EPS200: Atmospheric Chemistry and Physics

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Fall 2013

Deposition processes

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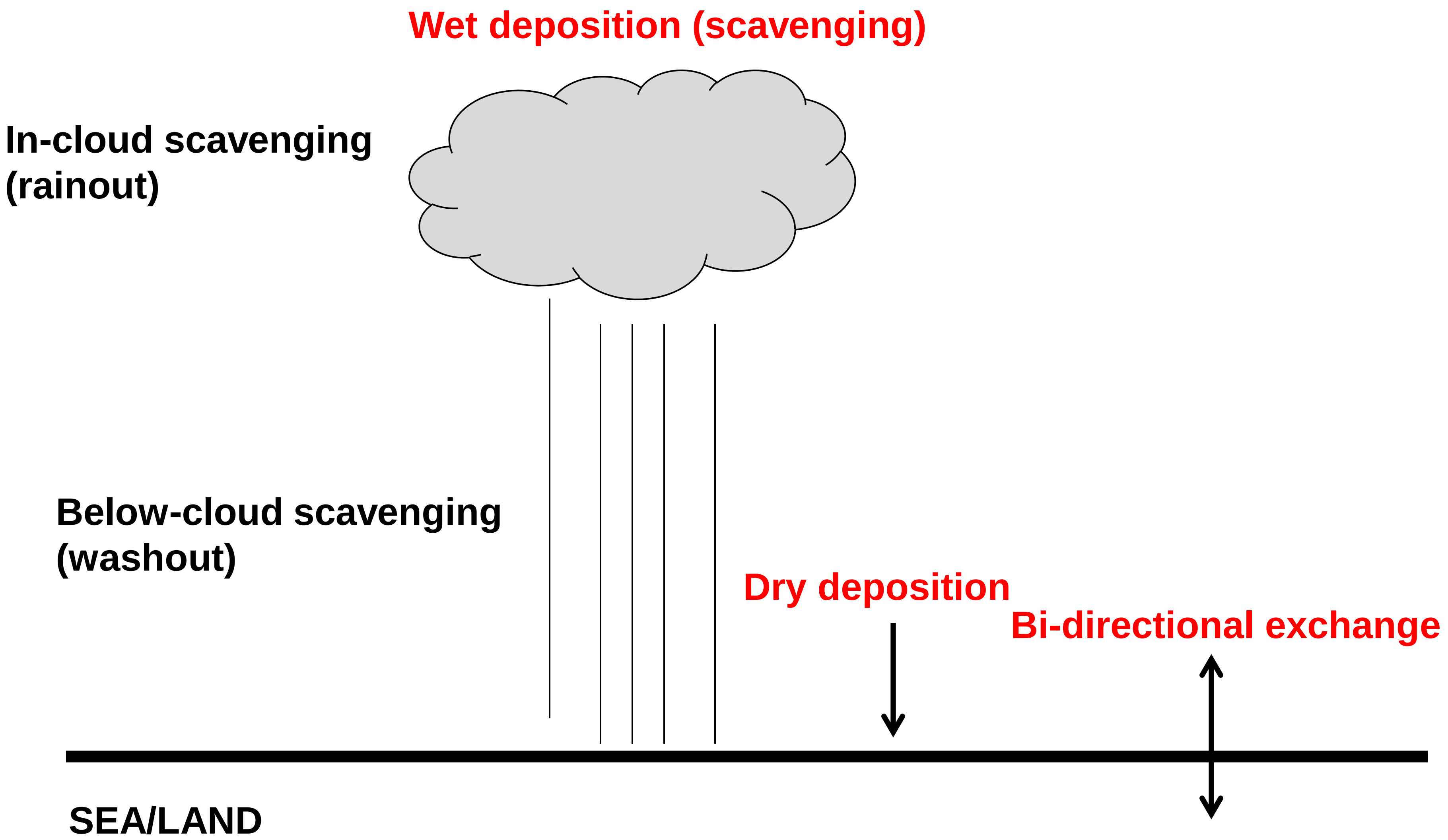
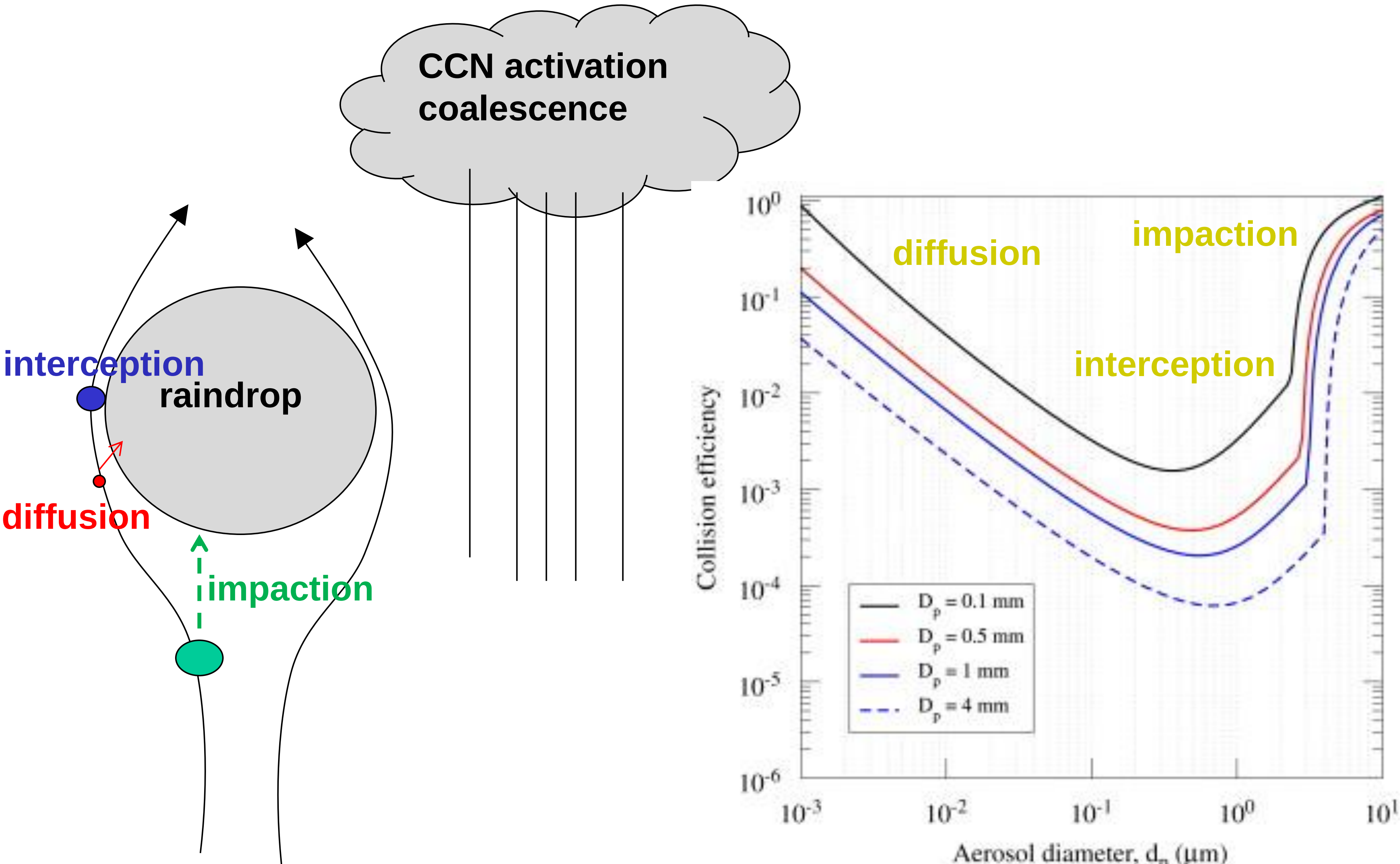


Aerosol scavenging processes



Scavenging of gases by liquid clouds and rain

Consider equilibrium

$$X(g) \rightleftarrows X(aq)$$

where X(aq) includes all dissolved species in fast equilibrium. Define effective Henry's law constant $K_H^* = [X(aq)] / p_X$

Then the fraction *f* of X incorporated into the liquid phase is

$$f = \frac{\{X(aq)\}}{\{X(g)\} + \{X(aq)\}} = \frac{1}{1 + \frac{1}{K_H^* LRT}}$$

where { } is concentration in moles per liter of air and *L* is the liquid water content (volume water per volume of air)

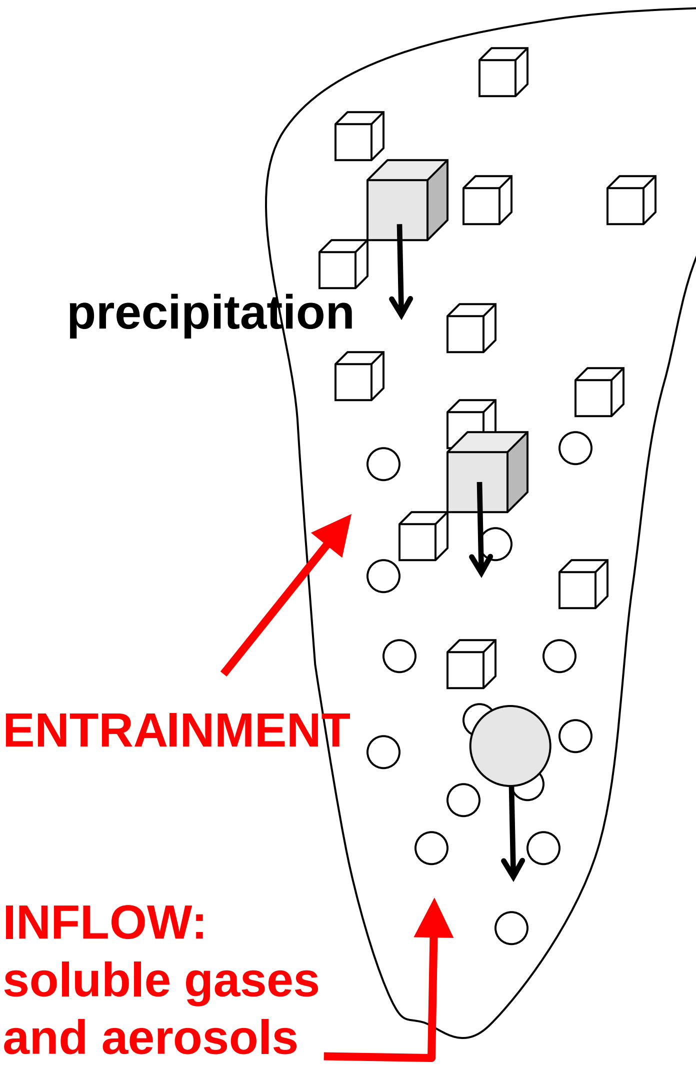
Effective Henry's law constants and gas-cloud partitioning

Species	K_H^*, M atm^{-1} (pH=4.5, T=280K)
O_3	1.8×10^{-2}
PAN	1.1×10^{1}
CH_3OOH	9.5×10^{2}
CH_2O	1.4×10^{4}
H_2O_2	4.1×10^{5}
NH_3	5.0×10^{6}
HNO_3	4.3×10^{11}

mostly in gas

mostly in cloud ($L \sim 10^{-7}$ v/v)

Variable gas/aerosol scavenging efficiencies in deep convection

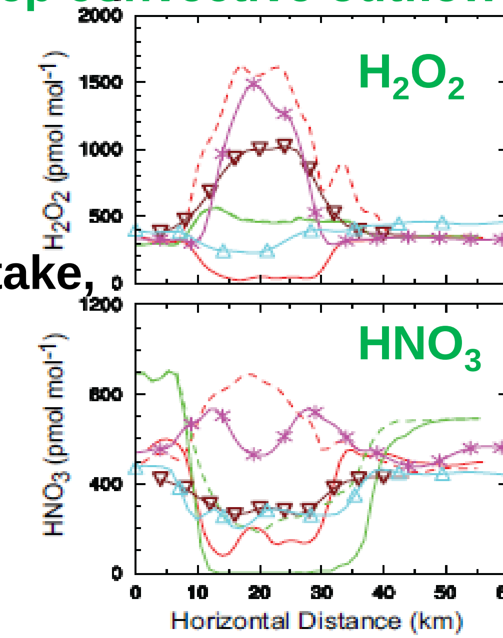


Cold cloud:
co-condensation, surface uptake,
aerosol scavenging?

Riming mixed cloud:
retention efficiency
upon drop freezing?

Warm cloud:
scavenging relatively
well understood

Model intercomparison
deep convective outflow



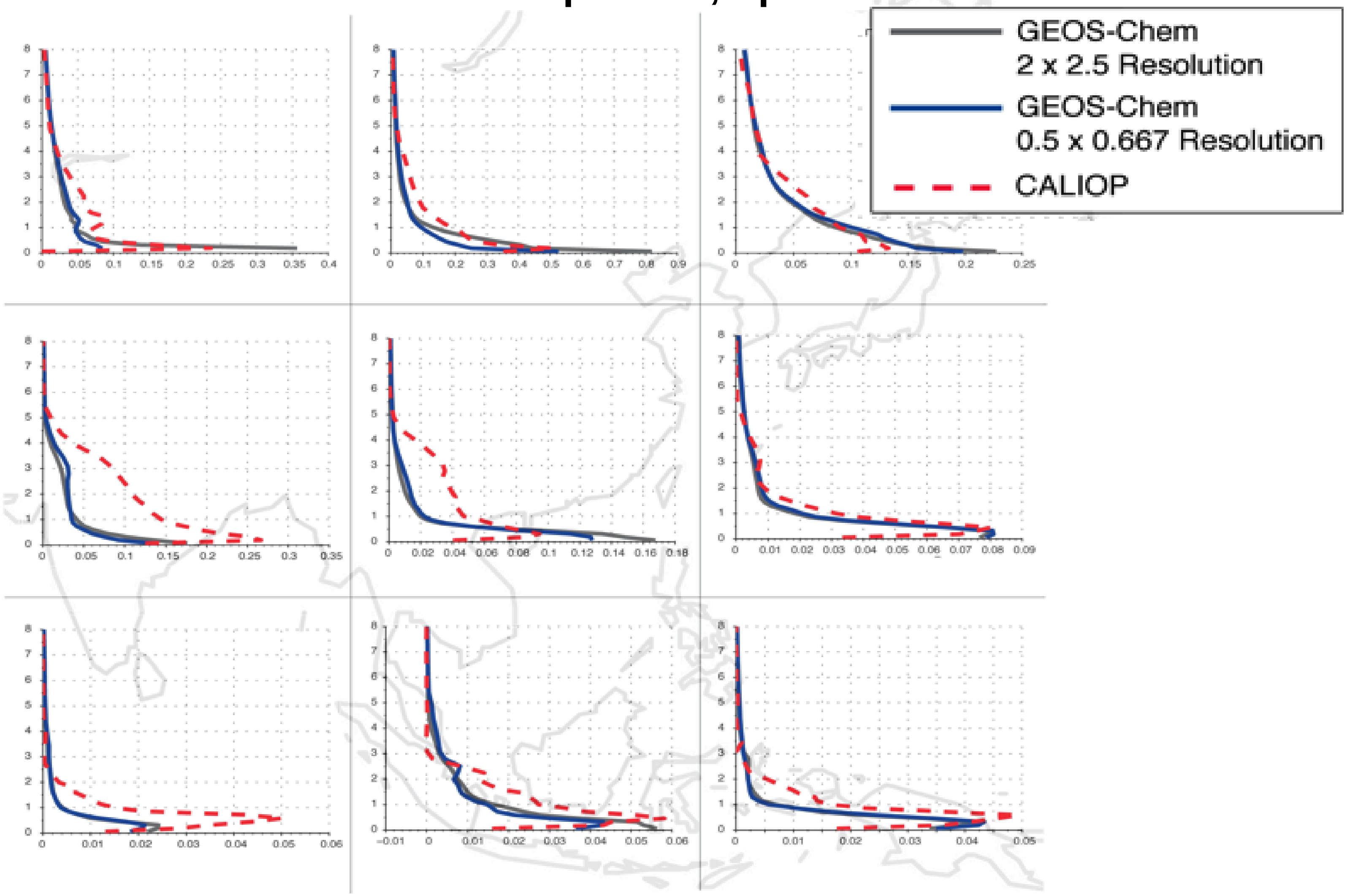
Barth et al. [2007]

CALIOP satellite data show variable aerosol scavenging

Scavenging is often less efficient than simulated in GEOS-Chem

Mean aerosol vertical profiles, April 2008

Altitude (km)

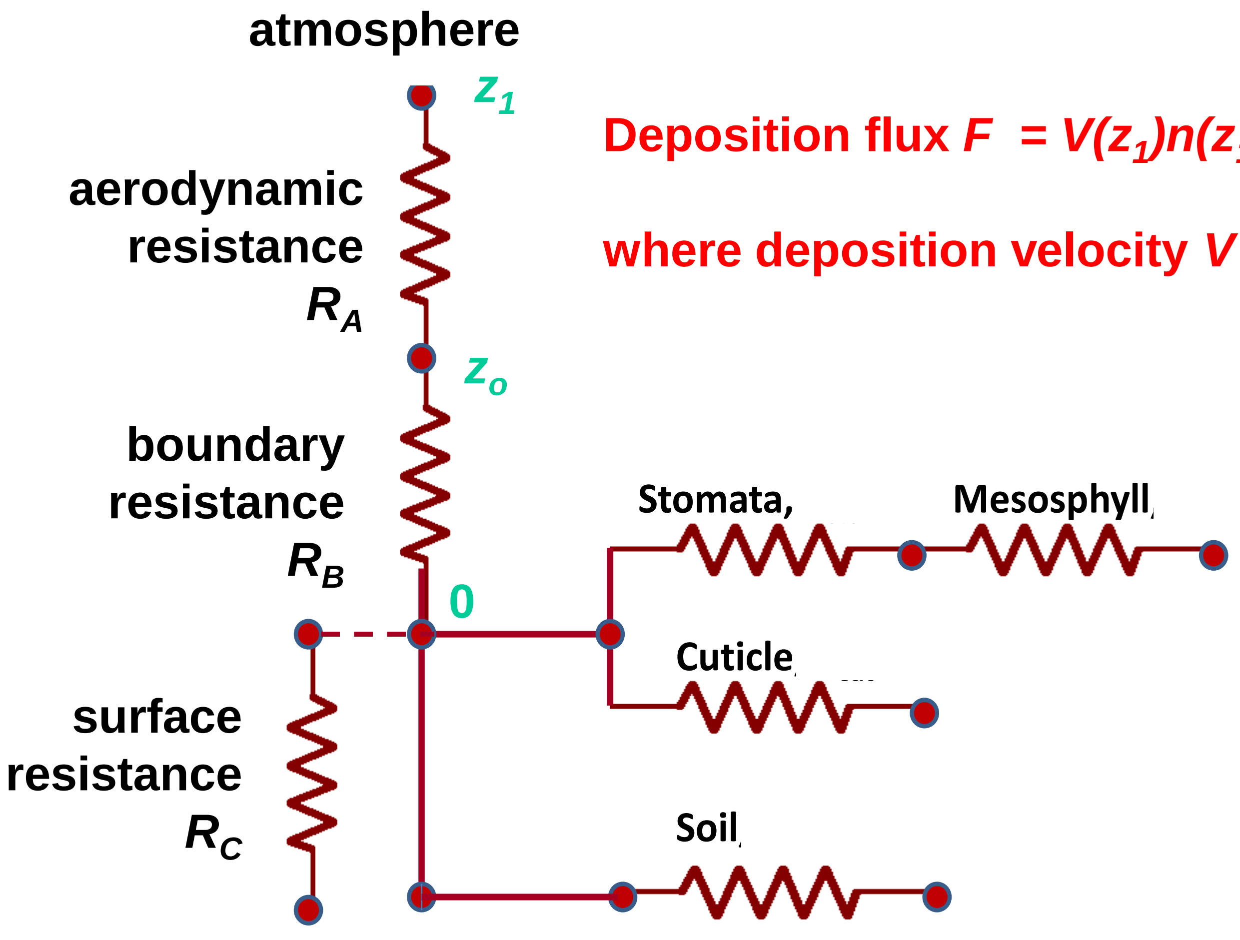


Aerosol extinction coefficient (km^{-1})

Patrick Kim(Harvard)

Dry deposition processes

Standard resistance-in-series model

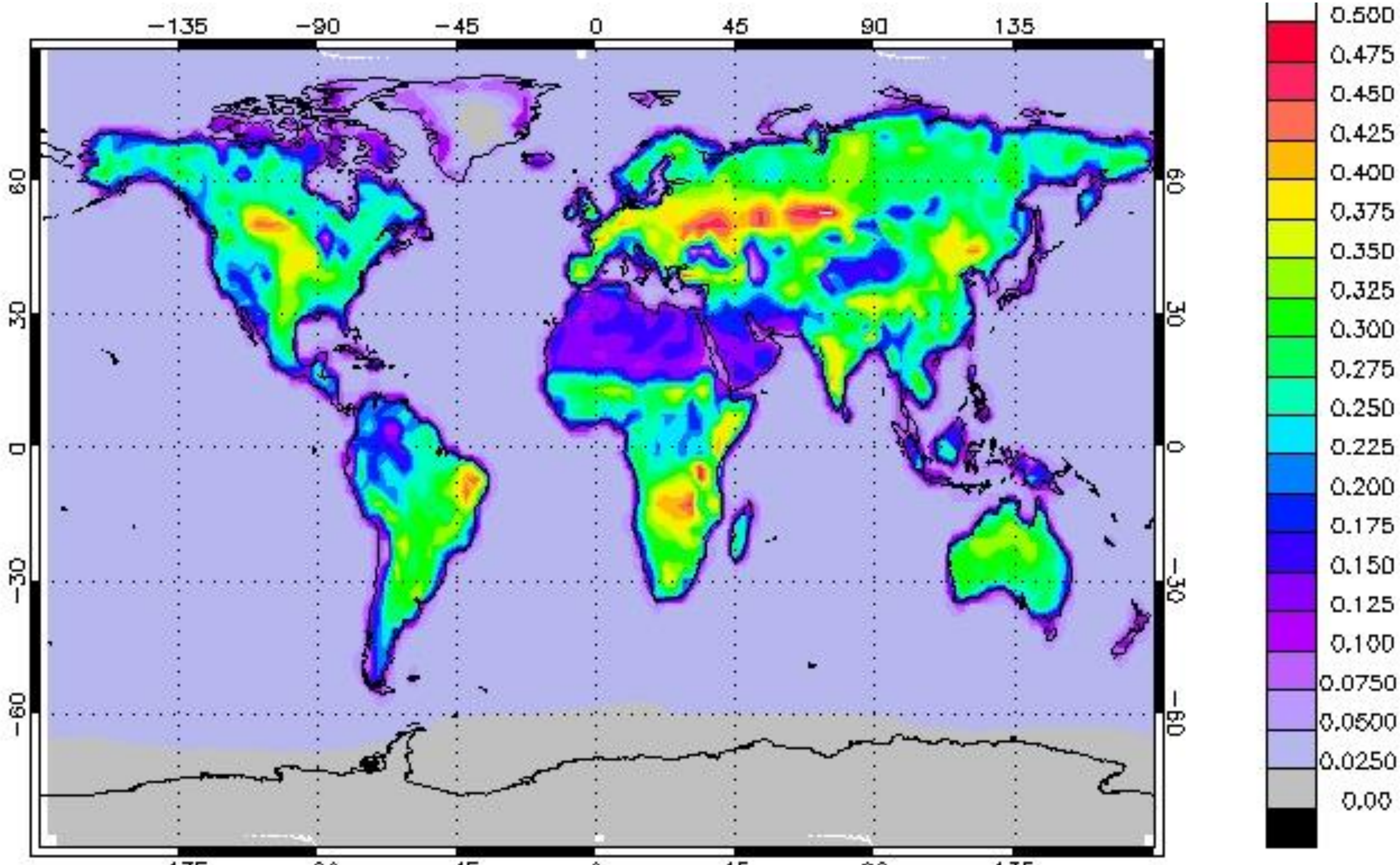


Deposition flux $F = V(z_1)n(z_1)$

where deposition velocity $V(z_1) = 1/(R_A(z_1) + R_B + R_C)$

Dry deposition velocity of ozone

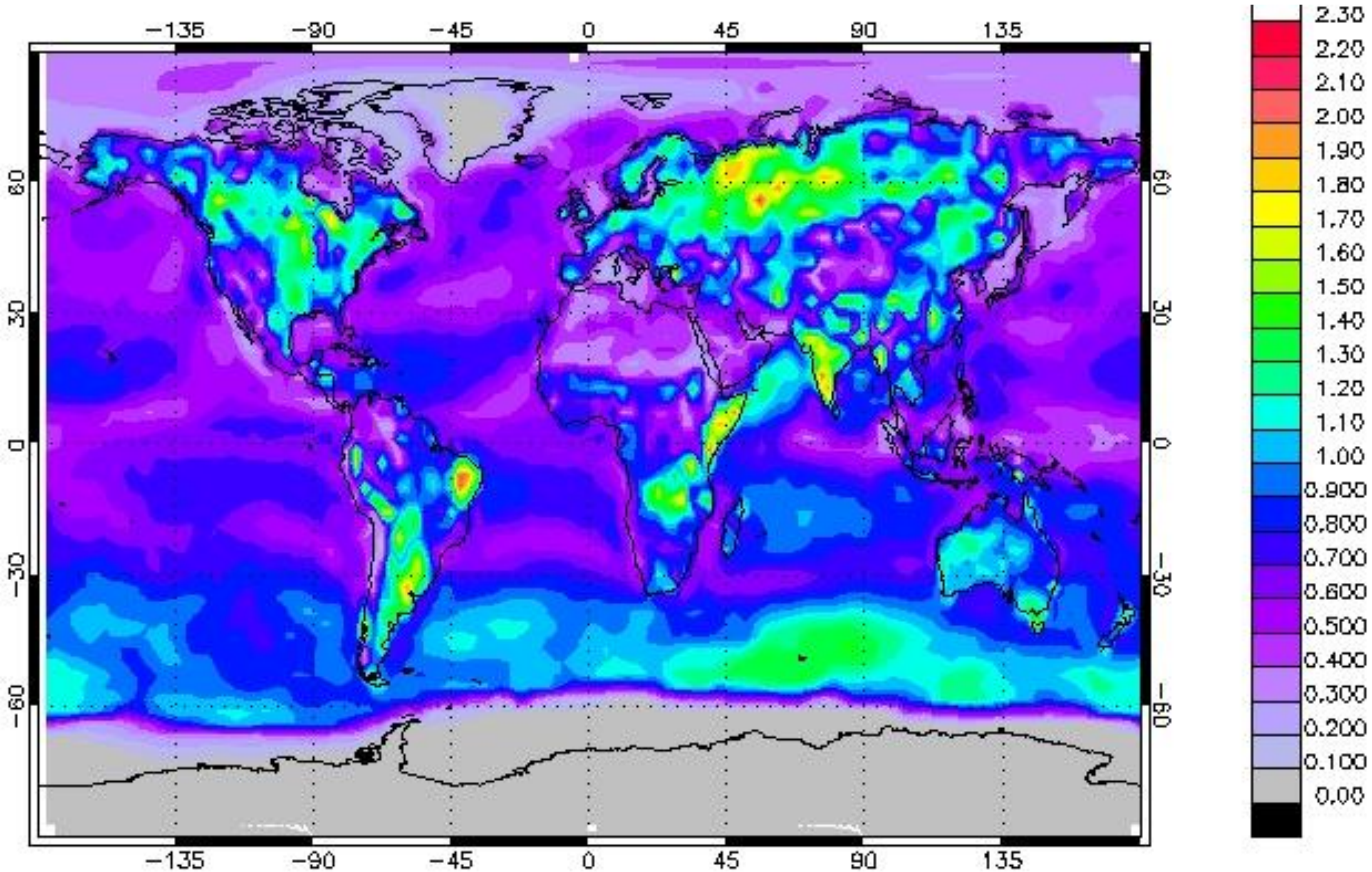
Monthly mean July values, MOZART model



Louisa Emmons, NCAR

Dry deposition velocity of HNO_3

Monthly mean July values, MOZART model



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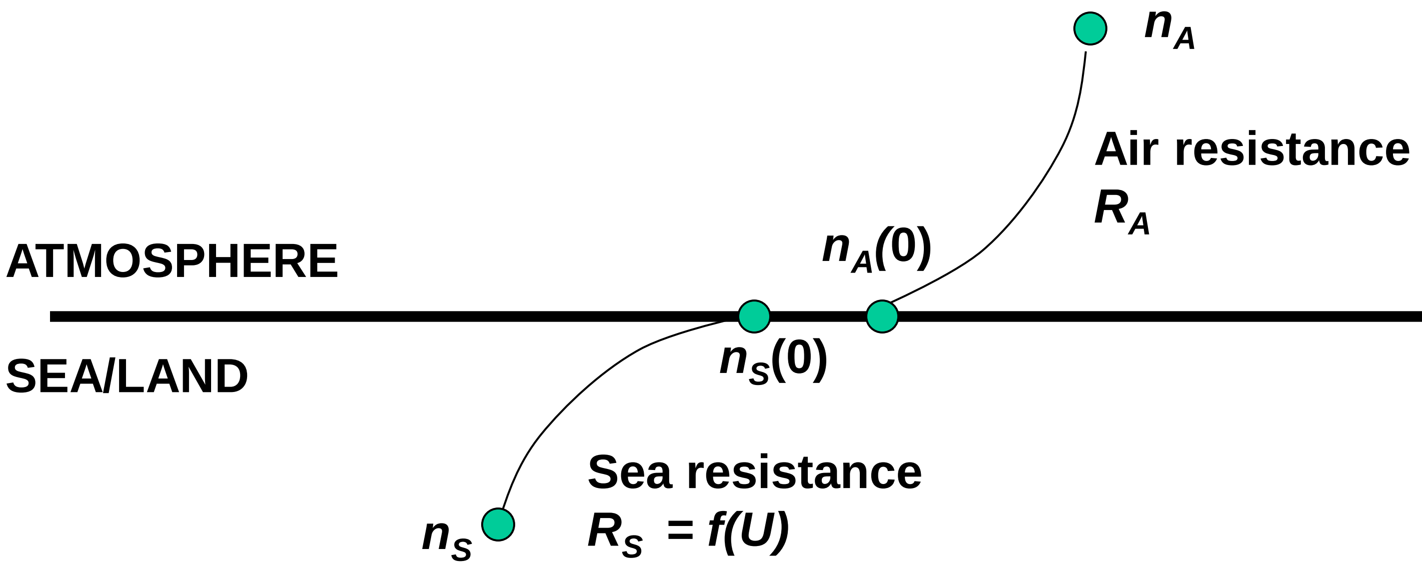
Bi-directional exchange



sea-air exchange velocity

Net deposition flux

$$F = \frac{1}{R_A + \frac{R_S}{K_H}} \left(n_A - \frac{n_S}{K_H}\right)$$