

## **THE METHODOLOGY OF THE CREATION OF MAPS SHOWING GLACIERS' CHANGES**

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Glaciers are a good indicator of climate changes. Melting of ice and as a result raising of sea level disturb many scientists, especially from the countries which part of a territory can find themselves under water. A research of glaciers is important for an analysis of processes which take place in the nature and a prognostication of the development of our planet.

The aim of this research is a development of the methodology of a creation of maps showing dynamics of glaciers for the territory of the archipelago Franz Josef Land in the last half of the century, and also the detection of factors, which influence most of all on this process. The archipelago is the most northern territory of the Russian Federation (almost the whole of the archipelago lies behind latitude 80° North). It consists of 191 islands, the majority of which is ice-covered. The geographic position of the islands makes difficulties for their research. Only little number of satellites has sufficient inclination of the orbit to include such high latitudes.

The first step was the creation of the common geographic base, which was received by deciphering of a remote satellite image, and the development of the mathematic base of the map. The common geographic base includes the elements, which are necessary for maps of scale 1:500 000 (hydrological objects, relief, meteorological stations, height spots and depth indexes, coastlines, magnetic anomalies). In view of the fact that relief considerably influences on glaciers, it was showed more detailed than it is necessary for maps of an appropriate scale: contour interval is 40 meters. In addition, relief shading is put, and it increases the obviousness of the map. For the reason that the different data had different projections, it was resolved to use the most widespread and convenient in use projection: UTM on the ellipsoid WGS-84 (zone 40). It was laid some claims to the scale: the high detail of the map, the necessity of a representation of the whole of the archipelago's territory and the size of the map, which allows using it in a field condition.

The second step of the creation of the map is the exposure of the glaciers' condition for two periods of time. The materials for 1950s and 2000s years were selected. The main source of the information, indicating the situation on the middle of the previous century, is topographic maps of scale 1:200 000, which were created in 1953 in USSR. These maps helped to make the DEM and the elements of the common geographic base. For our century, coastlines and relative changes of the surface were taken from the satellite image from the radiometer ERS-1/2, and data from the satellite IceSAT were used for the definition of absolute altitudes. Then the comparison of data was made. The interferogramms, which were received after data handling, give the information about relative changes of the surface, and after a comparison them with IceSAT profiles and the topographic maps, it can be accurately said how the surface had changed in the each point. Thus the horizontal and vertical changes, taking place in the last half of the century, are shown on the map.

Next step consists of mapping the additional thematic information, which is the characteristics of events and processes influencing on glaciers: winter air temperature and solid precipitation (for 2 periods), borders of offshore area and depth indexes of the ocean, magnetic and gravity anomalies. As well it is necessary to note that some characteristics of the glaciers are shown: glaciers winter velocity and height spots.

The distinctive feature of the maps is a bundle of geographic names, which were thoroughly checked. The language of the maps is English; however it is given a table where all geographic names being present on the map are translated into Russian.

The same work was made to create the maps of Island Victoria (the Russian Federation) and Kvitoya (Norway), which are drawn as the insert-maps of the scale 1:100 000 and 1:500 000 respectively. Additionally the images from the satellite ERS-1/2 and the profiles, showing the changes of the islands' surface, are placed on the map.

The final step was the design.

This map is the first cartographic production on the territory of the archipelago and adjoining islands after the publication of the topographic maps in 1953 year and it shows the up-to-date situation. It is necessary to take into consideration that it is the analytic map. The conclusions, which were drawn, were compared with data of field expeditions on the territory of the archipelago Franz-Josef Land. And the results of the comparison confirm the high accuracy of the map.

The methodology, which was developed during the research, can be applied for all regions difficult of access, on which there are glaciations. Its use gives a chance to analyze a situation and improve the accuracy of results in Polar Regions; before it was

virtually impossible. For example, before it was thought that glaciers only melt, however the created map showed that there is an accumulation of ice on some islands (Island Rainer).

## **Introduction**

Scientists from the different directions of geography study glaciers. It happens because glaciers changes can give the information about climate changes and the history of our planet.

The territory of the research is Franz Josef Land archipelago. It is the most northern territory of the Russian Federation (almost the whole of the archipelago lies behind latitude 80° North). It includes 191 islands, the majority of them are ice-covered.

There were some expeditions there, but the last maps, which were created, are dated 50-s of XX century. They are topographic maps made in USSR. Topographic maps display all elements of landscape and it helps in researches. They show the situation on the archipelago for the middle of XX century and they are the sole accurate source of information. It give the possibility to make a map about changes in the second half of century.

## **Methodology**

The first step consisted of a selection of data, a choice of the mathematic base and a creation of the common geographic base. The common geographic base includes the elements, which are necessary for maps of scale 1:500 000 (hydrological objects, relief, meteorological stations, height spots and depth indexes, coastlines, magnetic anomalies). They were received by deciphering of satellite image, from the topographic and other maps and literary materials. The relief is showed more detailed than it is necessary for maps of an appropriate scale: contour interval is 40 meters. The contours were taken from Russian topographic maps, scale 1:200 000. Using them we also created DEM and put the relief shading on the map. It increases the obviousness of the map. Besides scientific purposes the map is used in schools (in Graz, Austria).

We chose to use the most widespread and convenient in use projection: UTM on the ellipsoid WGS-84 (zone 40), because the maps is used in field and the majority of GPS-receivers utilize this projection. It was laid some claims to the scale: the high detail of the map, the necessity of a representation of the whole of the archipelago's territory and the size of the map, which allows using it in a field condition. That is why we applied the scale 1:500 000.

The second step was the creation of the thematic content. We used the remote sensing images from the satellites ERS – ½ and IceSAT to indicate the situation for the beginning of the XXI century. We made the interferograms from the radiometric images from the satellite ERS - ½ to identify the relative changes. The difference in colors (black or white) shows which process (accumulation or ablation) takes place. The IceSAT profiles give the information about altitude of points and with comparison to the topographic maps and the interferograms it is possible to say the absolute characteristics of the vertical changes. At first we printed parts of the map in the scale approximately 1:80 000 and indicated the territories with relevant changes, and then we digitized them in ArcGIS software taking into consideration the previous results.

The horizontal changes were created by comparison of the satellite images from the satellite ERS – ½ and the topographic maps.

We also display the information which describes the conditions on the archipelago: winter air temperature and solid precipitation (for 2 periods), borders of offshore area and depth indexes of the ocean, magnetic and gravity anomalies, and some characteristics of the glaciers: glaciers winter velocity and height spots. We took these data from different maps (maps of gravitation), the satellite images (glacier winter velocity), books and articles. This information should help scientists to indicate the factors which influence on the glaciers most of all.

The language of the map is English, but we added the table which includes the translation of all geographic names into Russian. So people from different countries can use this map. There are a lot of places which have two or more names, and the distinctive trait of our map is that we checked each name with sources. Thus all geographic names put on the map are official and current.

The same work was made for the insert maps, which show the island Victoria and Kvitoya of the scale 1:100 000 and 1:500 000 respectively. These maps display the vertical and horizontal changes of the glaciers, the conditions of the territory and the characteristics of the glaciers. We also added the images from the satellite ERS-1/2 and the profiles, which show the changes of the surface of these two islands.

The last step was design of the map, design of the edge and identification of exact positions of all parts of the map.

## **Conclusion**

This map is the first cartographic production on the territory of the archipelago and adjoining islands after the publication of the topographic maps in 1953 year and it

shows the up-to-date situation. The results of the expedition which took place in August 2008 confirmed the high accuracy of the map. But it is necessary to remember that the map was created in laboratory work without using data from any expeditions.

The methodology, which was developed during the research, can be applied for all regions difficult of access, on which there are glaciations. It can be considered as a new method of research Polar regions, and this method is not as difficult as those, which were known before.

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The described map can be found on the official site of the project SMARAGD (<http://dib.joanneum.at/smaragd>).