A43A-0224

Overview Of Haze And Smoke Measurements in Northern High Latitudes And California During ARCTAS Using The NASA Ames Airborne Sunphotometer And Associated In Situ And Remote Sensors

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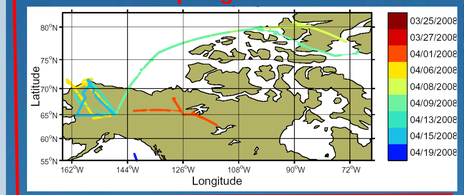
Abstract

The 14-channel NASA Ames Airborne Tracking Sunphotometer (AATS-14) operated in a suite of remote and in-situ sensors aboard the NASA P-3 aircraft during the 2008 Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) field campaign. Included were 7 Spring flights in the Arctic and 13 Summer flights (3 in California and 10 in Canada), each coordinated with one or more satellite overpasses, other aircraft (e.g., NASA B-200 and DC-8, NOAA P-3), and/or ground-based Aerosol Robotic Network (AERONET) measurements. This presentation gives an overview of AATS-14 aerosol optical depth (AOD) spectra and related parameters such as Angstrom exponent and fine mode fraction. We quantify the mutual consistency of AODs calculated from measurements by AATS-14, by the HiGEAR (University of Hawaii Group for Environmental Aerosol Research) suite of P-3 in-situ optical instruments, and by AERONET . The vertical integral of the HiGEAR in-situ scattering and absorption coefficients recorded during spiral profiles typically falls within ±(10% +0.02) of the AATS-14 AOD values interpolated to 450, 550 and 700 nm. Corresponding Angstrom exponents typically differ by ~0.1 if AOD>0.1. AATS-14 AODs adjusted for the contribution of the layer below the aircraft generally agree with the full column AERONET values to within the combined uncertainties. Example results from multiplatform comparisons are also shown. These results provide context for the more detailed AATS-14 results in other presentations, e.g., by Redemann et al. (focusing on the multi-platform, multi-sensor smoke case of 30 Jun 2008), Livingston et al. (comparisons to MODIS, MISR, OMI, POLDER, CALIPSO, and airborne lidar), and Shinozuka et al. (relationship to cloud condensation nuclei and other measurements).

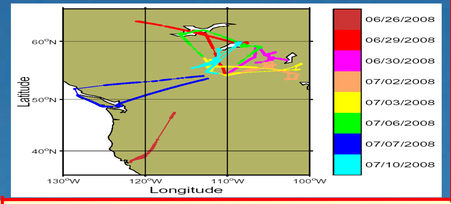
AATS/P-3B Flight Tracks During 2008 Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) Deployments

Spring—Arctic



Summer—California

Summer—Boreal Forest



Summary and Conclusions

AATS data from the ARCTAS flights listed below are being used in a wide variety of studies of Arctic haze, surface properties, and biomass smoke, including satellite validation (Livingston et al., **A43A-0154**), closure tests between radiometric and in situ data products, multi-sensor determinations of aerosol properties and effects (Redemann et al., **A41E-02**; Ottaviani et al., **A43A-0155**), as well as studies of Cloud Condensation Nuclei (Shinozuka et al., **A31G-07**), High Spectral Resolution Lidar (Ferrare et al., **A43A-0164**), aerosol radiative heating (Bucholtz et al., **A34B-01**), and snow surface albedo (Schmidt et al., **A43A-0159**) and bidirectional reflectance (Lyapustin et al., **A43A-0158**). Example results presented in this poster include:

- In 53 P-3 vertical profiles with altitude change >1 km, 66% of layer AODs from HiGEAR in situ scattering and absorption measurements were within ±(10%+0.02) of AATS layer AOD.
- In 5 profiles over AERONET sites, AATS and AERONET AODs had RMS difference 0.017.
- For AOD>0.1, AATS-HiGEAR Angstrom exponent (α) differences were typically <0.1.
- As with α, the comparison of AATS Fine-Mode Fraction (FMF) to HiGEAR Submicron-Mode Fraction (SMF) showed little dependence on whether AATS-HiGEAR AOD difference was <(10%+0.02). α, FMF, & SMF are all intensive properties, perhaps less sensitive to plume horizontal structure that causes AOD differences.

Detailed results are shown in the presentations cited above and listed in References.

Flt No.	Date	Track	Comments
4	1 Apr	Yellowknife-Fairbanks	CO & aerosol plume as predicted by models. Spiral & legs under CALIPSO, OMI track.
5	6 Apr	Fairbanks-Barrow-Fairbanks	Spiral & legs under B-200 & CALIPSO, OMI. Square spiral & radiation legs. Albedo, BRDF at Elson Lagoon.
6	8 Apr	Fairbanks-Thule	DC-8 comparison in stairsteps. Spiral over Eureka during CALIPSO, OMI OP. Albedo, BRDF.
7	9 APR	Thule-Fairbanks	Square spiral on CALIPSO, OMI track. BRDF & albedo, ice & cloud. AOD gradient & stack. CO & aerosol structure in predicted plume.

Flt No.	Date, 2008	Track	Comments
8	13 Apr	Fairbanks-North-Fairbanks	Cloud albedo & BRDF. In situ aerosol & CO in Asian transport episode to test models.
9	15 Apr	Fairbanks-Barrow-Fairbanks	Comparison & radiation stack w NOAA P-3 under B-200. Cascade impactor. Albedo, BRDF at Elson Lagoon with surface-based meas. Zero ozone over open leads. 6 special albedo sites. Radiation leg on CALIPSO, OMI track.
10	19 Apr	Fairbanks-Moffett over Pacific	DC-8 comparison on CALIPSO, OMI track. Steps in DC-8 lidar curtain. Square spiral during CALIPSO, OMI OP. Aerosol gradients predicted by models.

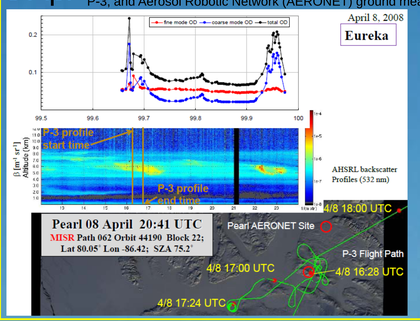
Data Flt No.	Date, 2008	Track	Comments
11	22 Jun	Moffett-Monterey Bay-Big Sur-Moffett	Power plant plume, CAR circles, ship plume, AERONET, lidar, Terra, sonde, wildfire smoke.
12	24 Jun	Moffett-Los Angeles-Moffett	19 ship plume crossings. Profiles under Terra & Aqua. Ocean BRDF (calm & 50-kt winds). Fire plumes & pollution plumes.
13 & 14	26 Jun	Moffett-Edmonton-Cold Lake	Lake Tahoe smoke radiation study in DC-8 lidar curtain & under Terra. Lake albedo & BRDF. Central Valley smoke gradient legs.

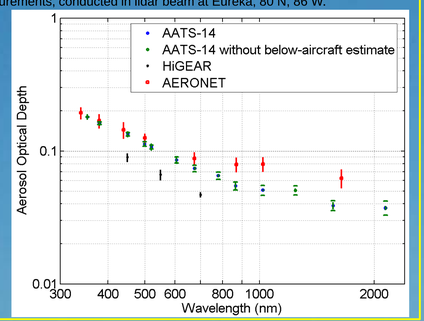
Flt No.	Date	Track	Comments
15	28 Jun	Cold Lake-Athabasca-Cold Lake	Sampled many fire plumes (incl. pyrocumulus) in many stages of development under B-200.
16	29 Jun	Cold Lake-Athabasca-Great Slave-Cold Lake	Fire plumes. Albedo, BRDF over lake & land. Ft. McMurray plume. DC-8 comparison scrubbed by clouds.
17	30 Jun	Cold Lake-NE-Cold Lake	CALIPSO, OMI underflight w AOD & in situ. Black & white smoke. In situ & radiation under B-200. BRDF over smoke pall. Asian pollution w dust as predicted by models.
18	2 Jul	Cold Lake-NE & E-Cold Lake	Radiation work under B-200. Aerosol evolution in downwind transport. Pyrocumulus.

Flt No.	Date	Track	Comments
19	3 Jul	Cold Lake-Ft. McMurray-Reindeer Lake-Cold Lake	Ft McMurray AERONET spiral in regional biomass haze. MODIS-MISR-MOPITT spiral. B-200 + CALIPSO, OMI spiral. Radiation stack. Forest BRDF. Fresh smoke sampling + downwind evolution. Radiation-AOD-in situ ramp.
20	6 Jul	Cold Lake-Great Slave-Athabaska-Cold Lake	Radiation profiles & legs under Terra. BRDF of blue & muddy water. Cloud edges under B-200. Dense smoke spirals under B-200. Radiation stacks. CAR in cloud. PyroCu outflow.
21	7 Jul	Cold Lake-British Columbia-Cold Lake	Radiative forcing efficiency of Asian/Siberian plume. Aerosol effects on MODIS-Terra cloud sensing. Tests of model aerosol, CO, & O_3 predictions. Radiation stacks. CAR circles over AERONET. In situ-AATS-AERONET spiral.
22	9 Jul	Cold Lake-Reindeer Lake-Athabaska-Cold Lake	Spirals & radiation legs under Terra-MISR. Radiation legs + stacks in fire plumes under B-200 + CALIPSO, OMI. Black & white smoke.
23	10 Jul	Cold Lake-Ft McMurray-Athabaska-Cold Lake	DC-8 intercomparison under B-200. Cloud edge work. Ft. McMurray sampling. Camsell & Viking fires—greatest CO, AOD>4.

8 Apr

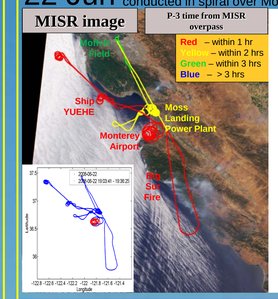
3-way comparison of Aerosol Optical Depth (AOD) from AATS, Hawaii Group for Environmental Aerosol Research (HiGEAR) in situ P-3, and Aerosol Robotic Network (AERONET) ground measurements, conducted in lidar beam at Eureka, 80 N, 86 W.

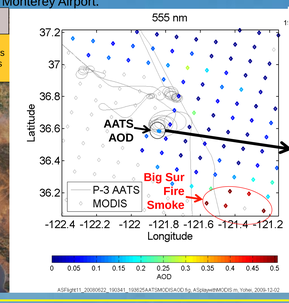


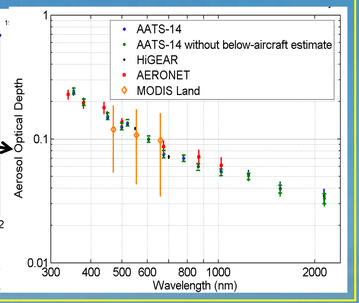


22 Jun

4-way comparison of AOD from AATS, HiGEAR in situ on P-3, AERONET ground measurements, and MODIS-Terra satellite conducted in spiral over Monterey Airport.

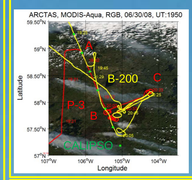


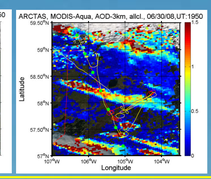


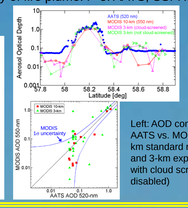


30 Jun

Multi-platform, multi-sensor coordination study of fire plume: P-3: AATS, SSFR, in situ; B-200: HSRL, RSP; A-train: MODIS-Aqua, CALIPSO, CERES



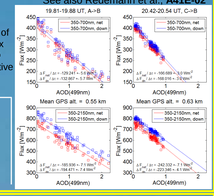




Right: Regression of radiative flux versus AOD yields radiative forcing efficiency

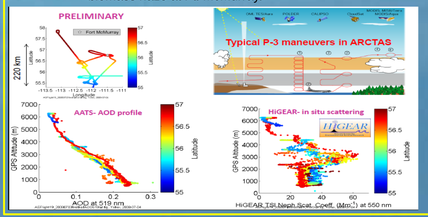
Left: AOD comparison, AATS vs. MODIS (10-km standard retrieval, and 3-km experimental with cloud screening disabled)

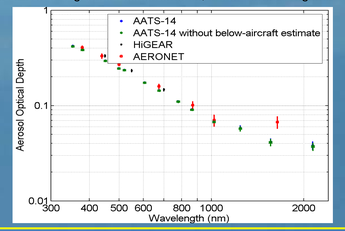
See also Redemann et al., **A41E-02**



3 Jul

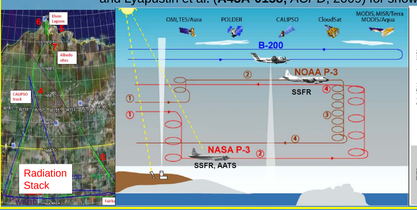
3-way comparison of AOD from AATS, HiGEAR in situ on P-3, and AERONET ground measurements, under Terra in regional biomass haze at Ft. McMurray.

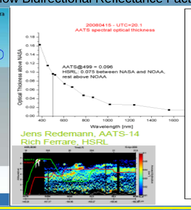


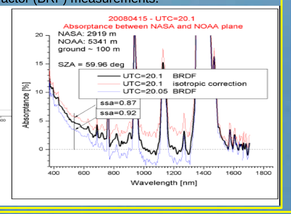


15 Apr

Radiation stack to determine aerosol absorption and single scattering albedo (SSA) by combining AATS and Solar Spectral Flux Radiometer (SSFR) data. See also Bierwirth et al. (**A13A-0185**), plus Schmidt et al. (**A43A-0159**) for surface albedo measurement and Lyapustin et al. (**A43A-0158;** *ACPD*, 2009) for snow Bidirectional Reflectance Factor (BRF) measurements.

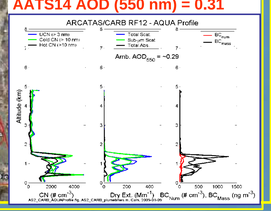






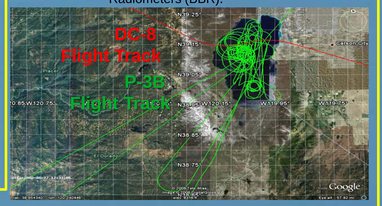
24 Jun

Comparison of layer AOD below 5 km from AATS & HiGEAR in profile under MODIS-Aqua in California wildfire plume aloft.



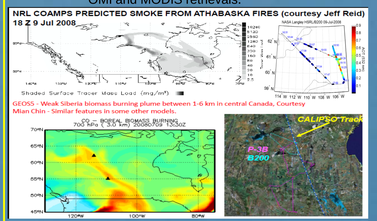
26 Jun

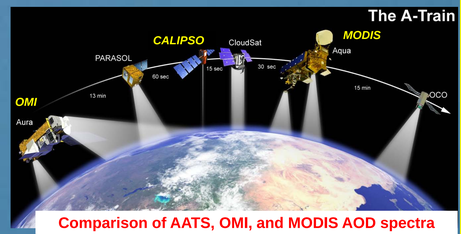
California wildfire smoke over Central Valley and Lake Tahoe in DC-8 lidar curtain below Terra. Potential radiation study using AATS, SSFR, CAR, HiGEAR, and Broad-Band Radiometers (BBR).

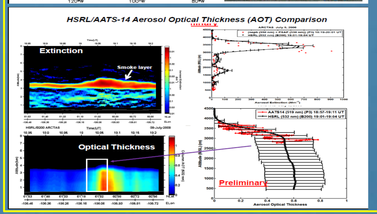


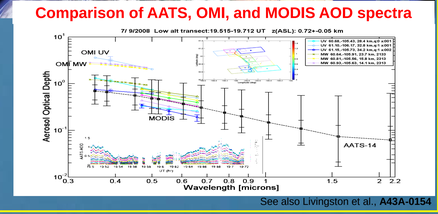
9 Jul

In biomass smoke plume predicted by NRL COAMPS and Goddard GEOS5, comparison of AOD and extinction vertical profiles from AATS and HiGEAR on P-3 with lidar profiles from HSRL on B-200 and CALIOP on CALIPSO. Comparison of AATS AOD with OMI and MODIS retrievals.





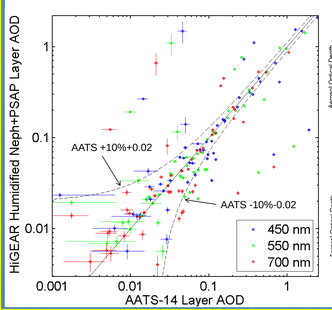


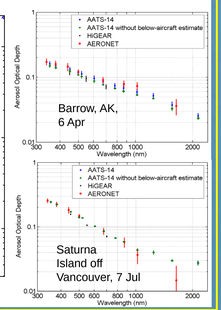


See also Livingston et al., **A43A-0154**

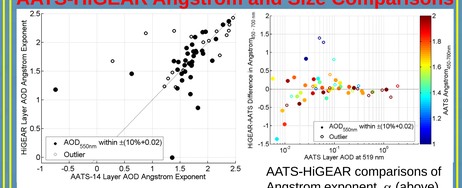
Overall AATS-HiGEAR-AERONET AOD Comparisons

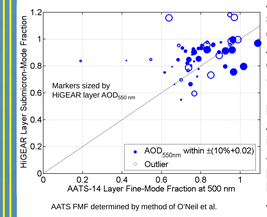
AATS-HiGEAR comparison (below left) includes 53 vertical profiles with altitude change >1 km. 66% of HiGEAR layer AODs were within ±(10%+0.02) of AATS layer AOD. Exceptions are from layers with strong horizontal structure (e.g., smoke plumes). AATS-HiGEAR-AERONET comparisons include 5 profiles over AERONET sites (Barrow & Saturna Island below right; Pearl above; Monterey, middle column; Fort McMurray, right column). AATS and AERONET AODs had RMS difference 0.017 (76%<0.02, 61%<0.015).





AATS-HiGEAR Angstrom and Size Comparisons



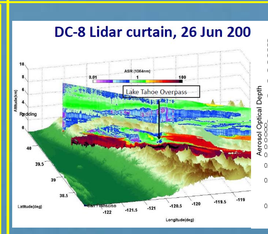


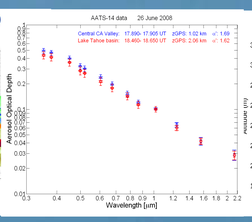
AATS FMF determined by method of O'Neil et al.

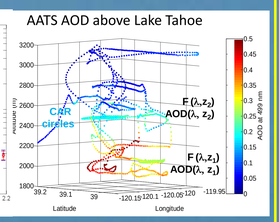
AATS-HiGEAR comparisons of Angstrom exponent α (above) show that for AOD>0.1, α differences were typically <0.1. As with α, the comparison (left) of AATS Fine-Mode Fraction (FMF) to HiGEAR Submicron-Mode Fraction (SMF) shows little dependence on whether AATS-HiGEAR AOD difference is <(10%+0.02). α, FMF, & SMF are all intensive properties, perhaps less sensitive to plume horizontal structure that causes AOD differences.

See also Shinozuka et al., **A31G-07**

DC-8 Lidar curtain, 26 Jun 200







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Ferrare, R. A., et al., Airborne High Spectral Resolution Lidar Aerosol Measurements during ARCTAS, AGU Fall 2009 Meeting, Paper **A43A-0164**, Poster Hall, 1:40-6:00 PM Thur 17 Dec 2009.

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Redemann, J. et al., The coordinated multi-sensor, multi-platform ARCTAS fire plume study on June 30, 2008, AGU Fall 2009 Meeting, AGU Fall 2009 Meeting, Paper **A41E-02**, Room 3004, 8:15 AM Thur 17 Dec 2009.

Schmidt, S. , et al., Airborne Measurement of Surface Albedo in Alaska, AGU Fall 2009 Meeting, Paper **A43A-0159**, Poster Hall, 1:40-6:00 PM Thur 17 Dec 2009.

Shinozuka, Y., et al., Challenges in remote sensing of CCN concentration: a comprehensive assessment with airborne measurements of AOD, CCN, chemical composition, size distribution, light scattering/absorption and humidity response in North America, AGU Fall 2009 Meeting, Paper **A31G-07**, Room 3004, 9:30 AM Wed 16 Dec 2009.