Sonde-Pi Receiver User Manual

Version 1.0

For any questions on the information in the User Manual, bug reports, and comments, please contact Alex Fritz (alex.fritz@noaa.gov)

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I. SONDE-PI OVERVIEW

The Sonde-Pi receiver is a small, portable hardware alternative to SkySonde Server that does not require a Windows computer to capture data from a radiosonde flight. **Note: SkySonde Client will still be required to view instrument data for flight preparation and during the flight.** It operates on 5V or 12VDC power and possesses all of SkySonde Server's key components. The Sonde-Pi consists of a Raspberry Pi (RPi), a power management and Real Time Clock (RTC) board, an Organic Light-Emitting Diode (OLED) screen, and cooling fan mounted in a custom 3D printed case. At least one (typically two) Software Defined Radio (SDR) dongle is plugged into the Sonde-Pi. Descriptions for each component can be found below:

– The RPi is the Single Board Computer (SBC) that demodulates the radiosonde transmission and writes the data to a .json file. This is a different format than the files SkySonde Client generates and can offer more insight into the performance of the antenna system.

– The RTC board provides power to the RPi itself, and keeps track of time even when the Pi is powered off with a coin cell battery inserted into the RTC board, it will overwrite the RPi's clock during startup if it is disconnected from the internet. Once the RPi is connected to the internet, it will use internet time instead. Discrepancies between the two times can be resolved and is covered in Section V. The RTC board draws very little power from the coin cell battery ($\sim$0.22 μA), and will most likely never need replaced.

– The OLED screen displays basic information on the Sonde-Pi's status and provides an additional interface for the user to control the receiver. Details on its use can be found in Section III.

– The SDRs used are an alternative for the SDRPlay and are typically encased in an aluminum heatsink with two Universal Serial Bus (USB) extension cables running to the Sonde-Pi, as the SDRs get relatively hot when in use. **Note: The Sonde-Pi does not support the SDRPlay brand of SDRs.**

– The cooling fan is a small 5VDC fan that will only turn on when the Sonde-Pi is capturing flight data. It will turn off if the Sonde-Pi falls below 30°C during a flight and turn back on once it rises above 30°C again. It is recommended to place the Sonde-Pi in a location that allows two inches (5 cm) of space between the fan and any wall or object.

A fully assembled Sonde-Pi can be seen in Figure 1 with each component highlighted in numbered boxes. Box #1 highlights the Sonde-Pi assembly (Raspberry Pi, RTC board, OLED, and cooling fan) in the custom 3D printed case with the cooling fan on the right side. In this image, the Sonde-Pi is powered by the 5V USB-C cable (Box #2) and connected to a shared network via ethernet (Box #3). Two SDRs are mounted inside the aluminum heatsink (Box #4) and connected to the Sonde-Pi with two USB extenders. Box #5 highlights the two coax cables that run from the SDRs to the preamps (Not shown in this Figure).
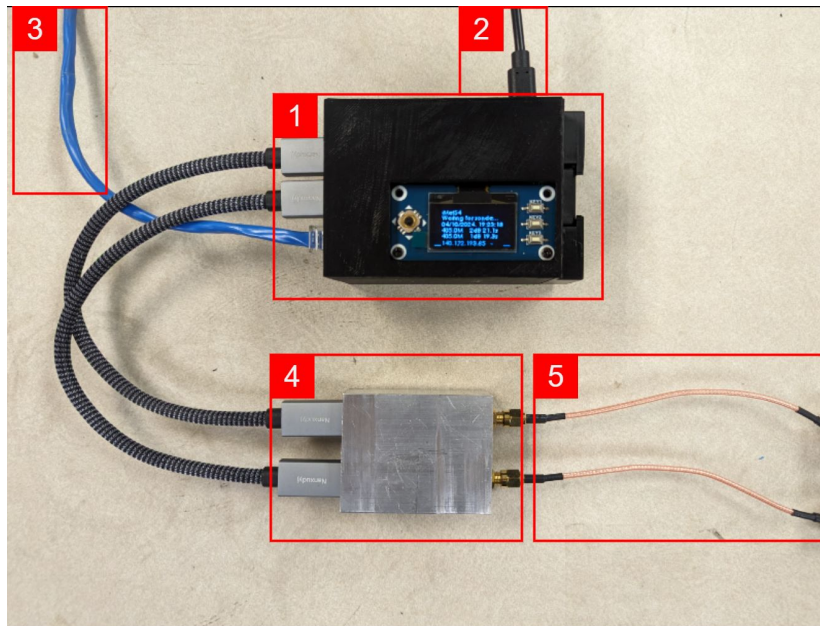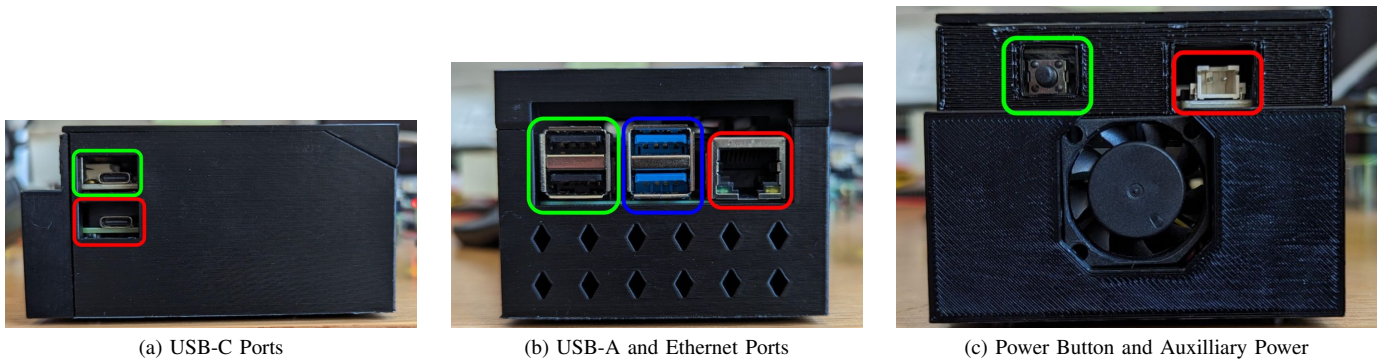
Fig. 1. Sonde-Pi Receiver

Figure 2 below shows closeup images of the various connectors and components of the Sonde-Pi. Most connectors on the Sonde-Pi serve different purposes and understanding each port's use is essential to operating the Sonde-Pi correctly.

(a) USB-C Ports   (b) USB-A and Ethernet Ports   (c) Power Button and Auxilliary Power

Fig. 2. Sonde-Pi Case Features

USB-C Ports

The two USB-C ports shown in Figure 2a serve two different functions. The port in the green box is the port on the RTC board and is used solely for a 5VDC power input. The power supply provided with the Sonde-Pi is a 20W supply that outputs 5V at 3.5-4A. Only a 5V supply should be plugged into this port. The USB-C port shown in the red box in Figure 2a is a regular USB-C port on the RPi that can be used for data transfer. This port is currently not used in software, but future updates may add some functionality to this. **Note: Do not plug 5V power into the USB-C port in the red box. The RTC board handles all power management for the Sonde-Pi, not the Raspberry Pi itself.**

USB-A and Ethernet Ports

There are four USB-A ports available on the Sonde-Pi, shown in Figure 2b. The ports in the green box in Figure 2b are USB 2.0 ports, and the ports in the blue box are USB 3.0 ports. Note that two SDRs can be plugged into any permutation of the four USB-A ports and the receiver will still function as expected. The ethernet port in the red box of Figure 2b is used as an interface between the Sonde-Pi and the user's computer.

Power Button and Auxilliary Power Port

On the opposite side of the USB-A and Ethernet ports is a cooling fan, a power button, and a secondary power input, shown in Figure 2c. The secondary power input shown in the red box of Figure 2c is a 12VDC connector that should only need to be used in the event of a failure in the 5V USB-C AC-DC converter. The cable with the female end of the connector should have been included when the receiver was installed. It is strongly recommended to use a supply that has is able to source 1.5A at minimum. The power button, shown in the green box of Figure 2c can serve two different functions depending on specific settings on the RTC board:

1) **Reset Button:** This is the typical use for the power button. The Sonde-Pi will turn on automatically once the RTC board has power (via the 5V USB-C or 12V connector). **Note: It takes approximately 30 seconds to a minute for the OLED screen to turn on once the Raspberry Pi has power.** When the power button is pressed, the Sonde-Pi will reboot. The OLED screen will turn off and after 30 seconds to a minute, the OLED screen will turn back on. To keep the Sonde-Pi powered off, the 5V or 12V power source will need to be disconnected. This configuration will ensure that the Sonde-Pi will automatically remain turned on in case of temporary power losses at its location. If power loss occurs during a flight, the Sonde-Pi will turn back on as soon as power is restored and it will retain the previous settings and resume data collection automatically.

2) **On-Off Button:** This configuration will rarely be used. The RTC board will occasionally blink a white LED when it has power, but the Raspberry Pi will not automatically turn on. When pressed, the power button will command the RTC board to supply the Raspberry Pi with power, and the OLED screen will turn on after 30 seconds to a minute. When pressed again, the power button will command the RTC board to cut off power from the Raspberry Pi, and the OLED screen will turn off. In this configuration, the power cable (USB-C or 12V connector) can remain plugged into the Sonde-Pi and it will still have the ability to be turned off for an extended amount of time. In the event of temporary power loss during a flight, the power button will need to be pressed to turn the Sonde-Pi back on to resume a flight.

Antennas and Receiver Setups

While the Sonde-Pi can be used with any antenna, the preferred antenna setup uses two omnidirectional antennas seen in Figure 3. This is a typical antenna mount for a permanent receiver, where the J-Pole and 14A are mounted to a vertical mast, giving the antennas some extra height over the structure they are mounted to. The preamps are located in a weather-resistant enclosure just out of frame in Figure 3 and should be no more than 5m (∼16 ft) away from the antennas. The coax cables from the preamps run from the enclosure into the building where the Sonde-Pi is located. This length is typically 15-30m (∼50-100 ft). Table I lists the specifications for each antenna. One key line in the table to note is the effective elevation angle. The J-Pole antenna performs well from 0 - 60°elevation, but starts dropping off above 60°, when the balloon is directly overhead. The 14A covers the blind spot seen by the J-Pole and its effective elevation angle overlaps with the J-Pole down to 20°.
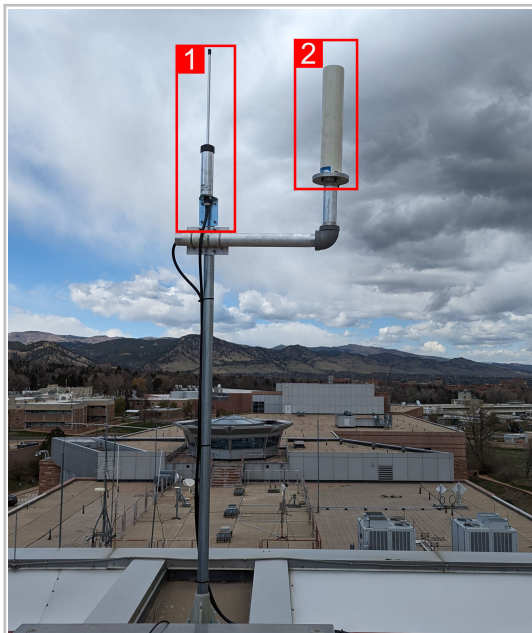

Fig. 3. Permanent Antennas Mounted in Boulder, CO

TABLE I
ANTENNA SPECIFICATIONS

Specification	J-Pole (#1)	14A (#2)
Antenna Type	3/4λ J-Pole	1/2λ Quadrafilar Helix
Effective Elevation Angle Range	0 - 60°	20 - 90°
Azimuth Range	0 - 360°	0 - 360°
Maximum Gain	4.15 dBi	3 dBi
Polarization	Vertical	Circular
Impedance	50 Ω	50 Ω
Connector	N-Type	N-Type

For sites that need a receiver at a second location, a mobile receiver will be used in place of a second permanent receiver. This allows the on-site staff flexibility in where the second receiver is set up depending on launch conditions. Figure 4a shows the first version of the mobile receiver. The Sonde-Pi, preamps, and DC power supply are all housed in the black pelican case (Fig. 4a, #3) with two N-type bulkheads, an ethernet bulkhead, and a power connector located on the bottom of the case (Figure 4b). The 14A (Fig. 4a, #1) and J-Pole (Fig. 4a, #2) antennas are mounted to a piece of aluminum angle that is attached to the same aluminum pipe as the pelican case. The N-type bulkheads are connected to the antennas when assembled, and the ethernet bulkhead is used as an alternative to using the Sonde-Pi's Wi-Fi. The tripod is adjustable to give the receiver a low, wide base if there are windy conditions at the time of launch. The aluminum pipe can be disconnected from both the tripod base and aluminum angle, allowing for easier transport.
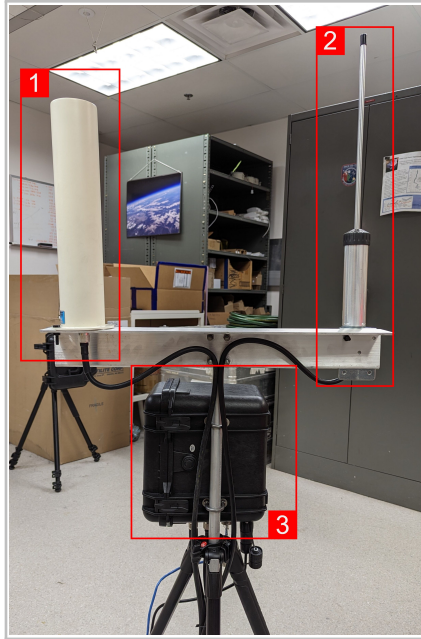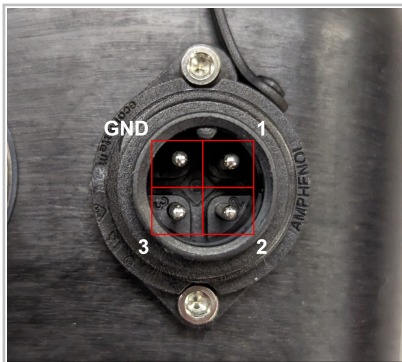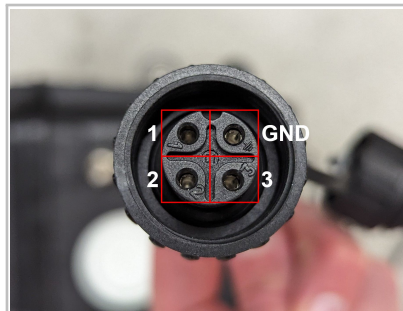

(a) Mobile Receiver
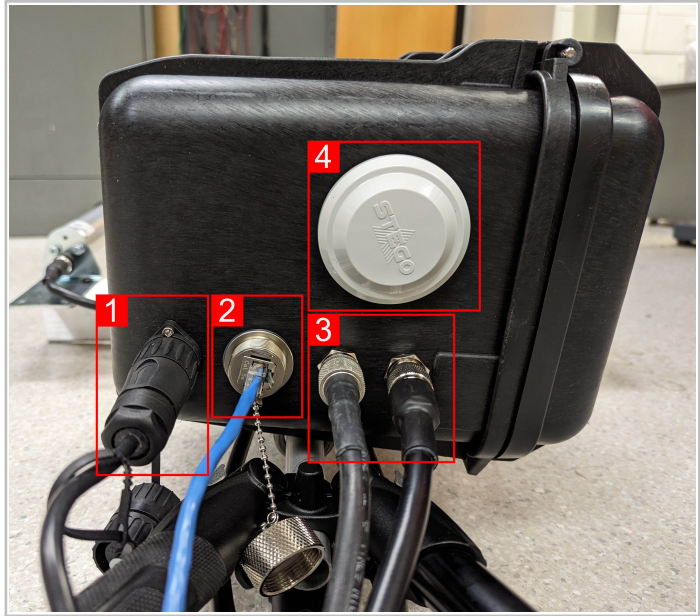
(b) Mobile Receiver Bulkheads

Fig. 4.

The power connector (Fig. 4b, #1) is a 4-pin connector that is custom-built for the mobile receiver on-site. The female end of the connector can be built in any location using any AC power plug to give the users flexibility for powering the receiver. The pinout for both the male and female end of the connector is listed in Table II. The Ethernet bulkhead (Fig. 4b, #2) is an optional connector since the Sonde-Pi's functions are available over Wi-Fi, but provides the user with an additional form of communication. The two N-Type connectors (Fig. 4b, #3) connect direclty to the antennas. The cables seen in these images are LMR-400, but will be swapped to a smaller size for convenience. An air vent (Fig. 4b, #4) will typically be installed to provide the Sonde-Pi inside with a source of cooler air.

(a) Male (Bulkhead)

(b) Female (Cable)

Fig. 5. Mobile Receiver Power Connectors

TABLE II
ANTENNA SPECIFICATIONS

Pin	Function
1	110-240VAC Live
2	110-240VAC Neutral
3	Unused
Earth GND	110-240VAC Earth GND

II. WEB INTERFACE

The Sonde-Pi has two methods to change receiver settings, a web interface and an OLED interface. The full screen web interface seen in Figure 6 contains far more information than the OLED interface and allows the user to download the flight data from the receiver. An image similar to this screen without the red boxes can be found in Figure 14 on page 14. A user can access the web interface with a computer or a mobile device in several ways, which will be covered in more detail in Section IV. Descriptions of each section of the interface follow where the number of each section relates to the number seen in Figure 6:
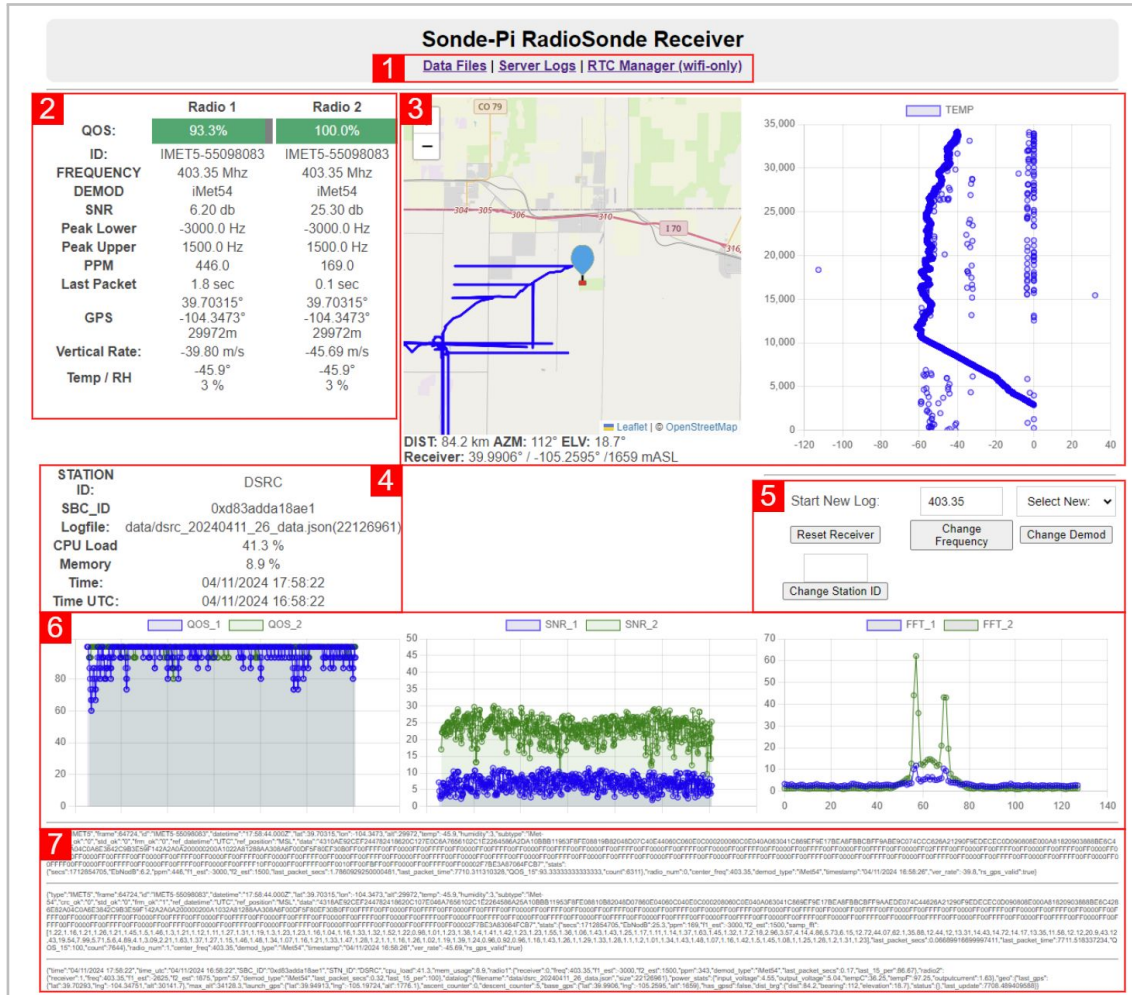

Fig. 6. Web Interface

1. Data Links

At the top of the web interface are the links to the data files. The *Data Files* link will direct the user to the storage location of the flight data. The .json files can be downloaded by a user and reprocessed in SkySonde Client to obtain a .raw file for use in SkySonde Processor. **Note: This link is the only route for a user to access the data files. If access to the web interface is somehow lost, please contact Alex Fritz for data recovery.** The *Server Logs* link directs the user to the location of the debug files produced by the RPi during operation. These files contain the status lines and will also display any errors that the RPi ran into during operation. Typically, a user will not need to access the server logs and will be requested when necessary. The *RTC Manager (wifi-only)* link sends the user to the RTC board control interface. This link is only accessible when the user is connected to the Sonde-Pi over its Wi-Fi and will only need to be accessed when requested.

2. Flight Information

This section of the interface displays the current settings of the Sonde-Pi and various metrics from the radiosonde that can be used to track the progress of the flight. The two columns labeled *Radio 1* and *Radio 2* refer to the two antennas and SDRs

that are connected to the Sonde-Pi. If only one SDR is connected to the RPi, only one of the columns will populate with information. **Note: It is recommended to label each SDR (1 or 2) and make note of which antenna is connected to which SDR. This can help to troubleshoot any complications that may occur.** Each column will update every time the Sonde-Pi receives a packet from the radiosonde (typically once every second). If it misses a packet, the data from the previously received packet will remain shown. The description of each line can be found in Table III.

TABLE III
DESCRIPTIONS OF THE FLIGHT INFORMATION SECTION

Line Name	Description
QOS	Short for Quality of Service, the two horizontal bars at the top display the percentage of the radiosonde packets that the Sonde-Pi received in the last 15 seconds and can be used to determine how well the receiver is performing.
ID	This is the packet ID transmitted from the radiosonde. This can be used to validate the type of radio packets being processed by the Sonde-Pi, but is primarily used in reprocessing.
FREQUENCY	The current frequency the Sonde-Pi is set to receive. This will range in values between 402-405 MHz. iMet-54s transmit at 1 MHz increments (402, 403, 404, 405) and iMet-4s transmit at 0.5 Mhz increments (402, 402.5, 403, 403.5, 404, 404.5, 405).
DEMOD	Short for demodulator, this displays the current radiosonde type the Sonde-Pi will attempt to demodulate. Set to iMet 54 for ECC/POPS/FPH flights and iMet 4 WB for ECC or ECC/FPH flights.
SNR	The Signal-to-Noise Ratio of the most recently received packet from a radio. This value will only populate when DEMOD is set to iMet54. Typical SNR values range between 5 and 30dB (will decrease as flight progresses).
Peak Lower and Peak Upper	These two metrics display the distance of the modulated radio signals from the Sonde-Pi's FREQUENCY setting in Hz. This value will only populate when DEMOD is set to iMet54. Typical values range between -700 and 700.
PPM	Short for Parts Per Million, this is used to calculate the frequency variation in the radiosonde signal. This value will only populate when DEMOD is set to iMet54.
Last Packet	The time that has elapsed (in seconds) since receiving a valid radiosonde packet.
GPS	This section displays the latitude, longitude, and altitude(in m) transmitted from the radiosonde. This section will only populate if the radiosonde has a valid GPS signal. If a radiosonde loses GPS but still transmits PTU or instrument data, the last good GPS data will remain displayed.
Vertical Rate	The ascent/descent rate in m/s.
Temp/RH	The air temperature (in °C) and relative humidity from the radiosonde.

3. Map and Air Temperature Plots

The interactive map on the left of this section shows the location of the balloon and receiving station throughout the flight as well as some information calculated from the radiosonde GPS data. This map serves a similar function to the map in SkySonde Client but is unable to predict the landing location of the balloon. The air temperature plot beside the map plots the radiosonde temperature as the flight progresses. The perfectly vertical and horizontal lines seen in the map correspond to bad radiosonde packets that were processed and contained aberrant latitude and longitude values. Those points on the map also correspond with the abnormal temperatures seen in the temperature plot. These data points can be ignored and will be filtered out in post processing.

4. Raspberry Pi Information

This section displays information related to the backend operation of the Raspberry Pi. Similar to the Flight Information section, the description of each line can be found in Table IV.

5. Sonde-Pi Controls

This section contains the components used to tune the Sonde-Pi to different frequencies and radiosondes. As indicated by the *Start New Log* text, the *Reset Receiver* button is used to start a new data(log) file during a flight. This can be used to separate pre-flight data and flight data without having to manually separate the data files later on. The *Change Frequency* button and the text box above it are used to set the receiver frequency. Values between 401 and 406 MHz can be entered into this text box. **Note: DO NOT change the frequency of the receiver during a flight. The radiosonde frequency will not change during a flight. Once the balloon has been launched, this number should not be adjusted.** The *Change Demod* Button and the dropdown menu above it are used to set the radiosonde demodulator. The *Change Station ID* button and the text box above it are used to change the Station ID, but should not be changed by a user unless requested.

TABLE IV
DESCRIPTIONS OF THE RASPBERRY PI INFORMATION SECTION

Line Name	Description
Station ID	The station ID is the four-character ID used to identify Sonde-Pi receivers.
SBC_ID	ID used to identify specific Raspberry Pis. This can be ignored for general use.
Logfile	This line will display the current name of the data(log) file the Sonde-Pi is writing to once a flight has started. While it is waiting for a radiosonde signal, it will display *waiting_for_sonde(undefined)*. Once the Sonde-Pi detects a radiosonde packet, it will update this field with the following structure below: $$data/\textbf{aaaa\_yyyymmdd\_bbbbbb}\_data.json(\textbf{ccccc})$$ Where **aaaa** is the four-character Station ID, **yyyymmdd** is the UTC date that the flight began, **bbbbbb** is a number related to the start time used to identify different data files written with the same UTC date, and **ccccc** shows the current size of the data file in bytes.
CPU Load	This shows the load of the RPi's current CPU load. This is typically 40-50%.
Memory	This shows the current memory usage of the RPi. This is typically 5-15%.
Time	This will display the local time that the Sonde-Pi is located. This is determined when connecting the Sonde-Pi to an active internet connection.
Time UTC	This displays the current UTC time, which can be determined when connected to an active internet connection or from the RTC board. **Note: The date used in the data file is UTC time, not local time.**

6. Signal Plots

These three plots provide the opportunity to view the signal statistics over time and can be used to determine how well the flight is progressing. The leftmost and middle plots display the QOS and SNR metrics, and the rightmost plot shows a frequency spectrum centered at the Sonde-Pi's set frequency. For the flight seen in Figure 6, the 14A was connected to Radio 1 (Blue Line in Signal Plots), and the J-Pole was connected to Radio 2 (Green Line in Signal Plots). The elevation angle for much of the flight was below 20°, and the 14A had worse reception than the J-Pole (Indicated in the SNR plot)

7. Raw Data Lines

The raw data lines found at the very bottom of the web interface are used primarily for debugging purposes. The top two sections of information contain the lines written to the data file from each radio. If only one SDR is attached, only one of these sections will be populated. The bottom section contains the status lines written to the debug file. Most of the information in the bottom section can be found elsewhere in the interface (FREQUENCY and CPU Load, for example) or is not relevant to normal operation of the Sonde-Pi.

III. OLED INTERFACE

The OLED board sits directly on top of the RTC board and provides a physical interface to the receiver if the web interface is unavailable or if manually changing it is more convenient. The screen displays the most important information from the web interface, allowing the user to control the Sonde-Pi entirely from the OLED with the exception of being able to access the flight data. The example screen in Figure 7 highlights the three major components of the OLED. The description of each numbered line in the cyan box can be found below:

1) **Radiosonde Demodulator:** Indicates which radiosonde the Sonde-Pi is set to demodulate. This matches the DEMOD line on the web interface.
2) **File Status:** Shows the data file status of the Sonde-Pi. This matches the *Logfile* line on the web interface.
3) **Date and Time:** Displays the current date and time the Sonde-Pi will use in the name of the data file.
4) **Radio 1 Status:** From left to right, this line displays the frequency that SDR 1 is set to (402.0M), its current SNR (3dB), and the elapsed time since receiving the previous packet (77.7s).
5) **Radio 2 Status:** This line displays the same information as the previous line. In the case of Figure 7, -999.0M, 0dB, and -99.0s indicates that only one SDR is plugged into the Raspberry Pi.
6) **IP Address:** This line displays the IP address of the Sonde-Pi. If the Sonde-Pi does not have a wired ethernet connection either to a network or directly to a computer (details in Section IV), this number will display 0.0.0.0. Once the Sonde-Pi is directly wired to either a computer or a network, this number will update and display the IP address where the flight data can be accessed.
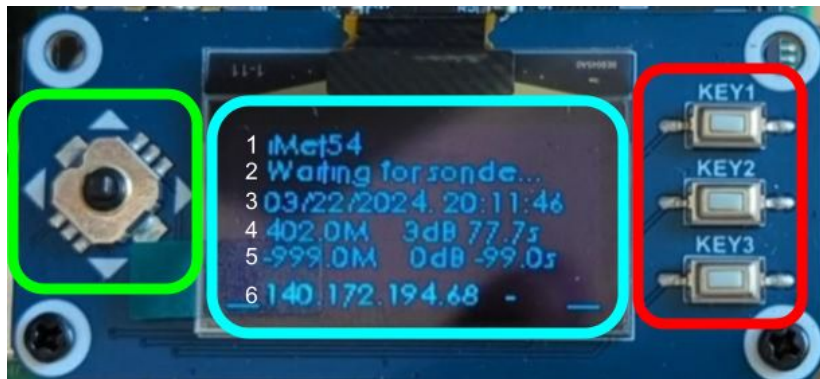

Fig. 7. OLED Interface

Once the Sonde-Pi detects a radiosonde signal, it will display a different screen with the name of the data file it will write to, then return to the main screen. Two bars will also appear on the far left and right side of the OLED as well. These bars are analagous to the QOS bars on the web interface. The joystick in the green box and the buttons in the red box are used to change the same settings that are adjustable on the web interface. The joystick is used to adjust the receiver frequency and to confirm selections from the joystick and the buttons. *KEY1* is used to cycle through the different radiosondes, *KEY2* is currently unused, and *KEY3* is used to reset the receiver, analogous to the *Reset Receiver* button on the web interface.

IV. CONNECTIVITY

The Sonde-Pi's web interface and TCP data stream is accessible through both its ethernet port and built-in Wi-Fi access point. The TCP data stream serves the same purpose that SkySonde Server does with regards to SkySonde Client. SkySonde Client can connect to the Sonde-Pi's TCP port and process the live data as the flight progresses. **Note: The web interface does not need to be open to connect SkySonde Client to the Sonde-Pi.** While all functionality is available through both ethernet and Wi-Fi, each connection method has its advantages and disadvantages. Figure 8 shows block diagrams of each method outlined below:

1) **Put the Sonde-Pi onto an existing network via ethernet:** This method of connection allows for multiple users to access the web interface if all users are on the same network. The Sonde-Pi's Wi-Fi is also available even if it is on a network. This method allows the user's computer to download maps and enables the Sonde-Pi to use the most accurate time possible since it has an internet connection.
2) **Connect the Sonde-Pi directly to a Computer via ethernet:** This method of connection offers access to the same features as method 1, but only one user will be able to access the Sonde-Pi via etherent. The Sonde-Pi's Wi-Fi is also available using this method. If the user's computer only has one ethernet port, it will only be able to connect to the

internet via Wi-Fi if available. For example, a laptop plugs into the Sonde-Pi via ethernet and connects to the internet via Wi-Fi. The laptop will be able to download maps for SkySonde Client and the Sonde-Pi web interface in this case.

3) **Keep the Sonde-Pi disconnected from any ethernet network:** This is the most restrictive method of connecting to the Sonde-Pi. The only connection option to the Sonde-Pi is via Wi-Fi. Unless the user's computer has internet access via ethernet, it will no longer have internet access as the Wi-Fi connection is to the Sonde-Pi. The web interface will not be able to download the map and it will remain blank throughout the flight.

(a) Method 1
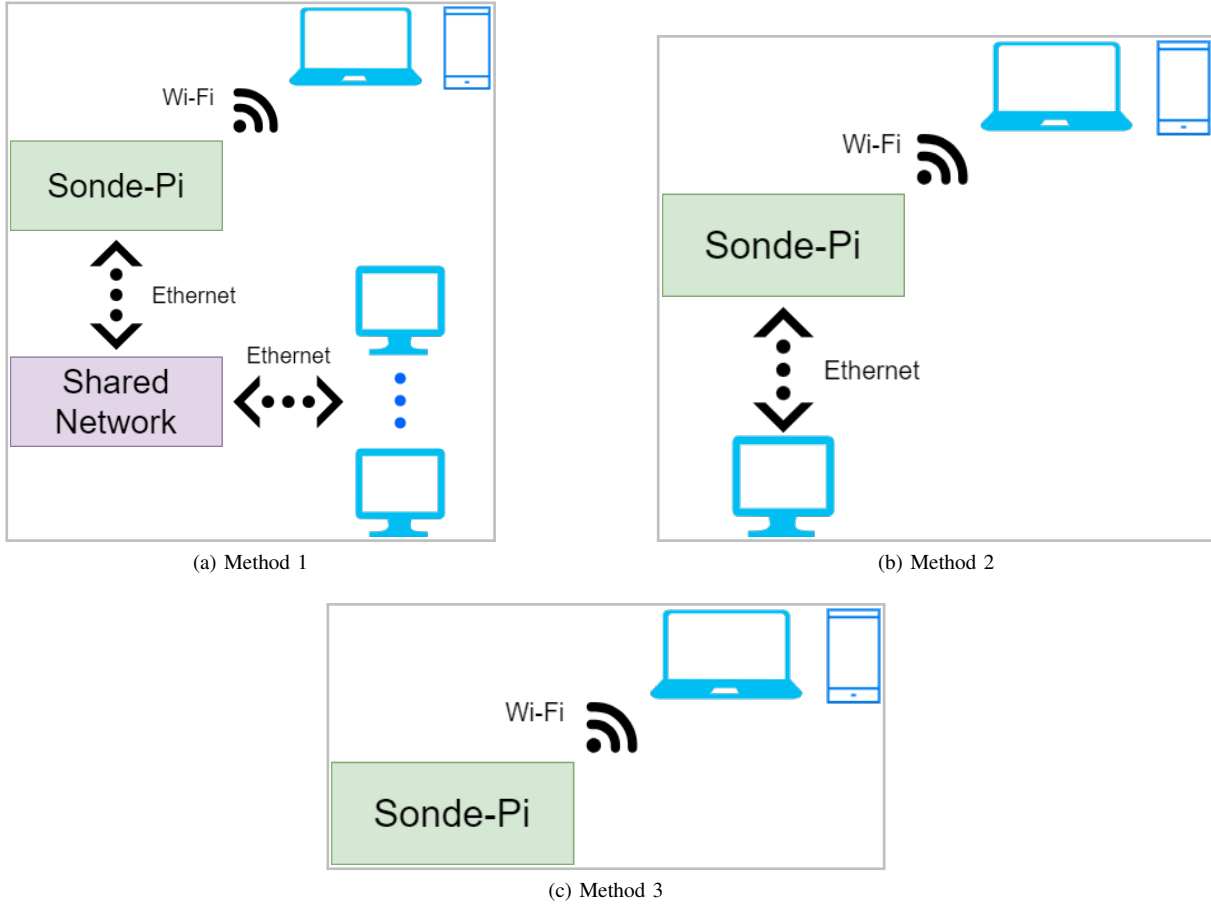
(b) Method 2

(c) Method 3

Fig. 8. Sonde-Pi Connection Methods

When using methods 1 or 2, the Sonde-Pi will generate an IP address and display it on the OLED screen. When the Sonde-Pi is not connected to anything via ethernet(method 3), the OLED will display *0.0.0.0* as the IP address. Despite what is shown on the screen, the IP address of the Wi-Fi is always *192.168.5.1*. Table V lists the different IP addresses and port numbers and can be used as a "cheat sheet" for determining how to connect to the Sonde-Pi.

TABLE V
CONNECTON SUMMARY AND EXAMPLES

Ethernet IP Address	Variable (Shown on OLED)
Wi-Fi IP Address	192.168.5.1
Web Interface Port #	8080
TCP Datastream Port #	1234
Example Ethernet Web Interface Address	140.172.194.37:8080
Example Wi-Fi Web Interface Address	192.168.5.1:8080

V. MAINTENANCE

The Sonde-Pi requires very little maintenance to remain operational. Maintenance will only need to be performed when requested, but the potential maintenance work is summarized below:

– **MicroSD Card Replacement:** If the Sonde-Pi is powered on 24/7, the microSD card will need an annual replacement due to their limited number of write cycles. The green box in Figure 9 shows the location of the microSD card on the Sonde-Pi. Before opening the Sonde-Pi's case, disconnect the USB-C or 12V power cable from the Sonde-Pi. To gain access to the microSD card, gently pull off the section of the case that houses the fan. It is recommended to use a small flathead screwdriver to slowly pull the end of the case off.**Note: If the Sonde-Pi is not left on 24/7, but is turned off after instrument calibration or a flight, the microSD card can be replaced every two years instead.** After swapping out the microSD card, a software update will be required. Instructions to perform a software update will follow the request to change the microSD card.
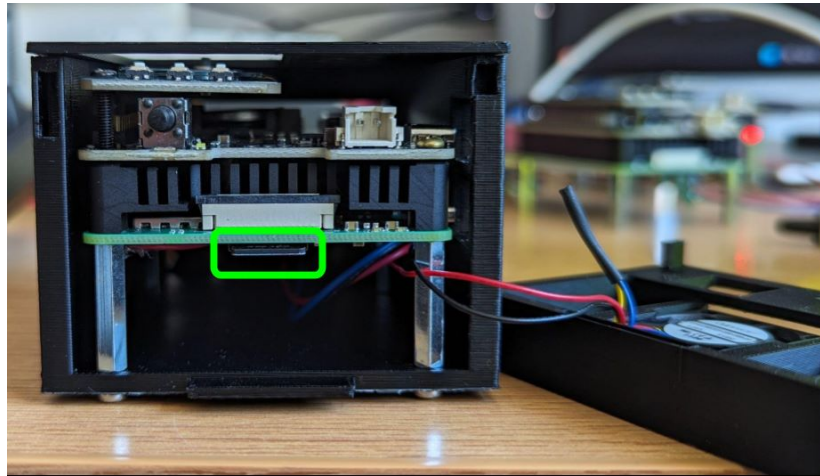
Fig. 9. MicroSD Card Location

– **RTC Board Clock Synchronization:** The RTC board's clock has a slight amount of drift, and has a maximum variance of approximately 1 minute per year. To keep the time on the Sonde-Pi as accurate as possible, it is recommended to synchronize the RTC clock with internet time once a year. To perform this, ensure that the Sonde-Pi is plugged into an active internet connection via ethernet and connect a computer or cell phone to the Sonde Pi's Wi-Fi. Next, click the *RTC Manager* link at the top of the web interface and the window seen in Figure 10 will appear. It is recommended to click or tap on the update button in the blue box first. That will enable automatic updates from the RTC board. After that, the synchronize button in the red box should be pressed, which will synchronize the RTC board's clock with internet time. Once that is complete, the user can resume using the Sonde-Pi as usual.
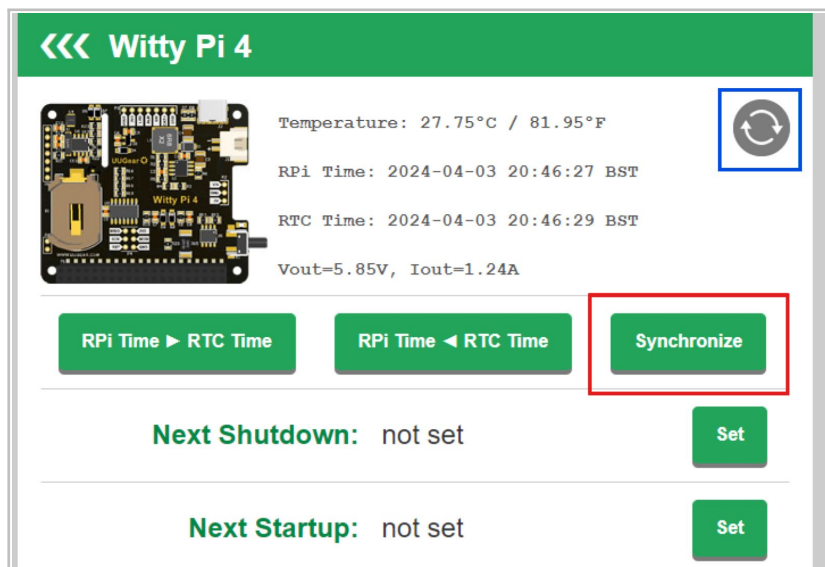

Fig. 10. RTC Board Interface

– **Clean out Dust:** If the Sonde-Pi is placed in a dusty or dirty location for an extended amount of time, it is strongly recommended to open the side of the case with the fan and blow pressurized air through the electronics and the heatsink to reduce dust buildup.

VI. STEP-BY STEP INSTRUCTIONS FOR A FLIGHT

Set the Correct Radiosonde and Transmission Frequency

1) The Sonde-Pi should be powered on if turned off, and the user should connect a computer or mobile device to the Sonde-Pi via one of the three methods covered in Section IV. Refer to Table V to find the correct IP address and port number.
2) Once connected, observe the OLED screen or access the web interface. Refer to Table V to find the correct IP address and port number for the web interface.
3) While the Sonde-Pi can demodulate signals from many different types of radiosondes, the two that are typically used are the iMet-54 and iMet-4. **Note: There are two different iMet-4 options on the Sonde-Pi, iMet 4 WB(Wide Band) and iMet 4 NB(Narrow Band). OZWV typically uses iMet 4 WB radiosondes, so the iMet 4 NB option will rarely be used.** The OZWV Scan option initially sets one antenna to demodulate iMet-54s, and the other antenna to demodulate iMet-4 WB. Once the Sonde-Pi detects either radiosonde, it will set both SDRs to demodulate the detected radio and continue operation.
4) **If using the OLED Interface:** To change the radiosonde demodulator on line 1, press *KEY1* on the right side of the OLED. A new screen will appear, indicating the currently selected demodulator. Continue pressing *KEY1* until the desired radiosonde is displayed. To lock in that radiosonde, press in on the joystick and wait a moment for the command to be sent to the RPi. To change the radiosonde frequency, press the joystick upwards or downwards to pull up the frequency adjustment screen. Each adjustment on the joystick will be in 0.25 MHz increments. Once the user has adjusted the number to the desired frequency, press inward on the joystick and wait a moment for the screen to update. Lines 4 and 5 on the OLED will now display the new frequency.
5) **If using the web interface:** To change the radiosonde demodulator, select the dropdown menu seen in Figure 11 and select the desired radiosonde. Press the *Change Demod* button to send the command to the Raspberry Pi and wait up to 10 seconds for the interface to update. To change the radiosonde frequency, type in the desired frequency or use the arrows on the right side of the text box above the *Change Frequency* button. This is typically in multiples of 0.5 MHz for iMet-4s and 1 MHz for iMet-54s. Once the desired frequency is entered into the text box, click the *Change Frequency* button and wait up to 10 seconds for the interface to update. **Note: The controls section of the web interface updates the frequency text box every 10 seconds when it gets a debug packet from the RPi. This update may override any changes made to the frequency text box prior to pressing the Change Frequency button. Always check the OLED or the FREQUENCY line on the web interface to verify the current frequency setting.**
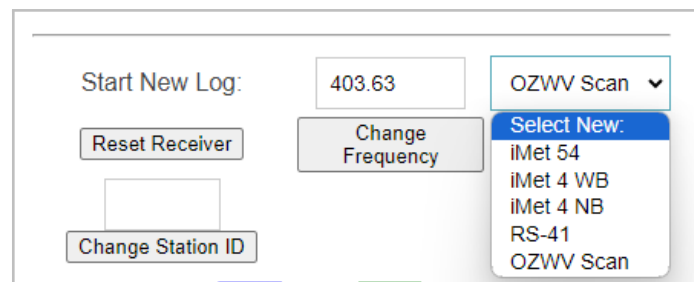

Fig. 11. Demodulation Options

Set Up SkySonde Client

6) Open SkySonde Client and set the Data Source to *SkySonde Server (realtime)*. Replace localhost in the IP Address box with the Sonde-Pi's IP address (From the OLED, or the Wi-Fi's IP address). The port number is set to 1234 by default and should remain the same.
7) Ensure that the radiosonde type in the bottom left corner of the SkySonde Client window matches the radiosonde selected on the Sonde-Pi and change any other instrument configurations desired.
8) Hit OK in the lower right corner once ready.
9) Turn a radiosonde on to check that data is pushed through to Client. **Note: It takes approximately 10 seconds for an iMet-54 to begin transmitting after turning the radiosonde on.** Refer to the SkySonde Client User Manual for any questions regarding SkySonde Client past this point in the process.

10) Figure 12 displays what the web interface may look like after turning on a radiosonde.
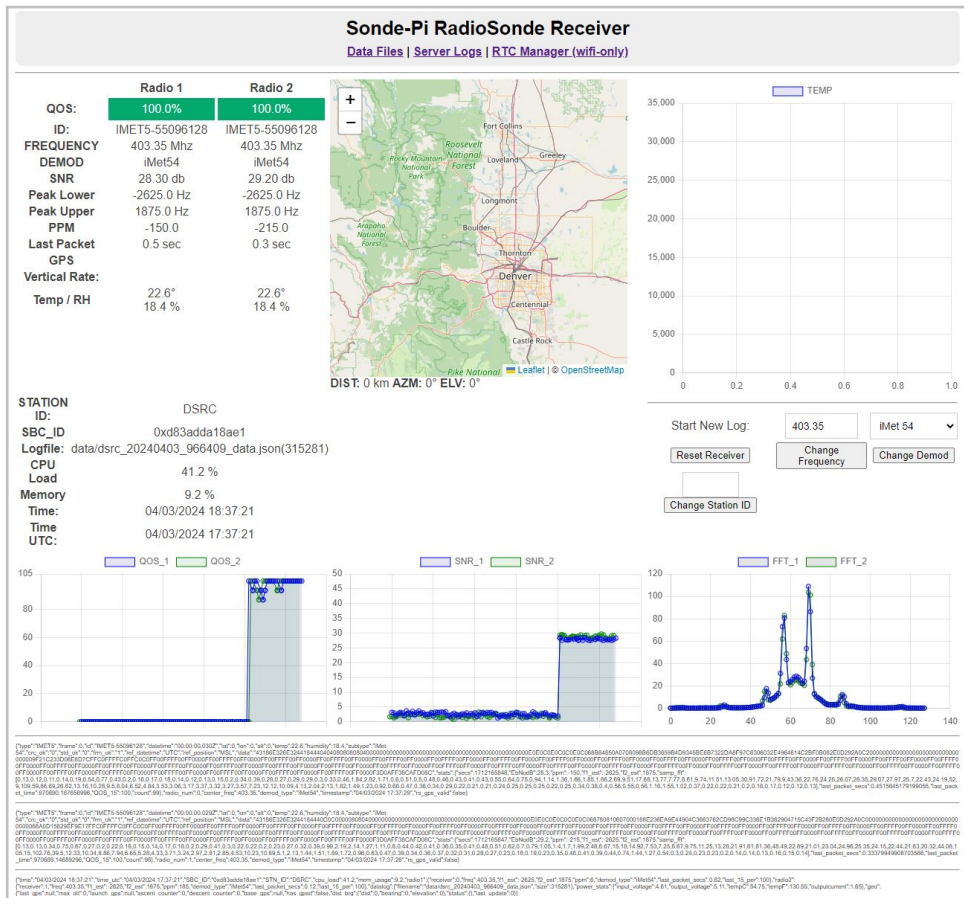

Fig. 12. Radiosonde Turned on Without GPS Signal

The QOS bars and plots should be updating, but the *GPS* data, *Vertical Rate*, and map will not update until the radiosonde has a GPS signal. **Note: The computer or phone the user is using the web interface on needs to have an internet connection to download the map. The map will remain blank if the device does not have an internet connection. If the device starts without internet and connects partway through a flight, the web interface can be refreshed and the map will download.** If the Sonde-Pi's DEMOD is set to iMet-54, the SNR and frequency spectrum plots will also begin updating. These plots will not update if DEMOD is set to iMet-4 WB or iMet-4 NB. **Note: It can be helpful to write down the Logfile name at this point to make it easier to retrieve the data file later on.**

11) The balloon's distance, azimuth, and elevation angle from the receiver is shown below the plot on the web interface. The receiver's location will be automatically calculated based on the release location of the balloon. However, not all launch sites share their location with the receiver, so it is recommended to manually set the receiver location (Ground Control Station, or GCS) to get the most accurate calculations. To set this, right click on the map if on a computer or tap and hold if on mobile, and the *Set GCS Here* option will appear, seen in Figure 13a. Once selected, wait up to 10 seconds, and an antenna symbol will appear on the map, seen in Figure 13b. The latitude, longitude, and altitude of the GCS location will appear below the map as well.

12) Once the radiosonde gets a valid GPS signal (can be checked in SkySonde Client by verifying that the number of GPS satellites is greater than 6 for an accurate signal), a balloon icon will appear on the map, seen in Figure 14. The distance, azimuth, and elevation angle values below the map will begin updating and continue for the duration of the flight.

13) Once the Sonde-Pi loses reception, it will wait 60 seconds before closing the data file it was writing to. If it detects the radiosonde again within 10-15 minutes of losing signal, the Sonde-Pi should continue writing to the same data file. If more than 15 minutes have passed, it will assume the first flight has ended and write to a new data file.
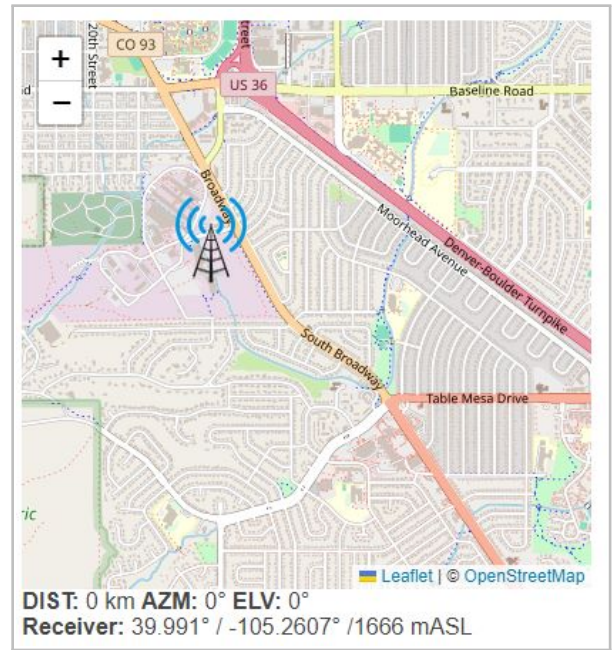
(a)   (b)

Fig. 13. Setting the Web Interface GCS

Retrieving the Flight Data

14) After the flight is complete, the user needs to access the web interface and click on the *Data Files* link near the top of the screen. A page similar to Figure 15 will appear. Each line on this page corresponds to a different data file that was previously generated. The leftmost column displays the name of the file, the middle column displays the UTC date and time that the file was last written to, and the rightmost column is the file size in bytes.

15) The data file can be downloaded in two ways:

a) Right-click on the name of the file and select the *Save link as...* option in the menu seen in Figure 16a. That will open a prompt to select the name of the file and download location.

b) Left-click on the name of the file to open it in the browser window. Once the file is opened, right click anywhere in the window and select the *Save as...* option in the menu. The example shown in Figure 16b shows what the users's screen may look like.

Note: Both examples are shown in Google Chrome on a Windows 11 laptop. It may look different in other browsers or older computers.
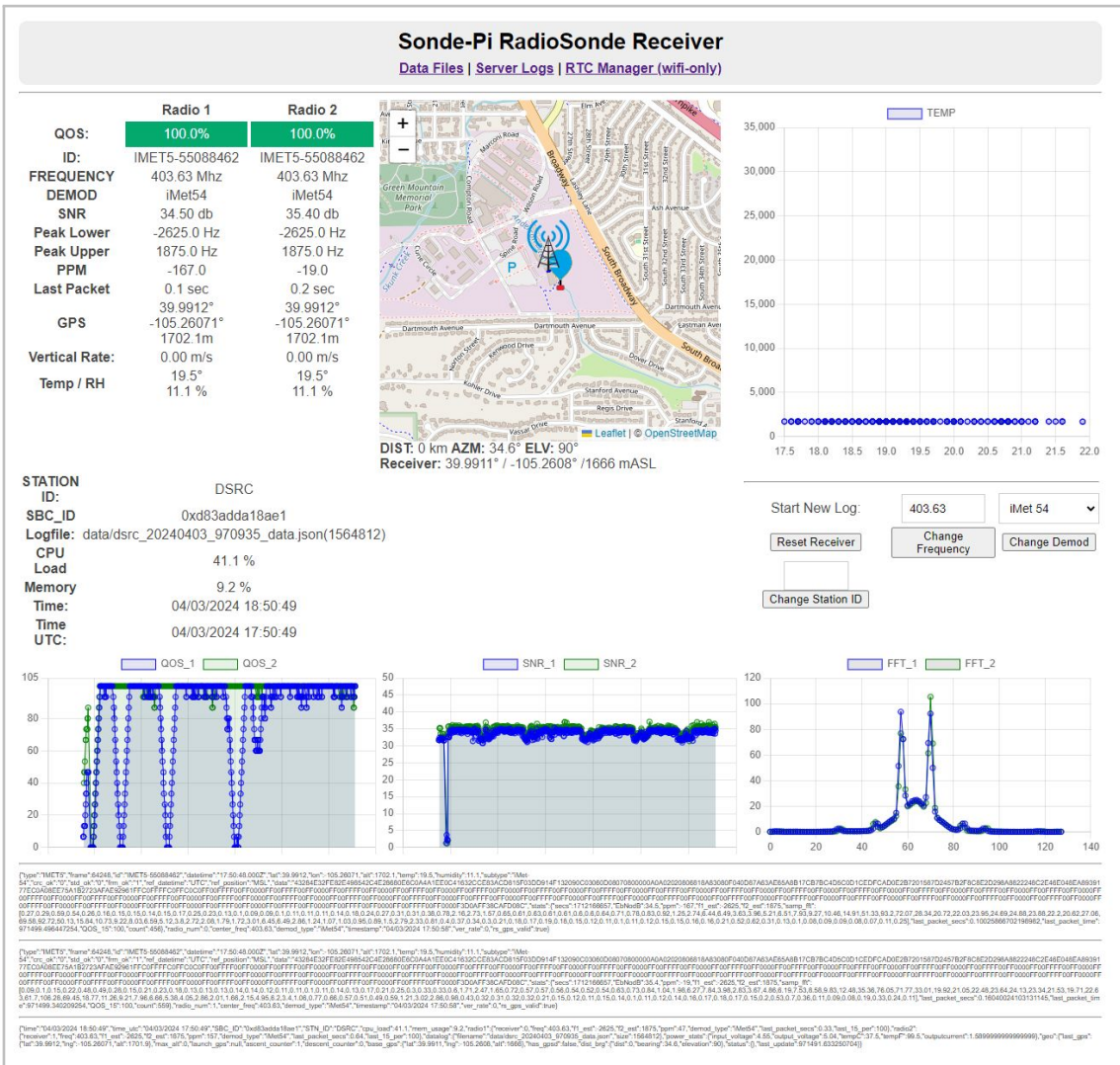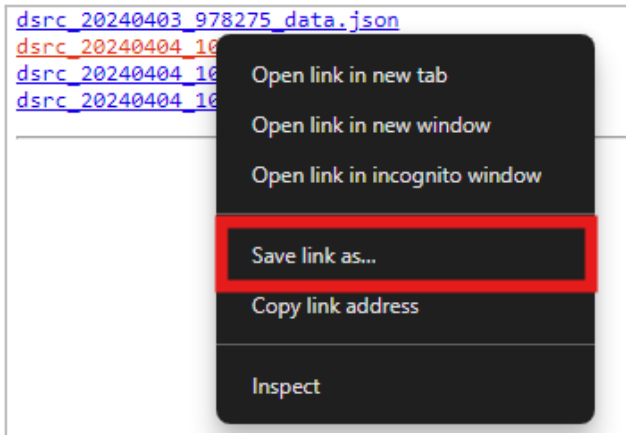
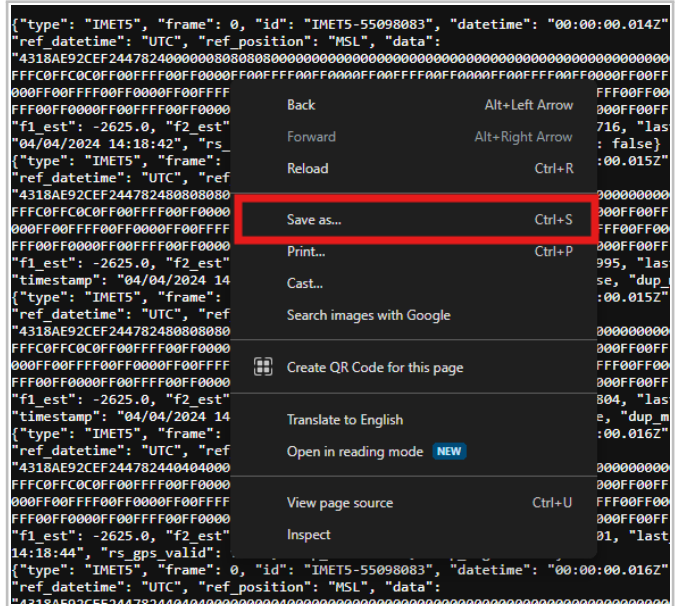Fig. 14. Radiosonde Turned on With GPS Signal

Fig. 15. Flight Data Folder

Fig. 16. Downloading the JSON Data Files (Chrome)

VII. TROUBLESHOOTING AND KNOWN BUGS

Known bugs in the Sonde-Pi software do exist, but there are short-term solutions to fix them. If new versions of the Sonde-Pi software fix the following known bugs, a new User Manual will be released and users will be notified. If any bugs not seen in this list appear, please click on the *Server Logs* link near the top of the web interface and download all of the server log files, similar to downloading the data files. Package all the log files into a .zip file and send the zipped folder with a description of the bug to Alex Fritz. **Note: It is important that the log files are downloaded the same day that the bug appeared, as the log files are deleted and re-written daily.**

Known Bug 1

Issue: Occasionally, the Sonde-Pi will receive radiosonde packets and the QOS plots will update as normal, but no data is actually extracted from the received packet. If SkySonde Client is running, none of the data fields will update either. This is a rare bug and should not occur often. If this becomes a common occurrence, please notify Alex Fritz.

Solution: Reboot the Sonde-Pi. The Sonde-Pi will retain the previous settings, so no changes will need to be made after a reboot.

Known Bug 2

Issue: While SkySonde Client is connected to the Sonde-Pi directly via Ethernet, over a shared network, or over the Sonde-Pi Wi-Fi, if a user breaks the connection between the Sonde-Pi and computer before closing SkySonde Client, that can cause the Sonde-Pi to freeze for approximately 20 minutes. It will still buffer the incoming data, but the web interface and OLED will not update. After approximately 20 minutes, the Sonde-Pi will resume the flight from where it was frozen and process the buffered data as well as the incoming data. If it occurred early on in the flight, the Sonde-Pi may catch up with the live data, but the balloon indicator may jump around between locations on the map while it is catching up. That will cause some issues in the exported data file and will make it difficult to work with later. A couple of example situations that have been known to cause the issue include, but are not limited to:

– Connecting a laptop to the Sonde-Pi over Wi-Fi and walking out of the Wi-Fi's range, breaking the connection
– Connecting a laptop to the Sonde-Pi over ethernet and unplugging the ethernet cable to switch to Wi-Fi

Solution: If the user is using SkySonde Client with the Sonde-Pi, they **MUST** close SkySonde Client before disconnecting from the Sonde-Pi. In the event that this does occur, **DO NOT** reboot the Sonde-Pi. It will continue to receive data, and it is preferable to get a data file that is out of order than an incomplete data file.

Known Bug 3

Issue

Web interface bogs down the user's computer, causing significant lag. If left running for even an hour during a flight, the web interface can create significant lag on a computer, even on a new laptop. This can make multitasking difficult and can be quite frustrating. The suspected cause of this is the large number of data points being plotted on the map, air temperature plot, and even the QOS and SNR plots.

Solution

If the user's computer starts to experience lag from the web interface, the browser window should be refreshed. This will clear all of the plots. **Note: This will not interfere with the Sonde-Pi's data collection. As long as the Sonde-Pi is powered on, connected to the antennas and set to the correct radiosonde and frequency, it will still capture data.** The web interface is not required to be open in order for the Sonde-Pi to capture a flight. It is only used to change Sonde-Pi settings and track the flight if the user does not want to have SkySonde Client open. As soon as the Sonde-Pi detects a radiosonde packet, it begins writing to a .json file. The web interface does not need to be open in order to connect SkySonde Client to the Sonde-Pi.

VIII. Software Updates

Any updates will be requested from Alex Fritz, and can be performed over any of the connection methods mentioned in Section IV. The user will need a SSH client like PuTTY or WinSCP to complete the update. Once a software update has been requested, or an SD card has been swapped, the instructions for updating the software will be sent along with the request.