HYPERSPECTRAL MODELING FOR EXTRACTING AEROSOLS FROM AIRCRAFT/SATELLITE DATA

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1.0 INTRODUCTION:

The upwelling radiance due to aerosols (L_A) detected by satellite sensors is related to the aerosol optical depth (δ_A) through the approximation given by Durkee, 1984, equation (1).

$$L_A \approx \frac{\omega_o F_o}{4\cos\phi} \; P(\theta) \cdot \delta_A \qquad (1)$$

where

ω_o = *SINGLE SCATTERING ALBEDO*

ϕ = *SATELLITE ZENITH ANGLE*

$P(\theta)$ = *SCATTERING PHASE FUNCTION AT ANGLE θ*

F_o = *INCIDENT SOLAR IRRADIANCE*

The above equation is valid for relatively thin optical depths (<0.3). Also, to first approximation L_A is approximately linear with (δ_A). The value of $P(\theta)$ is dependent upon the size and distribution of the aerosol particles (given in part by the ratio S_{12} identified below).

Currently the National Oceanic and Atmospheric Administration (NOAA) uses channel 1 (0.58 – 0.68 μm) of the Advanced Very High Resolution Radiometer (AVHRR) sensor to produce weekly global maps of aerosol optical depths. Durkee (1984) showed that a measure of the type and distribution of aerosols could be determined by the ratio S_{12} given by equation (2).

$$S_{12} = \frac{L_A \; (Channel\ 1)\ AVHRR}{L_A \; (Channel\ 2)\ AVHRR} \qquad (2)$$

where

$$Channel\ 1 = 0.58 - 0.68\ \mu m$$
$$Channel\ 2 = 0.725 - 1.10\ \mu m$$

It is noted that the calculations for δ_A and S_{12} are performed after subtraction of the Rayleigh optical depth.

For large values of S_{12} the aerosols are identified as continental origin (high concentration of small particles). For smaller values of S_{12} the aerosols are closer to marine origin (higher concentration of large particles).

2.0 PRESENT RESEARCH

Sensitivity studies using the AVIRIS bands are currently under investigation. The objective of this research is to develop improved algorithms for the determination of aerosol type (e.g., presently described by S_{12}).

Preliminary computer calculations have been made using LOWTRAN 7, which is the most advanced atmospheric code of the Air Force Geophysics Laboratory. LOWTRAN 7 permits the calculation of atmospheric transmission and absorption caused by aerosols and molecules along a non-homogenous path for a variety of aerosol models. The calculations used the Navy Aerosol Model (NAM) (Gathman, 1983), which was constructed for the marine environment using a three component size distribution model.

Calculations of the total transmittance (L_T), the path radiance (L_P) and the reflected radiance (L_r) were made as a function of wavelength (λ) from 0.4 to 2.4 μm for each of the 224 10 nm wide AVIRIS bands. These calculations were made for various types of atmospheres for the troposphere (0-2 km).

3.0 RESULTS

Figure 1 is a typical LOWTRAN 7 curve of upwelling total radiance (surface albedo = 0; 23 km horizontal visibility) at an altitude of 2 km. These curves were generated for the AVIRIS bands for the marine boundary layer of the troposphere using two different aerosol models: a) the Navy aerosol model (NAM) - open ocean type aerosols,

and b) no aerosols. The lower (no-aerosol) curve shows the typical Rayleigh distribution following the $1/\lambda^4$ decay, going to zero at approximately 0.9 μm. Superimposed on this curve are the gas absorption bands. The upper (navy aerosol) curve shows the combined contribution due to Rayleigh scattering, gas absorption and aerosols. The middle curve is the result of subtracting these two curves. This subtractive technique removes the Rayleigh scattering, thereby leaving the radiance due to aerosols. The ratio S_{12} is calculated after convolving the spectral radiance with the AVHRR bands. The AVIRIS bands will now be used in calculations to obtain the optimum band ratios for describing various types of aerosols.
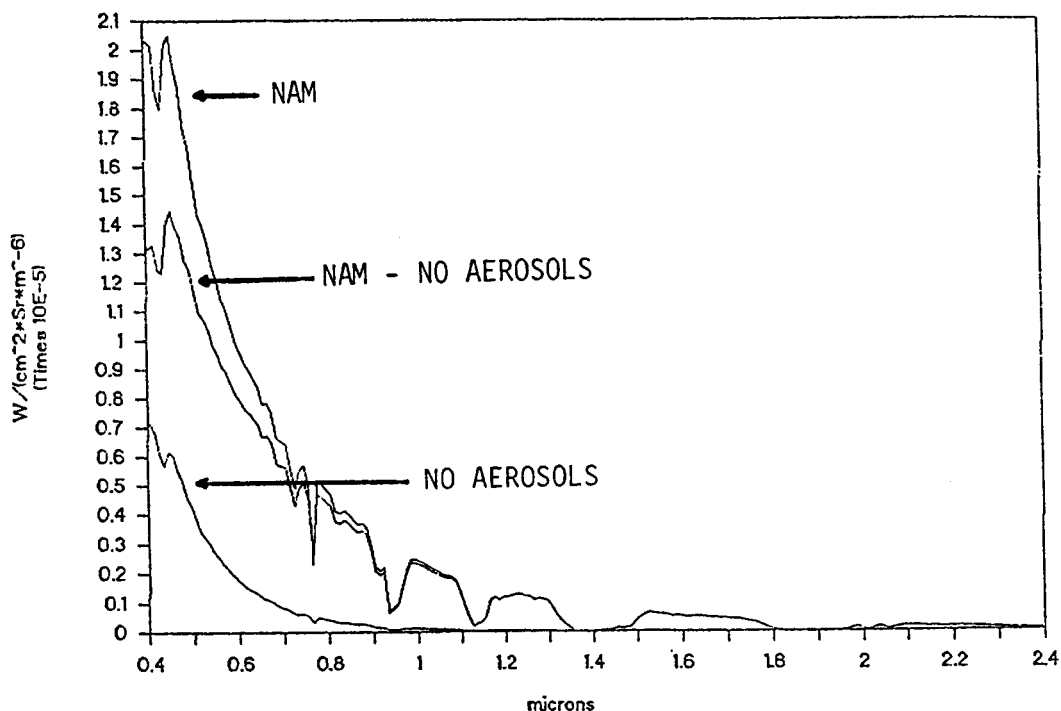

FIG. 1 LOWTRAN CALCULATIONS OF RADIANCE AT ALT = 2KM AND SURFACE ALBEDO = 0 FOR AVIRIS BANDS.

4.0 References:

Durkee, P. A. (1984), The relationship between marine aerosol particles and satellite-detected radiance, Ph.D. dissertation, 124pp. Colo. State University, Fort Collins.

Gathman, Stuart G. (1983), Optical properties of the marine aerosol as predicted by the Navy aerosol model, Optical Engineering 22 (1):057-062.