Kotelnikov Institute of Radio Engineering and Electronics of the Russian Academy of Sciences

6. Results of Scientific Research Obtained by Russian Scientists and Specialists during Implementation of Flight Scientific Programmes on Board of International Space Station

Three space experiments (SE) were performed in the Russian Segment of International Space Station (RS ISS) in 2012 – 2014: "Seyner", "Napor-MiniRSA", and “Uragan”. The experiments and the equipment used are listed in Table 5.1.

Table 5.1. Earth Observation Experiments, implemented on the RS ISS in 2012 -2014.

SE designation and the executing organization name	**SE object**	**Scientific instrument**
"Seyner" **(2009-2014)** ***VNIRO, Gagarin R&T CTC***	Upgrading the methodology of Russian fishery provision with information on World ocean water states retrieved from RS ISS crew observations	Standard equipment: camcorder HDV Sony HVR-Z7; digital camera Nikon D3X; digital camera Nikon D800; laptops RSS2, RSK1
«Napor -MiniRSA» ***S.P.Korolev RSC Energia***	Design and manufacture of compact on-board SAR C-band complex	SAR C-band (carrier frequency 5350 MHz), a system of optical telescopes - high (HRC) and medium (MRC) resolution cameras - as additional scientific equipment

6.1. SE “Seyner”

The purpose of the "Seyner" experiment is to show the possibility of using the results of observation the different types of hydrobiological communities by the crews of the RS ISS for the potential discovery of new promising fishing areas in remote areas of the oceans as an additional information resource.

In 2014, the two-year work cycle of the SE "Seyner" was completed in the RS ISS, which was focused on obtaining the original photographs by shooting the

aquatic areas of the oceans in the search of signs of high biological productivity areas. The results of this experiments have been reported at International scientific-practical conference "Scientific researches and experiments on the ISS" 9-11 April 2015, Moscow, which took place in IKI RAS [1]. Example of the program of observation the World ocean main areas in the period of October 2013– April 2014 is shown in Figure 5.1.

In the result of the experiment the bank of informative photographs of these areas of the World ocean was created, which can be used as benchmarks in identification of the indirect interpretive signs of high biological productivity zones of the aquatic environment, that are visually perceived and recorded by astronauts [1]. For the validation of the astronauts observations results, the maps of the sea surface temperature (SST) were compiled for the ocean fishing areas: South-East Pacific Ocean (SEP), South-West Atlantic (SWA), Central-East Atlantic (CEA), South-East Atlantic (SWE), North-West Pacific (NWP). At the same time there were analyzed the satellite data from the meteorological and geostationary satellites and synchronized with it water temperature measurements performed by ships and buoys. On the subject of the experiment were published 5 papers [1-5].

Figure 6.1. Example of the program of observation the World ocean main areas in the period of October 2013– April 2014. SE “Seyner”, RS ISS.

6.2. SE “Napor-miniRSA”

The experiments «Napor-miniRSA» at this stage, were performed to test the functioning of the system of optical telescopes aimed to obtain and transmit from the board of the service module on the ground station video images of the underlying surface of the Earth (including obtaining video images of the test sections, synchronous with the radar) to meet the needs of Russian and foreign organizations.

In 2013-2014 the telescopes of the high (HRC) and medium (MRC) resolution of the Canadian company EVC were delivered by the cargo spacecraft "Progress" to the ISS. The telescopes were installed on the outer surface of the CM by astronauts.

As a result, the telescope of the medium resolution has passed a full testing cycle at the SM of the ISS and is ready for work on request of customers in the framework of the space experiment. The telescope of a high resolution is under testing at the SM of the ISS.

There was performed the testing of two-phase pointing platform (HDP) software (SW), and were obtained the HRC camera images with the resolution of about 1.5 m. On the proposal of the company UrtheCast, a software was developed that use the data of the HRC camera gyros for DPN pointing. It is expected that the use of more accurate gyroscope data for DPN pointing will allow to obtain the higher resolution images from the camera. Figures 6.2 and 6.3 show examples of images taken by the cameras of medium and high resolution.

Roscosmos has appointed the "Scientific center for Earth operative monitoring" as the system operator of the optical telescopes, which will work at the operational phase of the optical telescope system on requests of customers.

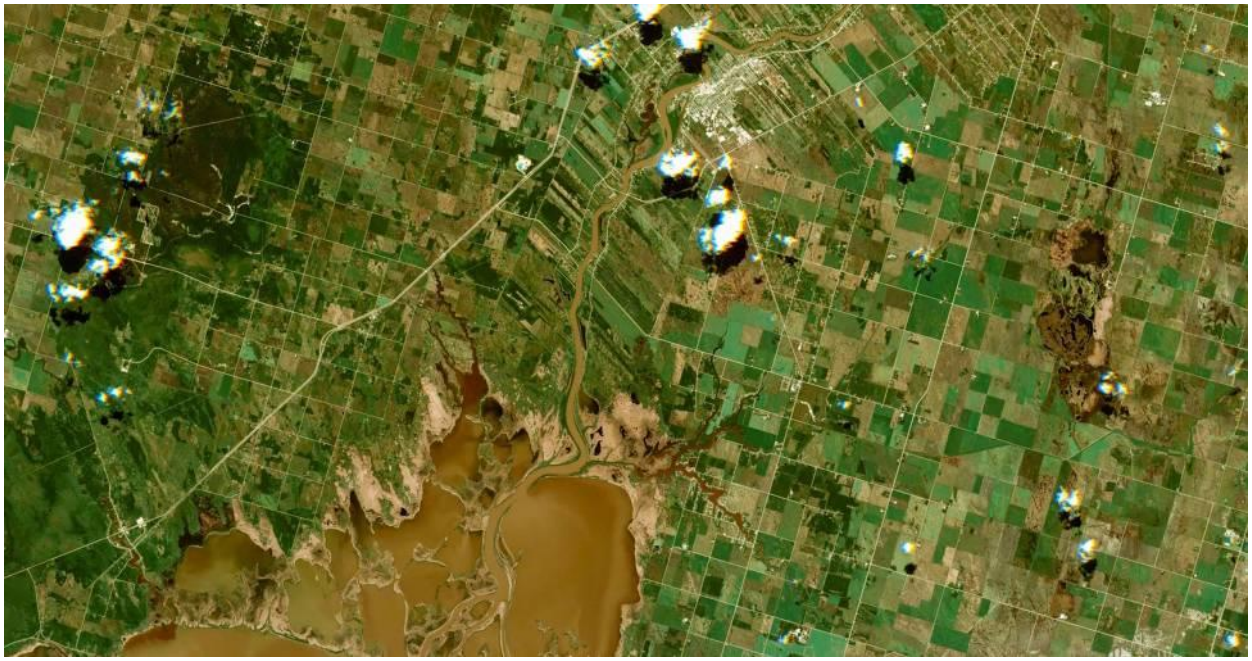

Figure 6.2 - Lake Winnipeg, Manitoba, Canada (the camera medium resolution)

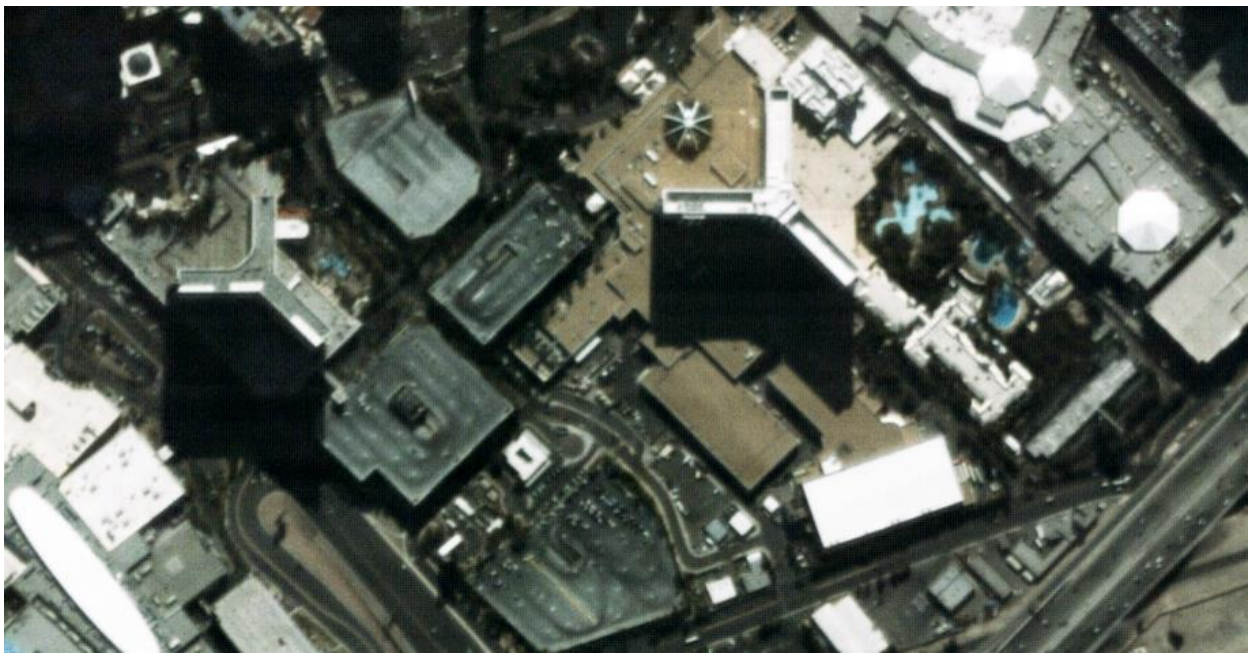

Figure 6.3 - USA, Los-Angeles (the high resolution camera).

6.2. SE “Uragan”

Satellite images and spectral information, obtained onboard the RS ISS, is widely used by various organizations in carrying out scientific research and in practice. Currently it established the possibility of their application in the study of these phenomena and related facilities:

- landslides, rock falls, avalanches, progress of glaciers;
- the dynamics of vegetation cover;
- volcanic activity, earthquake;
- scale floods, flood dynamics, debacle;
- forest fires;
- hot spots around the cities and oil film on the water surface;
- changes in the environment;
- dust storms;
- indicators of climate change;
- geological structures, etc.

The dynamics of land use in floodplains in Central Russia is studied over the past 11 years within the (SE "Uragan"). It used one of the marked advantages of shooting from the ISS - a detailed photography of curvilinear objects the size of hundreds and thousands of kilometers in 2 - 3 monitoring session. The main object is selected the (Don Valley) from its source near the town Novomoskovsk to the confluence of the Azov. Fig. 6.4 presents a fragment of the floodplain of the Don at the village Vyoshenskaya.

Figure 6.4 – The fragment of the floodplain of the Don

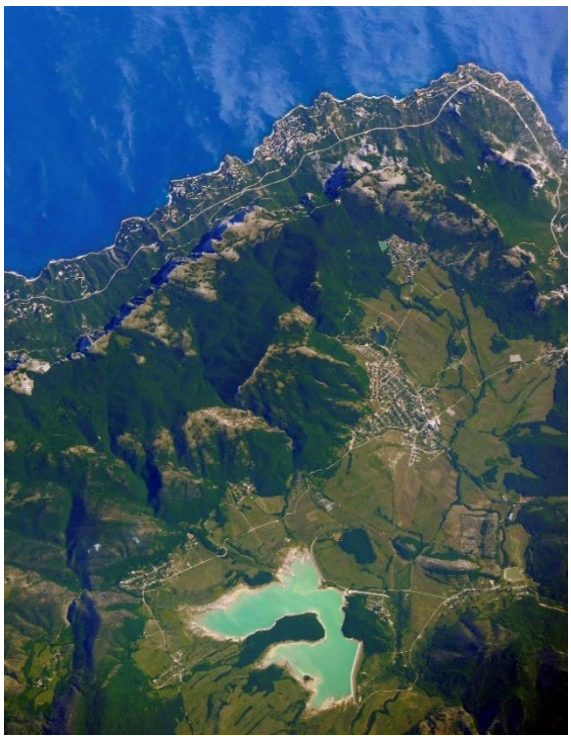

Figure 6.5 The mountainous part of Crimea (from Simeiz to Foros) is the most promising area for the extraction of artesian water.

Figure 6.6 – Meteor Crater (impact crater), Arizona, USA.

In 2014, it is scheduled to take pictures of the mountainous part of Crimea and to apply the data for the current mapping of the actual infrastructure and the definition of a natural situation. We have already begun to work on the study of geological and hydrological features of the Crimea to search for reserves of fresh water. According to satellite imagery and synchronous ground investigations, it found that the most promising area for production of artesian waters is a mountain area of Simeiz to Foros. Here on the northern slope of a ridge The most studied objects are used as standards, in order to find the modern and ancient impact craters, which have arisen in the fall of large meteorites. The impact crater in Arizona is show in the photograph (figure 5.6). This photograph was made on board the ISS.

The glaciers are a reliable indicator of climate change. Therefore, the study of the glaciers change is another important task of the research in order to assess and predict the regional and global climate change [6]. Due to climate warming, the glaciers have reduced their sizes and thickness and in the mass balance ablation dominates over accumulation.

Conclusion about the scale and pace of climate change will be more reliable the greater the number of glaciers will be brought for analysis. Global assessment of climate change can only be made as a result of the analysis of the dynamics of glaciers, which located in the mountains of both hemispheres of the Earth.

Survey more than 20 basic units of mountain glaciers is performed for the study the Earth's climate dynamics on the ISS RS. The glaciers of the mountain region Kun-Lun in northern Tibet react especially intensive to climate warming. In 2014, experts from the Institute of Geography RAS, together with glaciologists from China and the United States plan to implement the program by drilling two test glaciers (Fig. 5.7 shows a picture of one of them). In this case, it was used important advantage of satellite imagery - periodic opportunity to receive information about the remote areas of the globe and to follow the dynamics of

the object. The drilling is carried out on the glacier during the periods when it is in a state of progress, which is fixed on the photo. Simultaneously, according to the interpretation of satellite images determine the speed of movement of the front of the glacier, and also the possibility of creating a threat passing through his body kinematic wave voltage, which often give rise to fields of cracks and breaks.

In recent years the field measurements of the glaciers position in the mountains of our country were carried out by less than one percent of the total number of glaciers. The statistical materials are not enough [7]. It is therefore necessary to use data on changes in glaciers, based on the shots and the visual observations of astronauts aboard space stations.

In 2011, kinematic waves were detected on the surface of the Pamir Glacier Bearthe in the picture obtained from the ISS. On this basis, for 3 months before the start of the glacier movement, its stepping was predicted overlapping river Abdukagor valley.

Fig. 6.7. Glaciers Chong Auchan in Tibet - Research object glaciologists Russia, China and the United States.

Special methods have been developed for an operational definition of the speed of a glacier photographed from the space platform.

Photospectral system developed by the technical task of RSC "Energia" at the Research Institute of Applied Physical Problems AN Sevchenko (Minsk) is used to observe the erupting volcanoes, pollution and other objects on land and water surfaces.

As to 2014 status, it was conducted more than 100 sessions in the framework of EC "Uragan" with FSS instrument. It received more than 4,000 photographs and measurements of the spectral density of the radiance of the underlying surface, corresponding to them.

Fig. 6. Eruption picture (a) of the volcano Puyehue-Cordon Kaulle (Chile, 40,59º sl., 72,11º wl.) and measuring (spectral intensities) (b) of the volcanic plume.

Active volcanoes are one of the objects of study using FSS (Fig. 6). Now the information is accumulating about spectra of active volcanoes in various states located in South America and Italy: before the eruption, with the appearance of precursors (for example increase in seismic activity), during and after the eruption.

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