Geophysical Research Abstracts, Vol. 9, 05725, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05725

Constraining gas exchange parameterizations with ^{3}He/SF$_6$ tracer release experiments: Implications for global ocean CO$_2$ uptake

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Air-sea gas exchange is an important process that strongly influences the global biogeochemical cycling of trace gases such as CO_2. Global ocean CO_2 uptake can be estimated by combining parameterizations of gas transfer velocities and global wind speeds with global maps of air-sea pCO_2 disequilibrium. Over the past decades, several widely used gas exchange parameterizations have been proposed, and the resulting estimates of global ocean CO_2 uptake differ by a factor of two (0.9 to 1.9 pgC yr^{-1}). A problem with some of the parameterizations is that they are based on limited data, typically lacking observations in high wind speed regimes ($>$ 15 m s^{-1}). Recently, gas transfer velocities were obtained using the ^{3}He/SF$_6$ dual tracer technique in the Southern Ocean over a range of wind speeds, including high wind conditions, during the SOLAS Air-Sea Gas Exchange (SAGE) experiment. Using a new gas exchange parameterization based on the SAGE ^{3}He/SF$_6$ data yields global ocean CO_2 uptake of 1.3 $\pm$ 0.3 pgC yr^{-1}, within the range of previous estimates. These ^{3}He/SF$_6$-derived data have also enabled previously proposed gas exchange parameterizations to be evaluated. The two main results of this study are (1) By comparing the ^{3}He/SF$_6$-based gas transfer velocity measurements from the Southern Ocean with measurements obtained from the coastal ocean, the universality of these gas exchange parameterizations could be established; (2) Addition of our new ocean CO_2 uptake estimates and evaluation of published gas exchange parameterizations leads to a reduction in the range of global ocean CO_2 uptake estimates (1.2 to 1.6 pgC yr^{-1}), bringing them in line with other model- and data-based approaches.