Proposal Cover Page

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Proposal Number:

Date: 3/28/2003

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Name of Submitting Institution: Bay Area Environmental Research Institute

Congressional District: California #1

Proposal Title: NPP Science Team for Climate Data Records

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Budget:	**BAER**	**NASA Ames**	**Total**
Year 1 (October 2003-September 2004):	$74.5K	$14.1K	$88.6K
Year 2 (October 2004-September 2005):	$83.1K	$13.1K	$96.3K
Year 3 (October 2006-September 2006):	$90.5K	$13.6K	$104.1K
Total:	**$248.1K**	**$40.9K**	**$289.0K**

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ACRONYMS

AATS	Ames Airborne Tracking Sunphotometer(s)
ACE	Aerosol Characterization Experiment
ADAM	Asian Dust Above Monterey
AERONET	Aerosol Robotic Network
AIRS	Atmospheric Infrared Sounder
AOD	Aerosol Optical Depth
APMIR	Airborne Polarimetric Microwave Imaging Radiometer
ARM	Atmospheric Radiation Measurement
ASTER	Advanced Spaceborne Thermal Emission Radiometer
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS	Airborne Visible Infrared Imaging Spectrometer
CIRPAS	Center for Interdisciplinary Remotely Piloted Aircraft Studies
CDR	Climate Data Record
CERES	Clouds and the Earth's Radiant Energy System
CLAES	Cryogenic Limb Array Etalon Spectrometer
CLAMS	Chesapeake Lighthouse & Aircraft Measurements for Satellites
CrIS	Cross-track Infrared Sounder
CWV	Columnar Water Vapor
DOE	Department of Energy
EDR	Environmental Data Record
EOS	Earth Observation System
HIS	High-resolution Interferometer Sounder
HSB	Humidity Sensor Brazil
IGAC	International Global Atmospheric Chemistry
MAS	MODIS Airborne Simulator
MASTER	MODIS/ASTER Airborne Sensors
NAST	NPOESS Airborne Sounder Testbed
NOAA	National Atmospheric and Oceanic Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
OMPS	Ozone Mapping and Profiler Suite
PRIDE	Puerto Rico Dust Experiment
PSAP	Particle Soot Absorption Photometer
PSR	Polarimetric Scanning Radiometer
PW	Precipitable Water
SAFARI	Southern African Regional Science Initiative
SAGE	Stratospheric Aerosol and Gas Experiment
SAM	Stratospheric Aerosol Measurement
SBUV	Solar Backscatter Ultraviolet radiometer
SOLVE-2	SAGE III Ozone Loss Validation Experiment
TARFOX	Tropospheric Aerosol Radiative Forcing Observational Experiment
TOMS	Total Ozone Mapping Spectrometer
UV	Ultraviolet
VIIRS	Visible Infrared Imaging Radiometer Suite

1 ABSTRACT

We propose to become members of the NPOESS Preparatory Project (NPP) Science Team. NPP provides a "bridge" between the EOS Terra and Aqua missions and the NPOESS first operational satellite, currently planned for initial launch in the 2009 timeframe. The NPOESS and NPP data products are known as Environmental Data Records (EDRs), and – if suitable for long-term climate studies – Climate Data Records (CDRs).

Our expertise is highly relevant for the Visible Infrared Imaging Radiometer Suite (VIIRS) and the Ozone Mapping and Profiler Suite (OMPS) aboard the NPP platform. Our competency (as evidenced by our previous published research) will be highly valuable for the assessment of several planned NPP Environmental Data Records (EDRs) and their adequacy as equivalent Climate Data Records (CDRs). These Records are: aerosol optical thickness, aerosol particle size parameter, suspended matter, ozone total column, and precipitable water.

Our contributions to the NPP science team during the pre-launch phase will be

a) The **scientific support of algorithm development**

Many of the VIIRS solar reflective channel wavelengths either match exactly or are close to the Ames Airborne Tracking 14-channel Sunphotometer (AATS-14) wavelengths. Hence the AATS-14 algorithm work and its previous validation (see below) are of key importance for VIIRS. Our in-depth knowledge of algorithms and data to retrieve ozone in the UV and visible and water vapor in the near-infrared will be extremely valuable for the assessment of the ozone total column and precipitable water EDRs.

b) The further **development of the NPP Calibration-Validation Plan**.

We expect to be instrumental in the planning of coordinated measurement campaigns as set out in the Cal/Val plan. We have played scientific and organizational lead roles in numerous such campaigns.

After launch we propose that our team's expertise and instruments be a major part of the **NPP calibration and validation effort.**

The PI (Dr. Schmid) and Co-I's (Drs. Redemann and Russell) of this proposal have vast experience in the derivation, validation and improvements of EDRs and CDRs from orbital and sub-orbital platforms. We have employed an array of in-situ and remote sensing methods to measure aerosol optical properties, water vapor and ozone. We have emphasized the use of airborne sunphotometry as a unique link between space-based retrievals and a diversity of suborbital measurements.

To this end we have built two Ames Airborne Tracking Sunphotometers (AATS-6 and AATS-14) and operated them in numerous large field campaigns since 1985. Through these experiments the AATS team has made significant contributions to the airborne study of atmospheric aerosols. The AATS instruments' measurements of aerosol optical depth are used frequently in closure studies to investigate the ability of airborne in situ measurements of aerosol properties to predict measured attenuation of solar radiation. They have also been compared frequently to results from ground-based and airborne lidars. Most recently the airborne AATS observations have been used to evaluate the performance of aerosol transport models. Of most relevance to this proposal is that the AATS data have been used extensively in the validation of satellite sensors. At the time of writing this validation work is reported in 12 publications, validating 11 satellite sensors using data from 7 international field campaigns. The efforts of the AATS team have provided important aerosol information used in the revision of retrieval algorithms for the MISR and MODIS sensors aboard the NASA EOS Terra platform.

2 BACKGROUND AND RATIONALE

Some key measurement series initiated with the Earth Observing System's Terra and Aqua missions will be continued by the satellites and sensors of the NPOESS. NPP provides a "bridge" between the EOS Terra and Aqua missions and the NPOESS first operational satellite, currently planned for initial launch in the 2009 timeframe. The NPP mission is planned for launch in the 2007 time frame. At least four sensors will be flown on the NPP mission: the Visible Infrared Imaging Radiometer Suite (VIIRS), the Cross-track Infrared Sounder (CrIS), the Advanced Technology Microwave Sounder (ATMS), and the Ozone Mapping and Profiler Suite (OMPS). There is a possibility that a fifth sensor, the Clouds and the Earth's Radiant Energy System (CERES), may be added.

The derived products from NPP will include: land, ocean and atmospheric products. The NPOESS data products are known as Environmental Data Records (EDRs). It is NASA's intent to assure that these EDRs are also suitable for long-term climate studies. Following the nomenclature of the National Academy of Sciences these climate products will be called Climate Data Records (CDRs).

In what follows we demonstrate that our expertise (as evidenced by our previous research) is highly relevant for the assessment of planned Environmental Data Records (EDRs) and their adequacy as equivalent Climate Data Records (CDRs). We propose to become members of the NPOESS Preparatory Project (NPP) Science Team. Our expertise is relevant for the NPP VIIRS and OMPS instruments and for the following Atmospheric EDRs: aerosol optical thickness, aerosol particle size parameter, suspended matter, ozone total column, precipitable water. (As noted by the NRA, suspended matter includes, e.g., dust, sand, volcanic ash, sea salt, and smoke.)

3 INVESTIGATORS' EXPERTISE RELEVANT TO THIS PROPOSAL

The PI (Dr. Schmid) and Co-I's (Drs. Redemann and Russell) of this proposal have vast experience in the derivation, validation and improvements of EDRs from orbital and sub-orbital platforms:

Dr. Russell has been involved in atmospheric science since 1971, conducting aircraft, satellite and ground-based studies of atmospheric processes and climate change. Among the methods he employed are lidar measurements and simulations [e.g. *Russell et al.,* 1976, 1979, 1982a,b, 1983b; *Russell and Livingston,* 1984], sodar (acoustic radar) [e.g. *Russell et al.,* 1974; *Russell and Uthe*, 1978], and radiometry (including sun photometry) [e.g. *Russell and Shaw*, 1975; *Russell et al.,* 1993a].

Dr. Russell has been a member of the science teams for SAM II, SAGE, SAGE II and SAGE III (satellite sensors of stratospheric aerosols, ozone, nitrogen dioxide, and water vapor) from 1976-2002 [e.g. *Russell et al*., 1981, 1983a, 1984; *Russell and McCormick,* 1989]. Hence he has considerable first hand experience in activities expected to be performed by NPP science team members, such as review and preparation of sensor and algorithm documents, conduct of data simulation studies, development of calibration-validation plans, etc. (see section 5 of this proposal). Dr. Russell initiated and guided a study that developed a stratospheric aerosol climatology from SAGE II and CLAES measurements [*Baumann et al.,* 2003a and b], which represents a successful example of converting an EDR into a CDR (see section 4.2).

In 1984, Dr. Russell started the development of the first of two airborne sunphotometers: the 6-channel NASA Ames Airborne Tracking Sunphotometer (AATS-6), which flew its first mission in 1985 [*Matsumoto et al*., 1987]. Subsequently 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, and the University of Washington C-131A focusing on measurements of aerosol optical depth (λ=380-1020 nm). 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 cirrus clouds [*Pueschel et al*., 1988; *Pueschel and Livingston*, 1990], to measure tropospheric haze aerosols and their impact on atmospheric radiation and on remote measurements of the Earth's surface [*Spanner et al*., 1990; *Wrigley et al*., 1992; *Russell et al.*, 1999b], and to document the effect of the 1991 Pinatubo volcanic eruption on global-scale stratospheric aerosol optical depth spectra [*Russell et al*., 1993a,b; 1996; *Toon et al*., 1993].

In 1993, Dr. Russell started the development of the 14-channel NASA Ames Airborne Tracking Sunphotometer (AATS-14, initially λ=380-1558 nm). 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*., 1999a]. Dr. Russell was IGAC coordinator for TARFOX, where AATS-6 was flown on the University of Washington C-131A, hence marking the first experiment with two airborne sunphotometers [*Russell et al.,* 1999b].

Before joining the NASA Ames Airborne Sunphotometer Team (AATS) in 1997, Dr. Schmid worked with NOAA/AVHRR data (from 1989 to 1991) monitoring vegetation growth in Switzerland [*Schmid et al., 1991*]. The VIIRS instrument on NPP is based in part on the heritage of the AVHRR instruments.

In 1992 Dr. Schmid started working in the field of ground-based sunphotometry using state-of-the art instrumentation developed at the World Radiation Center in Davos, Switzerland [*Fröhlich et al*., 1995]. He published on refined techniques to retrieve aerosol optical depth, aerosol particle size distribution [*Schmid et al*., 1997], and columnar water [*Schmid et al*., 1996] from the direct solar beam transmission measurements a sunphotometer provides. Comparing the traditional Langley plot technique with the standard lamp/solar spectrum technique in two studies [*Schmid and Wehrli* 1995, *Schmid et al*., 1998], Dr. Schmid became an expert in radiometric calibration of solar instrumentation. After leaving the University of Bern and joining the AATS team, Dr. Schmid remained involved in sunphotometer algorithm work in Bern now conducted by Dr. Ingold [*Ingold et al.*, 2000, 2001b], and which now also included determination of total ozone from transmission measurements in the UV [*Ingold et al*., 2001a]. As further discussed in section 5, this algorithm work is of high relevance for NPP.

Dr. Schmid added the aforementioned additional expertise in sunphotometry to the AATS team. The capability to retrieve columnar water vapor (CWV) and ozone from the AATS measurements was added. The CWV retrieval was thoroughly tested by operating AATS-6 on the ground during two Dept. of Energy ARM program [*Ackerman and Stokes*, 2003] water vapor intercomparison experiments in 1997 and 2000 [*Schmid et al*., 2001; *Revercomb et al*., 2003]. During the 1997 campaign, Dr. Schmid also led a sunphotometer intercomparison comparing AOD and CWV from 5 different instruments [*Schmid et al*., 1999].

The Second Aerosol Characterization Experiment (ACE-2) in 1997 [*Russell and Heintzenberg*, 2000] was Dr. Schmid's first contact with airborne sunphotometry. AATS-14 was again flown on the Pelican aircraft, whereas AATS-6 operated successfully on a research ship. The AATS instruments conducted measurements of marine, European, and African aerosol optical depth spectra, as well as water vapor columns [e.g. *Livingston et al*., 2000, *Schmid et al*., 2000]. Using ACE-2 data, Dr. Schmid also pioneered the method of deriving spectral aerosol extinction $E_a(\lambda)$ and water vapor density ρ_w by differentiating AATS vertical profiles of AOD and CWV. An example obtained in a later campaign, ACE-Asia, is shown in section 4.5.

Dr. Redemann joined the AATS team in 1999. His previous expertise in aerosol research included in-situ, lidar and sunphotometer data [*Redemann et al*., 1998; 2000a; 2000b], further strengthening the AATS team. He is currently funded to perform validation of the MODIS 2.1µm channel AOD product over the ocean, an endeavor that depends largely on the airborne capabilities and spectral coverage of the AATS-14 instrument (see section 4.3.2).

The AATS team then participated in a series of large field experiments: the Puerto Rico Dust Experiment (PRIDE, 2000), the Southern African Regional Science Initiative (SAFARI-2000), the Asian-Pacific Aerosol Characterization Experiment (ACE-Asia, 2001), the Chesapeake Lighthouse & Aircraft Measurements for Satellites (CLAMS, 2001) and most recently the second SAGE III Ozone Loss Validation Experiment (SOLVE-2, 2003).

Through these experiments the AATS team has made significant contributions to the airborne study of atmospheric aerosols [e.g. *Livingston et al*., 2003, *Schmid et al.*, 2003, *Redemann et al*., 2001]. The AATS instruments' measurements of aerosol optical depth are used frequently in closure studies to investigate the ability of airborne in situ measurements of aerosol properties to predict measured attenuation of solar radiation. [*Hegg et al*., 1997, *Hartley et al*., 2000, *Collins et al.*, 2000, *Schmid et al*., 2000, *Wang et al*., 2002, *Magi et al*., 2003, *Schmid et al.*, 2002, *Redemann et al*., 2003]. They have also been compared frequently to results from ground-based and airborne lidars [e.g. *Ferrare et al*., 2000, *Schmid et al*. 2000; 2002; 2003] and most recently the airborne AATS observations have been used to evaluate the performance of aerosol transport models [*Chin and Ginoux*, 2002, *Colarco et al*., 2003]. The validation of such transport models is a crucial step in assessing these models' capabilities in predicting future climate change.

Of most relevance to this proposal is that the AATS data have been used extensively in the validation of satellite sensors. The TARFOX measurements mark the beginning of a series of publications on that subject. At the time of writing, the series includes 12 publications, validating 11 satellite sensors using data from 7 international field campaigns (see Table 1). As we will show the efforts of the AATS team have provided important aerosol information used in the revision of retrieval algorithms for the MISR and MODIS sensors aboard the NASA EOS Terra platform [*Schmid et al*., 2003, *Livingston et al*., 2003, *Levy et al*., 2002].

Table 1: Validation of satellite derived spectral AOD published by the PI and Co-I's of this proposal.

Sensor	Campaign	Region	Surface	Period	Publication
AVHRR	TARFOX	US East Coast	Ocean	July 1996	Veefkind et al., 1999
AVHRR	ACE 2	Canary Islands	Ocean	June/July 1997	Durkee et al., 2000 Livingston et al., 2000 Schmid et al., 2000
ATSR-2	TARFOX	US East Coast	Ocean	July 1996	Veefkind et al., 1999
ATSR-2	SAFARI 2000	Namibian Coast	Ocean	September 2000	Schmid et al., 2003
GMS-5	ACE-Asia	Eastern Asia	Ocean	April 2001	Wang et al, 2003b
GOES-8	PRIDE	Puerto Rico	Ocean	June/July 2000	Livingston et al., 2003 Wang et al., 2003a
MAS	TARFOX	US East Coast	Ocean	July 1996	Tanré et al. 1999
MISR	SAFARI-2000	Southern Africa	Ocean & Land	September 2000	Schmid et al., 2003
MISR	ACE-Asia	Eastern Asia	Ocean	April 2001	Kahn et al., 2003
MISR	CLAMS	US East Coast	Ocean	July/August 2001	Redemann et al., 2001
MODIS	PRIDE	Puerto Rico	Ocean	June/July 2000	Livingston et al., 2003 Levy et al., 2003
MODIS	SAFARI-2000	Southern Africa	Ocean & Land	September 2000	Schmid et al., 2003
MODIS	CLAMS	US East Coast	Ocean	July/August 2001	Levy et al., 2002
MODIS	ACE-Asia	Eastern Asia	Ocean	April 2001	Chu et al., in prep.
POAM	SOLVE-2	Arctic	Ocean & Land	Jan/Feb 2003	in prep.
SAGE 3	SOLVE-2	Arctic	Ocean & Land	Jan/Feb 2003	in prep.
SeaWiFS	ACE-Asia	Eastern Asia	Ocean	April 2001	Hsu et al, in prep.
TOMS	PRIDE	Puerto Rico	Ocean	June/July 2000	Livingston et al., 2003
TOMS	SAFARI-2000	Southern Africa	Land	September 2000	Schmid et al., 2003

4 EXAMPLE RESEARCH RESULTS RELEVANT TO THIS PROPOSAL

4.1 Scientific Motivation

Figure 1 and Figure 2 show schematically the scientific motivation and overall approach used in the AATS team's research. As indicated by Figure 1, aerosols produced by biomass burning, desert dust storms, urban pollution, and other processes form features recognizable from space on regional to intercontinental scales [e.g., *Husar et al*., 1997; *Kaufman et al*., 2002; Prospero et al., 2002]. These aerosols can change the climate by perturbing energy exchange between the sun, Earth, and space, as well as by redistributing energy within the atmosphere. Two gas-phase constituents, water vapor and ozone, are also relevant, because they interact with aerosols both chemically and physically, and they are themselves major players in the Earth's radiation budget. All three constituents—aerosols, water vapor, and ozone—can be retrieved quantitatively from spaceborne measurements. However retrieval accuracy is still being determined, because it depends strongly on constituent type, measurement conditions (e.g., over land vs. water, in or out of sun glint, in or out of cirrus or other cloud fields), and spaceborne measurement technique (e.g., multiangle, multiwavelength, polarization, nadir- vs. limb-viewing, passive vs. active, etc.).

The three constituent types can also be measured by airborne sunphotometry. We have emphasized the use of airborne sunphotometry as a unique link between space-based retrievals and a diversity of suborbital measurements. Figure 2 illustrates the coordination of satellite and suborbital measurements used in the field studies listed in Table 1.

In the remainder of this section we show illustrative results, relevant to the tasks of the NPP science team.

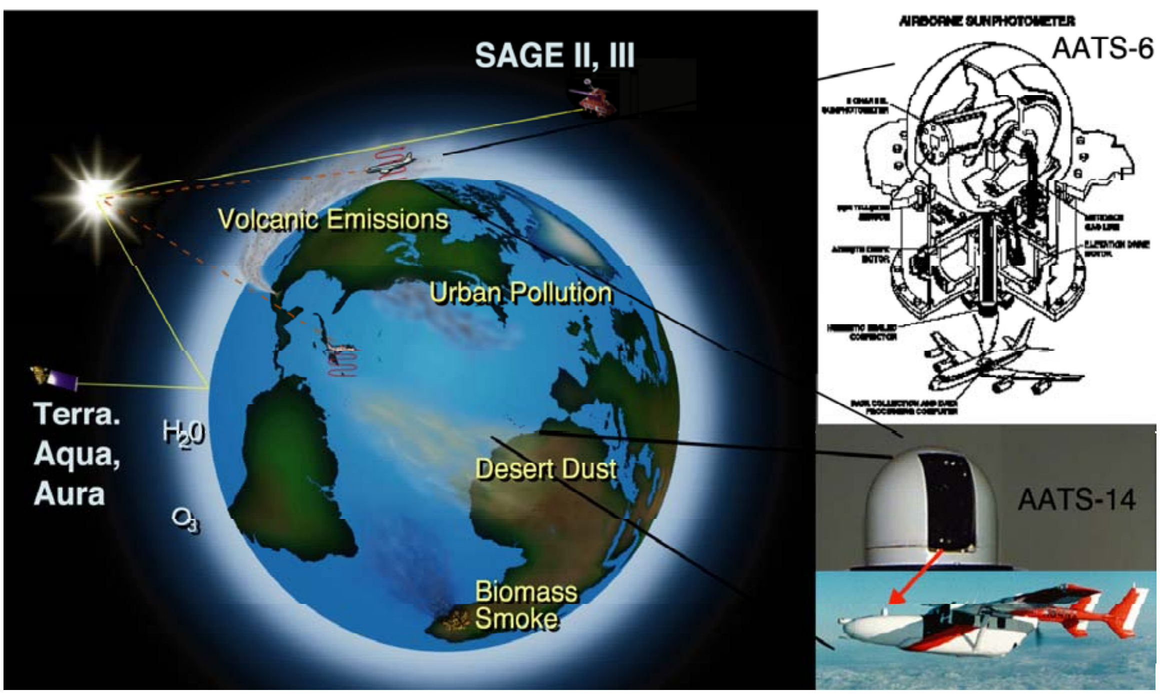


Figure 1: Schematic of the scientific motivation and overall approach used in the AATS team's research.

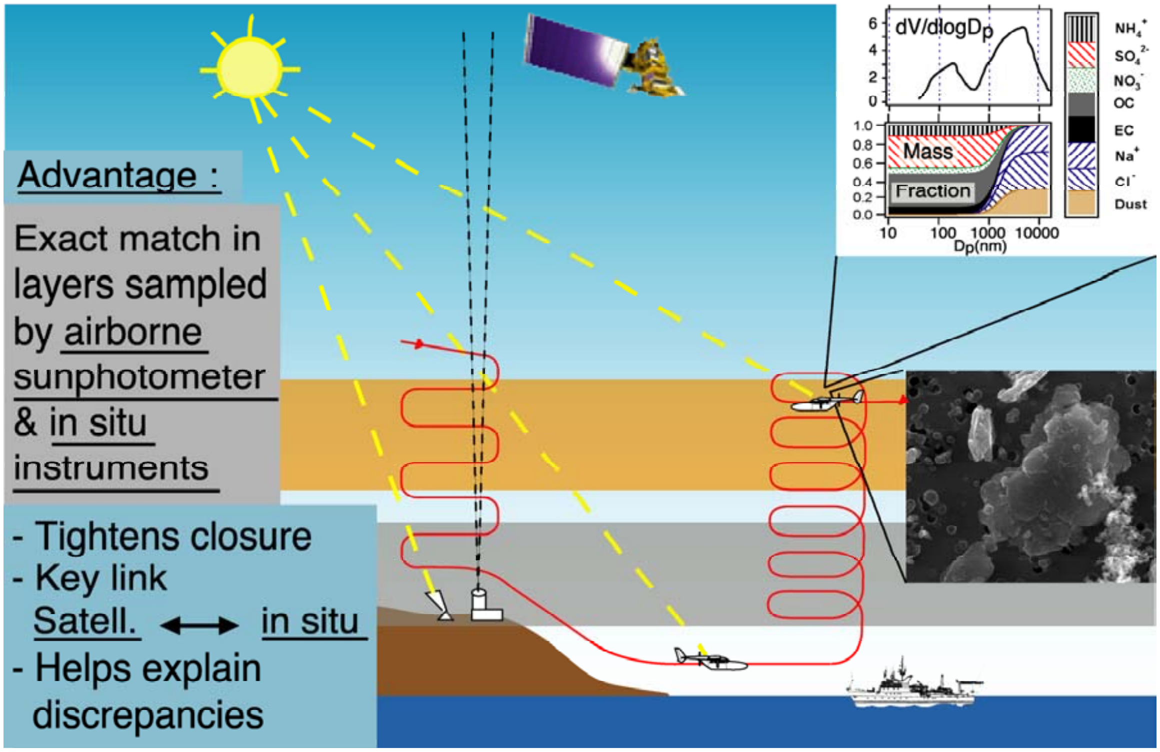


Figure 2: Schematic of the approach used in field experiments that coordinate a variety of suborbital measurements, including airborne sunphotometry, with satellite overflights. Example of size-resolved composition data is from *Wang et al*. [2002]. Electron microscope (EM) image of particles is courtesy of James Anderson, Arizona State University. EM image is 7 µm wide.

4.2 Stratospheric Aerosol Climatology from SAGE II and CLAES

As part of our work on the SAGE II Science Team we have guided the development of a stratospheric aerosol climatology. The climatology was produced by an algorithm that uses extinction measurements by SAGE II and CLAES. The algorithm uses the 4-wavelength SAGE II extinction measurements (0.385 to 1.02 µm) over the full period of the climatology (~15 years, 12/1984-8/1999) and adds CLAES 12.82 µm extinction measurements during the critical post-Pinatubo volcanic period when stratospheric aerosol radii were largest (January 1992 to May 1993). The climatology includes stratospheric aerosol multiwavelength extinction and optical depth, plus retrieved values and uncertainties for particle effective radius R_{eff}, surface area S, volume V, and size distribution width σ_g. Examples from this climatology published by *Baumann et al.,* [2003a and b] are shown in Figure 3 and Figure 4. The effect of the volcanic eruptions of Ruiz (Nov. 1985), Kelut (Feb. 1990) and Pinatubo (June 1991) is easily discerned.

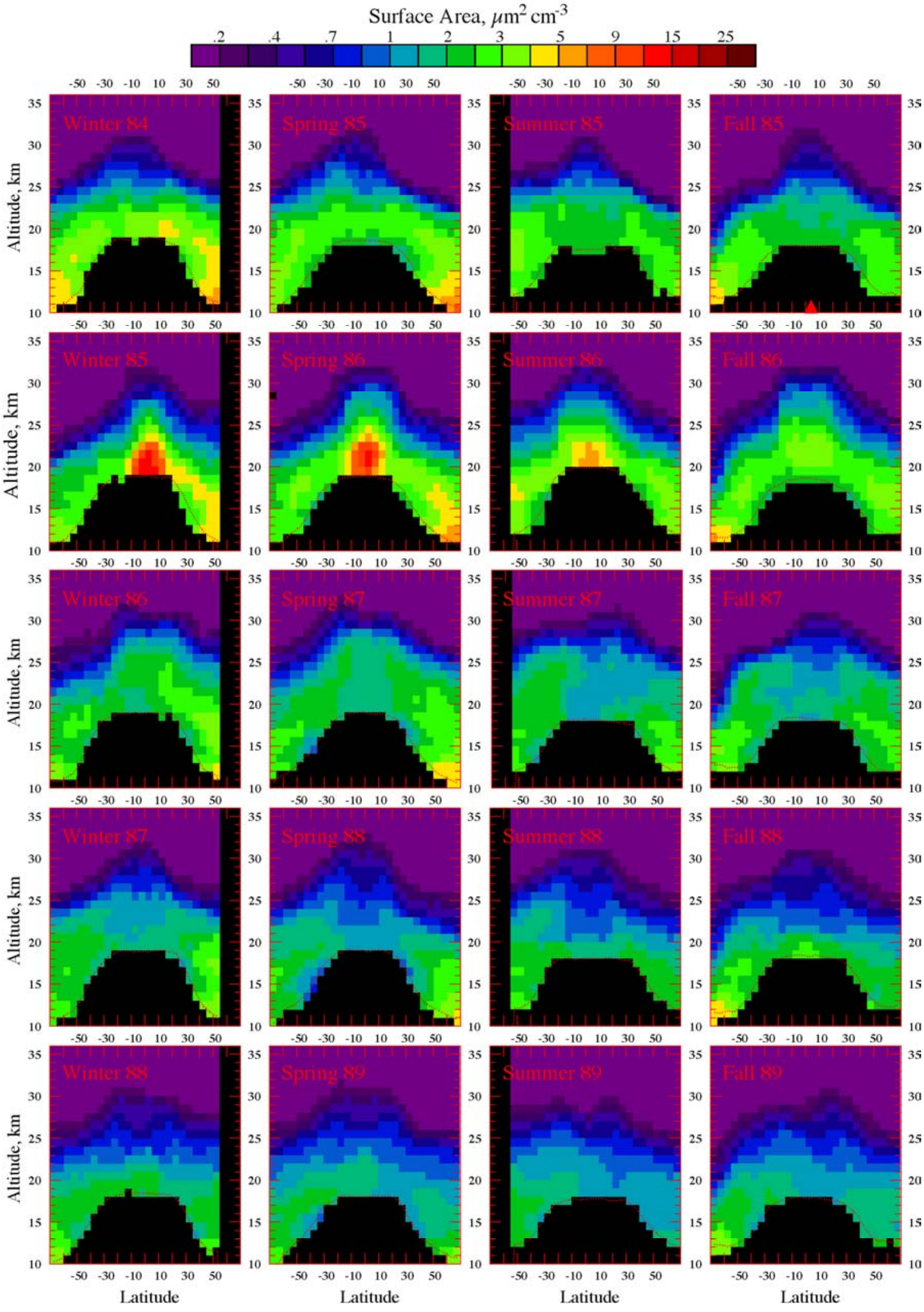


Figure 3: Seasonally averaged surface area of stratospheric aerosol CDR from Winter 1984 to Fall 1989, derived from SAGE II and CLAES EDRs [*Bauman et al.* 2003a]. Red triangle in the Fall 85 frame marks the latitude of the November 1985 Kelut eruption.

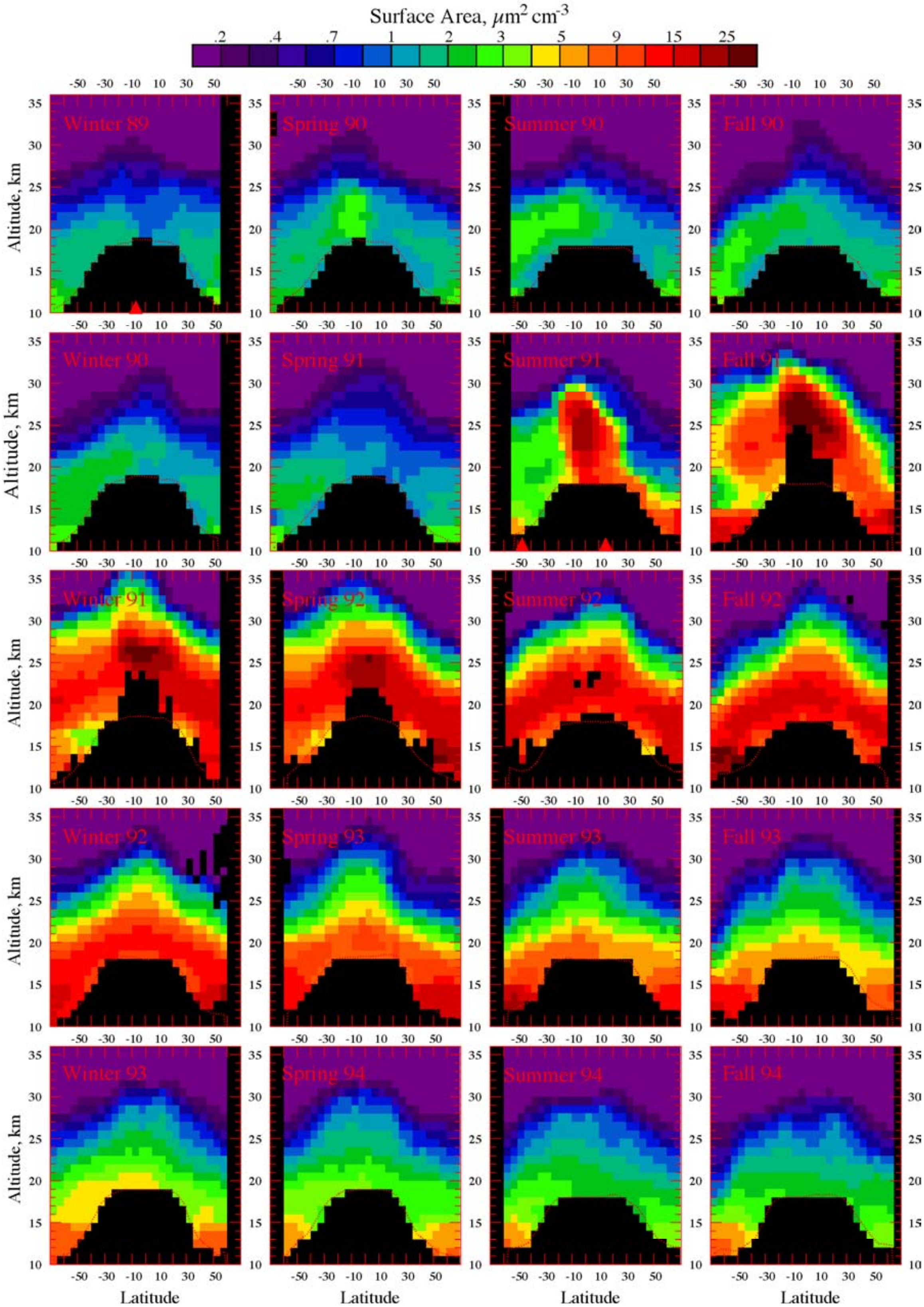


Figure 4: Seasonally averaged surface area of stratospheric aerosol CDR from Winter 1989 to Fall 1994, derived from SAGE II and CLAES EDRs [*Bauman et al.* 2003a]. Red triangles in the Winter 89 and Summer 91 frames mark latitudes of the February 1990 Kelut and Summer 1991 Pinatubo and Hudson eruptions.

4.3 Validation of Satellite Aerosol Optical Depth

During various field experiments (see Table 1) considerable effort was devoted to coordinating aircraft measurements with satellite overpasses. The aircraft measurements include aerosol optical depth spectra measured by an existing Ames Airborne Tracking Sunphotometer (AATS-14 or AATS-6). When measured on transects flown near the land or ocean surface, such optical depth spectra are useful for validating products from the satellite sensors. To date the AATS team has contributed to the validation of 11 satellite sensors using data from 7 international field campaigns (see Table 1). This section presents examples of such validation.

4.3.1 MODIS Dust Retrievals in PRIDE.

Figure 5 shows a scatter plot comparing aerosol optical depths (AOD) at four wavelengths, as retrieved by MODIS and as measured by AATS-6 flying near the ocean surface in the MODIS scene. All measurements were made in the Puerto Rico Dust Experiment (PRIDE). Data points with AOD>0.2 are from conditions dominated by Saharan dust transported to the Caribbean [*Reid et al*., 2002, 2003]. For the cases with little or no dust (AOD<0.2), MODIS and AATS-6 values are within ~1 error bar of the 1:1 line. In dust-dominated conditions (AOD>0.2), this is also true for AOD at wavelength 870 nm. However, at the shorter wavelengths, MODIS-retrieved AOD systematically exceeds the AATS-6 values. Thus, in dust-dominated conditions the slope of AOD vs. wavelength is steeper in MODIS-retrieved spectra than in AATS-6 spectra. This is shown explicitly in Figure 6, which plots the same data as spectra of AOD vs. wavelength. The likely cause of this slope difference is dust nonsphericity, which causes the MODIS retrieval to substitute more small mode aerosol for nonspherical large mode dust [*Remer et al*., 2002]. An updated MODIS algorithm that adds nonspherical phase functions is being developed to address this.

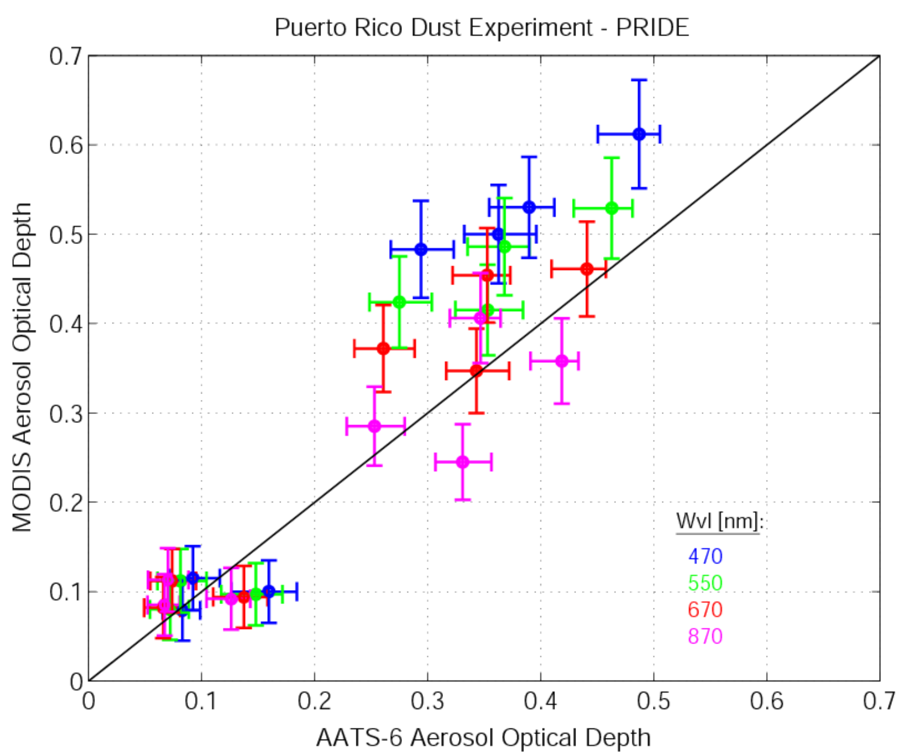


Figure 5: Scatter plot comparing AODs retrieved by MODIS to those measured by AATS-6 in PRIDE [*Livingston et al*., 2003].

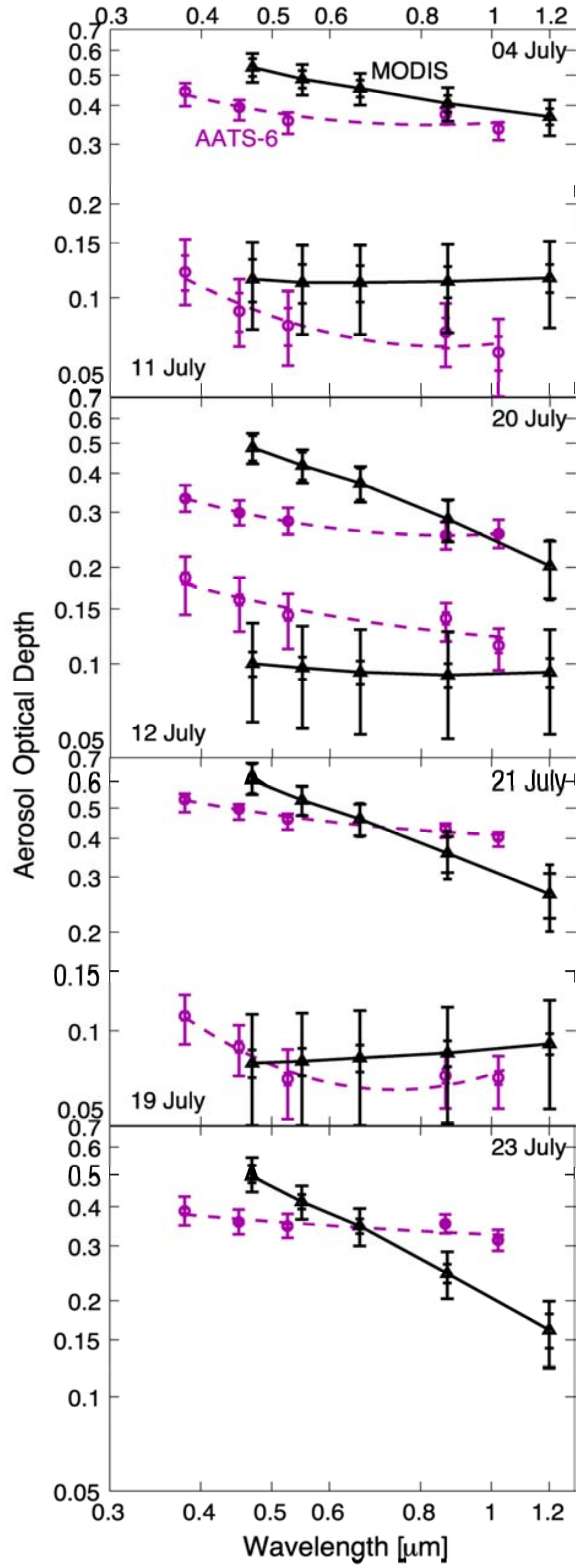


Figure 6: MODIS and AATS spectra for the 7 cases in Figure 5 [*Livingston et al.*, 2003].

4.3.2 MODIS Retrievals in SAFARI 2000

In SAFARI-2000, AATS-14 measured aerosol optical depth spectra aboard the UW CV-580 in the vicinity of Inhaca Island, Mozambique on August 24, 2000. Figure 7 (left) shows the comparison of AATS-14-derived to MODIS-derived aerosol optical thickness [*Schmid et al*., 2003] as a function of wavelength.

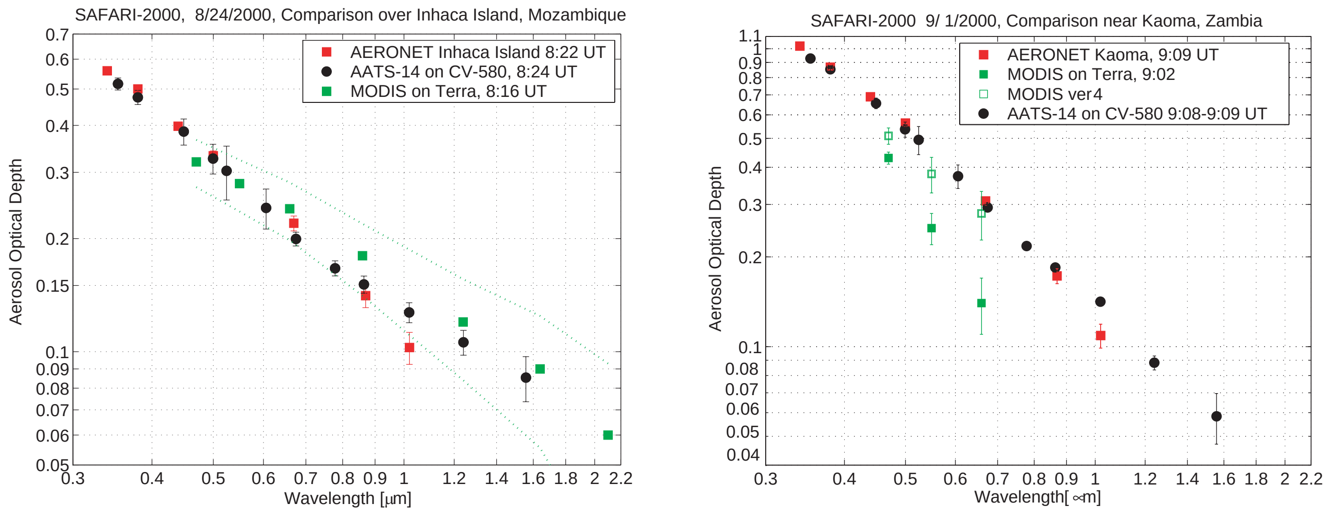


Figure 7: Comparisons of AOD spectra measured by AATS-14 and MODIS-Terra in SAFARI-2000, *Schmid et al*. [2003].

Also shown in Figure 7 are the concurrent measurements of AOD by AERONET (a global network of ground-based sunpotometers, [*Holben et al*., 1998]). The AATS-14 measurements shown represent the first published validation efforts of MODIS-derived AODs at wavelengths beyond 1.02 μm. Based on these and similar comparisons involving biomass burning aerosol, the MODIS team adjusted the single scattering albedo in the MODIS inversion algorithm to account for regional and seasonal variations. The new inversion algorithm (labeled "MODIS ver4" in Figure 7, right panel) yields considerably better agreement with AERONET and AATS-14.

Figure 7 (left panel) also illustrates the lack of validation of the longest MODIS wavelength channel at 2.13 μm. We have recently modified AATS-14 to include a channel at 2.139 μm. First MODIS validation at that wavelength is expected to be obtained from AATS-14 in ADAM-2003 (Asian Dust Above Monterey), an experiment to study Asian dust transported across the Pacific Ocean to the US West Coast in April of 2003.

4.3.3 MISR Retrievals in SAFARI 2000

During SAFARI-2000, AATS-14 was instrumental in identifying problems in the initial standard MISR retrievals of aerosol optical depth. Some of these problems were instrumental, while others pertained to the completeness of look-up tables used in the inversion of MISR radiance measurements to aerosol optical depth [*Schmid et al*., 2003]. As an illustration, the MISR AOD(λ) retrievals shown in Figure 8 come from the "beta" version of the standard retrieval, which is an early post launch, unvalidated version of the algorithm. This retrieval is based on a list of prescribed aerosol mixture models. Each mixture is tested in terms of how well it reproduces the MISR-measured path radiances [*Martonchik et al*., 1998; *Kahn et al.,* 2001]. Figure 8 shows the comparison of MISR retrieved AOD(λ) with AATS-14 during a low altitude pass of the Convair-580 within two adjacent 17.6×17.6 km^2 MISR regions off the Namibian Coast on September 11, 2000. In both regions, the "Clean Maritime" mixture (45% sulfate, 40% sea salt and 15% sea salt coarse) leads to good agreement at 558 nm and 672 nm; however, the MISR-derived AOD spectrum is too flat. The "Industrial Maritime" mixture (70% sulfate, 10% sea salt, 20% black carbon) leads to a spectral slope agreeing with AATS-14 but the MISR AOD values are then too high. The MISR algorithm finds a different best-fit mixture in the two adjacent regions, leading to a large change in best-fit AOD whereas AATS-14 indicates very little change in AOD.

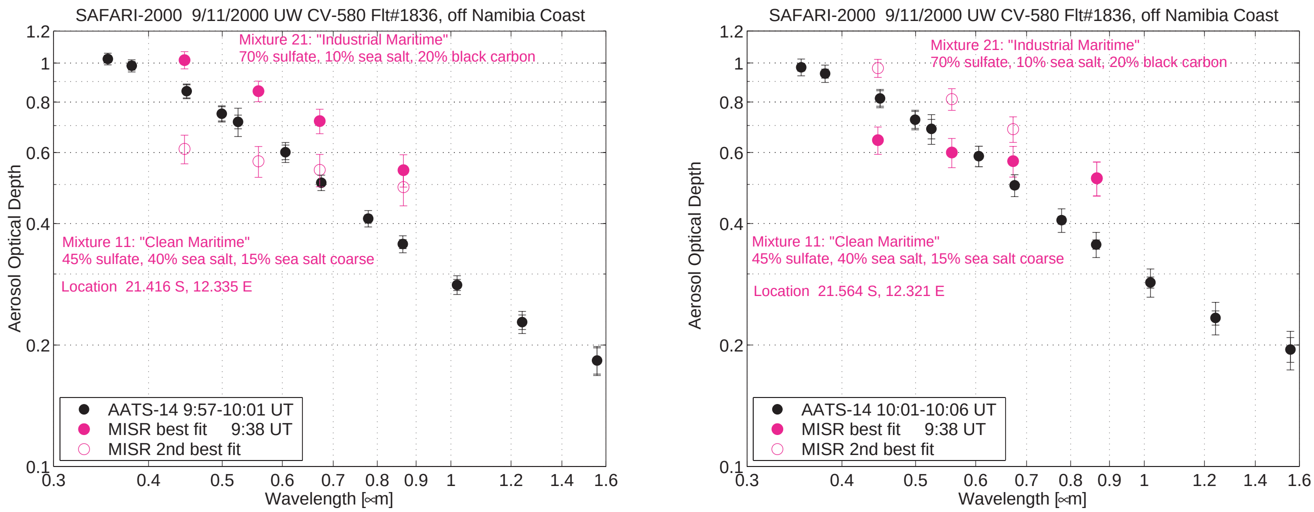


Figure 8: Comparison of aerosol optical depth spectra in two adjacent MISR pixels off the coast of Namibia, during SAFARI-2000, [*Schmid et al.*, 2003].

This spectral AOD comparison and others analyzed by the MISR team showed that a model including small, spherical, non-absorbing particles needed to be restored to the look-up tables used in MISR AOD retrievals. (It had been deleted early in the mission to reduce computer resource requirements.)

4.3.4 MISR Retrievals in ACE-Asia

MISR-AATS comparisons in ACE-Asia (not shown for brevity) confirmed that early MISR-derived AODs were skewed high for some low-light-level scenes. Subsequent experiments demonstrated that scattered light played a key role in this phenomenon, and led to a revision of the MISR low-light-level calibration (that significantly affects MISR-derived AOD over dark water) (R. Kahn, personal communication).

4.3.5 SeaWiFS Retrievals in ACE-Asia

Comparisons (e.g., Figure 9) between AATS measurements and SeaWiFS retrieved AOD yield good agreement if the new 4-wavelength *Hsu et al.* [2002] algorithm is used, but disagreement if using the standard SeaWiFS algorithm.

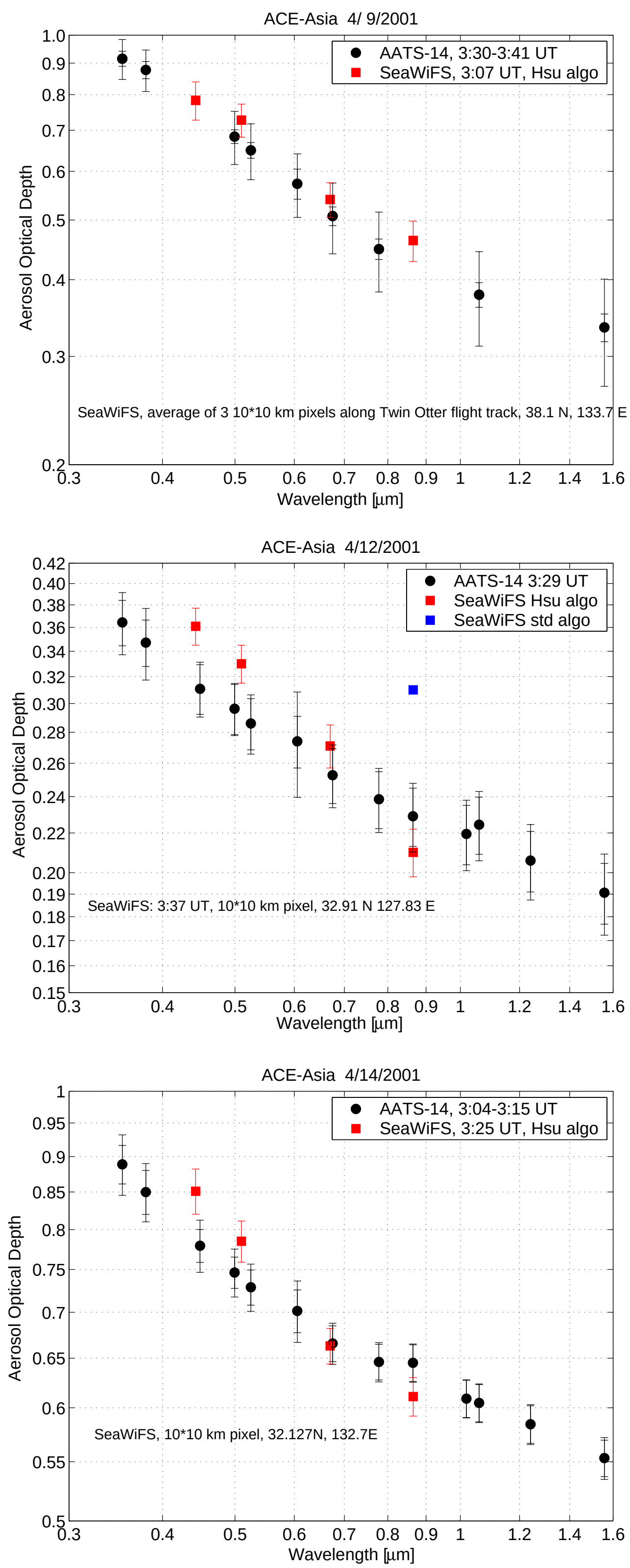


Figure 9: Comparison of spectral aerosol optical depth on April 9, 12 and 14, 2001 between AATS-14 and SeaWiFS, using the new 4-wavelengths algorithm by *Hsu et al*. [2002].

4.4 Comparison of columnar ozone from TOMS and AATS-14 during SOLVE-2

The AATS team is using the signature of the O_3 Chappuis-band (λ=450-800 nm, see Figure 13) to determine the columnar amount of O_3 from the AATS-14 measurements applying a method pioneered by *King and Byrne* [1976]. We have experimented with other methods (i.e. *Chu et al*., 1989, *Taha and Box*, 1999) but found the King and Byrne method to be suited best. During SOLVE-2, on January 21, 2003 the NASA DC-8 flew a transect from ~20°E to ~60°W. AATS-14 continuously measured the O_3 column above the plane which flew at an almost constant altitude of ~8 km a.s.l. In Figure 10 we compare the AATS-14 results with the retrievals from the TOMS satellite sensor. The O_3 column shows considerable variation, which is captured by both sensors. At the locations with the best spatial match-ups the TOMS values tend to be slightly larger, which is expected because the O_3 column below the airplane is not measured by AATS-14. We plan to account for that by including data from a down-looking O_3 lidar aboard the DC-8 [*Browell et al*., 1990].

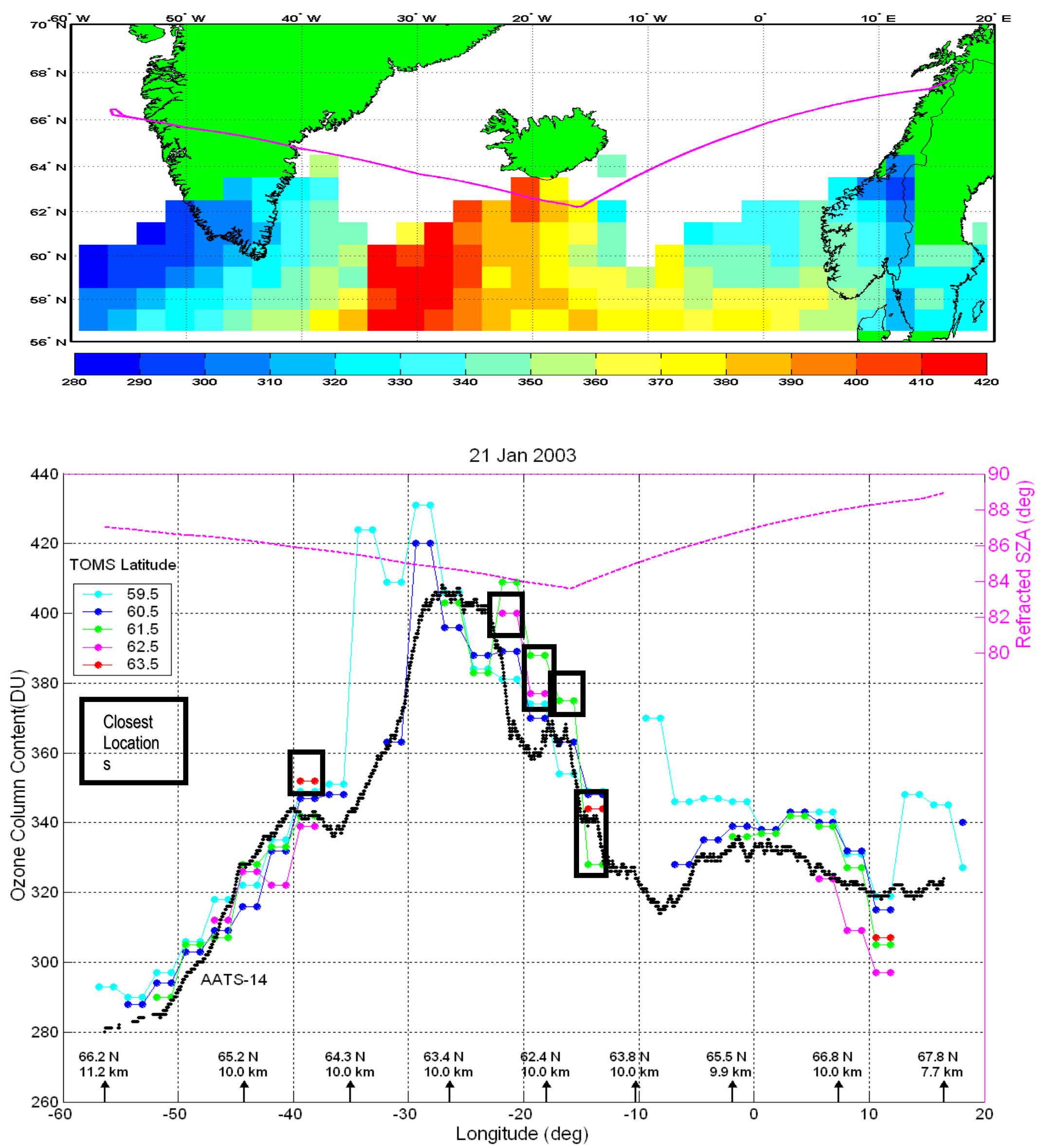
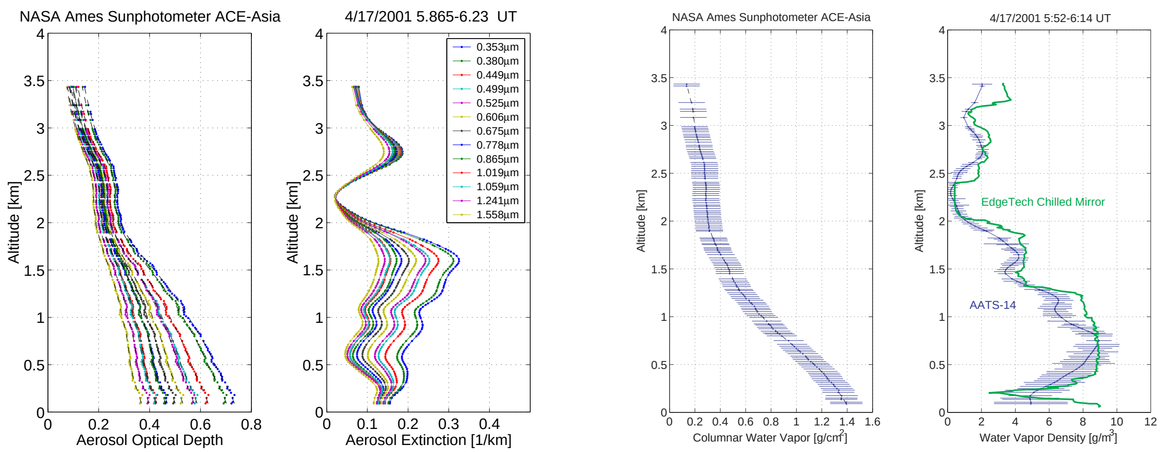


Figure 10: Columnar O_3 on January 21, 2003 from AATS-14 aboard NASA DC-8 and TOMS. Preliminary result.

4.5 AATS Aerosol and H_2O vertical profiles and closure studies

From AATS direct solar beam transmission measurements we derive spectral aerosol optical depths AOD(λ), columnar water vapor, CWV, and columnar ozone. Flying at different altitudes over a fixed location allows derivation of the same quantities in a given layer. Data obtained in vertical profiles allows derivation of spectral aerosol extinction $E_a(\lambda)$ and water vapor density ρ_w (see Figure 11)



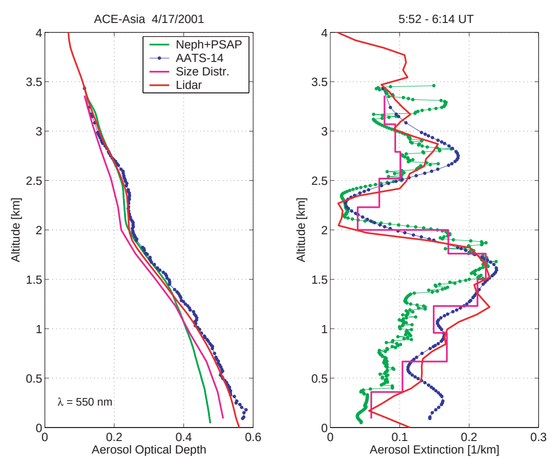


Figure 11: Top left: AOD profiles and derived extinctions at 13 wavelengths from 354 to 1558 nm calculated from AATS-14 measurements acquired during an aircraft ascent south of Korea on 17 April 2001 during ACE-Asia. Top right: Water vapor density derived from the profile of CWV. A comparison with a standard EdgeTech Chilled Mirror instrument is also shown. Bottom left: Comparison of aerosol extinction derived from AATS-14 measurements, aerosol size and composition distributions, the sum of aerosol scattering (nephelometer) and absorption (PSAP), and ship-based lidar measurements [*Schmid et al.*, 2002].

Measuring solar beam attenuation by an AATS on the same aircraft as in situ sensors allows a close match in the aerosol layers described by the attenuation and in situ measurements. Such a match allows the best-defined comparison between attenuation and in situ results. An example from ACE-Asia where the in situ extinction is computed as the sum of scattering (from humidified nephelometry) and absorption (PSAP instrument) is shown in Figure 11. Also shown is a concurrently measured aerosol extinction profile derived from a ship-based lidar system and values calculated from Mie theory using measured size distributions and size-resolved composition (used to determine the complex refractive indices) [*Wang et al.*, 2002]. Combining results from many such comparisons (usually called "closure studies") has shown that extinction values from in-situ scattering and absorption measurements were ~13% less than the values from AATS-14 [*Schmid et al.*, 2003].

4.6 AATS - AERONET comparisons

Measurements by AATS-6 have been compared to measurements from ground-based Cimel sunphotometers during two DOE ARM IOPs, when AATS-6 was operated on the ground to enable side-by-side comparisons of the instruments without concern about spatial homogeneity of the observed quantity. Figure 12 shows an example of a comparison of AATS-6 and Cimel derived CWV (columnar water vapor) and AOD (aerosol optical depth) at 380 and 1020 nm, respectively. These observations were taken during the 1997 ARM IOP at the SGP site in Oklahoma [*Revercomb et al*., 2003]. When using the same line-by-line model along with the same spectroscopic database in deriving CWV from the direct solar beam transmittance measured by AATS-6 and the Cimel instrument, *Schmid et al*. [2001] were able to show remarkable agreement (3%) in the two instruments' observations. *Schmid et al*. [1999] further showed that the concurrent measurements of AOD in the spectral range of 380 to 1020 nm determined from the two instruments agreed to within 0.012 (rms) or better.

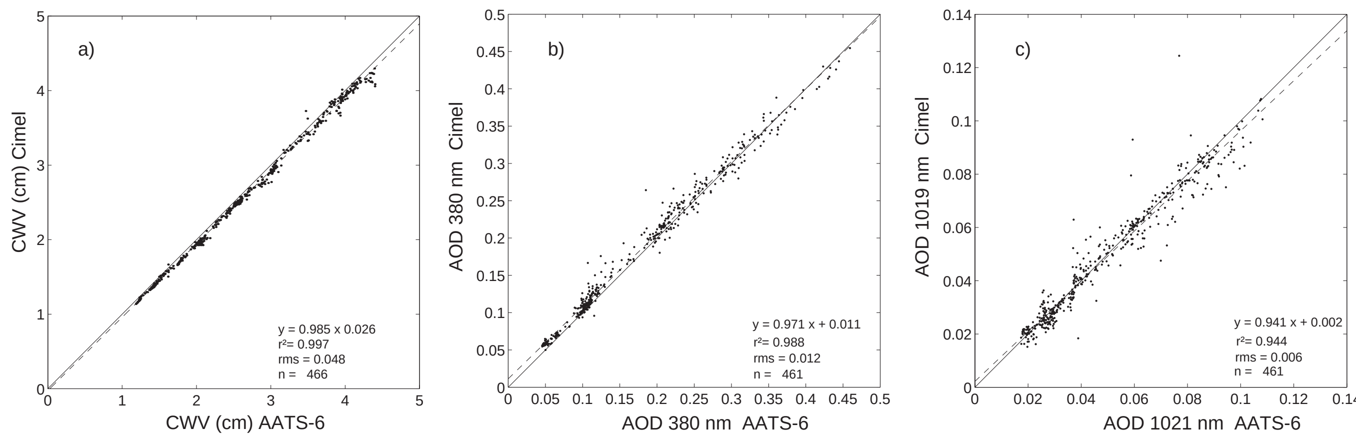


Figure 12: Statistical comparison of CWV and AOD at 380 and 1020nm as observed by AATS-6 and a Cimel instrument during the 1997 Fall ARM IOP, *Schmid et al*. [1999, 2001].

5 PLANNED ACTIVITIES AS NPP SCIENCE TEAM MEMBERS

We propose to become members of the NPP Science Team. As demonstrated in the previous sections and evidenced in the peer-reviewed literature our expertise is relevant for the NPP sensors VIIRS and OMPS and for the following Atmospheric EDRs pertinent to NPP:

- aerosol optical thickness
- aerosol particle size parameter
- suspended matter (e.g., dust, sand, volcanic ash, sea salt, smoke)
- ozone total column
- precipitable water

As spelled out in the NRA, NPP Science Team members will be expected to:

- Participate in about 4 technical interchange meetings and science team meetings per year at the NPOESS system contractor's site, sensor vendor's sites or NASA GSFC
- Review sensor and algorithm documents, algorithm code and system descriptions as appropriate
- Conduct data simulation studies as appropriate
- Prepare an algorithm analysis report and recommend algorithm improvement activities
- Participate in the preparation of a science operations concept document
- Support the further development of the NPP Calibration-Validation Plan
- Provide information to NASA on a variety of technical matters associated with NPP instruments and algorithms.

We are convinced that we will contribute to all of the expected items listed above. Of particular importance are our expected contributions to the NPP Calibration-Validation activities. The draft NPP Calibration-Validation plan http://jointmission.gsfc.nasa.gov/science/calibration.html stresses the importance of using

- aircraft validation data
- coordinated measurement campaigns.
- other satellite sensor data

The plan states "Aircraft data is important to the program both before and after launch. Before launch, it provides the means to demonstrate expected product performance and to establish algorithm approaches that will work in the presence of actual environmental conditions. After launch, it is a major part of system validation" The document then lists a series of aircraft sensors (NAST, Scanning HIS, MAS, PSR, APMIR, MASTER and AVIRIS) as key components for performing product validation. We argue that the AATS-14 instrument should be part of this list. The wavelengths of AATS-14 were chosen to allow separation of aerosol, O_3 and water vapor optical depth and at the same time measure AOD over a wide wavelength range (354-2139 nm) and determine the columnar amounts of O_3 and water vapor. Figure 13 shows the VIIRS and AATS-14 channel wavelengths in relation to atmospheric spectra. Since the VIIRS channels were also selected to allow aerosol and O_3 separation, many of its wavelengths either match exactly or are close to the AATS-14 wavelengths. Hence the AATS-14 algorithm work and its validation are of key importance for VIIRS. Before launch – as stated in the Cal/Val plan – "it provides the means to demonstrate expected product performance and to establish algorithm approaches that will work in the presence of actual environmental conditions." After launch AATS-14 and the AATS team's expertise will be a major part of system validation.

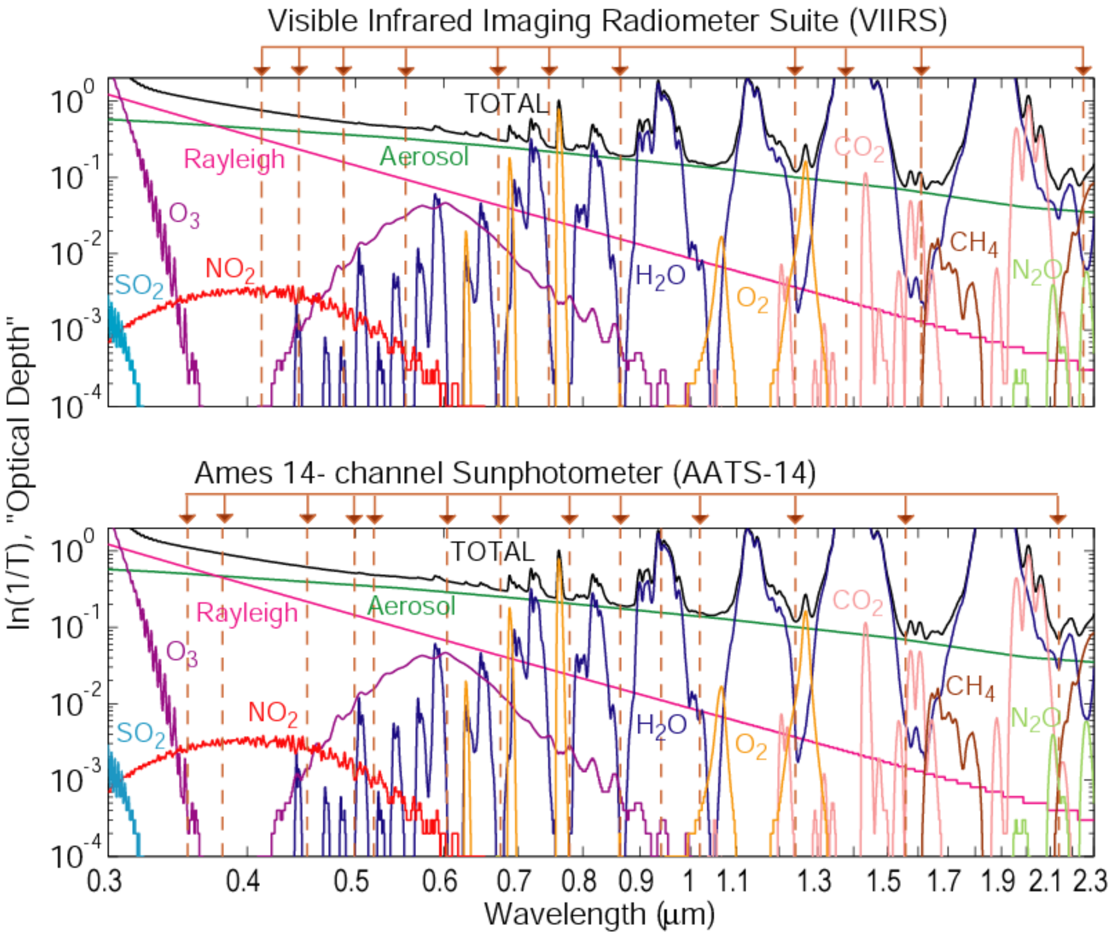


Figure 13: VIIRS (moderate resolution, solar reflective channels) and AATS-14 wavelengths (vertical lines with arrows) in relation to atmospheric spectra. The spectra of transmittance T of the direct solar beam at sea level were calculated using MODTRAN-4.3 with a Midlatitude Summer atmosphere, a rural spring-summer tropospheric aerosol model (Vis = 23 km), and the sun at the zenith. Current center wavelengths of AATS-14 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. VIIRS' moderate resolution, solar reflective channels are centered at 412, 445, 488, 555, 672, 746, 865, 1240, 1378, 1610, and 2250 nm, with FWHMs from 15-60 nm.

As shown in Figure 13, VIIRS does not cover the UV region. However this is accomplished by the OMPS instrument on NPP. OMPS will collect total column and vertical profile ozone data and continue the daily global data produced by the current ozone monitoring systems, the Solar Backscatter Ultraviolet radiometer (SBUV/2) and Total Ozone Mapping Spectrometer (TOMS), but with higher fidelity. OMPS consists of a nadir mapper, nadir profiler and a limb profiler, providing continuous spectral coverage from 250-1000 nm. As demonstrated in the previous sections the PI of this proposal has in depth knowledge of algorithms and data to retrieve ozone using the UV Hartley-Huggins band or the Chappuis band in the visible (see Figure 13).

The VIIRS precipitable water (PW equivalent to CWV in the absence of clouds) EDR will use five spectral bands in the infrared (3.7 µm, 4.05 µm, 8.55 µm, 10.76 µm, and 12.01 µm) for all retrievals. The CrIS and ATMS instrument on NPP will also produce PW EDRs. Validation of the PW EDRs is currently planned by comparing to AERONET and EOS (MODIS, AIRS/HSB) data. As NPP science team members we plan (in collaboration with the AERONET team) to upgrade the current AERONET

PW EDR which uses old H_2O spectroscopic data. As shown in section 4.6, doing so for a limited data set yielded remarkable agreement between AATS-6 and AERONET. We expect airborne measurements with AATS-14 to play a role in the validation phase of the PW EDRs (e.g., measure PW above clouds and along transects spanning a range of conditions).

We expect to contribute to the planning of coordinated measurement campaigns as set out in the Cal/Val plan. The AATS team has played lead roles in numerous such campaigns (e.g., TARFOX: P. Russell, lead scientist, ACE-2 CLEARCOLUMN: P. Russell co-lead scientist, ACE-Asia: P. Russell, radiation lead scientist, May 2003 ARM Aerosol IOP: B. Schmid, airborne measurements lead scientist). In addition, P. Russell has played lead roles in the validation and algorithm development for SAGE II and III aerosol products.

We also expect to contribute to the effort of using other satellite sensor data for NPP validation where, e.g., MODIS will serve as testbed for VIIRS algorithms. We are currently proposing the combined analysis of suborbital and satellite measurements of aerosol optical depth and columnar water vapor collected during recent field experiments, with the intent of joining the MODIS-Atmosphere Science Team and/or the MISR Science Team (NRA-03-OES-02). The proposed work is aimed at investigating the spatial variability in MODIS- and MISR-derived data products and assessing how well this variability is captured by satellite sensors and their data products. If funded, this research will greatly benefit this aspect of NPP validation.

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7 MANAGEMENT PLAN

7.1 Roles of PI's and Co-I's

Dr. Beat Schmid will be Principal Investigator. As such, he will be responsible for the overall scientific direction, project management, administration, and communications with NASA HQ. He will be responsible for completing the work on time and within budget.

Drs. Redemann and Russell (Co-Investigators) will assist the PI in the proposed activities as NPP science team member. Dr. Russell will assist in communications with NASA HQ.

As indicated in the NRA, participation at all meetings and reviews will be conducted by the PI or the Co-I's named in this proposal.

Ms. Stephanie Ramirez will work part-time on this project as a programmer under the PI's guidance.

BAER Institute and NASA Ames Research Center will furnish additional personnel necessary to accomplish the research.

8 CURRENT SUPPORT OF PI (B. Schmid)

Short Title	Agency/Task No.	Duration
Vertically resolved aerosol optical properties over the ARM SGP site	DOE ARM Science Team DE-AI03-03ER63535	11/2002-10/2005
AATS-14 aboard the CIRPAS Twin Otter during the May 2003 Aerosol IOP over the SGP ARM site	DOE ARM IOP funds ITF 355506-A	2/2003-12/2003
Quantification of aerosol radiative effects by integrated analysis of airborne measurements, satellite retrievals, and radiative transfer models	NOAA, OGP, Aerosol-Climate Interactions Program.	3/2003-2/2006
Global Aerosol Climatology (GACP)	NASA RTOP 622-44-75-10	10/1998-9/2003
SOLVE-2 Science Team	NASA	8/2002-6/2003

9 Budget

9.1 General Budget

NASA Ames Budget	FY04 Work Yr	FY04 $K / WY	FY04 Cost, $K	FY05 Work Yr	FY05 $K / WY	FY05 Cost, $K	FY06 Work Yr	FY06 $K / WY	FY06 Cost, $K	TOTAL Work Yr	TOTAL Cost, $K
P. Russell (Co-I)	0.10		0.0	0.10		0.0	0.10		0.0	0.30	0.0
Secty/Admin (SGG, SG, F etc)	0.02		0.0	0.02		0.0	0.02		0.0	0.06	0.0
Total	**0.12**		**0.0**	**0.12**		**0.0**	**0.12**		**0.0**	**0.36**	**0.0**
F&A costs* of Civil Servants above	0.12	43.0	5.2	0.12	45.0	5.4	0.12	47.0	5.6	0.36	16.2
F&A costs* of BAER employees below	0.50	11.5	5.8	0.50	9.1	4.6	0.50	9.5	4.8	1.50	15.1
Network and computer support			3.0			3.0			3.0		9.0
Division Reserve (1.5%)			0.2			0.2			0.2		0.6
Total NASA Ames			**14.1**			**13.1**			**13.6**		**40.9**

BAER Budget	FY04 Work Yr	FY04 $K / WY	FY04 Cost, $K	FY05 Work Yr	FY05 $K / WY	FY05 Cost, $K	FY06 Work Yr	FY06 $K / WY	FY06 Cost, $K	TOTAL Work Yr	TOTAL Cost, $K
B. Schmid (PI)	0.22	132	29.0	0.22	144	31.6	0.22	157	34.5	0.66	95.2
J. Redemann (Co-I)	0.16	120	19.2	0.16	130	20.8	0.16	142	22.7	0.48	62.7
S. Ramirez	0.12	60	7.1	0.12	65	7.8	0.12	71	8.5	0.36	23.4
Total	**0.50**		**55.4**	**0.50**		**60.3**	**0.50**		**65.7**	**1.50**	**181.3**
Computer Hardware			5.0			5.0			5.0		15.0
Travel			3.0			3.5			3.3		9.8
Publications			0.0			2.0			3.0		5.0
Total Direct Cost			**63.4**			**70.8**			**77.0**		**211.2**
Indirect Cost (17.5%)			11.1			12.4			13.5		37.0
Total BAER			**74.5**			**83.1**			**90.5**		**248.1**
Total Ames+BAER			**88.6**			**96.3**			**104.1**		**289.0**

*Explanation for Facilities & Administrative (F&A) Costs

For Civil Servants F&A =G&A +ASP+Directorate Reserve (see below)
For Co-op F&A =0.5*ASP

Directorate Reserve is $2.0k per workyear

General and Administrative (G&A) Costs are those not attributable to any one project, but benefiting the entire organization. G&A is calculated by dividing the ARC Institutional costs by the assigned direct workforce. Functions funded from G&A include Safety, Mail Services, Fire, Security, Environmental, Center Management and Staff, Medical Services, and Administrative ADP.

Allocated Service Pool (ASP) charges are not immediately identified to a project but can be assigned based on usage or comsumption. Functions funded include Computer Security, Network Replacement, ISO 9000, Utilities, Photo & Imaging, Maintenance, Data Communications, and Instrumentation.

9.2 Travel budget

Travel

	Airfare			Per Diem			Car				
	Trips	$/trip	Total	Days	$/day	Total	Days	$/day	Total	Misc	**Total**
FY2004											
Technical interchange meeting, assumed Boulder, CO											
Redemann	1	400	400	2	139	278	2	55	110	100	$888
Technical interchange meeting, assumed Santa Barbara, CA											
Schmid	1	250	250	2	156	312	2	55	110	100	$772
Science Team Meetings, assumed NASA Goddard											
Schmid	1	600	600	3	183	549	2	55	110	100	$1,359
Russell	1	600	600	3	183	549				100	$1,249
										FY04 BAER Total	**$3,019**
										FY04 Civil Servant Total	**$1,249**
FY2005											
Technical interchange meeting, assumed Boulder, CO											
Schmid	1	400	400	2	139	278	2	55	110	100	$888
Technical interchange meeting, assumed Santa Barbara, CA											
Russell	1	250	250	2	156	312	2	55	110	100	$772
Science Team Meetings, assumed NASA Goddard											
Schmid	1	600	600	3	183	549	2	55	110	100	$1,359
Redemann	1	600	600	3	183	549				100	$1,249
										FY05 BAER Total	**$3,496**
										FY05 Civil Servant Total	**$772**
FY2006											
Technical interchange meeting, assumed Boulder, CO											
Russell	1	400	400	2	139	278	2	55	110	100	$888
Technical interchange meeting, assumed Santa Barbara, CA											
Redemann	1	200	200	2	156	312	2	55	110	100	$722
Science Team Meetings, assumed NASA Goddard											
Schmid	1	600	600	3	183	549	2	55	110	100	$1,359
Redemann	1	600	600	3	183	549				100	$1,249
										FY06 BAER Total	**$3,330**
										FY06 Civil Servant Total	**$888**

10 Vitae

(a) Beat Schmid
Abbreviated Curriculum Vitae

Education

M.S.	1991	Institute of Applied Physics, University of Bern, Switzerland
Ph.D.	1995	Institute of Applied Physics, University of Bern, Switzerland
Postdoctoral Fellowship	1995-97	Institute of Applied Physics, University of Bern, Switzerland

Professional Experience
Bay Area Environmental Research Institute, Sonoma, CA (1997-Present)
Senior Research Scientist, Principal Investigator

University of Arizona, Tucson, AZ (Oct. 1995 -Jan. 1996)
Visiting Scientist

University of Bern, Switzerland (1989-1997)
Research Assistant (1989-1995)
Postdoctoral Researcher (1995-1997)

Scientific Contributions

- Conducted 10 years of leading studies in ground-based and airborne sun photometry: instrument design and calibration, development and validation of algorithms to retrieve aerosol optical depth and size distribution, H_2O and O_3.
- Participated with the NASA Ames Airborne Sun photometers in ACE-2 (North Atlantic Regional Aerosol Characterization Experiment, 1997, Tenerife). Extensive comparison of results (closure studies) with other techniques: lidar, optical particle counters, nephelometers, and satellites.
- Employed NASA Ames Airborne Sun photometers in the US Dept. of Energy, Atmospheric Radiation Measurement (ARM) program integrated fall 1997 and fall 2000 intensive observation periods in Oklahoma. Led sun photometer intercomparison. Extensive comparison of water vapor results with radiosondes, microwave radiometers, lidar, and Global Positioning System.
- Operated NASA Ames Airborne Sun photometers in SAFARI 2000 (Southern African Regional Science Initiative; August/September 2000). Validation of lidar and satellite retrievals.
- Participated with the NASA Ames Airborne Sun photometers in ACE-Asia (Asian Pacific Regional Aerosol Characterization Experiment; April 2001). Closure studies, satellite and lidar validation.
- Operated the NASA Ames Cavity Ringdown instrument in Reno Aerosol Optics Study (June, 2002). Comparison of aerosol extinction, scattering and absorption from various methods (cavitiy ring down, photo-acoustic, nephelometer, filter based)
- Led planning of DOE ARM May 03 Aerosol Intensive Observation Period. Responsible for airborne payload on the CIRPAS Twin Otter aircraft.
- Evaluated candidate methods for SAGE III satellite ozone/aerosol separation using airborne sunphotometer data.
- Applied NOAA/AVHRR satellite data to monitor vegetation growth in Switzerland

Scientific Societies/Editorships

- Associate Editor, *Journal Geophysical Research* (2002-)
- Member, American Geophysical Union and American Meteorological Society

Grants

- Principal Investigator, DOE ARM Science Team.
- Principal Investigator on two Cooperative Agreements between Bay Area Environmental Research Institute and NASA Ames Research Center since 2000. Responsible for research and financial administration of 3.5 fulltime scientists.
- Co-PI and Co-I on numerous research grants funded by NASA, NOAA, Office of Naval Research (ONR) and National Science Foundation (NSF).

Bibliography

- 28 peer-reviewed journal articles (8 first-authored and 20 co-authored)
- 5 peer-reviewed journal articles (1 first-authored and 4 co-authored) submitted recently
- 97 (23 first-authored and 74 co-authored) conference publications
- 13 invited talks at conferences, workshops and seminars

Publications relevant to this NRA are listed in section 6 of this proposal

(b) Jens Redemann
Abbreviated Curriculum Vitae

PROFESSIONAL EXPERIENCE

Senior Research Scientist	BAERI, Sonoma, CA	**April 1999 to present**
Research Assistant	UCLA, CA	**May 1995 to March 1999**
Lecturer	UCLA, CA	**Jan. 1999 to present**
Research Assistant	FU Berlin, Germany	**June 1994 to April 1995**

EDUCATION

Ph.D. in Atmospheric Sciences, UCLA.	**1999**
M.S. in Atmospheric Sciences, UCLA.	**1997**
M.S. in Physics, FU Berlin, Germany.	**1995**

RELEVANT RESEARCH EXPERIENCE

- NASA New Investigator Program, Principal Investigator, 2002-2005.
- Principal Investigator for the participation of AATS-14 (a narrow-band radiometer) in the CLAMS satellite validation study (July 2001). Responsible for proposal writing and experiment design, instrument integration, as well as scheduling and supervision of three group members.
- Developed a coupled aerosol microphysics and chemistry model to study the dependence of the aerosol single scattering albedo on ambient relative humidity.
- Related airborne measurements using a sunphotometer, a lidar (light detection and ranging) system and a spectral solar flux radiometer to in situ measurements of atmospheric (mineral dust) aerosols and gases and modeled the local radiative transfer in Earth's atmosphere.
- Participated in the SAFARI-2000, ACE-Asia, PRIDE and CLAMS field experiments aimed at investigating atmospheric aerosols. Member of CLAMS (Chesapeake Lighthouse Aerosol Measurements for Satellites) science team.
- Utilized satellite derived aerosol optical depth fields and aerosol properties from the ACE-Asia campaign to determine the aerosol radiative forcing of climate in the Pacific Basin troposphere.

HONORS / ORGANIZATIONS

Invited Presentation at the 5th International APEX workshop, Miyazaki, Japan.	**July 2002**
Invited Presentation at the Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS V).	**1999**
Outstanding Student Paper Award, AGU Fall meeting.	**1998**
NASA Global Change Research Fellowship Awards.	**1995-1998**
UCLA Neiburger Award for excellence in teaching of the atmospheric sciences.	**1997**

SUMMARY OF BIBLIOGRAPHY

12 peer-reviewed (6 first-authored) journal articles.

34 (23 first-authored) conference presentations.

Publications relevant to this NRA are listed in section 6 of this proposal

(c) Philip B. Russell
Abbreviated Curriculum Vitae

B.A., Physics, Wesleyan University (1965, Magna cum Laude; Highest Honors). M.S. and Ph.D., Physics, Stanford University (1967 and 1971, Atomic Energy Commission Fellow). M.S., Management, Stanford University (1990, NASA Sloan Fellow).

Postdoctoral Appointee, National Center for Atmospheric Research (1971-72, at University of Chicago and NCAR). Physicist to Senior Physicist, Atmospheric Science Center, SRI International (1972-82). Chief, Atmospheric Experiments Branch (1982-89), Acting Chief, Earth System Science Division (1988-89), Chief, Atmospheric Chemistry and Dynamics Branch (1989-95), Research Scientist (1995-present), NASA Ames Research Center.

NASA Ames Honor Award (2002, for excellence in scientific research). NASA Ames Associate Fellow (1995, for excellence in atmospheric science). NASA Space Act Award (1989, for invention of Airborne Autotracking Sunphotometer). NASA Exceptional Service Medal (1988, for managing Stratosphere-Troposphere Exchange Project). Member, Phi Beta Kappa and Sigma Xi.

Currently, Member, Science Teams for NASA's Earth Observing System Inter-Disciplinary Science (EOS-IDS) and the Asian Pacific Regional Aerosol Characterization Experiment (ACE-Asia) of the International Global Atmospheric Chemistry (IGAC) Project.

Previously, Mission Scientist for ACE-Asia C-130 flights addressing aerosol-radiation interactions. Co-coordinator for the CLEARCOLUMN component of IGAC's Second Aerosol Characterization Experiment (ACE-2). Coordinator for IGAC's Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX). Member, Science Teams for SAGE II and SAGE III (satellite sensors of stratospheric aerosols, ozone, nitrogen dioxide, and water vapor). Member, Science Team for Global Aerosol Climatology Project (GACP).

Previously, Editor-in-Chief (1994-95) and Editor (1993, 1996), *Geophysical Research Letters*. Chair, American Meteorological Society Committee on Laser Atmospheric Studies (1979-82). Member, AMS Committee on Radiation Energy (1979-81). Member, National Research Council Committee on Army Basic Research (1979-81).

Previously, Project Scientist, Small High-Altitude Science Aircraft (SHASA) Project to develop the Perseus A Remotely Piloted Aircraft (RPA, 1992-94). Member, NASA Red Team on Remote Sensing and Environmental Monitoring of Planet Earth (1992-3). Leader, NASA Ames Earth Science Advanced Aircraft (ESAA) Team (1990-94).

Over 100 peer-reviewed publications. Selected publications relevant to this NRA are included in section 6 of this proposal.