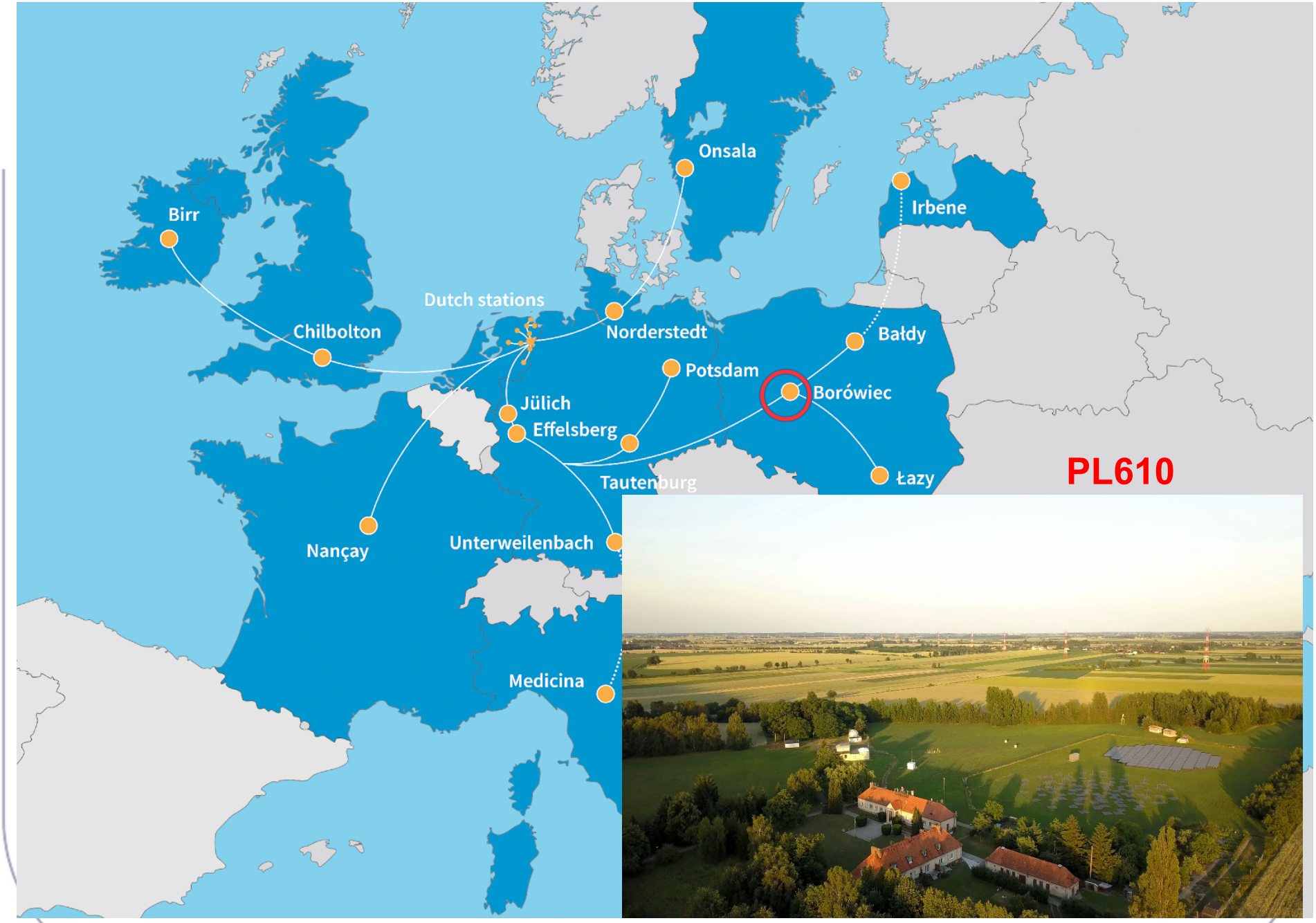
Monitoring of Space Weather conditions with LOFAR station in Borówiec

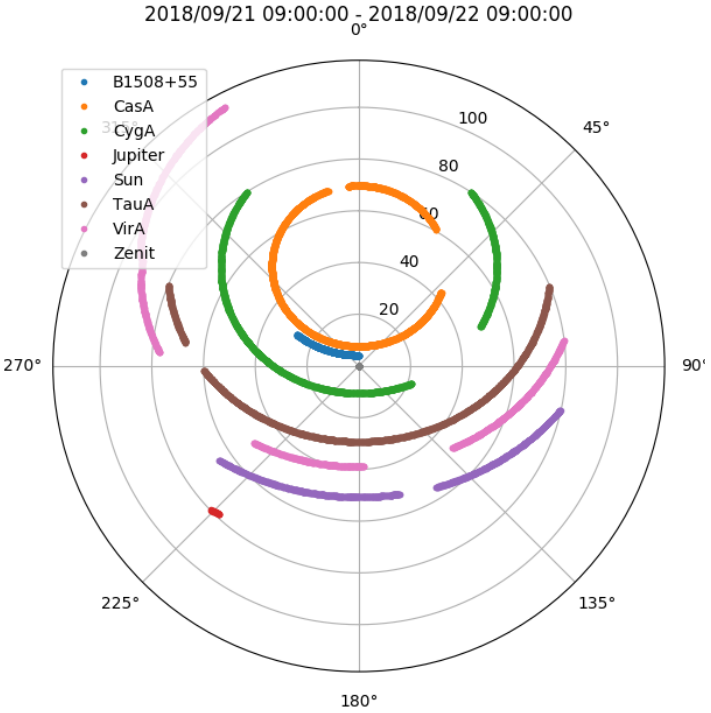
Hanna Rothkaehl, Barbara Matyjasiak, Mariusz Pożoga,, Marcin Grzesiak, Katarzyna Budzińska, Łukasz Tomasik, Roman Wronowski, Dorota Przepiórka, Barbara Atamaniuk

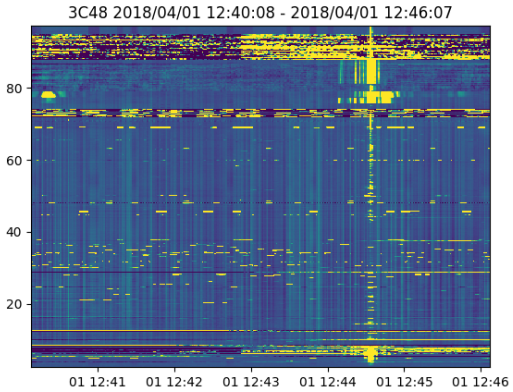
20-23 LOFAR Science, LEIDEN

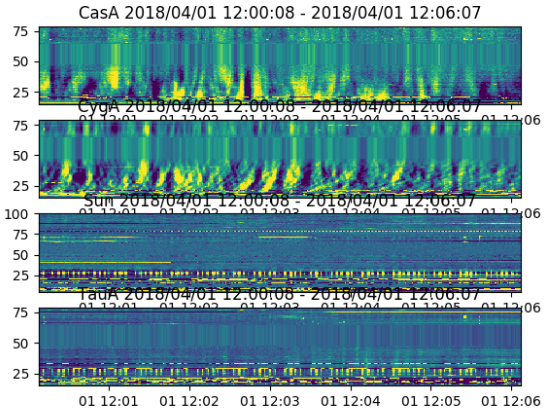

Onsala
Irbene
Birr
Dutch stations
Chilbolton
Norderstedt
Bałdy
Potsdam
Borówiec
Jülich
Effelsberg
Tautenburg
Łazy
PL610
Nançay
Unterweilenbach
Medicina

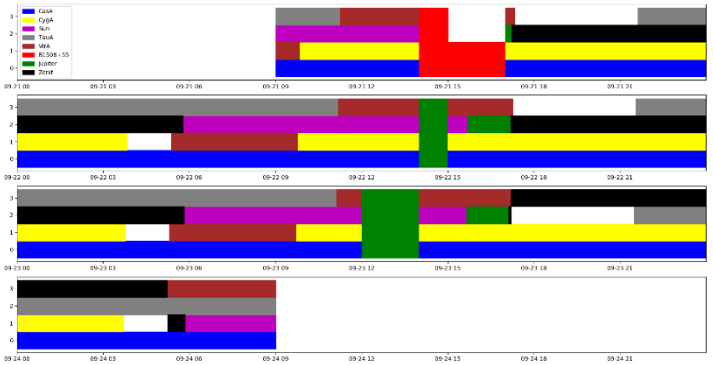
Observation scheduling system

- semi-automated (operator action needed to run the scheduler at the beginning of the local mode)
- simultaneous observations to 4 different objects
- different types of observations (change of bitmode, sources)
- observations are logged to the database – easier searching of files and better control over station work



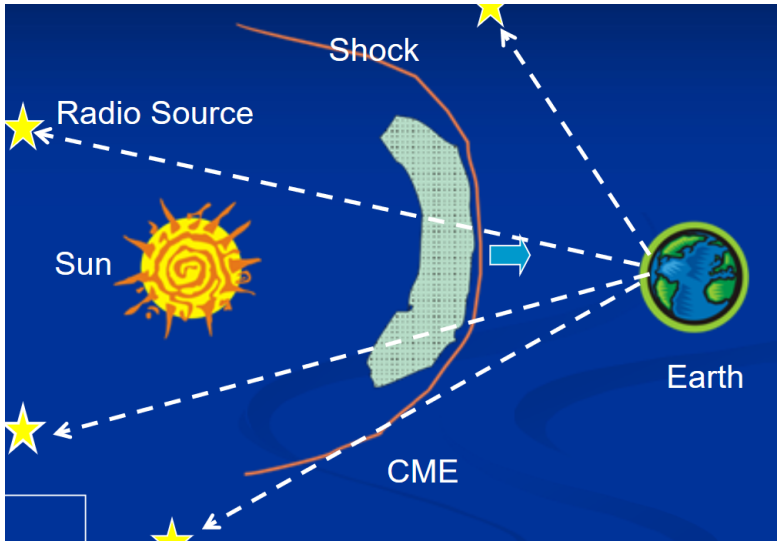


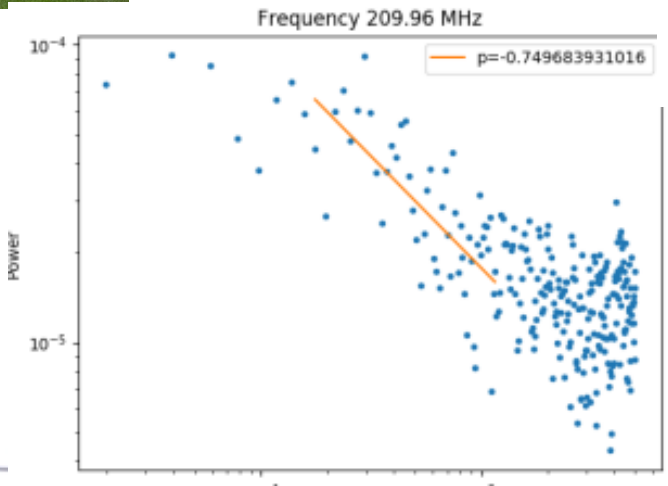


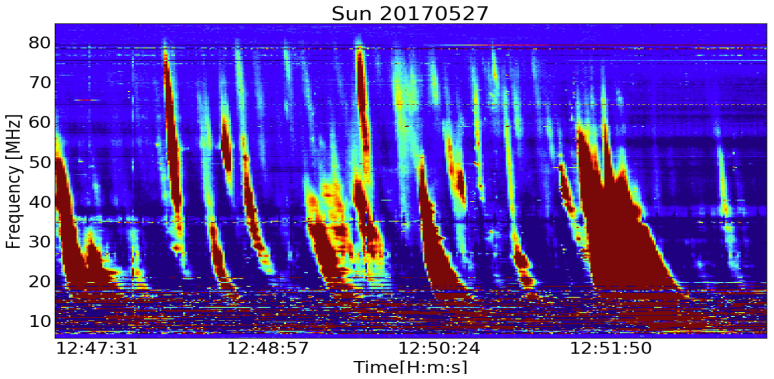


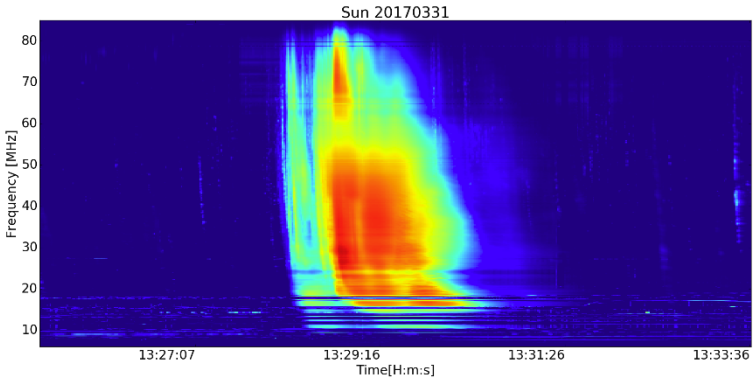
Research subjects out of CBK's interest: analysis of ionospheric and magnetometer scintillations. Results of both theoretical and observation analyse data will serve to this phenomenon's model construction and will be applied both in making ionospheric corrections at radio astronomy observation corrections and in Space Weather services.

Solar Wind parameters' analysis, mainly an intraplanetary scintillation analysis.







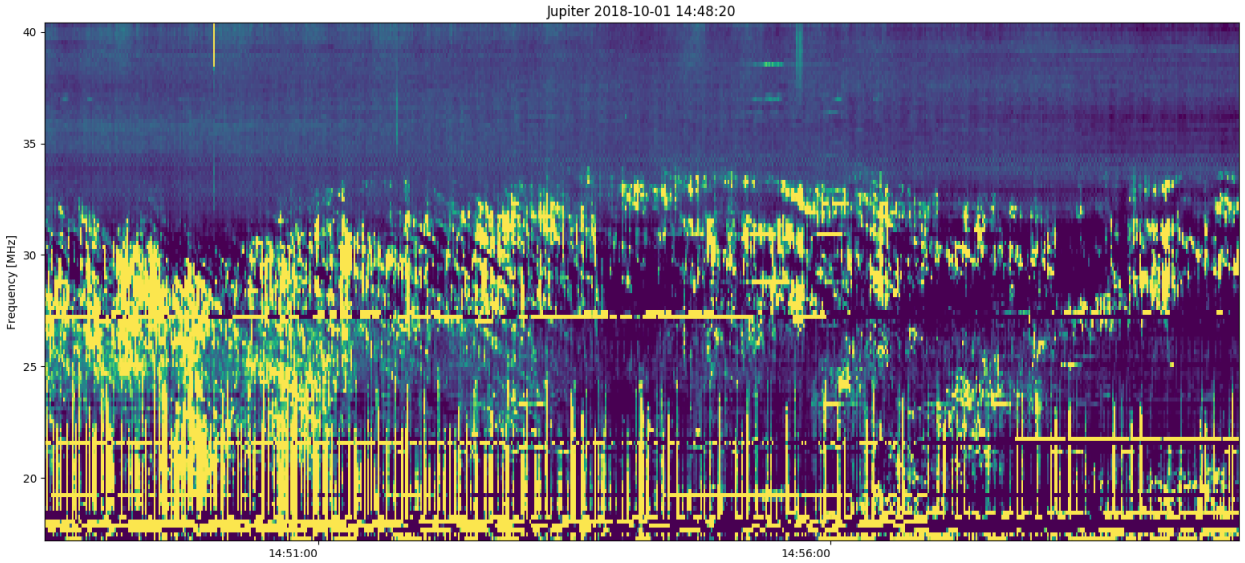


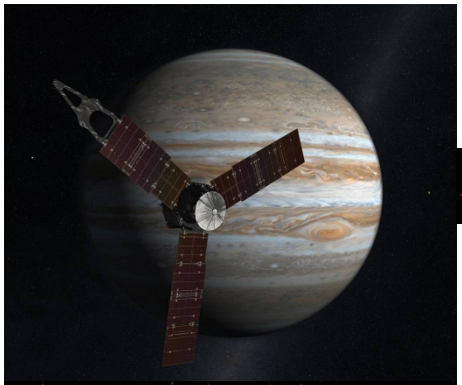
Jupiter observations

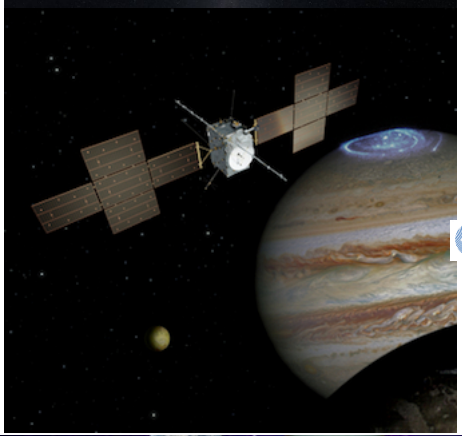
DAM emissions - Jovian decametric radio emission

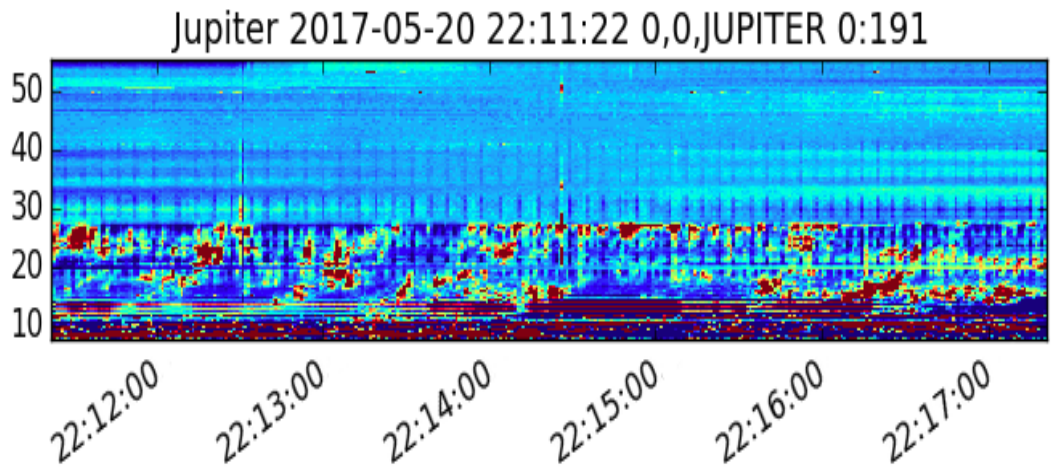
Follow-up for JUNO and JUICE missions

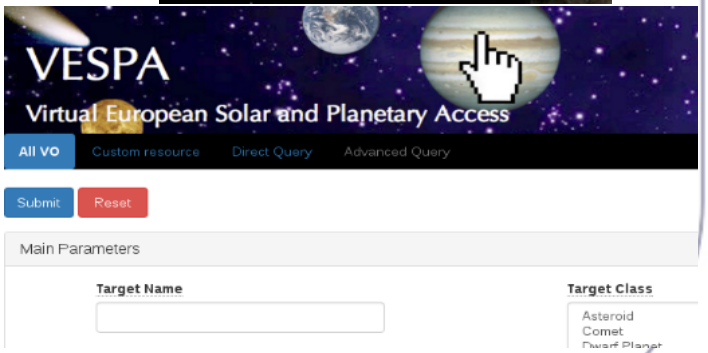
Observations accessible by VO





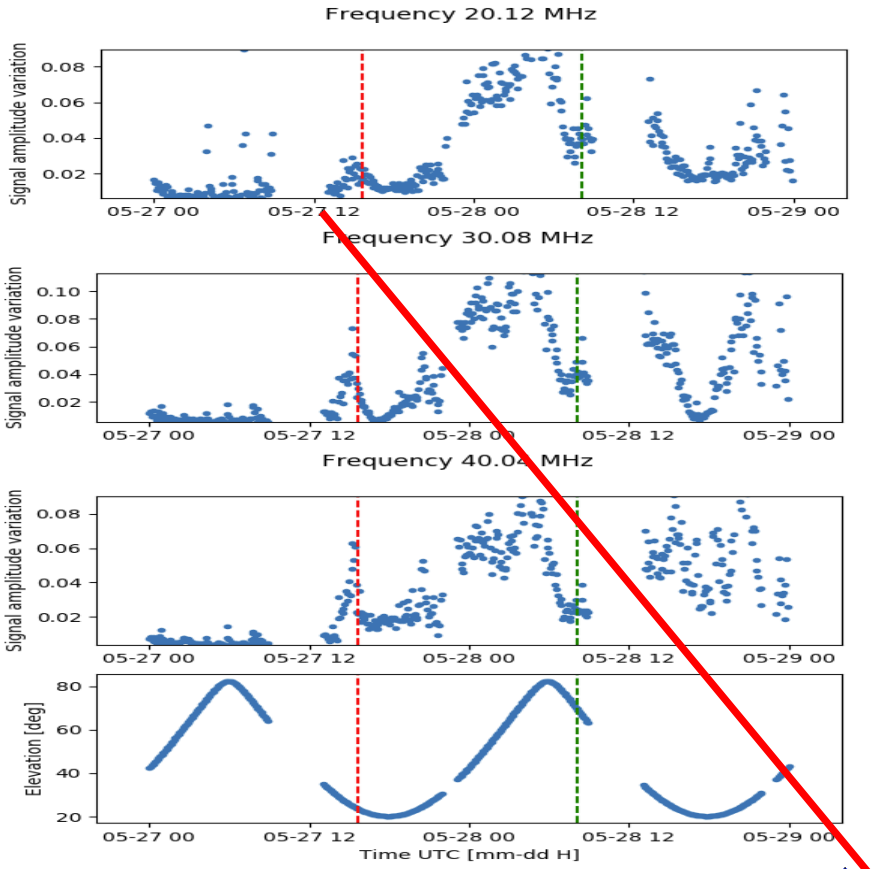




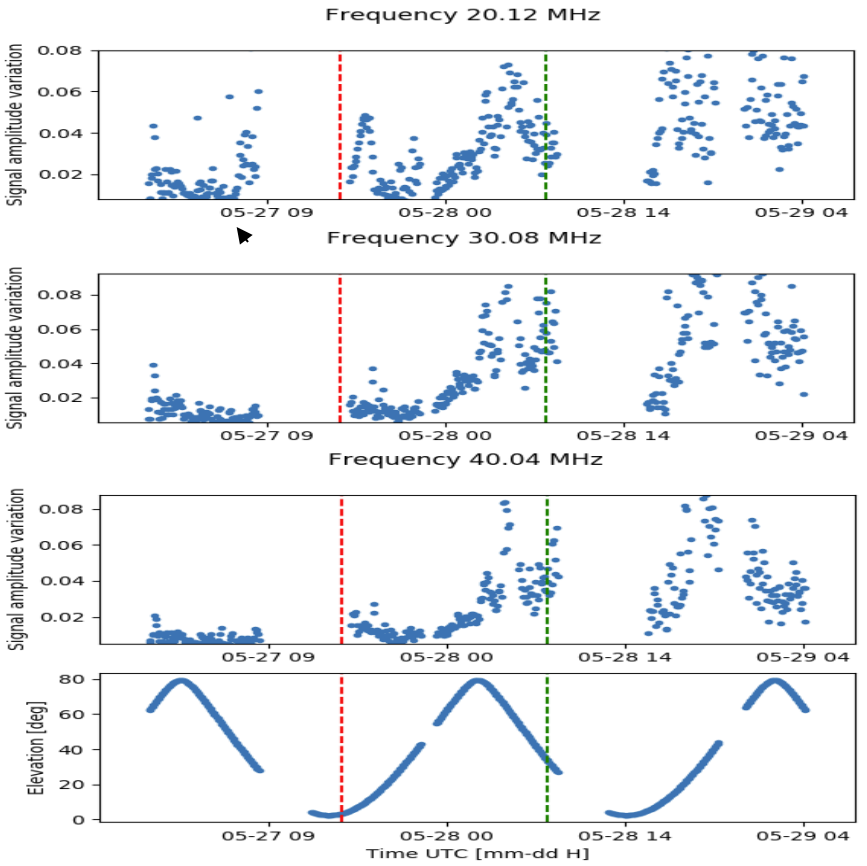


Geomagnetic storm 2017/05/27

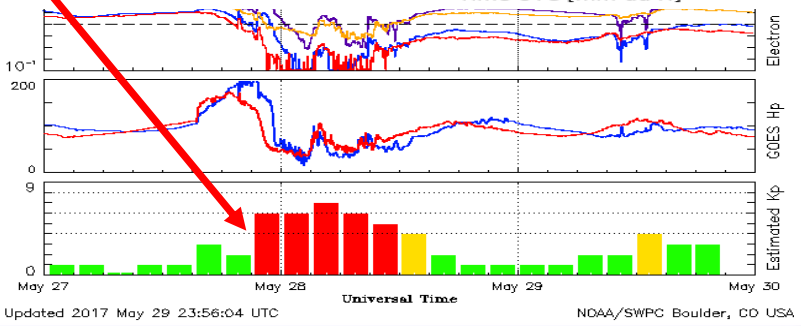
Cassiopea A



Cygnus A



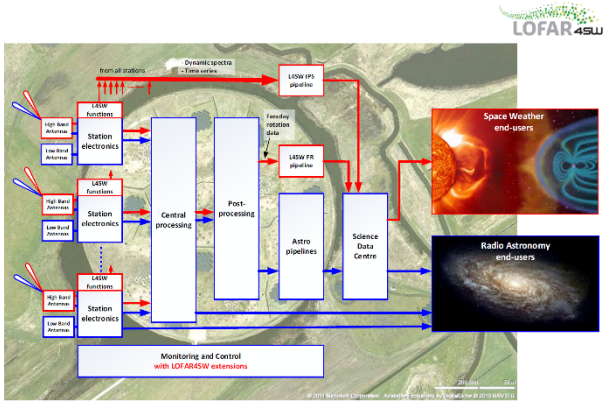
Type G3 geomagnetic storm (Kp index 7).
Red line - sudden commencement, green - min Dst index (-125 nT)
Signal amplitude variance for CasA and CygA.



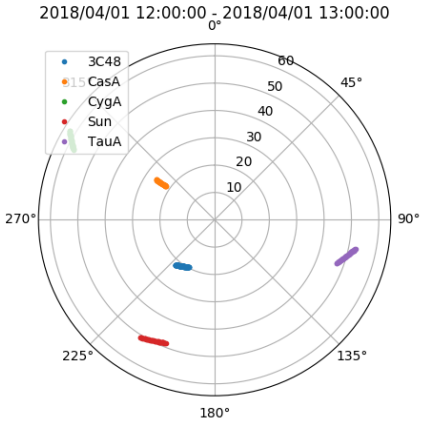
Ionospheric scintillation

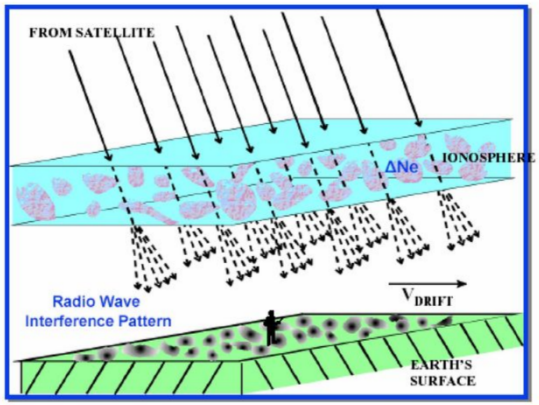
What would be provided:

1) Survey mode:
   - near real time S4 scintillation index for core stations and maybe for international stations (LBA antennas) ~ 5 min measurements every 1h/0.5h or less (to be discussed) -> useful for GPS navigation
   - additional parameters: pierce point, source elevation and azimuth, position of the Sun,
2) Daily statistics:
   - file with one day measurements accessible via e.g. VO

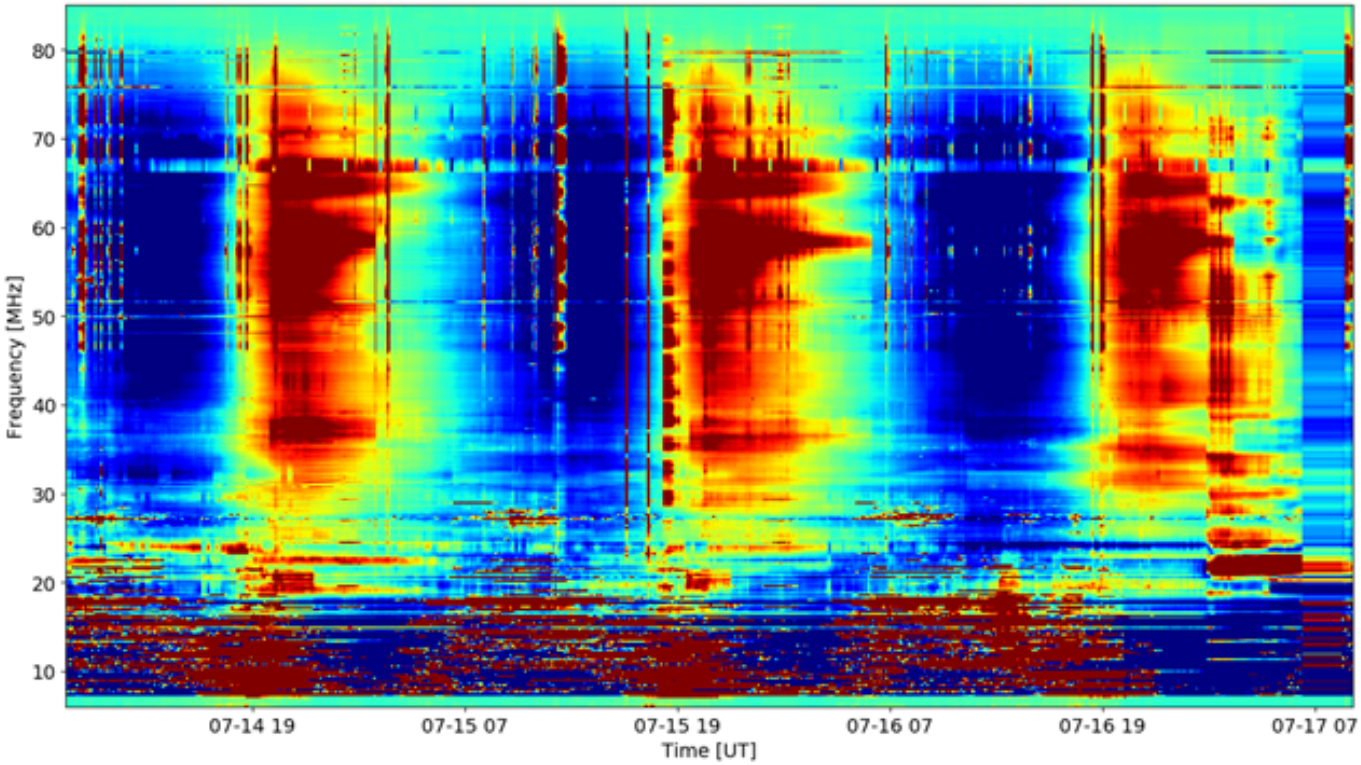


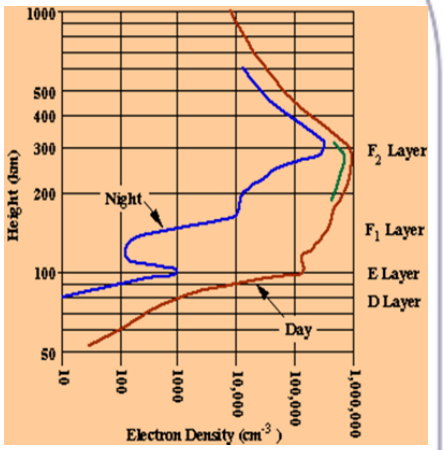
$$S_4 = \frac{\sqrt{\left\langle \left(I - \langle I \rangle \right)^2 \right\rangle}}{\langle I \rangle}$$



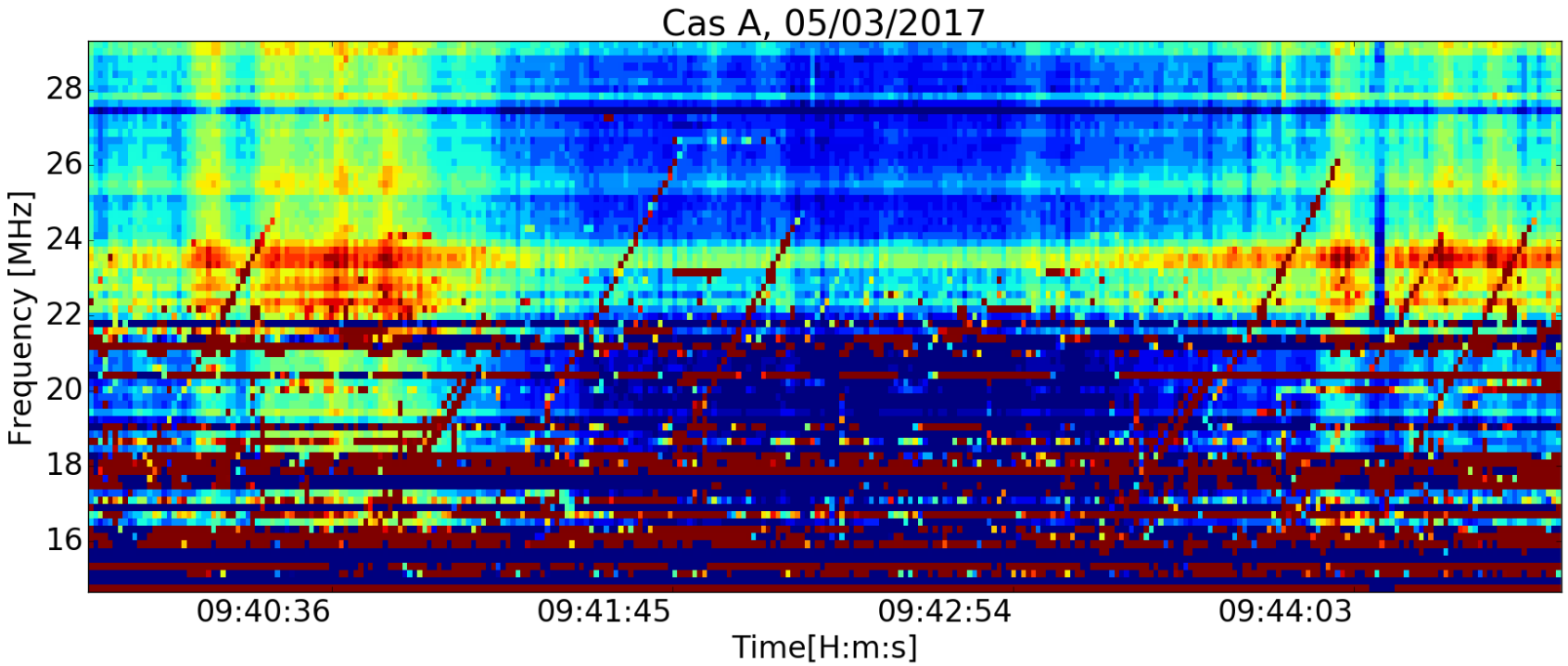


RFI

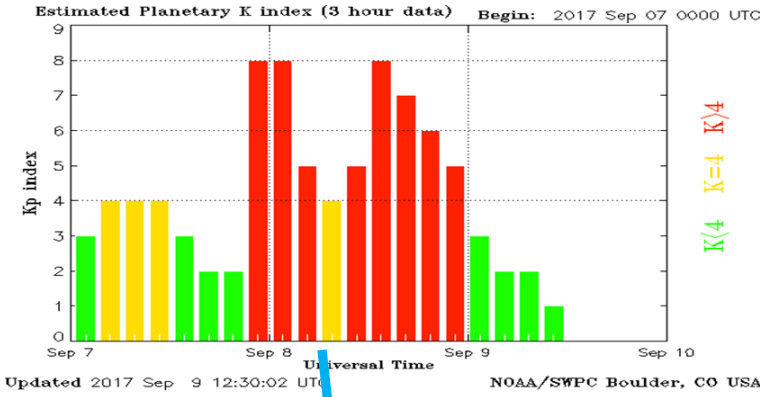




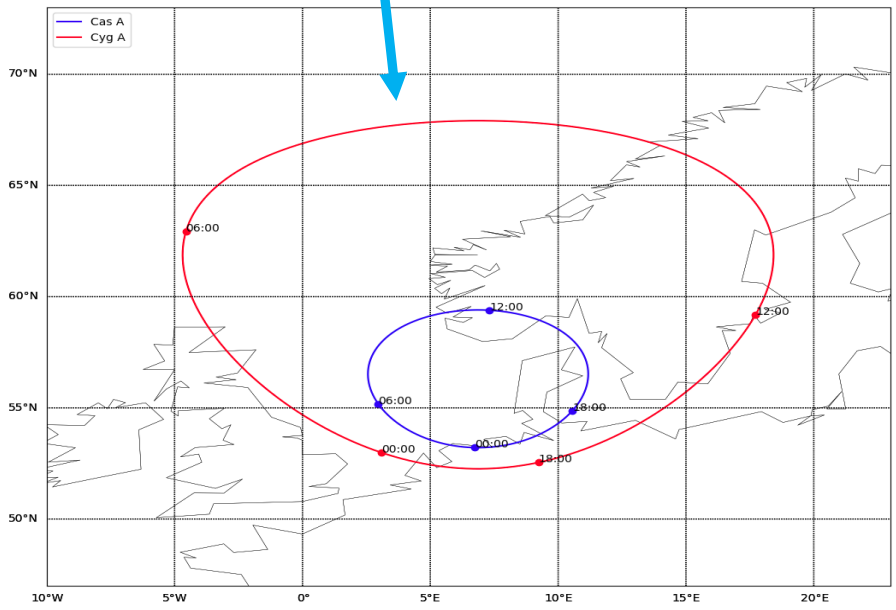
- Visible variation of signal attenuation by the ionosphere during the day. Increase in the radio noise after the sunset.
- Changes of critical frequency of F2 layer (foF2) during day - variation of the level of terrestrial radio signal reflection.
- Measurements were taken as a side-product of routine observation and can be a useful tool for ionospheric diagnostics.


Cas A, 05/03/2017
Frequency [MHz]
28
26
24
22
20
18
16
09:40:36
09:41:45
09:42:54
09:44:03
Time[H:m:s]

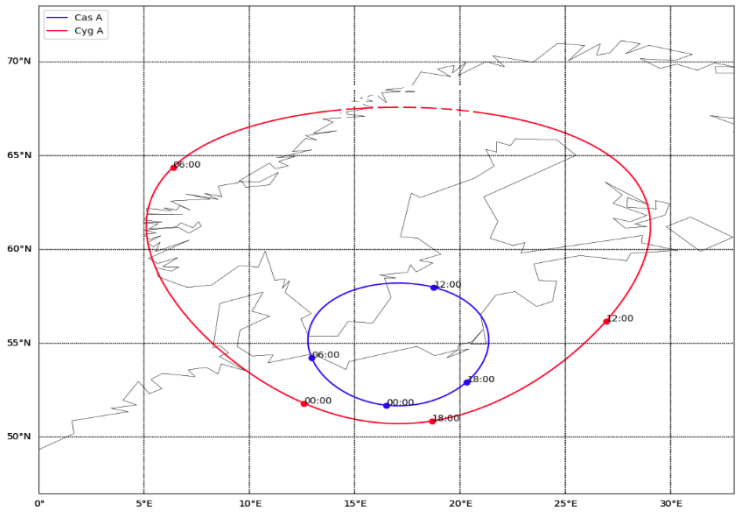
Pierce points of LOFAR observations 08.09.2018

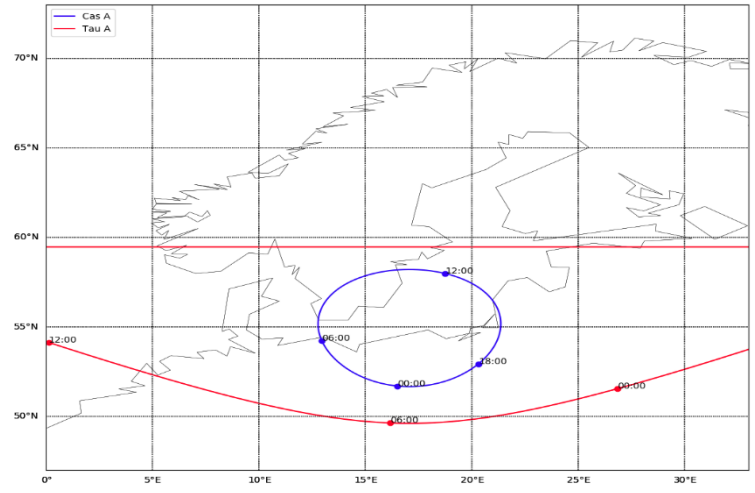


Core

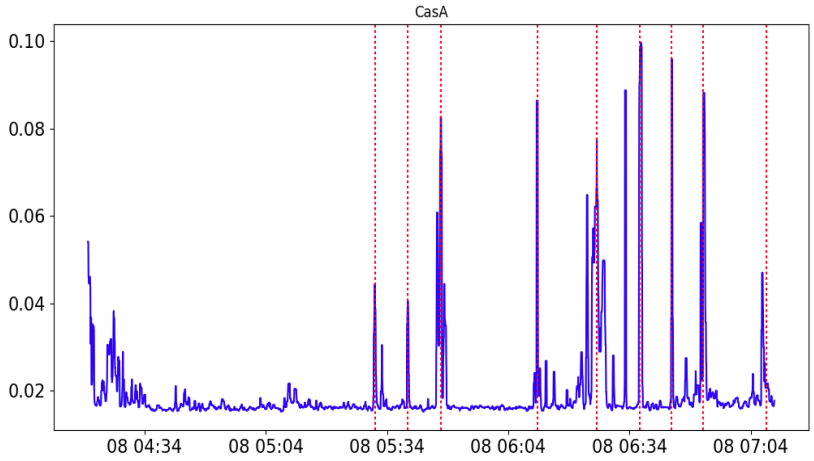


PL610

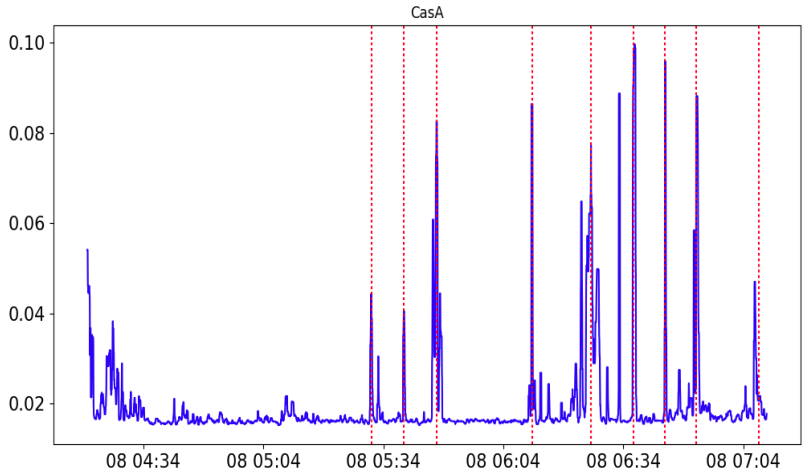


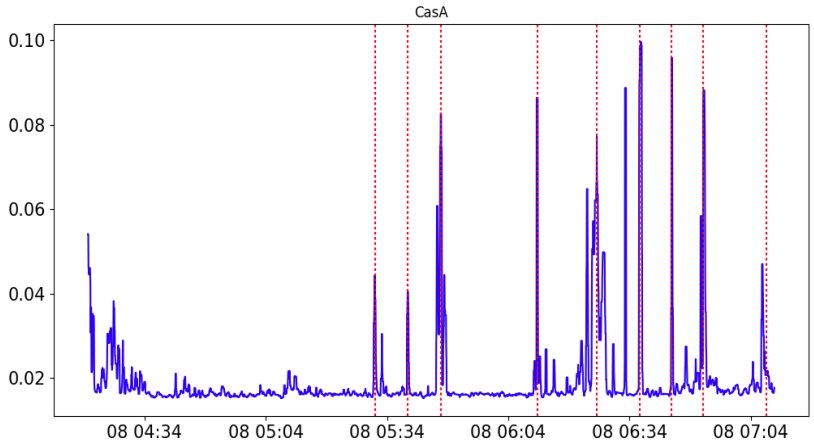


Amplitude scintillation

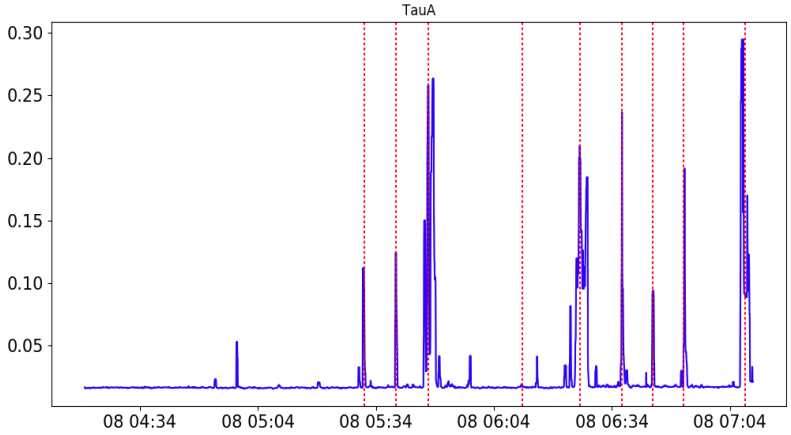


CS01

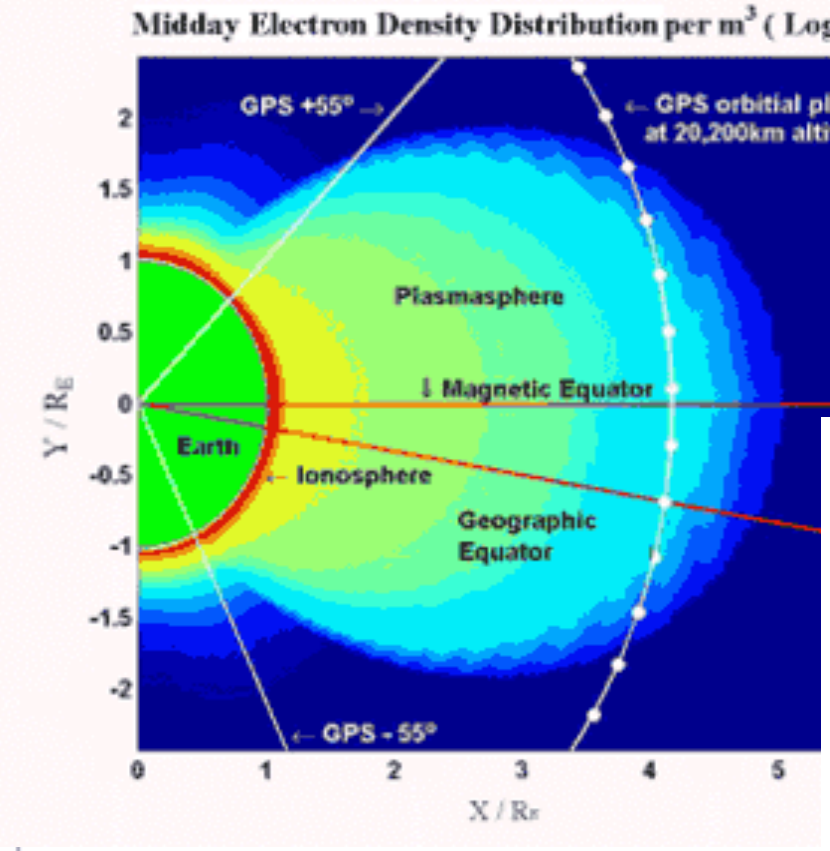


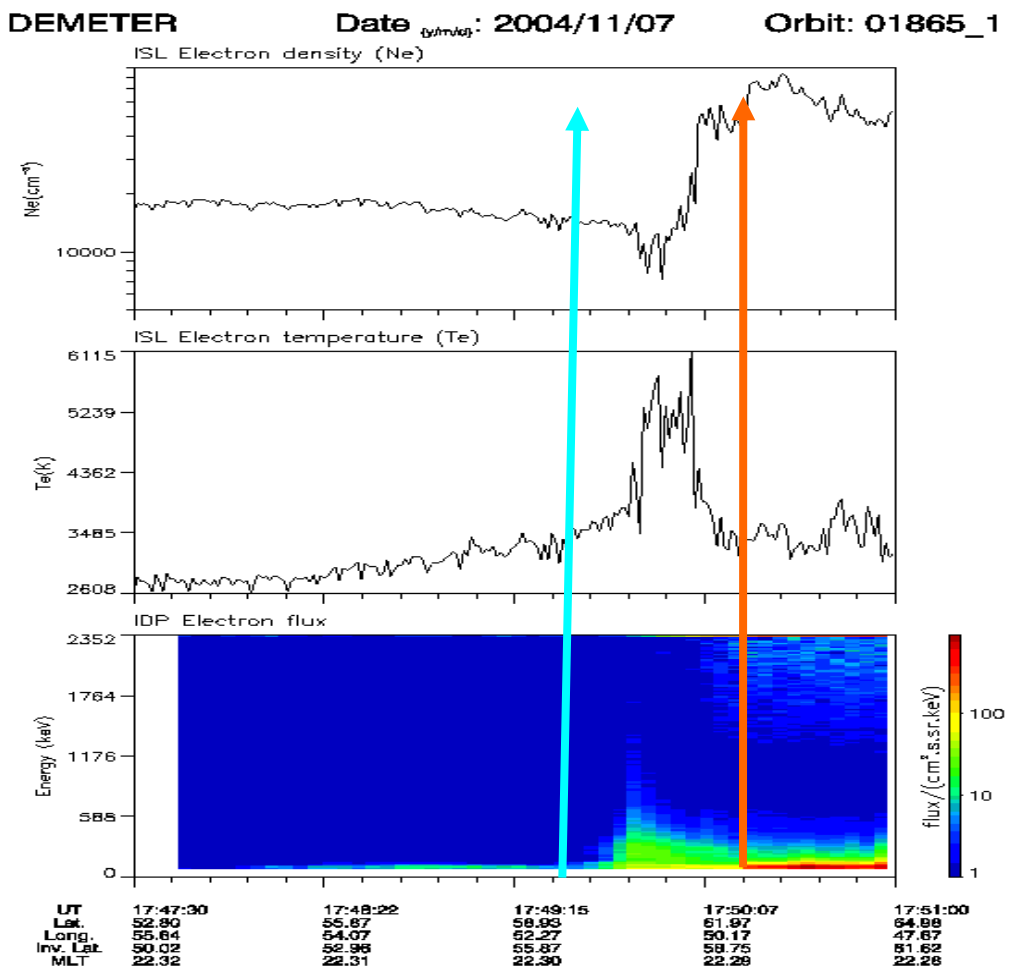


PL610



IONOSPHERIC TROUGH

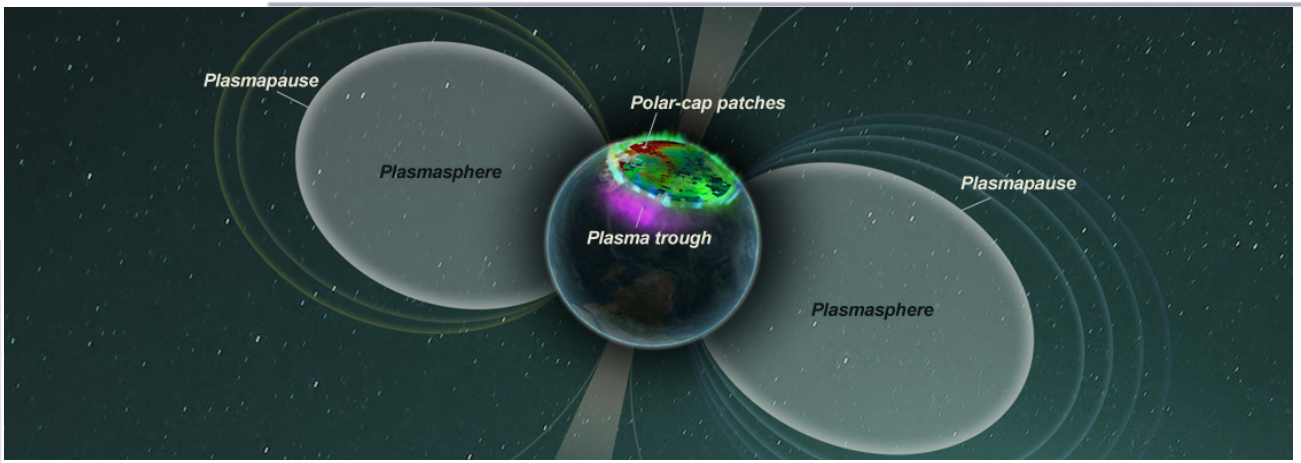




Alfven waves, EMIC, LHR, UHR

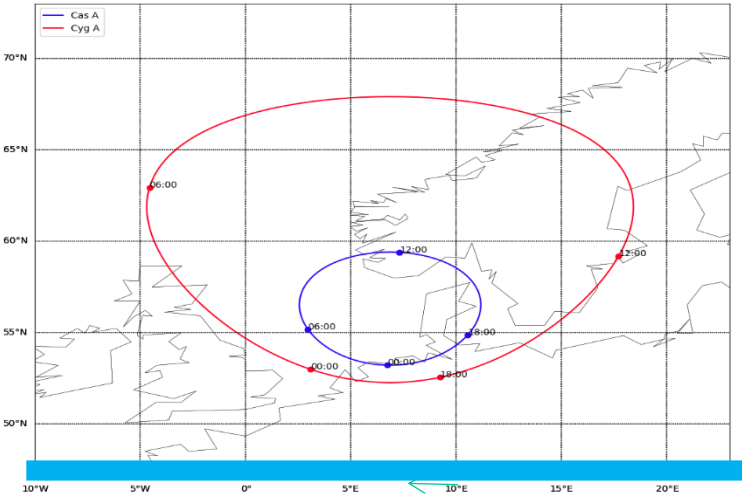
Frozen emissions,

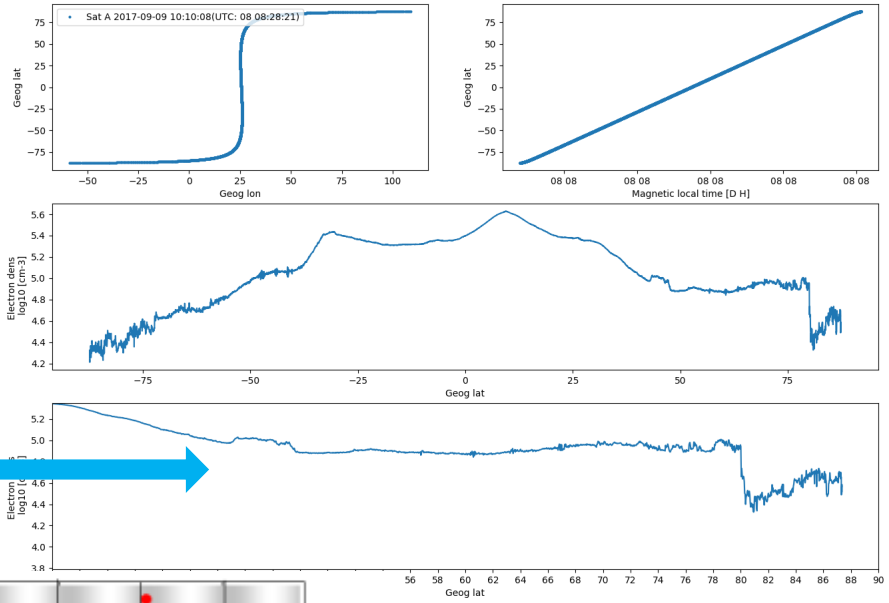
turbulent regions



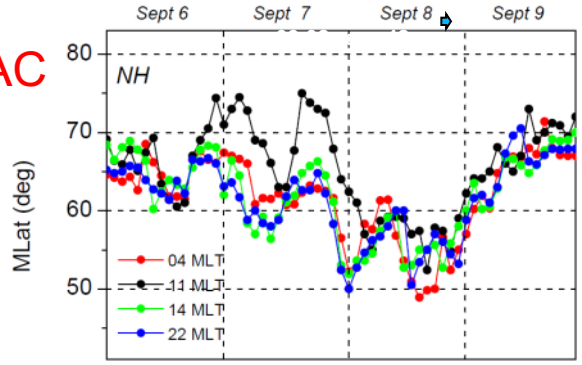
Top- side insitu diagnostics

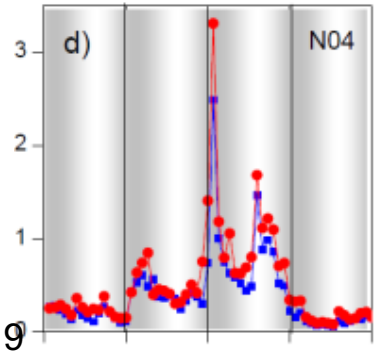
SWARM





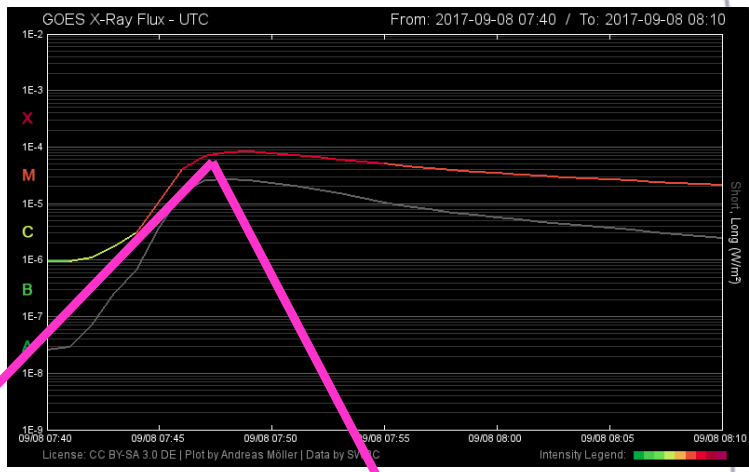
FAC

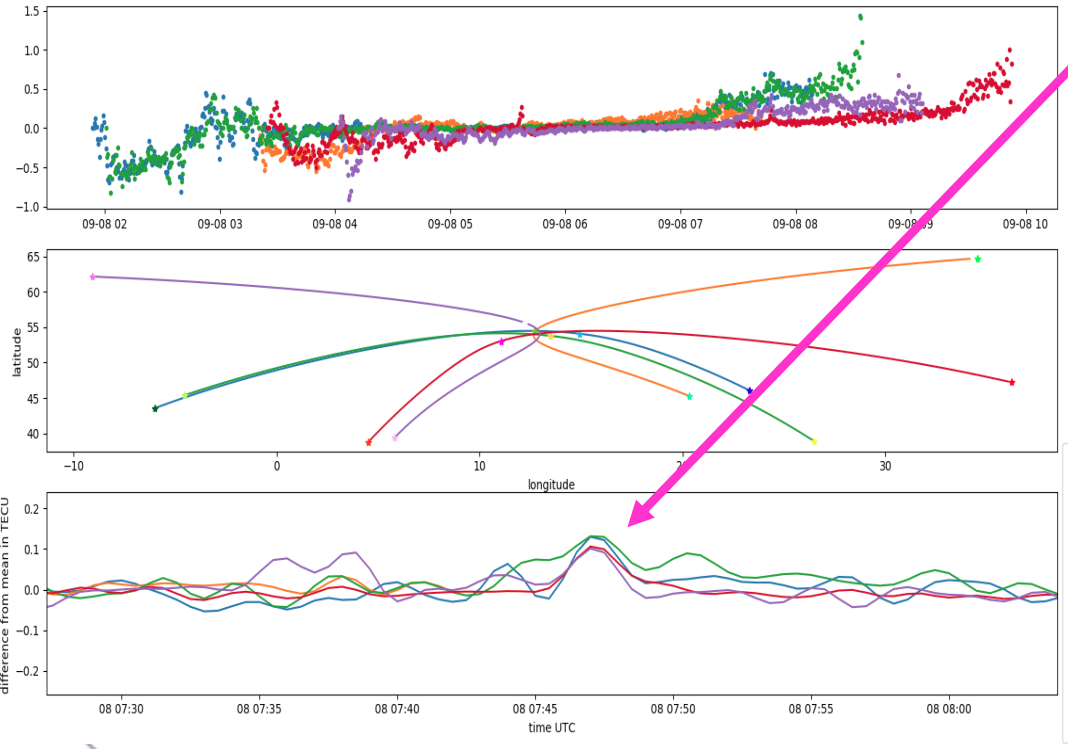


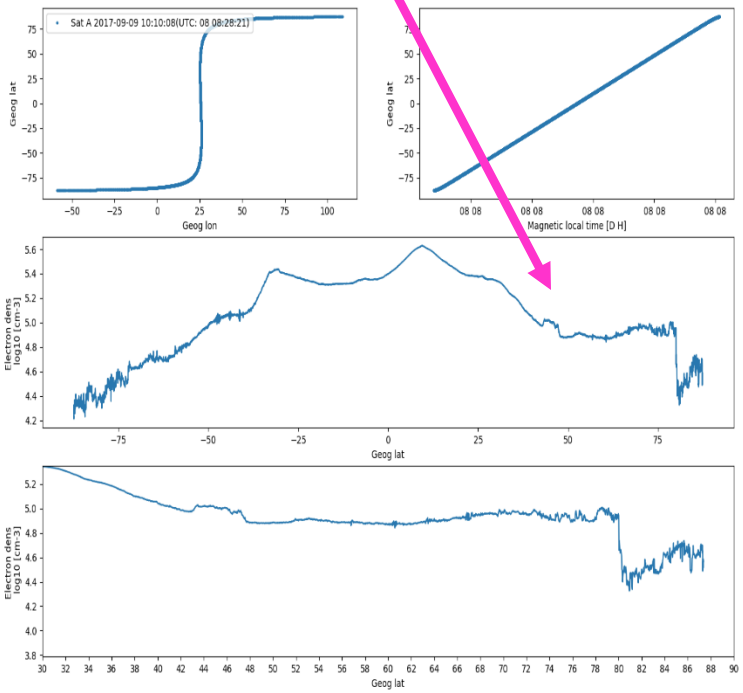


Lukianova 2019

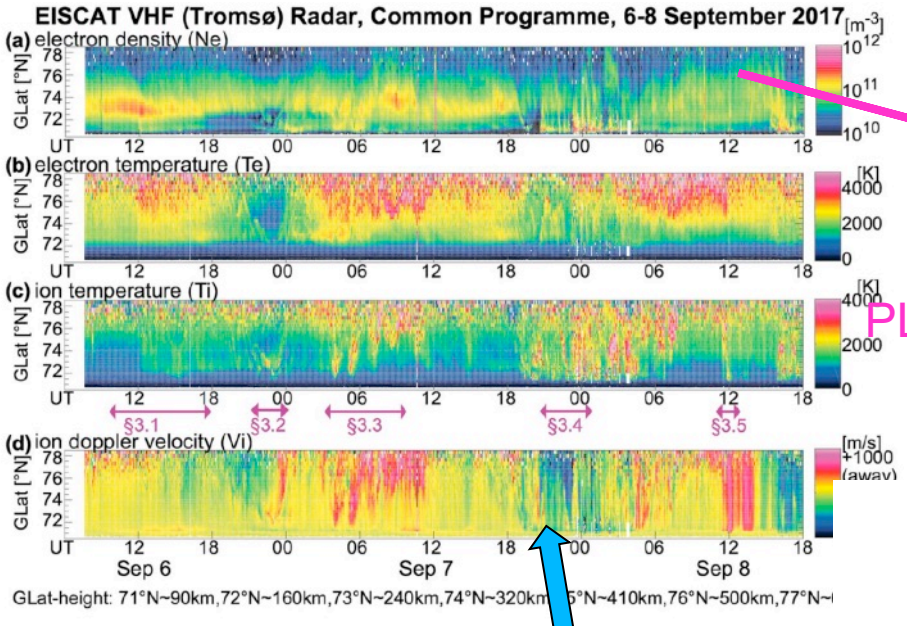
GPS and X-ray

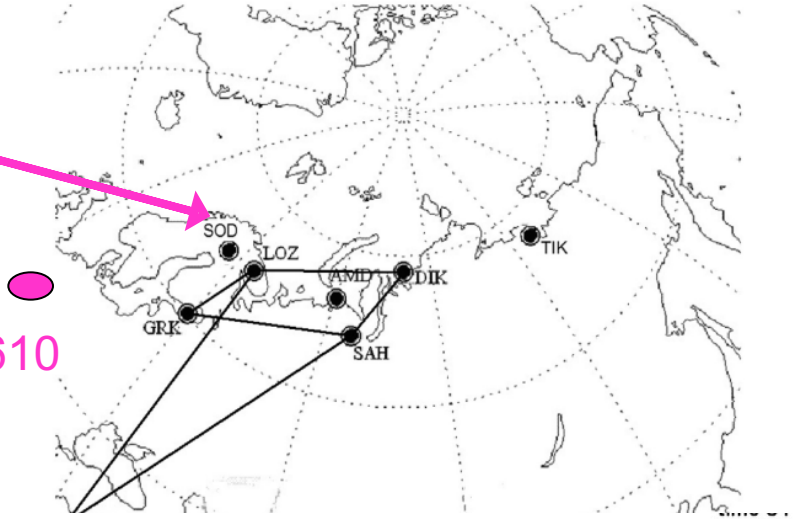

GOES X-Ray Flux - UTC
From: 2017-09-08 07:40 / To: 2017-09-08 08:10
Short_Long (W/m²)
License: CC BY-SA 3.0 DE | Plot by Andreas Möller | Data by SWPC
Intensity Legend:


latitude
longitude
difference from mean in TECU
time UTC

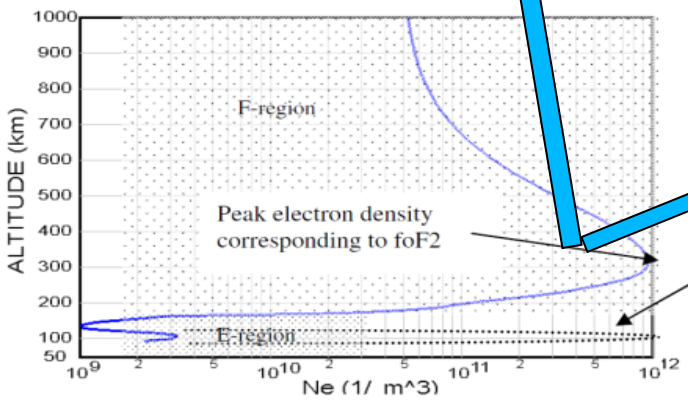

Geog lat
Geog lon
Magnetic local time [D H]
Electron dens log10 [cm-3]

Radars and riometr





Yamauchi 2018



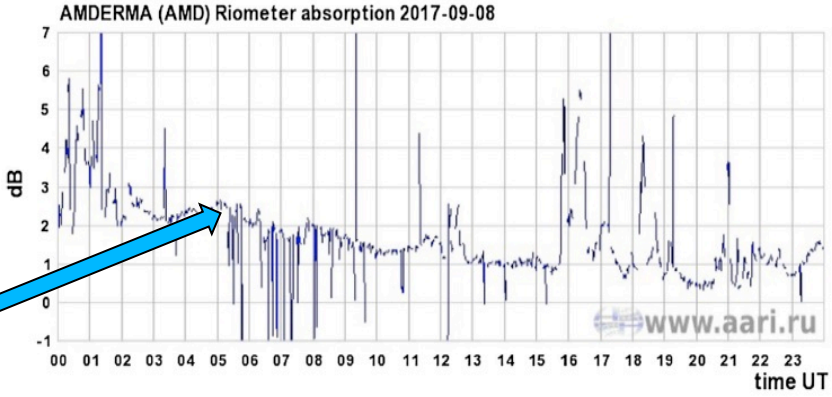


Fig. 6. Riometer absorption variations at Amderma (AMD) station during September 6–8, 2017. Top panel - September 6, middle panel - September 7, bottom panel - September 8.

D.V. Blagoveshchensky 2019

Case study of geomagnetic storm – new possibilities

Ionospheric condition

- **Ionospheric trough and plasmopause around 42-44 geographic latitude below Core and PL610 station.**
- **Field aligned current .**
- **Absorption small scales**
- **Enhancements of Spread-F layers**
- **Turbulent structures of ionosphere structures**

Possibilities of diagnostics small scales structures of ionosphe