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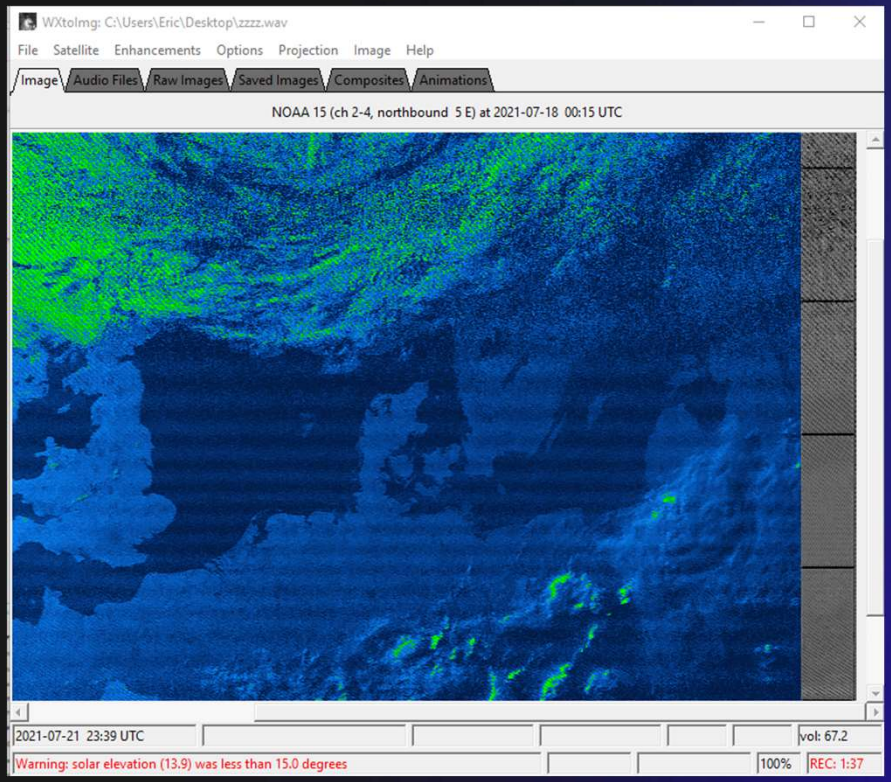
Decoding NOAA Weather Satellite Signals

Eric Escobar – W6WD

What are we doing?

Quick outline:

- What is NOAA?
- What Satellites are in orbit?
- What do these satellites transmit?
- When are these satellites overhead?
- How can we receive the transmitted signals?
- Capturing data with only a web browser.
- How do we decode the data?



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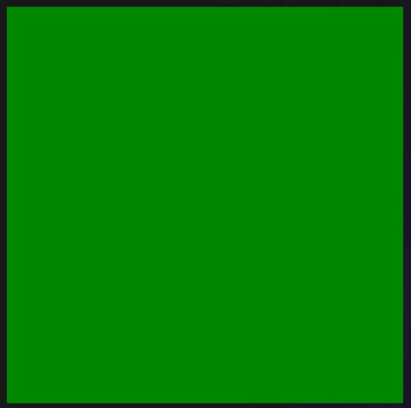
What is NOAA?

NOAA - National Oceanic and Atmospheric Administration

- “The NOAA Satellite and Information Service provides timely access to global environmental data from satellites and other sources to monitor and understand our dynamic Earth. We manage the Nation's operational environmental satellites and deliver data and information services such as Earth system monitoring and official assessments of the environment.” – NOAA.gov

- 4 Polar-Orbiting Satellites
  - NOAA -15
  - NOAA-18
  - NOAA-19
  - NOAA-20 <- Doesn’t transmit what we need



What do they transmit?

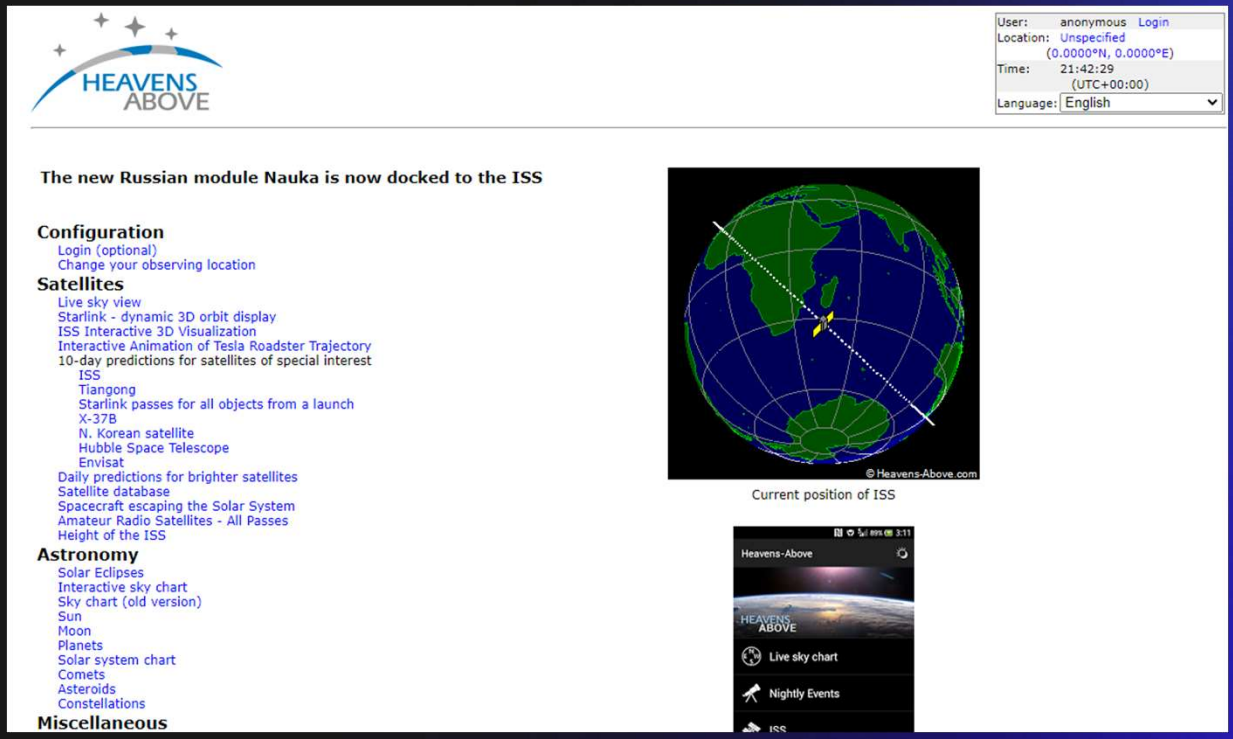
Lots of features, we'll only focus on one!

- Automatic Picture Transmission (APT) - Developed in the 1960's
- Broadcasts include:
  - Telemetry
  - Data synchronization
  - Images (horizontal scan lines)
- 2 lines / second - (4160 baud)
- 4 kilometers / pixel (8 bit images)

How do we track them?

Mobile Applications & Websites

- iOS – GoSatWatch - $10
- Android – Heavens-Above
- Web Browser – Heavens-above.com



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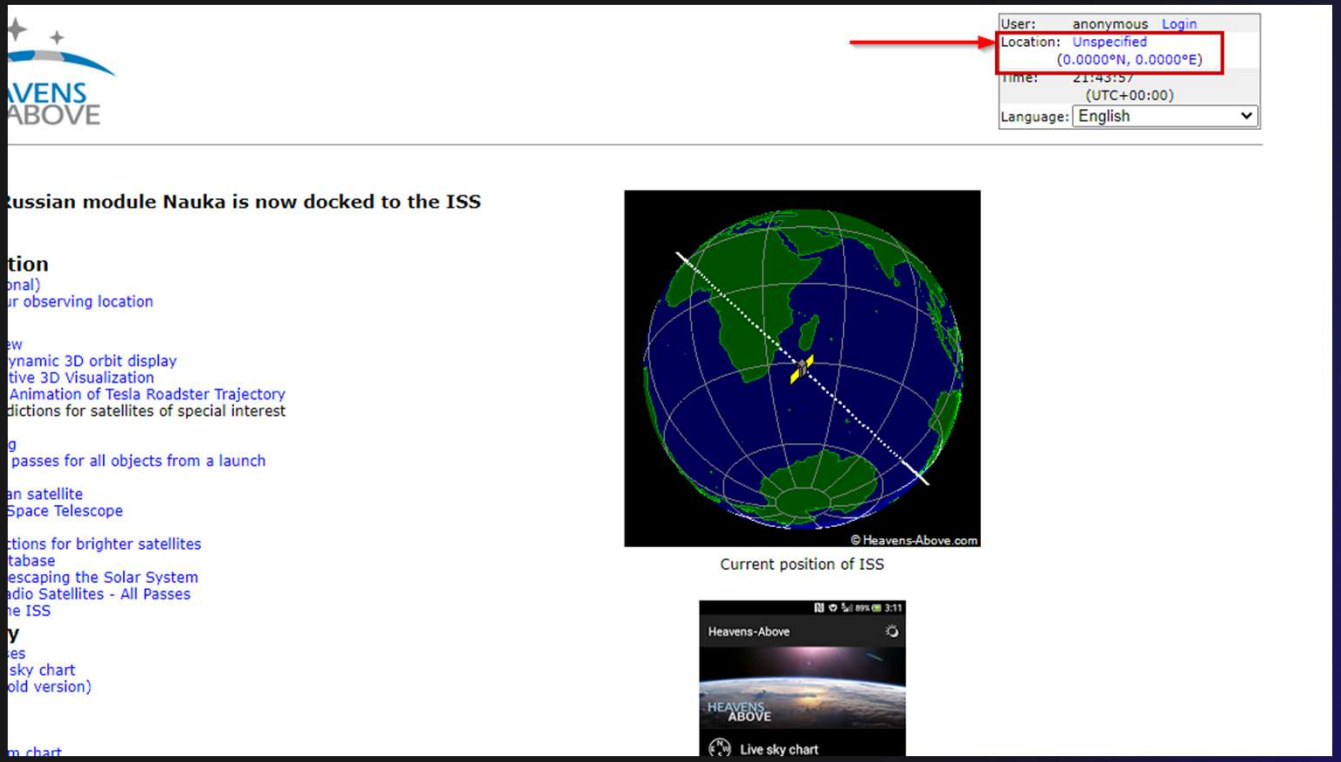
Mobile Applications & Websites



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How do we track them?

Mobile Applications & Websites

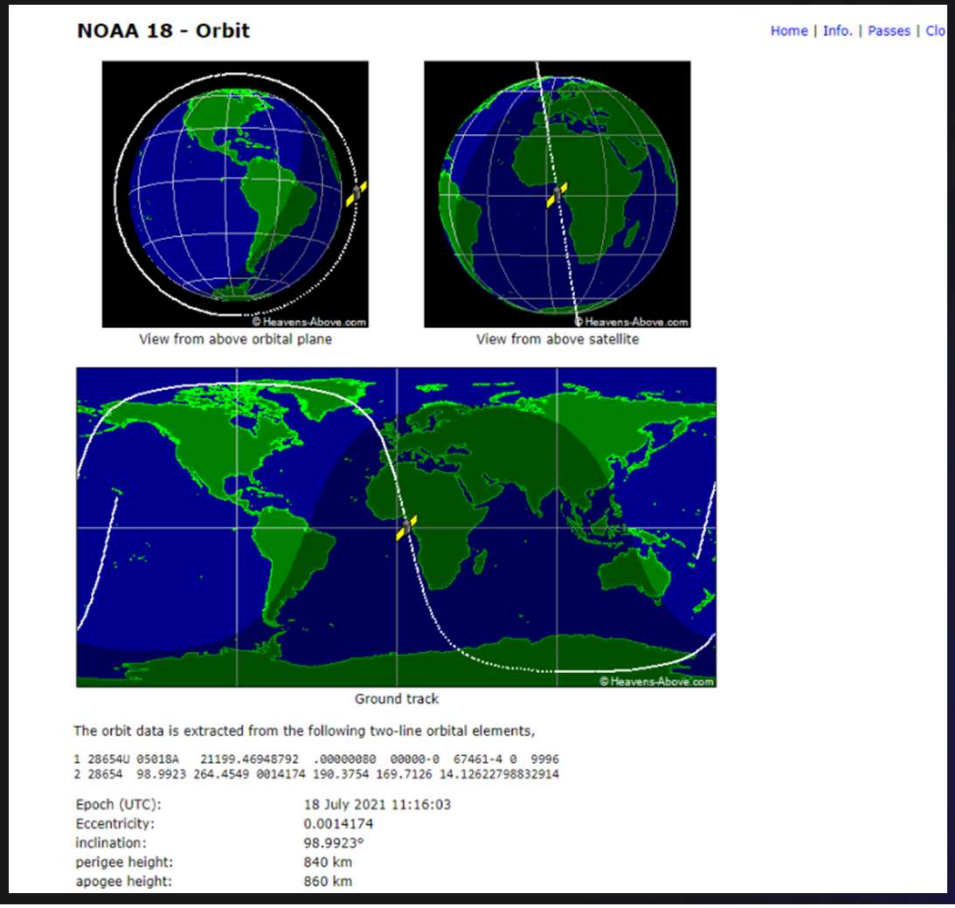
How do we track them?

Mobile Applications & Websites

Satellite	Date	Start	Highest point		End	Downlink Frequencies (MHz)
			Altitude	Azimuth		
UNISAT 6	02 Aug	19:00:04	21°	95° (E)	19:06:39	437.425
BEESAT 2	02 Aug	19:00:41	28°	247° (WSW)	19:07:20	435.950
FALCONSAT 3	02 Aug	19:03:00	55°	167° (SSE)	19:09:57	435.103
ITUPSAT 1	02 Aug	19:08:16	20°	95° (E)	19:15:23	437.325
RS-44	02 Aug	19:13:45	23°	69° (ENE)	19:26:52	435.640
NOAA 19	02 Aug	19:15:02	79°	256° (WSW)	19:25:58	137.1000
NOAA 15	02 Aug	19:22:51	69°	74° (ENE)	19:33:22	137.6200
DELFI C3	02 Aug	19:23:26	27°	72° (ENE)	19:29:59	145.870
TIGRISAT	02 Aug	19:23:51	35°	98° (E)	19:31:42	435.000
NUDT-PHONESAT	02 Aug	19:26:50	22°	264° (W)	19:32:28	437.300
HuskySat-1	02 Aug	19:26:52	12°	339° (NNW)	19:29:55	.
AO-27	02 Aug	19:49:50	28°	263° (W)	19:58:41	436.795
BEESAT	02 Aug	19:59:31	75°	103° (ESE)	20:09:04	436.000
METEOR M2	02 Aug	20:11:13	37°	262° (W)	20:21:07	137.100 / 137.900
Max Valier Satellite	02 Aug	20:11:57	21°	71° (ENE)	20:17:26	145.860
STRAND 1	02 Aug	20:24:03	49°	288° (WNW)	20:33:49	437.568

How do we track them?

Mobile Applications & Websites



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How do we capture data?

Capturing APT Data:

- Commercial hardware
  - Software Defined Radio (SDR) - Requires an antenna
    - $30 - R820T2 on Amazon
  - Baofeng radio – Requires an antenna
    - $26 – Baofeng UV-5R on Amazon
- From the internet
  - WebSDR.org

How do we capture data?

Interfacing with your radio / SDR

- Baofeng
  - Antenna coaxial cable (SO-239) to SMA-Female (Baofeng)
  - 2.5mm to 3.5mm audio cable (to computer / phone)
- RTL-SDR
  - Antenna coaxial cable (SO-239) to SMA-Male (SDR)

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How do we capture data?

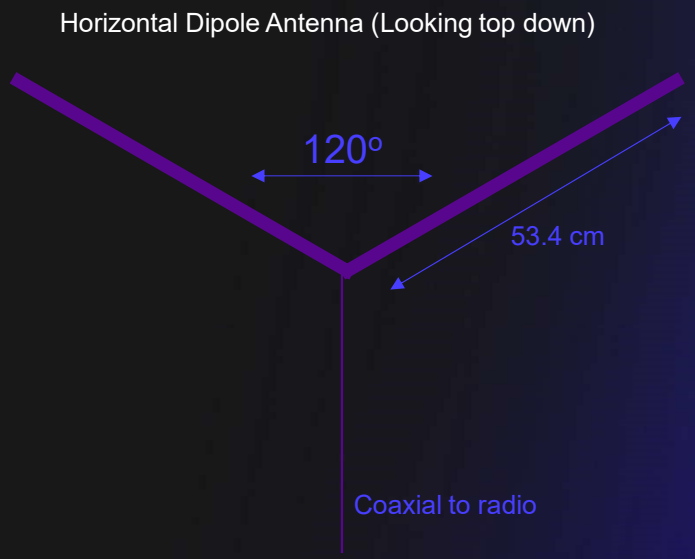
Building or buying an antenna:

- Purchasing antennas
  - Works well, but pricey. ($250)
  - https://www.antennas.us/store/p/404-UC-1374-531-4-dBic-VHF-APT-Weather-Satellite-Antenna-WXSAT.html
- Building your own
  - May not be tuned perfectly.
  - Time to build!

How do we capture data?

Building antenna:

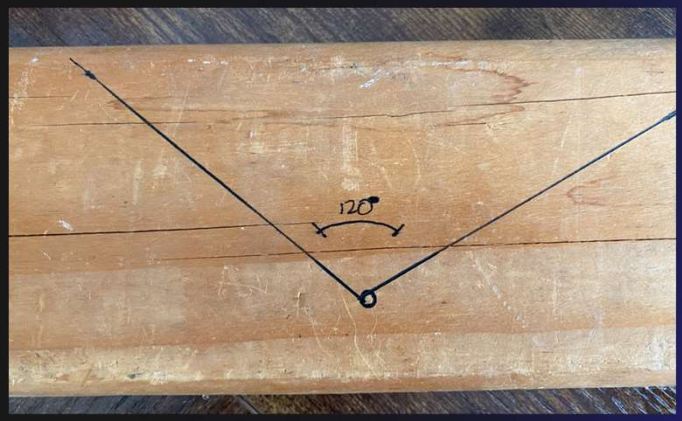
- H-Dipoles are easiest to build
- Materials:
  - Two metal rods (~3mm diameter) x 53.4cm long
  - Coaxial cable (match either your SDR or Baofeng)
  - Soldering iron
  - Scrap mounting material



How do we capture data?

Building a horizontal dipole antenna:

- Take some scrap mounting material
- Cut your aluminum rods
- Secure the rods to your material
- Doesn’t have to look pretty



How do we capture data?

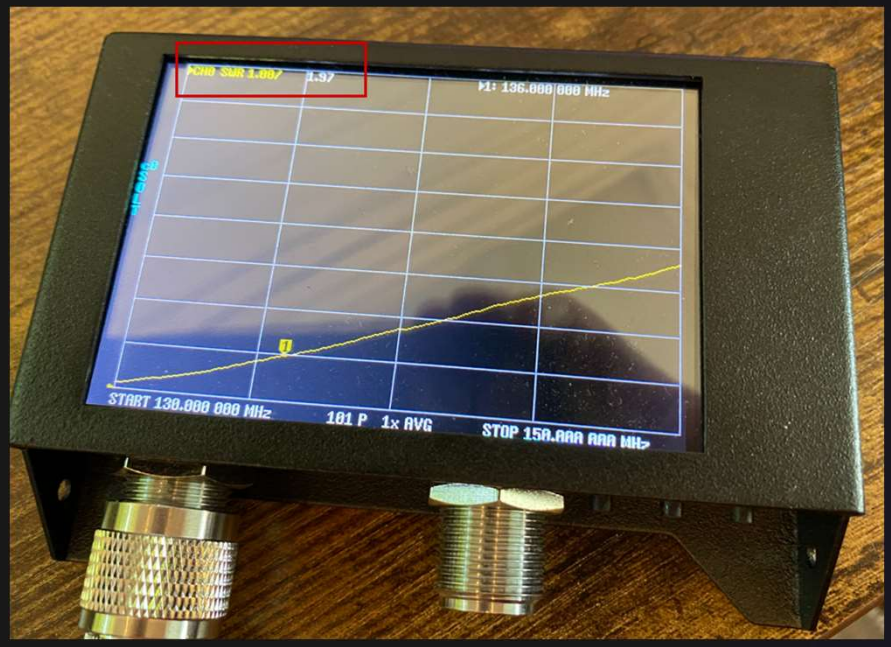
Building a horizontal dipole antenna:

- Strip your coaxial cable
- Solder your coaxial cable to the rods
- Make sure the ends do not touch!
- Let’s check the tuning….

How do we capture data?

Building a horizontal dipole antenna:

- (1 / 1.97) Standing wave ratio
  - Not terrible for $15



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How do we capture data?

No antenna? No Sweat!

WebSDR.org

- A WebSDR is a Software-Defined Radio receiver connected to the internet, allowing many listeners to listen and tune it simultaneously. SDR technology makes it possible that all listeners tune independently, and thus listen to different signals; this is in contrast to the many classical receivers that are already available via the internet.

  – WebSDR.org

- Free to use
- Receivers available all around the world.
- A quick word on wavelength & frequency
  - $3x10^8$ (m/s) / $137x10^6$ (cycles/s) = ~2.18 meters

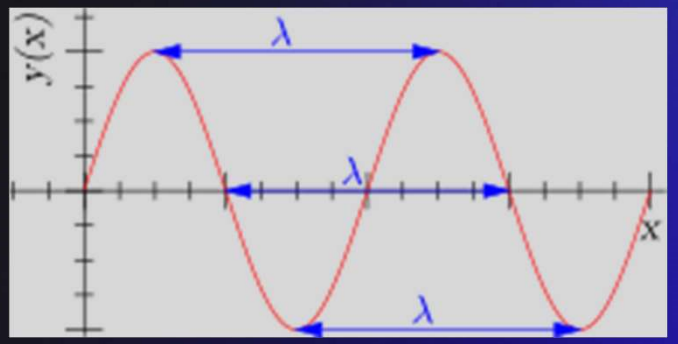
$$\lambda = \frac{v}{f}$$

How do we capture data?

No antenna? No Sweat!

- A quick word on wavelength & frequency
  - v = speed of light - 3×10^8 (meters /second)
  - f = frequency in Hertz (cycles / second)
  - λ = wavelength (meters)
- Sample calculation
  - 3×10^8 (m/s) / 137×10^6 (cycles/s) = ~2.18 meters

$$\lambda = \frac{v}{f}$$



How do we capture data?

Using WebSDR.org

Currently there are 175 servers active, with 970 users and 813 MHz of radio spectrum.

Filter band: 2m and region: Any and mobile support and covering 137 MHz.

Location and URL	Frequency range	Antenna	
Nuremberg Skyscraper http://nbgsdr.ddns.net/ JN59NJ; 4 users	26.464 - 28.000 MHz	Sirio GainMasterHW above 70m - SDRplay RSPdx Receiver	1
	136.670 - 138.206 MHz	KE-137 Cirkular Antenna with SAW Filter - RTL-SDR V3 Dongle	
	143.952 - 146.000 MHz	Diamond X-50 above 70m - RTL-SDR V3 Dongle	
	148.308 - 149.844 MHz	Diamond X-50 above 70m - RTL V3 Dongle	
	445.432 - 446.968 MHz		
European Space Agency Radio Club (PI9ESA) WebSDR http://erc-websdr.esa.int/ JO22FF; 0 users	136.476 - 138.524 MHz	Half-Turn QFH 2m	2
	143.976 - 146.024 MHz		
	433.976 - 436.024 MHz	Half-Turn QFH 70cm	
	435.976 - 438.024 MHz		
Home of K3FEF and W3TKP in Milford, Pennsylvania, NE USA. Weather sats, 10/11M, 6M, 2M! http://websdr2.K3FEF.com:8902/ FN21mh; 0 users	135.976 - 138.024 MHz	Custom QFH	3
	143.976 - 146.024 MHz	Discone	
	145.976 - 148.024 MHz		
	49.976 - 52.024 MHz	Comet CHA250B	
	51.976 - 54.024 MHz		
	26.976 - 29.024 MHz		
MiB websdr server in Novovoronezh http://websdr.vrn.ru:8901/ KO91oh; 1 users	136.476 - 138.524 MHz	Sirio SD-1300N discone antenna	4
	143.976 - 146.024 MHz		
	433.746 - 435.794 MHz		
	435.876 - 437.924 MHz		
RUSSIA Kola Peninsula Murmansk. http://websdr.aknot.ru:8901/ KP68nw; 0 users	135.966 - 138.014 MHz	Quadrifilar antenna	5
	145.232 - 146.768 MHz	antenna QFH	
	156.026 - 158.074 MHz		
	130.576 - 132.624 MHz		
	6.076 - 8.124 MHz	Long Wire test!	

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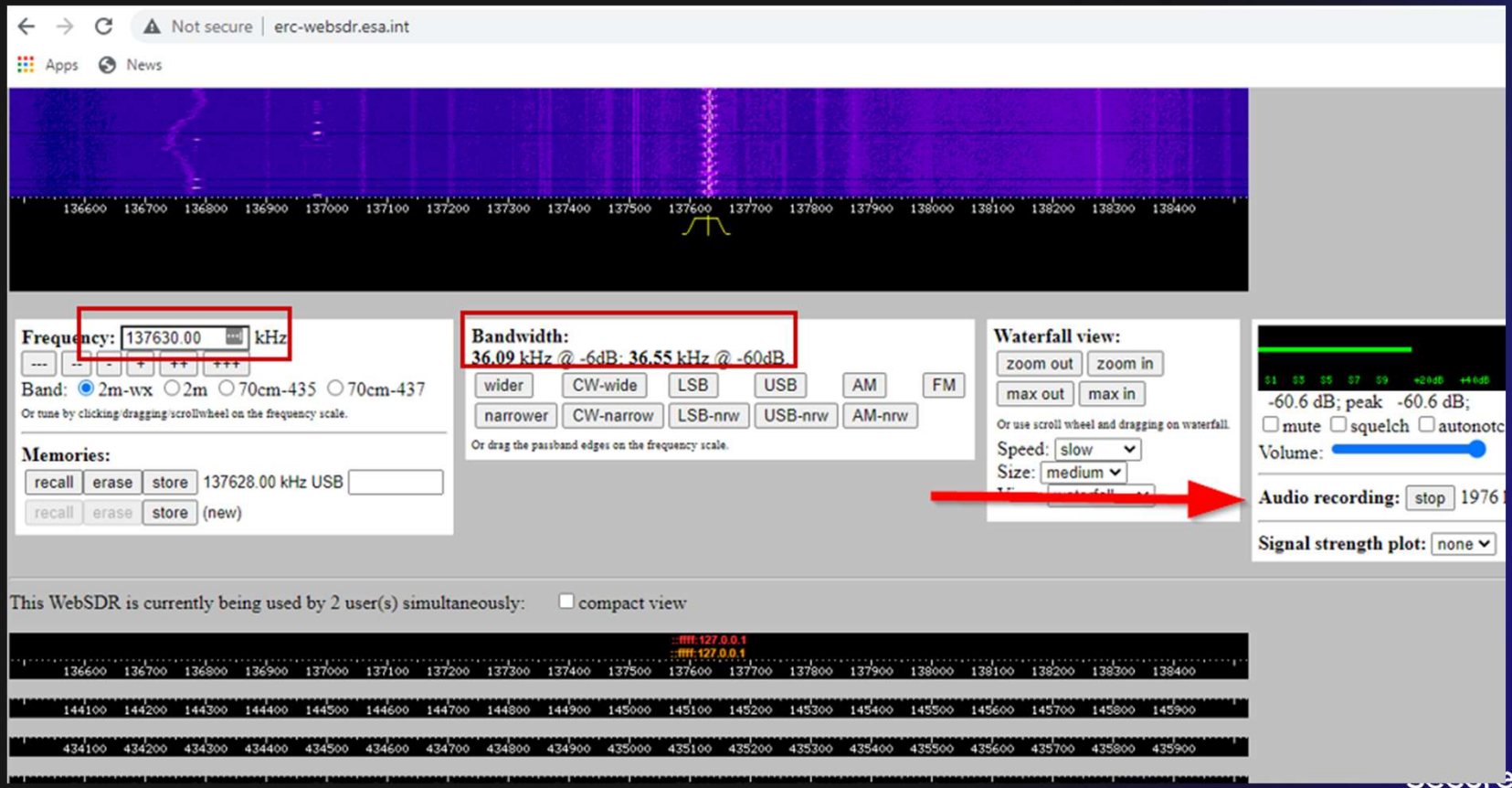
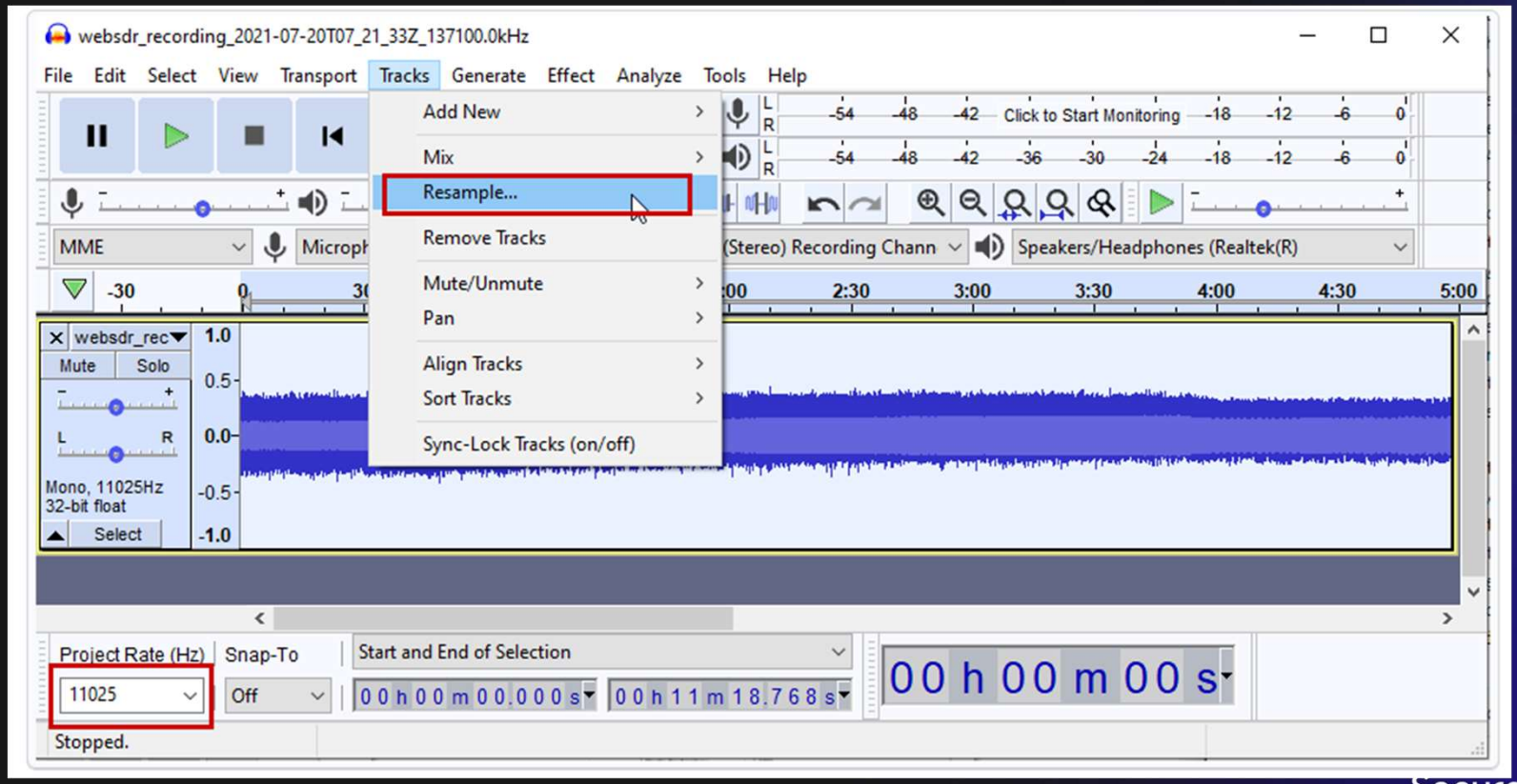


How do we decode data?

Using Audacity



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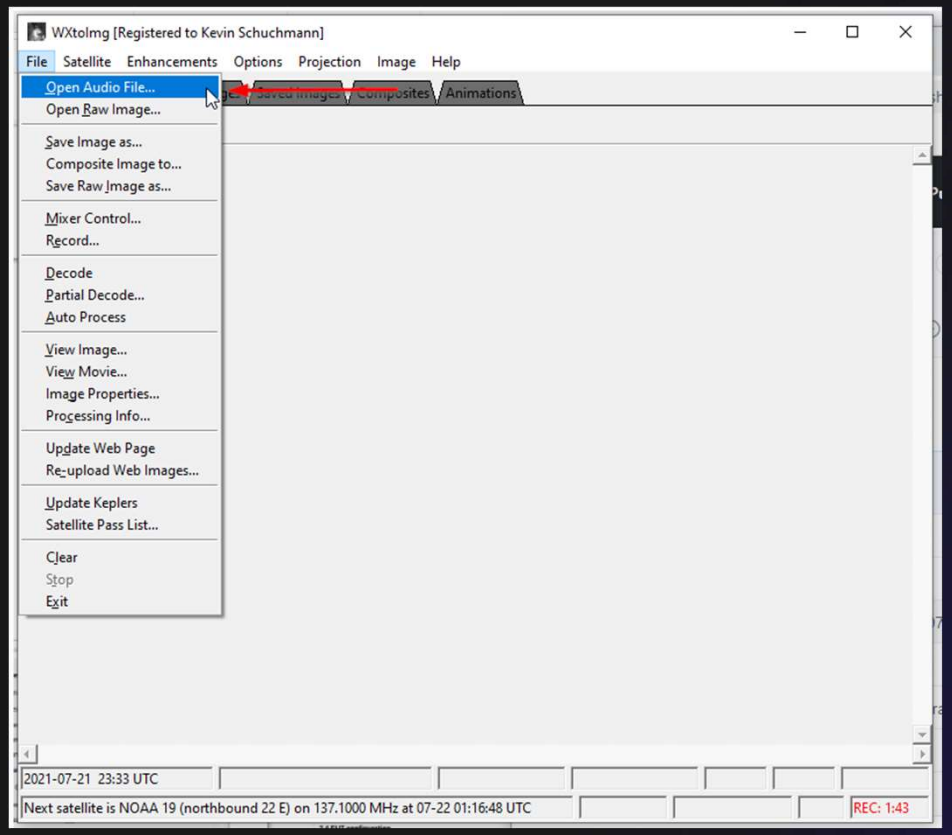
How do we decode data?

Decoding the audio

- WXtoImg
  - Software is outdated but still maintained as a beta
  - https://wxtoimgrestored.xyz/downloads/ (Use the beta version)
- NOAA-APT
  - Supported and updated
  - Has less features than WXtoImg
  - https://noaa-apt.mbernardi.com.ar/

How do we decode data?

Decoding the audio with WXtoImg



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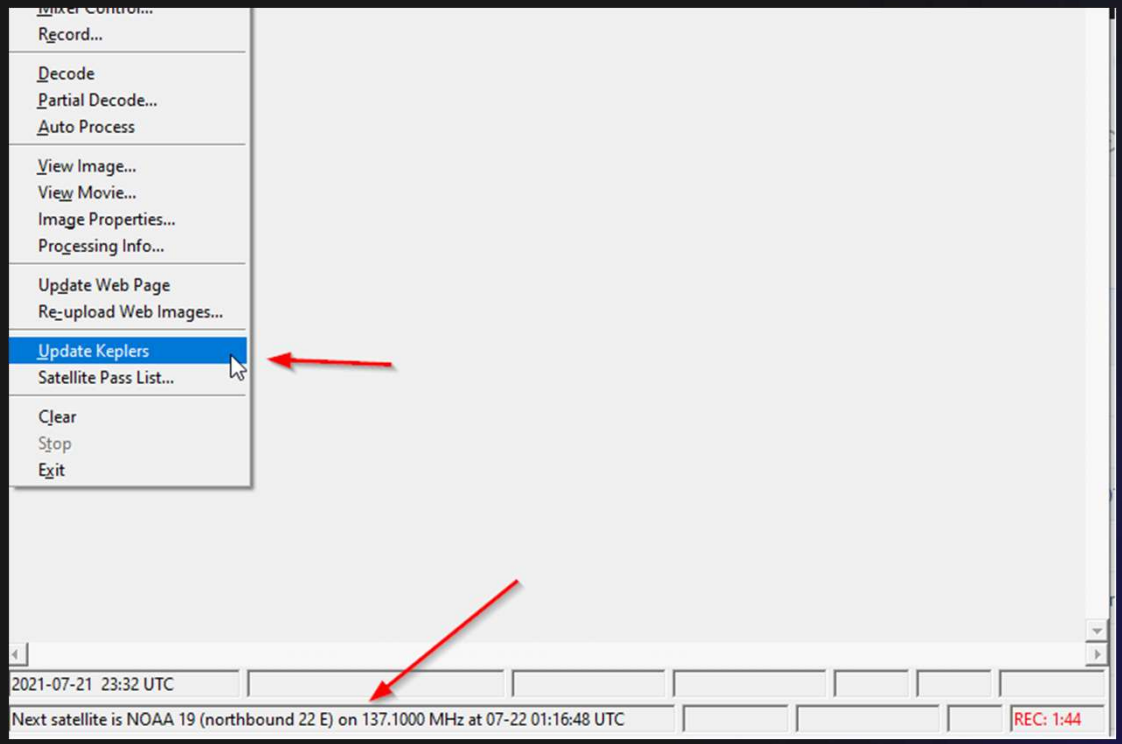
How do we decode data?

Decoding the audio with WXtoImg



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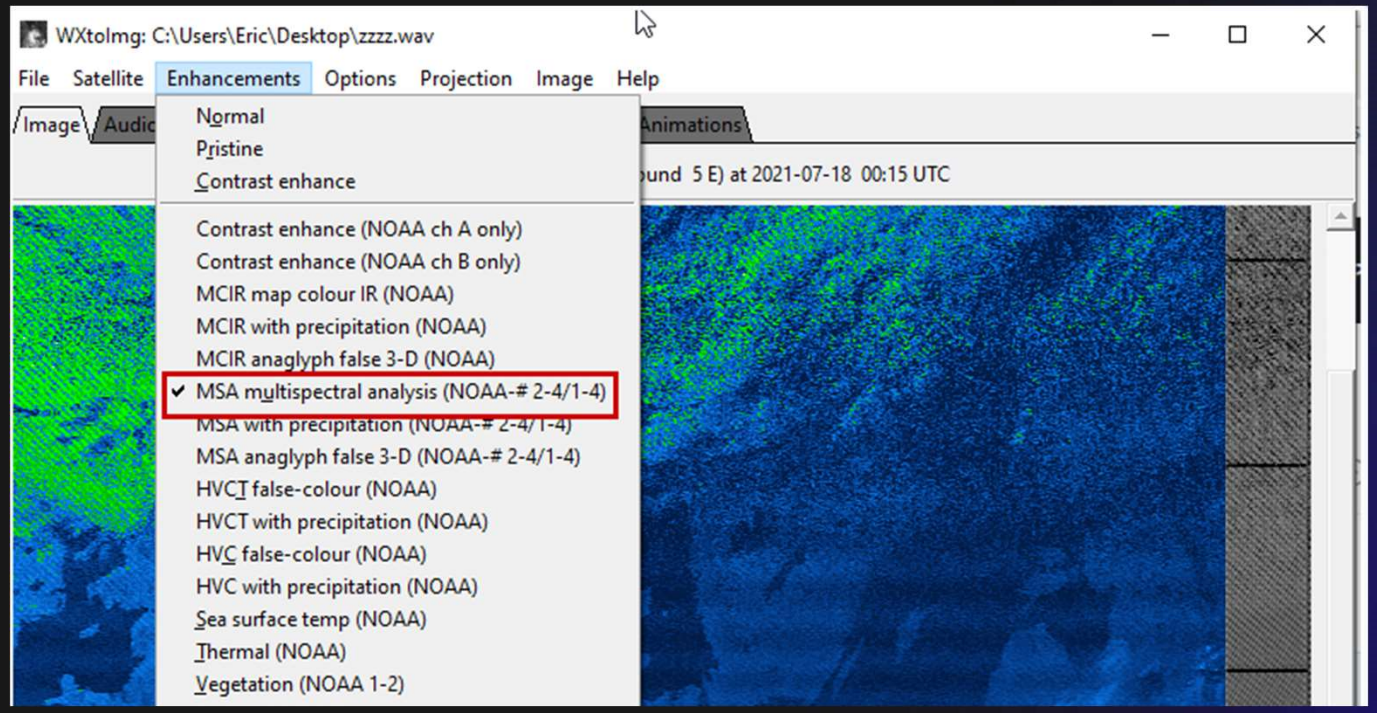
How do we decode data?

Decoding the audio with WXtoImg



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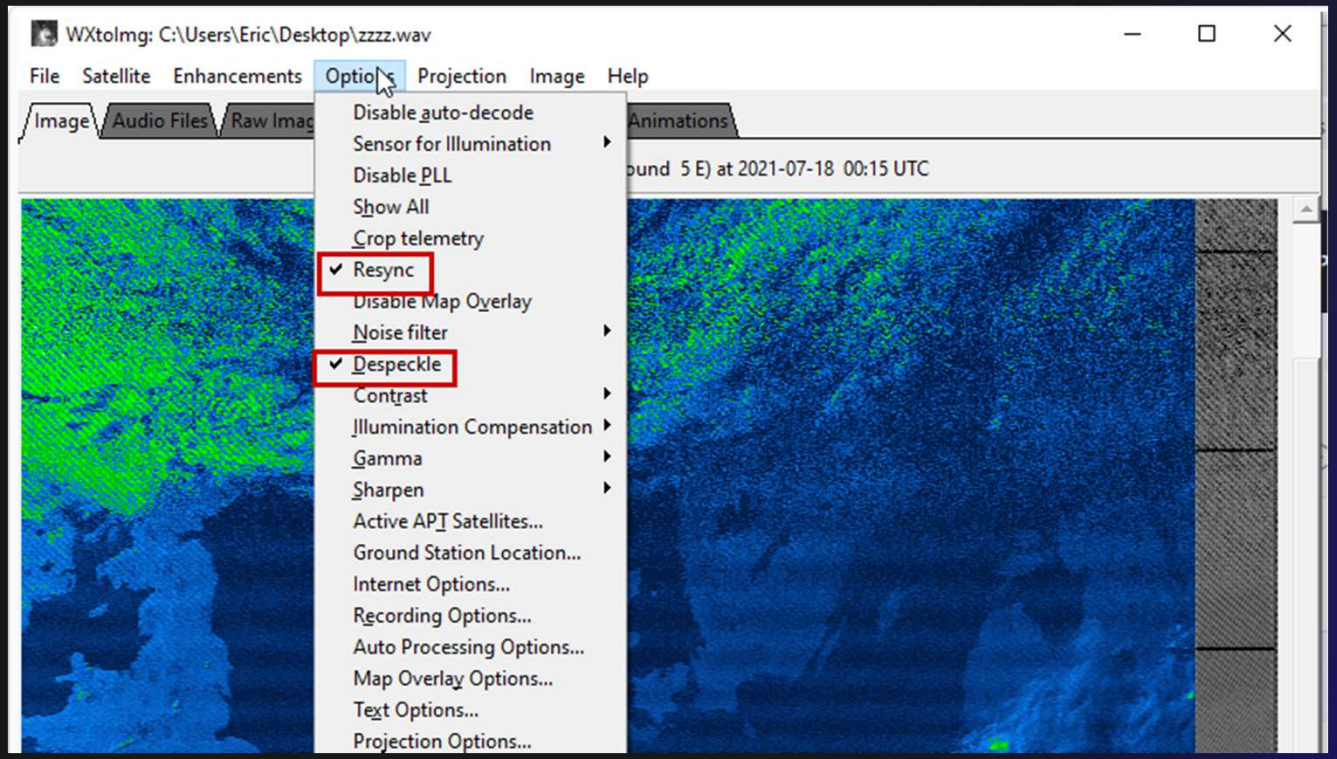

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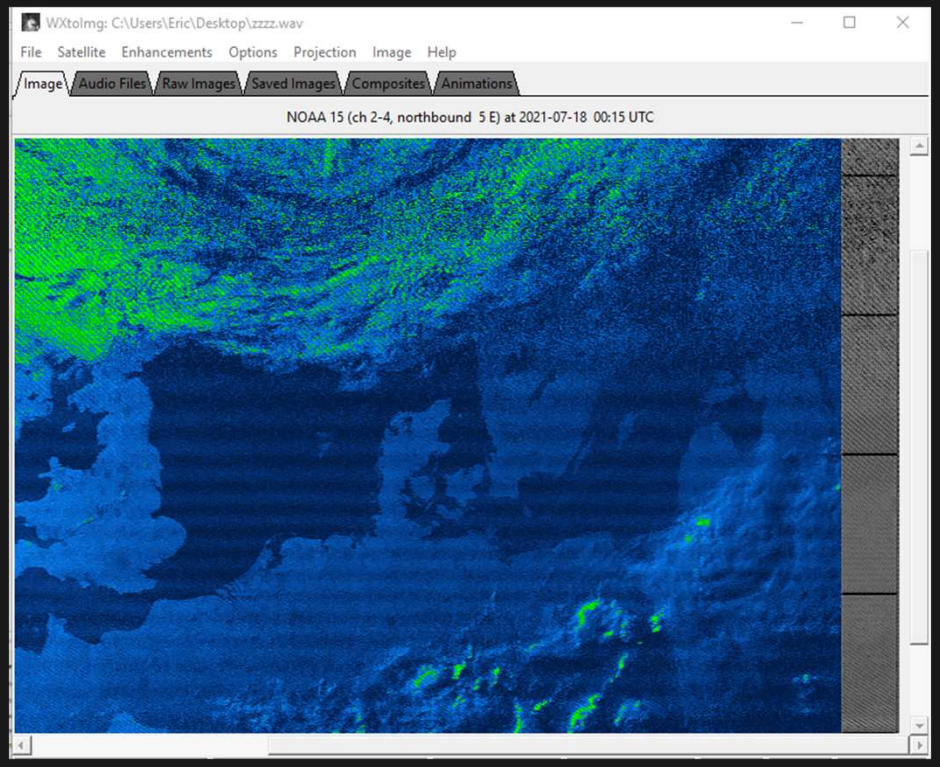

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Now what?

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