PACIFIC DOMINANCE TO GLOBAL AIR-SEA CO_2 FLUX VARIABILITY: A NOVEL ATMOSPHERIC INVERSION AGREES WITH OCEAN MODELS

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ABSTRACT
We address an ongoing debate regarding the geographic distribution of interannual variability in ocean - atmosphere carbon exchange. We find that, for 1983-1998, both novel high-resolution atmospheric inversion calculations and global ocean biogeochemical models place the primary source of global CO_2 air-sea flux variability in the Pacific Ocean. In ocean biogeochemical models, this variability is clearly associated with the El Niño / Southern Oscillation cycle. Both inversion and models indicate that the Southern Ocean is the second-largest source of air-sea CO_2 flux variability, and that variability is small throughout the Atlantic, including the North Atlantic, in contrast to previous studies.

INTRODUCTION
Inversions of atmospheric data and ocean biogeochemical models have been shown to be in approximate agreement as to the amplitude of interannual variability in air-sea CO_2 exchange (extremes of ±0.5 PgC/yr), but differ regarding the geographic distribution of this variability. Specifically, the importance of the middle and high latitude North Atlantic and the Southern Ocean to the global air-sea CO_2 flux variability is an issue of current debate [*Peylin et al.*, 2005]. While global biogeochemical ocean models place the dominant source of air-sea CO_2 in the Equatorial Pacific, inversions have suggested that the high latitudes may dominate.

McKinley et al. [2004b] propose that this model-inversion discrepancy may be a reflection of the specific inversion method used, in conjunction with the differences in the large-scale coherence in air-sea flux anomalies at high latitudes compared to the tropics. While traditional large-region inversions are well-suited for estimating flux anomalies characterized by basin-scale correlation lengths, they induce enhanced uncertainty for regions with shorter correlations. The problem is aggravated for two reasons. First, studies based on various methods [*Peylin et al.*, 2005; *Rödenbeck et al.*, 2003] indicate that ocean flux variability is smaller than land variability. Because atmospheric stations sample both land and ocean flux signals and inversions conserve mass, small relative errors in land flux estimates cause large relative errors in flux estimates in adjacent ocean regions. Second, the inverse problem of atmospheric transport is ill-posed: results are very sensitive to inconsistencies between inverse model and data. Large-region inversions are more prone to these sources of error.

The spatially highly resolving inversion methodology used by *Rödenbeck et al.,* [2003] limits the region of influence of a station to a smaller region than the large, basin-scale regions used in traditional approaches such as TransCom3. It therefore is able to limit errors caused by biases in *a priori* prescribed large-scale flux patterns. *A priori* correlations are applied to prevent gridscale noise, but this is a much softer and homogenous constraint than fixed regional structures.

RESULTS

We analyze the inversion of *Rödenbeck et al.,* [2003] and find that, as in ocean biogeochemical models, the Pacific Ocean dominates global air-sea CO_2 flux variability (Fig. 1). For both inversions and the model of *McKinley et al.*, [2004b], correlations of Global and Pacific timeseries are high: 0.69 – 0.93. Both methodologies also indicate that variability coming from the Southern Ocean is of secondary importance, and that variability throughout the Atlantic is small.

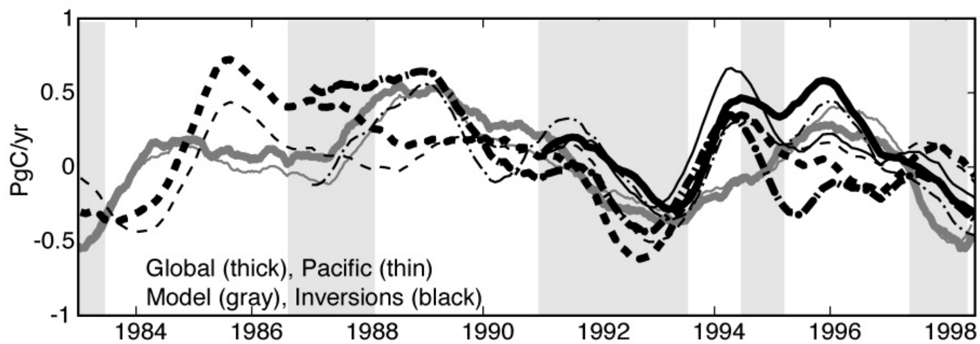

Fig. 1: Comparison of Global (thick) and Pacific (thin) flux variability. The 11-station inversion (1983-2000, dash, black), 16-station inversion (1987-200, dash-dot, black), and 19-station inversion (1991-2000, solid, black) of *Rödenbeck et al.* [2003] are compared to the ocean model (solid, gray) of *McKinley et al.* [2004b]. Gray background regions are El Niño periods.

REFERENCES

McKinley, G.A, C. Rödenbeck, M. Gloor, S. Houweling and M. Heimann (2004a) Pacific dominance to global air-sea CO_2 flux variability: A novel atmospheric inversion agrees with ocean models, *Geophys, Res, Lett., 31,* L22308, doi:10.1029/2004GL021069.

McKinley, G.A., M.J. Follows, and J. Marshall (2004b) Mechanisms of air-sea CO_2 flux variability in the Equatorial Pacific and the North Atlantic, *Global Biogeochem. Cycles, 18,* GB2011, doi:10.1029/2003GB002179.

Peylin, P., P. Bousquet, C. LeQuèrè S. Sitch, P. Friedlingstein, G. McKinley, N. Gruber, P. Rayner, and P. Ciais (2005) Multiple constraints on regional CO_2 flux variations over land and oceans, *Global Biogeochem. Cycles, 19,* GB1011, doi:10.1029/2003GB002214

Rödenbeck C., S. Houweling, M. Gloor, and M. Heimann (2003) CO_2 flux history 1982-2001 inferred from atmospheric data using a global inversion of atmospheric transport, *Atm. Chem. Phys. 3*, 1919-1964

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