Measurements of atmospheric O_2 and future carbon budgeting

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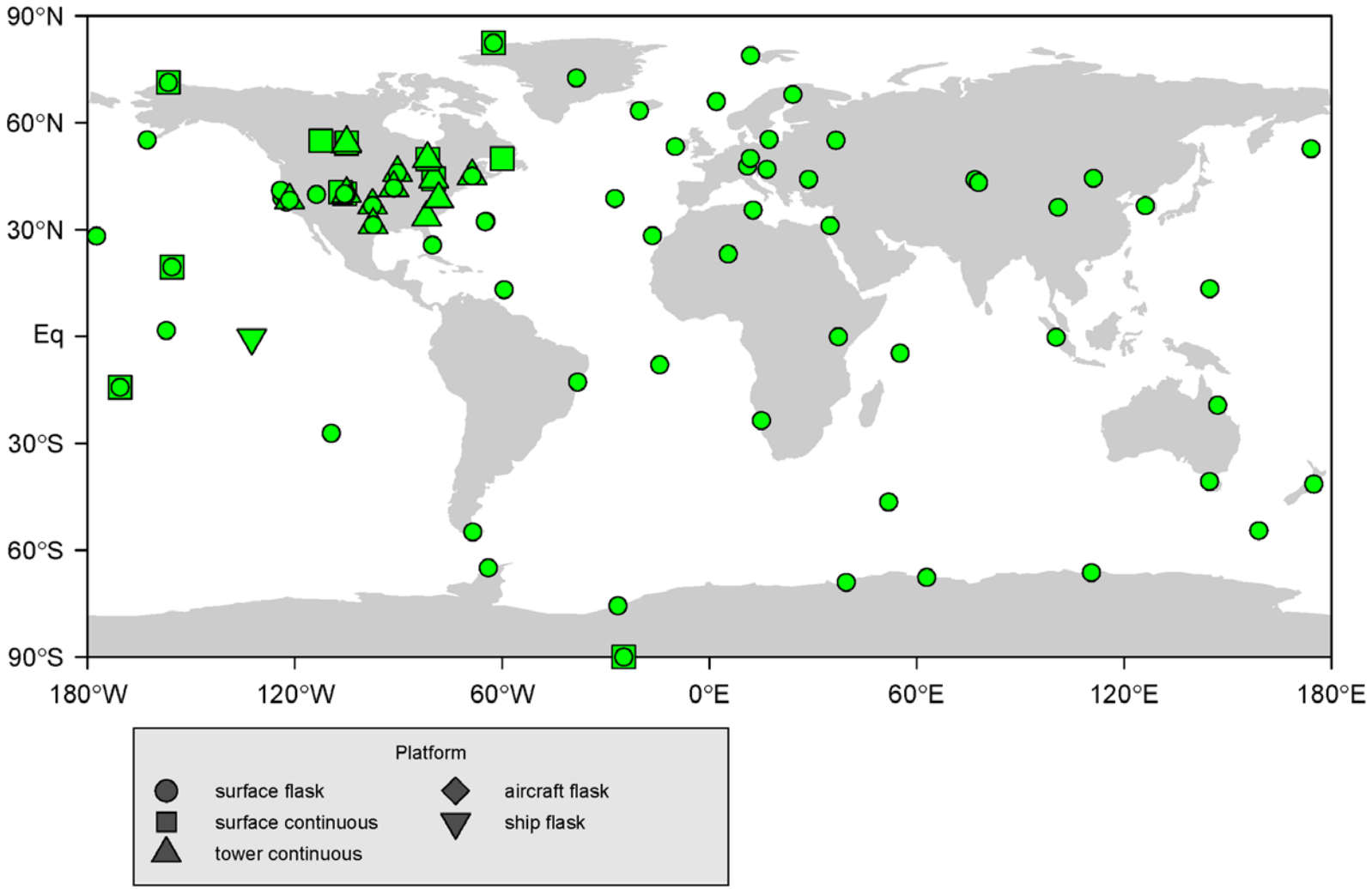
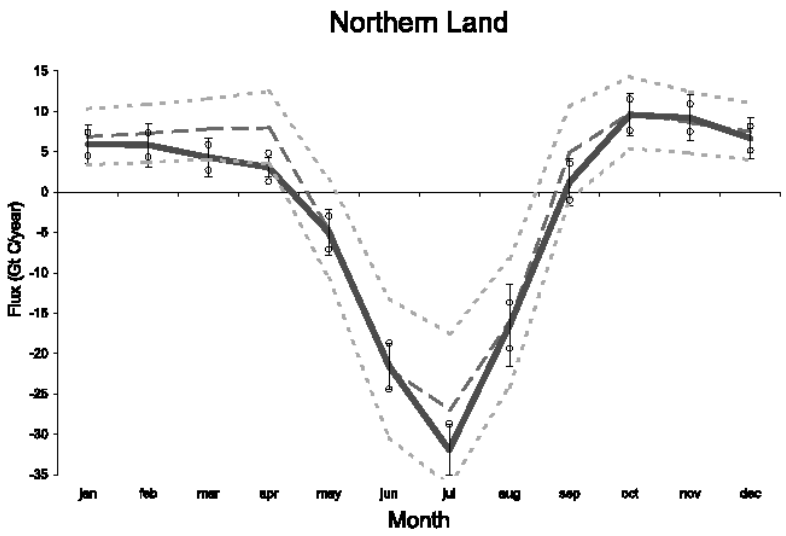
Outlook circa 1990

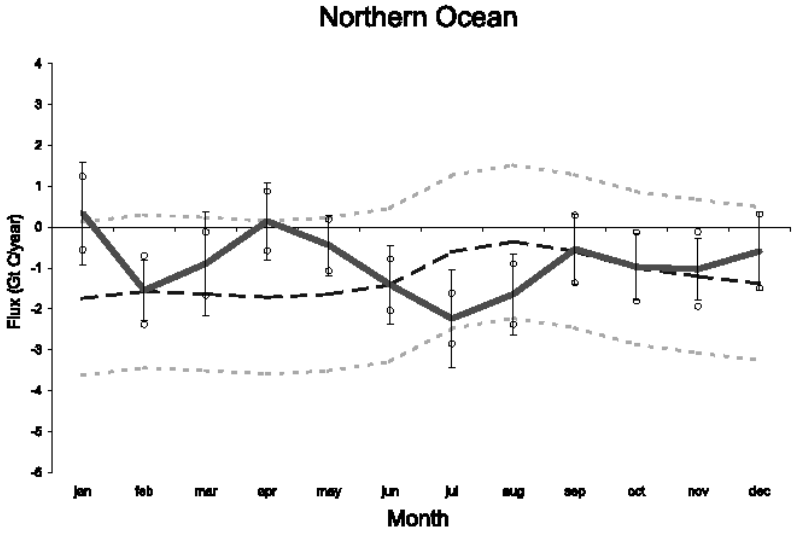
- Missing sink problem
- Tans et al 1990 on northern terrestrial Sink

Carbon Tracker Network



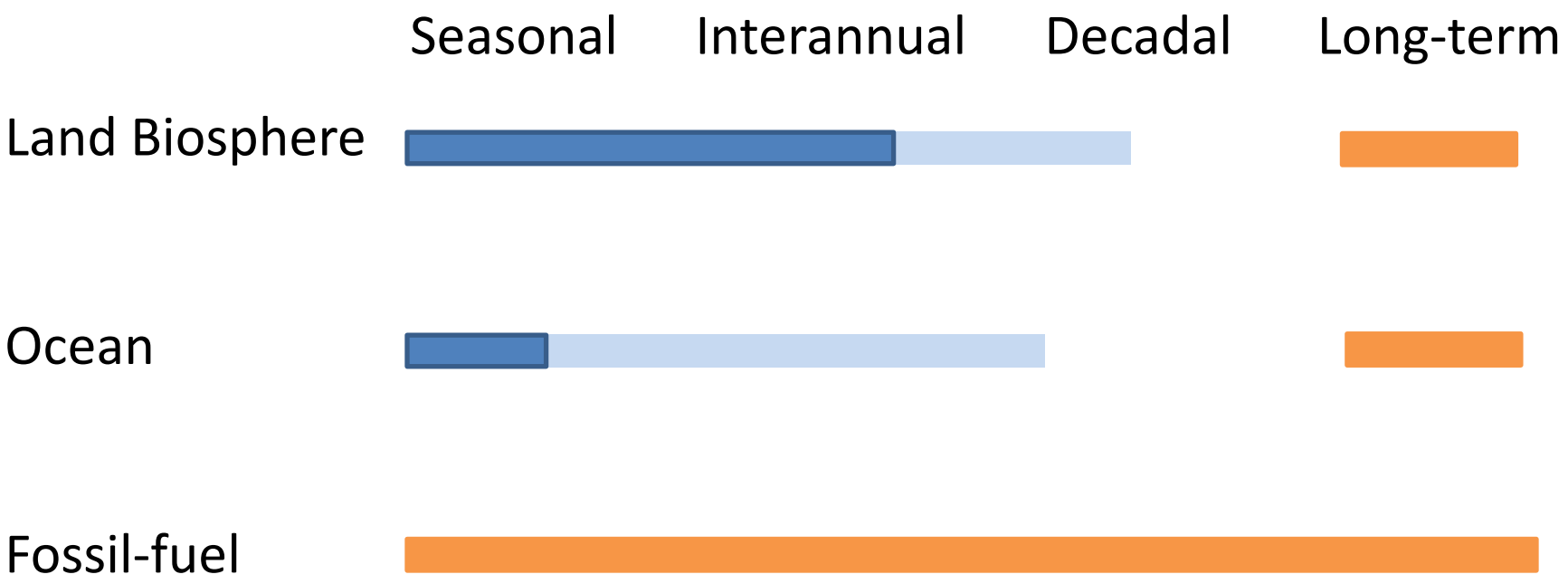
Inversion results, Transcom example





From Gurney et al (2004) Transcom 3

Current capabilities from inverse calcs



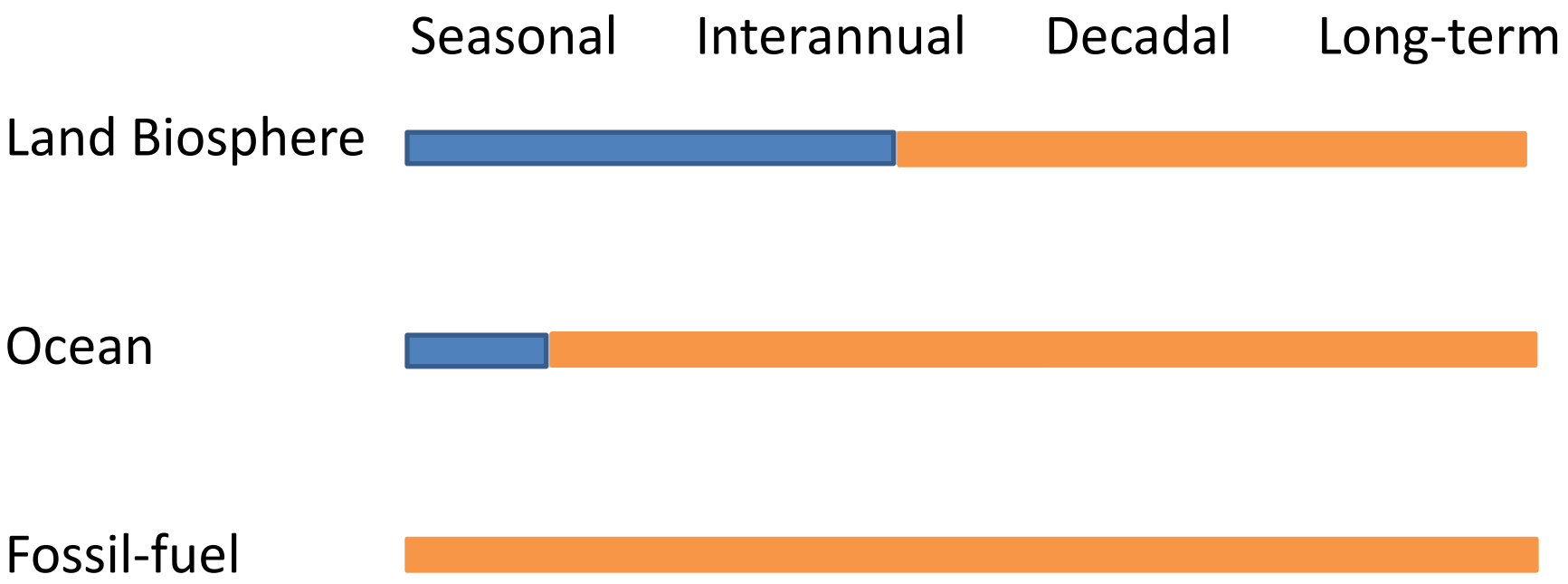
Ocean fluxes in carbon tracker

- Priors from inverse ocean calculation
- Assumes steady ocean circulation
- CO_2 fluxes driven by atmosphere alone
- Neglect fluxes driven by circulation/biology changes
- Defensibly state of the art

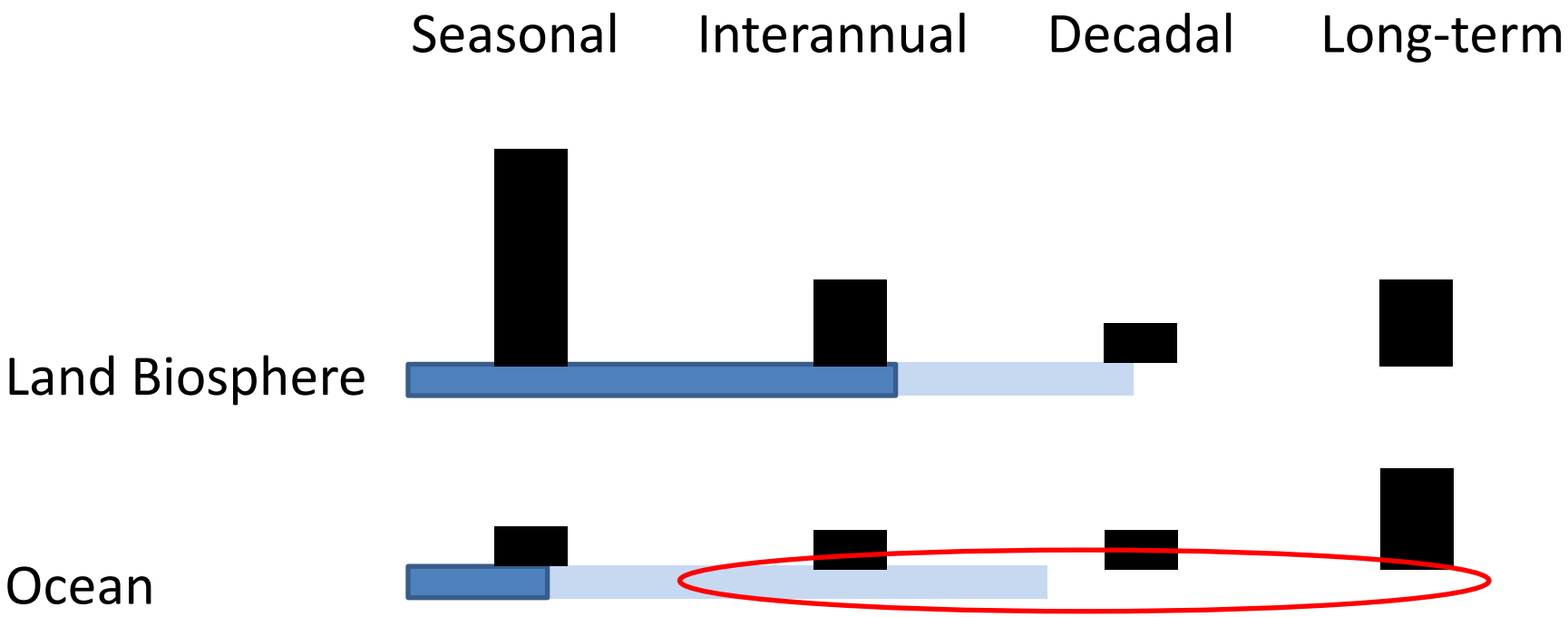
How can we improve flux estimates on longer time scales?

- Increase spatial resolution of observations(?)
- Improve the constraints on ocean fluxes

Current capabilities from inverse calcs



Current capabilities from inverse calcs



Other constraints on oceans

Repeat hydrography (very coarse in space and time)

Argo float program (essentially no chemistry)

Ocean time series (very few in number)

Satellite ocean color (skin deep, continuity issues)

pCO_2 surface obs (very sparse in most regions)

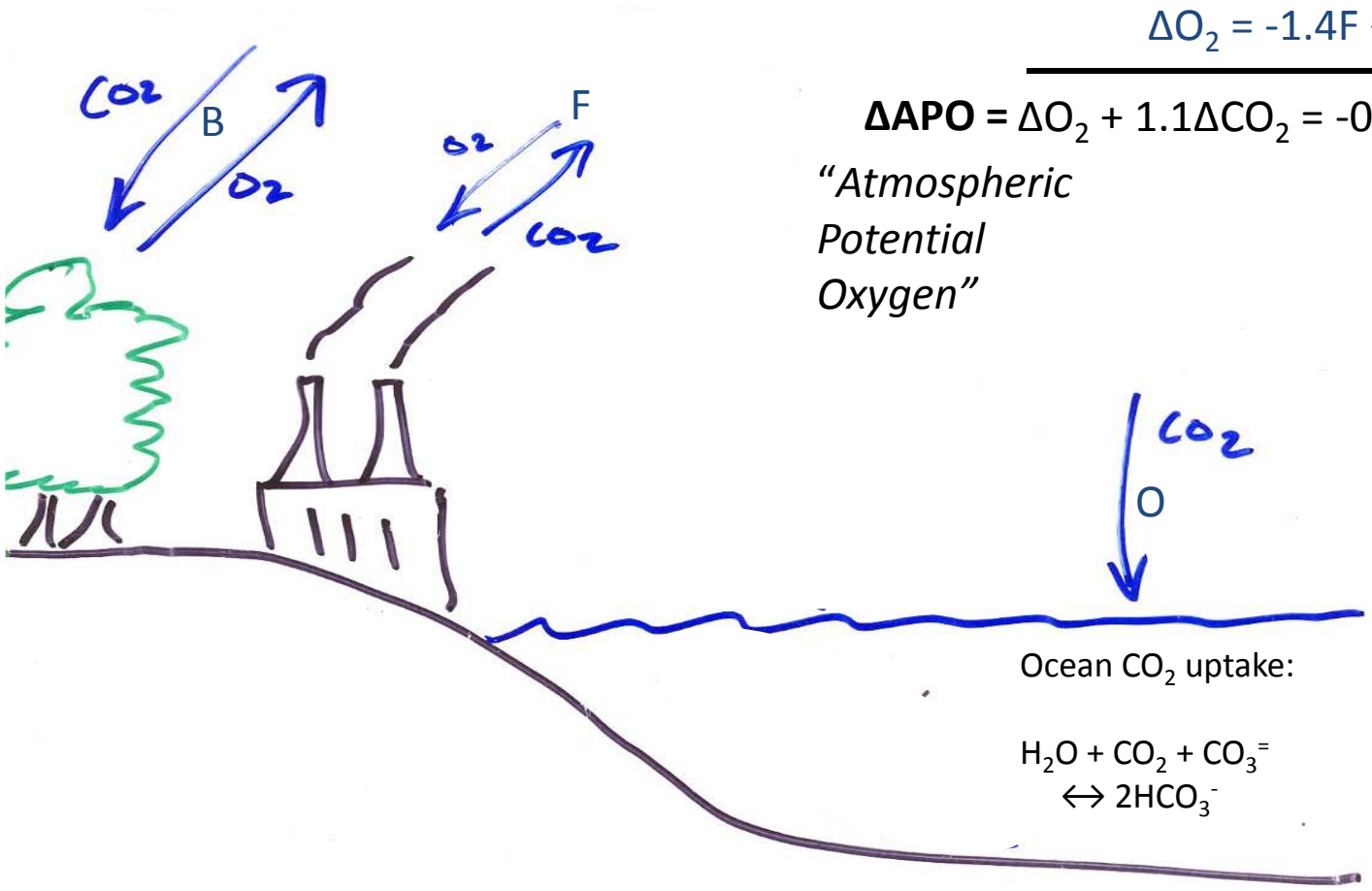
Atmospheric CO_2 & O_2 budgets

$\Delta CO_2 = F - O - B$

$\Delta O_2 = -1.4F + 1.1B$

ΔAPO = $\Delta O_2 + 1.1\Delta CO_2 = -0.3F - 1.1O$

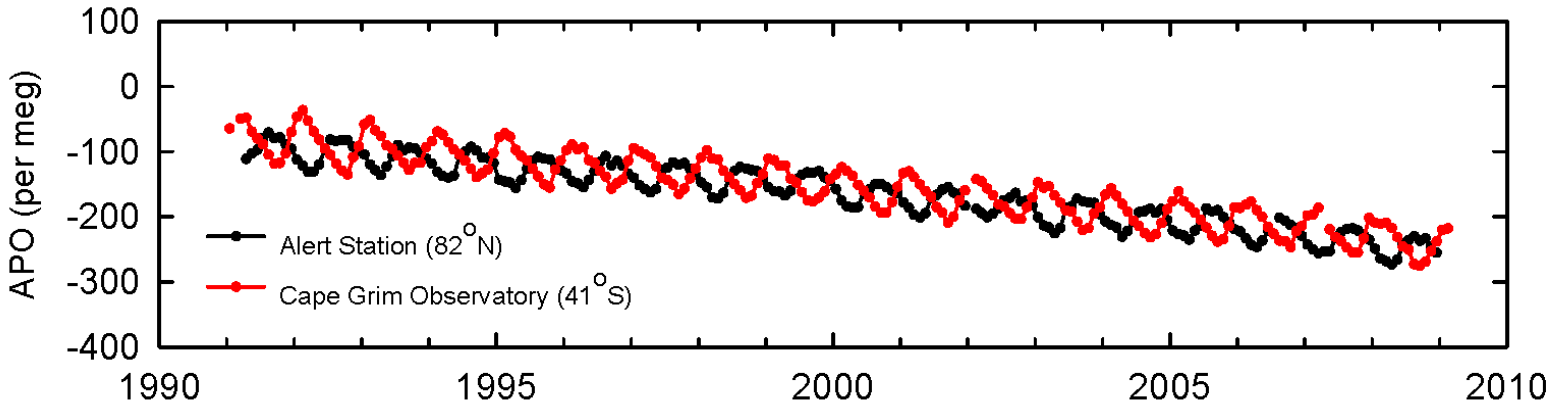
"Atmospheric Potential Oxygen"



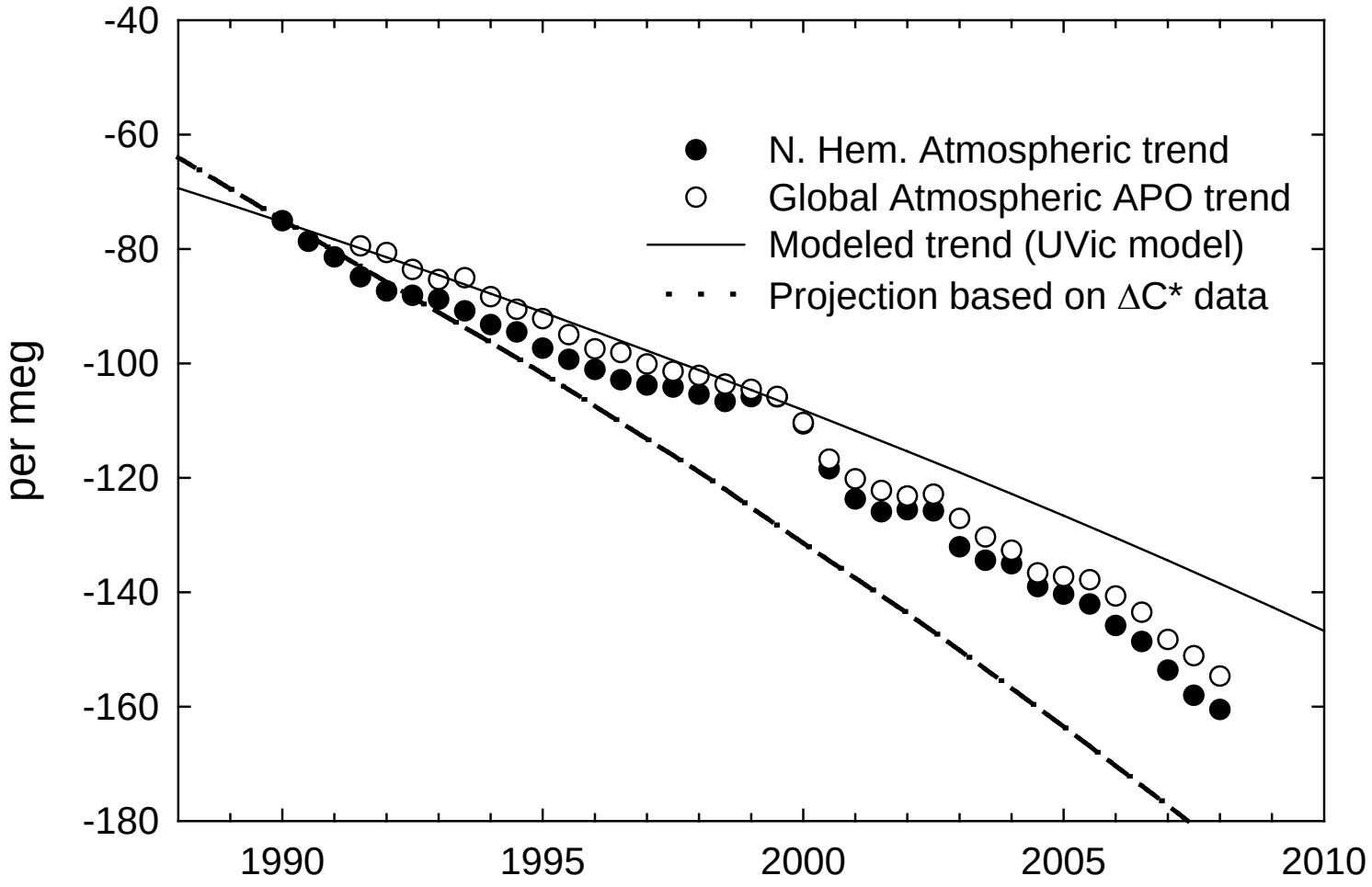
Ocean CO_2 uptake:

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

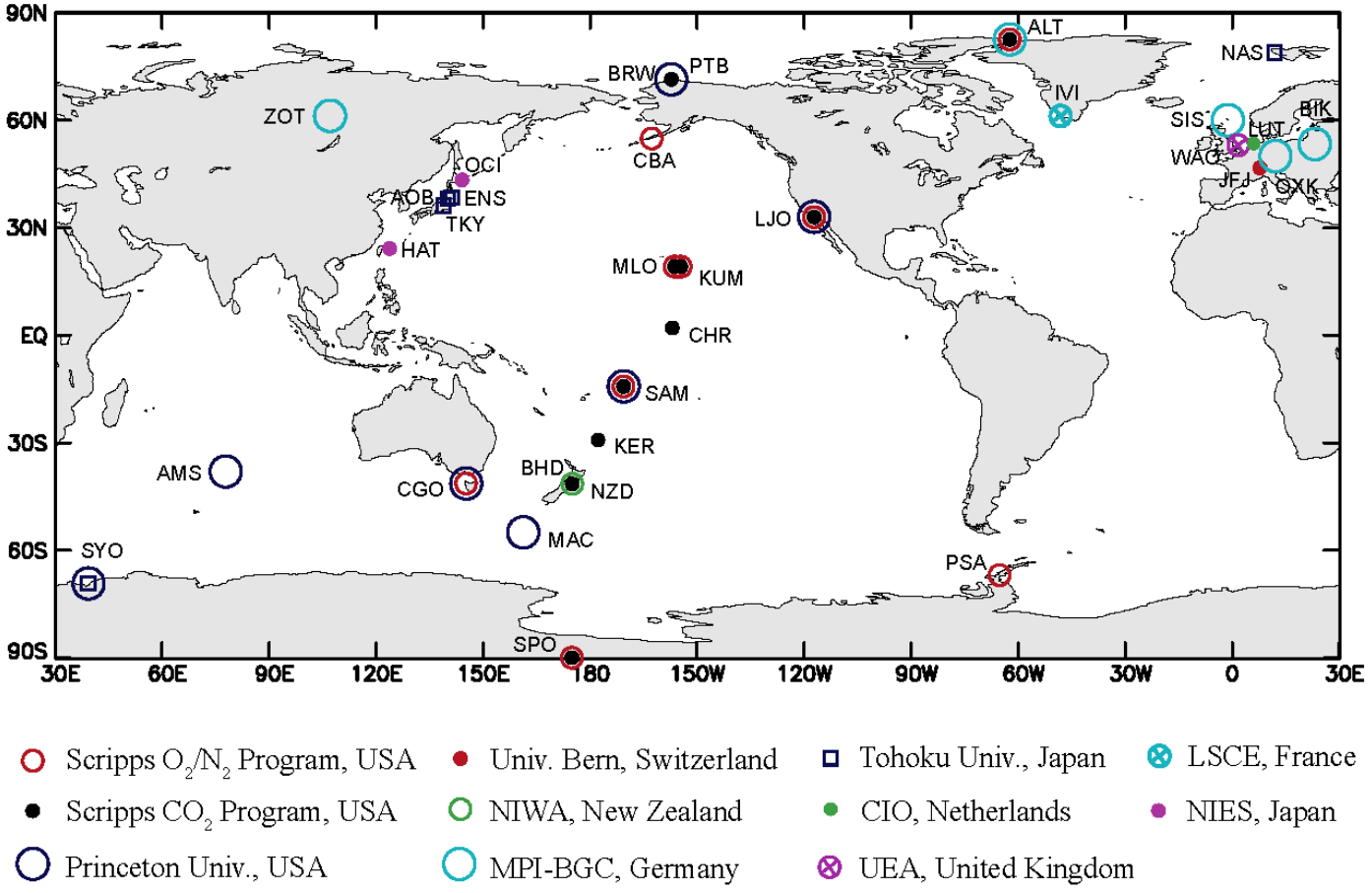
Northern and Southern APO records



Fossil-fuel corrected APO trend



Stations with atmospheric O_2 observations



Recap

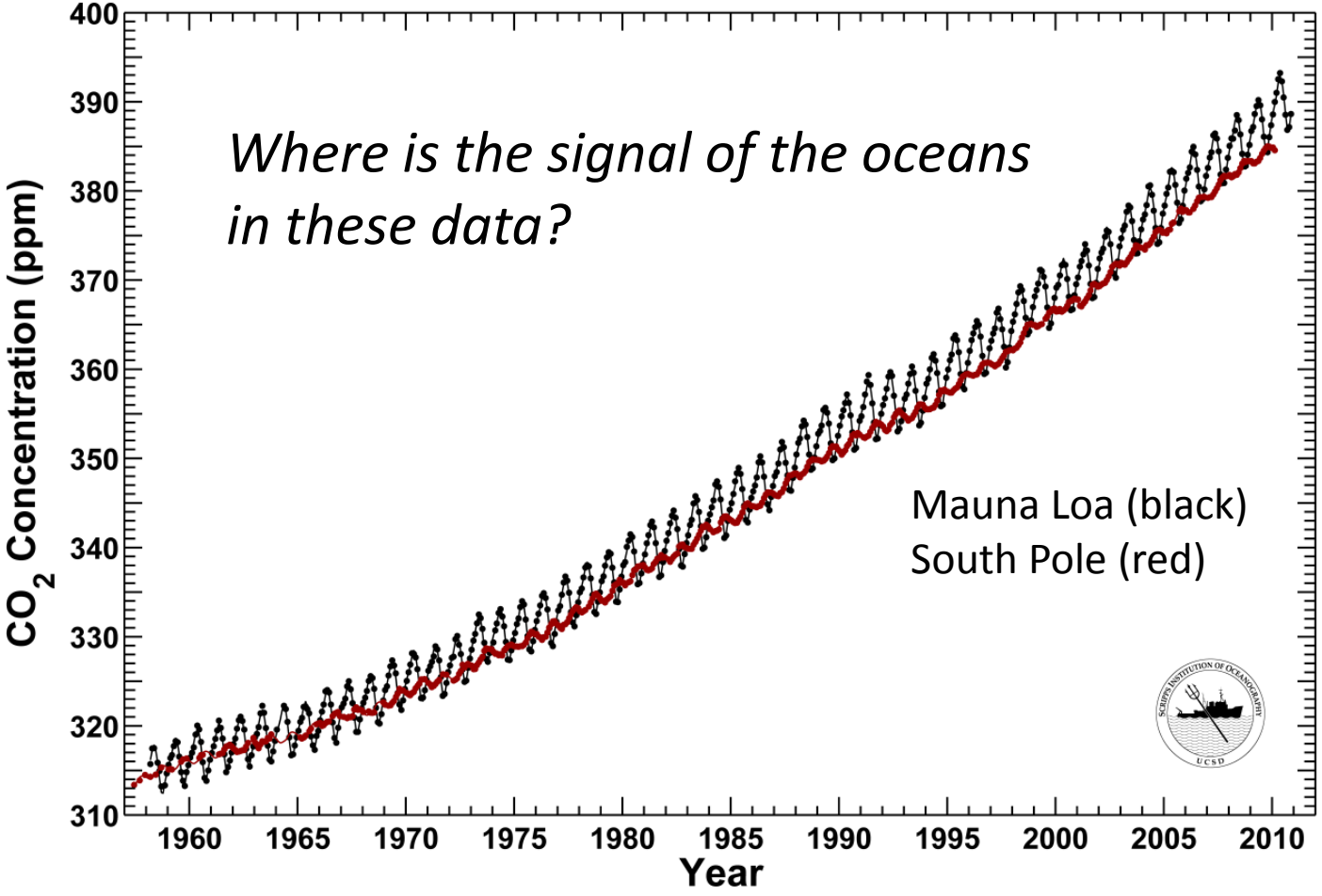
- To make CO_2 network relevant to climate problem need to solve problem of how to constrain ocean CO_2 flux variations on decadal time scales.

- O_2 data are highly relevant to this goal

  -20-year records exist

  -constrain processes controlling air-sea CO_2 fluxes on all relevant time scales

Northern and Southern CO_2 records



What are key steps going forward?

- Incorporate O_2 observations into data assimilation systems, such as CarbonTracker.

- Move towards inversions that optimize processes controlling fluxes rather than the fluxes themselves.

- Enhance ocean modeling component to assimilate changing ocean physics (e.g. Argo data, etc).

- Ensure continuity of O_2 observing network as integral part of CO_2 effort.

What are key steps going forward?

- These developments are needed to meet minimal goals for a carbon observing systems.

- Relevant for issues of ocean acidification, deoxygenation, fisheries resources, etc.

The carbon cycle