Comprehensive Exam May 21, 2009, MPO 531 Question:

Consider a layer of dust moving westward off of the African continent. The layer is characterized by a single-scattering albedo of 0.9, asymmetry parameter of 0.8, and optical depth of 0.3 (all are broadband shortwave values).

a. Define single-scattering albedo (ω_0), asymmetry parameter (g) and the optical depth (τ).
b. How much sunlight is transmitted, absorbed, and scattered back to space by the aerosol layer the first time through? Neglect multiple scattering within the aerosol layer, assume a solar zenith angle of 30^0, and show the relevant equations. Express as a fraction.
c. For two underlying surfaces - a desert with an albedo of 0.35 and an ocean albedo of 0.05 - estimate the total percentage of sunlight reflected back to space.

d. Now the dust layer subsides into a marine boundary layer of mean temperature 15^0 C. What supersaturation is needed for condensation of water vapor onto the aerosol particles to occur? Derive the relevant equation first, then substitute in numbers. If pressed for time, skip the latter. Assume the dust is monodisperse and wettable with a radius of 0.2 micron.

Recall σ is the surface energy of water (0.076 J/m^2), n the number density of molecules in water ($3.3 * 10^{28}$ m^{-3}), k the Boltzmann's constant ($1.38 * 10^{-23}$ J/(deg*molecule)), and e_{sat} the saturation vapor pressure with respect to a plane surface of water at temperature T, given by Bolton's formula as $e_{sat} = 6.112*\exp(17.67*T/(T+243.5))$, with T in Celsius.