Example 1

1. Determine the optical properties of a atmosphere layer with molecular water vapor absorption and aerosol scattering. The water vapor density is $\rho_v = 10\ \mathrm{g/m^3}$ and mass absorption coefficient is $k_\lambda = 0.03\ \mathrm{m^2/kg}$. The aerosol has a volume extinction coefficient of $\beta_{ext} = 0.2\ \mathrm{km^{-1}}$, single scattering albedo of $\omega = 0.9$, and asymmetry parameter of $g = 0.75$.

We want to find β, ω, and g for the combination of water vapor and aerosol. First, calculate the volume extinction coefficient due to water vapor

$$\beta_{H2O} = k_\lambda \rho_v = (0.03\ \mathrm{m}^2/\mathrm{kg})(0.010\ \mathrm{kg}/\mathrm{m}^3) = 0.0003\ \mathrm{m}^{-1} = 0.3\ \mathrm{km}^{-1}$$

Since molecular absorption does not scatter light, the single scattering albedo is zero ($\omega_{H2O} = 0$).
The total extinction is the sum of the two extinction coefficients:

$$\beta_{tot} = \beta_{H2O} + \beta_{aero} = 0.5\ \mathrm{km}^{-1}$$

The total single scattering albedo is found by adding the scattering coefficients:

$$\beta_{tot}\omega_{tot} = \beta_{H2O}\omega_{H2O} + \beta_{aero}\omega_{aero}$$

$$\omega_{tot} = \frac{\beta_{H2O}\omega_{H2O} + \beta_{aero}\omega_{aero}}{\beta_{tot}} = \frac{(0.2\ \mathrm{km}^{-1})(0.9)}{0.5\ \mathrm{km}^{-1}} = 0.36$$

The total asymmmetry parameter is found by adding the scattering coefficient weighted asymmetry parameters:

$$\beta_{tot}\omega_{tot}g_{tot} = \beta_{H2O}\omega_{H2O}g_{H2O} + \beta_{aero}\omega_{aero}g_{aero}$$

$$g_{tot} = \frac{\beta_{aero}\omega_{aero}g_{aero}}{\beta_{tot}\omega_{tot}} = \frac{\beta_{aero}\omega_{aero}g_{aero}}{\beta_{aero}\omega_{aero}} = g_{aero} = 0.75$$