Surface Aerosol Radiative Forcing Derived From Observations During PRIDE, SAFARI-2000 and ACE-ASIA and at UCLA Surface Site

R. A. Hansell, K.N. Liou and S.C. Ou,
Department of Atmospheric Sciences, University of California, Los Angeles, Los Angeles, California

S.C. Tsay
GSFC NASA, Greenbelt, Maryland

- Instrumentation – description,calibration, thermal offset
- Aerosol Surface Radiative Forcing
- Model Comparisons

Scientific Objectives

- Calibration and processing of broadband solar radiometers, Cimel sun-photometer and MFR data
- Development of a cloud screening algorithm and characterization of thermal offset in UCLA radiometer data
- Determining surface aerosol radiative forcing utilizing retrieved AOT's and radiometer data

Primary Instrumentation in Study

- **Multiple Filter Shadow-Band Radiometer (MFR-7)**
  - It has 6 narrowband channels: 0.94,0.866,0.672,0.614,0.498,0.414 µm) and 1 broadband channel (0.3 – 1.1 µm)
  - measures direct-normal irradiance from observed diffuse/total horizontal
- Solar constants for each band are cross-calibrated with Cimel sun-photometer and Langley method.
- **Cimel Sun-Photometer (CE-318A): (AERONET)**
  - It has 8 narrowband channels: (1.02,0.936,0.870,0.670,0.500,0.440,0.380,0.340 µm)
- Direct sun/sky radiance measurements
- Calibration (performed every 9-12 months)
  - GSFC reference calibrated at MLO,Hawaii
  - Sky radiance calibration done with GSFC integrating sphere

Primary Instrumentation in Study

- **Multiple Filter Shadow-Band Radiometer (MFR-7)**
  - **Solar constants for each band are:**

Pride		Safari		Ace-Asia		Ace-Asia	
wavelength(µm)	watts/m^2/st	wavelength(µm)	watts/m^2/st	wavelength(µm)	watts/m^2/st	wavelength(µm)	watts/m^2/st
0.866	1.0162	0.866	0.9680	0.866	1.1689	0.866	1.01072
0.672	1.6601	0.672	1.5740	0.672	1.7323	0.672	1.60919
0.614	1.7715	0.614	1.6251	0.614	1.8111	0.614	1.85220
0.498	2.2821	0.498	2.2088	0.498	1.9478	0.498	2.1852
0.414	1.7688	0.414	1.6611	0.414	1.2366	0.414	1.7674

UCLA Surface Radiation Site

UNSHADED EPPLEY PYRANOMETER (PSP) MEASURES TOTAL IRRADIANCE

SHADED K&Z CM21 PYRANOMETER MEASURES DIFFUSE IRRADIANCE

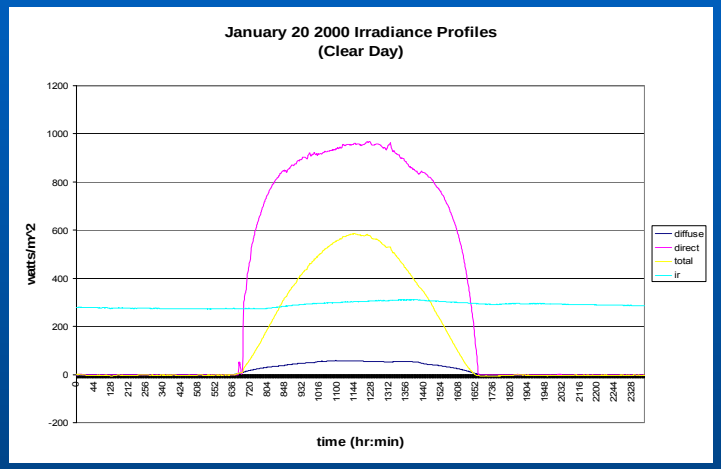
CHI PYROHELIOMETER

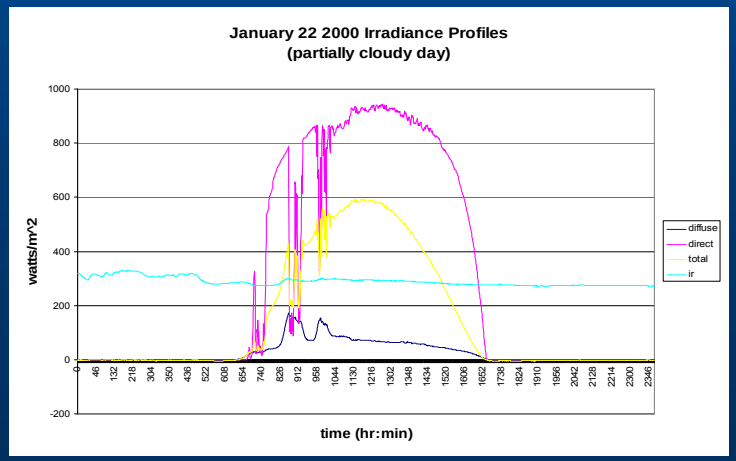
K&Z CG1 PYRGEOMETER

EPPLEY PYRGEOMETER (PIR)

Cimel 318A

Profile examples



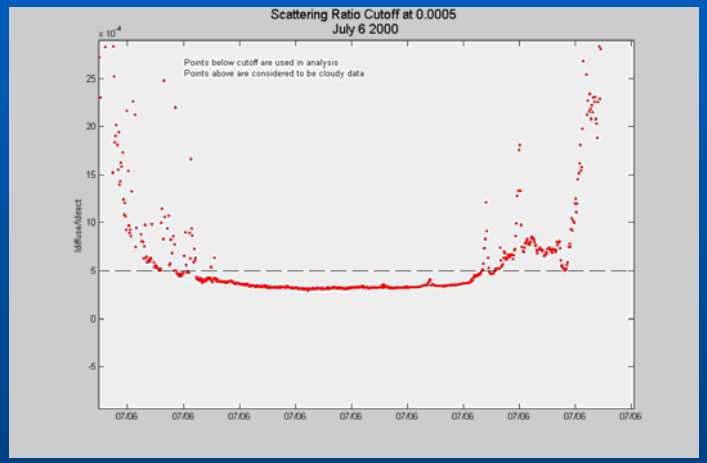


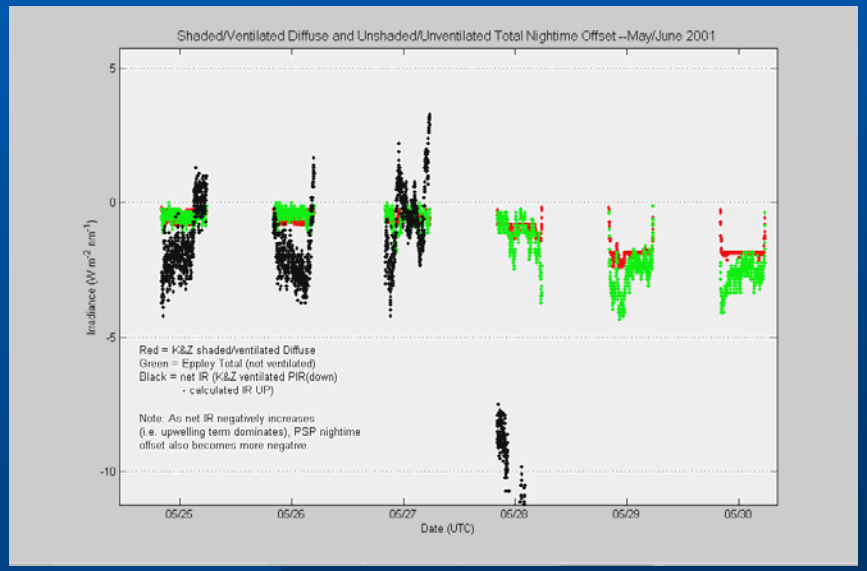
Thermal Offset-UCLA Data/Cloud Removal Technique

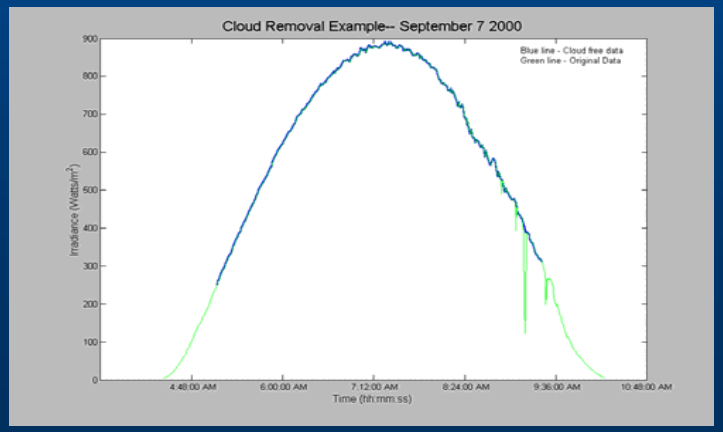
Method employed (Haeffelin, M. et al. 2001)

1. Observed night-time offset < 5 Watts/m^2
2. Thermal offset of the PSP can be related to the net IR irradiance at the PIR thermopile

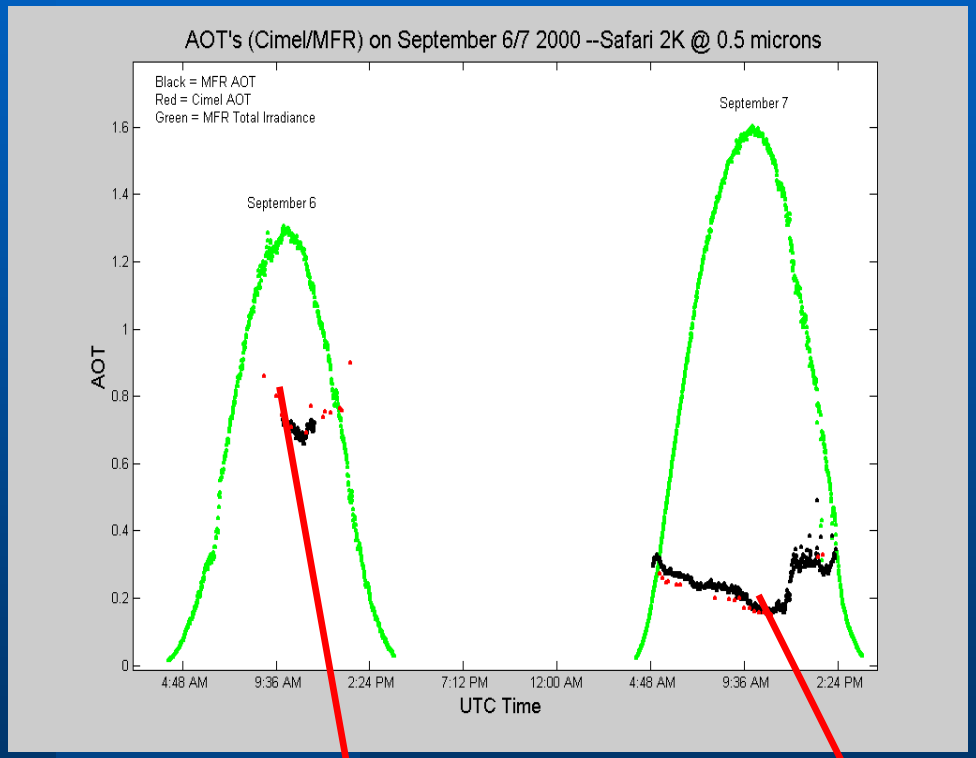
By evaluating the daily ratios of the observed diffuse irradiance to the observed direct irradiance, a relative measure of atmospheric scatter and hence cloud coverage can be inferred:







MFR Aerosol Optical Depth Retrieval Approach



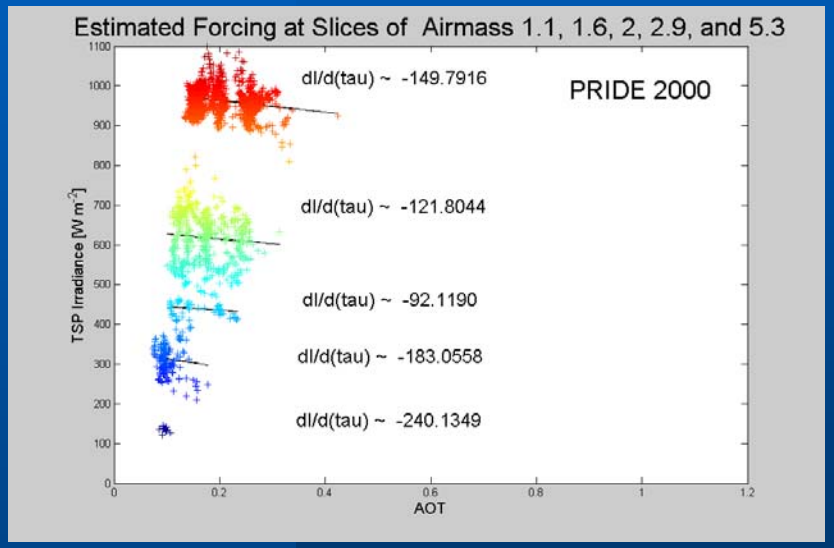
1. MFR data interpolated to Cimel time
2. Cloud screening algorithm and high zenith angle filter applied
3. Cimel's optical depth and air mass used to find MFR's TOA spectral flux
4. Beer's Law is used to determine the MFR total optical depth.
5. Ozone and Rayleigh scattering correction applied to data
6. Correlation coefficient = 0.9262

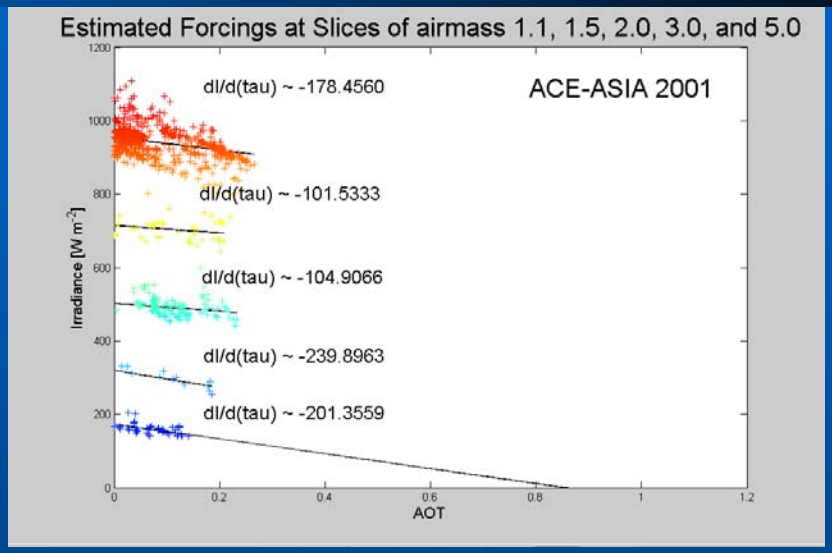
Red = Cimel AOT

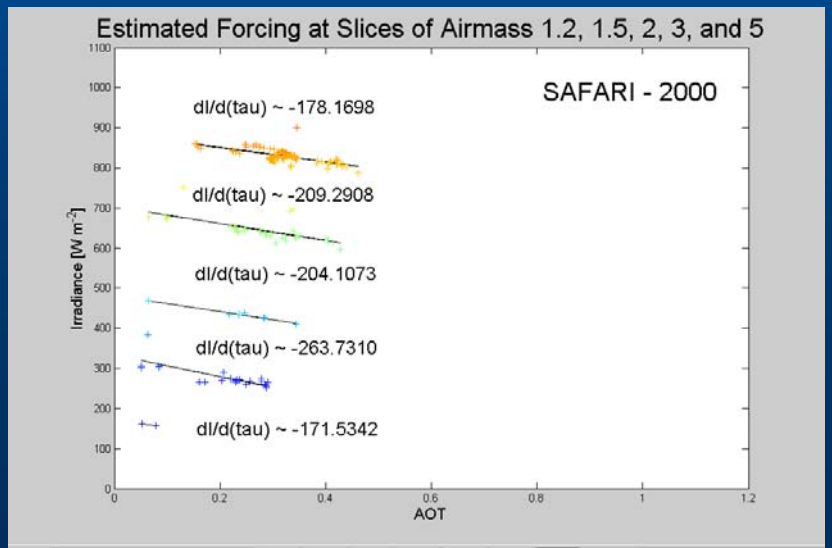
Black = MFR AOT

Surface Radiative Forcing Over Campaign Period

Units in watts/m^2





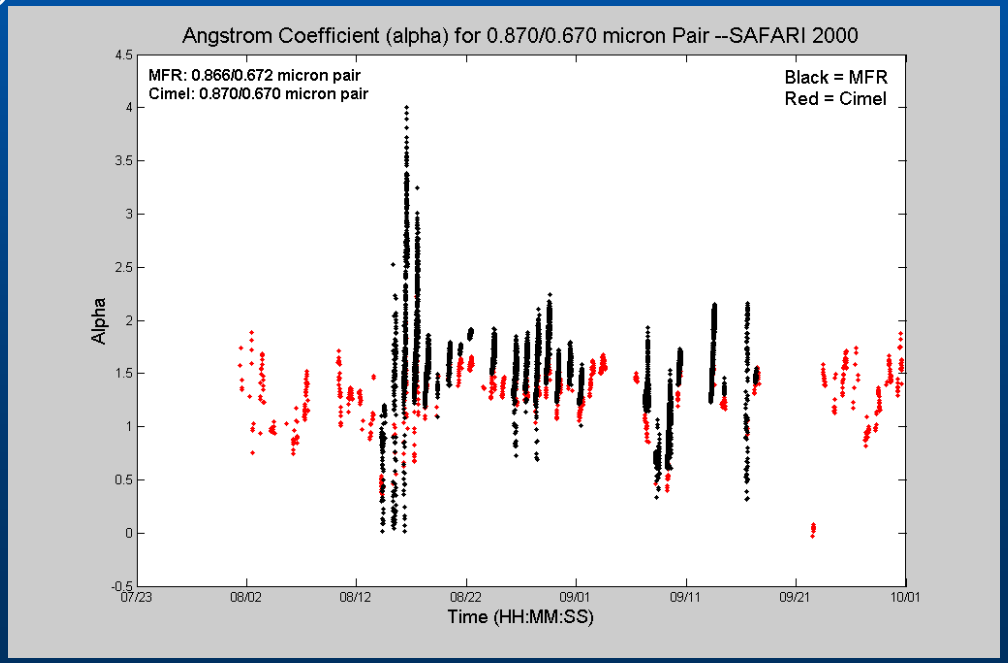


Angstrom Power Law

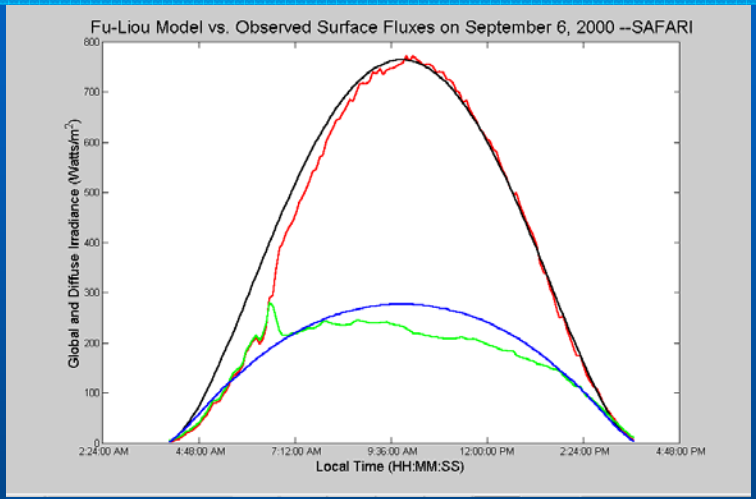
- **Empirical relation first suggested by Angstrom (1929) to model turbidity:**

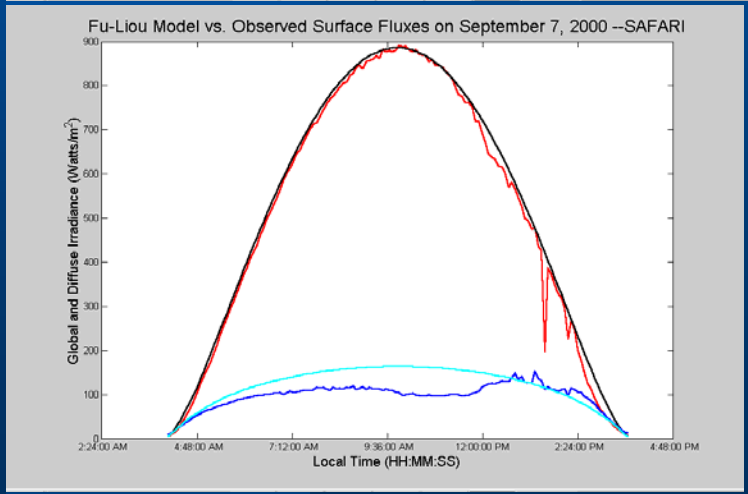
$$\tau_a(\lambda) = \beta \lambda^{-\alpha}$$

- **Log-log plot of τ vs. λ yields info regarding medium's turbidity (β) and particle size (α)**

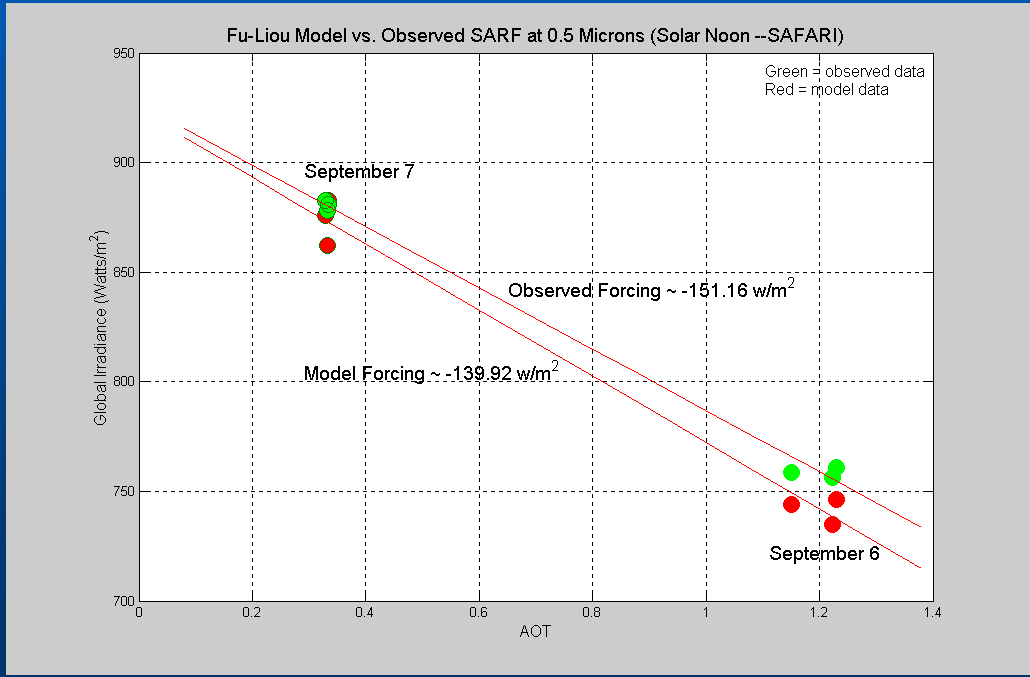


Fu-Liou Model Surface Fluxes (0.5μm)





Model / Observed Data Comparison



Conclusions

- An approach for finding the SARF has been developed and used for recent field campaigns
- Cloud removal scheme is effective
- Retrieved MFR AOT's compare well with AERONET's Cimel sun-photometer
- PSP Thermal offset not important – UCLA data
- Further research required in SARF studies including model comparisons