



Marine Variables and Unit Transformation

The WOA 11 variables, processed as a baseline for Climate Insights, consist of Dissolved Nitrate Concentration at Surface, Dissolved Oxygen Concentration at Surface, Dissolved Phosphate Concentration at Surface, and Dissolved Silicate Concentration at Surface. Other variables are the ensemble mean of 1985- 2005 GCM historical runs. All the baseline and change patterns were interpolated to 0.25-degree grid cells using a bi-linear interpolation method.

The unit transformation of marine biogeochemical variables follows the guide from the International Council for the Exploration of the Sea (ICES12).

$\mu\text{mol/l} = \mu\text{g-at/l} = \text{mmol/m}^3 = \mu\text{M mg/m}^3 = \mu\text{g/l}$
 $1 \text{ l} = 1 \text{ dm}^3 = 10^{-3}\text{m}^3 \approx 1 \text{ kg}$

Phosphorus (P)

MW P = 30.973762 $\mu\text{g/l P}$

$1 \mu\text{g P/l} = 1/\text{MW P} = 0.032285 \mu\text{mol/l}$

Phosphate Phosphorus (PO₄-P)

MW PO₄ = 94.971482 $\mu\text{g/l}$

$1 \mu\text{g/l PO}_4 = 1/\text{MW PO}_4 \mu\text{g/l} = 0.010529 \mu\text{mol/l}$ $1 \mu\text{g/l PO}_4 = \text{MW P}/\text{MW PO}_4 = 0.326138 \mu\text{g/l P}$

Nitrogen (N)

MW N = 14.006720 $\mu\text{g/l N}$

$1 \mu\text{g N/l} = 1/\text{MW N} = 0.071394 \mu\text{mol/l}$

Nitrate Nitrogen (NO₃-N)

MW NO₃ = 62.005010 $\mu\text{g/l}$

$1 \mu\text{g/l NO}_3 = 1/\text{MW NO}_3 \mu\text{g/l} = 0.016128 \mu\text{mol/l}$ $1 \mu\text{g/l NO}_3 = \text{MW N}/\text{MW NO}_3 = 0.225897 \mu\text{g/l N}$

Nitrite Nitrogen (NO₂-N)

MW NO₂ = 46.005580 $\mu\text{g/l}$

$1 \mu\text{g/l NO}_2 = 1/\text{MW NO}_2 \mu\text{g/l} = 0.021736 \mu\text{mol/l}$ $1 \mu\text{g/l NO}_2 = \text{MW N}/\text{MW NO}_2 = 0.304457 \mu\text{g/l N}$



Marine Variables and Unit Transformation

Ammonium Nitrogen (NH₄-N)

MW NH₄ = 18.038508 µg/l

1 µg/l NH₄ = 1/ MW NH₄ µg/l = 0.055437 µmol/l 1 µg/l NH₄ = MW N/MW NH₄ = 0.776490 µg/l N

Silicate Silicon (SiO₃-Si)

MW SiO₃ = 76.083820 µg/l

MW Si = 28.085530 µg/l

1 µg/l SiO₃ = 1/ MW SiO₃ µg/l = 0.013143 µmol/l 1 µg/l SiO₃ = MW Si/MW SiO₃ = 0.369139 µg/l Si

1 µg Si/l = 1/MW Si = 0.035606 µmol/l

Hydrogen Sulphide Sulphur (H₂S-S)

MW H₂S = 34.080894 µg/l

MW S = 32.065000 µg/l

1 µg/l H₂S = 1/ MW H₂S µg/l = 0.029342 µmol/l 1 µg/l H₂S = MW S/MW H₂S = 0.940850 µg/l S

1 µg S/l = 1/MW S = 0.031187 µmol/l

Oxygen (O₂)

Molar volume at STP = 22.391 l

Molar weight of oxygen = 31.998 g Atomic Mass of oxygen = 15.994 g/mol

1 µmol O₂ = .022391 ml

1 ml/l = 1000/22.391 = 44.661 µmol/l

1 mg/l = 22.391 ml/31.998 = 0.700 ml/l

1 mg-at/l = 15.994x22.391/31.998 = 11.192 ml 1liter = 0.001 m³

1ml/l = 44.661 mmol/m³=0.044661mol/m³