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Validation of Satellite Overland Retrievals of AOD at Northern High Latitudes with Coincident Measurements from Airborne Sunphotometer, Lidar, and In Situ Sensors during ARCTAS

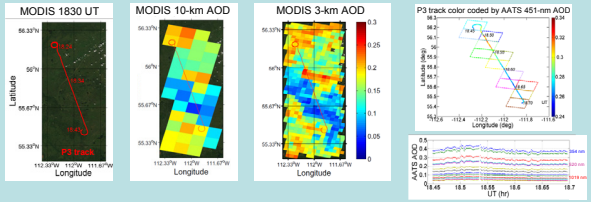
J. Livingston[1], Y. Shinozuka[2,3], J. Redemann[4], P. Russell[2], S. Ramachandran[5], R. Johnson[2], Q. Zhang[4], A. Clarke[6], S. Howell[6], C. McNaughton[6], S. Freitag[6], V. Kapustin[6], R. Ferrare[7], C. Hostetler[7], J. Hair[7], O. Torres[8], P. Veefkind[9], L. Remer[10], S. Mattoo[10,11], R. Levy[10,11], D. A. Chu[12]

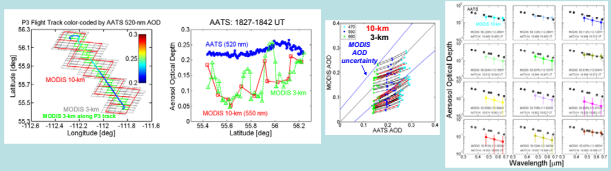
[1]SRI International, Menlo Park, CA, [2]NASA Ames Research Center, Moffett Field, CA, [3]NASA Postdoctoral Program, ORAU, Oak Ridge, TN, [4]Bay Area Environmental Research Institute, Sonoma, CA, [5]Physical Research Laboratory, Ahmedabad, INDIA, [6]SOEST, University of Hawaii, Honolulu, HI, [7]NASA Langley Research Center, Hampton, VA, [8]Center for Atmospheric Sciences, Hampton University, Hampton, VA, [9]Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands, [10]NASA Goddard Space Flight Center, Greenbelt, MD, [11]Science Systems and Applications, Inc. (SSAI), Lanham, MD, [12]Joint Center for Earth Systems Technology/University of Maryland, Baltimore County (JCET/UMBC), Baltimore, MD

Abstract

The 2008 Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) field campaign presented a unique opportunity for validation of satellite retrievals of aerosol optical depth (AOD) over a variety of surfaces at northern high latitudes. In particular, the 14-channel NASA Ames Airborne Tracking Sunphotometer (AATS-14) was operated together with a variety of in-situ and other remote sensors aboard the NASA P-3B research aircraft during both the spring and summer phases of ARCTAS. Among the in-situ sensors were a nephelometer and particle soot absorption photometer (PSAP) operated by University of Hawaii Group for Environmental Aerosol Research (HIGEAR). P-3B science missions included several coincident underflights of the Terra and A-Train satellites during a variety of aerosol loading conditions, including Arctic haze and smoke plumes from boreal forest fires. In this presentation, we compare AATS-14 AOD spectra with full column AOD retrievals from coincident measurements by MODIS and OMI for four low altitude, near-horizontal P3 transects during the ARCTAS summer deployment. These cases included measurements of two smoke plume events, on 30 June and 9 July, and of a spatially homogeneous, low to moderate AOD loading event during the Terra and Aqua overpasses on 3 July.

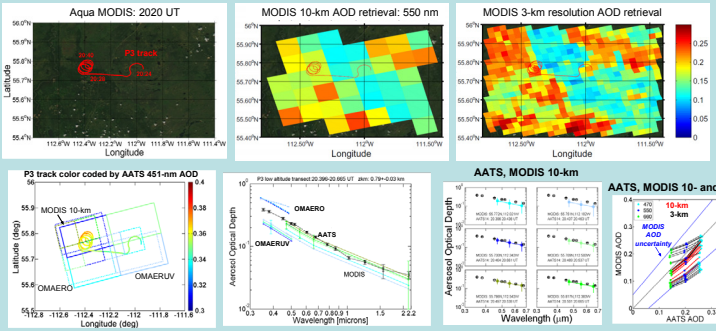
03 July 2008: Terra Overpass with Clear Sky, Moderate AOD





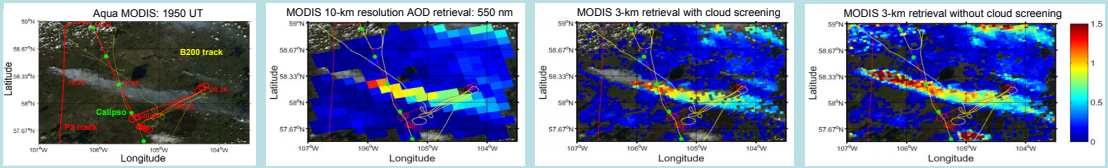
- MODIS AOD retrievals underestimate AATS AODs and exhibit greater variability than the AATS data along this P3 cloud-free horizontal transect flown at altitudes 0.6-1.0 km MSL.
- No AOD contributions (estimated from the coincident HiGEAR in-situ measurements) below the aircraft have been added to the AATS AODs shown here. These amount to a few percent.

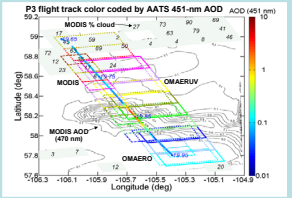
03 July 2008: Aqua, Aura Overpass with Clear Sky, Moderate AOD

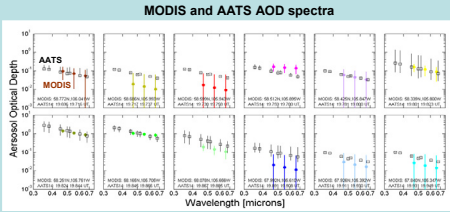


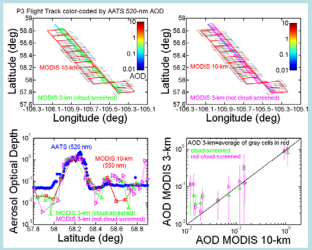
- Aqua-MODIS data taken in the same (though limited) region about two hours later yield AOD retrievals that agree better with the AATS AODs. OMAERUV retrievals underestimate and OMAERO retrievals overestimate AATS AODs.

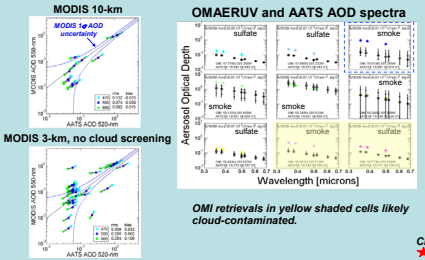
30 June 2008: Aqua-MODIS, Aura-OMI Overflight of Smoke Plume



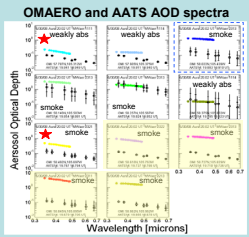








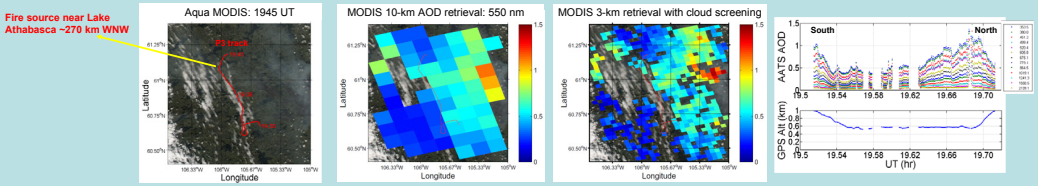
OMI retrievals in yellow shaded cells likely cloud-contaminated.



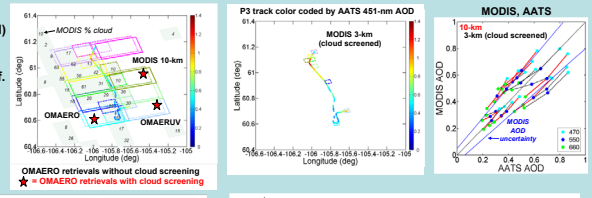
Cloud screening turned off for OMAERO retrievals
★ = Retrievals produced with cloud screening on

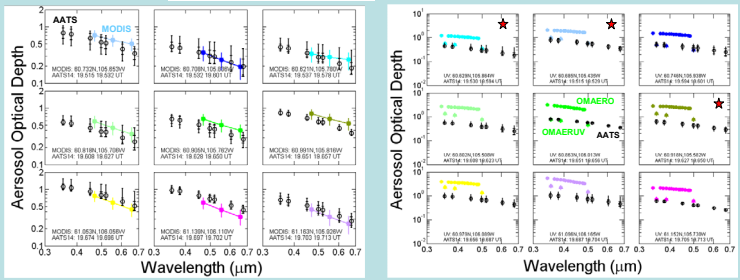
- The MODIS 10-km and 3-km AOD retrievals map the smoke plume successfully.
- MODIS 3-km AOD retrievals are noisier than the corresponding 10-km results.
- The standard MODIS cloud screen rejects cloud-free pixels in the heart of the plume (olive and green cells) due to high variability of the radiance.
- Horizontal plume structure causes differences between AATS and satellite AODs because AATS views a small subset of the satellite grid cell.
- In light of the different viewing regions, AATS and OMI retrievals paint a fairly consistent measure of AOD within the smoke plume (green).
- OMAERO AOD retrievals exceed AATS and OMAERUV AODs outside the plume.
- The OMAERO cloud screen rejects cloud-free pixels in the smoke plume.

09 July 2008: Aqua, Aura Overpass of Smoke Plume and Partly Cloudy Sky



The OMAERO grid cells (dotted) shown in the plot to the right represent retrievals produced with cloud screening turned off. With cloud screening applied, as done for the standard (archived) OMAERO retrievals, the algorithm yields AOD results only in the three grid cells with the red stars.





- MODIS 10-km and 3-km AOD retrievals agree well with AATS AODs.
- OMAERUV AODs generally agree with AATS AODs, except in likely cloud-contaminated cells. All OMAERO AODs exceed the AATS AODs.

Conclusions

- AATS and satellite sensor AODs have been compared for four events on three days: a thick smoke plume in an otherwise cloud-free sky ~50-80 km downwind of the fire source, a smoke plume ~270 km downwind of the fire source and under partly cloudy conditions, and two cloud-free P3 transects with relatively low to moderate, spatially homogeneous AOD (~0.20-0.25 in the mid-visible).
- Aqua-MODIS AOD retrievals at 10-km (standard MODIS product) and 3-km (experimental) resolution through the smoke agree with the AATS measurements. However, the standard MODIS cloud screen rejects cloud-free pixels in the heart of the plume. The Terra-MODIS retrievals underestimate AATS AODs and exhibit much more variability along the P3 transect under the moderate, homogeneous aerosol loading on 3 July. Aqua-MODIS retrievals agree better with the AATS AODs for data acquired in the same general location two hours later.
- MODIS 3-km AOD retrievals are noisier than the 10-km results.
- Both OMI retrieval algorithms yield AODs consistent with the AATS AODs in the heart of the thick smoke plume. The near-UV (OMAERUV) retrieval algorithm consistently yields AODs that agree better with the AATS values than does the multiwavelength (OMAERO) retrieval scheme, which overestimates AATS (and MODIS and OMAERUV) AODs outside the smoke plume.
- Horizontal plume structure results in differences between satellite and AATS AODs because AATS views a small subset of the satellite grid cell.

Future Work

- Identify and expand AOD comparisons to include coincidences with other satellite sensors, such as MISR and POLDER.
- Use HiGEAR in-situ aerosol scattering and absorption measurements to estimate and add the AOD contribution below the P3 aircraft to the AATS AODs. Where necessary (i.e., for elevated smoke plumes) and available, use aerosol layer height information from coincident measurements by the NASA B-200 High Spectral Resolution Lidar (HSRL) and or by satellite sensors (such as CALIOP aboard CALIPSO).
- Compare AATS profiles of aerosol extinction with coincident HSRL and CALIOP measurements.
- Identify the source of differences between AATS and Terra-MODIS AODs for the cloud-free AOD case on 3 July.

See Russell et al. poster A43A-0224 (this session) for an overview of AATS and P3 measurements during the ARCTAS summer deployment.