Update of ICOS OTC Station Labelling Requirements

Introduction

In the beginning of ICOS, there has been no official distinction between marine ICOS stations as submitted to the Head Office after the labelling process - all stations have been given a default Class 1 classification.

Therefore the classification strategy for labelling stations needs to be revised based upon the variables that they measure and their relation to wider goals of ICOS OTC. All stations must measure a minimum set of variables to qualify as a Class 2 station, meaning that they measure the minimum variables to an accuracy required to meet the ICOS goals. If they measure extra variables that allow ICOS to pursue further scientific questions, they will qualify as a Class 1 station. This is in line with the classification scheme used by the ATC and ETC, which also classify stations by the variables that they measure.

It is crucial to note that the above distinction is the *only* basis on which a station is classified as Class 1 or Class 2 - there is **no indication of the station's quality**. The fact that a station has passed the complete labelling process is an implicit endorsement that it provides data of excellent quality. Indeed, future network designs (a key component of the OTC's activities) may determine that Class 1 stations are not required in every location - it may be beneficial to deploy multiple Class 2 stations as opposed to more Class 1 stations.

<u>Transition</u>
Any stations that are labelled before 01. April 2019 will be reclassified according to the new scheme. There will be no reassessment of data quality, since we will already have established that the data is acceptable to OTC; the only changes will be based on the number of variables measured.

The Labelling Scheme

The stated aim of the ICOS RI is:

> *ICOS shall provide harmonised and high-precision scientific data on carbon cycle and greenhouse gas budget and perturbations.*

Regarding Carbon cycle this leads to two central goals for observations:

1. <u>Quantifying air-sea CO_2 Fluxes</u>

2. <u>Assessing Variability and Drivers</u>

Limitations of ocean pCO_2 measurement capabilities on fixed ocean stations (FOS) mean that fluxes cannot be determined to the accuracy desired for large scale carbon budgets. Meanwhile, it is most common that Carbon-VOS lines measure pCO_2 rather than other carbon system variables. Therefore:

- Carbon-VOS are most suited to quantifying fluxes

- FOS are most suited to assessing variability and drivers

These will define the basis for a station achieving Class 2 status within ICOS OTC.

If a Carbon-VOS measures the additional variables required to assess variability and drivers, it will become a Class 1 station. For FOS, measuring additional variables that give greater insight into the drivers (namely nutrients) will mean that station becomes Class 1[1].

From the above, the classifications for each type of station are detailed below:

	Carbon-VOS	**FOS**
Class 2 (minimum required variables)	pCO_2 (±2 µatm)	pCO_2 (±10 µatm) Alkalinity or DIC Oxygen
Class 1 (additional variables)	Alkalinity or DIC Oxygen	Surface: Nutrients (nitrate, silicate and phosphate)

Note: This table does not contain variables that may be required for validation of measurements

Accuracy Requirements

The table below lists the accuracy requirements of all target variables and the associated variables required to produce them (Temperature, Salinity etc.). The accuracy is the same whether variables are measured directly or calculated via a proxy. The stated accuracies for variables needed to become a Class 1 station are based on the "weather goal" introduced by Newton et al. (2014) and implies an uncertainty of:
pH = 0.02
Alkalinity (TA), Dissolve Inorganic Carbon (DIC) = 10 µmol kg−1

[1] Additional capabilities, such as measurements at depth, were considered as a distinguishing factor for Class 1. However, the cost and difficulty involved in upgrading stations for this purpose means that this is not a realistic proposition for most stations within the next few years.

Carbon-VOS

Variable	Frequency	Accuracy	Required for Class
Sea surface fCO_2	Quasi-continuous	±2 µatm	2
Intake temperature (SST)	Continuous	±0.05 °C	2
Water vapour pressure	Continuous	±0.5 mbar	2
Equilibrator pressure	Continuous	±2.0 mbar	2
Equilibrator temperature	Continuous	±0.05 °C	2
Delta-T (Intake/Equilibrator temperature difference)	Continuous	< 1.5 °C (normal) < 3 °C (ice edge)	2
Sea surface salinity (SSS)	Continuous	± 0.1 psu	2
Alkalinity	**	10 µmol kg^{-1}	1*
Dissolved Inorganic Carbon	**	5 µmol kg^{-1}	1*
Dissolved oxygen	**	±2%	1

*At least one of these variables must be provided.

**The frequency of these additional variables will be decided on during the labelling process based on the area where the station is operating.

FOS

Variable	Desired Frequency	Accuracy	Required for Class
Sea surface pCO_2	3/day (coastal) 1/day (open ocean)	±10 µatm	2
Sea surface temperature	3/day (coastal) 1/day (open ocean)	±0.02 °C	2
Sea surface salinity	3/day (coastal) 1/day (open ocean)	±0.1 psu	2
Alkalinity	**	4 µmol kg^{-1}	2*
Dissolved Inorganic Carbon	**	2 µmol kg^{-1}	2*
Dissolved oxygen	3/day (coastal) 1/day (open ocean)	±2%	2
Dissolved nutrients	**	±1%	1

* At least one of these variables must be provided.

**Frequency of measurements will be discussed during evaluation of the station following the observation goals stated above.

Other Variables

For validation purposes:

pH must be measured for pCO_2 validation purposes. OTC will compare sensor pCO_2 with calculated pCO_2 from other carbon variables. The recommended variable pairs for such calculation are pH-DIC or pH-TA, which meet the required ICOS OTC accuracy. The variable pair DIC- TA should not be used for the validation calculation as the accuracy is not within the ICOS OTC requirement.

Additional: Some stations measure variables that are not included in the above specifications (e.g. methane). ICOS OTC will not process these variables, but will ensure that they are archived in the Carbon Portal.

References:

Newton, J.A., Feely, R.A., Jewett, E.B., Williamson, P., Mathis, J., 2014. Global Ocean Acidification Observing Network: Requirements and Governance Plan 57 pp.