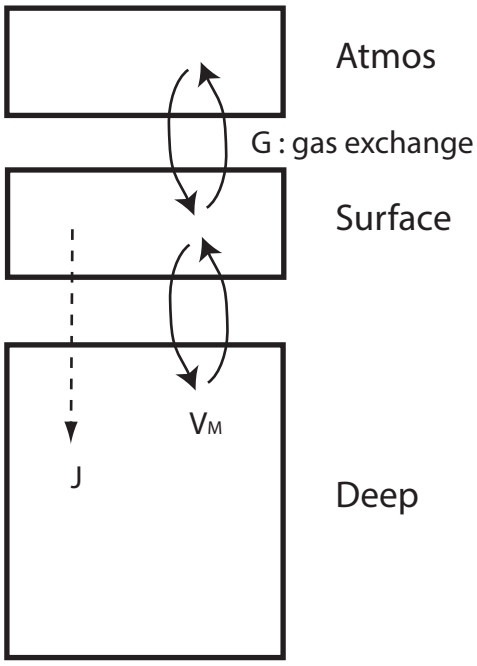
**EAS 4305/6305 Physics and Chemistry of the Oceans**
Homework #9: Due before class, November 29th

## Transient Ocean Carbon Uptake

### Numerical 1-box atmosphere 2-box ocean model

Consider the 1-box atmosphere 2-box ocean model of the global carbon cycle from HW #8 and week12 exercise. We will use this model as a tool to investigate the controls on the uptake of anthropogenic carbon dioxide. All the parameters are the same as HW #8. The gas transfer coefficient, **G**, is set to **2000 m/yr**.




### The 1% per year simulation

Initializing from the steady-state solution for the preindustrial carbon cycle, we will perform a 100-year simulation increasing atmospheric $pCO_2$ by 1% each year.

a. What will be the atmospheric $pCO_2$ level at year 100?

b. Assuming that the concentration of surface ocean DIC is very close to the equilibrium with the overlying atmosphere, calculate the analytic solution for the, **Cs**, at year 100.

c. Perform the 100-year simulation increasing atmospheric $pCO_2$ by 1% each year. Plot $\mathbf{pCO_2^{atm}}$ and $\mathbf{pCO_2^{ocn}}$ together as a function of time. Plot **Cs** and **Cd** together as a function of time. Compare **Cs** at year 100 with your answer to (b).

d. Calculate the surface **pH**, **Buffer factor**, and **yearly carbon uptake** as a function of time. Briefly comment on how they relate to each other.

**G** can control the rate of air-sea gas transfer, and $\mathbf{V_M}$ can control the ventilation of deep water. Their magnitudes are uncertain but are potentially important for ocean carbon uptake.

e. Perform several simulations with different values of **G** and $\mathbf{V_M}$, recording the cumulative carbon uptake for each case. Then, plot the cumulative carbon uptake as a function of **G** and $\mathbf{V_M}$, and briefly comment on relative importance of these parameters.

**GHG scenarios (optional extra credit)**

We will perform 300-year simulations (year 1800 to 2100) increasing atmospheric $pCO_2$ according to different emission scenarios.

Download the atmospheric $pCO_2$ data (rcp_scenarios.mat) based on the Representative Concentration Pathway (RCP). From 1800 to 2005, it is based on the historic $CO_2$ data. From 2006 to 2100, it is based on different socio-economic models that results in equivalent radiative forcing of 2.6, 4.5, 6.0 and 8.5W/$m^2$ in year 2100.

f. Plot the **$pCO_2^{atm}$** from each RCP scenario.

g. Perform four 300-year simulations using the RCP scenarios. Plot **Cs**, **Cd**, **Buffer factor**, and **yearly carbon uptake**, as a function of time.

h. Plot **surface pH** as a function of time. Briefly comment on the severity of ocean acidification in different scenario.