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# MODIFICATION PARAMETERS OF THE IONOSPHERE PLASMA ABOVE THE POLLUTION ZONES IN THE EURO-ARCTIC REGION

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**Abstract.** We have analysed the satellite measurements of low-frequency emission (0.1 ÷ 20 kHz) intensity, low energy electron fluxes and plasma temperature above the radioactive pollution zones in the seas of the Arctic Ocean, North Atlantic and Euro-Arctic region, established from testing sea water and bottom precipitation samples. It is shown that the zones of simultaneous variations in the above ionospheric parameters are coincident with the radioactive pollution zones and with those of intense helium and hydrogen ion fluxes. We evidence that the radioactive pollution zones can be detected by the satellite measurements of ionosphere plasma parameters above different regions of the Earth's surface.

## Introduction

From the data of "Intercosmos-19" satellite, a previously unknown effect of low-frequency emission excitation and variations of electron flux density above the deep faults of the Earth's crust has been revealed. This result suggests that the ionosphere can be an indicator of geodynamic processes in the lithosphere. It is known that the anthropogenic pollution zones in the lower atmosphere and bottom hydrosphere are mostly attached to the zones of deep faults. The distribution of radioactive element concentration depends on the soil and bottom relief peculiarities, which are connected with the structure of the Earth's crust and geodynamic processes in it (Migulin et al., 2000).
There are dangerous kinds of pollution in the seas and atmosphere, including the artificial radioactive materials produced by nuclear explosions, nuclear navy and civil ships, in using the basins of polar shelf for nuclear waste disposal, etc. The identification of radioactive pollution zones is currently an important problem for controlling the radiation situation in the regions.

## Data

We have analysed the satellite measurements of low-frequency emission (0.1 ÷ 20 kHz) intensity, low energy electron fluxes and plasma temperature above the radioactive pollution zones in the seas of the Arctic Ocean, North Atlantic (Sergeeva et al., 2004) and Euro-Arctic region. For the chosen orbits, the geophysical conditions were weakly disturbed ( $K_p = 2 \div 4_+$ ). The intensity of the low-frequency emissions at frequencies: 140, 450, 800, 4650, 15000 Hz for the electric and magnetic components, low energy (50-150 eV) electron fluxes and plasma temperature ($T_н$) were measured. In some cases, above the deep faults, simultaneous intensive variations of these ionospheric parameters were observed (Figure 1). In Fig. 1a are shown simultaneous intense variations of the three parameters observed on March 15, 1979 at 18.46-18.48 and 18.50.30-18.54 UT at orbit 233.
The zones of simultaneous variations of low-frequency emission intensity, low energy electron fluxes and plasma temperature turned out to be above the radioactive pollution zones, which had been earlier detected by testing sea water and bottom precipitation samples (Matishov et al., 1994, 1998) in the region of the Greenland Sea (18.46-18.48 UT), South-Barents basin and Novaya Zemlya (18.50.30-18.54 UT).
The Japanese satellite "ISS-b" flew at the altitude of about 1070 km above the South-Barents, Novaya Zemlya, and the Kola coast. It detected helium and hydrogen ions (Summary plot, 1983). The projections of orbits 234 and 1537 above the region under study onto the Earth's surface are given in Fig. 1 b, where the distribution of helium and hydrogen ions is shown. The time and location of the zones of simultaneous variations in the low-frequency emission intensity, low energy electron fluxes and plasma temperature are indicated on the orbit projections.

a)

b)

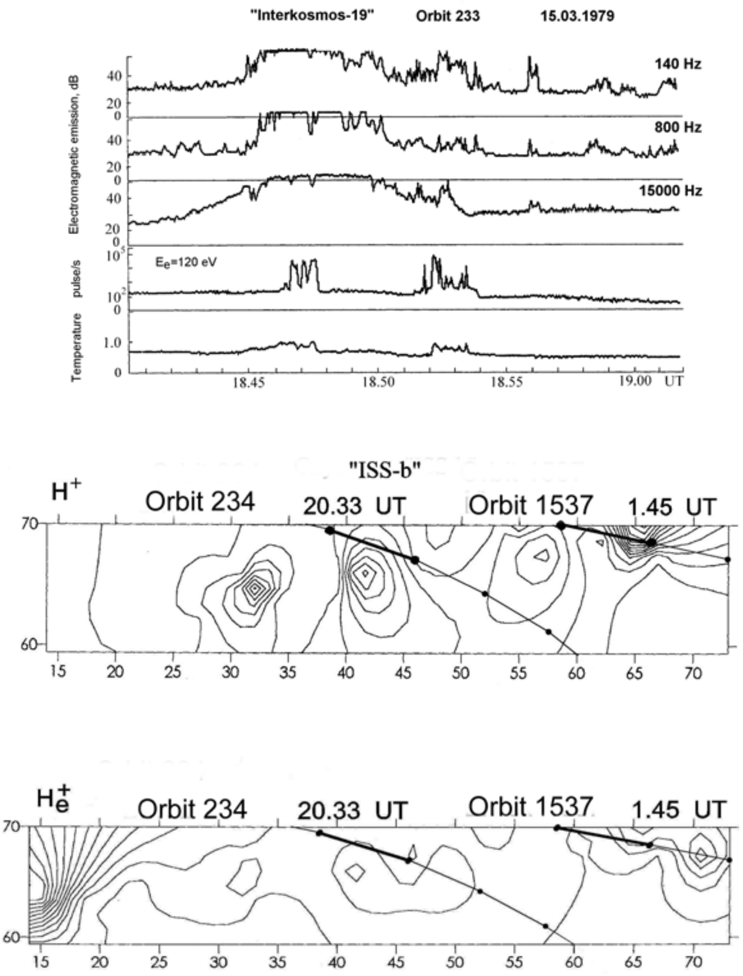


Figure 1. Satellite measurements of: (a) VLF-emission intensity, low energy electron fluxes and ionospheric plasma temperature, (b) hydrogen and helium ions.

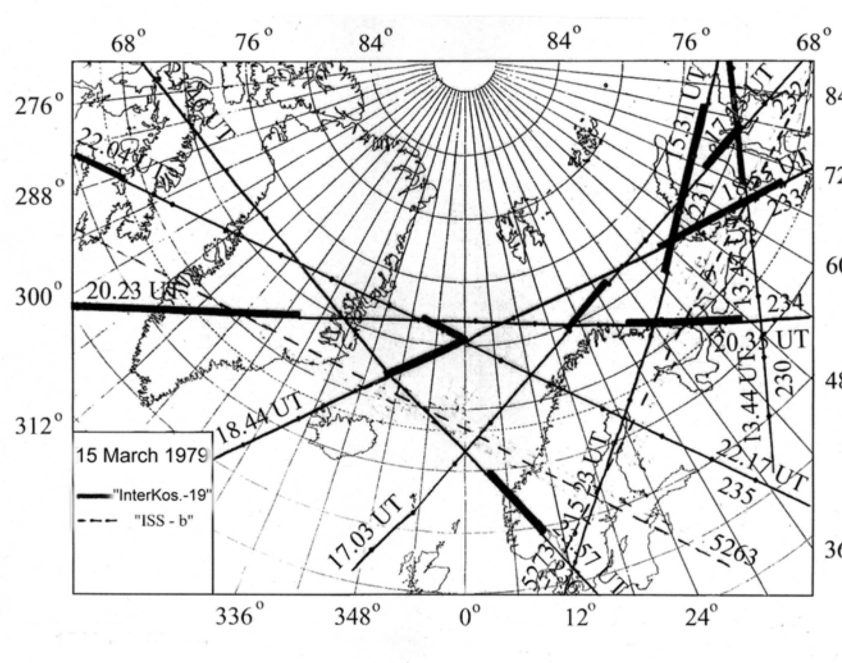


Figure 2. The map of orbit projections onto the Earth's surface.

It is seen from Figure 1 that the zones of the simultaneous variations in the above-listed parameters are spatially coincident with the regions of helium and hydrogen ion registration at 1.44-1.45 UT (orbit 1537 above the South-Barents basin ) and at 20.33-20.34 UT (orbit 234 above the Kola coast ). Hence, the radioactive pollution zones can be detected from satellite measurements of ionospheric plasma parameters above various regions of the Earth's surface. The light ions of helium and hydrogen can also be an indicator of radioactive pollution. The specific simultaneous changes of the ionosphere plasma parameters above radioactive pollution zones are quite distinct: for several seconds the low energy electron fluxes vary by 1,5-2 orders of magnitude, plasma temperature increases by 20-25% compared to the background value, low-frequency emission intensity increases by 30%. Based on this finding, we propose a new method for detection of radioactive pollution zones described in detail in (Larkina et al., 2003, 2004).

The projections of "Intercosmos 19" satellite orbits onto the Earth's surface are shown in Figure 2 a (1537, June 14, 1979; 231-235 March 15, 1979), in which the time and location of the zone of simultaneous variations in the low-frequency emission intensity, low energy electron fluxes and plasma temperature are also indicated. In Figure 2 we show the radioactive pollution zones, established in the manner described above. These are the zone of Novaya Zemlya and Barents- Kara Seas, the south-west zone of the Barents Sea and the north- west Atlantic (the Greenland and the Northern Seas), the Central Barents basin, the zone of the Kola coast, the zone in the head Yenisei and Ob rivers, the zone of the South Greenland, Canada, the south-west zone of Scandinavian Peninsula.

The radioactive pollution zones in the region of Novaya Zemlya and north-west Atlantic are shown in Figures 3 and 4. It is known from publications that in Novaya Zemlya bays of the Barents and Kara Seas, the containers with hard radioactive waste had regularly been buried from 1965 to 1986 (Zolotkov, 1991). Different maps indicating burial places of more than 11000 radioactive waste containers as well as of 15 used nuclear submarine reactors in the Barents, Kara Seas around Novaya Zemlya have been published. The accumulation sites of hard radioactive wastes in the archipelago of Novaya Zemlya of the Barents, Kara Seas are shown with crosses in Figure 3 a (Morozov, 2000). The map of pollution of the bottom water environment of the Barents, Kara Seas by artificial radio nuclides of caesium-137 was drawn based on the analysis of samples of sea water and bottom precipitation (Strand et all, 1993). The South-Barents basin is characterized by an increased concentration of artificial radionuclide- caesium-137 in bottom precipitations (Matishov et al., 1998). Simultaneous variations of low-frequency emission intensity, low energy electron fluxes and ionospheric plasma temperature are observed at orbits 231–233 and 1537 above this pollution zone (Figure 1). As mentioned above, the zone of simultaneous variations of ionospheric parameters in the period of 1.44-1.45 UT at orbit 1537 is coincident with that of intense helium and hydrogen ion fluxes above the South-Barents basin (Figure 1 b). Fragments of the orbits (232-235, 1537) mapped onto the Earth's surface are shown in Figure 4 a. The time and location of the considered zones are also indicated. The distribution of caesium-137 concentration in the water layers of the seas of the Northwest Europe in 1981 is shown in Figure 4b (Vakulovskiy et al., 1985; Kershaw et. all, 1993). The size of circle diameters is proportional to the level of contamination.

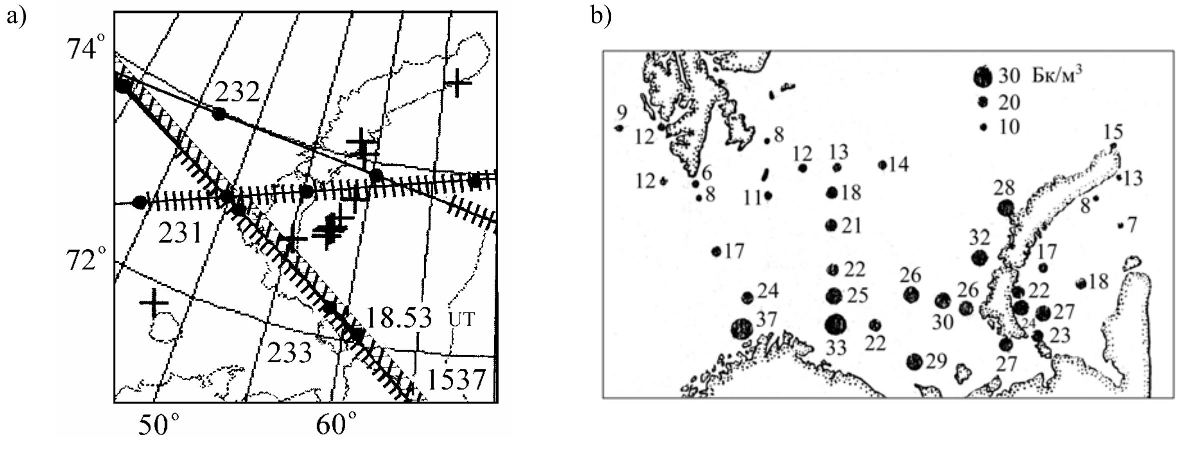


Figure 3. The radioactive pollution zone of Novaya Zemlya and the Barents, Kara Seas.

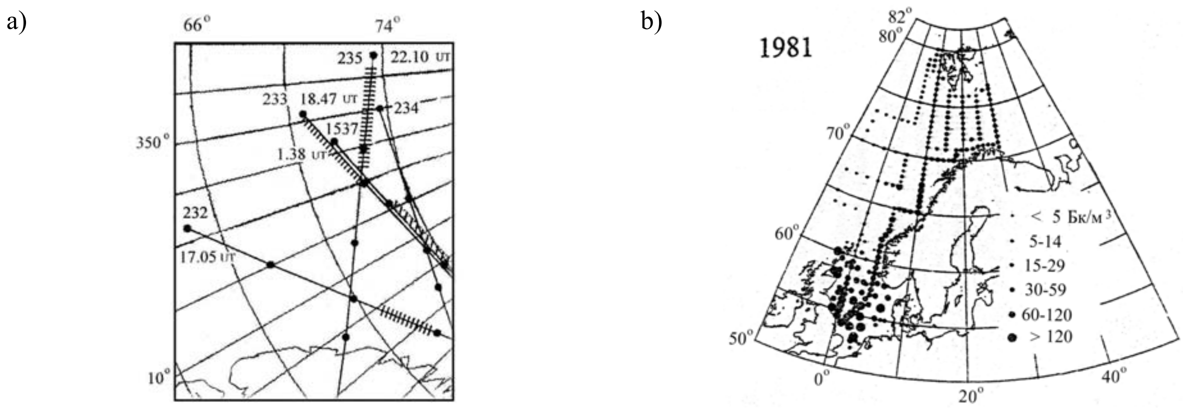


Figure 4. The South-West radioactive pollution zone of the Barents Sea and North-West Atlantic.

The disposals of radioactive wastes from the facilities processing nuclear fuel, that were especially numerous at the end of the 70s, are the main source of pollution in the North Atlantic basin (Shellafield, the UK). The radionuclides caesium-137 and other isotopes, getting into the sea with the wasted fuel, are carried by sea currents from the Irish Sea to the North Atlantic and Northern Sea.

We have detected the radioactive pollution zone of South Greenland and the Canadian zone (the Baffin Land Island, Figure 2) by satellite measurements of ionospheric plasma parameters, as described above. The artificial radionuclides, emitted into the atmosphere, result in the formation of polluted layers deep inside the thick cover of Greenland, North American and Spitsbergen glaciers. Testing of sea water probes near the Greenland shores showed that the highest caesium-137 concentrations are observed along the eastern cost (Matishov, 2001).

## Summary

Simultaneous variations of ionospheric parameters above the radioactive pollution zones in the seas of the Euro-Arctic region and North-West Europe are registered. The density of low energy electron fluxes, as well as plasma temperature, vary sharply at satellite altitudes.

The radioactive pollution zones can be detected from satellite measurements of the ionospheric plasma parameters above different regions of the Earth's surface.

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