Geophysical Research Abstracts
Vol. 15, EGU2013-12398-1, 2013
EGU General Assembly 2013

Precipitation and the global air-sea CO_2 flux

Christopher J Zappa and Wade R McGillis
Lamont Doherty Earth Observatory, Columbia University, Palisades, NY, USA

Atmosphere-ocean interactions play a crucial role in the regional and global budgets of biogeochemical trace gases and in the transport of volatile pollutants. A plethora of processes has been shown in individual studies to play varying roles in regulating air-sea gas fluxes, which continually work to adjust the balance of constituents in the upper ocean. Therefore, a better understanding of mechanisms controlling air-water gas exchange and ocean mixing is needed to improve model predictions of the spatial variability of air-sea fluxes.

Wind has been the predominant driver of gas exchange in the open ocean because it plays a central role in the generation of turbulence through the transfer of momentum to waves and currents. As a result, numerous relationships between k and wind speed have been developed [e.g., Liss and Merlivat, 1986; Wanninkhof, 1992; Wanninkhof and McGillis, 1999]. However, many processes and mechanisms, both related and unrelated to wind forcing, have been determined to influence gas exchange, including short wind waves [e.g., Bock et al., 1999], microscale wave breaking [e.g., Zappa et al., 2004], bubble-mediated transfer [Asher and Wanninkhof, 1998; Farmer et al., 1993; Woolf and Thorpe, 1991; Woolf, 1993], organic films [e.g., Frew et al., 2004].

Rain is one process unrelated to wind forcing that is known to enhance the gas transfer velocity [Ho et al., 2000; Takagaki and Komori, 2007; Zappa et al., 2009]. Rain also plays a significant role in the exchange of CO_2 between the ocean and atmosphere, through surface layer chemical dilution and via export of carbon from the atmosphere by wet deposition. Recently, we have determined that these effects play a significant role in the uptake of CO_2 in the western equatorial Pacific [Turk et al., 2010]. However, global bulk estimates of air-sea CO_2 flux have to date ignored these effects [Takahashi et al., 2002; Takahashi et al., 2009].

Here, we use monthly global precipitation measurements from the Global Precipitation Climatology Project Version 2.1 Combined Precipitation Data Set, a global monthly climatology of the atmosphere-ocean surface $p(CO_2)$ difference [Takahashi et al., 2009] and a surface dilution model to provide an estimate of the enhanced transfer, chemical dilution and deposition effects of rain on the global air-sea CO_2 flux. Our results show that during high rainfall events, chemical dilution from the rain can lower the surface ocean $p(CO_2)$ in these regions by more than 30 microatm. This increases the air-sea $\Delta p(CO_2)$ in ocean sink regions, while in ocean source regions $\Delta p(CO_2)$ is lowered and can potentially turn a weak source into a sink. As this effect is confined to a very near-surface layer it is neglected in surface mixed layer and climate models as well as by standard measurements of surface $p(CO_2)$ that are normally made at 3-5 m depth. During rain, the gas transfer velocity is also increased which embellishes the increase in $\Delta p(CO_2)$ and further enhances the sink potential, but this effect is smaller. Depending on the region, the annual net air-sea CO_2 flux can change by more than 100%. In this study, the precipitation results in making chemical dilution, enhanced gas transfer, and wet deposition significant contributions to the ocean CO_2 sink.