

Workshop LABRE/AMSAT-BR

Open Satellite Project

Pardinho, São Paulo

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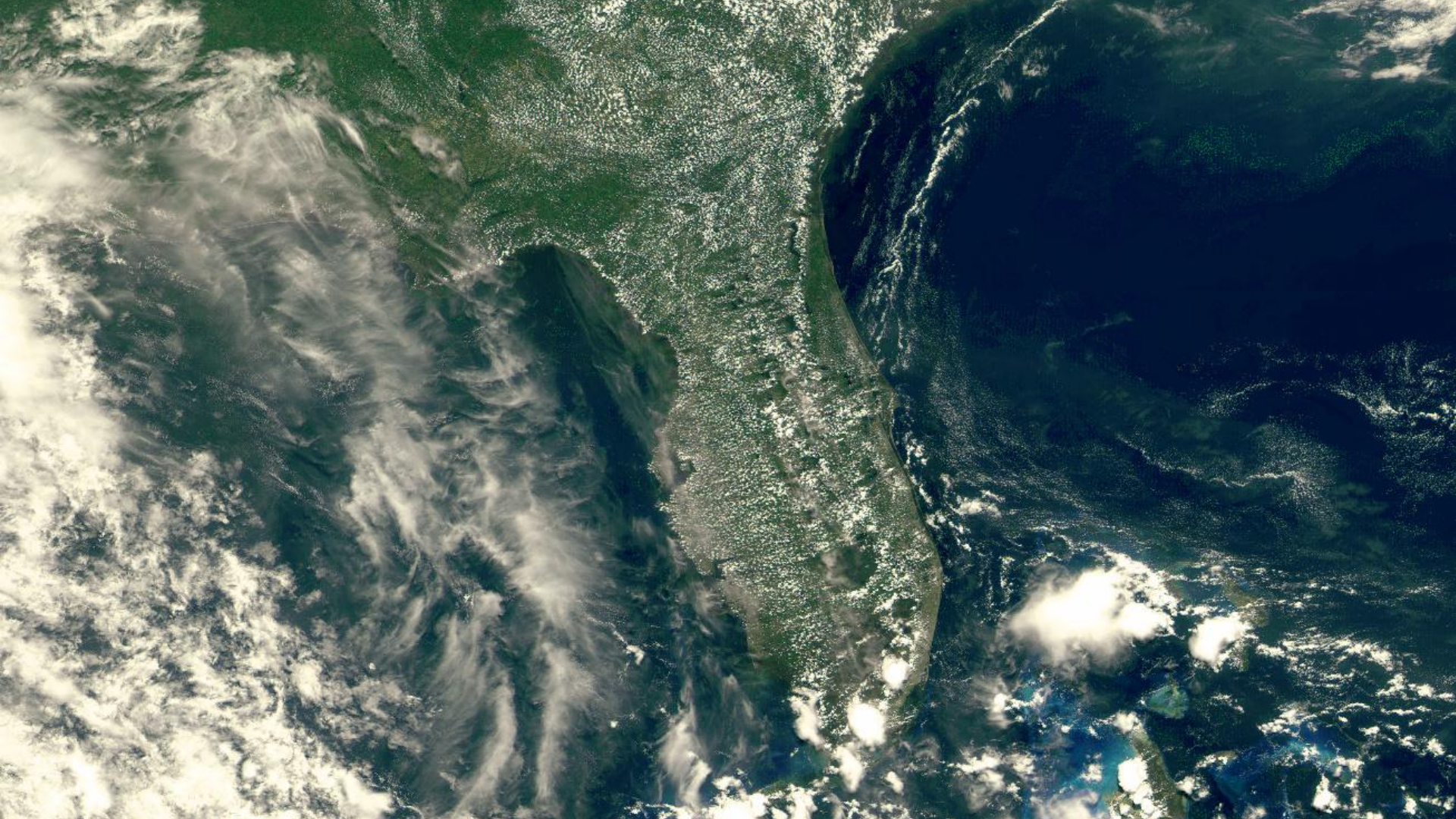
November 17, 2018

PU2SPY

Open Satellite Project

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

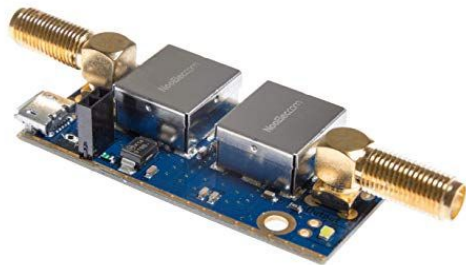




GOES-16 - L-Band HRIT

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

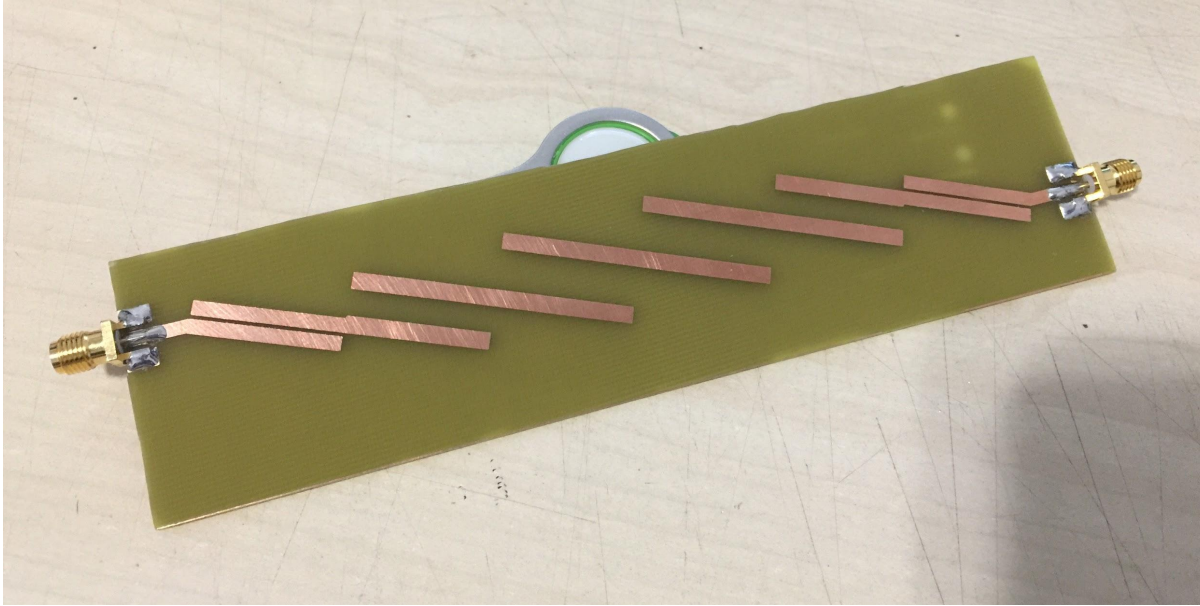
Wi-Fi/GSM Grid Antenna



Also required:

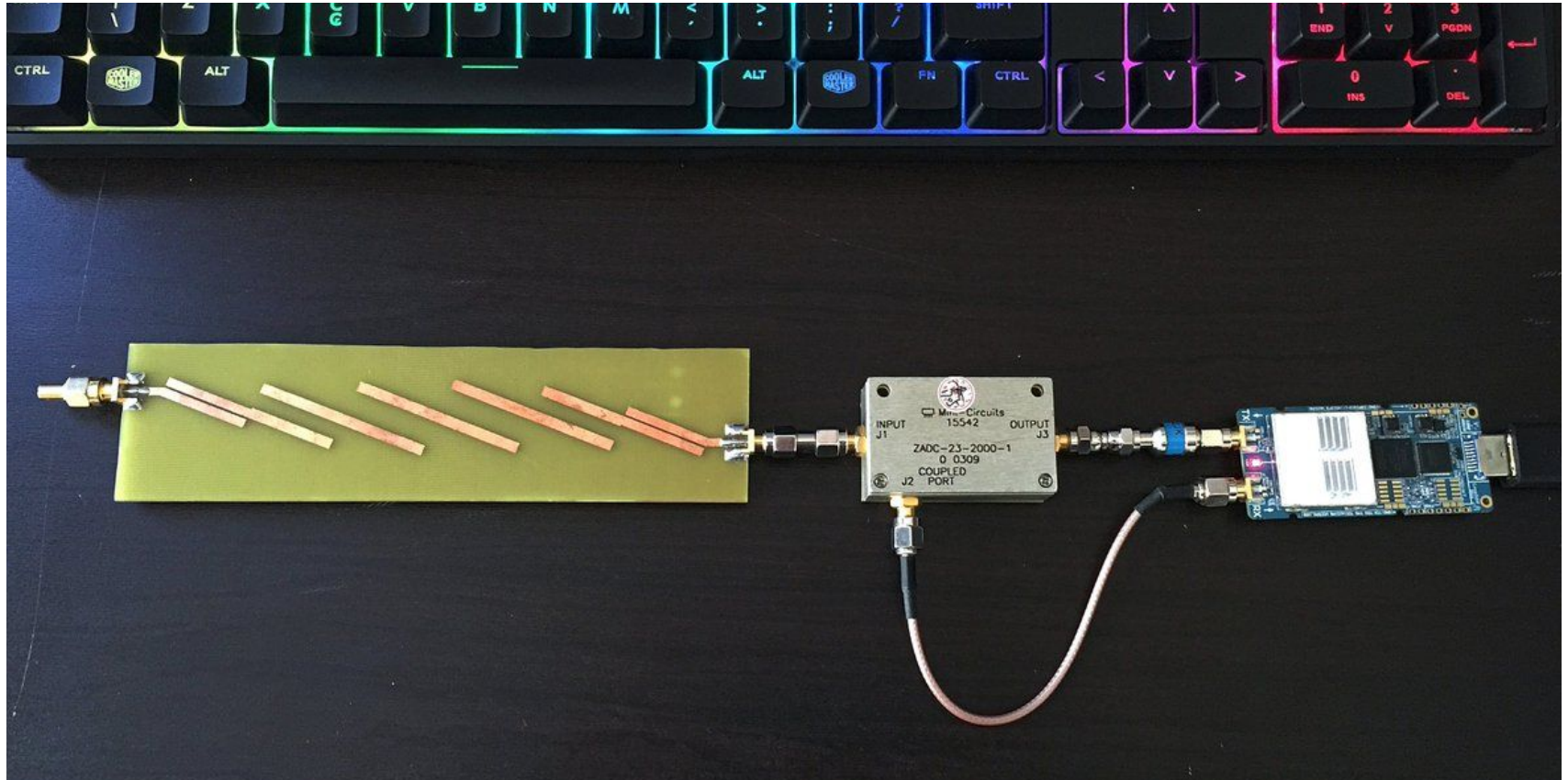
- + L-Band LNA
- + L-Band Bandpass Filter

L-Band Bandpass Filter

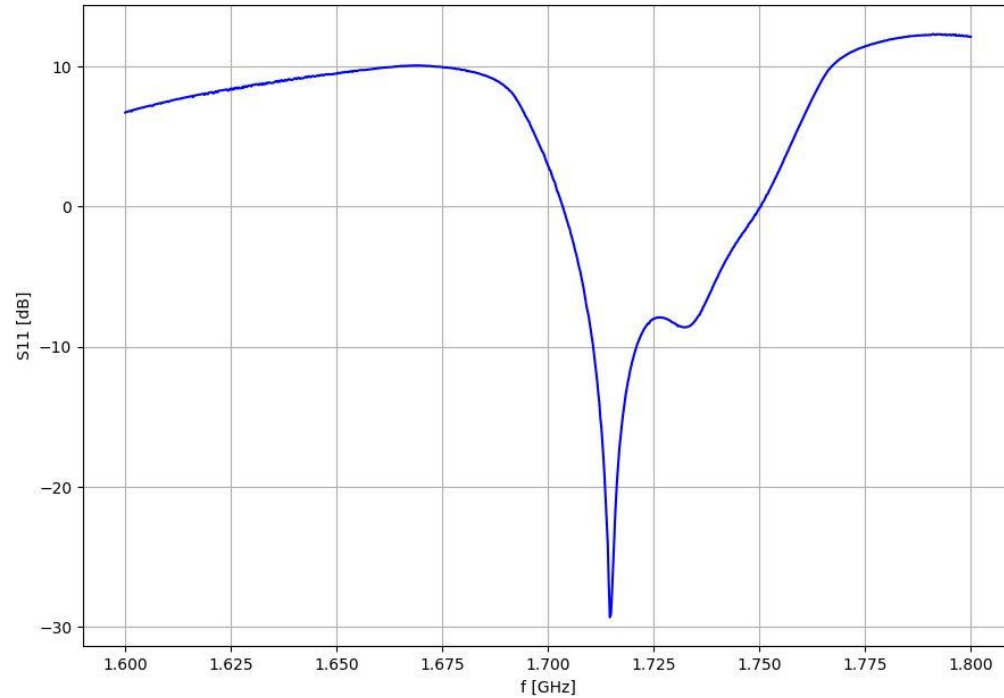


- 5th Order Butterworth Bandpass Filter
- Coupled Microstrip with 50 Ohms Impedance
- 1.67 GHz to 1.72 GHz

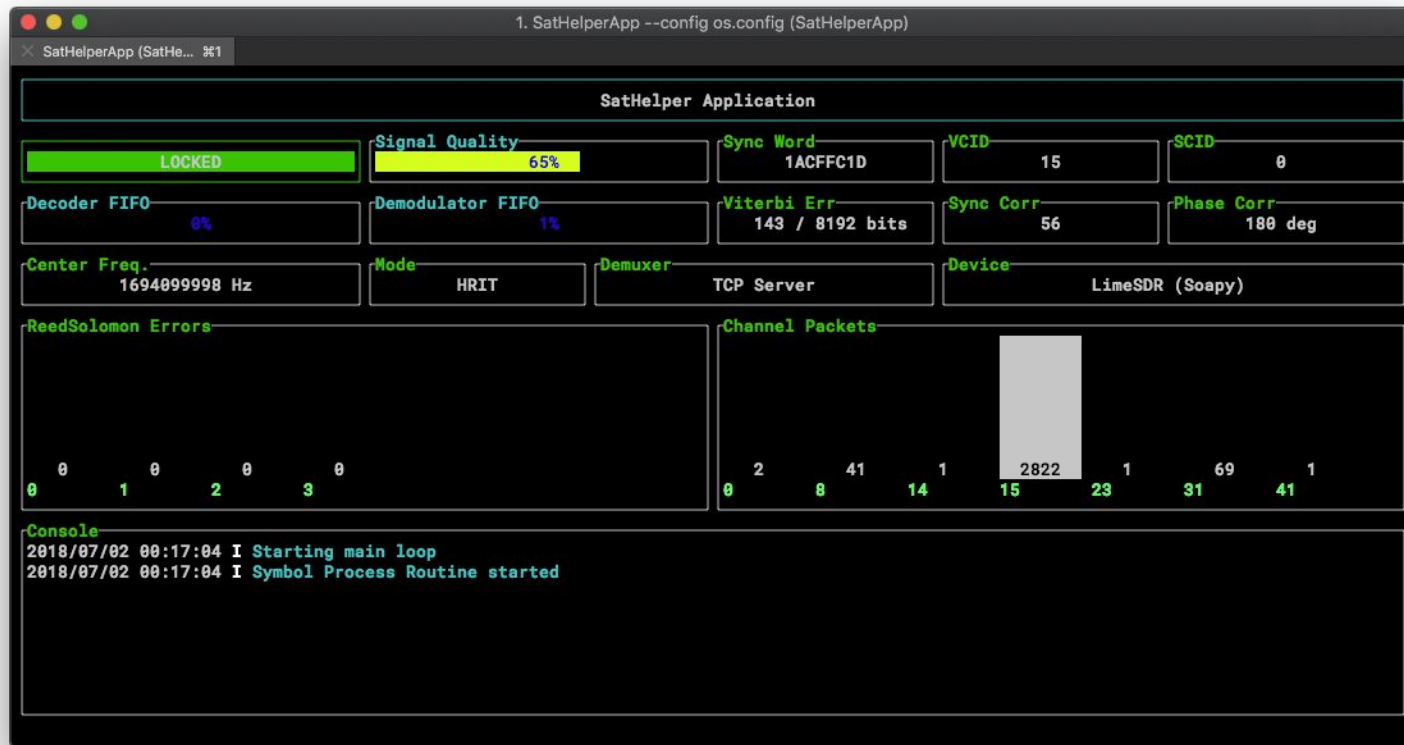
L-Band Bandpass Filter



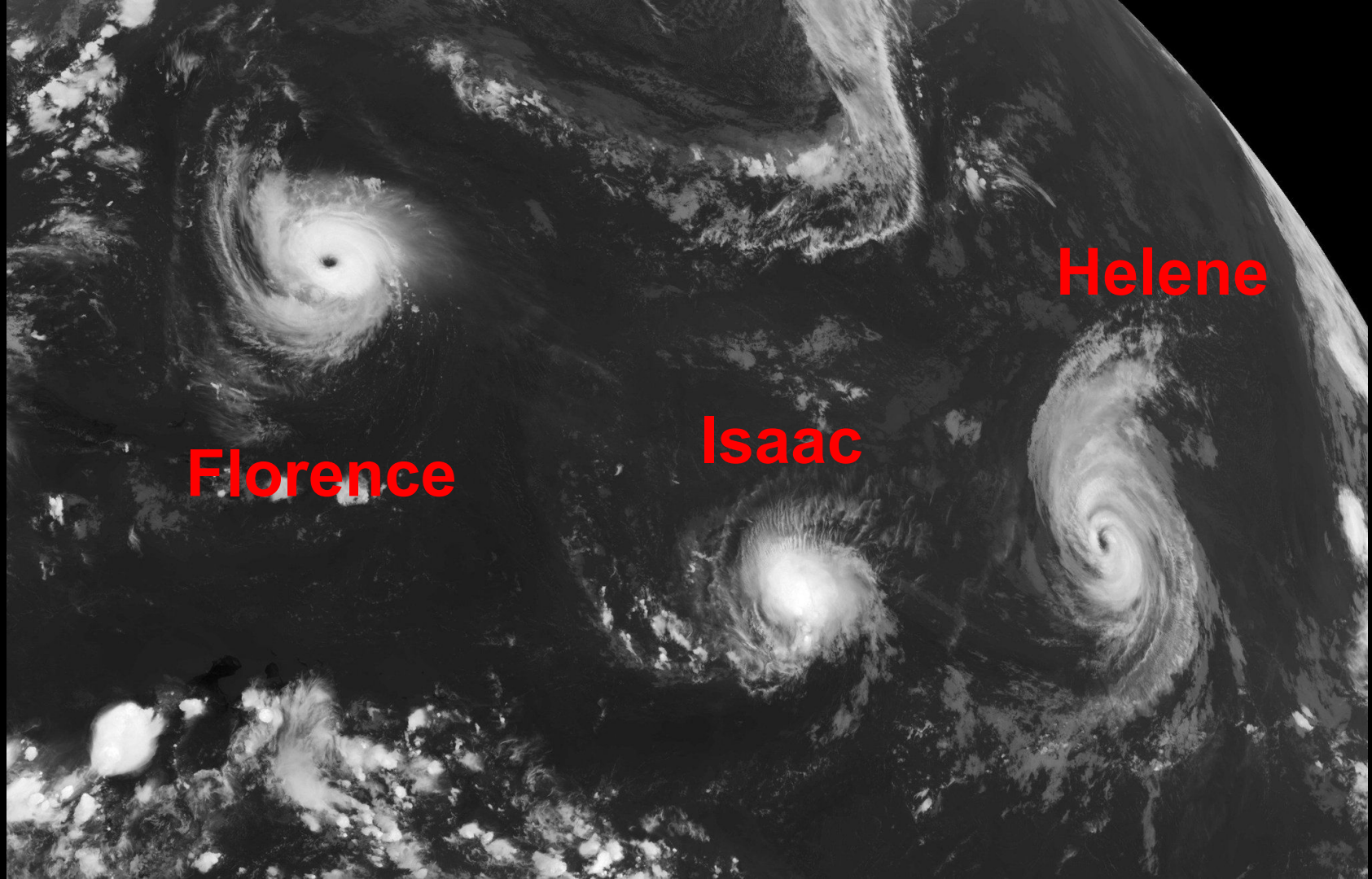
L-Band Bandpass Filter



Software - SatHelperApp





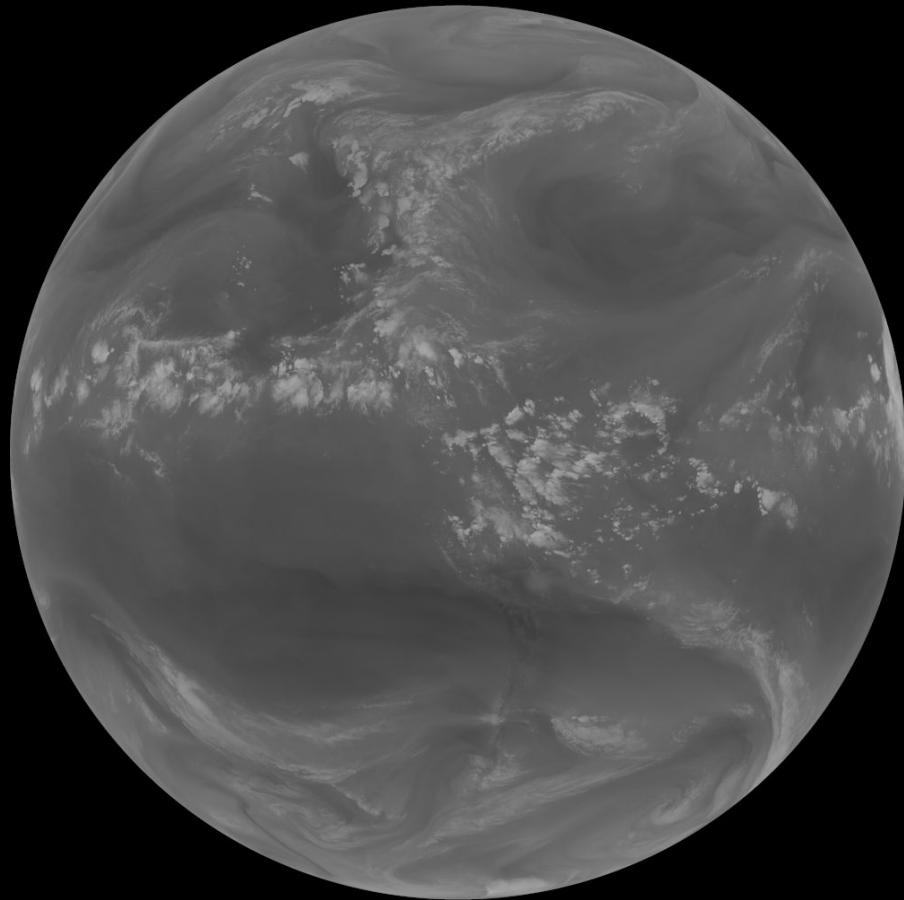
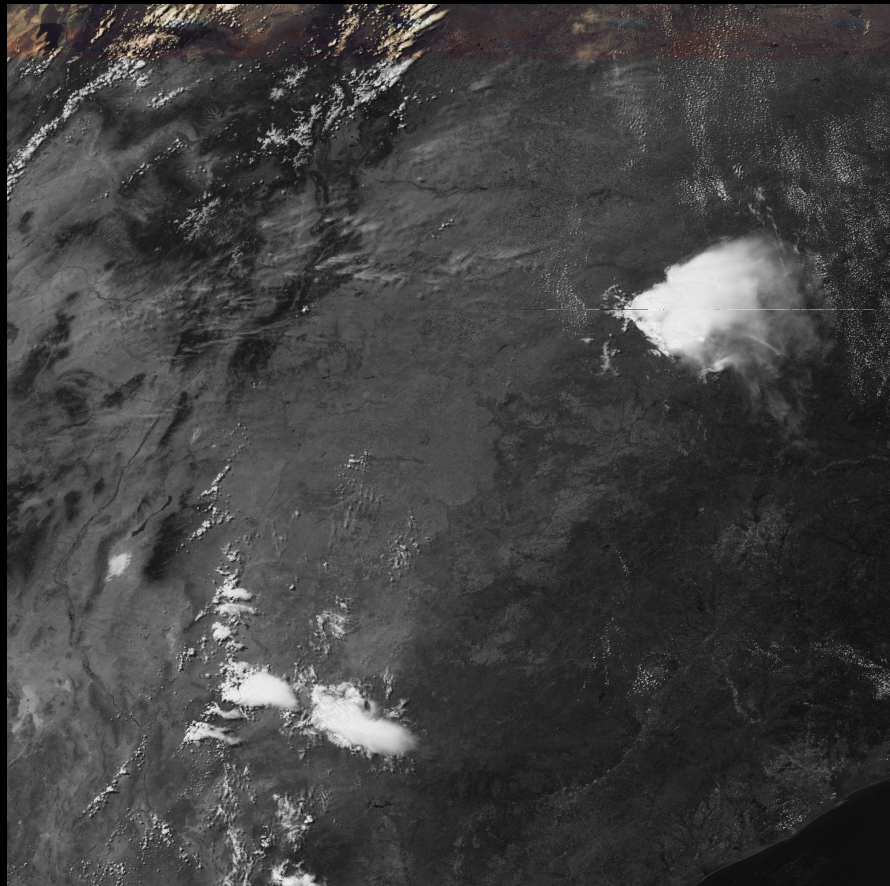


Florence

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



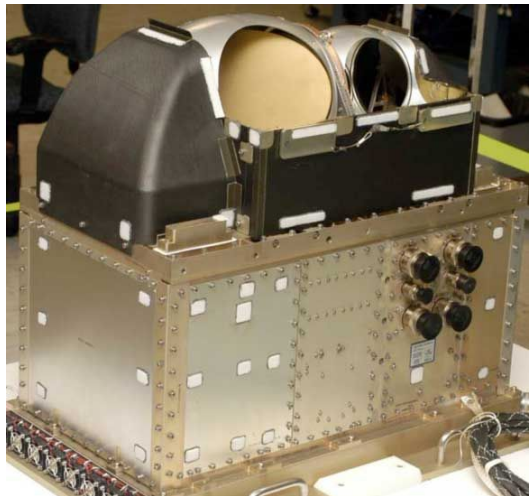
NPP/NPOESS - Instruments

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

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

● Currently Supported by OSP

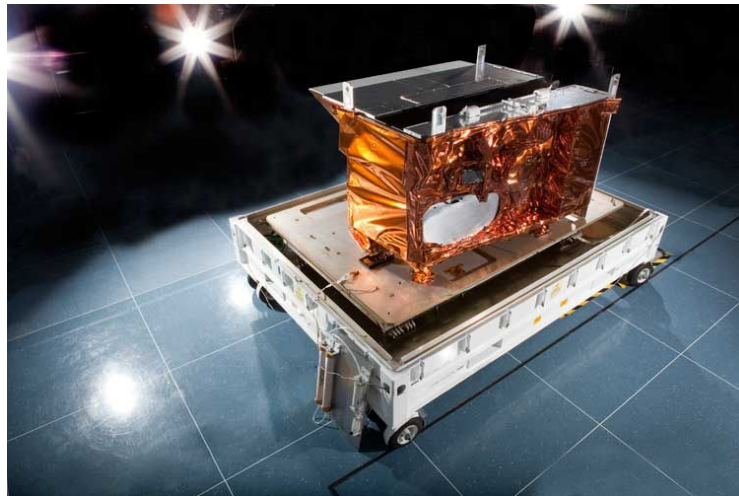
● To be supported...



ATMS



OMPS

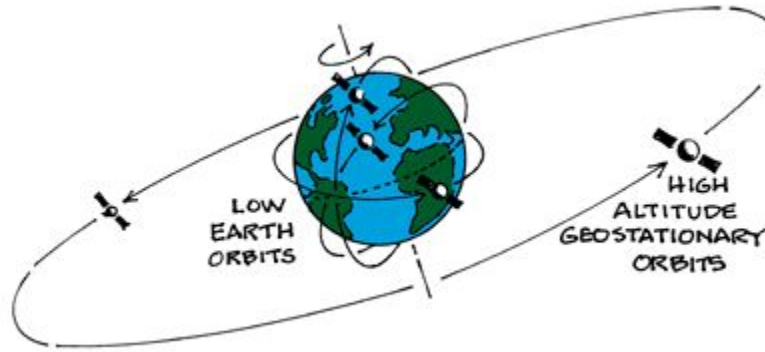


VIIRS

NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

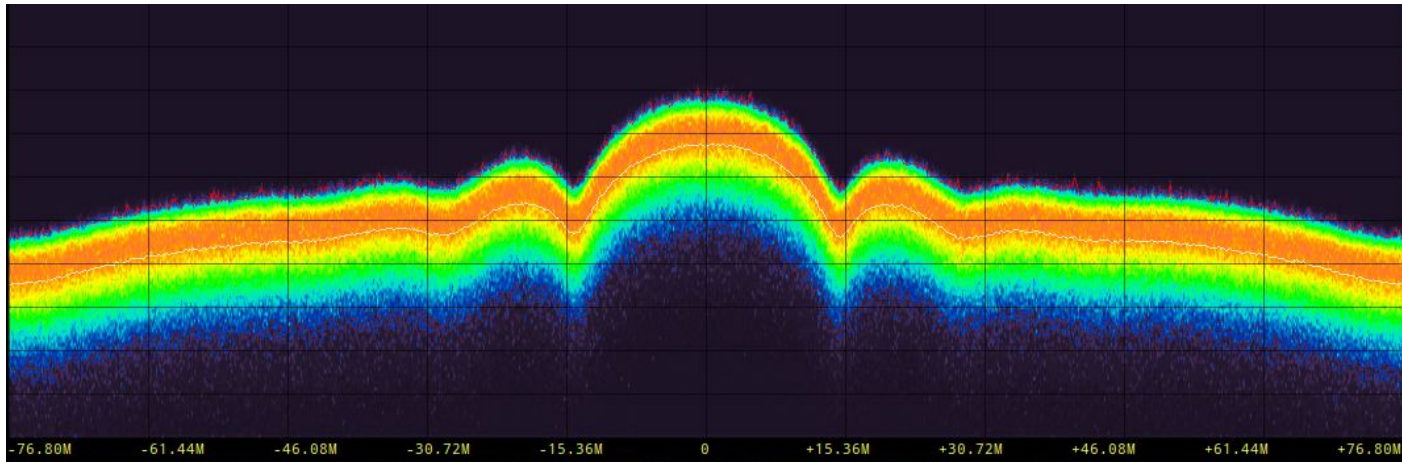
- Moving Fast (Polar Orbit)
- X-Band Signal (>7.8 GHz)
- Huge Bandwidth (30 MHz)



NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

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



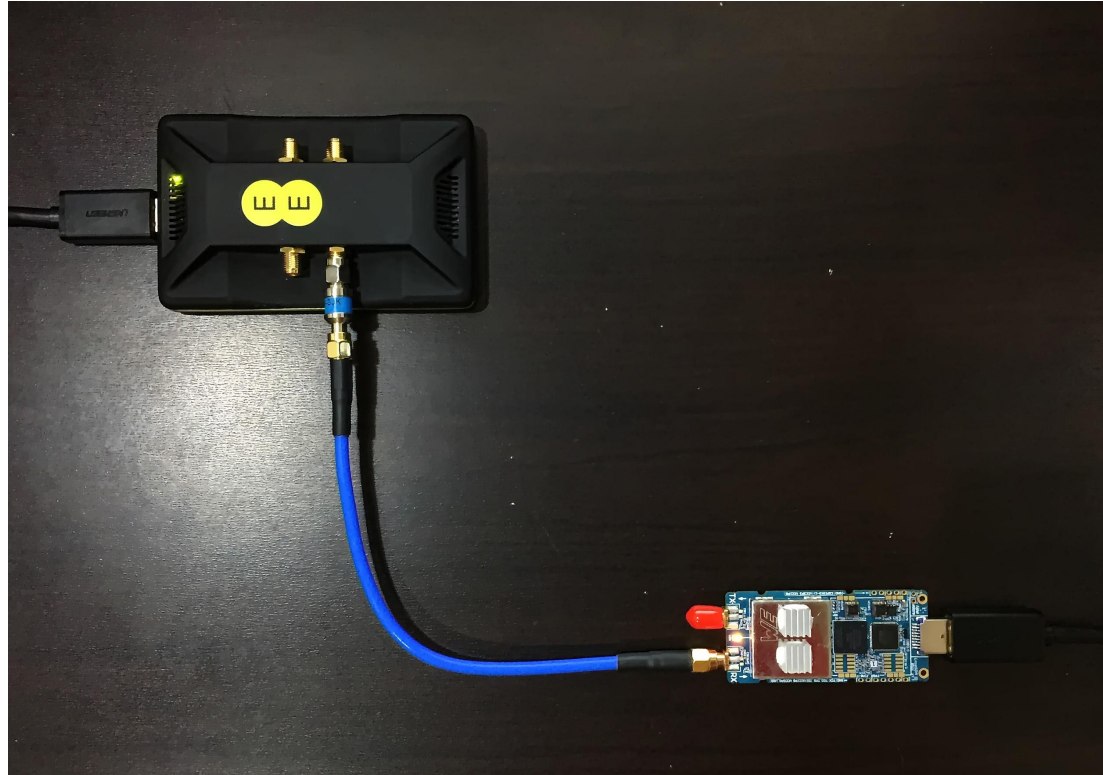
NPP/NPOESS - X-Band High Rate Datalink

Level: Hard

SDRs with Minimum Specs

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

Downconverter still needed.



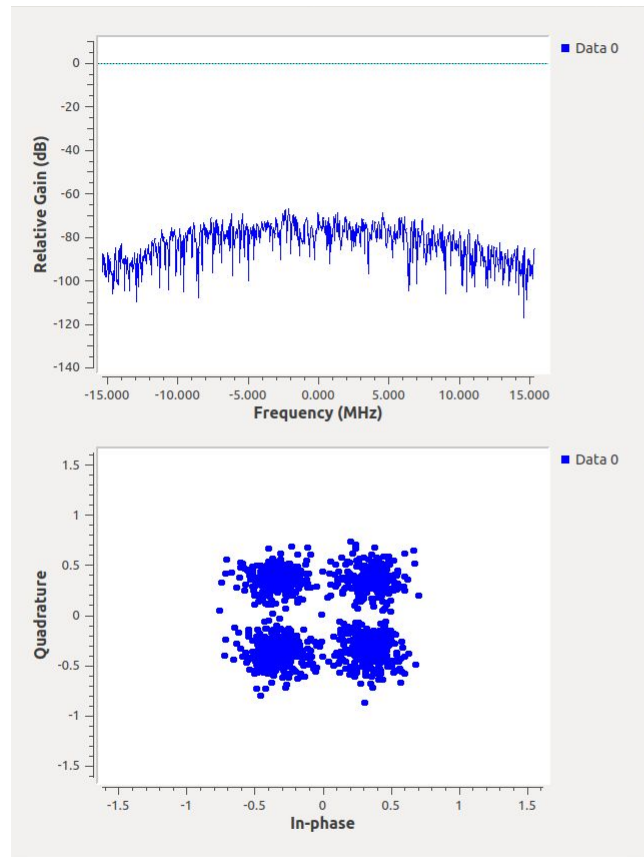
NPP/NPOESS - X-Band High Rate Datalink

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

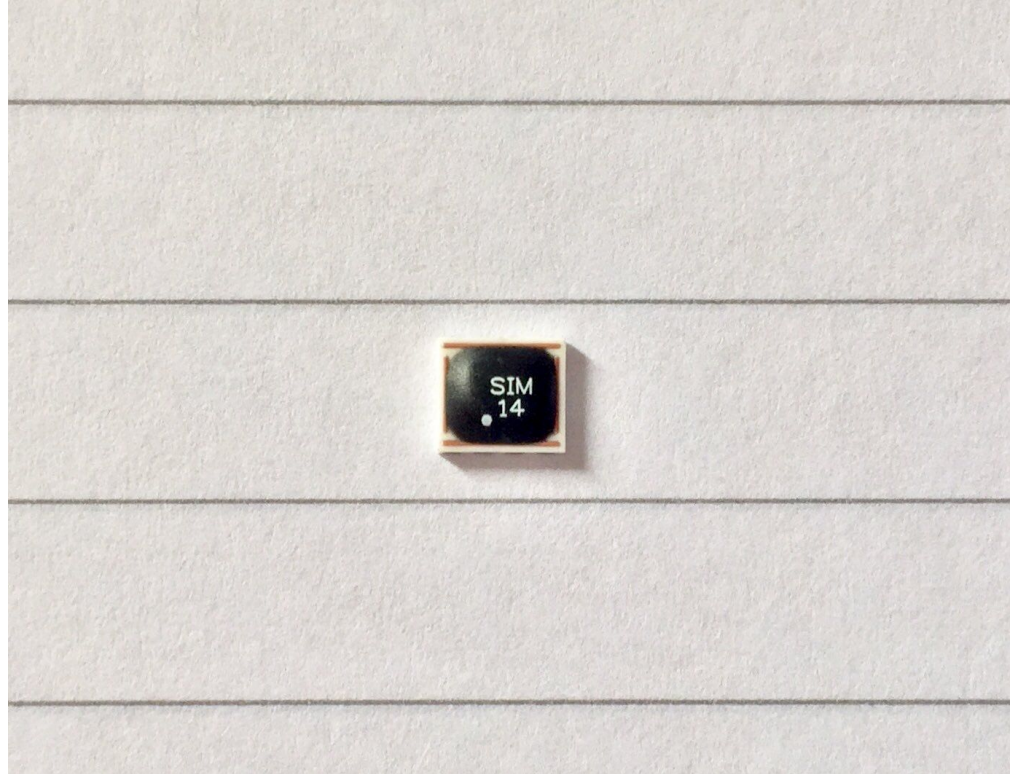
Demodulation

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

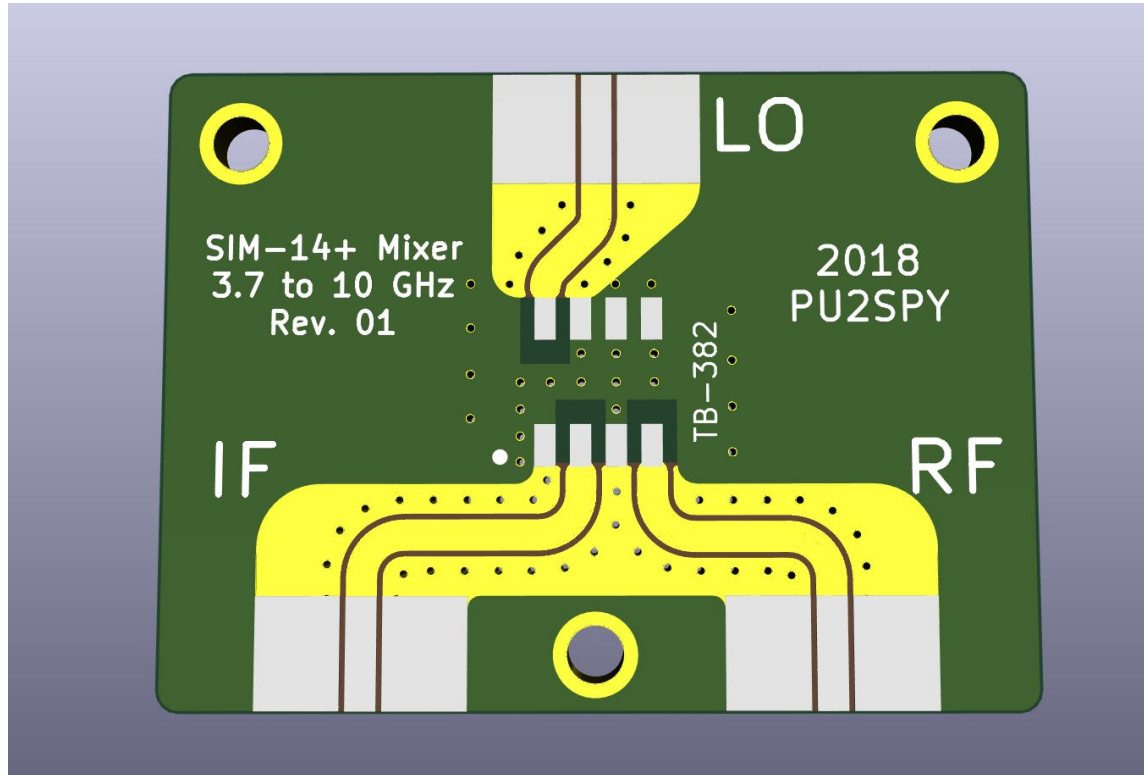
Modulation	QPSK
Bandwidth	30 MHz
Frequency	7812 MHz
Polarization	RHCP
I/Q Power Ratio	1:1
TX Power	8 Watts

NPP/NPOESS - X-Band High Rate Datalink

Downconverter

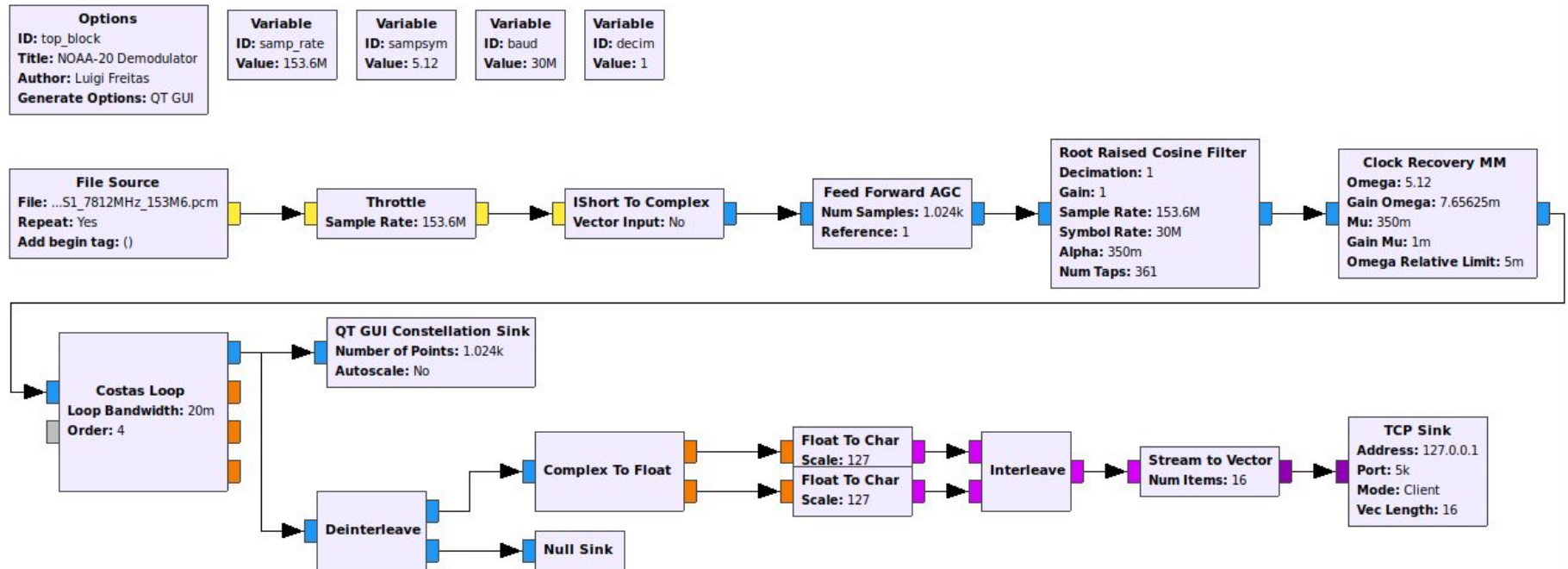


NPP/NPOESS - X-Band High Rate Datalink Downconverter



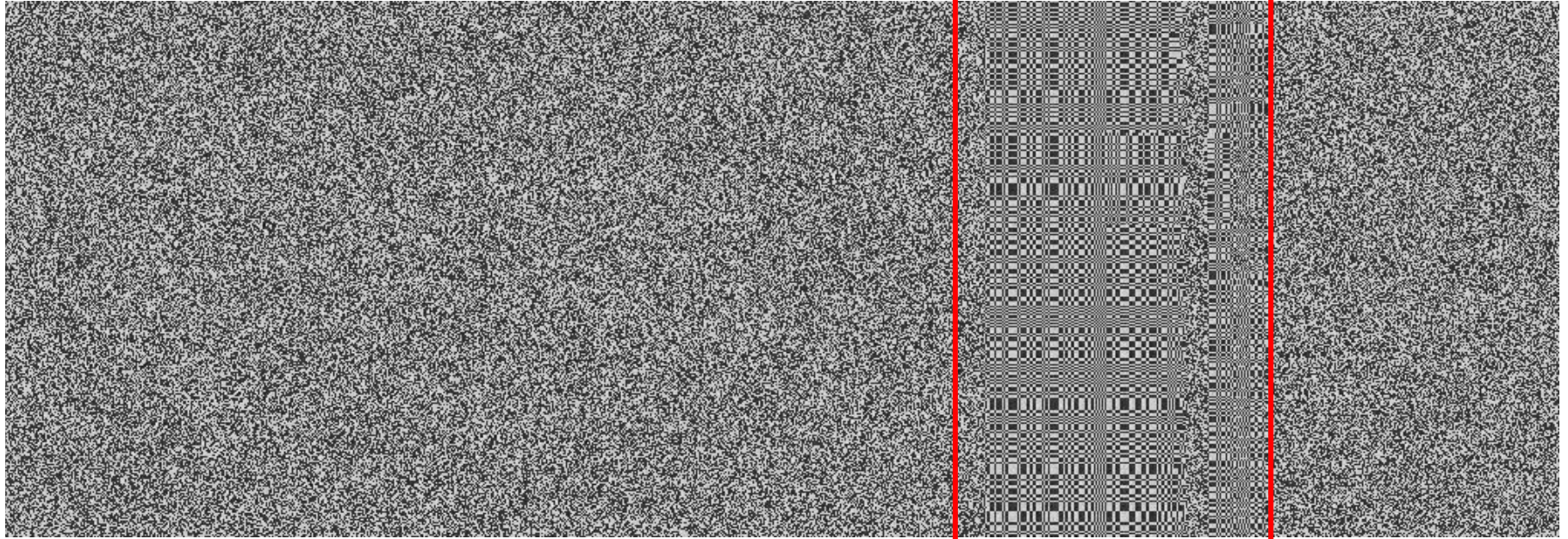
NPP/NPOESS - X-Band High Rate Datalink

Demodulation



NPP/NPOESS - X-Band High Rate Datalink

Demodulation

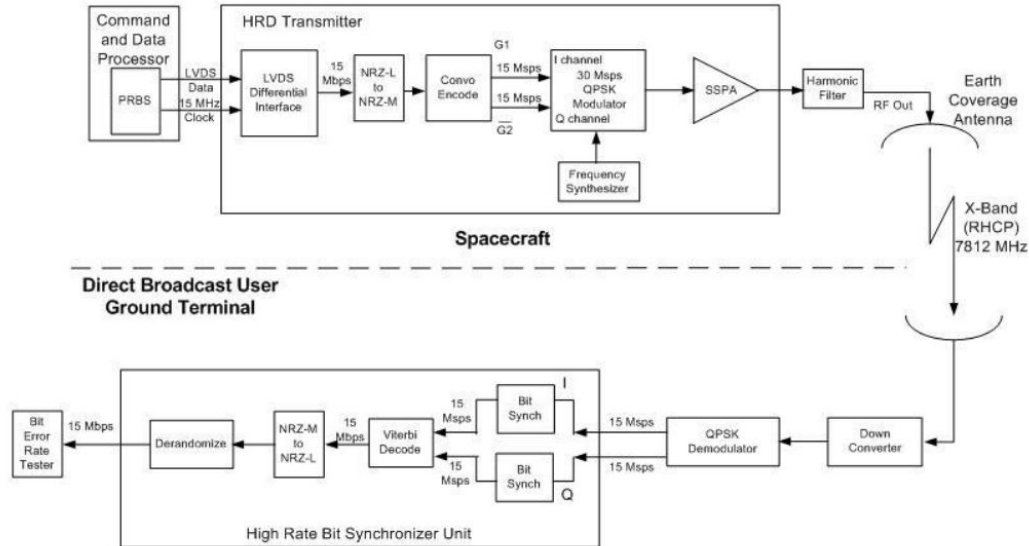


Encoded Sync Word

NPP/NPOESS - X-Band High Rate Datalink

Decoding

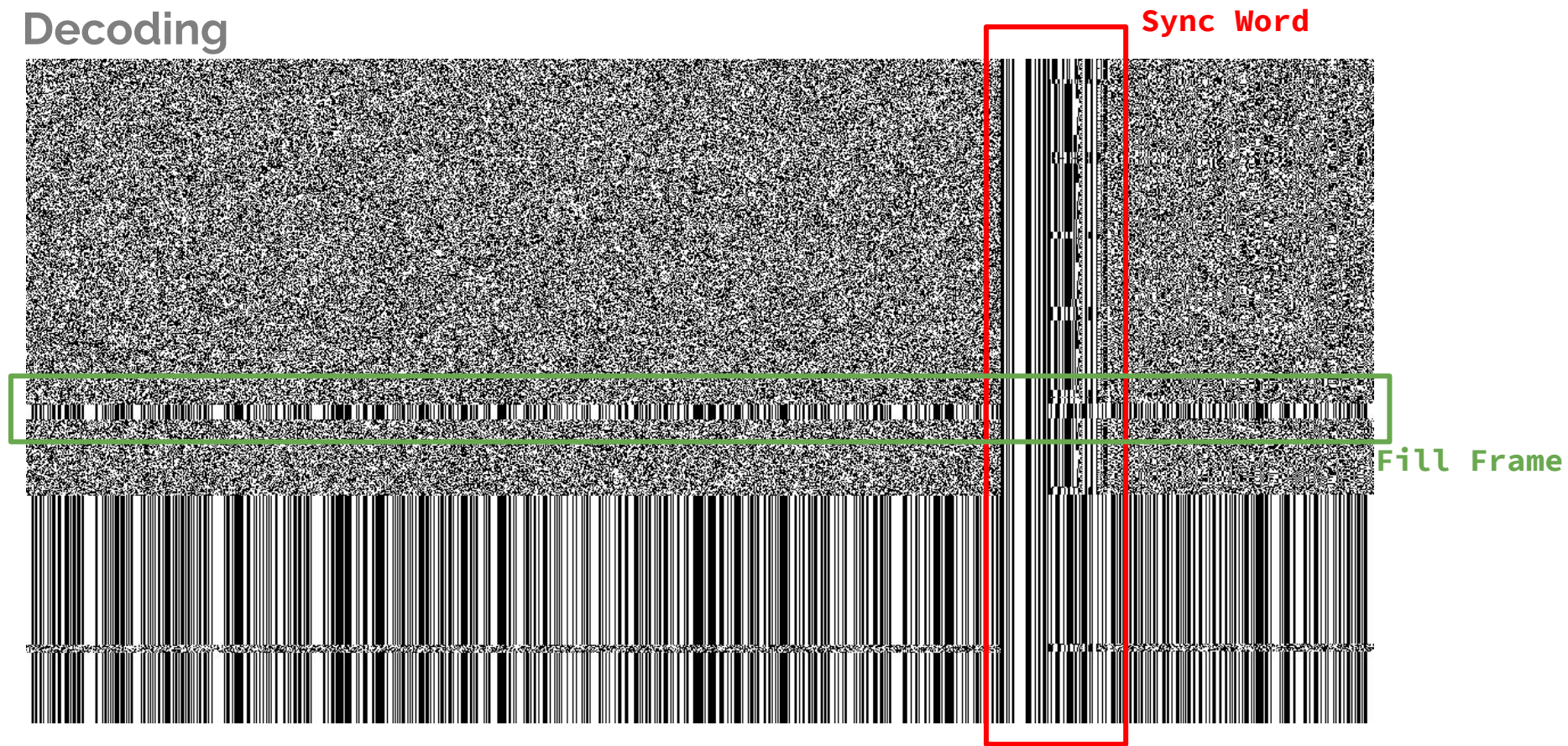
- Almost identical to the HRIT.
- Differential Encoding Applied.
- No puncturing.



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

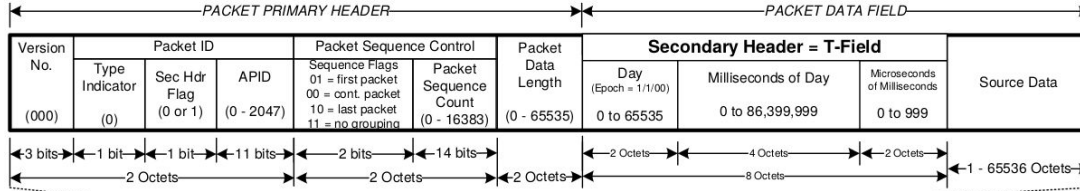
Decoding



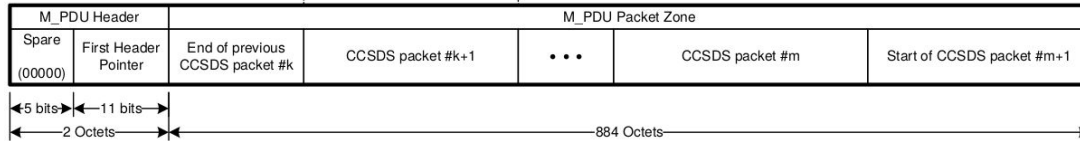
NPP/NPOESS - X-Band High Rate Datalink

CCSDS Demuxing

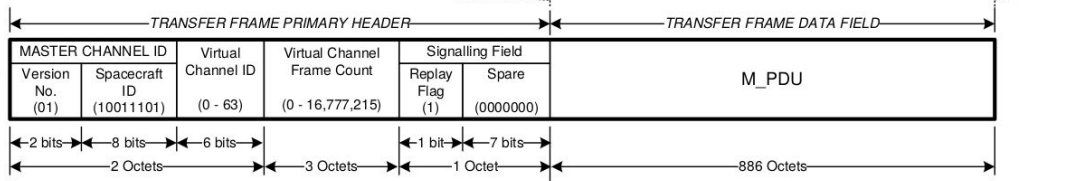
Version-1 CCSDS Space Packet (ref: CCSDS 133.0-B-1, Fig. 4-1 & Fig 4-2)



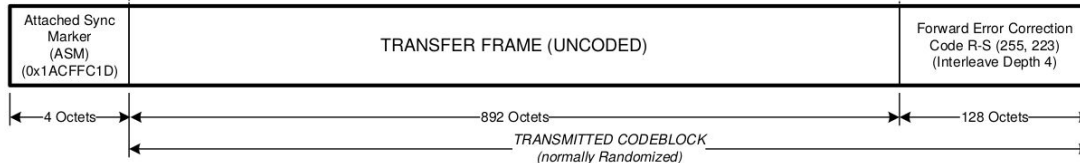
Multiplexing Protocol Data Unit (ref: CCSDS 732.0-B-2, Fig. 4-3)



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

Space Packet

Multiplex Data Unit

Transfer Frame

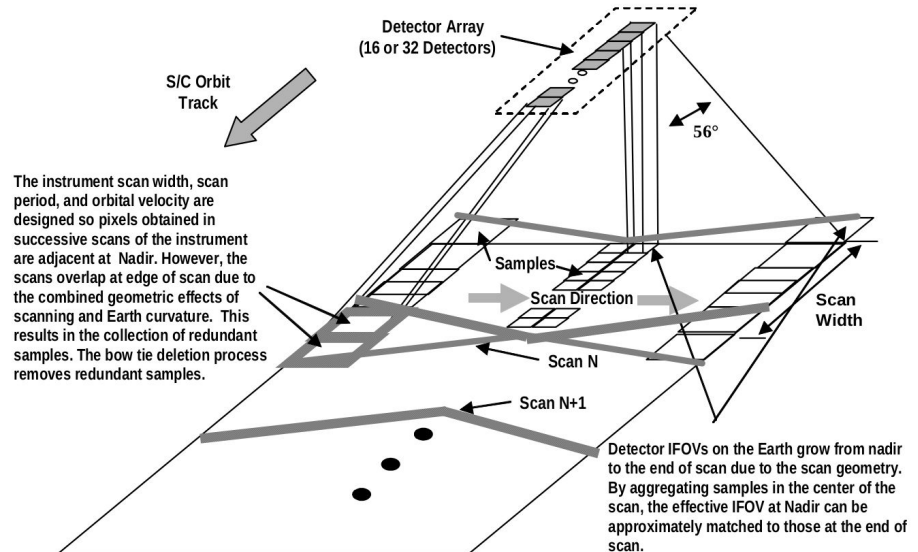
Channel Data Unit

Raw CCSDS Data

NPP/NPOESS - X-Band High Rate Datalink

VIIRS 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	
	Type Indicator	Sec Hdr Flag	APID	Sequence Flags	Sequence Count					VIIRS Sequence Count	Packet Time [2]	Format Version	Instrument Number	Spare	HR Meta Data	Checksum
3	1	1	11	2	14	16	64	8	8	32	64	8	8	16	1168	16
Octets	2			2		2	8	1	1	4	8	1	1	2	146	2
Value	000	0	1	varies	01	varies	173	varies	zeros	varies	varies	2	2	zeros	varies	varies

0 = Telemetry Packet

1 = Secondary Header Present

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.

HR Meta Data															TOTAL 1168 146
	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	
Bits	1	1	4	10	32	64	8	8	16	32	16	16	16	944	
Octets	2				4	8	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															

0000 Live Data
0001- 1111 Test Data Patterns

Filled with zeros if unused

Filled with zeros if unused

Notes:

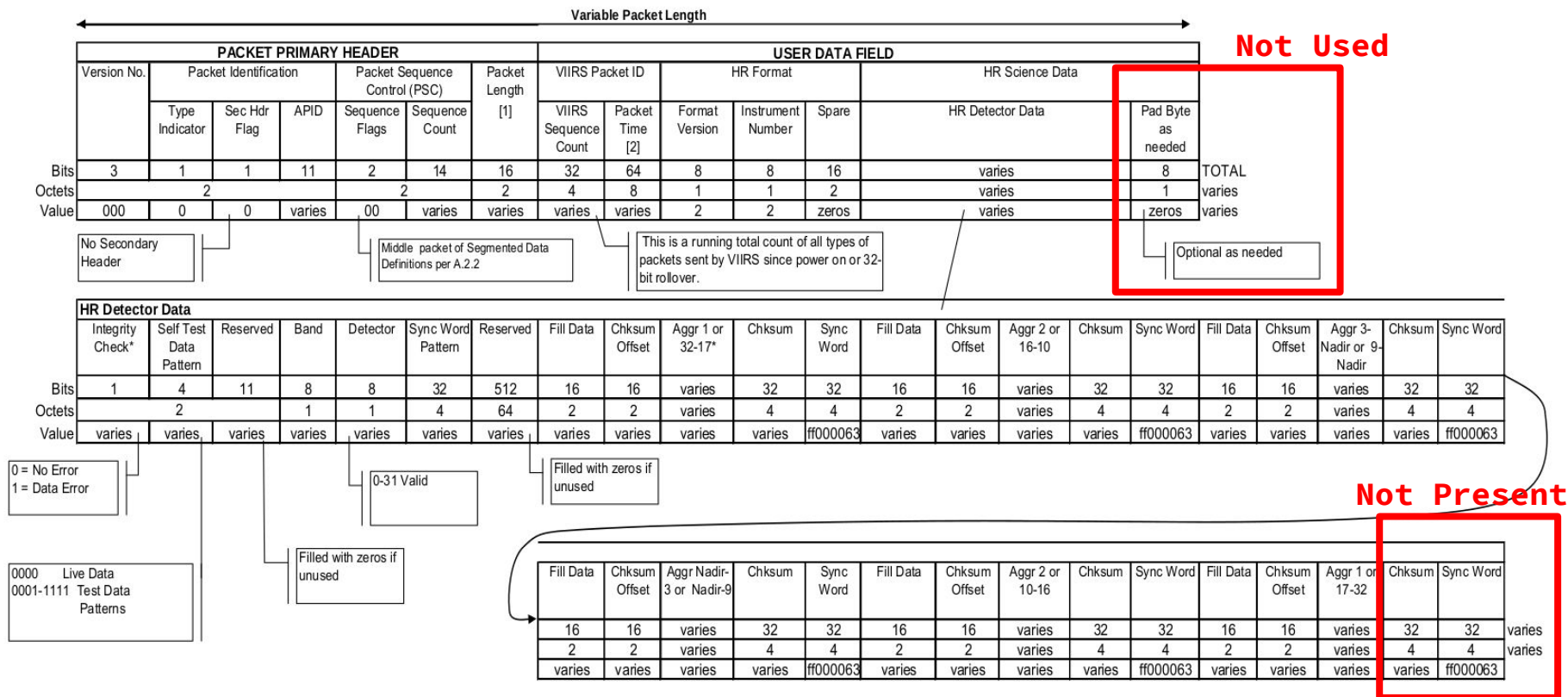
[1] Packet length is the number of bytes after the primary header minus one.

[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.

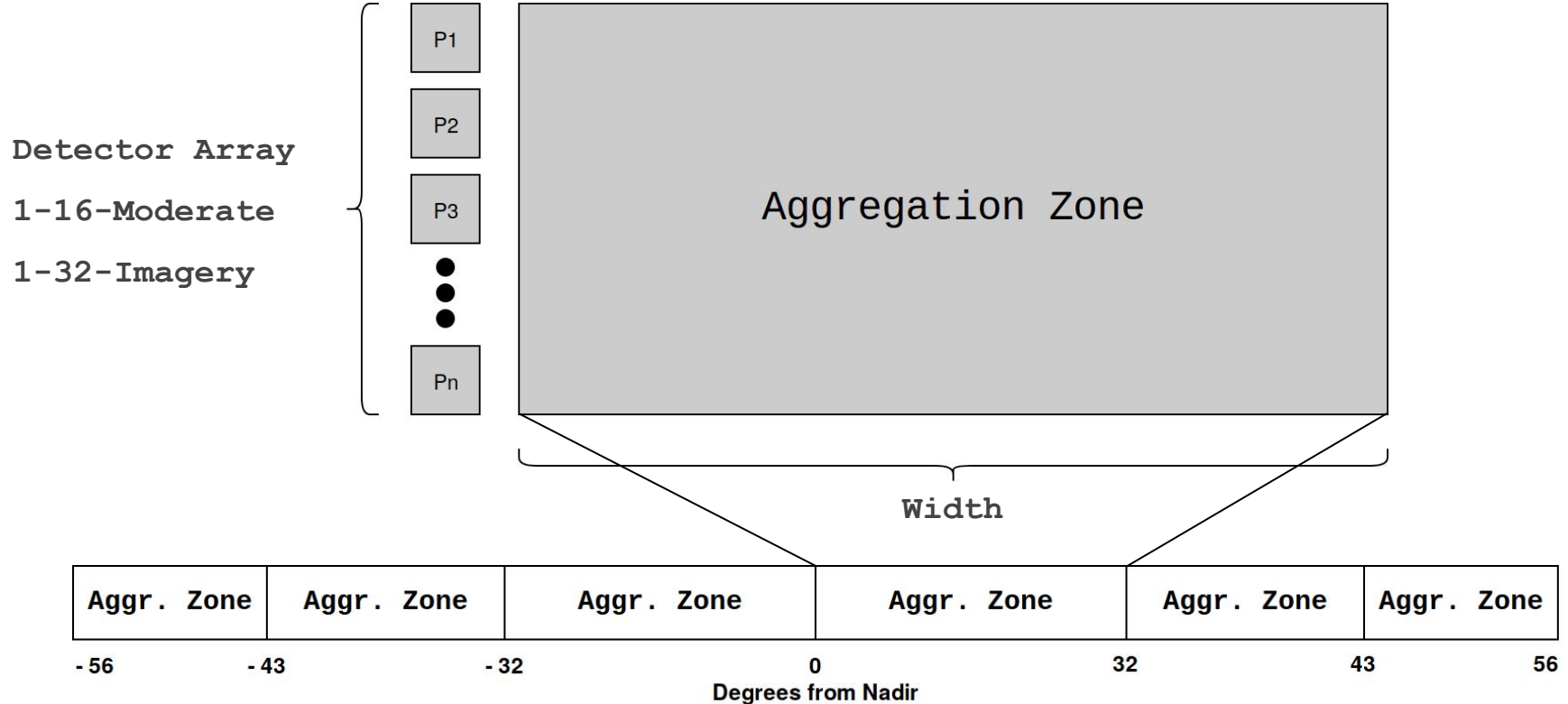
NPP/NPOESS - X-Band High Rate Datalink

VIIRS Science Data - Imager Data Body



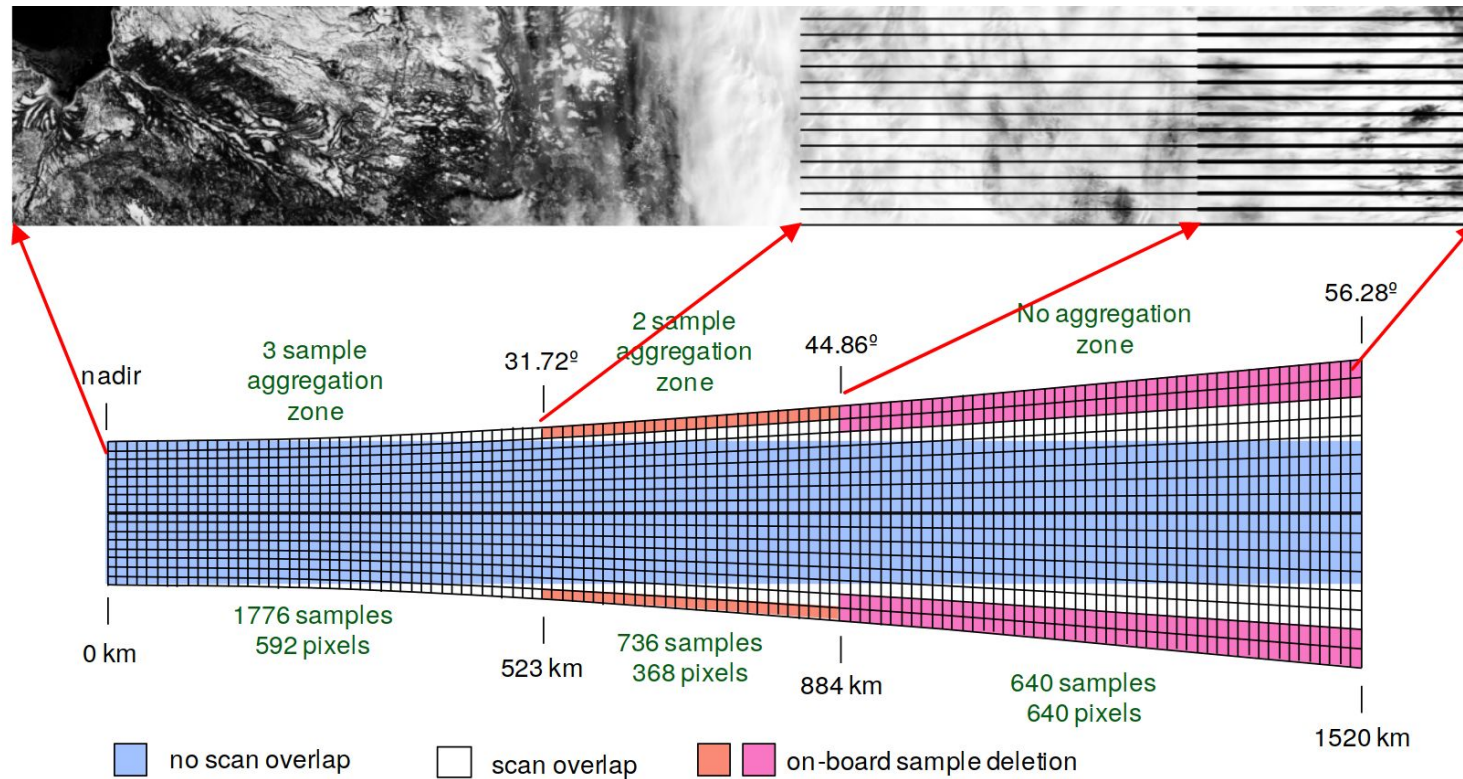
NPP/NPOESS - X-Band High Rate Datalink

VIIRS Science Data



NPP/NPOESS - X-Band High Rate Datalink

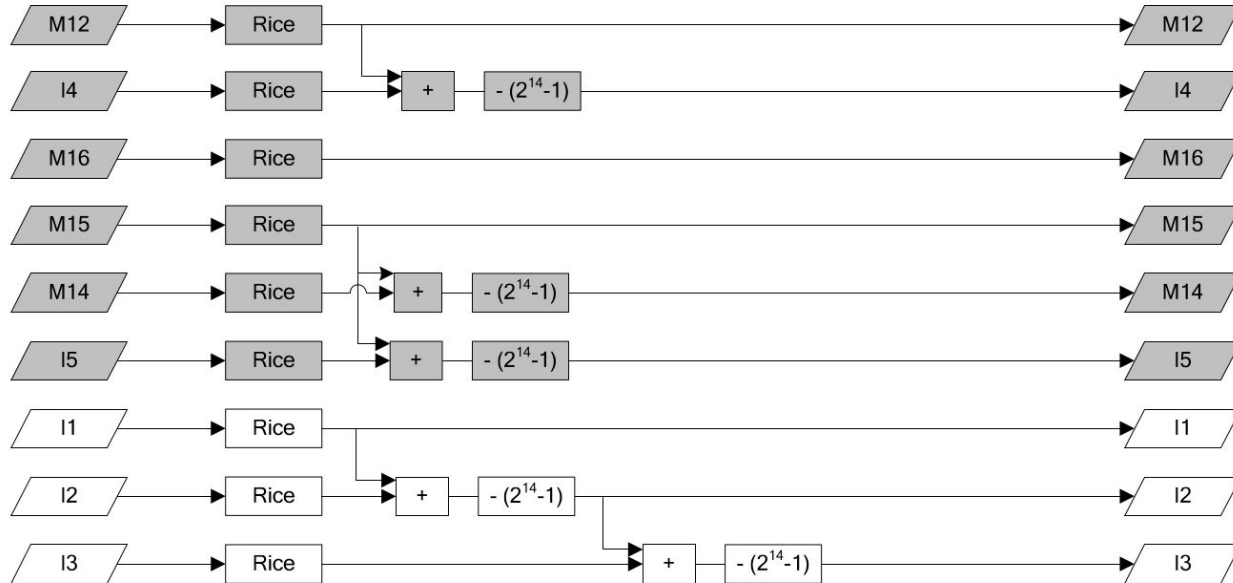
VIIRS Science Data - Bow Tie Deletion

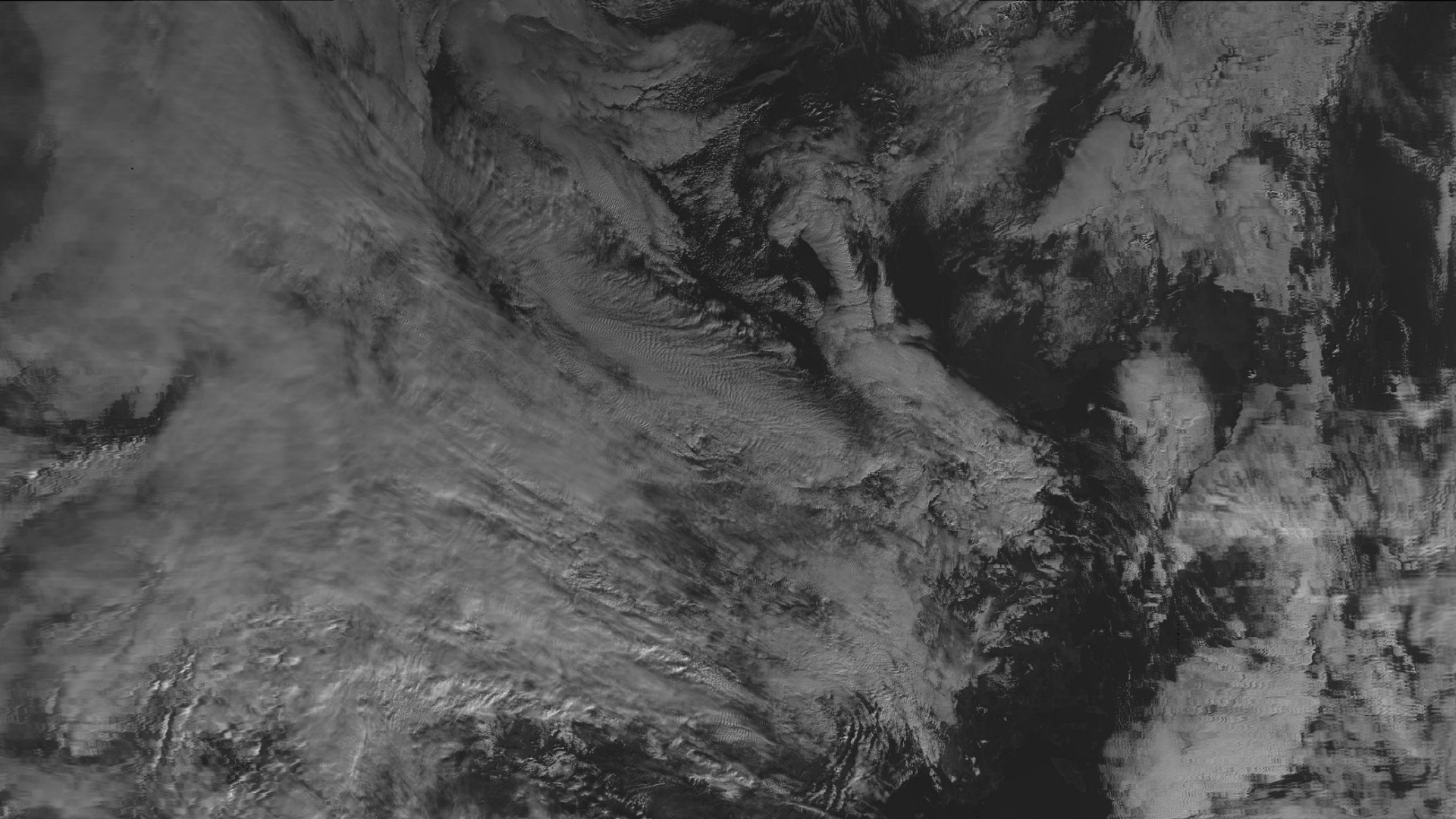


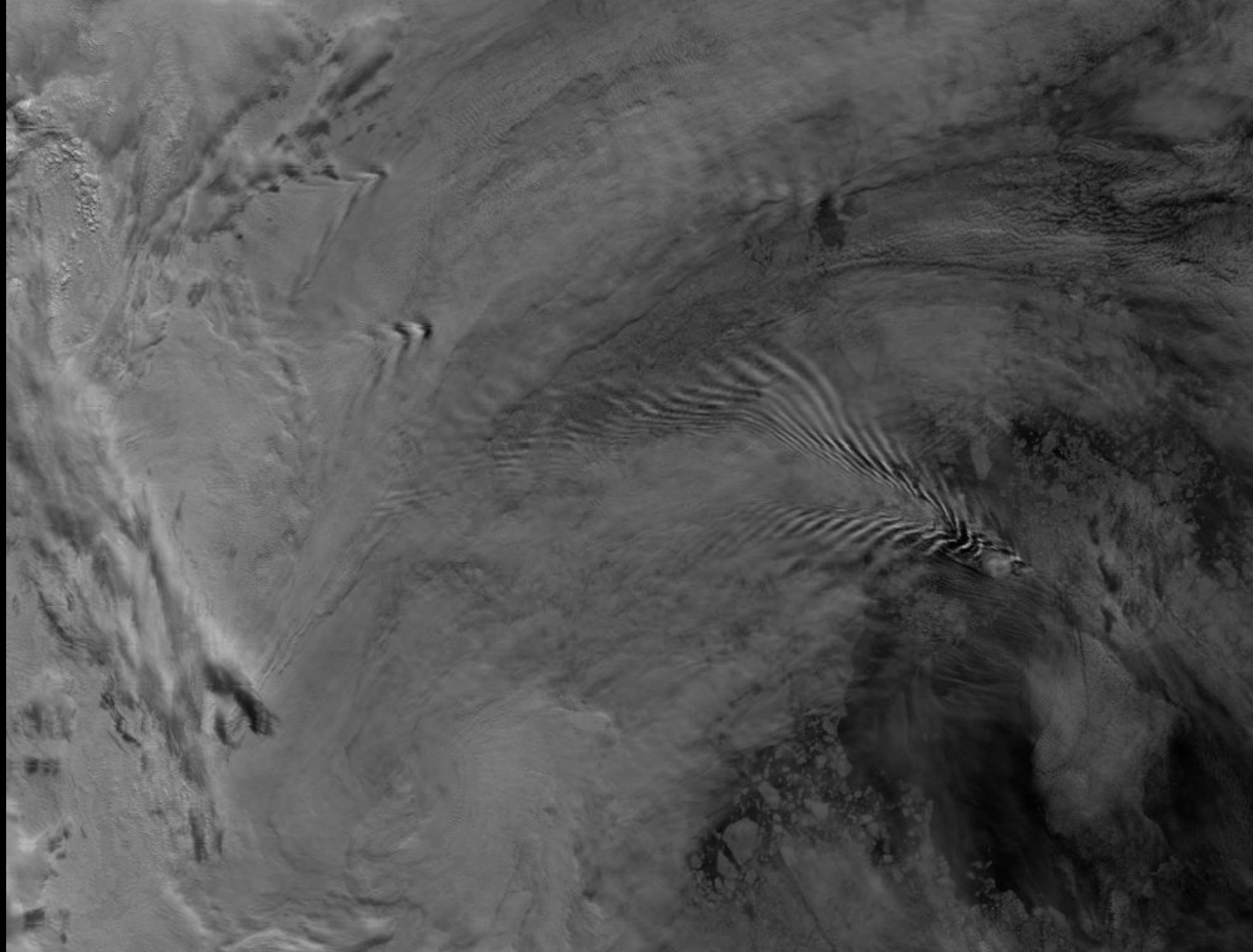
NPP/NPOESS - X-Band High Rate Datalink

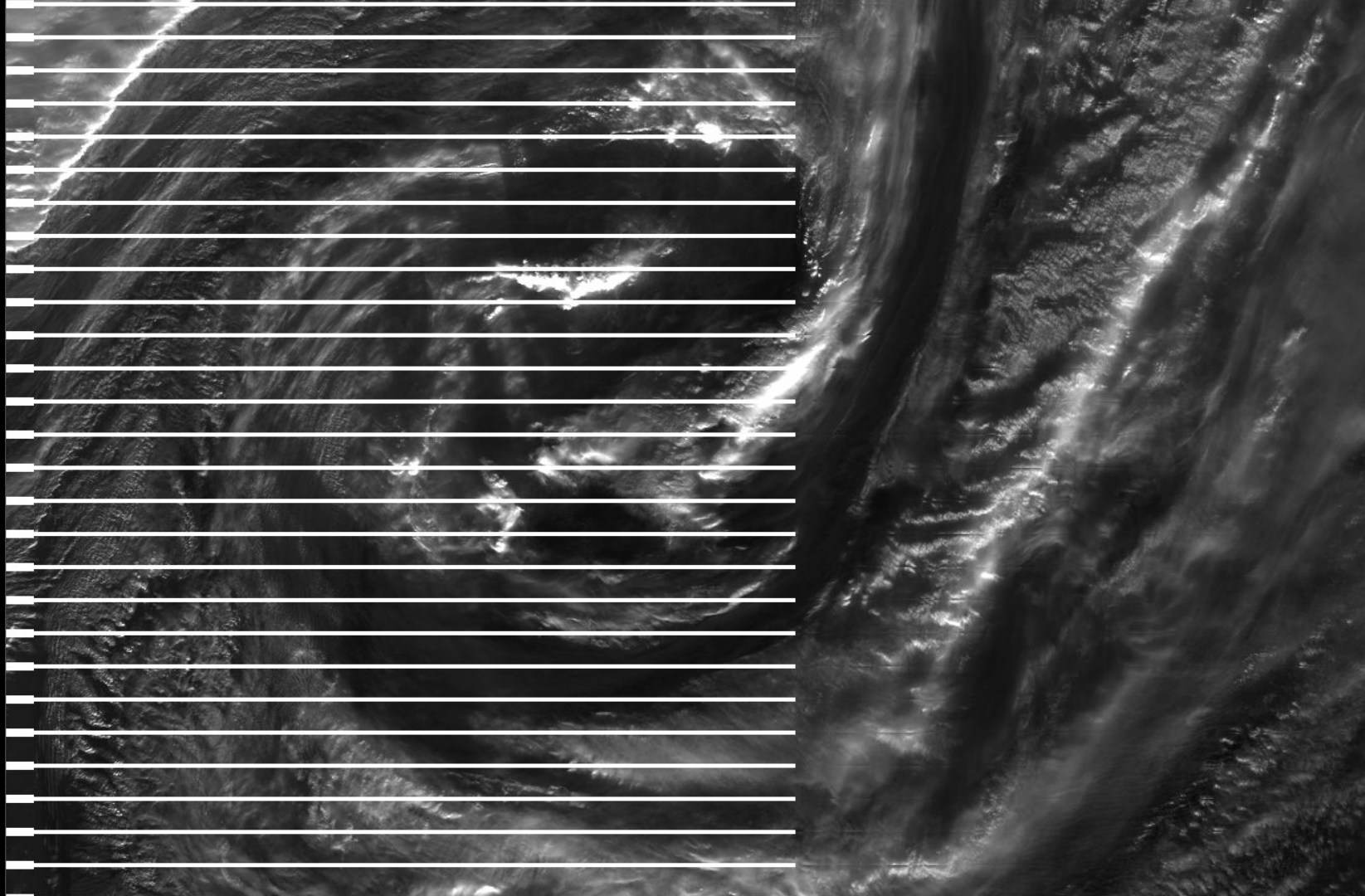
VIIRS Science Data

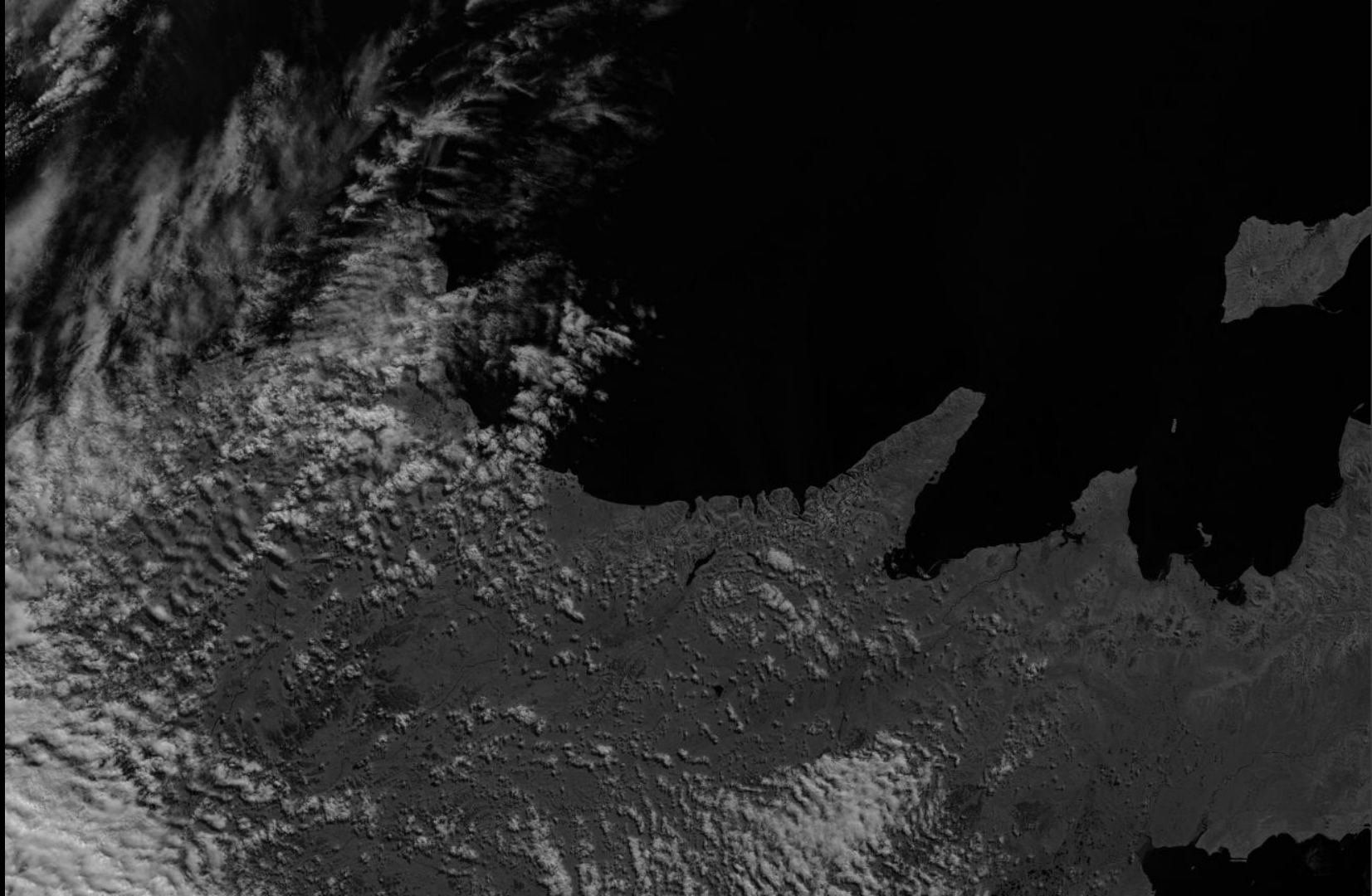
- Every Channel is RICE encoded.
- Additional Differential encoding on some Infrared Channels.

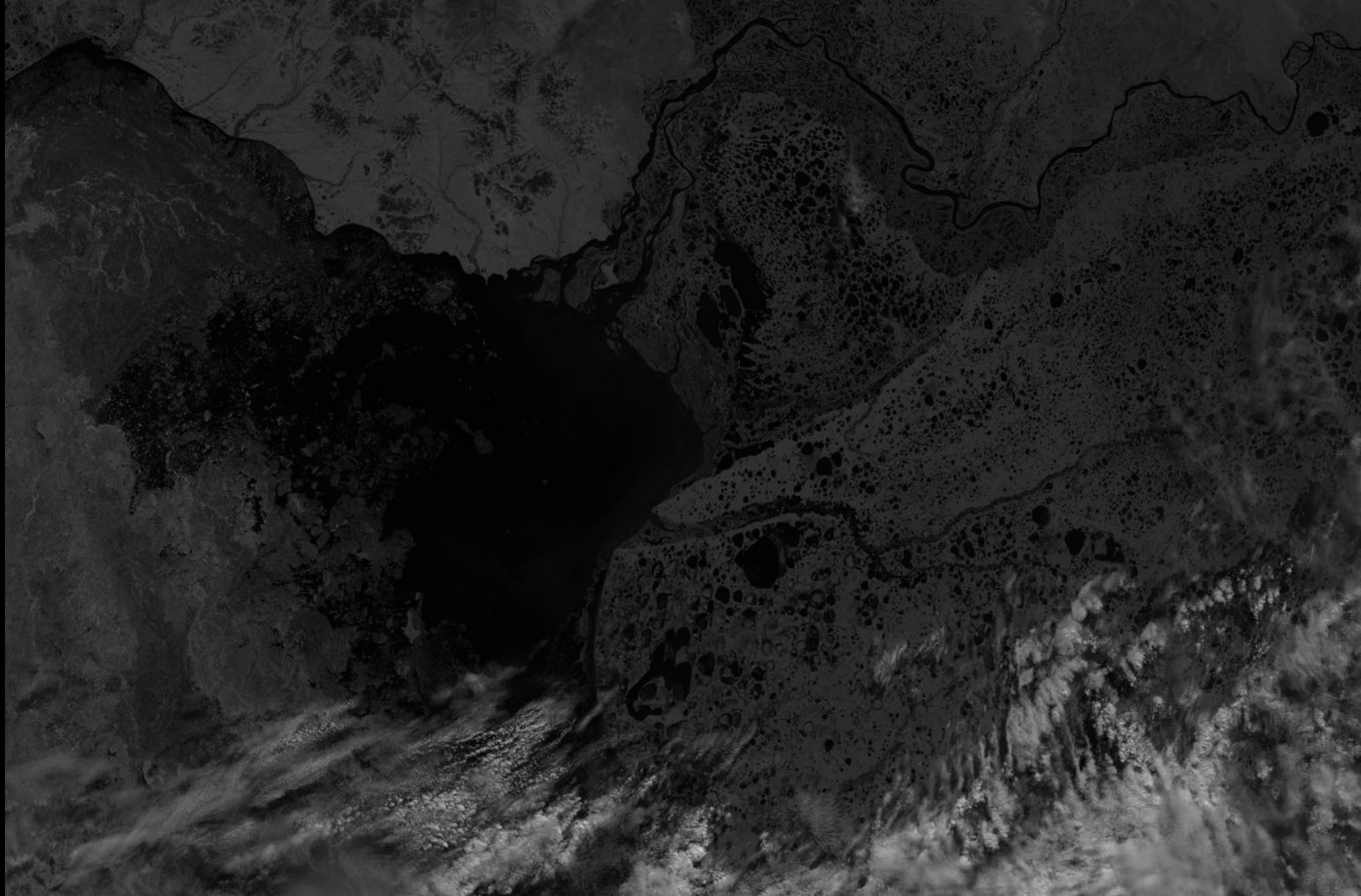


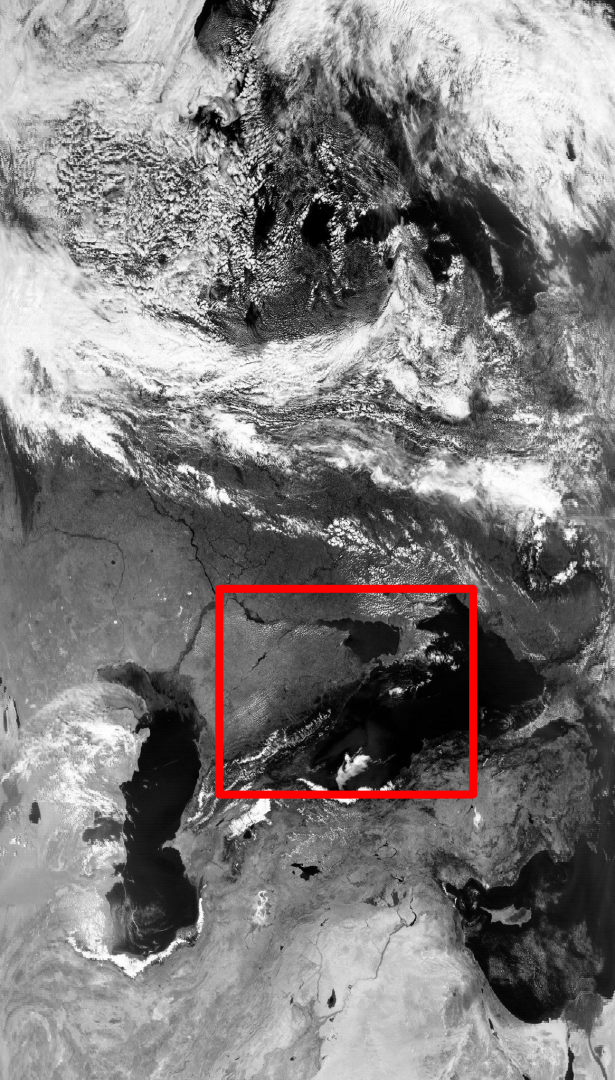












WeatherDump - LEO Satellites (HRD, HRPT & LRPT)

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

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



Any Questions?

My Contact

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GitHub: @luigifreitas

Slides will be available at:
<https://luigifreitas.me>

Special Thanks

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