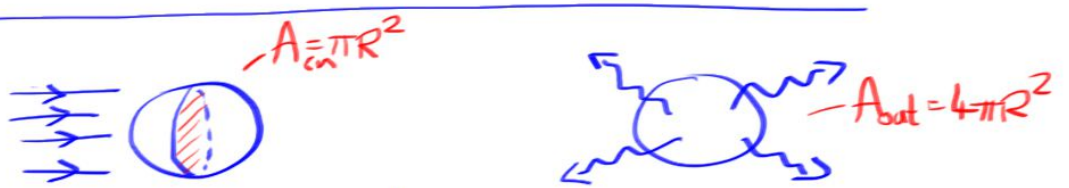
Model for atmospheric T and $[H_2O]$, $[CO_2]$.



$$C\left(\frac{dT}{dt}\right) = \underbrace{(1-\alpha(T))\frac{S_0}{4}}_{\dot{Q}_{in}} - \underbrace{\left(1-\frac{1}{2}\varepsilon(T,[H_2O],[CO_2])\right)\sigma T^4}_{\dot{Q}_{out}} \quad \left[\frac{W}{m^2}\right]$$

- C: effective heat capacity, $2.08 \cdot 10^{-8} \frac{J}{K m^2}$
- $\alpha(T)$: albedo, 0.3
- S_0: solar irradiance, 1370 W/m^2
- ε: emissivity, 0.78
- σ: black-body radiation law, $567 \cdot 10^{-8}$
- $[\cdot]$ ppm

Empirical models:

- $\alpha(T) = 0.7 - 0.4 \dfrac{e^{(T-265)/5}}{1+e^{(T-265)/5}}$ — 0.7 ice ($T<250$); 0.3 land ($T>280$)

(Fluth et al 2012)

- $\varepsilon(T, [H_2O], [CO_2]) = 1.24 \left[\dfrac{[H_2O]\, P_{atm}\, 10^{-6}}{T}\right]^{1/7} + \dfrac{0.019}{3.71} \log \dfrac{[CO_2]}{280}$

(Brutsaert 1975) (Myhre et al 1998)

Simplification: oceans neglected ...

Concentrations:

$$\frac{d[H_2O]^{(t)}}{dt} = \frac{1}{\tau_{H_2O}}\left([H_2O]_0 - [H_2O]^{(t)}\right) + P_{H_2O} \qquad \left[\frac{ppm}{yr}\right]$$

τ_{H_2O}: 2.5e-2 yrs (10 days)

$[H_2O]_0$: 1e4 ppm

$$\frac{d[CO_2]^{(t)}}{dt} = \frac{1}{\tau_{CO_2}}\left([CO_2]_0 - [CO_2]^{(t)}\right) + P_{CO_2} \qquad \left[\frac{ppm}{yr}\right]$$

τ_{CO_2}: 40 yrs

$[CO_2]_0$: 280 ppm

P_{CO_2}: 5 ppm/yr

$$\frac{du}{dt}^{(t)} = \frac{1}{\tau}\left[U - u(t)\right]$$

$$u(t) = U + Ce^{-t/\tau}$$