ASVCO2®

Autonomous Surface Vehicle CO_2 Sensor

Instrument Naming Requirements

Purpose:

To ensure that ASVCO2™ instruments built and operated by disparate groups produce high quality data that meets or exceeds the CO_2 accuracy standard determined in Sabine et al. (2020), and that the data are traceable to the WMO CO_2 scale.

Measurement

The ASVCO2™ instrument will:

1. Use the air-sea equilibration method, and be built per the most recent version of the NOAA-PMEL ASVCO2™ build specifications (including mechanical drawings, electronics hardware, and firmware) available, upon formal agreement, from NOAA-PMEL.
2. Have in situ calibration of the nondispersive infrared (NDIR) CO_2 gas analyzer prior to each measurement with, at a minimum, a 2-point calibration: 0 ppm and a WMO-traceable CO_2 reference gas with a CO_2 concentration that is higher than the expected field measurements. The reference gas should be no more than 50% greater than the maximum value expected in the field.
3. Have accompanying measurements of relative humidity (accuracy < 2%) and air temperature (accuracy < 0.3 °C) in the NDIR sample stream, sea surface temperature (accuracy < 0.01 °C) & sea surface salinity (accuracy < 0.5 PSU).
4. Have published field accuracy specifications against reference measurements for any new deployment configuration (including the specific equilibrator design and installation platform) in a peer-reviewed publication.
5. Be serviced per NOAA-PMEL refurbishment specifications, ASVCO2 Refurbishment Checklist is publicly available on the NOAA-PMEL website.
6. For additional details on the methodology, see Sabine et al. (2020) and Sutton et al. (2014).

Quality Assurance (QA)

Before every deployment each ASVCO2™ instrument will pass:

1. Laboratory testing of accuracy over a range of WMO-traceable CO_2 reference gases.
    - Minimum # of reference gases segmented into the following ranges: 0-2 ppm (x1), 3-300 ppm (x1), 301-775 ppm (x3), and highest NDIR calibration gas concentration (x1). If CO_2 values expected in the field are >775 ppm, also include: 776-1075 ppm (x1), 1076 - highest NDIR calibration gas concentration (x1). Reference gases will have differences in CO_2 concentration of > 50 ppm, and will include 2 gas concentrations bracketing the mean expected field value within +/- 100 ppm.
    - A minimum of 3 duplicate measurements for each reference gas will be collected, and the ASVCO2™ will be set up to run in its deployed configuration.
    - For the combined set of reference gases from 0-775 ppm, the ASVCO2™ will have a mean CO_2 residual < 2 ppm, a maximum CO_2 residual < 4 ppm, and a standard deviation of the mean residual < 2 ppm.
2. Laboratory accuracy and stability check in a seawater tank against a reference system
    - Reference system will:

- Have a published accuracy of < 2 ppm and include in situ calibration with at least one non-zero reference gas traceable to WMO standards.
- Be independently verified for accuracy using a different instrument that meets or exceeds the reference system's accuracy and is calibrated in situ with more than two non-zero WMO traceable reference gases, or by a NOAA-PMEL approved 3rd party lab, on an interval of < 1 year.
- Be in good working order and serviced per manufacturer's specifications.
- Have an identical instrument (design and manufacturer) that has participated in at least one international seawater pCO_2 instrument intercomparison with a demonstrated accuracy of 2 ppm.

- ASVCO$_2$™ will be set up to run in its deployed configuration, including using the expected sampling schedule, instrument state settings, and the hoses, equilibrator and airblock that the system will use in the field.
- A minimum of 72 hours of hourly measurements will be compared, ideally covering the range of CO_2 expected in the field or ± 100 ppm of ambient air xCO_2 (whichever range is wider).
    - In comparison with the reference system for the range of water CO_2 concentrations between 0-775 ppm, the ASVCO$_2$™ will have a mean seawater dry xCO_2 residual < 3 ppm, a maximum CO_2 residual < 4 ppm, and a standard deviation of the mean residual < 3 ppm.
    - In comparison with the reference system, when the lab air CO_2 concentration is stable and < 775ppm, the ASVCO$_2$™ will have a mean air dry xCO_2 residual < 2 ppm and a standard deviation of the mean residual < 3 ppm.

Data Management and Quality Control (QC)

ASVCO$_2$™ manufacturers will conduct the following QC and management procedures:

1. The data generated by the ASVCO$_2$ ™ instrument and associated metadata will meet Surface Ocean CO_2 Atlas (SOCAT) quality flag C or better, and include both seawater and air CO_2 values.
2. The data generated by the ASVCO$_2$ ™ instrument will contain metadata that meets the SOCAT submission requirements for flags A-D and includes the "ASVCO2(a trademark of NOAA)" device/ instrument name, the instrument's serial number and manufacturer, the date of the last WMO-certified reference gas QA test and water tank QA validation, and the concentration and serial number of the WMO-traceable CO_2 reference gas used for in situ calibration of the CO_2 measurements.
3. Results of the QA tests will be stored and available to data users upon request.
4. Publications that make use of ASVCO$_2$™ generated data will identify the "ASVCO$_2$™" name.

Scientists using the ASVCO$_2$™ data are encouraged to QC delayed-mode data and submit to SOCAT including:

1. Post-deployment, CO_2 measurements are reprocessed from the raw NDIR detector counts and re-calculated using in situ reference gas calibration coefficients. Data are then quality-controlled and assigned WOCE flags (see Sutton et al. 2014).

Contacts

The ASVCO$_2$™ was developed by NOAA's Pacific Marine Environmental Laboratory. For questions and inquiries about the ASVCO$_2$™ or these requirements, please contact: oar.pmel.moored.CO2@noaa.gov.

References

Sabine, C., Sutton, A., McCabe, K., Lawrence-Slavas, N., Alin, S., Feely, R., et al. (2020). Evaluation of a new carbon dioxide system for autonomous surface vehicles. Journal of Atmospheric and Oceanic Technology. https://doi.org/10.1175/JTECH-D-20-0010.1

Sutton, A. J., Sabine, C. L., Maenner-Jones, S., Lawrence-Slavas, N., Meinig, C., Feely, R. A., et al. (2014). A high-frequency atmospheric and seawater *p*CO2 data set from 14 open-ocean sites using a moored autonomous system. Earth Syst. Sci. Data, 6(2), 353-366. https://doi.org/10.5194/essd-6-353-2014