

A composite background image showing a snowy mountain range, a city skyline, an airplane, a satellite, wind turbines, and an offshore oil rig.

GNSS RFI IN EUROPE STATUS AND PREDICTIONS

Aiden Morrison, 14.06.2023

Outline

- The ARFIDAAS monitoring system network and its motivations
- What data we have captured in four years of monitoring
- The hunt for trends
- Signs of signal evolution
- Predictions for the future

GNSS disruption incidents – sometimes they make the news

Truck driver has GPS jammer, accidentally jams Newark airport

An engineering firm worker in New Jersey has a GPS jammer so his bosses don't know where he is all the time. However, his route takes him close to Newark airport, and his jammer affects its satellite systems.

BY STEVE MURRAY FOR ENR | NOVEMBER 11, 2013 8:52 AM EDT



JAMMER: How jamming of GPS signals by a driver affected to Newark Airport. From ENR.com

'Forgotten' GPS jammer costs motorist €2,000



Pilotene mister GPS-signalet i Finnmark. Det kan knyttes til russiske øvelser

«Det er grunn til å tro at det kan relateres til militære øvelsesaktiviteter utenfor norskekysten», sier Luftfartstilsynet.



which was downed in eastern Iran -

The Chirp Jammer: a GPS hit and run

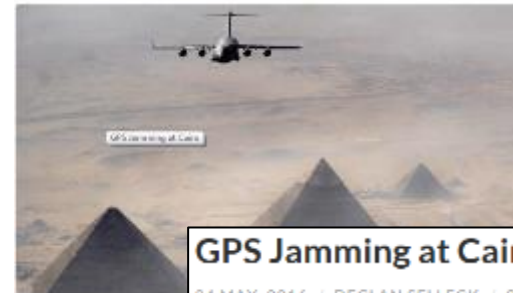


The C50 device that brought a multi-million euro project to a standstill



Luftambulansen mistet navigasjonssystemet på vei til pasient. Årsaken sto i sigarettene i en bil.

Piloten var overlatt til det han så ut vinduet for å finne veien til den kritisk syke pasienten.



GPS Jamming at Cairo

24 MAY, 2016 / DECLAN SELLECK / 3 COMMENTS

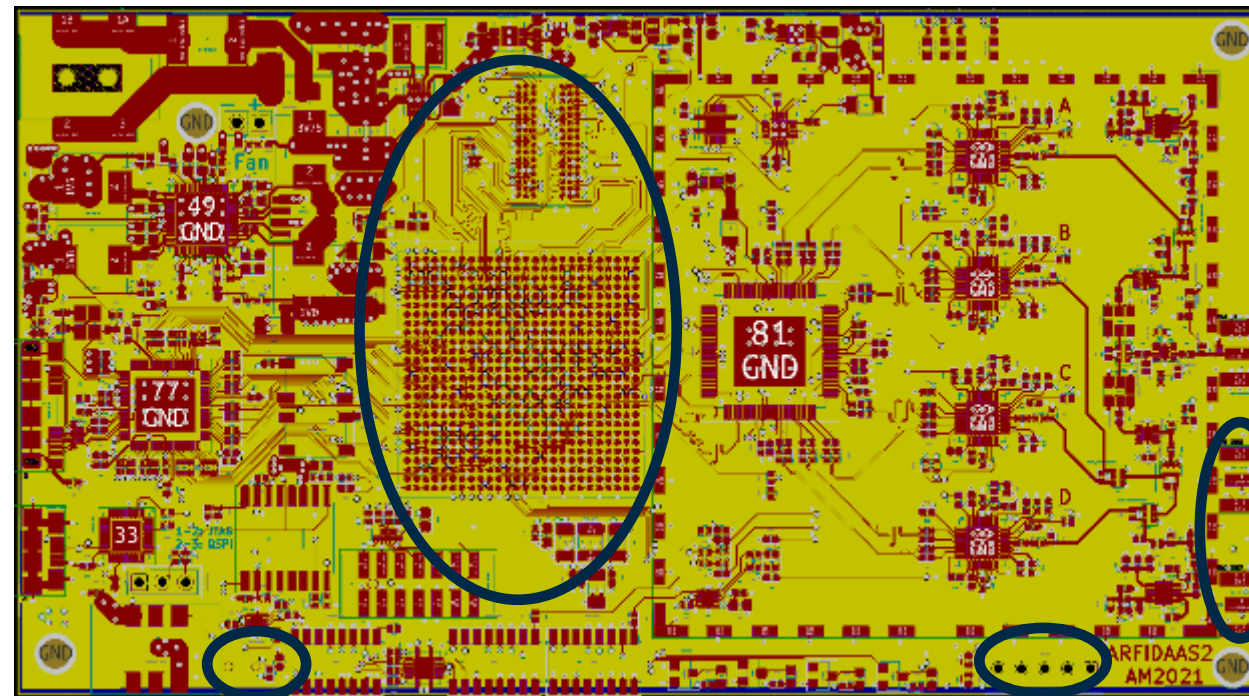
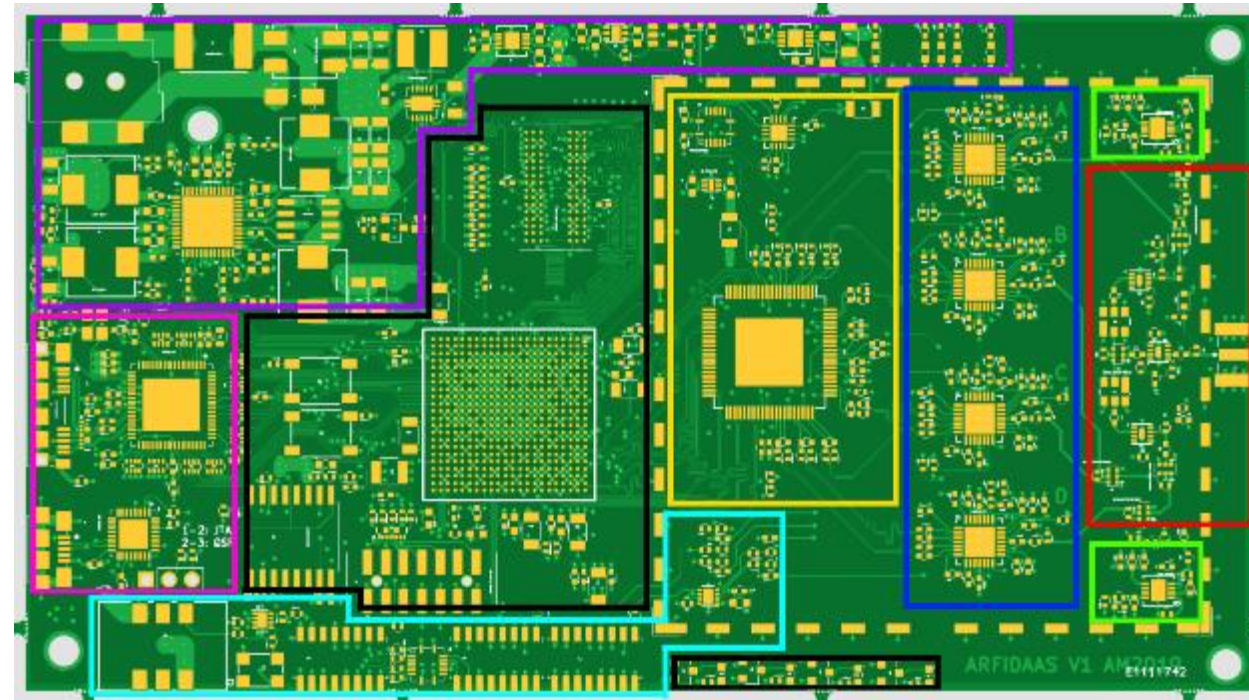
'We hacked U.S. drone': Iran claims it electronically hijacked spy aircraft's GPS and tricked aircraft into landing on its soil

By: Craig Mackenzie and Mark Duell
Updated: 10:36 EDT, 19 December 2011

Custom monitoring hardware

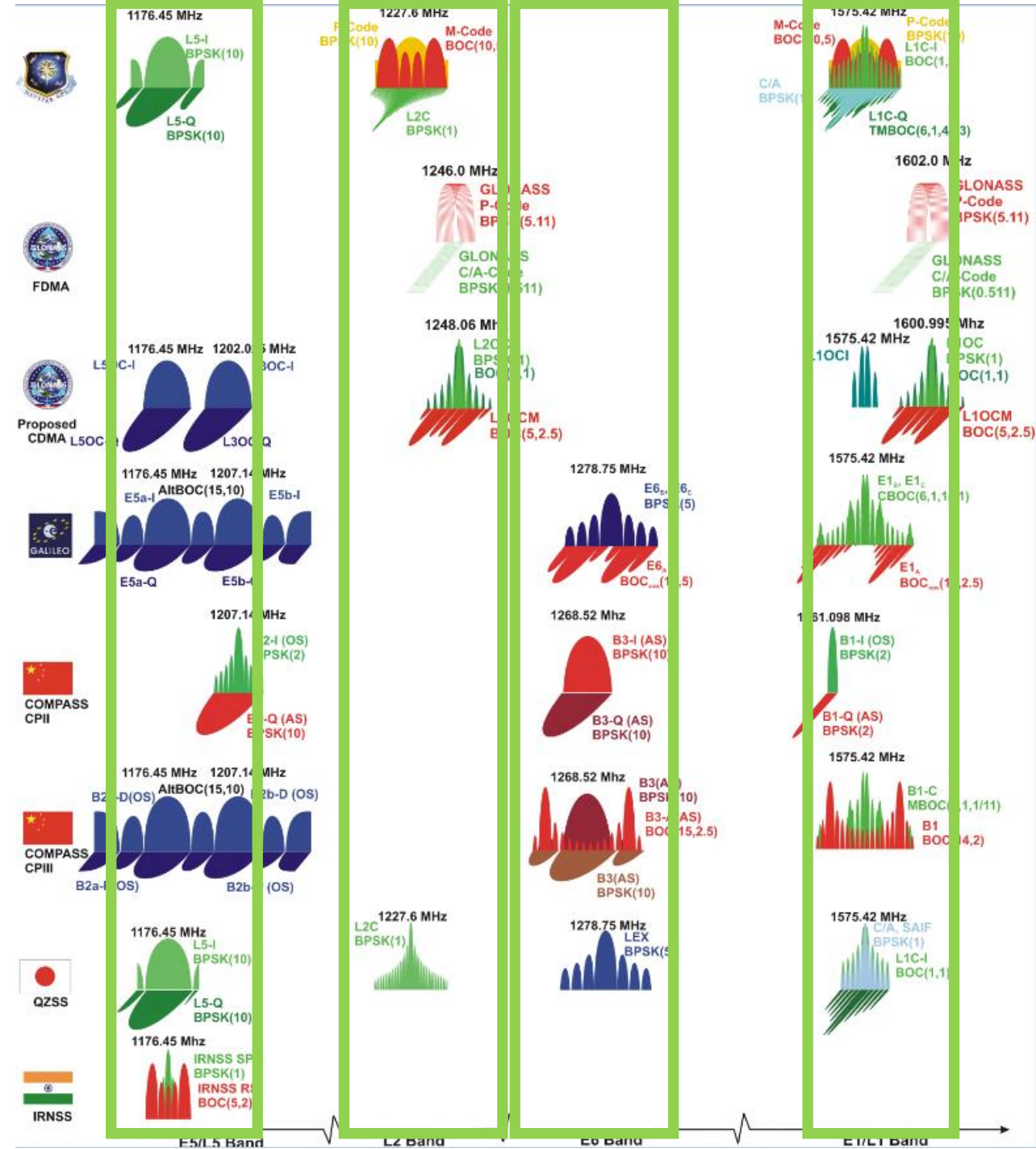
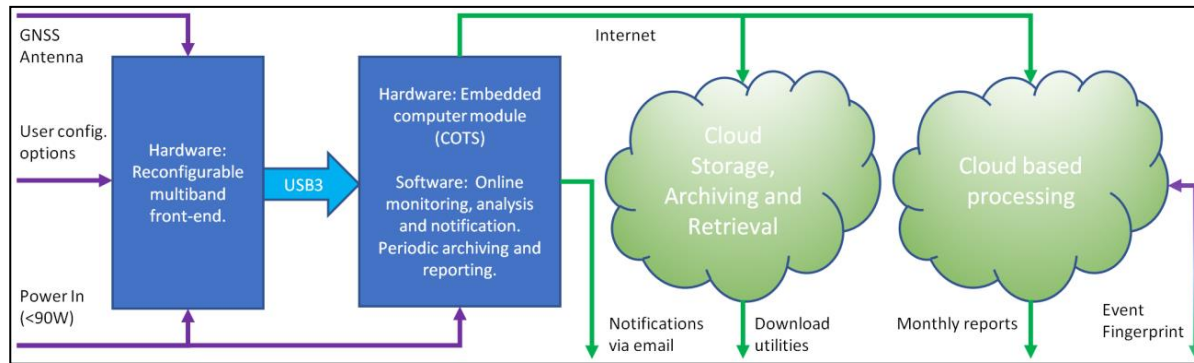
- ARFIDAAS uses custom hardware to capture events
 - Prefiltering to isolate the GNSS bands
 - In-band power measurement
 - Tunable automatic gain control
 - Low-phase noise

- What is monitored and why?



Data captured

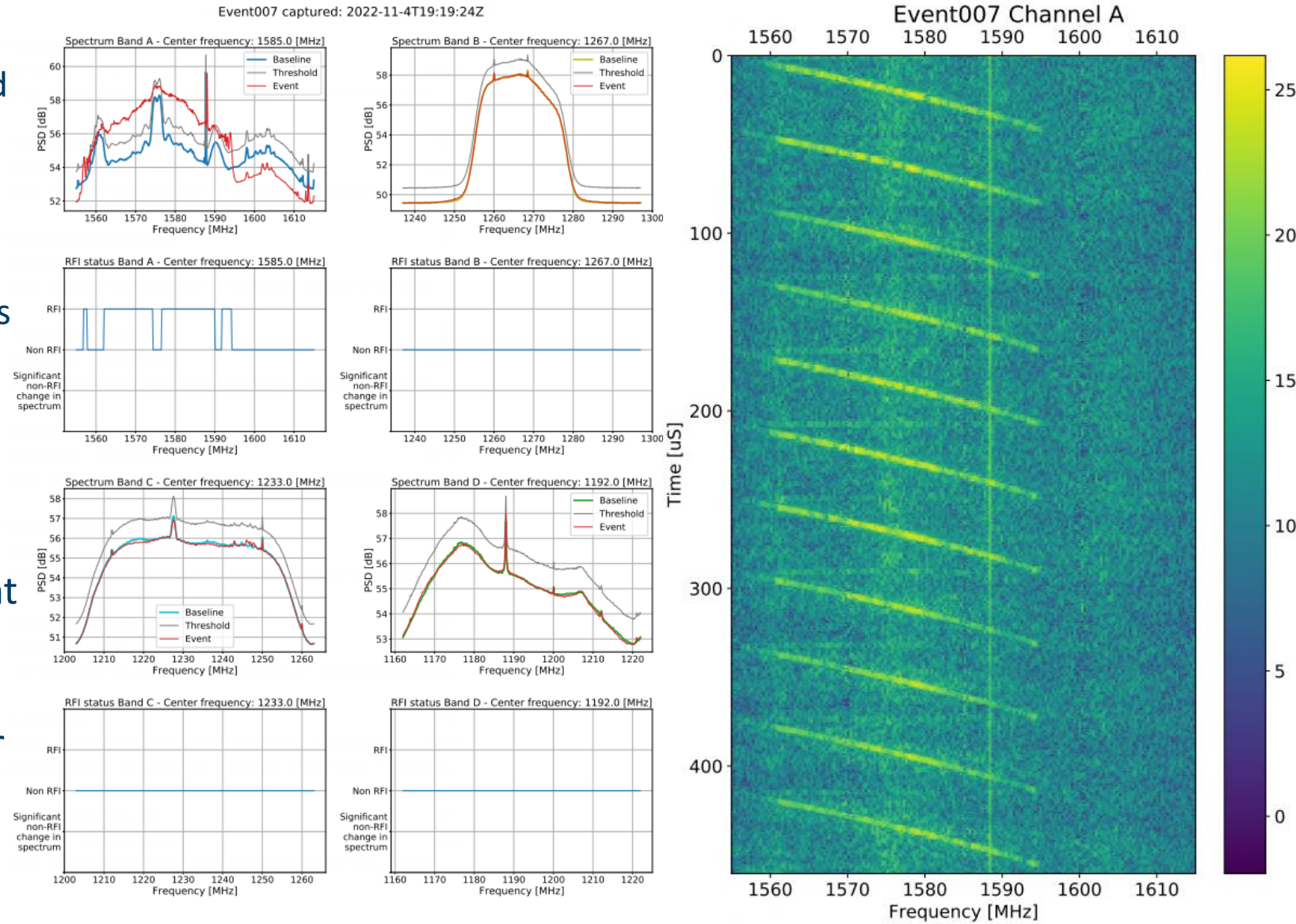
- The system monitors 220 to 280 MHz of spectrum
 - Covers all of the main lobes of all the L-band signals
 - Up to 75 MHz x4 is available, so the side-lobes of Alt-BOC can partially covered



Individual event reporting

- The user receives notification within ~30 seconds of the detection
 - The email contains spectrograms and waterfall plots
- Detection is multi-staged
 - 1) In-band power after the SAW filters
 - 2) Automatic gain control feedback state in bands
 - 3) Magnitude and duration gating
- After, the notification is sent the event is classified
 - We will talk about this more later
 - Who is jamming and why?

7



Some people are malicious, some think it's a magic bubble

- The way jammers are marketed is troubling
 - People are paranoid about tracking
 - People do not understand the legality
 - Nowhere in the marketing material does it say 'highly illegal'
 - The advertised range makes it sound like this is a 'bubble' around your car

Here is the full list of frequencies which this device is able to work with:

- GSM800 and GSM1900 in USA, GSM900 and GSM1800 in Europe
- CDMA850 in both USA and Europe
- ★ GPS L1, L2 and L5 bands, GLONASS
- WiFi, Bluetooth and all devices operating at 2.4GHz
- 3G frequency

Specifications:

- ★ Working Radius: 15 meters
- Signal Power: 1200mW



www.jammer-store.com

- Even if the 1200 mW is shared between all six bands this is > 1km range
- The propagation environment between the jammer and the victim varies widely
 - Car body can introduce up to 20dB of attenuation in some directions
 - Some jammers have adjustable power levels to compensate

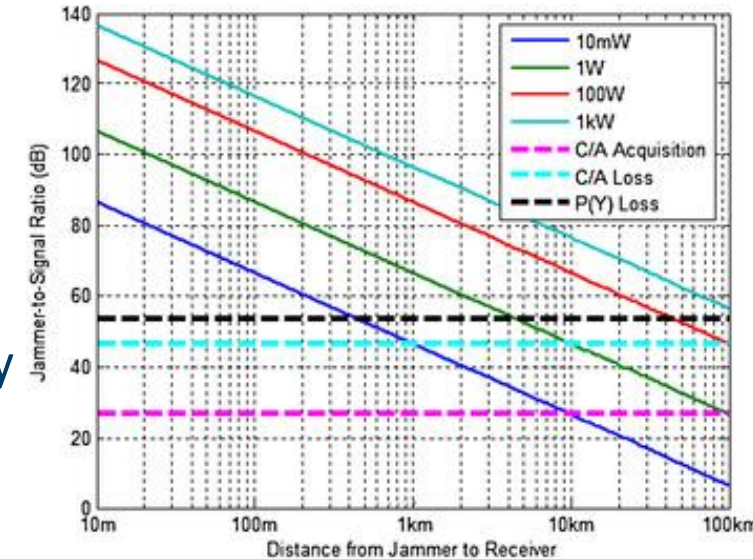
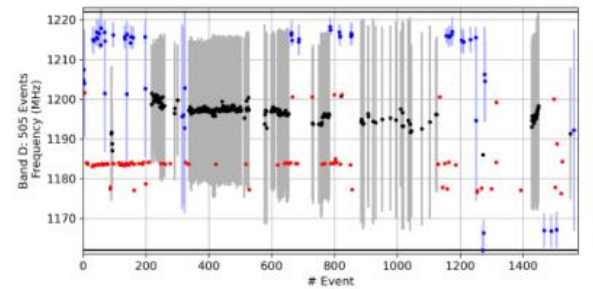
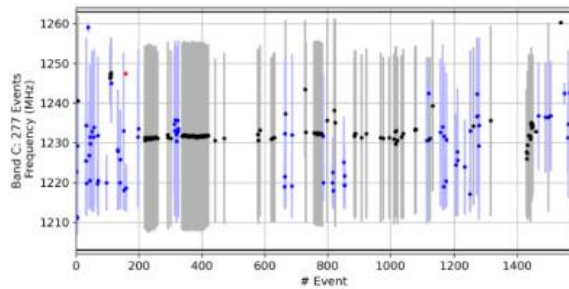
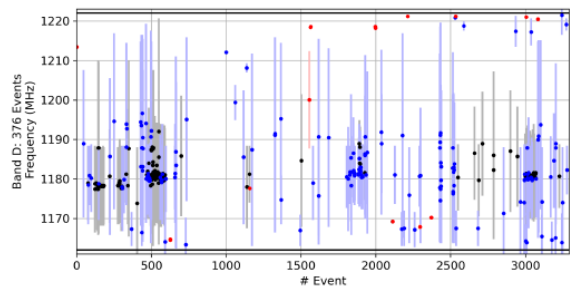
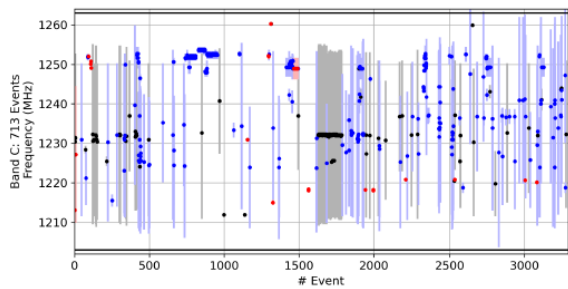
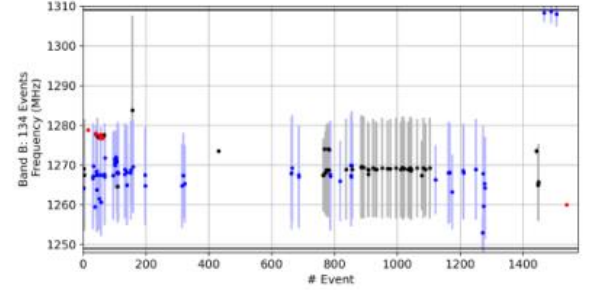
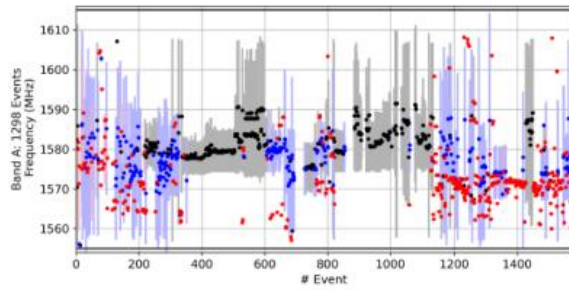
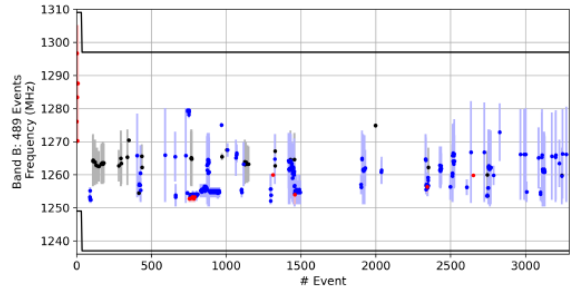
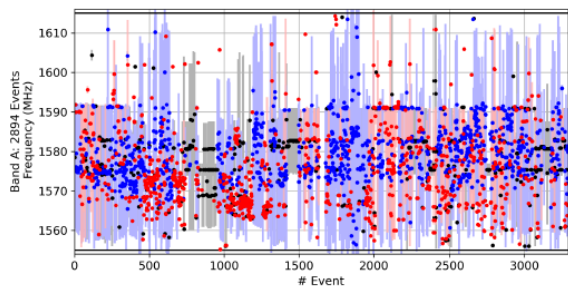
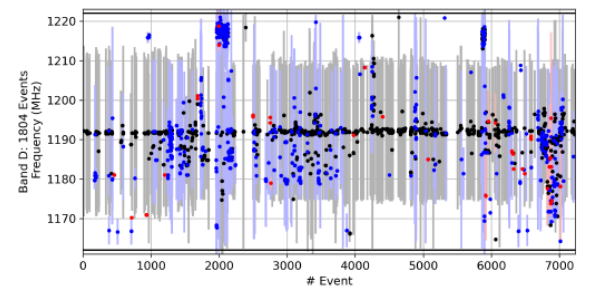
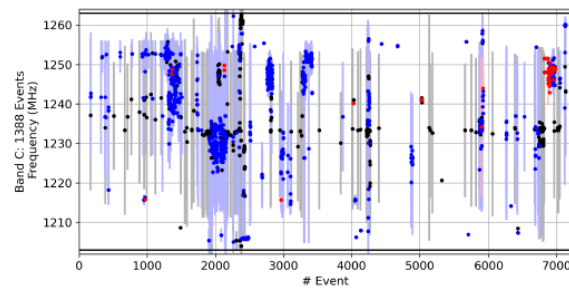
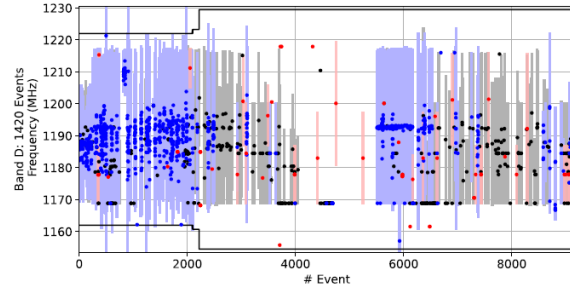
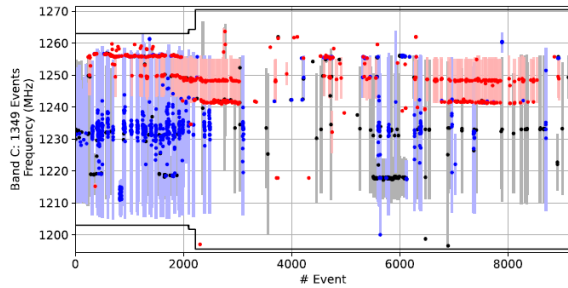
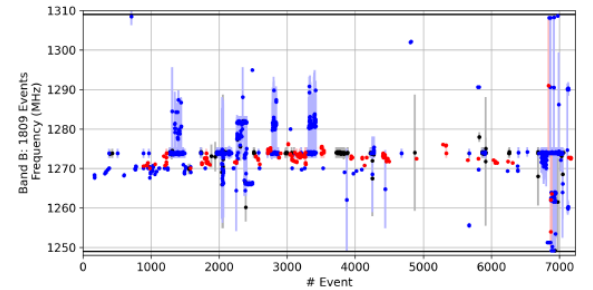
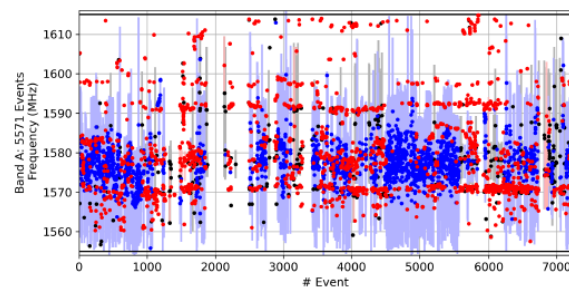
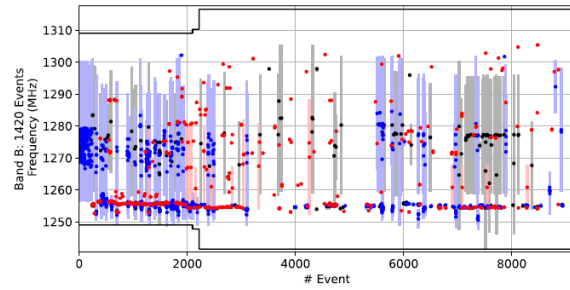
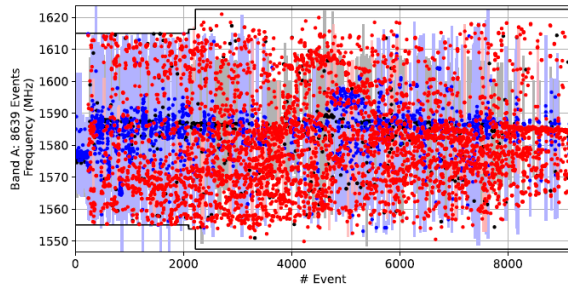


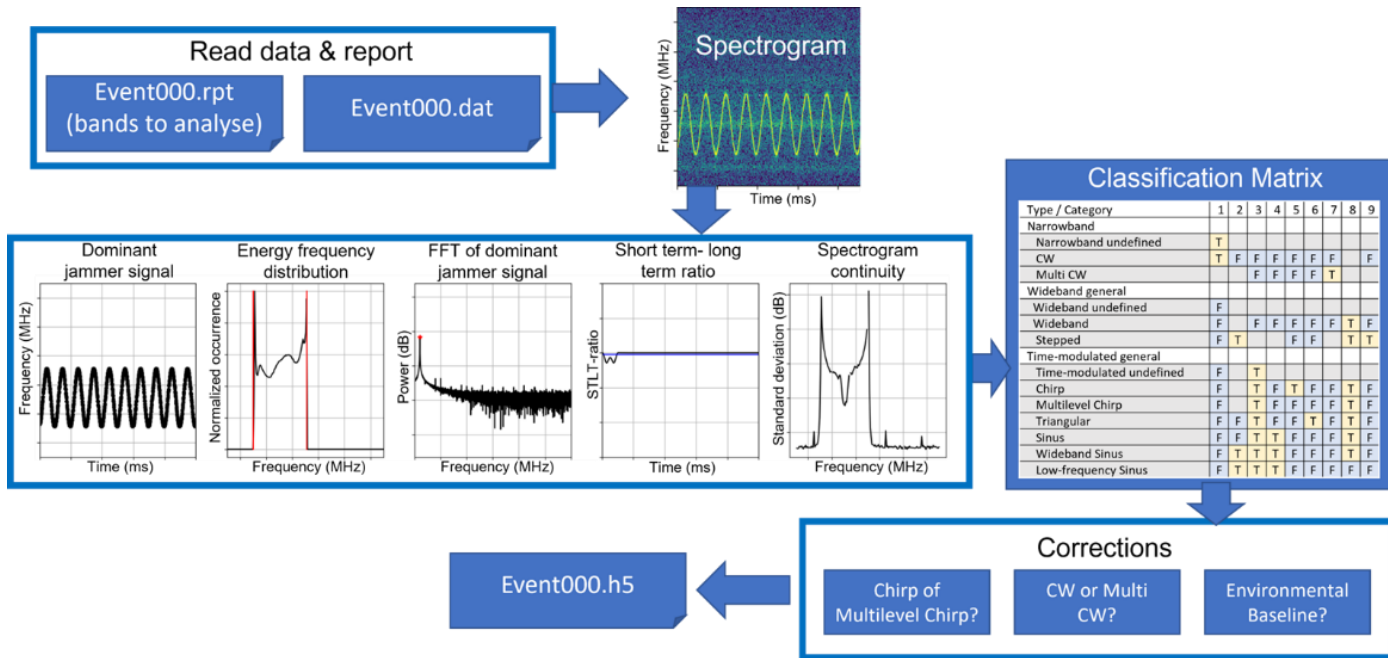
Image from Glomsvoll and Bonenberg

- It's not all intentional though...

Approximately 20000 events from four long-running stations



Classification and reporting

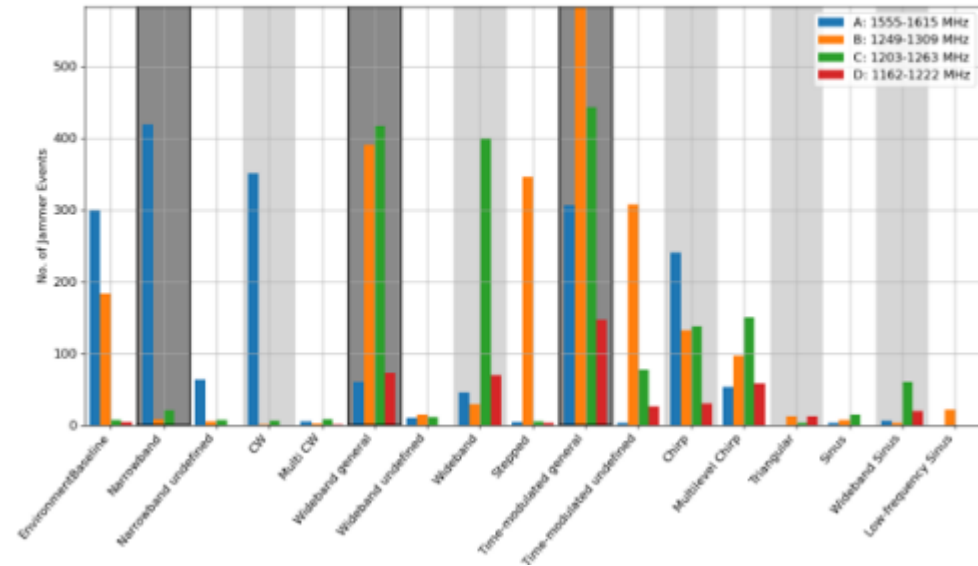


Report

Periodic statistical reporting software (SW7)

ARFIDAAS II Project

Author(s)
Anja Diez

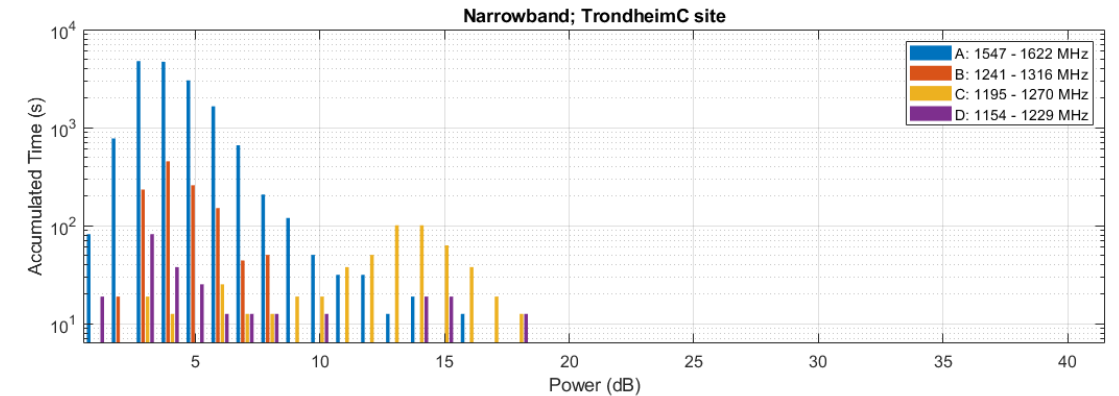
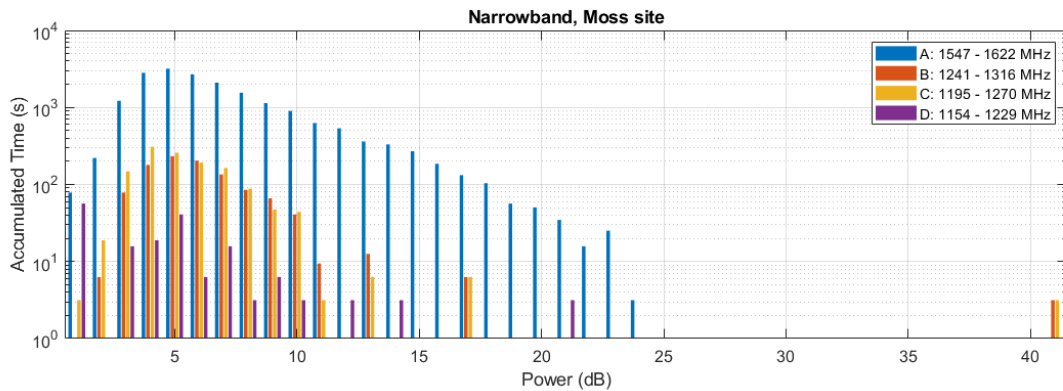
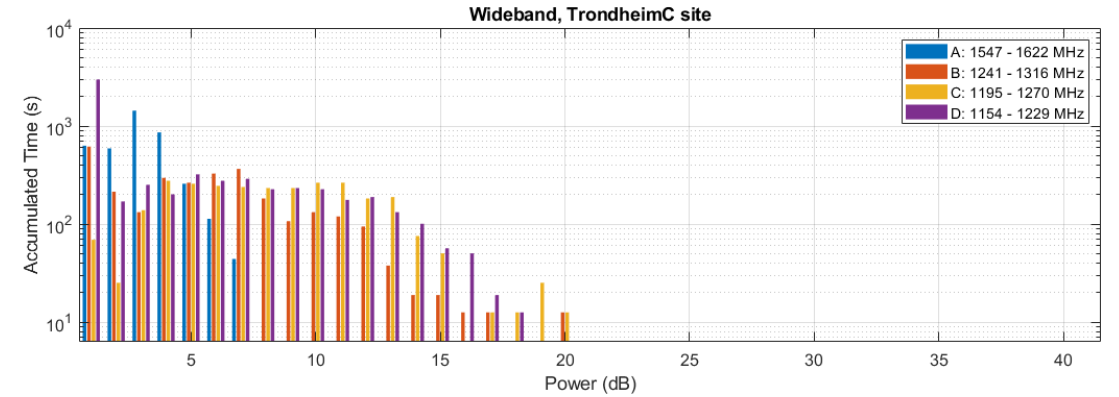
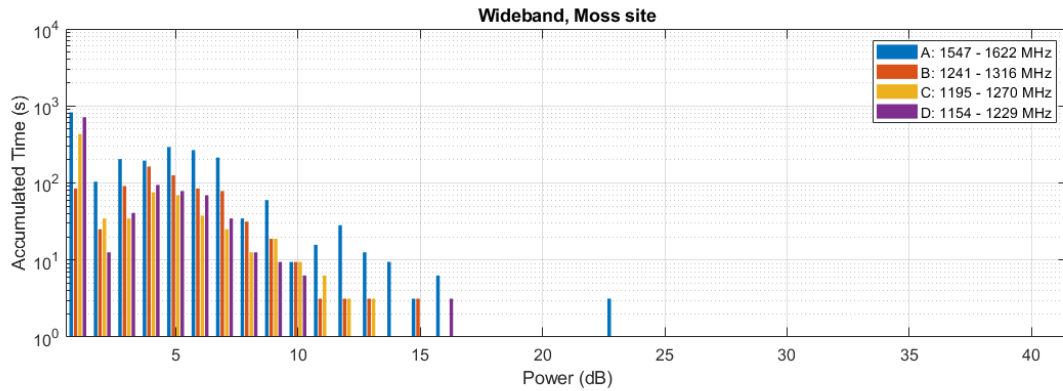
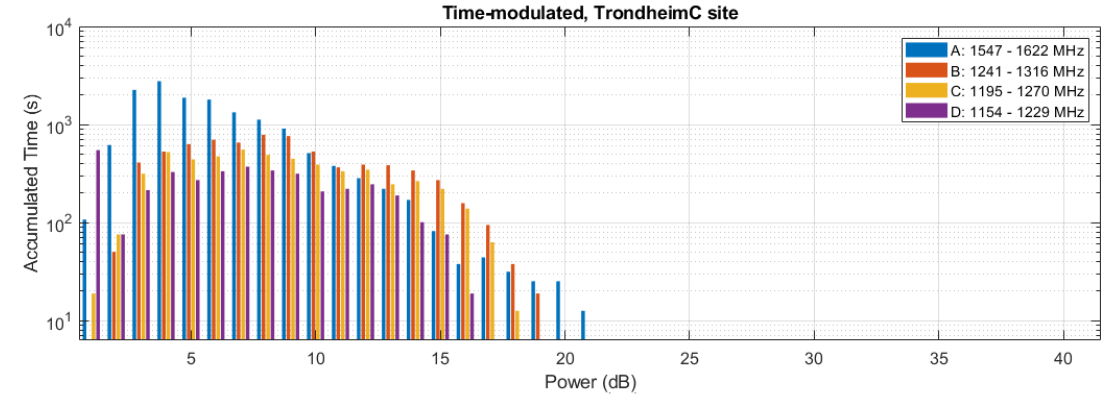
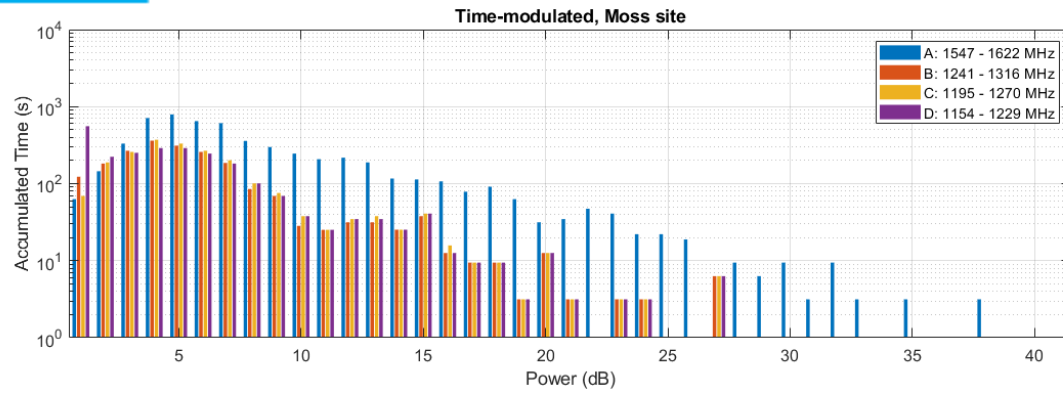


Aggregate statistics over several long running sites

Site	Dominant RFI type on band A	Dominant RFI type on band B	Dominant RFI type on band C	Dominant RFI type on band D
Moss	Narrowband	Time-modulated	Time-modulated	Time-modulated
Trondheim	Narrowband	Time-modulated	Time-modulated	Time-modulated
Trondheim B	Baseline/ Time-modulated	Time-modulated/ Wideband/Baseline	Time-modulated	Time-modulated
Trondheim C	Narrowband/ Time-modulated	Time-modulated	Time-modulated	Wideband/ Time-modulated
Asker	Wideband/Narrowband	Time-modulated/ Wideband	Wideband	Wideband
Amsterdam	Time-modulated/ Narrowband/ Wideband	Time-modulated	Time-modulated	Wideband/ Time-modulated

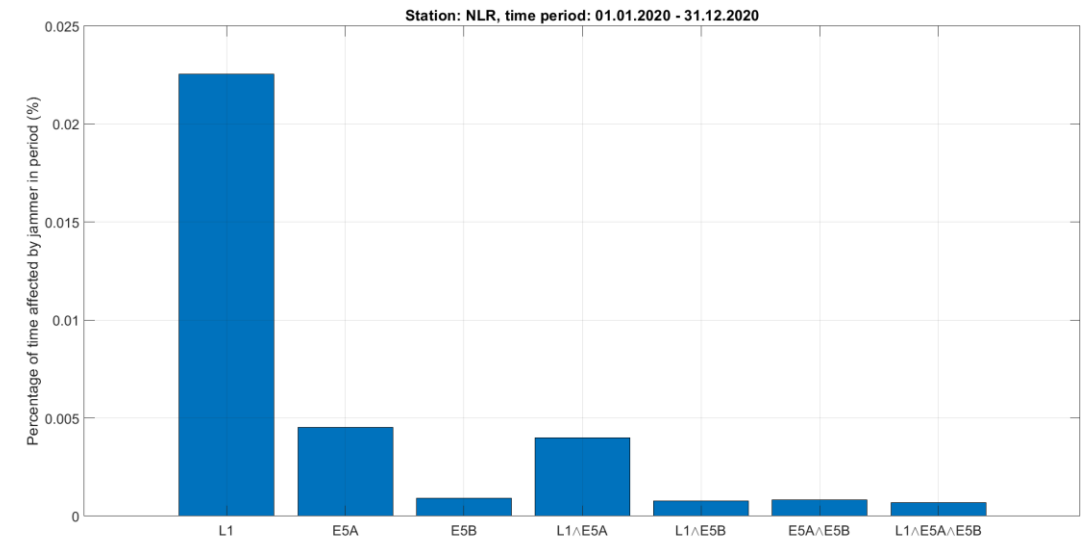
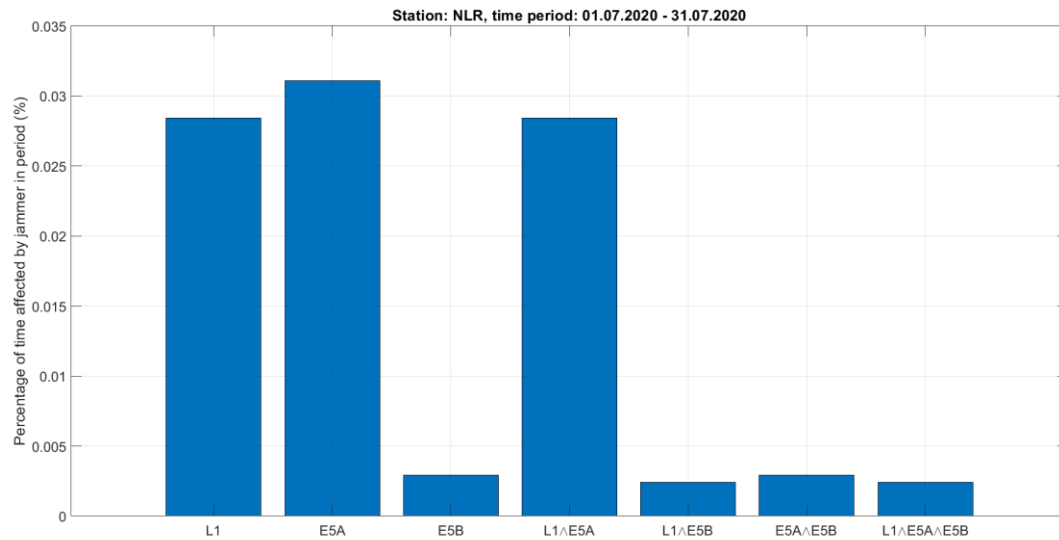
			Average RFI presence per day (sec)				
Site	Days of observation	Total number of events	All bands accumulated	A	B	C	D
Moss	466	13361	58.7	57.0	9.8	9.1	10.1
Trondheim	890	10445	24.0	18.1	12.8	9.8	4.3
Trondheim B	730	6808	14.6	9.9	3.4	10.0	9.7
Trondheim C	911	11372	47.2	36.7	14.8	9.6	13.5
Asker	521	2469	16.6	15.2	1.8	5.1	5.8
Amsterdam	713	4881	26.9	26.1	4.3	6.4	3.8
Total	4231	49336					
Un-weighted Average			31.3	27.2	7.8	8.3	7.9

Comparison of power level distributions between sites

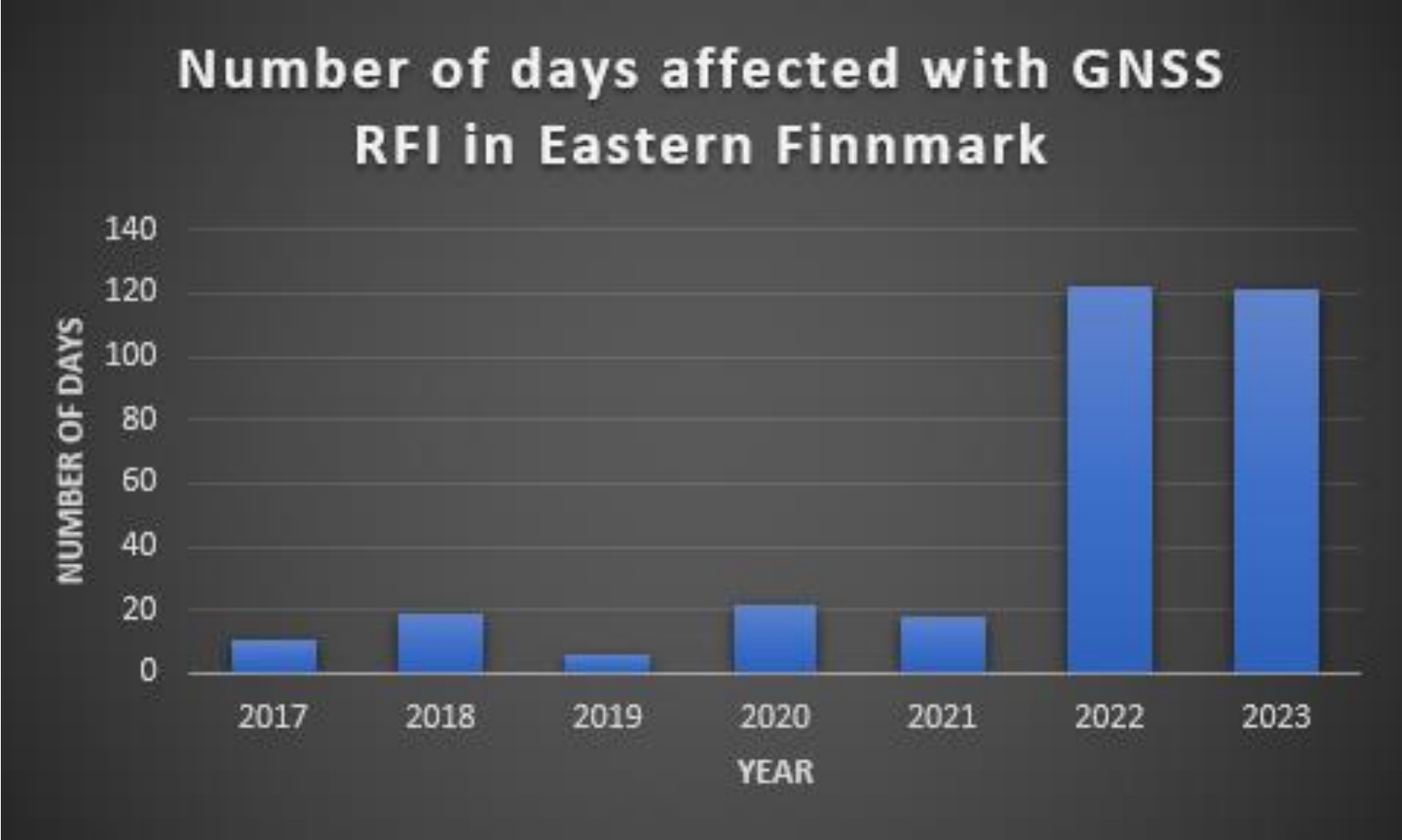


Data period 2019-2023

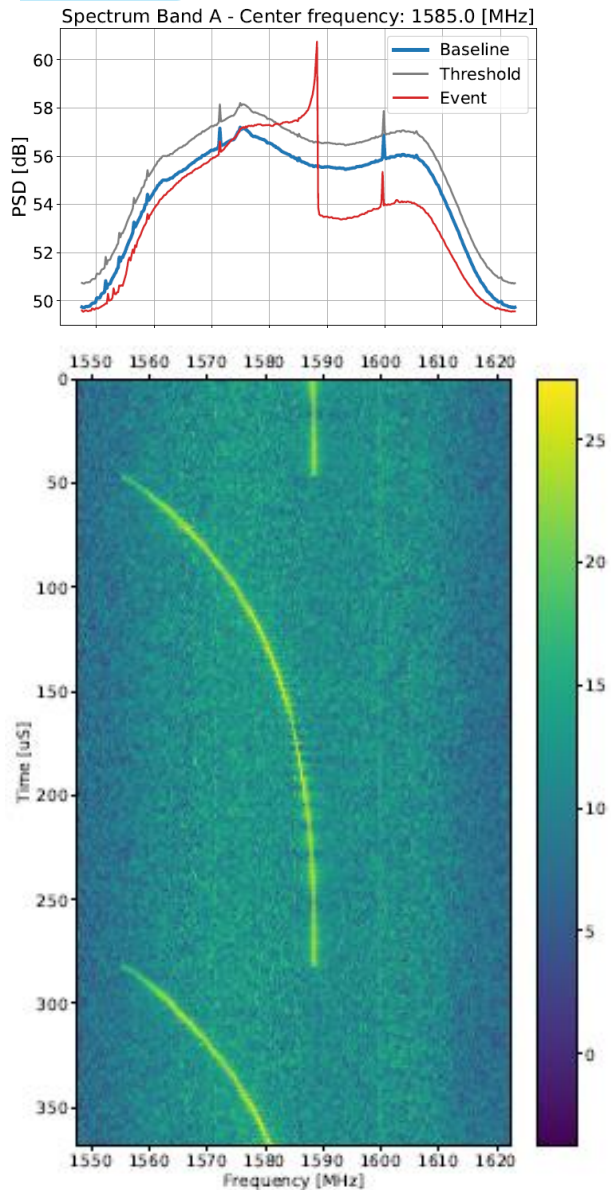
- Sites are still being activated in 2023 and others shut down
- Long segments of common observation periods most common in 2020-2021
 - Trivia test: What event might have caused changes to road use patterns in this time period?
 - A second opinion in the hunt for trends?



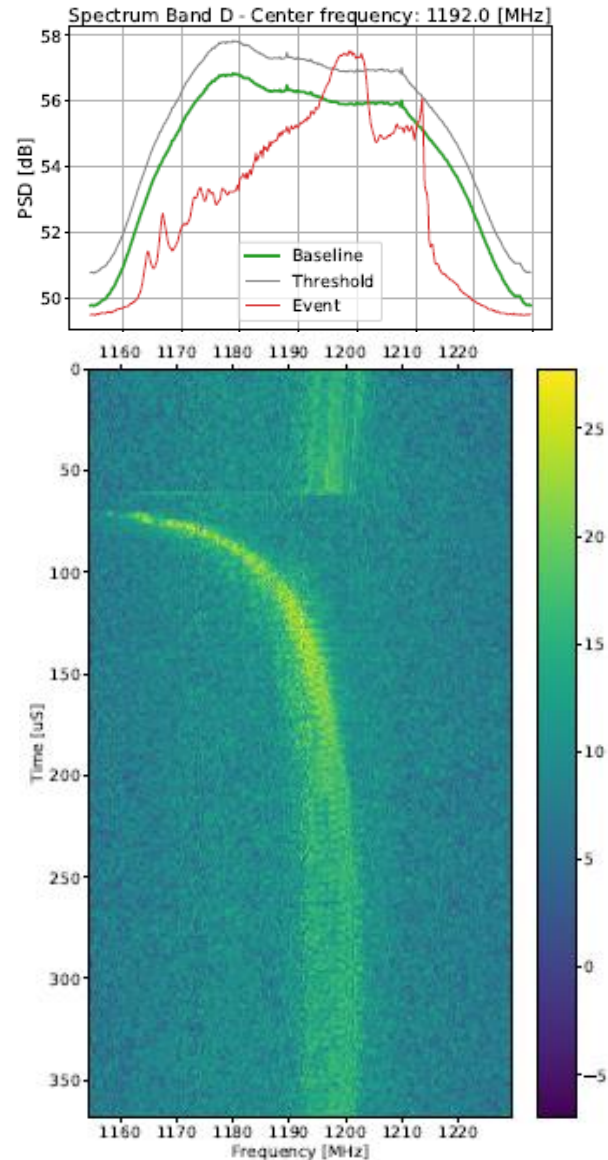
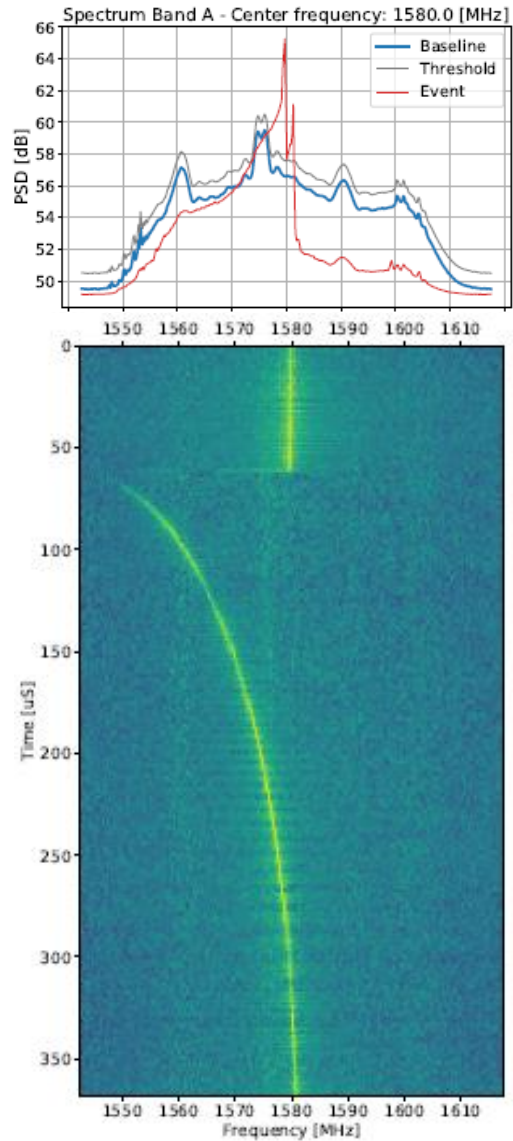
Other data shows clear trends



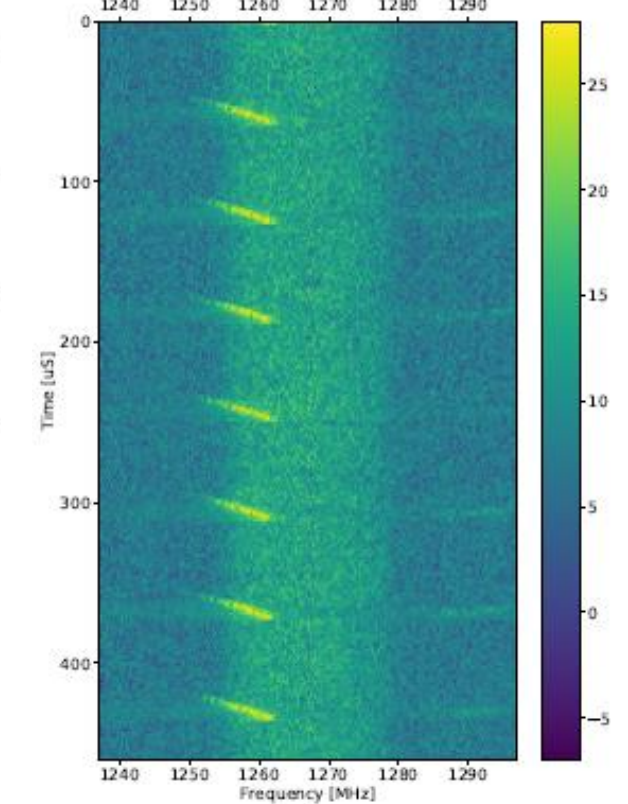
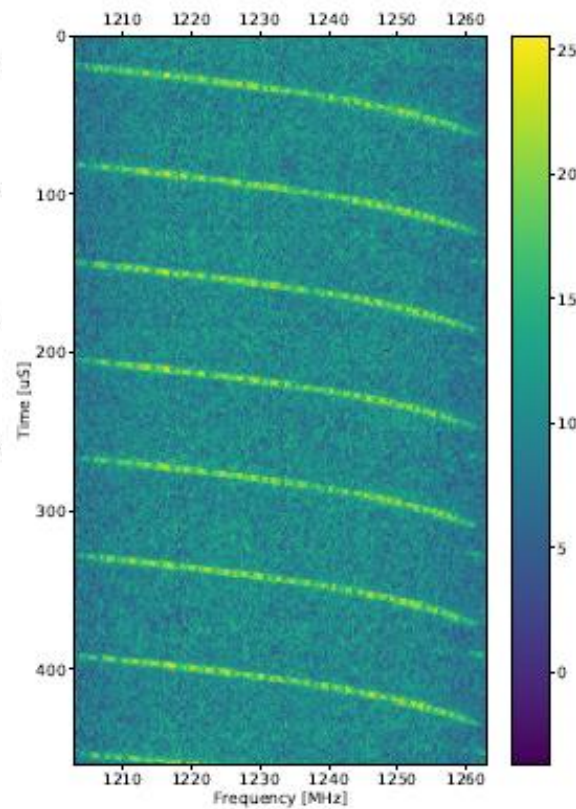
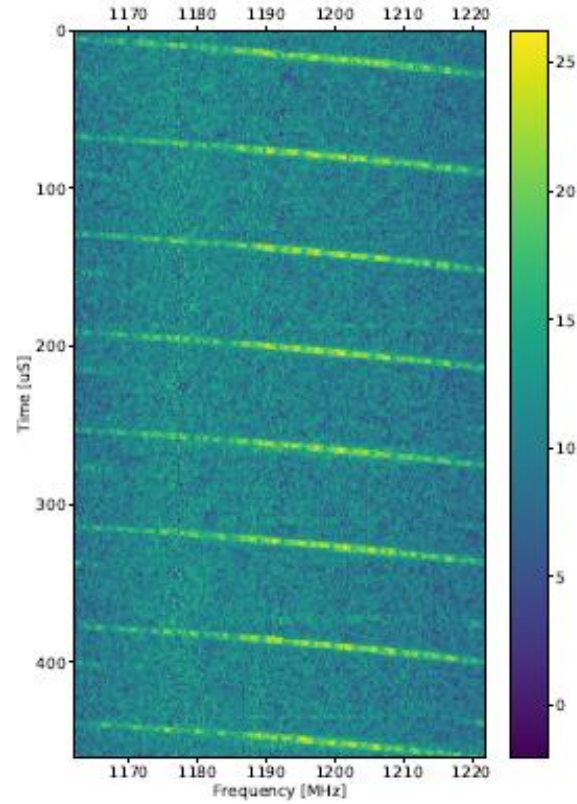
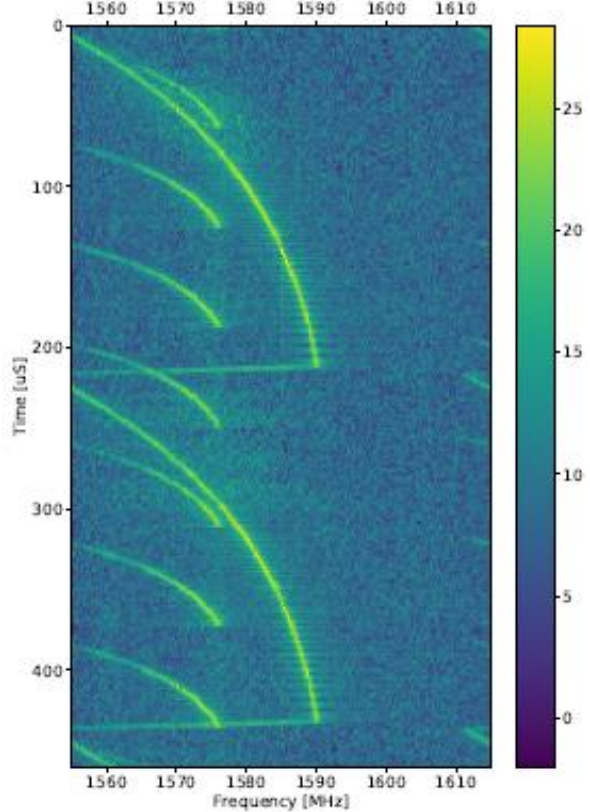
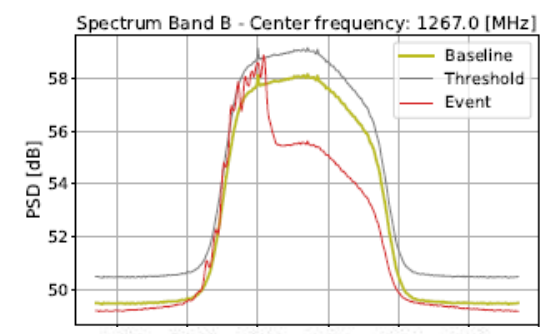
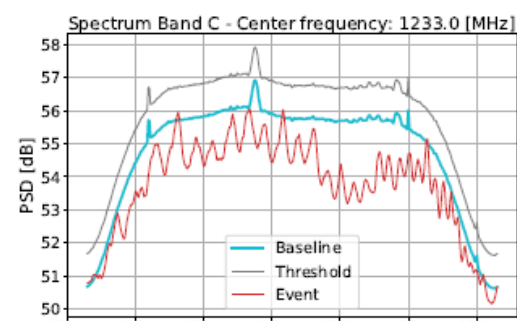
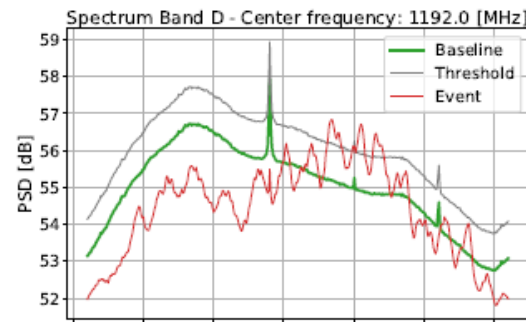
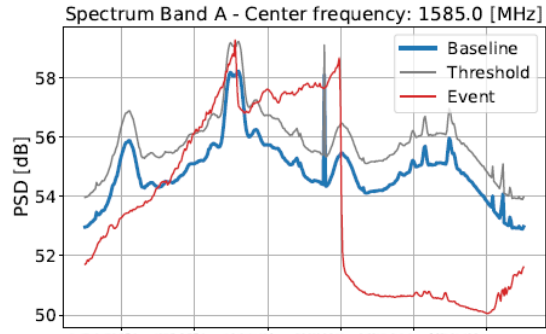
Signs of signal evolution – 1 of 3



Signs of signal evolution – 2 of 3

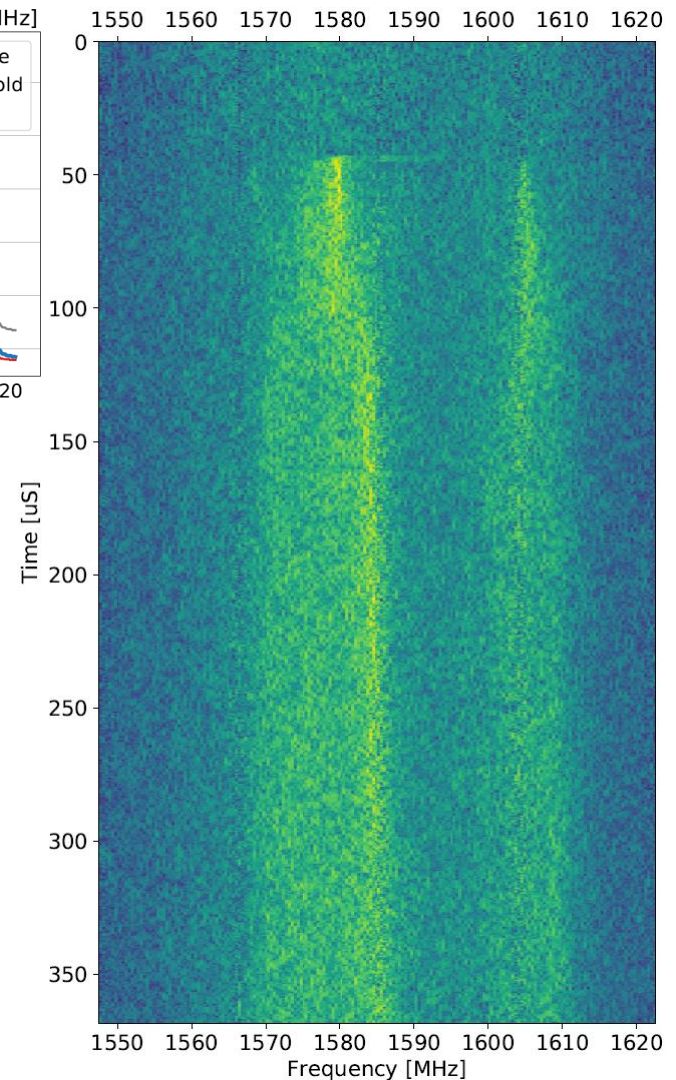
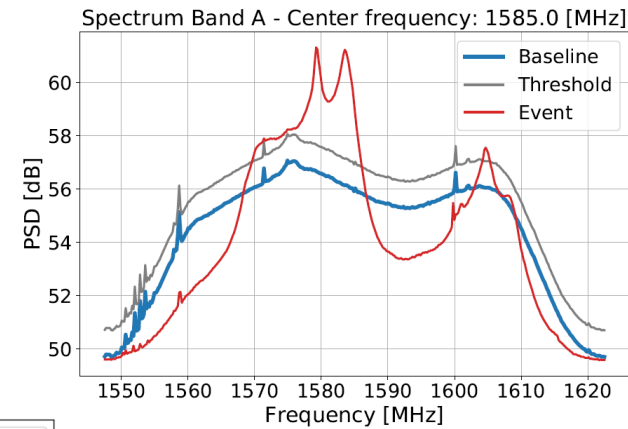
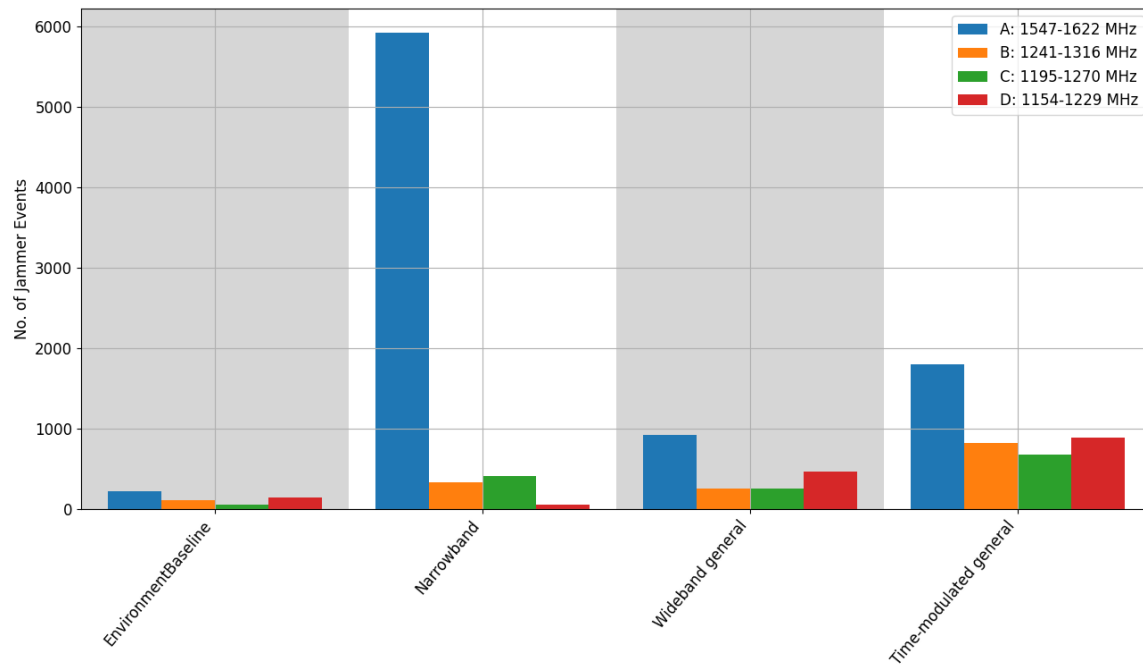


Signs of signal evolution – 3 of 3



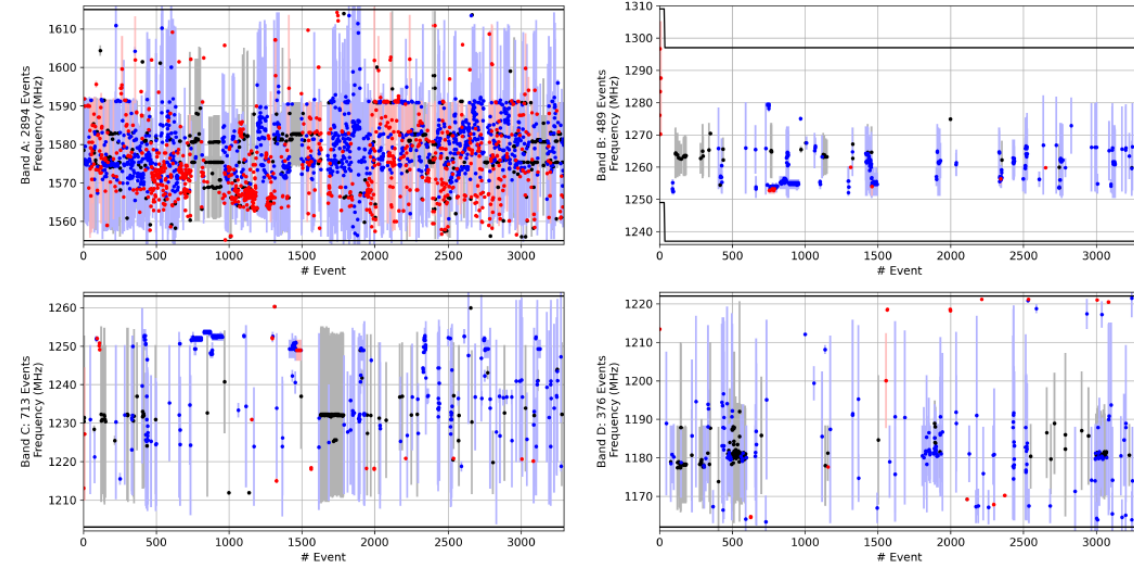
How common is spoofing?

- Non-stationary distribution of RFI
 - Activation and stabilization?
 - Coincidentally Targets L1/E1 and G1
 - Could this be spoofing?
- Reasons to suspect other Environment Baseline events



Predictions for the future and conclusions

- Narrowband events could proliferate in the L2 and E5 bands
- Cat-and-mouse game between mitigations and jammers
- The good news: RFI presently not threatening basic uses
- The bad news: RFI at these levels is already a serious concern for sensitive applications



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Amsterdam	Time-modulated/ Narrowband/ Wideband	Time-modulated	Time-modulated	Wideband/ Time-modulated

Thank you for your attention!



Teknologi for et bedre samfunn