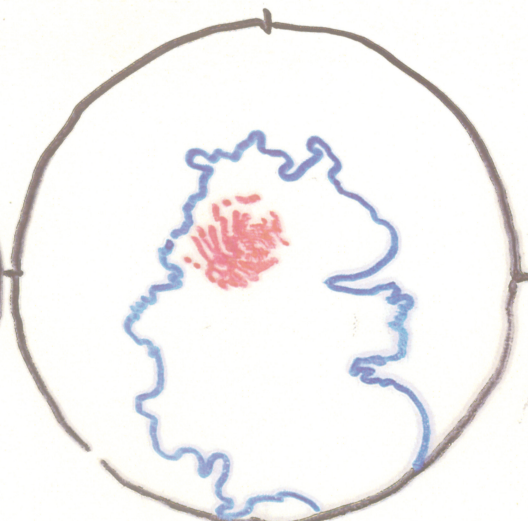
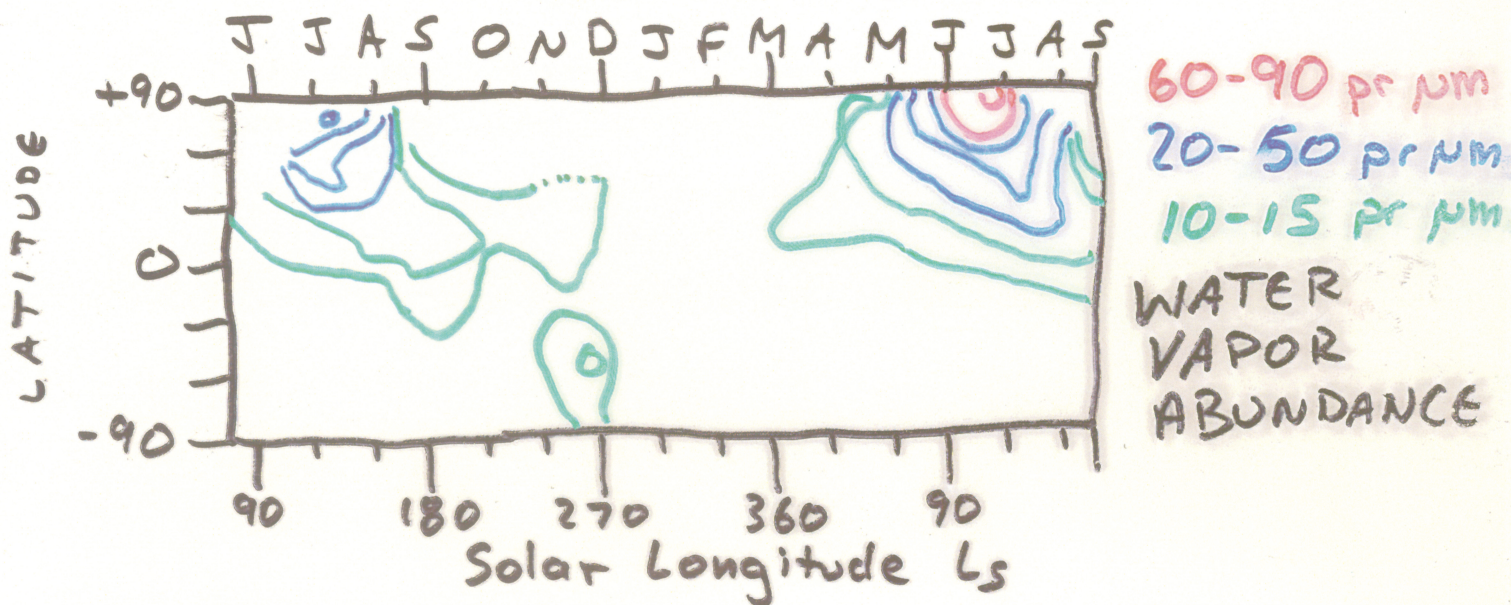
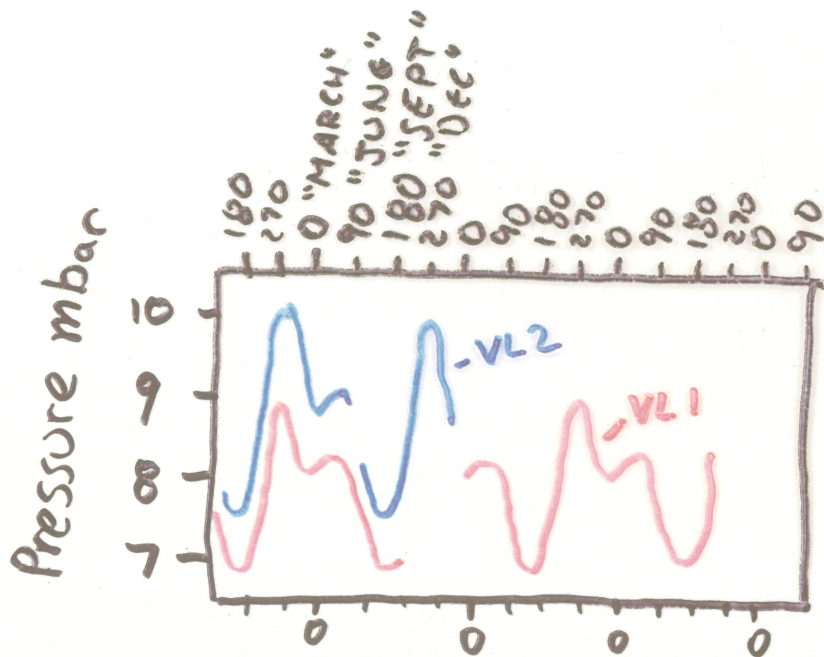




ELEVATED
POLAR
TERRAIN

RESIDUAL CAP

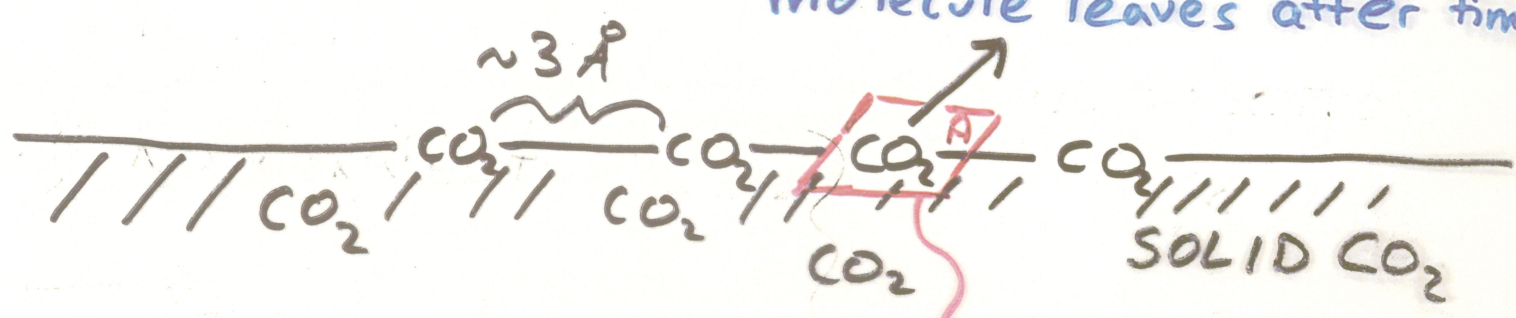
WATER VAPOR

binding energy

Q/RT — temperature
gas constant

residence time $t = t_0 e^{Q/RT}$

Maxwell dist. of velocity $\Rightarrow$ molecule leaves after time t



Area for 1 surface molecule $A \approx 10^{-15} \text{ cm}^2$

$$N_{\text{sub}} = \frac{1}{At} = \frac{1}{At_0 e^{Q/RT}}$$

BINDING ENERGY, Q/R (K)

CO_2	~ 3200	$\leftarrow \text{CO}_2$ less tightly bound.
H_2O	~ 6100	

$N_{\text{sub}} = \text{FLUX INTO VACUUM (molecule/cm}^2\text{/s)}$

$\text{CO}_2 @ 150\text{K}$	$\sim 3 \times 10^{21}$
$\text{H}_2\text{O} @ 200\text{K}$	$\sim 5 \times 10^{17}$

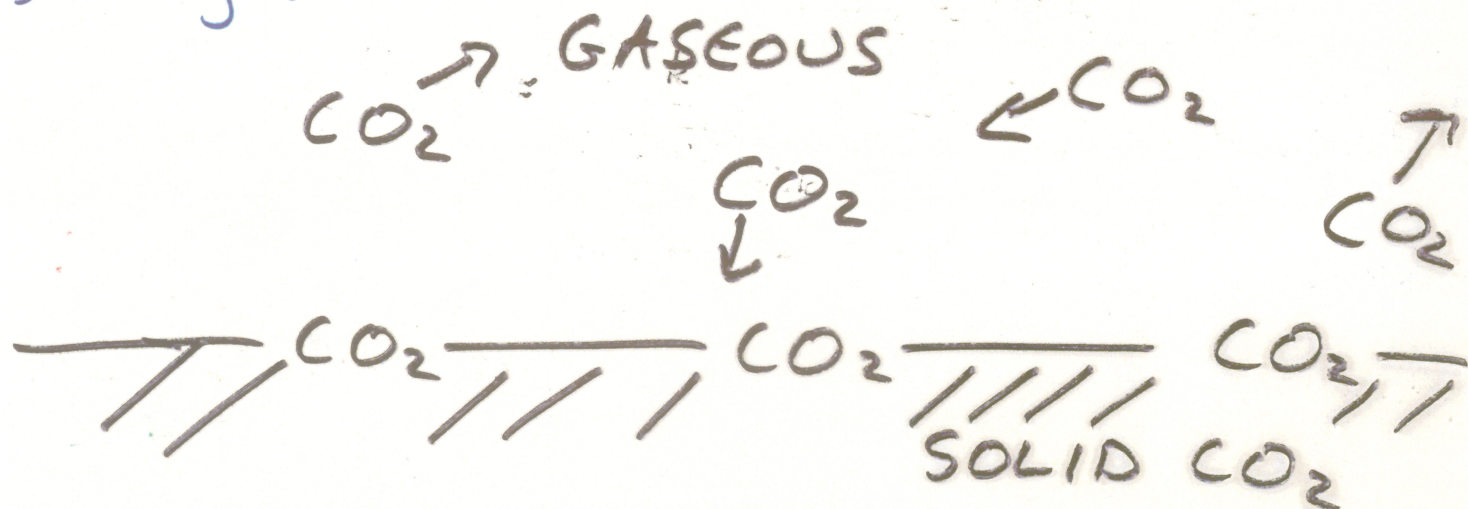
Flux of molecules striking surface

$$F \approx \frac{1}{4} \frac{P}{kT} \bar{u}$$

pressure

number density

average molecular velocity



$$\dot{N}_{\text{COND}} = - \frac{1}{4} \frac{P}{kT} \bar{u} C_{\text{STICK}}$$

sticking coef.

IN STEADY-STATE, $\dot{N}_{\text{SUB}} + \dot{N}_{\text{COND}} = 0$

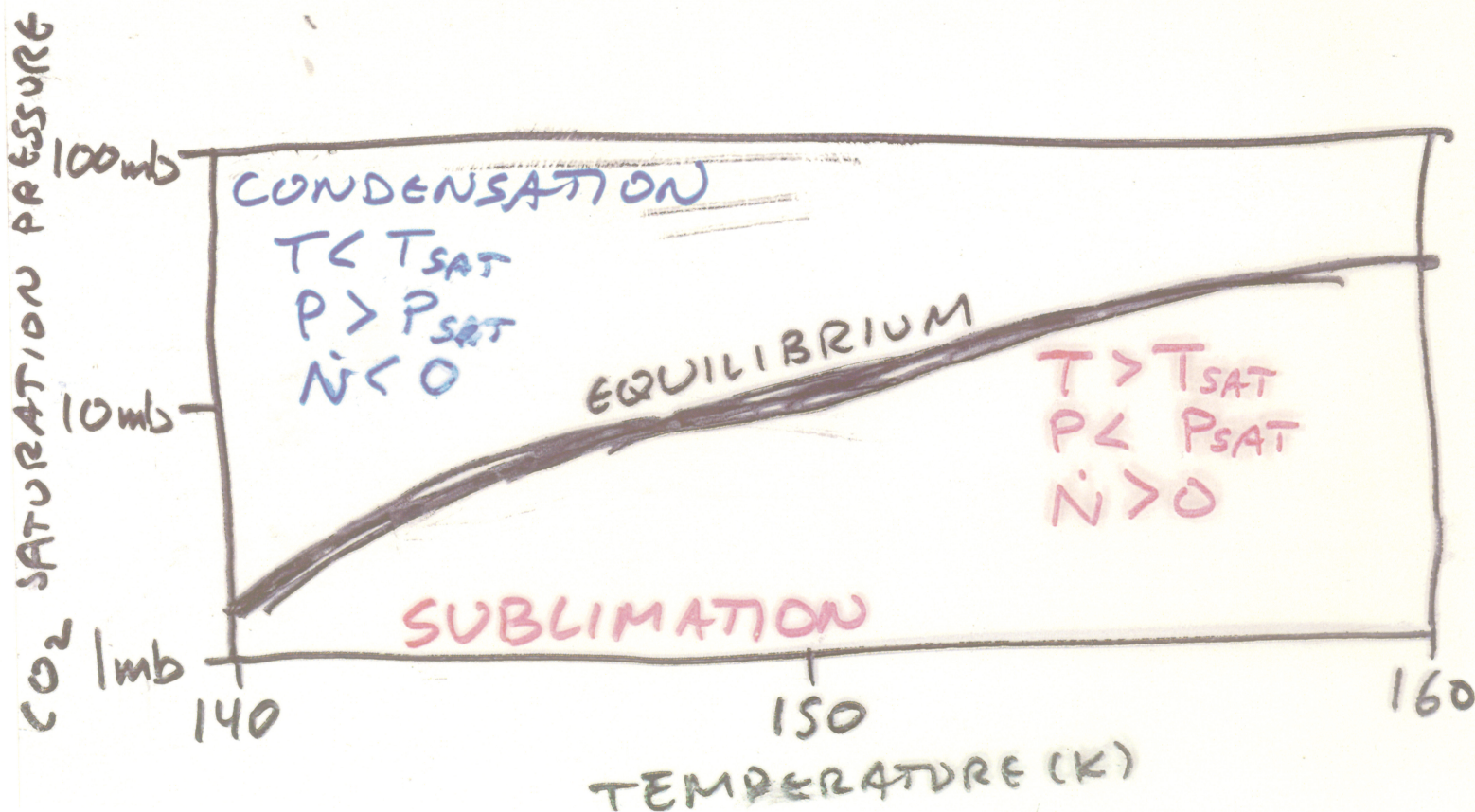
$$\frac{1}{A t_0 e^{Q/RT}} + \frac{1}{4} \frac{P_{\text{SAT}}}{kT} \bar{u} C_{\text{stick}} = 0$$

$$\rightarrow P_{\text{SAT}} \approx \frac{4 kT}{A t_0 \bar{u} C_{\text{stick}}} e^{-Q/RT}$$

AWAY FROM STEADY STATE SATURATION VAPOR PRESSURE

$$\dot{N} = \dot{N}_{\text{SUB}} + \dot{N}_{\text{COND}} \approx \frac{P_{\text{SAT}} - P}{\bar{u} m} \text{ mass of a molecule}$$

for CO_2 , $\dot{N} \approx \Delta P \times 5 \times 10^{20} \text{ molec./cm}^2/\text{s}$
P_{SAT} - P in mbar



BUFFERED "LEIGHTON-MURRAY" ATMOSPHERE — ENERGY BALANCE.

STEP 1 - GLOBAL ENERGY BALANCE.

ASSUME - DIFFUSION IS SMALL

- LOCAL FLUXES $\gg$ GLOBAL AVG
(MOSTLY MOVING CO₂ AROUND)

$$\int (1-A) F_{\odot} d\Omega = \int \sigma \epsilon T_{\text{sat}}^4 d\Omega$$

frost albedo solar insolation frost Stefan-Boltzman emissivity sat'n temperature

.... and solve for $T_{\text{sat}} \sim 145 \text{ K}$.

STEP 2 - LOCAL ENERGY BALANCE

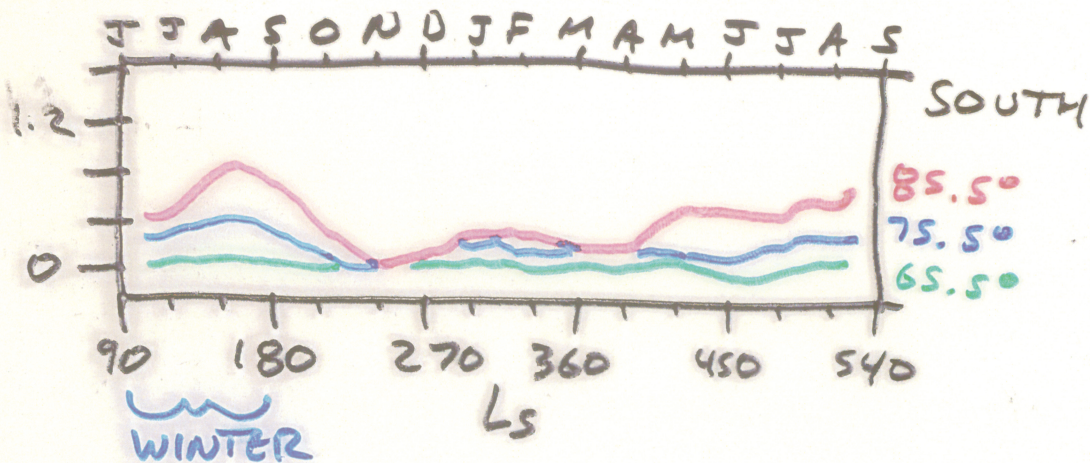
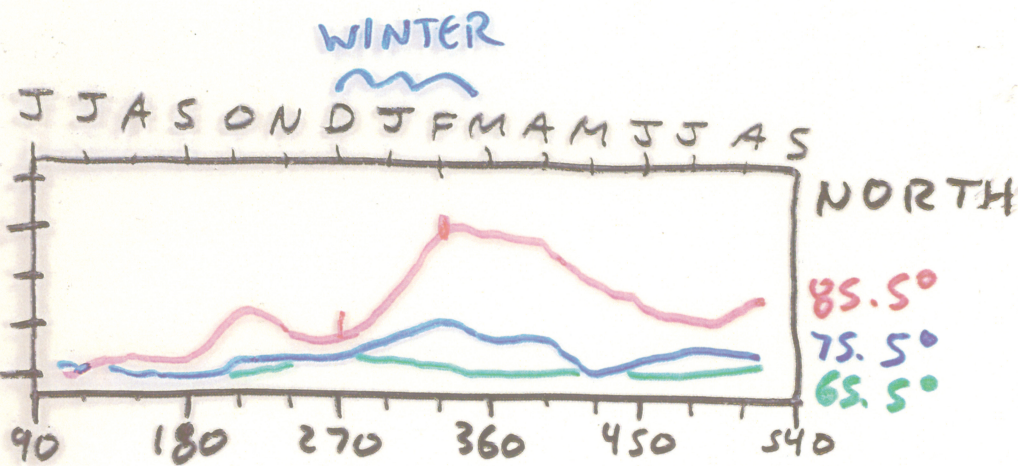
$$(1-A) F_{\odot} - \sigma \epsilon T_{\text{SAT}}^4 - \dot{N}/L + \text{diffusion} = 0$$

latent heat

$$\begin{aligned} \text{for CO}_2 \quad L &= 4.5 \times 10^8 \text{ erg/g} \\ &= 3.3 \times 10^{-14} \text{ erg/molec} \end{aligned}$$

THIS WORKS FOR CO₂
NOT FOR H₂O

ELEVATION CHANGE Δh (cm)



LOCAL FLUXES (NORTHERN WINTER) 85.5°, 270-330° Ls

$$\Delta t \sim 114 \text{ d} \sim 10^7 \text{ s}$$

$$\Delta h \sim 80 \text{ cm}$$

$$\Delta M = \rho \Delta h \sim 72 \text{ g/cm}^2$$

$$\Delta N_\lambda = \Delta M / m \sim 10^{24} \text{ molecules/cm}^2$$

$$\dot{N}_\lambda = \frac{\Delta N_\lambda}{\Delta t} \approx 10^{17} \text{ molecules/cm}^2/\text{s}$$

WATER VAPOR FLUXES (NEAR $L_S = 90$)

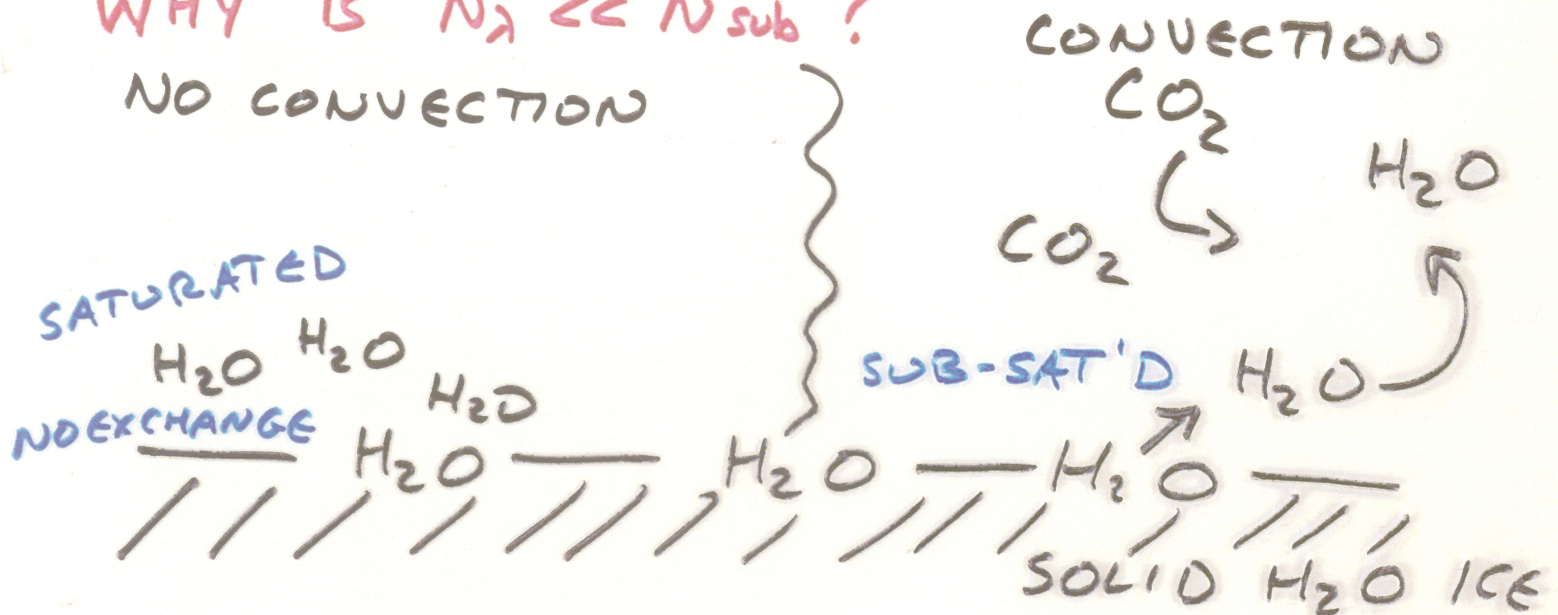
$$\Delta t = 50 \text{ d} = 4 \times 10^6 \text{ s}$$

$$\Delta M \approx 90 - 50 \text{ pr } \mu\text{m} \approx 0.004 \text{ g/cm}^2$$

$$\Delta N = \Delta M / m \sim 1.4 \times 10^{20} \text{ molecule/cm}^2$$

$$\dot{N}_\lambda = \Delta N / \Delta t \sim 3 \times 10^{13} \text{ molecule/cm}^2/\text{s}$$

WHY IS $\dot{N}_\lambda \ll \dot{N}_{\text{sub}}$?



THIS WORKS BECAUSE H₂O lighter than CO₂.

SOURCES OF H₂O

- NORTHERN RESIDUAL CAP
- (SOUTHERN CAP)
- REGOLITH