

Evaluating Biogeochemical Change in the Arctic using Atmospheric Oxygen (O₂/N₂) and the CMIP5 Models

Cindy Nevison

University of Colorado

Ralph Keeling, Manfredi Manizza

Scripps Institution of Oceanography

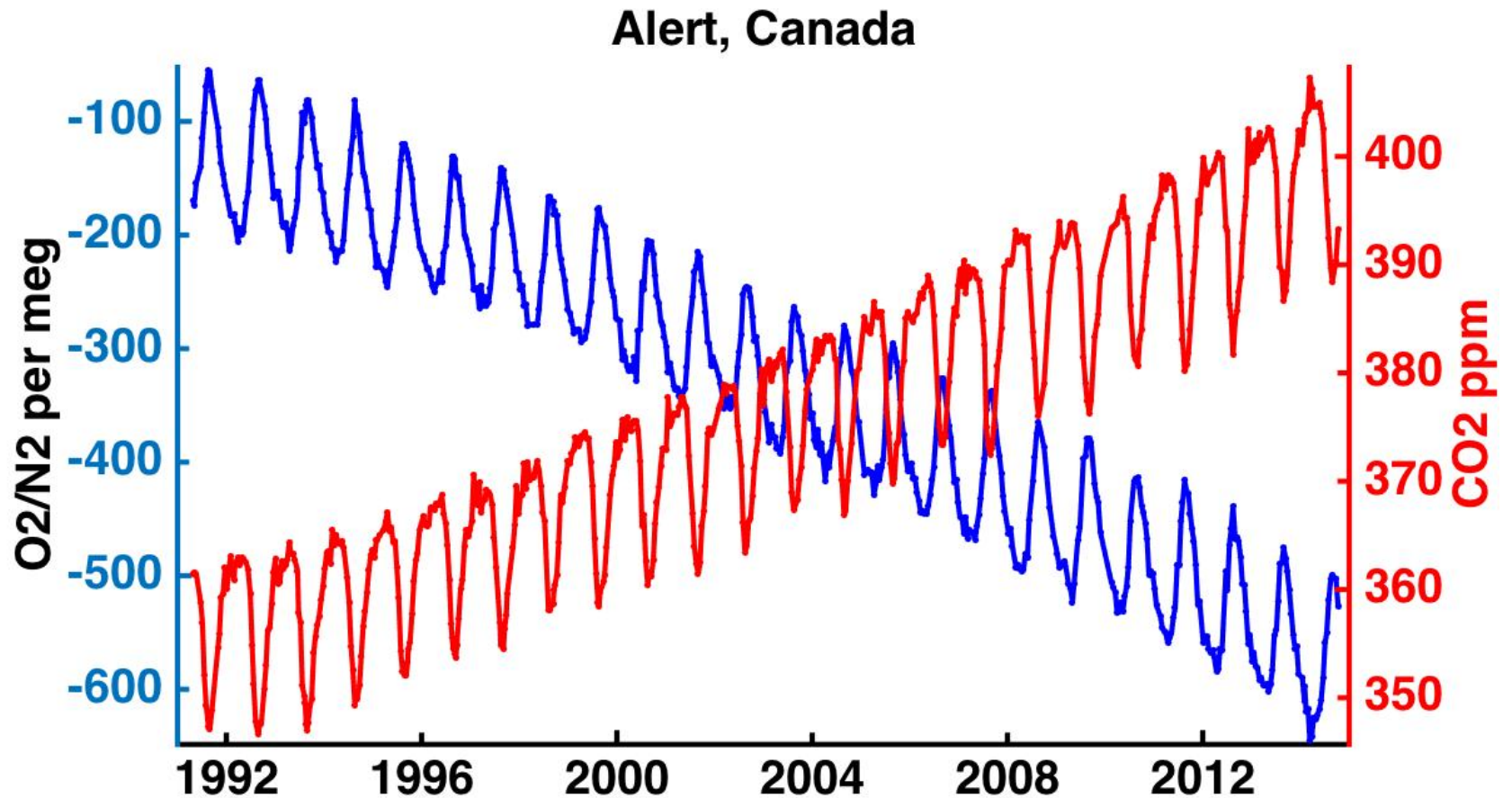
NSF Arctic Observing Open Science Meeting

Seattle, Nov 18, 2015

Acknowledgements:

NSF Arctic Research, NASA Ocean Biology and Biogeochemistry, Michael Bender, Nicolas Cassar, Andrew Schuh, Keith Lindsay

Atmospheric O₂/N₂: Decreasing Trend and Seasonal Cycles

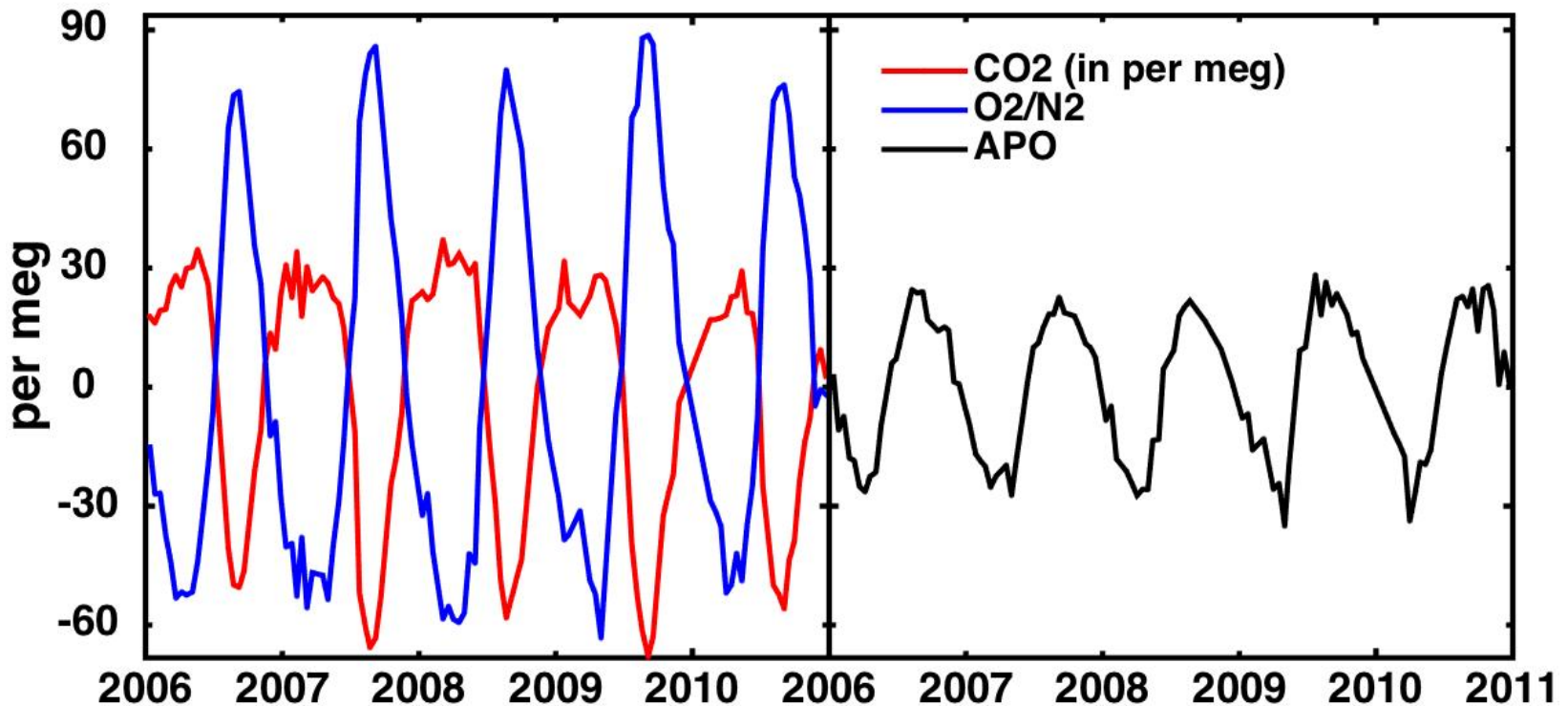


Scripps data from Keeling et al.

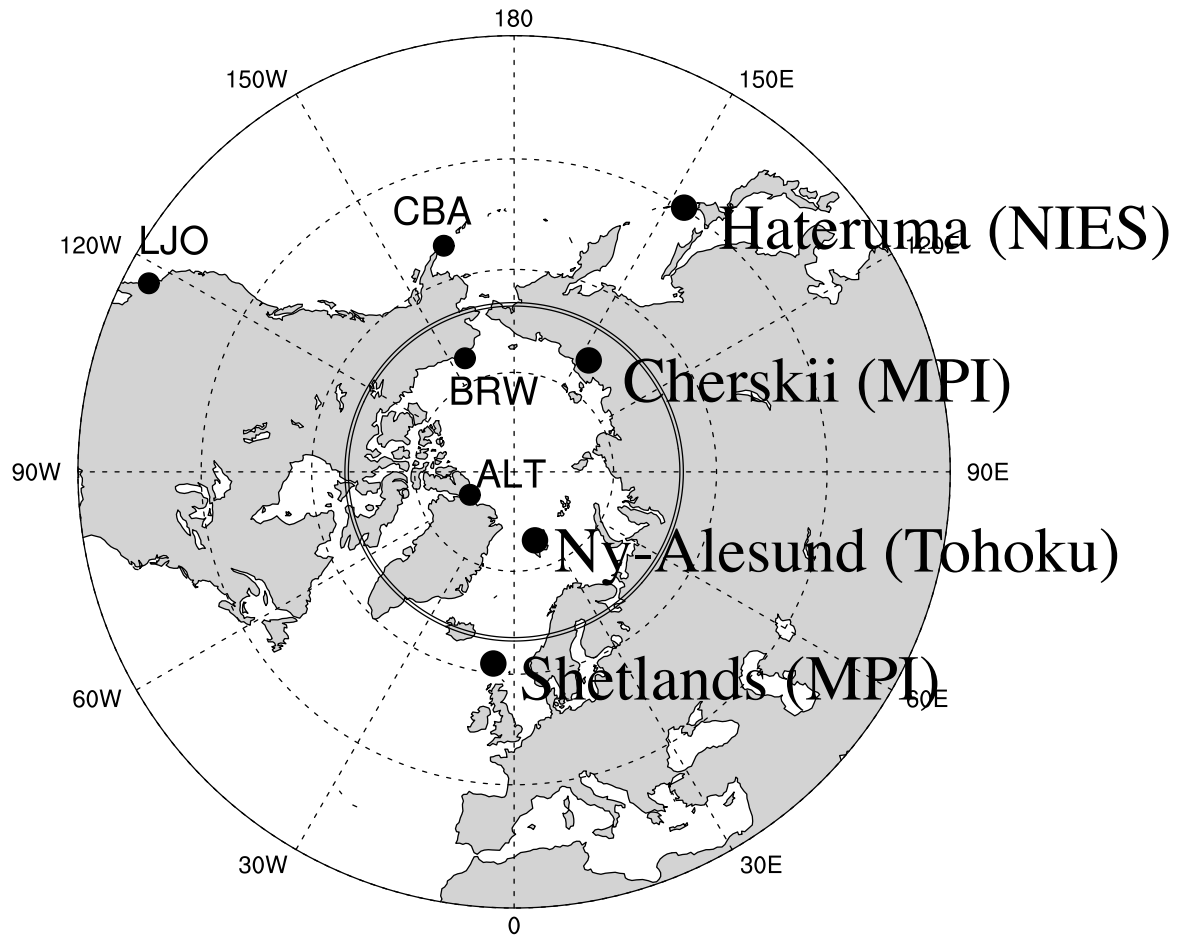
Atmospheric Potential Oxygen

Alert, Canada: Remove Land Signal from O_2/N_2 using CO_2 data

$$APO \sim O_2/N_2 + CO_2$$

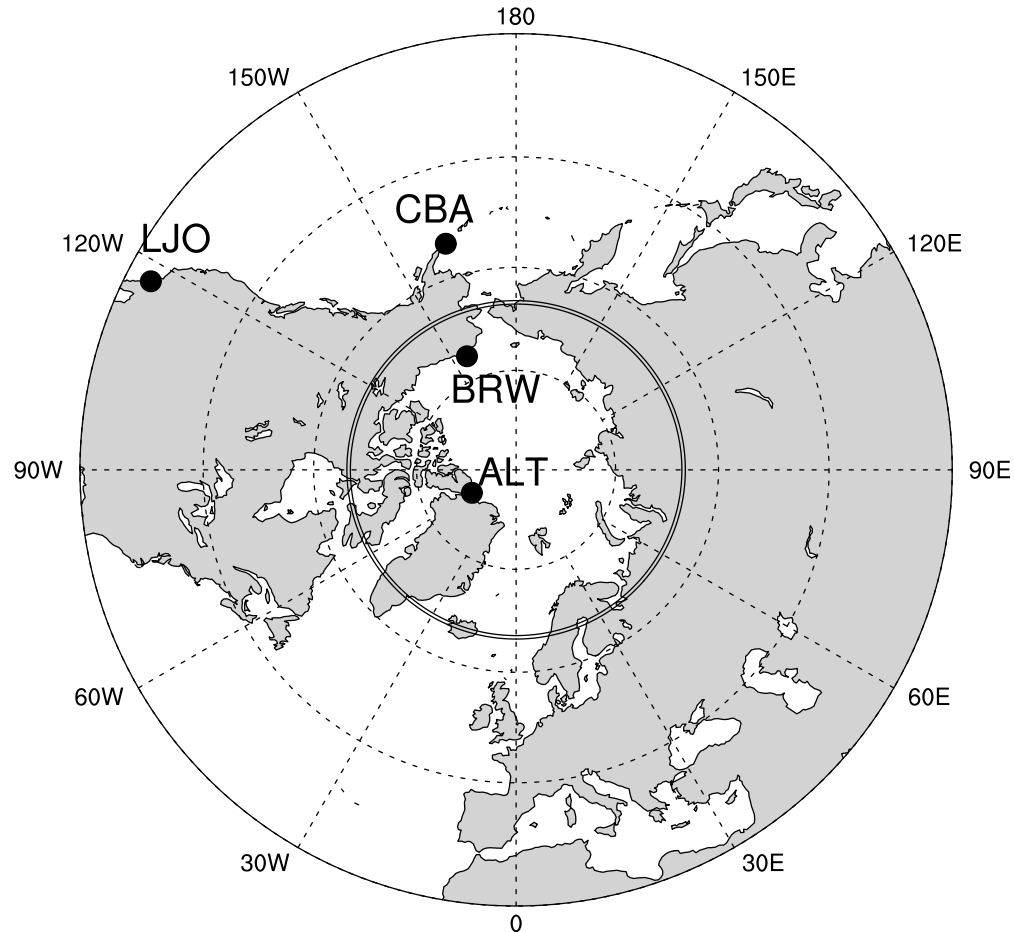


Detrended Scripps data from Keeling et al.



APO Monitoring Sites

Scripps Institution of Oceanography (SIO)

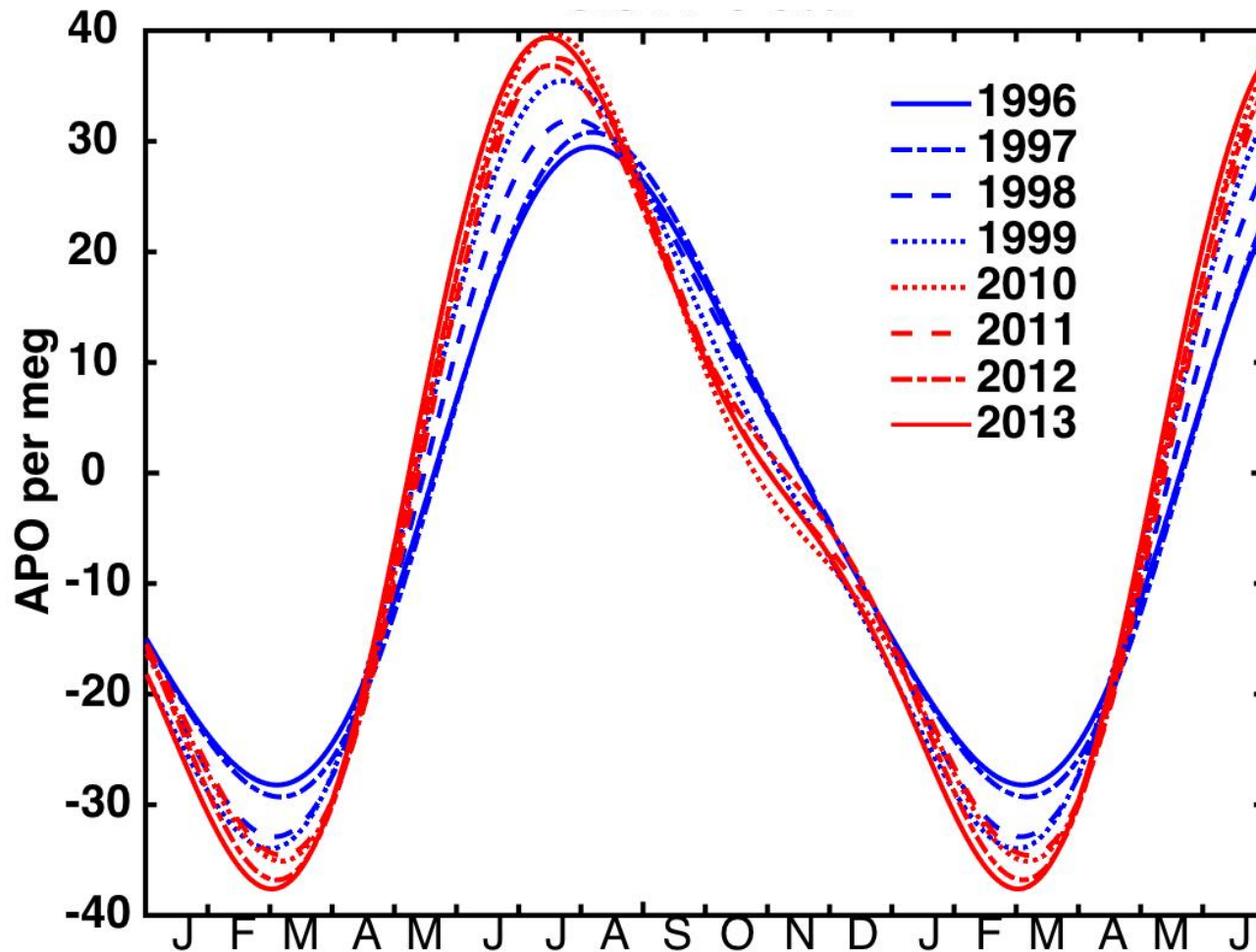


Changes in APO Seasonal Cycle

- Historical period of observation
~1991-1995 through 2015
- Future under RCP8.5 scenario
~2100

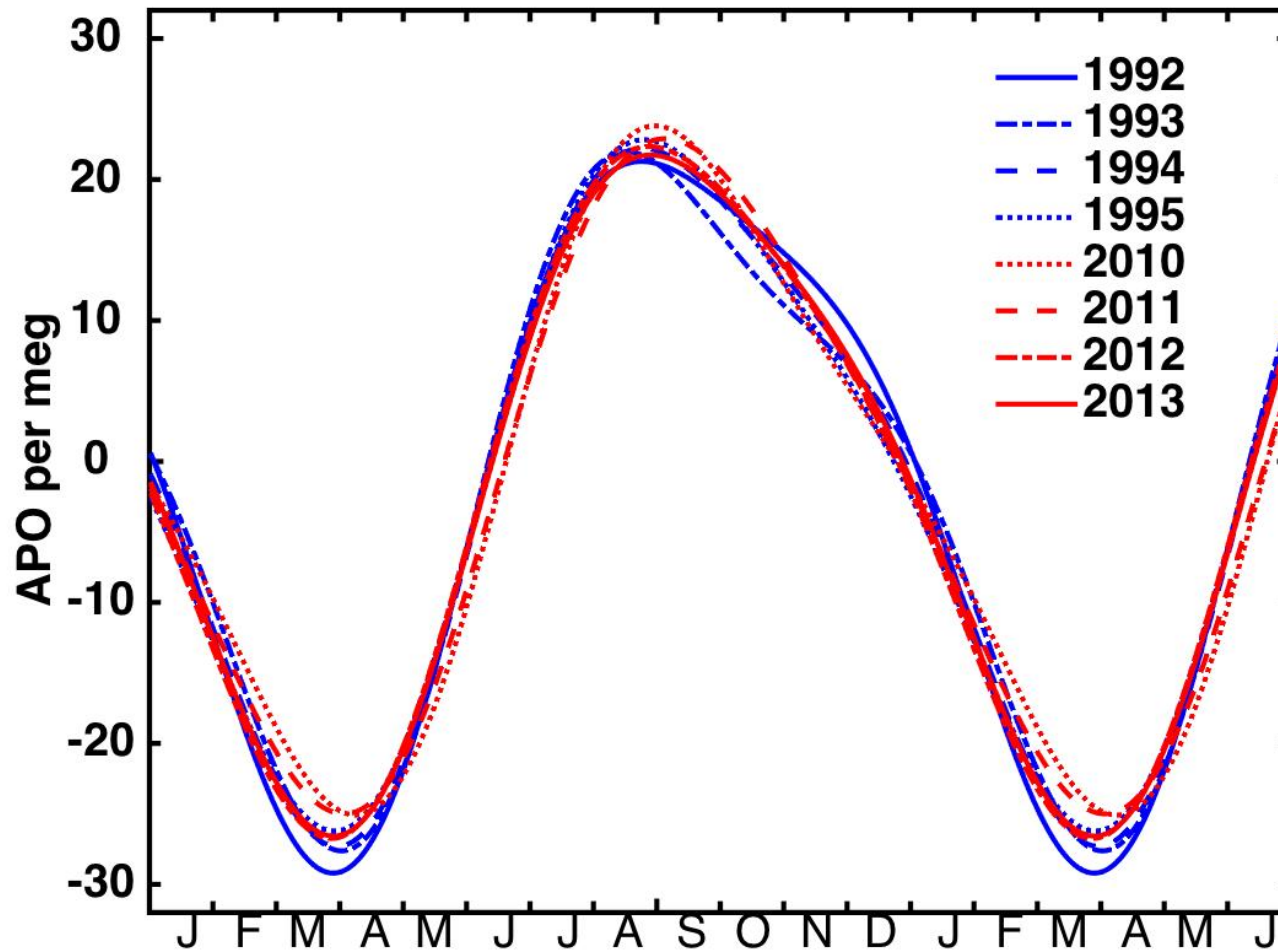
Observed Changes in APO

Cold Bay, Alaska 1995-2015



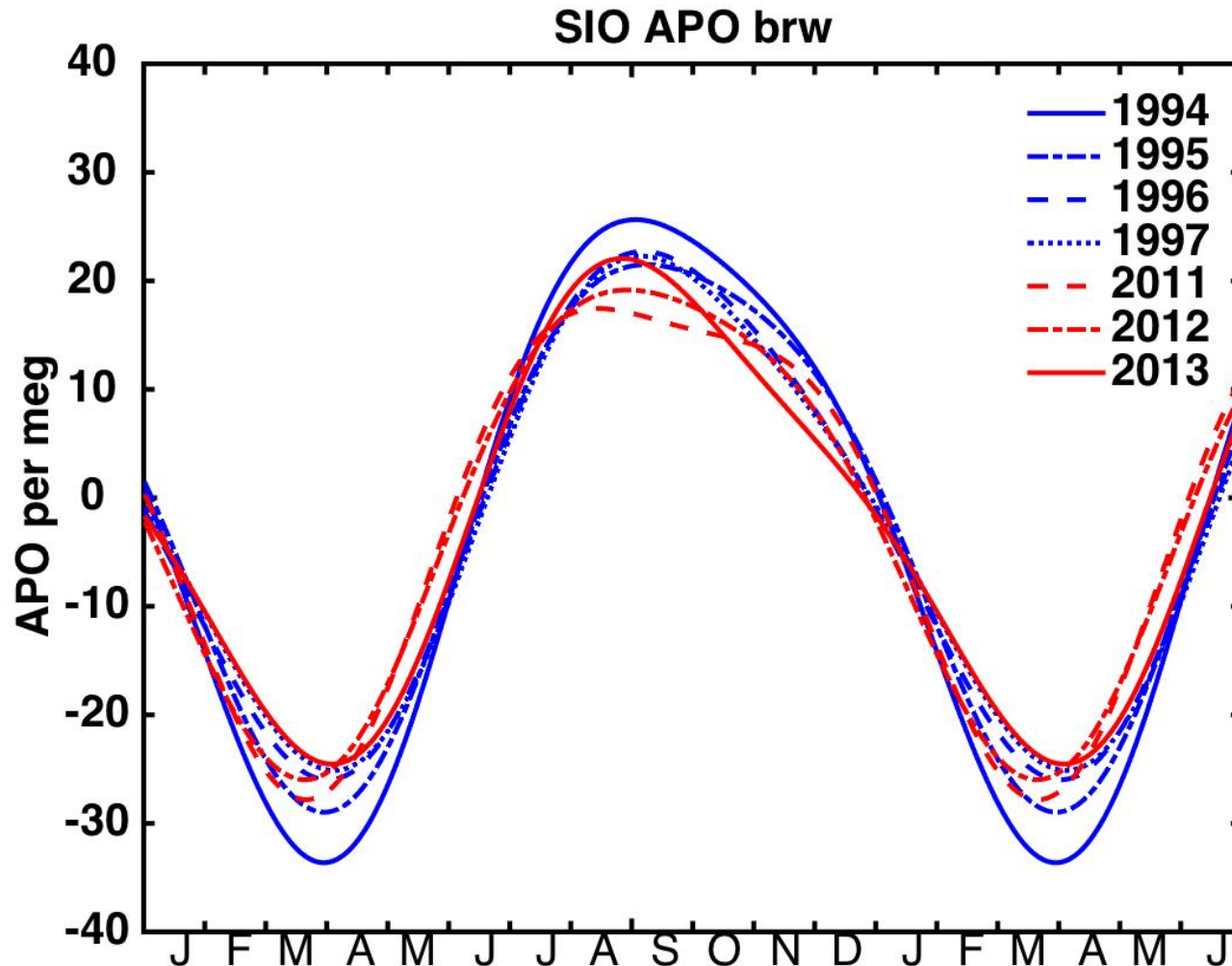
Observed Changes in APO

Alert, Canada 1991-2015



Observed Changes in APO

Barrow, Alaska 1993-2015



Observed Changes in APO Seasonal Cycle 1991-95 to 2015

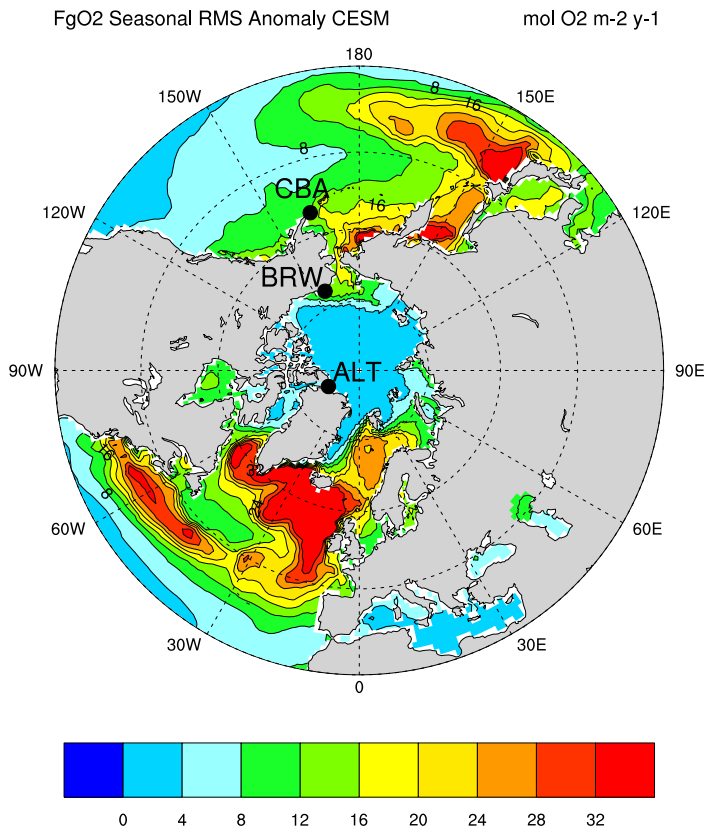
Alert, Canada: No major trends.

Barrow, AK: Hints of earlier spring rise,
increased fall ventilation.

Cold Bay, AK: Rise in APO has shifted 10 days
earlier, amplitude has increased ~ 25%.

Model APO

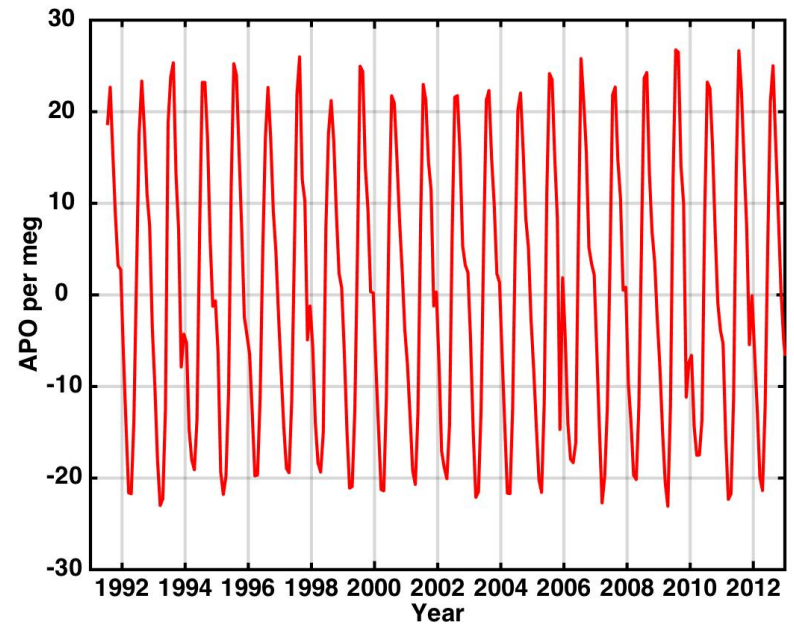
GEOS-Chem forced with CESM air-sea O_2 , CO_2 fluxes



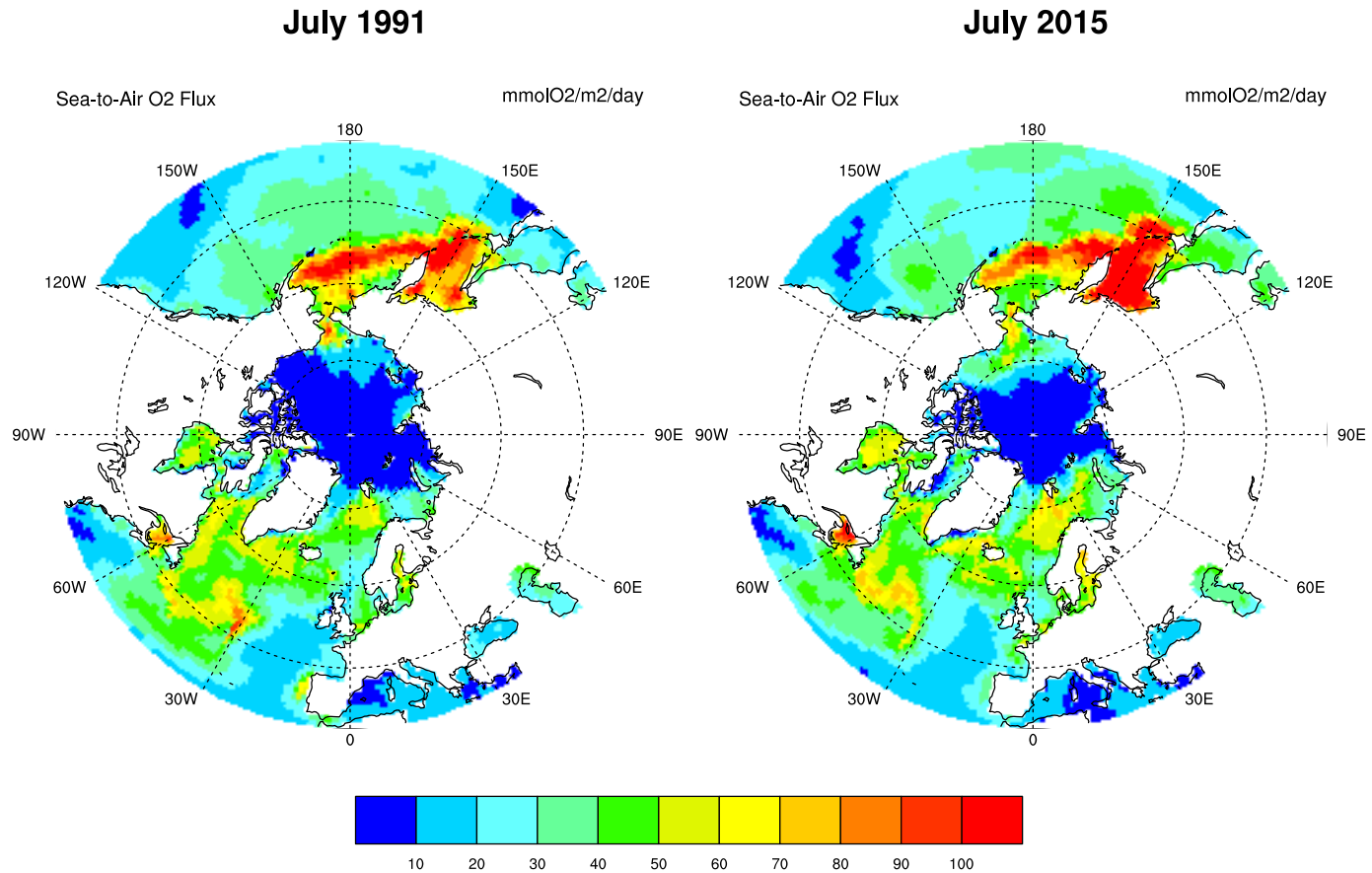
GEOS-Chem
Atmospheric
Transport
Model (2x2.5°)



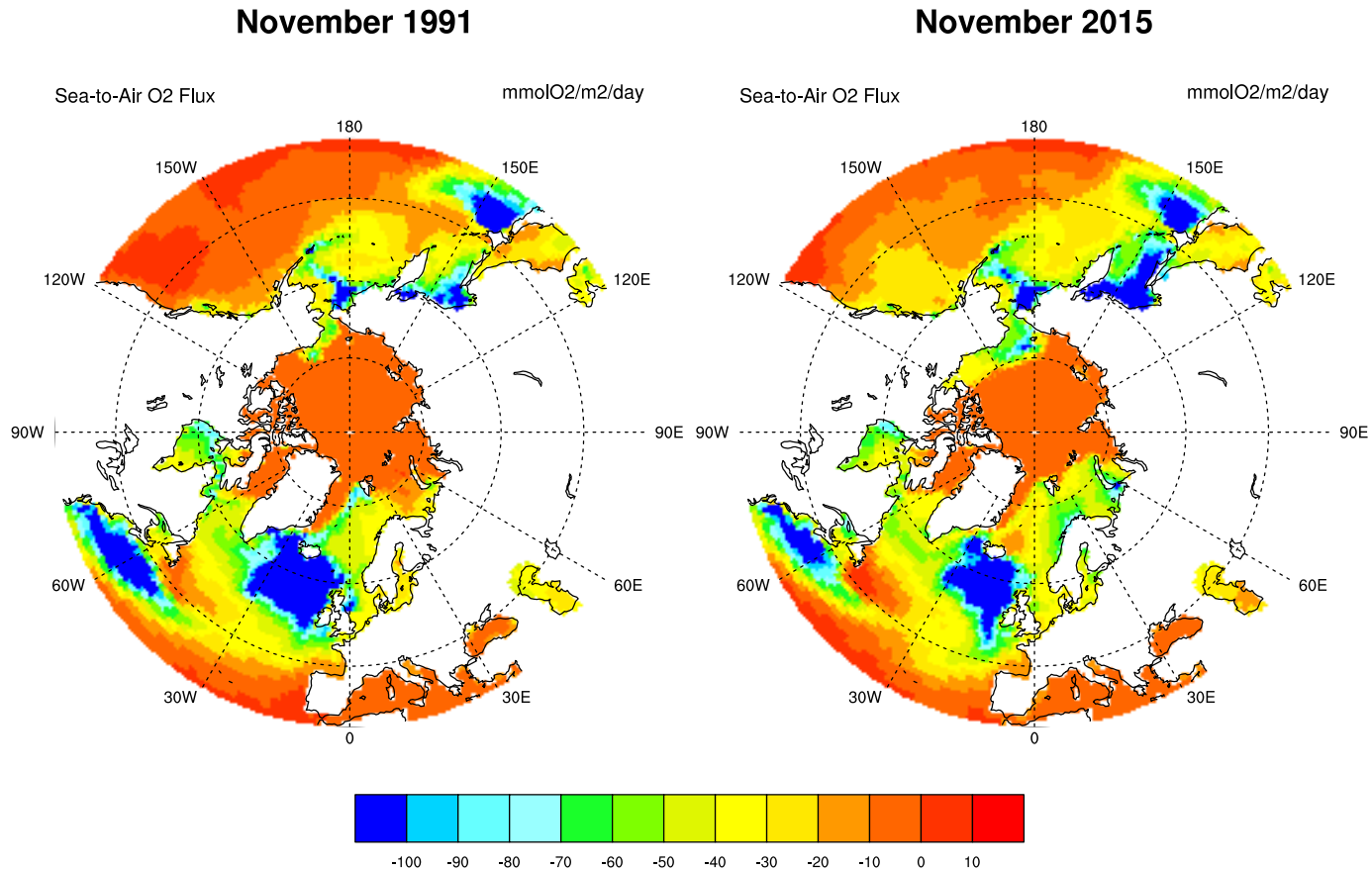
Model APO Time Series Barrow, Alaska



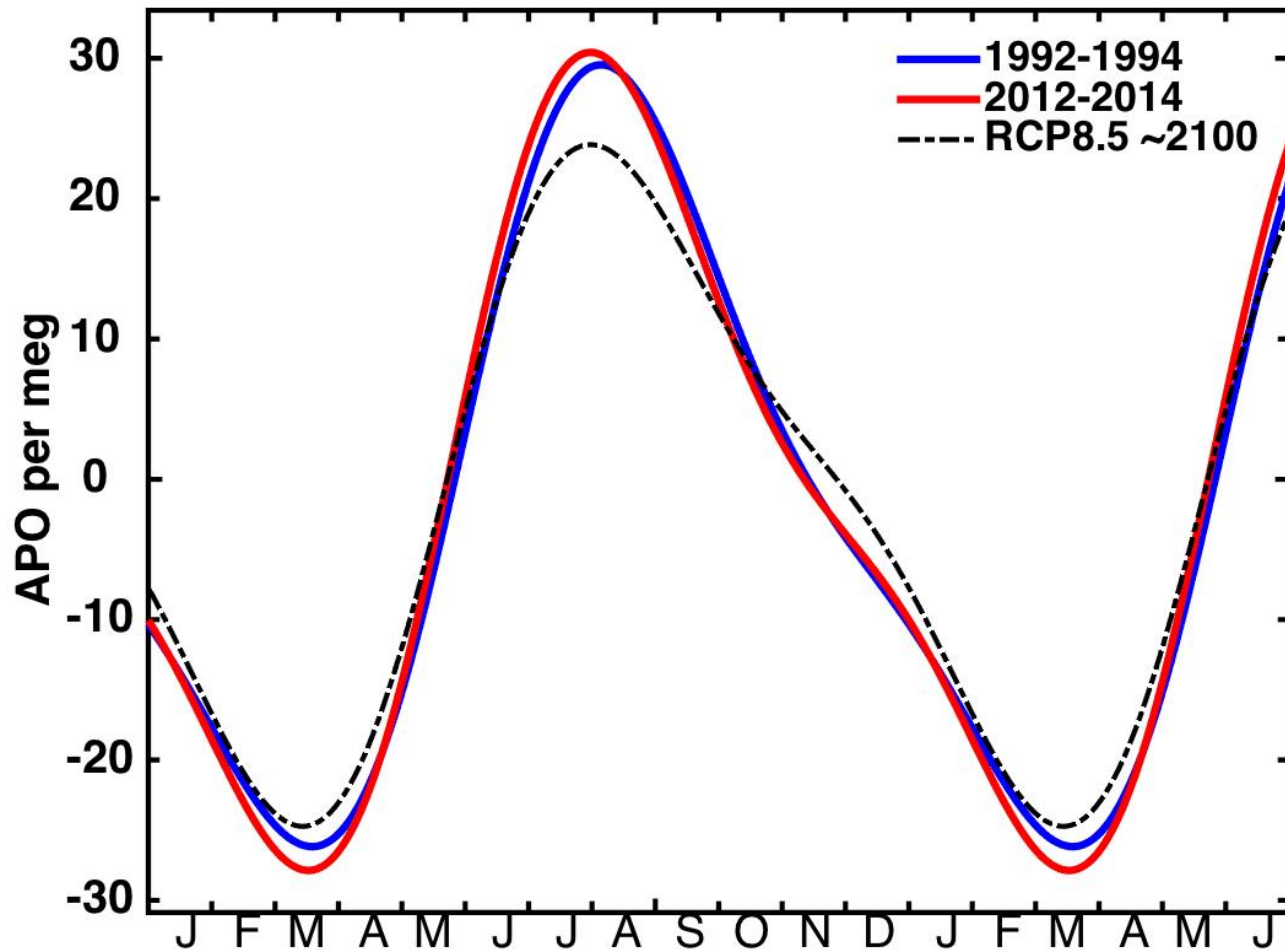
CESM ocean biogeochemistry model summer air-sea O₂ flux 1991 v. 2015



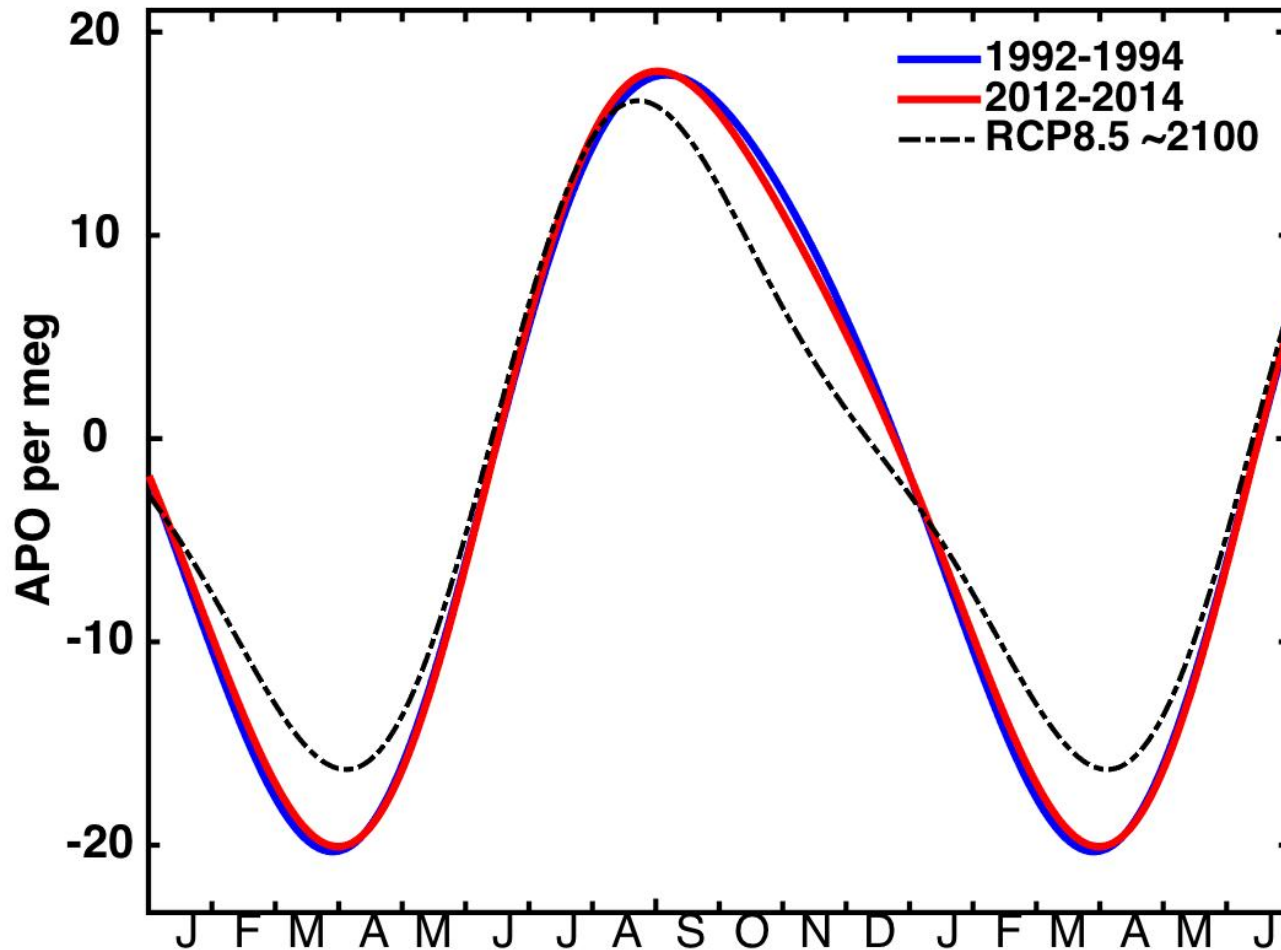
CESM ocean biogeochemistry model autumn air-sea O₂ flux 1991 v. 2015



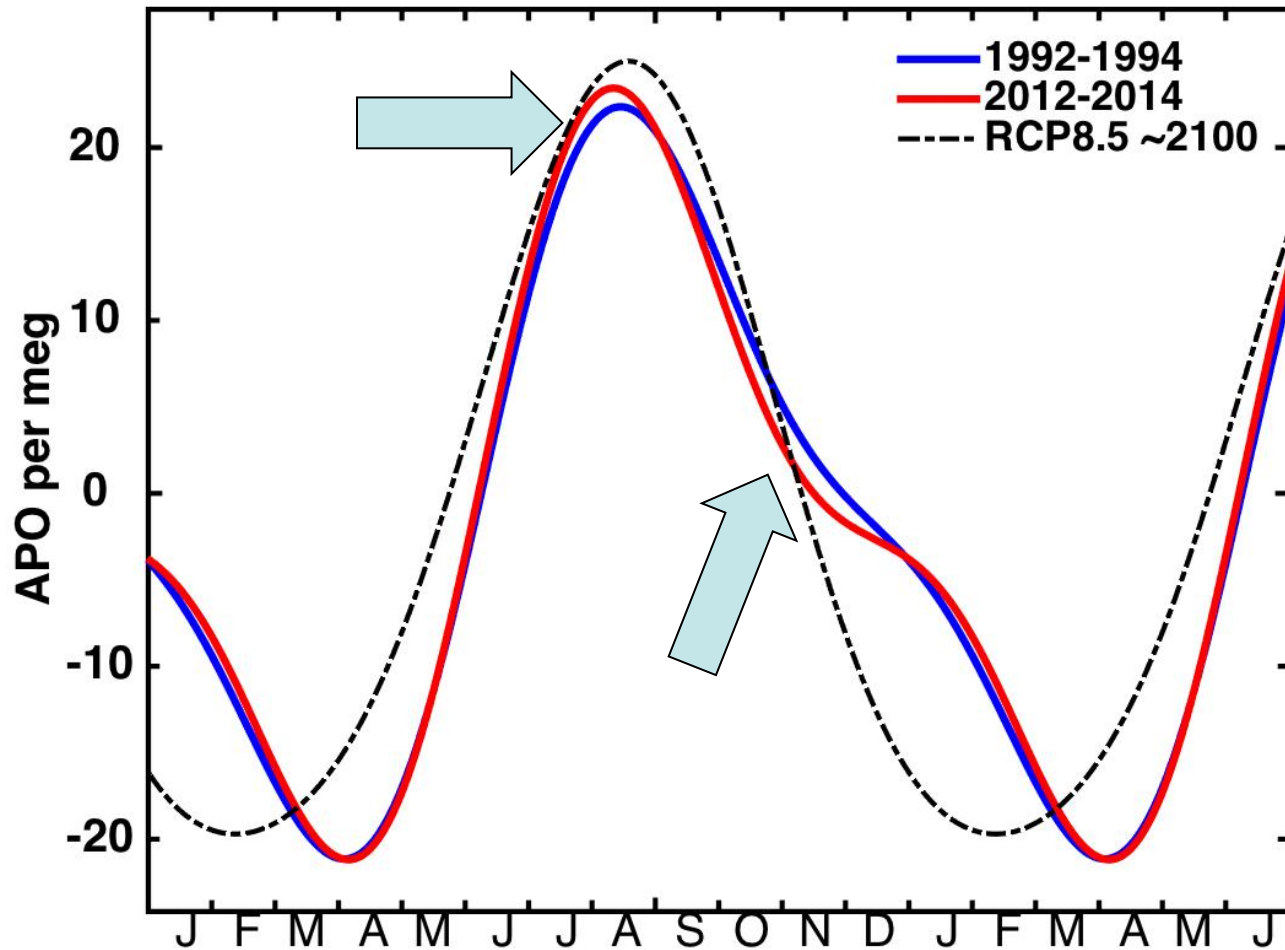
Modeled Changes in APO Cold Bay, Alaska



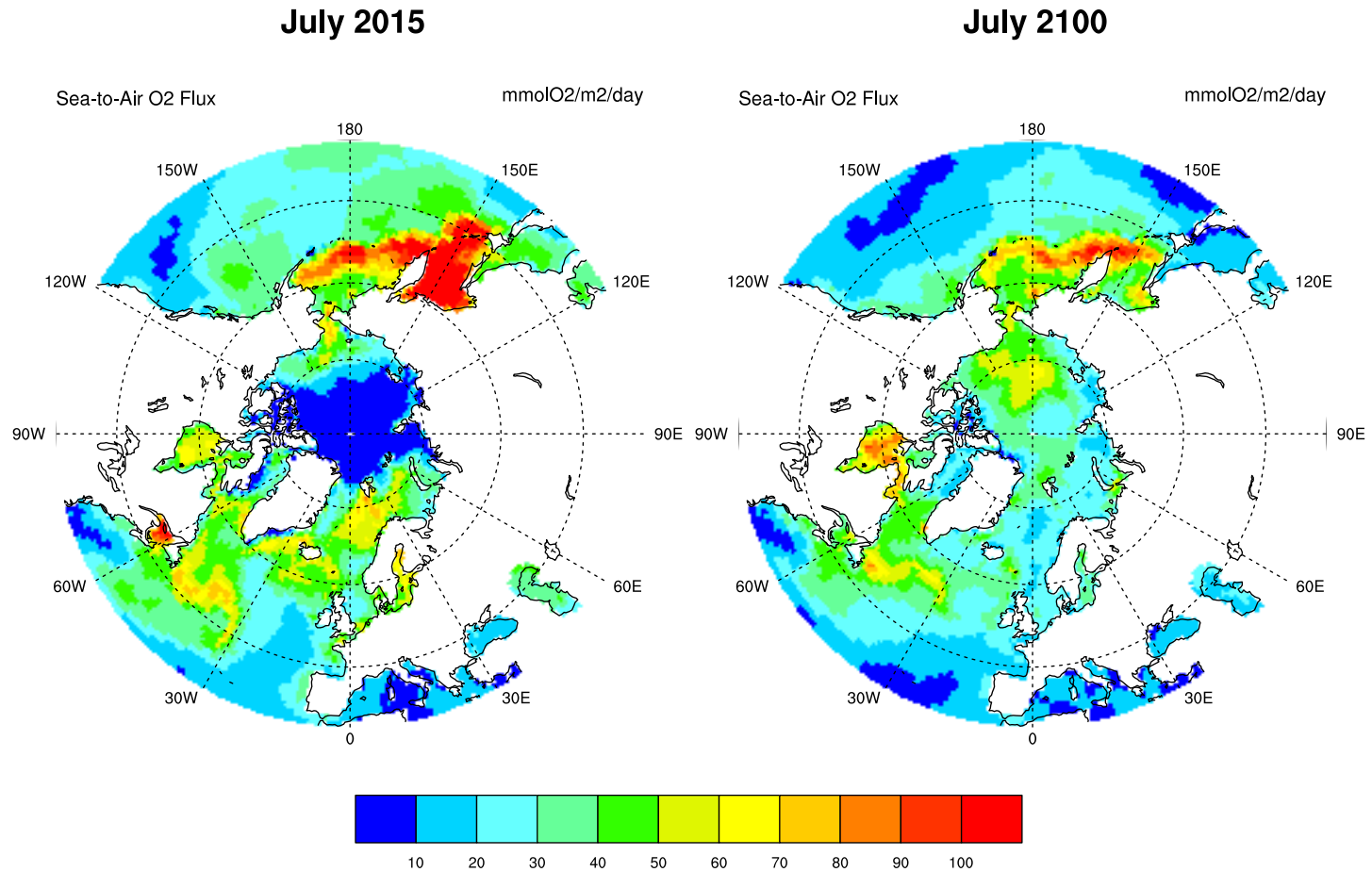
Modeled Changes in APO Alert, Canada



Modeled Changes in APO Barrow, Alaska



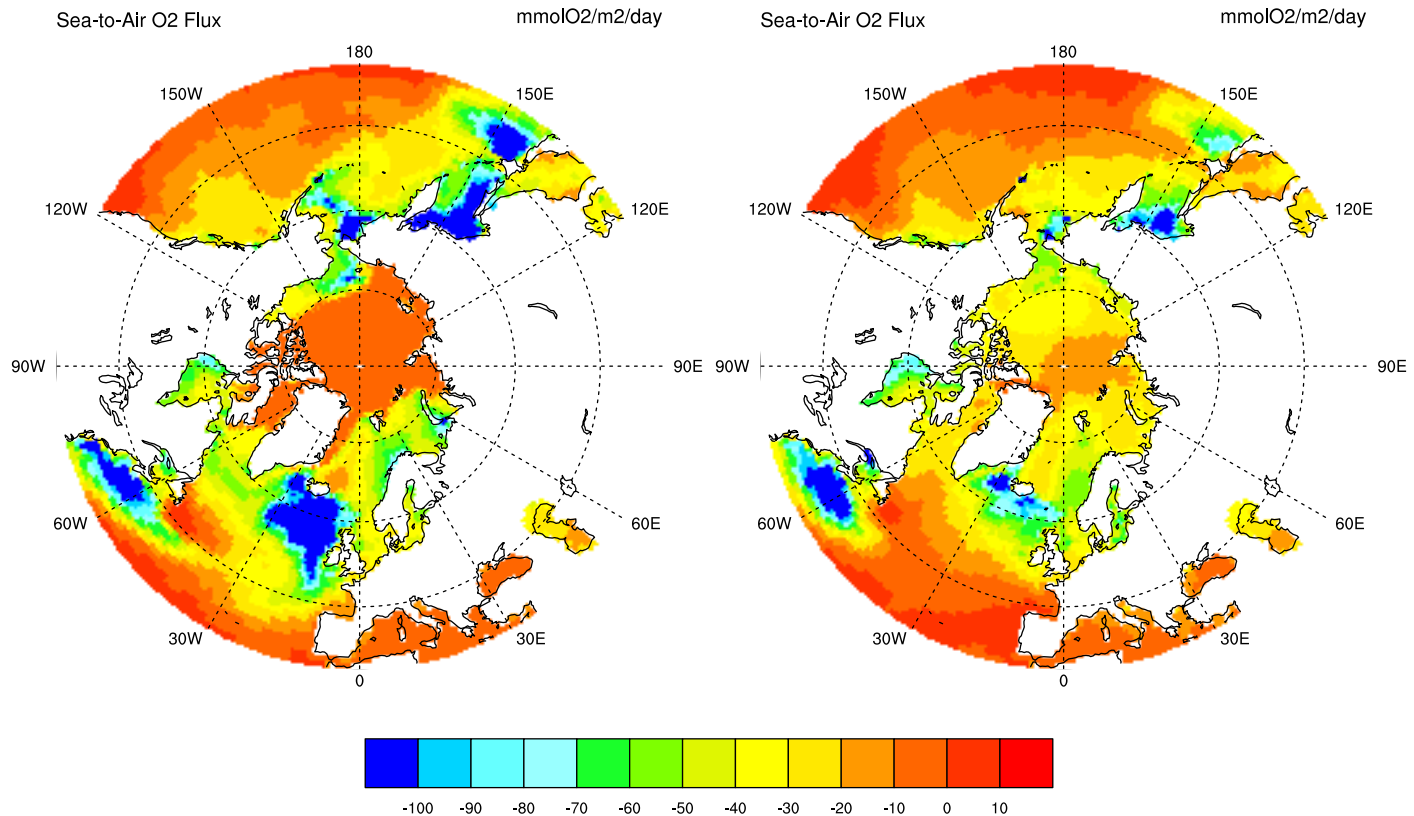
CESM ocean biogeochemistry model summer air-sea O₂ flux 2015 v. 2100



CESM ocean biogeochemistry model autumn air-sea O₂ flux 2015 v. 2100

November 2015

November 2100

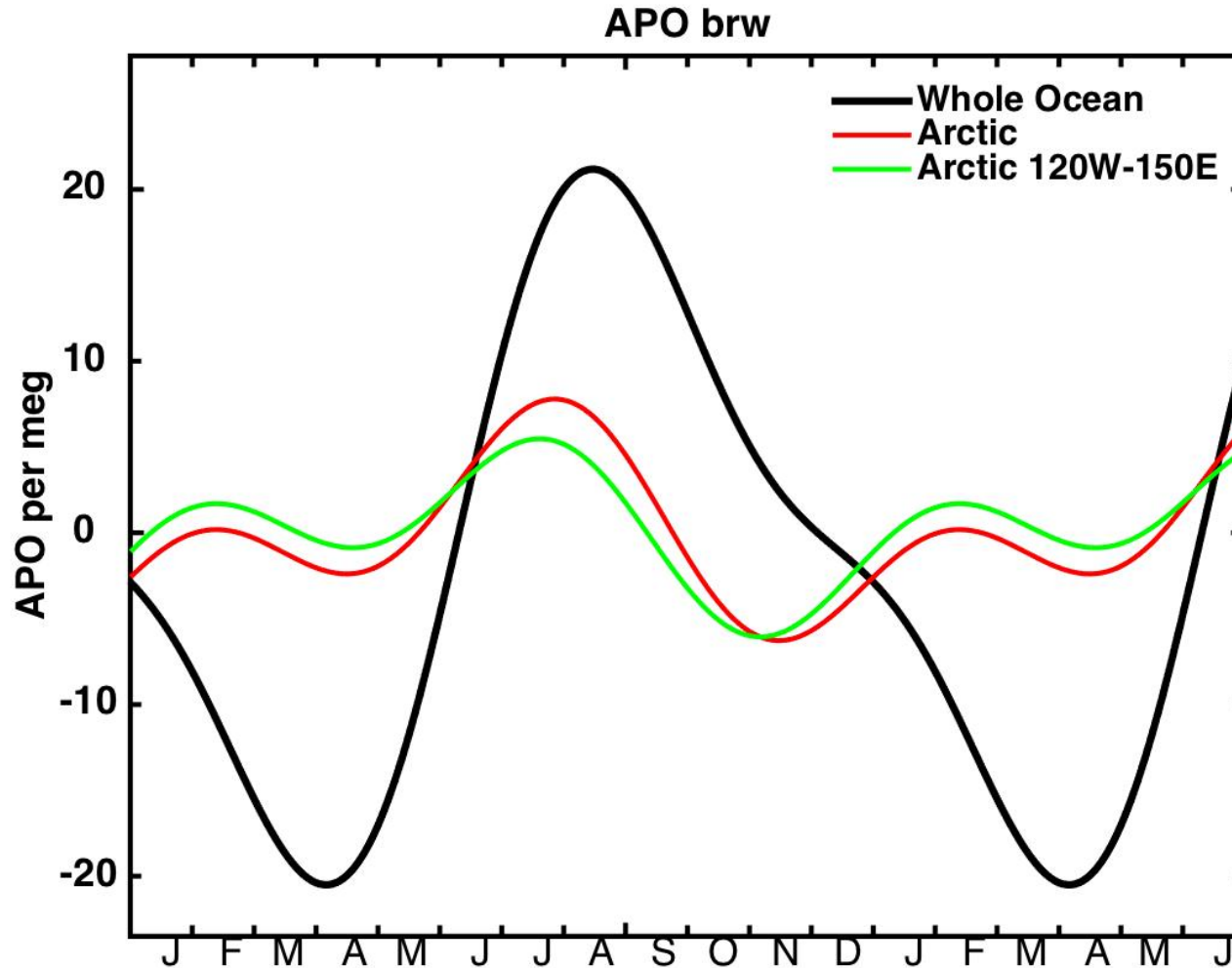


Conclusions

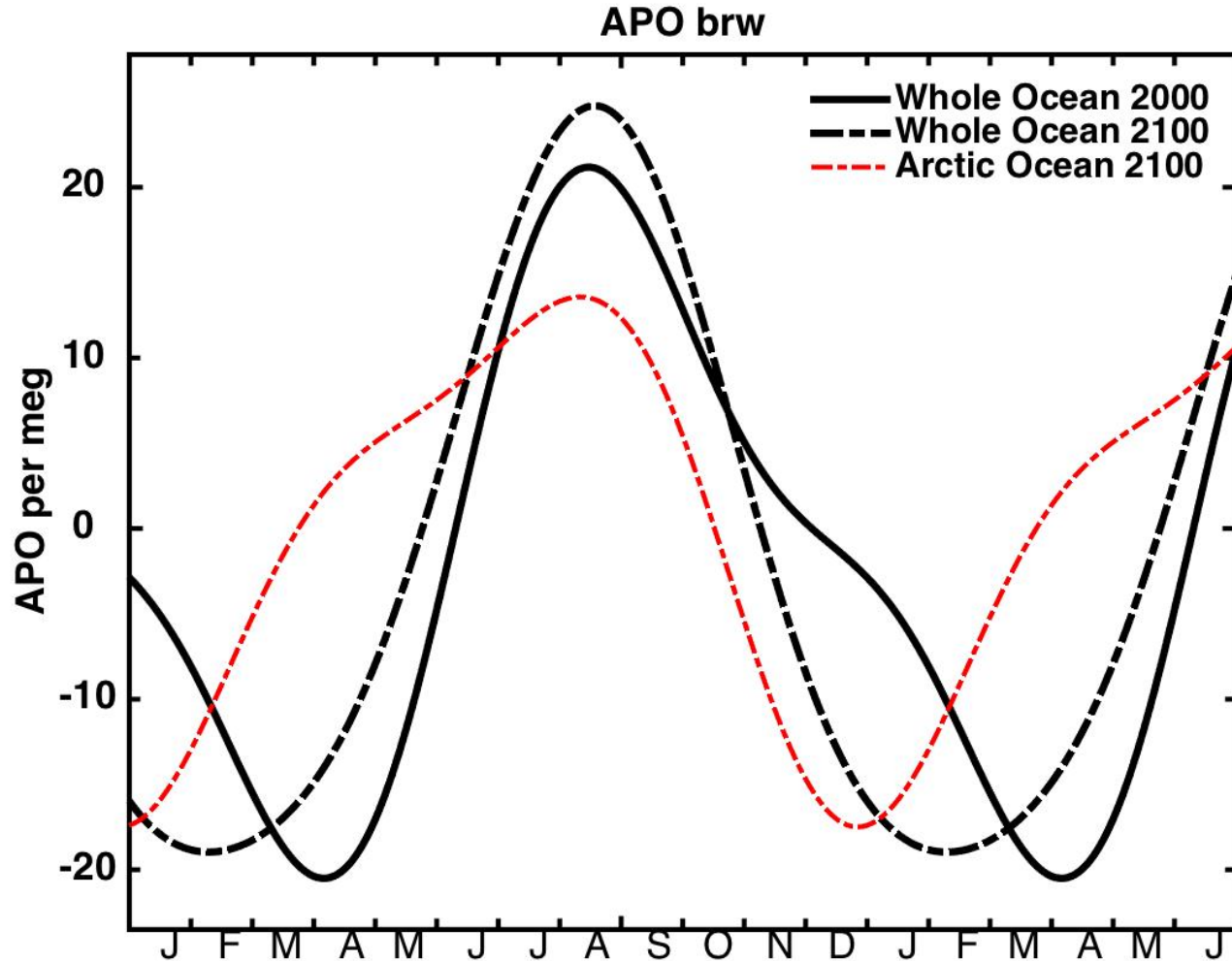
- 1) Changing APO seasonal cycles provide a measure of large-scale changes in ocean biogeochemistry, including spring/summer production and fall/winter ventilation.
- 2) At northern APO monitoring sites (ALT, BRW, CBA), time series from early 1990s show varying degrees of change, indicating earlier spring rise in production and increased Arctic Ocean ventilation in fall.
- 3) Ocean biogeochemistry models predict significant future changes in the APO seasonal cycle, with competing influences from increases in productivity and ventilation in the Arctic Ocean and declines in the N Pacific and N Atlantic.

Extra Slides

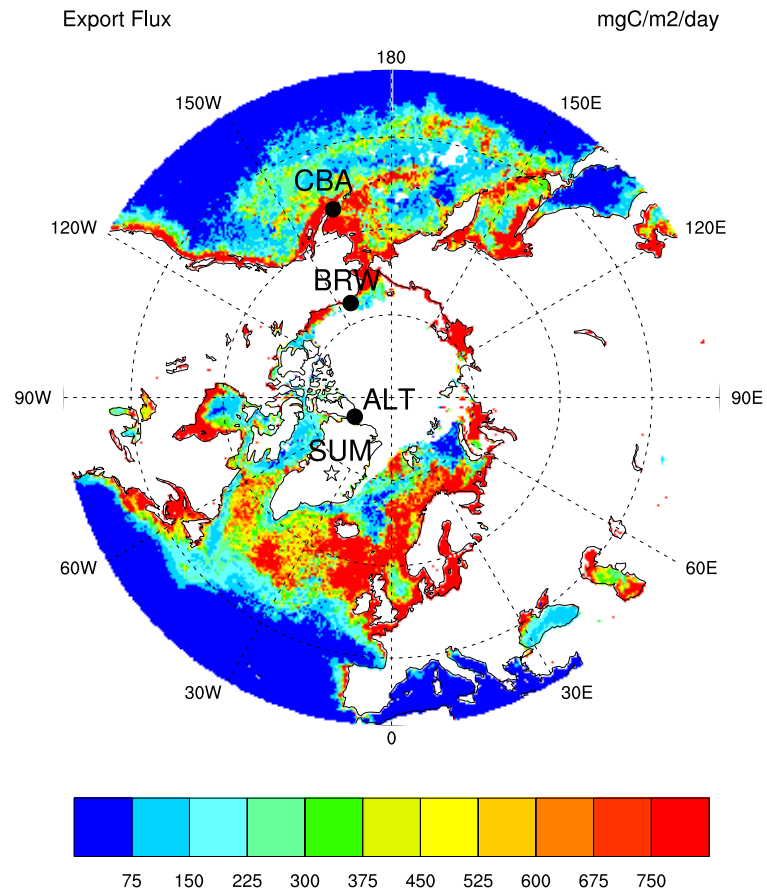
Arctic Ocean Contribution to Barrow APO circa 2000



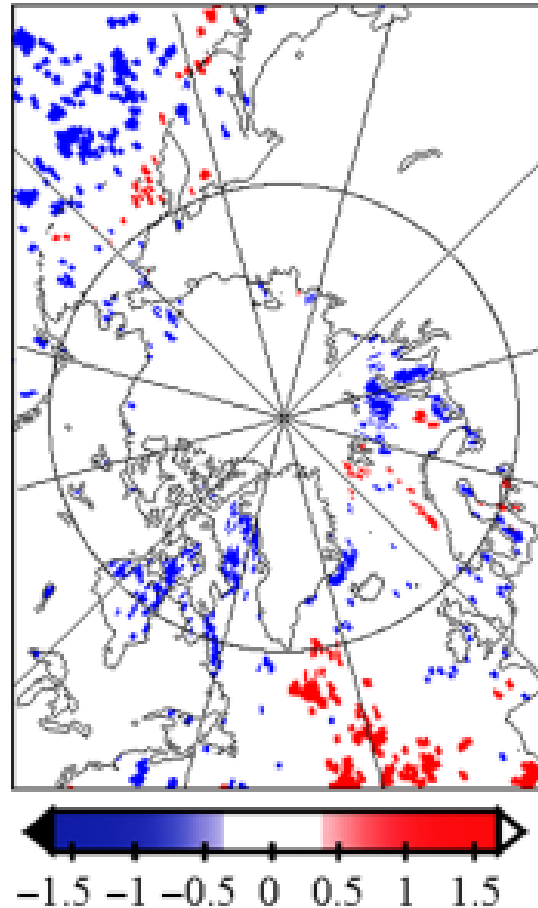
Changing Arctic Ocean Contribution to Barrow APO



Aug Northern Hemisphere



1997-2009 trends in timing of Chl seasonal maximum from satellite ocean color

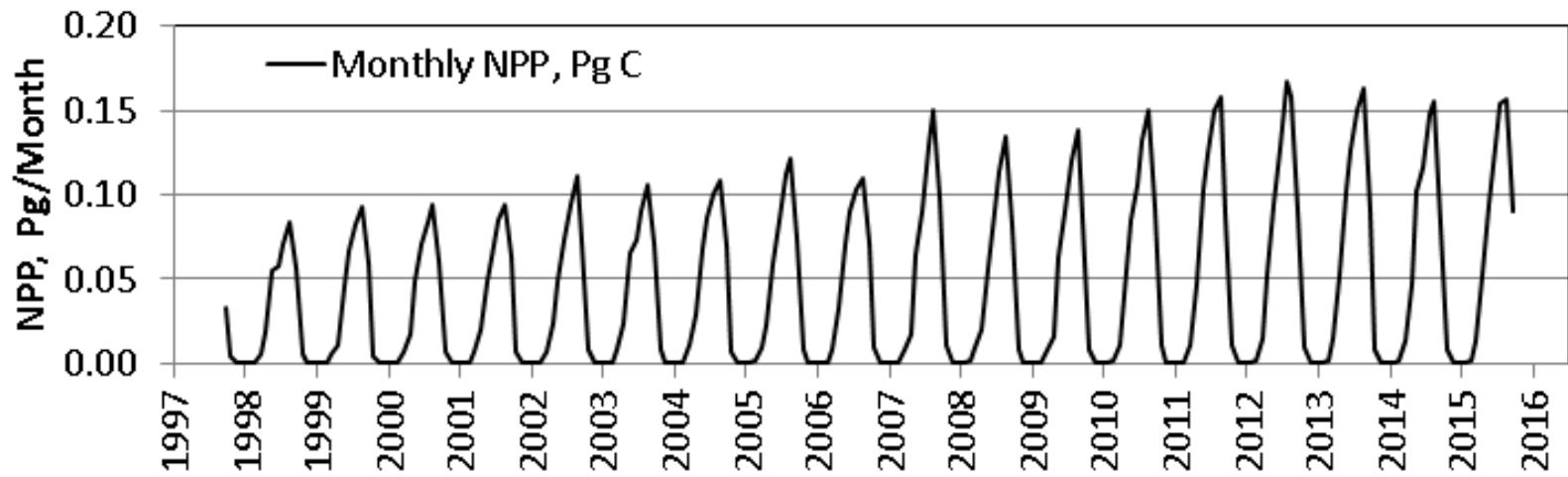


In Arctic,
patterns
correspond to
regions of sea ice
loss.

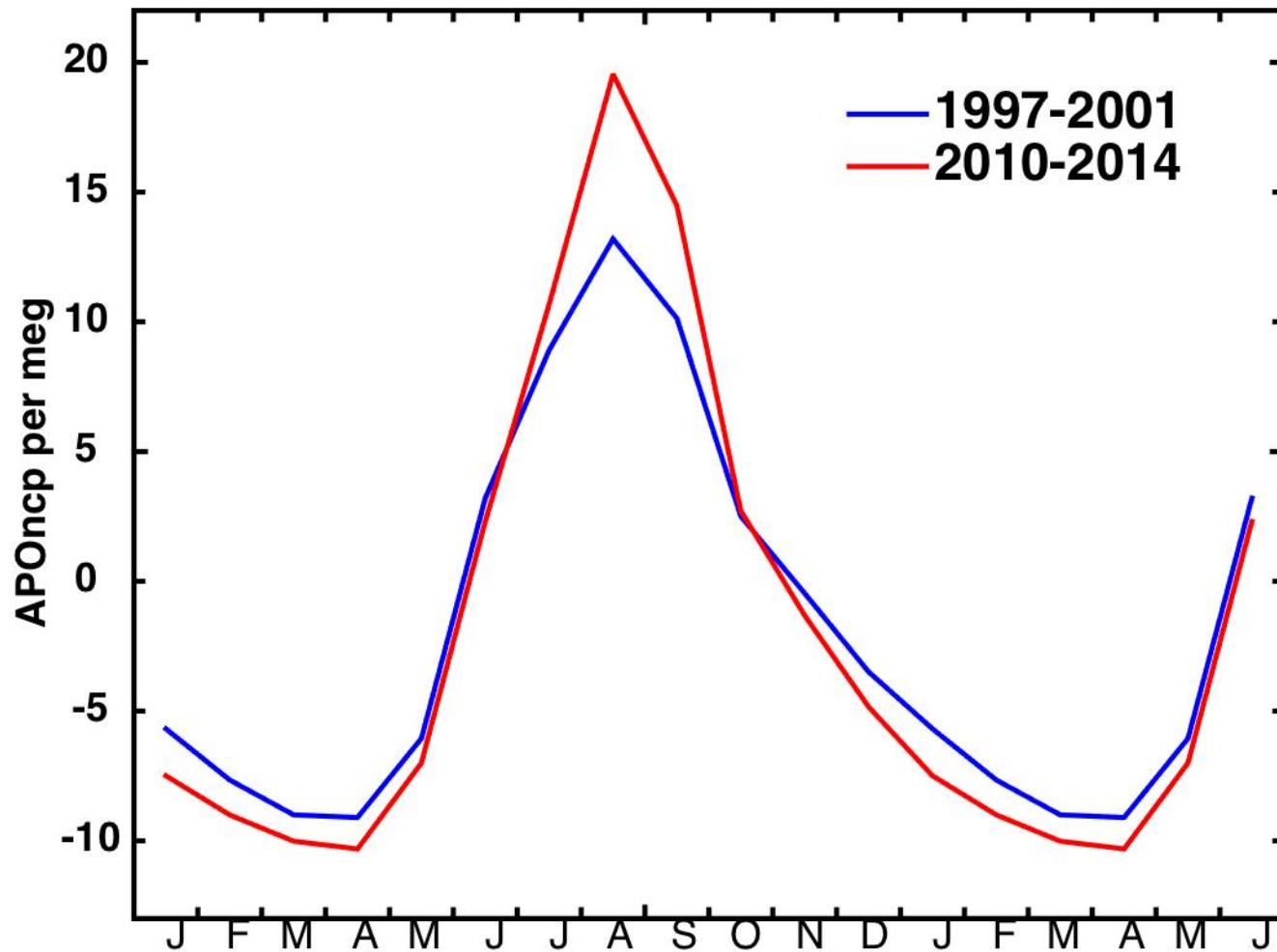
(Kahru et al., 2010)

day per year

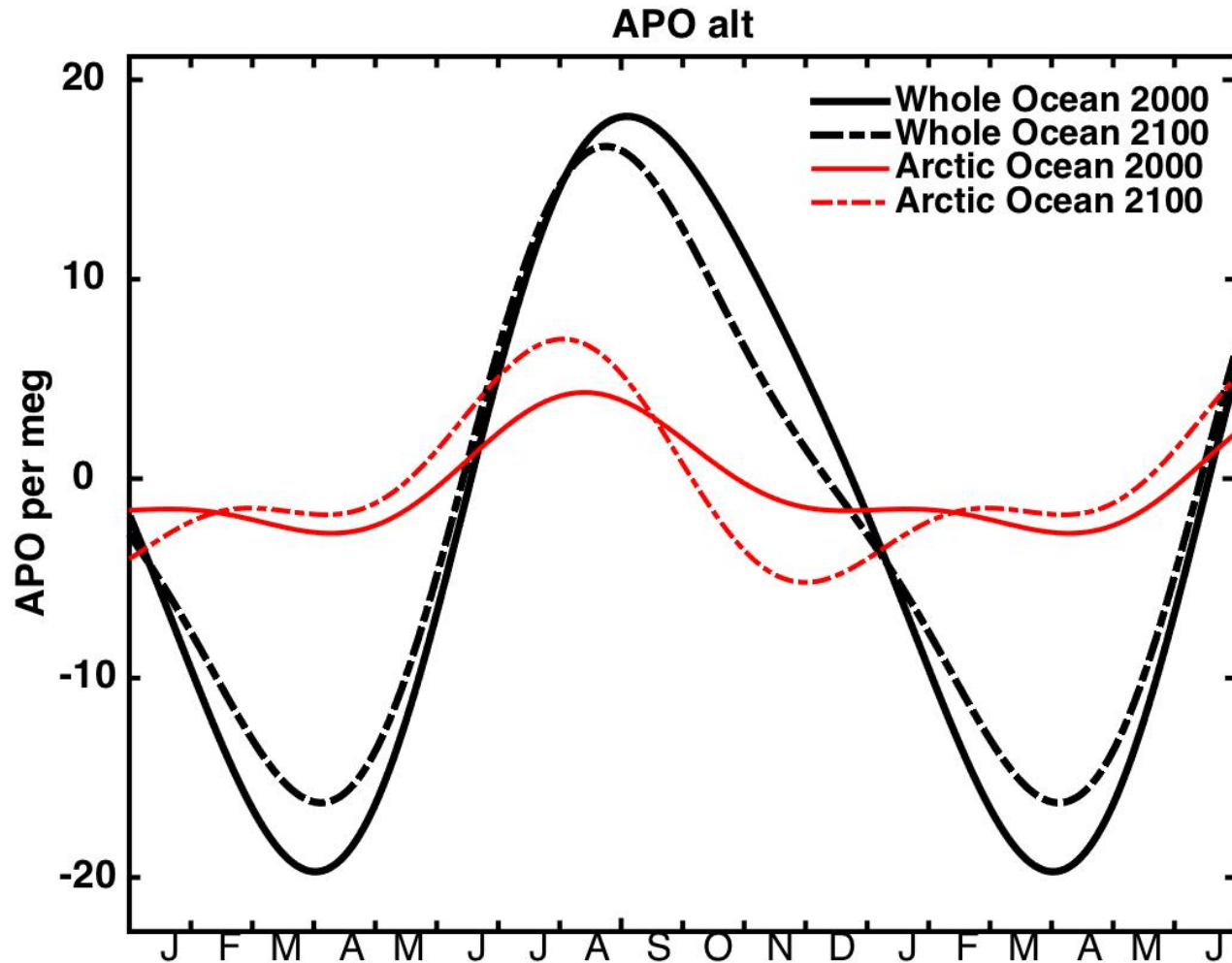
Satellite Ocean Color



Satellite Ocean Color



Changing Arctic Ocean Contribution to Alert APO



What causes Seasonal Cycles in APO?

How are they linked to carbon export production?

