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Global Data Products Help Assess Changes to Ocean Carbon Sink

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Net oceanic uptake of the greenhouse gas carbon dioxide (CO_2) reduces global warming but also leads to ocean acidification [*Intergovernmental Panel on Climate Change* (*IPCC*), 2007]. Understanding and predicting changes in the ocean carbon sink are critical to assessments of future climate change. Surface water CO_2 measurements suggest large year-to-year variations in oceanic CO_2 uptake for several regions [*Doney et al.*, 2009]. However, there is much debate on whether these changes are cyclical or indicative of long-term trends. Sustained, globally coordinated observations of the surface ocean carbon cycle and systematic handling of such data are essential for assessing variation and trends in regional and global ocean carbon uptake, information necessary for accurate estimates of global and national carbon budgets.

The Carbon Dioxide Information Analysis Center (CDIAC) has been assembling ocean carbon data from international contributors since 1993. A large amount of relevant data, however, cannot be found at CDIAC, having been archived at other data centers or kept private. Furthermore, the data are in varied formats and often have insufficient documentation. All these factors have been effective barriers to generating global CO_2 synthesis products essential for assessing changes in the ocean carbon sink.

In response to this, the international ocean carbon research community initiated the Surface Ocean CO_2 Atlas (SOCAT; http://www.socat.info/) in April 2007 [*International Ocean Carbon Coordination Project* (*IOCCP*), 2007]. This project aims to improve access to surface water fugacity of CO_2 (fCO_2, similar to partial pressure) data from all ocean areas, to optimize their documentation and quality control (QC), and to ensure their long-term storage.

SOCAT Framework, Quality Control, and Products

Approximately 50 international seagoing marine carbon scientists and data managers have generously donated their time and expertise to SOCAT. These participants were organized into seven regional groups and a global coordination group. Six international workshops were held to resolve data integration and QC issues. The scientists developed protocols, software, and an interactive Web-based tool for data QC. SOCAT procedures were designed to be transparent and fully documented. Many additional data not yet in CDIAC were retrieved from data originators, public Web sites, and other data centers. Regional group members checked the documentation accompanying the data and carried out data QC. Whenever the QC process highlighted problems, data were suspended for revision by the data provider. A quality flag was assigned to each data set, and only good-quality data were included in SOCAT products.

SOCAT version 1.5, public since September 2011, contains 6.3 million surface water CO_2 measurements from the global oceans and coastal seas. The data originate from 1851 voyages by research vessels, commercial ships, and moored as well as drifting platforms. Two SOCAT products have been created: (1) a global data set of surface ocean fCO_2 from 1968 to 2007 (Figure 1) recalculated using a uniform procedure and subject to QC checks and (2) a global, gridded, monthly mean surface water fCO_2 data product with minimal temporal and spatial interpolation. The SOCAT data products and individual cruise files can be downloaded from PANGAEA (http://www.pangaea.de/), an International Council for Science World Data System, and CDIAC (http://cdiac.ornl.gov/oceans/). The data products can also be accessed via an interactive data visualization and analysis tool, the Live Access Server, and Ocean Data View (links available at http://www.socat.info/).

Applications of Products and Future SOCAT

Currently, two types of global surface ocean CO_2 synthesis products are publicly available: the SOCAT products and the Lamont-Doherty Earth Observatory (LDEO) climatologies [*Takahashi*

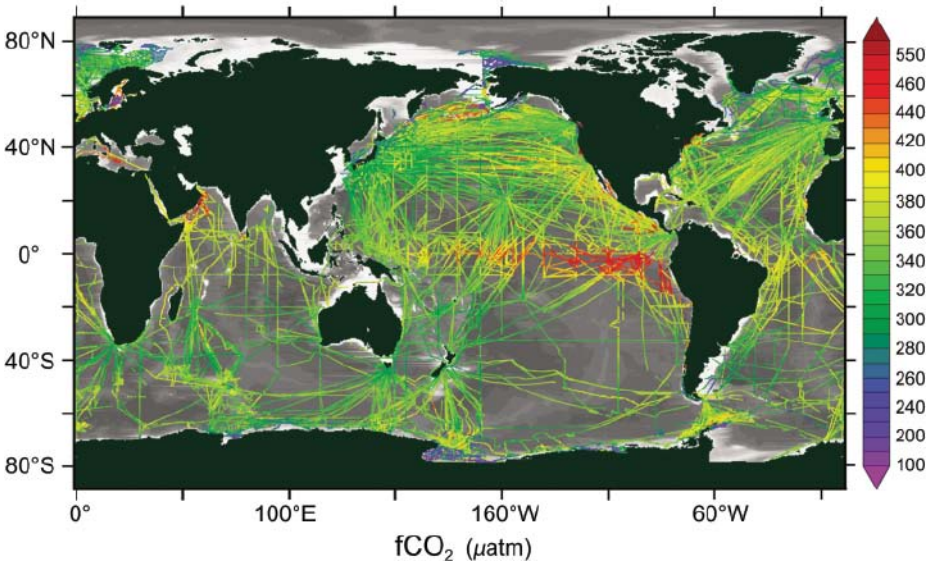

Fig. 1. Surface water fCO_2 (similar to partial pressure) measured in microatmospheres (μatm) in the global oceans and coastal seas from 1968 to 2007. Data are from Surface Ocean CO_2 Atlas (SOCAT) version 1.5. Note the uneven data distribution across the oceans and coastal seas.

et al., 2009]. Although the SOCAT and LDEO products share many original data sources, QC and extrapolation procedures used for creating the gridded products are very different. Nonetheless, both sources of information can help researchers evaluate CO_2 air-sea fluxes for constraining global carbon budgets.

Potential applications of the SOCAT products include studies of seasonal, year-to-year, and decadal variations in the ocean carbon sink at regional and global scales. Global data products provide much-needed initialization and validation fields for ocean carbon cycle models, as used by *IPCC* [2007].

The SOCAT project has revealed major room for improvement in the way that scientists report and document data. The SOCAT community, together with IOCCP, hopes to address this by developing a largely automated data submission and QC system. Work on the second SOCAT release has started. The inclusion of additional parameters, e.g., those relevant for ocean acidification research, is under consideration. Marine carbon scientists are strongly encouraged to promptly submit their surface water CO_2 data with accompanying documentation for inclusion in global synthesis products. Data submissions should follow the recommended formats (see http://cdiac.ornl.gov/oceans/submit.html).

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