Science Highlight

Global surface ocean alkalinity climatology

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In many parts of the ocean alkalinity (A_T) data are severely limited compared to the sea surface salinity (SSS) and temperature (SST) data sets, which are several orders of magnitude larger. Therefore, determining the global distribution of surface A_T is problematic. Empirical algorithms that relate surface A_T to SSS and SST are particularly useful in constructing the global distribution of A_T when combined with the global fields of SSS and SST.

The first set of global relationships of salinity-normalized A_T with SST [Millero et al., 1998] was derived using subsets (n = 1,740) of historical A_T data as well as those collected during the global carbon survey of the 1990s. Since the global A_T relationships first became available, a significant number of new A_T measurements have been added to the global data set. Recently, Lee et al. [2006] used surface A_T measurements (n = 5,692) from the Global Ocean Data Analysis Project (GLODAP) v1.1 data set [Key et al., 2004] to determine the relationships of A_T with SSS and SST for different ocean regimes. A function of SSS and SST in the form

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

fits A_T data for each of five oceanographic regimes within an area-weighted uncertainty of ±8.1 μmol kg^{-1} (1σ).

The global distribution of surface A_T for August calculated using the derived A_T algorithms [Lee et al., 2006] applied to climatological SSS and SST fields [Conkright et al., 2002] is shown in Figure 1. The surface A_T field shows broad maxima in the central gyres centered at about 25^o north and south of the Equator, similar to the pattern for salinity. Poleward of the tropics and subtropics, the annual excess precipitation over evaporation increases, and thus salinity decreases, with latitude. As a result, the values of A_T generally decrease with increasing latitude. Seasonal changes in the intensity of the convective mixing here are additional key factors that act to change surface A_T in a measurable way. During seasonal cooling, the intensive vertical mixing brings deep waters rich in $CaCO_3$-driven A_T to the surface, and thus increases surface A_T. During seasonal warming, however, the shoaling of the mixed layer makes the contribution of A_T-rich deep waters to the change in surface A_T minimal.

The magnitude of seasonal A_T variability (Figure 2) is directly proportional to the seasonal variations in salinity. Seasonal A_T variations are generally larger in the tropics and subtropics than in the higher-latitude oceans. In particular, larger amplitudes of seasonal variability are observed in areas where freshwater inputs through rivers (e.g. near the Amazon River and the Bay of Bengal) and the melting of ice (e.g. near sea-ice edges) are significant, or where tropical upwelling occurs.

Finally, since the five regional A_T algorithms presented in Lee et al. [2006] were derived from the most comprehensive surface A_T data available, we propose that this new set of A_T equations should be used for the prediction of surface A_T over large oceanic areas where SSS and SST values are known.

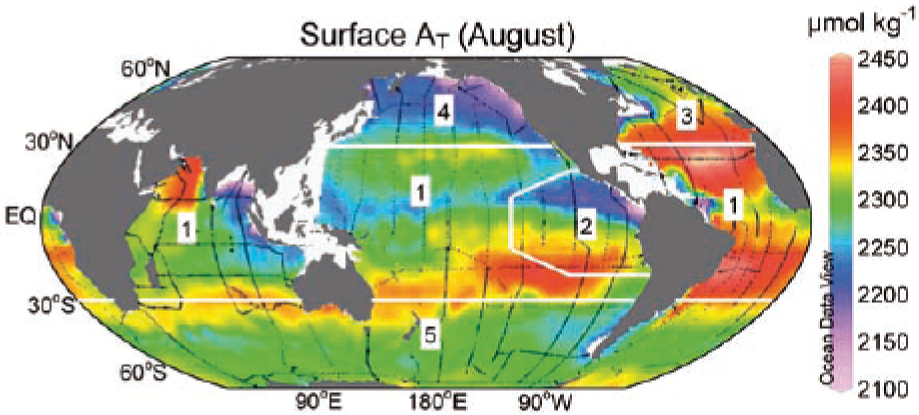

Figure 1. Global distribution of surface A_T (μmol kg^{-1}) for August for the world's ocean. White lines represent the approximate boundaries for the five different regions with unique A_T algorithms and the numerical numbers represent the five regions. Crosses denote locations of sampling stations.

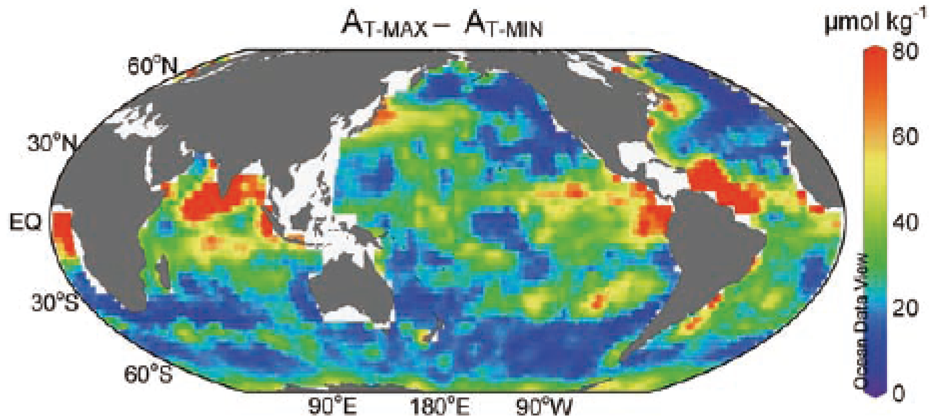

Figure 2. Distribution of the seasonal amplitude (maximum $A_{T\text{-}MAX}$ – minimum $A_{T\text{-}MIN}$) of surface A_T predicted from the regional A_T relationships given in Lee et al. [2006], applied to monthly mean sea surface salinity and temperature fields.

References

Conkright, M. E. et al. (2002), *World Ocean Database 2001*, vol. 1, Introduction, edited by S. Levitus, NOAA Atlas NESDIS 42, 167 pp., Natl. Oceanic and Atmos. Admin., Silver Spring, Md.

Key, R. M., et al. (2004), *A global ocean carbon climatology: Results from Global Data Analysis Project (GLODAP)*, Global Biogeochem. Cycles, 18, doi:10.1029/2004GB002247.

Lee, K., L. T. Tong, F. J. Millero, C. L. Sabine, A. G. Dickson, C. Goyet, G.-H. Park, R. Wanninkhof, R.A. Feely, and R. M. Key (2006), *Global relationships of total alkalinity with salinity and temperature in surface waters of the world's oceans*, Geophys. Res. Lett., 33, L19605, doi:10.1029/2006GL027207.

Millero, K. Lee, and M. Roche (1998), *Distribution of alkalinity in the surface waters of the major oceans*, Mar. Chem., 60, 111-130.