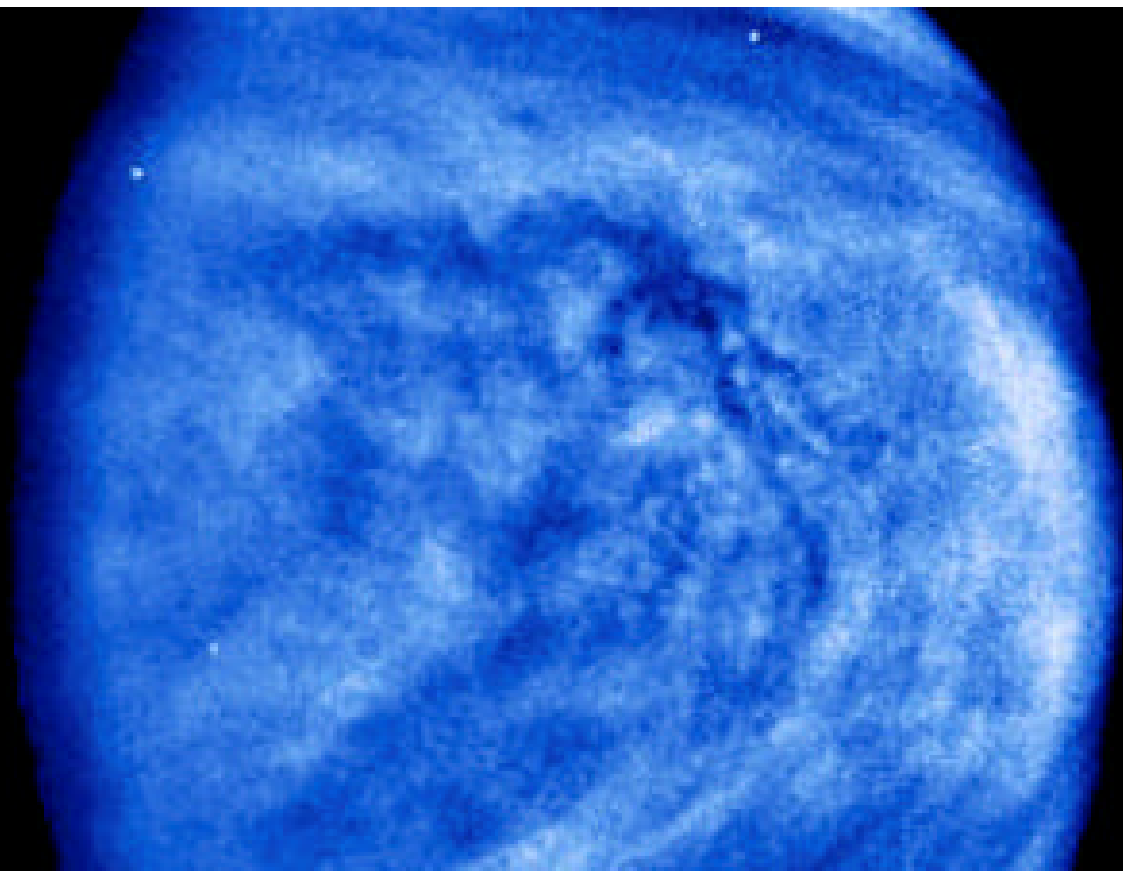


Aerosols in planetary atmospheres

microphysics

dynamics

radiation



micrometeorites

Photochemical production

nucleation

condensation

convection

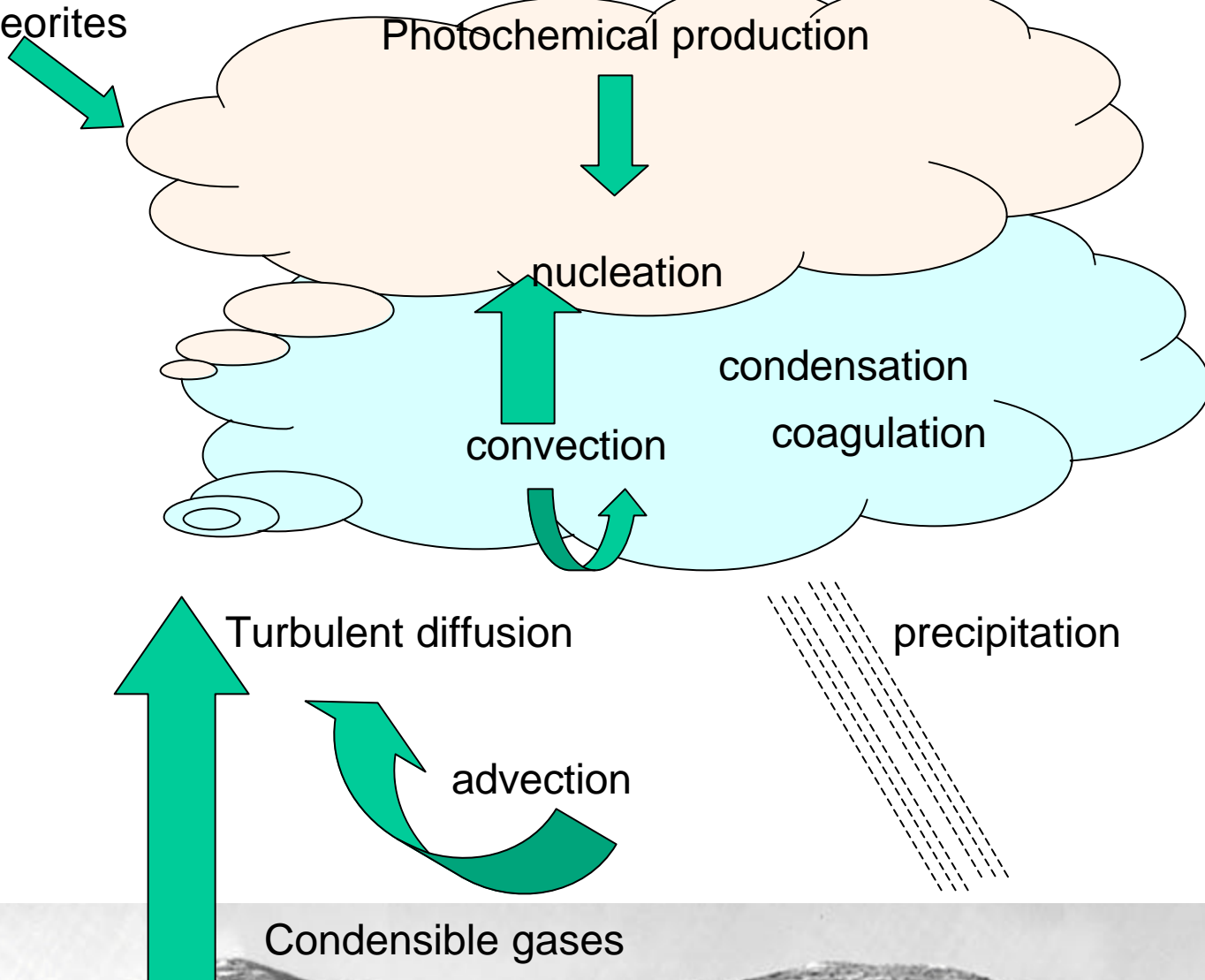
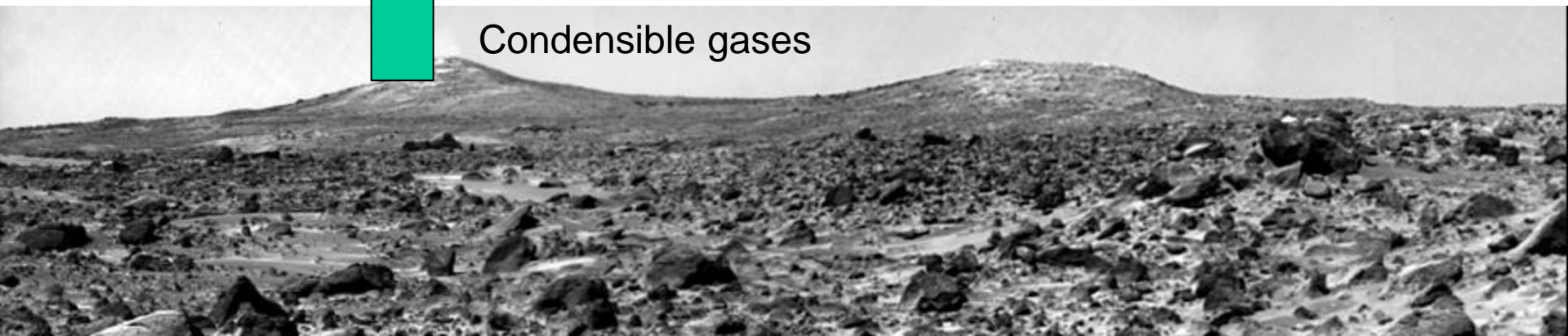
coagulation

Turbulent diffusion

precipitation

advection

Condensible gases



Aitken cores	$10^{-3} - 10^{-1} \mu\text{m}$
soil weathering products	$0.1 - 10 \mu\text{m}$
crystal clouds (cirruses)	$1 - 50 \mu\text{m}$
cloud drops	$10 - 500 \mu\text{m}$
raindrops	$0.1 - 10 \text{ mm}$

Homogeneous nucleation

$$J_{\text{hom}} = \frac{1}{r} \left(\frac{2N_A^3 M S}{p} \right)^{1/2} \left(\frac{e_{\text{sat}}}{RT} \right)^2 s e^{-\frac{F_{\text{hom}}}{kT}},$$

surviving germs have to be created by fluctuations

$$F_{\text{hom}} = \frac{4pa_g^2 S}{3}, \quad a_g^2 = \frac{2MS}{RT r \ln(S+1)},$$

Heterogeneous nucleation

$$J_{het} = \frac{4p^2 r^2 Z e_{sat}}{(2pmkT)^{1/2}} a_g^2 c_{1,l} e^{-\frac{F_{het}}{kT}},$$

$$F_{het} = \frac{pa_g^2 S}{3} (2+m)(1-m)^2.$$

**m is the ratio of surface tension
of nucleation core and condensate particle**

Condensational growth

$$\frac{dr}{dt} = \frac{S + 1 + A_k}{r} \cdot \frac{e_s DM}{r RT}$$

Kelvin correction

$$A_K = \frac{2s M}{RT r r}$$

Coagulation

*Loss of particle **a** by collision with any other*

*Birth of particle **a** by coalescence of any pair **x** and **a-x***

$$\frac{\partial f(a)}{\partial t} = - \int_0^{\infty} K_b(a, x) f(a) f(x) dx + \frac{1}{2} \int_0^a K_c(x, a-x) f(x) f(a-x) dx.$$

For Brownian coagulation $K(r_1, r_2) = \frac{2kT\alpha(r_1 + r_2)(r_1^2 + r_2^2)}{r_1^2 r_2^2}$

Smoluchowsky iterative solution: $K \sim r$

$$f_k = \frac{t^{k-1}}{(t+1)^{k+1}}, \quad t = 8pDn_0t.$$

Analytical solutions are also known for

$$K(r_1, r_2) = A + B(r_1 + r_2) + Cr_1r_2$$

The case $K(r_1, r_2) \sim r_1^l r_2^l, \quad l > 1$

results in runaway coagulation

Final continuity equation

$$\frac{\partial n}{\partial t} = -\nabla(n(\mathbf{v} + \mathbf{u})) - \frac{\partial}{\partial r}(nr) + \nabla \left(K \mathbf{r} \nabla \frac{n}{r} \right) + Q_n^+ + Q_c - Q_b - Q_n^-,$$

*Sedimentation
& advection*

*Condensation
& sublimation*

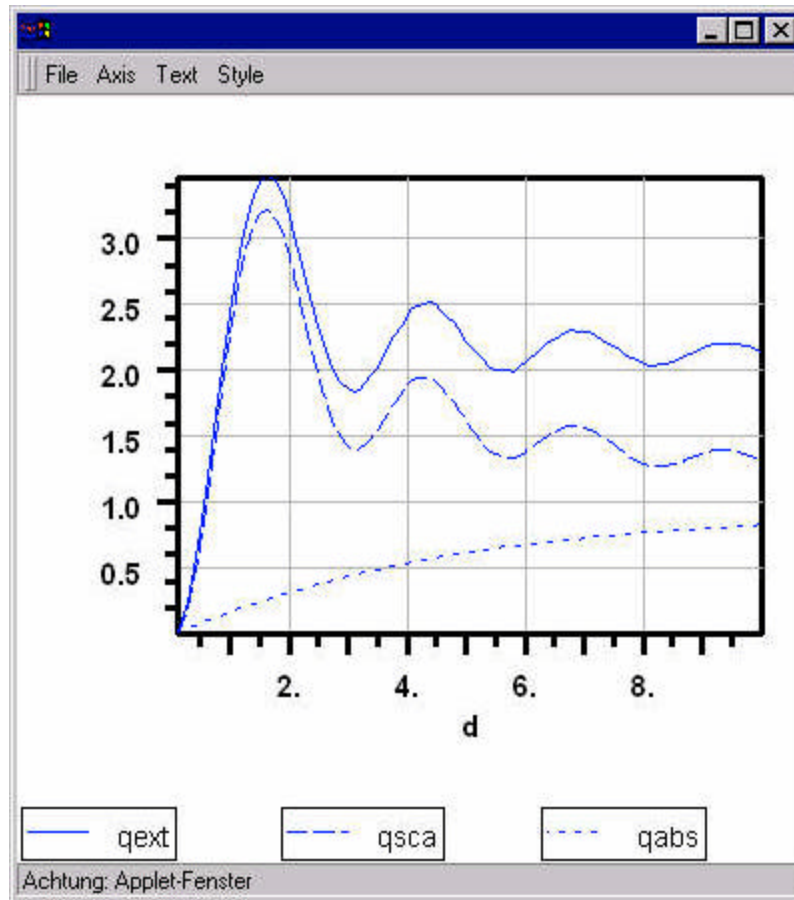
Eddy diffusion

$$t_{cond} \sim 1-10^5 \text{ s}$$

$$t_{adv} \sim 10^5-10^6 \text{ s}$$

$$t_{diff} \sim 10^6-10^8 \text{ s}$$

Light scattering by spherical particles: Mie theory



Venus cloud deck

70 km

Photochemically produced
cores $\sim 0.2 \mu\text{m}$

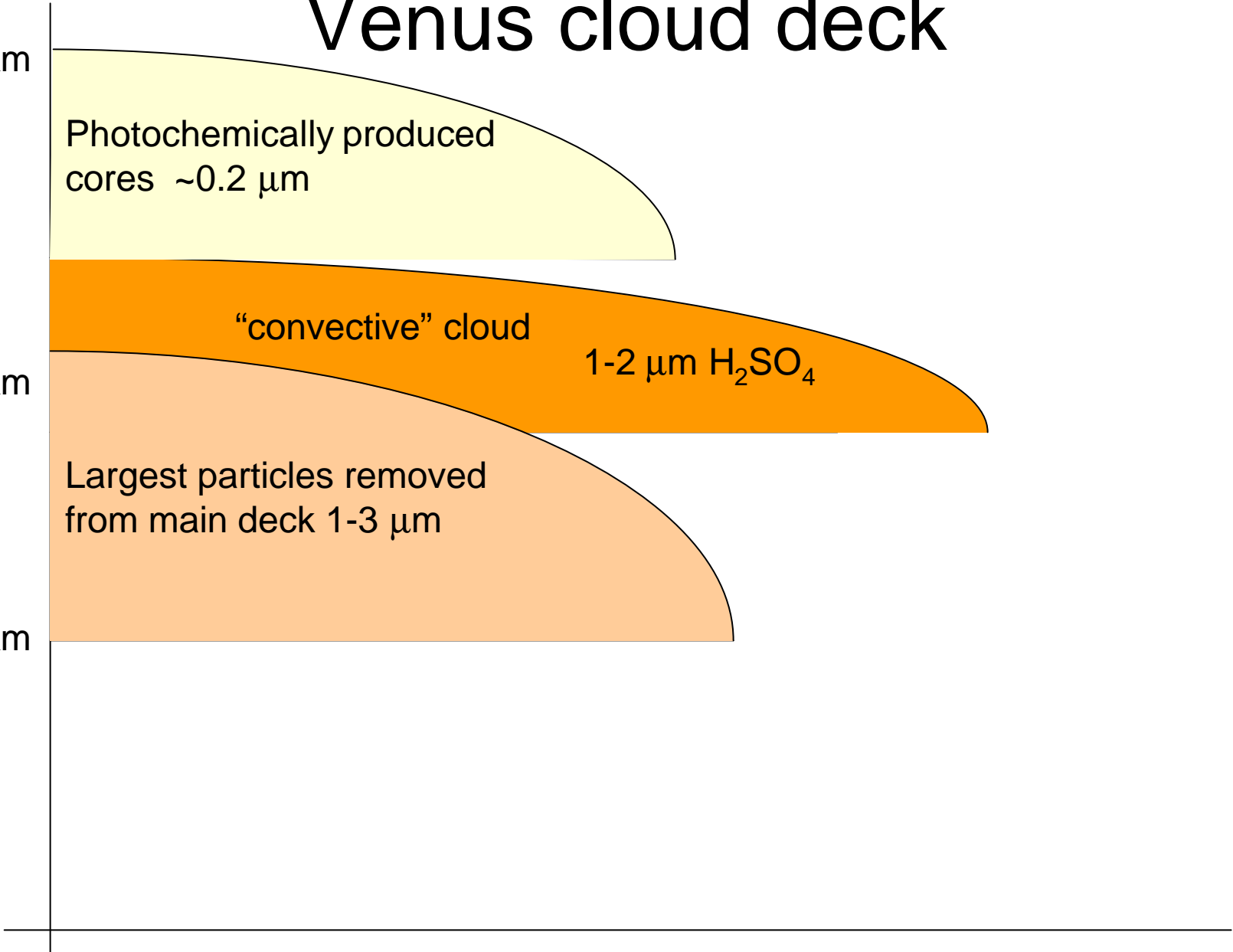
“convective” cloud

1-2 μm H_2SO_4

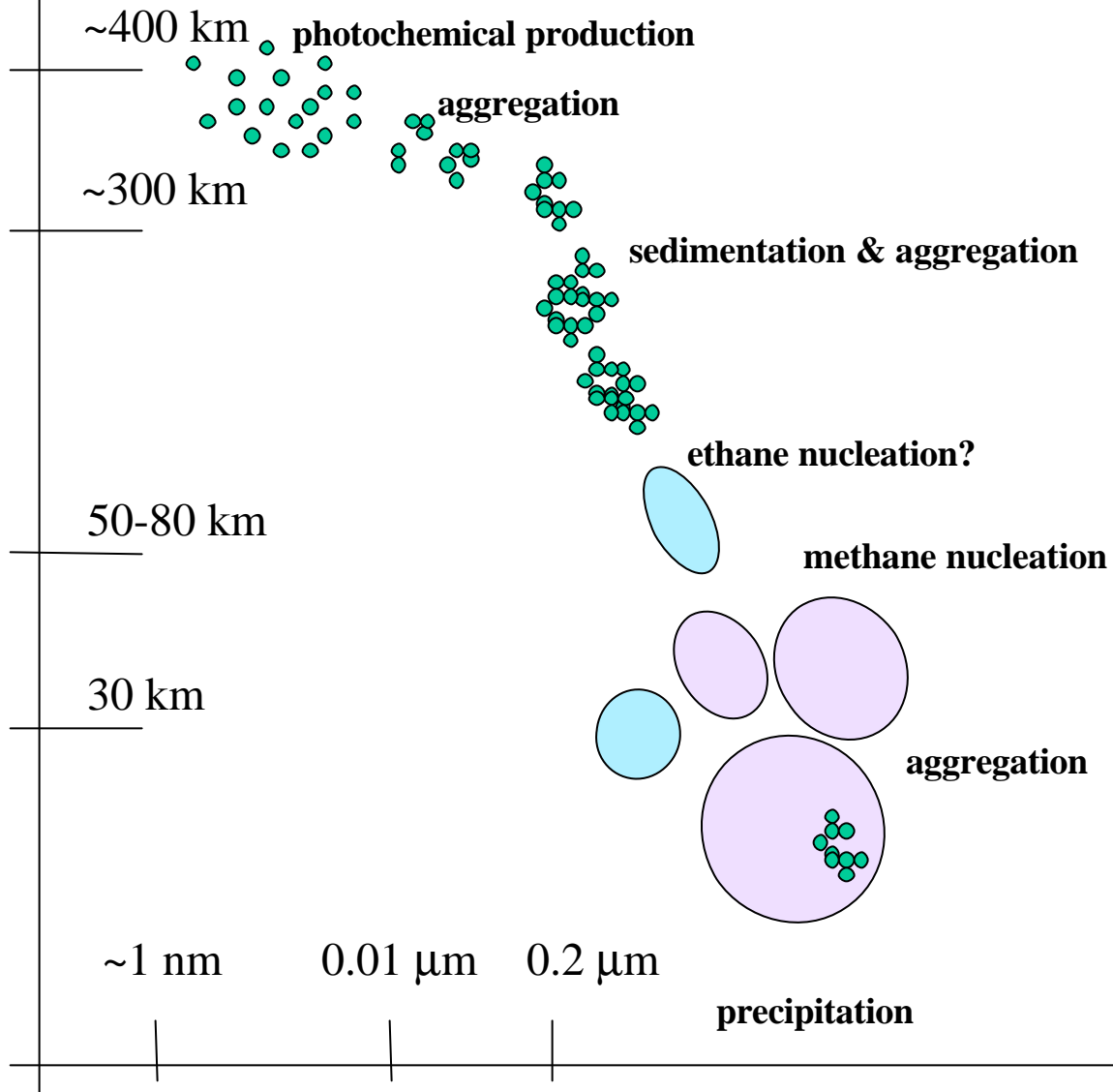
55 km

Largest particles removed
from main deck 1-3 μm

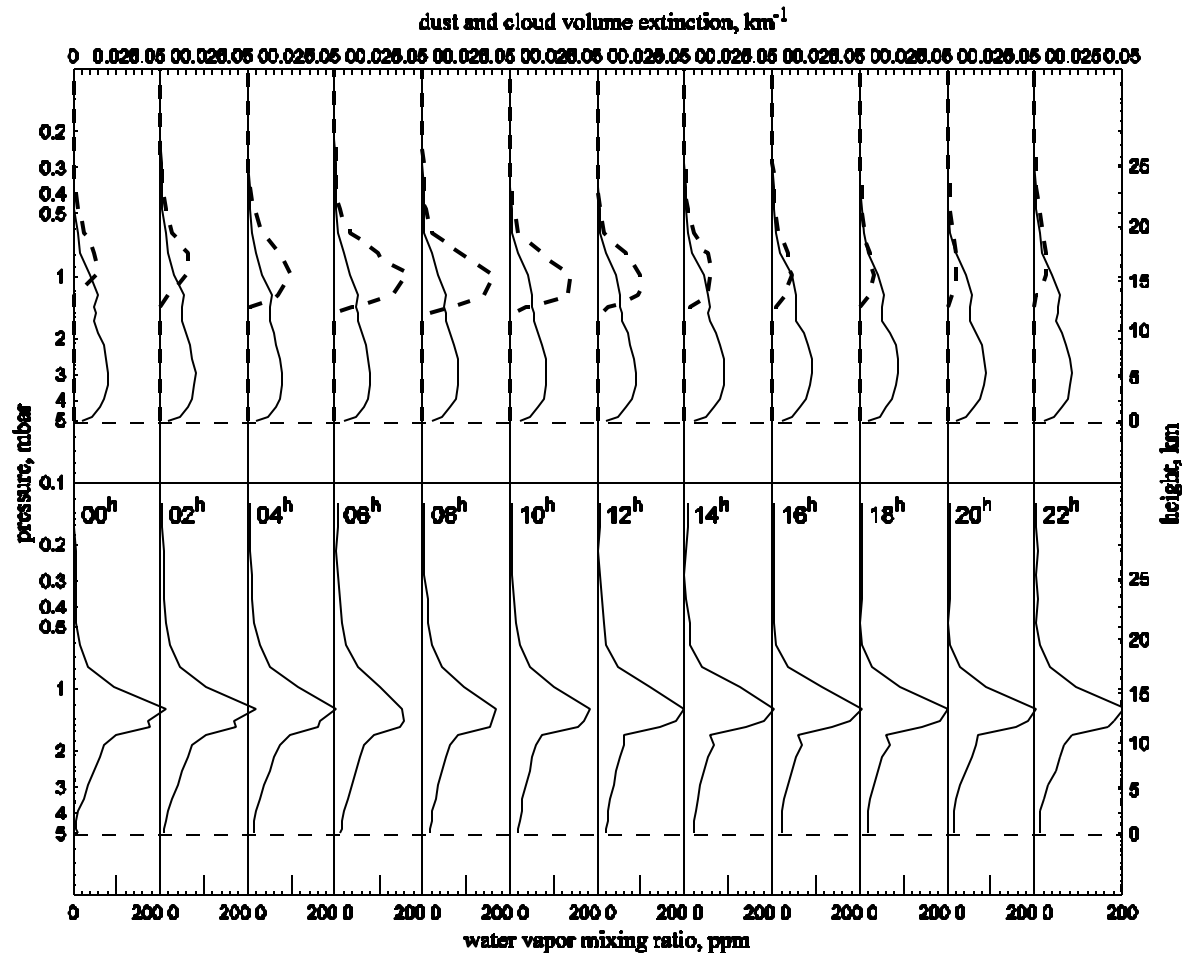
30 km



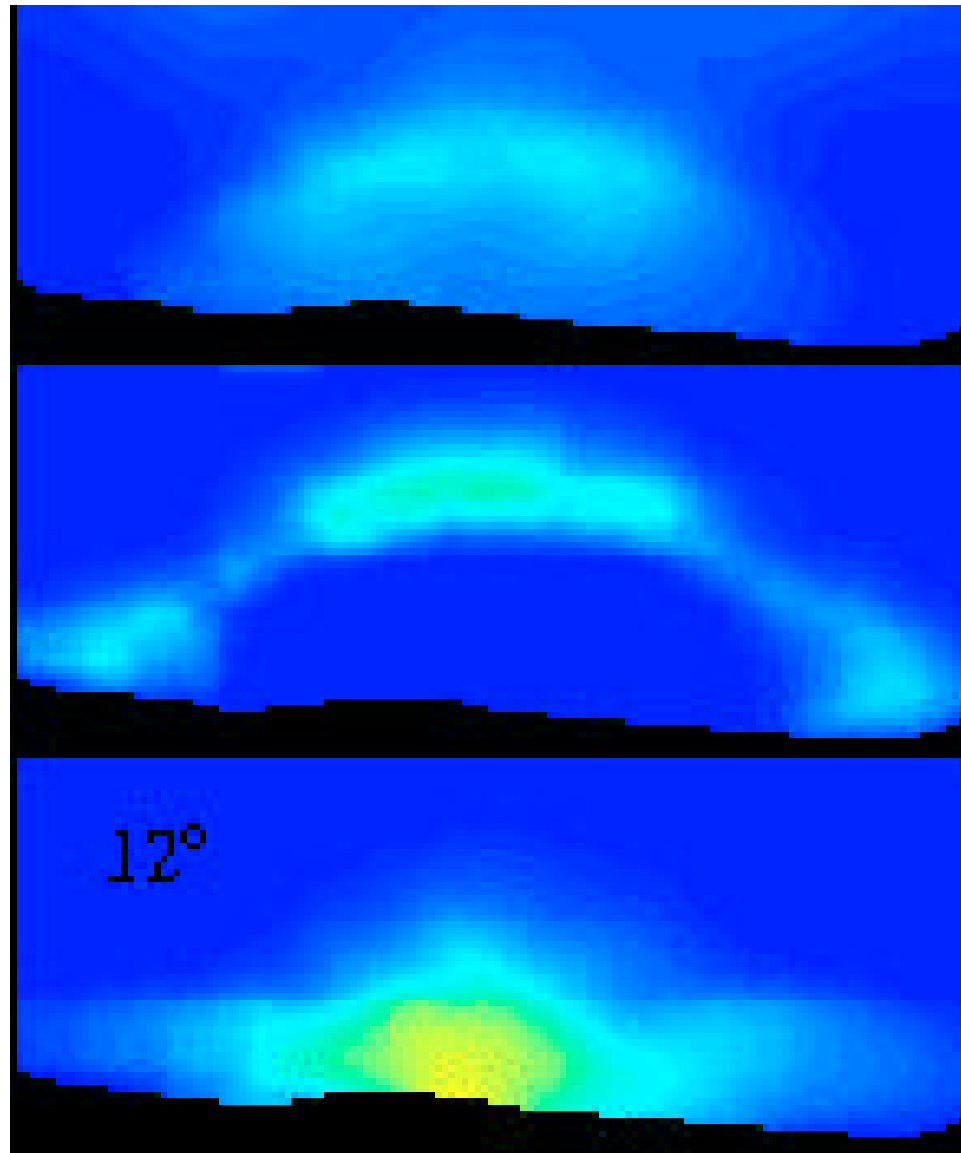
Aerosols in Titan's atmosphere



Diurnal cycle of Martian aerosols



Seasonal evolution of Martian global-scale clouds



water vapor

water ice clouds

dust