THE EFFECT OF CARBON DIOXIDE EMISSION ON GLOBAL WARMING

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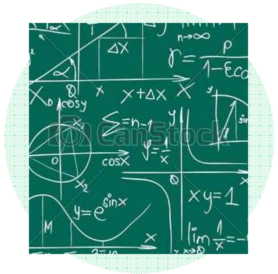


Background Theorem

- The First law of thermodynamics
- Dalton's law
- Henry's law

Some of Assumption

- Some Assumption for Application

Application to the Earth System

- Part 1
- Part 2
- Result : Part1 + Part2

Background Theorem

Background Theorem

The First Law of Thermodynamics

The sum of heat and work in a system is constant

1. Heat is a form of energy(Joules law)
2. Energy is conserved, $Q = \Delta U + \Delta W$

where Q = heat

ΔU = change of internal energy of the system

ΔW = work done by the system

In general, for a unit mass we write

$$dq = du + dw$$

Background Theorem

Dalton's law

Note that each individual gas obeys the ideal gas law.

Following this law, we can derive the specific gas constant for the mixture of air gases

$$P=\sum_i P_i\ ,PV=\sum_i n_i RT=RT\sum_i n_i$$

Background Theorem

Henry's law

formulated by William Henry in 1803

At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

$$C = H \times P_{gas}$$

C : solubility of a gas at fixed temperature in a particular solvent

H : Henry's law constant

P_{gas} : the partial pressure of the gas

Background Theorem

Henry's law

Henry's law Constant is Temperature dependence

Find Henry's law by the Experiment(Plummer and Busenberg)

$$\log H_{CO_2,w} = 108.3865 + 0.01985076 \cdot T - \frac{6919.53}{T} - 40.45154 \cdot \log T + \frac{669365}{T^2}$$

*Unit

H : mol/(kg atm)

T : K

Background Theorem

Heat of Solution

The Enthalpy change associated with the dissolution of a substance in a solvent at constant pressure, resulting in infinite dilution.

expressed in kJ/mol, and it is the amount of heat energy that is released or absorbed when a solution is formed

Some of Assumptions for Application

Some of Assumptions

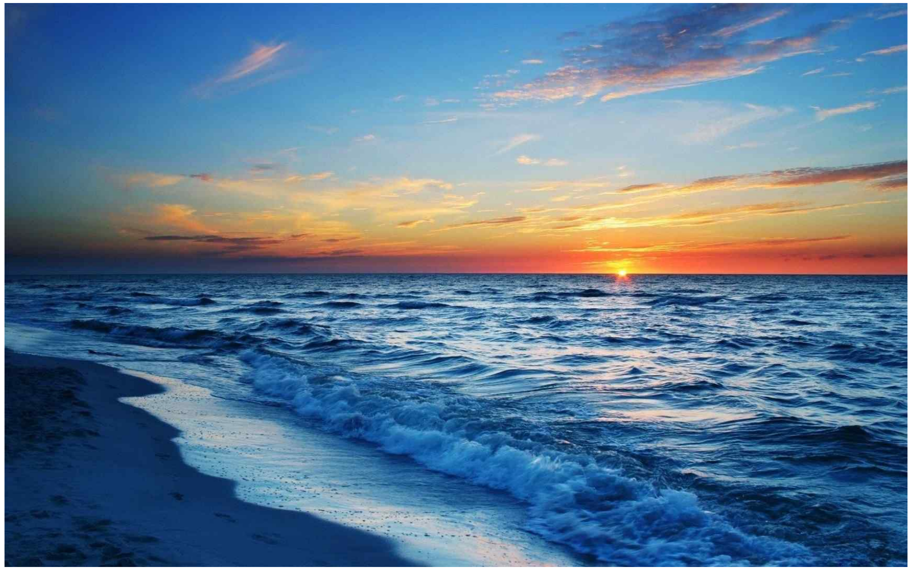
The ratio of land and Ocean

land : Ocean = 0.29 : 0.71

Some of Assumptions

The material of Ocean

Assume the Ocean is made up of pure water only



Problem : It's hard to see the effects of salinity

Some of Assumptions

The Radiation Effect between Ocean and Atmosphere

Assume the Ocean's Radiation(infrared) absorb into the atmosphere and space by 20:1

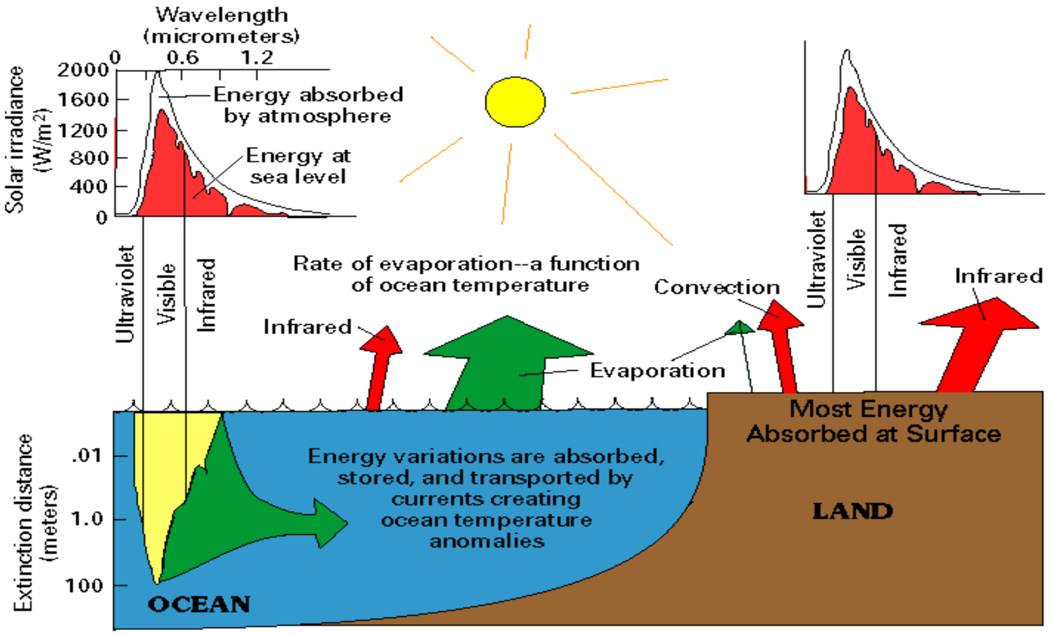
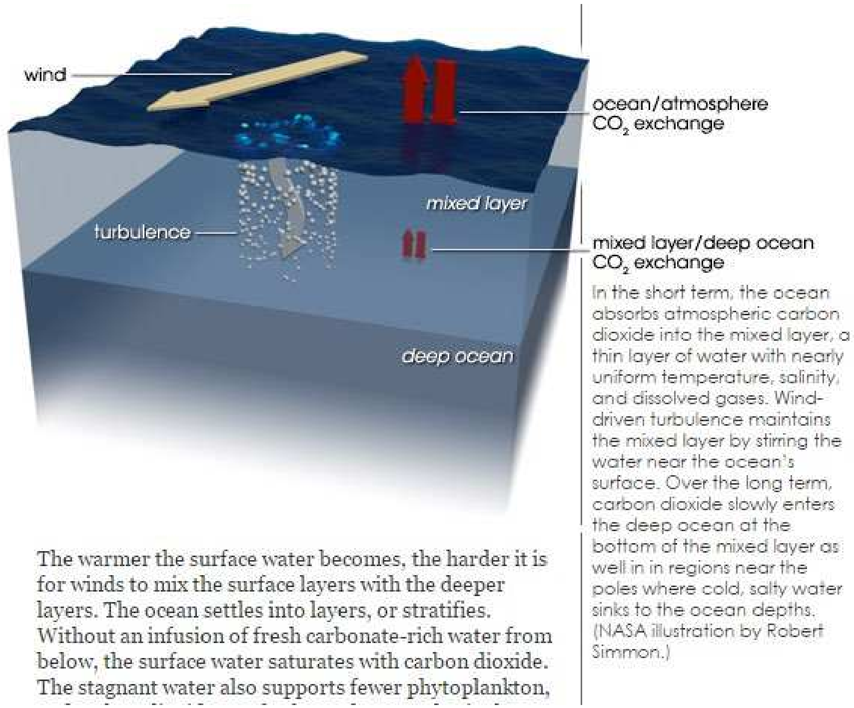


Figure 1. Depth of extinction of the solar radiation spectrum in water

Some of Assumptions

The matter exchange between Ocean and Atmosphere

Assume the matter exchange occur at mixed layer.

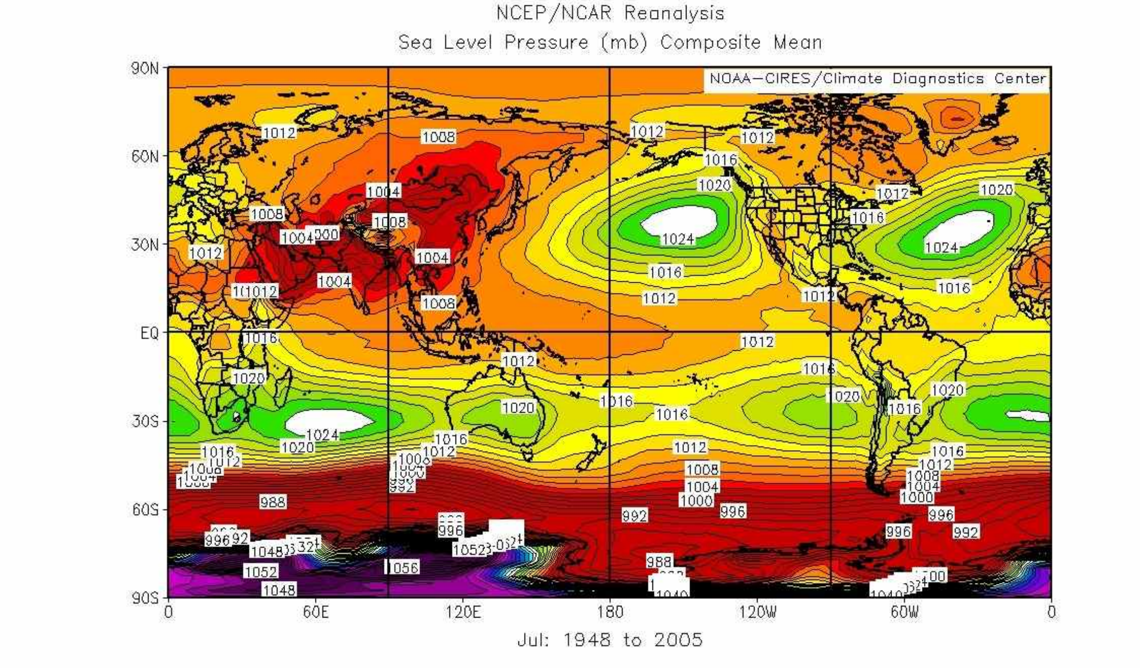


depth of mixed layer: 200m

Some of Assumptions

The air pressure

Assume the surface pressure is 1000hPa.

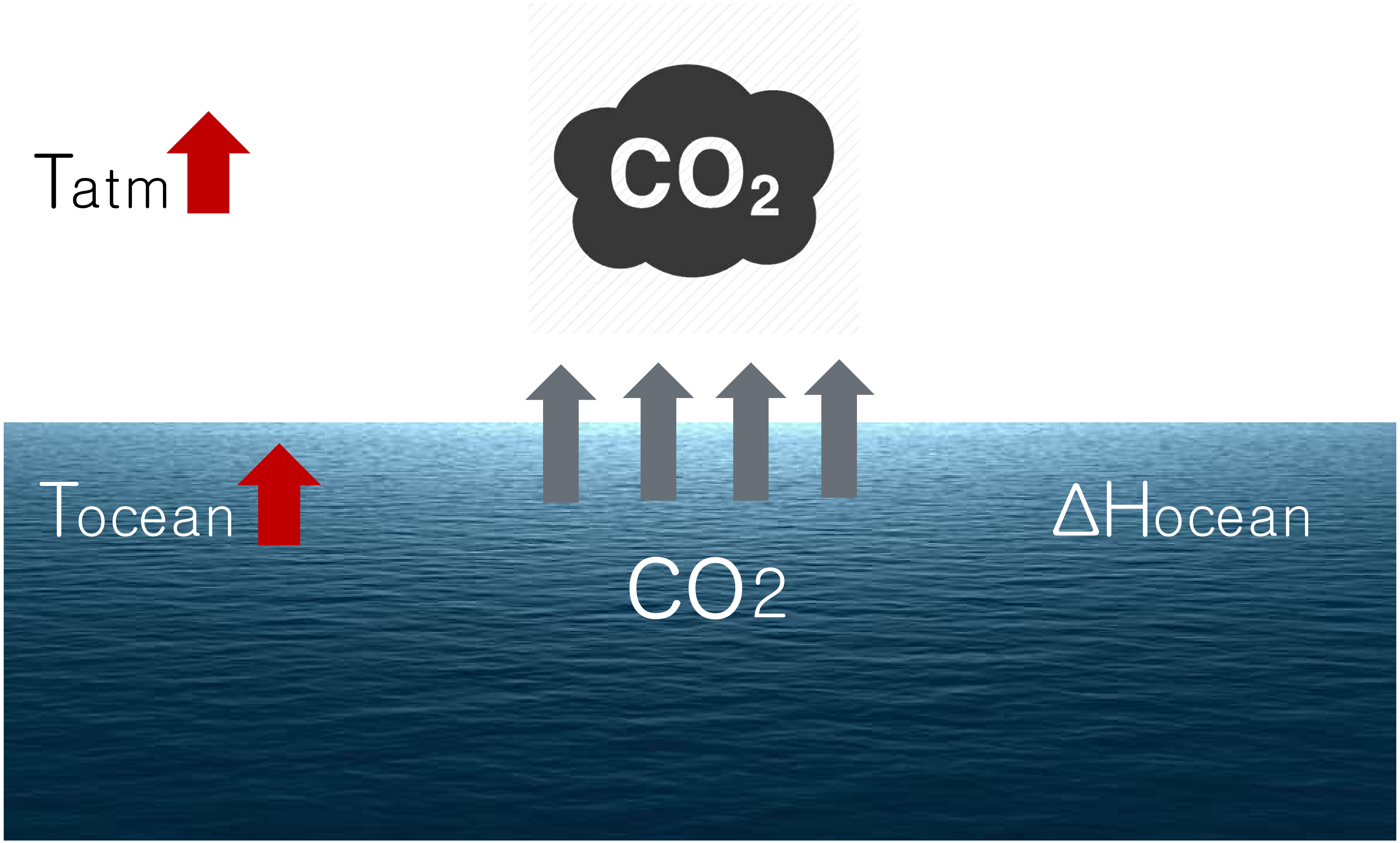


1bar = 1 atm

Application to the Earth System

Application to the Earth System

Part 1



Application to the Earth System –Part 1

The Volume and area of Ocean

$$V_{total} = 0.71 \times \int_{R-d}^{R} 4\pi r^2 dr$$

$$= 0.71 \int_{6371-0.2}^{6371} 4\pi r^2 dr$$

$$= 7.24 \times 10^7 km^3 = 7.24 \times 10^{16} m^3$$

$$A_{total} = 0.71 \times 4\pi R^2 = 3.6215 \times 10^{14} m^2$$

Application to the Earth System –Part 1

Calculate molarity of CO2

$$m_{CO_2} = HP_{CO_2}$$

$$\ln H_{CO_2,w} = 108.3865 + 0.0198507T - 6919.53/T - 40.45154\ln T + 669365/T^2$$

$$d\ln H_{CO_2,w} = 0.0198507dT - d(\frac{6919.53}{T}) - 40.45154d\ln T + d(\frac{669365}{T^2})$$

$$dH_{CO_2} = H_{CO_2}(0.0198507 + \frac{6919.53}{T^2} - \frac{40.45154}{T} - \frac{2\times 669365}{T^3})dT$$ (단위 : mol/(kg*bar))

Application to the Earth System –Part 1

Difference in heat of dissolution

$$dm_{CO_2} = (HdP_{CO_2} + P_{CO_2}dH)$$

$$\rho V_{total} \times dm_{CO_2} = (HdP_{CO_2} + P_{CO_2}dH)\rho V_{total}$$

$$dP_{CO_2} = P_0 dw_{CO_2}$$: 돌턴의 부분 압력 법칙

$$dm_{CO_2} = (HP_a dw_{CO_2} + P_{CO_2}dH)$$

Application to the Earth System –Part 1

Difference in heat of dissolution

$$dw_{CO_2} = \frac{m_{CO_2} + dm_{CO_2}}{m_{all\ \ gas}} = \frac{2.533\times10^{16} + dm_{CO_2}}{1.40\times10^{20}}$$

$$|dP_{CO_2} = P_a\left(\frac{m_{CO_2} + dm_{CO_2}}{m_{all\ \ gas}}\right) = P_a\left(\frac{2.533\times10^{16} + dm_{CO_2}}{1.40\times10^{20}}\right)$$

Application to the Earth System –Part 1

Difference in heat of dissolution

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$$dm_{CO_2} = \left(HP_a\left(\frac{1.533\times10^{16} + dm_{CO_2}}{1.40\times10^{20}}\right) + P_{CO_2}dH(T)\right)$$

Application to the Earth System –Part 1

Difference in heat of dissolution

$$dm_{CO_2} - HP_a \frac{dm_{CO_2}}{1.40 \times 10^{20}} = HP_a \times (1.1 \times 10^{-14}) + P_{CO_2} dH_{CO_2,w}$$

$$dm_{CO_2} = \frac{10^{-14} H_{CO_2} P_a + P_{CO_2} H_{CO_2} [0.01985076 + \frac{6919.53}{T^2} - \frac{40.45154}{T} - \frac{2 \times 669365}{T^3}] dT}{(1 - H_{CO_2} P_a \frac{1.1}{1.4 \times 10^{20}})}$$

$$\Delta m_{CO_2} = \frac{10^{-14} H_{CO_2} P_a (T' - T) + P_{CO_2} H_{CO_2} [0.01985076 (T' - T) - (\frac{6919.53}{T'} - \frac{6919.53}{T}) - 40.45154 \ln T'/T + (\frac{669365}{T'^2} - \frac{669365}{T^2})]}{(1 - H_{CO_2} P_a \frac{1.1}{1.4 \times 10^{20}})}$$

$$\Delta H = -19.4 \Delta m_{CO_2} (kJ)$$

Application to the Earth System –Part 1

If Temperature increase 0.1 Celsius

$$H_{CO_2} = 29.3\, mol\,m^{-3}bar^{-1}$$

$$P_a = 100000pa = 1bar,\ \ P_{CO_2} = 0.00033bar$$

$$T = 25℃ = 298K$$

Gas	Partial pressure in atmosphere [bar]	Henry's law coefficient [mol/(m^3 bar)]	Concentration in seawater [μmol/kg SW]	[mg/kg SW]
CO_2	0.00033	29.3	9.45	0.4
N_2	0.7808	0.5	383.4	10.7
O_2	0.2095	1.0	206.3	6.6
Ar	0.00934	1.1	10.11	0.4

Application to the Earth System –Part 1

If Temperature increase 0.1 Celsius

ΔHocean = -5.4806 J/m2

편집기 - co2.m   변수 - deltam_co2

co2.m

```
%해수의 부피 계산
v_t=0.71*(4/3)*pi*(R^3-(R-d)^3); % unit : 7.24*10^7km^3
v_t= v_t * 10^9; %unit : m^3

%해수 면적 계산
A = 0.71*4*pi*R^2;
A = A * 10^6;

%CO2 몰수 변화
m_co2=H*p_co2; %0.0097 mol/kg

deltam_co2=((10^(-14))*29.3*1*(Td-T)+0.00033*29.3*(0.10985076*(Td-T)-(6919.53/Td
M_co2 = deltam_co2 * rho * v_t;

delenthalpy=-19.4 * M_co2/A; %kJ/m^2
delenthalpy_w = 1000* delenthalpy; %W/m^2

%열역학 1법칙 활용
deltaT=delenthalpy_w/cpw; %-0.0012K/m^2
```

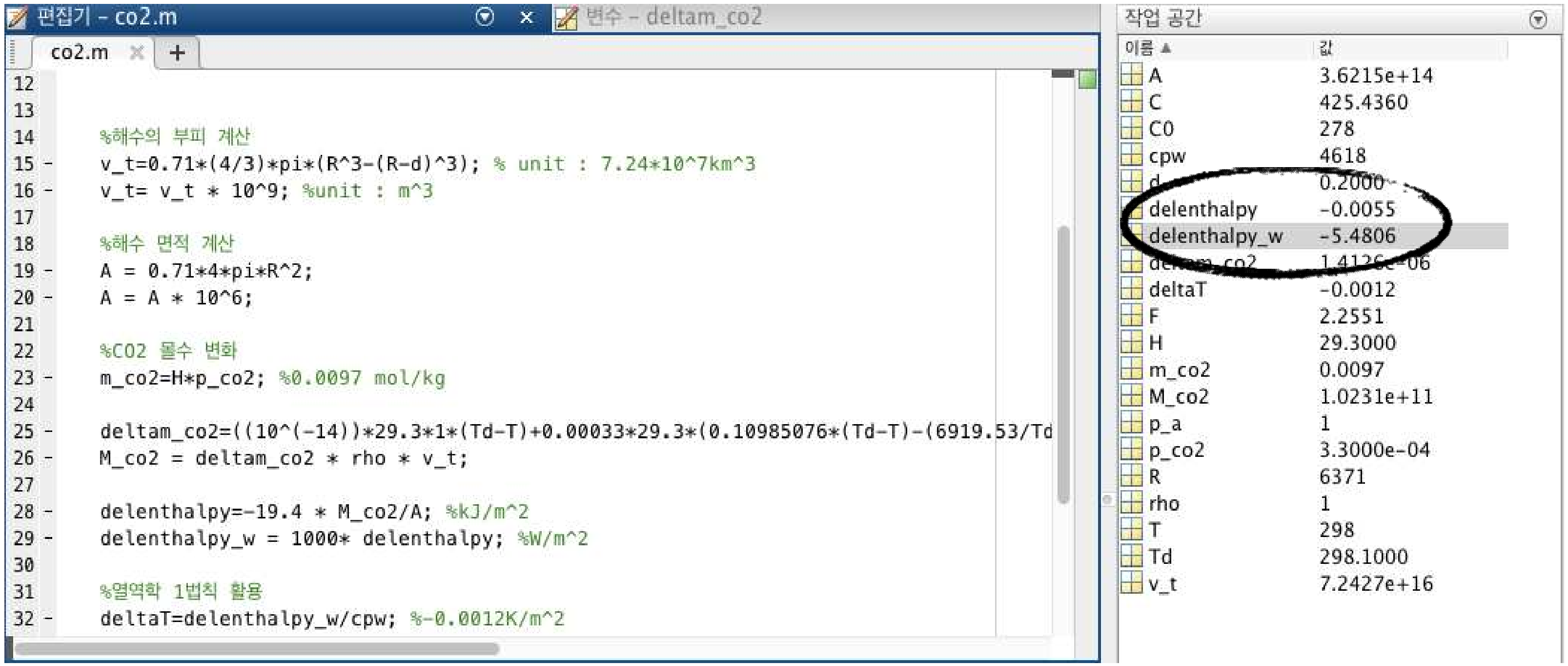
작업 공간

이름 ▲	값
A	3.6215e+14
C	425.4360
C0	278
cpw	4618
d	0.2000
delenthalpy	-0.0055
delenthalpy_w	-5.4806
deltam_co2	1.4126e-06
deltaT	-0.0012
F	2.2551
H	29.3000
m_co2	0.0097
M_co2	1.0231e+11
p_a	1
p_co2	3.3000e-04
R	6371
rho	1
T	298
Td	298.1000
v_t	7.2427e+16

Application to the Earth System –Part 1

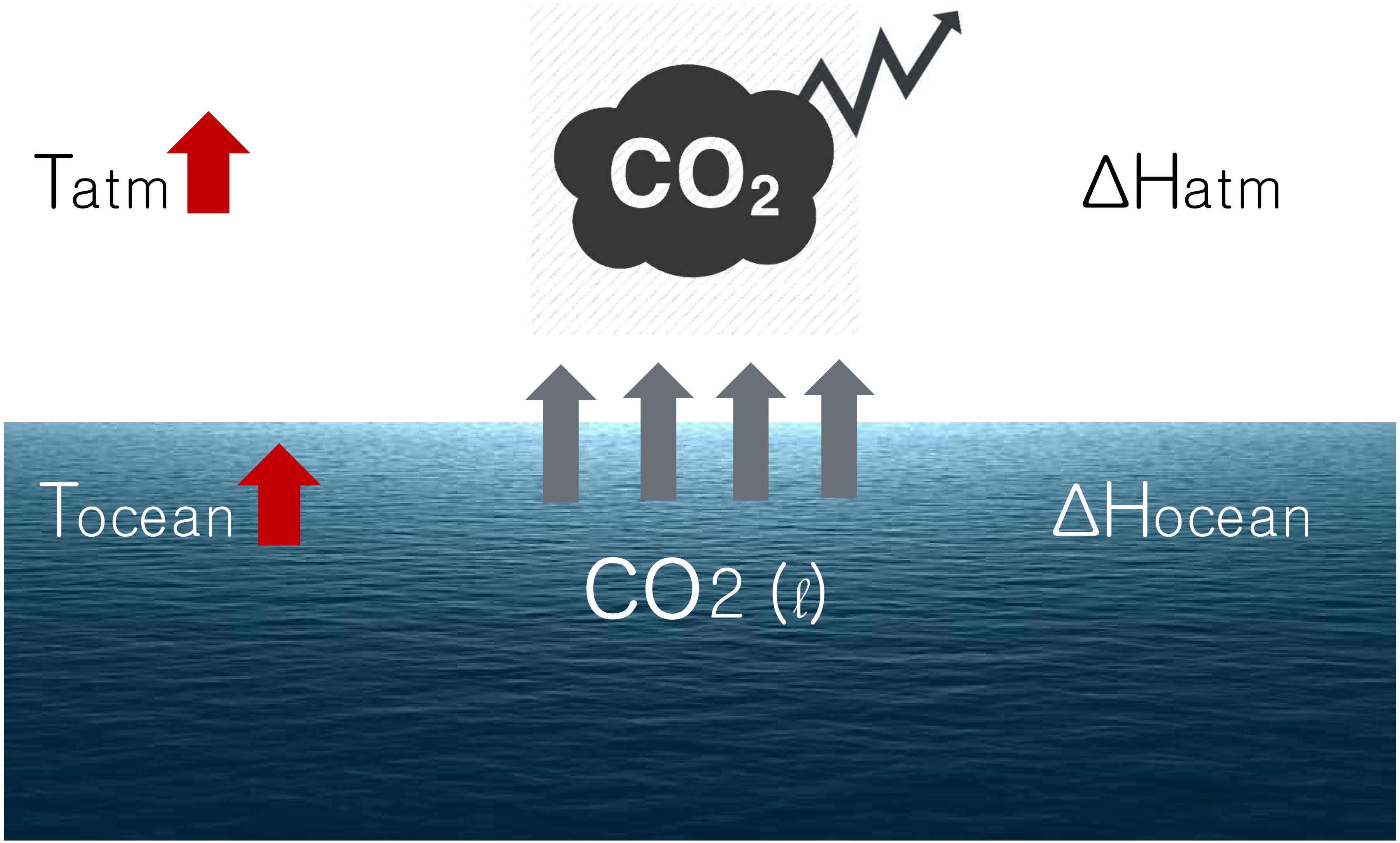
If Temperature increase 0.1 Celsius

ΔHocean = -5.4806 J/m2 → **ΔH1 = +4.7619 J/m2**



Application to the Earth System

Part 2



Application to the Earth System –Part 2

Green House effect by CO2 emission

Table 2.2: Expressions used to derive radiative forcing for past trends and future scenarios of greenhouse gas concentrations

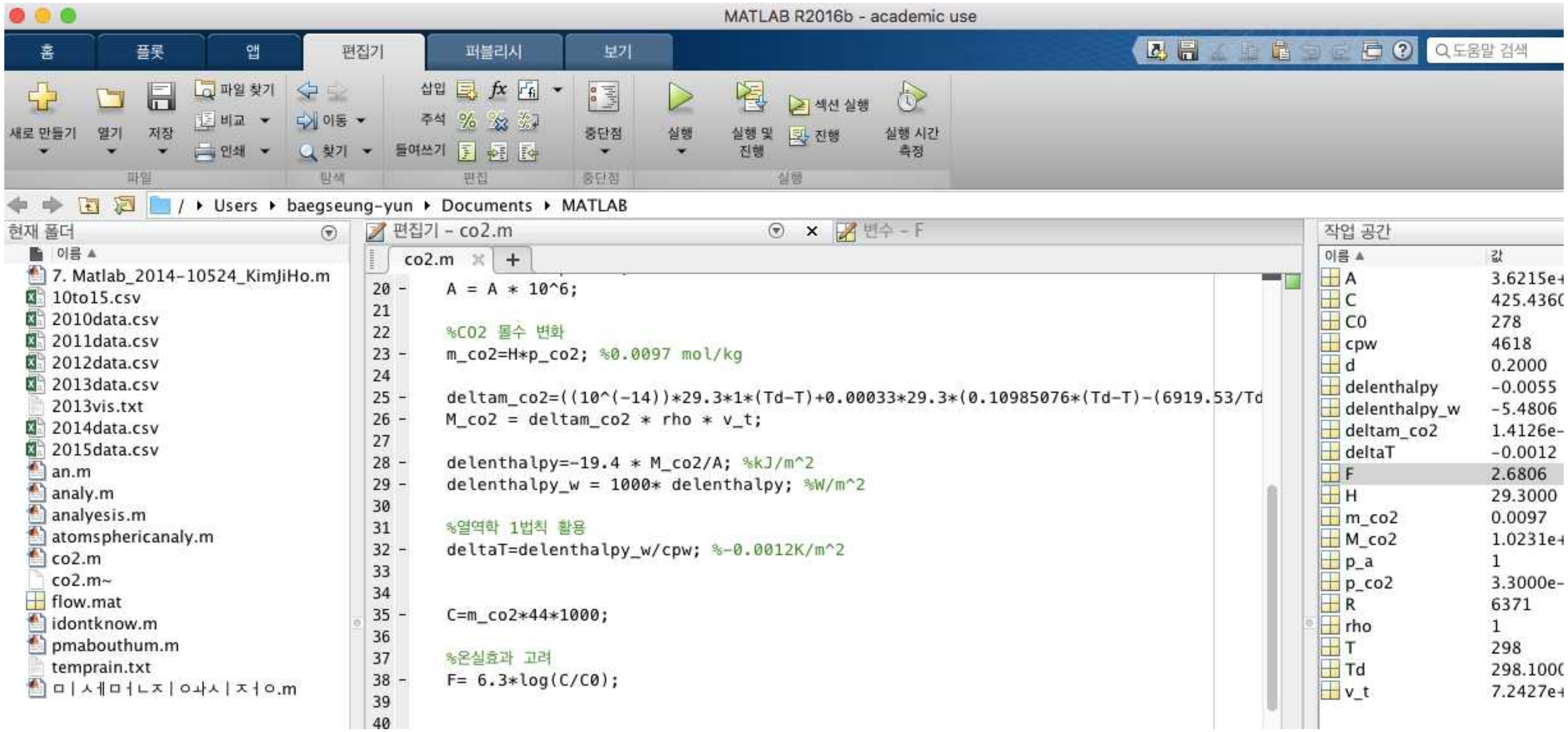
TRACE GAS	RADIATIVE FORCING APPROXIMATION GIVING ΔF IN Wm^{-2}	COMMENTS
Carbon dioxide	$\Delta F = 6.3 \ln (C/C_0)$ where C is CO_2 in ppmv for C < 1000 ppmv	Functional form from Wigley (1987), coefficient derived from Hansen et al (1988)
Methane	$\Delta F = 0.036 (\sqrt{M} - \sqrt{M_0}) - (f(M, N_0) - f(M_0, N_0))$ where M is CH_4 in ppbv and N is N_2O in ppbv Valid for M <5ppmv	Functional form from Wigley (1987), coefficient derived from Hansen et al (1988) Overlap term, f(M, N) from Hansen et al (1988)*
Nitrous Oxide	$\Delta F = 0.14 (\sqrt{N} - \sqrt{N_0}) - (f(M_0, N) - f(M_0, N_0))$ with M and N as above Valid for N <5ppmv	Functional form from Wigley (1987), coefficient derived from Hansen et al (1988) Overlap term from Hansen et al (1988)*

C_0 =278 ppm, C can be derived by dm_{CO2}

Application to the Earth System –Part 2

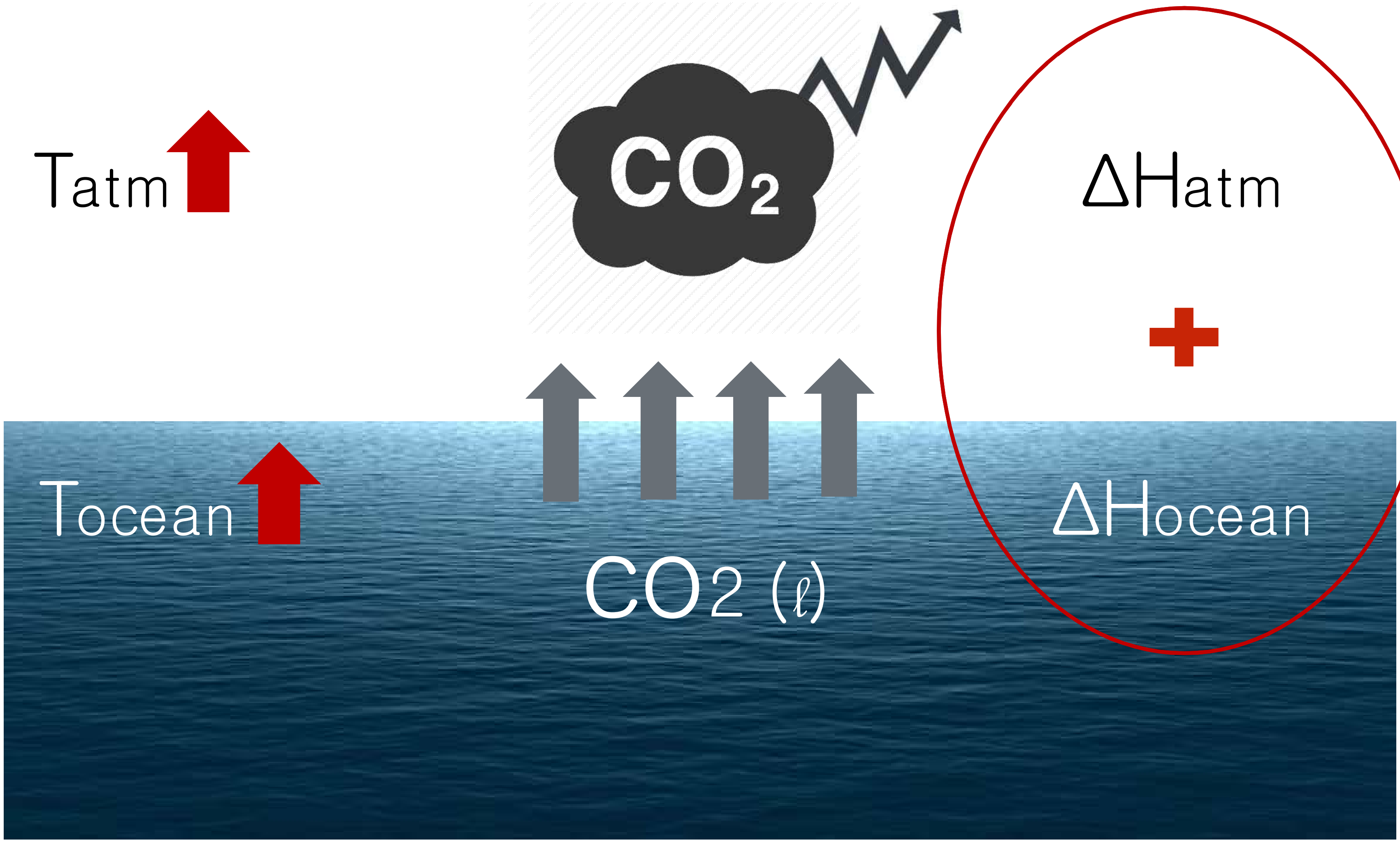
Green House effect by CO2 emission

ΔH_2 = 2.6806 J/m2



Application to the Earth System

Final



Application to the Earth System –Part1 + Part2

Is it positive or negative?

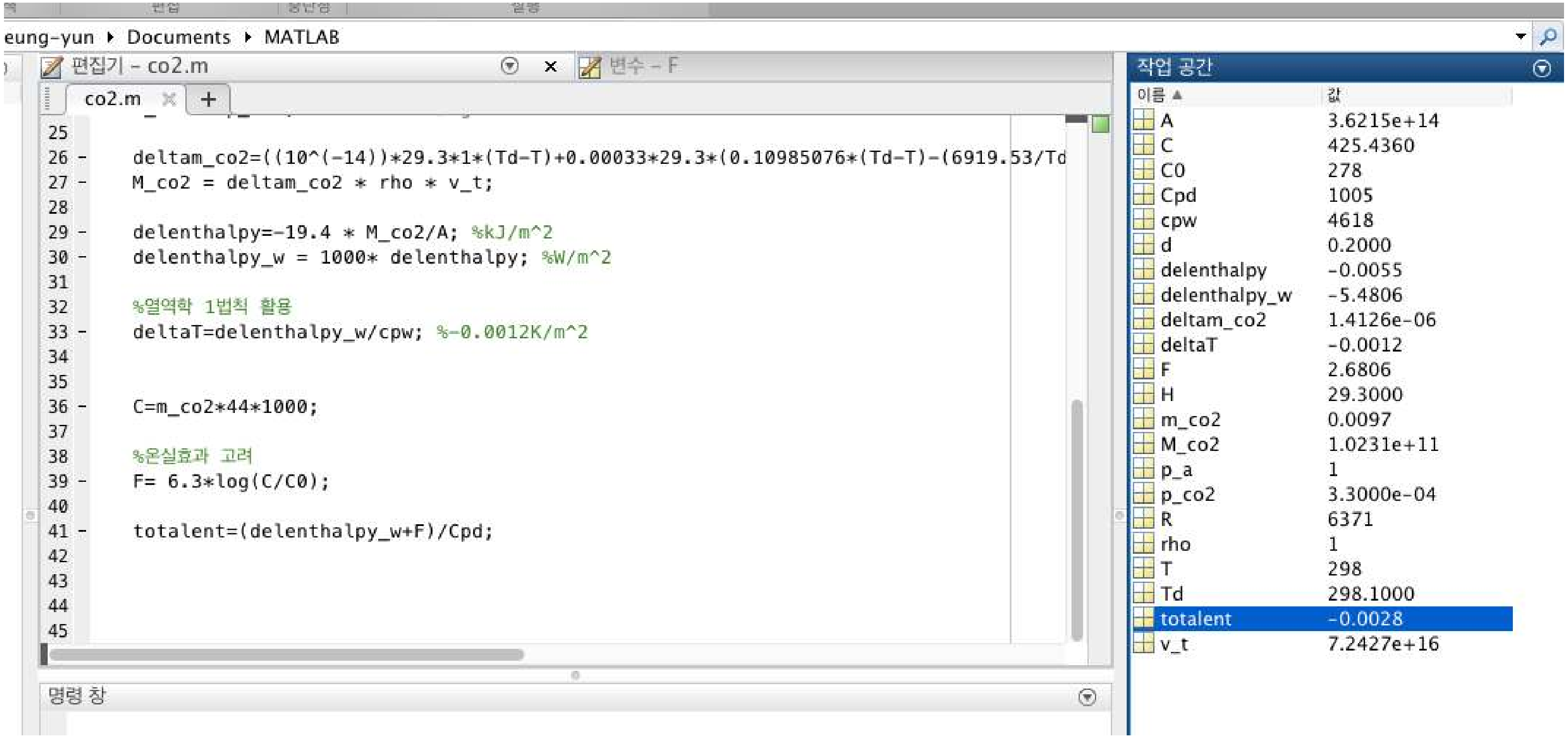
If the process is Isobaric we can calculate the temperature difference.

temperature difference=(part1+part2)/cpd

Application to the Earth System –Part1 + Part2

Is it positive or negative?

+ 4.5×10^{-7} K



Reference

- Rogers R R, M K Yau, A short Course in Cloud Physics, 1-7.
- Hansen, J I Fung, A Lacis, D Rind, S Lebedeff, R Ruedy and G Russell, 1988, Global climate changes as forecast by Goddard Institute for Space Studies Three Dimensional Model J GeoplnsRes 93 9341 9364.
- Wigley T M L, 1987, Relative contributions of different trace gases to the greenhouse effect, Climate Monitor, 16, 14-29
- http://sundoc.bibliothek.uni-halle.de/diss-online/04/04H141/t5.pdf

Thank You