GLOBAL SURFACE ALKALINITY FROM AQUARIUS SATELLITE

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Introduction

The unprecedented salinity coverage from the AQUARIUS satellite provides the opportunity to calculate surface alkalinity globally. In the oceans, total alkalinity (TA) is a gauge of the ability of seawater to neutralize acids. TA can be measured in seawater samples, and is defined as:

$$ TA = [\text{HCO}_3^-] + 2[\text{CO}_3^{2-}] + [\text{OH}^-] + \text{other minor bases} $$

There is a strong correlation between surface ocean TA and salinity (Broecker and Peng, 1982; Millero et al., 1998 a, b, Lee et al., 2006) (Figs. 1a, 1b). Processes affecting TA include addition of freshwater by precipitation and sea ice melting, mixing, and removal during evaporation and sea ice formation. Non-conservative behavior has been shown to affect TA, specifically production of CaCO$_3$ that reduces TA and dissolution of CaCO$_3$ that increases TA (Bates et al., 1996c; Wann et al., 1998).

Empirical relationship between TA, SSS and SST

In earlier work (Lee et al., 2006), the ocean was divided into five regions where an empirical relationship was used to represent surface TA as a function of SSS and SST:

$$ TA = a + b (SSS - 35) + c (SSS - 35)^2 + d (SST - 20) + e (SST - 20)^2 $$

The coefficients were defined for five ocean regions: the subtropics (30°N-20°S), Southern Ocean (20°S-60°S), North Atlantic (30°N-60°N), North Pacific (30°N-60°N), and Southern Hemisphere (30°S-90°S).

Spatial variability

Satellite data (2012) are presented that show the difference between annual average TA and SSS at each grid point from the global annual average, respectively, of TA = 2285 and SSS = 34.067 using satellite SSS and SST.

There are small differences between satellite 2013 and 2012 annual (and monthly, not shown) averages (±8.4 µmol/kg) (Fig. 7a), which are highly correlated with salinity differences (Fig. 7b). Differences reflect variability from year to year in heating, cooling, eddies, currents, fronts, etc. In 2012 as compared to 2013, most of the ocean areas are slightly lower (−10 µmol/kg) at TA and SSS satellite data. Differences between satellite TA and WOD 2011 and WOA 2001 (not shown) and these are probably also related to biases in version 2.0 AQUARIUS data. Reported biases for the version 2.0 AQUARIUS SSS are mostly in the high latitudes, southern hemisphere, Asia-Pacific, under ITCZ, and eastern and western North Atlantic (Lagerloef et al., 2013). Most of the differences between satellite TA and WOD 2011 are within ±20 µmol/kg (Fig. 6, which is about the global RMS for the version 2.0 AQUARIUS derived TA data.

Conclusions

AQUARIUS satellite data allow global mapping of TA. Spatial and temporal variability in TA are mostly due to variability in salinity. Spatial variability in TA and salinity exceed temporal variability – seasonal and within the 2000s decade and climatology – by an order of magnitude for TA. The northern hemisphere has the most spatial and monthly variability in TA and salinity, while less variability in Southern Ocean TA is due to upwelling of waters enriched in TA.

References


