Atmospheric Signatures of Changing Global Biogeochemistry

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In 1957, Roger Revelle called attention to humanities "great geophysical experiment", i.e. release of billions of tons of CO_2 from fossil-fuel burning. As this "experiment" now slowly plays out, a major need is to track the fate of the excess CO_2 and to understand impacts on land and ocean ecosystems. Measurements of greenhouse gases by NOAA and other programs now constitute the core of an observing system to satisfy this need. The Scripps Inst. of Oceanography also plays a key role by tracking changes in the atmospheric O_2 abundance and maintaining links to early measurements.

One surprise coming from these observations is evidence that land ecosystems are serving as a sink for a significant fraction the excess carbon dioxide from fossil-fuel burning. Ecosystems remote from direct human influences have evidently been thrown out of steady state by a range of processes and are accumulating carbon unusually. Evidence for this sink is compelling found from a variety of methods, including from measurements of atmospheric O_2 abundance. Additional compelling evidence for large changes in land ecosystem comes from measurements of the seasonal cycle in atmospheric CO_2.

In contrast, there is little evidence that marine ecosystems - at least those remote from coastal influences - have undergone such large changes. While the oceans are absorbing excess CO_2, this is mostly a physical, not a biological, process. But just as the absence of evidence is not evidence for absence, it could just be that we lack strong long-term atmospheric constraints on marine ecosystems. Whereas atmospheric CO_2 data provides a wealth of information on land processes, they do a poor job of resolving ocean biological processes because the buffering chemistry of CO_2 in seawater slows the response of atmospheric CO_2 to processes originating from within the ocean.

This talk will highlight evidence for changes in land ecosystems from measurements and CO_2 and its isotopes, and will illustrate a path forward to resolving changes in marine ecosystems and related impacts on the ocean carbon sink via measurements in atmospheric O_2 concentration, particularly via the tracer "atmospheric potential oxygen" APO, which is effectively the sum of the O_2 and CO_2 concentrations, which shows rich variability of marine origin.

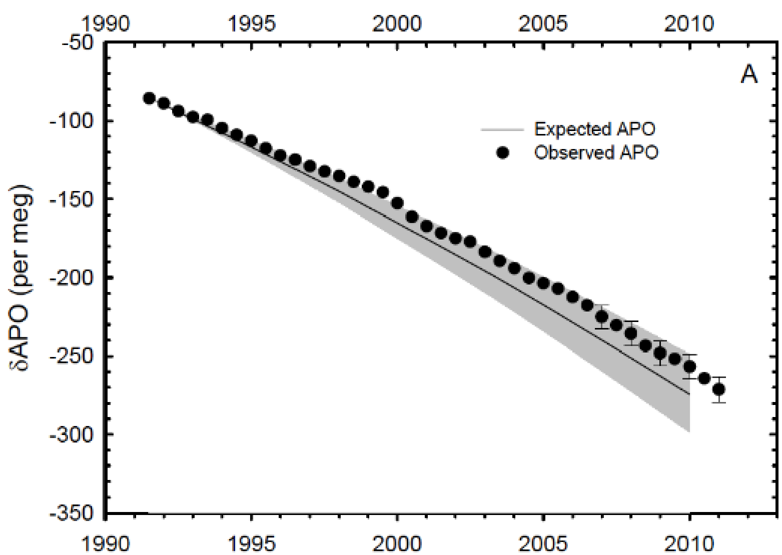

Figure 1. Global average APO derived (black circles) compared to trend computed from a model calculation (line) which accounts for fossil-fuel burning (which depletes APO because burning fossil-fuel consumes more O_2 per carbon than normal respiration) and ocean uptake of anthropogenic CO_2. The APO decrease may also be influenced by air-sea O_2 and CO_2 fluxes driven by processes internal to the ocean, which are neglected in the model.