Changes in the Seasonal Cycle of APO at Cold Bay

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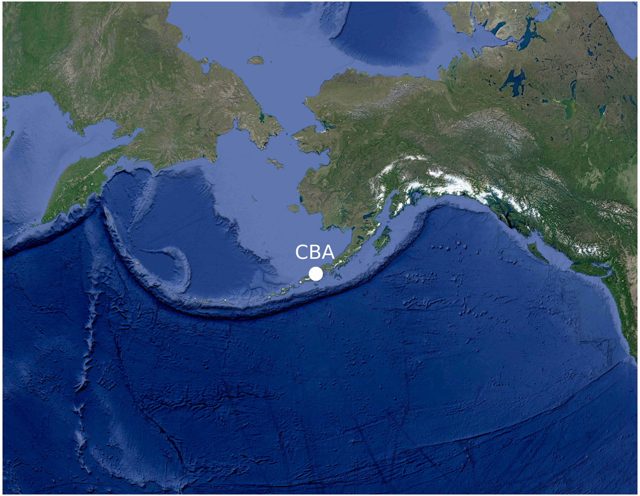
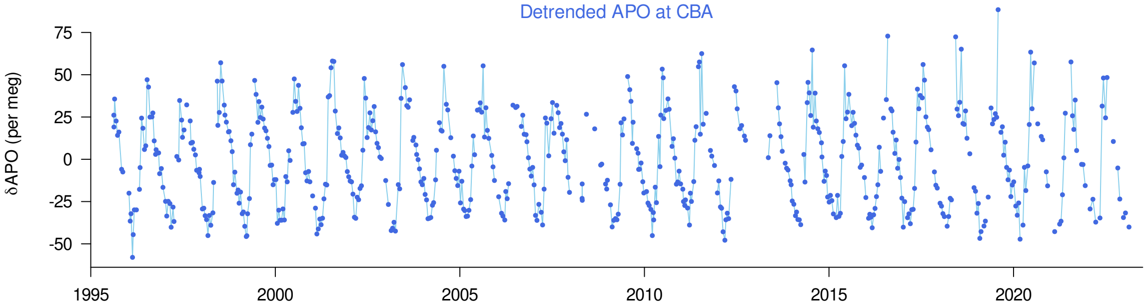
Cold Bay, Alaska (CBA)

- 55.20 °N, 162.72 °W, 25 m a.g.l.
- Housed at NOAA weather station
- Measurements began in 1995, continue to present
- Samples taken with 5 L glass flasks every ~2 weeks
- Measured at SIO for O_2/N_2, CO_2, and Ar/N_2 (since 2002)





Line breaks indicate gaps > 30 days.

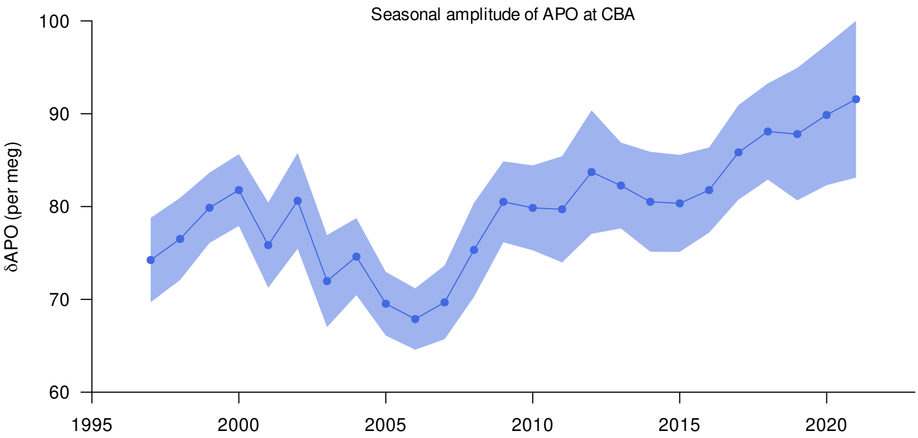
There is a large seasonal cycle in APO at CBA with evident year-to-year differences.

Algorithm to extract the amplitude of the seasonal cycle:

- Bootstrap the time series (previously detrended)
- Select 3 year window (at least 80%)
- Fit 2 harmonics + linear term
- Discard outliers >10 per meg and refit
- Compute amplitude as peak to trough from curve fit
- Select next 3 year window until end of time series
- Repeat 999 times

Advantages: reduces the noise from sparse observations, is robust to gaps

Disadvantages: slightly smooths the resulting amplitude time series



The seasonal amplitude shows both interannual variations and a long-term trend.

Why is this interesting?

- The Arctic is changing rapidly
- The atmosphere integrates large spatial signals

What is driving the change in amplitude at CBA?

- Atmospheric dynamics: changing transport, boundary layer height
- Terrestrial/combustion: Changes in CO_2 (marine or terrestrial), fossil fuel emissions
- Ocean processes: solubility processes, NPP, gas exchange, ventilation
- A combination of all three

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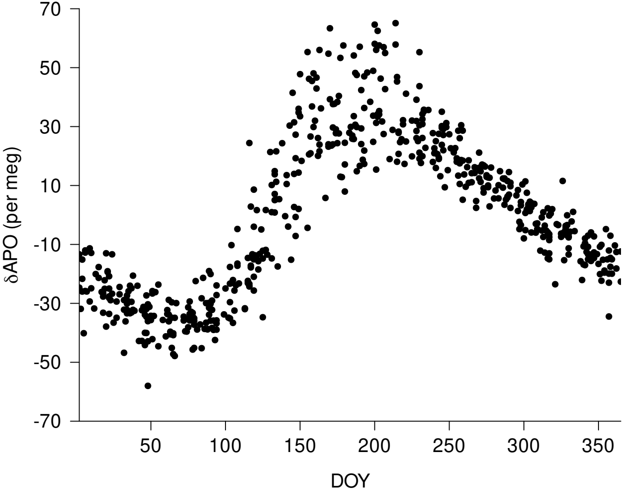
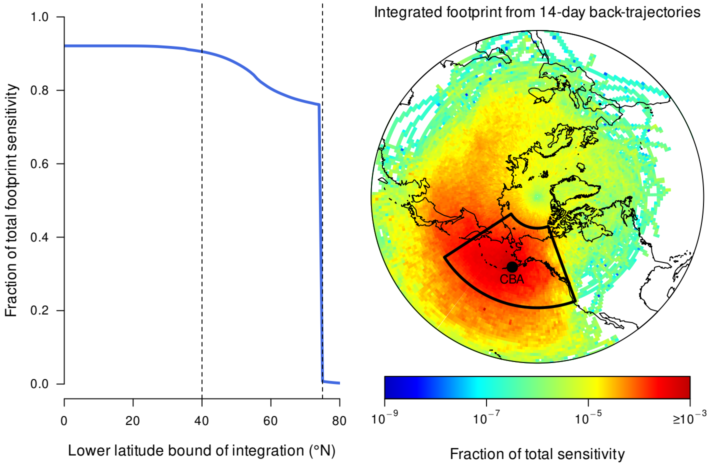


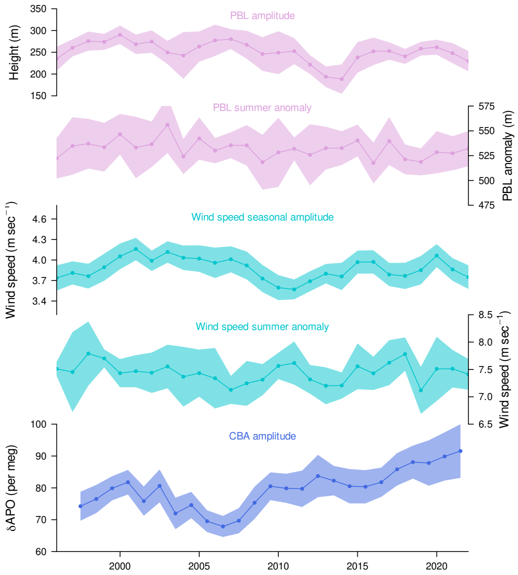
Highest variability is in spring and summer, during which many positive enhancements can be seen.

Atmospheric dynamics

- Are fluxes essentially constant, but transport is altering the signal?
- Is the gas exchange velocity changing?

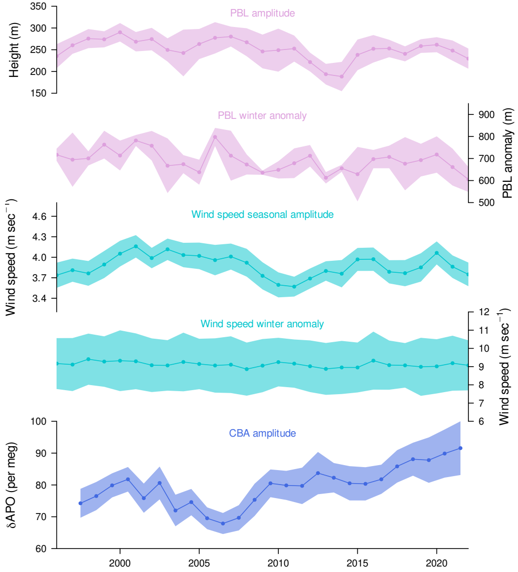


Domain chosen because it contains 90% of the sensitivity, and previous work has linked the amplitude of APO at CBA to fluxes between 40 and 70 °N (Morgan et al., 2021, JGR Oceans).



Data from Modern-Era Retrospective analysis for Research and Applications 2 (MERRA-2) v5.12.4, 40–75°N

No strong associations between PBL or wind speed, and trends at CBA.



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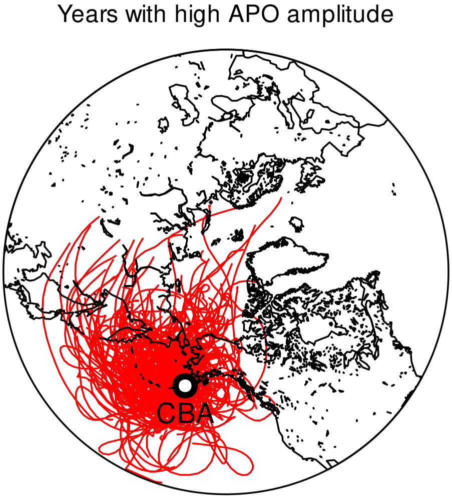
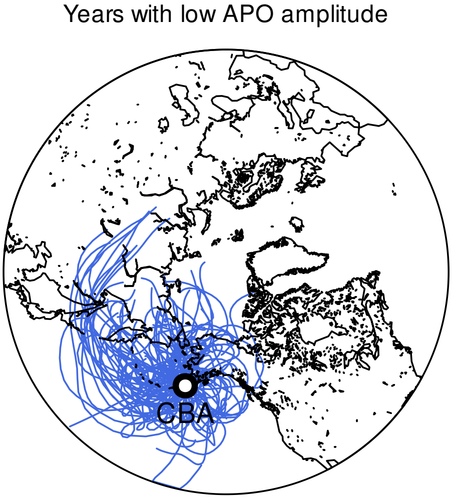
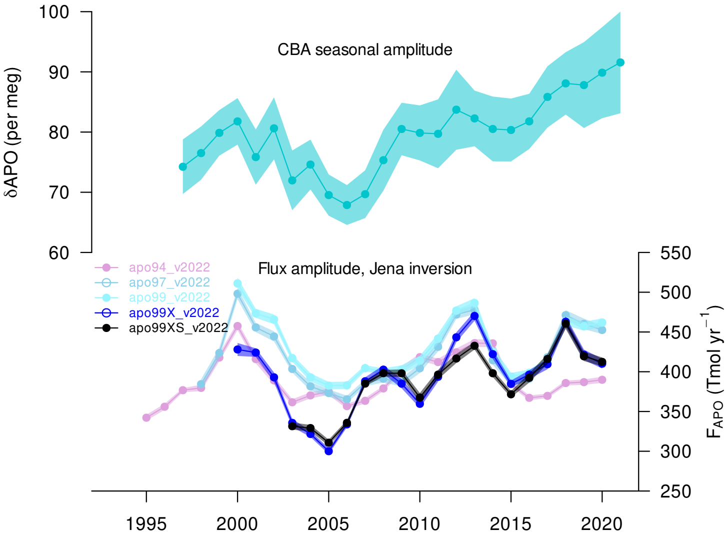




No clear differences in transport between years with high and low APO amplitude.

Ocean processes

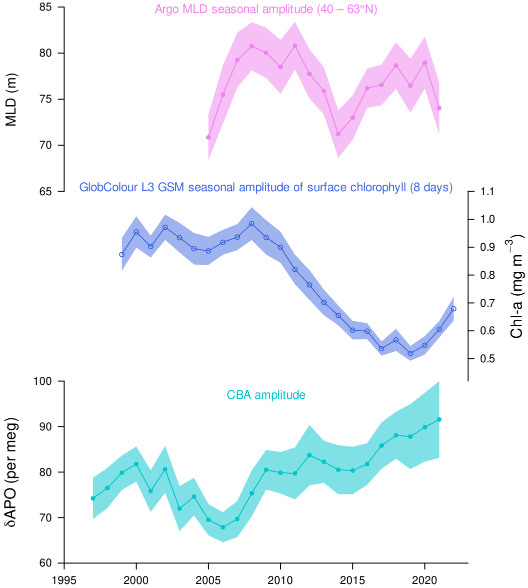
- Is the flux of APO changing?
- If so, why?

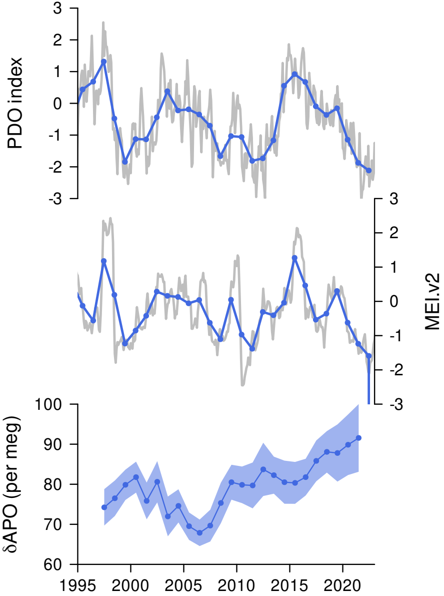


Jena inversion results disagree. 99x and 99XS show a trend in the amplitude of the flux (40–75 °N).

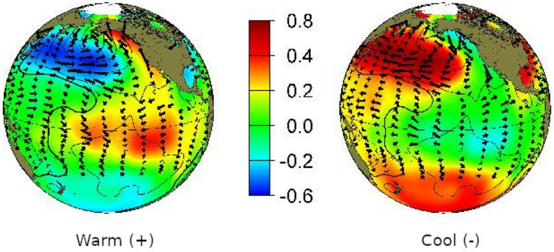
Observed MLD amplitude shows small interannual variability and no trend (40–75 °N).

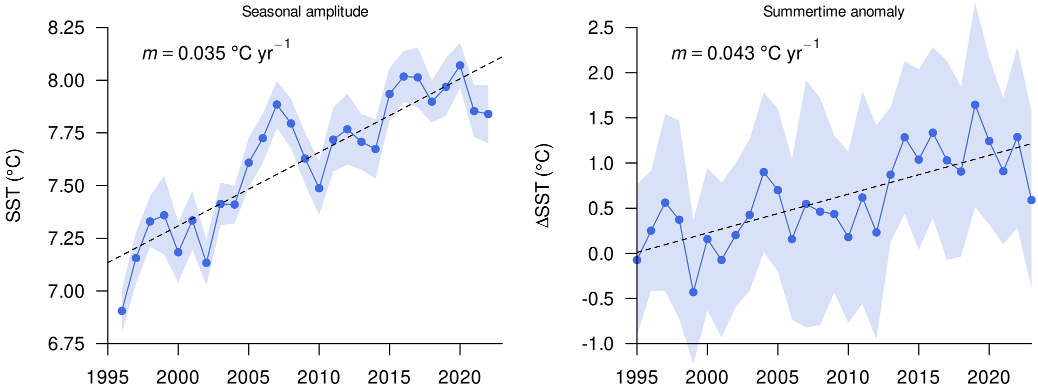
The seasonal amplitude of surface chlorophyll (from satellites) has declined precipitously (40–75 °N).



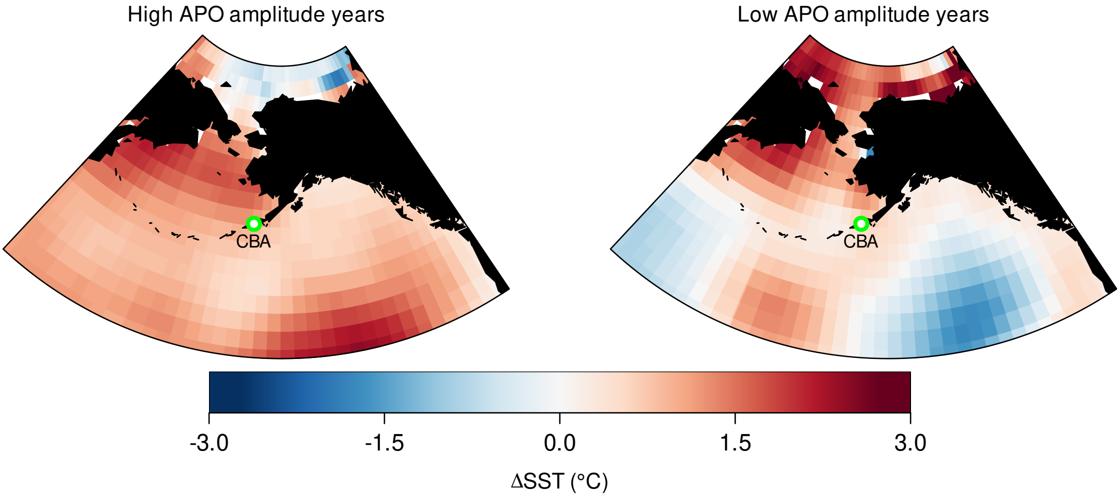


Climate indices may explain some of the interannual variability, but not the trend.

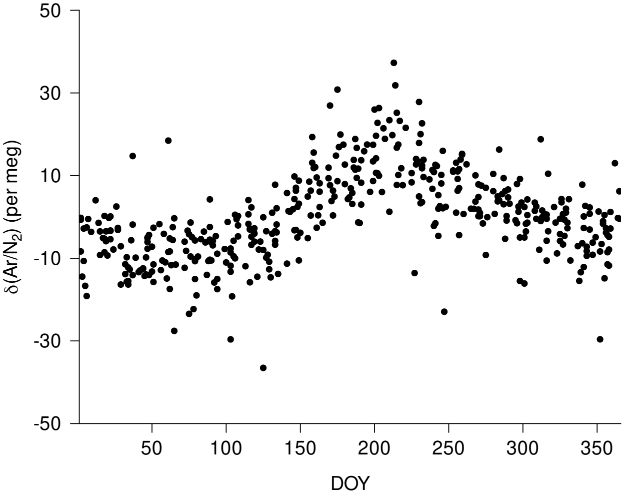




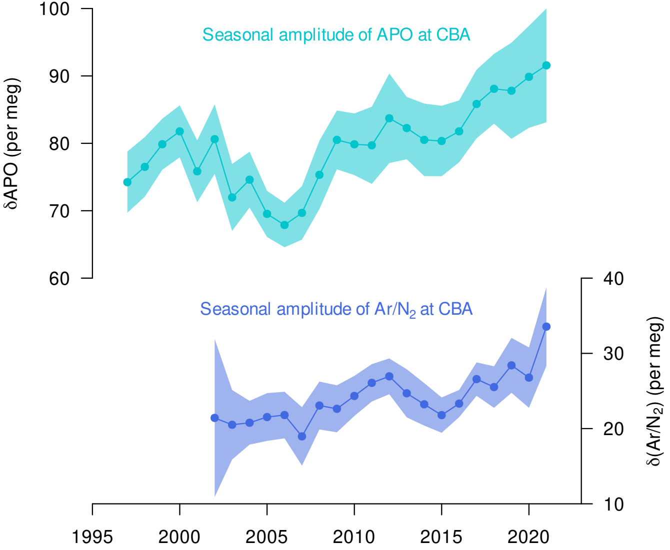
Both the amplitude and summer anomaly of SST has increased (40–75 °N).



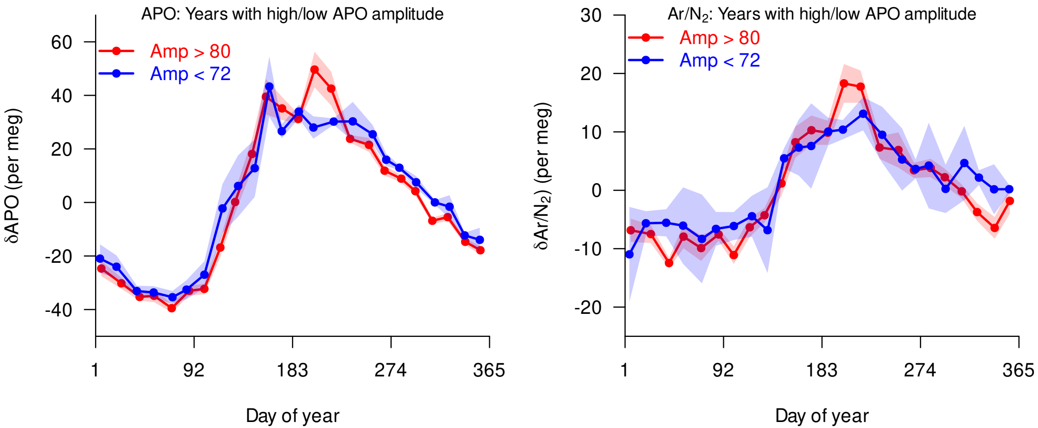
Summer SST anomalies in high amplitude years are higher than in low amplitude years.



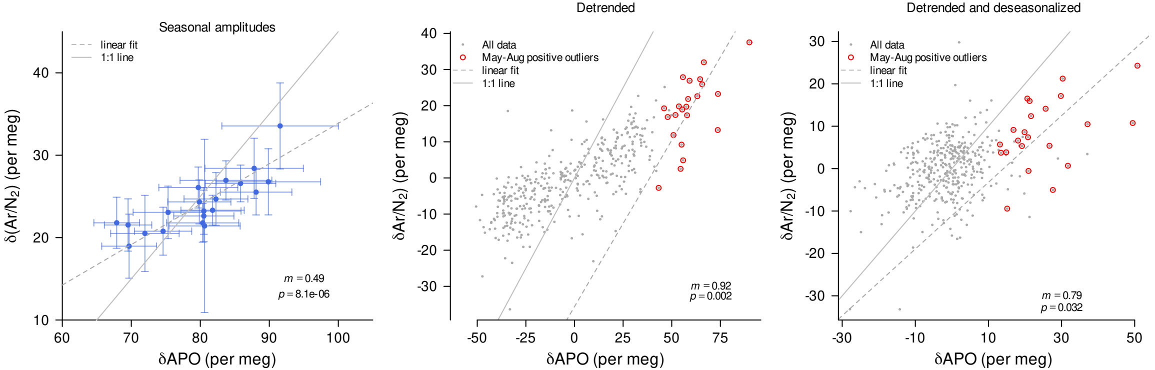
If solubility effects are impacting the amplitude, it should be visible in Ar/N_2.



The amplitude in Ar/N_2 is also increasing.



Ar/N_2 obs. are noisy, but show a summertime enhancement similar to APO during years with high APO amplitude.



APO and Ar/N_2 are correlated across multiple temporal scales.

Summary

- The amplitude of the seasonal cycle at APO shows year-to-year differences and a long-term trend
- These differences are not greatly impacted by atmospheric dynamics and appear to be related to a real change in the amplitude of the flux of APO from the Bering Sea and North Pacific
- The trend appears to be substantially driven by solubility-related changes