ICOS
INTEGRATED CARBON OBSERVATION SYSTEM

# Data management and quality control procedures within the Ocean Thematic Centre of the European RI ICOS

Benjamin Pfeil, Steve Jones, Tobias Steinhoff, Meike Becker, Alex Vermeulen, Rocio C. Primo, Erik Sandquist+++

UNIVERSITAS BERGENSIS

Bjerknes Centre for Climate Research

BCDC Bjerknes Climate Data Centre

NORCE

ICOS
INTEGRATED CARBON OBSERVATION SYSTEM

# An introduction to the Ocean Thematic Centre of the European RI ICOS

Benjamin Pfeil, Steve Jones, Tobias Steinhoff, Meike Becker, Alex Vermeulen, Rocio C. Primo, Erik Sandquist+++

Universitas Bergensis
NORCE
PML Plymouth Marine Laboratory
Bjerknes Centre for Climate Research
BCDC Bjerknes Climate Data Centre
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL
University of Exeter

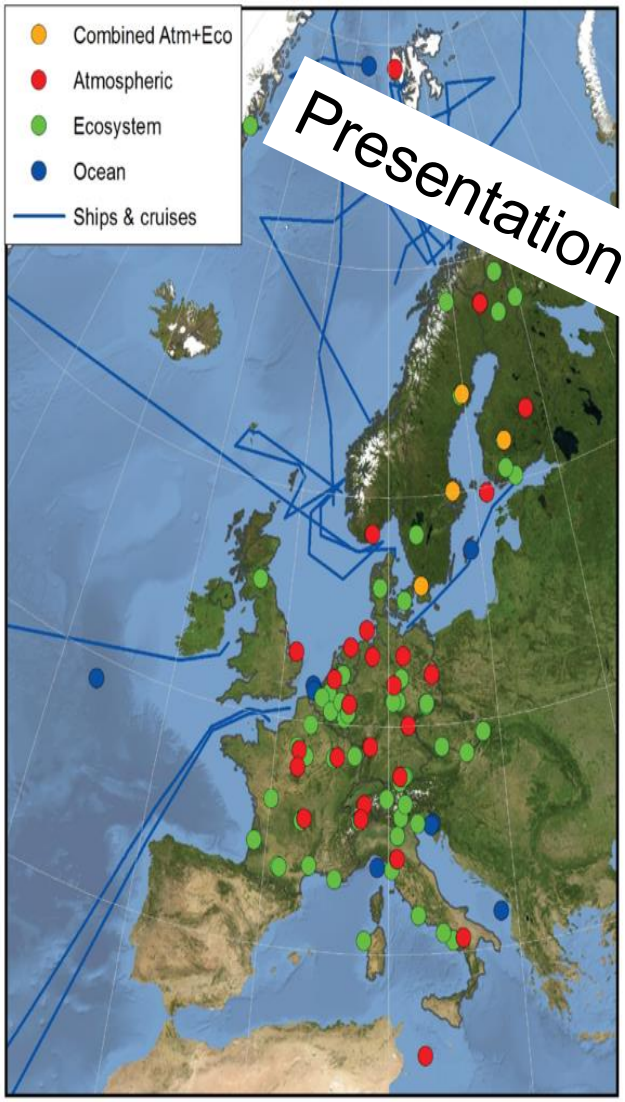
# Integrated Carbon Observation System (ICOS)

**Scientific Mission:**

- Increase fundamental understanding of carbon cycle, greenhouse gas budgets and perturbations, and underlying processes
- Increase ability to predict future changes
- Verify the effectiveness of policies aiming to reduce greenhouse gas emissions
- Foster technical and scientific innovation
- Contribute in education and capacity building

**https://www.icos-ri.eu**

# ICOS Stations






**134 measurement stations**
**12 Member countries**

20 Ecosystem stations

33 Atmosphere stations

21 Ocean stations

including two stations in Greece
one in French Guyana, La Reunion, Cape Verde
(not visible here)

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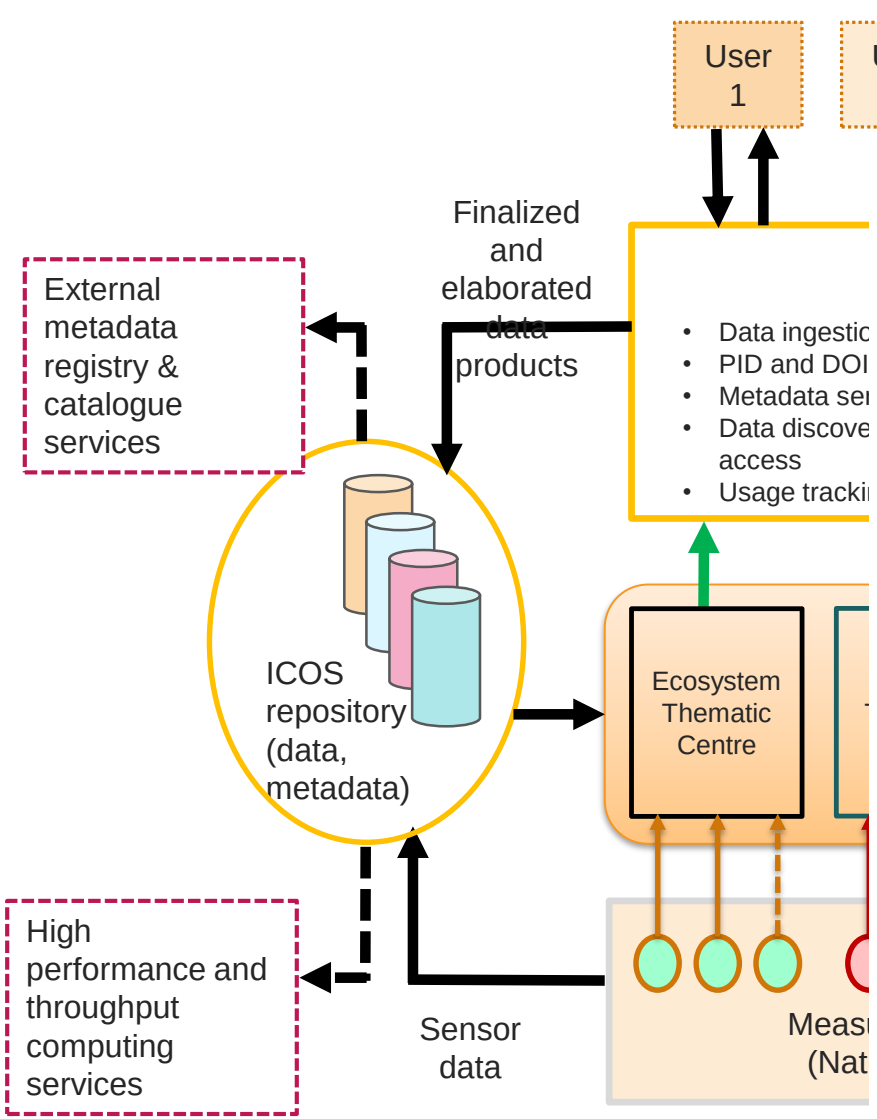
# ICOS Data Flow




- ✓ Standardized data processing
- ✓ Centralized quality control
- ✓ Scientific QC performed by the station PI
- ✓ Data provenance, curation and archiving
- ✓ Clear open data license
- ✓ Data citation

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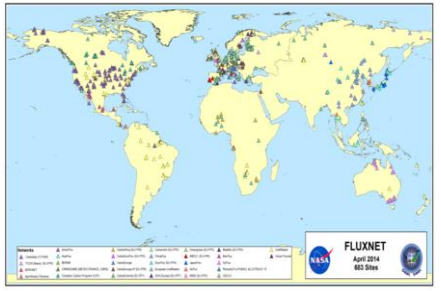
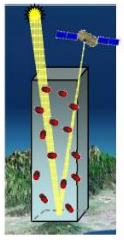
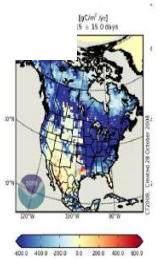
# Global integration

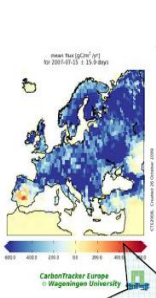



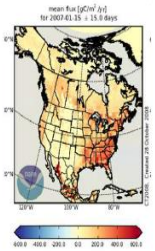


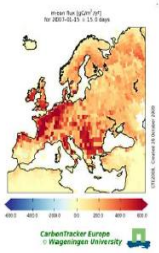
Satellites





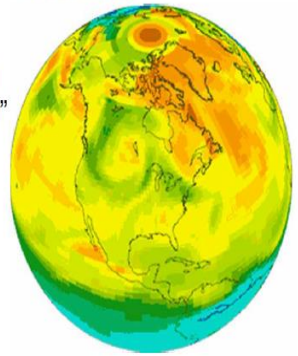




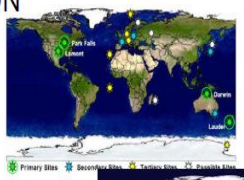



China

"Carbon Weather"

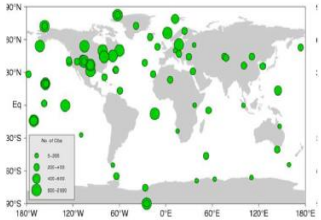



TCCON

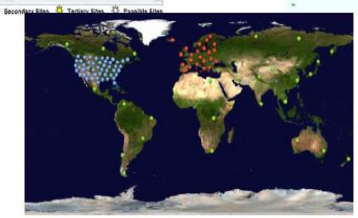


SE Asia

Current Network

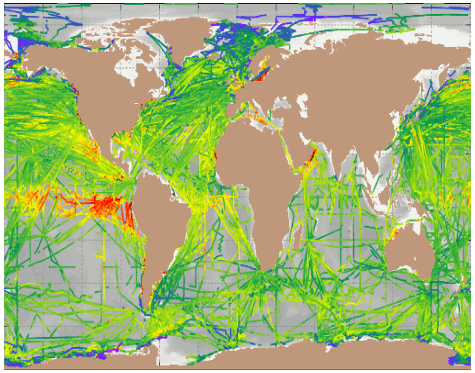


Earth Networks



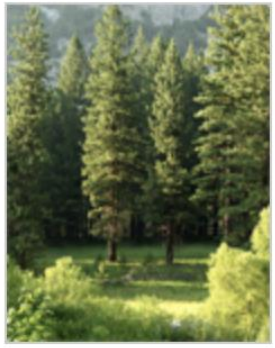
Brazil





# The Global Carbon Project

The Global Carbon Project (GCP) integrates knowledge of greenhouse gases for human activities and the Earth system. Our projects include global budgets for three dominant greenhouse gases — carbon dioxide, methane, and nitrous oxide — and complementary efforts in urban, regional, cumulative, and negative emissions.

| **Intensification of carbon uptake by Northern Hemisphere Vegetation** | **Wetland fluxnet synthesis for methane, Fort Collins, CO, USA, 13-16 May 2019** | **Second State of the Carbon Cycle Report (SOCCR2)** |
|---|---|---|
|  |  |  |
| new paper | meeting | website |

## Science Highlights


Carbon Budget 2018

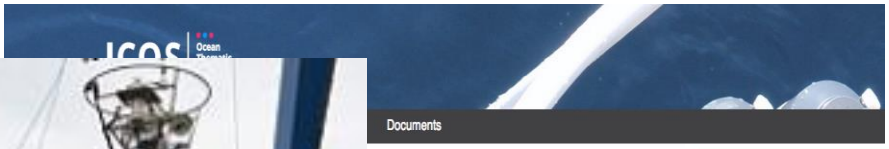

Methane Budget 2016


$N_2O$ Budget coming soon

More Highlights...

# The Ocean Thematic Centre

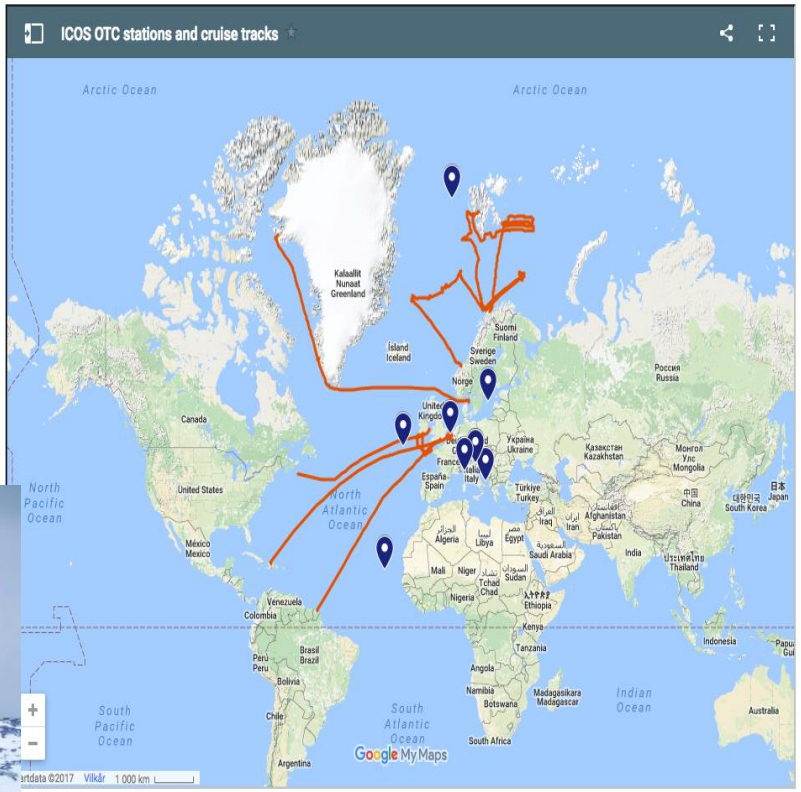
ICOS Ocean Thematic Centre



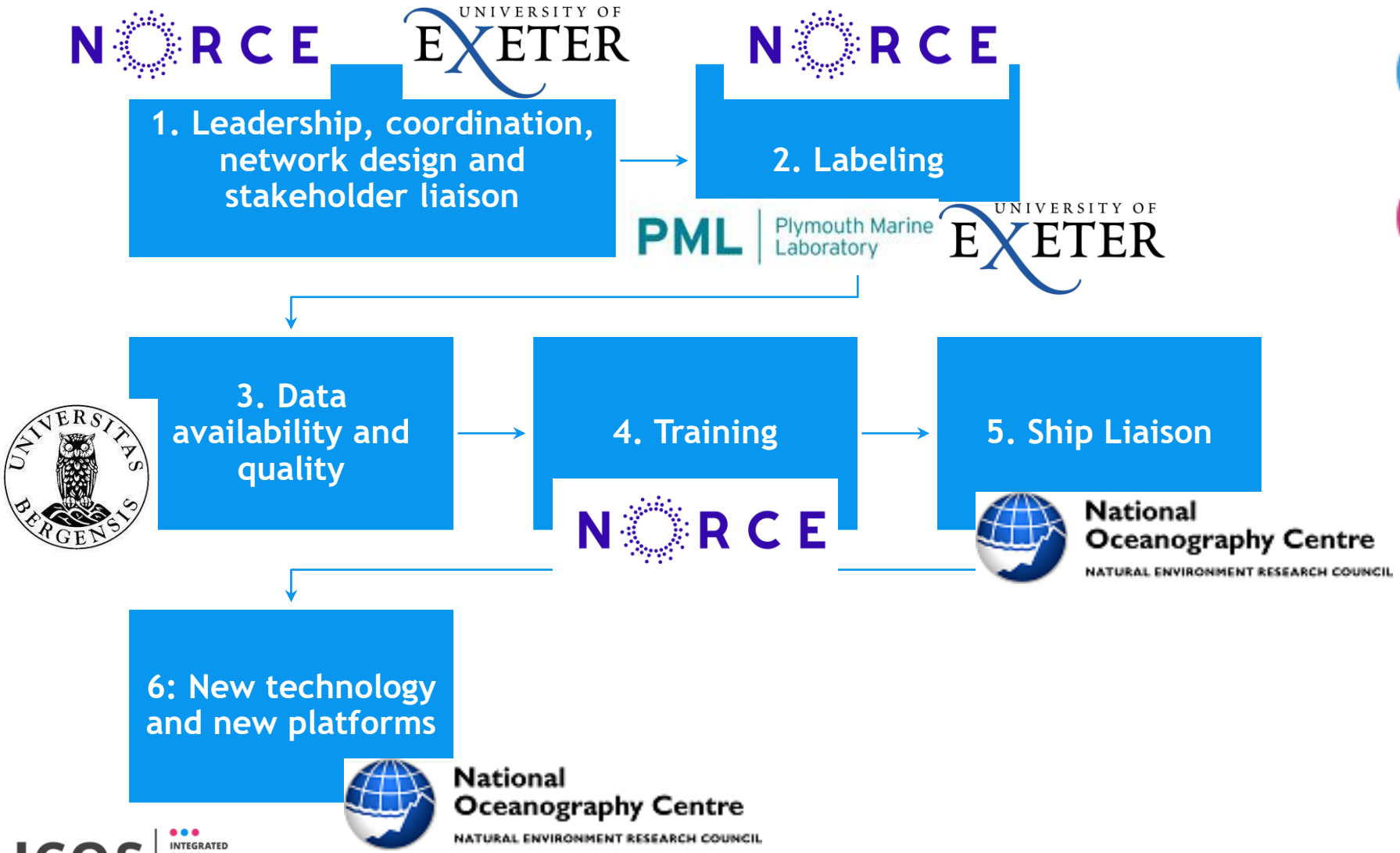

OUSE GAS BALANCE WITH
MENTS

VIDES HARMONIZED AND HIGH PRECISION SCIENTIFIC DATA
ATIONS. ICOS DATA IS OPENLY AVAILABLE AT THE CARBON
HOP FOR ALL ICOS DATA PRODUCTS.

European research infrastructure Integrated Carbon Observation




# OTC tasks and mission



# Which precision do we actually need?

GOA-ON Global Ocean Acidification Observing Network

United Nations Educational, Scientific and Cultural Organization | Intergovernmental Oceanographic Commission

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD


**Target 14.3:**
**minimize and address the impacts of ocean acidification**

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# Which precision do we actually need?

**The [illegible] goal**

- relative spatial [illegible]s and short-term variation
- supporting mechanistic response to and impact on local, immediate ocean acidification dynamics.

Implies an uncertainty of:

- pH ~0.02
- TA, DIC ~10 µmol kg$^{-1}$
- $pCO_2$ ~2.5% relative uncertainty

**The <u>climate</u> goal**

- to assess long-term trends with a defined level of confidence,
- supporting detection of the long-term anthropogenically [illegible]ven changes in [illegible]raphic conditions and ca[illegible]mistry over multi-decada[illegible]ales.

Implies an unce[illegible]

- pH ~0.003
- TA, DIC ~2 µmol kg$^{-1}$
- pCO2 ~0.5% relative uncertainty

Presentation by Meike Becker (University of Bergen)

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# ICOS Oceans $CO_2$ sensors - moorings


## Contros HydroC $CO_2$

- Membrane equilibration
- IR $CO_2$ detection
- Auto zeroing
- Pre/post calibration necessary

## Sunburst SAMI-$CO_2$

- Membrane equilibration
- colorimetric reagent method

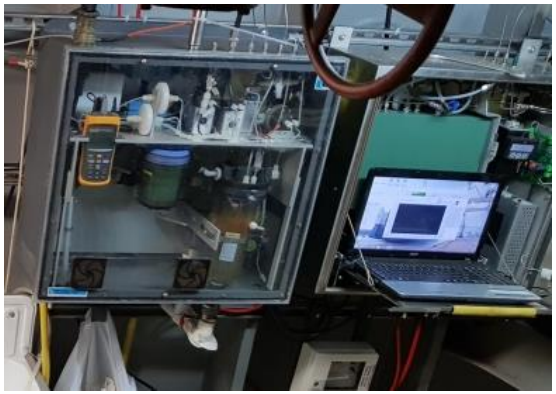

## Pro Oceanus $CO_2$-Pro

- Membrane equilibration
- IR $CO_2$ detection
- Auto zeroing



Photos: http://sunburstsensors.com, http://pro-oceanus.com, https://www.kongsberg.com

# ICOS Oceans $CO_2$ sensors – Carbon-VOS

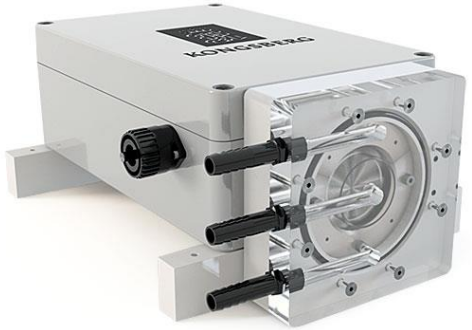



## Water/air equilibrator based systems

- Standard: General Oceanics
- Several custom built systems
- Bubble/spray… equilibration
- IR CO2 detection (other detectors possible)


## SubCtech OceanPack $pCO_2$

- Membrane equilibration
- IR $CO_2$ detection
- Auto zeroing, standard gases possible



## Contros HydroC $CO_2$ FT

- Membrane equilibration
- IR $CO_2$ detection
- Auto zeroing
- Pre/post calibration necessary

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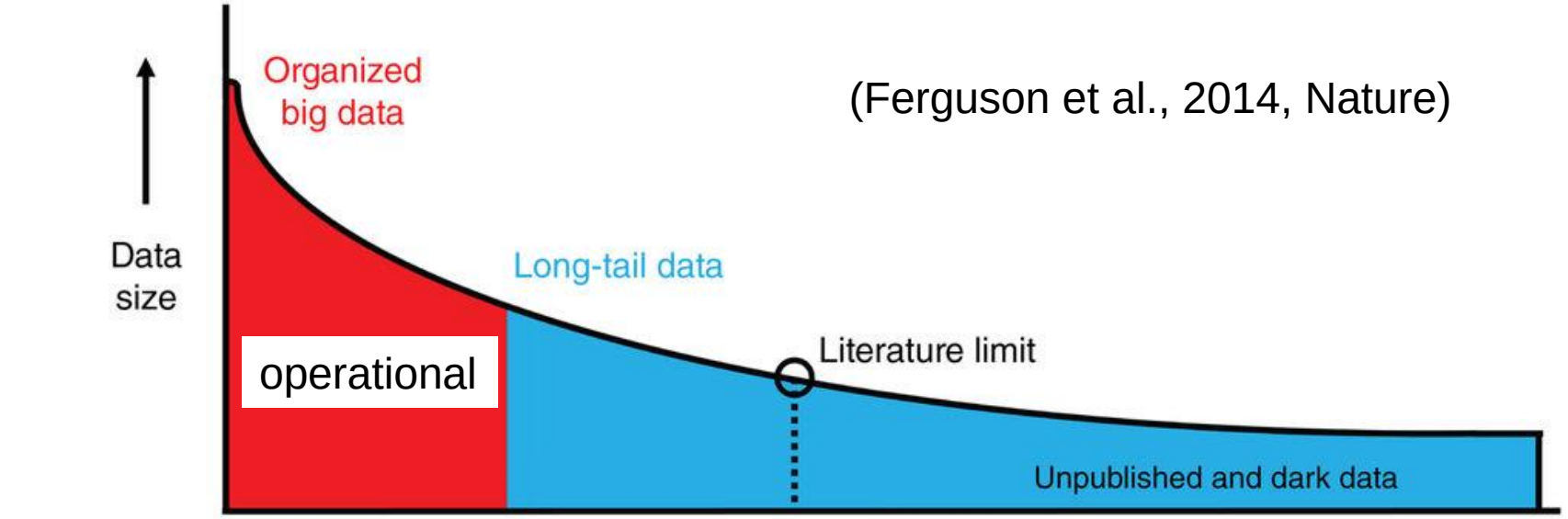
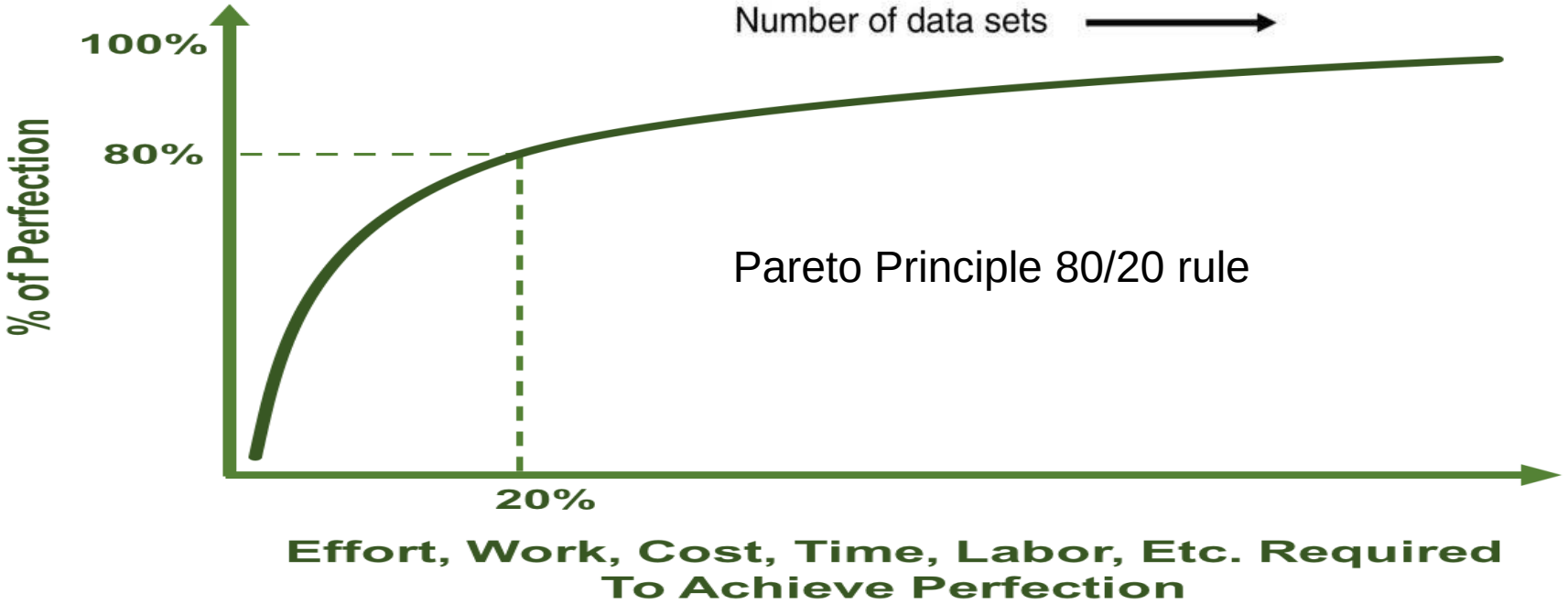
# Challenge of handling climate goal data:

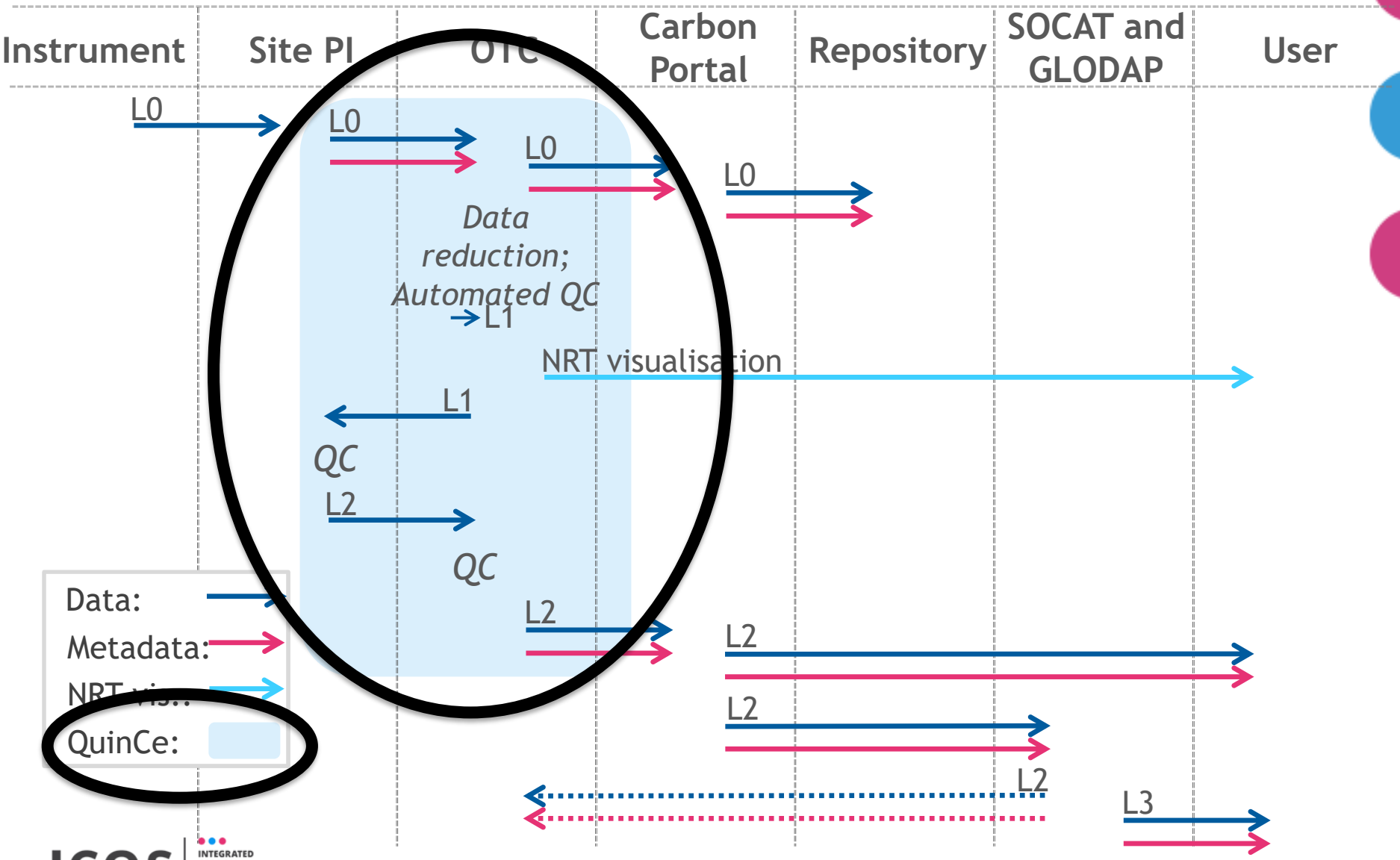



(Ferguson et al., 2014, Nature)




Pareto Principle 80/20 rule

# Data Lifecycle Within OTC

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# QuinCe - *online tool for data reduction and quality control of surface ocean fCO2 data*

Poster by Steve Jones (University of Bergen)

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# QuinCe - Motivation

- A single, centralised tool - data from all sources is treated with the same community-approved algorithms
- Removes code development responsibilities from scientists
- Open Source code increases traceability and transparency
- Reduces data handling work required by scientists
- Flexible architecture will allow shorter development time for new projects using different types of data

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# QuinCe - Features

- Upload data in any text format
- Individual sensor calibration adjustments can be applied
- Data reduction is performed automatically, with calibration to gas standards
- Automated QC routines detect common issues
- Extensive plotting and mapping tools for manual QC
- All QC decisions (automatic and manual) are recorded for future traceability
- Automatic submission to ICOS, CMEMS INSTAC and SOCAT
- Near Real Time processing allows fully automatic data flow from ship to publication within minutes

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# QuinCe - Future developments

- Complete metadata integration
- More intelligent automatic QC routines based on previous data sets and external data sources
- Uncertainty propagation
- Longitudinal study of instrument performance
- More variables (pH, O2 ...)

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Name | **Files and Columns** | Run Types | Other Info

## Column Assignments

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Run Type | 0/1 | Intake Temperature | 1 | Salinity | 0 | Equilibrator Temperature | 0 |
| Equilibrator Pressure (absolute) | 0 | Equilibrator Pressure (differential) | 0 | Atmospheric Pressure | 0 | $xH_2O$ | 0 |
| $CO_2$ | 0 | Other Temperature | 0 | Other Pressure | 0 | Air Flow | 0 |
| Water Flow | 0 | Pump Speed | 0 | | | | |

TSG ✕ | $CO_2$ ✕

**Date/Time**

No columns assigned

**Position**

**Longitude**

**Column:** Column 3 ✕
**Format:** 0° to 360°

**Latitude**

**Column:** Column 2 ✕
**Format:** -90° to 90°

**Primary Position File**

Primary position file? **NO**

Set As Primary Position File

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | Column 8 | Column 9 | Column 10 | Column |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 57.14566 | 8.42750 | 0.00000 | 21.530579 | 5.6550 | 5.4621 | | | 3.8578 | 0.696 |
| 2 | 57.14566 | 8.42666 | 0.00278 | 21.530694 | 5.6713 | 5.4946 | | | 3.8578 | 0.696 |
| 3 | 57.14550 | 8.42566 | 0.00556 | 21.530810 | 5.6929 | 5.4994 | | | 3.8578 | 0.696 |
| 4 | 57.14550 | 8.42482 | 0.00833 | 21.530926 | 5.7067 | 5.5232 | | | 3.8505 | 0.694 |
| 5 | 57.14550 | 8.42382 | 0.01111 | 21.531042 | 5.7265 | 5.5394 | | | 3.8432 | 0.693 |
| 6 | 57.14550 | 8.42300 | 0.01389 | 21.531157 | 5.7420 | 5.5475 | | | 3.8505 | 0.694 |
| 7 | 57.14550 | 8.42200 | 0.01667 | 21.531273 | 5.7592 | 5.5674 | | | 3.8358 | 0.692 |
| 8 | 57.14550 | 8.42116 | 0.01944 | 21.531389 | 5.7765 | 5.5845 | | | 3.8358 | 0.692 |
| 9 | 57.14550 | 8.42016 | 0.02222 | 21.531505 | 5.7902 | 5.5896 | | | 3.8285 | 0.691 |
| 10 | 57.14550 | 8.41932 | 0.02500 | 21.531620 | 5.8040 | 5.5920 | | | 3.8358 | 0.692 |
| 11 | 57.14550 | 8.41832 | 0.02778 | 21.531736 | 5.8212 | 5.5908 | | | 3.8285 | 0.691 |
| 12 | 57.14550 | 8.41750 | 0.03056 | 21.531852 | 5.8333 | 5.6078 | | | 3.8212 | 0.689 |
| 13 | 57.14550 | 8.41650 | 0.03333 | 21.531968 | 5.8393 | 5.6163 | | | 3.8285 | 0.691 |
| 14 | 57.14550 | 8.41566 | 0.03611 | 21.532083 | 5.8419 | 5.6146 | | | 3.8285 | 0.691 |
| 15 | 57.14550 | 8.41466 | 0.03889 | 21.532199 | 5.8504 | 5.6276 | | | 3.8285 | 0.691 |
| 16 | 57.14550 | 8.41382 | 0.04167 | 21.532315 | 5.8608 | 5.6295 | | | 3.8212 | 0.689 |

- Date/Time
- Longitude
- Latitude
- Run Type
- Intake Temperature
- Salinity
- Equilibrator Temperature
- Equilibrator Pressure (absolute)
- Equilibrator Pressure (differential)
- Atmospheric Pressure
- $xH_2O$
- $CO_2$
- Other Temperature
- Other Pressure
- Air Flow
- Water Flow
- Pump Speed

Add File

Cancel | Back | Next

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# Benguela Stream (Labelling) - Standard Concentrations

***Deployment Date***

*Select the date on which the standards were deployed*

2014-06-24

***Standard Concentrations***

*Enter the concentration for each gas standard*

| Standard | Concentration |
|---|---|
| 000 | 0.0 |
| 250 | 260.36 |
| 350 | 361.14 |
| 450 | 460.69 |

Save Cancel

***Calibration Date***

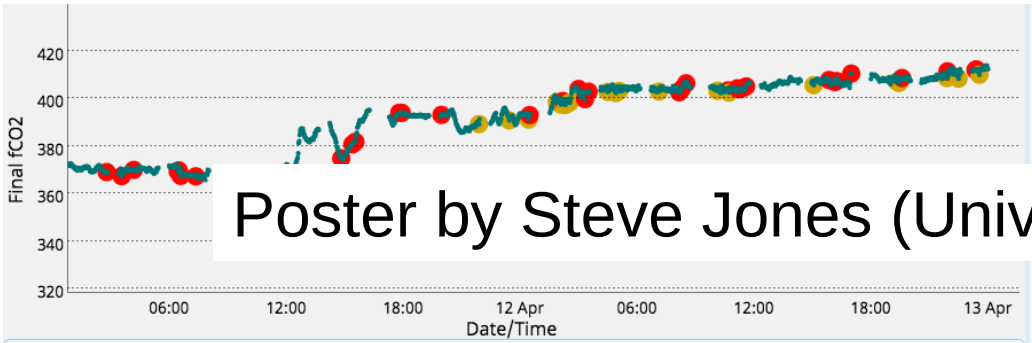
*Select the date on which the calibration was perform*

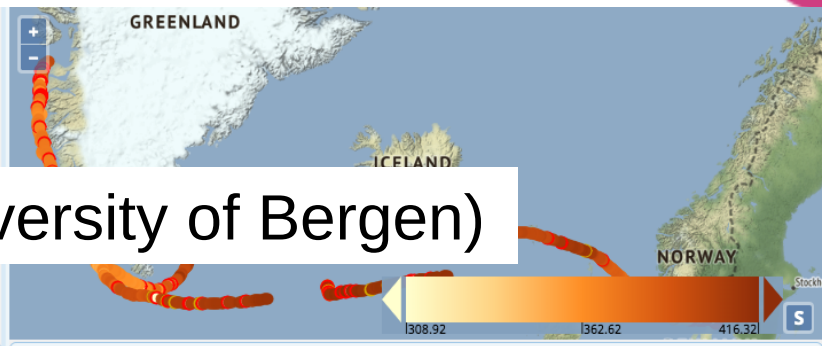
2015-04-28

***Calibration coefficients***

*Enter the calibration coefficients for each sensor*

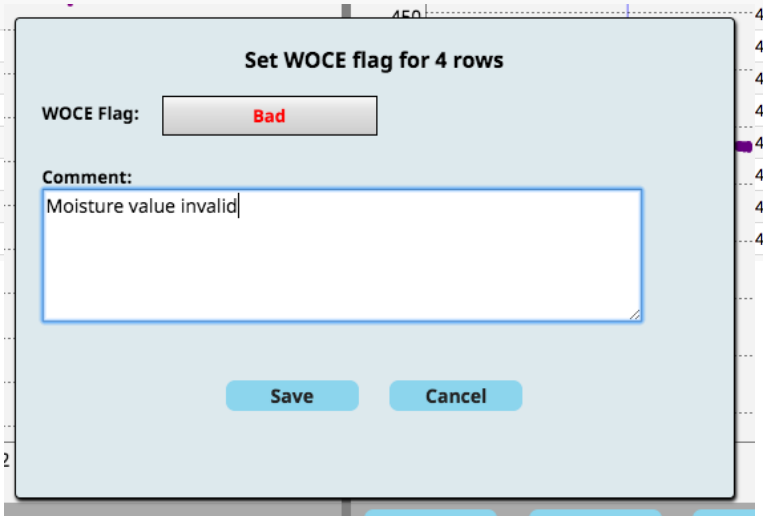
| Sensor | Intercept | x |
|---|---|---|
| Intake Temperature: Aanderaa | 0.0 | 1.0 |
| Salinity: Seabird | 0.0 | 1.0 |
| Equilibrator Temperature: PT100 (Top) | 0.9721 | 9.8304 |
| Equilibrator Temperature: PT2000 (Bottom) | 0.0 | 1.0 |
| Equilibrator Pressure: Omega | 878.41 | 40.377 |




# Poster by Steve Jones (University of Bergen)

| Date | Longitude | Latitude | Intake Temperature | Salinity | Equilibrator Temperature | Equilibrator Pressure (differential) | Ambient Pressure | xH2O | CO2 | fCO2 | Automatic QC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2019-04-14 12:03:07 | -25.537 | 59.076 | 7.557 | 35.000 | 7.740 | 0.160 | 995.410 | 1.430 | 425.800 | 412.789 | Good |
| 2019-04-14 12:04:39 | -25.526 | 59.078 | 7.575 | 35.000 | 7.780 | -0.810 | 995.200 | 1.430 | 425.340 | 411.561 | Good |
| 2019-04-14 12:06:11 | -25.515 | 59.079 | 7.563 | 35.000 | | | | | 425.030 | 408.524 | Bad |
| 2019-04-14 12:07:43 | -25.505 | 59.081 | 7.563 | 35.000 | | | | | 425.310 | 411.816 | Good |
| 2019-04-14 12:09:15 | -25.494 | 59.083 | 7.559 | 35.000 | | | | | 426.070 | 410.658 | Questionable |
| 2019-04-14 12:10:47 | -25.483 | 59.084 | 7.558 | 35.000 | | | | | 426.710 | 411.097 | Questionable |
| 2019-04-14 12:12:19 | -25.473 | 59.086 | 7.555 | 35.000 | | | | | 426.750 | 415.517 | Good |
| 2019-04-14 12:13:51 | -25.463 | 59.087 | 7.559 | 35.000 | | | | | 426.930 | 412.960 | Good |
| 2019-04-14 12:15:23 | -25.452 | 59.088 | 7.554 | 35.000 | | | | | 427.340 | 407.477 | Bad |
| 2019-04-14 12:16:55 | -25.442 | 59.090 | 7.549 | 35.000 | | | | | 427.770 | 413.017 | Good |

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## Quality Control for Biogeochemical Data - Workshop

September 24 and 25 at NOAA/PMEL in Seattle, WA

**Objectives**

- Workshop deliverables will be guidance that can be applied by the ICOS OTC and NOAA OAP developer groups towards an implementable solution
- Determine what degree of level 1 and level 2 quality control is acceptable for which variables, and what can be implemented by developer groups
- Determine what degree of QC automation is possible for both level 1 and level 2.
- SOCAT, GLODAP, ICOS, NOAA OAP, US BGC ARGO networks participated

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Want to learn more?

Presentation by J.-M. Rintala
and M. Becker
Poster by S. Jones

https://otc.icos-cp.eu

or talk to us

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