STEMM-CCS – Cseep Technique for Attribution in Environmental Monitoring

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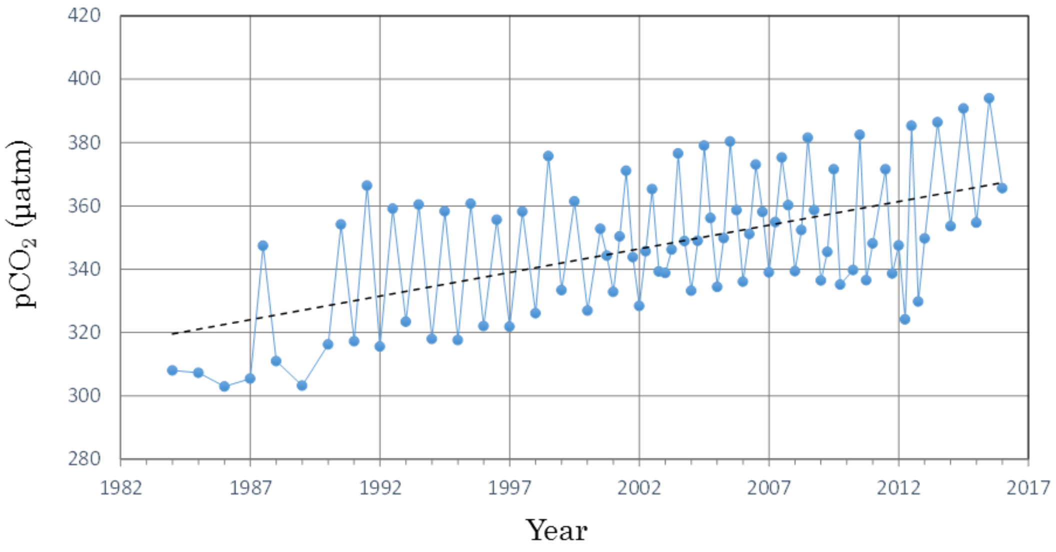
The Role Of Attribution

- Attribution is determining if an anomaly in the environment represents leakage or something else
- Regulations favor identifying anomalies using baseline CO_2 concentrations or tracers such as carbon isotopes.
- Experience shows that these methods can flag an anomaly but they dont necessarily attribute its source.
- We need quick transparent methods for attribution of anomalies

Complexity of Environmental Systems

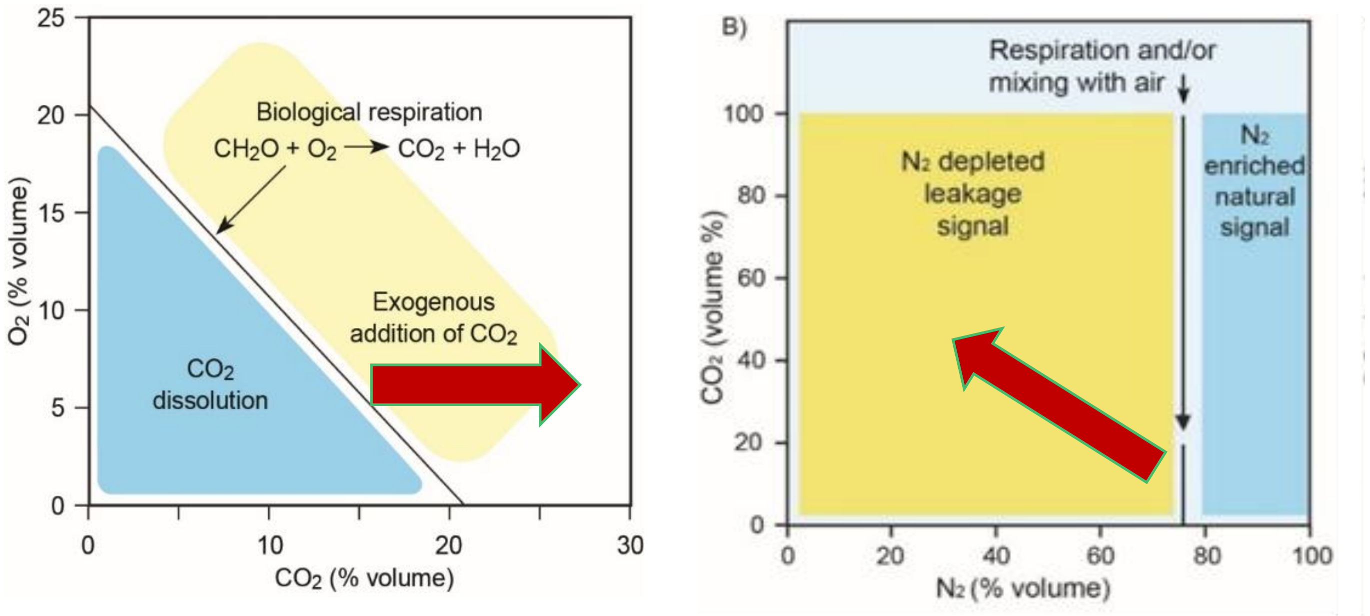
- Using “baselines” is problematic because they are not stable.
- Climate change is causing baselines to shift.
- This will inevitably cause false positives for leakage.



Time series of surface seawater CO_2 level near Japan. Source data by Japan Meteorological Agency, Courtesy of Jun Kita, RITE

Onshore- Process-Based Soil Gas Ratios

- Uses simple gas relationships to identify **processes.**
  - Biologic respiration
  - Methane oxidation
  - Dissolution
  - Leakage
- No need for years of background.
- Method can be applied in any environment regardless of variability



Romanak et al., 2012, Geophysical Research Letters, *39* (15).
Romanak et al., 2014, International Journal of Greenhouse Gas Control, 30, 42-57
Dixon and Romanak, 2015, *International Journal of Greenhouse Gas Control*, *41*, 29-40

Bio-oceanographic Source Attribution

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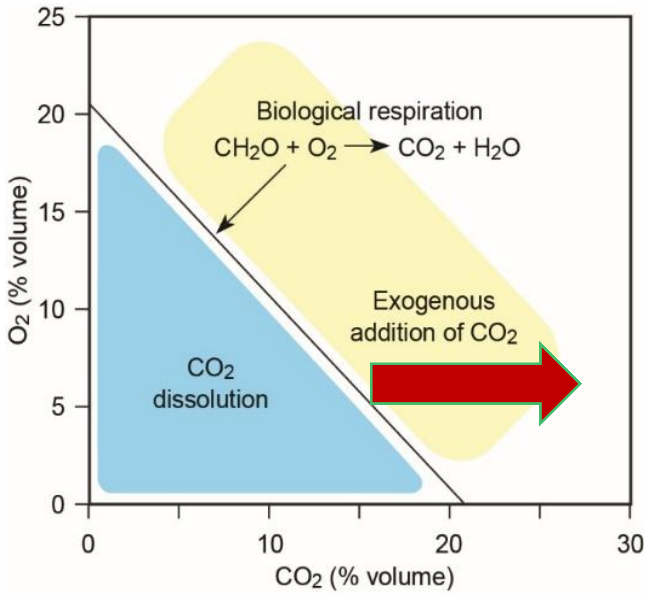
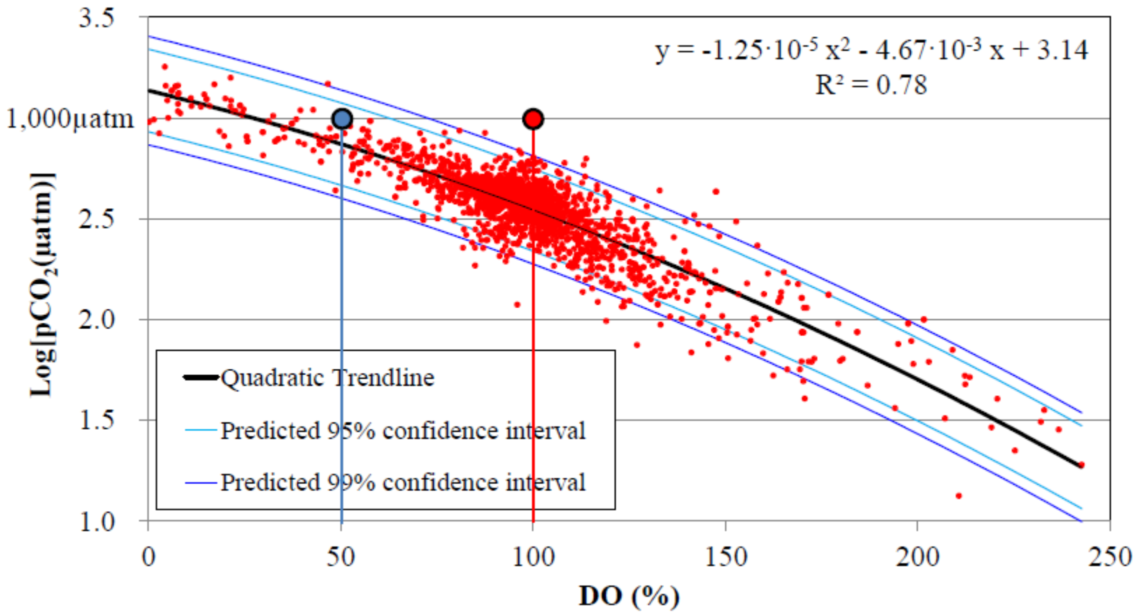
Onshore:
Process-Based Method



Katherine Romanak, BEG, USA

IEAGHG Meetings

Offshore:
Bio-Oceanographic Method



Jun Kita, MERI, Japan

Tomakomai Project

- Tomakomai Offshore demonstration project Hokkaido Japan
- Derived leakage thresholds from 1 year of baseline data
- Injection began April 2016 with routine environmental monitoring plan
- May, 2016, operations were halted after 7,163 ton CO_2 was injected
- High CO_2 levels observed in the routine monitoring
- February 2017 operations resumed

courtesy of Jun Kita, MERI

Tomakomai Environmental Monitoring

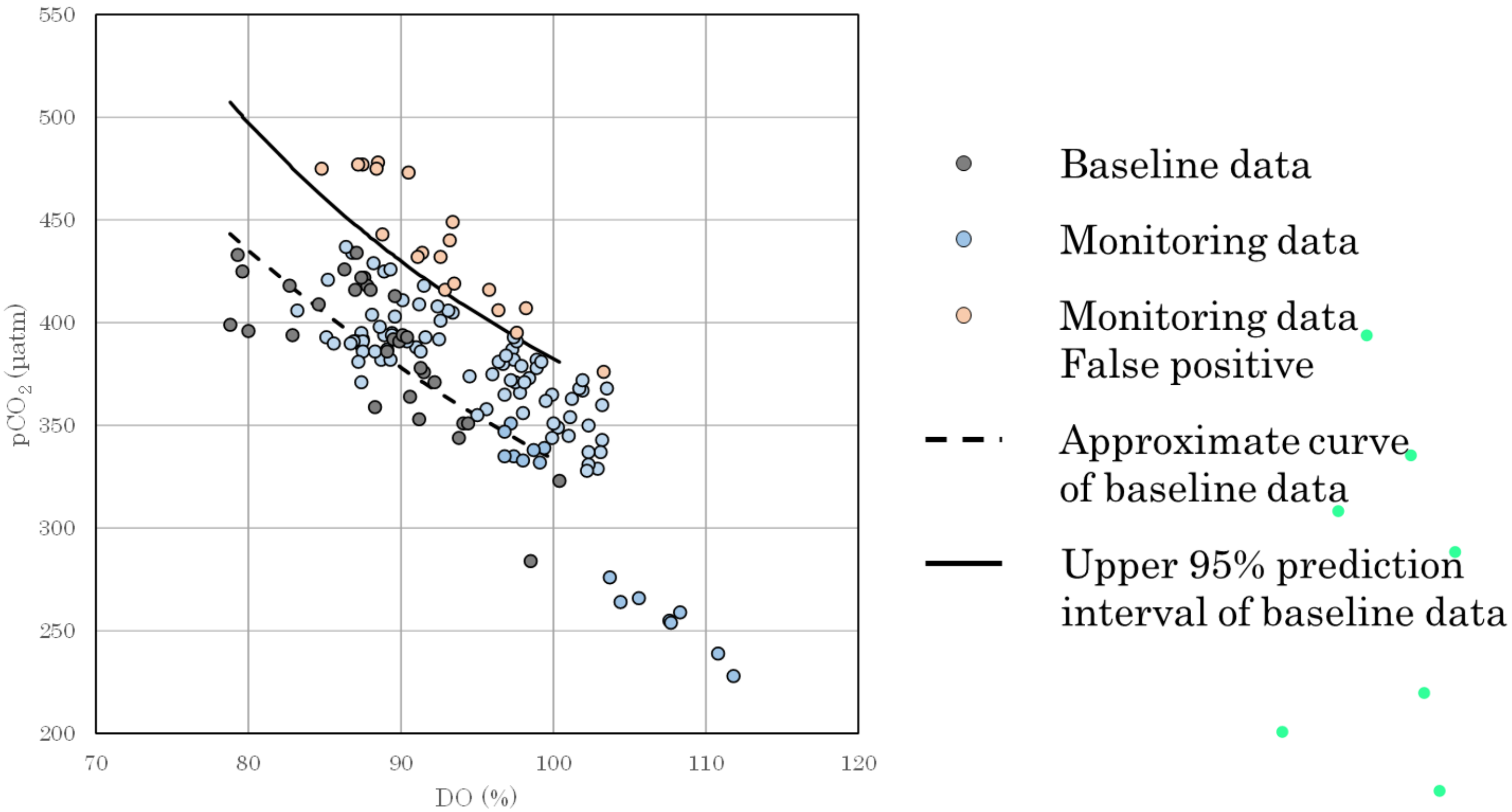
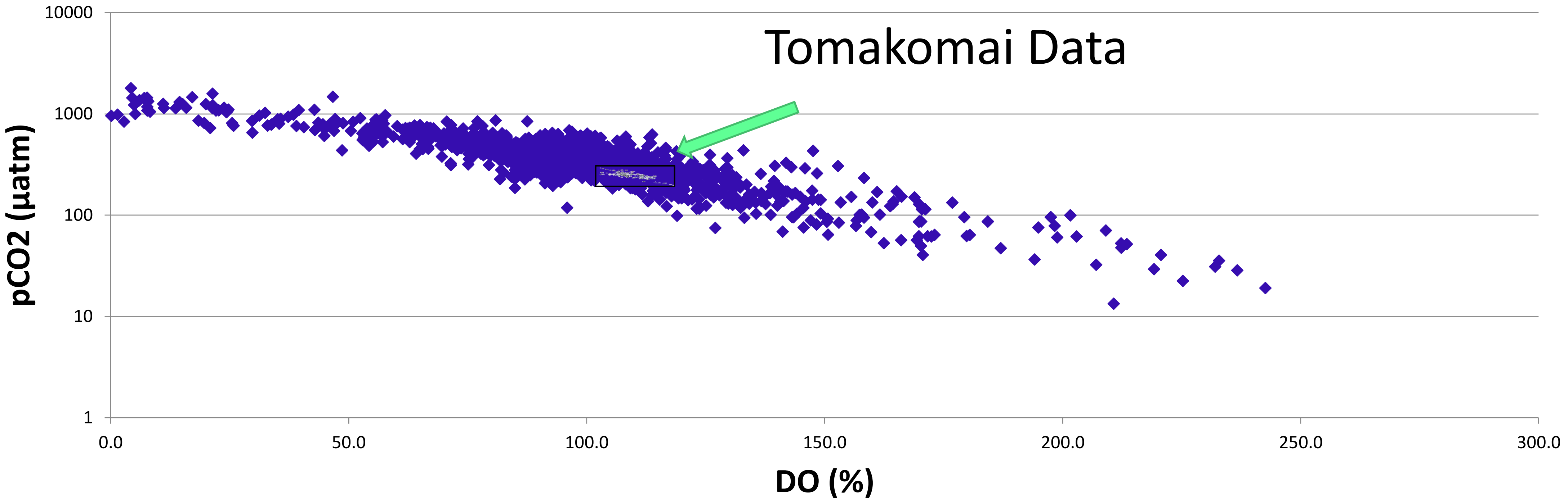


Fig. Relationship between oxygen saturation (DO) and CO_2 partial pressure (pCO_2) of bottom seawater (2 m above the seafloor).

Jun Kita, 2017, 2nd International Workshop on Offshore Geologic CO2 storage

1 year Tomakomai Data
vs
10 Years of Osaka Bay Data



Short about the C_{seep} method

Process-based method developed to:

- Determine baseline dissolved inorganic carbon for a site - characterisation
- Distinguish CO_2 seepage signal from the natural variability - attribution
- Quantify excess CO_2 dissolved in seawater - quantification

Features:

- Flexible implementation and area coverage
- Suitable for automation

Requirements:

- Math. model of main processes - site specific
- Data: CO_2system variables, hydrography and nutrients

Further development:

- New sites & stakeholder friendly presentation

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Detection and quantification of CO_2 seepage in seawater using the stoichiometric C_{seep} method: Results from a recent subsea CO_2 release experiment in the North Sea

Abdirahman M. Omar [a], Maribel I. García-Ibáñez [a 1], Allison Schaap [d], Anna Oleynik [b], Mario Esposito [c], Emil Jeansson [a], Socratis Loucaides [d], Helmuth Thomas [e], Guttorm Alendal [b]

Estimatation of natural C-variability

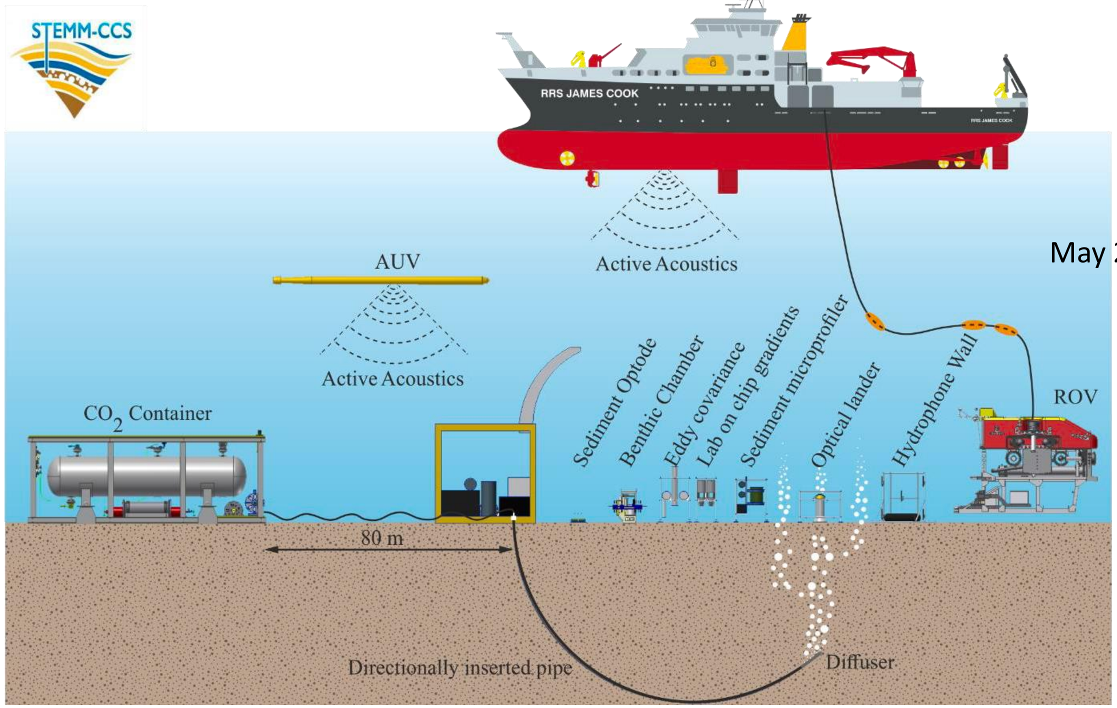
Dissolved inorganic carbon: $C = C_b + C_{nat} + C_{seep}$

Approach: quantify natural variability and filter it out for easy identification of CO_2 seepage

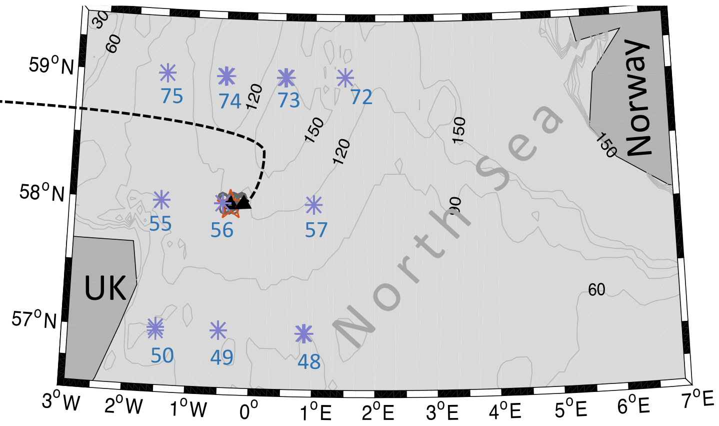
Main processes governing C changes	Parameterisation
Organic matter cycling	$C_{omc} = R_{C:P} * \Delta PO_4$
Calcium carbonate cycling	$C_{ccc} = R_{C:PA} * \Delta PA$
Mixing between water masses	$C_{mix} = \mathrm{dPA/dS} * \Delta S$
Air sea CO_2 exchange	$C_{ant} = \mathrm{dC/dt} * \Delta time$

C_{nat}
(computed natural variability)

Data from the STEMM-CCS experiment and multi-year baseline cruises



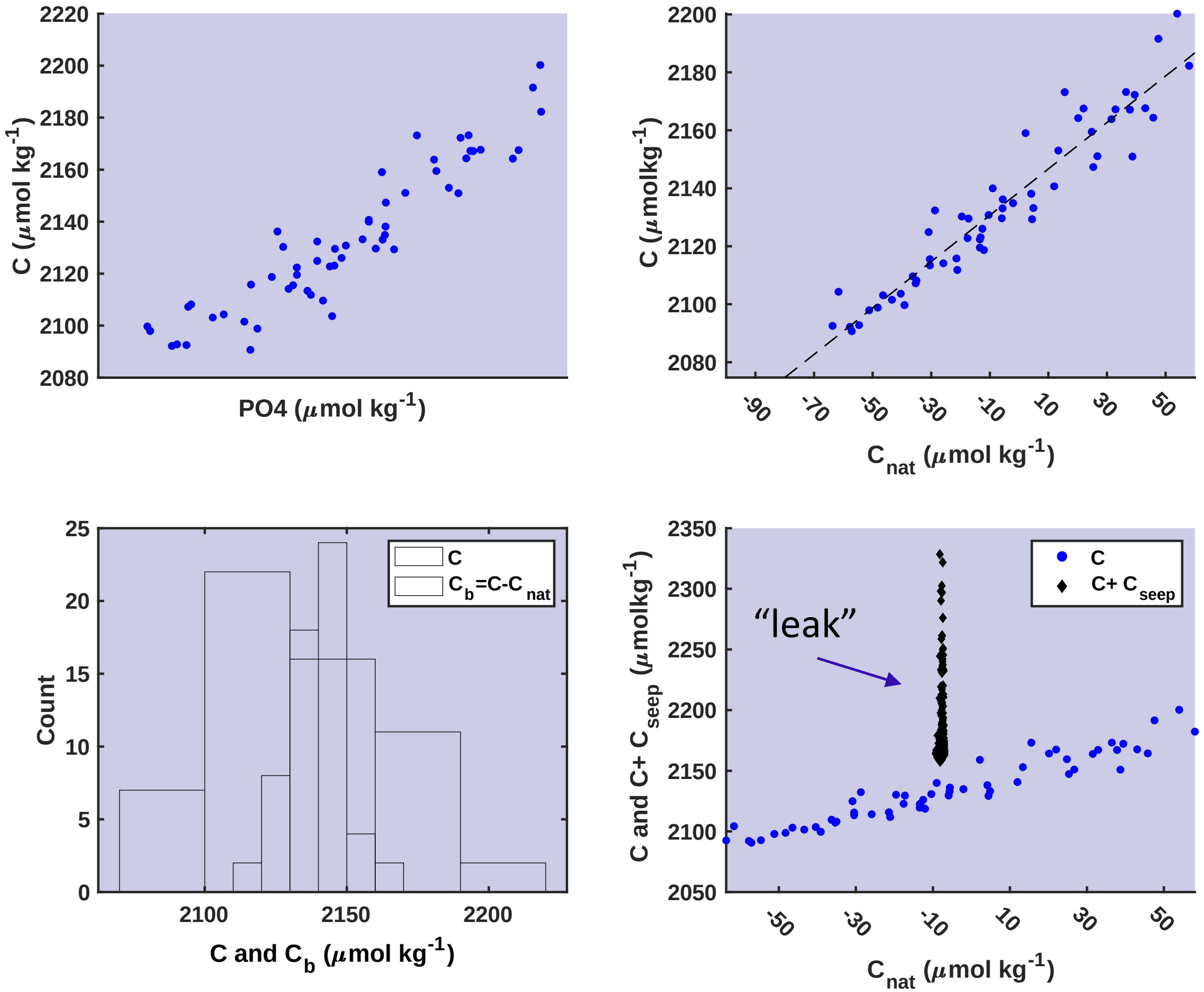
May 2019



Data from: 2001, 2002, 2005, 2008, 2011, 2017, 2018, 2019

Leakage Attribution

- Organic matter cycling is the primary driver of near seafloor C-variability (upper left graph)
- C-variability successfully computed, i.e., strong linear relationship between observed and computed (upper right)
- Substantial minimization of variability (lower left)
- Seepage C fall above of the C-C_{nat} line (lower right)



Thank you for your attention!

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NATIONAL ENERGY TECHNOLOGY LABORATORY