For Long timescales we have considered:

C flux in → [ocean + atmosphere] → C flux out

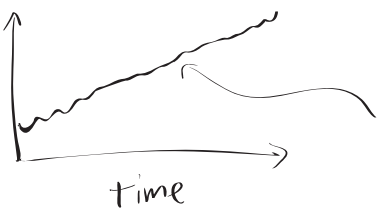
Now, we will consider:

[atmosphere (Carbon)] 2% of C

↓↑ in equilibrium

[ocean (carbon)] 98% of C

Motivating Q's: Look at Mauna Loa pCO_2 record >



How much added C for a given rise in pCO_2?

Will that rate change in the future? (Yes)

Atmosphere

$CO_2(g)$

Ocean $CO_2(a) + H_2O \longleftrightarrow HCO_3^- + H^+ \longleftrightarrow CO_3^{2-} + 2H^+$

Solubility coefficient → K_0

$CO_2(g) \longleftrightarrow CO_2(a)$

reminder Henry's Law: dissolved gas in liquid is proportional to partial pressure above liquid

$$K_0 = \frac{CO_2(a)}{CO_2(g)}$$

equilibrium constant → K_1

① $CO_2 + H_2O \longleftrightarrow HCO_3^- + H^+$

$$K_1 = \frac{[HCO_3^-][H^+]}{[CO_2]}$$

* Where did $[H_2O]$ go?
- at equilibrium the activity of H_2O is constant at 1
- similar to the assumption we made for major elements in trace element partitioning

$$\leftarrow \frac{[H^+]^2}{[H^+]} = \frac{[H^+]}{1}$$

② $HCO_3^- + H^+ \longleftrightarrow CO_3^{2-} + 2H^+$

$$K_2 = \frac{[CO_3^{2-}][H^+]}{[HCO_3^-]}$$

$K_1, K_2 = f(\text{salinity, temp, pressure})$

③ $DIC \equiv \sum CO_2 = [CO_2] + [HCO_3^-] + [CO_3^{2-}]$

"Dissolved inorganic carbon"

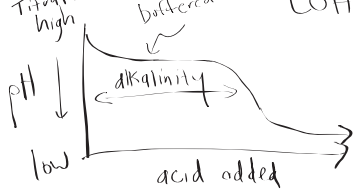
$$pH = -\log C[H^+]$$

Alkalinity is a quantity that represents a solutions capacity to resist change towards lower pH (more acidic)

④ Carbonate Alkalinity, $CA = [HCO_3^-] + 2[CO_3^{2-}]$

Total Alkalinity, TA

$TA = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-] + [OH^-] + \text{minor components} - [H^+]$



Four equations, six unknowns

$[H^+], [CO_2], [HCO_3^-], [CO_3^{2-}]$, DIC, CA

$[CO_2], [H^+]$, DIC, or TA can be measured

measure 2, system is determined