Solar-tracking Radiometry platform (So-Rad)

User Manual

PML | Plymouth Marine Laboratory

Original documentation:

This version of the User Manual is the original copy which has not been translated. Any discrepancies with instructions which may be found elsewhere or provided in any other than the original language are to be resolved by referring to the latest version of this document.

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1. System overview

1.1. Purpose

The purpose of the Solar-tracking Radiometry platform (So-Rad) is to maintain optimal viewing angles of radiance sensors recording water-leaving reflectance, avoiding sun glint and platform shading even when deploying from moving platforms such as ships or buoys. So-Rad is developed to operate autonomously, with low power consumption, integrating commercially available (ir)radiance sensors and providing remote connectivity. Following initial configuration, So-Rad will determine when measurement conditions are met to trigger the connected sensors at set intervals, store the sensor response and metadata, and communicate these to a centralized repository when a data connection is available.

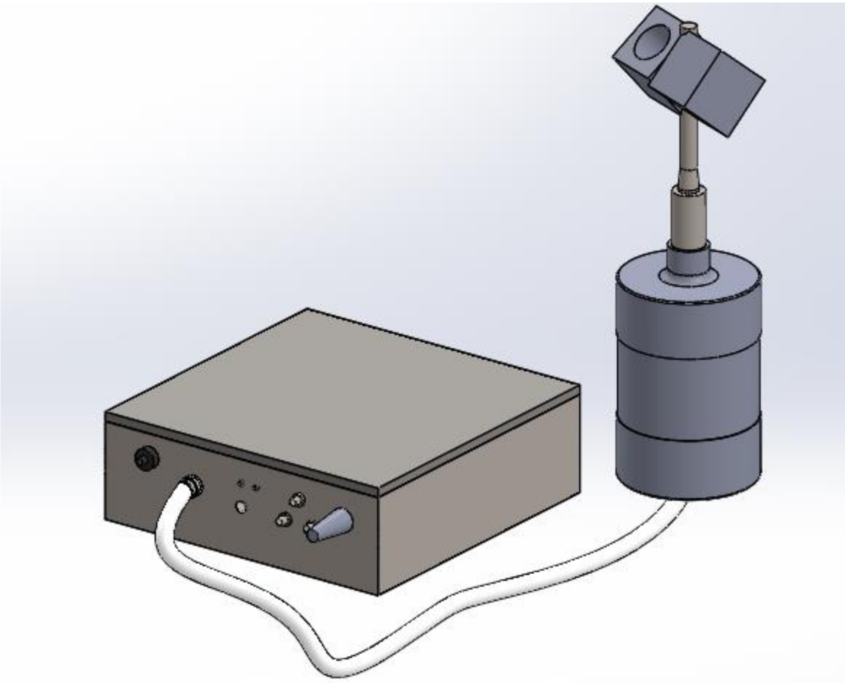


Figure 1: The So-Rad control unit (left) and motor enclosure (right).

1.2. What is included

The So-Rad system and its main components are shown in Figure 2. Three spectroradiometers and their cabling, as well as bracketry to fit the system to the deployment platform, are normally provided by the user. A So-Rad consists of a control unit, a motor enclosure with clamps for two radiometers, cabling and a universal mount for the motor enclosure.

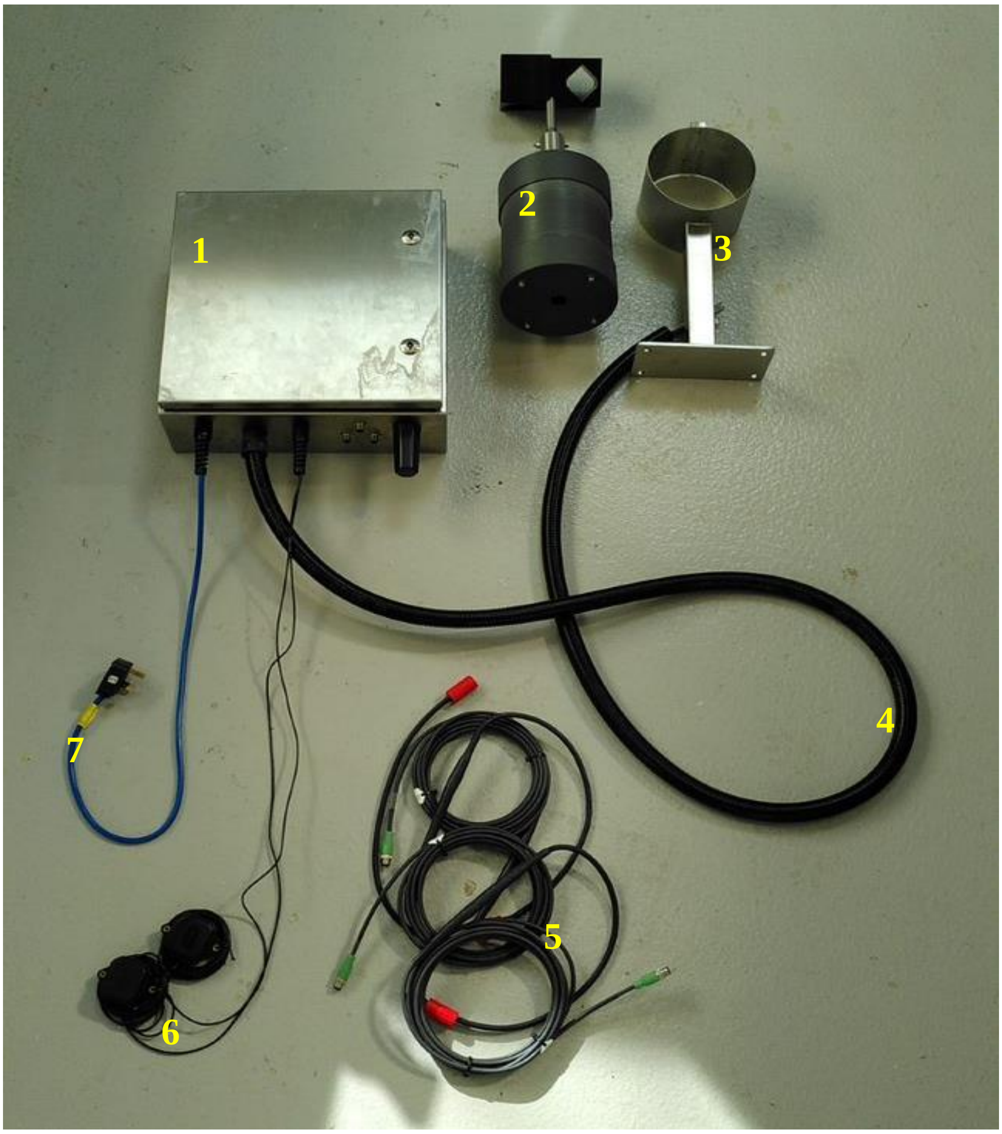


Figure 2. So-Rad unit with (1) Control unit, (2) motor enclosure, (3) mounting bracket, (4) motor cables, (5) sensor cables, (6) GPS receivers and (7) AC mains power cord. The control unit and motor enclosure are connected by a pre-assembled weather-proof cable conduit.

2. System specifications

2.1. Safety

The user/operator is responsible for reading and observing all warnings contained in this document whilst handling the equipment:

- Failure to adhere to the listed Warnings may result in serious injury or death.
- Failure to adhere to the listed Cautions may result in injury or damage to property.

2.1.1. Warnings

Compulsory actions:

- Installation, wiring, cable connections, operation/controlling, inspecting and troubleshooting should be performed by qualified personnel. Failure to do so may result in fire, electric shock, injury or damage to the equipment.
- The control unit should not be opened whilst connected to external power. Opening the control unit should generally be avoided to prevent risk of damage to internal components.
- Any alarms generated by the motor driver require removal of the cause. Continued operation without removal of the cause of the alarm may cause malfunction of the equipment, leading to injury or damage of property.
- Input power voltages must be kept within the specified range. Failure to do so may result in fire or electric shock.
- The tripping of an internal fuse is caused by an internal defect. If damage or malfunction occurs during installation, immediately power off and contact the manufacturer.
- Ensure that the Earth terminal on the input voltage (AC) is connected to ground. For DC installations, ensure that the chassis of the control unit is grounded through the mount point or install a separate ground point.
- Install an external fused operating switch to control power to the So-Rad.
- Secure cabling to prevent damage and trip hazards.

Prohibited actions

- Do not use the built-in fused terminal as primary power on/off mechanism.
- Do not modify or repair the unit or any of its components (see ‘open source provisions’ below)
- No parts should be removed or replaced by unqualified personnel.
- No parts should be overloaded with additional mass, voltage or current.
- Do not open the unit in a wet environment or with wet hands.
- Do not transport, install, perform inspections or form connections to the product while it is connected to power. Doing so may cause electric shock.
- Do not forcibly bend cable, pull cable, pinch cables. This may cause fire or electric shock.

2.1.2. Cautions

Prohibited:

- Do not use the product beyond its specifications. This may cause electric shock, injury or damage to the equipment.
- Keep sensors and cabling attached to the motor enclosure clear of objects that might obstruct free rotational movement. Obstruction may cause damage to cabling.
- Keep body parts clear of the rotation of the motor and attached sensors and cabling.

- Do not disconnect cabling to the motor enclosure when the unit is powered on.
- Do not disconnect the pre-assembled cable conduit between control unit and motor enclosure.

Compulsory:

- When an abnormal operation occurs, immediately cease operation by switching off external power to the equipment. Failure to do so may result in injury, fire, or electric shock.
- Two persons are needed to install the equipment.
- Protect the equipment from excessive water exposure, frost and heat.
- For each deployment and at appropriate intervals, check all cables and seals for wear and maintain good seals.
- Only use software provided by the manufacturer.
- Dispose of the product correctly in accordance with laws and current government regulations.

2.1.3. Open-source and open-device provisions

So-Rad is developed to be an open-source platform. The unit you have received was built to tested specifications. Developers and operators may make changes to the equipment and software to suit their specific needs whilst respecting the CC-BY-NC International license and operational safety. The manufacturer intends to assist in these procedures with technical advice. However, the manufacturer cannot accept responsibility for the proper functioning and safety of the equipment changed by modifications to hardware or software unless tested and adopted in their own specifications. The following notices are provided purely for information to potential developers:

- So-Rad contains moving parts and is classified as an electric motor device under the EC Low Voltage Directive, whilst providing for relevant health and safety precautions listed in the EC Machinery Directive (see Appendix A for compliance notices). Operating safety is ensured programmatically, limiting rotation speed. The combined motor torque and rotation speed are insufficient to cause harm to people working with the equipment. The motor home position and rotation limits are set and tested during manufacturing but can be freely changed by the operator. Changing the 'steps_per_degree' setting in the configuration file can cause the motor to move beyond intended rotational limits (but not speed). On power-up and when restarting the software, the motor returns to home position at medium speed. Any movement following this is at low speed.
- So-Rad is provided by default for 230 VAC input power supply. Internally, the system uses 24 VDC from which 12VDC and 5VDC lines are also powered. It is possible to modify the power supply to 24VDC or 12VDC input by changing the built-in power supply unit to a different type. The manufacturer can provide advice on the selection of an appropriate supply. This work should only be carried out by qualified individuals.
- Do not overclock the Raspberry Pi controller as this may cause overheating.
- Do not connect unapproved devices to the GPIO connector of the controller as this may cause damage to the device. All peripherals connected to the device via any interface (such as GPIO, USB, or other) must be compliant to operational standards within the country of use. Should peripherals not include cables/connectors the used cable/ connector must provide adequate insulation and operation such that the performance and safety requirements are met.
- Do not directly contact the GPIO Pins of the controller to avoid static discharge and damage.
- Warnings and cautions of each individual component are provided by their respective manufacturers. The So-Rad manufacturer can provide copies on request. An overview of these warnings and cautions is also provided in the So-Rad Construction Manual. The latest version of

this document is available on request and a history of published ('frozen') versions is kept at https://doi.org/10.5281/zenodo.4485804.

- Software feature requests and code improvements can be submitted through the So-Rad Github repository at https://github.com/monocle-h2020/so-rad

2.1.4. Intrusion protection

The electronics enclosure has been tested to withstand water intrusion equivalent to IP66. The operator should periodically inspect and maintain good seals around cable glands (front and base of control unit) and mounting points (rear corners), correcting any wear caused by prolonged exposure to the environment. The electronics enclosure should always be installed in the correct orientation (vertically with cable connectors pointing down) to prevent water ingress. If the control unit is the lowest point in the installation, a weep hole may be created at the lowest point of the cable conduit between motor enclosure and control unit, although water ingress from the motor enclosure is highly unlikely. A vent is included in the control unit to regulate pressure and humidity and to prevent internal condensation. It is advised to mount the enclosure in a sheltered location for ease of maintenance and longevity. It is normal for the control unit and motor enclosure to feel warm to the touch.

The motor enclosure has been designed to withstand water intrusion equivalent to IP67. This has been tested with the enclosure submerged without its cable attachments (port blanked off). With cabling attached, water intrusion protection of at least IP66 applies.

2.1.5. Operating conditions

The control unit has a recommended operating range for temperature between 0 - 40°C and relative humidity 20-85%. Internally, the USB hub (40°C) and motor driver (50°C) are least heat-resistant and these should not be moved nearer to other 'hot' components. Temperature and humidity of the control unit, and temperature of the motor unit are monitored during operation and shown in the system log and web interface. The operator is advised to take precautions to prevent exceedance of these limits, by mounting the control unit in a sheltered location and not opening the control unit in wet conditions.

The control unit enclosure is made of A304 grade stainless steel. Bracketry is made of A316 grade stainless steel. For applications where exposure to salt spray is expected, the operator is advised to limit direct exposure of salt water to the control unit and cable connectors to prolong equipment life. Should wear or damage occur, components may be replaced by a qualified professional (see also section 2.1.3 'open device provisions').

2.1.6. Component and assembly compliance testing

All electronical components of the So-Rad assembly were sourced commercially and bear the CE marking. The So-Rad assembly complies with EC regulations for Low Voltage Equipment and Electromagnetic appliances, whilst general product safety and relevant health and safety precautions of the Machinery directive are also adhered to. Testing and assessment reports and general risk assessment are available from the manufacturer on request. A certificate of conformity to EC/UKCA standards is included as Appendix A.

2.2. Technical specifications

Dimensions		Height (mm)	Width (mm)	Depth (mm)	Weight (kg)
Control unit	Enclosure only	400	400	15	13
	With mountings and connectors	420	400	15	
Motor unit	Including sensor holders but without sensors and brackets	560	175 (diameter)		6

Power consumption	max 18 W typical 15 W
Input power	230 VAC (default) 24 VDC (modified on request) 12 VDC* (modified on request)
Recommended external switched fuse	1 A @ 230 VAC 2A @ 24 VDC 3A @ 12 VDC

3. Deployment guide

The following instructions assume installation on a ship.

3.1. Selecting a suitable location for each component

Position of the sensors: The So-Rad motor enclosure is ideally place near the bow of the ship on small vessels, or alongside the front edge, where it can obtain a wide view of the water without influence from spray or ship wake. Avoid mounting the system below or beside tall structures which may cause shading. The downwelling irradiance sensor may be placed further away as convenient where it can receive downwelling light unobstructed.

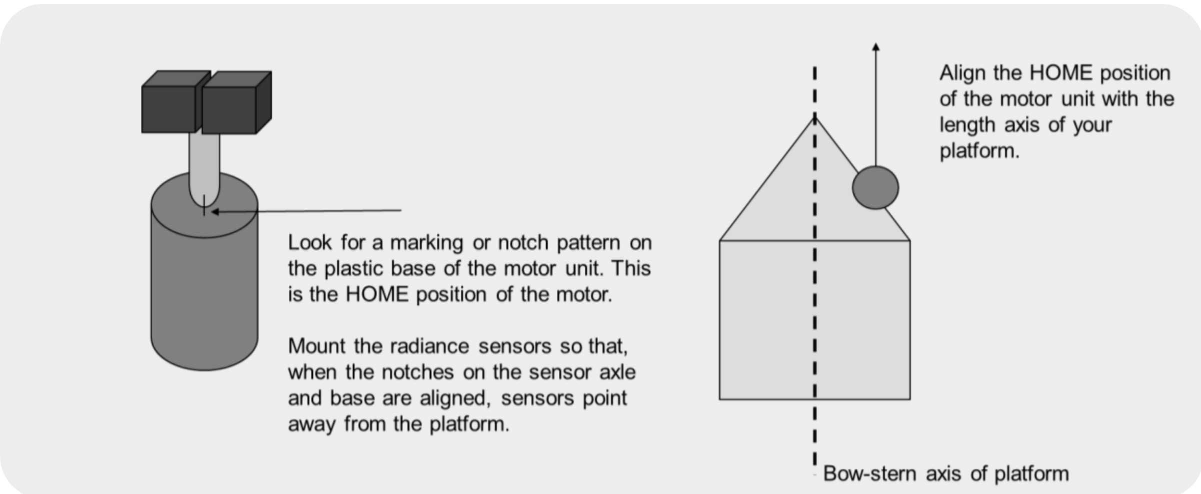


Figure 3: How to align the motor home axis with the ship.

Position of the control unit: So-Rad systems are provided with 2.5m cabling between control unit and motor enclosure by default, or up to 19.5m length on specific request. Sensor cabling for TriOS RAMSES instruments is not included by default, but available at lengths starting from 10m. Extension cables for the sensors are also available starting at 25m length. Refer to the specifications provided by the manufacturer if you are producing your own cabling solution.

The length of the power supply cabling should be considered when deploying a 12VDC or 24VDC modification. Consult an electrician to measure the voltage drop over the supply line and upgrade cabling as required. As a guideline, supplying 12VDC over 15m will require 2.5mm^2 stranded copper wire. The use of rubber sheath cabling is advised in outdoor and particularly marine applications.

Mounting the motor enclosure: because every platform is different you will need to produce a suitable mounting counterpart to the square end plate which terminates the motor enclosure bracket. You may be able to bolt the square end plate directly to a vertical surface. Usually, a clamp to a railing or pipe will be required. The dimensions of the end plate are 200 mm W x 100 mm H. The bolt holes are 170 mm (long edge) and 70 mm (short edge) apart (all measured centre-to-centre). Each hole is 11mm in diameter with the centre located 15mm from each edge.

Two radiance sensors (e.g. TriOS RAMSES ARC) will be mounted on the motor enclosure, one pointing at the water surface and one at the sky. Note that each So-Rad is built for a specific sensor type. From 2022 onwards, this is the TriOS RAMSES G2 (2nd generation) sensors. Older systems may use the TriOS RAMSES G1 sensors. Do not attempt to connect another sensor type than specified in the documentation you received with the So-Rad as this may cause damage to the sensors and the So-Rad. Consult the So-Rad manufacturer for advice if a change is required. The So-Rad software is designed to work with three sensors of the same type only.

An irradiance sensor (e.g. TriOS RAMSES ACC) should be mounted at a suitable location where it cannot be shaded by platform structure (but observe that it remains well below any lightning rods), in the vicinity of the control box. No clamp is provided for the downwelling irradiance sensor. It can be secured (slightly extending above) existing structure such as masts or poles or railing using jubilee clips and rubber sheeting. Scaffolding clamps may also be used but should not be overtightened. Note that scaffolding materials, particularly bolts, may corrode rapidly in marine environments.

There are **two satellite positioning receivers** which should ideally be installed in parallel with the bow-to-stern axis of the platform (gps_offset = 0) or at a straight angle to this (gps_offset = 90). They need not be placed in the centre of the ship but should be parallel or perpendicular to the bow-stern axis. Place them at > 1 m (ideally more) distance from each other (heading accuracy increases with distance between the receivers). A connection diagram is printed on the control unit, or refer to Figure 5 and Figure 11 further below. Observe that the most accurate positioning is achieved when the receivers are mounted at equal height on a flat metal surface without major structures above or around. For example, it is better to allow 1m spacing between the receivers on the metal roof of a cabin than to have them 2m apart but surrounded by plated metal, as this can create bounced satellite signals, decreasing accuracy.

3.2. Installation steps

Tools required: Allen keys, (ratchet) spanners, anti-slip rubber sheet, cable ties, bubble level

1. Install the motor enclosure near the forward bow or along the front-side of the ship, providing the largest unobstructed view of the water surface while avoiding the wake of the ship. Align the ‘home’ axis of the motor housing (normally indicated by a notch on front and/or rear side)

with the ship bow-stern axis by rotating the grey housing, then fasten the bolts. Refer only to the home position marked on the housing, not the position of the sensor holders as these may not be in the home position during installation. When the So-Rad starts, these will align.

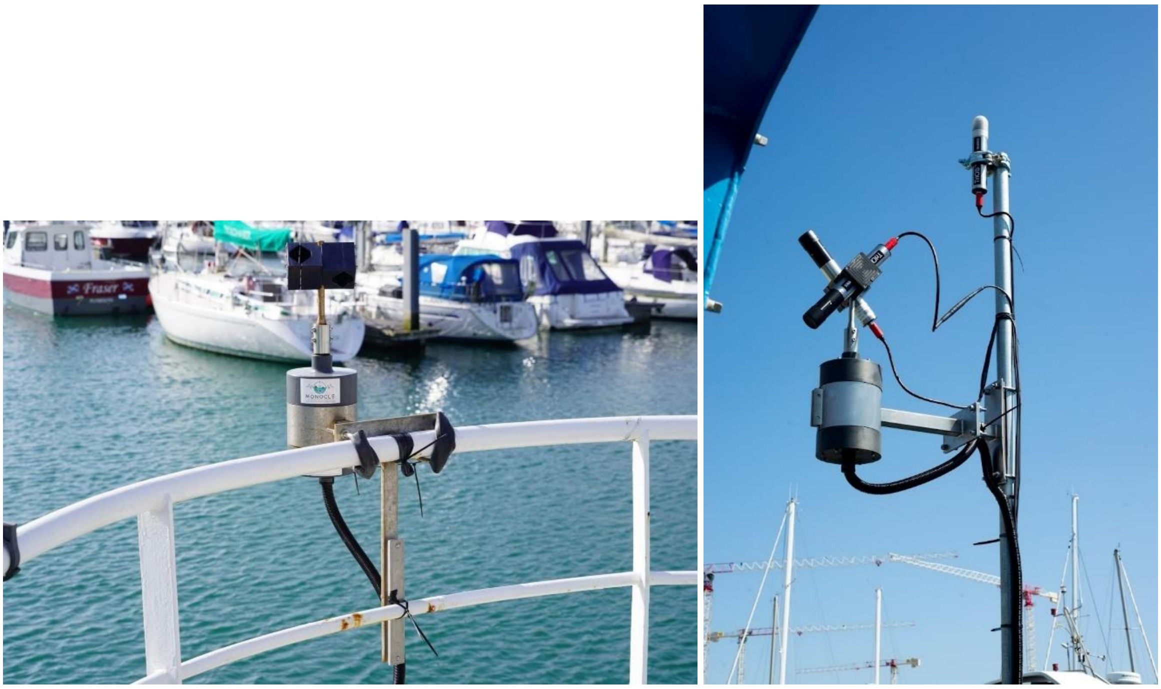


Figure 4: Examples of installed motor enclosure on a horizontal railing and a vertical pole.

2. Attach the radiance sensors to the motor platform. The sensor brackets point at 40 degrees forward angles, either up or down. Do not over-tighten the sensor brackets. To provide grip, wrap a rubber sheet (the inner tube of a bicycle tyre works well) around the sensors to prevent them from slipping and to protect their labelling.
3. Secure cables to the ship to ensure sufficient rotational movement of the sensors while keeping cable loops tight enough to prevent them catching and getting stuck. The motor torque is limited to prevent damage to caught cables, but if motor movement is blocked for more than 5 seconds this will place the motor into alarm mode and the So-Rad will stop taking measurements until movement is cleared and the system is reset.
4. Install the irradiance sensor at a high point on the ship where it is free from shading by any ship structure. This sensor must point straight up (light collector fully level). The sensors and their cabling are interchangeable: any radiometer can be connected to any of the three cables. When using TriOS RAMSES sensors, a scaffolding clamp can be used to secure the irradiance sensor but take care not to over-tighten. For marine deployments use stainless steel jubilee clips.
5. Mount the controller unit using appropriate fastenings. Ensure the position of the control unit is level because the tilt angle of the So-Rad is measured inside the control unit. On ships or buoys, choose a sheltered location or mount a plate between the control unit and the direction of spray.
6. Mount the GPS receivers along the length or width axis of the ship. Observe the diagram shown next to the connectors to place the receivers to the front and rear, or to port and starboard. Both receivers should have an equally unobstructed view of the sky and be mounted on similar surfaces, a metal plate is best as a base. The further the receivers are

placed apart, the higher the accuracy of the ship heading and location. Avoid placing the receivers within 1 m of each other. Secure cables.

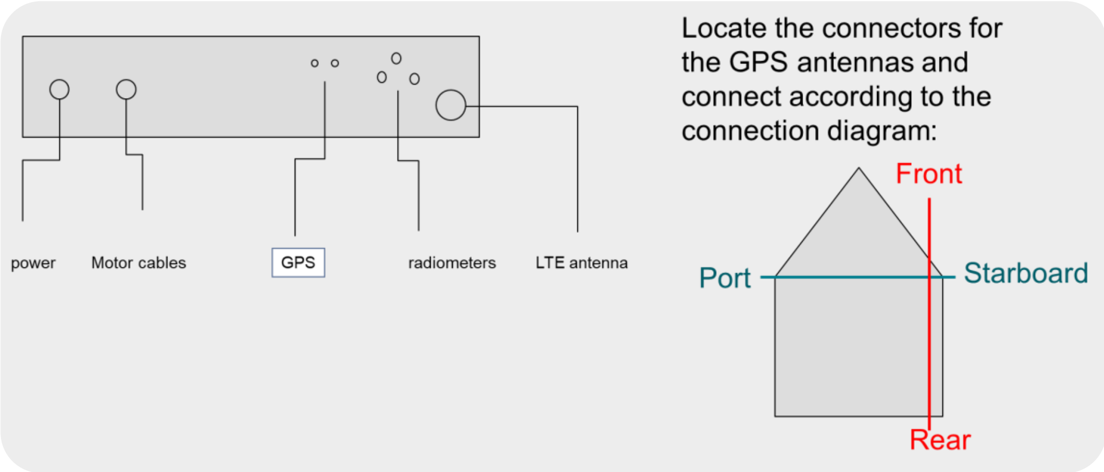


Figure 5: Connecting the GPS antennas

7. Connect any remaining data / communication cables. Before connecting external power ensure that external power supply to the control unit is disconnected.
8. Open the control unit (only in dry conditions) using the key provided and ensure the mains fused terminal switch is in the ON position. Close the control unit and secure from further access.
9. Secure any remaining cables to ship structure using cable ties.
10. Switch on the external power supply to the So-Rad.
11. Connect to the So-Rad web interface using the connection details provided to finish the site-specific configuration.

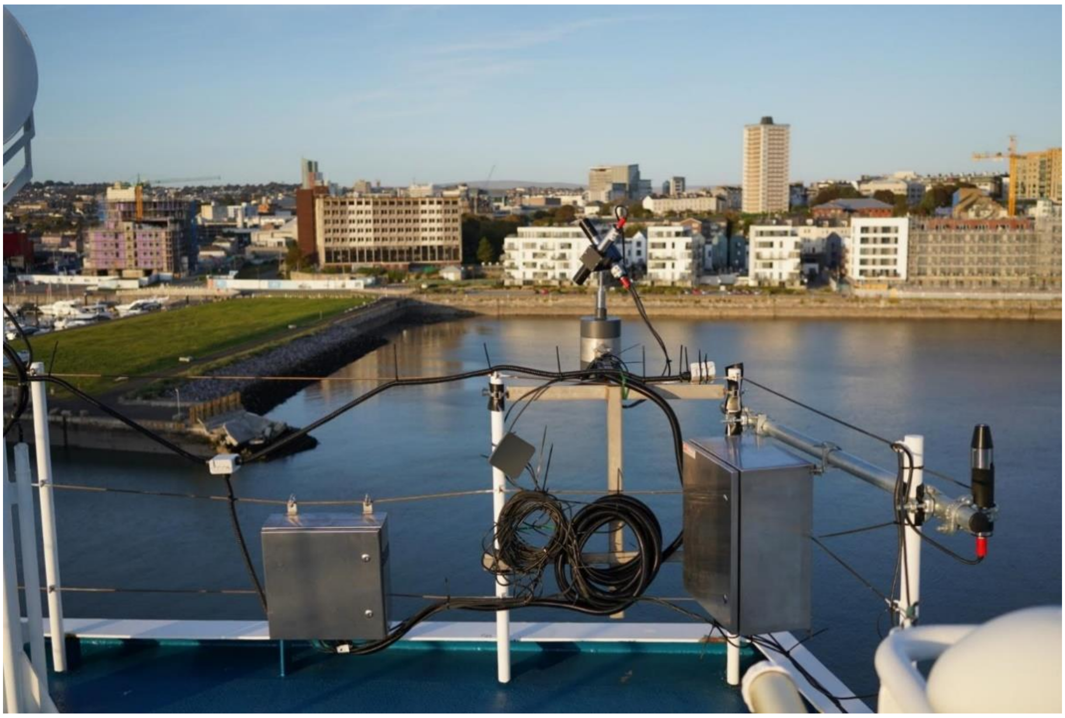


Figure 6: So-Rad installed on the passenger ferry *Armorique* traversing the English Channel between Plymouth (UK) and Roscoff (France). This configuration includes a battery and solar power charger.

3.3. Maintenance

During operation:

- Clean sensor optics daily to weekly with purified water using a wash bottle. Use soft tissue to rub away any persistent fouling.

Prior to deployment:

- A bead of silicon grease should be rubbed onto the seal of the control unit before deployment. This seal should be kept clean and free of debris.

During deployment:

- Ensure that connectors at the bottom of the control unit and motor enclosure have not loosened during transport.
- Use only nuts and bolts made of stainless steel. Marine grade stainless steel is recommended.

3.4. System configuration

3.4.1. Connecting to the web interface

This section contains instructions on the site-specific configuration of the So-Rad using the web interface. The web interface can be reached by connecting to the So-Rad WiFi hotspot or via the internet if the system is configured for remote operation

Connecting via internet (recommended):

1. From your own internet-connected device (PC, tablet, phone) open a browser and navigate to the unique URL for the So-Rad (provided in your system documentation)

Connecting locally:

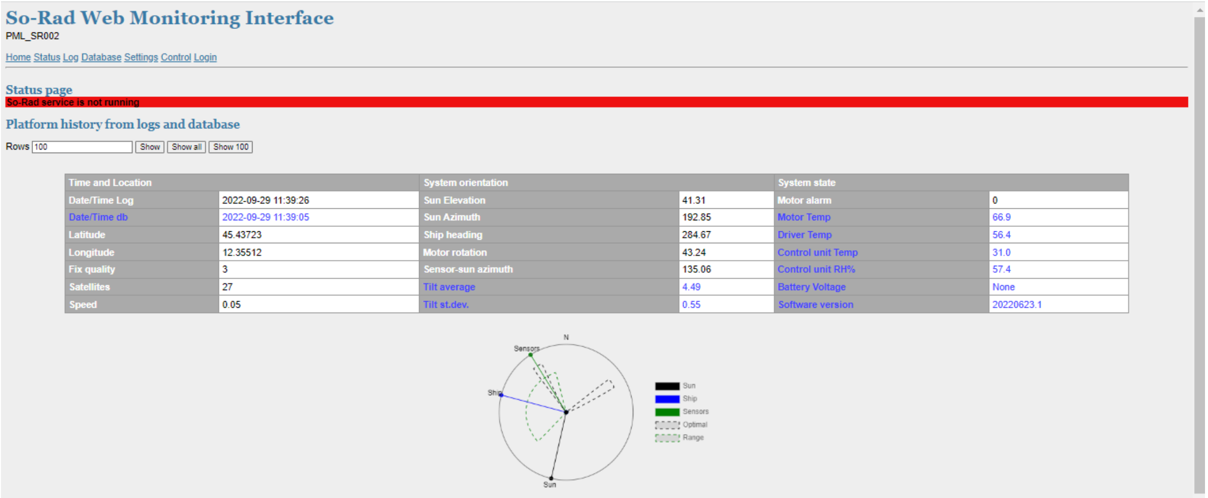
1. Connect to the Wi-Fi network broadcast by your So-Rad (see system documentation)
2. Open a web browser and enter the (static) IP address of the So-Rad (provided, or use an IP scanner).

Once connected, the web interface will show as in Figure 7 below.

Figure 7: Home page of the web interface

The web interface has several menu items from where, during routine operation, system operation can be followed. Note that prior to first use, not all screens may display information as these are read from the built-in database and log files which get populated during use.

Note: the running status of the So-Rad service is shown in several menus. Stopping the service will allow system tests to be carried out and restarting the service will load any new settings. However, the running status of the service does not imply that measurements are carried out, as this depends on (1) the operator entering valid settings; (2) environmental conditions being met; (3) sensors and peripherals being correctly connected. To ensure that the system is operating as intended, refer to the **Status** page (Figure 8) to see when the last measurement was taken and to the **Logs** page to diagnose any errors.



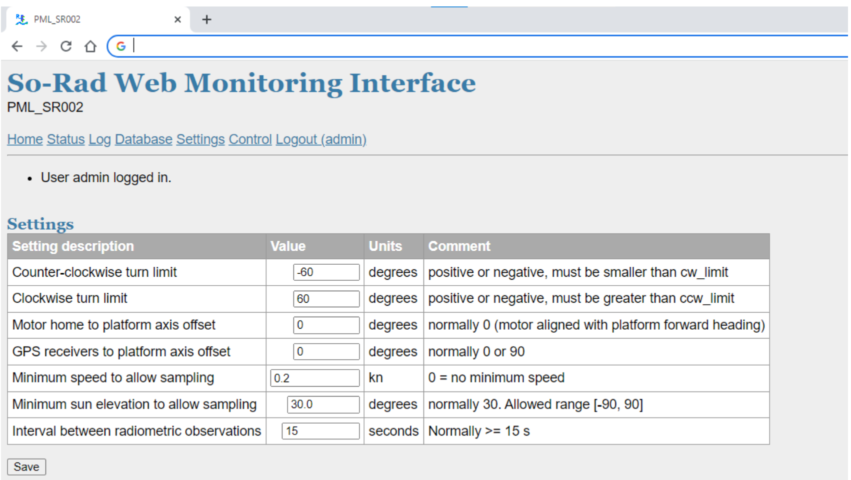
Time and Location		System orientation		System state	
Date/Time Log	2022-09-29 11:39:26	Sun Elevation	41.31	Motor alarm	0
Date/Time db	2022-09-29 11:39:05	Sun Azimuth	192.85	Motor Temp	66.9
Latitude	45.43723	Ship heading	284.67	Driver Temp	56.4
Longitude	12.35512	Motor rotation	43.24	Control unit Temp	31.0
Fix quality	3	Sensor-sun azimuth	135.06	Control unit RH%	57.4
Satellites	27	Tilt average	4.49	Battery Voltage	None
Speed	0.05	Tilt st.dev.	0.55	Software version	20220623.1

Figure 8: Status page

3.4.2. Updating system settings

A password is required to change system settings. This will have been provided with your system documentation. In the menu, click on 'Settings', then enter username 'admin' and the password.

1. Log in through the So-Rad web pages by clicking on a protected pages such as **Settings** (user = *admin*, password provided in system documentation)
2. Update settings as required (see descriptions below) and click **Save**
3. Click on **Control** and select 'Restart So-Rad service' to activate the new settings.



Setting description	Value	Units	Comment
Counter-clockwise turn limit	-60	degrees	positive or negative, must be smaller than cw_limit
Clockwise turn limit	60	degrees	positive or negative, must be greater than ccw_limit
Motor home to platform axis offset	0	degrees	normally 0 (motor aligned with platform forward heading)
GPS receivers to platform axis offset	0	degrees	normally 0 or 90
Minimum speed to allow sampling	0.2	kn	0 = no minimum speed
Minimum sun elevation to allow sampling	30.0	degrees	normally 30. Allowed range [-90, 90]
Interval between radiometric observations	15	seconds	Normally >= 15 s

Figure 9: Settings page (available after logging in as admin user)

Settings per item

Counter-clockwise turn limit and **Clockwise turn limit**: determine the maximum angles of rotation as indicated in Figure 10 below.

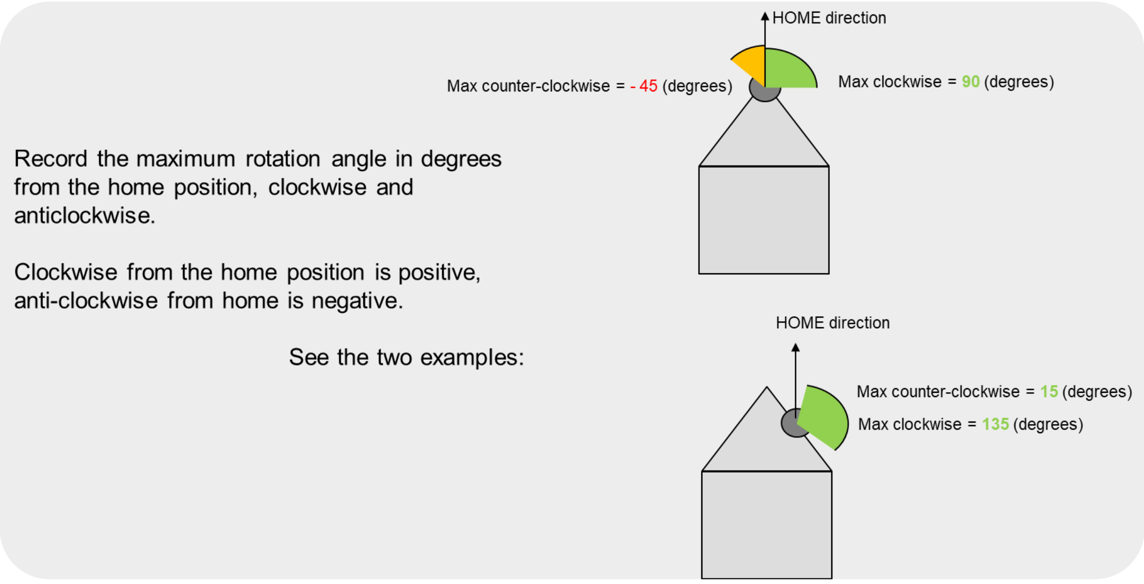


Figure 10: Determining the maximum angles of rotation

Motor home to platform axis offset: This is normally kept zero but can be used to correct for an offset between the motor home direction and the platform bow-stern axis. The sensor and motor rotation status is less straightforward to interpret from log files if this option is used, so it should only be used if the offset cannot be physically corrected by rotating the motor housing, or if the motor home position has been altered programmatically and no longer aligns with the markings on the housing (this programming is normally not available).

GPS receivers to platform axis offset: determine the angle between the GPS receivers and the home direction of the motor/sensors as illustrated in Figure 11 below.

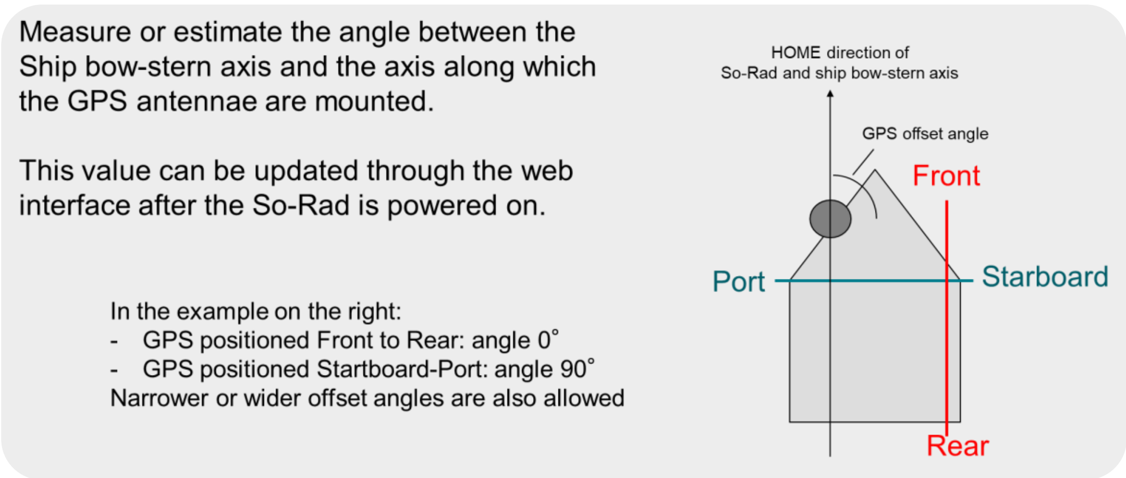


Figure 11: Determine the GPS offset angle

Minimum speed to allow sampling: use this value to specify a lower speed threshold (in knots, i.e. nautical miles per hour) below which the So-Rad will idle. On stationary platforms set this value to 0 (the speed limit will be ignored).

Minimum sun elevation to allow sampling: set this to the sun elevation angle above which sampling will start. The recommended setting is 30 degrees

Interval between radiometric measurements: set to determine the minimum sampling interval in seconds. When the interval has passes and the system is ready (all other threshold conditions satisfied), the system will rotate the sensors to the optimal viewing azimuth and take a new measurement. Note that TriOS RAMSES sensors normally require at least 5 s to complete and download new measurements.

After changing any settings, click **Save** to store the settings in the local configuration file, the next screen will confirm the action. The configuration file is read every time the So-Rad is started. A restart can be forced under the **Control** menu (available to logged in admin user only). Here, the service controlling the operation of the So-Rad can also be stopped (e.g. while configuration takes place). This menu also provides access to several system tests, which most users can ignore. To run any tests, the service must first be stopped. The results of system tests will be shown after the test completes. The control menu can also be used to reboot the control system. The control menu is shown in Figure 12.

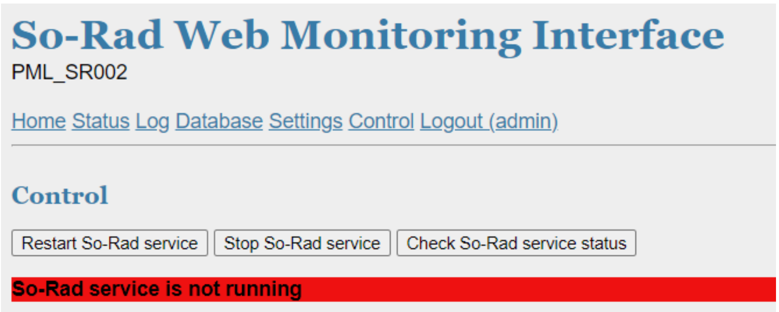


Figure 12: Control menu showing the So-Rad service status

4. System monitoring

4.1. Web interface

See section 3.4.1 for instructions on how to connect to the web interface. The following sections explain the status information available in the **Status** and **Logs** sections of the web interface.

4.1.1. Status page

The **Status** page contains three types of information. The first is a table of the most recent entries in the local database and log file. The selector limits the depth to which the log file is read. Items in white are read from the log file, items in blue are read from the database. When the So-Rad has not yet produced information for each of the fields, the Status page may show a warning message instead.

Status page

So-Rad service is not running

Platform history from logs and database

Rows 100 Show Show all Show 100

Time and Location		System orientation		System state	
Date/Time Log	2022-09-29 11:39:26	Sun Elevation	41.31	Motor alarm	0
Date/Time db	2022-09-29 11:39:05	Sun Azimuth	192.85	Motor Temp	66.9
Latitude	45.43723	Ship heading	284.67	Driver Temp	56.4
Longitude	12.35512	Motor rotation	43.24	Control unit Temp	31.0
Fix quality	3	Sensor-sun azimuth	135.06	Control unit RH%	57.4
Satellites	27	Tilt average	4.49	Battery Voltage	None
Speed	0.05	Tilt st.dev.	0.55	Software version	20220623.1

Figure 13: System state variables table

Following the status table follows a diagram which shows the latest read direction of the ship, sun and sensors. The dashed areas mark the allowable range for sensor rotation (green) and the optimal angles for sun glint avoidance (black).

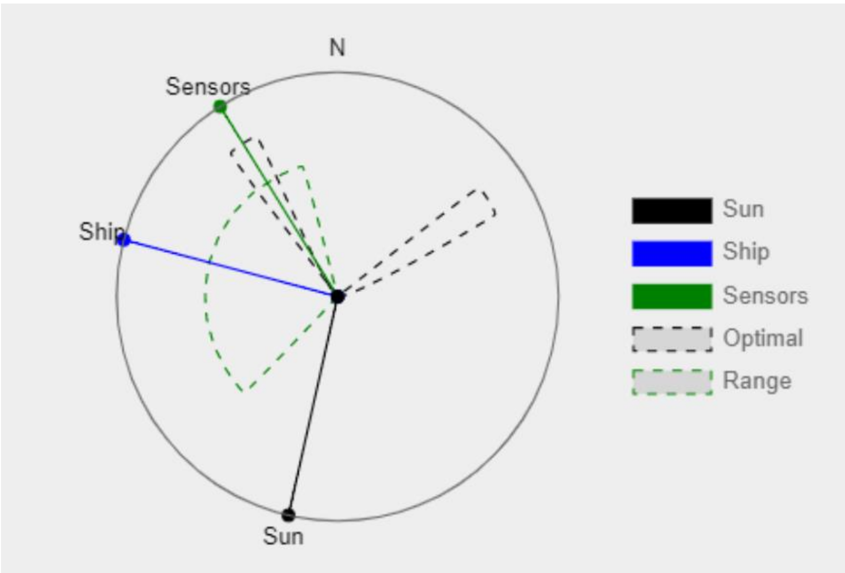


Figure 14: System orientation status diagram

The final section shows the latest entries into the log file on system readiness. This can help to troubleshoot conditions preventing new measurements. In the example shown below, all systems are ready but the conditions for ship speed is not met.

Sampling status (1=Ready, 0=Waiting)						
Time	GPS	Radiometers	Speed	Heading	Motor	[Battery]
2022-09-29 11:39:26	True	True	False	True	True	
2022-09-29 11:39:18	True	True	False	True	True	
2022-09-29 11:39:06	True	True	False	True	True	
2022-09-29 11:39:01	True	True	False	True	True	
2022-09-29 11:38:58	True	True	False	True	True	
2022-09-29 11:38:53	True	True	False	True	True	
2022-09-29 11:38:45	True	True	False	True	True	

Figure 15: Sampling status table

4.1.2. Logs

The **Logs** section shows the latest information written to the So-Rad system log file. The information is given in reverse order with the most recent messages showing first. The logs are particularly useful to quickly determine that the system is running and what it is doing, or to start troubleshooting. For example, the screenshot below shows two anomalies. The first is a critical error indicating the system did not receive a response from the connected sensors. The second is a gps signal interpretation error caused by an incomplete data package (this is common when the system is just starting up).

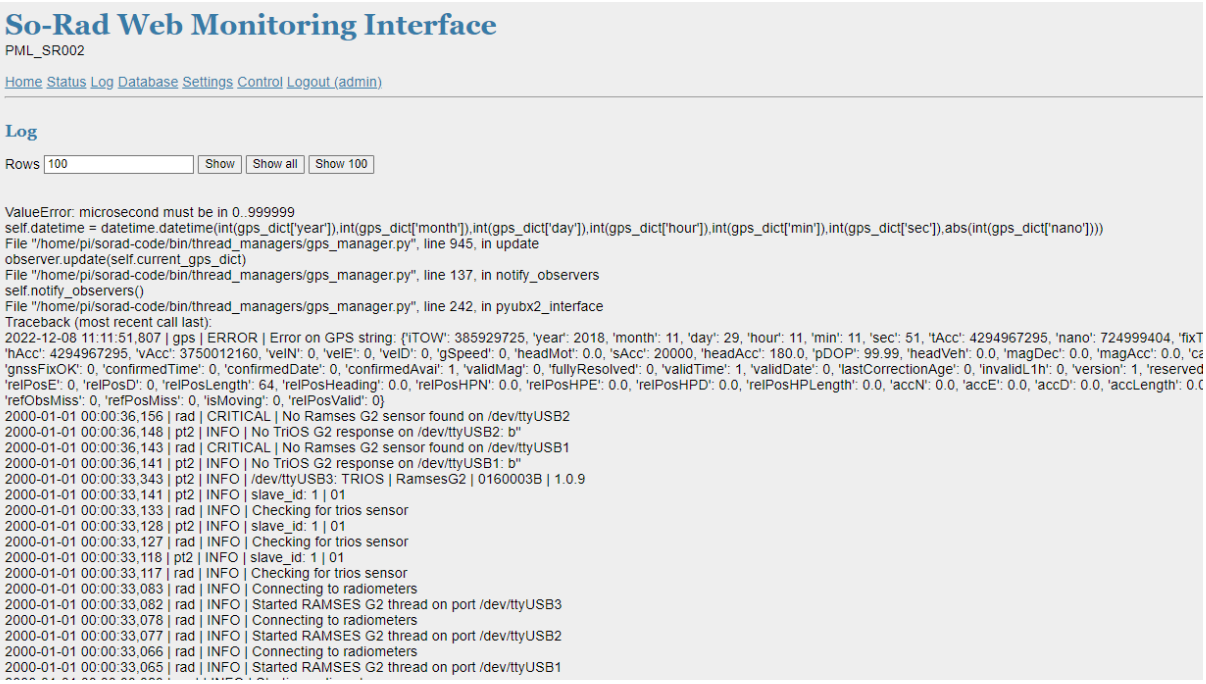


Figure 16: Log page showing the system having trouble starting up.

Under normal operating conditions, the log file will show a repeating cycle of messages indicating system readiness, any completed measurements and reports of data/status upload attempts. Below is an example, sorted by time (on the **Log** page these would be shown in reverse):

```
2022-09-27 07:56:09,859 | main | INFO | 175 | Bat None GPS 1 Head 1 Rad 1 Spd 1 (7.69) Sun 0 (27.63) Tilt 4.32 Motor 1 (0) |
SunAz 125.28 Ship 136.12 Motor 0.00| Fix: 3 (29 sats) | RelViewAz: 10.84 (-> 70.84) | loc: 45.43546 12.36183
2022-09-27 07:56:09,860 | root | INFO | Check cycle completed in 1.874851547000162 s
2022-09-27 07:56:09,880 | root | INFO | 175 | 0 samples pending upload. Waited 53.1 s since last connection attempt
```

```
2022-09-27 07:56:17,398 | main | INFO | 176 | Bat None GPS 1 Head 1 Rad 1 Spd 1 (7.94) Sun 0 (27.64) Tilt 4.62 Motor 1 (0) |
SunAz 125.30 Ship 139.76 Motor 0.00| Fix: 3 (29 sats) | RelViewAz: 14.46 (-> 74.46) | loc: 45.43533 12.36201
2022-09-27 07:56:17,400 | root | INFO | Check cycle completed in 4.4116894929998125 s
2022-09-27 07:56:17,421 | root | INFO | 176 | 0 samples pending upload. Waited 60.7 s since last connection attempt
2022-09-27 07:56:19,663 | root | INFO | 176 | Instrument status update on remote server succeeded
```

Looking at the individual messages tells us the following:

```
2022-09-27 07:56:09,859 | main | INFO | 175 | Bat None GPS 1 Head 1 Rad 1
Spd 1 (7.69) Sun 0 (27.63) Tilt 4.32 Motor 1 (0) | SunAz 125.28 Ship 136.12
Motor 0.00| Fix: 3 (29 sats) | RelViewAz: 10.84 (-> 70.84) | loc: 45.43546
12.36183
```

The first part consists of the logging timestamp, the part of the program reporting (‘main’), the logging level (‘INFO’) and finally a counter (175). The counter increases by one at each cycle of system checks. The counter has no other function than to show which set of messages belong to a single run of the system checks.

The second part of the message contains information on system readiness and some key system variables which determine whether the sensors are pointed in the right viewing direction. Each term is explained as follows:

`Bat None`	Battery status not monitored (no battery connected to this system)
`GPS 1`	GPS information is good
`Head 1`	Heading information is good
`Rad 1`	Radiometers are ready for the next sample
`Spd 1 (7.69)`	Ship speed exceeds the minimum threshold and is currently 7.69 kn.
`Sun 0 (27.63)`	Sun angle limit not met (elevation is 27.63, below the threshold set)
`Tilt 4.32`	Tilt in the last 5-s averaging period was 4.32 degrees
`Motor 1 (0)`	The motor is ready (1) and the error code is 0 (no errors).

The line continues with information about several elements of viewing geometry:

`SunAz 125.28`	The sun azimuth (compass direction) is 125.28 degrees
`Ship 136.12`	The ship azimuth (compass direction) is 136.12 degrees
`Motor 0.00`	The motor rotation angle is 0 degrees (motor is in home position)
`Fix: 3 (29 sats)`	The GPS fix quality is 3, using 29 satellites to provide a solution.
`RelViewAz: 10.84 (-> 70.84)`	The relative viewing azimuth between sensors and sun is 10.84. The best achievable azimuth is 70.84 degrees.
`loc: 45.43546 12.36183`	The current latitude and longitude of the system.

The next line reads:

```
… | 176 | Check cycle completed in 1.874851547000162 s
```

Which tells us that the system cycle took 1.9 s which is typical when no sampling or data uploads take place.

```
… | 0 samples pending upload. Waited 60.7 s since last connection attempt
… | Instrument status update on remote server succeeded
```

These last messages show us that there are no radiometric messages pending upload. However, when 60s have passed without the system reporting to the remote server, a connection is made to broadcast the latest instrument status, and this was successful.

4.2. Dashboard

An instrument activity dashboard is available through the following URL:

https://rsg.pml.ac.uk/dashboards/d/JUzLKd9nz/monocle-so-rad

This dashboard is for high-level system monitoring. The first panel displays a map with the location of the most recent 1000 observations per So-Rad platform (Figure 17). Zooming in and clicking on individual measurements provide some key metadata such as time, speed and tilt.

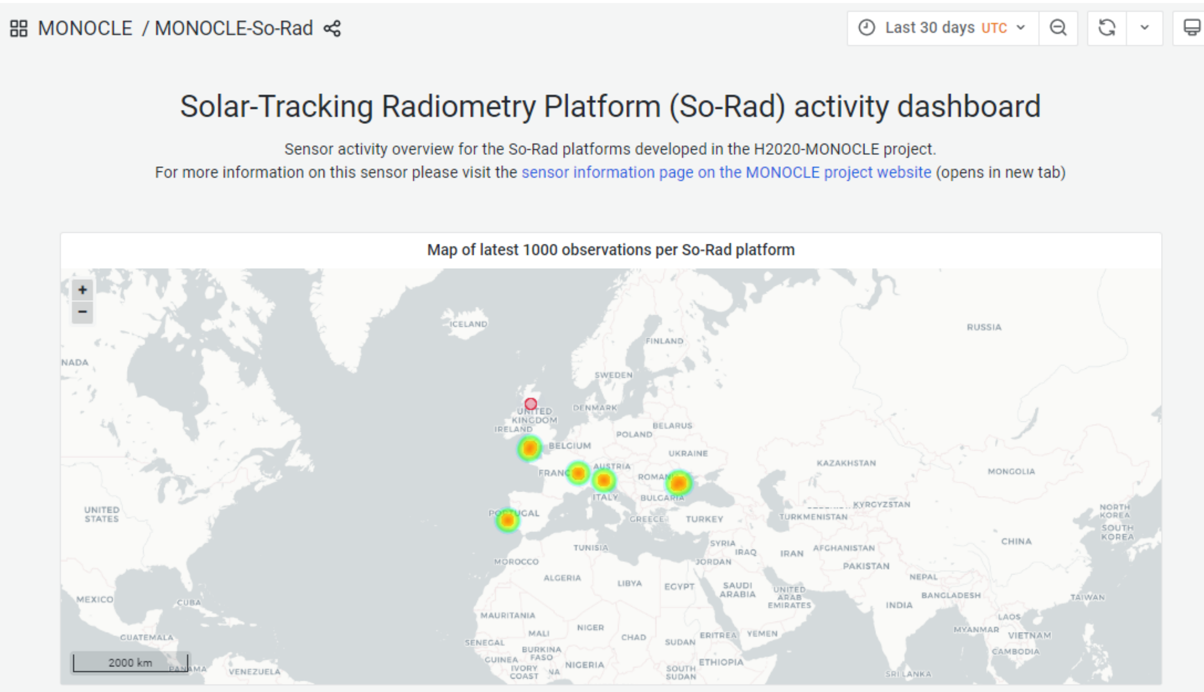


Figure 17: Most recent sampling locations per platform

The next set of panels provide some basic quality control information, such as the achieved viewing azimuth relative to the sun and the platform speed (Figure 18). These graphs are bound by the time selector in the upper-right corner of the dashboard page. Thus, if a platform was not active in this period, no data markers will show. The legend nevertheless returns a positive count for the number of records ‘seen’ by the dashboard.

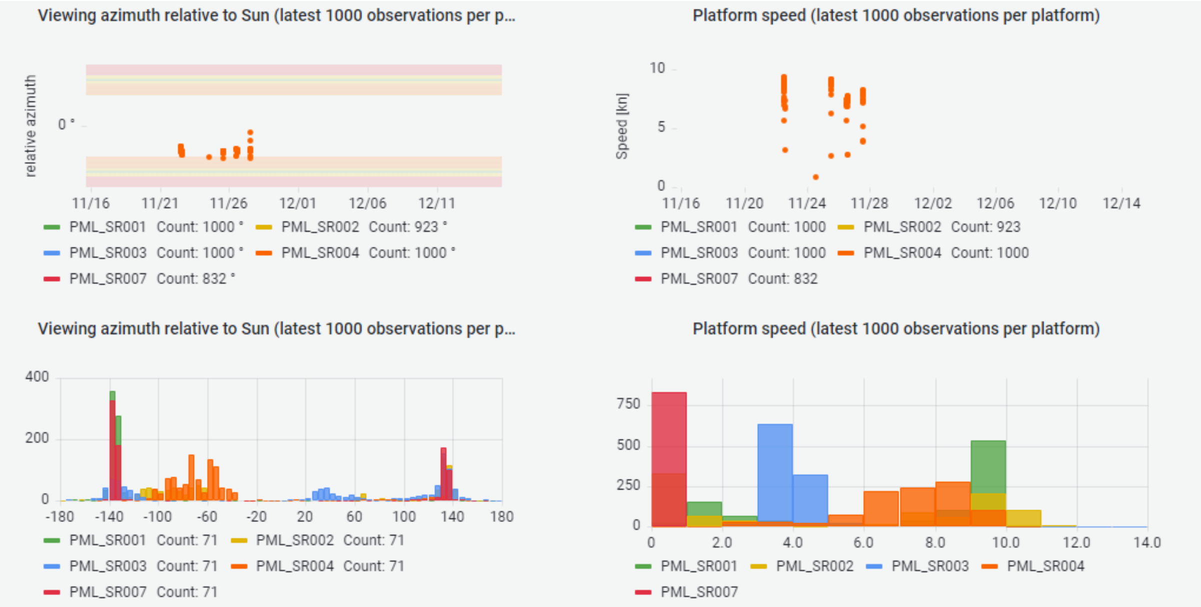


Figure 18: key quality control metrics

The next panels provide an overview of the sum of samples recorded by each instrument platform, grouped by the most recent day, week, month, quarter and year, and for the whole database (Figure 19).

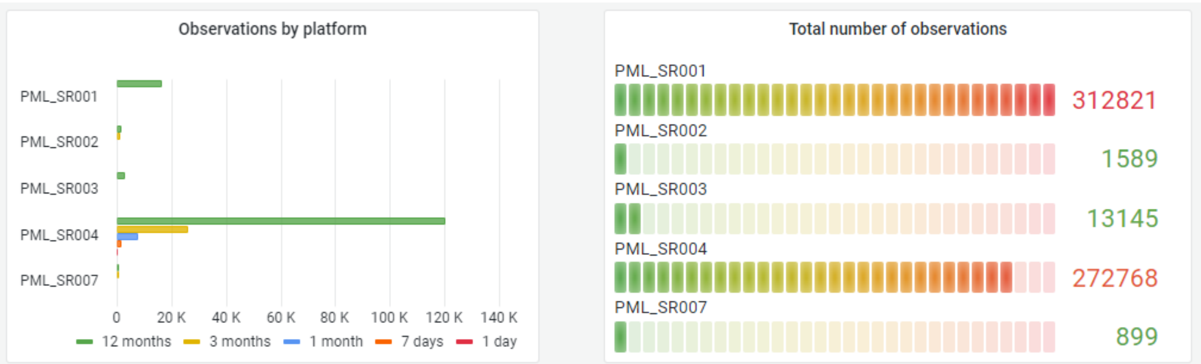


Figure 19: Number of observations per instrument platform

Below the graphical panels is a table from which the latest observations can also be browsed. Note that not all information relating to a measurement is shown through the dashboard.

5. Retrieving data

5.1. Geoserver

Several data layers can be accessed via a Geoserver instance. These layers offer a readily formatted.

At the time of writing, additional interfaces and data services are under development.

Geoserver data layers support the Web Map Service (WMS) and Web Feature Service (WFS) standards.

The front-end is at https://rsg.pml.ac.uk/geoserver/web/

The data layers for the So-Rad can be found by searching for the keyword 'sorad' in the Layer Preview.

Layers include:

rsg:sorad_public_view_fp_rrs	(Rrs from Fingerprint algorithm)
rsg:sorad_public_view_3c_full	(Rrs from 3C algorithm, radiance spectra)
rsg:sorad_public_view_fp_full	(Rrs from FP algorithm, radiance spectra)
rsg:sorad_public_view_meta	(System and location metadata only)
rsg:sorad_public_view_activity	(Activity per instrument platform)

Link to WMS getCapabilities: https://rsg.pml.ac.uk/geoserver/wms?request=getCapabilities

Link to WFS getCapabilities: https://rsg.pml.ac.uk/geoserver/wfs?request=getCapabilities

5.2. MONDA

A package for Python 3.8 and up is available through the Python Package Index (Pypi) to help get started with programmatic download of So-Rad data, as long as the data are registered in the back-end service with a public license. MONDA uses the Geoserver layers through the WFS standard to retrieve So-Rad data.

Please refer to https://pypi.org/project/monda/ for instructions. The package is maintained through https://github.com/monocle-h2020/MONDA.

Appendix A

Declaration of Conformity

CE UKCA

We,	Plymouth Marine Laboratory Prospect Place Plymouth PL1 3DH United Kingdom
declare that the product	Solar-tracking Radiometry Platform (So-Rad) Identifiers: PML-SR*[XXX]*
is in conformity with Council Directives	**2014/30/EU (EMC Directive)** **2014/53/EU (RE Directive)**

Based on testing carried out during August 2022.

Dated standards to which conformity is declared:

Standard	Description
EN 301 489-1 V2.2.3 (2019/11)	Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 246 GHz
EN 55032: 2015	Conducted RF Emissions
EN 55032: 2015	Radiated Emissions
EN 61000-4-2: 2009	Electrostatic Discharge
EN 61000-4-3: 2006 A1 A2	Radiated RF Immunity 80 MHz to 6GHz
EN 61000-4-4: 2012	Fast Transient and Burst Immunity
EN 61000-4-5: 2014 A1	Surge Immunity
EN 61000-4-6: 2014	Conducted RF Immunity
EN 61000-4-11: 2004	Mains Dips and Interruptions
EN 61000-3-2: 2014	Harmonics
EN 61000-3-3: 2013	Flicker
EN 300-328 V2.2.2 (2019-07)	Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz band
4.3.1.10	Spurious Emissions (limited to 6 GHz)
4.3.2.2	Output power (e.i.r.p)
EN 60945: 2002	Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results
EN 60945 : 2002	Conducted RF Emissions 10 kHz to 30 MHz
EN 60945 : 2002	Magnetic Radiated Emissions 150 kHz to 30 MHz
EN 60945 : 2002	Radiated Emissions 30 MHz to 2 GHz

The manufacturer also declares the conformity of above-mentioned product with the actual required safety standards in accordance with **2014/35/EU (Low-voltage directive)** and relevant health and safety precautions of the **2006/42/EC (Machinery directive)** regarding Type B apparatus (EN 14118:2018).

Signed by the manufacturer:

Date: 17 January 2023

Name: Professor J Icarus Allen
Title: Chief Executive
Signature:

PML | Plymouth Marine Laboratory