1.1. History of ice conditions observations in freeze-up seas

The history of ice observations is closely connected with Arctic exploration history. Several stages of study can be separated, every of which reflects it's own principal approach to ice observation arrangement and is connected with particular stage of observation instruments and methods development or is the cause of information demand.

The first stage – the most long-term – is connected with process of getting separate and unperiodical data about ice cover of freeze-up seas during trade of other type of activity. In the given period the process of ice data obtaining wasn't independent type of activity.

The first written evidence about sea ice is relative to 350 and 310 years B.C. It was said, that Greek Pytheas from Massalia reached a "gloomy land", next to which "there is no sea or land or air with some mixture of all a this hanging in space". Some separate written evidences about appearance of first Norsemen in the Arctic Seas were found.

In this period development of sea ice mapping technologies occurred independently from ice science development – ice study, and mostly came after development of seafaring in Arctic – compiling of sea navigational maps (charts).Seafarers noticed separate ship and expeditions navigation, distinguished stages of North exploration, but at the same time they hadn't always fixed information about natural phenomena and processes. First historical data about pomors, who had first settlements on the White Sea coast, was in XI century. Parallel to walrus and seal hunting they were getting an experience of ice navigating and gave it to each other as separate written notices or verbal messages. According to this evidences Lomonosov M.V. in the second half of XVIII century wrote "The brief description of different travels by Northern Seas and showing the possible route by Siberian Ocean to Eastern India". In the third chapter of this book, called "About possibility of navigation by Siberian Ocean to Eastern India, considered by natural circumstances", he wrote: "The main difficulty in this routing is cold, i.e. ice, made from it. So this subject must be considered very serious, because it is located to Northern Ocean and our route, and the main theory of warm and cold, and ice appearance should be fully described".

In his research M.V. Lomonosov summarized separate data about ice characteristics and propagation in the Arctic Ocean and made some science hypothesis, summaries and forecasts, and also made public special terminology of ice science, which wasn't significantly changed till nowadays.

Specifically he wrote: "… Drifting sea ice is showing three types":

1) Small grease ice, which like snow floats in water, sometimes it is prickly, but despite of some connection, flexible and isn't harmful for ships;

2) Mountains of irregular shape, which depth under water is from 30 to 50 sajenes, above

water part is 10 or more, cracking all the time, like wood in oven, therefore can be indentified at night or in fog, and navigators must be careful, because they are dangerous id storm, especially on shallow areas, when cracking with noise;

3) Hummocked ice or ice floes, sometimes lasting for several versts, mixed with small ice. A lot of similar ice floats and gets ships stuck. It is necessary to distinguish floating ice mountains (№2) from type which consists from broken hummocked ice.

Considered differences and amount of ice, it is necessary to observe these movements in Siberian Ocean. Bit it is impossible without having information about currents, high and low tides, which are followed by great ice, only small and thin follow the wind, and hummocked ice are moved mostly by lower water, so often opposite movements of small and great ice are seen at one place..”

This science work by Lomonosov M.V. is very valuable even at the moment, not only because it was the first general summarizing attempt of expedition observation, but because the range of thoughts, hypothesis and summaries, which became the basis of independent science direction – ice study - was given in this book.

The first through navigation on the route of Northern Sea Route was occurred by Swedish scientist A.E. Nordensheld with supply of Russian goldminer A.M. Sibiriyakov, Swedish King Oscar II and manufacturer O. Dixon only in 1878.

On the boarder of XIX - XX centuries polar expedition on schooner *Zarya* headed by E.Toll was organized under management of Russian Imperial Science Academy. Expedition purpose was to investigate the Laptev Sea and Novosibirskiye islands. New materials in meteorology, polar ice, geology, geophysics, biology and zoology were received.

In 1910–1915 the Hydrographic Expedition to the Arctic Ocean was organized onboard the ships of the icebreaking type *Taymyr* and *Vaygach*, which made the epoch-making geographical discovery of the twentieth century – the Severnaya Zemlya archipelago. Observations f ice cover were episodic during expedition. Nevertheless, it was noticed, that Arctic Seas are not covered with ice ultimately, and their ice regime is not similar for different years.

However, observations were not regular and obtained data were fixed with time intervals sometimes till several years, which didn’t assist to formation of entire picture about ice origin in Arctic and ice cover dynamics in the Polar Seas and in Arctic Ocean.

This stage of observations development, characterized by non-systematic approach to data receiving in ice science, when information about ice cover condition was obtained incidentally with occurrence of other main purpose, lasted almost till second decade of XX century.

By the end of this period the necessity of occurrence of special organization, having wide financial and technical facilities, icebreakers and icebreaking type ships, network of radio and meteorological stations to provide navigation in ice, became obvious. By this time (1911-1915) experience of organization radio stations in Arctic, which gave to ships meteorological and ice information, was stored. V.A. Rusanov suggested, that it was necessary to provide aerial observations using balloon, located on board.

This approach started systematical mapping of ice regime from results of special ice observations. Planes started to be used in observations for navigation support. It allowed providing regular observations of propagation, features, dynamics of sea ice and its interannual variability.

The first visual remote observations of sea ice were made in 1897 by Salomon Andree from the air balloon during his attempt to reach the North Pole. This flight demonstrated the possibility of visual remote observations of the sea ice, but simultaneously showed that balloons were not viable for this purpose.

In 1913, following the expedition onboard the icebreaking ships *Taymyr* and *Vaygach,* the possibility of using an airplane specifically for ice reconnaissance was proposed by B.A. Vilkitskiy. The Russian pilot Yan Nagursky on the hydro-airplane *Maurice Farman* implemented this idea in 1914. This is the birth of the airborne ice reconnaissance and marks the beginning of sea-ice remote sensing.

During 1918-1921 flights were not conducted.

Observational flights were provided again after and of Civil War in 20s to support transport operations in Arctic Ocean. As early as 1920, the first Siberian “bread-expedition” sailed from Arkhangelsk to the Ob’ and Yenisey River mouths and from 1921 to 1928, the Kara Sea trade-exchange expeditions were made on a regular basis. For supervising these expeditions, the Committee of the Northern Sea Route (CNSR) was set up in 1920 and the Northern Research Commercial Expedition was established, which was commissioned to conduct not only the geographical studies but also investigations in the interests of many branches of the national economy (geological exploration, fishery, hunting, etc.). During this period navigation support on Northern Sea Route was absent.

In 1925 the Northern Research Commercial Expedition was reorganized to the Research Institute on the Study of the North (from 1930, the All-Union Arctic Institute). In the sphere of activity of this institute, predominantly the oceanographic, meteorological, geophysical and geographic investigations were developed.

Parallel to it in USSR United Weather Service is establishing.

Next stage (20s - late 40s of XX century) was the stage of beginning of regular navigation on NSR and, respectively, organization of regular system of hydro meteorological (and ice) observations.

Constant increasing of transportation volume needed increasing of terms of polar navigation, what was impossible without caravan steering with the help of icebreaker and regular, not episodic, air reconnaissance on route.

In these escort ice reconnaissance flights, routes were made from the ship as radial track lines with the distance from it over 50–100 km. For surveying some sea area, the sketch of the routes presented a combination of parallel and radial track lines.

Considered period of Arctic exploration coincided with development of aircraft building and their active usage in different activities – military, transport and touristic. In fact on dirigible NORGE R. Amundsen in May of 1926 first flew over the North Pole. Large aerial photography was occurred in Arctic. In 1931 German dirigible LZ-127 *Graf Tsepellin* flew with science purpose above Soviet Arctic and occurred detailed aerial photography over its territory and water area, covered with sea ice.

Flight route was Friedrichshafen (Germany) - Leningrad – Franz-Joseph Land (Tikhaya Bay) – Northern Zemlya – Taymyr peninsula – Dixon Island – Novaya Zemlya - Arkhangelsk - Leningrad - Germany.

Director of ARI Samoilovich R.L. headed science crew of specialists, accompanied flight on board of dirigible. During three days *Graf Tsepellin* had passed Franz-Joseph Land, Northern Zemlya, Taymyr peninsula and Novaya Zemlya. From the moment of departure from Leningrad and till arrival to Berlin dirigible spent 106 hours in air or 4 days and 10 hours. Aerial photography was occurred during flight. Specialists estimate, that *Graf Tsepellin* did work equivalent to 2-3 years of hard work with usage of icebreakers. 90 measurements were done from dirigible and plenty of other observations and researches. During expedition first Molchanov’s spheres-radiosondes were set in Polar sky, with height of rising up to 20 km.

However, science world didn’t see results of aerial photography. German officials said, that film was light-struck. There is an opinion, that materials were not lost, but were used by Germany in planning of military activities in Arctic during Great Patriotic War.

Planes were also widely used in sea ice observations, beginning from 1929 duration of air reconnaissance flights started to increase. Hydroplanes, based on water areas near harbors and polar stations, were used in ice, trade and aerial photography reconnaissance. Flights had mostly searching pattern – planes approached to ships, then went according their route and back. They sent verbal message (on radio) to captains of ships or icebreakers about ice regime and probable route. Flights routes were mostly absent on ice charts.

Development of navigation on NSR increased, and airborne reconnaissance planes needed obtaining of more précised information about ice condition and its propagation. At the same time unification of observation rules became obvious. In 1938 sector of navigation characteristics developed “Temporary navigation manual for ice airborne reconnaissance of 1938». It was considered, that route composition must be provided by pilot. Pilots or navigators performed ice observations – visual assessment of the ice distribution and characteristics – in addition to their main duties. With no aids and instructions, the pilots themselves developed indicators characterizing ice conditions and methods for compiling the ice charts. The observers determined, assessed and plotted the ice edge position, concentration, shapes of ice floes and characteristics of their surface (level, ridged, snow puddles) on the charts.

It is necessary to note that the flight charts at that time were not quite accurate while the navigation equipment of airplanes included only a magnetic compass (operating not quite reliably under the Arctic conditions), a speedometer and a navigation cursor.

In 30s flights in Arctic didn't have particular science purpose, they were connected with ice reconnaissance, planes testing in Arctic conditions, providing medical service, exploration new routes, fur export and social tasks.

In 1932 planes were used during expedition for aerial observation of inner part of Chukchi Peninsula and total geographic and geological reconnaissance with direct science purpose.

Tactics of air reconnaissance before 1933 had episodic character. Observations occurred by navigator, and each of them contributed in development of observations methods and ice mapping.

1936 year – can be called last year of "escort aircraft" usage together with ice-breaking type ships leaders. Hydroplanes were used with this purpose, which were delivered to regions of work on ships disassembled. These ships at the same time served as airdromes – bases. Before departure hydroplane were put in water, and after landing it was taken back on board.

Main amount of hydroplanes was based in comfortable for landing and setting off closed bays, rivers or near polar stations or settlements. But they couldn't be referred to escort aviation any more. Thus, in 30s *ice observations — visual estimation of ice propagation and ice condition – were occurred by pilots or navigators as additional task to their maim duties. Military and transport planes were used for observations.*

Pilots themselves developed indicators characterizing ice conditions and methods for compiling the ice charts defined decoded features by themselves, because there weren't any special documents or instructions. During ice charts compiling they used conventional designations, listed in ship instructions. The observers determined, assessed and plotted the ice edge position, concentration, shapes of ice floes and characteristics of their surface (level, ridged, snow puddles) on the charts. The development and improvement of the method of visual airborne ice observations also continued in subsequent years.

In December 1932, by the Decision of the USSR Government, the Main Administration of the Northern Sea Route (MANSR) was created. Among planning and providing of sea operations and their hydro meteorological supplement The MANSR had to be in charge for river transport in the

North, arrangement of seaports and airports, development of industry, exploration of minerals, trading, etc.

Simultaneously, the HMS system was developed and improved, its scientific center being the Arctic Research Institute This system included: polar stations, weather bureau, ice reconnaissance aircrafts, Marine Operations Headquarters (MOH) onboard line icebreakers and service of long-range forecasting and planning of marine operations at ARI.

Marine expeditions of the Ice Patrol began regular operations in 1935–1937. They recorded the ice edge location and carried en-route oceanographic observations.

Planes had a very limited range and were not suitable for conducting ice observations and preparing ice charts onboard.

Apart from that, organization of stable ice observations had difficulties with imperfect planning of ice observations – *the quantity of planes and specialists (board observers) were not enough and conditions for mapping on board were imperfect.*

At first, in 1933 special for ice reconnaissance R. Bartini developed plane project – distant arctic reconnaissance plane. It was supposed, that it would be some kind of northern all-terrain plane. It was a flying submarine, able to sett off and land on water and ice. Length of ship hull was 18,4 m and width - 2,8 m. Plane was produced in the end of 1935. Testing was occurred in Leningrad in spring of 1936. Flight duration under overloading mass 9000 kg was more than 20 hours. According to tests in MANSR it was decided to construct five vehicles, but this project wasn't finished.

In nearly the same time another specialized for Arctic plane was developed. It was named "Amphibia of northern region". Plane was constructed in Leningrad in spring of 1935, but also wasn't produced in series.

In 1929 V.Yu. Vize suggested organizing science drifting station, which was opened in 6th of June, 1937 near the North Pole. After 9 months of drift (274 days) station was transported to the Greenland Sea. Ice floe passed more that 2000 km. Meteorological and hydrological researches about ice condition occurred on station during entire drift.

In 1938 the Department of Ice Service was created at the ARI, which was later called the Department of Ice Forecasting. From that time the pre-navigation ice reconnaissance was conducted (first, in June, then with extending navigation dates, in May and April). Based on data of these reconnaissance flights, ARI developed ice forecasts for arctic navigation and planned sea operations.

From 1939, board-observers were assigned to some ice reconnaissance aircraft. They provided uninterrupted observations during flight and didn't disturb on plane routing and other navigators duties. Such approach significantly simplified navigator's work in complicated weather conditions, especially when planes had to move flyby. On the other hand, necessity of registering uninterrupted observations and maximum differentiating of ice characteristics made obvious necessity of creating united system of ice terminology, conventional designations and mapping, development of quantitative estimations and estimation methodic of ice cover.

Nomenclature of sea ice charts compiling was in general developed and tested to middle of 40s, and wasn't significantly changed till 50s.

Purpose of ice reconnaissance before 1940 mainly was search of most successful routes among ice for caravans of transport ships and icebreakers. Listed observations were not enough accurate to make some science summaries.

During the years of Great Patriotic War, the major part of the cargo turnover was from east to west, and main goods and food supplies were transported along the NSR.

For unification of ice reconnaissance, occurred in war period, in MANSR was validated and developed standard scheme of flight routes. Decade ice reconnaissance was occurred more or less regularly, regions and terms of navigation reconnaissance were defined and corrected depending on ice conditions and navigation regime.

The conditions for performing ice reconnaissance significantly improved after putting two-engine airplanes *LI – 2*, reequipped for purposes of ice reconnaissance. Additional fuel tanks were installed in the passenger cabins increasing the flight range and duration, and for observers, blisters were equipped considerably improving the observation conditions and a table for plotting the ice charts.

System of conventional designations in this period significantly improved. From 1941 observers began to assess the total ice concentration in tenths, which was given in a circle. In 1942 coloring of the zones in accordance with concentration gradations zone was applied, an in winter – coloring by age.

Thus, by the end of the war the terminology, scales and a system of symbols were mainly elaborated with only some minor changes and additions introduced later.

By the middle of the 1940s, ARI specialists jointly with pilots and navigators of Polar Aviation summarized this work and prepared a comparatively complete manual on visual airborne ice reconnaissance that was published in 1946.

Working technology foresaw entering results in ice air observations log. Flight conditions – altitude, visibility, wind, course, shore orientation marks and turning point coordinates – were registered in log. Then after the flight route correction, the working ice chart was prepared based on these records. Observers marked registered route parts with similar characteristics of ice cover. After plotting two or three track lines, it was generalized and zones with the same characteristics were identified by method of spatial interpolation and depicted by the adopted conventional designations.

Observations were made in the band of 19–20 flight altitudes (ice edge, boundaries of zones of different concentration) to 2-3 altitudes (age composition), which is explained by a different reliability and, in general, possibility to determine some characteristics or other at larger observation angles. The accuracy and reliability of the assessment of sea-ice parameters and characteristics significantly depended on the conditions of illumination, horizontal visibility, meteorological conditions and the correct choice of the flight altitude under the specific conditions.

The observation data were disseminated to users in several ways.

By first one, immediately after landing at the airport combined with the MOH, the working ice chart copy was transferred to the Headquarters.

For transferring the reconnaissance results to icebreakers and ships, the method of dropping was widespread – an ice chart copy was put to a special box with a long red ribbon and a wooden buoy, which was dropped from a low-level flight to the icebreaker’s or ship’s deck.

The method of ice observation data transmission from board aircraft in the form of radio-telegraph ice reports – a prototype of modern formats of letter-digital ice charts was also very widespread.

Depending on the type of reconnaissance, the ice conditions were described either along the flight route or over the area – characteristics of ice zones and turning points of their boundaries were enumerated.

Period from the beginning of 50s and till 70s was stage of most intensive usage of visual ice reconnaissance, because methods of observation and observations instruments corresponded with each other – there were methodic of providing observations on board of special equipped planes.

During this period re-equipment of the fleet began. Three line icebreakers of the type *Captain Belousov* were built, 1960–1969 – five diesel-electric icebreakers of the *Moskva* type. In 1959 first nuclear icebreaker *Lenin* was produced with a power 44 000 h/p. Ships of the Arctic ice class ULA *Lena* type are implemented.

From 1960 helicopters, located on icebreakers’ deck started to be used in Arctic air reconnaissance. As a rule, their crew consisted from pilot and board-observer (icebreaker hydrologist).

Main feature of helicopter reconnaissance is its uninterrupted connection and interaction with icebreaker or ship, because helicopter sets off, when icebreaker needs help in defining further route in complicated ice conditions.

Another feature is probability to make detailed picture of ice propagation and its condition, received from plane of air reconnaissance. When the velocity of plane is high, it is physically impossible to fix small details. Thus, ice conditions on charts of plane reconnaissance are rather generalized. Helicopter reconnaissance presents ice regime before the caravan or icebreaker on small area. Helicopter, having less velocity and purpose to find optimal route, searches for details.

This feature of helicopter reconnaissance sometimes were considered as “optical illusion” in eyes of some navigators. They suggested that ice reconnaissance can use helicopter and powerful icebreaker only. But without plane reconnaissance, during which main features of ice regime were defined, or without image with high resolution, received from satellite, helicopter reconnaissance didn’t work.

Other feature of helicopter reconnaissance was complete dependence from local weather conditions.

Usage of helicopter in transport ships steering with leadership of powerful icebreakers and preliminary observation of ice regime from data of plane reconnaissance increases velocity of ship caravan in two times.

And, finally, helicopter and icebreaker can be used as instrument for studying ice cover composition in different spatial scales, its structure and condition, and also propagation of ice tensions and decay. In many cases icebreakers work for long time on particular limited part of route, and many aspects of ice cover variability can be studied. Disadvantage of helicopter reconnaissance is, that under large flying time only a small amount of ice charts is left, useful for science research of large water areas.

System of hydro meteorological support was developed parallel with development of air instruments of ice reconnaissance:

- About 100 polar meteorological stations worked,
- Six regional radio meteorological centers (in Amderma, on Dixon, Chelyuskin, in Tiksi, Pevek and on Cape Schmidt) worked,
- Four Arctic science-research observatories (is. Kheisa, Tiksi, Pevek, Dixon).
- Three-level system of HMS was formed;
- Central Forecasting Service in Moscow;
- Service of long-range navigation forecasting and planning at AARI on base of ARI;
- Scientific-operational groups at three Marine Operations Headquarters (Dikson, Tiksi and Pevek).

In 1964, MANSR was reorganized to the Administration of the Northern Sea Route (ANSR) of the Ministry of Marine Fleet (MMF) with surveillance functions. Transport ships and icebreakers were given to the MMF shipping companies, the Administration of Polar Aviation to the Ministry of Civil Aviation and the HMS for shipping in the Arctic and Antarctic and its operators (AARI, RRMC, a network of polar stations) were transferred to the USSR Hydro meteorological Service.

In the 1950s, visual airborne ice reconnaissance continued to be the main tool for sea-ice monitoring and HMS of arctic navigation. Annually, 30–40 airplanes carried out 500–700 ice reconnaissance flights. However, the accuracy of visual observations did not already satisfy navigators and scientists.

Necessity of science generalization data about sea ice for purpose of analyze and forecast determined the need in receiving and systematization of data amount, which visual reconnaissance couldn't give.

These circumstances made conditional necessity to transit to instrumental ice observations, and under direct supply of navigation. Next stage in sea ice observations (1960-1970) became stage of testing and implementation of technical instruments n sea ice observations.

In the 1940s, aerial photography was the only airborne remote-sensing tool. Just in the end of this period AARI first did experimental planned aerial photography of sea ice, and in 1951 aerial photography group was formed. In 1967, the Laboratory of Instrumental Ice Reconnaissance was created on the basis of this group at the same department and in 1984 – an independent Department for improvement of the system and methods of ice observations was established.

Aerial photography is difficult to transport to users in appropriate terms. Film, separate cadre is impossible to proceed in faster regime, and make complicated photogrammetric proceeding of planned-prospective shots on board. Thus, aerial photography couldn't be used in operational purposes.

In 1950-1970 in addition to aerial photography new remote instruments started to be used in ice observations: panoramic radio station and a radar video-pulse meter of ice thickness, which allowed to measure ice thickness with accuracy 10 % in range 45-250 cm within limits of operational height from 200 to 2000 m.

In 1964 development of side-looking radar station started special for ice reconnaissance. In 1965 it was used in first ice observations. In September 1967 work of aerial side-looking radar station *Toros* were finished, and they equipped 2 planes AN-24 (cruising speed of 45(M75 km/h, flight range 2700 km, operating altitudes 5000-6000 m). In the tail compartment, a topographic aerial photo camera and a device for dropping the box with the ice chart to the icebreakers and ships from a low altitude were also installed.

Radar images were screened on an operational indicator and were simultaneously registered on the photo film of the electronic photo recording device. The photo films were developed by liquid photo reagents by means of a special processing device on board providing a possibility of their operational use.

In testing period of ice observation instruments it was possible to work with large amount of data. It allowed developing methods of proceeding information and images decoding, parallel with creating instruments themselves. Already in 1970, the methodological instruction *Airborne* *observations of the ice cover using SLAR Toros* and methods for coordination were created. Analytical programs of radar images proceeding were composed.

Nit' system was introduced into operation. The system Nit' included an airborne complex Nit'-C and the icebreaker's data receiving and processing complex Nit'-L. The system Nit'-C provided the possibility of real time translation of radar images via a special radio line to an icebreaker or any other ground-based receiving point.

Among NSR planes with Nit' C system on board were used for ice observations on entire Arctic water area.

Next stage in development of instruments and methods of ice observations (1970 - 1980) became stage of instruments usage and implementation in operational practice information, received from space instruments of remote sensing.

TIROS-1 satellite launched in USA in 1960 had the onboard instrumentation including TV cameras predominantly for cloud observations. First publications with the indication of possible use of satellite images for sea ice observations appeared in 1961. In 1966 the Russian satellite of the *Meteor-1* series made by-frame imaging using two TV cameras with optical axes deviated from the vertical. The information was received only by the main ground-based receiving stations (Moscow, Novosibirsk and Khabarovsk). Image study gave experience of sea ice decoding and practice of ice charts compiling from television satellite images.

In 1975, the first satellite of the *Meteor-2* series was launched. Information in the analogue format was transmitted not only to the main receiving centers, but also in the on-line transmission mode to the automated information receiving points (AIRP). Constant operation in the on-line mode allowed using the received information for addressing operational tasks while simultaneous work in the storage mode made it possible to make ice observations on a global scale. Thus, AARI could receive images from Arctic and Antarctic. From this moment quantitative methods of proceeding satellite information at users objects started to develop. In the same year, 1975, an algorithm and software for analytical geolocation using a rather imperfect computer Iskra-1250 were elaborated.

First oceanographic satellite *Seasat* was launched in the USA on 8 of June, 1978.

In 1979 began the development of the oceanographic satellite with Side-Looking Radar (SLR) *Okean* series and it was launched on September 28, 1983. The instrumentation onboard this spacecraft in addition to SLR included scanning sensors in the optical range, passive microwave radiometer RM-08 and a system for data collection and transmission from the automatic buoys. Satellite data in the on-line transmission and storage-replay modes were transmitted both to the main receiving stations and to the AIRP. The work program included not only the spacecraft creation but also the development of the methods of processing and using the received information. During the period of satellite construction, a preliminary methodological handbook was prepared.

After launch in September 1983 (space craft "Kosmos-1500") information was successfully used for ship steering in ice.

In February 2000, the last satellite of this series (*Okean-01*, No. 7) ended active operation.

By the mid-1970s, it became obvious that operational receiving of ice and hydro meteorological information for the entire Arctic Ocean, its maximum combining and use of advanced technologies for automatic processing and analysis, taking into account constantly expanding and changing requirements of different users, is feasible only on the basis of a systems approach to solving these tasks.

In 1975-1976, AARI developed a concept of the Automated Ice-Information System for the Arctic (AIISA). It envisaged combining and correlated functioning of all main subsystems such as: information acquisition and collection, processing, analysis, calculations and forecasts, transmission and dissemination.

In 1986 system AIISA as part of AARI was exploited.

Base of measure complex till early 1990-s consisted from planes and satellite observations. Data using, received on polar stations, drifting stations "Northern Pole", automatic ice stations and ship observations, was provided.

Analyze of technical facilities of ice observations, showed, that under their complex usage all necessary navigation data can be received with high accuracy.

Spatial resolution of board instruments of modern satellites made plane observations not necessary on entire water area of Arctic Ocean.

It is necessary to mention, that of radar imaging for operational observation of ice cover, especially in polar and near polar latitudes can facilitate. The most advantage, comparing to optical observation system, is radar imaging can be provided, e.g. from Canadian RADARSAT-1, in a day, at night, and under any weather conditions. In winter with very short light day and with large periods of unfavorable weather radar imaging cab be the only technology fro receiving operational information about ice cover.

In winter in the North or in mild or southern latitudes it is typical, when complete cloudiness can be observed for a week or more, which make impossible survey in optical range. Radar imaging by means of radar SAR satellite RADARSAT-1,2 gives opportunity to receive images with resolution 8, 25, 50 and 100 m. Images are used in shipment supply, ice study and ice observations.

Remote sensing information at present time can be used with strategy purposes, in marine operations, in compiling of long-term and short-term forecasts. It is obligatory used by navigators in route planning of helicopter aerial reconnaissance.

Significant advantages of space observation – occurrence of frequency of information arrival and efficiency of proceeding – make possible fixing of natural phenomena, which change rapid, in different time periods. Automatic technologies allow dividing ice by its concentration. As a result ice charts are composed from satellite data in navigation period, and also in autumn-winter and spring period (ice formation, ice clearance).

Among ice charts, composed by satellite images, the following types can be separated:

- Large-scale charts and plans of ice cover condition with scale 1:100 000 and larger on limited territory (in gulfs, straights, harbors);

- Operational ice charts with scale 1:200 000-1:300 000;

- Observation ice charts (monthly, decade). Such charts express ice cover condition on area of several seas (with scale 1:7 500 000 and less). They are used in science study and ice forecasting;

- Special charts, characterized ice regime. E.g., charts of particular ice age type propagation, charts of average and extreme edge location and ice boundaries, charts of average hummocking, charts of decay and other. On these charts summarized results of first observational and operational charts are presented.

At present moment best construction of ice observations is searched to provide national economy activity and exploration and transportation of hydrocarbonic raw materials from territories of Russian continental shelf. Variants of creating observation system, including orbit group of specialized satellites on polar ellipse orbits, when one satellite observes Arctic Ocean water area during 4-6 hours, is considered. Specialists – decoders of remote sensing information – would play the most important roles.