Study of electromagnetic parameters of Space Weather in the ionosphere. Project's: "Chibis-M", "Obstanovka (1 stage)", "Vernov".

S. Klimov, V. Grushin, D. Novikov, M. Dolgonosov, V. Gotlib, V. Pilipenko
*Space Research Institute of the RAS, Moscow, **Russia*** sklimov@iki.rssi.ru

K. Georgieva, B. Kirov
*Space Research and Technology Institute of the BAS, Sofia, **Bulgaria***

Cs. Ferencz, P. Szegedi
Eötvös *University, Budapest, **Hungary***

V. Korepanov, S. Belyayev, A. Marusenkov, D.Dudkin, V. Pronenko
*Lviv Centre of Institute of Space Research, Lviv, **Ukraine***

The study and monitoring of the electromagnetic environment of the Earth and of the Earth-like planets (e.g. Moon, Venus, Mars and Mercury) has also great importance, because this opens the door for the comparative study of these planets, their evolutions and actual states.

Investigating the long-time trend in some important areas of the Earth atmospheric electrical parameters (*Maercz and Harrison, 2003*), VLF natural signal intensity (*Smith et al., 2008*), Schumann resonance intensity (*Sattori et al., 2009*), a significant decreasing of the total lightning activity was detected.

Is the cause of this phenomenon the actual global warming of our planet?

Actually we have no final answer to this important question what allows us to say that the satellite monitoring of electromagnetic environment of the Earth is a very actual task.

Large amount of archived satellite data gathered during these earlier missions 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.

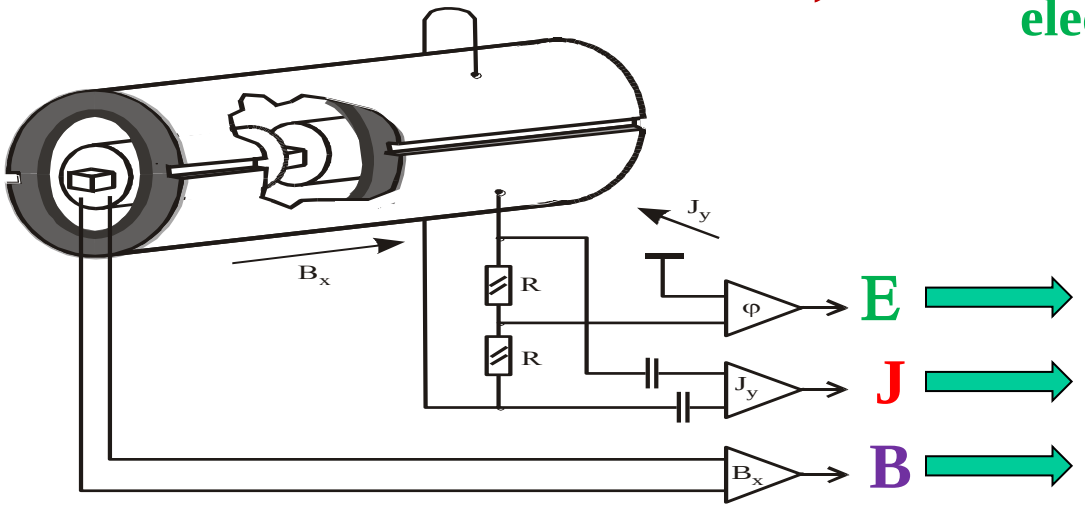
The IWS has been developed (in the frame of the FP7 POPDAT project http://popdat.cbk.waw.pl) and opened for public access by ionosphere experts. IWS is forming a database, derived from archived ionospheric wave records to assist the ionosphere and Space Weather (SW) research, and to answer the following 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*).

Now in the IWS configuration it is possible to include the new data from projects: "Chibis-M" – 2012-2014, "Obstanovka (1 stage)" – 2013-2014, "Vernov" – 2014.

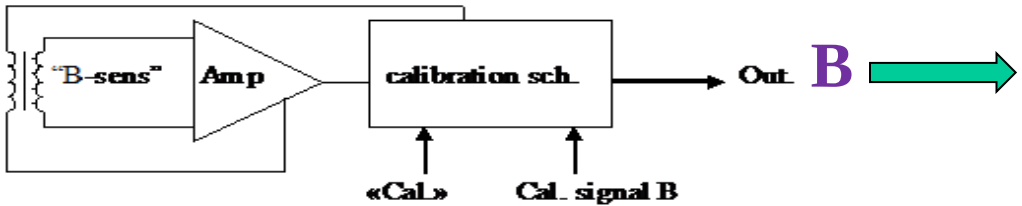
In this projects was used Magnetic Wave Complex (MWC) in the frequency range of 0.1 Hz – 40 kHz – (sensors – Lviv Centre of Institute for Space Research of NASU-SSAU, the SAS3 instrument – Space Research Group of Eo¨tvo¨s University and BL Electronics Ltd.).

MWC - 120 dB dunamic range

Combined Wave Probe – CWP1, CWP2

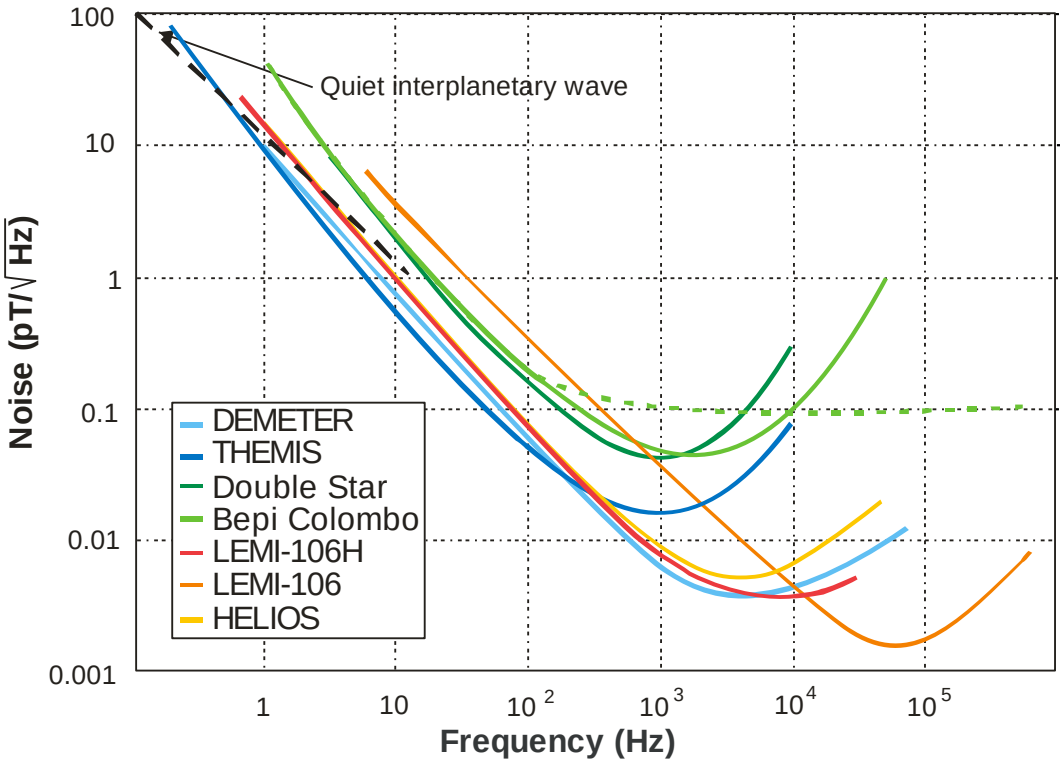


Search-coil magnetometer



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

Combined Wave Probe - CWP



The MWC worked in two modes:

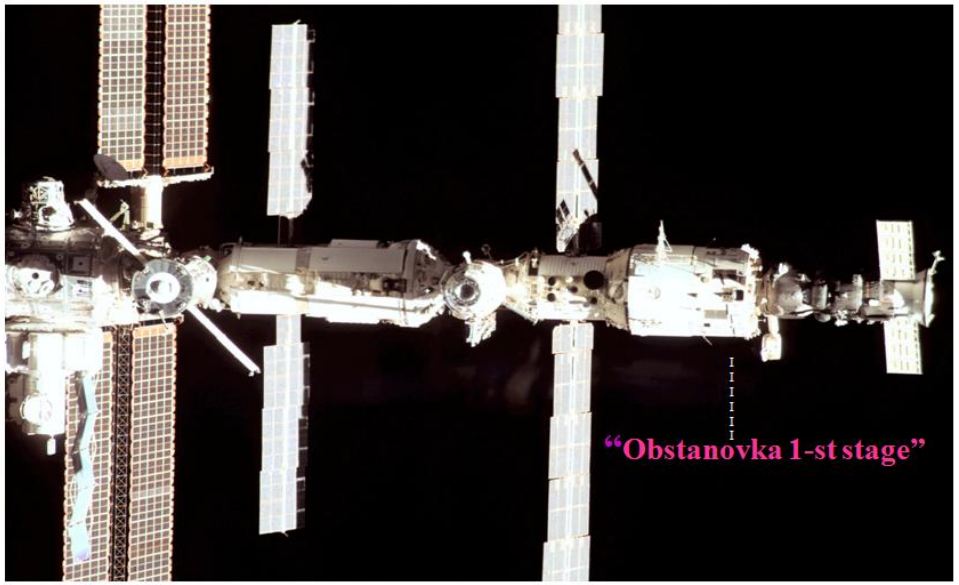
- **registration and transmission by telemetry channels to a waveform of electromagnetic radiation. This mode is *"wave form";***
- **registering signals, by on-board computer calculations of the spectra of electromagnetic radiation and their subsequent transfer by telemetry channels. This mode is *"monitoring".***

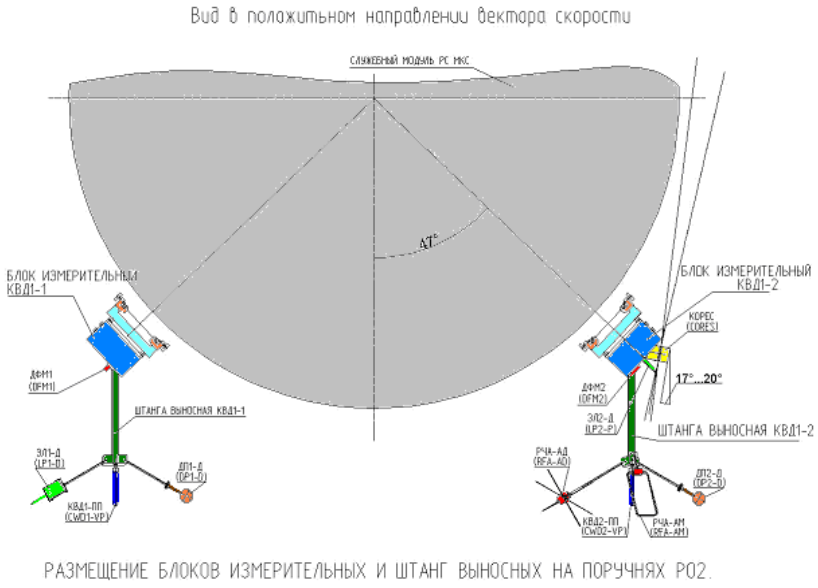
Experiment «Obstanovka 1-st stage», 2013-2015

http://www.cosmos.ru/obstanovka/eng/index.htm

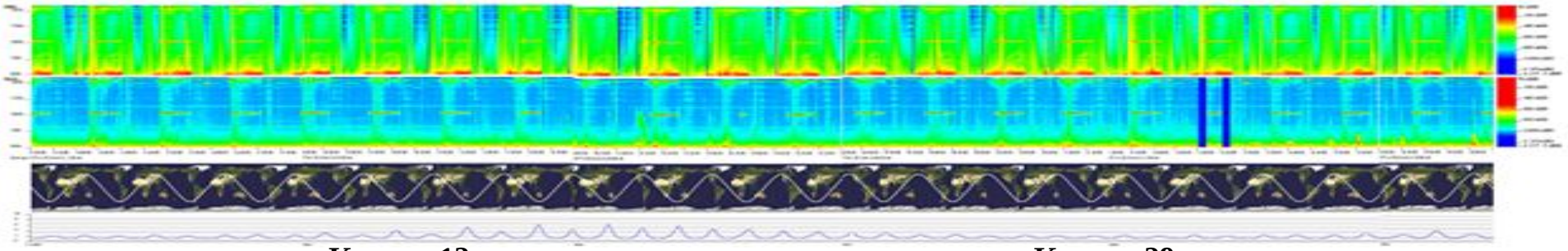
For Space Weather research (as well as atmospheric weather) and ionosphere dynamic studies, in the first place, it is necessary to conduct continuous monitoring of the study.

On a number of methodological and organizational reasons more fully monitoring studies were conducted in the experiment "Obstanovka (1 stage)“ .



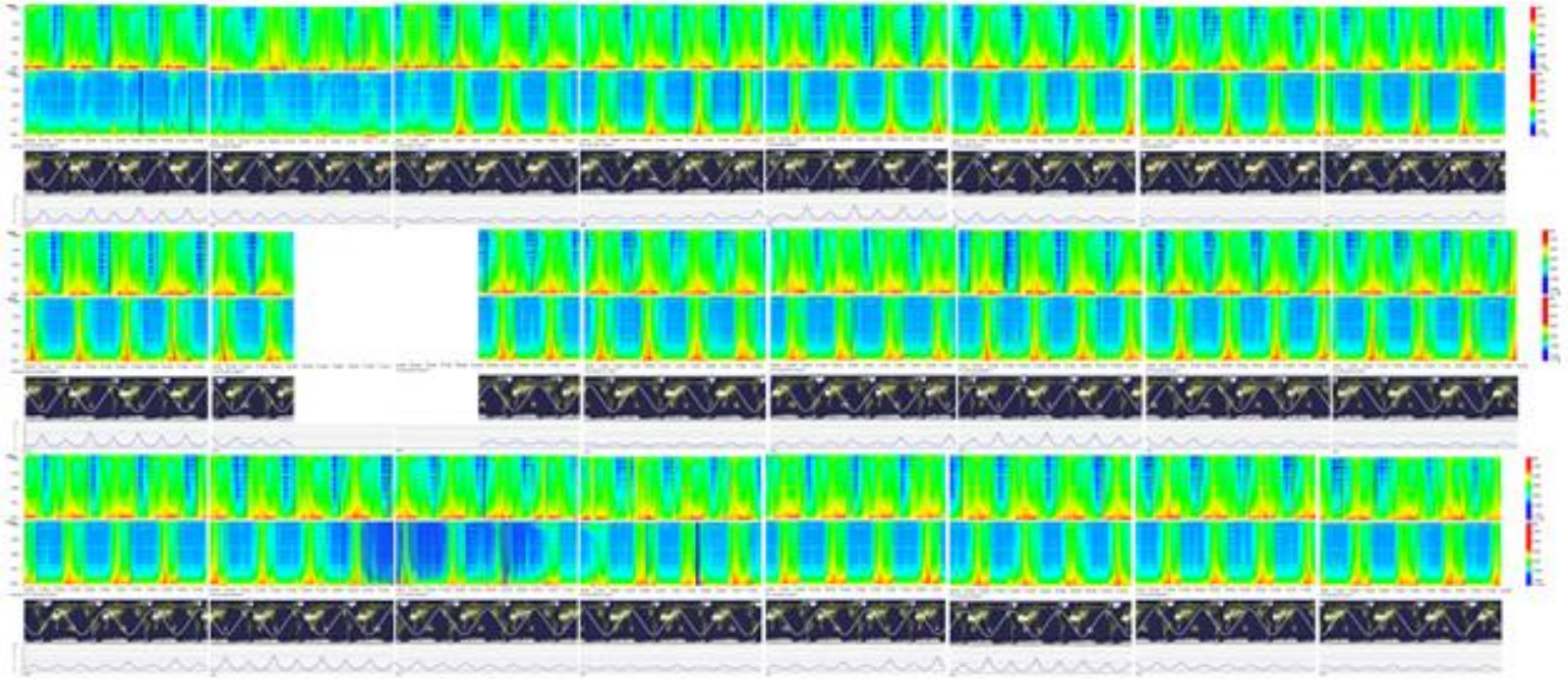


ISS «Obstanovka 1-st stage» 2 days (April 2013, 23-24)



Kp sum 12o Kp sum 29o

ISS «Obstanovka 1-st stage» 5 days (June 2013, 15-19)



15-Kp sum 7o 16-Kp sum 3- 17-Kp sum 5+ 18-Kp sum 7- 19-Kp sum 8+

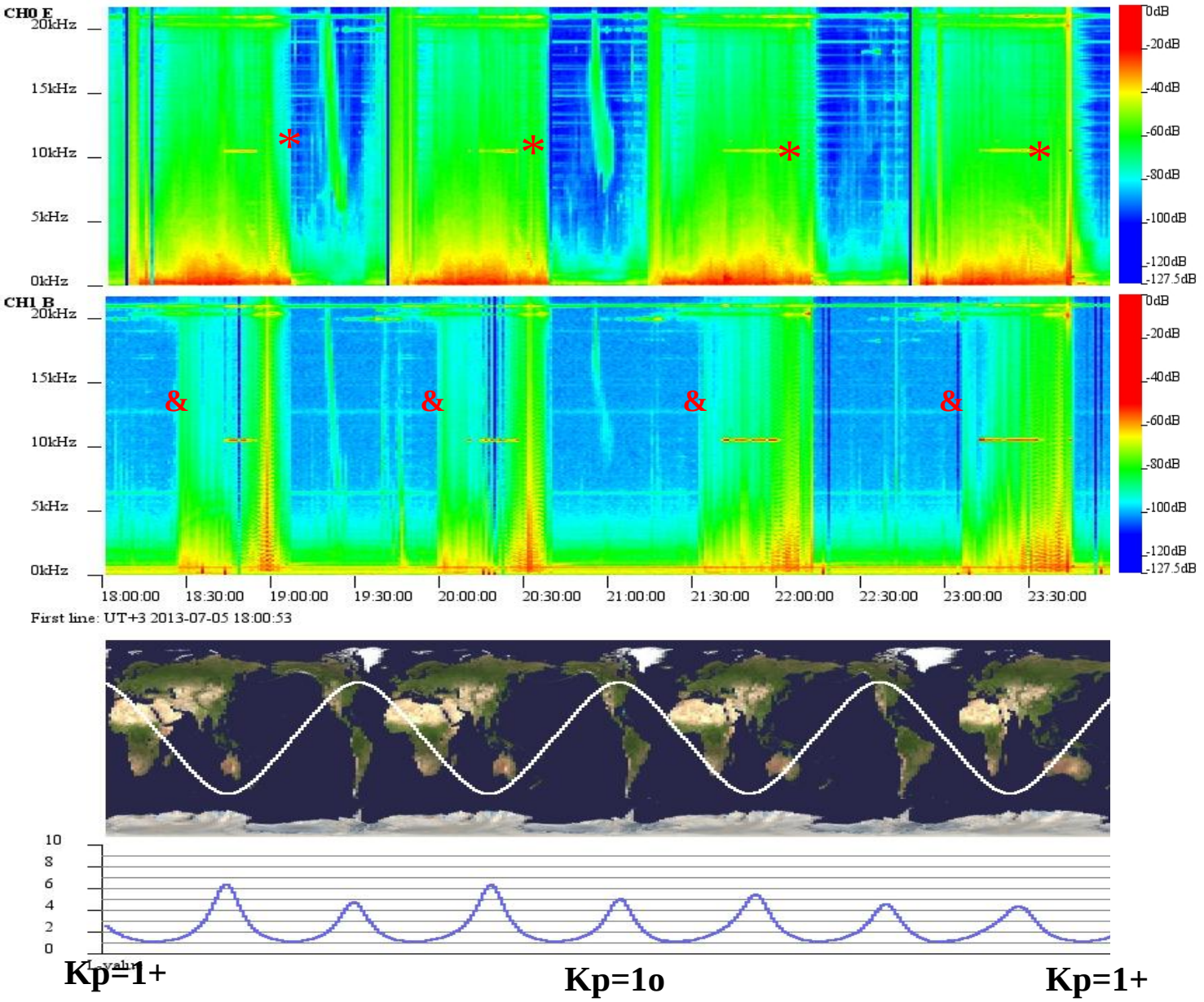
A typical example of monitoring studies (0.01-22kHz) in the experiment "Obstanovka (1 stage)". *2013-07-05, UT+3 18:00-24:00* (4 orbits).

E

B

orbit

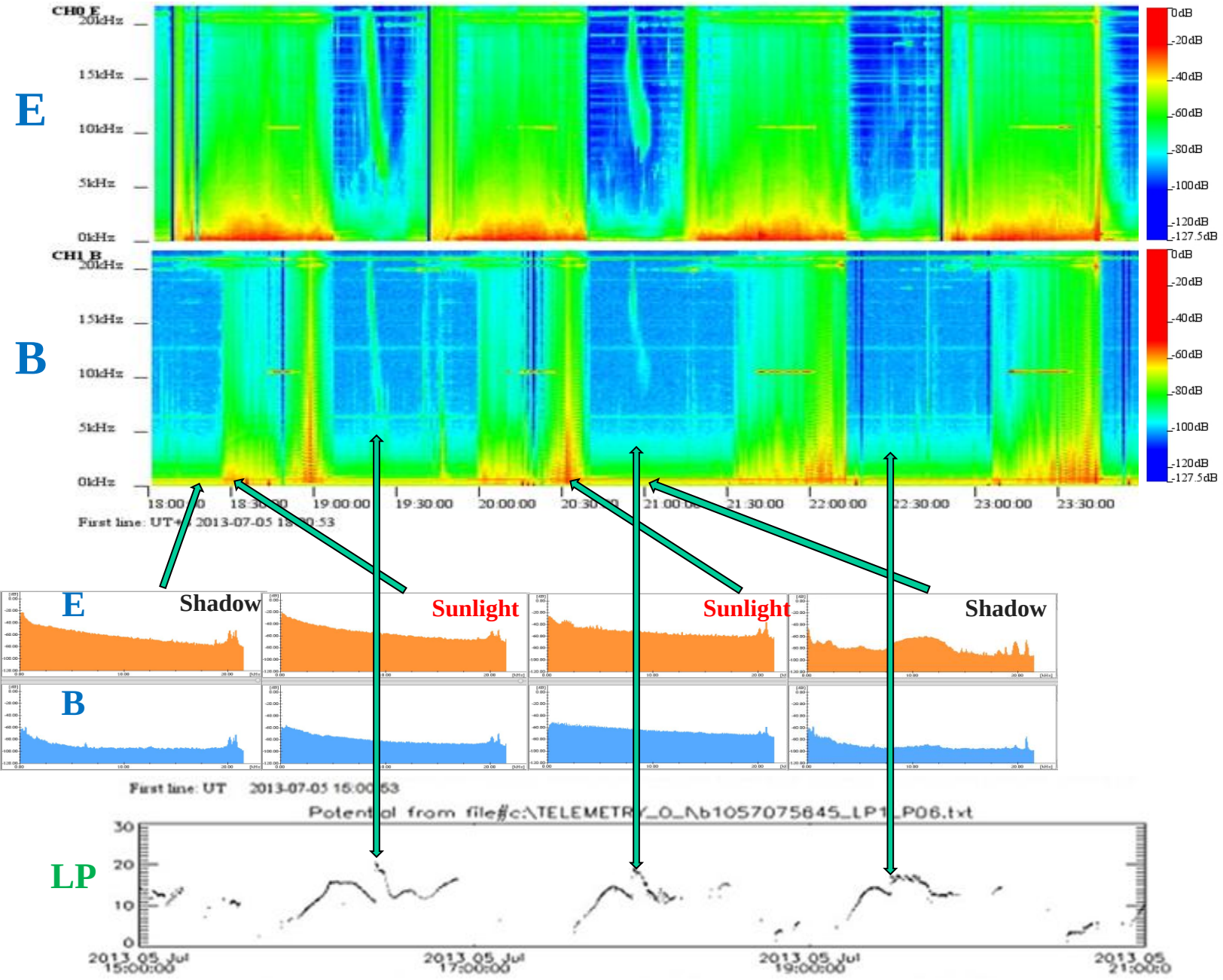
L



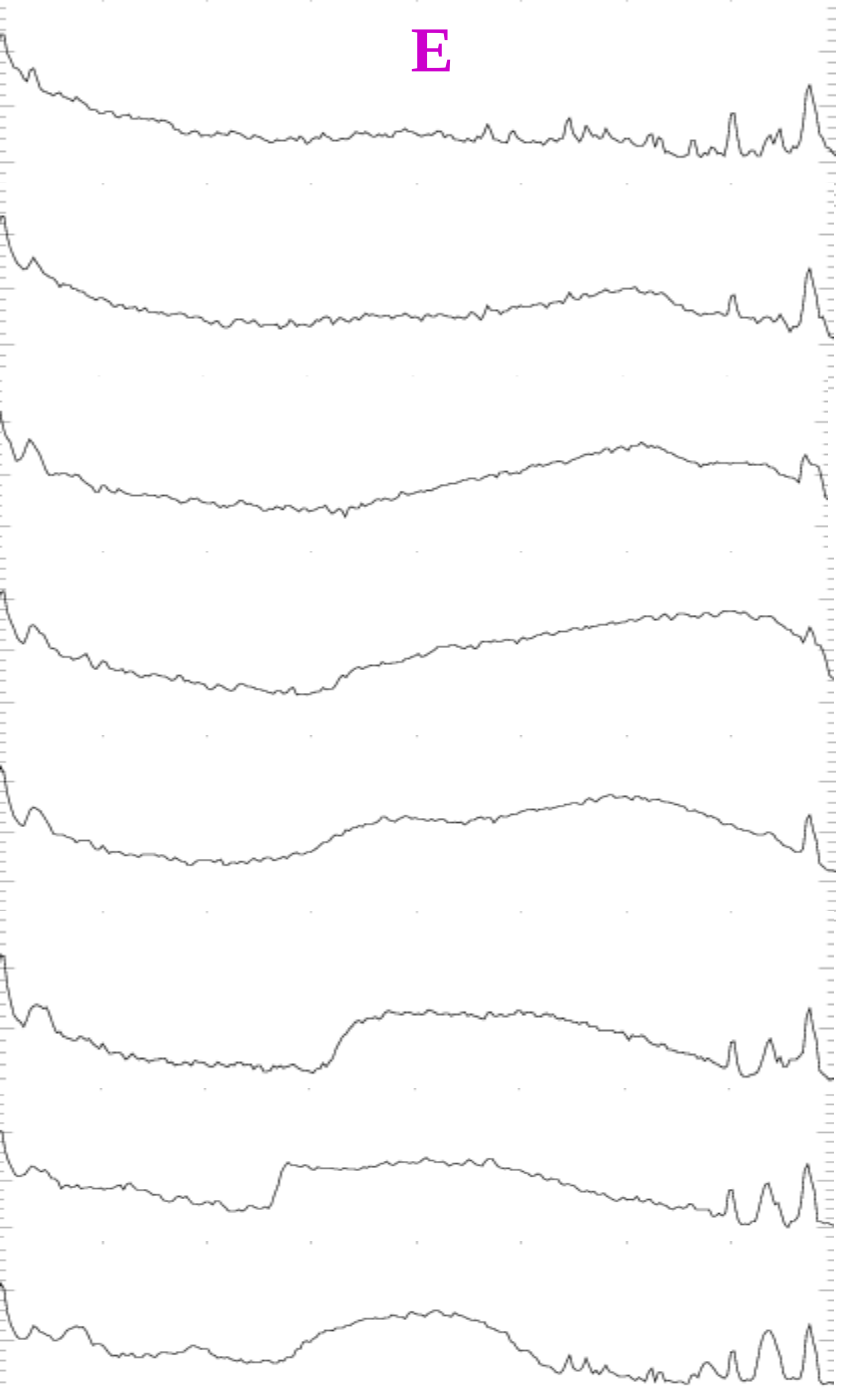
2013/07/05

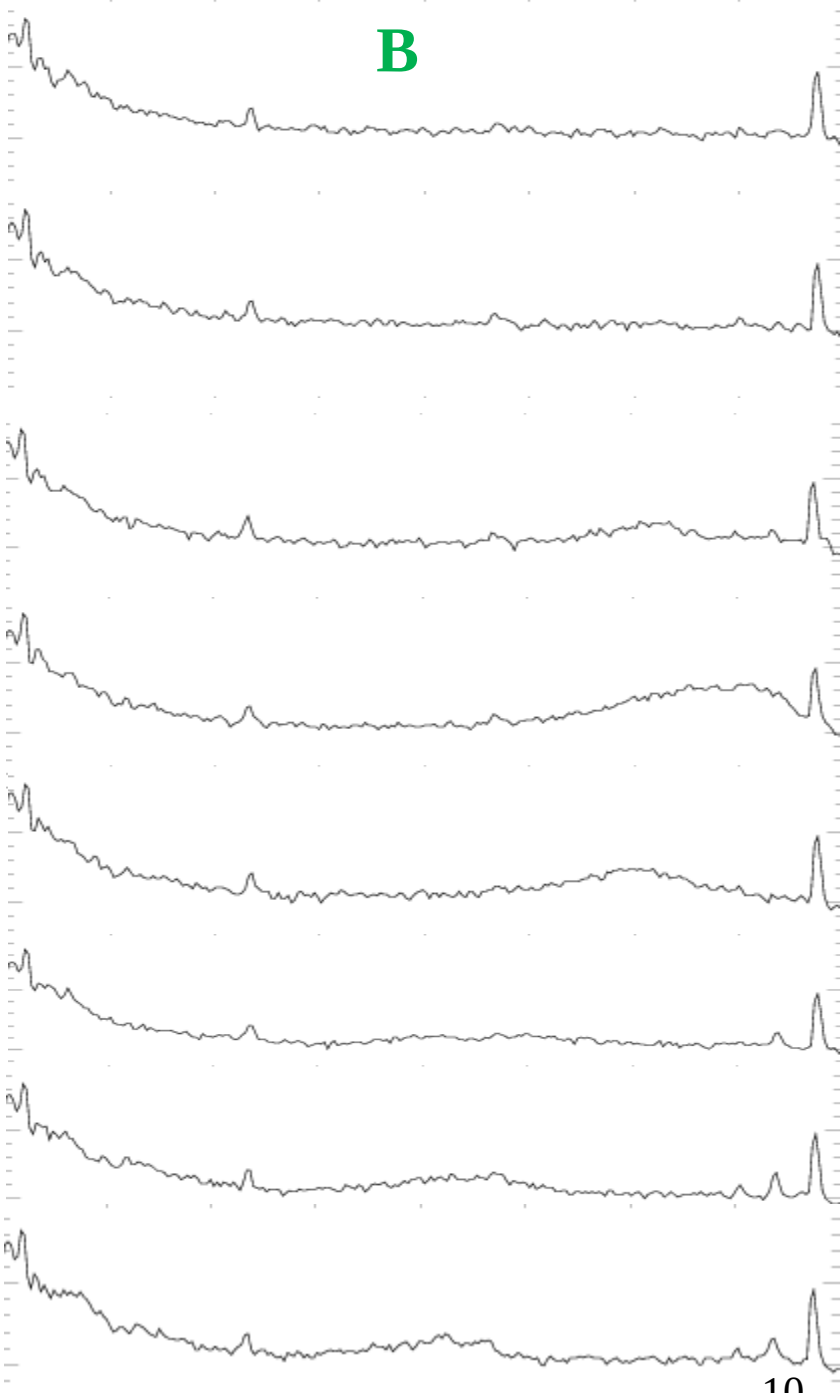
Evt 18:20:10
&Shd 18:26:31
*Sun 19:00:19
Mrt 19:06:43
Evt 19:53:05
&Shd 19:59:26
*Sun 20:33:14
Mrt 20:39:38
Evt 21:26:00
&Shd 21:32:20
*Sun 22:06:08
Mrt 22:12:33
Evt 22:58:55
&Shd 23:05:15
*Sun 23:39:03
Mrt 23:45:27

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

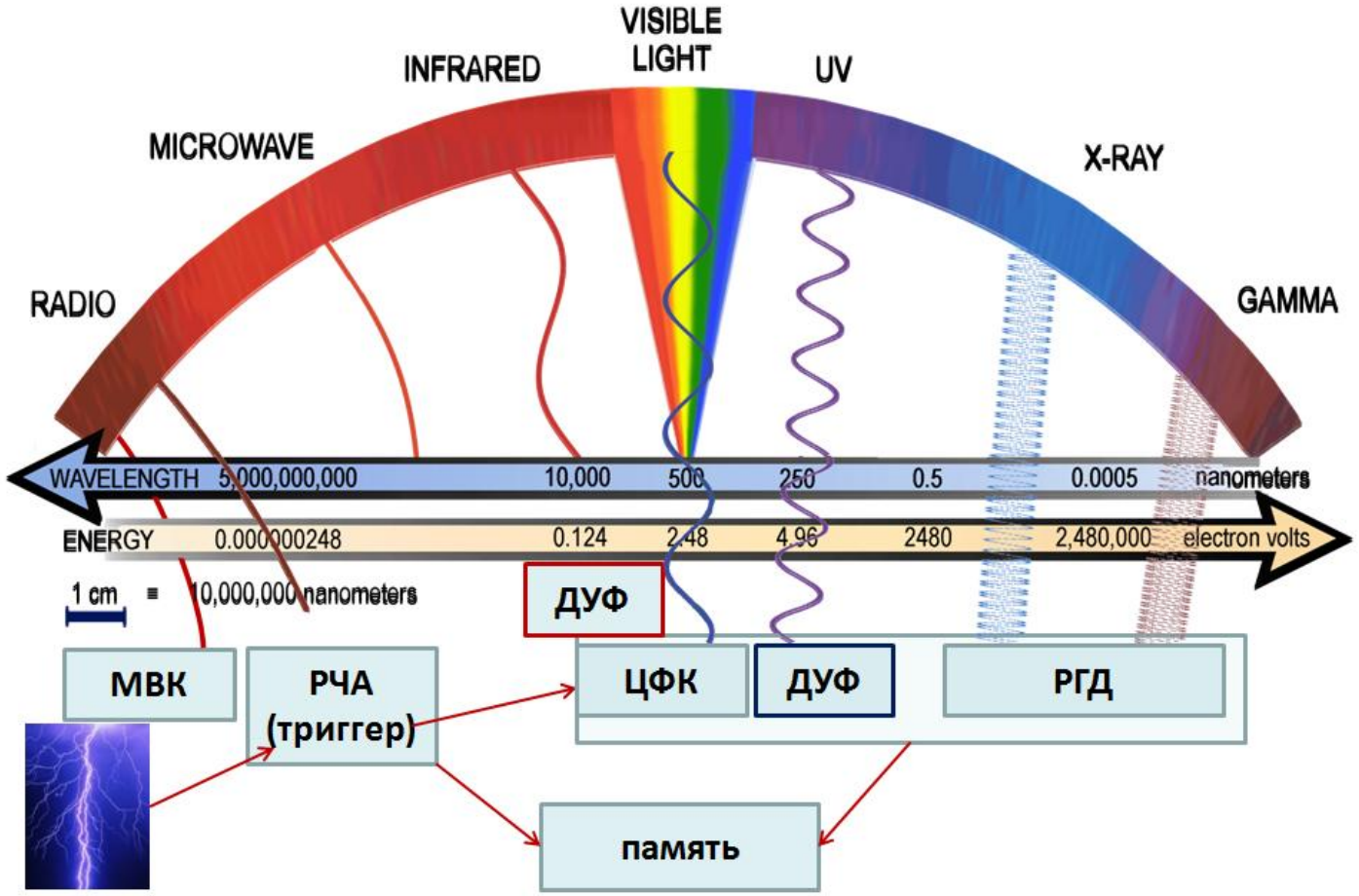

E


B

Micro-satellite “Chibis-M”, 2012-2014.

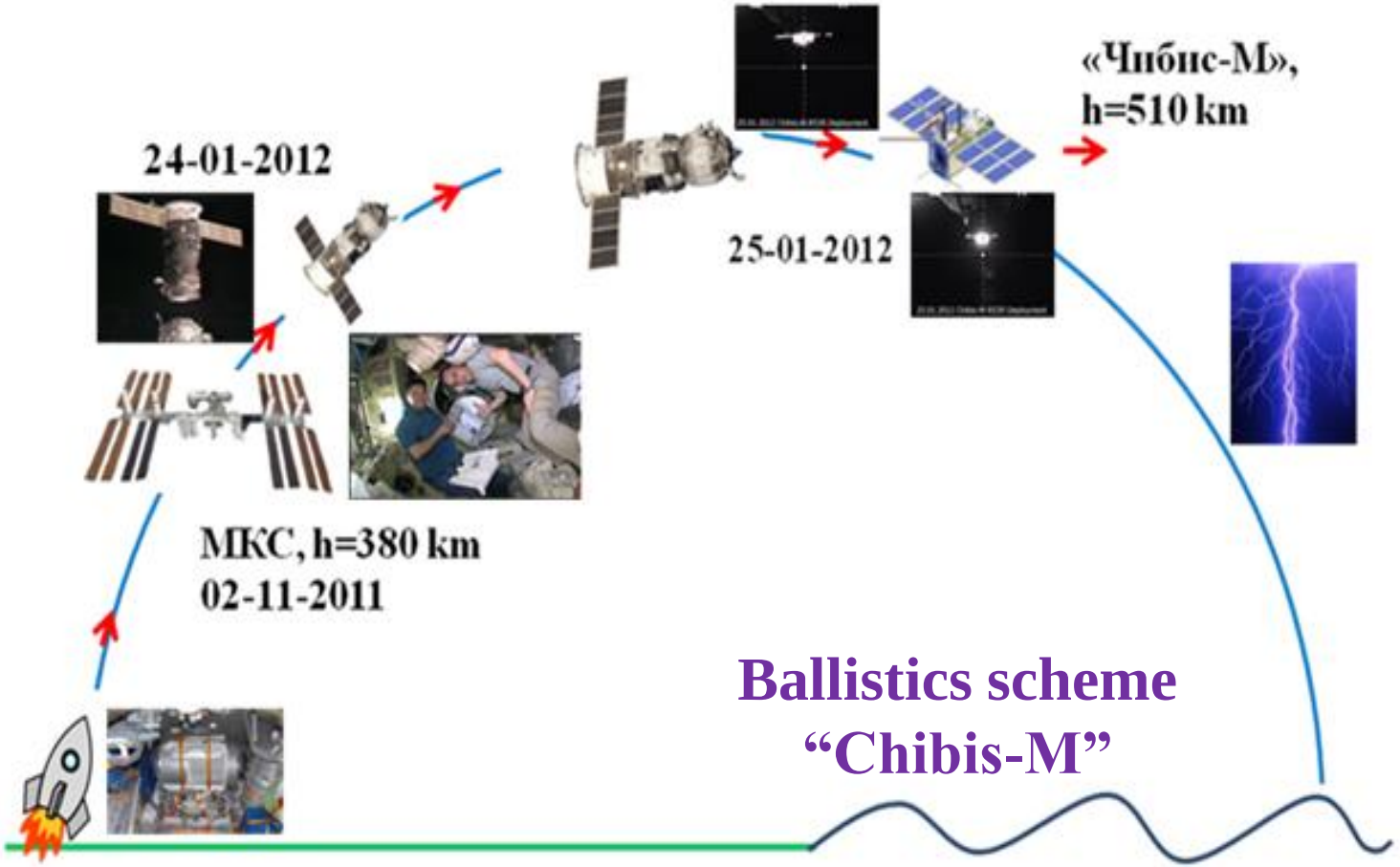
Studies of atmospheric lightning.

For the study of new physical processes in high-altitude atmospheric lightning discharges and mechanisms for their preparation requires a comprehensive study of gamma radiation, infrared and ultraviolet radiation, of electromagnetic waves in a wide frequency range with an unprecedented high (better share microseconds) time resc



Micro-satellite “Chibis-M”, 2012-2014.

Specificity of space experiments in the infrastructure of the ISS by using the ship "Progress".



«Chibis-M»
h = 513 km.
Liftime
960 days

In the infrastructure of the Russian segment of the ISS scheme of microsatellites delivery into orbit are used.

Micro-satellite “Chibis-M”, 2012-2014.

Specificity of space experiments in the infrastructure of the ISS by using the ship "Progress".

ISS RS. Cosmonauts O. Kononenko and A. Shkaplerov conduct preparatory work with TLC "Chibis-M".

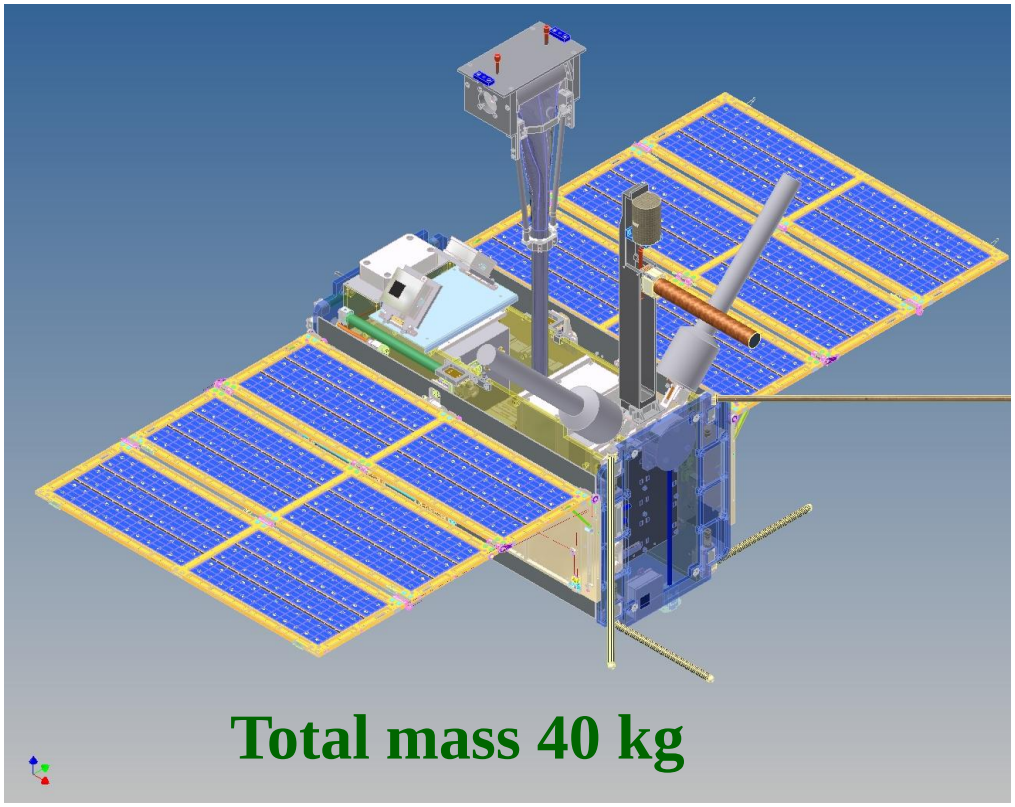
Micro-satellite “Chibis-M”, 2012-2014.

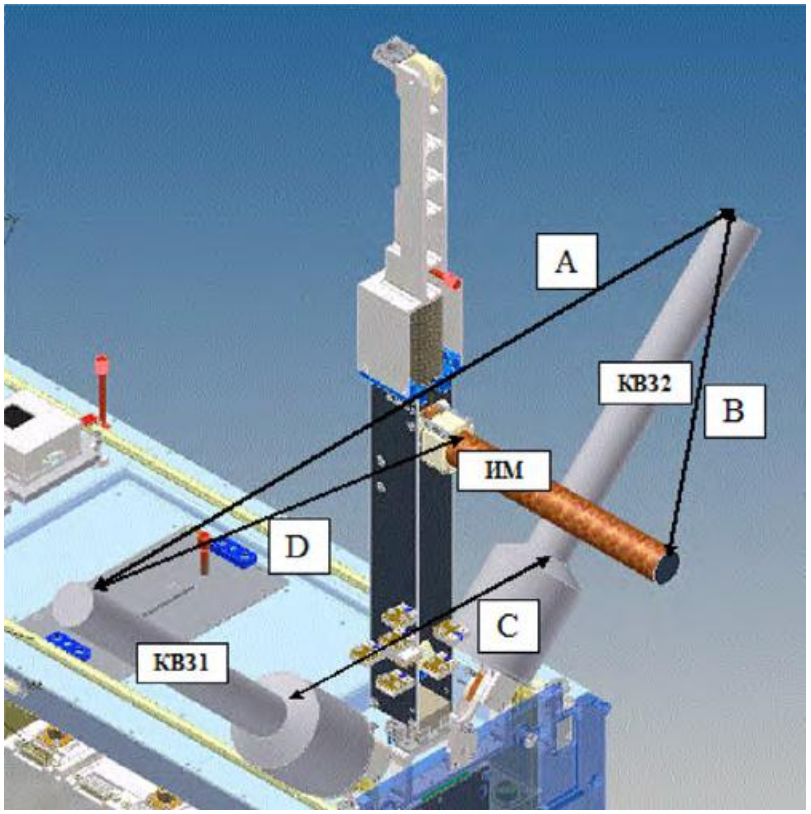
January 25, 2012 microsatellite "Chibis-M“ went out from the TLC on board the cargo spacecraft "Progress M-13M", located in the autonomous flight.

Micro-satellite “Chibis-M”, 2012-2014.

http://chibis.cosmos.ru

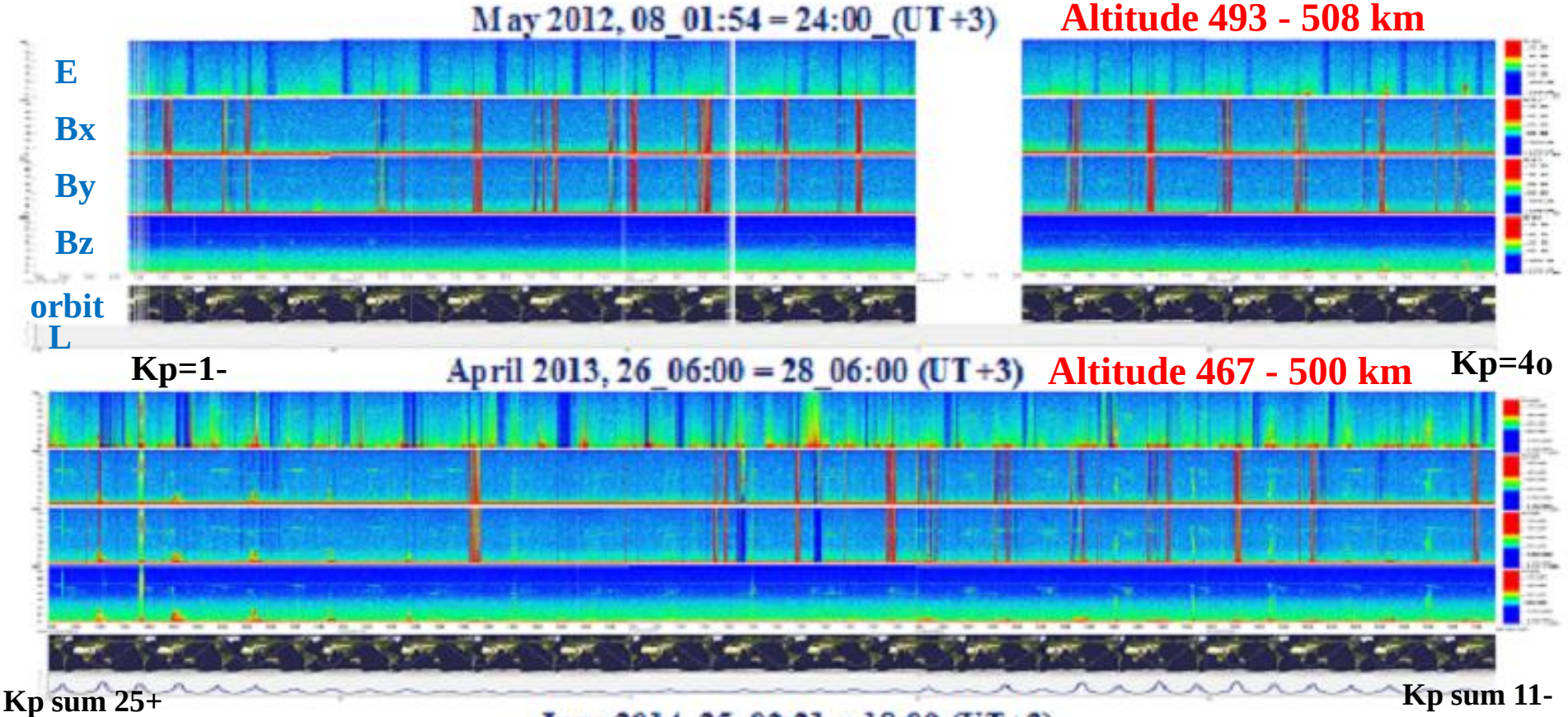
Separation from the ISS the Progress space vehicle raised its orbit altitude and the “Chibis-M” was separated from it and was delivered at the circular orbit 513 km height and 52 deg. inclination.



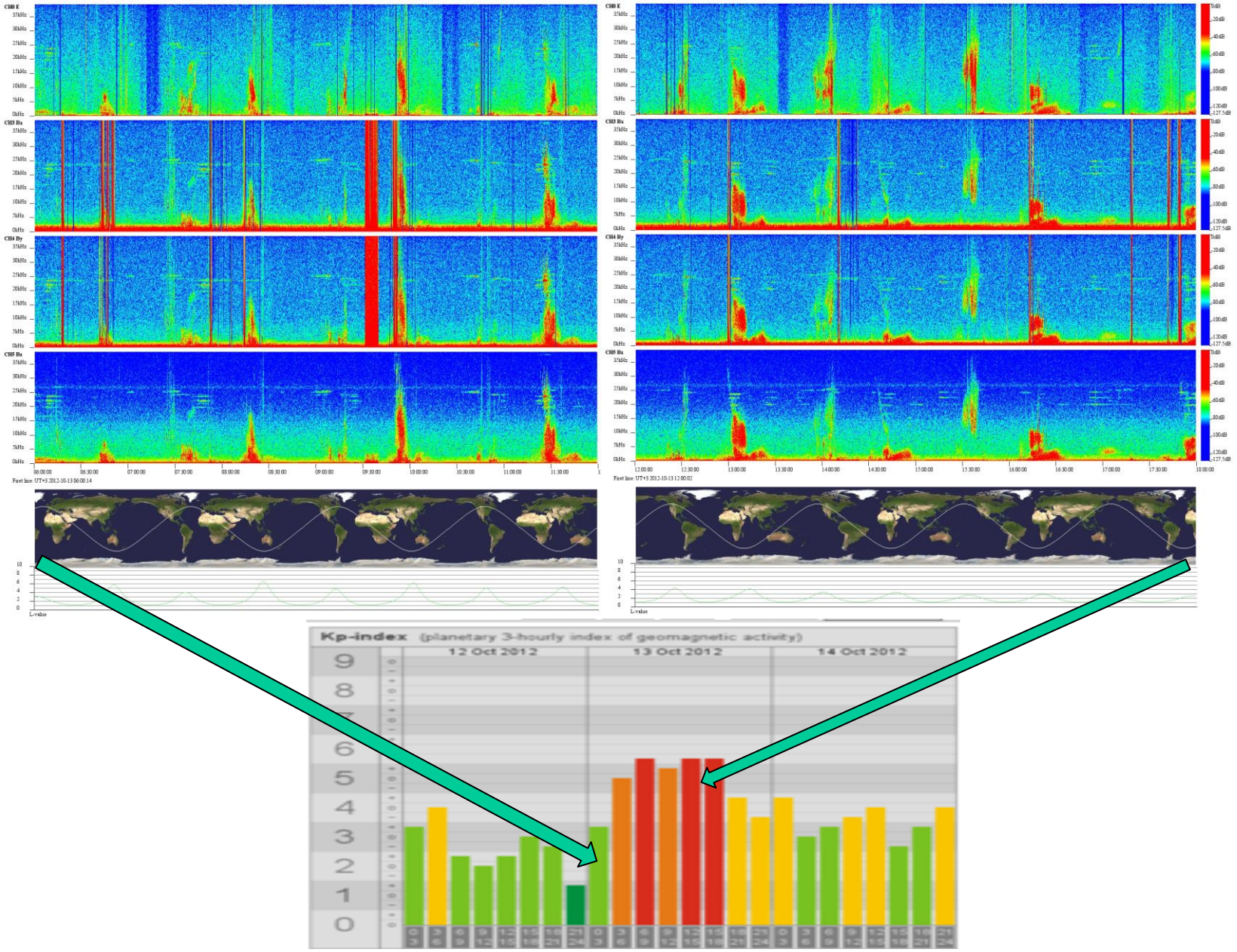


Sensors of the MWC: KB31 and KB32 – combined wave probes WP (sensor length 245 mm), BM – the induction magnetometer (sensor length 205 mm). Configuration: A = 597 mm; B = 376 mm, C = 250 mm, D = 299 mm

Micro-satellite “Chibis-M”, 2012-2014.

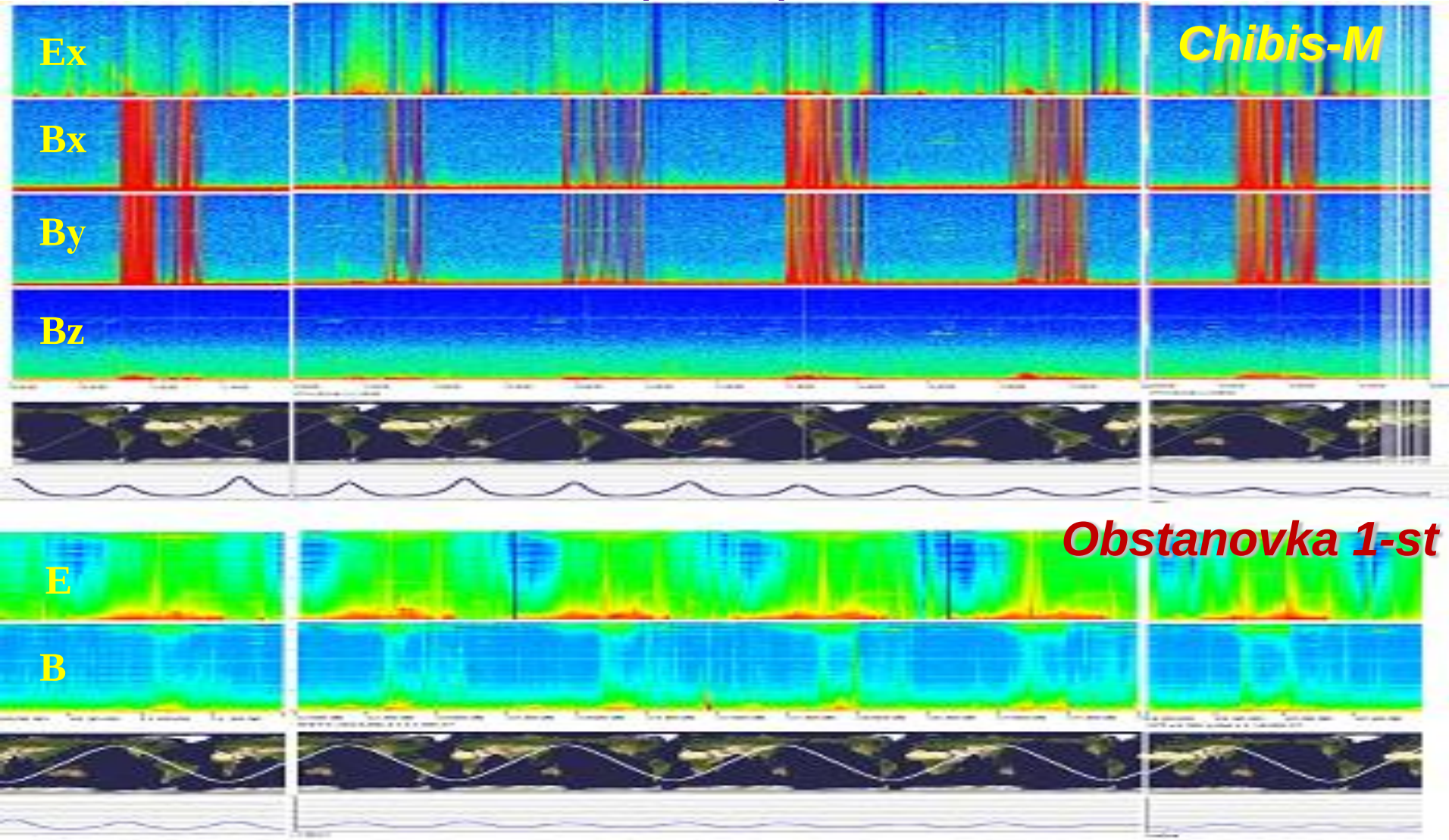


“Chibis-M” 2012/10/13 03:00 = 15:00 UT



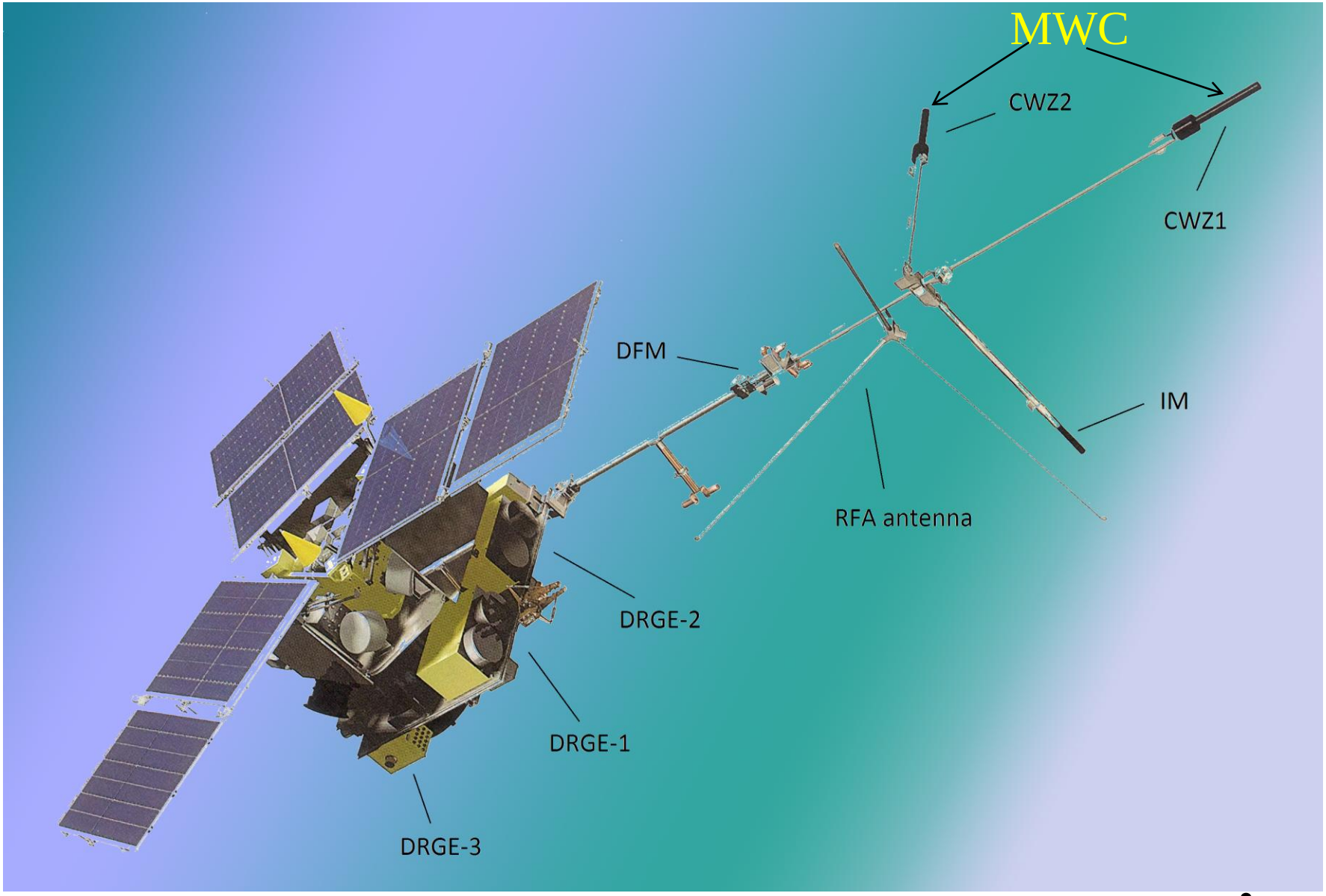
Synchronous data of Chibis-M and Obstanovka 1-st stage

2013.06.11 (UT+3) 10:00-20:00



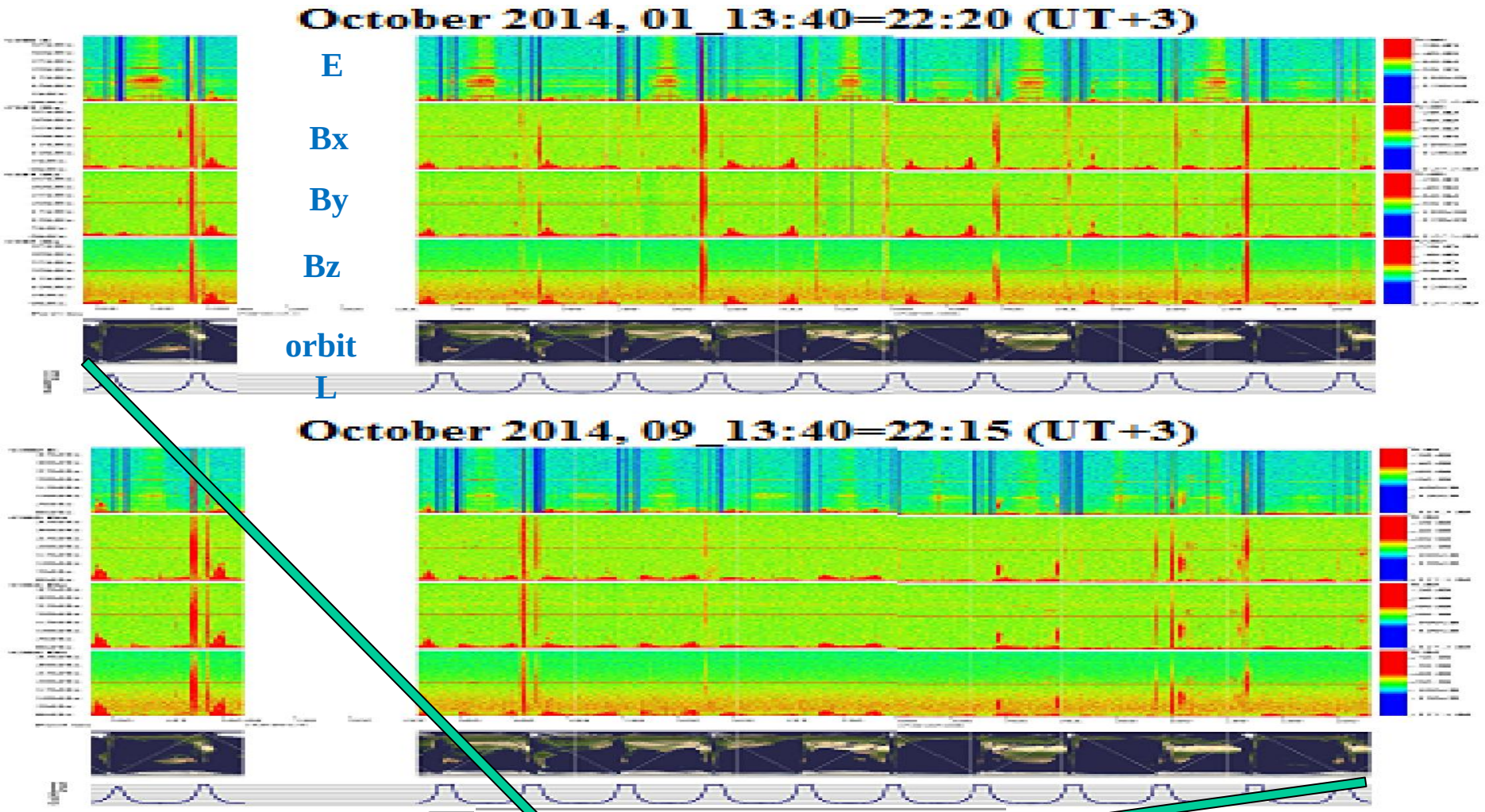
Top-down: "Chibis-M": E, Bx, By, Bz – frequency 0.01-39kHz,
"Obstanovka 1-st stage": E, B – frequency 0.01-23кГц.

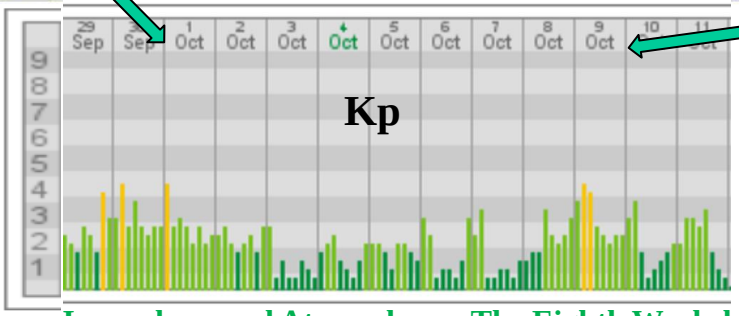
Satellite *VERNOV, 2014*



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

Satellite "*VERNOV*"



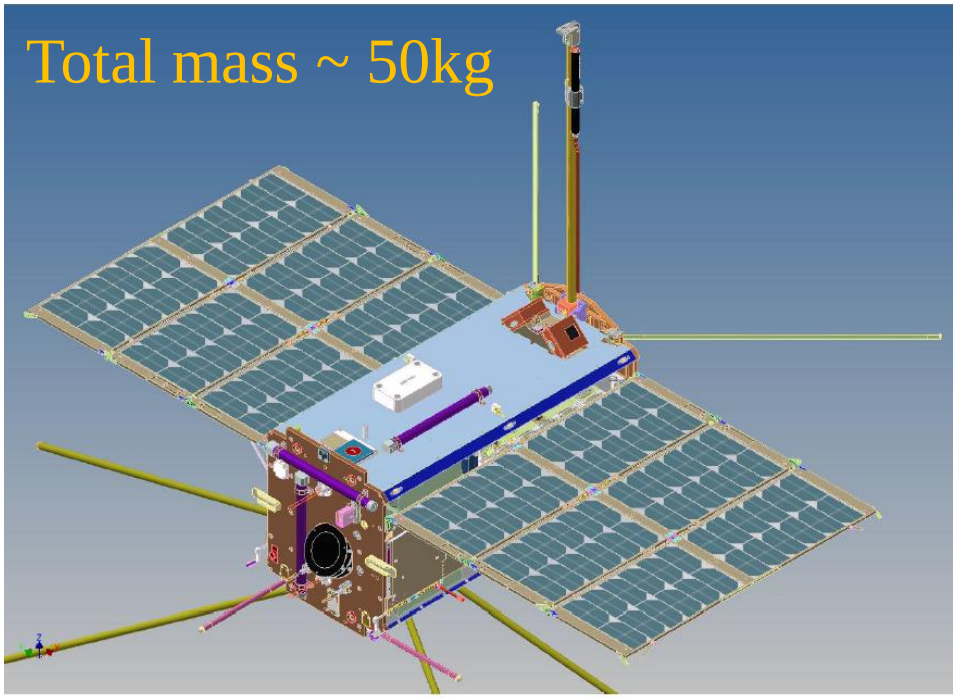


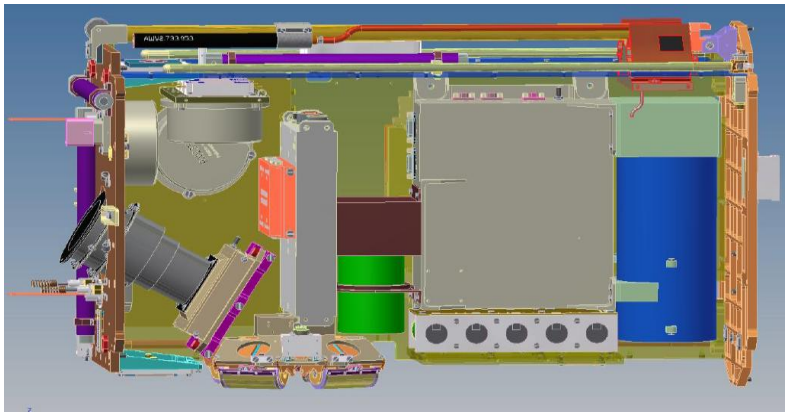
In "Long-term Programme of scientific research and experiments planned on the Russian segment of the ISS," the KNTC of the Roscosmos (decision No. 03 dated 24.12.2012) included 3 space experiments whis use of the MWC:

1. Micro-satellite "Chibis-AI", 2019-2023.

"Study of the nature of high-altitude lightning and related processes in the atmosphere and ionosphere on the basis of the microsatellite "Chibis" using the cargo ship "Progress" (code – **"Chibis-AI").**

2016 - end of phase A, transition to phase B



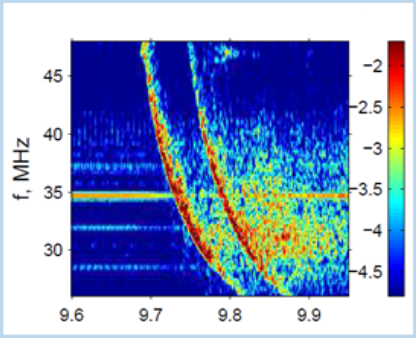


1. Micro-satellite "Chibis-AI", 2019-2023.

What is known at the moment:

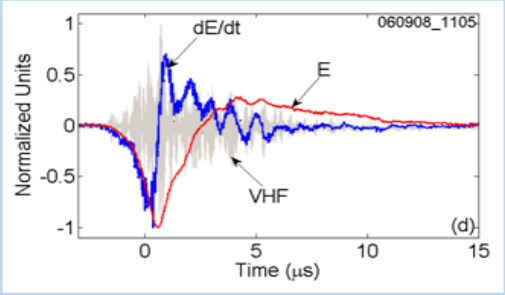
- **3000 events in the gamma range (BATSE, RHESSI, Fermi, AGILE, CORONAS-Photon and Vernov);**
- **1 in synchronous gamma - two different SC;**
- **1 in synchronous gamma - ray optics and different SC;**
- **NO simultaneous observations at gamma - ray and radio!!!**

TIPP

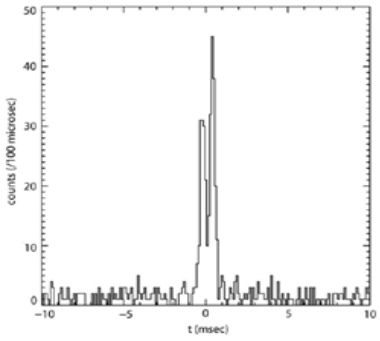


Trans-Ionospheric Pulse Pair

NBP

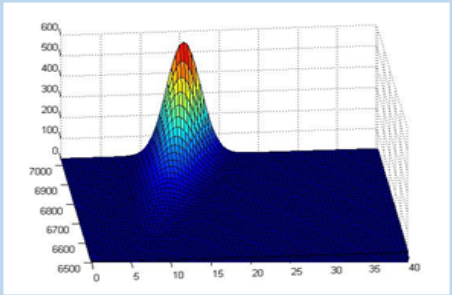


Narrow Bipolar Pulse

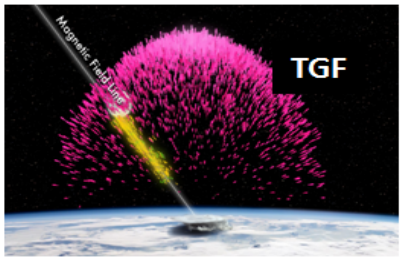


TGF

CID



Compact Intracloud Discharge



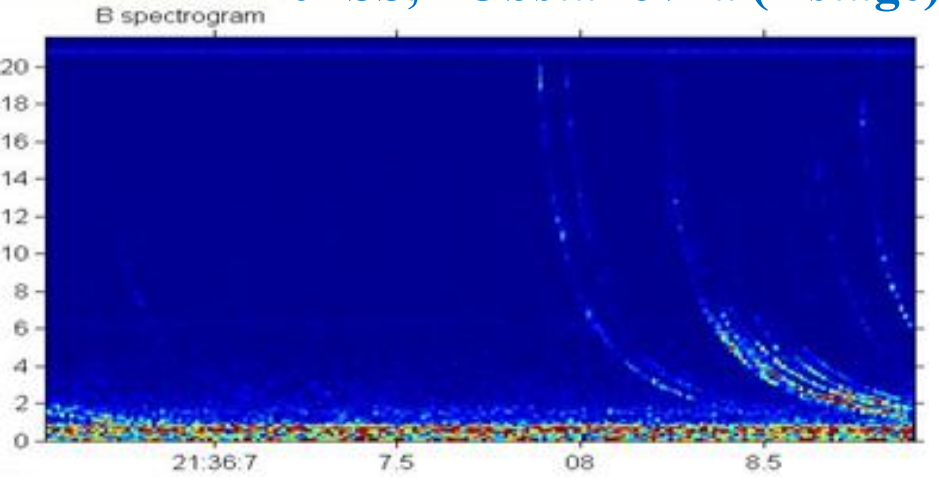
Terrestrial Gamma-Flash

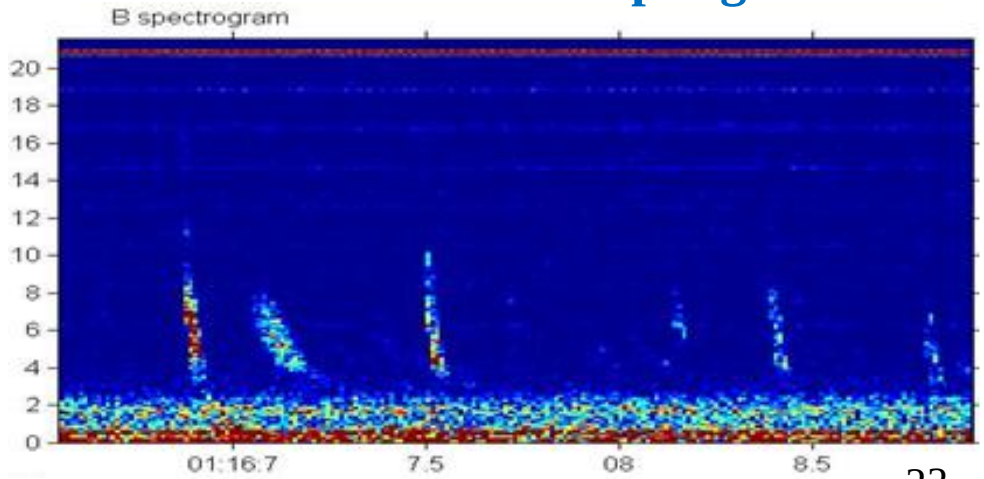
2. Experiment «Obstanovka 2-nd stage», 2019-2025.

The subjects of the study "Obstanovka 2-nd stage" experiment (2019-2005) they are:

- **Parameters of the electromagnetic situation with the vector measurements in the zone of the installation of equipment.**
- **Geophysical and anthropogenic processes against the background of interaction s with the ionosphere plasma.**
- **Recommendations regarding the guarantee of monitoring geophysical and anthropogenic processes with the use of a method of combined wave diagnostics.**

The ISS, "Obstanovka (1 stage)". Waveform – 50 kHz sampling.

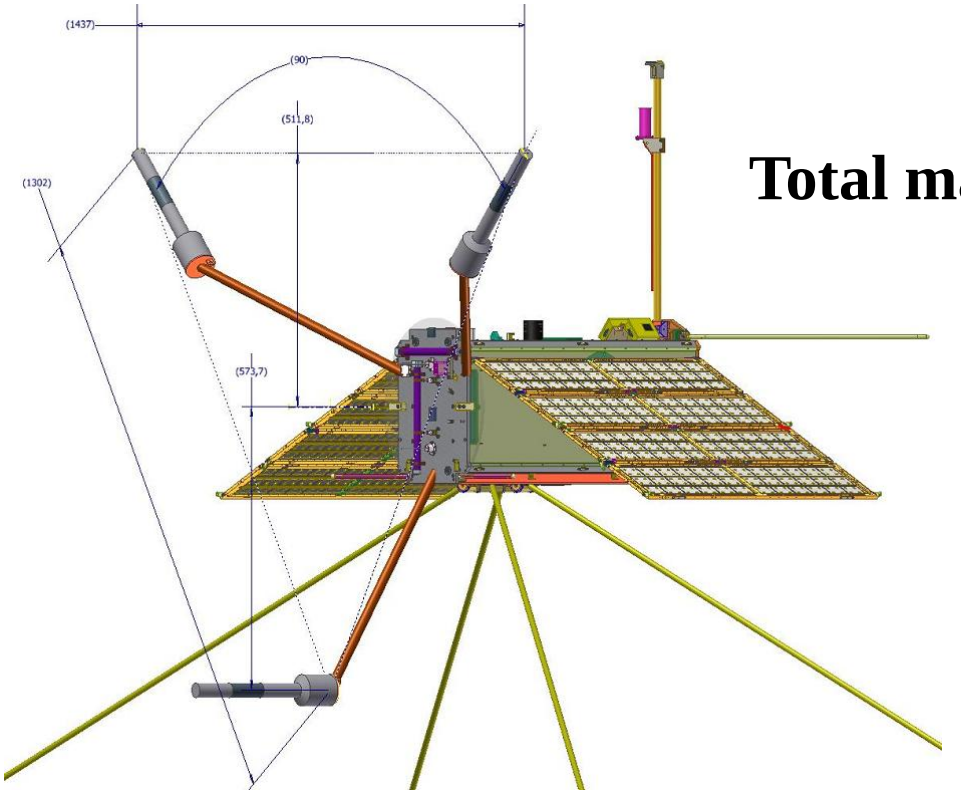




3. Micro-satellite "Trabant" – 2019-2023.

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

Conclusion.

1. Monitoring measurements on the ISS provide an opportunity to investigate how short-period and 11-year variations of ionosphere electromagnetic parameters of Space Weather. The observed "anthropogenic" impacts of infrastructure of the ISS is deterministic.

2. Monitoring measurements on the micro-satellites integrated into the infrastructure of the ISS, ensure the high accuracy of spectral - temporal resolution. It is necessary to take special measures to reduce the impact of electromagnetic devices, systems for orientation of micro-satellites.

3. Monitoring measurements on polar satellites will significantly widen the range of research of electromagnetic parameters of Space Weather.

4. The intensity of the electromagnetic parameters in the sub-auroral region can serve as physical parameter of space weather in the ionosphere .

Thanks for the attention