Ames Airborne Tracking Sunphotometer, AATS-14

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The 14-channel NASA Ames Airborne Tracking Sunphotometer (AATS-14, Fig. 1) measures the transmission of the solar beam in 14 spectral channels. Azimuth and elevation motors controlled by differential sun sensors rotate a tracking head, locking onto the solar beam and keeping detectors normal to it. The AATS-14 tracking head mounts outside the aircraft skin, to minimize blockage by aircraft structures and avoid data contamination by aircraft-window effects.

Each channel consists of a baffled entrance path, interference filter, photodiode detector, and preamplifier. Filters are at wavelengths 354 - 2139 nm (Fig. 2), chosen to allow separation of aerosol, water vapor, and ozone transmission. The filter/detector sets are temperature-controlled to avoid thermally-induced calibration changes. Detectors in the two longest-wavelength channels incorporate thermoelectric coolers. The other 12 channels are maintained at an elevated temperature by foil heaters.

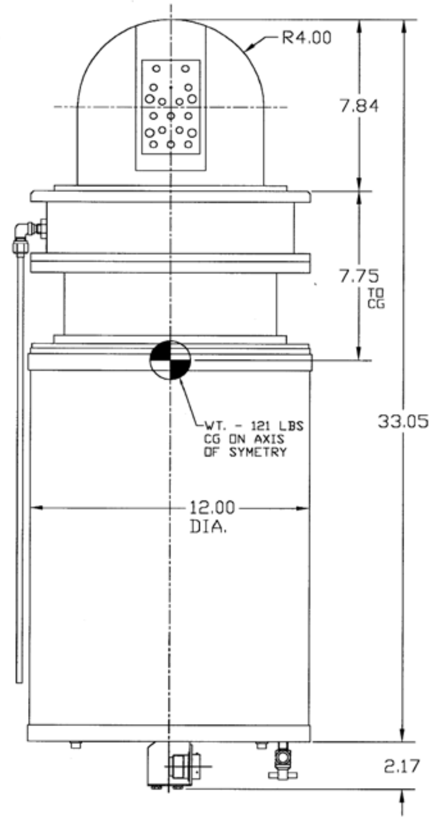
Sun tracking is achieved continuously, independent of aircraft pitch, roll, and yaw, provided rates do not exceed ~8° s^{-1} and the sun is above aircraft horizon and unblocked by clouds or aircraft structures (e.g., tail, antennas). AATS-14 uses a quad-cell photodiode to derive azimuth and elevation tracking-error signals.

Data are digitized and recorded by an onboard data acquisition and control system. Real-time data processing and color display are routinely provided. The real-time science data set includes the detector signals, derived optical depths and water vapor column content, detector temperature, sun tracker azimuth and elevation angles, tracking errors, and time. Radiometric calibration is determined via Langley plots, either at high-mountain observatories or on specially designed flights. Repeated calibrations show that the instrument maintains its calibration (including window and filter transmittance, detector responsivity and electronic gain) to within 1% in most spectral channels for periods of several months to a year.

AATS-14 was developed under the NASA Environmental Research Aircraft and Sensor Technology (ERAST) Program. AATS-14 is designed to operate on a variety of aircraft, some of which may be remotely piloted or autonomous. Hence it can locate and track the sun without input from an operator and record data in a self contained data system. In addition, it can interface to an aircraft-provided telemetry system, so as to receive and execute commands from a remote operator station, and transmit science and instrument-status data to that station.

AATS-14 made its first science flights on the Pelican (modified Cessna) aircraft of the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) during the Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX) in July 1996 [Russell et al., 1999]. Other missions in which AATS-14 has participated include the second Aerosol Characterization Experiment (ACE-2) [Schmid et al., 2000], South African Regional Science Initiative (SAFARI) 2000 [Schmid et al., 2002], Asian Pacific Regional Aerosol Characterization Experiment (ACE-Asia) [Russell et al., 2002], and Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) [Redemann et al., 2002].

Figure 1. Fourteen-channel Ames Airborne Tracking



Sunphotometer (AATS-14). Dimensions are in inches.

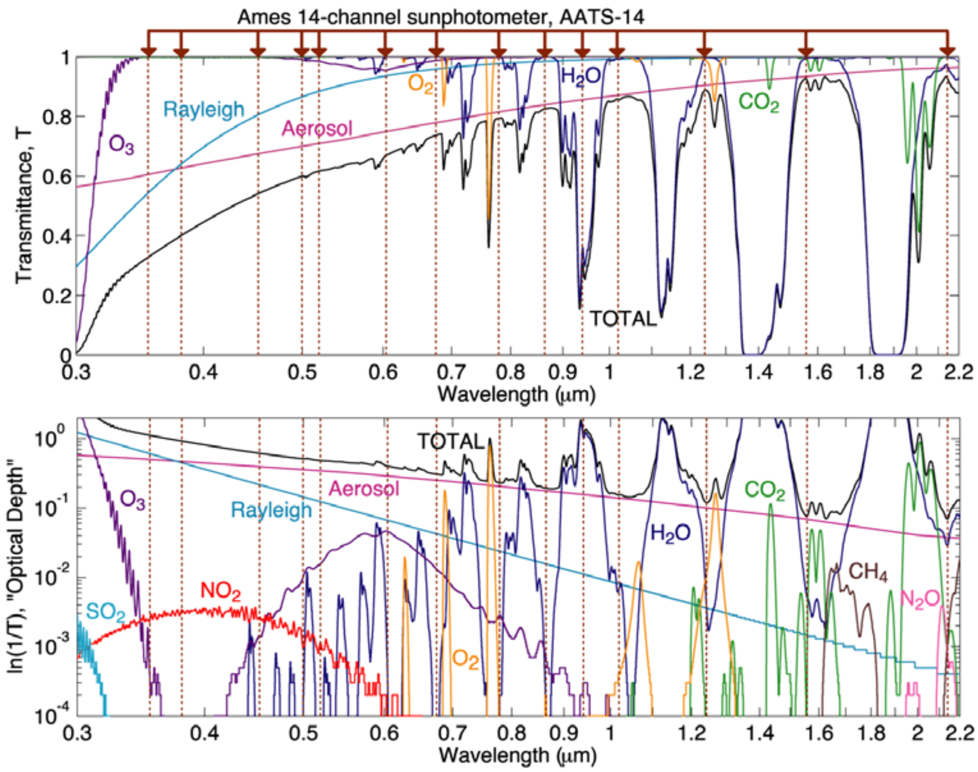


Figure 2. AATS-14 channel wavelengths (vertical lines with arrows) in relation to atmospheric spectra. The spectra of transmittance T of the direct solar beam at sea level were calculated using MODTRAN-4.3 with a Midlatitude Summer atmosphere, a rural spring-summer tropospheric aerosol model (Vis = 23 km), and the sun at the zenith. Current center wavelengths of channel filters are 354, 380, 453, 499, 519, 604, 675, 778, 865, 941, 1019, 1241, 1558, 2139 nm. Filter full widths at half-maximum (FWHM) are 5 nm, except for the 353 and 2139 nm channels, which have FWHM 2 and 17 nm, respectively.

References

Russell, P. B., J. M. Livingston, P. Hignett, S. Kinne, J. Wong, and P. V. Hobbs, Aerosol-induced radiative flux changes off the United States Mid-Atlantic coast: Comparison of values calculated from sunphotometer and in situ data with those measured by airborne pyranometer, *J. Geophys. Res., 104*, 2289-2307, 1999.

Schmid, B., Livingston, J. M., Russell, P. B., Durkee, P. A., Collins, D. R., Flagan, R. C., Seinfeld, J. H., Gassó, S., Hegg, D. A., Öström, E., Noone, K. J., Welton, E. J., Voss, K., Gordon, H. R., Formenti, P., and Andreae, M. O., Clear sky closure studies of lower tropospheric aerosol and water vapor during ACE-2 using airborne sunphotometer, airborne in-situ, space-borne, and ground-based measurements. *Tellus B 52*, 568-593, 2000.

Redemann, J., B. Schmid, J. M. Livingston, P. B. Russell, J. A. Eilers, P. V. Hobbs, R. Kahn, W. L. Smith, Jr., B. N. Holben, C. K. Rutledge, M. C. Pitts, M. I. Mishchenko, B. Cairns, J. V. Martins, and T. P. Charlock, Airborne Measurements of Aerosol Optical Depth and Columnar Water Vapor in support of the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) Experiment, 2001, Abstracts, 11th Conference on Atmospheric Radiation, American Meteorological Society, Ogden, UT, June 3-7, pp. 20, 2002.

Russell, P. B., Flatau, P. J., Valero, F. P. J., Nakajima, T., Holben, B., Pilewskie, P., Bergin, M., Schmid, B., Bergstrom, R. W., Vogelmann, A., Bush, B., Redemann, J., Pope, S., Livingston, J., Leitner, S., Hsu, N. C., Wang, J., Seinfeld, J., Hegg, D., Quinn, P., and Covert, D., Overview of ACE-Asia Spring 2001 investigations on aerosol-radiation interactions, 11th Conference on Atmospheric Radiation, American Meteorological Society, Ogden, Utah, 3-7 June 2002, Postprint Volume, pp. 1-4.

Schmid, B., J. Redemann, P. B. Russell, P. V. Hobbs, D. L. Hlavka, M. J. McGill, B. N. Holben, E. J. Welton, J. Campbell, O. Torres, R. A. Kahn, D. J. Diner, M. C. Helmlinger, D. A. Chu, C. Robles Gonzalez, and G. de Leeuw, Coordinated airborne, spaceborne, and ground-based measurements of massive, thick aerosol layers during the dry season in Southern Africa, *J. Geophys. Res.*, in press, 2002.

Weight, Power, Size, and Related Information, AATS-14

Part	Weight	Size (19" panel or other)	Power Required (watts, amps)	Type of Power (V, Hz)	External Sensor Location
a. Telescope head w electronics/data system cylinder	131.6 lb. (Includes 121-lb head w/elec., 3.5-lb isolator, 1-lb reinforc. ring, 0.4-lb torque link, 0.7-lb mount bolts, 5-lb cable bundle.	Outside A/C: 8" OD dome (hemisphere) atop 5" H pedestal. (Total H: 9" above A/C skin) Inside A/C: 12" D x 18" H cylinder. (+ laptop computer for checkout and test flights)	5.5A 154 W peak or 4.2 A @ 500 W peak	28 VDC or 120VAC, 50-400 Hz with additional 55-lb power supply.	Top of cabin, nose, wing, or pod. 9" D port (See note.)
b. Operator station (laptop computer)	6-lb laptop & cable, 15-lb tray w/slides.	Laptop computer. Optional tray mounts in 19” rack.	~0.8 A 92 Watts	120 V, 60 Hz	N/A
c. N_2 gas bottle	30 lb	7.5” Dia x 21” H	N/A	N/A	N/A

Note: Telescope dome needs to be mounted as far as possible from viewing obstructions such as A/C tail and antennas.