Ames Airborne Tracking Sunphotometers, AATS-6 and AATS-14

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1. Introduction

The NASA Ames Airborne Tracking Sunphotometers (AATS-6 and AATS-14) measure the transmission of the solar beam in six and 14 spectral channels, respectively. 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 each 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 integral preamplifier. The filter/detector/preamp sets are temperature-controlled to avoid thermally-induced calibration changes. Each instrument includes an entrance-window defogging system to prevent condensation (a problem otherwise common in aircraft descents). In general, 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 obstructions (e.g., tail, antennas). Data are digitized and recorded by an onboard data acquisition and control system. Realtime data processing and color display are routinely provided. The 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 instruments maintain their 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.

2. Six-Channel Tracking Sunphotometer (AATS-6)

The six-channel instrument [Fig. 1, *Matsumoto et al*., 1987] uses a differential-shadowing sun sensor to drive the azimuth and elevation tracking motors. The window-defogging system uses bottled dry nitrogen, which also aids in overall instrument thermal control. The six filter/detector/preamp sets are mounted in a common heat sink maintained at 45 ±1 °C. Filter wavelengths are shown in Fig. 2. Filter full widths at half-maximum (FWHM) are 5 nm. Data are digitized and recorded by a laptop computer-based data acquisition and control system, with realtime, onboard processing and color display.

AATS-6 has flown on a variety of aircraft, including the NASA CV-990, C-130, and DC-8, the Sandia National Laboratories Twin Otter, the University of Washington C-131A, and a Piper Navajo. These measurements have been compared with SAGE II measurements of free-tropospheric and stratospheric aerosols [*Russell et al*., 1986; *Livingston and Russell*, 1989] and used to characterize the spectral optical depth of oil- and forest-fire smokes and thin clouds [*Pueschel and Livingston*, 1990], to measure tropospheric haze aerosols and their impact on atmospheric radiation and on remote measurements of the Earth's surface [*Wrigley et al*., 1992; *Russell et al*., 1999], and to document the effect of the 1991 Pinatubo volcanic eruption on global-scale stratospheric aerosol optical depth spectra [*Russell et al.*, 1993, 1996; *Toon et al.,* 1993]. In addition, AATS-6 operated successfully on the ship R/V Vodyanitsky in the second Aerosol Characterization Experiment (ACE-2), making measurements of marine, European, and African aerosol optical depth spectra, as well as water vapor columns [*Livingston et al.,* 1997].

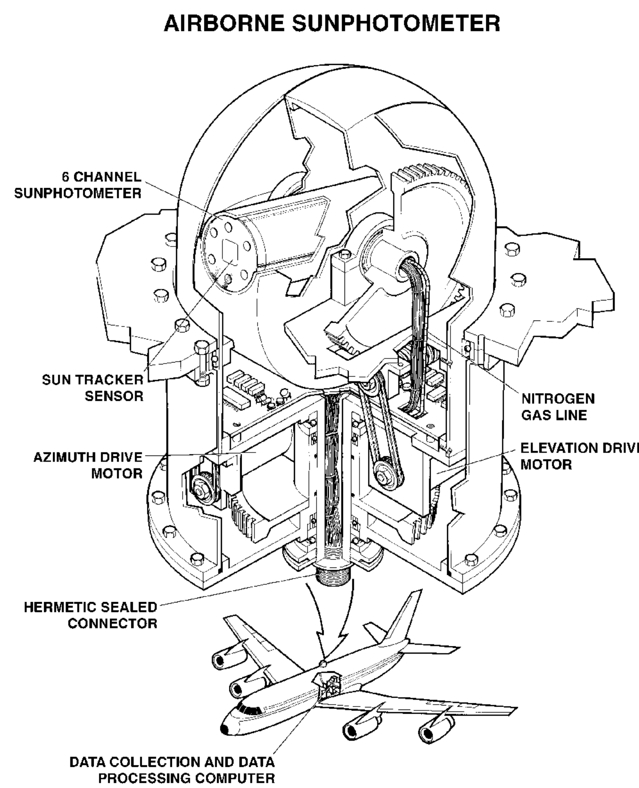

Figure 1. Six-channel Ames Airborne Tracking Sunphotometer (AATS-6).

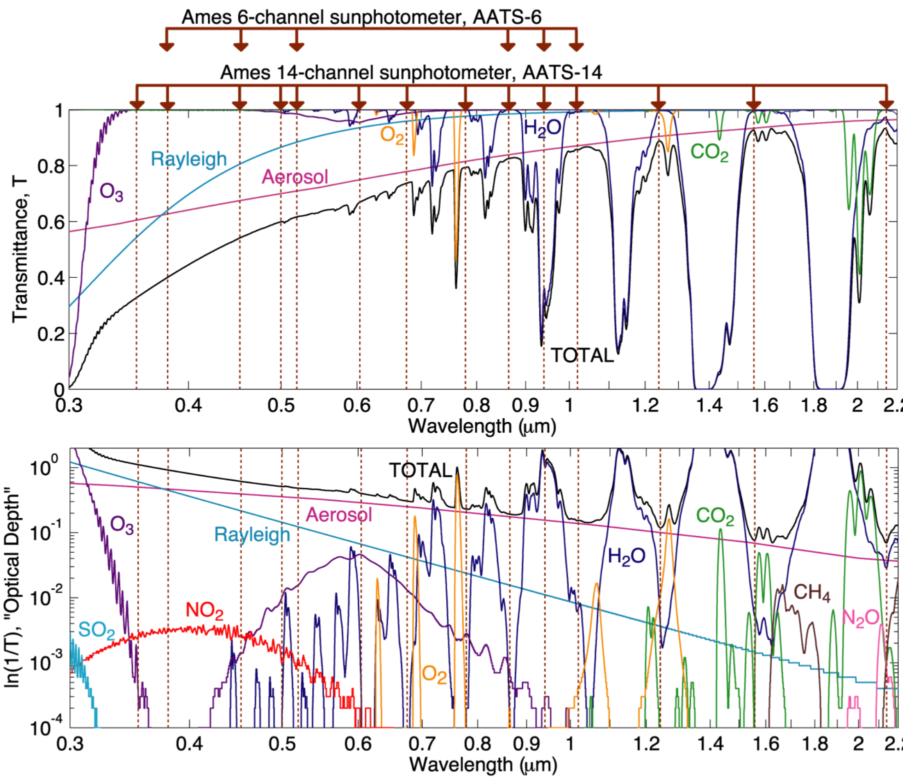

Figure 2. AATS-14 channel wavelengths (vertical lines with arrows) in relation to atmospheric spectra. The spectra of transmittance T of the direct solar beam at sea level were calculated using MODTRAN-4.3 with a Midlatitude Summer atmosphere, a rural spring-summer tropospheric aerosol model (Vis = 23 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.

3. Fourteen-Channel Tracking Sunphotometer (AATS-14)

AATS-14 (Fig. 3) was developed under the NASA Environmental Research Aircraft and Sensor Technology (ERAST) Program. It provides 14 spectral channels in the same tracking-head size as the six-channel instrument, with a more compact and automated data/control system. 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 uses a quad-cell photodiode to derive azimuth and elevation tracking-error signals. Window defogging is achieved by a foil heater. Channel filters are at wavelengths from 354 to 2139 nm (Fig. 2), chosen to allow separation of aerosol, water vapor, and ozone transmission. Detectors in the two longest-wavelength channels incorporate thermoelectric coolers. The other 12 channels are maintained at an elevated temperature by foil heaters.

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].

AATS-14 completed its first flights on a pressurized aircraft in June 1999, when it made test flights on the NASA DC-8. It made many successful DC-8 flights in the second SAGE III Ozone Loss and Validation Experiment (SOLVE II). For more information, see http://geo.arc.nasa.gov/sgg/AATS-website/

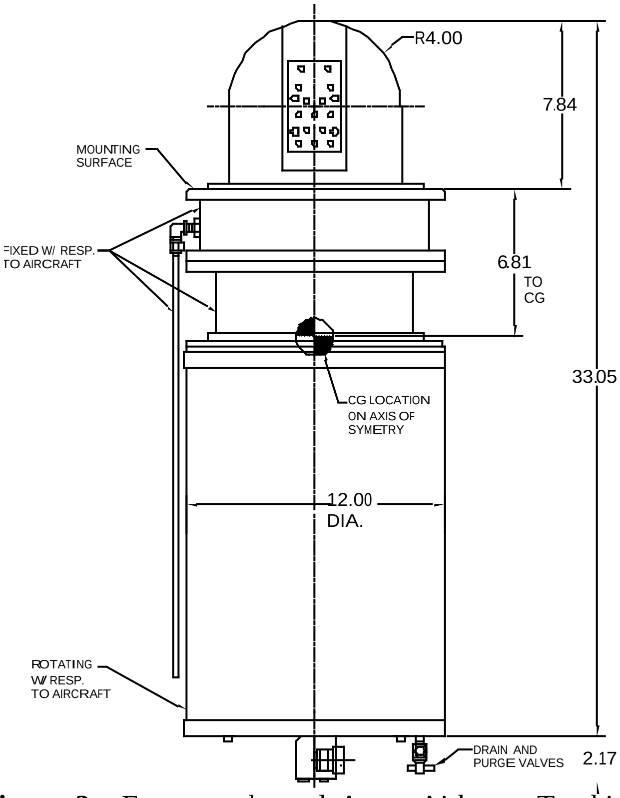

Figure 3. Fourteen-channel Ames Airborne Tracking Sunphotometer (AATS-14). Dimensions are in inches.

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Weight, Power, Size, and Related Information

1. Six-Channel Ames Airborne Tracking Sunphotometer (AATS-6):

Part	Weight	Size (19" panel or other)	Power Required (watts, amps)	Type of Power (V, Hz)	External Sensor Location
a. Sunphotometer telescope	62 lb. (Includes 27-lb head, 1-lb bearing, 5-lb isolator, 1-lb reinforc. ring, 1 lb mounting bolts, 27-lb cable)	Telescope dome 8" OD, Cylinder flange 10" OD Overall telescope height ~15" w/o. bottom cable connector. Extends ~6" above A/C skin, 9" below. Mounted in Zenith port.	See (b.)	See (b.)	Zenith or near-zenith port (See note.)
b. Data/control system	39 lb. (Includes 27-lb control box; 5-lb laptop w/ 2-lb charger and 5-lb rack tray)	13" total rack height in 19" rack mount panel. (Includes 9" high control box and 4" high laptop tray)	3.1 A control box plus 0.8 A laptop	120VAC, 60Hz	N/A
c. N_2 gas bottle	30 lb	7.5" Dia x 21" H	N/A	N/A	N/A
d. *Optional	45-lb 13" diagonal color monitor (needs rack tray). 4-lb printer w/ charger	15" rack height in 19" panel	1.3A	120VAC, 60Hz	N/A

2. Fourteen-Channel Ames Airborne Tracking Sunphotometer (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	125.6 lb. (Includes 114-lb head w/elec., 3.5-lb isolator, 1-lb reinforc. ring, 0.4-lb torque link, 0.7-lb mount bolts, 6-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.