SPACE::LAB

05/09/2019 o 18:00

Košice, Bulharská 4

esa

Z družice na Košice: zaostrené na teplo v meste

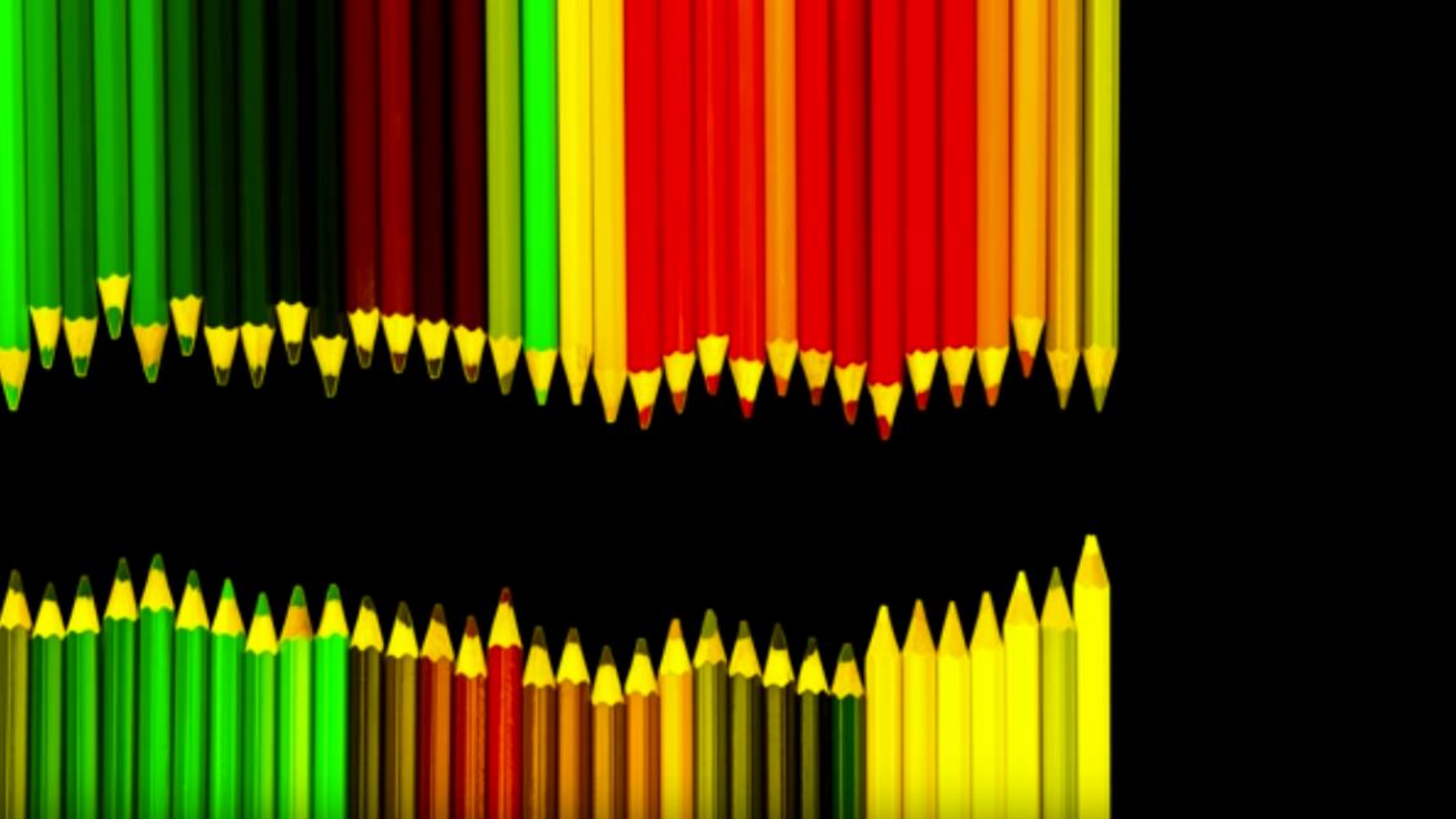
Michal Gallay

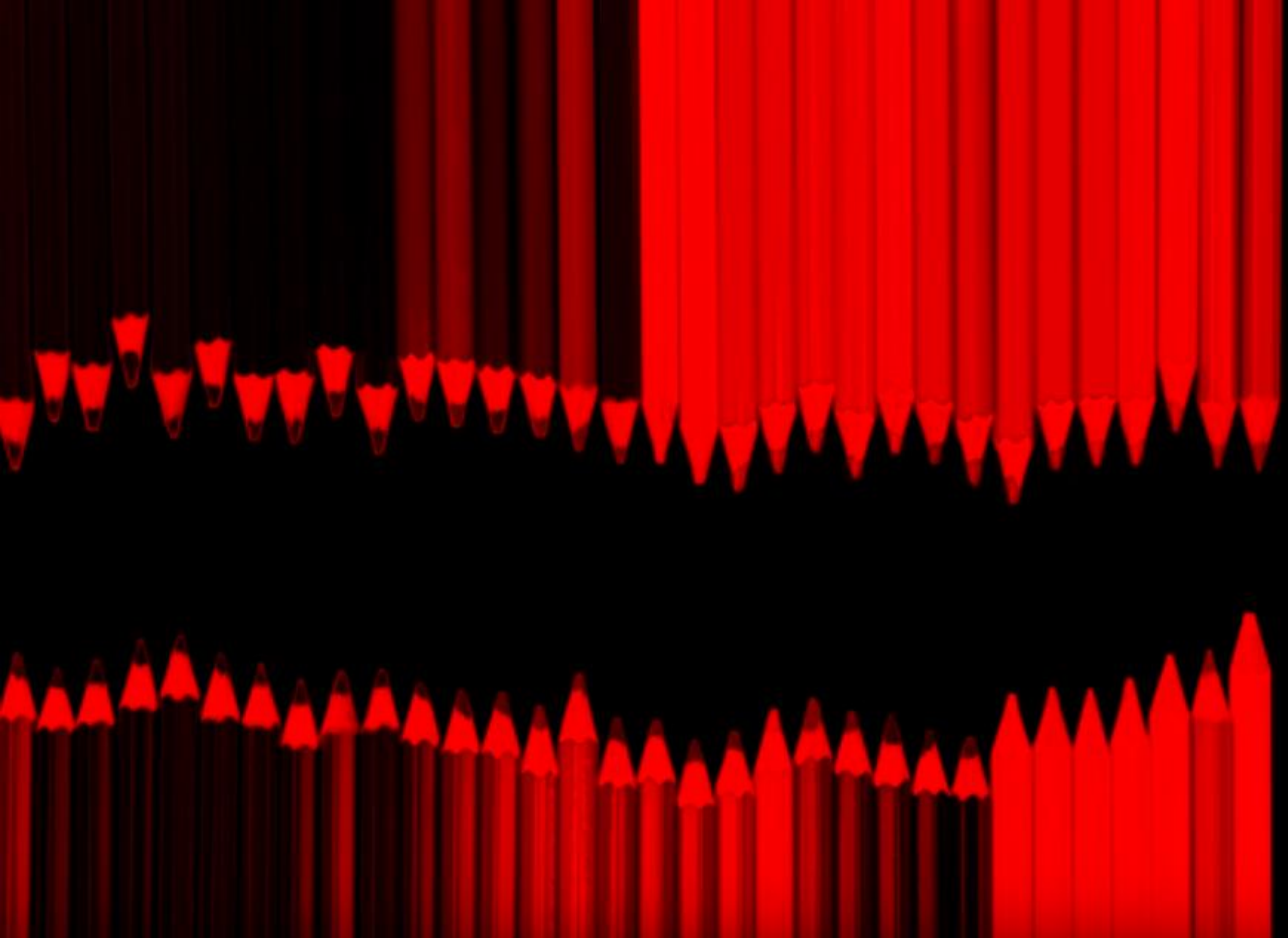
Univerzita Pavla Jozefa Šafárika v Košiciach

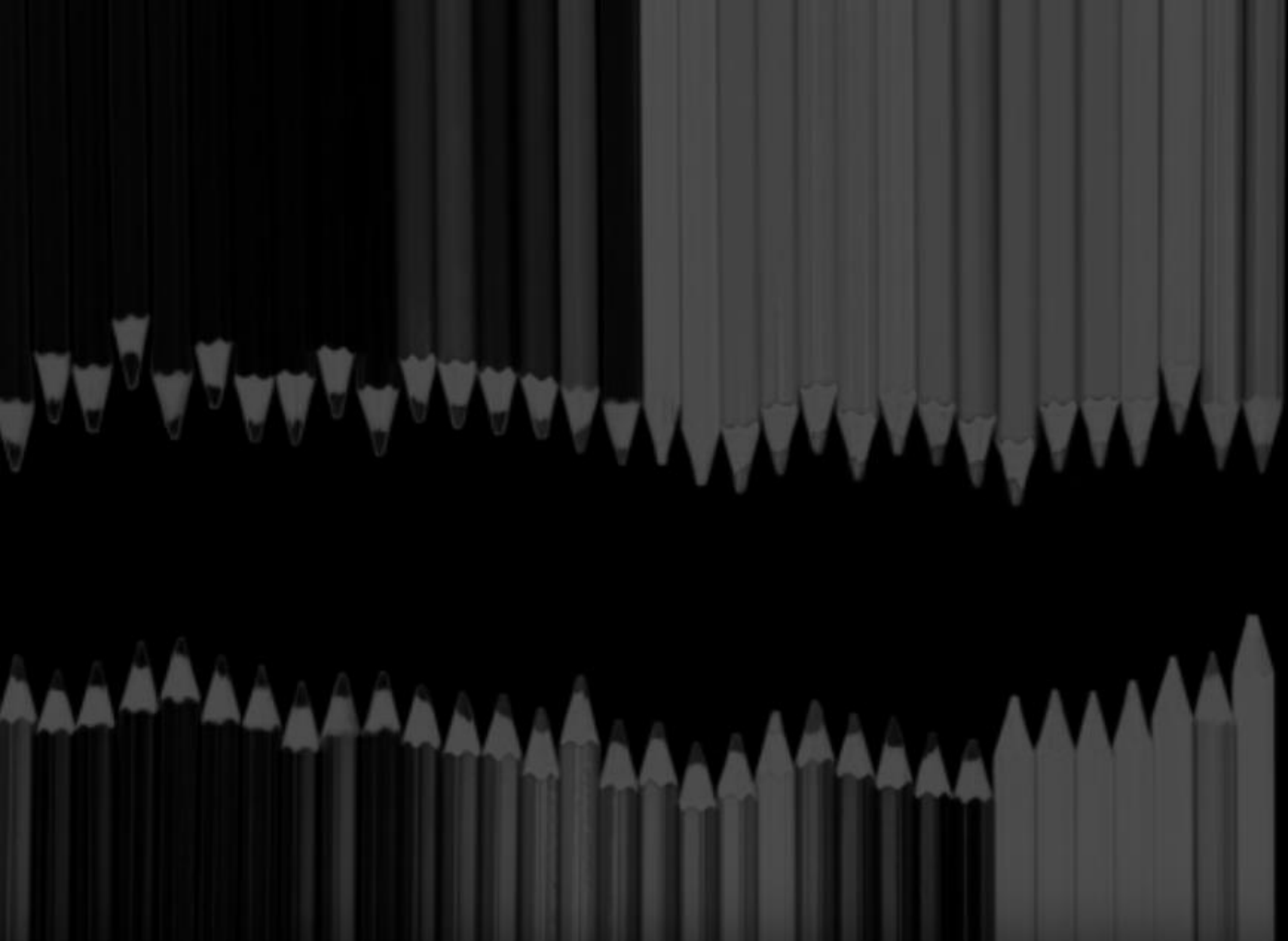
ÚSTAV GEOGRAFIE
Prírodovedecká fakulta UPJŠ v Košiciach

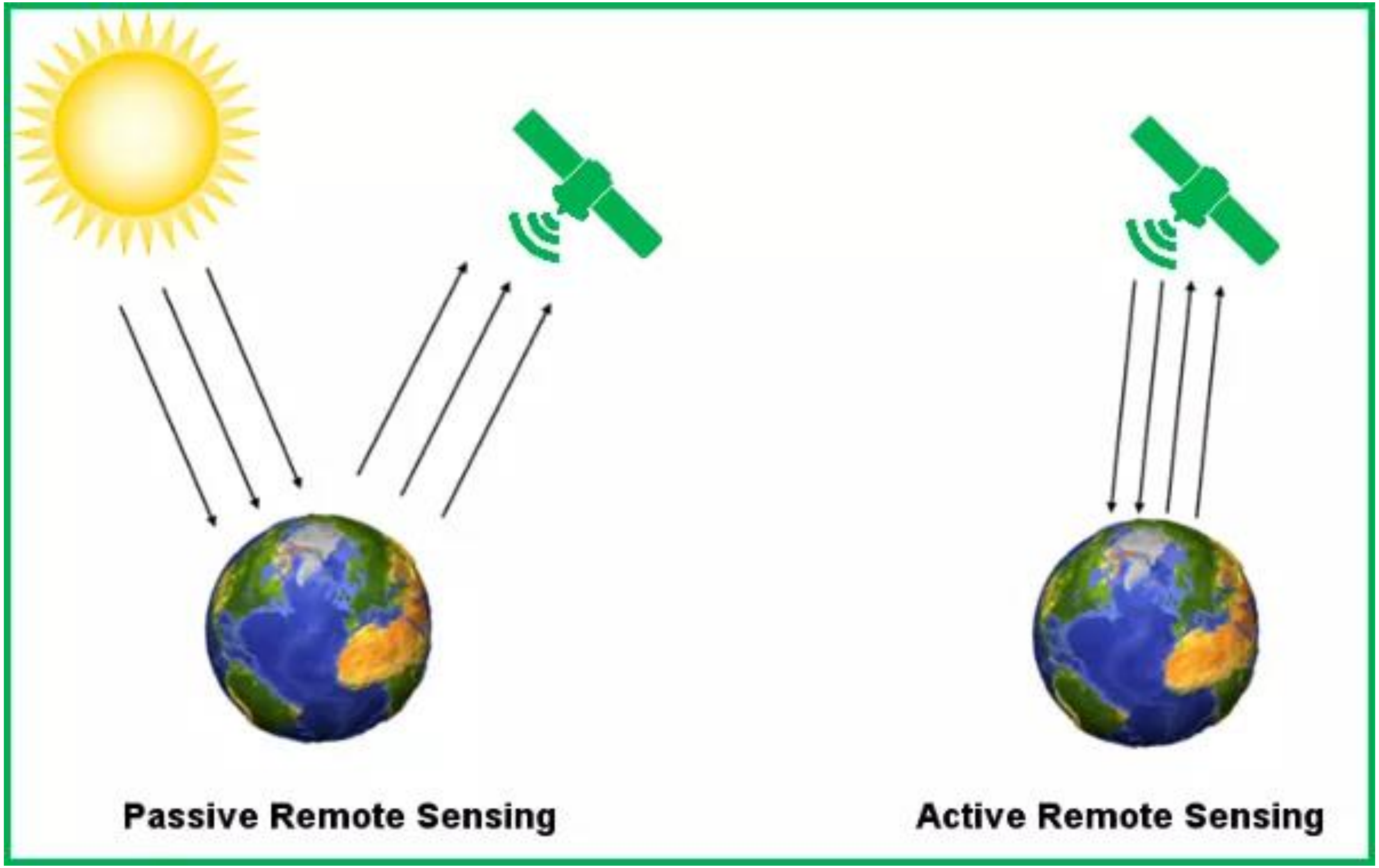
O čom to bude?

- Diaľkový prieskum Zeme
- Termálne snímanie
- Mestský ostrov tepla
- Projekt SURGE – modelovanie teploty v Košiciach



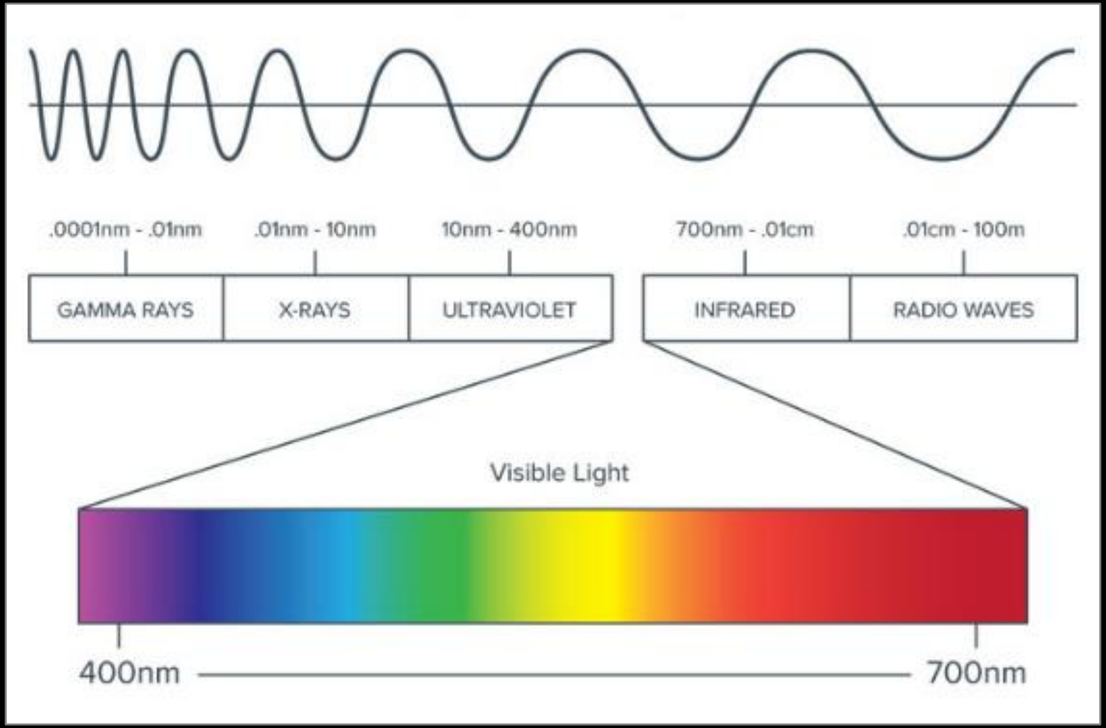


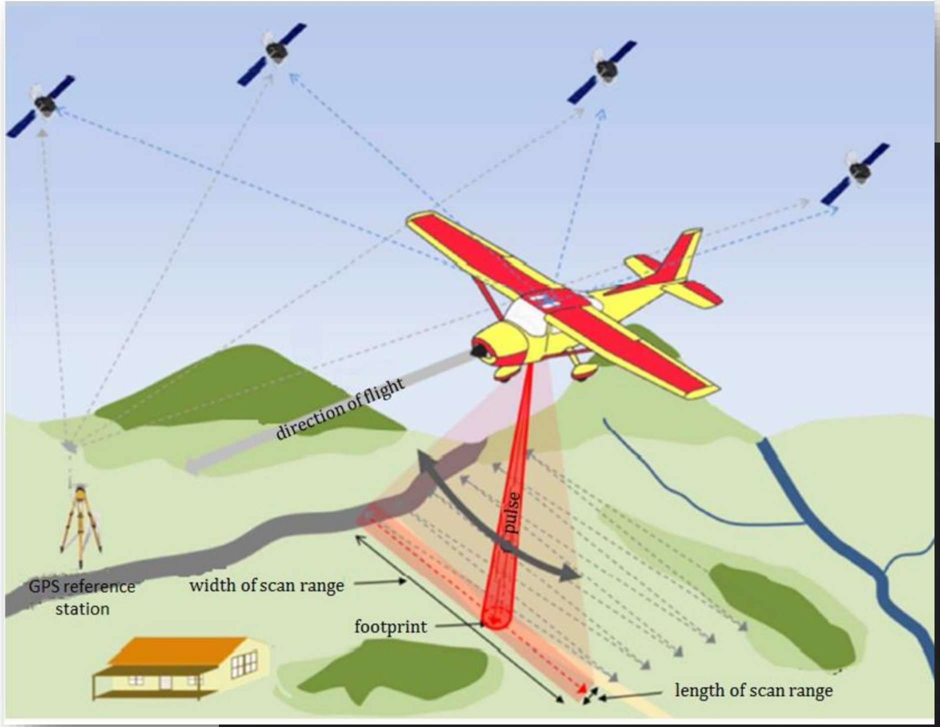


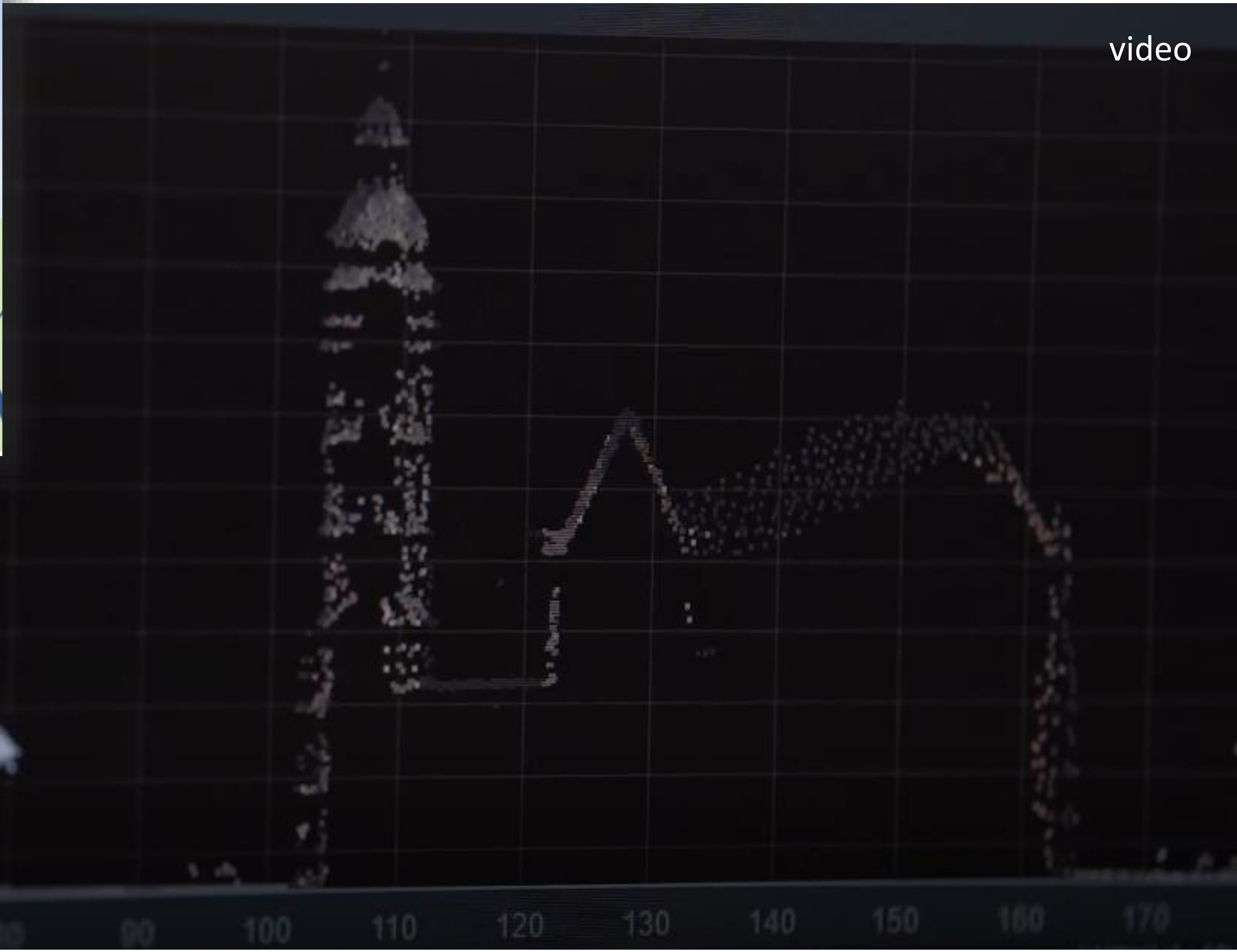

Passive Remote Sensing
Active Remote Sensing

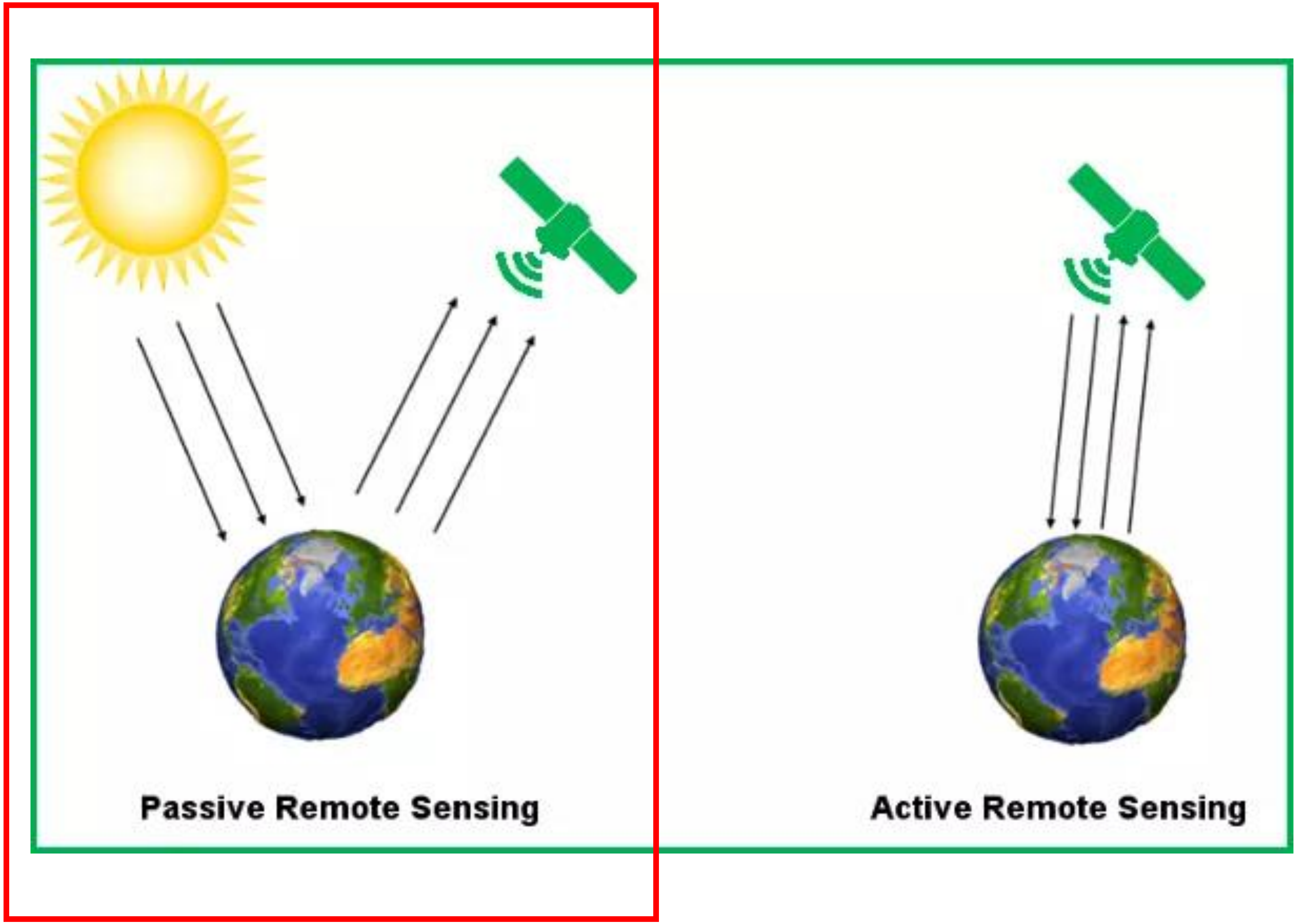
EVERY SINGLE SATELLITE ORBITING THE EARTH

Multispektrálne snímanie

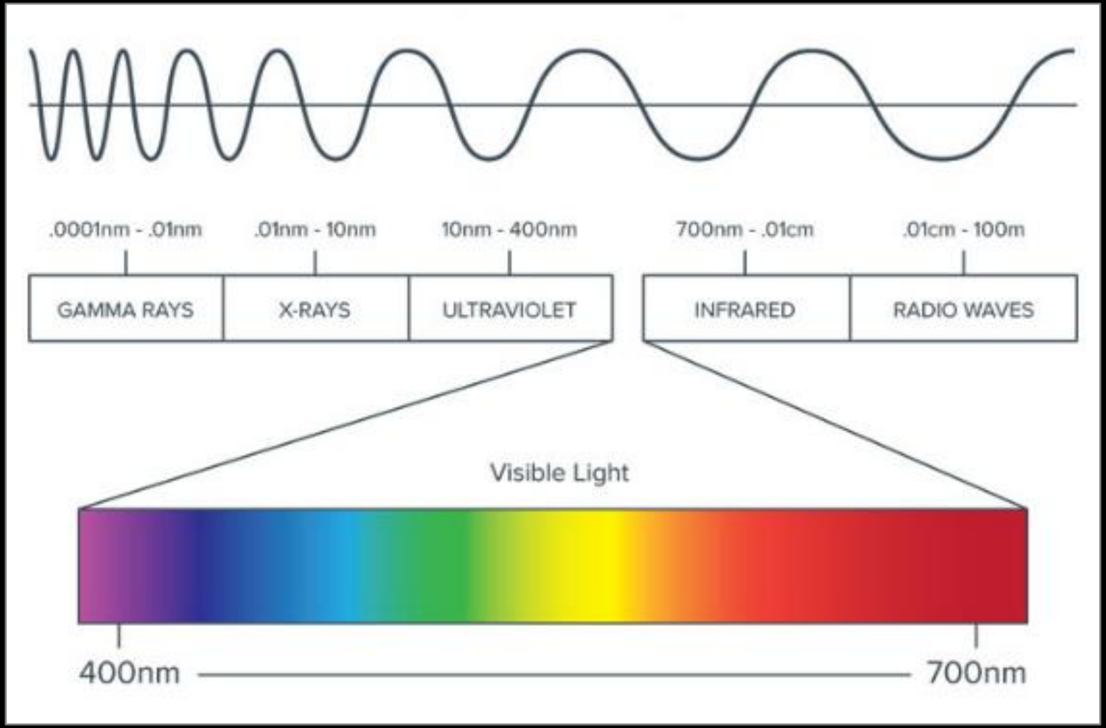


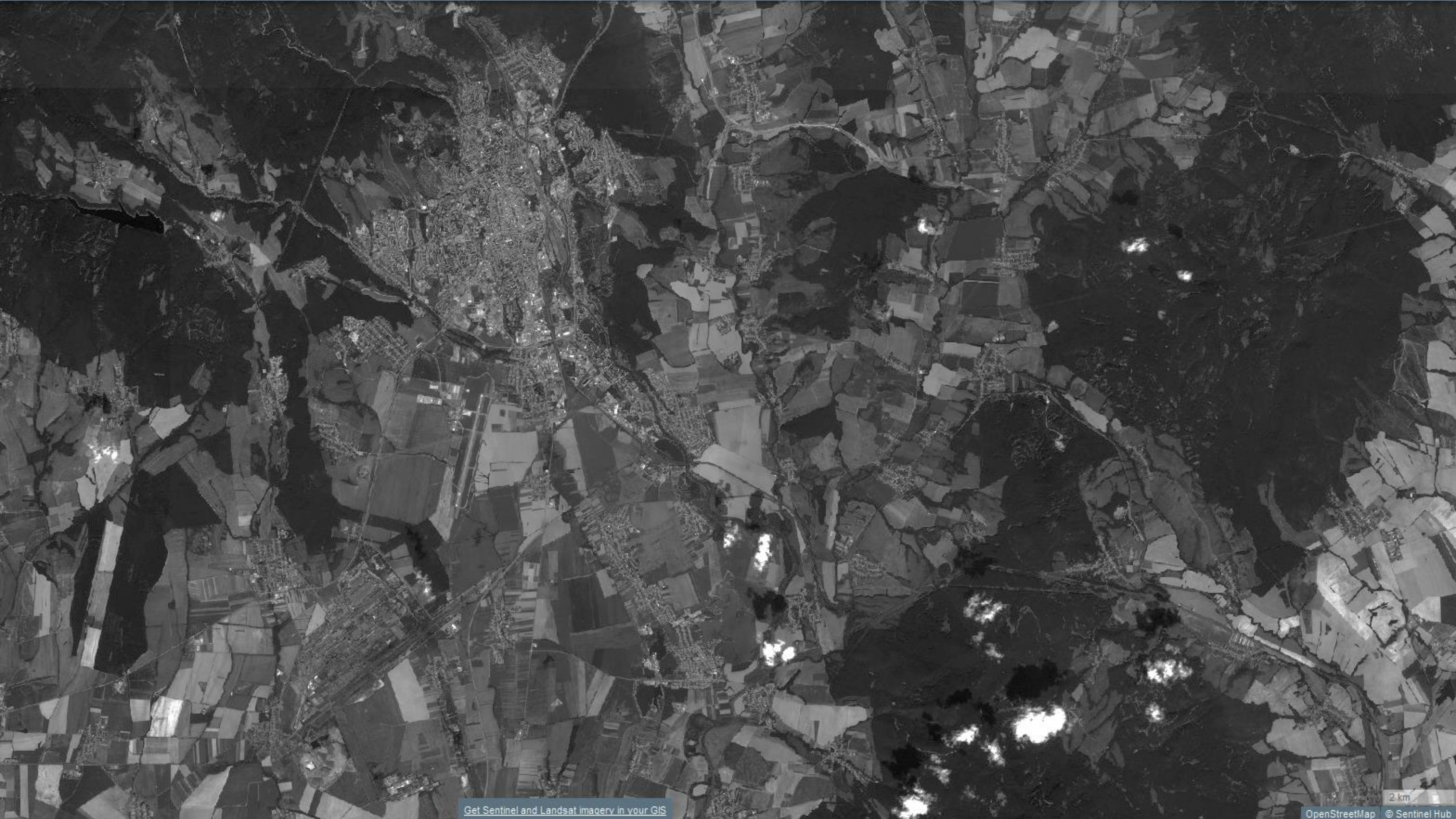

direction of flight
pulse
GPS reference station
width of scan range
footprint
length of scan range

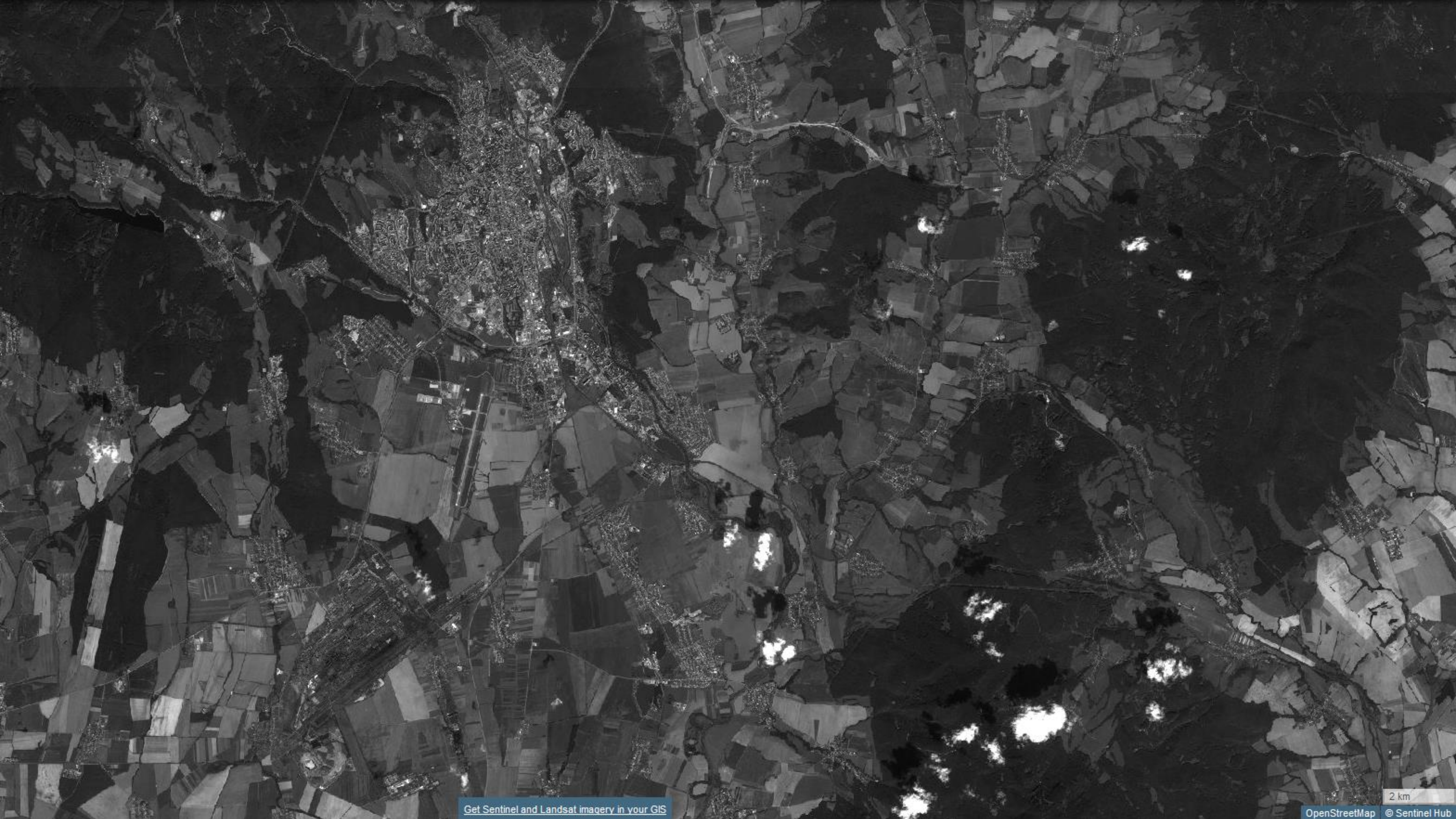

video
90
100
110
120
130
140
150
160
170


Passive Remote Sensing
Active Remote Sensing

Multispektrálne snímanie

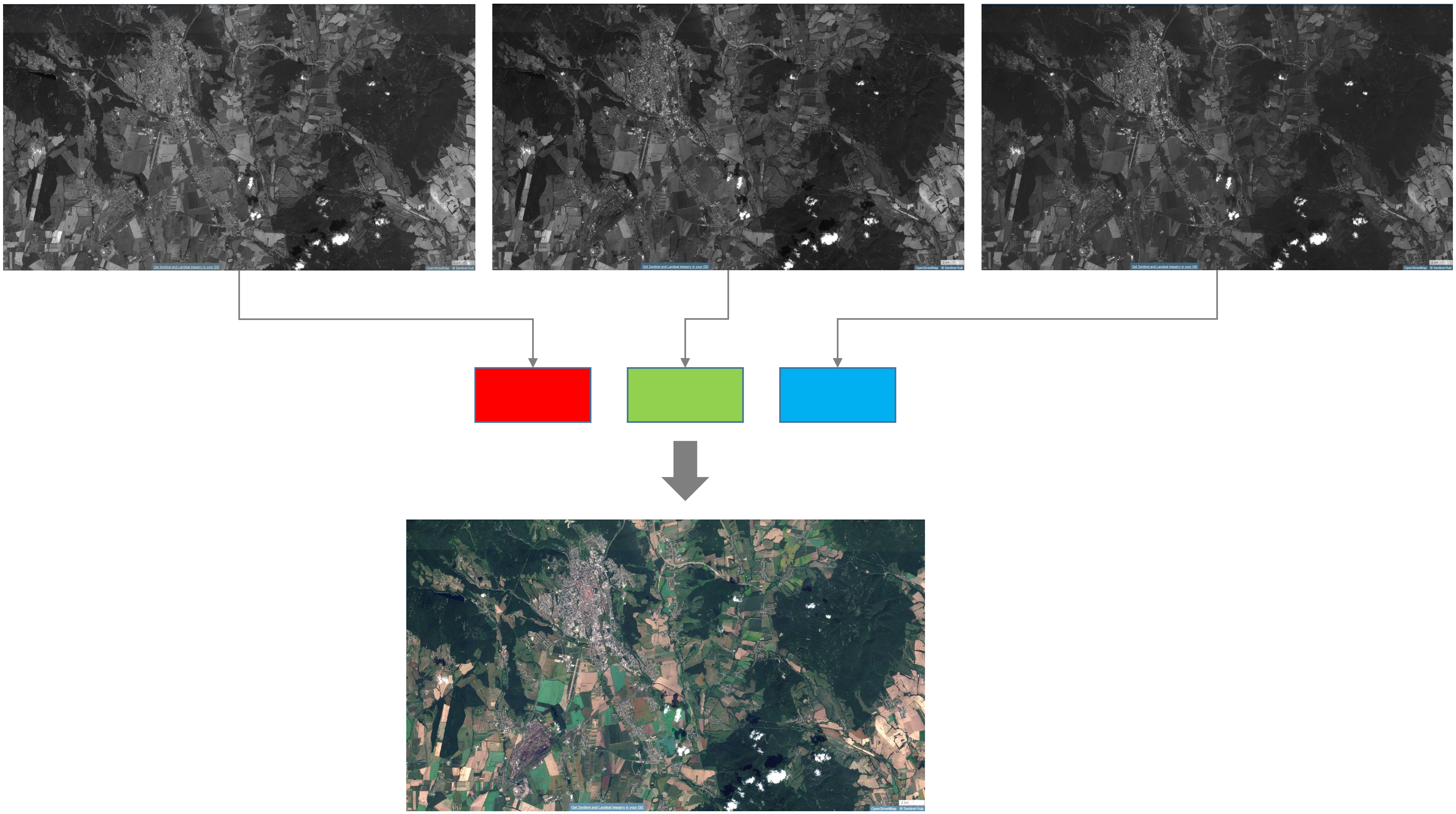



2 km
Get Sentinel and Landsat imagery in your GIS
OpenStreetMap © Sentinel Hub


Get Sentinel and Landsat imagery in your GIS
2 km
OpenStreetMap
© Sentinel Hub

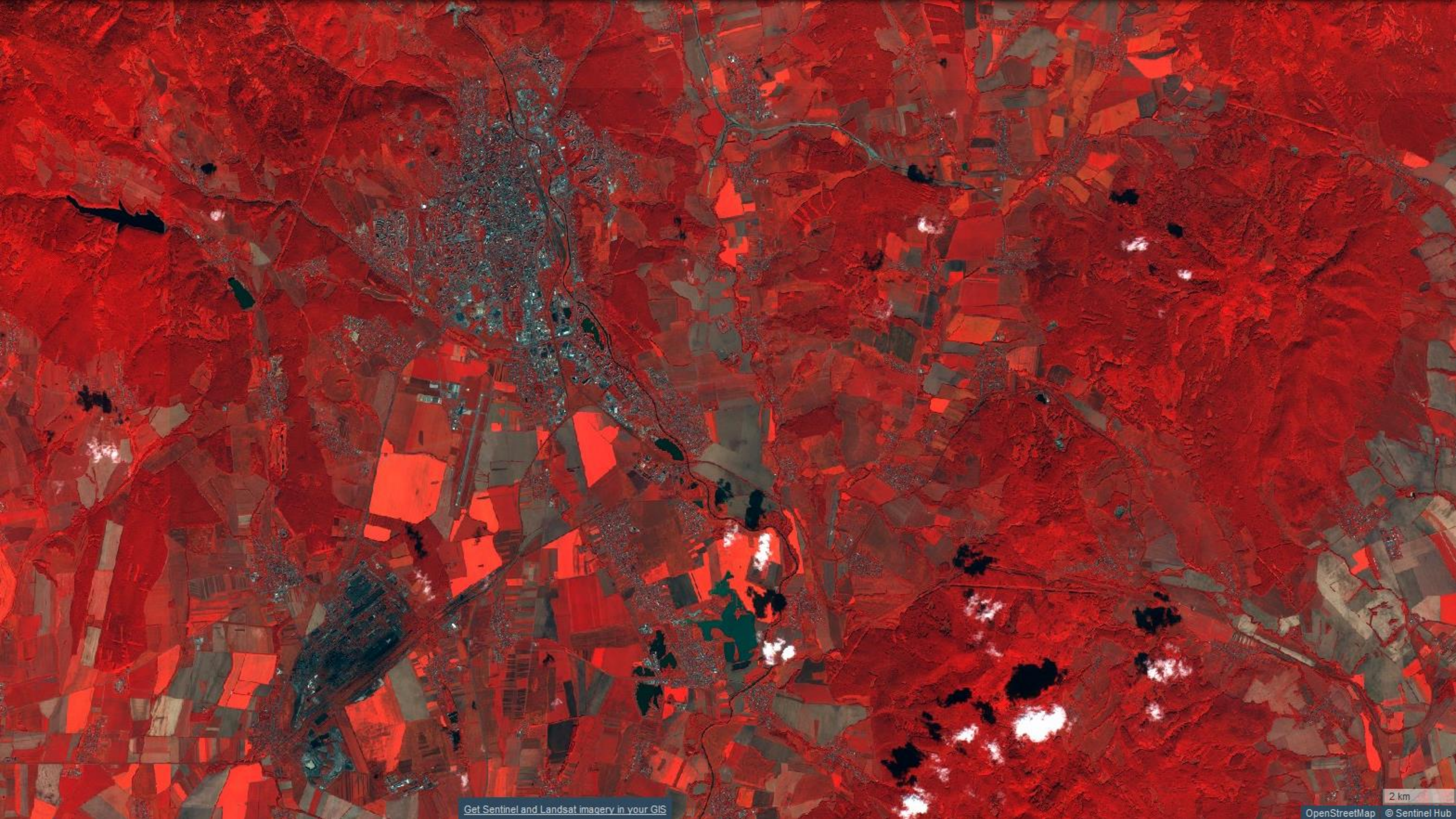

2 km
Get Sentinel and Landsat imagery in your GIS
OpenStreetMap
© Sentinel Hub


Get Sentinel and Landsat imagery in your GIS
2 km
OpenStreetMap
© Sentinel Hub



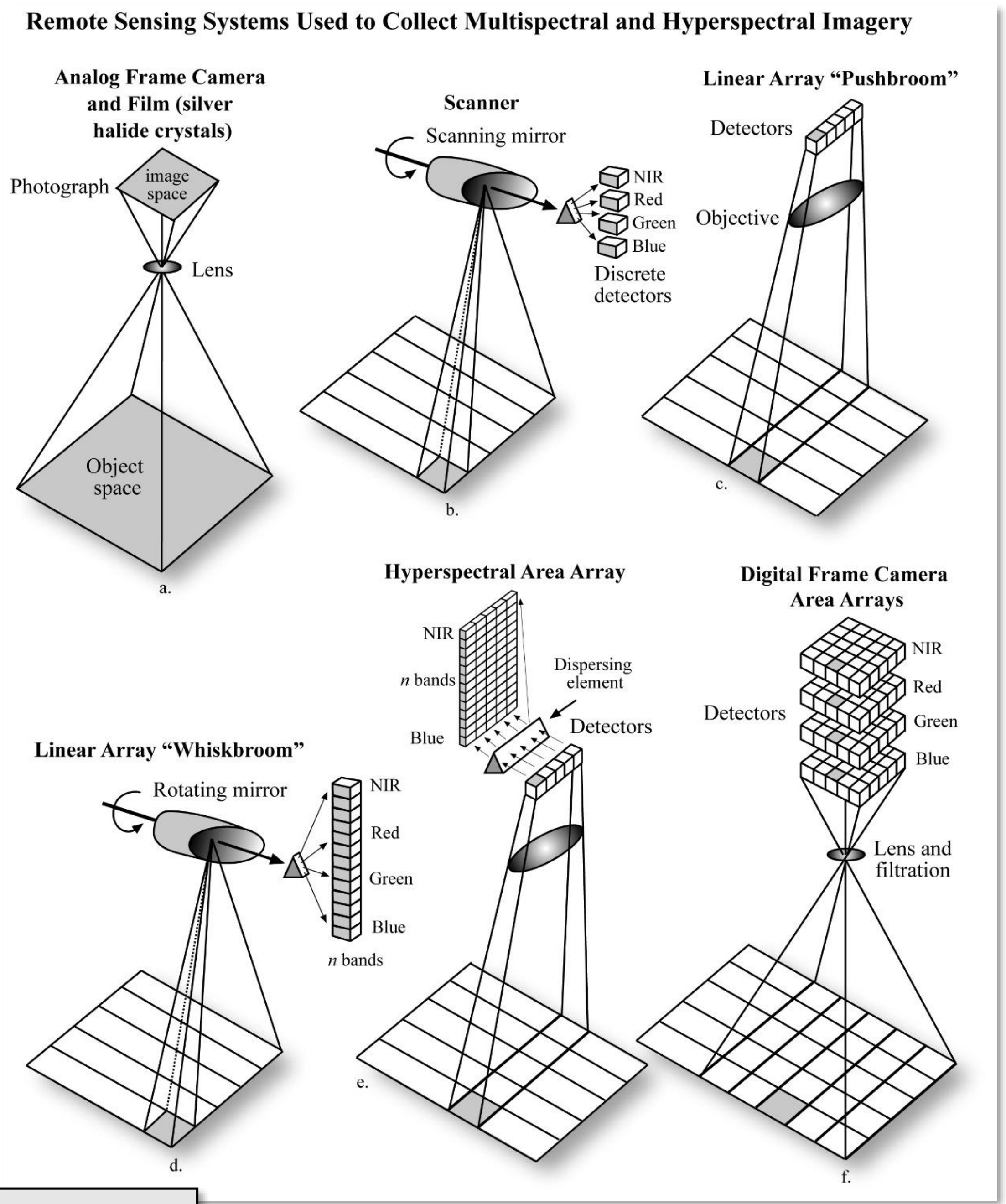
Get Sentinel and Landsat imagery in your GIS
2 km
OpenStreetMap
© Sentinel Hub


2 km
Get Sentinel and Landsat imagery in your GIS
OpenStreetMap
© Sentinel Hub


Get Sentinel and Landsat imagery in your GIS
2 km
OpenStreetMap © Sentinel Hub

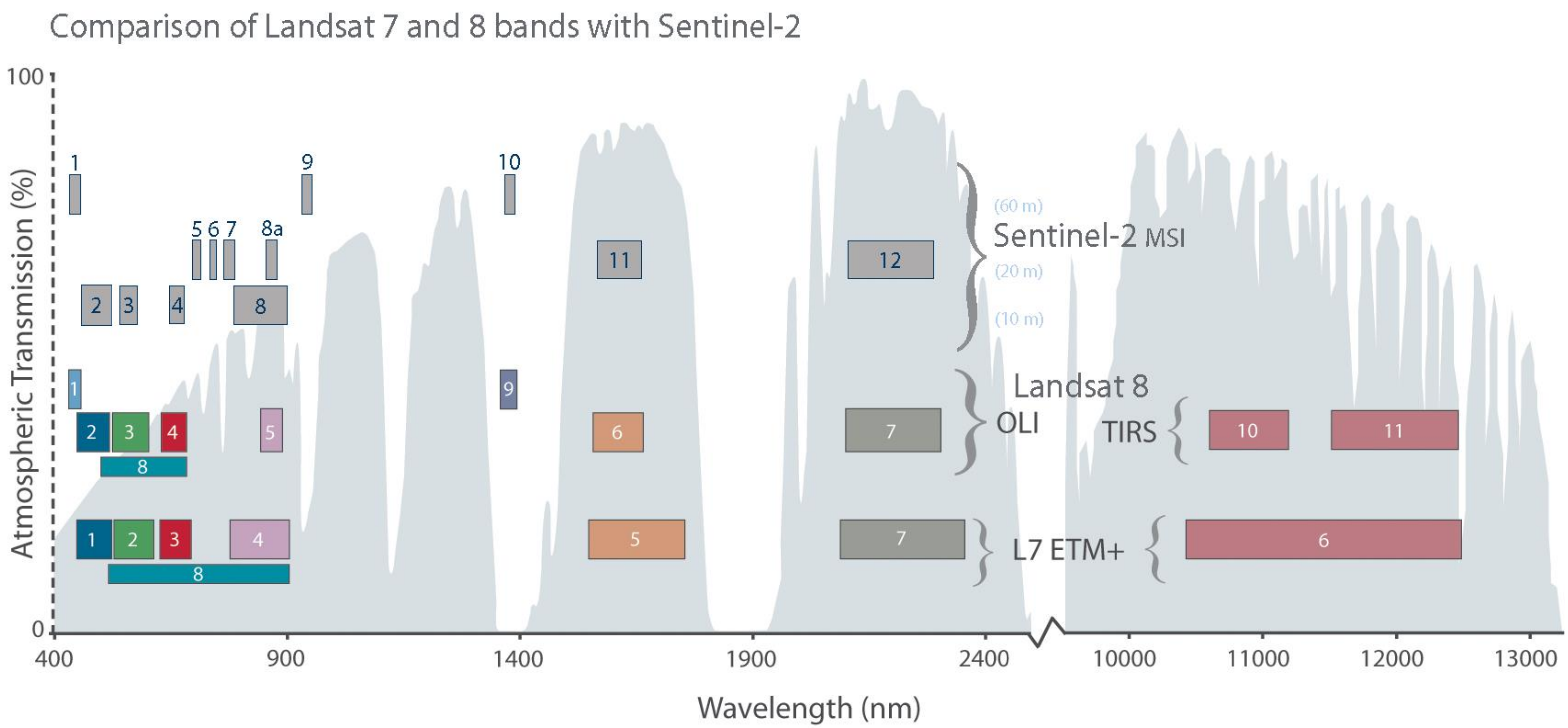
Get Sentinel and Landsat imagery in your GIS
2 km
OpenStreetMap
© Sentinel Hub

DPZ systémy pre multispektrálne a hyperspektrálne skenovanie



Jensen, 2007

SPOT
LANDSAT
MODIS
SENTINEL 2
IKONOS
GeoEye



Comparison of Landsat 7 and 8 bands with Sentinel-2
100
0
Atmospheric Transmission (%)
1
9
10
5 6 7
8a
2
3
4
8
11
12
(60 m)
Sentinel-2 MSI
(20 m)
(10 m)
1
9
2
3
4
5
8
6
7
Landsat 8
OLI
TIRS
10
11
1
2
3
4
8
5
7
L7 ETM+
6
400
900
1400
1900
2400
10000
11000
12000
13000
Wavelength (nm)

Raw Images

Landsat 8 Collection 1 DN values, representing scaled, calibrated at-sensor radiance.

Top of Atmosphere

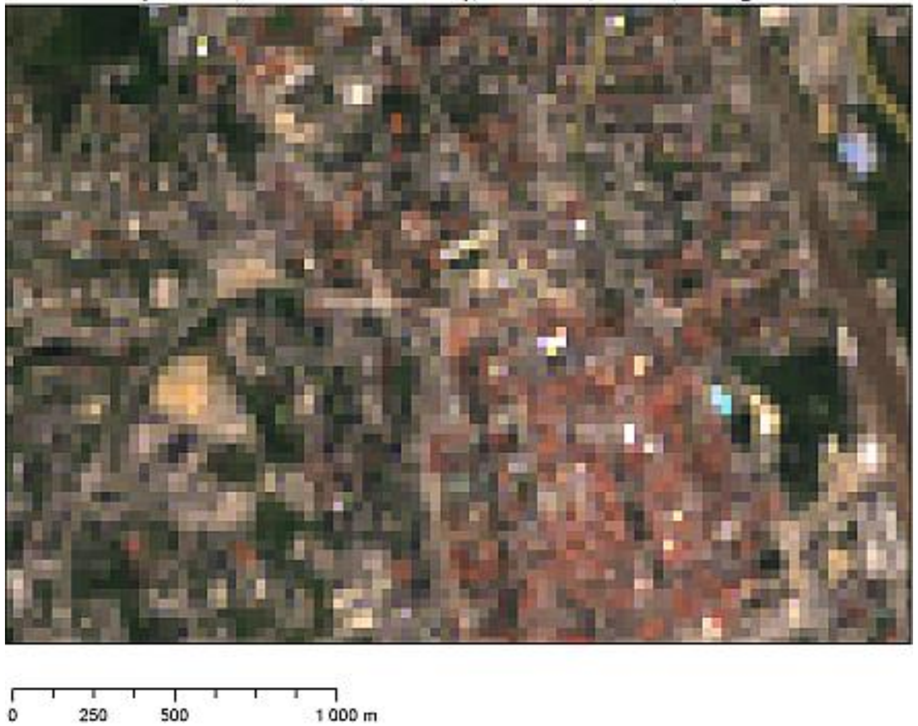
Landsat 8 Collection 1 calibrated top-of-atmosphere (TOA) reflectance

Surface Reflectance

Atmospherically corrected surface reflectance from the Landsat 8 OLI/TIRS sensors

Sentinel 2A (Red=B2, Green=B3, Blue=B4), cell=10m, Košice, 17. feb. 2016

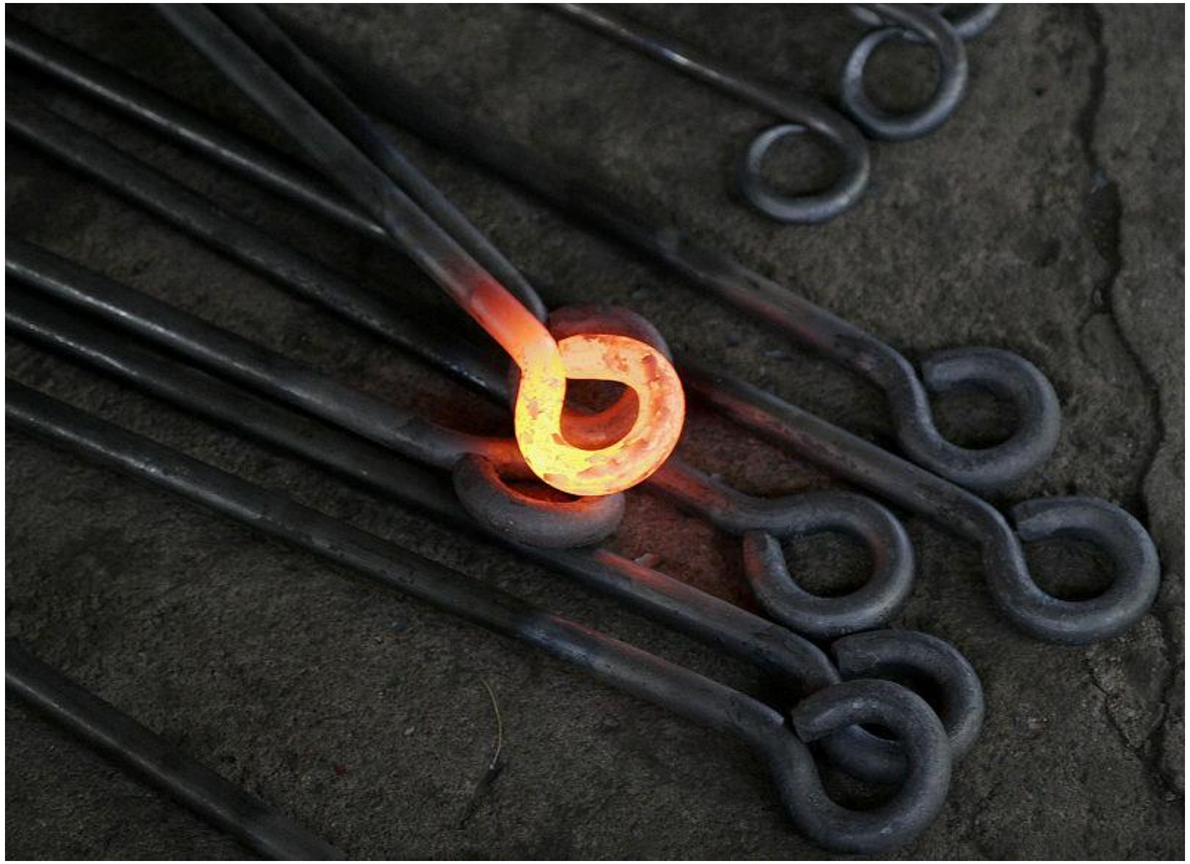
LANDSAT 8 (Red=B4, Green=B3, Blue=B2), cell=30m, Košice, 6. august 2015

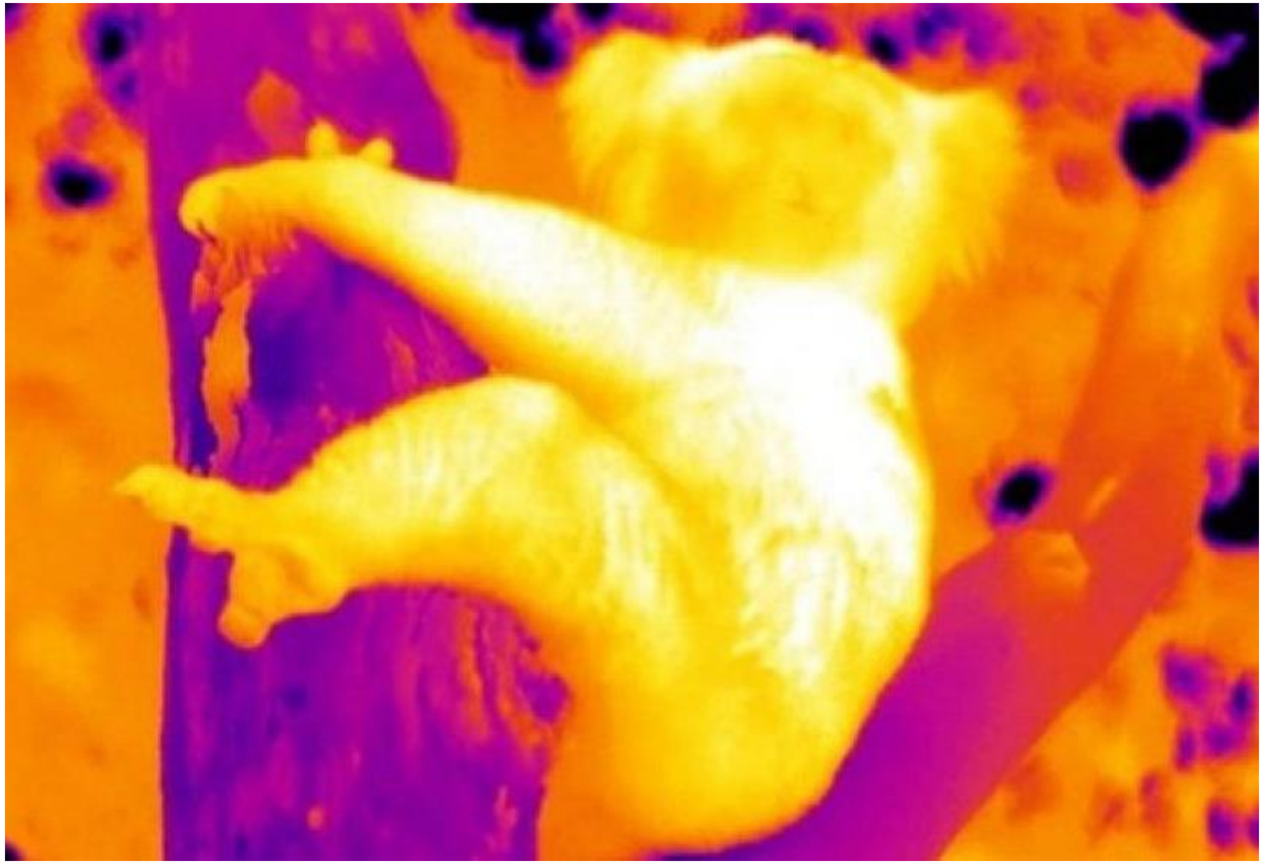


Landsat-7 ETM+ Bands (µm)			Landsat-8 OLI and *TIRS* Bands (µm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

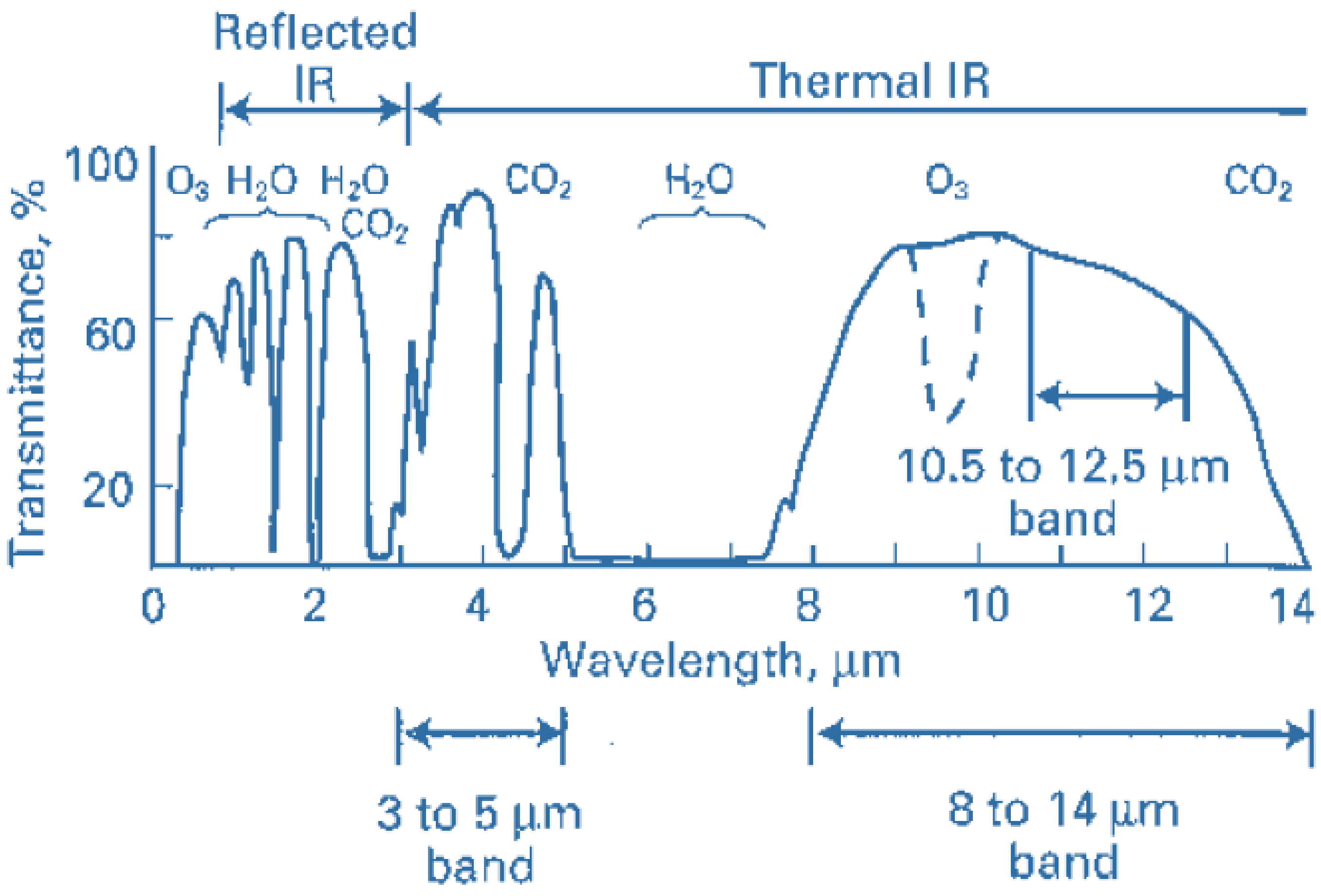
Table 2-1. OLI and TIRS Spectral Bands Compared to ETM+ Spectral Bands

Termálne vyžarovanie a snímanie





Atmosférické okná pre termálne snímanie



Source: Sabins (1997)

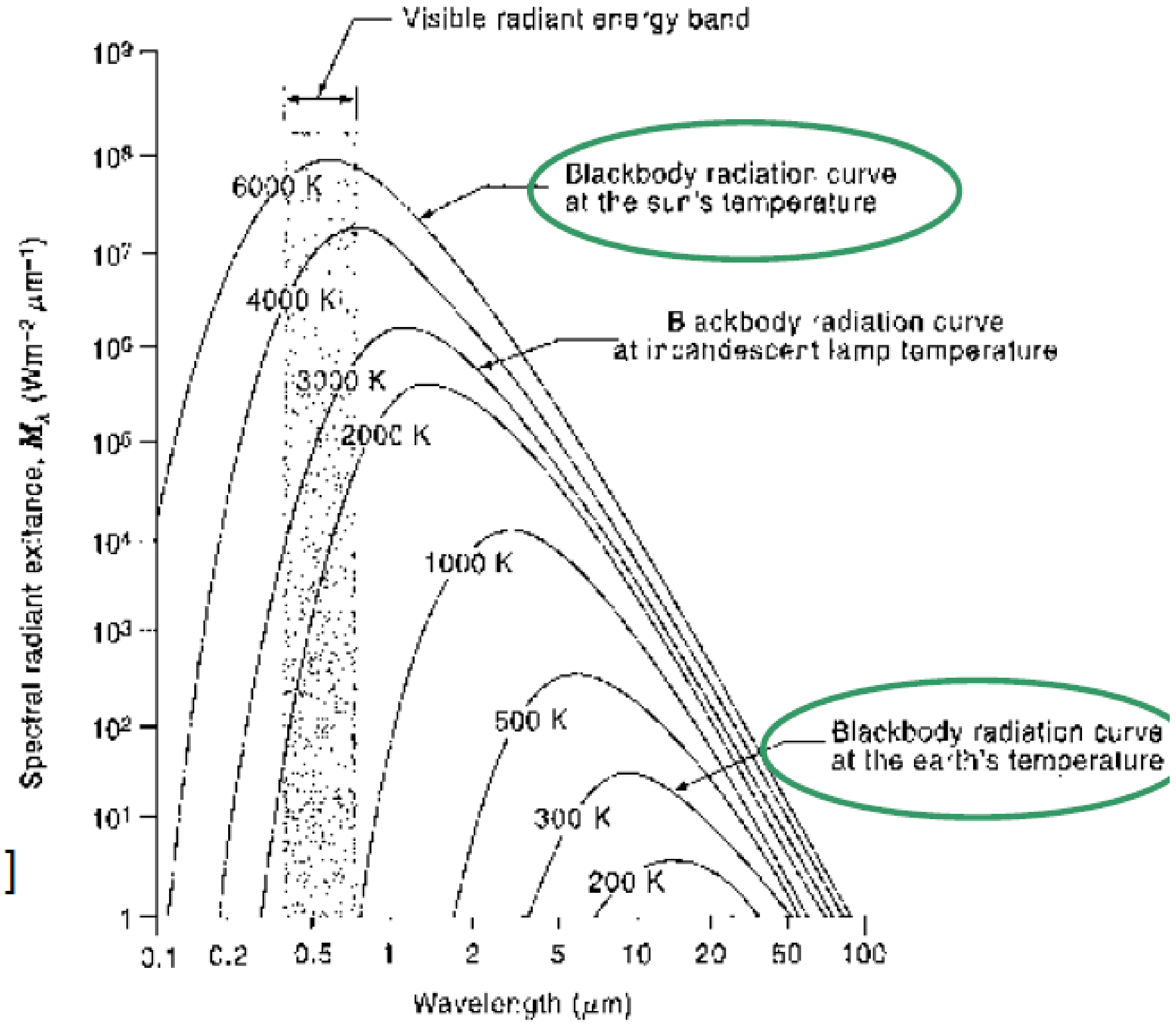
Dr. Claudia Kuenzer
German Remote Sensing Data Center, DFD
German Aerospace Center, DLR
email: claudia.kuenzer@dlr.de

Planck's Blackbody Radiation Law

Describes the electromagnetic radiation emitted from a blackbody at a certain wavelength as a function of its absolute temperature.

$$M_\lambda = \frac{2\pi h c^2}{\lambda^5 \left(e^{hc/\lambda k T} - 1\right)}$$

M_λ = spectral radiant exitance [W m^{-2} µm^{-1}]
h = Planck's constant [6.626 x 10^{-34} J s]
c = speed of light [2.9979246 x 10^{8} m s^{-1}]
k = Boltzmann constant [1.3806 x 10^{-23} J K^{-1}]
T = absolute temperature [K]
λ = wavelength [µm]



Source: Lillesand et al. (2008)

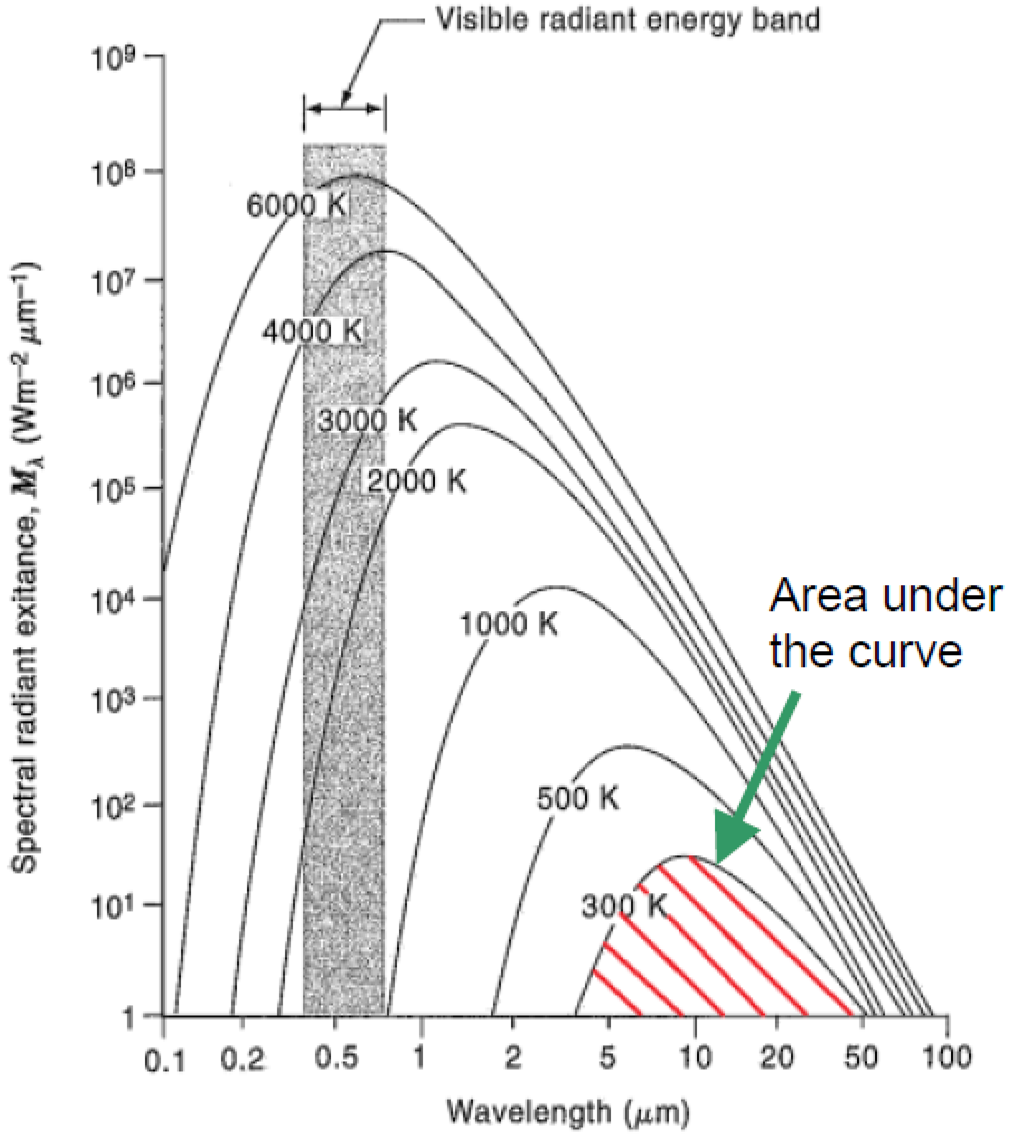
Stefan-Boltzmann Law

Describes the <u>total</u> electromagnetic radiation emitted by a blackbody as a function of the <u>absolute temperature</u> which corresponds to the area under the radiation curve (integral).

$$M = \sigma T^4$$

M = total radiant exitance [W m²]
T = absolute temperature [K]
σ = Stefan-Boltzman constant
[5.6697 x 10^{-8} W m^{-2} K^{-4}]

→ The higher the temperature of the radiator, the greater the total amount of radiation it emits.



Source: Lillesand et al. (2008)

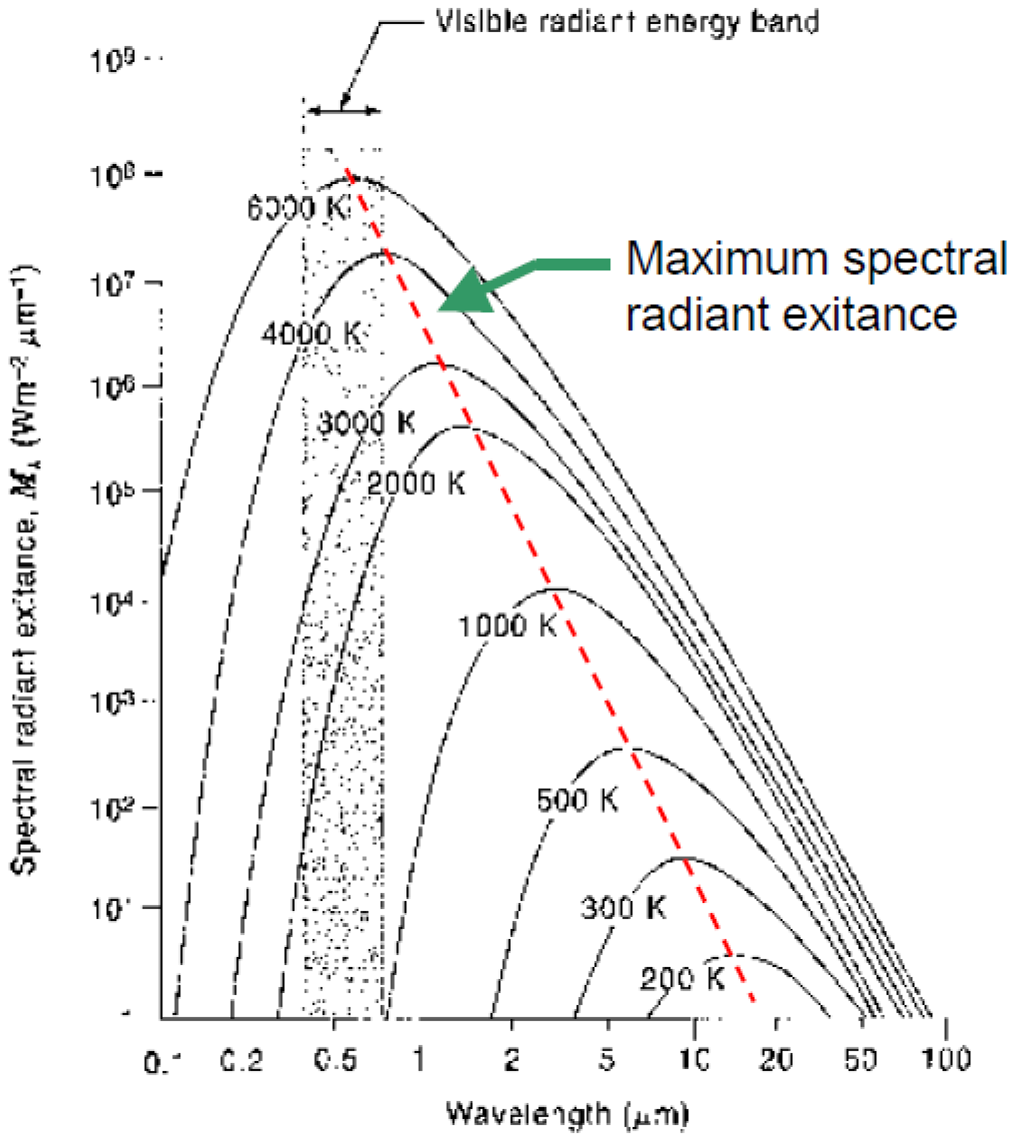
Wien‘s Displacement Law

Describes the wavelength at which the maximum spectral radiant exitance occurs.

$$\lambda_{max} = \frac{A}{T}$$

λ_{max} = wavelength of maximum spectral radiant exitance [µm]
A = Wien‘s constant [2897.8 µm K]
T = absolute temperature [K]

→ With increasing temperature λ_{max} shifts to shorter wavelengths.



Source: Lillesand et al. (2008)

Odvodenie teploty povrchu

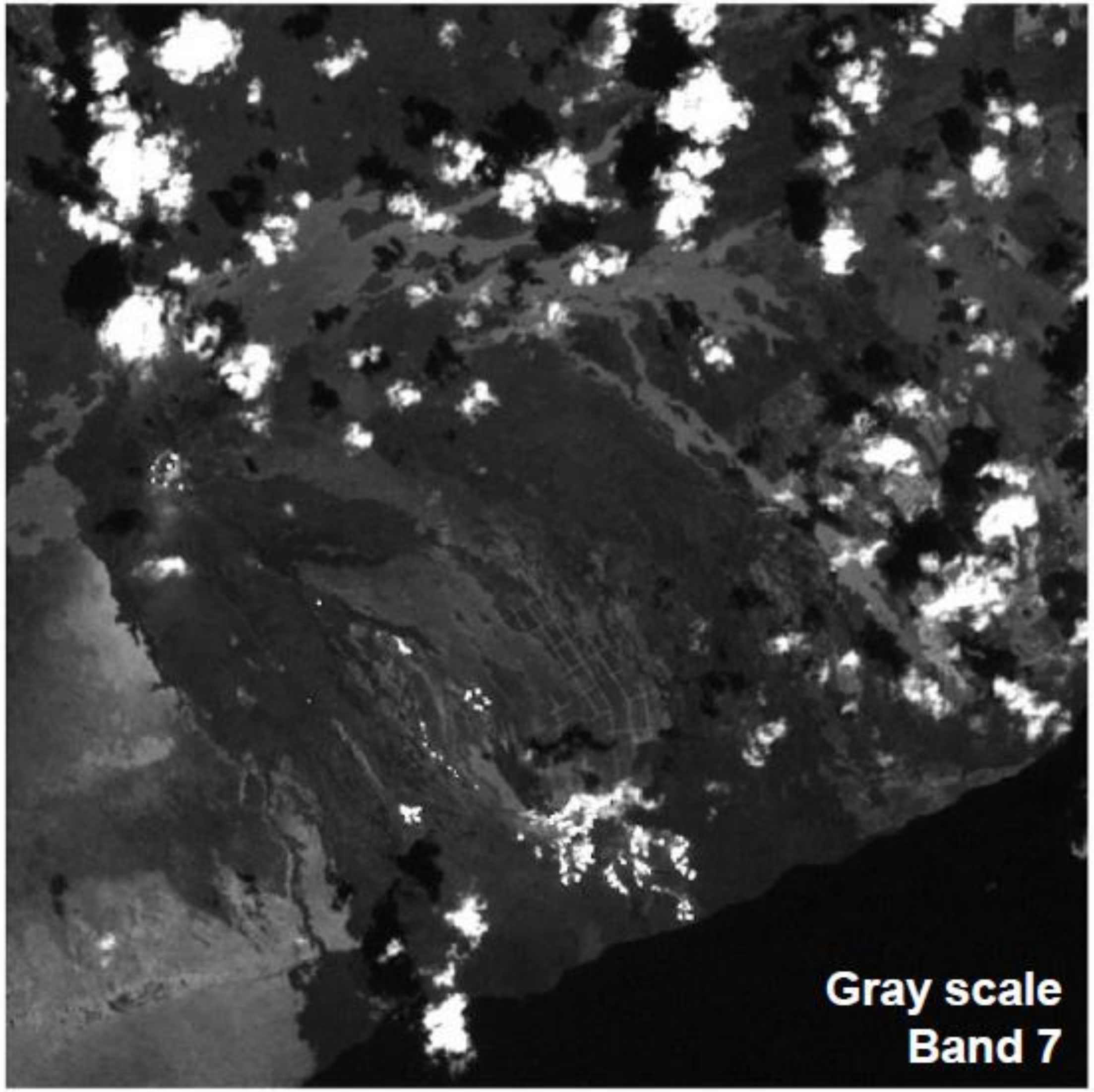
DN
- DN – to Radiance

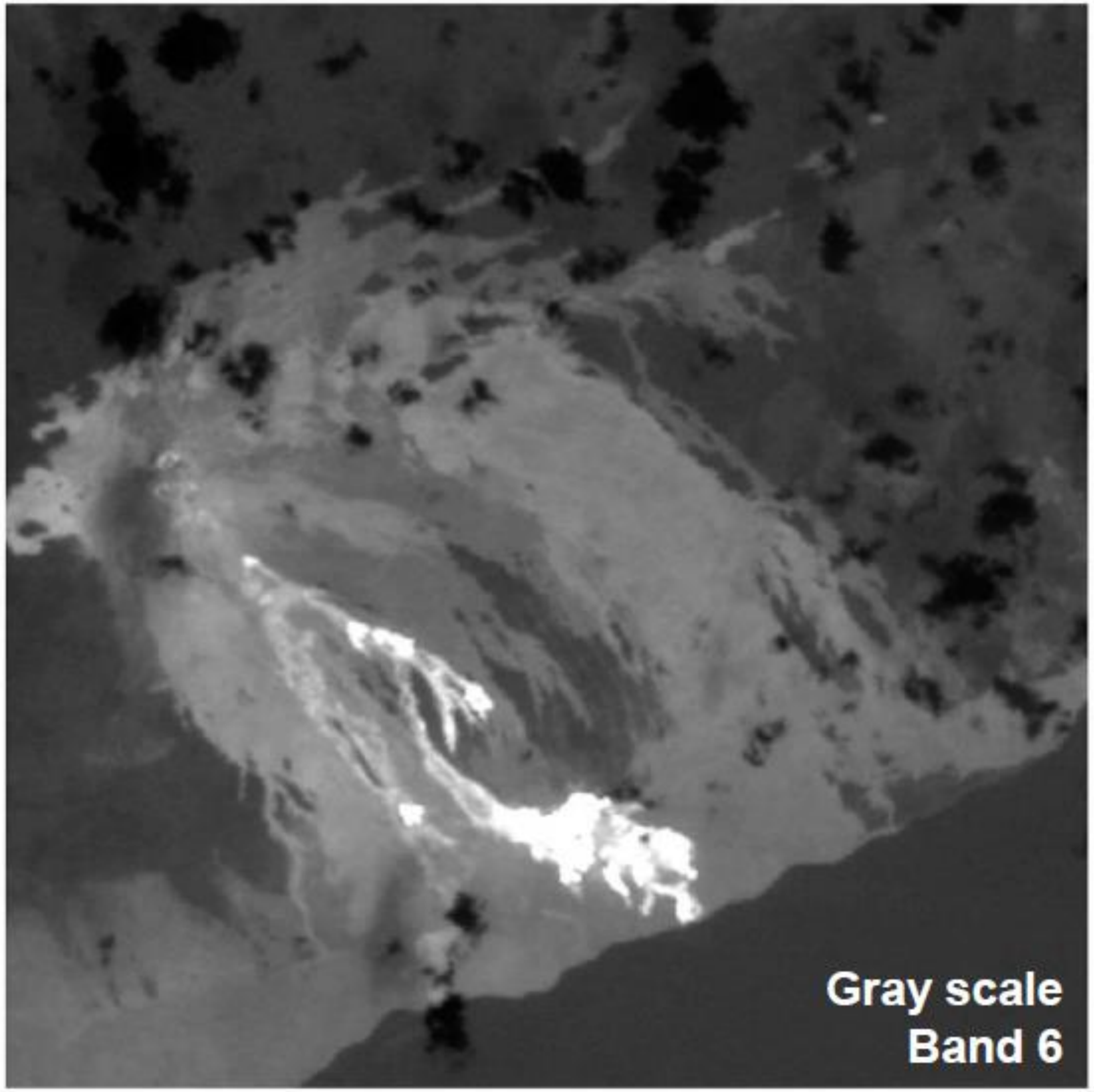
BT
- Radiance to **at sensor** temperature

LST
- **At sensor** brightness temperature **to surface temperature**

SWIR versus TIR

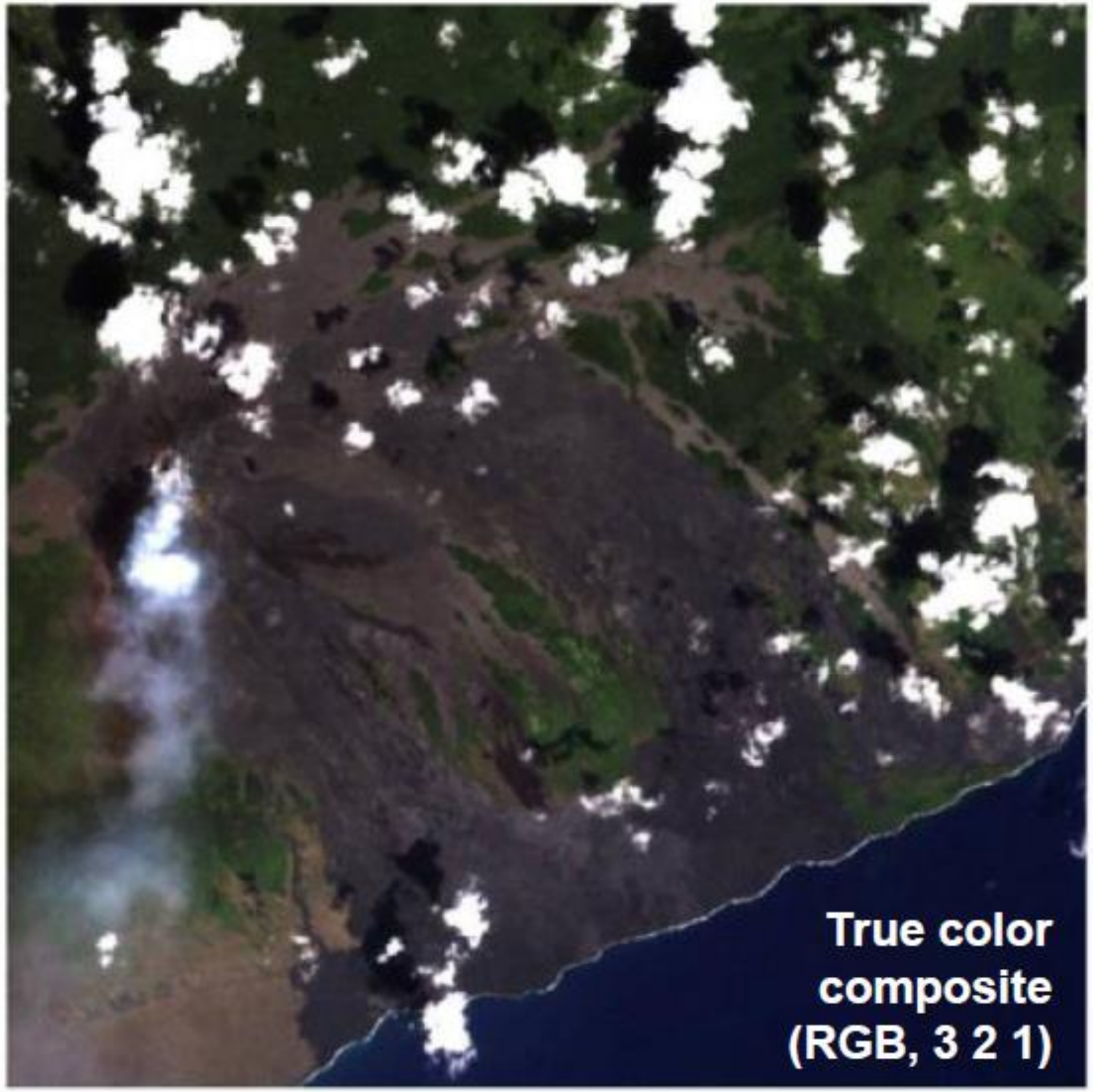
Landsat 7 ETM+ 14. Feb. 2000, Kilauea Volcano (Hawaii)

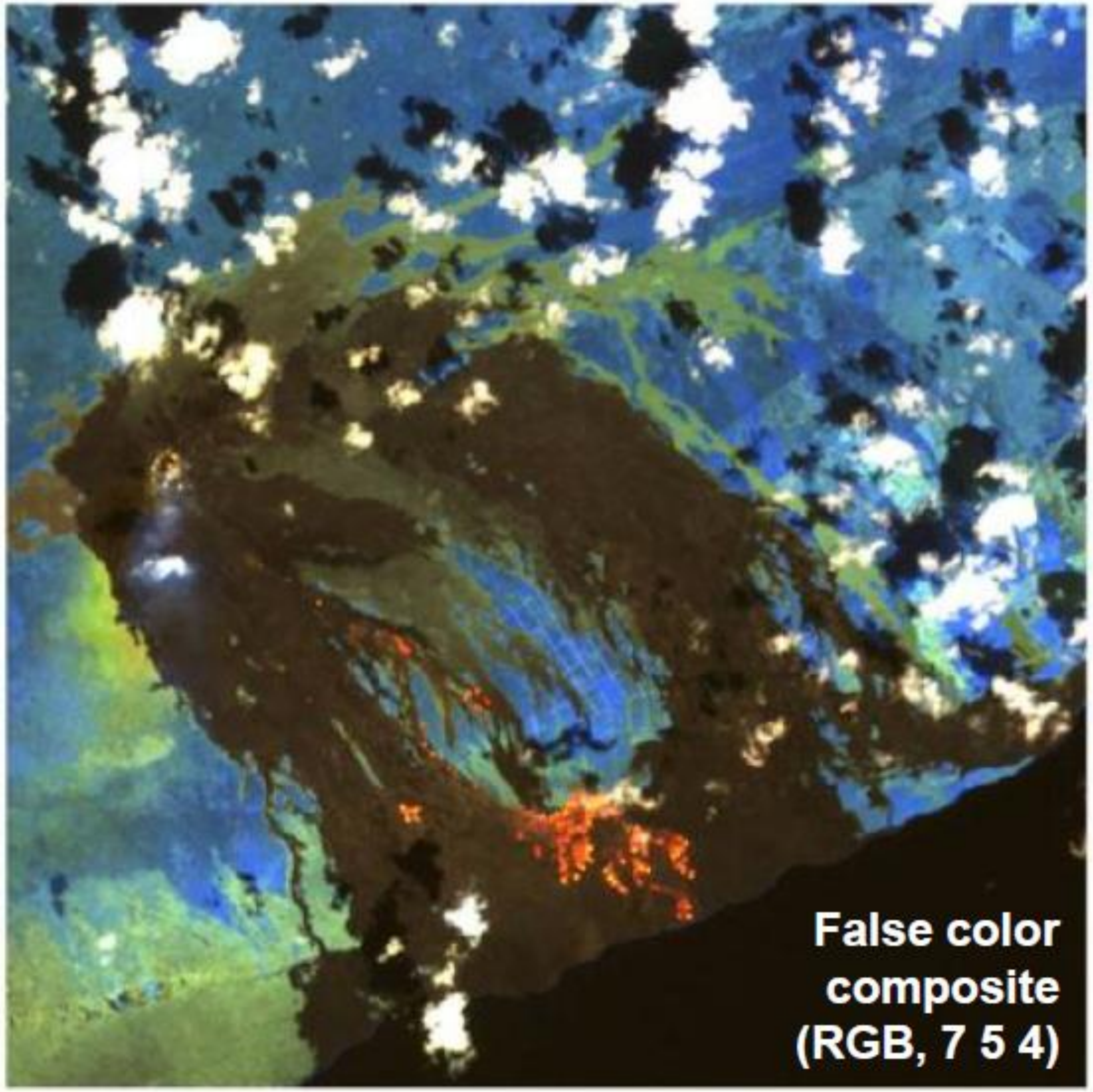




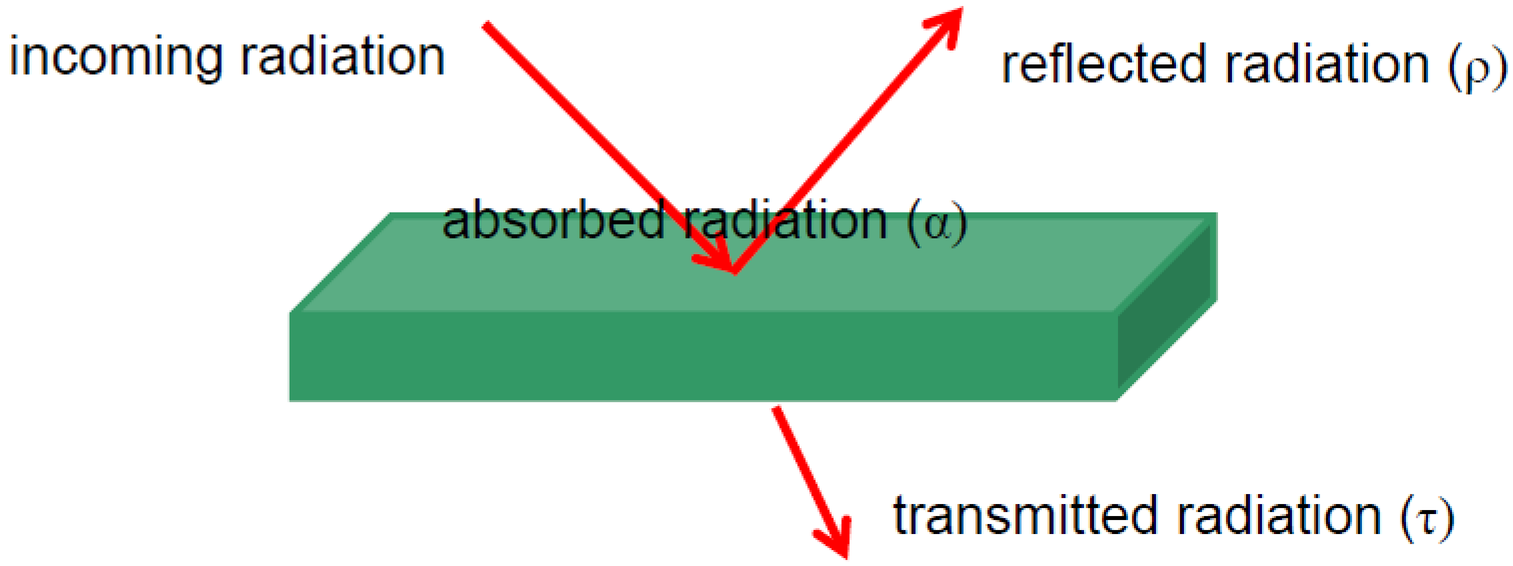
VIS versus SWIR

Landsat 7 ETM+ 14. Feb. 2000, Kilauea Volcano (Hawaii)





Interaction of Radiation with Terrain Elements



$$\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$$

α, ρ, τ are **wavelength dependent** and represent **ratios** between the **absorbed**, **reflected** and **transmitted** components of the incident energy striking a terrain element and the **total energy** incident on the terrain element, respectively.

Radiation of real Materials and Emissivity

Real materials do not behave like blackbodies. They emit only a fraction of the radiation emitted by a blackbody at the equivalent temperature. This is taken into account by the EMISSIVITY, or the emissivity coefficient (ε):

$$\varepsilon_\lambda = \frac{\text{radiant exitance of an object at a given temperature}}{\text{radiant exitance of a blackbody at the same temperature}}$$

Emissivity can have values between 0 and 1. It is a measure of the ability of a material both to radiate and to absorb energy.

M = total radiant exitance [W m²]
T = absolute temperature [K
σ = Stefan-Boltzman constant]

Kirchhoff's Radiation Law

According to Kirchhoff's radiation law: $\varepsilon_\lambda = \alpha_\lambda$ (for a blackbody)

Spectral emissivity of an black body object equals its spectral absorbance:
"good absorbers are good emitters"

On the basis of Kirchhoff's radiation law α_λ can be replaced with ε_λ:

$$\varepsilon_\lambda + \rho_\lambda + \tau_\lambda = 1$$

Since most objects are **opaque (do not let radiation transmit)** to thermal infrared radiation (τ_λ = 0):

$$\varepsilon_\lambda + \rho_\lambda = 1$$

→ **The higher an object's reflectance in the thermal IR region, the lower its emissivity and vice versa.**

!!! Radiation of real Materials !!!

Provided that the emissivity of a material is known, its absolute temperature (kinetic temperature, T_{kin}) can be derived from the radiation it emits. If the emissivity is not considered, only the brightness temperature (radiant temperature, T_{rad}) of the material can be determined. Since it is valid that:

$$T_{rad} = \varepsilon T_{kin}$$

sensed touched

the radiant temperature of a real material is always lower than its kinetic temperature. However, for a blackbody with ε = 1 it applies that:

$$T_{rad} = T_{kin}$$

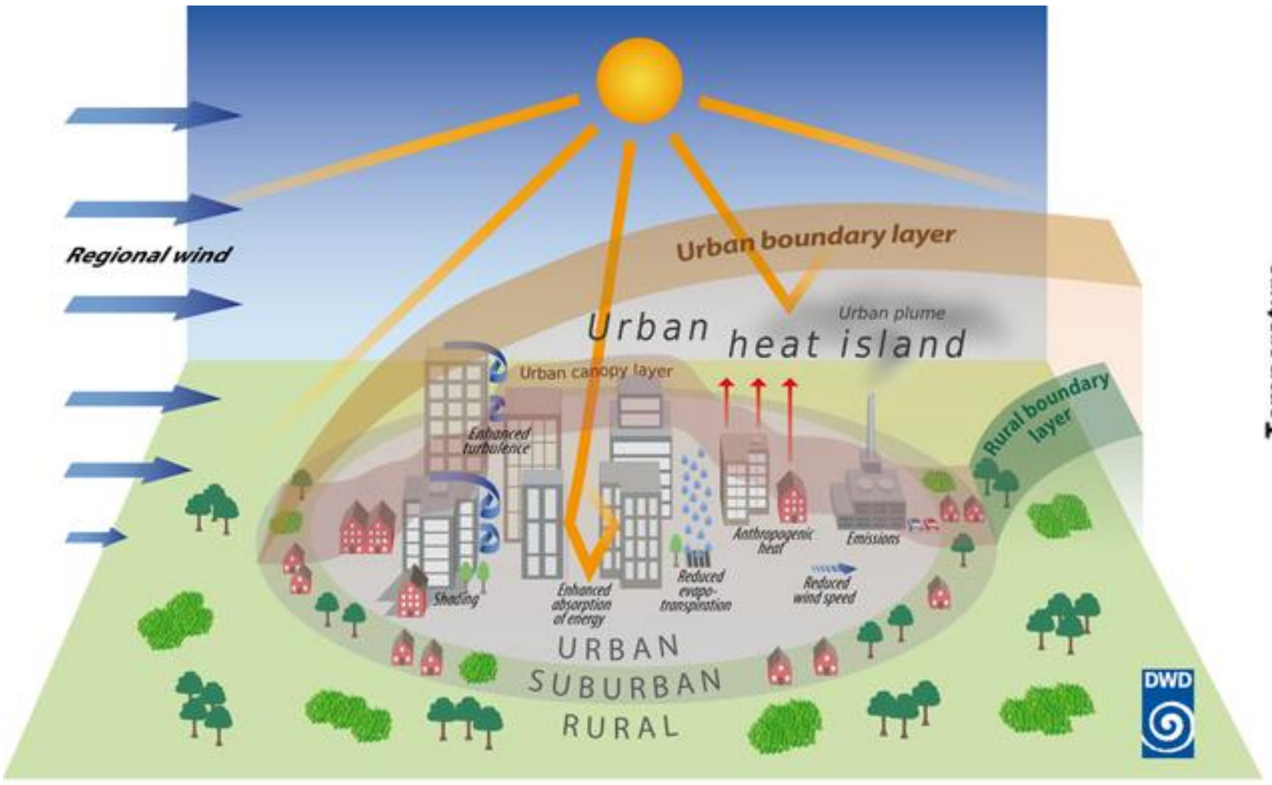
Radiation of real Materials

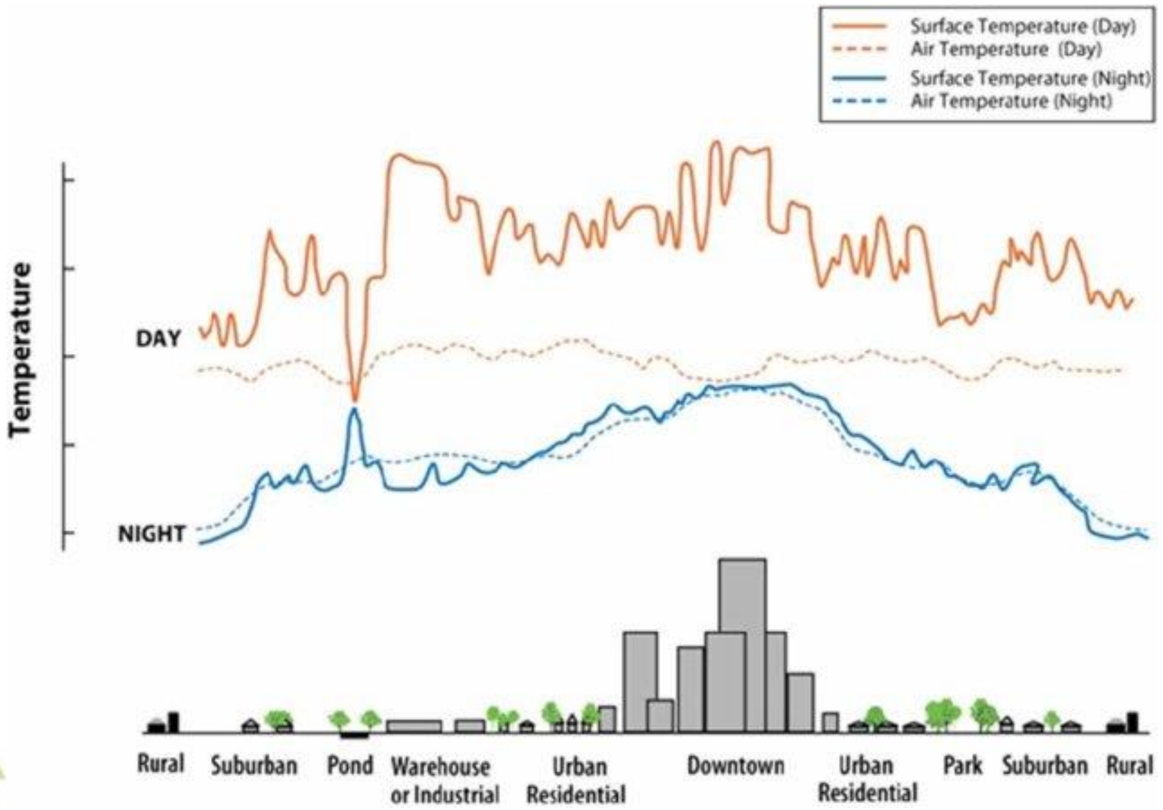
Emissivity depends on wavelength, surface temperature, and some physical properties of the surface, e.g. water content, or density.

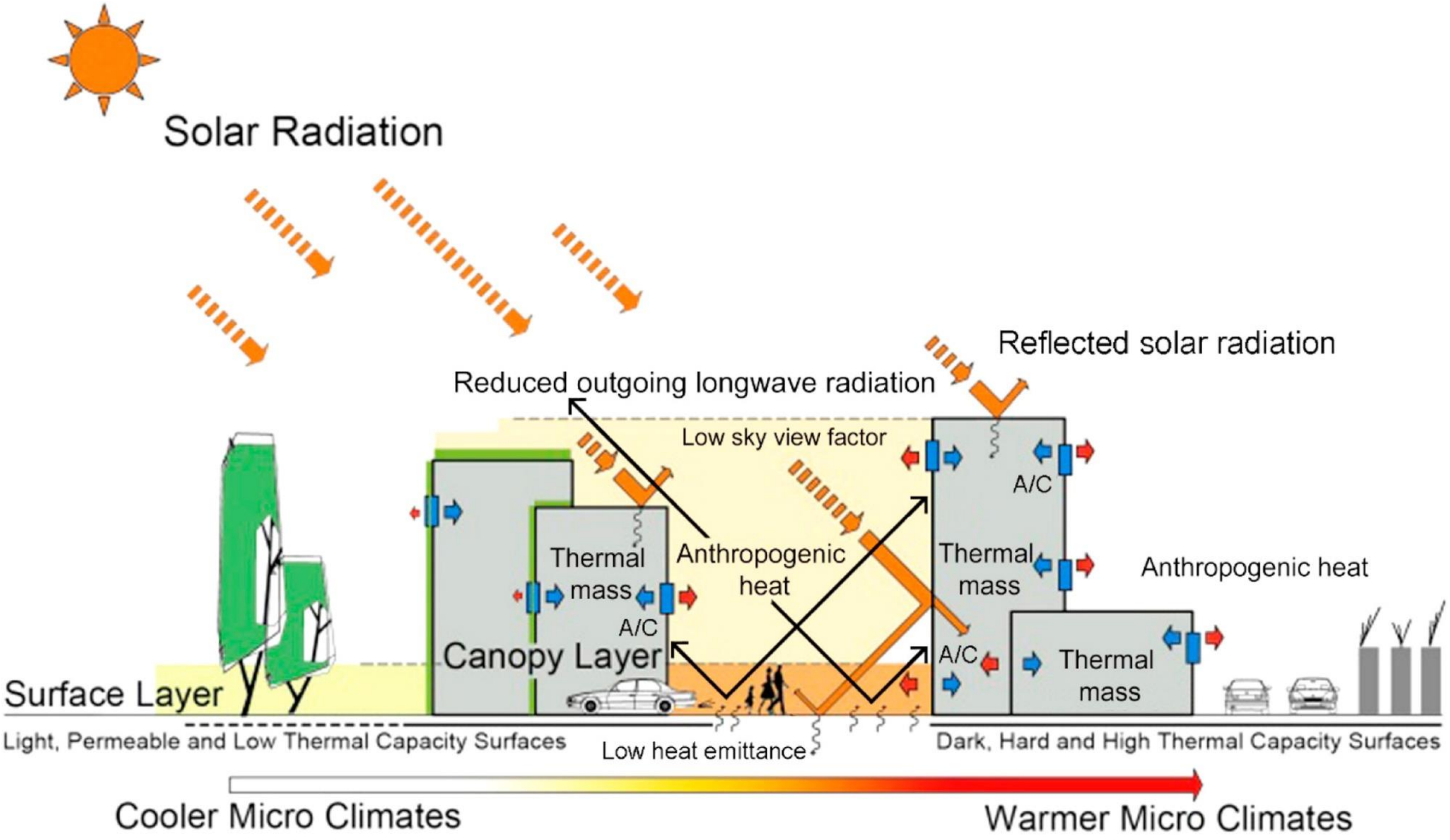
Material	Average Emissivity over 8-14 µm
Clear water	0.98 - 0.99
Healthy green vegetation	0.96 - 0.99
Dry vegetation	0.88 - 0.94
Asphaltic concrete	0.94 - 0.97
Basaltic rock	0.92 - 0.96
Granitic rock	0.83 - 0.87
Dry mineral soil	0.92 - 0.96
Polished metals	**0.06 - 0.21**

Source: Lillesand et al. (2008)

Mestský ostrov tepla

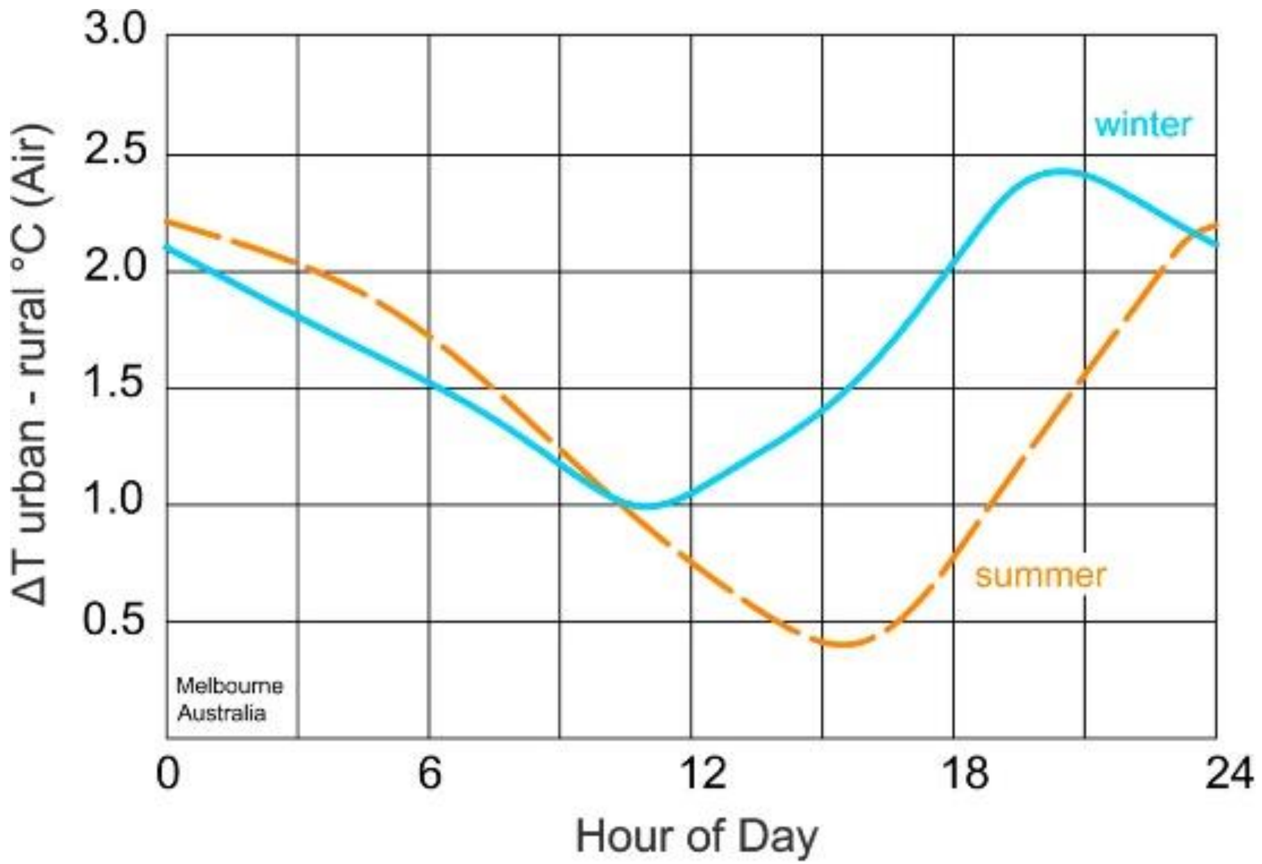






Ali Soltani, Ehsan Sharifi, Daily variation of urban heat island effect and its correlations to urban greenery: A case study of Adelaide, Frontiers of Architectural Research, Volume 6, Issue 4, 2017, Pages 529-538.

Teplotný rozdiel mesto – vidiek, deň a noc, zima a leto



Ali Soltani, Ehsan Sharifi, Daily variation of urban heat island effect and its correlations to urban greenery: A case study of Adelaide, Frontiers of Architectural Research, Volume 6, Issue 4, 2017, Pages 529-538.

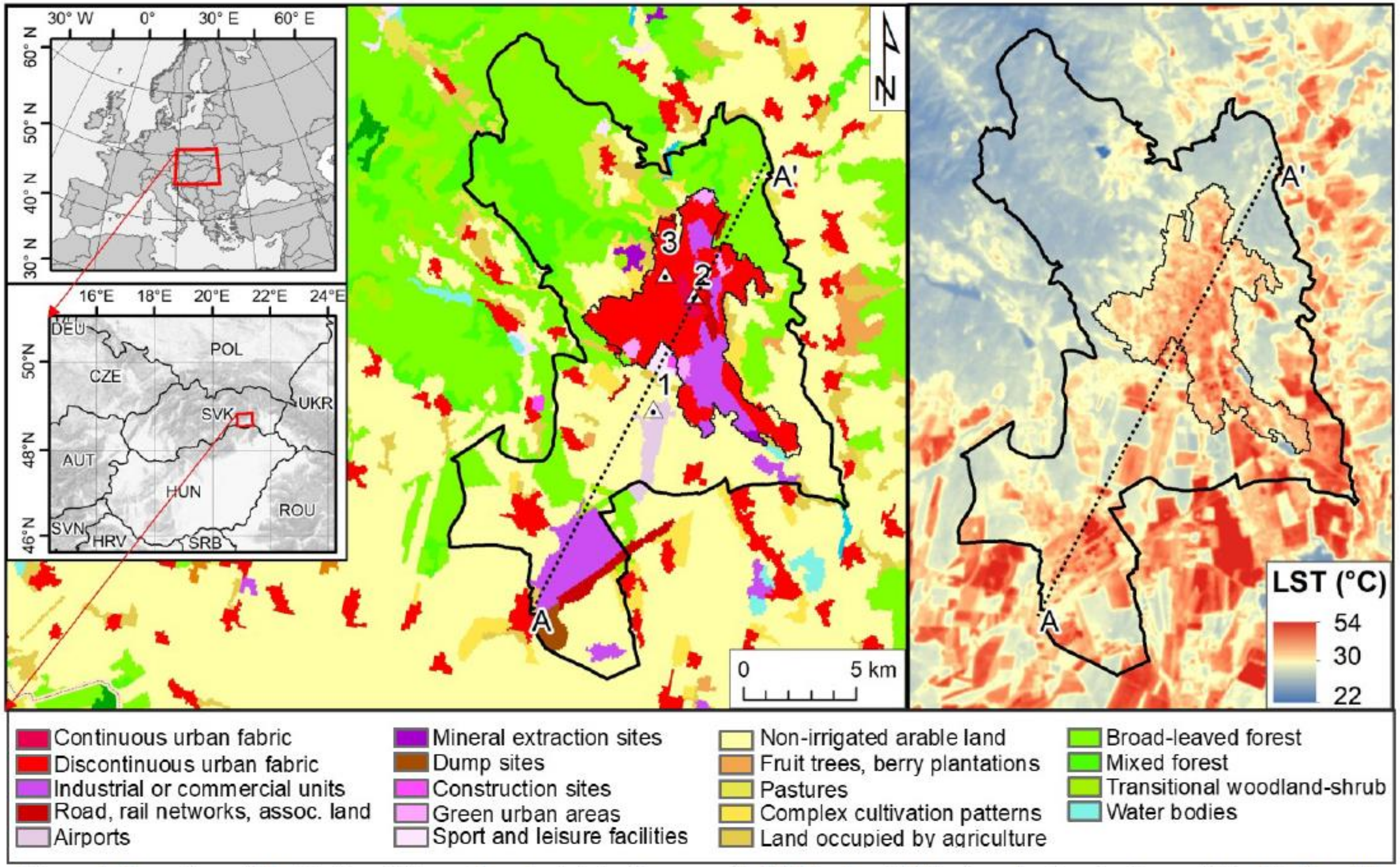


Figure 1. Location of the Košice City as the administrative area (thick black solid line) and urbanized core (thin black solid line) overlaid on CORINE Land Cover 2012 and land surface temperature (LST) 6 August 2015 with the meteorological stations at the airport (1), city centre (2), and at the Technical University in Košice (3). Vertical profile along the line A-A‘ is displayed in Figure 3.

Mestský ostrov tepla

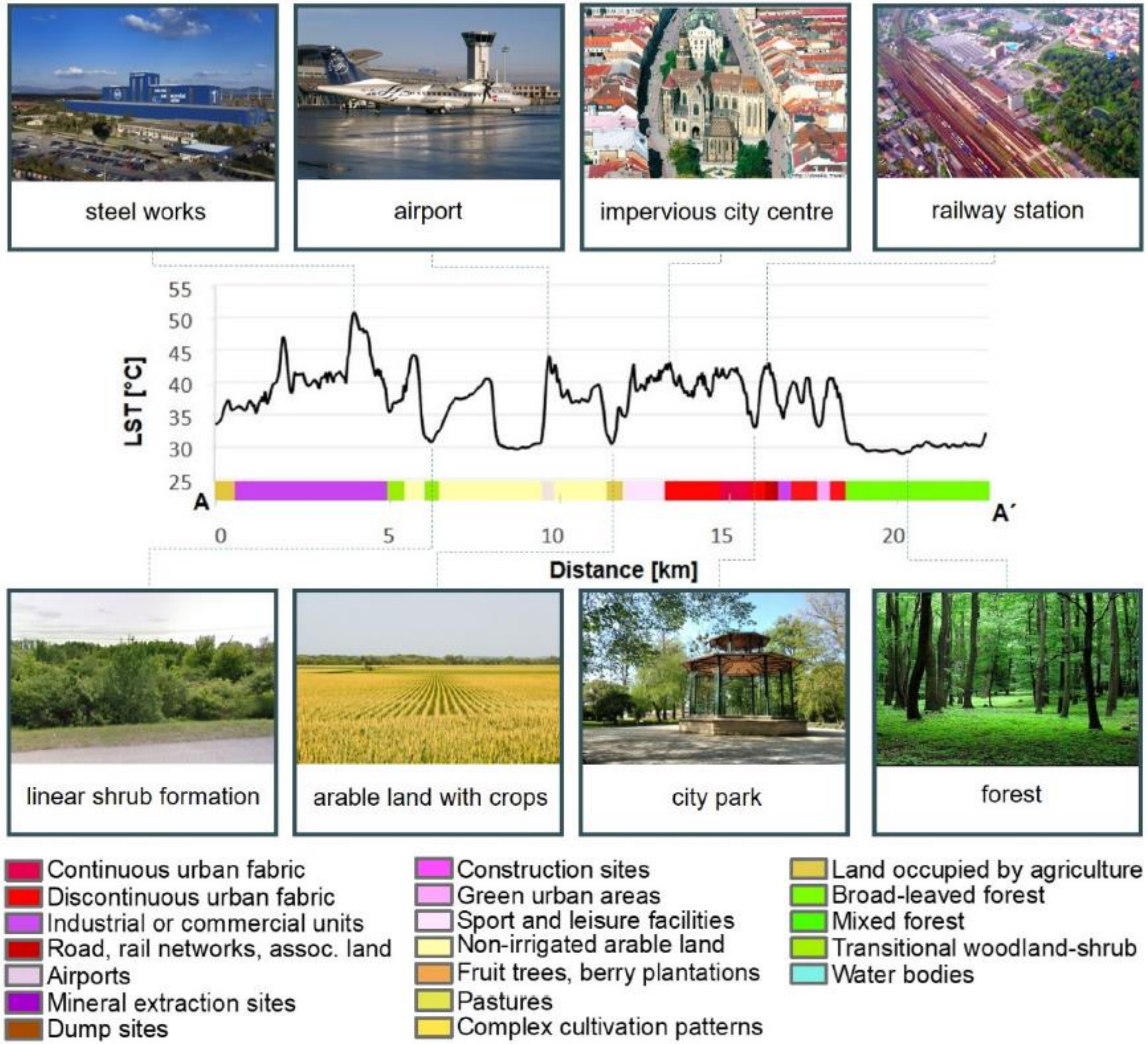
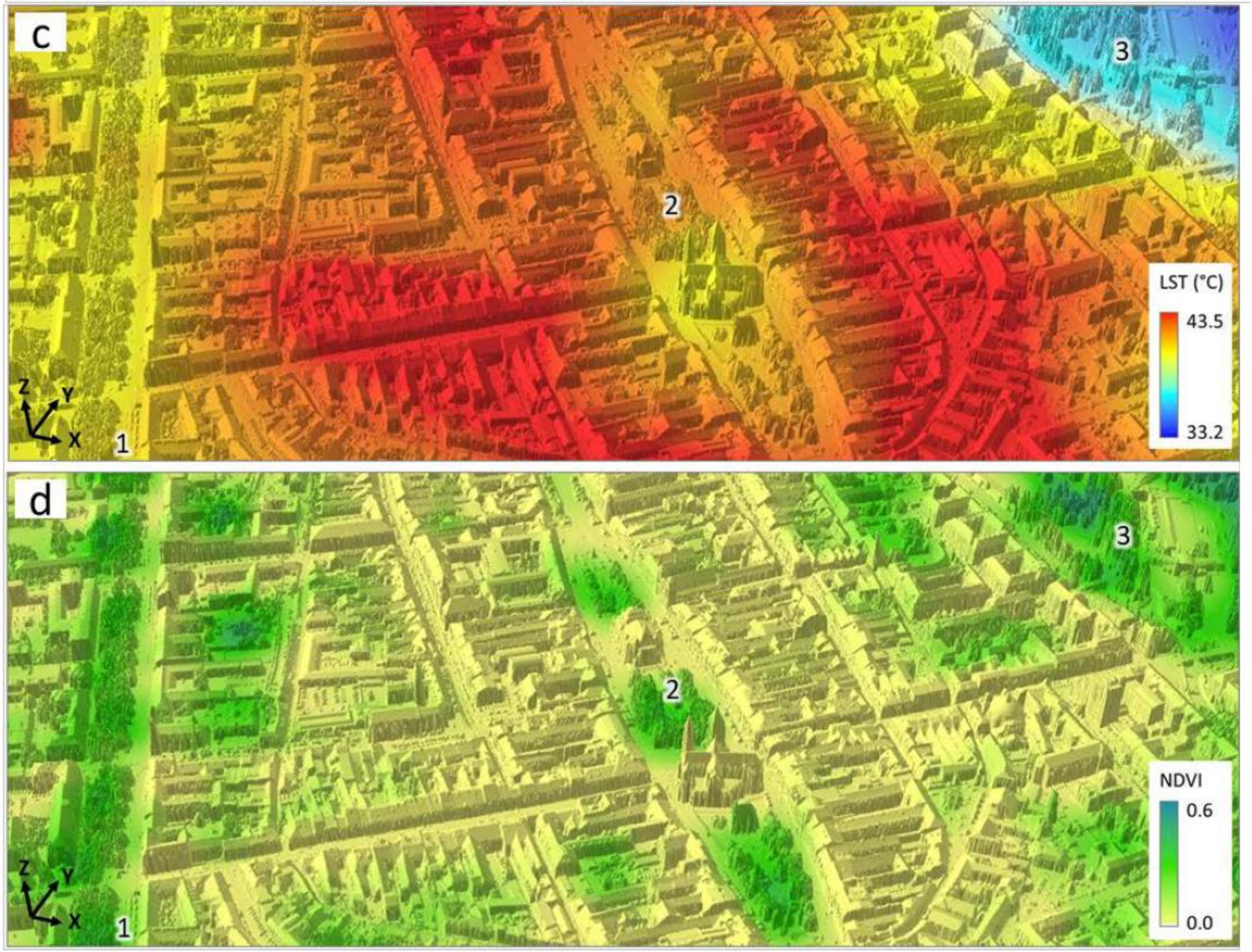
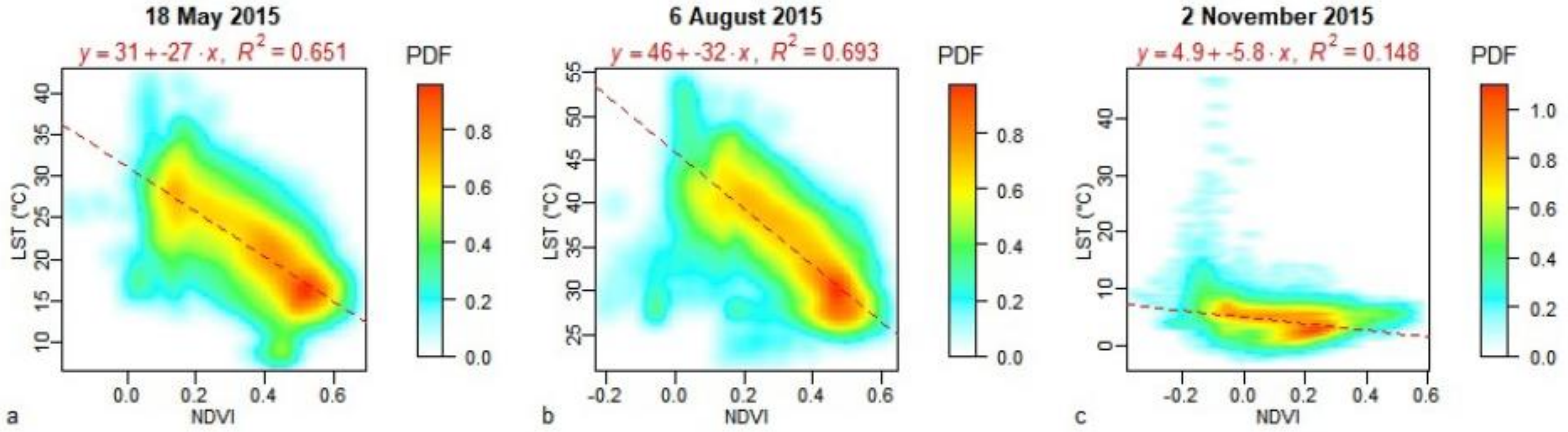


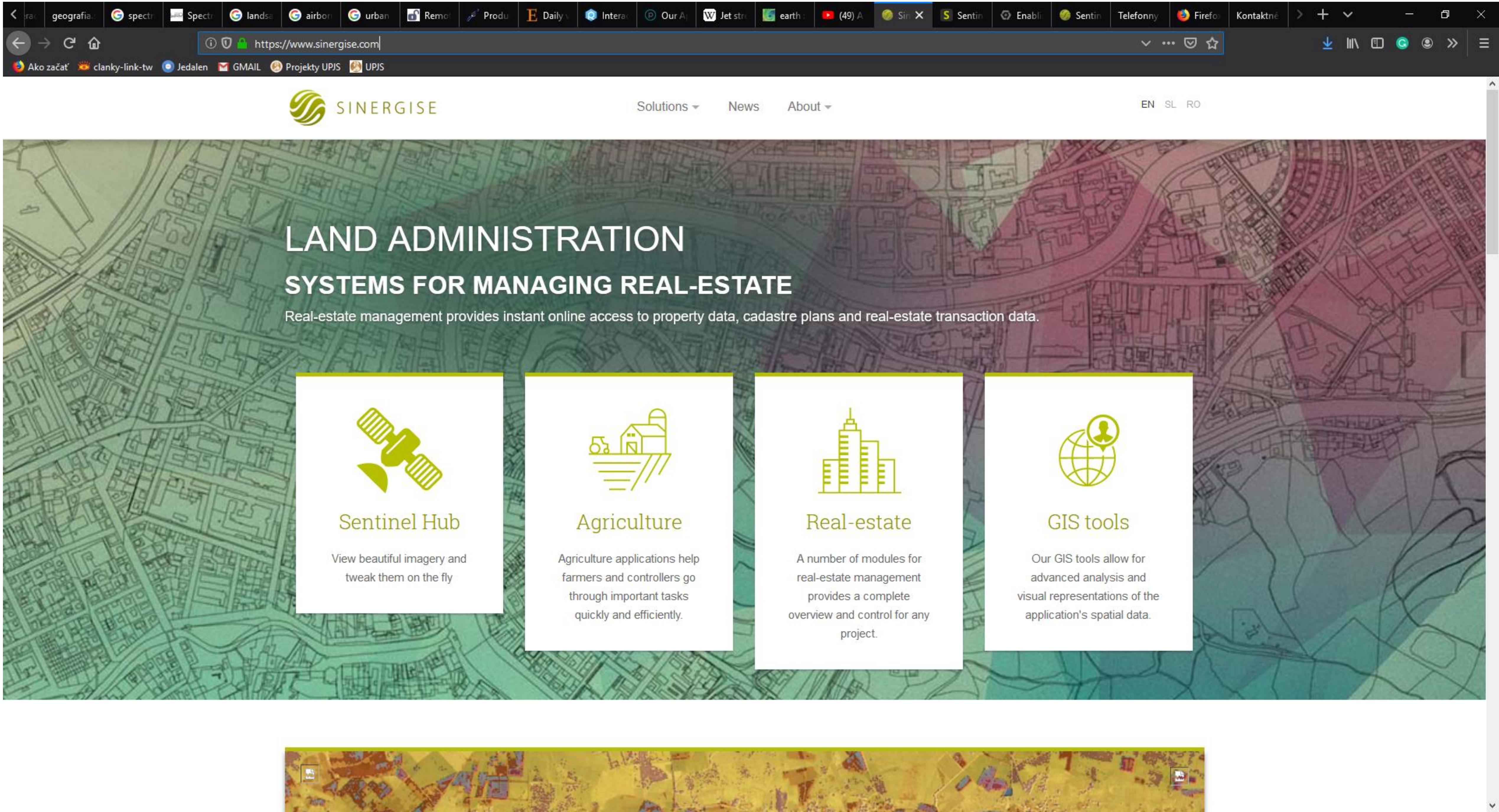
Figure 3. A-A´ profile in Fig. 3 through CLC 2012 land cover classes and the LST surface on 6 August 2015 with photographs illustrating the land cover.

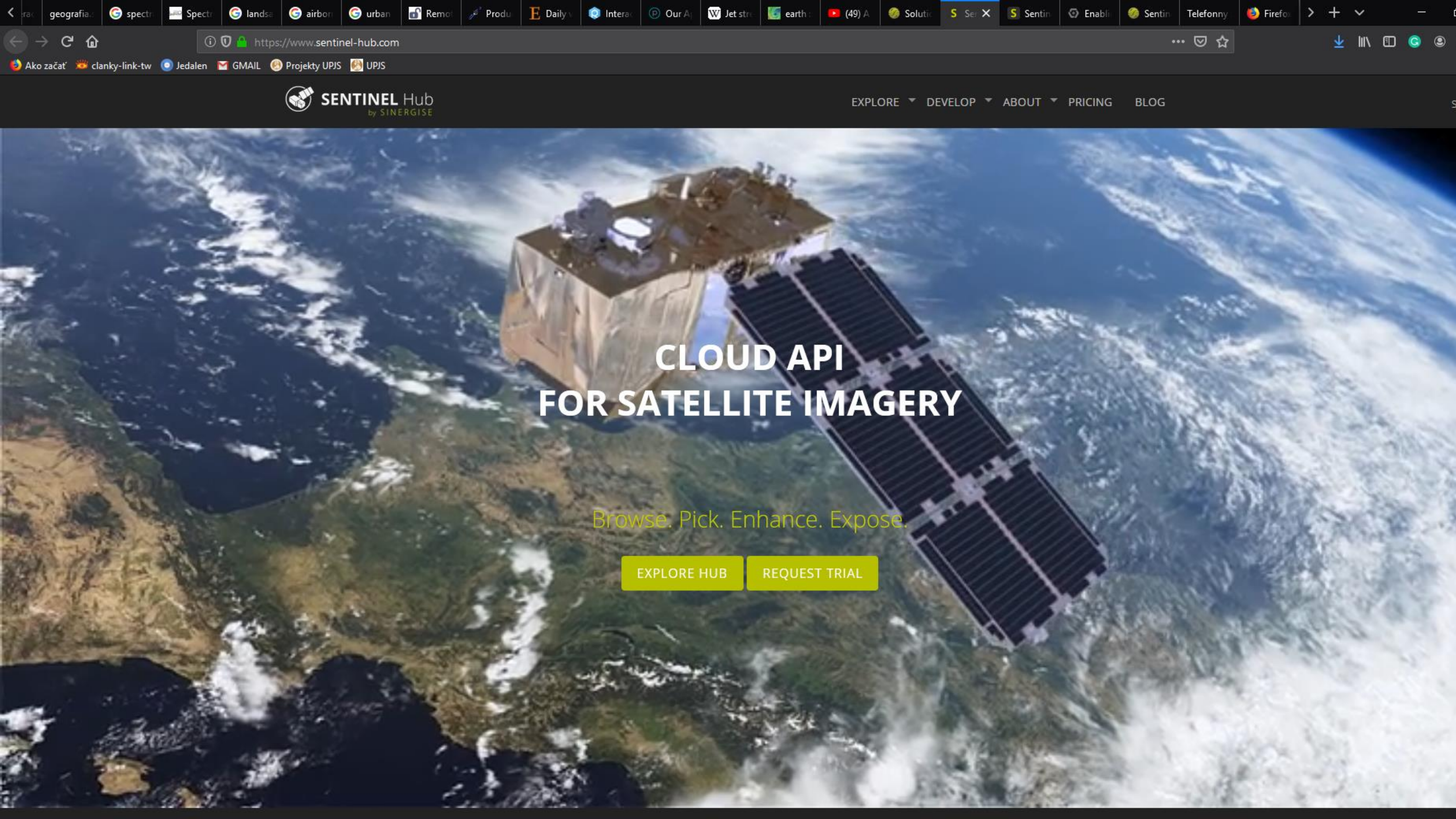


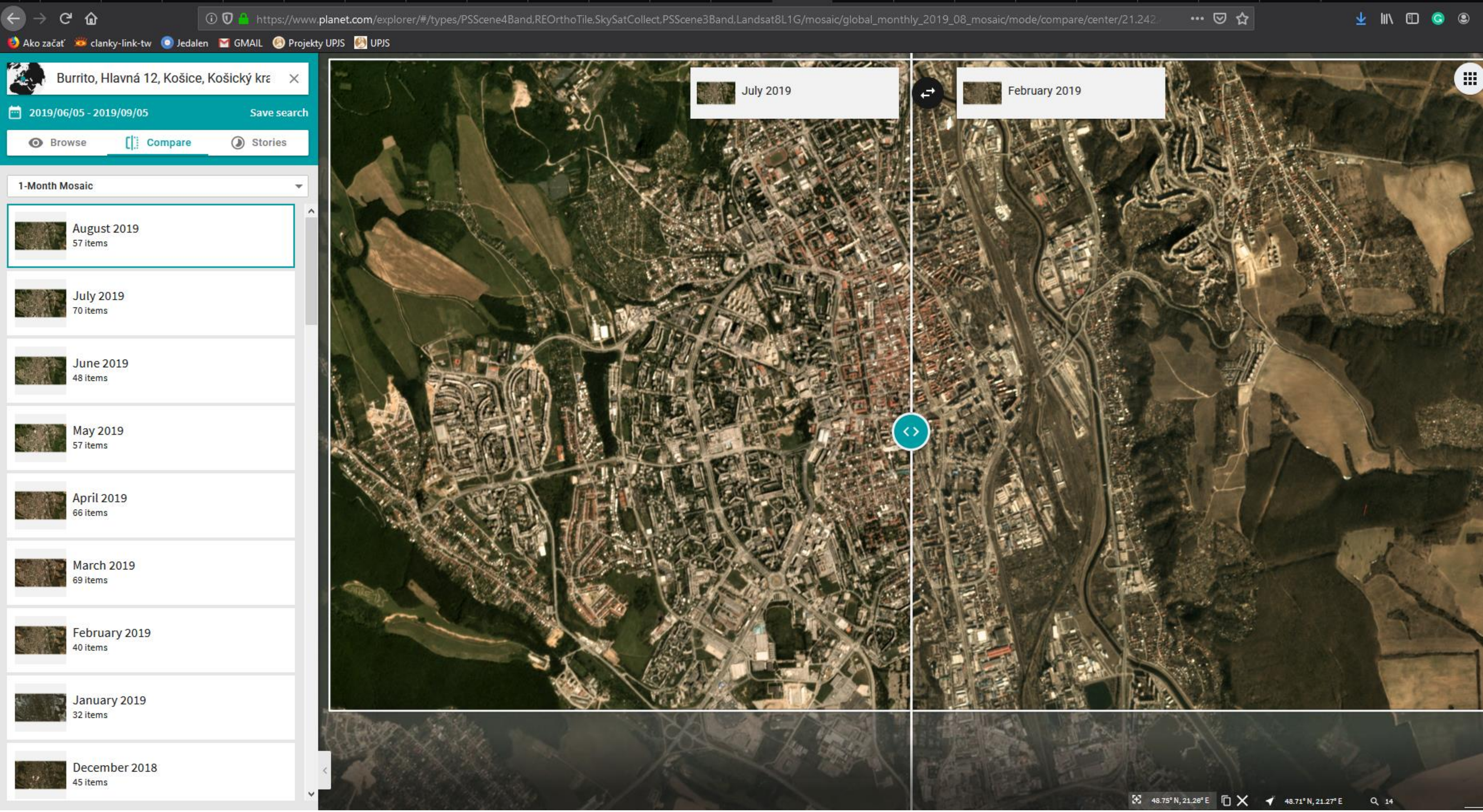
c
1
2
3
LST (°C)
43.5
33.2
Z
Y
X
d
1
2
3
NDVI
0.6
0.0
Z
Y
X

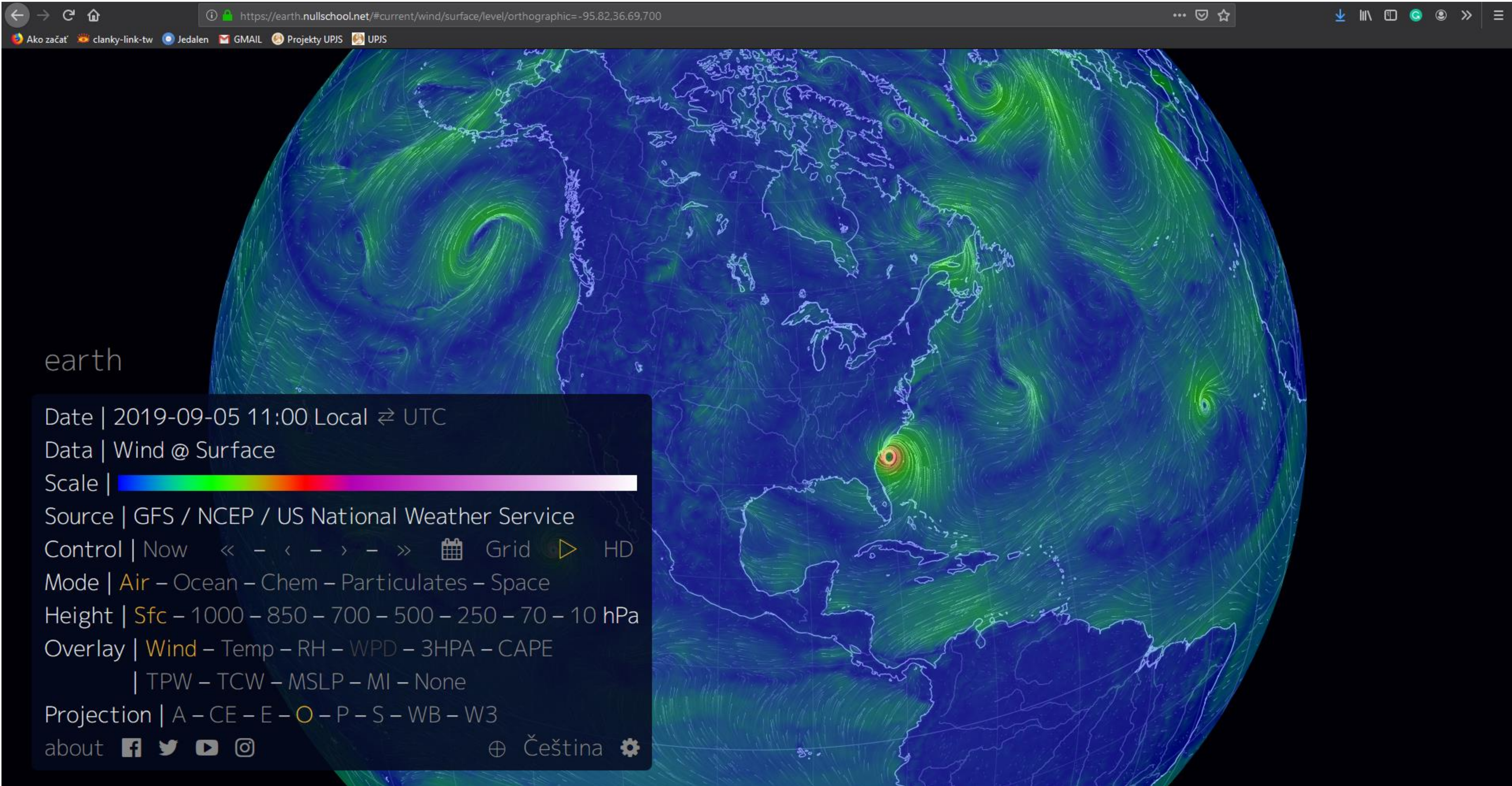


18 May 2015
y = 31 + -27 · x, R² = 0.651
PDF
LST (°C)
NDVI
a
6 August 2015
y = 46 + -32 · x, R² = 0.693
PDF
LST (°C)
NDVI
b
2 November 2015
y = 4.9 + -5.8 · x, R² = 0.148
PDF
LST (°C)
NDVI
c


https://www.sinergise.com
SINERGISE
Solutions
News
About
EN SL RO
LAND ADMINISTRATION
SYSTEMS FOR MANAGING REAL-ESTATE
Real-estate management provides instant online access to property data, cadastre plans and real-estate transaction data.
Sentinel Hub
View beautiful imagery and tweak them on the fly
Agriculture
Agriculture applications help farmers and controllers go through important tasks quickly and efficiently.
Real-estate
A number of modules for real-estate management provides a complete overview and control for any project.
GIS tools
Our GIS tools allow for advanced analysis and visual representations of the application's spatial data.


https://www.sentinel-hub.com
Ako začať
clanky-link-tw
Jedalen
GMAIL
Projekty UPJS
UPJS
SENTINEL Hub
by SINERGISE
EXPLORE
DEVELOP
ABOUT
PRICING
BLOG
CLOUD API
FOR SATELLITE IMAGERY
Browse. Pick. Enhance. Expose.
EXPLORE HUB
REQUEST TRIAL


https://www.planet.com/explorer/#/types/PSScene4Band,REOrthoTile,SkySatCollect,PSScene3Band,Landsat8L1G/mosaic/global_monthly_2019_08_mosaic/mode/compare/center/21.242
Ako začať
clanky-link-tw
Jedalen
GMAIL
Projekty UPJS
UPJS
Burrito, Hlavná 12, Košice, Košický kra
2019/06/05 - 2019/09/05
Save search
Browse
Compare
Stories
1-Month Mosaic
August 2019
57 items
July 2019
70 items
June 2019
48 items
May 2019
57 items
April 2019
66 items
March 2019
69 items
February 2019
40 items
January 2019
32 items
December 2018
45 items
July 2019
February 2019
48.75° N, 21.26° E
48.71° N, 21.27° E
14


https://earth.nullschool.net/#current/wind/surface/level/orthographic=-95.82,36.69,700
Ako začať
clanky-link-tw
Jedalen
GMAIL
Projekty UPJS
UPJS
earth
Date | 2019-09-05 11:00 Local ⇄ UTC
Data | Wind @ Surface
Scale |
Source | GFS / NCEP / US National Weather Service
Control | Now « – ‹ – › – » Grid ▷ HD
Mode | Air – Ocean – Chem – Particulates – Space
Height | Sfc – 1000 – 850 – 700 – 500 – 250 – 70 – 10 hPa
Overlay | Wind – Temp – RH – WPD – 3HPA – CAPE
| TPW – TCW – MSLP – MI – None
Projection | A – CE – E – O – P – S – WB – W3
about
Čeština

SPACE::LAB

05/09/2019 o 18:00
Košice, Bulharská 4

esa

Ďakujem za pozvanie a pozornosť!

Z družice na Košice: zaostrené na teplo v meste

michal.gallay@upjs.sk
https://geografia.science.upjs.sk/

UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH • 1959 •

ÚSTAV GEOGRAFIE
Prírodovedecká fakulta UPJŠ v Košiciach