Atmos. Chem. Lecture 18, 11/18/13: Particulate matter: Properties

Particles + water (cloud formation)

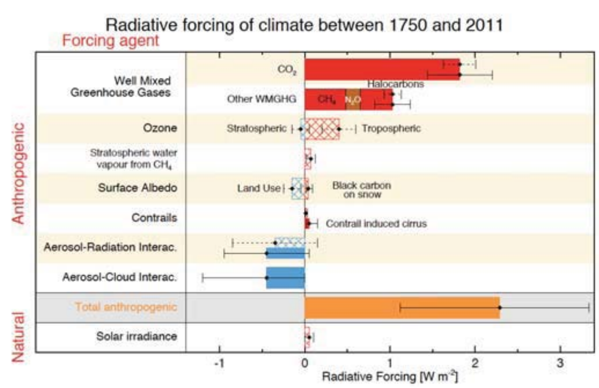
Particles + light (scattering, absorption)

PSet 4 due Nov. 25

Particles + light, particles + water

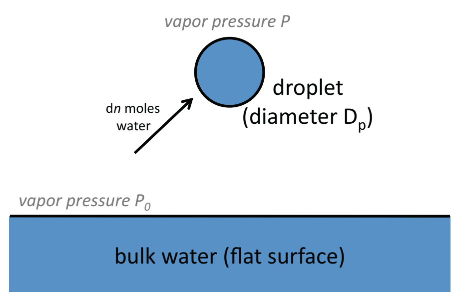
Climate effects of particles:

- Direct: scattering, absorption of radiation
- Indirect: changes to cloud properties (albedo) and lifetime



IPCC AR5, 2013

Vapor pressure over a droplet



[*Note: Additional material is discussed here during lecture.*]

Kelvin effect

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S&P

"Köhler Curve"

$$\ln\left(\frac{P}{P_0}\right) = \frac{4M_w\sigma_w}{RT\rho_w D_p} - \frac{6n_s M_w}{\pi\rho_w D_p^3}$$

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Köhler Curves

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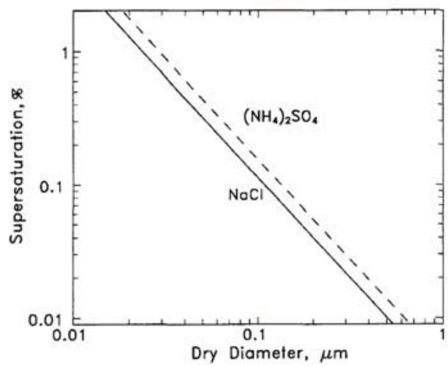
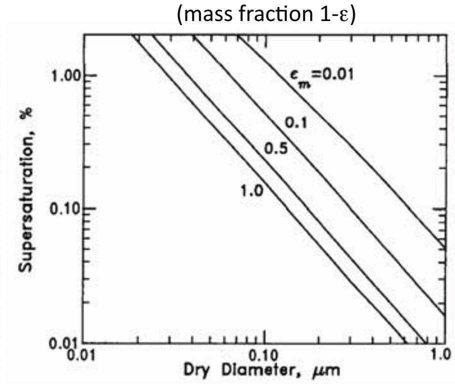
Critical supersaturation

Soluble species only



Some insoluble species
(mass fraction 1-ε)



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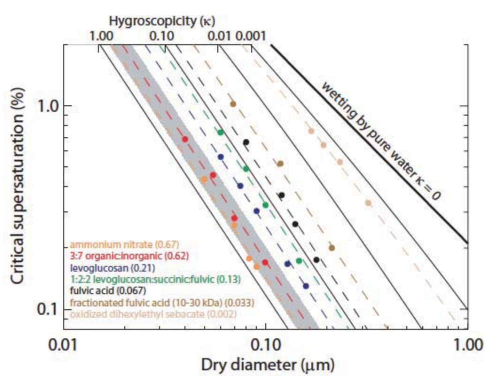
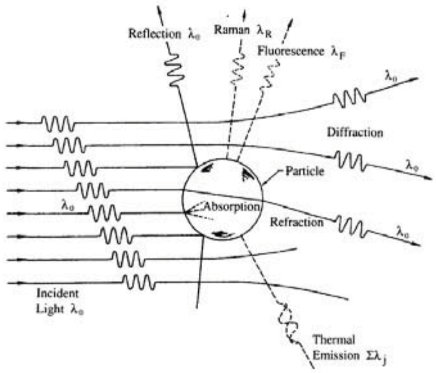
"κ-Kohler theory"



for more information, see:
Petters and Kreidenweis, *ACP* 7:1961 (2007)
Petters and Kreidenweis, *ACP* 8:6273 (2008)

Interaction between light and a particle



complex index of refraction:
m = n + i k

TABLE 15.2 Refractive Indices of Atmospheric Substances at λ = 589 nm (Unless Otherwise Indicated)

Substance	$m = n + ik$		
	n	k	
Water	1.333	0 (see Table 15.1)	
Water (ice)	1.309		
NaCl	1.544	0	
H_2SO_4	1.426[a]	0	
NH_4HSO_4	1.473[b]	0	
$(NH_4)_2SO_4$	1.521[b]	0	
SiO_2	1.55	0	(λ = 550 nm)
Carbon[c]	1.95	−0.79	(λ = 550 nm)
Mineral dust[d]	1.56	−0.006	(λ = 550 nm)

[a] Stelson (1990), assuming a 97% pure (by mass) mixture of H_2SO_4 with H_2O.
[b] Weast (1987).
[c] Bond and Bergstrom (2006) report a narrow range of refractive indices of light-absorbing carbon. The value in the table represents the upper limit.
[d] Tegen et al. (1996).

key descriptors: $b_{ext} = b_{scat} + b_{abs}$
$(C_{ext} = C_{scat} + C_{abs})$
$(Q_{ext} = Q_{scat} + Q_{abs})$

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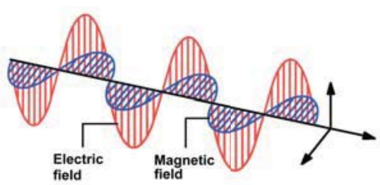
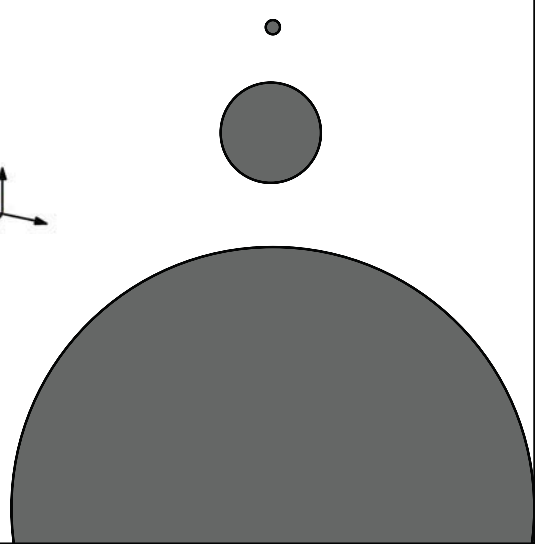
Importance of particle size





Mie Theory

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Nice, compact description:
http://plaza.ufl.edu/dwhahn/Rayleigh%20and%20Mie%20Light%20Scattering.pdf

online calculator: http://omlc.org/calc/mie_calc.html
downloadable program (PC only!): http://www.philiplaven.com/mieplot.htm

Mie Theory

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Mie Scattering: Size, angle

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Mie Scattering: Dependence on size, volume

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Dependence on RH (size)

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Phase of inorganic salts

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