The SIO O_2 Program: Constraints on Long-term Carbon Cycle Changes Through Measurements of Atmospheric Oxygen

E. Morgan[1], C. Nevison[2], M. Manizza[1], and R. Keeling[1]

[1]Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA 92037; 858-822-1642, E-mail: ejmorgan@ucsd.edu
[2]Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, CO 80309

The Scripps O_2 Program maintains long-term time series measurements of atmospheric CO_2, O_2/N_2 ratio, and Ar/N_2 ratio, through a global network of flask sampling sites. Measurements have been made regularly since the 1990s at nine locations [with a tenth site at Utqiaġvik, Alaska (BRW) added to the network in 2011]. This ~30-year record can be leveraged to estimate the global terrestrial and oceanic CO_2 sinks (Keeling and Shertz, 1992; Keeling and Manning, 2014). We present an update of these sink estimates and discuss sources of uncertainty. For the period 2010–2016, we find a net land sink of 1.09 ± 0.97 Pg C yr^{-1} and an ocean sink of 3.62 ± 0.66 Pg C yr^{-1}. In context of land-use emissions of around 2 Pg C yr^{-1}, the net land sink of 1.1 Pg C yr^{-1} requires a residual sink of ~ 3 Pg C yr^{-1}. The ocean sink is on the high end of recent estimates and subject to several important caveats, which will be discussed.

We also highlight some recent work on the seasonality of $\delta(O_2/N_2)$ in the Southern Hemisphere. Since much of the seasonality of O_2 change is driven by the terrestrial biosphere, we focus on the tracer atmospheric potential oxygen (APO), $APO \simeq O_2 + 1.1CO_2$, which combines CO_2 and $\delta(O_2/N_2)$ variations to produce a quantity that is insensitive to the land biosphere fluxes. We find a significant correlation between wintertime APO seasonal anomalies and the Southern Annular Mode (SAM) at select sites in the Southern Hemisphere (see figure). Negative anomalies of APO occur in years of greater wind stress, and hence ventilation of subsurface waters, at higher latitudes.

References:

Keeling and Shertz, 1992. *Nature*, 358:723–727.

Keeling and Manning, 2014. *Treatise on Geochemistry*, Vol 5, 385–404.

Marshall, 2003. *J of Clim*, **16:** 4134–4143.

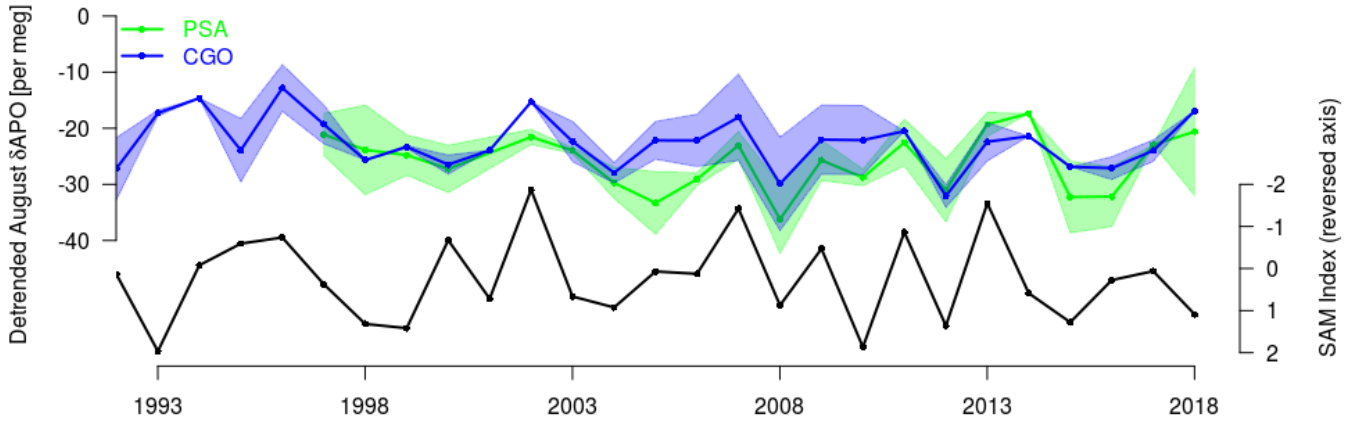

Figure 1. In the top panel, detrended APO in August for two flask sampling sites, Palmer Station, Antarctica (PSA) and Cape Grim Observatory (CGO). Bottom panel: SAM index shown in black with y-axis reversed; data from Marshall, 2003.