



Status of preparations for the Sentinels in Sweden

Validation and applications of data from Sentinel-2

Mats Rosengren, Metria

2nd Workshop “Preparations for the Sentinel-2 in Europe”

Oslo, 11-12 October 2016



Background

Current operational use of SPOT/IRS/Landsat in Sweden using yearly national satellite data coverages

- **Yearly national clear cut mapping** for legal monitoring (Swedish Forest Agency) [started 1999 -
- **National Forest Inventory** based kNN timber volume estimates (NFI -Swedish University of Agricultural Sciences)
- **KNAS - Recurrent mapping** updates for all nature reserves, national parks, Natura2000 and other protected areas (appr 70 000 km²) (Swedish EPA/Metria)
- Based on **SACCESS** data – Swedish national satellite data archive – yearly coverages, free, jointly funded and sponsored by:

- *Swedish National Space Board*
- *Lantmäteriet (National Land Survey of Sweden)*
- *Swedish Environmental Protection Agency*
- *Swedish Forest Agency*
- *Swedish University of Agricultural Sciences*

- *Metria AB*
- *4 Forest Companies*
- *Holmen AB*
- *SCA Svenska Cellulosa Aktiebolaget*
- *Sveaskog*
- *Bergvik Skog*

SACCESS – Swedish National Satellite Data Archive

(success.lantmateriet.se)

- SPOT5/ SPOT4/ IRS / Landsat Yearly national coverages 2005 – 2014 →
- One best “cloud free” coverage per year from vegetation season
- Historical coverages 1970ies (MSS), 1980ies (TM), 1990ies, 2000
- Used for Land Cover change mapping and monitoring
- Free access to residents/companies registered in the Nordic Countries

Startsida Maps Real Property About Lantmäteriet Work at Lantmäteriet

You are here: Success

Contact us Retailers

Success

Success helps you to study changes in the Swedish landscape and environment over the past three decades. Everyone can overview the available imagery. You must register (see [ordering data](#)) to order full-resolution mosaics and scenes ([full-resolution example products](#)). Need help to get started? [Read how](#).



Area name:

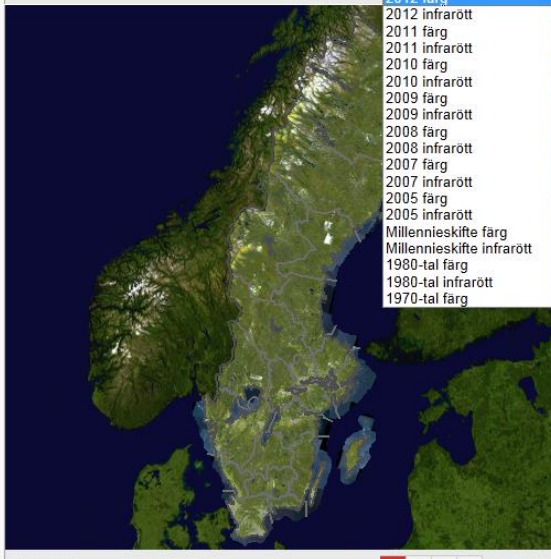
Order products

[Order products in chosen area](#)

Find the desired area using quick search, or by zooming and dragging the map. To limit the area further, use the Mark tool. Zooming can be done with the zoom buttons or by double-clicking.

Shopping cart

The cart is empty



2012 färg
2012 färg
2012 Infrarött
2011 färg
2011 Infrarött
2010 färg
2010 Infrarött
2009 färg
2009 Infrarött
2008 färg
2008 Infrarött
2007 färg
2007 Infrarött
2005 färg
2005 Infrarött
Millennieskifte färg
Millennieskifte Infrarött
1980-tal färg
1980-tal Infrarött
1970-tal färg

☐ Mark

Zoom out 0 1 2 3 Zoom in

Navigation

- » [Startsida](#)

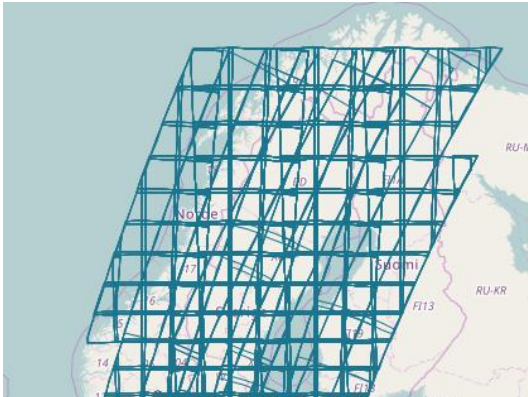
Read more

- » [About Success](#)
- » [How does it work?](#)
- » [What do the different data sets contain?](#)
- » [Ordering data](#)
- » [High-resolution example products](#)
- » [Contact](#)

The products are free of charge thanks to special government funding and a cooperation with the following sponsors:



SACCESS – Currently Used as Temporary Sentinel-2 Distribution Solution

- Operated by Lantmäteriet (National Mapping Agency)
/ Spacemetric adaptation for Sentinel-2
 - 2016 Sentinel-2 Temporary "mirror" solution waiting for the Swedish Collaborative Ground Segment [Swea]
 - All Sentinel-2 data over Swedish AOI downloaded from the Collaborative Data Hub when available
 - Reformatted single tile products tiles reprojected into SWEREF99
 - Simplified products (band subsets)
 - BGRN (B2,B3,B4,B8) 10m
 - ATM (B1,B9,B10) 60m
 - RGB (B4,B3,B2) 10m
 - MIR (B11,B12) 20m
 - TM (B2,B3,B4,B8,B11,B12) 10m
 - REDEGE (B5,B6,B7,B8A) 20m
- 



- Multilayer files (GeoTIFF or BIL)
- Simplified file names



Summary – Sentinel CGS Preparations Sweden

Continuation of Success type Services / Expanded with Sentinel-1,2, and 3

- ❑ Dec 2014: 2 CGS Studies for SNSB
 - User Needs (Metria) and Technical Study (Spacemetric)
- ❑ Review and Technical Requirements (Jan 2016)
- ❑ March 2016: SNSB ITT for Swedish Sentinel Collaborative Ground Segment with delivery T0 + 15 months
- ❑ March 2016: Preliminary solution within Success for Sentinel-2 data distribution.
- ❑ May 2016: Contract issued to Spacemetric for SWEA
(**S**wedish **E**arth data **A**ccess **h**ub)



- *SWEA Planned start of operations Q1/2017*
- *First version already delivered*

Inventory of Swedish Users Needs – Sentinel-1, 2 and 3

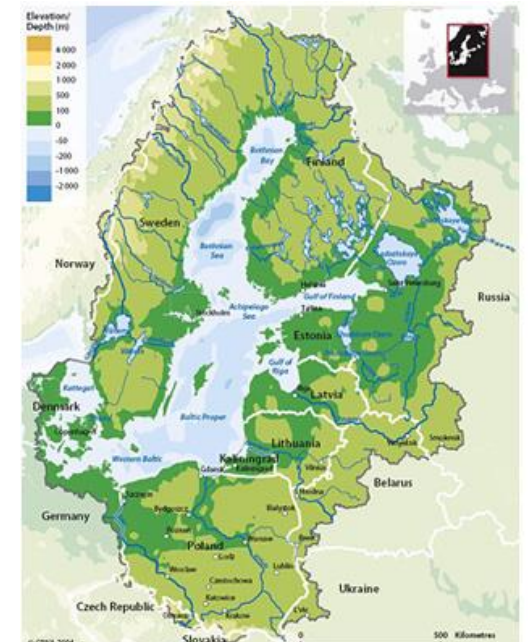
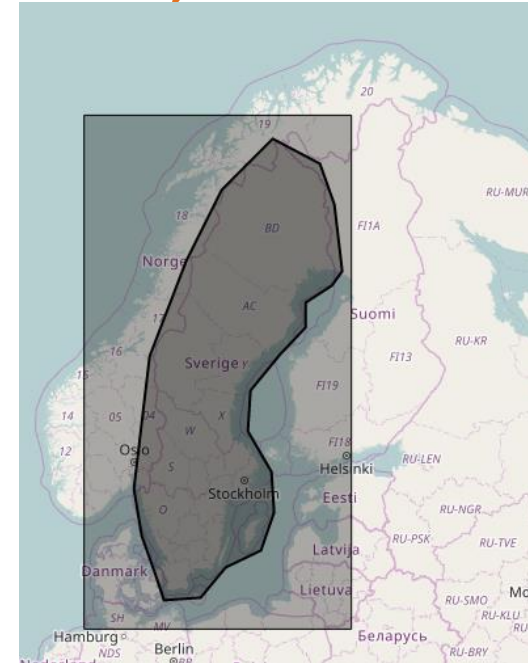
Geographic AOIs

Primary areas

1. Sweden – land area, lakes and coastal waters
[*appr 450 000 km²*]
2. Baltic Sea and Western Sea (Kattegatt and Skagerak)
[*appr 450 000 km²*]
3. Baltic Sea Drainage Basin [*additional 1 665 000 km²*]

Secondary areas – on request

1. Arctic Sea
2. Limited areas globally (in support of projects)



Swedish User Categories – from Saccess user statistics

- Large forest companies
- Swedish Forest Agency
- RS and GIS Consulting Companies in forestry and environment
- Swedish Environmental Protection Agency through consultants (Metria and others)
- SLU (Swedish University of Agricultural Sciences)
- Swedish Board of Agriculture
- Forest owners
- Consulting companies
- Environmental organisations
- Students of GIS and Remote Sensing
- Research groups
- Private persons

Inventory of Swedish User Needs

<i>User type – data needs</i>	<i>Potential users (examples)</i>
Sweden systematic recurrent coverage (S1 archive; S2 all; S3 all)	Swedish Forest Agency SEPA Forest Companies Sw Board of Agriculture Lantmäteriet (SLU, SkogForsk, Research Institutes Metria, Brockman, other companies WWF, Nature Protection Associations
Baltic Sea Drainage Basin (S1 archive; S2 all; S3 all)	SMHI SEPA, Scientists, WWF, Nature Protection Associations
Sweden “Emergency” 24 h (S2, S1, S3)	MSB (Swedish Civil Contingencies Agency) ...
S1 och S3: NRT 30 min - 3 h (Sea ice services, shipping, oil spills, wind, waves, forest fires, etc.	SMHI Swedish Maritime Administration Swedish Coast Guard MSB
Global interests (S1, S2, S3)	MSB, Swedish Armed Forces, SMHI Commercial companies, WWF, NGO:s, SIDA, Research

Input Products Requested

Product type	Applications (examples)
Sentinel-1 L1 SLC (slant range geometry)	Archive, Interferometric applications, ground movements, land cover (?). starting point for higher level products
Sentinel-1 L1 GRD (ground range)	Sea ice, shipping, oil spill, storm fellyings ...
Sentinel-1 L2 Ocean	Marine applications
Sentinel-2 L1B (sensor geometry)	Archive, starting point for higher level products
Sentinel-2 L1C (orthorectified)	Basic product for most applications, basic time series Land cover, forestry, agriculture, urban mapping, change detection (clear felled areas, land use change), environmental monitoring (forest damages, fire scars, long term changes), image backdrops in GIS, image map services Starting point for L2 products (atmospheric corrected, biophysical parameters)
Sentinel-2 L2A (BOA)	Required for advanced time series based services, automatic change monitoring,

Input Products Requested (cont'd)

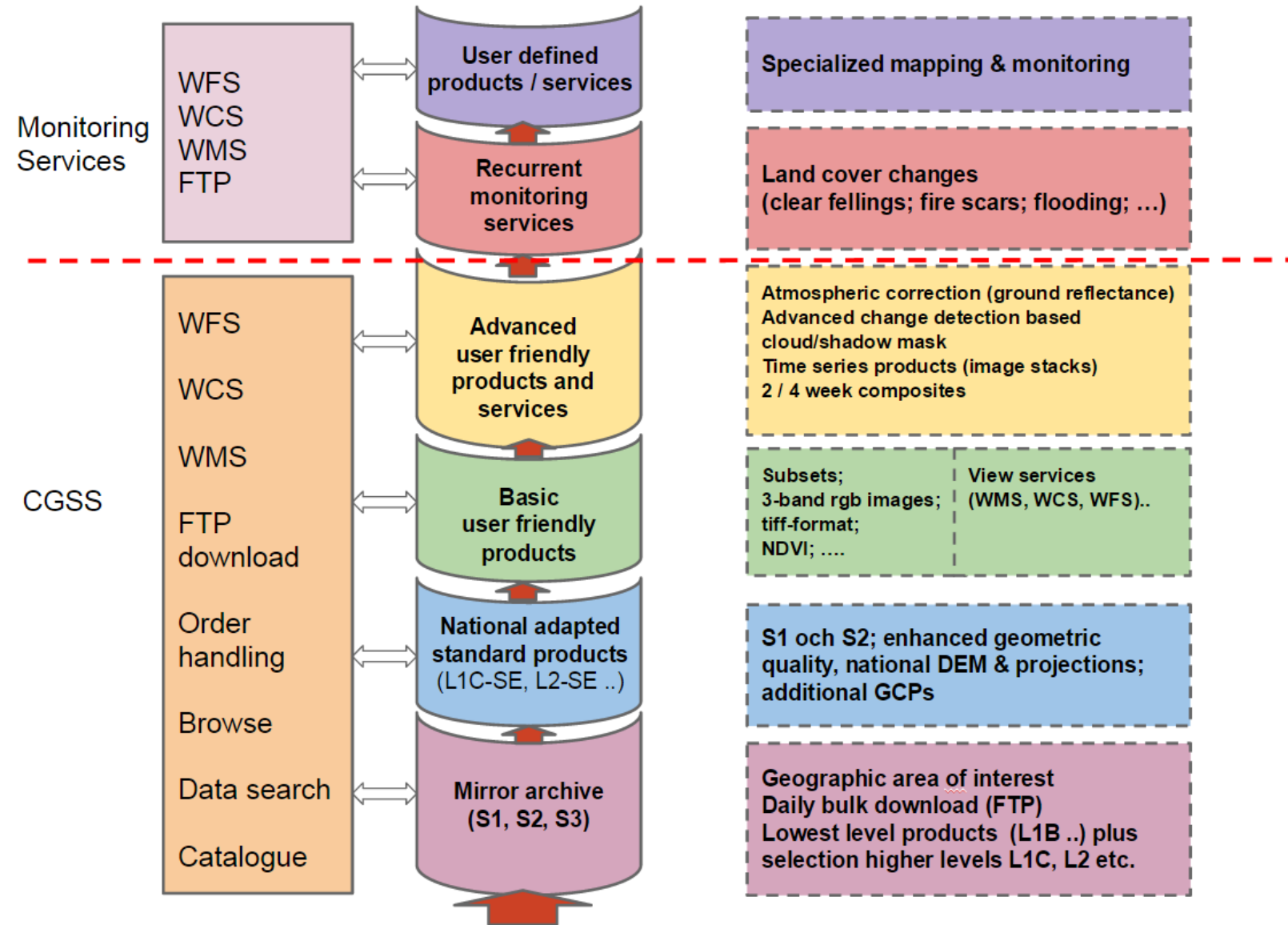
Sentinel-3 OLCI Level 1B SLSTR Level1B	Land vegetation monitoring (global), Marine water quality Water temperature
Sentinel-3 OLCI L2 Land (ESA product	Global and regional vegetation dynamics and change
Sentinel-3 OLCI L2 Water	Marine water quality, algae blooms
Sentinel-3 EUMETSAT products	Marine applications, atmosphere, meteorology,

Common Technical User Requirements

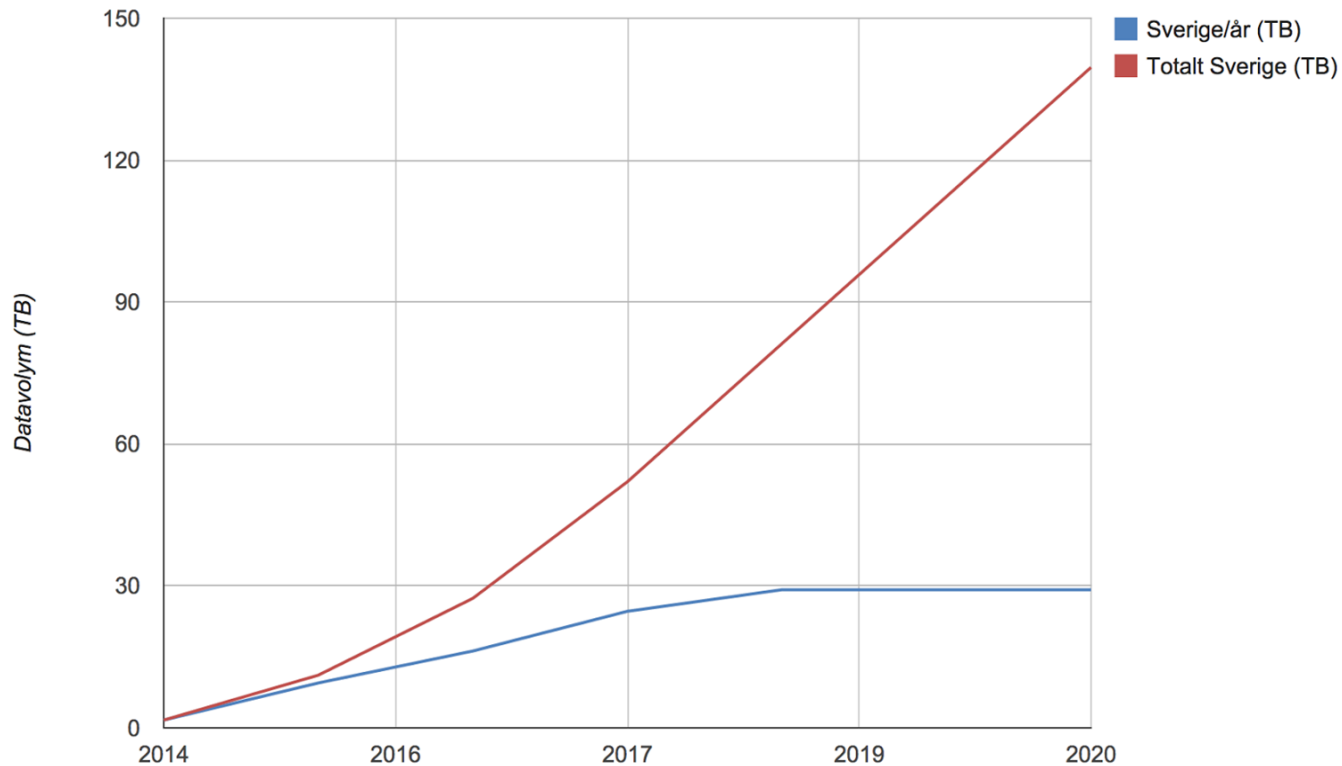
- Subpixel absolute *geometric accuracy* enabling time series analysis and integration with local GIS data and aerial photos
 - *Corrections for scene offsets and coarse DEM required !!*
- Local Swedish map *projection* (SWEREF99)
- *Cloud/shadow masks!*
- *User friendly* data formats and simplified standard products (band subsets, 3 band images for visual backdrop..)
- Fast and simple access to data

A Swedish Collaborative Ground Segment Concept

User Vision (modular implementation)



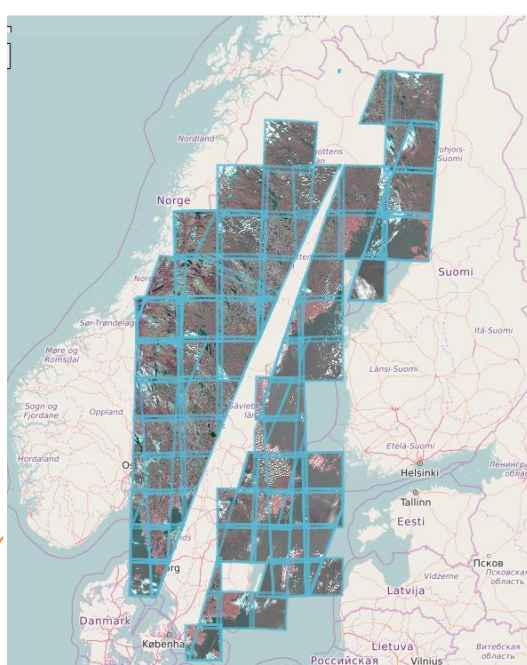
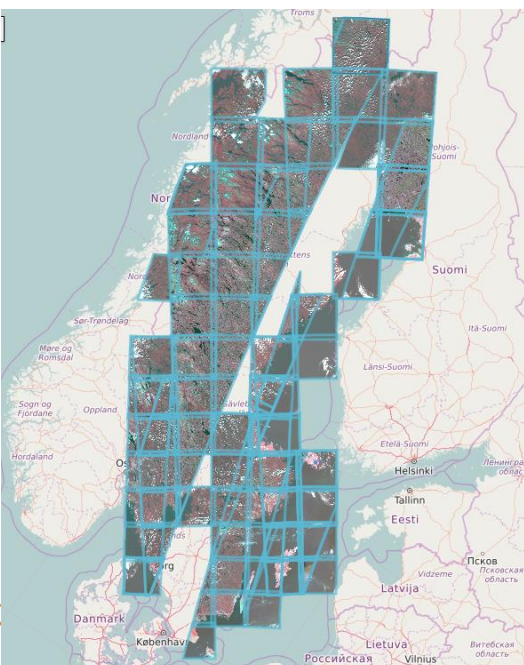
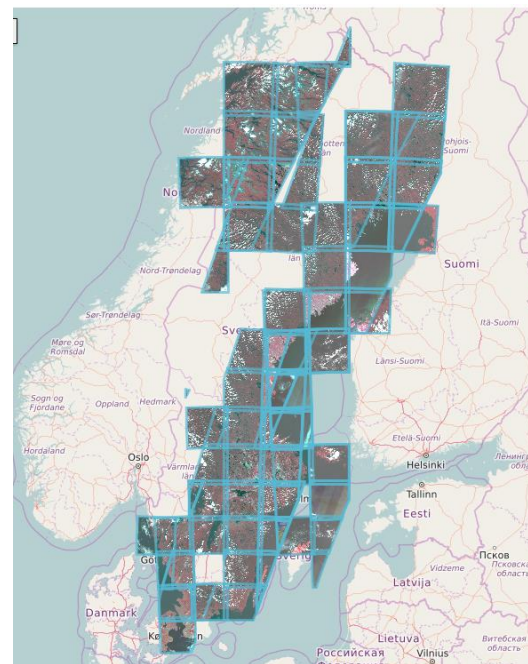
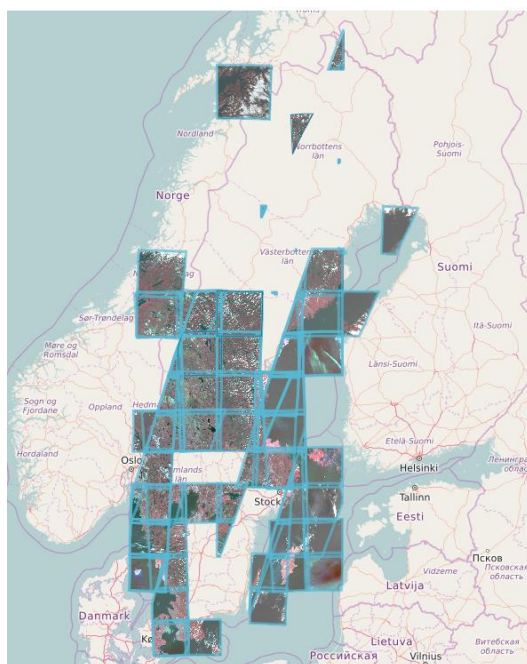
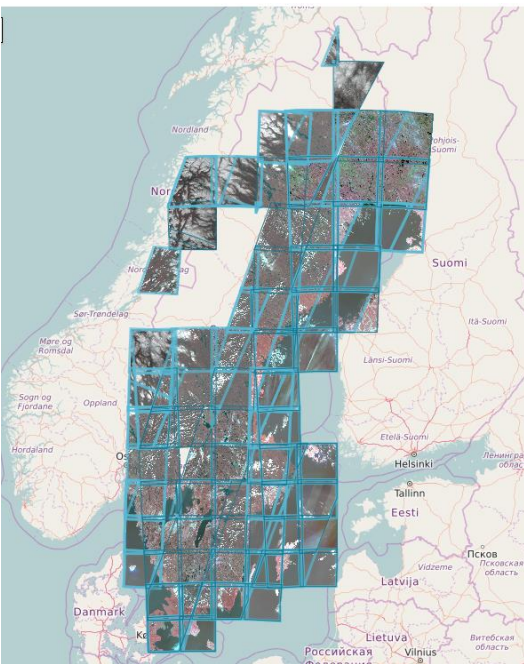
Data Volumes -Sweden



Estimation: 1% av Sentinel Global Data Volume

SWEA – ITT requirements

- ☐ Input data sources: from Sentinel-1, 2, and 3
- ☐ Landsat (MSS, TM, ETM+, OLI/TIRS) IRS-P6/R2 and SPOT 1- 5 (continuation of Saccess services)
- ☐ Systematic NRT download from ESA HUB
- ☐ Permanent AOI + temporary AOIs on request
- ☐ Search functions
- ☐ Orthorectification to SWEREF99, RT90, UTM, WGS84 (?), ETRS90(?) + user defined projections
- ☐ Mosaics from single pass
- ☐ Enable floating definition of subsets
- ☐ Composites (week, month, season etc)
- ☐ Temporal stacks ("datacubes")
- ☐ Raster image map products (NDVI etc)
- ☐ Metadata standards requirements
- ☐ Cloud mask exports
- ☐ Predefined standard data products



SWEA – Under construction

Swea, the Swedish Collaborative Ground Segment

An open procurement May 2016.

Spacemetric selected in a competition with three bidders, including Amazon.

A complete service based infrastructure will be delivered in 2017 including the first year of operation.



User defined products

subscriptions

A ground segment is by definition focused on streams of new data. Make sure users can subscribe on data streams covering a specific area.

coordinate systems

Make sure image data is presented in a projection and coordinate system that the user can handle.

automated mosaics

Most users want coverage, for example mosaics or synthesis images with last 10 days of pixels.

time series

Time series makes the image data very interesting for change detection studies.

Make sure user can access historical data from many sensors and mix with new arriving data.

Sweat

the wishlist

automation

Define what you want and get it processed automatically.

Together with subscriptions it becomes a declarative way of working.

data cubes and delivery

Datacubes formatted, corrected and delivered directly to your desktop.

clouds

The Sentinel cloud metadata is useful for statistical purposes but not for mosaicing. Automated processes are dependent on cloud masks including both cloud and shadow.

more data

The Success historical archive with a timeline of precision corrected data ranging from the 1980's until today.

Landsat 8 can be handled in the same way as Sentinel 2.

correction

Time series or data cubes need to be corrected into sub-pixel accuracy to be useful.

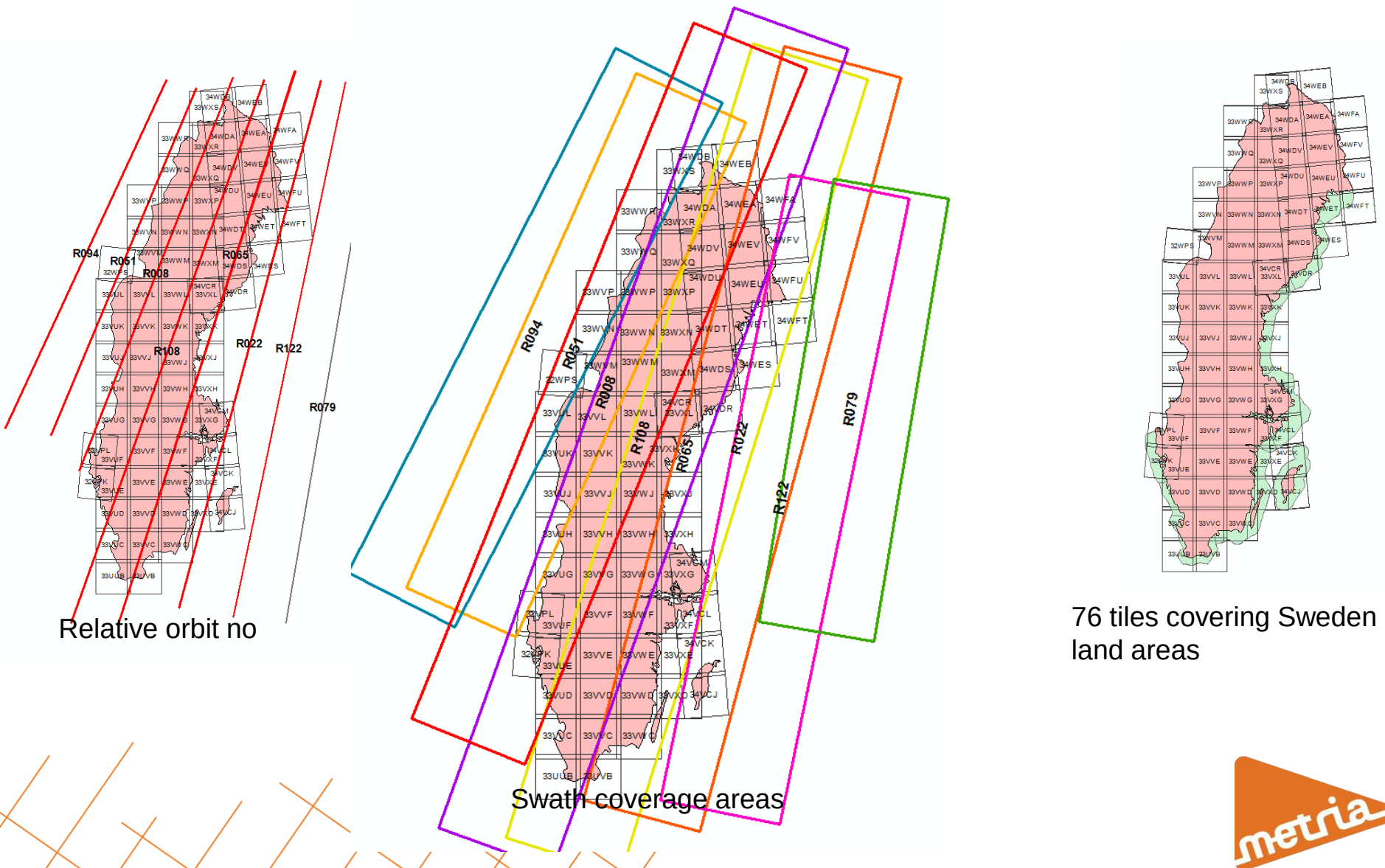
Radiometric TOA correction is essential.

Swea, the Swedish Collaborative Ground Segment

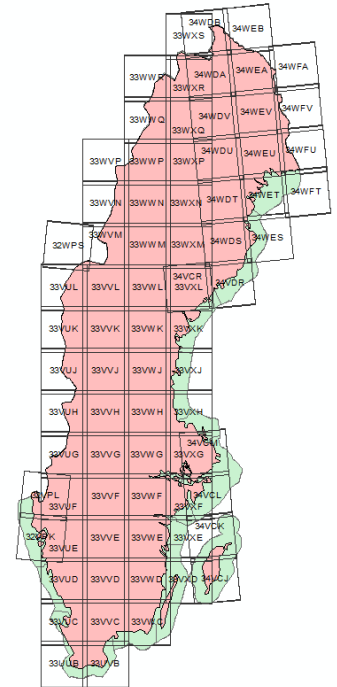
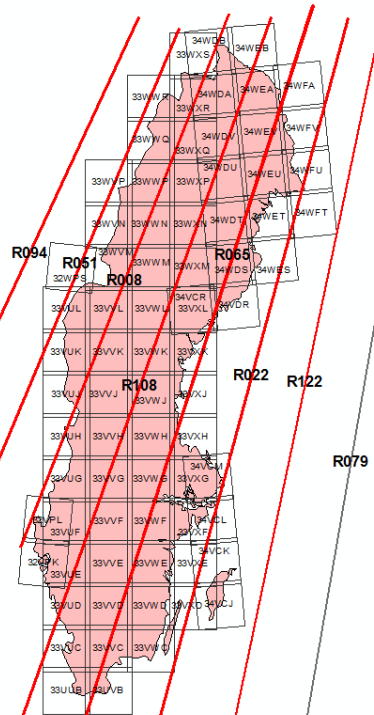
An open procurement May 2016.
 Spacemetric selected in a competition with three bidders, including Amazon.
 A complete service based infrastructure will be delivered in 2017 including the first year of operation.



Metria Activities – Download of all Sentinel-2 over Sweden



Metria Activities – Download of all Sentinel-2 over Sweden

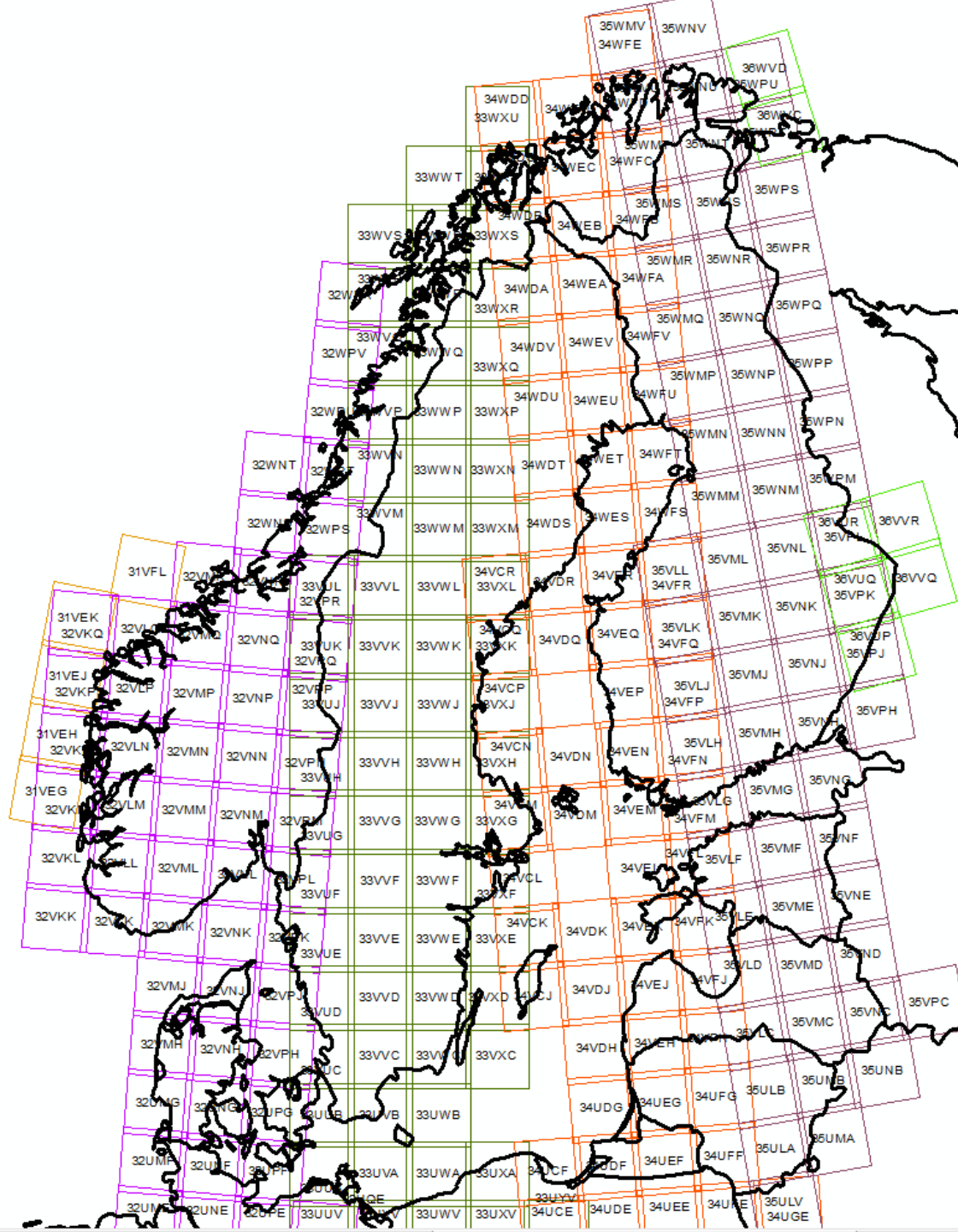


76 tiles covering Sweden
land areas

Best pixel composite - August 2015

S2_L1C1_20150809-103016027
S2_L1C1_20150813-101026027
S2_L1C1_20150815-105046027
S2_L1C1_20150819-103026027
S2_L1C1_20150820-100016027
S2_L1C1_20150823-101016027





Common Preparation Steps for Customer Projects

- ☐ Download
- ☐ Unpack and rename
- ☐ Preparation of swath QL mosaics (KML-format)
- ☐ Preparation of Virtual Image Stacks (ERDAS *.vsk / gdal VRT-format)
 - 10 m bands (B2,3,4,8)
 - 20 m MIR (B11,12)
 - 20 m /10 m red edge (B5,6,7,8A)
 - 60 m atm (B1,9,10)
 - 10 m "TM" product (B2,3,4,8,11,12)
- ☐ Reprojection to SWEREF99
- ☐ Resampling of 20m bands to 10m
- ☐ Mosaicing of single band "scenes"
- ☐ "Best" pixel composites (flexible rules)

Key issues for preparation to be solved

- ❑ Adjustment of global residual geometric offsets
(still 10-15 m in some datasets)
- ❑ Need for adjustments of local residual errors due to for low accuracy DEM used (in mountain areas north of 60 deg N)
- ❑ Automatic cloud / shadow mask generation
 - Method development based on time series and differences vs "best" cloud free reference composite

Projects in development and production

- ☐ CadasterENV / New Swedish Land Cover Data
- ☐ Agricultural Block Data Base control and revision / Swedish Board of Agriculture
- ☐ Automatic clear cut mapping / Swedish Forest Agency

CadasterENV Sweden

- National mapping
- Stage1 funded by ESA (SPOT-5)
- Developed 2012 - 2015
- Swedish national and regional users
- Implementation of Sentinel-2 based production 2016-2017



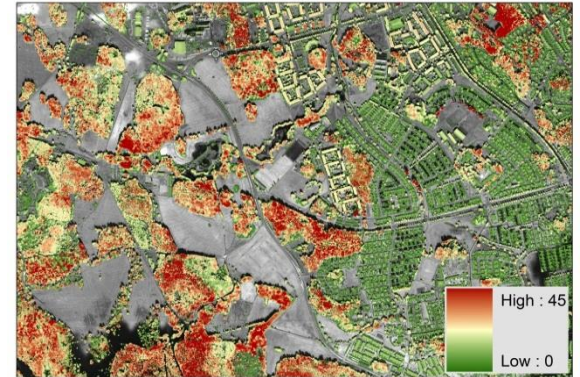
Combination of input data



Sentinel-2 10m



VHR (alt orthophoto) 0,5-2m



LIDAR

→ Sentinel 2A/2B will give us a new image every 5th day (2nd-3rd day in the north)
= improved chance for cloud free data, better class separation)

CadasterENV 2016

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

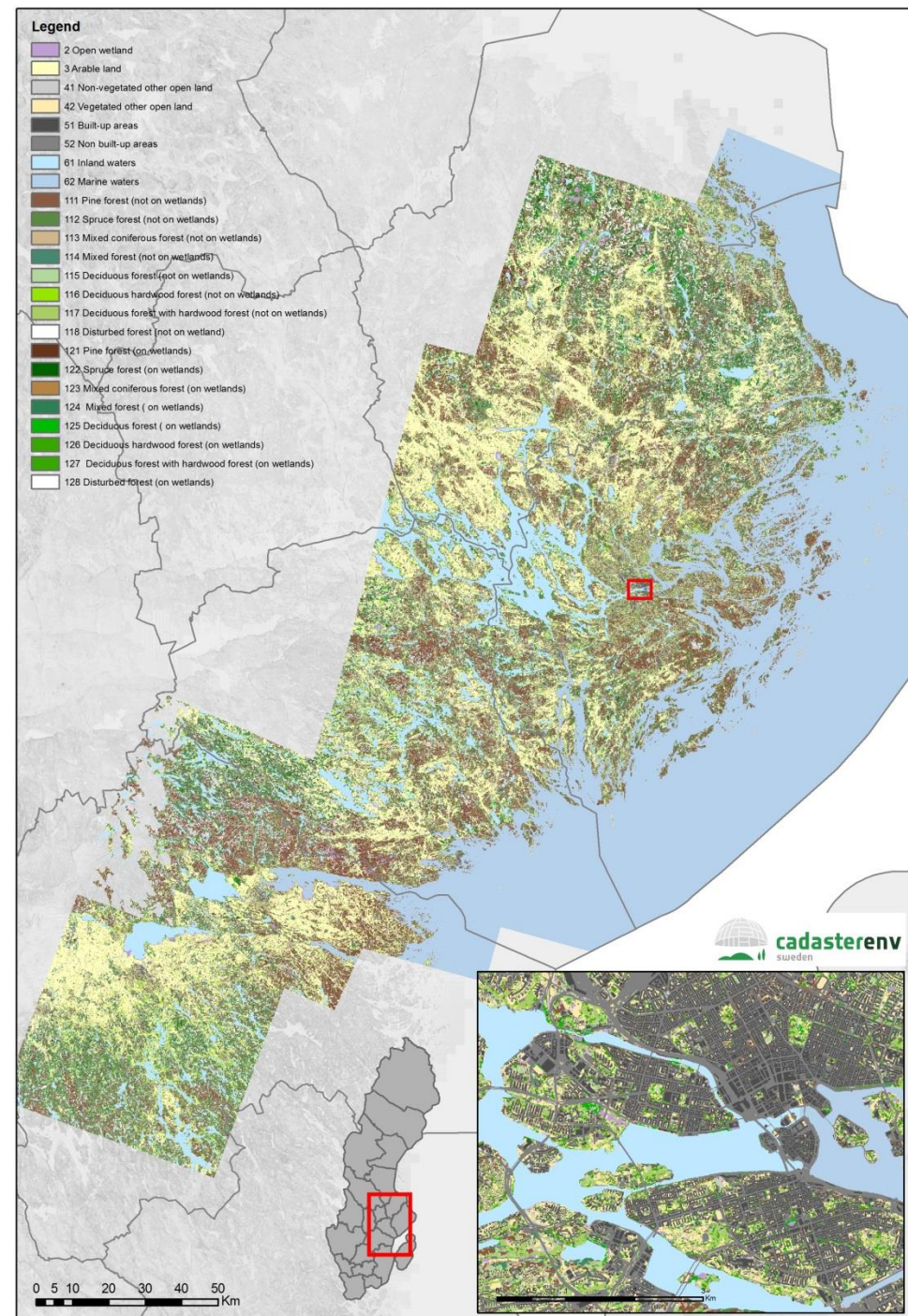
We will focus on:

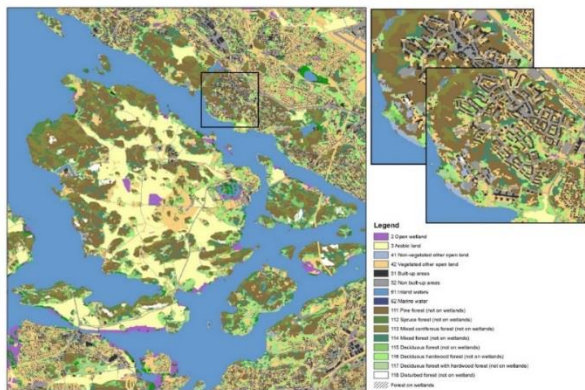
1. Methods to separate open land into arable land and different types of grasslands and wetlands.
2. Methods to delineate water and wetlands using average water levels.
3. Methods to improve the accuracy of deciduous forest classes.
4. Methods for incorporating Sentinel 2 data in to the production chain of CadasterENV and assessment of cost.

Products

National Land Cover:

- A map with 24 thematic classes
 - Level 1-3
 - HR/VHR
 - Raster 10/2 meter
- Separate layers (attributes)
 - Land use
 - Tree height
 - Density
 - Productivity





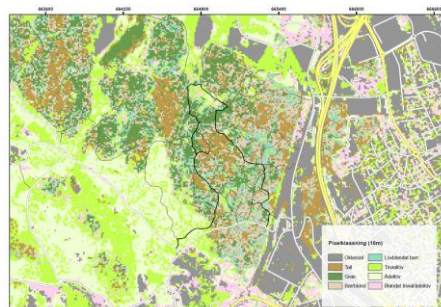
New land cover map



Nature 2000 habitat mapping



Fuel type maps



Radio wave coverage

Ecosystem services

Forest continuity

Monitoring wetlands

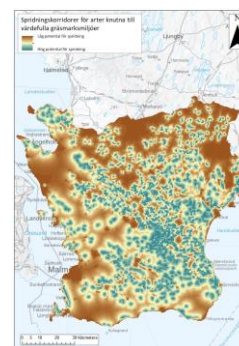
Biotope database



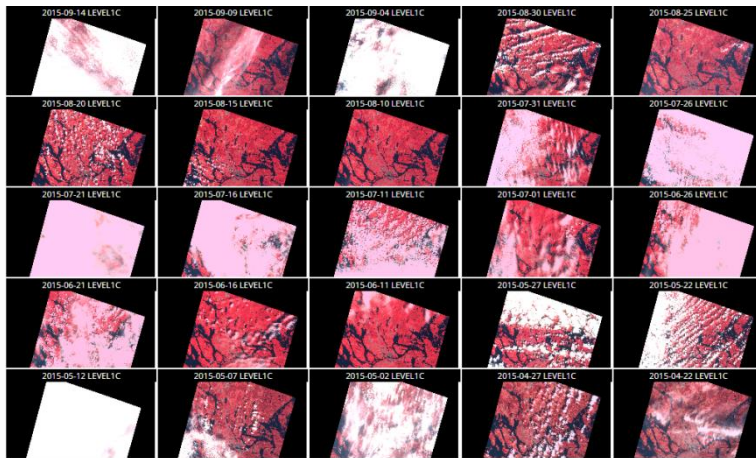
Urban green areas



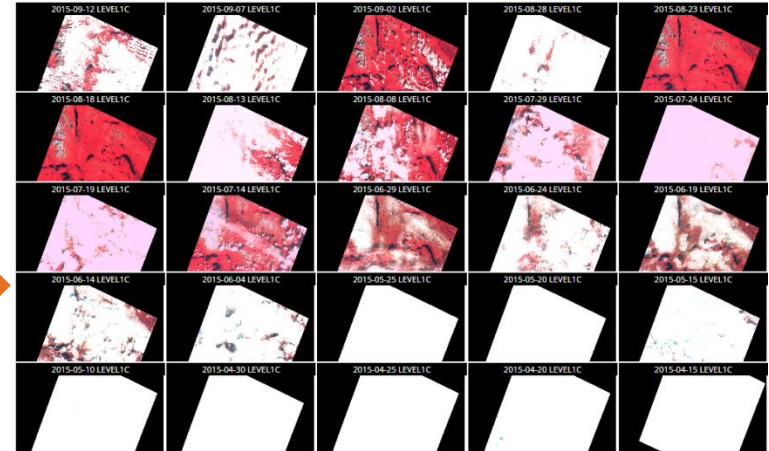
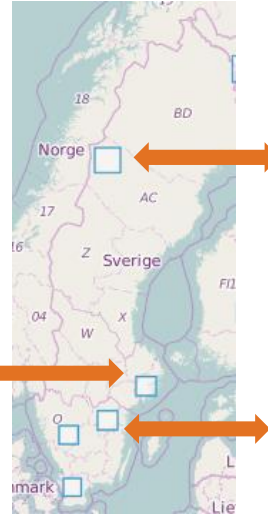
Green infrastructure



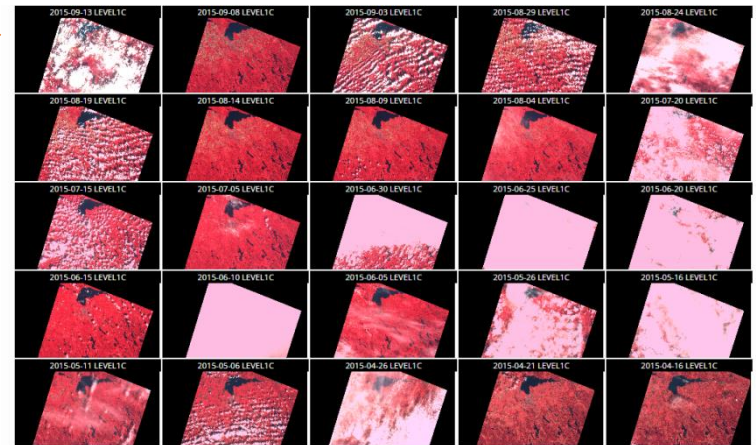
What are the problems to be solved by time series from Sentinel-2 data?



Sweden : Stockholm



Sweden : Västerbotten



Sweden : Östergötland

Sentinel-2

Expected improvements with Sentinel-2 data:

- Better accuracy classifying;
 - Mixed deciduous forest and deciduous forest
 - Water and other 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 other ash forest)
 - Mountainous areas
- Identifying slow change
 - 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)
 - ...



Sentinel-2 preparations at Swedish Forest Agency

LANTMÄTERIET

Saccess Sverige

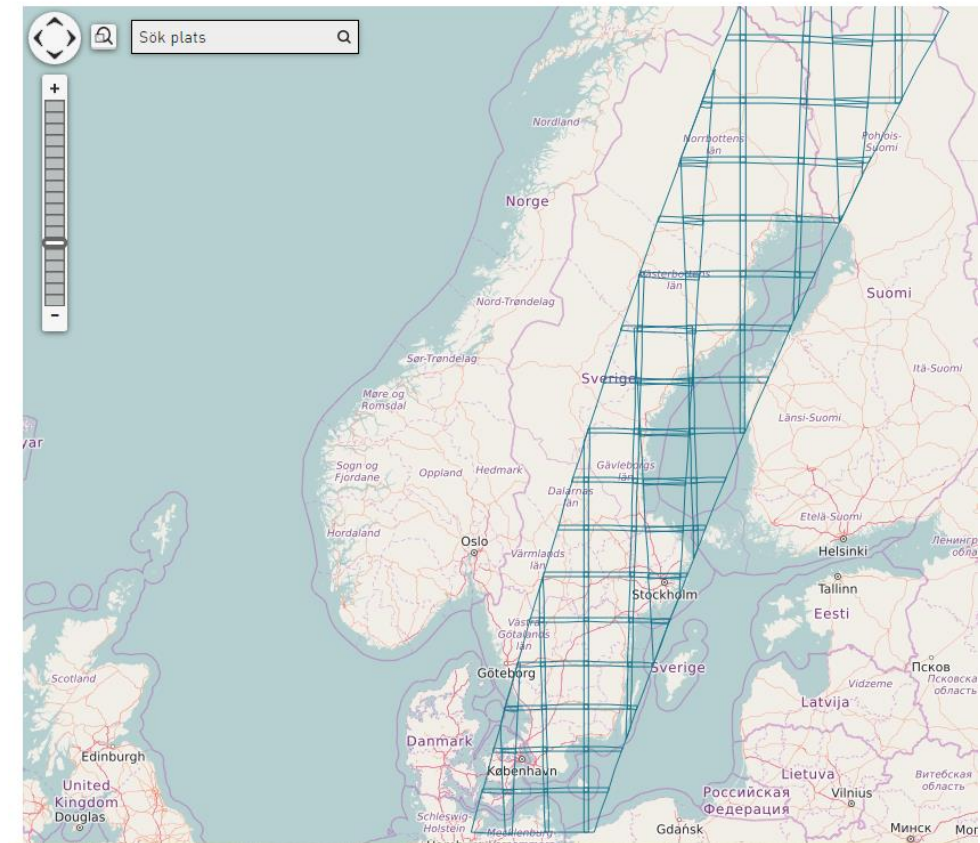
Så här gör du

Saccess Danmark

Sentinel 2

Sentinel 2

- Data over Sweden are automatically downloaded from Saccess temporary Sentinel-2 hub every day



Sentinel-2 preparations at Swedish Forest Agency

Cloud detection and masking

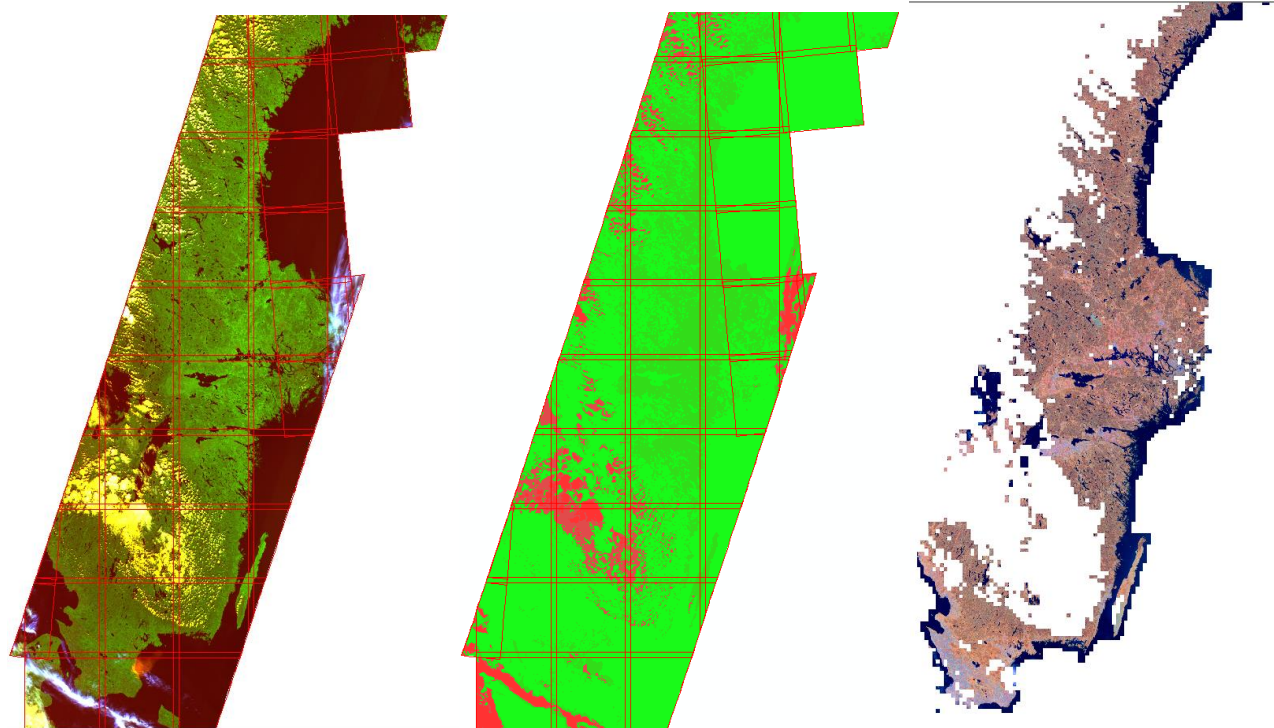
Two approaches

- Simple classification
- FMASK (by Zhu & Woodcock)

Cloud free areas are extracted

Clouds and shadows

- Major issue
- Difficult to handle
- Must be performed automatically



Sentinel-2 preparations at Swedish Forest Agency

Image data usage

Currently

- Image backdrop
- Check cuttings (cut or not)
- Monitoring of protected areas

Coming soon

- Quick clear-cut detection
- Improved analysis of the need for pre-commercial thinning

