Geophysical Research Abstracts
Vol. 18, EGU2016-1180, 2016
EGU General Assembly 2016

On which timescales do gas transfer velocities control North Atlantic CO_2 flux variability?

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The North Atlantic is an important basin for the global ocean's uptake of anthropogenic and natural carbon dioxide (CO_2), but the mechanisms controlling this carbon flux are not fully understood. The air-sea flux of CO_2, F, is the product of a gas transfer velocity, k, the air-sea CO_2concentration gradient, ΔpCO_2, and the temperature and salinity-dependent solubility coefficient, α. k is difficult to constrain, representing the dominant uncertainty in F on short (instantaneous to interannual) timescales. Previous work shows that in the North Atlantic, $\Delta pCO_2$and k both contribute significantly to interannual F variability, but that k is unimportant for multidecadal variability. On some timescale between interannual and multidecadal, gas transfer velocity variability and its associated uncertainty become negligible. Here, we quantify this critical timescale for the first time. Using an ocean model, we determine the importance of k, $\Delta pCO_2$and α on a range of timescales. On interannual and shorter timescales, both $\Delta pCO_2$and k are important controls on F. In contrast, pentadal to multidecadal North Atlantic flux variability is driven almost entirely by ΔpCO_2; k contributes less than 25%. Finally, we explore how accurately one can estimate North Atlantic F without a knowledge of non-seasonal k variability, finding it possible for interannual and longer timescales. These findings suggest that continued efforts to better constrain gas transfer velocities are necessary to quantify interannual variability in the North Atlantic carbon sink. However, uncertainty in k variability is unlikely to limit the accuracy of estimates of longer term flux variability.