

THE POSSIBILITIES OF APPLICATION OF SATELLITE
DATA FOR MONITORING ICE CONDITION IN
THE ANTARCTIC REGION

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Commission IV

ABSTRACT

Based on satellite observation in visible and microwave ranges the possibility of investigation of ice formation process and ice melting in high latitude zones of the World Ocean is considered. The modern methods of data acquisition of the borders of drift ice, size of ice fields, age of ice formations are analysed. The methods of construction of weekly ice charts of the Arctic and Antarctic regions resulting from satellites, aircrafts and vessel observations are considered. The analysis of ice distribution in the Antarctic region in light period of 1980 - 1984 seasons is made. Annual and seasonal dynamics of ice cover is estimated. The results obtained are of practical and theoretical interest for ecological studies and for the investigations of possibilities of exploitation of live resources of the Antarctic region. The data available can be used for the development of some methods for prediction of ice conditions in the South Ocean.

The processes of ice formation and ice destruction are the main elements of oceanographic regime in the high latitudes of the World Ocean and in the seas of temperate latitudes. Ice is the major factor which produces the effect on the security of navigation and performance of various sea operations. The successful fishery in freezing seas is possible only on the basis of good understanding of the ice situation. The knowledge of the peculiarities of ice regime is necessary in planning and performance of the scientific research in different almost inaccessible region.

Sea ice can be used as a tracer in studying large-scale oceanic circulations, streams, rotations and other sea water dynamic features. The quantity of ice in partially freezing seas is the main index of winter type and good predictor of some productive processes in forecoming spring period.

The process of melting ice in the Antarctic region provides the complex of hydrometeorological processes at the edge of drifting ice and icebergs. The production of phytoplankton in these regions can be compared with some highly productive zones of the World Ocean. High abundance of phytoplankton at melting edges of drift ice is responsible for considerable formations of macrozooplankton and various fish species. Therefore, the investigations carried out aboard the R/V "Gizhiga" in the Atlantic sector of Antarctic region revealed a group of icebergs around which at the distance of 50 miles a concentration of macrozooplankton was observed. The total biomass of this concentration was estimated at about several hundreds of thousand tones.

Sea ice serves as a habitat for numerous marine animals such as penguins and crabeater seals. In high latitudes the ice distribution and shift produces a considerable impact on marine animal migrations, promoting the distribution of some species and restricting the distribution of the others.

Due to its physical properties ice is considered to be one of few parameters of marine environment which can be easily detected by remote sensing. Ice formations can be observed in visible, infra-red and radio-range waves of the electromagnetic spectrum. Each method mentioned above has its own advantages and limitations.

At present TV-images, obtained from meteorologic satellites of "Meteor" are used in the Soviet Union for operative deciphering. The application of these images allows for the determination of large ice-floes, icebergs, ice-filds, the locations of channels and polynias, ice unity and age with a high degree of accuracy. On the basis of this information the Hydrometeorological Service of the USSR regularly constructs 5-day charts of ice situation in Arctic and Antarctic region.

After geographical bridging of some TV-images from satellite the composite photographs in the polar stereographic projection (the scale 1:15000 000) are made (Fig.1)

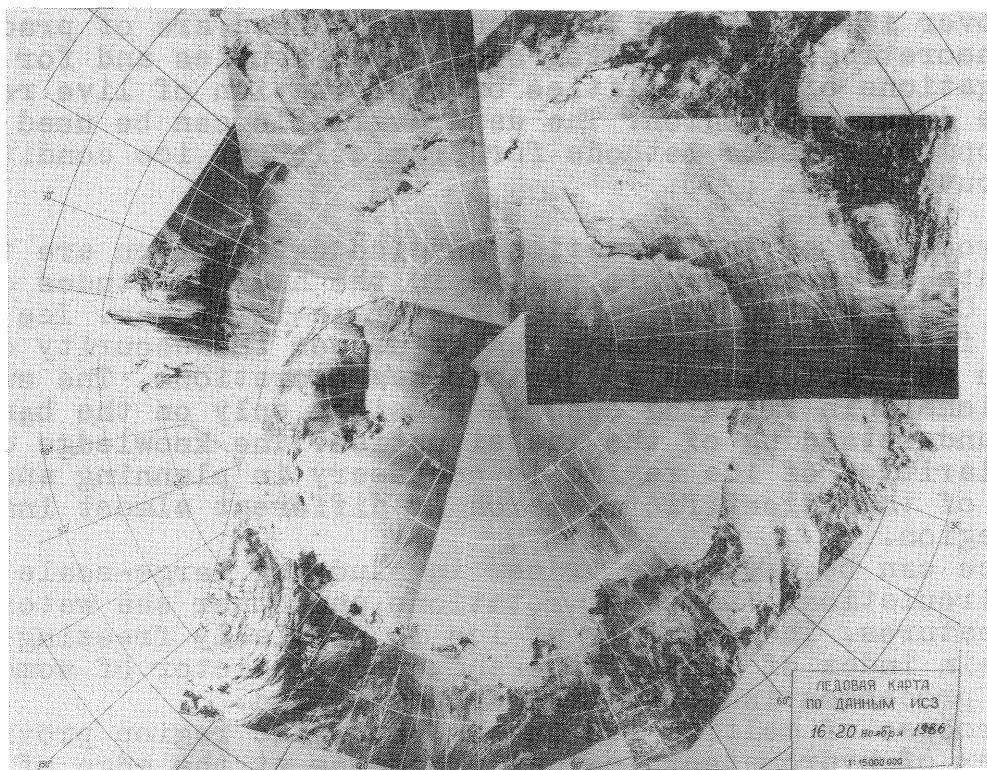


Fig. 1 An example of composite photographs of TV-images from satellite "Meteor"

By deciphering the borders of drift ice, the location of fast shore ice, the position of ice-fields, borders of various density and age, the location of channels and polynias are determined. The data obtained from the analysis of satellite information are refined and supplied by some information from shore stations, vessels and aircrafts. The refined information is transferred to the blank of the charts of Arctic and Antarctic

region in the composite photograph scale and projection. Weekly charts serve as the synthesis of satellite information, observation of aircraft, vessels and shore stations. Since 1985 for the construction of charts the radar data obtained from satellite "Kosmos-1500" was used. The satellite equipment allowed for the acquisition of data on motion and ice distribution irrespective of the condition and synoptical situation. On the radar images the ice fields and icebergs, vast extensive zones, shelf and continental glaciers are easily differentiated. The series of several radar images of the same aquatic area allows for the detection of general drift of sea ice, for estimation of the dynamics of large polynias and for the determination of the tendencies of ice compression and rarity. Figure 2 demonstrates the composite of the Antarctic ice cover. This figure is made on the basis of radar images of satellite "Kosmos-1500". Various ice formations are perfectly distinguished on the images.

Weekly charts are used for the estimation of seasonal dynamics and annual changes of ice conditions and for the determination of the extreme borders of the ice cover development. Ice charts serve as the basis for the estimation of ice drift rate and can be used for various predictions.

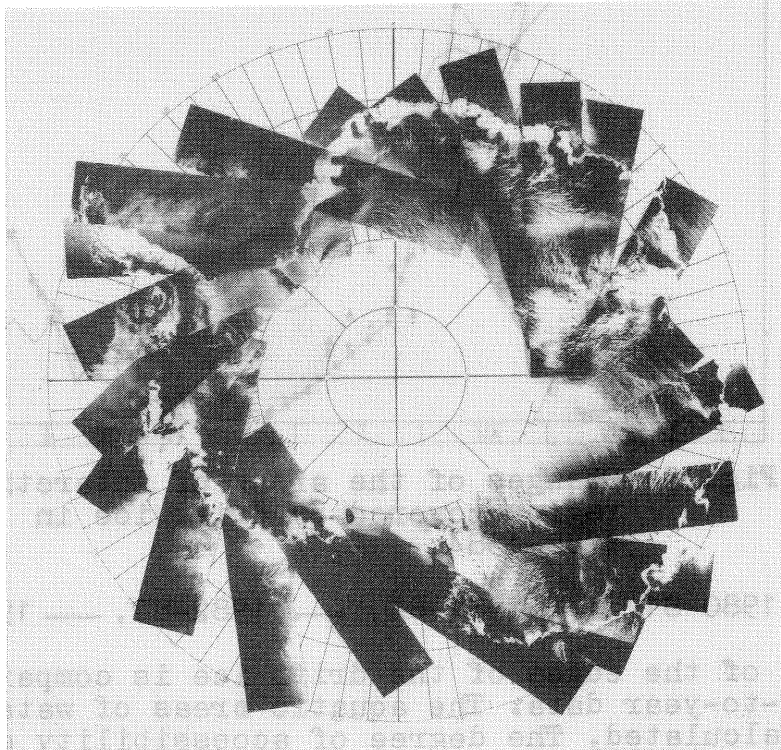


Fig. 2 An example of composite photographs of radar-images from satellite "Kosmos-1500"

Recently the Soviet Union as well as the other countries performs the studies on biological resources of the South Ocean. The investigation of the biological structure of the South Ocean demonstrated that existance of the whole complex of sea organisms functioning on the basis of macrozooplankton abundance

occurring in the highly productive pelagic zone combined with the natural zone of drift ice. The viability of the whole complex of these organisms are found to depend on ice conditions, which becomes more intensive in summer.

Based on satellite data the monitoring of ice conditions in high latitude zones was carried out. The charts broadcasted by Hydrometeorological Service of the USSR are received by the vessels and by different scientific institutions. The charts thus obtained are registered by graphical table on the magnetic disks and demand future processing. In particular for the performance of monthly analysis of the ice processes in Antarctic region the charts of the average monthly and extremal borders of ice cover development both in the whole South Ocean and in some region are made.

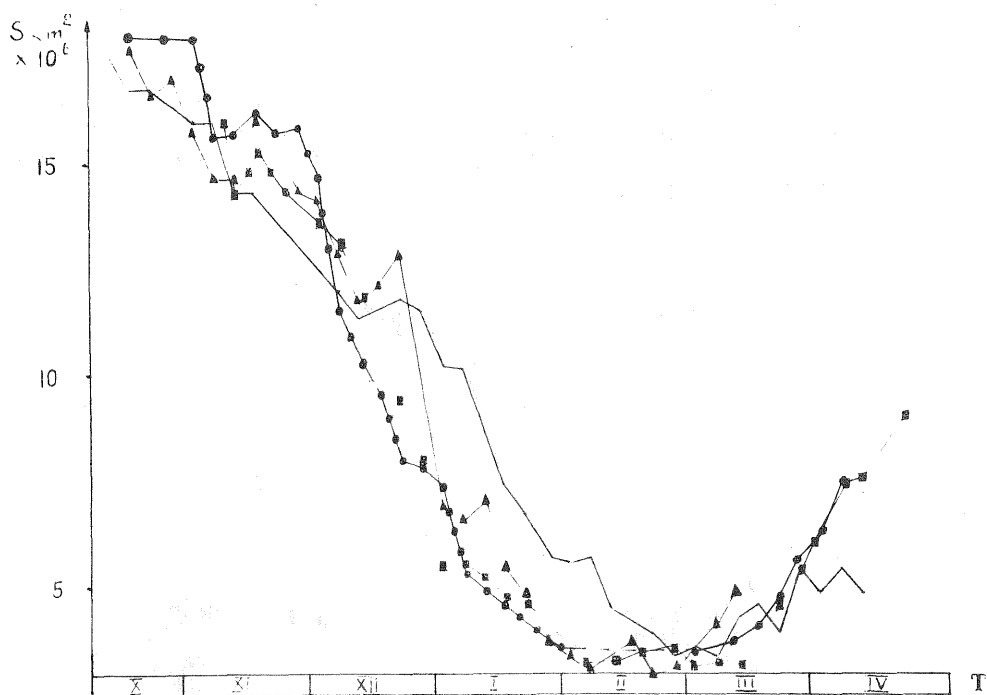


Fig. 3 Changes of the areas of Antarctic region covered by drift ice in 1980-1984

■ 1980-81, ▲ 1981-82, ● 1982-83, — 1983-84

The location of the edges of the drift ice is compared with the average year-to-year data. The aquatic areas of waters covered by ice are calculated. The degree of accessibility of some regions is also evaluated in seasonal and year-to-year aspects. Figure 3 demonstrates the graphical changes of the areas covered by drift ice in 1980-1984. As a rule the maximal development of ice-cover is observed in October. The edge of the drift ice is approximately located at latitude of 60°S . The areas covered by ice was 17-18 mln.km². When the antarctic spring begins the ice area gradually reduces. The most intensive destruction of ice cover is observed in late December - early January. The intermediate maximum observed in late November and December in all years are of interest. By early February the area

of the drift-ice reaches its minimal values and composes 2,5 - 3 mln. km². In the whole the edge of fast shore and drift-ice almost coincides with the slope of slightly mobile ice of the Antarctic regions. By late March a new period of ice formation begins. By the end of observation (in mid-April) the ice area doubles and reaches 6-7 mln. km². In spite of the common tendencies in the process of ice formation in the Antarctic region in some years the several variations in the rate of ice-formation and ice-melting were observed. Thus the presented diagram illustrates the considerable variations in 1983-1984 as compared with previous seasons. It is known, that the first half of the season the ice conditions were more severe. In January and February the area of water was covered by ice by 2-3 mln. km² more than usual. In the second part of the season the tendency changed. Figure 4 illustrates the extremal boundaries of drift ice in light period of 1982-1984.

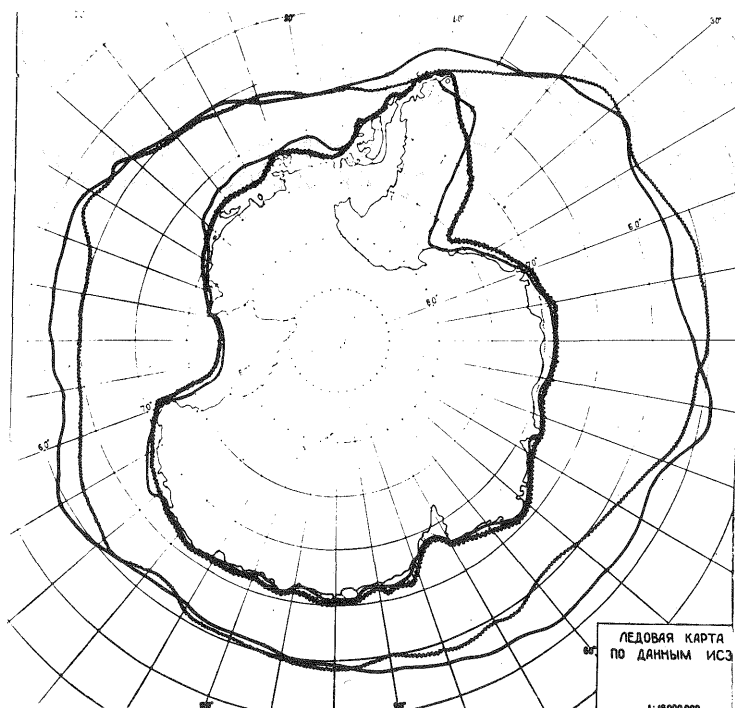


Fig. 4 Extremal boundaries of drift-ice in season
 ~~~~~ 1982-83 and — 1983-84

In 1983-1984 the maximal development of the ice cover was observed in October - November. From the beginning of October till late November the ice area reduced from 18 to 13 mln. km<sup>2</sup>, which was by 2-3 mln. km<sup>2</sup> less than observed last year. The most significant changes in the location of the borders of maximal development of ice cover were observed in central parts of the Indian and Pacific Ocean sectors. The average monthly edge of October 1983 was located 2-4° southward than that in last year. From the beginning of December 1983 till middle of February 1984 the ice area reduced from 13 to 4 mln. km<sup>2</sup>. During these months more severe ice condition were registered. In December 1983 the ice area was by 2-4 mln. km<sup>2</sup> more than last year. By the end of March - early April 1984 the ice area ex-

tended to 5,5 mln. km<sup>2</sup>. In this period in 1983 the process of ice formations was more intensive. By the beginning of April 1983 the area of drifting ice was 7.5 mln. km<sup>2</sup>. All the above mentioned examples show that the satellites provide the valuable information on distant regions. The results of satellite observations are of great practical value for researches. The material obtained can serve as a basis for improving of the prediction of ice conditions in the Antarctic region.

#### REFERENCES

1. Промысловая океанография. Под.ред. Д.Е. Гершановича, Москва, Агропромиздат, 1986г.
2. Исследования распределения и динамики морских льдов по ТВ-снимкам ИСЗ "Метеор". Временная инструкция, Ленинград, Гидрометеоиздат, 1978г.
3. Бурцев А.И., Кровотынцев В.А., Назиров В.М. и др. Радиолокационные карты Арктики и Антарктиды по данным ИСЗ "Космос-1500" и предварительные результаты их анализа. Исследования Земли из космоса, № 3, 1985г.
4. Любимова Т.Г., Макаров Р.Р., Шуст К.В. и др. Биологические ресурсы Южного океана. Обзорная информация ЦНИИТЭИРХ. вып. 2, 1983г.