O_2 quantity conversions

SCOR WG 142:

Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders

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Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms

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Recommended implementation

A. Conversion from mL L^{-1} (MLPL_DOXY) to µmol L^{-1} (MOLAR_DOXY)

This conversion is required to convert Sea-Bird oxygen sensor data given in mL O_2 (gas at S.T.P) per L of seawater (i.e., MLPL_DOXY in mL_{STP} L^{-1}) into µmol O_2 per L of seawater (i.e., MOLAR_DOXY in µmol L^{-1}). The conversion is valid both for salinity-corrected and salinity-uncorrected O_2 data.

$$c_{O_2}\ (\mu mol\ L^{-1}) = 44.6596 \cdot c_{O_2}\ (mL_{STP}\ L^{-1})$$

The molar volume of oxygen used here is 22.3916 L_{STP} mol^{-1} (Garcia and Gordon 1992). Its reciprocal gives the conversion factor of 44.6596 µmol mL_{STP}^{-1}.

B. Conversion from mg L^{-1} to µmol L^{-1} (MOLAR_DOXY)

For some applications, oxygen concentration is given as mass O_2 per L of seawater, e.g., mg L^{-1}. The molar weight of O_2 determines the conversion factor to µmol O_2 per L of seawater (i.e., MOLAR_DOXY in µmol L^{-1}). The conversion is valid both for salinity-corrected and salinity-uncorrected O_2 data.

O_2 quantities

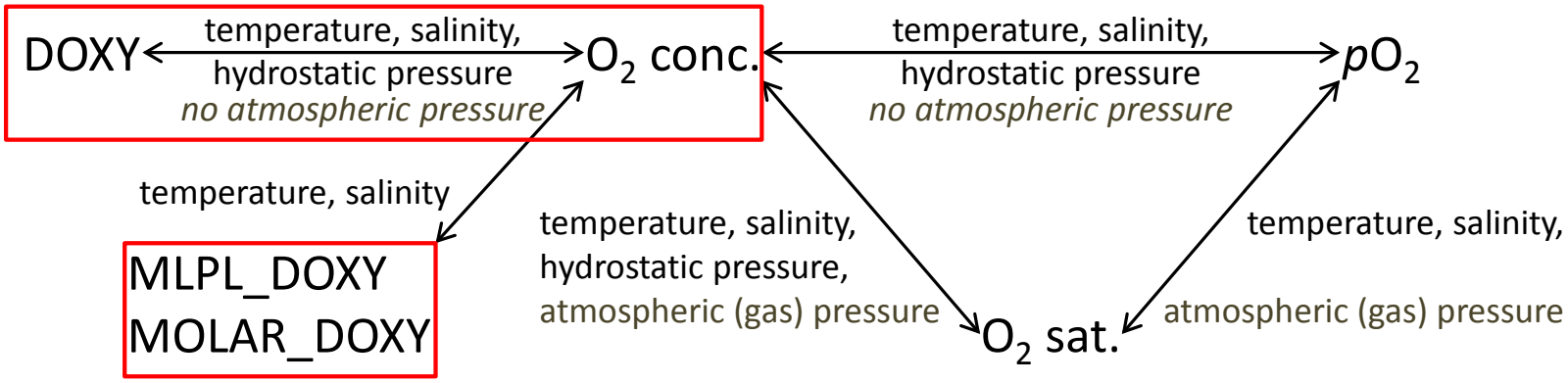
There are three (equivalent) ways to state the O_2 content of seawater:

- O_2 concentration:
  amount of O_2 in a given volume (molarity, µmol L^{-1}) or mass of seawater (molinity, µmol kg^{-1}, DOXY)

- O_2 partial pressure pO_2:
  (hypothetical) gas pressure in equilibrium with the seawater if O_2 were the only gas in the gas mixture (at the same conditions, i.e., temperature T, hydrostatic pressure P, ...); units of mbar

- O_2 saturation:
  ratio of the O_2 amount present in a given sample and its equilibrium O_2 concentration (or ratio of pO_2 to the equilibrium air pO_2); dimensionless / %

Conversion between O_2 quantities



(Matlab code available)

Currently, O_2 sensor manufacturers use different temperature & salinity dependencies (solubility equation). This affects the conversion of the sensor output (MLPL_DOXY / MOLAR_DOXY) to the final O_2 concentration (DOXY).

However, the *conversion* should not depend on the manufacturer but only on physical principles and be uniform for all O_2 sensors

→ SCOR WG142 recommendations for O_2 quantity conversions to be used instead of (varying) manufacturer equations.

Details

A. Conversion from mL L^{-1} (MLPL_DOXY) to µmol L^{-1} (MOLAR_DOXY)

B. Conversion from mg L^{-1} to µmol L^{-1} (MOLAR_DOXY)

C. Conversion from salinity-uncorrected MOLAR_DOXY optode data to salinity-corrected, molar oxygen concentration $c_{O_2}(T,S)$

D. Conversion from salinity-uncorrected MOLAR_DOXY optode data to partial pressure pO_2

E. Conversion from molar oxygen concentration $c_{O_2}(T,S)$ to oxygen partial pressure pO_2

F. Conversion from molar oxygen concentration $c_{O_2}(T,S)$ to oxygen concentration DOXY on the molinity scale

This conversion is just added for completeness in an Argo framework, to give the final fully corrected O_2 concentration in units of molinity, i.e., µmol kg^{-1} seawater (DOXY).

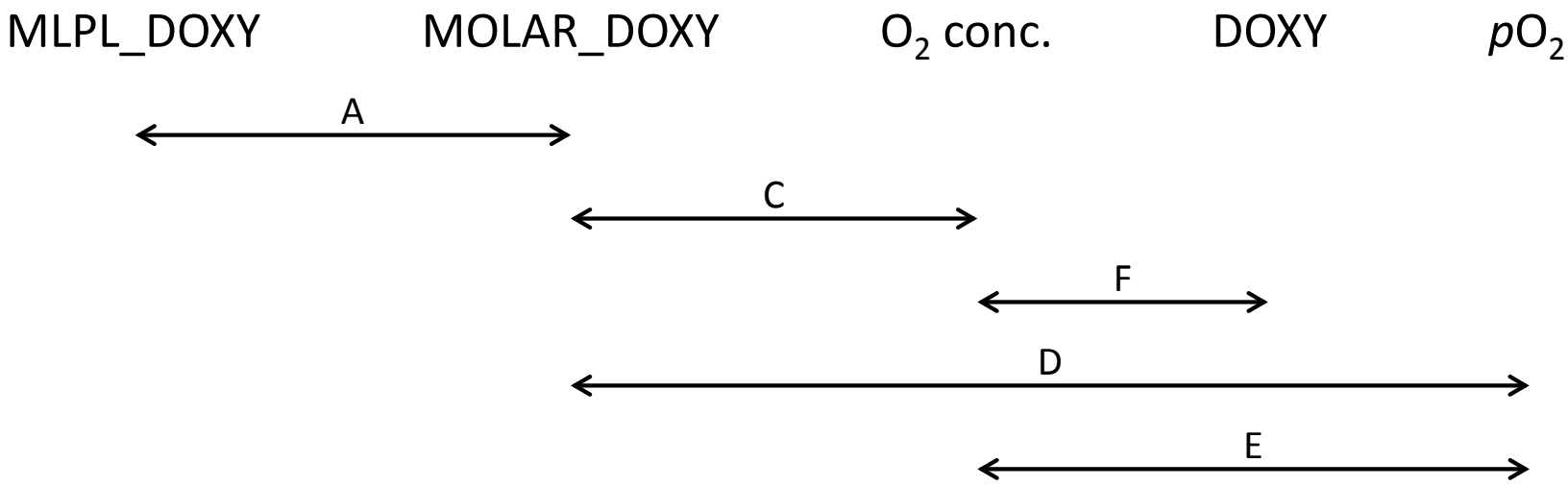
$$c_{O_2}\ (\mu mol\ kg^{-1}) = c_{O_2}\ (\mu mol\ L^{-1}) / rho\ ,$$

where

Argo Standard?

rho = potential density of seawater (kg L^{-1}) referenced to a hydrostatic pressure of 0 dbar and using practical salinity. We recommend using the equation of state based on Fofonoff and Millard (1983) and Millero et al. (1980).

Summary



- Provides a reference set of equations for O_2 conversions
- Uniform for all O_2 sensors, independent of manufacturers
- Should use the best available temperature (TEMP?)
- Includes calculation of partial pressure pO_2 required for in air measurements, because it is not possible to state a DOXY in air (= amount of O_2 in a given mass of seawater, µmol kg^{-1})