

ENAMS – Results & Outlook

Electrical Noise Area Measurement System

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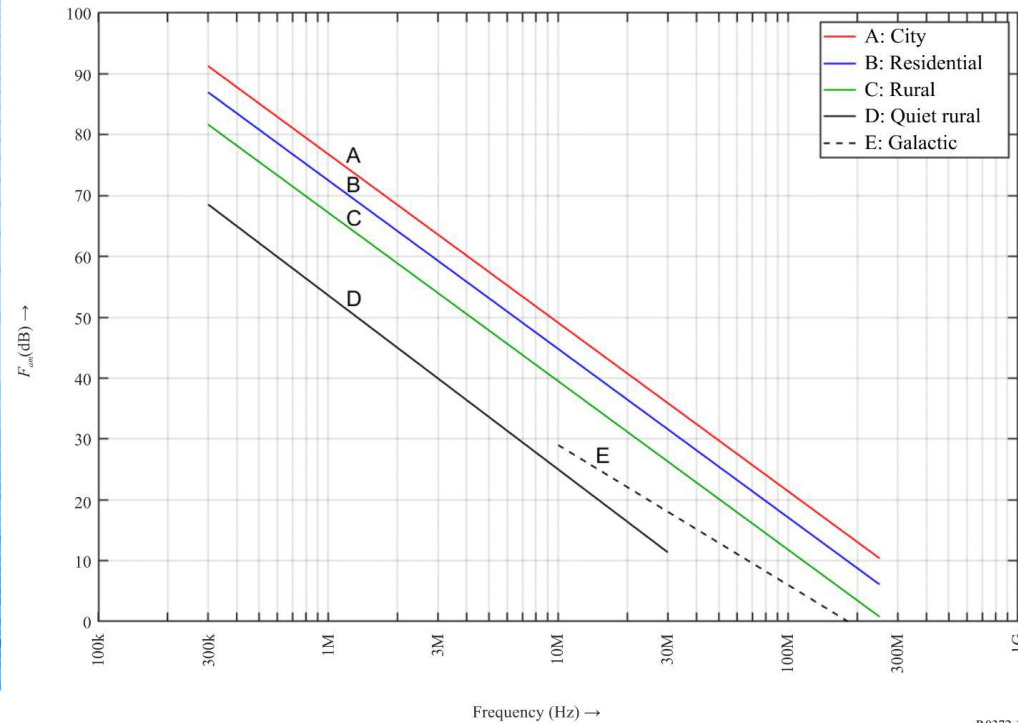
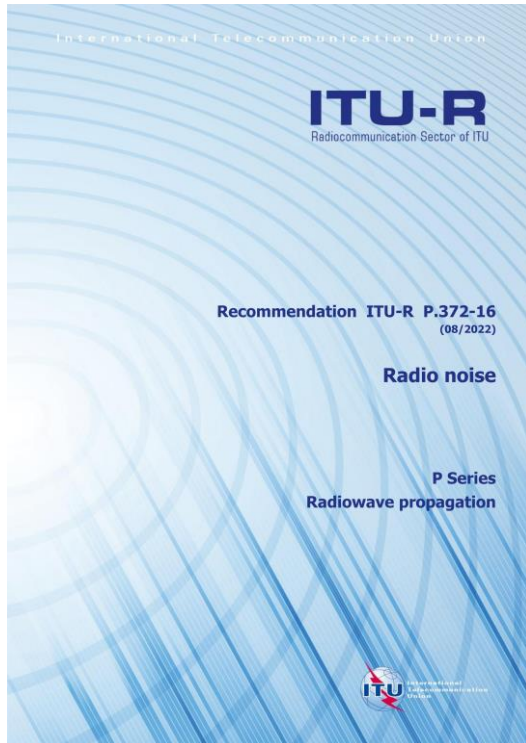


Agenda



1. Motivation - ITU Radio Noise
2. ENAMS – A Brief Technical Introduction
3. ENAMS Diagrams & Evaluations
4. Spectra of ITU location types
 1. Rural
 2. Residential
 3. City / Industrial
5. Spectra of typical Interferers
 1. VDSL
 2. Photovoltaic Inverters
 3. Photovoltaic Optimizer
 4. LED - Lamps
6. What else can be seen with ENAMS
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ITU Radio Noise



- For efficient spectrum management minimal man made noise is of significant importance
- Up to now for spectrum management and the design of radio equipment the well known curves of ITU P-372 and its data measured in the 1960's form still the foundation for many design considerations
- Due to the unbroken growth of the number of electronic devices and the accelerating substitution of fossil energies in the course of electrification the radio noise levels might have changed.
- Therefore the knowledge about the development of the interference levels seems to be a must

ENAMS – what is it?

ENAMS is an interference field strength measurement system, i.e. an automatic reception system distributed primarily throughout Germany for recording the level of interference in the frequency range 66 kHz - 31 MHz

Why do we need ENAMS ?

The ENAMS project was initiated by DARC e.V. because the German Federal Network Agency (Bundesnetzagentur, BNetzA) did no longer carry out general interference measurements after 2011, and therefore the increase in the general interference level in recent years due to the proliferation of interfering electronic devices in residential and commercial areas is no longer documented.

With ENAMS, amateur radio is now in a position to measure the relevant interference level itself and to contribute to the discussion on limit values. In some cases, inappropriate measurement systems and procedures are used, leading to incorrect results. It is therefore in the interest of amateur radio to present the correct measurements and interference situations. .

IARU Requests More ENAMS



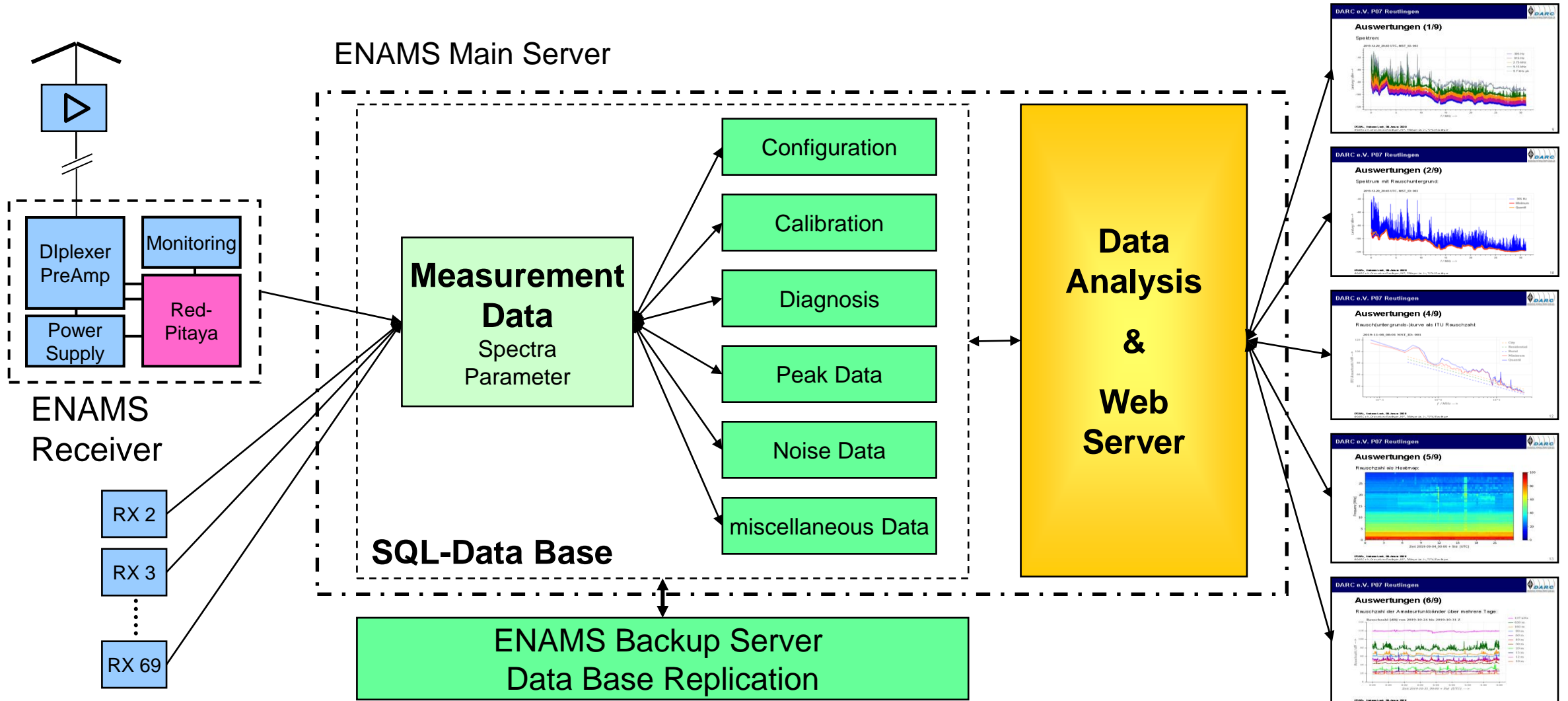
1. Most of the countries in IARU R1 have no monitoring of radio noise (besides those countries using ENAMS 1.0)
2. IARU considers and awarded ENAMS as a successful contribution for amateur radio interference monitoring
3. Therefore IARU encouraged DARC e.V. to provide more ENAMS units to enable IARU R1 member societies to do their own interference monitoring
4. IARU member societies have then the possibility to approach their responsible administrations for frequency management with their own locally acquired data
5. Joint activities in many countries will help to form an alliance for the protection of amateur radio frequencies and beyond

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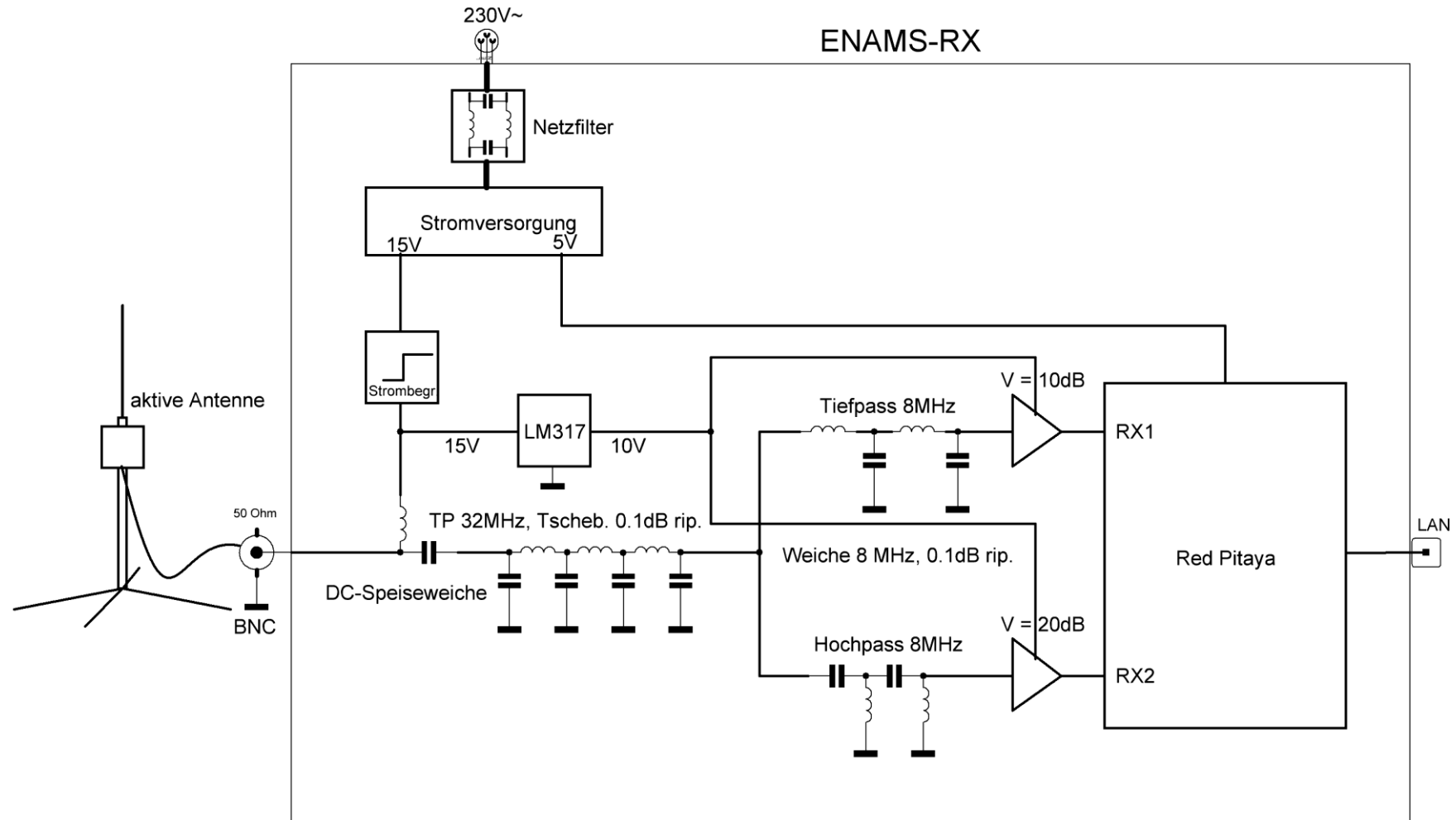


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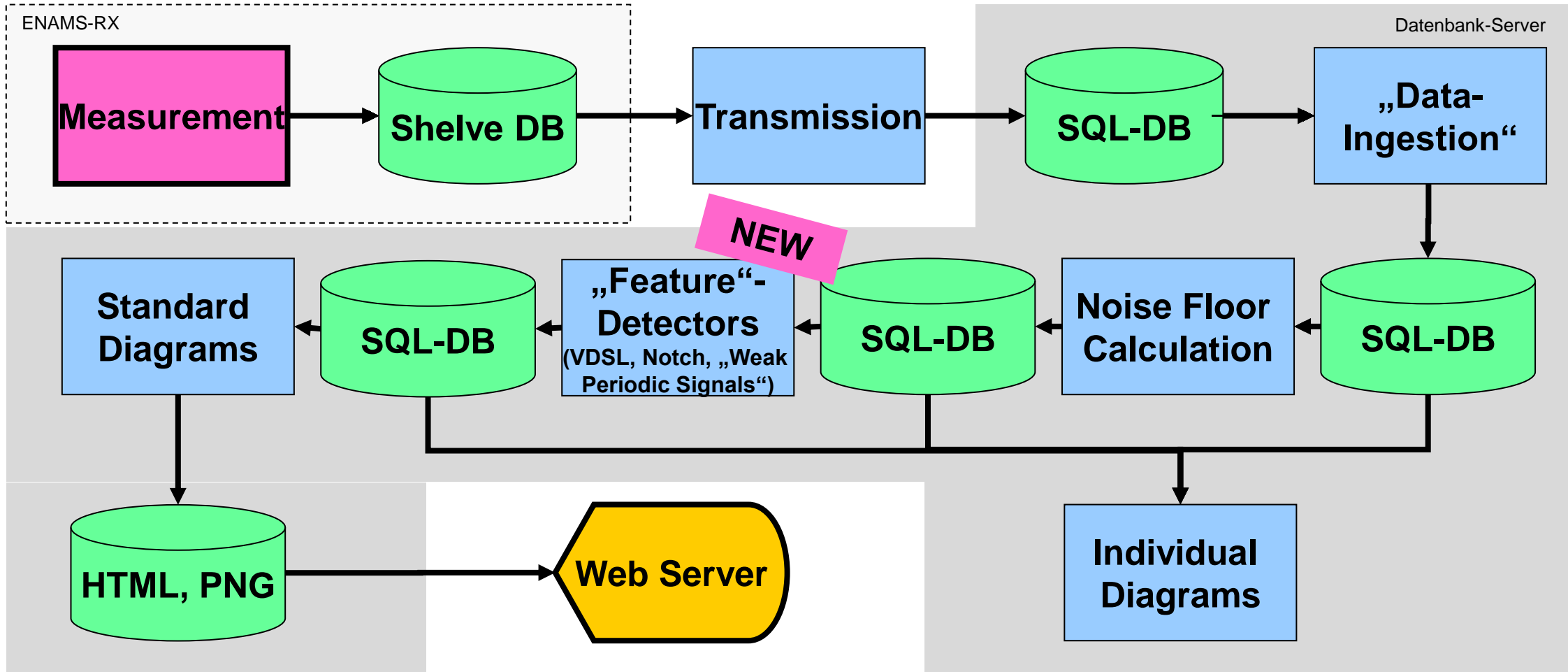
ENAMS – System Diagramm



ENAMS – Receiver Block Diagram



ENAMS – Automated Data Pipeline



Measurement Data Storage Processing Display

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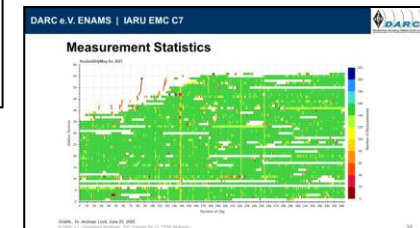
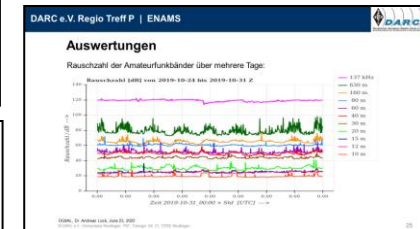
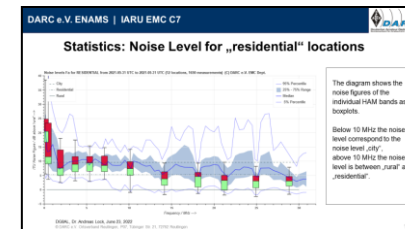
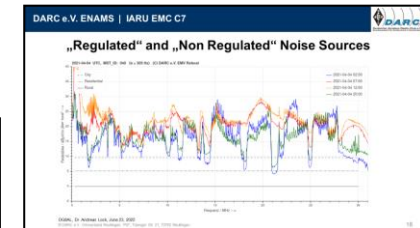
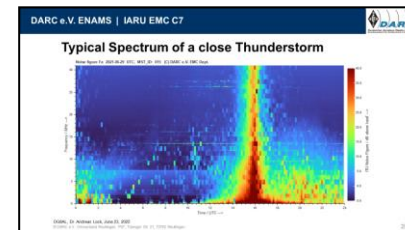
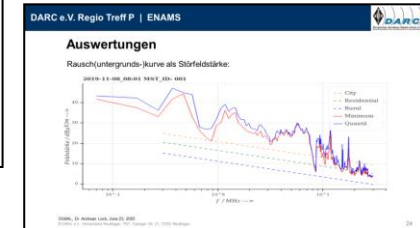
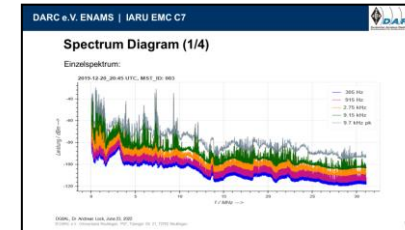


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ENAMS Diagrams



1. Power density plot
2. Field strength diagram
3. Noise floor diagrams
 - a. Single curve
 - b. Multiple curves: 4 per day, 7 per evening
 - c. Multiple curves: 4 x 6 to cover 24 hours
4. Heatmap (144 measurements day, 3D plot)
5. Time series
6. Statistical evaluations
7. Diagnostics:
 - a. Overview of DCF77 & DCF49
 - b. Number of Measurements per day and station

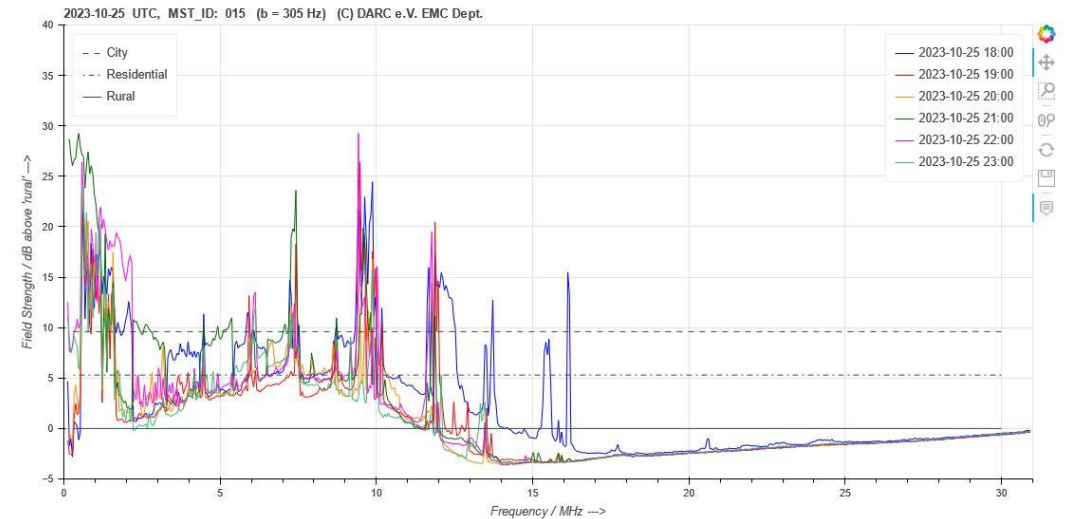
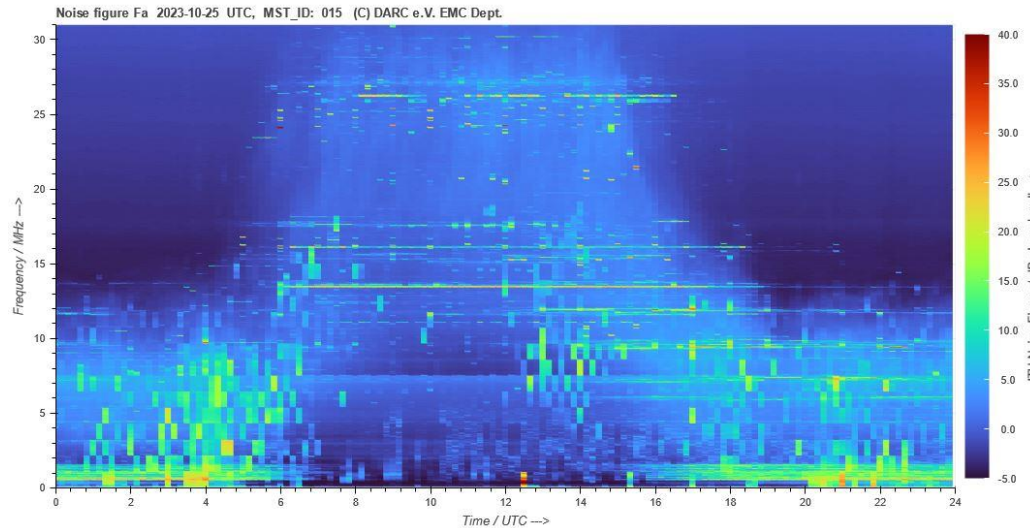


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Typical Rural Station (Landshut #15)

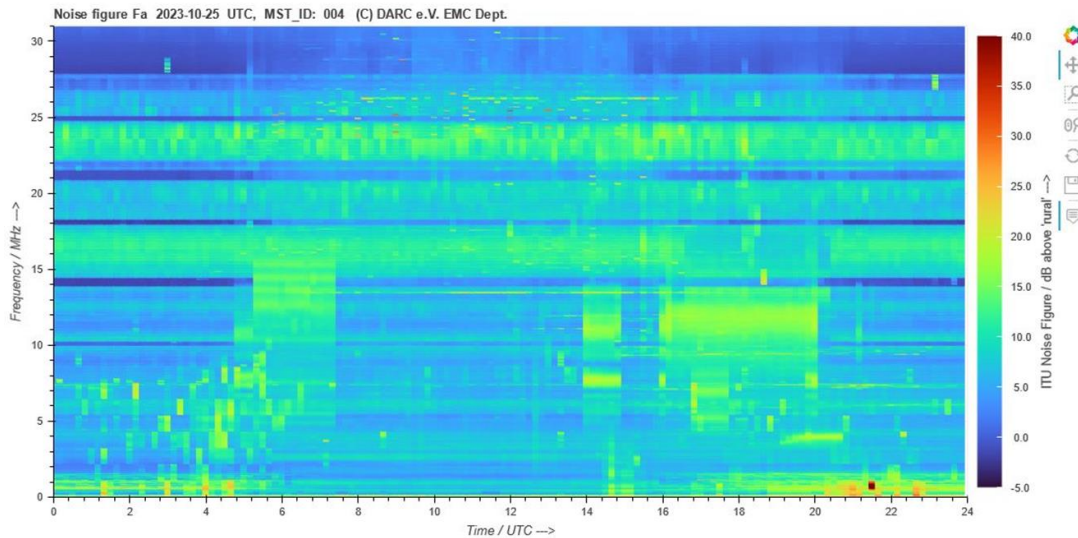


HM015_2023-10-25

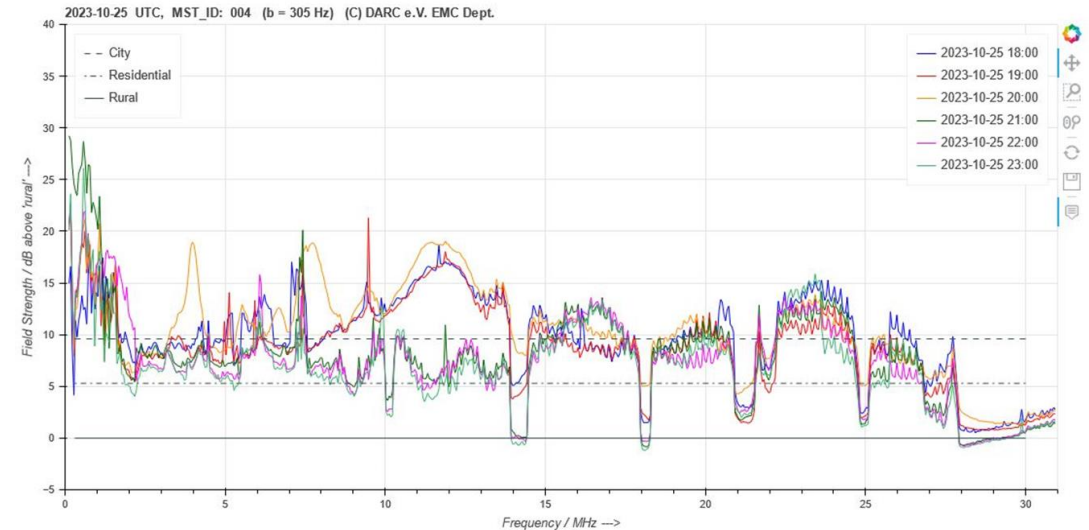
NFN64015_2023-10-25 18:00 Uhr – 23:00 Uhr

- Back ground noise on rural level and even below
- Light blue area shows distant noise sources
- Ionospheric attenuation suppresses distant noise during the day, MUF is indirectly visible
- Distant lightnings can be seen as „pixels“

Typical Residential Station (Weissenhorn #04)



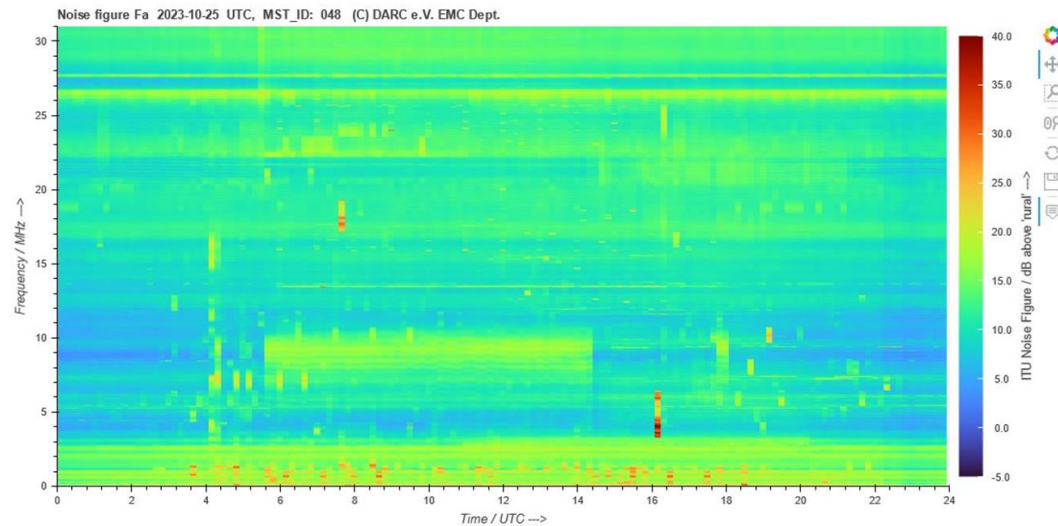
HM004_2023-10-25



NFN62004_2023-10-25, 18:00 Uhr – 23:00 Uhr

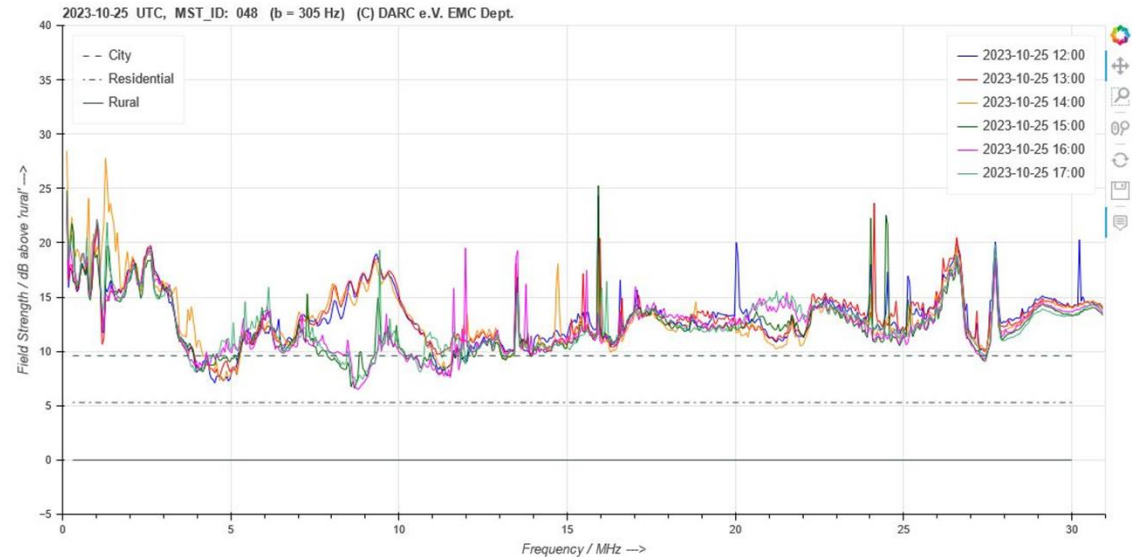
- Noise floor on residential level, below 10 MHz noise level above „residential“ due to local interferers
- Notches are visible as dark blue lines in the heatmap as well as in the noise spectra
- Bottom of notches are even on rural level but "filled up" during the day
- Noise level increases during the day

Typical City Station (Cottbus #48)



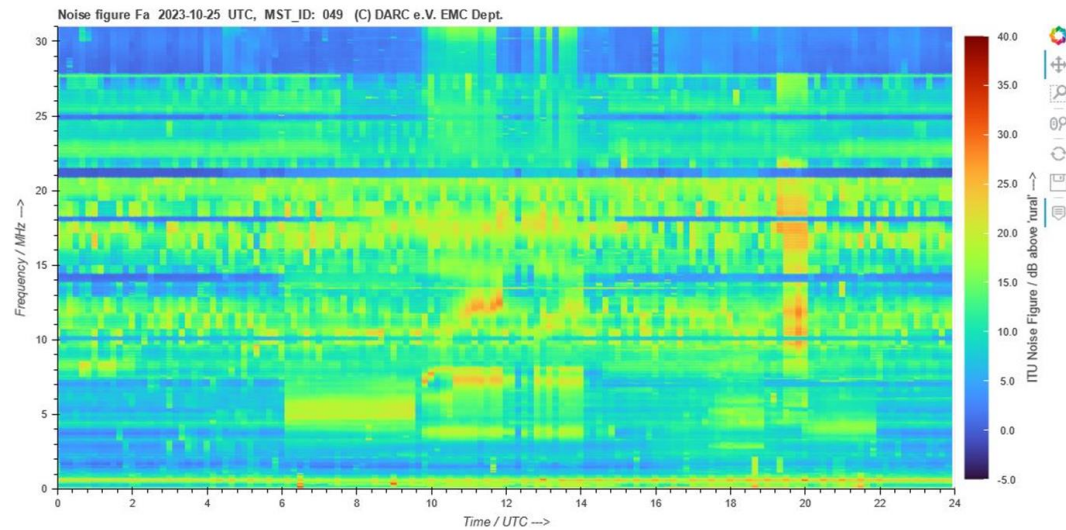
HM048_2023-10-25

- Noise floor on city level and slightly above
- Below 10 MHz noise level above „city/industrial“ due to local interferers especial during the day
- No notches are visible in the heatmap nor in the noise spectra
- Noise level increases during the day



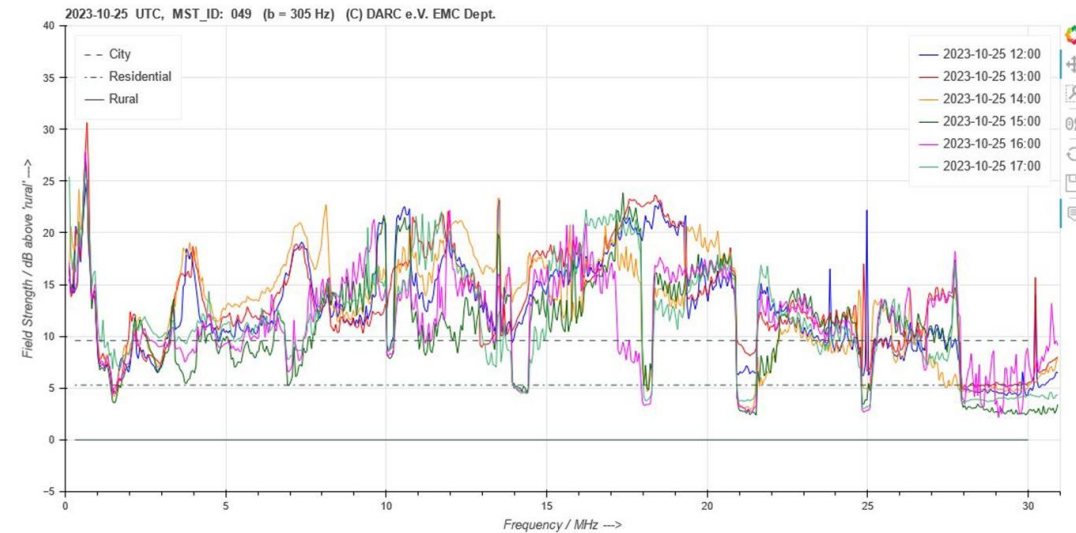
NFN63048_2023-10-25, 12:00 Uhr – 17:00 Uhr

Other City Station (Munich #49)



HM049_2023-10-25

- Noise floor on city level and at the edges of the spectrum slightly below
- Below 10 MHz noise level is not increased
- Notches are visible in the heatmap and in the noise spectra but are partly filled up during the day
- Bottom of the notches on residential level or even below



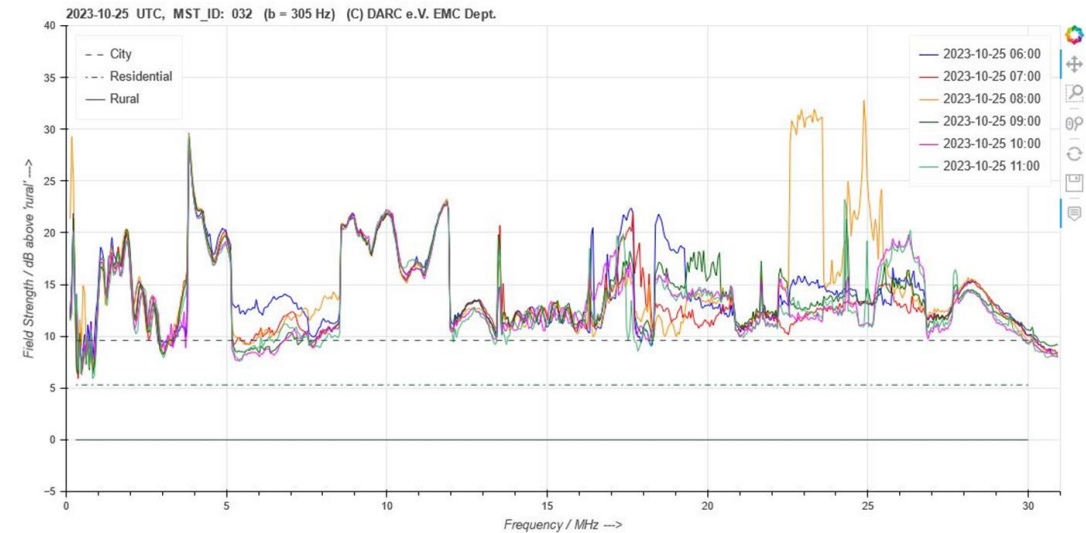
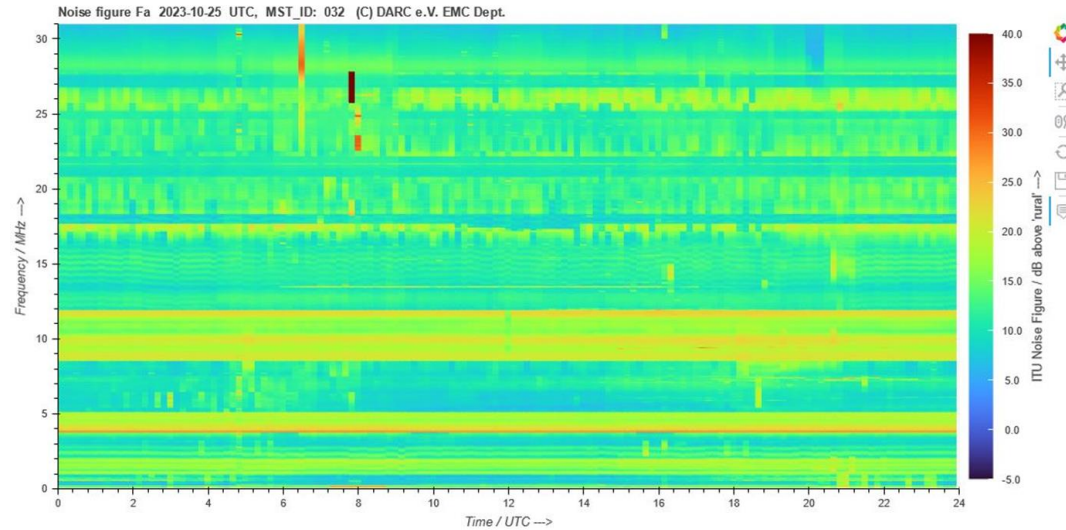
NFN63049_2023-10-25, 12:00 Uhr – 17:00 Uhr

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Interferences caused by VDSL (Dresden #32)



HM049_2023-10-25

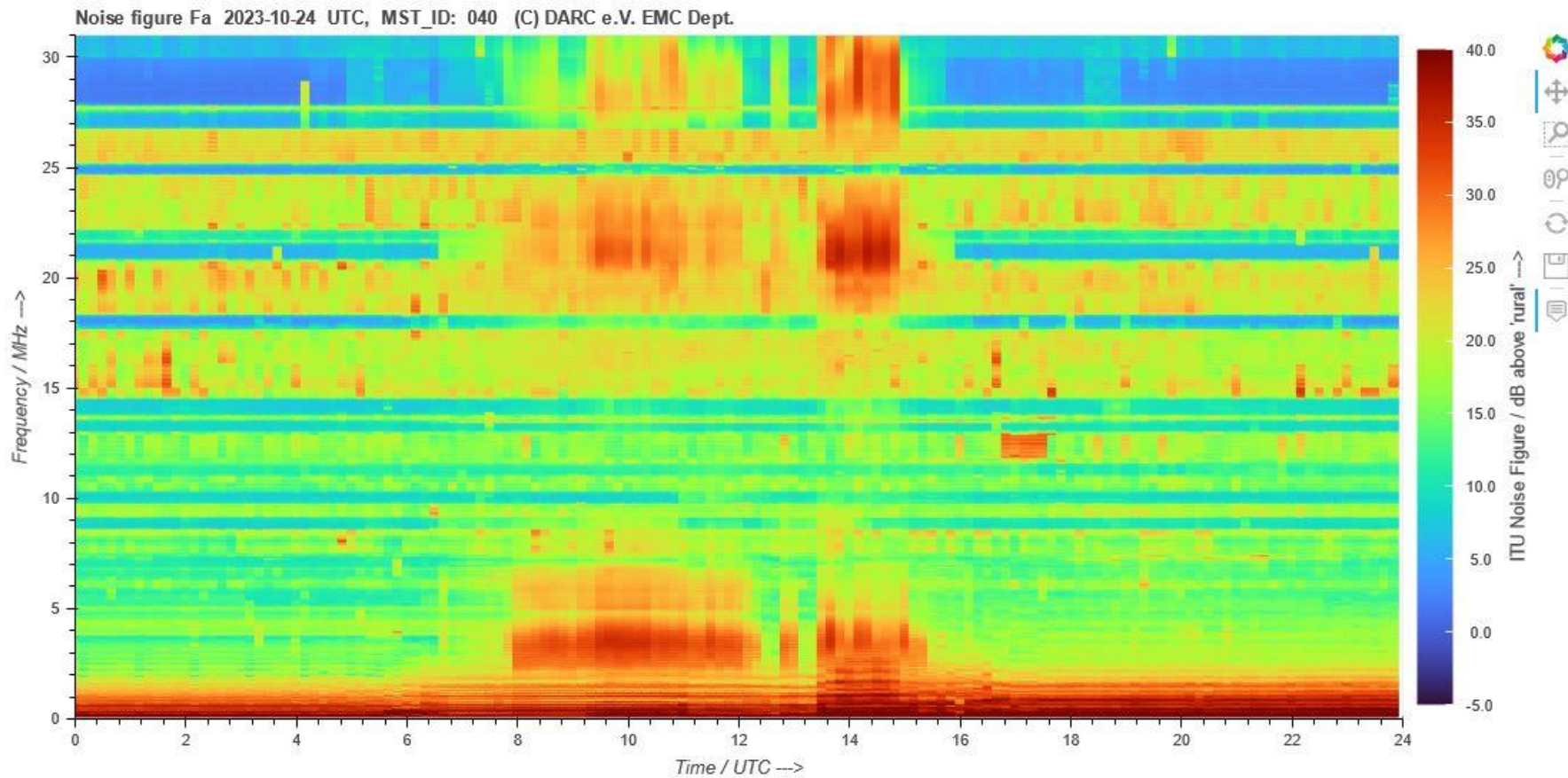
- Noise floor on city level
- Upload sections of VDSL 2 at 3.8 – 5.2 MHz and 8 MHz – 12 MHz clearly visible
- No notches visible in the heatmap nor in the noise spectra

NFN63049_2023-10-25, 12:00 Uhr – 17:00 Uhr

Interferences by Photovoltaic Installations

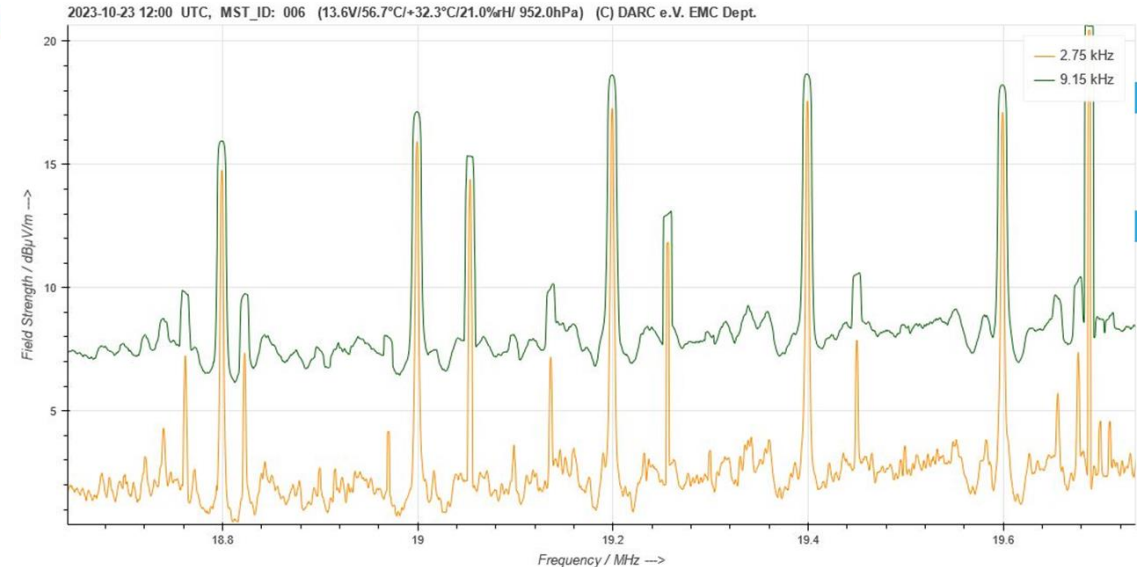
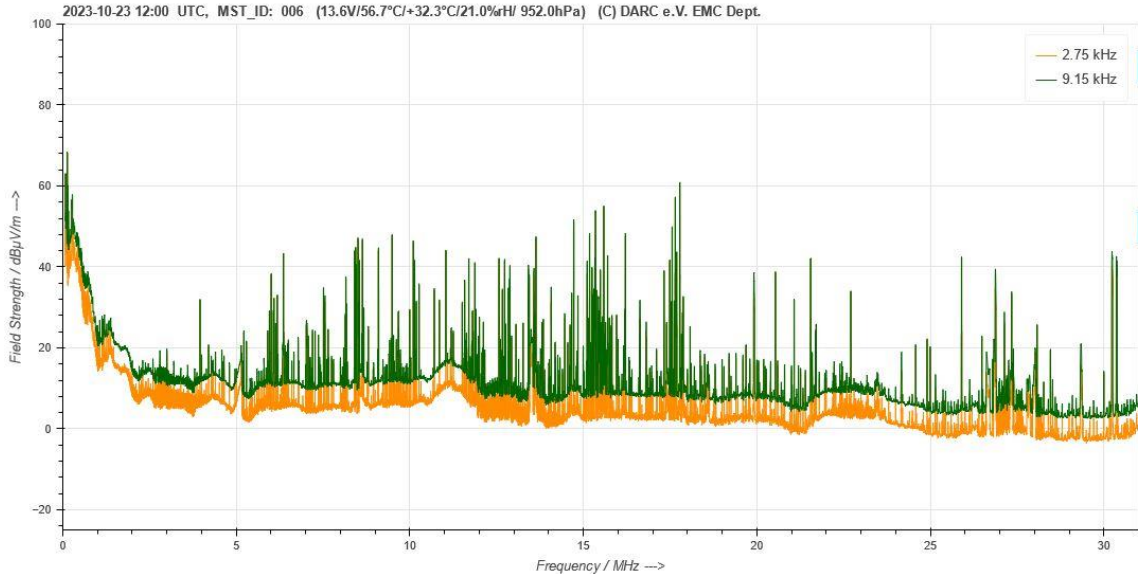


Interferer PV installation Bonn #40



HM040_2023-10-24

Solar Optimizer (Weissenhorn #06)



S006_2023-10-23

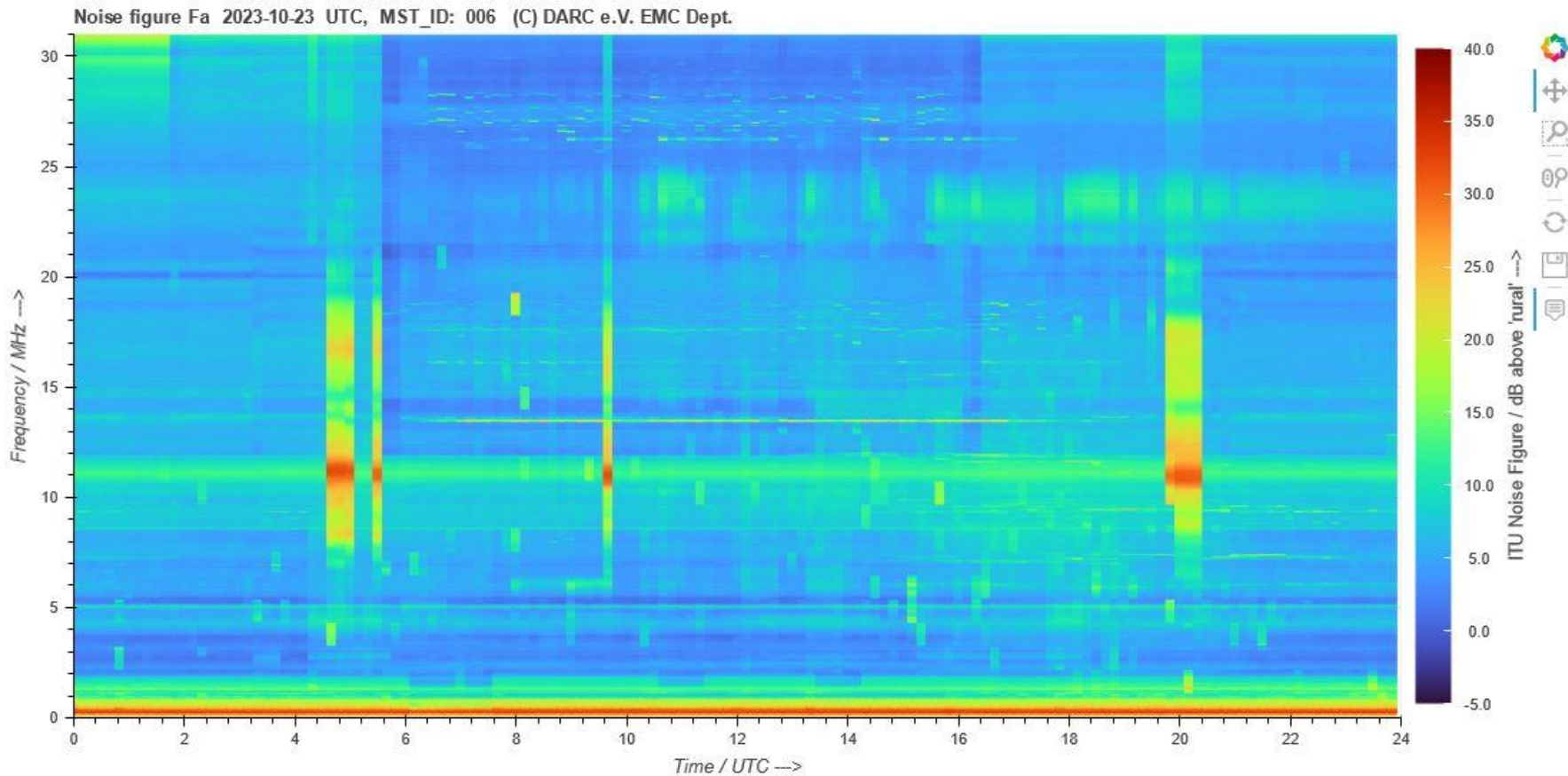
S006_2023-10-23

- Harmonics can be seen in large sections of the spectrum
- Peaks show up at every 200kHz
- Sometimes these peaks are “smeared” out due to variation of the base frequency

Interferences caused by LED Lamps



Interferer LED street lamp



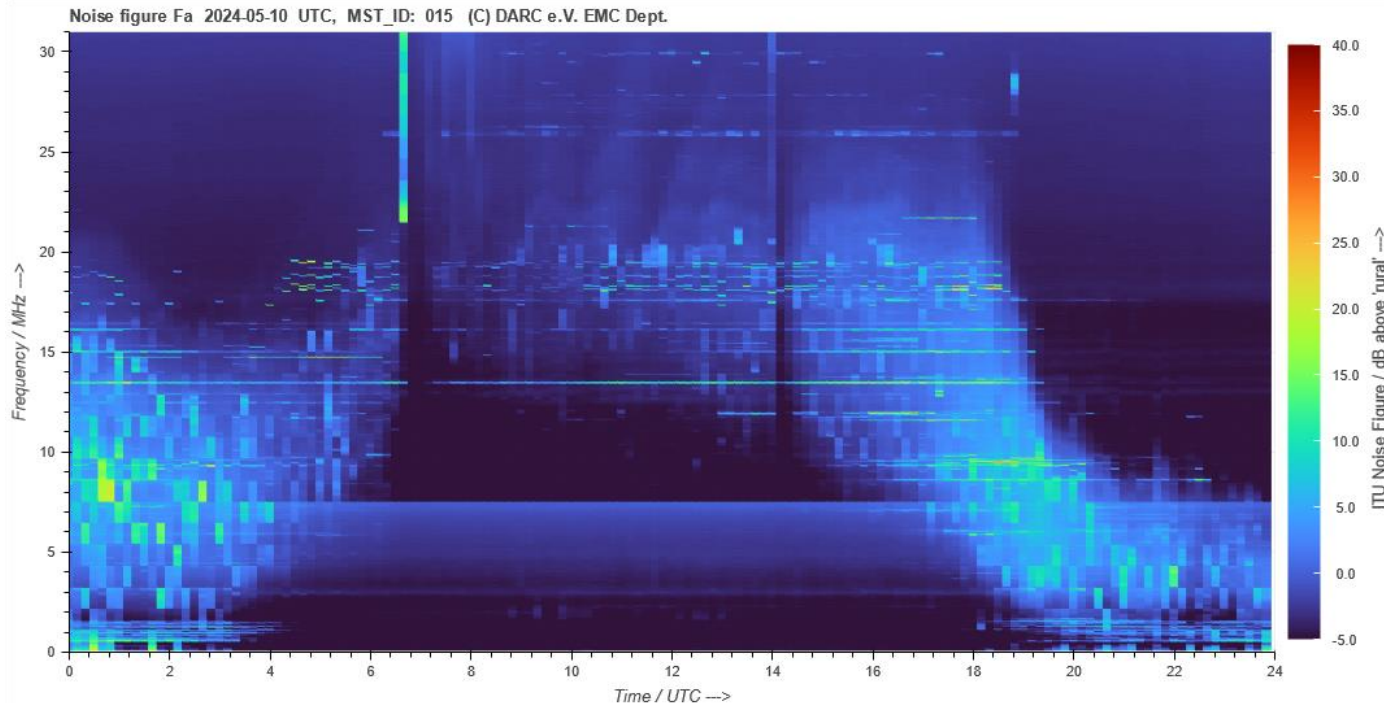
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Mögel Dellinger Effect (Landshut #15)

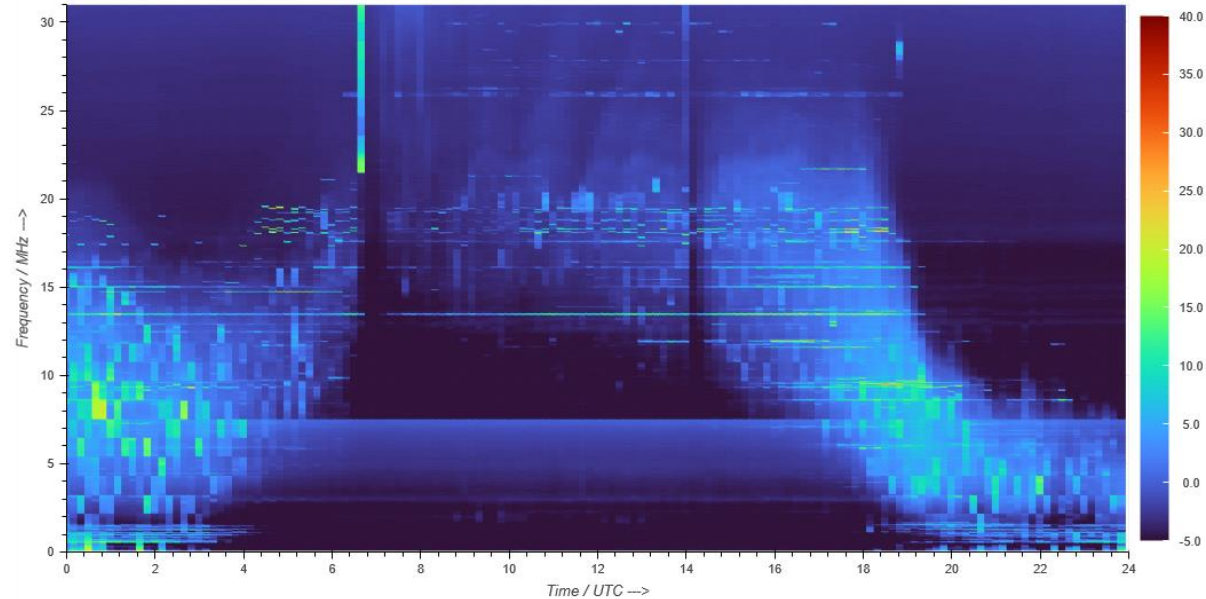


- At 8:00 UTC and 14:00 UTC on May 10th 2024 a drop out of complete RF shortwave propagation can be seen due to strong solar CME activity
- The first drop out is preceded by an intense radio burst
- Back ground noise is on rural level and even below
- Light blue areas show distant noise sources
- Ionospheric attenuation suppresses distant noise during the day, MUF is indirectly visible
- Distant lightnings can be seen as „pixels“

Radio Wave Propagation (Example)

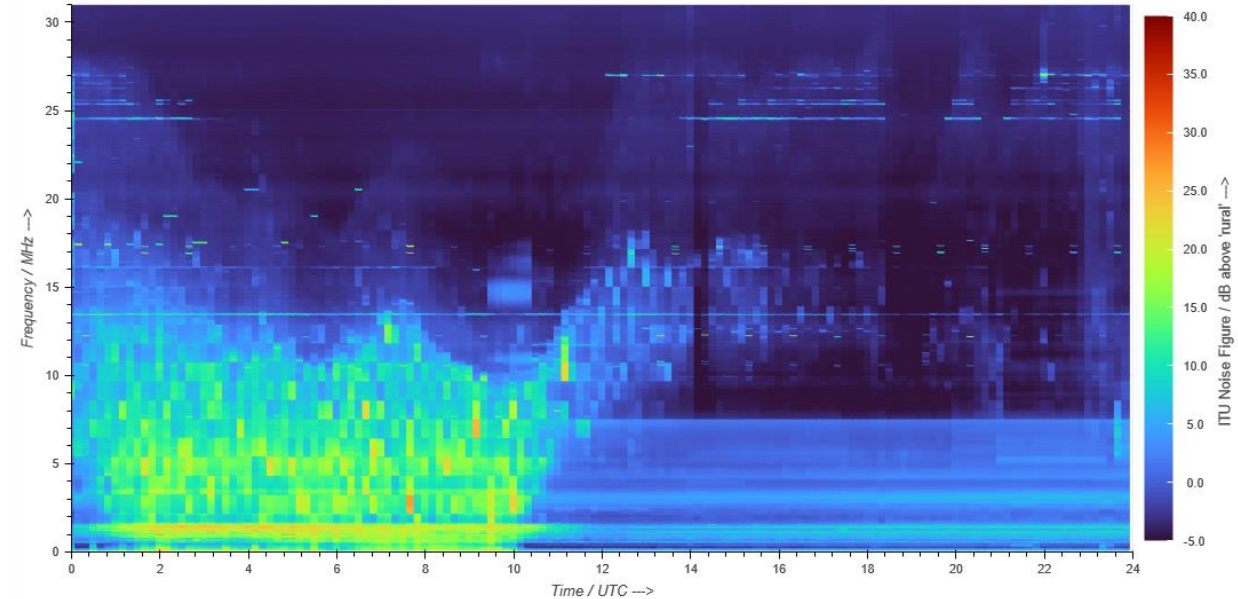


Noise figure Fa 2024-05-10 UTC, MST_ID: 015 (C) DARC e.V. EMC Dept.



HM015_2024-05-10 Landshut

Noise figure Fa 2024-05-10 UTC, MST_ID: 202 (C) DARC e.V. EMC Dept.



HM202_2024-05-10 Virginia Beach USA

- At 14:00 UTC drop outs of the RF radio wave propagation can be seen in Europe (Landshut #15) as well as in the US (Virginia Beach #202). Northern hemisphere was in a position where solar CME could affect both locations.
- Even further drop outs seem to have happened later which could not be detected in Europe
- In the data of the New Zealand station no CME impact was visible

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Outlook – Next Steps 2024 ff



1. ENAMS 2.0:

IARU R1 requested more receiving stations. First prototypes of an improved version of the ENAMS receiver – ENAMS 2.0 – are available having advanced features:

- Local storage of data up to 5 years, i.e. stations can be offline and are easily relocatable
- I/Q data are stored for up to one hour and can be retrieved
- Storage of raw and calibrated data
- More computing power enables extended features (not tested yet) :
 - measurement cycle could be reduced to 5 minutes
 - Band width could be set to 157 Hz

2. ENAMS Diagrams & Evaluations will be continued and extended by feature detectors

3. Third party assessment of system planned to get “quality” label, i.e. system has proven and “certified” measurement capabilities

ENAMS 2.0 – First Operational Prototype



First operational
ENAMS 2.0 prototype was
shown at HAM Radio 2024
in Friedrichshafen !

1. ENAMS has proven useful and supports with its data the protection of HAM Radio frequencies and beyond
2. Our data show that the man-made noise level between 66kHz and 31MHz has increased over the years compared to values given in ITU P.372,
 - Especially below 10 MHz there is a significant increase due to electronic devices
 - Above 10 MHz the noise figures in HAM radio bands are still close to the ITU P.372 values
 - Above 10 MHz HAM radio bands are clearly visible as notches in the spectra and in some city locations the noise level in the notches is even on residential level
3. Different types of interferers are identified
 - VDSL, PLC
 - Photovoltaic equipment, especially “balcony” solar power stations
 - LED lamps, many types of inverters
 - ... and the list will be continued
4. ENAMS can also make radio wave propagation effects visible, i.e. Mögel-Dellinger, ...

Thank you for your attention!

Time for questions

