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Application of Geoinformation Technologies for Minimization of Thyroid Gland Diseases in the Impact Areas of the Radioiodine Fallout

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Please note that the presented materials have not yet been published

Introduction

Modern geoinformation technologies are widely used in spatial data analysis including distribution of specific diseases.

Although thyroid goiter has been known since ancient times, it was not earlier than the middle of XIXth century when a French scientist C. Chatin has related this disease to deficiency of the chemical element (iodine). And not earlier than 1938 a Russian scientist A. Vinogradov has coined the notion of biogeochemical provinces to distinguish areas of specific endemic disease of geochemical origin and summarized natural factors contributing to goiter manifestation.

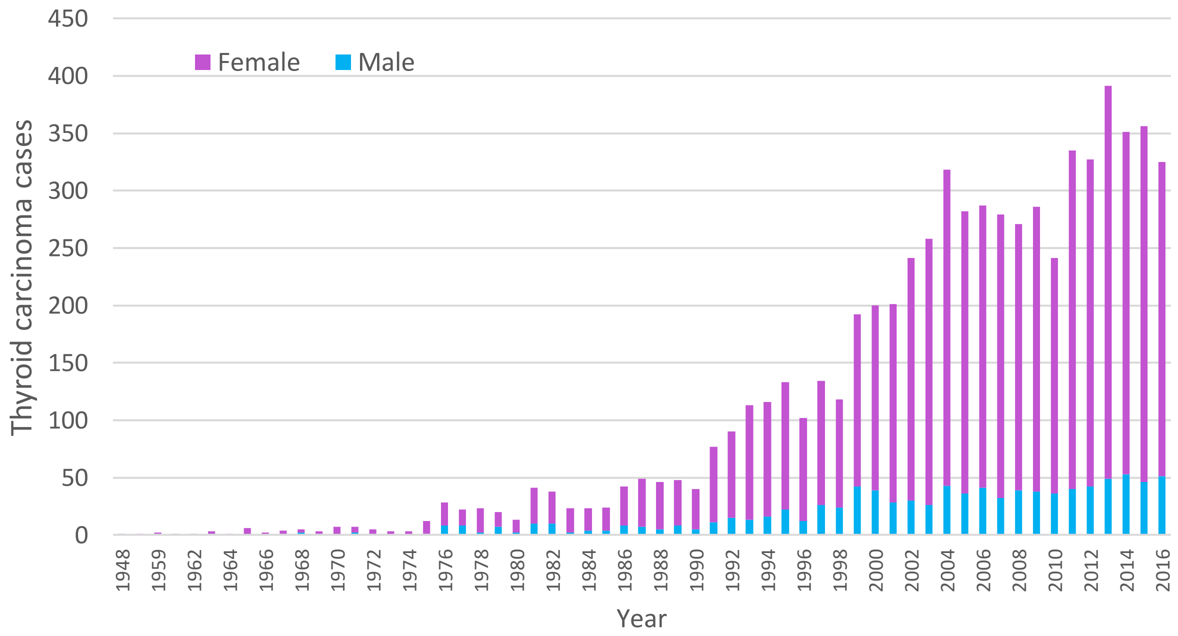
The Chernobyl accident has highlighted the problem of a combined negative impact of artificial and natural factors of geochemical origin.

Thyroid cancer distribution before and after the Chernobyl accident

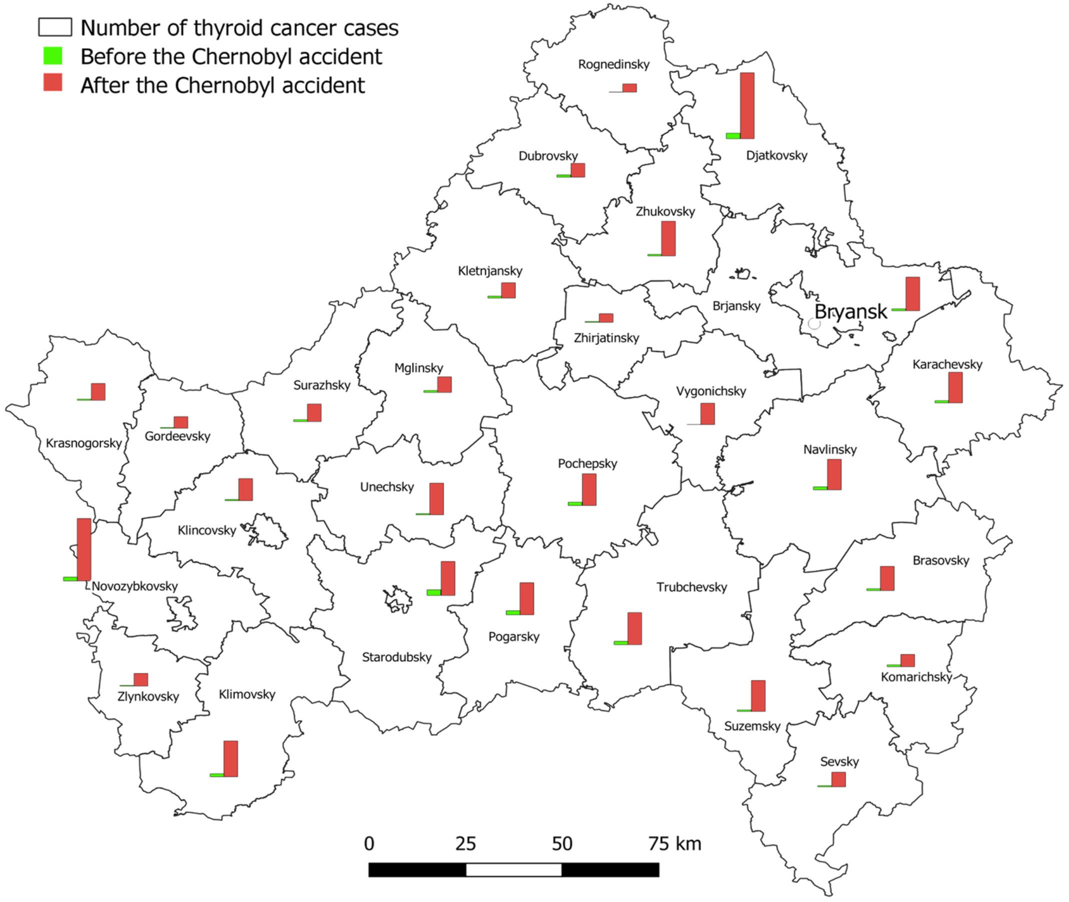
There was a considerable increase of papillary thyroid cancer cases five years after the Chernobyl accident.

Chernobyl accident lead to atmospheric fallout of radioactive isotope ^{131}I which followed the natural iodine pathway and concentrated in thyroid gland causing its irradiation.

Affected areas were known for stable iodine deficiency in local diets.

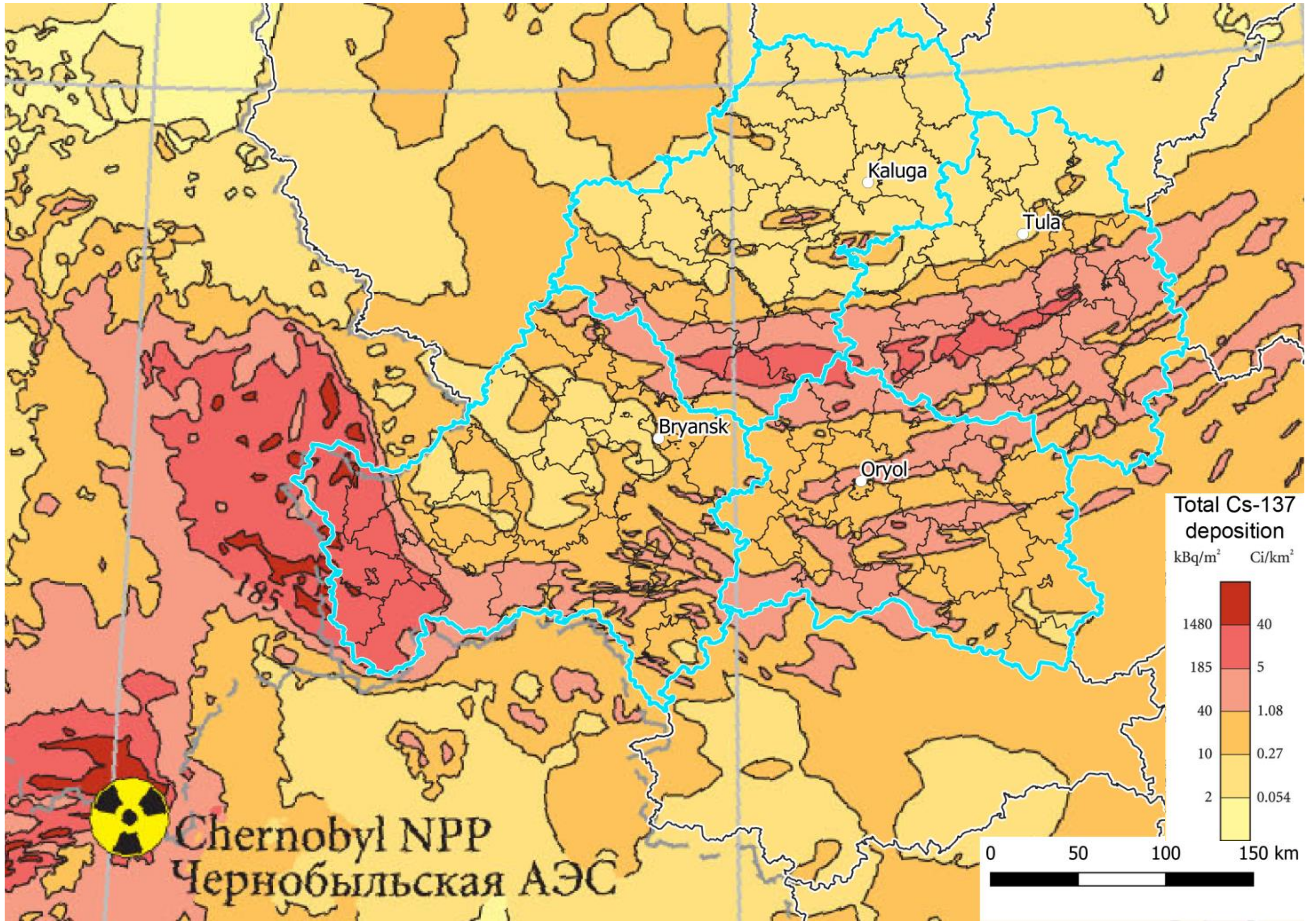


Papillary thyroid cancer dynamics in the Bryansk region



Papillary thyroid cancer dynamics in the Bryansk region administrative districts

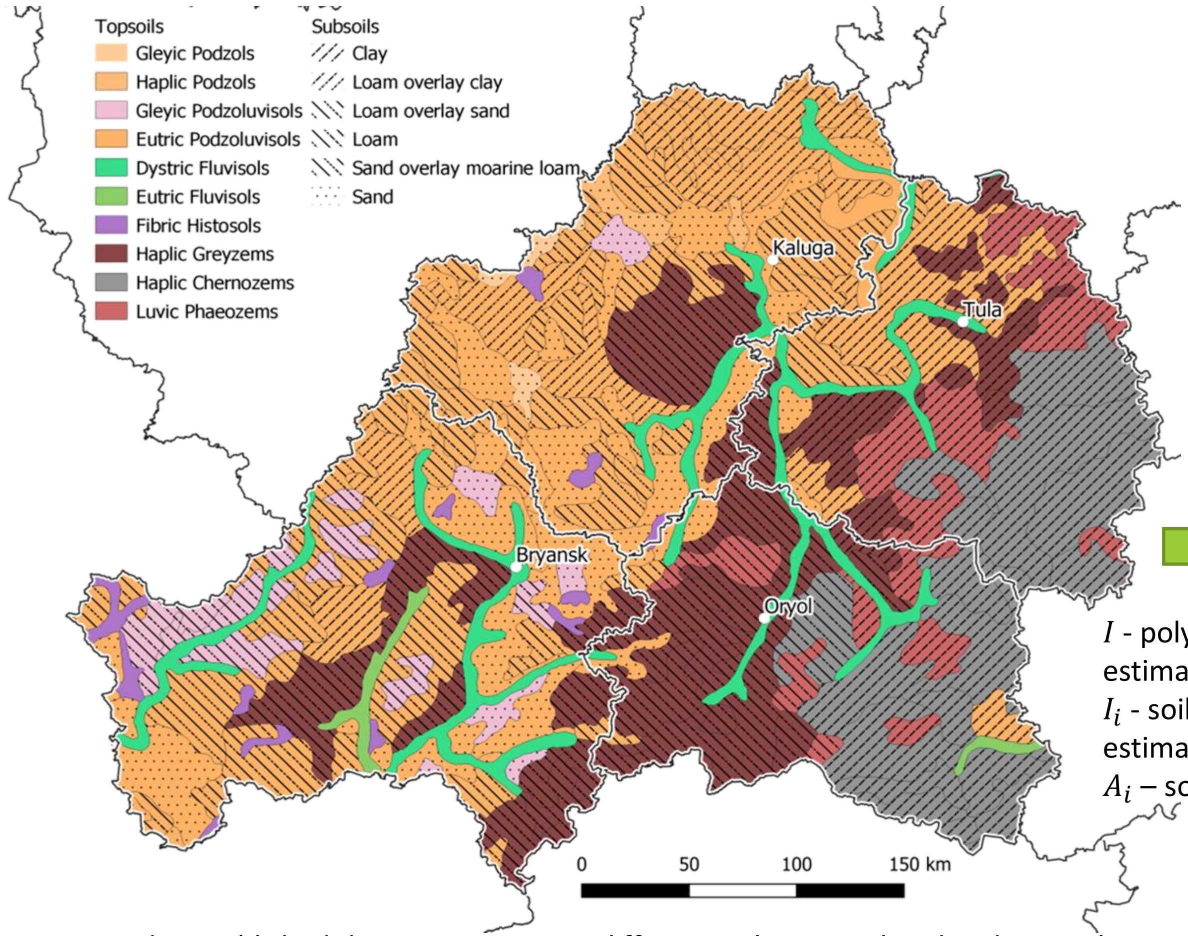
Specialized geographic information system



To study the geochemical factors responsible for distribution of the thyroid gland diseases in Chernobyl fallout area we have created and develop a specialized geographic information system basing on the idea of a two-layers spatial structure of modern noosphere (*Korobova, 2017*) according to which the natural geochemical background reflected in the soil cover structure is overlain by technogenic contamination fields and the observed spatial distribution of endemic diseases result from a combined negative effect of the overlay.

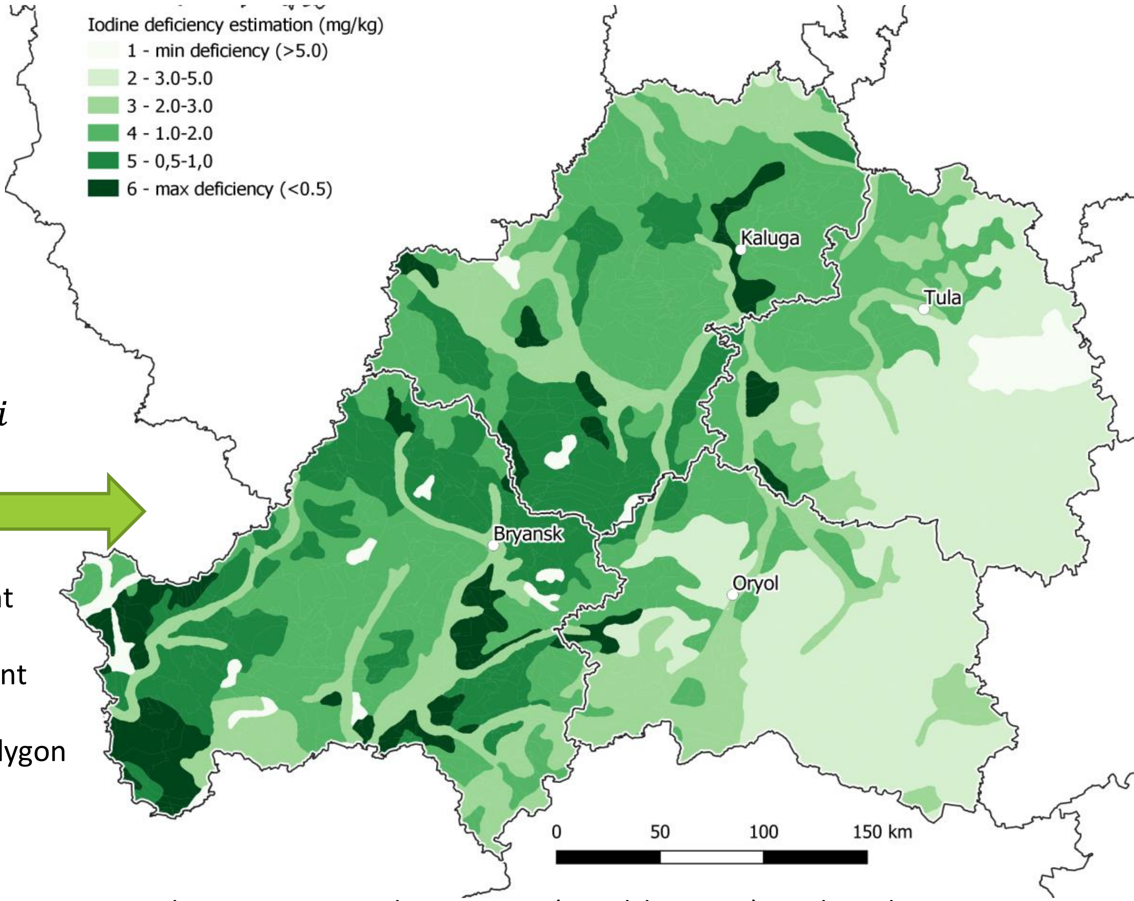
The study was performed for 4 regions subjected to the Chernobyl accident (Bryansk, Oryol, Kaluga and Tula regions).

Mapping Iodine deficiency



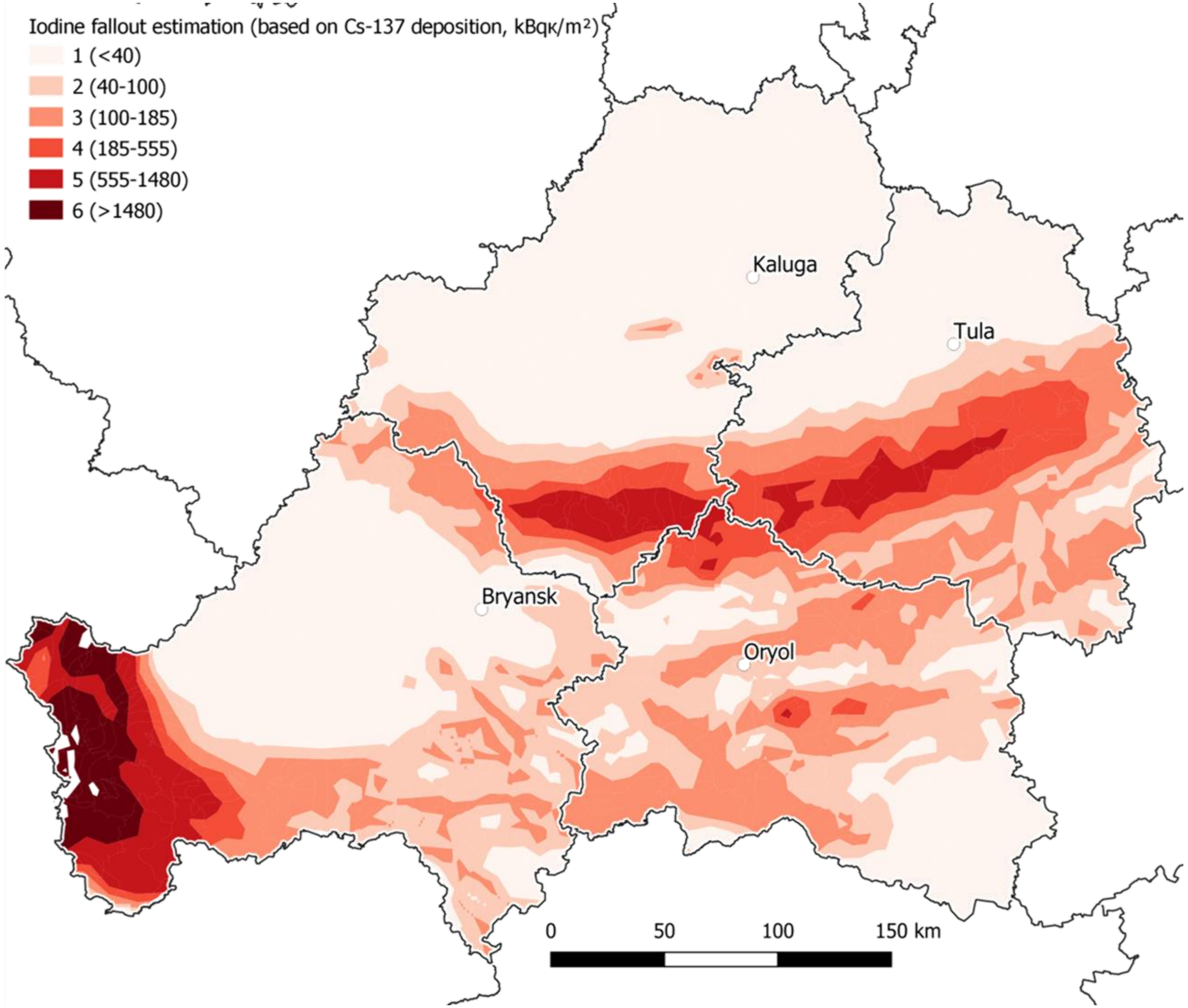
$$I = \sum_{i=1}^{4} I_i \, A_i$$

I - polygon iodine content estimation;
I_i - soil type iodine content estimation;
A_i – soil area share in polygon



Based on published data on I content in different soils on one hand and microelements threshold concentration in soils causing microelementoses (Kovalsky, 1974) on the other, every soil type and soils combination in vicinity of settlements were evaluated in terms of iodine supply. This allowed creation of the maps of iodine deficiency for the study area. Based on soil iodine evaluation, the area was divided into 6 zones with the range from 1 (for maximum iodine concentration in soils and its minimum deficiency) to 6 (for minimum iodine concentration and maximum deficiency).

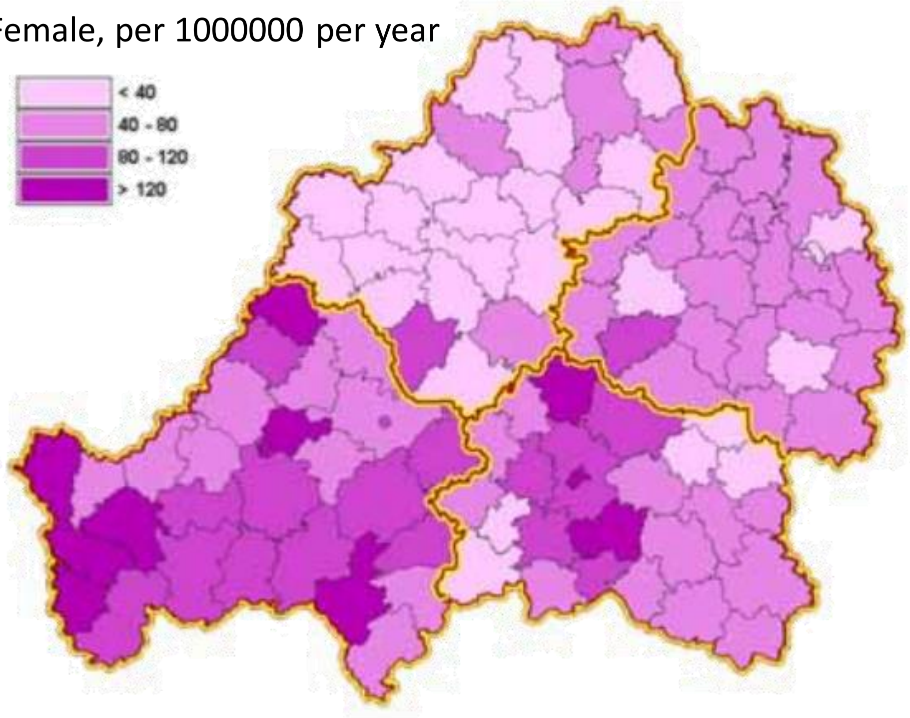
Iodine contamination



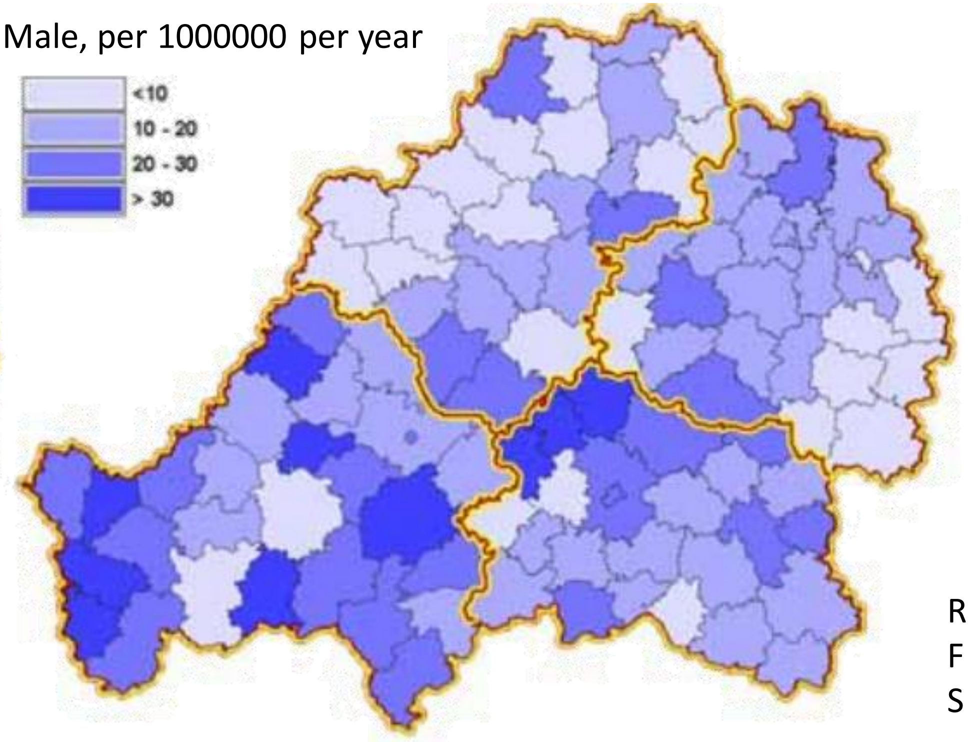
Basing on cartographic data on the contamination of ^{137}Cs and the published correlation between ^{137}Cs and ^{131}I fallout, a map of radioiodine contamination was constructed and the study area was divided into 6 zones.

Standardized morbidity rate of thyroid cancer (code C-73 ICD-10)

Female, per 1000000 per year



Male, per 1000000 per year



	β	standard error (β)	p-value
Intercept term			0,12
Iodine fallout evaluation	0,45	0,09	0,000003
Natural iodine deficiency evaluation	0,19	0,09	0,03

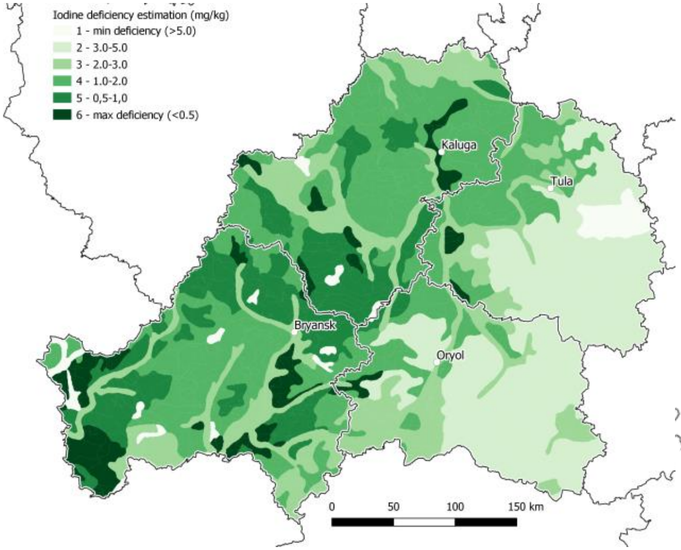
R=0,72F+0,28S

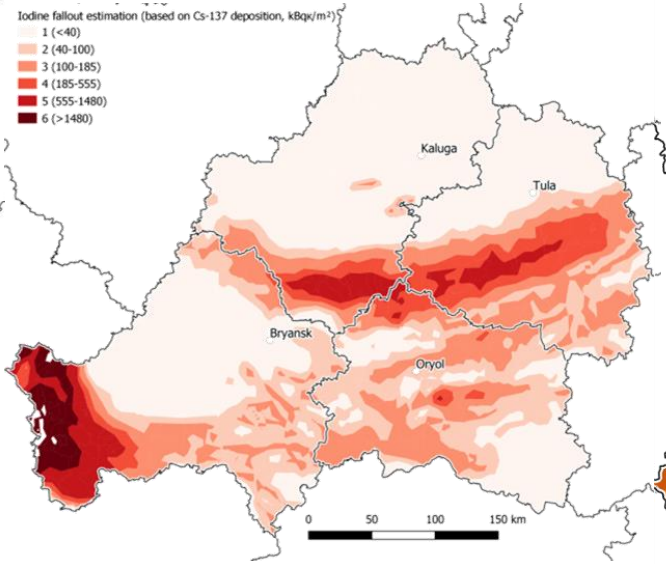
R – total risk (1 to 6)
F – iodine fallout evaluation (1 to 6);
S – natural iodine deficiency in soils (1 to 6)

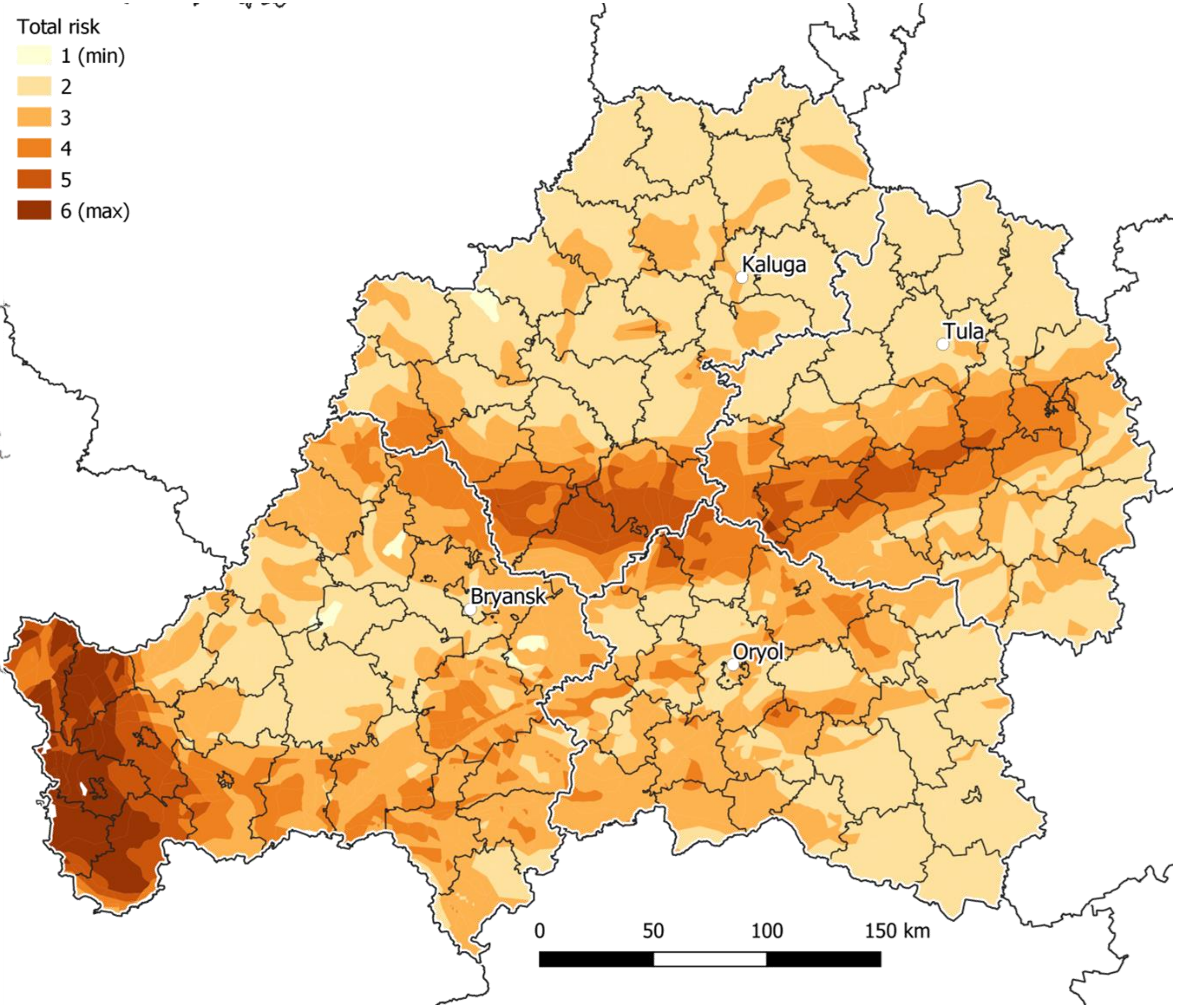
Medical data: Ivanov et al. The main results of radio-epidemiology analysis of RGMDR data // Radiation and risk. 2005. №S3. (in Russian)

To estimate contribution of natural iodine deficiency and radioiodine fallout regression analysis was performed to evaluate a combined risk for 93 rural districts. As a result, the formula to evaluate natural-technogenical risk was calculated.

Overlay

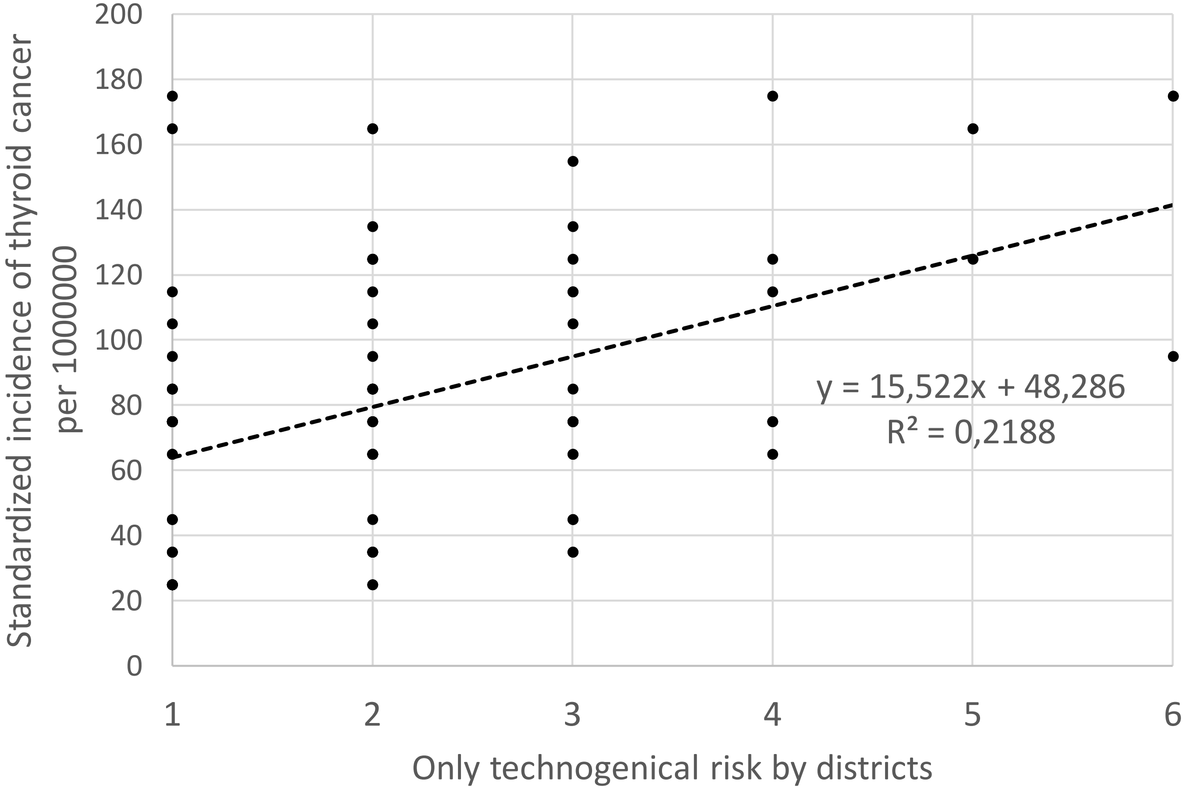


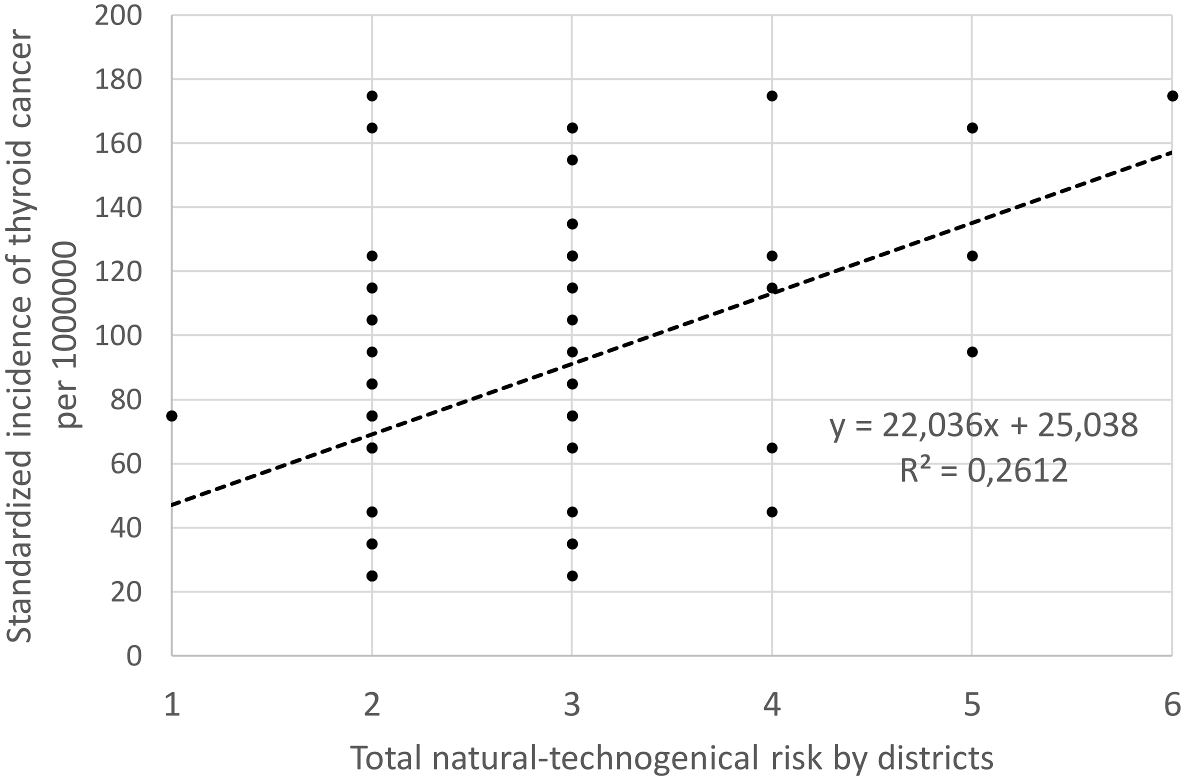




An overlay of natural iodine deficiency and technogenic iodine fallout map layers classified by 6 zones from minimum to maximum risk allowed to identify 6 zones and to evaluate a combined risk for 93 rural districts.

Comparison of risk map and medical data





Comparison of the created combined risk map and radionuclide contamination map with regional medical data on standardized incidence of thyroid cancer (code C-73 ICD-10) in different regions showed a very high variation, however the correlation was higher if both geochemical factors were considered ($r = 0.505$, $p < 0.01$) compared to the map of the levels of radionuclide loss ($r = 0.468$, $p < 0.01$). All this, obviously, demonstrates that the proposed GIS technology will be useful in spatial evaluation of distribution of thyroid diseases and adequate minimization of thyroid cancer incidence in areas subjected to radioiodine impact.

Thank you for your attention!