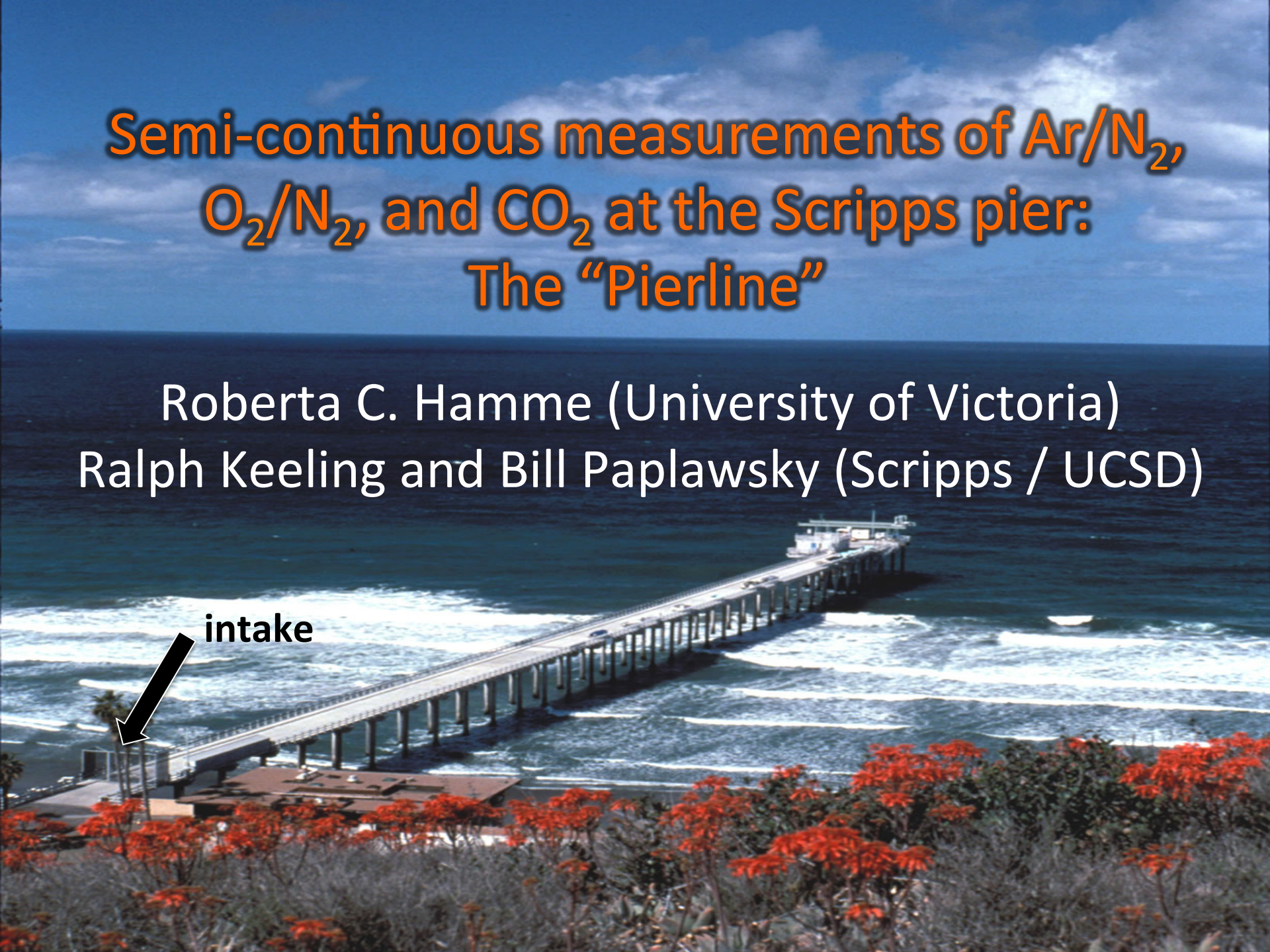
Semi-continuous measurements of Ar/N_2, O_2/N_2, and CO_2 at the Scripps pier: The "Pierline"

Roberta C. Hamme (University of Victoria)
Ralph Keeling and Bill Paplawsky (Scripps / UCSD)



Semi-continuous measurements of Ar/N_2 at La Jolla

Started by Tegan Blaine

11+ years of data nearly every weekend, on usual flask instrument

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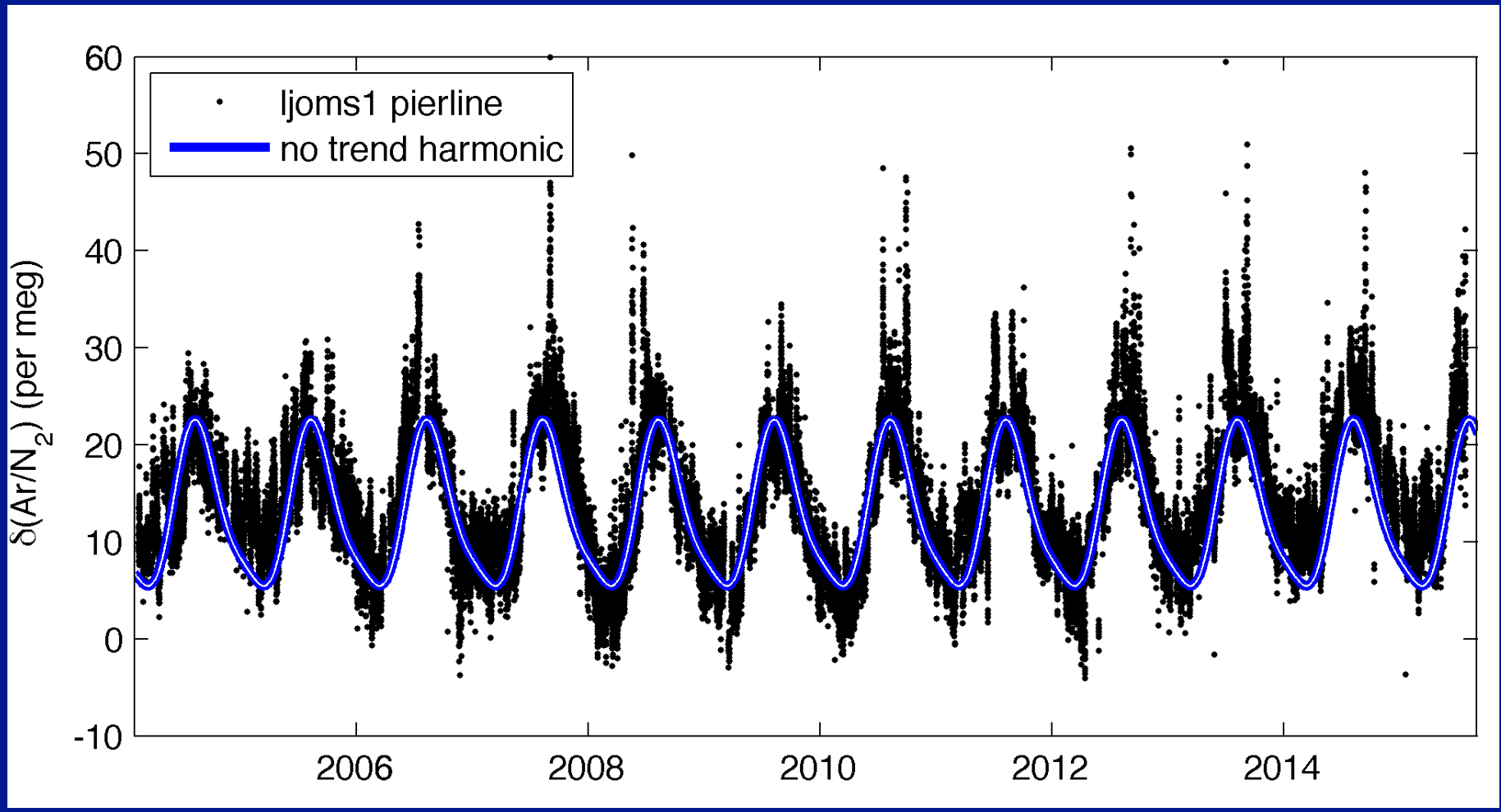
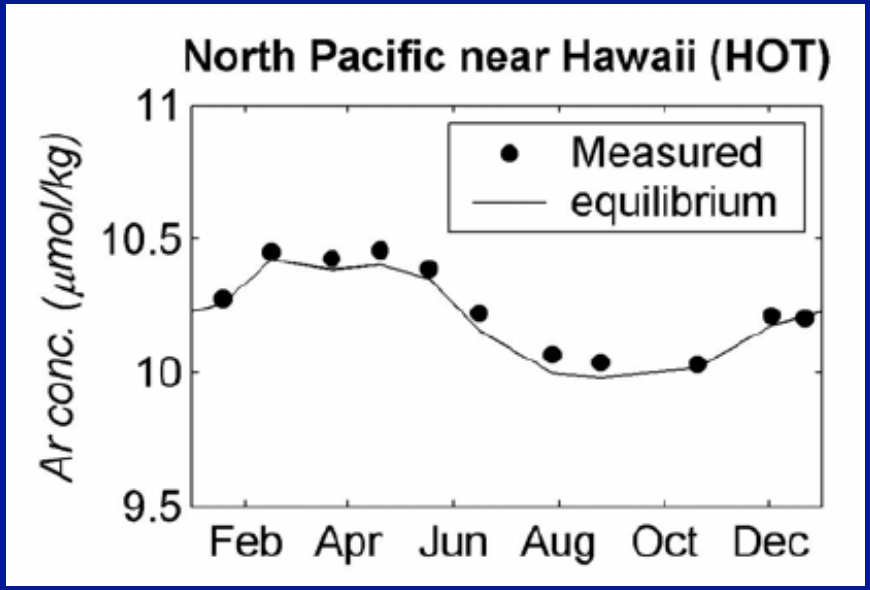
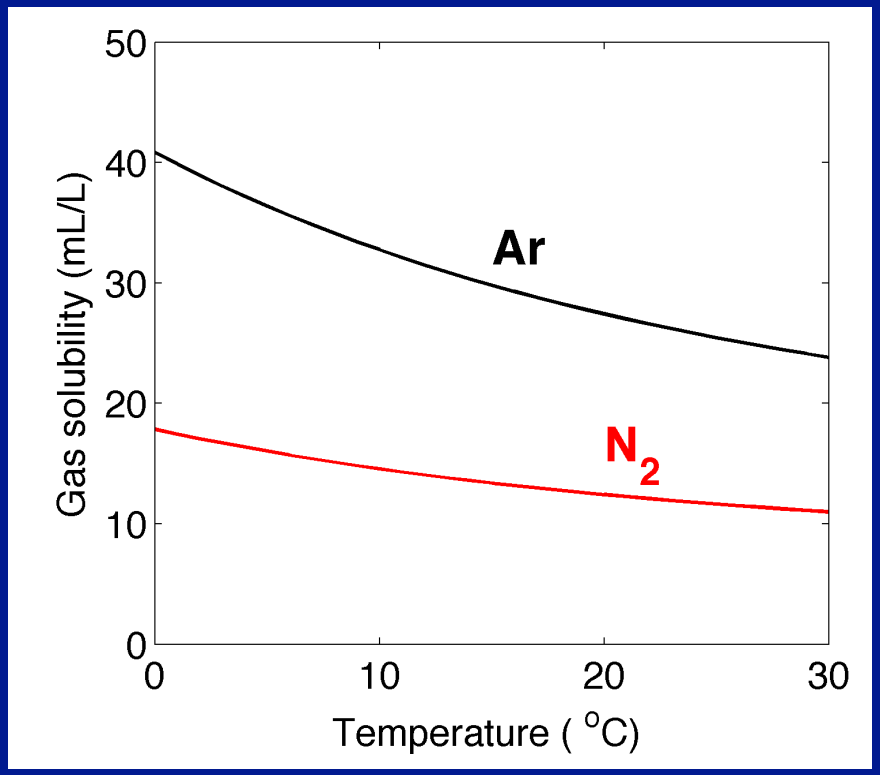
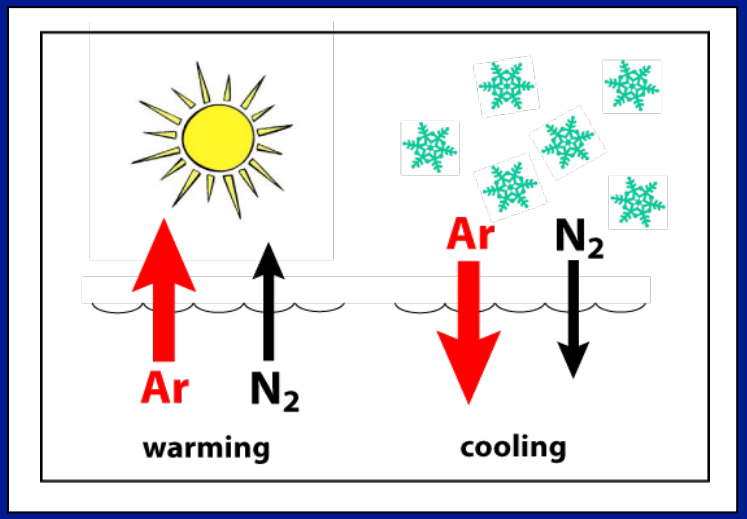


Atmospheric Ar/N_2 = tracer of ocean heat content

- Ar is about twice as soluble as N_2 in seawater
- Warming ocean increases atmospheric Ar/N_2, cooling opposite



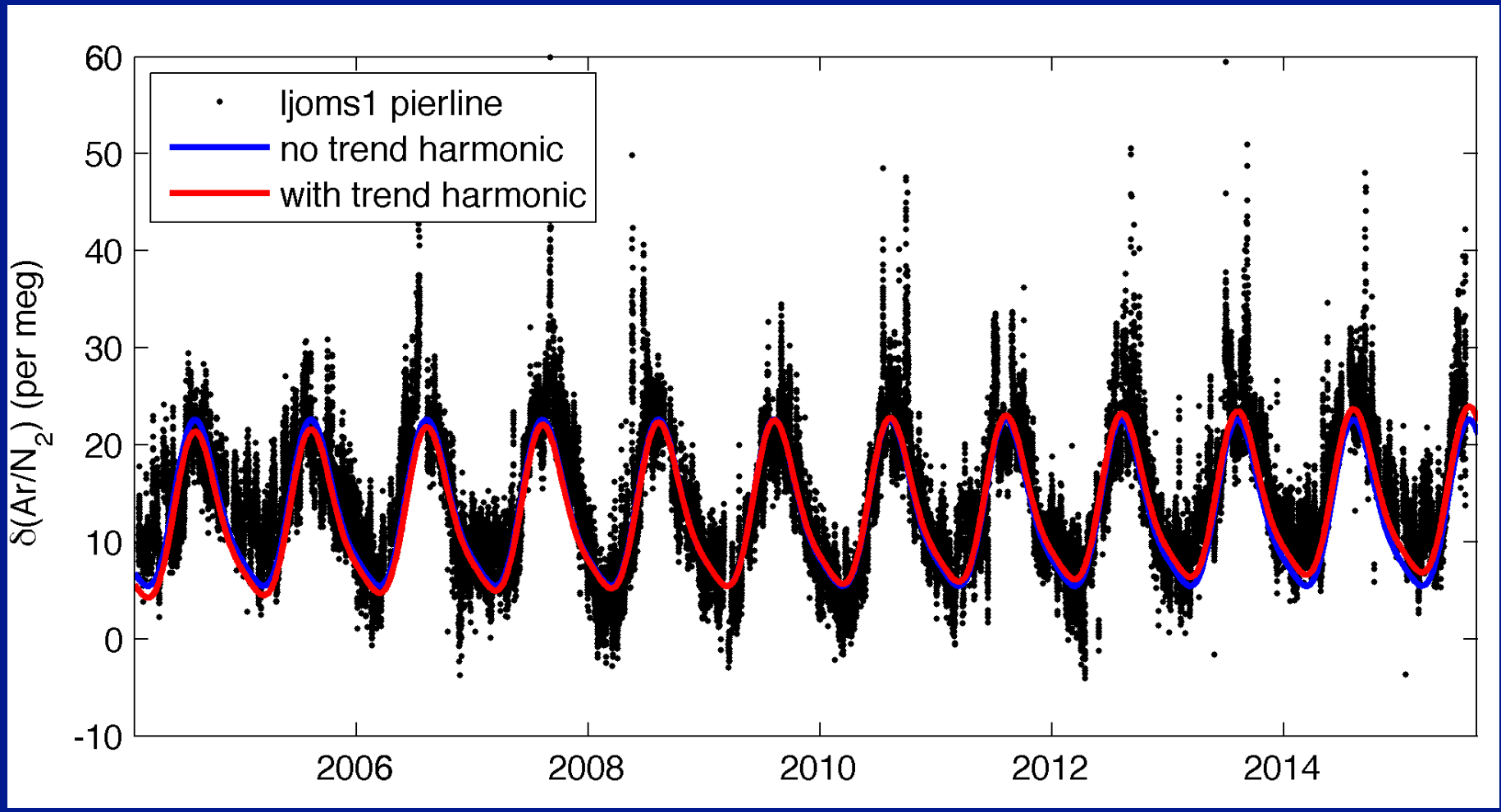




Semi-continuous measurements of Ar/N_2 at La Jolla

Drift in time series of +0.23 per meg / year

Expected trend is rise of +0.3 per meg / year



Semi-continuous measurements of Ar/N_2 at La Jolla

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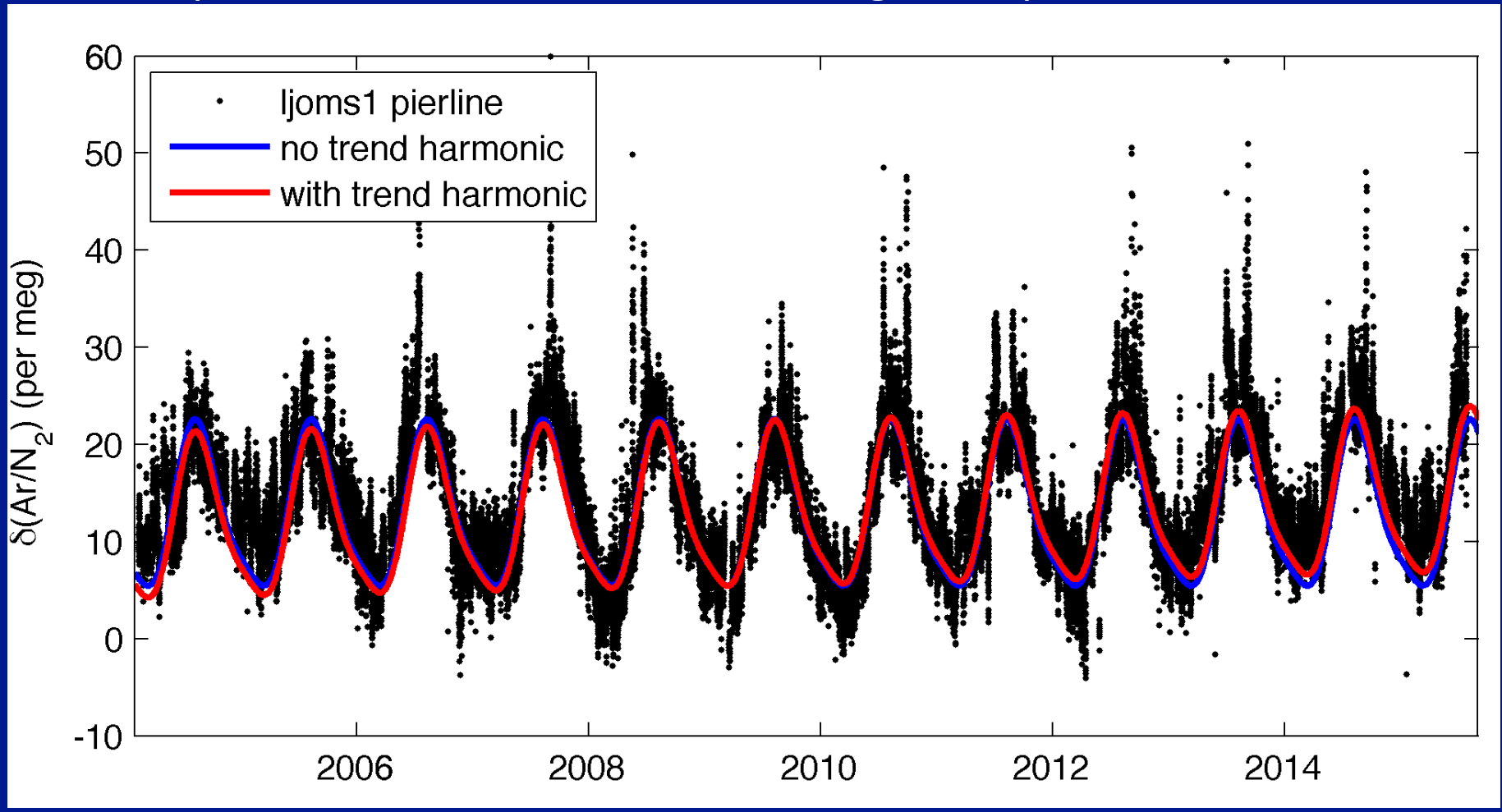
Expected trend is rise of +0.3 per meg / year

Except interannual variations are large compared to trend

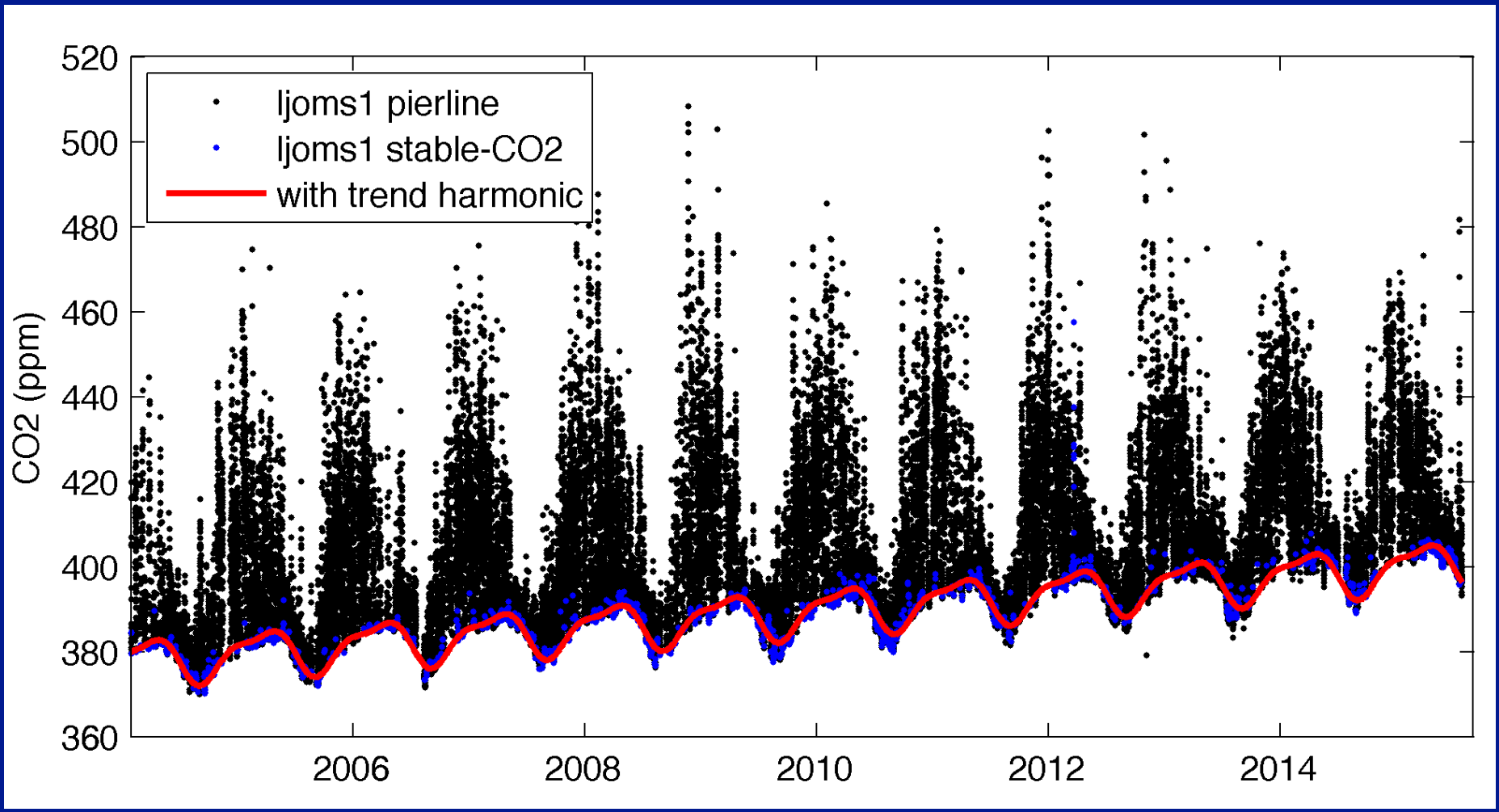


Seasonal cycle is 17 per meg peak to trough

Semi-continuous measurements of CO_2 at La Jolla

Large industrial / fossil fuel excursions from background values

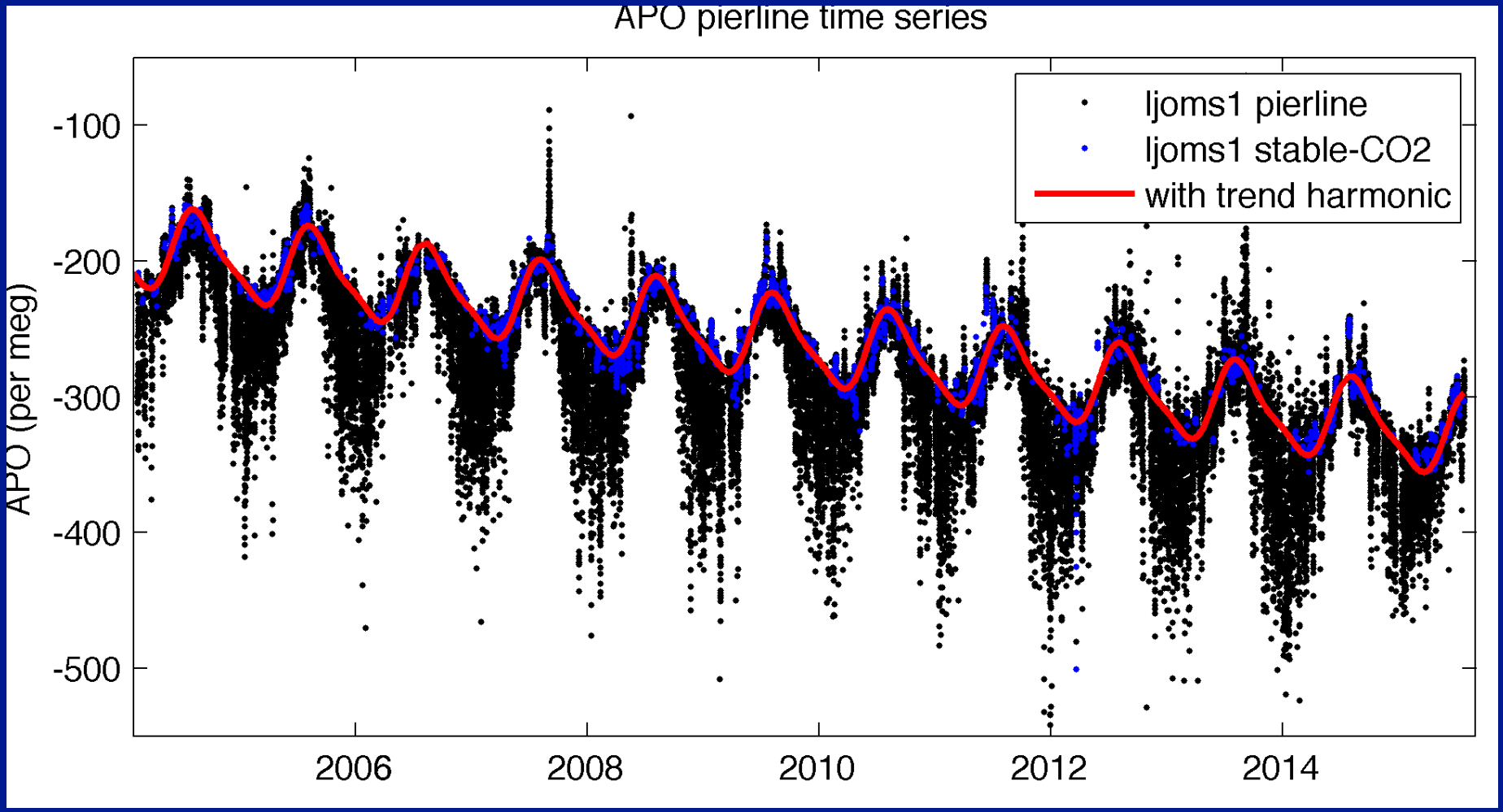
Identify background values as times with stable CO_2 (hourly std dev of < 0.35ppm, blue points) to define trend and seasonal cycle



Semi-continuous measurements of APO at La Jolla

Industrial excursions still perturb much of the record

Some high APO events in summer (will compare to Ar/N_2)

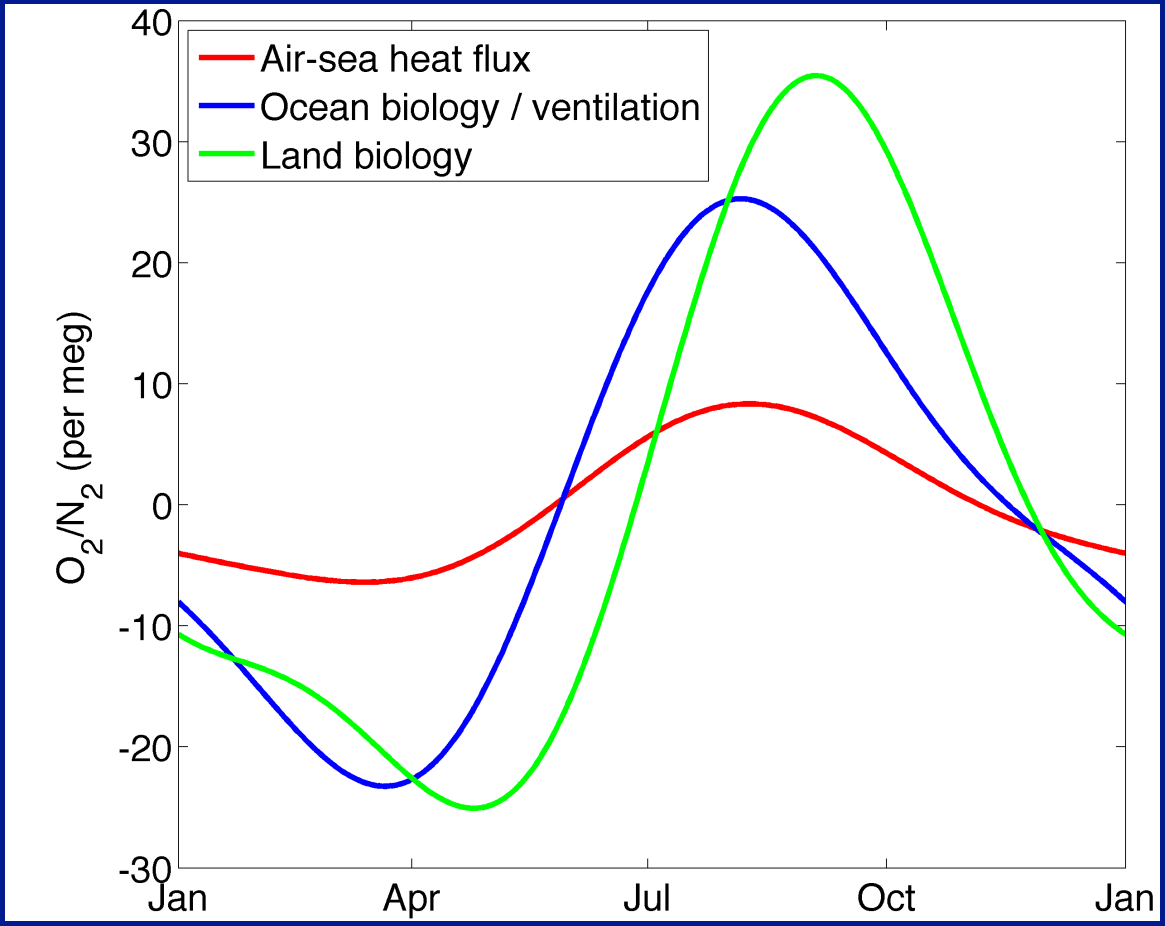


Deconvolution of seasonal cycles

Baseline CO_2 cycle yields land biology, Ar/N_2 corrected for solubility differences yields air-sea heat flux, Ocean biology / ventilation is the rest (APO – heat flux)

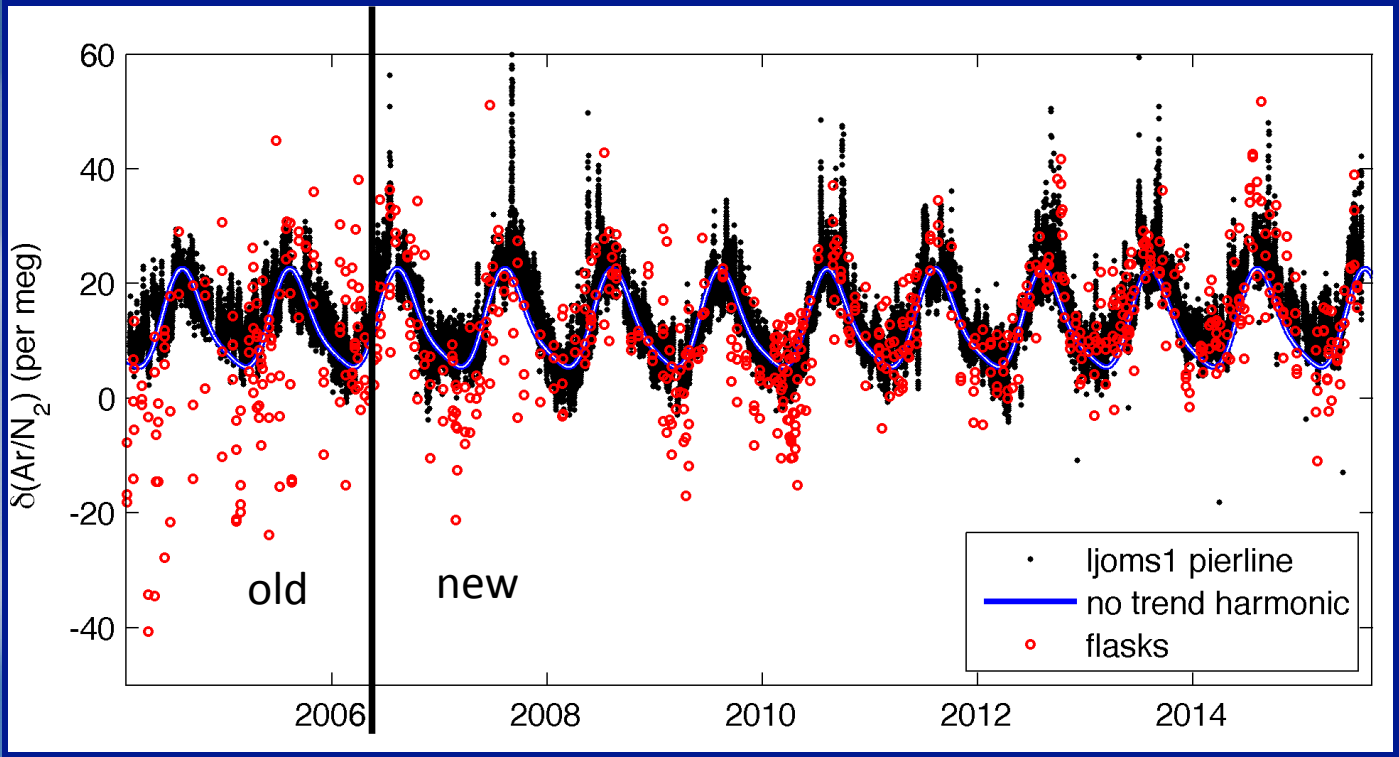
Air-sea heat flux causes 23% of APO fluxes detected at La Jolla

Ocean minimums and maximums line up within a week



Pierline precision much better than flasks for Ar/N_2

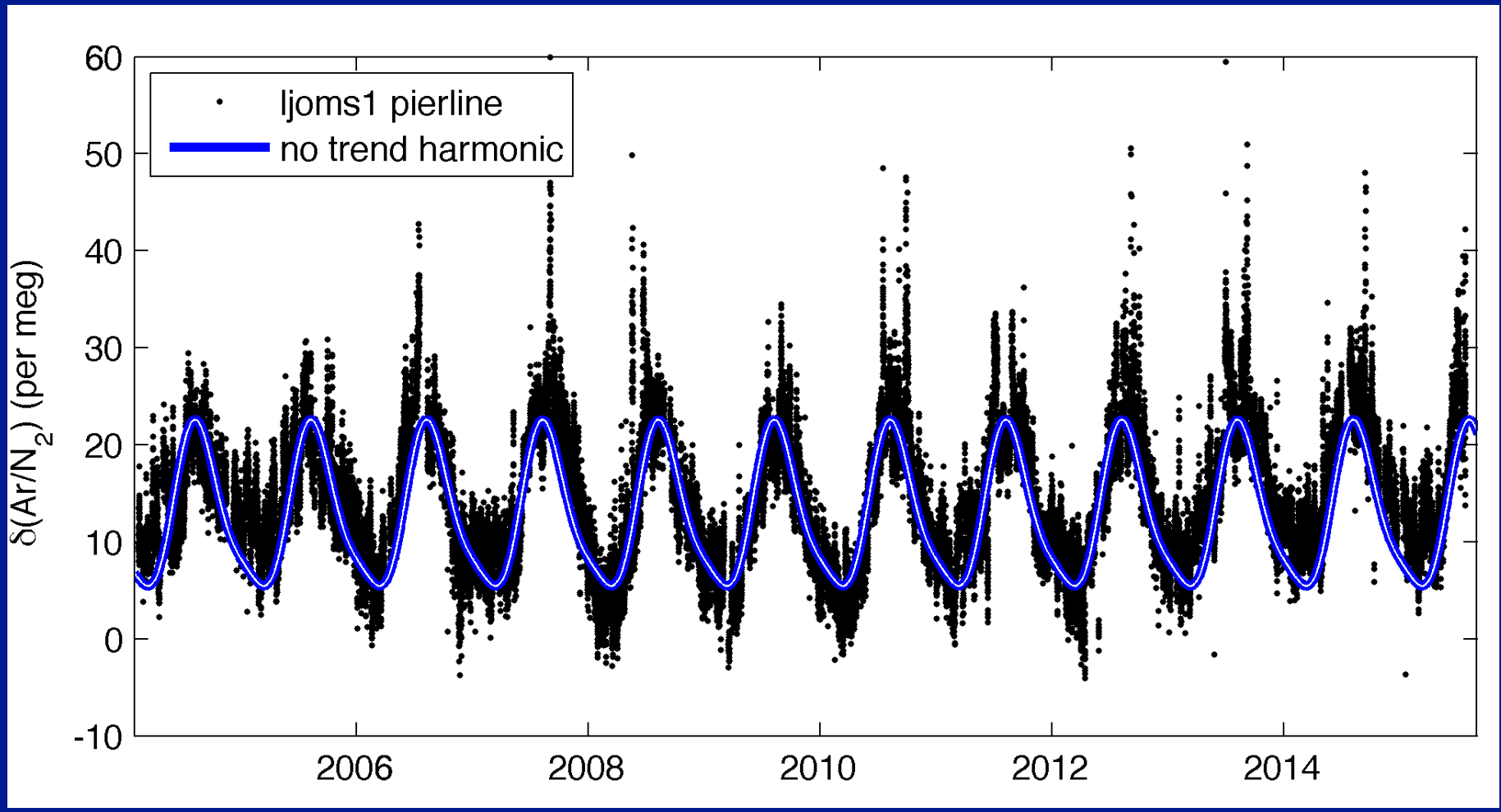
Pierline is still far more precise than flask measurements
Aspirator on inlet in mid-2006 improved flask measurements



Interannual variability in record is large

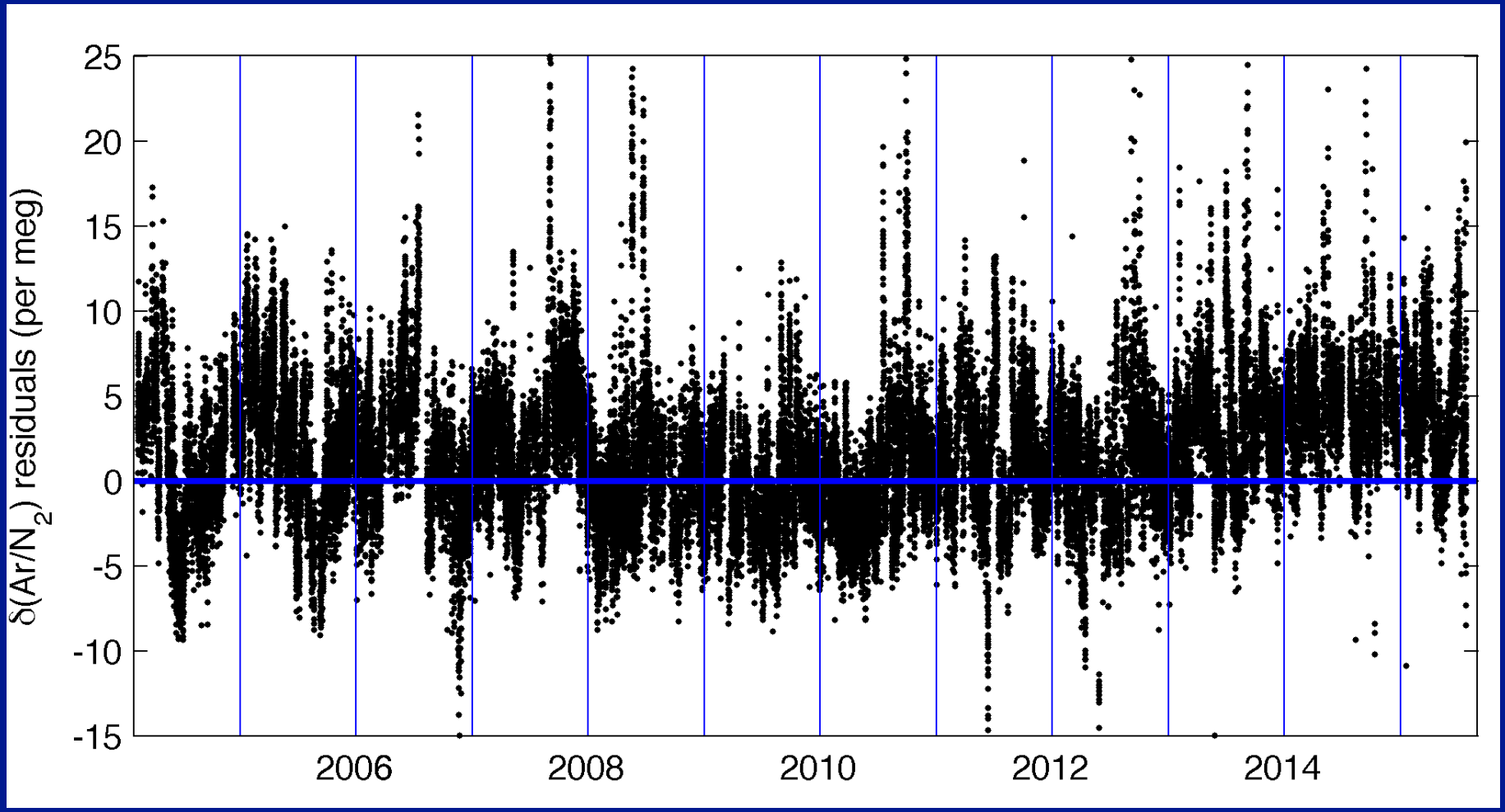
Recent data since 2013 is above the regular seasonal cycle

Winter 2005 also unusually high



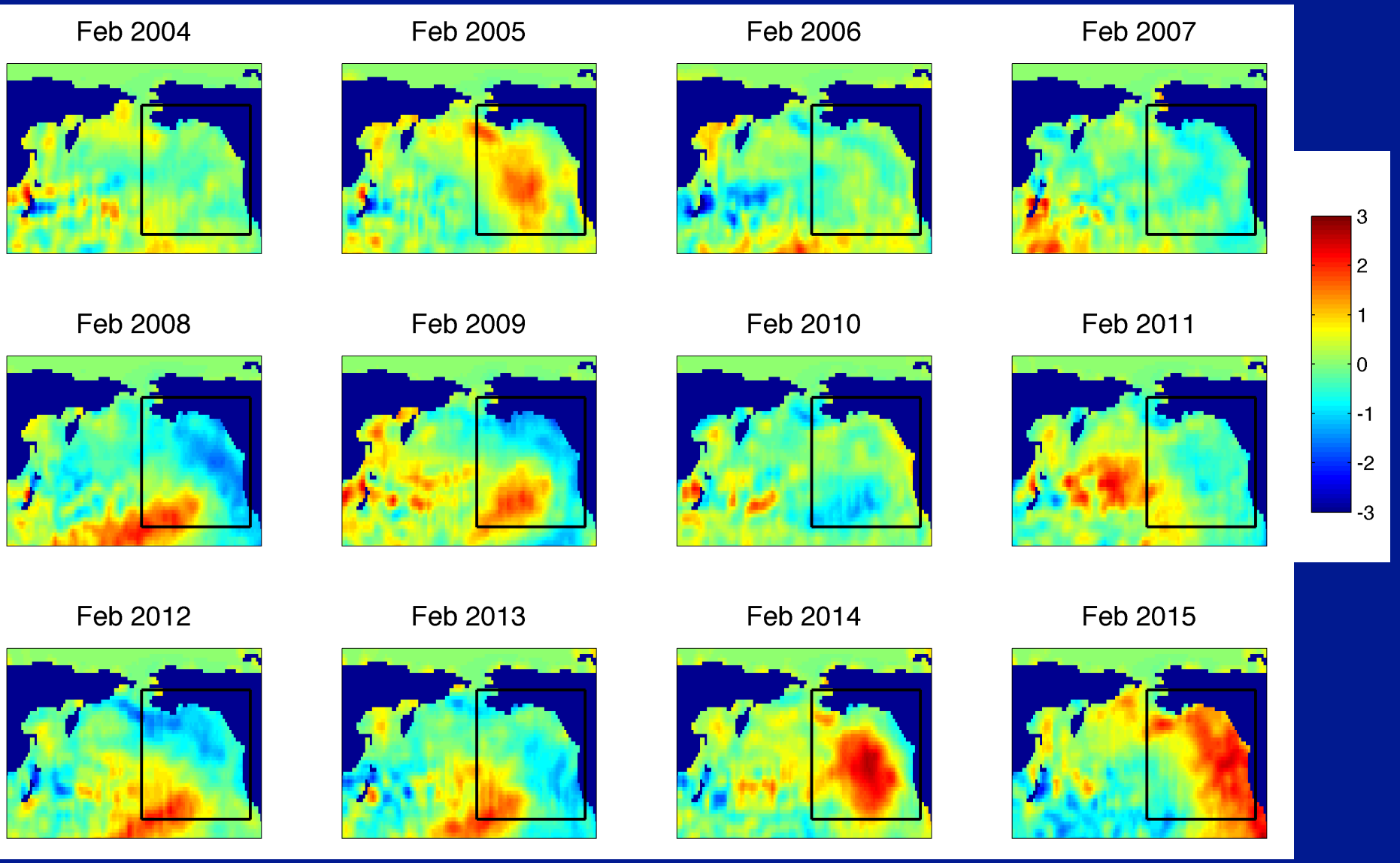
Interannual variability in record is large

Residuals from the regular seasonal cycle show similar deviations



Wintertime North Pacific Sea Surface Temperature Anomalies

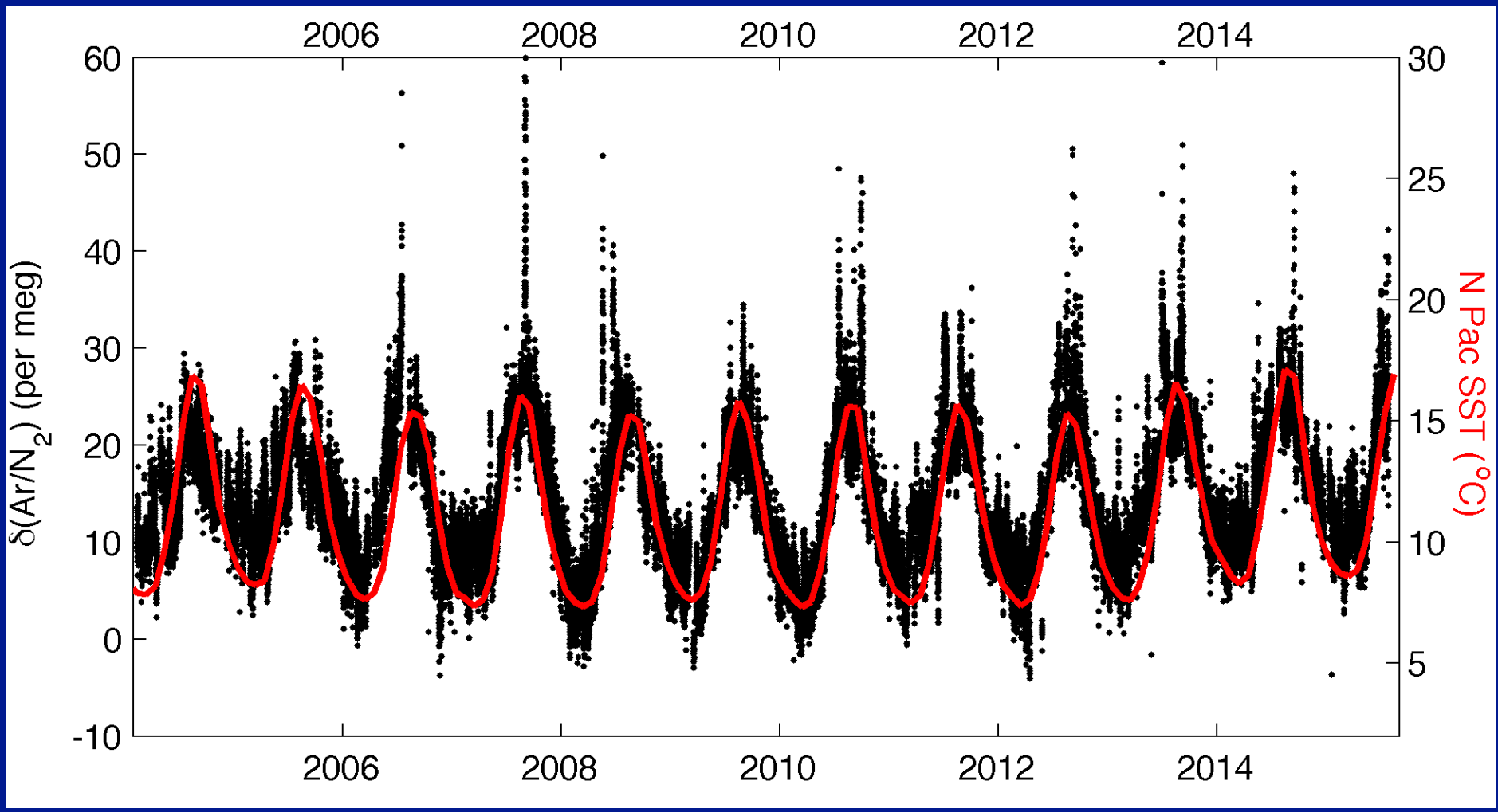
Feb 2005, 2014, 2015 are standout warm years



NOAA Optimum Interpolation SST product

La Jolla Ar/N_2 tracks North Pacific mean SST fairly well

Full time series of each



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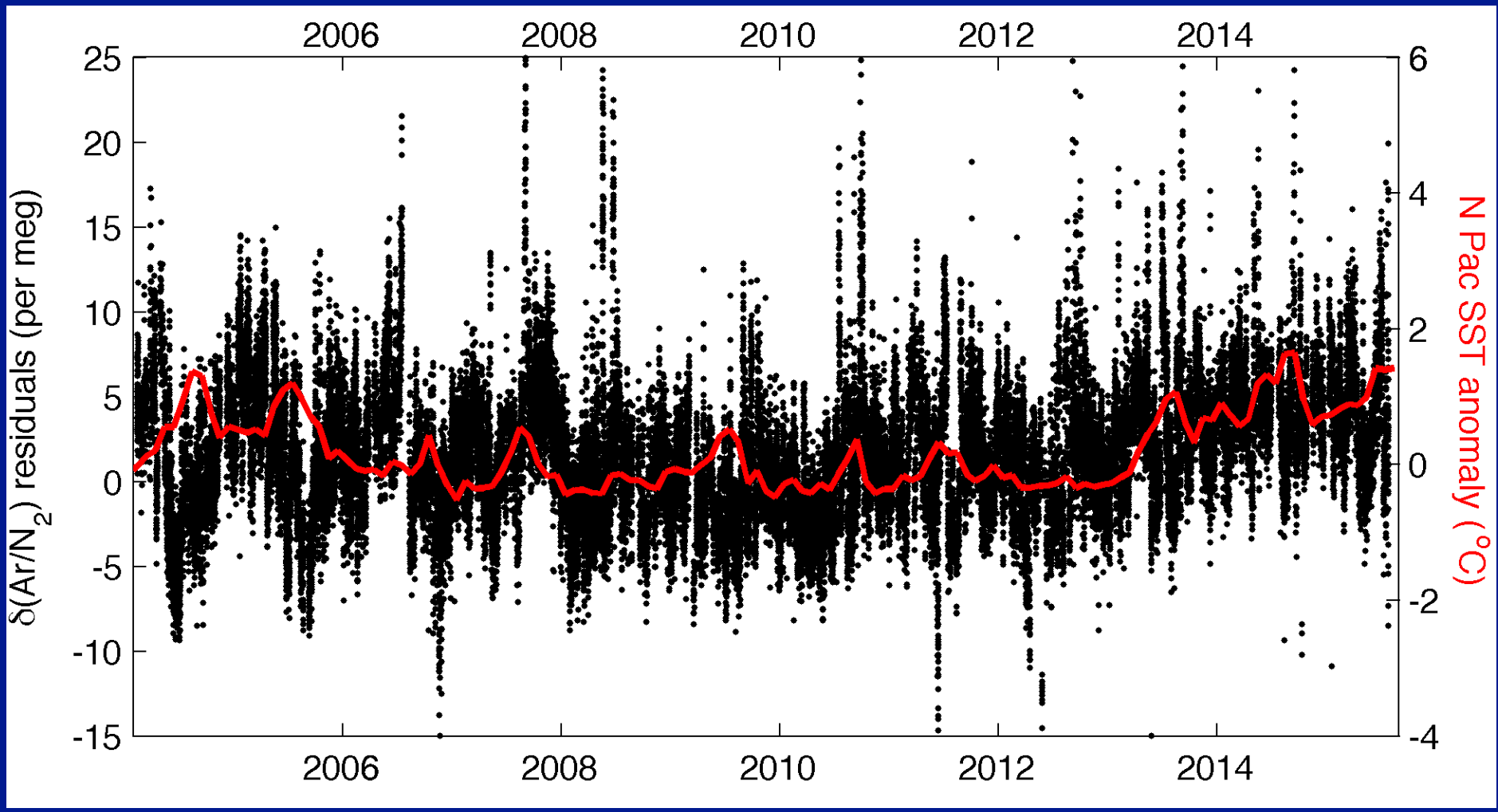


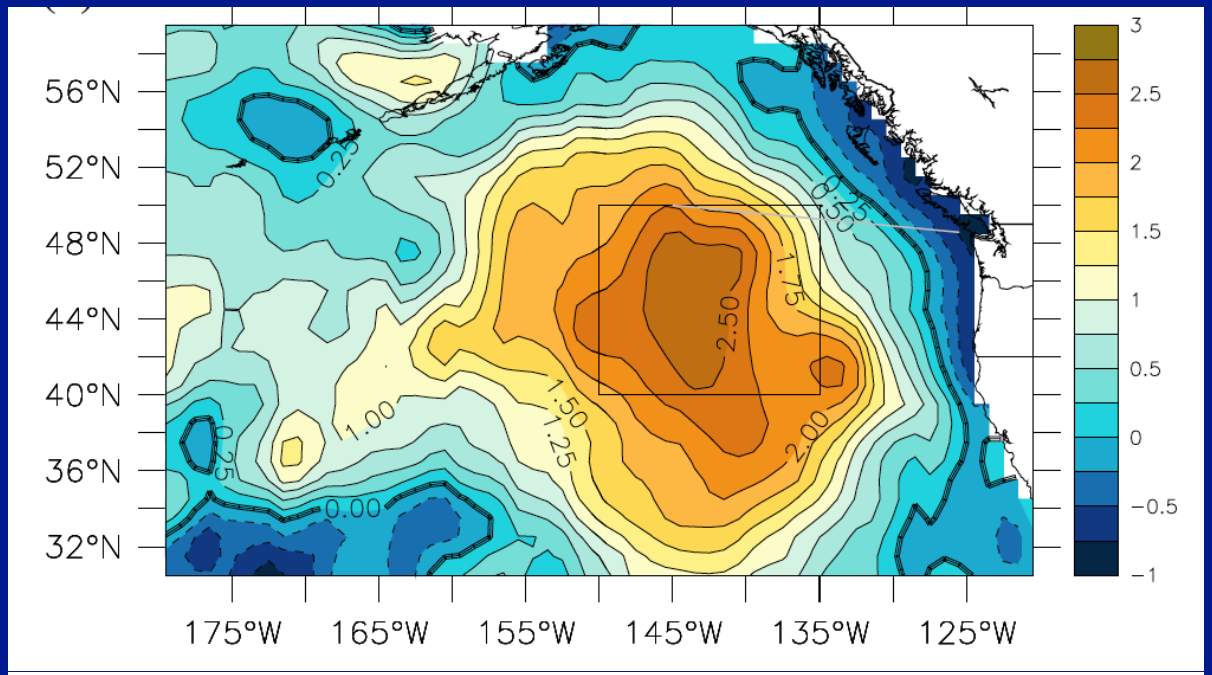
“The Blob” – Anomalously warm N Pacific SST

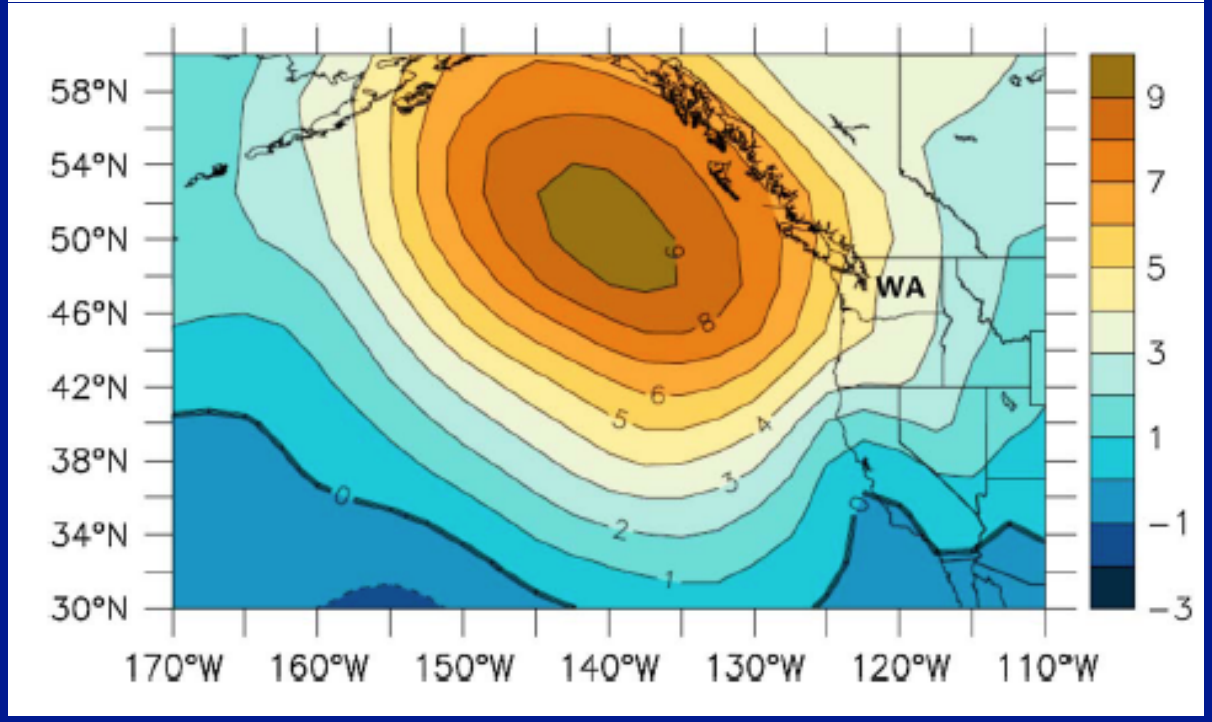
Feb 2014 SST anomaly (°C) from NCEP GODAS relative to 1981-2010 mean

High SLP suppressed wind stress and winter heat loss

Oct 2013 – Jan 2014 SLP anomaly (hPa) relative to 1981-2010 mean

(Bond, Cronin, Freeland, Mantua (2015) Geophys. Res. Lett.)





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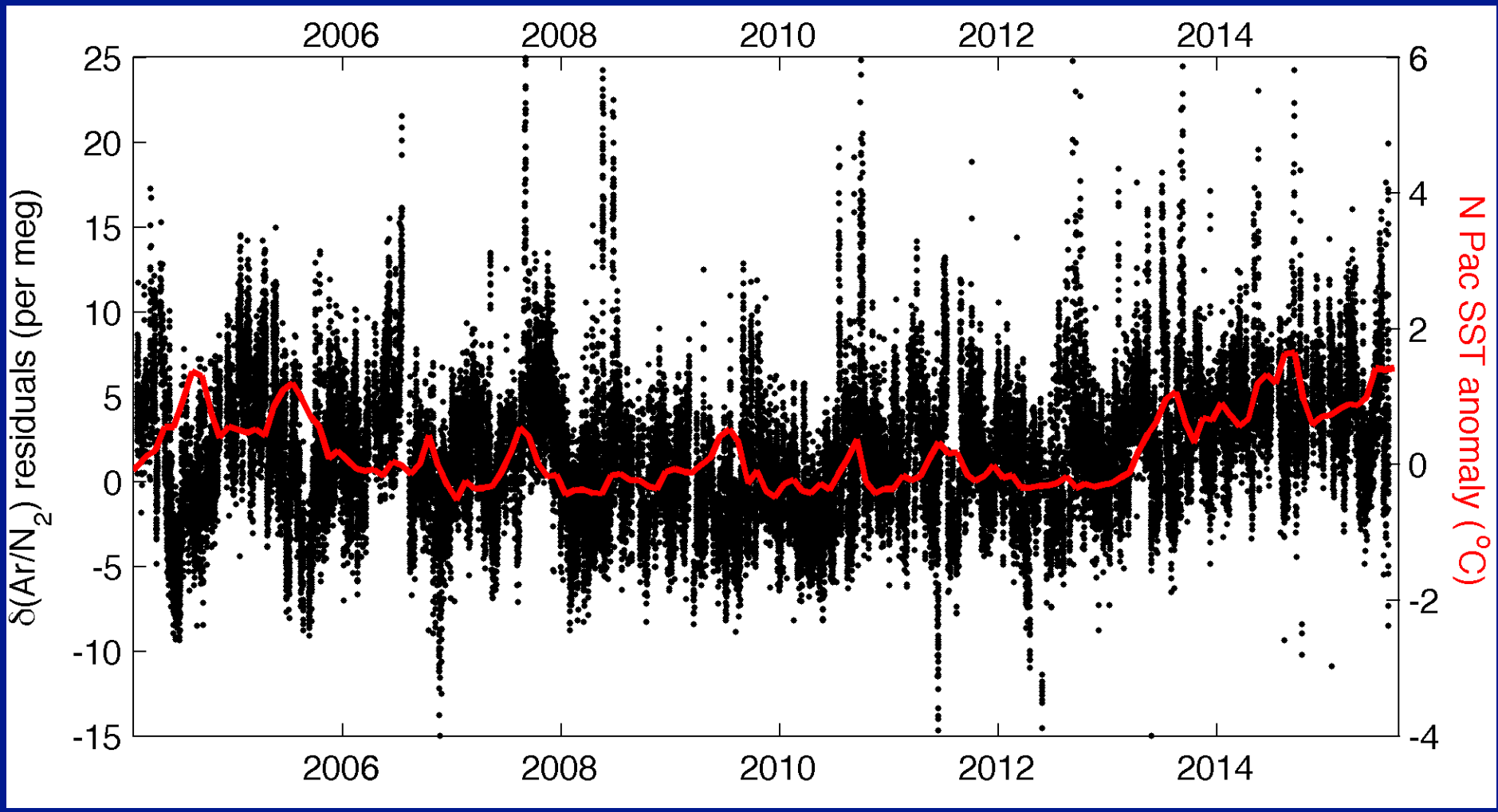
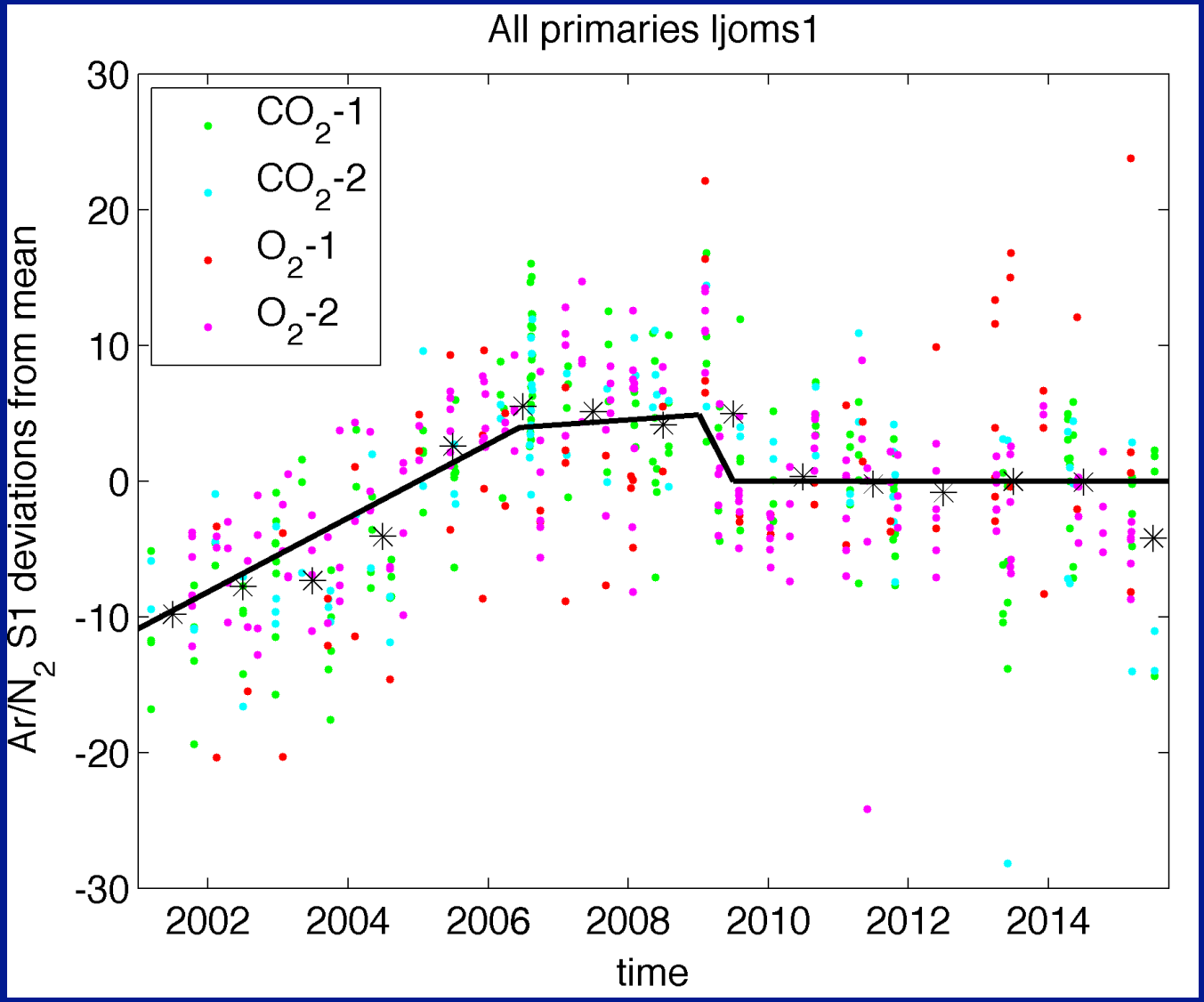


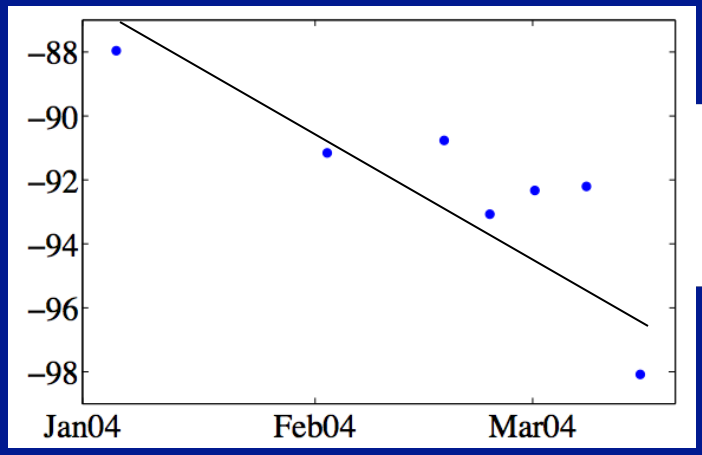
Ar/N_2 Primaries on ljoms1 (S1 scale)

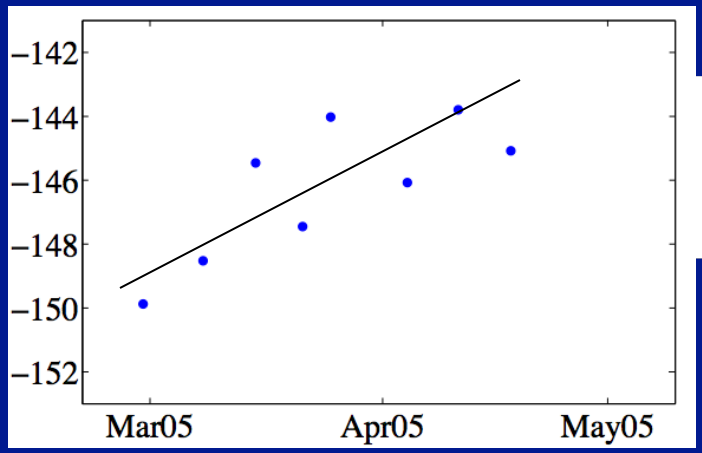
Tank stability was a significant issue pre 2006

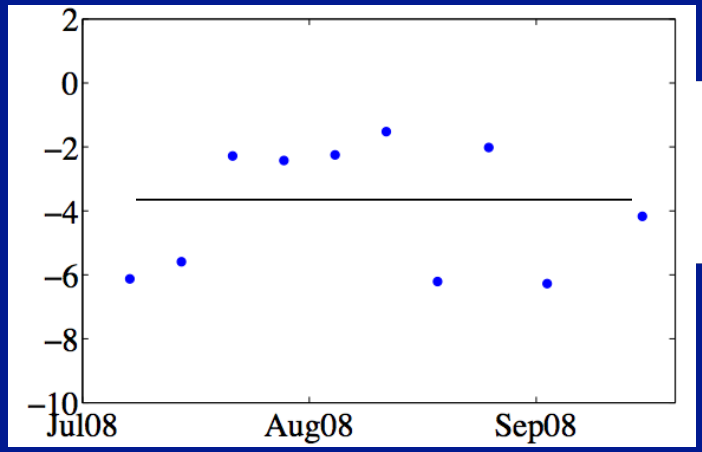
Source of sudden offset in 2009 unclear



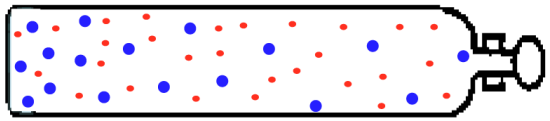
Pier working tank Ar/N_2 concentrations



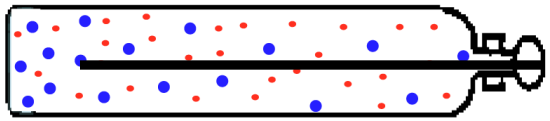




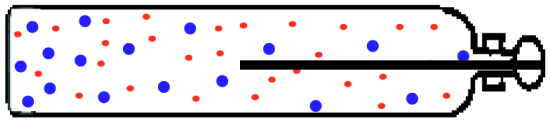
Lateral gradients must exist even in horizontal cylinders



No diptube



Too long diptube



Just right

Adding diptubes to remove gas from exact center of cylinder improved standard stability (working tanks and hi-lo-ox cylinders)

Hi span gets short diptube 12-Jun-2006
Lo span gets long diptube 28-Jan-2005,
Short diptube 17-Nov-2006
Ox span gets short diptube in Oct-2008

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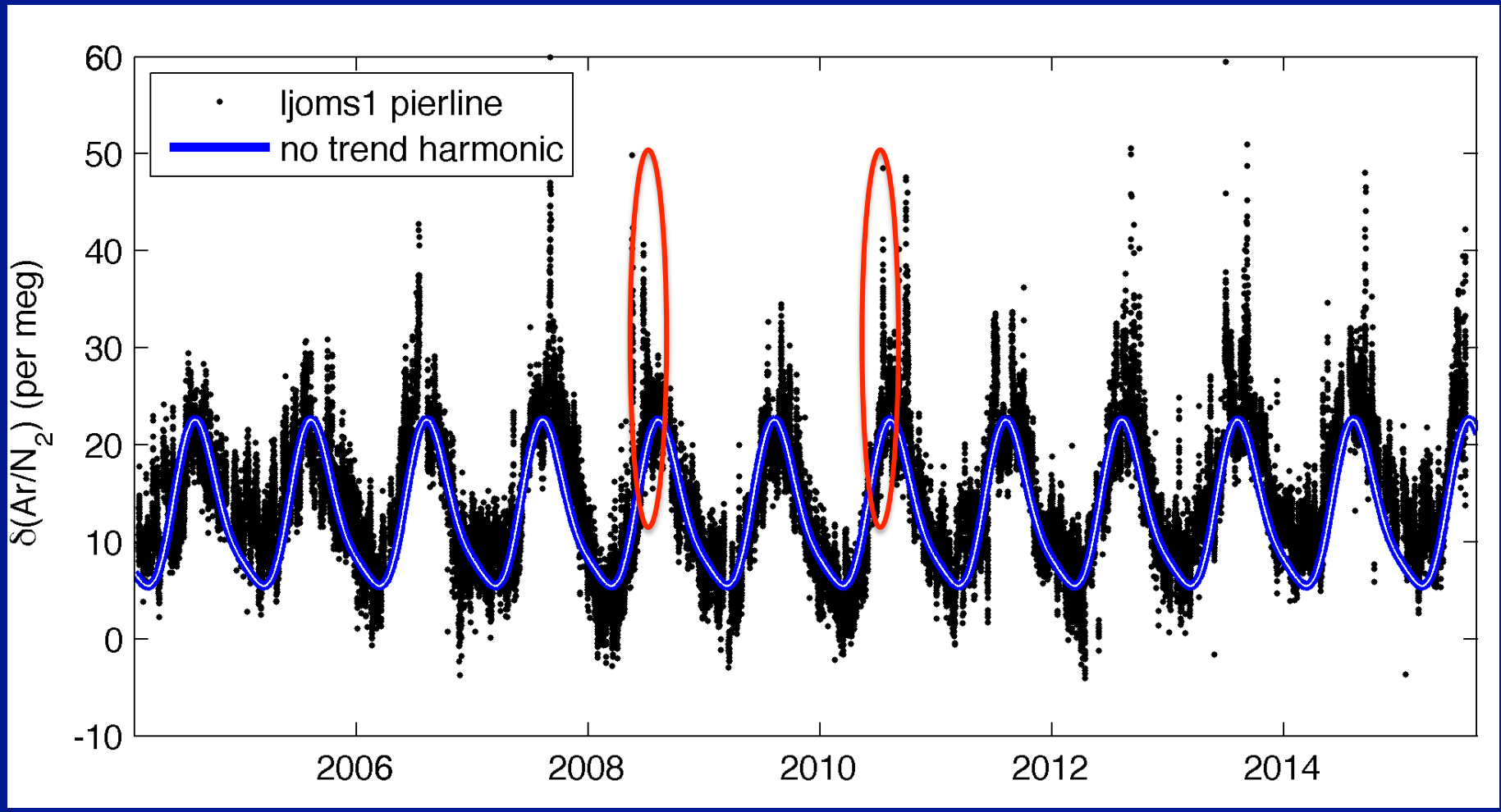
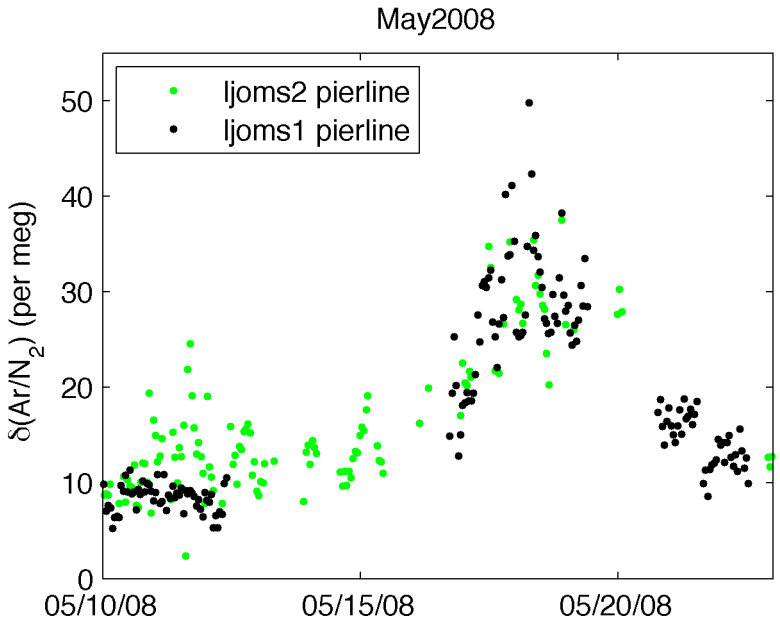
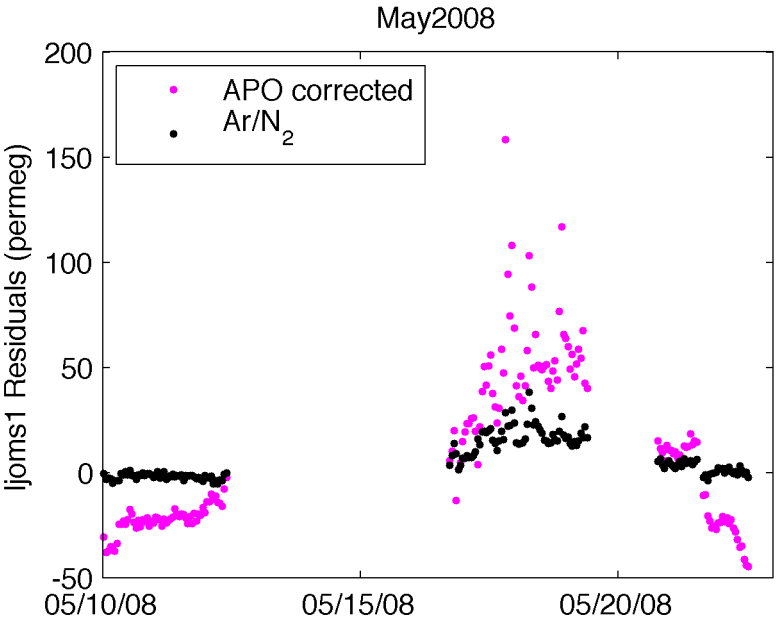


Short, high Ar/N_2 events

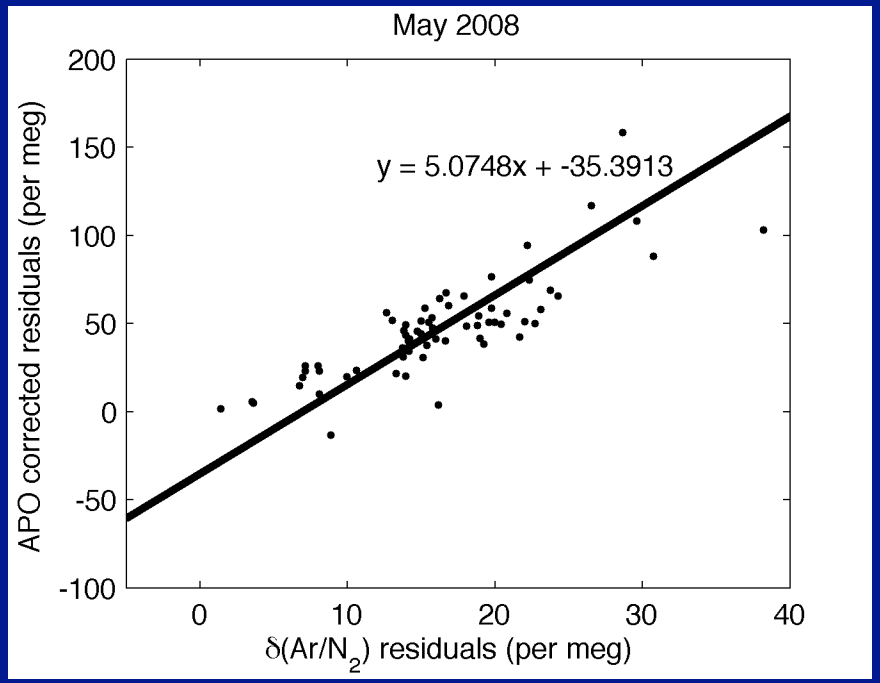




Events have higher APO, but not with consistent Ar/N_2 / APO ratio

CO_2 not necessarily high or baseline

Air masses tend to come over coastal zone



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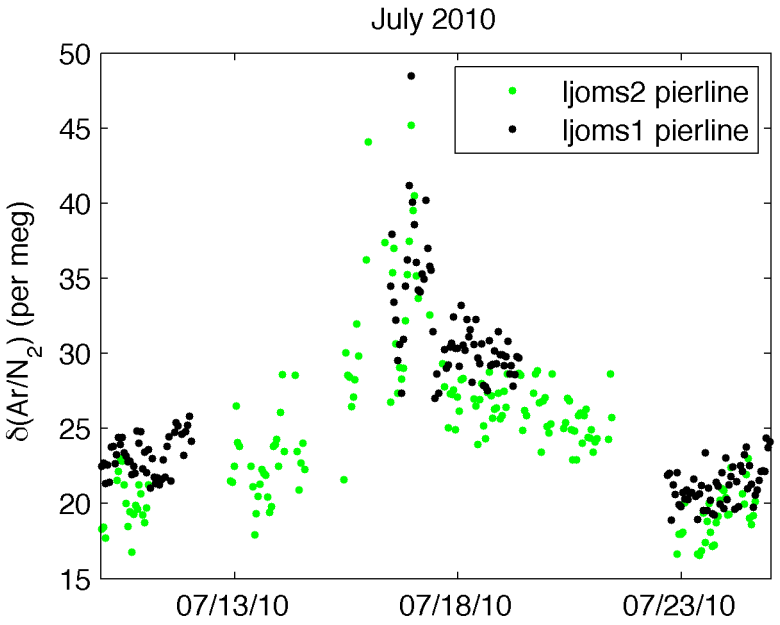
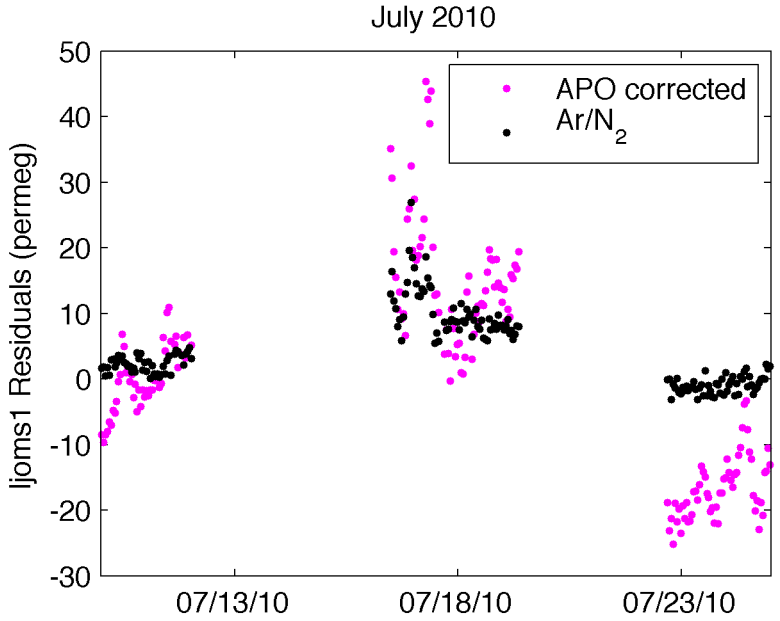
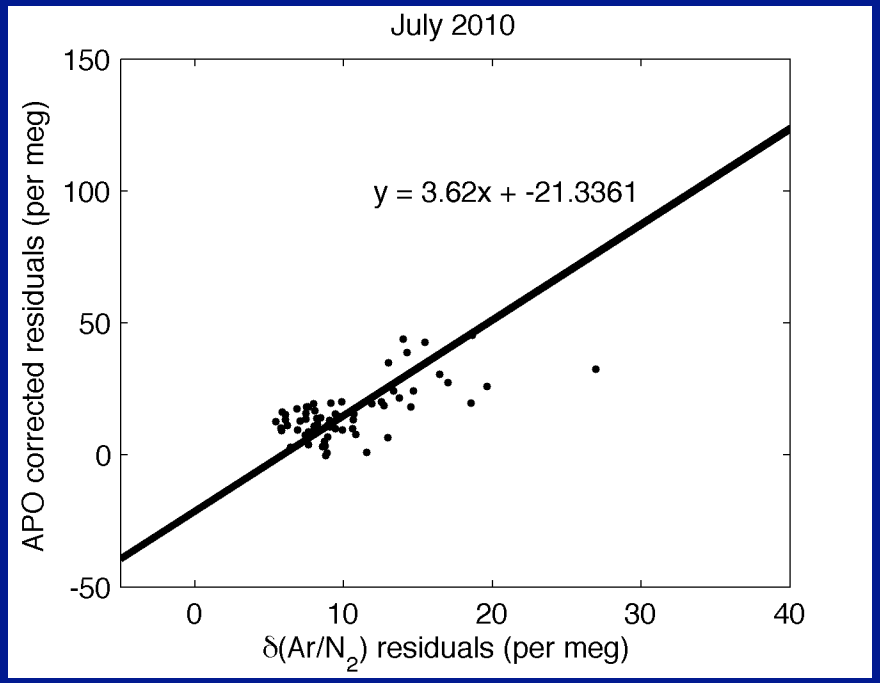




No clear correlation with Air T, Wind Direction, etc…

Anecdotal evidence that events occur during fog, suggesting a role for atmospheric inversion and thin boundary layer

What is best proxy for this?



Conclusions

- 11+ years of semi-continuous Ar/N_2, APO data at La Jolla
- Global warming trend cannot be detected yet
- Seasonal deconvolution indicates heat fluxes drive 23% of APO cycle
- Interannual variability may be linked to North Pacific temperature changes
- Enigmatic short term events show high Ar/N_2 and high APO

Remaining questions

- Are the interannual variations robust to standard calibration?
- Are recent Ar/N2 increases related to ocean warming, anomalous atmospheric transport, or both?
- What proxy could be used to prove high events are linked to boundary layer dynamics?