Dark Target/Deep Blue Aerosol Retrieval Merge for VIIRS SNPP and NOAA-20

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Aerosol Optical Depth as a Climate Data Record

• Dark Target uses the same retrieval algorithm across multiple sensors

• Offsets in AOD caused by differences in instrument design, calibration, or degradation over time (Remer et al. 2020, Sawyer et al. 2020, Levy et al. 2018)
Aerosol Optical Depth as a Climate Data Record

- MODIS Aqua reached 20 years and VIIRS SNPP reached 10 years in 2022, with MODIS Terra at 22
- Terra and Aqua crossing times are now drifting, but planned to continue through 2026
- VIIRS v2.0 is now publicly available for SNPP and NOAA-20 (archive set 5200)
Differences between Dark Target versions

Scatter plots and histograms taken from 1°×1° gridded daily average AODs, May-Aug 2019

- Algorithm now uses image resolution L1b for cloud masking, GMAO for ancillary data, 1.64μm channel for snow mask
- Fixes several bugs, including blank stripes caused by cirrus flag/quality flag issue
- Now reports Mean_Reflectance_Land and STD_Reflectance_Land for all seven channels
- Metadata expansion and clarification
- Overall distribution of QA-filtered AOD values remains the same
- Higher-resolution cloud mask can retrieve closer to cloud edges with less cloud contamination
Differences between VIIRS sensors

Scatter plots and histograms taken from 1°×1° gridded daily average AODs, May-Aug 2019

- SNPP and NOAA-20 have the same equatorial crossing time but fly half an orbit apart, so true collocation is rare
- Matched grid cells may come from multiple orbits, especially at swath edges
- Single-sensor retrievals are more common
- Correlation is as expected for Dark Target on different sensors
- AOD distribution is higher for SNPP than for NOAA-20, whether for matched grid cells or single-sensor retrievals
- SNPP is biased high compared to AERONET. Is NOAA-20 too low, or just low enough?
The slope of the linear regression for each 1°×1° grid cell plotted where p ≤ 0.01. 21-year (top) and 11-year (bottom) trends in monthly mean QA-filtered AOD show regional and seasonal agreement between Terra, Aqua, and SNPP.
Slope of the linear regression for each 1°×1° grid cell plotted where $p \leq 0.01$

21-year trends in Ångström exponent (top) and fine mode fraction (bottom) show less agreement between Terra and Aqua.
MODIS C7 L1b and Dark Target

- Latest C7 L1b test does not significantly change Aqua Dark Target, but increases Terra AODs over land, thereby increasing Terra-Aqua offset compared to C6.1
- Found systematic changes in cloud masking, sampling, and aerosol model selection
- Changes in retrieved AOD have magnified effects on particle size parameters
- MODIS atmosphere teams have discussed results with MCST
MODIS-VIIRS Continuity for the AOD Record

- Without calibration adjustment, VIIRS Dark Target AODs show offsets comparable to the offset between MODIS Terra and Aqua, which is mostly due to calibration rather than diurnal cycle differences in AOD or sampling.

- Applications that already use mixed Terra and Aqua retrievals can consider SNPP and NOAA-20 in continuity with MODIS without adjustment.

- Applications that require a single seamless record may need calibration adjustments to bring SNPP closer to a reference sensor.

- The reference sensor must be current if adjustment factors change over time—SNPP/Aqua factors will become outdated after the end of the Aqua record.

- Transition from MODIS Aqua to VIIRS NOAA-20 as the reference sensor would keep the calibration closest to AERONET.
MODIS C7 will include Dark Target/Deep Blue in single M*D04 product, as in previous collections

• File structure based on netCDF for VIIRS
• Geophysical parameters grouped by Dark Target, Deep Blue, or Combined
• L3 products will follow this structure, gridded averages via Yori
• Deep Blue will retrieve over land and ocean for MODIS as well as VIIRS
• Final DTDB merge logic TBD
Dark Target/Deep Blue Merge for VIIRS

• In the meantime, how to create a C6.1-like merge for VIIRS v2.0?
  • Preliminary code (Shana Mattoo) applies C6.1 merge logic to AERDB_L2 and AERDT_L2 products to generate DTDB arrays
  • Does it make more sense to share merge code, or to publish a third product?
  • Problem: major algorithm updates to Deep Blue v2.0 make the merge less similar to Aqua C6.1 over bright surfaces

• Should a VIIRS continuity product also include SNPP-Aqua or NOAA20-Aqua radiometric adjustments?
  • Different groups suggest ”Xcal” and “trend” corrections for different combinations of MODIS and VIIRS bands
  • Currently testing a Dark Target retrieval for SNPP adjusted to Aqua-like reflectances (Mijin Kim)
### VIIRS (SNPP) X-calibration Coefficient

from 2023 MODIS/VIIRS Science meeting, A. Lyapustin et al.

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A. Lyapustin et al., 2023, RSE
VIIRS SNPP with xCal vs. AERONET, September 2019

• Brings greater number of AERONET-collocated SNPP retrievals within expected error

• Reduces, but does not eliminate, SNPP high bias

• Greater reduction in SNPP vs. Aqua bias found when combined with corrections to surface reflectance parameterization (Mijin Kim)
Summary

• Dark Target for VIIRS v2.0 is now available on LAADS (AS5200) for SNPP and NOAA-20
• Algorithm updates improve cloud masking, fix bugs, and expand on reported parameters and metadata, but AOD distributions remain close to v1.1
• VIIRS NOAA-20 is offset lower than both SNPP and Aqua
• Trends in AOD largely agree between sensors
• MODIS C7 will have new L1b calibration, new file structure, new DTDB merge logic
• VIIRS DTDB requires a continuity merge with different logic from intended future versions
• Dark Target group is testing calibration adjustments to SNPP and NOAA-20