

## The NASA Ames Airborne Tracking Sunphotometer (AATS-14) in SEAC<sup>4</sup>RS: Instrument Description, Science Goals, and Supplemental Information

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In SEAC<sup>4</sup>RS the NASA Ames Airborne Tracking Sunphotometer, AATS-14 (see image below), will fly aboard the DC-8 during the Southeast Asia deployment. (As an option, the newer instrument 4STAR may be substituted for AATS after initial science flights.) AATS-14 measures direct solar beam transmission at 14 wavelengths between 354 and 2139 nm in narrow channels with bandwidths between 2 and 5.6 nm for the wavelengths less than 1640 nm and 17.3 nm for the 2139 nm channel. The transmission measurements at all channels except 940 nm are



used to retrieve spectra of aerosol optical depth (AOD). In addition, the transmission at 940 nm and surrounding channels is used to derive columnar water vapor (CWV) [Livingston *et al.*, 2008]. Methods for AATS-14 data reduction, calibration, and error analysis have been described extensively, for example, by Russell *et al.* [2007] and Shinozuka *et al.* [2011]. For SEAC<sup>4</sup>RS, AATS-14 will be calibrated before and after the experiment at Mauna Loa Observatory (MLO) using the Langley plot technique.

AATS-14 measurements of spectral AOD and CWV obtained during aircraft vertical profiles can be differentiated to determine corresponding vertical profiles of spectral aerosol extinction and water vapor density. Such measurements have been used extensively in the characterization of the horizontal and vertical distribution of aerosol optical properties and in the validation of satellite aerosol sensors. For example, in the Aerosol Characterization Experiment-Asia (ACE-Asia), AATS measurements were used for closure (consistency) studies with in situ aerosol samplers aboard the NCAR C-130 and the CIRPAS Twin-Otter aircraft, and with ground-based lidar systems. In ACE-Asia, CLAMS (Chesapeake Lighthouse & Aircraft Measurements for Satellites, 2001), the Extended-MODIS- $\lambda$  Validation Experiment (EVE), INTEX-A, INTEX-B, and ARCTAS, AATS results have been used in the validation of satellite sensors aboard various EOS platforms, providing important aerosol information used in the improvement of retrieval algorithms for the MISR and MODIS sensors among others.

In SEAC<sup>4</sup>RS, specific goals of AATS-14 aboard the DC-8 are to:

1. Provide the multi-spectral optical depth measurements listed in the Aircraft Payloads table of the SEAC<sup>4</sup>RS Planning Document, plus simultaneous water vapor column measurements, in conditions away from clouds, above clouds, and near cloud-aerosol boundaries,
2. Perform integrated analyses of the aerosol optical depth (AOD), water vapor, and associated data sets from aircraft, satellites, and surface measurements in support of SEAC<sup>4</sup>RS goals in:
  - a. satellite validation, especially in the difficult environments of cloud-aerosol boundaries and aerosol above clouds,
  - b. aerosol effects on radiative energy budgets and cloud remote sensing caused by aerosols from anthropogenic sources, wildfires and other natural sources (e.g., marine, volcanic) as affected by the monsoon circulation and ENSO state,
  - c. aerosol-cloud interactions, and
  - d. science definition of such NRC Decadal Survey-recommended missions as ACE and Geo-CAPE.

In many of the above analyses, we plan to combine AATS data with measurements collected by other sensors aboard the DC-8, including the Solar Spectral Flux Radiometers (SSFR). Specifically, by combining AATS and SSFR data we intend to derive aerosol radiative forcing from simultaneously measured radiative flux and AOD gradients, to study the effect of AOD above cloud on cloud property retrievals by SSFR and satellites, to study the influence of aerosols on cloud radiative forcing, and to derive spectra of aerosol absorbing fraction (1-SSA) in thick polluted layers.

Further information on AATS instrumentation, measurements, and analyses, including previous AATS-14 deployments on the DC-8 and other aircraft is at

<http://geo.arc.nasa.gov/sgg/AATS-website/>.

## References

- Livingston, J.M., B. Schmid, P.B. Russell, J. Redemann, J.R. Podolske, and G.S. Diskin, Comparison of Water Vapor Measurements by Airborne Sun Photometer and Diode Laser Hygrometer on the NASA DC-8. *J. Atmos. Oceanic Technol.*, 25, 1733-1743, doi:10.1175/2008JTECHA1047.1, 2008.
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### AATS-14 in SEAC<sup>4</sup>RS: Supplemental Information

Parameters measured	Technique	Averaging Time	Resolution/Accuracy
Multiwavelength optical depth (354-2139 nm)	Tracking Sunphoto-meter	Typically 3 s	<u>Resolution:</u> Slant OD ~0.002
Water vapor column			Slant WV ~0.0005 to 0.006 cm <sup>-1</sup>
Multiwavelength extinction and water vapor density when aircraft flies vertical profiles			<u>Accuracy:</u> Aerosol optical depth (AOD) ~0.01 Column water vapor (CWV) ~10%

#### **Instrument operational preferences and constraints**

- Location on DC-8: Away from obstructions to viewing sun. Current planned location, 62° #3 viewport, is acceptable but not as good as the 62° #1 viewport where AATS-14 flew in SOLVE II.
- AATS window cleaning: The AATS entrance window must be cleaned before each flight and inspected after flight. This requires access to the DC-8 roof by stairs or lift (unless a new procedure for mounting/demounting AATS from inside the DC-8 cabin is devised—something Adam Webster has mentioned, but so far is not designed or implemented).
- AATS bucket: Between flights the AATS head needs to be covered with its bucket. This prevents rain from entering AATS. The bucket needs to be removed before flight (usually by the window cleaner) and replaced after flight. As with window cleaning, this requires access to the DC-8 roof by stairs or lift.
- Aircraft speed: No restrictions.
- T, P: No hard restrictions, but very cold conditions are challenging, especially after being exposed to moisture. The risk is freezing water in the AATS bearings, which prevents sun tracking.
- Ascent/descent rates: No restrictions.
- Bank angles: Prefer  $\leq 30^\circ$ .
- Smoke contamination: We need ~30 seconds warning before penetrating dense smoke or clouds, so we can park AATS. Usually the pilot gives us this warning.
- Clouds: AATS data on aerosol optical depth (AOD) are interrupted when a cloud blocks the AATS-to-sun viewing path. AATS column water vapor (CWV) data persist when AATS tracks the sun through thin cirrus.
- High altitude sampling issues: As mentioned above, very cold conditions are challenging, especially after being exposed to moisture.

#### **Critical observable to transmit in real time to ground planning teams**

- I would suggest AOD at one or a few wavelengths, plus maybe CWV. We have not done this before, but these values are calculated and displayed onboard in real time. What is the procedure for getting these values into the telemetry stream?