Effects of climate fluctuations to Subpolar Ural and subarctic forest changes

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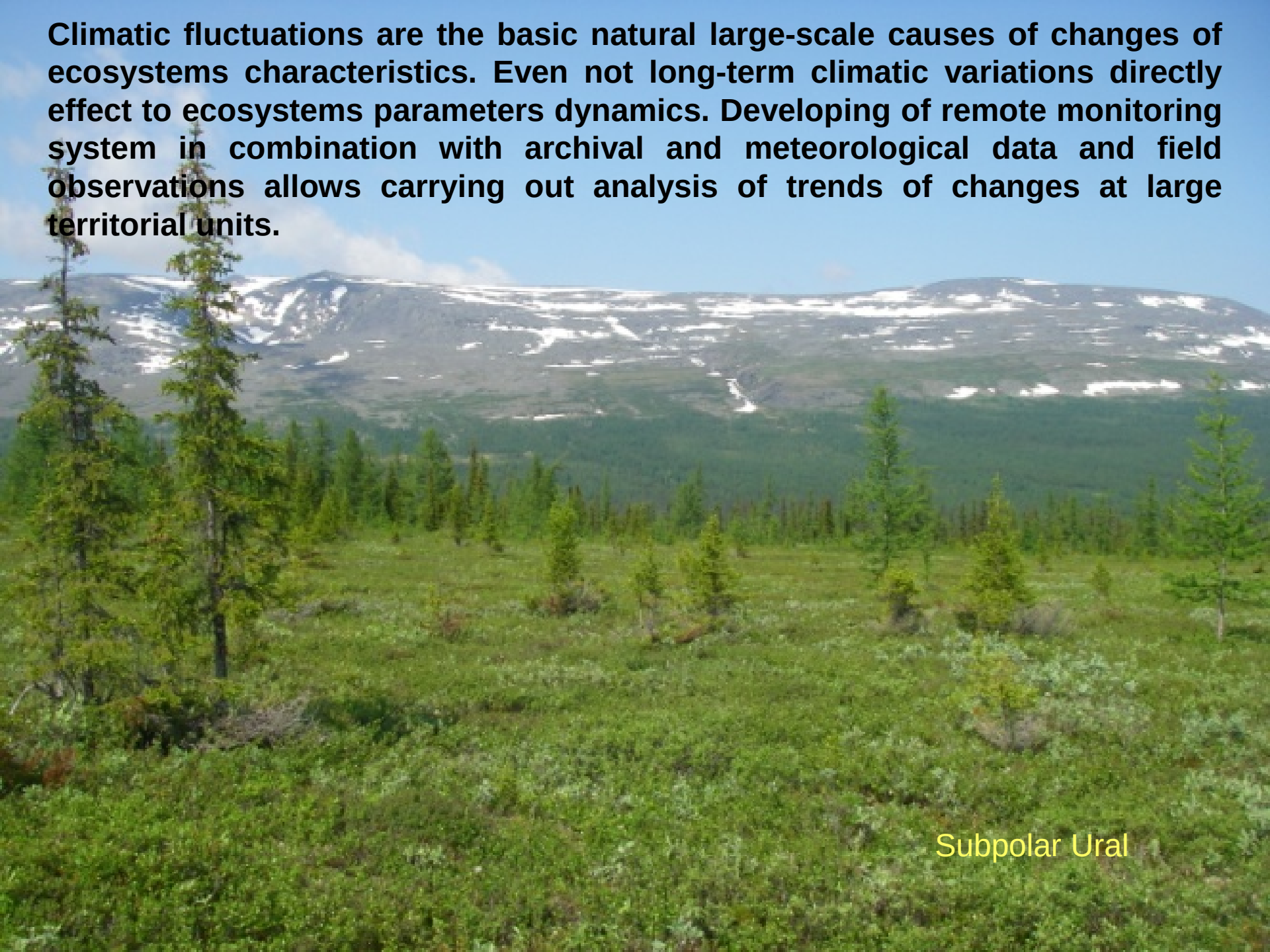
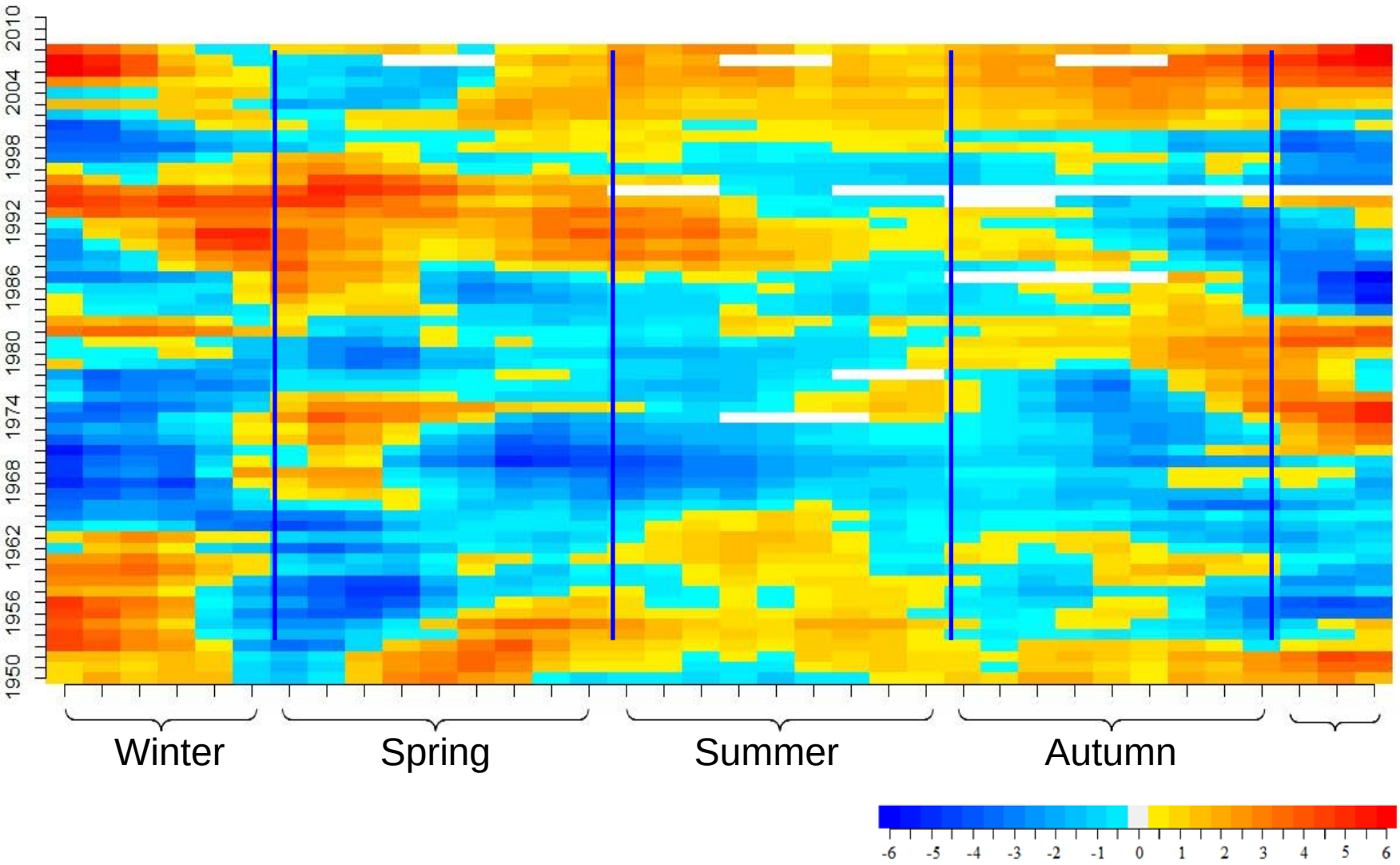
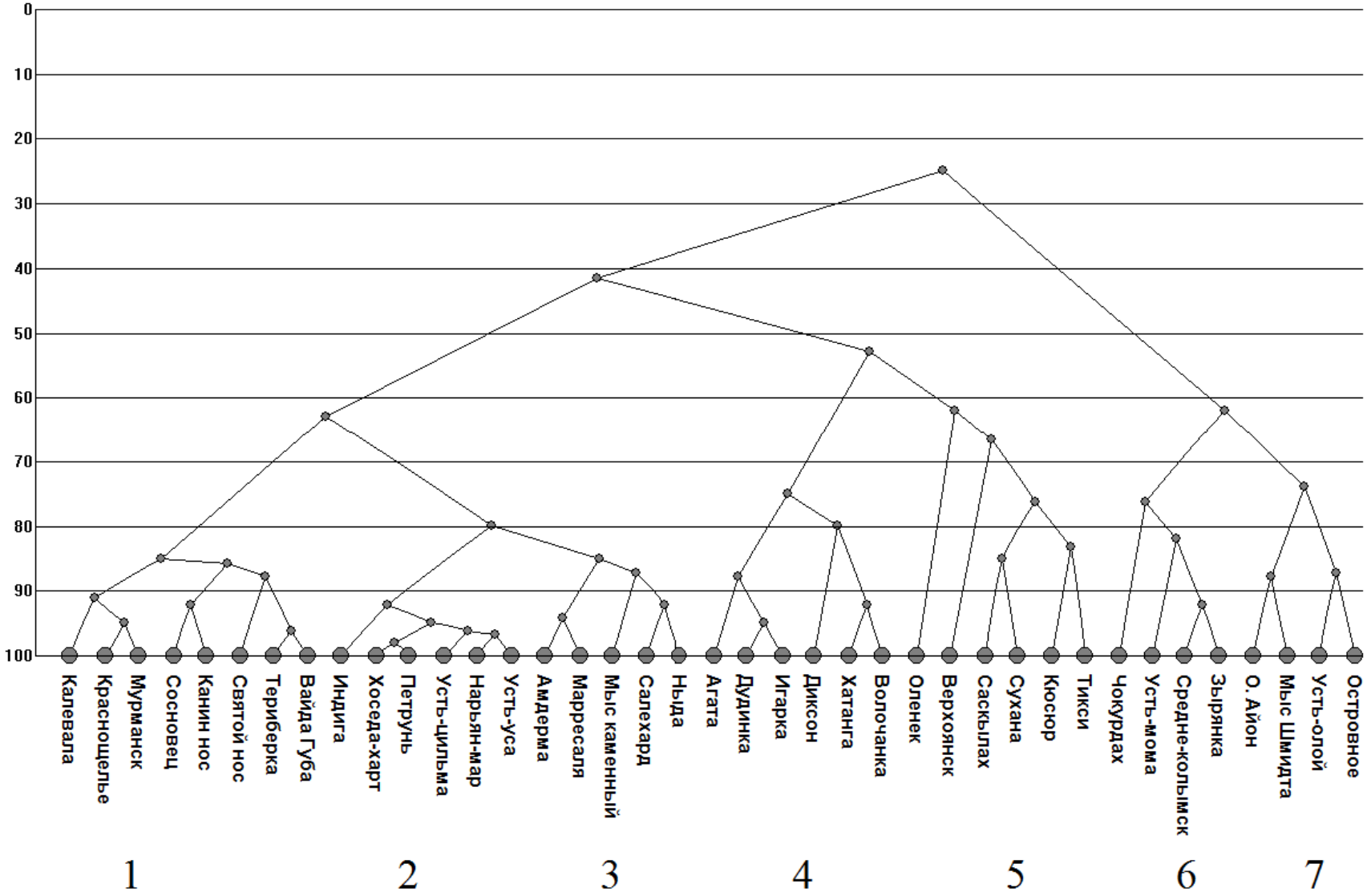
Climatic fluctuations are the basic natural large-scale causes of changes of ecosystems characteristics. Even not long-term climatic variations directly effect to ecosystems parameters dynamics. Developing of remote monitoring system in combination with archival and meteorological data and field observations allows carrying out analysis of trends of changes at large territorial units.

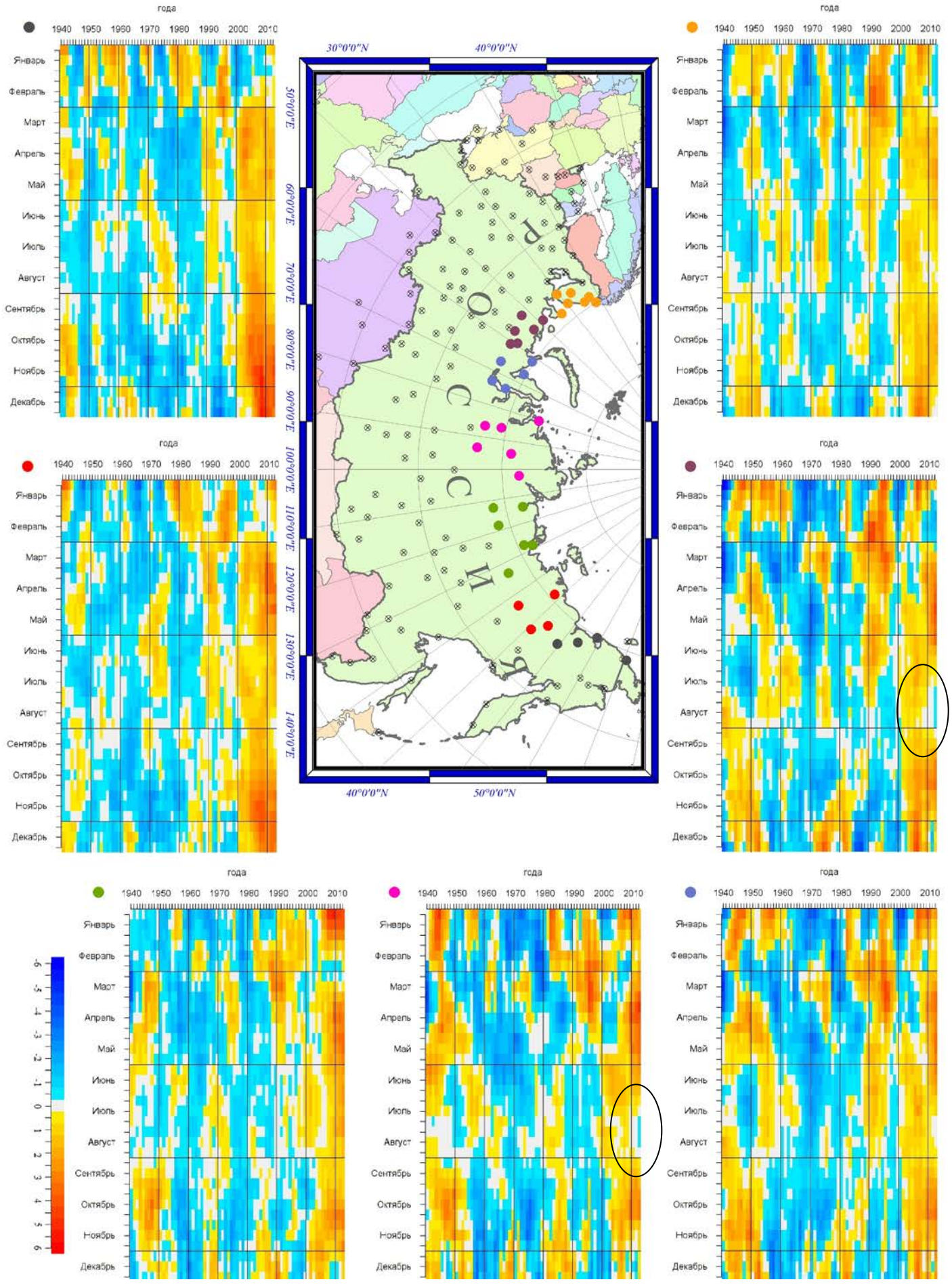


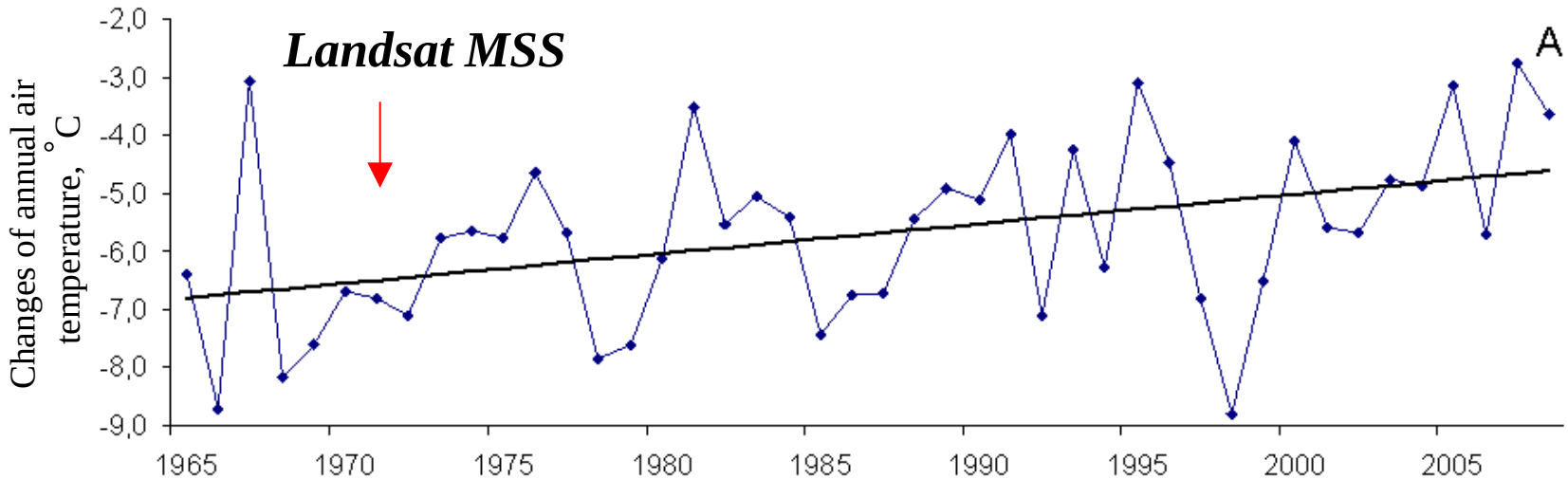
Deviation from average value, Δ°C (data base: ib.komisc.ru/climate)



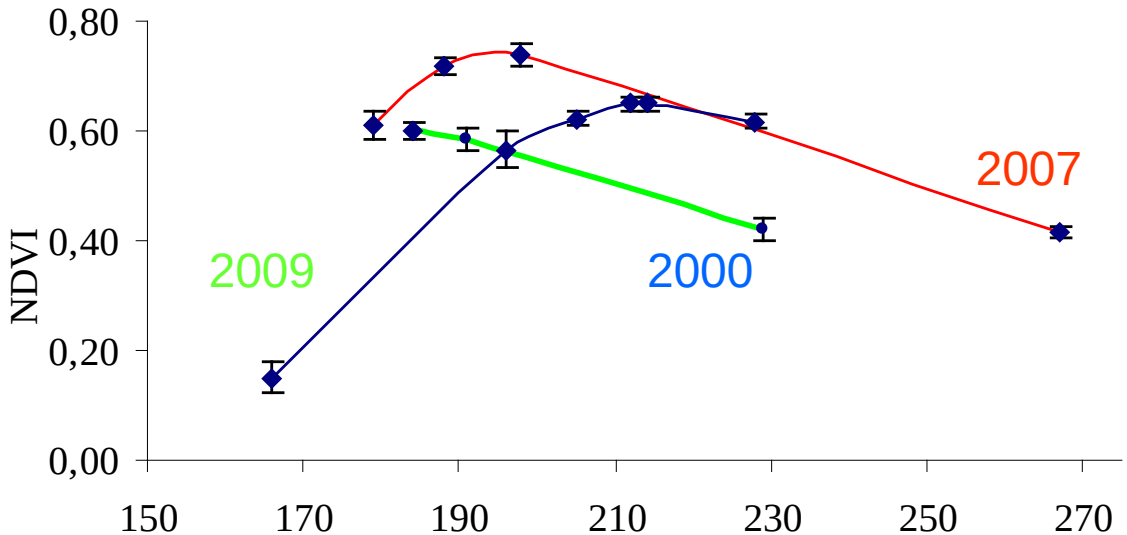
Meteostation Choseda-Chard data


0
10
20
30
40
50
60
70
80
90
100
Калевала
Краснощелье
Мурманск
Сосновец
Канин нос
Святой нос
Терибе́рка
Вайда Губа
Индига
Хоседа-Хард
Петрунь
Усть-Цильма
Нарьян-Мар
Усть-Уса
Амдерма
Марресаля
Мыс каменный
Салехард
Ныда
Агата
Дудинка
Игарка
Диксон
Хатанга
Волочанка
Оленек
Верхоянск
Саскылах
Сухана
Кюсюр
Тикси
Чокурдах
Усть-Мома
Средне-Колымск
Зырянка
О. Айон
Мыс Шмидта
Усть-Олой
Островное
1
2
3
4
5
6
7


года
1940 1950 1960 1970 1980 1990 2000 2010
Январь
Февраль
Март
Апрель
Май
Июнь
Июль
Август
Сентябрь
Октябрь
Ноябрь
Декабрь
30°0'0"N
40°0'0"N
50°0'0"N
60°0'0"E
70°0'0"E
80°0'0"E
90°0'0"E
100°0'0"E
110°0'0"E
120°0'0"E
130°0'0"E
140°0'0"E
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6



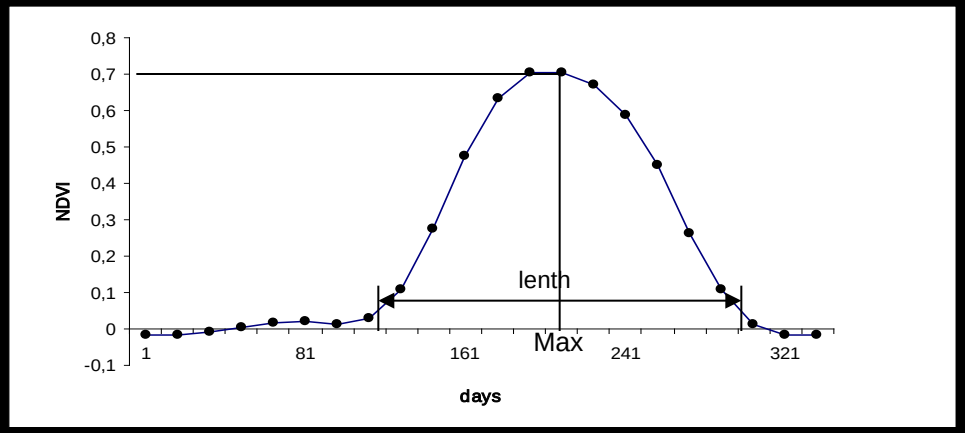
The annual air temperature dynamic per 1965-2008 years period (A). The line is a common trend of changes (y=0.05x-6.85; R^2=0.18).

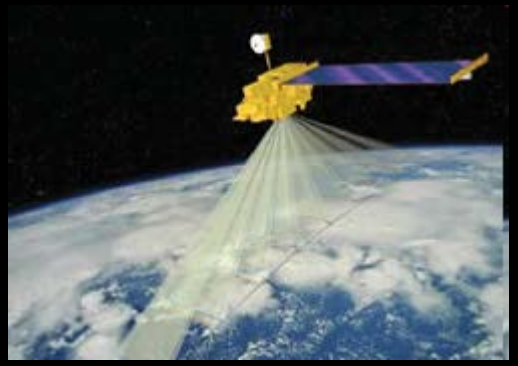


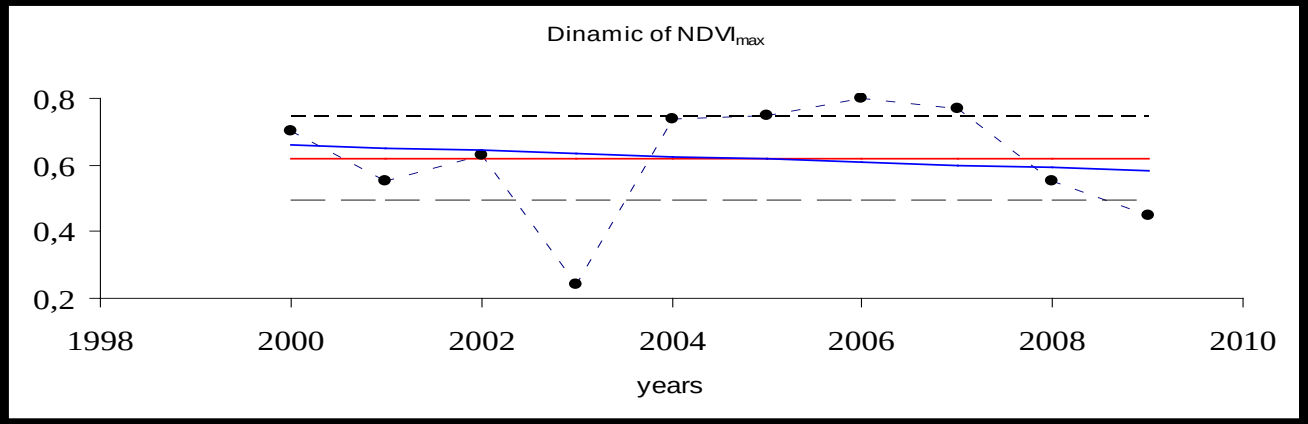
Dynamics of average daily air temperatures leveled for 5 days in the study region (Vorkuta) (A.). Changes of the *ChlI* index during vegetation period for herbaceous willow forests class by sensors data of different-season/different-year Landsat TM5 scenes. Keys: 2000 – 1, 2007 -2, 2009 -3 (B.).

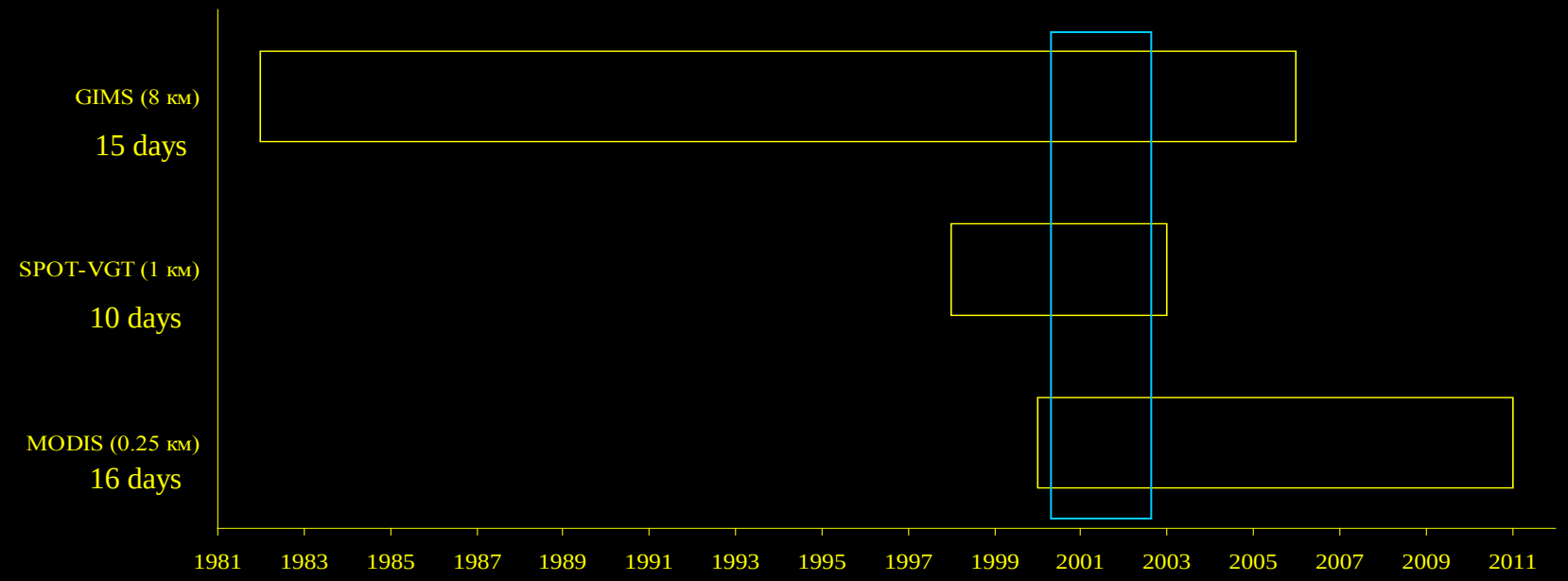
The analisis of NDVI $_{MAX}$ for 2000-2009 years by MODIS (Moderate-resolution Imaging Spectroradiometer)

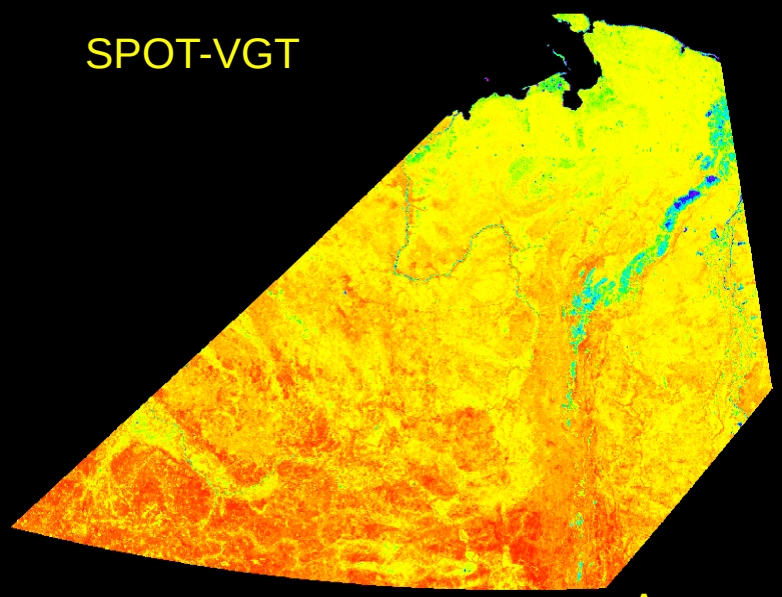
16 –days composites



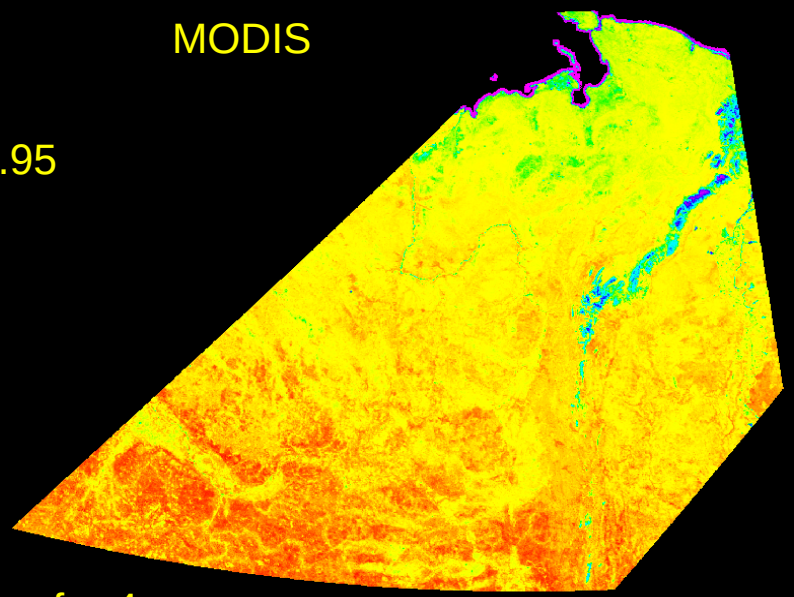








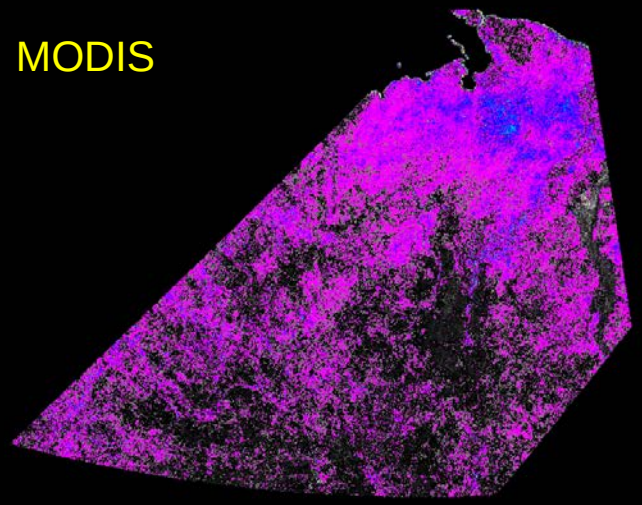
r=0.95



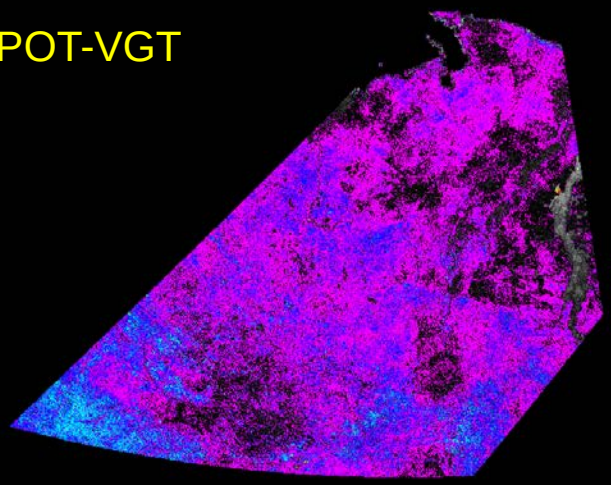
Average $ndvi_{max}$ for 4 years

$NDVI_{MAX}$ trends (β) for 4 years period the same resolution

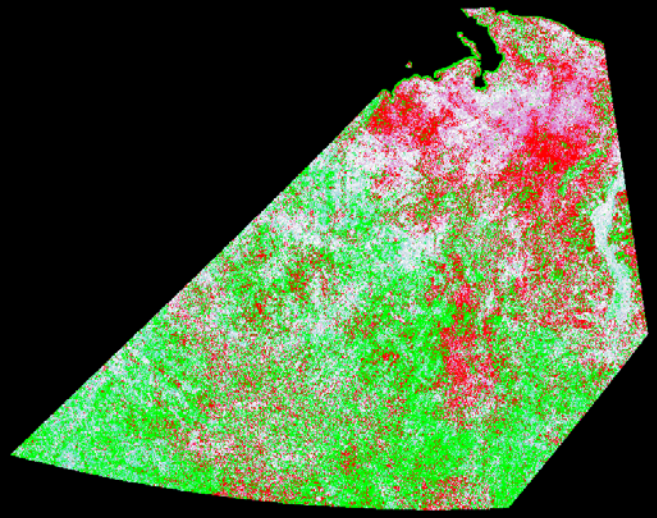
MODIS



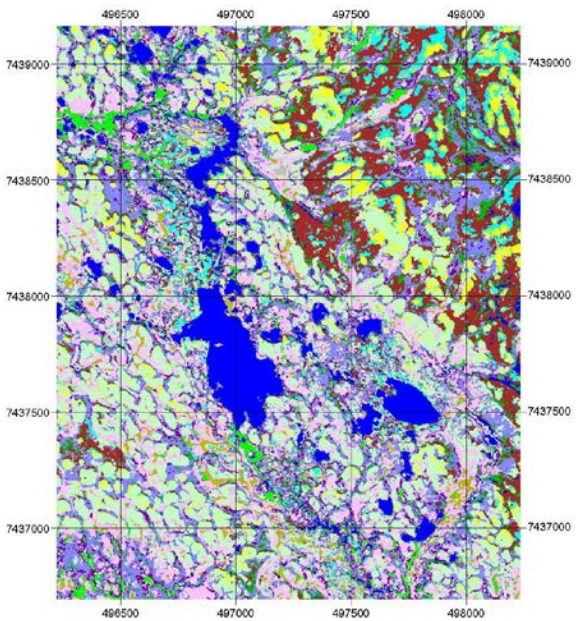
SPOT-VGT

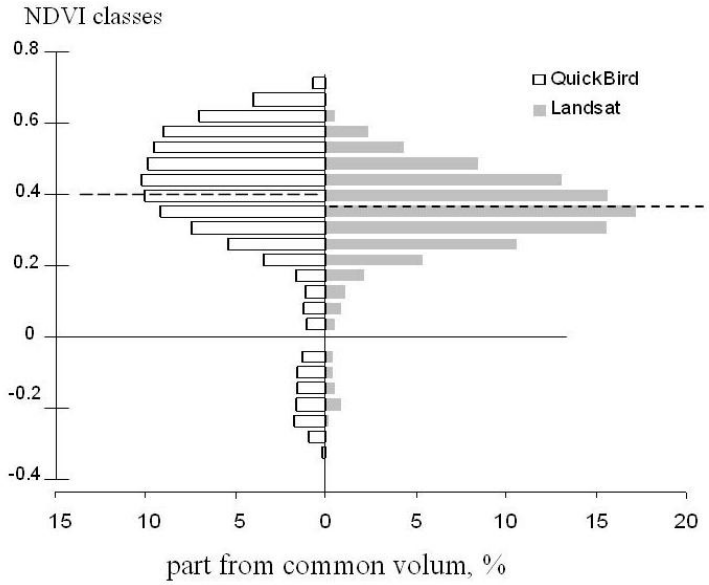


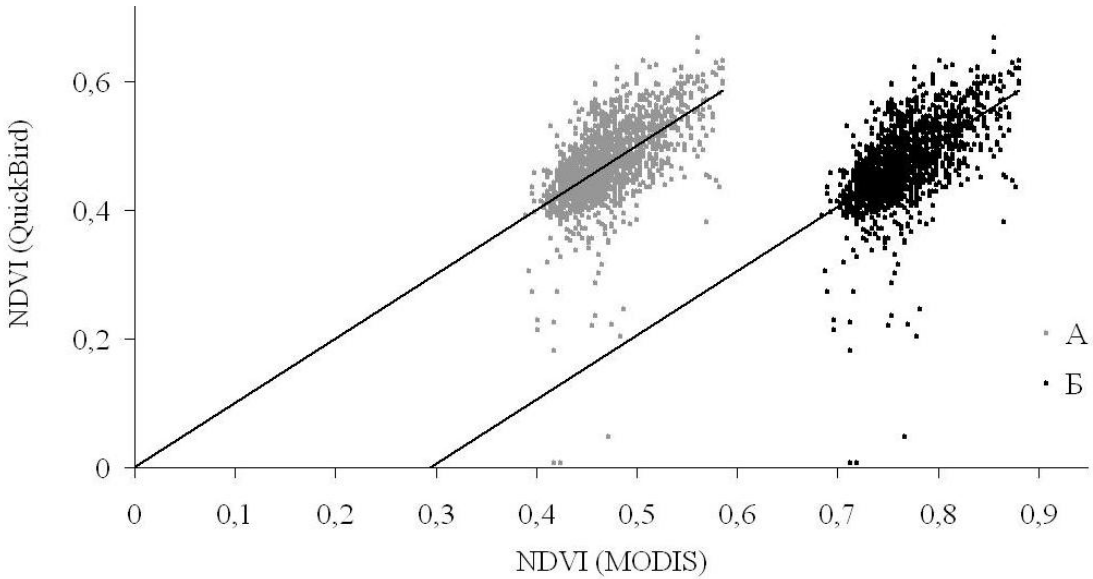
$(k_{MODIS}-k_{SPOT\text{-}VGT})/(k_{MODIS}+k_{SPOT\text{-}VGT})$

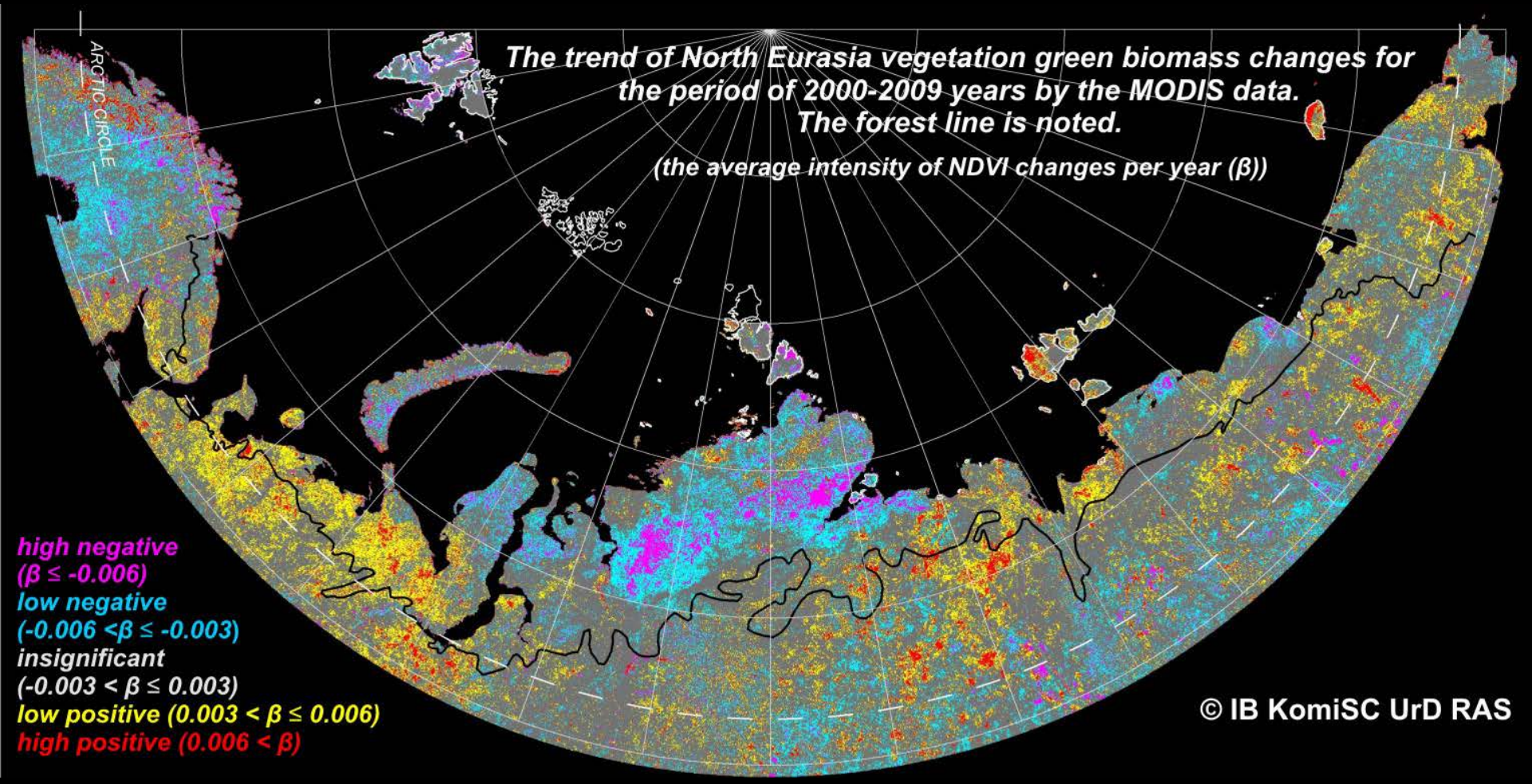


r=0.127

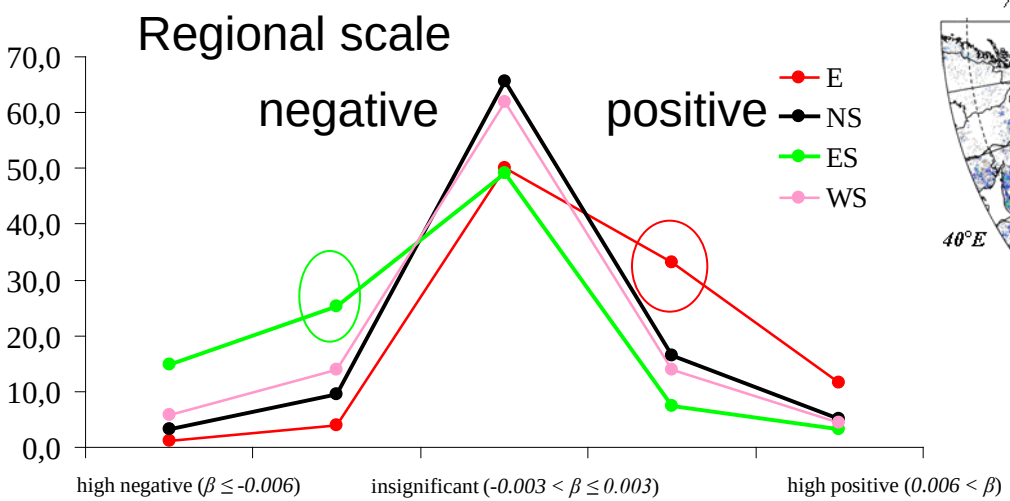

496500
497000
497500
498000
7439000
7438500
7438000
7437500
7437000

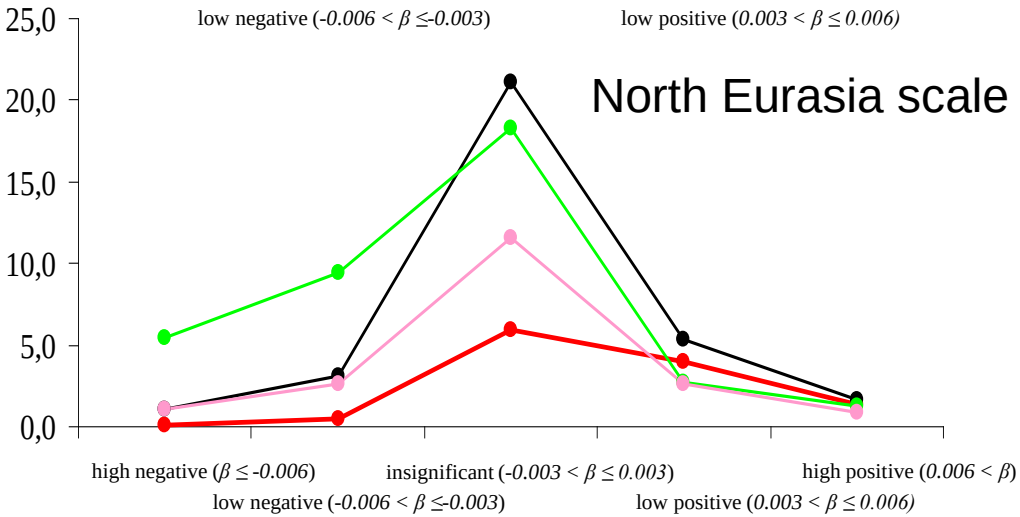

NDVI classes
QuickBird
Landsat
0.8
0.6
0.4
0.2
0
-0.2
-0.4
15
10
5
0
5
10
15
20
part from common volum, %

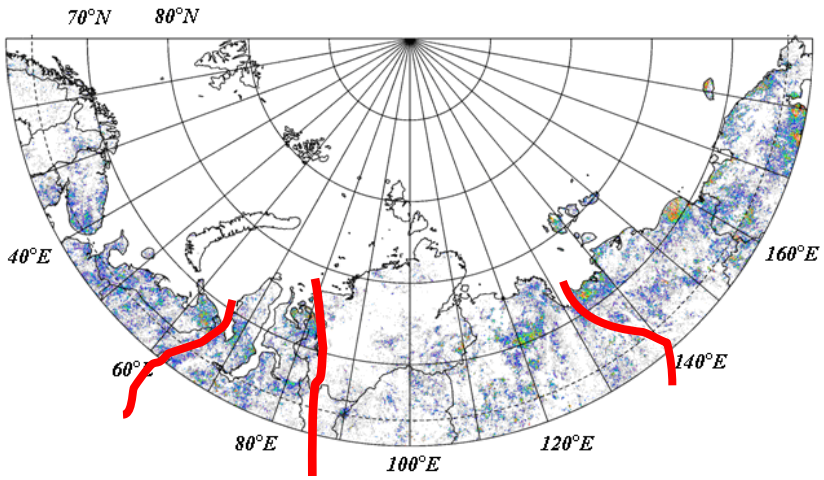

NDVI (QuickBird)
0,6
0,4
0,2
0
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
NDVI (MODIS)
А
Б


The trend of North Eurasia vegetation green biomass changes for the period of 2000-2009 years by the MODIS data.
The forest line is noted.
(the average intensity of NDVI changes per year (β))
ARCTIC CIRCLE
high negative
(β ≤ -0.006)
low negative
(-0.006 <β ≤ -0.003)
insignificant
(-0.003 < β ≤ 0.003)
low positive (0.003 < β ≤ 0.006)
high positive (0.006 < β)
© IB KomiSC UrD RAS

Area of poligons with $NDVI_{MAX}$ trends (β) for North Eurasia per 10 years period (2000-2009) (% of area).

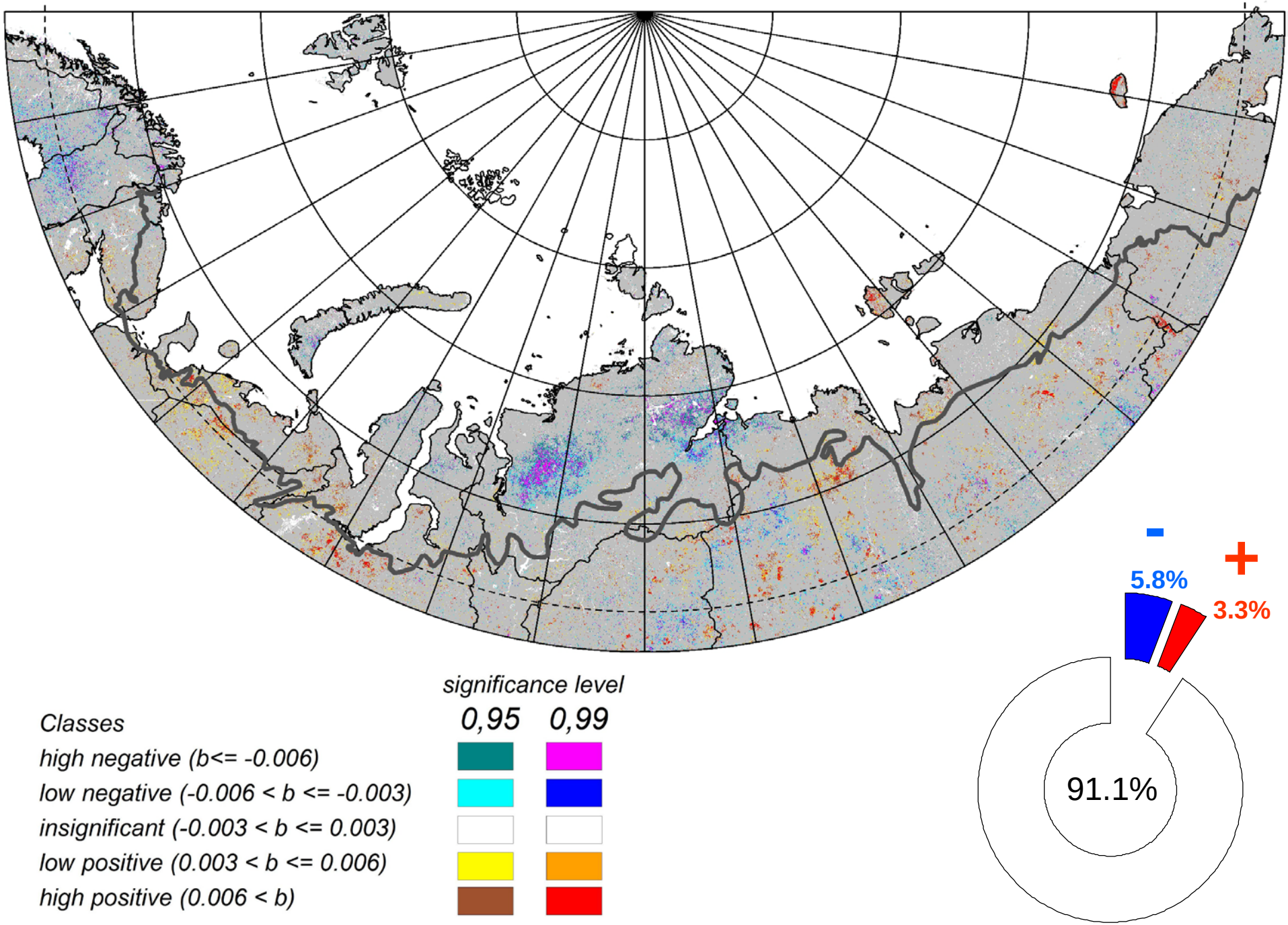




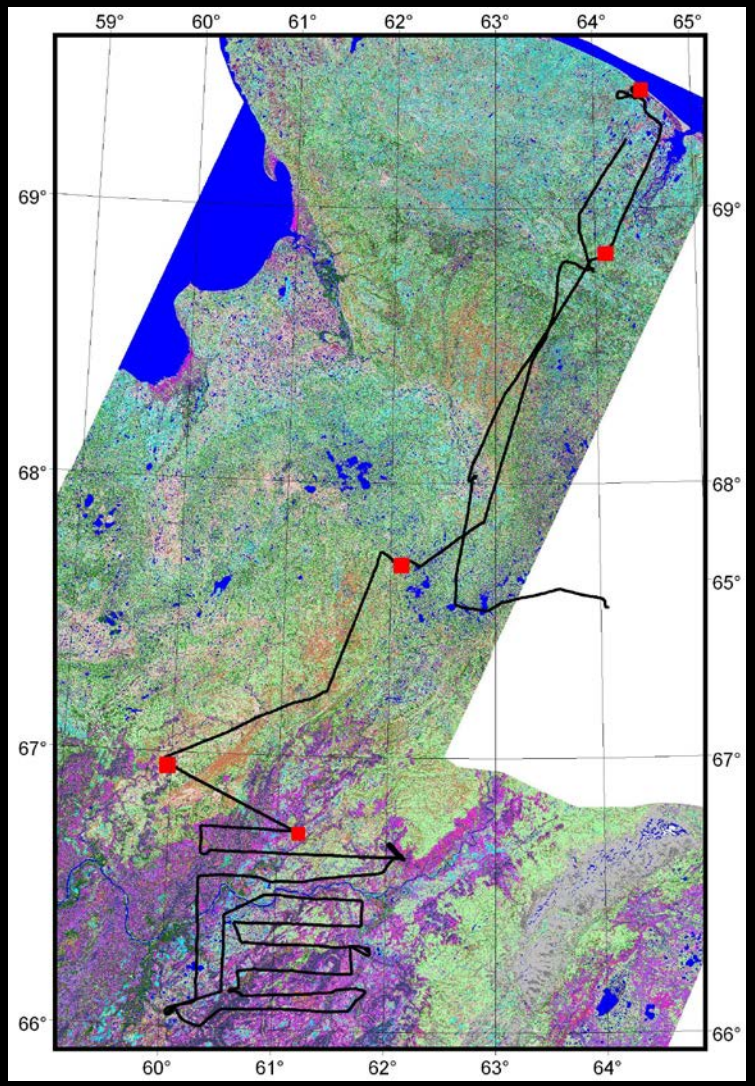


Statistical analysis of NDVI dynamics was performed separately for the European part of Eurasia (E), West Siberia (WS), East Siberia (ES), and North-East Siberia (NS) Olson et. all., 2011

*E – Europe part, WS – West Siberia, ES – East Siberia, NS – Northeast Siberia


-
+
5.8%
3.3%
91.1%
significance level
0,95
0,99
Classes
high negative (b<= -0.006)
low negative (-0.006 < b <= -0.003)
insignificant (-0.003 < b <= 0.003)
low positive (0.003 < b <= 0.006)
high positive (0.006 < b)

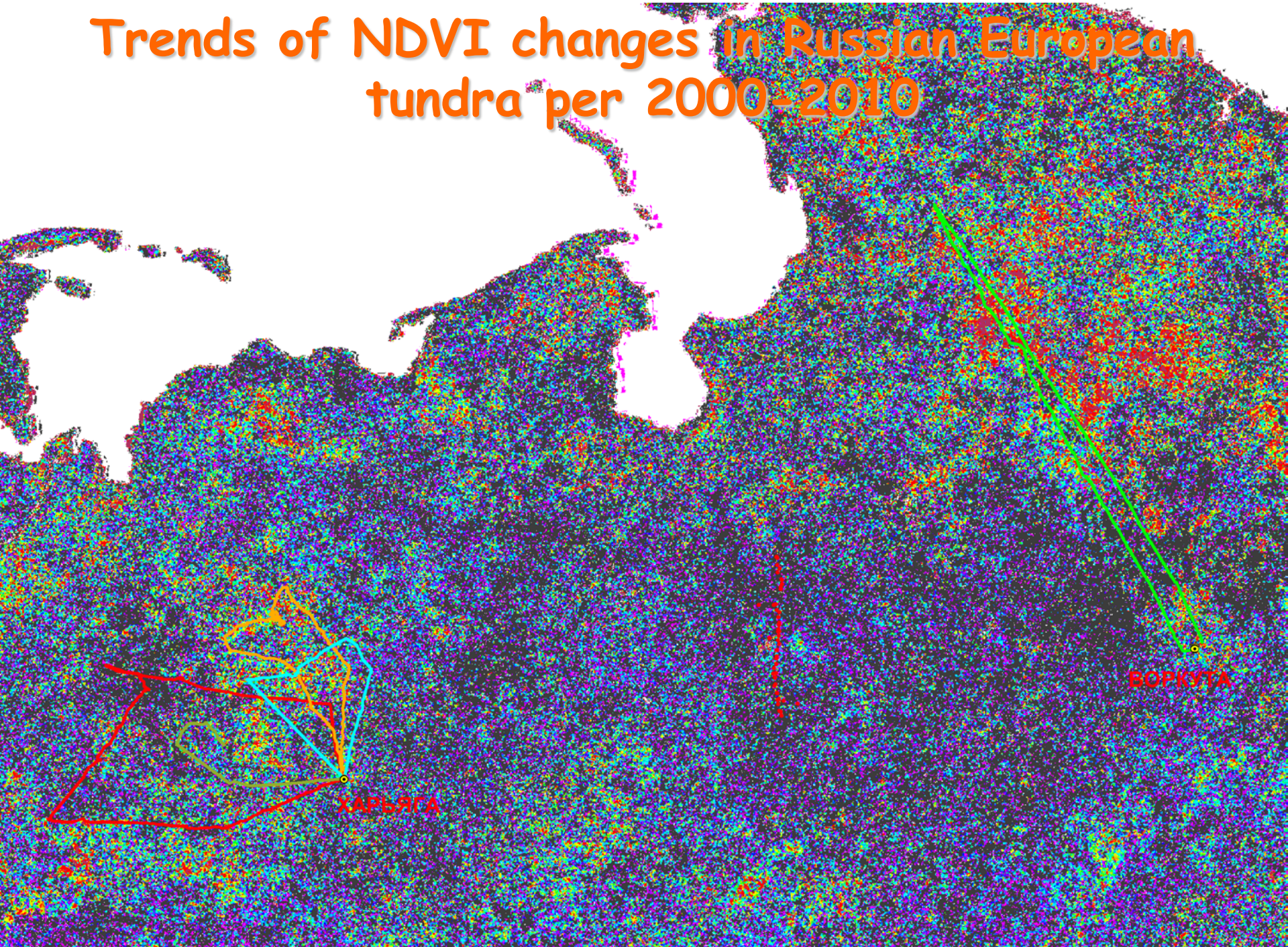
№ 47-2012 Customer: «Murmansk land surveyor company"
"Geoothanical survey of "Abez" and "Petrunskoe" reindeer herding pusters.

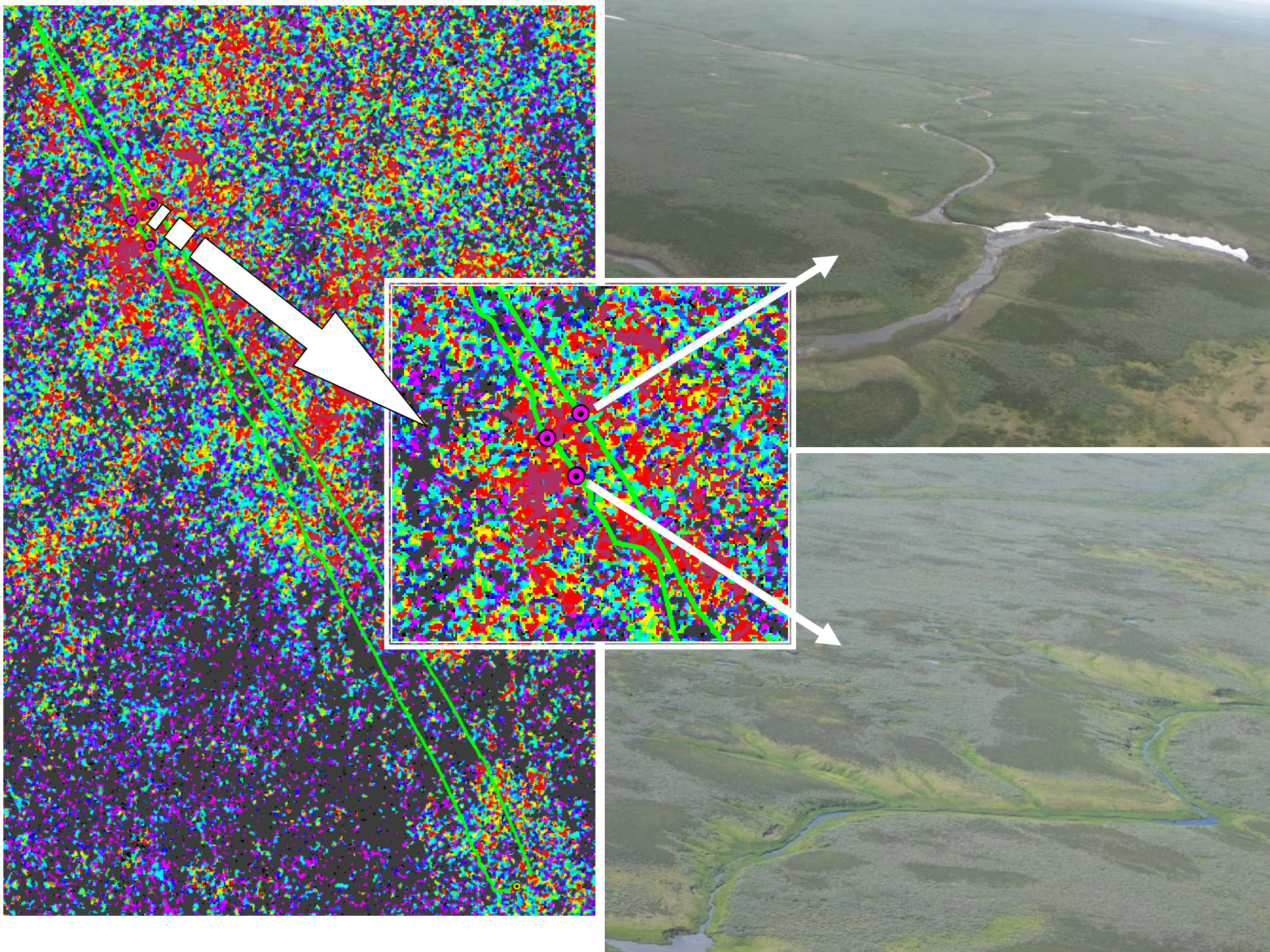


Distribution of field monitoting sites

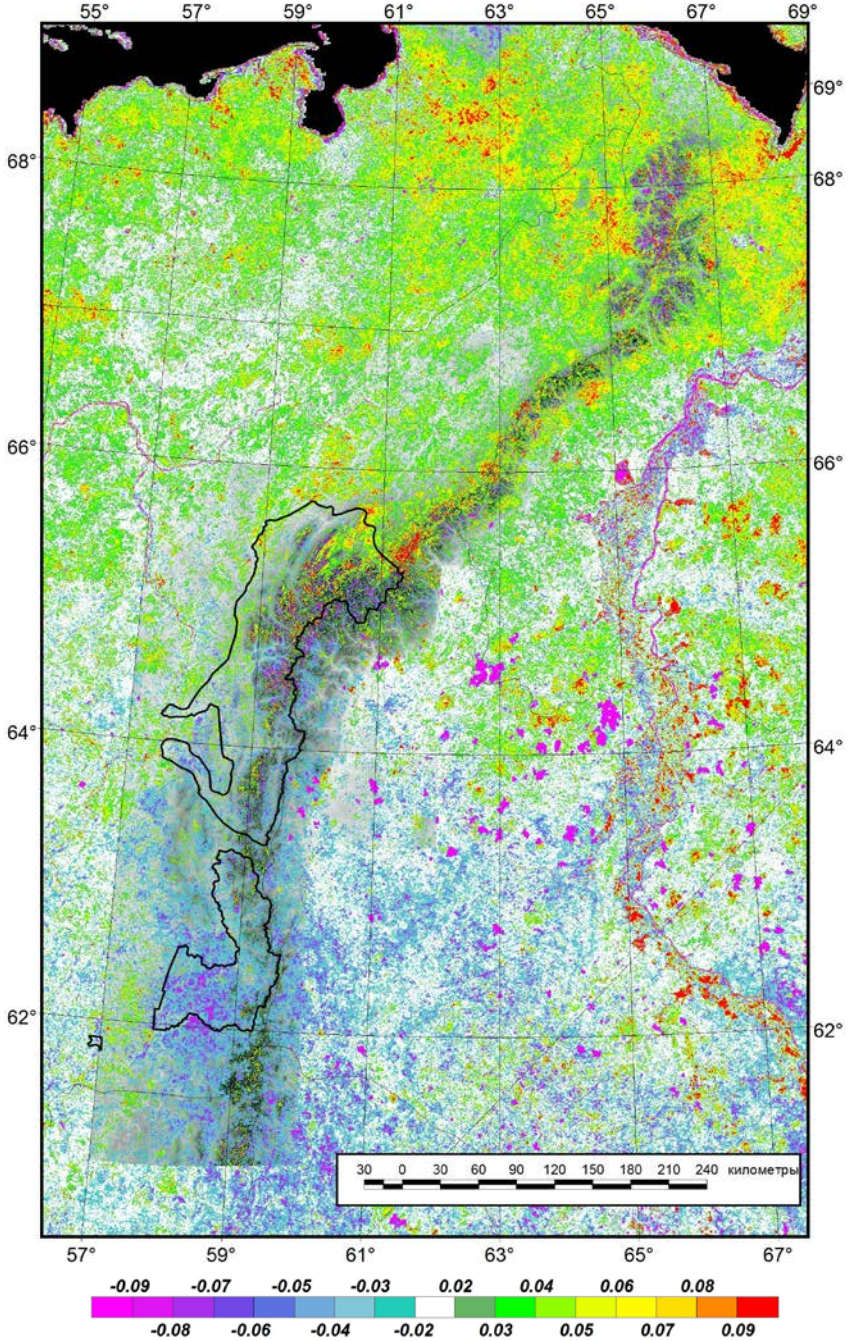
unmanned aerial vehicles (UAV)

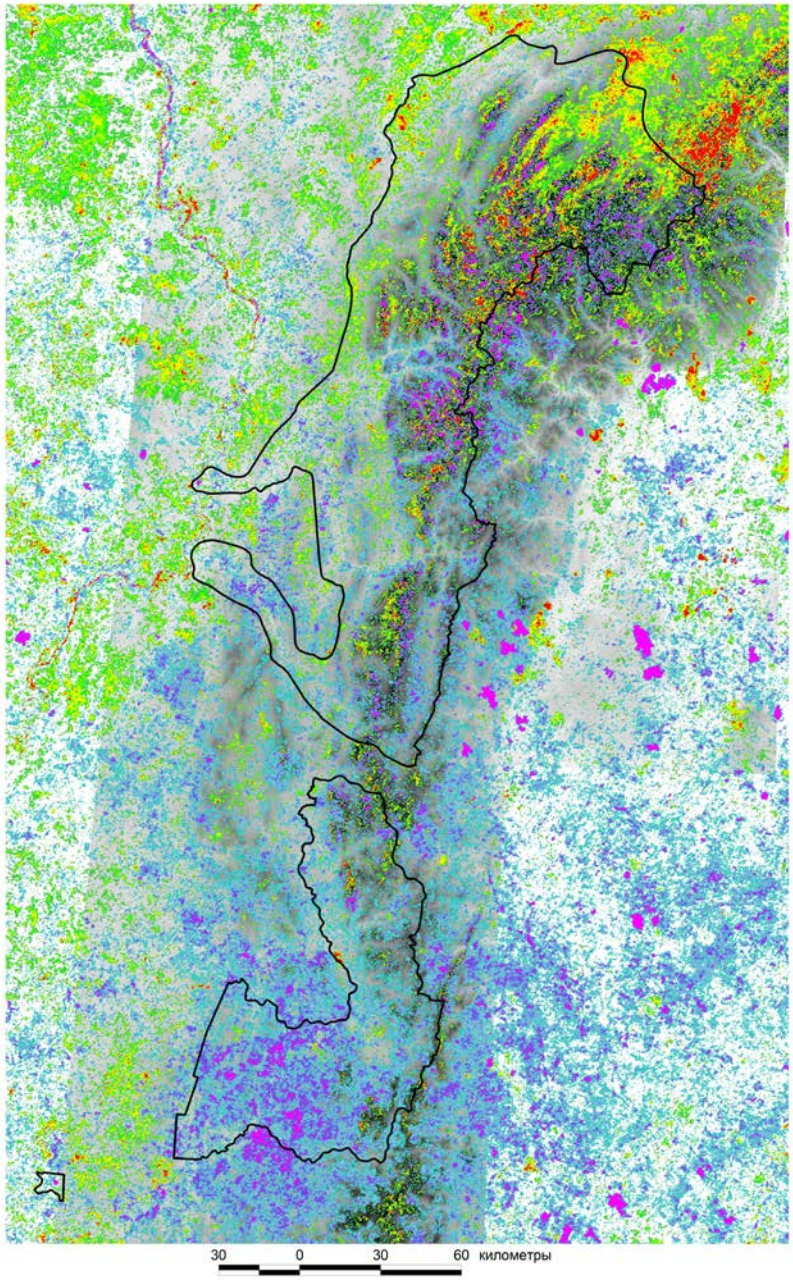
Trends of NDVI changes in Russian European tundra per 2000-2010



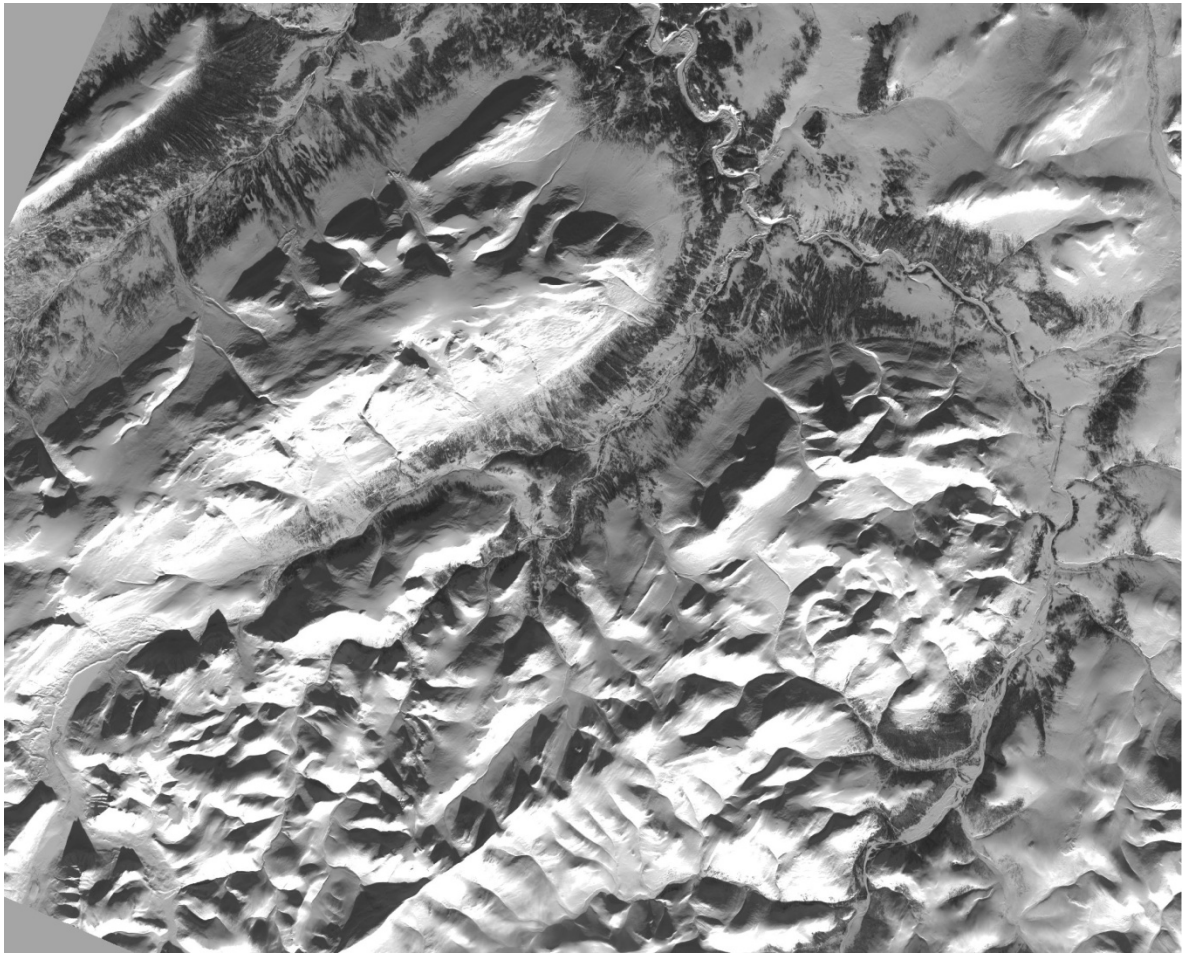


Changes near Ural mountains



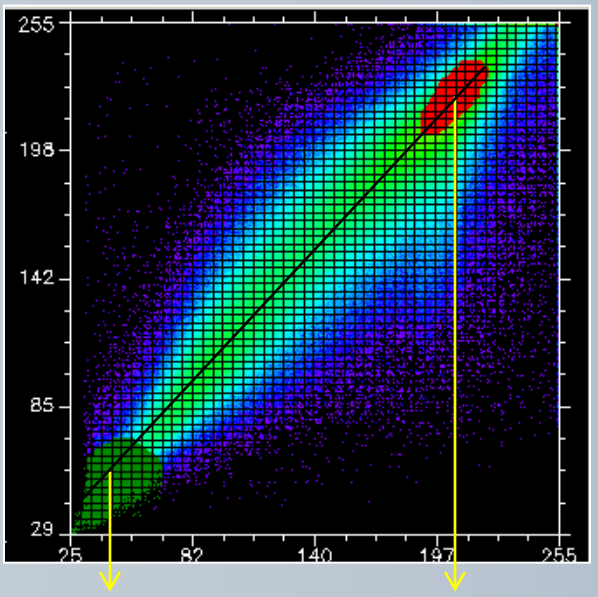


The temporal density changes of Ural forest



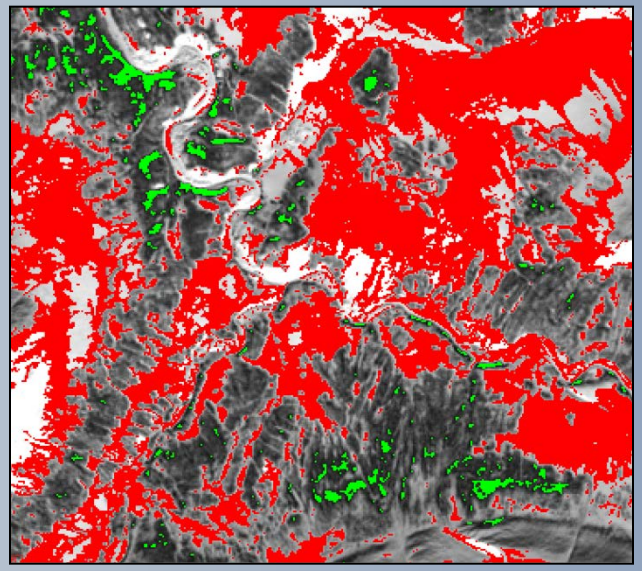
The list of processed images.

Scene parameters	Shooting date	time, GMT	Sun height	Sun azimuth
L5 168_14	8.4.1988	06:50	30.5	159.9
L7 168_14	9.4.2000	07:16	31.6	167.3
L7 168_14	30.3.2002	07:13	27.5	165.9
L5 167_14	4.10.2006	07:12	19.9	172.3



Density 90-100%

Density 0%

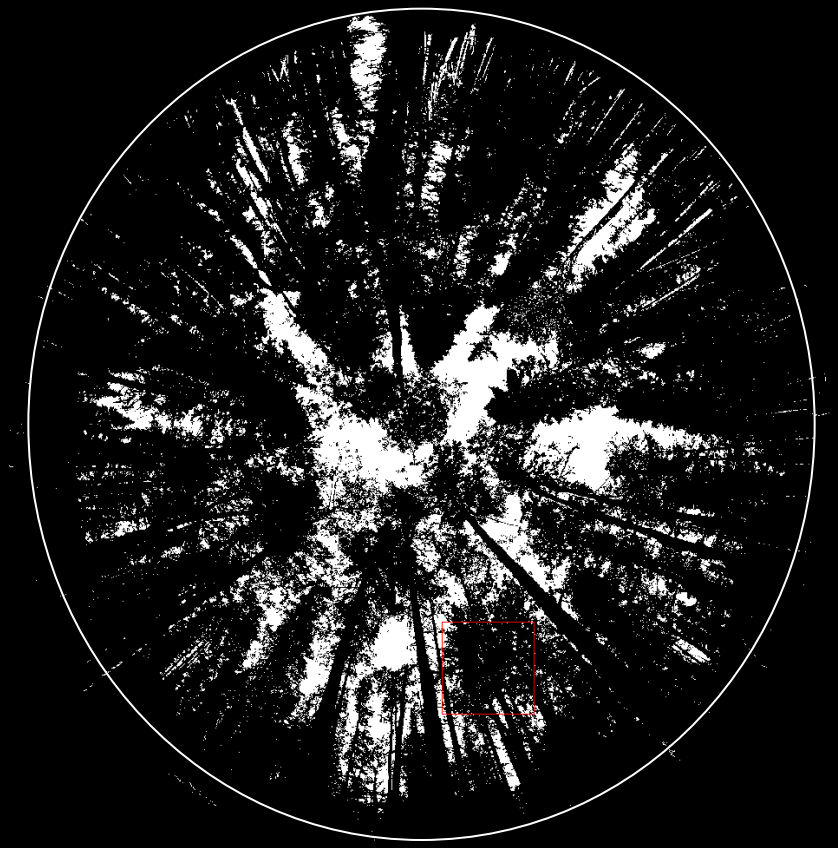


For contrast components were selected the trees cover (more than 90%) and open snow sites. The values calculated for trees stands density was scaled in interval 0-100%. Result of processing of 1988-2006 images were transformed to thematic maps reflected the density of a trees (%) for each year.

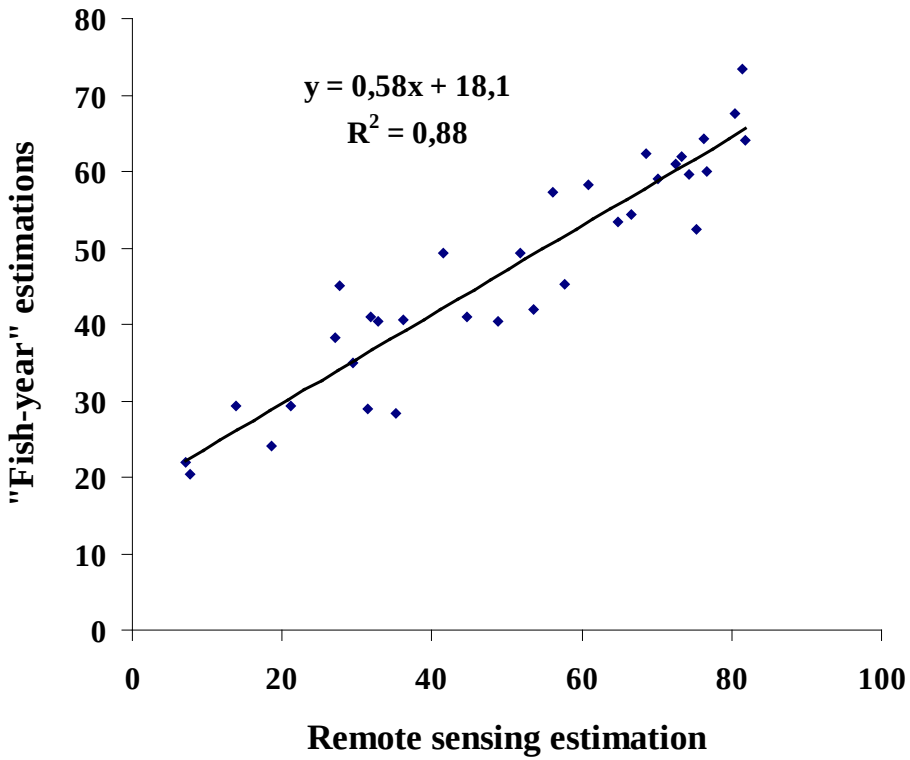
Field calibration of model with «Fish eye»

Image of «Fish eye» view

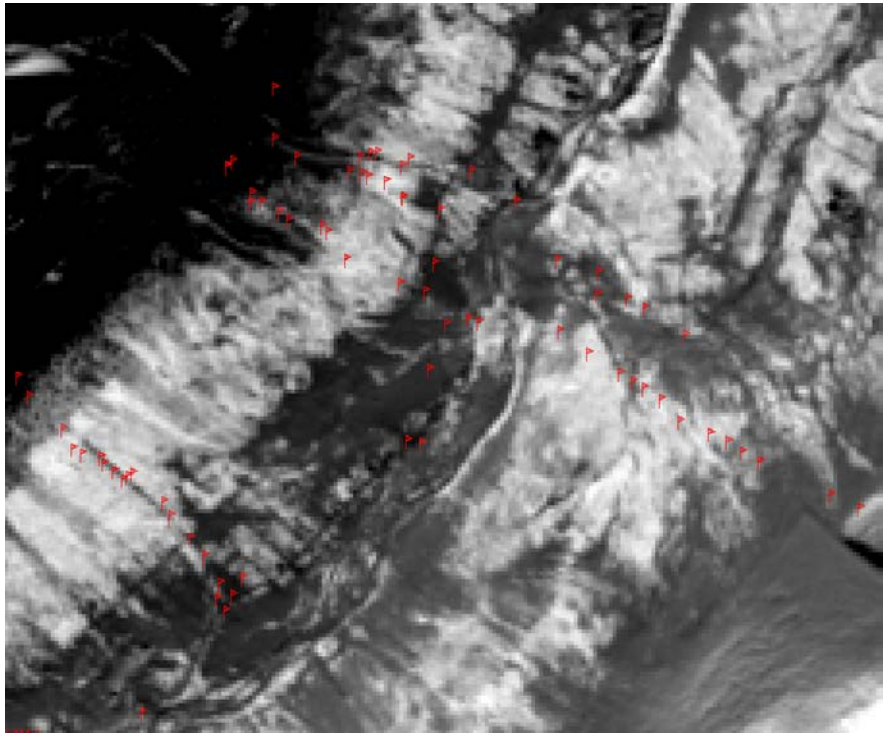
Bipartite classification (forest density= 78,6 %)



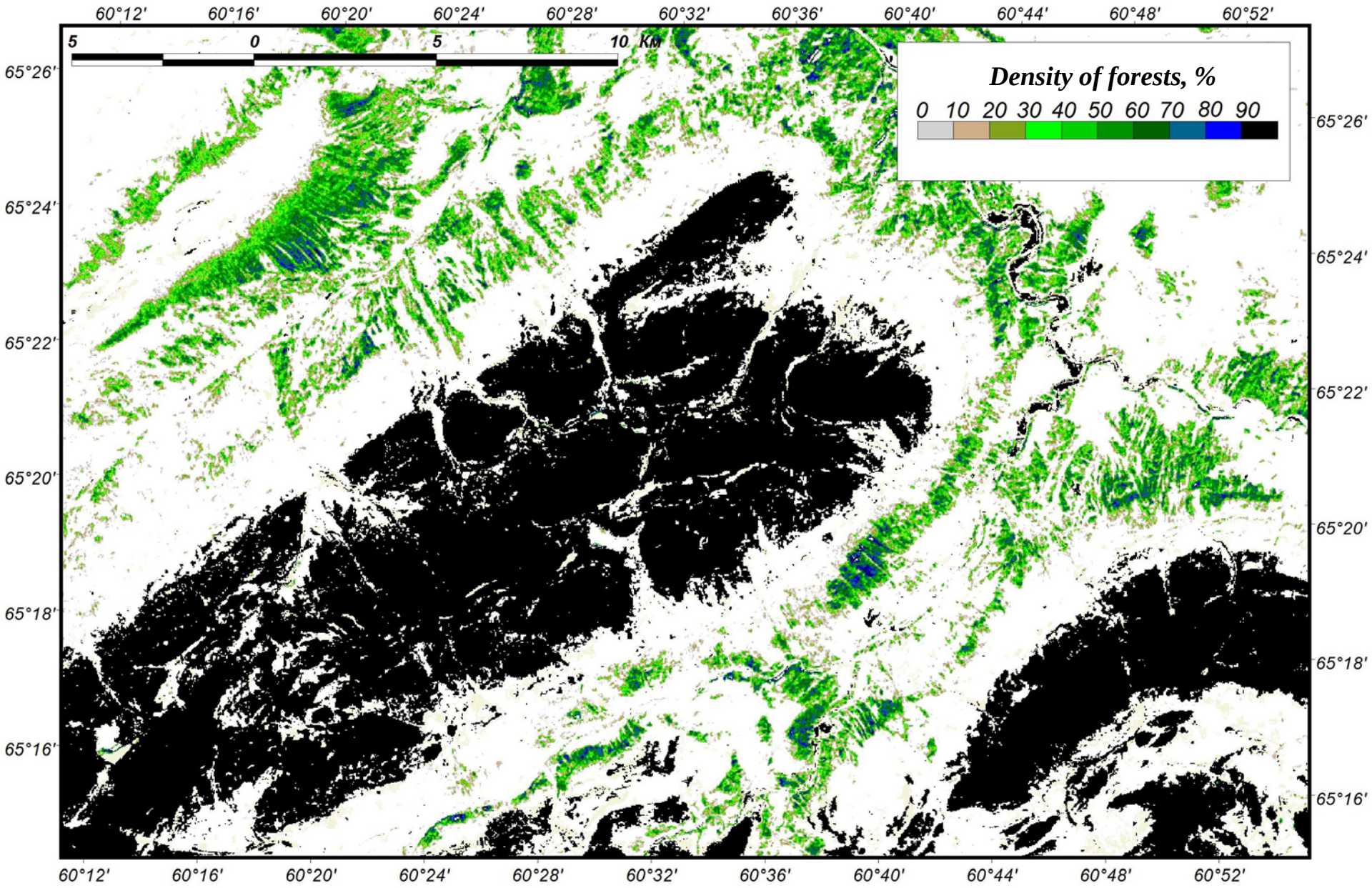
Creating a model for evaluation crown density with remote sensing data

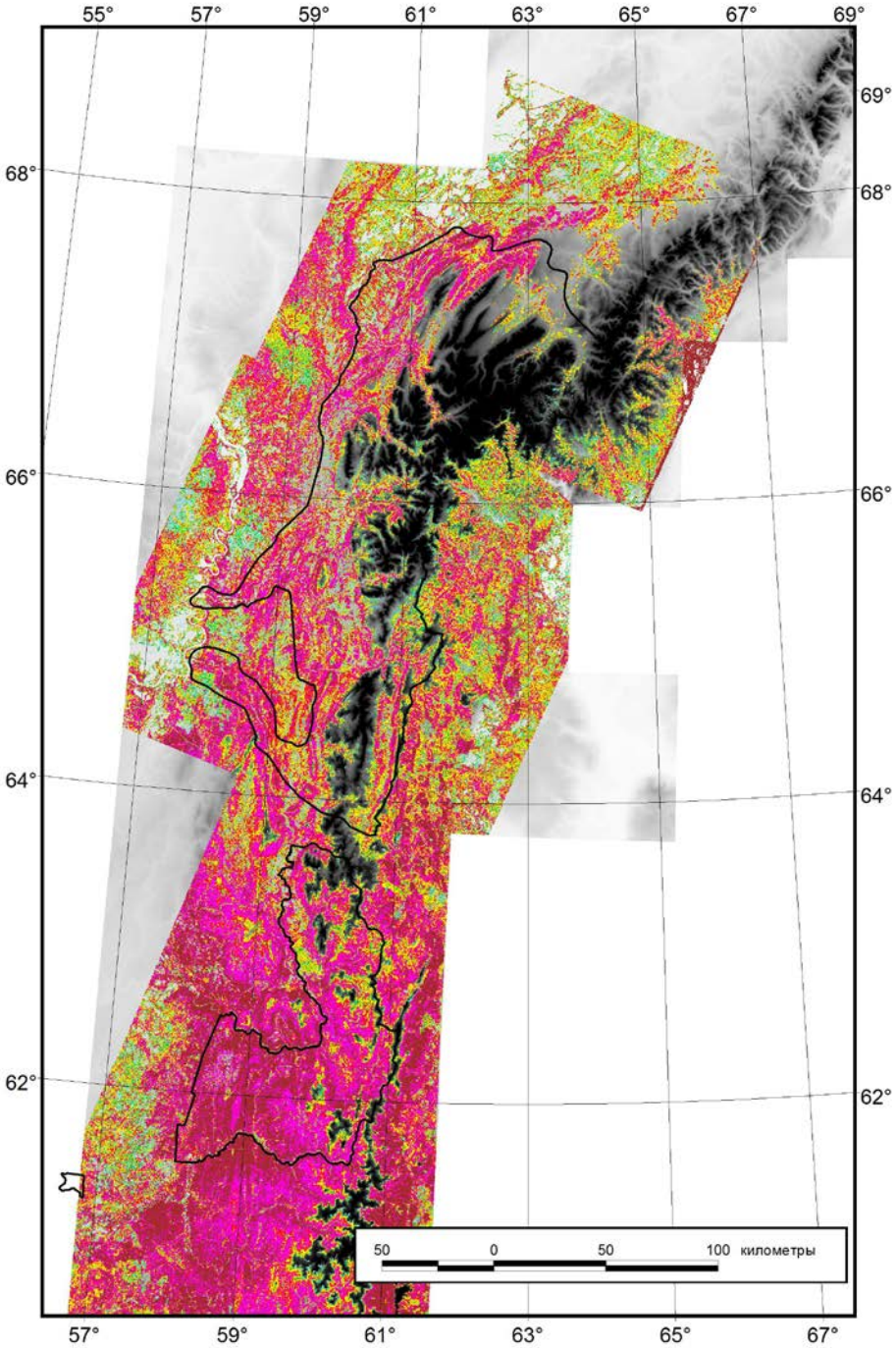


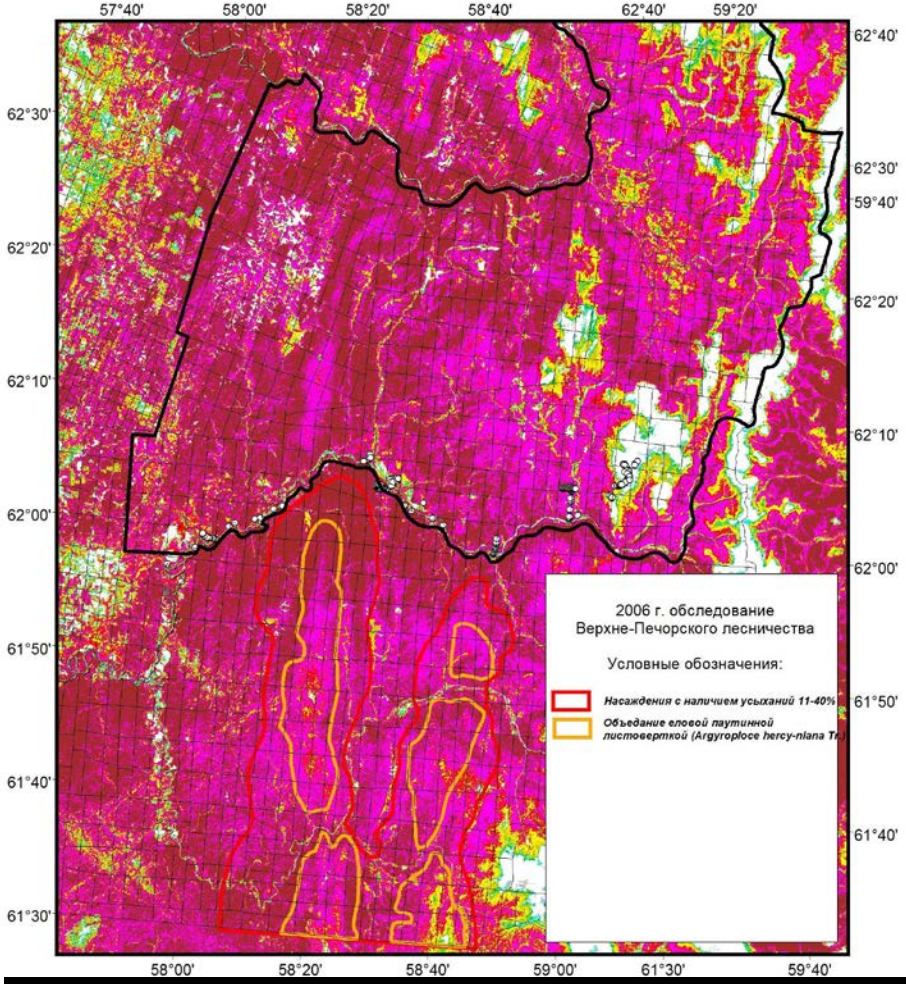
Model relations

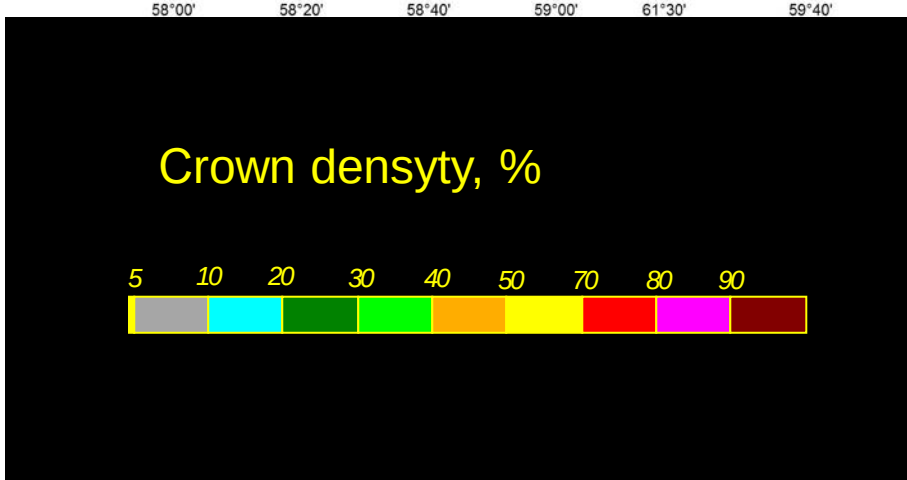


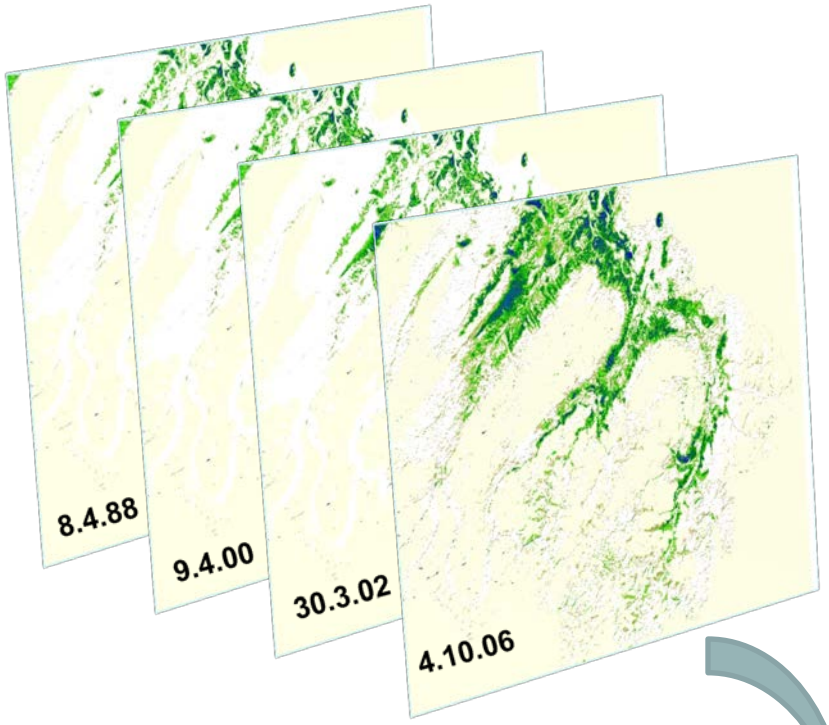
GPS coordinats on satellite model

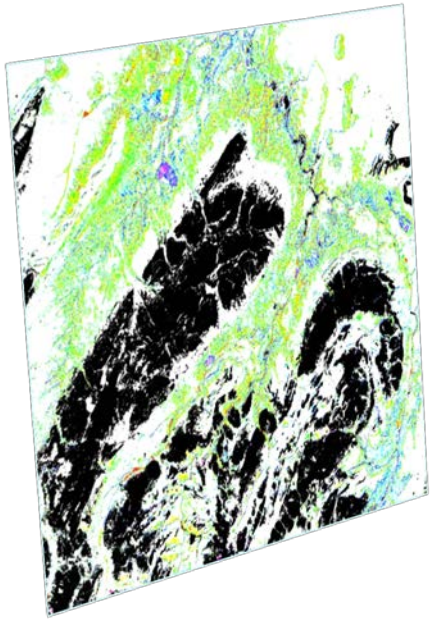

60°12'
60°16'
60°20'
60°24'
60°28'
60°32'
60°36'
60°40'
60°44'
60°48'
60°52'
65°26'
65°24'
65°22'
65°20'
65°18'
65°16'
5 0 5 10 Км
Density of forests, %
0 10 20 30 40 50 60 70 80 90

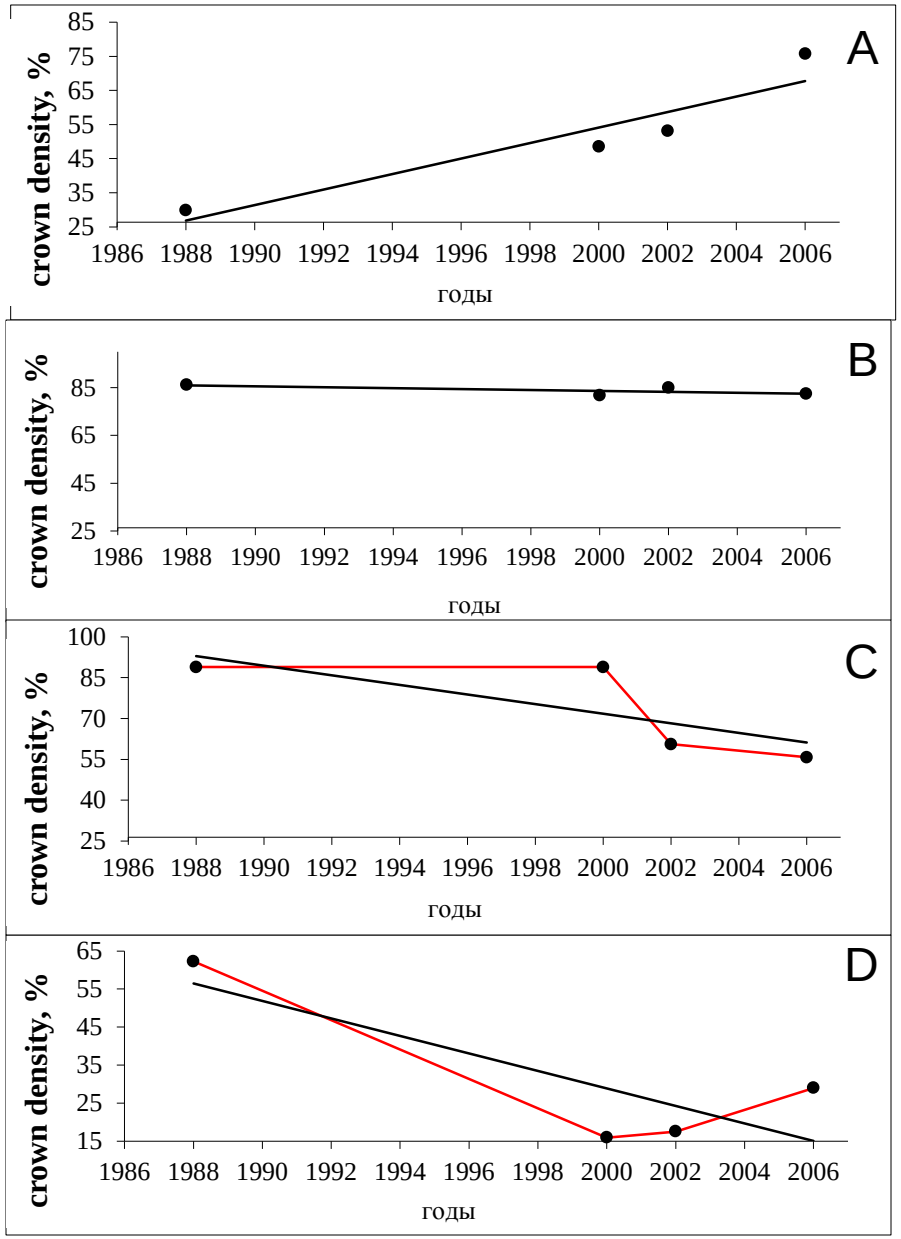

55°
57°
59°
61°
63°
65°
67°
69°
68°
66°
64°
62°
50
0
50
100 километры


57°40'
58°00'
58°20'
58°40'
62°40'
59°20'
62°30'
62°20'
62°10'
62°00'
61°50'
61°40'
61°30'
59°40'
58°00'
58°20'
58°40'
59°00'
61°30'
59°40'
2006 г. обследование
Верхне-Печорского лесничества
Условные обозначения:
Насаждения с наличием усыханий 11-40%
Объедание еловой паутинной листовертхой (Argyroploce hercy-niana Tr

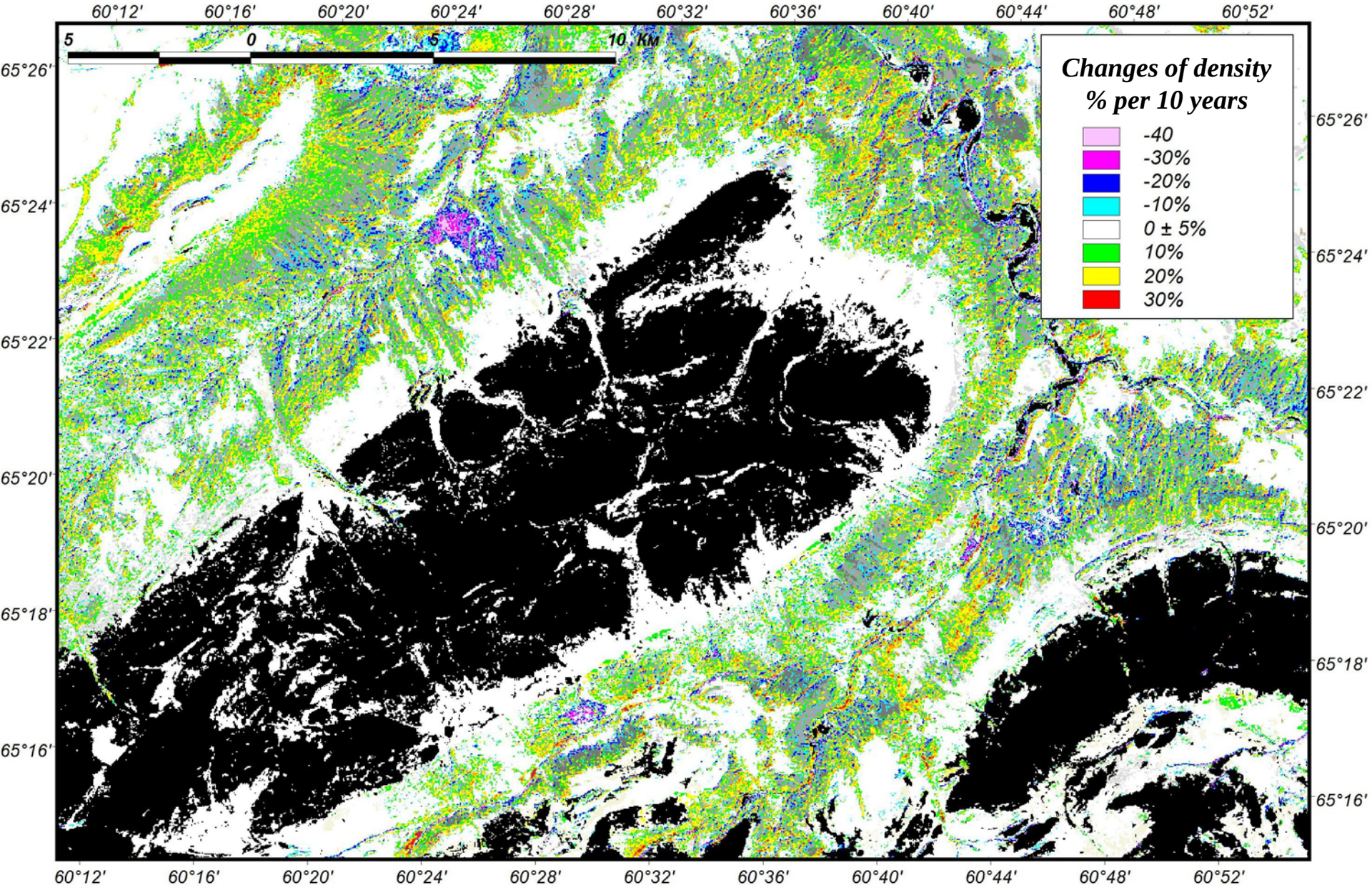

Crown densyty, %
5
10
20
30
40
50
70
80
90

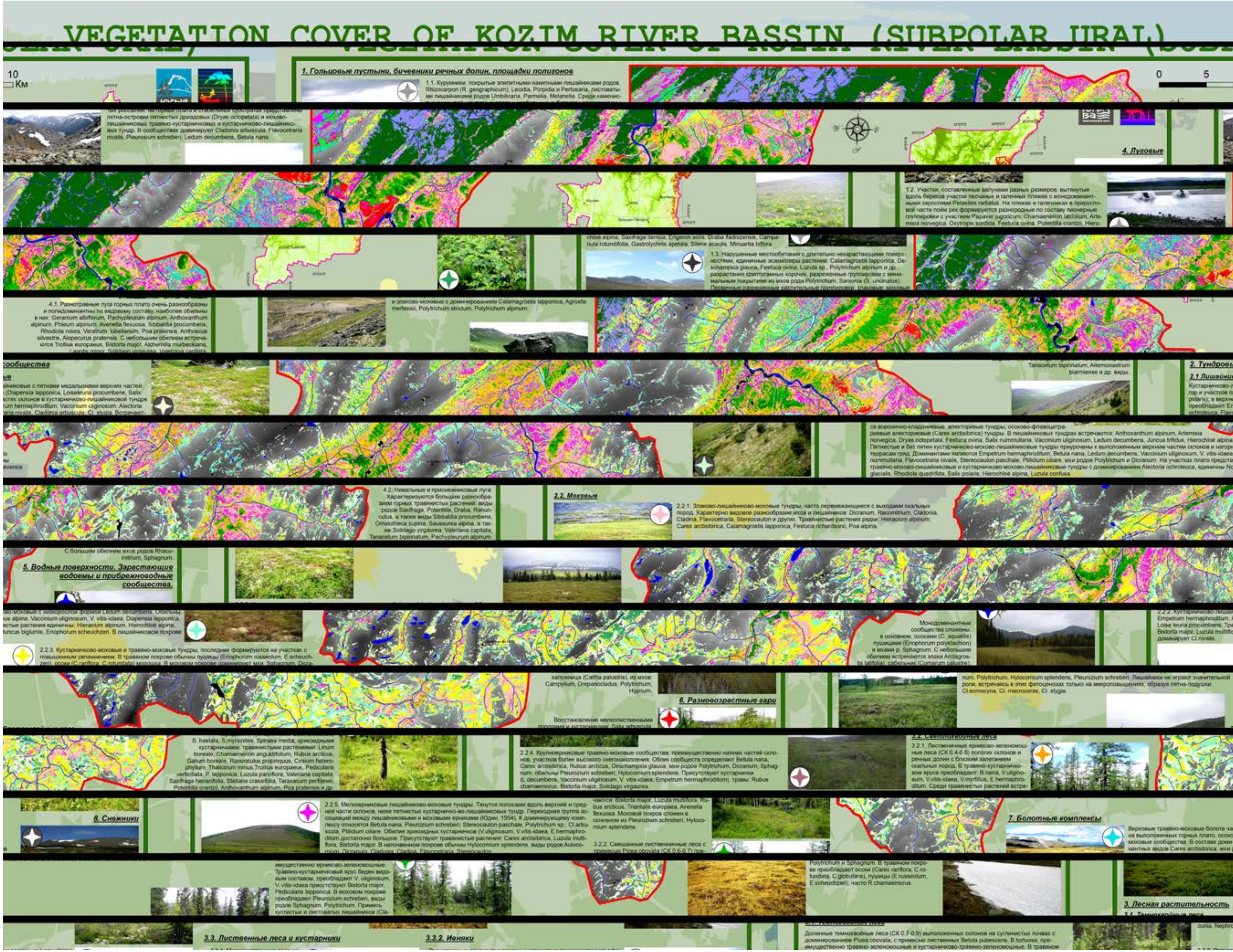






An example of calculation and possible combinations of pixel data between images. A – rare Larix low shrubs forests or sparse growth of trees , B – the valley dark coniferous forests with dominant of Picea obovata , C – fire 2000, D - – fire between 1988 and 2000.


Changes of density
% per 10 years
-40
-30%
-20%
-10%
0 ± 5%
10%
20%
30%
5
0
5
10 KM
60°12'
60°16'
60°20'
60°24'
60°28'
60°32'
60°36'
60°40'
60°44'
60°48'
60°52'
65°26'
65°24'
65°22'
65°20'
65°18'
65°16'


VEGETATION COVER OF KOZIM RIVER BASSIN (SUBPOLAR URAL)
1. Гольцовые пустыни, бичевники речных долин, площадки полигонов
4. Луговые
2. Тундровые
2.2. Моховые
5. Водные поверхности. Зарастающие водоемы и прибрежноводные сообщества.
6. Разновозрастные гари
7. Болотные комплексы
8. Снежники
3. Лесная растительность
3.3. Лиственные леса и кустарники
3.3.2. Ивняки

The comparing analysis of changes in different forest classes demonstrated that density of trees crown of classes with low density groups changed in last years more intensively than in dense classes. More stable was classes with density more than 0.9, per observation period they are only a little reduce feature. The analysis of contours of classes of rare forest demonstrated more extensive growth of parameter.

The distribution of density classes and forest classes in 2002 year (numerator) and change of they relative areas between 1988-2002 years (%).

density classes (%)	classes of forests				total
	T1	C1	C2	C3	
<10	-	0.1 -0.1	0.5 -0.8	8.7 -3.4	9.3 -4.3
10-30	-	0.6 -0.7	4.0 -4.5	19.1 1.2	23.7 -3.9
30-50	0.1 -0.1	3.0 -3.0	11.1 1.2	9.9 4.0	24.2 2.1
50-70	0.9 -0.5	13.9 -0.2	8.1 3.4	2.2 0.6	25.1 3.3
70-90	4.7 0.6	11.0 2.9	0.8 0.0	-	16.9 3.3
> 90	0.7 -0.2	0.1 -0.3	-	-	0.9 -0.5
total	6.5 -0.3	28.6 -1.3	24.5 -0.6	40.3 2.2	100.0

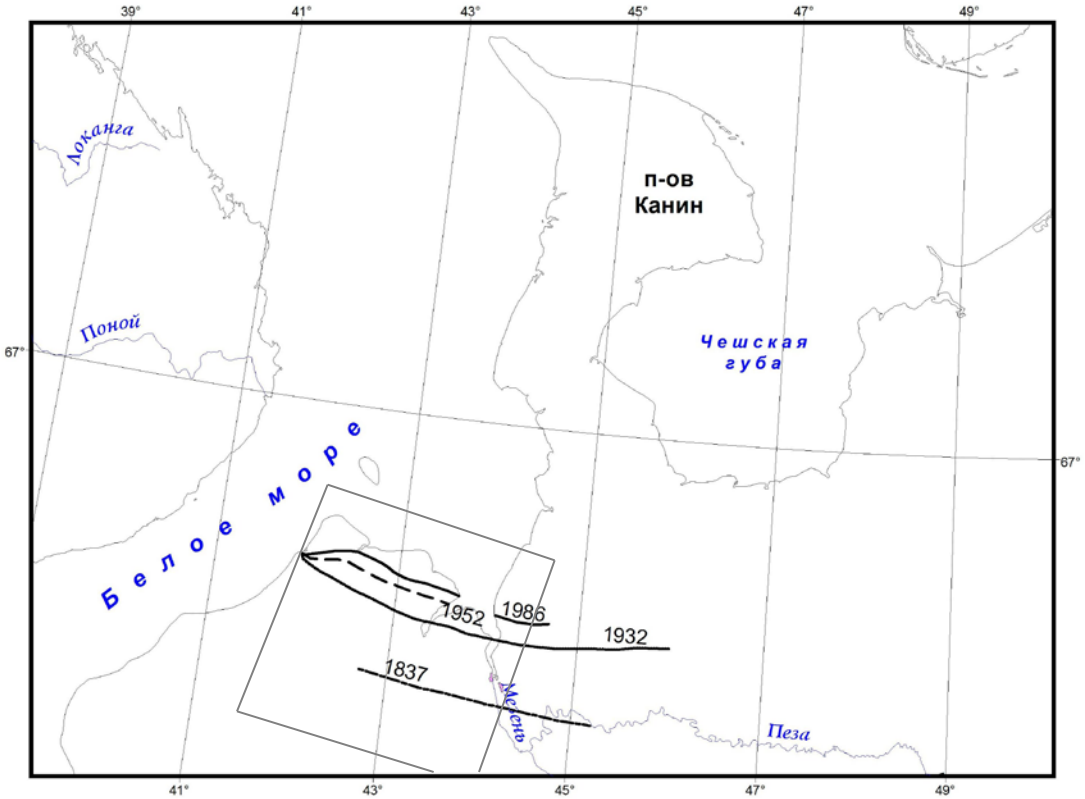
T1 – (6.5% of area) The valley dark coniferous forests with dominant of *Picea obovata*. The crown density varies from 0.6 to 0.9.

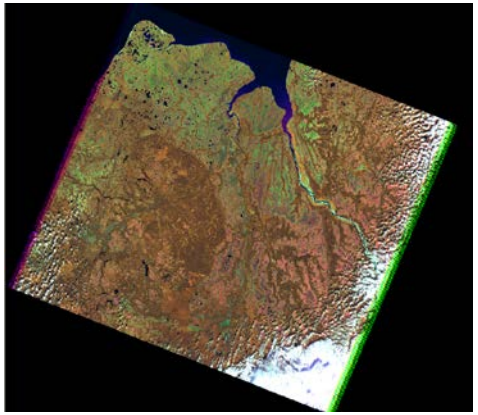
C – Light coniferous forests (93.5% of area)

C1 – Mixed *Larix* and *Picea* forests (28.6%) with crown density 0.4 - 0.6% located mainly on higher or lower sites in border with **T1** classes with less developed soils.

C2 – *Larix* shrub forests (24.5 %) located on gentle slopes and river valleys with close location of rocks with crown density 0.3 -0.5%.

C3 – Rare *Larix* low shrubs forests or sparse growth of trees (40.3 %) mainly located in taiga-tundra ecoton zone with crown density <0.3.



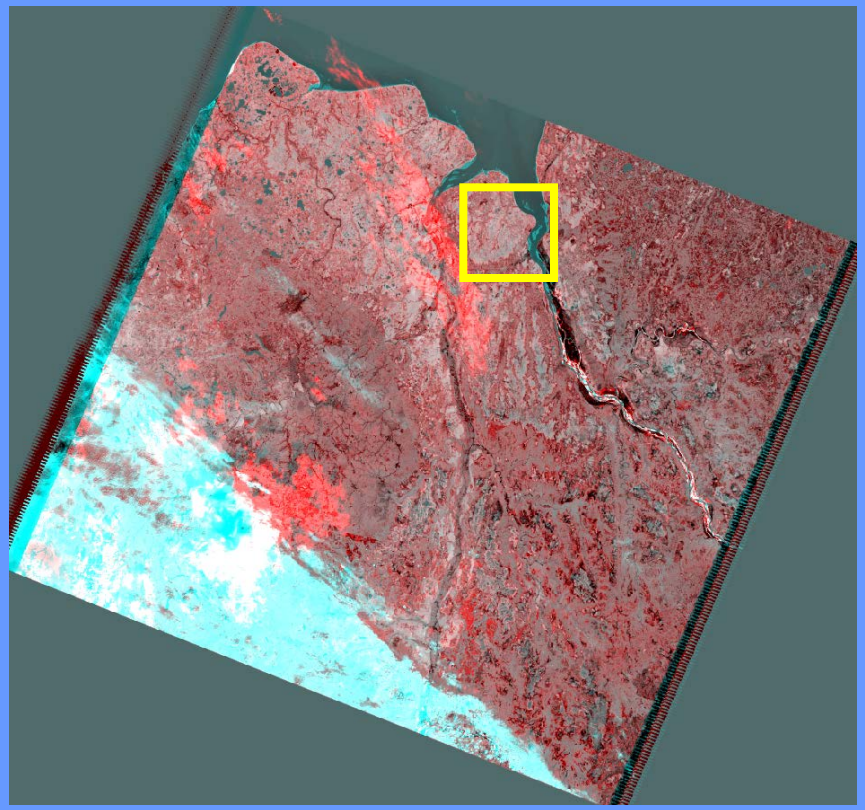


1837 – Shrenk expedition (near Mezen noted permafrost layer)

1933 – Datskii N.G. expedition
(cited: Sumgin M.I. permafrost. L: AS USSR, 1934. 65 p.

1952 and 1986 – Archangelskii science centre data

Degradation of permafrost boder for 115 years near 45-50 km



10.07.1988 - 28.07.2009
(21 period)

For the among annual changes in ecosystems per observation period the *Disturbance Index, DI* was calculated (Healey et.al., 2005):

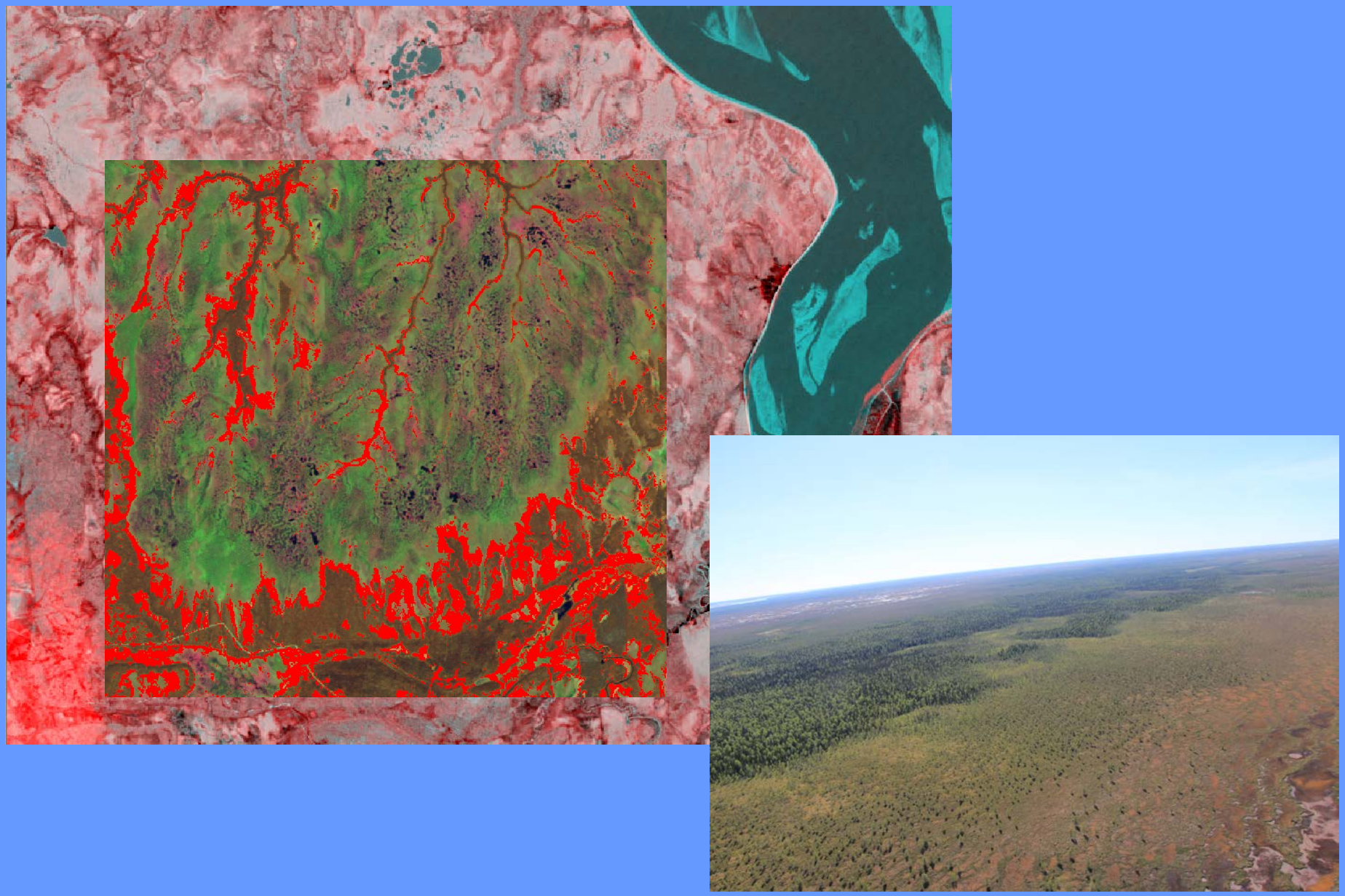
$$DI = B_r - (G_r + W_r). \qquad (1),$$

were the Br, Gr, Wr – scaled volumes of features Brightness, Greenness и Wetness, after transformations:

$$B_r = (B - B_m) / B_\sigma$$
$$G_r = (G - G_m) / G_\sigma \qquad (2),$$
$$W_r = (W - W_m) / W_\sigma ,$$

and B, G, W – volumes of pixels; Bm, Gm, Wm – average volumes and Bσ, Gσ, Wσ – standard deviations. The volumes of B, G and W are prepared after standard Tasseled Cap procedures (King et.al., 2001; Huang et.al., 2001).

(King et.al., 2001; Huang et.al., 2001).



2014

Thus a border between forest-tundra zones was observing as possible parameter for research of biocenosis changes under climatic influence. The special interest directed to researching of mountain forests (Shijatov et all., 2005; 2009). It connected with brighter expressiveness of an ecological gradient in cenotical conditions at compact area than on a flat plane. The basic tendencies of changes of forest communities are fixed in advancement of border of wood species at the top border of mountains wood-line and increase of crones density, increasing of tree-rings growth that reflects climatic shifts. The characteristic of a density of forest stands is used as the most important indicator for revealing of time changes of forests.

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