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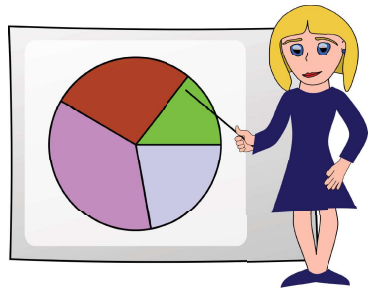
Heat islands and green infrastructure in urban areas
Webinar 2021-10-05

Presented by:
Greger Lindeberg and Sara Wiman
www.geografiskainformationsbyran.se
Stockholm, Sweden

Content

- Presentation of participants
- Presentation of the EO4GEO project
- Urban green infrastructure and ecosystem services
- EO-derived data and satellite sensors – background
- Urban Heat Islands – temperature from satellite
- Summary and conclusions
- Questions from participants



Co-funded by the Erasmus+ Programme of the European Union

The Space/Geospatial Sector Skills Alliance

Towards an innovative strategy for skills development and capacity building in the space geo-information sector supporting Copernicus User Uptake

THE INSTRUMENTS

www.eo4geo.eu

- An ontology-based **Body of Knowledge** (BoK) for the space/geospatial sector (extending the existing GI BoK with EO/Copernicus concepts).
- A set of BoK-based **innovative tools**.
- A series of **curricula and a portfolio of training modules** directly usable in the context of Copernicus and other relevant programs.
- A series of **learning actions** for a selected set of strategeic scenario's in three sub-sectors to test the approach.
- A **Long-term Action Plan** to be endorsed to roll-out and sustain the proposed solutions.
- The support of a strong group of **Associated Partners** mostly consisting of associations or networks active in space/geospatial domain.

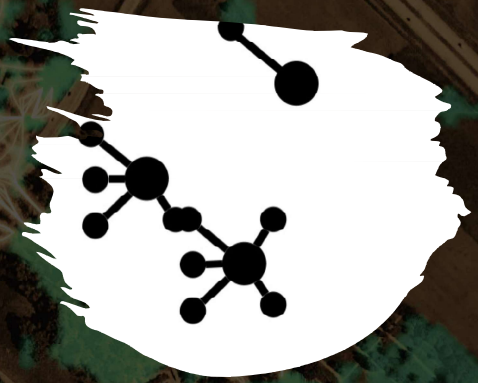
Definitions

- **Green Infrastructure** - an ecologically functional network of habitats and structures, natural areas and landscaped elements that are designed, used and managed in such a way that biological diversity is preserved and ecosystem services that are important to society are promoted throughout the landscape. (Swedish environmental Protection Agency)
- **Ecosystems** are defined as "A dynamic complex of plant, animal and micro-organism communities and their non-living environment that interacts into a functional unit" (CBD – convention on Biological Diversity).
- **Ecosystem services** are defined as "The direct and indirect contribution of ecosystems to human well-being"
  (TEEB -Economics of **Ecosystems** and Biodiversity).

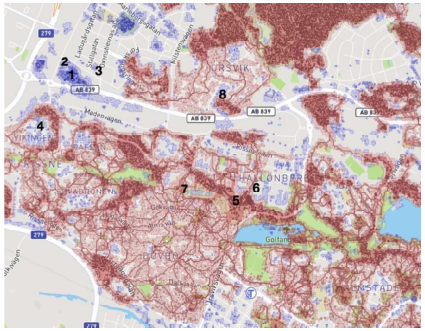
Concept for habitat networks

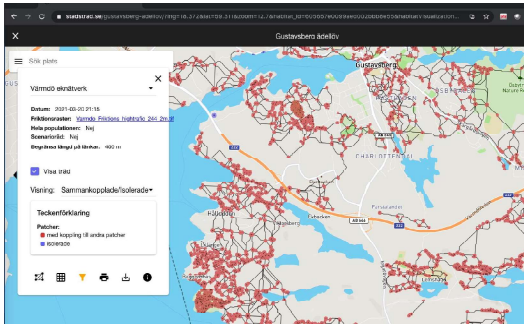
Trees are connected

- Forest areas large enough for reproduction
- Spreading links, short enough for the specie in question
- Connected or isolated?
- Stepping stones – important trees or small groups of trees



Habitat networks





Source: stadstrad.se

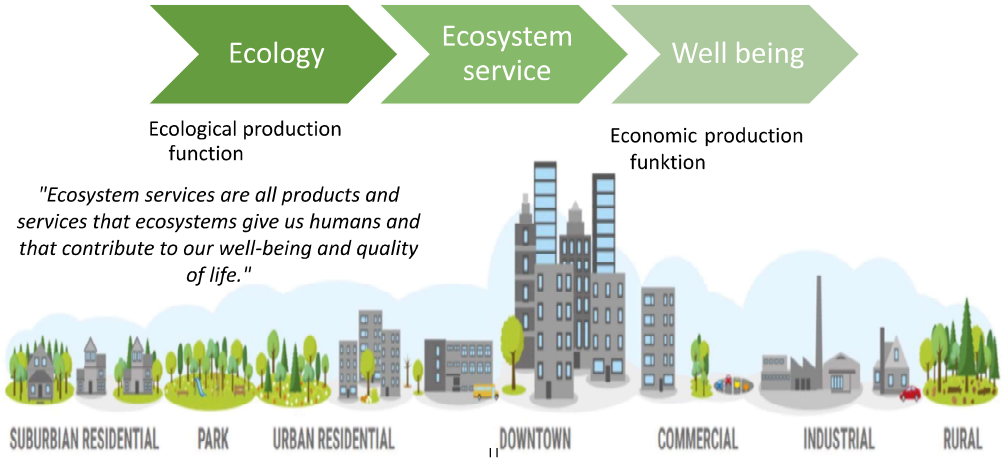
Red color for larger patches of forest that are connected via spreding links
Blue patches are large enough, but not connected.
Second image: Selected trees for an oak network

Green Infrastructure

An ecologically functional network of habitats and structures, natural areas and landscaped elements that are designed, used and managed in such a way that biological diversity is preserved and ecosystem services that are important to society are promoted throughout the landscape.

- Green infrastructure - a prerequisite for ecosystem services
- For ecosystems to work, connections between different biotopes are required
- Isolated species are depleted, which means that the ecosystems in which they are included function less well
- The result will be a deterioration of the ecosystem services we want from the ecosystems.

Exosystem services - a value chain from ecological production to value for human.



Ecosystem services

Supporting -Soil formation -Biodiversity -Primary production -Habitat	**Provisioning** -Food and fiber -Wood -Clean Water -Medicinals	
	Regulating -Climate Regulation -Pollination of crops -Store carbon -Control flooding	
	Cultural -Inspiration -Recreation -Education -Aesthetic	

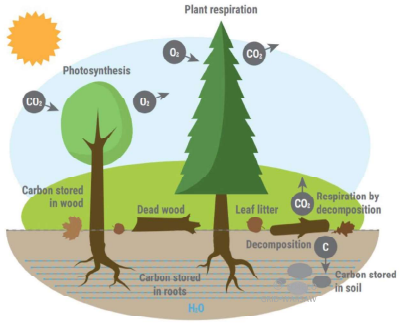
Ecosystem services –
a value chain from ecological production to value for humans

- Carbon control
- Local climate control
- Storm water control
- Pollution reduction
- Habitat networks

EST – Carbon control

- 50% of dry weight of a tree comes from the carbon present in the atmosphere as carbon dioxide
- When trees die the carbon goes back to the atmosphere
- Urban trees act as "carbon sink"

However, carbon sequestration (climate mitigation) is not the key ecosystem service of urban trees

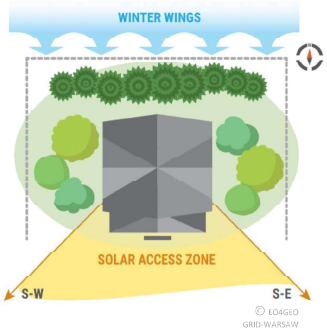


EST – Energy conservation

Trees provide shade and block wind

Potential energy conservation results:

- Heat savings (Kwh)
- Cooling savings (Kwh)

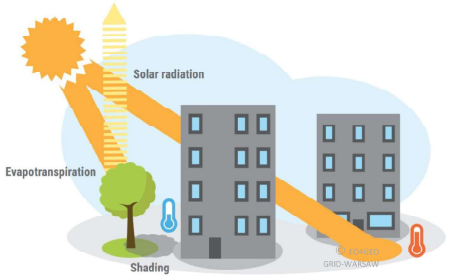


EST – Local climate control

Urban Heat Island (UHI) occurs when the city proper records are much higher temperatures than nearby rural areas

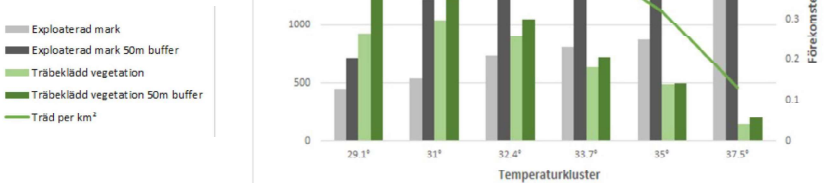
Trees reduce the UHI in the summer period by:

- Evapotranspiration
- Deflection of solar radiation



Trees and temperature in urban areas

The presence of temperature regulating factors and the presence of trees per square kilometer in each temperature cluster. The presence of tree-covered vegetation increases the lower the temperature in each temperature cluster. The number of trees per km2 is also increasing in the cooler temperature clusters



Temperature varies in the city

same time, various environment

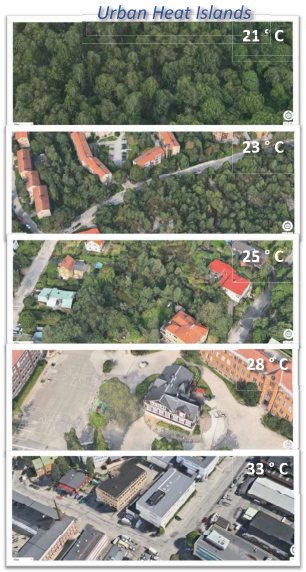
21 ° C - Trees provide both shade and evaporation, two important factors that explain that forests are cooler than grassland.

23 ° C - Many trees in residential areas provide cooler outside and indoor temperatures.

25 ° C - As the number of trees and their height decreases, the temperature increases.

28 ° C - In environments with few trees and large open and hardened surfaces, the heat increases faster.

33 ° C - - In environments with a small amount of green spaces and large open and impervious surfaces, the heat increases faster.



EST – Storm water control

Impervious surfaces are the main contributor excess stormwater runoff
The trees can help to manage the runoff by:

- Retention of precipitation water in canopies
- Water interception and uptake by roots

EST – Pollution reduction

Trees clean the air from pollutants like micro particles

©IDEAS FOR ACTION

www.stadstrad.se - for visualizing the values of urban trees

- Tree inventory and management
- Habitat networks (green infrastructure)
- Ecosystem services
- Collaborative projects

Urban Ecosystem services

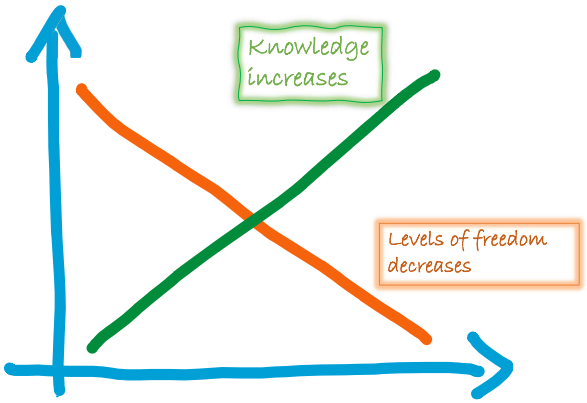
for the sustainable development of cities and urban areas, it is important to interact with and develop nature's ecosystem services, which give humans benefits we often take for granted or do not see.

Source:
the Swedish Environmental Protection Agency
the Swedish National Board of Housing, Building and Planning

A dilemma in planning

We know more as the project continues, but our opportunities for change are diminishing.

Conclusion: early knowledge has a great value for planning!



stadsträd.se

The use of satellite data - some years ago we saw this coming….

- More data
- Better availability to data
- Possibilities to study time series of images, with short time intervals
- The cloud problem not as problematic
- Service development – commonly non-experts are users
- Spreading to other industries (
- More data -> analysis and processing near the data
- Cloud processing, sand boxes for developers


EO-derived data and satellite sensors
© ESA
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Copernicus
• Land Monitoring
• Marine Monitoring
• Atmosphere Monitoring
• Emergency Management
• Security
• Climate Change
© ESA
25

Sentinels – the backbone of Copernicus

Sentinel 1 – radar imaging
All weather, day/night applications

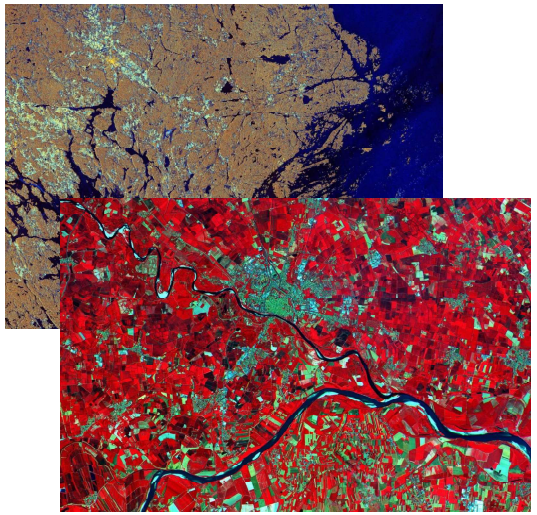
Sentinel 2 – Optical imaging
Land applications: urban, forest, agriculture,..

Sentinel 3+6 – Ocean and global land monitoring, high precision ocean altimetry

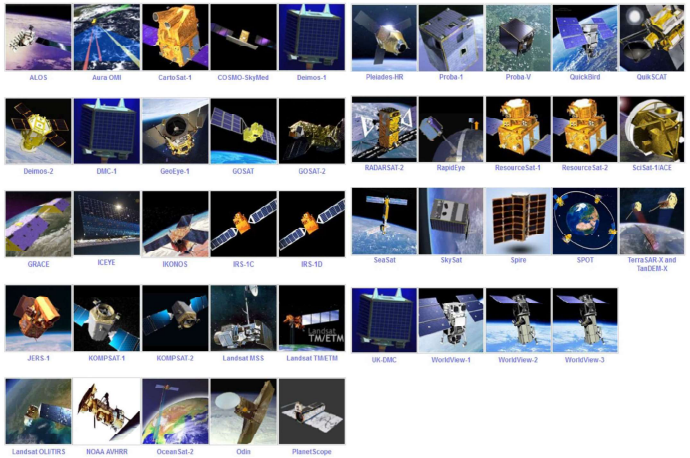
Sentinel 4+5 – Atmosphere composition monitoring, from a geostationary (-4) and a polar orbit (-5)

Example of products

- Sentinel-1
  - Interferometric radar
  - C-band (c. 5 cm)
  - Stripmap, IW, EW (5 – 100 m res)
- Sentinel-2
  - Optical data
  - 13 band (10-60m res)
  - Ortho corrected
  - TOA, (BOA)



Third Party Missions supported by ESA



ESA multi-mission ground systems:

- Acquire data
- Process data
- Archive data
- Distribute data

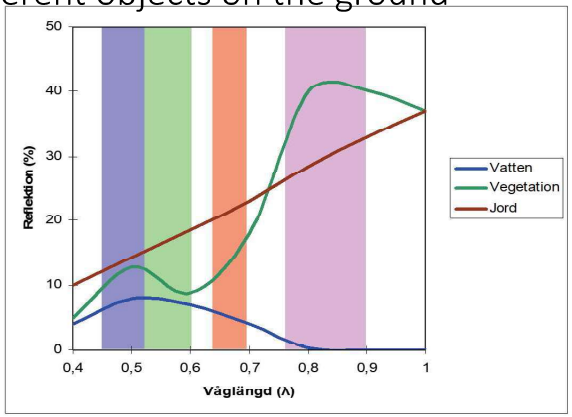
Resolution

- Geometrical - level of detail (pixel size)
- Radiometric - digital levels per band (8-14 bits = 256 – 16384 DN)
- Spectral - wavelength bands (number, sensitivity)
- Temporal - revisit time to the same place

Detaljeringsgrad - geometrisk upplösning

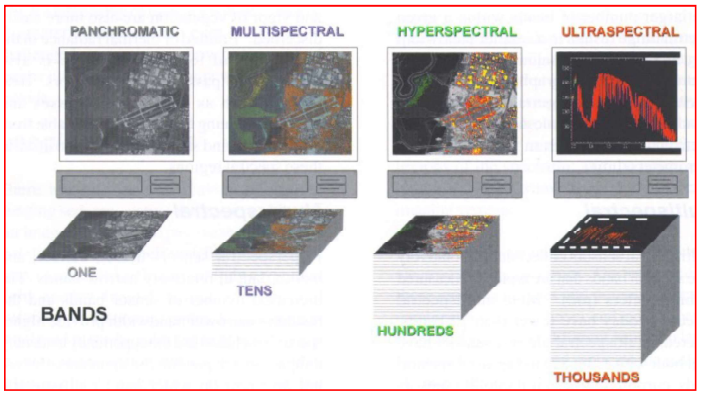
8cm, 0.5m, 1m, 10m

Spectral resolution and characteristics for different objects on the ground



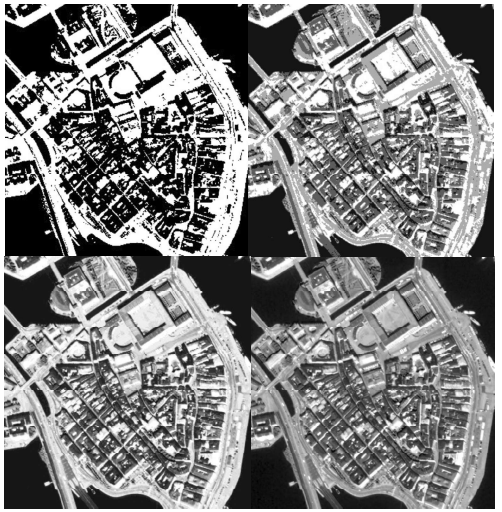
Spectral resolution

Number of wavelength bands



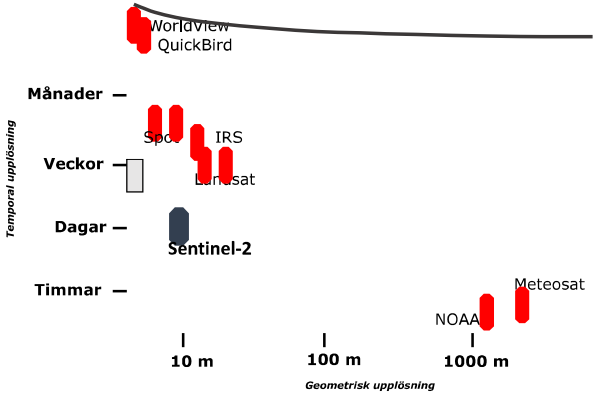
Radiometric resolution - no of digital levels

- 1 bit – 2
- 2 bits – 4
- 4 bits – 16
- 8 bits – 256

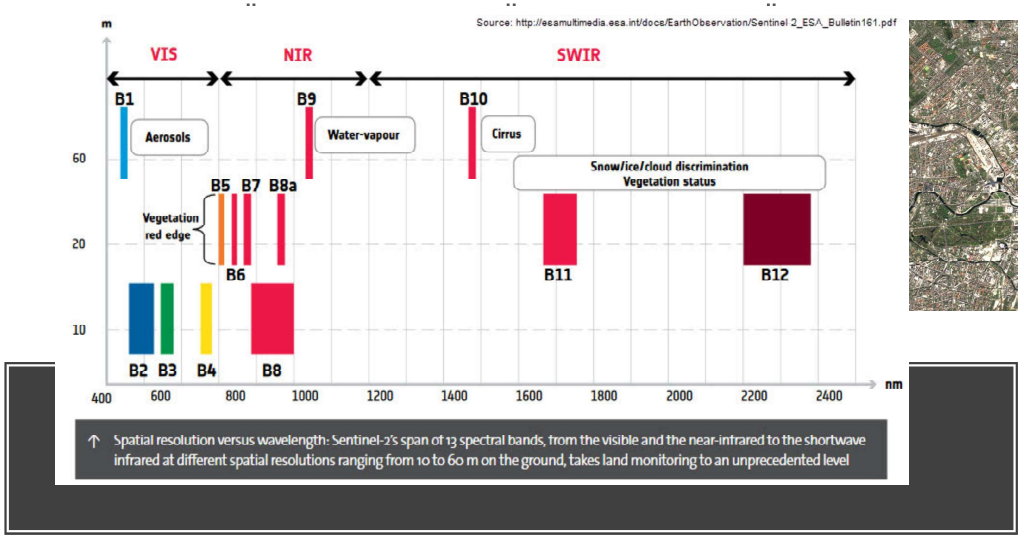


Temporal vs geometric resolution

- with no regard to programming possibilities

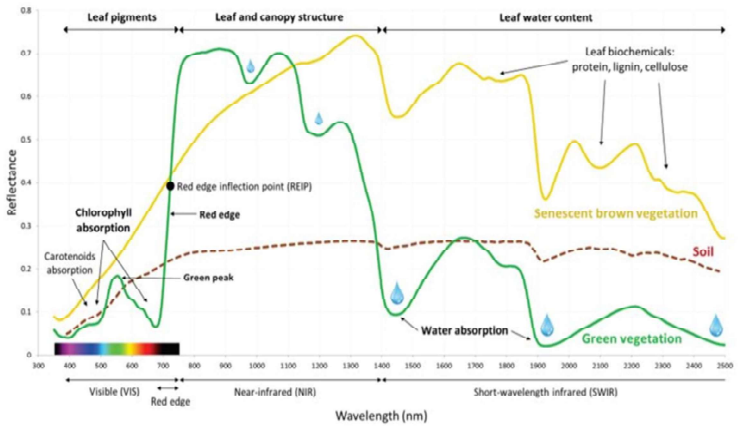


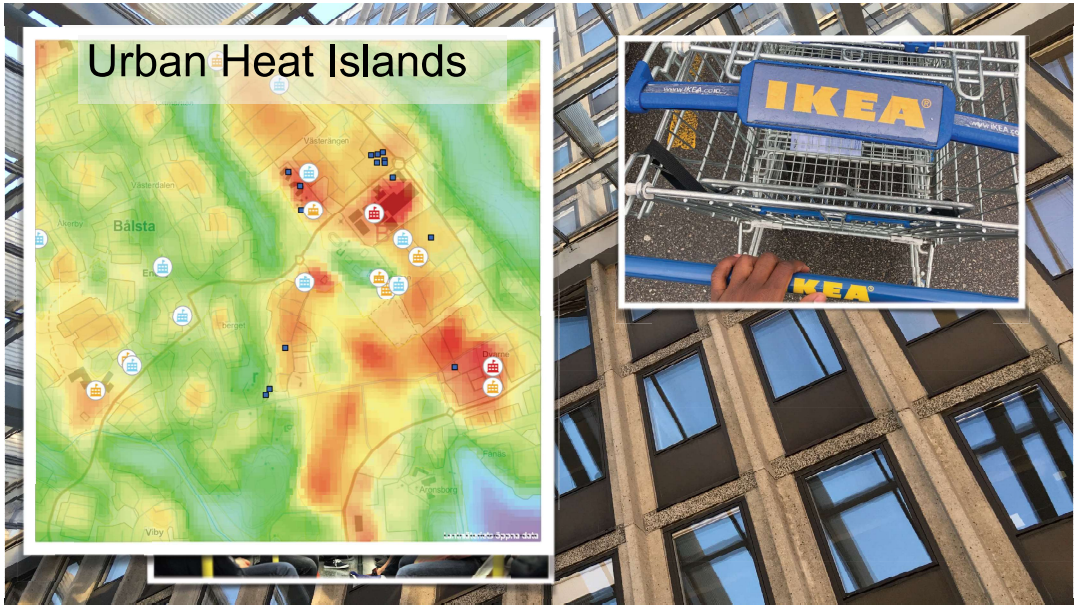
Source: http://esamultimedia.esa.int/docs/EarthObservation/Sentinel-2_ESA_Bulletin161.pdf



↑ Spatial resolution versus wavelength: Sentinel-2's span of 13 spectral bands, from the visible and the near-infrared to the shortwave infrared at different spatial resolutions ranging from 10 to 60 m on the ground, takes land monitoring to an unprecedented level

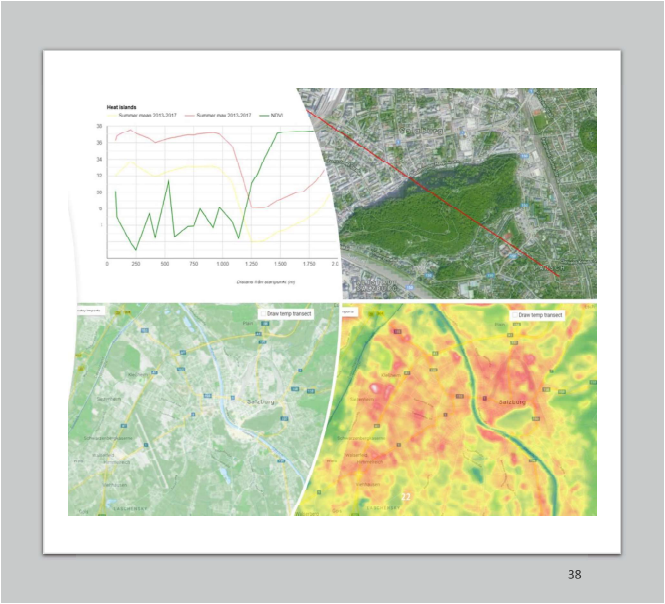
Vegetation and spectral reflectance



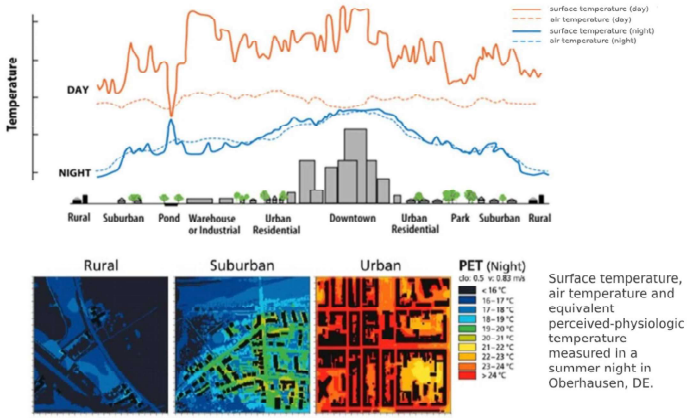


Urban heat islands (UHI) and vegetation

- Mapping UHI with satellite data
- Mapping vegetation with satellite data

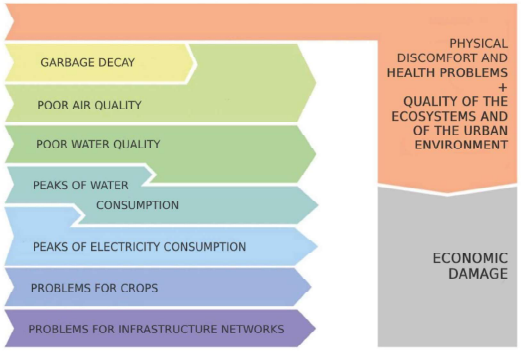


What constitutes UHI



Surface temperature, air temperature and equivalent perceived-physiologic temperature measured in a summer night in Oberhausen, DE.

What are the concequences of Urban heat?

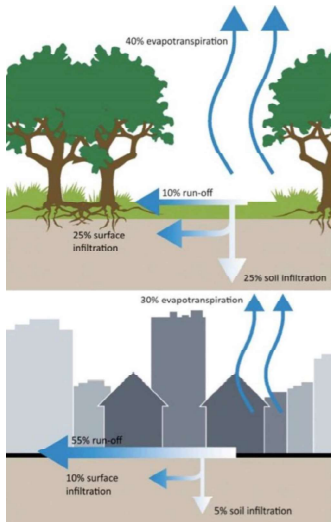


GREEN INFRASTRUCTURE

Evapotranspiration: combined effect of evaporation of water from the soil and plant transpiration (photosynthesis)

Water storage in the soil: prolongation of the cooling effect due to evaporation

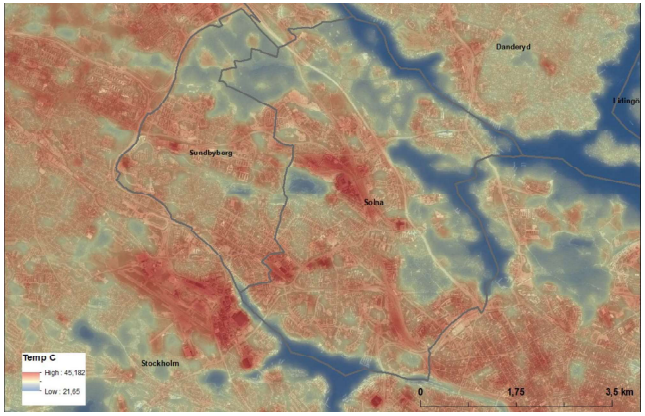
Shading and surface protection against direct irradiation



Surface temperature from satellite

Warm
- Large black roofs
- Impervious surfaces
- Short-cut lawns

Cool
- Forest
- Water
- Leafy areas

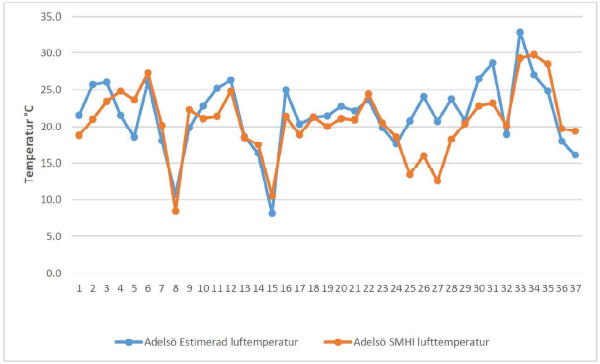


Max temperatures Stockholm county 2013-2018

Images from wikipedia, Copyright creative commons (CC BY-SA 3.0)

Satellite surface temperature vs measured air temperature

Mätstation	Differens	Standardavvikelse
Adelsö	2,7°	2,0°
Arlanda	6,3°	5,3°
Berga	2,3°	1,8°
Bromma	4,7°	3,3°
Landsort	4,3°	1,8°
Observatoriekullen	3,8°	2,8°
Skarpö	6,2°	4,3°
Svanberga	3,6°	4,2°
Tullinge	2,9°	1,9°
Medel:	**4,1°**	**3,0°**

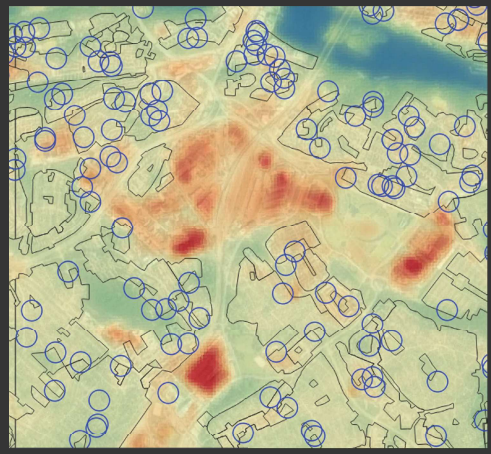


Estimated air temperature (from satellite) compared with measured temperature from 37 dates at SMHI's weather station on Adelsö, Sweden.

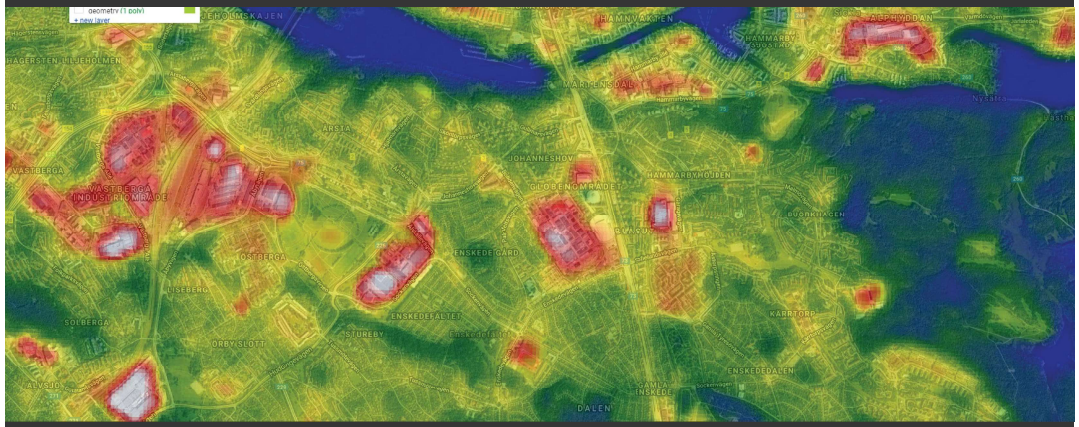
eo4geocourses

Data

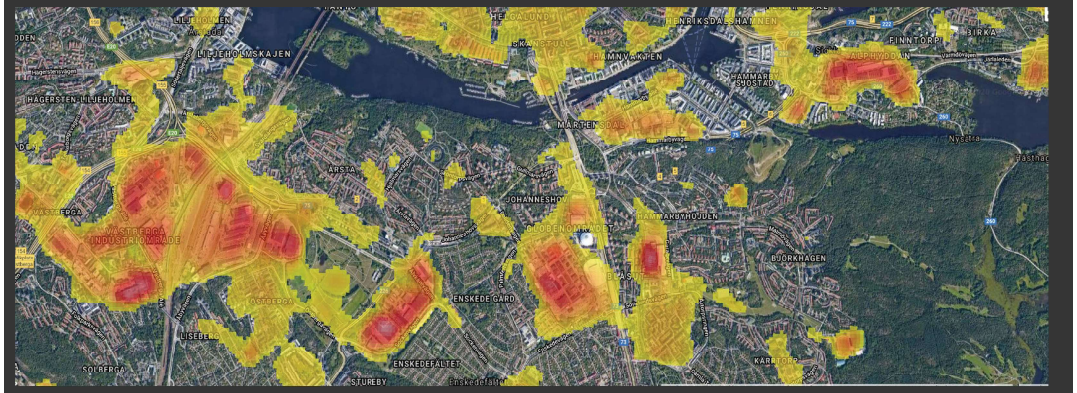
Landsat TIRS time-series
Bulidings
Population data
Green infrastructure
Pre-schools



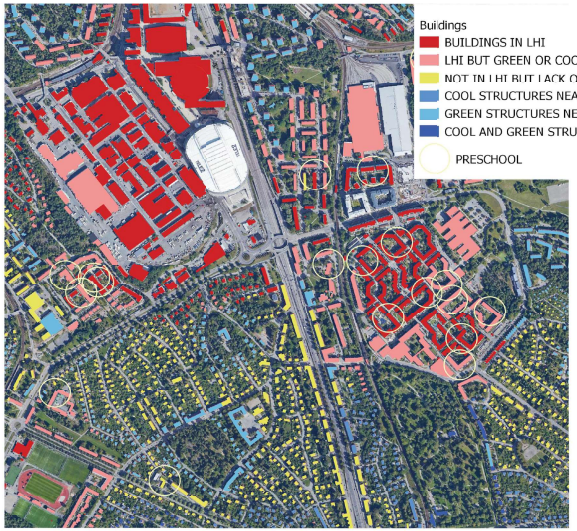
Surface temperature maps

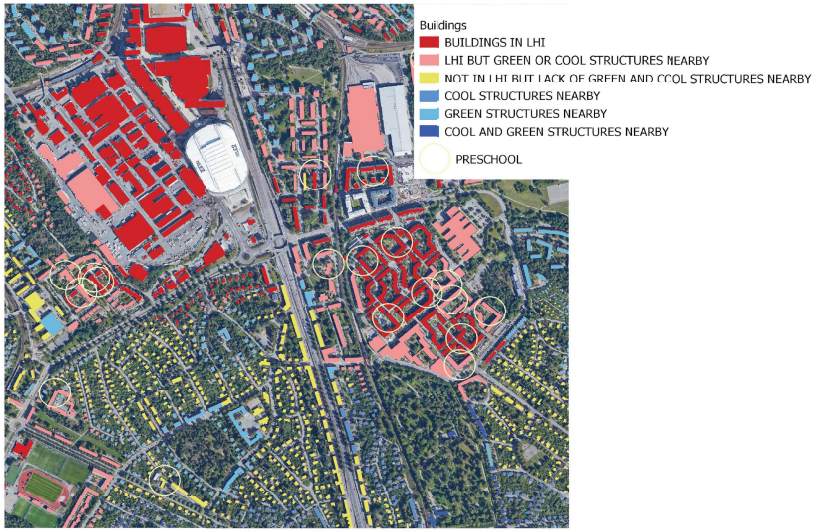


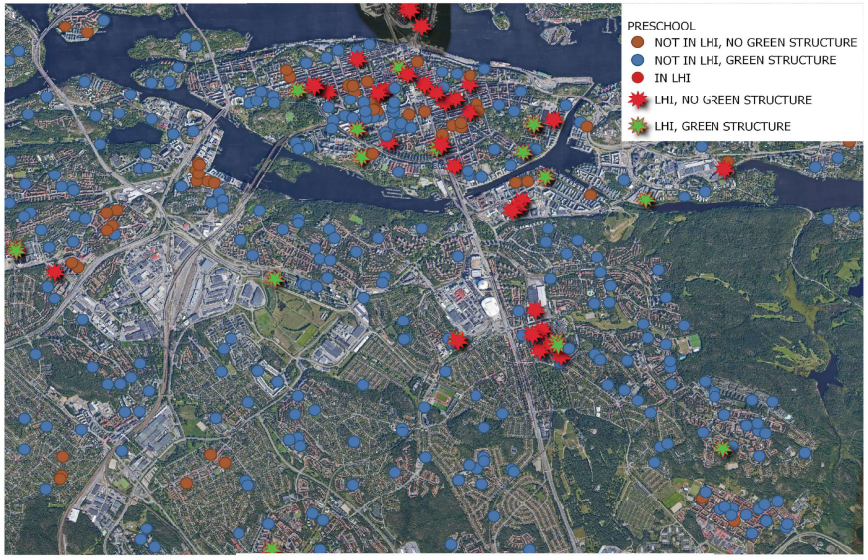
Delineation of high temperature hotspots



Delineation of cool structures

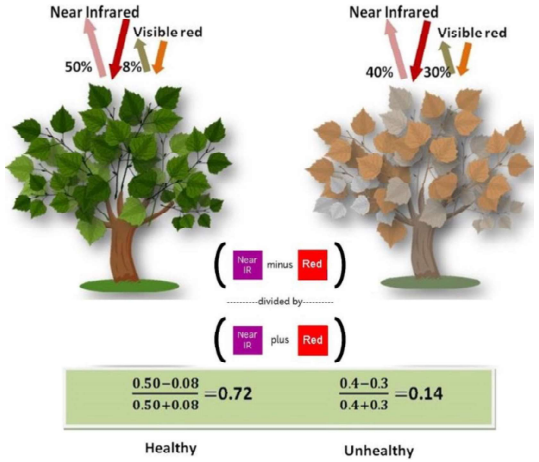



Buidings
BUILDINGS IN LHI
LHI BUT GREEN OR COOL STRUCTURES NEARBY
NOT IN LHI BUT LACK OF GREEN AND COOL STRUCTURES NEARBY
COOL STRUCTURES NEARBY
GREEN STRUCTURES NEARBY
COOL AND GREEN STRUCTURES NEARBY
PRESCHOOL


PRESCHOOL
NOT IN LHI, NO GREEN STRUCTURE
NOT IN LHI, GREEN STRUCTURE
IN LHI
LHI, NO GREEN STRUCTURE
LHI, GREEN STRUCTURE

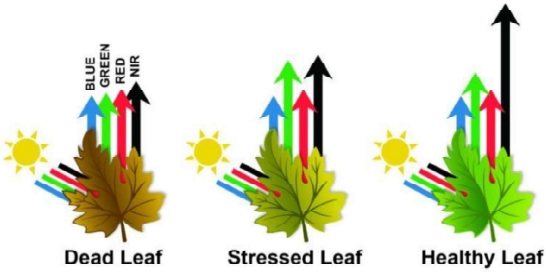
Vegetation indices

- Spectral indices dedicated to vegetation analysis are developed based on the principle that the healthy vegetation reflects strongly in the near-infrared (NIR) spectrum while absorbing strongly in the visible red.

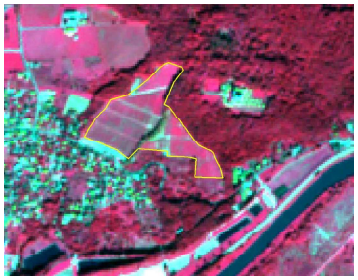


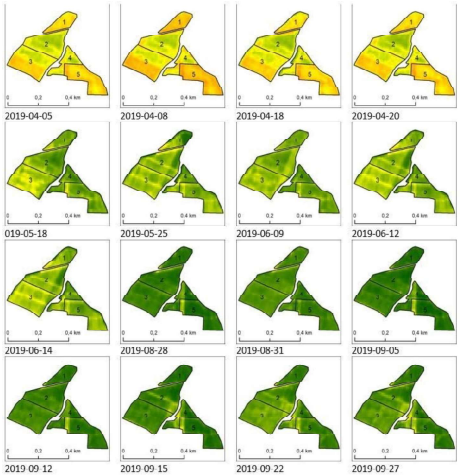
Spectral signature

- In green healthy plant:
  - Chlorophyll absorbs large proportion of red and blue spectrum for photosynthesis and strongly reflects in green
  - strong reflectance in near infrared (NIR) due to leaf structure and condition
  - lower reflectance in shortwave infrared (SWIR) influenced by water content, which absorbs infrared energy.

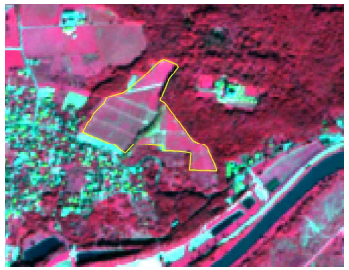


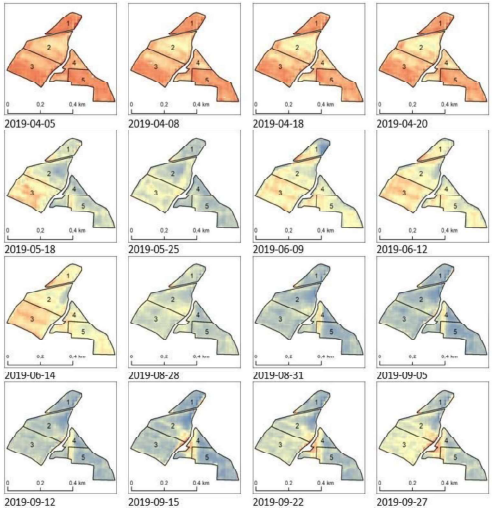
Multi- temporal NDVI (timeseries)

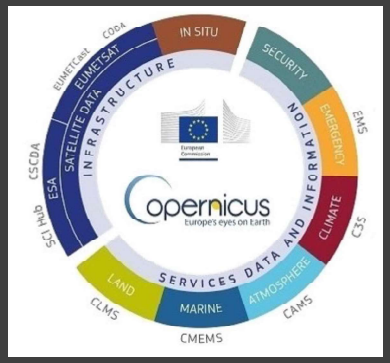


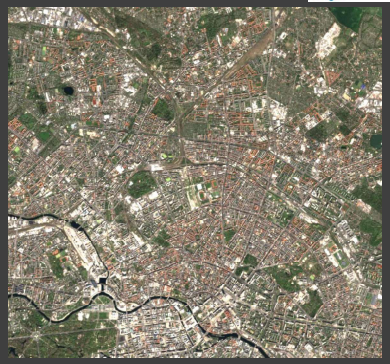


Multi-temporal NDMI – Moisture index (timeseries)









Data services and access

COPERNICUS LAND MONITORING SERVICE (CLMS)

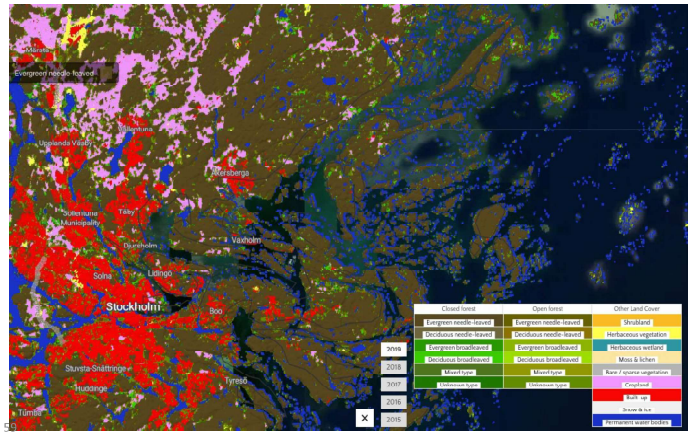
CLMS provides **geographical information** on land cover and its changes, land use, vegetation state, water cycle and earth surface energy variables **to a broad range of users** in Europe and across the World.

- It **supports applications** in a variety of domains such as spatial and urban planning, forest management, water management, agriculture, food,...
- CLMS is **jointly implemented by** the European Environment Agency (EEA) and the European Commission DG Joint Research Centre (JRC).
- The Land Monitoring Service has been in operational use since 2012 (https://www.copernicus.eu/en/services/land).

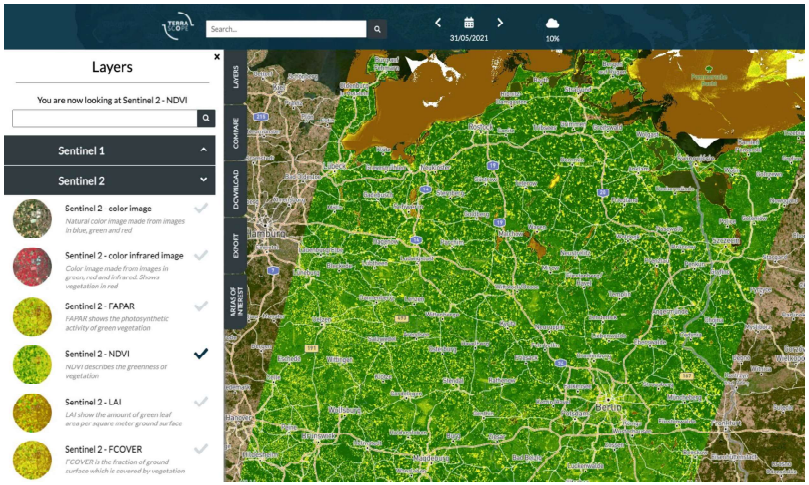
CLMS - applications

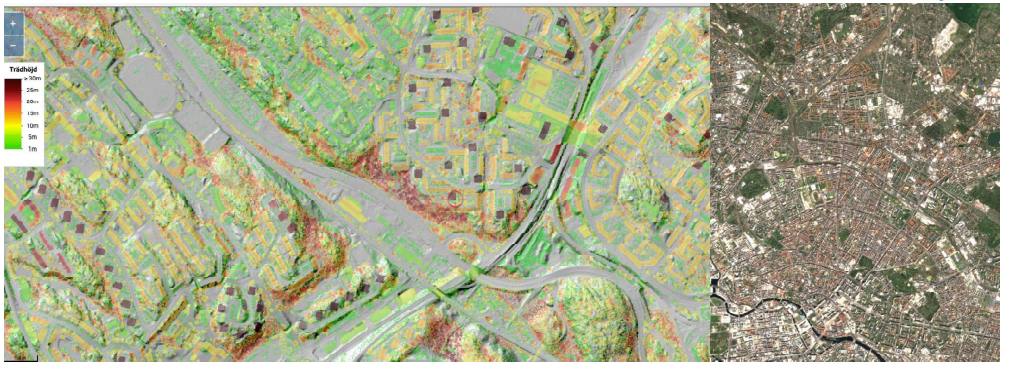
- Spatial and urban planning
- Forest management
- Water management
- Agriculture and food security
- Nature conservation and restoration
- Ecosystem accounting
- Climate change mitigation

Viewing and downloading (https://land.copernicus.eu/global/)



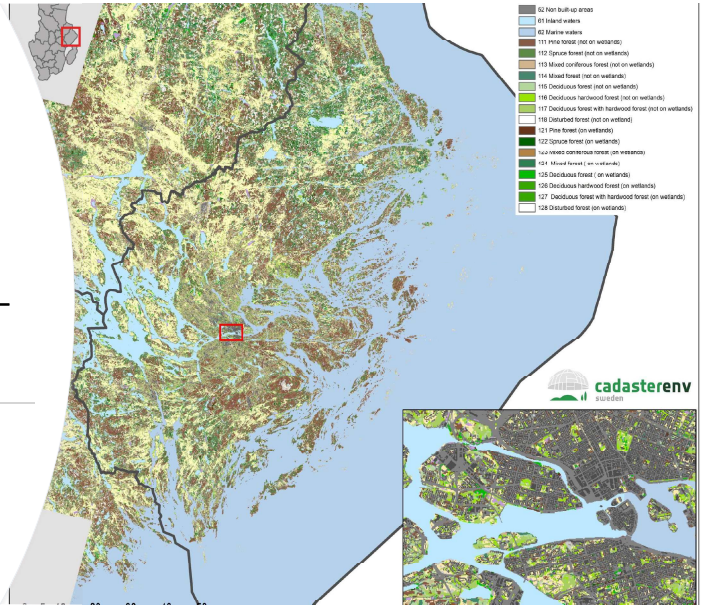
Terrascope viewer https://terrascope.be/en



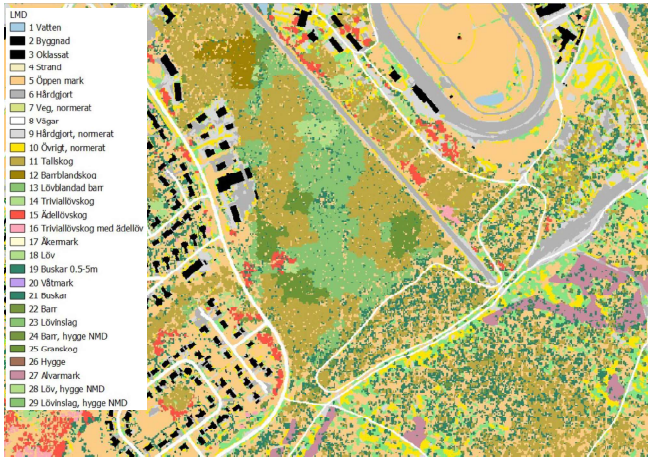


Other data sources

NMD (Swedish landcover) 10m resolution satellite product–

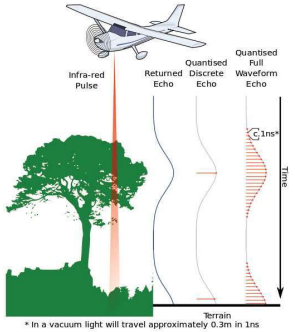


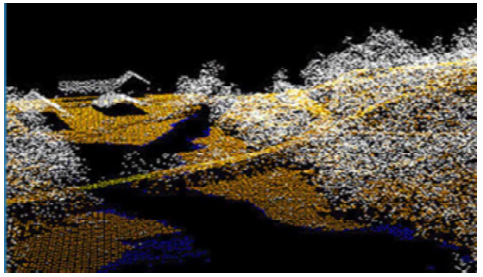
High-resolution landcover maps (1m)



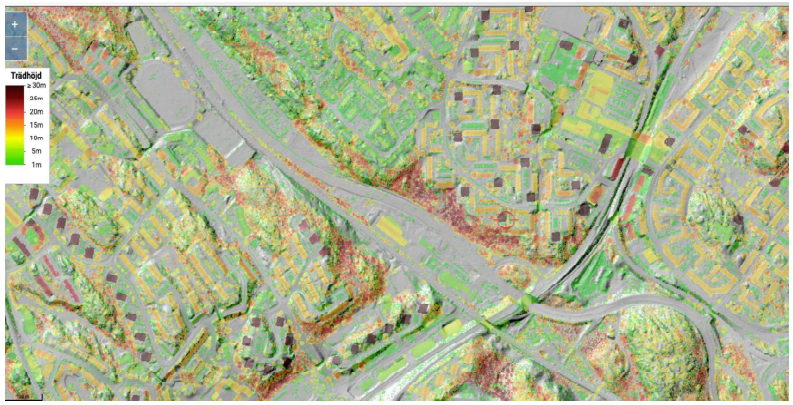
Comparison LMD (1m) vs NMD (10m)

Airborne LIDAR data





Lidar-derived treeheight map (Skogsstyrelsen.se)



Lidar-derived treemap (stadsträd.se)

Discussion, Q and A

Conclusion

- Urban greenery need to be involved in early planning stages
- a well-planned and developed green infrastructure in urban areas is necessary to achieve ecosystem services
- Ecosystem services is the value that nature creates for humans and need to be accounted for on economical terms
- EO data can be used for estimation and mapping of green infrastructure and ecosystem services
- For further questions, please contact us:

www.geografiskainformationsbyran.se

Discussion, Q and A

Workshop

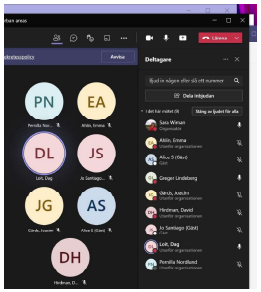
Hitta satellitdata och annan information

Bearbetning satellitdata – yttemperatur

- Korrigering
- Temperaturkurvor
- Tröskling
- Beräkna vegetationsindex

Analys

- Okulärt - korrelationen värme vegetation
- Statistik
- Värme kopplat till vegetation
- Grön infrastruktur
  - Krontäckning
  - Träd, habitatnätverk
- EST


Avsluta
Deltagare
Dela inbjudan
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DL
JS
JG
AS
DH