

Oxygen session

Summary of O₂ optode knowledge

Henry Bittig, LOV

Agenda

Hardware

- Sensor updates

New or unresolved issues

- In-situ conditioning
- 'Hook' at base of profile – develop QC test

Resolved issues

- O₂ conversions (S)
- P dependence
- Time response effect & correction

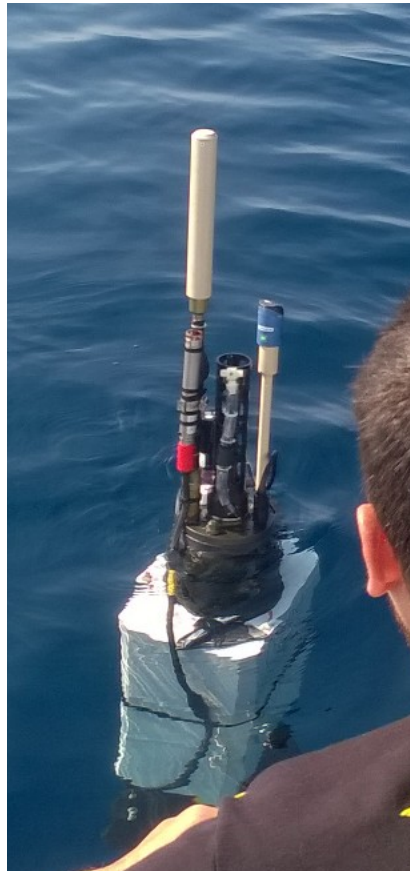
Soon resolved issues

- Long-term stability (pre-deployment / 'storage' drift)
- In air measurement daytime dependence & in-situ trend
- How to best correct O₂ data using in air & in-situ measurements (DM)

Acknowledgements: SCOR WG 142, SOCCOM O₂ ad hoc group

Sensor news?

- Rinko ARO-FT feedback → Kanako Sato
- Contros HydroFlash O₂ feedback:
First 100 m test profile on dual-O₂
LOV float (Aanderaa 4330 & Contros)
- ?



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New or unresolved issues

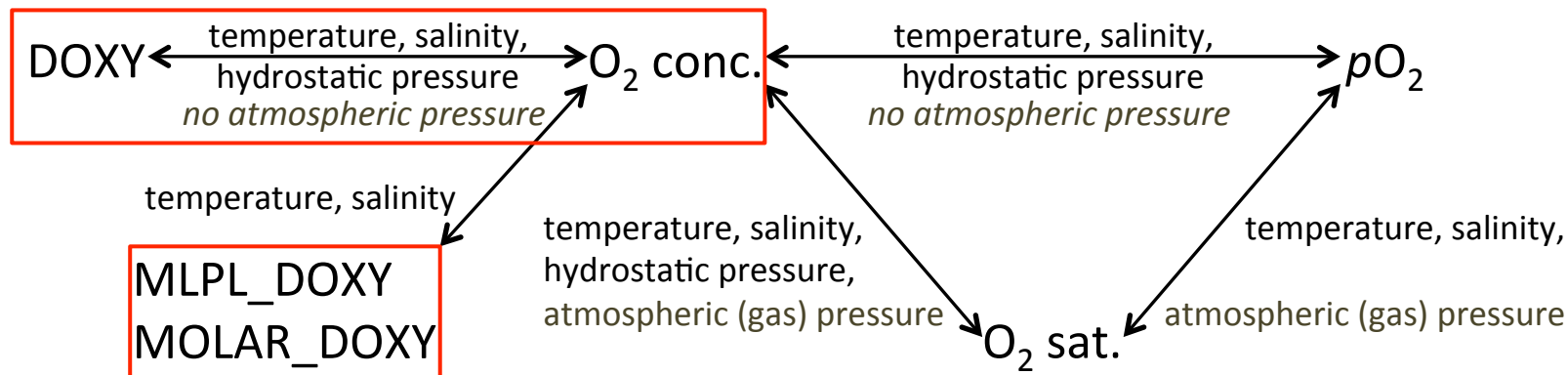
- In-situ conditioning
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Better addressed / soon resolved issues

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Unified conversion between O₂ quantities



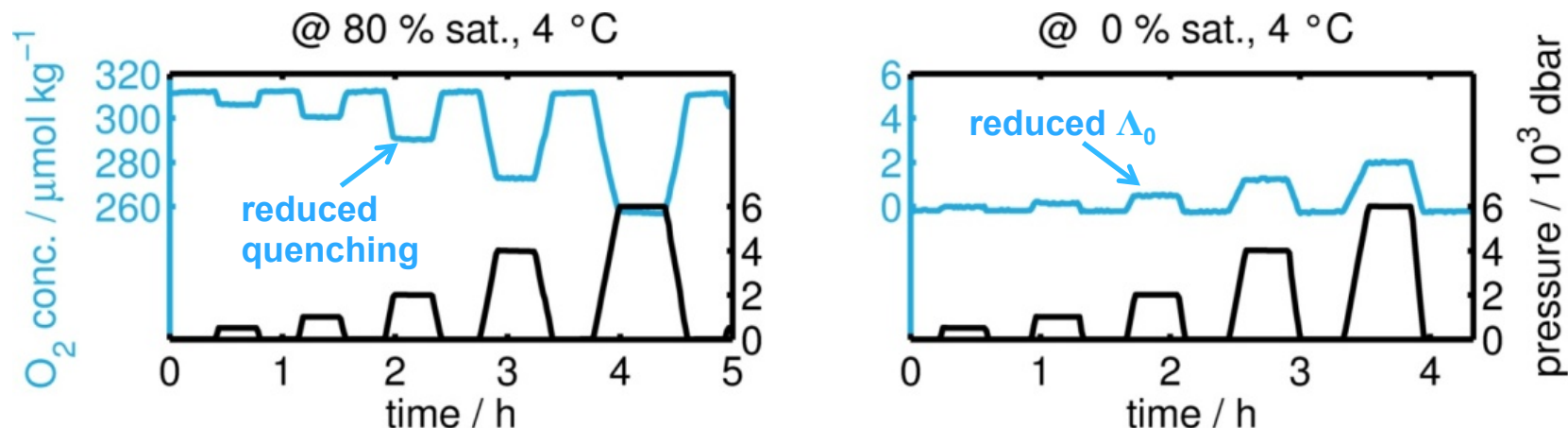
O₂ sensor manufacturers use different temperature & salinity dependencies (solubility equation). However, the *conversion* should not depend on the manufacturer but only on physical principles and be uniform for all O₂ sensors

- SCOR WG142 recommendations for O₂ quantity conversions to be used instead of (varying) manufacturer equations.
- Salinity correction was incomplete

$$c_{O_2}(T,S) = S_{\text{Corr}} \cdot \frac{1013.25 - p_{H_2O}(T,S=0)}{1013.25 - p_{H_2O}(T,S)} \cdot c_{O_2}(T,S=0) .$$

Included in new DAC cookbook version

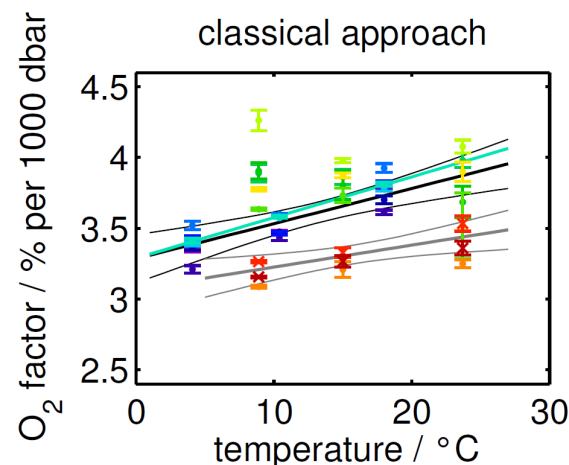
- approx. linear with P : due to different molar volume of O_2 in seawater and in membrane



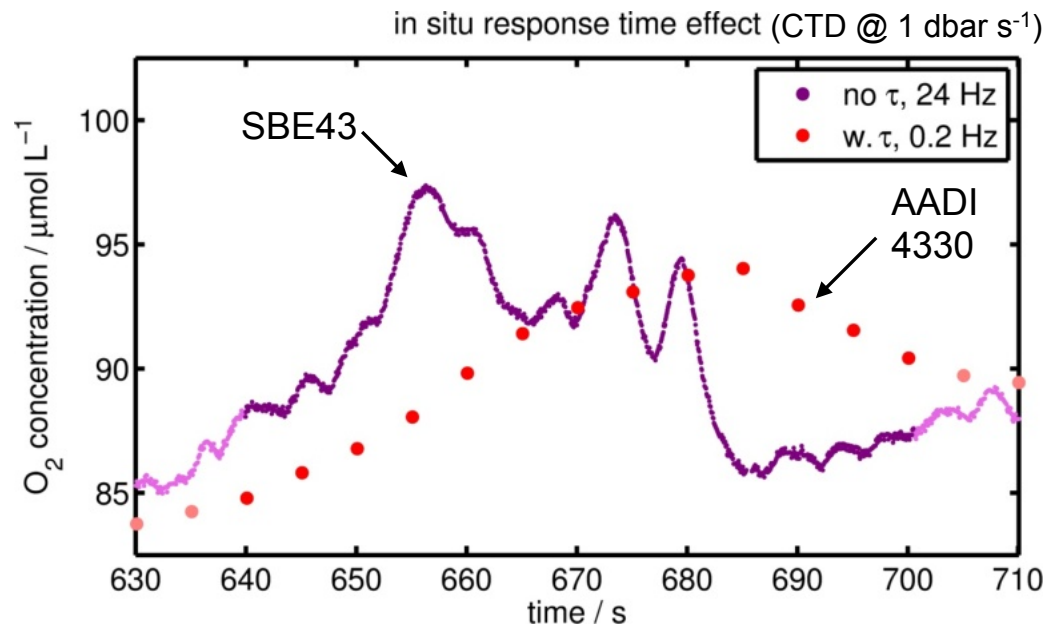
- 2 processes: O_2 dependent and O_2 independent
- affected by temperature
- uncertainty of ~ 0.3 % per 1000 dbar due to variability between sensors

Included in new DAC cookbook version

Bittig et al. 2015, Pressure response of Aanderaa and Sea-Bird oxygen optodes, J. Atmos. Oceanic Techn., 32:2305-2317

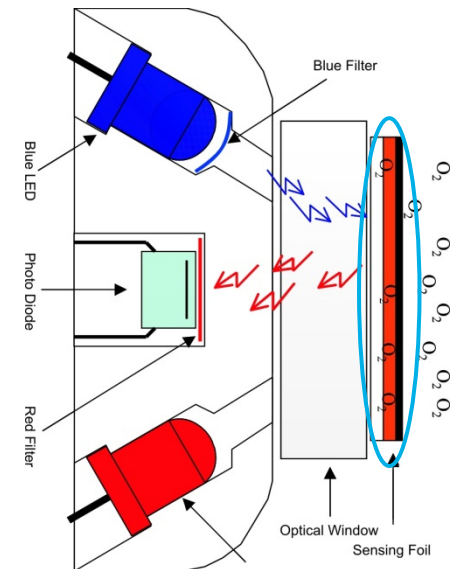


- affects both fine scale resolution & lag/hysteresis



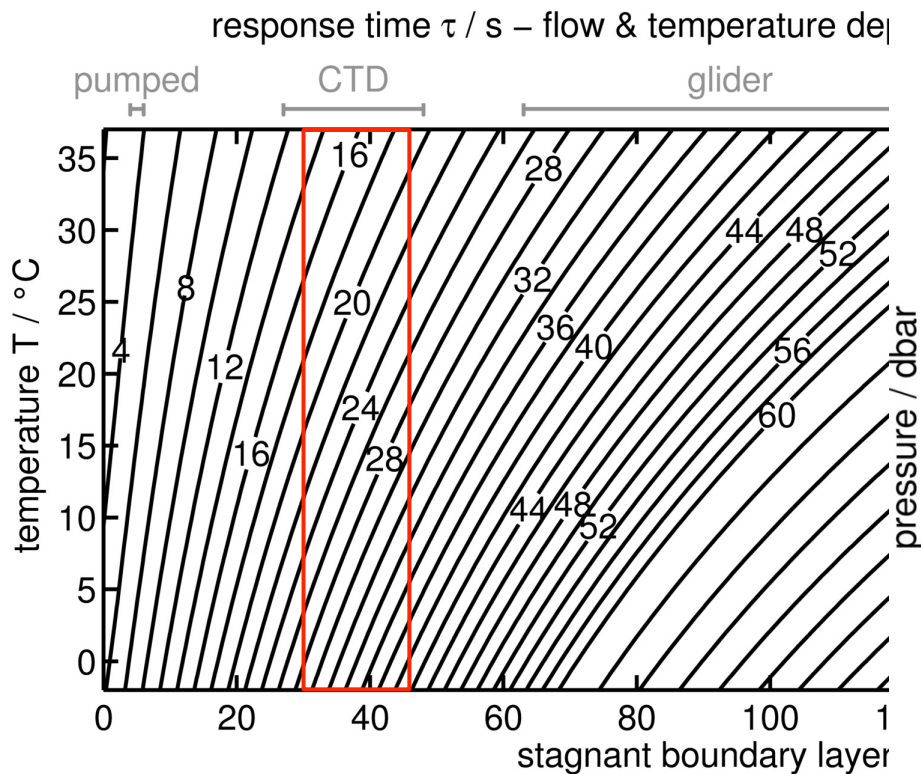
- T-dependent & flow-dependent

→ O₂ diffusion in/out of the sensing membrane

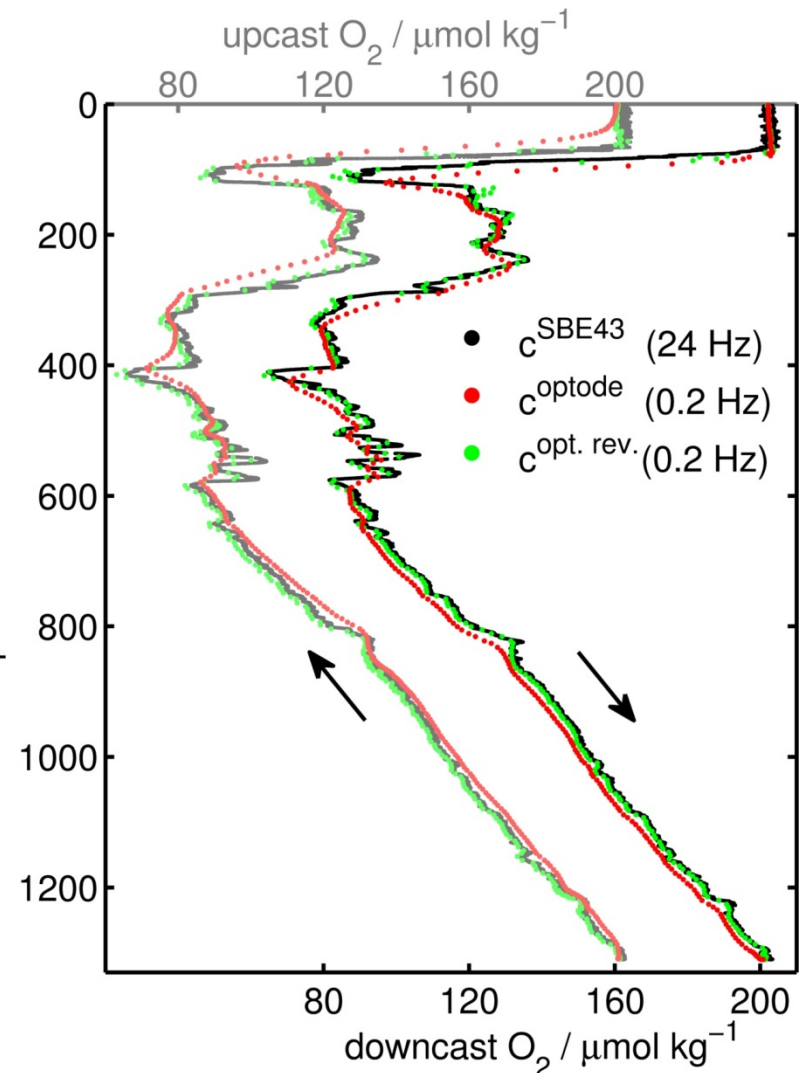


Time response prediction: Deconvolute temperature and flow effects

based on lab & field characterization:



1. use to predict τ
2. use τ to inverse-filter / reconstruct O_2

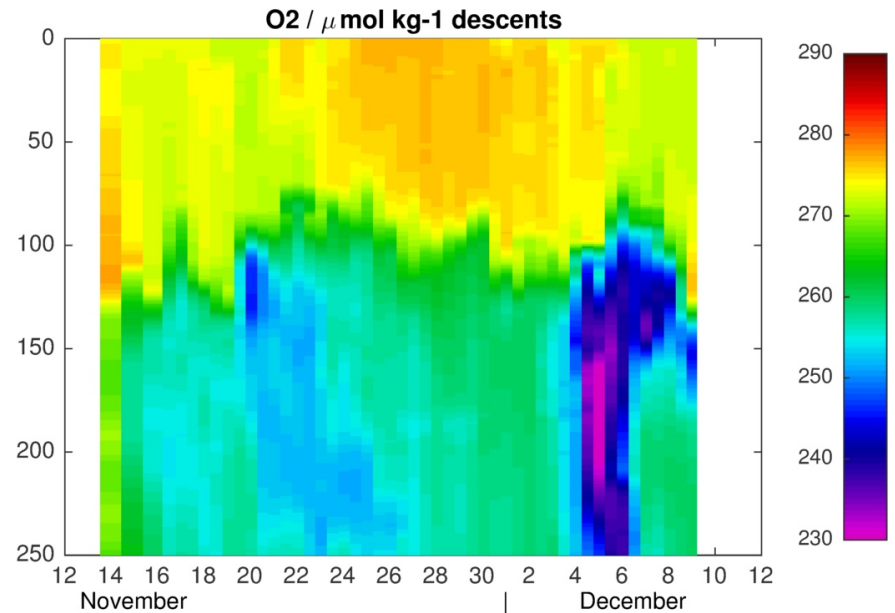
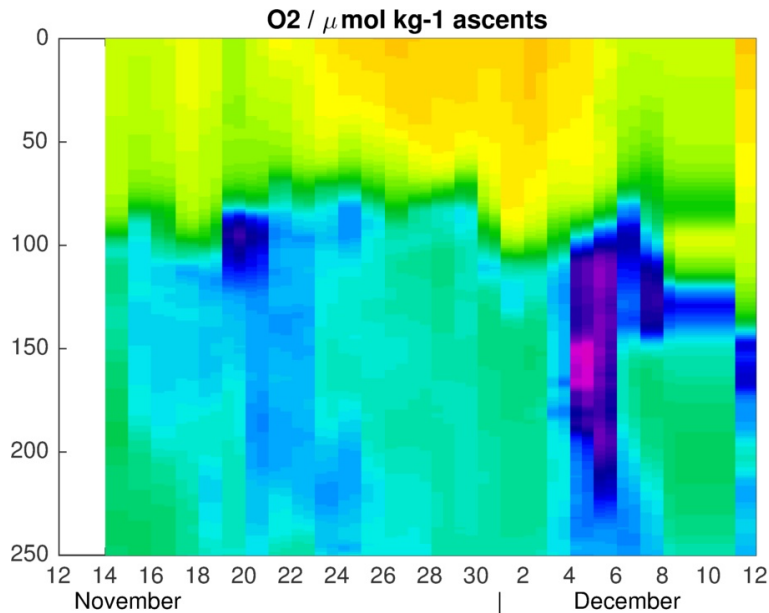


... time response (ctd.)

Effect of slow, unpumped optodes is visible in the data.

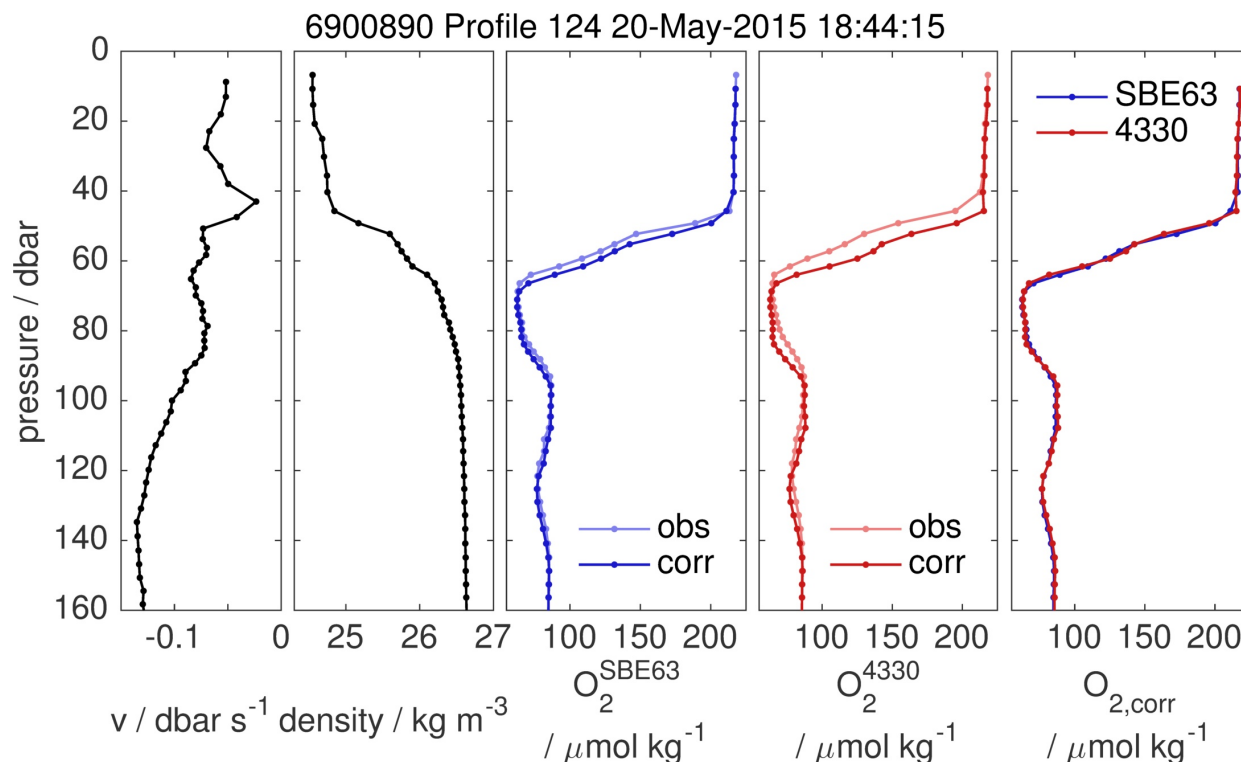
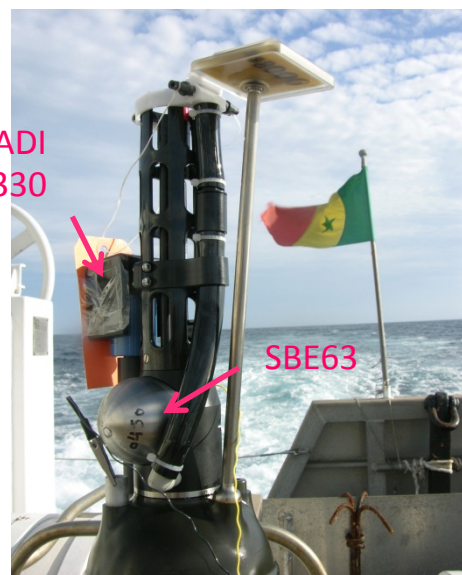
But only unpumped (open) optodes capable of in air measurements (see slide before)...

Aanderaa 4330 optode on metbio003 (NAT)



Dual-O₂ float experience

Measurement times
need to be known
for τ correction



- Pumping of SBE63 does improve data quality (faster response).
- Flow regime characterized for Aanderaa optodes.
- Both optodes can be corrected for time response.

Bittig & Körtzinger (2016), Ocean Sci. Discuss., subm.

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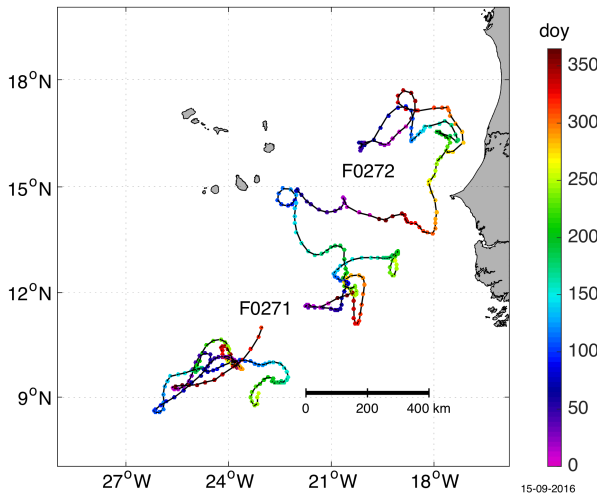
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Better addressed / soon resolved issues

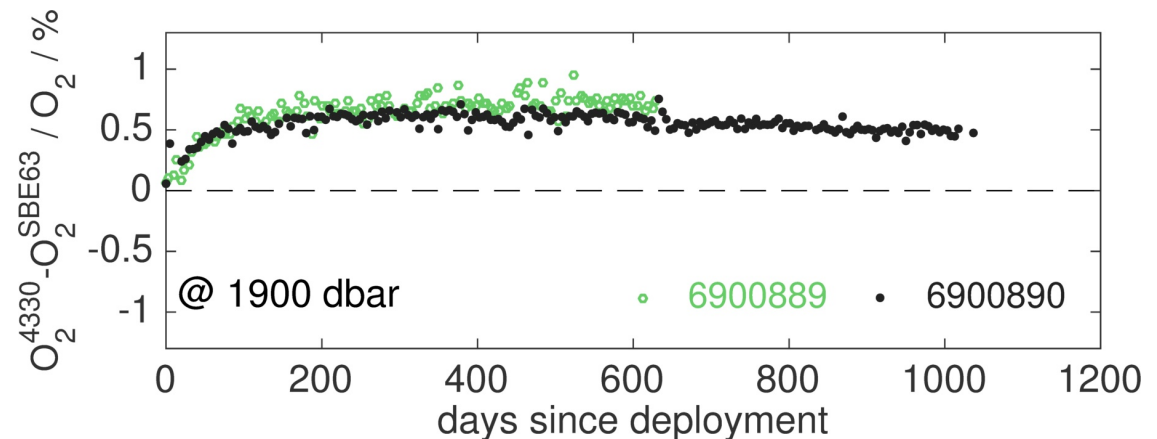
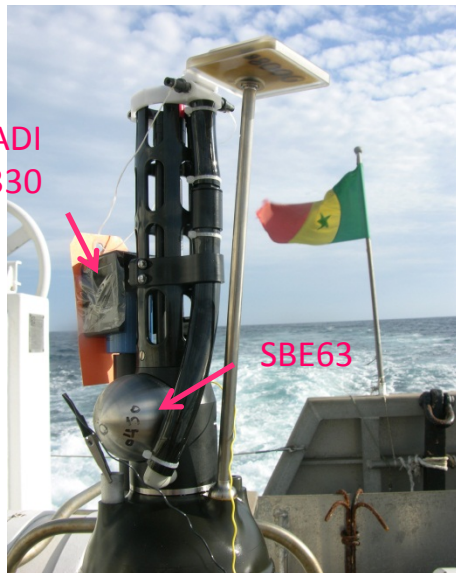
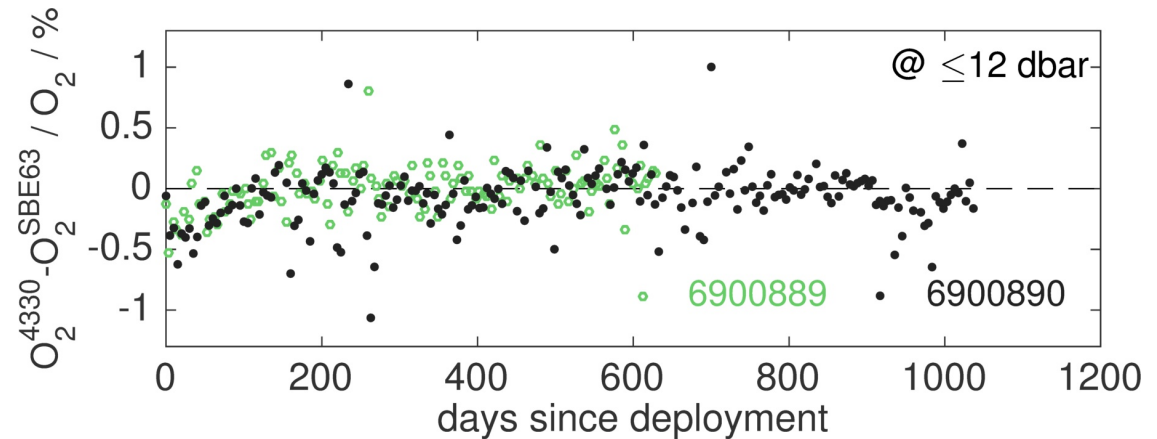
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In-situ conditioning?



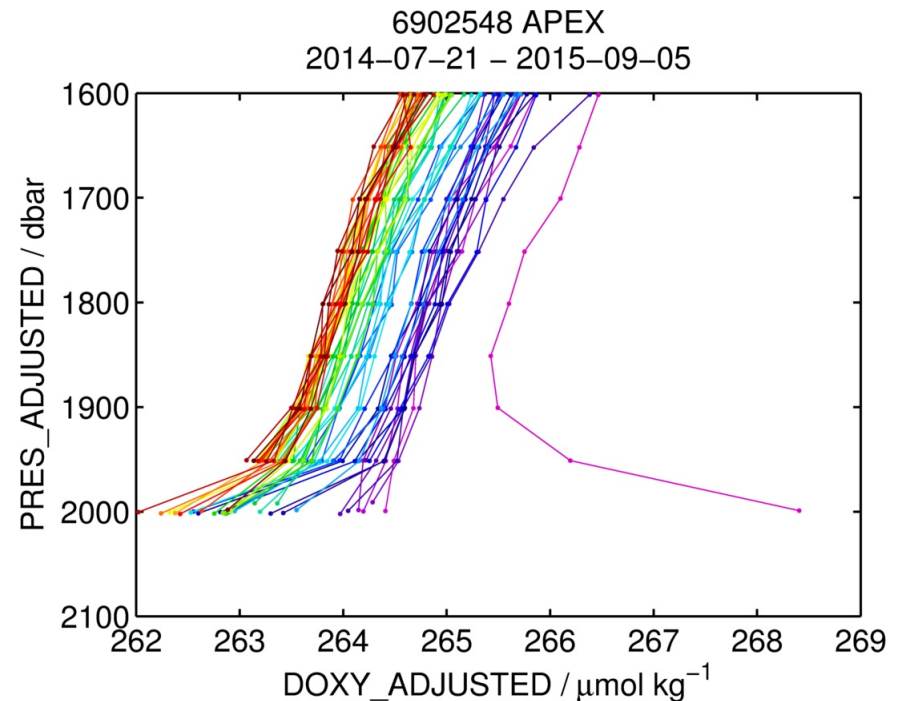
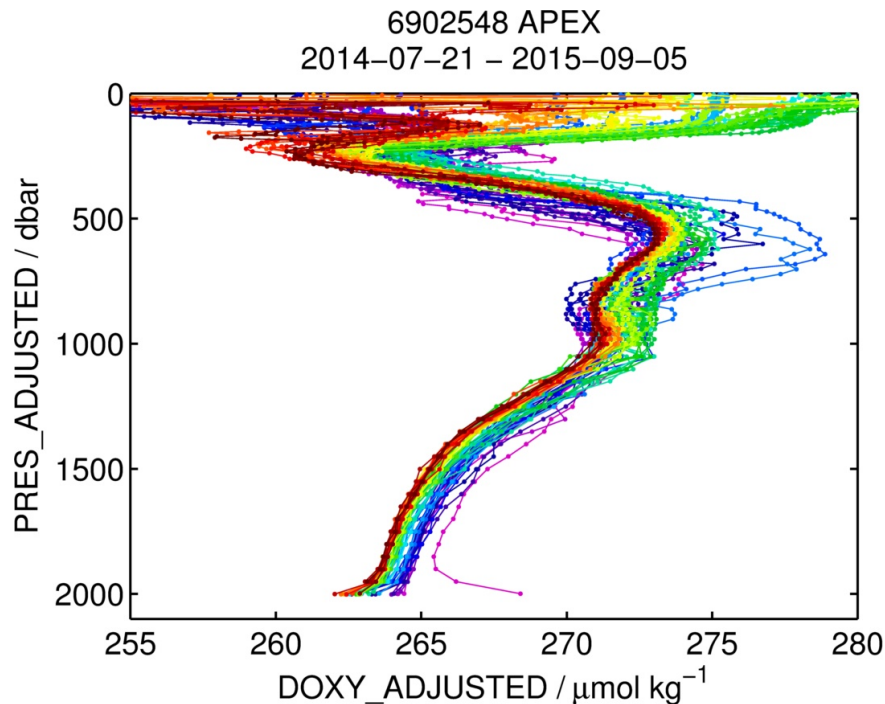
- In-situ 'stabilizing' effect for one or both 4330 and SBE63 optodes after 40 cycles/6 months?
- Both optodes have similar in-situ stability.



Bittig & Körtzinger (2016), Ocean Sci. Discuss., subm.

'Hook' at base of profile

- First profile (purple): Float outgassing?
 - Remaining profiles: Start of profile always lower than “expectation”
 - Pronounced with Provor floats
 - Cause: In-situ O_2 consumption at base of profile? Relation with bbp spikes when float starts to ascent? → Unknown...
- QC test necessary !



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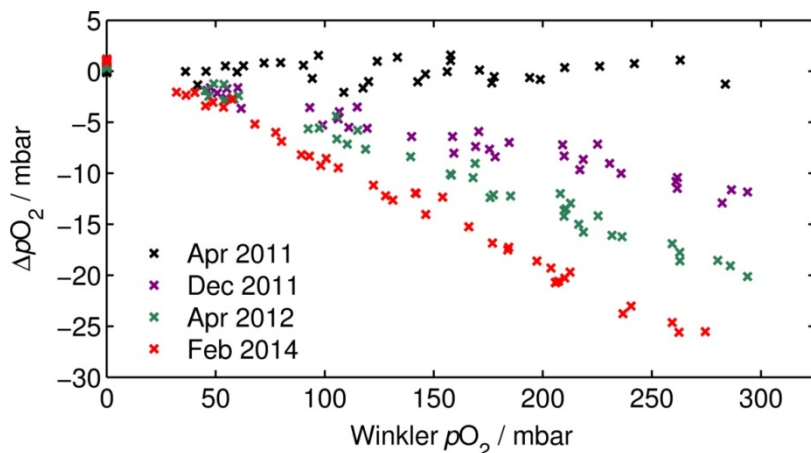
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Challenge: Long-term stability

Optodes tend to drift: Field offsets of $\sim 10\%$ to factory calibr. not uncommon

- 'Storage' drift is systematic



similar observations:

- C. Neill, AADI optodes
- H. Uchida, AADI optode
- S. Jaeger, SBE63, Poster OSM2016

Bittig & Körtzinger (2015)

J. Atmos. Oceanic Techn. 32:1536–1543.

→ Well-constrained drift 'storage'
drift behaviour from lab: linear with O_2

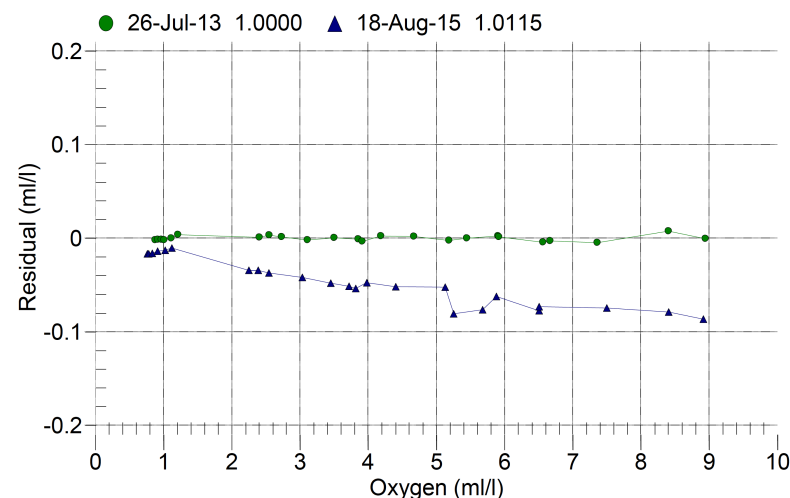
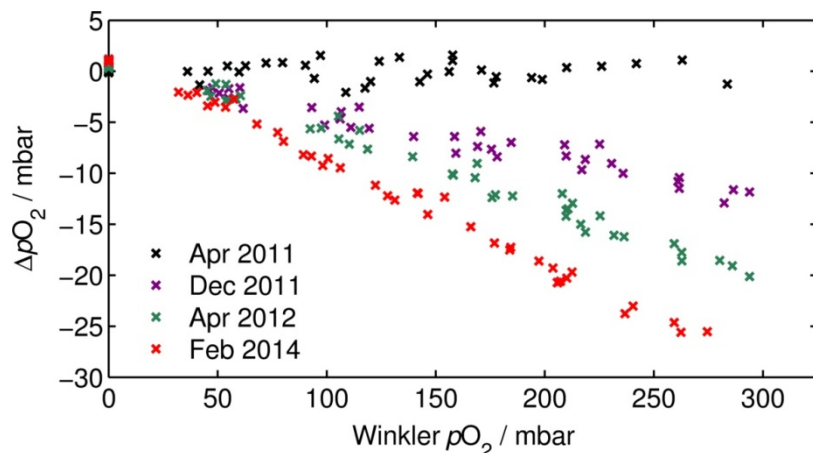


Fig. 3 Pre- and post-calibration data from the same SBE63 ODO sensor as plotted in Fig.1. Residuals show a slope drift of -1.2% after the two year period.

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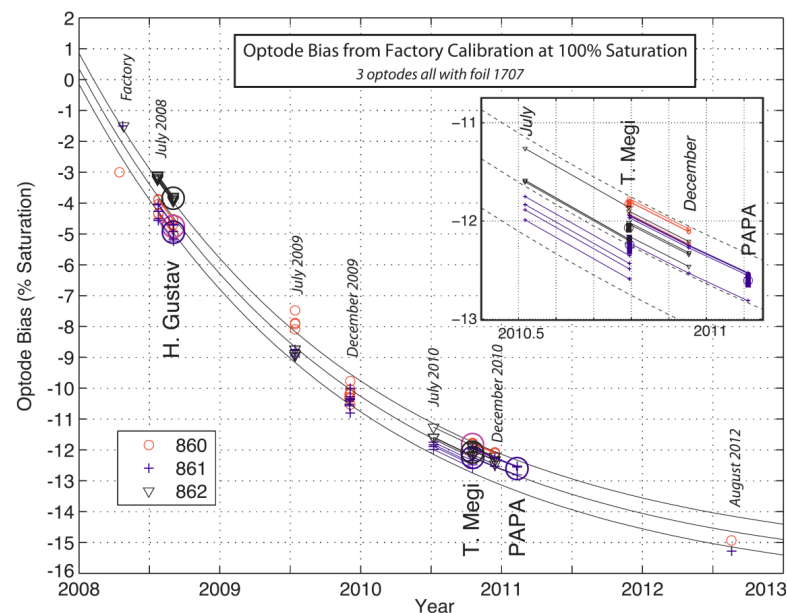


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- Drift rate decreases with time



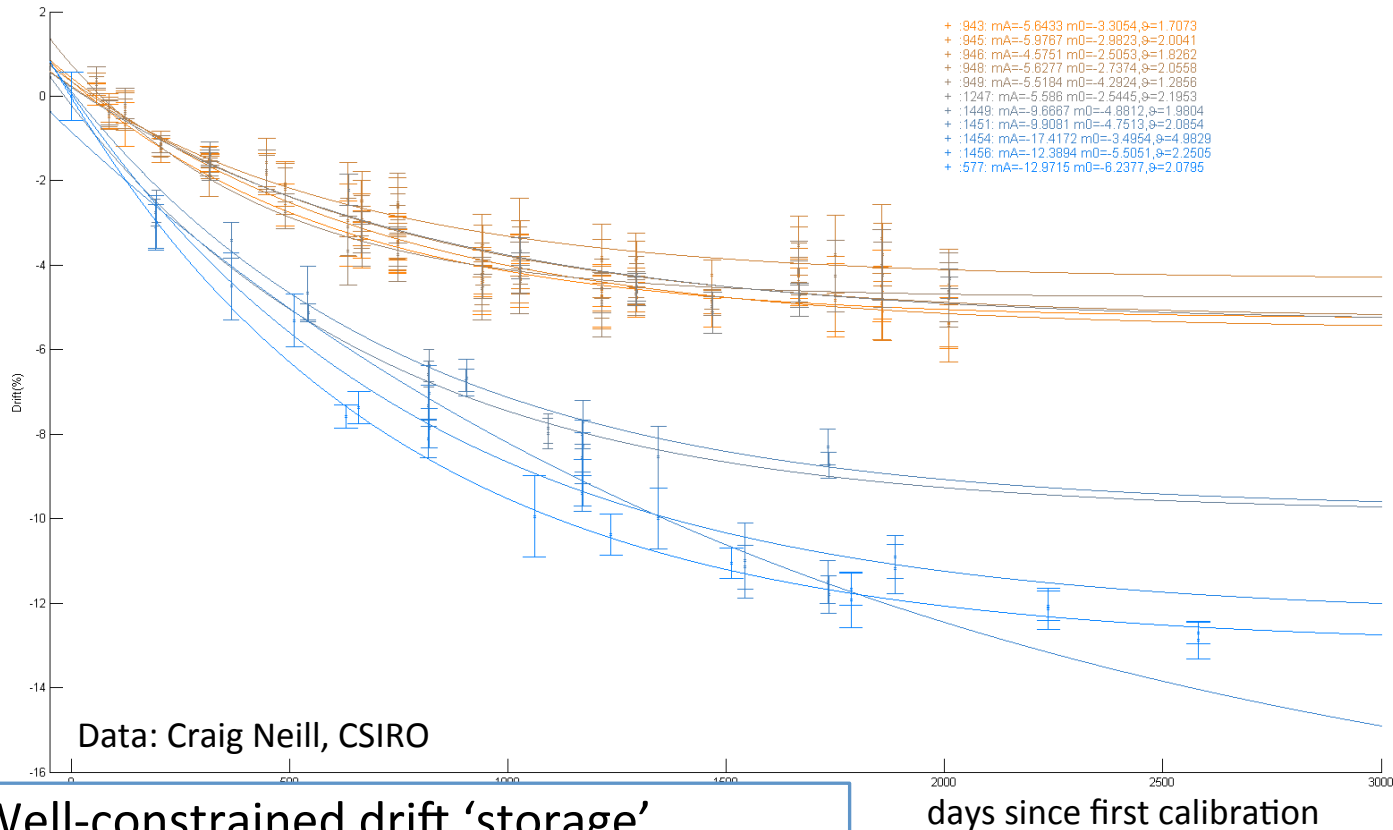
D'Asaro & McNeil (2013)
J. Atmos. Oceanic Techn. 30:1896–1906.

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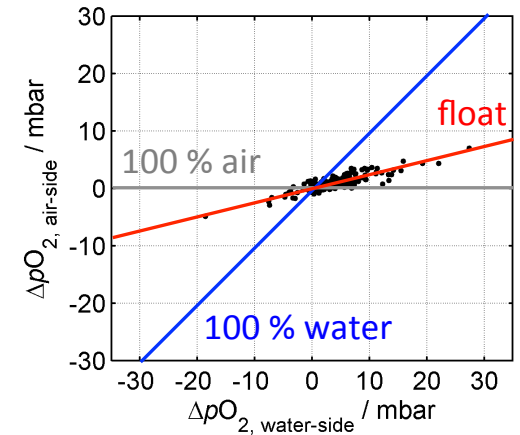
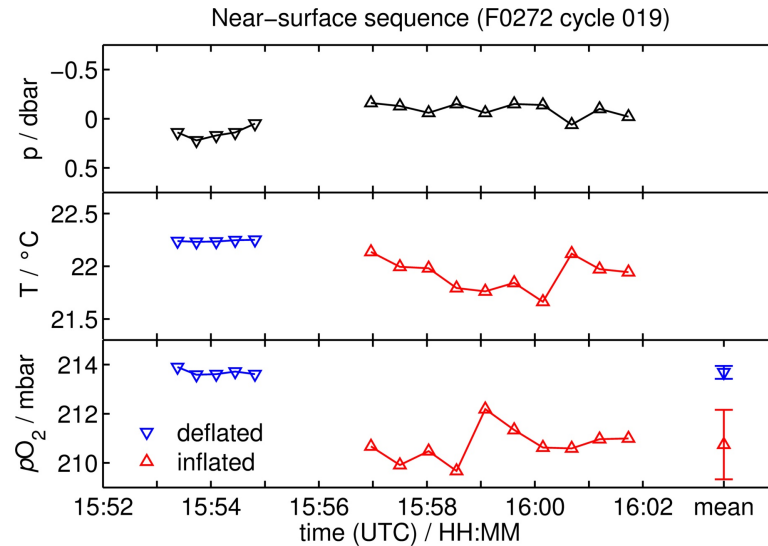
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O₂ optode in air measurements

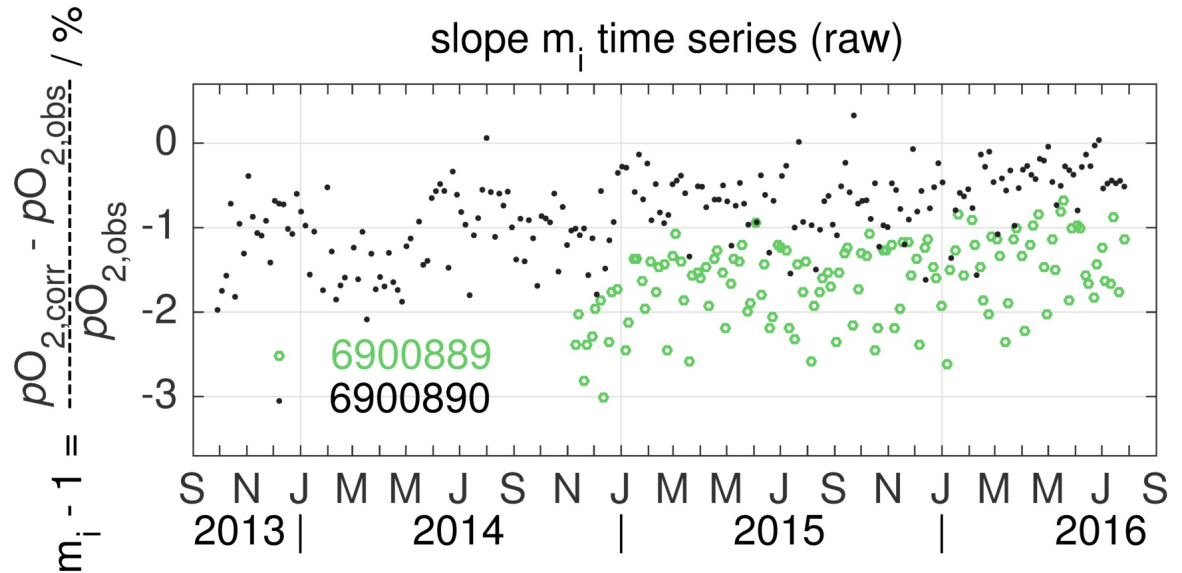
For each surfacing, optode $pO_{2,\text{optode}}$ in air, optode $pO_{2,\text{water}}$ in the surface water, and reference air $pO_{2,\text{air}}$ are compared.



- Works with optode on 10 cm stalk for floats with air bladder
- Need higher stalk for Provors to get >30 cm out of water?!

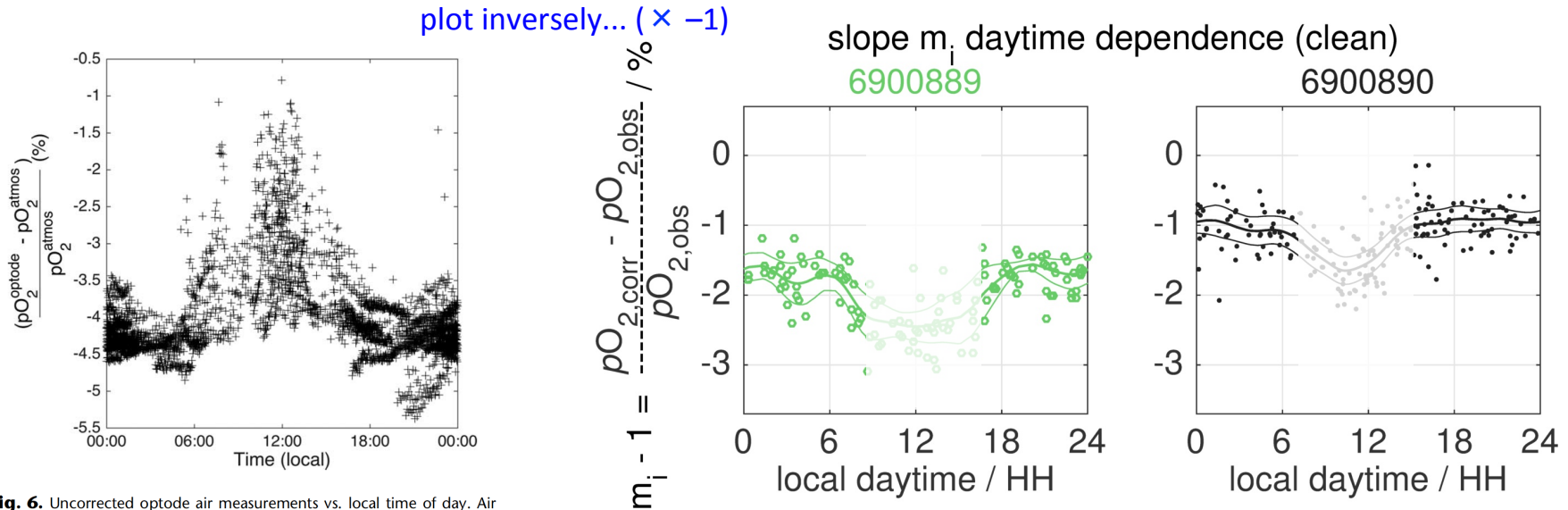
O₂ optode in air measurements

- Slope changes in-situ
~Bushinsky et al. 2015
- Optode 'reads higher' O₂ in air during the day
~Bushinsky et al. 2015
- Effects super-imposed



O₂ optode in air measurements

Optode in-air data are **biased** high during mid-day (~0.6 – 2.5 %).
Currently being reinvestigated for a larger number of floats.



From Bushinsky et al., 2016

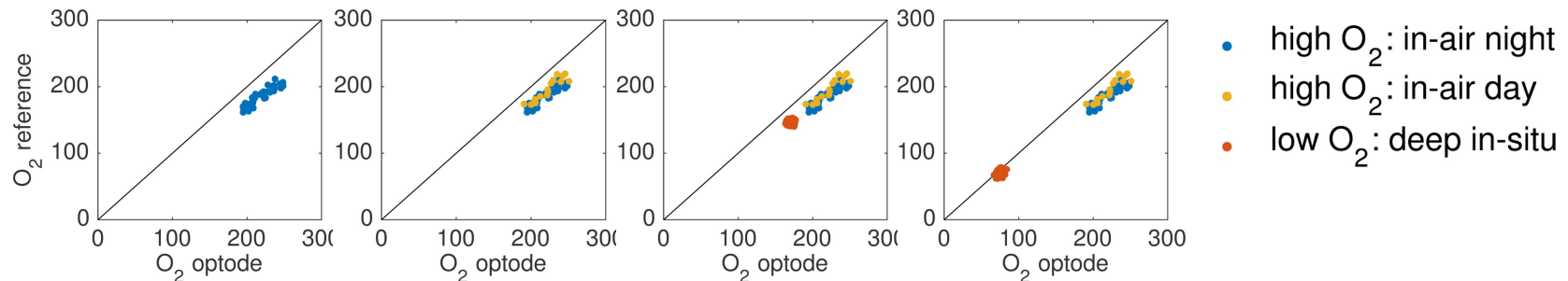
From Bittig & Körtzinger, 2016. Ocean Sci. Discuss. Submitted.

Data with sun elevation $< 15^\circ$ seem unbiased.
→ profile (only) at night?!

O₂ correction (SOCCOM O₂ ad-hoc group)

- Optimal methodology for sampling O₂ in air and how to implement day/night sampling in line with other sensors?
- How to use air data to correct pre-deployment / 'storage' optode drift?
- How to deal with in-situ trends in O₂ air data?
- Best procedure to adjust O₂ data? Same approach for 'storage' drift and in-situ trend?

E.g., only night time air data? Include in-situ data at depth?, ...



Summary (ADMT-related)

- QC test needed for 'hook' at base of profile.
- Measurement times for time response correction
- How to (re-)organize surfacing times for Biogeochemical-Argo floats?
- Homogenization of metadata to find DOXY floats
- Conversion to v3.1 and DMQC of (legacy) DOXY floats
- DM tools to perform DOXY QC