

Research on Soil Moisture and Evapotranspiration using Remote Sensing

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Jasna 2/4



Field Measurements at the Middle Biebrza Basin

May, June, July, August 2000

May, June, July 2001

May, June, July 2002

Satellite Images:

Landsat TM - May 2000

SPOT/VEGETATION – May 2000; May 2001

ERS/ATSR – May 2000; May 2001

ERS. SAR – May, June, July, August

NOAA/AVHRR

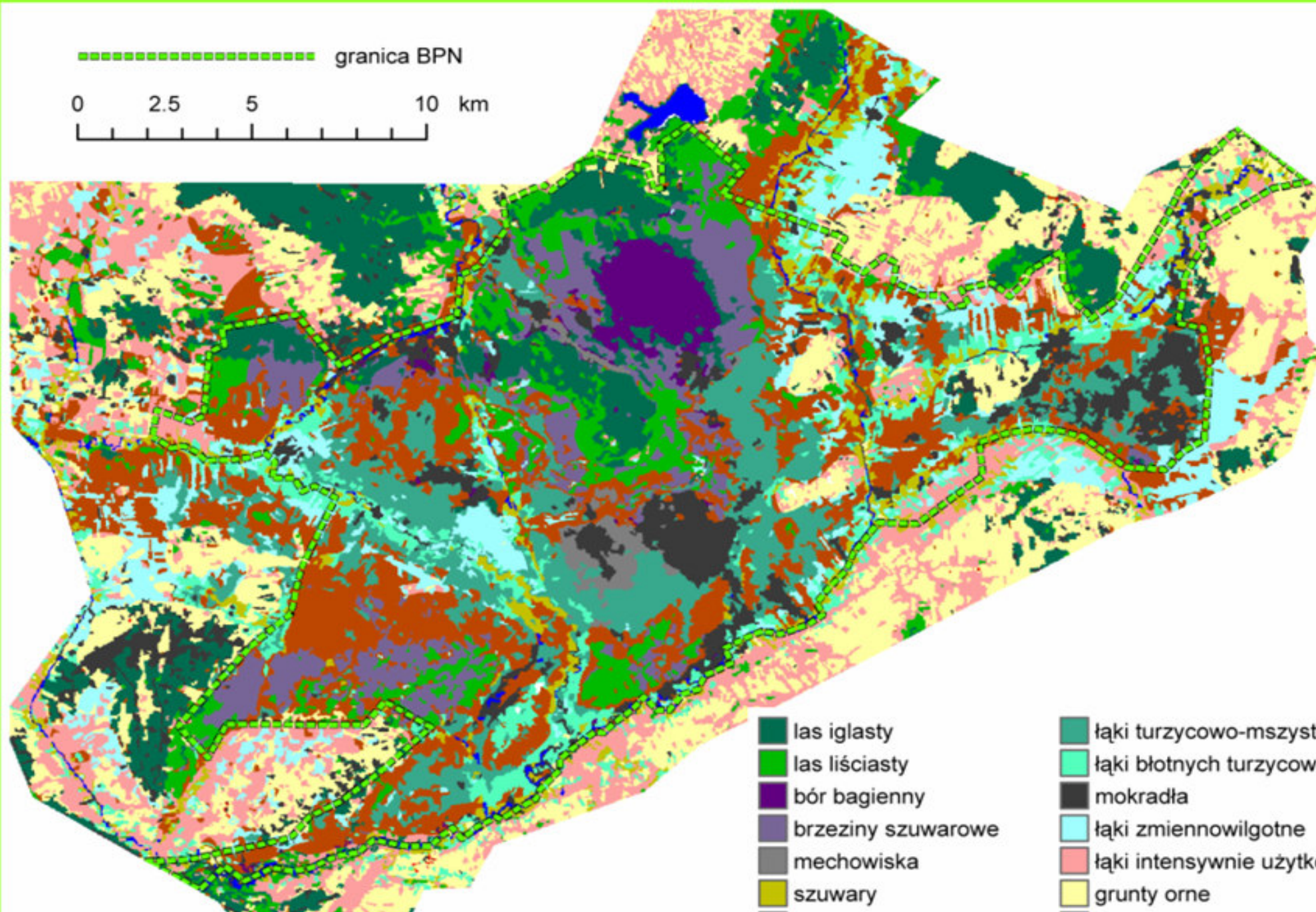
ERS-SAR 1995, 1997, 2000, 2001, 2002 - 2003

ENVISAT

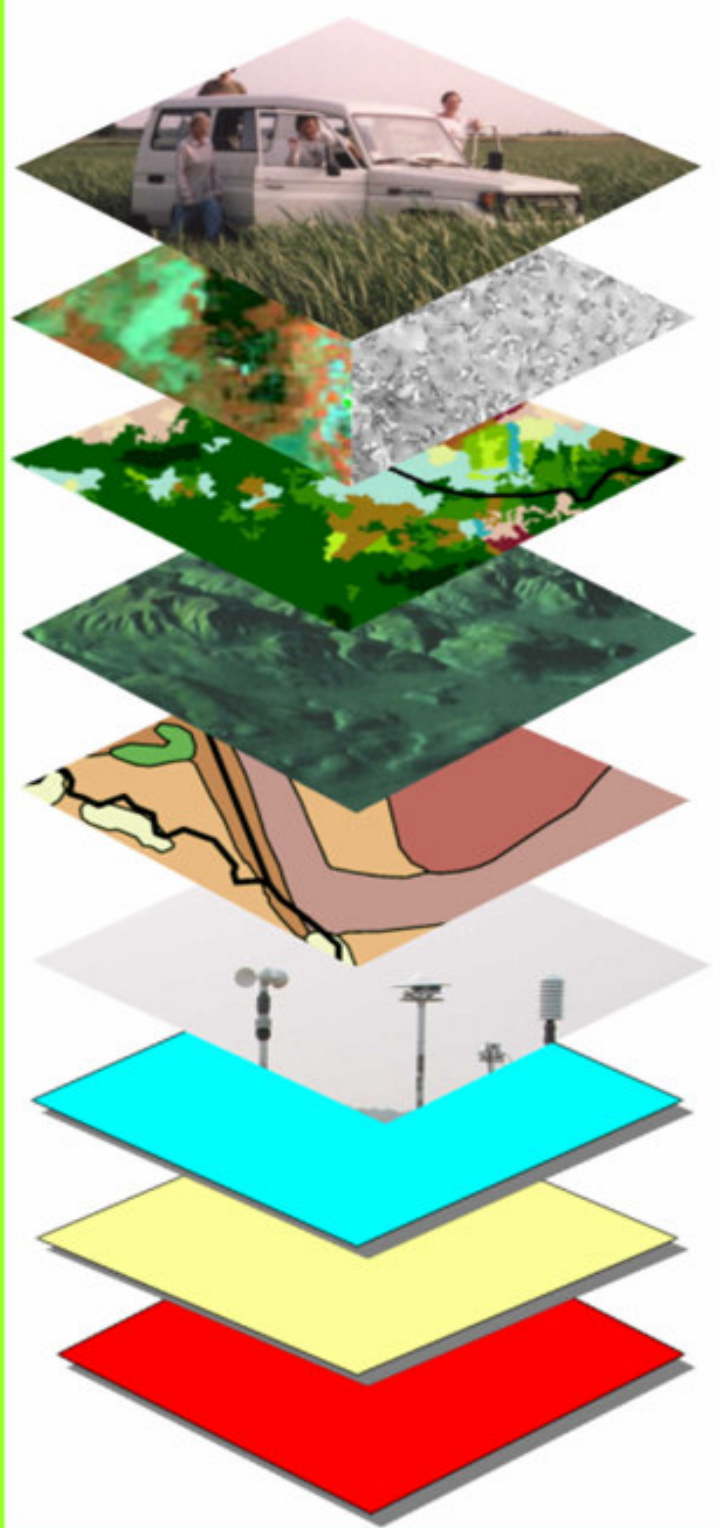
TERRA – MODIS; ASTER

----- granica BPN

0 2.5 5 10 km



- | | |
|--------------------|-----------------------------|
| las iglasty | łąki turzycowo-mszyste |
| las liściasty | łąki błotnych turzycowisk |
| bór bagienny | mokradła |
| brzeziny szuwarowe | łąki zmiennowilgotne |
| mechowiska | łąki intensywnie użytkowane |
| szuwary | grunty orne |
| zakrzaczenia | woda |



Field data

Satellite data
optical and microwave

Land Use

Digital Terrain Model

Soil Map

Meteorological Data

Evapotranspiration
soil moisture

Modelling

Water Balance

INSTITUTE OF GEODESY AND CARTOGRAPHY



Satellite Data

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graph TD; SD[Satellite Data] --> OD[OPTICAL DATA]; SD --> MD[MICROWAVE DATA]; OD --> CV[Classification of vegetation]; OD --> LAI[LAI]; OD --> ET[EVAPOTRANSPIRATION]; MD --> SM[Soil Moisture];
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OPTICAL DATA

**Classification
of vegetation**

LAI

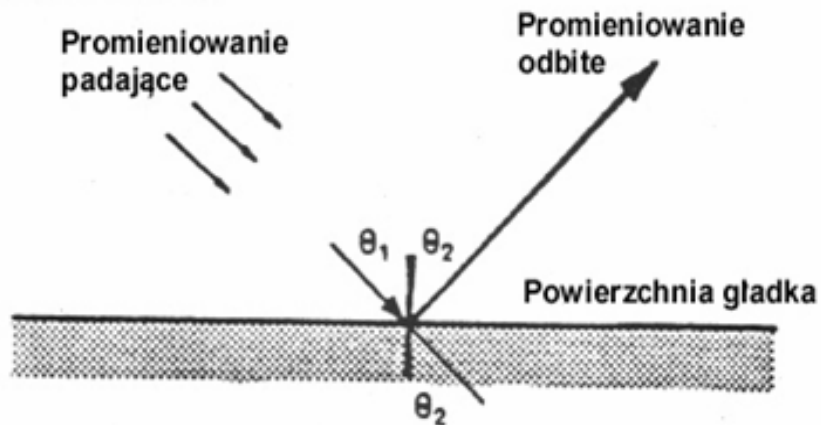
EVAPOTRANSPIRATION

MICROWAVE DATA

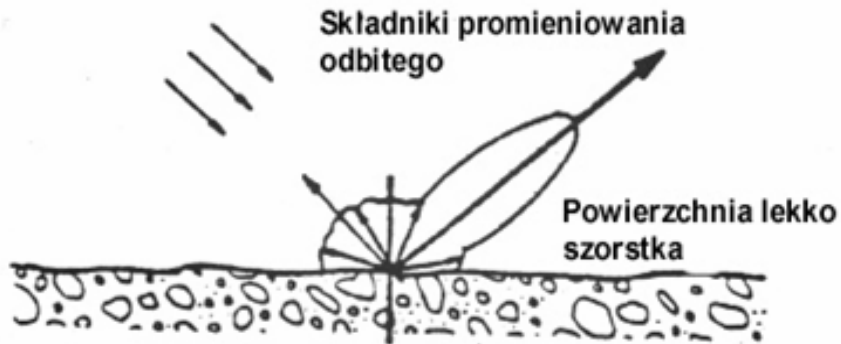
Soil Moisture

ERS-2. PRI The impact of ground truth variables on microwave signals expressed by backscatter coefficient has been examined

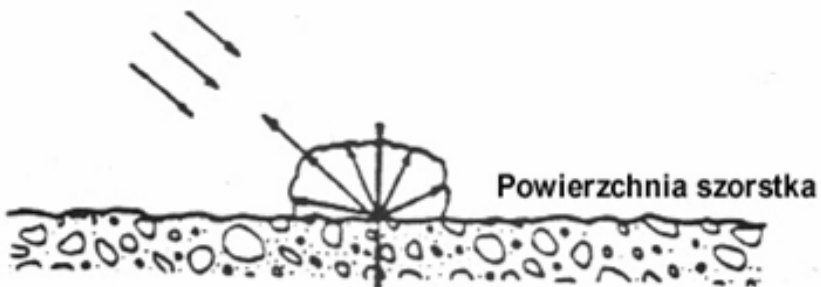
Odbicie lustrzane



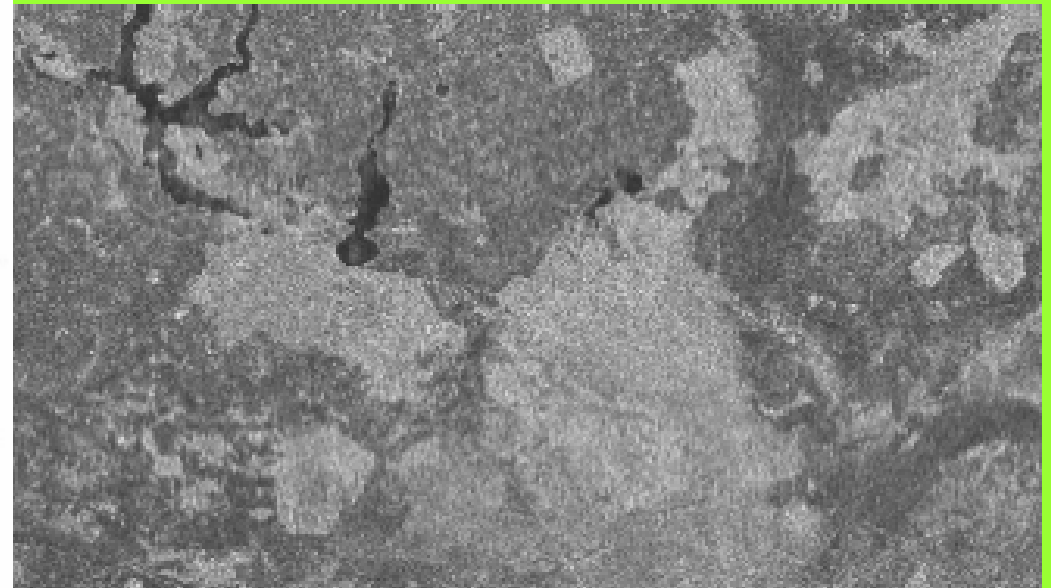
Odbicie mieszane



Odbicie rozproszone



Smoothed area reflects radiation as mirror surface, what causes minimal return to the receiver. Such objects are dark.



Rough area reflects radiation in different angles what causes that most of the radiation returns to the receiver. Such surfaces are light

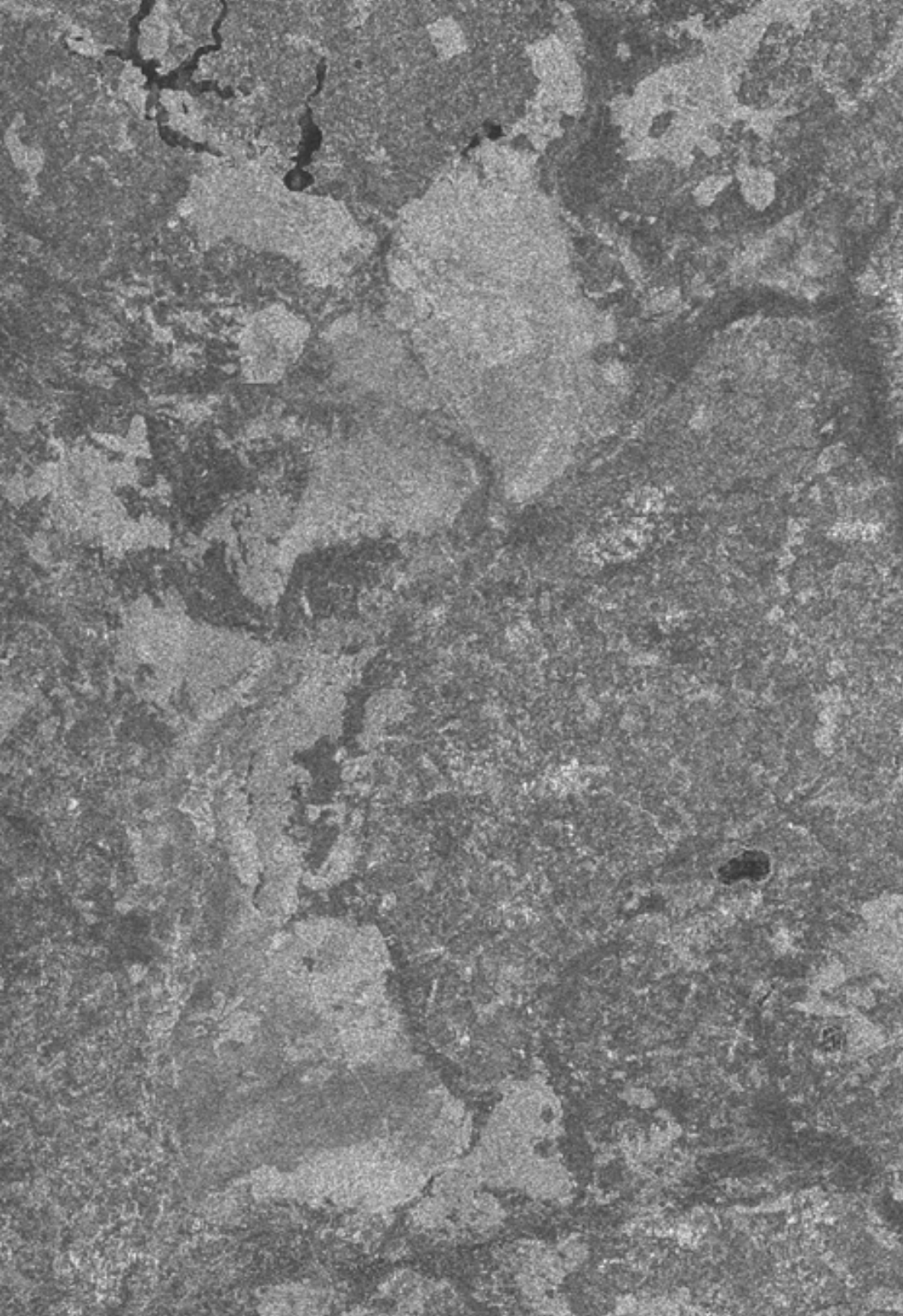
The registered microwave signal depends on:

Configuration of the system (stable):

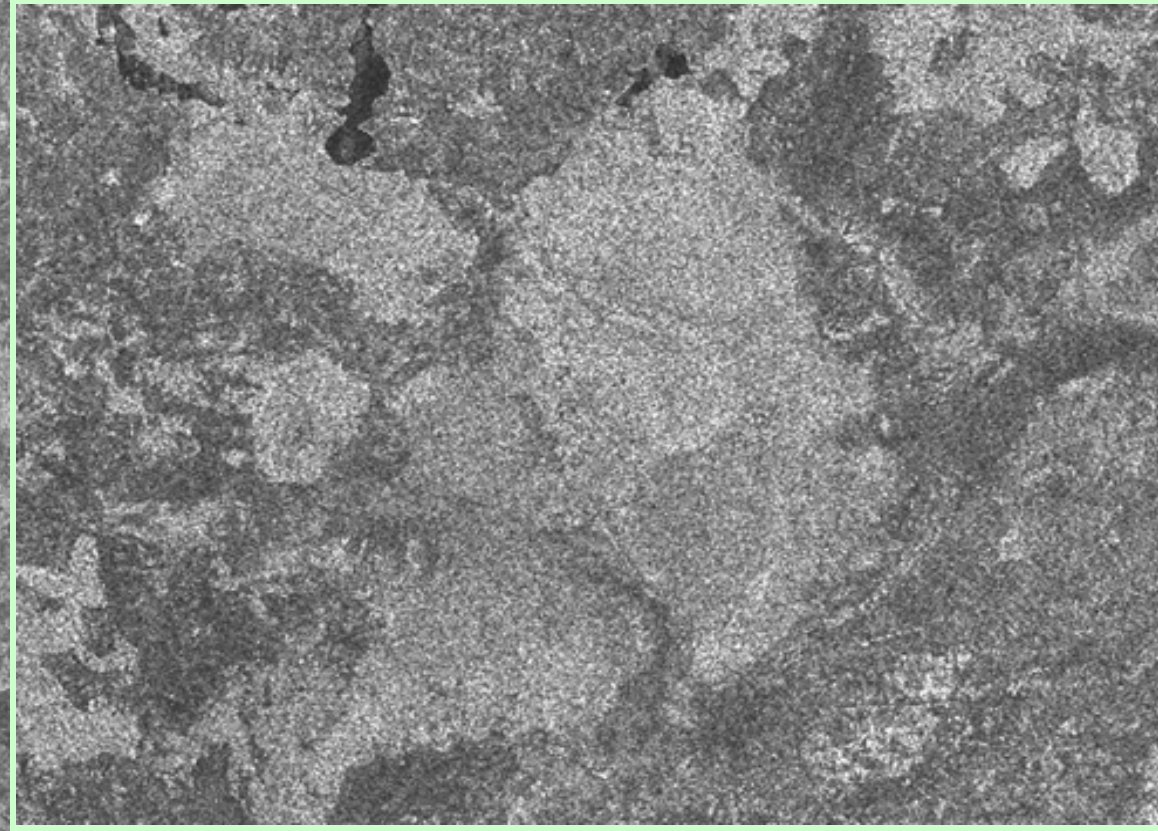
- **frequency (length) of generated wave,**
- **polarisation (VV, HH; cross - HV, VH),**
- **angle of radiation between perpendicular and the surface**

Surface properties (variable):

- **Surface roughness**



ERS-2.SAR Image 22.06.2000



Backscattering coefficient

16 14 13 12 11 10 9 8 7 6 [dB]



woody, chmura

5 0 5 km

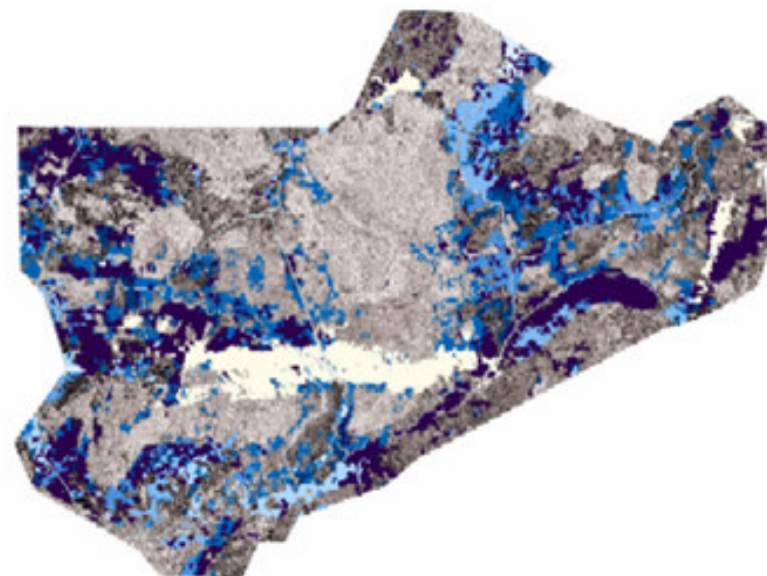
Soil moisture for grassland classes

20 30 40 50 60 70 [% obj.]

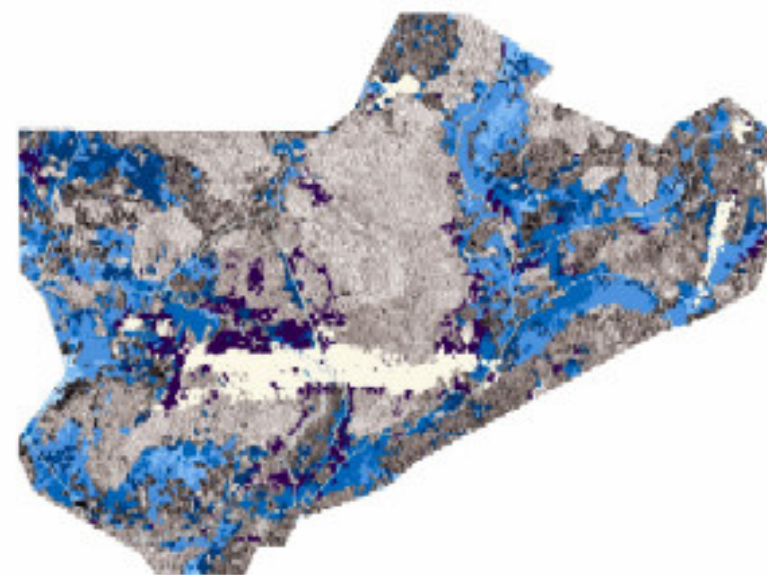
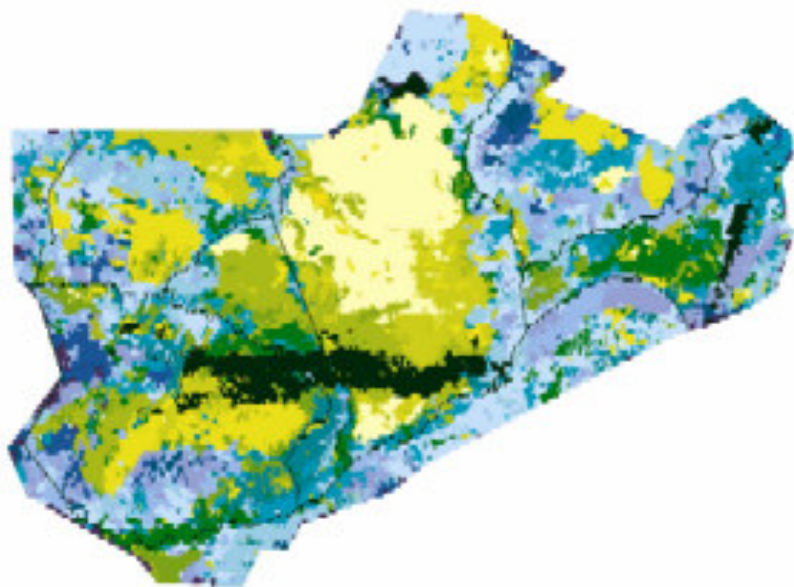


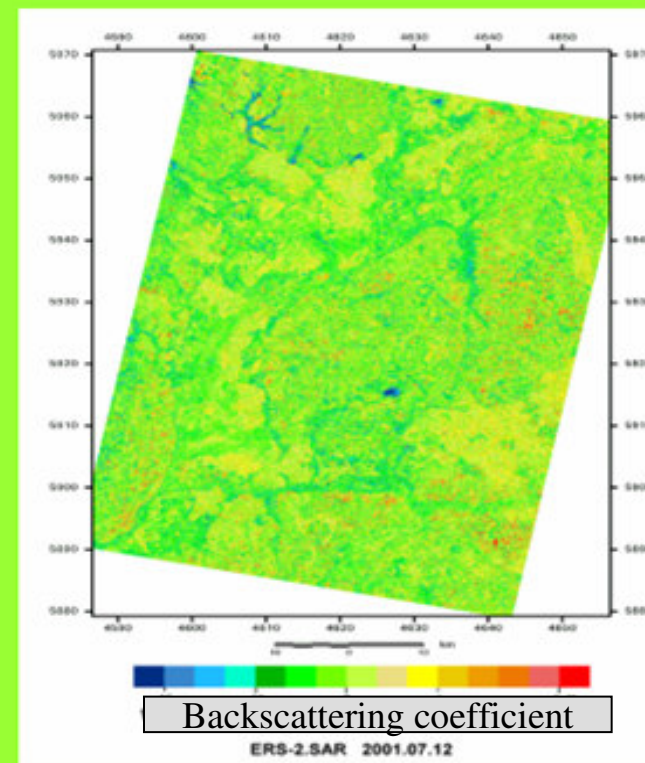
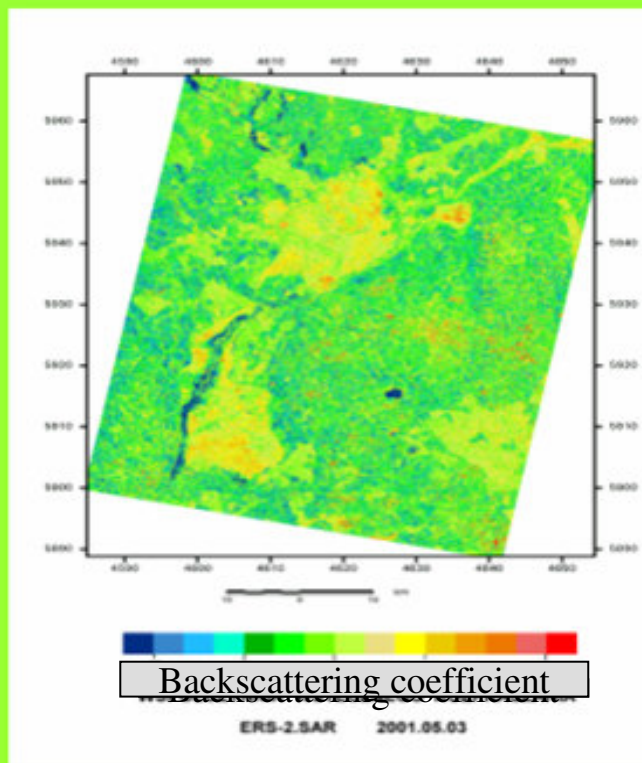
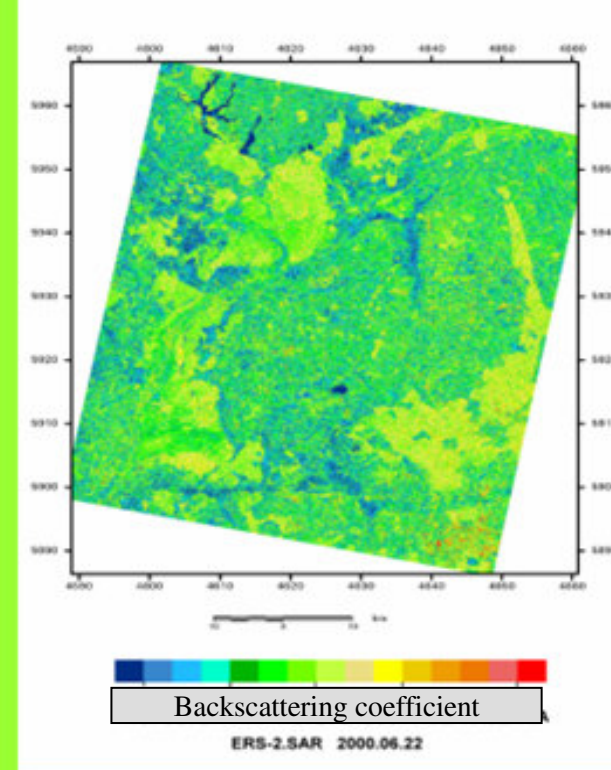
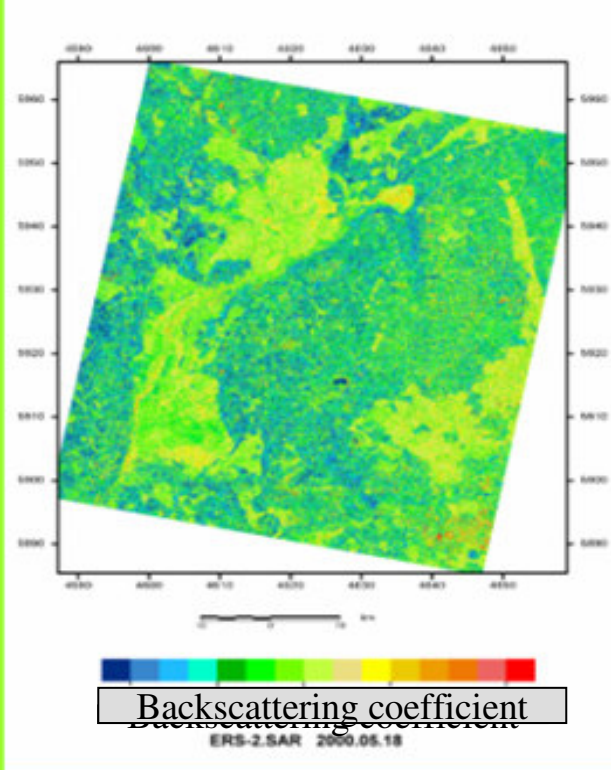
woody, chmura

E]



ER



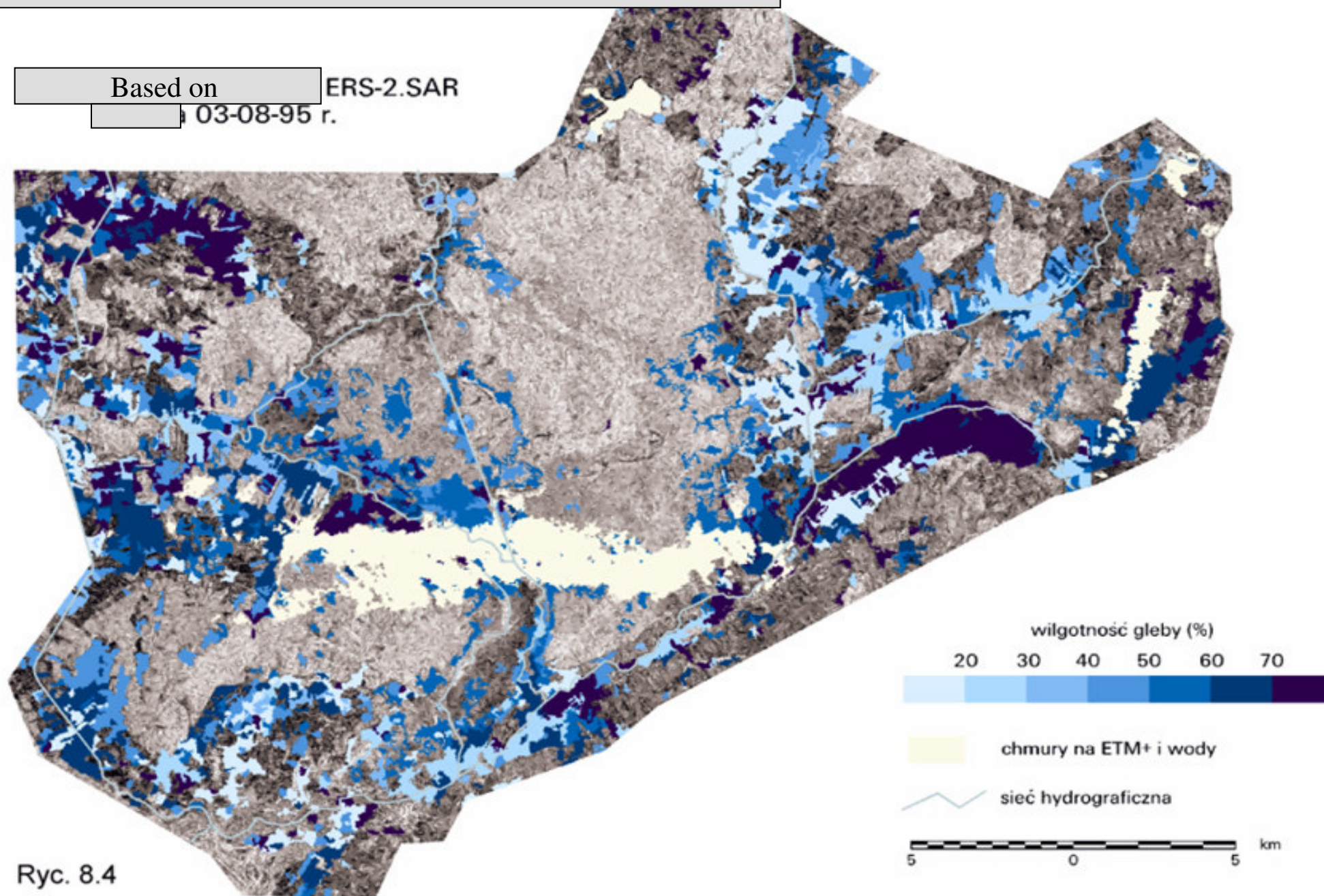


Soil Moisture in the classified grassland areas

Based on

ERS-2.SAR

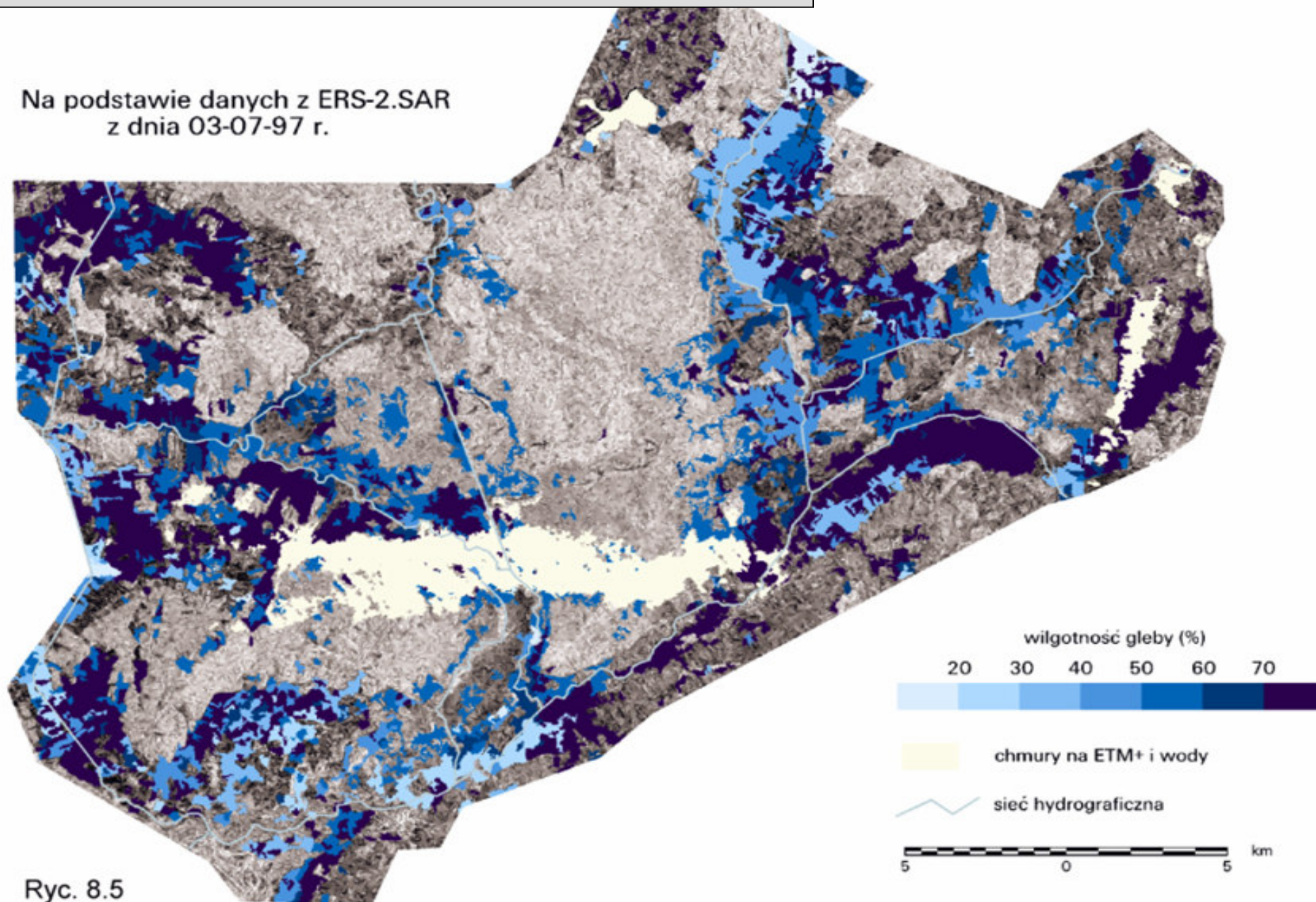
03-08-95 r.



Ryc. 8.4

Soil Moisture in the classified grassland areas

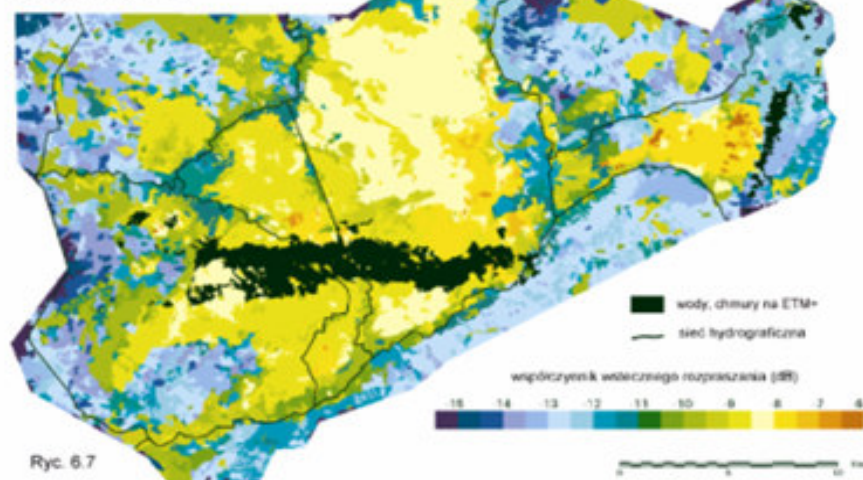
Na podstawie danych z ERS-2.SAR
z dnia 03-07-97 r.



Ryc. 8.5

Uśredniony współczynnik
wstecznego rozpraszania mikrofal

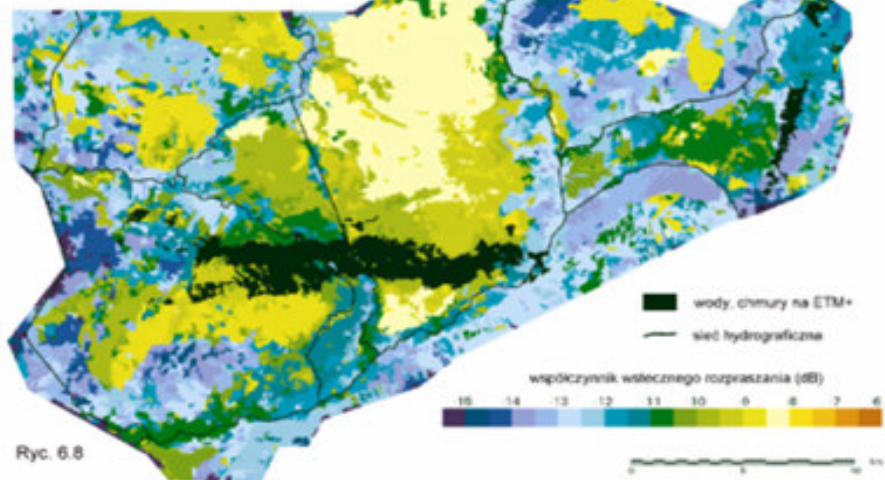
ERS-2.SAR 18-05-00



Ryc. 6.7

Uśredniony współczynnik
wstecznego rozpraszania mikrofal

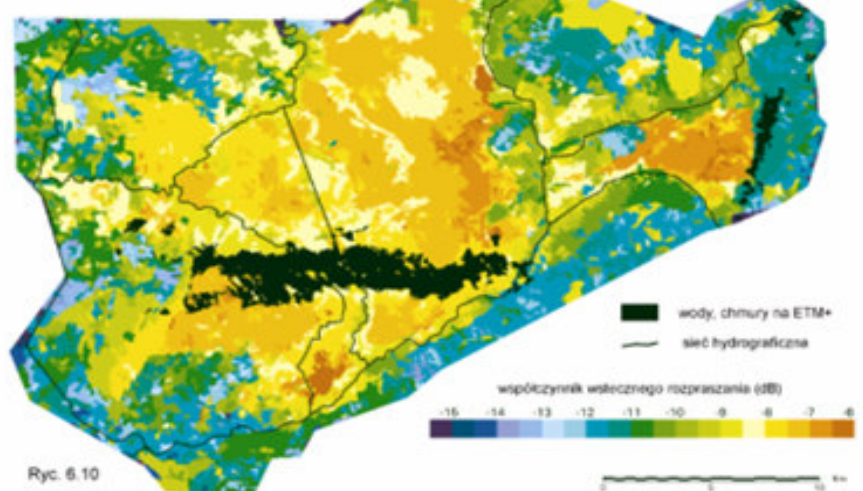
ERS-2.SAR 22-06-00



Ryc. 6.8

Uśredniony współczynnik
wstecznego rozpraszania mikrofal

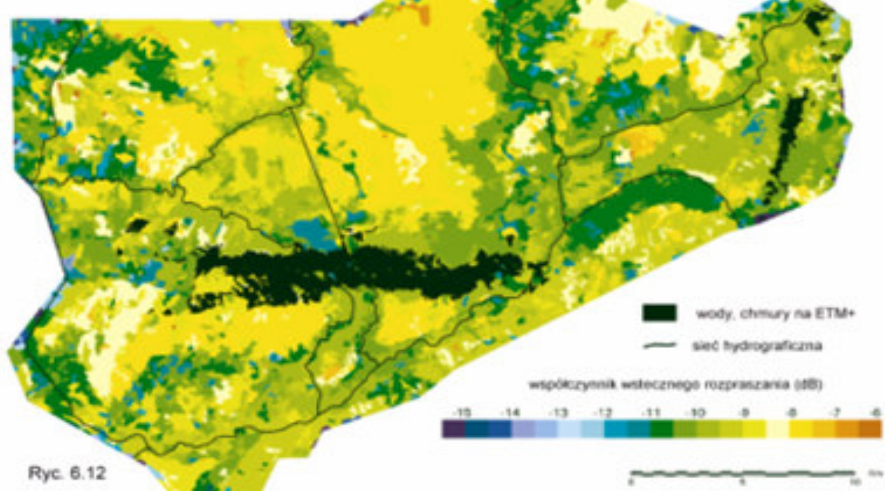
ERS-2.SAR 03-05-01



Ryc. 6.10

Uśredniony współczynnik
wstecznego rozpraszania mikrofal

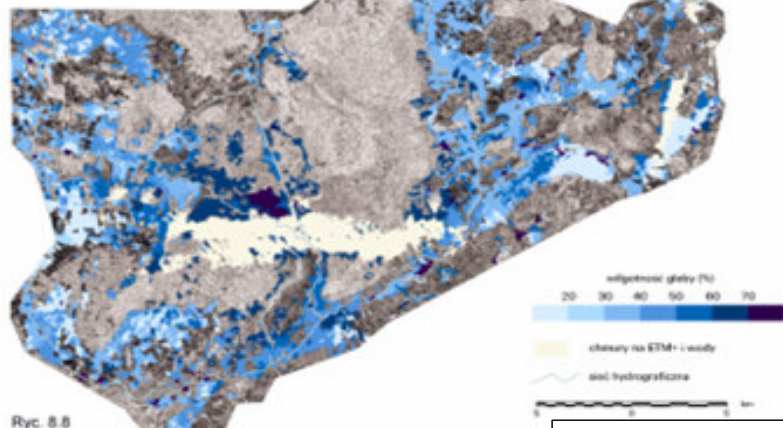
ERS-2.SAR 12-07-01



Ryc. 6.12

WILGOTNOŚĆ GLEBY UŚREDNIONA W KLASACH UŻYTKÓW ZIELONYCH

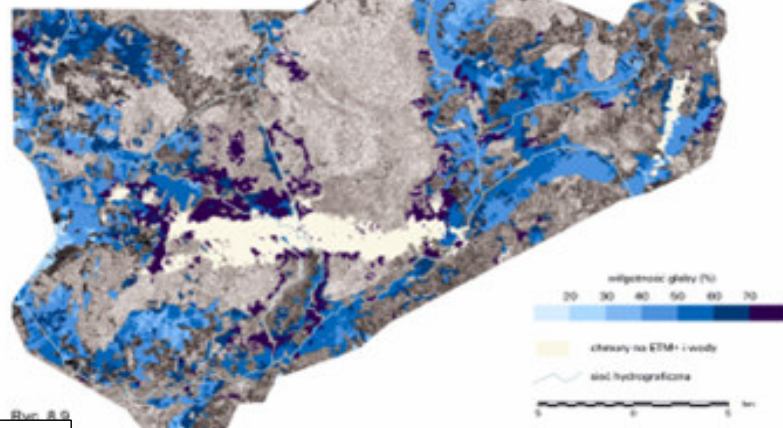
Na podstawie danych z ERS-2 SAR z dnia 18-05-00 r.



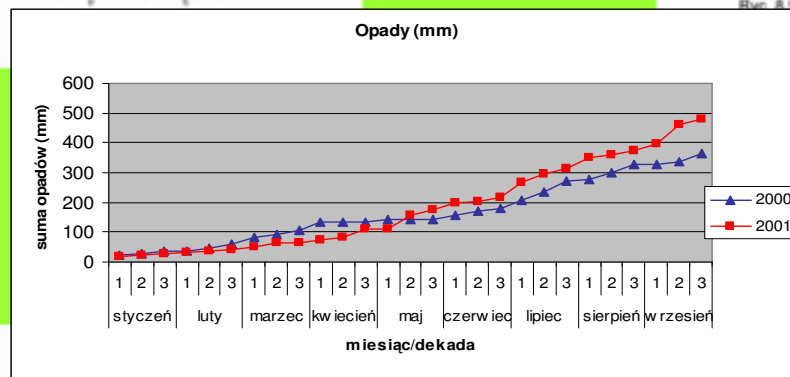
Ryc. 8.8

WILGOTNOŚĆ GLEBY UŚREDNIONA W KLASACH UŻYTKÓW ZIELONYCH

Na podstawie danych z ERS-2 SAR z dnia 22-06-00 r.



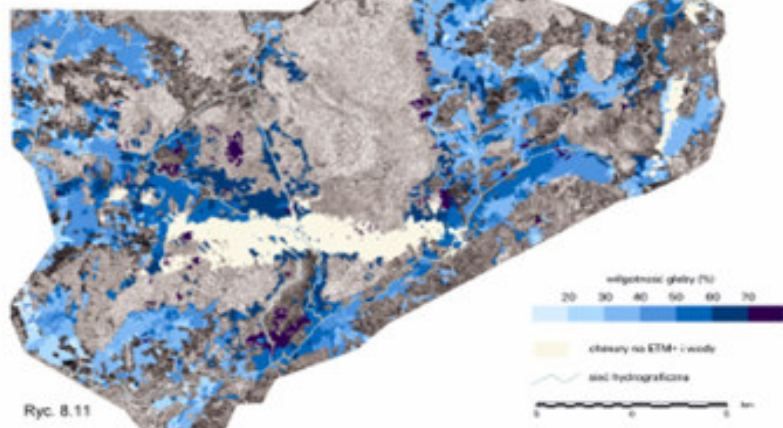
Ryc. 8.9



$$W = f(\text{klasa roślinności, LAI, } \sigma^{\circ})$$

WILGOTNOŚĆ GLEBY UŚREDNIONA W KLASACH UŻYTKÓW ZIELONYCH

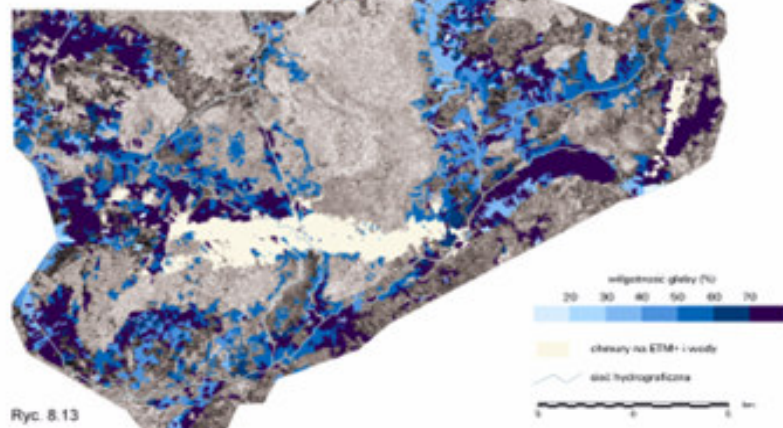
Na podstawie danych z ERS-2 SAR z dnia 03-05-01 r.



Ryc. 8.11

WILGOTNOŚĆ GLEBY UŚREDNIONA W KLASACH UŻYTKÓW ZIELONYCH

Na podstawie danych z ERS-2 SAR z dnia 12-07-01 r.



Ryc. 8.13

OPTICAL DATA

Satellite/ Radiometer/	Wavelength μm					
	Blue	Green	Red	NIR	SWIR	SWIR
Landsat ETM Spectral resolution	0.45-0.52 0.07	0.52-0.60 0.08	0.63-0.69 0.06	0.76-0.90 0.14	1.55-1.75 0.20	2.08-2.35 0.27
SPOT/VEGETA TION-Spectral resolution	0.43-0.47 0.04		0.61-0.68 0.07	0.78-0.89 0.11	1.58-1.75 0.17	
ERS2/ATSR		0.54-0.56 0.02	0.64-0.66 0.02	0.86-0.88 0.02	1.45- 1.75 0.3	
NOAA/AVHRR			0.58-0.68 0.10	0.72-1.1 0.38		

Radiative
temperatur
e

8-14 μm

8-14 μm

8-14 μm

$$RN = LE + H + G$$

where:

RN - the rate of net gain of heat from radiation (measured) (Wm^{-2})

LE - the rate of loss of latent heat by evapotranspiration (Wm^{-2})

H - the rate of sensible heat loss by convection (Wm^{-2})

G - the rate of heat loss into the ground (measured) (Wm^{-2})

The values of the rate of sensible heat loss by convection (H) has been calculated as follows:

$$H = (pC_p(T_s - T_a))/r_a$$

p - air density (kgm^{-3})

C_p - specific heat of air ($\text{Jkg}^{-1}\text{K}^{-1}$)

T_s - surface temperature from ATSR corrected due to atmospheric water vapour

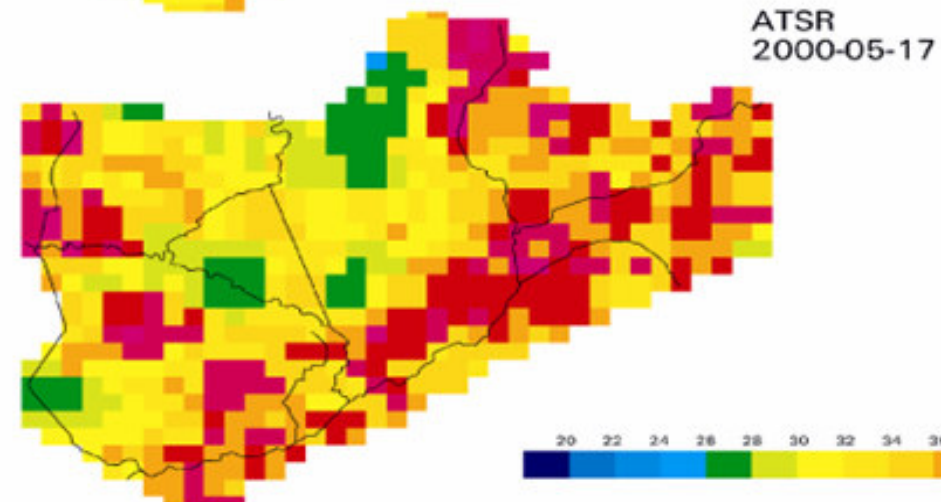
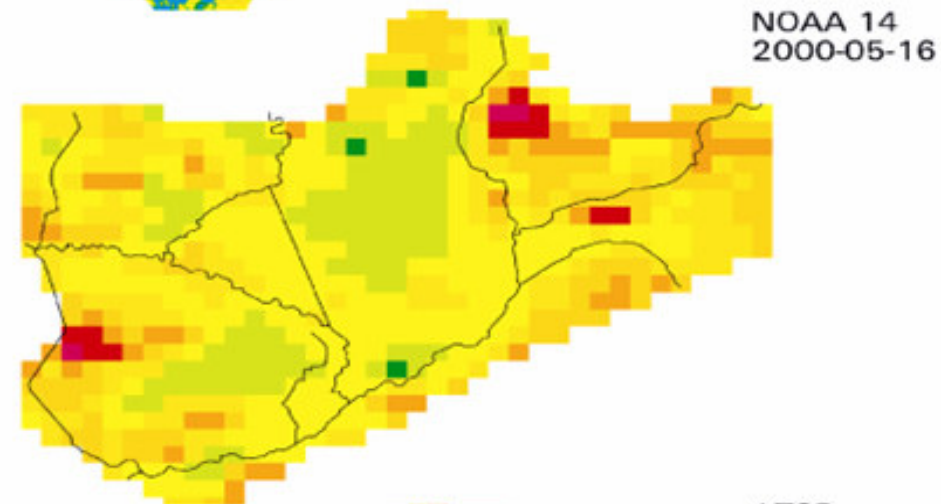
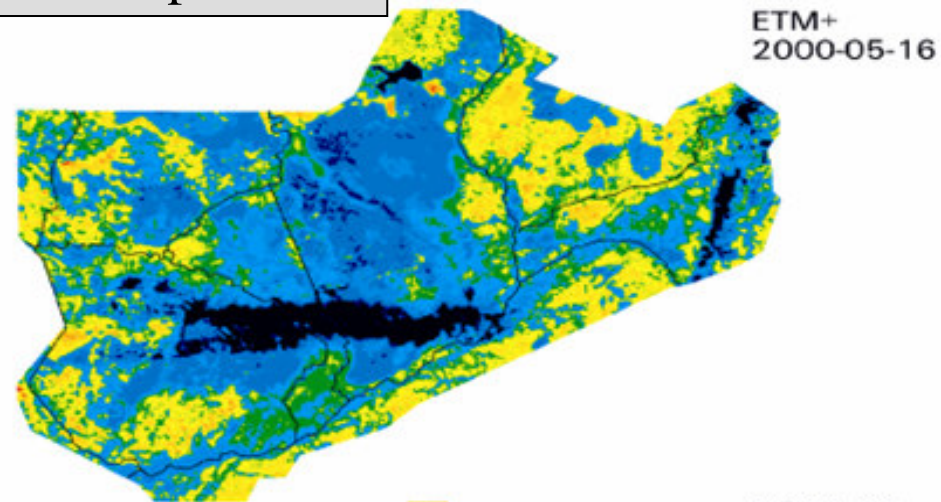
T_a - air temperature measured at the study area ($^{\circ}\text{C}$)

r_a - air resistance for heat transfer (sm^{-1})

The values of air resistance (r_a) have been calculated as follows:

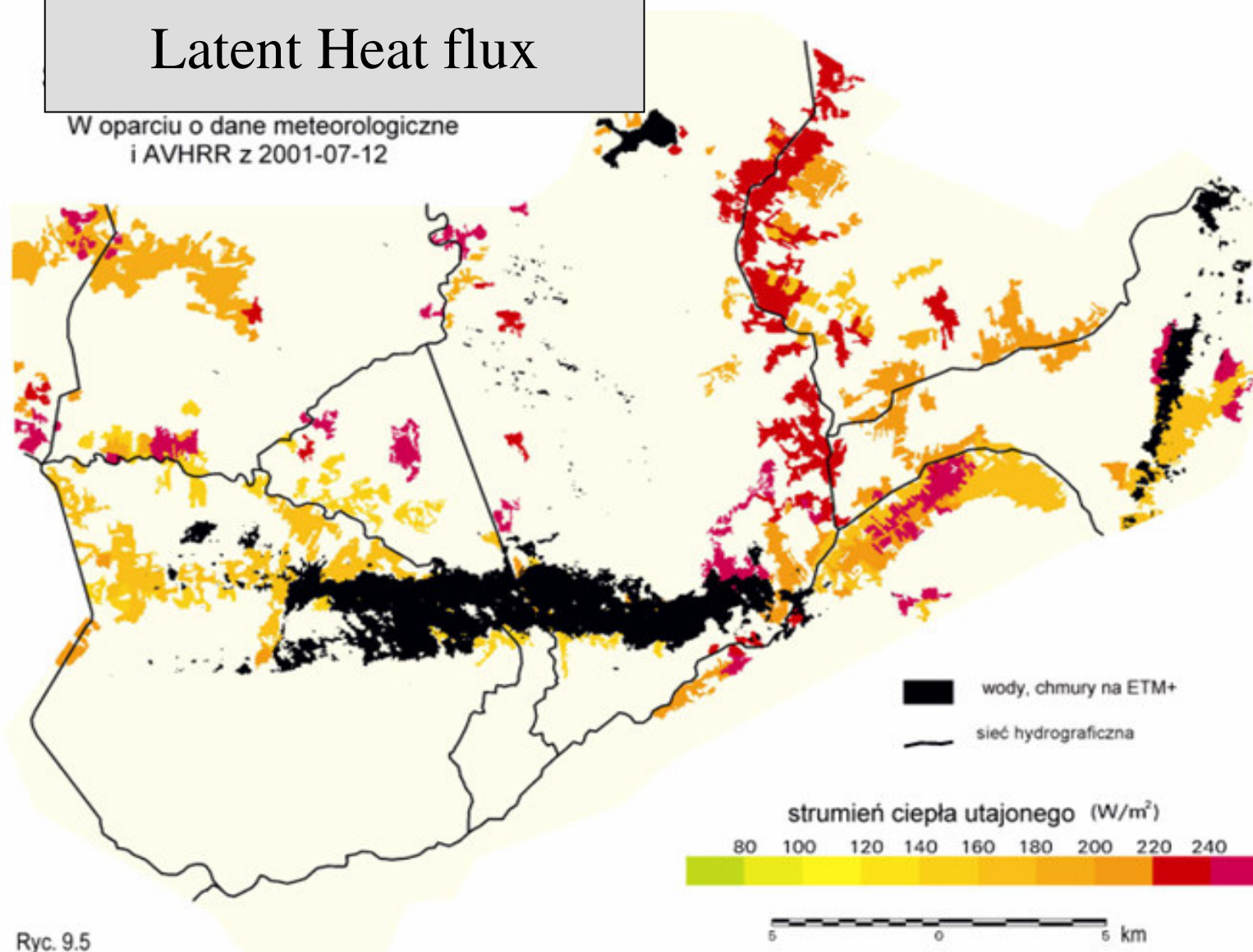
$$LE = RN - H - G$$

Surface Temperature

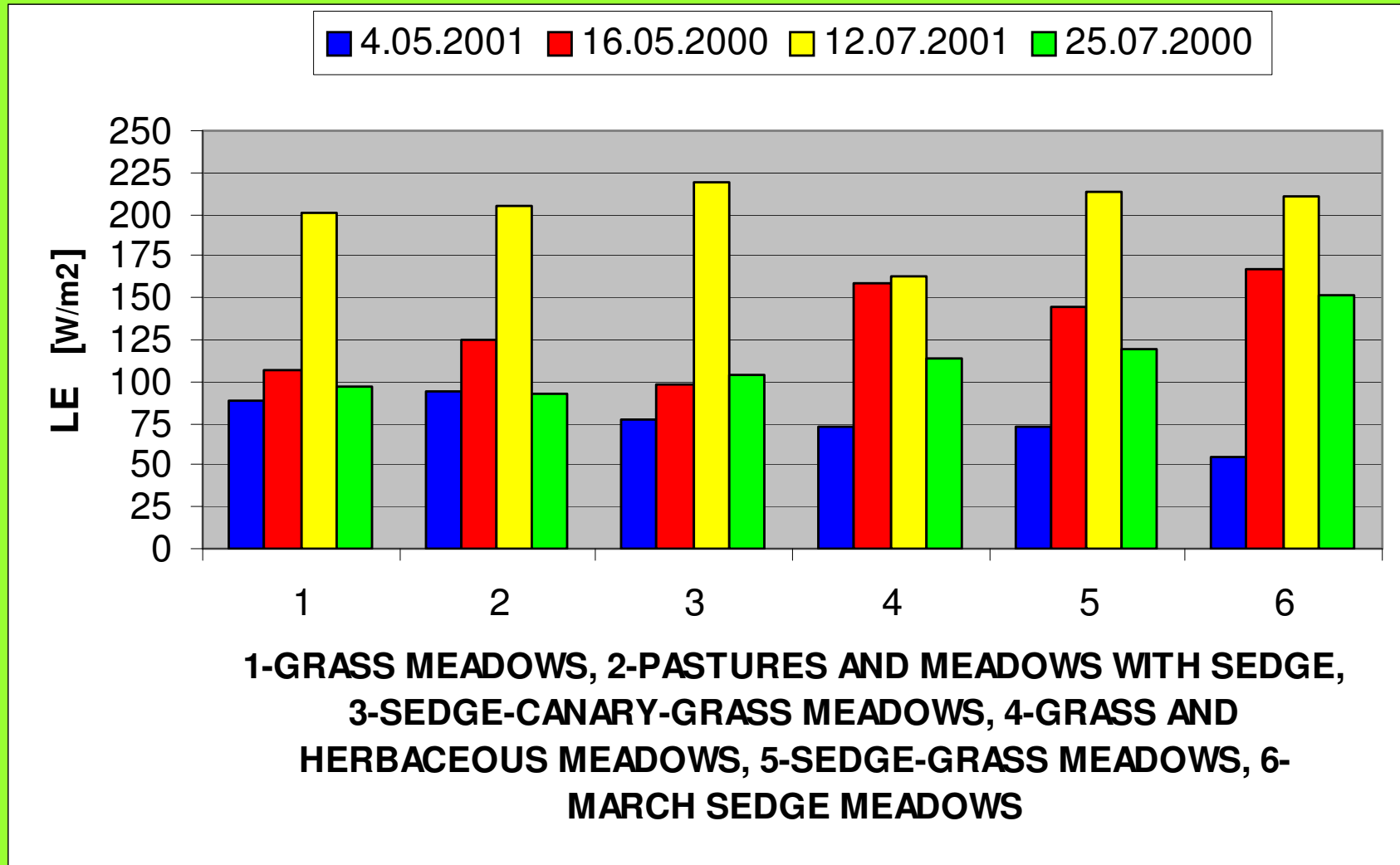


Latent Heat flux

W oparciu o dane meteorologiczne
i AVHRR z 2001-07-12



Ryc. 9.5

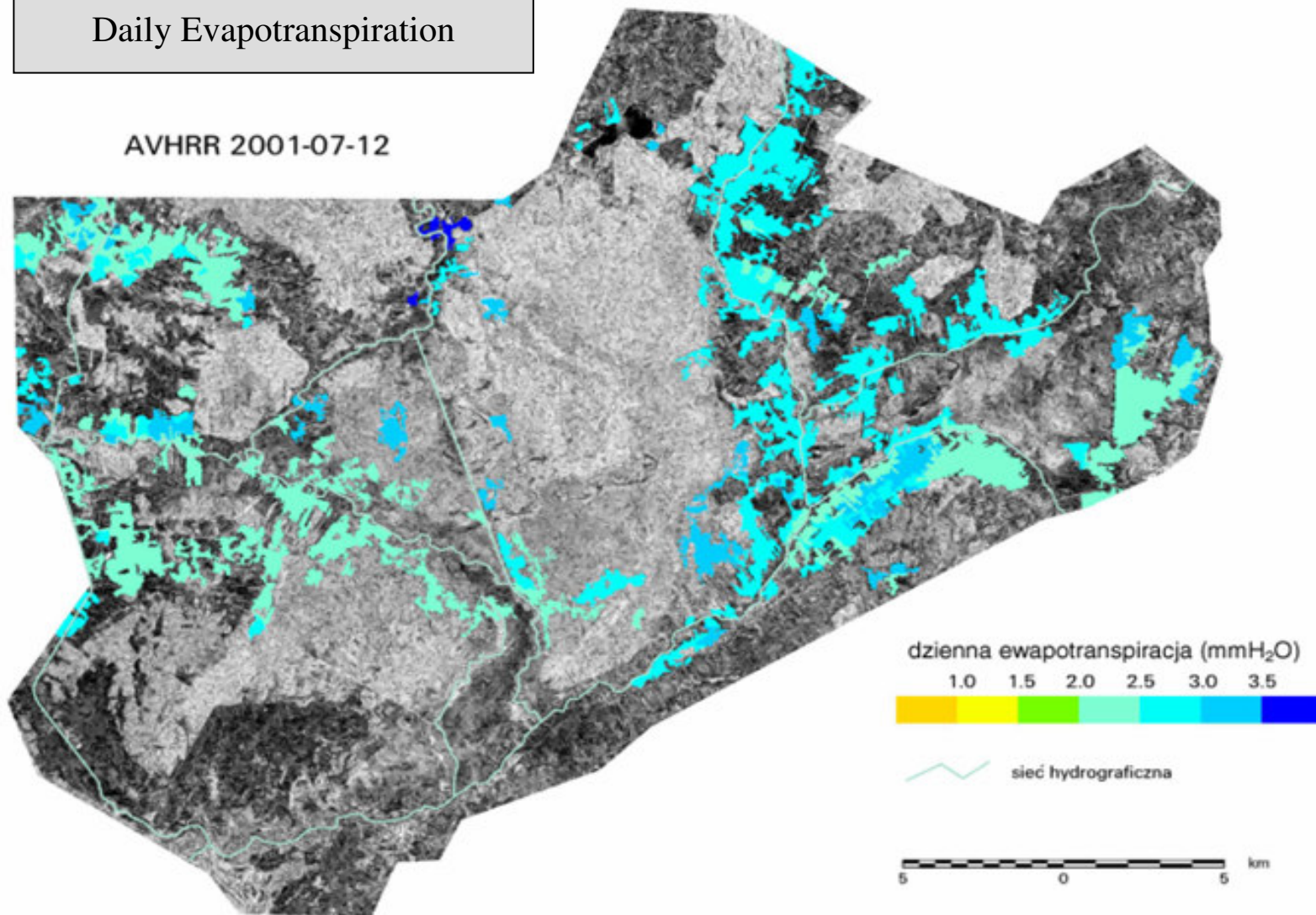


$$\frac{LE_i}{RN_i} = \frac{E_D}{RN_D}$$

$$E_D = \frac{LE_i}{RN_i} \times RN_D$$

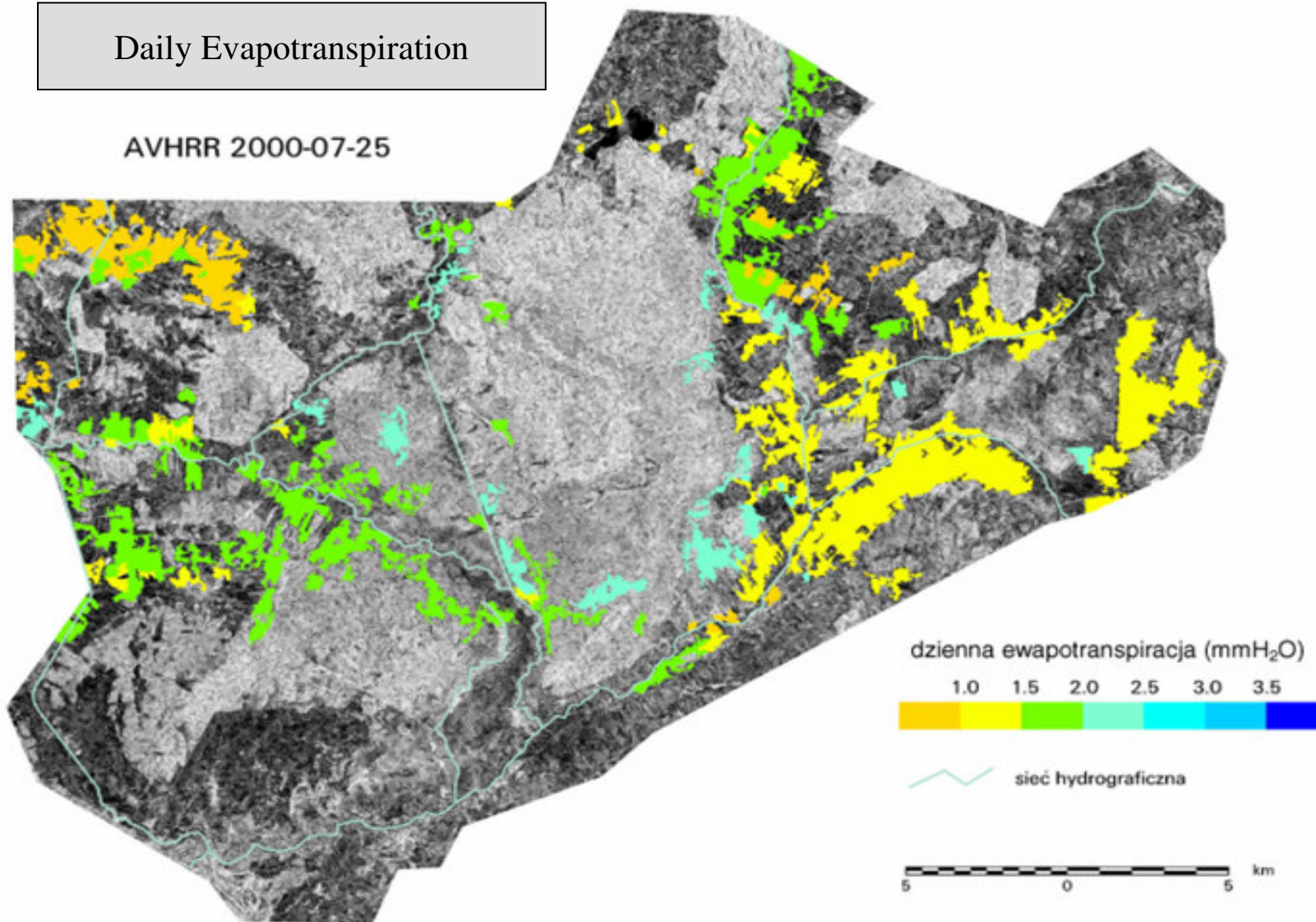
Daily Evapotranspiration

AVHRR 2001-07-12

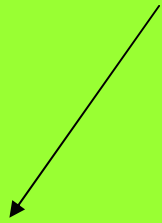


Daily Evapotranspiration

AVHRR 2000-07-25



$$\sigma^0 = \sigma_v^0 + \tau^2 \sigma_s^0$$



Grassland classes



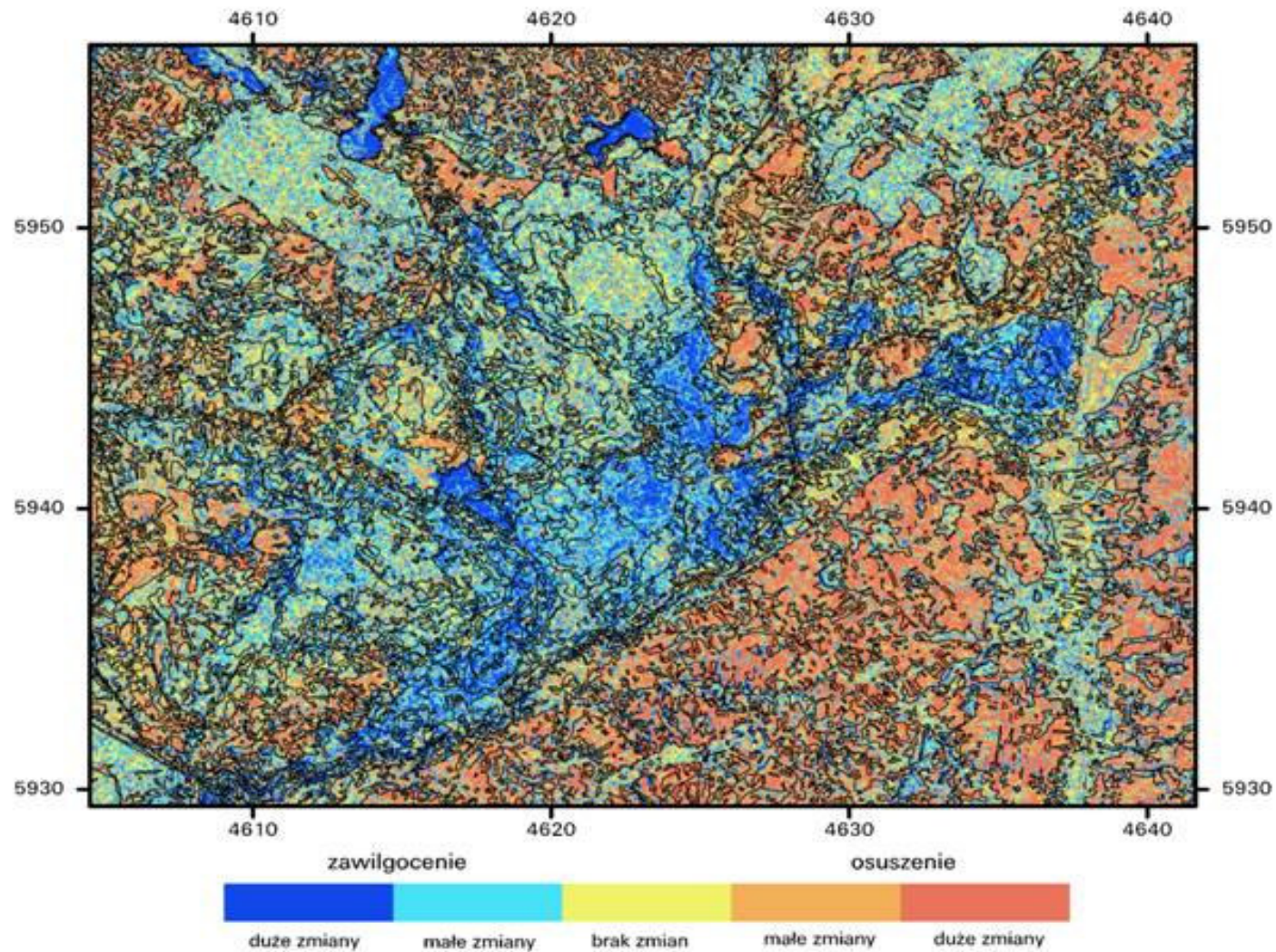
Soil moisture

LAI (GEMI, NDVI...)

Vegetation impact expressed by indices

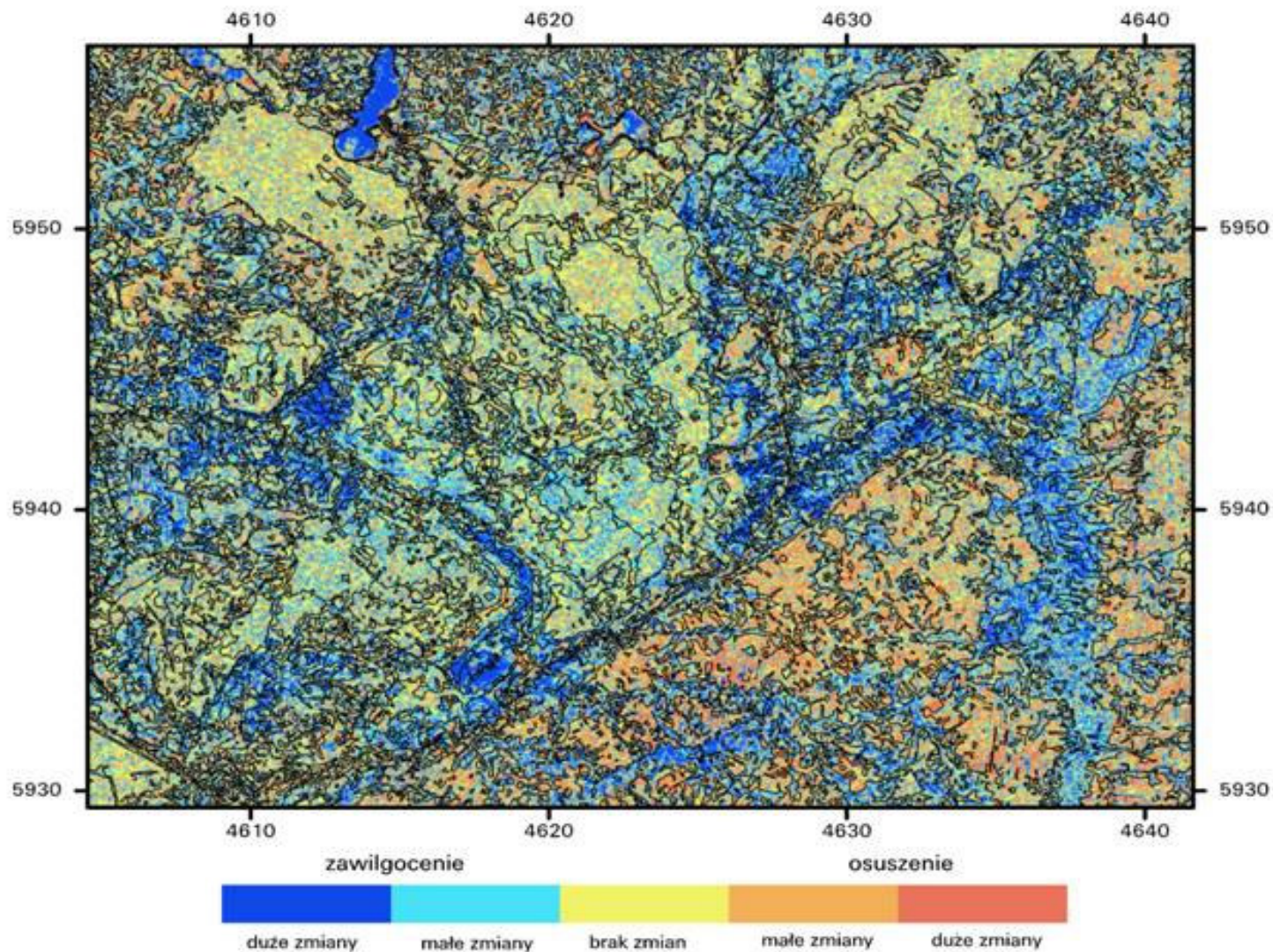
Soil moisture – using new derived index

$$IW = \frac{\sigma_a - \sigma_s}{\sigma_w - \sigma_s}$$



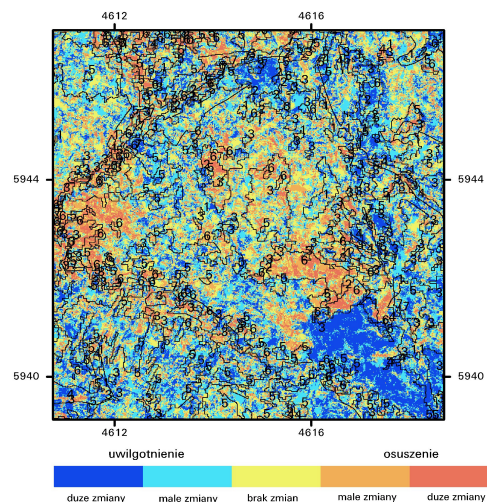
Zmiany uwilgotnienia terenu Basenu Środkowego Biebrzy
(na podstawie obrazów mikrofalowych ERS2.SAR z dn. 18.05.00 w stosunku do 25.05.95)

Changes in humidity on 18.05.00 in relation to 25.05.95(based on ERS2-SAR data)



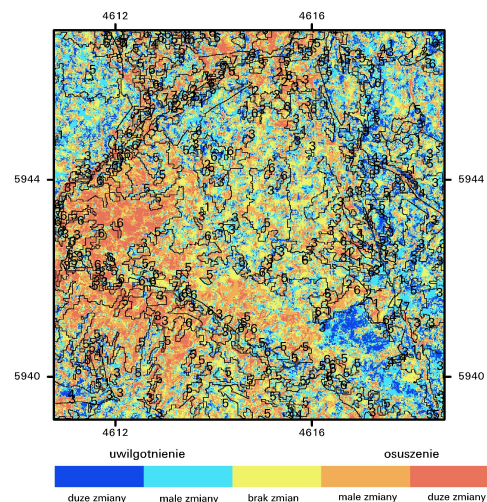
Zmiany uwilgotnienia terenu Basenu Środkowego Biebrzy
(na podstawie obrazów mikrofalowych ERS2.SAR z dn. 07.06.01 w stosunku do 22.06.00)

Changes in humidity on 07.06.01 in relation to 22.06.00(based on ERS2-SAR data)



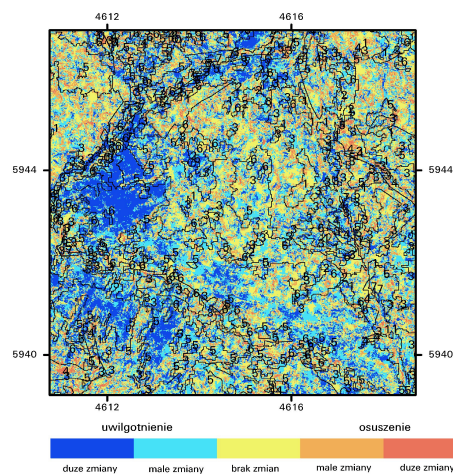
- 1 - lasy
- 2 - bór bagienny
- 3 - użytki zielone
- 4 - grunty orne
- 5 - zakrzaczenia, szuwały
- 6 - mokradła
- 7 - wody

Zmiany uwilgotnienia fragmentu terenu Basenu Środkowego Biebrzy
(na podstawie obrazów mikrofalowych ERS2.SAR z dn. 18.05.00 w stosunku do 25.05.95)



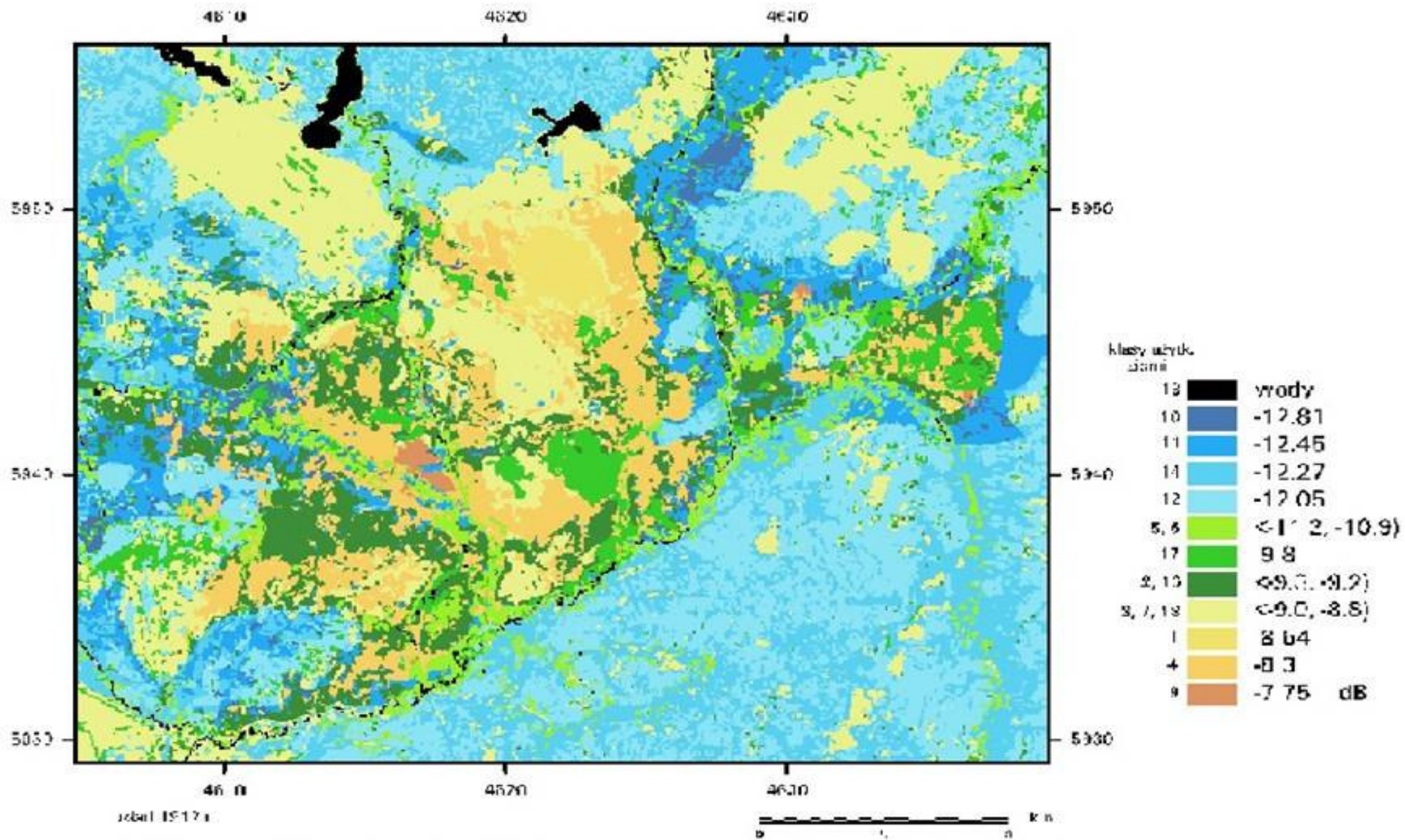
- 1 - lasy
- 2 - bór bagienny
- 3 - użytki zielone
- 4 - grunty orne
- 5 - zakrzaczenia, szuwały
- 6 - mokradła
- 7 - wody

Zmiany uwilgotnienia fragmentu terenu Basenu Środkowego Biebrzy
(na podstawie obrazów mikrofalowych ERS2.SAR z dn. 22.06.00 w stosunku do 29.06.95)

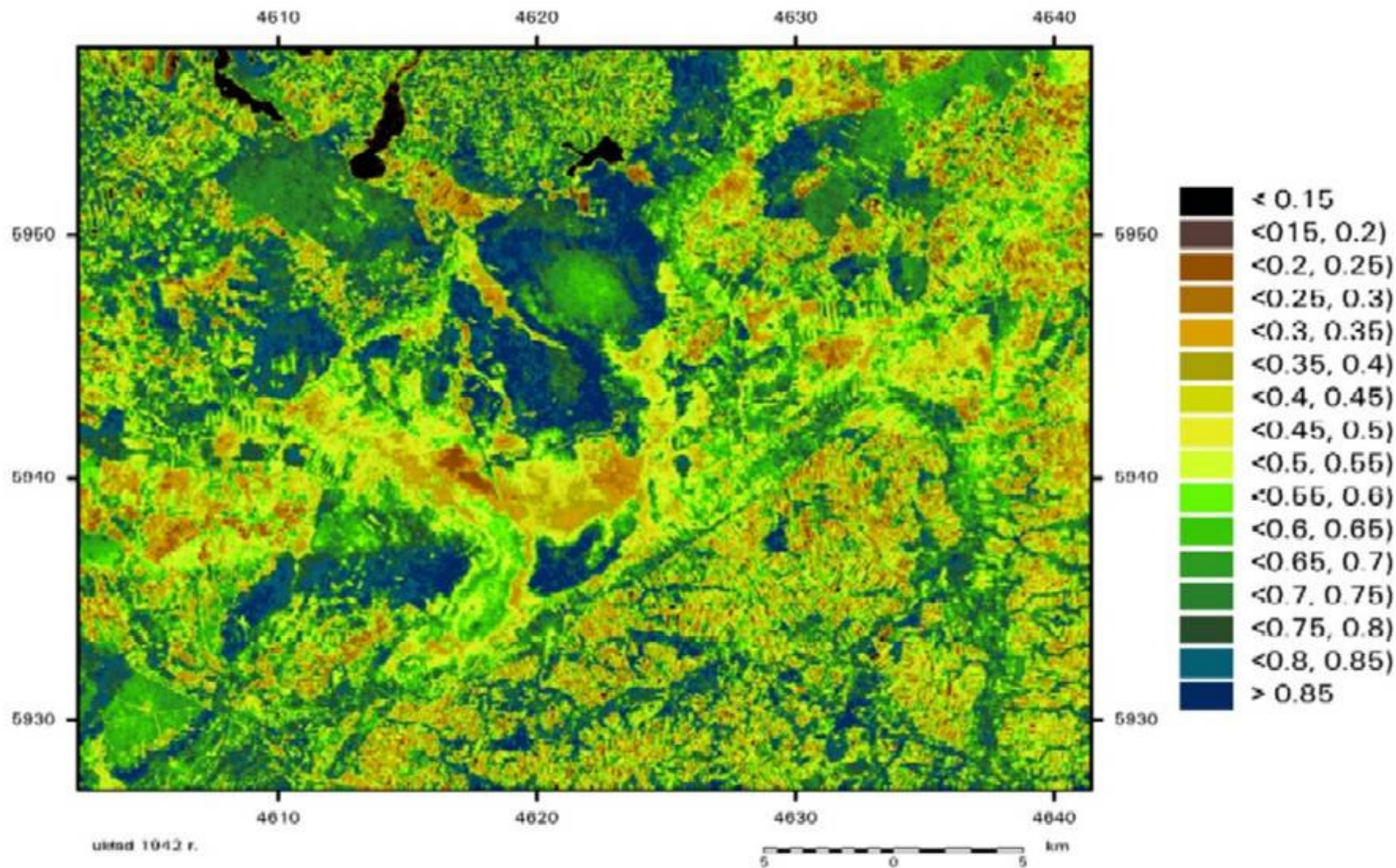


- 1 - lasy
- 2 - bór bagienny
- 3 - użytki zielone
- 4 - grunty orne
- 5 - zakrzaczenia, szuwały
- 6 - mokradła
- 7 - wody

Zmiany uwilgotnienia fragmentu terenu Basenu Środkowego Biebrzy
(na podstawie obrazów mikrofalowych ERS2.SAR z dn. 07.06.01 w stosunku do 22.06.00)



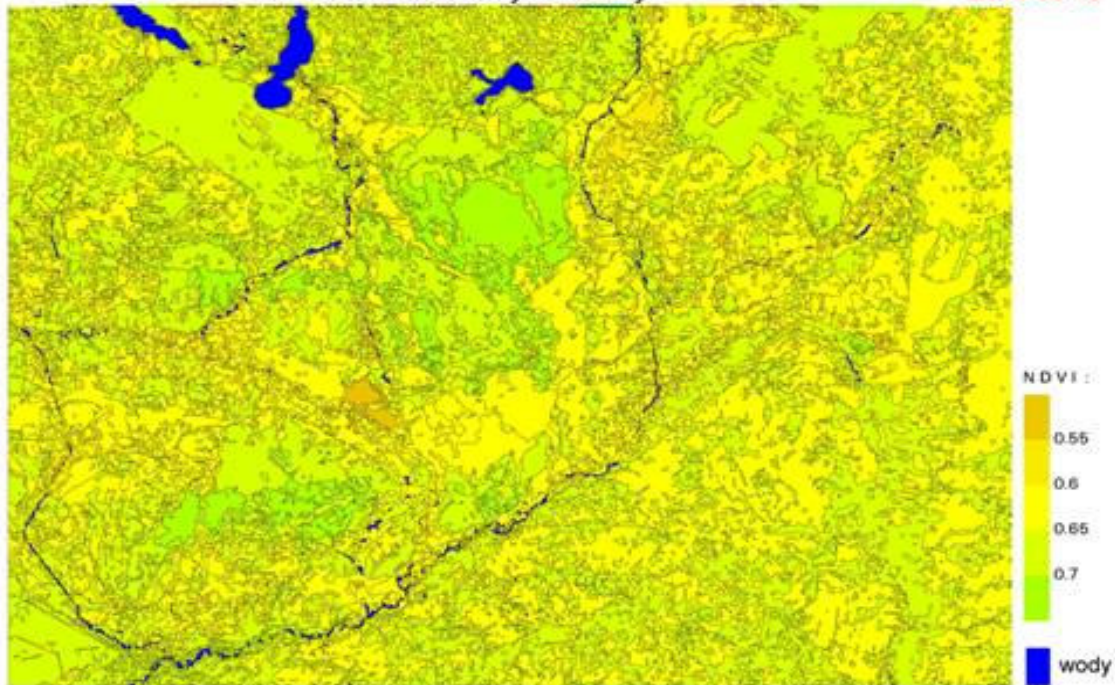
Average backscattering coefficient in each land use class calculated from ERS-2. SAR 18.05.2000



NDVI index from Landsat ETM 16 05 2000

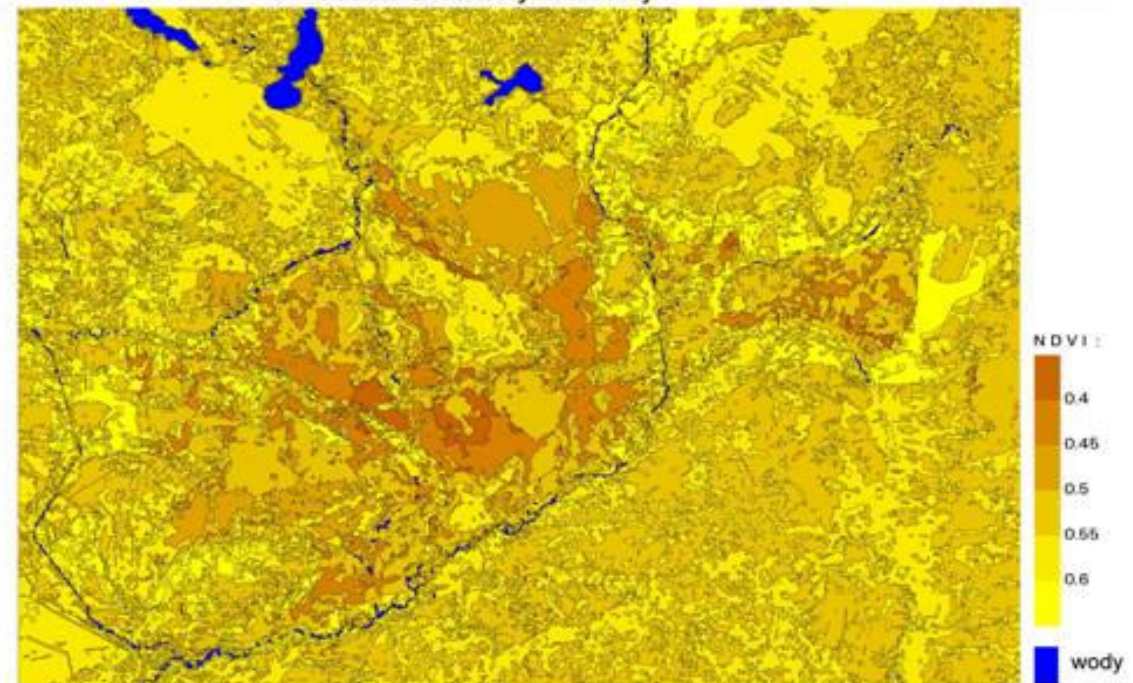
Wartości wskaźnika NDVI w klasach pokrycia/użytkowania terenu
w Basenie Środkowym Biebrzy

VEGETATION
2000-05-16

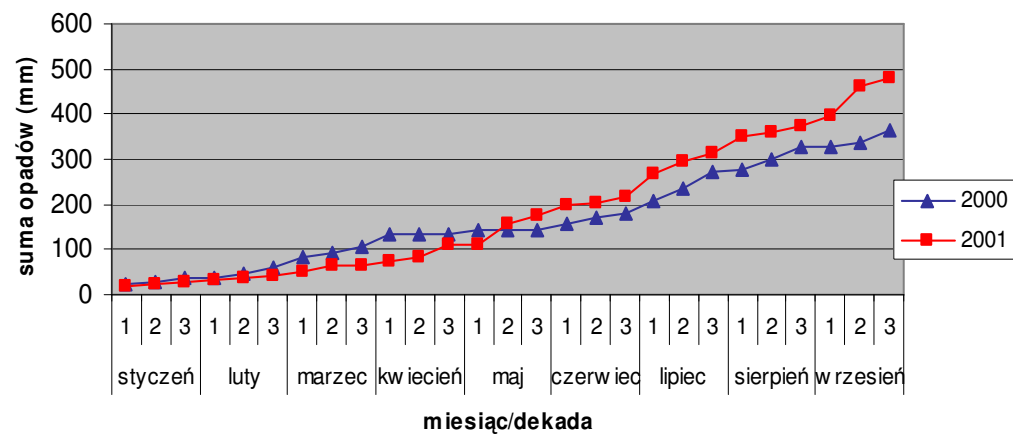


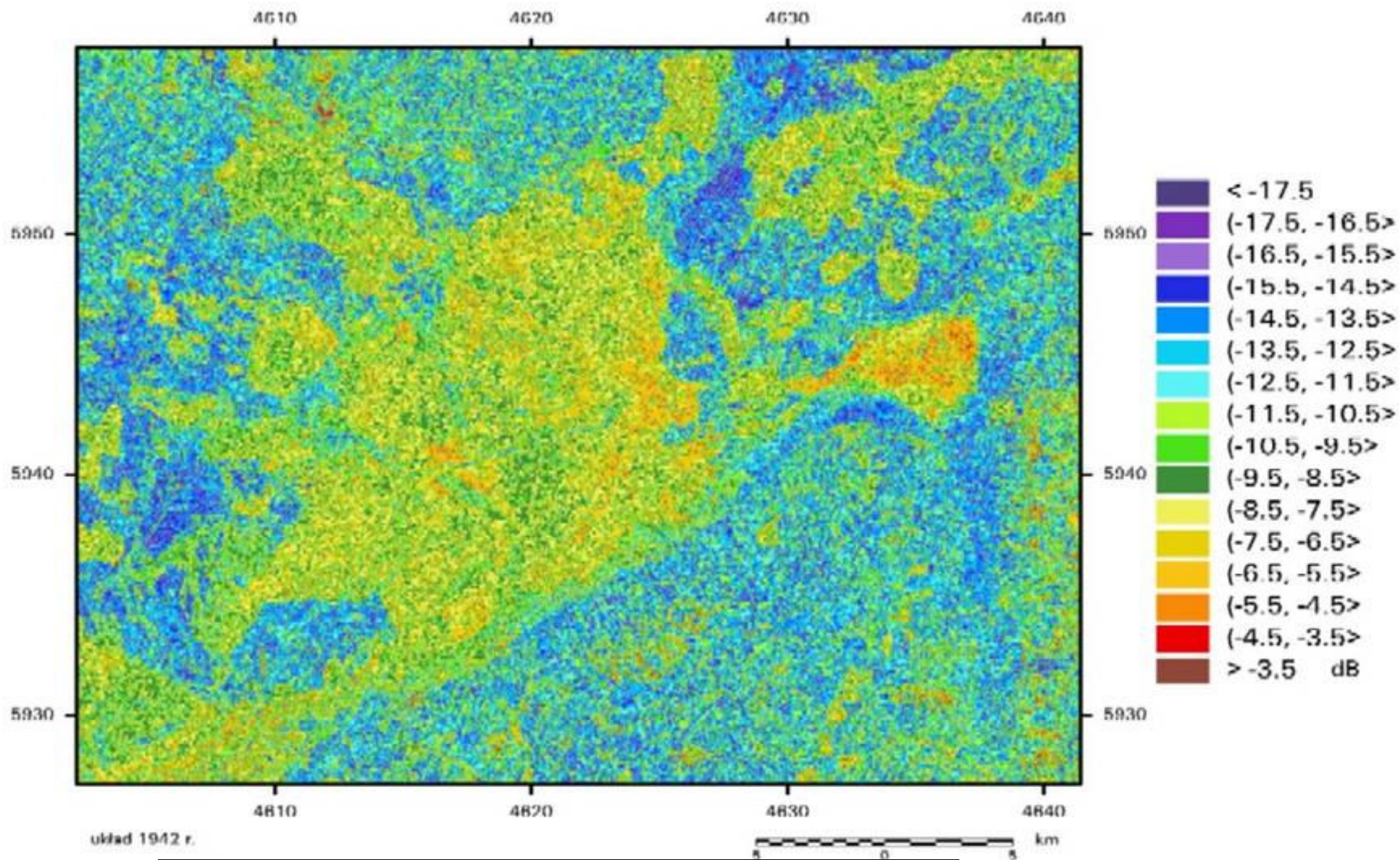
Wartości wskaźnika NDVI w klasach pokrycia/użytkowania terenu
w Basenie Środkowym Biebrzy

VEGETATION
2001-05-03

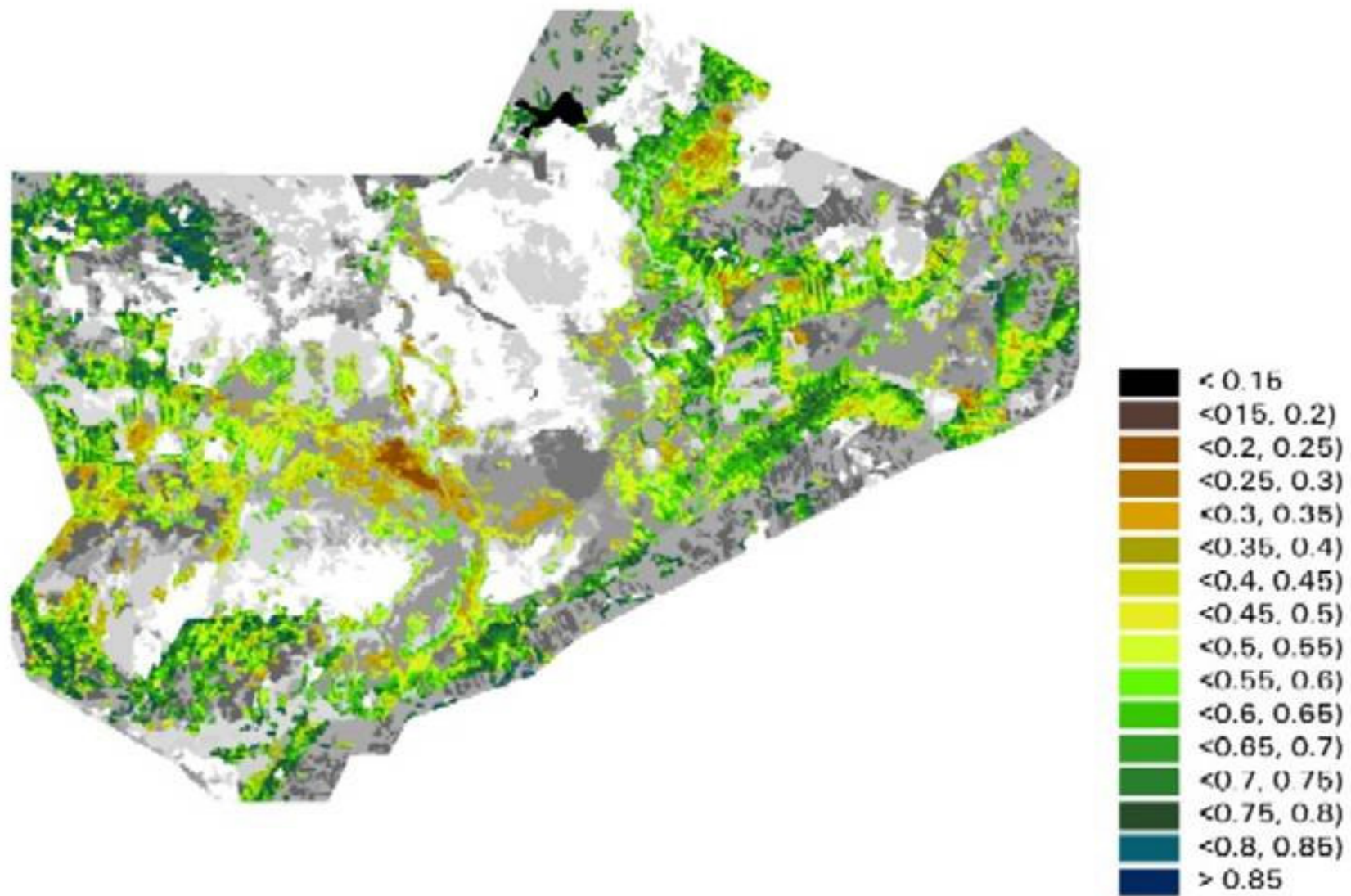


Opady (mm)

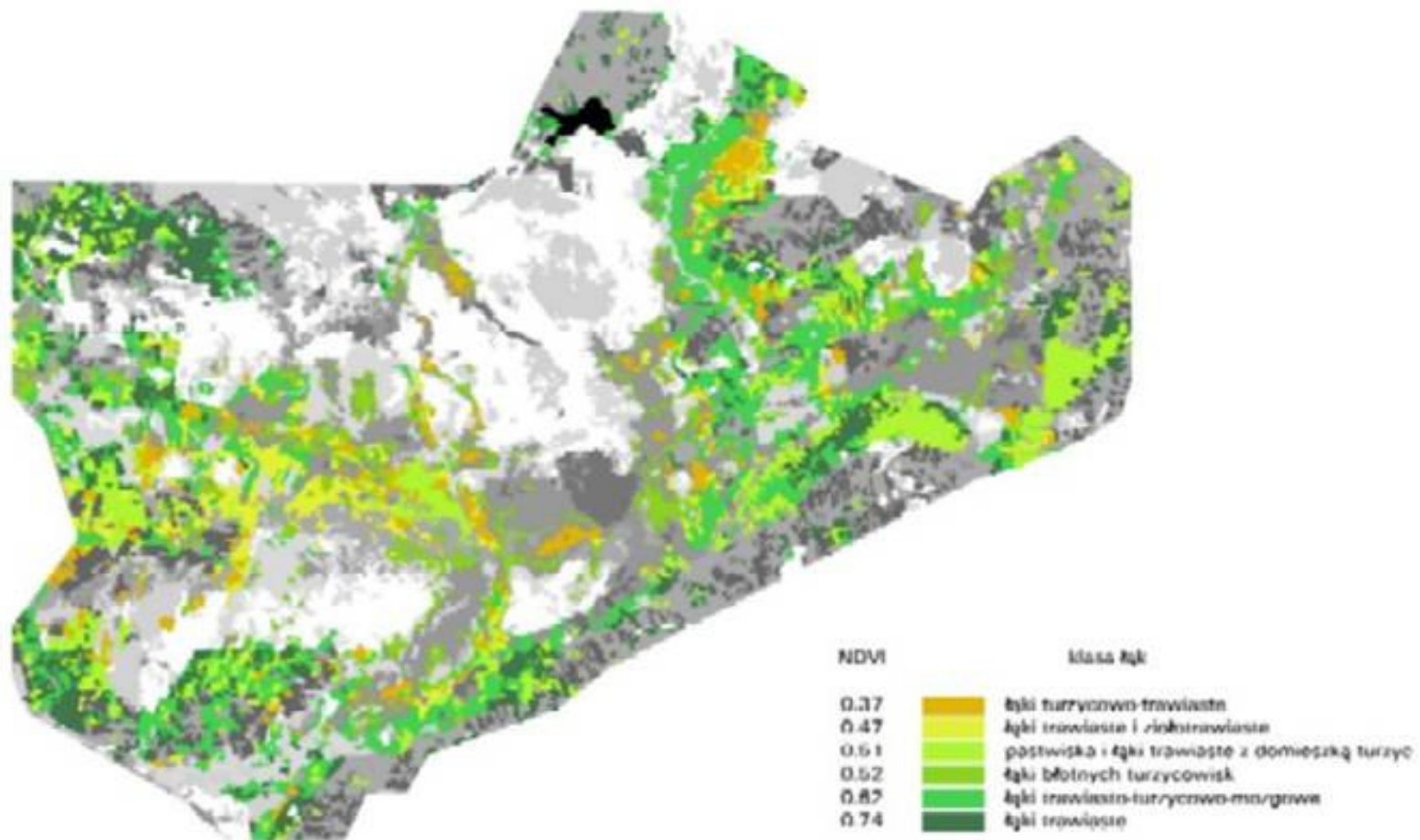




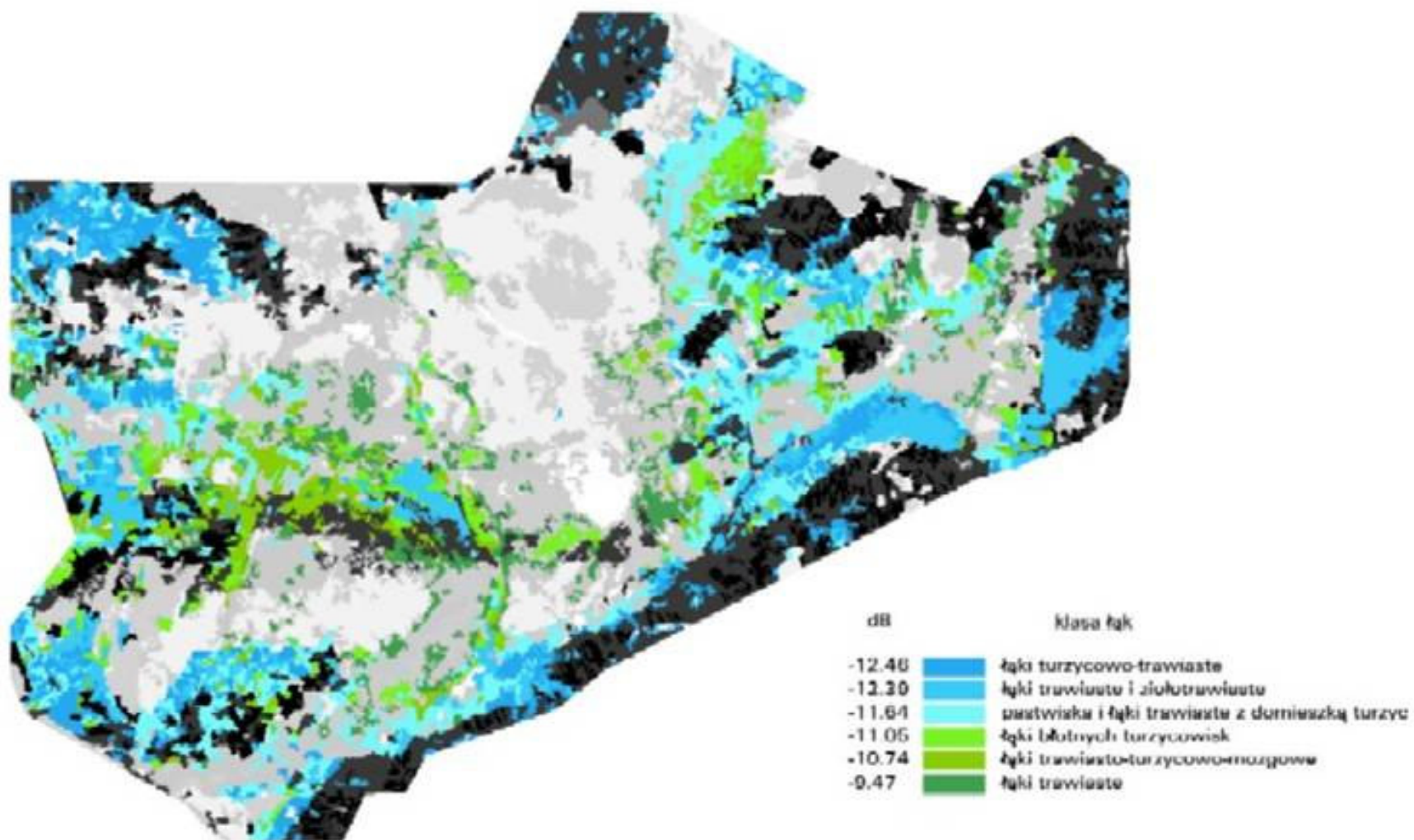
Backscattering coefficient from ERS.2 SAR 18.05.2000



NDVI for grassland classes using ERS2.SAR 18.05.2000



Average values of NDVI for grassland classes using Landsat ETM 16.05.2000



Average values of backscattering coefficient for grassland classes using ERS2.SAR- 18.05.2000

Flooded Areas

ENVISAT ASAR

18.03.2003

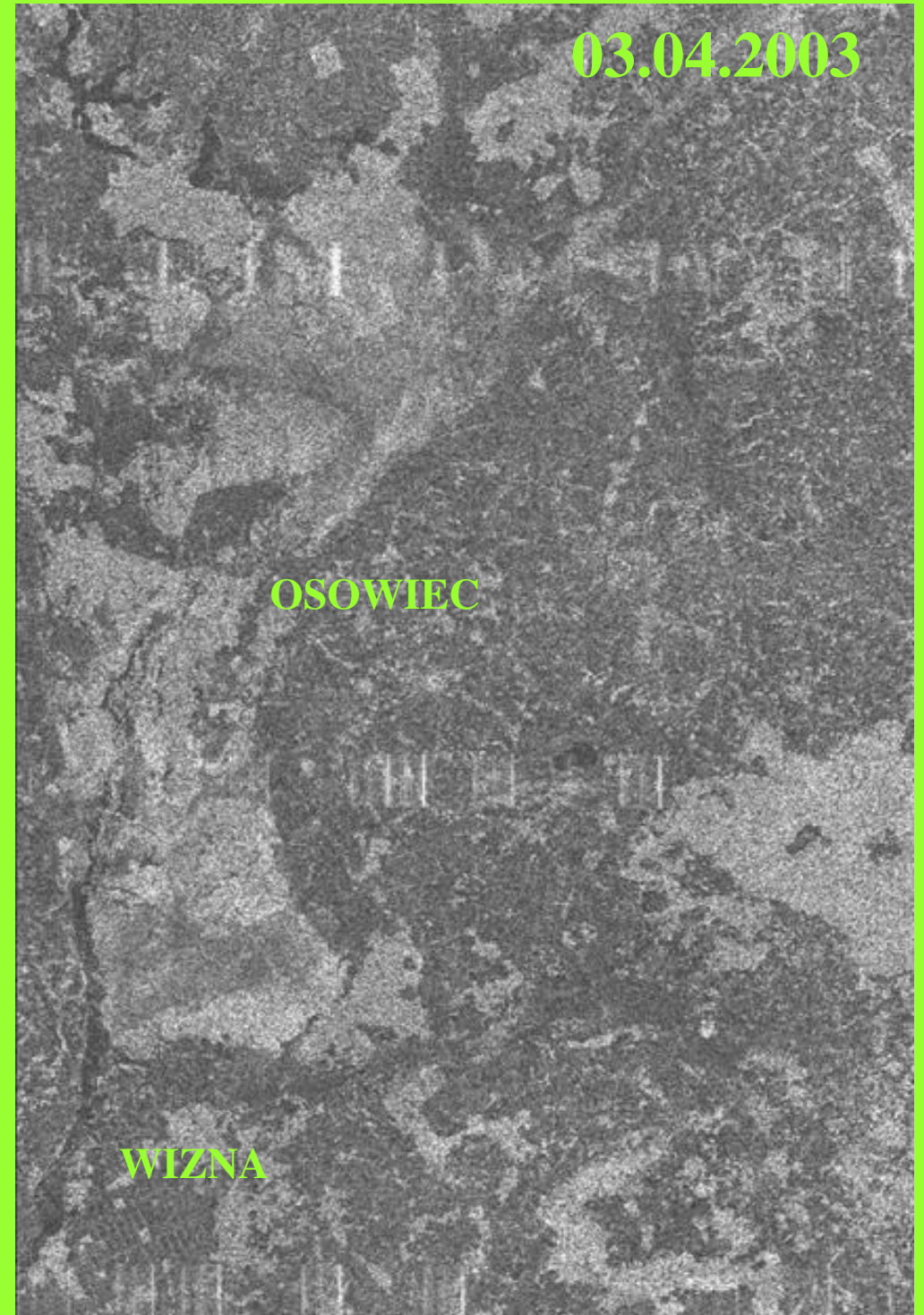
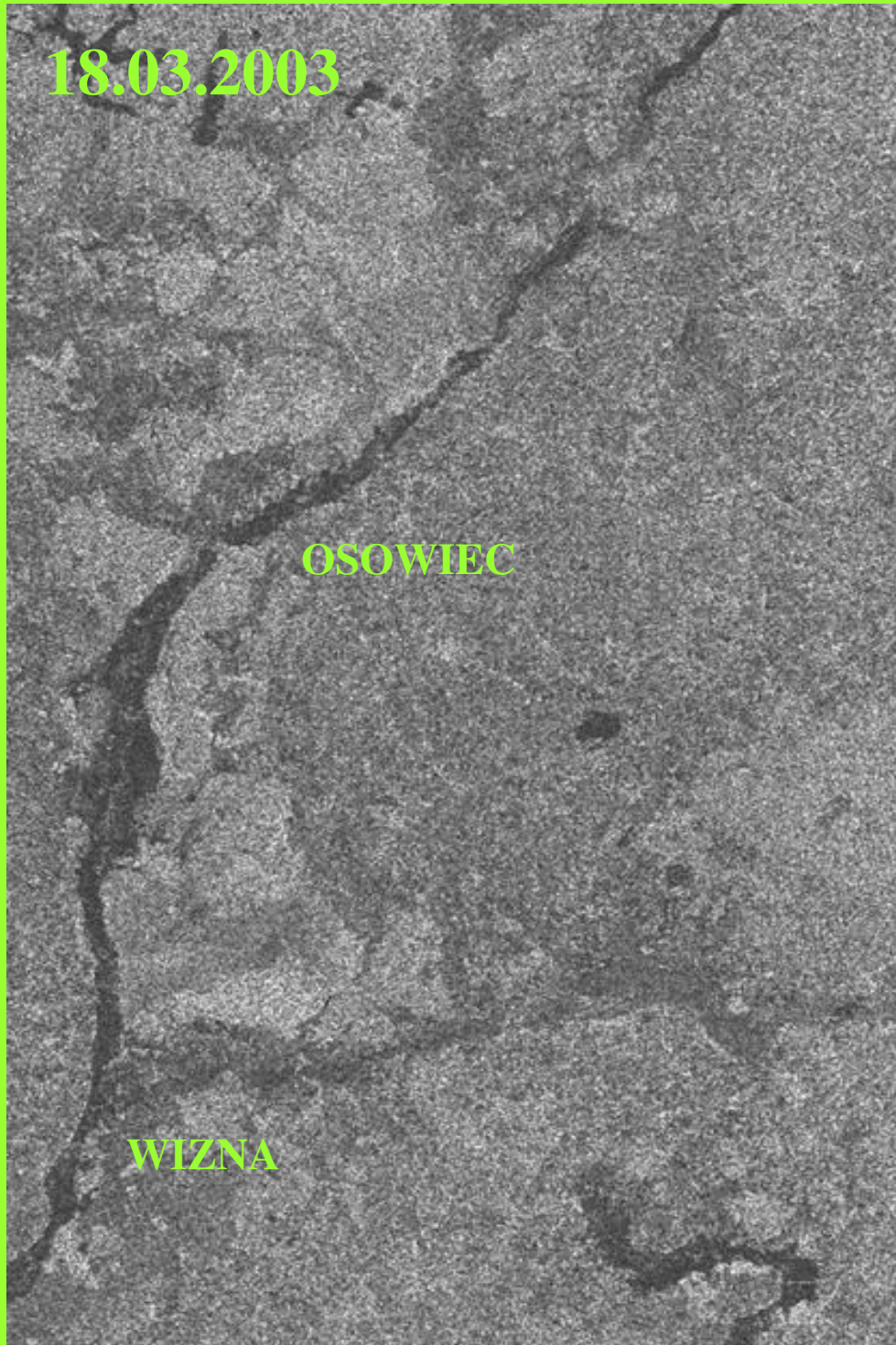
OSOWIEC

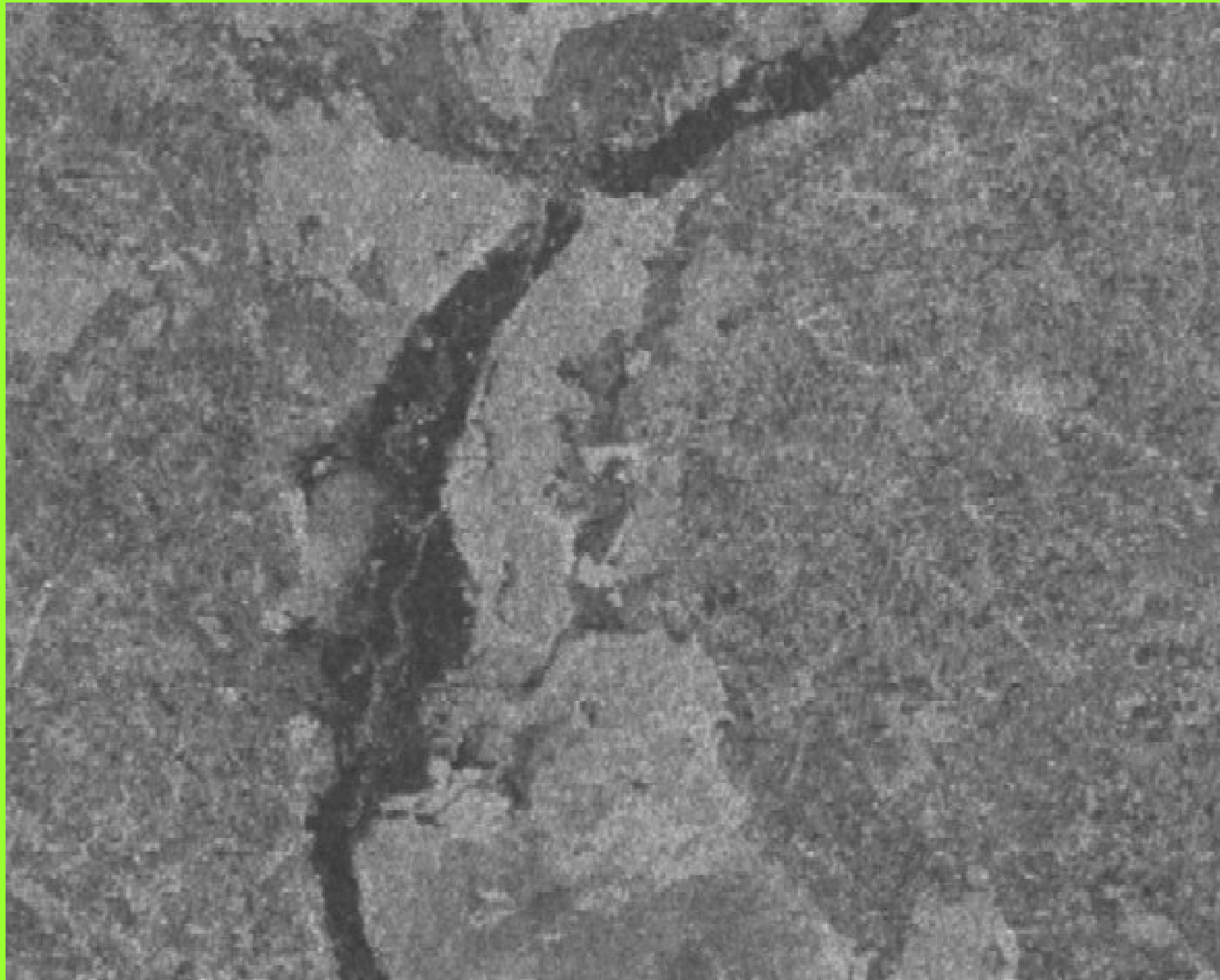
WIZNA

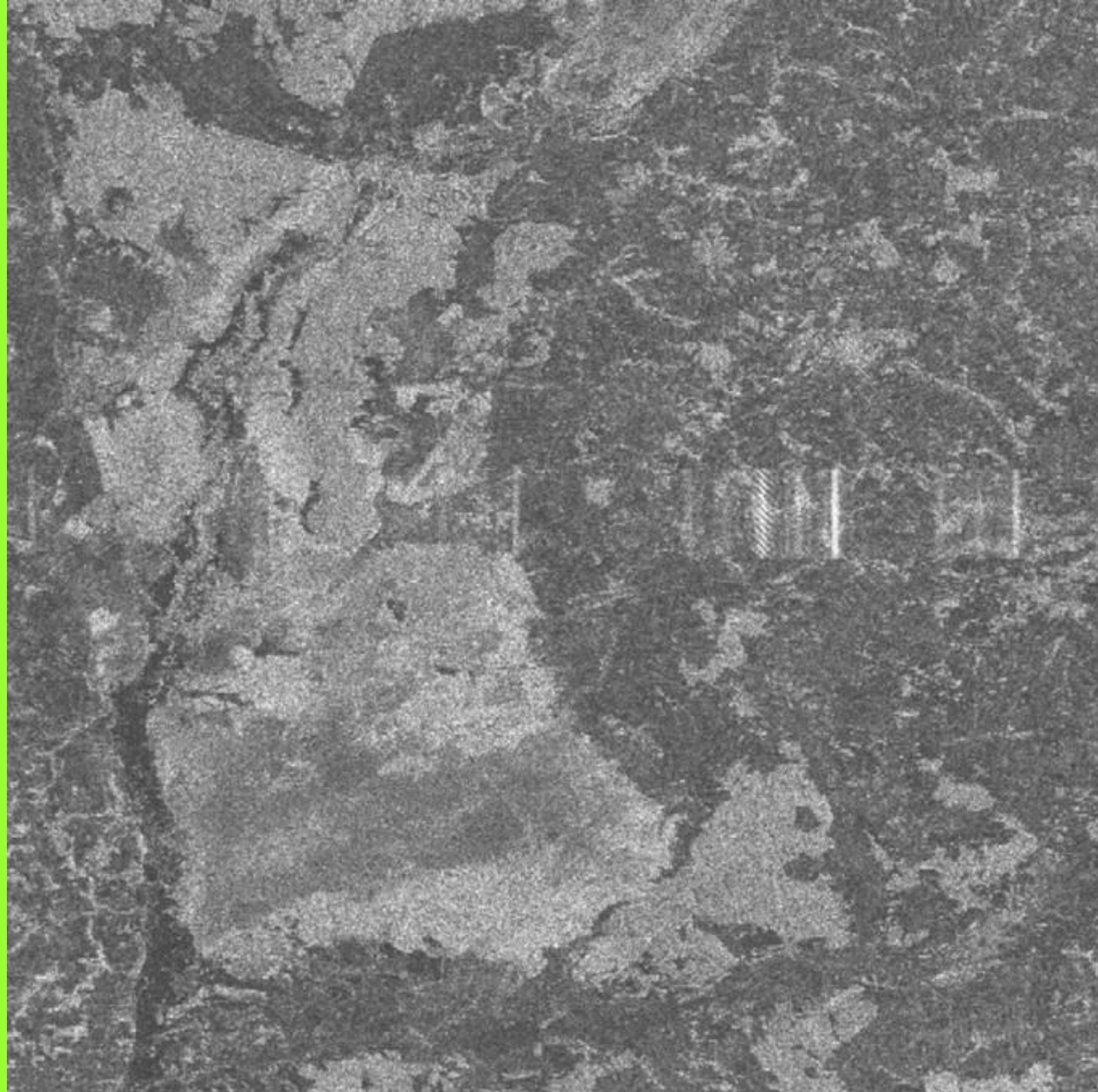
03.04.2003

OSOWIEC

WIZNA

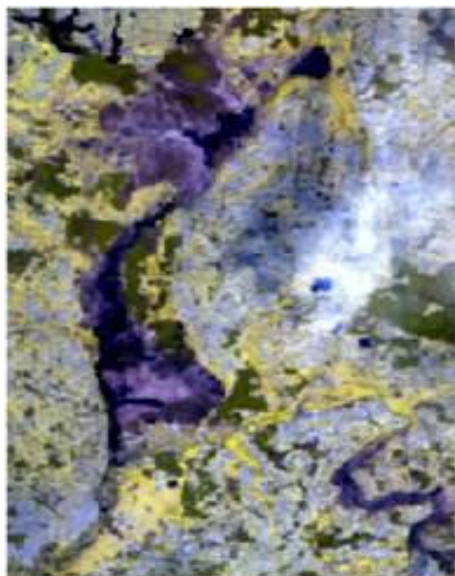








MERIS IMAGE from 21.04.2003



MERIS - kompozycja (RGB) kanałów 10, 13, 7