SWEPOS GNSS SIGNAL DISTURBANCE MONITORING

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NKG working group for GNSS positioning
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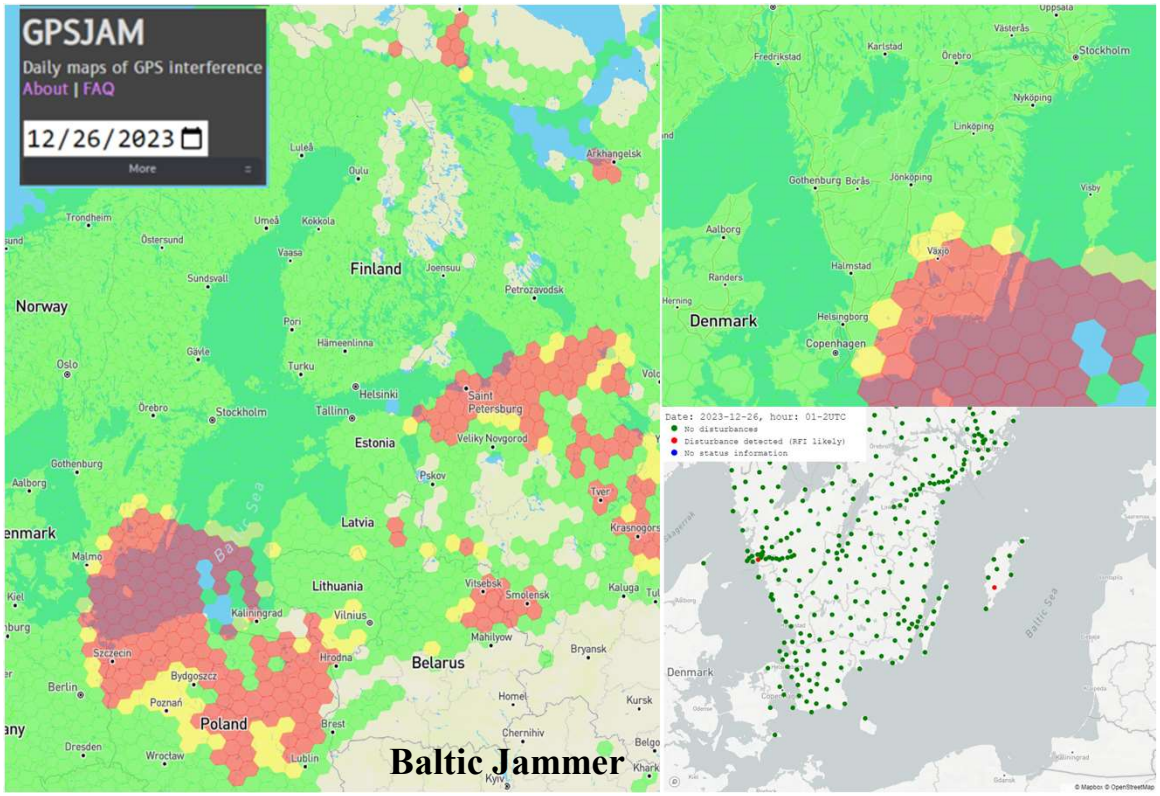
LANTMÄTERIET

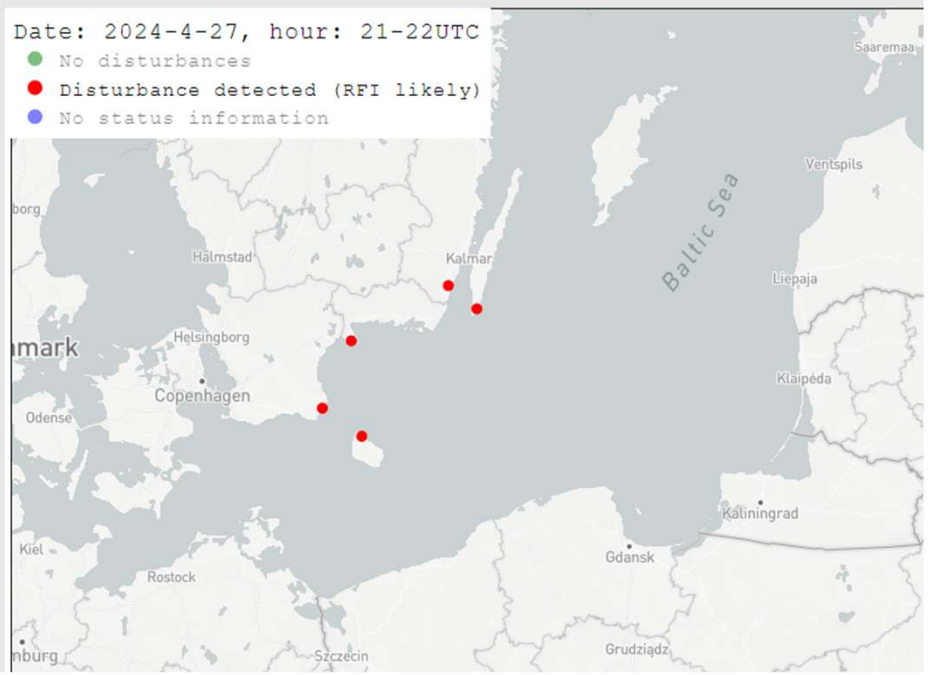
Motivation

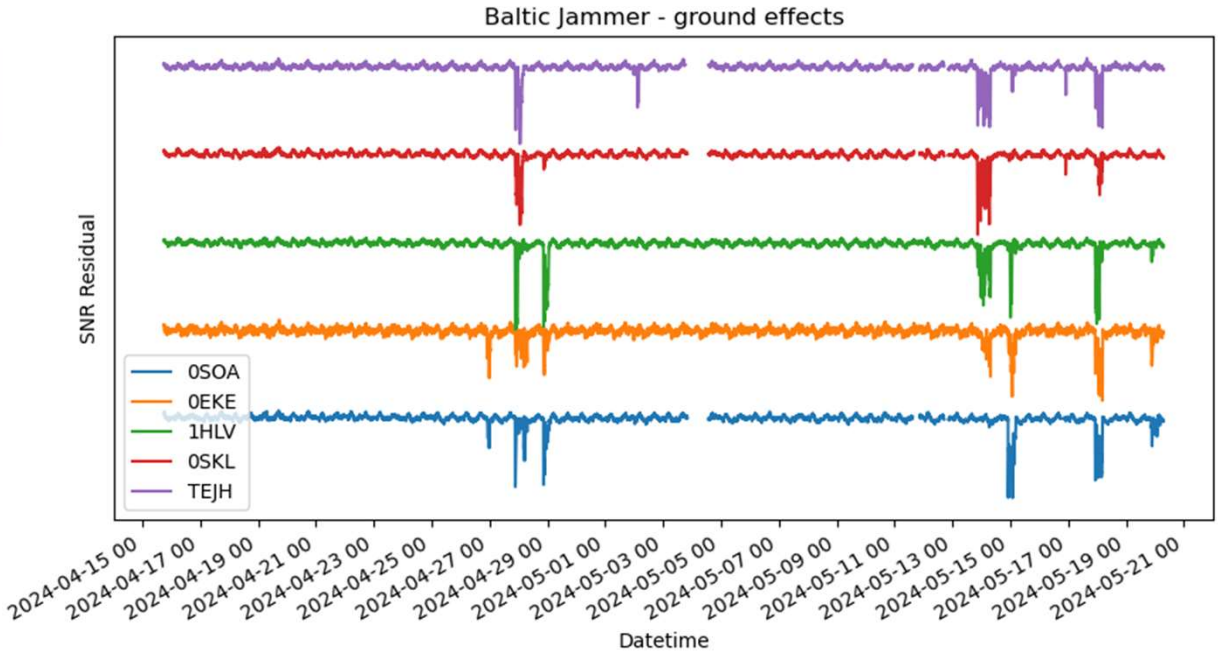
- Part of SWEPOS data quality check
- Increased jamming and spoofing events globally
  - International interference is increasing
  - Spoofing 500% increase in 2024
  - Some systems do not easily recover
  - Some erroneously report recovery
- Situational awareness is a cornerstone to resilience
  - GNSS interference detection and monitoring using existing infrastructure such as SWEPOS
  - ADS-B (Automatic Dependent Surveillance-Broadcast) GNSS signal situational awarenes
  - There is more interest in using maritime AIS (Automatic Identification System) data



Baltic jammer – ground effects

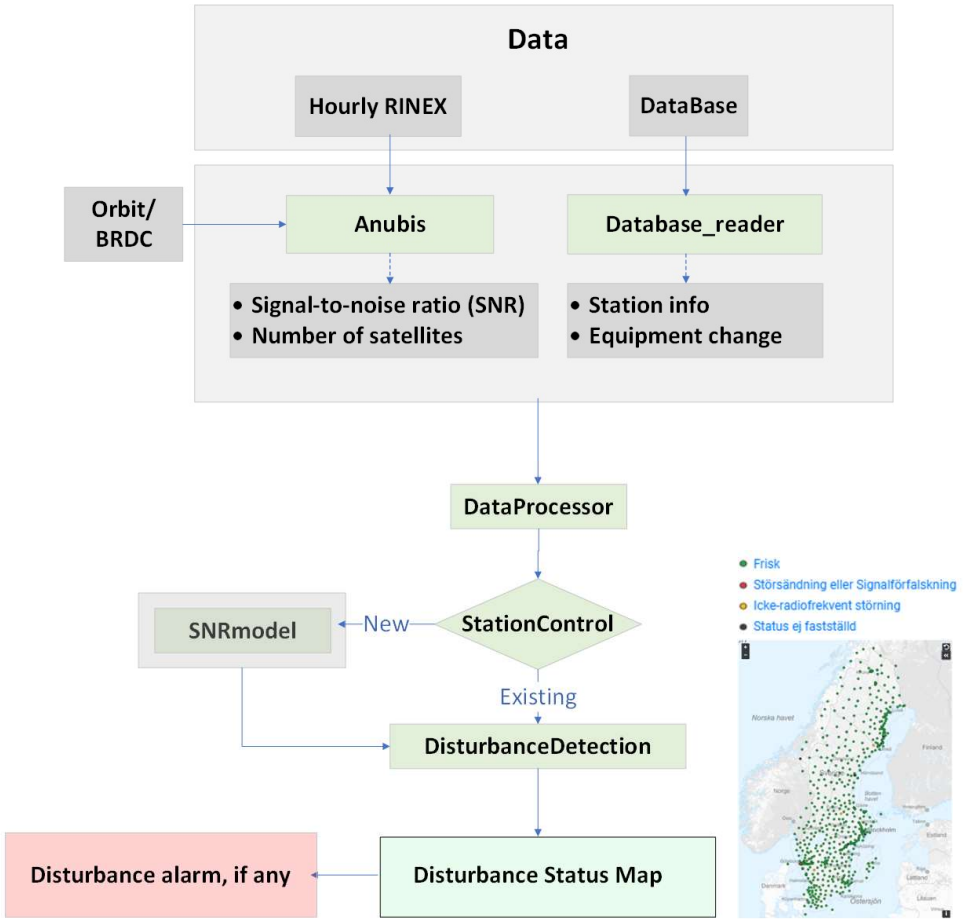
- Affects L1 band
- Interference central frequencies: 1561, 1575 och 1603 MHz



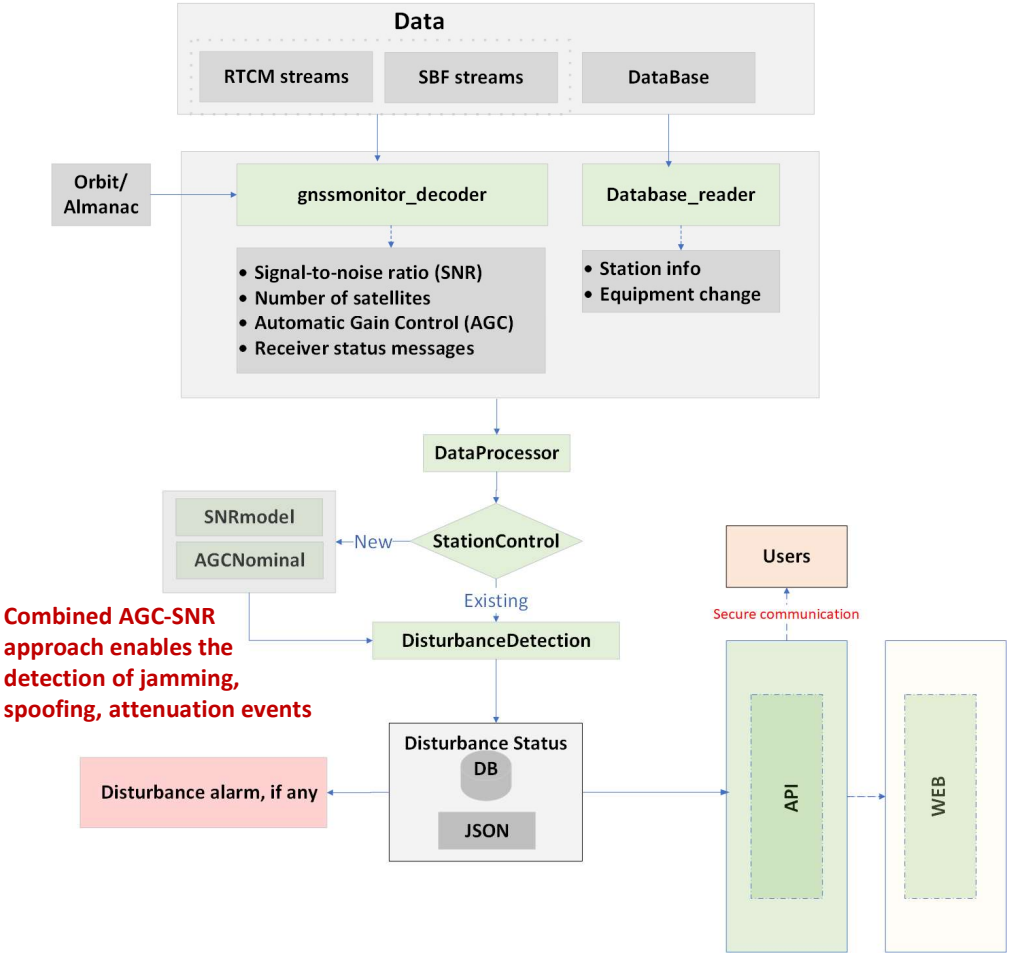


- First recorded event: April 27, 2024
- Last recorded event: July 22, 2024

Now: Near-real time monitoring

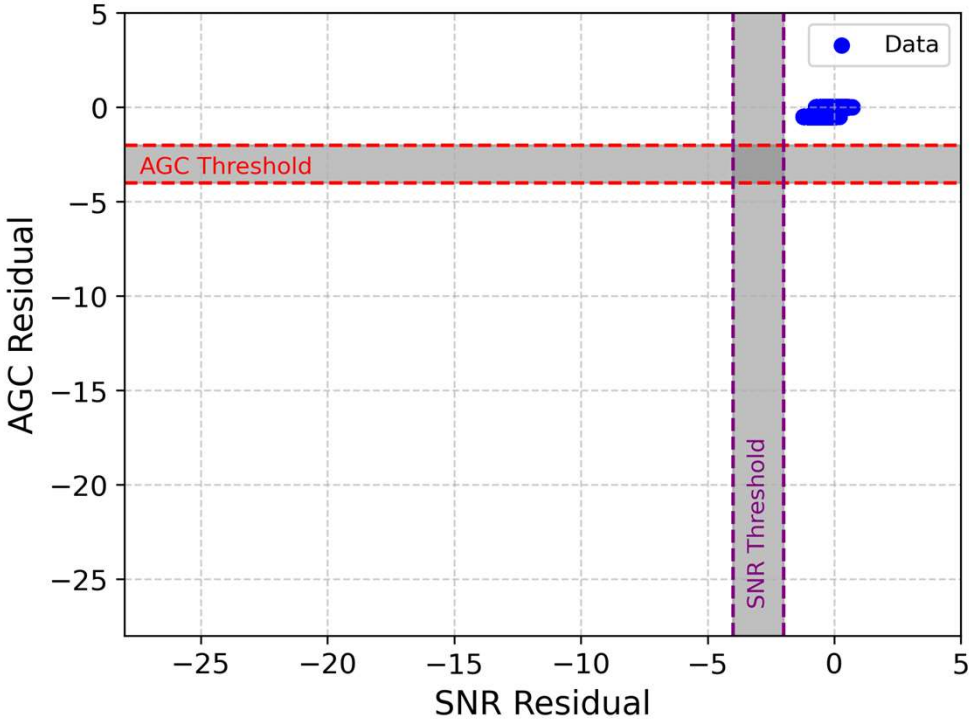


Next: Real time monitoring



Combined AGC-SNR approach for GNSS signal interference detection

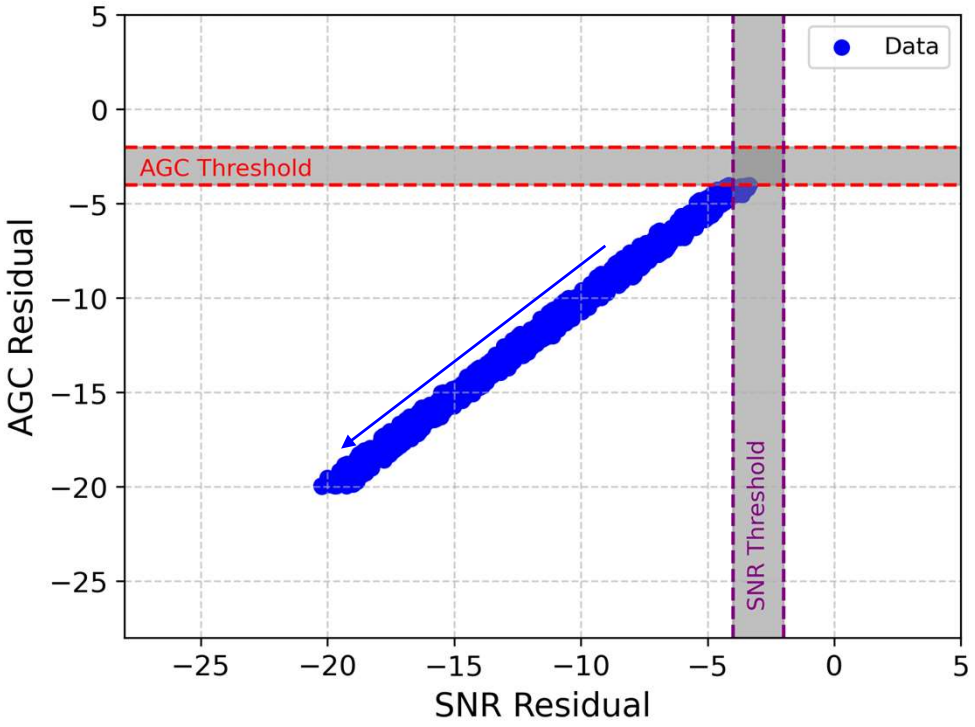
Jammer-Spoofer-Attenuation (JSA) zone



- Nominal
  - Interference free

Combined AGC-SNR approach for GNSS signal interference detection

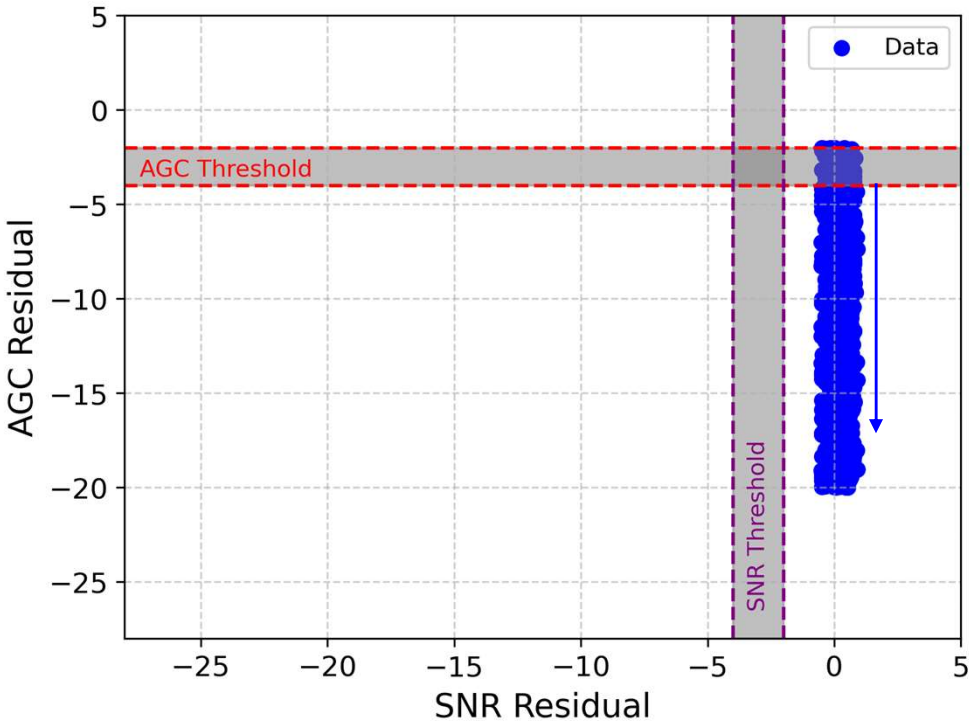
Jammer-Spoofer-Attenuation (JSA) zone



- Nominal
  - Interference free
- Jamming
  - SNR and AGC drops

Combined AGC-SNR approach for GNSS signal interference detection

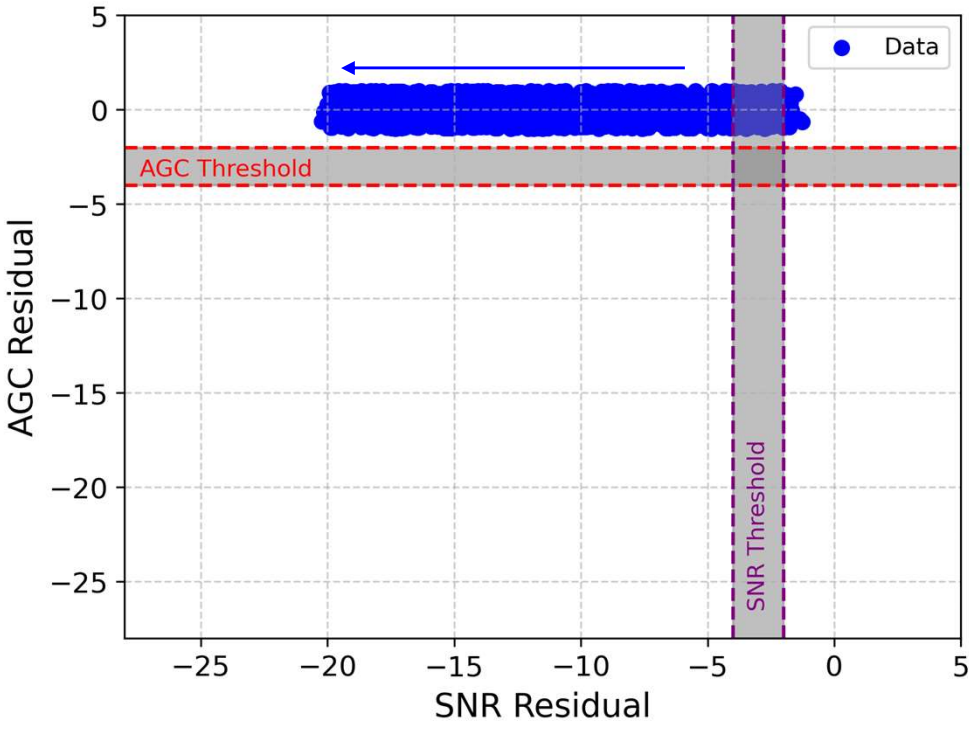
Jammer-Spoofer-Attenuation (JSA) zone



- Nominal
  - Interference free
- Jamming
  - SNR and AGC drops
- Spoofing
  - AGC drops
  - SNR increases or remains the same

Combined AGC-SNR approach for GNSS signal interference detection

Jammer-Spoofer-Attenuation (JSA) zone



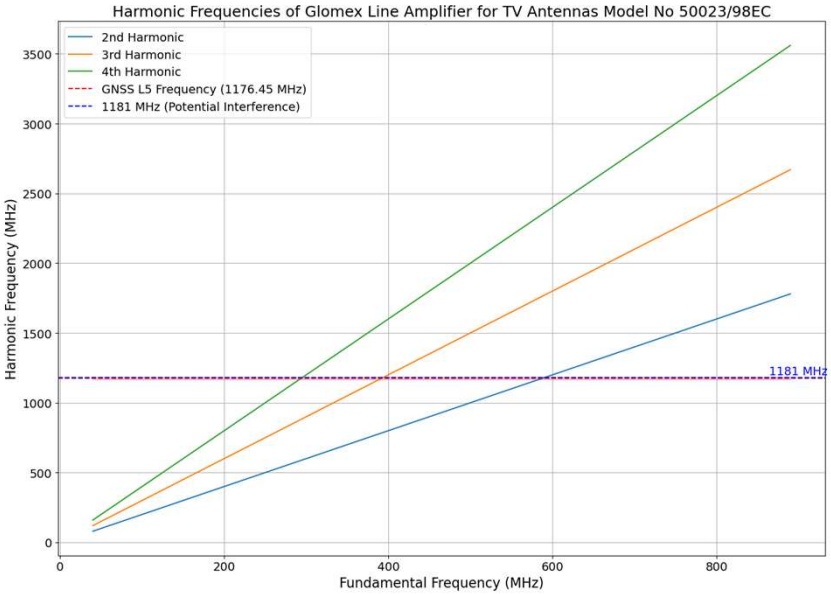
Computer Generated data

- Nominal
  - Interference free
- Jamming
  - SNR and AGC drops
- Spoofing
  - AGC drops
  - SNR increases or remains the same
- Signal attenuation – leads to poor signal
  - AGC remains the same
  - SNR may drop
  - Signal attenuation
    - Tree foliage, snow, ionospheric scinitllations?
- Faulty equipment (e.g., Antenna/Splitter/Cable problems?)
  - Show different behavior

Actual disturbance at a SWEPOS station – 0GIS, type – RFI

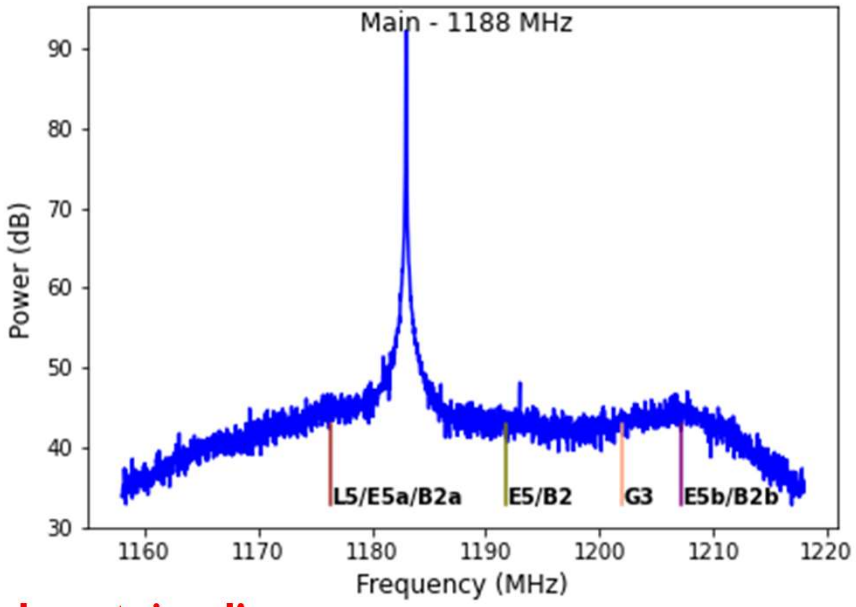
Source - TV antenna amplifier on a boat

- GLOMEX 50023/98EC amplifier
- Adjusts antenna gain
- Operating frequency far from GNSS – Harmonics is likely cause



Effect – L5 band

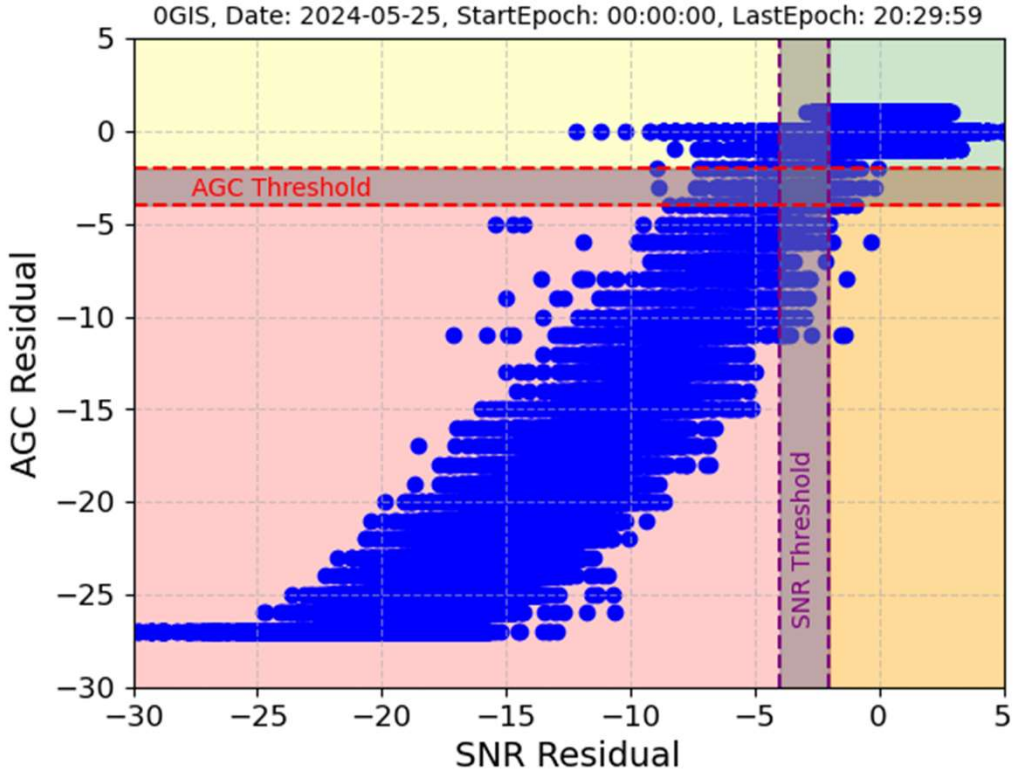
- GPS, GAL, BDS affected
- RFI centered at 1181(2nd harmonics of 590.5 MHz)

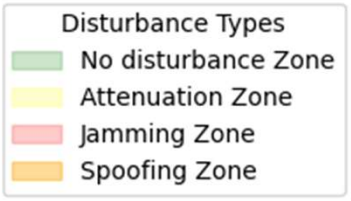


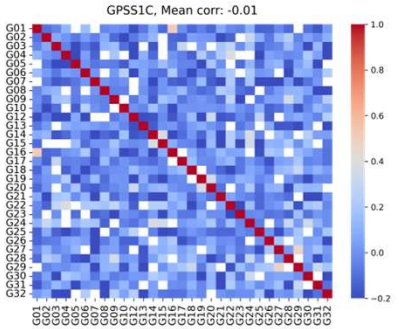
Source located and contained!

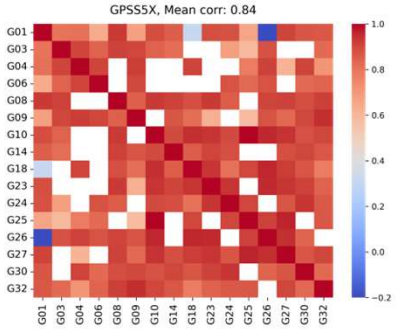
Actual disturbance at a SWEPOS station – 0GIS

AGC-SNR combined approach





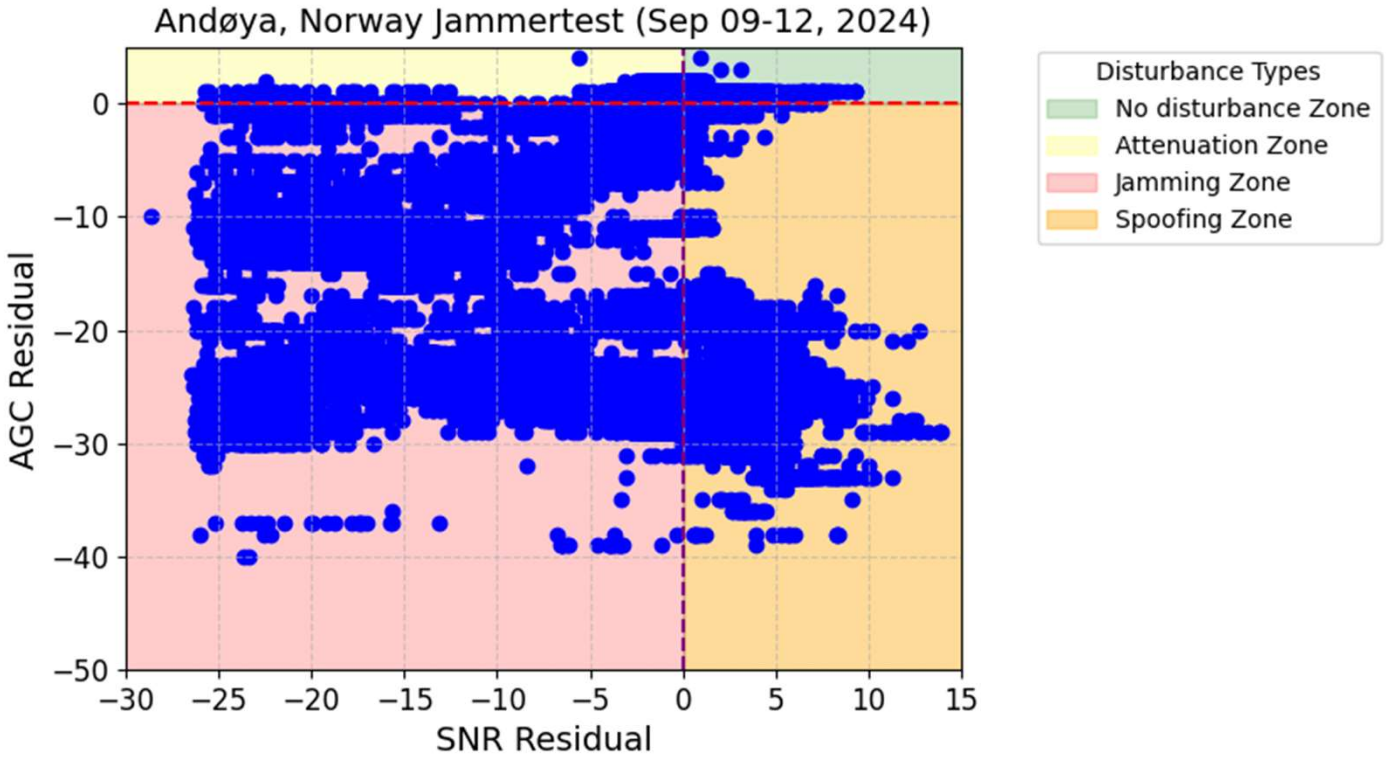




SNR of the affected signal is correlated among satellites tracked simultaneously

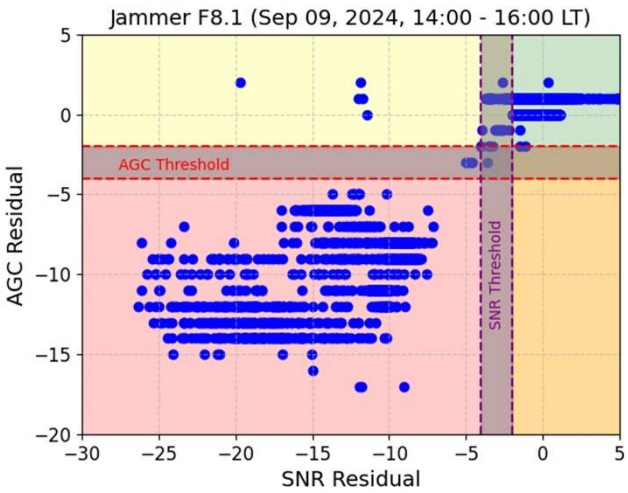
Actual disturbance – Andøya, Norway Jammer test 2024

- Data from NLS Finland
- Septentrio PolarX5
- Receiver mitigation on/off
- Data shown for GPS L1 only
- SNR and AGC nominals obtained from no interference periods

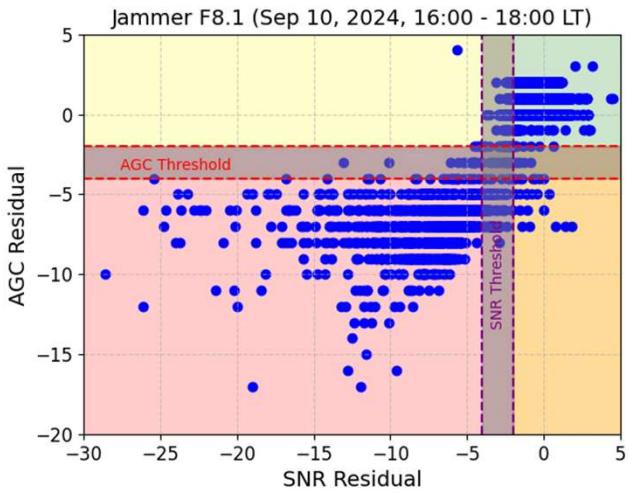


Andøya, Norway Jammer test

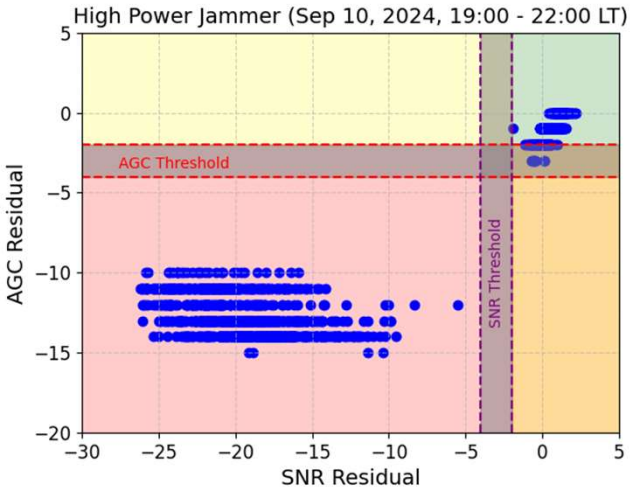
Jamming



- Jammer F8.1 ”Porcus Major
  - Power 50W
  - Sweep rate 100KHz
  - Test bands ’L1’, ’E1’, ’B1C’, ’G1’, ’L2’, ’L5’, ’E5a’, ’B2a’



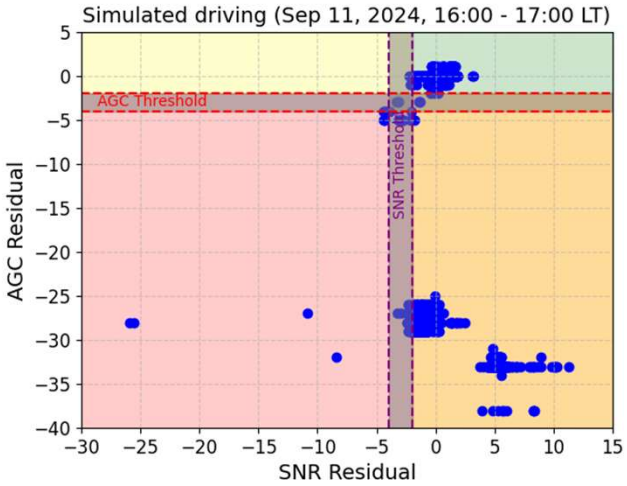
- Jammer F8.1 ”Porcus Major
  - Power 50W
  - 50 W frequency drift
  - Sweep time 1 minute
  - Test bands ’L1’, ’E1’, ’B1C’, ’G1’, ’L2’, ’L5’, ’E5a’, ’B2a’



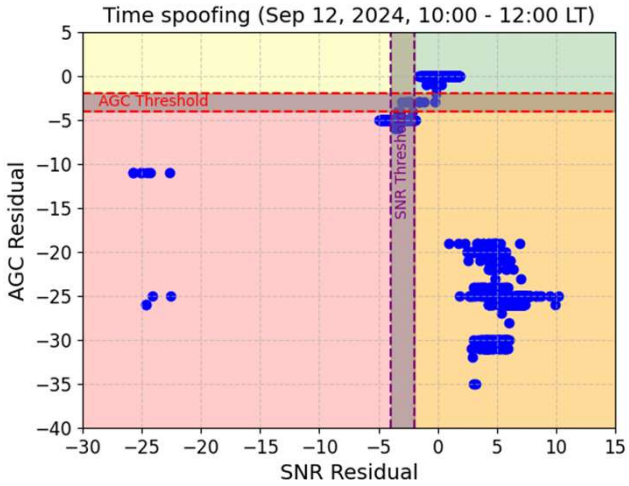
- High Power PRN jamming
  - Power 100W
  - Test bands ’L1’, ’E1’, ’B1C’, ’G1’, ’L2’, ’L5’, ’E5a’, ’B2a’
  - Transmitter F8.1

Andøya, Norway Jammer test

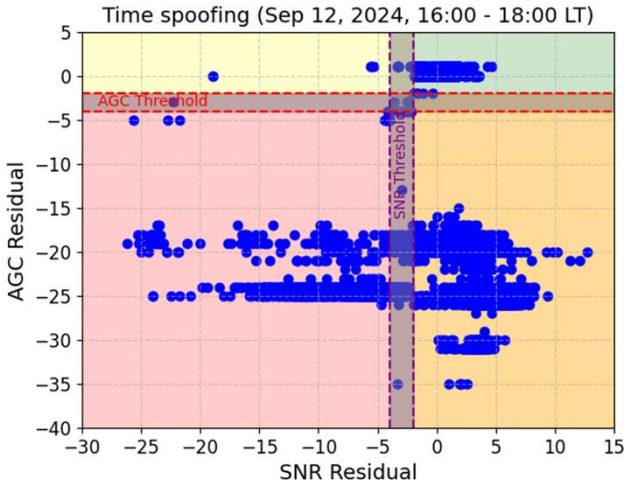
Spoofing



- Simulated driving (route 1). GPS L1 C/A and Galileo E1
  - Power 0.316 W
  - Initial jamming prior to spoofing
  - Equipment S



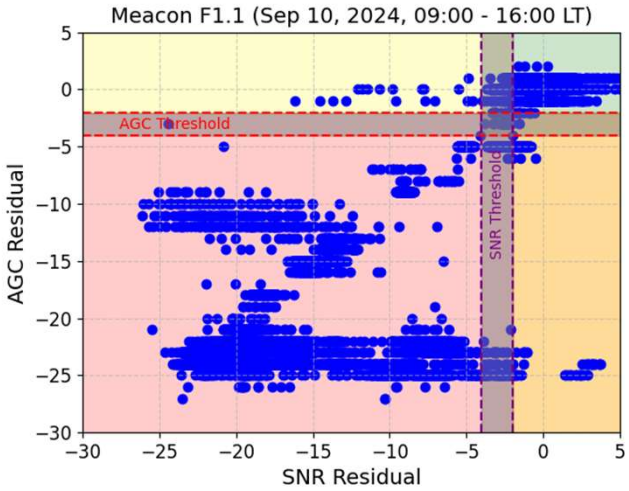
- Static + Pseudorange error. GPS L1 only
  - No jamming
  - Initial jamming and continuous jamming
- Time offset
  - No jamming
  - Fixed spoofed position
  - Power ramp and jump



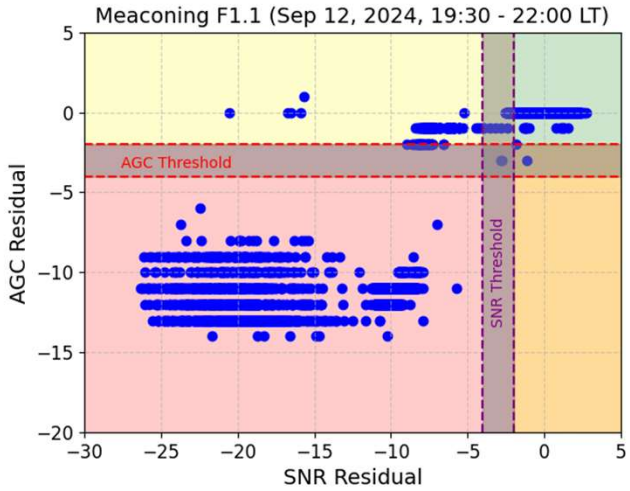
- Static + Pseudorange error, with initial and continuous jamming
- Static + UTC-parameter nav. Data manipulation (removing leap seconds)
  - Fixed spoofed position
  - Removing -145 leap seconds – spoofed signal says back in 2016

Andøya, Norway Jammer test

Meaconing



- Meacon F1.1 ”Porcellus”:
  - Several scenarios

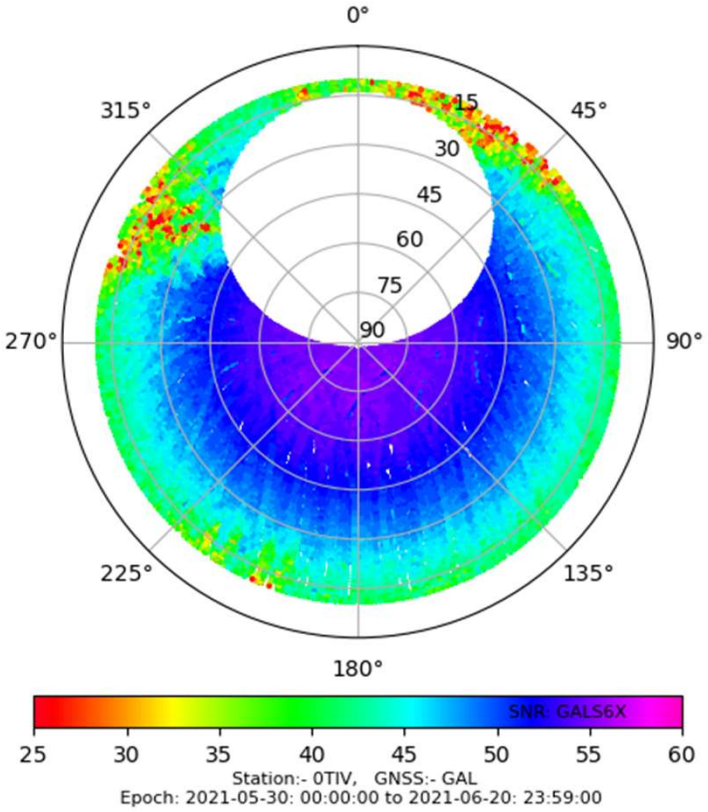


- Meacon F1.1 ”Porcellus”:
  - 10W meaconing from receiver RX1
  - Test bands ’L1’, ’E1’, ’B1C’, ’L2’

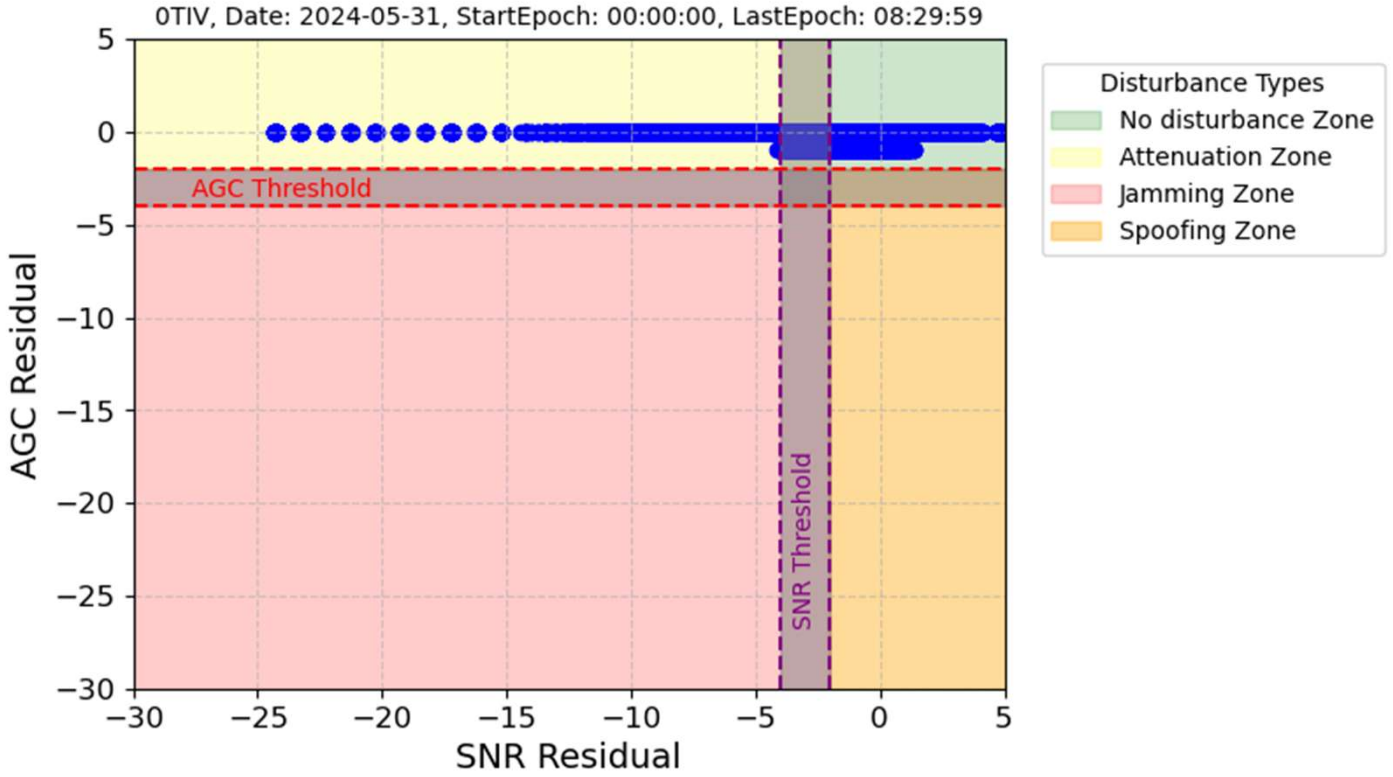
- **The re-radiated is strong enough to cause AGC drops**
- **Two copies of the same GNSS signal (direct, re-radiated) – as not time/phase aligned – can cause correlation degradation which leads to SNR drops**

Actual disturbance at a SWEPOS station – 0TIV, type - Attenuation

Source – Large trees near by



Effect – All bands

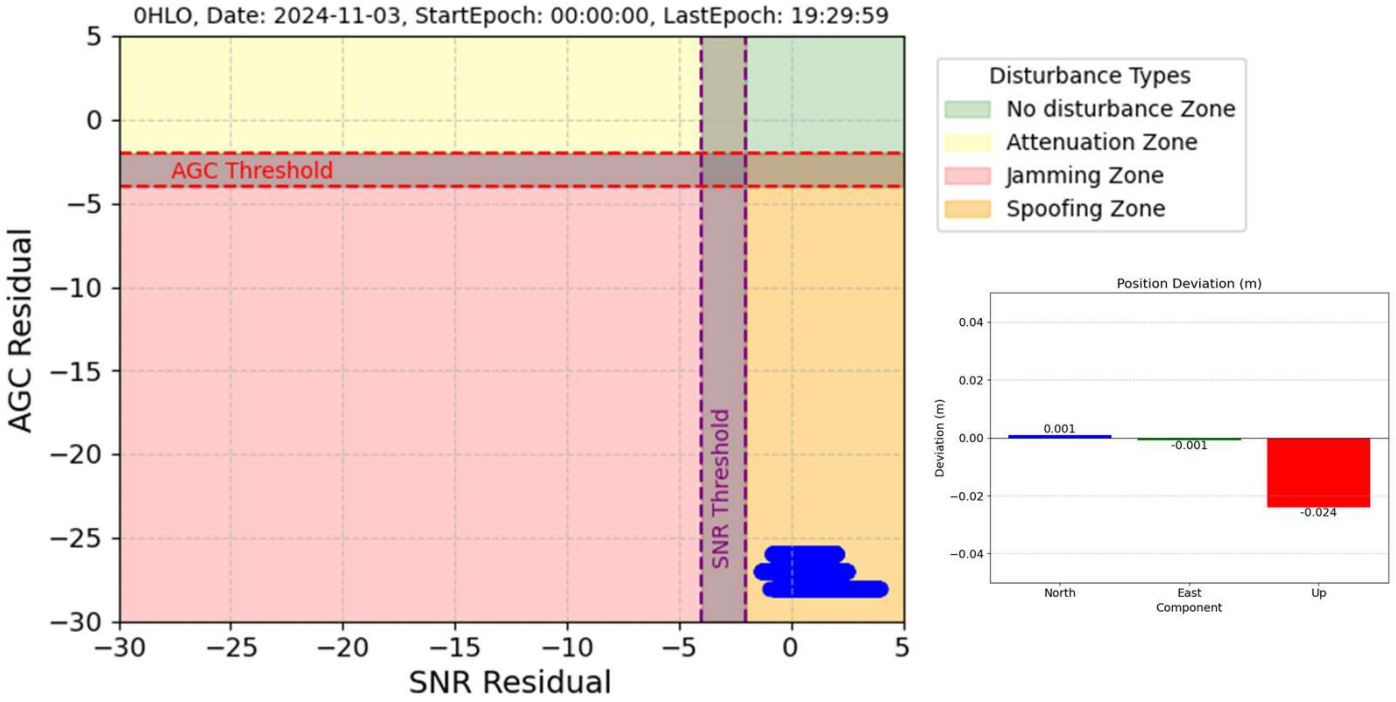


Actual disturbance at a SWEPOS station – 0HLO, type – Equipment change

Source – Antenna splitter

- GPS Networking ALDCBS1X4-N amplifier
- Signal-amplified without external power supply
- Provides 18 dB amplification

Effect – All bands

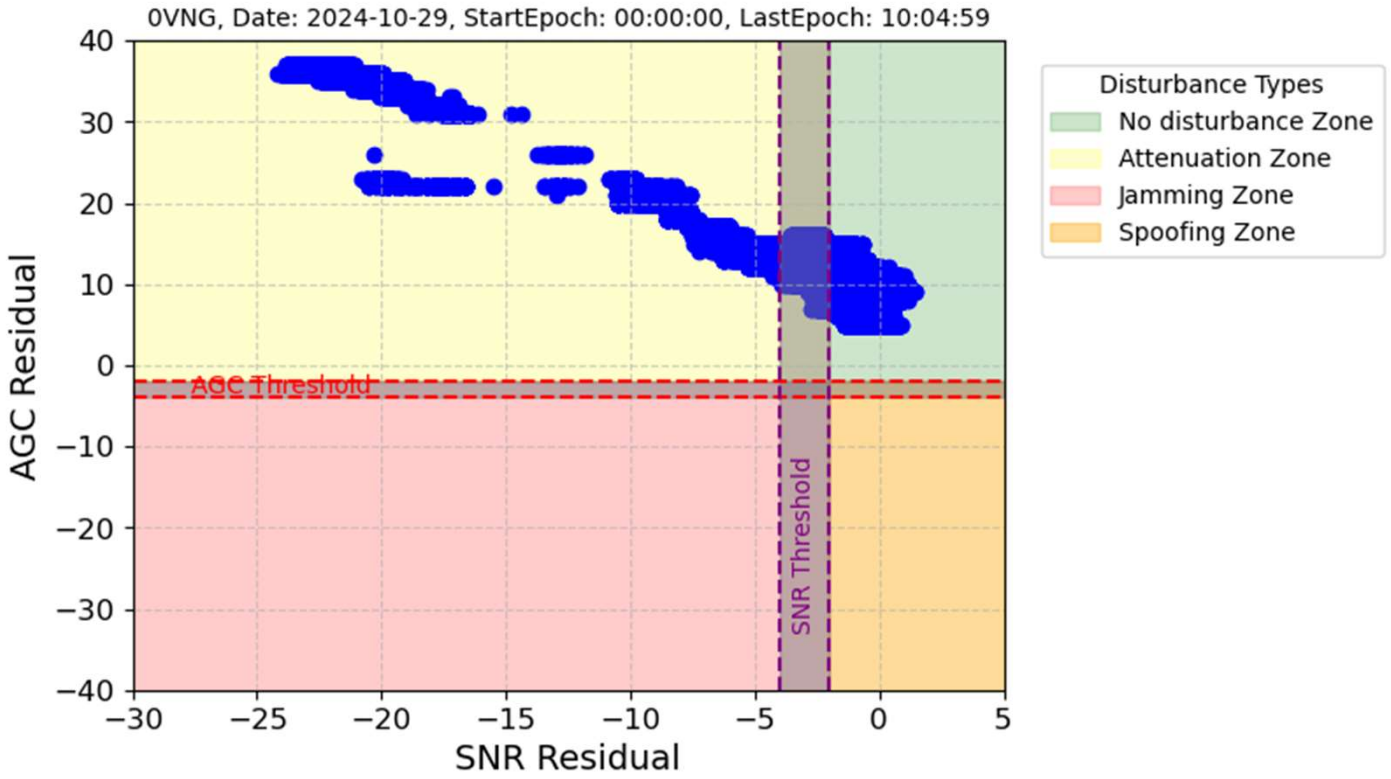


- **AGC drops to avoid overloading the receiver front end because of amplified input**
- **SNR remains the same the amplified splitter increased both signal and noise levels proportionally**

Actual disturbance at a SWEPOS station – 0VNG

Source – Faulty antenna cable

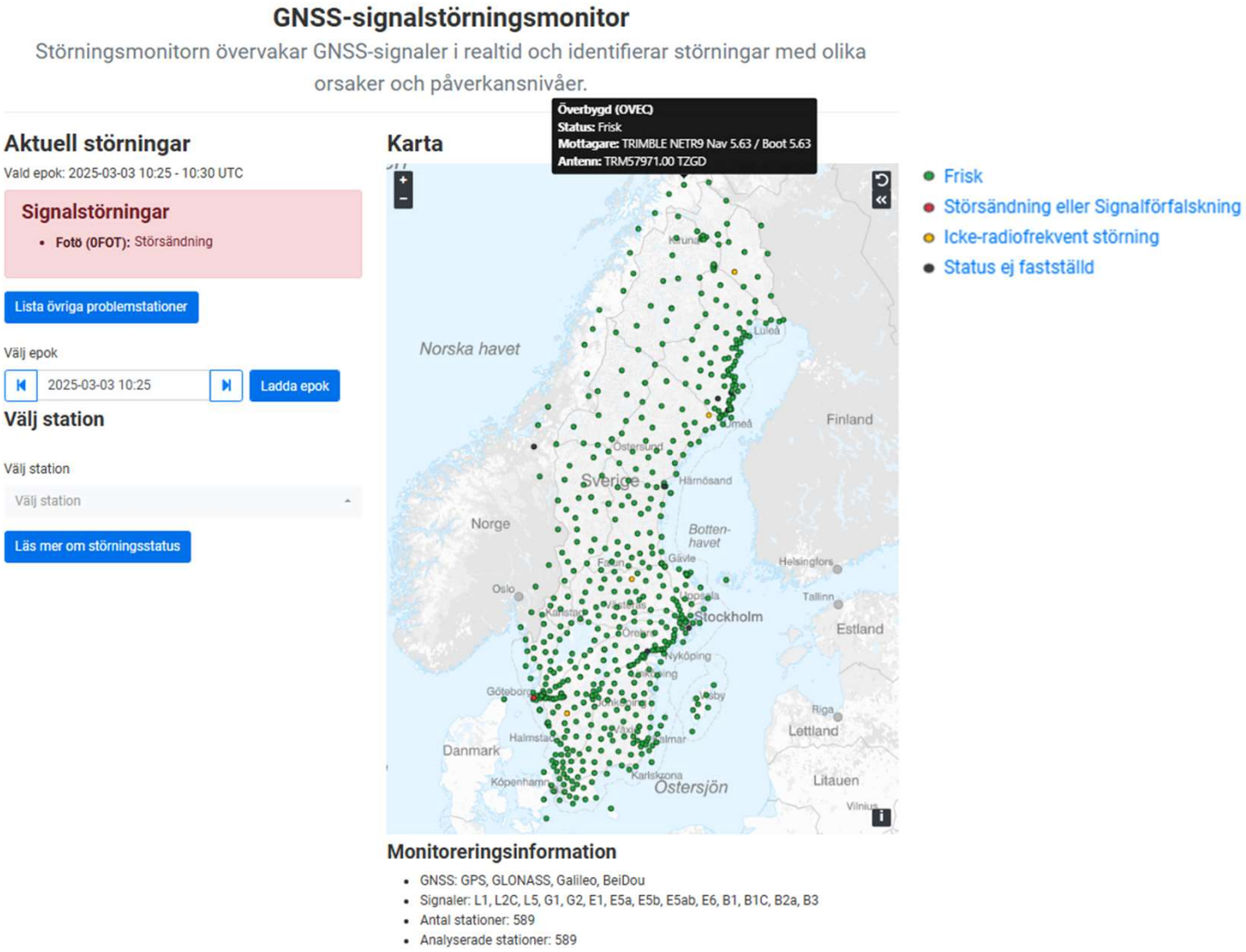
Effect – All bands



SNR drops, AGC increases – The system amplifies the signal to achieve adequate signal level

Status!

- API and web release March 31



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