Unknown radio emission at about 3 MHz recorded in Norway

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Abstract
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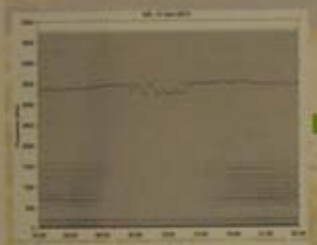
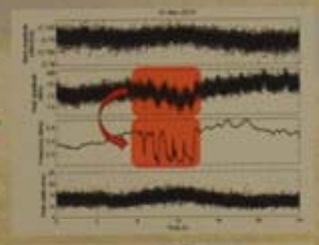
A. Broadband electric field measurements in Hessdalen Valley (Norway)

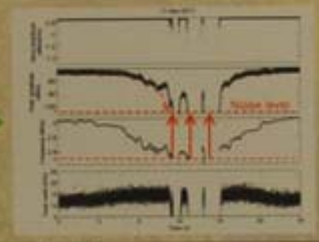
The same instrumentation is used for lightning and sprite observations:
- vertical electric field measurements using a vertical dipole:
  - broadband: 1 kHz – 5 MHz
  - event duration: 50 ms
  - acquisition card: 100 Msamples/s, 14 bits
  - recurrence: every 5 seconds (more than 17 000 events / day). In lightning and sprite research, triggering over a determined threshold is used, but here the threshold is unknown.
- dating with GPS
- data storage on a removable hard disk (1 TB ~ 3 month of data).

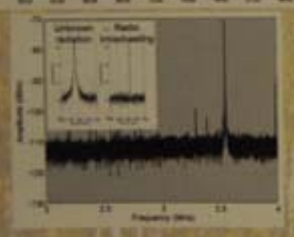
B. Description of the unknown 3-MHz radiation

The instrument has been installed in September 2010 during the "Hessdalen phenomenon" Science Camp (for more details see the poster XY710 by B.G Hauge and S. Montebugnoli and poster XY709 by J. Zlotnicki et al., this session). The objective was to detect a possible radiation from those luminous phenomena. Since, it has been left in the field to maximize the chance of common observation. We have data for 277 days over one year (75%). Power failure is the main reason of the lack of data (the instrument works in a desolated place hard to get in during the winter).
About 4.5 millions spectra have been calculated to reduce the dataset. When we look at the data we were surprised to see a strong emission around 3 MHz which frequency varies significantly during the day. We detect automatically this emission and calculate its frequency, its peak amplitude, and its bandwidth.





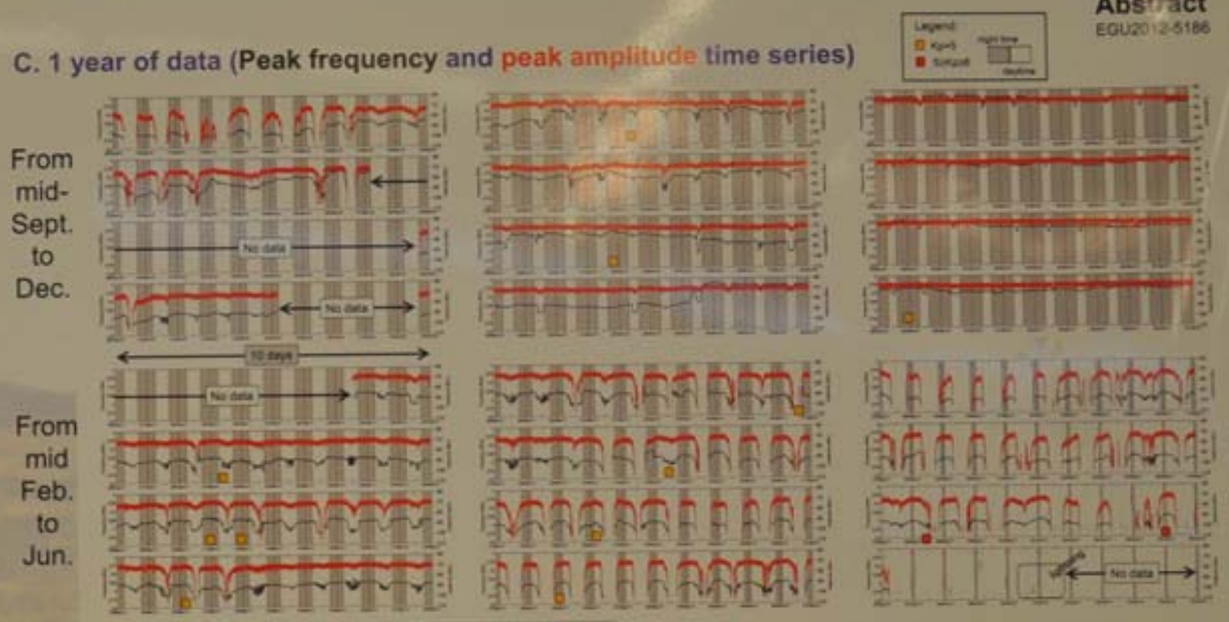




Characteristics:
- **Peak frequency: short and long time variability**
- Peak amplitude: about -70 dBm
- **Peak amplitude varies simultaneously with the peak frequency**
- **Radiation disappears (i.e. down noise level) when peak frequency is below a threshold**
- Bandwidth is from 10 to 20 kHz
- **This radiation seems to be non related to voluntary human activity because: its bandwidth is larger than radio broadcasting (< 9 kHz) and its peak frequency varies strongly with time.**

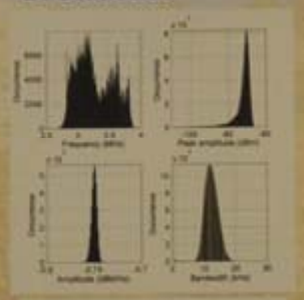
Real signal or bias:
Different experiments have been realized to check if this radiation is real or due to technical bias.
- The same experiment has been deployed in France and this continuous radiation does not appear: this radiation is not due to an internal resonance or internal radiation.
- The amplitude of other radiation (radio broadcasting) has the expected order of magnitude
- Last November, when the radiation was present, a test has been performed. All other electronic system have been switched off and switched on one by one. When every system was off, the radiation was still there. It is not due to stray transmitters.

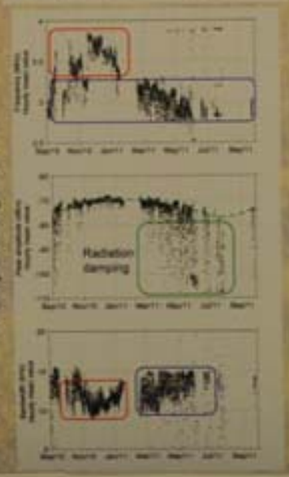
C. 1 year of data (Peak frequency and peak amplitude time series)



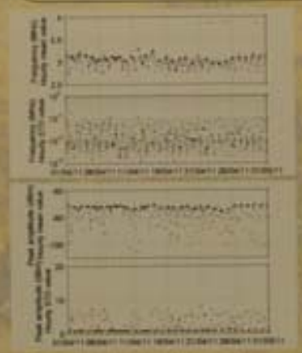
- **Quasi continuous emission from November to March**
- **Emission fully disappears in June**
- **No correlation with magnetic activity**

D. Statistics

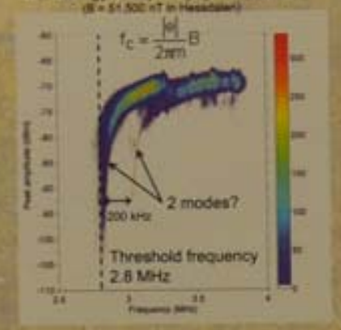




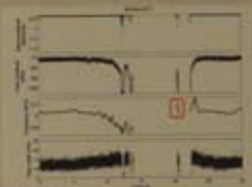
Main trends
- **Peak frequency varies from 2.8 to 3.8 MHz.** There is **a daily variation of about 0.5 MHz range**. Its hourly standard deviation is about 0.01 MHz.
- **Peak amplitude** varies from -75 dBm and -68 dBm. **A yearly variation** is observed with a **maximum in January** and a **minimum in July**.
- **2 classes (modes)** can be distinguished:
  - from ~3.3 MHz to 3.8 MHz, mainly during winter
  - from 2.8 to ~3.3 MHz during the rest of the year
- **Below 2.8 MHz, the radiation disappears**. When the peak frequency is lower than 3 MHz, it is strongly reduced down to -110 dBm (noise level)
- **Bandwidth** is from 10 to 16 kHz. It is weaker when the peak frequency is higher (December/January).



Electron gyrofrequency f_c = 1.44 MHz
(B = 51 500 nT in Hessdalen)



E. Daytime Hessdalen phenomenon on 6 April, 2011



Comment:
On April 6th, the magnetic field was perturbed but a shift of 200 kHz would require a magnetic field perturbation 10 times stronger than measured.
Moreover, the emission disappeared and appeared at more than 3 MHz while it always disappears when the frequency is lower than 2.6 MHz.
Could the "Hessdalen phenomenon » change the propagation conditions in such a way that the emission could reappear at 18h19 UT for 15 minutes?

Discussion on the origin of this radiation
Daytime radiation: The origin of such emission is not so obvious. A short literature study shows that such emission is not known. Some signals with large spectral width are observed due to aurora (in specific magnetic conditions), but they are never seen during daytime due to the strong absorption when these waves propagate through the D region of the ionosphere. **This radiation probably does not propagate on large distance** otherwise it has to be absorbed when it propagates through the D region or it has to show strong amplitude variations which are not observed.
Peak frequency: We notice however that the radiation frequency threshold is close to the double of the electron gyrofrequency (2.88 MHz). Nevertheless, processes to produce a plasma on Earth are not easy to maintain. We have to know if this field is electrostatic or electromagnetic. For instance, we plan some complementary experiments in the field to measure simultaneously this radiation with a mobile system.
Peak frequency variability: The frequency shift of this emission is a very important feature of this radiation. Two hypothesis have been examined to explain this shift:
1. if we assume it is due to a **Doppler effect**, this means that the transmitter, which produces this emission, has **a speed of 5000 m/s** (which is close to some measurements performed with a heliovalve in Hessdalen valley in 1983-84).
2. if the radiation is related to the electron gyrofrequency, it would change when the Earth magnetic field varies. To explain a 100 kHz frequency shift, **the Earth magnetic field perturbation must vary by more than 7%**, when it is only a maximum of 2% (1000 nT) during magnetic storm. Moreover, **as frequency shift is also observed during quiet day, there is probably not strong relation with the magnetic conditions.**