MEASUREMENTS AND MODELS OF ATMOSPHERIC POTENTIAL OXYGEN (APO)

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ABSTRACT

Measurements of atmospheric O_2/N_2 ratios and CO_2 concentrations can be combined to form the tracer Atmospheric Potential Oxygen (APO), reflecting primarily ocean biogeochemistry and atmospheric circulation. Building on the work of Stephens *et al.* [1998], we present a new set of APO observations including shipboard collections from the equatorial Pacific. Our data show a smaller interhemispheric gradient than observed in past studies and a substantial APO maximum around the equator. Following a modeling approach developed by Gruber *et al.* [2001], we compare these observations with APO fields generated by a set of oceanic and atmospheric models. Overall, our model results agree well with observations, but small differences suggest that modeled north-south transport may be too vigorous, air-sea fluxes may be too coarsely resolved in some regions, and seasonal trapping of surface fluxes may be excessive in some model locations.

Our dataset comprises measurements of atmospheric O_2/N_2 and CO_2 from the cooperative air sampling networks run by Princeton University and Scripps Institution of Oceanography [*Bender et al.*, 2005; *Keeling et al.*, 1998]. Our data cover the period from 1996-2003 and include observations taken on ships of opportunity sailing in central Pacific during this time. In addition to the O_2/N_2 and CO_2 values, many of these samples have associated Ar/N2 measurements. We use these Ar/N2 measurements to correct the O_2/N_2 values for site-specific biases, since the true spatial gradients in Ar/N_2 are expected to be very small [*Keeling et al.,* 2004], and processes which bias the Ar/N_2 values tend to also bias O_2/N_2.

Using these observations, we create a climatological annual-mean north-south gradient in APO. The data are somewhat sparse both temporally and spatially, so we adopt two different methods of filling gaps: a 2-dimensional interpolation scheme and a set of fits to seasonal cycles. Both give similar results (Fig. 1).

To interpret these gradients, we follow the method developed by Gruber *et al.* [2001], and use empirically based estimates of air-sea O_2, N_2 and CO_2 fluxes as the lower boundary condition for the TM3 atmospheric model [*Heimann and Körner*, 2003]. We process the model output and data identically.

The dominant feature of the observations is a low-latitude maximum in APO, reflecting the vigor of equatorial upwelling and accompanying fluxes of nutrients, dissolved gasses and heat. There is also a small interhemispheric gradient. Both of these features are reproduced well by our model. We have also examined the climatological seasonal cycles of APO at various locations, which are generally matched by the model. Some data-model differences do exist, but comparison with other work shows that the choice of atmospheric transport model can change the modeled APO values enough to resolve many of the data-model discrepancies. Another possible explanation for some of these differences is the limited spatial resolution with which the air-sea gas fluxes are resolved. Finally, we note that our observed interhemispheric gradient is significantly smaller than earlier studies, pointing to a significant temporal trend in this quantity.

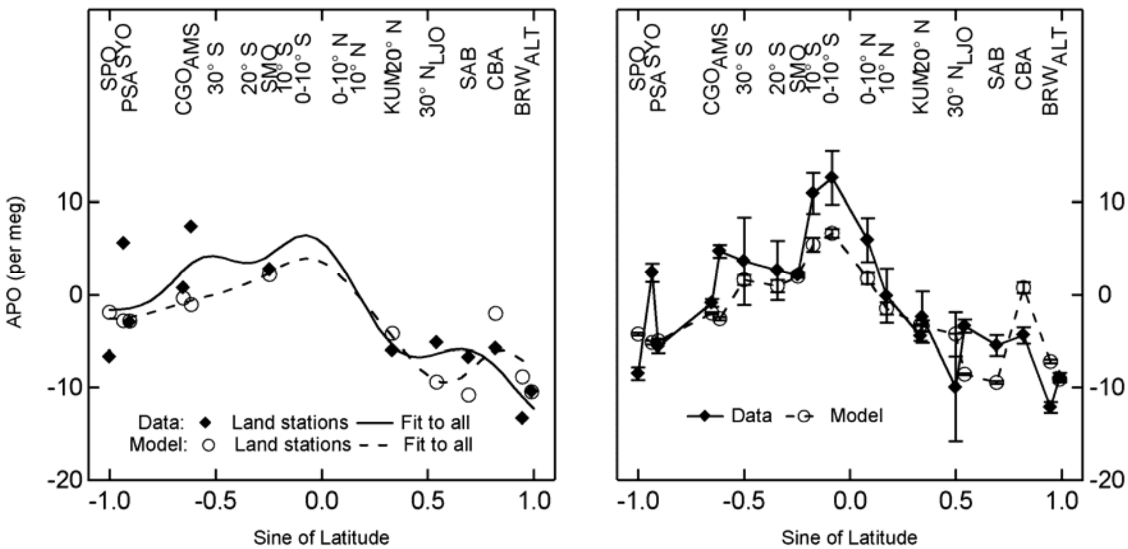

Fig. 1: Observations and models of the north-south APO gradient. The left panel shows a 2-dimensional interpolation between observations. Lines are determined by both the land stations and shipboard data (not shown). The right panel shows values derived from fits to seasonal cycles. Error bars reflect only uncertainty in the fits to the seasonal cycles and lines between points simply guide the eye.

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