

# CadasterENV Sweden

A satellite image of Earth showing the continent of Europe and the northern part of Africa. The image is in a false-color composite, with land areas appearing in shades of green and yellow, and water bodies in dark blue. The curvature of the Earth is visible at the top of the frame.

—  
Time series in support of a multi-purpose land  
cover mapping system at national scale

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# Background – CadasterENV Sweden

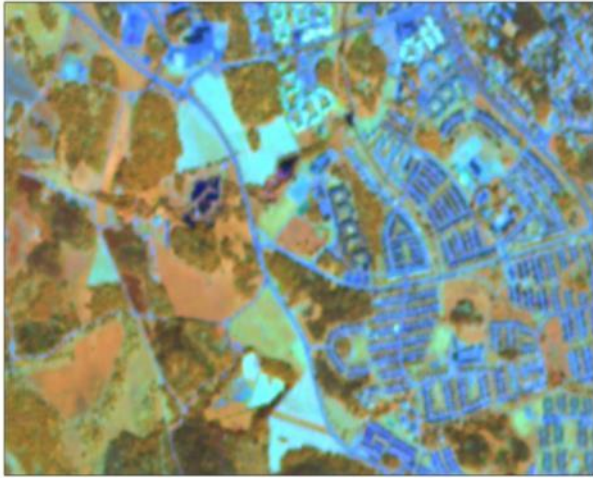
- National mapping (at 10 m and 2 m pixel size)
- Stage1 funded by ESA
- Developed 2012 – 2015 by Metria
- Defined by Swedish national and regional users



# Stepwise development

- Stage 1: CadasterENV – ESA financed project 2012-15
  - Spot 5 (10 m) [large areas] and Plèiades [urban]
  - ALS – airborne lidar (DEM and object heights)
  - Ancillary data (buildings, water bodies, LPIS..)
- Stage 2: Time series based methods for specific purposes (2016) using data from
  - Spot5Take5 and Sentinel-2
- Stage 3: Full scale implementation and production
  - Budget for project start mid 2016
  - Aim for full production 2017 – 2018
  - Added support from new users

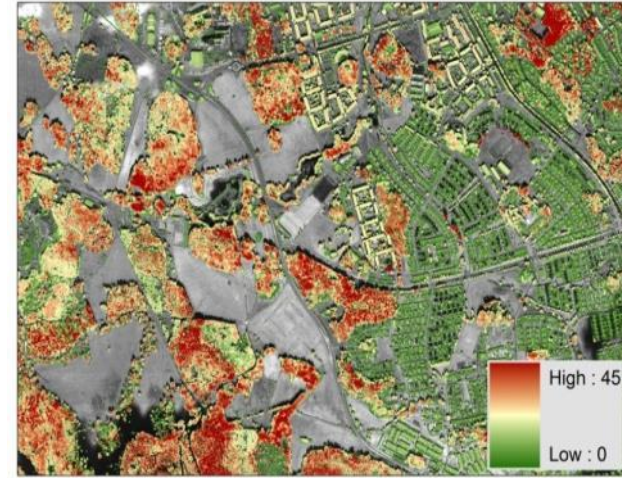
# Primary Input data



SPOT5 10m



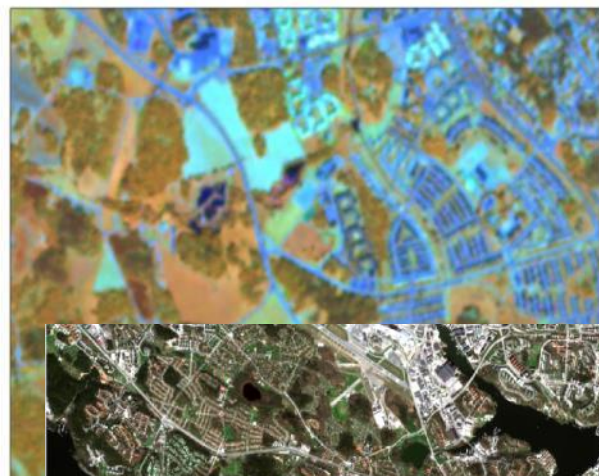
VHR (alt orthophoto) 0,5-2m



LIDAR



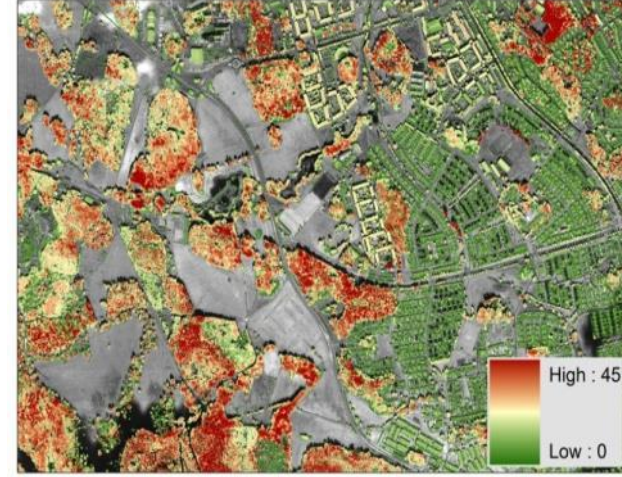
# Primary Input data



Sentinel 2A/2B 10m



VHR (alt orthophoto) 0,5-2m



LIDAR

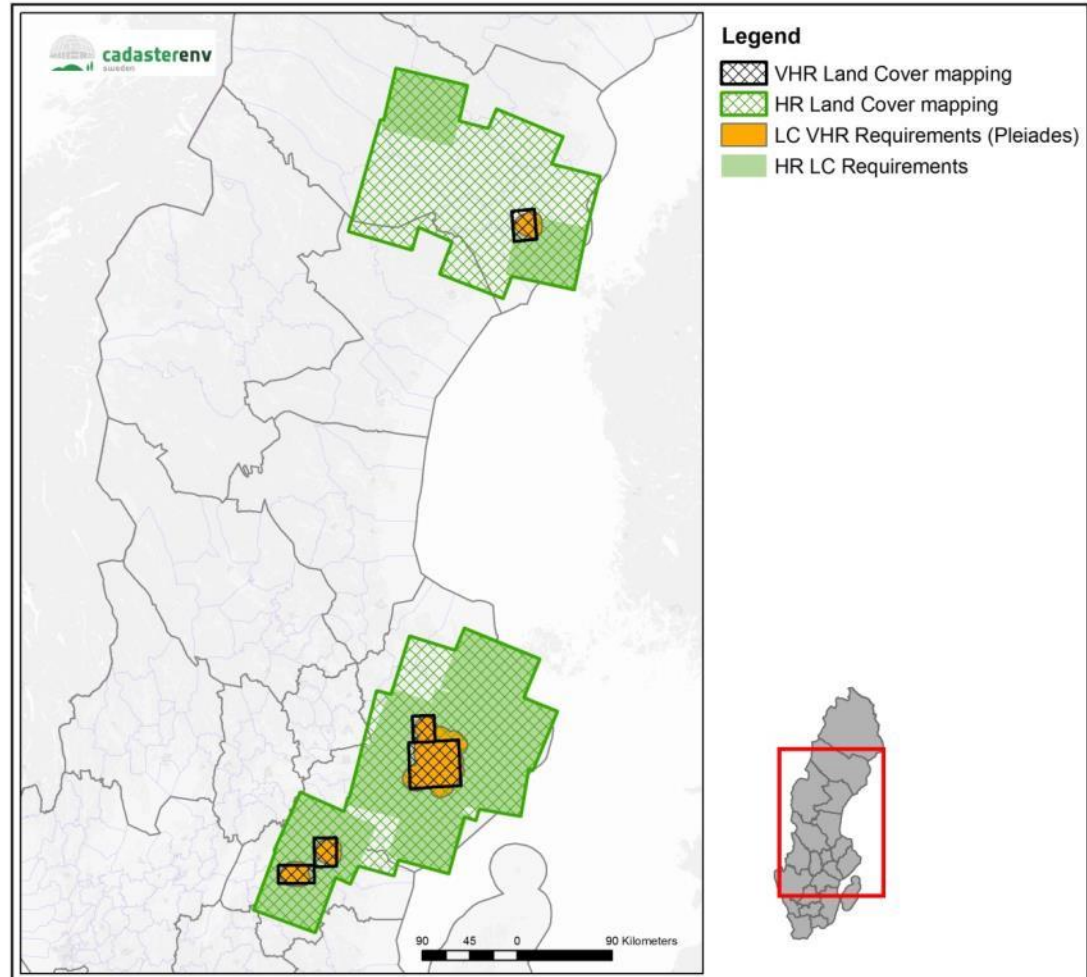
# Mapped areas - stage1

## HR (10 m resolution):

- Stockholm county
- Östergötland county
- Västerbotten county

## VHR (2 m resolution MS):

- Stockholm
- Linköping
- Norrköping
- Umeå





# Products

## Joint user defined legend meeting a diversity of requirements

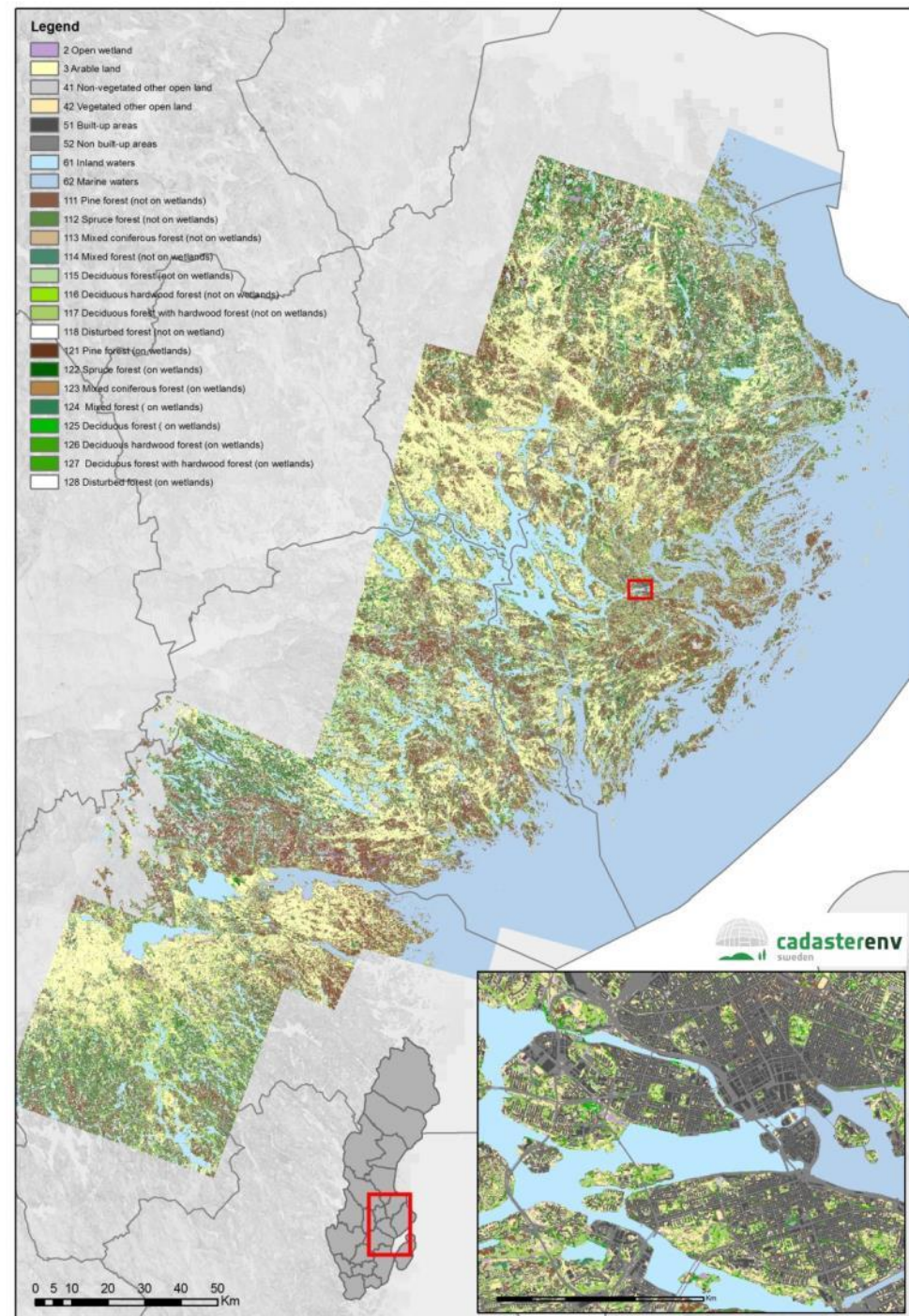
### ➤ Map with 24 thematic classes

- ✓ Level 1-3
- ✓ HR / VHR
- ✓ Raster 10 / 2 meter
- ✓ MMU
- HR: 10 m pixel product and 0.05 – 0.1 ha for different classes*
- VHR: 2 m pixel product*

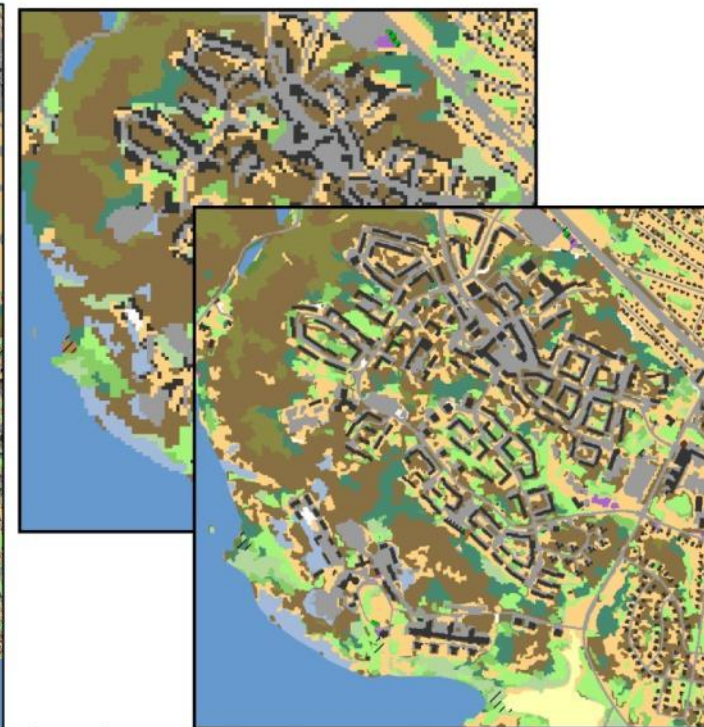
- ✓ Many forest classes

### ➤ Separate layers (attributes)

- ✓ Land use
- ✓ Tree height
- ✓ Tree density
- ✓ Productivity





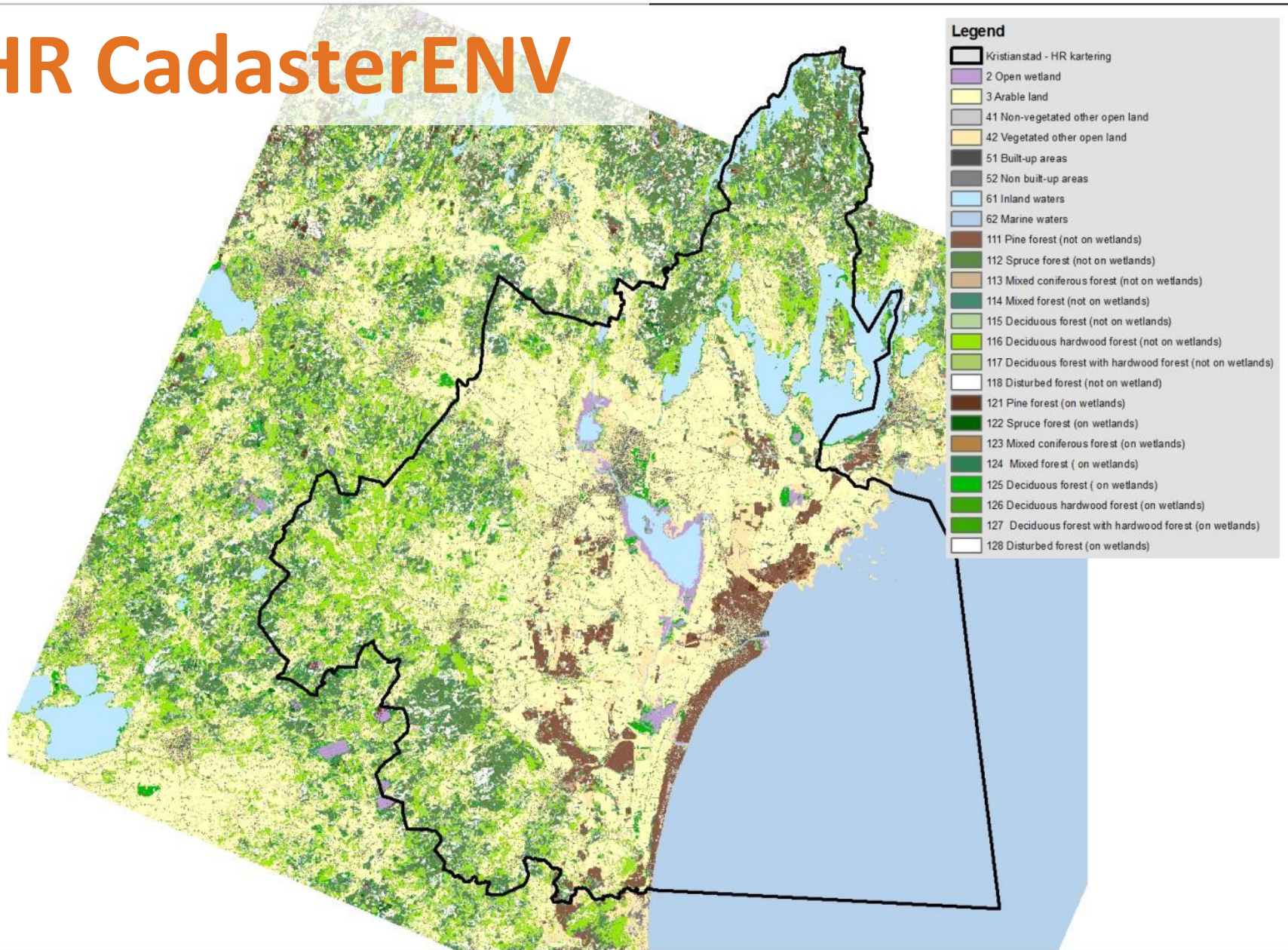


### Legend

- 2 Open wetland
- 3 Arable land
- 41 Non-vegetated other open land
- 42 Vegetated other open land
- 51 Built-up areas
- 52 Non built-up areas
- 61 Inland waters
- 62 Marine water
- 111 Pine forest (not on wetlands)
- 112 Spruce forest (not on wetlands)
- 113 Mixed coniferous forest (not on wetlands)
- 114 Mixed forest (not on wetlands)
- 115 Deciduous forest (not on wetlands)
- 116 Deciduous hardwood forest (not on wetlands)
- 117 Deciduous forest with hardwood forest (not on wetlands)
- 118 Disturbed forest (not on wetland)
- Forest on wetlands

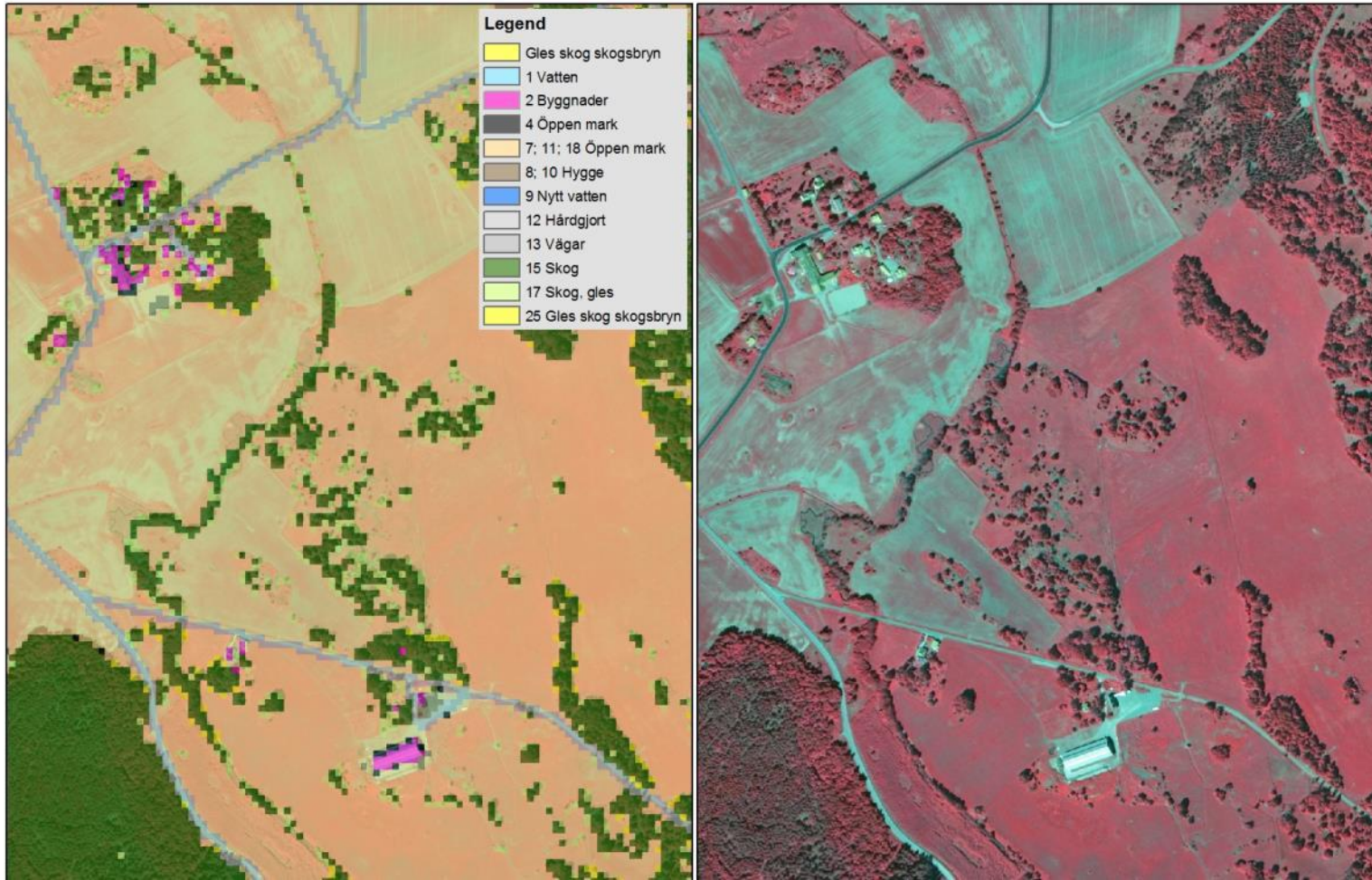


# HR CadasterENV





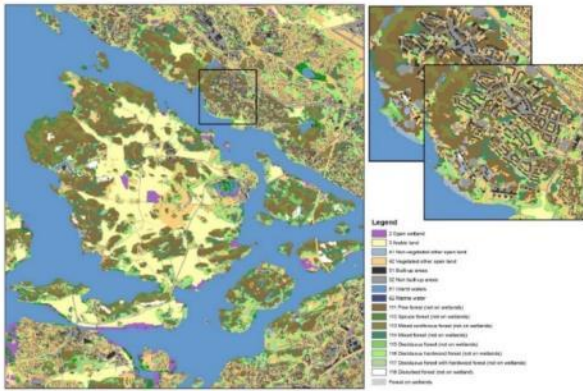
# Forest - HR CadasterENV





# Examples of downstream use

*New land cover map*



**Nature 2000 habitat mapping**



**Fuel type maps**



**Radio wave coverage**

**Ecosystem services**

**Forest continuity**

**Monitoring wetlands**

**Biotope database**



**Urban green areas**



**Green infrastructure**



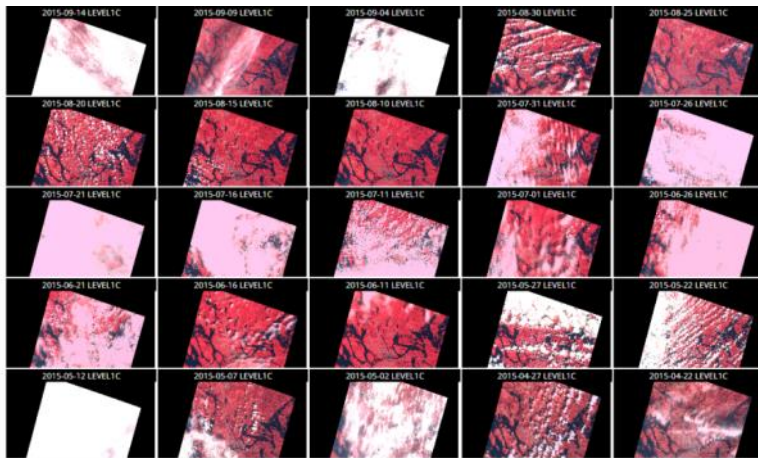
# What are the problems to be solved by Sentinel-2 data and time series?

The major problem is availability of useful data

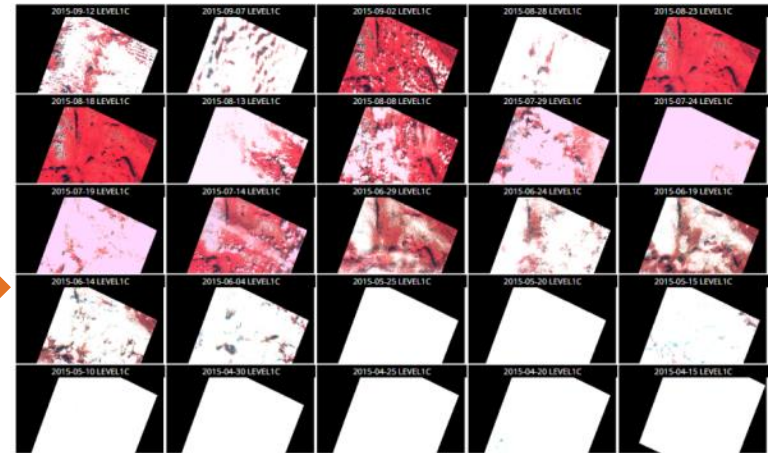
- Short vegetation season (< 8 weeks in northern Sweden)
- Low sun angle (from september)
- Clouds (1-2 week cloudfree episodes of high pressure)
- Use of mosaics/composites for classification
- Phenology for agriculture, wetlands, deciduous forest types ...)
- Multi-year data for delineation of changes



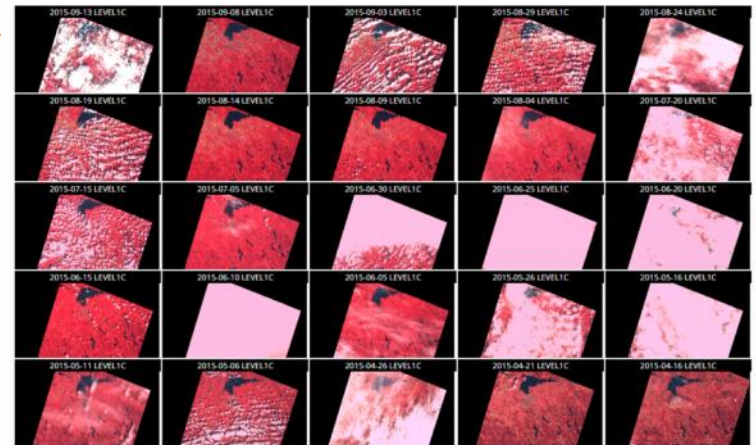
# Data availability with 5 day revisit



Sweden : Stockholm



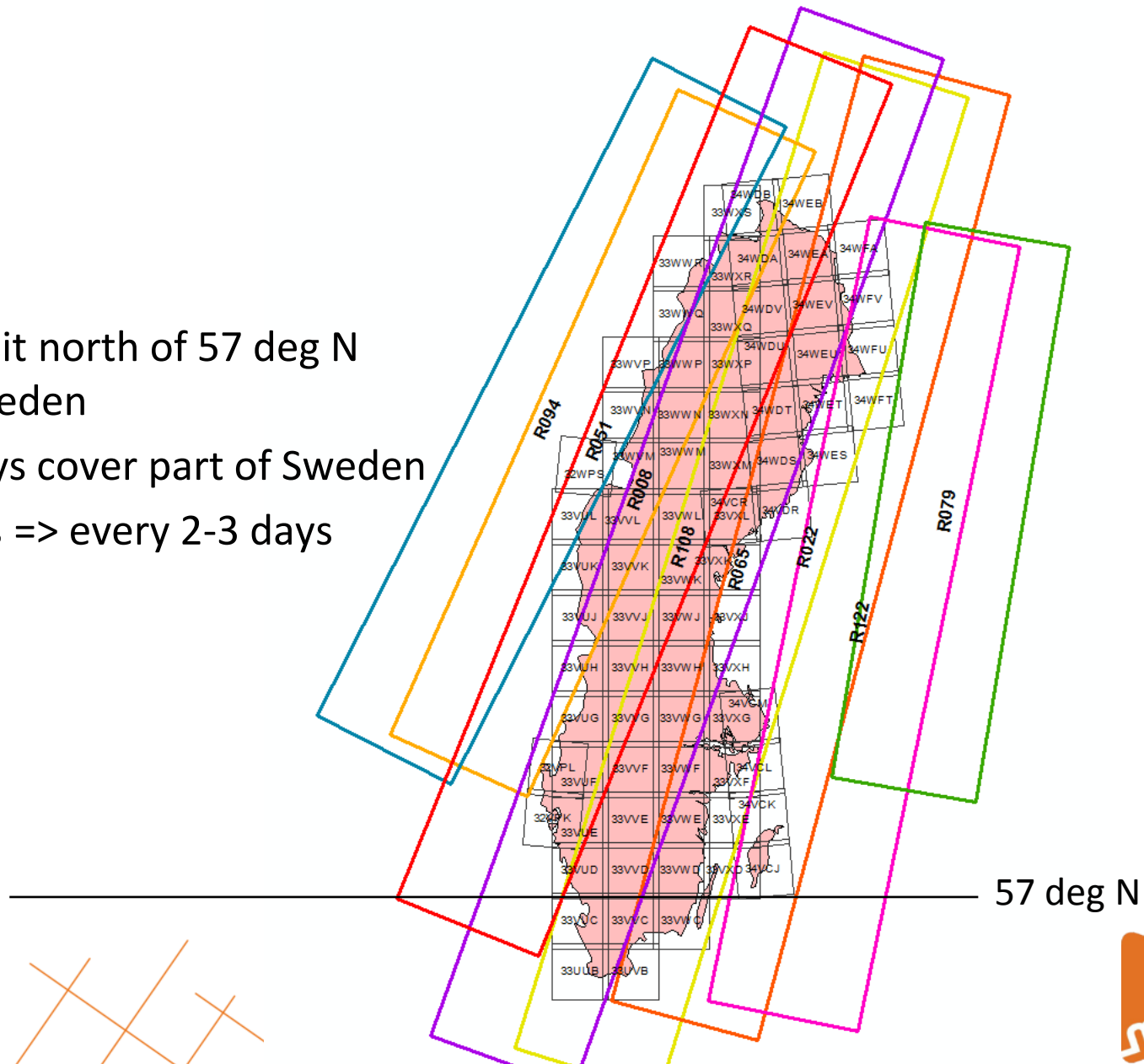
Sweden : Västerbotten



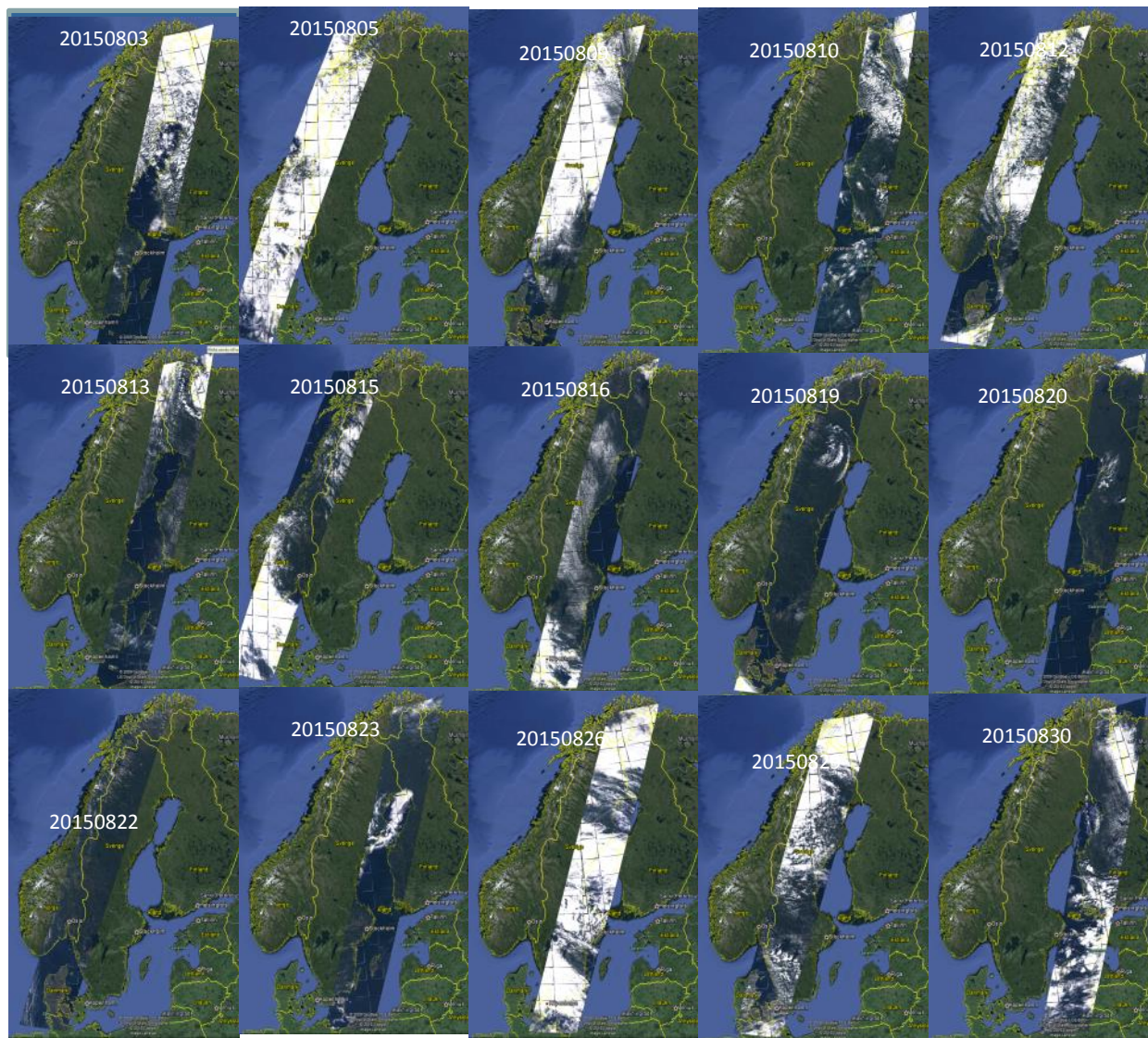
Sweden : Östergötland

# Sentinel-2 relative orbits

- 5 day revisit north of 57 deg N  
90% of Sweden
- 7 of 10 days cover part of Sweden
- 2 satellites => every 2-3 days







## Sentinel-2 Sweden August 2015

# "Best pixel" composite



S2\_L1C1\_20150809-103016027  
S2\_L1C1\_20150813-101026027  
S2\_L1C1\_20150815-105046027  
S2\_L1C1\_20150819-103026027  
S2\_L1C1\_20150820-100016027  
S2\_L1C1\_20150823-101016027

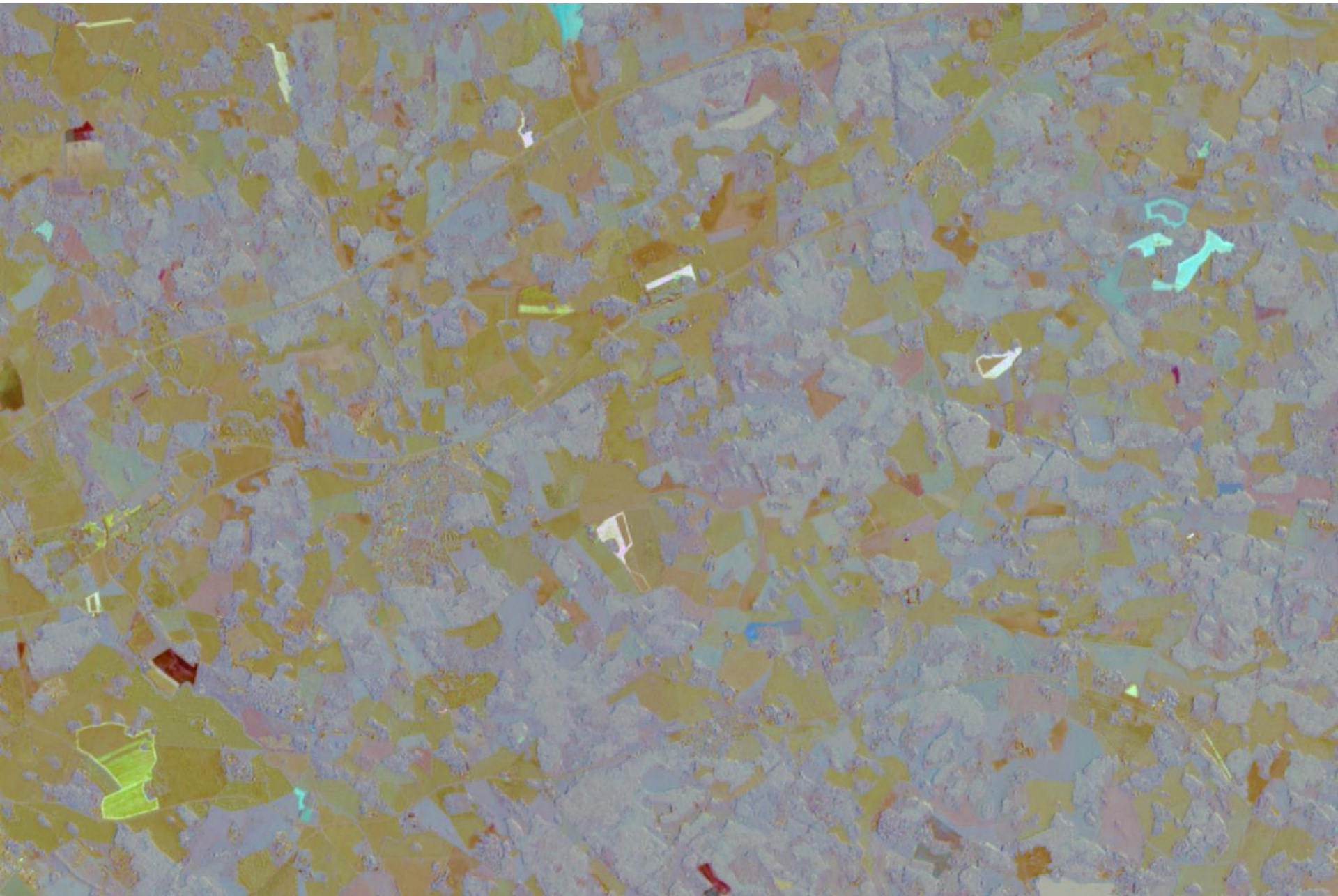


# Sentinel-2 for CadasterENV

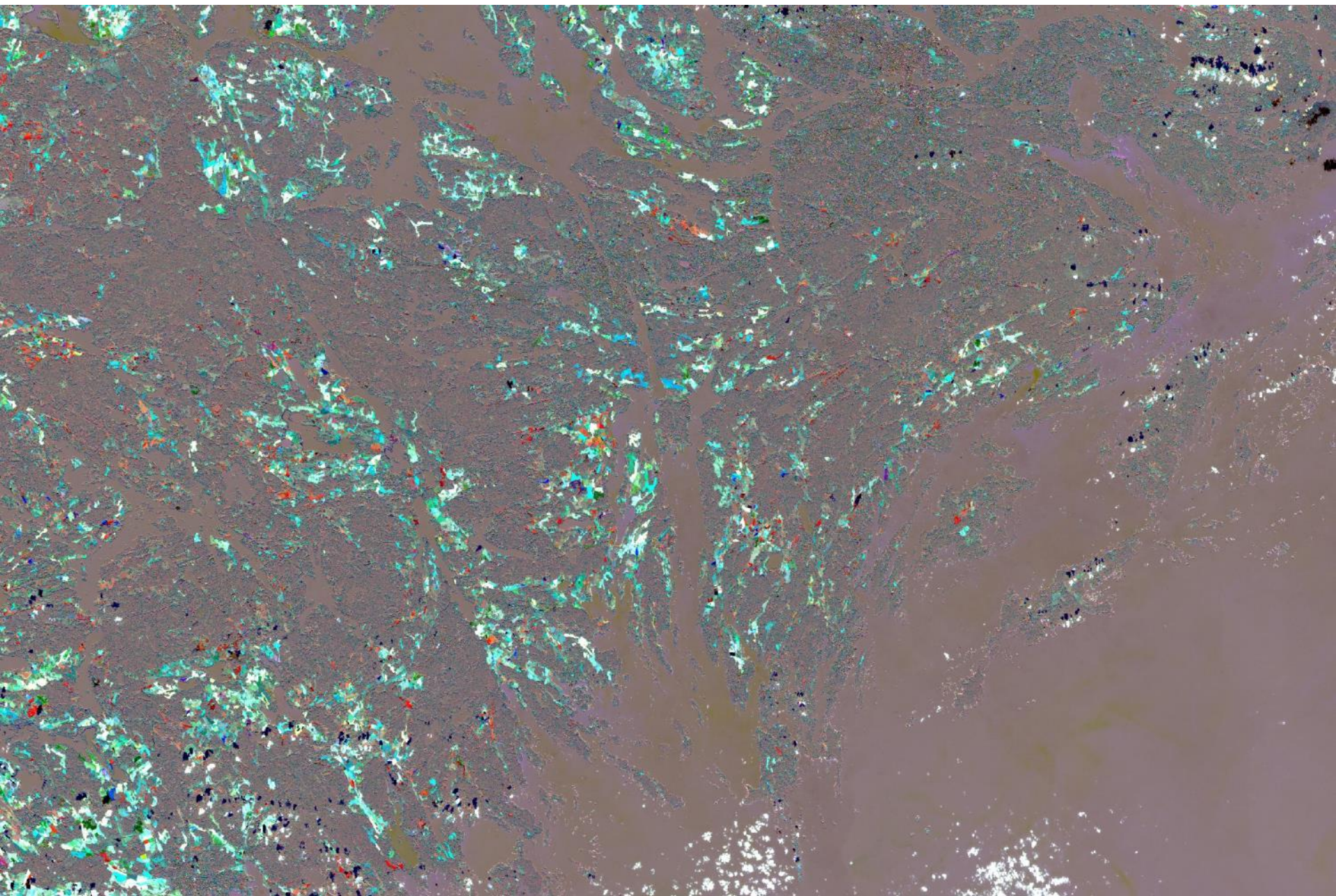
Expected improvements with Sentinel-2 data:

- Better classification accuracy
  - Mixed deciduous forest and deciduous forest
  - Water and och aquatic vegetation (average water level)
  - Open wetlands
  - Arable land/Other open land
- A more detailed classification
  - Sub classes in open land based on field layer vegetation (e.g. grassland/moore and heathland)
  - Deciduous forest classes (e.g. oak and och ash forest)
  - Mountaenous areas
- Identifying slow change
  - Long term transition from arable land to other open land and transitions between different forest classes.
  - Overgrowth
- More cost effective method
  - Larger scenes
  - More scenes (access to more cloud free scenes from optimal time of year)
  - More automatic processes
  - ...











# CadasterENV 2016

ESA funding to Metria during 2016 to further develop methods of mapping and production of CadasterENV using Sentinel 2 (and SPOT5Take5).

We will focus on:

1. Methods to divide the open land class into arable land and different types of grasslands and wetlands (**phenology from time series**)
2. Methods to delineate water and wetlands using average water levels (**seasonal variation**)
3. Methods to improve the accuracy of deciduous forest classes (**phenology**).
4. Methods for incorporating Sentinel 2 data in to the production chain of CadasterENV and assessment of cost.

Results november 2016.



# Preparation of satellite data for national mapping with 10m pixels

## Before 2016

Large manual and costly effort to prepare data

- Select suitable imagery from the national yearly SPOT archive
- Manual cloud /cloud shadow masking
- Post classification mosaiking of many small pieces

## From 2016 –

More cloud free pixels from suitable dates

- Automatic cloud and shadow detection
- Use of seasonal composites /time series
- Automatic methods needed to handle all the data

# A robust cloud and shadow mask is required

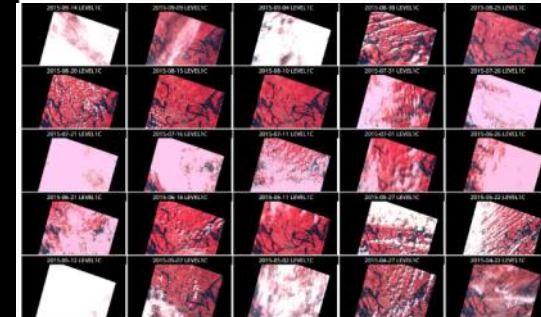
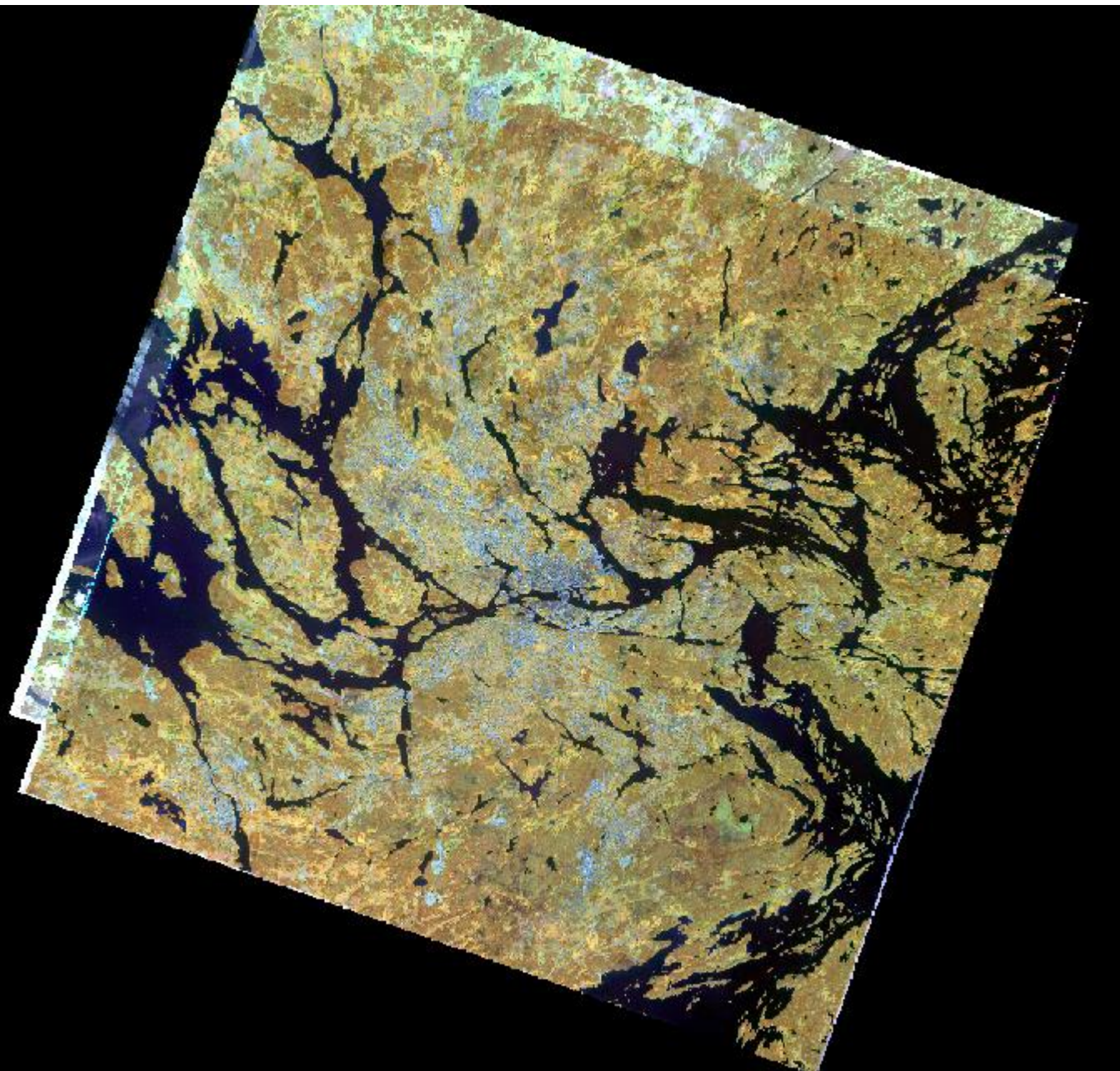
- Sentinel2 L1C cloudmasks are a good starting point
- These will be expanded and improved
- Cloud shadow masks is the main issue



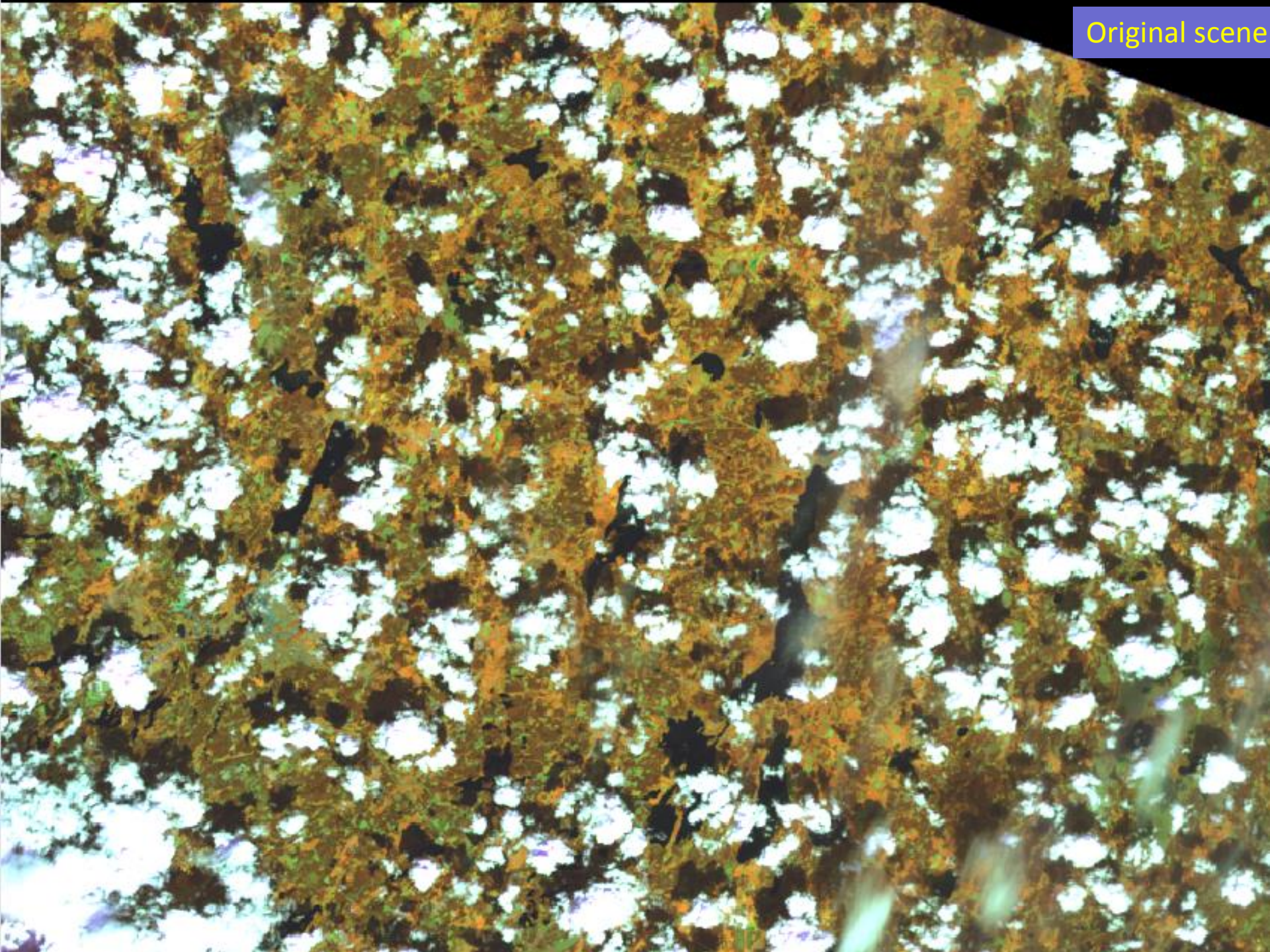
# A concept for an automatic improvement of cloud masks and added cloud shadow masks

1. L1C TOA reflectance
2. Use reasonable cloud free images ( $< 50\%$ ) to make a reference cloud free composite images (p25, p50, p75 ..)
3. Make bandwise difference images target – reference scene
4. Set bandwise TOA thresholds for extracting clouds / shadows.
5. Remove shadow pixels without neighboring cloud
6. Expand masks
7. Iterate

# Spot5Take5 15 scenes median cloud free reference







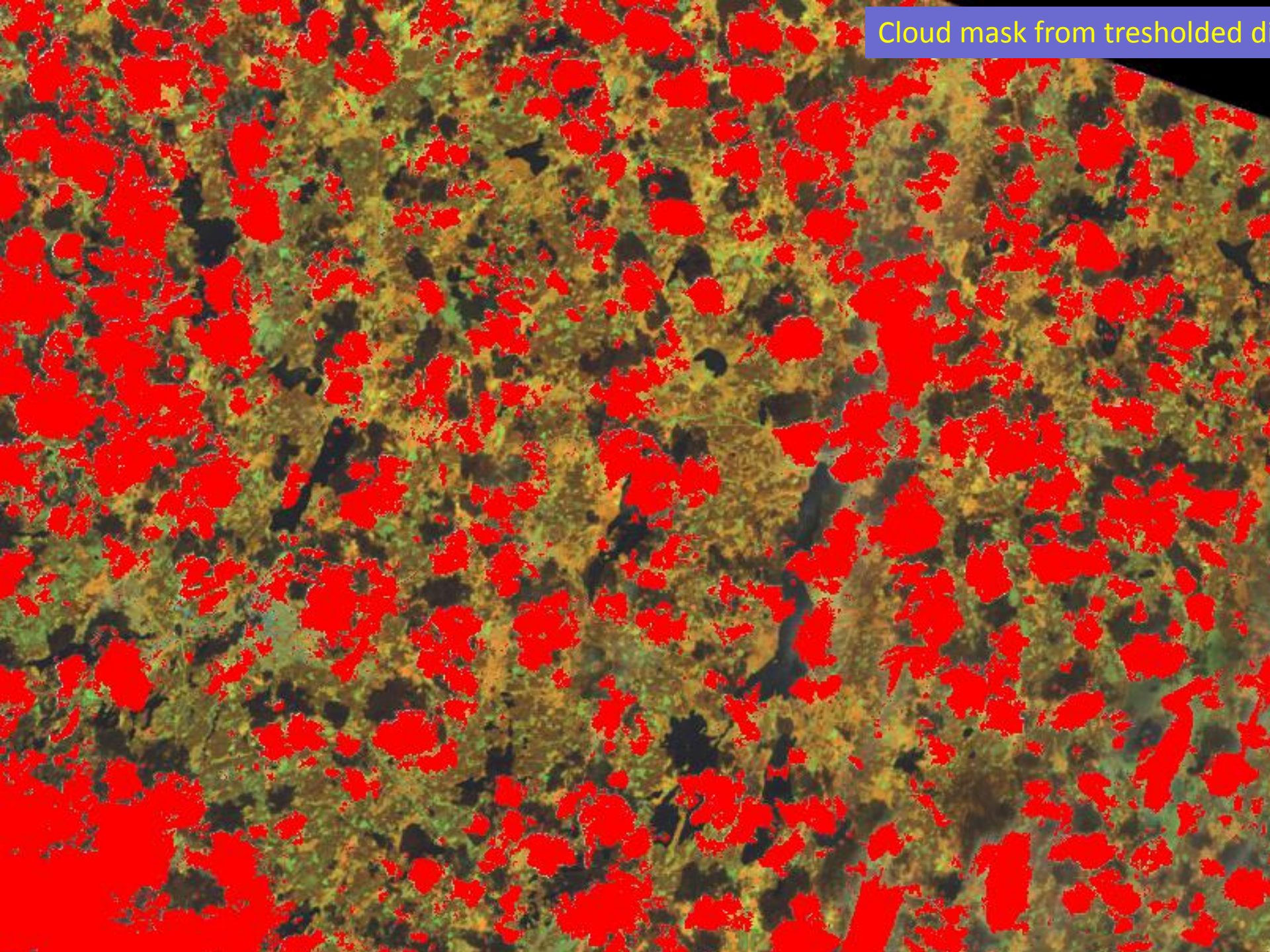


Difference vs cloud free reference compos



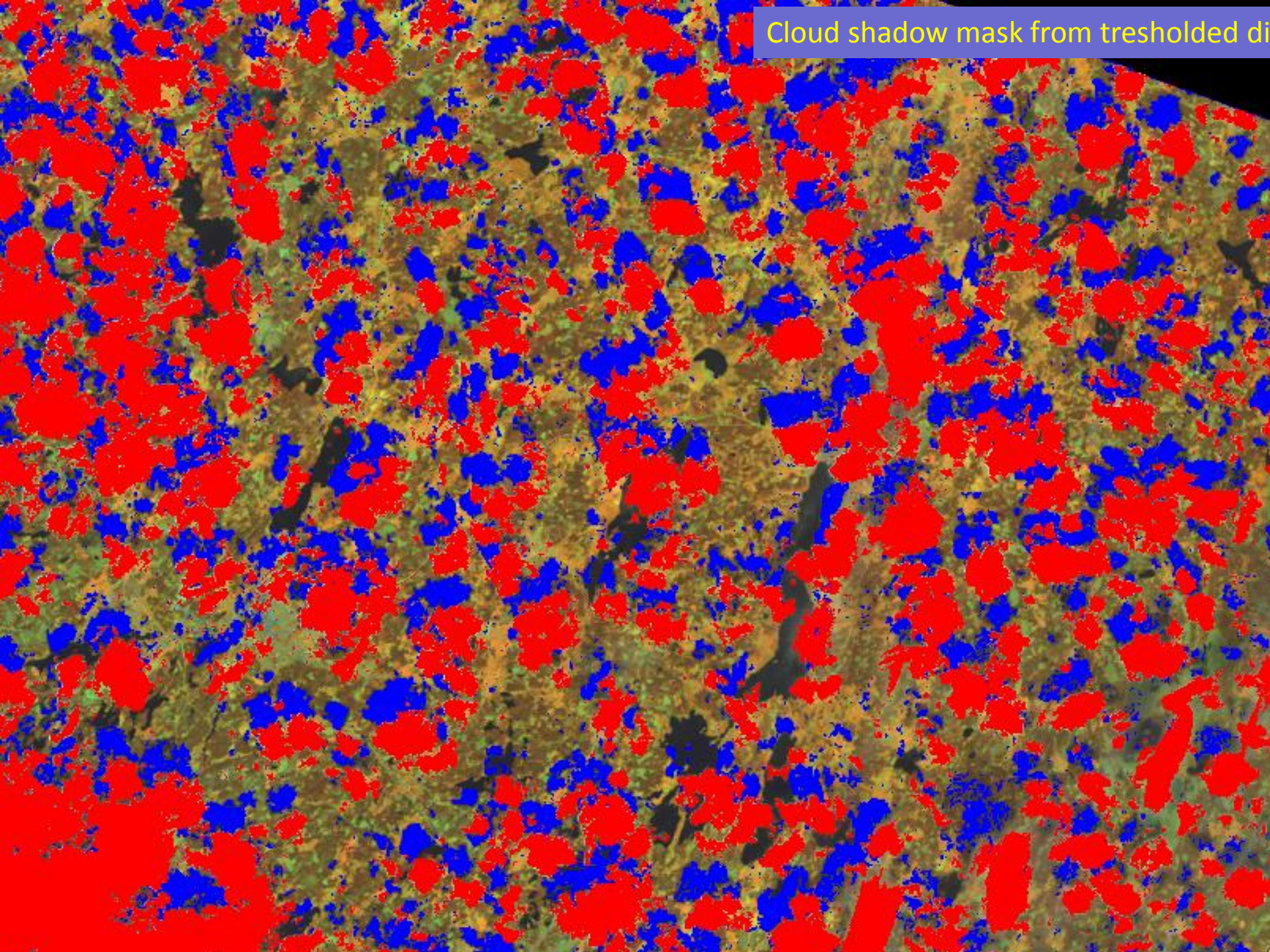


Cloud mask from tresholed d

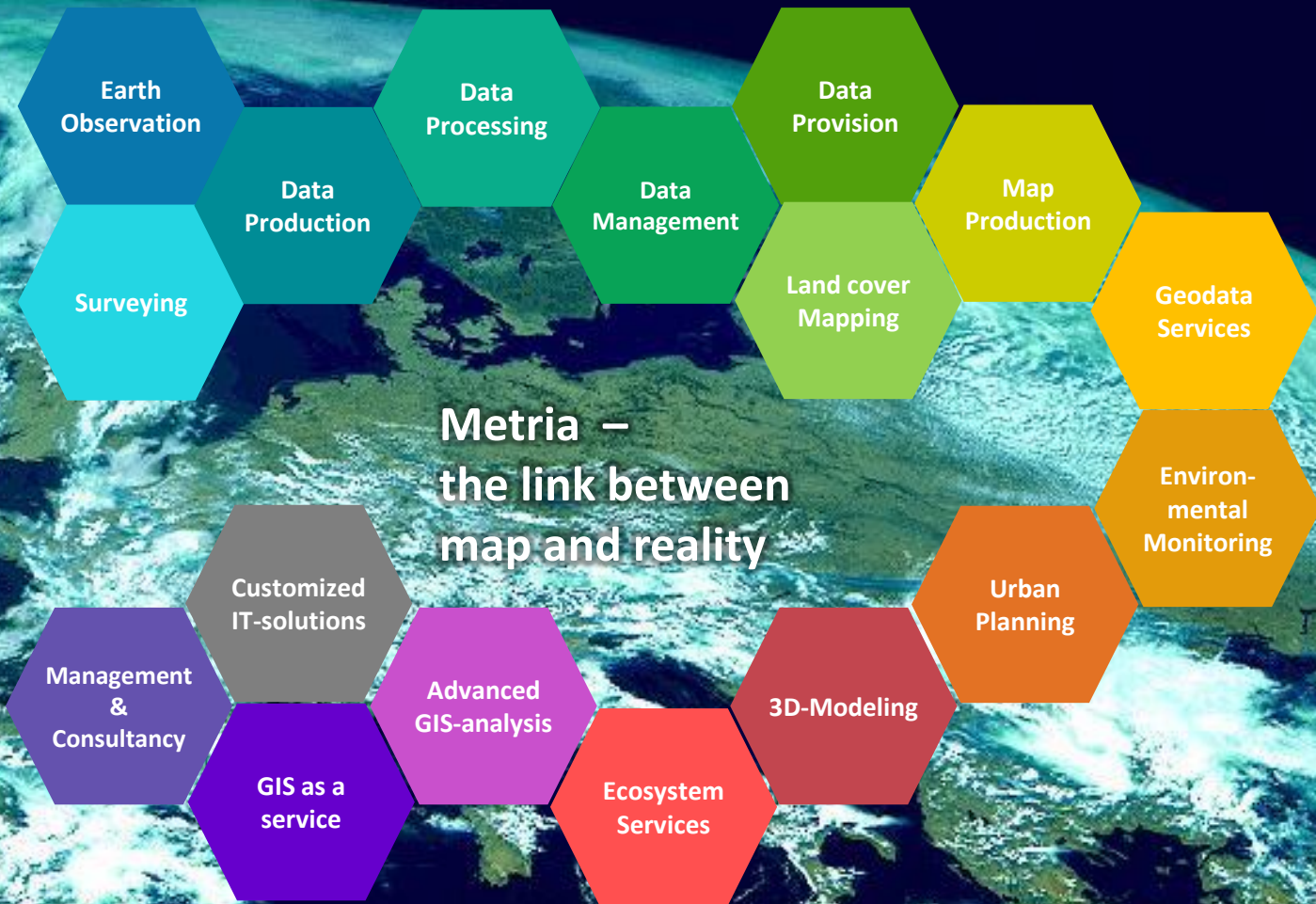




Cloud shadow mask from tresholed di







**Metria –  
the link between  
map and reality**

**Thank you!**  
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