Measurements of the Aerosol Light-Scattering Coefficient at Ambient and 85% Relative Humidity on the ONR Pelican During ACE-2

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LONG-TERM GOALS

Our first major goal is the acquisition of simultaneous measurements of aerosol optical properties as a function of ambient RH together with measurements of the aerosol size distribution to permit calculation of the dry aerosol size distribution and optical properties (the quantities most appropriate for climate modeling). A second goal is the determination of the dry aerosol surface-to-volume ratio for a variety of marine environments. This parameter is quite important in the global-scale modeling of aerosol indirect forcing.

OBJECTIVES

The immediate objective of this grant was to measure the hygroscopic light-scattering factor aboard the ONR Pelican during ACE-2, these measurements to be made simultaneously with measurements of the aerosol size distribution by other investigators.

APPROACH

To measure the RH dependence of the light-scattering coefficient, two identical nephelometers sampled the ambient air, one measuring at an RH slightly below ambient and one at an RH well above ambient. Additionally, a third nephelometer operated by the University of Stockholm at an RH of ~30% was utilized. The two U.W. nephelometers were used to interpolate the light scattering at ambient RH and all three nephelometers were used to determine the slope of the hygroscopic light-scattering curve for each sample. This curve is of the form:

$$\sigma_{scat}(RH) = \sigma_{scat}(\text{Reference RH}) \left\{ \frac{(1 - RH)}{(1 - RH_{ref})} \right\}^{-\gamma}$$

where the parameter γ essentially defines the hygroscopicity of the aerosol (cf. Hämel, 1976). Values of γ were derived at six second intervals and then averaged over various appropriate intervals to enhance signal-to-noise ratios.

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WORK COMPLETED

Good values for the γ(gamma) parameter were in fact obtained during more than a dozen flights of the ONR Pelican during ACE-2. Hence, we have accomplished our objective for the ACE-2 study. What remains to be done is to complete the analysis of the impact of gamma on various key parameters and to compare the results with those of other studies (well underway).

RESULTS

Several important results have already been derived from the ACE-2 data set. First, hygroscopic growth factors (γ's) have been derived from the three main aerosol types encountered in ACE-2: background marine, polluted and Saharan dust. Frequency distribution of γ for these three different populations are shown in Figure 1. Another interesting result has been an assessment of the impact of the aerosol hydration on the top of the atmospheric irradiances generated by aerosol backscatter. Shown in Figure 2 are preliminary model calculations for two different cases comparing model generated irradiances, based on in-situ measurements on the aerosols encountered, with actual measured irradiances from AVHRR overpasses. The impact of varying degrees of hygroscopicity is quite evident. Finally, we have found a linear relationship between the *dry* aerosol number and volume concentrations similar to those previously seen in TARFOX. An example of this is shown in Figure 3, in which the constant slope of the linear regression yields the number to volume ratio: universality of this parameter has large implications for remote retrieval of aerosol properties.

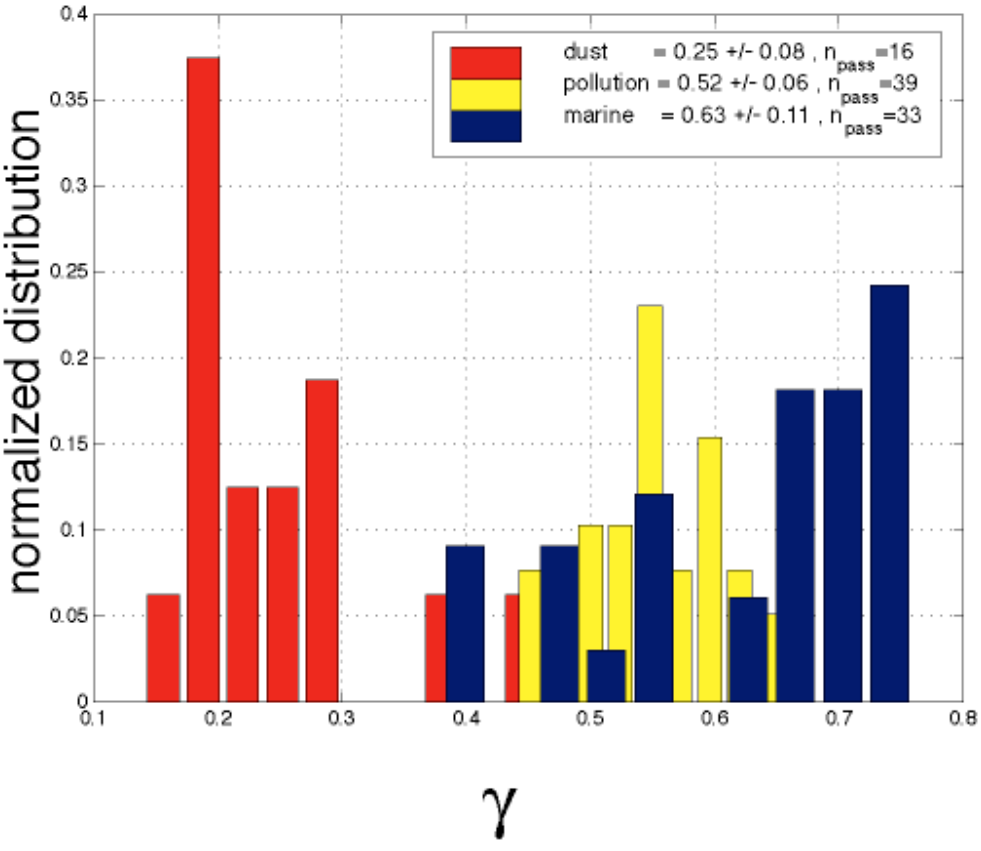


Figure 1.

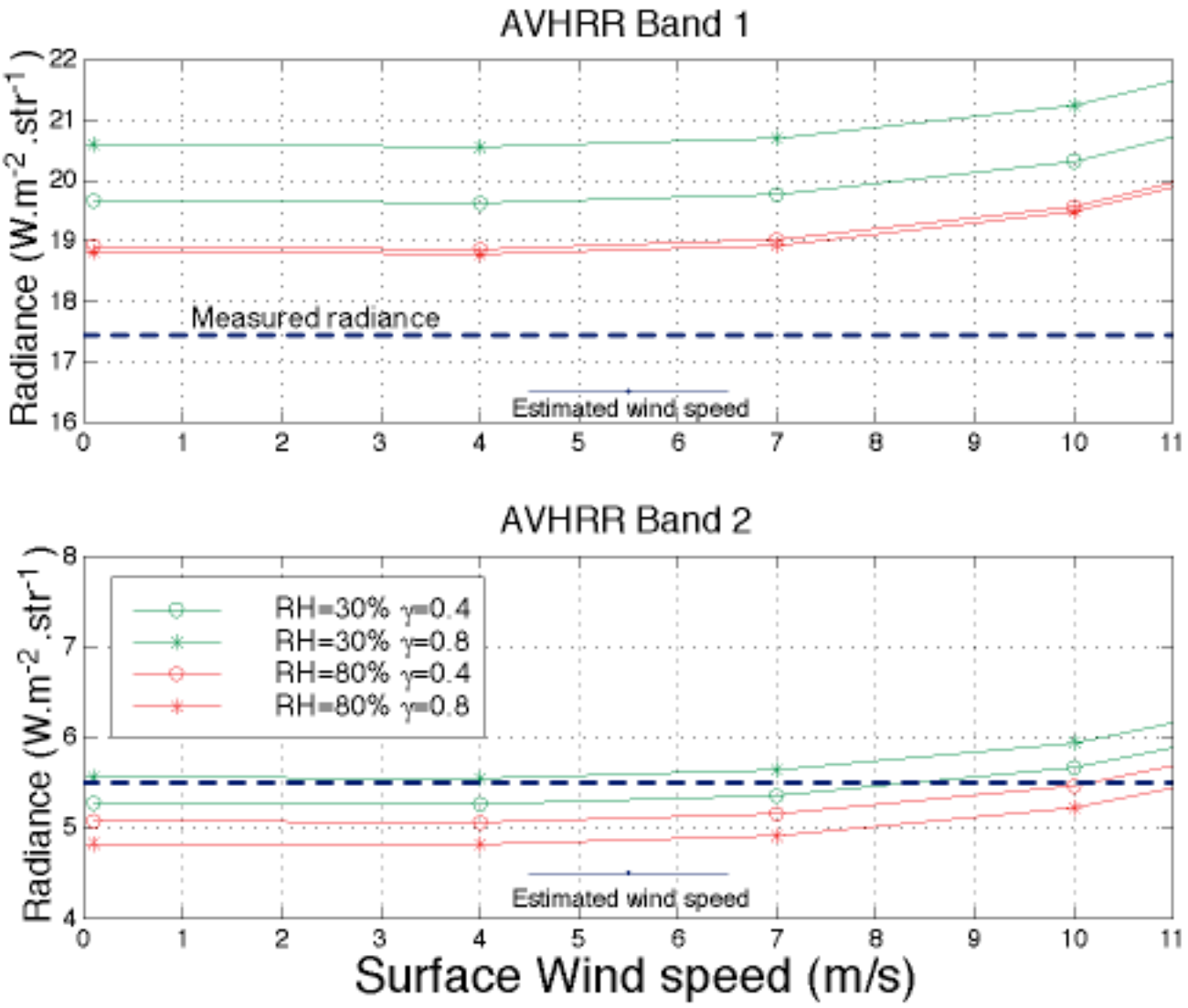
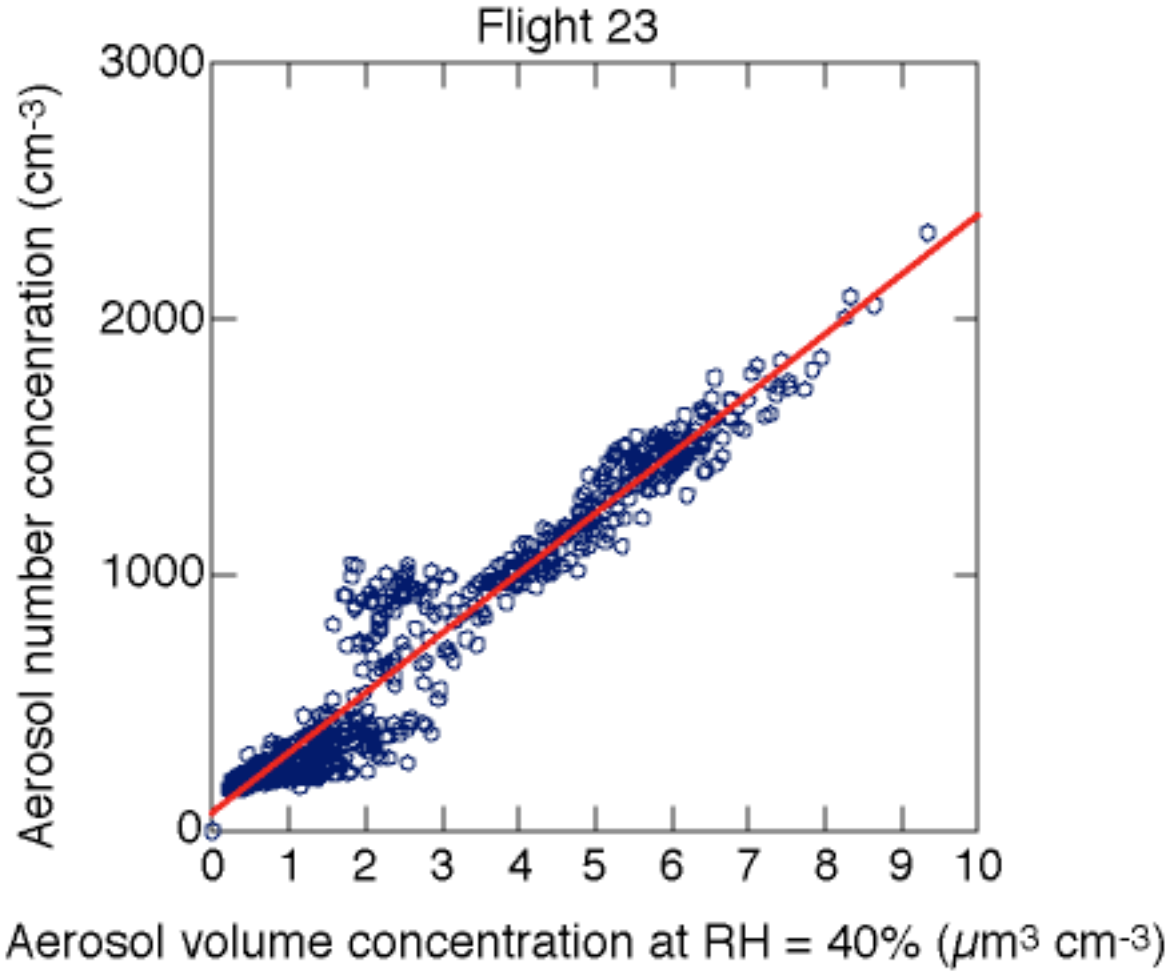

AVHRR Band 1
Radiance (W.m-2.str-1)
Measured radiance
Estimated wind speed
AVHRR Band 2
RH=30% γ=0.4
RH=30% γ=0.8
RH=80% γ=0.4
RH=80% γ=0.8
Estimated wind speed
Surface Wind speed (m/s)

Figure 2.



Plot of aerosol number vs. volume concentration for the entire flight of July 20, 1997.

Figure 3.

IMPACT/APPLICATIONS

The impact of ambient RH on the properties of ambient aerosols must be dealt with in all remote retrievals if the fundamental dry aerosol properties are to be obtained. This work will aid in addressing this issue.

TRANSITIONS

The hygroscopic growth factors derived from the ACE-2 data are being utilized by most other members of the Pelican team in interpretation of their data.

RELATED PROJECTS

A very large number of investigators in ACE-2 were also interested in measuring aerosol hygroscopicity and its impact on aerosol optics. They are far too numerous to deal with here.

REFERENCE

Hämel, G., The properties of atmospheric aerosol particles and functions of the relative humidity at thermodynamic equilibrium with the surrounding moist air, *Adv. Geophys., 19,* 73-188, 1976.

IN-HOUSE/OUT-OF-HOUSE RATIOS

One hundred percent out of house.