ERTO

Copernicus Evolution – Research for harmonised and Transitional water Observation

TriOS Hyperspectral Radiometer User Guide

UNIVERSITY of STIRLING

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The CERTO project (Copernicus Evolution: Research for harmonised Transitional water Observation) aims to address this lack of harmonisation by undertaking research and development necessary to produce harmonised water quality data from each service and extend Copernicus to the large number of stakeholders operating in transitional waters.

For further information see www.certo-project.org

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Contents

List of figures and tables

1. Delivery checklist

Check all equipment in the TriOS set (Figure 1 and Table 1), make sure everything is included in the PELI case before and after each field campaign.

Figure 1. Equipment in the TriOS set.

Table 1. Delivery checklist of the TriOS set

Item	Name
1	SAM_5098 irradiance sensor
2	SAM_846D radiance sensor
3	SAM_847C radiance sensor
4	IPS104
5	GPS
6	Laptop
7	AC laptop charger
8	Data cable
9	Sensor cable
10	DC laptop charger
11	Steel panel

Item	Name
12	Plastic clamp
13	Plastic clamp
14	Plastic clamp
15	Mast clamp
16	Mast clamp
17	Plug adapter
18	Plug adapter
19	Spanner
20	TriOS AC power cable
21	TriOS DC power cable
22	PELI case

Note:

- An extra AC power source or a 12V DC battery is needed for the TriOS.
- A pole is needed, size between 48 and 30mm diameter will fit the adjustable clamps.
- The item number in Table 1 is same as the number on the yellow label of each equipment, e.g., item number "1" in Table 1 corresponding to "T001" on the yellow label on SAM_5098 irradiance sensor.

2. Set up

Step 1: install the three plastic clamps at the marked three positions on the steel panel (Figure 2).

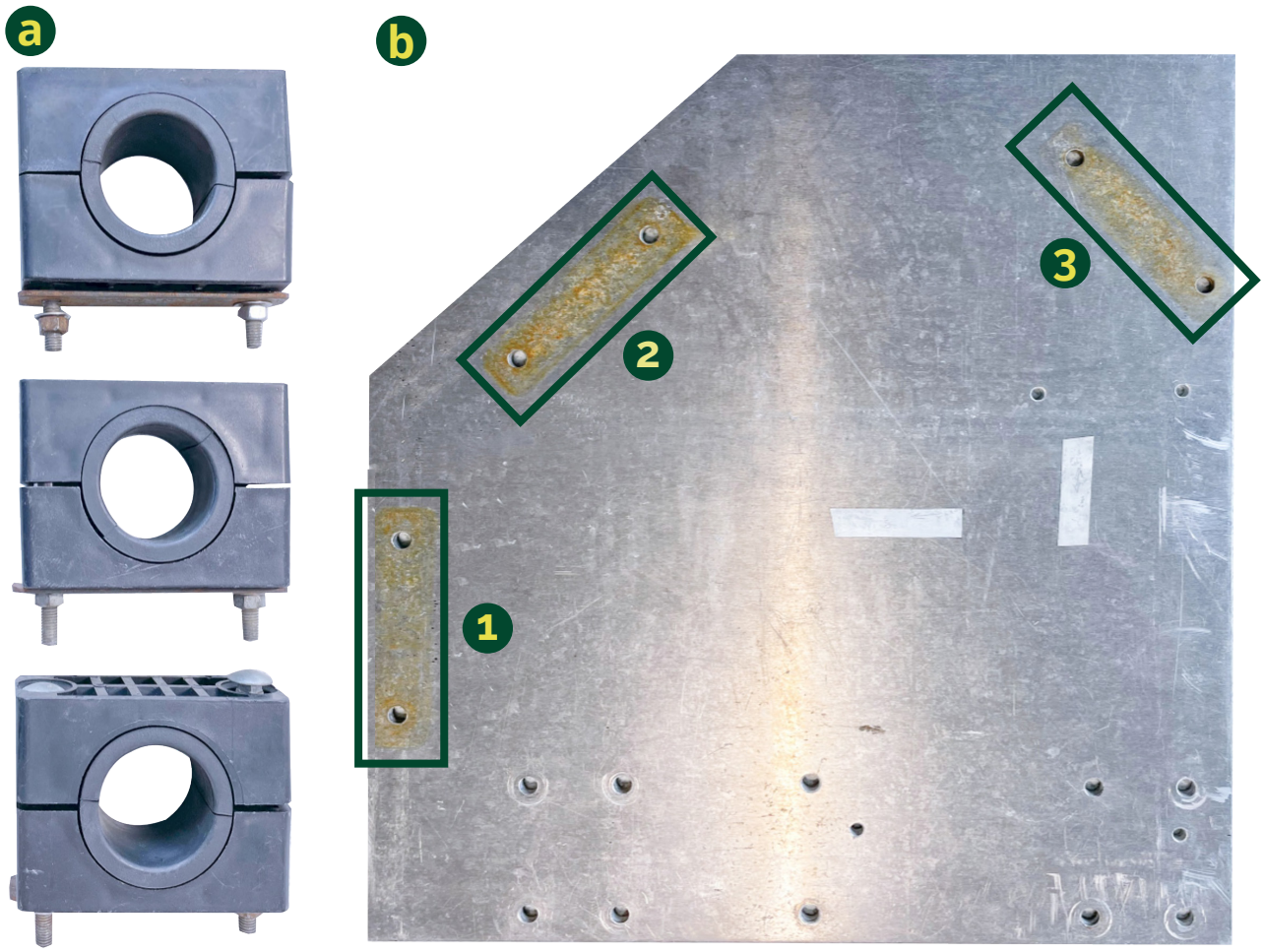

Figure 2. (a - left) three plastic clamps. (b - right) steel panel, sensor position 1: SAM_5098 (irradiance), position 2: SAM_846D (radiance), position 3: SAM_847C (radiance).

Step 2: Mount the three TriOS RAMSES sensors on the steel panel using the plastic clamps (Figure 3), make sure the irradiance sensor (SAM_5098) at position 1 in Figure 2b, one radiance sensor (SAM_846D) at position 2 in Figure 2b, and the second radiance sensor (SAM_847C) at position 3 in Figure 2b.

Figure 3. TriOS RAMSES sensors mounted on the steel panel.

Step 3: connect the three TriOS RAMSES sensors with sensor cables. Firstly, plug the sensor cable's connector into the bulkhead connector on the RAMSES (Figure 4a). Secondly, turn the locking-sleeve clockwise to tighten connector on the bulkhead connector (Figure 4b). Make sure the sensor model marked on the cable is same as the sensor model marked on the sensor (e.g., SAM_5098 in Figure 4a).

Figure 4. (a) connect the sensor cable. (b) lock the connector

Step 4: connect the other end of the sensor cables to the IPS104 interface and power supply unit. Check the number marked on the cable (Figure 5a), and then connect cable 1, 2, 3 to CH1, CH2, CH3 on the IPS104 respectively (Figure 5b).

Figure 5. (a) sensor cables with marked number. (b) connected cables to IPS104 interface and power supply unit.

Step 5: install the steel panel at an appropriate position on the boat using the two mast clamps (Figure 6a), such as a pole on the deck of the boat (Figure 6b, the pole is not included in the PELI case, and need to be prepared separately, any pole between 48 and 30mm diameter will fit the adjustable clamps). Make sure the geometry of the sensors is correct, i.e., irradiance sensor is straight upward, and the two radiance sensors are 40 degrees upward and downward respectively (Figure 6b).

Make sure there is no influence from superstructure on the irradiance sensor (SAM_5098) measurement, and make sure the downward radiance sensor (SAM_847C) is pointing to water surface. Adjust the steel panel and keep the radiance sensors at a 135° azimuth angle (i.e., 135° away from the sun, Figure 10).

Figure 6. (a) two mast clamps. (b) the position of the steel panel, and the geometry of TriOS sensors.

Step 6: connect GPS to PC's USB port at the left side, and connect IPS104 using data cable to PC's USB port at the right side (Figure 7).

Figure 7. GPS port at the left side and sensor port at the right side of the PC.

Step 7: connect IPS104 to a power source (power source is not included in the PELI case, need to be prepared separately). There are two options for the power, you can use either a 12V DC battery or a AC power from the boat (Figure 8), but make sure only select one of the two power options. Switch the button on IPS104 to power on. Check the LEDs on the IPS104, if all connection is correct, the "POWER" LED is green, and the "DATA" and "CMD" LEDs are yellow. Note that, the yellow LEDs will flash when sensors are taking measurements.

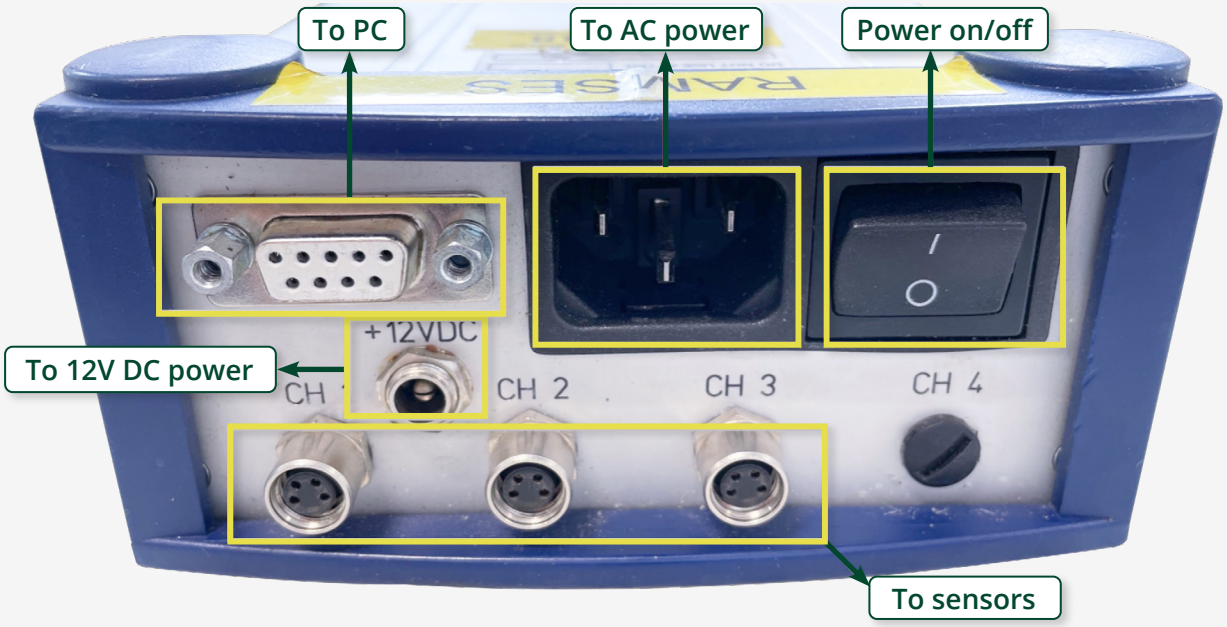

Figure 8. All connections to the IPS104 interface and power supply unit.

3. Take measurements

The measurement of TriOS RAMSES is controlled through a python code called “pyTrios”, users can configure the measurement through a “.bat” file and run it in PC’s Command Prompt. The PyTriOS library is hosted at **https://github.com/StefanSimis/PyTrios**

Step 1: set up the parameters for the measurement. Open folder “C:\pyTrios\” in the PC, right click on the configuration file “start_1_sample.bat”, and then click “edit” to open the file using text editor. A total 10 lines of settings will appear (see **Figure 9** below) in the file. Change the following parameters before taking measurement:

- tcom: the COM port of TriOS RAMSES sensor.
- samples: the number of samples you want to measure, e.g., “samples=300” in Figure 9, which indicates the program will stop automatically after finishing 300 measurements (note, one measurement include 3 spectra and 1 GPS location).
- period: the time period (minutes) you want to take measurement, e.g., “period=10” in Figure 9, which indicates the program will stop automatically after 10 minutes’ measurement.
- caloutfile: the output file name of measured data, these data (spectra) are calibrated. Need to set up this parameter for each station, recommended format is “studysite_date_station_cal.txt”, for example, “PlymouthSound_20210929_st1_cal.txt”.
- rawoutfile: the output file name of measured raw data, these data (spectra) are not calibrated. Need to set up this parameter for each station, recommended format is “studysite_date_station_raw.txt”, for example, “PlymouthSound_20210929_st1_raw.txt”.
- gps: the COM port of GPS.

NOTE: the COM ports of TriOS RAMSES sensor and GPS can be found in the PC’s Device Manager (see **point 1** in Trouble Shooting). Please do check the time in the PC and make sure it’s **UTC time** (see **point 2** in Important Notes).

```
@echo off
set tcom=3
set samples=300
set period=10
set vchn=1
set vcom=1
set calpath=calfiles090620
set caloutfile=PlymouthSound_20210929_st1_cal.txt
set rawoutfile=PlymouthSound_20210929_st1_raw.txt
set gps=4
set inttime=0
@echo on
python Rrs_example.py %tcom% -samples %samples% -period %period% -
plotting -vchn %vchn% -vcom %vcom% -calpath %calpath% -calout
%caloutfile% -rawout %rawoutfile% -GPS %gps% -inttime %inttime%
```

Figure 9. Example of the configuration file.

Step 2: adjust the direction of the TriOS steel panel, and make sure that the downward radiance sensor (SAM_847C) is pointing to water surface with a 40° zenith angle, and a 135° azimuth angle (i.e. 135° away from the sun) during the whole measurement period (Figure 6b and Figure 10).

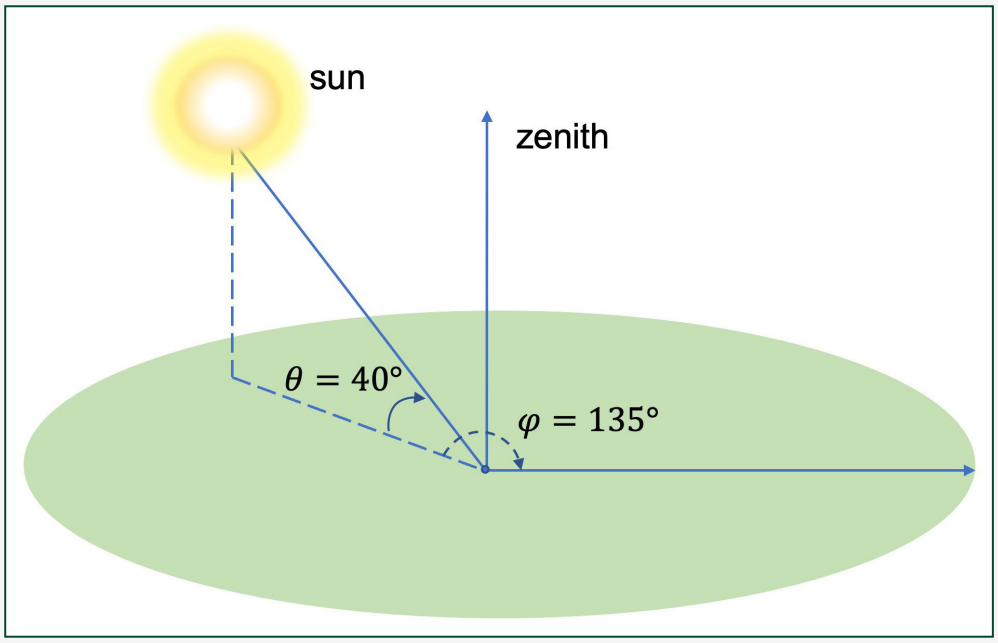

Figure 10. Geometry of TriOS measurement.

Step 3: in the PC, go to the Start menu > All Programs > Accessories > open the Command Prompt. In Command Prompt, type in "CD C:\pyTrios\" to locate to the "start_1_sample.bat" file folder, then type in the file name of "start_1_sample.bat" and press enter button on the keyboard to start the measurement (Figure 11a). Alternately, double click on the "start_1_sample.bat" file, it will run in Command Prompt.

When the pyTrios starts working, it will first check the sensor calibration files, sensor connection and GPS connection, and then start to take measurement (Figure 12). If all settings and connections are correct, the program will first show the calibration files of all three sensors (point 1 in Figure 12), then these sensors connected with the PC will be listed in a bracket "[ ]" (point 2 in Figure 12, three sensors). GPS status will also show (for example, point 3 in Figure 12, "Fix quality 0, -3.91815666667"). If no GPS signal is received, it will show "Fix quality 1, None".

After the program checking all connections, it will start to measure automatically, a window will pop up and show the results of measured spectra from three sensors (Figure 11b and 11c). The number of measurement (counting from 1) and the time of the measurement will also show at the top of the spectra window (e.g., "spectrum 16 at 2021-06-10 16:03:34" in Figure 11c). Note that one measurement includes three spectra from three sensors and a location from GPS at the same time (Figure 11c, point 4 in Figure 12).

NOTE: if there is no GPS connection/signal from the beginning of the measurement, the program will also start to measure (see more in Figure 20 and point 4 in Trouble Shooting chapter).

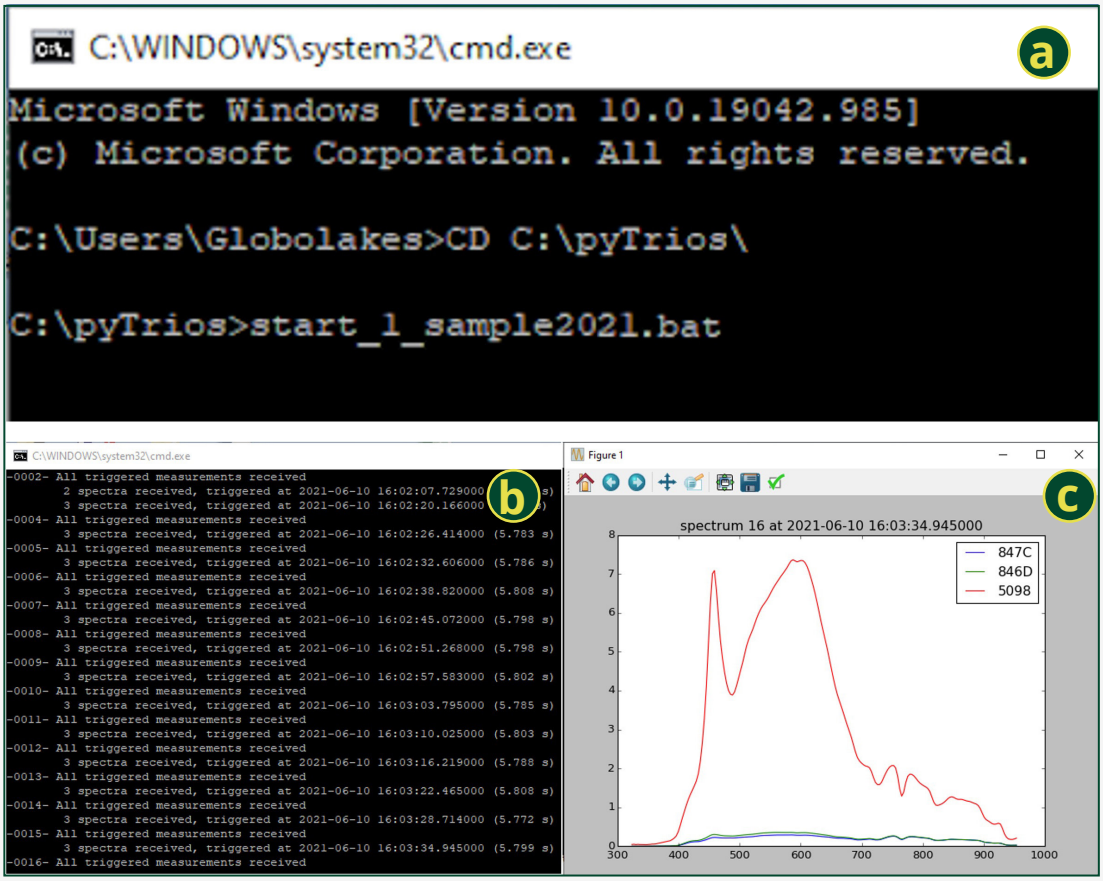

*Figure 11. Example of running pyTrios in Command Prompt. Note: the spectrum in figure (c) is just an example, it's **NOT** the real water spectra in the field.*

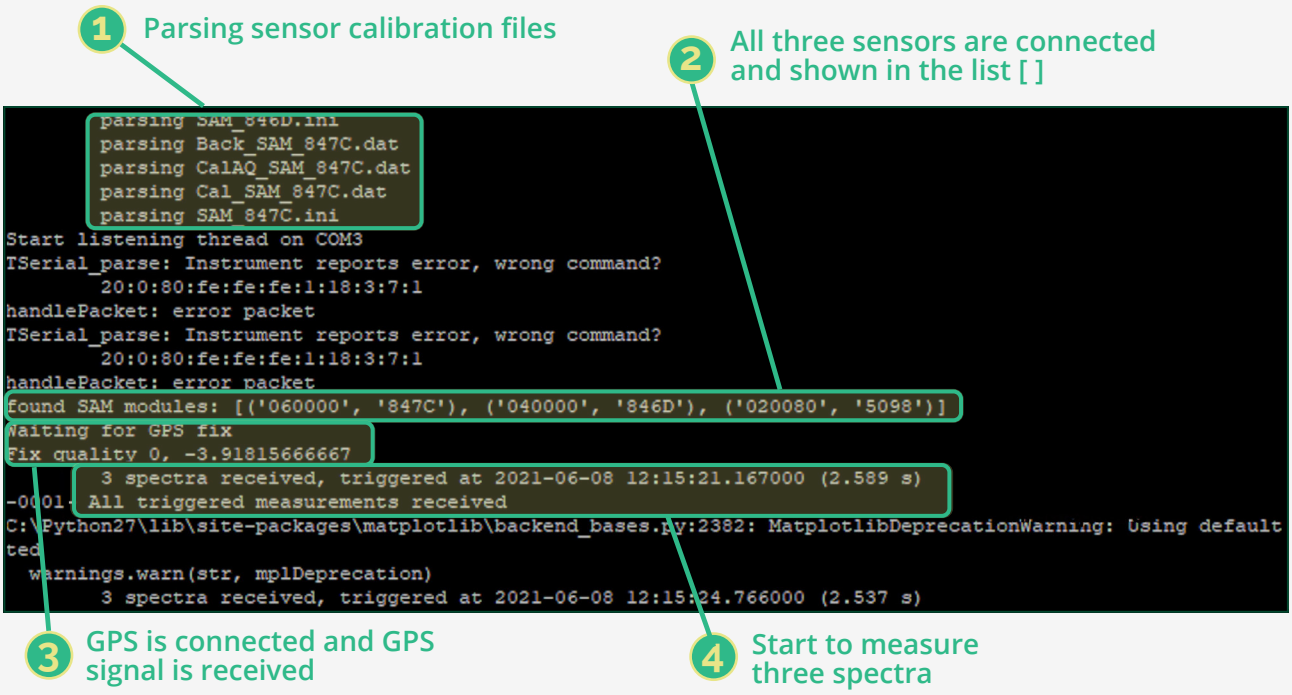

Figure 12. Example of running pyTrios successfully.

Step 4: to stop the measurement, there are three ways:

- press “ctrl+c” in Command Prompt, when the message “Terminate batch job (Y/N)?” appears, type “Y” and press enter button, then the pyTrios program will stop.
- set up the number of measurements in the second line of “start_1_sample.bat”, e.g., “samples=300” in Figure 9, then pyTrios program will stop automatically after finishing 300 measurements, and show the message “Press enter to close” (Figure 13).
- set up the time period of measurements in the third line of “start_1_sample.bat”, e.g., “period=10” in Figure 9, then pyTrios program will stop automatically after measuring 10 minutes, and show the message “Press enter to close” (Figure 13).

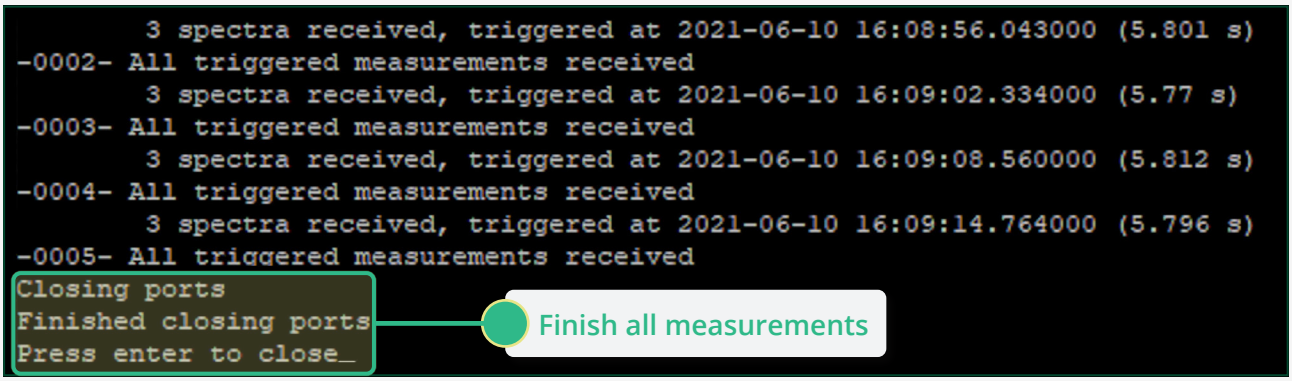

Figure 13. Example of the message after finishing all measurements.

NOTE: if an error happens during the measurement, pyTrios will also stop taking measurement, please see Trouble Shooting chapter for more information.

Step 5: after finishing all measurements, power off IPS104, disconnect sensors, disassemble all equipment, clean the sensors (if necessary, e.g., water spray, dust) and pack up all the equipment carefully.

4. Data download

All measured data will be stored in two ".txt" files for each station, these ".txt" files will be saved in the same folder of pyTrios, i.e., "C:\pyTrios\". One file (e.g., PlymouthSound_20210929_st1_raw.txt) contains the raw value of the measured spectra, another file (e.g., PlymouthSound_20210929_st1_cal.txt) contains the calibrated value of the measured spectra. The name of the ".txt" file is the one set up in the file "start_1_sample.bat" (Figure 9). For example, in this manual, the output files are "PlymouthSound_20210929_st1_raw.txt" and "PlymouthSound_20210929_st1_cal.txt".

In the output file, data is comma separated, and contains the following value:

- Date and time: in format of "YYYY-MM-DDThh:mm:ss".
- GPS data: latitude and longitude in decimal degree, following with two columns of ancillary data.
- Device information: showing the spectra measured by which sensor, i.e., SAM_5098, SAM_846D or SAM_847C.
- Integration time: integration time of RAMSES sensors.
- Spectra data: spectra measured by TriOS RAMSES sensors, from 323.3 nm to 953.6 nm with 3.3 nm intervals.

NOTE: if no GPS signal is received, there will be five blank columns in the output files.

5. Trouble shooting

If an error or problem happens when taking measurement in the field, please refer to the following method to fix it.

1 How to find the COM port

Go to the PC's Device Manager, then find the "Ports (COM&LPT)" (green area in Figure 14). For example, in Figure 14, in the "Ports (COM&LPT)", the one "Prolific USB-to-Serial Comm Port (COM4)" is GPS port, so COM port number is "4". The one "USB Serial Port (COM3)" is TriOS RAMSES sensor port, so COM port number is "3".

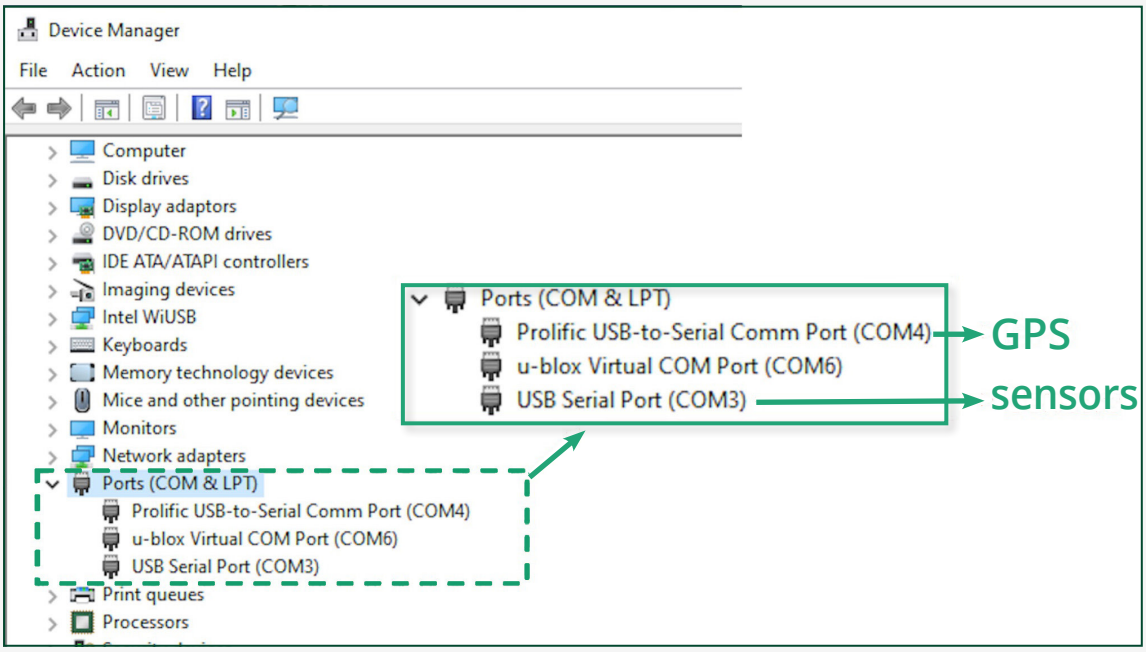

Figure 14. The GPS COM port and TriOS RAMSES sensor COM port.

2 Cannot connect the COM port

Error: when pyTrios cannot connect a COM port, the measurement will not start and an error message will appear, showing "Error connection to port COMx" (Figure 15), the last character "x" is the COM port number. If the COM port connection or the connection of one sensor is suddenly lost during measurement, a COM port error will appear (Figure 16).

How to fix it: power off IPS104, check all cable connections, check the COM port in the PC's Device Manager, and make sure the COM port number is correct. Power on IPS104, and start the measurement again.

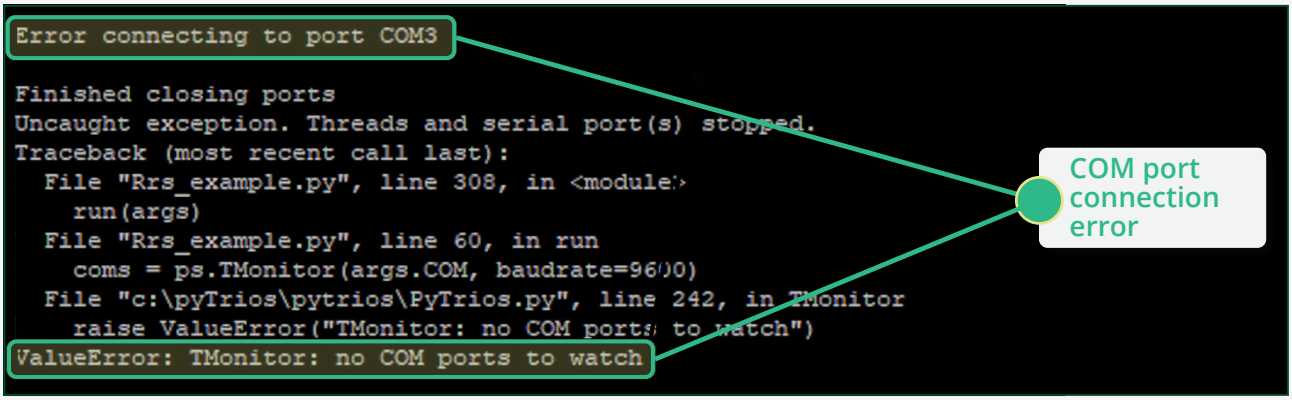

Figure 15. COM port connection error.

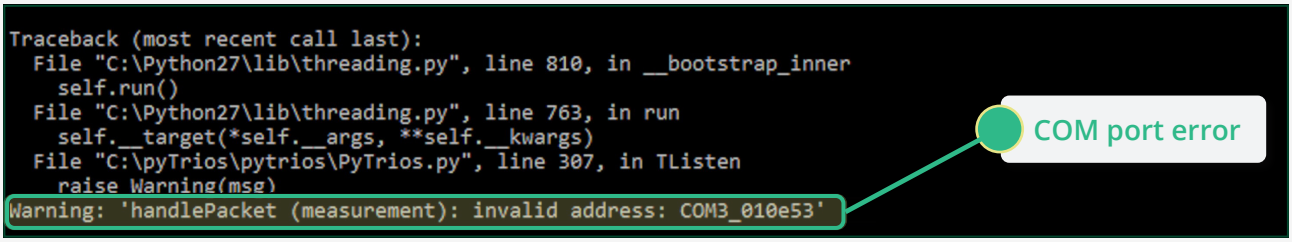

Figure 16. COM port error during measurement.

3 Cannot connect TriOS sensors

Error: if all sensors are well connected to the PC, the name of three sensors will be listed in the bracket of "[ ]" (see point 2 in Figure 12). If one or more sensors are not connected to the PC, the name of these sensors will not appear in the bracket of "[ ]". For example, in Figure 17, only two sensors (SAM_847C, SAM_846D) are connected, one sensor (SAM_5098) is not connected. In Figure 18, all three sensors are not connected.

How to fix it: power off IPS104, unplug data cable from PC. Check all sensor connections, plug data cable to PC, power on IPS104, and start measurement again.

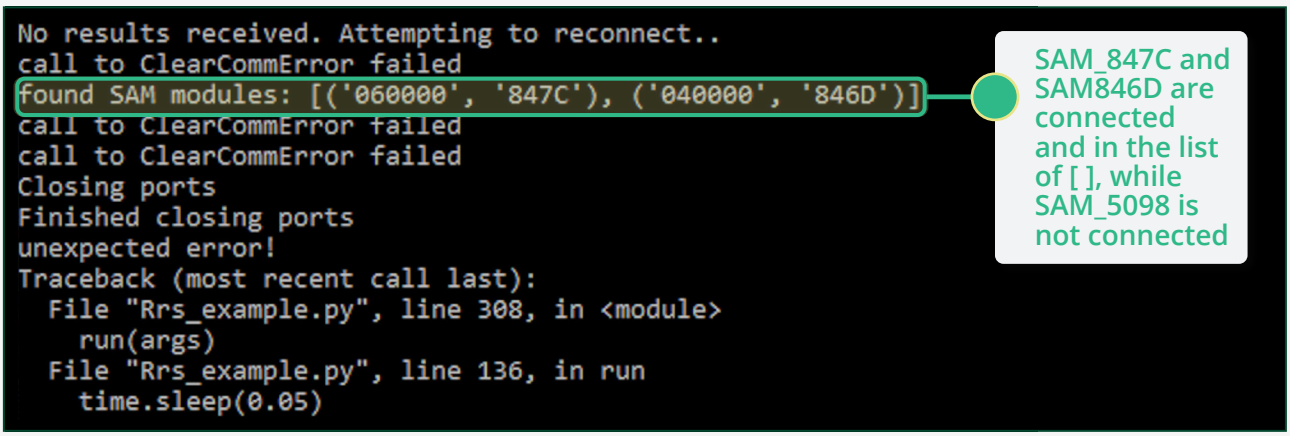

Figure 17. Error example, two sensors are connected, but one sensor is not connected.

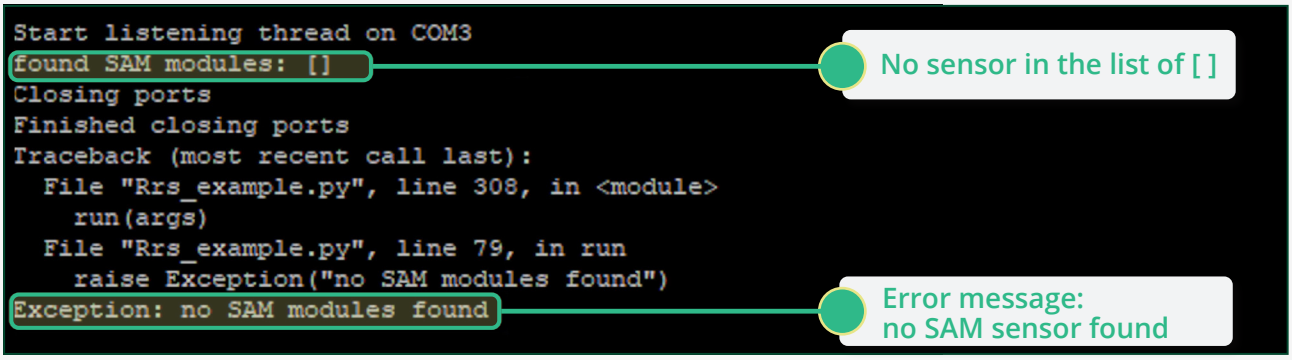

Figure 18 Error example, all three sensors are not connected.

4 Lose GPS connection/signal

Error: if the GPS connection/signal is suddenly broken during the measurement, the program will stop automatically, and an GPS error message will appear (Figure 19). If the GPS signal is not received from the beginning of the measurement but RAMSES sensors are well connected, the measurement of spectra will start, following with messages showing "Waiting for GPS fix,..., GPS timed out"(Figure 20), in this case, there are only spectra data in the output file.

How to fix it: unplug GPS from PC, plug GPS to PC again, and restart the measurement.

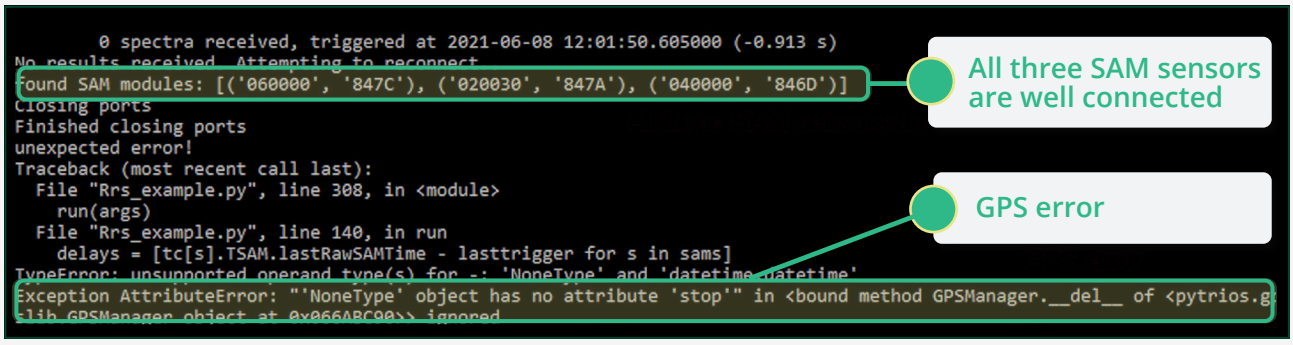

Figure 19. GPS connection/signal suddenly lost during the measurement, the program will stop and show a GPS error.

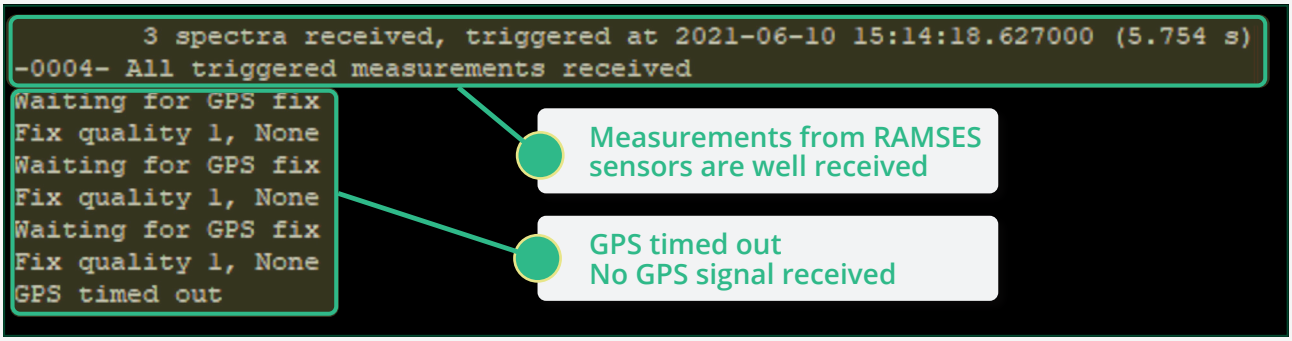

Figure 20. No GPS signal from the beginning of the measurement, it will show messages regarding to GPS, but spectra measurement will continue.

6. Important notes

1	Before taking any measurement, please check the optical window of all TriOS RAMSES sensors and make sure they are clean.
2	Before taking measurement, please check and make sure it's UTC time in the PC, so that to keep the timestamp of measurement from different study sites consistent. If the time in the PC is a local time, please change it to UTC time.
3	During the measurement, it is IMPORTANT to keep the radiance sensors (SAM_846D and SAM_847C) at a 135° azimuth angle to avoid sunglint from water surface (Figure 6b and Figure 10).
4	Install the TriOS set at an appropriate place on the boat, make sure there is no contaminations in RAMSES sensor's view field.
5	It is recommended to take many repeated measurements for one station, to guarantee there are enough good measurements after removing any questionable measurements in later data processing stage. For example, for low dynamic waters, take at least one hundred (>100) measurements for each station.
6	Put the GPS at an open area with nothing covered on it, so that to get better GPS signal.
7	Keep all equipment and connection as stable as possible during measurements, this will greatly help to reduce the possibility of errors.
8	Make sure the PC is fully charged before going to the field. If a DC battery is used for TriOS sensors, make sure it is fully charged before going to the field.
9	If an error happens during the measurement, the pyTrios will stop, after fixing the problem and restart the pyTrios, the measured data will be appended to previous results in the same file. For example, before the error happens, 50 measurements are finished, after fixing the error, the new measured data will be appended to the 50 measurements measured before error happens. Please remember or take a note of the number of measurements when an error happens, which can help to ensure the total number of measurements for one station (for example, >100 for low dynamic waters).
10	It is recommended to check the spectral value and shape in the window (Figure 11c) when taking measurement in the field, if the spectral value or shape is strange, stop the measurement, check all connections and settings, and try to measure again. DON'T compare your spectral shape and value with the one in Figure 11c, it's NOT the real water spectra.