Composition, chemistry & clouds

Terrestrial planets

	Venus	Earth	Mars	Titan
N_2	3.5%	78%	2.7%	90-97%
O_2	0-20	21%	0.13	-
CO_2	96.5%	350	95.3%	10 ppb
CO	30-1000	0.2	700	10
H_2O	30	<3%	<100	0.4 ppb
SO_2	~200	-	-	
CH_4	-	3	10 ppb	4%
C_2H_2	-	~9 ppb		2
C_2H_6	-	~14	-	10

Giant planets

	Sun	Jupiter	Saturn	Uranus	Neptune
H_2	83.5%	86.4%	96.3%	85%	85%
He	19.5%	13.6%	3.2%	15%	15%
H_2O		600	?	?	?
CH_4		2000	4500	~2%	~3%
NH_3		~1000	500	<200	<200
H_2S		77	?	?	?

Other trace gases: PH_3, GeH_4, AsH_3, C_xH_y

Tenuous atmospheres (in cm^{-3})

	Mercury	Moon	Pluto	Io
O	$4\ 10^4$			+
Na	$3\ 10^4$	70		+
He	$6\ 10^3$	$\sim 10^4$		
N_2			+	
Ar		$\sim 10^4$		
SO_2				10^{11}-10^{12}

Physical processes

- **Condensational equilibrium**
  - *Atmospheric H_2O on Earth and Mars*
  - *CO_2 on Mars*
  - *N_2 on Pluto and Triton*
- **Physical buffering by surface**
  - *Mars: regolith-atmosphere H_2O exchange*
- **Volcanic/ geiser activity**
  - *Io: SO_2 atmophere*
  - *Enceladus: H_2O supply by geisers*
- **Sputtering**
  - *Mercury: Na*
- **Capture from solar wind**
  - *Moon and Mercury: H, He*

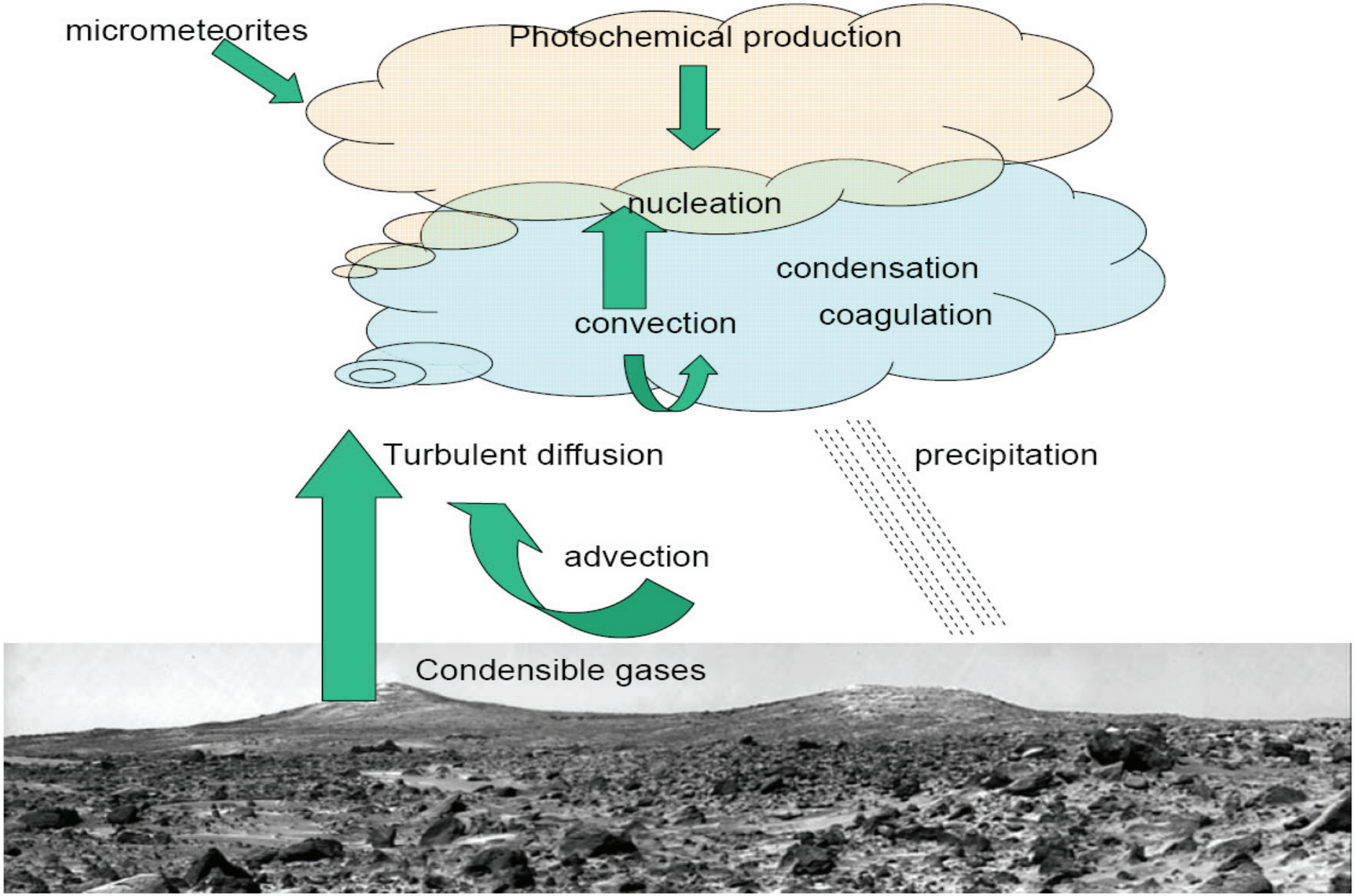
Chemical processes

- **Thermochemistry**
  - *Venus lower atmosphere*
- **Photochemistry**
  - *CO on Venus and Mars*
  - *Upper atmosphere of Titan*
- **Chemical buffering by surface minerals**
  - *Venus: atmospheric SO_2 and carbonates/ pyrites*
- **Heterogeneous chemistry on dust particles**
- **Biogenic / antropogenic influence**

Aerosols and clouds

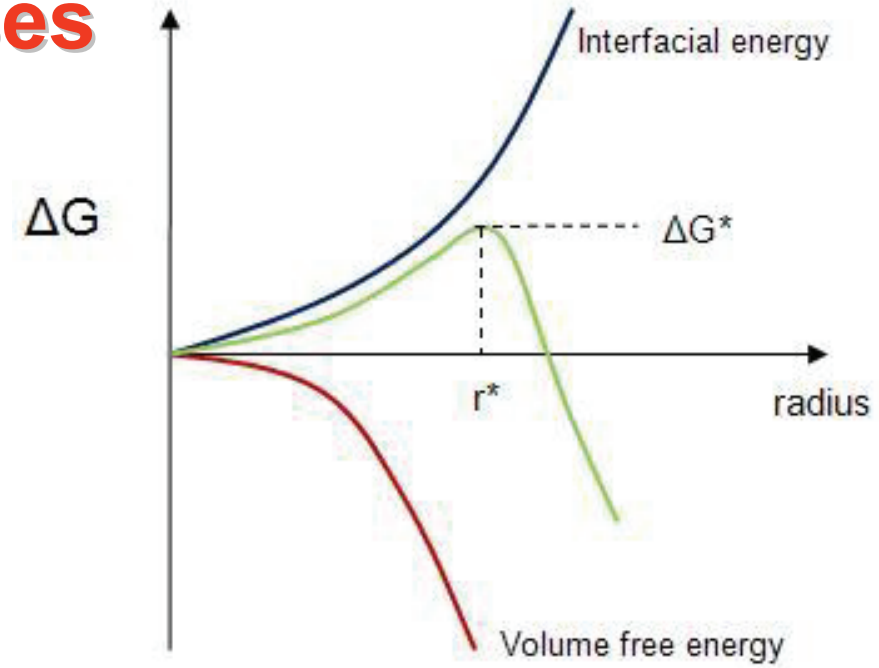
- **Condensational clouds**
  - *Earth: H_2O clouds*
  - *Mars: mesospheric CO_2 layers*
  - *Giants: NH_3 and H_2O ice clouds*
- **Chemical aerosols**
  - *Jupiter and Saturn: $NH_3 + H_2S \rightarrow NH_4SH$ (solid)*
- **Photo-chemical aerosols**
  - *Venus: $SO_2 + H_2O + h\nu \rightarrow H_2SO_4$ (liquid)*
  - *Titan: $CH_4 + h\nu \rightarrow C_xH_y$ (tholines)*
  - *Earth: photochemical smog*
- **Dust**
  - *Mars & Earth*

Microphysical processes



Microphysical processes

- **Homogeneous nucleation**



- **Heterogeneous nucleation**

- **Diffusional growth**

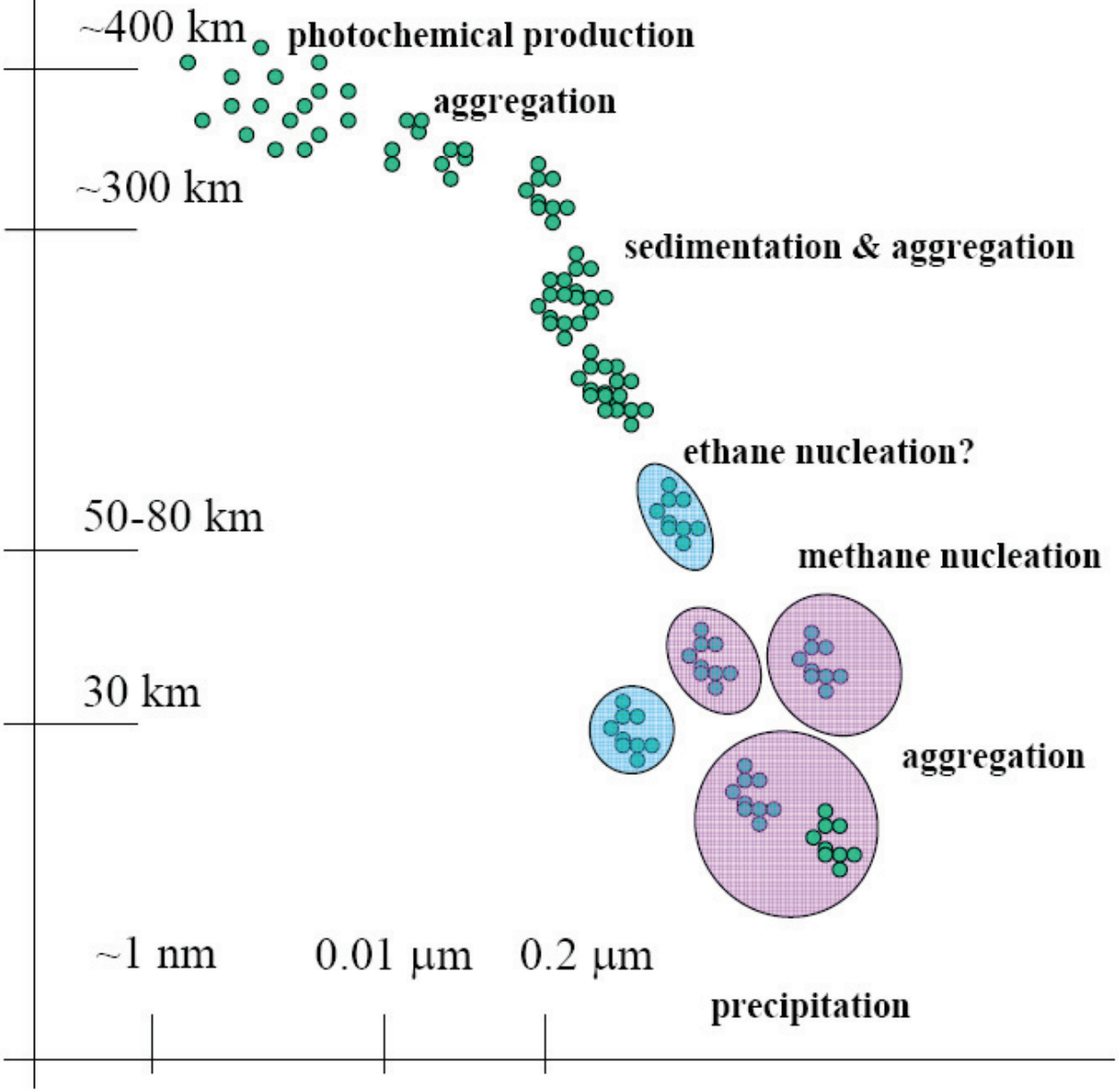
$$r\frac{dr}{dt} \sim S - 1$$

  - *small droplets grow faster*
  - $r \sim \sqrt{t}$

- **Coagulation** $\frac{dn}{dt} \sim Kn^2$

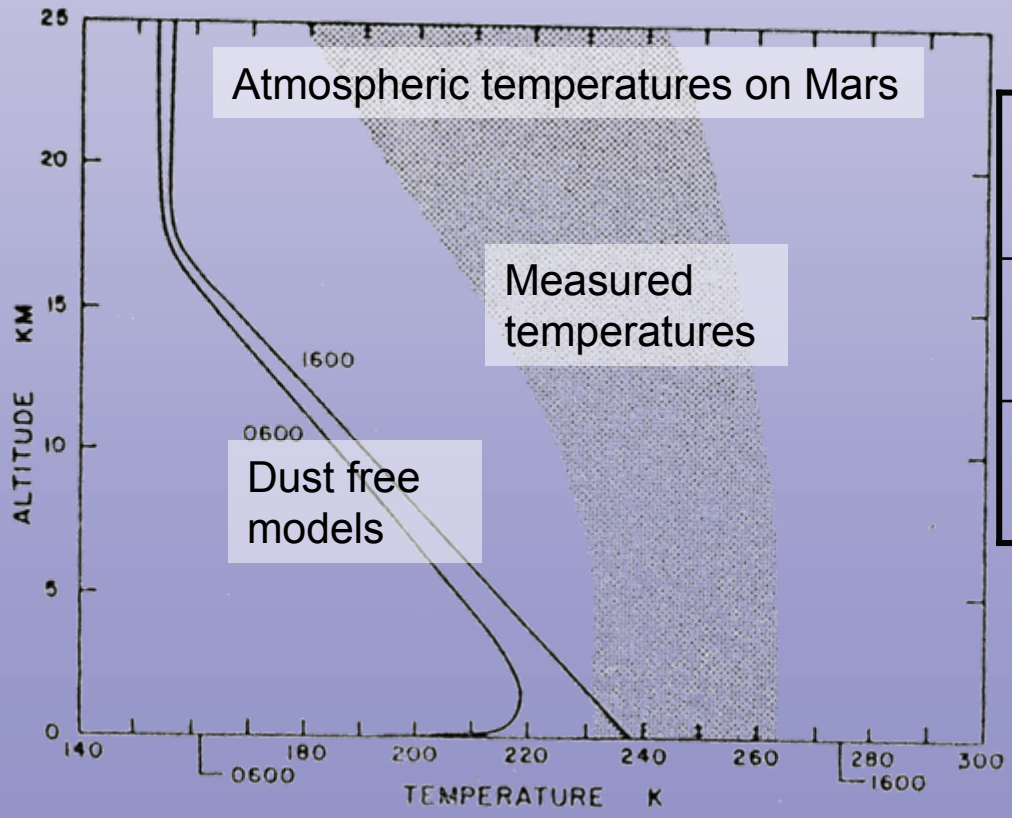
- **Sedimentation** $v \sim r^2$

Aerosols in Titan's atmosphere



Aerosol effects

- **Radiative effects**
  - *Deposited solar energy: Earth vs Venus*
  - *Greenhouse effect: Venus & Mars*



	Solar flux, W/m²	Albedo	Deposited Solar energy
Earth	**~1300**	**0.4**	**780**
Venus	**~2600**	**0.75**	**650**

- **Cleaning of the atmosphere**