Satellite mapping of threats of ecological safety in the coastal zone of the Gulf of Finland

Victor Gornyy, Andrei Kiselev, Sergei Kritsuk, Iscander Latypov, Andrei Tronin

Scientific Research Center for Ecological Safety (SRCES RAS)

v.i.gornyy@mail.ru

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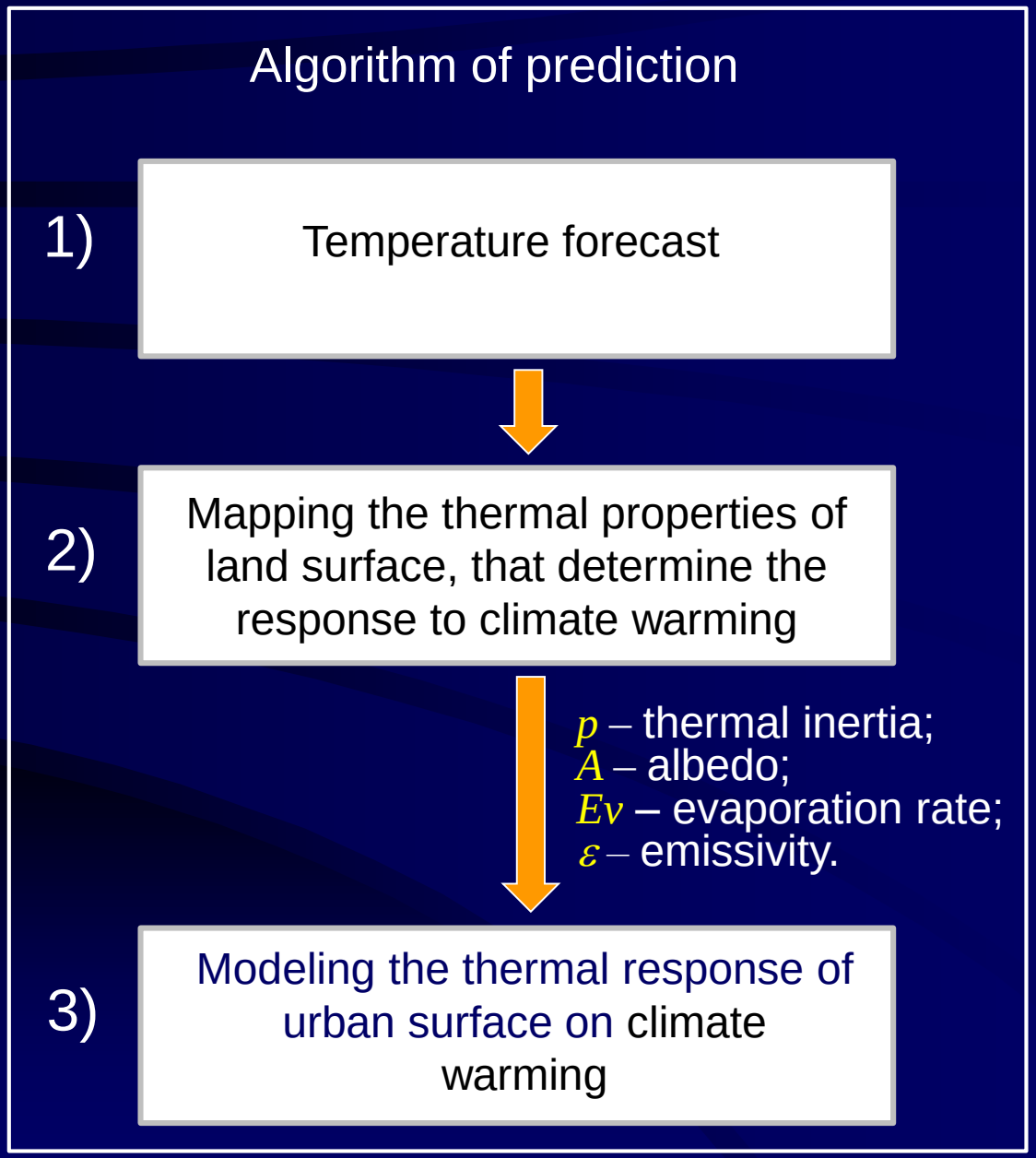
2018

Threats to the ecological safety of the St. Petersburg population due to a climate warming

Main threats:

- roadbed and tire wear due to asphalt melting;
- emission of pollutants;
- accelerated reproduction of harmful insects;
- blackouts as a result of the mass switching on of climate control systems;
- growth of climate sensitive diseases and mortality of population, as a result of overheating of environment.

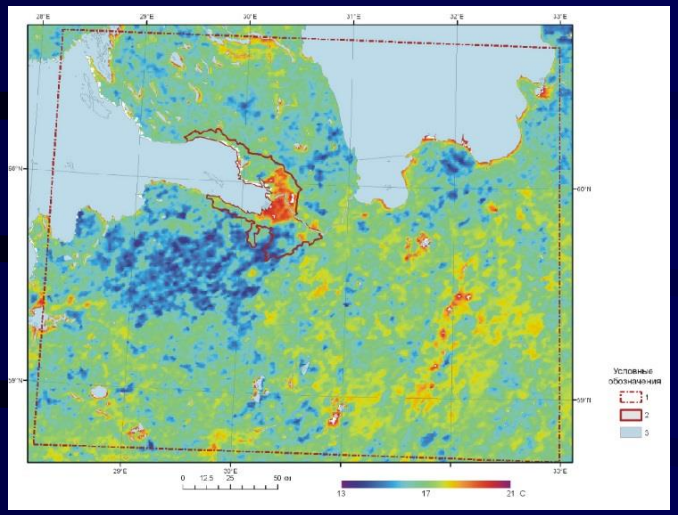
The thermal response of St. Petersburg to climate warming



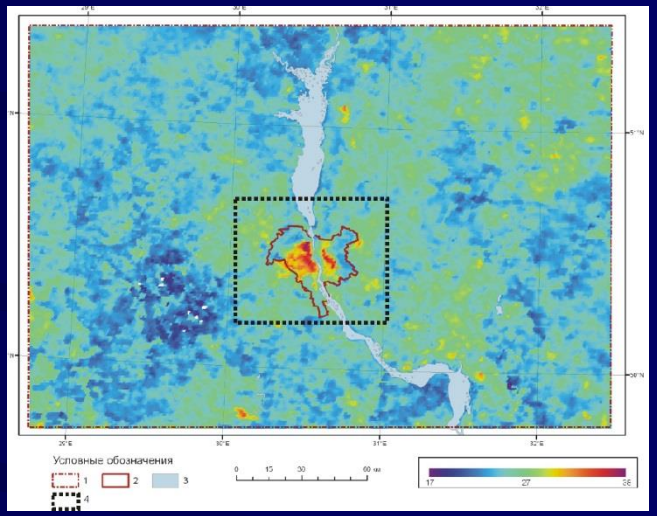
Prediction of surface temperature in the St. Petersburg Heat Island

Day-time urban surface temperature in the end of July according Aqua(MODIS) satellite

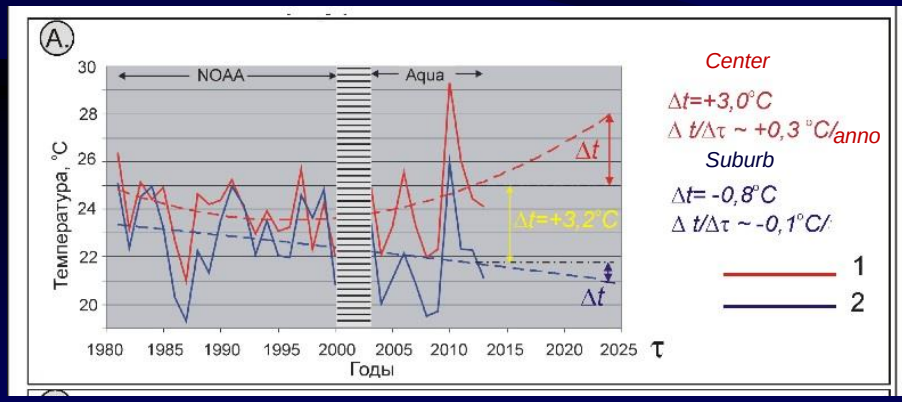
St. Petersburg (Russia)



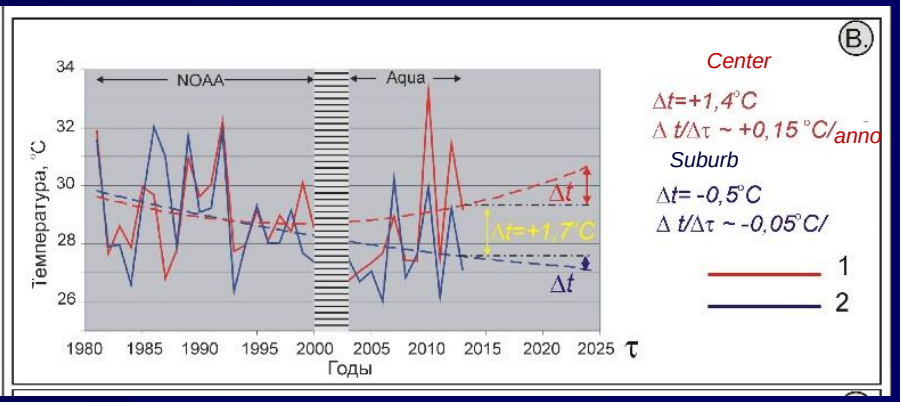
Kiev (Ukraine)



St. Petersburg (Russia)



Kiev (Ukraine)

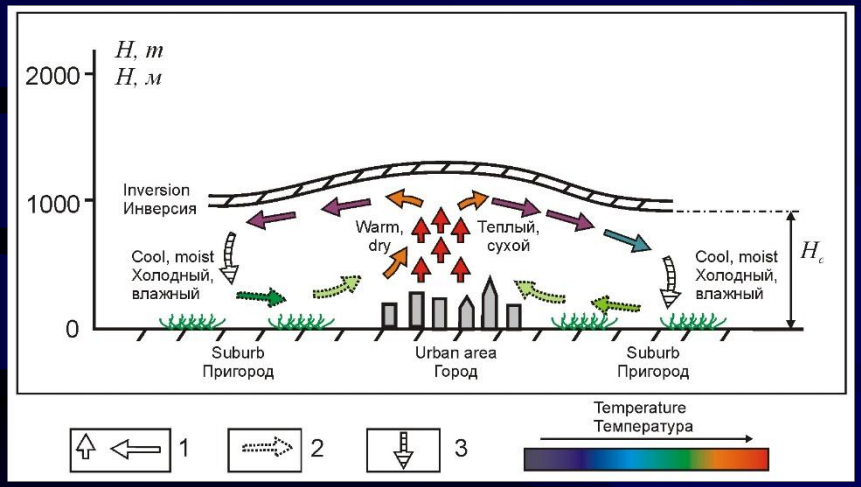


В.И. Горный, В.И. и др. Прогноз тепловой реакции городской среды Санкт-Петербурга и Киева на изменение климата (по материалам съемок спутниками EOS и Landsat) // Современные проблемы дистанционного зондирования Земли из космоса. 2016. Т. 13. № 2. С. 176–191.

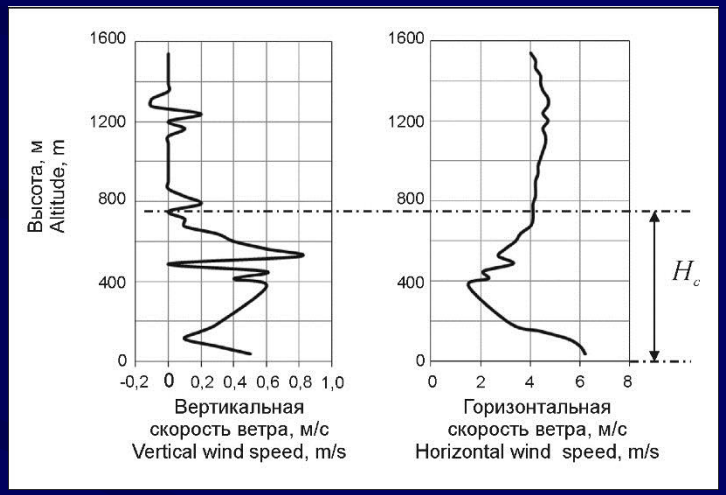
Air convection in the St. Petersburg Heat Island

Experimental proofs

Model of air circulation
inside a urban heat island
(Cotton, Pielke, 2007)



Vertical profiles of wind speed
(June 22, 2015 г, 15 : 07)
According lidar sounding
(Сапунов и др., 2016)



H_c – height of convective sell

В.И. Горный и др. О циркуляции воздушных масс в «тепловых островах» городов // Современные проблемы дистанционного зондирования Земли из космоса. 2017. Т. 14. № 4. С. 207–212.

Forecast of St. Petersburg surface temperature in 2024

Beginning of August 2024
(according NOAA and Aqua satellite data)

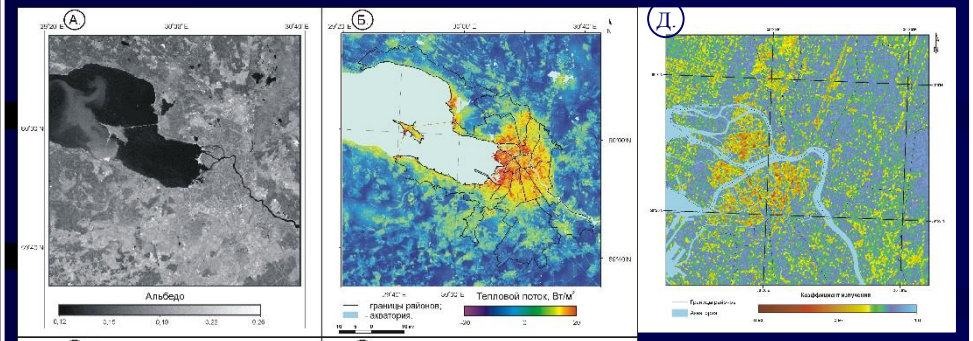
Characteristics	Day time land surface temperature
Long term level of trend in 2014 г.	+25,1°C
Long term level of trend in 2024 г.	+28,1°C
Average, during the most heated day in 2024 (at least)	+37,1°C
Local maxima in 2024 (at least)	+50,4°C

Temperature of bitumen melting in a road cover: *+33°C - +51°C.*
(Russian State Standard 11506)

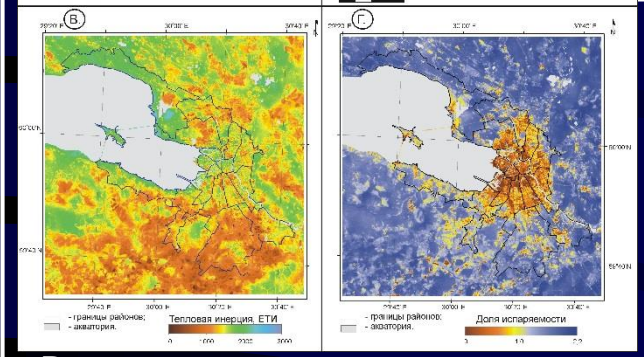
Thermal properties of St. Petersburg surface

Maps

A. B. C.

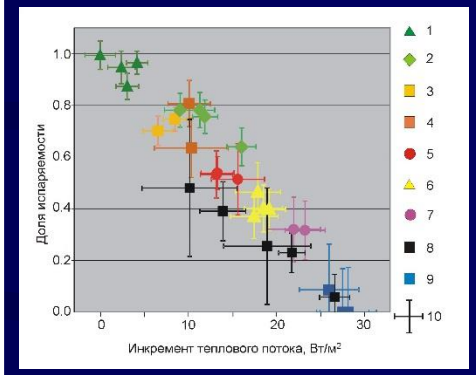


D. E.



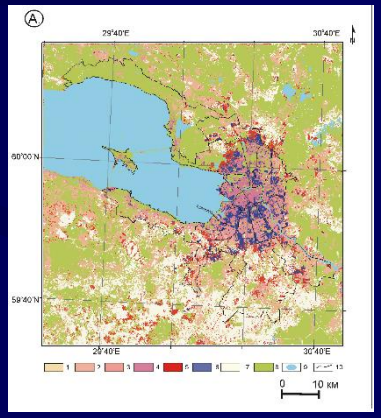
A. Albedo.
B. Anthropogenic heat flux.
C. Emissivity.
D. Thermal inertia.
E. Portion of evaporation.

Specificity of thermal properties of functional zones

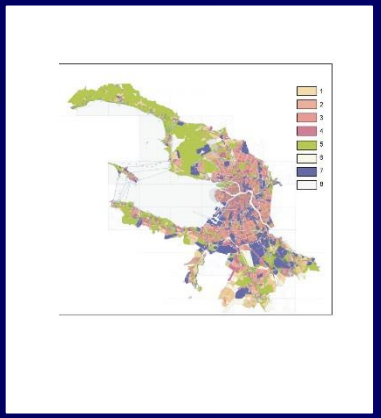


Functional zones:
1. Recreational in suburbs
2. Recreational inside city
3. Private houses (Dachas).
4. Low-rise, multi-family buildings
5. Multi-storey - new buildings
6. Mid-rise and multi-storey
7. Downtown: Social - business
8. Transport infrastructure
9. Industrial
10. Confidence intervals

Classification of thermal properties



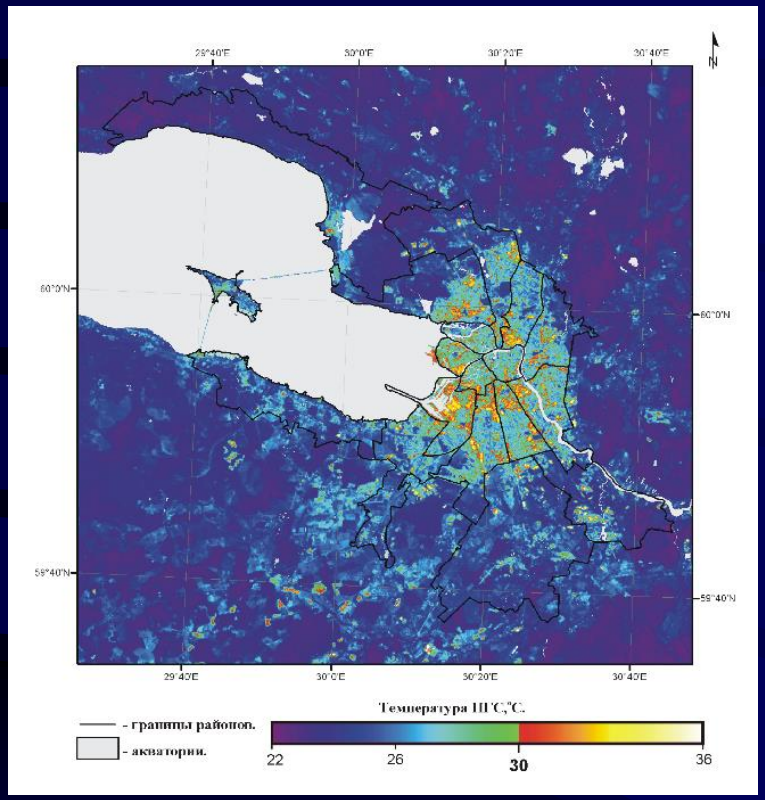
Functional zones



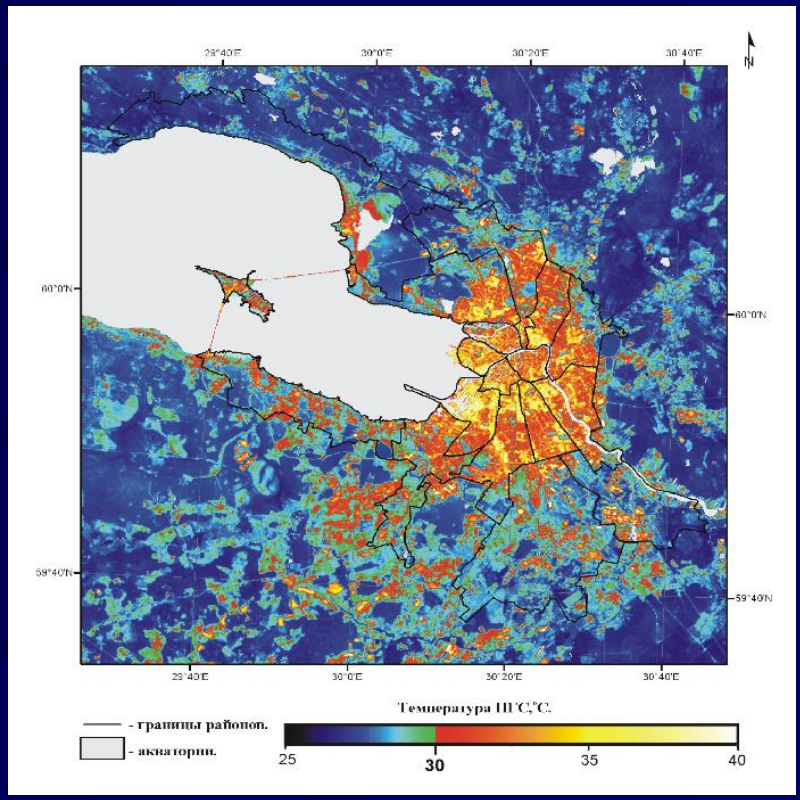
В.И. Горный и др. Теплофизические свойства поверхности городской среды (по результатам спутниковых съемок Санкт-Петербурга и Киева) // Современные проблемы дистанционного зондирования Земли из космоса. 2017. Т. 14. № 3. С. 51–66

Thermal response of St. Petersburg to climate warming

Long term level of surface temperature trend in 2014: +25,1°C



Long term level of surface temperature trend in 2024: +28,1°C



Percent of areas, overheated over +30°C :

2%

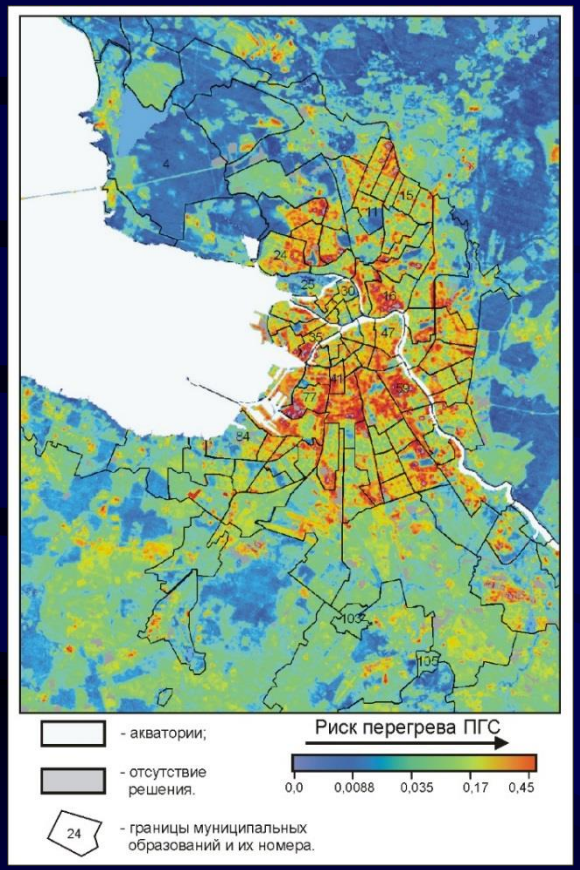
38,3%

А. А. Тронин, В. И. Горный, В. Н. Груздев, Б. В. Шилин. Многолетние аэрокосмические наблюдения температуры земной поверхности Северо-Западного региона РФ // Современные проблемы дистанционного зондирования Земли из космоса. 2017. Т. 14. № 6. С. 73–96.

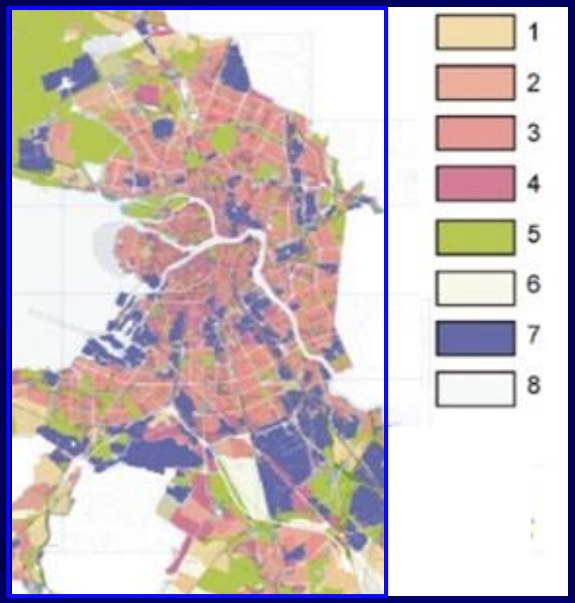
Risk of St. Petersburg surface overheating

Risk of St. Petersburg surface overheating

Map of risk of overheating over +30°C of St. Petersburg surface



Functional zones of St. Petersburg (General plan 2015-2025)



7. Industrial and transport zones

Risk of overheating of St-Petersburg municipal districts (MD)

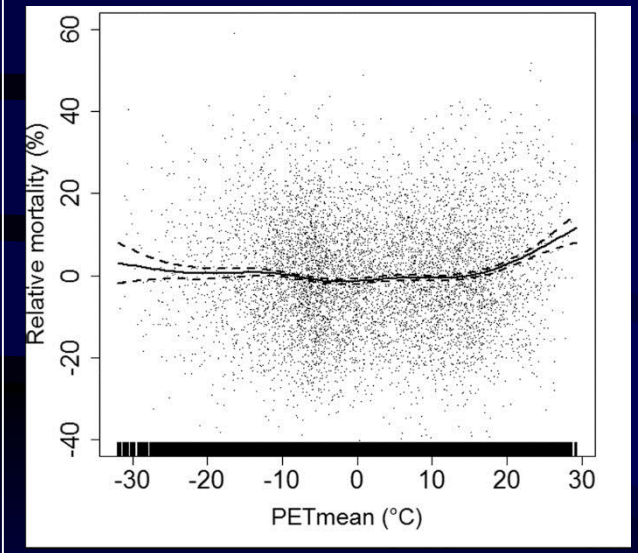
MD	Risk	MD	Risk
Sestroretsk	0.001	Yugo-Zapad	0.138
Pavlovsk	0.012	Finlyandskii	0.190
Aptekarskii	0.056	Narvskii okrug	0.269

Mortality of St. Peterburg population

Mortality rising after air temperature elevation

Helsinki helped to St. Petersburg

Mortality in Helsinki versus apparent temperature (1994 - 2014)



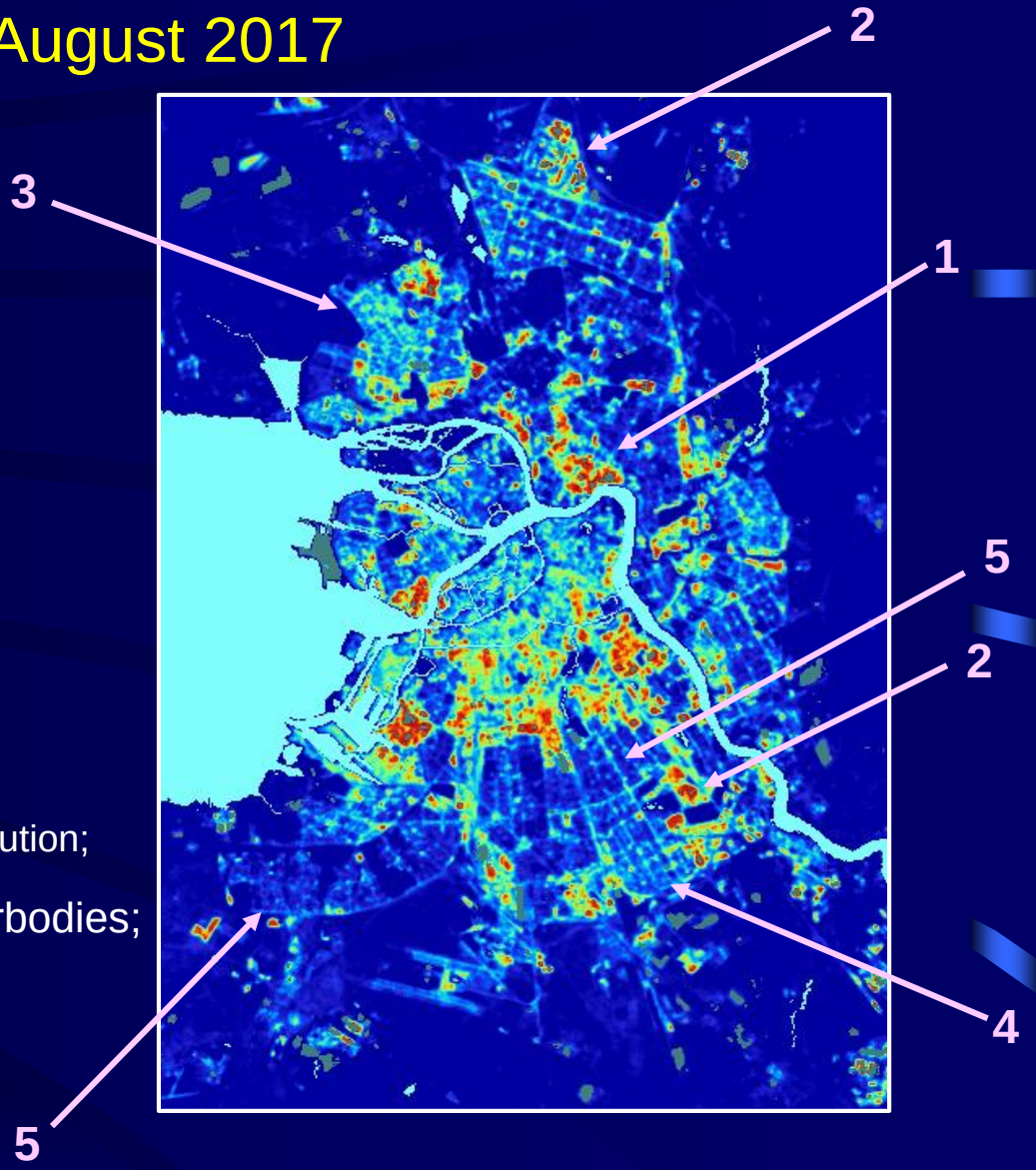
Economic loss of one early death is 2 270 000 rubles.

(*Оценка риска и ущерба от климатических изменений, влияющих на повышение уровня заболеваемости и смертности в группах населения повышенного риска: Методические рекомендации. - М.: Федеральный центр гигиены и эпидемиологии Роспотребнадзора, 2012.— 48 с.).*

Mortality in St. Petersburg caused by overheating June-August 2017

Mortality : 223 people

Economical loss: 500 million rubles



- no solution;
- waterbodies;

1. Industrial zones - old.
2. Industrial zones - modern.
3. “Sleeping areas” modern.
4. “Sleeping areas” 1980-th.
5. “Sleeping areas” 5-story buildings.

Satellite mapping
of
the accumulated ecological damage
to
forest ecosystems

Surface Energy Budget

Surface energy balance:

$$S * (1-A) = H + LE + G + R \quad (1)$$

where:

S – shortwave solar radiation;
A – surface albedo;
H – sensible heat flux;
LE – latent heat flux;

G – heat flux in the soil;
R – far IR radiation budget;

$$H = k * \rho * c * \Delta T/\Delta h \quad (2)$$

$$LE = D*\rho*L*\Delta e/p_a\Delta h \quad (3)$$

where:

$\Delta T = T_{LS} - T_{air}$, - temperature difference between the surface and air on the height Δh;
k – heat exchange (turbulent) coefficient ;
ρ, c – air density and heat capacity;

$\Delta e = e_{surf} - e_{air}$; vapor partial pressure difference between the surface and air on the height Δh;
D – mass exchange (turbulent diffusion) coefficient;
p_a – air pressure
L – specific latent heat;
ρ – air density;

Data

Object of investigation: Taiga Biome ecosystems of Leningrad Oblast' of Russia and Finland

Flux towers:

1 – Siikaneva
2 – Hyytiala
3 – Kumpula
4 - Torni

Investigating territory

Data

Hyytiala flux tower

Forest

2

Siikaneva flux tower

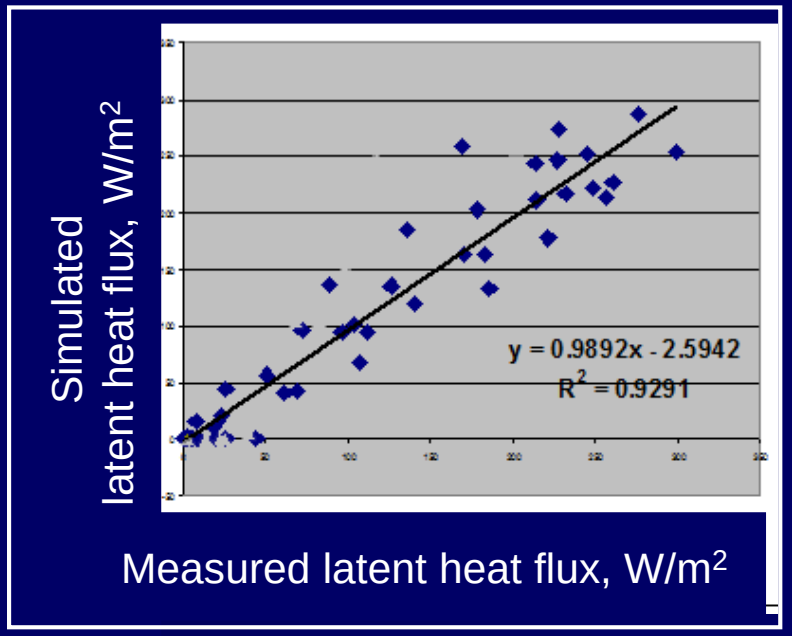
Marshland

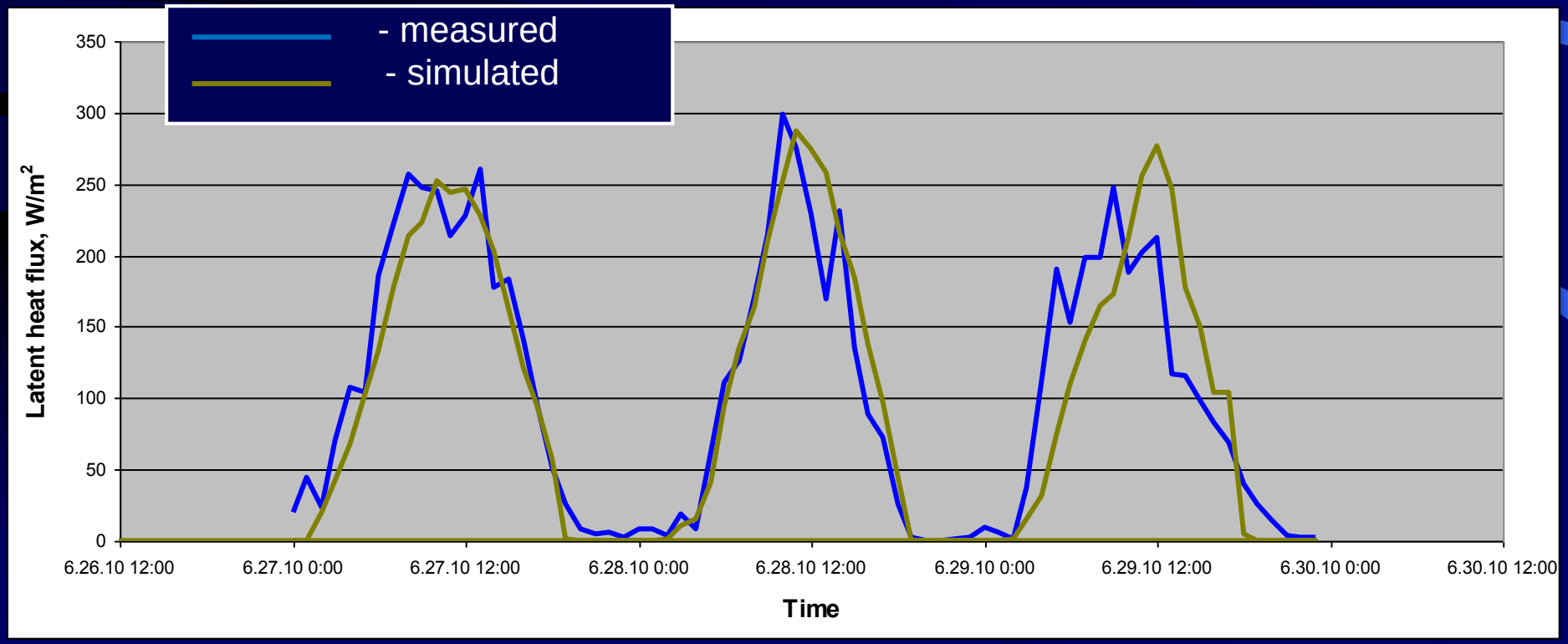
1

Forest

Latent Heat Flux:

- measured at Hyytiala flux tower;
- simulated by used satellite & meteorological data.

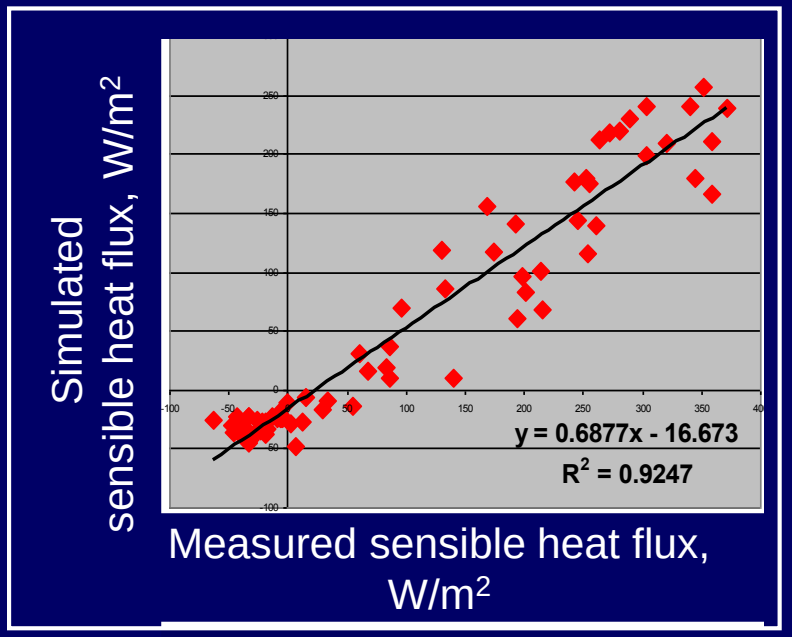


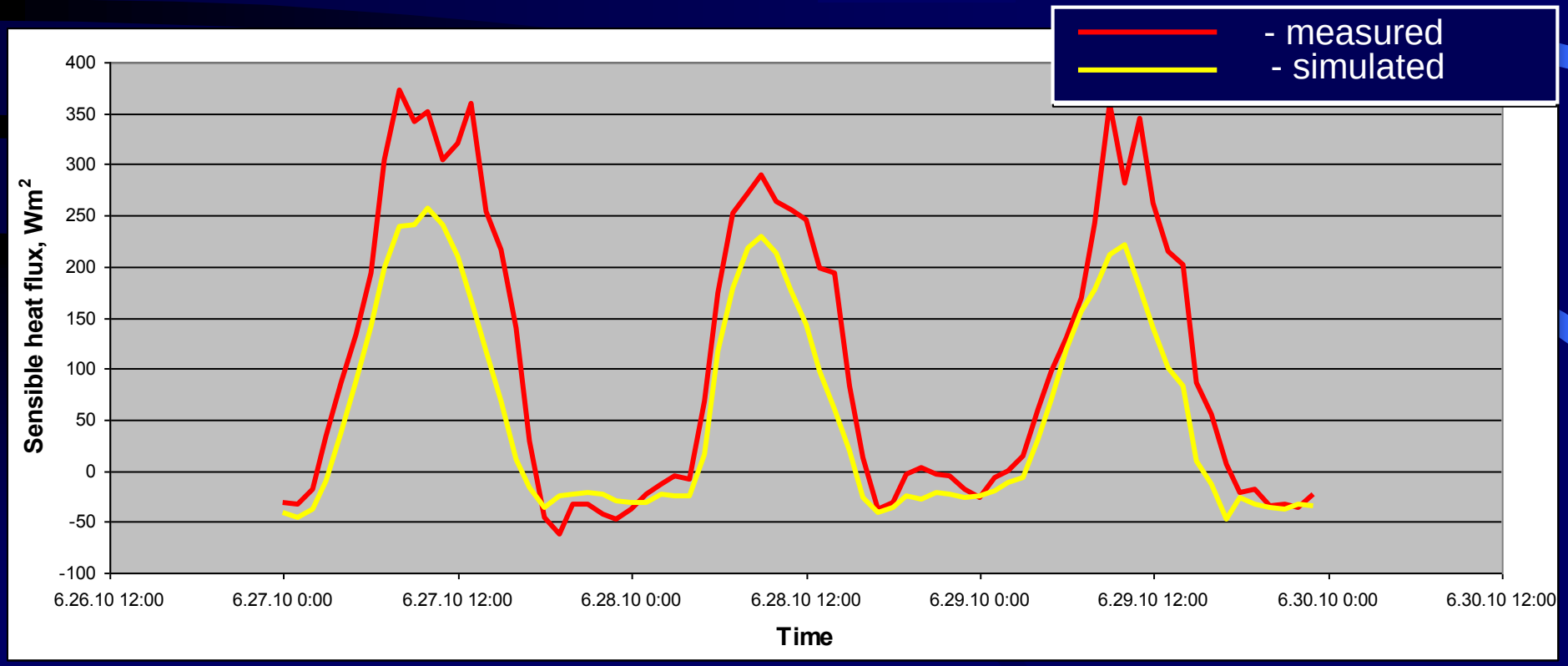


Forest

Sensible Heat Flux:

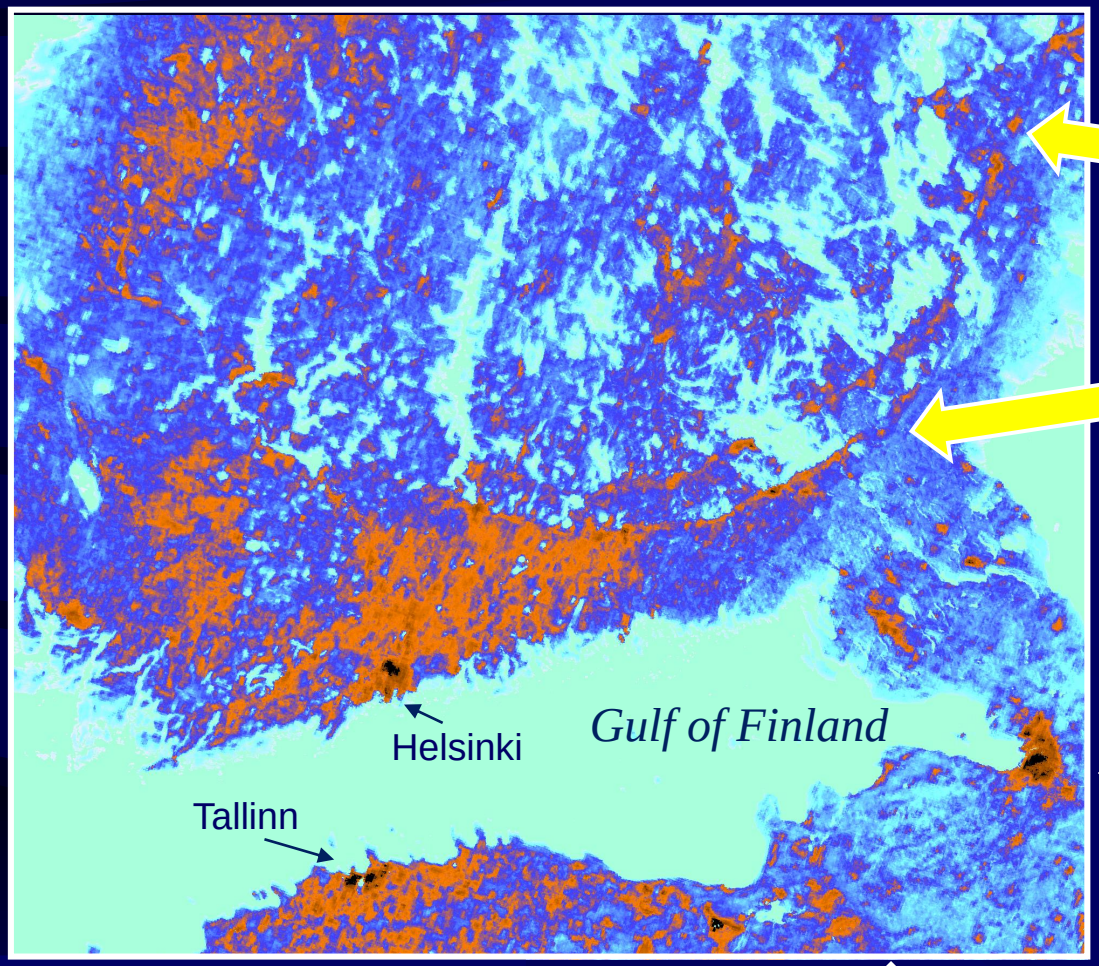
- measured at Hyytiala flux tower;
- simulated by used satellite & meteorological data.





Map of Evaporation Rate

27-29, June 2010



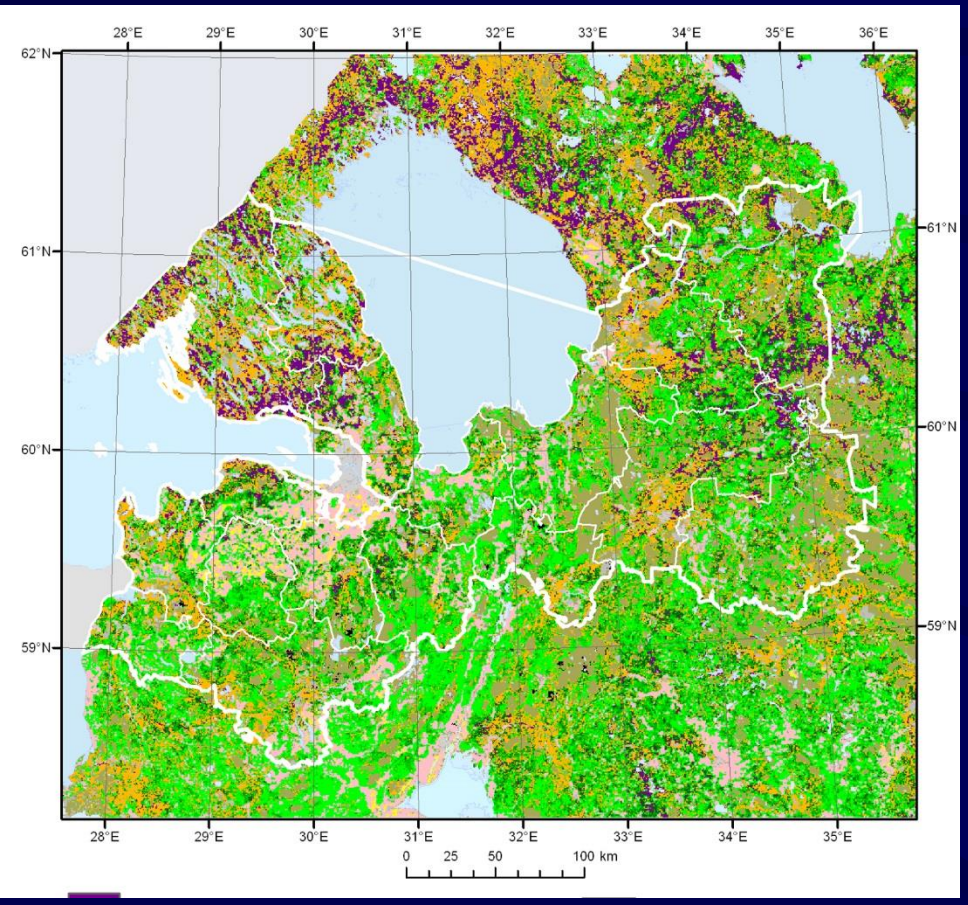
Russia - Finland border

Saint-Petersburg

Russia - Estonia border

Forests of Leningrad Oblast’

Map of vegetation
according satellite data
(Space Research Institute)



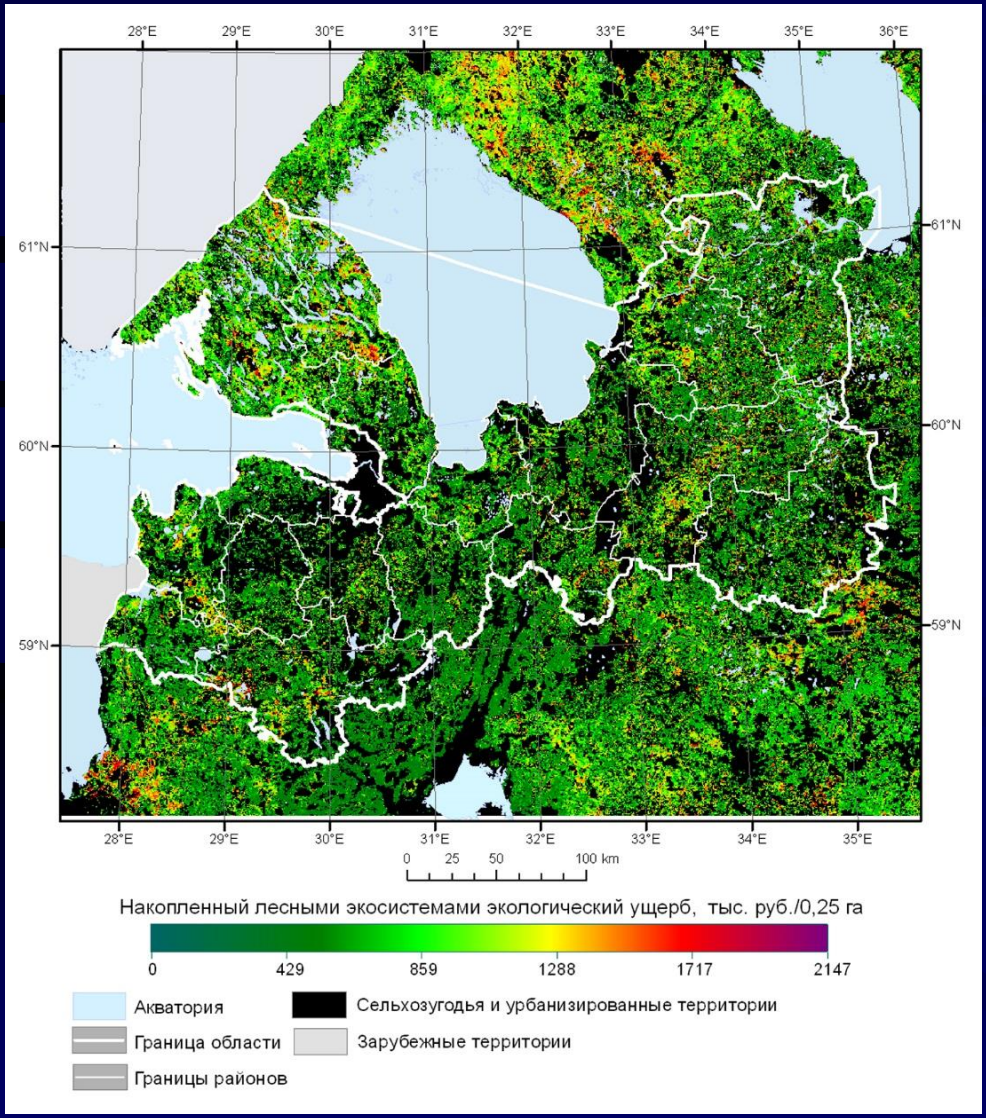
Forests:

- Dark conifer
- Light coniferous
- Deciduous
- Mixed with a predominance of conifers
- Mixed
- Mixed with a predominance of deciduous
- Meadows
- Marsh
- Forest cinder
- Arable land
- Soils and outcrops of rocks
- Water bodies
- Urbanized areas

- Border of Oblast’
- Border of regions
- Foreign territories

Cost of accumulated ecological damage to forest ecosystems

Map of value of ecological damage to forest ecosystems



Cost of accumulated ecological damage of districts of Leningrad Oblast'

District	Damage 10^6 rubles	District	Damage 10^6 rubles
St.Petersburg	834	Kiros\vskii	4 081
Boksitogorskii	10 832	Lodeinoplskii	9 934
Volosovskii	2 970	Lomonosovskii	2 253
Volhovskii	7 159	Luzhskii	8 886
Vsevolozhskii	5 271	Podporozhskii	15 980
Vyborgskii	16 631	Priozerskii	8 437
Gatchinskii	3 000	Slancevskii	3 980
Kingiseppskii	5 116	Tihvinskii	12 680
Kirishskii	4 380	Tosnenskii	5 110

Map of districts

Water flood
in the mouth of river Neva

Sentinel -1 radar image of Gulf of Finland

Neva water flood

Date: 27.09.2018 Time: 04 h 25 min Greenwich time

Structure of waves

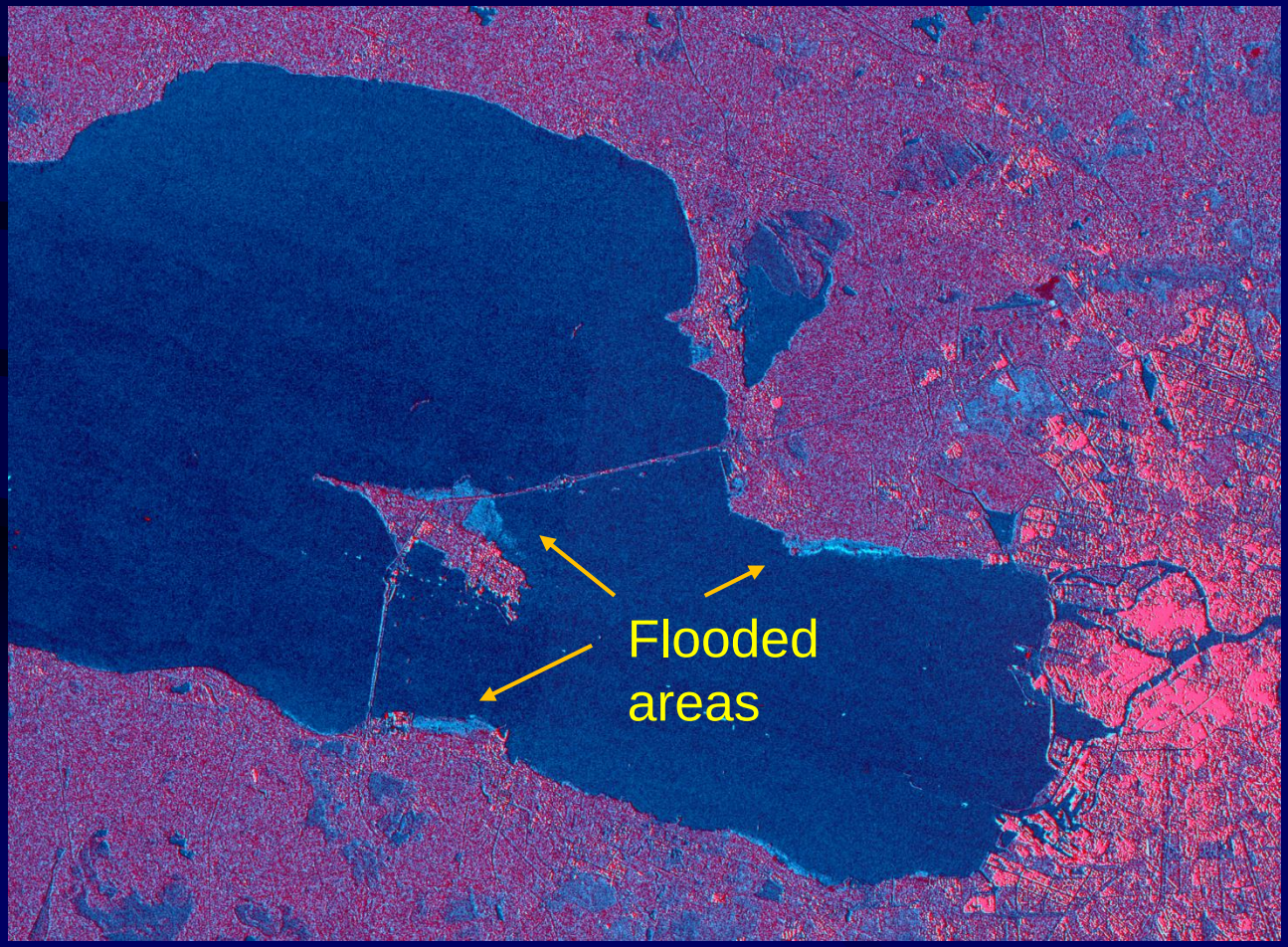
Reflected signal

Sentinel 1 radar image of Gulf of Finland

Neva water flood

Differences between 27.09.2018 – 15.09.2018.

Blue color – water flood



Thank you for your attention!