Aerosol Working Group Contributions
Accomplishments for 2006

Aerosol IOP '03 Field Campaign Yields 18-Paper Special Issue of JGR

The ARM Aerosol Intensive Operation Period (IOP) field campaign in 2003 has yielded an unprecedented eighteen peer-reviewed papers published in a special issue of the Journal of Geophysical Research. These papers capture the state of the science in terms of measurement of the optical properties of ambient-state aerosols. This special issue includes results from successful "first-ever" instrument deployments and provides measurement comparisons involving both redundant and independent determinations of key aerosol optical properties that govern the direct and indirect effects of aerosols on climate.

See slide 1

Raman Lidar Upgrades Promise New Measurement Capabilities.

The ACRF Raman Lidar at the Southern Great Plains operating for over a decade is the world's first "turn-key" Raman lidar system designed for continuous autonomous operation. Following the discovery of significant degradation of optical components, the ACRF Raman Lidar was renovated. Beyond simple replacement of degraded elements, the system was upgraded with significant enhancements including data acquisition electronics and channels which promise exciting new measurement products. Signal to noise of existing channels has been vastly improved while new channels provide the potential to measure vertical profiles of temperature and profiles of liquid and ice water content.

ARM Lidar Validation Experiment (ALIVE) Demonstrates Improvements Following Lidar Upgrades:

Preliminary results from the ARM Lidar Validation Experiment suggest markedly improvements in reducing discrepancies between the lidar retrieved extinction profiles and the AATS-14 sun photometer reference measurements. Understanding these differences between simultaneous measurements of aerosol extinction has important implications for extending aerosol extinction retrievals to all ARM sites.

See slide 2

In-situ Aerosol Profiler Aircraft Upgrade and Instrument Platform Expansion

The in-situ Aerosol Profiler (IAP) represents the proof-of-concept of operationally conducting routine aerosol sampling with a light payload aircraft. The IAP was straining the capabilities of the Cessna C-172N while more measurement capability was desired. The IAP aircraft platform was upgraded to a larger Cessna 206 with capability to support additional measurement instrumentation. The additional instrumentation will permit multiple wavelength measurement of aerosol scattering and absorption and will eventually permit these optical measurements at three relative humidities as well.

See slide 3

Ground-based In-Situ Measurements of Aerosol Properties have been Significantly Extended.

ARM has expanded on the surface measurements of aerosol properties through the deployment of an Aerosol Observing System (AOS) with the ARM Mobile Facility (AMF) in Niamey, Niger. Comprehensive aerosol measurements of Saharan dust are being collected and are calling into question long-held beliefs regarding Saharan dust composition. Also, the capabilities of the existing ACRF Southern Great Plains AOS have been significantly extended with the addition of a Cloud Condensation Nuclei (CCN) counter and also with the deployment of a new Trans-Differential Mobility Analyzer (TDMA) which provides unparalleled determinations of fine mode particle size, hygroscopicity, volatile fraction, and much, much more.

First Annual Meeting of the Aerosol Indirect Effect Assessment (Aerosol IDEA) Special Focus

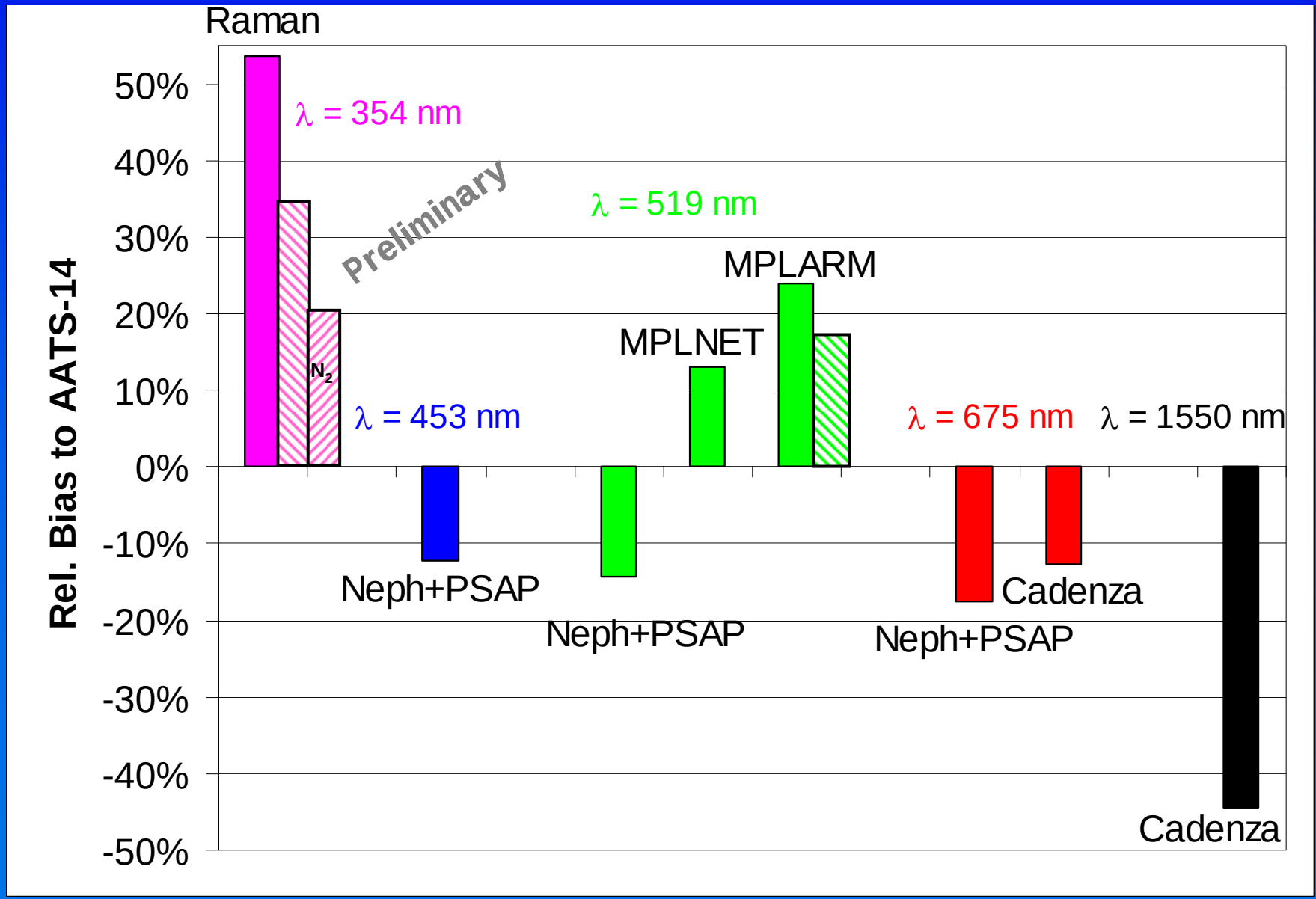
Indirect effects of aerosols (i.e., influence of aerosols on cloud droplet number and cloud albedo) have been recognized for many years as a potentially important mechanism for climate modification, however estimates of the magnitude of the indirect effect of anthropogenic aerosol are still highly uncertain. Because the indirect effect is such a complicated problem in terms of its physics and chemistry, research in this area has emphasized both observations and modeling. Thus, the ARM Aerosol Working Group and Cloud Parameterizations and Modeling Working Group will jointly host the first annual Aerosol IDEA meeting in September of 2006 to focus on this critical topic and to catalyze efforts to quantitatively assess the aerosol indirect effect.

ARM Aerosol IOP (SGP, May 2003)
18 Papers in 2006 JGR Special Issue

Topics

- Aerosol Extinction, Absorption, Scattering,
- Aerosol Particle Size Distribution
- Aerosol Asymmetry Parameter
- Aerosol Composition
- Aerosol Hygroscopicity
- Aerosol Transport
- Radiative Closure
- Cloud Condensation Nuclei
- Cloud Drop Effective Radii

ALIVE: Improvement in Lidar Extinction



IAP Aircraft Upgrade

Cessna 172 (2000-2005)

Cessna 206 (2006→?)

- Routine max. altitude increased from 12 kft. to 15 kft.
- Scientific payload significantly increased (weight, power, volume)
- Improved absorption measurement (3 wavelengths, less noise)
- Improved *f(RH)* measurement (4 nephelometer system)
- Better inlet system → Improved sampling of large particles
- Improved sampling of trace gases (continuous analyzers and more flask samples) through DOE Carbon Program

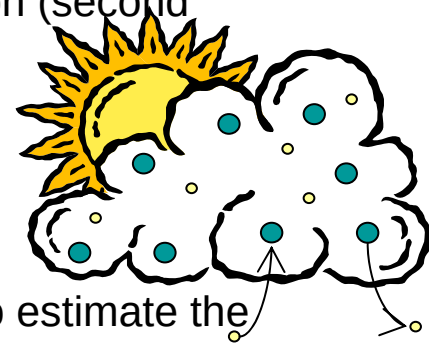
Andrews, Jefferson, Ogren, Sheridan, Torn

Aerosol Indirect Effects

Graham Feingold, Steve Ghan, Yangang Liu, Joyce Penner, Steve Schwartz

Aerosol indirect effect = influence of aerosol on global energy balance by influencing cloud droplet or crystal number and hence cloud optical depth

- without changing water content (first indirect effect)
- with changing water content by influencing initiation of precipitation (second indirect effect



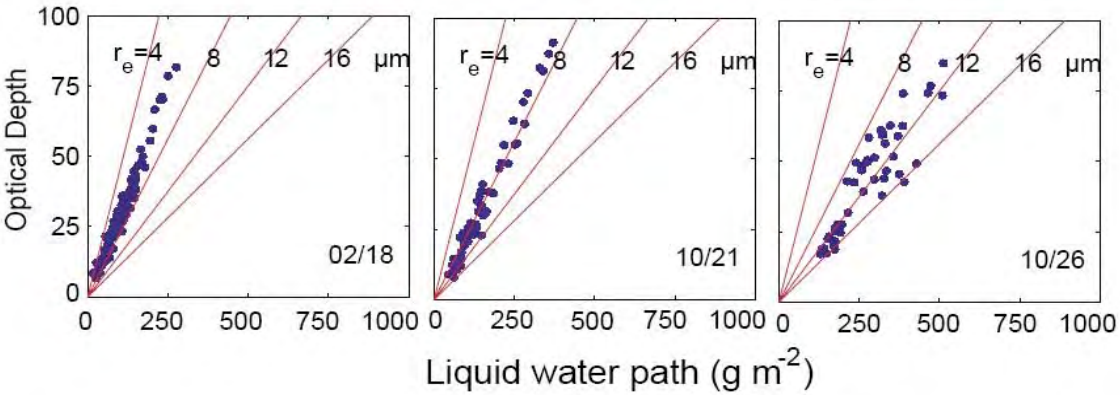
ARM Contributions

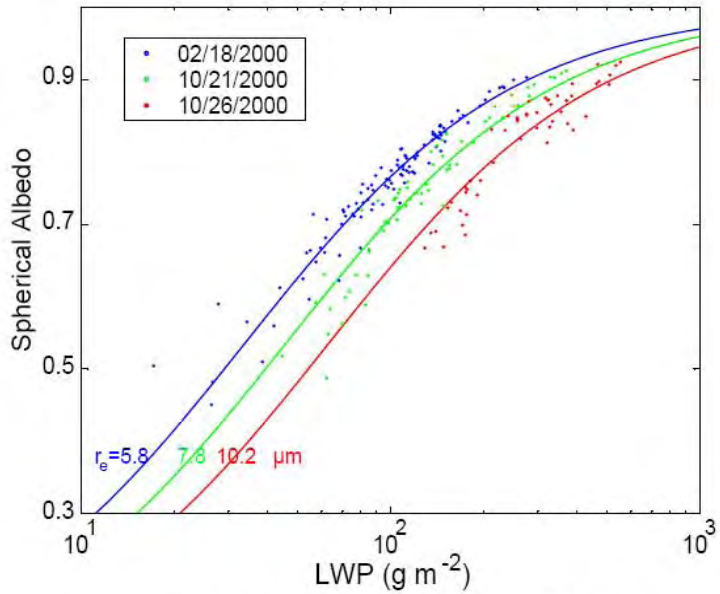
- Application of the first physically-based treatment of droplet number to estimate the first and second indirect effect.
- First estimate of the influence of aerosol on cloud optical depth through influence of aerosol on the width of the droplet size distribution.
- Development of the first physically-based treatment of the initiation of precipitation from liquid water clouds.
- First spatially-resolved estimate of uncertainty of the first indirect effect.
- First ground-based estimates of the first indirect effect.
- Development of the first ground-based methods to retrieve profiles of water uptake and cloud condensation nuclei concentration.
- First detection of longwave indirect effect in Arctic.
- Adoption of ARM indirect effects treatment by NCAR CCSM.

CLOUD ALBEDO AND FORCING CALCULATED FROM MEASURED EFFECTIVE RADIUS AND LIQUID WATER PATH

North Central Oklahoma

Effective radius determined from slope of Optical depth vs. Liquid water path





Cloud albedo is calculated for observed data and for average effective radius for each day. Forcing is calculated for indicated conditions relative to October 26.

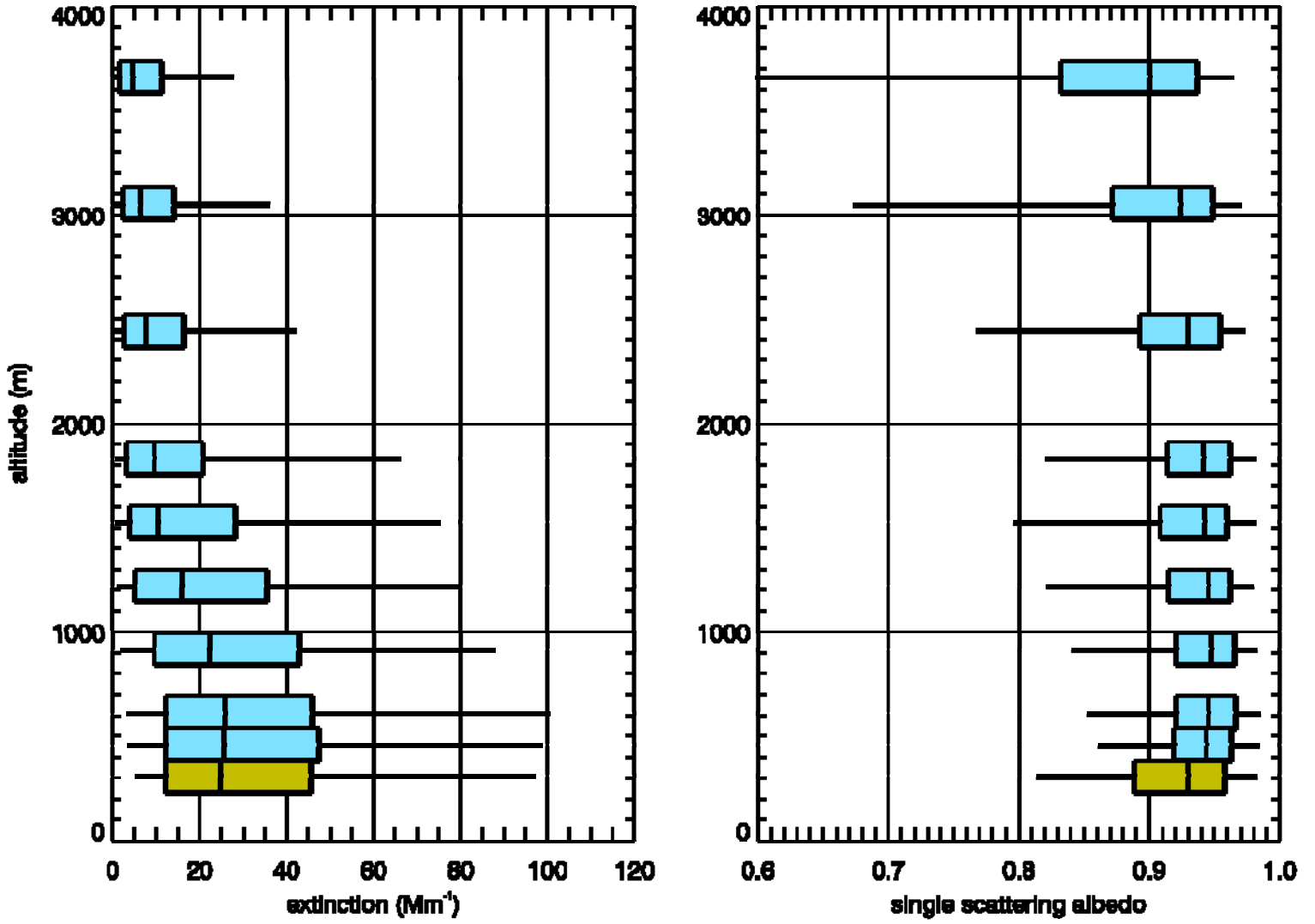
Radiative forcing for solar zenith angle 60° and liquid water path 100 g m^{-2}

Date, 2000	Effective radius r_e, μm	Optical Depth	Net flux at TOA W m^{-2}	Forcing relative to 10/26, W m^{-2}
10/26	10.2	15.1	293	—
10/21	7.8	20.8	266	27
02/18	5.8	28.3	240	53

Kim, Schwartz, Miller, and Min, JGR, 2003

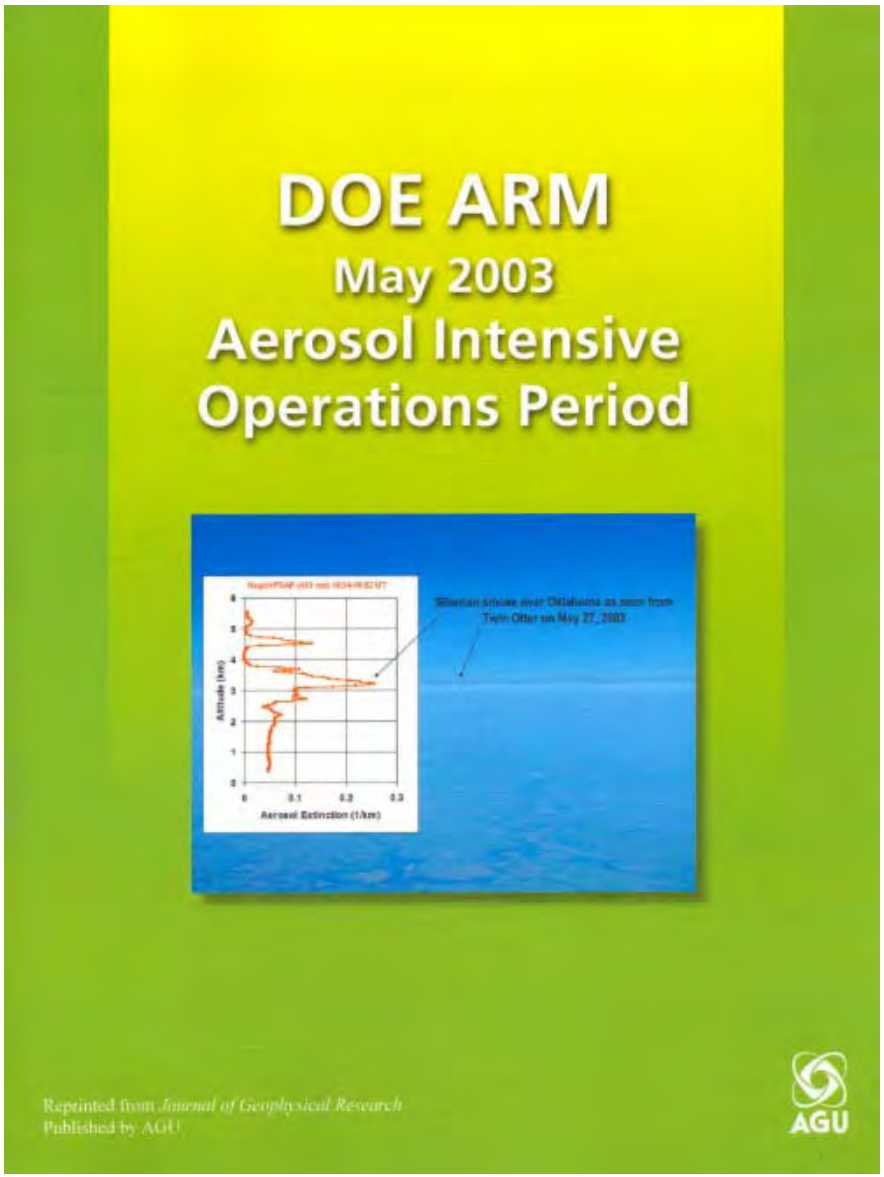
Regular *in situ* Aerosol Profiles

Flights March 2000 - mid-April 2006, λ=550 nm, for $D_p < 1\ \mu m$



E. Andrews, A. Jefferson, J. Ogren, P. Sheridan, M. Torn.

Aerosol IOP Special Issue in JGR

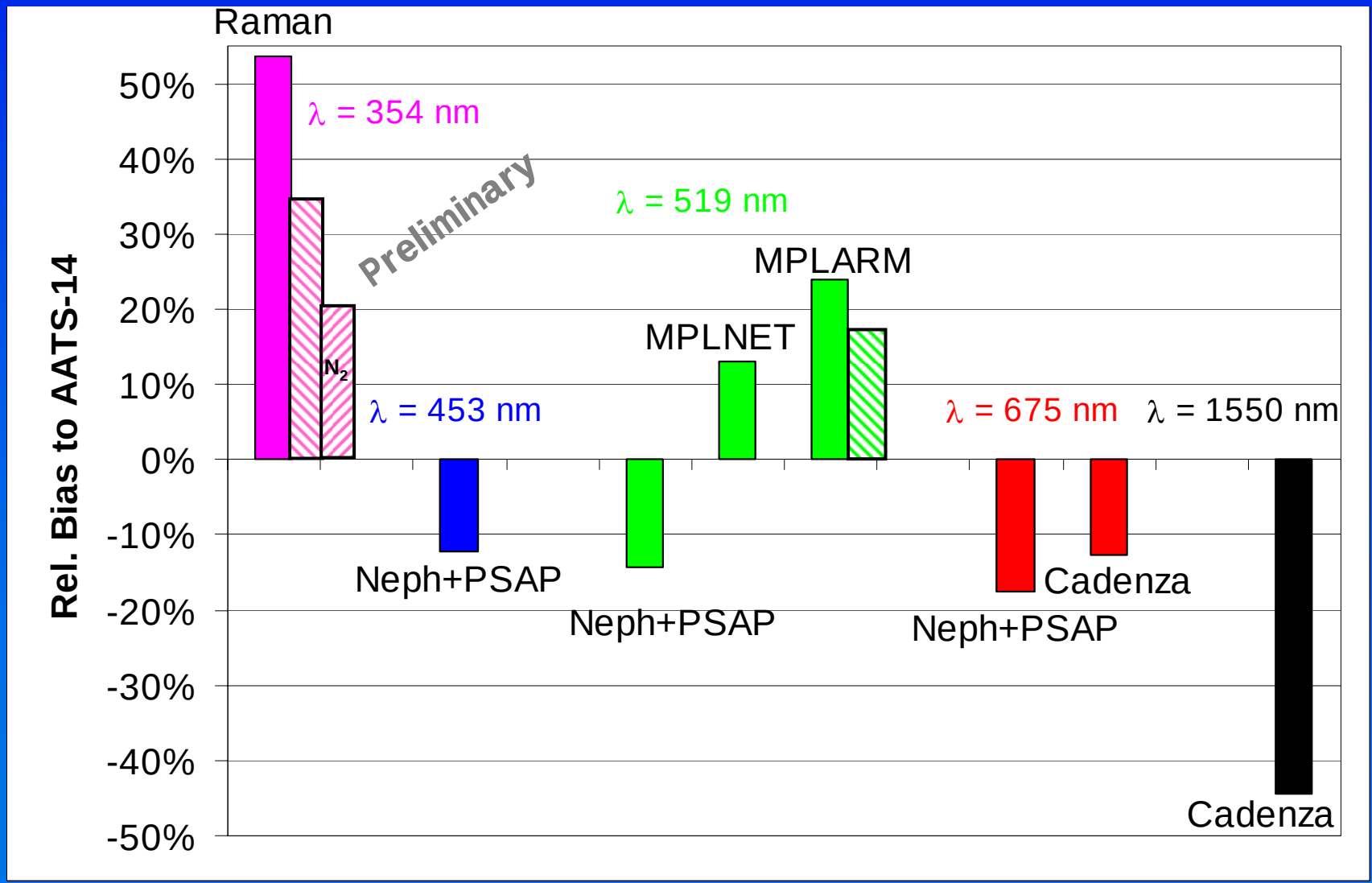


- 15 March 2006 issue
- 15 articles available in print
- 18 articles available on line
- 100 bound hard copies to be distributed
- Topics:
  - Aerosol Extinction, Absorption, Scattering,
  - Aerosol Particle Size Distribution
  - Aerosol Asymmetry Parameter
  - Aerosol Composition
  - Aerosol Hygroscopicity
  - Aerosol Transport
  - Radiative Closure
  - Cloud Condensation Nuclei
  - Cloud Drop Effective Radii

ALIVE: Improvement in Lidar Extinction

(ALIVE hatched bars) over situation in 2003 (Aerosol IOP, solid bars)

Schmid, Ferrare, Flynn, Turner



Aerosol Properties over the ARM SGP – Measured vs. Modeled

- Aerosol measurements acquired over the SGP site are used to evaluate and hopefully improve global aerosol transport model simulations
- Although model simulations of total column AOT show agreement among themselves and with measurements, significant differences exist in vertical distributions
  - Deviations between mean aerosol extinction profiles are generally small for altitudes above 2 km, and grow considerably larger below 2 km
  - Models have lower aerosol extinction near the surface
- Significant differences in vertical distributions remain even when prescribed emissions and meteorology are used