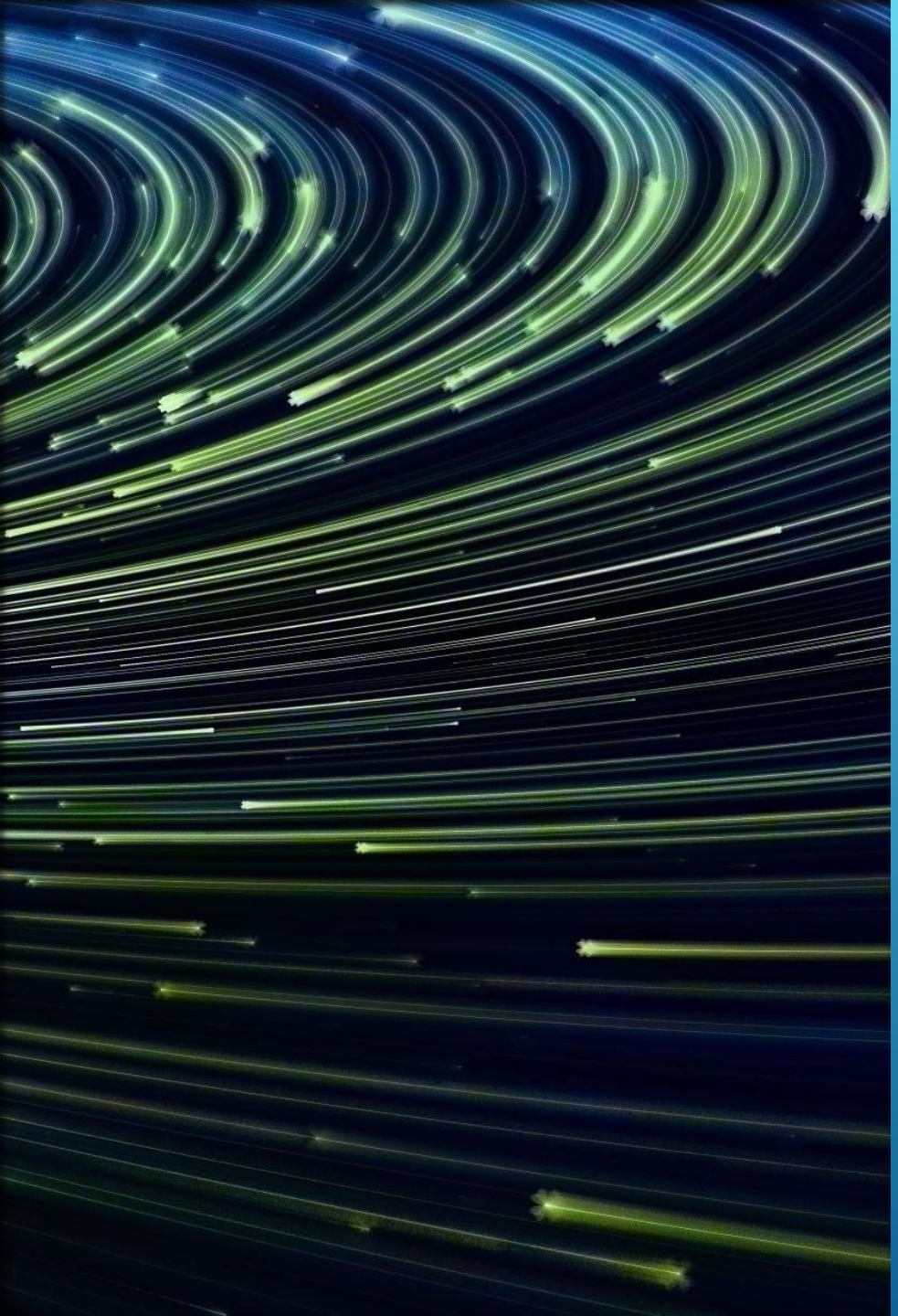
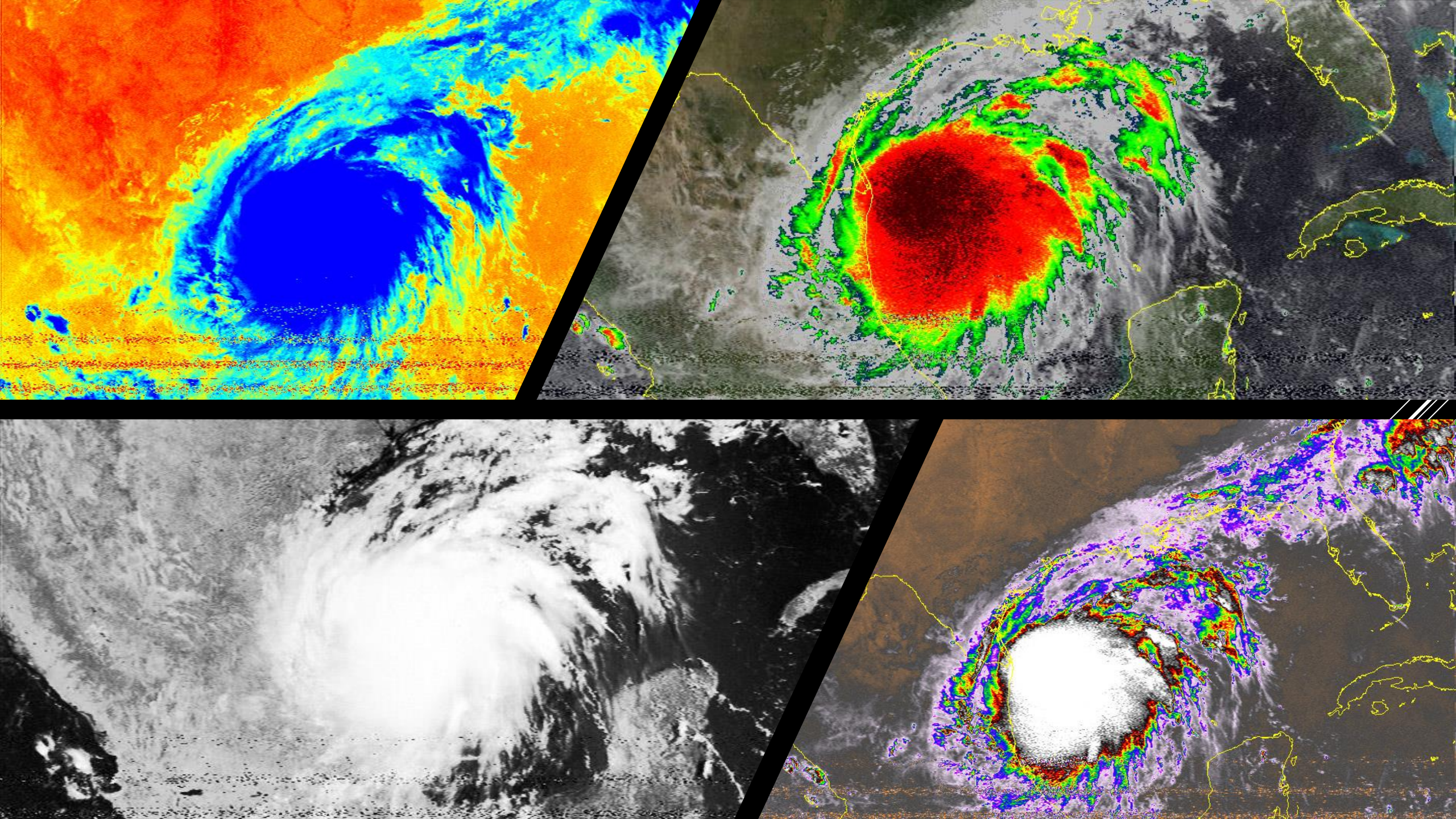


GETTING STARTED RECEIVING NOAA WX SATELLITE IMAGES

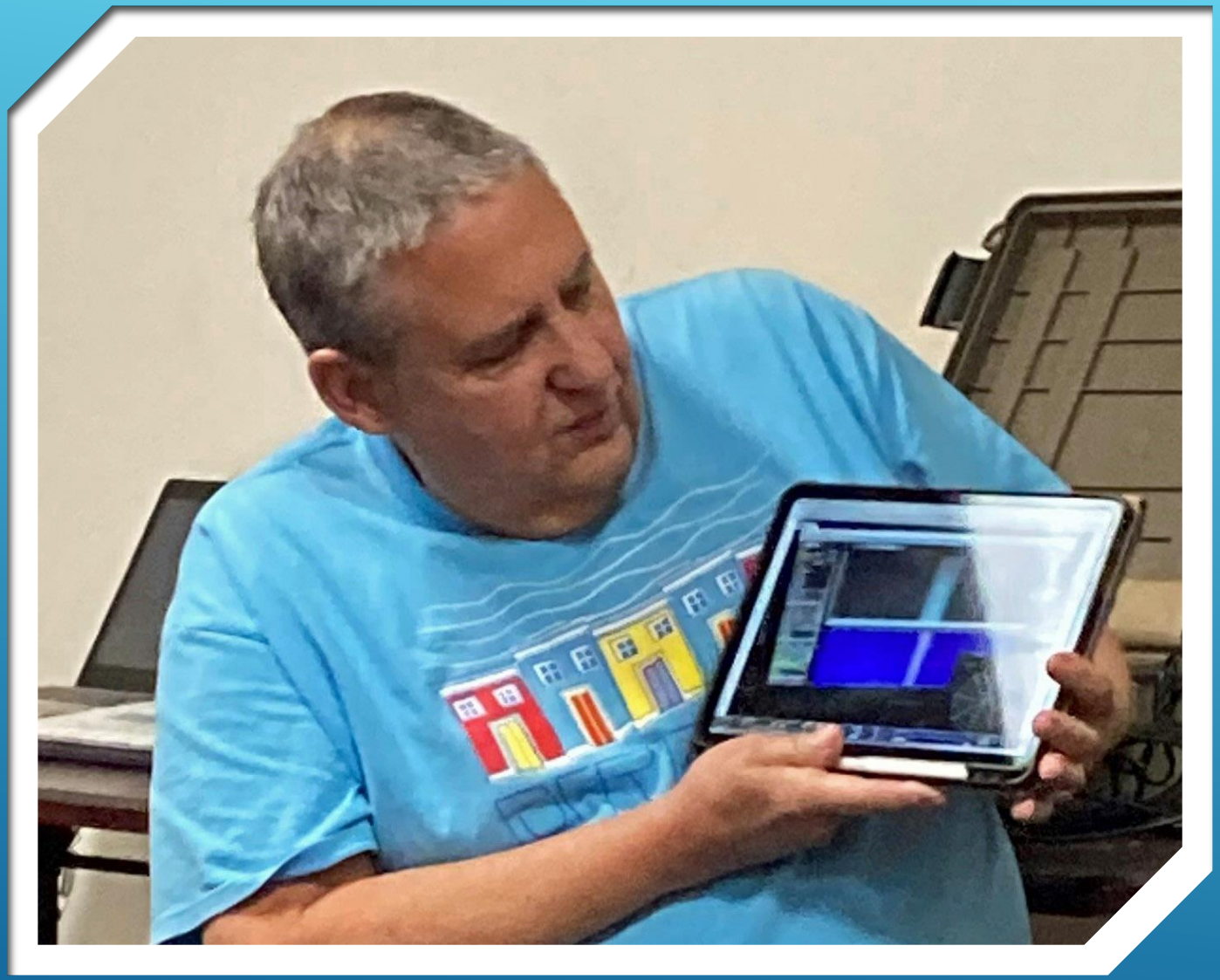
Jack Weaver – AA5VZ



- AARC Show-n-Tell
- July 16, 2024

- **Demonstration of a fully operational**
- **NOAA POES Wx Satellite Ground Station**
- **using a Raspberry Pi-5 computer**

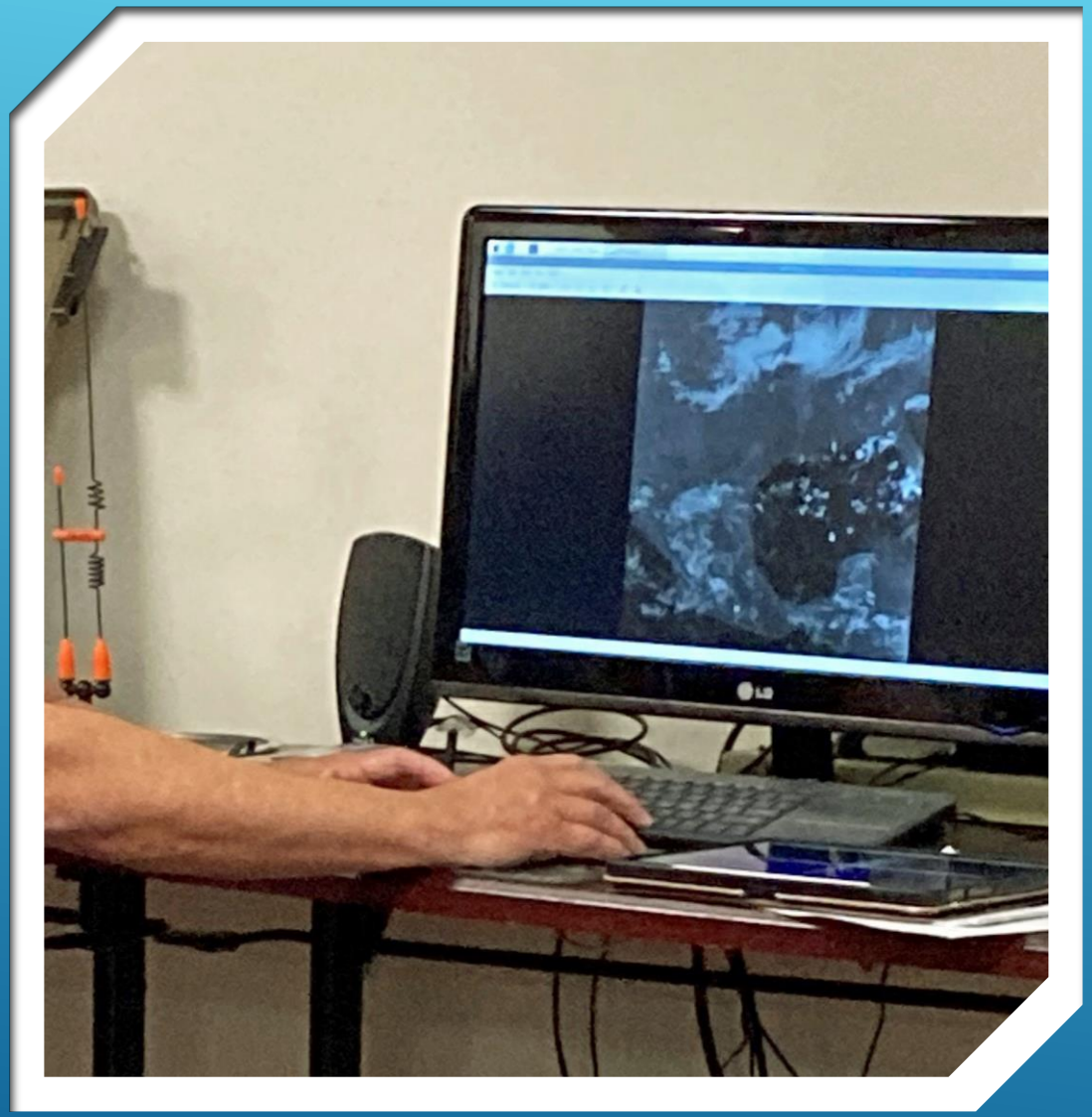
BACKGROUND



BACKGROUND

- AARC Show-n-Tell
- July 16, 2024

- **Talking points:**
- **What comprises a basic ground station for receiving Wx images?**
- **What a satellite pass looks and sounds like using SDR software**
- **Recording and storing the captured image file stream with SDR++ software.**
- **Processing and storing the resulting image data with SatDump application software.**



BACKGROUND

- AARC Show-n-Tell
- July 16, 2024

- **Decoded a pre-recorded file-stream**
- **Displayed the resulting cloud and rainfall image maps**
- **Offered to follow up with a more detailed presentation on the subject matter including antenna requirements.**

SO, LET'S GET STARTED!

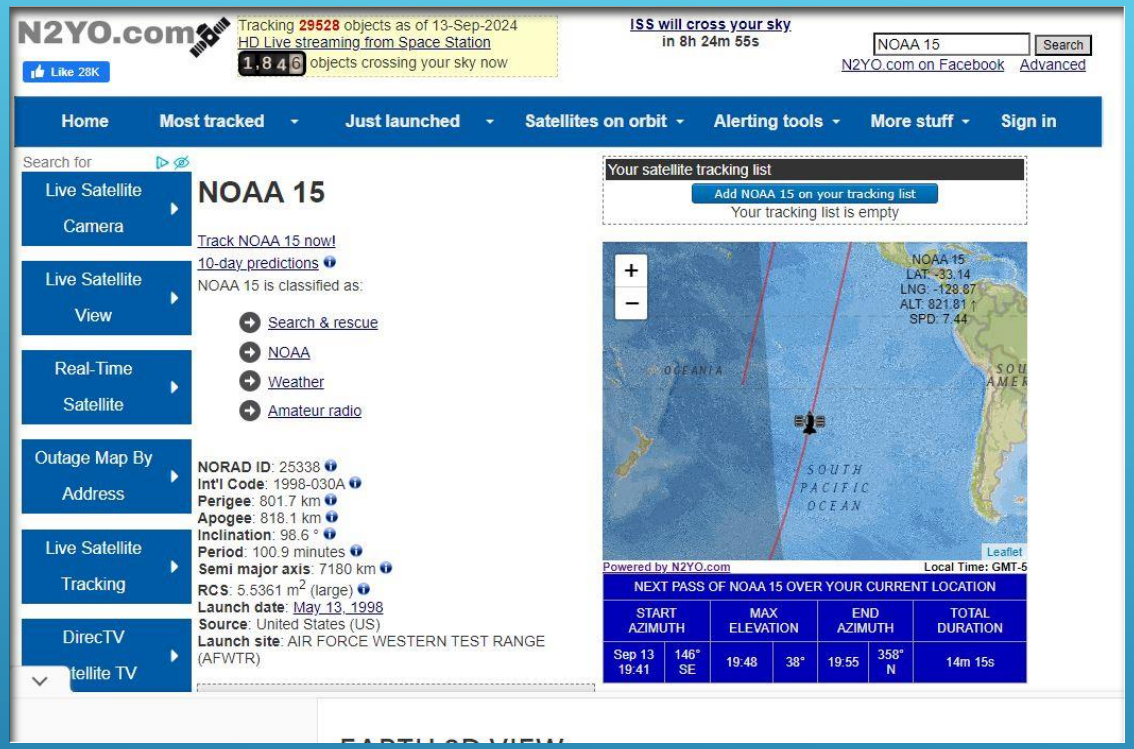
WHAT DO I NEED?

- Inexpensive SDR Rx Dongle
- Antenna
- PC or Laptop running Windows (Linux and Mac versions are available)

- WX Image Capture Software (free)
- WX Image Processing Software (free)

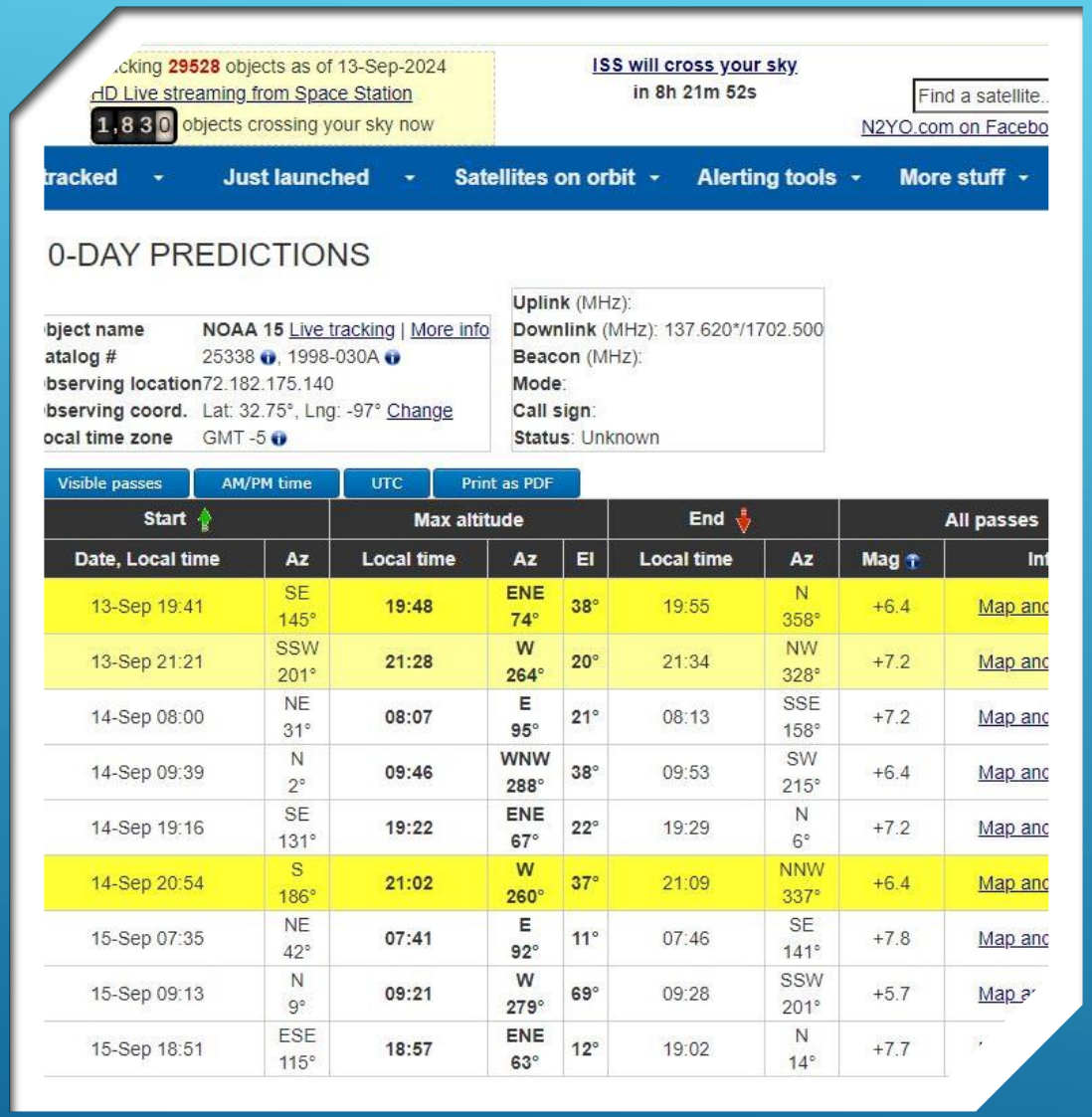
- Schedule of Satellite Passes across your area

- Recommended: Satellite Tracking Software (some free)



- Variety of ways to obtain pass schedules
- N2YO.COM site shown here
- Enter Satellite Name
  - NOAA 15
  - NOAA 18
  - NOAA 19
- Click on “Search”
- Click on “10-Day Predictions”
- Results shown on next screen

SATELLITE PASS SCHEDULE



cking **29528** objects as of 13-Sep-2024
HD Live streaming from Space Station
1,830 objects crossing your sky now

ISS will cross your sky
in 8h 21m 52s

Find a satellite..
N2YO.com on Facebo

tracked | Just launched | Satellites on orbit | Alerting tools | More stuff

0-DAY PREDICTIONS

bject name NOAA 15 Live tracking | More info
atalog # 25338, 1998-030A
bserving location 72.182.175.140
bserving coord. Lat: 32.75°, Lng: -97° Change
ocal time zone GMT -5

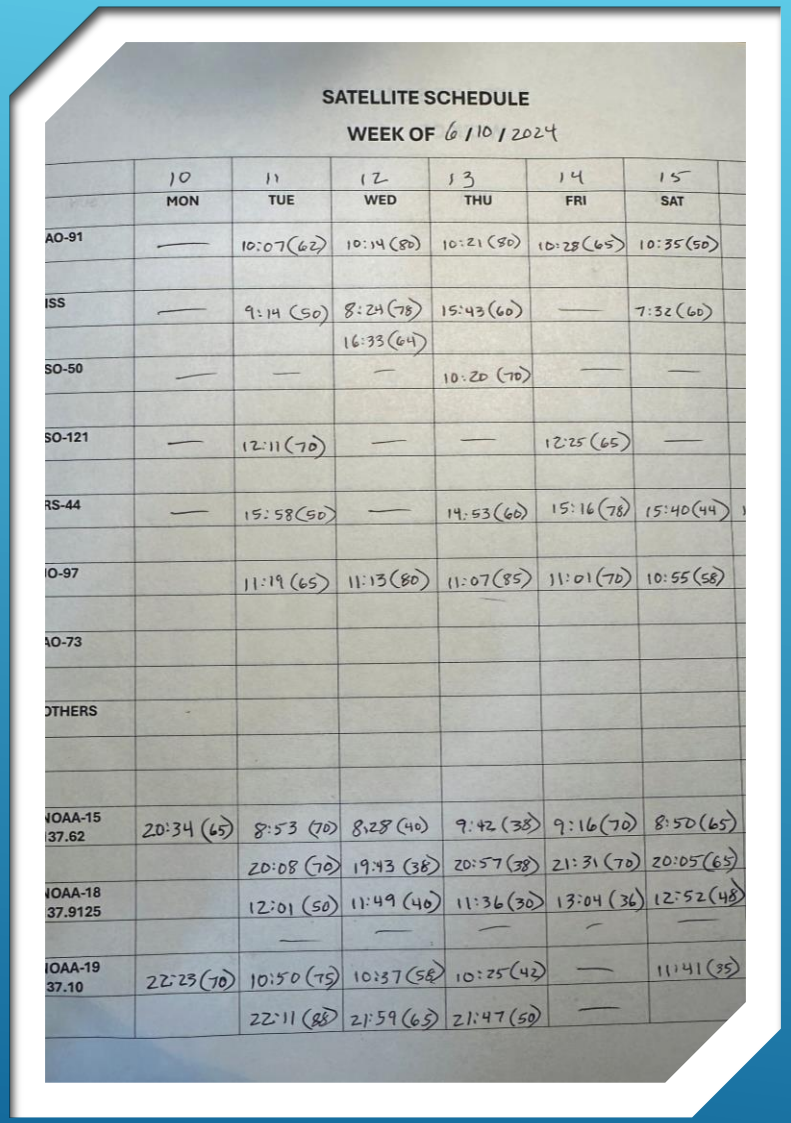
Uplink (MHz):
Downlink (MHz): 137.620*/1702.500
Beacon (MHz):
Mode:
Call sign:
Status: Unknown

Visible passes | AM/PM time | UTC | Print as PDF

Start		Max altitude			End		All passes	
Date, Local time	Az	Local time	Az	El	Local time	Az	Mag	In
13-Sep 19:41	SE 145°	**19:48**	**ENE 74°**	**38°**	19:55	N 358°	+6.4	Map and
13-Sep 21:21	SSW 201°	**21:28**	**W 264°**	**20°**	21:34	NW 328°	+7.2	Map and
14-Sep 08:00	NE 31°	**08:07**	**E 95°**	**21°**	08:13	SSE 158°	+7.2	Map and
14-Sep 09:39	N 2°	**09:46**	**WNW 288°**	**38°**	09:53	SW 215°	+6.4	Map and
14-Sep 19:16	SE 131°	**19:22**	**ENE 67°**	**22°**	19:29	N 6°	+7.2	Map and
14-Sep 20:54	S 186°	**21:02**	**W 260°**	**37°**	21:09	NNW 337°	+6.4	Map and
15-Sep 07:35	NE 42°	**07:41**	**E 92°**	**11°**	07:46	SE 141°	+7.8	Map and
15-Sep 09:13	N 9°	**09:21**	**W 279°**	**69°**	09:28	SSW 201°	+5.7	Map a
15-Sep 18:51	ESE 115°	**18:57**	**ENE 63°**	**12°**	19:02	N 14°	+7.7	

- N2YO 10-Day Prediction Results Page
- Variety of ways to display results
- Page is printable as .pdf document

SATELLITE PASS SCHEDULE



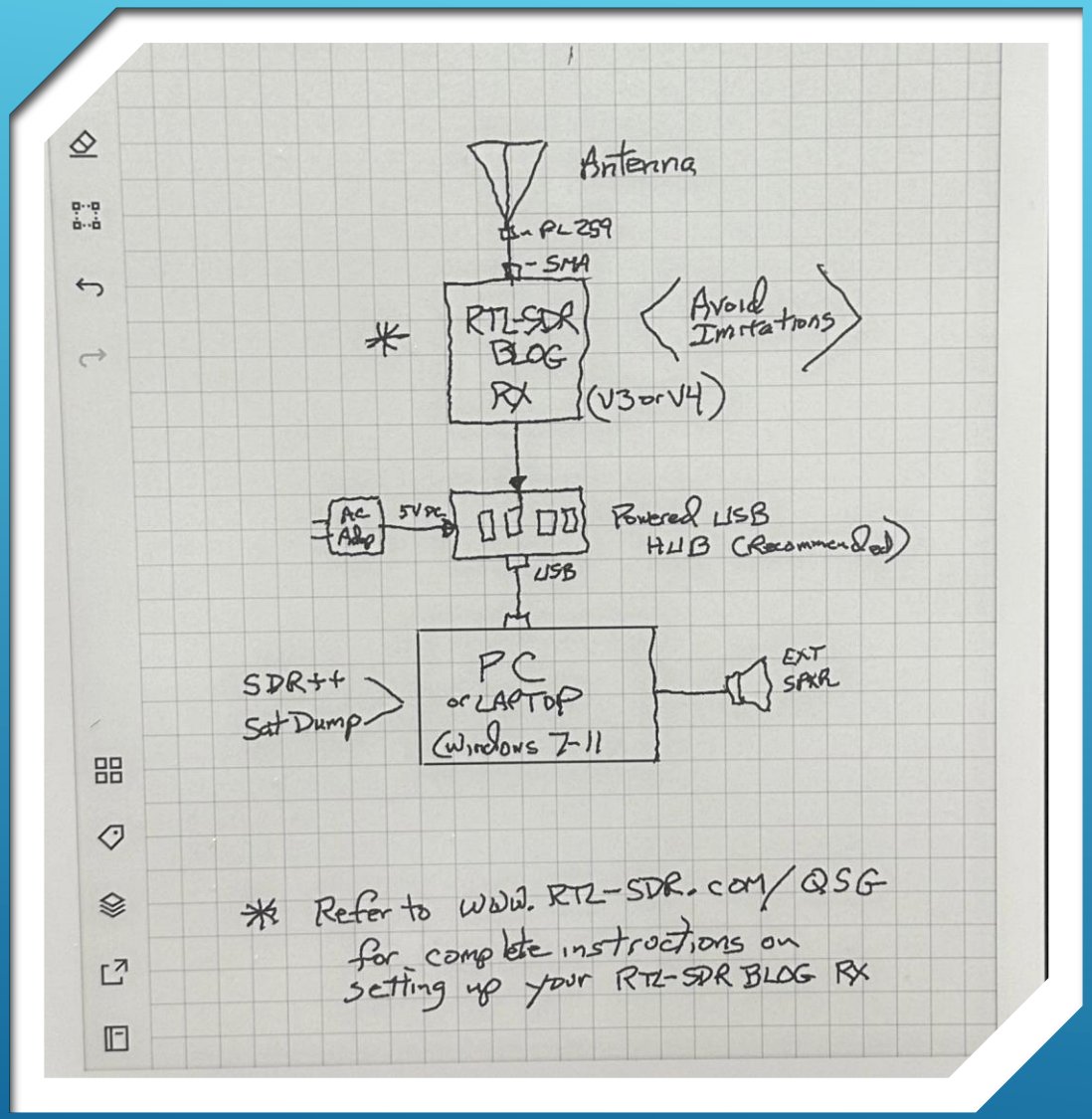
SATELLITE SCHEDULE

WEEK OF 6 / 10 / 2024

	10 MON	11 TUE	12 WED	13 THU	14 FRI	15 SAT
AO-91	—	10:07 (62)	10:14 (80)	10:21 (80)	10:28 (65)	10:35 (50)
ISS	—	9:14 (50)	8:24 (78)	15:43 (60)	—	7:32 (60)
			16:33 (64)			
SO-50	—	—	—	10:20 (70)	—	—
SO-121	—	12:11 (70)	—	—	12:25 (65)	—
RS-44	—	15:58 (50)	—	14:53 (60)	15:16 (78)	15:40 (44)
IO-97		11:19 (65)	11:13 (80)	11:07 (85)	11:01 (70)	10:55 (58)
AO-73						
OTHERS						
NOAA-15 137.62	20:34 (65)	8:53 (70)	8:28 (40)	9:42 (38)	9:16 (70)	8:50 (65)
		20:08 (70)	19:43 (38)	20:57 (38)	21:31 (70)	20:05 (65)
NOAA-18 137.9125		12:01 (50)	11:49 (40)	11:36 (30)	13:04 (36)	12:52 (48)
		—	—	—	—	—
NOAA-19 137.10	22:23 (70)	10:50 (75)	10:37 (58)	10:25 (42)	—	11:41 (35)
		22:11 (88)	21:59 (65)	21:47 (50)	—	

- Example of my Weekly Satellite Pass Schedule
- Lists all satellites of interest to me
- NOAA Wx Satellites (w/frequencies) at bottom
- **Produced every Sunday afternoon**
- I use Ham Radio Deluxe to view future pass schedules for this worksheet
- Shows Satellite Name, Date, Start Time (AOS) and maximum Elevation (in parenthesis).

SATELLITE PASS SCHEDULE



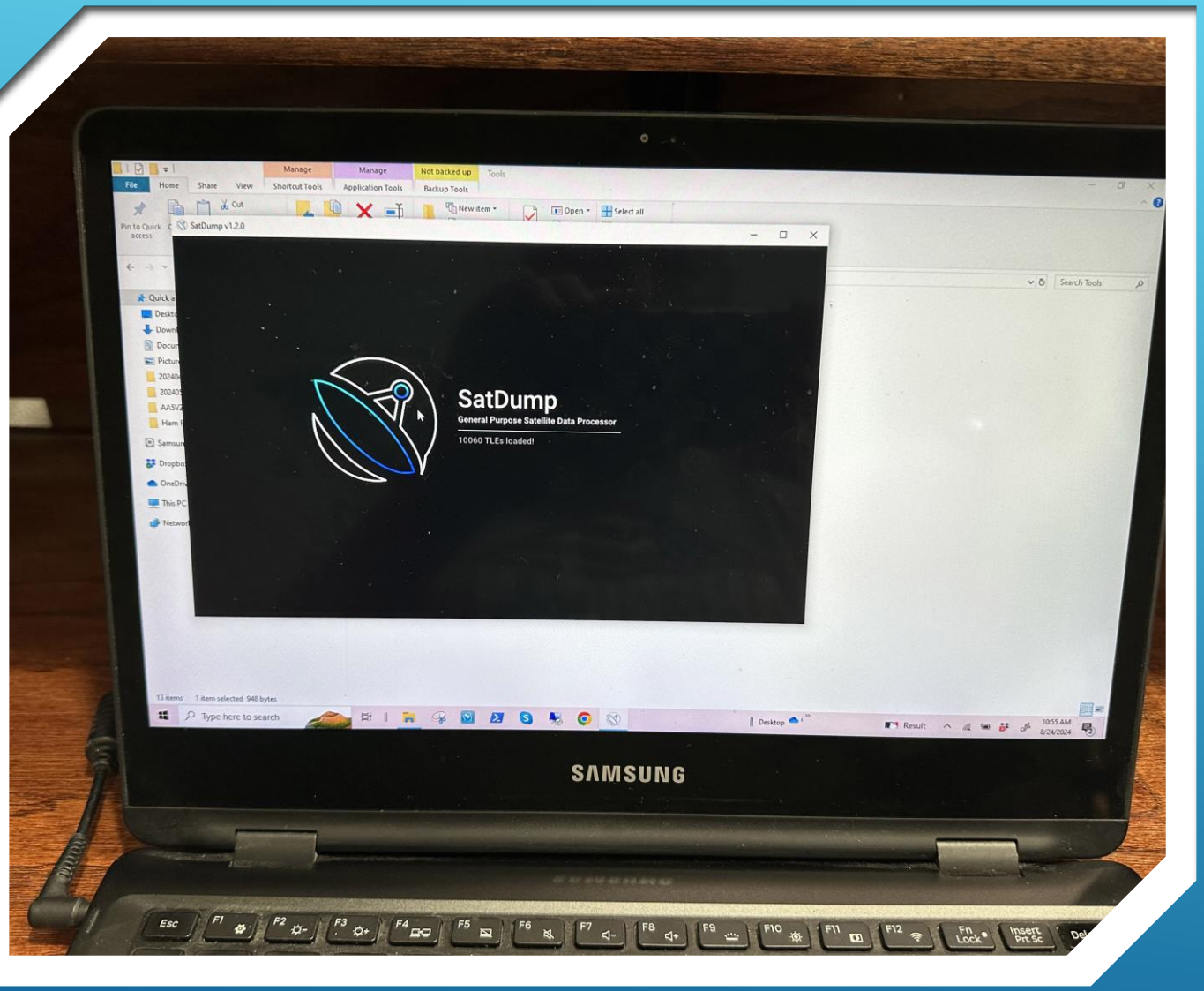
GROUND STATION BLOCK DIAGRAM

SDR RECEIVER

- Available from Amazon or RTL-SDR.com for under $35.00 (add $10.00 w/antenna kit)
- Full set-up instructions, user manuals and software downloads at RTL-SDR.com.
- *** Use Only "RTL-SDR BLOG" Brand
  - Other brands may not work correctly
- V3 (Black or Silver)
  - Separate Driver installation required.
  - Works well with Windows (and RPi).
  - Limited HF capability (only VHF is needed for NOAA POES satellites).
- V4 (Black)
  - Separate Driver installation required.
  - Works well with Windows.
  - Great HF capability in addition to VHF/UHF reception.
  - With RPi, may have driver compatibility issues with image processing software.

SOFTWARE (FREE)

- **SDR++ (Receive and Record WX Image Data Stream)**
  - **www.sdrpp.org**
- **SatDump (Process and Display Recorded Image Data Stream)**



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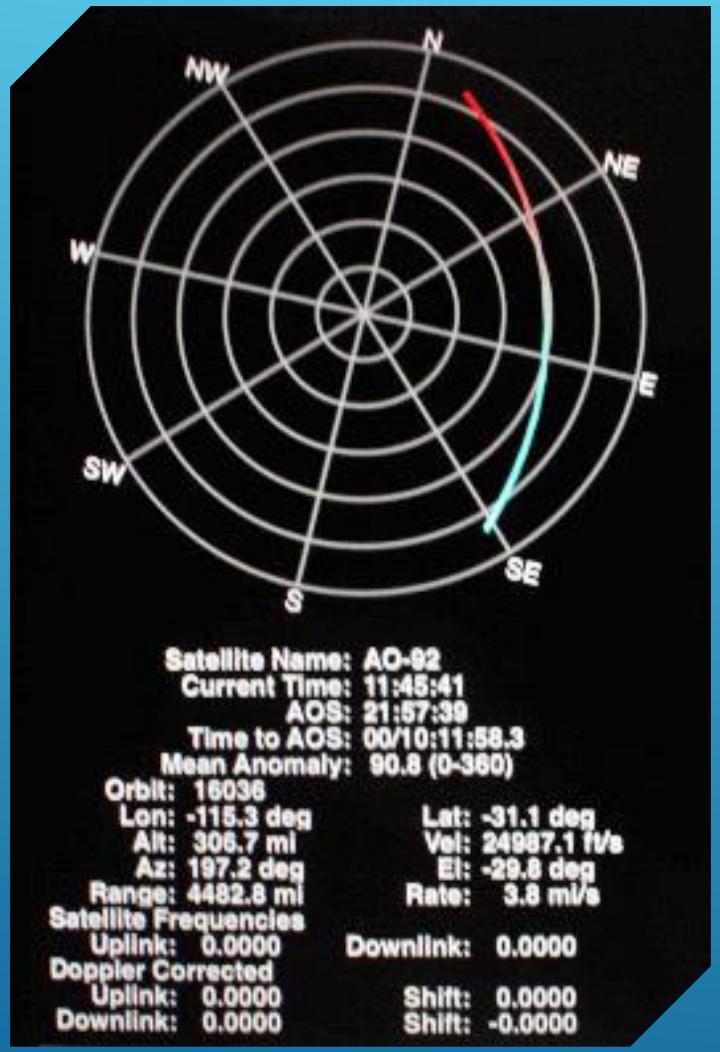
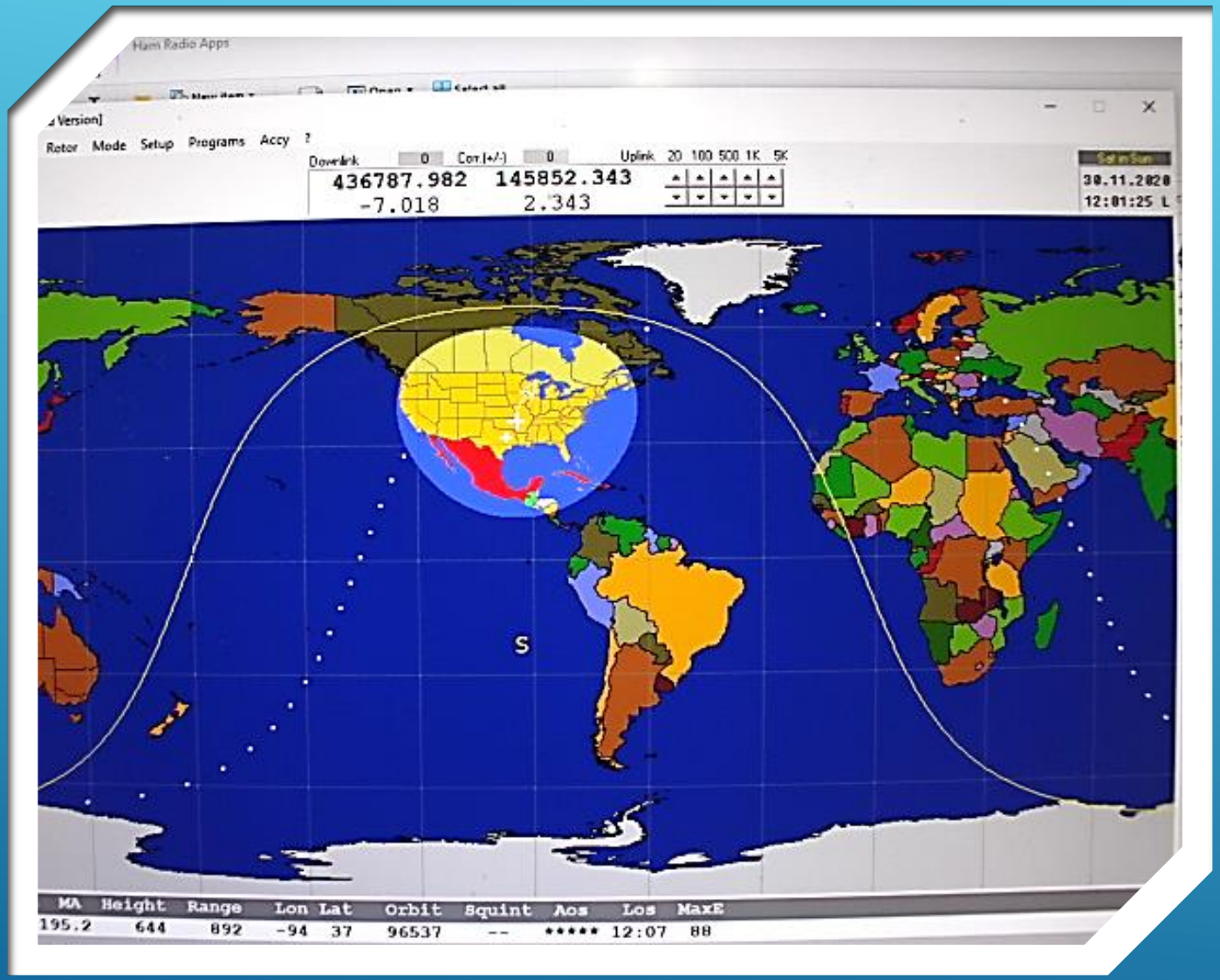


- Smart Phone
- I-Pad
- recommended, but NOT required to get started)
- Usually downloadable by paid subscription

SATELLITE TRACKING APP



OPTIONAL SOFTWARE (FREE TRIAL VERSION)

- **SatPC32 (Satellite Tracking Software)**
- **Windows-based**
- **Available on-line**

- **Helpful, but NOT required to get started**

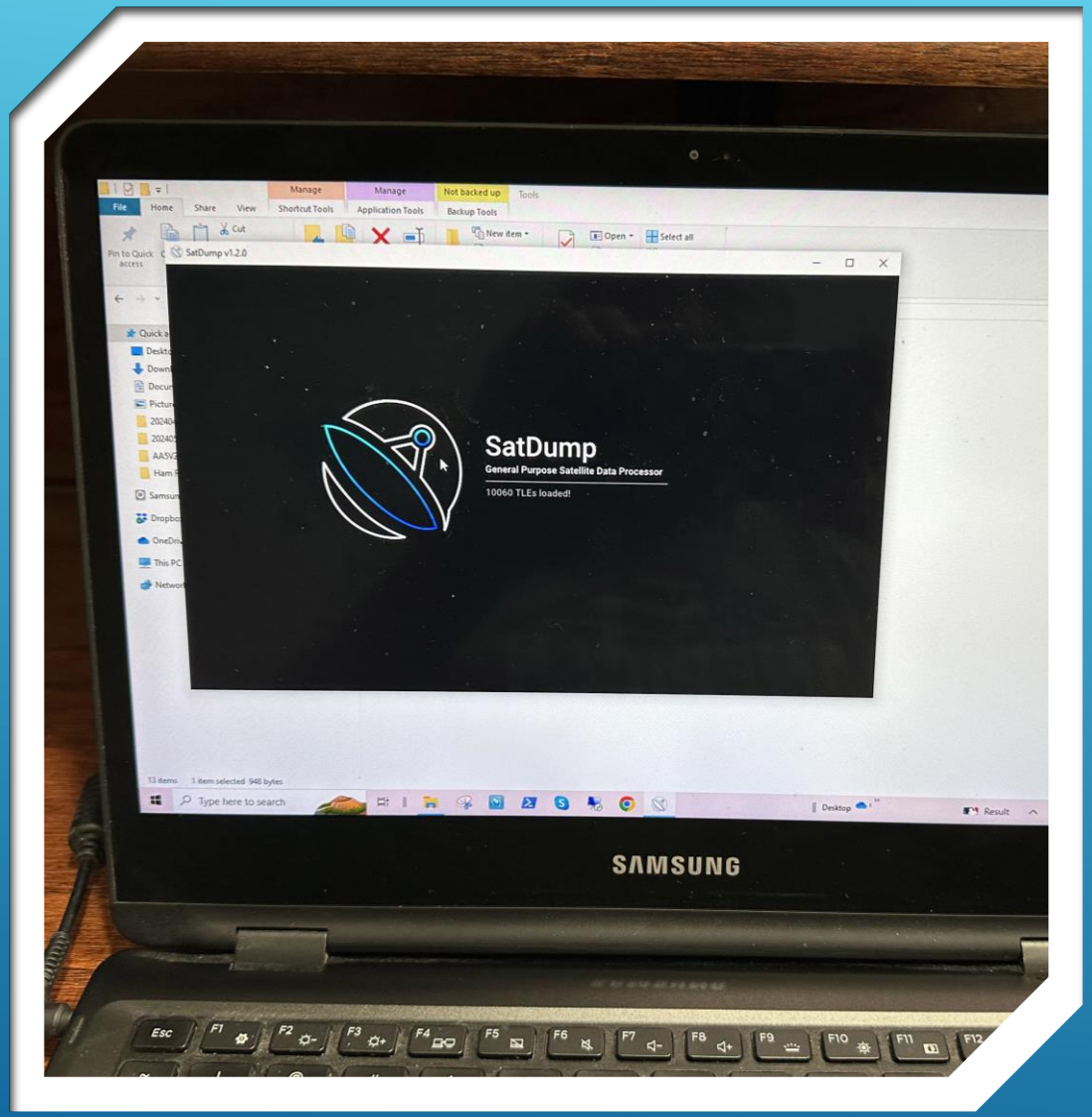
STATION SETUP (WINDOWS)

COMPUTER

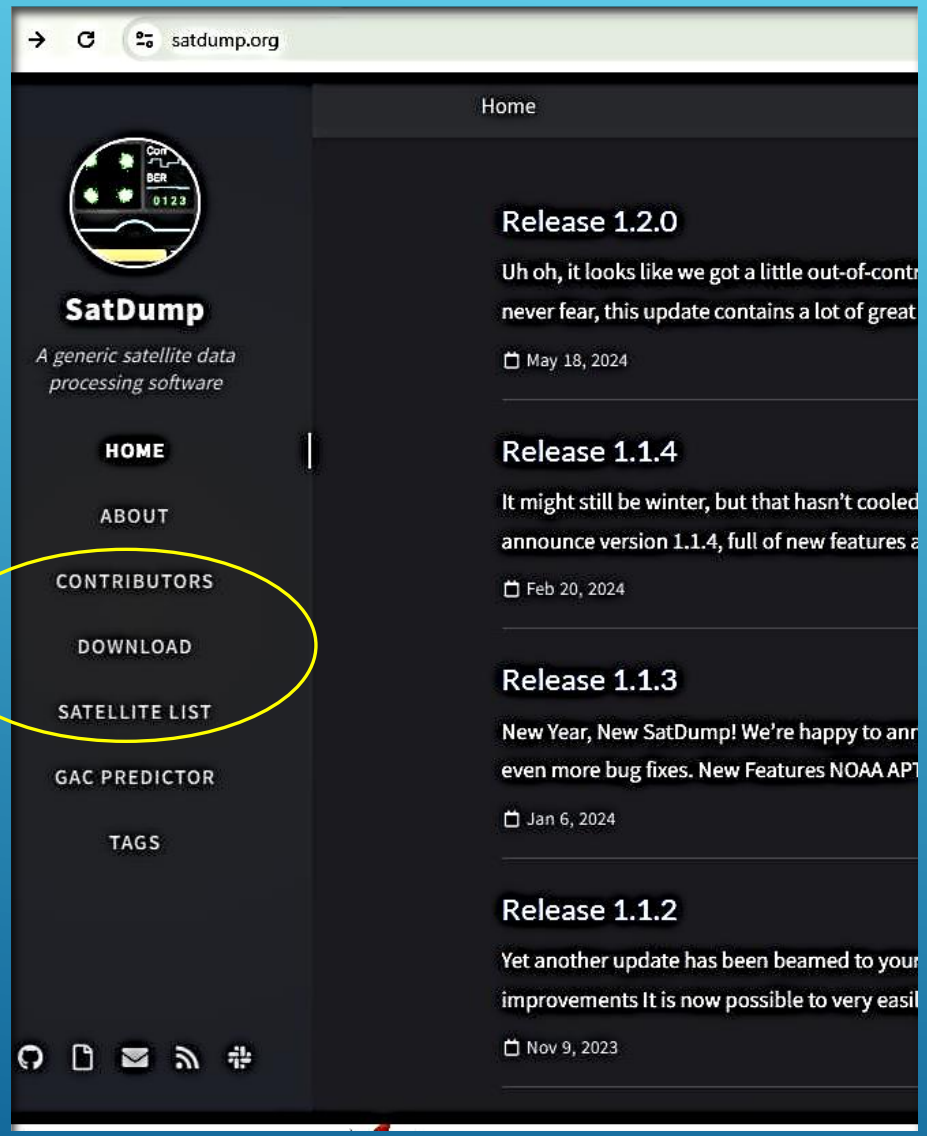
- Desktop PC
- Laptop
- Windows 7 thru 11
- Dongle works in my USB Port
- Powered USB Hub is preferred

SETTING UP TO RX VIA RTL-SDR DONGLE

- Download/Install SDR Dump software (www.sdrdump.org)
- Connect RTL-SDR Rx to USB port or a powered USB Hub.
- Note: V3 or V4 User Manual available for download from www.rtl-sdr.com
- ***Suggested Precaution - Create a new Recovery Set-Point before next step
- Install Drivers using Zadig (www.rtl-sdr.com)
- Download/Unzip/Install SDR++ software (www.sdrpp.org)
- Connect an Antenna
- Run SDR++
- Perform basic settings for operation
- Test for signal Reception

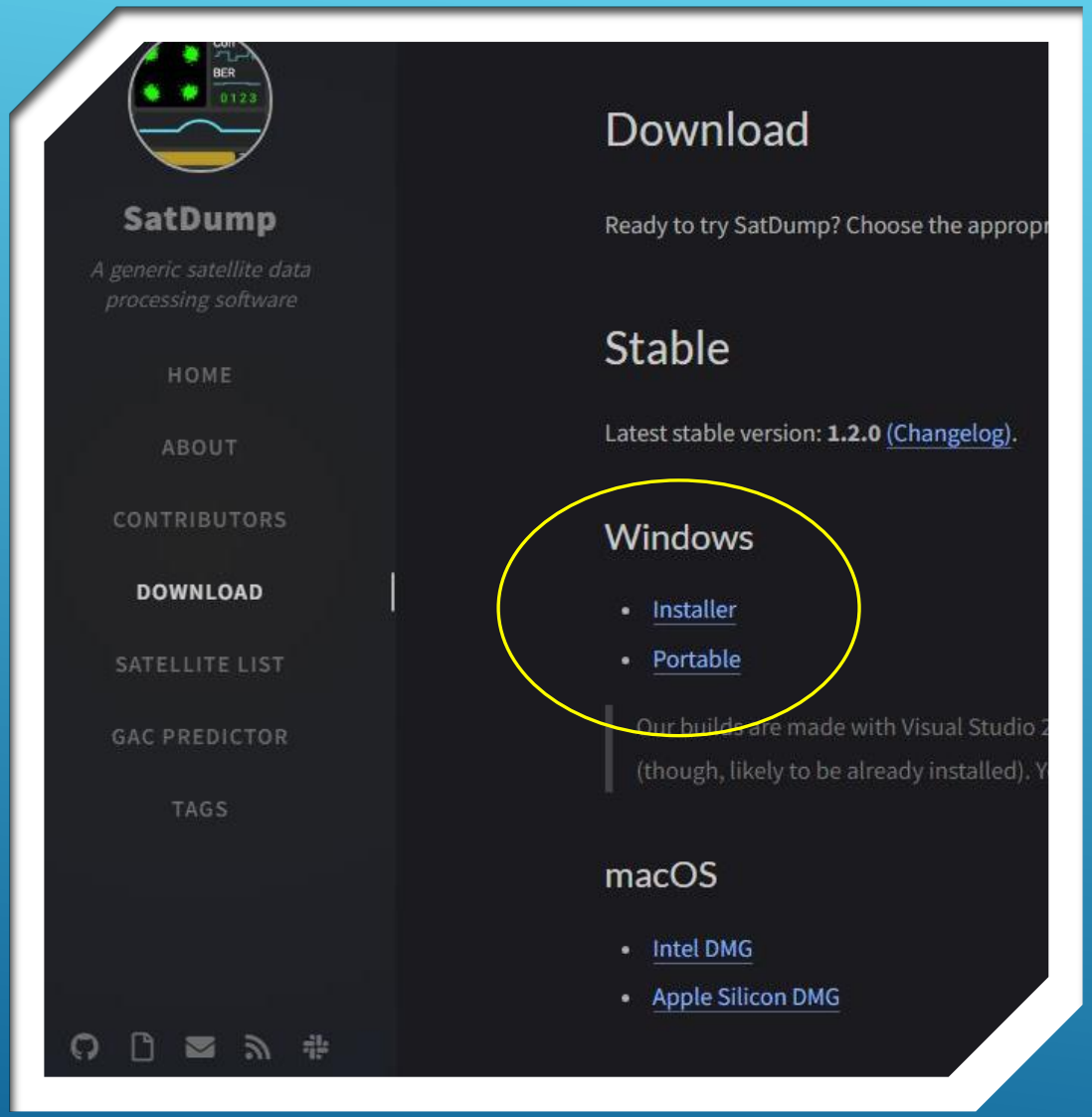


INSTALL SATDUMP SOFTWARE ON YOUR WINDOWS PC



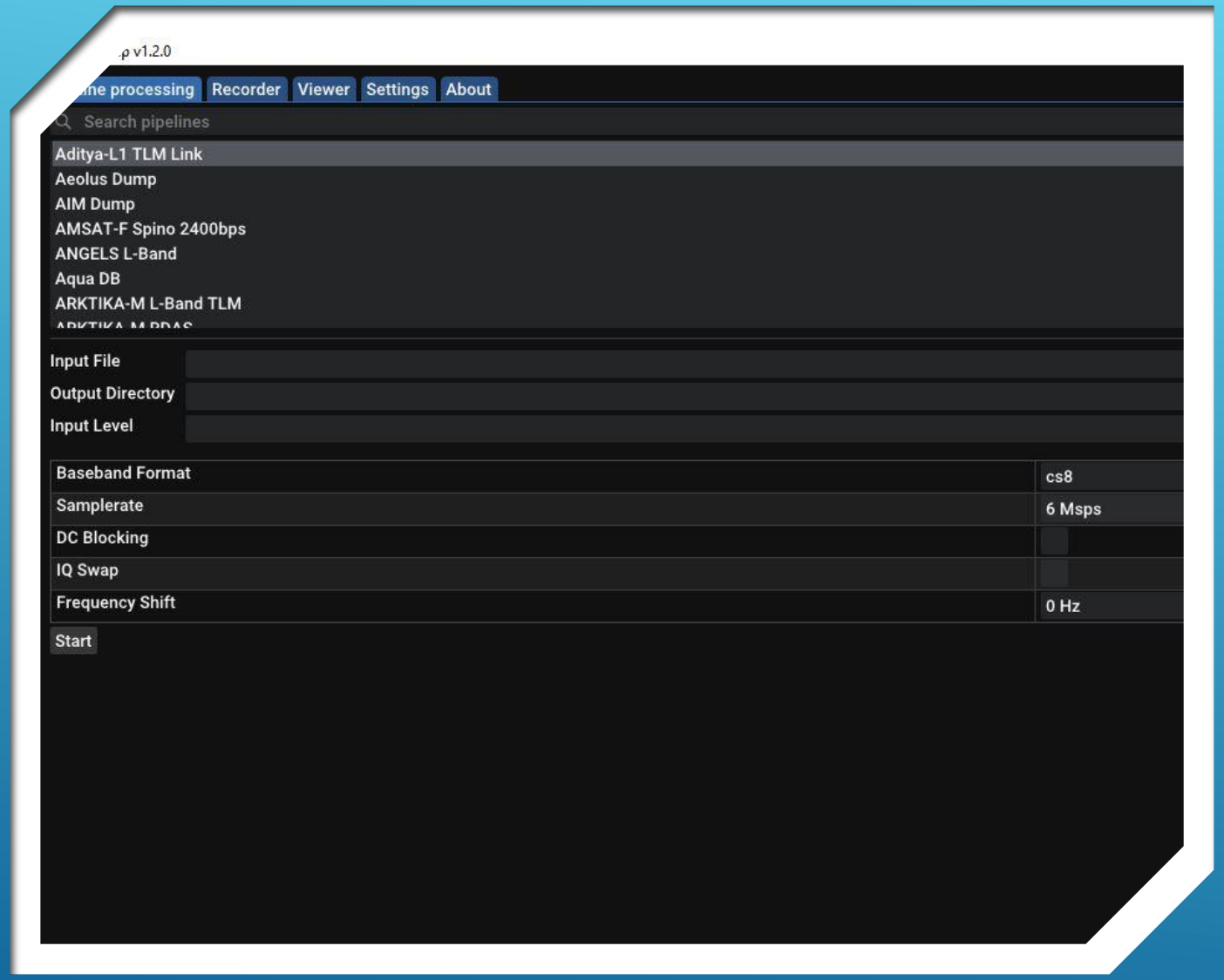
- Go to SatDump Web Site
- www.satdump.org
- Download/Install SatDump software as follows…
- Click on "Download"
- On the following page…

INSTALL SATDUMP ON A WINDOWS PC

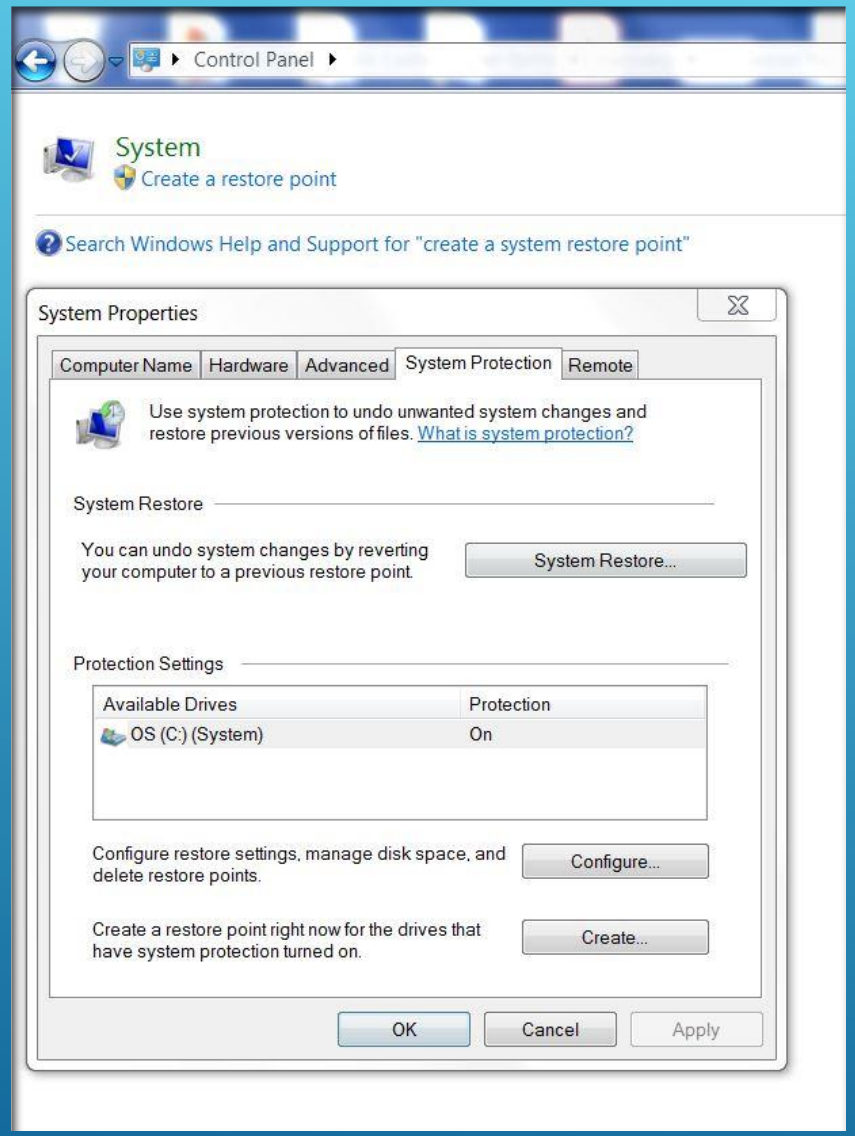


- **Under Windows, click “Installer”**
- **Find and open the SatDump-Windows_x64_Installer.exe file in your downloads directory**
- **Follow prompts to complete the installation**

INSTALL SATDUMP ON A WINDOWS PC

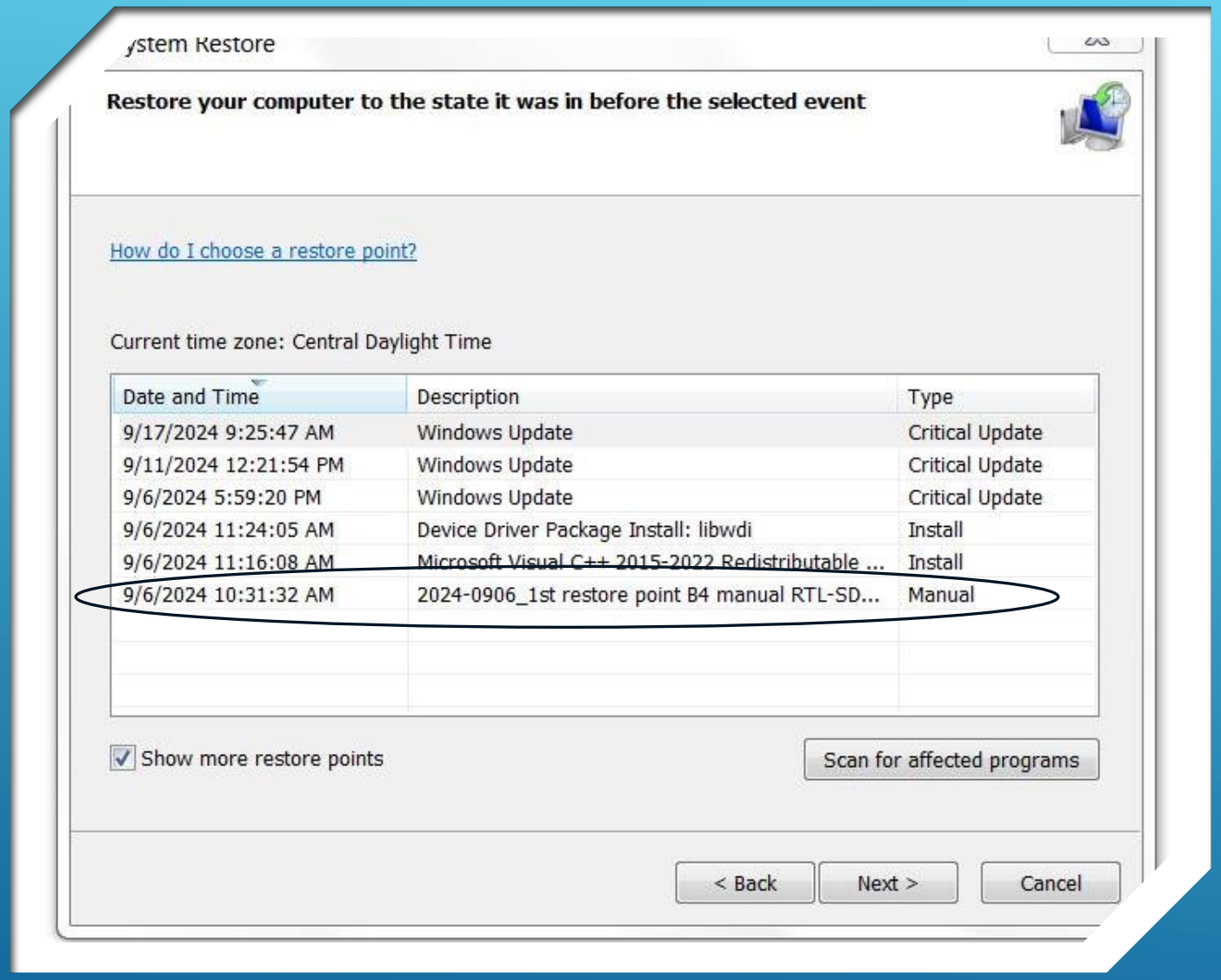


- **Upon completion…**
- Open “SatDump”
- Verify Desktop is displayed
- Close SatDump for now



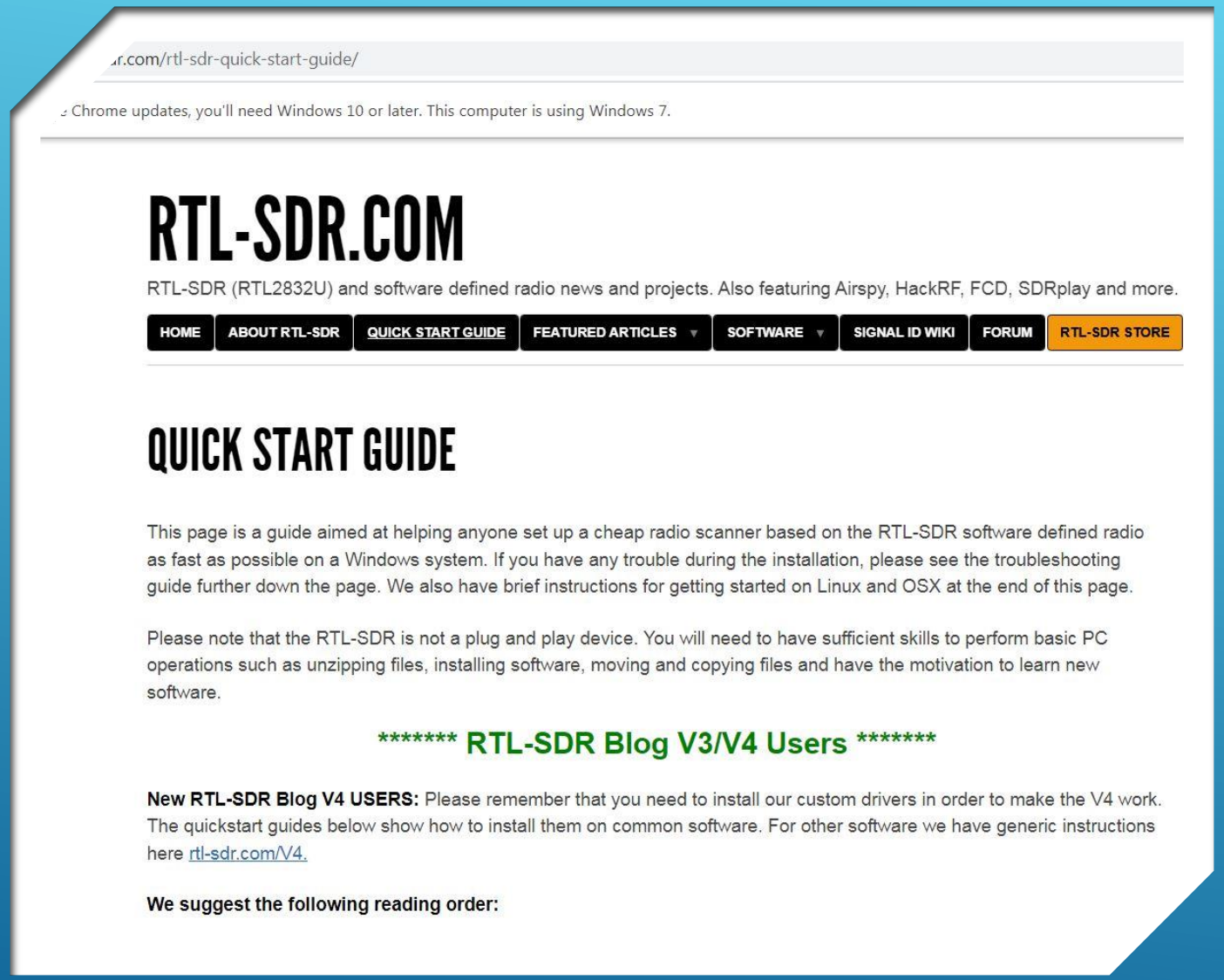
- Go to Control Panel
- Search for "Create a System Restore Point"
- Select Drive
- Click "Create"
- Follow Prompts

CREATE RESTORE POINT – (OPTIONAL)



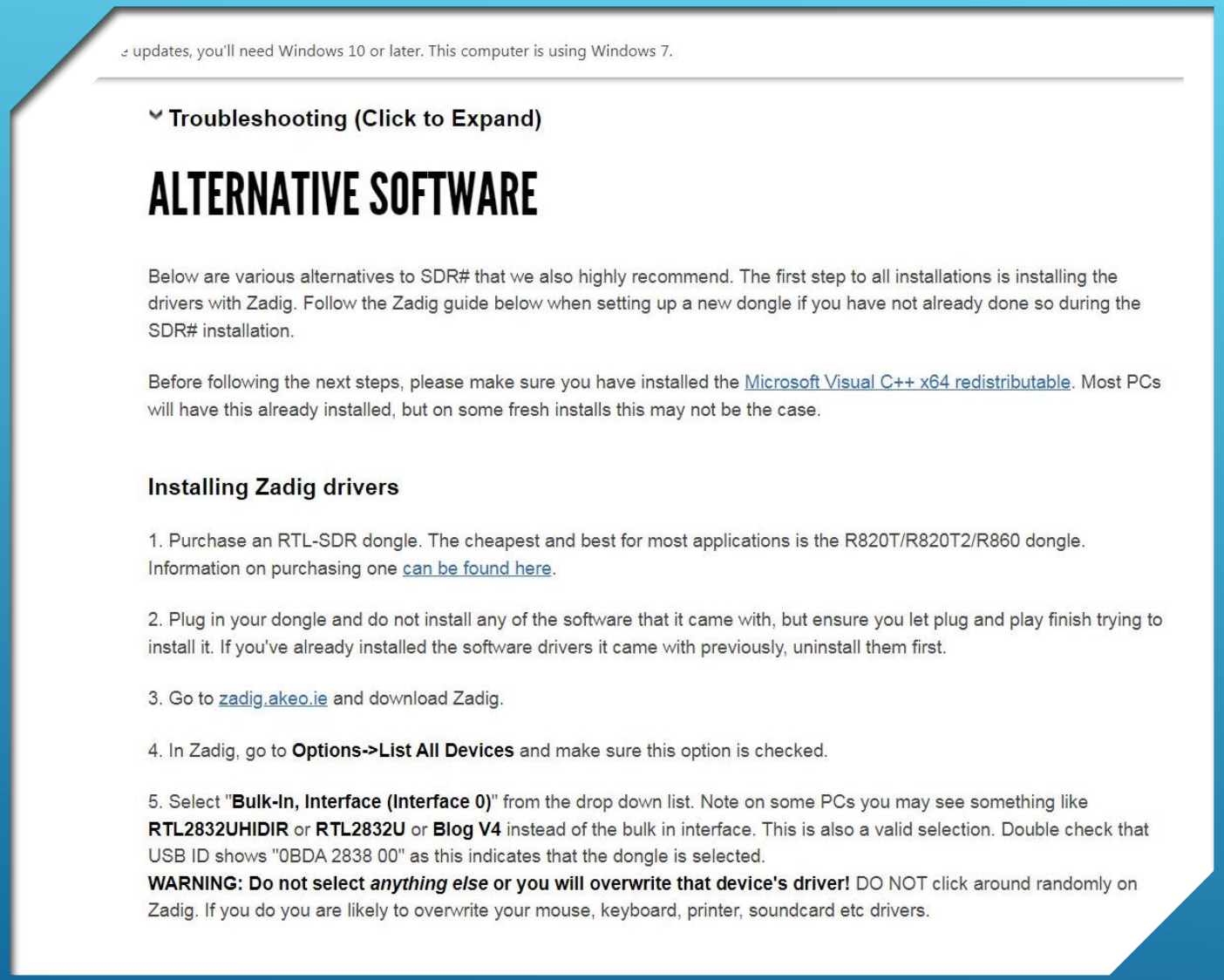
CREATE RESTORE POINT – (OPTIONAL)

- **Give restore point a meaningful name**



INSTALL DRIVERS (USING ZADIG)

- **Go to RTL-SDR website**
- **www.rtl-sdr.com**
- **Click “Quick Start Guide” tab**
- **Scroll down to “Alternative Software”**
- **Follow instructions to install Drivers**
- **Install SDR++ Software**



e updates, you'll need Windows 10 or later. This computer is using Windows 7.

Troubleshooting (Click to Expand)

ALTERNATIVE SOFTWARE

Below are various alternatives to SDR# that we also highly recommend. The first step to all installations is installing the drivers with Zadig. Follow the Zadig guide below when setting up a new dongle if you have not already done so during the SDR# installation.

Before following the next steps, please make sure you have installed the Microsoft Visual C++ x64 redistributable. Most PCs will have this already installed, but on some fresh installs this may not be the case.

Installing Zadig drivers

1. Purchase an RTL-SDR dongle. The cheapest and best for most applications is the R820T/R820T2/R860 dongle. Information on purchasing one can be found here.

2. Plug in your dongle and do not install any of the software that it came with, but ensure you let plug and play finish trying to install it. If you've already installed the software drivers it came with previously, uninstall them first.

3. Go to zadig.akeo.ie and download Zadig.

4. In Zadig, go to **Options->List All Devices** and make sure this option is checked.

5. Select "**Bulk-In, Interface (Interface 0)**" from the drop down list. Note on some PCs you may see something like **RTL2832UHIDIR** or **RTL2832U** or **Blog V4** instead of the bulk in interface. This is also a valid selection. Double check that USB ID shows "0BDA 2838 00" as this indicates that the dongle is selected.
WARNING: Do not select *anything else* or you will overwrite that device's driver! DO NOT click around randomly on Zadig. If you do you are likely to overwrite your mouse, keyboard, printer, soundcard etc drivers.

INSTALL DRIVERS (USING ZADIG)

- Go to RTL-SDR website
- www.rtl-sdr.com
- Click “Quick Start Guide” tab
- Scroll down to “Alternative Software”
- Follow instructions to install Drivers
- Continue down the list

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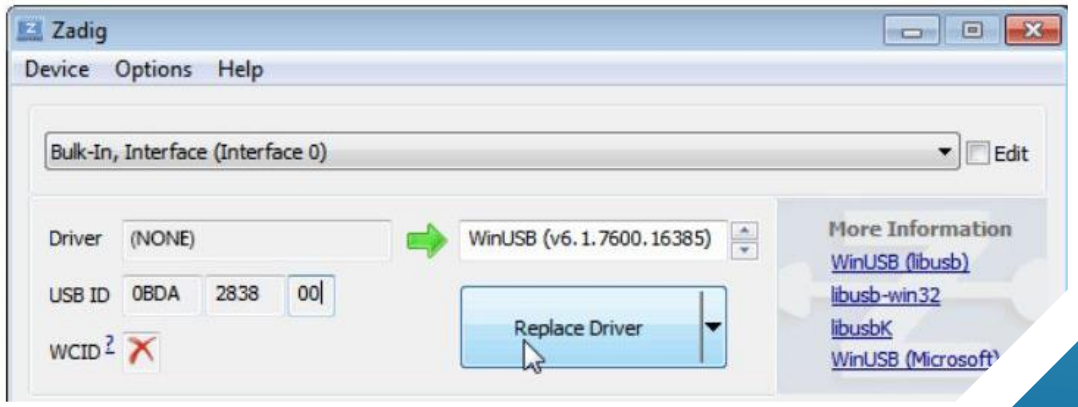

DRIVERS (USING ZADIG) INSTALL

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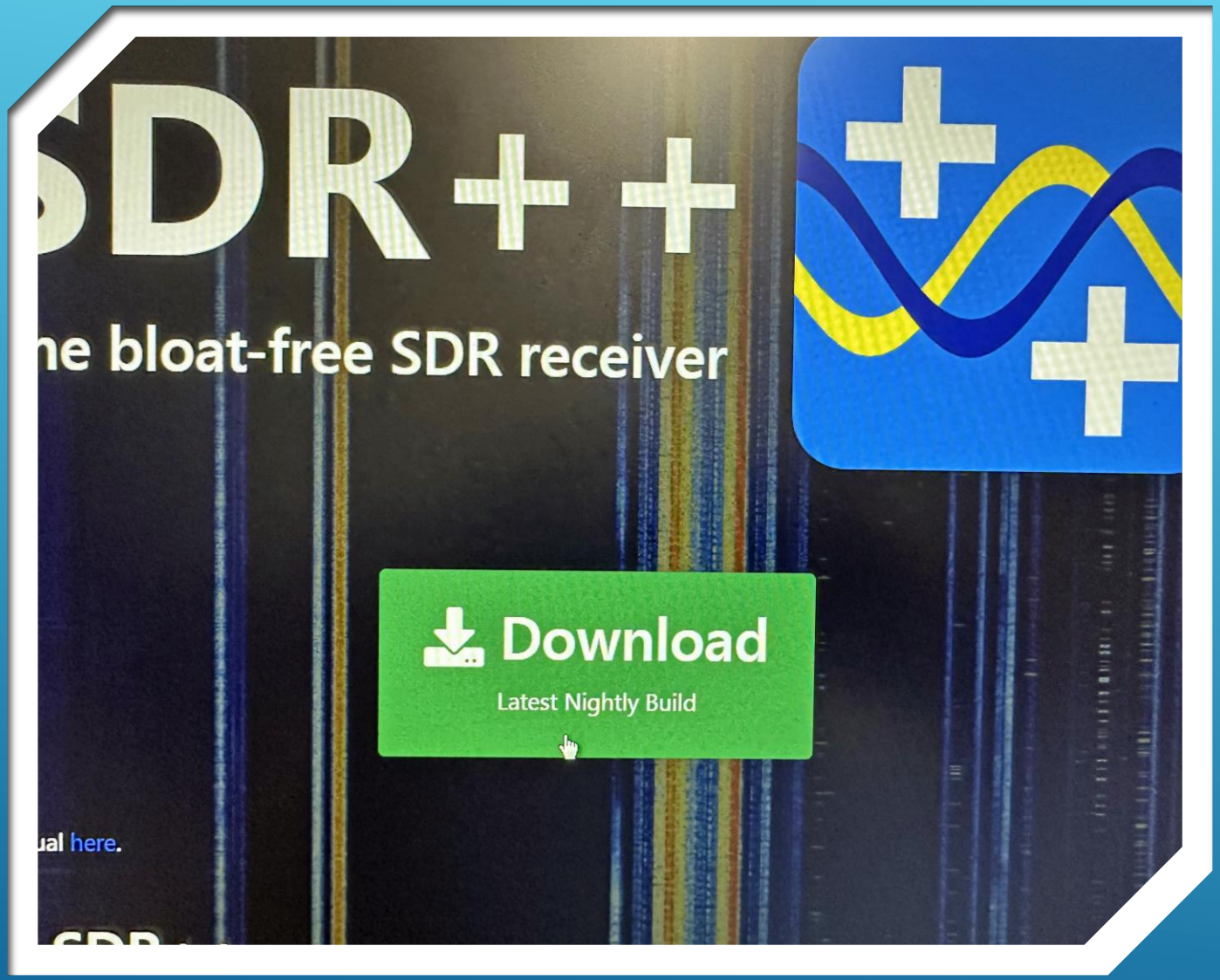
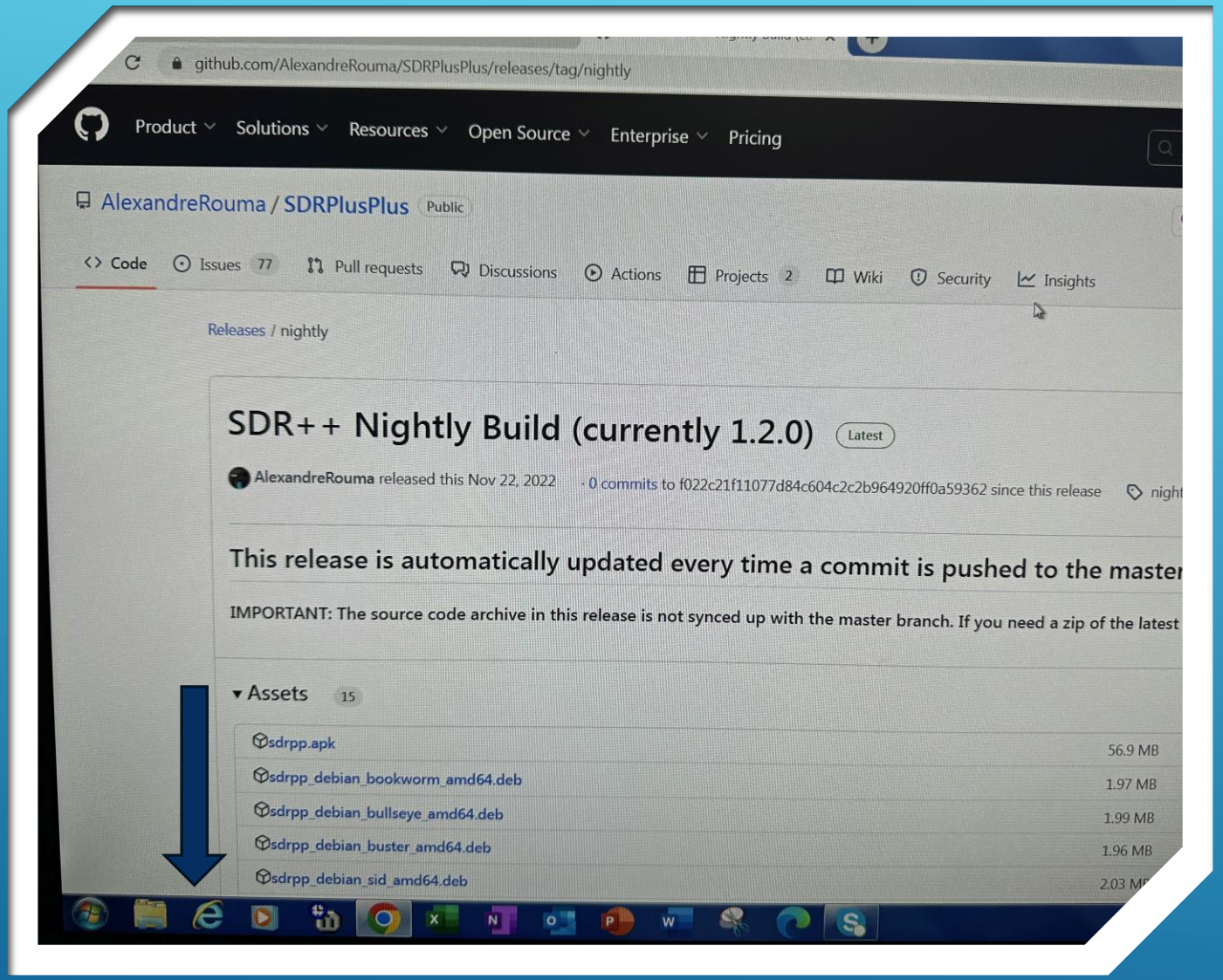
- Follow instructions to install Drivers
- When finished…
- Install SDR++ Software



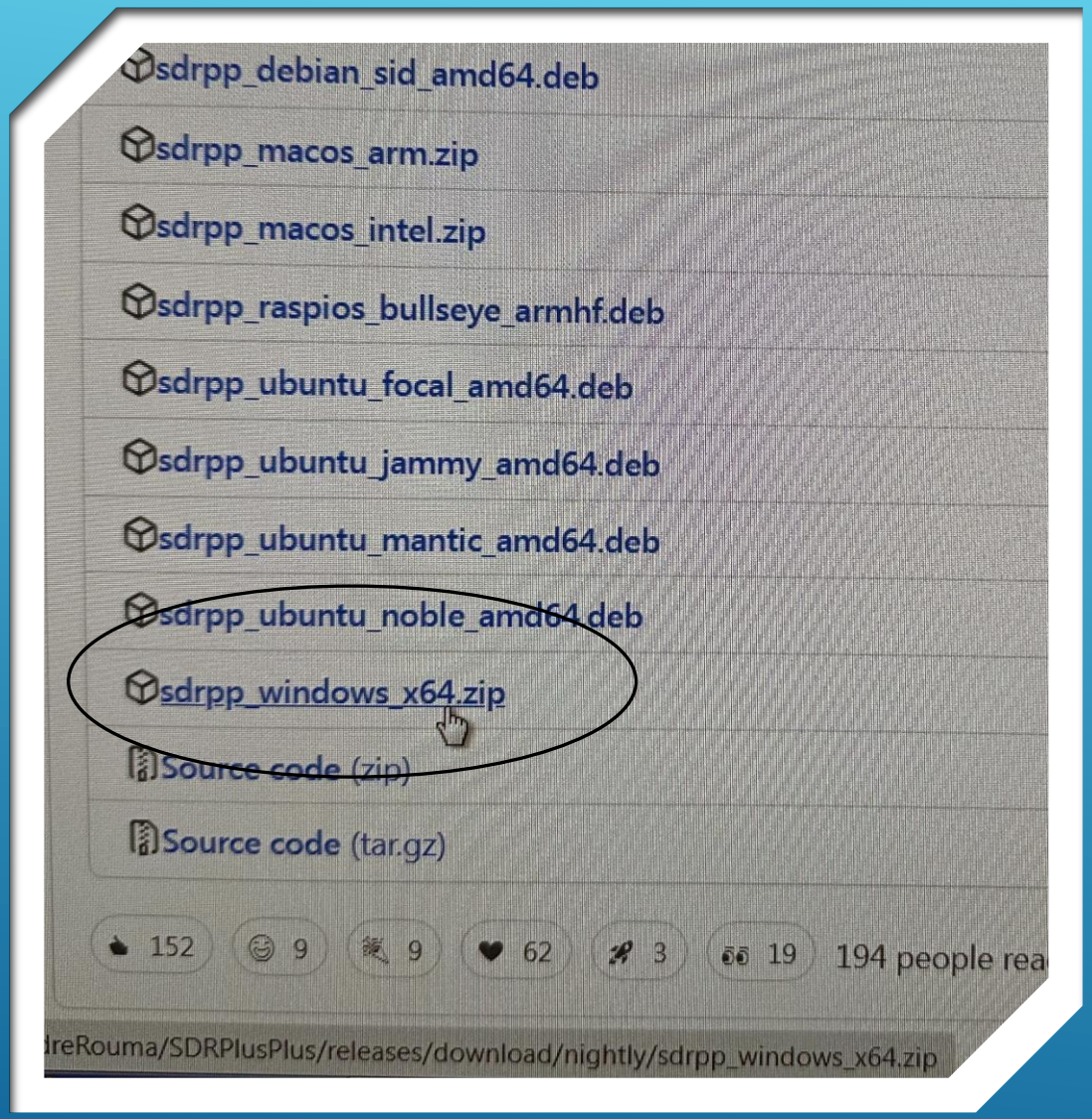
INSTALL SDR++ ON A WINDOWS PC

- **Go to SDR++ Web Site**
- **www.sdrpp.org**
- **Download/Unzip/Install SDR++ software as follows…**
- **Click on “Download”**
- **On the following page…**



INSTALL SDR++ ON A WINDOWS PC

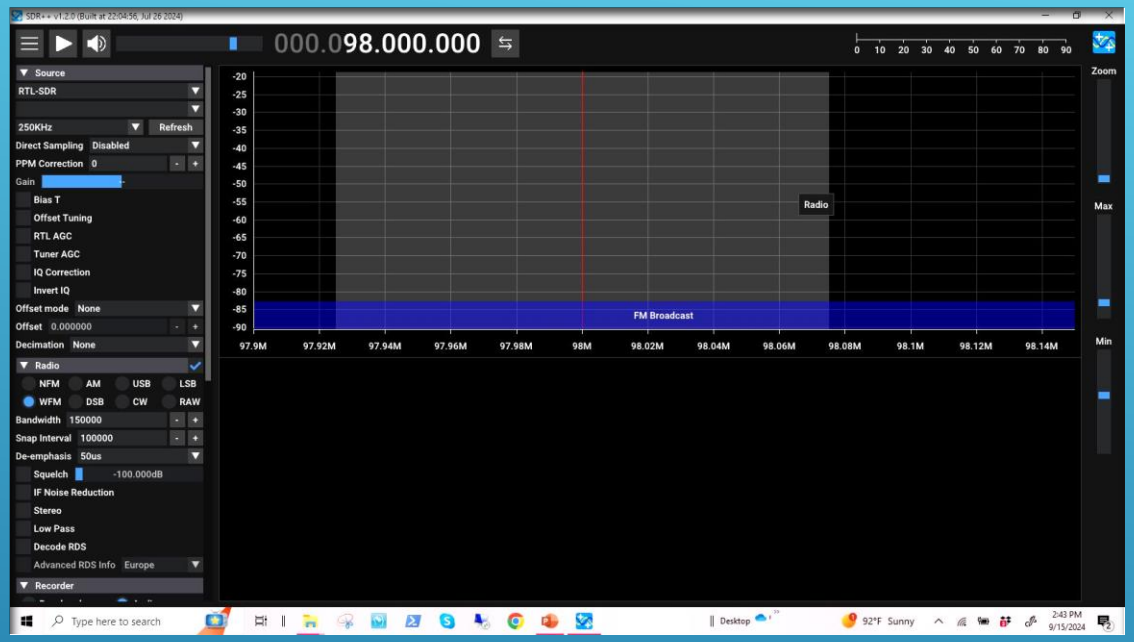
- **Scroll down the "Assets" list…**
- **Look for the file matching your operating system…**



- continue scrolling down the “Assets” list…
- Click here to download the “zipped” installation file for Windows
- When finished, extract all the files from the zipped installation file and open the “sdrpp.exe” file from the extracted list to install and start the program application.

INSTALL SDR++ ON A WINDOWS PC

SDR++ DESKTOP

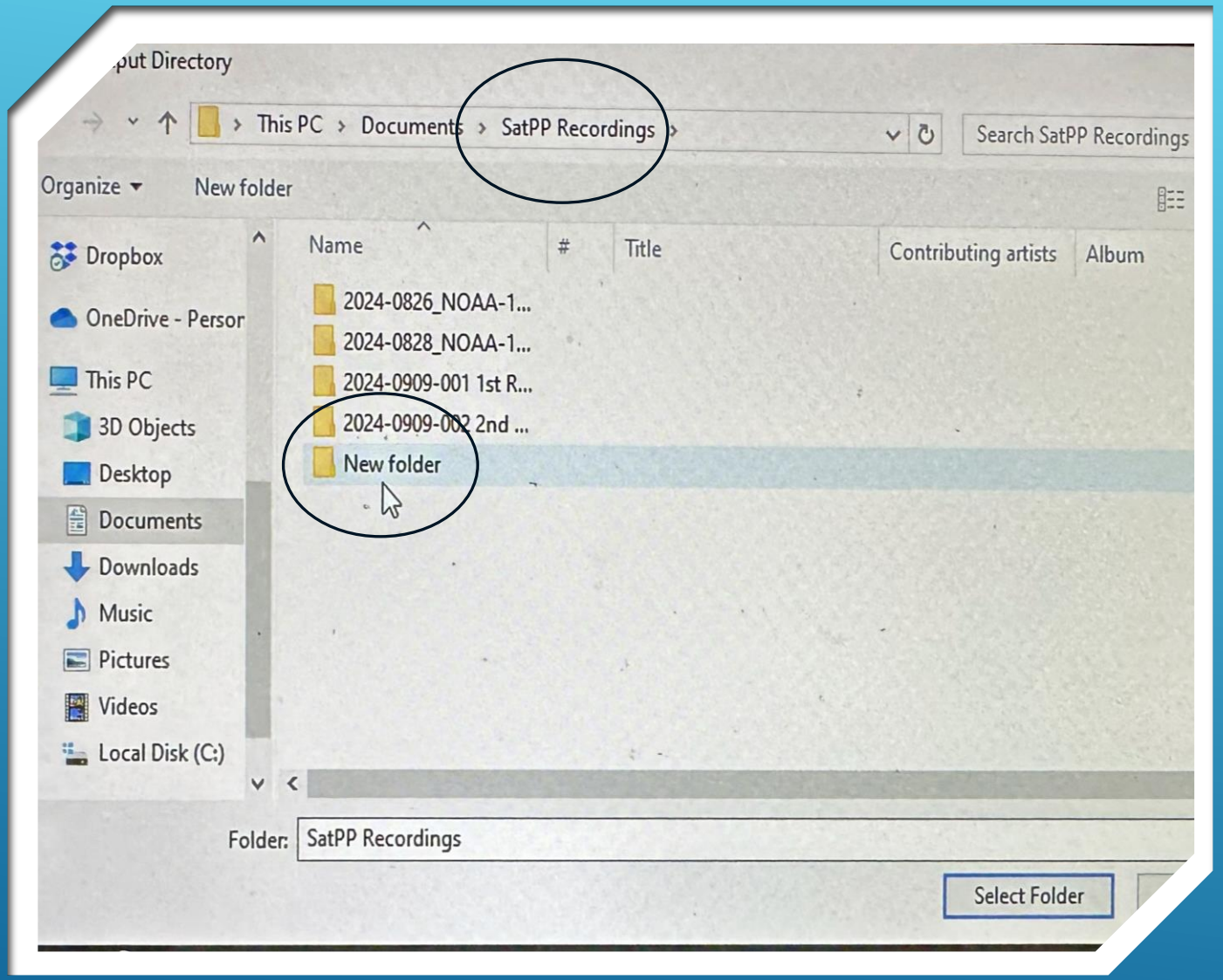


- SDR++ Startup…
- Wait until all modules load
- Verify blank Desktop displayed
- Note: SDR++ will not receive radio traffic correctly or even at all until drivers have been installed manually.
- Perform initial setup from RTL-SDR Quick Guide
  - SDR++ Setup Guide (steps 6-10)
- Plug an antenna into the SDR dongle
- Explore and become familiar with receiving radio signals with your device.

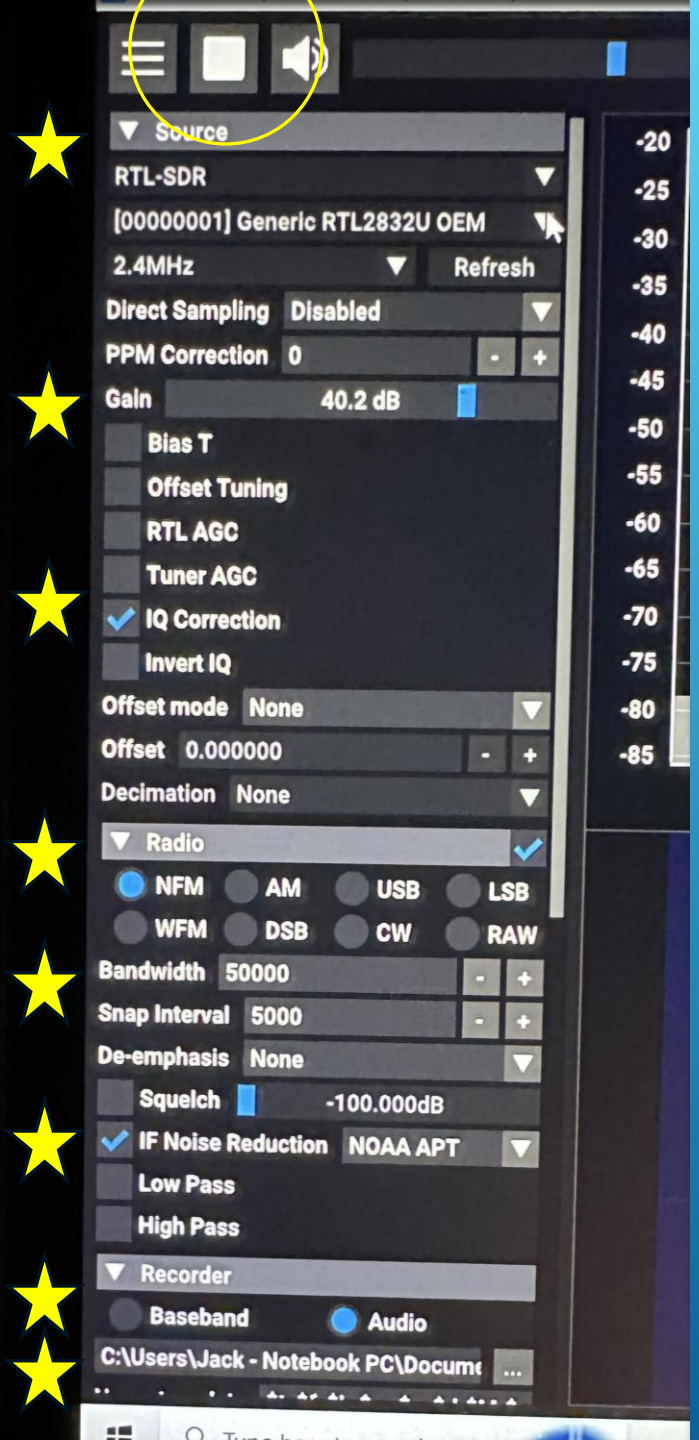
RECEIVING & CAPTURING NOAA WX IMAGE SIGNALS

- Ensure the RTL-SDR Device is connected to a USB port
- Ensure a proper Antenna for the desired signal is connected to the RTL-SDR device
- Established and assign a folder to store captured Pass Audio Recordings
- Start SDR++ Application
- Ensure correct settings made in SDR++

RECEIVING & CAPTURING NOAA WX IMAGE SIGNALS

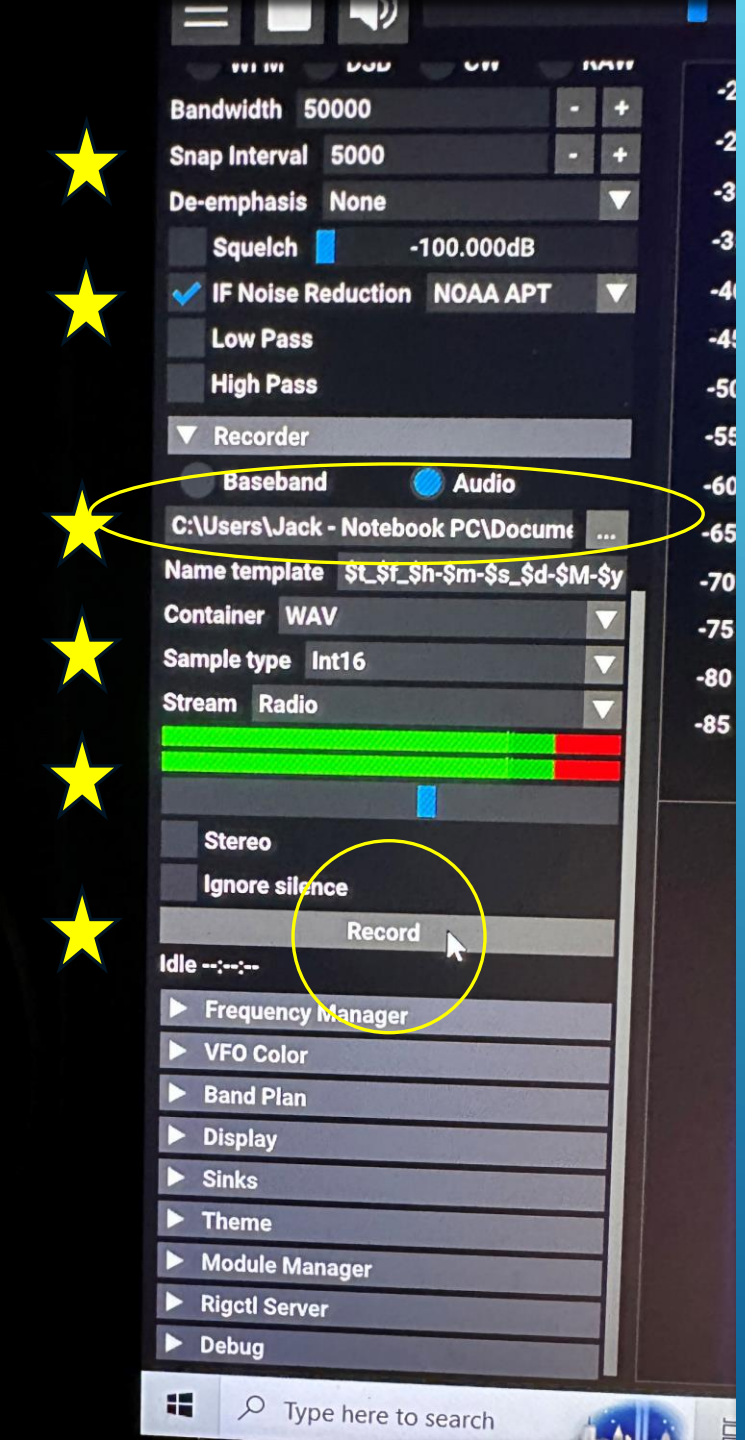


- First, Create an area to store and process pass recordings.
- Go to Documents folder and create a new folder titled, “SatPP Recordings”.
- Open that folder and create a folder titled, “New folder”
- NOAA Satellite pass audio recordings will initially be stored here, automatically.
- SAT Dump will get the recording from here, process it and save the deciphered images back into this folder.
- The folder can then be renamed, and a new, empty folder can be created for a future satellite pass.



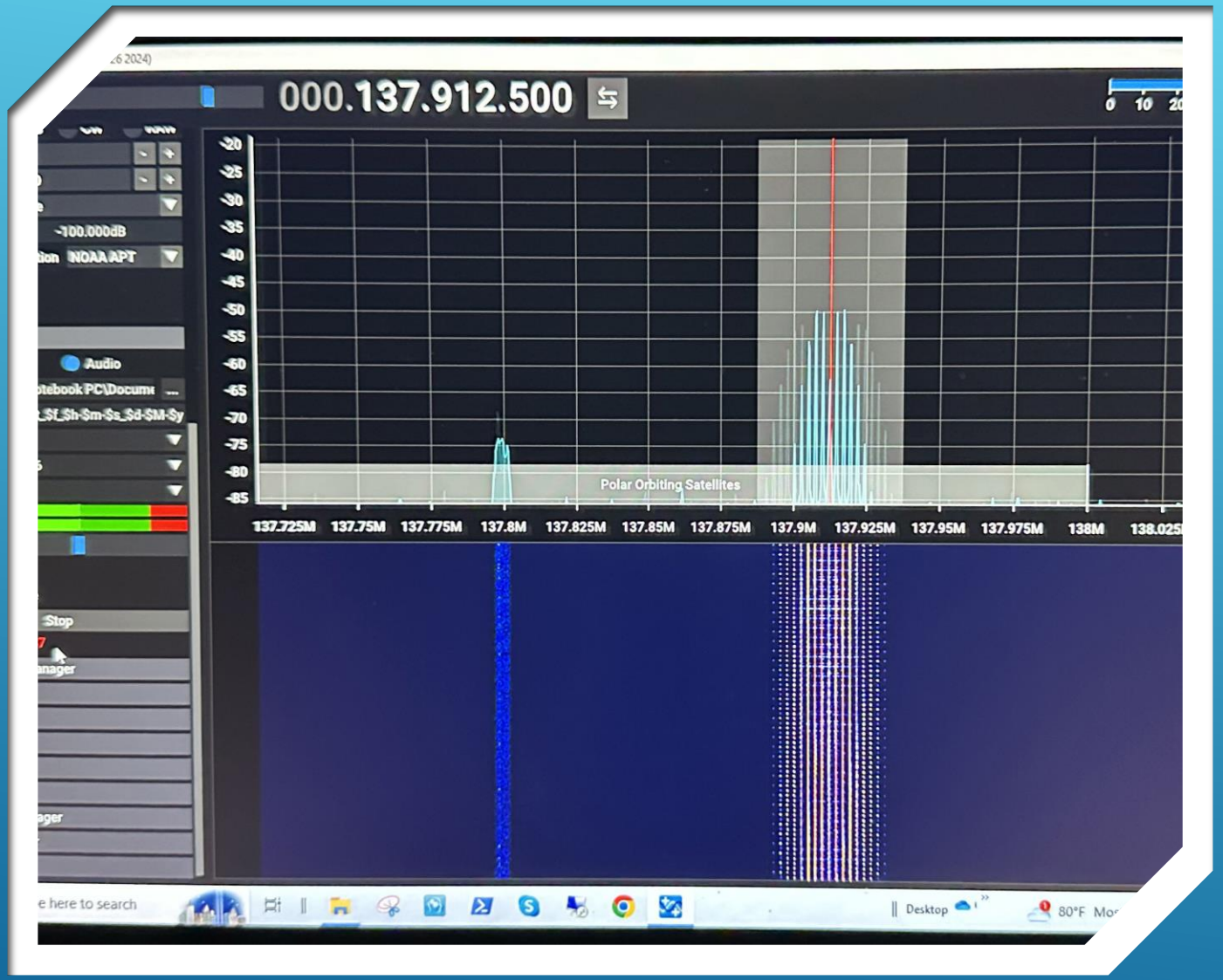
- Stars indicate settings to be mindful of for NOAA satellite reception.
- Before pressing the radio start button (circled):
- Be sure your SDR device name is selected and displayed in the Source window
- Select “IQ Correction” and “IF Noise Reduction (NOAA APT)” as indicated
- Set Radio to “NFM” mode
- Set Bandwidth to 50000 and Snap Interval to 5000
- Set Recorder to “Audio “
- * Important… (bottom) Select and Enter the Directory and File Folder where you want the recorder to store subsequent satellite pass recordings you will capture

RECEIVING & CAPTURING NOAA WX IMAGE SIGNALS



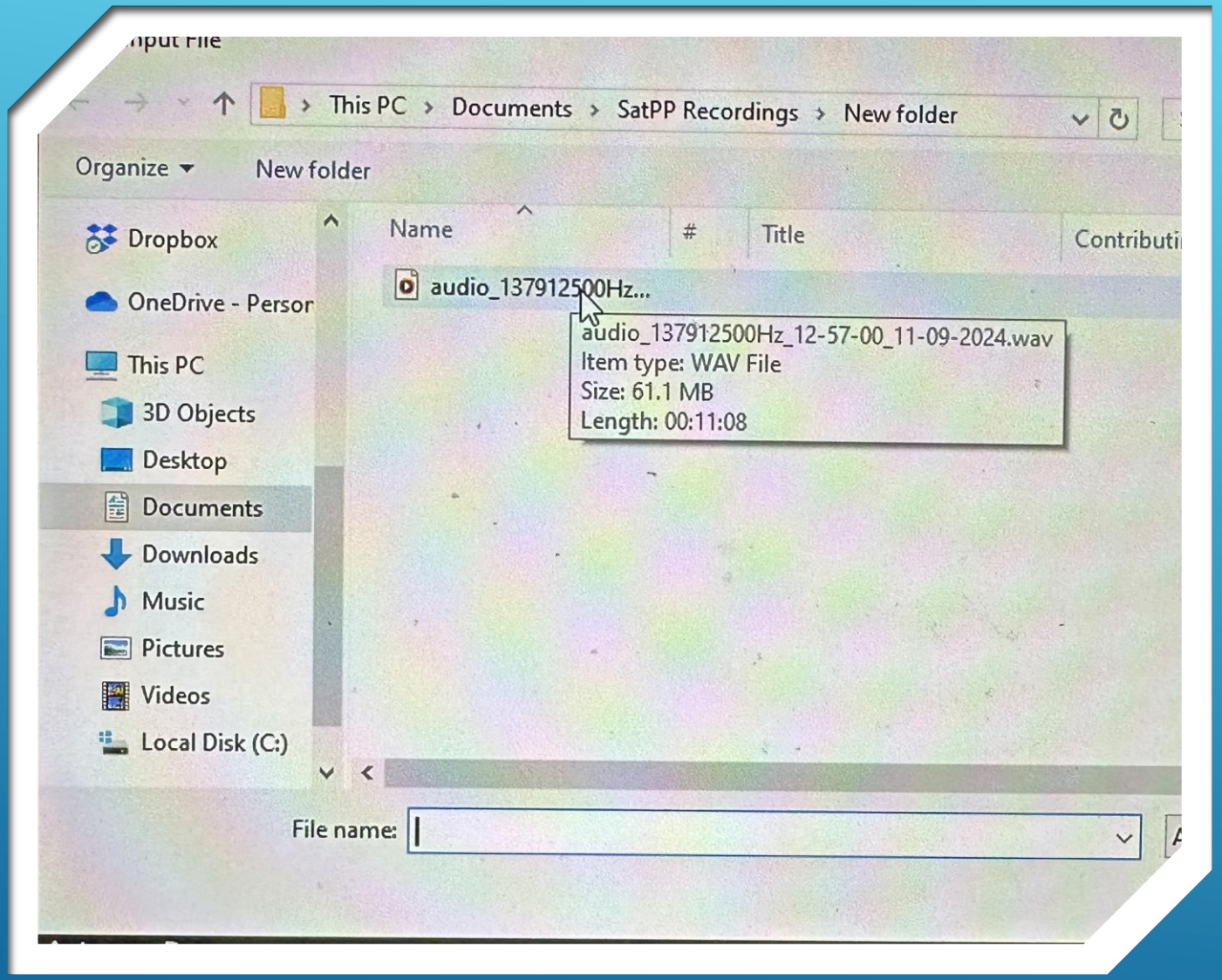
- Stars indicate settings to be mindful of for NOAA satellite reception.
- Note: The recording will be stored in the folder you previously created and specified here. If you did not make that assignment, you will not have a recording to process!
- The recorder is started and stopped by clicking on the "Record" bar. When not recording, the indicated state is "Idle…"

RECEIVING & CAPTURING NOAA WX IMAGE SIGNALS



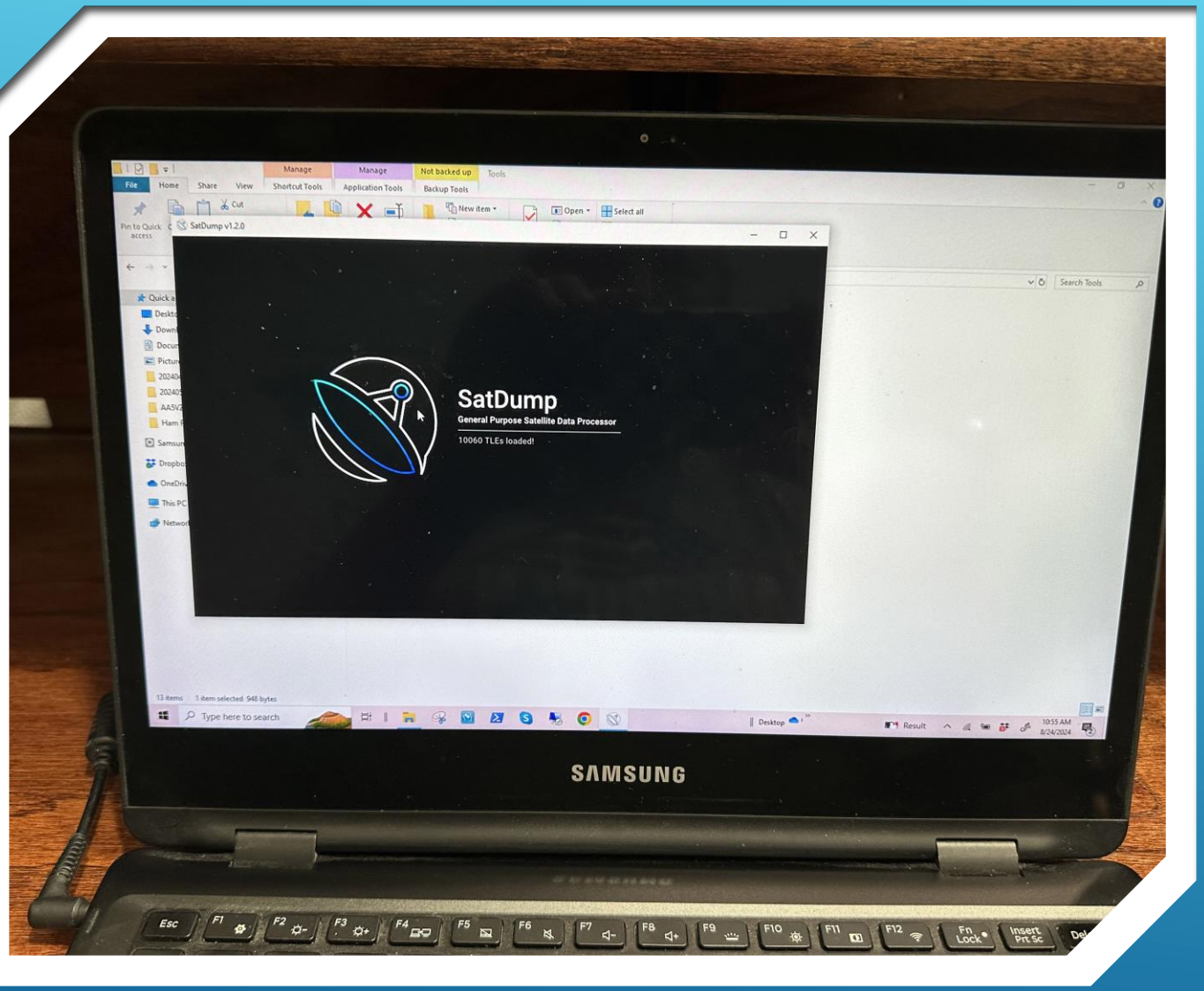
RECEIVING AND RECORDING A SATELLITE SIGNAL

- Activate the SDR++ Receiver
- Ensure correct satellite frequency is displayed
- Watch/listen for active satellite signal
- When signal rises above the noise floor go ahead and start recording.
- At some point the noise “hash” will disappear and the only sound you hear is the satellite and its clock “ticks”
- When the pass nears the end and the signal peak is just above the noise floor, stop recording.
- Close out of the program



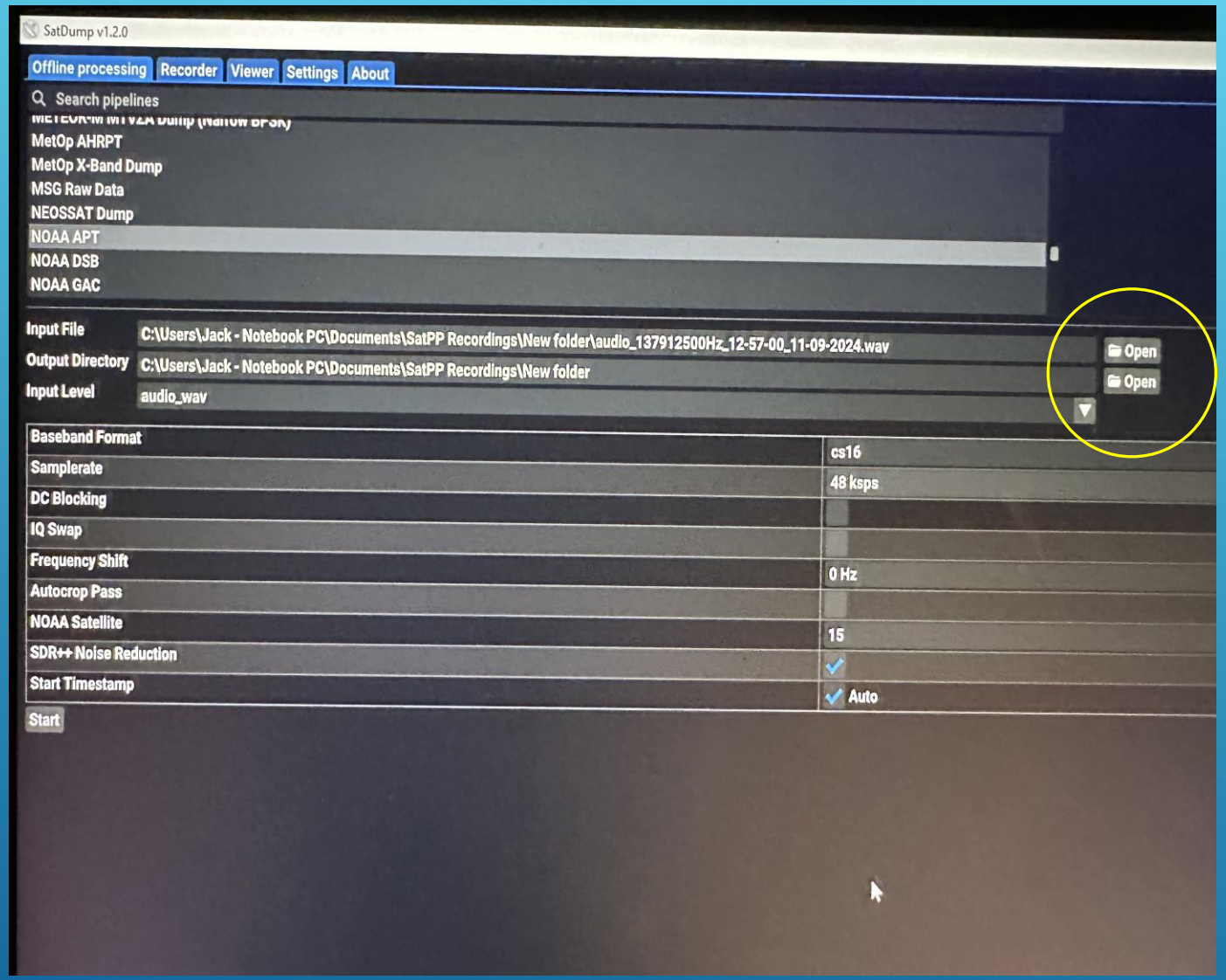
SETTING UP AND USING SDR++

- Go to File Manager
- Open the "New folder" you previously created.
- Verify that the audio file recorded during your satellite pass is stored in the folder.
- If so, it is time to process the image data captured during the pass.
- Close out of File Manager



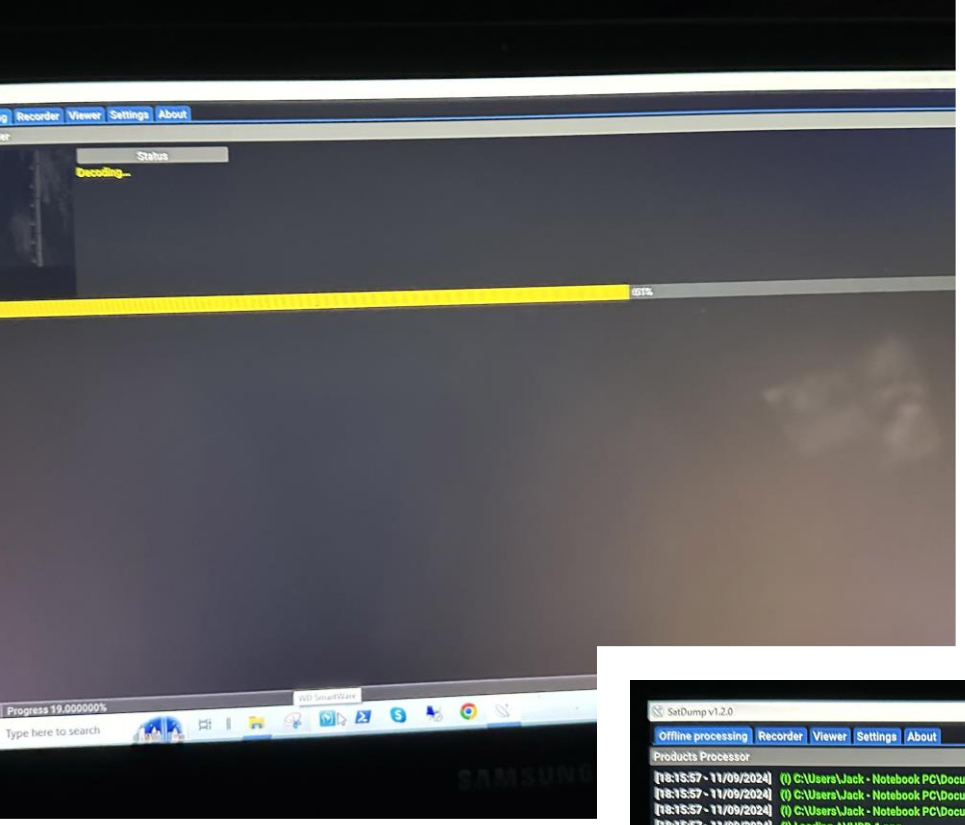
PROCESS RECORDED IMAGE DATA

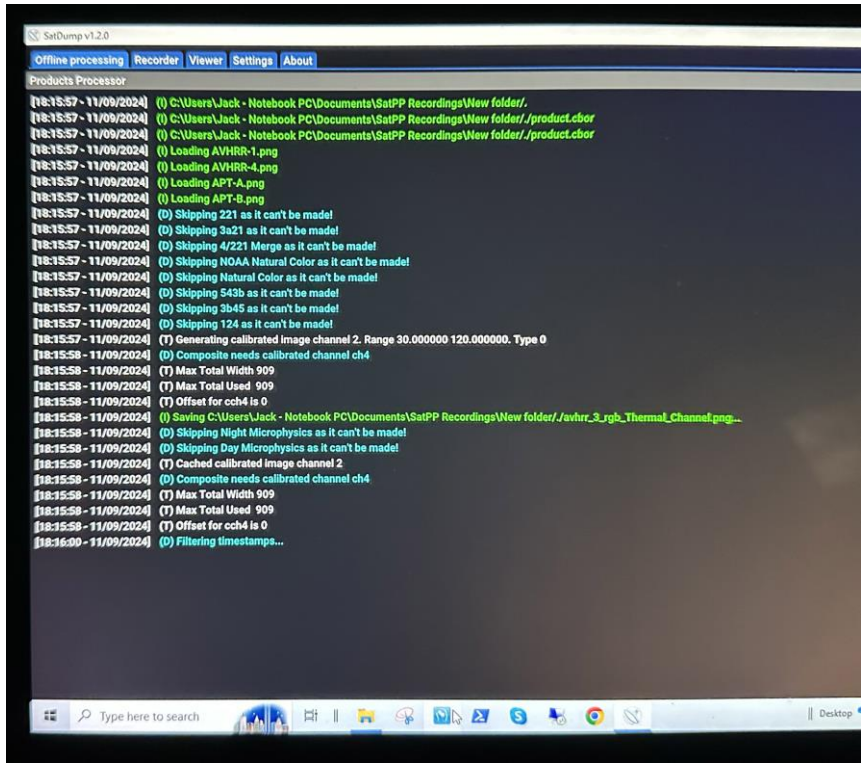
- **Start SatDump**



PROCESS RECORDED IMAGE DATA

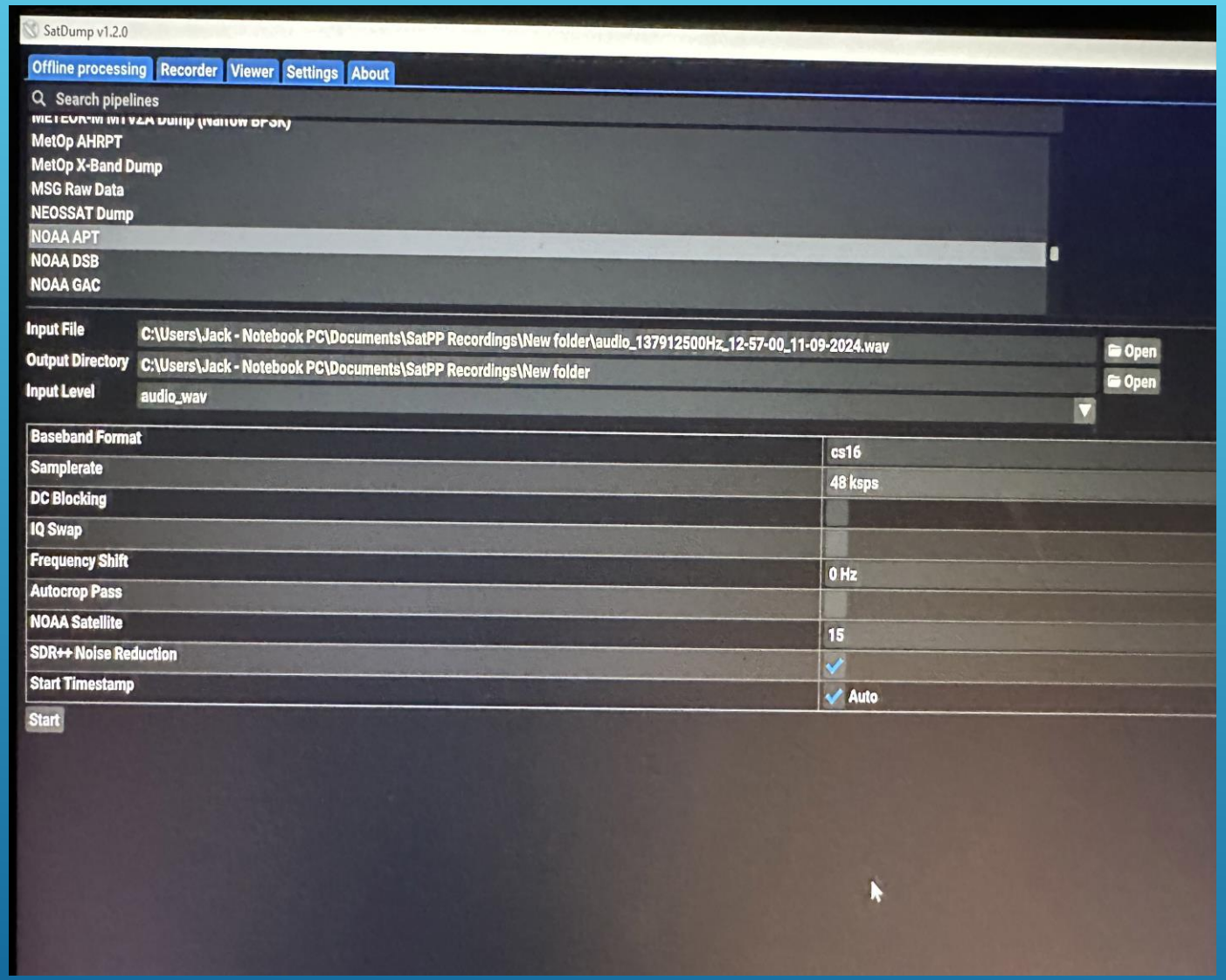
- Start SatDump
- Scroll and select “NOAA APT”
- Input File - Open/Select the recorded audio file name in the “New folder” you created
- Output Directory - Open/select the “New folder” icon in your “SatPP Recordings” directory
- Input Level – select “audio_wav”
- Click “Start” when ready to process the recorded data





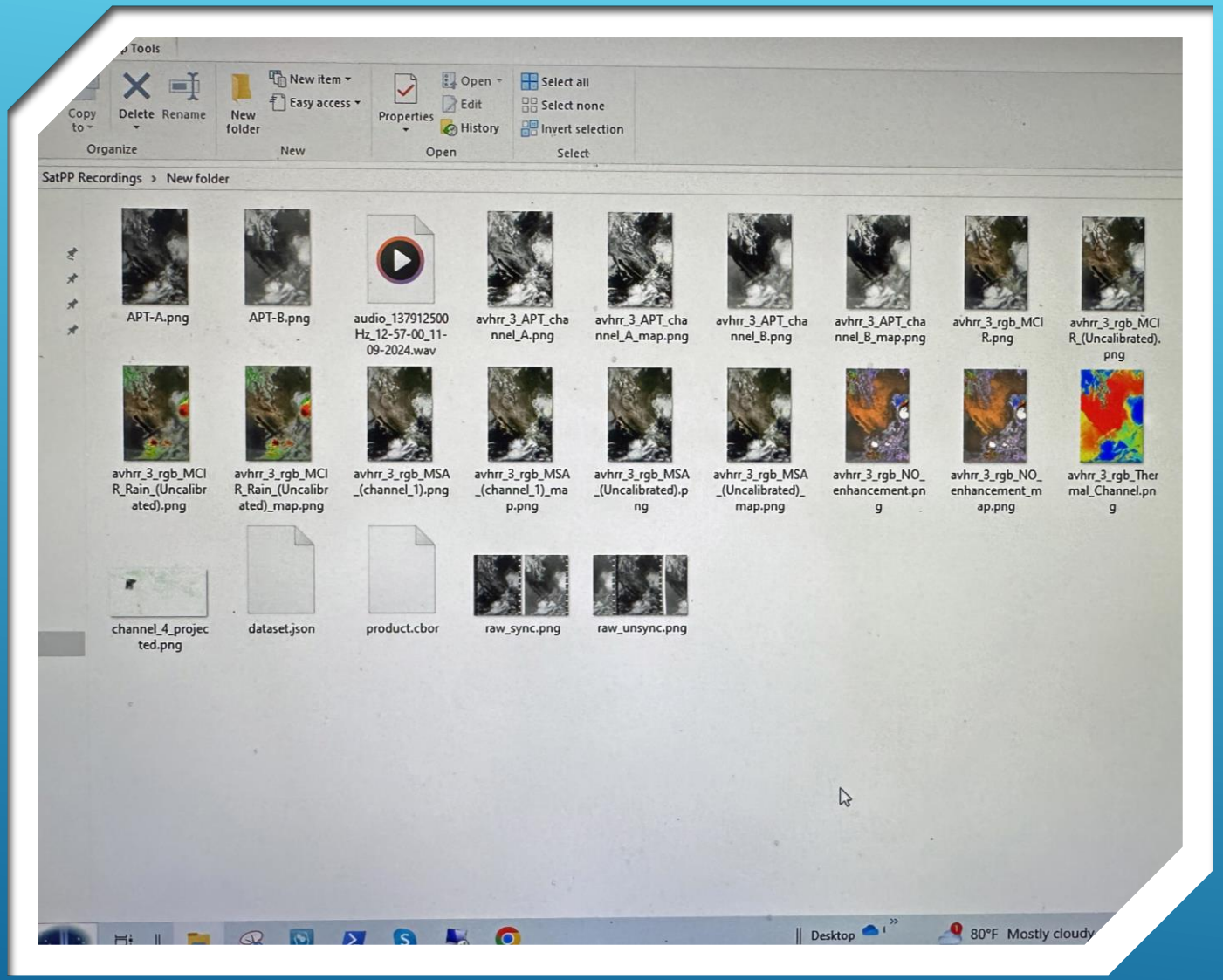
PROCESS RECORDED IMAGE DATA

1. File is loading
2. Image products are being assembled and saved to your designated folder



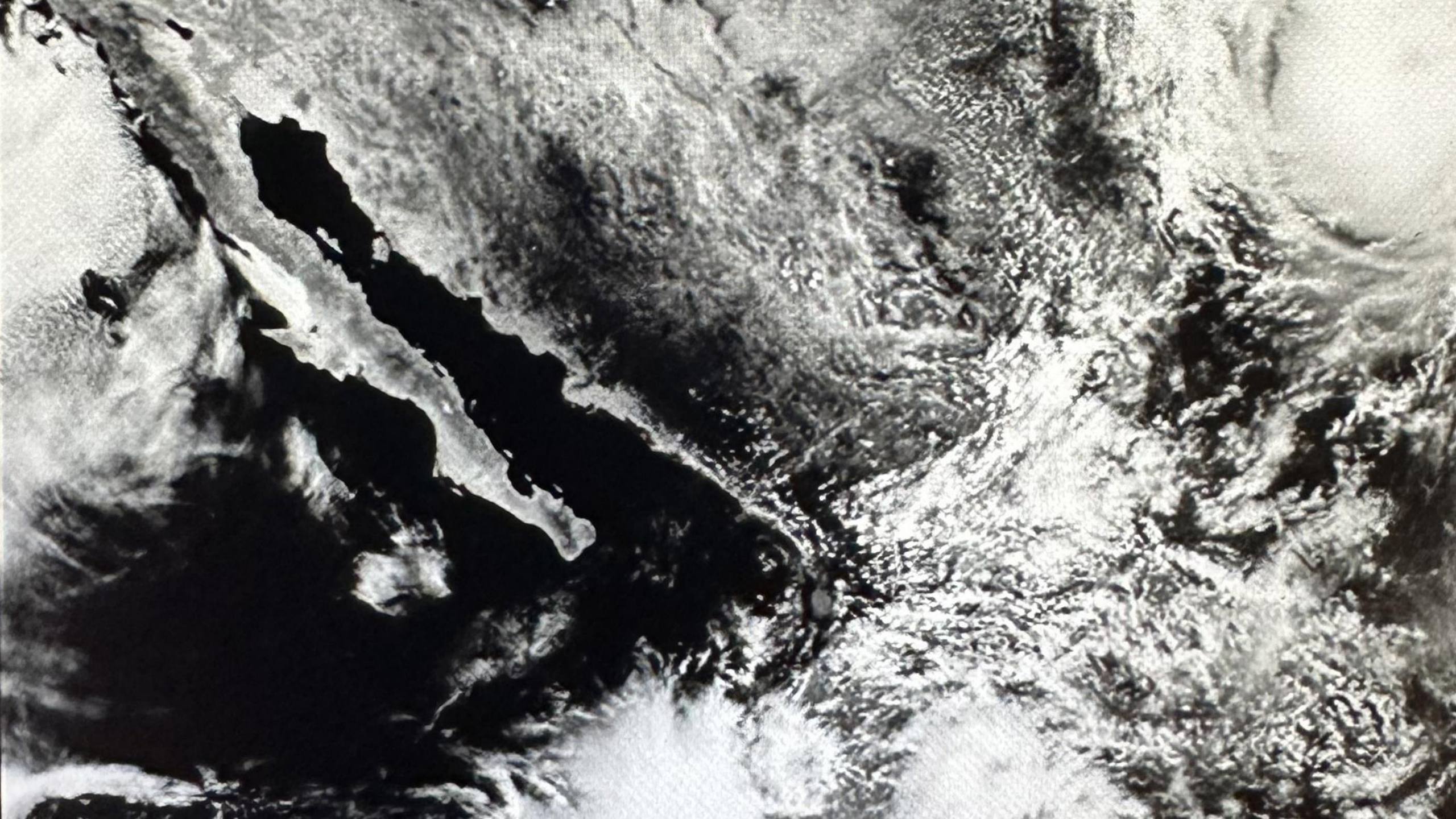
PROCESS RECORDED IMAGE DATA

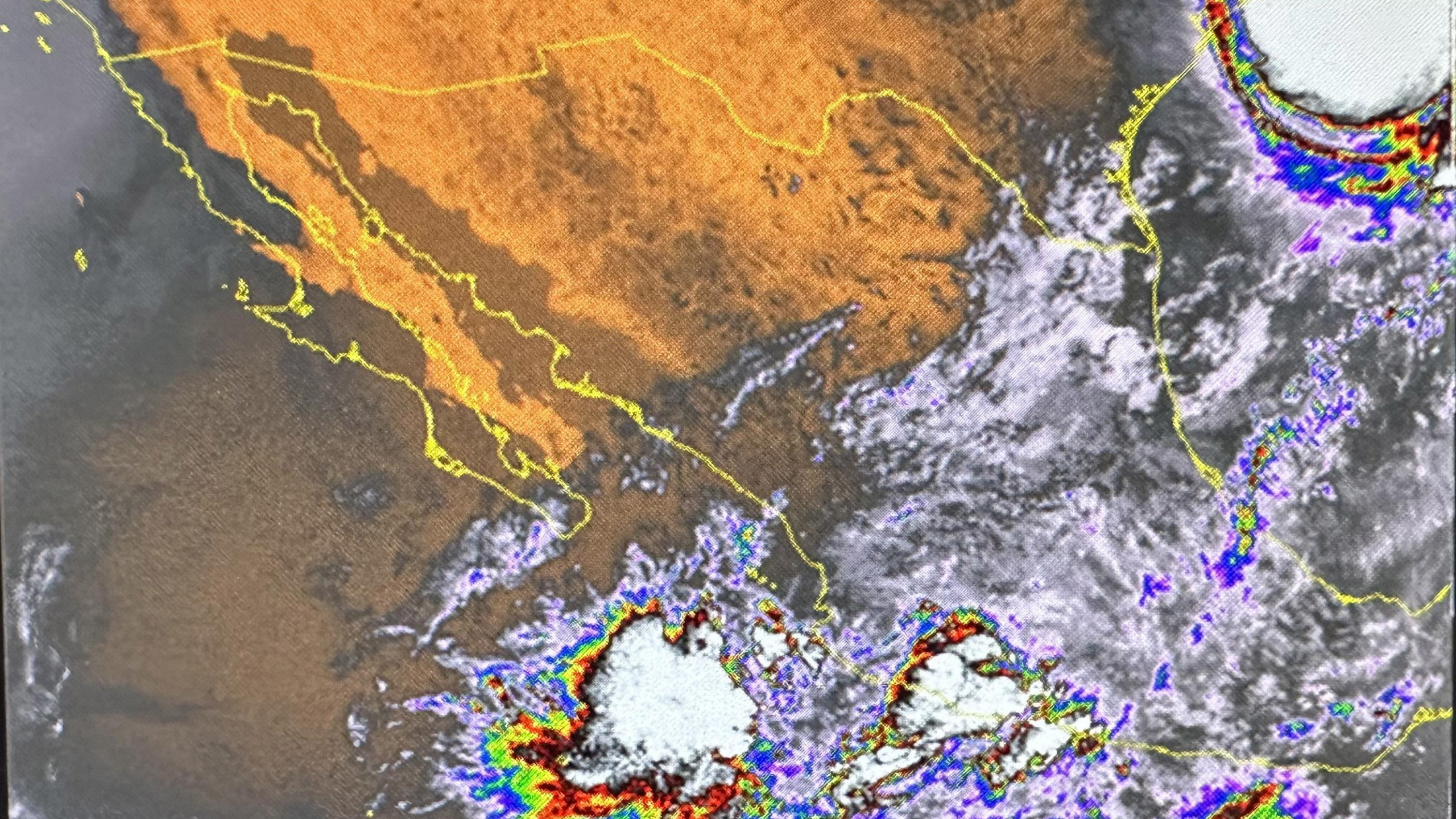
- Screen returns to this state when processing has completed
- Images can be seen under the “Viewer” tab.
- Alt… Close out of SatDump
- Open File Explorer and open the folder titled, “New folder” in your “SatPP Recordings” directory.

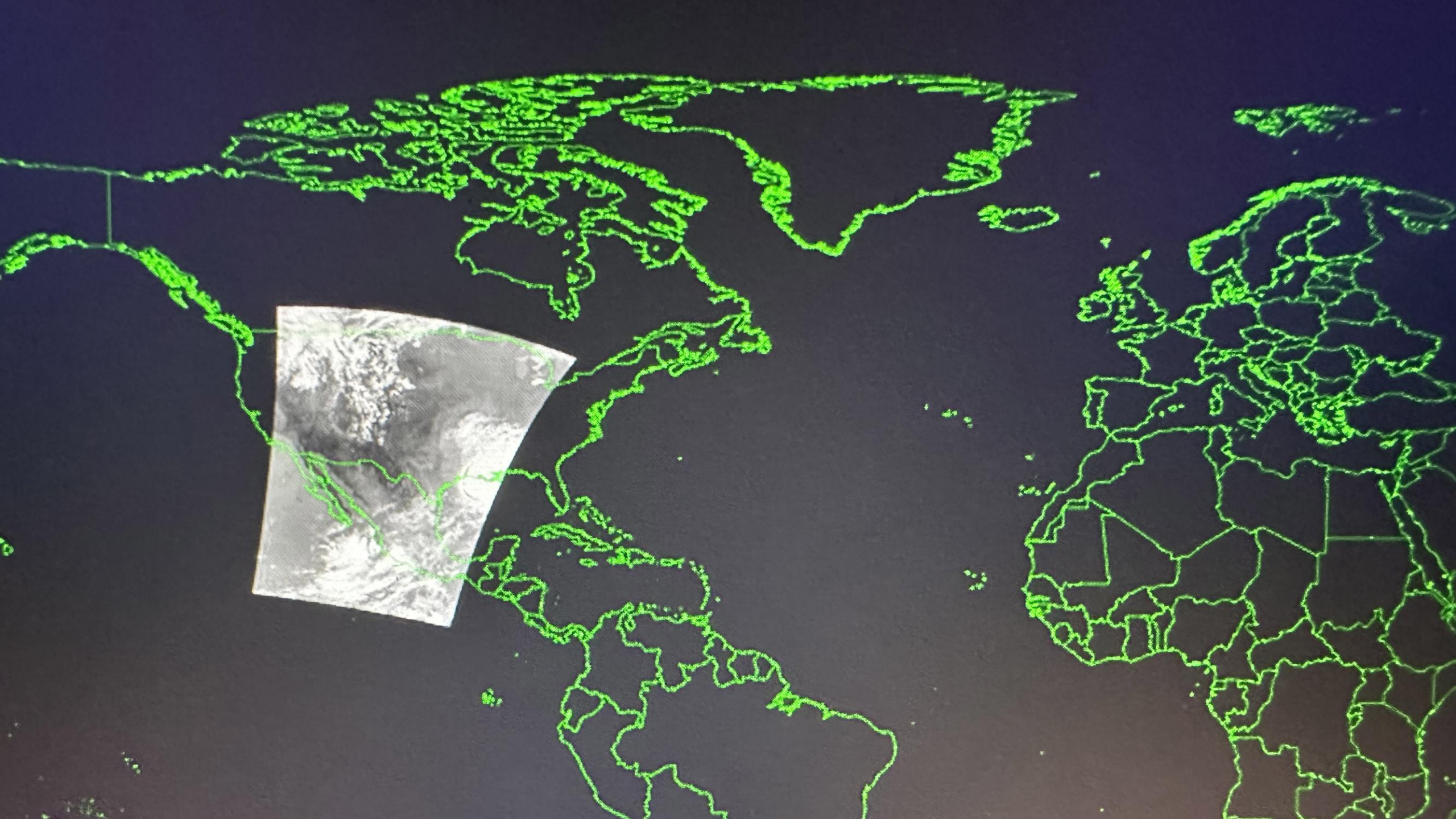


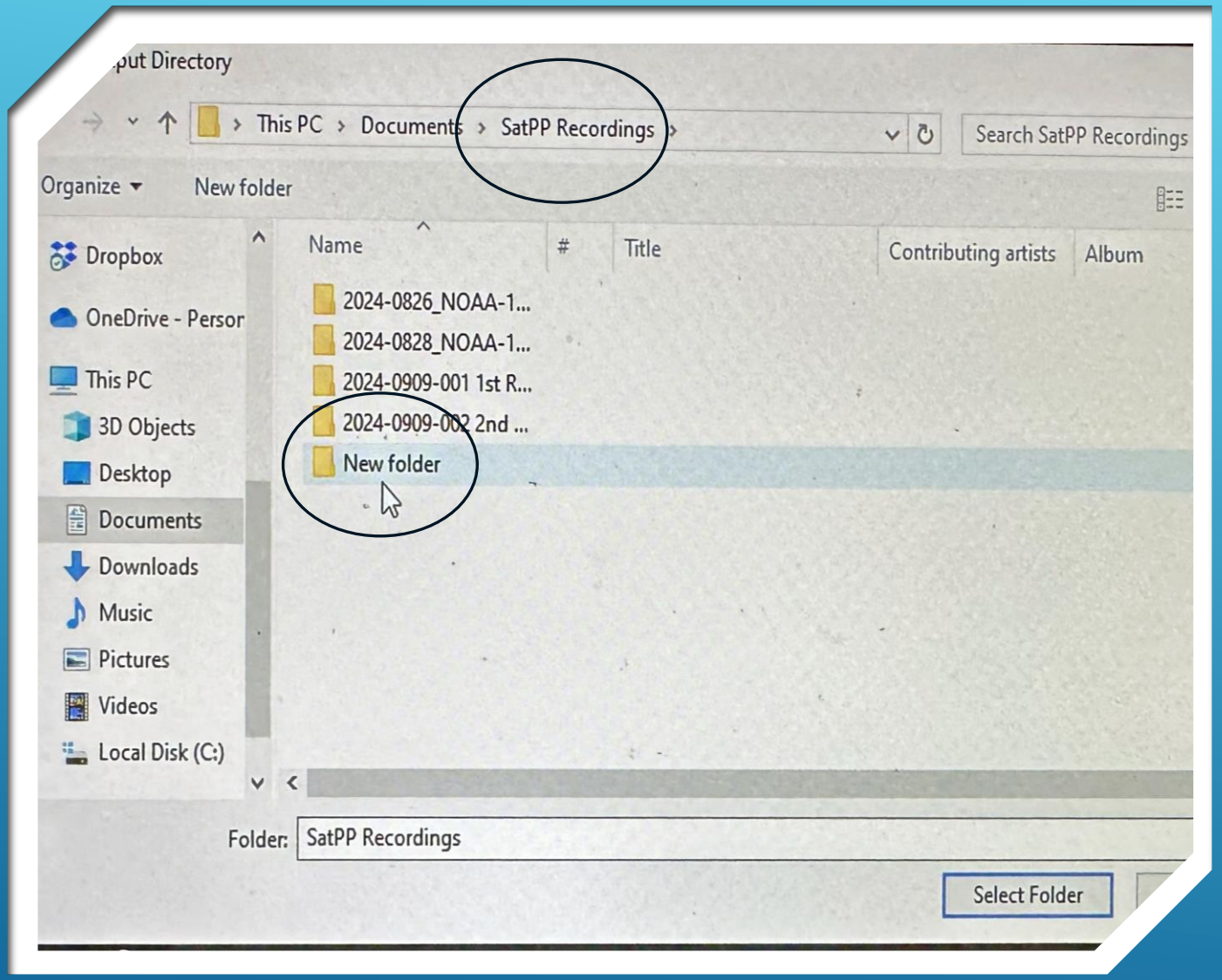
PROCESS RECORDED IMAGE DATA

- Go to File Manager
- Open the “New folder” you previously created.
- Folder now contains all of the decoded image products in addition to the original audio recording.
- Select and view each image file as desired.



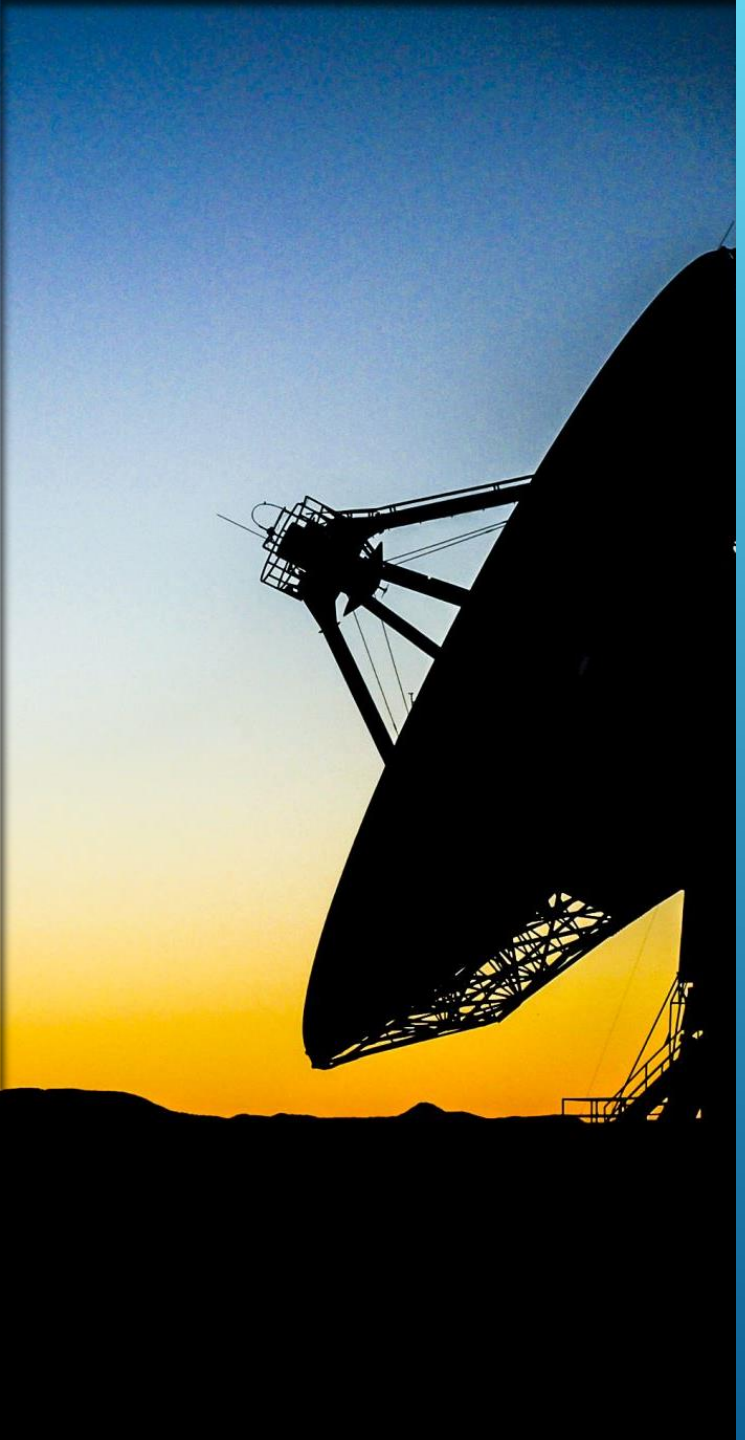






PROCESS RECORDED IMAGE DATA

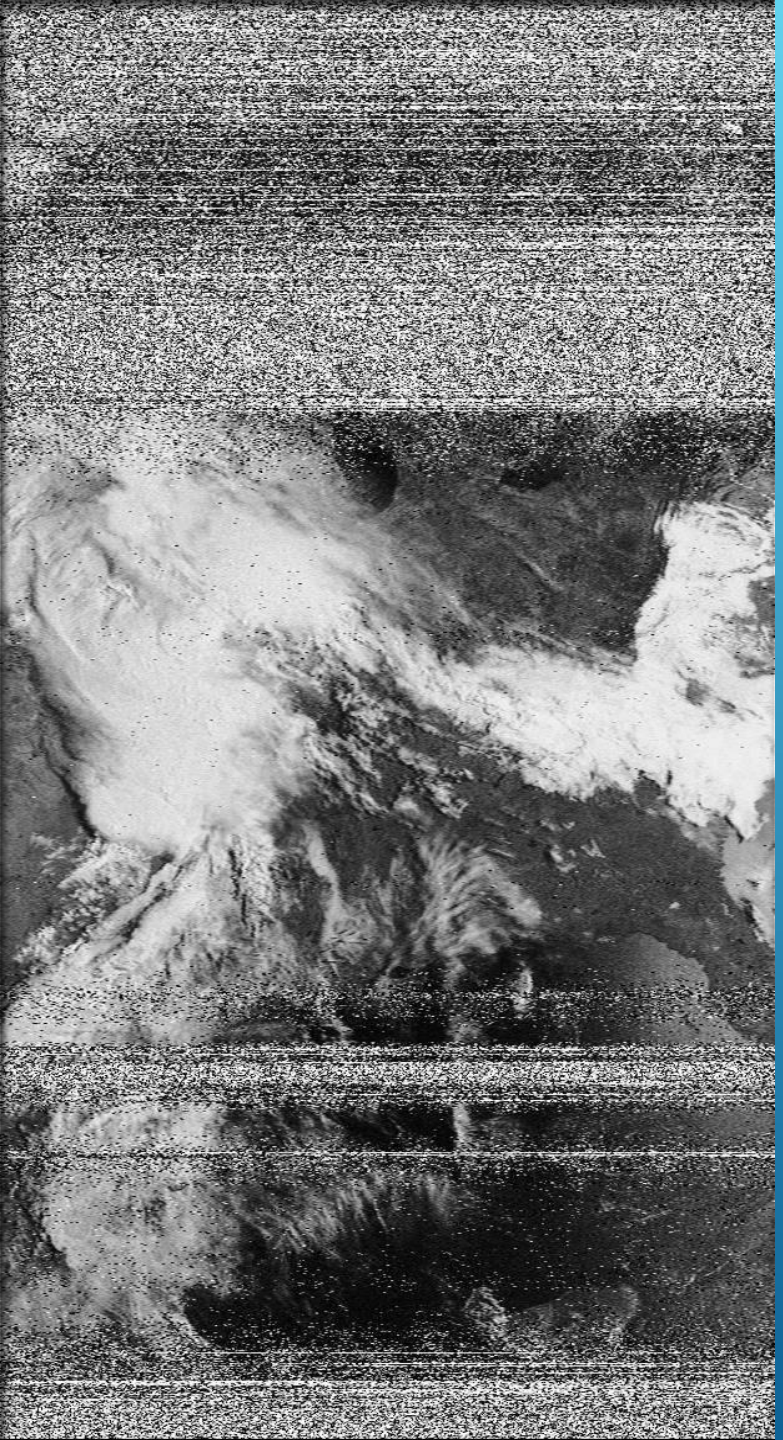
- **When finished, rename the "New folder" appropriately.**
- **Now create an empty "New folder" in preparation to capture future satellite passes.**
- **You are now ready to receive and record the incoming audio stream from a new satellite pass.**



ANTENNAS

- Discone
  - Commercial grade antenna
  - Good results on low elevation passes
  - Not suitable for overhead passes
- V-Dipole
  - Good starter antenna
  - Easy to build yourself
  - Low materials cost
- QFH (Quadrifiler Helix)
  - Very effective Omni-AZ/EL antenna
  - Somewhat advanced construction skills needed
  - Higher materials cost (~$100.00)

- **Discone**
  - I started with this
  - Comet Discone (DS-150S)
  - Commercial made antenna
  - Easy to Assemble
  - ~ $120.00 cost
  - Wide Band VHF-UHF-6m RX
  - Can transmit on 2m and 70cm bands
  - I achieved mixed results on low/mid-elevation satellite passes
  - Unsuitable for higher elevation passes (>40 deg)

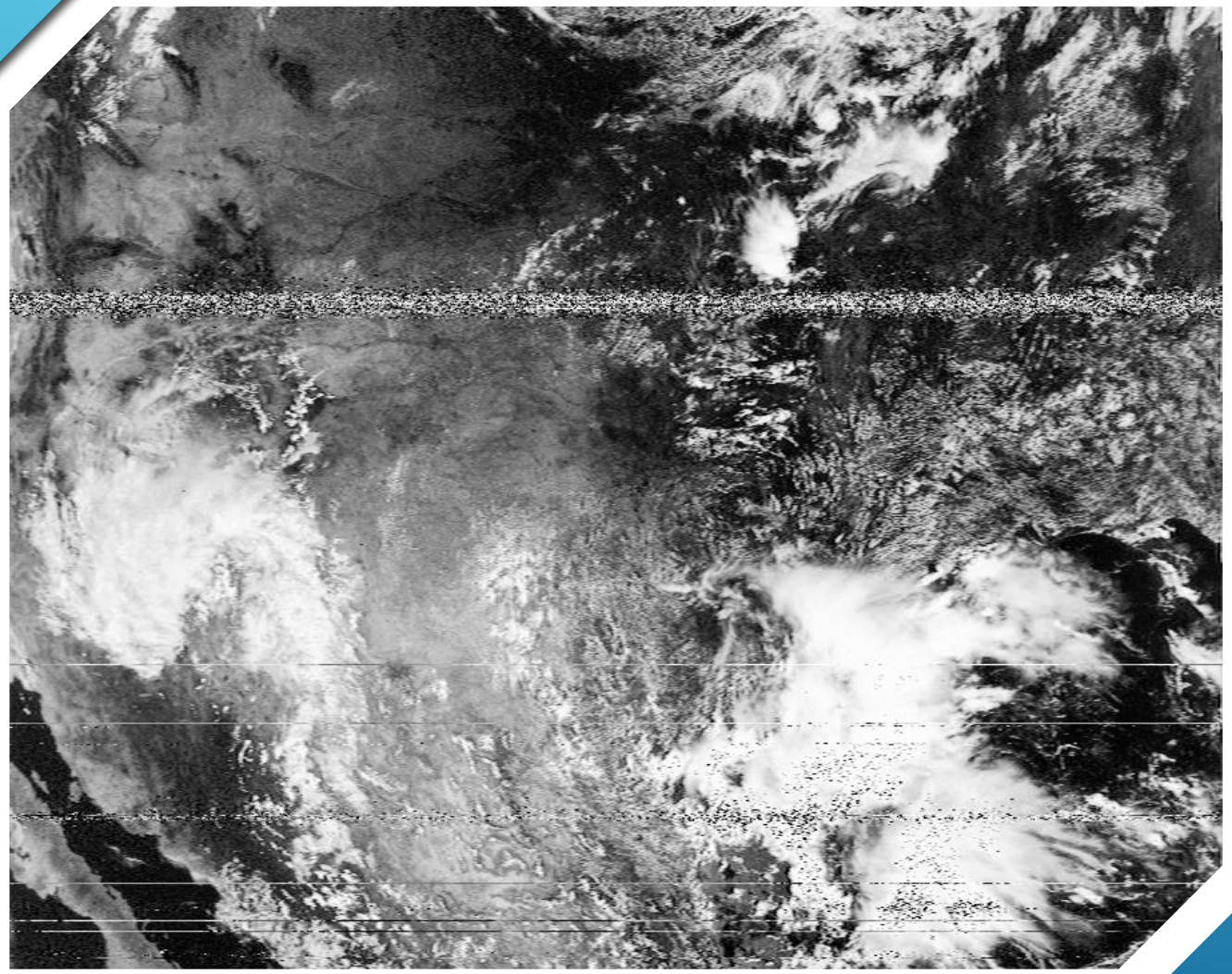


Discone

Results from a low level pass

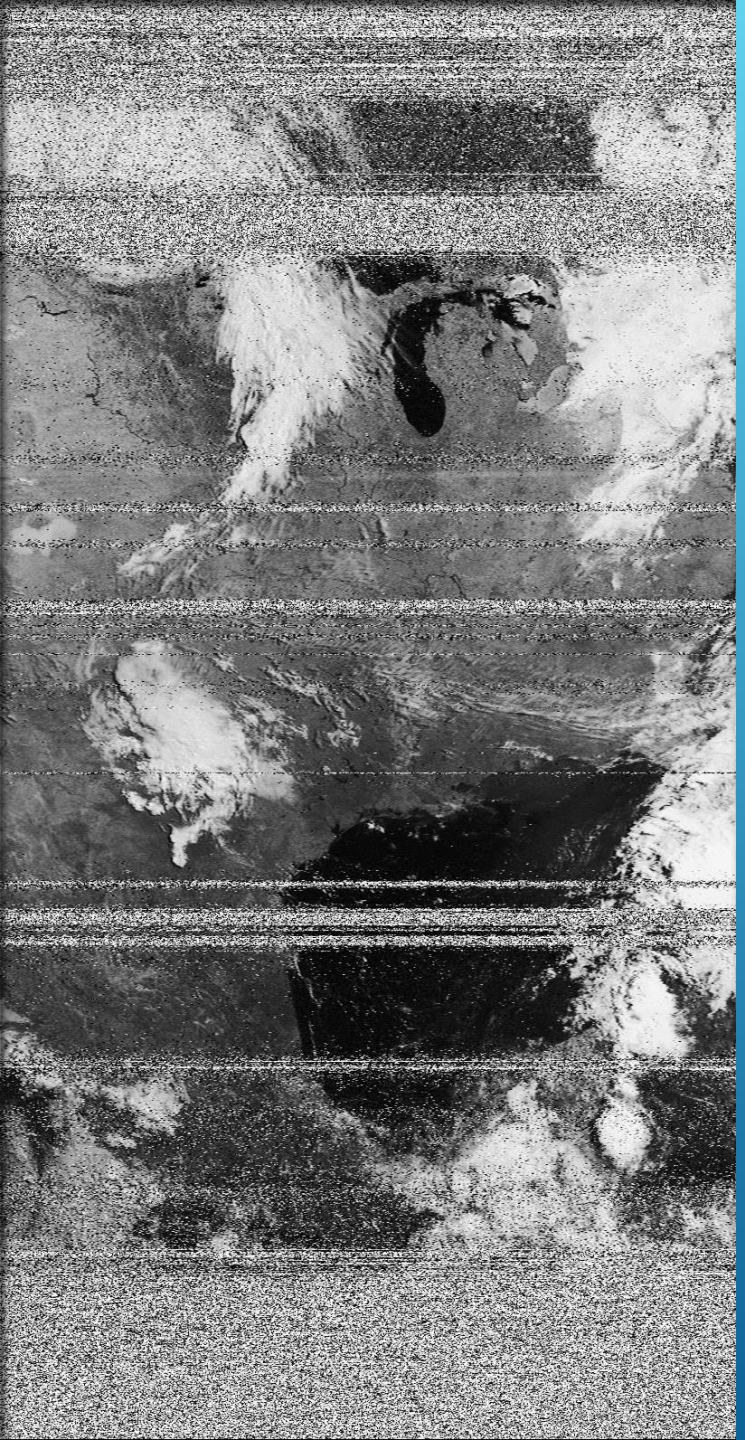
(circa 36 deg.)

- **V-Dipole**
  - Good starter antenna
  - Easy to build yourself
  - Low materials cost

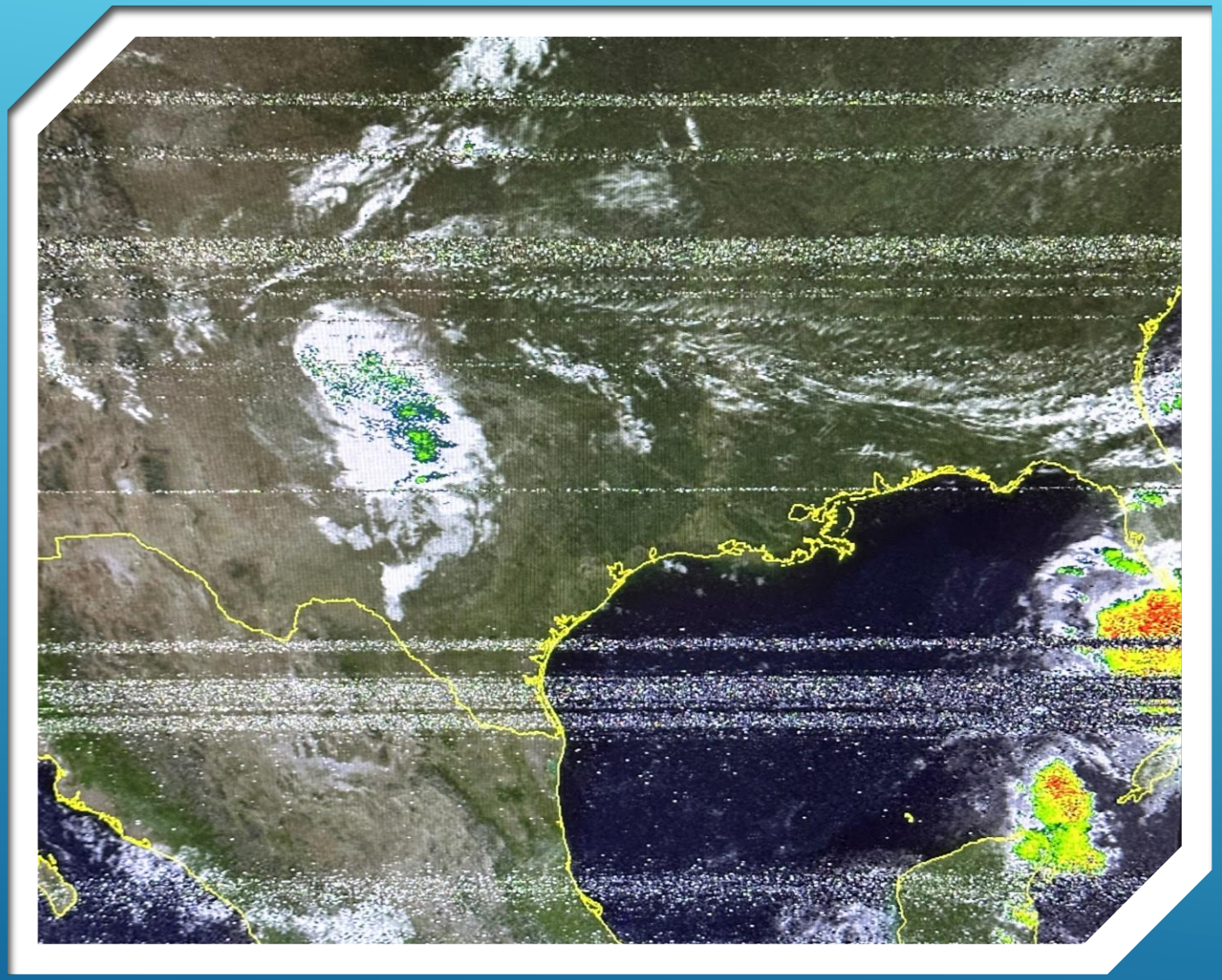


- **V-DIPOLE**
- **85 deg. Pass**

- **QFH (Quadrifiler Helix)**
  - Effective Omni-AZ/EL antenna
  - Robust
  - Somewhat advanced construction skills needed
  - Higher materials cost (~$100.00), less mounting

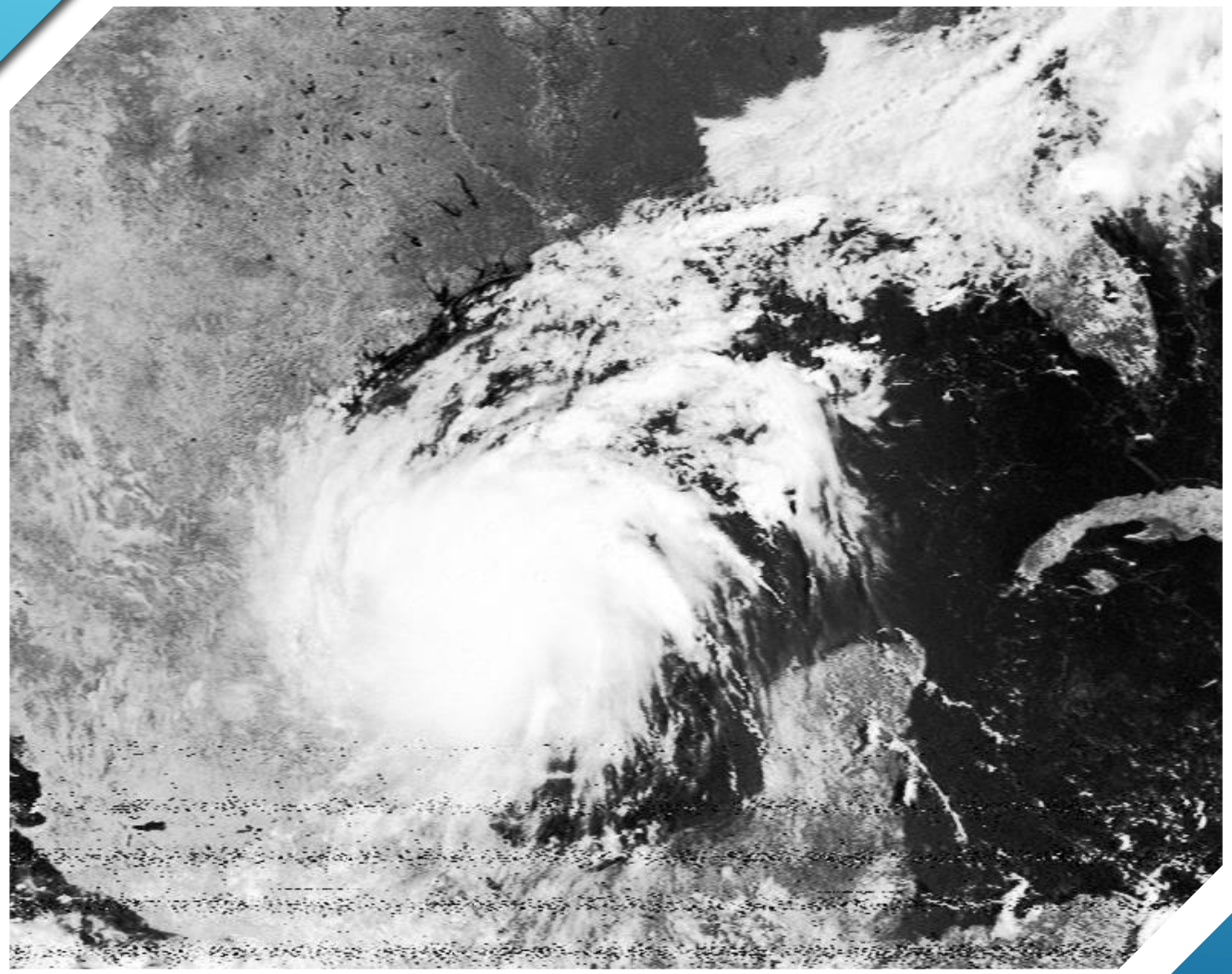


(QFH) Quadrifiler Helix



(QFH) Quadrifiler Helix

- **Arrow Satellite Dual Yagi**
  - Commercially manufactured antenna
  - Designed for 2m/70cm but receives well on 137Mhz
  - Must always be directed toward the satellite
  - Light weight for Hand-held or Tri-pod support
  - ~ $200.00 w/Duplexer

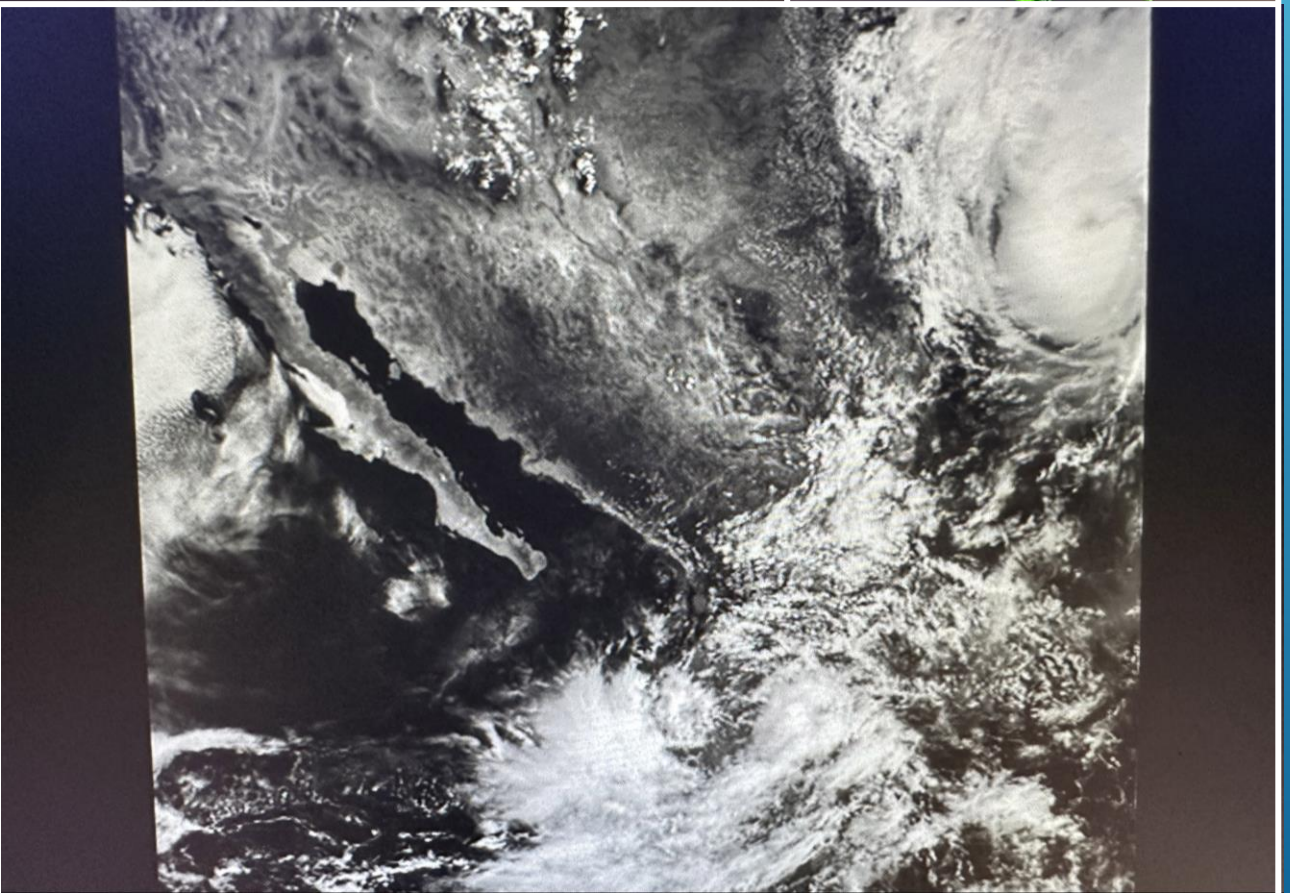


Arrow Yagi

9/9/2024

Tropical Storm Francine in formation

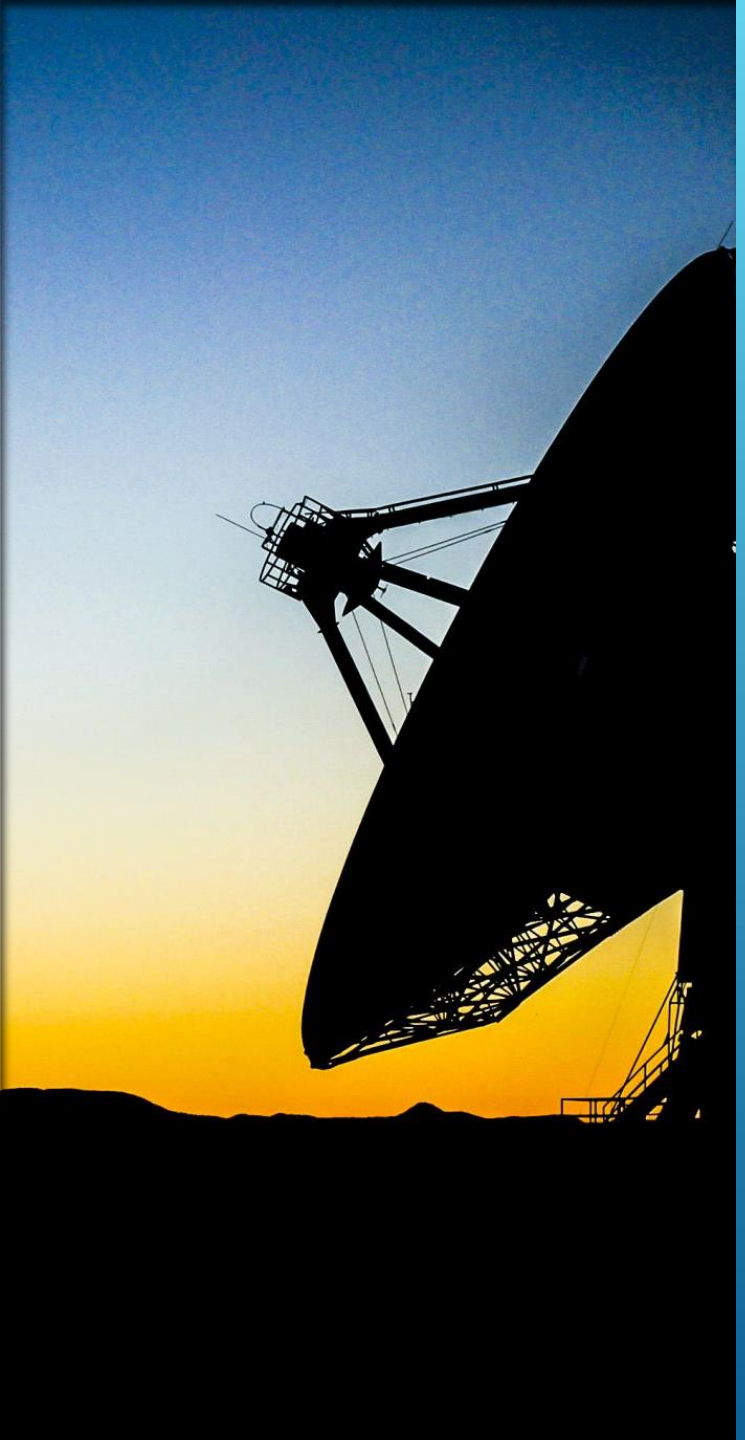
- **M2 Satellite Yagi Array**
  - Professional quality / Commercially produced
  - Designed for 2m/70cm but works for 137Mhz Rx
  - Intended for Permanent Installations
  - Requires advanced Assembly / Installation skills
  - Requires a robust AZ/EL Rotor System
  - High Expense item



M2 Satellite Yagi Array

9-11-2024

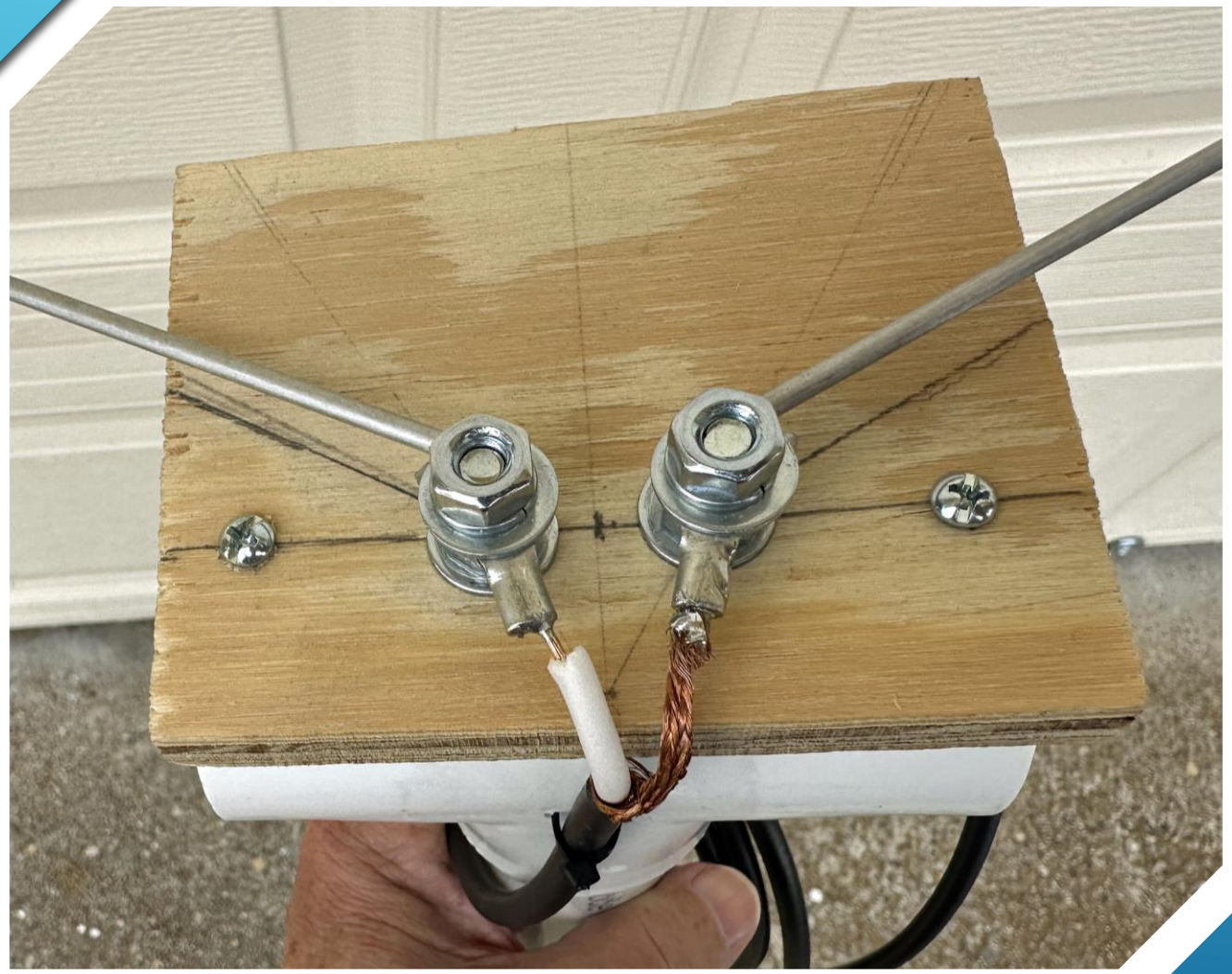
Hurricane Francine making landfall



ANTENNA CONSTRUCTION PROJECTS

- V-Dipole
  - Good starter antenna
  - Easy to build yourself
  - Low materials cost
- QFH (Quadrifiler Helix)
  - Very effective Omni-AZ/EL antenna
  - Somewhat advanced construction skills needed
  - Higher materials cost (~$100.00)

- **V-Dipole**
  - Great little starter antenna
  - Easy to build yourself
  - Low materials cost
  - Detailed plans available on-line
  - www.a-centauri.com/articoli/noaa-poes-satellites-reception

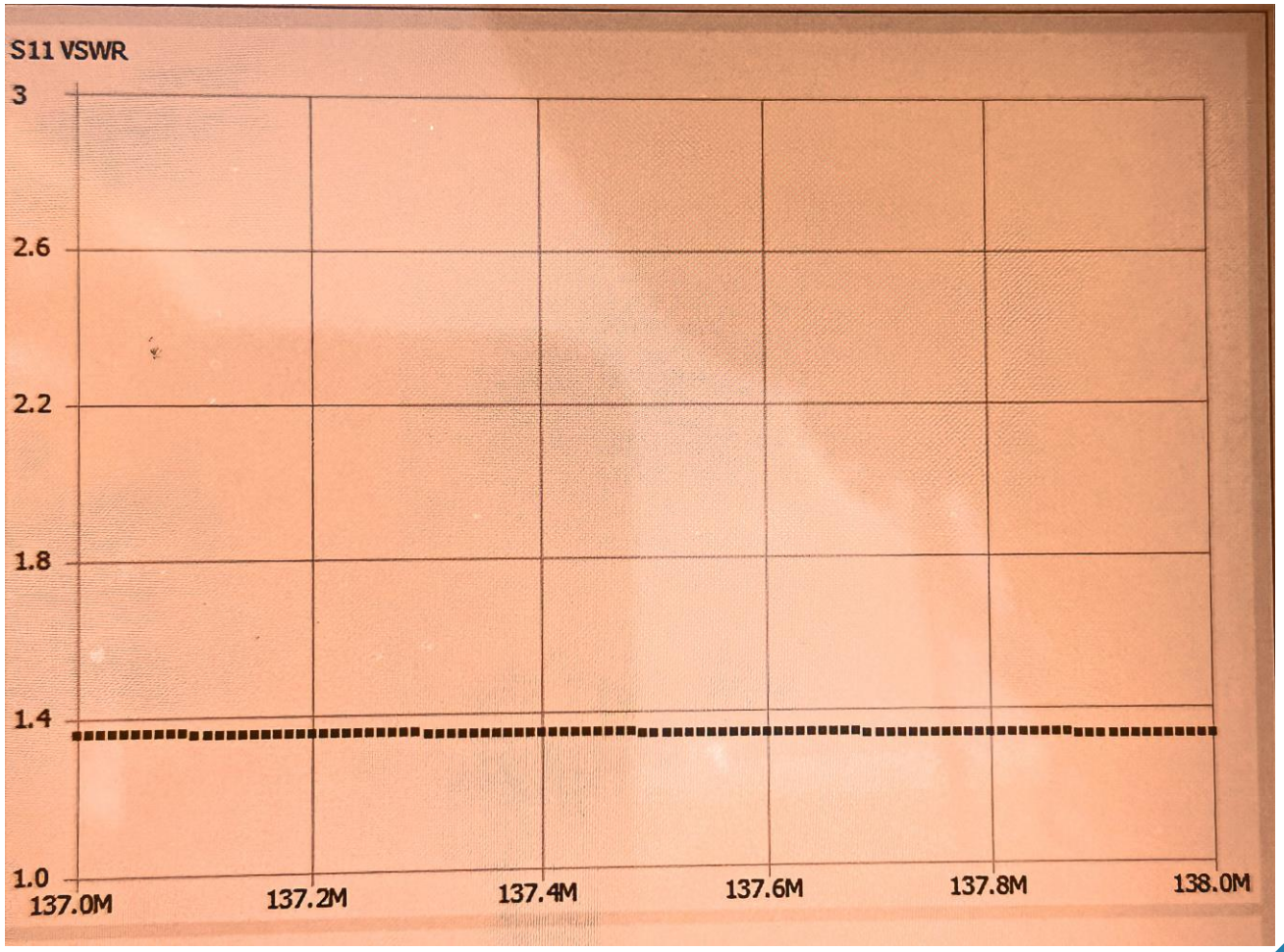


V-DIPOLE CONSTRUCTION

- **Each Leg is 21 inches**
- **Includes cable length to coax split-out**
- **V-Spread is 120 degrees**

V-DIPOLE CONSTRUCTION

- Side View
- For All-Weather use…
  - Eliminate plywood base
  - Use Stainless-Steel hardware
  - Seal exposed cable and connections
  - Glue all PVC joints for permanent mounting outdoors

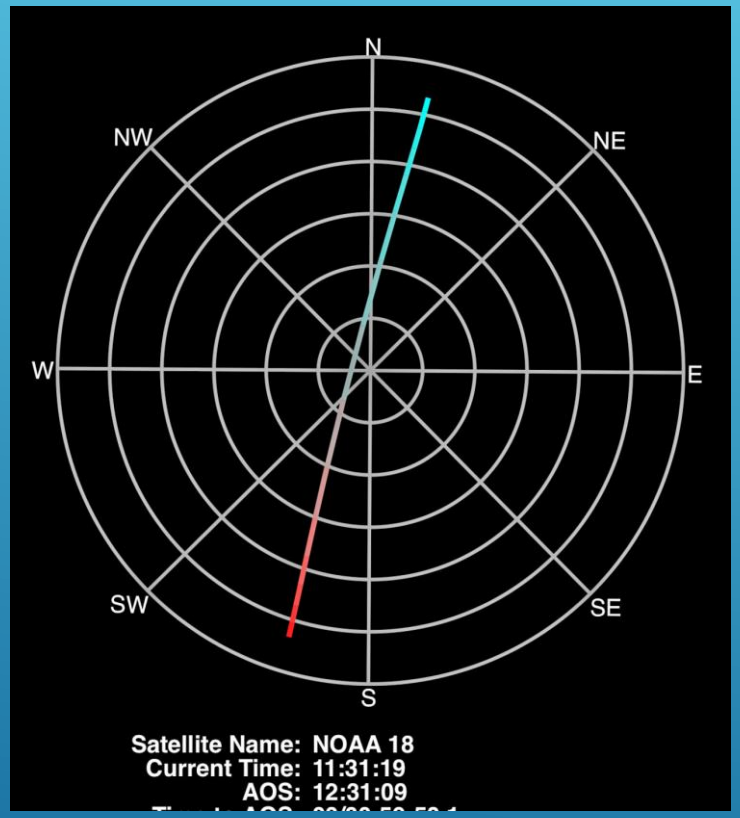


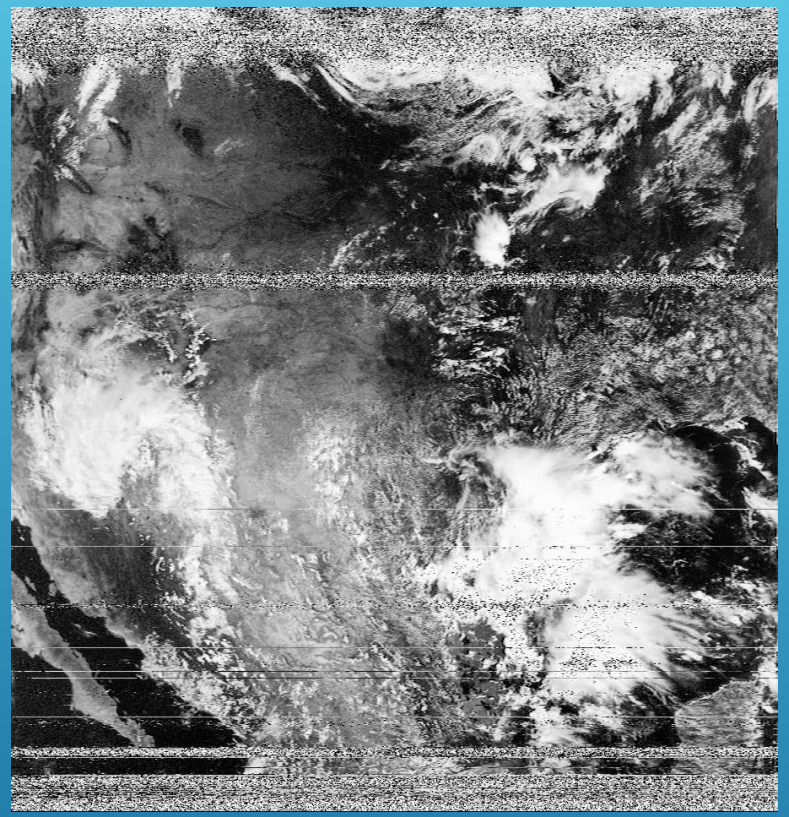
V-DIPOLE CONSTRUCTION

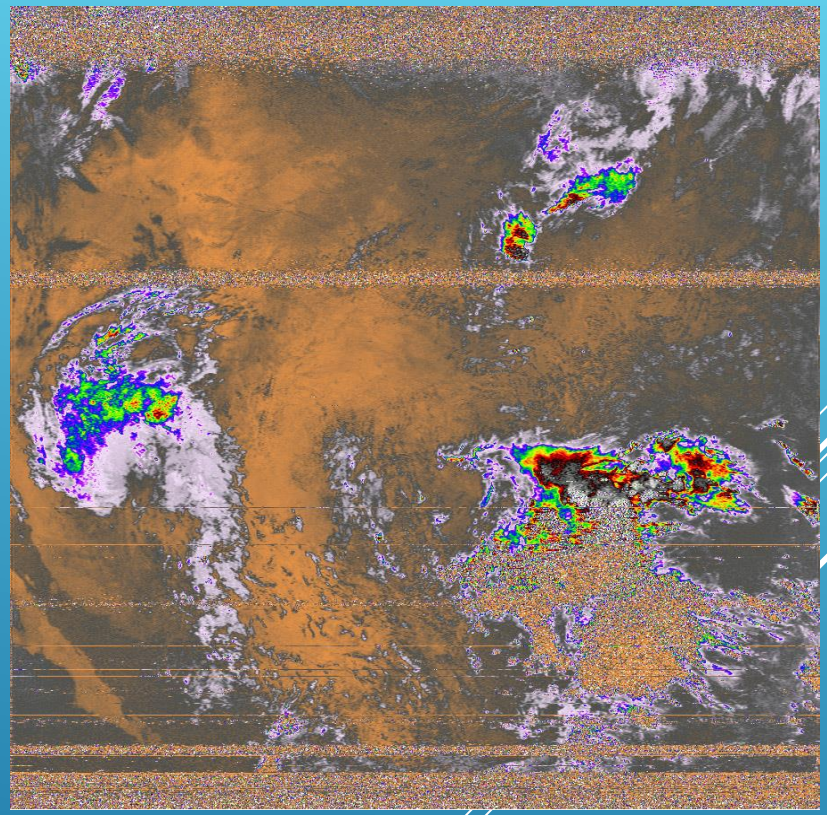
- SWR Measurement using
- NANO VNA
  - Range: 137MHz – 138MHz
  - SWR flat ~ 1.4 : 1

V-DIPOLE

- A complete Backyard Ground Station
- Portable – take to parks, etc
- Minimal set-up / tear-down effort
- Good results attainable

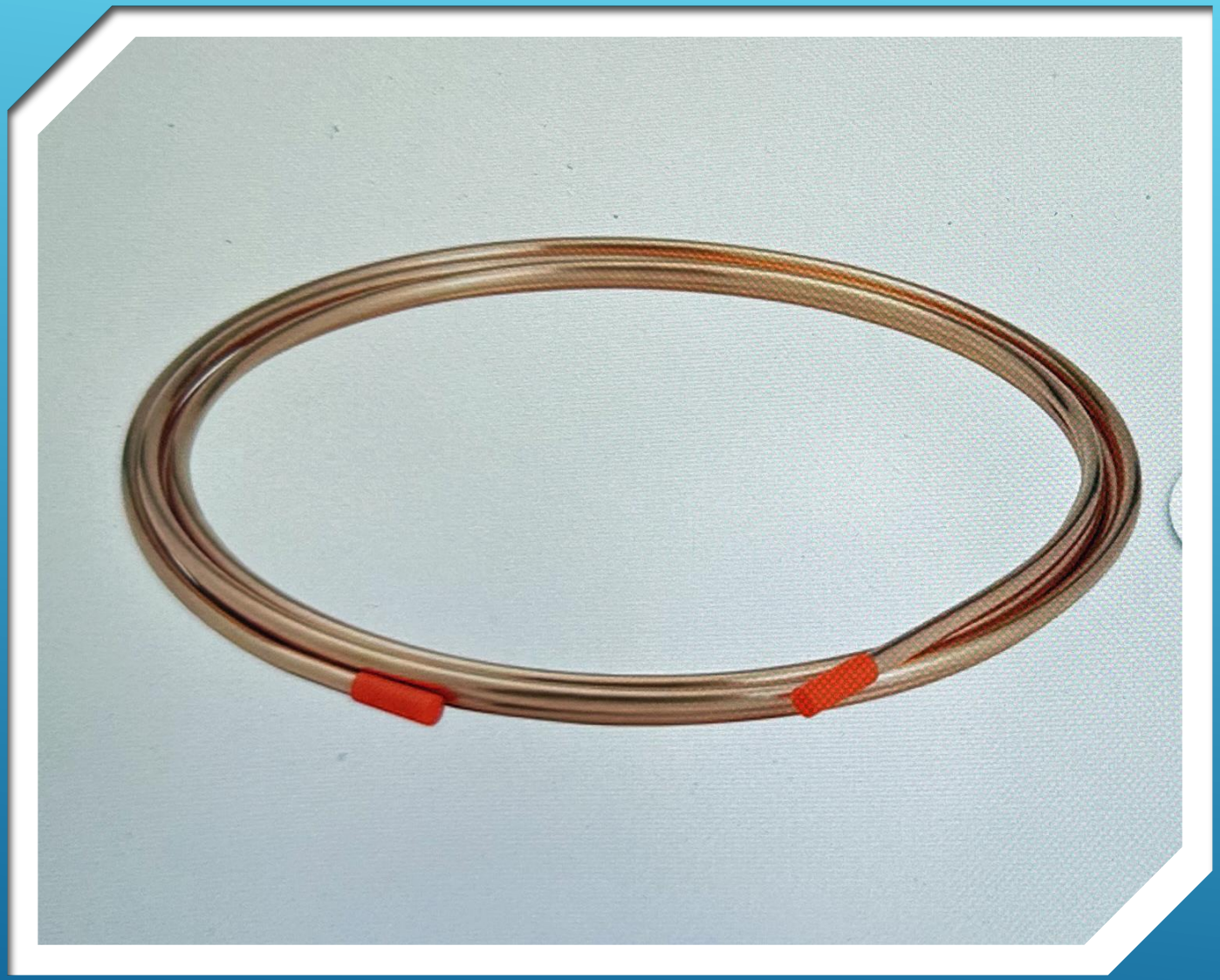

N
NW
NE
W
E
SW
SE
S
Satellite Name: NOAA 18
Current Time: 11:31:19
AOS: 12:31:09





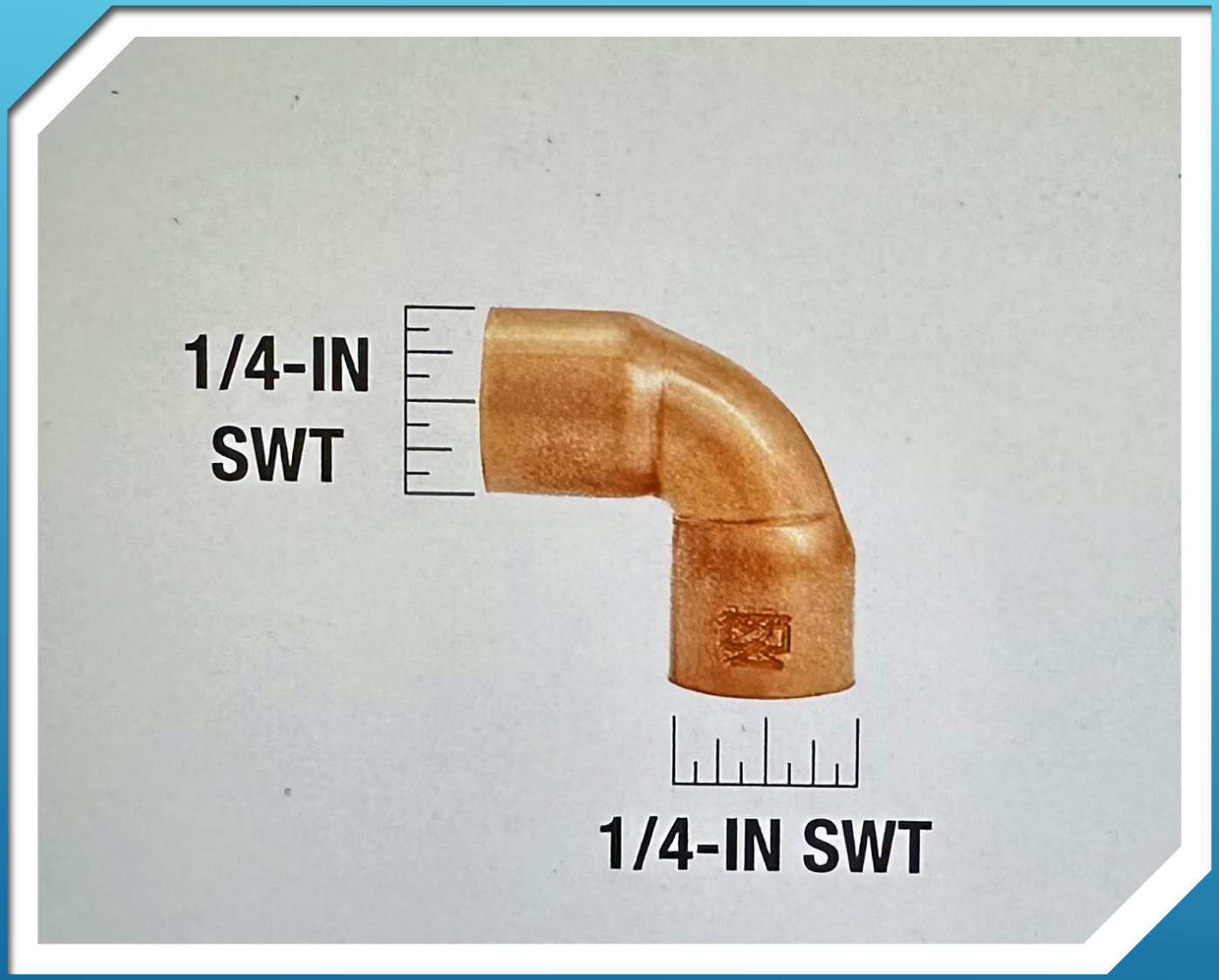
- Robust Construction
- All-Weather Outdoor Use
- Omni-Directional
- Good Low/High-Elevation Response
- Great all-around performance
- Advanced construction skills/tools required
  - Cutting, Drilling, Tube-Bending, Sweat-Soldering
- Expect higher materials cost
- Detailed plans available on Internet
- https://usradioguy.com/wp-content/uploads/2020/05/20200307-How-To-Build-A-QFH.pdf

QFH ANTENNA



QFH-ANTENNA CONSTRUCTION

- Copper Materials
- 3/8 inch O.D. Copper Refrigerator Tubing, 20 ft.
- Available from Lowes and Home Depot
- ACE Hardware may carry it



QFH-ANTENNA CONSTRUCTION

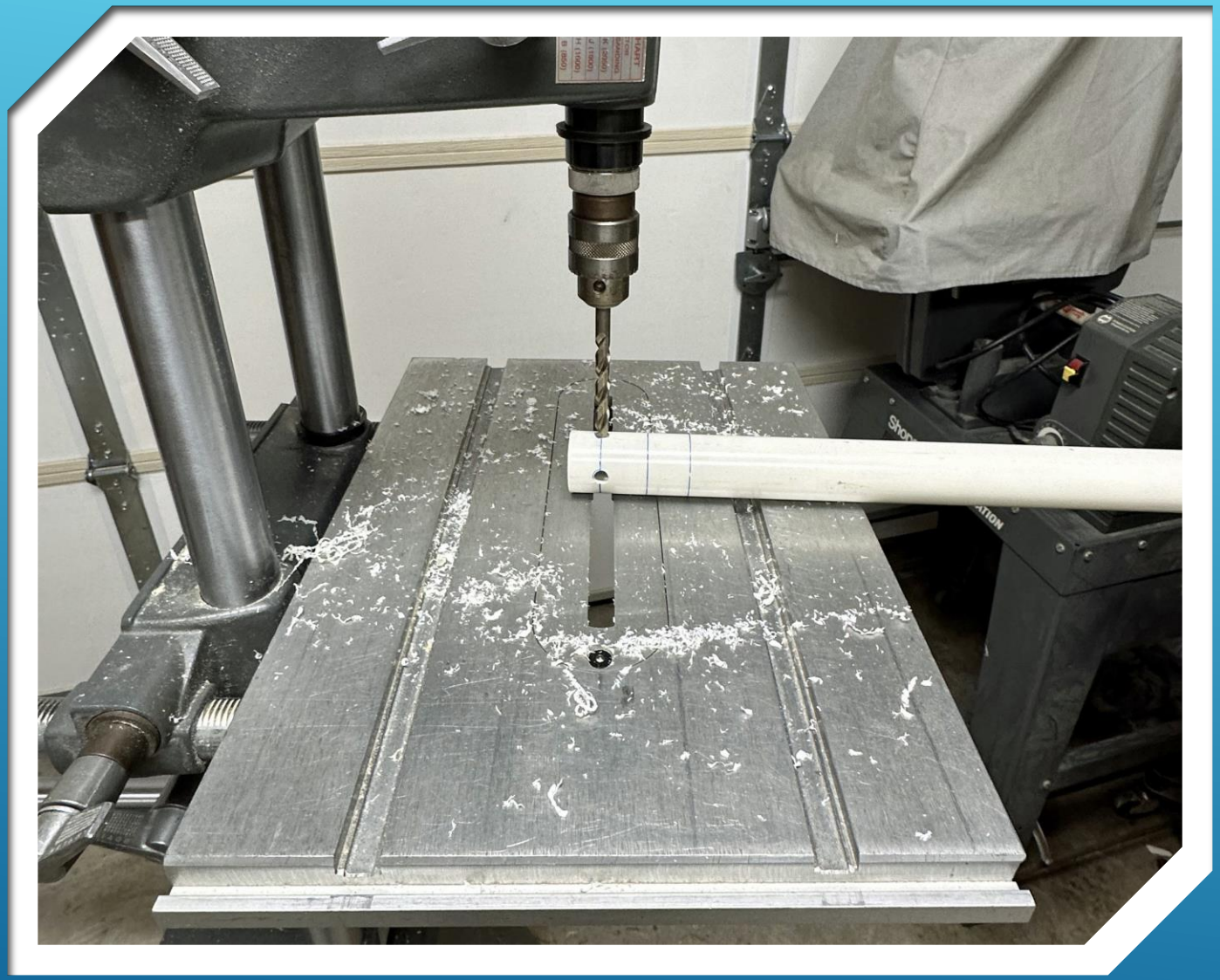
- Copper Materials
- “SR 90 ELBOW”
- 1/4-in I.D. Copper Tubing Elbow, 90 deg.
- Available from Lowes
- ACE Hardware may carry it

QFH-ANTENNA CONSTRUCTION

- Copper Materials
- Straighten and Cut tubing as specified.
- Use a tubing cutter, NOT a hacksaw
- Lengths given in metric units.
- Metric tape measure helpful
- Otherwise, consult Google to convert mm to inches

QFH-ANTENNA CONSTRUCTION

- Copper Materials:
- Cut out a “Bending Jig” to aid in shaping the curved pieces.
- I used string and pencil to draw the arcs.
- Author used cardboard. I used plywood.
- Outer curved edge was for the two longer elements.
- Cut inner arc with bandsaw and use new edge to shape the two shorter elements.



QFH-ANTENNA CONSTRUCTION

- Vertical Support
- Use 1½" PVC Tubing
- Mark up and drill tubing to specs.
- Start with small bit size and work up to final size.
- Drill press works best

- Vertical Section
- Christmas tree stand makes great support while building the antenna.
- Spray paint vertical section for more professional appearance
- Paint top-cap while loosely attached to the vertical upright.
- Short copper stub inserted in top hole prevents cap from being pressed on too tightly during painting.

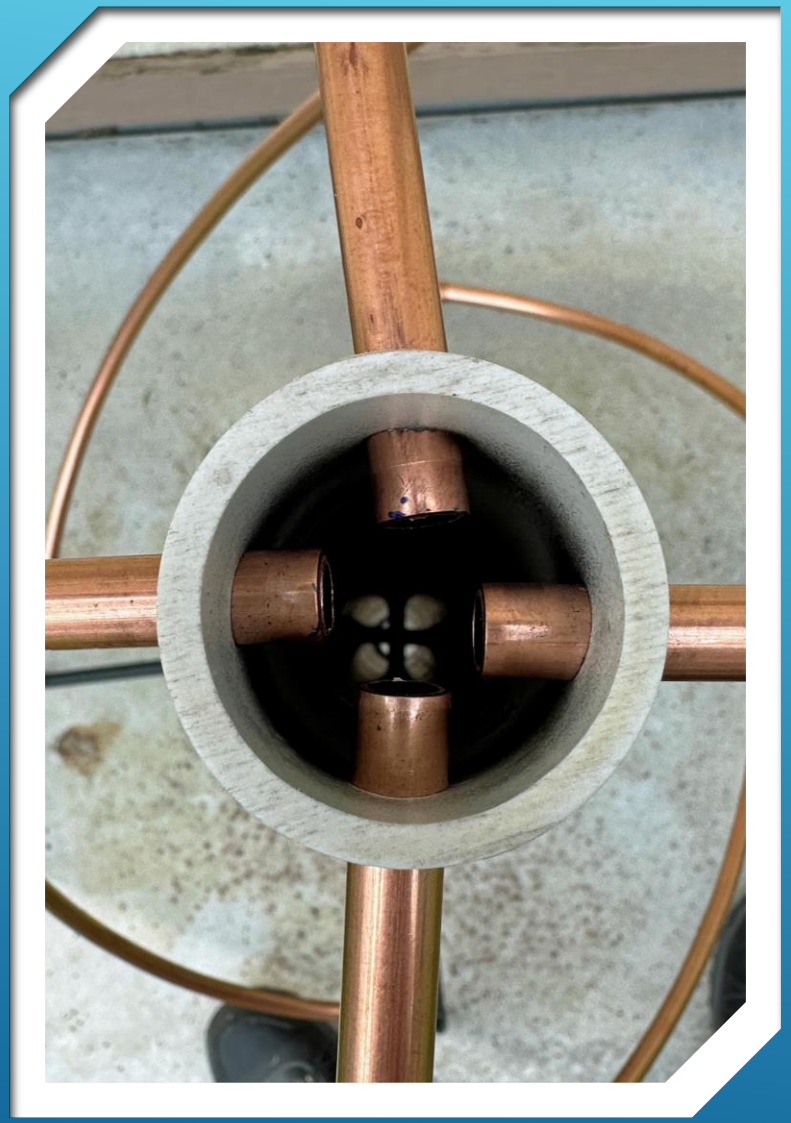
QFH-ANTENNA CONSTRUCTION

- **Assembly:**
- **Follow instructions closely and begin assembly of the straight copper sections.**
- **Pay close attention to placement of the longer and shorter pieces.**

QFH-ANTENNA CONSTRUCTION

QFH-ANTENNA CONSTRUCTION

- **Assembly:**
- **Attach curved sections to straight sections as instructed, joining pieces with 90-deg. elbows.**
- **Pay close attention to placement of the longer and shorter pieces.**



- **Assembly:**
- **Top view**
- **Inspect upper element spacing inside pipe.**
- **Elements should be separated with equal spacing as shown.**

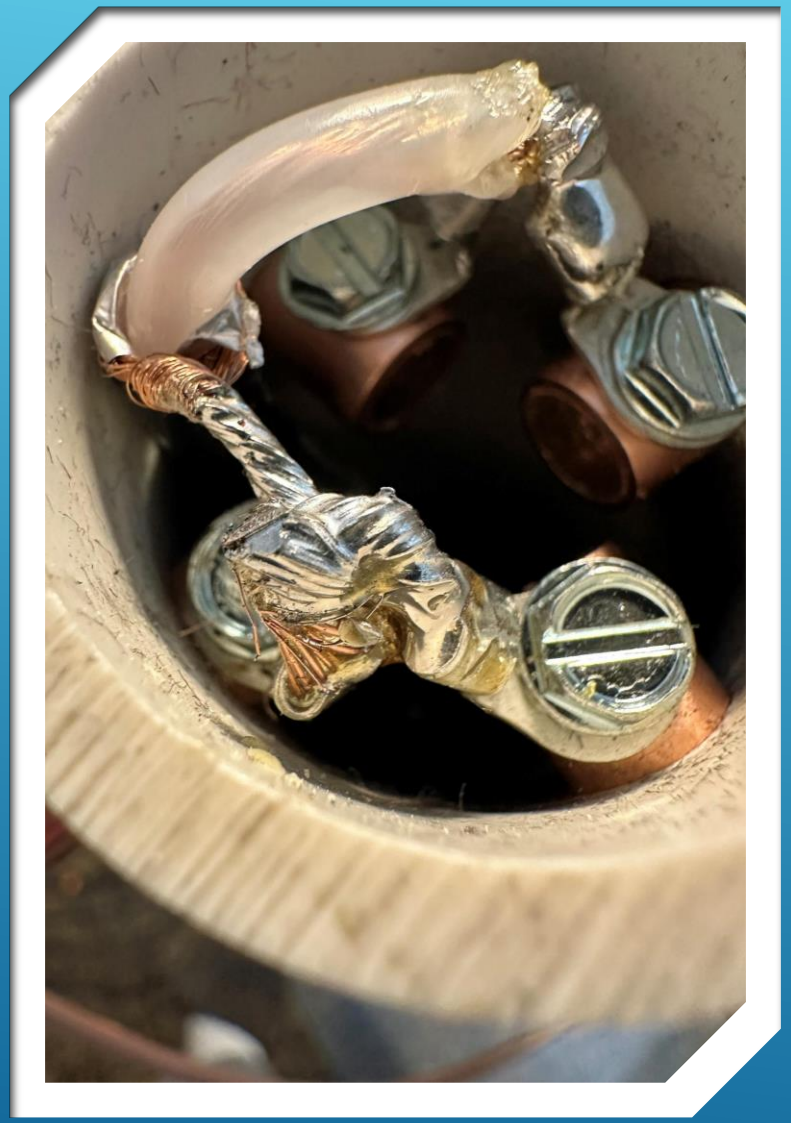
QFH-ANTENNA CONSTRUCTION

QFH-ANTENNA CONSTRUCTION

- **Assembly:**
- **Carefully sweat-solder all elbow joints**
- **Use a wet cloth above the joint to retard heat conduction toward the PVC pipe.**
- **Elements should be separated with equal spacing as shown.**

- Assembly:
- Post-soldering inspection
- Ensure all joints have been soldered
- Gently perform minor shaping adjustments (by hand) to the copper structure, as necessary.

QFH-ANTENNA CONSTRUCTION



- Harness Assembly:
- From outside the PVC pipe, insert Coax into the top balun-coil hole, run it up to upper element ends and attach per instructions.
- It will be necessary to pre-drill the copper tube ends in preparation to accept the self-tapping screws.
- Do not torque the screws too tightly or you may strip the threads in the copper tubing.
- The PVC Cap will protect the connections from moisture and contamination but can be easily removed for later inspections.

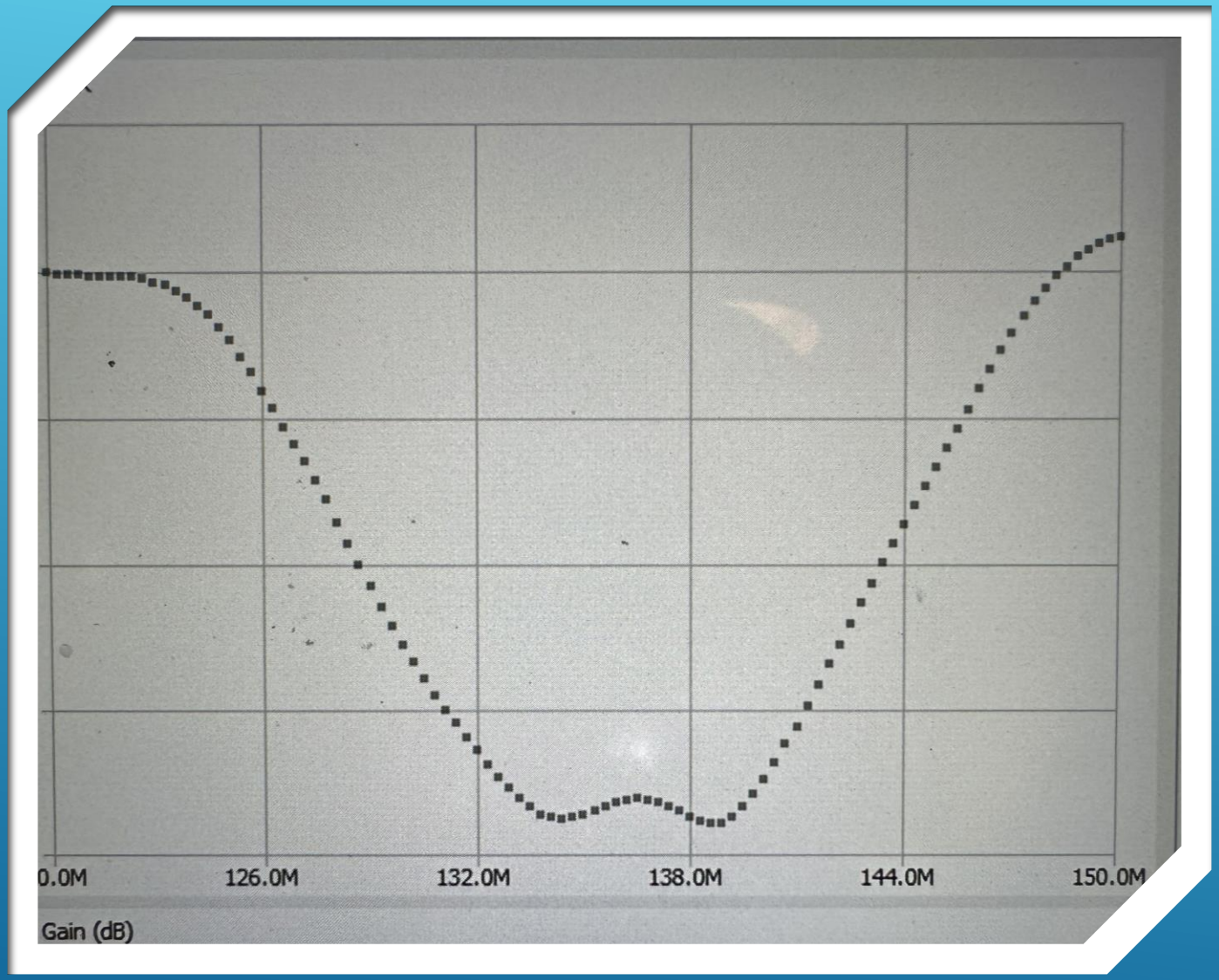
QFH-ANTENNA CONSTRUCTION

- Harness Assembly:
- Wind the coax accordingly to form a balun coil.
- Insert the lower coil-end into the bottom hole and route coax inside the PVC tube to the bottom.
- Terminate bottom coax-end with a PL-259 connector.
- Seal all seams and pipe openings with a silicon sealant compound for weather-proofing.

QFH-ANTENNA CONSTRUCTION

- Final Inspection and Sealing:
- Use instrument to measure SWR of the finished product.
- Determine best location and mounting method for your home installation.
- Note: Coax quality and lead-length will affect results

QFH-ANTENNA CONSTRUCTION



QFH-ANTENNA CONSTRUCTION

- **SWR Measurement taken using Nano VNA.**
- **SWR averaged less than 1.2 from 133MHz to 140MHz.**
- **NOAA POES Satellites transmit between 137-138 MHz.**

- Original Installation at my QTH

QFH-ANTENNA CONSTRUCTION

DISCUSSION

RESOURCES

- www.AMSAT.org
- www.N2YO.com
- YOUTUBE videos
- GOOGLE
- **https://www.rtl-sdr.com/qsg**
- **https://www.sdrpp.org/**
- **https://www.satdump.org/**
- **https://usradioguy.com/wp-content/uploads/2020/05/20200307-How-To-Build-A-QFH.pdf**
- **www.a-centauri.com/articoli/noaa-poes-satellites-reception**

GETTING STARTED RECEIVING NOAA WX SATELLITE IMAGES

Jack Weaver – AA5VZ