

# High frequency radio emissions as a manifestation of physical processes in the auroral plasma

Hanna Rothkaehl, Barbara Matyjasiak, Agata Chuchra, Roman Schreiber,  
Michał Marek, Dorota Przepiórka

Space Research Centre of Polish Academy of Sciences  
Warsaw, Poland

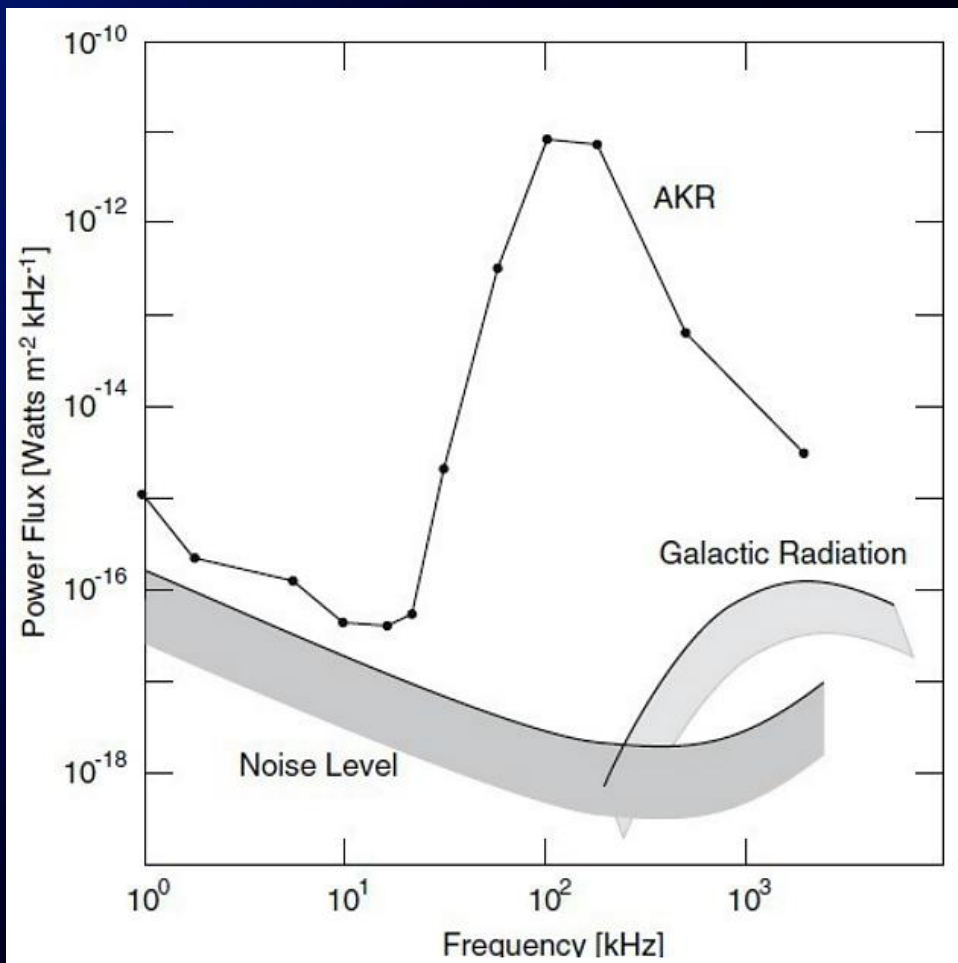


European Geosciences Union General Assembly  
3-8 May 2020, Vienna, Austria

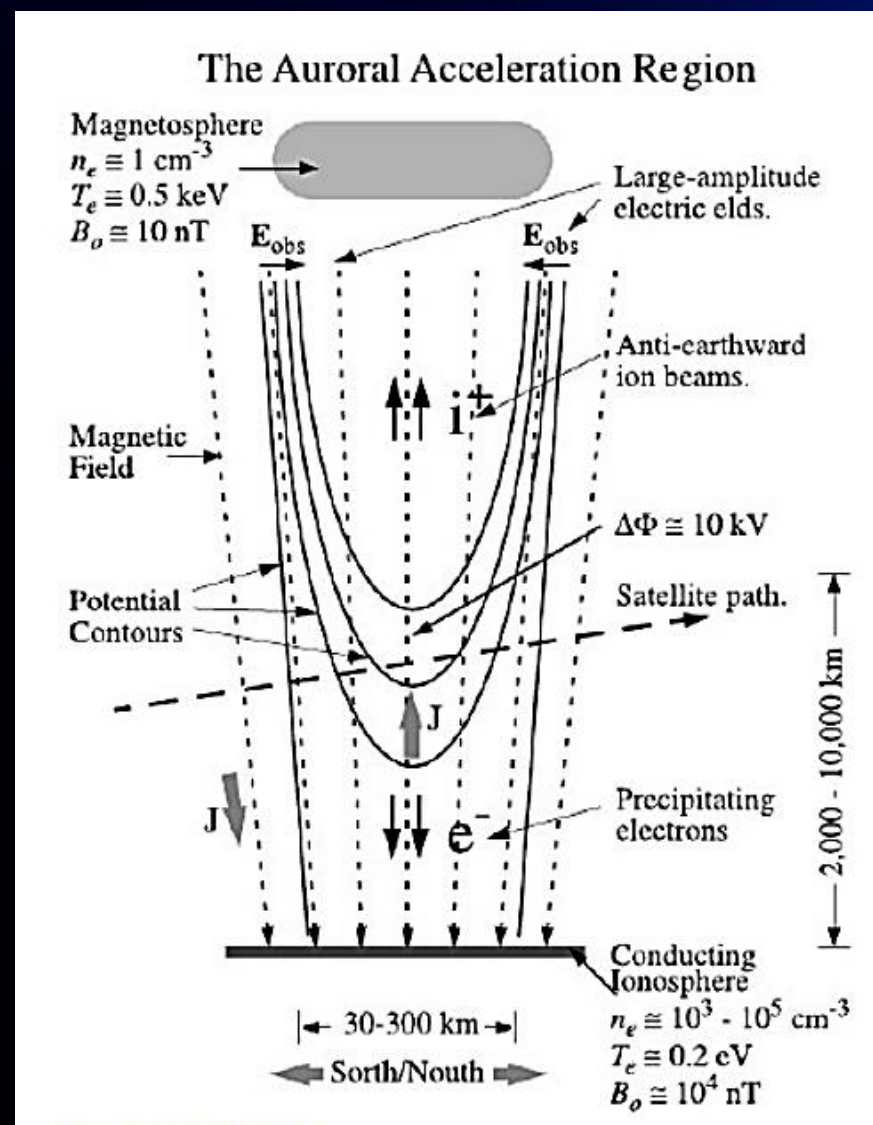


# Auroral Kilometric Radiation (AKR)

- It is a superluminous wave mode in the frequency range from around 50 to about 700 kHz, with the peak intensity around 250 kHz.
- It originates in auroral zones low-density source cavities in auroral zones between altitudes 1–3  $R_E$  above Earth's surface along auroral field lines.
- It is generated by the weakly relativistic electron-cyclotron maser mechanism, which excites the lower-branch X-mode, low-harmonic upper-branch X-modes, O-modes and Z-modes (at different growth rates).
- The prevailing emission is X-mode radiation emitted outward and observable only from space.
- It is the most powerful natural radio radiation from Earth.



Treumann, 2006

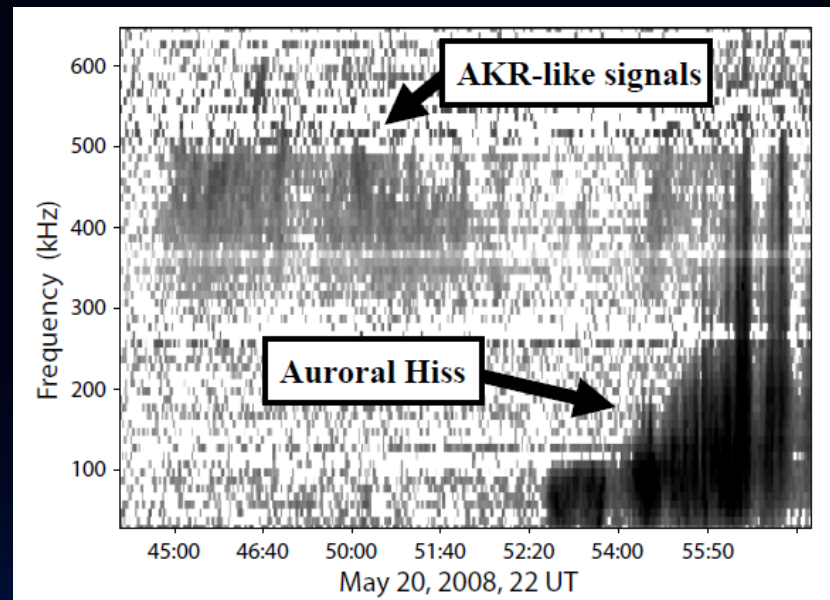


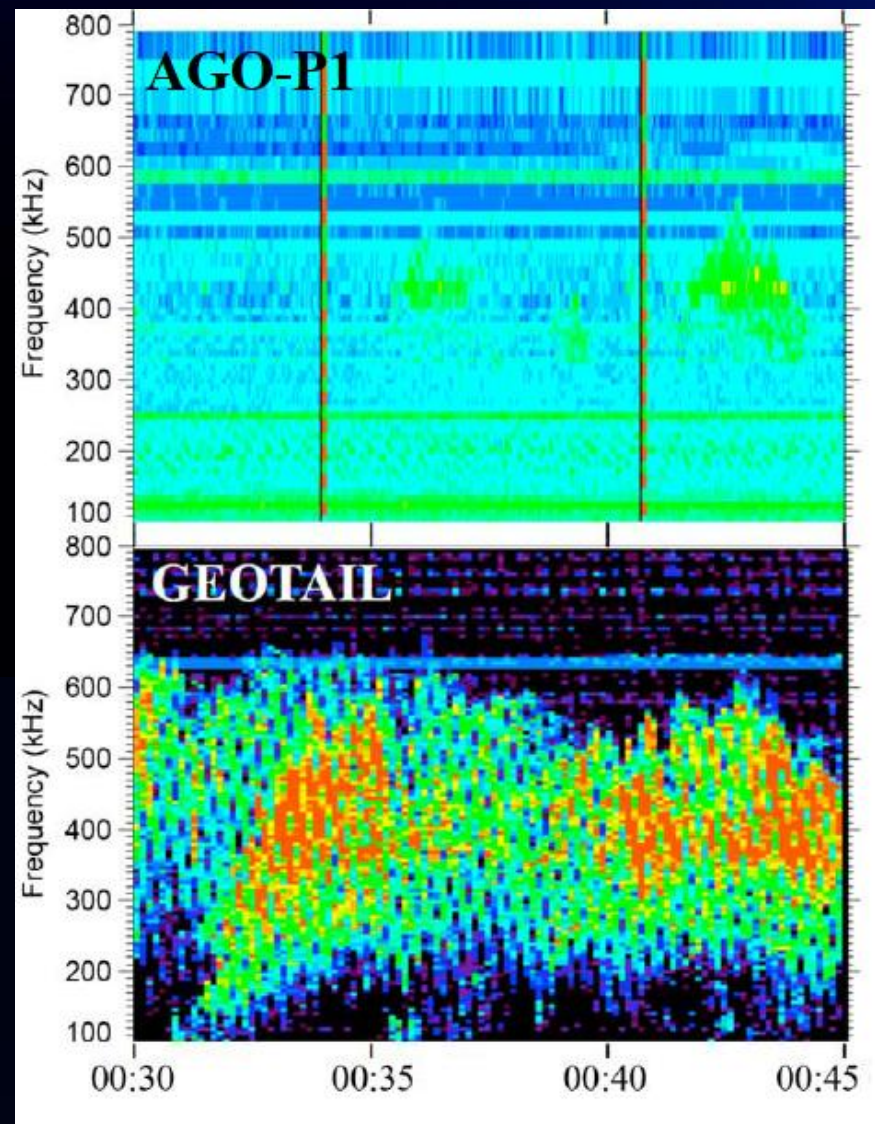
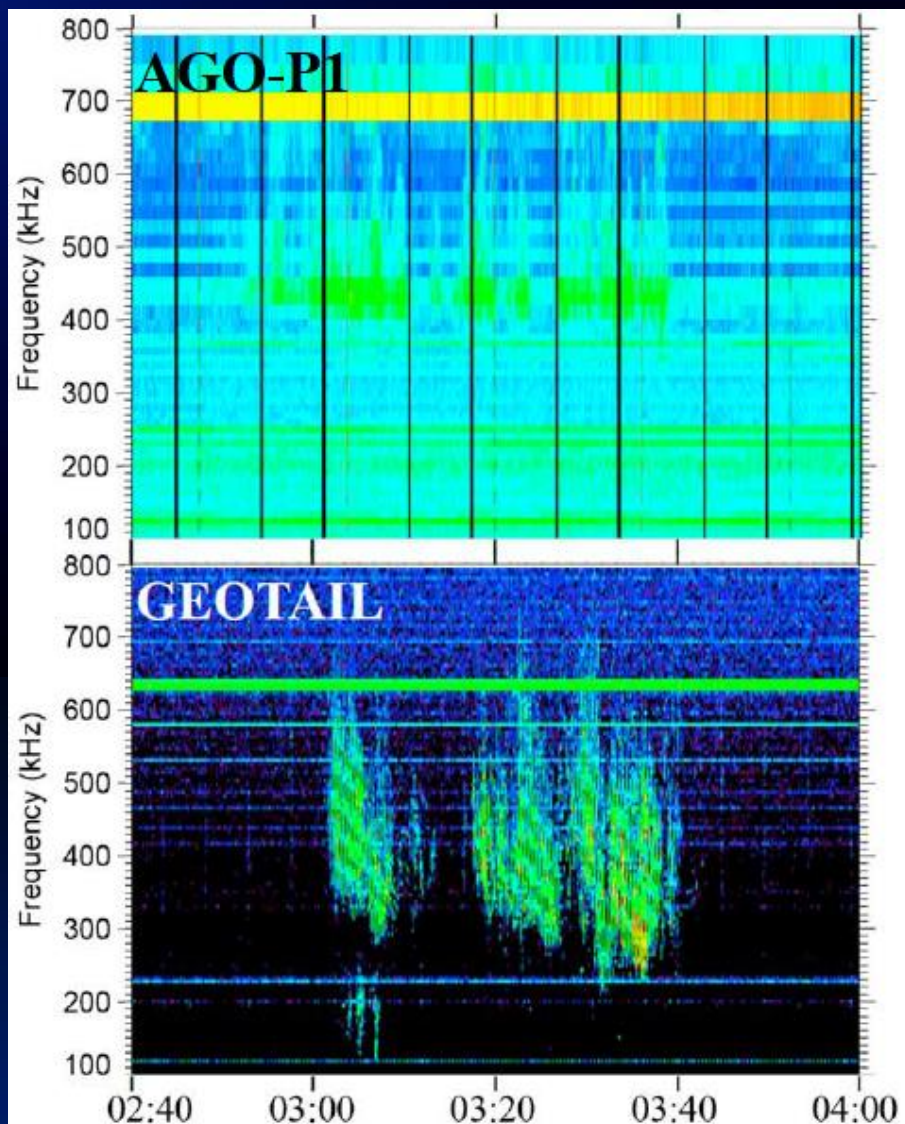
Ergun et al., 2000



# AKR-like emissions

- Observations suggest, that a component of auroral kilometric radiation penetrates to low altitudes and it is known as AKR-like emission.
- Full-resolution measurements of ground-level AKR-like signals showed that their fine structure highly resembles that of AKR as known from measurements of high-resolution spacecraft receivers.
- The analysis made by J. LaBelle et al. (2015) led to the first measurement of the polarization of a ground-level AKR-like signal, which indicates it to be right-hand polarized, suggesting propagation in the whistler mode in the ionosphere.





Examples of spectrograms of AKR-like emissions measured at AGO-P1 (Automatic Geophysical observatory in Antarctica) and simultaneous AKR measured with the Geotail satellite on 5th July (left) and 19th July (right) of 2008. Labelle et al. (2015)





RELEC (Relativistic ELECtrons) is a set of instruments on board Vernov satellite. Observations from solar-synchronous orbit with inclination  $98,4^\circ$  in the altitude range 650 - 850 km. RELEC observations cover practically full magnetic latitude range and sometimes we can observe AKR-like emissions even a few degrees above 80 invariant latitude.

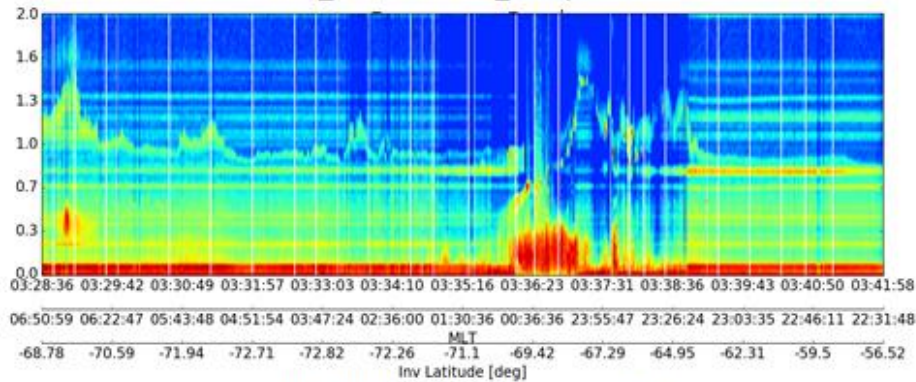
### Scientific goals of RELEC

- Magnetosphere relativistic electron acceleration and precipitation research.
- Study of high-energy particles acting in the upper atmosphere and ionosphere.
- Search of transient phenomena (TLE) in possible connection with energetic particle interactions in the atmosphere
- Study of acceleration processes in the atmosphere as the possible source of high energy magnetosphere electrons

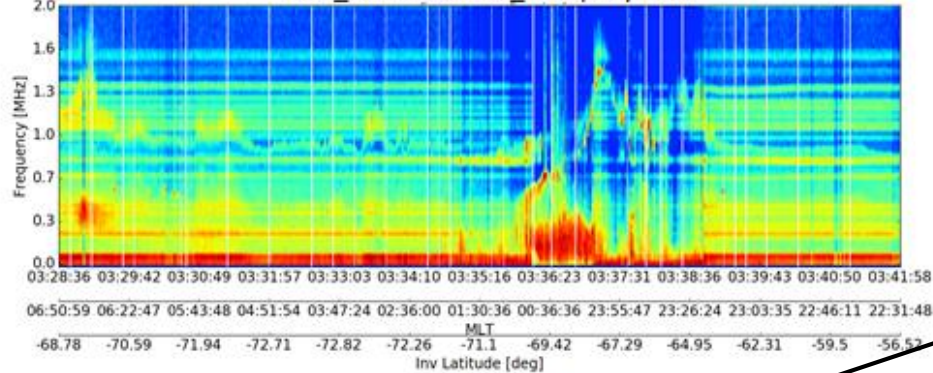


Date = 2014-08-03,  
Start time(UTC) = 03:28:36, End time(UTC) = 03:41:58

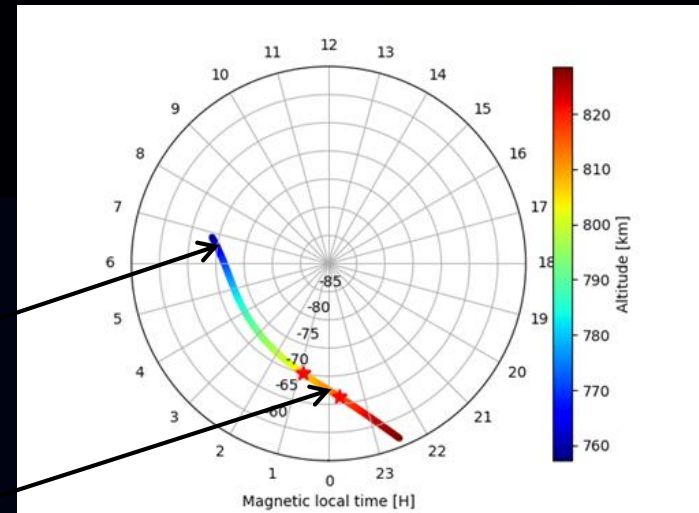
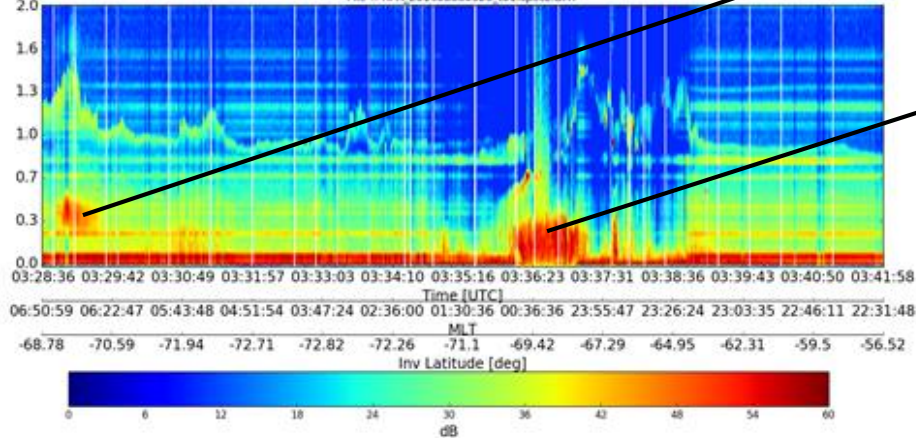
RFA\_201408030623\_t01.specx.DAT



RFA\_201408030623\_t01.specy.DAT



RFA\_201408030623\_t01.specz.DAT



AKR-like emissions measured  
with RELEC

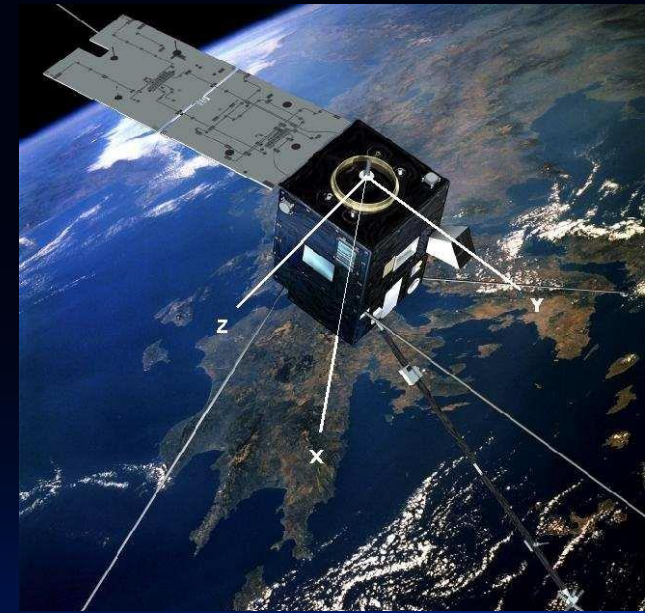


# DEMETER → Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions

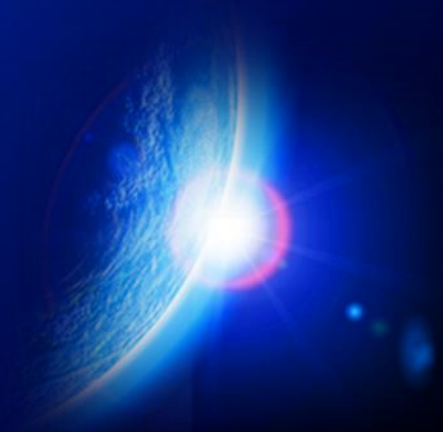
Similar observations were made by DEMETER satellite, but only for magnetic latitudes lower than  $\sim 65^\circ$

DEMETER was a French microsatellite mission with the purpose to observe geophysical parameters of the terrestrial environment and to give a global information on the Earth's electromagnetic environment.

Observations were made from orbit with inclination  $98,3^\circ$  in the altitude range 697 - 722 km.



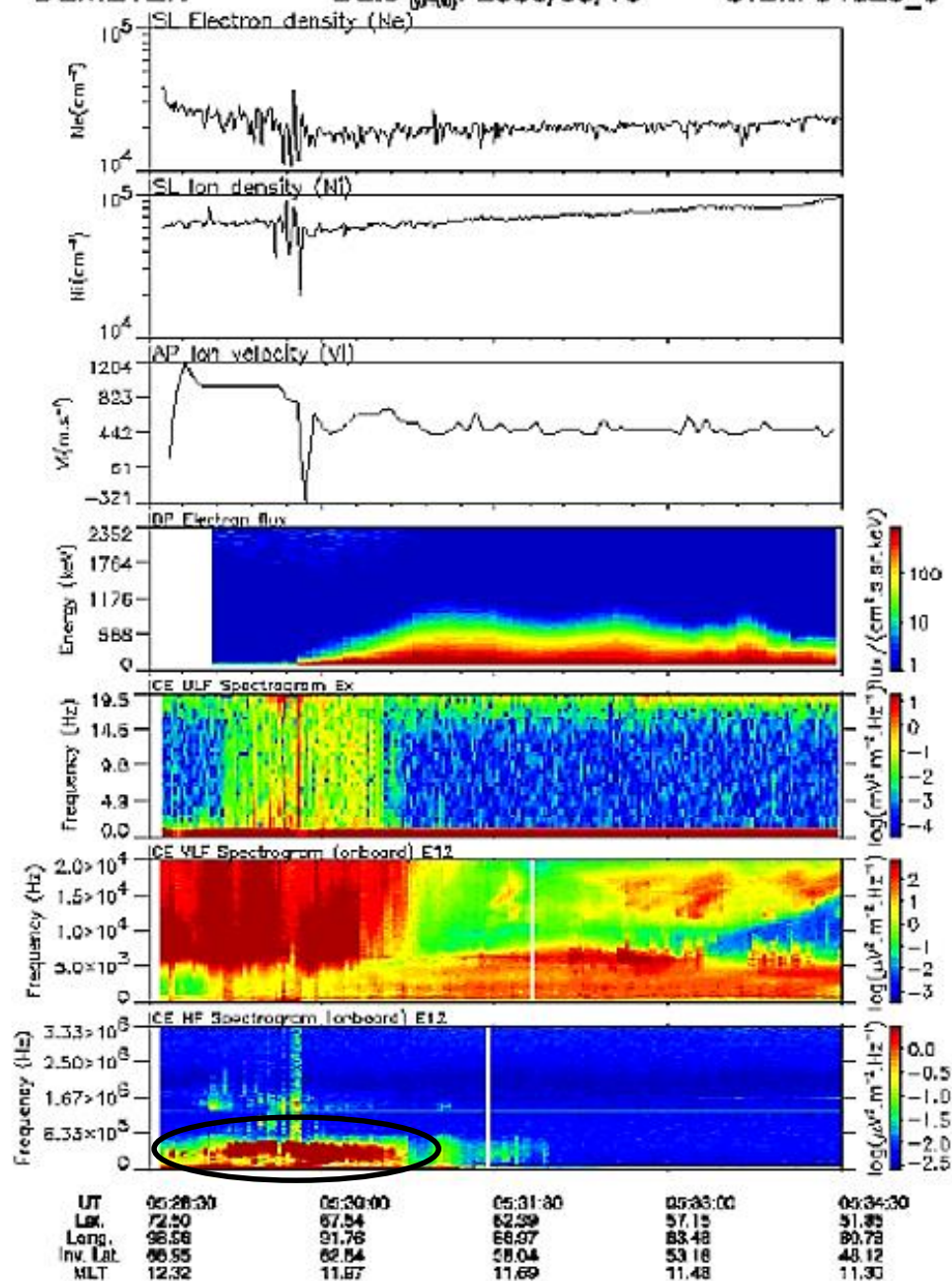




DEMETER

Date (YYYY): 2005/05/16

Orbit: 04623\_0



# Summary

- AKR-like emissions are common features for low and high altitude and different MLT.
- 450 AKR-like signal events registered by RELEC instrumentation between July and December of 2014 indicated location between  $65^\circ$  and  $82^\circ$  invariant latitudes for north and south hemispheres.
- The observed emissions are located below local electron gyrofrequency.
- We have found more than three hundred cases of AKR-like emissions, registered by RELEC, between August and December of 2014.
- AKR-like emissions are localized within the northern and southern auroral ovals with maximum occurrence at around  $75^\circ$  invariant latitude.
- RELEC observations of AKR-like emissions in the Earth's ionosphere cover much wider range of invariant latitudes than previously observations (e.g. DEMETER).
- The mechanism of the propagation of AKR signals to the ground is not known, but there are suggestions that Z-mode of AKR signal (which was excited in X- and Z-modes) convert to the whistler mode on strong density irregularities below the source region, where the frequency is below the local cyclotron frequency, followed by propagation of the whistler mode waves to low altitude with resulting radiation similar to the outgoing X-mode.



# High frequency radio emissions as a manifestation of physical processes in the auroral plasma

Hanna Rothkaehl, Barbara Matyjasiak, Agata Chuchra, Roman Schreiber,  
Michał Marek, Dorota Przepiórka

Space Research Centre of Polish Academy of Sciences  
Warsaw, Poland

Contact:  
[hrot@cbk.waw.pl](mailto:hrot@cbk.waw.pl)



European Geosciences Union General Assembly  
3-8 May 2020, Vienna, Austria

