

INTERANNUAL VARIABILITY IN ATMOSPHERIC POTENTIAL OXYGEN FROM THE SCRIPPS ATMOSPHERIC OXYGEN FLASK SAMPLING NETWORK

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ABSTRACT

The influence of air-sea fluxes on atmospheric oxygen can be separated from terrestrial influences using the tracer Atmospheric Potential Oxygen (APO). Data collected by the Scripps atmospheric oxygen flask sampling network exhibits interannual variability in APO coherent over the northern hemisphere. The timing of these changes correlates with climatic changes in the North Pacific.

ATMOSPHERIC TRACERS OF AIR-SEA FLUXES

Records of atmospheric O₂ and CO₂ concentrations are almost mirror images of each other (Fig. 1). They are dominated by a long-term trend driven by anthropogenic burning of fossil fuels and a seasonal cycle driven by the photosynthesis/respiration of the terrestrial biosphere. The contributions from the terrestrial biosphere can be removed by combining the observed O₂ and CO₂ signals to create the tracer Atmospheric Potential Oxygen (APO) [Stephens *et al.* 1998]:

$$APO = \delta(O_2/N_2) + \left(\frac{1.1}{0.2095}\right)(CO_2 - 350)$$

where the factor 1.1 is the ratio of CO₂ to O₂ consumed during photosynthesis or produced during respiration [Severinghaus 1995], and the factors 0.2095 and 350 just serve to convert between units of ppm and per meg and to normalize the CO₂ concentrations. The resultant observed seasonal cycle in APO is mainly driven by air-sea fluxes of O₂, because the air-sea equilibration time of O₂ is about ten times faster than that of CO₂. APO also shows a distinct long-term trend driven both by burning of fossil fuels (CO₂/O₂ = 1.4) and by ocean uptake of CO₂ [Stephens *et al.* 1998].

DATA AND DISCUSSION

We present measurements of APO from nine locations around the globe in the Scripps Institution of Oceanography atmospheric oxygen flask sampling network, with measurements extending back as far as 1990 for some stations. After removal of the long-term trend and local seasonal cycles, similar patterns

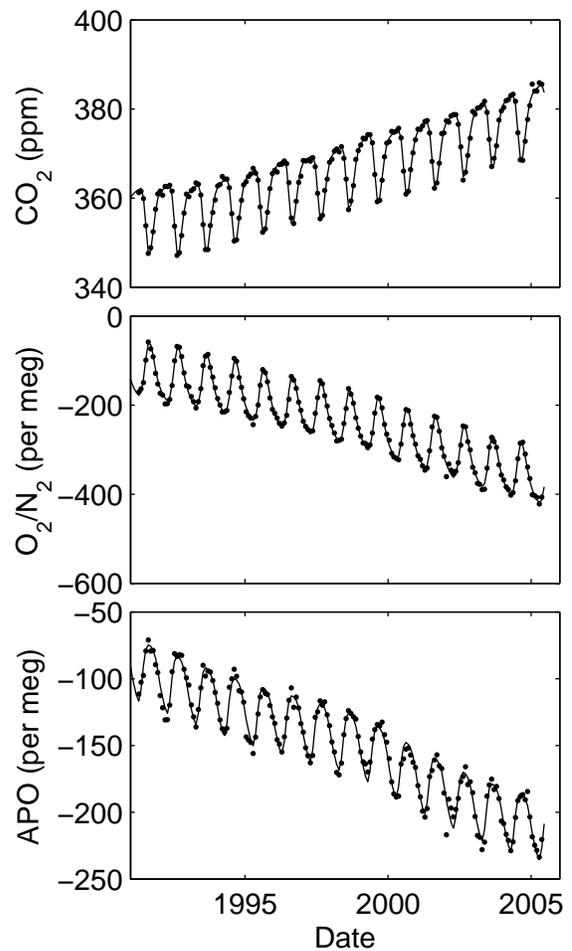


Fig.1 – Monthly averages of atmospheric CO₂ (ppm), O₂ (per meg) and APO (per meg) measured in flasks collected at Alert (82°31'N 62°21'W). Note the expanded scale for APO.

of interannual variability are visually evident among the northern hemisphere stations. A principal component analysis confirms that the dominant mode of variability is coherent over the northern extra-tropics. In these northern hemisphere stations, APO increases to a maximum in 1999, followed by an abrupt two year decrease (Fig. 2).

The timing of this maximum appears to correlate with climatic anomalies in the North Pacific, including sea surface temperature patterns and zonal wind speed changes. We explore the possible mechanisms driving the observed variability in APO, which may be caused by persistent large-scale changes in gyre circulation and ventilation, sea surface temperature, biological production and/or wind-driven gas exchange [McKinley *et al.* 2000]. By understanding the source of this interannual variability, we continue to develop APO as an

integrative tracer of large-scale gas fluxes between the atmosphere and ocean. This in turn will lead to better constraints over ocean uptake of anthropogenic CO₂ [McKinley *et al.* 2003], the kinetics of gas exchange [Keeling *et al.* 1998], and variability in ocean models [Stephens *et al.* 1998].

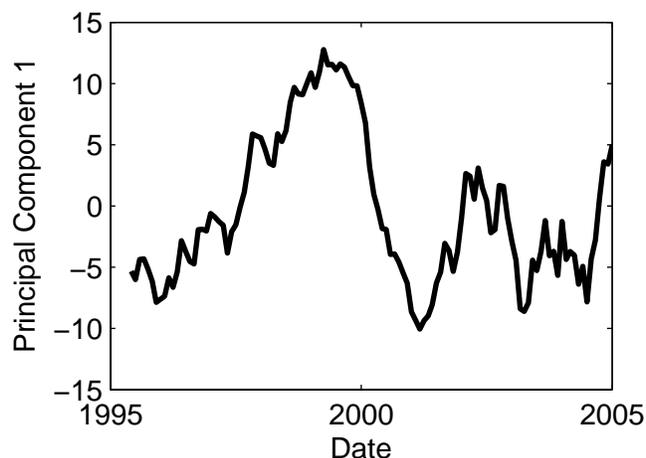


Fig. 2 Time-series of the leading principal component of interannual APO variability. This EOF was derived from monthly APO anomalies treated with a 6 month running mean, measured at the six longest-running locations.

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