Climatological distribution of aragonite and calcite saturation states in the global oceans

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Surface distribution of aragonite and calcite saturation states was reported by Feely et al. [2009a] and Takahashi et al. [2014]. The saturation horizons (depths where saturation state is equal to 1) in both spatial and vertical dimensions were presented by Feely et al. [2009b] using data collected before 1999. Over the past decade, ocean station data with multiple carbon parameters measured have nearly doubled. The richer data could enable a better depiction of the global distribution of aragonite and calcite saturation states. We used data from the Global Ocean Data Analysis Project (GLODAP), the Carbon Dioxide in the Atlantic Ocean (CARINA), the Pacific Ocean Interior Carbon (PACIFICA), and some recent cruise data sets to re-examine the distribution of aragonite and calcite saturation state. The saturation states were calculated from in-situ temperature, pressure, salinity, dissolved inorganic carbon (DIC), total alkalinity (TA), silicate and phosphate. Surface aragonite saturation state (Ω_{arag}) in the open ocean was always supersaturated (Ω>1), ranging between 1.1 and 4.2. It was above 2.0 (2.0-4.2) between 40°N and 40°S, but decreased towards higher latitude to below 1.5 in polar areas. Vertically, Ω_{arag} was highest in the surface mixed layer (SML). Seasonally, surface Ω_{arag} above 30° latitudes was about 0.06 to 0.55 higher during warmer months than during colder months in the open-ocean waters of both hemispheres. Decadal changes of Ω_{arag} in the Atlantic and Pacific Oceans showed that Ω_{arag} in waters shallower than 100 m depth decreased by 0.10±0.09 (–0.40±0.37% yr^{-1}) on average from the decade spanning 1989-1998 to the decade spanning 1998-2010. The study identifies the Arctic and Antarctic oceans, and the upwelling ocean waters off the west coasts of North America, South America and Africa as regions that are especially vulnerable to ocean acidification. We also discuss the mechanisms controlling global distribution of aragonite and calcite, and examine its decadal and seasonal changes.