

The Sensitivity of Shortwave Radiative Forcing and Heating Rates to the Aerosol Vertical Profile

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1. Motivation

We are investigating the sensitivity of the shortwave broad-band heating rate profiles (and aerosol radiative forcing profiles) to the vertical profiles of aerosol extinction, single-scattering albedo, and asymmetry parameter (i.e., the ARM Aerosol Best Estimate, ABE) for clear-sky conditions.

We are assessing the results not only at TOA and the surface but throughout the vertical profile. As inputs we are using slightly idealized case studies from RADAGAST (Niger, 2006), ACE-Asia (Sea of Japan, 2001) and the ARM Aerosol IOP (Oklahoma, 2003). These case studies encompass a wide range of aerosols and surface conditions.

2. Definitions

$$F_{net} = F_{\downarrow} - F_{\uparrow}$$

$$ARF = F_{net}(with\ aerosol) - F_{net}(without\ aerosol)$$

$$HR = \frac{\partial T}{\partial t} = -\frac{1}{\rho c_p} \frac{\partial F_{net}}{\partial z}$$

$$AHR = HR(with\ aerosol) - HR(without\ aerosol)$$

F : Flux

ARF : Aerosol Radiative Forcing

AHR : Aerosol Heating Rate

T : Temperature

t : time, z : Altitude

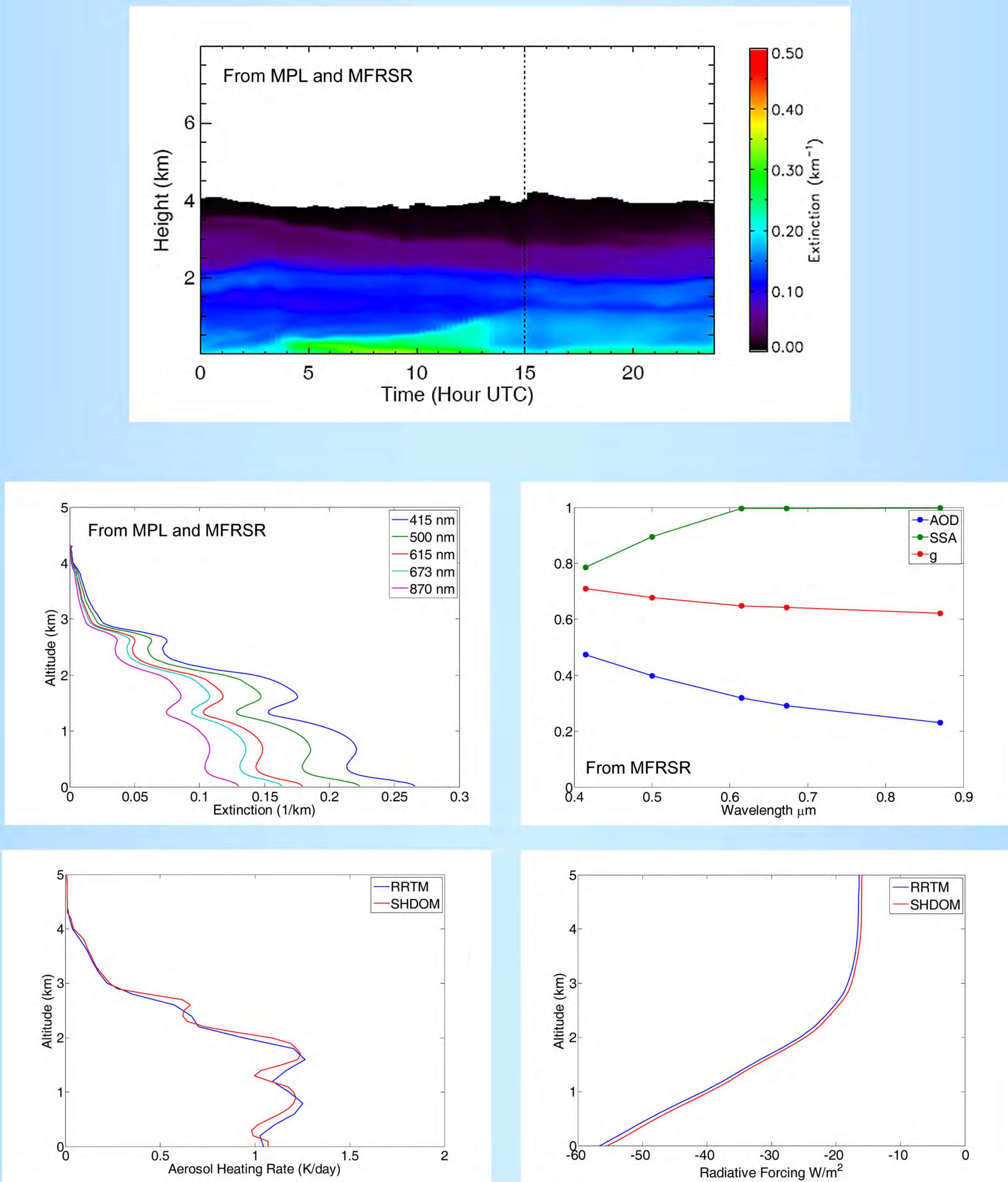
ρ : air density, c_p : specific heat capacity

3. Inputs

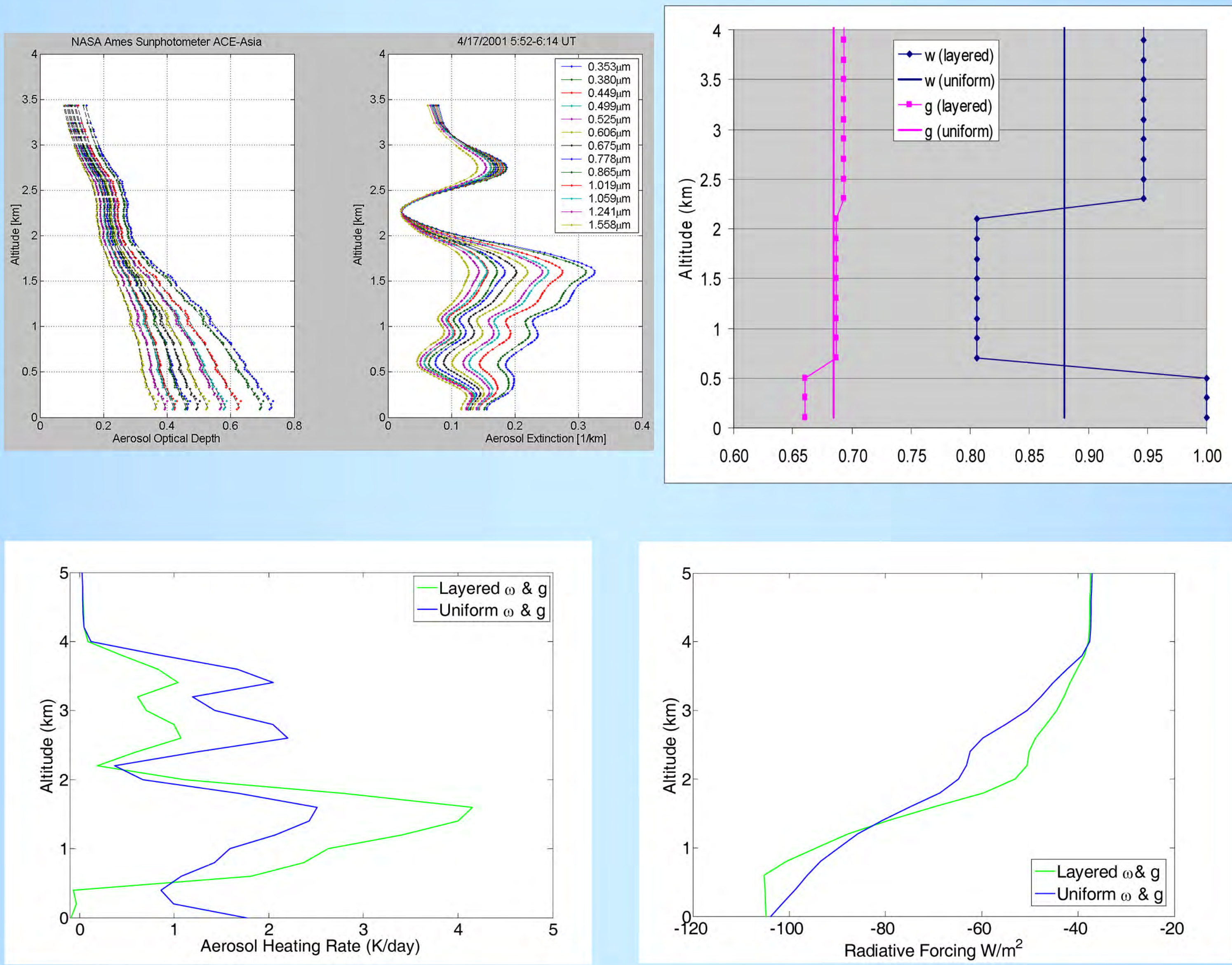
	Case 1	Case 2	Case 3
	Niger	Sea of Japan	SGP
Extinction	See plot	See plot	See plot
Single Scattering Albedo, ω	See plot	See plot	See plot
Asymmetry Parameter, g	See plot	See plot	See plot
H ₂ O, O ₃ , p, T	Meas.& Mid Sum	Meas.& Mid Sum	US62
Surface Albedo	Dry Sand	Dark Ocean	Green Vegetation
Solar Zenith Angle	59°	42°	45°

3. Results

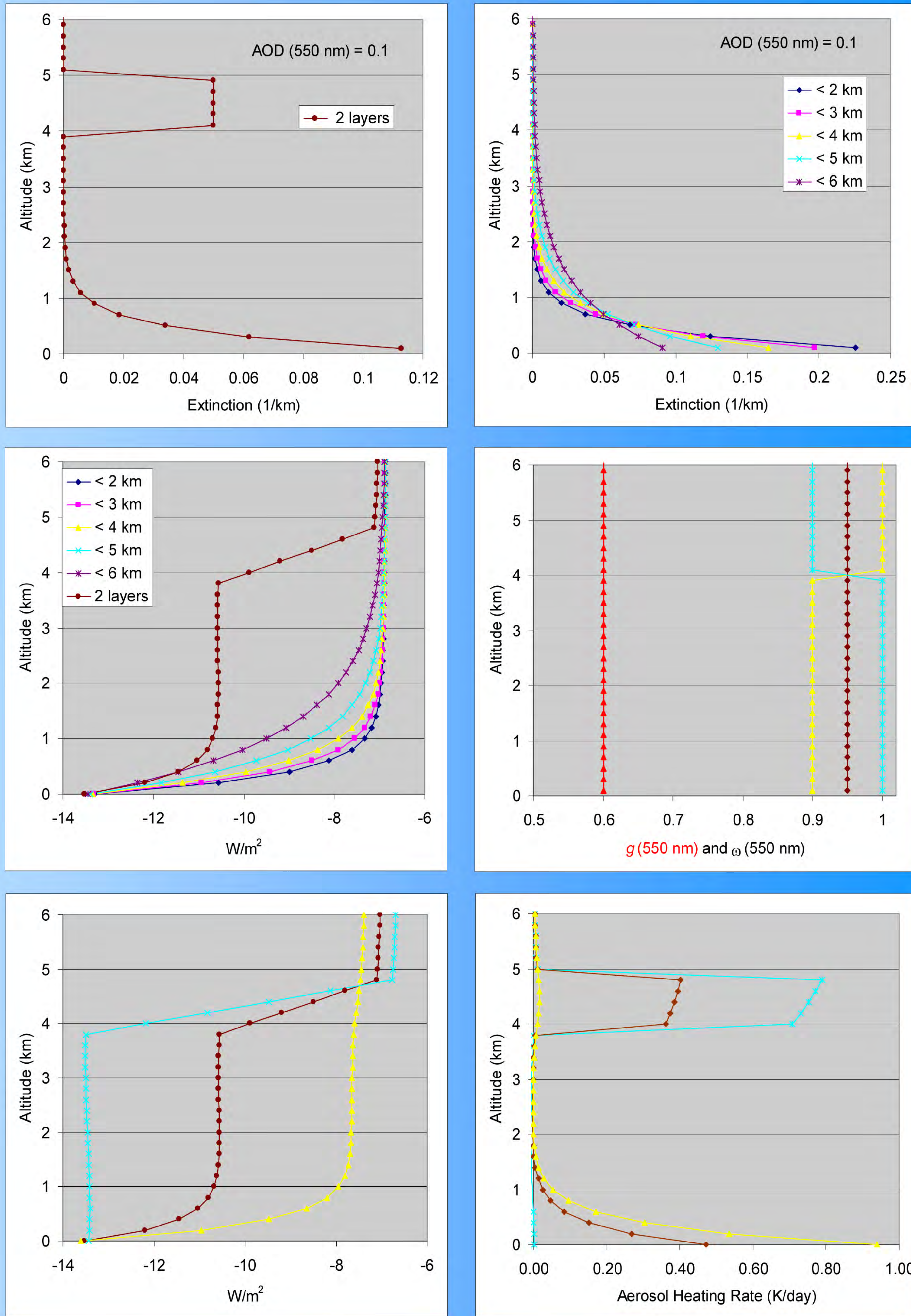
Case 1: Niamey, Niger



Case 2: ACE-Asia, Sea of Japan



Case 3: SGP, Oklahoma



4. Summary

Results indicate that the shape of the aerosol extinction profile has very little impact on TOA and surface forcing. However, as long as the aerosol is not purely scattering (i.e. $\omega < 1$), the shape of extinction profile is important for the vertical profiles of forcing (and heating rates). In contrast, the shape of the aerosol absorption profile has a slight impact on TOA and surface forcing but is the main driver for the forcing and heating rate profiles. Unfortunately, the vertical profile of aerosol absorption is a quantity that currently can be measured with rather large uncertainties only.