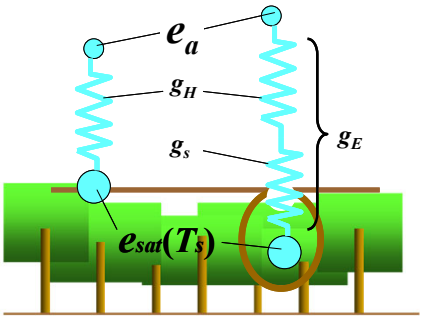
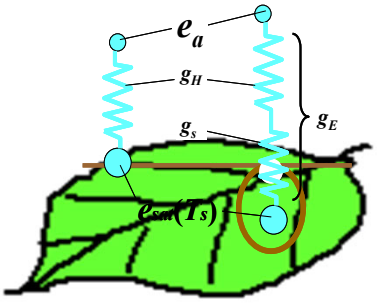
g_Hについて

群落: $$g_H = \frac{\kappa^2 u}{\left(\ln \frac{z-d}{z_0}\right)^2}$$



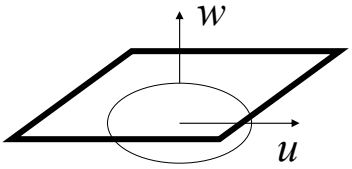
個葉: $$g_H = k\sqrt{\frac{u}{l}}$$



1

群落

まずは**運動量フラックス**



(kg m/s)/(m²s)

$$\frac{\rho l^2 w}{l^2} u = \rho u w$$

kg/(m²s)　m/s

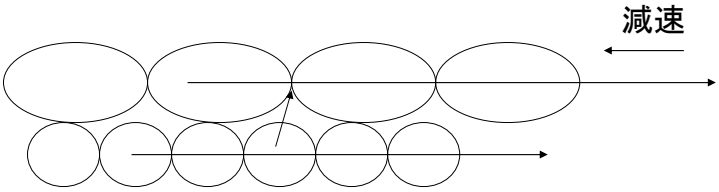
$$\overline{\rho u w} = \rho \overline{(\bar{u} + u')(\bar{w} + w')} = \rho \overline{u' w'}$$

(kg m/s)/(m²s) = Ns/ (m²s) = N/m²

運動量フラックスは**せん断応力**

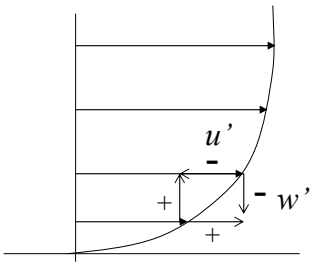
2

運動量フラックスはせん断応力



$$\tau = -\rho\overline{u'w'} \quad \text{(kg m/s)/(m}^2\text{s) = N/m}^2$$

$\underline{u'w' < 0}$



3

フラックスは拡散係数で表現できる

$$F = -K\frac{dC}{dz}$$

$$\text{m}^2/\text{s}\ \frac{\text{kg/m}^3}{\text{m}} = \text{kg/(m}^2\text{s)}$$

$$\text{m}^2/\text{s}\ \frac{\text{mol/m}^3}{\text{m}} = \text{mol/(m}^2\text{s)}$$

$$\text{m}^2/\text{s}\ \frac{\text{(kg m/s)/m}^3}{\text{m}} = \text{(kg m/s) / (m}^2\text{s)}$$

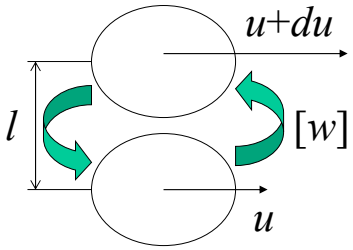
運動量濃度

$$\tau = -\rho\overline{u'w'} = K_M\frac{d(\rho u)}{dz}$$

$$= \rho K_M\frac{du}{dz}$$

4

運動量フラックスで考える



Prandtlの混合距離理論

$$[w] = l\left|\frac{du}{dz}\right| \qquad \frac{[w]}{l} = \left|\frac{du}{dz}\right| \ (/\mathrm{s})$$

単位時間当たり交換運動量

$$\rho l^3 du\left|\frac{du}{dz}\right| = \rho l^4 \frac{du}{dz}\left|\frac{du}{dz}\right|$$

$$-\rho\overline{u'w'} = \frac{1}{l^2}\rho l^4 \frac{du}{dz}\left|\frac{du}{dz}\right| = \rho l^2\left|\frac{du}{dz}\right|\frac{du}{dz} = \tau$$

K_M

5

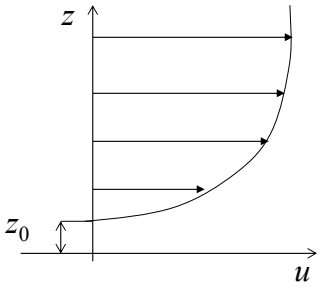
- $l = \kappa z$　κ：カルマン定数
- $\tau, -\rho\overline{u'w'}$ は高さ方向で一定：コンスタントフラックス層
- $-\overline{u'w'} = u_*^{\,2}$ を導入

$$\rho u_*^{\,2} = \rho l^2\left(\frac{du}{dz}\right)^2$$

$$u_* = \kappa z\frac{du}{dz}$$

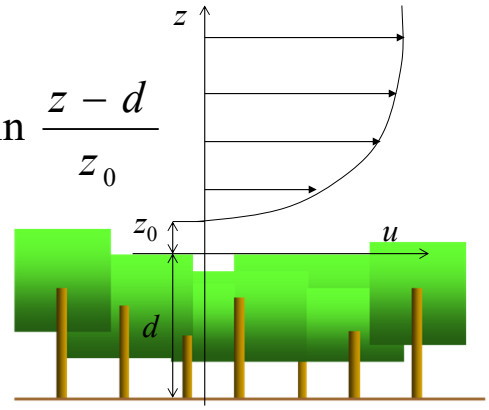
風速対数則

$$u = \frac{u_*}{\kappa}\ln\frac{z}{z_0}$$



6

$$u = \frac{u_*}{\kappa} \ln \frac{z-d}{z_0}$$



さて、ある条件で

$$K_M = K_H = K_E = \kappa u_* (z-d)$$

$$H = -K_H \frac{d(\rho c_p T)}{dz}$$ を考えてみよう。

7

$$\frac{H}{\rho c_p} = -K_H \frac{dT}{dz} = -\kappa^2 (z-d)^2 \frac{du}{dz}\frac{dT}{dz}$$

$$= -\kappa^2 \frac{du}{d\ln z}\frac{dT}{d\ln z}$$

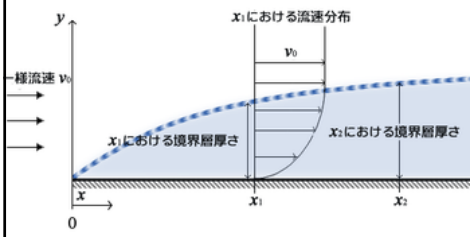
$$H = \rho c_p g_H (T_s - T_a)$$ より（$T_s - T_a = -dT$）

$$g_H = \frac{\kappa^2 u}{\left(\ln \frac{z-d}{z_0}\right)^2}$$

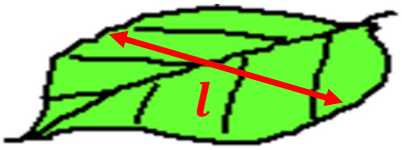
8

個葉

$$g_H = k\sqrt{\frac{u}{l}}$$



$$g_H = 1.4 \times \frac{0.664\rho_a D_h R_e^{\frac{1}{2}} P_r^{\frac{1}{3}}}{l}$$



$$g_H = 0.93\rho_a D_h^{\frac{2}{3}} \nu^{\frac{1}{6}} \sqrt{\frac{u}{l}}$$

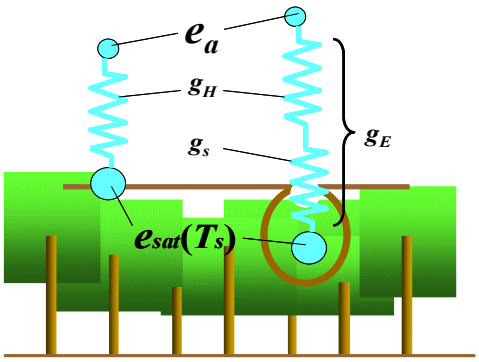
$$S = l^2$$

9

遮断蒸発

$$\lambda E = \frac{\Delta(R_n - G) + \rho c_p g_H (e_{sat}(T_a) - e_a)}{\Delta + (1 + g_H/g_s)\gamma}$$

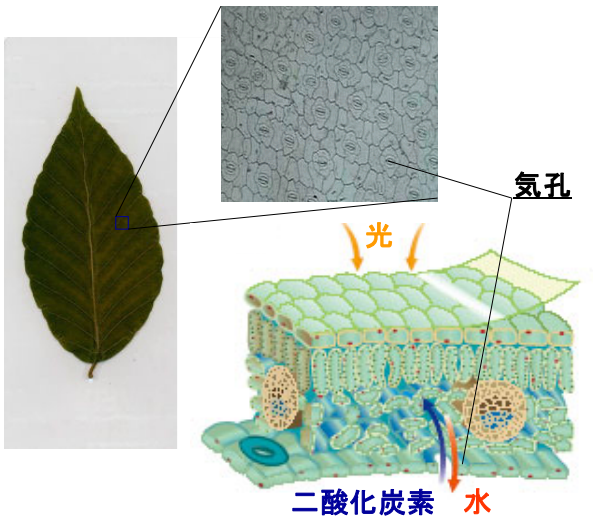
$g_s \to \infty$ ： 完全湿面



10

g_sについて

群落も個葉も基本は“気孔”



11

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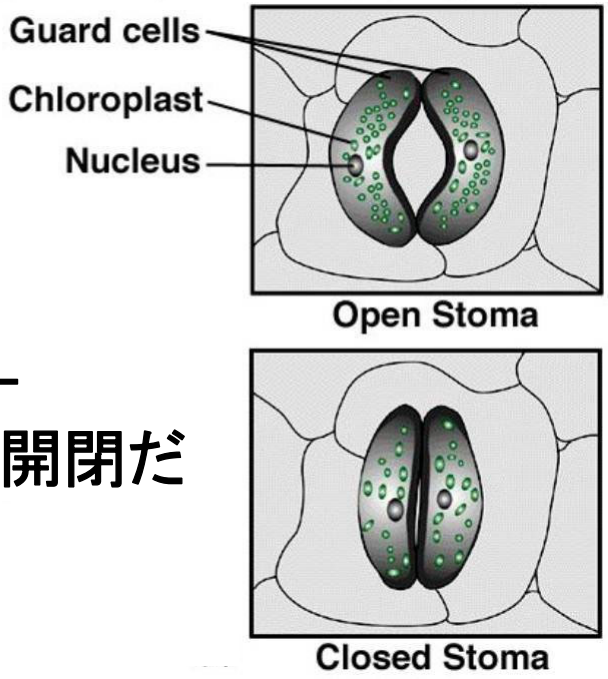
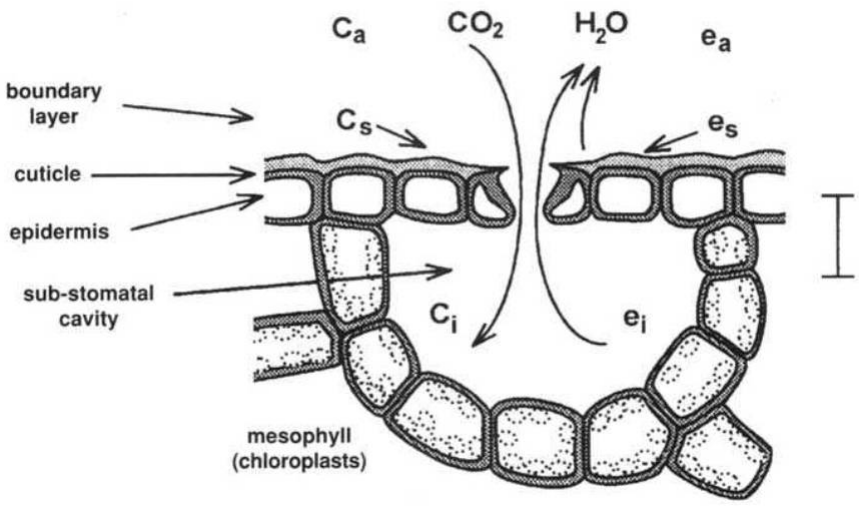


蒸散とは－
気孔の開閉だ

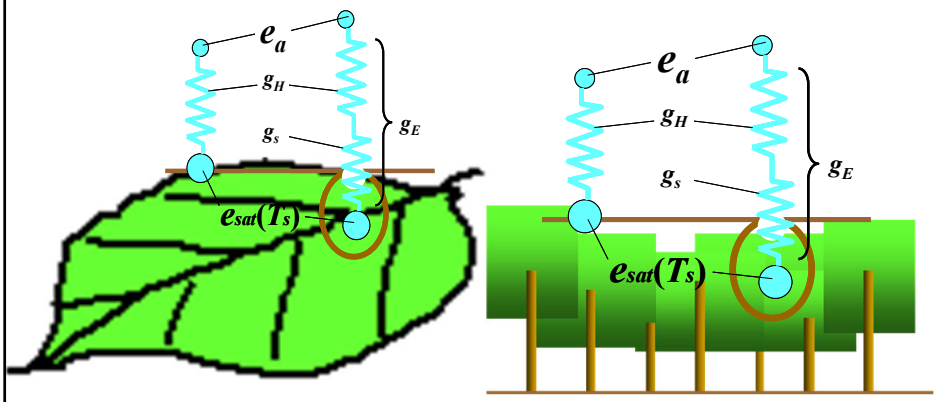
12



これを群落に適用することもある。

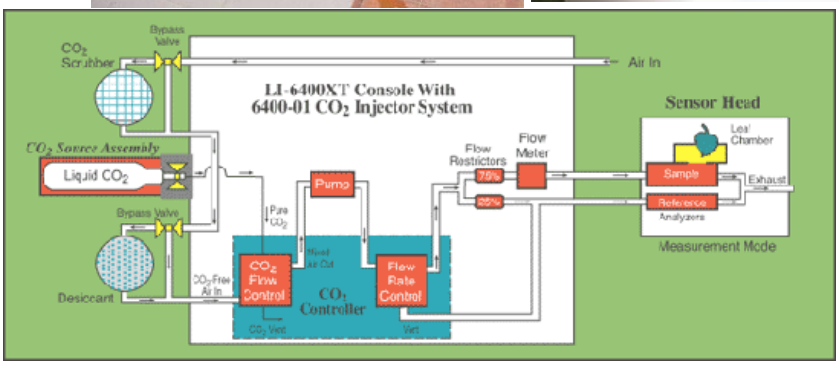
13

群落も個葉も基本は“気孔”



14

個葉



15

個葉

$$\frac{g_{sw}g_{aw}}{g_{sw}+g_{aw}} \approx g_{sw} \leftarrow g_{aw} = m\sqrt{\frac{u}{d}}$$

$$E = g_{sw}(C_{ws} - C_{wa})$$

既知

16

群落

$$\lambda E = \frac{\Delta\left(R_n - G\right) + \rho c_p g_H \left(e_{sat}(T_a) - e_a\right)}{\Delta + \left(1 + g_H / g_s\right)\gamma}$$

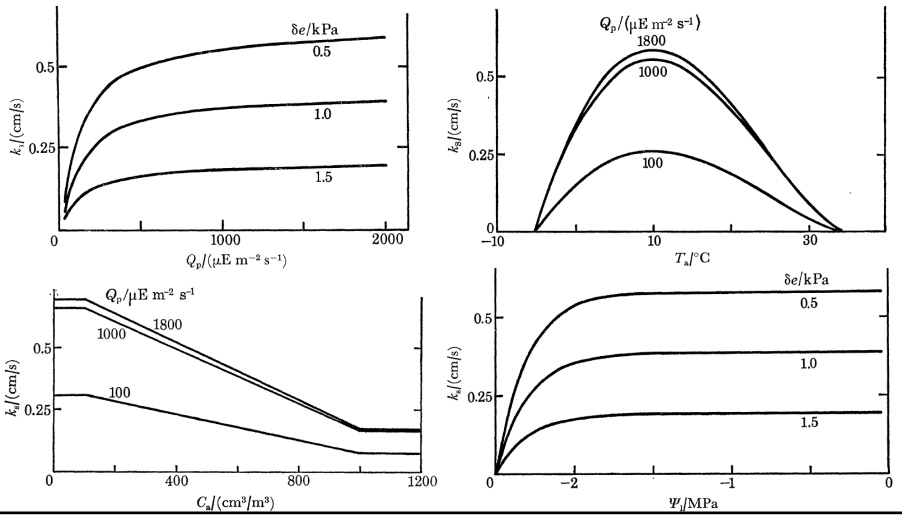
g_s以外、気象観測により全て既知

17

色々な g_s (個葉でも群落でも)の表現

1．Jarvis モデル

$$g_S = g_{Smax} f_1(Q_0) f_2(D_s) f_3(T_a) \ldots$$



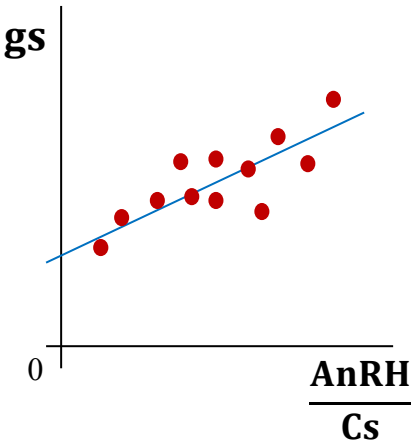
18

2．Ball-Berry モデル

$$\frac{Ci}{Cs} = \text{const.} \quad \text{からの修正}$$

$$\frac{Ci}{Cs} = 1 - \frac{e_{sat}(T)}{me_a} = 1 - \frac{An}{gsCs}$$

$$gs = m\frac{AnRH}{Cs} + g0$$



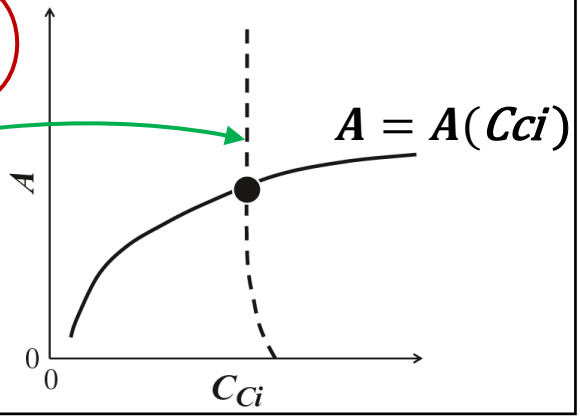
19

3．Leuning モデル

※Ball-Berryモデルの改造

$$g_{sC} = a_{sC}\frac{Af(D_s)}{C_{Cs} - \Gamma} + g_{sC0}, \quad f(D_s) = \left(1 + \frac{D_s}{D_0}\right)^{-1}$$

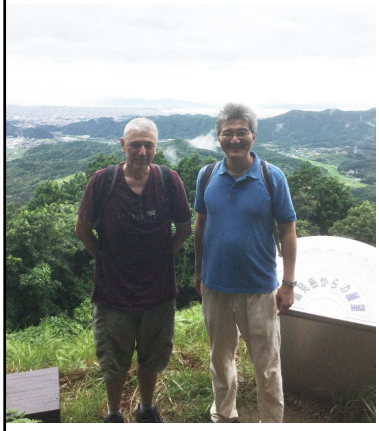
$$C_{Ci} = C_{Cs} - \frac{A}{g_{sC}}$$

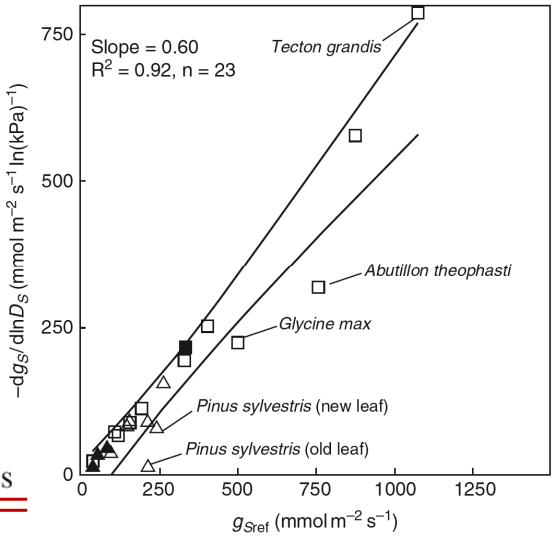


20

4．Oren モデル

$g_S = K_S \frac{A_S}{A_L} \frac{1}{D} \frac{1}{h} [\psi_s - (\psi_L + h\rho_w g)]$ からの変形





$$g_S = g_{Sref} - \delta \ln D_s$$

21

5．Medlyn モデル

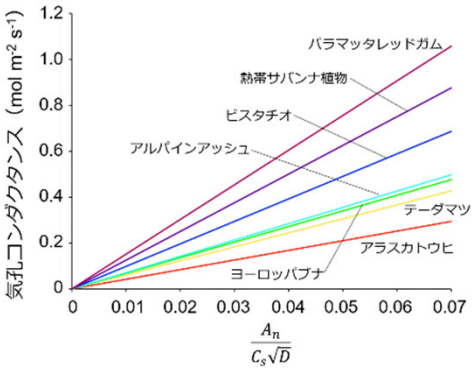
$TR - \lambda A_n$ の時間積分が最小となる問題 $\frac{\partial TR}{\partial A_n} - \lambda = 0$

$\frac{An}{TR} = \frac{Cs - Ci}{1.6D}$ $\mathbf{Aj = J\frac{C - \Gamma *}{4C + 8\Gamma *}}$ の３式から、Ciの２次方程式を導く。

$$g_{sh}^{*} \approx g_0 + 1.6\left(1 + \frac{g_l}{\sqrt{D}}\right)\frac{A_n}{C_s}$$

光合成生産に対する最適水利用

※ $g_l \propto \sqrt{\Gamma^* \lambda}$



22