Formulae for Temperature Corrected pCO2

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# Temperature Corrected pCO2

It turns out pCO2 is not a simple measure of the concentration (or activity) of CO2 in water, as it is strongly influenced by temperature. Even at a fixed concentration of CO2 in seawater, there will be fluctuations in pCO2 due only to changes in temperature.

Here is an informal argument for why this is true: At higher temperatures, CO2 is less soluble in sea water. At equilibrium, partitioning of CO2 between atmosphere and ocean water will shift more CO2 to the atmosphere, thus raising the partial pressure of CO2 in the atmosphere that equilibrates with the CO2 in the water.

More formally, carbon dioxide (gas) in the atmosphere is in thermodynamic equilibrium with [CO2] in the water, (where [CO2] here (by convention) refers to the sum of activities of CO2 and H2CO3 in solution.

Thus at equilibrium,

where , the *fugacity* of CO2, is “virtually equal to the partial pressure.” Unfortunately, is not constant, but depends on temperature and salinity. One semi-empirical model for that relationship is the following (From Weiss 1974 but also presented elsewhere):

(Note that temperatures need to be expressed in Kelvin)

Weiss, RF. 1974. Carbon dioxide in water and seawater: the solubility of a non-ideal gas. Marine chemistry 2 (3), 203-215.

# Takehashi et al. 2002 Relationships

Here we follow a formula for calculating a “Temperature Corrected” pCO2, which is derived from methods in Takehashi et al. 2002. The “temperature corrected” version adjusts for the thermodynamic effect of temperature on pCO2 just discussed.

Takahashi, Taro & Sutherland, Stewart & Sweeney, Colm & Poisson, Alain & Metzl, Nicolas & Tilbrook, Bronte & Bates, Nicholas & Wanninkhof, Rik & Feely, Richard & Chris, Sabine & Olafsson, Jon & Nojiri, Yukihiro. (2002). Global sea-air CO2 flux based on climatological surface ocean pCO2, and seasonal biological and temperature effects. Deep Sea Research Part II: Topical Studies in Oceanography. 49. 1601-1622. 10.1016/S0967-0645(02)00003-6.

Takahashi et al. 2002 used direct calculation of “temperature corrected” pCO2 as a surrogate for changes in CO2 concentration, and conversely, estimates of “expected” thermal pCO2”, as estimates of the magnitude of the fluctuations in pCO2 one would expect to see due to temperature alone, if there were no changes in [CO2].

The Takehashi et al. 2002 equations are as follows:

## “Expected pCO2” at Observed Temperature

## “Temperature Corrected” pCO2

This is approach addresses the thermal dependence of pCO2 by calculating what the observed pCO2 would have been at some reference temperature (rather than estimating [CO2] as Weiss did). Here we use as our reference temperature.

Equations from Takehashi et al. 2002 do not LOOK similar to Weiss’s equations, but they are nearly equivalent. At fixed salinity near full sea water, they essentially differ only by a constant.