

Workshop LABRE/AMSAT-BR

Open Satellite Project

Pardinho, São Paulo

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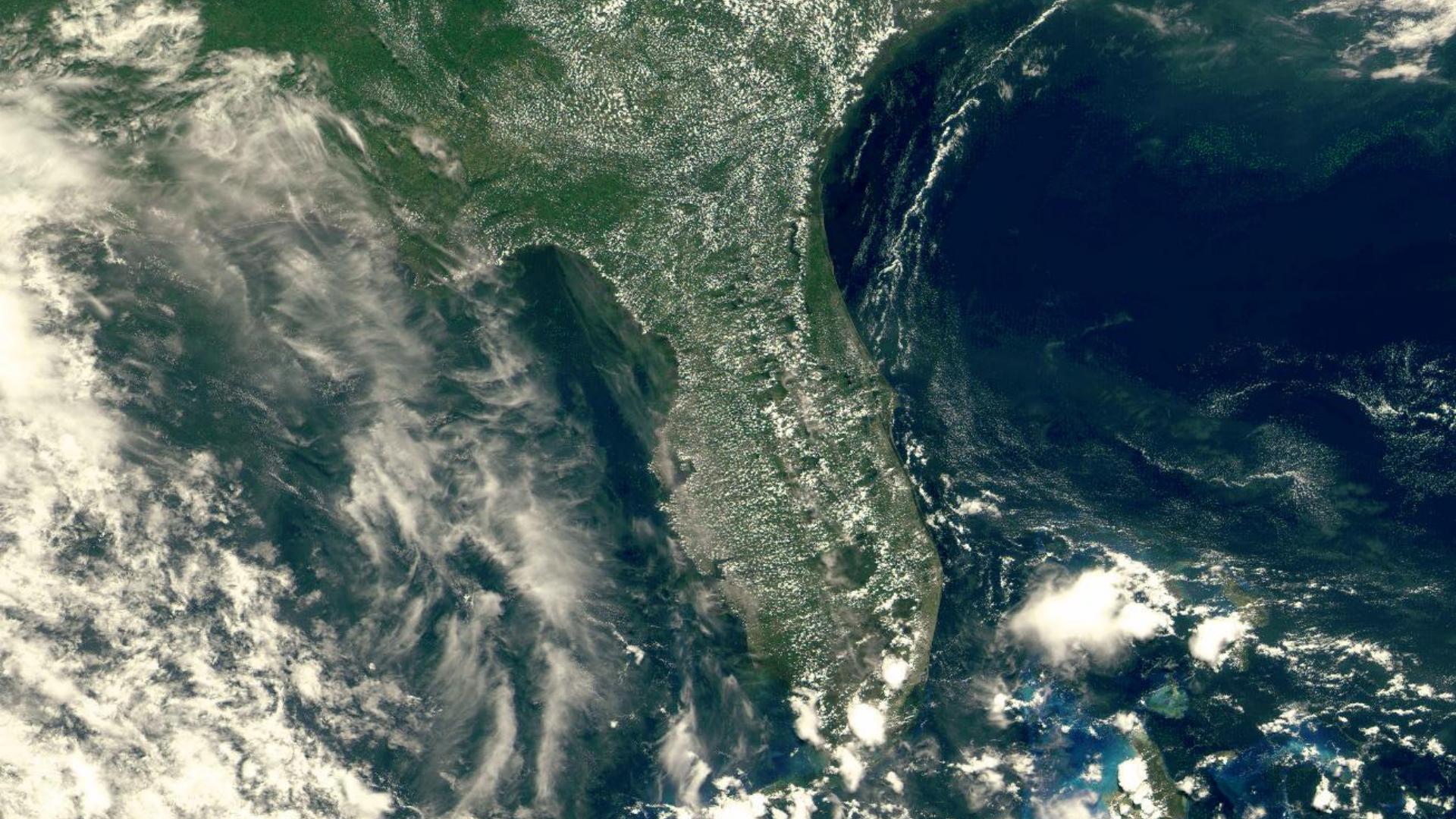
November 17, 2018

PU2SPY

Open Satellite Project

- Non-profit organization.
- Open-Source Software.
- Focused in Weather Satellites.
- Five Datalinks Currently Supported.
- Mainly Geostationary Spacecraft.
- Awesome Earth Pictures!



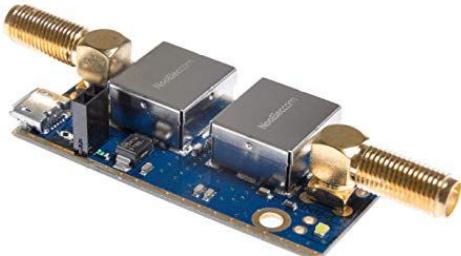


Wi-Fi/GSM Grid Antenna

GOES-16 - L-Band HRIT

Level: Starter

- L-Band Signal (1.694.100 MHz)
- Low Bandwidth (~1 MHz)
- Fixed Position (Geostationary)
- Standard low overhead encoding



\$35 SAWbird



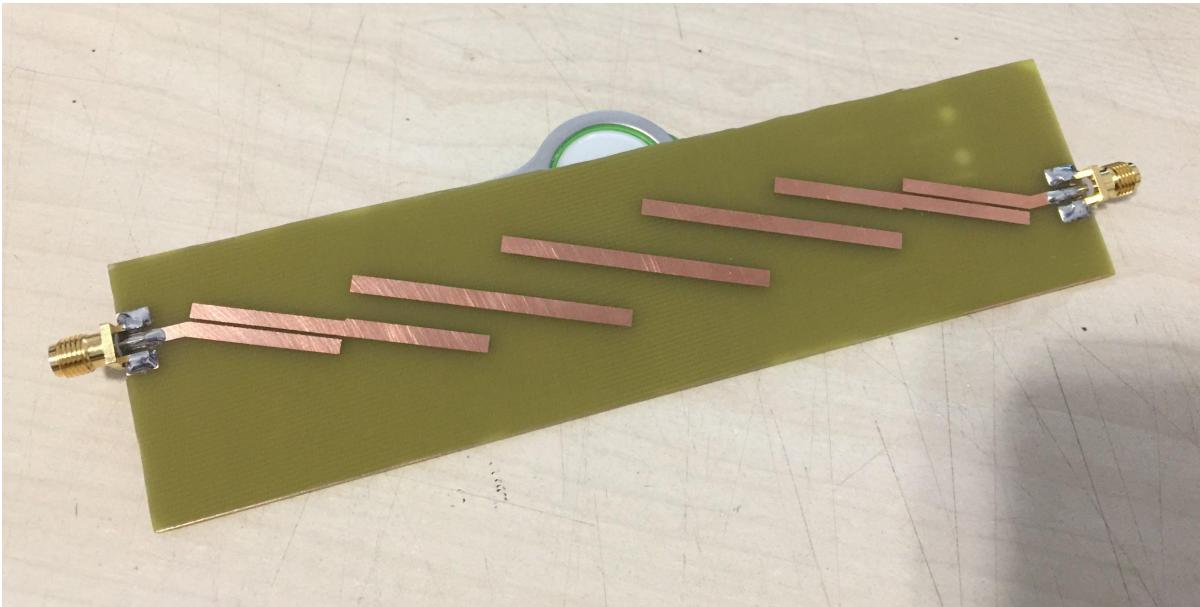
\$21 RTL-SDR V3



Also required:

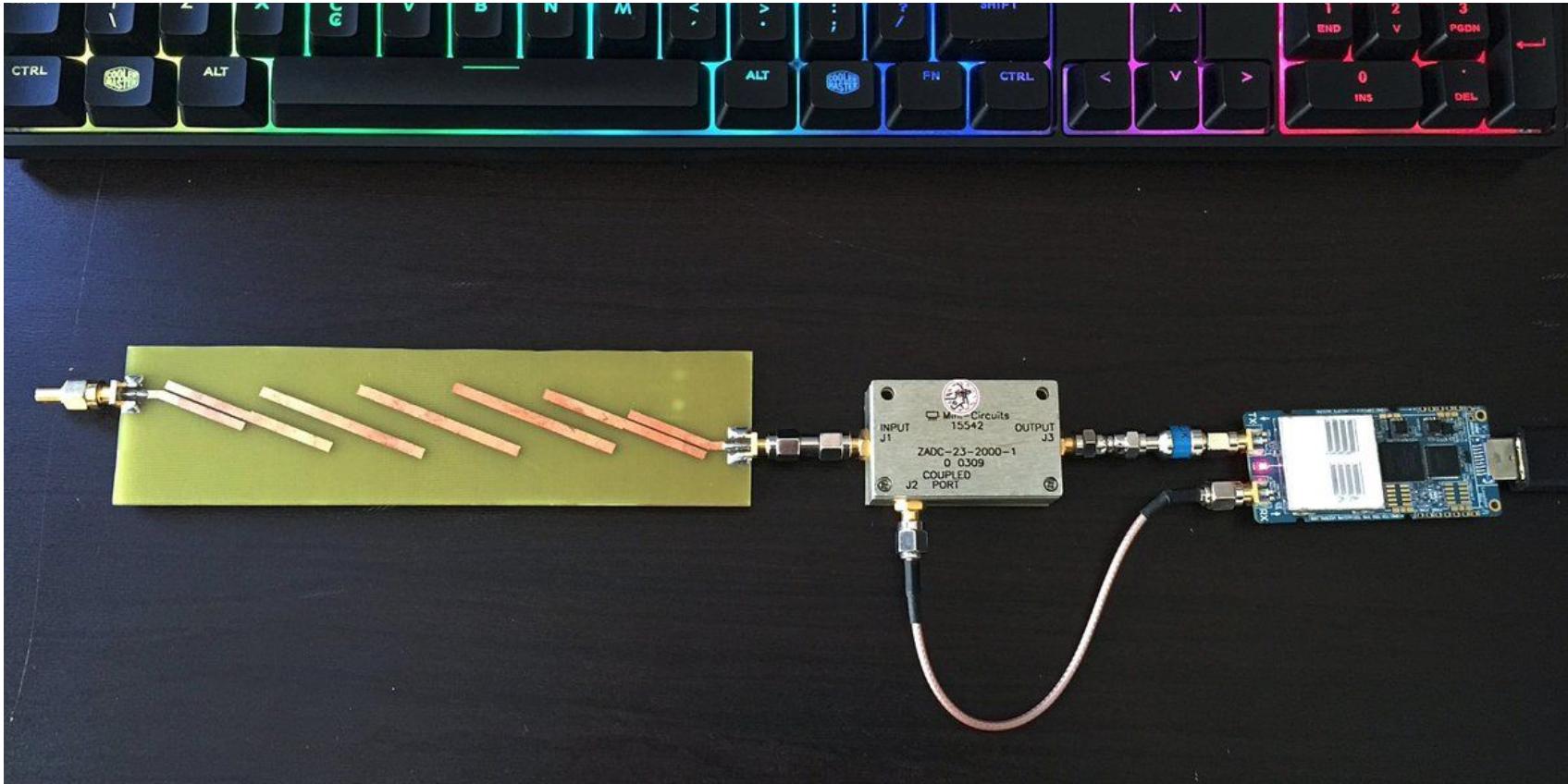
- + L-Band LNA
- + L-Band Bandpass Filter

L-Band Bandpass Filter

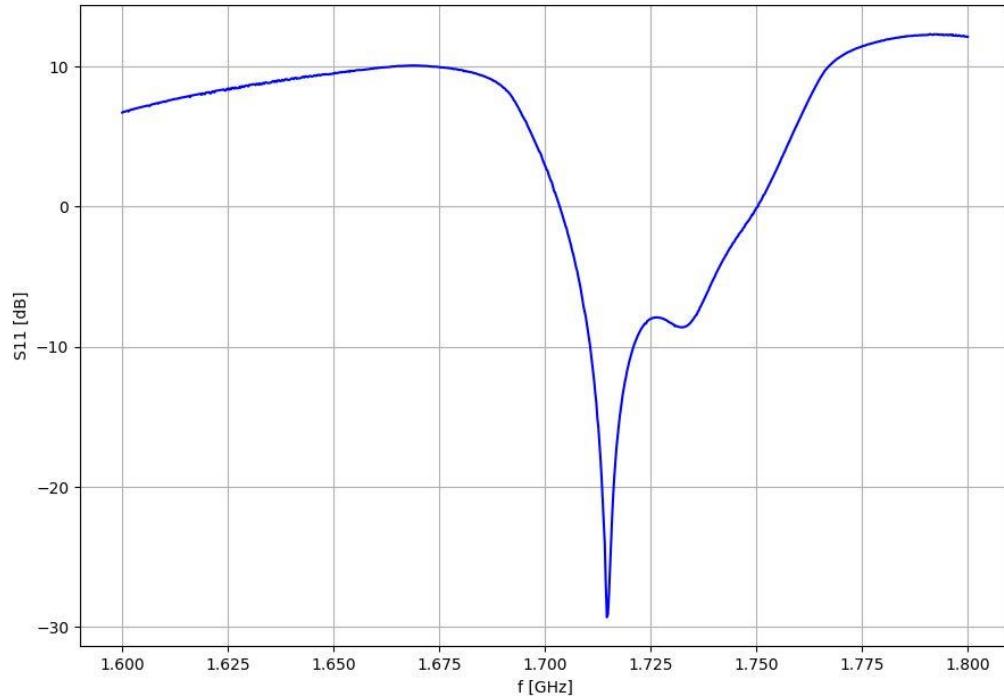


- 5th Order Butterworth Bandpass Filter
- Coupled Microstrip with 50 Ohms Impedance
- 1.67 GHz to 1.72 GHz

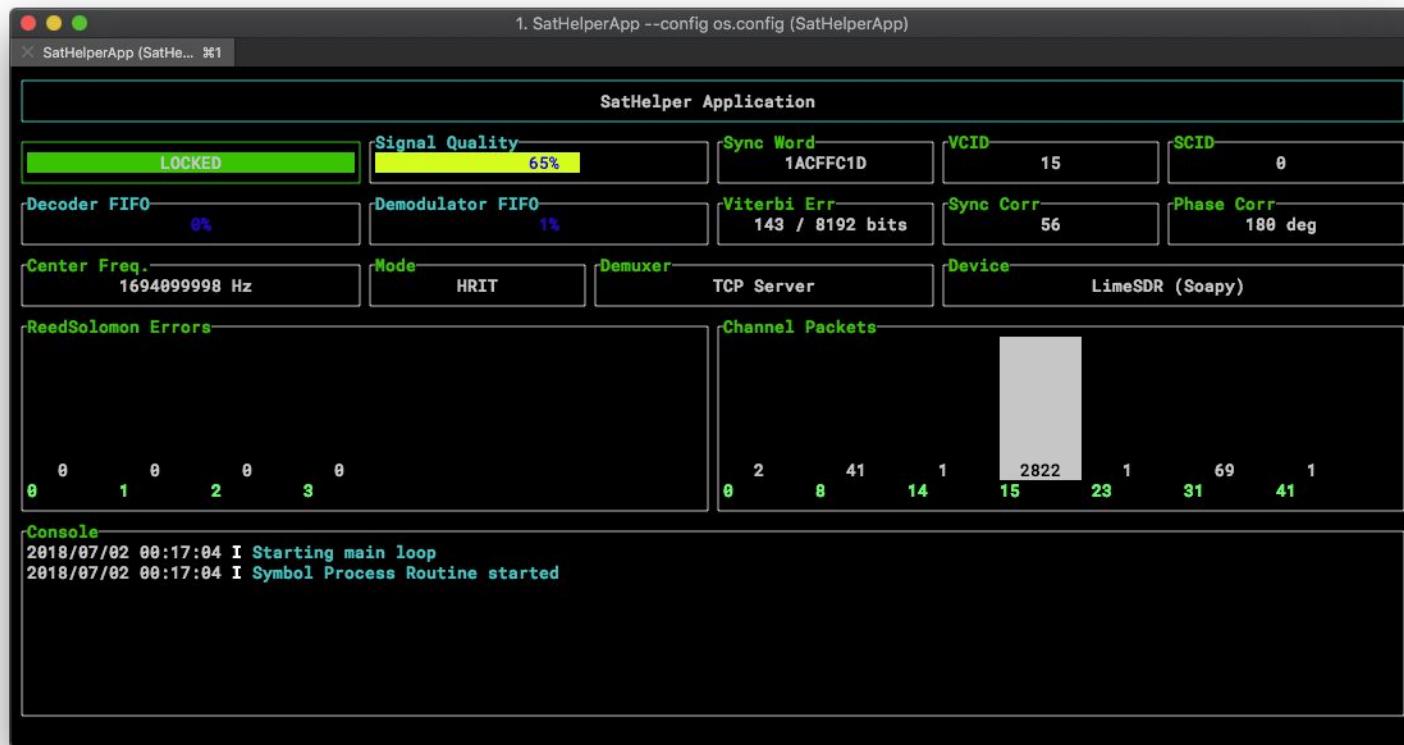
L-Band Bandpass Filter



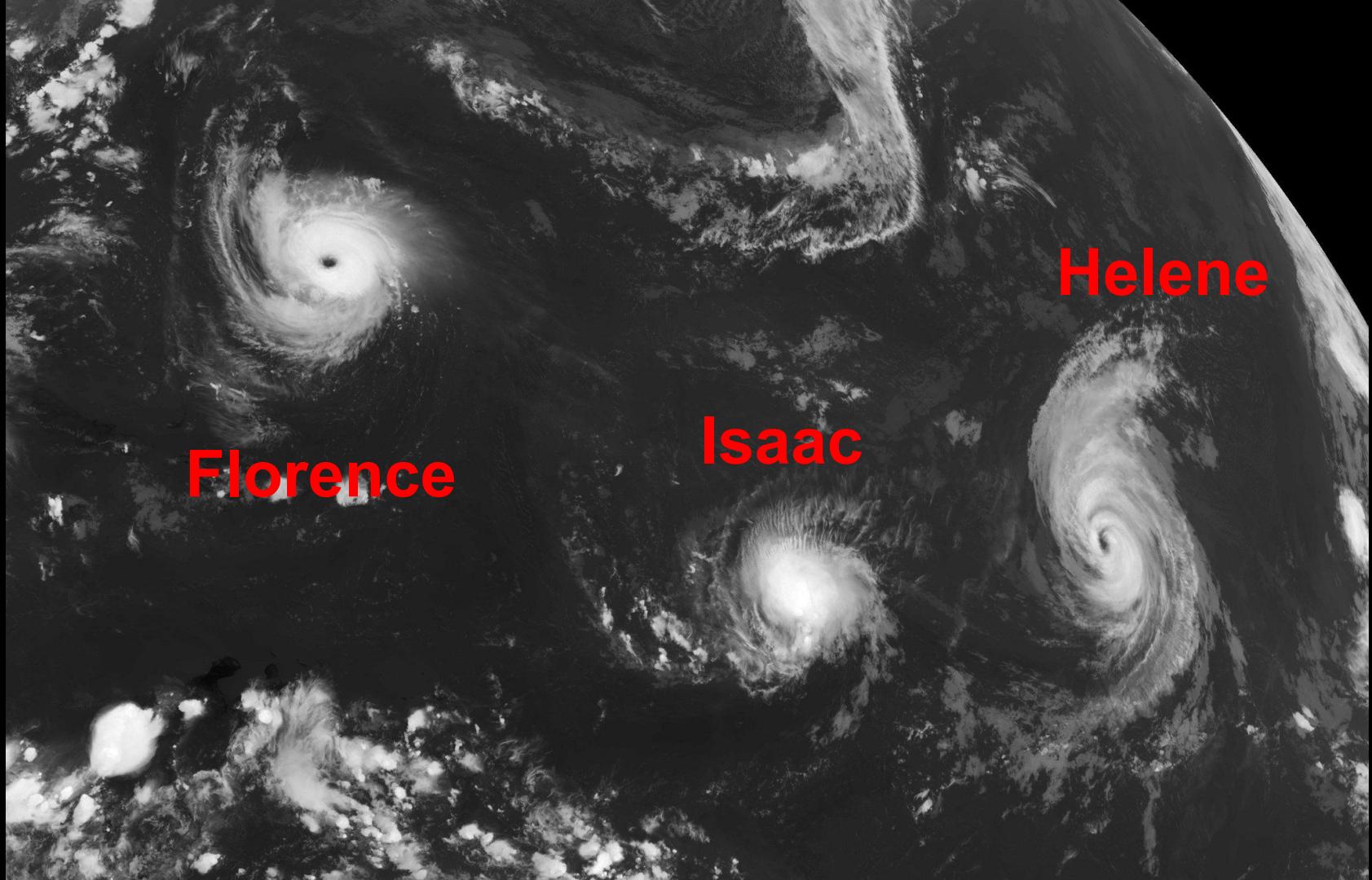
L-Band Bandpass Filter



Software - SatHelperApp





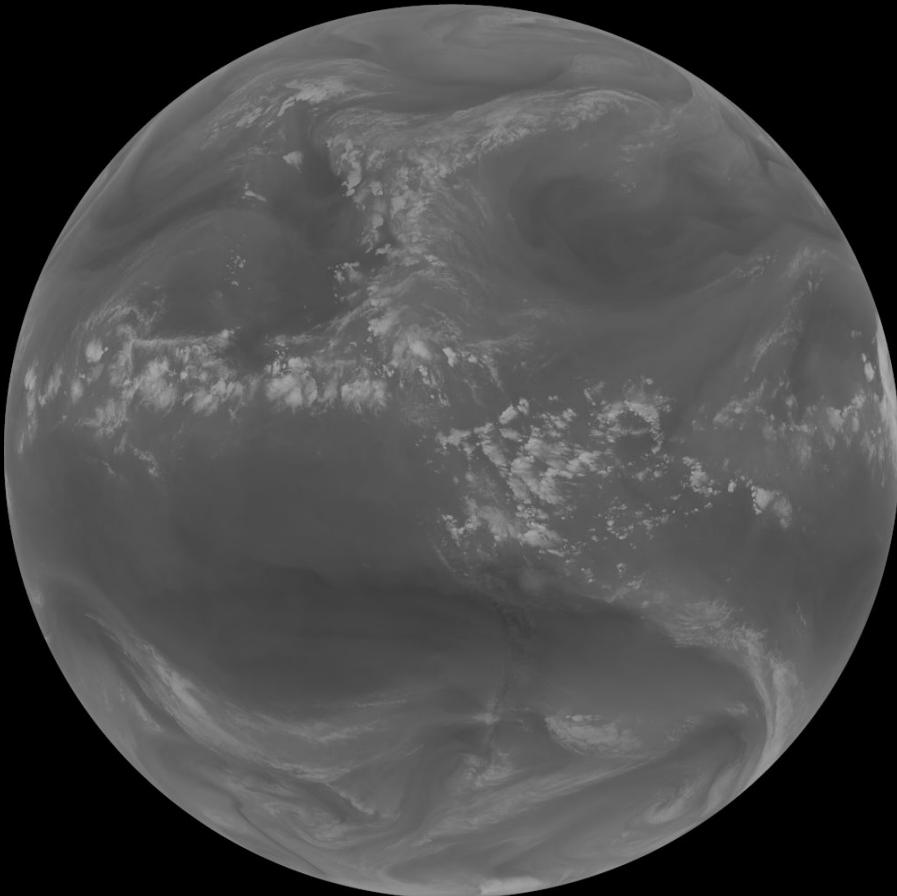
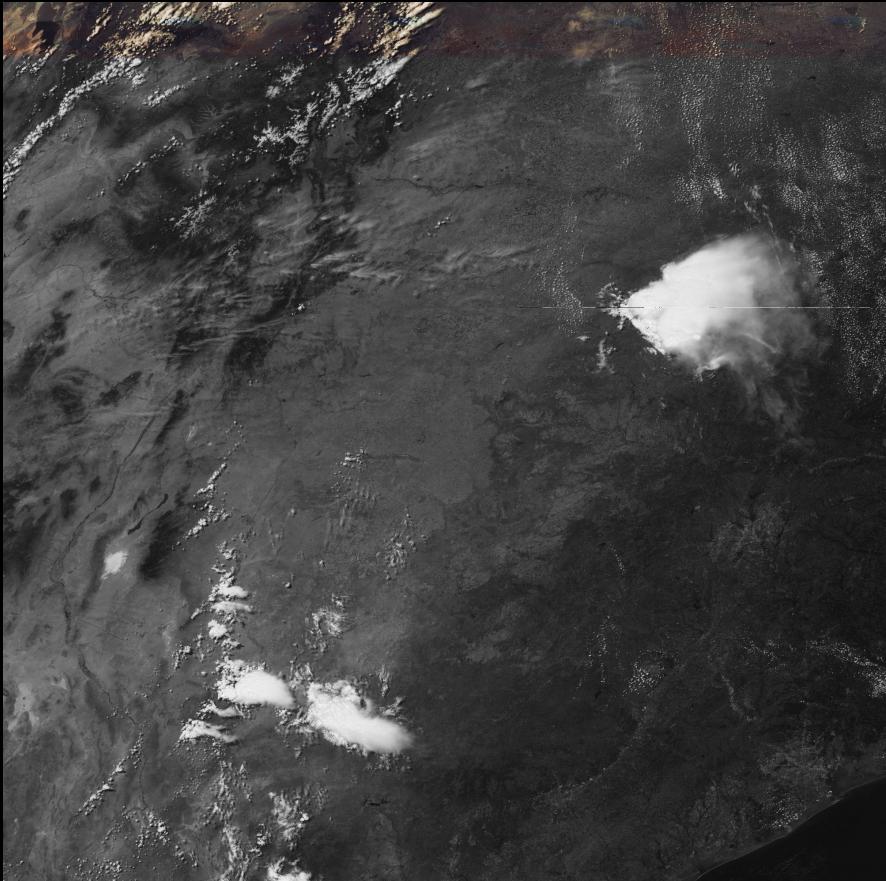


Florence

Isaac

Helene

Products from GOES-16 HRIT



Next Step for OSP

Polar Orbiting Satellites WeatherDump

X-Band

- NPP/NPOESS - Suomi & NOAA-20
- MODIS - Terra & Aqua
- FengYun
- MetOp

L-Band

- NOAA-19, 18 & 16
- FengYun
- MetOp



Currently Supported



To be supported...

NPP/NPOESS - Suomi & NOAA-20

New generation polar-orbiting earth science satellites from NASA/NOAA.

Current Satellites

- Suomi NPP
- NOAA-20 NPOESS

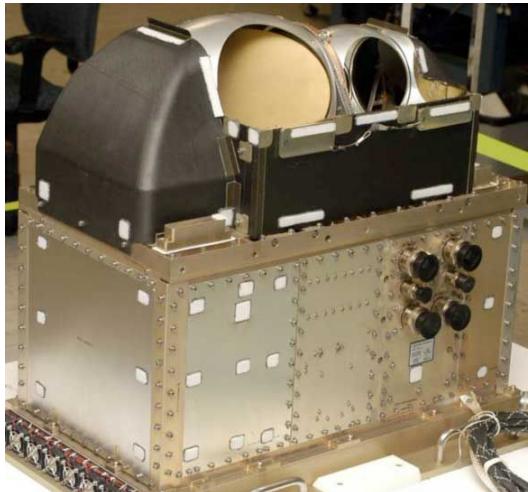
Planned Satellites

- JPSS-2 ~2021
- JPSS-3 ~2026
- JPSS-4 ~2031



NPP/NPOESS - Instruments

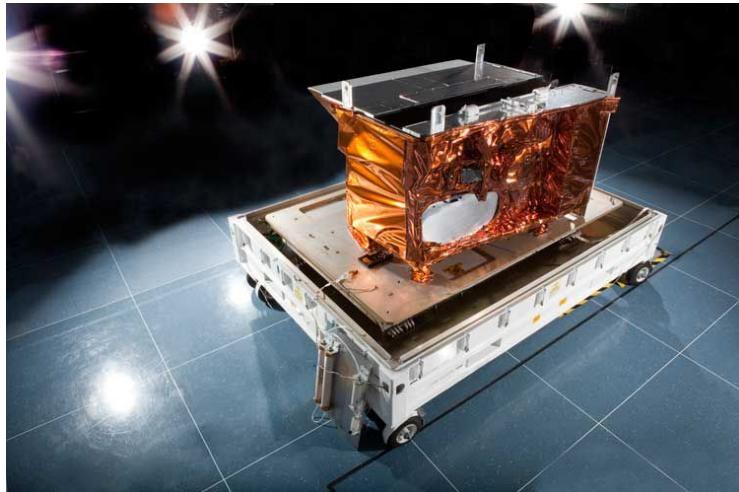
- VIIRS - Visible Infrared Imaging Radiometer Suite
- OMPS - Ozone Mapping and Profiler Suite
- CrIS - Cross-track Infrared Sounder
- ATMS - Advanced Technology Microwave Sounder



ATMS



OMPS



VIIRS

Data from all these instruments are present on the X-Band Datalink.

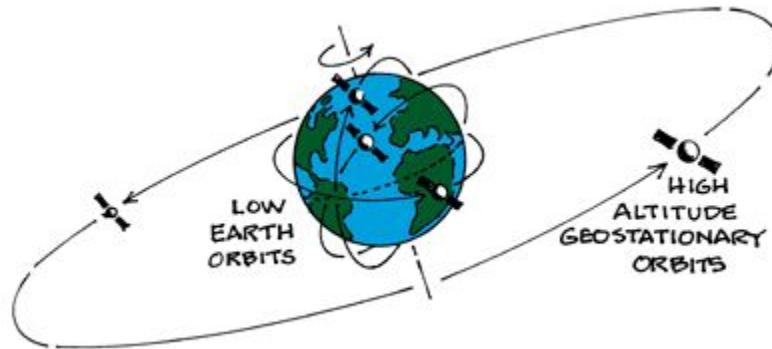
● Currently Supported by OSP

● To be supported...

NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

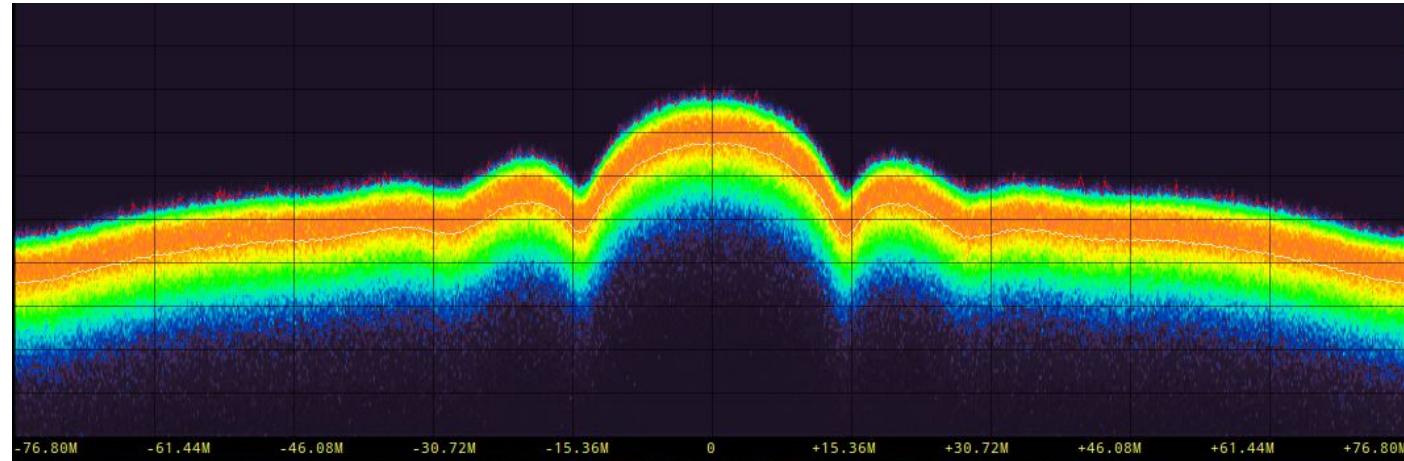
- Moving Fast (Polar Orbit)
- X-Band Signal (>7.8 GHz)
- Huge Bandwidth (30 MHz)



NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

- Moving Fast (Polar Orbit)
- X-Band Signal (>7.8 GHz)
- **Huge Bandwidth (30 MHz)**



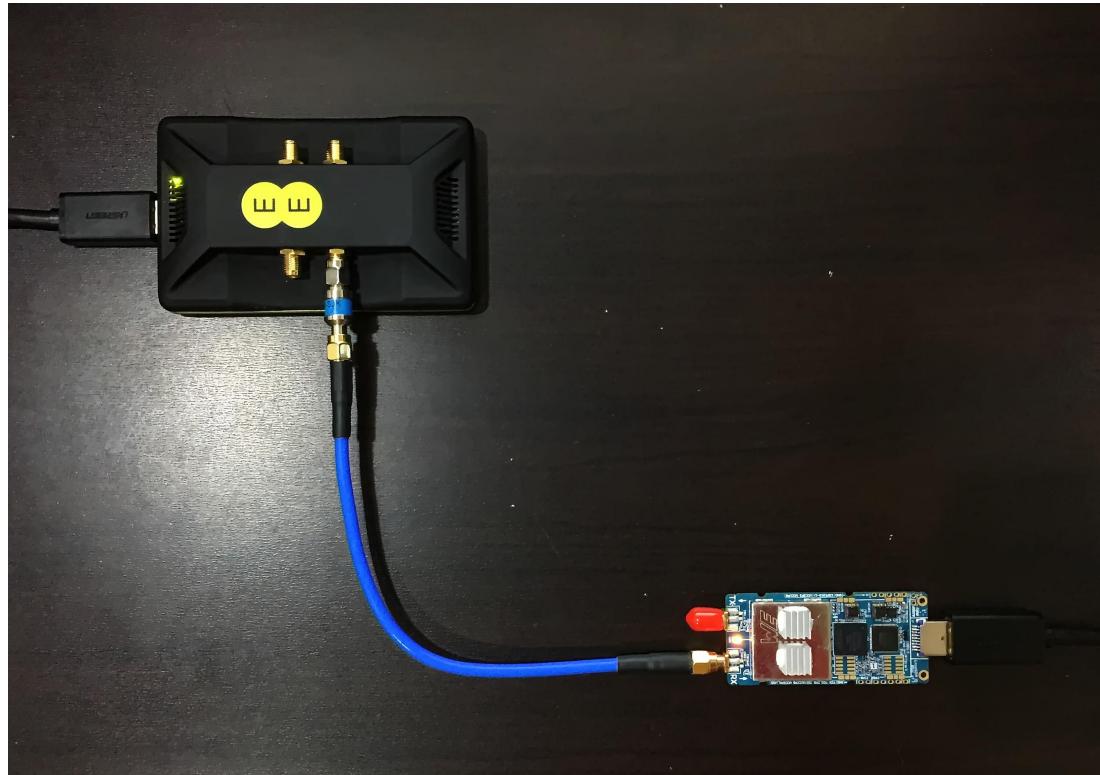
NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

SDRs with Minimum Specs

- LimeSDR USB
- BladeRF
- XTRT
- USRP
- LimeSDR Mini (?)

Downconverter still needed.



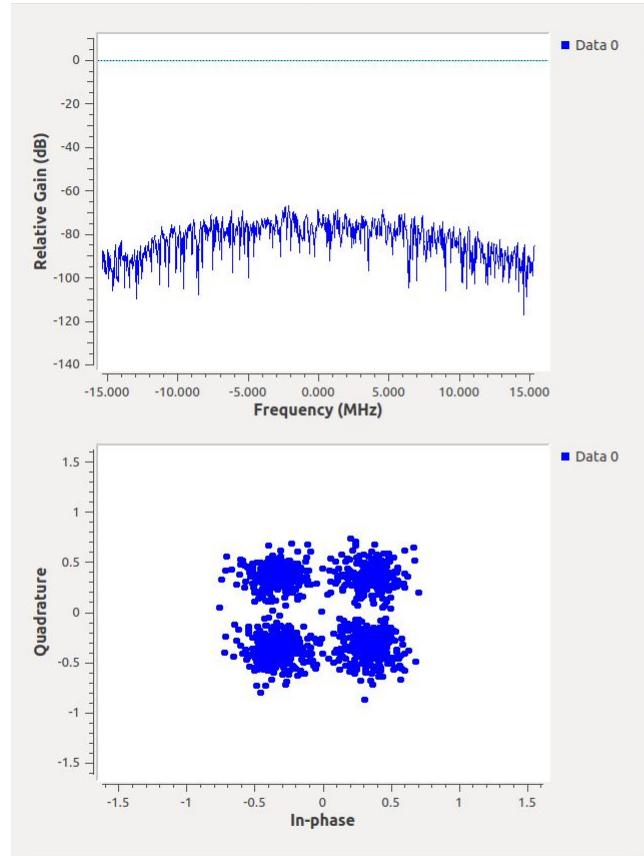
NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

SDRs with Minimum Specs

- LimeSDR USB
- BladeRF
- XTRT
- USRP
- LimeSDR Mini (It Works!)

Downconverter still needed.



NPP/NPOESS - X-Band High Rate Datalink

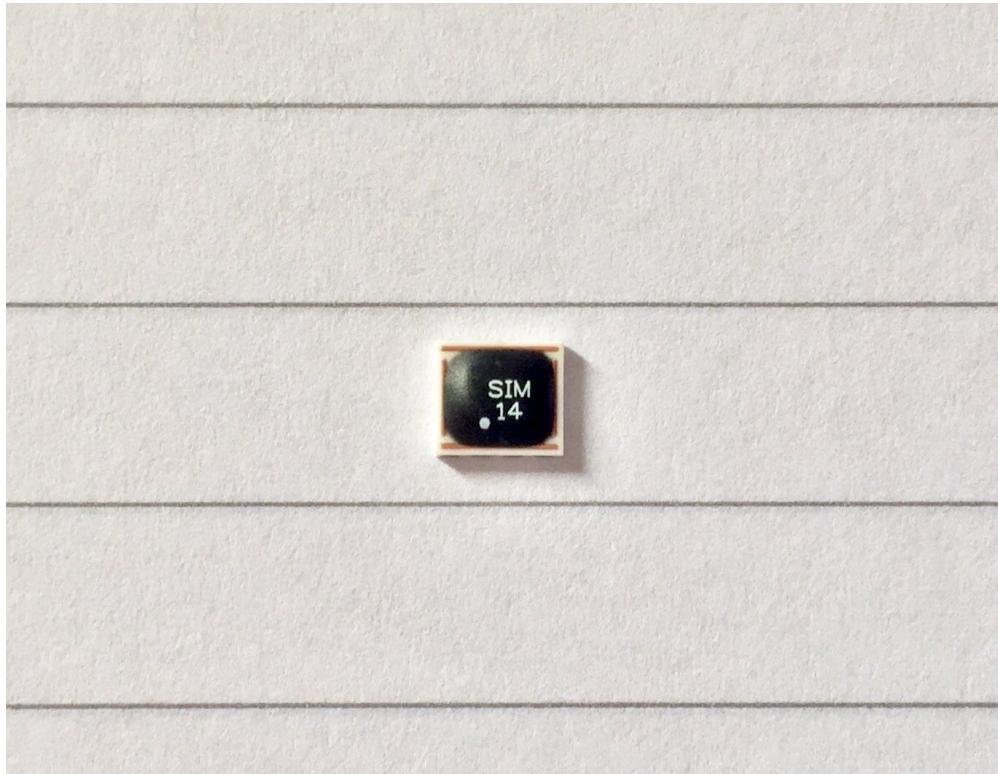
Demodulation

- Made with GNU Radio Companion.
- Just recently became viable.
- Currently impossible to be done in real-time.
- GPU Acceleration can be applied.

Modulation	QPSK
Bandwidth	30 MHz
Frequency	7812 MHz
Polarization	RHCP
I/Q Power Ratio	1:1
TX Power	8 Watts

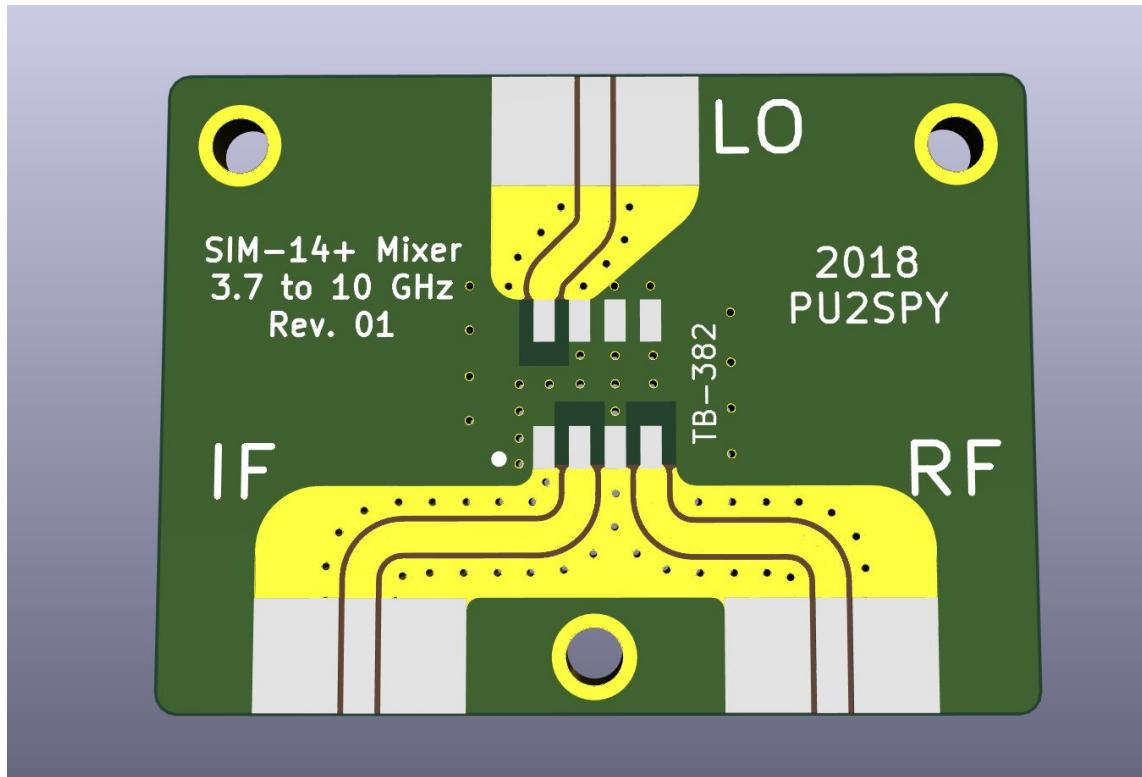
NPP/NPOESS - X-Band High Rate Datalink

Downconverter

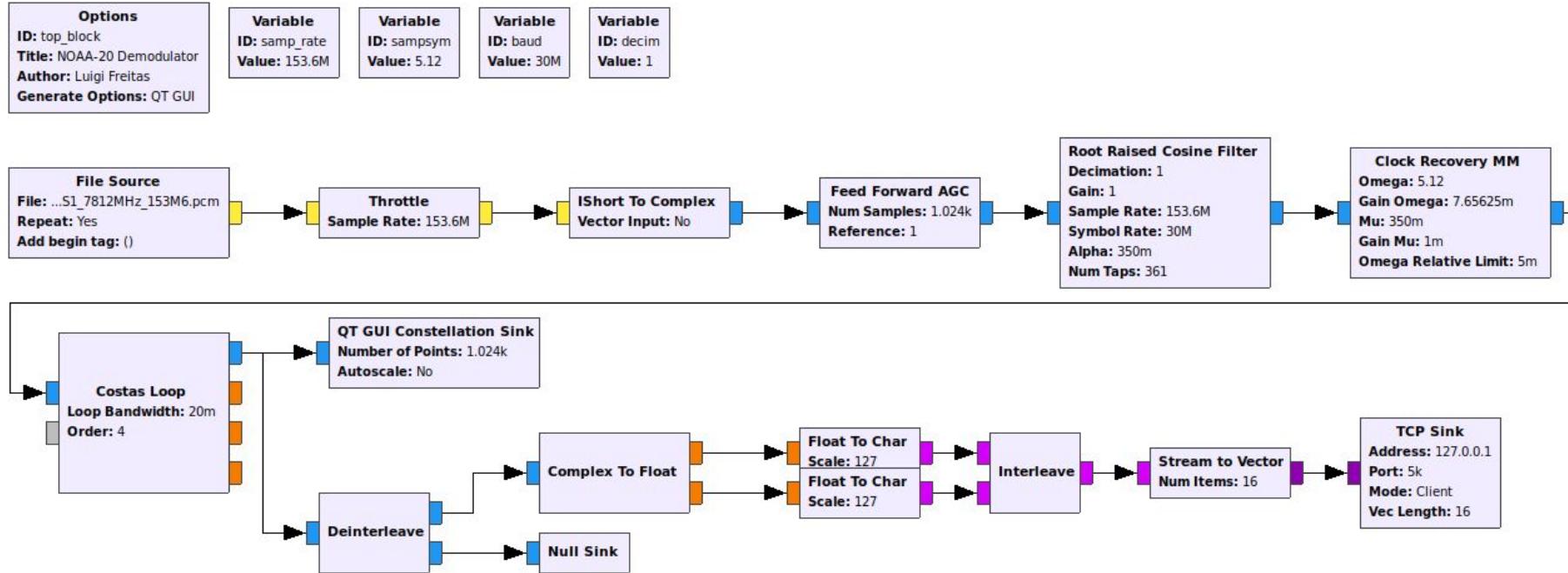


NPP/NPOESS - X-Band High Rate Datalink

Downconverter

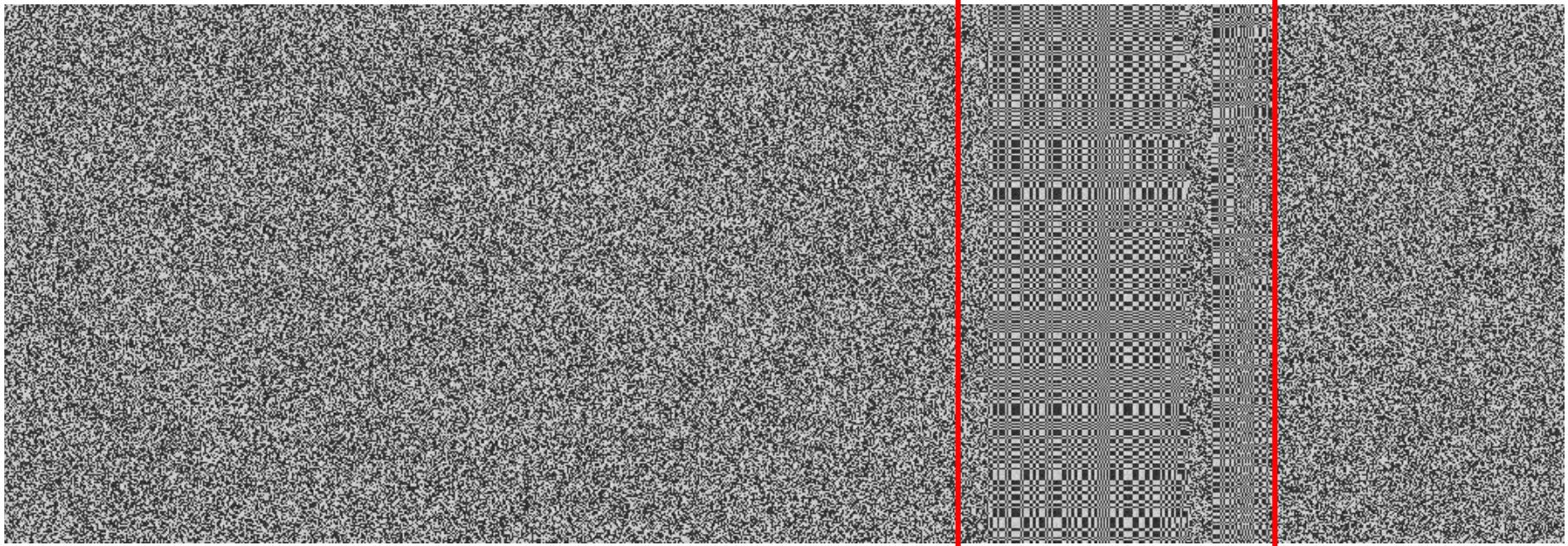


NPP/NPOESS - X-Band High Rate Datalink Demodulation



NPP/NPOESS - X-Band High Rate Datalink

Demodulation

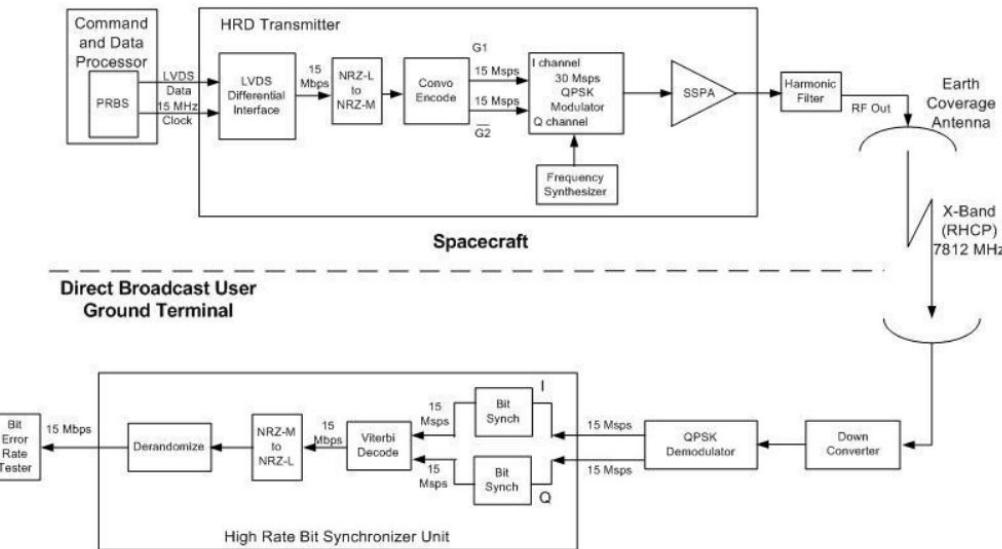


Encoded Sync Word

NPP/NPOESS - X-Band High Rate Datalink

Decoding

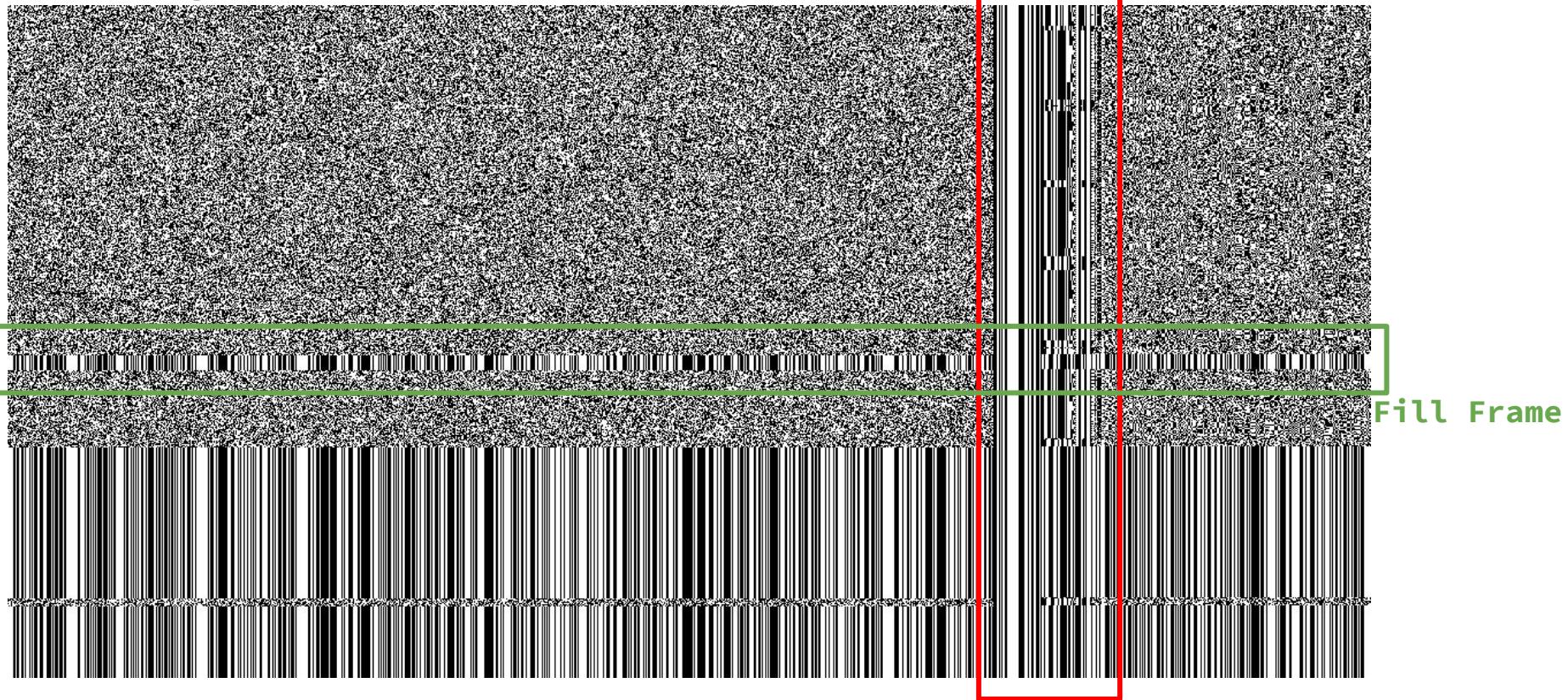
- Almost identical to the HRIT.
- Differential Encoding Applied.
- No puncturing.



FEC	1/2
Sync Word	0x1ACFFC1D
Input Data Rate	30 Mbps
Output Data Rate	15 Mbps
Differential Encoding	NRZ-M

NPP/NPOESS - X-Band High Rate Datalink

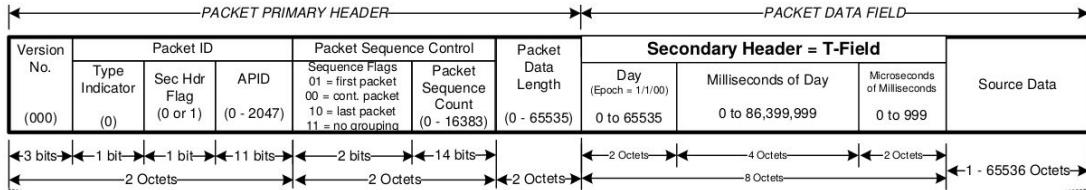
Decoding



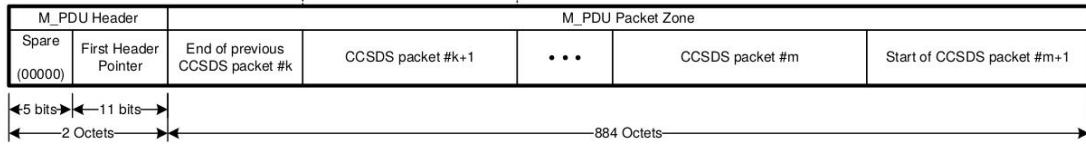
NPP/NPOESS - X-Band High Rate Datalink

CCSDS Demuxing

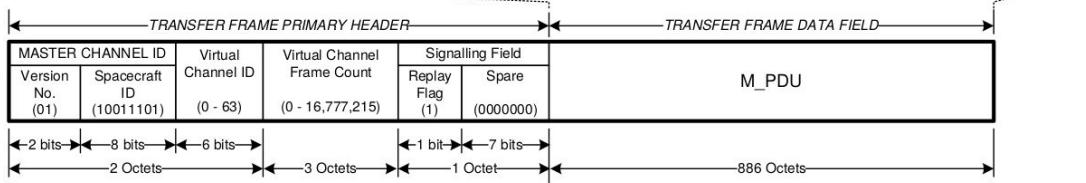
Version-1 CCSDS Space Packet
 (ref: CCSDS 133.0-B-1,
 Fig. 4-1 & Fig 4-2)



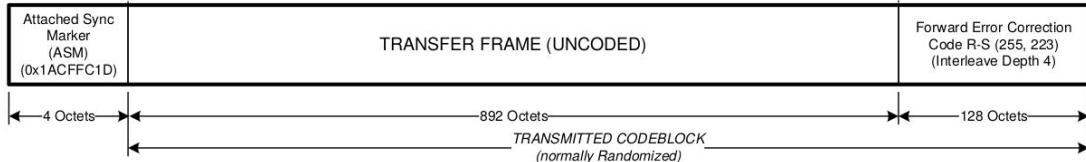
Multiplexing Protocol Data Unit
 (ref: CCSDS 732.0-B-2,
 Fig. 4-3)



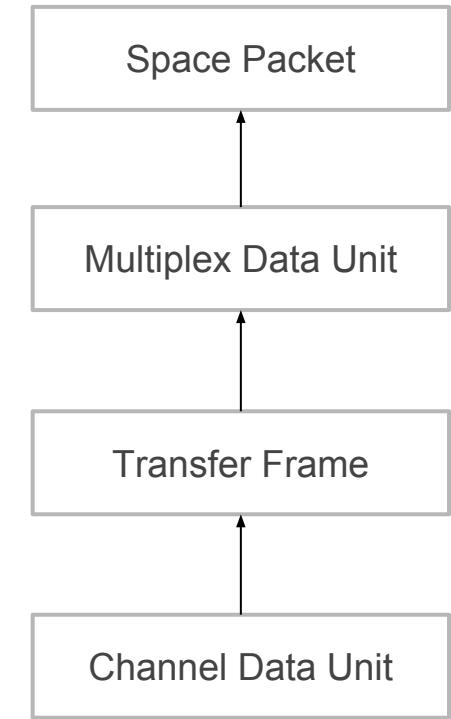
AOS Transfer Frame
 (ref: CCSDS 732.0-B-2,
 Fig. 4-2)



Channel Access Data Unit
 (ref: CCSDS 131.0-B-2)



Ready for Instrument Specific Processing

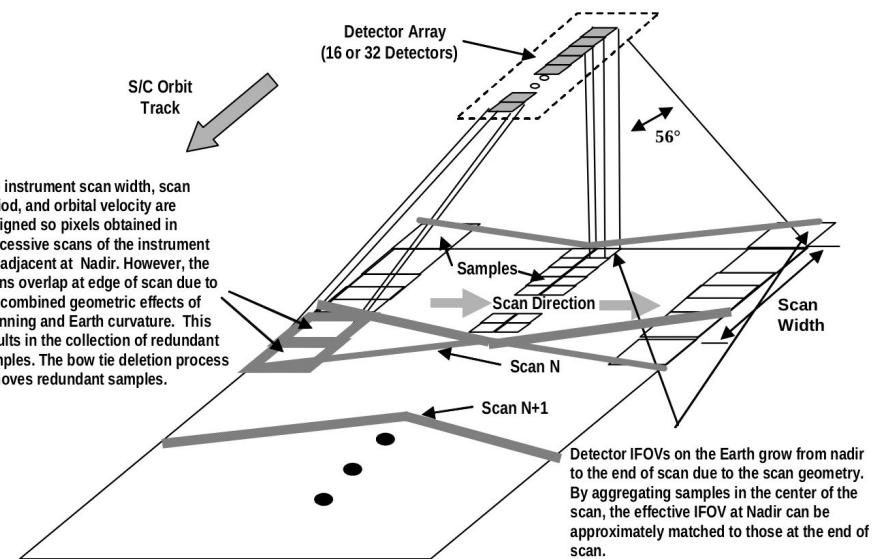


Raw CCSDS Data

NPP/NPOESS - X-Band High Rate Datalink

VIIIRS Science Data

- 24 Imager Channels.
- APIDs ranging from 800 to 823.
- 5 High Resolution Channels (375 meters per pixel).
- 17 Moderate Resolution Channels (750 meter per pixel).
- Image Depth: 15-bits Grayscale



NPP/NPOESS - X-Band High Rate Datalink

VIIRS Science Data - Header

	PACKET PRIMARY HEADER						SECONDARY HEADER			USER DATA FIELD						
	Version No.	Packet Identification		Packet Sequence Control (PSC)		Packet Length	Time of Day Start of Data [2]	Number of Packet Segments 1	Spare	VIIRS Packet ID		HR Format		HR Science Data		
Bits Octets Value	Type Indicator	Sec Hdr Flag	APID	Sequence Flags	Sequence Count	[1]	2	8	8	VIIRS Sequence Count	Packet Time [2]	Format Version	Instrument Number	Spare	HR Meta Data	Checksum
	3	1	1	11	2	16	64	8	8	32	64	8	8	16	1168	16
		2			2	2	8	1	1	4	8	1	1	2	146	2
	000	0	1	varies	01	varies	173	varies	zeros	varies	varies	2	2	zeros	varies	varies
	0 = Telemetry Packet		Segmented data, First packet. Definition per A.2.2		VIIRS Sequence Count is a running total count of all types of packets sent by VIIRS since power on or 32-bit rollover.						16-bit arithmetic Checksum of HR Meta Data Field. Filled with zeros if not used.					
	1 = Secondary Header Present															

HR Meta Data															TOTAL
HAM Side	Scan Synch	Self Test Data Pattern	Reserved		Scan Number	Scan Terminus [2]	Sensor Mode	VIIRS Model	FSW Version	Band Control Word	Partial Start	No. of Samples	Sample Delay	Reserved	
1	1	4	10		32	64	8	8	16	32	16	16	16	944	
		2	4		8	1	1	1	2	4	2	2	2	118	
Value	varies	varies	varies	varies	varies	varies	varies	varies	varies	varies	varies	varies	varies	varies	
	0000 Live Data		0001-1111 Test Data Patterns		Filled with zeros if unused						Filled with zeros if unused				

Notes:

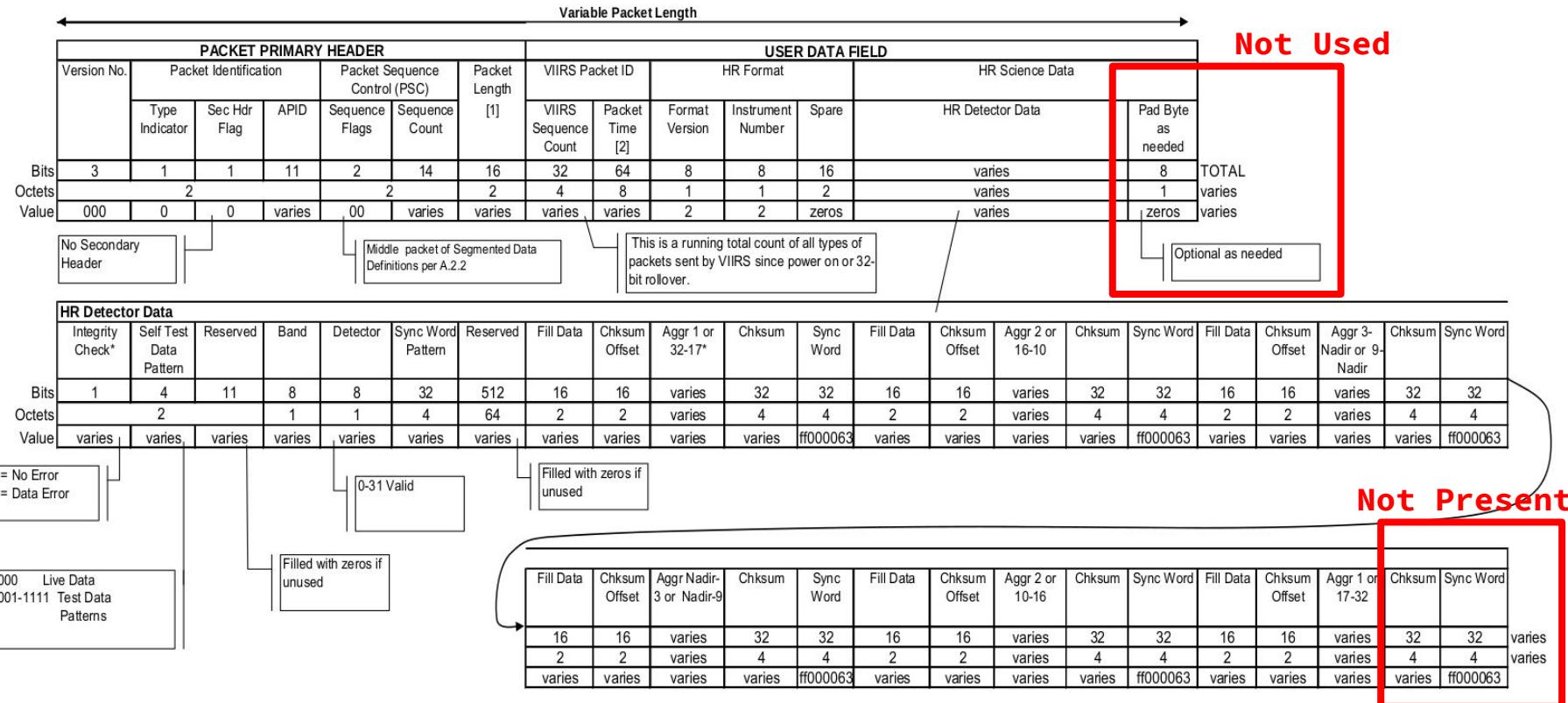
[1] Packet length is the number of bytes after the primary header minus one.

[2] "Time of Day Start of Data", "Packet Time", and "Scan Terminus" fields are 64-bit CCSDS Day Segmented Time Code format as defined in CCSDS 301.0-B-2 (1958 January 1 epoch, 16-bit day, 32-bit msec, 16-bit μ sec). "Time of Day Start of Data" field is Start of Scan.

3. All packet fields are big endian.

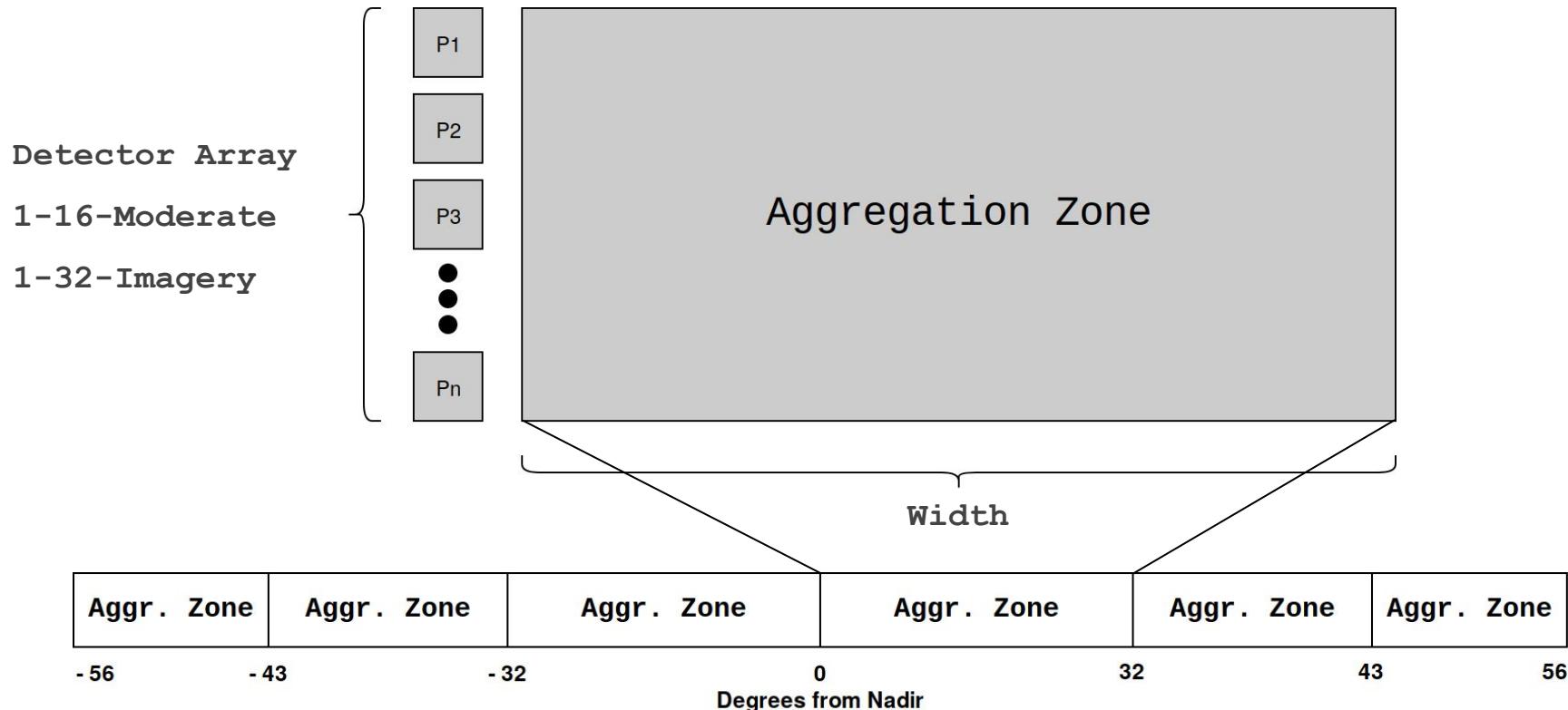
NPP/NPOESS - X-Band High Rate Datalink

VIIRS Science Data - Imager Data Body



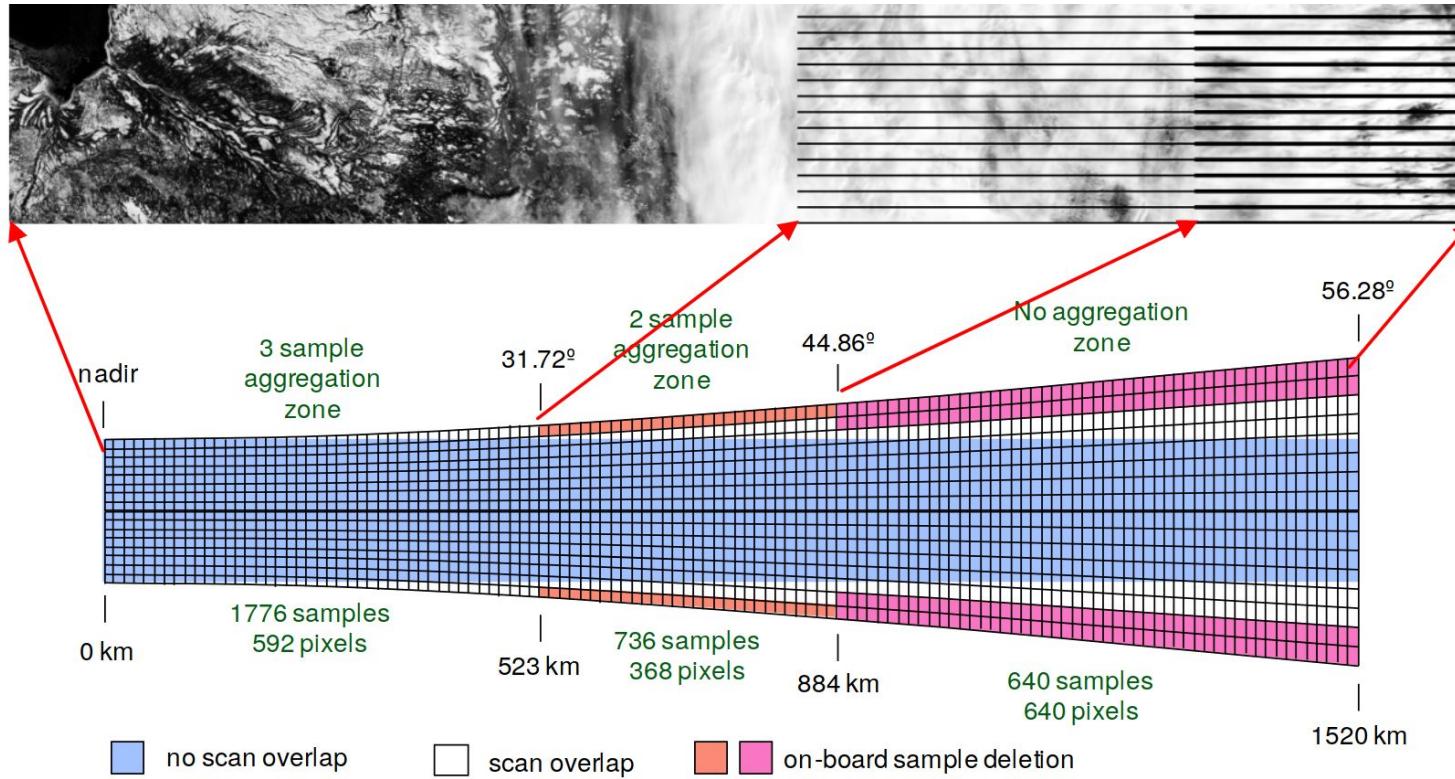
NPP/NPOESS - X-Band High Rate Datalink

VIIIRS Science Data



NPP/NPOESS - X-Band High Rate Datalink

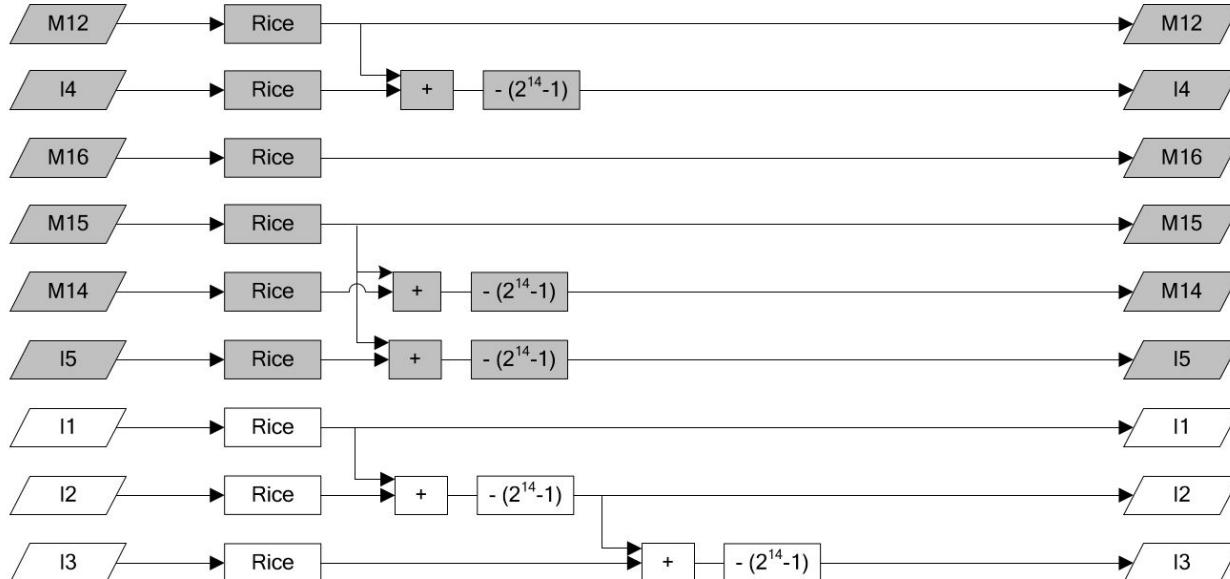
VIIIRS Science Data - Bow Tie Deletion

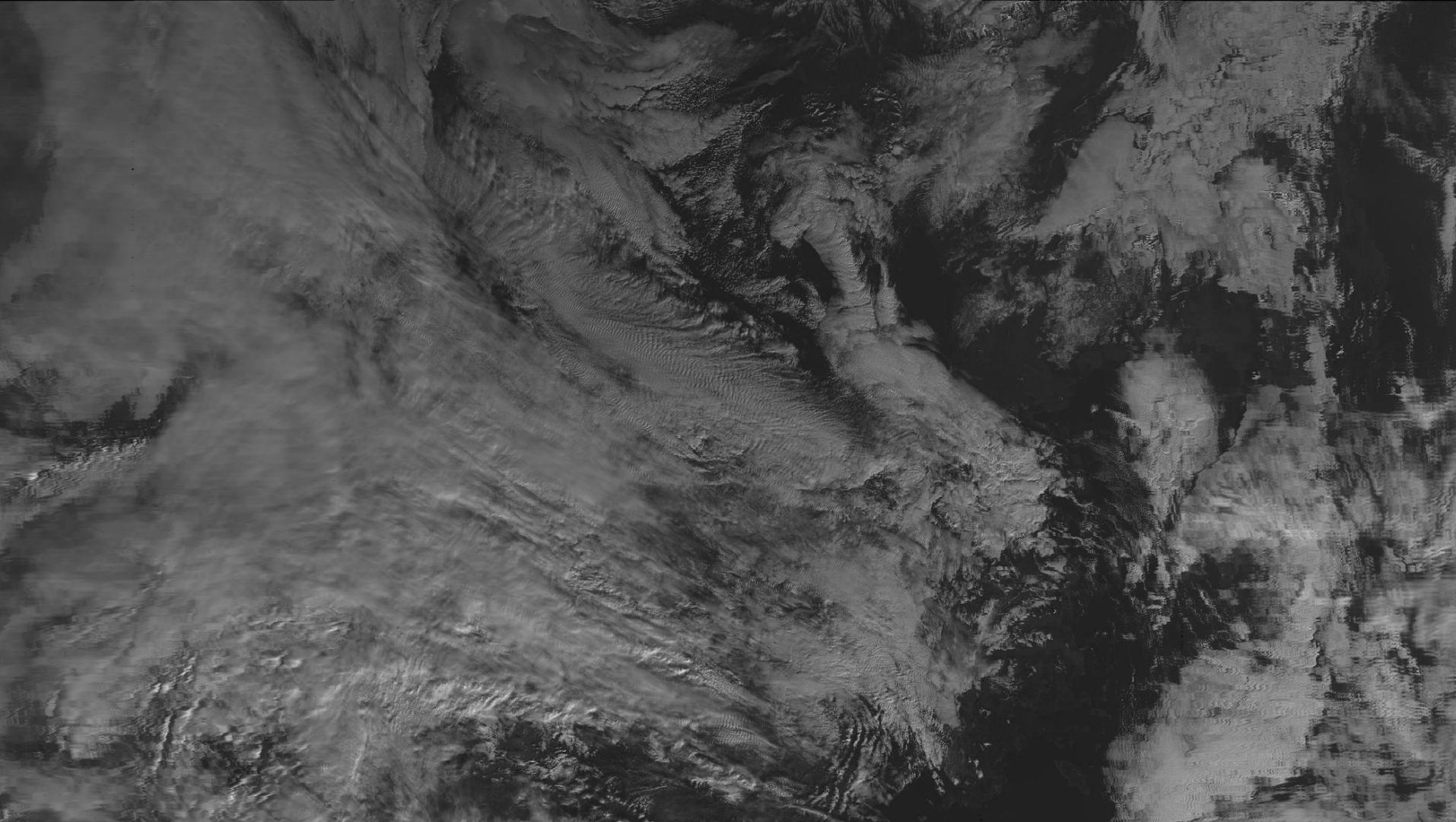


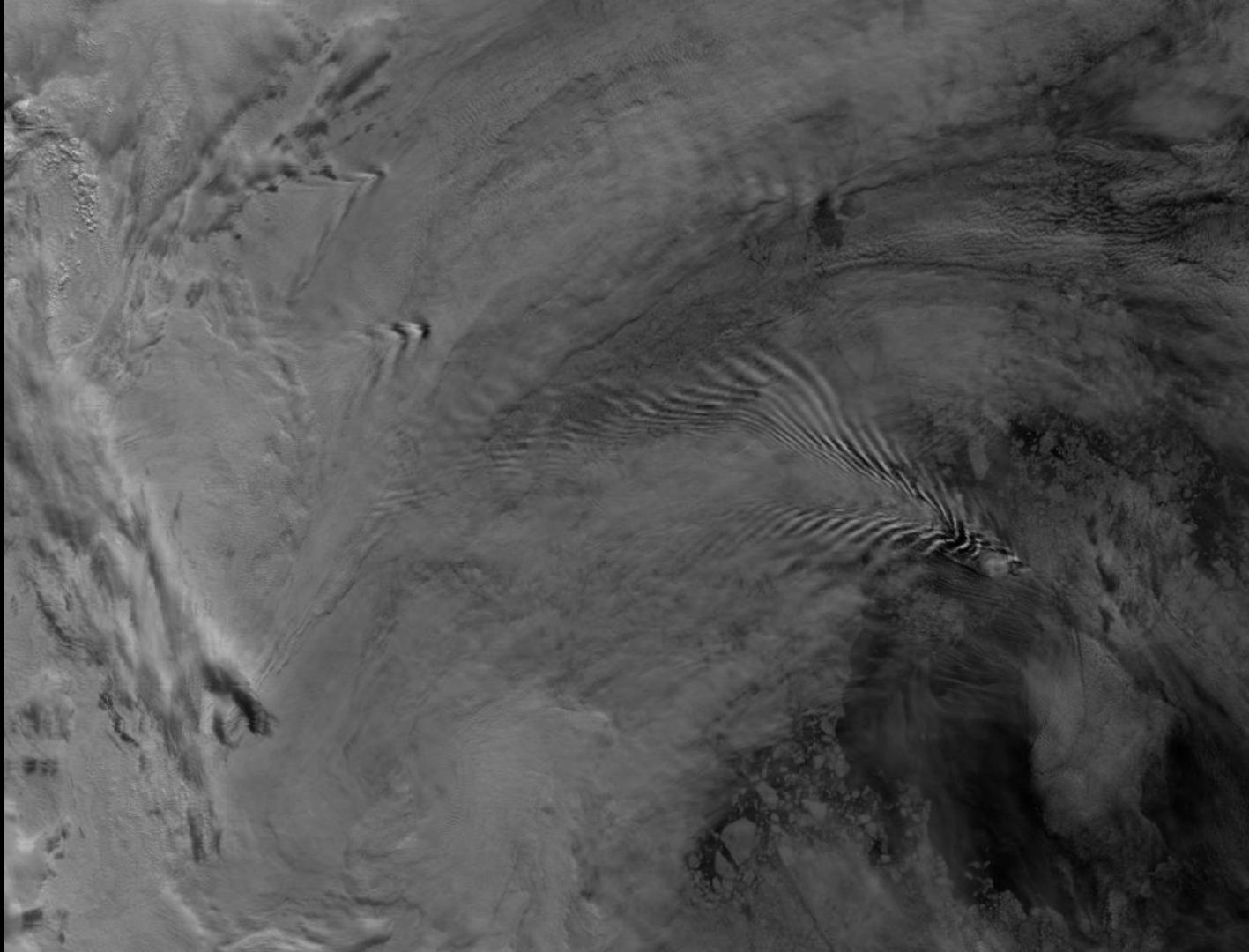
NPP/NPOESS - X-Band High Rate Datalink

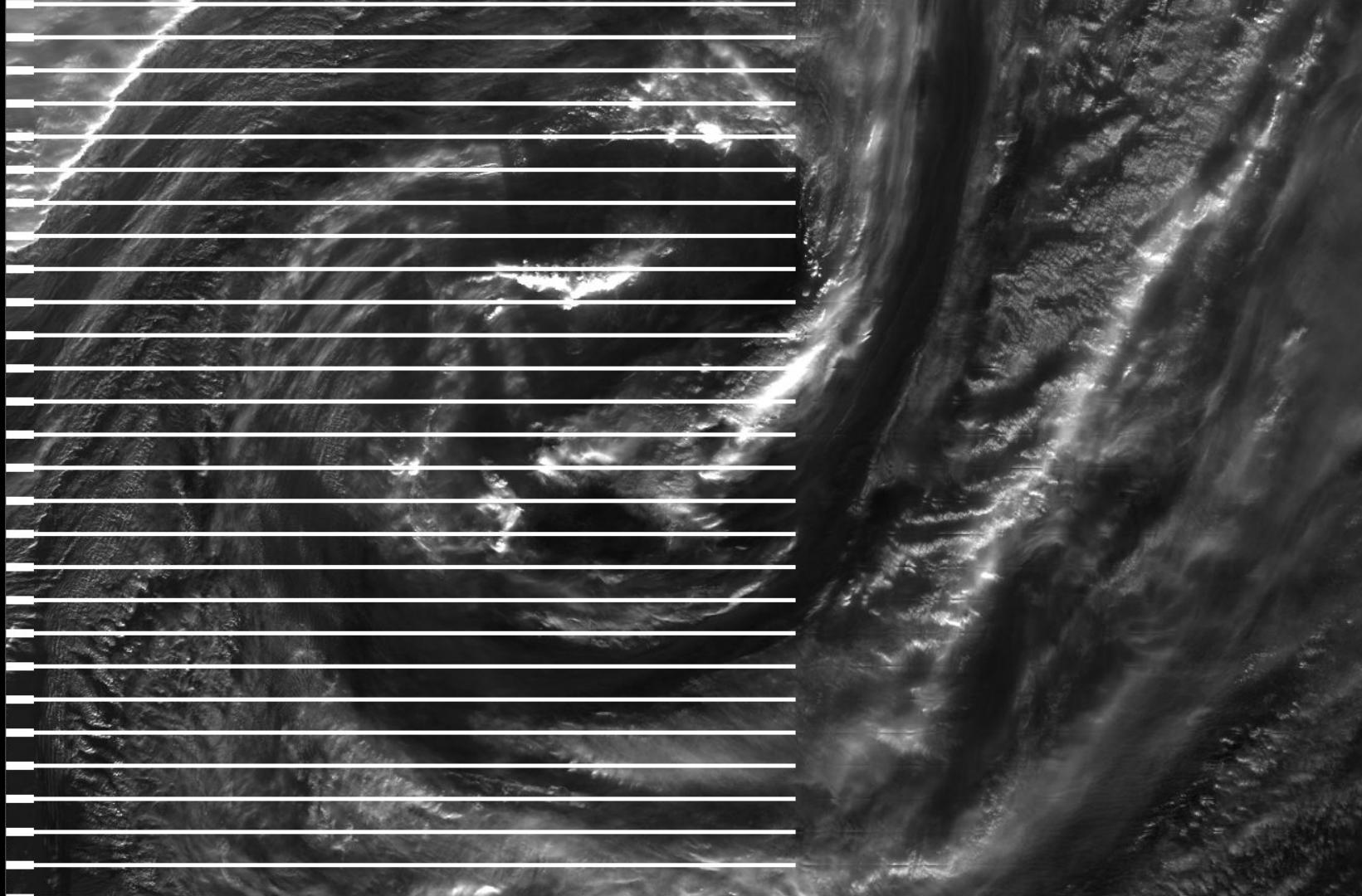
VIIIRS Science Data

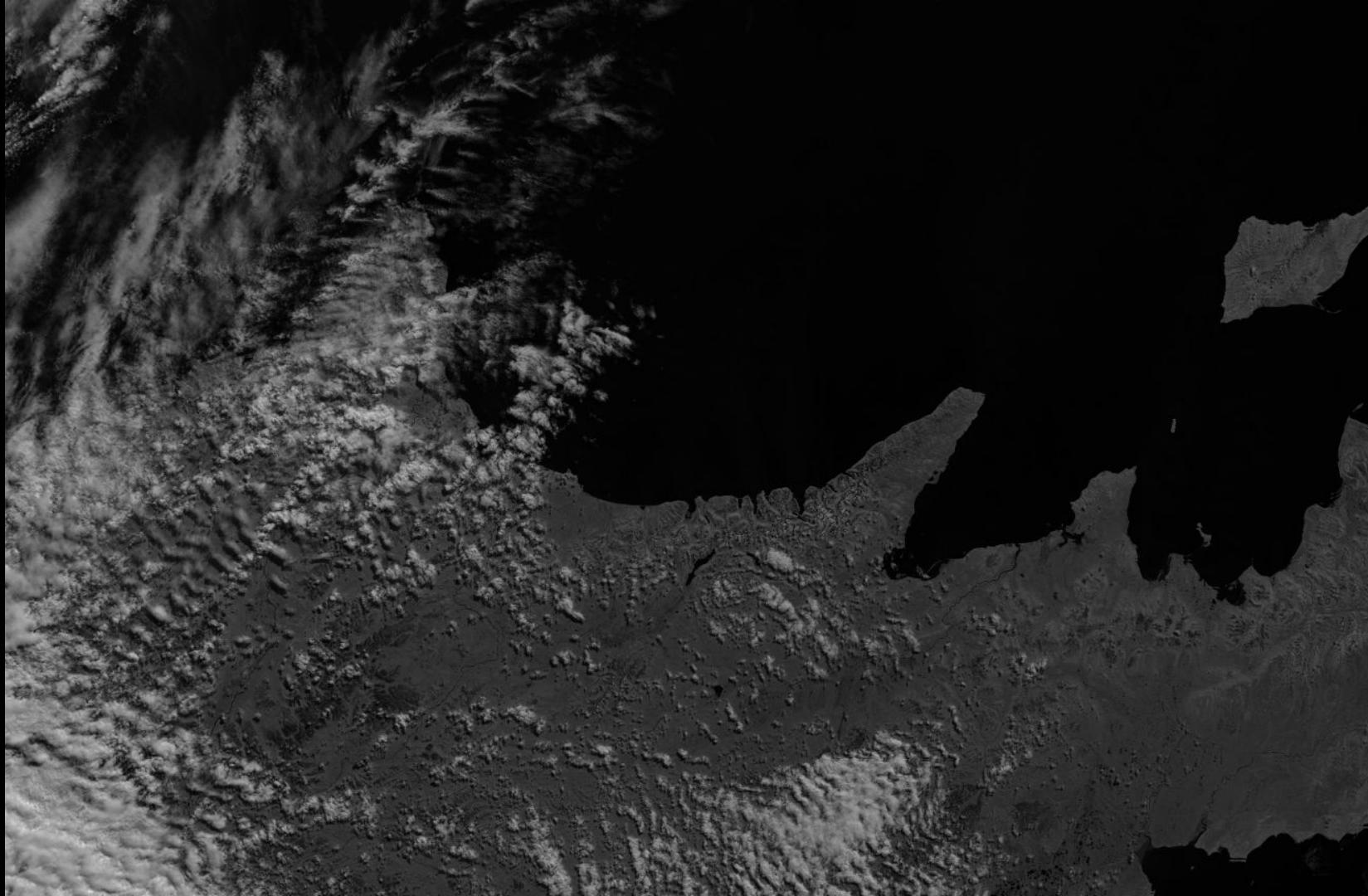
- Every Channel is RICE encoded.
- Additional Differential encoding on some Infrared Channels.

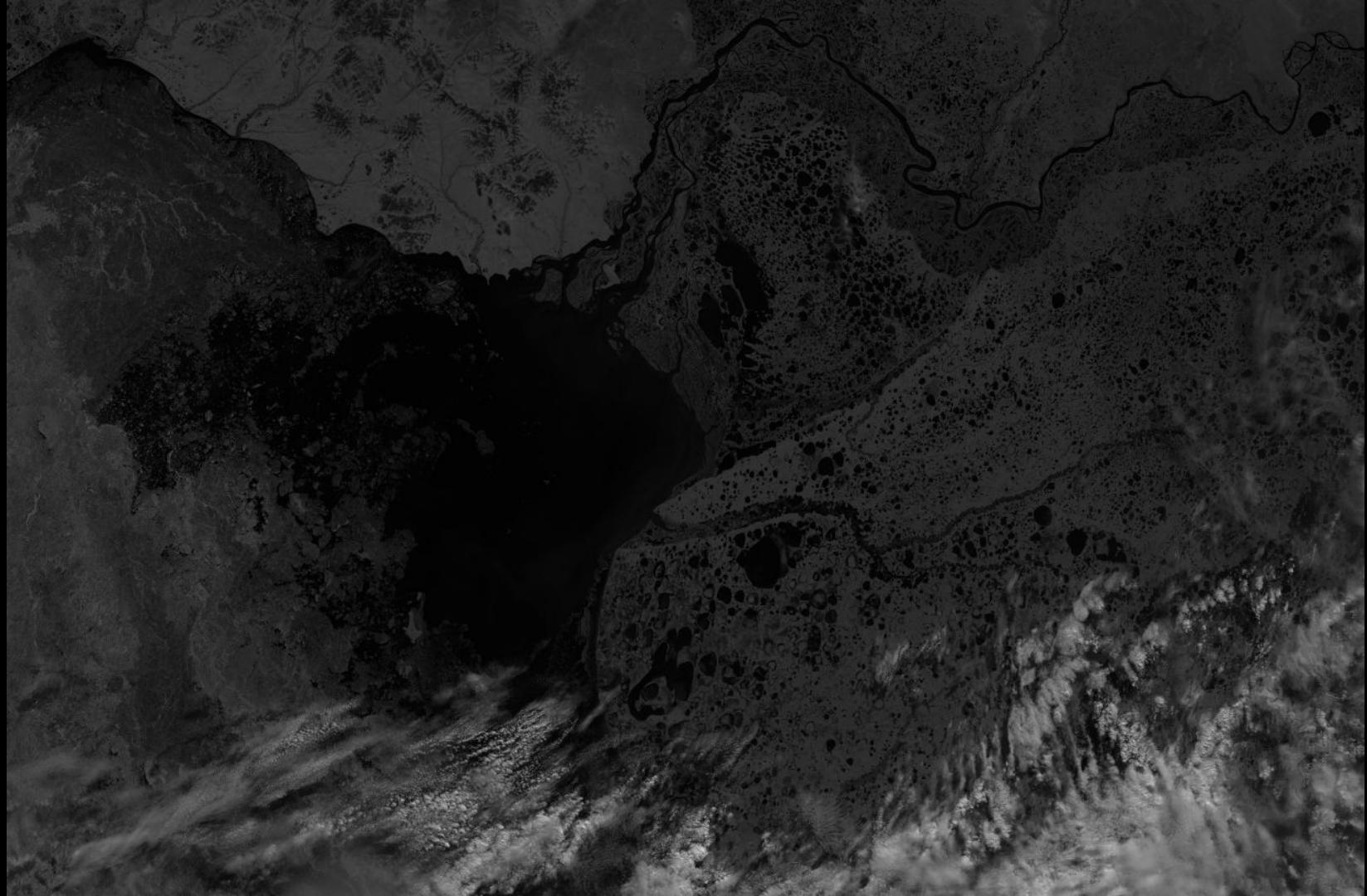


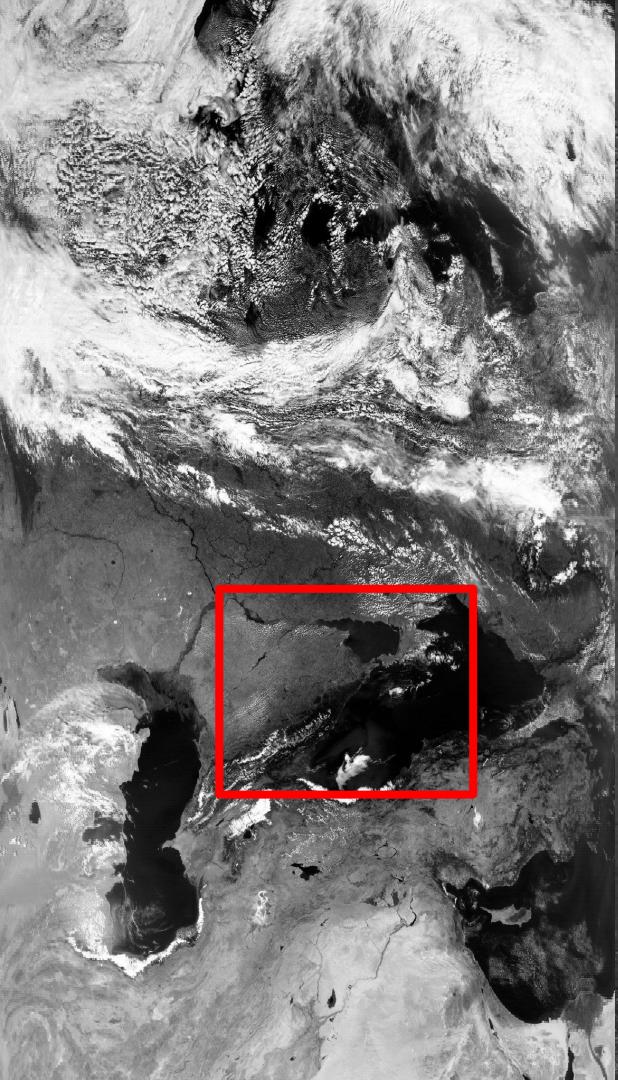












WeatherDump - LEO Satellites (HRD, HRPT & LRPT)

SatHelperApp - GEO Satellites (HRIT, LRIT, GRB & TLM)

<http://github.com/opensatelliteproject/>



Any Questions?

My Contact

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Slides will be available at:

<https://luigifreitas.me>

Special Thanks

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