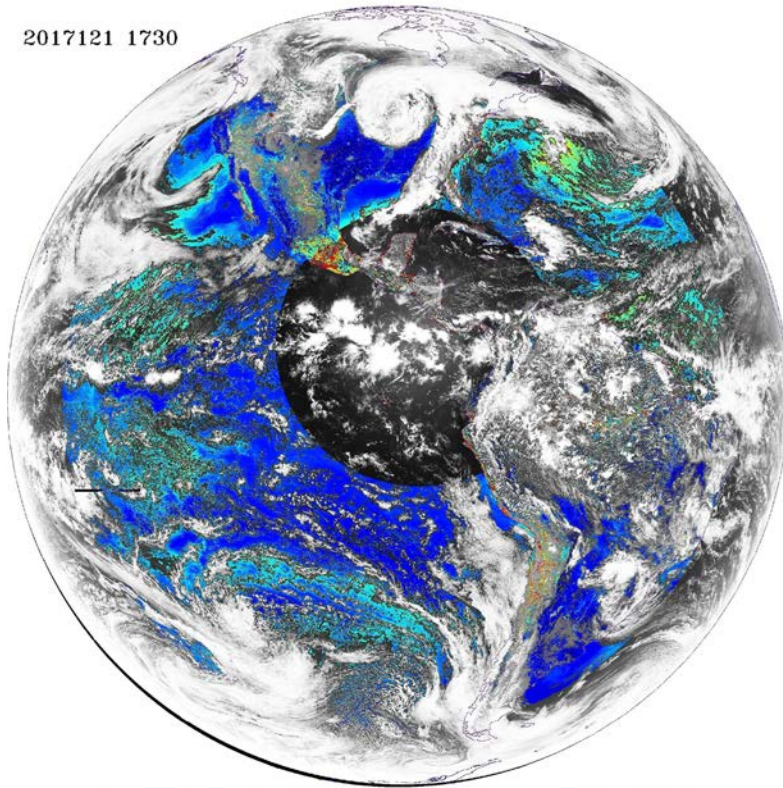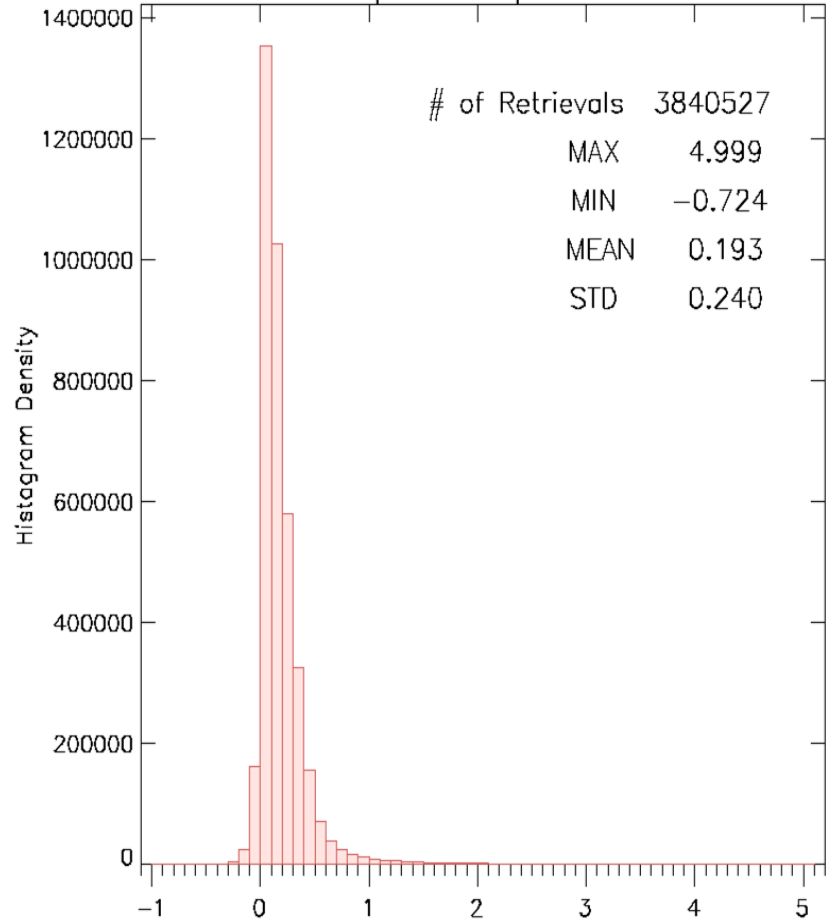
AOD retrievals are available except when inputs are missing, cloud or snow is present, or in sunglint region. 550-nm AODs are within expected range.

NOAA Satellite Aerosol Product Workshop September 25-26, 2017
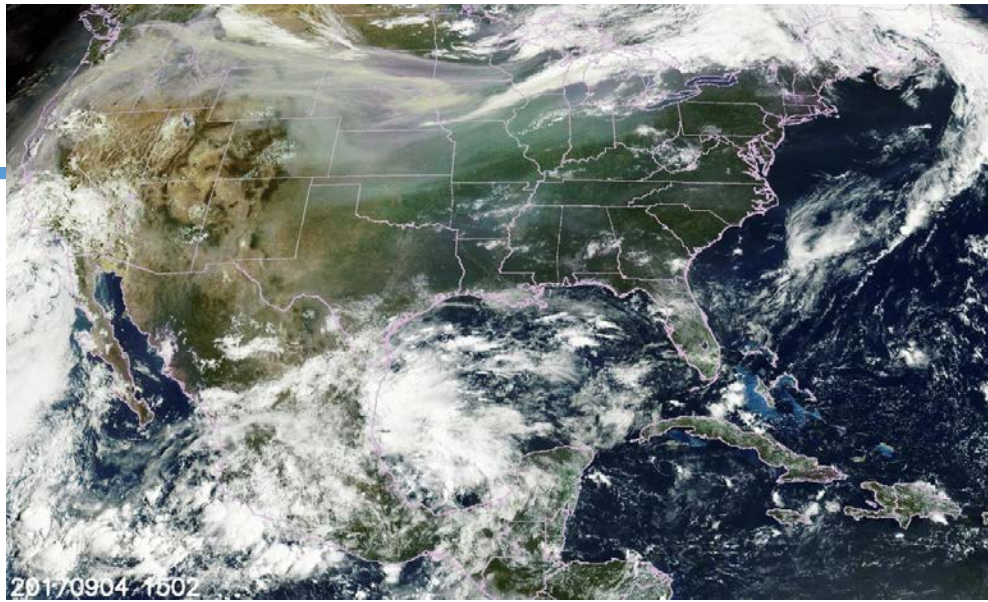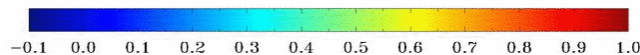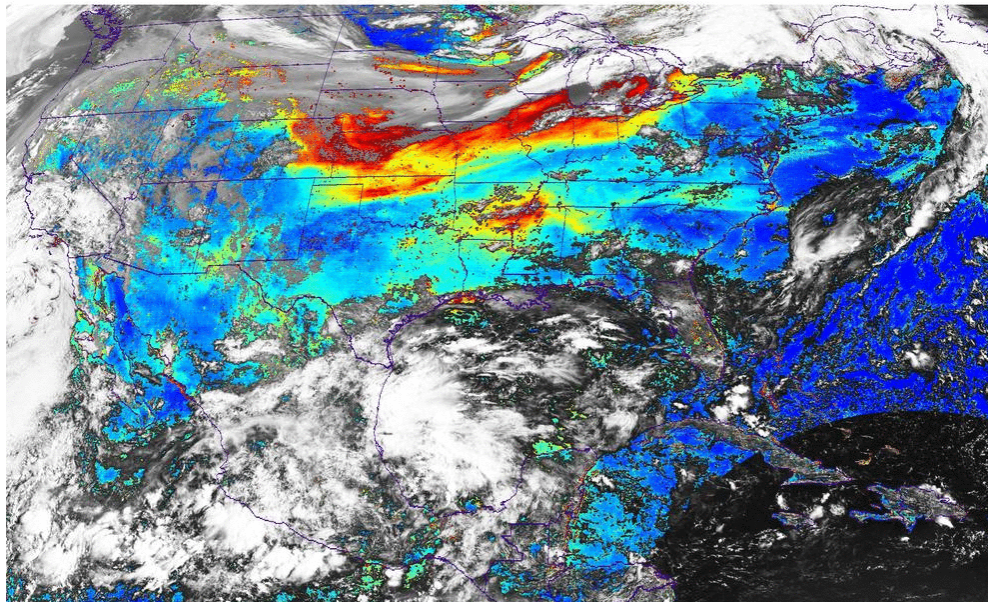
Smoke-case Sep 4, 2017, CONUS

Synthetic RGB

550-nm AOD

Aerosol Optical Depth at 550nm

These GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.
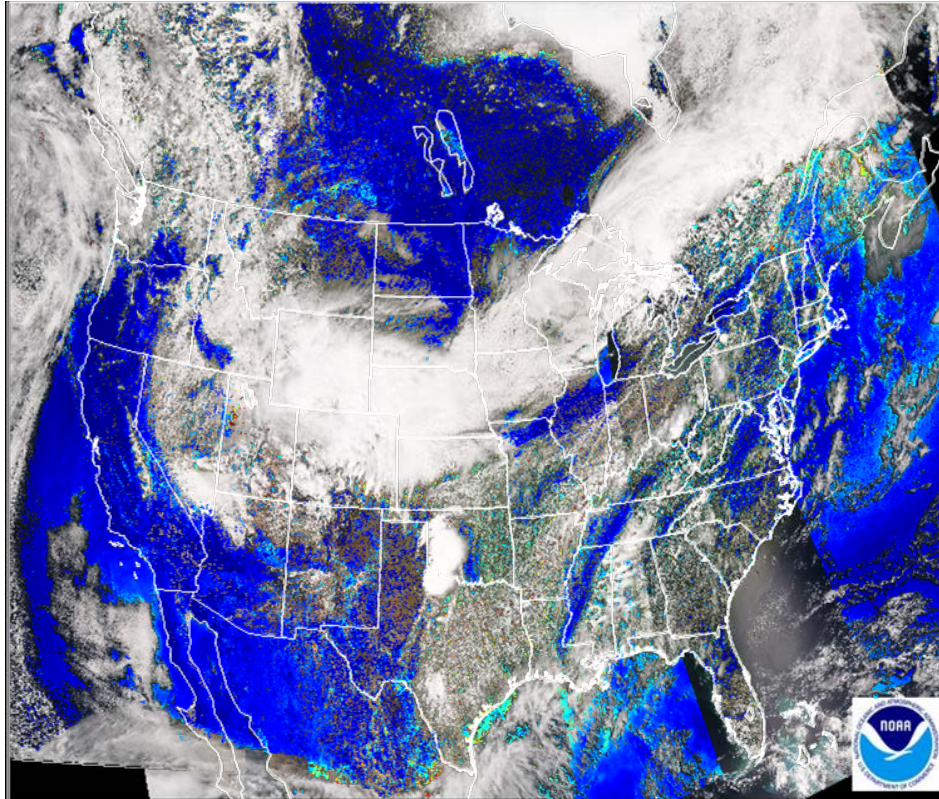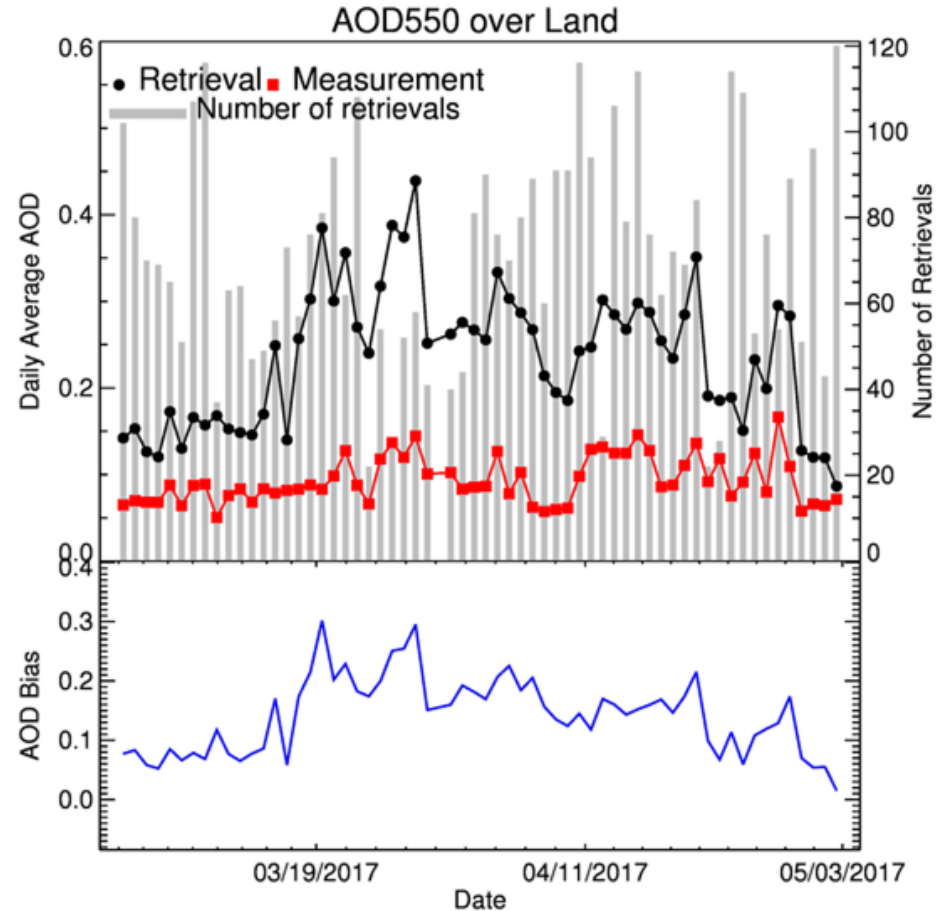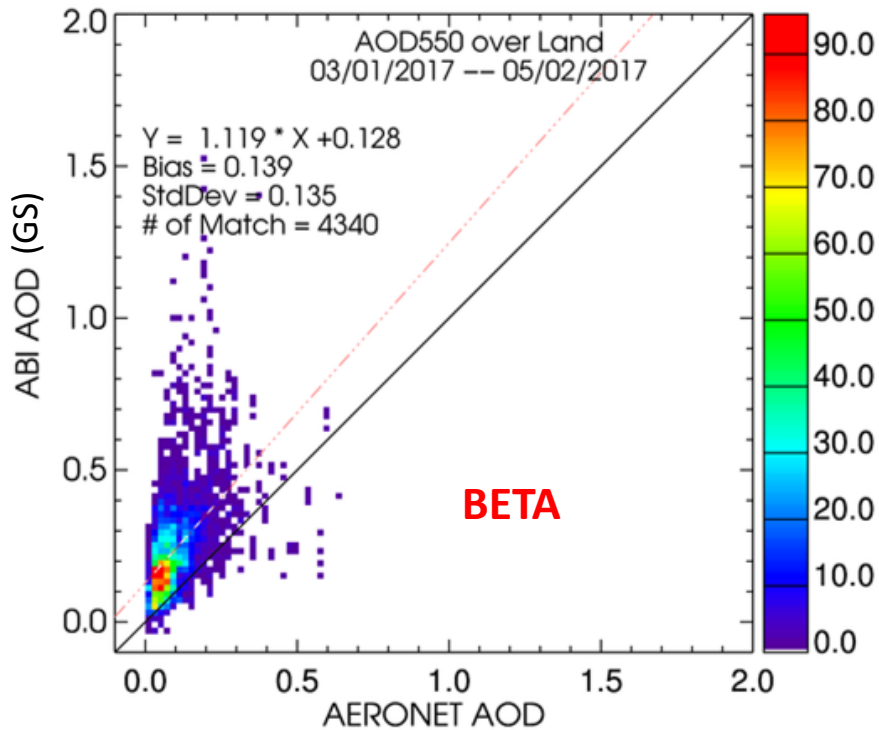
VIIRS vs. ABI AOD Image Comparison
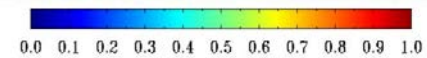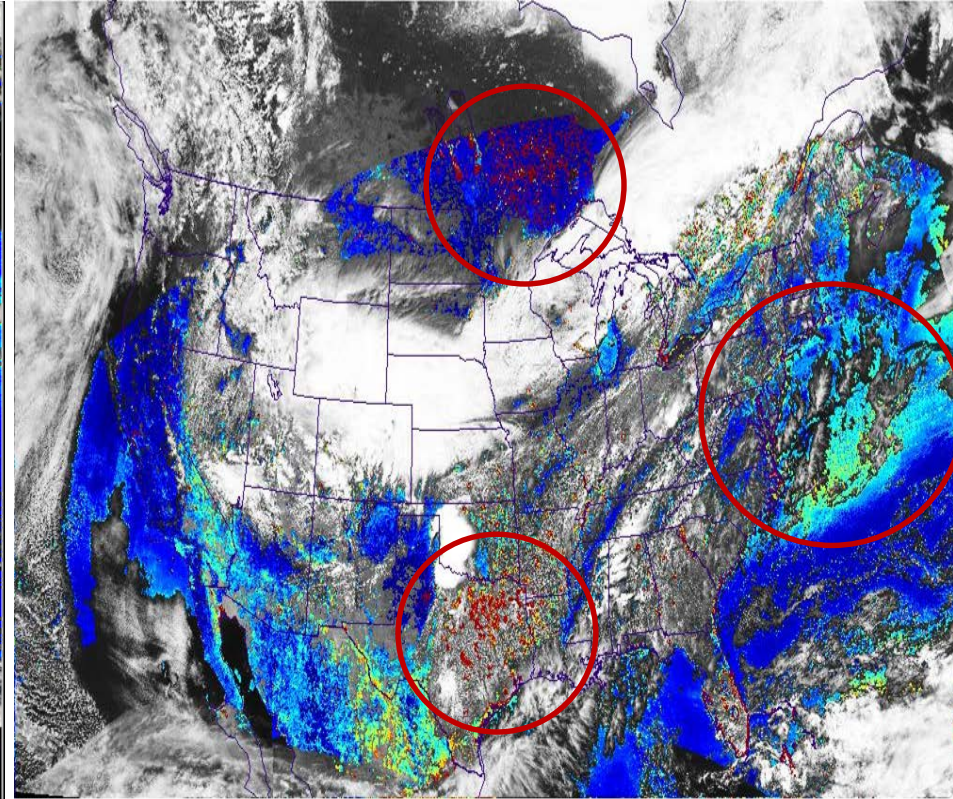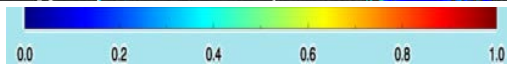
These GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.
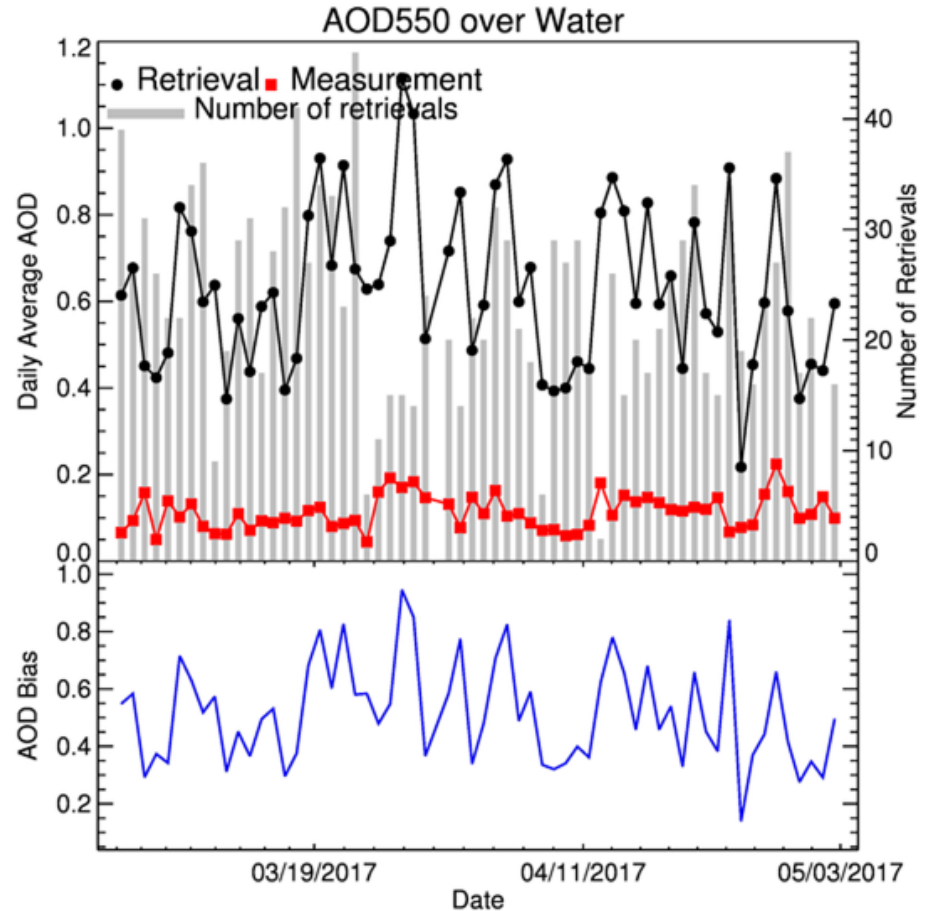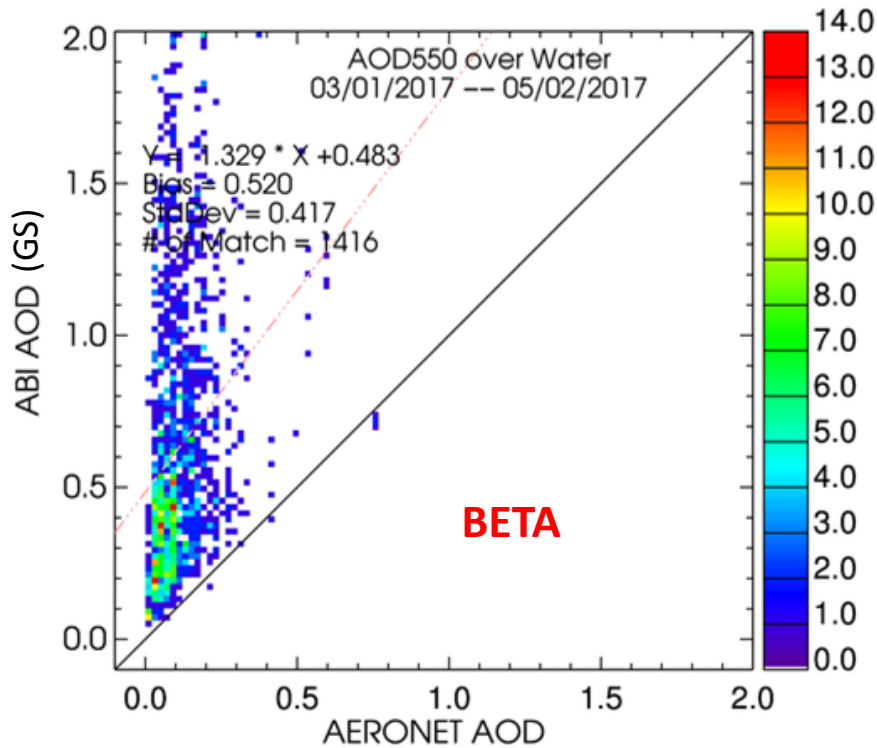
Evaluation with AERONET - Land

Possible contributors to AOD over-estimation: non-ABI LUT, gas coefficients, surface reflectance relationships; large reflectances due to solar calibration anomaly between ~03/15 -04/28. Daily mean AOD bias decreased after calibration correction on April 28.
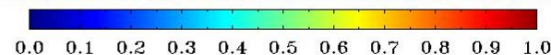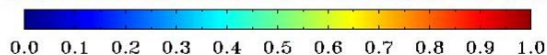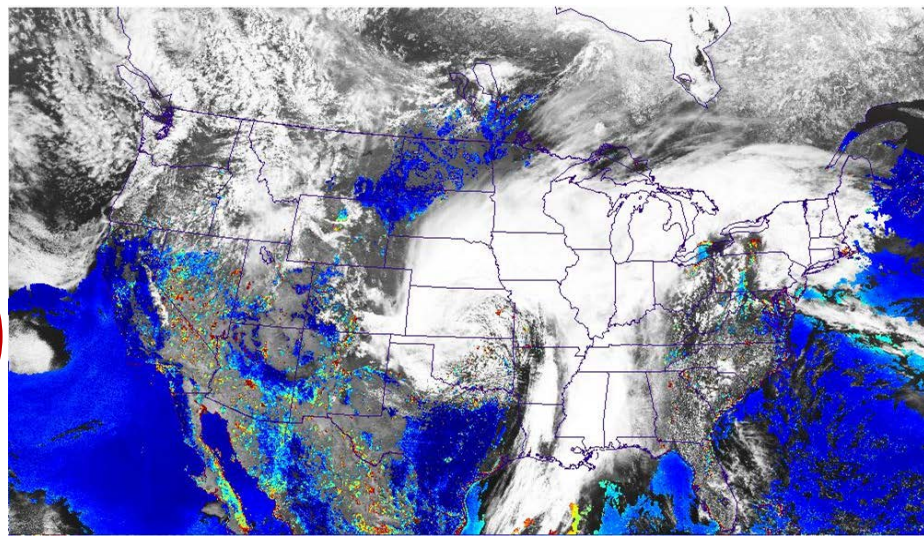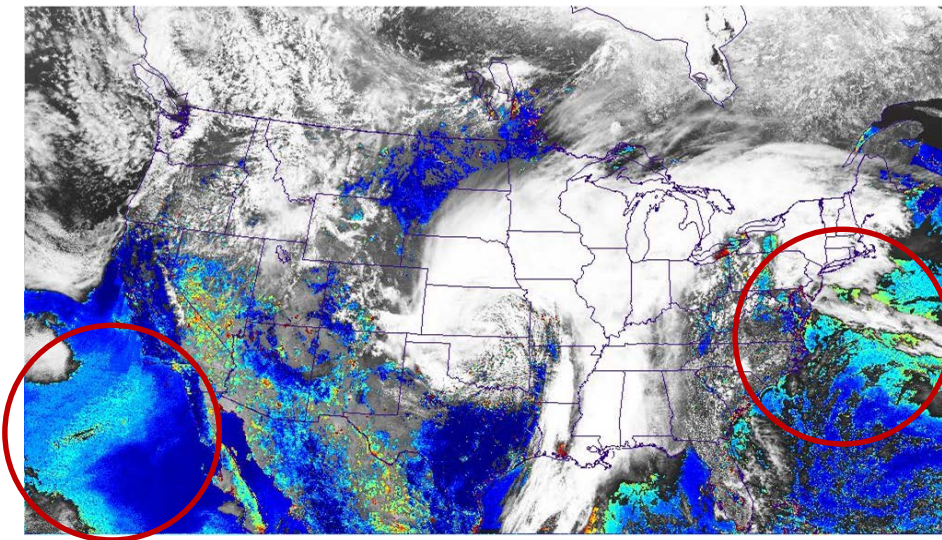
Evaluation with AERONET - Water

Unexpected large over-estimation of AOD over water.
Possible error sources: same as for land, but not sufficient to explain large bias.

Day 04/30/2017

GS ABI 1845 UTC

ST ABI 1845 UTC

GS and local ST AODs differ, especially over water at highlighted areas. Assuming algorithms are the same (!) differences must be due to differences in some of the inputs (ancillary data ?).

These GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.

Path Forward – Ongoing Work

- Updated baseline algorithm:
  - Update of ABI LUT, channel-related coefficients; surface relationships
  - Implement internal tests for detection of cloud, snow, ice, shallow water, etc. pixels.

- Need to derive solar & view angle dependent surface reflectance relationships (need large amount of data)

- ST goal is to switch algorithm from Baseline to "Enterprise (EPS)" (AOD over snow-free bright surface; more extensive internals tests, etc.)
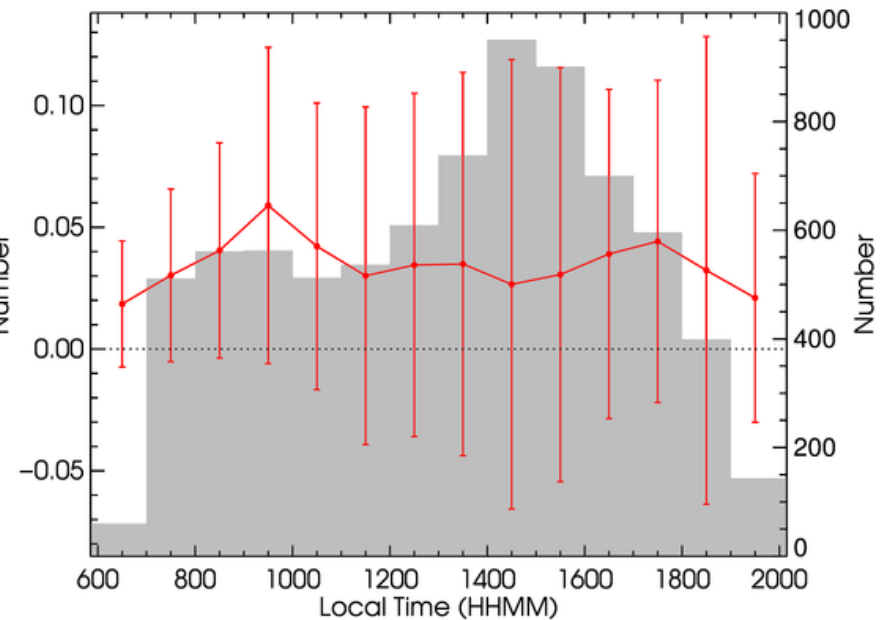
Evaluation of AOD from updated algorithm with AERONET

Over Land
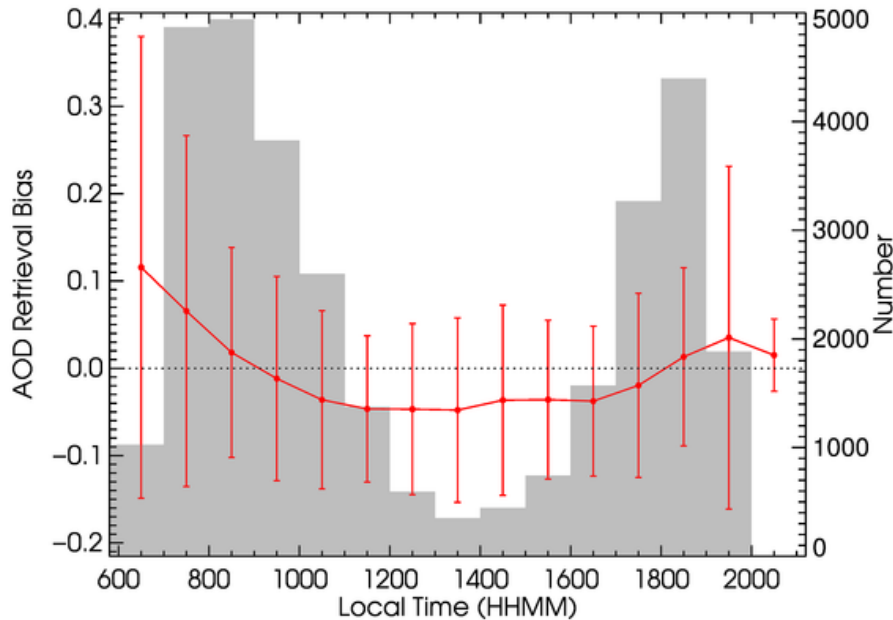
Over Water

- ABI-AERONET difference for 04/29/2017 – 07/25/2017
- ABI AOD is from Updated baseline algorithm: ABI LUT, coefficients and land surface relationship
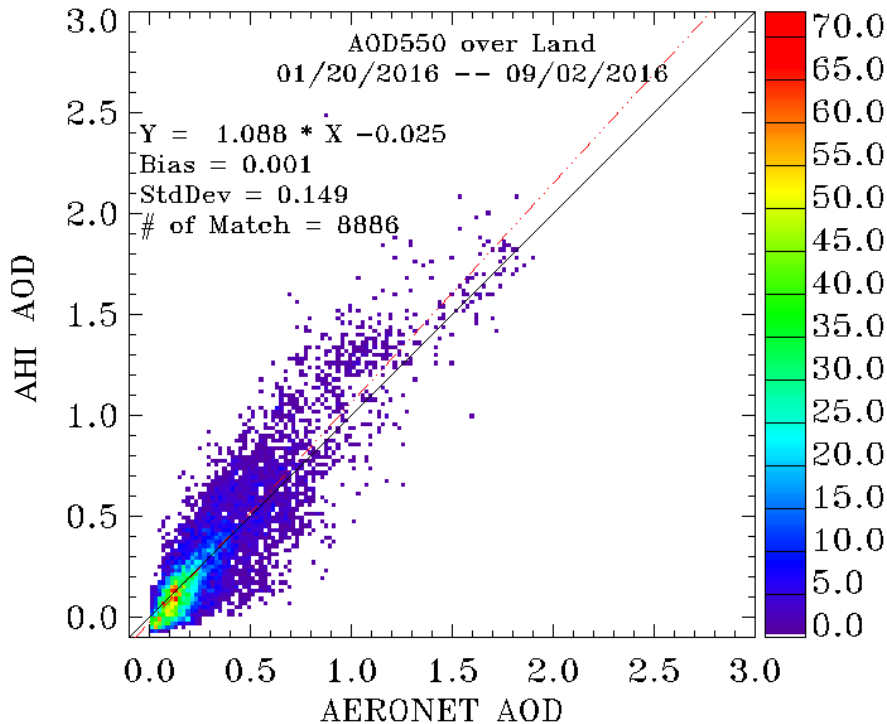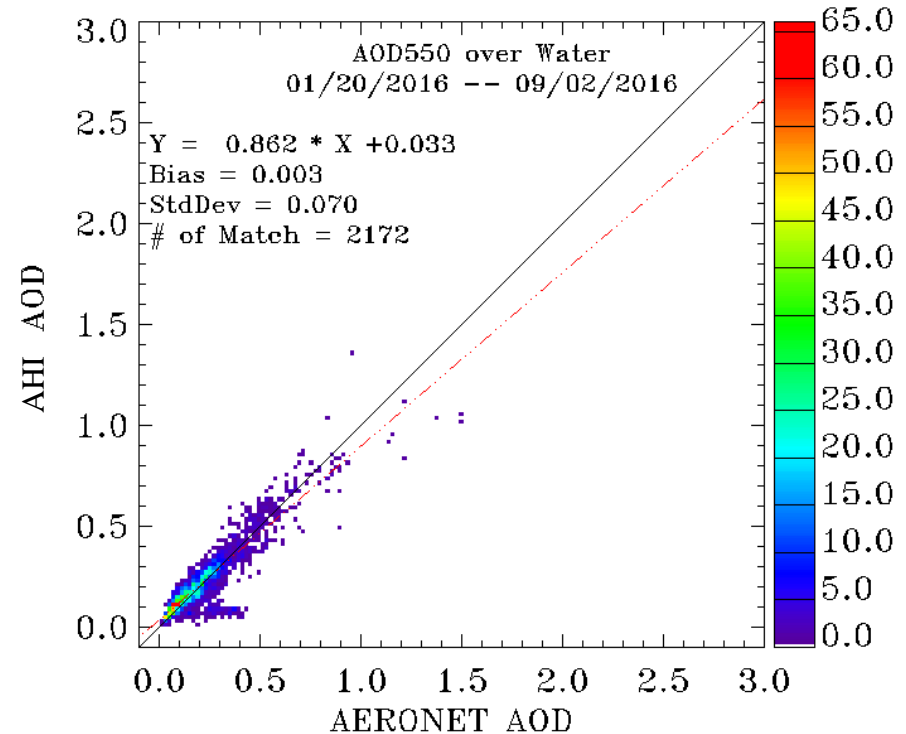- Bias depends on local time (solar and view angles) over land

AHI AOD vs. AERONET

Over Land

(high+medium quality)

Over Water

(high quality+shallow water)

AOD550 over Land
01/20/2016 -- 09/02/2016

$Y = 1.088 * X - 0.025$
Bias = 0.001
StdDev = 0.149
# of Match = 8886

AOD550 over Water
01/20/2016 -- 09/02/2016

$Y = 0.862 * X + 0.033$
Bias = 0.003
StdDev = 0.070
# of Match = 2172

- Updated baseline algorithm applied to AHI on Himawari-8. AHI-specific LUT, parameters. Internal tests.
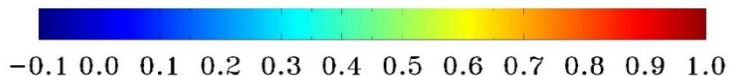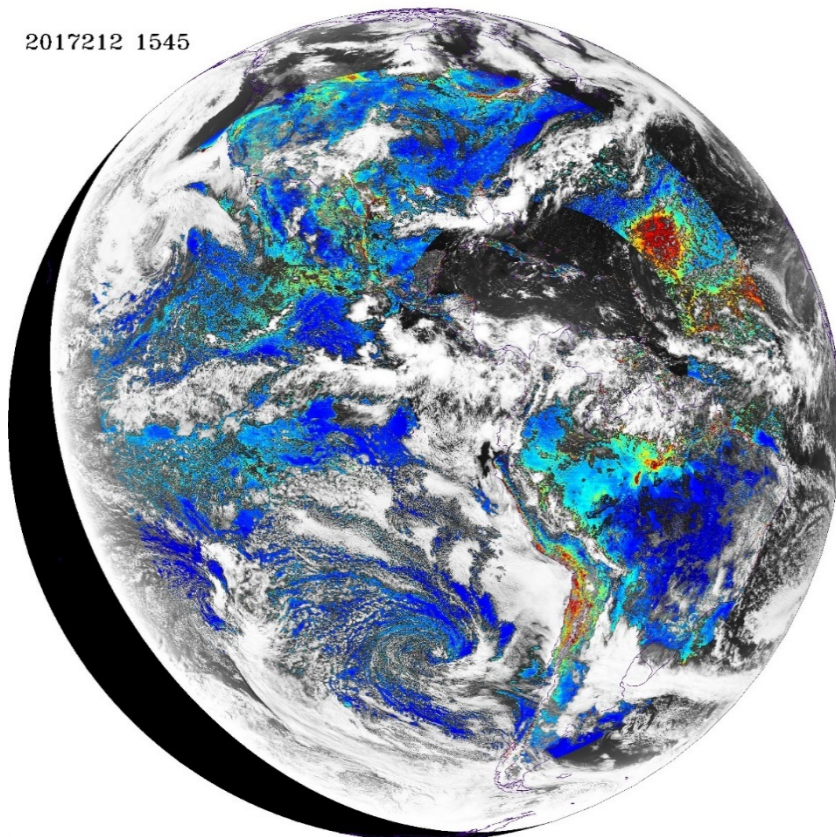
GS vs. Updated Baseline AOD Images

GS Good Quality
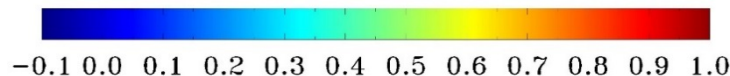
Aerosol Optical Depth at 550nm

2017212 1545

Updated Baseline High Quality

Aerosol Optical Depth at 550nm

2017212 1545

−0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
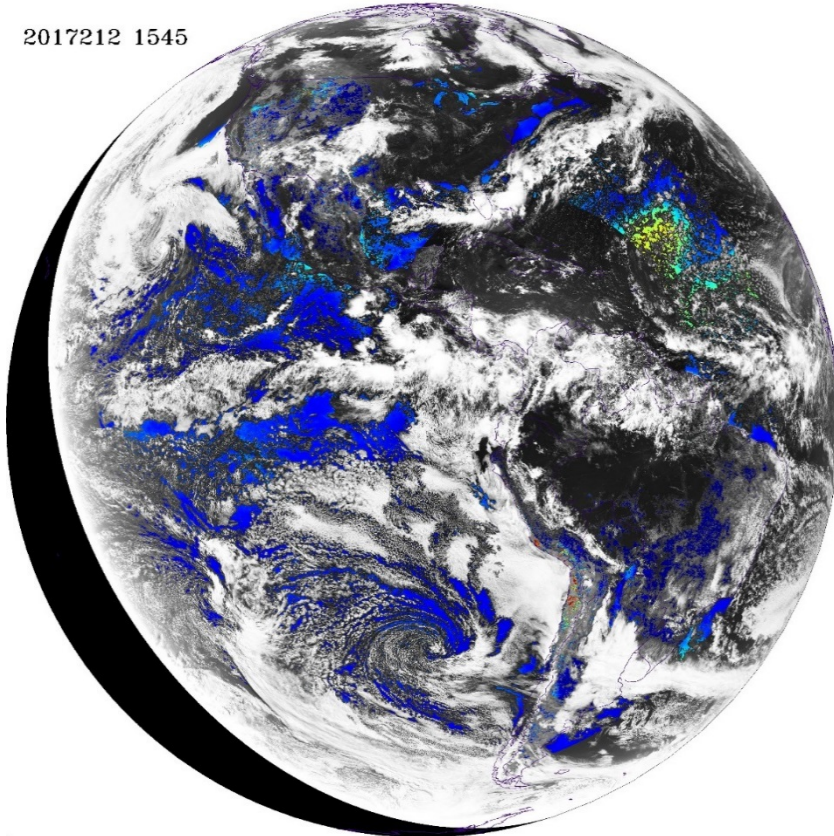
−0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
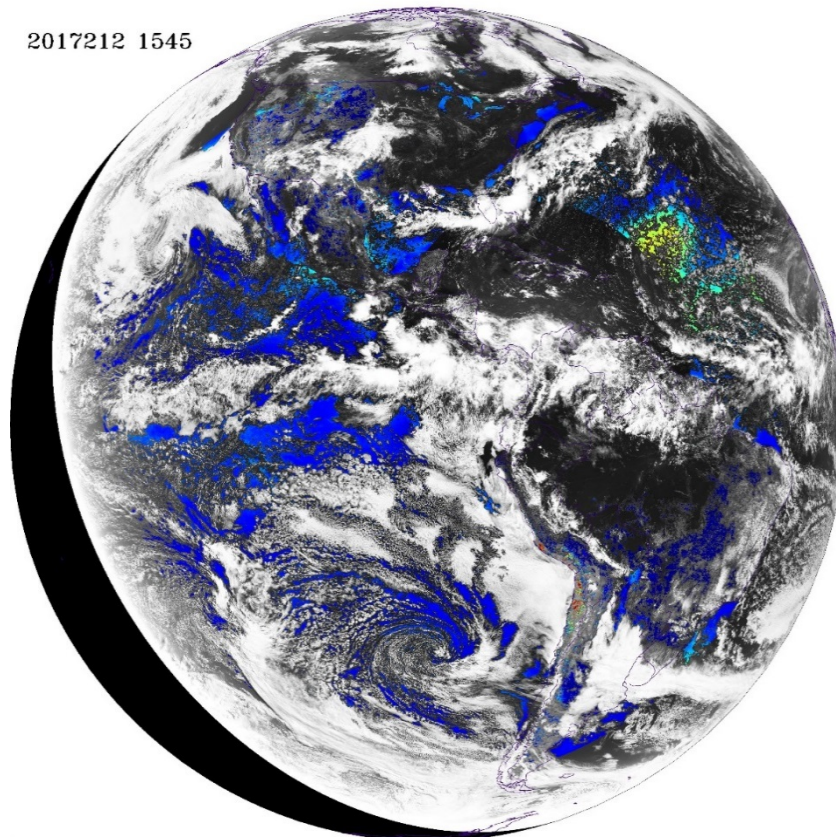
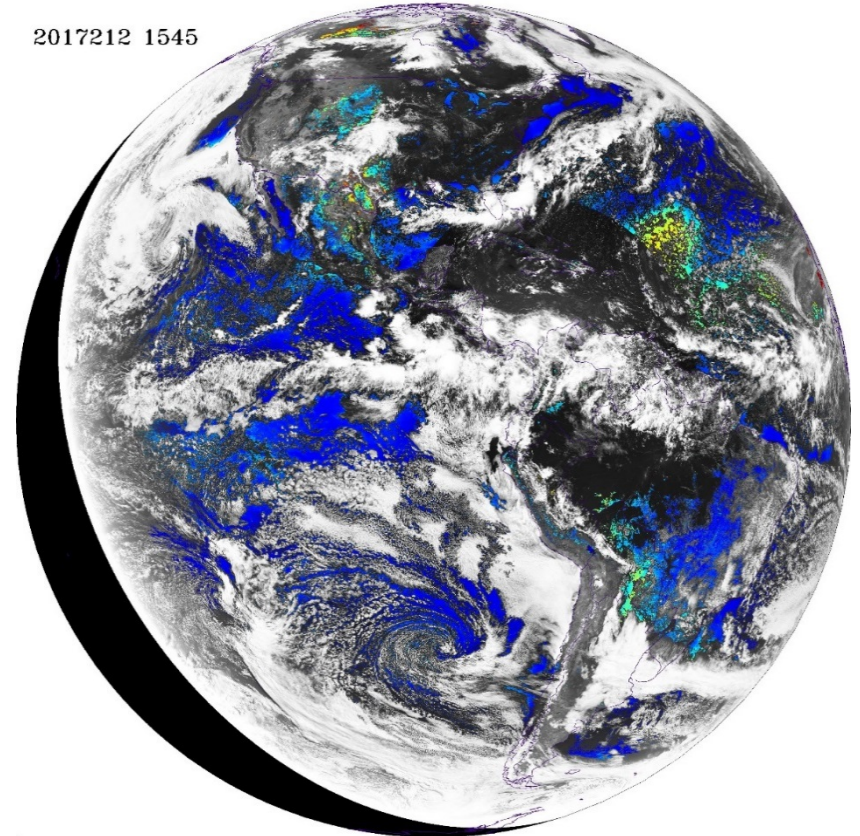# Updated Baseline vs. EPS AOD Images

Updated Baseline High Quality

Aerosol Optical Depth at 550nm

2017212 1545

EPS High Quality

Aerosol Optical Depth at 550nm

2017212 1545

EPS algorithm with ABI look-up-table, channel related coefficients and ABI land surface relationship.

Summary

- **ABI AOD is beta**:
  - Current GS algorithm has non-ABI LUTs and parameters,
  - Large biases especially over water,
  - Blocks of data are frequently missing.

- Currently deriving ABI-specific LUTs, gas parameterization and surface reflectance relationships

- **Provisional: Jan 2018; Full validated: Sep 2018**

- GOES-16 becomes operational early Jan 2018 (?)
  - 14 days for drift from current (89.3^o W) to operational position at 75.2^o W. Drift starts in the first week of Dec.
  - ABI is in safe mode, no data capture and distribution.
  - 3-6 more days to data flow.
  - May impact Provisional/Validated schedule.

Useful Documents

At http://www.goes-r.gov/resources/docs.html :

- Advanced Baseline Imager (ABI) Fact Sheet

- ABI Bands Quick Information Guides

- ABI Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter – Algorithm Theoretical Basis Document

- GOES-R Product Definition and Users' Guide (PUG) Volume 5 (L2+ Products)