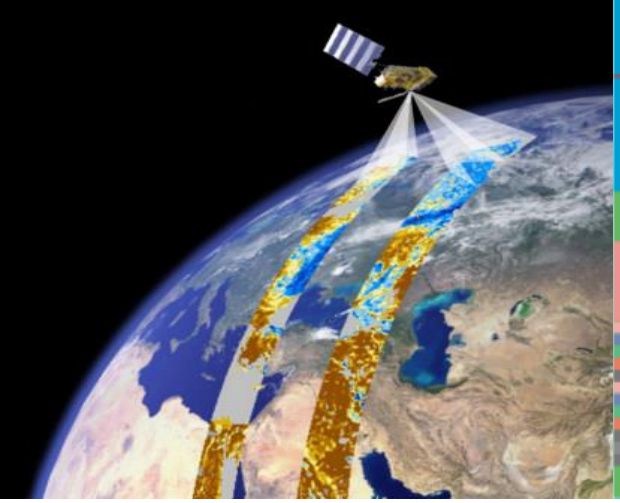
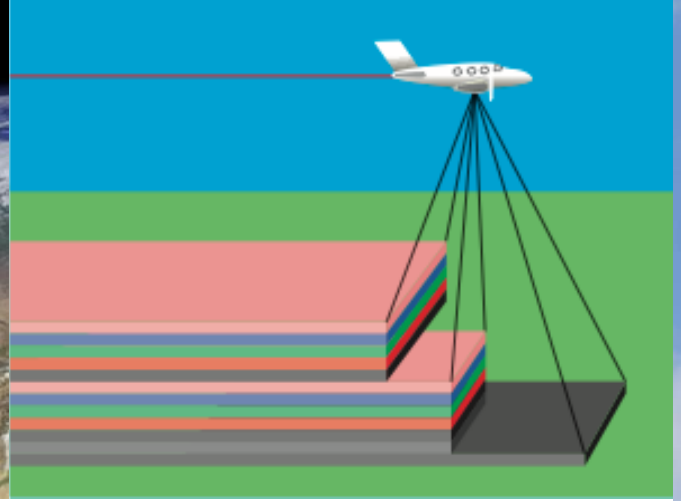
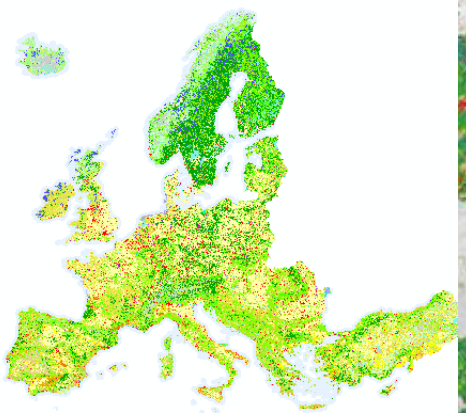
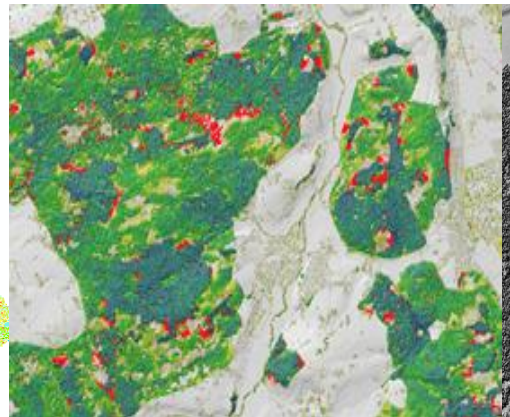
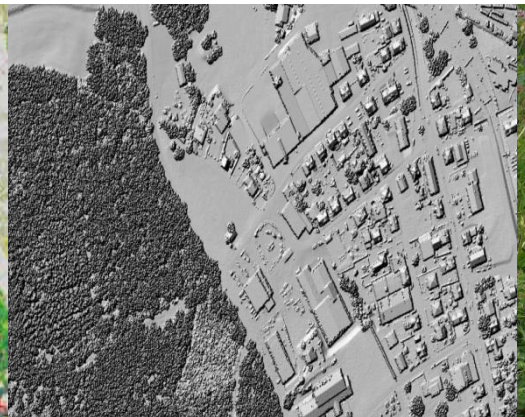



Monitoring land cover / land use with satellites and airborne systems

Charlotte Steinmeier

Content

- Presentation of WSL
- Remote sensing
  - overview of monitoring systems
  - scale of monitoring
  - data quality
  - methods
- Thematic examples
  - landscape
  - land use
  - natural hazards
- Verification

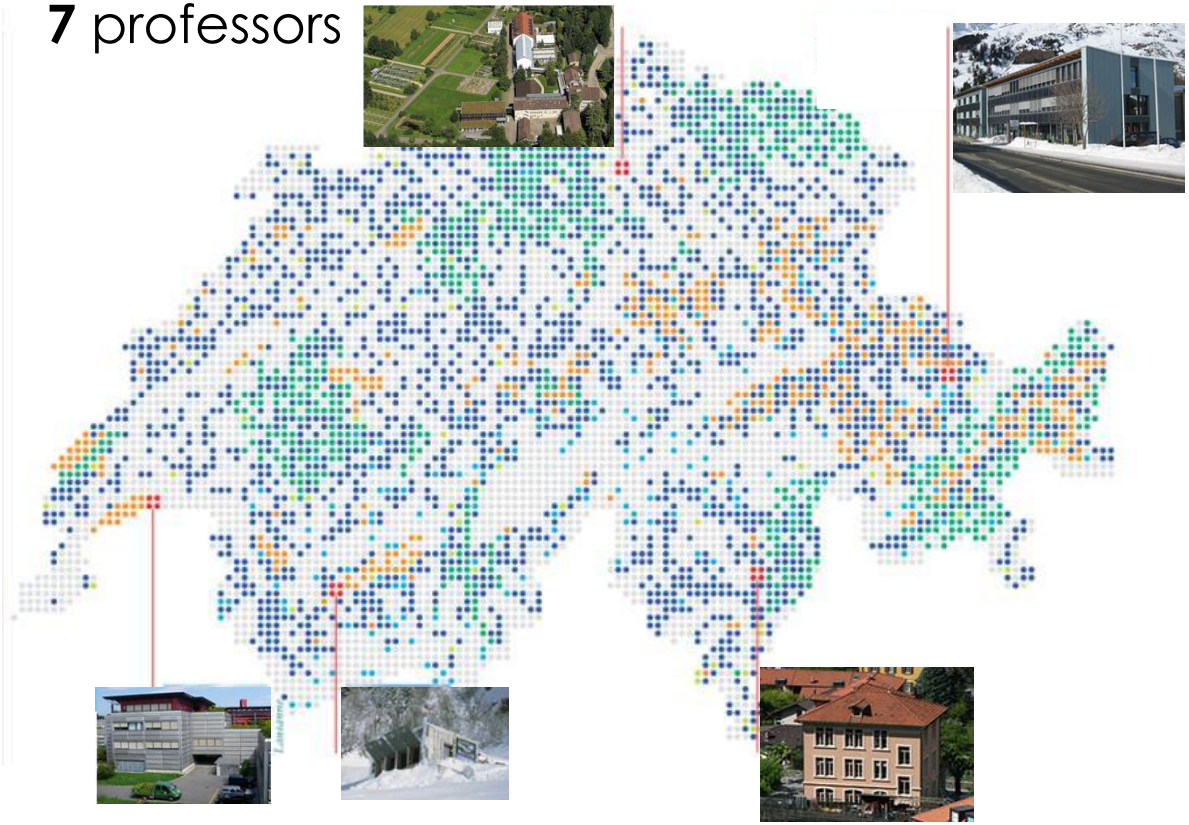
WSL

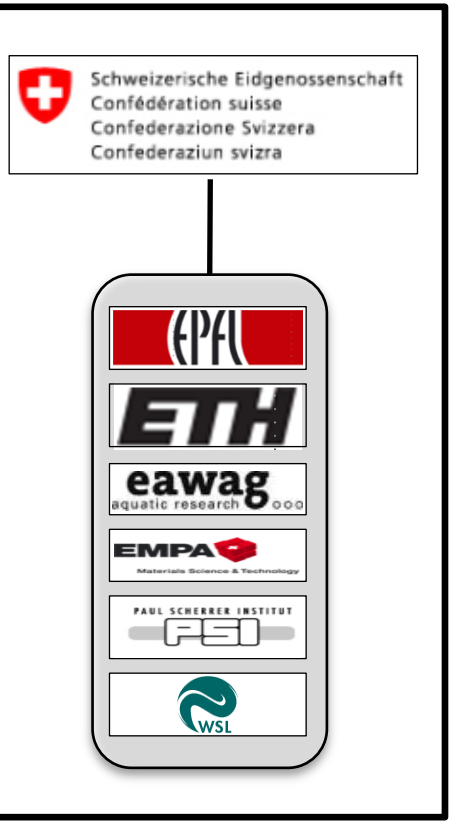
5 locations

6000 experimental and research plots

580 employees

7 professors

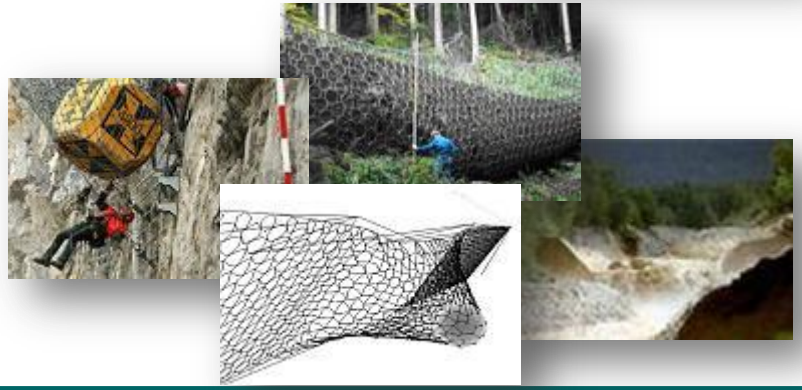




WSL *Research Focus* **Natural Hazards**

Avalanches
Building, Dynamics, Protection, Warning

Snow
Physics, Hydrology, Climatology

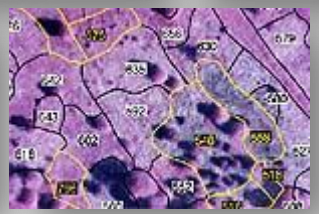


Rock Fall, Debris Flow
Dynamics, Modelling, Protection

WSL *Research Focus* **Landscape and Conservation Biology**

Biodiversity, Conservation Biology

Landscape Development and Quality



WSL *Research Focus* **Forest**

Forest Ecosystems

Forest Resources

Forest Management

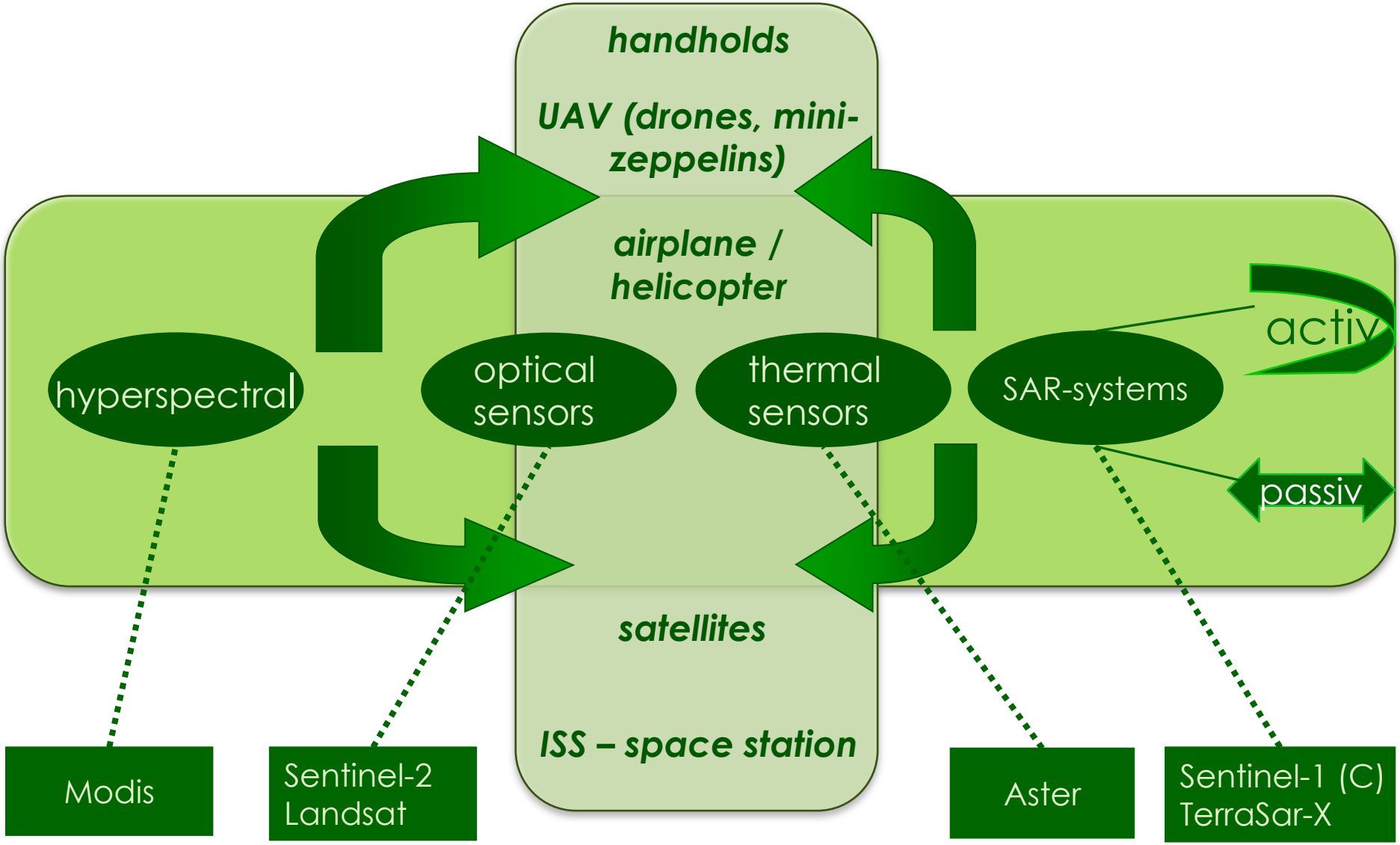
Remote Sensing

Wikipedia:
https://en.wikipedia.org/wiki/Remote_sensing

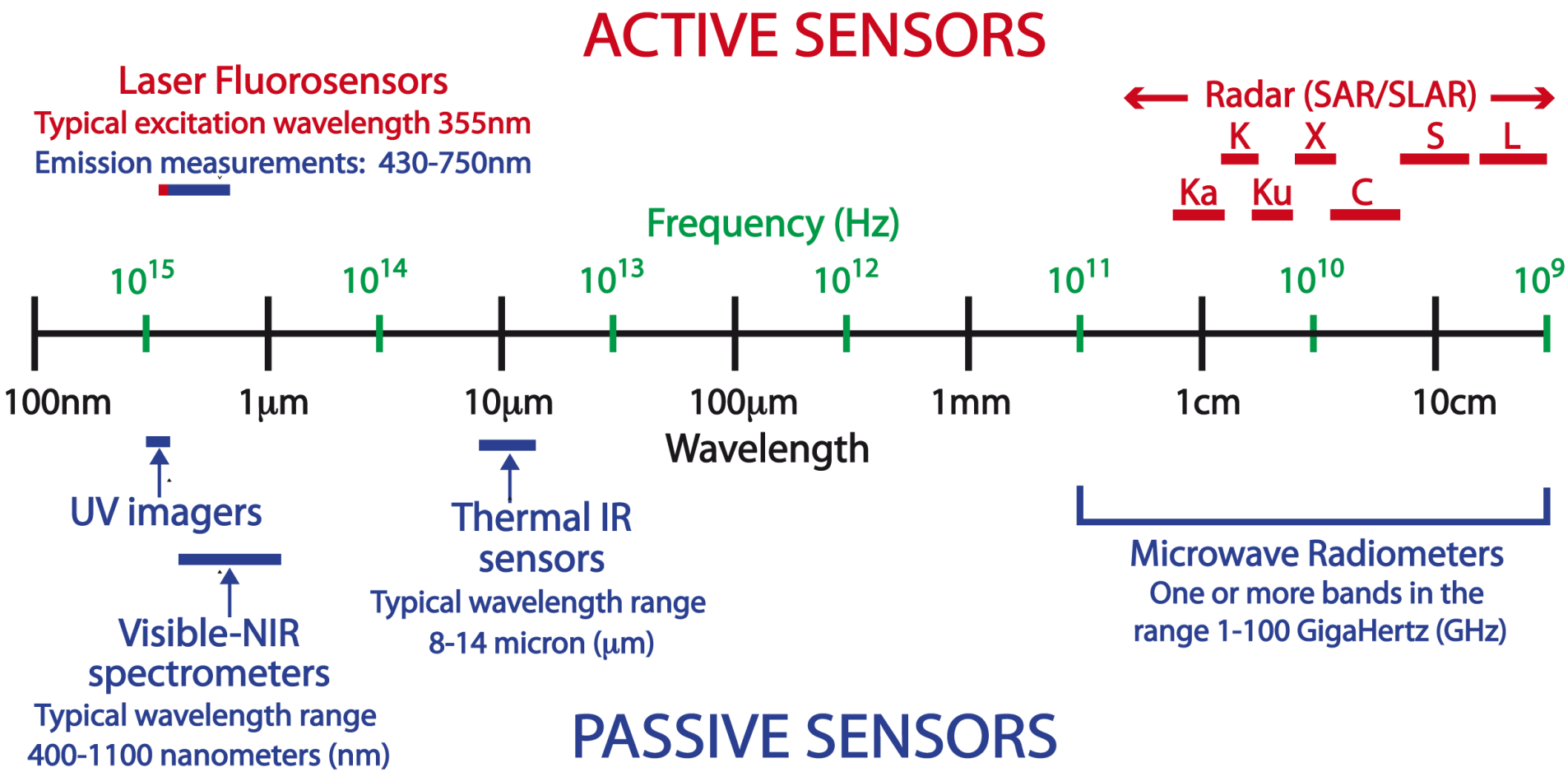
Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation.

Remote sensing is a sub-field of geography.

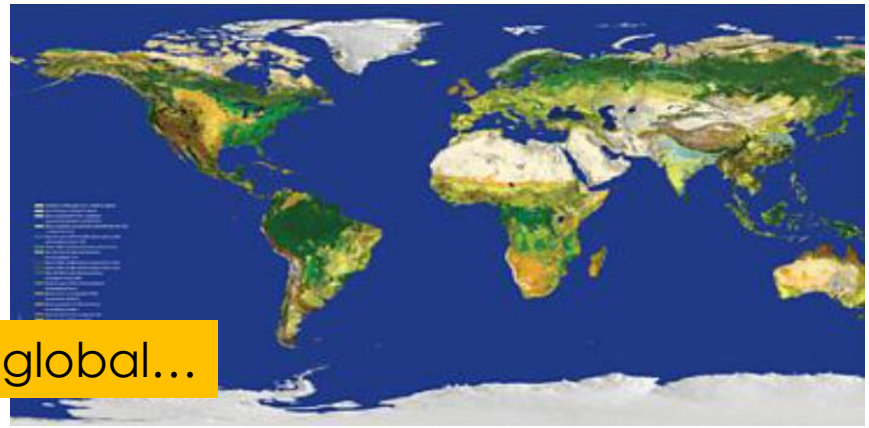
Monitoring Systems



Spectral range



Land Monitoring - Scale

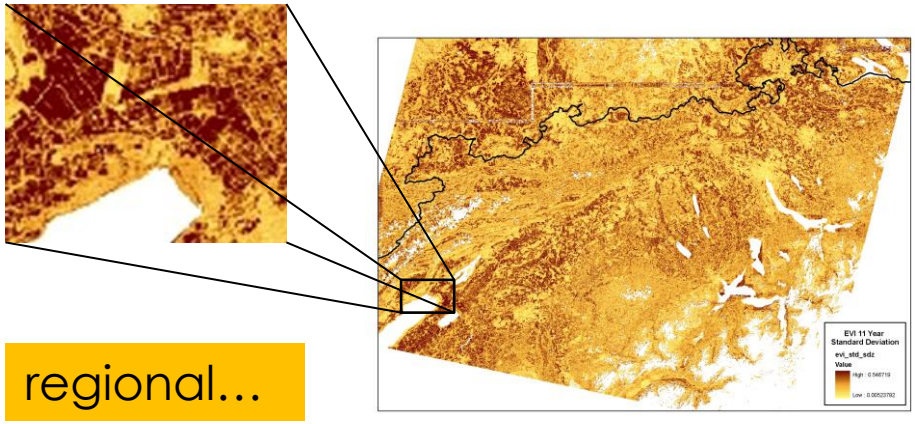


global…

local

…

panEuropean…



regional…

Land Monitoring - Scale

- **global scale**
- regional scale
- local scale

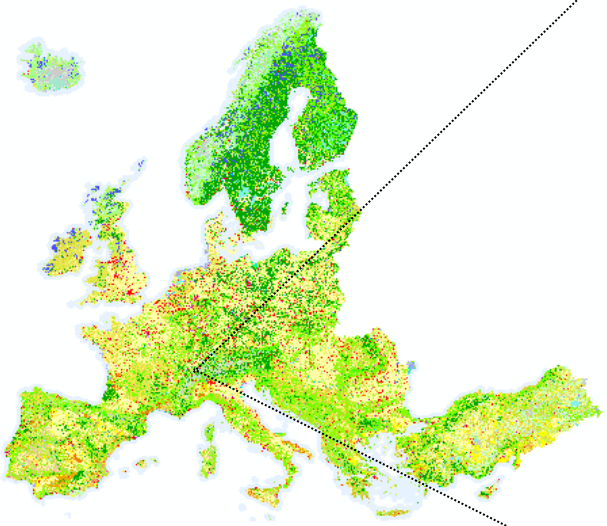
e.g.
- 1 km – 100 km
- often variables
- Often input for models

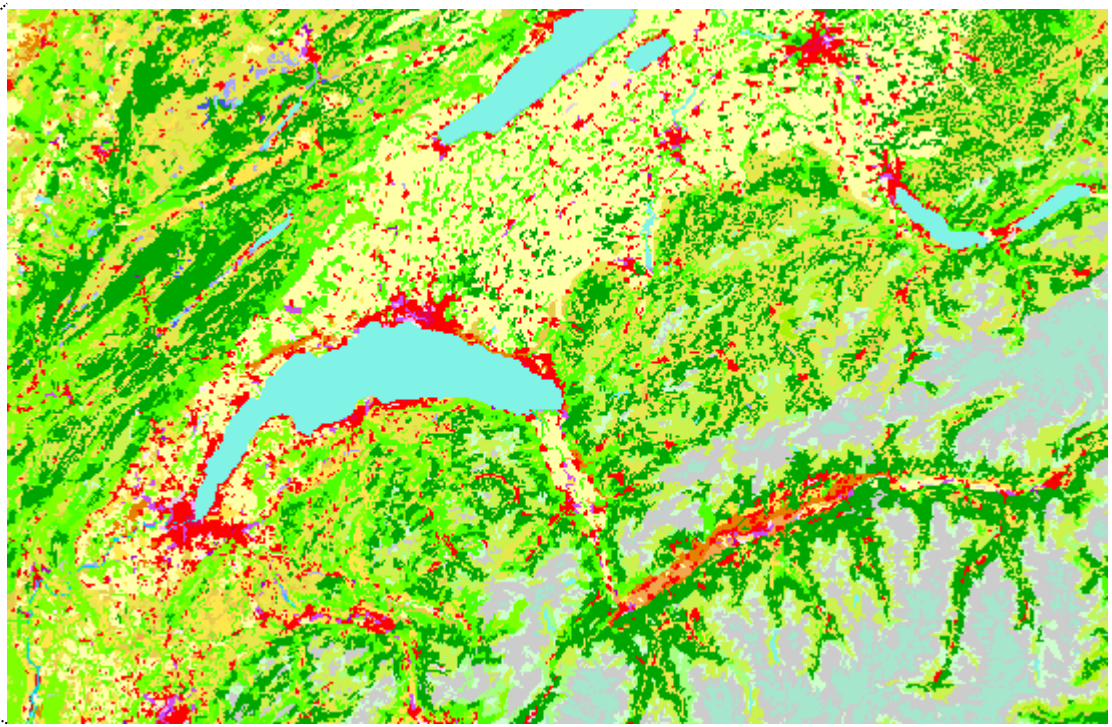
Land Monitoring - Scale

http://www.wsl.ch/fe/landschaftsdynamik/projekte/corine_landcover_update/index_DE

- global scale
- **regional scale (pan European)**
- local scale

CORINE Land Cover





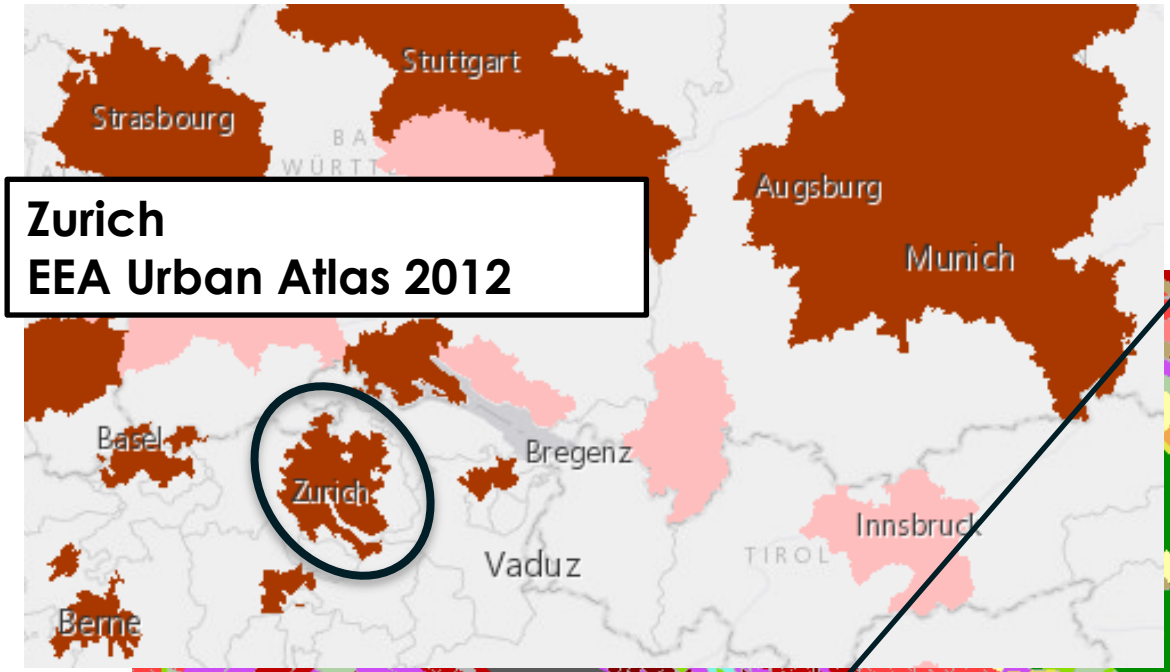
Geneva

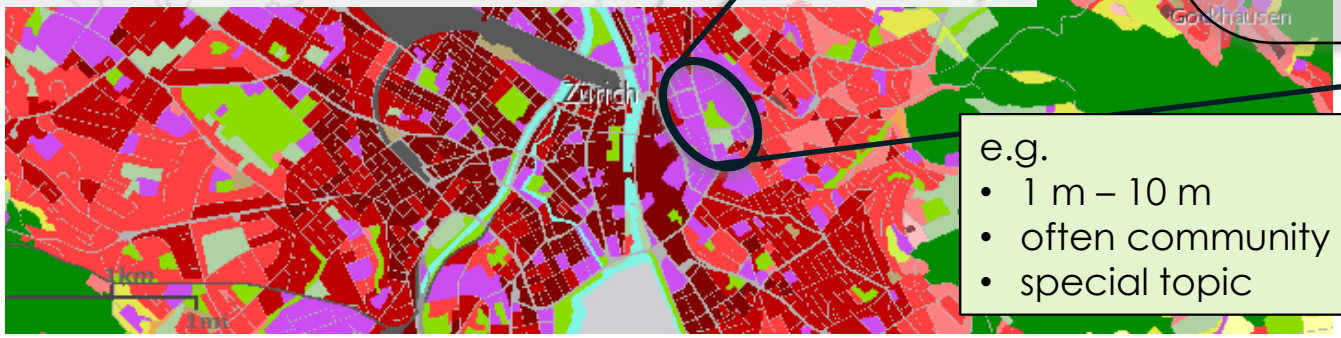
e.g.
- 20 m – 1 km
- often national interest
- often special themes

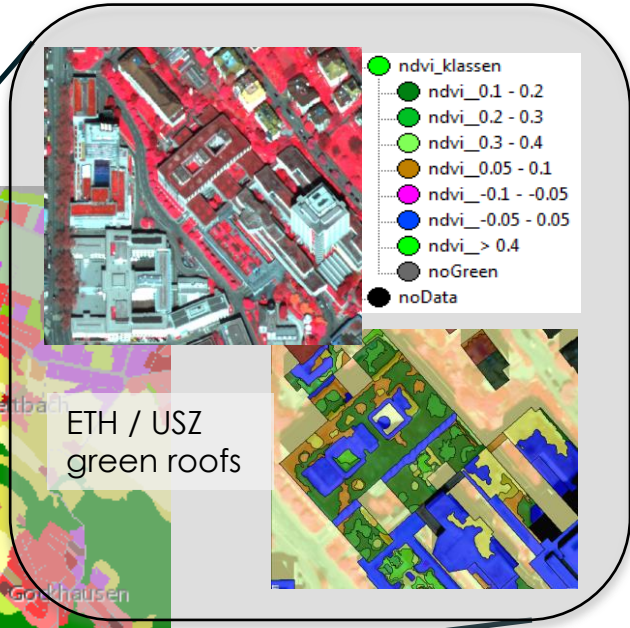
Land Monitoring - Scale

http://www.eea.europa.eu/data-and-maps/data/urban-atlas
http://www.wsl.ch/fe/landschaftsdynamik/projekte/mapping_urban_green_assessment_indicators/index_EN

- global scale
- regional scale
- **local scale**



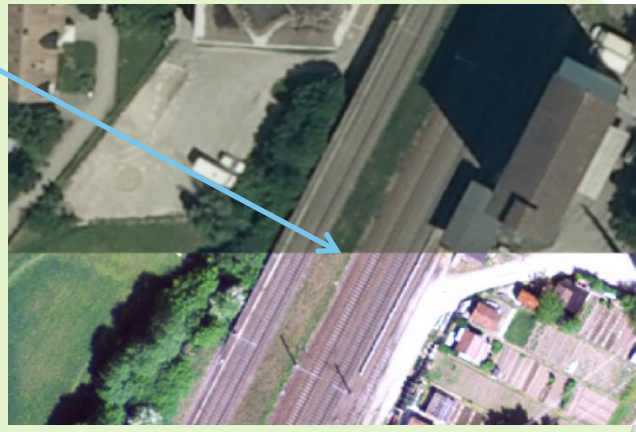


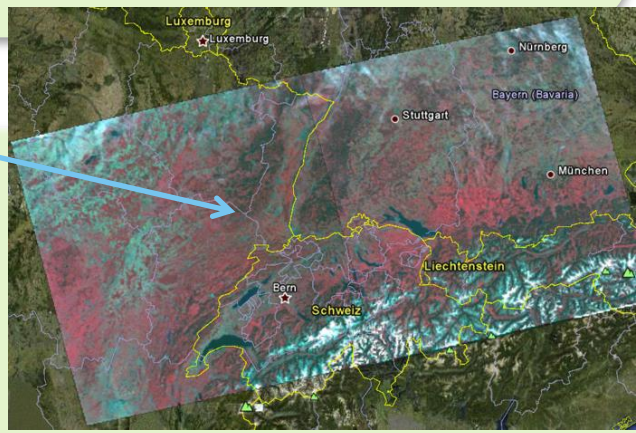


e.g.
- 1 m – 10 m
- often community level
- special topic

Data Quality

- **Sensors**
  - CCD / lenses (hardware quality)
  - radiometric resolution (8 bit, 16 bit,…)
  - availability of metadata
- **Repeat Cycle**
- **Geometric Resolution**
- **Swath width**





- **Weather**
  - aerosols
  - haze
  - clouds
- **Topography**
- **Time of Year**
  - Shade / vegetation cover
- **Costs**

Data Quality

- **Sensors**
  - CCD / lenses (hardware quality)
  - radiometric resolution (8 bit, 16 bit,…)
  - availability of metadata
- **Repeat Cycle**
- **Geometric Resolution**
- **Swath width**

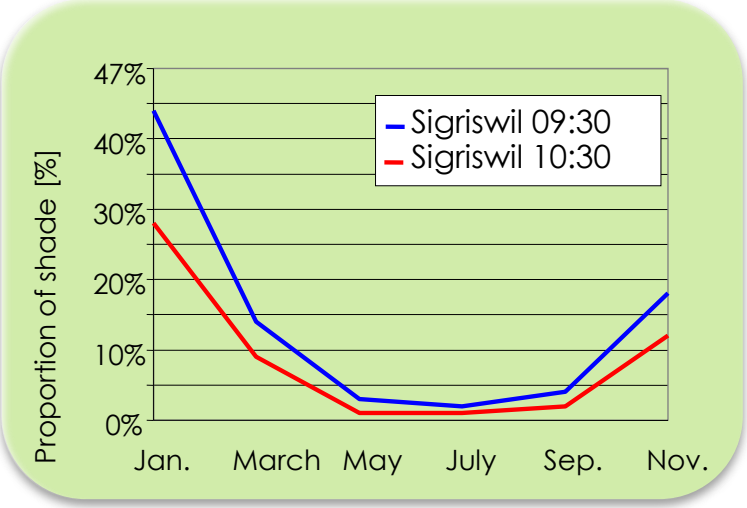
- **Weather**
  - aerosols
  - haze
  - clouds
- **Topography**
- **Time of Year**
  - Shade / vegetation cover
- **Costs**

Data Quality

Shade

March, 06th 2000

August, 12th 2000

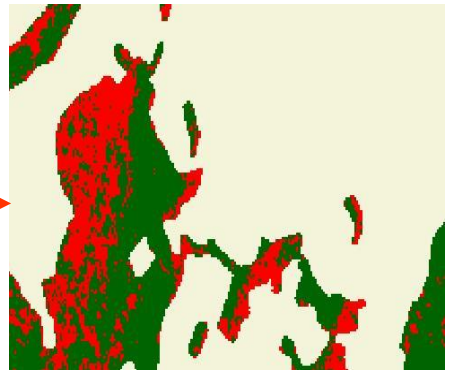


https://www.google.com/url?q=http://www.wsl.ch/fe/landschaftsdynamik/projekte/remote_sensing_methods_storm_damages_forests/Scand.J.forest_2003&sa=U&ved=0CAUQFjAAahUKEwj9xeiJo7DHAhVL1hQKHXjGAEY&client=internal-uds-cse&usg=AFQjCNHxqJfY-E8XxqnaCCusI9nbkd9JbQ

Data Quality

Decidious trees leaveless

Ikonos
March, 06



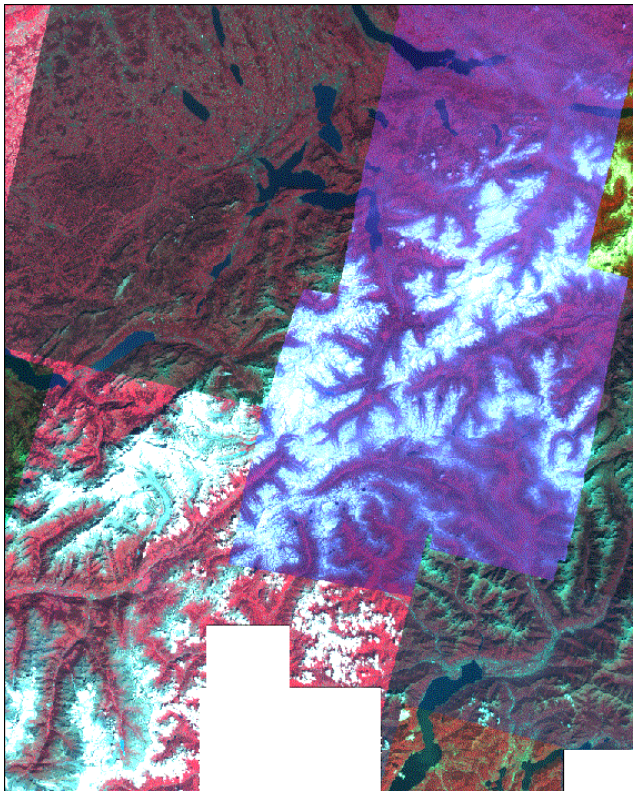
Errors

Ikonos
August, 12

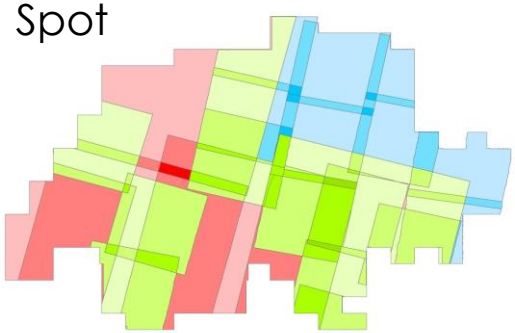
https://www.google.com/url?q=http://www.wsl.ch/fe/landschaftsdynamik/projekte/remote_sensing_methods_storm_damages_forests/Scand.J.forest_2003&sa=U&ved=0CAUQFjAAahUKEwj9xeiJo7DHAhVL1hQKHXjGAEY&client=internal-uds-cse&usg=AFQjCNHxqJfY-E8XxqnaCCusI9nbkd9JbQ

Data Quality

Image 2006



C1: 5 IRS + 17 Spot

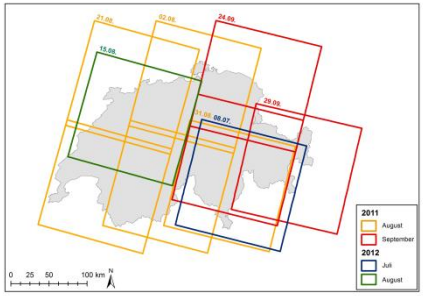


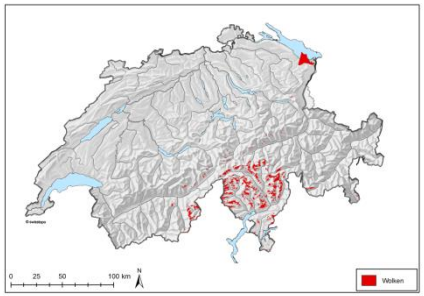
IRS

Spot

IRS + Spot

Image 2012





C2: 125 Rapid Eye

http://www.wsl.ch/dienstleistungen/publikationen/pdf/12359.pdf

Methods

classification

automatic

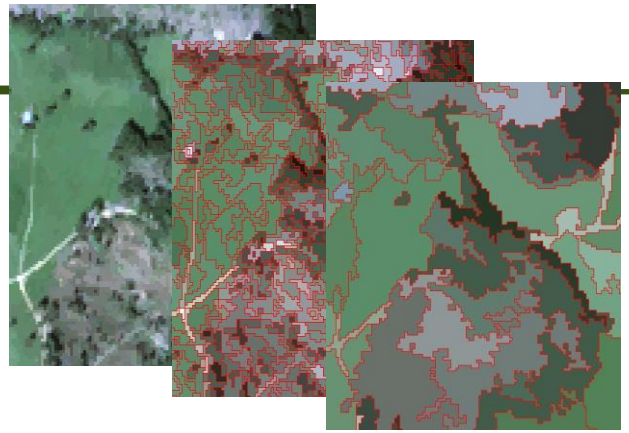
supervised

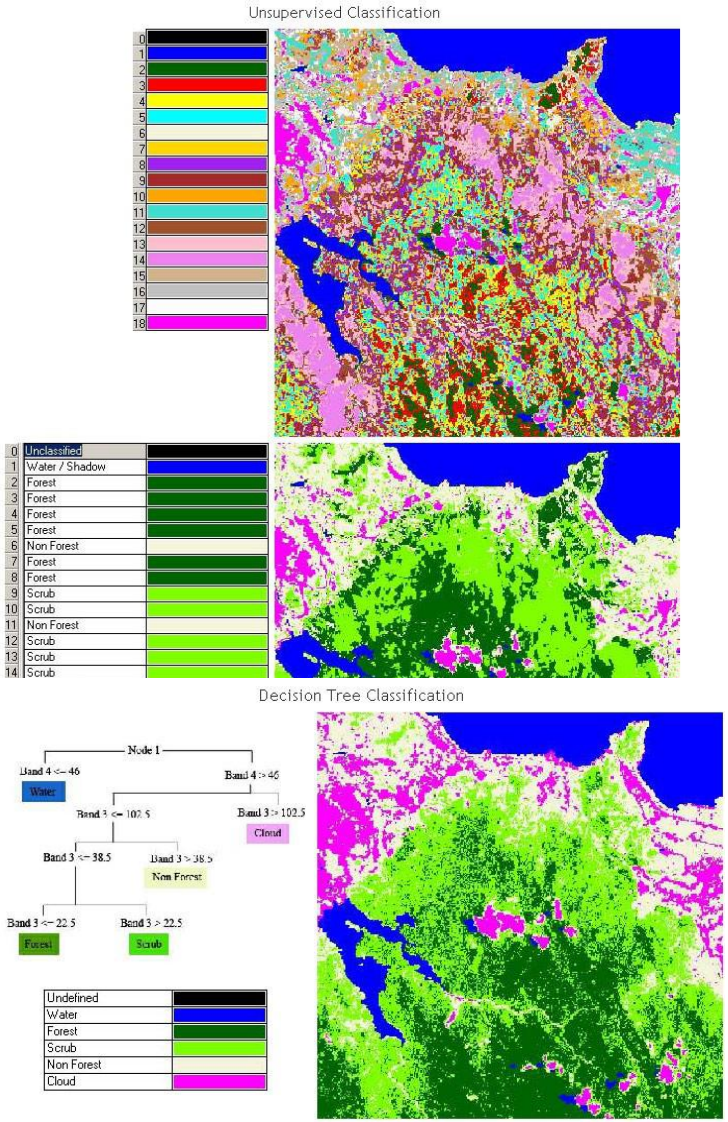
unsup

statistical

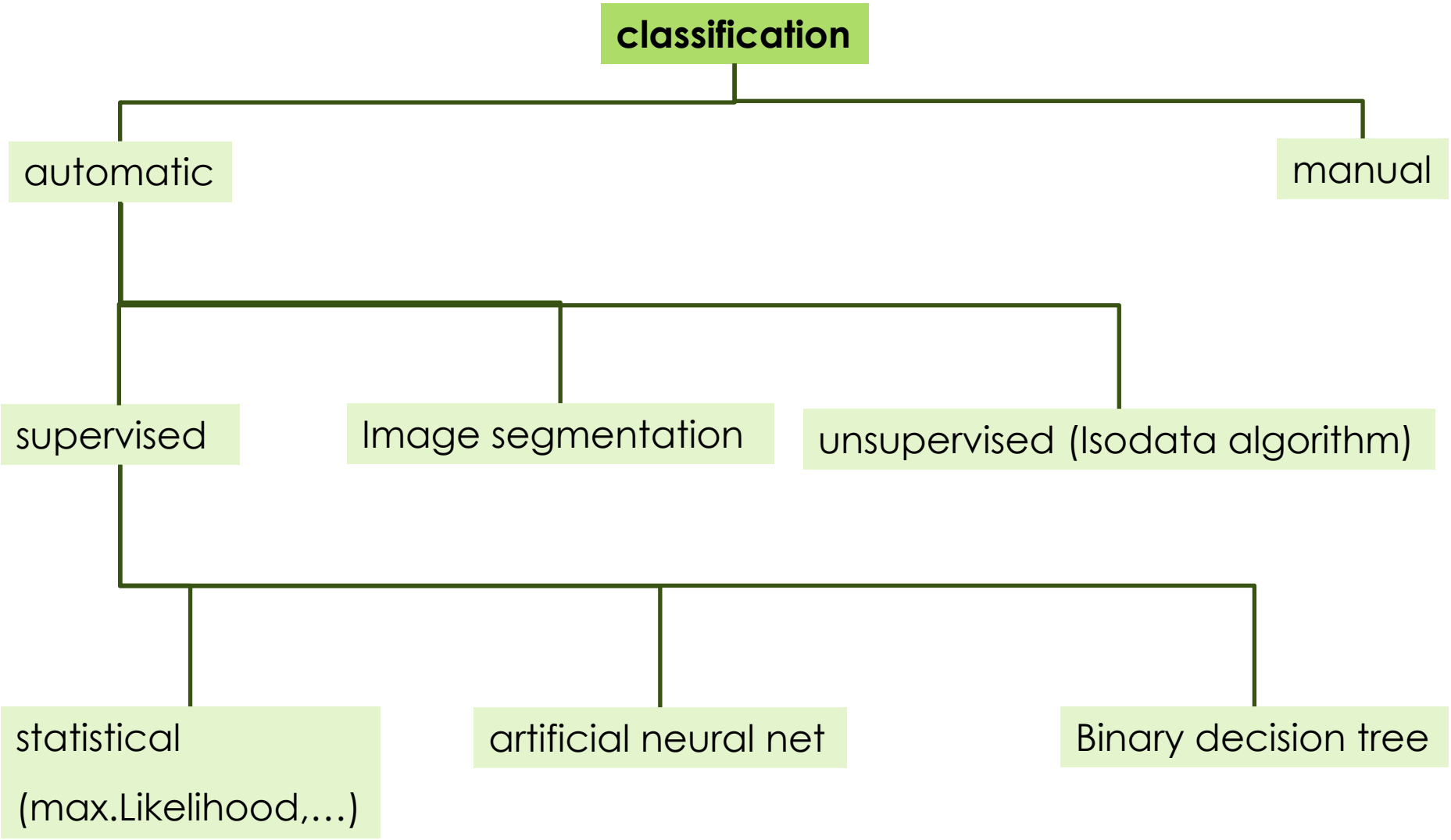
(max.Likelihood,…)

artificial neural net





Methods


classification
automatic
manual
supervised
Image segmentation
unsupervised (Isodata algorithm)
statistical
(max.Likelihood,…)
artificial neural net
Binary decision tree

Methods

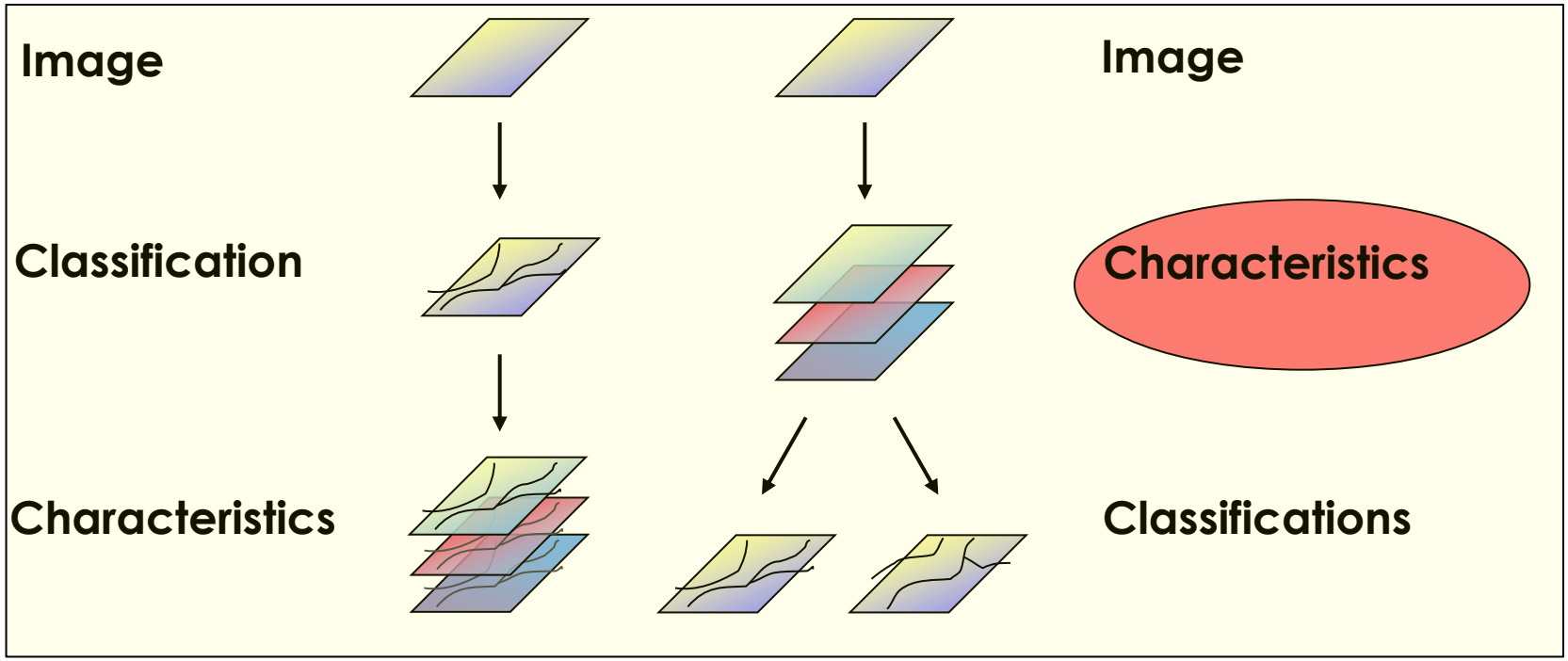
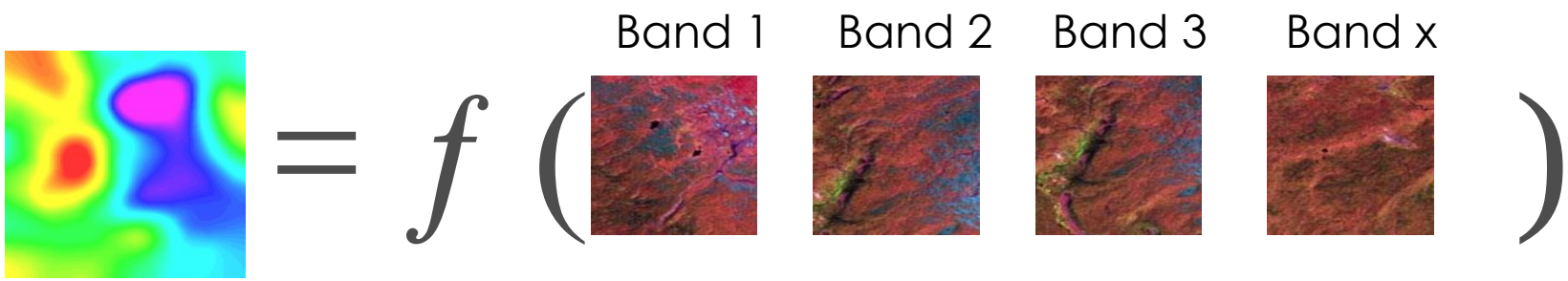
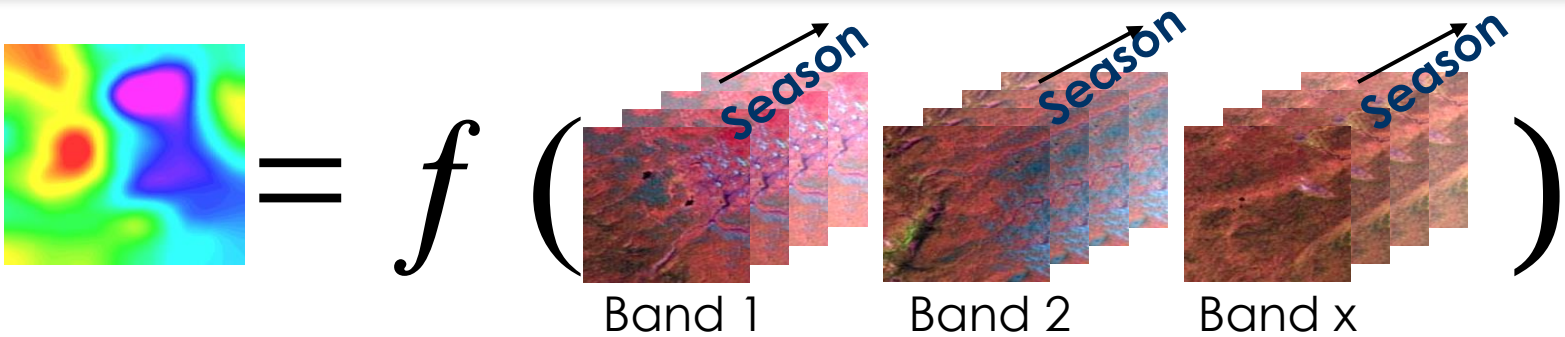


Image
Classification
Characteristics
Image
Characteristics
Classifications

Methods



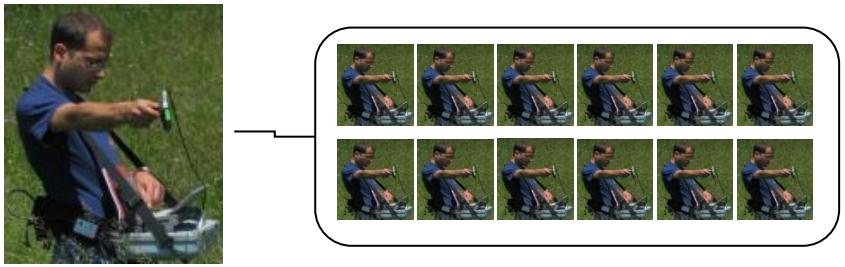
Operational mapping → NFI, storm damages, reporting, …



New national LC/LU products → land cover **characteristics**

grassland type, fractional covers,
deviation over time

Example Grassland Characteristics



Semi-Mesic

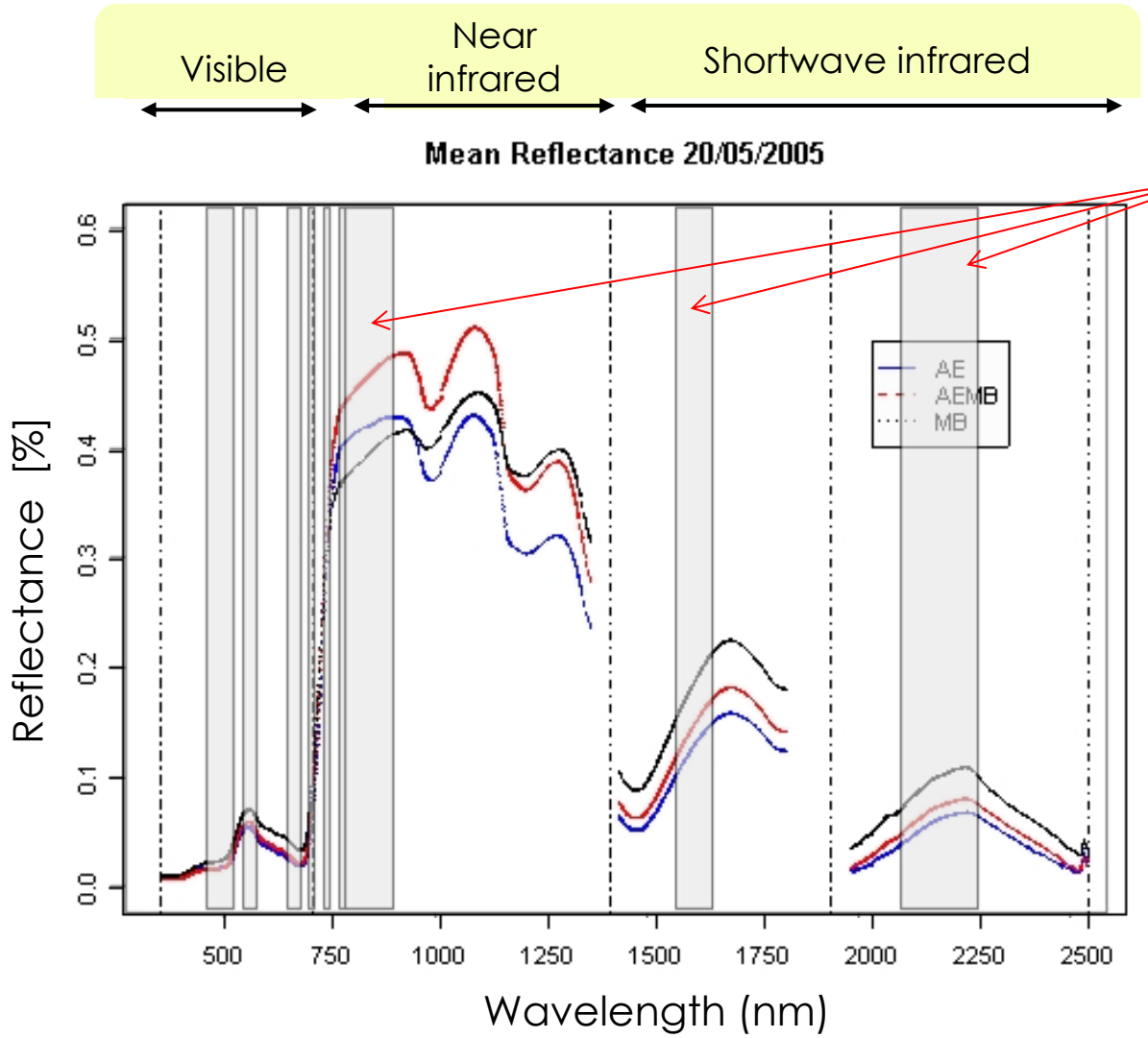
20th May **7th June** **30th June** **15th August** **18th September**

Dry

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season

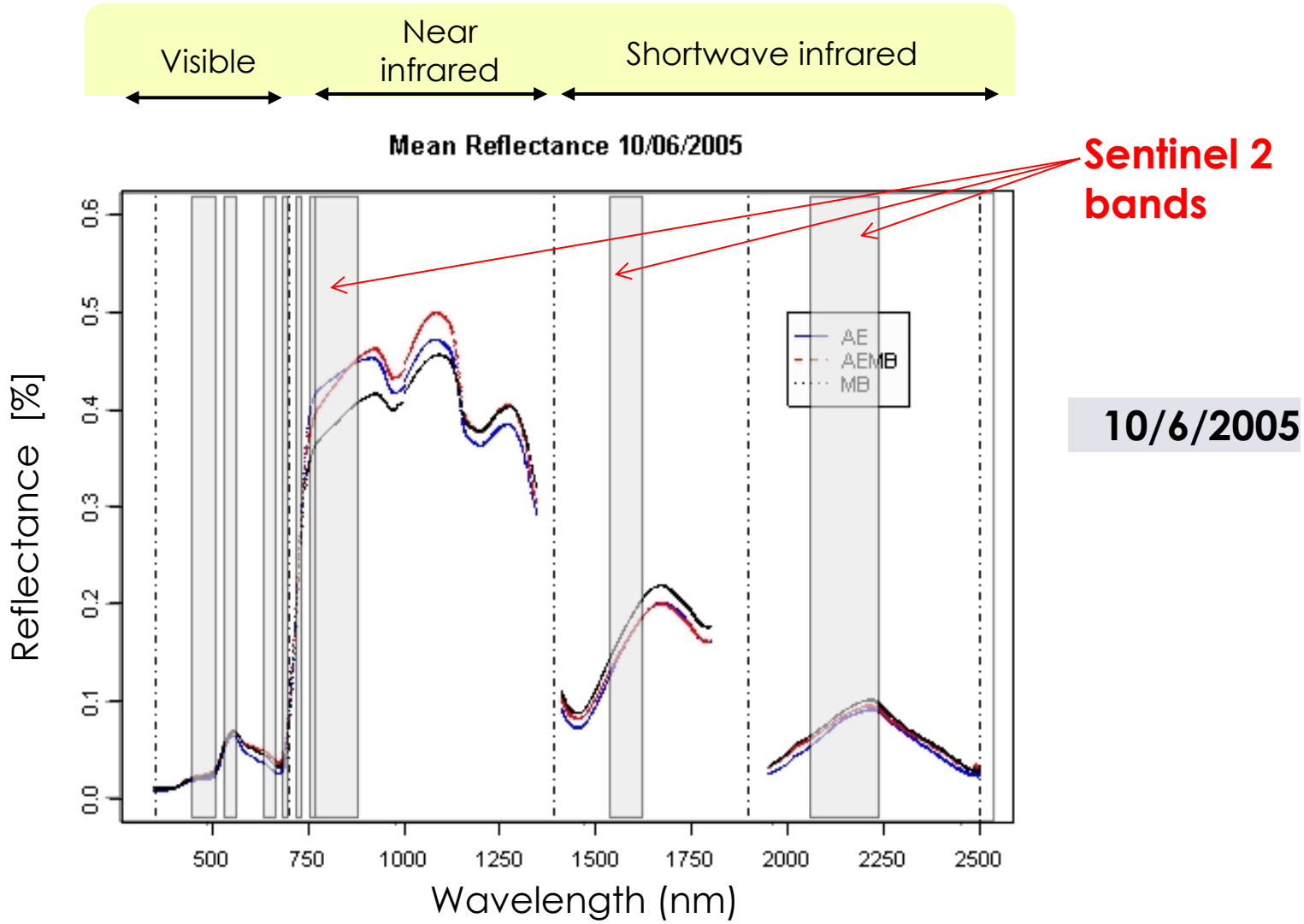


20/5/2005

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season

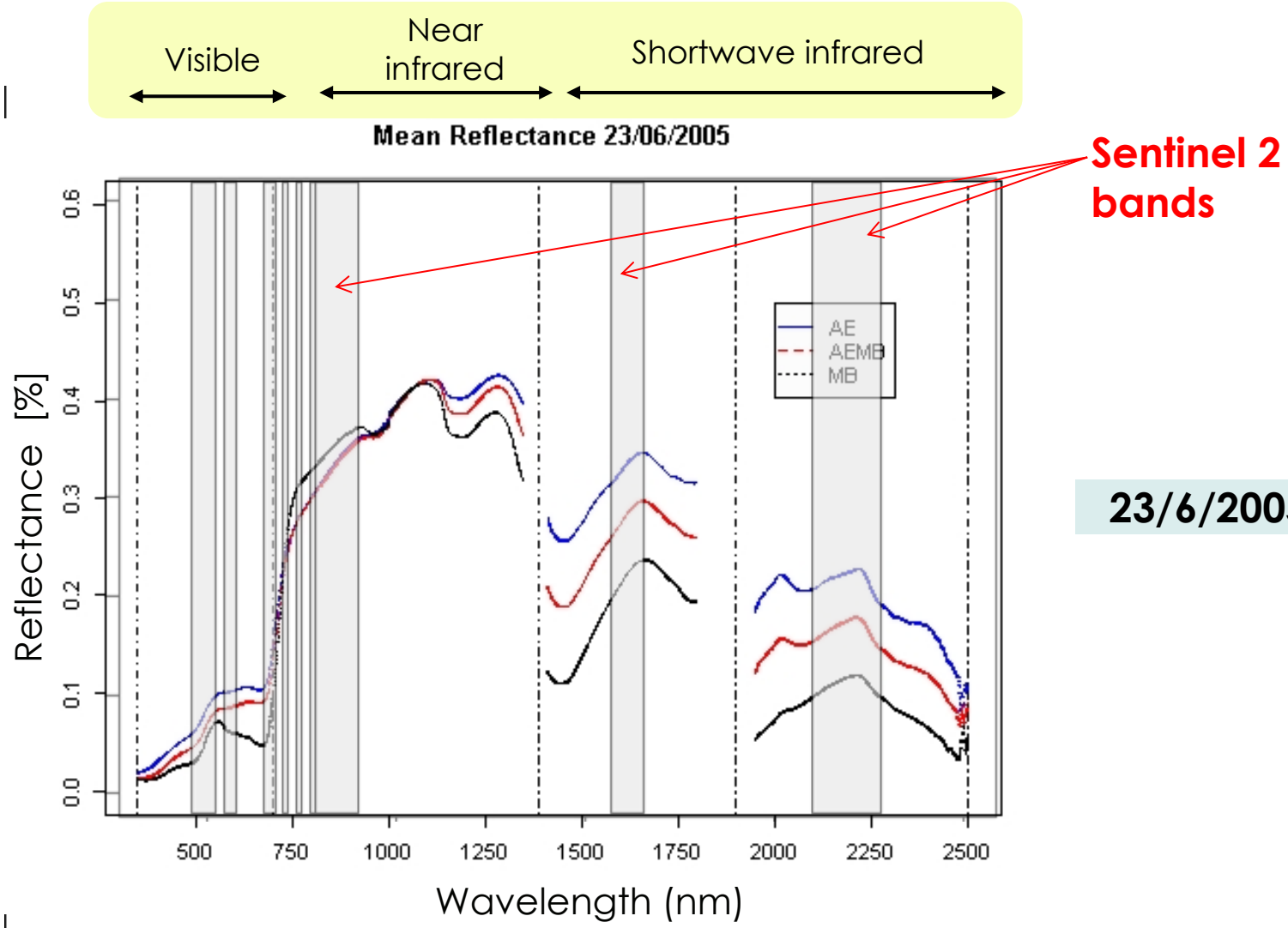


10/6/2005

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season

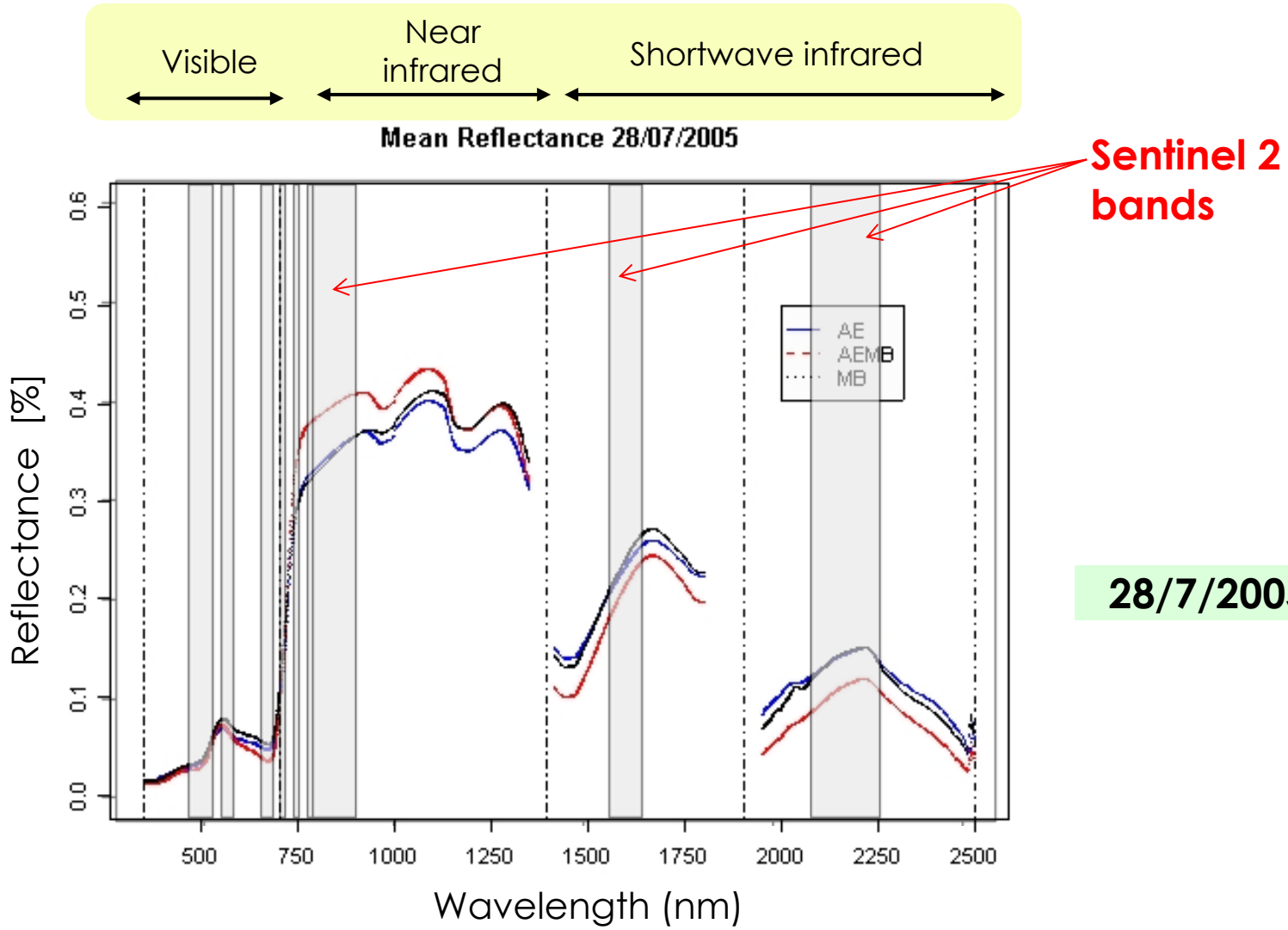


23/6/2005

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season

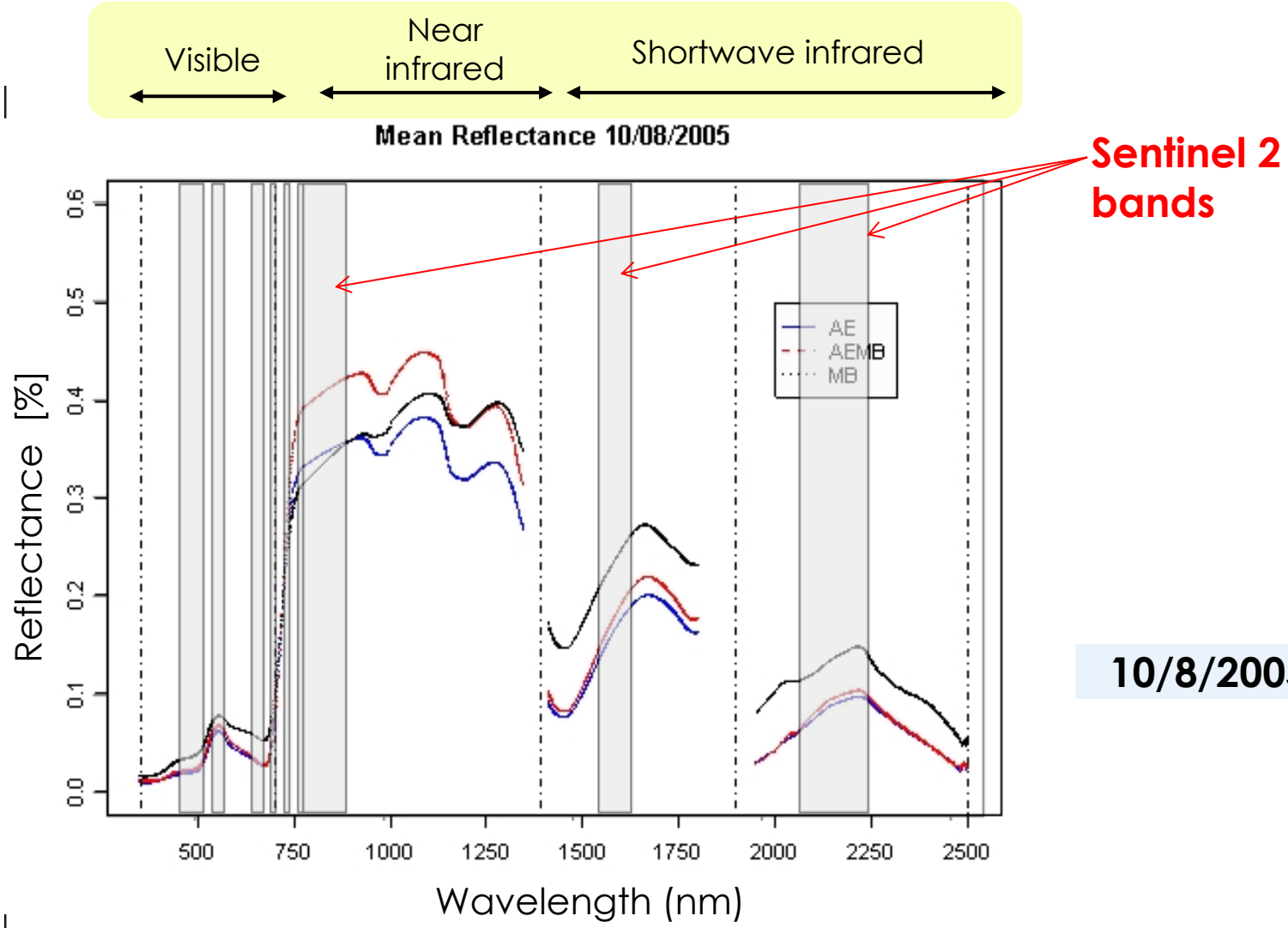


28/7/2005

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season

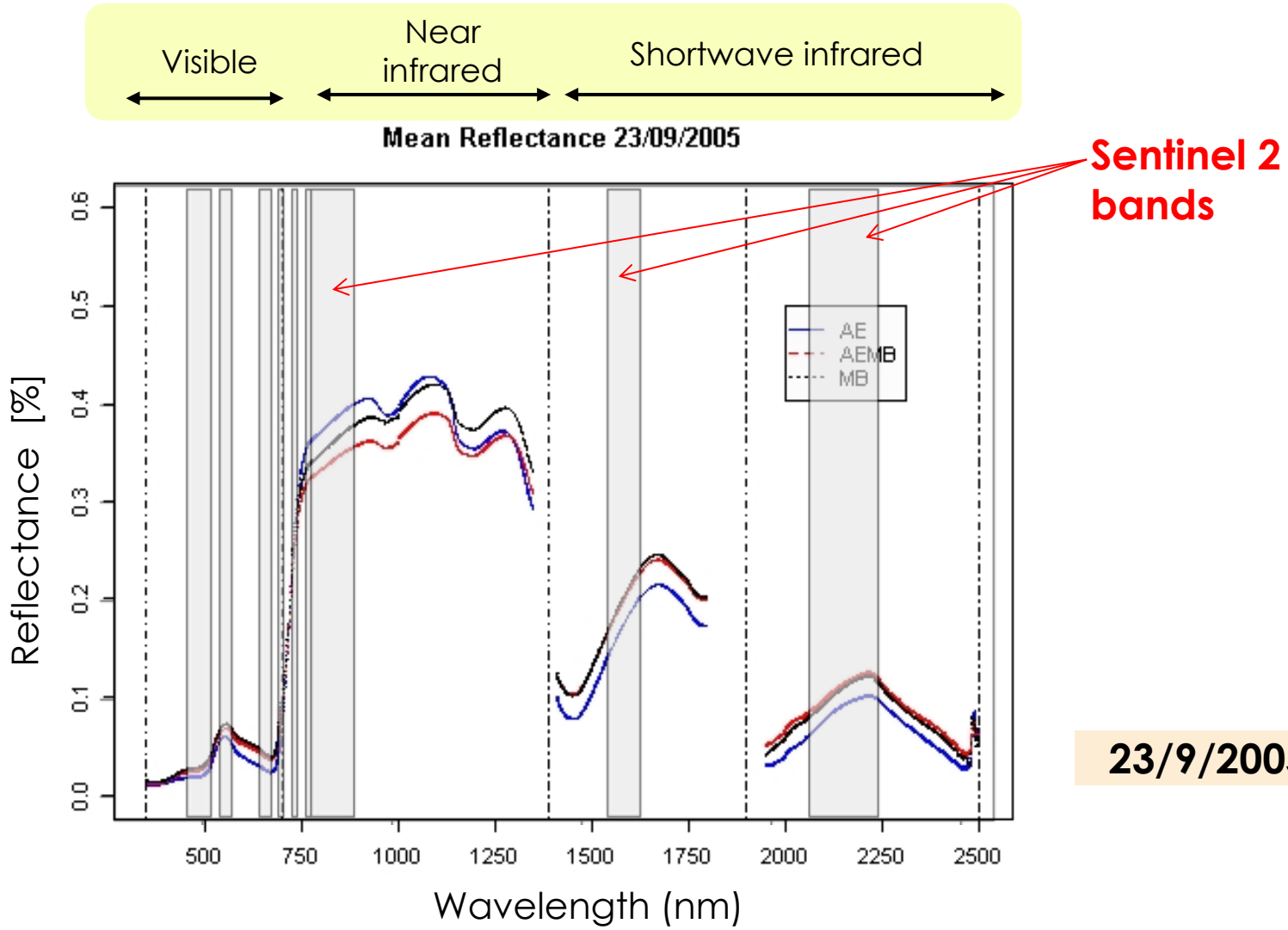


10/8/2005

http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Grassland Characteristics

Example 2005 season



23/9/2005

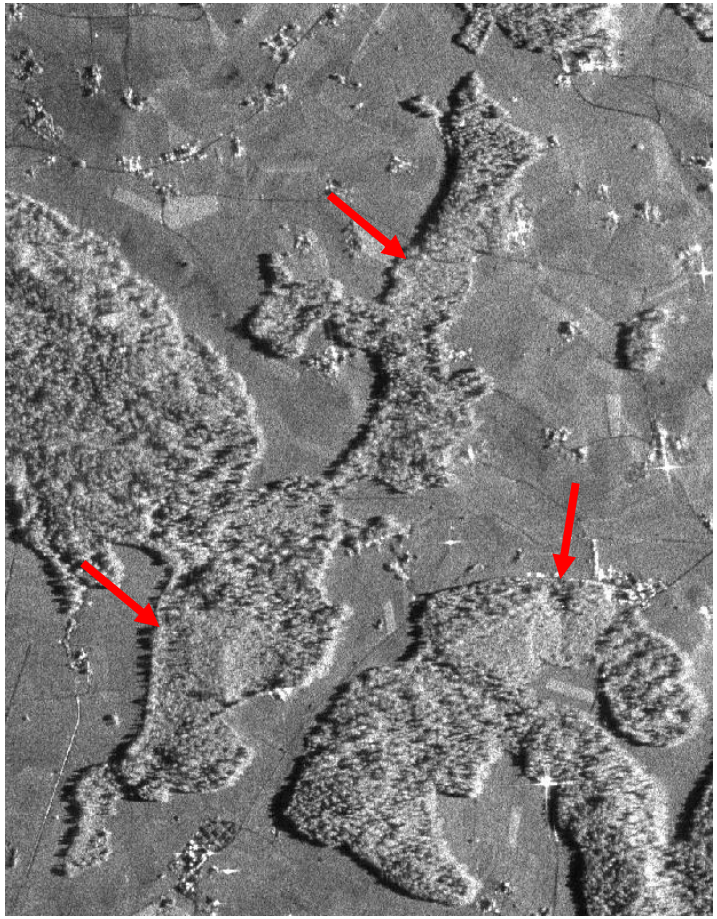
http://www.wsl.ch/staff/niklaus.zimmermann/research/achilleas.ehtml

Example Windthrow in Forest (Lothar)

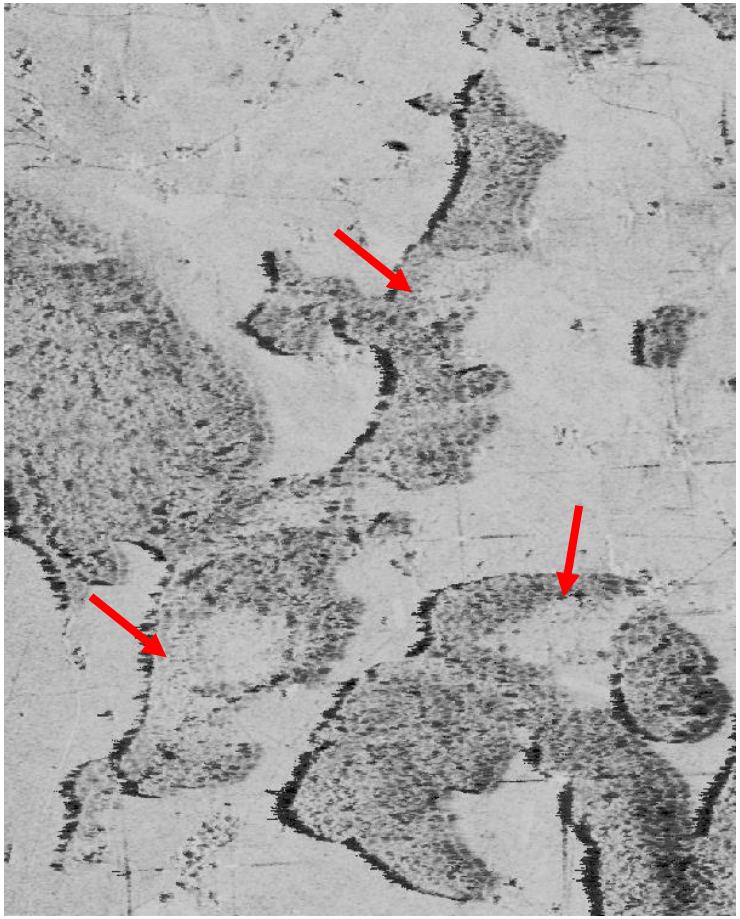
http://www.wsl.ch/fe/landschaftsdynamik/projekte/remote_sensing_methods_storm_damages_forests/index_EN

SAR X-band

backscatter coefficient



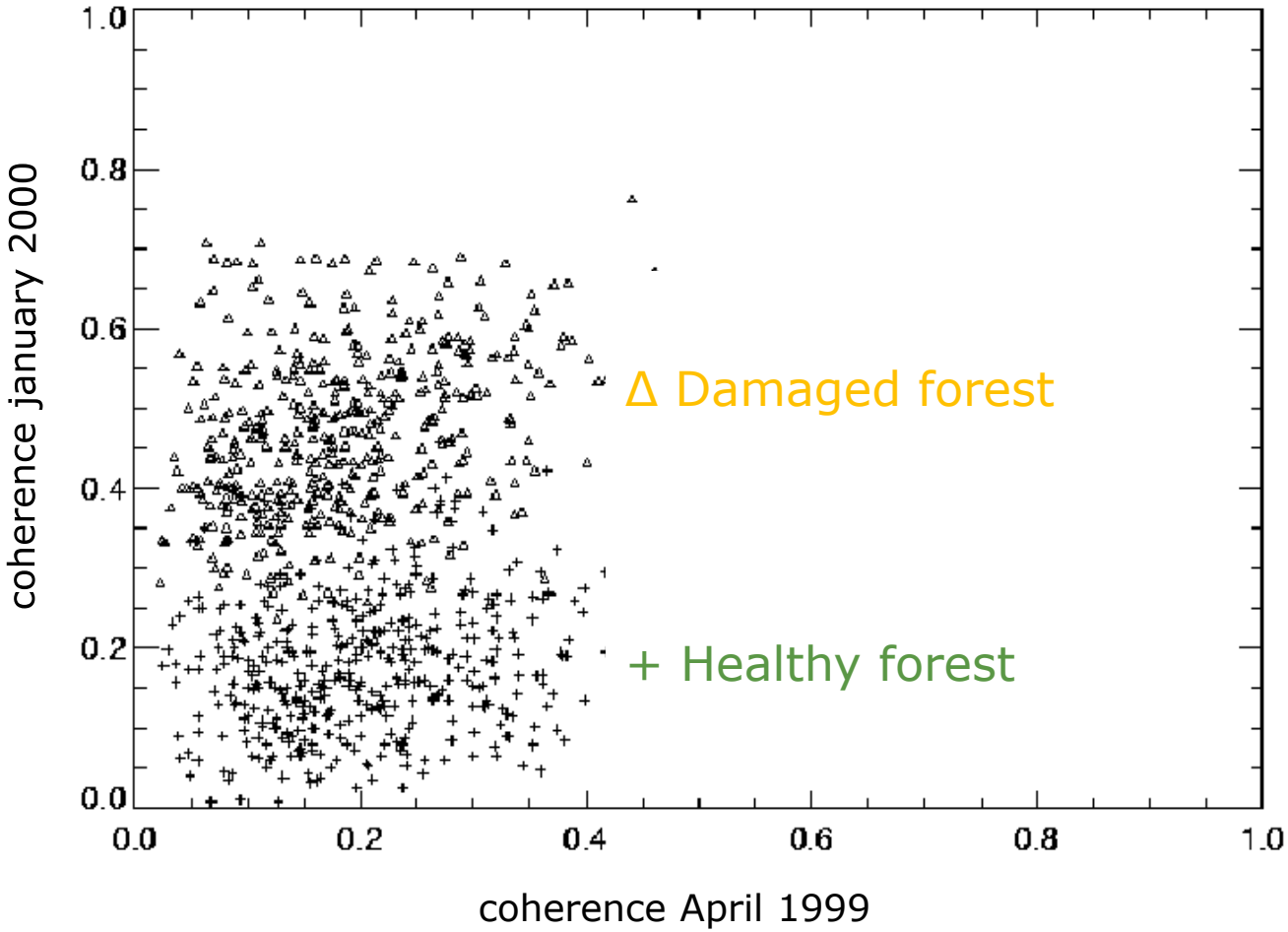
coherence



Example ERS 1/2 Windthrow in Forest (Lothar)

http://www.wsl.ch/fe/landschaftsdynamik/projekte/remote_sensing_methods_storm_damages_forests/index_EN

X band coherence



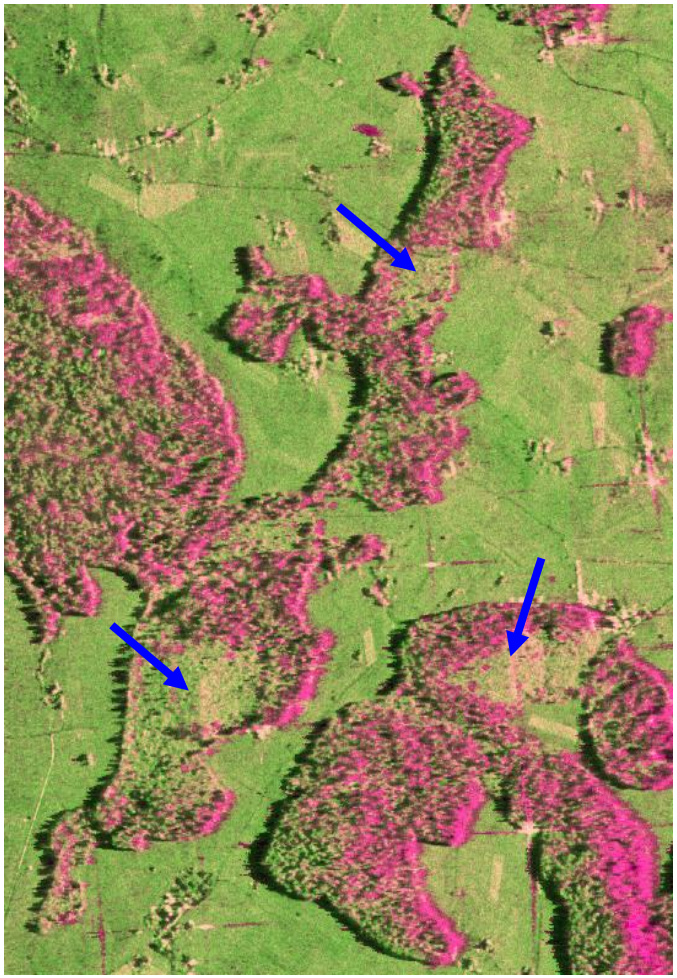
Example – ERS 1/2 Windthrow in Forest (Lothar)

Radar X-band

backscatter coefficient

+

coherence

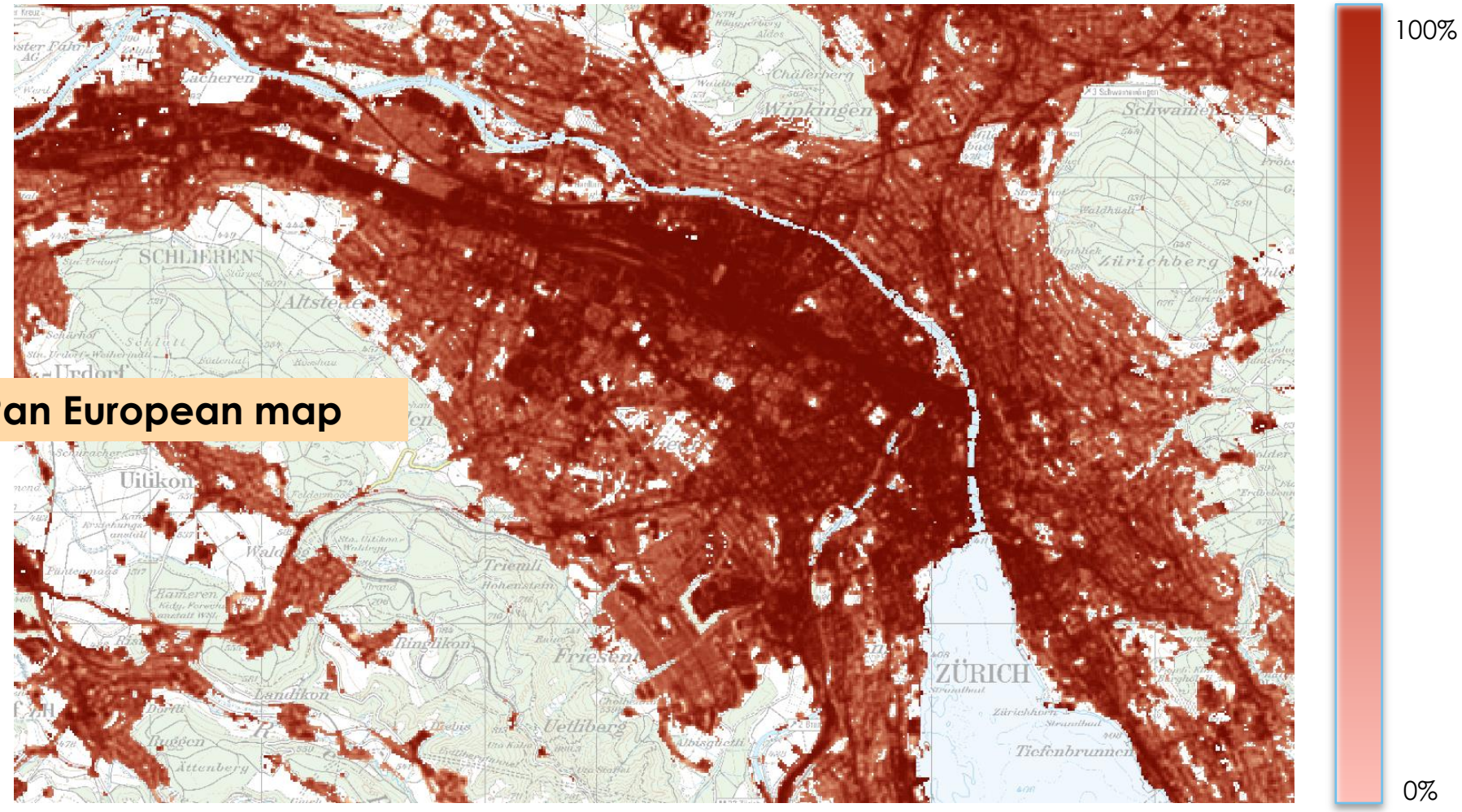


Storm damage

https://www.google.com/url?q=http://www.wsl.ch/dienstleistungen/publikationen/pdf/4955.pdf&sa=U&ved=0CA4QFjADahUKEwjt5K7so7DHAhUGPhQKHQDTArA&client=internal-uds-cse&usg=AFQjCNGC75B5M5Q0mHSSY9ouWYALsQzkog

Density of imperviousness (per 400 m²)

http://www.wsl.ch/fe/landschaftsdynamik/projekte/gmes_landcover_mapping/validation_results

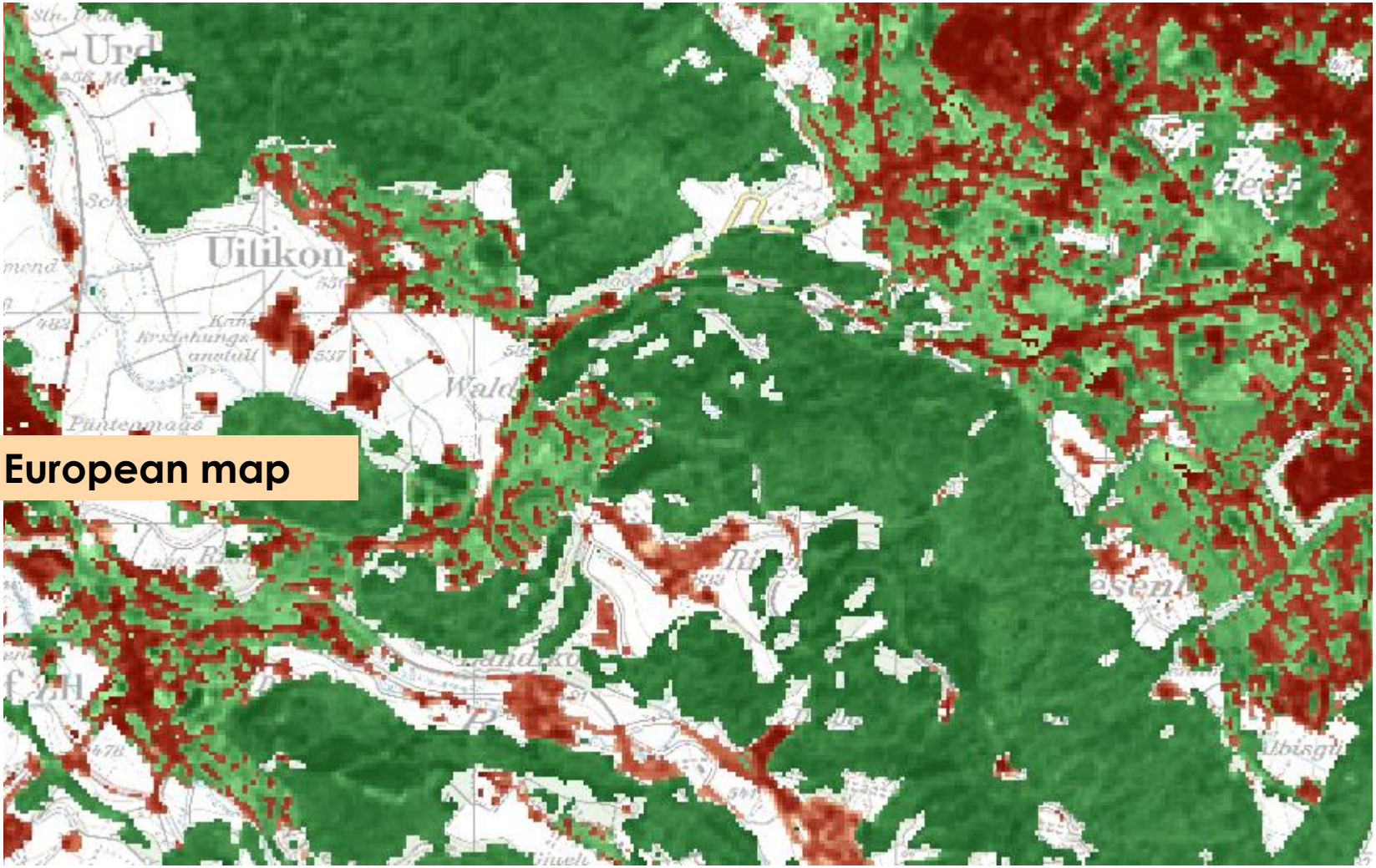


Density of tree cover (per 400 m²)

http://land.copernicus.eu/pan-european/high-resolution-layers/view

Tree Cover + Imperviousness Density (per 400 m²)

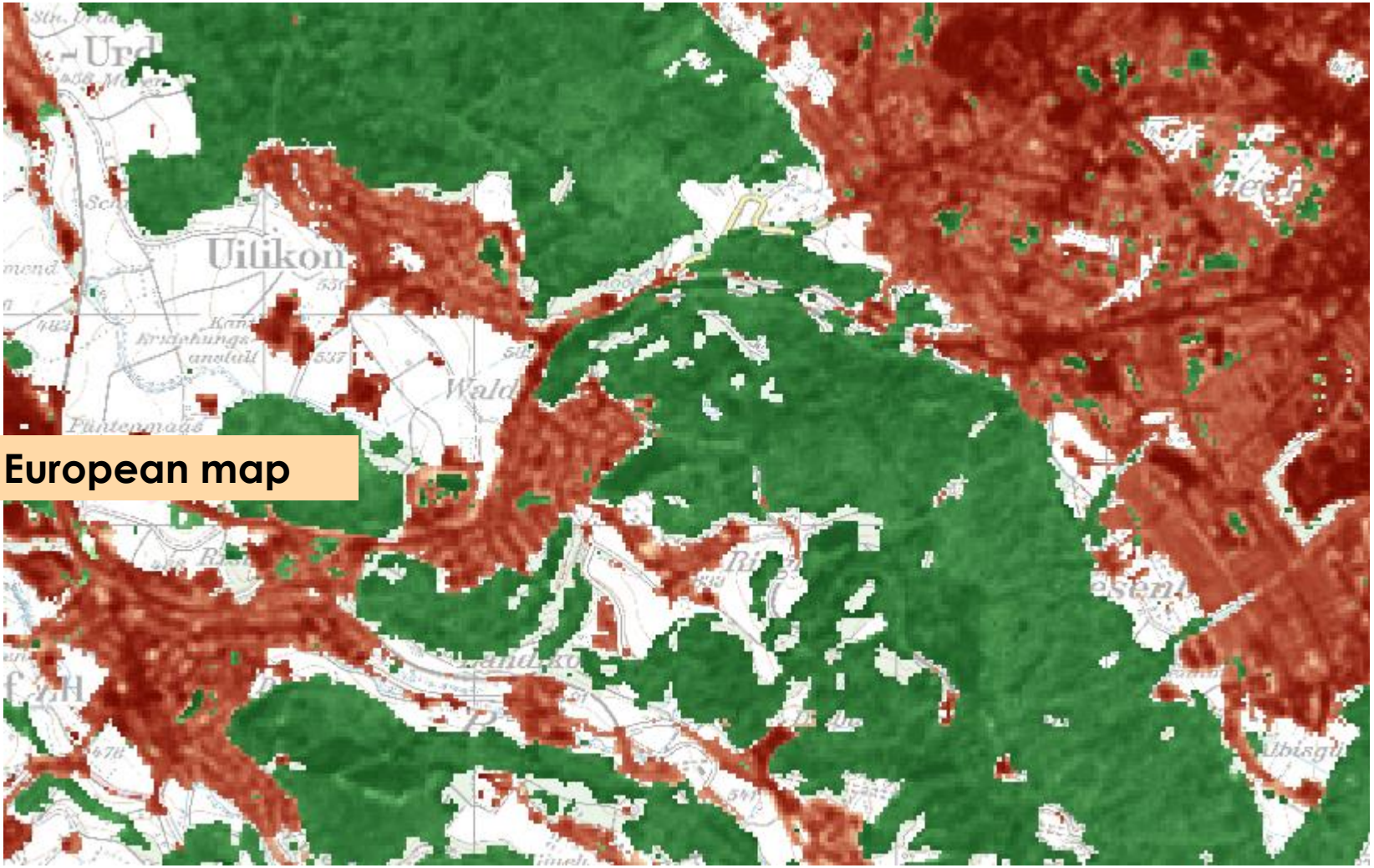
http://land.copernicus.eu/pan-european/high-resolution-layers/view



Pan European map

Tree Cover + Imperviousness Density (per 400 m^2)

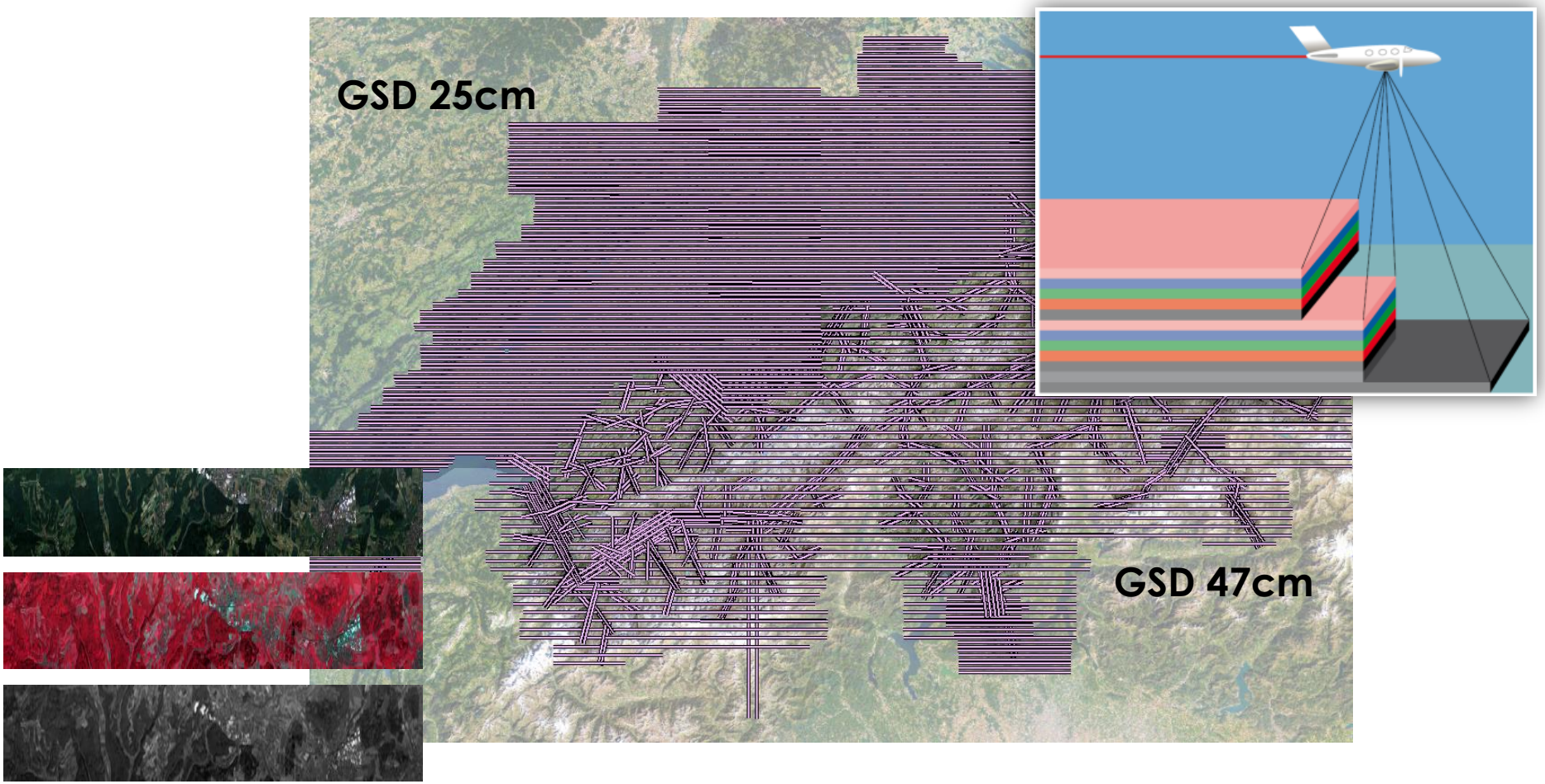
http://land.copernicus.eu/pan-european/high-resolution-layers/view



Pan European map

Example Digital Surface Model (DSM)

Since 2005: ADS40/80 sensor –
updating every 3 years by Federal Office of Topography swisstopo



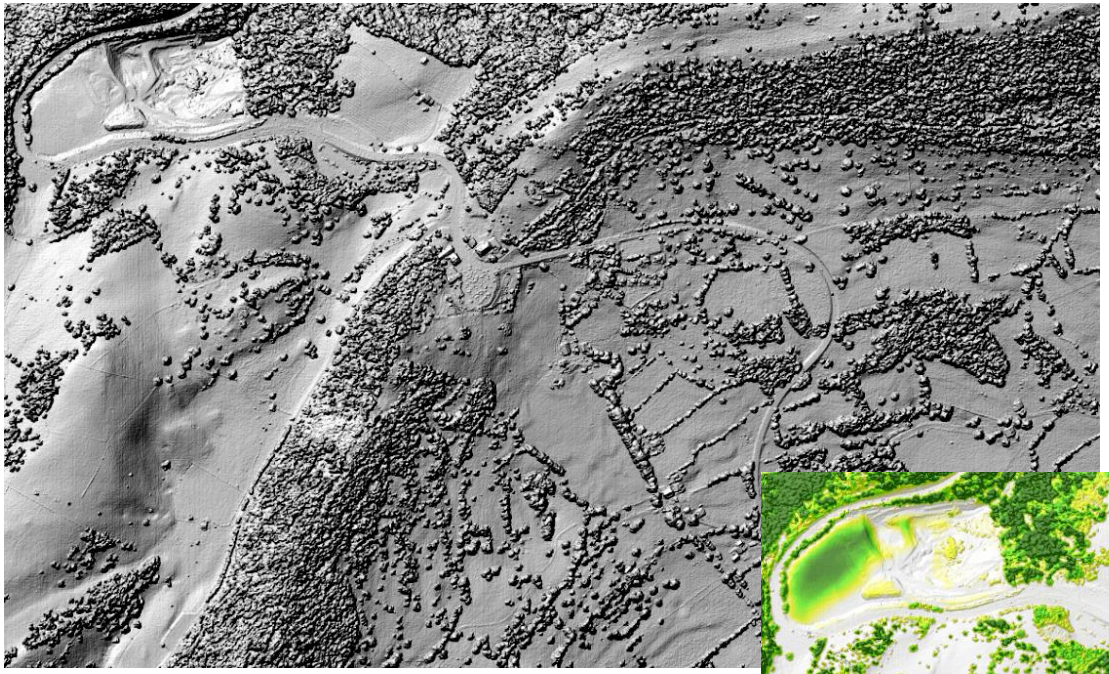
Example Digital Surface Model (DSM)

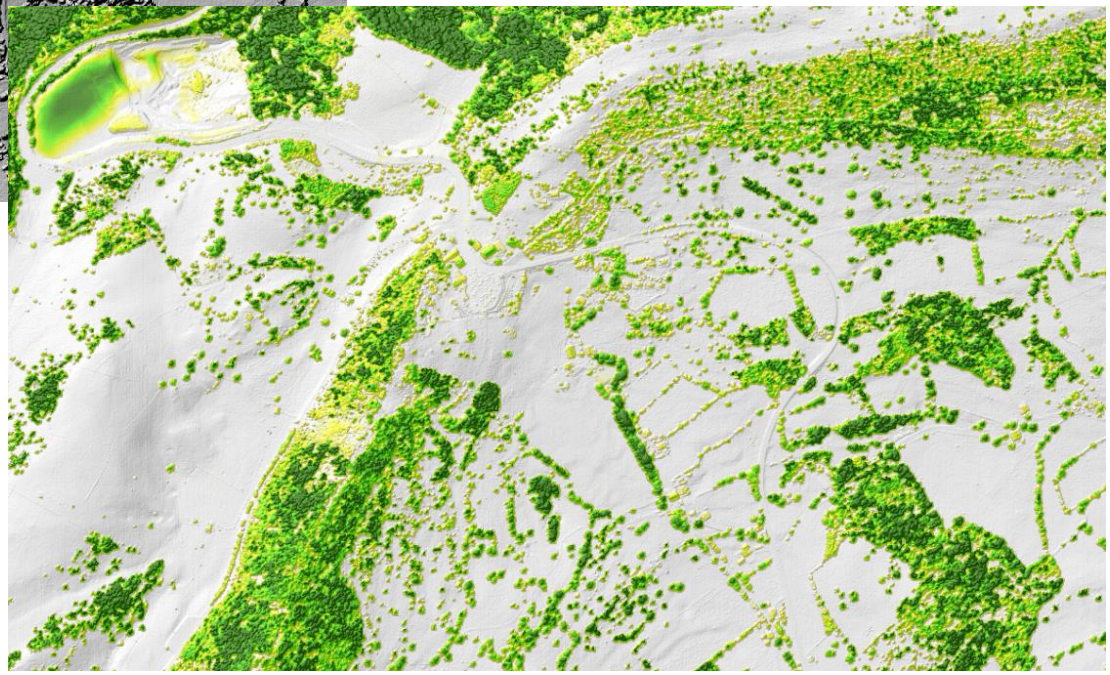
Calculation Time: ~ 180 days
~41‘000 km^2
20 jobs running parallel

http://www.wsl.ch/fe/landschaftsdynamik/projekte/switzerland_3d/index_EN

Example Vegetation Height Model

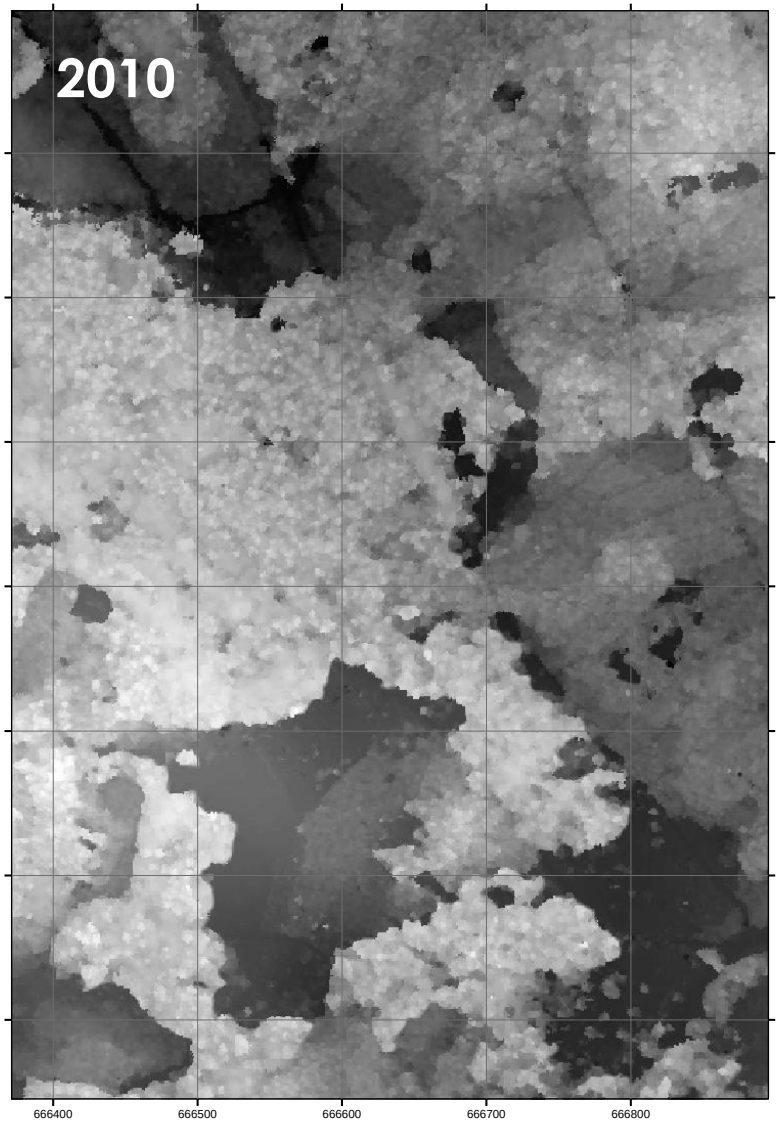
http://www.wsl.ch/fe/landschaftsdynamik/projekte/switzerland_3d/index_EN

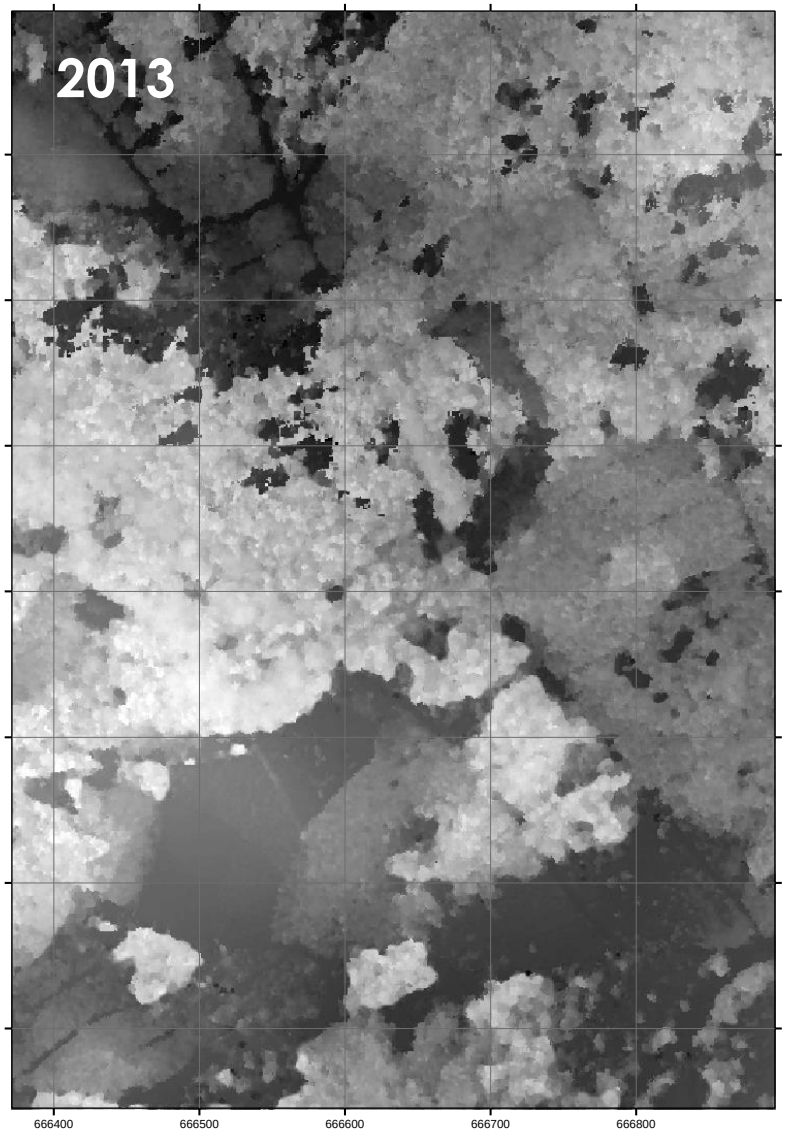




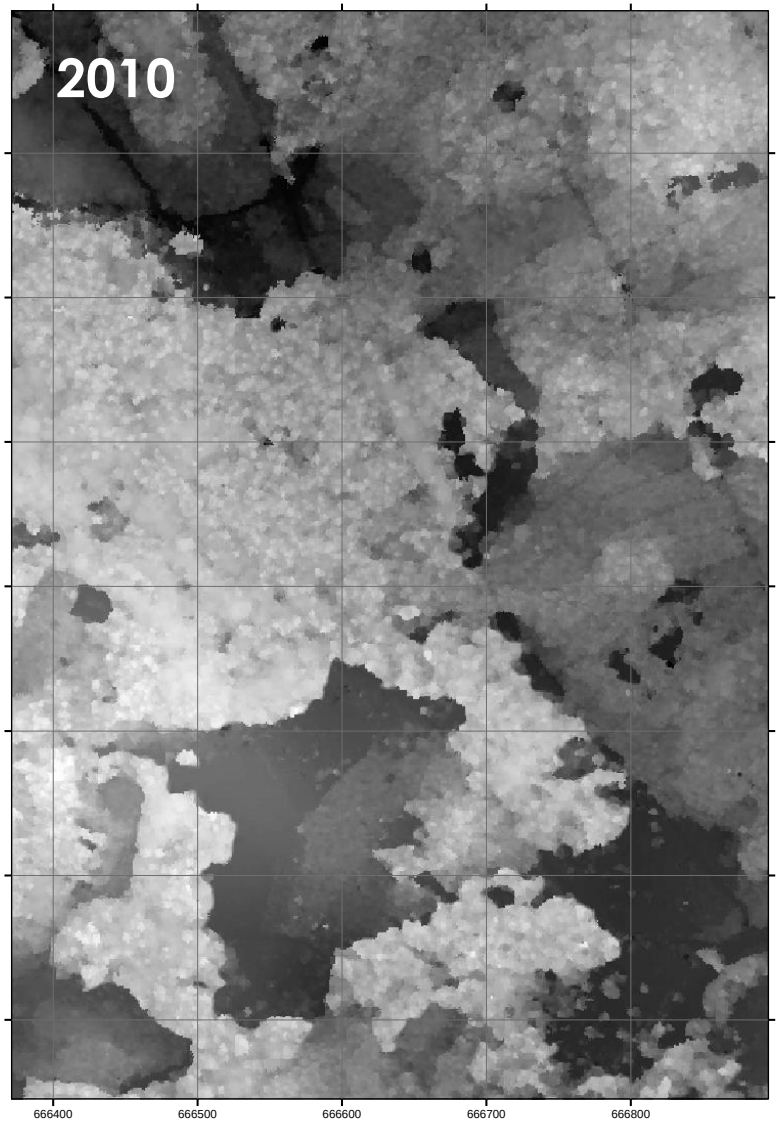
Based on swissAlti3D

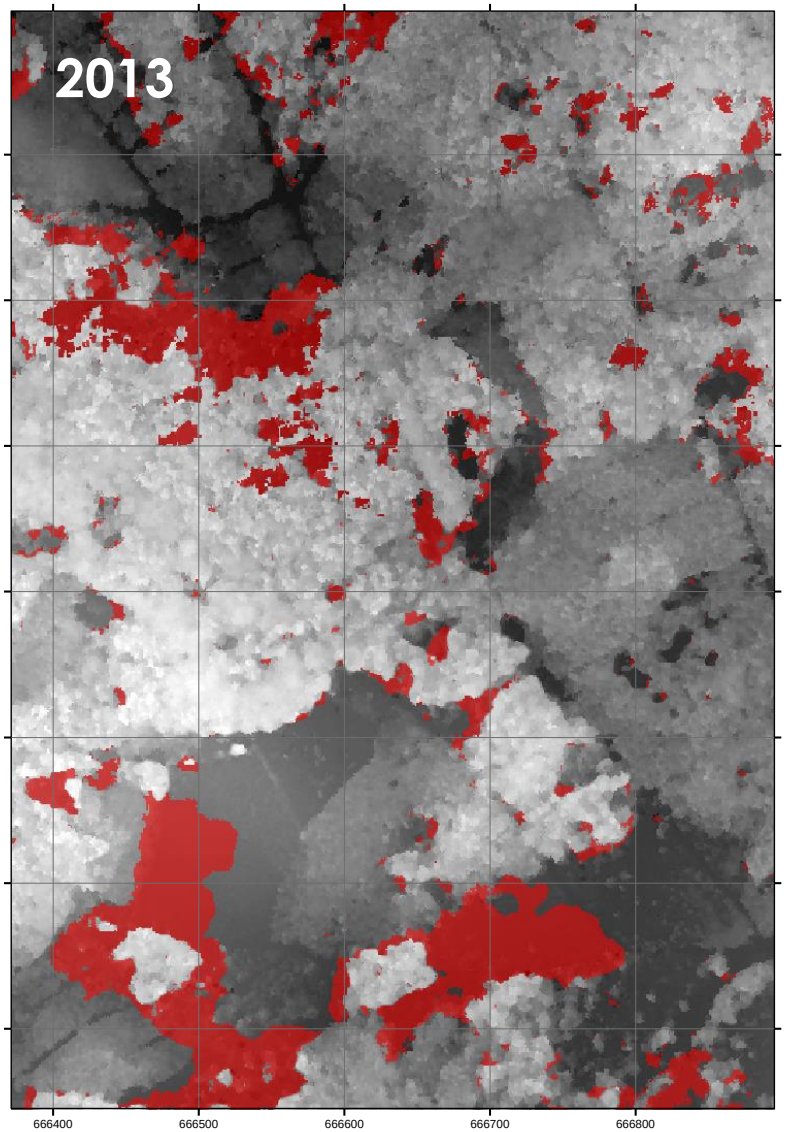
Example Forest Change





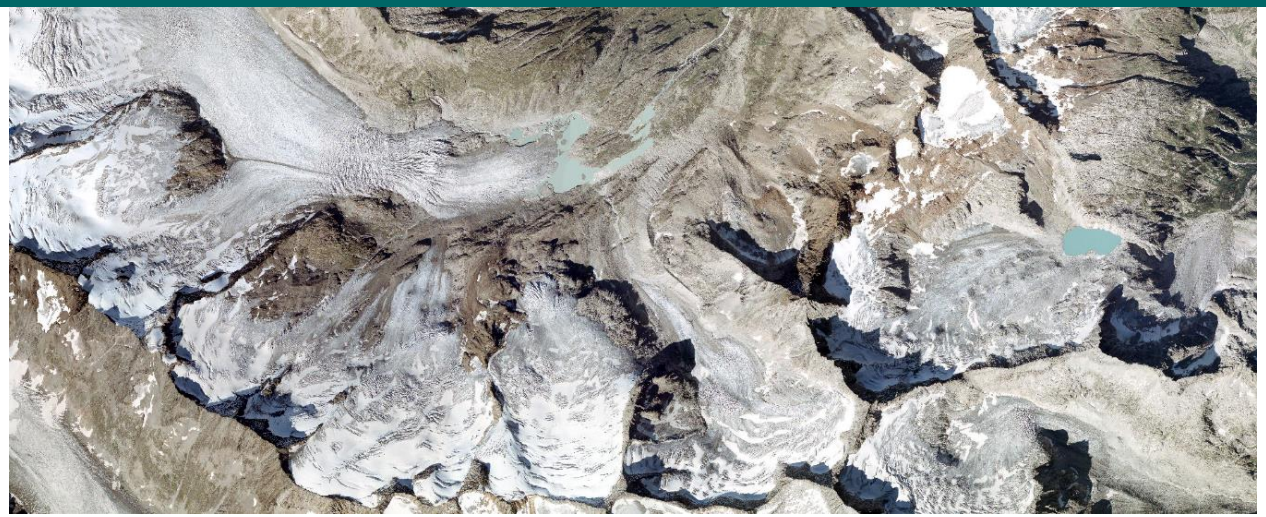
Example Digital Surface Model (DSM)

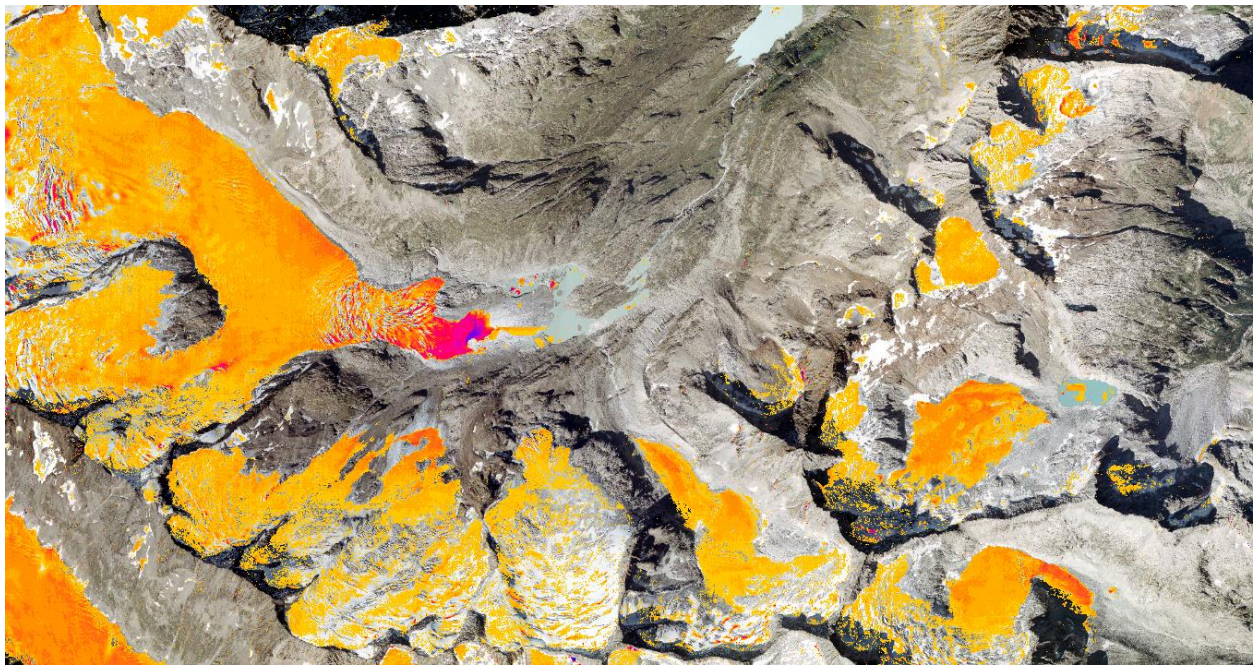




Example High Resolution Snow Height Maps

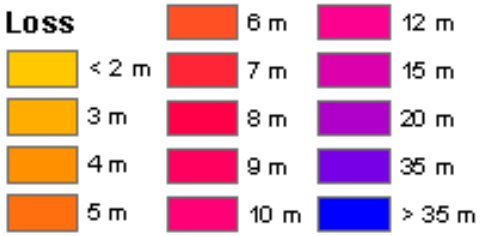
(660’000/162’400)





2009 - 2010

2010 - 2011



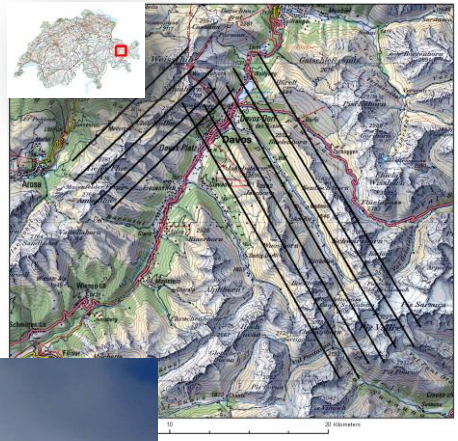
http://www.wsl.ch/fe/warnung/projekte/DEMalpine/index_EN

Example High Resolution Snow Height Maps

https://www.google.com/url?q=http://www.wsl.ch/fe/landschaftsdynamik/projekte/switzerland_3d/2013_Ginzler_Marty_Buhler_DGPF&sa=U&ved=0CAgQFjACahUKEwi2osS0p7DHAhXMbhQKHfgBD4U&client=internal-uds-cse&usg=AFQjCNEp_YipluNBGHQHMmPMiYcWYne57g

Test Area Davos

- **47 km² / 135 km²**
- **1470 – 3200 m asl**



Why ?

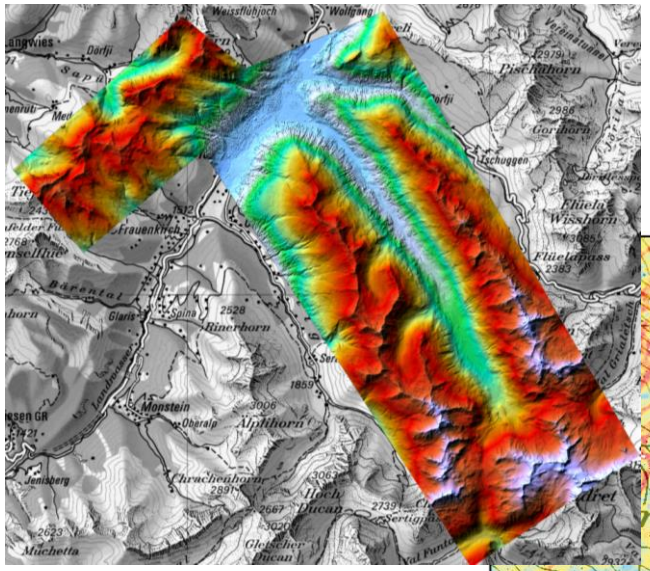
Snow hydrology (snow water equivalent, energy production, meltwater estimation)

Avalanche research (mass balance, wind saltation, avalanche risks)

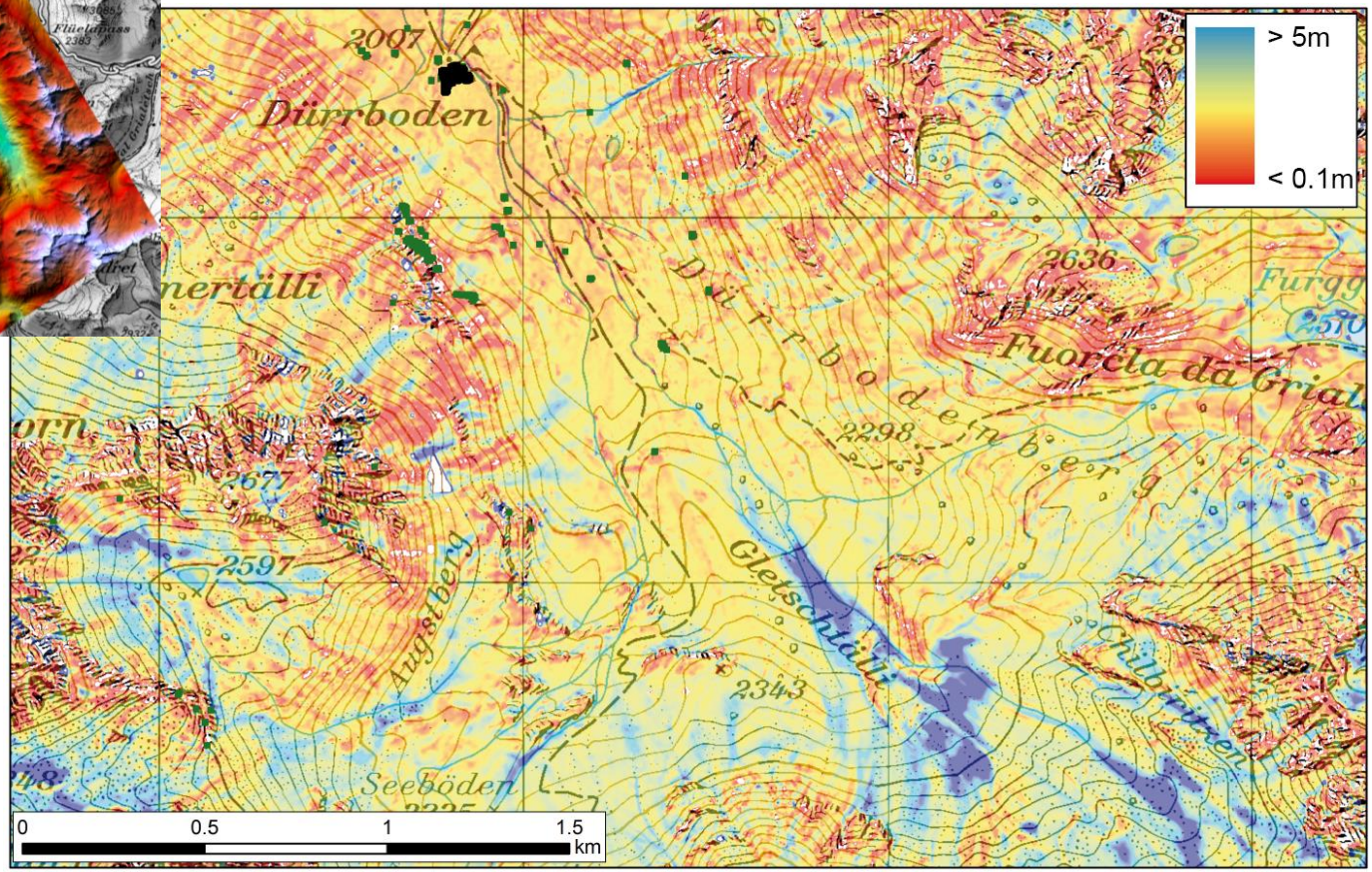
Ecology (time of becoming snow free, habitat modelling, plant ecology)

Example High Resolution Snow Height Maps

http://www.slf.ch/ueber/organisation/warnung_praevention/projekte/Fernerkundung/index_EN



Testgebiet Dischmatal

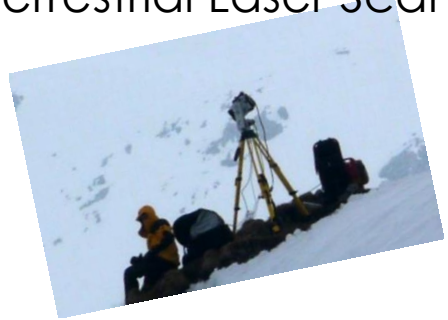


Example High Resolution Snow Height Maps

http://www.slf.ch/ueber/organisation/warnung_praevention/projekte/Fernerkundung/index_EN

References

- DGNSS 137 points
- Terrestrial Laser Scan



Comparison ADS winter DSM with Leica GPS measuremets

μ = 0.20m
median = 0.26m
Std.dev = 0.34

	TLS	ADS	Diff.
mean snow height	2.29m	2.36m	7cm
standard deviation	0.95m	0.94m	1cm

Monitoring with UAVs

http://www.wsl.ch/info/mitarbeitende/boesch/index_EN

Asctec Falcon 8

Camera: Sony NEX-7 24MP, 20mm

Payload: ~600g

Weight: 2200g

Sensefly eBee

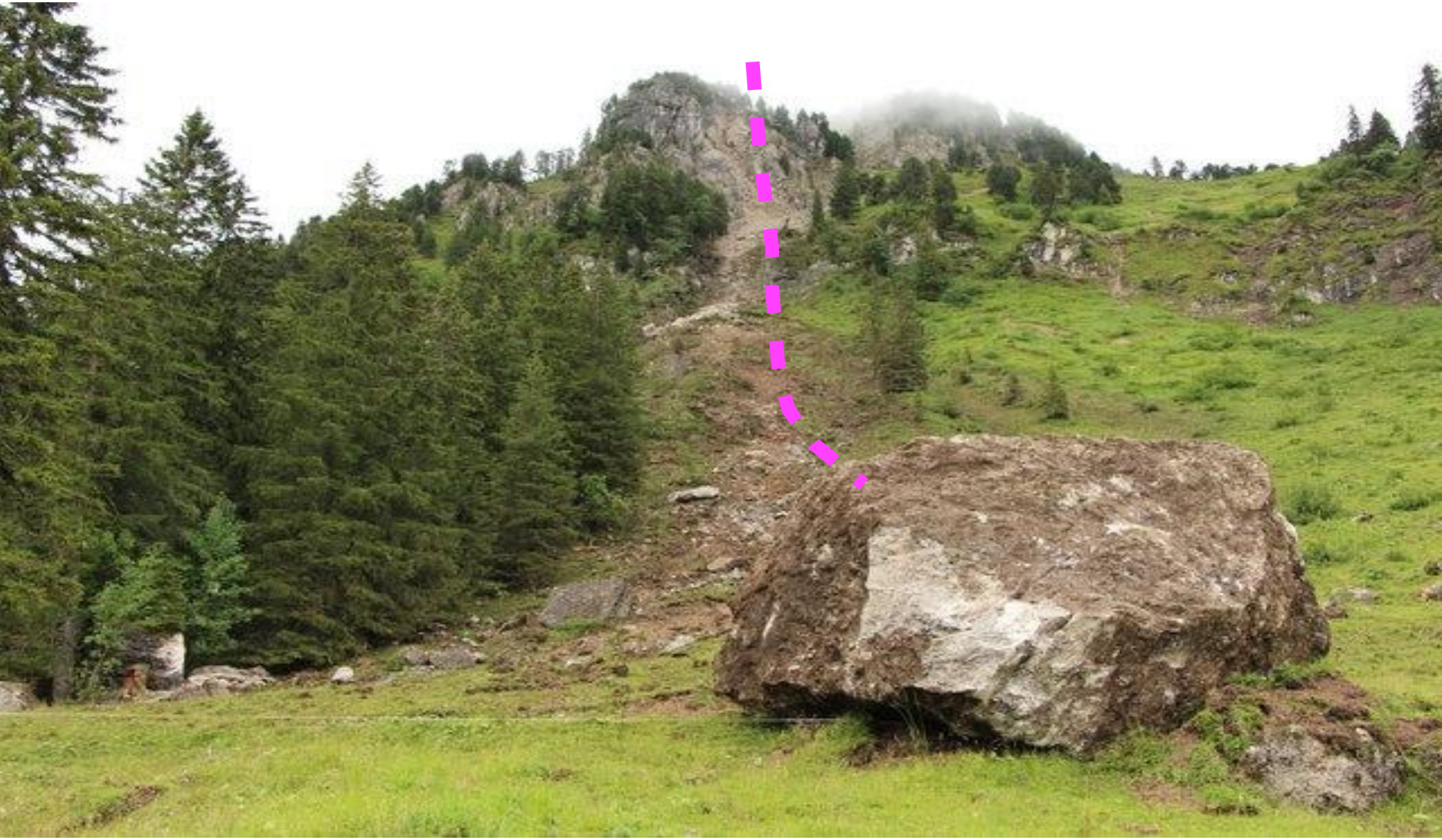
Camera: Canon S110 16MP

Payload : ~180g

Weight : 700g

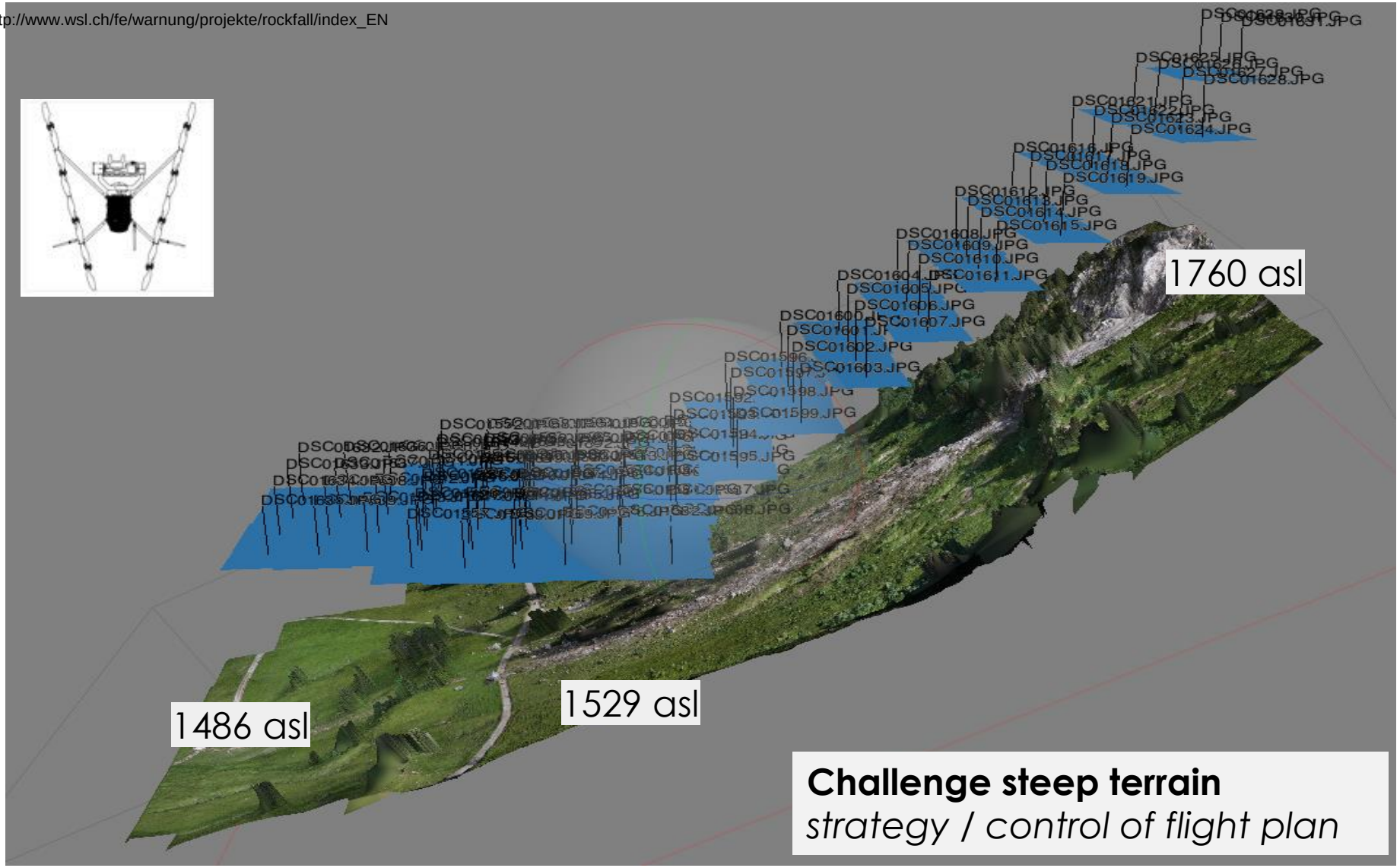
Rockfall Roggenstock/Sz 30.07.2014

http://www.wsl.ch/fe/warnung/projekte/rockfall/index_EN



Rockfall Roggenstock/Sz 30.07.2014

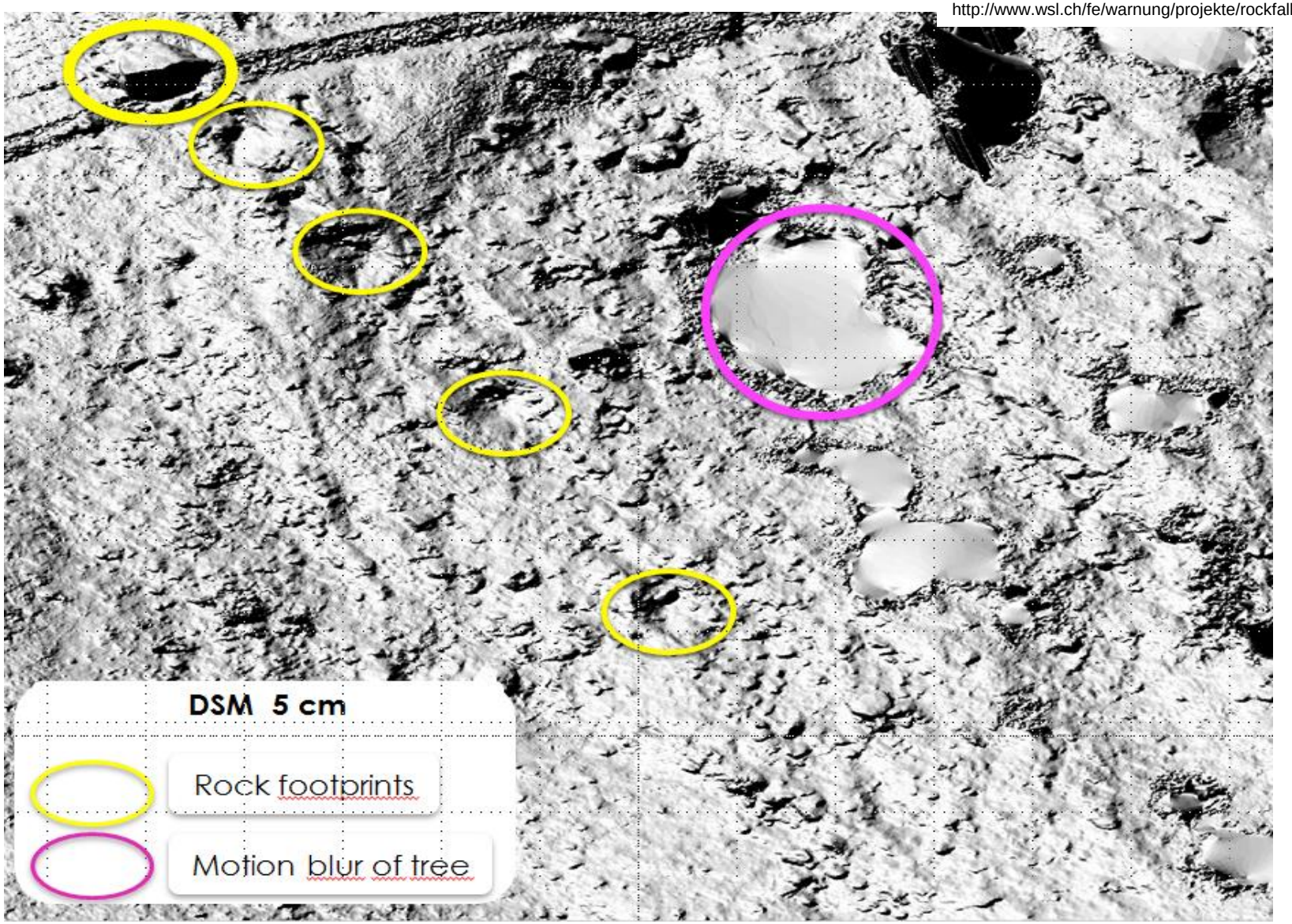
http://www.wsl.ch/fe/warnung/projekte/rockfall/index_EN



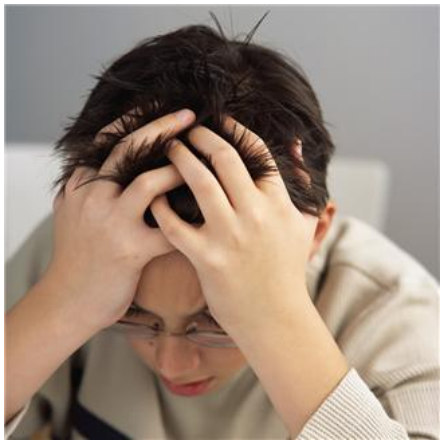
Challenge steep terrain
strategy / control of flight plan

Rockfall Roggenstock/Sz 30.07.2014

http://www.wsl.ch/fe/warnung/projekte/rockfall/index_EN

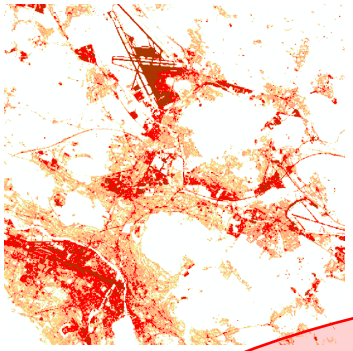


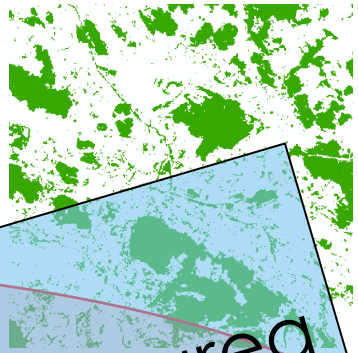
Verification / QA

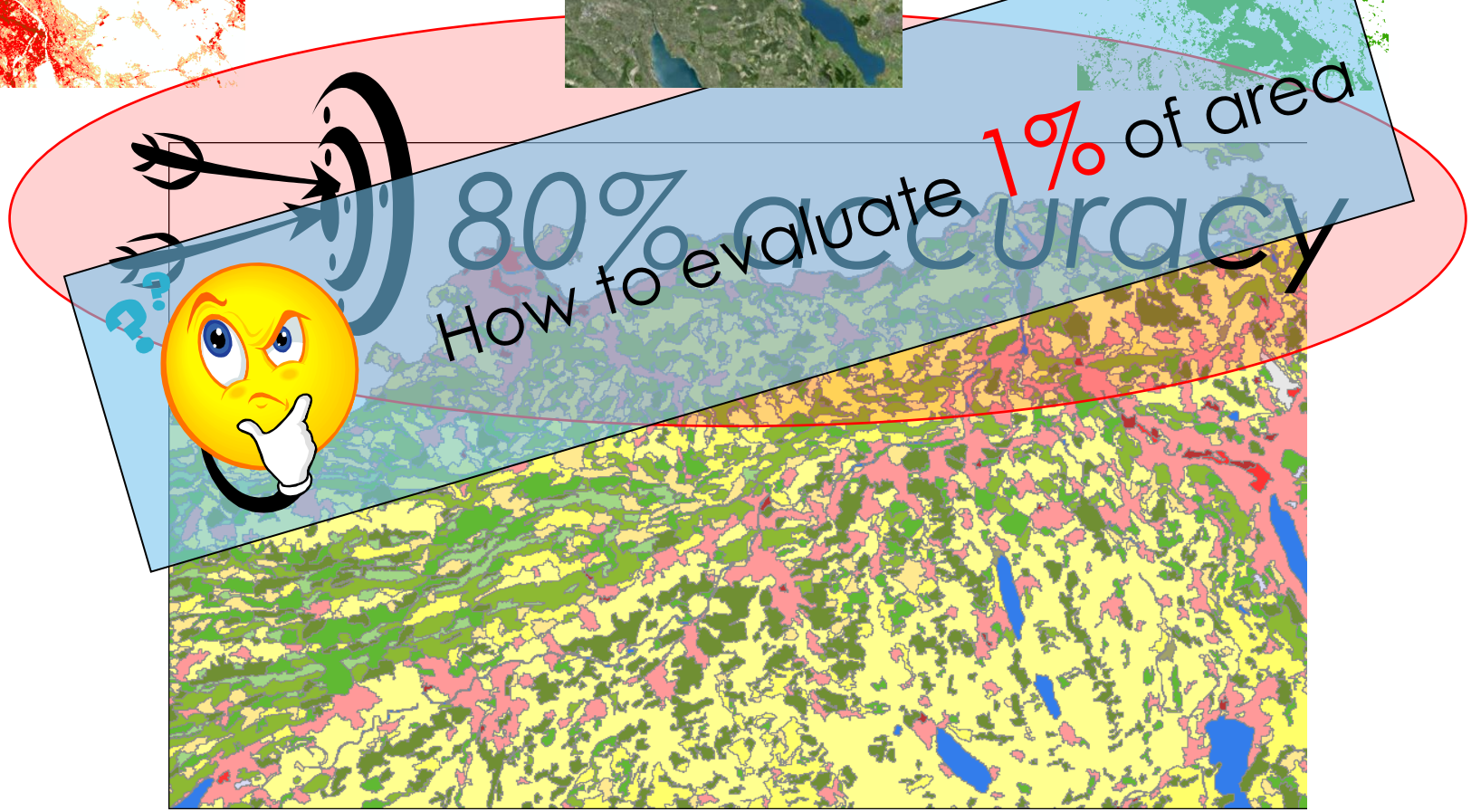


- ***Geometric accuracy:***
  - Wrong border (totally ↔ transition zone)
  - Omission errors
  - Orthorectification of image base
- ***Thematic accuracy :***
  - same class on higher level (e.g. deciduous ↔ coniferous)
  - different class (e.g. agriculture ↔ natural grassland)
- ***Reference data:***
  - Availability
  - Geometric accuracy
  - Interpretation
  - Product type dependent

Verification / QA

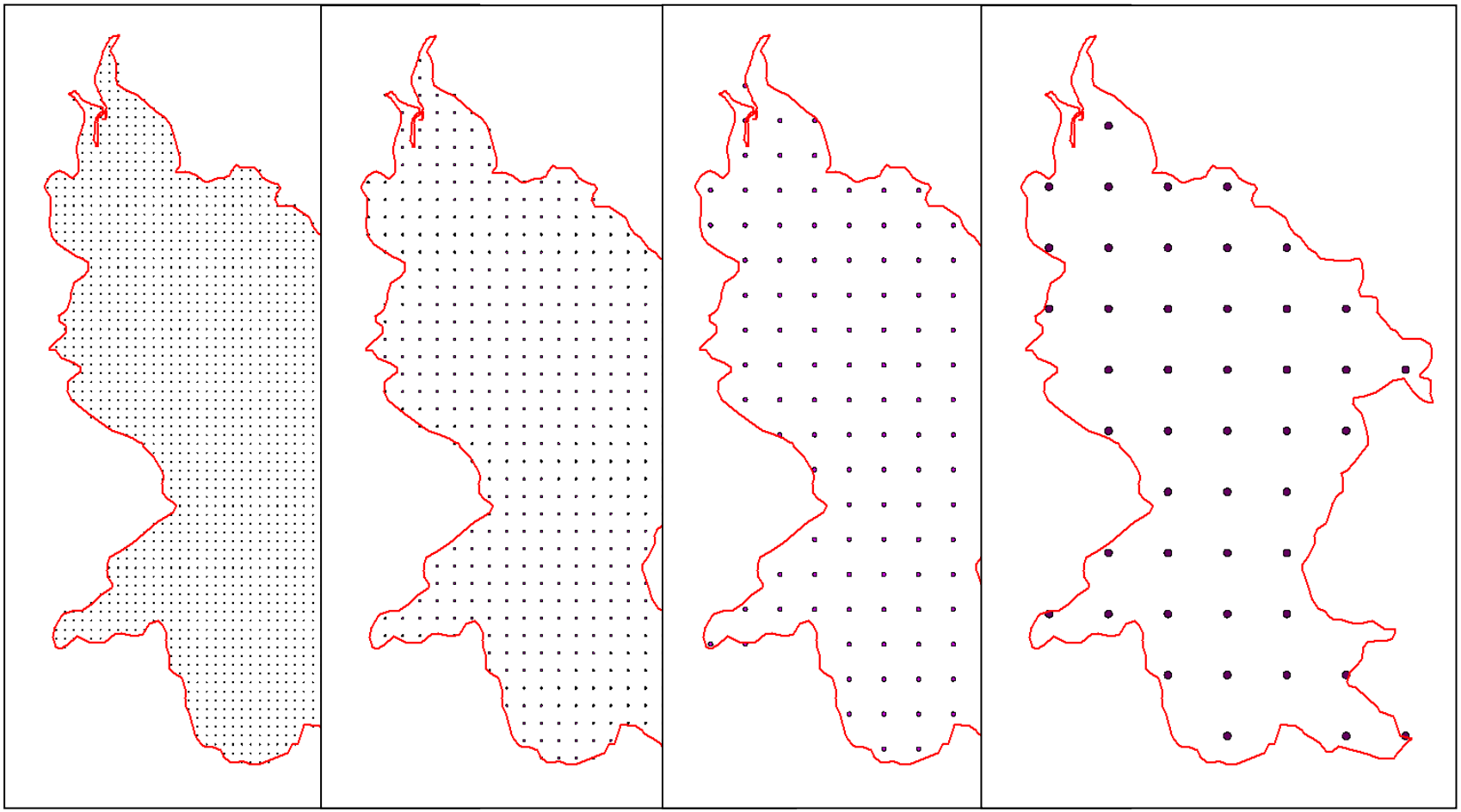




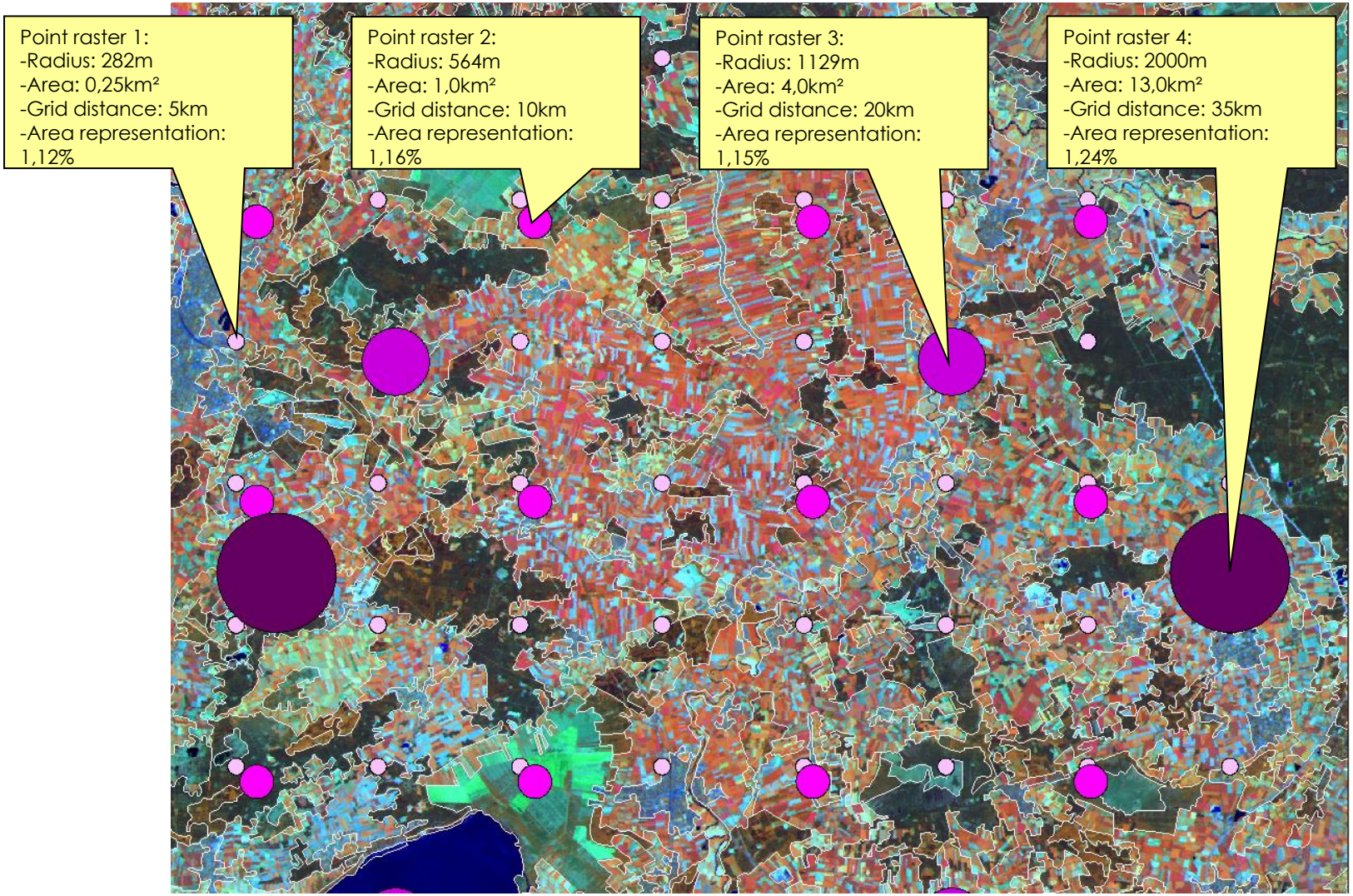


Verification / QA

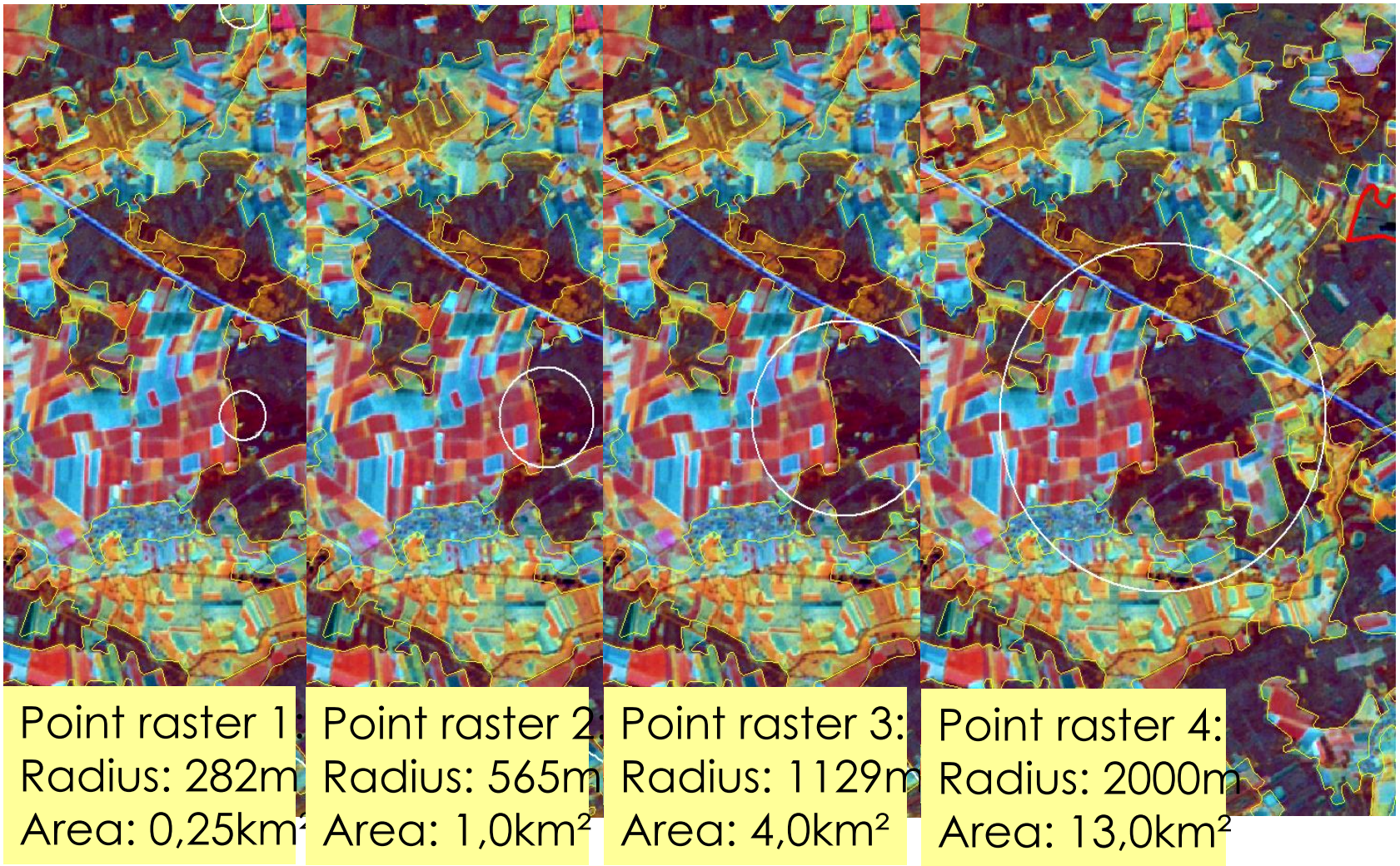
1% of area: sample size ↔ sample density



Verification / QA



Verification / QA



Verification - accuracy measurements

$$\text{Overall accuracy} = \frac{\text{total number of correct classifications}}{\text{total number of classifications}}$$

$$\text{User accuracy} = \frac{\text{number of correct classifications}}{\text{total number of classifications in the category}}$$

$$\text{Producer accuracy} = \frac{\text{total number of correct classifications}}{\text{total number of groundtruth pixels}}$$

$$\text{Kappa coefficient} = \frac{\text{Overall accuracy - random distribution}}{\text{1 - random distribution}}$$

commission = 1- user accuracy

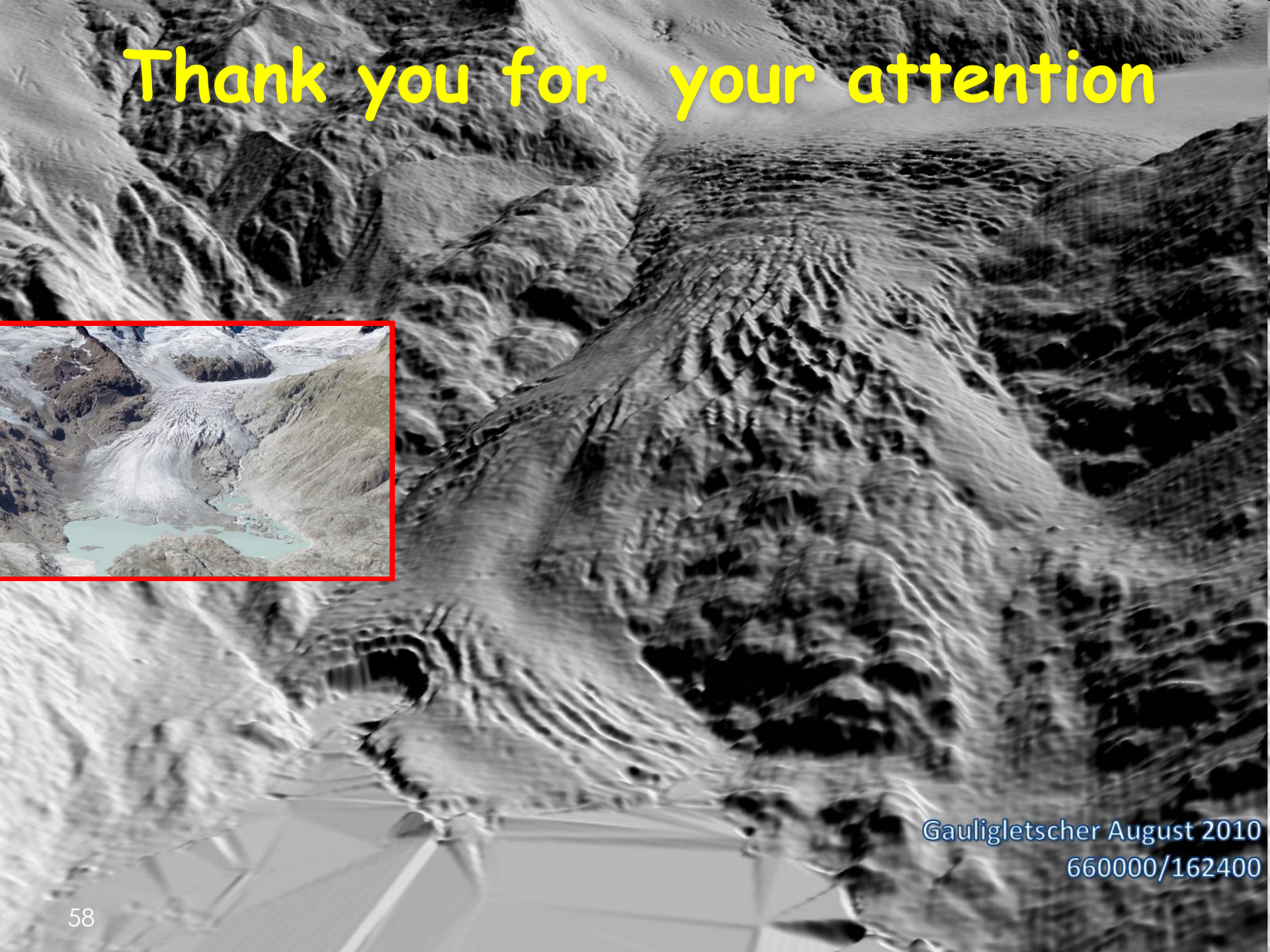
omission = 1-producer accuracy

QA_Example: European Tree cover map

http://www.wsl.ch/info/mitarbeitende/steinmei/index_EN

Comparison to 9'907 NFI Plots

	Forest		Non Forest	
	Commission error	Omission error	Commission error	Omission error
CH	**2.9** ±0.3	**3.0** ±0.3	**1.3** ±0.1	**1.3** ±0.1

		Commission error	Omission error	Commission error	Omission error
	+	**9.4** ±1.9	**8.6** ±1.7	**5.5** ±1.0	**5.2** ±0.9
	-	**0.7** ±0.5	**0.7** ±0.5	**0.2** ±0.1	**0.2** ±0.1
altitude 400m (5 strata)	+	**7.7** ±1.1	**19.7** ±2.7	**2.8** ±0.8	**2.9** ±0.8
	-	**1.7** ±0.5	**5.1** ±0.7	**0.4** ±0.1	**0.4** ±0.1
exposition (4 strata)	+	**9.5** ±1.3	**10.5** ±1.0	**9.1** ±0.9	**8.3** ±0.9
	-	**8.2** ±1.1	**7.6** ±1.0	**3.8** ±0.5	**3.9** ±0.6
slope (3 strata)	+	**7.7** ±1.0	**8.8** ±0.7	**6.7** ±0.5	**6.8** ±0.5
	-	**0.2** ±0.1	**7.4** ±1.0	**1.4** ±0.2	**3.0** ±0.3

Thank you for your attention