THE 15TH RUSSIAN-CHINESE WORKSHOP ON SPACE WEATHER
September 9–13, 2024, Irkutsk, Russia

CHINA-RUSSIA JOINT RESEARCH CENTER ON SPACE WEATHER:

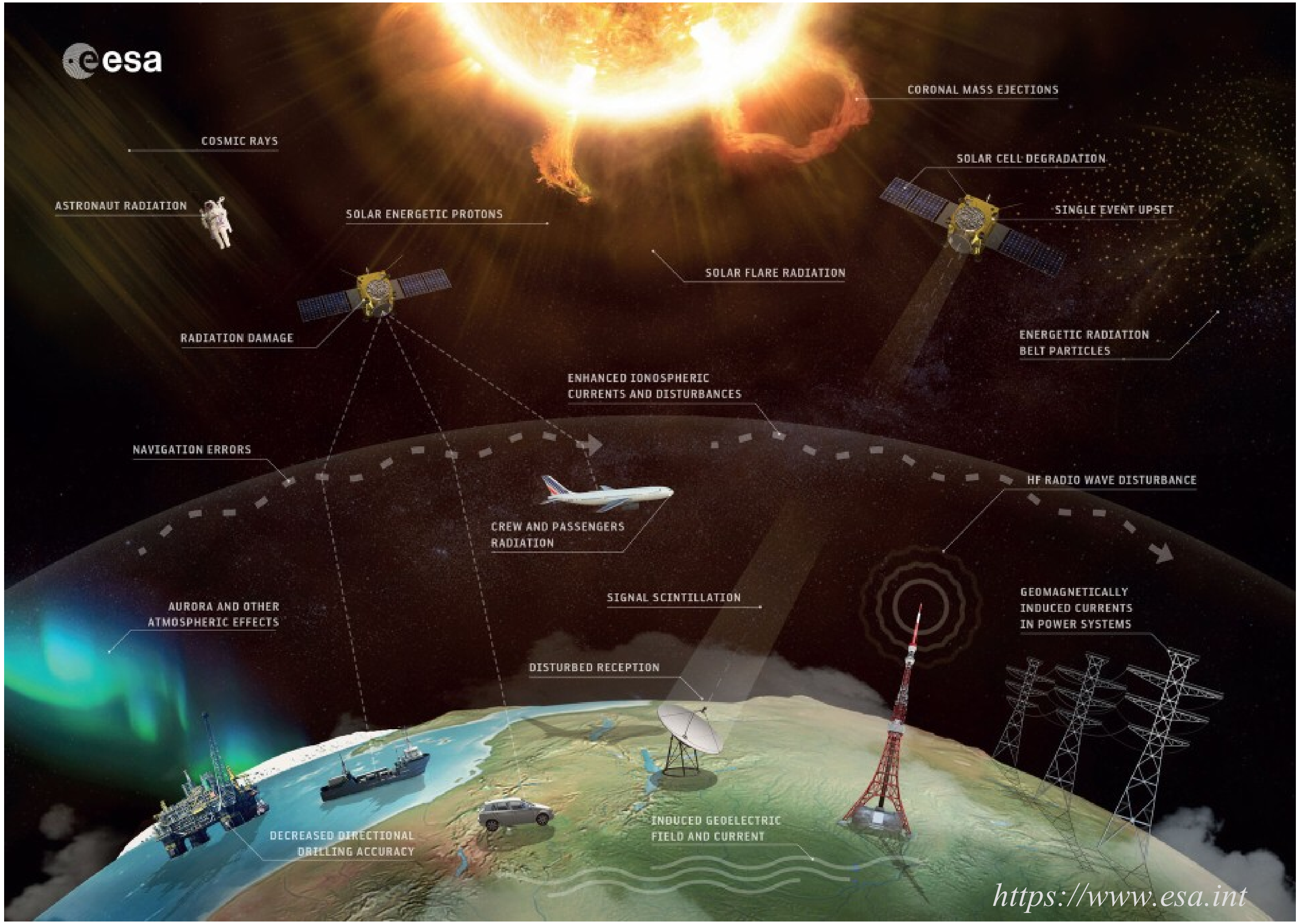
24 YEARS OF COOPERATION

Medvedev A.V.

Institute of Solar-Terrestrial Physics SB RAS
Irkutsk, Russia

Space Weather: major challenges

- development of observation tool networks
- advancement of knowledge about processes in near-Earth space
- development and improvement of empirical and theoretical models



Chinese-Russian Joint Research Center

Main research areas

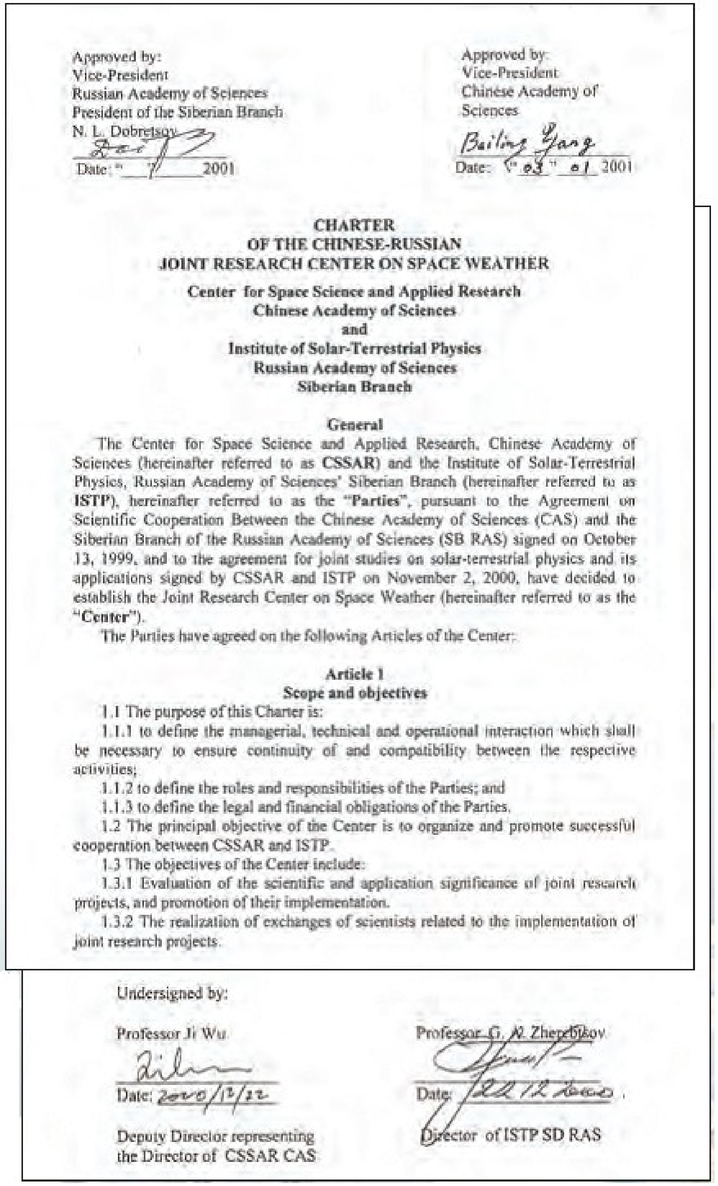
- *solar activity related to solar disturbances*
- *propagation of solar disturbances through the solar corona and interplanetary space*
- *dynamic processes of various spatial and temporal scales associated with the near-Earth space disturbances*
- *propagation of disturbances in the Earth's ionosphere and atmosphere from high to middle and low latitudes*
- *diagnostics of near-Earth space and forecasting techniques*
- *interaction between near-Earth space and the Earth's atmosphere*
- *global space weather system and its response to external influences*

Chinese-Russian Joint Research Center

First Workshop

December 14-19, 2000
Irkutsk, Russia

First Charter



Approved by:
Vice-President
Russian Academy of Sciences
President of the Siberian Branch
N. L. Dobretsov
Date: "___" ______ 2001

Approved by:
Vice-President
Chinese Academy of Sciences
Date: "03" 01 2001

CHARTER
OF THE CHINESE-RUSSIAN
JOINT RESEARCH CENTER ON SPACE WEATHER

Center for Space Science and Applied Research
Chinese Academy of Sciences
and
Institute of Solar-Terrestrial Physics
Russian Academy of Sciences
Siberian Branch

General

The Center for Space Science and Applied Research, Chinese Academy of Sciences (hereinafter referred to as **CSSAR**) and the Institute of Solar-Terrestrial Physics, Russian Academy of Sciences' Siberian Branch (hereinafter referred to as **ISTP**), hereinafter referred to as the "**Parties**", pursuant to the Agreement on Scientific Cooperation Between the Chinese Academy of Sciences (CAS) and the Siberian Branch of the Russian Academy of Sciences (SB RAS) signed on October 13, 1999, and to the agreement for joint studies on solar-terrestrial physics and its applications signed by CSSAR and ISTP on November 2, 2000, have decided to establish the Joint Research Center on Space Weather (hereinafter referred to as the "**Center**").

The Parties have agreed on the following Articles of the Center:

Article 1
Scope and objectives

1.1 The purpose of this Charter is:

1.1.1 to define the managerial, technical and operational interaction which shall be necessary to ensure continuity of and compatibility between the respective activities;

1.1.2 to define the roles and responsibilities of the Parties; and

1.1.3 to define the legal and financial obligations of the Parties.

1.2 The principal objective of the Center is to organize and promote successful cooperation between CSSAR and ISTP.

1.3 The objectives of the Center include:

1.3.1 Evaluation of the scientific and application significance of joint research projects, and promotion of their implementation.

1.3.2 The realization of exchanges of scientists related to the implementation of joint research projects.

Undersigned by:

Professor Ji Wu
Date: 2000/12/22
Deputy Director representing
the Director of CSSAR CAS

Professor G. A. Zherebtsov
Date: 22 12 2000
Director of ISTP SD RAS

Co-directors of the Chinese-Russian Joint Research Center

Wu Ji
Director of NSSC CAS

Geliy Zherebtsov
Director of ISTP SB RAS

Aleksandr Potekhin
Director of ISTP SB RAS

Wang Chi
Director of NSSC CAS

Andrey Medvedev
Director of ISTP SB RAS

2000 **2012** **2018**

Chinese-Russian Joint Research Center in Numbers

about
60
scientific projects

15
Chinese-Russian Workshops on Space Weather

about
200
exchange visits

24
years

over
10
joined institutes

over
400
joint scientific articles

over
230
joint scientific reports on workshops and conferences

2
collective monographs

Chinese-Russian Joint Research Center

Workshops

Chinese-Russian Joint Research Center
Broad cooperation

National Astronomical Observatories of China CAS

Institute of Geology and Geophysics CAS

Peking University

Yunnan Astronomical Observatory CAS

China Research Institute of Radiowave Propagation

Shandong University

National Space Science Center CAS

Institute of Solar-Terrestrial Physics SB RAS

Shafer Institute of Cosmophysical Research and Aeronomy SB RAS

Pushkov Institute of Earth Magnetism, Ionosphere and Radio Wave Propagation RAS

Space Research Institute RAS

Central Astronomical Observatory of RAS at Pulkovo

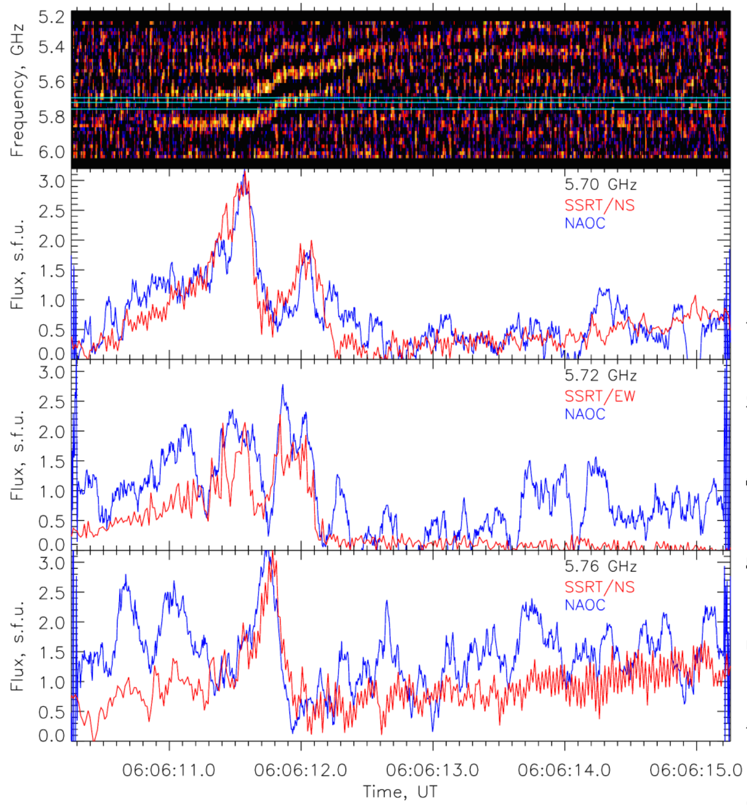
Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS

Polar Geophysical Institute RAS

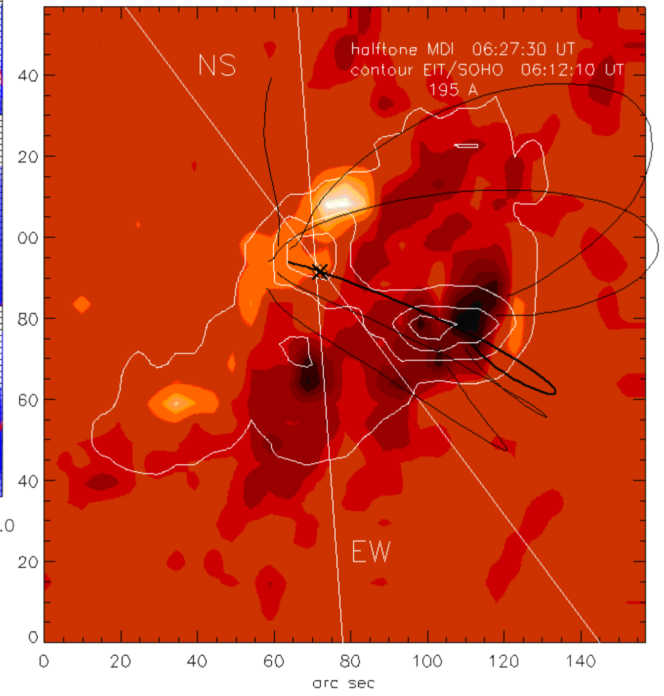
Main scientific results

First observations of a microwave zebra pattern

ISTP SB RAS, NAOC



In 2003, the researchers from ISTP RAS and NAOC first detected a zebra pattern in the microwave range.



Dynamic spectra and time profiles of the burst with zebra pattern (left). Structure of the active region with the zebra pattern source (right).

The zebra pattern was observed simultaneously at the Siberian Solar Radio Telescope and the spectropolarimeter of the Huairou Solar Observing Station.

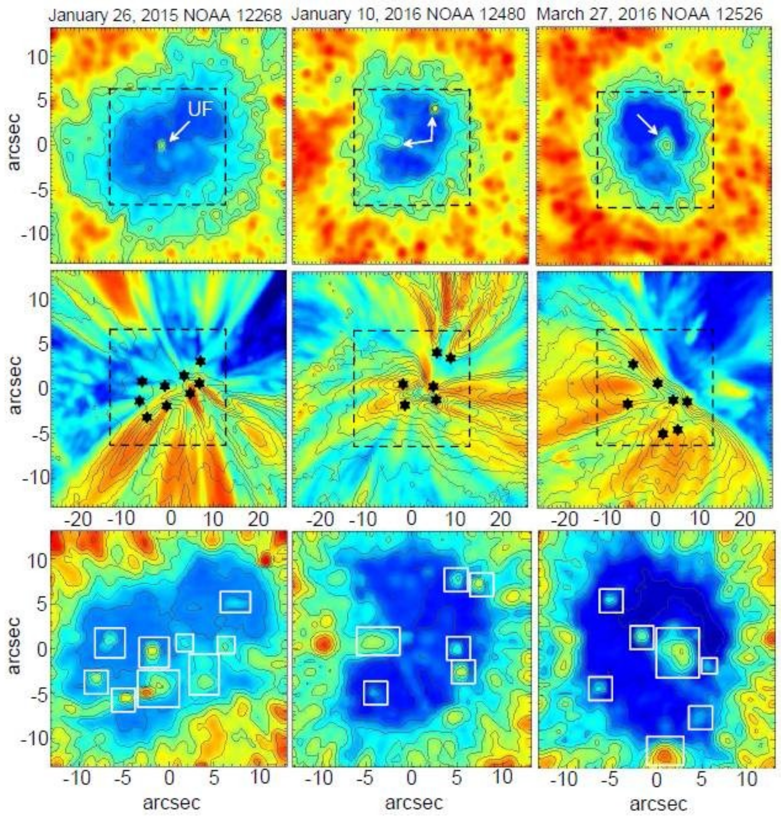
This combination has allowed us to determine not only spectral, but also spatial characteristics of the event.

It was concluded that the most probable generation mechanism of the zebra pattern was a nonlinear interaction of harmonics of plasma waves known as Bernstein modes.

Altyntsev A.T., Kuznetsov A.A., Meshalkina N.S., Rudenko G.V., Yan Yihua, On the origin of microwave zebra pattern. Astronomy and Astrophysics. 2005. v. 431. p. 1037.

Main scientific results

Fine wave dynamics in umbral flash sources



Sunspot active regions on 26.01.2015, 10.01.2016, and 27.03.2016 (top and middle). Umbral regions are shown by broken black rectangles, UF sources are indicated by arrows. Original maps overlapped on variation maps of UV emission during observation (bottom). The small white rectangles show sources of UFs.

ISTP SB RAS, YAO CAS

For the first time, information was obtained on the dynamics of wave processes in small angular solar magnetic structures associated with the occurrence of short-term brightening of ultraviolet radiation in the sunspot umbra (Umbral flashes or UFs).

The observed UFs can be categorized into two types:
- background UFs are associated with the random increase of separate parts of wave fronts propagating in the upper layers of solar atmosphere;
- local UFs are associated with increased wave activity near the footpoints of magnetic loops.

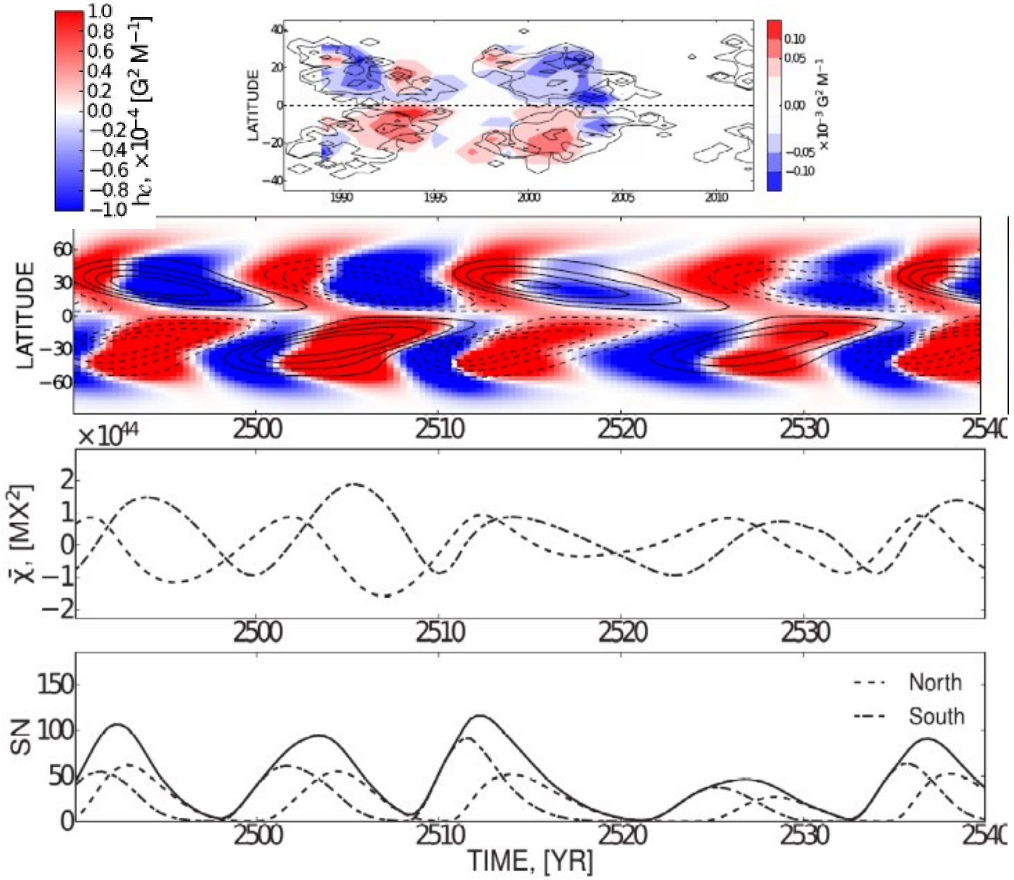
It was concluded that the brightening in the shadow is a response to a global process of increase of the wave activity covering the entire atmosphere above the sunspots.

Sych R., Wang M. Fine wave dynamics in umbral flash sources. Astronomy & Astrophysics. 2018. v. 618. id.A123.

Main scientific results

The origin of the helicity hemispheric sign rule reversals in the mean-field solar-type dynamo

NAOC, ISTP SB RAS, IZMIRAN, MSU



Magnetic helicity observations at the Huairou Solar Observing Station

Observations of solar magnetic helicity at the Huairou Solar Observing Station over the past two solar cycles revealed reversals of the helicity hemispheric sign rule (negative in the North and positive in the South hemispheres).

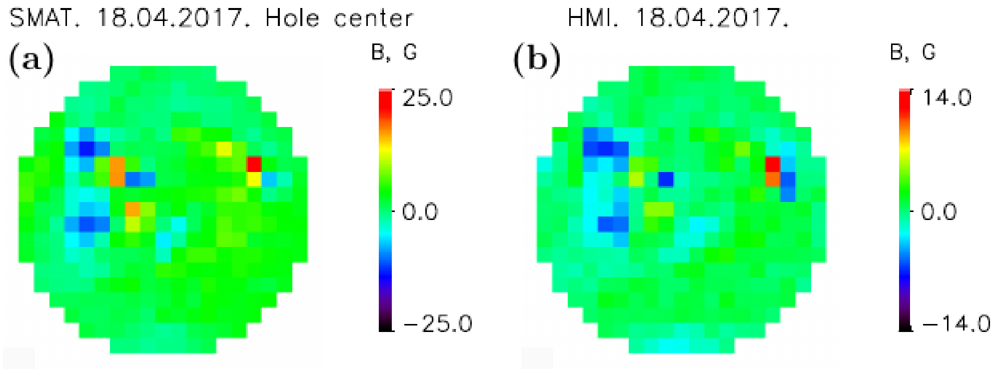
The obtained results suggest that the magnetic helicity of a large-scale axisymmetric field can be treated as an additional observational tracer for the solar dynamo and it probably can be used for the solar activity forecast as well.

Pipin V.V., Zhang H., Sokoloff D.D., Kuzanyan K.M., Gao Y. The origin of the helicity hemispheric sign rule reversals in the mean-field solar-type dynamo. Monthly Not. Royal Astron. Soc. 2013. v. 435. p. 2581.

Main scientific results

Improvement of full-disk measurements of the Sun longitudinal magnetic fields at the Huairou Observing Station

NAOC, ISTP SB RAS



Comparison of improved SMART magnetograms (a) with data from the SDO/HMI space telescope, which are considered exemplary (b).

The SMA Telescope of the Huairou Observing Station is one of the few instruments in the world capable of receiving full-disk magnetograms.

As a result of joint Russian-Chinese studies of the instrumental characteristics of SMAT, some problems were identified that impede high-precision measurements of weak background magnetic fields of the Sun.

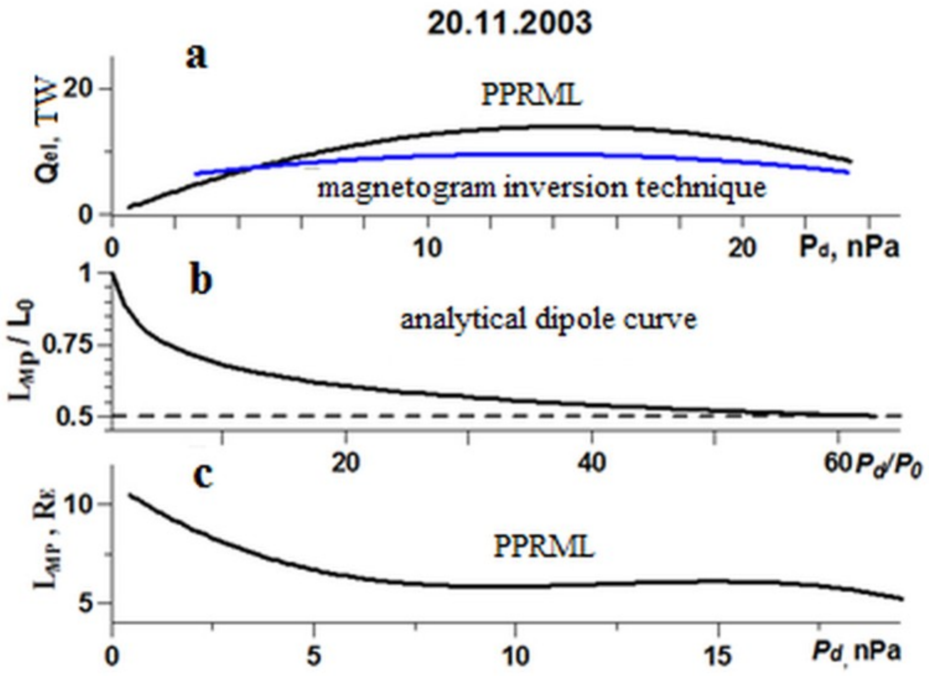
However, methods to improve the quality of SMAT measurements were proposed, resulting in a significant increase in data reliability.

Demidov M.L., Wang X.F., Wang D.G., Deng Y.Y. On the Measurements of Full-Disk Longitudinal Magnetograms at Huairou Solar Observing Station. Solar Phys. 2018. v. 293. A146.

Main scientific results

Saturation of the magnetosphere and the polar cap during superstorms

ISTP SB RAS, NSSC CAS, CALT CAS



Saturation during an increase in the SW dynamic pressure Pd in 20.11.2003 storm: electromagnetic energy flux Qel (a), subsolar magnetopause radius Lmp (b, c)

Using data from more than 110 ground-based geomagnetic observatories and the magnetogram inversion method developed at ISTP SB RAS, new patterns of the magnetosphere saturation process were obtained: stopping the growth of the electromagnetic energy flux through the magnetosphere boundary and the polar cap from the solar wind (SW) with its unusual intensification during superstorms.

It is shown that saturation is caused not only by the growth of the southern component of the interplanetary magnetic field but also by the increase in the SW dynamic pressure. Saturation was explained by the magnetosphere finite compressibility.

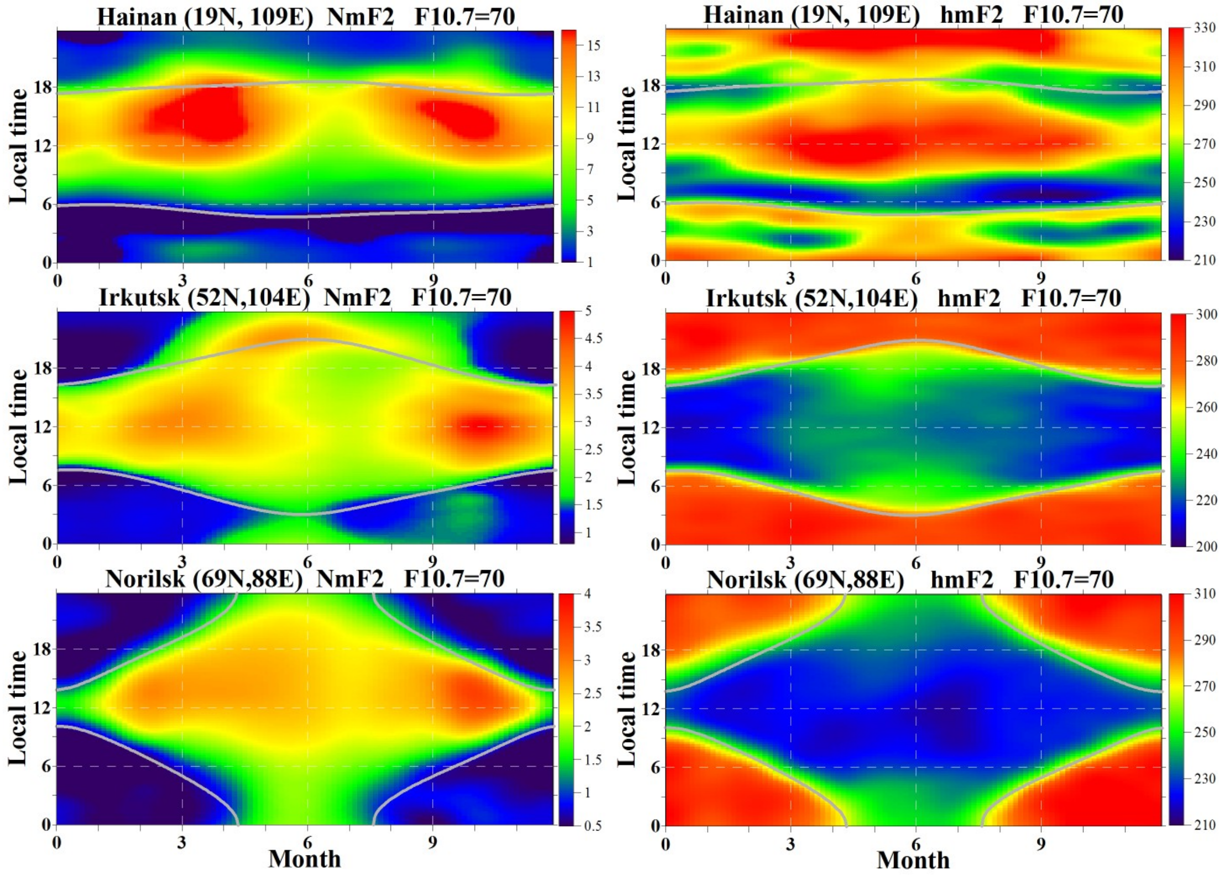
This result was confirmed by global MHD modeling with PPRML Chinese model.

Mishin V.V., Mishin V.M., Karavaev Yu., Han J.P., Wang C. Saturation of the Poynting flux and the finite compressibility of the magnetosphere during superstorms: Results of the magnetogram inversion technique and global PPMLR-MHD model. Geophys. Res. Lett. 2016. v. 43. p. 6734.

Main scientific results

Local empirical models of regular ionospheric variations

ISTP SB RAS, NSSC CAS



Diurnal-seasonal variations in NmF2 [10^5 cm^{-3}] (left) and hmF2 [km] (right) under low solar activity.

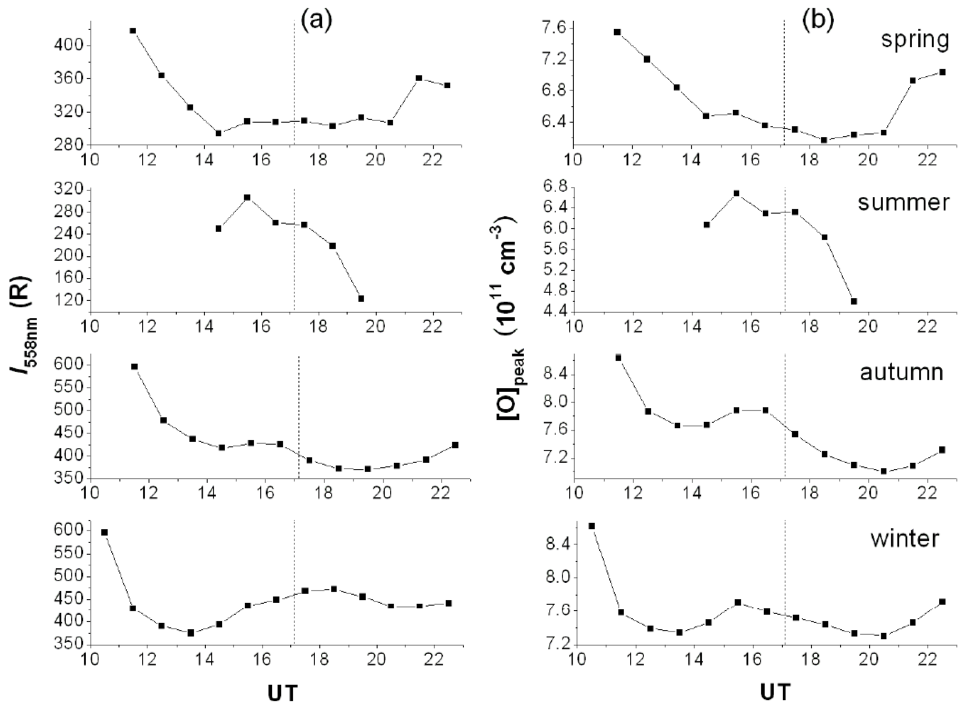
Local empirical models of regular ionospheric variations were created based on long-term ionospheric measurements with vertical sounding ionosondes located in Irkutsk, Norilsk and on Hainan island.

General properties and regional features of the high-, mid- and low latitude ionosphere were identified based on the created models.

Ratovsky K.G., Shi J.K., Oinats A.V., Romanova E.B. Comparative study of high-latitude, mid-latitude and low-latitude ionosphere on basis of local empirical models. Adv. Space Res. 2014. v. 54. N 3. p. 509-516.

The estimate of the peak density of atomic oxygen between 2000 and 2004 at 52ºN

NSSC CAS, ISTP SB RAS



Nocturnal behaviors of the [OI] 557.7 nm nightglow emission intensity (a) and the derived max [O] (b) in four seasons (the dotted line represents midnight in SLT).

A method for deriving the peak density of atomic oxygen in the Mesosphere and Low Thermosphere (MLT) region from atomic oxygen [OI] 557.7 nm nightglow intensity was developed.

Nocturnal and the seasonal variations in the 557.7 nm intensity and in the derived peak density of atomic oxygen were analyzed based on data obtained at the ISTP SB RAS Geophysical observatory in 2000-2004.

The results show:

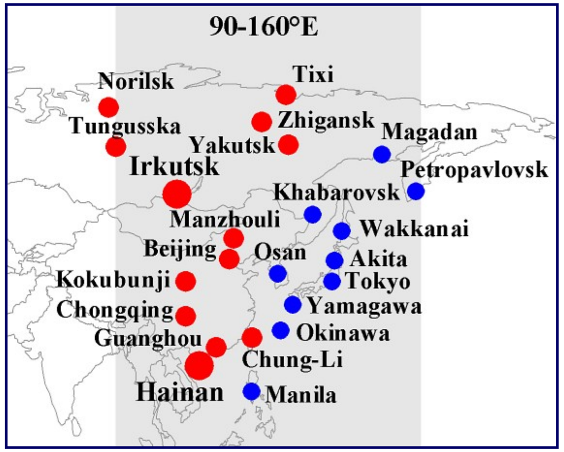
- **nocturnal variations of the 557.7 nm emission intensity change with season;**
- **nocturnal and the seasonal variations of the peak density of atomic oxygen are generally similar to those of 557.7 nm airglow intensity.**

Hong Gao, Jiyao Xu, Mikhalev A.V., Wei Yuan, Medvedeva I.V. The estimate of the peak density of atomic oxygen between 2000 and 2004 at 52ºN. Proceedings of SPIE, 2009. Vol. 7296, 72960M.

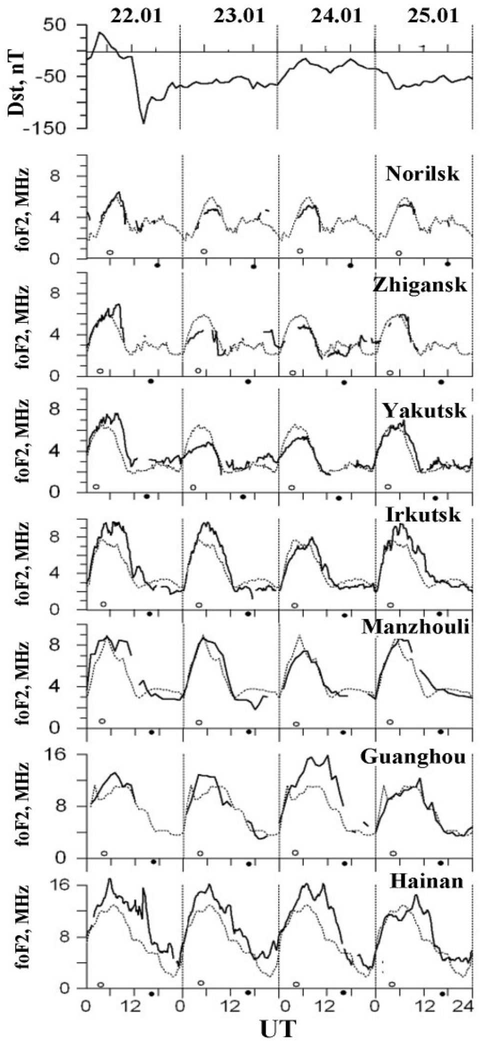
Main scientific results

Ionospheric response to geomagnetic storms at the meridional chains of ionosondes in the East Asian region

ISTP SB RAS, NSSC CAS



Meridional chains of ionosondes in the East Asia.



Ionospheric response to January 22-23, 2004 strong geomagnetic storm at meridional chain of ionosondes.

In 2000-2017, coordinated studies of the ionospheric effects of geomagnetic storms were carried out at the meridional chains of ionosondes located in the East Asian sector (90°-160°E) in Russia and China. Chains in the European and American sectors were also used.

Findings:

- medium-latitude ionosphere shows properties of high-latitude ionosphere during superstorms;
- differences in the East Asian ionospheric response to geomagnetic storms in high and low solar activity;
- longitudinal alternation of positive and negative ionospheric response during the recovery phase of some storms.

Pirog O.M., Polekh N.M., Romanova E.B., Zherebtsov G.A., Shi J.K., Wang X. Study of ionospheric response to magnetic superstorms in the East Asian sector. J. Atmos. and Solar Terr. Phys. 2010. v. 72. N 2-3. p. 164-175.

From meridional chains to IMCP

Observations at the Norilsk and Yakutsk meridional chains of stations

1969 - 1983

Led by
ISTP SB RAS,
SICRA SB RAS

Norilsk meridian **Yakutsk meridian**

Instruments

- magnetovariation station
- all-sky imager
- zenith photometer
- scanning photometer
- ionosonde

International Magnetospheric Study (IMS) 1976-1979

Expeditions

1969 - at the Yakutsk Meridian

1973 - at the Norilsk meridian

1976 - "Siberia-IMS-76", start of synchronous observations at the Yakutsk and Norilsk meridians

1979 - "Siberia-IMS-79"

1982-1983 - "Taimyr-82

Observations at the Norilsk and Yakutsk meridional chains of stations

Basic organization principles

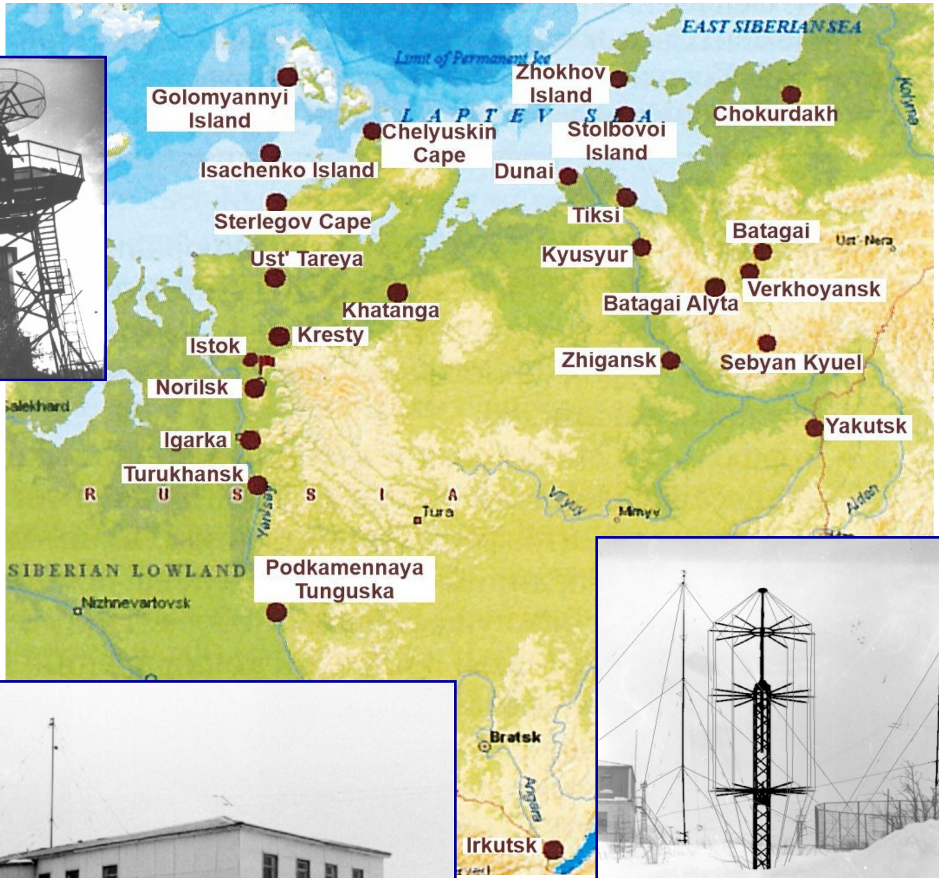
- Positioning stations along the meridian with the least scatter in longitude to minimize errors related to longitudinal effects.

- Two or three meridional chains are required to study longitudinal effects and monitor the geophysical conditions.

- Equipping the chain stations with geophysical instruments of different types (magnetometers, ionosondes, photometers) to not only record processes in different geospheres, but also to study their interaction and identify physical mechanisms.

Norilsk meridian

Yakutsk meridian



Norilsk complex magneto-ionospheric station

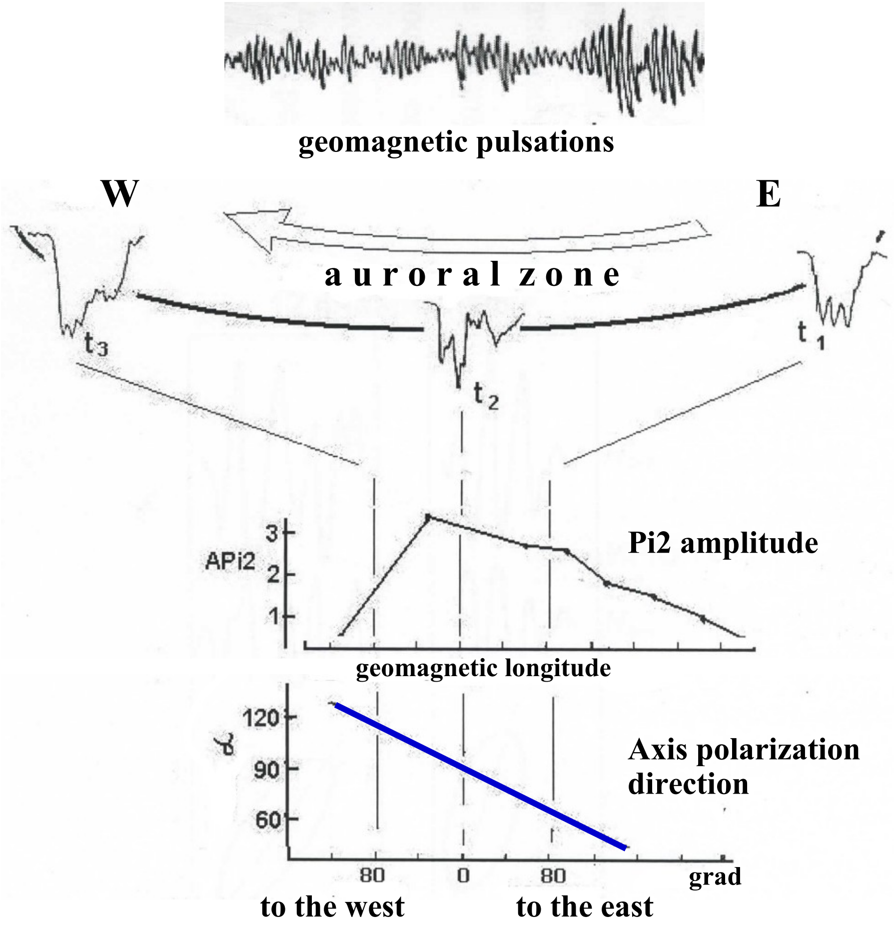
Observations at the Norilsk and Yakutsk meridional chains of stations

Substorm in geomagnetic pulsations

Longitudinal and latitudinal dimensions of the sources of Pi2 and Pi1B pulsations were determined, their relation to auroras was shown for the first time.

Amplitude and spectral composition of the mid-latitude Pi2 pulsations were shown to be controlled by the state of ionospheric F2 layer.

A method to determine the longitude of substorm in the auroral using the parameters of mid-latitude Pi2 pulsations was developed.



Scheme of substorm development in the auroral zone and in middle latitudes

Rakhmatullin R.A. Thesis for the degree of Doctor of Science (Physics and Mathematics). Irkutsk. 2010.

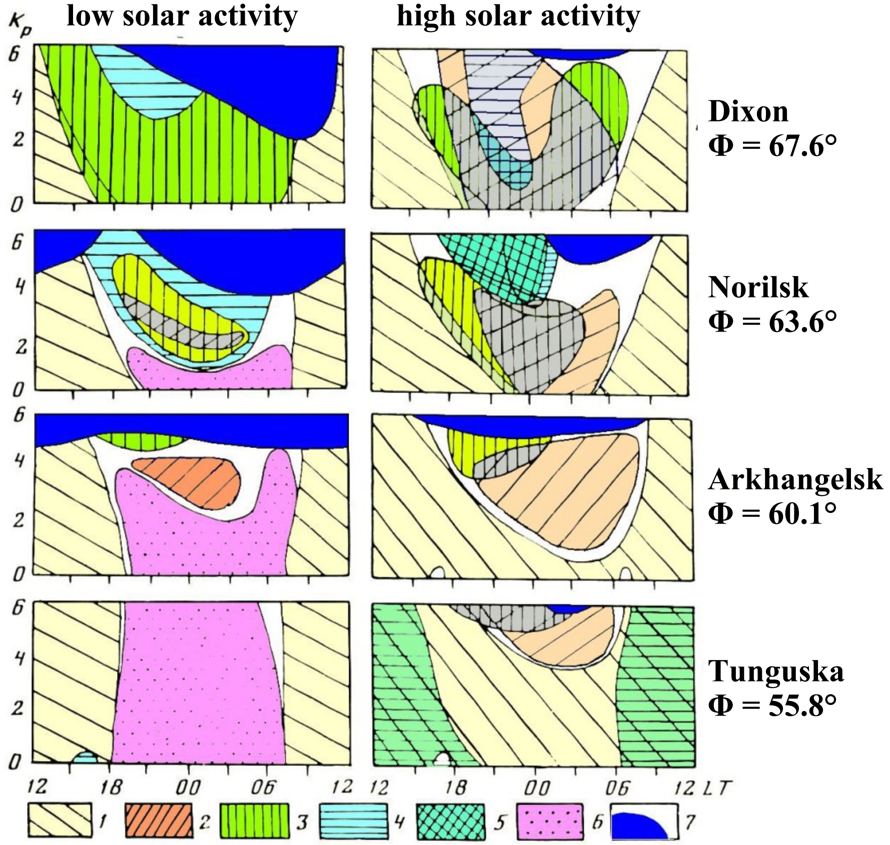
Observations at the Norilsk and Yakutsk meridional chains of stations

Model of ionospheric substorm

An equation describing the position of the Main Ionospheric Through (MIT) under different magnetic activity was obtained.

Schemes of ionospheric substorm development north of the MIT in LT-Kp coordinates at different latitudes were constructed, and the effect of solar activity was revealed.

A regional model of critical frequencies of the E- and F-regions for the Norilsk meridian was developed.

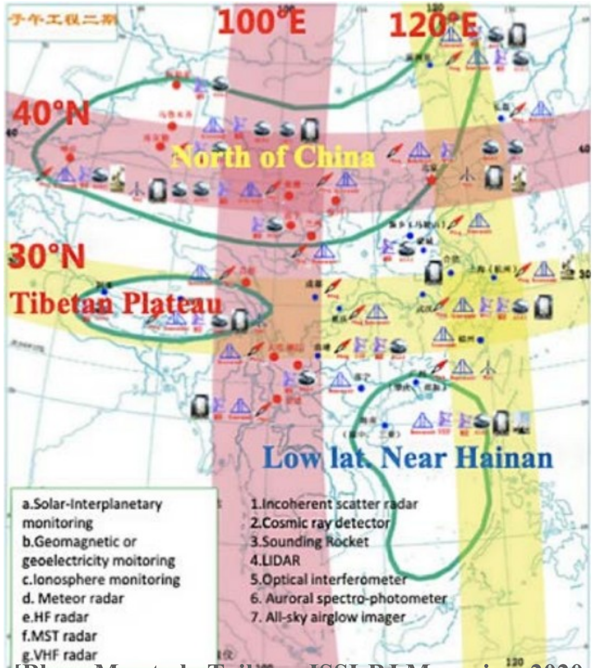


Schemes of the development of ionospheric substorm under low and high solar activity.

Zherebtsov G.A., Pirog O.M., Razuvaev O.I. Structure and dynamics of the high-latitude ionosphere. Studies on geomagnetism, aeronomy, and the physics of the Sun. 1986. V. 76. P. 165-177.

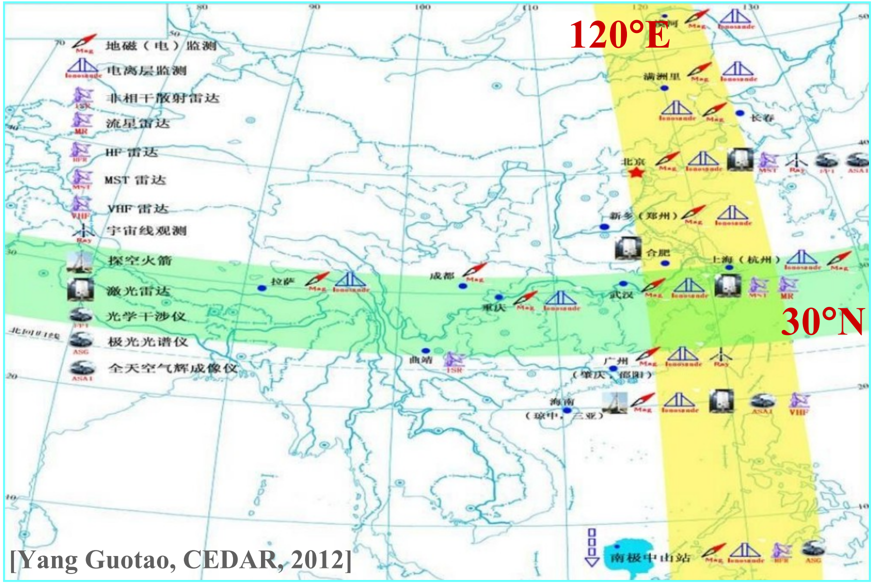
Chinese Meridian Project (CMP)

CMP-phase II



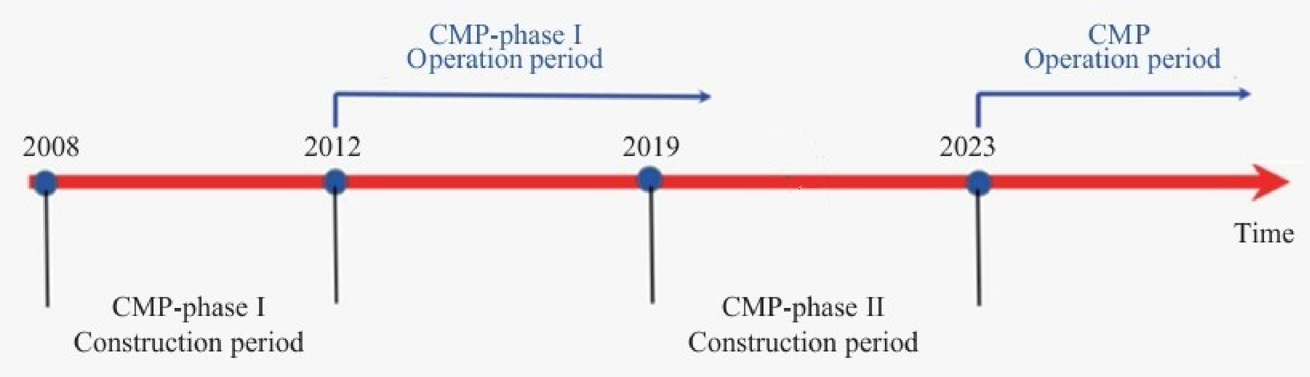
[Blanc M., et al., Taikong ISSI-BJ Magazine, 2020, N19]

CMP-phase I



[Yang Guotao, CEDAR, 2012]

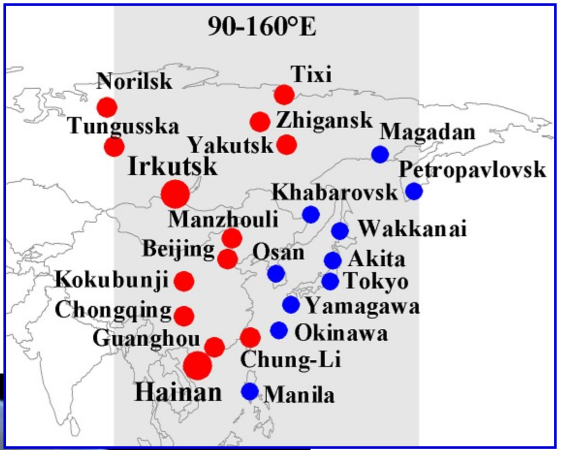
In the early 1990s, Prof. Wei Fengsi proposed, for the first time, the concept of a national meridian circle project.
[http://imcp.ac.cn/en/about/planning/]



[Wang Chi, et al., Chin. J. Space Sci., 2022, 42(4)]

Chinese Meridian Project (CMP) Phase I

Joint studies within the framework of the Chinese-Russian Joint Research Center since 2005.

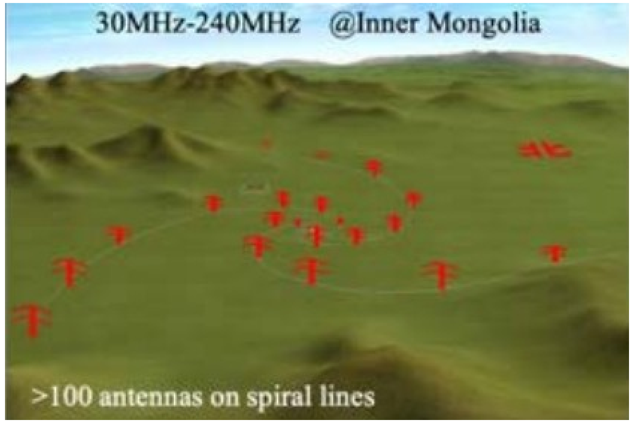


Zherebtsov G.A., Shi Jiankui, Perevalova N.P., Polekh N.M., Zolotukhina N.A.
Ionospheric disturbances in East-Asian region. Moskow. 2021.

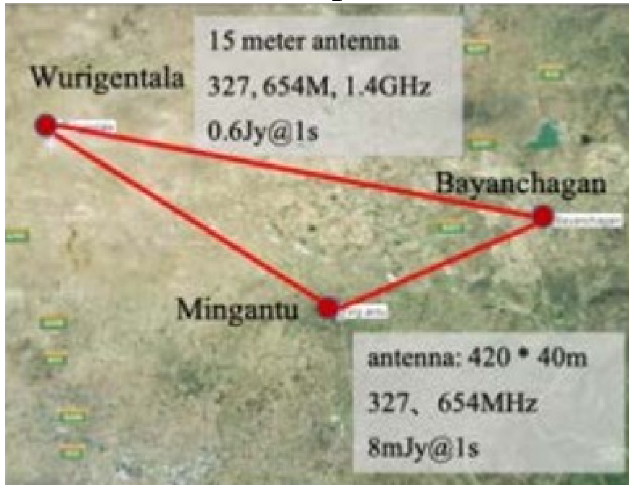
Chinese Meridian Project (CMP) Phase II

31 stations
nearly 300 instruments
along 100°E and 120°E,
and 30°N and 40°N

Radio Heliograph



3-station IPS telescope



3-station IS radar

Some innovative instruments

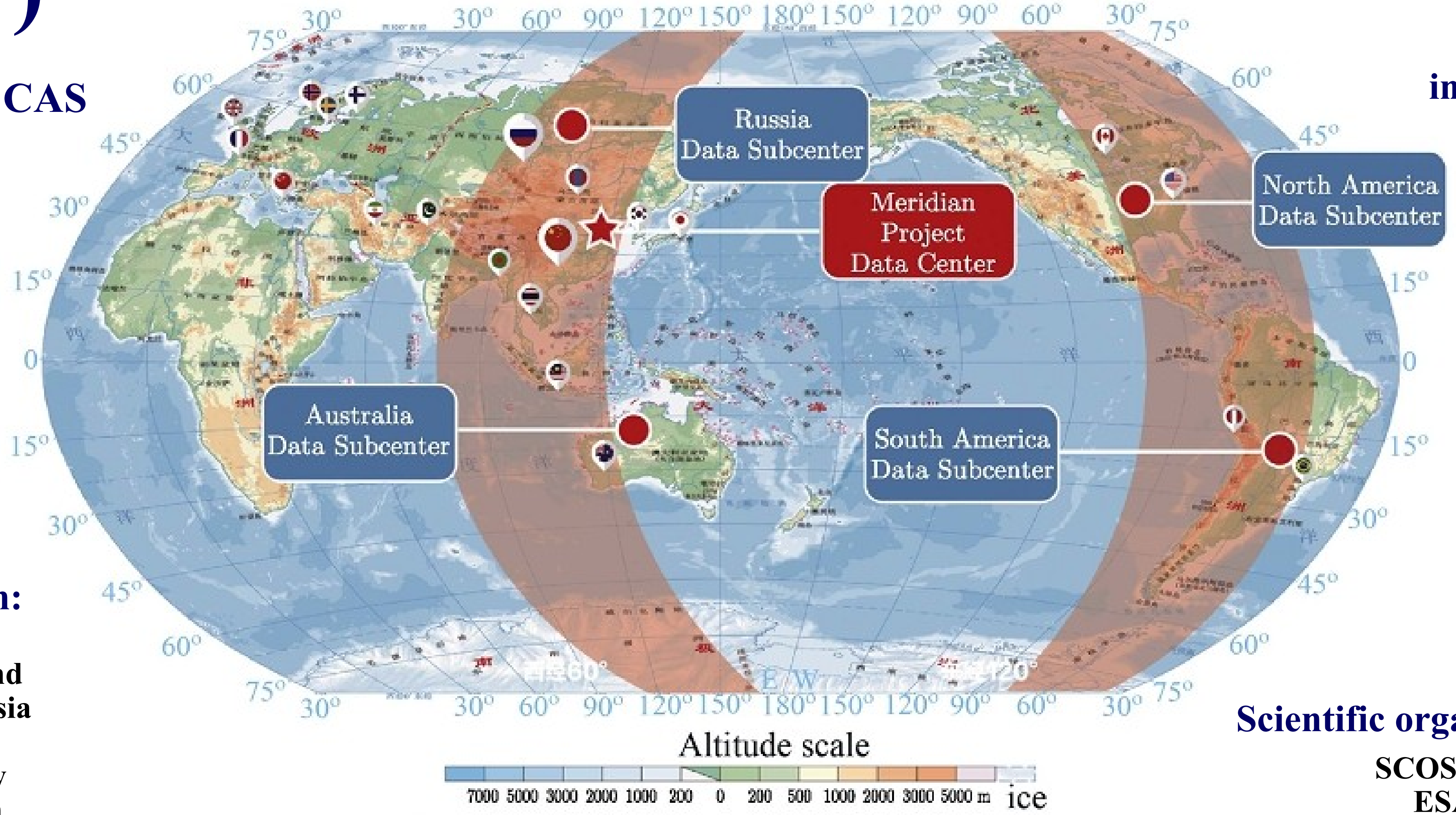
[Blanc M., et al., Taikong ISSI-BJ Magazine, 2020, N19]

[https://www.meridianproject.ac.cn/]

International Meridian Circle Program (IMCP)

Led by NSSC CAS

Over 1000 instruments



[Liu et al., Chin. J. Spase Sci., 2020, 40(5)]

Participants from:

China, Russia, Brazil, Australia, Canada, USA, UK, Japan, Thailand, Indonesia, France, Norway, Sweden, Mexico

Scientific organizations:

SCOSTEP
ESA
EISCAT
SuperDARN

National Heliogeophysical Complex of the Russian Academy of Sciences (NHC RAS)

Led by ISTP SB RAS

Articles on NHC project:
Solar-Terrestrial Physics. 2020.
Vol. 6. Iss. 2.

https://doi.org/10.12737/2500-0535-2020-6-2

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

ПОСТАНОВЛЕНИЕ

от 26 декабря 2014 г. № 1504

МОСКВА

Об осуществлении бюджетных инвестиций в проектирование и строительство объектов капитального строительства "Укрупненный инвестиционный проект "Национальный гелиогеофизический комплекс Российской академии наук", 1 этап"

Правительство Российской Федерации **п о с т а н о в л я е т :**

1. Осуществить в 2014 - 2017 годах бюджетные инвестиции за счет бюджетных ассигнований федерального бюджета в проектирование и строительство объектов капитального строительства "Укрупненный инвестиционный проект "Национальный гелиогеофизический комплекс Российской академии наук", 1 этап" согласно приложению.

2. Установить, что государственным заказчиком в отношении указанных в пункте 1 настоящего постановления объектов является Федеральное агентство научных организаций, застройщиком (заказчиком) - федеральное государственное бюджетное учреждение науки Институт солнечно-земной физики Сибирского отделения Российской академии наук.

3. Федеральному агентству научных организаций - главному распорядителю средств федерального бюджета, Министерству образования и науки Российской Федерации, Министерству экономического развития Российской Федерации и Министерству финансов Российской Федерации обеспечить в 2014 - 2017 годах финансирование за счет бюджетных ассигнований федерального бюджета работ по проектированию и строительству объектов, указанных в пункте 1 настоящего постановления, с распределением в соответствии с приложением к настоящему постановлению.

Председатель Правительства
Российской Федерации — Д.Медведев

Scientific Advisor of the Project
Academician Gely A. Zherebtsov

The project «National Heliogeophysical Complex of RAS» includes interrelated sub-projects (instruments):

In the field of solar physics:

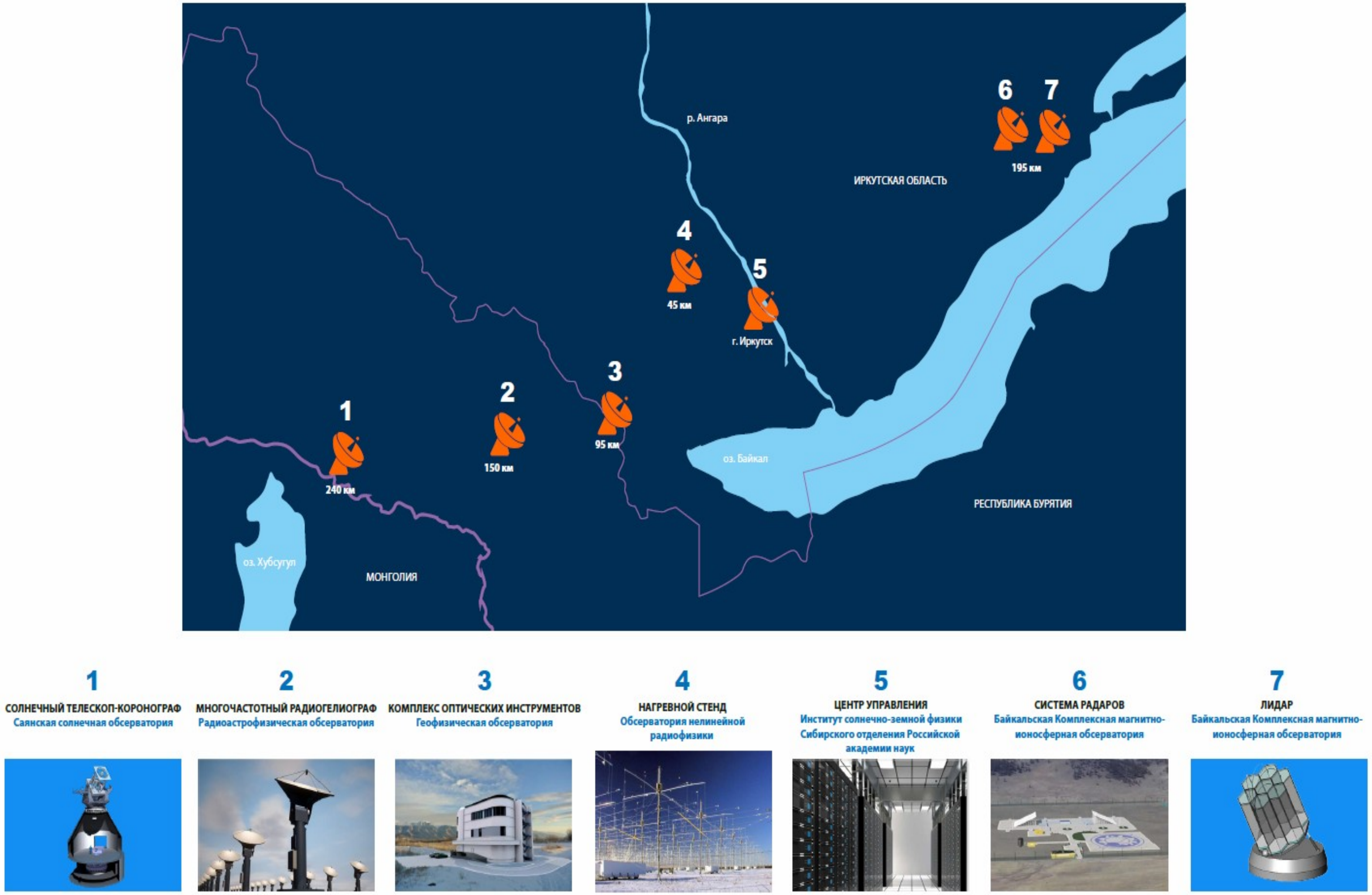
Large Solar Telescope-Coronagraph;
Multi-wave Radioheliograph;

In the field of near-Earth space physics:

IS-MST radar;
Arctic network of coherent HF radars;
Lidar-Optical Complex;
HF Ionospheric heating facility.

Data from the created instruments of the Complex will be integrated with the infrastructure of the Shared Equipment Center in the Control and Data Processing Center.

National Heliogeophysical Complex RAS



NHC instruments in Eastern Siberia.

Instruments

Large Solar Telescope-Coronagraph

Multiwave Radioheliograph

Optical Complex

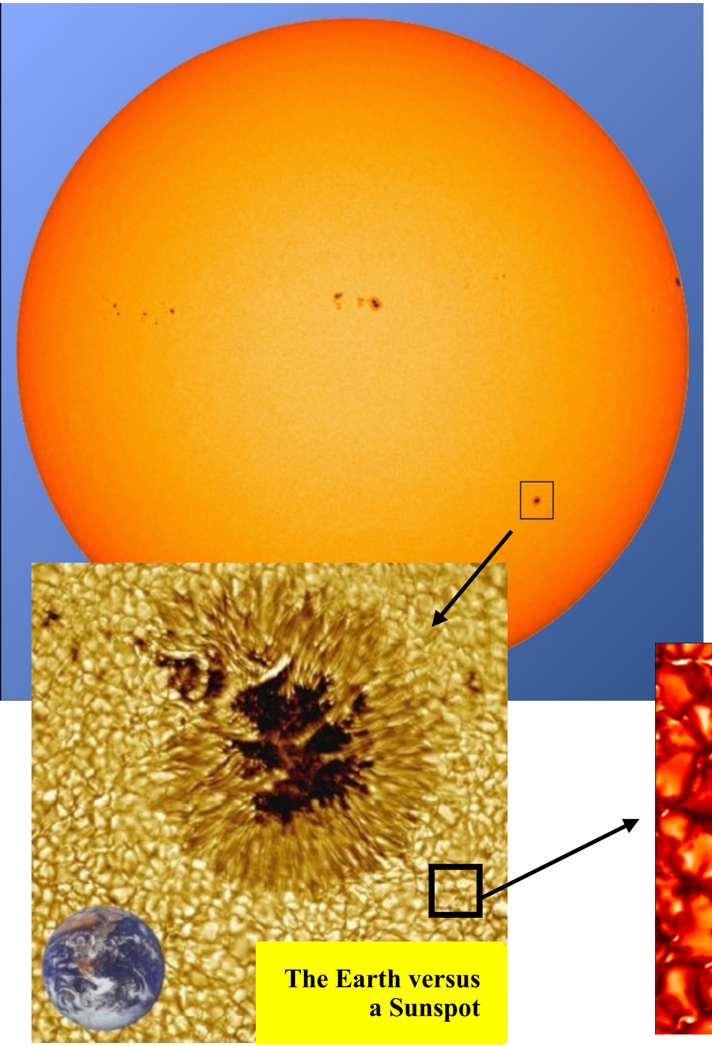
Heating facility

Data Processing Center

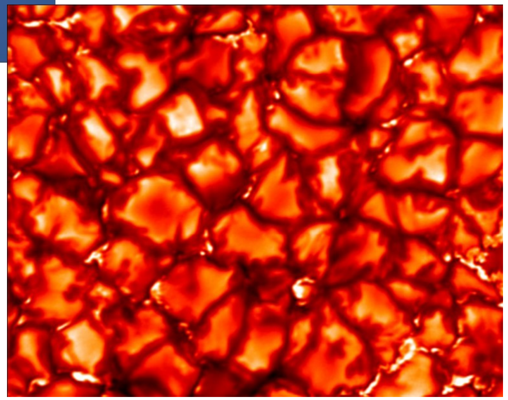
Radiophysical Complex for Atmospheric and Ionospheric Research

Lidar

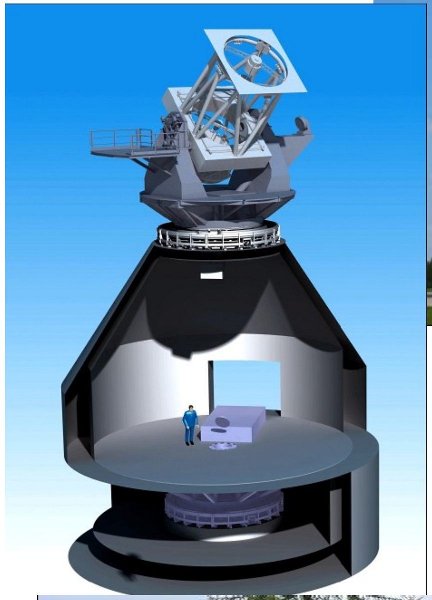
Large Solar Telescope-Coronagraph (LST-3) with a mirror 3 m in diameter

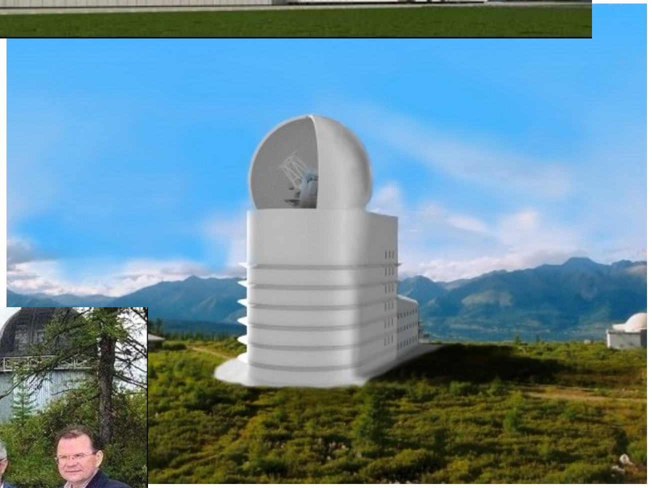


Effects of increasing
the telescope resolution



General view
of LST-3



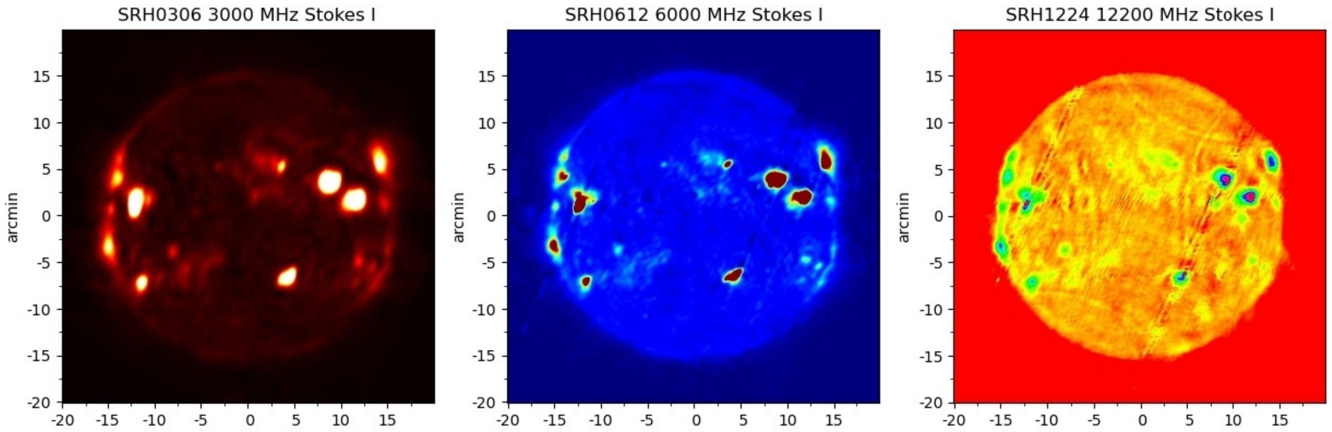


General view of LST-3
buildings

Groundbreaking ceremony
of the LST-3. August 5, 2023

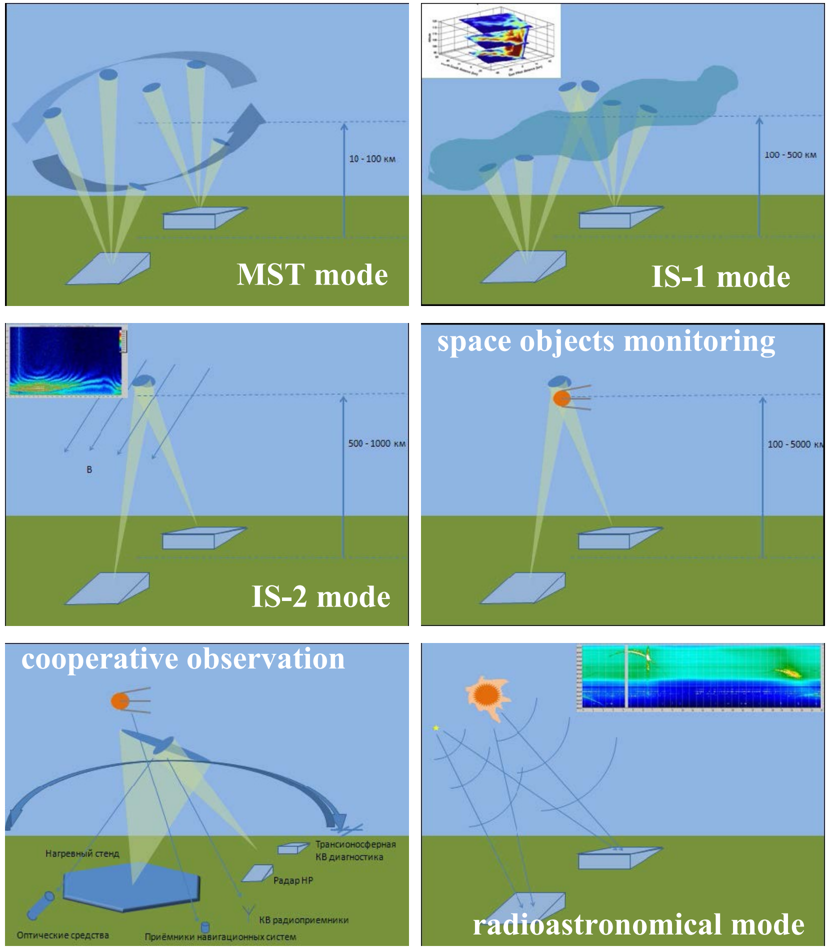
NHC RAS

Multiwave Radioheliograph

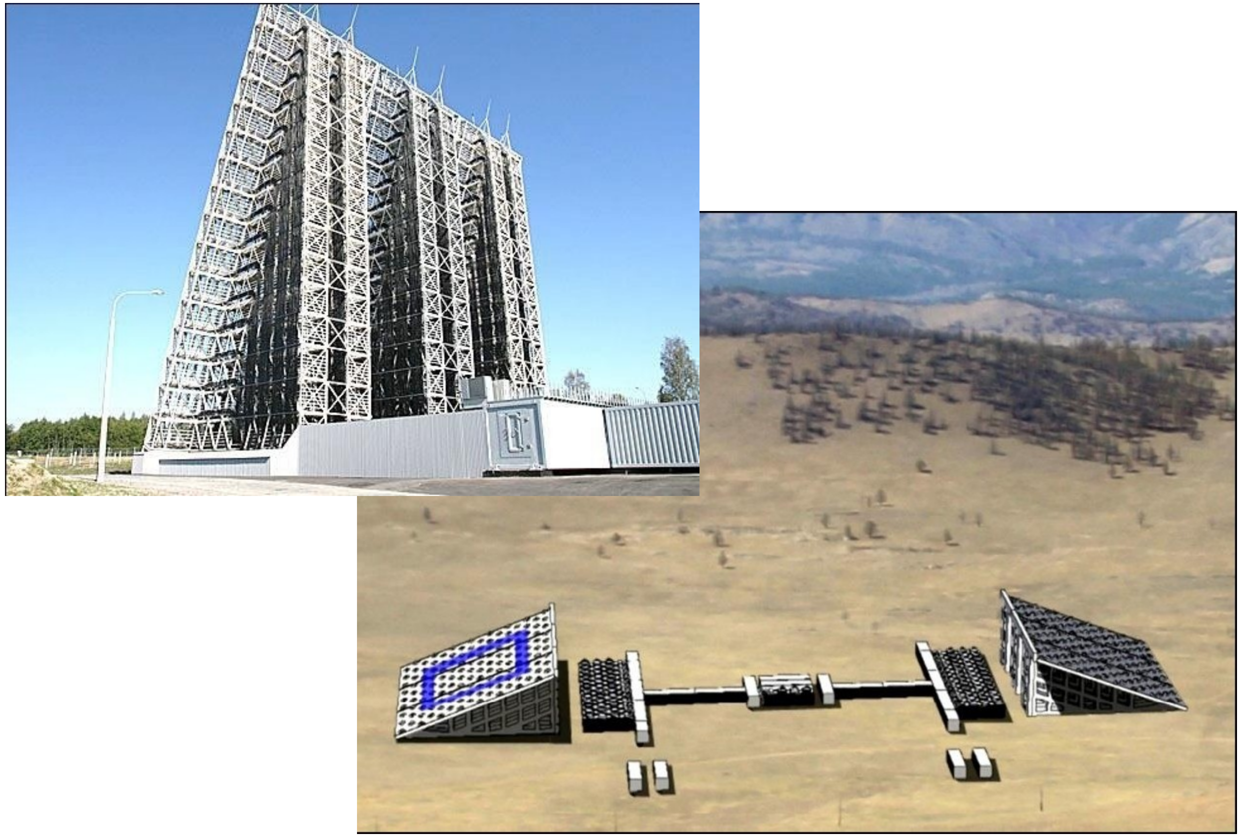


Solar images at 3.0, 6.0, 12.2 GHz obtained by Ragioheliograph on September 16, 2023

Radiophysical Complex (RPhC)

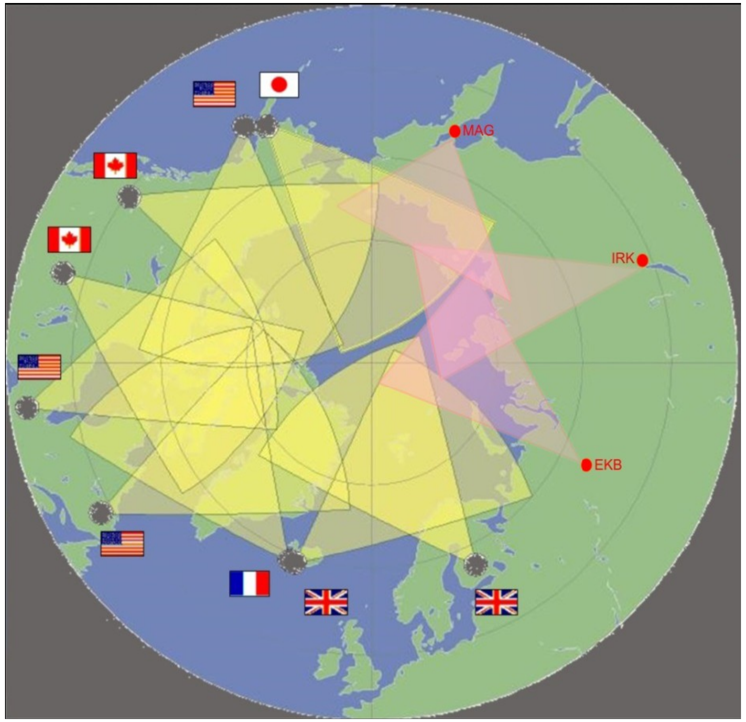


Operating modes of IS-MST radar

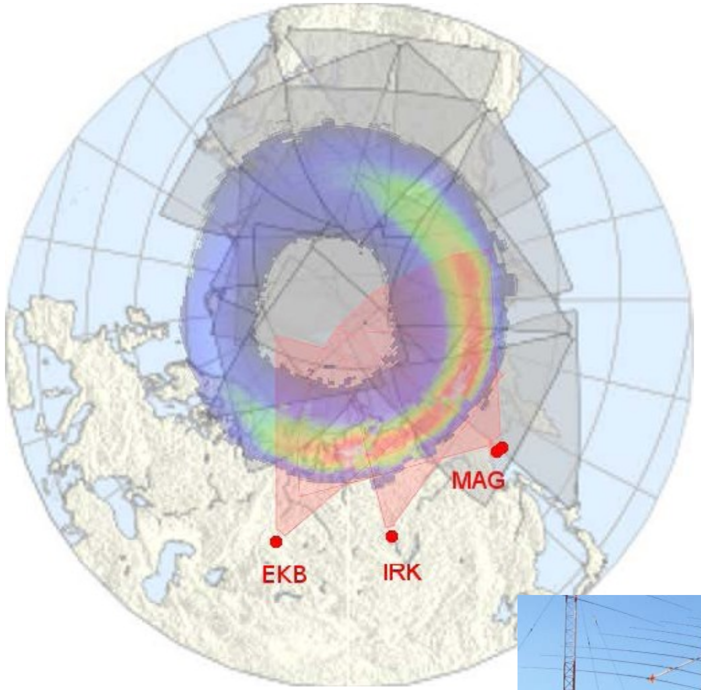


General view of the IS-MST radar near lake Baikal

Network of Coherent Ionospheric Radars (SECIRA)



Position of SuperDARN radars
and their fields of view



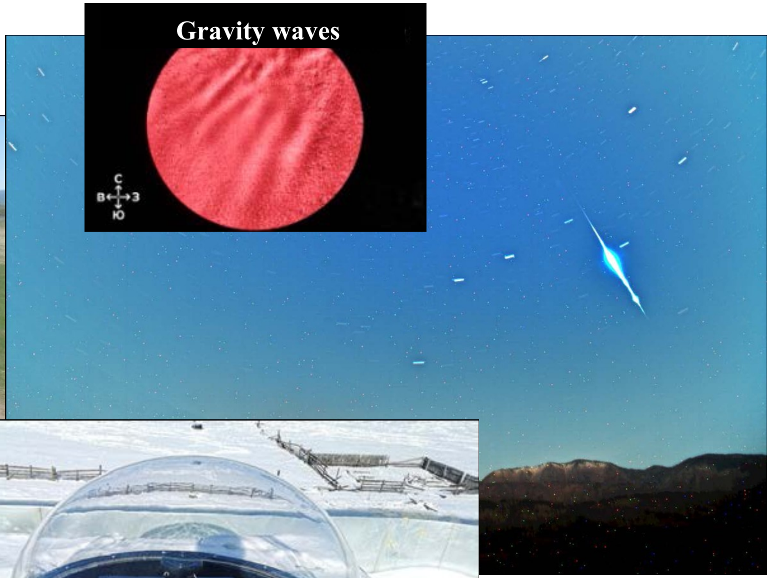
Monitoring of the
ionosphere in Arctic

EKB radar

Coherent radars
of
ISTP SB RAS

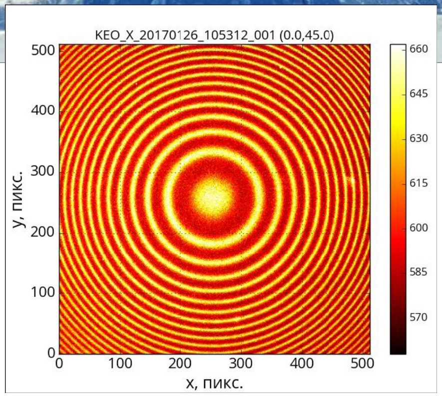
MAG radar

Lidar Optical Complex (LOC)



Complex of passive optical instruments

Mesostratospheric lidar



Monitoring of atmospheric processes and phenomena

Operating and Data Processing Center

Irkutsk, in-service date 2024

Main goals

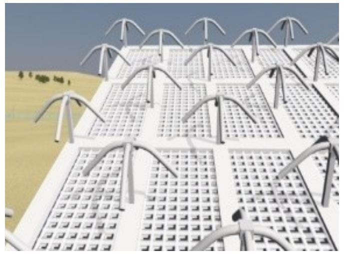
-Shared Equipment Center: carrying out experiments to the benefits of scientific organizations
-Preparing data products for end users (customers)
-Space weather conditions: warning s and alarms for consumers

-Online control of working modes of the instruments of the National Heliogeophysical Complex
-Collecting data from NHC instruments
-Data processing
-Data storage

Radioheliograph

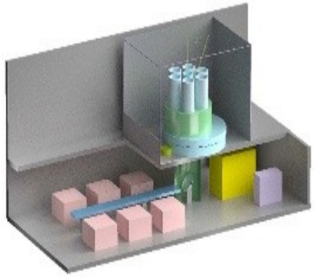
Large Solar Telescope-Coronagraph

Radar system



Heating Stand

MS Lidar



Optical Instruments

Data Center

I очередь строительства «Центр Управления»

Вид с Юго-Восточной стороны

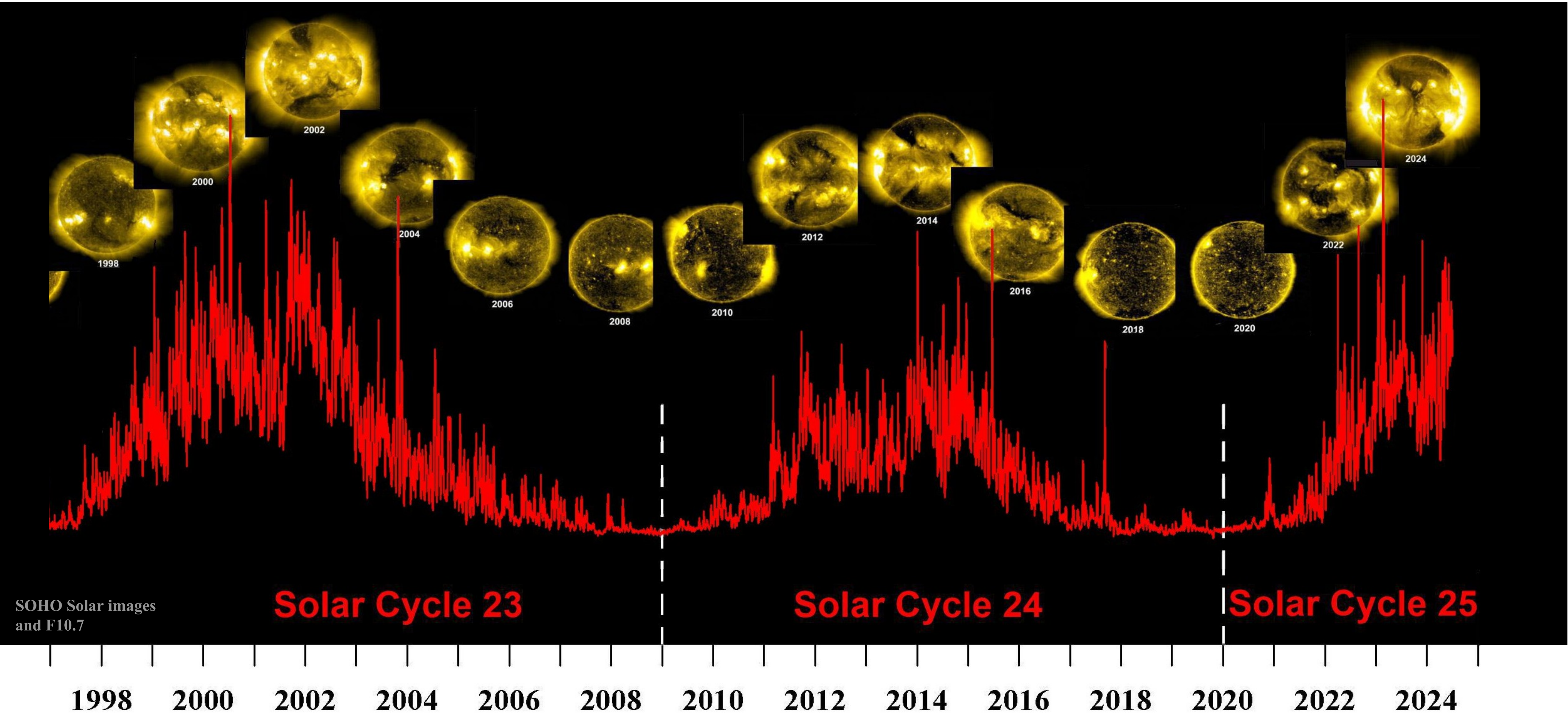
National Heliogeophysical Complex RAS

A qualitatively new level of fundamental and applied research in solar-terrestrial physics

Participation in international programs including IMCP and China-Russia Joint Research Center

Chinese-Russian Joint Research Center

2 Solar Cycles together



THE 15TH RUSSIAN-CHINESE WORKSHOP ON SPACE WEATHER

September 9–13, 2024, Irkutsk, Russia

Thank You!

NSSC