Windsond S2

User manual

Windsond from Sparv Embedded AB is a novel weather sounding system for an immediate view of local conditions at different altitudes. A single person can bring the complete system to any location and do a sounding within minutes. Sondes with the ‘reusable’ option are easy to recover and reuse, which lowers operating costs drastically.

Multiple soundings can be active simultaneously and multiple ground stations can receive the measurements and control the soundings. The included computer software visualizes measurements in real-time and gives the operator easy control over the sounding.

The “S2” model is the second generation of sondes with many improvements over the S1 model, including lower weight, simplified operation and more robust radio link. S2 uses the new radio receiver RR4.

Tips and warnings

- Test the system before going on an important first mission!
- We recommend to not use Windsond near densely populated areas.
- Observe any local regulations on the release of unmanned balloons and assure there is no risk of mid-air collisions with aircrafts. Some areas have special restrictions of the airspace.
- The sonde contains a bright LED. Don’t hold the sonde closer than 20 cm to any eyes when it is flashing.
- Helium is a safe gas to use. If using hydrogen instead, make sure to follow hydrogen safety guidelines.
- For most accurate temperature readings close to the ground, keep the sonde in shade until launch (but with a view of the sky for GPS). The temperature sensor needs to be ventilated by the air flow to avoid reading elevated temperature due to solar radiation.
- The sonde arm and solar radiation shield are fragile. Treat with care, avoid bending and inspect for damage before launch.
- The top of the enclosed body houses the GPS. Don’t hold this area of the sonde.
- The spool must be removed before the sonde can measure T and RH correctly.
- The sonde is ESD sensitive -- the electronics may be damaged by built-up electrical charge if touched.

Needed parts

- A canister of helium
- A laptop running Windows, preferably with internet connection
- For reusable sondes: A vehicle for retrieving the sonde again
- For reusable sondes: GPS device to navigate to the sonde landing coordinates

Installation

Install the Windsond Desktop software and license file, and verify the contact with the RR4 receiver.

Optional: Install Google Earth for desktop to display maps:
https://www.google.com/earth/about/versions/#download-pro

Preparing the launch

Decide and set the RR4 radio parameters through the software. To update these settings for the sondes, connect each sonde to RR4 with the black cable. Verify that RR4 receives radio packets from the sonde.

Optional: Keep the sonde connected to RR4 with the included black cable to charge the sonde battery. If the sonde battery is completely discharged, charging takes 90 minutes. S2 may be stored in a charged state for several months before the sounding.
⚠ S2 will not charge in freezing temperatures or above +45 ℃.

Connect the antenna to RR4, without tightening the SMA connector hard. The magnetic base antenna gives better reception than the stub antenna. The magnetic antenna works best when placed in the middle of a metallic surface such as a car roof.

Planning the launch site
A tool like https://predict.sondehub.org/ can help to plan the sonde trajectory. (Fill in the Descent Rate 8 m/s in the tool.) Make sure to follow local and airspace regulations. When possible, plan the landing at a safe distance from buildings.

Using multiple sondes

Multiple sondes can be used at the same time, with some restrictions. This includes any previously launched sondes that can still be heard over radio.

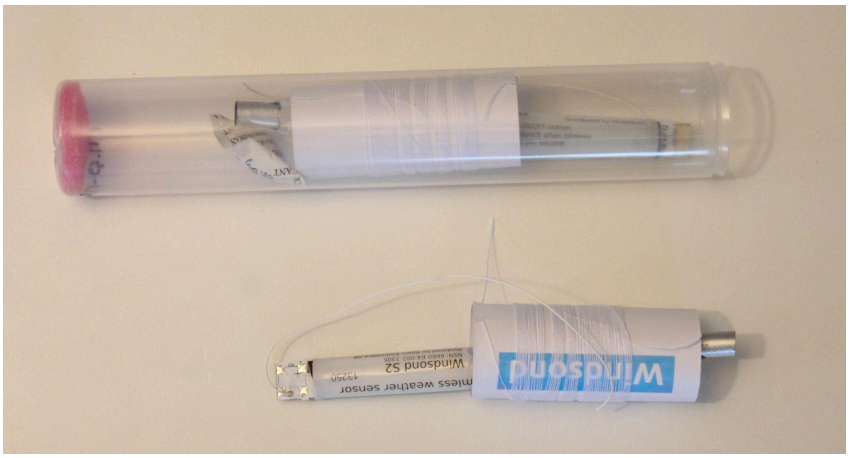
Timeslots: The sondes use timeslots to not transmit at the same time. A sonde will occupy its timeslot from the time it's turned on until it lands – not only during the sounding ascent.
The number of timeslots can be configured for the RR4, in the range 1-126. The default setting is 3 timeslots, for a maximum of 3 simultaneously transmitting sondes. To

change these or other radio settings, first contact Sparv to properly understand the ramifications. When the settings are changed, it's necessary to connect each sonde to RR4 via the cable, and run the software. This will update the sonde settings to those of the RR4. Then the sondes can be used immediately, or be turned off for later use.

Sonde ID: To use multiple sondes the sondes need to have compatible Sonde IDs. The easiest way to assure this is to only combine sondes with consecutive[1] IDs and not turning on more sondes than timeslots. With the default setting of 3 timeslots, For example, this means the sondes with IDs 100, 101 and 102 can be turned on simultaneously, but not 100, 101 and 103 as that leaves a gap in the number series. If the sonde IDs are not compatible then radio packets from one sonde may be interpreted as coming from another sonde.

GPS fix: In order to synchronize their transmissions the sondes need to have a GPS fix. Before a GPS fix some packets may be lost or not even transmitted at all, depending on a setting. When the sondes have a GPS fix, they blink in synchronization.

How to launch



1. **Unpack:** Remove a S2 from the transparent plastic tube. Straighten the antenna to point away from the sonde. Inspect the radiation shield for damage. It's recommended to keep the spool over the parasol, as shipped.
2. Connect RR4 to the PC, start it and start the Windows software "Windsond".
3. **Start:** Press the button to start the sonde.

[1] The exact constraint is that all the Sonde IDs modulo the number of timeslots are unique.

The button is a pressure-sensitive spot “ ” next to the label “ON/OFF”. To reach the button, the spool might need to be pushed up slightly. The sonde blinks green and white once when it starts. For reusable sondes, the sonde also beeps when starting.

⚠ If the sonde reacts differently, see the troubleshooting” section.

4. Optional: Connect the sonde to RR4 with the included black cable to charge the battery. This is required to also set the S2 radio settings to match RR4, if not synchronized since before.

   ⚠ The white connector must be inserted straight to avoid bending the pins.

5. Inflate the helium balloon and seal it. As a starting point, inflating the supplied 9 gram balloon with helium to 120-123 cm circumference gives a rise rate of 2 m/s.

   ⚠ It is not safe to use hydrogen with the reusable sondes!

6. Dislodge the tether line from the two cuts in the spool and pull out enough line to tie it to the balloon.

7. **Wait for ready:** The sonde blinks with two green flashes every 5 seconds while waiting for a GPS fix and the ground station. Make sure the sonde has a good view of the sky.

If S2 is connected to RR4 by cable (optional): If RR4 has a GPS fix, it will transfer GPS data to S2 to speed up the S2 GPS acquisition time. The RR4 “sonde status” LED will also show if the sonde is ready.

   The sonde is ready for launch when it blinks green once per second. Reusable sondes will also beep every five seconds when ready for launch.

   ⚠ Check the status panel in the software to verify all subsystems are green before proceeding, to avoid losing the sonde during flight.

8. **Unwind:** Hold the spool and let the balloon pull on the tether line to unspool the line. With this technique, there’s no risk of yanking on the balloon since the sonde will be automatically pulled up and launched when the tether is fully unspooled. See the separate S2 launch guide’ document for this suggested technique.

   ⚠ Do not unwind the line onto the ground -- it will easily snag and tangle.

   ⚠ Be careful not to let the sonde swing and hit anything on the ground before the balloon lifts the sonde.

If aborting the launch, turn off the sonde by pressing the button again. The sonde will flash green quickly during one second to signal that it is turning off.

⚠ If the sonde isn't turned off, it will drain the battery and must be charged again before the next sounding.

Balloon

Sparv offers two standard balloon sizes, but Windsond works with other balloons too. Balloons are normally made from latex. These expand as they ascend, since the gas expands as the pressure decreases with altitude. At altitude 5500 m (18000 ft), the pressure is halved and the balloon has double the volume. Over-inflating the balloon might make it burst before the peak altitude.

Balloon storage

Optimum storage temperature is 20 to 22 degrees Celsius. Keep balloons away from any heat sources, such as motors and hot water pipes. Do not store balloons in a vehicle or garage where temperatures fluctuate. Balloons should be kept away from direct light sources, such as sunlight, incandescent lights, and fluorescent lights. The balloons can be used for many years if properly stored, but we recommend using the balloons within a year after delivery.

Reusable sondes

This section is for reusable sondes (with -R in the article number). It doesn't apply to single-use sondes or dropsondes.

Picking the landing location

There are two different conditions that each will cause the sonde to detach from the balloon thread and fall to the ground:

- The sonde exceeds the programmed cut-down altitude AGL for a couple of seconds
- The user sends a manual cut-down command

During the flight, Windsond Desktop predicts the landing location from ascent rate, wind conditions and from the assumed future fall speed. Predictions are given after the sonde ascends above 60 m AGL. The landing location of an immediate cut-down is predicted with an accuracy generally better than 50 m. This accuracy mostly depends on predicting the right fall speed (configured in menu File -> Settings). Predictions of landing locations are also given on Google Earth for some higher cut-down altitudes and for the currently set cut-down altitude. These assume the current wind direction and speed will prevail at higher altitudes. Since the wind probably changes to some degree at higher altitudes, keep an eye on how the predictions change with time.

Behavior after landing

Using the Windsond software, reusable sondes can be configured to behave in one of two ways after landing.

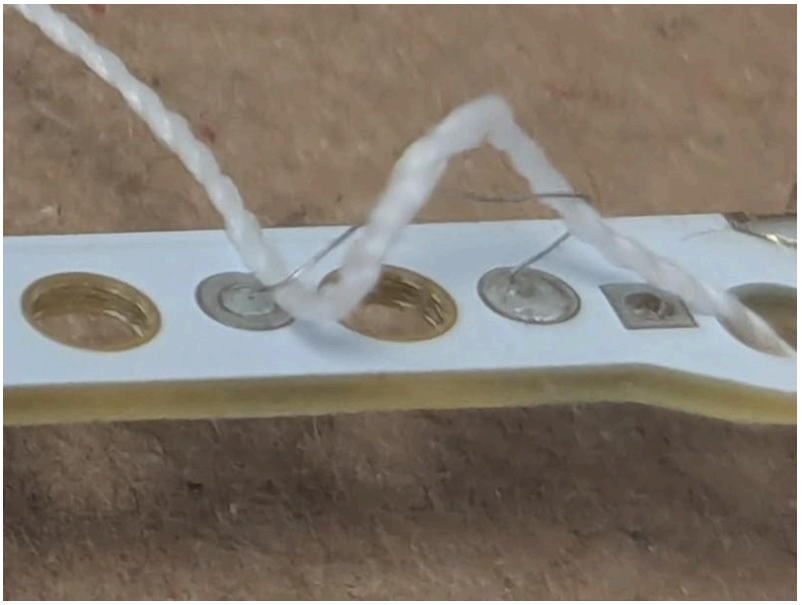
Beacon at once: Starts beeping and blinking automatically when the sonde lands. Beeps and blinks every 5 seconds for 45 minutes, then every 15 seconds for three hours. Since the beacon mode consumes a lot of power, the sonde enters the "silent" mode to save power if not recovered after 3:45 hours. This mode has a maximum lifetime of 20.8 hours, but the time is reduced by the preceding sounding.

Silent: The sonde doesn't beep or blink. It only transmits a radio signal every 20 seconds. If the receiver and software pick up the signal, they will automatically send back a signal to the sonde, requesting the sonde to switch to the beacon mode. This requires the software to be running. Silent mode is expected to last ~60 hours with a fully charged battery. After a sounding, the silent mode lifetime depends on how much energy the sonde expended during the preceding launch and flight.

Preparing sondes for the next launch

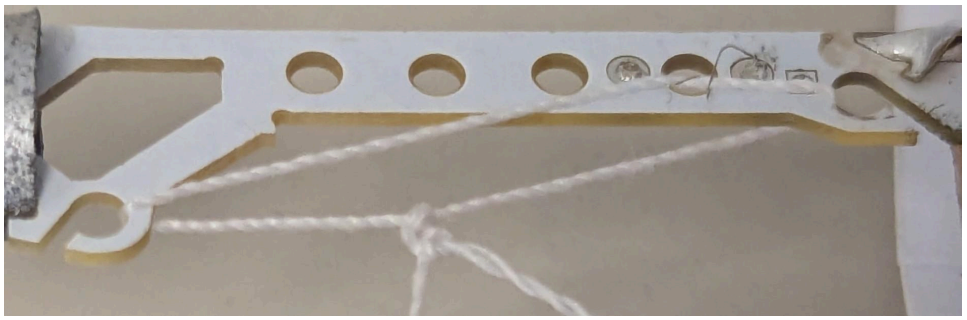
Measure five meters of the included thread, to use as a new tether line. It's recommended to use the thread supplied with the sondes, as other threads may be harder for the sonde to detach from.

Thread the new tether line twice around the thin metal wire. Run the thread through the open loops. Tie the thread to itself (not to the sonde) so the metal wire can disconnect the tether from the sonde when it severs the tether. Tie the tether line tightly so that it doesn't come loose through the open loops. Use double knots.



How to wind the tether around the metal wire.

The tightened tether line is twisted around the metal wire.



The tether line is tightly tied between the two open loops.

Charge the battery again by connecting the sonde to RR4 and turning on RR4. RR4 can be powered over USB from a computer (or power bank) or it can use its internal battery. A full charge takes about 90 minutes and the RR4 battery has the capacity to charge about 5 S2's. RR4 will not charge the sonde outside the allowed 0~+45 ℃ range.

Inspect the parasol before reuse. A damaged parasol can cause the falling sonde to gain a speed that is dangerous on landing.

Tethersonde

Normal radiosondes react to changes in pressure by starting a sounding cycle. A sonde can be given the role tethersonde to disable this behaviour. This also makes it so that the sonde movement is not equal to the wind. The role can be set in Windsond Desktop while the sonde is connected via a cable.

Sondes with onboard logging

This section is for sondes with onboard logging (with -N64 in the article number).

To load data from the sonde you will need Sparvio Logger. Then connect the sonde via RR4 or SA1. In Sparvio logger you will then go to the settings tab and select the COM port in the dropdown for SA1 or RR4 (marked as SA1 adapter in older versions of Sparvio Logger). You can then go to the logs tab and load the data.

Troubleshooting

Symptom	**Cause and remedy**
No white flash at start. Quick green blinking and then no more response.	The sonde has too low battery charge to recommend doing a sounding.
Green flashes five times per second.	There is a hardware fault. It's unlikely the sonde will recover by itself.
No response at all when pressing the button.	The sonde is out of battery or broken. Try connecting to a turned on RR4 with the cable.
No response at all when connecting to the RR4 cable.	The sonde is broken or RR4 is out of battery.
Other issues	Try upgrading Windsond Desktop using the "Check for updates" menu item. If this doesn't help, contact support@sparvembedded.com.

Windsond Desktop

Soundings can be viewed in the Windsond Desktop application.

When the software gains contact with a new sonde a window dedicated to the sonde pops up. The sonde window features a number of tabs to display various aspects of the sonde and the sounding. Above the tabs there is a status text in bold font, showing the current state of the sonde. Closing the Receiver window will close the application and should not be done until the sounding is complete.

The File menu of the Receiver window contains options to load the data of a previous sounding, to view the ongoing flight path in Google Earth and change various settings such as units of metrics.

Among other things, the Settings dialog offers a list of output formats to generate for soundings, in addition to the proprietary .sounding file format. Users can also define their own export formats. The file fileformat_template.csv.txt contains instructions on how to define custom file formats. The template is found in the directory Windsond was installed in.

Multiple sondes are supported. Each started sonde will open a window specific to that sonde. The window is named by the first time of contact. When opening a previous sounding, a control panel is also shown, supporting start/pause and jumping in the series of received data.

It is recommended to install Google Earth to be able to predict the landing location on a map. Test Google Earth before the first sounding, using a sample sounding file to make sure it works as expected. A sample sounding is included in the Windsond Desktop installation directory.

Windsond Desktop can also use the OziExplorer mapping software for visualization.

Google Earth

Google Earth is available as a free download from
https://www.google.com/earth/about/versions/#download-pro

Windsond Desktop creates a file windsond_live.kml with three-dimensional tracks of all ongoing soundings and loaded files. For ongoing soundings with reusable sondes, some predicted landing sites are marked on the map to help plan for a suitable landing.

The KML file is loaded into Google Earth by the main window menu option "Google Earth live view". This requires Google Earth to be installed and associated with the KML file suffix (as it is per default).

The file windsond_live.kml makes Google Earth regularly load another file which lists the active sondes. Each sonde is in turn a separate file, reloaded every five seconds. Inside Google Earth, it might be necessary to double-click windsond_live.kml in the Places panel to focus on the flight.

There are three options for accessing map materials, to help plan the landing location:

- With a mobile internet connection, Google Earth downloads the needed maps automatically
- Recently viewed areas are remembered ("cached") so scrolling through the area in advance can preserve those maps once the internet connection is out of reach.
- Google Earth can load and project other maps to become independent of internet data, but such maps have to be acquired somehow.

OziExplorer

Windsond supports the mapping software OziExplorer for visualization. Enable this in the Settings dialog, then start OziExplorer manually. OziExplorer has better support for offline maps than Google Earth.

OziExplorer is available to buy from http://www.oziexplorer.com.

Time & Date

Windsond Desktop uses the computer date, time, and timezone. So in case the time does not match the timezone on the computer running Windsond Desktop it is possible to get incorrect times, but the relative times will still be correct.

Sonde modes

The sonde goes through a few “modes” during a sounding. Here is a brief description of them. The modes are described for the scenario of a normal radiosonde, not a tethersonde or dropsonde.

Init The sonde is on but does not have a GPS fix and is not ready for launch.
Ready The sonde has received a GPS fix and is ready for launch.
Rising The sonde has detected a launch and is rising.
Cutdown The sonde is cutting of the tether.
Falling The sonde has detected a fall and is falling.
On ground, beeping See the behavior after landing chapter.
On ground, sometimes beeping See the behavior after landing chapter.
On ground, silent See the behavior after landing chapter.

Storage

New sondes have the battery charged to 40% as is recommended for storage and shipping. This is often enough for a sounding. The battery depletes by about 1% per month, depending on storage temperature. A storage temperature of 5~20 ℃ is preferred if keeping the charge is important.
As the battery size is optimized to last for a full sounding without carrying too much unused capacity, it is recommended to top up the battery before launch when the sonde has been stored for an extended period.

Physical overview

At the top of the sonde, a reflective solar radiation shield houses the temperature and humidity sensors.

The antenna points down towards the ground. A 5 meter tether line connects the sonde arm to a helium balloon. Reusable sondes can cut off the tether line by melting it with electric current, to fall down before the balloon bursts from high altitude.
A “parasol” of white plastics attached to the top of the body helps to slow the fall of the sonde, to save the sonde and objects on the ground from damage upon landing. The parasol wraps around the body during storage.

Environmental considerations

Windsond does not contain materials harmful to the natural environment. Neither battery nor electronics components contain heavy metals. The latex balloons used are biodegradable. We ask our users to recover and dispose of the sondes when possible.

GNSS jamming and spoofing detection

Jamming is someone maliciously transmitting noise in the GNSS radio frequency band, drowning out the weak satellite signals and preventing any receivers in the vicinity from acquiring a GNSS fix. **Spoofing** means to generate false GNSS signals, making any listening receivers deduce erroneous locations.

The Windsond software can attempt to detect GNSS signal jamming and spoofing attempts and warn the user. The detection can be enabled in the settings. The detection is done in two ways:
1. Reporting detection from the S2 GNSS chip
2. Software detection by looking at inconsistent position or altitude changes or values

The software detection looks for any of these signs:

- If the sondes ever seem to have an unreasonable velocity
- If the distance between two positions that are reported within 15 minutes of each other would require a velocity exceeding 75 m/s
- If the pressure altitude and the GNSS altitude differ by more than 2000m
- If the vertical velocity from pressure differs from the one from GNSS by more than 50 m/s.

If Windsond detects suspected spoofing this will be shown in the GNSS status field, as well as in the header of the sounding window in Windsond Desktop. This works both for live soundings and loaded .sounding files. Output files are still generated based on the received data.

It is possible to get false positives; for example if the signal gets weak due to moving indoors, this might be mistaken as GNSS jamming. False negatives are also possible, where actual spoofing or jamming is not detected. It is up to the user to judge if spoofing is actually happening and treat the data appropriately.

Firmware Upgrade

Note that you must use a version of Windsond Desktop that is at least as new as the firmware of S2 and RR4. You can however use newer Windsond Desktop.

The firmware on the sonde can be upgraded using SA1 and Sparvio App. First connect the SA1's USB connection to a computer running Sparvio App. Then connect the sonde to the SA1 using the blue SSP-I2C cables. Then go to the Firmware upgrade tab in Sparvio App. You then put the sonde in bootloader mode by pressing the button in Sparvio App. And then you press the upgrade button. Finally press the "Exit bootloader" button in Sparvio App. The firmware version listed in Sparvio App will now be the latest version!

Disclaimers

Sparv Embedded and its employees are not liable for any direct or indirect losses or damages arising from the use of Windsond, with causes including but not limited to measurement errors, equipment failure or misuse.

Contact

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