Two decades of atmospheric O_2 measurements and their implications

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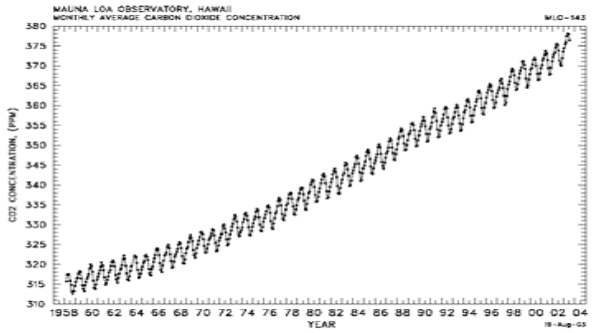
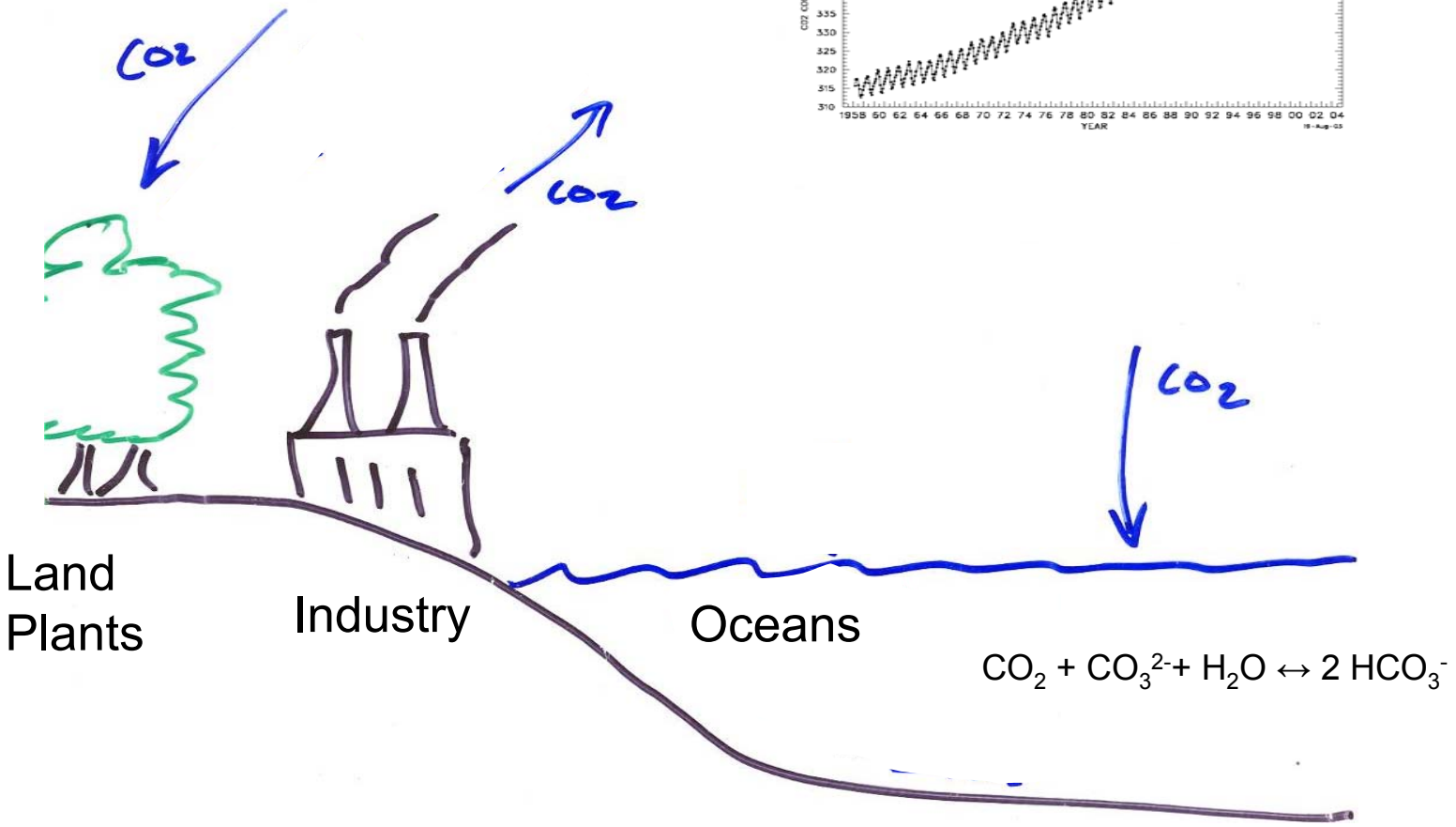
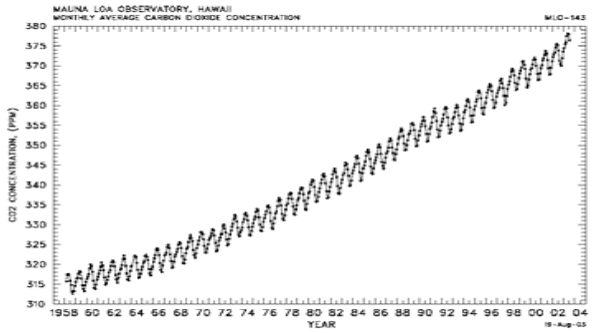
Controls on atmospheric CO_2 increase

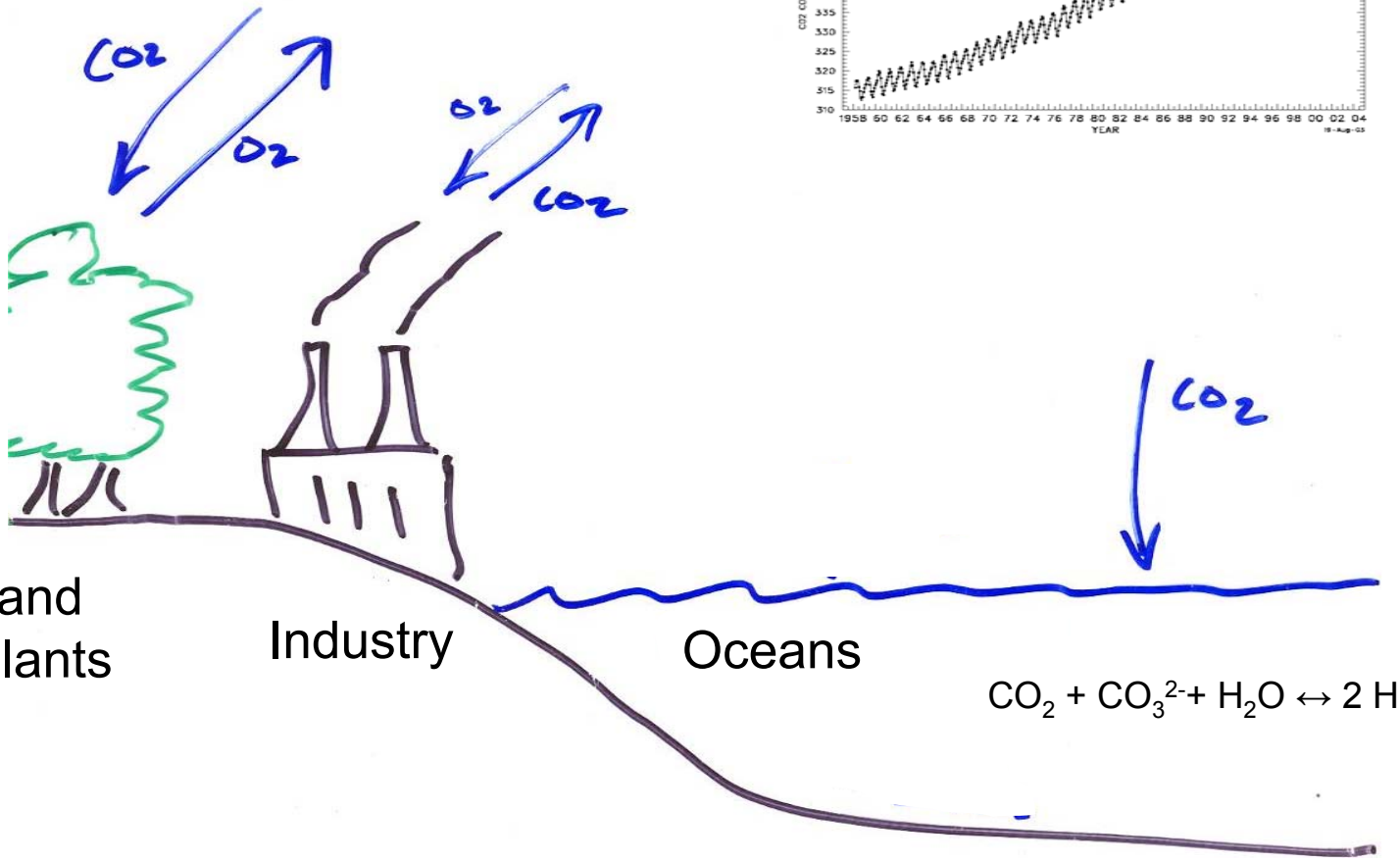




$CO_2 + CO_3^{2-} + H_2O \leftrightarrow 2\ HCO_3^-$

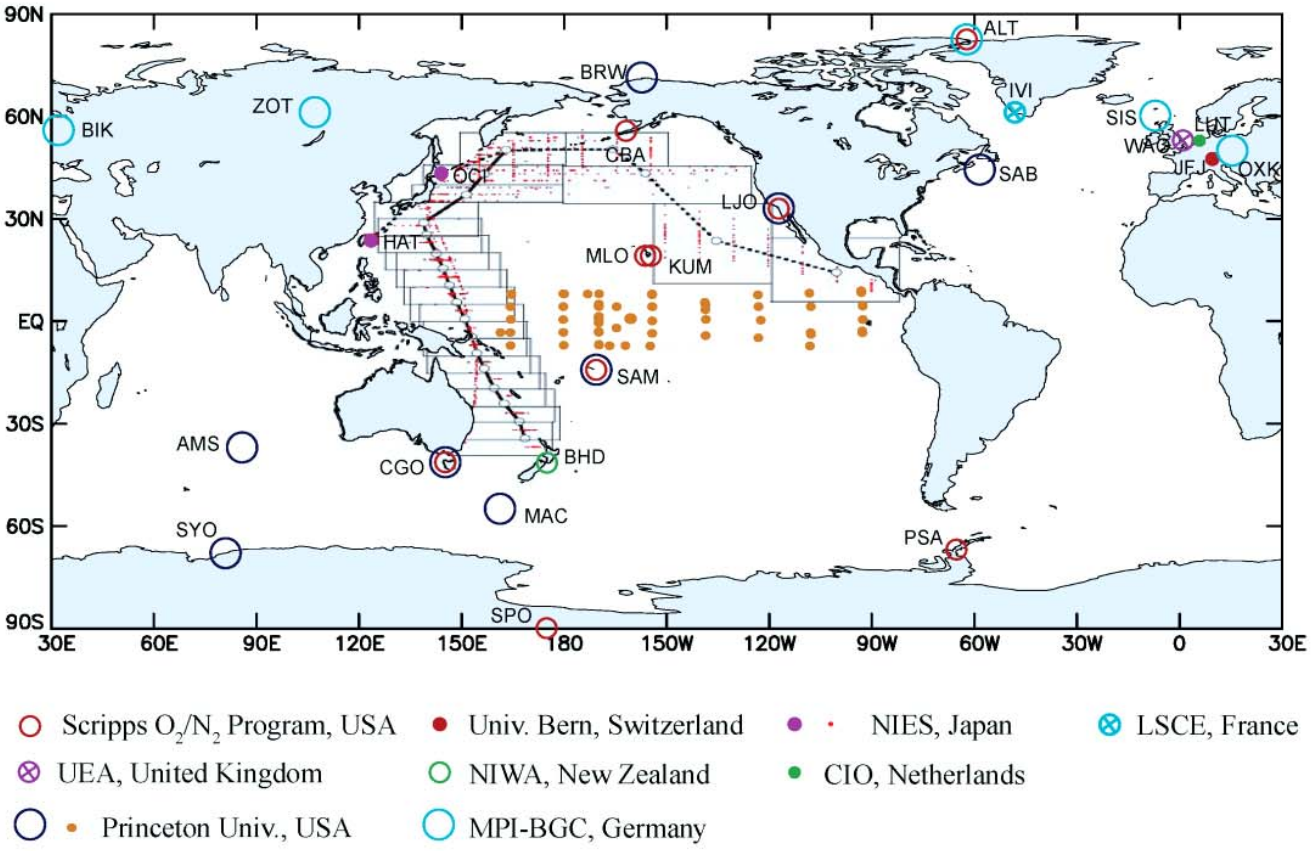
Controls on atmospheric CO_2 and O_2



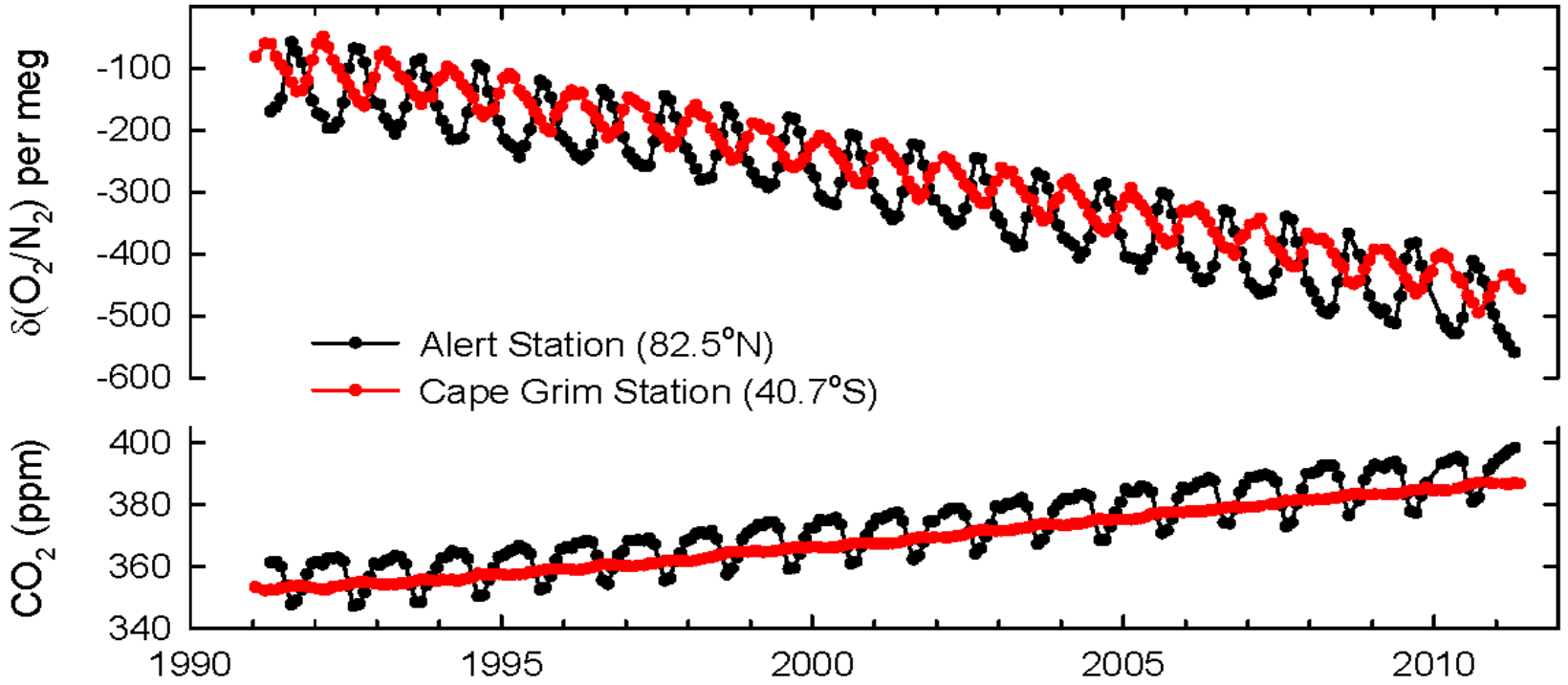


$CO_2 + CO_3^{2-} + H_2O \leftrightarrow 2\ HCO_3^-$

Evolving global O_2/N_2 measurement network



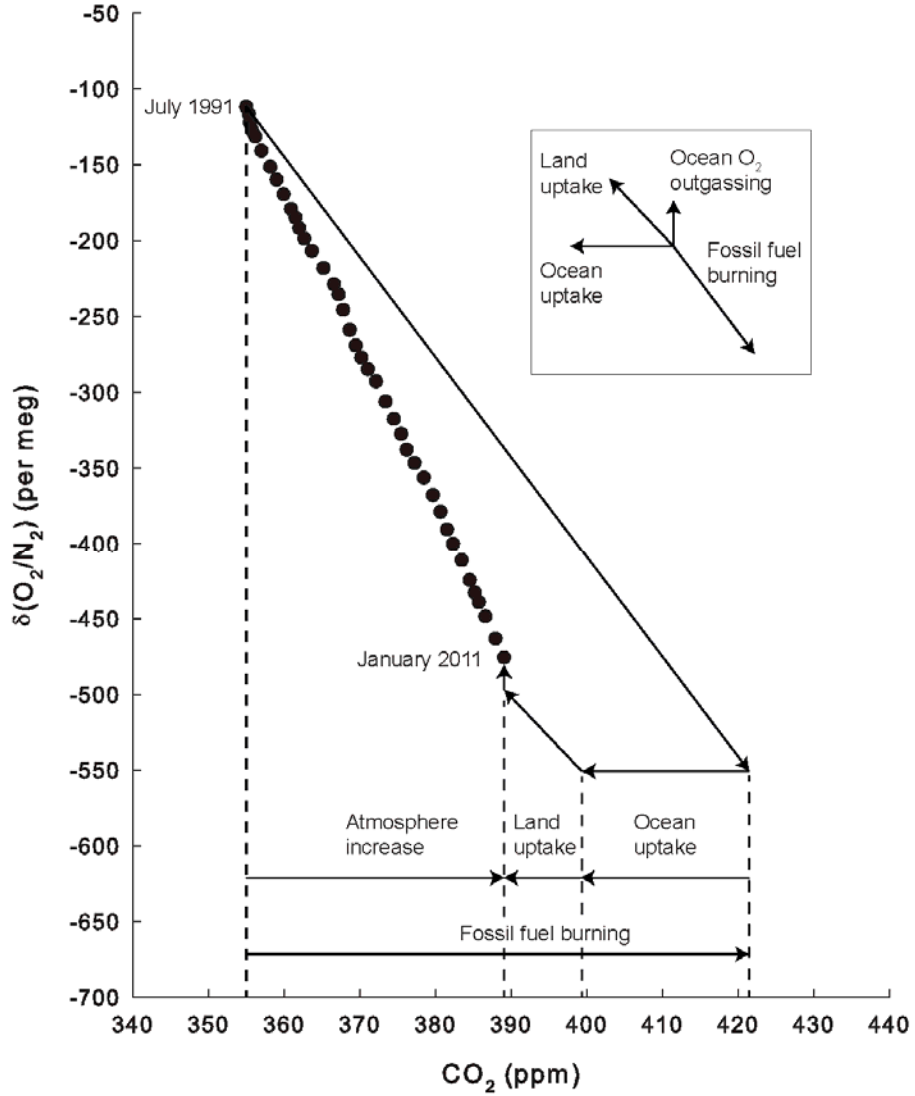
O_2/N_2 and CO_2 trends



$$\delta(O_2/N_2) = \frac{(O_2/N_2)_{sample} - (O_2/N_2)_{reference}}{(O_2/N_2)_{reference}}$$

4.8 per meg ~ 1 ppm

Vector diagram of O_2 and CO_2 changes



Budgets in different periods

Time frame	Fossil-fuel Pg C yr^{-1}	Atm. CO_2. Pg C yr^{-1}	Ocean sink Pg C yr^{-1}	Land sink Pg C yr^{-1}
1990-2000	6.39 (0.38)	3.23 (0.04)	1.83 (0.57)	1.33 (0.75)
2000-2010	7.81 (0.47)	4.04 (0.04)	2.61 (0.55)	1.16 (0.80)
1991.5-2011	7.24 (0.43)	3.74 (0.02)	2.34 (0.52)	1.16 (0.75)

Land-sink implication

O_2-based land sink = 1.2 ± 0.8 (1991.5 - 2011)

Land Sink = Land use emission - Residual sink

Recent land-use emission ~ 1.3±0.8

Residual sink ~ 2.5 ± 1.1

Units: Pg C yr^{-1}

Ocean sink implication

O_2-based ocean sink: 2.34 ± 0.55 (1991.5 - 2011)

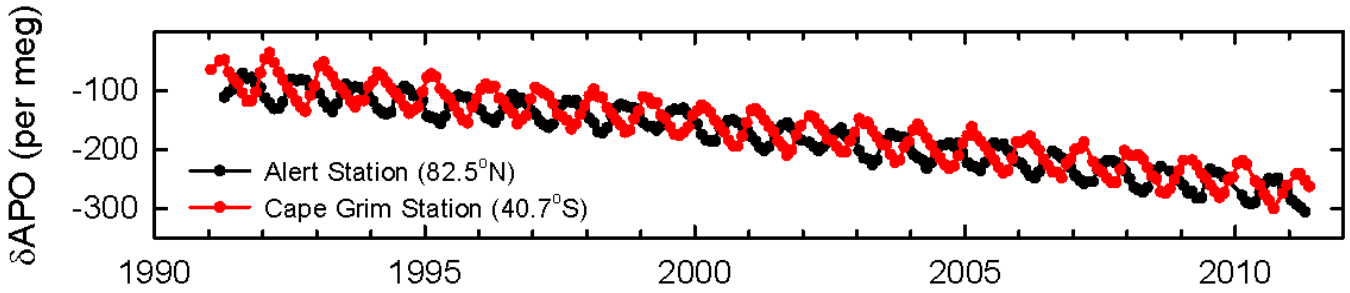
CFC-based ocean sink: 2.3 ± 0.6
(Khatiwala et al., 2009)

Units: Pg C yr^{-1}

Comparison places bounds on non-anthropogenic effects on ocean CO_2 uptake CO_2

Trend in APO

$$APO \approx O_2 + 1.1\ CO_2$$



Global trend in APO

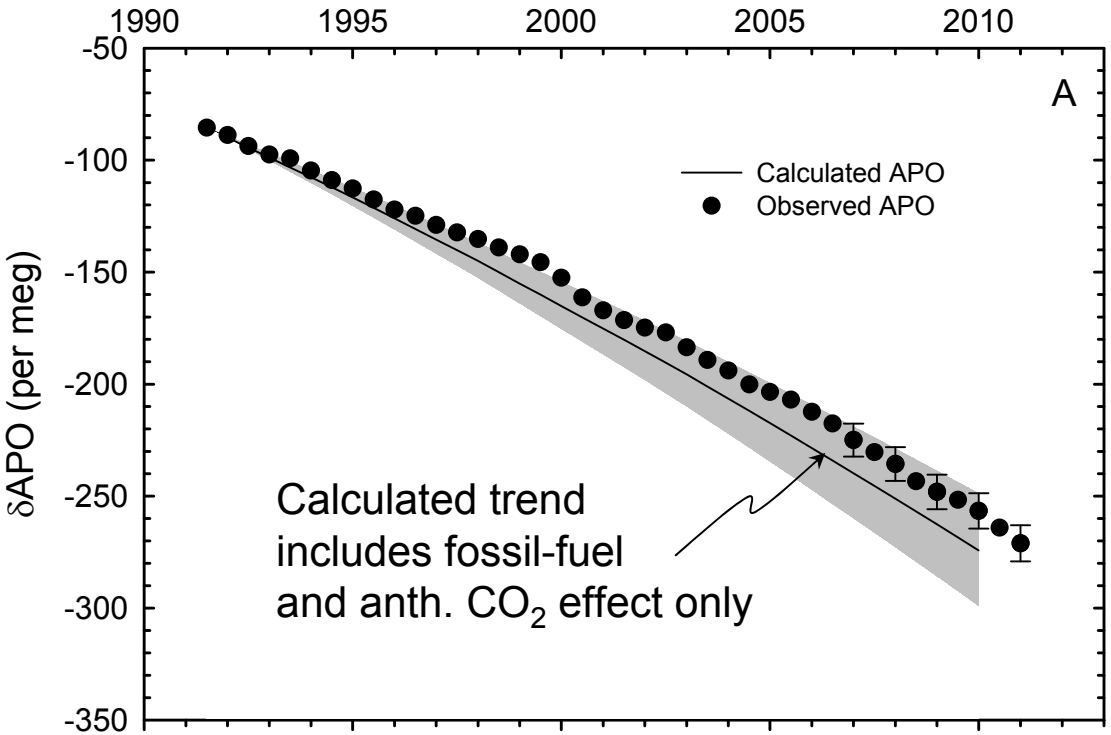
<u>Contributions to APO trend</u>

Fossil-fuel effect
Ocean uptake of CO_2*
Ocean impact on O_2
Ocean impact on N_2

*Includes

(1) contributions forced by changes in atmosphere i.e. "anthropogenic CO_2"

(2) contributions from by changes within oceans

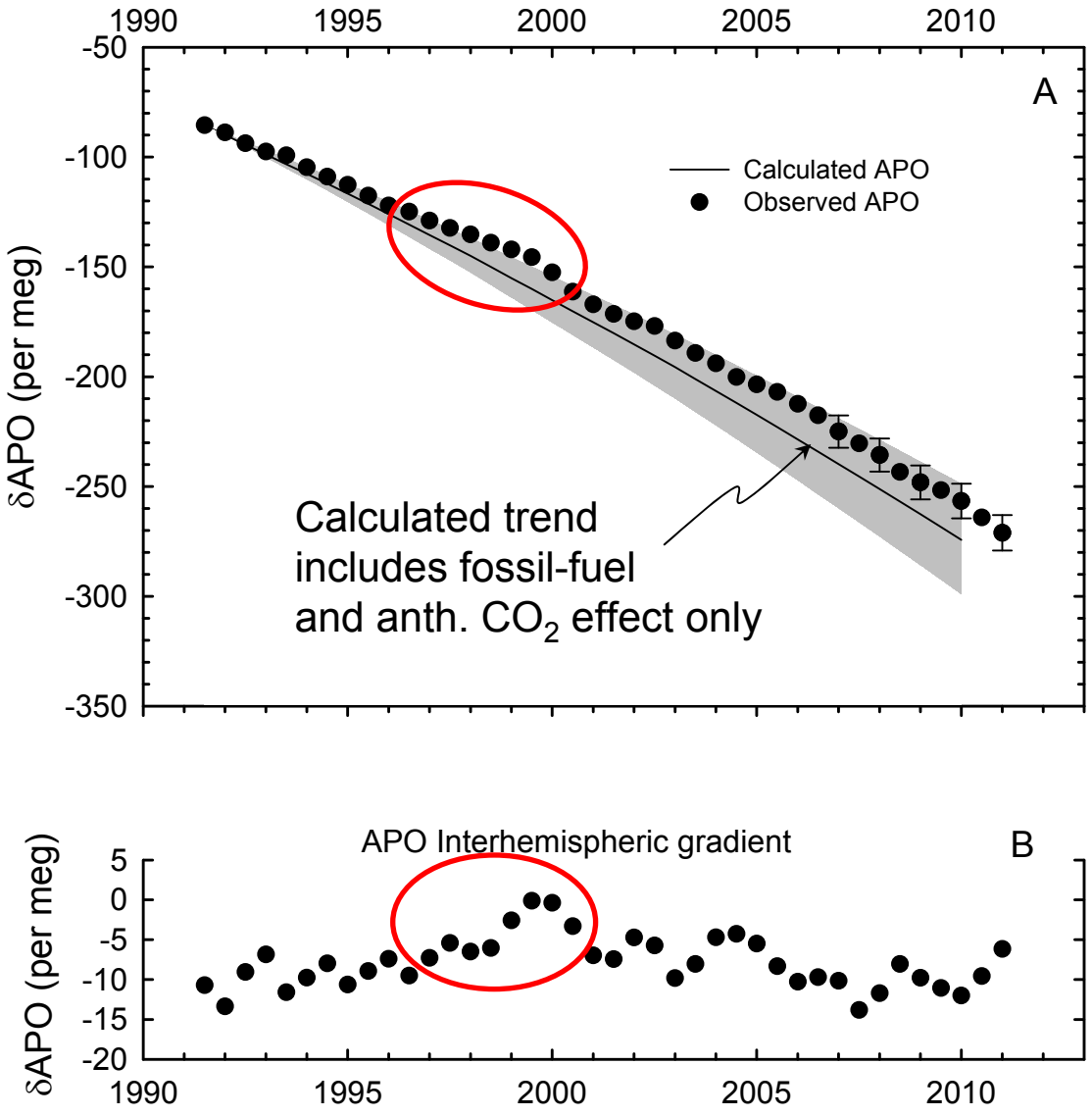


Global trend in APO

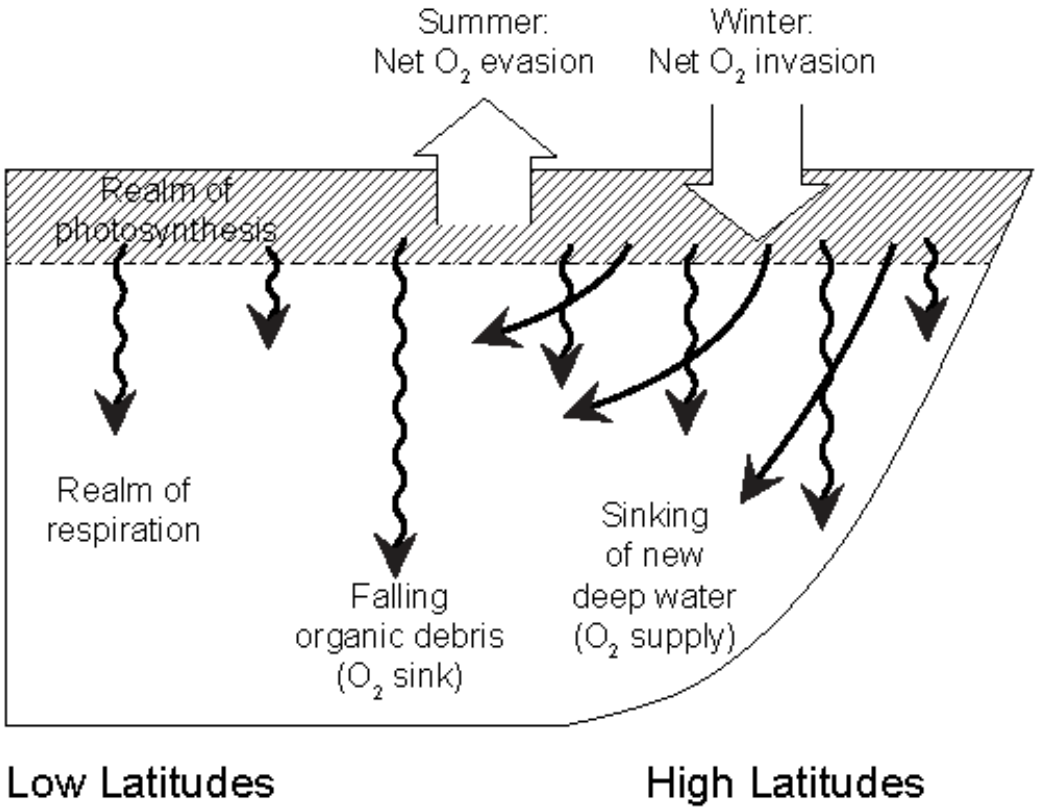
1996-2006 feature seen in both global anomaly and gradient.

Anomaly is mostly in Northern Hem.

Impacts decadal budgets 1990-2000 and 2000-2010



Seasonal Cycles in O_2/N_2

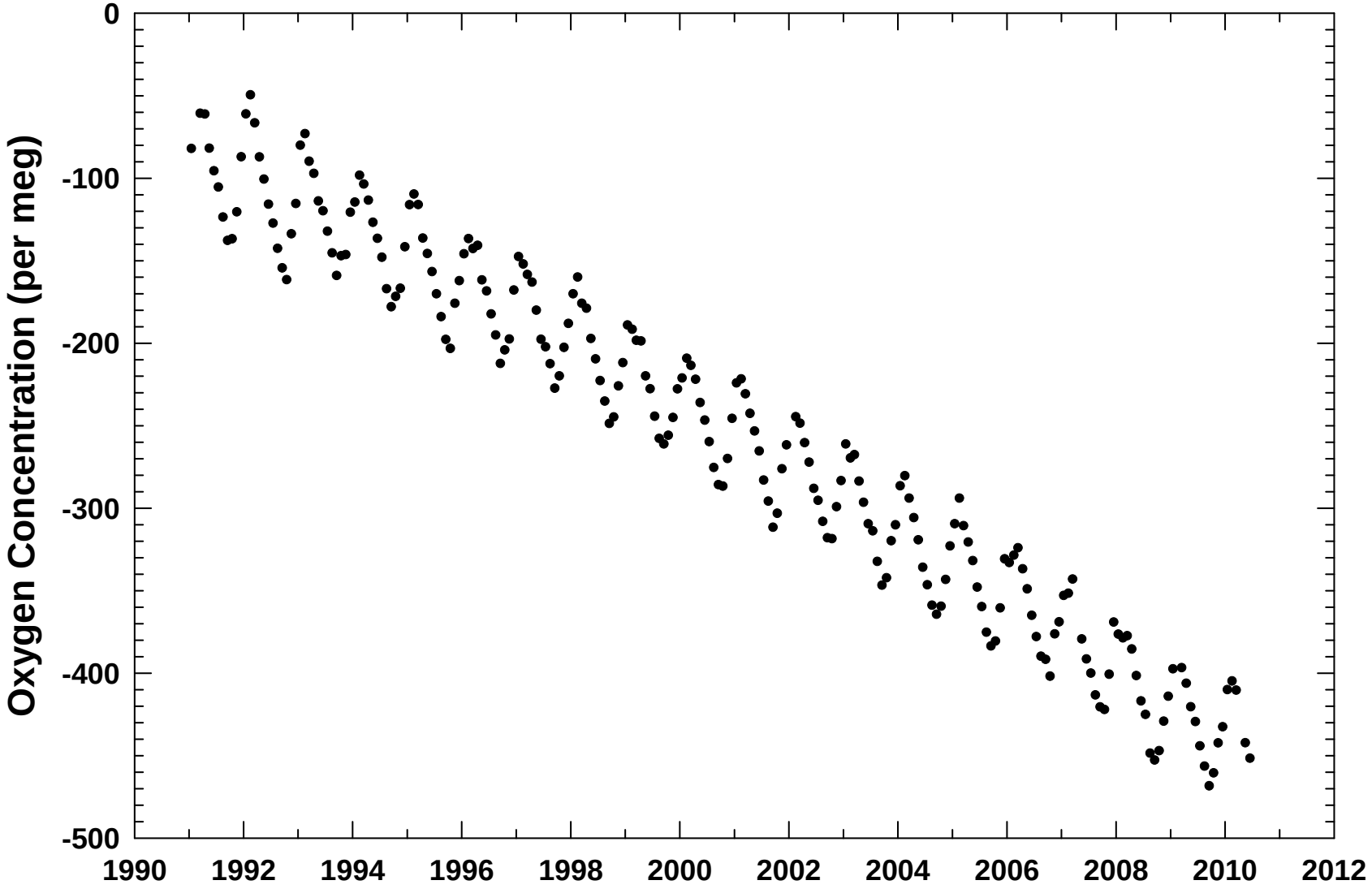


How is ocean productivity changing with time?

Boyce et al. (2010) Nature 466, 591-692 suggest 1% per year decline in ocean biomass, possibly linked to warming.

Can we see evidence of a perturbation of this magnitude in the O_2 cycles?

Cape Grim (41°S)



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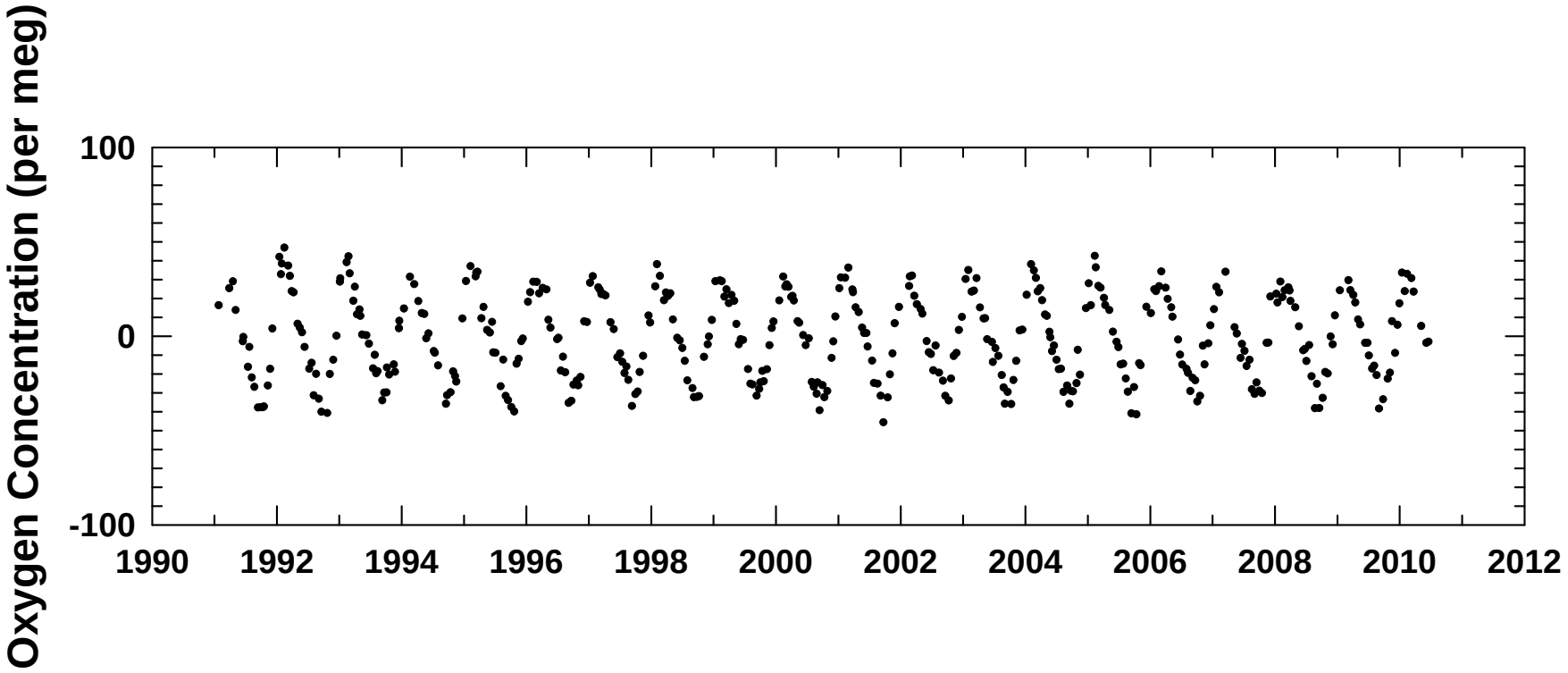

Thank You