

Ames Airborne Tracking Sunphotometer, AATS-14

Philip B. Russell, John M. Livingston, Beat Schmid, Jens Redemann, and James Eilers
NASA Ames Research Center, Moffett Field, CA 94035-1000
prussell@mail.arc.nasa.gov

The NASA Ames Airborne Tracking Sunphotometers measure the transmission of the solar beam in a number of spectral channels. AATS-14, shown in Fig. 1, has 14 such channels. Azimuth and elevation motors controlled by differential sun sensors rotate a tracking head so as to lock on to the solar beam and keep detectors normal to it. The tracking head of the instrument mounts external to the aircraft skin, to minimize blockage by aircraft structures and also to avoid data contamination by aircraft-window effects.

Each channel consists of a baffled entrance path, interference filter, photodiode detector, and preamplifier. Channel filters are at wavelengths from 354 to 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 $\sim 8^\circ \text{ s}^{-1}$ and the sun is above aircraft horizon and unblocked by clouds or aircraft obstructions (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].

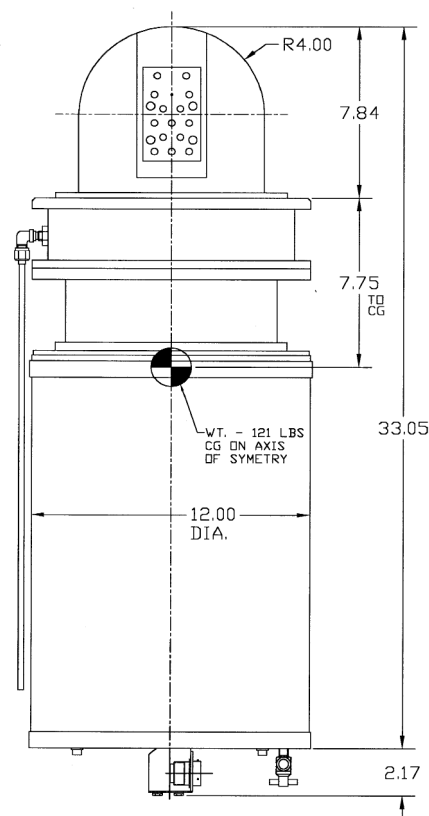


Figure 1. Fourteen-channel Ames Airborne Tracking Sunphotometer (AATS-14). Dimensions are in inches.

Ames Airborne Tracking Sunphotometers

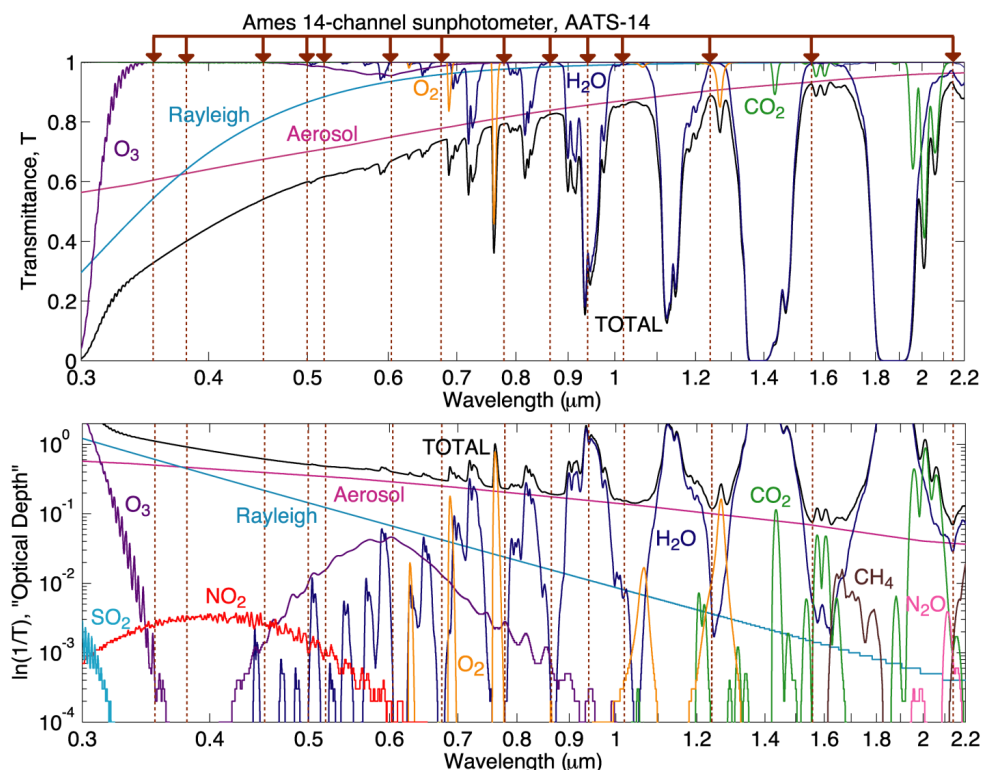


Figure 2. AATS-14 channel wavelengths (vertical lines with arrows) in relation to atmospheric spectra. The spectra of transmittance T of the direct solar beam at sea level were calculated using MODTRAN-4.3 with a Midlatitude Summer atmosphere, a rural spring-summer tropospheric aerosol model ($Vis = 23$ 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 354 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. R. 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.*, *108(D13)*, 8496, doi:10.1029/2002JD002297, 2003