The particularity of investigation of ELF-VLF electromagnetic radiation on sun-synchronous orbits. Project RELEC/*Vernov*.

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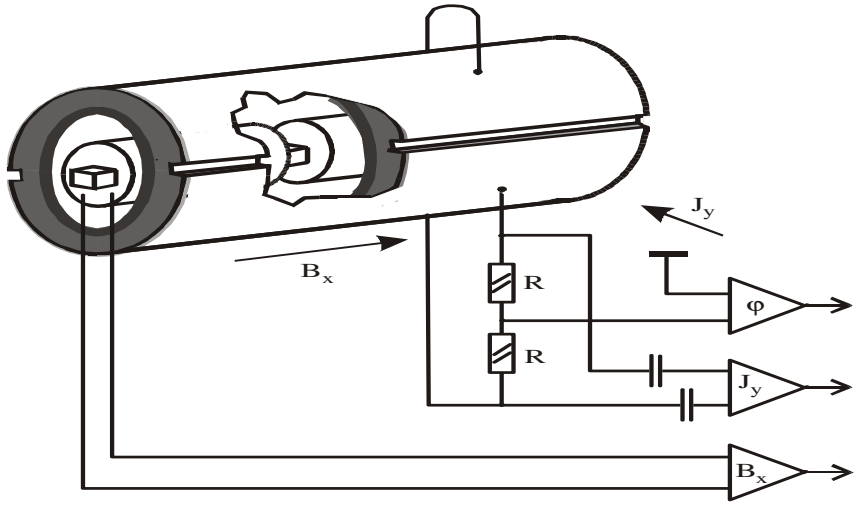
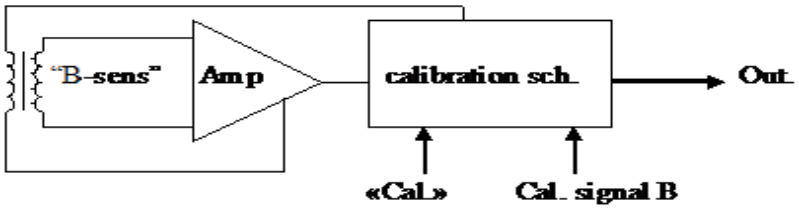
In RELEC/*Vernov* project was used Magnetic Wave Complex (MWC) in the frequency range of 0.1 Hz – 40 kHz – (sensors – Lviv Centre of Institute for Space Research of NASU-SSAU, the SAS3 instrument – Space Research Group of Eo¨tvo¨s University and BL Electronics Ltd.).

MWC - 120 dB dunamic range

Combined Wave Probe – CWP1, CWP2

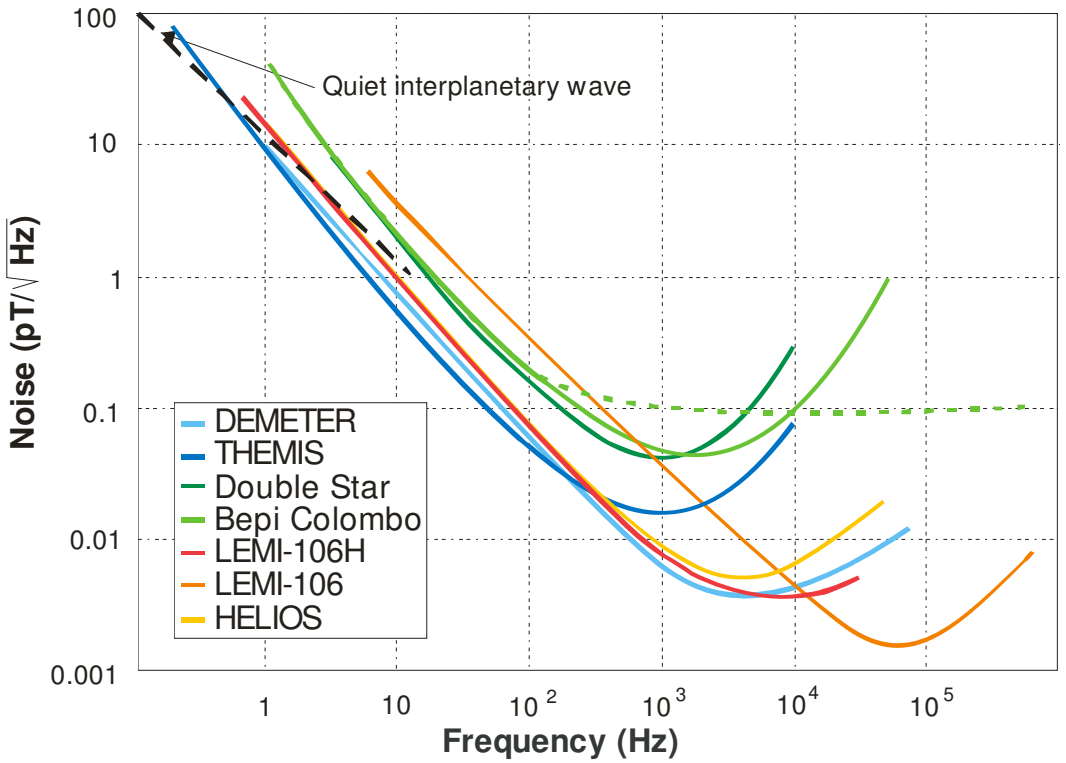


Search-coil magnetometer



The SAS is a complex and flexible electromagnetic wave measuring and data managing equipment

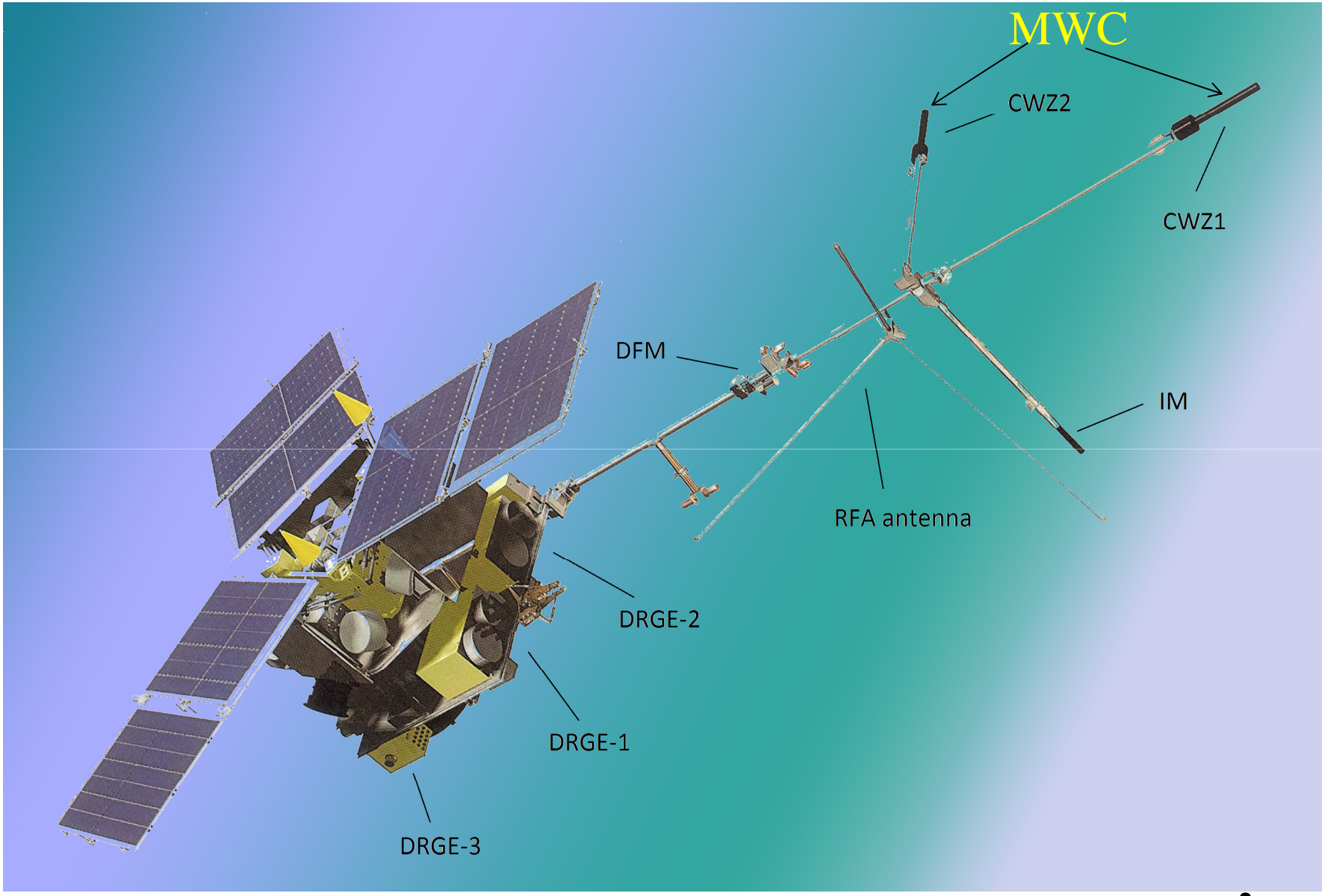
Combined Wave Probe - CWP



The MWC worked in two modes:

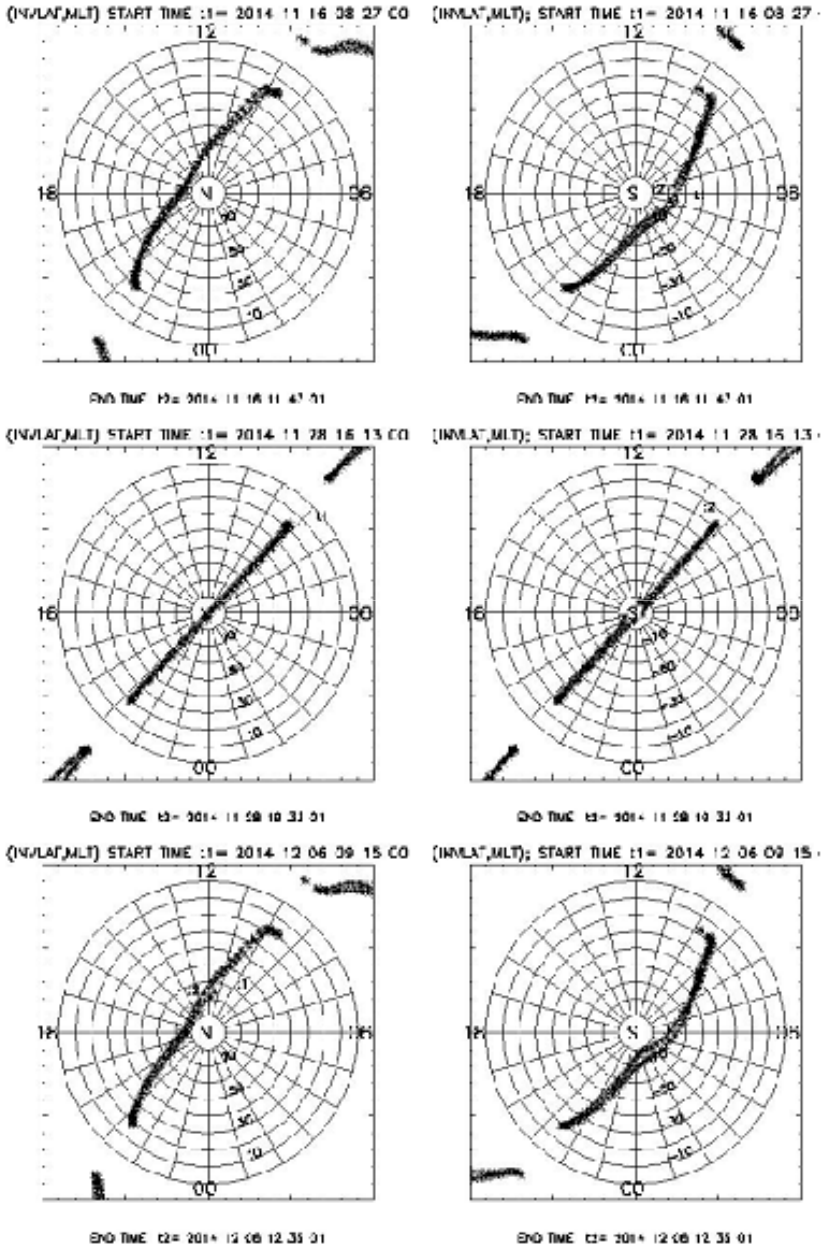
- **registration and transmission by telemetry channels to a waveform of electromagnetic radiation. This mode is *"wave form";***
- **registering signals, by on-board computer calculations of the spectra of electromagnetic radiation and their subsequent transfer by telemetry channels. This mode is *"monitoring".***

Satellite *VERNOV, 2014*



Sun-synchronous orbit, altitude from 640 to 830 km, inclination of 98.4° .

sun-synchronous orbits



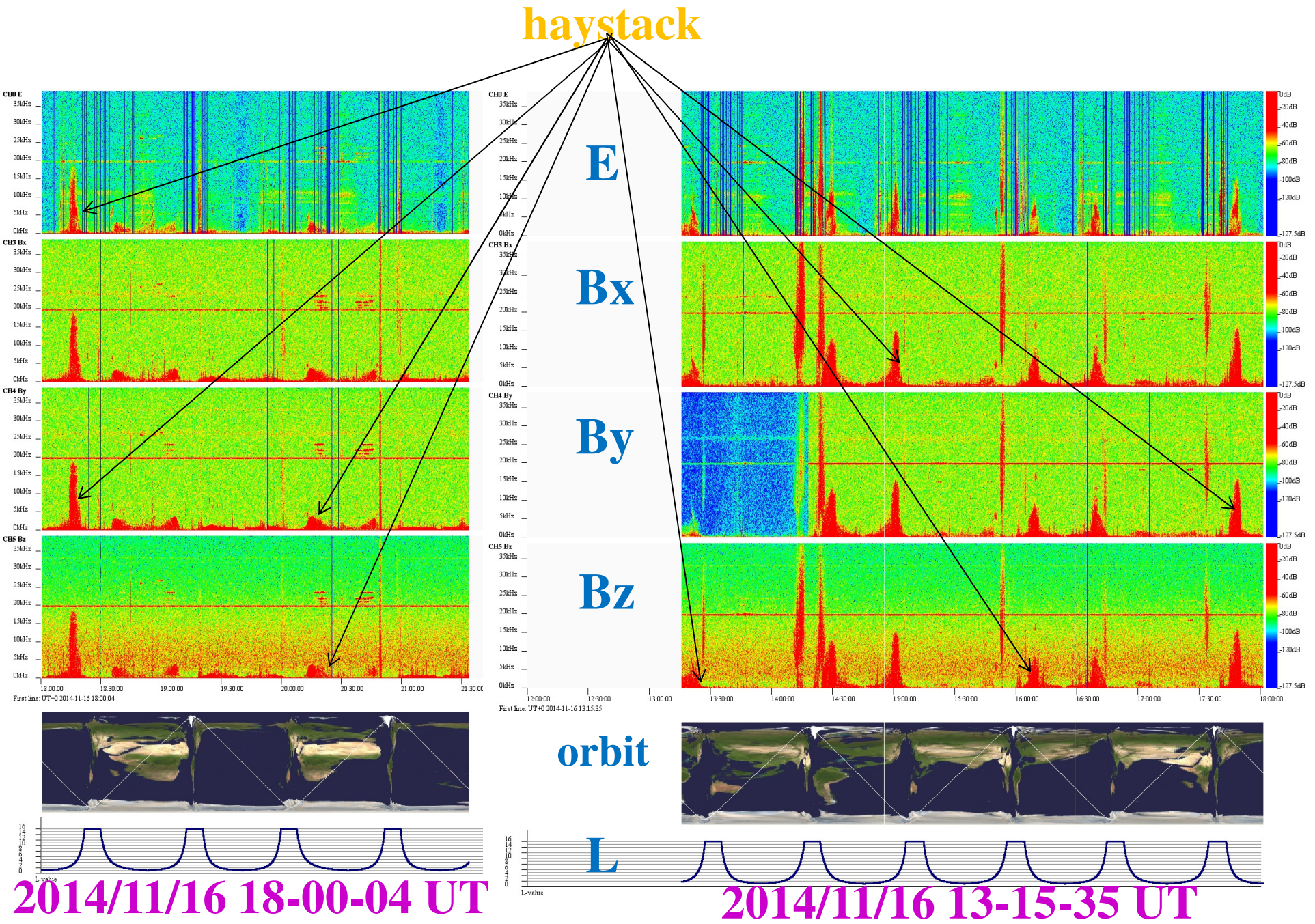
Database of monitoring measurements of the spectra of the MWC has been formed.

Each spectrum represents the average value for 6.5 s:
-*one* electric field component *E;*
- *three* orthogonal magnetic field components *Bx, By, Bz.*

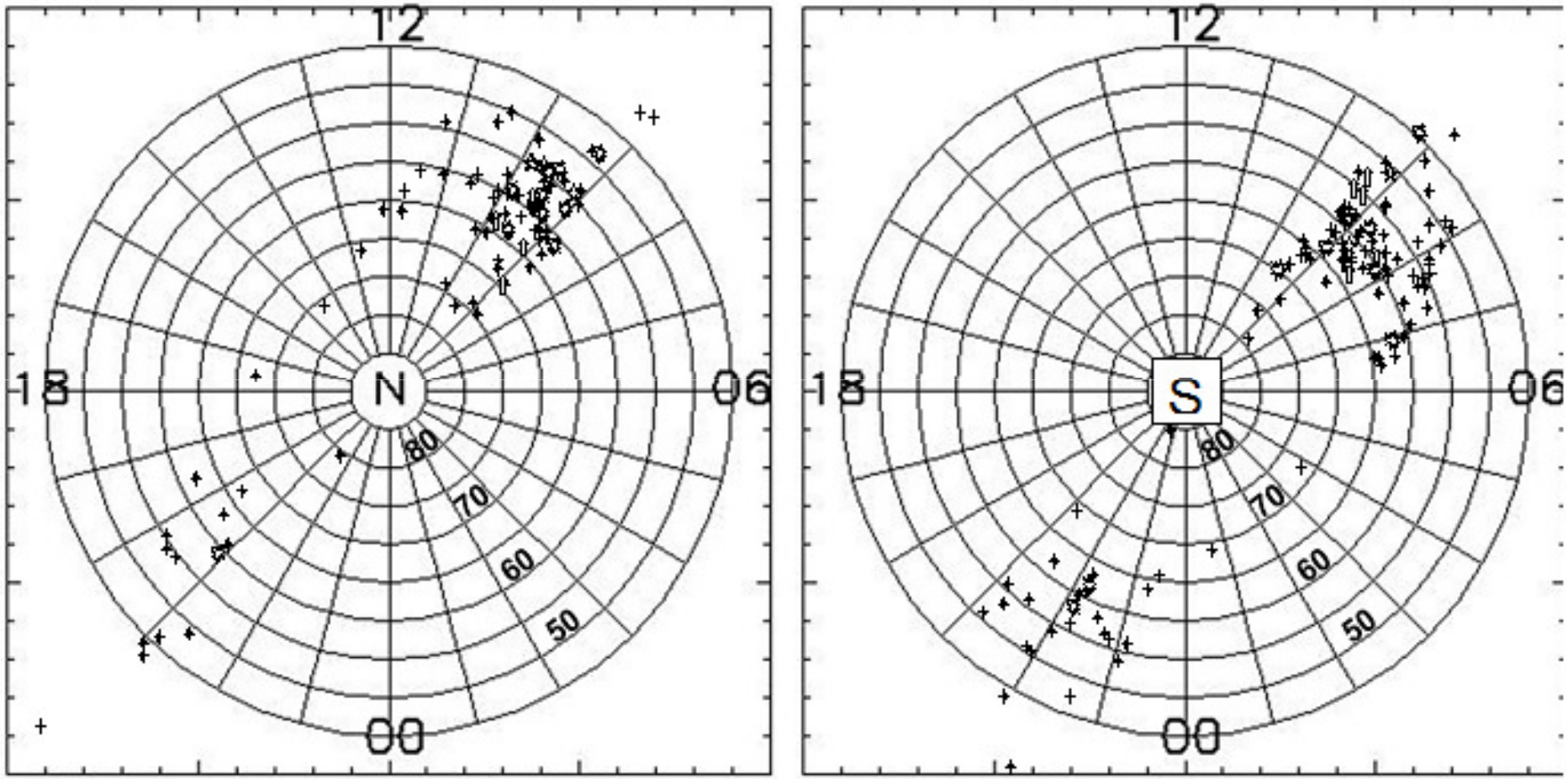
These spectra every 16 seconds recorded in the memory of the MWC and, later in the communication transmitted to the Ground

M.I. Panasyuk, S.I. Svertilov, V.V. Bogomolov et al. **Experiment on the *Vernov* satellite*:* Transient Energetic Processes in the Earth's Atmosphere and Magnetosphere. Part II. First Results.** *Cosmic Research, 2016, Vol. 54, No. 5, pp. 343–350,* published in Kosmicheskie Issledovaniya, 2016, Vol. 54, No. 5, pp. 369–376.

From the dataset of 900 hours we saw 3 types of events conventionally called:
"haystack"
"oblique"
"intense broadband emission" (IBE)


haystack
E
Bx
By
Bz
orbit
L
2014/11/16 18-00-04 UT
2014/11/16 13-15-35 UT

haystack

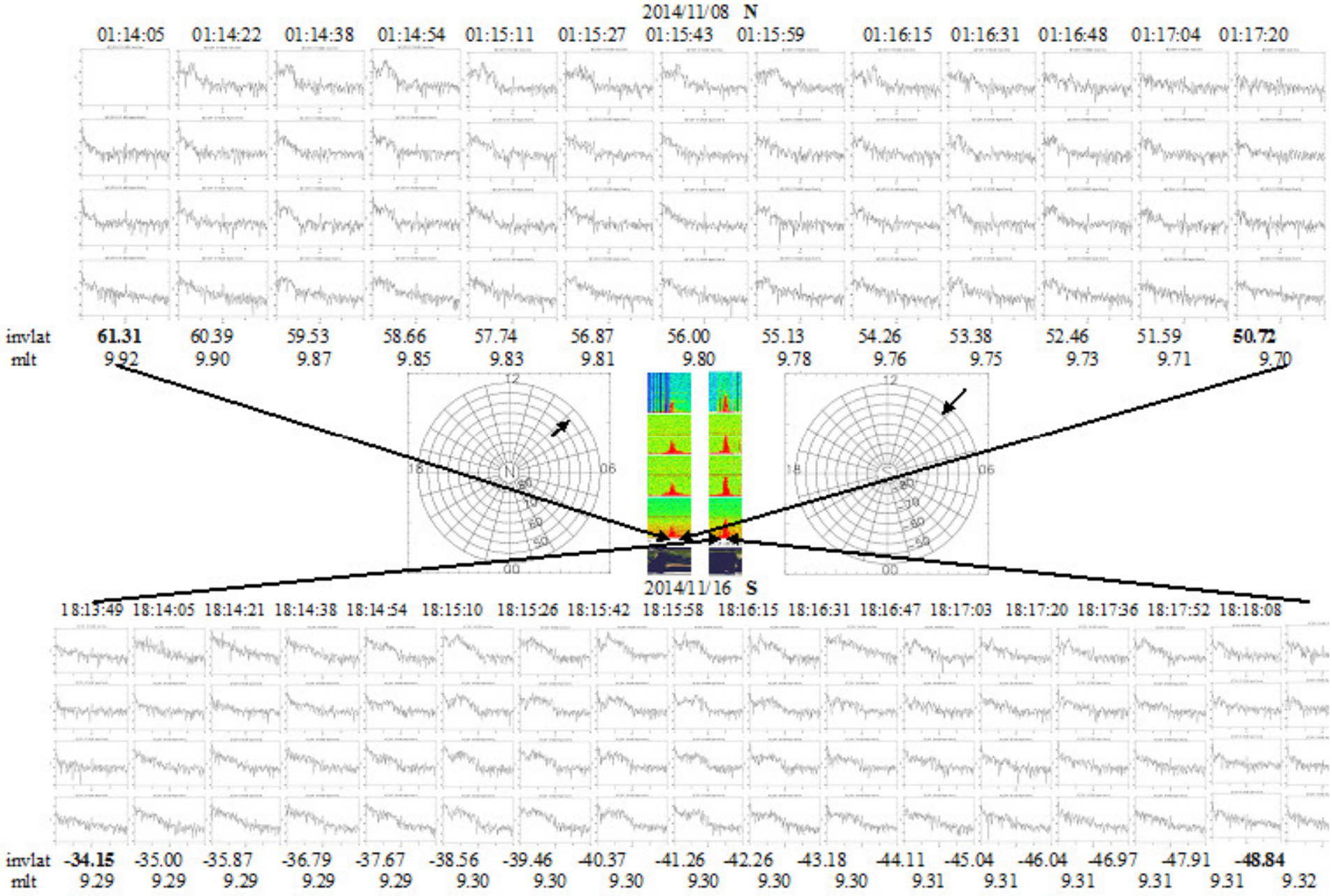


+ < 5 kHz; ✡ > 5kHz; ✡ > 10kHz; ⇧ > 15kHz

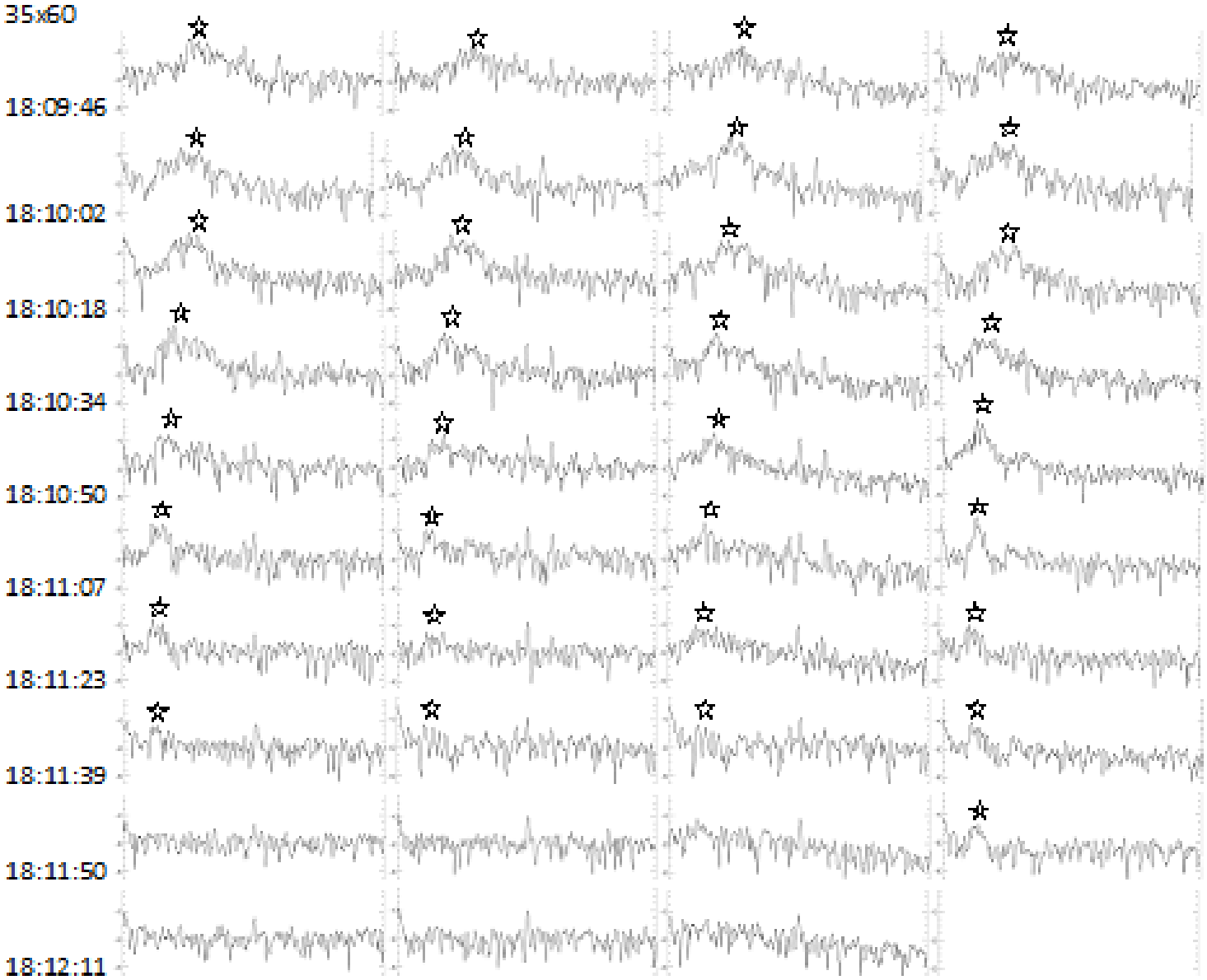
11/01 – 12/08

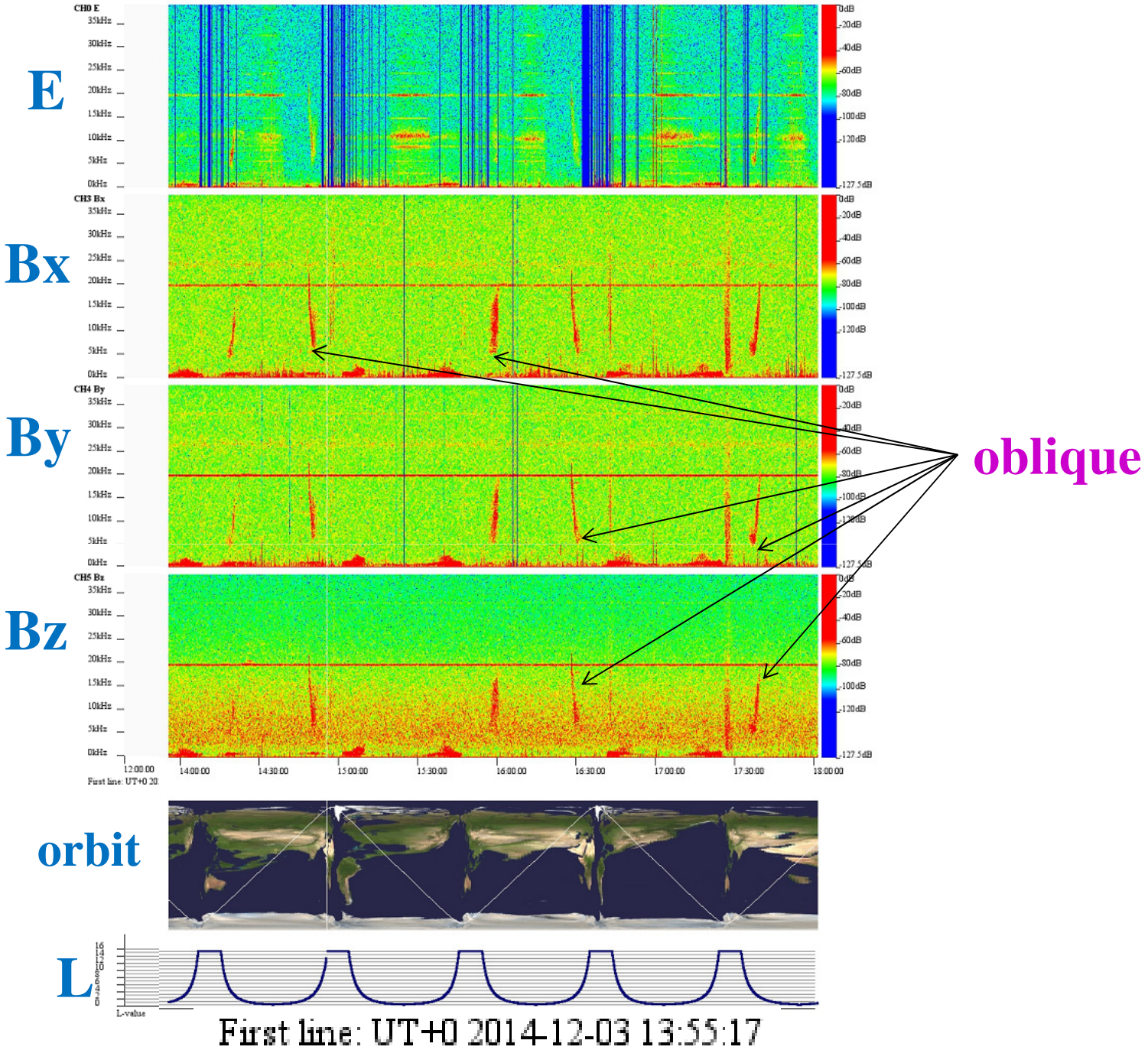
2014

haystack

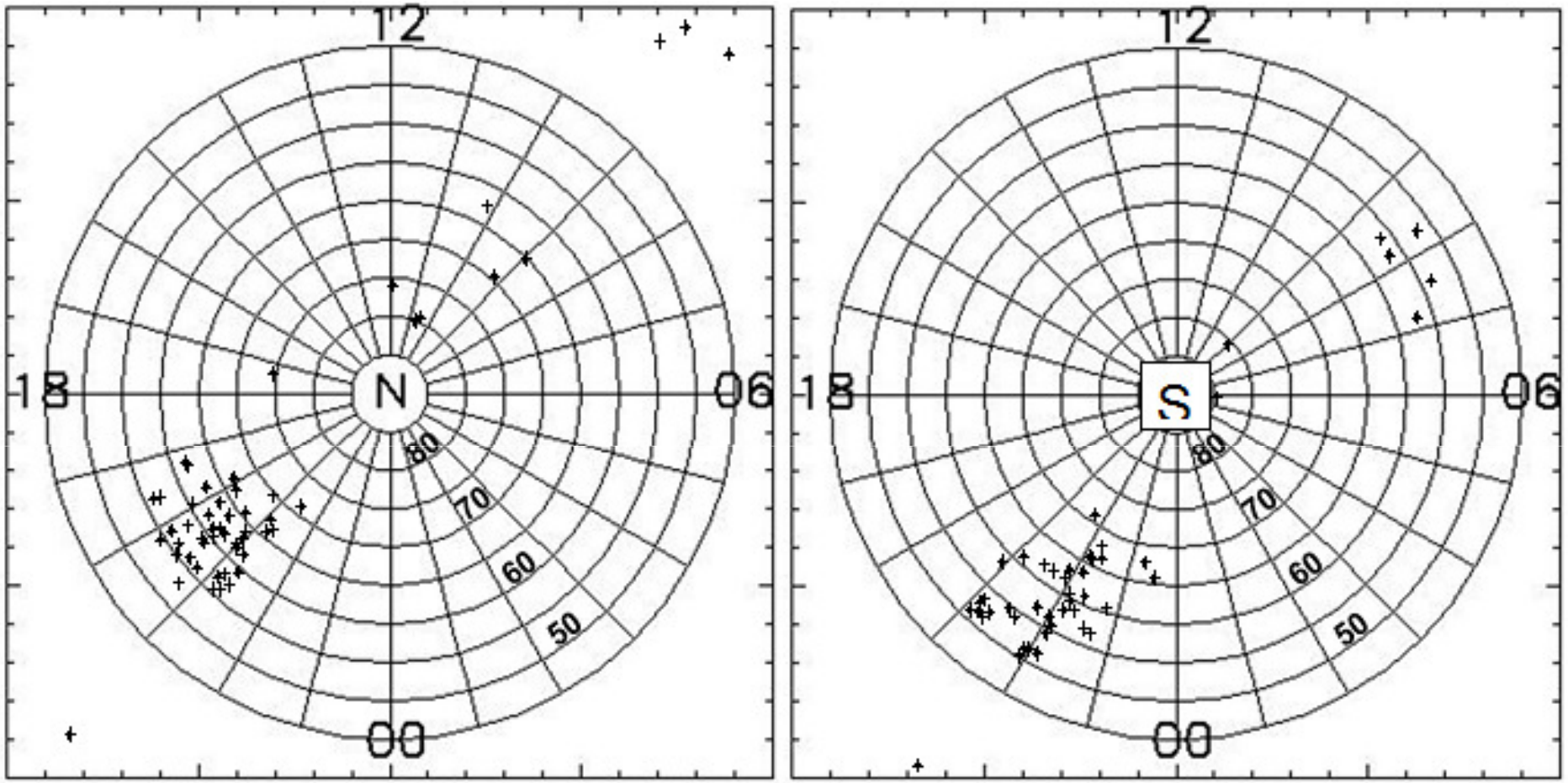

2014/11/08 N
01:14:05 01:14:22 01:14:38 01:14:54 01:15:11 01:15:27 01:15:43 01:15:59 01:16:15 01:16:31 01:16:48 01:17:04 01:17:20
invlat 61.31 60.39 59.53 58.66 57.74 56.87 56.00 55.13 54.26 53.38 52.46 51.59 50.72
mlt 9.92 9.90 9.87 9.85 9.83 9.81 9.80 9.78 9.76 9.75 9.73 9.71 9.70
2014/11/16 S
18:13:49 18:14:05 18:14:21 18:14:38 18:14:54 18:15:10 18:15:26 18:15:42 18:15:58 18:16:15 18:16:31 18:16:47 18:17:03 18:17:20 18:17:36 18:17:52 18:18:08
invlat -34.15 -35.00 -35.87 -36.79 -37.67 -38.56 -39.46 -40.37 -41.26 -42.26 -43.18 -44.11 -45.04 -46.04 -46.97 -47.91 -48.84
mlt 9.29 9.29 9.29 9.29 9.29 9.30 9.30 9.30 9.30 9.30 9.30 9.31 9.31 9.31 9.31 9.31 9.32

haystack


35x60
18:09:46
18:10:02
18:10:18
18:10:34
18:10:50
18:11:07
18:11:23
18:11:39
18:11:50
18:12:11


E
Bx
By
Bz
oblique
orbit
L
First line: UT+0 2014-12-03 13:55:17

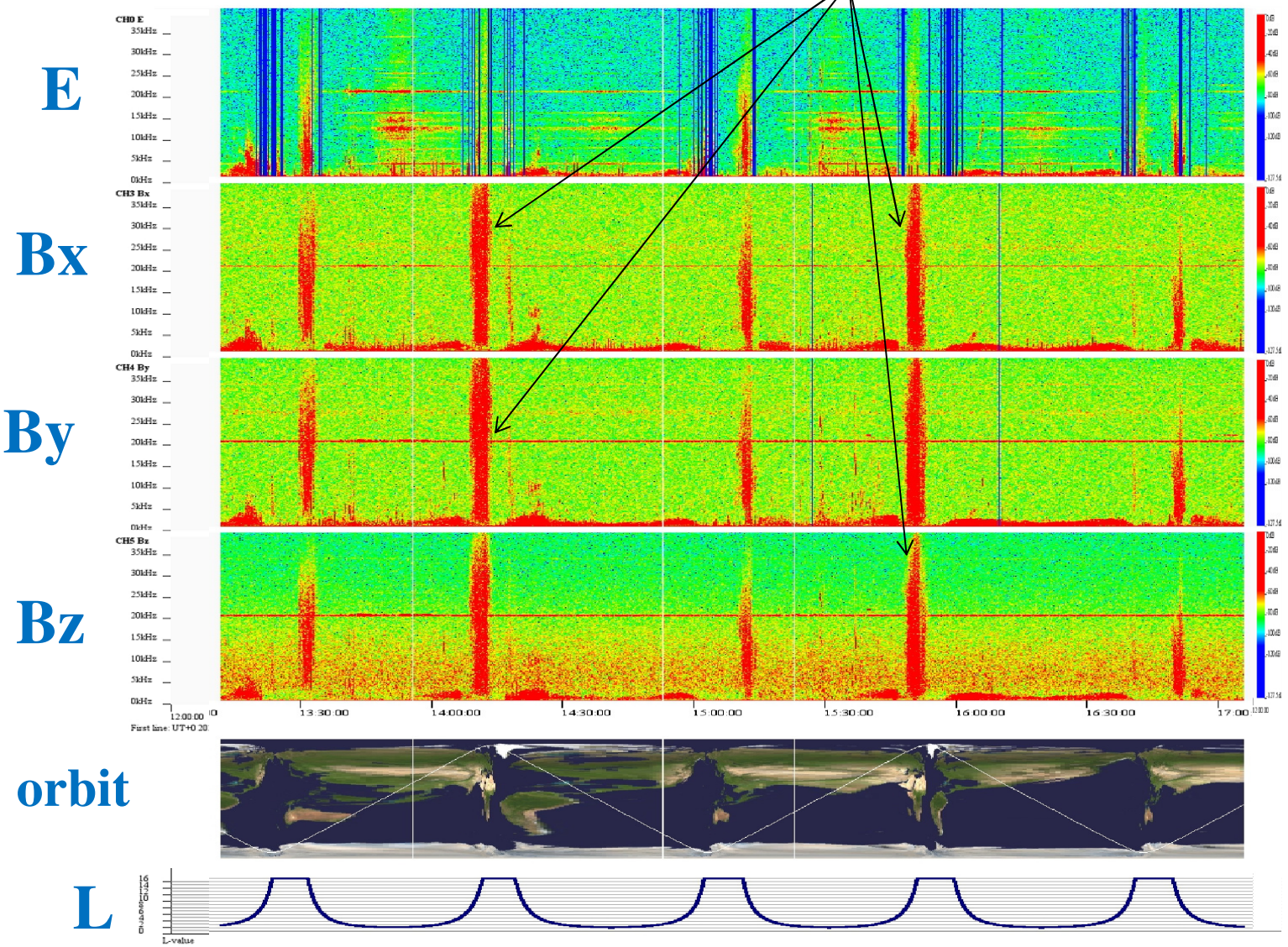
oblique



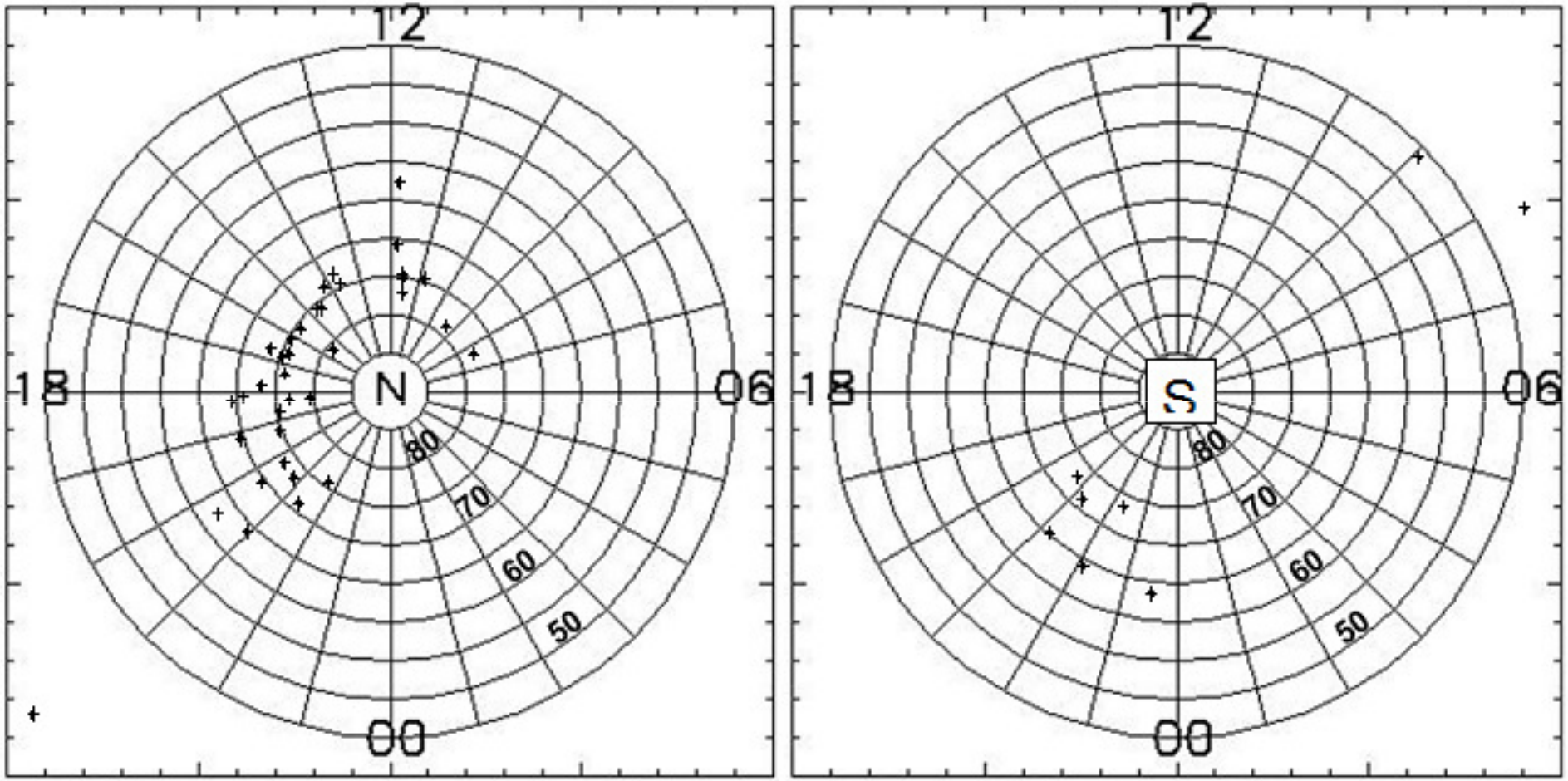
09/04 -12/06

2014

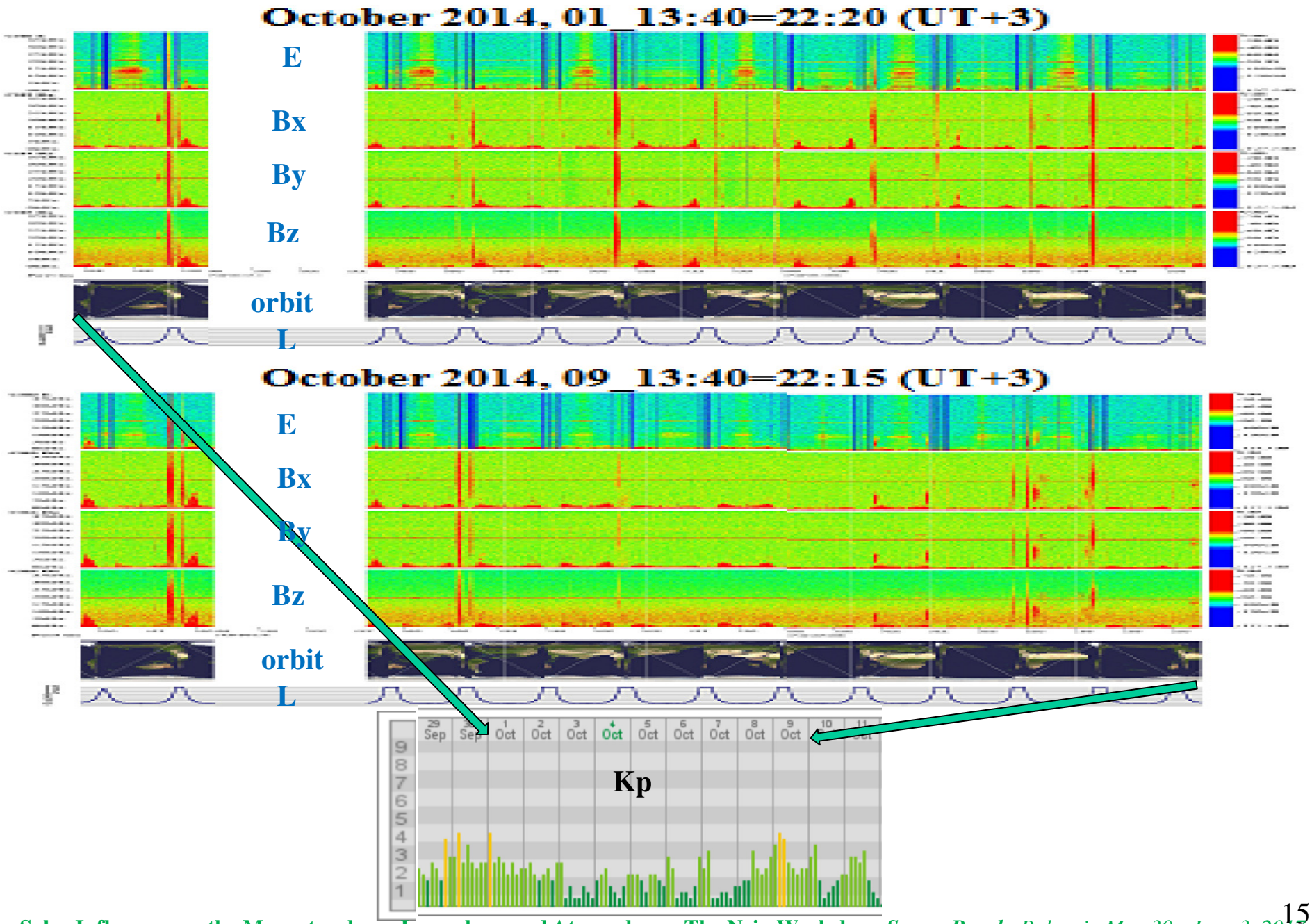
intense broadband emission (IBE)



MWC data. 21/08/2014 13:11:45-17:06:00 UT.


12
18
06
00
N
80
70
60
50
12
18
06
00
S
80
70
60
50

Satellite "*VERNOV*"



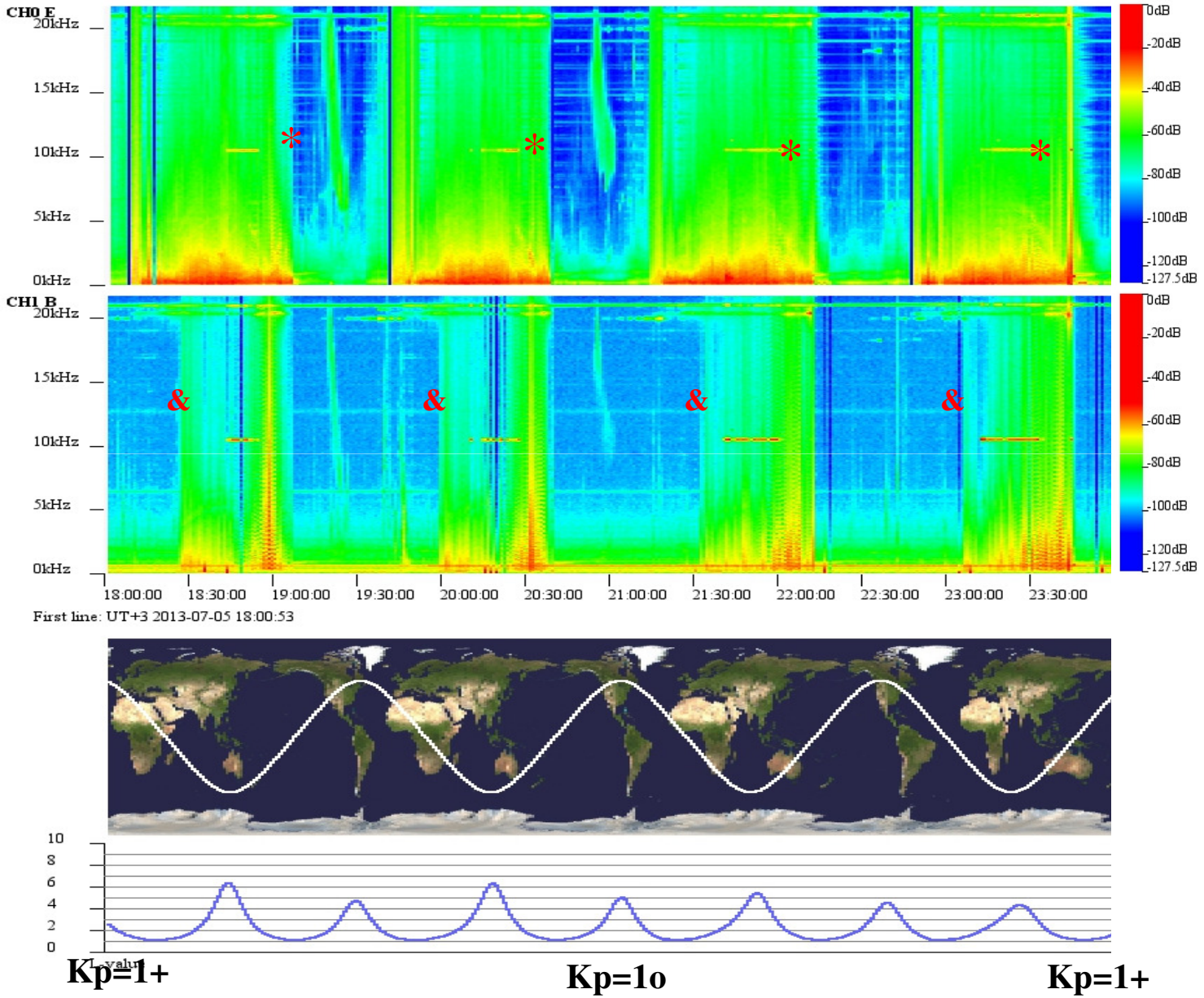
A typical example of monitoring studies (0.01-22kHz) in the experiment "Obstanovka (1 stage)". *2013-07-05, UT+3 18:00-24:00* (4 orbits).

E

B

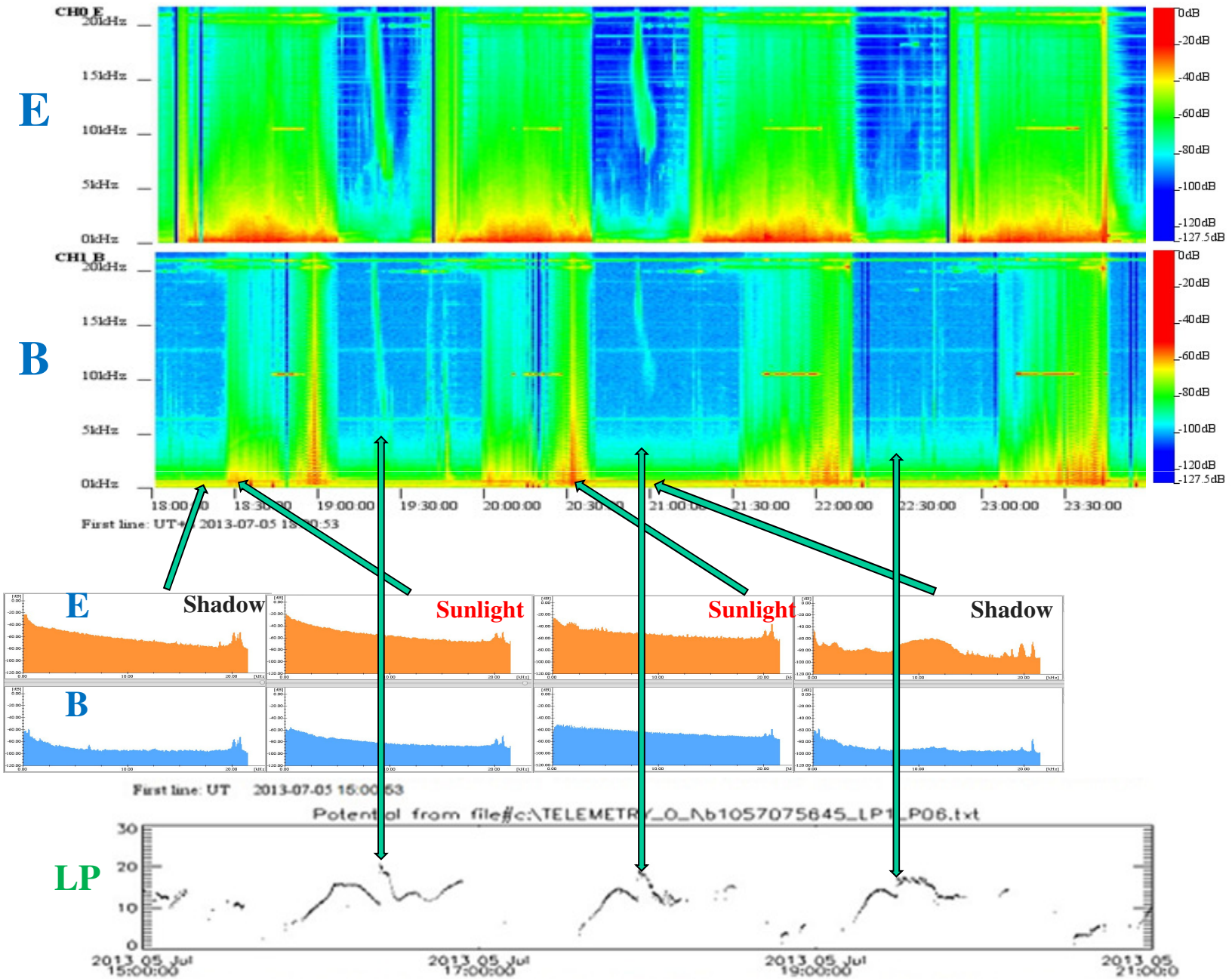
orbit

L



2013/07/05
Evt 18:20:10
&Shd 18:26:31
*Sun 19:00:19
Mrt 19:06:43
Evt 19:53:05
&Shd 19:59:26
*Sun 20:33:14
Mrt 20:39:38
Evt 21:26:00
&Shd 21:32:20
*Sun 22:06:08
Mrt 22:12:33
Evt 22:58:55
&Shd 23:05:15
*Sun 23:39:03
Mrt 23:45:27

The ISS, "Obstanovka (1 stage)". *2013-07-05, 18:00-24:00 (UT+3).*

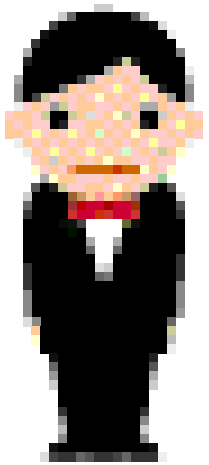


2013/07/05
Evt 18:20:10
&Shd 18:26:31
*Sun 19:00:19
Mrt 19:06:43
Evt 19:53:05
&Shd 19:59:26
*Sun 20:33:14
Mrt 20:39:38
Evt 21:26:00
&Shd 21:32:20
*Sun 22:06:08
Mrt 22:12:33
Evt 22:58:55
&Shd 23:05:15
*Sun 23:39:03
Mrt 23:45:27

For further analyses of this events you need to associate the spatial-temporal distribution of parameters of geomagnetic activity, ionospheric regions as well as data of the ground geophysical observatories.

This will allow us to consider time-frequency characteristics of ELF-VLF emissions as parameters of space weather.

Thanks for the attention

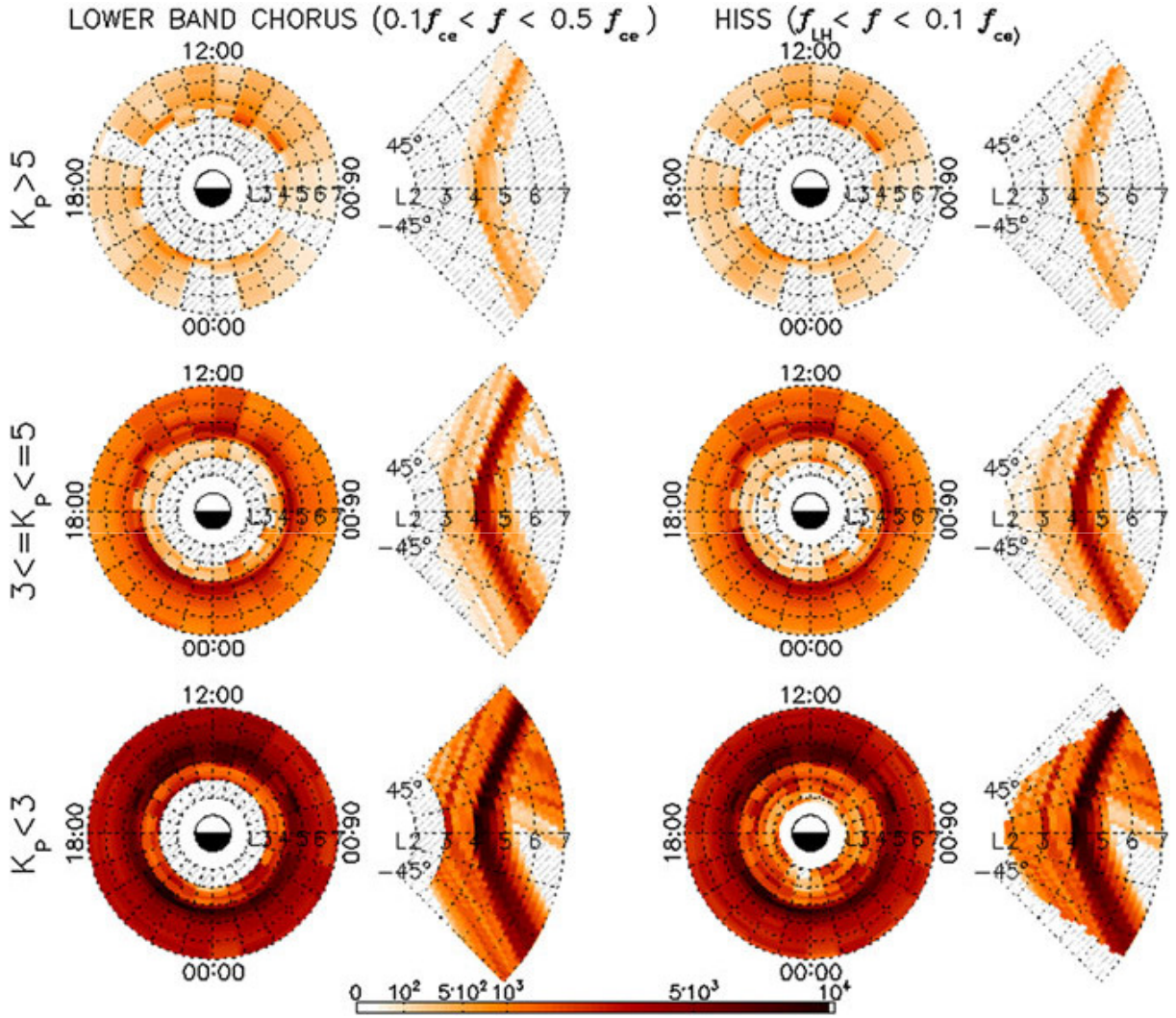


Large amount of archived satellite data gathered during the RELEC/*Vernov* mission are successfully integrated in various models of the upper atmosphere and ionosphere.

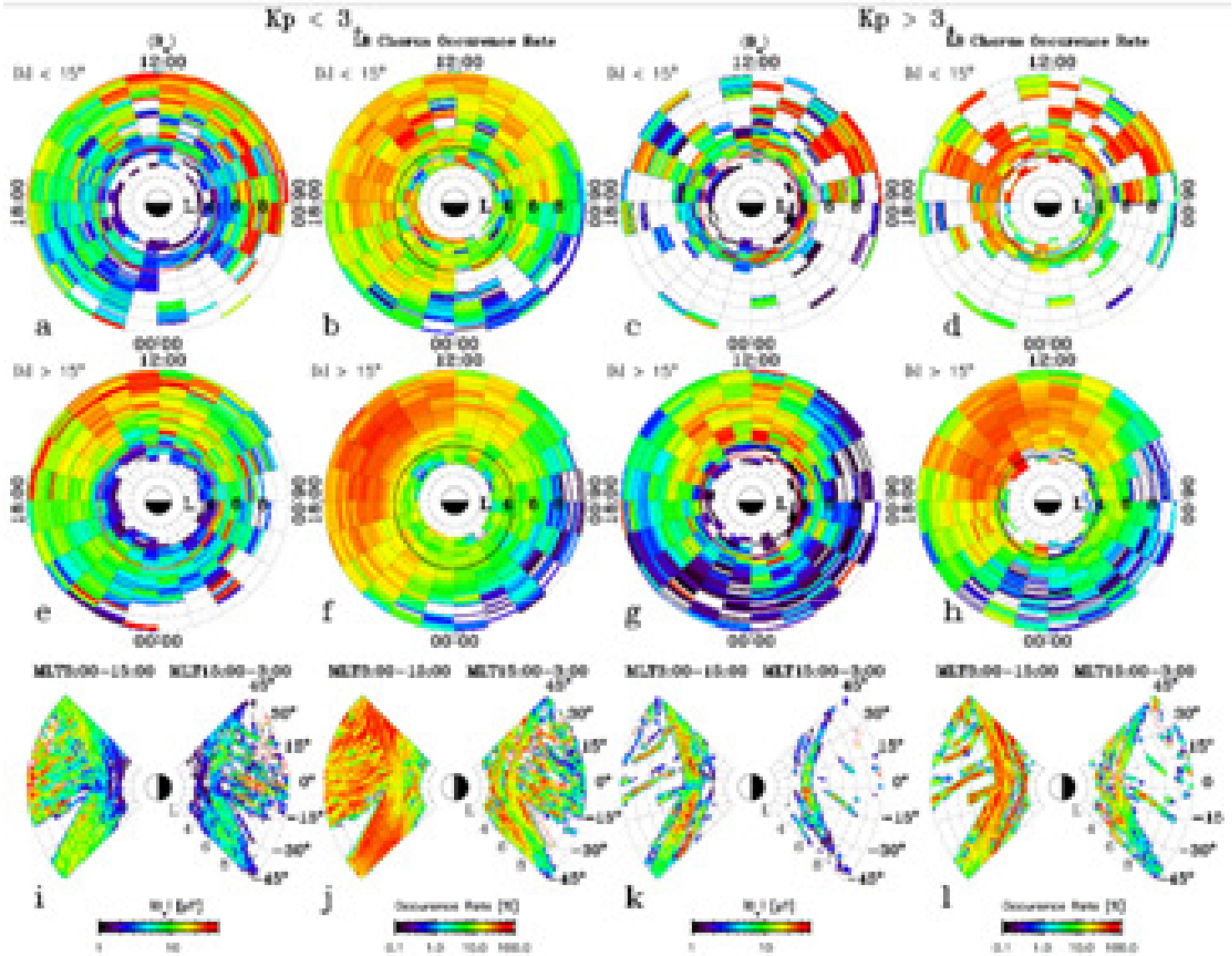
New data mining techniques form the base of the idea of the Ionosphere Waves Service (IWS). The aim of the IWS is not that it would include any new kind or set of measured data, but serving purely the derived parameters of described wave-like phenomena, obtained by specific algorithms.

The IWS has been developed (in the frame of the FP7 POPDAT project http://popdat.cbk.waw.pl) and opened for public access by ionosphere experts. IWS is forming a database, derived from archived ionospheric wave records to assist the ionosphere and Space Weather (SW) research, and to answer the following questions: How can the data of earlier ionospheric missions be reprocessed with current algorithms to gain more profitable results? How could the scientific community be provided with a new insight on wave processes that take place in the ionosphere? (*Ferencz et al., 2014*)**.**

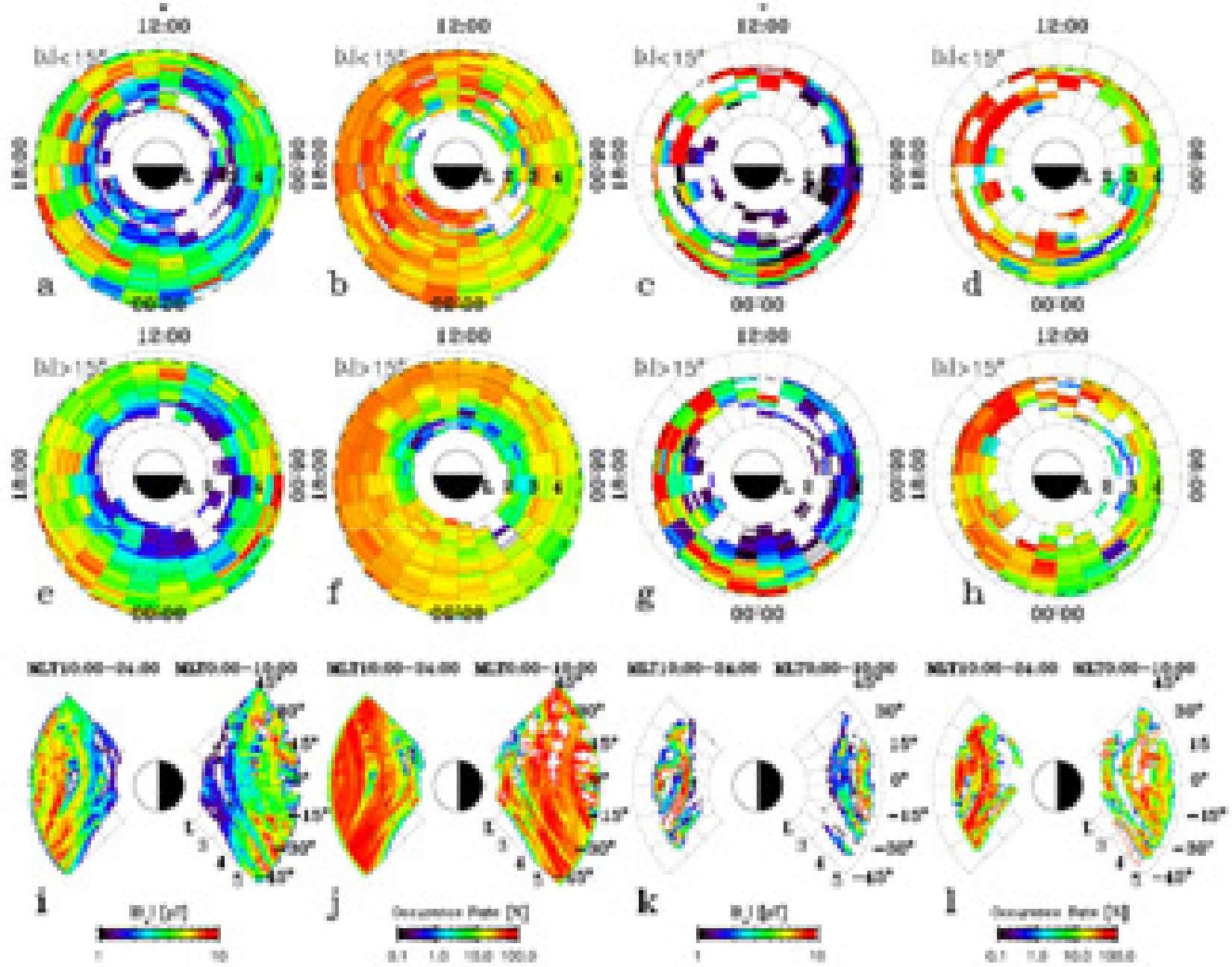
Agapitov, O., A. Artemyev, V. Krasnoselskikh, Yu. Khotyaintsev, D. Mourenas, H. Breuillard, M. Balikhin, G. Rolland. **Statistics of whistler mode waves in the outer radiation belt: Cluster STAFF-SA measurements.** JGR: SPACE PHYSICS, VOL. 118, 3407–3420,



Data coverage for the CLUSTER STAFF-SA measurements during 2001–2010 (left panels) for the LB chorus frequency range (0.1*fce < f < 0.5fce) and (right panels) for the hiss frequency range (fLH < f < 0.1fce) in dependence on L-shell, (bottom panels) and MLT for geomagnetic activity: low (Kp < 3, top* panels), *intermediate* (3 <Kp <5), *high (Kp > 5).*



(a) Equatorial chorus averaged wave intensity and (b) occurrence rate shown in *L-shell/MLT* frame for quiet geomagnetic conditions (*Kp 3). (c and d) Distributions of averaged intensity and* occurrence rate for disturbed conditions (*Kp > 3) are shown, respectively. Distributions for midlatitude* chorus are shown in Figures 3e and 3f *Kp 3 and 3g and h Kp > 3 in the same format. (i) Chorus* averaged wave intensity and (j) occurrence rate are shown in *L-shell/ frame for Kp 3, Figures 3k* and 3l, respectively, show distributions for *Kp > 3.*

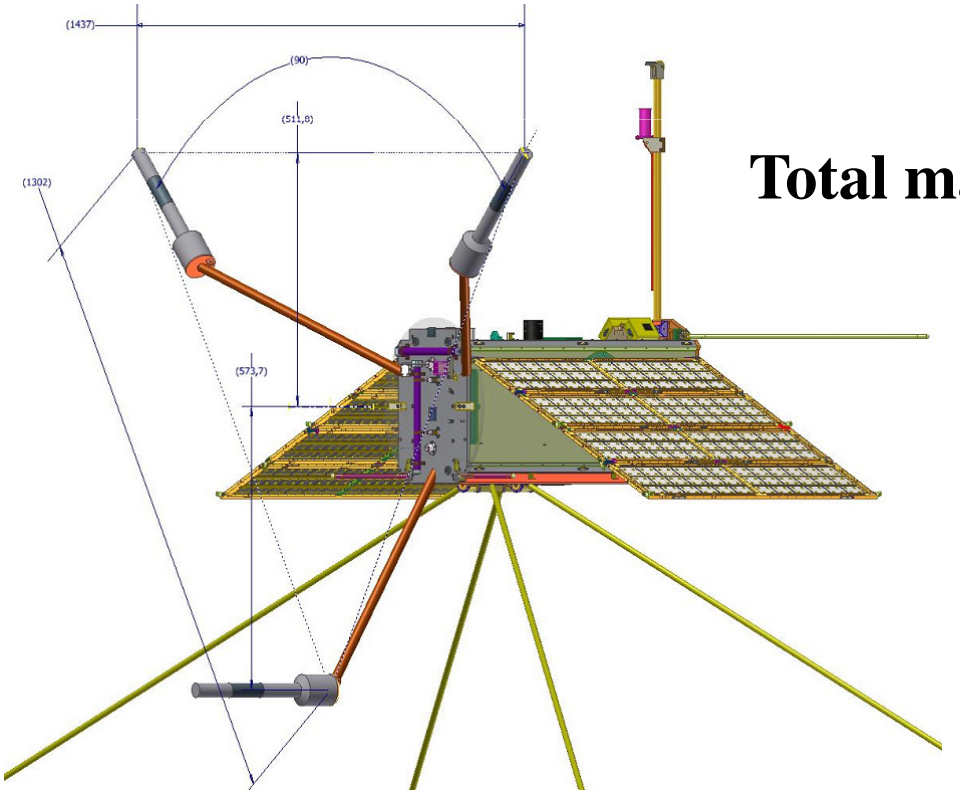


The averaged wave magnetic field intensity and occurrence rate of plasmaspheric hiss in the same format as in Figure 2.

Micro-satellite "Trabant" – 2019-2023.

Basic objective mission of the "Trabant" is the development of the electromagnetic clean micro-satellite, which well be integrated into the infrastructure of the RS ISS.

Wave Complex (MWC) in the frequency range of 0.1 Hz – 80 kHz and instrument for study the high-frequency fluctuation of the ionospheric plasma concentration - a key scientific tools "Trabant".



Total mass ~ 50 kg