Project of Reconstruction of RAS, Havana in Joint Network of the Services of SUN and SPACE WEATHER

Bogod V.M., Storozhenko A.A., Tlatov A.G., Lesovoi S.G. (Russian side)

Omar Pons, Marta Uratsuka, Ramses Zaldívar, Pablo Sierra (Cuban side)

УЧАСТНИКИ СОВЕТСКИХ ЭКСПЕДИЦИЙ 1969-1991 гг.

Богод В.М.
Венгер
Гольнев В.Я.
Дравских З.В.
Евграфов Н.С.
Ипатов А.В.
Кайдановский М.Н.
Коновалов Ю.Н.
Коркин Э.Н.
Лебедев
Перваков А.А.
Смоленцев С.

Борисевич П
Гельфрейх Г.Б.
Госачинский И.В.
Дравских А.Ф.
Желенков С.
Ильин Г.Н.
Кокорин Ю
Коржавин А.Н.
Дмитриев В.М.
Нагнибеда В.Н.
Петерова Н.Г.
Юровский В.Ф.

BACKGROUND HISTORY

- 1969 September 11, - The observatios the solar eclipse by a Soviet expedition.
- 1969 - Creation of the Havana radio astronomy station, with support by the Castro government, by the Pulkovo observatory (GAO), by the Special astrophysical observatory (SAO).
- 1969 - Start of the regular observations of the Sun with an accuracy of measuring the total radio emission flux up to 2%.
- 2006 - Stopping the regular observations.

- 2018 - 2019 the Russian Foundation of Basic Researches (№18-52-34004) and Cuban Foundation CITMA announced joint grants and started the joint activities to renovate the Cuban station.

The Havanian RAS opening in the IGA.

Report by A. Jimenez (**a member of the government)**
on the prospects of astronomy in Cuba

About our collaboration during 2019.

- 2019 - Two expeditions of Russian scientists to the IGA were organized.

Aims - To determinate the actual state of the station in Havana. The evaluation of oppornunity of the polygons in Kokavalle and Picadura for future work.

- 2019 - one expedition of IGA staff visited to Russia (SAO) and MAS.

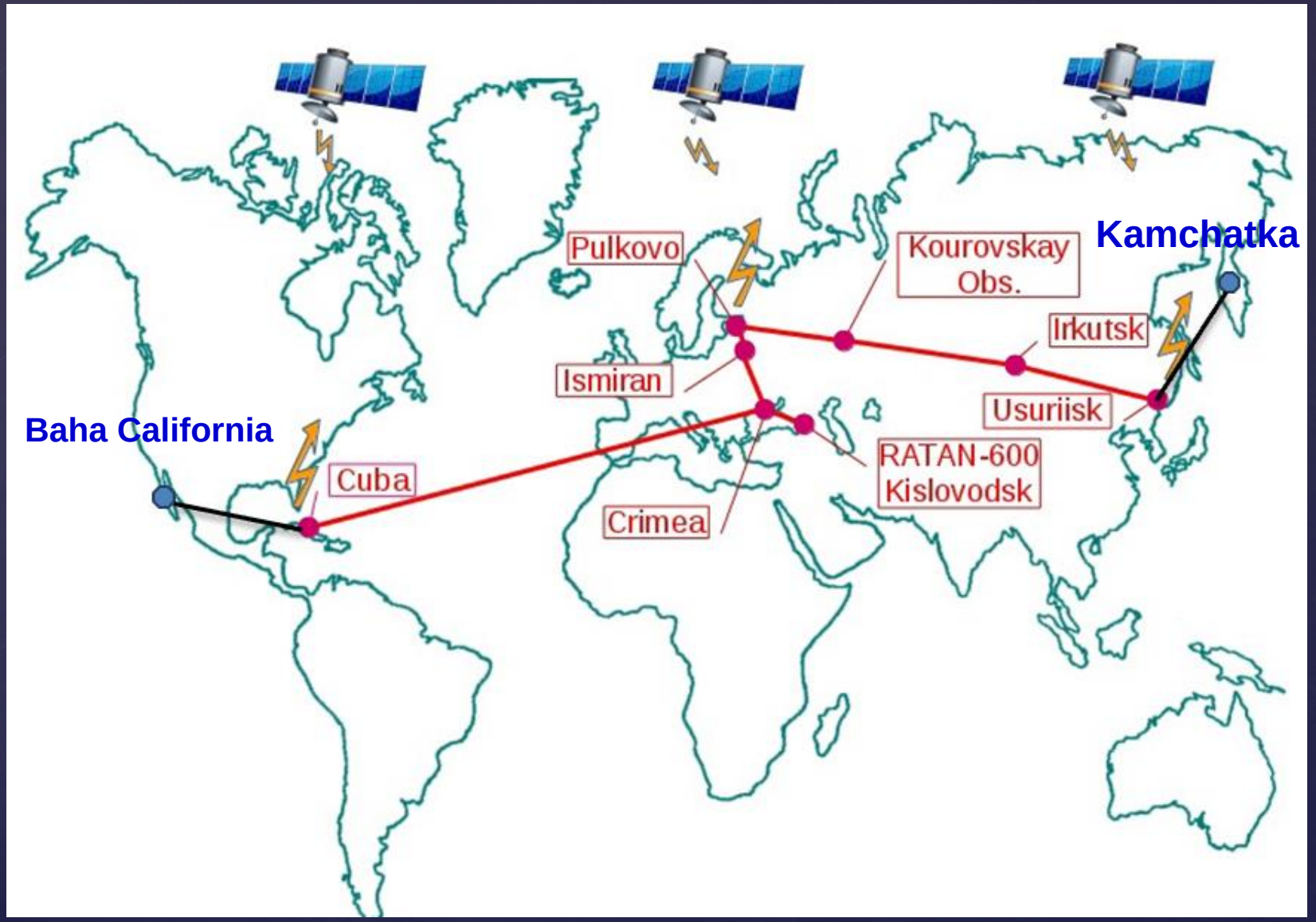
Aims – The acquainting with major radio telescopes in RUSSIA, as well as methods of observations on RATAN-600 and other instruments at the MAS GAO station.

- 2018-2019 – The development of conception of new patrol stations for services the Sun and Space Weather, Development of technical and methodic questions. Publication of the papers and reports on the conferences.

The main aims of the project.

1. To create a network of solar patrol stations (SPS) located throughout the length of Russia and Cuba to provide continuous monitoring of Solar activity.
2. To develop the conception of fully automated (SPS).
3. The infrastructure of the SPS should provide the automated monitoring, calibration and data collection, transmission and reception of the data from each patrol stations, control and management of all processes inside the station, such as monitoring of all technical parameters, temperature, humidity, dust, video monitoring of the station's operation both inside and outside, security alarm and vandal-proof notification.
4. The network should consists of about 10 SPS, which situated along longitudinal full day coverage with location in Kamchatka, Ussuriysk, Irkutsk, the Urals, Kislovodsk, Crimea, and Cuba.

POSSIBLE LONG-RANGE PLACEMENT OF SPS

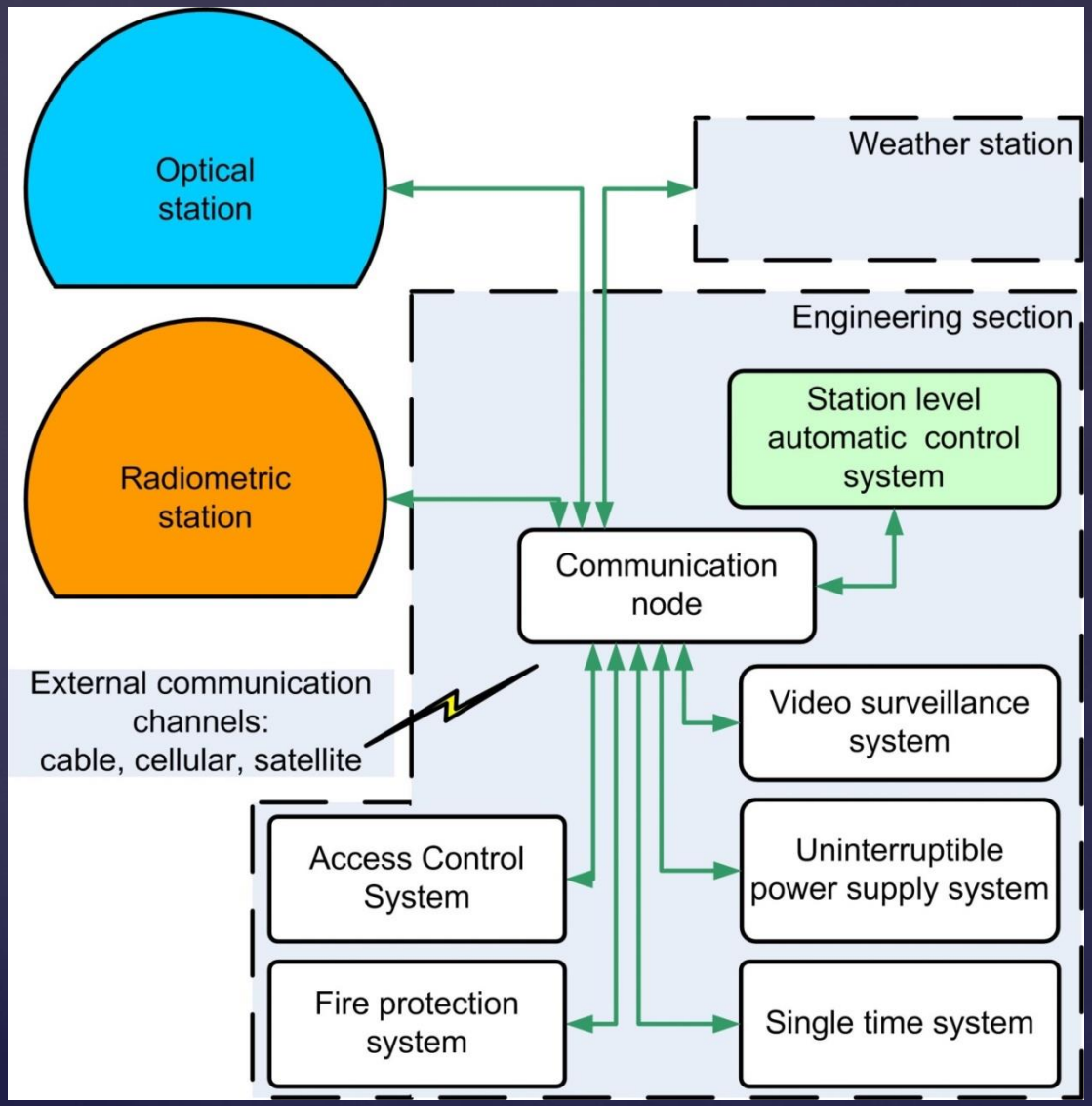


POSSIBLE LONG-RANGE PLACEMENT OF SPS (CALCULATIONS)

Location of the Sun Service patrol station	Longitude L	Time zone P	Duration of obs. D
Kamchatka	+160 dg	+11(-3,+8)	8
The Ussuri astrophysical Observatory of Feb RAS	+132 dg	+9(13,5)	8
Irkutsk, ISTP	+104,8 dg	+7(10,2)	8-10
Kourovka Observatory of the Ural Federal University	+59,5 dg	+4(9,0)	8-10
Kislovodsk Mountain Observatory of the Pulkovo Observatory	+42,3 dg	+3(8,-2)	8-10
IZMIRAN, Troitsk	+37,3 dg	+2(7,-3)	8-10
Crimean astrophysical observatory	+34 dg		8-10
Kaliningrad Observatory of IZMIRAN	+20.4 dg		
The Tenerife Observatory of Moscow state University	-16.3 dg		
Cuba, Havana	-82.5 dg	-5(0,-10)	8-10
Mexico, Baja California	-110 dg	-8(-3,+1)	8-10

Δ(Lmax-Lmin)+D=19+8=·27·hours·the·total·time·overlap·exceeds·the·daily·interval·with·account·Kamchatka·and·Mexico¶

INFRASTRUCTURE OF THE SPS.



LIST OF EQUIPMENT

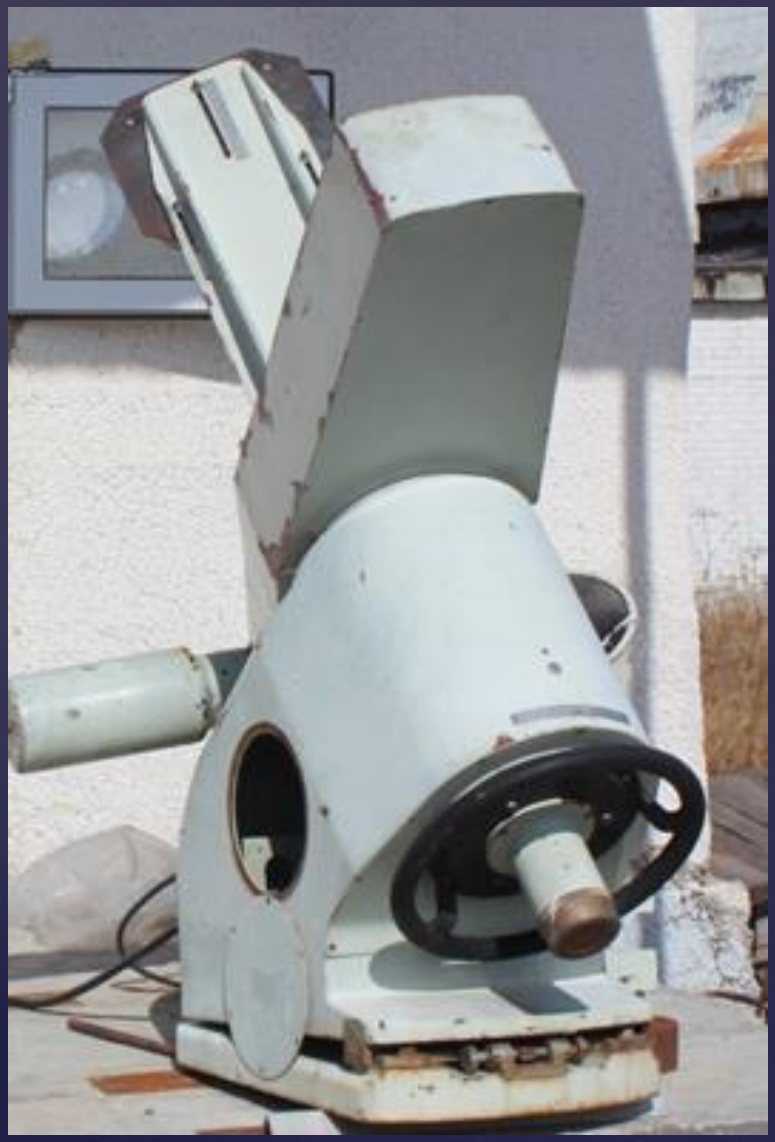
The radiospectrograph CM-band for the estimation of coronal magnetic fields

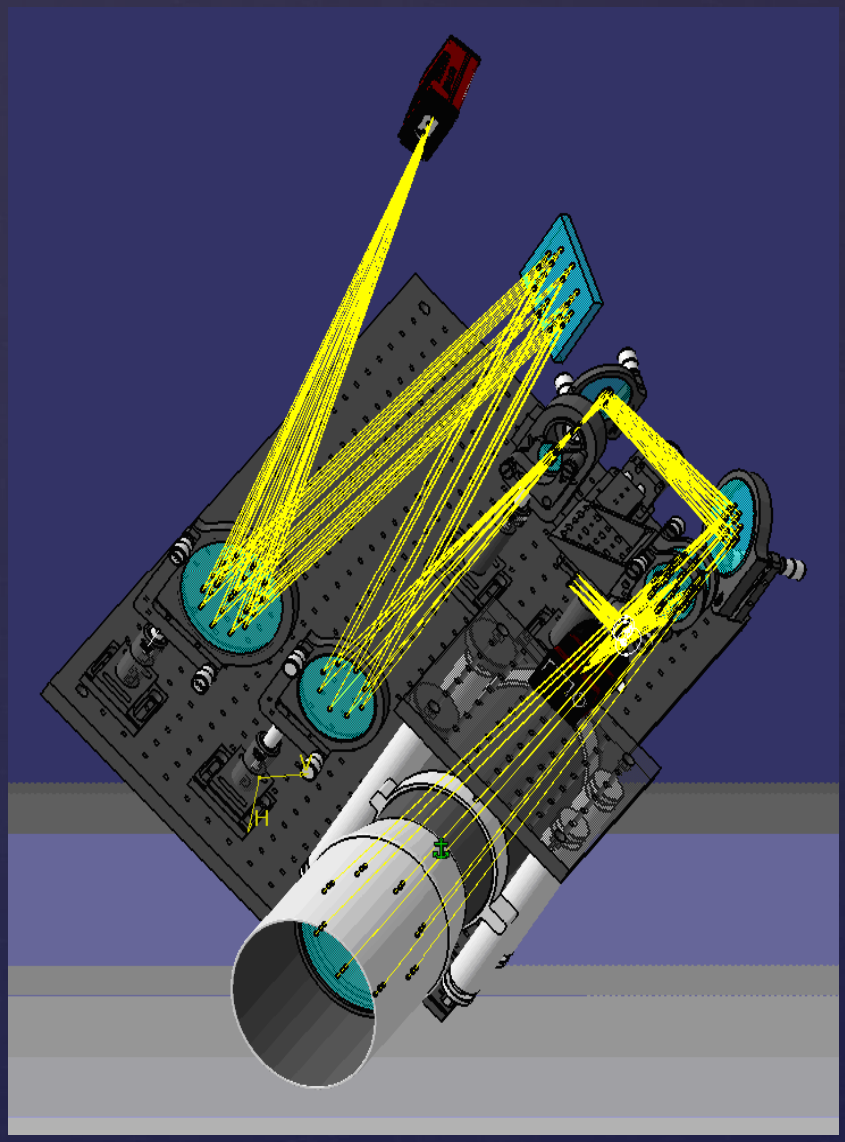
Radiometer of 10.7 cm to duplicate the Wolf number service.

Radio spectrometer MV band for NS and CME estimation.

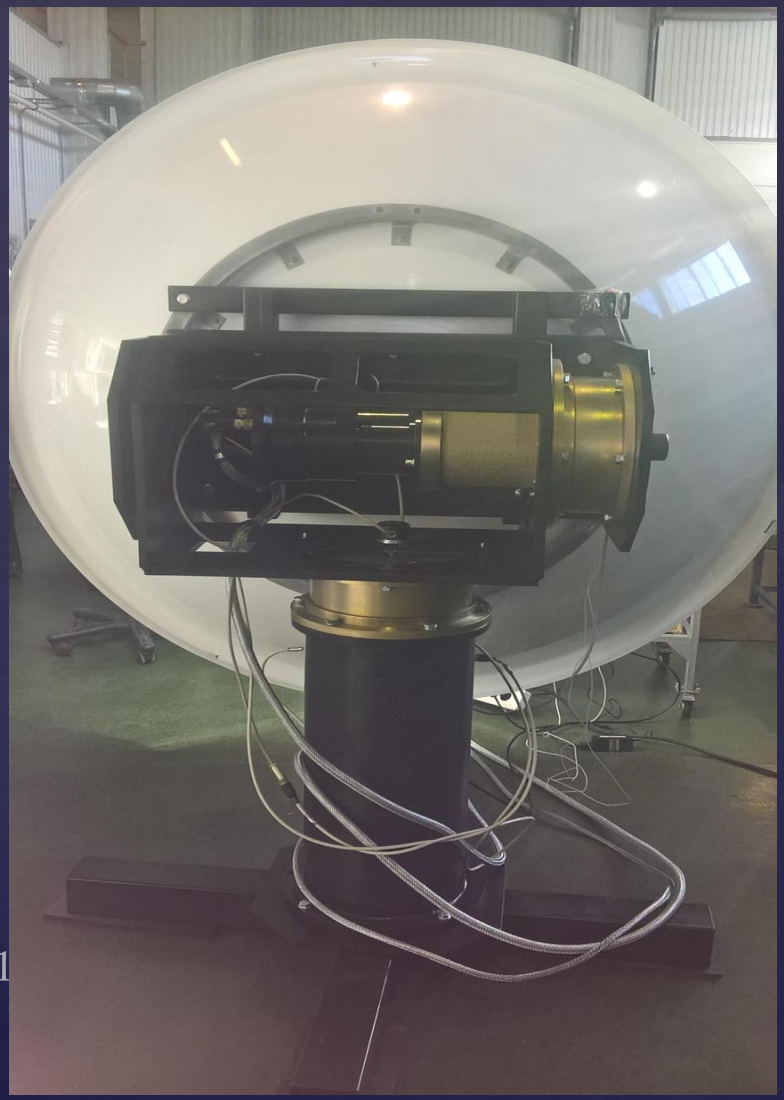
Optical telescope SPOT for observing activity in the lines CA IIK, H-alpha, He10830, sun disk Magnetograms, CME and hard radiation.

SOLAR PATROL OPTICAL TELESCOPE (SPOT)





PARAMETERS OF THE PROPOSED SPECTROPOLARIMETER



1) Ranges 5-15 cm
(6 GHz-2 GHz)

Spectrometer
for 3 frequency points:
6 GHz, 2.8 GHz, 1.5 GHz

2) Ranges 70-500 MHz

Spectrometer with:

- frequency resolution: 1 MHz;
- temporal resolution: 0.5 s;
- number of frequency channels: 430;
- recording of Stokes *I* and *V*

THE MAIN PHYSICAL OBJECTIVES OF THE PROJECT

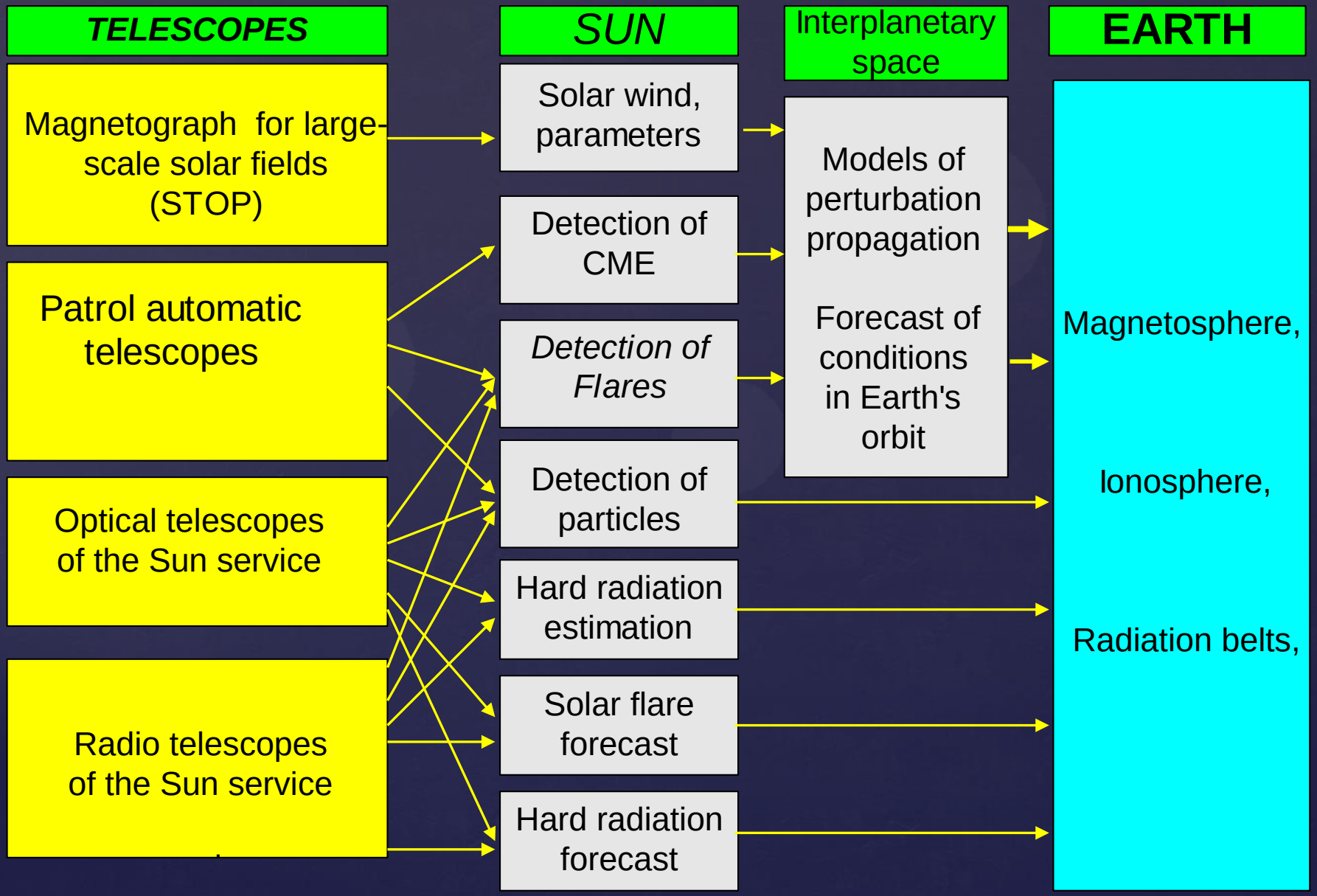
The network of **SPS** in automatic mode give us the next:

1. Real-time information about solar activity in continuous mode,
2. Creating on-line models for analysis of observational data,
3. Long-term homogeneous series of observations,
4. Development of an operational forecast of space weather state.

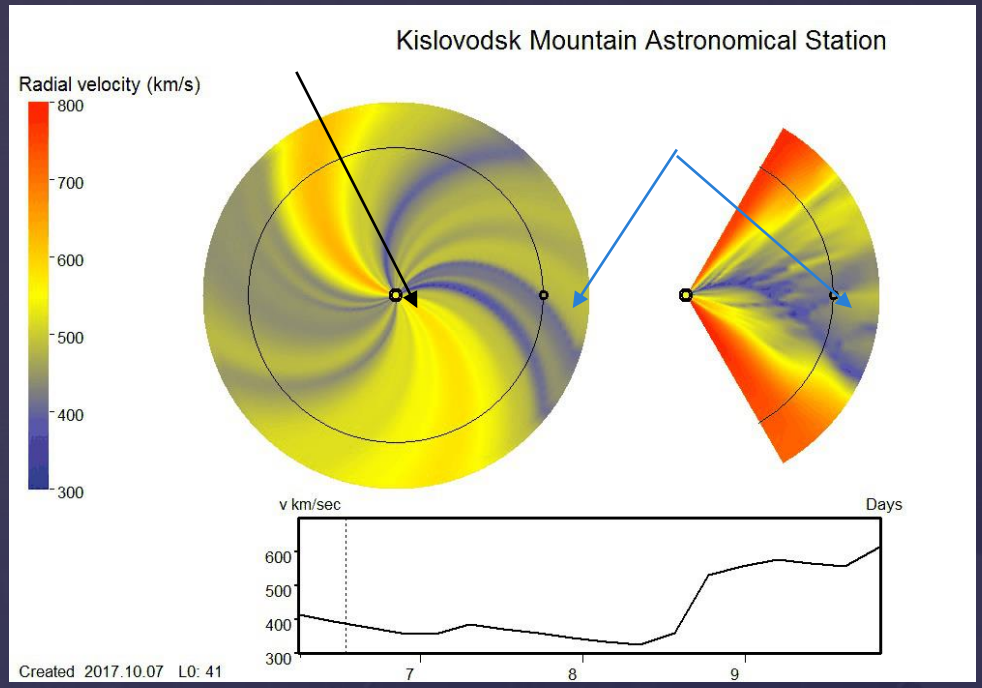
And the next physical data bases one can obtain for:

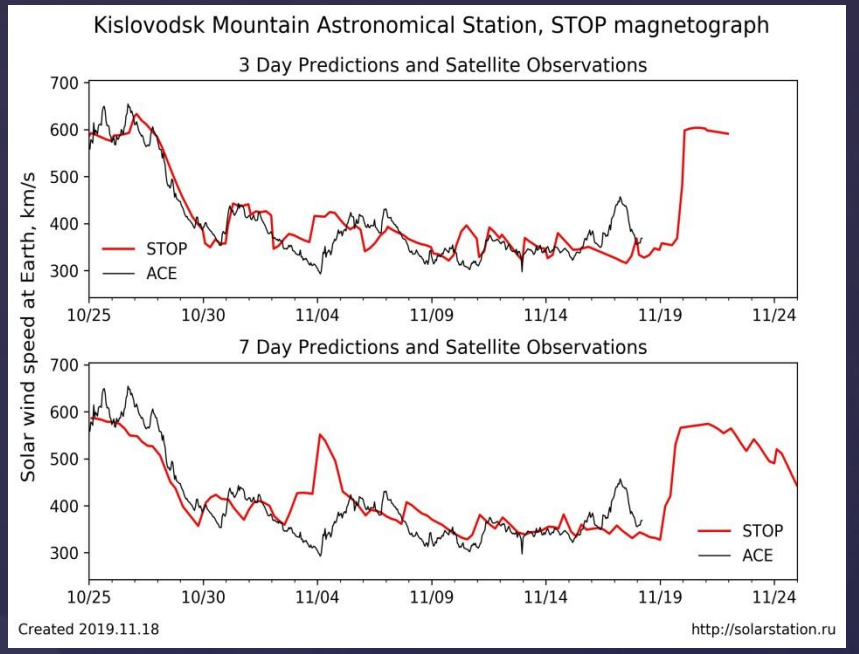
1. Forecast and continuous monitoring of solar flares using optical and radio data;
2. Forecast and continuous monitoring of coronal mass emissions from optical and radio data;
3. Forecast of SPACE WEATHER phenomenon at the Earth's orbit;
4. Forecast of the impact of solar burst events and hard radiation on the Earth magnetosphere;
5. Creation of long homogeneous observations of solar activity ("Space climate").

Observations of Solar activity and Space Weather forecast using ground-based instruments



1. Task. Forecast of quasi-stationary solar wind flows. 3-d Modeling of the heliosphere.



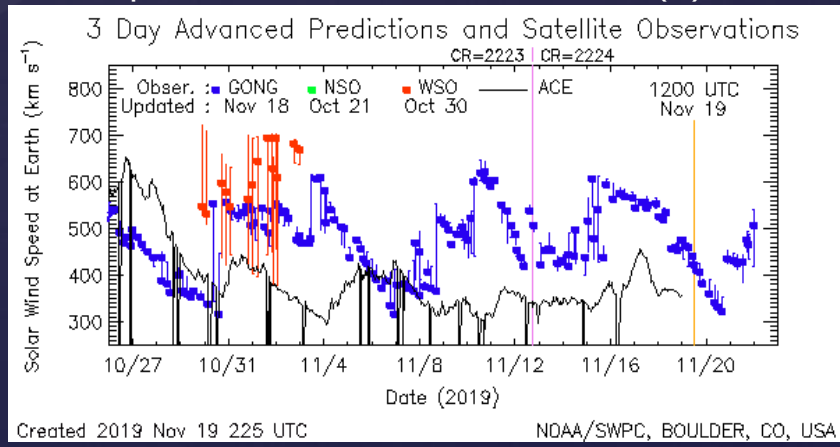


Comparison of the 3-day and 7-day forecast (__) of the SV speed with the measured values (--)

The problem of predicting recurrent solar wind flows is solved in the heliosphere and in the earth's orbit on the base of ground-based magnetographic observations.

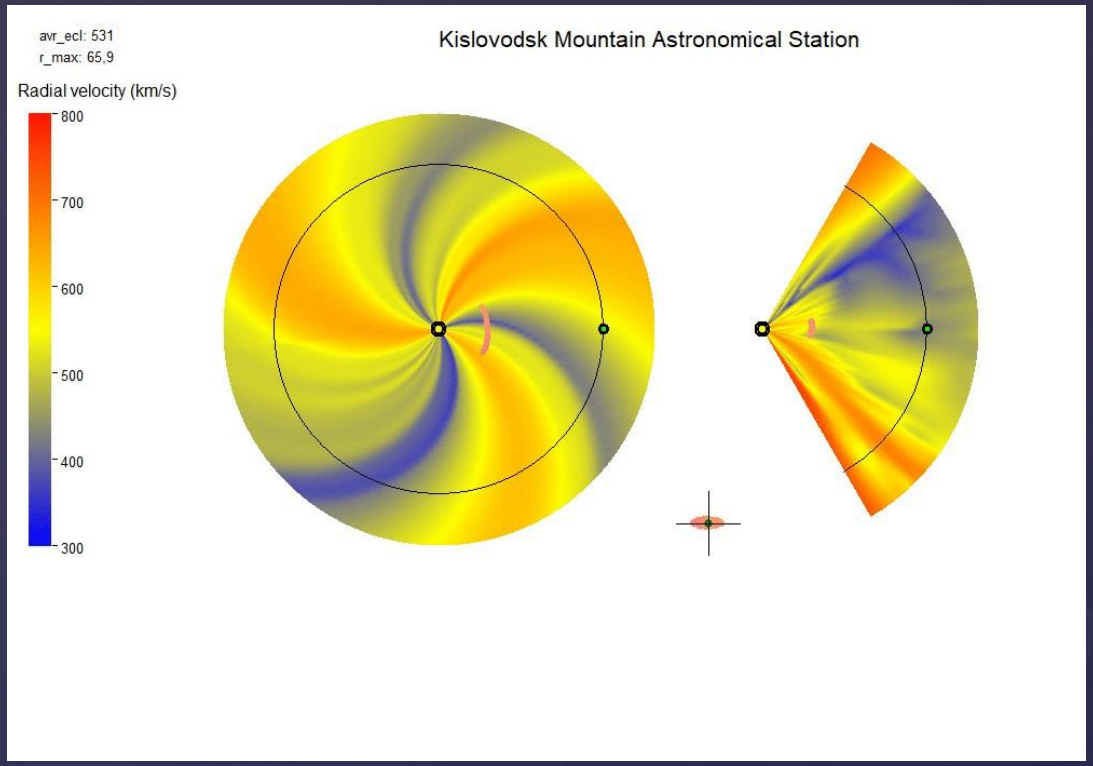
The magnetograph has been working since 2014. the Forecast is being fulfilled since 2017. (www.solarstation.ru).

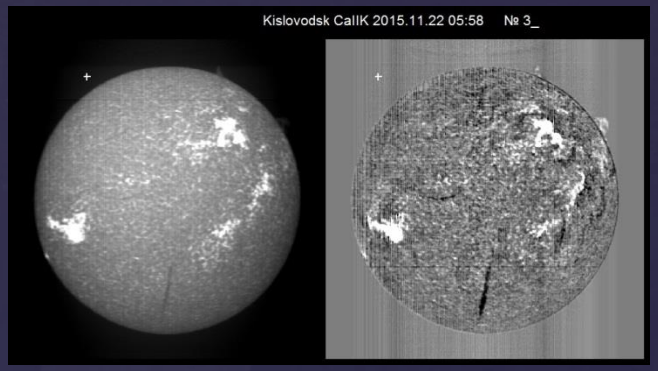
Our forecasts are better than the American ones!



Comparison of the 3-day forecast of the speed of SV according to US data, SWPC

2. Detecting and modeling the propagation of coronal mass ejections (CME) based on observations of patrol telescopes (initial stage) and the calculated velocity of the SW.





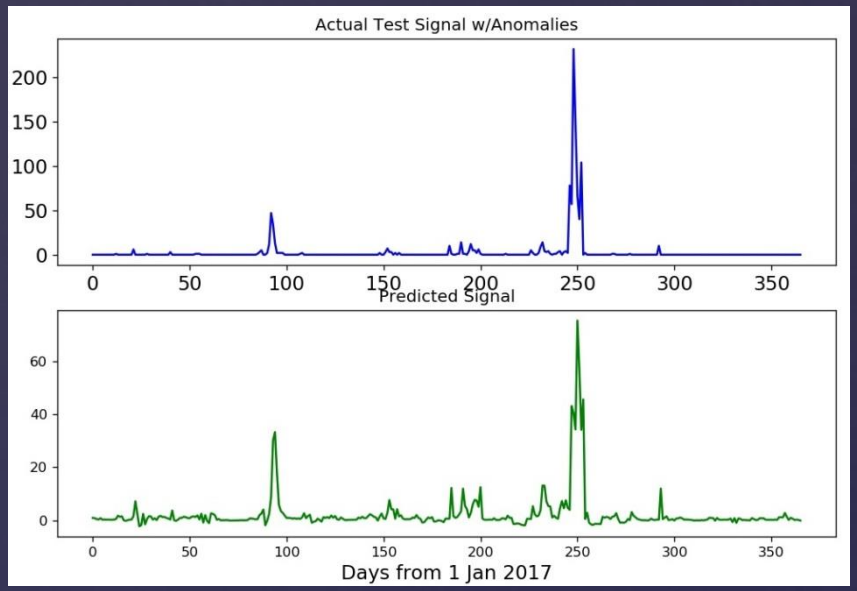
Coronal ejection November 22, 2015

Animation of the CME propagation in the heliosphere under the interaction with SW.

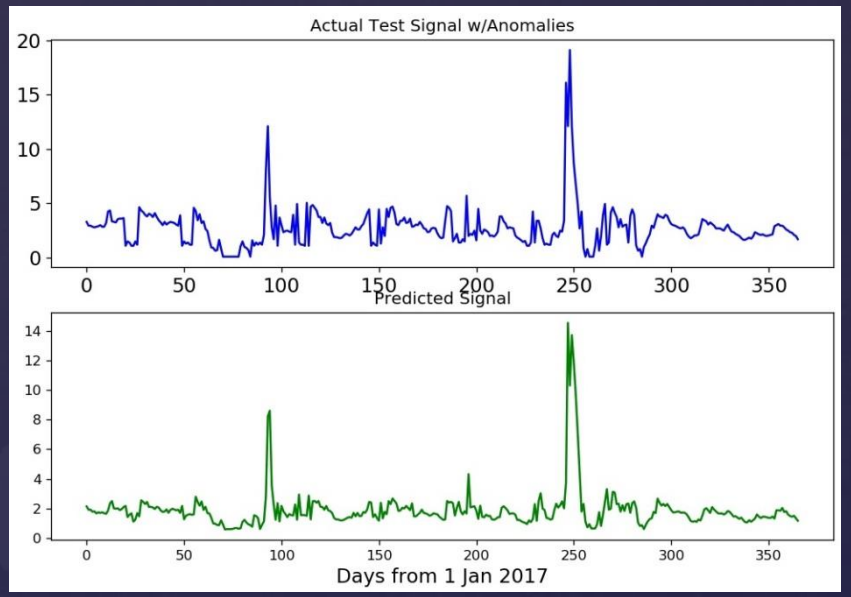
Patrol ground-based telescopes allow detecting the time, direction, and speed of the CME at the initial stage. This serves as the initial conditions for determining the GEO-efficiency of the CME. This model is analogous to model SWPC forecast (ENLIL). Up to 5 days in advance.

3. Forecast of solar flares and background radio emission flux based on ground observations.

Ground-based optical and radio telescopes for prediction solar flares and hard particles



Forecast of the power and number of solar radio sources based on ground observations of "classical" optical and radio telescopes for the next day in 2017.



Forecast of the background flux of hard radiation (GOES observations) based on ground observations of "classical" optical and radio telescopes, for the next day in 2017.

CONCLUSION

1. On the basis of regular (SYNOPTIC) ground-base observations, it is possible to create an effective system for predicting the main Space Weather factors: SW, CME, solar flares and hard radiation flows. Methods, models, and observational tools have already been created.

2. The continuous ground-based **SPS observations** is the version of cheep and quick decision the important problem, which independently from bad weather and political problems.

3. The ground-based **SPS** data will be used also to perform practical tasks: (i) monitoring, (ii) analyzing and forecasting the state of Solar Activity (flares, ultraviolet and x-ray radiation fluxes, etc.), (iii) analysis of radiation conditions and (iv) geomagnetic activity, (v) radio wave propagation conditions, (vi) the state of the ionosphere and atmosphere around Earth.

4. Modern data collection and transmission technologies on **SPS** allow the exchange of information between **SPS** and the Central point without time losses.

5. At the next stages of reconstruction of the new Solar Service, it is expected to develop models of the near-earth environment and methods for forecasting various aspects of Space Weather.

Our publications (in 2019).

1. E. F. Ivanov, A.V. Gubin, S. V. Lesovoy, Ramses Zaldivar Estrada, Project of solar spectropolarimeter for space weather forecast, Solar-earth physics. 2019. Vol. 5. No. 4.
2. Tlatov A. G., Berezin I. A., Strelkov M. A. Modeling of coronal mass emission propagation and forecast of geomagnetic activity based on ground patrol observations, Geomagnetism and Aeronomy, 2020, (in press).
3. Bogod V. M. 1, Storozhenko A. A. 1, Tlatov A. G. 2, Omar Pons3, Marta Uratsuka3, Ramses Zaldívar3, Sierra Pablo3 PROJECT DEVELOPMENT OF RECONSTRUCTION OF HAVANIAN RADIOASTRONOMIC STATION AS PART OF RUSSIAN SERVICES OF SUN AND SPACE WEATHER, Geomagnetism and Aeronomy, 2020, (in print).
4. Tlatov A. G. 1, Bogod V. M. 2, Berezin I. A. 1 FORECASTING SPACE WEATHER PARAMETERS BASED on SYNOPTIC GROUND OBSERVATIONS, Geomagnetism and Aeronomy, 2020, (in print).
5. Bogod V. M., Kuzanyan K. M., Lesovoy S. V., Storozhenko A. A., Tlatov A. G., Omar Pons, Marta Uratsuka, Ramses Zaldívar, Sierra Pablo DEVELOPMENT of the project for the RECONSTRUCTION of the HAVANA radio ASTRONOMY STATION as PART of the RUSSIAN SOLAR and SPACE WEATHER SERVICES, Geomagnetism and Aeronomy, 2020, (in print).
6. Peterova N.G., Bogod V.M., Rodrigues R.E., Sierra P. RESULTS OF ECLIPSE OBSERVATIONS BY THE HABANA RADIOASTRONOMY STATION. TO 50-JUBILY HRS FOUNDATION, Geomagnetism and Aeronomy, 2020, (in print).
7. A.A. Abunin, M.A. Abunina, A.V. Belov, I.M. Chertok: Peculiar Solar Sources and Geospace Disturbances on 20–26 August 2018, Solar Phys (2020) 295:7

Our reports on grants (in 2019).

1. At a seminar at the Institute of Geophysics and Astronomy, February 2019.

Dr. of Sci. Bogod V. M. Storozhenko A. A. History of cooperation between Cuba and Russia (USSR) and the results obtained.

2. Lecture at the faculty of physics of the University of Havana, may 2019.

Dr. of sci. Kuzanyan K. M. Cyclical activity of the Sun, existing Dynamo theories and observational signs of cyclicity on different time scales.

3. Reports at the seminar at the Institute of Geophysics and Astronomy, may 2019

A. G. Tlatov.

- Three-Dimensional reconstruction of solar wind parameters and forecast of geomagnetic activity.
- 70 years of the mountain station of the Pulkovo Observatory. Observations of solar activity, main results, development prospects.

FINAL CONCLUSION

Our unique idea in the project is that:

- using simultaneous data from the Sun around the World,
- using cheep ground **SPS** observations in wide range
- and our new modelling,
- It is possible to receive very important information for Russian Space Weather for civil and special aims and so liquidate absence in this very important directions.

Thank you for your attention!

How about in USA?
SPACE WEATHER PREDICTION CENTER (SWPC)

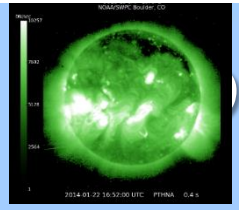
Boulder, SWPC

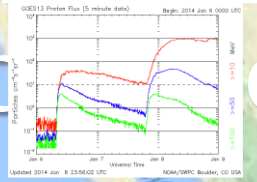
Omaha, 557thWW

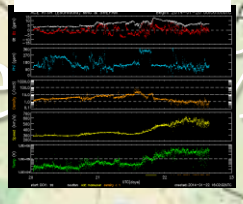
External Space Weather Data Store (E-SWDS)

SWPC > AF

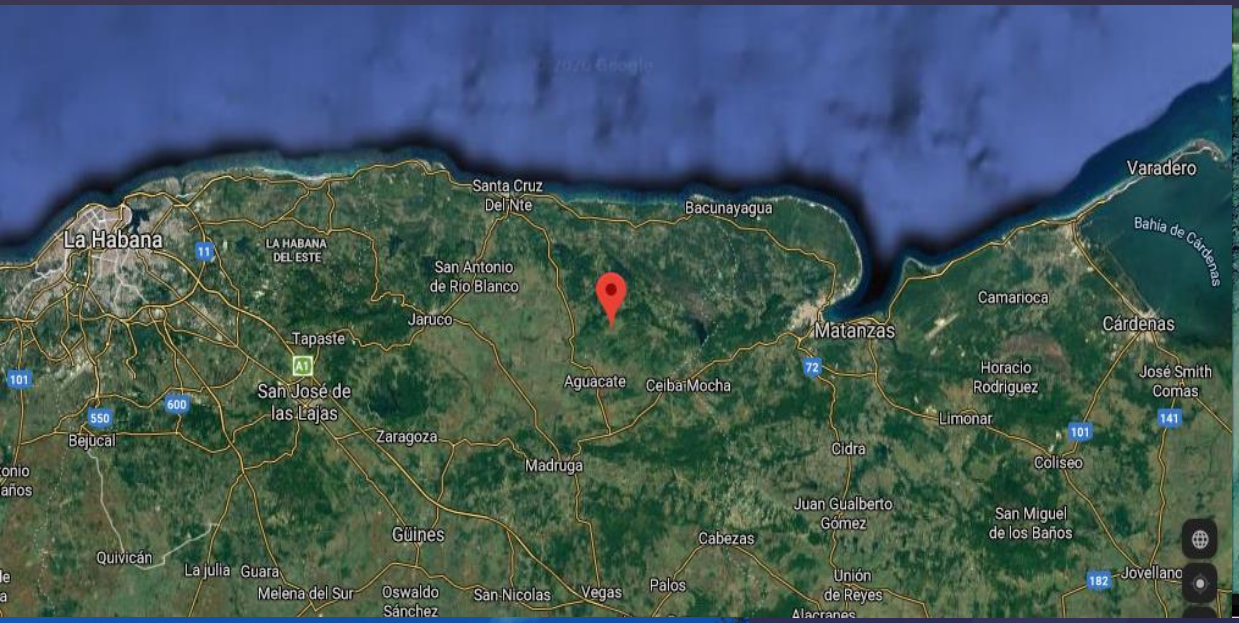
SWPC < AF







Map of the area in Picadura Valley, about 80 kilometers to the East from Havana.



Creation of the observatory in Picadura Valley for the Cuba-Russia projects.