*St. Petersburg Scientific Research Center for Ecological Safety RAS*

# Satellite mapping of ecological risks and damages

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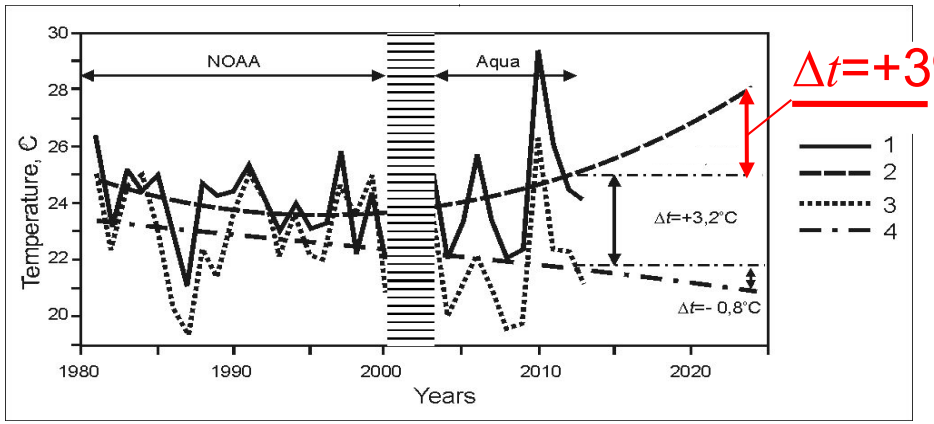
Saint-Petersburg — Helsinki
2020

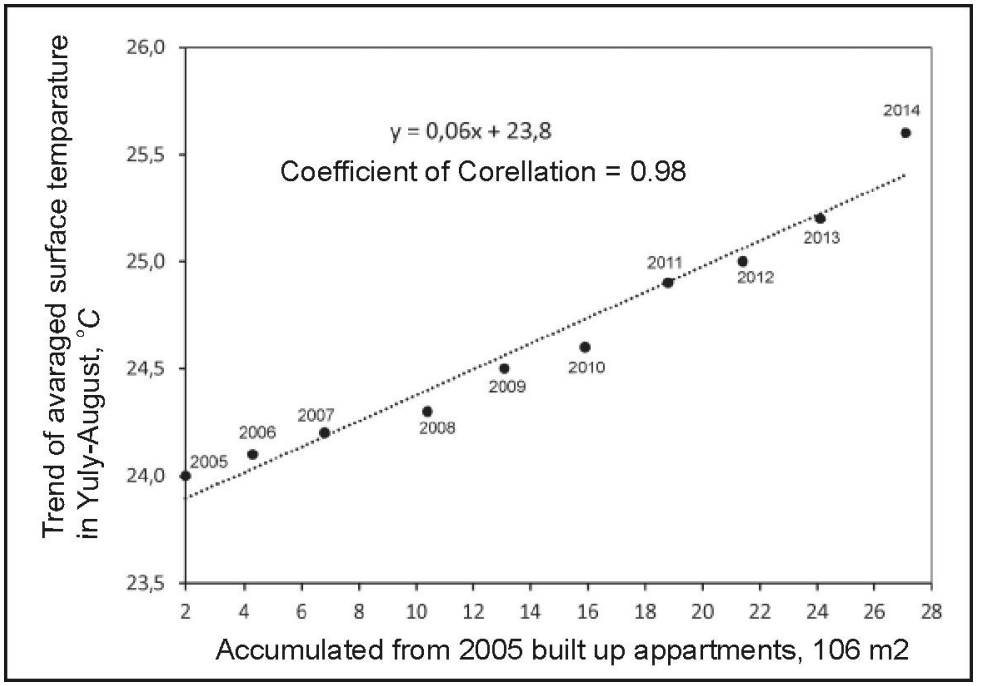
# 2 Hazard of urban surface overheating

Forecast of St. Petersburg surface temperature * in 2025 (on the base of satellite IR survey)




1. Day time surface temperature, averaged for squer of St.Petersburg for the period from July 4 up to August 5.
2. Trend for St.Petersburg.
3. Day time surface temperature,averaged for squer of Leningrad Oblast' for the period from July 4 up to August 5).
4. Trend for Leningrad Oblast'.

Strong linear dependance of St. Petersburg surface temperature from accumulated area of built up appartments

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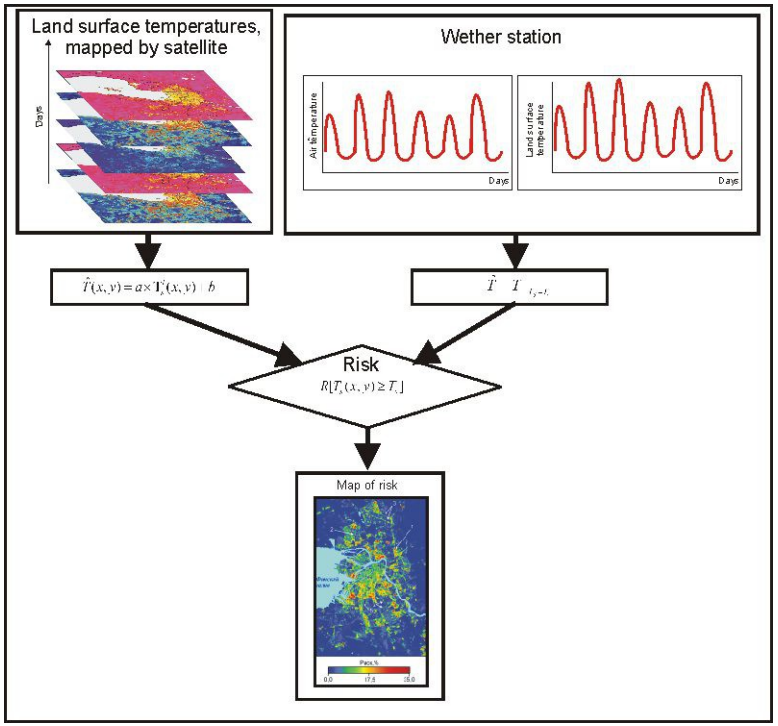
* *Gornyy V.I. Et al., Forecast of Saint-Petersburg and Kiev thermal replies on climate change (on the basis of EOS and Landsat satellite imagery) // Sovremennye problemy DZZ iz kosmosa. 2016. Vol.. 13. No. 2. PP. 176–191. http://d33.infospace.ru/d33_conf/sb2016t2/176-191.pdf*

# 3 Risk (probability) of traffic collaps in St. Petersburg due to road cover «melting»

$$R(T_S \geq T_o) = \int_{\hat{T}}^{\infty} f(T)dT;$$

$R$ - risk (probability) of road cover softening; $f(T)$ - Gaussian function; $T$ - maximum air temperature at weather station; $T_S$ - land surface temperature; $T_o$ - temperature of road bitumen melting; $T_o$=+33°$C$; $\hat{T}$ - maximum air temperature, corresponded to $T_o$ on the land surface.

## Algorithm




Technique of risk mapping uses spatiall - time dependance between temperatures of land surface and air.

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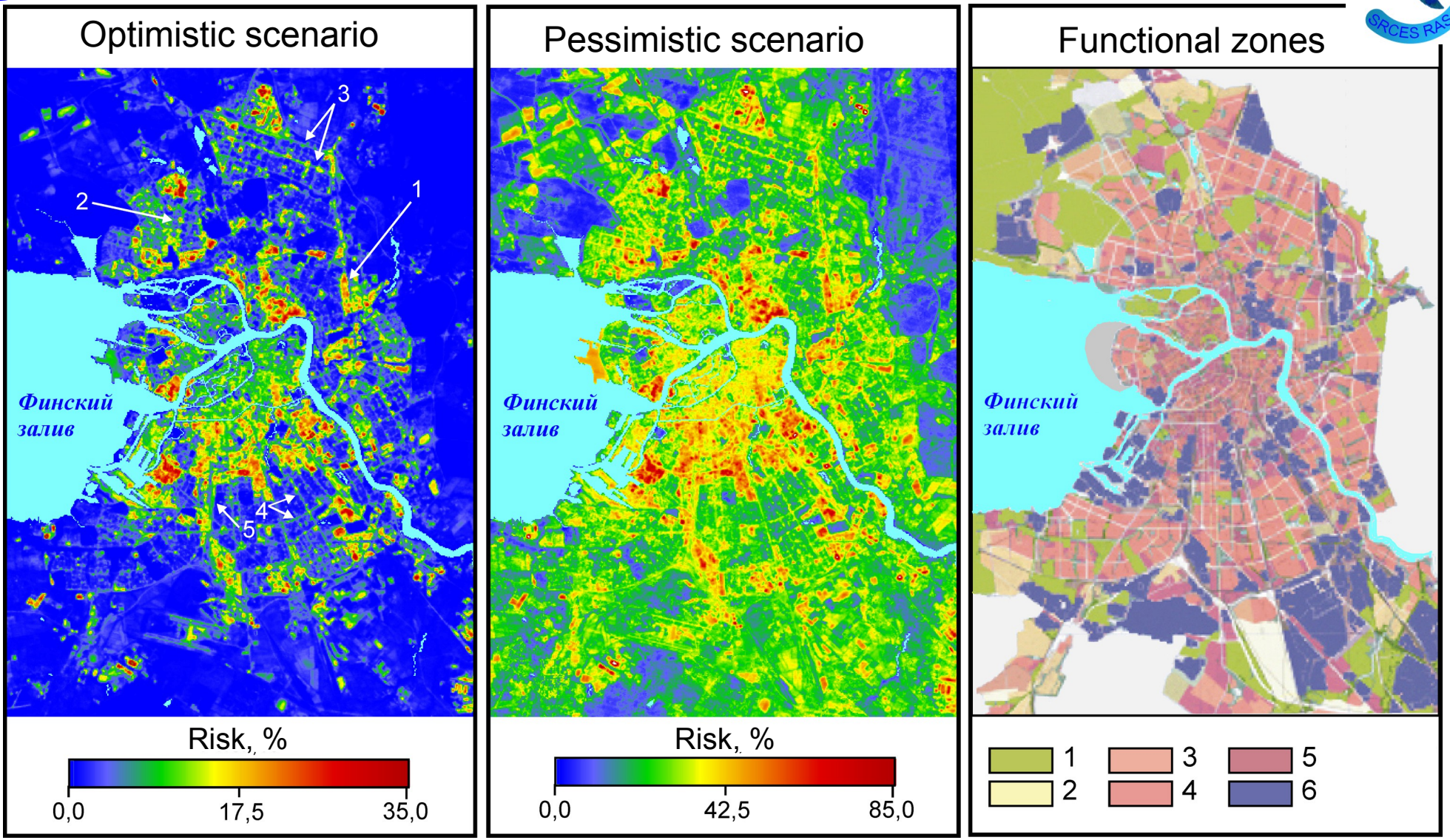
** Kritsuk et al.Satellite risk mapping of urban surface overheating (by the example of Saint Petersburg) // Sovremennye problemy DZZ iz kosmosa*. Vol. 16. No. 5, 2019. pp.34-44. *http://d33.infospace.ru/d33_conf/sb2019t5/34-44.pdf*

# 4 Maps of risk of road cover softening




Zones: 1. Recriacin; 2.Leningrad Oblast'; 3-5. Residential; 6. Industrial.

I $R(T_S \geqslant +33\,^{\circ}\mathrm{C}) = 35\,\%$ - road softening will be ones during 12 years with probability 99,1%

f $R(T_S \geqslant +33\,^{\circ}\mathrm{C}) = 85\,\%$ - road softening be ones during 3 years with probability 99,7%

f

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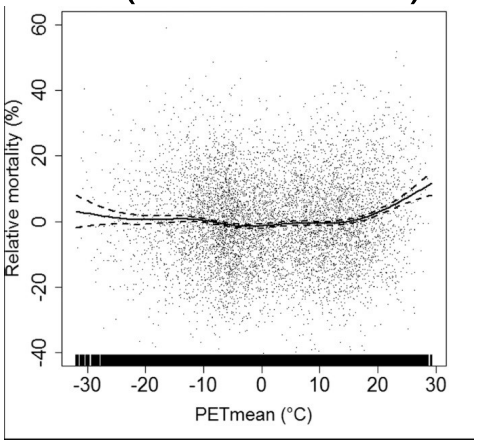
# Overheating and mortality

Dependence of mortality in Helsinki from daily averaged physiologically equivalent temperature* (1994 -2014)

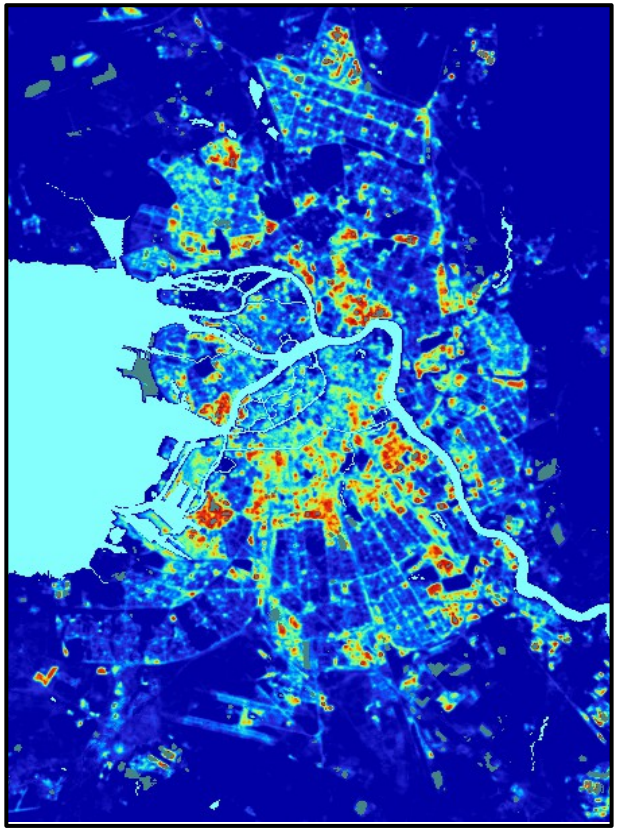



$T_o$= + 21.5°C

Expected number of death for the mapped territory of St. Petersburg are 223

Economical losses are ~ 500 million Rubles/year.

Preliminary map of risk of death from overheating



Risk of death, %

0.0 0.04 0.08

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* *Ruuhela R. Biometeorological Assessment of Mortality Related to Extreme Temperatures in Helsinki Region, Finland, 1972–2014 / R. Ruuhela, K. Jylha, T. Lanki, P. Tiittanen and A. Matzarakis // Int. J. Environ. Res. Public Health. – 2017. - 14, - P. 944. https://pubmed.ncbi.nlm.nih.gov/28829351/*

# Thermodynamic approach to ecosystem health mapping*

*On the base of : Jorgensen S. E., Svirezhev Yu.M. Towards a Thermodynamic Theory for Ecological System // Oxford: Elsevier, 2004. - 366 p.*

## Quantitative criterion:

$I_T$ - Thermodynamic Index of Ecosystem Health Disturbance (TIEHD)

$$I_T \sim (Ex_o - Ex_b) / Ex_o$$

$Ex_o - Ex_b$ - the portion of the solar exergy, directed to parry load;

$Ex_o$ - the solar exergy absorbed by ecosystem;

$Ex_b$ - *the portion of the solar exergy spent on biomass formation;*

$Ex_b$ - can be expressed over an evaporation rate.

Thus, the evaporation rate is the measure of ecosystem health**

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* *Victor Gornyy et all. Remote Mapping of Thermodynamic Index of Ecosystem Health Disturbance // Journal of Environmental Protection, 2010, 1, 242-250. (http://www.SciRP.org/journal/jep)*

** *V. I. Gornyy et al. Thermodynamic approach to satellite mapping of accumulated ecological losses of forest ecosystems // Sovremennye problemy DZZ iz rjsmosa. 16(4), 2019. http://d33.infospace.ru/d33_conf/sb2019t4/124-136.pdf*

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# Sensetivity advantage*

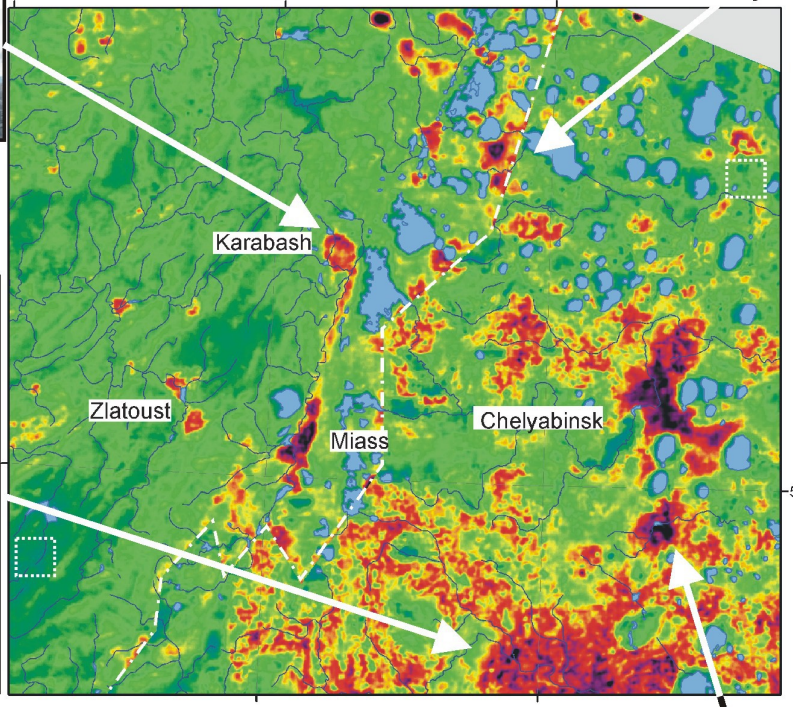
## South Ural Region

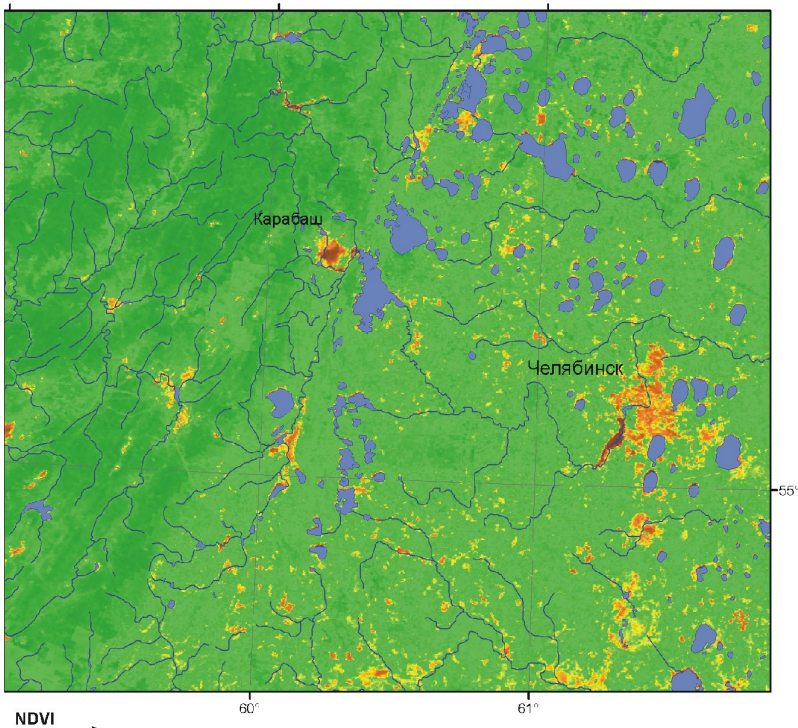
TIEHD

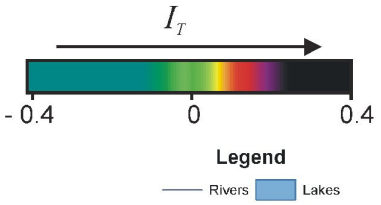
Vegetation index NDVI

Copper smelting plant

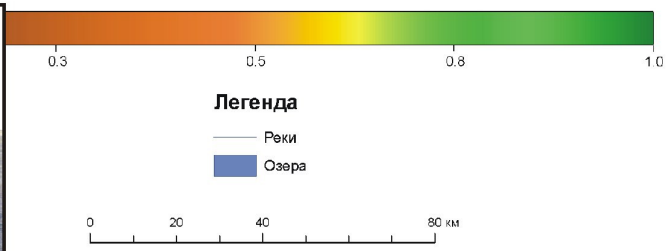
Dust from two heat power plants




Korkino braun coal open cast

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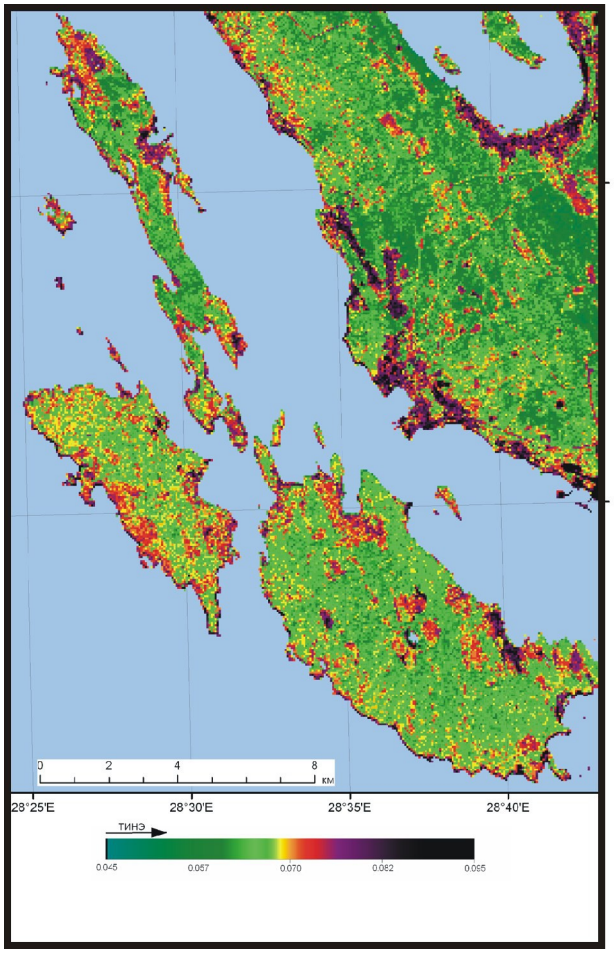
* *Victor Gornyy et al. Remote Mapping of Thermodynamic Index of Ecosystem Health Disturbance // Journal of Environmental Protection, 2010, 1, 242-250. (http://www.SciRP.org/journal/jep)*

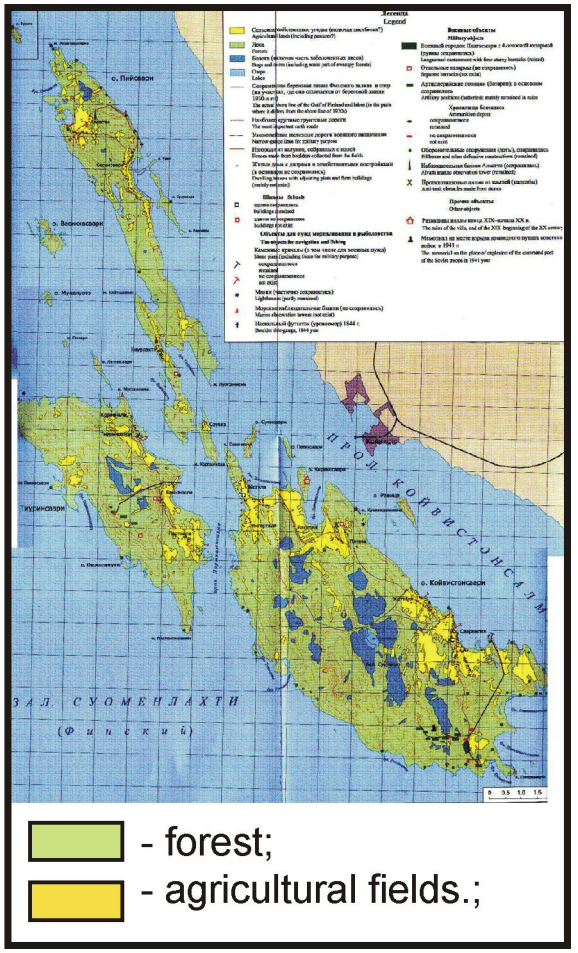
# 8 Sensitivity of large scale map of TIEHD*

## Nature reserve «Bereozovye ostrova», Gulf of Finland

Map of TIEHD




Landuse map
1930-th epoche
(according to V. Khramtsov)




TIEHD sensitivity is sufficient to map forests, which replaced agricultural fields during last 50 years

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** Gornyy V., et al. Verifi cation of large scale maps of thermodynamic index ecosystem health disturbance // Sovremennye problemy DZZ iz kosmosa. 2013. Vol. 10. No 4. pp. 201-212.*
http://d33.infospace.ru/d33_conf/sb2013t4/201-212.pdf

# Accumulated ecological losses of forest ecosystems*

$$L=DV_o$$

$L$ - accumulated ecological losses, rubles/km$^2$;

$D$ — ecosystem disturbance indicator;

$V_o$ — cost of healthy ecosystem, rubles/km$^2$;

$$D=(E_o-E)/E_o = (1-E/E_o)=1-EQR$$

$E_o$, $E$ — specific evaporation rate of healthy and disturbed ecosystems, kg/m$^2$day;

$EQR$ - Ecological Quality Ratio).

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* Gornyy et al. Thermodynamic approach to satellite mapping of accumulated ecological losses of forest ecosystems // *Sovremennye problemy DZZ iz kosmos*a. 2019. 16(4), pp. 124-136. *http://d33.infospace.ru/d33_conf/sb2019t4/124-136.pdf*

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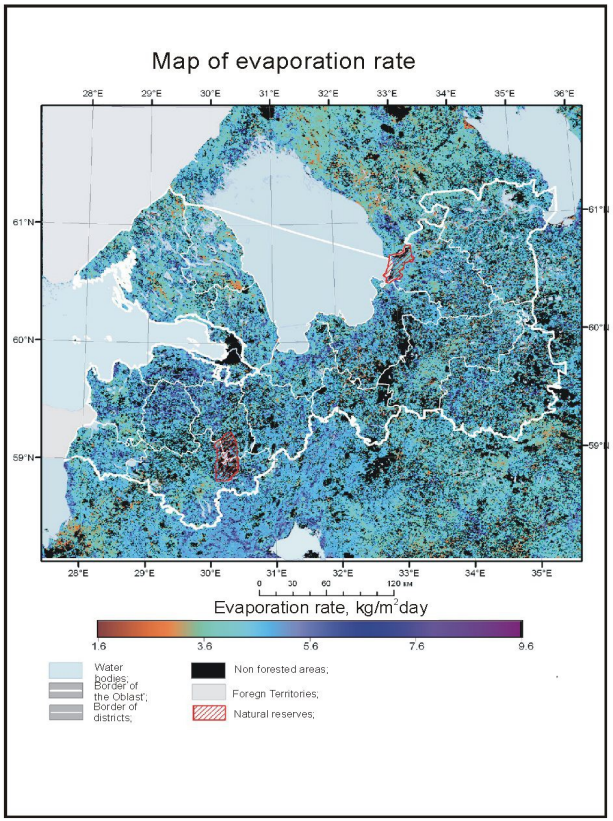
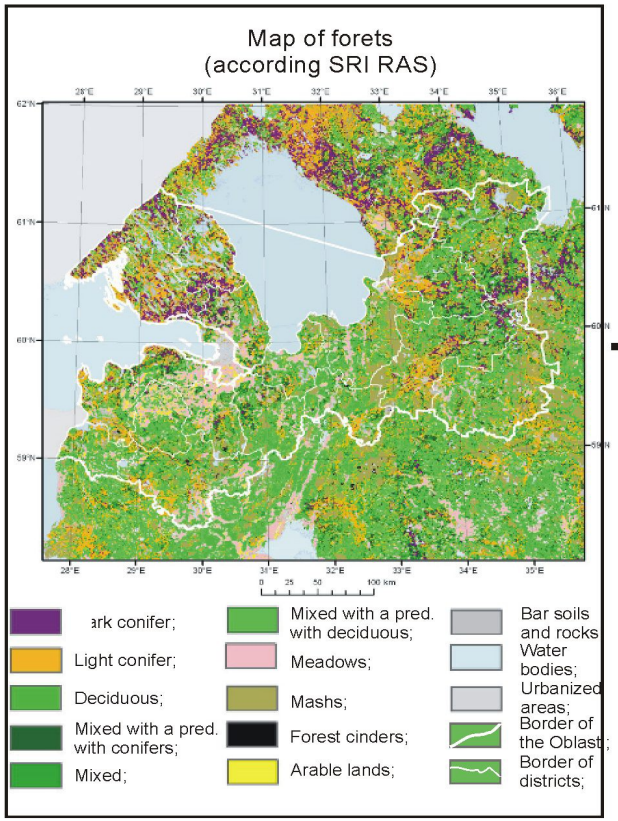
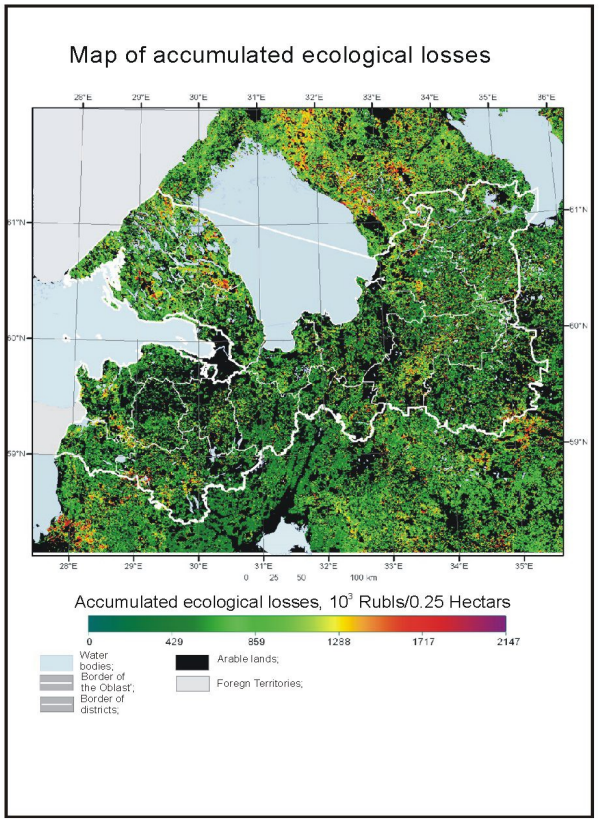
# Leningrad Oblast'

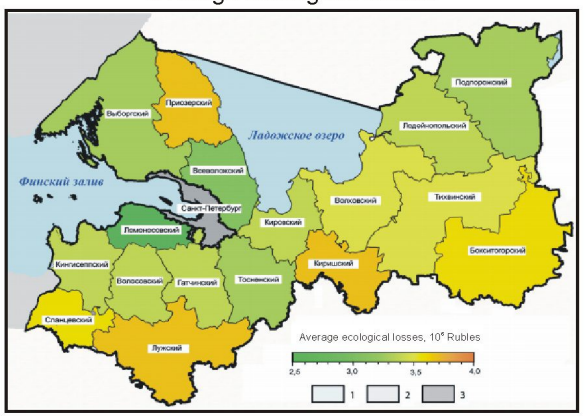



And




Scheme of district ranking according to average ecological losses




Cost of accumulated ecological damage of districts of Leningrad Oblast'

| District | Damage $10^9$ Rubles | District | Damage $10^9$ Rubles |
|---|---|---|---|
| Boksitogorskii | 48 | Lodeinoplskii | 40 |
| Volosovskii | 14 | Lomonosovskii | 9 |
| Volhovskii | 33 | Luzhskii | 42 |
| Vsevolozhskii | 20 | Podporozhskii | 61 |
| Vyborgskii | 61 | Priozerskii | 32 |
| Gatchinskii | 13 | Slancevskii | 19 |
| Kingiseppskii | 22 | Tihvinskii | 51 |
| Kirishskii | 21 | Tosnenskii | 24 |

**Information support for desigion makers:**

**ranking districts according to ecological demages.**