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STANDARD OPERATING PROCEDURE	
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Revision History

Revision No.	Name	Date of Revision	Description of Change(s)
J-AMCD-SFSB-SOP-4380-0	Original SOP	08/24/2021	Issuance
J-AMCD-SFSB-SOP-4380-1	Revision 1	05/09/2022	Added Data Analysis Code Appendix E
J-AMCD-SFSB-SOP-4380-2	Revision 2	08/01/2022	Improved QA and training documentation
J-AMCD-SFSB-SOP-4380-3	Revision 3	05/7/2023	Revised SENTINEL Appendix E, minor changes throughout

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1. Scope and Applicability

A fenceline Sensor Pod (SPod) refers to any air sensor-based system deployed near a potential ground-level air pollution source to improve understanding of emissions. Sensit Technologies (Valparaiso, IN) produces the SENSIT® SPOD, a specific type of fenceline sensor. This SOP provides supporting information for the deployment, operation, basic data processing, and quality assurance (QA) and quality control (QC) of the SENSIT® SPOD fenceline sensor, with canister grab sample (CGS) acquisition system. This SOP is designed to supplement the user manual "*SENSIT SPOD Sensor Operation Manual and Configuration Guide, Version 1.1, April 2020*",[1] and the *SENSIT SPOD Sensor Maintenance Guide, Version 1, May 2020*".[2] The SENSIT® SPOD (hereafter called "SPod") is modeled after the EPA SPod volatile organic compounds (VOC) fenceline sensor.[3-10] The SPod and CGS system deployed together are referred to as "SPod/CGS". This SOP covers these topics:

- SPod/CGS pre-deployment QA/QC procedures
- SPod/CGS field deployment, operation, and QA/QC procedures
- CGS installation, shipping, and handling
- SPod data visualization and QA using the EPA SENsor Intelligent Emissions Locator (SENTINEL) software

The target audience for this SOP is field and data analysis personnel utilizing this technology. This SOP does not describe the operation of support equipment, such as generators, transport trailers, meteorological stations, gas cylinders and dilution systems, or distance measurement devices.

2. Summary of Method

In general, an SPod is a lower-cost sensor system that combines wind field and air pollutant concentration measurements to detect emission plumes and help locate and assess the source of emissions at or near the fenceline of facilities. An SPod typically combines components such as air sensors, a microcomputer, an anemometer, and communication in a single field package. An SPod may have a battery and the capability to operate using solar power if required. This SOP is for a commercial version of the SPod made by SENSIT Technolgies.[1] This SPod package contains a photoionization detector (PID) sensor that produces a non-speciated, approximately calibrated concentration measure of a subset of VOCs and hazardous air pollutants (HAPs) that can be ionized with a 10.6 eV PID, as well as sensors for measuring temperature (temp), relative humidity (RH), and pressure (press). In the current configuration, the effective PID detection sensitivity ranges from approximately 0.02 parts per million (ppm), by volume, to 2 ppm under best operating conditions. Other components of this SPod package include a sonic anemometer, photovoltaic power source, onboard operating and data logging system containing a secure digital (SD) flash memory card, and wireless capability cell phone modem for remote communication. The SPod can be deployed with a CGS acquisition system (called SPod/CGS system). The SPod/CGS system is part of EPA's Next Generation Emissions Measurement (NGEM) program.

The SPod/CGS system can be operated in the field to remotely collect 1.4L CGS samples, where the sample acquisition is triggered by elevated SPod PID signal or other means. Because of the rapidly changing nature of near-source plumes, an approximate 20 second duration "canister grab sample" is typically conducted using the SPod/CGS system[10] but canister time integration can be adjusted with minor modifications. Canister sample collection specifics are detailed in the project-specific quality assurance project plan (QAPP). Acquired CGSs are sent to the laboratory identified in the QAPP for analysis, typically by EPA Method TO-15A (US EPA 1999).[11]

3. Definitions/Acronyms

Table 3.1: Common terms used in this SOP listed in alphabetical order

Term	Definition
2D Sonic	wo-dimensional sonic anemometer
AMCD	Air Methods and Characterization Division
BCP	background correction procedure used in fenceline monitoring applications
Cal-check	SPod calibration check.
CEMM	Center for Emission Measurement and Modeling
CGS	Canister grab sample
COC	chain of custody
Deg C	unit of temperature, degrees Celsius (aslo °C)
DQI	data quality indicator
CGS	canister grab sample
eV	electron Volt
GPS	global positioning system
HAP	hazardous air pollutant
LPM	Litter per minute
mV	millivolt
NGEM	Next Generation Emission Measurement
Node	single SPod location
ORD	Office of Research and Development
ppb	part per billion, always meaning "by volume" in this SOP
PID	photoionization detector
PN	part number
ppm	part per million, always meaning "by volume" in this SOP
Press	atmospheric pressure (typically mbar)
QA	quality assurance
QAM	Quality Assurance Manager
QC	quality control
QAPP	quality assurance project plan
RH	relative humidity (%)
Sec Dat	secondary data check (QA reasonableness check)
SD	secure data card for storing SPod data
SDI	source direction indicator plot
SENTINEL	SENsor Intelligent Emissions Locator, EPA SPod QA and visualization software
SFSB	Source and Fine Scale Branch
SOP	standard operating procedure
SPod	fenceline Sensor Pod, a lower cost fenceline sensor system, (here SENSIT® SPOD)
SPOD	SENSIT® SPOD, a specific type of fenceline SPod
TBD	To be determined
Temp	temperature of the air measured by a SPod sensor in deg C
VOC	volatile organic compound
WS	wind speed (typically mph for Sensit SPod)
WD	wind direction (degrees from north)

4. Health and Safety Warnings

The SPod/CGS is designed to detect and assess emissions plumes. The current SPod/CGS design works only in "near-fenceline" applications where localized emission plumes may be present. The source to separation distance for a fenceline application is defined here as 50 m to 500 m. Since the SPod is not certified as intrinsically safe, it cannot be deployed in potentially hazardous environments because the unit's electronics (as with any sensor or vehicle) have could potentially act as an ignition source and trigger an explosion if a large flammable gas concentration exists.

WARNING: Since the SPod is not certified as intrinsically safe, it cannot be used in potentially explosive environments.

The general health and safety precautions for field measurement activities are described in separate health and safety plans and are not detailed in this SOP. Aside from safe area siting, the primary safety hazard associated with SPod-deployment and use is the physical handling of heavy gas cylinders that may be used on the EPA test range and the installation of SPod/CGS mounting poles and fixtures at the deployment location. Canisters and SPod units may be shipped in boxes or a rugged, heavy carrying case. Safety precautions must be taken when handling the boxes and carrying case as to not cause personal injury. Proper safety precautions and safety equipment must be used for handling and/or installation functions along with "dig safe" procedures and proper site permitting. These safety and site permission functions should be covered in the project-specific safety plan related to the deployment.

In general, care must be taken to secure equipment, so it does not produce a falling or tipping hazards under high wind or potentially interfere with unrelated site equipment or operations. Caution must also be used when deploying near roadways due to vehicle hazards and care must be taken to minimize or eliminate the possibility of creating driver distraction hazards while selecting the deployment site. General precaution with use of electrical equipment or in the field or installations near power lines must be followed and all necessary site safety checks must be performed, and permissions acquired. Typically, SPod PID operation is checked with low concentrations [500 parts per billion (ppb) or 1.0 parts per million (ppm) by volume] of isobutylene, but if other gases are used, care must be taken with potentially hazardous aspects of these gases and details should be described in project-specify safety plans.

5. *Cautions/Interferences*

There are two types of method interferences for the 10.6 eV PID-based SPod/CGS systems: physical and analytical.

5.1. Physical Interferences:

Physical interference refers to external conditions or component malfunctions that may negatively affect SPod/CGS operation. For the purposes of this SOP, physical interferences may result in loss of operation of all or part of the SPod/CGS system. The loss of operation (loss of data) for the SPod may be temporary or permanent in nature but a loss of data integrity for an acquired canister sample is permanent, generating a laboratory analytical sample that carries the appropriate QA flag depending on the issue. The following are examples of physical interferences affecting SPod/CGS performance:

- Operational temperatures outside of -10°C to 50°C will cause operational failure without special preparations.[1]
- The SPod/CGS system requires cellular signal for data transmission.
- Heavy rain or dew (condensation) may result in water collecting on the PID sensor or inlet screen causing the SPod to enter into a temporary nonoperational state or a state that produces erroneous data (analytical interference). The SPod and canister box must be inspected to for water tightness.
- Physical obstructions, such as freezing rain, accumulated dirt, or insects may impact the inlet to the SPod PID sensor or the CGS, and therefore affect operation.
- A loss of power as may occur if the solar panel is blocked by snow or experiences >3-5 cloudy days (if solar power without second battery is used). Grass clippings and leave are also a potential issue.
- Physical interferences include component malfunctions or operational issues with the SPod sensors or communications systems that may require unit reset (power off/power on) to clear. If a sensor ceases to operate or begins to operate in an unstable fashion, a physical fault is likely, and replacement may be required.

- The performance of the SPod sonic anemometer may be impacted by the presence of physical interferences (trees, telephone poles, etc.) in vicinity of the SPod/CGS. The unit must be positioned and oriented correctly to ensure data validity. Established true north from Google Earth™ images.
- CGS sampling units and canisters may develop a vacuum leak leading to a loss of sample integrity. Vacuum pressure for each canister must be measured and recorded on chain of custodies (COCs). (1) Pressures are measured by lab before release for use in field to -30"Hg. (2) Pressures are measured just before installation while in field to ensure no leaks have occurred before sampling, (3) Pressures are measured after the sample has been collected in field to ensure sample has collected and some vacuum still remains. (4) final vacuum pressure taken by GC lab after returned from field to ensure no further vacuum loss after collection from field has contaminated sample. Analytical Interferences:

5.2. Analytical Interferences:

Analytical interferences refer to the issues that prevent the SPod/CGS from performing its design function (detecting fenceline emission plumes) when no physical interferences are present. In fenceline sensor applications where the SPod/CGS system is proximate to the source under study, wind-advected emission plumes create a rapidly time-varying signal on the SPod PID sensor, which can be mathematically isolated from the VOC background and drift signals and assessed as part of data analysis procedures.[9,10] The following analytical interferences can affect this fenceline-style data analysis:

- Degradation of sensor sensitivity over time. Over time, the PID sensor may lose sensitivity creating analytical and CGS trigger level uncertainty. This interference is avoided using periodic in-field sensor calibration checks with 1.0 ppm isobutylene gas as described in this SOP.
- A serious potential analytical interference is associated with source signal that does not originate from the source under observation. For example, a truck may park temporally near a sensor location and the exhaust from the truck could create signal on the SPod and possibly trigger a canister. The protection against this analytical interference is proper siting, investigation of the signal character, and use of supporting speciation and auxiliary sensor, or observation data. The specific procedures involved in minimizing this type of analytical interference is described in the project-specific QAPP.
- Because these are lower cost NGEM systems, general PID sensor or electronic malfunction may occur. Under certain conditions, it is possible for a sensor to fail creating a temporally sustained erroneous signal. It is also possible to receive an artifact signal caused by electronic noise from an SPod system or communication malfunction. These conditions may manifest as an unrealistically stable and very low sustained reading or erratic and unrealistically high signal at the upper end of the output, or non-physical signal data point noise-like spikes. As described in this SOP, QA screening must occur to flag these conditions and remove them from analysis. Over progressive design revisions and with the implementation of sensor heaters[3-6] the frequency of these malfunction states have decreased over time for the EPA SPod and are believed to be even less frequent in the Sensit SPod (subject of this SOP). Operation in extreme RH environments make this this type of malfunction more prevalent.[1]
- An important potential analytical interference for the SPod is associated with low temporal frequency PID sensor baseline drift with RH and temp. This low frequency (slow temporal response) signal is convolved with airshed (background) VOC levels present in the atmosphere that can exhibit similar temporal variability. Under certain ranges of conditions, it is theoretically possible to use the measured RH and temp as part of a post-processing model attempting to separate background drift from real background VOC signal, but this is not covered in this SOP. For fenceline sensor applications, a background correction procedure (BCP) that separates the higher frequency (temporally sharp) emission plume signal from the slower drift and air shed signal is utilized (and described).[10]
- Under sudden atmospheric changes, (e.g., a thunderstorm outflow, sharp RH, temp, and/or press swing, condensation) there is potential for high frequency artifact signal to be produced. This form of a “sharp artifact drift signal” may look similar to certain types of near-field emissions plumes and

represents an analytical interference. The frequency of occurrence of this type of event is low and procedures described in this SOP assist in identifying and flagging these events for removal from the processed dataset.

- The CGS apparatus or individual CGS may become contaminated during shipment, during sampling, or after sampling a high concentration air sample. Pre-deployment canister blank testing must be performed on the SPod/CGS system to ensure that contaminants are not present in the sampling device. A background sample should be taken using the SPod/CGS system directly after field installation or after a suspected high concentration sample to ensure the sampling apparatus has not become contaminated to minimize carry over effects during subsequent sampling.
- The CGS sample may carry a combination of chemical species from the source under study and from interfering sources resulting in source assessment and attribution complexity. This analytical interference is assessed on a case-by-case basis utilizing project-specific information and statistical analysis across a sample set. These procedures are not described in this SOP.
- The SPod/CGS system is subject to a false trigger of the CGS. A Type 1 false trigger of CGS system can occur when the trigger threshold is crossed by some malfunction (electronic noise signal spike or power surge) or by a background drift issue. Because the CGS acquisition and its laboratory analysis are independent of SPod operation, a Type 1 false trigger typically represents a valid CGS but is not necessarily related to a local source of emission (potentially a background sample). A Type 2 false trigger of the CGS system is defined as being caused by a real emission plume or elevated airshed air pollutant PID signal that is not related to the source under study (e.g., caused be by an interfering source). A Type 2 false trigger is typically a valid sample but not necessarily representative of the primary source under study. Type 1 and Type 2 false trigger flags are assigned in post analysis using a combination of sensor data, wind conditions, secondary data, field notes, and laboratory speciated analysis. These procedures are project and case-specific and not described in this SOP.

6. Personnel Qualifications/Responsibilities

There are six types of trained personnel required to successfully deploy and manage an SPod/CGS which are described in the following subsections: (6.1) SPod/CGS Field Operator, (6.2) SPod Data Analyst, (6.3) SPod/CGS Advanced Operator, (6.4) VOC Laboratory Lead (or VOC Specialist), (6.5) Site Engineering Lead, and (6.6) Data Synthesis Lead. In all cases, the trained person has signed the appropriate training form and has passed the training assessment. The person has ensured that the fully signed forms documenting training have been transmitted the to the appropriate project and QA managers and has retained a copy for their records.

6.1. SPod/CGS Field Operator:

This trained person has met the laboratory and field safety training requirements of their organization and has secured legal site access permission to visit and manage the hands-on operation for one or more SPod/CGS systems. The person has read and understood this SOP, Reference 1 and 2, and the site-specific QAPP. The person understands daily SPod operation and calibration check procedures. The person has mastered the CGS change-out, pressure checks, proper COC documentation, and canister shipping procedures. The person understands how to perform simple replacement and orientation of equipment on a developed site and is able to perform simple maintenance around the site (e.g., weed whacking). The person has signed the appropriate training form contained in Appendix A (specifically form A1) and has transmitted the form to the project manager (as per QAPP) QA and retained a copy for their records.

6.2. SPod Data Analyst:

This trained person has read and understood this SOP, References 1, 2, and 10 and the site-specific QAPP. The person has the proper software and suitable computer for basic SPod data analysis using SENTINEL and can access the data. The person can produce first level summaries of data, can screen for gross QA issues or malfunctions, and will communicate results as per QAPP. The person has signed the appropriate training form contained in Appendix A (specifically form A2) and has transmitted the form to the project manager (as per QAPP) and retained a copy for their records.

6.3. SPod/CGS Advanced Operator:
This trained person meets criteria 6.1 and 6.2, has read additional references, and has the ability, tools, and training to properly site and orient solar-powered and tripod-based (temporary) SPod/CGS systems at locations they may legally access. The person has the software and computer capability and knowledge to change the settings of the SPod/CGS system for site specific needs. The person can perform more advanced data analysis and execute more complicated QA screening procedures outlined in this SOP to diagnose specific issues that may need attention. The person can properly maintain records and order supplies (such as isobutylene calibration check gas) that are needed for operation of the systems in various projects. The person has signed the appropriate training form contained in Appendix A (specifically form A3) and has transmitted the form to the project manager (as per QAPP) and retained a copy for their records.

6.4. VOC Laboratory Lead (or Specialist):
Not described in this SOP, this person has mastered the procedures for cleaning, shipping, documenting, and analyzing CGSs. The person can summarize data and maintain laboratory equipment and records as per QAPP and related SOPs. This training is recorded separately with documentation kept by the VOC analysis laboratory.

6.5. Site Engineering Lead:
Not described in this SOP, this person has the project management and engineering training, experience, and the operational authority to set up (and/or commission set up of) semi-permanent monitoring sites, power drops, security, and legal site access and insurance agreements (as needed). A Site Engineering Lead may not be required for temporary siting with solar power. This training is recorded separately with documentation kept by the organization employing the Site Engineering Lead.

6.6. Data Synthesis Lead (or Specialist):
Not described in this SOP, scientific investigator(s) combine information for SPod, CGS analysis, and other metadata to form conclusions about sources and emission events. This person must have a well-developed knowledge of roles 6.1-6.5 as well as experience in analysis of complex datasets that combine concentration measurements with wind field analysis. The documentation of training for this role is evidence by named service in this capacity in the QAPP as approved by the Quality Assurance Manager (QAM).

7. Equipment and Supplies

Refer to the manual[1] page 6 and Appendix F for images of the SPod fenceline sensor covered in this SOP. The user must read and follow this manual and the calibration and maintenance guide,[2] which are augmented by procedures described in this SOP. SPod/CGS installation requires the following primary equipment and supporting apparatus. For long-term deployments, more robust mounting fixtures are required. This SOP assumes security at the fenceline or other provisions are in place to prevent unauthorized access to the system. This SOP does not cover laboratory equipment and supplies needed to clean and analyze CGSs. Equipment requirements include temporary or semi-permanent installation gear (Section 7.1). Equipment in 7.2 (calibration gear) is required and 7.3 (CGS gear) is optional and used only if canisters are to be acquired. The following forms are required for all deployments and testing activities.

- SPod/CGS Settings Configuration Form (Appendix B)
- SPod Calibration with Zero and Calibration Check Form (Appendix C)
- SPod/CGS Site Deployment Form (Appendix D)

7.1. SPod (no CGS) using Tripod or Fixed installation, solar power or land power:

- Safety equipment (as per safety plan)

- Sensit SPod with high sensitivity Ion Science 10.6 eV PID, anemometer, secure digital (SD), card SIM card, 4G Modem, Cellular activation, and web access [Sensit part numbers (PNs) 937-00000-52, 360-00631, 360-00571,500SPOD0-01,500-SPOD0-10]. [*See Appendix F, Figure F1, image of SPod*]
- Sensit SPod to computer USB connection cable
- SPod analysis software, SENTINEL, and "CoolTerm" program for adjusting settings
- Compass, GPS, camera, Teflon tape, bubble level
- Flathead screwdriver, crescent wrench, other basic hand tools
- SPod physical mounting system (e.g., clamps) for pole, fence, or tripod, (Sensit, PN 870-00132)
- Sensit solar panel and connection cables (for solar-powered installations)
- SPod tripod (for shorter-term installations) [*see Figure Appendix F, Figure F2 SPod on tripod with no CGS and solar power*]
- Land power with ground fault interrupt 15-amp 110 V outlet (for land-powered installations)
- Sensit low voltage outdoor SPod power supply (for land-powered applications)
- Weather-proof power cord (for land-powered-applications, PN part #: 870-00147
- Pallet-based or fixed pole mounting system for longer deployments (Jacobs Technology) [*see Appendix F, Figure F3 SPod with quad CGS and solar panel on Jacobs pallet system*]
- 4-step step ladder is recommended for access to SPod for maintenance on a Pallet system.
- Sandbags, concrete blocks, and ratchet-strap tie-downs for securing tripod or pallet to ground
- Calibration equipment described in 7.2

7.2. SPod Calibration Equipment (Required):

- Equipment in 7.1 suitable for specific deployment type (temporary or semi-permanent)
- Air, ultrazero VOC free (e.g., Airgas PN: AI UZP58, size 58DAL, CGA C10, documented VOC <10ppp)
- 1.0 ppm ± 2% isobutylene calibration cylinder certified standard spec (e.g., Airgas PN: X02NI99CPI600T9, size 58DAL nitrogen balance, CGA C10)
- Gas cylinder regulator, flow rate 0.5 LPM that is verified to mate with selected disposable cylinder (e.g., Airgas PN: Y1147045-AG)
- Sensit SPod calibration flow-through check sensor cap (Sensit PN 880-00066)
- 5 feet of 0.25-inch Teflon tubing with 0.25-inch Swagelok nut, ferrule, and union to connect cylinder value to SPod calibration check sensor cap [*see Appendix F, Figure F4 field calibration example*]

7.3. SPod/CGS for Triggered Canister Acquisition (optional):

- All equipment in 7.1 or 7.2
- Sensit SPod CGS trigger system (Sensit technologies), [*see Appendix F, Figures F5 and F6*], aslo called a canister valve controller, Sensit PN870-00118
- Trigger solenoid(s) (up to four), and connection cabling (Sensit technologies)
- Sampling inlet(s) for application, typically 2 µm sintered fret, Swagelok fittings, 180 deg turn and rain umbrella for 25 second triggered CGS, Entech brand silonite filtered grab sampler (no restrictor)- SKU: 01-39-RS-0
- CGS and canister fixturing system (Jacobs Technology)
- Specified quantity of 1.4 L Silonite coated canisters (Entech Instruments, PN: 01-29-MC14LQT)
- Vacuum pressure gauge with Micro-QT® fitting (Entech, PN: 01-29-70010QT), or Dwyer electronic vacuum gauge, calibrated sold by Grainger PN 55EJ11
- Canister shipping container, e.g. Entech PN 01-29-20400
- SPod/CGS Canister COC Forms (from QAPP)

8. Reagents and Standards

Reagents and standards needed for laboratory analysis of CGS are not described in the SOP.
To execute zero and span calibrations, a supply of VOC-free air and a low ppm-level isobutylene gas standard are required. In Section 7.2, two small format field cylinders were specified:

- Air, ultrazero VOC free (e.g., Airgas PN: AI UZP58, size 58DAL, CGA C10)
- 1.0 ppm ± 2% isobutylene calibration cylinder certified standard spec (e.g., Airgas PN: X02NI99CPI600T9, size 58DAL nitrogen balance, CGA C10)

Other forms zero air generation and isobutylene gas standards may be used, such as:

- 1.0 ppm ± 5% isobutylene in air balance (e.g., PortaGas PN 315-120013)
- 0.5 ppm ± 2% isobutylene in air balance (e.g., Airgas PN X02AI99CP580082A2)
- 5.0 ppm ± 5% isobutylene in N2 air balance (e.g., Airgas PN X02NI99C15A6H87)- requires ultrazero air dilution to below 2.0 ppm using calibrated mass flow controllers.

9. *Procedures*

The following procedures describe SPod/CGS set up, operation, select QA/QC procedures, and basic data analysis. Some procedures will vary as noted depending on equipment configuration [e.g., sections 7.1, 7.2, and 7.3 (optional)].

9.1. SPod/CGS Settings Configuration and Example Data File:

As described in the SPod user manual[1], the Sensit SPod/CGS internal system settings can be configured for a variety of power and communication options and selection of the types and threshold levels for canister triggering. To configure this SPod/CGS system, an SPod/CGS Advanced Operator (Section 6.3) must connect a computer with a CoolTerm terminal emulator program to the SPod and follow the procedures in the SPod user manual starting on page 35. This connection requires a special USB to SPod cable that is described in the manual and supplied with the unit. For details on the connection procedure and description and management of settings, refer to the user manual. The settings may be changed based on the project and should be described in the QAPP.

Prior to deployment, the settings of each SPod must be verified to ensure that they are set as per project requirements. Figure 9.1.1 shows a screen image of an SPod's settings that are displayed during unit start-up with CoolTerm communication active. The screen is visible within the first 10 secs of start-up and can also be accessed through the settings menu by entering "YES" before the start-up countdown ends and also by entering "DISPLAY" on the command line. The device settings (e.g., this screen image) must be recorded on the SPod/CGS Settings Configuration Form (Appendix B) and submitted to project records. Any change in settings requires proper documentation through creation of another configuration form. The current example shows an SPod with no CGS set up for solar power, basic PID sensor heater enabled at a set point of 15, and with no PID offset applied. Other settings and sub menus are described in the user manual.[1]

```
SPOD Firmware v5.94

Checking For Sampler...SPOD Can v1.9

Sensor ID: SPOD01181
With MET, Filter: 10
System DATE,05/24/22 18:48:41
Network Time: Enabled, UTC
Battery Voltage: 14.37
Power Source: Solar Power
Output Mode: Streaming
Communication Mode: Cellular, Unlocked
Network Selection: Automatic
Cellular Protocol: Periodic HTTP Power Down with TLS
Output Data Rate: 10
Cellular Output Ratio: 90
Server Address: https://api.sensitconnect.net/sensors-data/addSensorsData
Access Point Name: zipitwireless.com.attz
GPS Mode: Disabled
PID1 Hours: 134
Sensor Heater: Enabled
Temp Set: 15
Dew Point Control: Disabled
PID1 Offset(ppb): 0.00, Not Constrained
```

Figure 9.1.1: Screenshot of SPod settings

The output file from the SPod is a comma delimited text file. With the above configuration, the file will appear as shown in Figure 9.1.2 with (b) showing the data in the form and with the headers applied by the EPA R-Code processing software called "SENTINEL" (Appendix E). The column labels differ here slightly from that expression found in the user manual but are so structured to help in discrimination of the raw and processed data forms, with the latter described in Section 9.5.

```
SPOD00106,DATE,12/21/19  07:59:08,PID1,109.07,224.30,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,211.10,TC,1506,25,1507,BATT,14.27,CHRG,0.13,RUN,79.89,TRIG,0,0,0,0
SP[illegible]6,DATE,12/21/19  07:59:18,PID1,107.93,223.49,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,201.30,TC,1510,24,1507,BATT,14.24,CHRG,0.04,RUN,80.87,TRIG,0,0,0,0
SP[illegible]6,DATE,12/21/19  07:59:29,PID1,107.92,223.48,T,-3.40,RH,79.40,P,1014.00,WS,0.60,WD,199.10,TC,1510,24,1510,BATT,14.24,CHRG,0.01,RUN,78.48,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:39,PID1,108.25,223.71,T,-3.50,RH,79.40,P,1014.00,WS,0.60,WD,201.40,TC,1510,24,1507,BATT,14.21,CHRG,0.00,RUN,76.25,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:49,PID1,108.20,223.67,T,-3.50,RH,79.40,P,1014.00,WS,0.60,WD,190.20,TC,1510,23,1507,BATT,14.20,CHRG,0.00,RUN,78.10,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  07:59:59,PID1,107.95,223.50,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,197.90,TC,1510,22,1507,BATT,14.18,CHRG,0.00,RUN,80.85,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:09,PID1,107.87,223.44,T,-3.50,RH,79.40,P,1014.00,WS,0.50,WD,193.50,TC,1510,21,1507,BATT,14.16,CHRG,0.00,RUN,78.44,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:19,PID1,107.62,223.26,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,195.80,TC,1505,21,1507,BATT,14.16,CHRG,0.00,RUN,74.47,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:29,PID1,108.40,223.82,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,195.20,TC,1503,22,1507,BATT,14.12,CHRG,0.00,RUN,77.01,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:39,PID1,108.95,224.21,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,199.80,TC,1503,23,1507,BATT,14.13,CHRG,0.00,RUN,80.70,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:00:50,PID1,112.63,226.83,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1503,24,1507,BATT,14.35,CHRG,145.71,RUN,79.22,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:13,PID1,113.08,227.15,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1504,24,1507,BATT,14.45,CHRG,158.91,RUN,81.04,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:43,PID1,115.98,229.21,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1507,24,1507,BATT,14.42,CHRG,153.93,RUN,81.07,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:01:53,PID1,125.74,236.17,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1512,23,1507,BATT,14.41,CHRG,53.67,RUN,50.93,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:04,PID1,133.48,241.68,T,-3.50,RH,79.50,P,1014.00,WS,0.50,WD,198.00,TC,1512,22,1507,BATT,14.38,CHRG,18.71,RUN,53.99,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:14,PID1,142.52,248.12,T,-3.30,RH,79.70,P,1014.00,WS,0.80,WD,170.10,TC,1511,23,1513,BATT,14.35,CHRG,6.53,RUN,67.16,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:24,PID1,149.72,253.25,T,-3.50,RH,79.70,P,1014.00,WS,0.60,WD,173.10,TC,1510,22,1507,BATT,14.33,CHRG,2.28,RUN,75.74,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:34,PID1,152.41,255.17,T,-3.50,RH,79.70,P,1014.00,WS,0.70,WD,171.20,TC,1510,21,1507,BATT,14.31,CHRG,0.79,RUN,79.10,TRIG,0,0,0,0
SPOD00106,DATE,12/21/19  08:02:44,PID1,153.33,255.82,T,-3.50,RH,79.70,P,1014.00,WS,0.80,WD,167.30,TC,1505,21,1507,BATT,14.28,CHRG,0.28,RUN,76.97,TRIG,0,0,0,0
```

(b)

SPod S/N	Date (mm/dd/yy)	Time (hr:min:sec)	RawPID (ppb)	RawPID (mV)	Temp (deg C)	RH (%)	Pres (mBar)	WS (mph)	WD (deg)	S1 Temp (arb)	S1 Heat (0-255)	S1 Set (arb)	Bat Volt (V)	Charge Current (mA)	Operate Current (mA)	Trig Port Stat	Trig Flag Stat	Trig Active Flag	Trig Sample Flag
SPOD00106	12/21/19	7:59:08	109.07	224.3	-3.5	79.4	1014	0.5	211.1	1506	25	1507	14.27	0.13	79.89	0	0	0	0
SPOD00106	12/21/19	7:59:18	107.93	223.49	-3.5	79.4	1014	0.5	201.3	1510	24	1507	14.24	0.04	80.87	0	0	0	0
SPOD00106	12/21/19	7:59:29	107.92	223.48	-3.4	79.4	1014	0.6	199.1	1510	24	1510	14.24	0.01	78.48	0	0	0	0
SPOD00106	12/21/19	7:59:39	108.25	223.71	-3.5	79.4	1014	0.6	201.4	1510	24	1507	14.21	0	76.25	0	0	0	0
SPOD00106	12/21/19	7:59:49	108.2	223.67	-3.5	79.4	1014	0.6	190.2	1510	23	1507	14.2	0	78.1	0	0	0	0
SPOD00106	12/21/19	7:59:59	107.95	223.5	-3.5	79.5	1014	0.5	197.9	1510	22	1507	14.18	0	80.85	0	0	0	0
SPOD00106	12/21/19	8:00:09	107.87	223.44	-3.5	79.4	1014	0.5	193.5	1510	21	1507	14.16	0	78.44	0	0	0	0
SPOD00106	12/21/19	8:00:19	107.62	223.26	-3.5	79.5	1014	0.5	195.8	1505	21	1507	14.16	0	74.47	0	0	0	0
SPOD00106	12/21/19	8:00:29	108.4	223.82	-3.5	79.5	1014	0.5	195.2	1503	22	1507	14.12	0	77.01	0	0	0	0
SPOD00106	12/21/19	8:00:39	108.95	224.21	-3.5	79.5	1014	0.5	199.8	1503	23	1507	14.13	0	80.7	0	0	0	0
SPOD00106	12/21/19	8:00:50	112.63	226.83	-3.5	79.5	1014	0.5	198	1503	24	1507	14.35	145.71	79.22	0	0	0	0
SPOD00106	12/21/19	8:01:13	113.08	227.15	-3.5	79.5	1014	0.5	198	1504	24	1507	14.45	158.91	81.04	0	0	0	0
SPOD00106	12/21/19	8:01:43	115.98	229.21	-3.5	79.5	1014	0.5	198	1507	24	1507	14.42	153.93	81.07	0	0	0	0
SPOD00106	12/21/19	8:01:53	125.74	236.17	-3.5	79.5	1014	0.5	198	1512	23	1507	14.41	53.67	50.93	0	0	0	0
SPOD00106	12/21/19	8:02:04	133.48	241.68	-3.5	79.5	1014	0.5	198	1512	22	1507	14.38	18.71	53.99	0	0	0	0
SPOD00106	12/21/19	8:02:14	142.52	248.12	-3.3	79.7	1014	0.8	170.1	1511	23	1513	14.35	6.53	67.16	0	0	0	0
SPOD00106	12/21/19	8:02:24	149.72	253.25	-3.5	79.7	1014	0.6	173.1	1510	22	1507	14.33	2.28	75.74	0	0	0	0
SPOD00106	12/21/19	8:02:34	152.41	255.17	-3.5	79.7	1014	0.7	171.2	1510	21	1507	14.31	0.79	79.1	0	0	0	0
SPOD00106	12/21/19	8:02:44	153.33	255.82	-3.5	79.7	1014	0.8	167.3	1505	21	1507	14.28	0.28	76.97	0	0	0	0

Figure 9.1.2: (a) Raw data from SPod output text file, (b) same information with EPA headers from R-Code processing, described subsequently.

9.2. SPod/CGS Error Debugging:

If a communication or operation issue arises with the SPod/CGS, an SPod/CGS Advanced Operator (Section 6.3) may access internal error codes to assist in debugging as described in the SPod user manual.[1] These procedures are not described in this SOP.

9.3. Cal-check and Single Point Span Calibration with Zero:

This procedure describes the calibration and testing of the 10.6 eV PID sensor contained in the SPod using equipment and supplies referenced in Section 7.2. and the gas standards discussed in Section 8. Other sensors that are part of the SPod either do not require routine calibration or provide secondary (non-critical) data and are not covered in this SOP. Depending on project-requirements, non-PID sensors may be subject to calibration/testing procedures as per the QAPP. There are two types of standard PID sensor procedures, the calibration check (Cal-check) and the single point span calibration with zero. The steps of these procedures are described in Appendices C1 and C2, respectively. Each procedure tests the response of the PID to 1.0 ppm concentration of isobutylene, delivered to the sensor while in the SPod housing at a flow rate of 0.5 LPM. Note that an alternate concentration of 500 ppb may be used based on project specific requirements. The concentration should be below 2.0 ppm as this represents the effective range of the PID sensor (when using the default Ion Science HS sensor).

9.3.1. Cal-check:

A Cal-check is a simple in-field procedure that is performed in a similar fashion to 9.3.2 but the zero gas point is not used and the computer connection is not required (no settings are changed). The Cal-check verifies SPod PID functionality, approximate sensor responsivity, PID calibration factor, and can verify CGS trigger operation (if desired).

As described in Section 5.2, the field-deployed baseline levels of the SPod PID can vary due to sensor drift (analytical interference) in addition to real changes in air shed VOC concentrations.[10] This baseline drift, coupled with the unknown composition of the emission plume make absolute SPod calibration difficult. The in-field Cal-check procedure provides a snap-shot view of the sensor's response to the 1 ppm isobutylene that carries a defined PID response factor of 1.0. This response does not equate to the sensor's response to plumes observed at the site that carry an unknown composite response factor. Acquisition of CGSs can assist in understanding the plume composition and PID sensor response by using a combination of individual response factors based on speciated laboratory analysis. To perform the Cal-check, ensure that the materials described in Section 7.2 are in hand and perform the steps outlined in Appendix C1 with refences to operational manuals.[1,2] The physical connection of the disposable cylinders, CGA C10 regulators, and tubing with adequate ventilation is covered in basic field operator training and is not described here.

9.3.2. Single Point Span Calibration with Zero:

Prior to entering the field, each SPod should be calibrated following the procedures of Appendix C2 and reference 2 with 1.0 ppm isobutylene (or other as specified in the QAPP). It is typically the case that procedure 9.3.1 precedes full calibration in order to document response prior to settings change (following Appendix C1). The current procedure uses a VOC-free zero gas and 1.0 ppm isobutylene span gas (Section 7.2) to zero the unit and calibrate the PID response at a single point. Since SPod system settings will be altered, the full calibration procedure requires computer communication via "Cool Term" as indicated in the operation and calibration manual.[1,2] This procedure is the minimum requirement for pre-deployment calibration and the project specific QAPP may call for additional procedures or assessments for specific compounds. Calibration may also be performed in the field if necessary.

9.4. SPod Deployment and Site Documentation:

- ***Warning!*** ***The SPod/CGS fenceline sensor is not intrinsically safe so cannot be located in a potentially hazardous area where explosive atmospheres may exist.***
- ***Warning!*** ***The SPod/CGS and solar panel (if used) must be robustly secured under heavy wind load. Securing equipment to the ground using pegs, spikes, or other ground penetration cannot be attempted without permission and approved ground survey.***

The selection of optimal SPod/CGS siting for remote observation of a potential source is critical to project success. When choosing a specific deployment location, it is important to select an area with an unimpeded wind flow that is proximate to the potential source under study (typically 50 m to 300 m distance). An open line of site to the potential source area is highly recommended. This is important to ensure efficient transport of potential emission plumes from the source to the sensor location and to collect wind data that is an accurate representation of the site conditions. It is critical to take care in the alignment and securing of the anemometer on the SPod to true north direction using hand-held GPS and comparative measures.

The SPod/CGS should be deployed in a location with relatively flat terrain and away from local obstructions (e.g., trees, buildings, hills). If the SPod/CGS deployment site must be near a potential obstruction, ensure that the unit is located at a horizontal distance that is at least two times the height of the obstruction if you are upwind of the obstruction in the direction of the source under observation, and six times the height of the obstruction if downwind. In some cases, the SPod may be attached to a tall pole or structure that provides an open line of site in the direction of the source but has obstructed wind flow in the opposite direction (due to the mounting structure). This situation must be documented, and special data anlysis screening used since only the unimpeded wind sectors can be considered (flag off-axis values). Since the SPods are typically located at ground level, they are not effective at monitoring elevated sources like tall emission stacks. Deployments very near intersections (within 20 meters for example) or where vehicles/trucks may idle or launch under load are not recommended and special QA procedures may be required.

For solar-powered deployments, the SPod should be oriented so that the solar panel is facing south (this should be verified using a compass, GPS, or smart phone), and the area should be free of shade for 8 hours. Each SPod, CGS trigger system, and canister (if used) must be properly fixtured to the site apparatus (e.g., installed pole, pallet/pole system, or heavy tripod) and that site apparatus must itself be secured so that it does not blow over under wind load. Due to "dig safe" utility restrictions on ground penetrations, securing a

pallet/pole system or tripods and/or solar panel (if used) is typically accomplished using sandbags, concrete blocks and ratchet straps. Securing equipment to the ground using pegs, spikes, or other ground penetration cannot be attempted without permission and approved ground survey. Avoid placing equipment too close to roadways for technical reasons and because the equipment can cause a driving distraction hazard.
After connecting and securing the SPod/CGS system and power supply (land or solar) and checking the integrity and robustness of fixturing, the unit is ready to turn on. Push the power button and look for the blinking green light.[1] Access the internet through a secondary computer to verify data feed on the website and with the password described in project-specific documentation. Fill out the Site Deployment Form (Appendix D). The system is now operational and after a one-hour warm-up time, is ready for QA testing (Section 9.5). If errors are noted in startup, see Procedure 9.2

9.5. SPod/CGS In-field and Pre-deployment QA Testing:

This section describes QA procedures for the SPod/CGS system that may be performed prior to or during field deployment (in-field). Standard pre-deployment tests help ensure that the equipment is in good working order and that all fixturing, and power supply variables are known before incurring travel expenses to the field. If a deployment is local and/or temporary, pre-deployment checks may be accomplished in the field as part of the actual deployment. This is done at risk since if the units fail the deployment test, the deployment cannot continue. As noted, many of the tests described in this section are the same as tests performed periodically while deployed (in-field) and are documented in the same manner.

9.5.1. SPod Single Unit QA Table:

This QA procedure uses the SENTINEL data analysis program (Appendix E) to read-in and generate a summary QA table of basic statistical information for a single SPod for a specified time interval (Table 9.5.1, Appendix E pg. 39-40). The SPod Data Analyst must first retrieve the data file for the day to be analyzed from the data repository (Sensit Connect site, or potentially from EPA Viper[14], with code modifications required). The retrieval can be a partial day. The typical analysis time for a QA table is 60 minutes, but an analysis period of 60 seconds is also used for calibration procedures. A QA table on newly generated or historic data can help verify functionality of the SPod's sensor systems or to assist in auditing of SPod data during a study.

Once an SPod is operating and stabilized (i.e., >2 hours of operation in deployment conditions), transfer a daily data file from the Sensit Connect Site to a computer configured for SPod data analysis and execute SPod SENTINEL R-Script as per Appendix E to generate the QA table (see example Table 9.5.1) as a HTML report. The SPod Data Analyst will review the table and append it to the forms required for procedures 9.3 (Appendices C1 and C2), 9.4 (Appendix D), or for QA audits or other procedures described in the QAPP. If parameters are out of tolerance, the SPod Data Analyst and/or SPod/CGS SPod Field Operator must notify the appropriate party and take corrective action as per QAPP technical lead instructions.

The Analyst must review the QA table for any cells that are in red text, indicating values that are not in QA tolerance. Note that QA parameter tolerance guidance is only valid for cases where the SPod is deployed outdoors, no strong source is present, and calibration procedures are not taking place. Typically, a 60-minute QA table time period is used but a 1-minute version of the QA table is associated with calibration activities (Section 9.3). Data completeness [DataComp] tracks the level of missing data in the subject period and is a simple percentage of data acquired during that time frame. The BCP PID (ppb) value is derived from the background correction (BCP) algorithm applied to the Raw value time series.

Table 9.5.1 Example SPod Single Unit QA Table (Attach to Appendix C or D or document as per QAPP)

2023-02-16 01:00:00 to 2023-02-16 02:00:00

Time periods with canister collections: FALSE

	Mean	Median	StdDev	Min	Max	DataComp
Data Quality QA:						
Raw PID (ppb)	32.9	29.2	15.1	11.7	68.2	100
BC PID (ppb)	24.1	20.4	15.2	2.6	59.6	100
Raw PID (mV)	107.5	104.8	11.1	91.9	133.5	100
Temp (Deg C)	10.7	10.7	0.2	10.4	11.2	100
RH (percent)	77.1	77.3	1.1	74.9	78.7	100
Pressure (mBar)	985	985	0	985	985	100
WS (mph)	0.3	0.3	0.2	0	0.7	100
WD (deg)	192.7	219.8	124.2	0	352.5	100
Operational QA:						
S1 temp (arb)	2054.9	2054	7.3	2037	2075	100
S1 Heat (0-255)	36.3	36	1.1	34	39	100
S1 Set (arb)	2054.9	2054	6.7	2042	2074	100
Bat volt (V)	14	14	0.1	13.8	14.2	100
Charge Current (mA)	108	2.6	188.5	0	689.9	100
Operate Current (mA)	101.4	100.3	5.9	91.7	131.6	100

* Values determined by a location at 892 ft above sea level

9.5.2. SPod Collocated Unit QA Table:

If two or more SPod/CGS systems are collocated (operating side by side), additional cross-unit QA comparisons can be conducted. Execute procedure 9.5.1. for both units for the same time periods and generate the SPod/CGS QA Testing Form for each unit. Run SENTINEL R-script contained in Appendix E to automatically compare the collocated and time-aligned data from the two units and generate Table 9.5.2.

The SPod Data Analyst will review the table, referring to the QAPP for acceptance tolerances (currently under development but typically +/-20% for non-PID values). The Analyst appends forms required for procedures, such as 9.4 (Appendix D), or for QA audits or other procedures described in the QAPP. It is possible for the collocated comparison to include time periods during which an SPod PID Cal-check was performed (procedure 9.3.1). In this event, it is important to ensure that both units that were subjected to procedure 9.3.1 in exactly the same manner within the comparison window or the results will likely differ because of this introduced artificial concentration. It is not recommended to perform this comparison for time periods that include full calibration (procedure 9.3.2) events since SPod PID settings were altered. Ideally, PID values should be similar between the units (particularity BC PID values) but the final assessment of similarity typically focuses on values above method detection limit which requires another additional SPod data analysis completed int eh SENTINEL app as per Appendix E and the QAPP.

Table 9.5.2: Example SPod Collocated Unit QA Table (Attach to Appendix D or record as per QAPP)

2023-03-10 01:00:00 to 2023-03-10 02:00:00

	Mean	Median	StdDev	Min	Max	DataComp
Data Quality QA:						
Raw PID (ppb)	-13.2	-13.1	-1.4	-10.6	-22.2	0.3
BC PID (ppb)	-3.1	-2.9	-1.4	-0.4	-12.3	0.3
Raw PID (mV)	-3.1	-3.1	-0.6	-2.0	-8.3	0.3
Temp (Deg C)	0.2	0.2	0.0	0.1	0.1	0.3
RH (percent)	-1.0	-1.0	0.1	-1.1	-0.7	0.3
Pressure (mBar)	-0.9	-1.0	-0.3	0.0	-1.0	0.3
WS (mph)	-0.1	-0.2	0.1	-0.1	0.1	0.3
WD (deg)	8.9	9.7	5.8	-34.5	-49.3	0.3
Operational QA:						
S1 temp (arb)	7.1	9.0	-1.1	4.0	7.0	0.3
S1 Heat (0-255)	10.1	10.0	0.0	11.0	10.0	0.3
S1 Set (arb)	7.1	8.0	-1.4	4.0	4.0	0.3
Bat volt (V)	0.1	0.1	0.0	0.0	0.1	0.3
Charge Current (mA)	52.0	19.2	32.7	0.1	95.7	0.3
Operate Current (mA)	64.6	65.6	-0.9	61.2	52.9	0.3

* Values determined by a location at 892 ft above sea level

9.6. CGS Deployment and QA Procedures:

This SOP covers basic procedures for field use of canisters with an SPod/CGS system. Additional procedures associated with canister preparation, shipping, and general system cleanliness checks utilized by the EPA/ORD/CEMM/AMCD VOC Laboratory are described in J-AMCD-AAB-SOP-675-0 "Standard Operating Procedure for Cleaning Air Sampling Canisters with the Entech 3100A Canister Cleaner", SOP ID J-AMCD-AAB-SOP-675-0,[12] and "Standard Operating Procedure for Remotely Operated Canister Systems (ROCS)[13], SOP ID J-AMCD-SFSB-SOP-4231-0.[13] Canister analysis is typically performed by method TO-15.[11] If another laboratory is used to supply CGSs, equivalent procedures must be documented in the QAPP.

The SPod/CGS system typically uses 1.4 L Entech Silonite® coated stainless steel canisters for acquisition of whole air grab samples that are cleaned and evacuated to a final pressure of 10 mTorr. The CGSs are typically shipped within 48 hours after cleaning in a carrying case or shipping box to the field along with the COC forms contained in the QAPP, a manual pressure gauge, and return shipping labels. Canisters must be shipped back to analysis laboratory within 2 weeks of being received in the field. Hold times in the laboratory upon return from field deployment is less than 2 weeks prior to analysis. Hold times may change depending on requirements stated in the QAPP.

9.6.1. CGS Deployment Procedures:

The following procedures are used to deploy canisters in the SPod/CGS system:

- First, remove a canister that will be used to take a sample from the shipping container. Note that one canister is labeled a "field blank" and should not be used to take a sample.
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Check that the canister valve is screwed on tightly by twisting it clockwise.
- Using the supplied manual vacuum pressure gauge, measure the canister pressure and record the pressure on the sampling COC under "Initial Press.". If the pressure is greater than -28" Hg, the canister valve has leaked. Do not use the canister for sampling. Note on canister tag and Sampling COC when canister is suspected to have leaked.
- To install canister on SPod/CGS unit: pull up outer casing of female Micro-QT® connector on the canister inlet, push the canister male valve as far as it will go, then release the outer casing. Secure the canister in place with the Velcro straps. Check that the connection is secure by gently pulling apart the two items. If they can't be easily pulled apart the connection is secure. [see Figure F5]
- When removing the canister, check the CGS final pressure and record on the COC under "Final Pressure".
- To prepare for return shipping, confirm that the canister QT valves are all tight (turn clockwise). To prepare canisters and sampling supplies for return shipment, place canisters in their individual boxes and place them in the shipping box. Canisters should be shipped upright.
- If returning the vacuum gauge, wrap it in bubble wrap and place it back in a Ziploc bag. Pack it into one of the canister boxes.
- Fill out bottom half of Shipment COC and sign (make a copy for records). Return shipment and sampling COCs in Ziploc bag and place back in shipping box.
- Close carrying case and affix return shipment sticker.
- Ship canister box back to EPA RTP within 2 weeks of initial delivery date to field site.

9.6.2. CGS Trigger Test, Leak Check, and Field CGS Grab Tests:

For deployments that use CGSs, it important to confirm that the canister acquisition system is working as intended. Prior to deployment, routine setup trials should be performed as part of basic system checks to ensure that the SPod/CGS unit can properly trigger a canister acquisition on command and by reaching intended PID threshold levels, if so configured. Trigger solenoid inlet cleanliness should also be established as outlined in the EPA CEMM AMCD "Standard Operating Procedure for a Remotely Operated Canister System", to test for canister blank level contamination using clean laboratory air conditions.

In addition to initial SPod/CGS setup and commissioning trials, field versions of these procedures can be used to periodically confirm that the CGS trigger system is working properly, and that the CGS system is not leaking. These procedures can also be used to acquire a field CGS that can represent a valid field sample with some relation to source signal depending on wind transport condition and PID levels. These tests described below may be performed together or separately. These tests may be performed prior to deployment or at any time during deployment. If the system is set up to trigger on a specific PID level, be prepared to supply an appropriate concentration and duration for isobutylene gas spike to the unit and confirm the trigger execution. Note that execution of the SPod PID Calibration Check (Procedure 9.3.1) may produce a canister trigger event (depending on trigger level settings). During the trigger test, it is important to verify (usually by an audible click) that the CGS canister solenoid is opening for the proper period of time. If an CGS is attached to the unit, it will be triggered and may contain some quantity of isobutylene from the surrounding air. Note that the following tests are performed in open air conditions and will reflect concentrations (including potential source emissions).

Perform the following steps, suitably document results, and ensure the triggers are reset for next operation.

- Place the SPod/CGS system outdoors under ambient deployment conditions. Clearly describe the deployment conditions in notebooks, forms, and COCs as appropriate.
- Transport clean canister(s) to the position of the SPod/CGS system and allow the canisters to equilibrate temperature (keep out of direct sunlight).
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Record the starting pressure in the CGS using a quick connect manual vacuum pressure gauge in the COC. The CGS pressure must be less than < -28".
- Write the sample ID on the sampling COC and the canister tag as detailed in project QAPP. If sample labels have been prepared, affix appropriate sample ID label on sampling COC and canister tag.
- Check that the canister valve is screwed on tightly by twisting it clockwise.
- To install canister on SPod/CGS unit: pull up outer casing of female Micro-QT® connector on the canister inlet, push the canister male valve as far as it will go, then release the outer casing. Secure the canister in place with the Velcro straps. Check that the connection is secure by gently pulling apart the two items. If they can't be easily pulled apart the connection is secure.
- To execute an CGS leak check procedure, leave the untriggered evacuated canister on the SPod/CGS inlet and wait at least 24 hours. Confirm via SPod CGS data field that the SPod did not trigger the canister during the waiting period.
- Perform the CGS leak check by removing the canister and rechecking the pressure to ensure there is no discernable change has occurred and record findings on the COC.
- If unit passes leak check, proceed to the next step. If unit failed, ensure all plumbing connections are tight, and repeat leak test. The canister inlet fitting may need to be replaced if leak test failure continues. Otherwise, further diagnostic leak testing may be necessary to determine the source of leak in the system. Suitably document canister condition on COC.
- If a trigger and blank test are to be performed, the same canister may be used. replace the canister on SPod/CGS inlet.
- Trigger the canister by performing by manual, or software trigger.[1]
- Remove the canister and measure the CGS pressure which must be between 5" and 15" or a trigger/inlet issue occurred and must be diagnosed.
- Record canister ID, initial and final canister pressure, and sampling start and end time on COC and transfer sample to VOC lab for analysis.
- Canister samples are typically analyzed by GC/MS for target VOCs specified in the QAPP.
- Acquired CGS target analyzed concentrations collected from the SPod/CGS unit during these tests must not be >20 pptv higher than reference sample. If contamination is confirmed, purge SPod/CGS units with humidified zero air for a few hours and repeat blank qualification test. If contamination issue persists, the components of the plumbing may need to be replaced.

9.7. SPod Default Data Analysis:

This specifics of the data analysis and visualization for the Sensit SPod can depend on the deployment scenario, distance to source, number of sensor nodes, etc., and should be described in the project specific QAPP. An example of an R Shiny application (SENTINEL) developed to process Sensit SPod data is described in Appendix E. This application synthesizes data over time from one or two collocated sensors at a single site (future revisions will include capability to process multiple sites). The SENTINEL code and all other processing code can be found at the EPA Bitbucket repository described in Appendix E.

10. *Data and Records Management*

The following data and records will be generated in a typical SPod deployment. It is the responsibility of the SPod Operator and Data Analyst to generate proper forms, records, and notebook entries as part of general operation procedures and as specified in the QAPP. It is the responsibility of the Project Lead to ensure records are being kept and to organize and archive the data and records as required by the QAPP and the scientific data management plan (SDMP). Paper records and forms, COCs, scanned notebook pages, and digital photos shall be converted to PDF files for including in the project file. Typical data and records include:

- QAPP and site-specific safety plan
- SPod time series data in daily files (e.g., Sensit data.txt files EPA Viper files, as per QAPP)
- Training and certification records (Appendix A) Sensit SPod SOP Training Certifications
- SPod/CGS Setup Configuration Form (Appendix B)
- SPod Calibration with Zero and Calibration Check Form (Appendix C)
- SPod/CGS Site Deployment Form (Appendix D)
- QA tables as generated from procedures 9.5.1 and 9.5.2
- Calibration gas cylinder information
- Evacuated canister COC forms (as per QAPP)
- SPod daily analysis summary files as per Appendix E
- VOC laboratory raw analysis data (chromatogram files – retained by VOC laboratory lead)
- VOC laboratory reduced data and notes (Microsoft Excel files and PDFs)
- Secondary metrological data (e.g., from local airport) for reasonableness checks (various)

11. *Quality Assurance/Quality Control*

The following are default QA/QC procedures for Senit SPod deployment. Additional data acceptance tolerances and calibration details may be described in the project specific QAPP. This description is for the issuance of the SOP #J-AMCD-SFSB-SOP-4380-2. As Sensit SPod deployments commence and field data become available for review, adjustments to these QA procedures and acceptance tolerances will occur and be documented in future revisions to this SOP. In addition to the QA/QC summary contained in Table 11.1, current acceptance values for a 60-minute single unit QA table is contained in Table 11.2. Values outside of these acceptance ranges will be flagged red in the SENTINEL QA tables and should be reviewed by the SPod Data Analyst. Appendix E contains some additional procedures for processing and review daily data summaries.

Table 11.1. Summary of basic QA/QC procedures for prototype SPod/CGS set up and use

Condition	Training Requirements	Procedure	Accepting Criteria	Corrective Action	Frequency
SPod/CGS device configuration	Sections 6.1, 6.2, 6.3	Section 9.1 and Appendix B	SPod must be configured as per QAPP	Redo procedure and generate new form / repair unit if necessary	Prior to deployment and on any configuration change
SPod Cal-check	Sections 6.1, 6.2, 6.3	Section 9.3.1 and Appendix C1	± 30% of calibration span value (1 ppm)	Perform 9.3.2 or repair unit if necessary	Upon deployment and once every three months if in use
SPod Span Calibration with Zero	Sections 6.1, 6.2, 6.3	Section 9.3.2 and Appendix C2	± 10ppb (zero) ± 10% of calibration span value (1 ppm)	Repeat 9.3.2 or repair unit if necessary	Before deployment, on 9.3.1 fail and annually
SPod/CGS deployment form	Sections 6.1, 6.2, and 6.3 if necessary	Section 9.4, Section 9.3.2, and Appendix D	SPod must meet siting requirements pass Cal-check (9.3.1) and exhibit nominal operation	Improve siting, and/or Perform calibration and generate new form / repair unit if necessary	Once at deployment

Condition	Training Requirements	Procedure	Accepting Criteria	Corrective Action	Frequency
QA Table generation	Section 6.2	Section 9.5.1 and 9.5.2 for collocated SPods	Table 9.5.1 or 9.5.2 or tolerances described in the QAPP	Consult with project lead, calibrate, or repair unit if necessary	As part of installation procedures and once per week or as per QAPP
SPod/CGS Canister leak and cleanliness check	Section 6.1 and 6.4	Section 9.6	Verification and documentation of leak check and SPod/CGS cleanliness	Perform maintenance as required	Prior to deployment and as per QAPP

Table 11.2 contains current acceptance values for a 60-minute single unit QA table, described in Section 9.5.1. These values assume minimal VOC source impact and no calibration activity. The acceptance tolerances for a number of parameters are shown and these values will be revised after additional field data is acquired. Certain measures are related to equipment operational state. A low Charge Current or low Bat Volt, for example, may mean that the land power or solar power are not properly connected or operating, and the sensor will stop working when the on-board battery is drained. A low S1 heat value (<15 in the setup example of Figure 9.1.1) may mean the sensor heater has failed or is not enabled. Sensor QA levels that detect unrealistically low PID signal variability or out-of-tolerance high and low signal levels help isolate certain types of sensor failure modes but are not comprehensive. Acceptance values for the collocated SPod QA table comparisons (Section 9.5.2) are in development and will be described in a future version of this SOP.

Table 11.2: Target acceptance values for 60-minute, 10 second SPod single unit QA table

Parameter	**QA-acceptable ranges**
Raw PID (ppb)	-200 to 5000
BC PID (ppb)	-200 to 5000
Raw PID (mV)	-300 to 10000
Temp (Deg C)	-25 to 50
RH (percent)	10 to 100
Pressure (mBar)	800 to 1020
WS (mph)	0 to 12
WD (deg.)	0 to 360
S1 Temp (arb)	500 to 5000
S1 Heat (0-255)	0 to 255
S1 Set (arb)	500 to 3000
Bat Volt (V)	0 to 15
Charge Current (mA)	0 to 2000
Operate Current (mA)	50 to 200

Note: These values were derived from a long-running multi-sensor SPod study at ~900 ft above sea level. These values are subject to change over time with further data collection, and the users should check values independently to be sure they agree with the QA flagging.

12. References

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Appendix A: Sensit SPod SOP Training Certifications

Refer to Section 6 of this SOP. The below named training lead certifies that the below named operator or analyst has met the training, experience, and authorization requirements described in Section 6 for the Sensit SPod/CGS system. The training lead certifies that training was successfully tested (record initials). Prepare 1 form for each person and indicate N/A where training requirements have not been met or are inappropriate.

SPod/CGS Field Operator (Section 6.1):
Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________
Description of training test. The operator was observed to correctly complete the following: Passed

(1) Physical set up and connections of SPod, CGS, and power system ______
(2) Check/adjustment of anemometer to North (as per manual) for the specific siting ______
(3) Turn on and check of SPod error codes as per manual ______
(4) Cal Check Procedure Step 9.3.1 and completion of form in Appendix C1, Steps 1-5 ______
(5) CGS change-out Procedure 9.6.1 including COC completion ______

SPod Data Analyst (Section 6.2):
Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________
Description of training test. The operator was observed to correctly complete the following: Passed

(1) Data and sensor status view and download (Appendix E) ______
(2) Operation of R-script for data analysis and QA Table generation (Appendix E pg. 39) ______
(3) Knowledge check of overall R-script shiny app application ______
(4) Completion of Analyst section of all forms and E-notebook documentation requirements ______
(5) Demonstration of sensor malfunction detection and corrective action notification ______

SPod/CGS Advanced Operator (Section 6.3):
SPod Data Analyst (Section 6.2):
Name and organization of person trained: ___________________________
Signature of person trained: ___________________________
Name and organization of training lead: ___________________________
Signature of training lead: ___________________________
Date when training test was completed: ___________________________
Description of training test. The operator was observed to correctly complete the following: Passed

(1) Demonstration of SPod Operator and Data Analyst training ______
(2) Demonstration of SPod configuration change and completion of Appendix B ______
(3) Full calibration with zero Procedure 9.3.2 and completion of appendix C2 ______
(4) Demonstration of advanced SPod maintience procedures ______
(5) Demonstration of SPod documentation and E-notebook documentation requirements ______

Appendix B: SPod/CGS Setup Configuration Form

Procedure Step 9.1 (one form per SPod/CGS)
Required Training: To complete this procedure, personnel must be trained as at minimum an SPod/CGS Field Operator (Section 6.1), SPod Data Analyst (Section 6.2), and SPod/CGS Advanced Operator (Section 6.3).

(1) Operator name and signature____
(2) Date and time (local):____
(3) SPod S/N: ____
(4) CGS system S/N (if used):
____
(5) Solar or land power deployment?______________________________________
(6) SPod deployment QAPP title/ID:______________________________________
(7) SPod deployment QAPP version date:___________________________________
(8) Has the QAPP been consulted for SPod/CGS settings configuration information (Yes/No)?________
(9) How many CGS's to be used on this SPod?__________________________________
(10) Connect to SPod and take a screen shot of the current device configuration and attach to this form
(11) Make changes and take a screen shot of the new device configuration and attach to this form
(12) Describe changes below, initial and date the attached forms, and create necessary records:

____
____
____
____
____
____
____
____

Appendix C1: Calibration Check (Cal-check) Form

Procedure Step 9.3.1 (Cal-check). To complete Steps 1-6 of this procedure, personnel must be trained as an SPod/CGS Field Operator (Section 6.1). To complete Steps 8-14, personnel must be an SPod Data Analyst (Section 6.2). Complete one form for each SPod. The standard calibration concentration is 1 ppm isobutylene in air balance, but other concentrations (such as 500 ppb) may also be used (record in Step 4). The default Cal-Check acceptance level is ± 25% of actual, unless otherwise specified in the QAPP. Consult Section 7 for necessary equipment supplies. Make sure the SPod has been operating for > 2 hours to allow sufficient time for PID to stabilize. Consult project safety plan and ensure adequate ventilation before gas release.

(1) Operator name and signature:____
(2) Date, time, and SPod location:____
(3) SPod S/N and CGS system S/N (if used):____
(4) Isobutylene gas cylinder information and concentration:________________________________
(5) Perform Cal-check by connecting 1 ppm (or other) isobutylene supply to SPod PID with sensor calibration cap and flow gas at 0.5 LPM for exactly three minutes (180 seconds). **Make sure to accurately record the start time (ST) and end time (ET) of the gas flow in the below form on line "Step 6."** Turn off gas, remove calibration cap, and return system to operation.

Cal-Check Step	Cal-Check Description	Gas Flow Start Time (ST) Local (hr:min:sec)	Gas Flow End Time (ET) Local (hr:min:sec)	Mean Conc. (ppb)	Stdev Conc. (ppb)	Min. Conc. (ppb)	Max. Conc. (ppb)
6	Gas flow (flow 3 min. total)			N/A	N/A	N/A	N/A
7	Pre Cal-check Test (1 hour)						
8	Analysis 1 (1 min.) (start at T+60 sec)						
9	Analysis 2 (1 min.) (start at ST+75 sec)						
10	Analysis 3 (1 min.) (start at ST+90 sec)						

(11) Analyst name and signature:____
(12) Date, time, and location analysis performed:____
(13) Download data and perform procedure 9.5 for a 1-hour (60 minute) time period directly prior to (but not including) the Cal-check "Step 6". Attach the output of the R-script QA table to this form and transcribe indicated results to above table (Step 7). This provides a snap-shot of current operation.
(14) Perform procedure 9.5 for a 1-minute (60 second) time period during the cal check. The analysis time period should begin <u>at exactly 1-minute (60 seconds) after the Cal-check ST</u>. Transcribe indicated results to the above table (Step 8) and attach the output of the R-script to this form and label "Cal-check Analysis 1".
(15) Perform procedure 9.5 for a 1-minute (60 second) time period during the Cal-check. The analysis time period should begin <u>at exactly 1.25-minutes (75 seconds) after the Cal-check ST.</u> Transcribe indicated results to above table (Step 9) and attach the output of the R-script this form and label "Cal-check Analysis 2".
(16) Perform procedure 9.5 for a 1-minute (60 second) time period during the cal check. The analysis time period should begin at exactly <u>1.5-minutes (90 seconds) after the Cal-check ST</u>. Transcribe indicated results to above table (Step 10) and attach the output of the R-script to this form and label "Cal-check Analysis 3".
(17) As per QAPP, determine if calibration or repair is required. Record determination and notes below.
Notes:____
____
____
____
____
____

Appendix C2: Calibration with Zero Form

Procedure Step 9.3.2 (calibration with zero). To complete this procedure, personnel must be trained as an SPod/CGS Advanced Operator (Section 6.3). Complete one form for each SPod. The standard calibration concentration is 1 ppm isobutylene in air balance, but other concentrations (such as 500 ppb) may also be used (record in Step 5). Consult Section 7 for necessary equipment supplies. Make sure the SPod has been operating for > 2 hours to allow sufficient time for PID to stabilize. Consult project safety plan and ensure adequate ventilation before gas release.

(1) Operator name and signature:____
(2) Date, time, and SPod location:____
(3) SPod S/N and CGS system S/N (if used):____
(4) Zero gas cylinder Information:____
(5) Isobutylene gas cylinder information and concentration:__________________________________
(6) Connect computer to SPod and take a screen shot of the current device configuration as per 9.1 and attach to this form. This documents settings before calibration change.
(7) Make sure device has been operating for > 2 hours to allow sufficient time for PID to stabilize.
(8) Using the Sensit calibration cap, proper tubing, and 0.5 LPM flow rate, connect ultrazero VOC-free air cylinder to calibration cap and tubing and flow gas into open air to clear supply line for two minutes, turn off gas flow.
(9) Perform zero-point calibration by connecting ultrazero VOC-free air cylinder to SPod PID with sensor calibration cap and flow gas at 0.5 LPM for three minutes (180 seconds). **Make sure to accurately record the start time (ST) of the gas flow in the below table in "Steps 9, 10, and 11".** Keep gas flowing.
(10) After three minutes and while flowing gas, execute zero change on the device by sending the command "ZERO1".[2] **Make sure to accurately record the change time (CT) of settings adjustment in the below table.**
(11) Keep gas flowing for an additional two minutes after the change has been enacted. **Make sure to accurately record the end (ET) of the gas flow below form using local cell phone time**. Turn off gas flow but leave calibration cap in place.
(12) Switch regulator and tubing to the isobutylene calibration cylinder.
(13) Perform span calibration by flowing gas at 0.5 LPM for two minutes (120 seconds). **Make sure to accurately record the start time (ST) of the gas flow in the below table in "Steps 13, 14, and 15".** Keep gas flowing.
(14) After two minutes and while flowing gas, execute span change on the device by sending the command"SPAN1:XXX" where XXX is the concentration of isobutylene in the calibration cylinder. **Make sure to accurately record the change time (CT) of settings adjustment in the below table.**
(15) Keep gas flowing for an additional two minutes after the change has been enacted. **Make sure to accurately record the end (ET) of the gas flow below form using local cell phone time**. Turn off gas flow and remove calibration cap. Return the sensor to operating conditions (e.g., reconnect CGSs and reset triggers)
(16) Download data and perform procedure 9.5 for a 1-hour (60 minute) time period directly prior to (but not including) the Cal-check or the calibration steps. Attach the output of the R-script to this form and transcribe indicated results to below table (Step 13). This provides a snap-shot of operation before calibration change.
(17) Perform procedure 9.5 for a 1-minute (60 second) time period before the zero-point change time (CT) but while zero gas was flowing to document the zero gas level before settings change. The start time of the analysis should be set to Step 7, CT-75 seconds. Transcribe indicated results to the below table (Step 14) and attach the output of the R-script to this form and label "Zero Analysis Pre".
(18) Perform procedure 9.5 for a 1-minute (60 second) time period after zero-point change time (CT) but while zero gas is still flowing to document the zero gas level after the setting change. The start time of the analysis should be set to Step 7, CT+75 seconds. Transcribe indicated results to the below table (Step 15) and attach the output of the R-script to this form and label "Zero Analysis Post".
(19) Perform procedure 9.5 for a 1-minute (60 second) time period before the span-point change was made but prior to the end of span gas flow to document the span gas set point change. The start time of the analysis should be set to Step 11, CT-75 seconds. Transcribe indicated results to the below table (Step 16) and attach the output of the R-script to this form and label "Span Analysis Pre".
(20) Perform procedure 9.5 for a 1-minute (60 second) time period after span-point change time (CT) but while span gas is still flowing to document the span gas level after the setting change. The start time of the analysis should be set to Step 11, CT+75 seconds. Transcribe indicated results to the below table (Step 17) and attach the output of the R-script to this form and label "Span Analysis Post".

(21) Take a screen shot of the current device configuration as per 9.1 and attach to this form. This documents settings before after calibration change and prior to resuming operation.

Calibrate Step(s)	Calibration Description	Gas Flow Start Time (ST) Local (hr:min:sec)	Change Time (CT) Local (hr:min:sec)	Gas Flow End Time (ET) Local (hr:min:sec)	Mean Conc. (ppb)	Stdev Conc. (ppb)	Min. Conc. (ppb)	Max. Conc. (ppb)
9,10, and 11	Zero Gas Flow (flow 5 min. total)				N/A	N/A	N/A	N/A
13, 14, and 15	Isobutylene gas (flow 4 min total)				N/A	N/A	N/A	N/A
16	Pre Calibration Test (1 hour)		N/A					
17	Zero Analysis Pre (1 min.) (start at CT-75 sec)		N/A					
18	Zero Analysis Post (1 min.) (start at CT+15 sec)		N/A					
19	Span Analysis Pre (1 min.) (start at CT-75 sec)		N/A					
20	Span Analysis Post (1 min.) (start at CT+15 sec)		N/A					

Notes:____

Appendix D: SPod/CGS Site Deployment Form

Procedure Step 9. (one form per SPod/CGS)
Required Training: To complete Steps 1-26 of this procedure, personnel must be trained as an SPod/CGS Field Operator (Section 6.1). To complete Steps 27-35, personnel must be an SPod Data Analyst (Section 6.2).

(1) Operator name and signature____
(2) Deployment date and SPod start time:____
(3) Site name and GPS coordinates:____
(4) SPod S/N: ____
(5) CGS system S/N (if used): ____
(6) Solar or land power deployment?____
(7) SPod deployment QAPP title/ID:____
(8) SPod deployment QAPP version date:____
(9) Install SPod/CGS system and power on (do not install canisters):____________________
(10) Are there collocated SPod/CGSs? (Yes/No, list S/Ns)____________________
(11) Are there other collocated systems? (Yes/No, describe)____________________
(12) Was SPod North rotation orientation confirmed? (Yes/No)____________________
(13) Was SPod fixture integrity confirmed? (Yes/No)____________________
(14) Was SPod working electrical power confirmed? (Yes/No)____________________
(15) Was SPod cell signal confirmed? (Yes/No)____________________
(16) Was SD data card operation confirmed? (Yes/No)____________________
(17) Was site security confirmed? (Yes/No)____________________
(18) Was site safety check confirmed? (Yes/No)____________________
(19) Take site photos documenting deployment, list file names, and append photos to this record:________
____
____
____
____
(20) Does the deployment meet siting requirements? (Yes/No)____________________
(21) Execute Steps procedure 9.3.1 (Cal-check) as per Appendix C and append partially completed Cal-check to record the accurate start and end times of span gas flow for the SPod Data Analysist.
(22) Access the data repository from the field using procedures described in the QAPP and verify data is streaming without error and that Cal-check is likely within tolerance.
(23) Enter the approximate value of the Cal-check from cursory data inspection:____________________
(24) How many CGS's to be used on this SPod?
____
(25) Install canisters as per procedure 9.6.1 and QAPP and complete COCs.
(26) The unit is now in unverified operation, add deployment notes or observations:____________________
____
____
____
____
____
____
____

To complete Steps 27-35, personnel must be trained an SPod Data Analyst (Section 6.2).
(27) Execute Steps 19-23 of procedure 9.3.1 (Cal-check) as per Appendix C and complete associated forms
(28) Did the 1-hour Pre Cal-check Test pass QA tolerance as per Section 11 and QAPP? (Yes/No)__________
(29) Did the SPod pass Cal-check? (Yes/No)?____________________

(30) Was a field calibration and zero performed?______________________________

(31) Date of last full SPod calibration (append form):______________________________

(32) Date of last device configuration (append form):______________________________

(33) If the answer to Step 10 is Yes, conduct procedure 9.5.2 on 1 hour of data and append QA table.

(34) Is the deployment operation verified? (Yes/No):______________________________

(35) SPod Data Analyst Notes:______________________________

Appendix E: SENTINEL User Guide -V1.0 (January 2023)

SENTINEL R Shiny Application User Guide

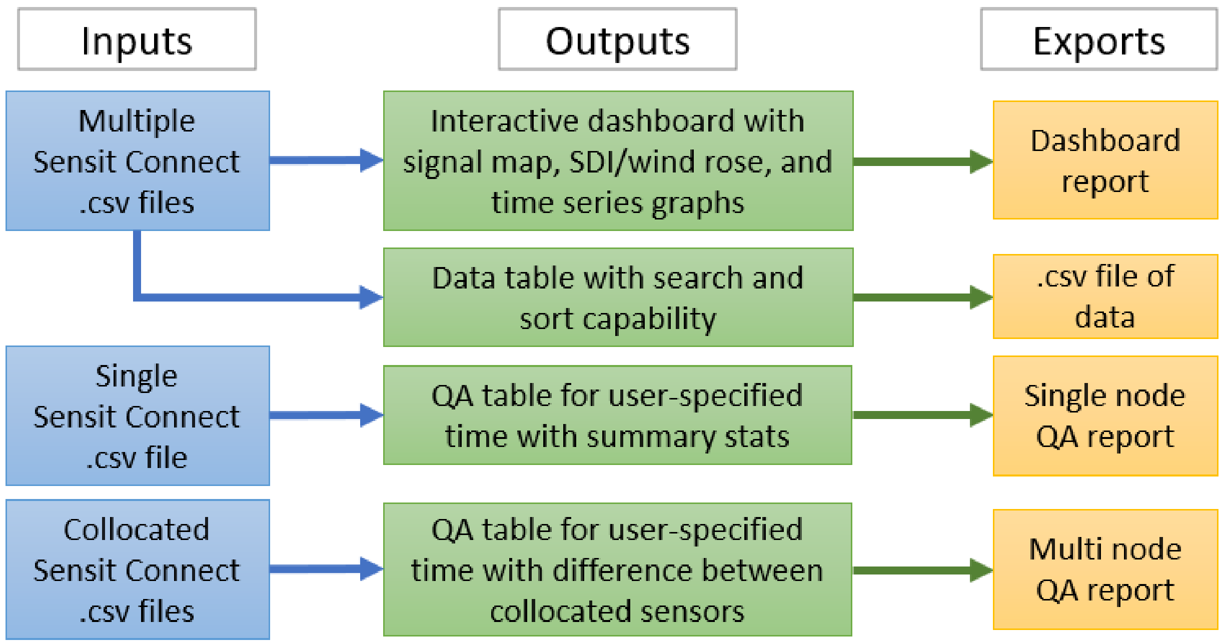
Version: 1.0 (January 2023)

Contents

App Overview

Sentinel (SENsor Intelligent Emissions Locator) is a R shiny application[1,2] that can be run with an access link on cloud.gov. It is currently in a development/prototype phase. This application is intended to provide non-coding users with visualization and graphical insights to Sensit low-cost fenceline sensor (SPod) data. These sensors can generate a large amount of data, which can be overwhelming for users to process manually. This application is also useful for generating Quality Assurance (QA) tables as required by the SOP for Sensit SPod Fenceline Sensor and Canister Grab Sample System Deployment and Operation (J-AMCD-SFSB-SOP-4380-2).

This app can be most easily run with the cloud.gov link but interested users can find the code on the Sentinel Bitbucket repository and run the code from R Studio. An overview diagram of the application inputs and outputs is shown below:



Downloading Data with Sensit Connect

Data can be downloaded from the Sensit Connect Website (sensitconnect.net) at a daily frequency for each individual sensor. Most SPod sensors are programmed automatically to report data at 30 seconds. This is acceptable by the app; however, the original code is programmed for 10 second frequency of data output. For more information on changing output settings on Sensit SPods, consult the Sensit Spod user manual.

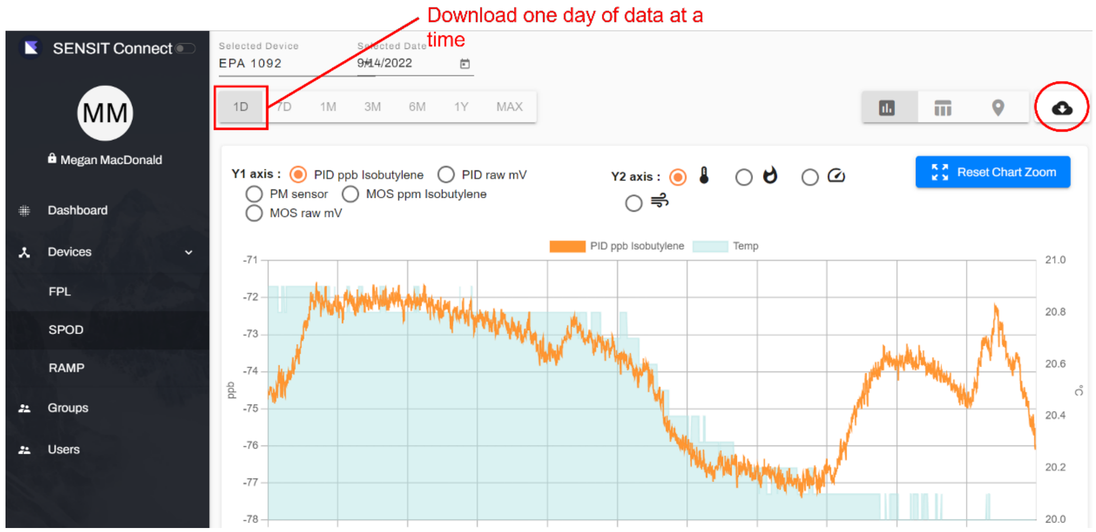


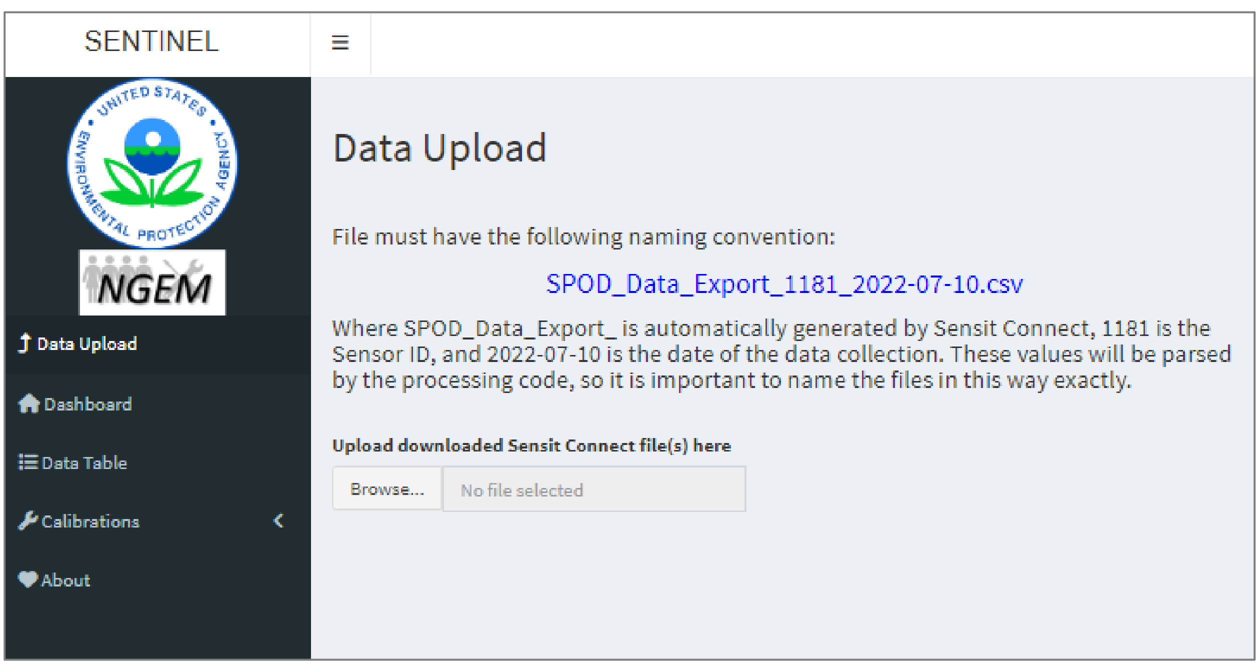
Figure 1: Dashboard of a specific SPod on the Sensit Connect website

Data must be downloaded as a .csv file with the following naming convention:

"SPOD_Data_Export_1181_2022-07-10.csv"

Where "SPOD_Data_Export_" is automatically generated by Sensit Connect, "1181" is the Sensor ID, and "2022-07-10" is the date of the data collection. These values will be parsed by the processing code, so it is important to name the files in this way exactly. These files can be saved anywhere, but it is recommended to keep them grouped in a folder for ease of uploading to the SENTINEL Shiny app.

Data Upload



All pages of SENTINEL contain the sidebar (which can be closed with the three horizontal lines button) and the main page. The sidebar options are Data Upload (the landing page), the interactive dashboard, the data table, calibration (single node or multi node) and an about page that contains resources. The user can click the NGEM logo to be taken

to the NGEM webpage. The landing page is where the user can input their files that have been downloaded and named as stated above from the Sensit Connect site. These files should be in .csv form.
Once these files are uploaded, a status bar in the form of three blue vertical lines will appear as the files are processed. This processing involves applying automatic QA functions, that scan the data and look for values out range or repeating values and flag them accordingly in an appended QA column. This column is later visible in the Data Table viewer. Flag values in this column are as follows:

#	Description
0	No QA issues, passing values
1	Missing value or NA
2	Very negative PID (> -10 ppb)
3	Very high PID (> 1500 ppb)
4	Repeated concentration, wind speed or wind direction values > 10 times in a row
5	Check for illogical wind values (speed > 12, direction outside of 0-360)

The script will then conduct baseline correction on the 10 second data using the getBaseline function, which is stored in the app folder. This function calculates a baseline with the "df" input set to 4, which is a slowly varying fit. It then subtracts this out to minimize any environmental drift present in the data.

The u and v vector directions are then calculated based on the 2D sonic wind direction and wind speed. These will be vector averaged in the final step of summarizing the data to 5 minutes. If the wind direction data were averaged without converting to u and v vectors, there would be inaccuracies when averaging 360 and 0 degrees. The formulas for these conversions are below:

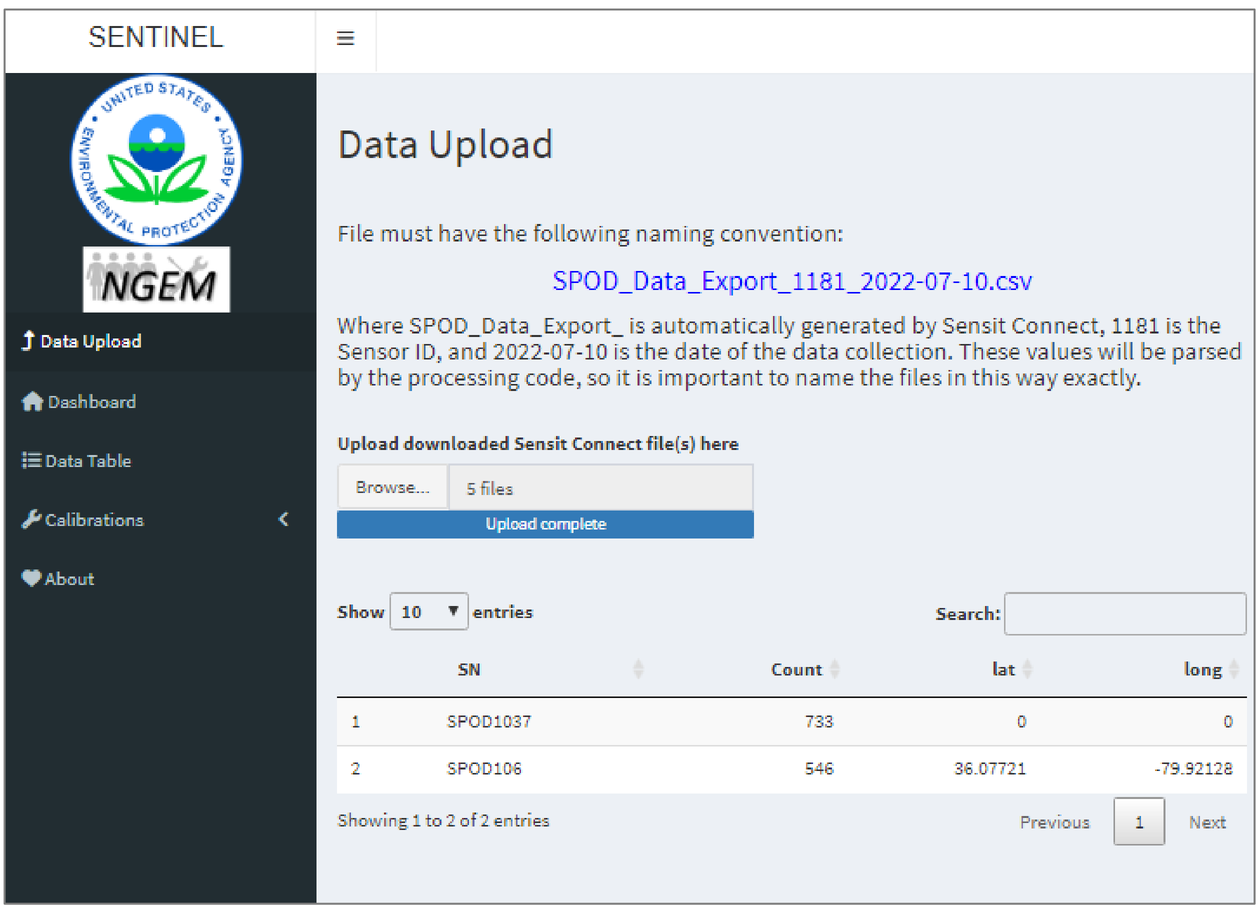
$$\mathrm{u} = \mathit{Wind\ Speed}\ \times \sin(2\pi\ \times \frac{\mathit{Wind\ Direction}}{360})$$
$$\mathrm{v} = \mathit{Wind\ Speed}\ \times \cos(2\pi\ \times \frac{\mathit{Wind\ Direction}}{360})$$

The code then checks for latitude and longitude values. It is not required to have GPS configured on the sensor to use the Sentinel Shiny App. If latitude and longitude columns are not detected, the code will input 0 values for these columns and the mapping capabilities in the dashboard will be limited.
Once these initial processing steps are done, the code will use the dplyr[3] package to group the data in whatever frequency it is uploaded in to 5 minutes. The following columns are created in this aggregation for each 5-minute period, which will be used for analysis throughout the application. The method Detection Limit (MDL), Wind Speed (ws), and Wind Direction (wd) columns are appended after the 5-min aggregation. Canister columns will only be populated if the sensor is configured for canisters and canisters have been collected previously/at that time.

Column	Definition	Calculation
bc.pid.ppb	Background corrected data (ppb)	5-min mean
Pid.sd	The standard deviation of background corrected data (ppb)	5-min standard deviation
rawPID_ppb	Raw concentration data (ppb)	5-min mean
temp	Temperature data (C)	5-min mean
RH	Relative humidity data (%)	5-min mean
pressure	Pressure data (mbar)	5-min mean
u.wind	Calculated u values (see above formula)	5-min mean
v. wind	Calculated v values (see above formula)	5-min mean
s1temp	Sensor temperature (arbitrary units)	5-min mean
s1heat	Sensor heater output (0 = off, 255 = fully on)	5-min mean
set	Sensor setpoint (arbitrary units)	5-min mean

bat_volt	Battery voltage (volts)	5-min mean
chg.current	Charge current in milliamps	5-min mean
opp.current	Operating current in milliamps	5-min mean
trigportstat	Port status (NA indicates no collections)	List of unique values in 5-min period
trigactivestat	Trigger status (1 indicates active trigger)	List of unique values in 5-min period
trigactiveflag	Active Port (numbers indicate which port is currently active)	List of unique values in 5-min period
trigsampleflag	Event status (current sampling event or complete sampling event)	List of unique values in 5-min period
lat	Latitude (deg.)	Unique values in 5-min period
long	Longitude(deg.)	Unique values in 5-min period
QA	QA flags (See table on page 3)	List of unique values in 5-min period
MDL	Method Detection Limit	3 * median daily standard deviation
wd	Wind Direction (deg)	Atan2 function
ws	Wind Speed (mph)	Sqrt function
SN	Serial number of Unit	Parsed from file name

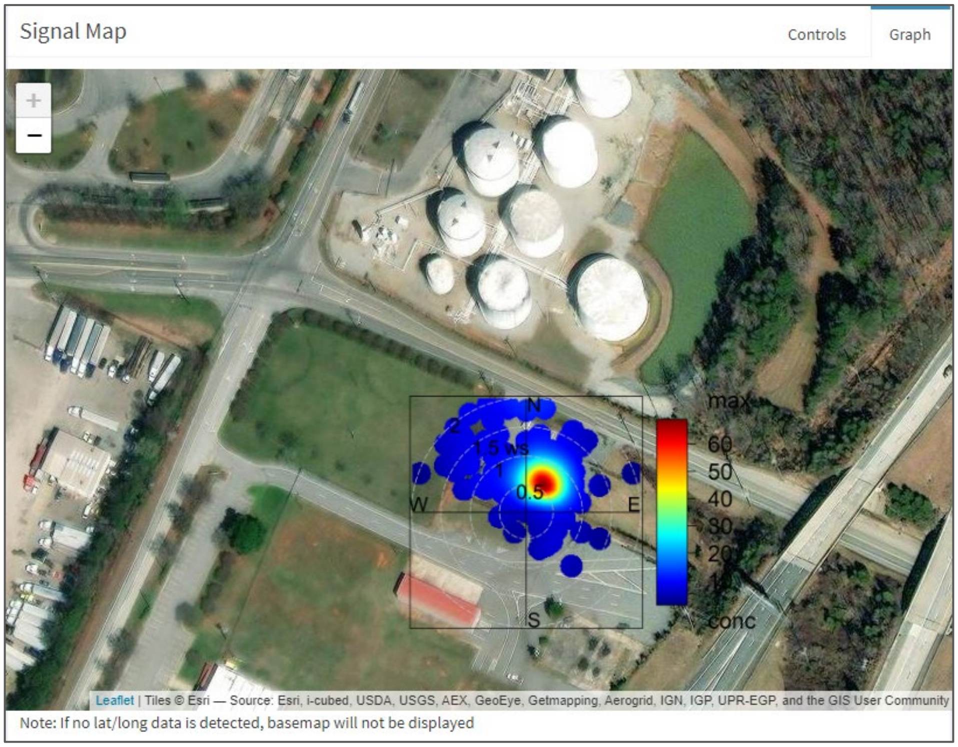
The application will display a simple summary table once all files are uploaded showing the unique serial numbers, latitude/longitude values, and a row count of how many entries are associated with that serial number. Any sensors with no latitude or longitude columns (not GPS-enabled) will show a 0 for latitude and longitude values.



Dashboard

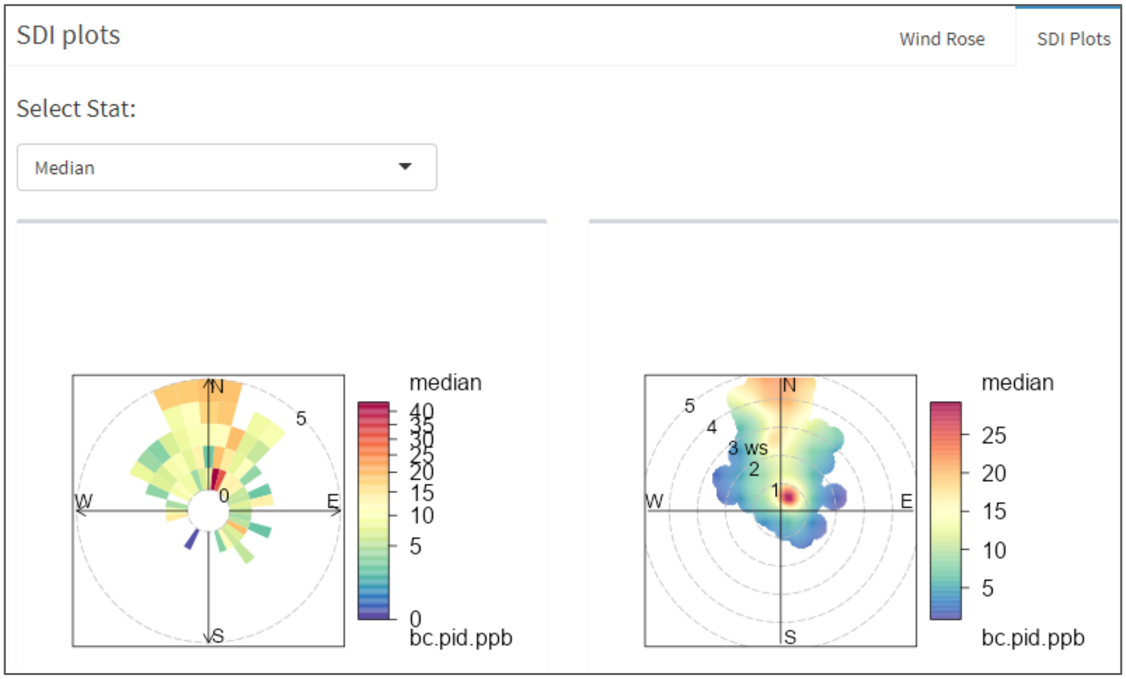
Once the user has uploaded their data through the data upload page, the dashboard components are loaded based on those files. The dashboard (developed using the shinydashboard package[4]) consists of a signal map, SDI plots, and Time series graphs. There is drop down menu that will be automatically populated with available units to display. There is also a report export button. More detail on each of the sections is given below.

Signal Map



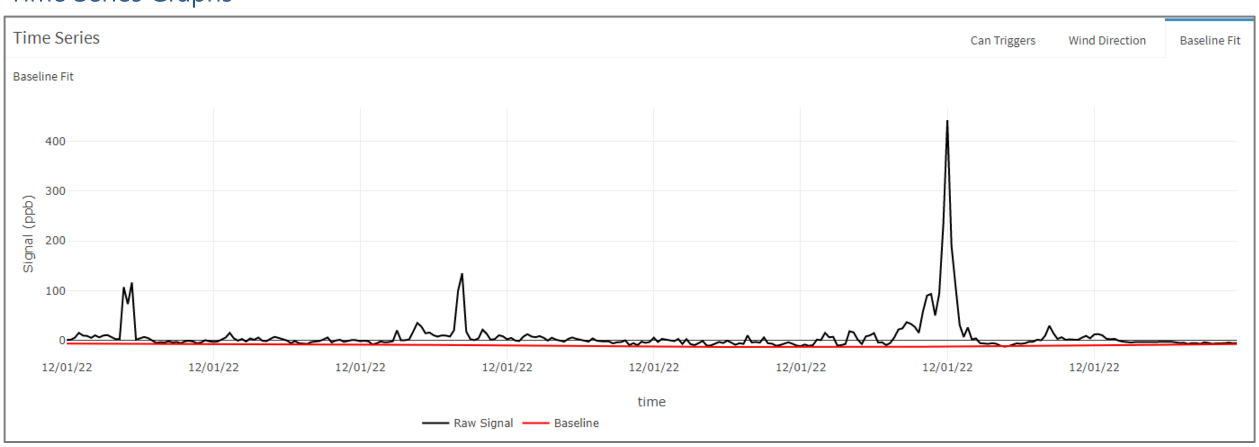
The signal map pane consists of 2 tabs. The first is a controls tab, which allows the user to select some inputs, and the second is the graph display. The graph display can be panned and zoomed with the mouse as well as using the +/- controls in the upper left-hand corner. These plots are built using the polarmap function in the openair package[5]. This is run with a leaflet basemap, from Esri World Imagery. We refer to this kind of plot as a Source Direction Indicator Plot. On the Controls tab, the user can use the slider to limit wind speed on the SDI plot to a certain range. The user can also choose the different statistic they would like to see applied to the graph, with the options of Median, weighted mean, or maximum. More information on these stats can be found in the SDI plot section. If the sensor did not include latitude and longitude data, the base map will not appear, and instead a grey screen will be displayed.

SDI plots

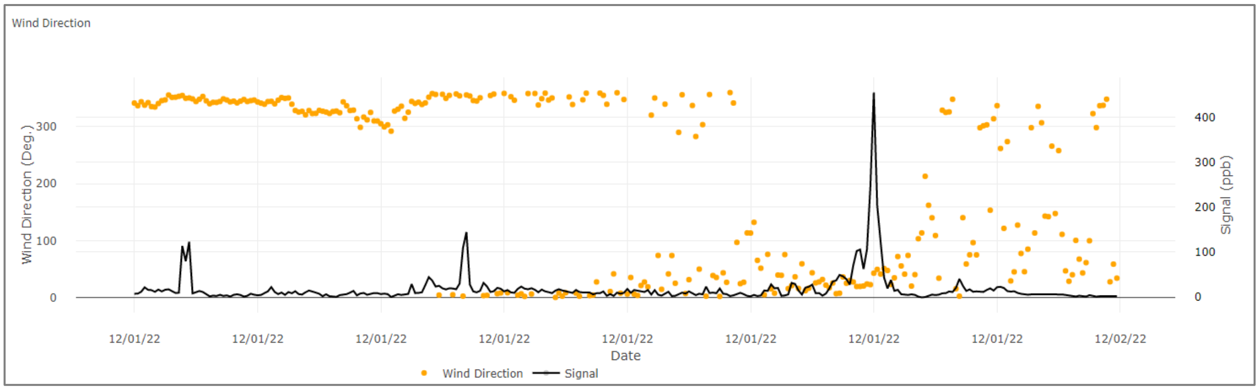


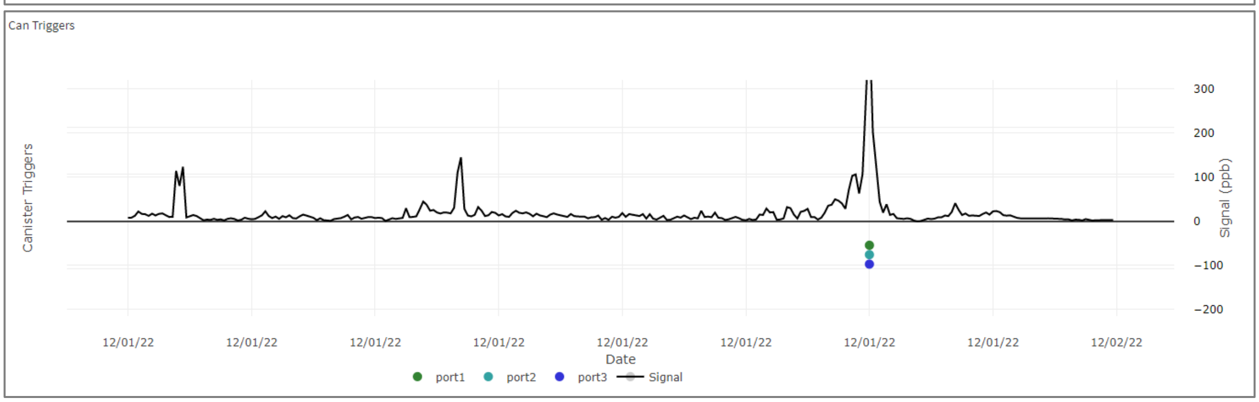
This panel contains two tabs, one containing a wind rose and the other containing two SDI plots. The SDI plot panel contains a polar frequency plot on the left, and an interpolated SDI plot (polarplot) on the right. More information about these functions can be found in the Openair Book and the Openair user manual. The authors of these packages also provide some extra info in a companion R journal article. The user has the option to select between several stats. These stats are each applied to the wind speed and wind direction bins shown in the polar frequency, and then interpolated with smoothing parameters in the SDI plot. The weighted mean stat is calculated as (concentration * frequency of occurrence). The wind rose plot shows overall wind conditions as a frequency of counts by wind direction. Wind speed is binned by color in the wind rose plots.

Time Series Graphs



There are three tabs in the time series pane: a baseline fit tab, a wind direction and concentration tab, and a can trigger and concentration tab. All three of these plots are made using the plotly package[6], which allows for the user to hover over points and zoom/pan on the graph. If the user hovers the mouse in the upper right-hand corner of the graph, there are a suite of options available. One of these, the camera icon, can export a .png image of the graph. The user can also select an axis and drag it up or down to pan down only one axis at a time. The baseline fit tab shows the raw signal as a black trace and the baseline fit as a red trace. The wind direction tab shows the wind direction points as yellow dots and the signal as a black trace. This is useful for matching the periods of elevated signal with wind direction. Finally, the canister trigger graph shows the signal as a black line trace and any canister acquisitions during that period color coded by port. Note that the y axis value of the canister trigger is not used – there are separated by distance in the event of multiple triggers in one 5-minute period (shown below). Note that no triggers will be present if the sensors are not configured to collect canister samples or if no triggers were recorded during this time frame.

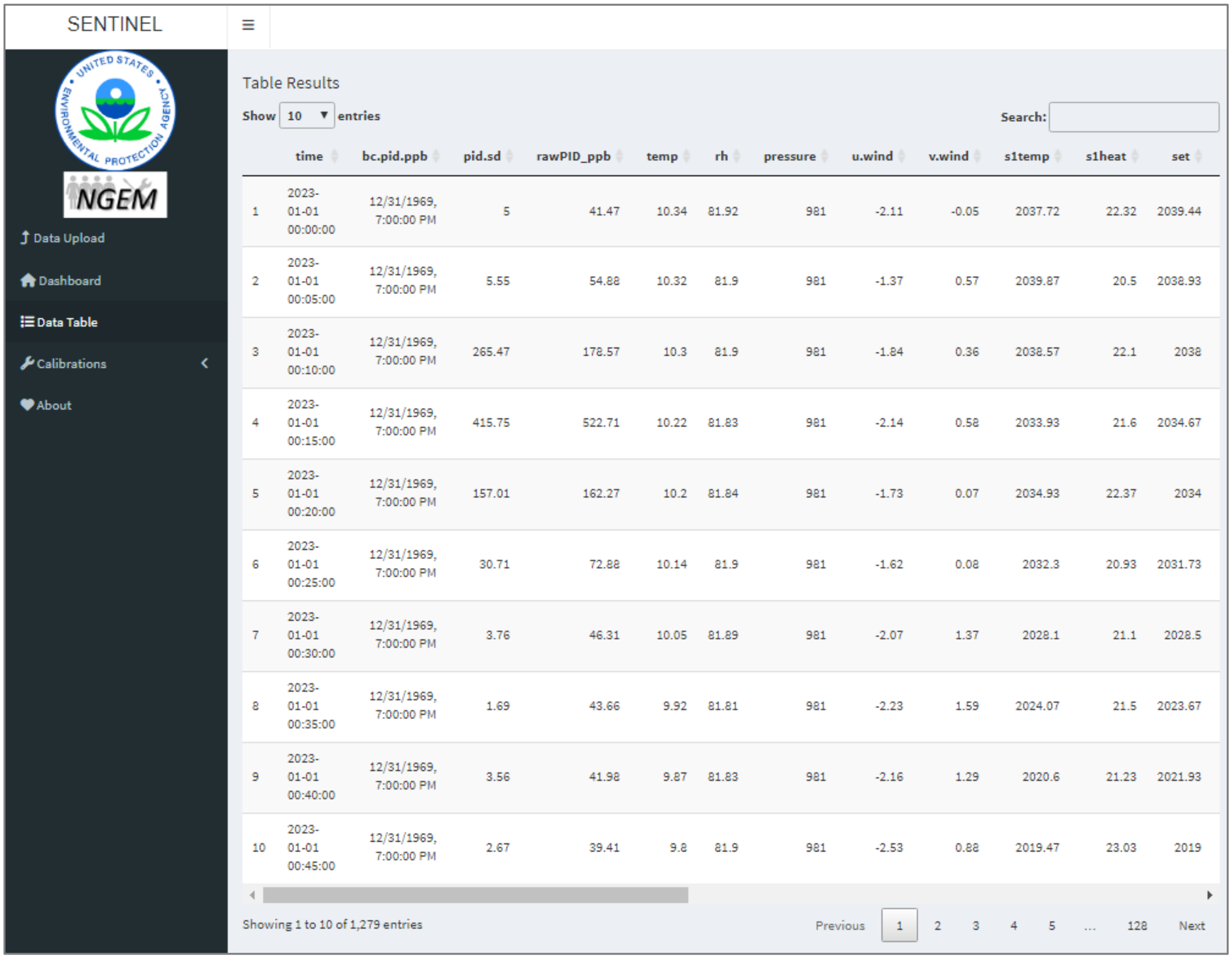




Export to PDF

The top of the dashboard provides an option for a user to generate a report of the data displayed on the dashboard. This report will be output as a pdf and will contain the SDI plot, the Wind Rose, and the three time series graphs (no zoom options can be saved in that export). The signal map cannot be exported since it is not a static image. The report can be saved to the user's device, edited in adobe acrobat, and printed as a document.

Data Table



	time	bc.pid.ppb	pid.sd	rawPID_ppb	temp	rh	pressure	u.wind	v.wind	s1temp	s1heat	set
1	2023-01-01 00:00:00	12/31/1969, 7:00:00 PM	5	41.47	10.34	81.92	981	-2.11	-0.05	2037.72	22.32	2039.44
2	2023-01-01 00:05:00	12/31/1969, 7:00:00 PM	5.55	54.88	10.32	81.9	981	-1.37	0.57	2039.87	20.5	2038.93
3	2023-01-01 00:10:00	12/31/1969, 7:00:00 PM	265.47	178.57	10.3	81.9	981	-1.84	0.36	2038.57	22.1	2038
4	2023-01-01 00:15:00	12/31/1969, 7:00:00 PM	415.75	522.71	10.22	81.83	981	-2.14	0.58	2033.93	21.6	2034.67
5	2023-01-01 00:20:00	12/31/1969, 7:00:00 PM	157.01	162.27	10.2	81.84	981	-1.73	0.07	2034.93	22.37	2034
6	2023-01-01 00:25:00	12/31/1969, 7:00:00 PM	30.71	72.88	10.14	81.9	981	-1.62	0.08	2032.3	20.93	2031.73
7	2023-01-01 00:30:00	12/31/1969, 7:00:00 PM	3.76	46.31	10.05	81.89	981	-2.07	1.37	2028.1	21.1	2028.5
8	2023-01-01 00:35:00	12/31/1969, 7:00:00 PM	1.69	43.66	9.92	81.81	981	-2.23	1.59	2024.07	21.5	2023.67
9	2023-01-01 00:40:00	12/31/1969, 7:00:00 PM	3.56	41.98	9.87	81.83	981	-2.16	1.29	2020.6	21.23	2021.93
10	2023-01-01 00:45:00	12/31/1969, 7:00:00 PM	2.67	39.41	9.8	81.9	981	-2.53	0.88	2019.47	23.03	2019

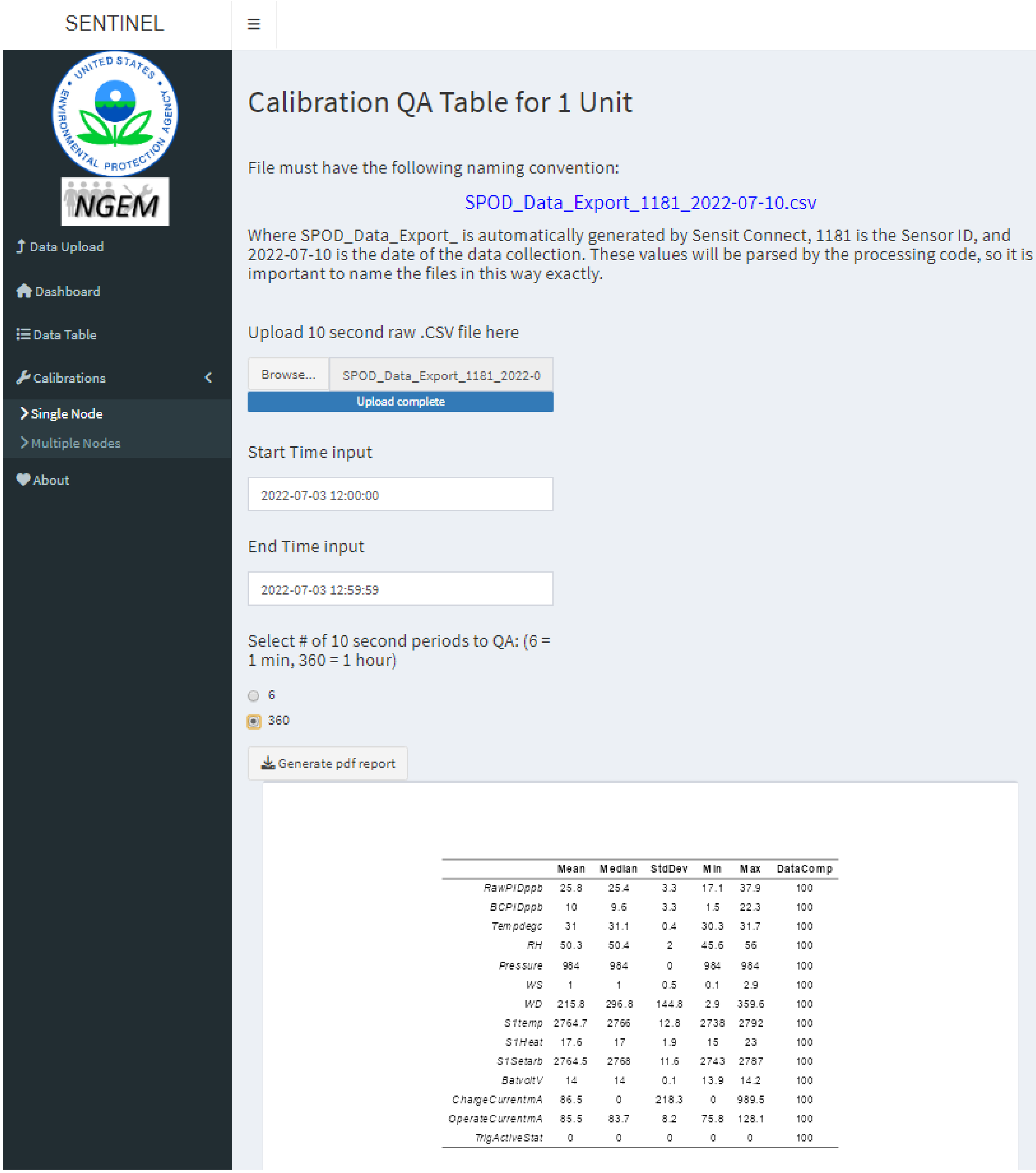
The Data Table page allows the user to see the uploaded data in a 5-minute aggregated tabular form. Selecting the "Download .CSV data" button will export a .csv file of the compiled data and calculations. More entries can be displayed if the user changes the drop-down menu in the top left-hand corner. In the top right, there is a search bar where the user can search for values. The data is automatically organized by date, but the user can sort by other columns using the arrows at the top of each column. More rows can be seen by using the previous and next buttons in the bottom left. Scrolling to the right will show more columns. Definitions for these columns can be found on page 4 of this guide. Note that values in the canister trigger columns are encoded. Explanations of these values are shown in the table below:

Port Status (canister column 1)	
15	Port 1-4 installed; none collected
31	Port 1-4 installed; port 1 collected
63	Port 1-4 installed; port 1-2 collected
127	Port 1-4 installed; port 1-3 collected
255	Port 1-4 installed; port 1-4 collected
Trigger Status (canister column 2)	
1	Trigger occurring in this time frame
Active Port (canister column 3)	
1	Port 1 collecting
2	Port 2 collecting
4	Port 3 collecting
8	Port 4 collecting
Event Status (canister column 4)	
1	Port 1 started
17	Port 1 started; Port 1 complete
19	Port 2 started; Port 1 complete
51	Port 2 complete; Port 2 complete; Port 1 complete
55	Port 3 started; Port 2 complete; Port 1 complete
119	Port 3 complete; Port 2 complete; Port 1 complete
127	Port 4 started; Port 3 complete; Port 2 complete; Port 1 complete
255	Port 4 complete; Port 3 complete; Port 2 complete; Port 1 complete

QA Tables

These options (single node and multi node) allow the user to create a QA table based on a time frame for a single sensor or two collocated sensors. These are useful for ensuring the sensor is running nominally as well as determining how similar two sensors located side-by side are reporting. These tables are required to be collected during calibrations or cal-checks as defined in the SOP.

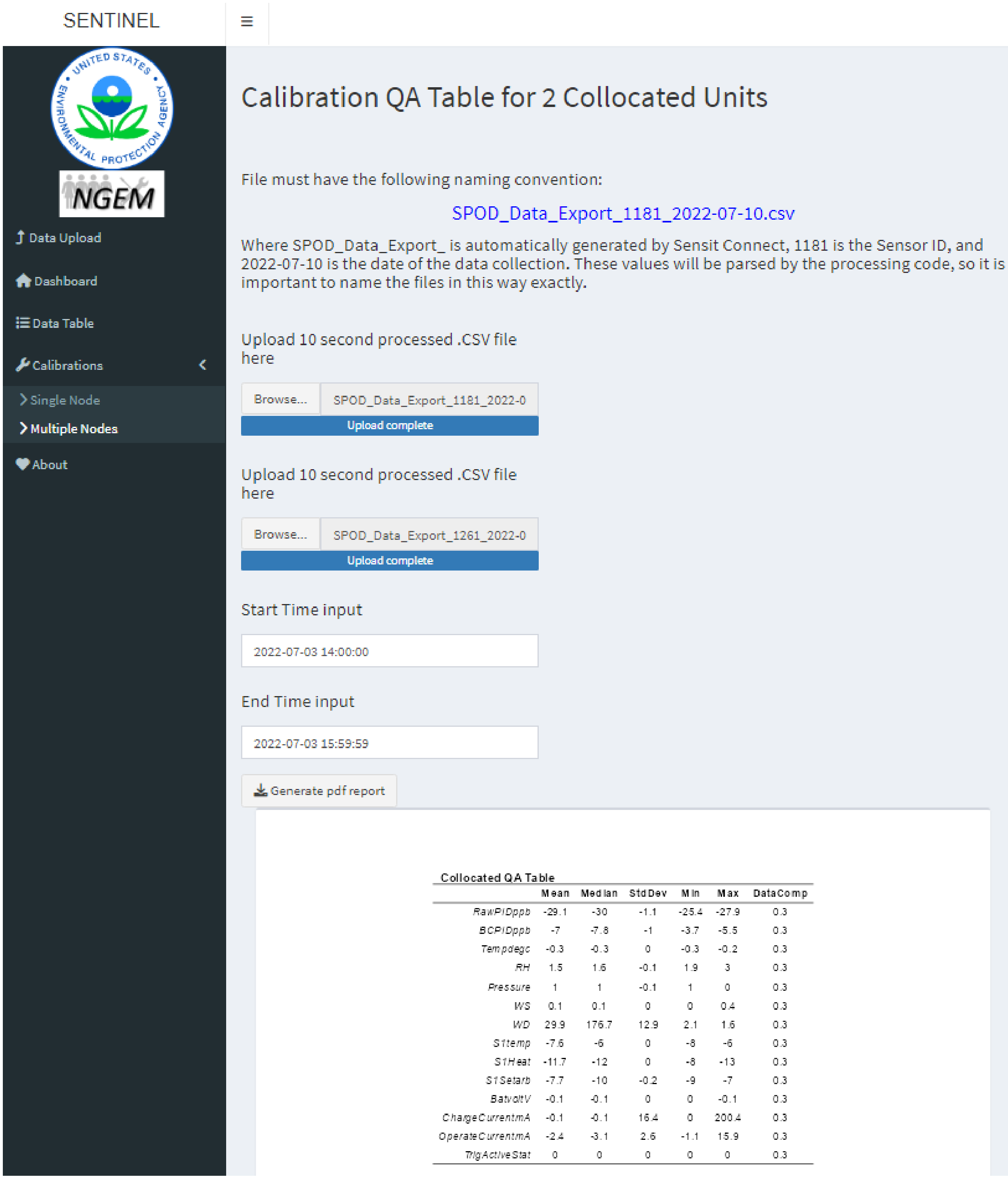
Single Node



	Mean	Median	StdDev	Min	Max	DataComp
RawPIDppb	25.8	25.4	3.3	17.1	37.9	100
BCPIDppb	10	9.6	3.3	1.5	22.3	100
Tempdegc	31	31.1	0.4	30.3	31.7	100
RH	50.3	50.4	2	45.6	56	100
Pressure	984	984	0	984	984	100
WS	1	1	0.5	0.1	2.9	100
WD	215.8	296.8	144.8	2.9	359.6	100
S1temp	2764.7	2766	12.8	2738	2792	100
S1Heat	17.6	17	1.9	15	23	100
S1Setarb	2764.5	2768	11.6	2743	2787	100
BatvoltV	14	14	0.1	13.9	14.2	100
ChargeCurrentmA	86.5	0	218.3	0	989.5	100
OperateCurrentmA	85.5	83.7	8.2	75.8	128.1	100
TrigActiveStat	0	0	0	0	0	100

The Single node calibration requires the user to enter their Sensit connect raw file (named in the same way as general files are named) and the start and end time that they would like to QA. For a calibration on 10 second data, this will likely be only 1 minute. For other QA purposes, this could be 1 hour. The user should select either 6 seconds (1 minute) or 360 seconds (1 hour), so the table shows the correct data completeness value. The table that is generated will show summary stats for data categories which can used to judge if the sensor is calibrating or performing as expected during that time frame. The user can then select the “Generate PDF report” button to get a pdf output with the QA table. This is an excellent option for record keeping.

Multi Node



	Mean	Median	StdDev	Min	Max	DataComp
RawPIDppb	-29.1	-30	-1.1	-25.4	-27.9	0.3
BCPIDppb	-7	-7.8	-1	-3.7	-5.5	0.3
Tempdegc	-0.3	-0.3	0	-0.3	-0.2	0.3
RH	1.5	1.6	-0.1	1.9	3	0.3
Pressure	1	1	-0.1	1	0	0.3
WS	0.1	0.1	0	0	0.4	0.3
WD	29.9	176.7	12.9	2.1	1.6	0.3
S1temp	-7.6	-6	0	-8	-6	0.3
S1Heat	-11.7	-12	0	-8	-13	0.3
S1Setarb	-7.7	-10	-0.2	-9	-7	0.3
BatvoltV	-0.1	-0.1	0	0	-0.1	0.3
ChargeCurrentmA	-0.1	-0.1	16.4	0	200.4	0.3
OperateCurrentmA	-2.4	-3.1	2.6	-1.1	15.9	0.3
TrigActiveStat	0	0	0	0	0	0.3

The multi node tab operates similarly to the single node tab expect the user is prompted to enter a secondary node to be compared to the first node. For this comparison to be effective, the two selected nodes should be collocated, so sensor agreement can be evaluated. The user once again enters the start and end time, and a table will appear. This table is the simple difference between the two nodes (the first node – the second node). The user has the option to export this QA table to a pdf for record keeping. These outputs are built in R Markdown (example shown below).

Multi Node QA Table

QA Table ID: SPOD1181SPOD1261_2022_07_03_14_00_00_15_59_59

Unit 1 S/N: SPOD1181

Unit 2 S/N: SPOD1261

Subtraction = SPOD1181 - SPOD1261

Date: 2022-07-03

Start and End Time: 14:00:00 to 15:59:59

Output Date: 2023-01-24

R Code Version: Version 1.2

Data Analyst Name and Signature: ______________________________

Notes: ______________________________

Table 1: 2022-07-03 14:00:00 to 2022-07-03 15:59:59

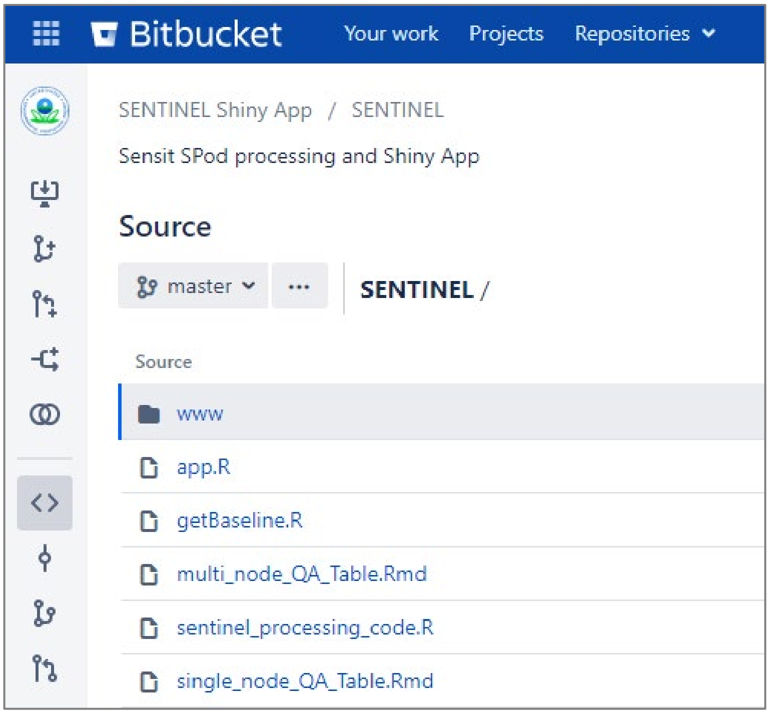
	Mean	Median	StdDev	Min	Max	DataComp
RawPIDppb	-29.1	-30.0	-1.1	-25.4	-27.9	0.3
BCPIDppb	-7.0	-7.8	-1.0	-3.7	-5.5	0.3
Tempdegc	-0.3	-0.3	0.0	-0.3	-0.2	0.3
RH	1.5	1.6	-0.1	1.9	3.0	0.3
Pressure	1.0	1.0	-0.1	1.0	0.0	0.3
WS	0.1	0.1	0.0	0.0	0.4	0.3
WD	29.9	176.7	12.9	2.1	1.6	0.3
S1temp	-7.6	-6.0	0.0	-8.0	-6.0	0.3
S1Heat	-11.7	-12.0	0.0	-8.0	-13.0	0.3
S1Setarb	-7.7	-10.0	-0.2	-9.0	-7.0	0.3
BatvoltV	-0.1	-0.1	0.0	0.0	-0.1	0.3
ChargeCurrentmA	-0.1	-0.1	16.4	0.0	200.4	0.3
OperateCurrentmA	-2.4	-3.1	2.6	-1.1	15.9	0.3
TrigActiveStat	0.0	0.0	0.0	0.0	0.0	0.3

About Page

The about page contains the version number of the code, and the contact information if any user finds questions or bugs (macdonald.megan@epa.gov). There are also some links on the about page that might be helpful for new users. These include some information about SDI plots, the Sensit user manual, and some EPA presentations/articles about fenceline sensors. The associated SOP and User manual are also included on this page, as well as acknowledgements to contributors to this project.

Accessing Code

For users who are curious about the actual Shiny R Code used to build the app, the code folder is available on the SENTINEL EPA Bitbucket Repository. This requires a user to be given access to see the code repository; please email macdonald.megan@epa.gov for access requests. Once the user has access, they can see the files in the code folder on Bitbucket. This includes the www folder (where images on the app are stored), the getBaseline function, the R Markdown template documents for pdf outputs, and the "app.R" code. Bitbucket is updated with new code commits and version control records as the app is further developed.



References

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2. Winston Chang, Joe Cheng, JJ Allaire, Carson Sievert, Barret Schloerke, Yihui Xie, Jeff Allen, Jonathan McPherson, Alan Dipert and Barbara Borges (2022). shiny: Web Application Framework for R. R package version 1.7.2. https://CRAN.R-project.org/package=shiny
3. Hadley Wickham, Romain François, Lionel Henry and Kirill Müller (2022). dplyr: A Grammar of Data Manipulation. R package version 1.0.9. https://CRAN.R-project.org/package=dplyr
4. Winston Chang and Barbara Borges Ribeiro (2021). shinydashboard: Create Dashboards with 'Shiny'. R package version 0.7.2. https://CRAN.R-project.org/package=shinydashboard
5. Carslaw, D. C. and K. Ropkins (2012). openair --- an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.
6. Carson Sievert (2020). Interactive Web-Based Data Visualization with R, plotly, and shiny. Chapman and Hall/CRC Florida.

Resources

More information on R Shiny Applications:

- Mastering Shiny Bookdown Site

More information on SPod deployments:

- Rubbertown Next Generation Emissions Measurement Demonstration Project (Journal article)
- Demonstration of VOC Fenceline Sensors and Canister Grab Sampling near Chemical Facilities in Louisville, Kentucky (Journal article)
- Sensor Pod (SPod): An Approach for VOC Fenceline Monitoring and Data Analysis (EPA Tools and Resources Webinar)
- Next Generation Emission Measurements (NGEM) Advancements (EPA ORISE Meets the World Seminar)
- Fenceline and Community Sensor Applications and Comparisons (Air Sensors International Conference video)
- EPA Researchers Develop New Air Monitoring Technology to Understand leaks and Irregular Emissions from Sources (Science Matters Article)

Appendix F: Reference Figures

Figure F1. Sensit SPod unit with anemometer and PID sensor

Figure F2. Sensit SPod unit on tripod powered by solar panel

Figure F3. Sensit SPod units and canister system on pallet stand powered by solar panel

Figure F4. Sensit SPod units and calibration gas cylinder on pallet stand

Figure F5. Sampling hardware for collecting grab samples

Figure F6. EC sampling system attached to a Sensit Spod unit