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Space



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User needs

- User: State Bureau of Surveying and Geoinformation Schleswig-Holstein, Germany
- User need: Update of topographic maps by European Mapping Agencies
 - Detection of land cover and Land use changes
- Key challenge
 - Large areas to be updated by field campaigns or manual interpretation of aerial images
- Key Task:
 - reduction of workload by Copernicus based automatic change detection



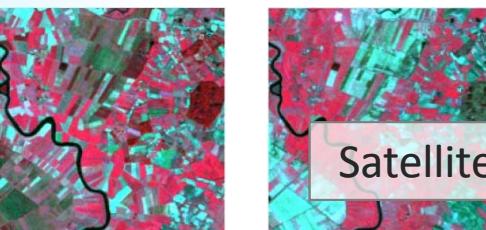
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European Commission



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Use case: Service design



Land Cover Classes:

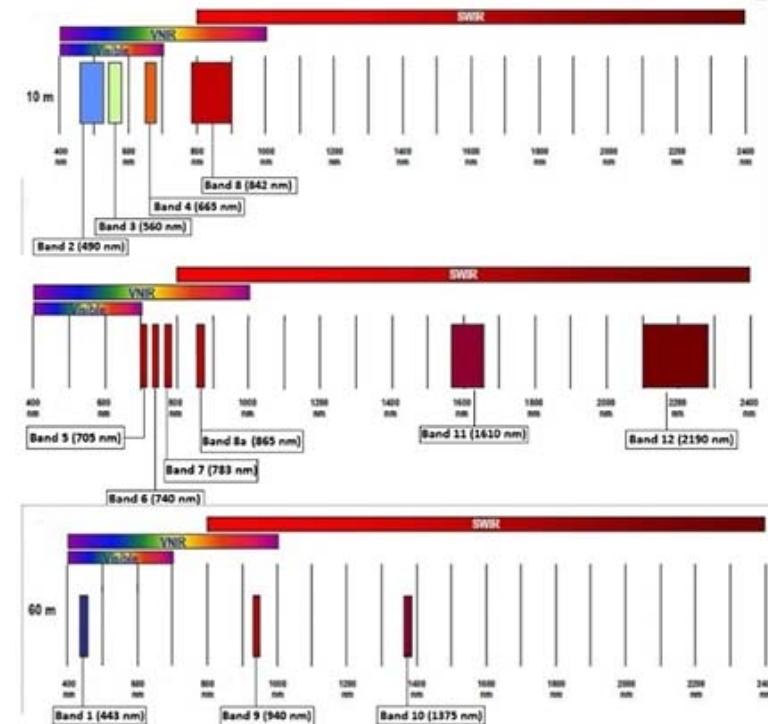
- Sealed
- Grassland
- Cropland
- Forest / Shrubs
- Water
- Wetland
- Open soil / Sand
- Shadow (no LC class)



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Use case: Facts

- Sentinel-2 provides multispectral data
 - 13 spectral bands
 - Resolutions ranging from 10 m to 60 m
- Possible derivation of land cover indices
 - Normalized Difference Vegetation Index
 - Normalized Difference Water Index
 - Normalized Difference Snow Index

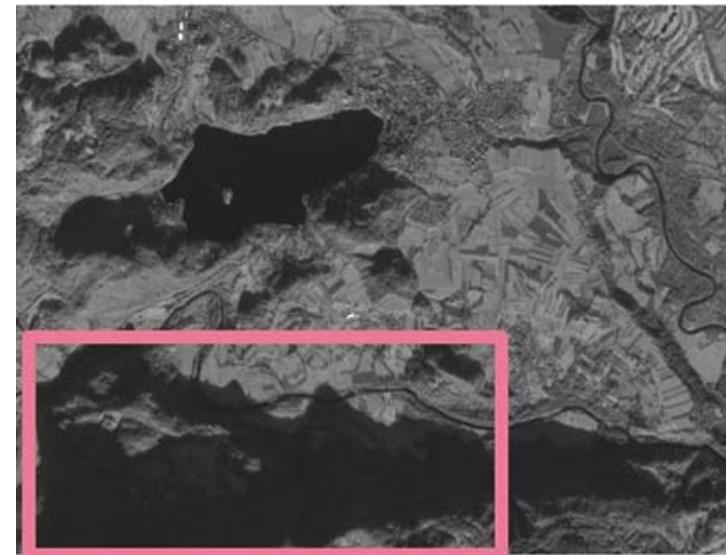




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Use case: Facts

- Detection of land cover types based on reflectance at different spectral bands
 - Distinct spectral signatures of land cover types
- Key challenge
 - Partial or even total loss of spectral information due to shadows

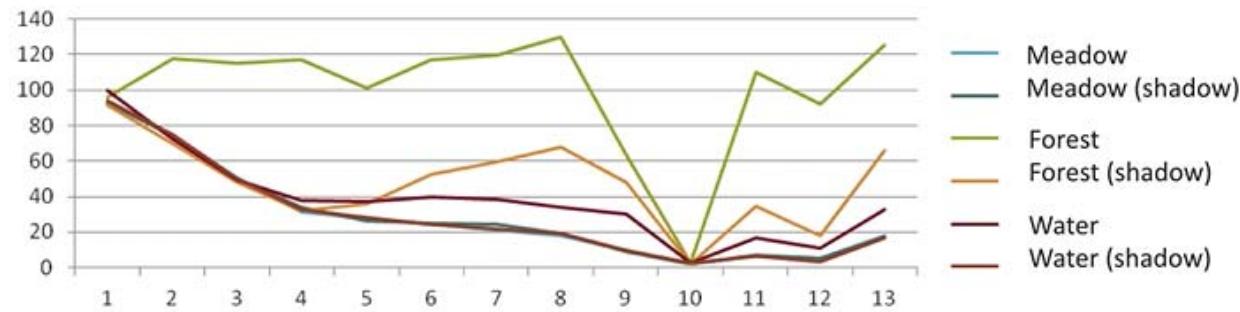




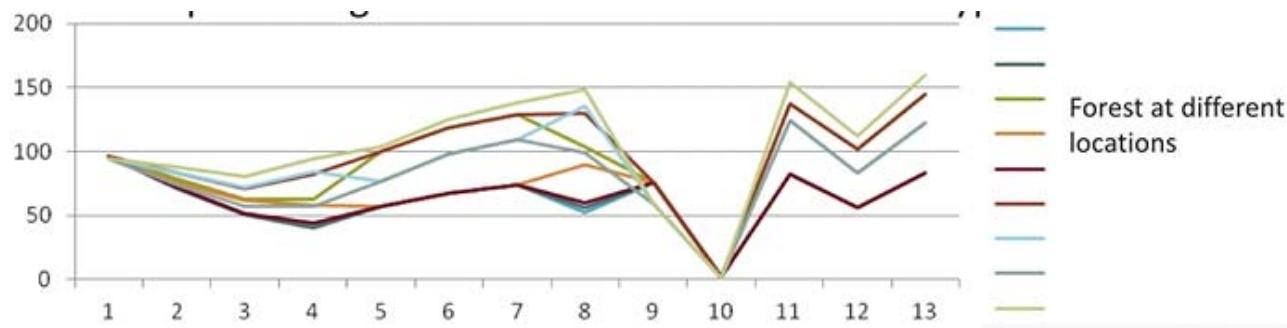
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Use case: Facts

- Different spectral signatures for different land cover types



- Different spectral signatures of the same land cover type



The screenshot shows the Copernicus Open Access Hub website. At the top, there is a blue header bar with the text "Copernicus Open Access Hub". On the left side of the header, there is a "Copernicus" logo featuring a globe with a satellite orbiting it. Below the header, the main content area has a blue banner with the "Copernicus" logo, a satellite icon, and the text "Copernicus Open Access Hub", along with the logos for "esa" and "European Commission". The main content area contains a "Welcome to the Copernicus Open Access Hub" message. Below this, there is a section with four buttons: "Open Hub", "API Hub", "S-3 PreOps Hub", and "GNSS Hub". The "API Hub" button is highlighted with a red circle. At the bottom of the page, there are links for "User Guide", "Open Source Portal", and "Reports & Stats". In the bottom right corner, there are logos for "Copernicus Europe's eyes on Earth", the European Commission, and the European Space Agency (ESA). The URL in the browser address bar is <https://scihub.copernicus.eu>.



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Copernicus Open Access Hub

Sentinel Loader: Direct integration of Sentinel-2 image data

- Automatic download and archiving of all available data for a defined area of interest via Copernicus API Hub
- Automatic pre-processing of the images (layer stacking, tiling, atmospheric correction)

The screenshot shows a desktop application window titled "D:\PROJEKTE\SentinelConnectorPrototype\bin\SentinelConnectord.exe". On the left, a terminal window displays command-line output for searching and downloading Sentinel-2 products. On the right, a file explorer window lists three temporary files generated by the process.

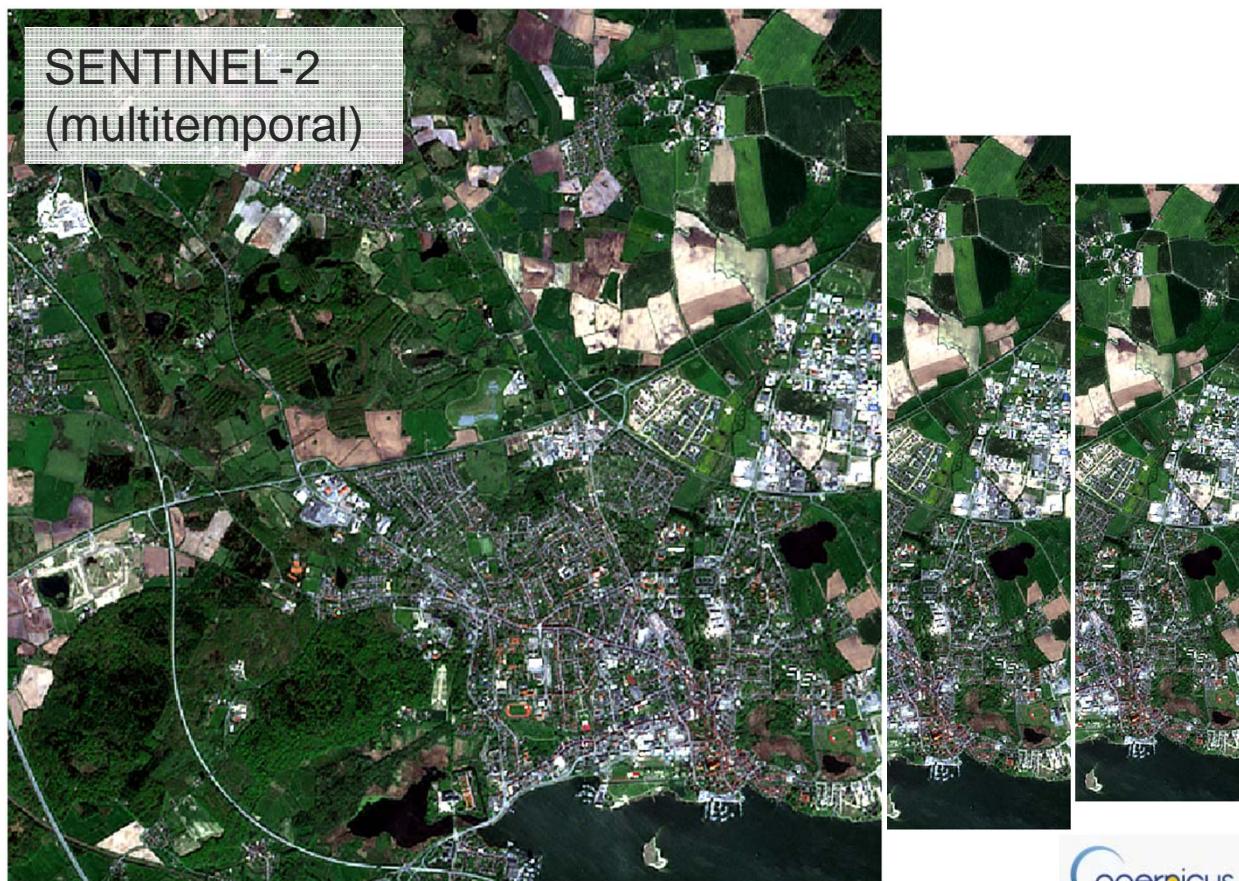
```
D:\PROJEKTE\SentinelConnectorPrototype\bin\SentinelConnectord.exe
Looking for products ingested after last update @ [2015-08-13T00:00:00Z]
HTTPRequest was sent successfully for URL https://scihub.eoPortal.org/api/v1/Products?where=ingestionDate:[2015-08-13T00:00:00Z,2015-08-13T23:59:59Z]&format=json&q=S2MSI1C%20AND%20<footprint>%22Intersects<POLYGON(<6%2042,17%2042,17%2049,6%2049,6%2042)</footprint>%22)&start=0&rows=100.
getStreamFromUri() successful for https://scihub.eoPortal.org/api/v1/Products?where=ingestionDate:[2015-08-13T00:00:00Z,2015-08-13T23:59:59Z]&format=json&q=S2MSI1C%20AND%20<footprint>%22Intersects<POLYGON(<6%2042,17%2042,17%2049,6%2049,6%2042)</footprint>%22)&start=0&rows=100.
Found 7 result(s); beginning download.
HTTPRequest was sent successfully for URL https://scihub.eoPortal.org/api/v1/Products?where=ingestionDate:[2015-08-13T00:00:00Z,2015-08-13T23:59:59Z]&format=json&q=S2MSI1C%20AND%20<footprint>%22Intersects<POLYGON(<6%2042,17%2042,17%2049,6%2049,6%2042)</footprint>%22)&start=0&rows=100.
getStreamFromUri() successful for https://scihub.eoPortal.org/api/v1/Products?where=ingestionDate:[2015-08-13T00:00:00Z,2015-08-13T23:59:59Z]&format=json&q=S2MSI1C%20AND%20<footprint>%22Intersects<POLYGON(<6%2042,17%2042,17%2049,6%2049,6%2042)</footprint>%22)&start=0&rows=100.
```

Name
20150818T132319245_a0a526dd_7ff6_4259_84f5_a26f0f1a7f2e
20150818T132347599_fe84a234_f655_49e6_8288_aef5ff5070e8
20150818T132309_d8858a81_d80a_42ca_90f1_6cc024f21a4b.temp



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Input Data



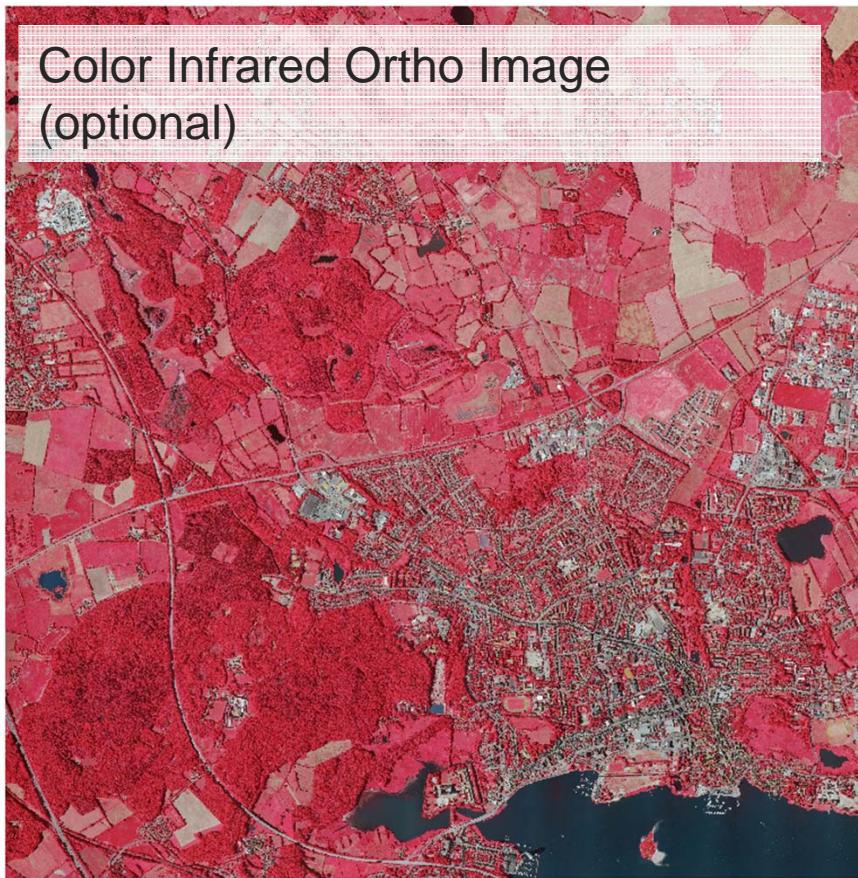
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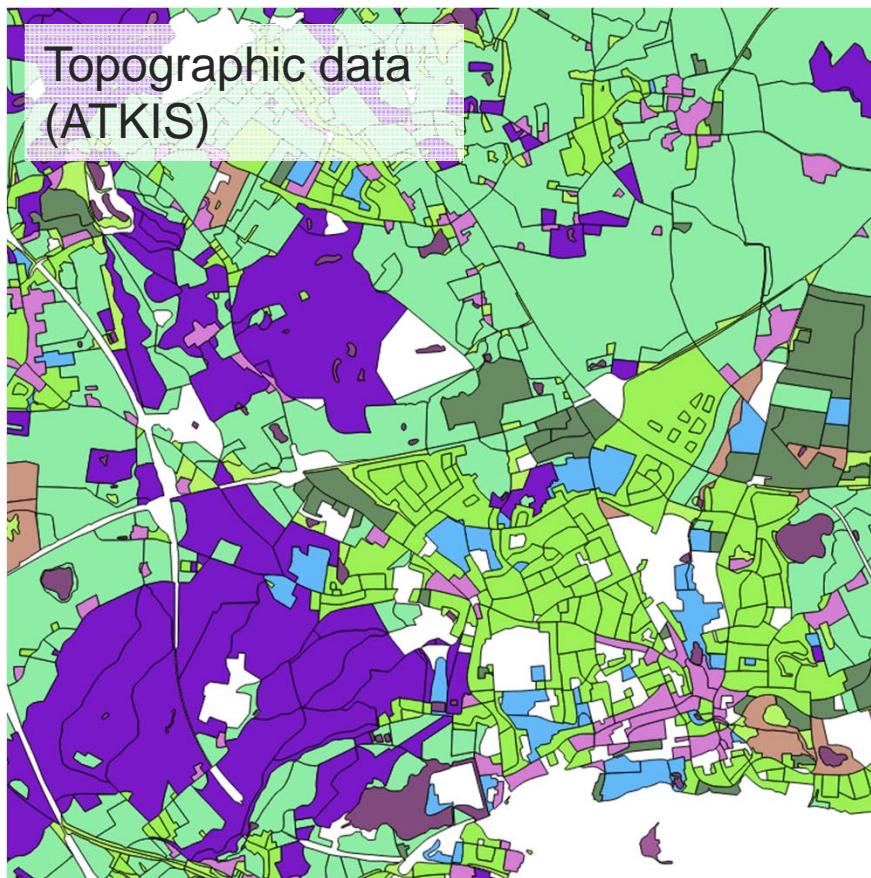
Input Data





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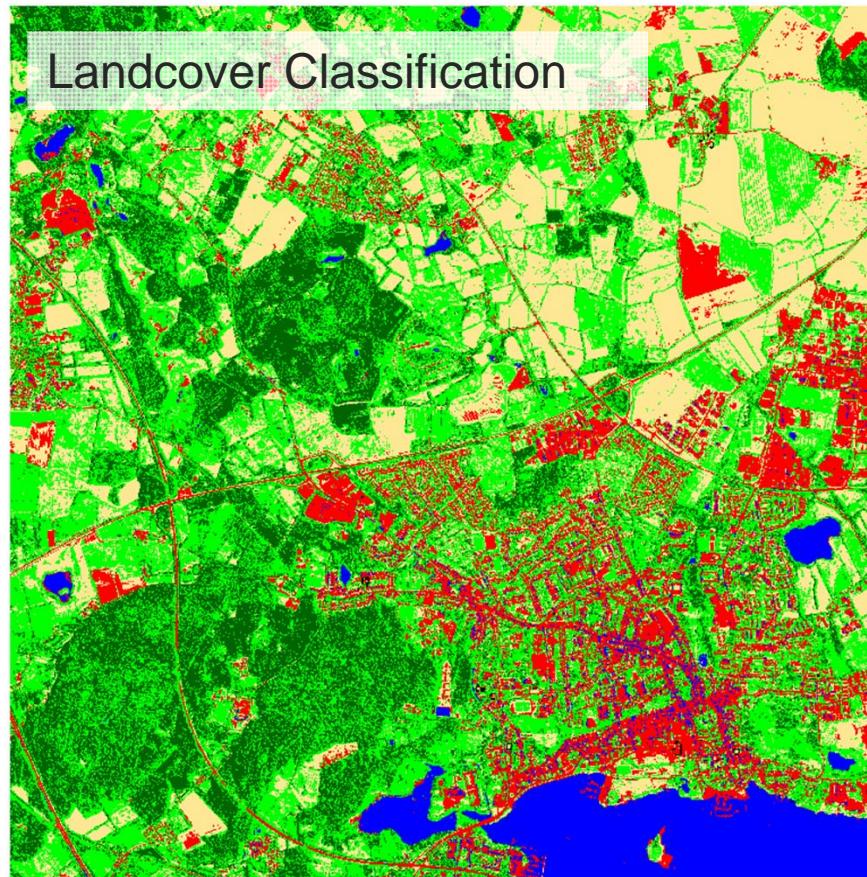
Input Data





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Intermediate Result: Landcover Classification



Land Cover Classes:

- Sealed
- Grassland
- Cropland
- Forest / Shrubs
- Water
- Wetland
- Open soil / Sand
- Shadow (no LC class)



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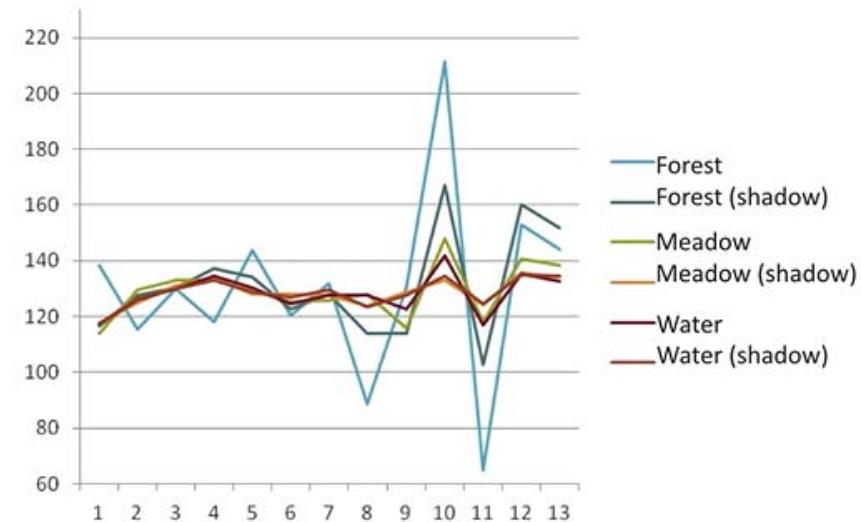
Optimization on shadow reduction

- Machine learning on:
 - Second derivative of spectral signature
 - Texture analysis with Grey level co-occurrence matrix (GLCM):

$$\text{Contrast: } \sum_{i=1}^m \sum_{j=1}^n (i - j)^2 GLCM(i, j)$$

$$\text{Energy: } \sum_{i=1}^m \sum_{j=1}^n (GLCM(i, j))^2$$

$$\text{Homogeneity: } \sum_{i=1}^m \sum_{j=1}^n \frac{GLCM(i, j)}{1 + |i - j|}$$





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Optimization on shadow reduction

- Mac

gcamClassification

Load TIFF
Load BMP
Store Bayes
Load Bayes
Test Bayes
Run Script
Test->Output
Deshadowing

Control variables:
Class ID: 1
Feature value range: 0
255
No feature levels 64

Classification test:
BMP4Class
SaveBMPClass
Run Script

Legend:
Forest
Forest (shadow)
Meadow
Meadow (shadow)
Water
Water (shadow)

Land Cover Classification:
Set working dir
Run Learning
Classify S2

OK

12 13



Copernicus

Optimization

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Homo

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gLearnClassification

Load TIFF

Load BMP

Store Bayes

Load Bay

Control variables:

Class ID:

Feature value range:

No feature levels

Land Cover Classification:

Set working dir

Run Learning

Classify S2

Report

Report

Report

Report

Class 0---BuiltUp---

Precision: 75.85

Recall: 79.82

F1_score: 77.78

Class 1---Farmland---

Precision: 50.66

Recall: 77.06

F1_score: 61.13

Class 2---Forest---

Precision: 94.54

Recall: 91.09

F1_score: 92.78

Class 3---Meadow---

Precision: 44.58

Recall: 77.23

F1_score: 56.53

Class 4---Water---

Precision: 87.54

Recall: 85.24

F1_score: 86.37

----- TOTAL -----

Precision: 88.17

Recall: 88.17

F1_score: 88.17

Report

Report

Report

Report

Class 0---BuiltUp---

Precision: 89.06

Recall: 88.03

F1_score: 88.54

Class 1---Farmland---

Precision: 85.71

Recall: 88.31

F1_score: 86.99

Class 2---Forest---

Precision: 96.99

Recall: 96.74

F1_score: 96.86

Class 3---Meadow---

Precision: 74.10

Recall: 78.92

F1_score: 76.43

Class 4---Water---

Precision: 94.87

Recall: 95.45

F1_score: 95.15

----- TOTAL -----

Precision: 95.01

Recall: 95.01

F1_score: 95.01

X

OK



Optimization

- Mac

Control variables:

- Class ID:
- Feature value range:
- No feature levels

Contract
Land Cover Classification
Energy
Homo

Set working dir

Run Learning

Classify S2

OK

12 13

Open
S2A_OPER_MSIL1C_TL_SGS_20151228T154435_A002693_T33TVM.con > TestArea_1
Search TestArea_1

Area_01.tif Area_02.tif Area_03.tif Area_04.tif Area_05.tif Area_06.tif Area_07.tif
Area_08.tif Area_09.tif Area_10.tif Area_11.tif Area_12.tif Classification.tif

File name: Image (*.tif)

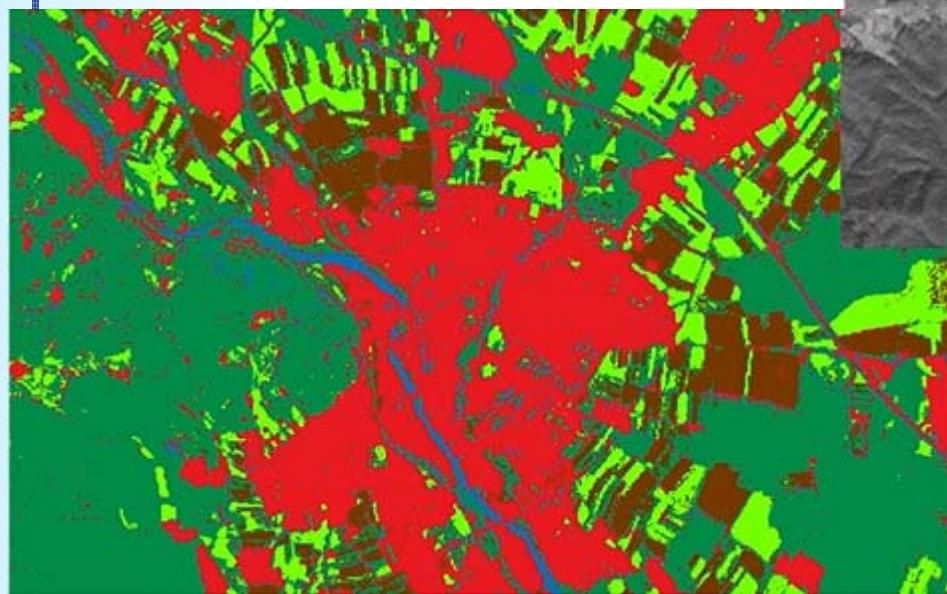
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The screenshot shows the 'gLearnClassification' software interface. On the left, there's a sidebar with sections like 'Contract', 'Land Cover Classification', 'Energy', and 'Homo'. Below these are buttons for 'Set working dir', 'Run Learning', and 'Classify S2'. The 'Classify S2' button is circled in red. In the center, there's a 'Control variables' section with dropdowns for 'Class ID', 'Feature value range', and 'No feature levels'. To the right of this is a 'File name' input field and a 'File type' dropdown set to 'Image (*.tif)'. Below these are buttons for 'Open' and 'Cancel'. A large 'OK' button is at the bottom right of the central area. At the very bottom right, there's a Copernicus logo and a European Commission logo.



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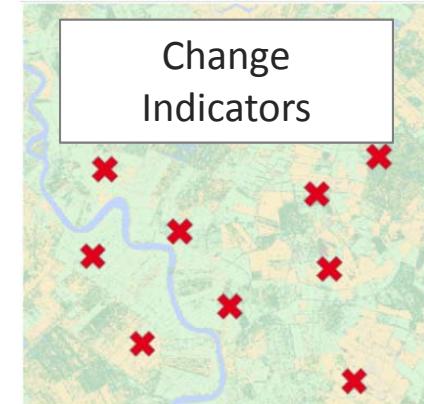
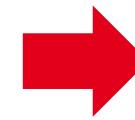
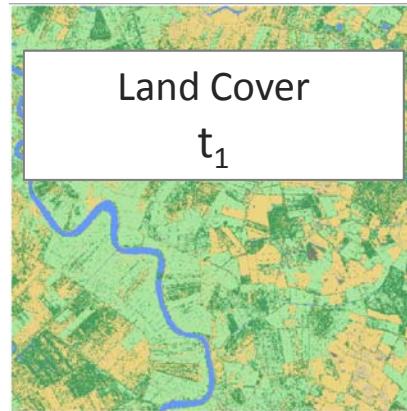
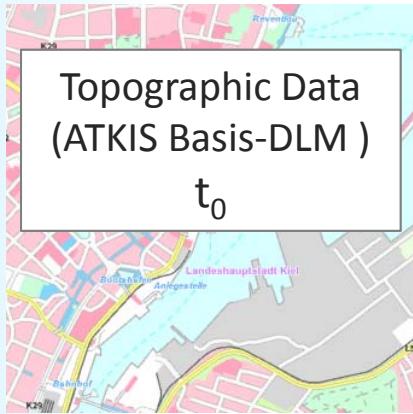
Optimization on shadow reduction





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Change detection approach



Processing the **change indicator data set**:

Object-based comparison and translation of

land use (27 polygonal object classes („Tatsächliche Nutzung“) and

land cover (8 land cover classes (7+1) from the supervised classification)



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Change detection approach

- Translation of land use to land cover in an object-based evaluation catalogue matrix

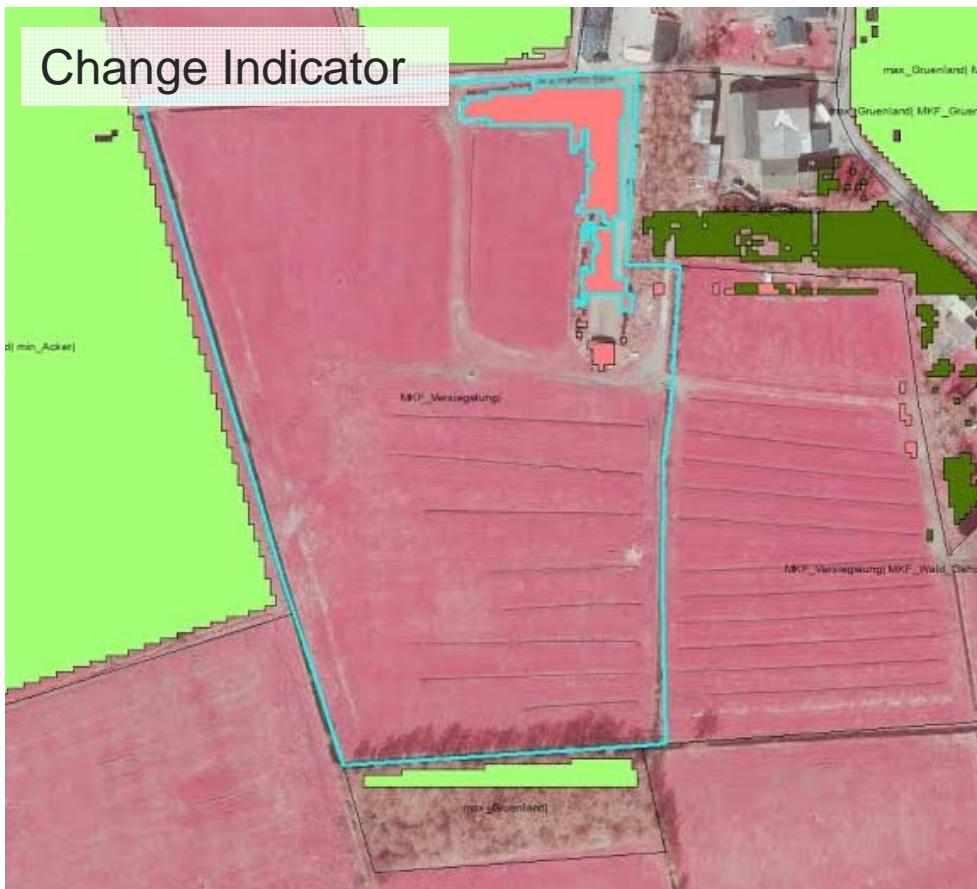
	Versiegelung	Grünland	Acker	Wald/Gehölz	Wasser	Feuchtflächen	Offenboden/Sand
41000 Siedlung							
41001 AX_Wohnbauflaeche	x	x	x	x	-	x	x
41002 AX_IndustrieUndGewerbeflaeche	x	x	x	x	-	x	x
41003 AX_Halde	x	x	-	-	-	-	x
41004 AX_Bergbaubetrieb	x	x	-	-	x	x	x
41005 AX_TagebauGrubeSteinbruch	x	-	-	-	x	x	x
41006 AX_FlaecheGemischterNutzung	x	x	x	x	-	x	x
41007 AX_FlaecheBesondererFunktionalerPraegung	x	x	x	x	-	x	x
41008 AX_SportFreizeitUndErholungsflaeche	x	x	x	x	-	x	x
41009 AX_Friedhof	x	x	-	x	-	-	x
42000 Verkehr							
42001 AX_Strassenverkehr	x	x	-	x	-	-	x
42002 AX_Strasse							

- Comparing ATKIS polygons with the land cover classification via an xml-based rule set
- Rule set: Relative proportion of area & absolute minimum mapping unit



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Final result: Change Indikator





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User Evaluation

Evaluation by the State Bureau of Surveying and Geoinformation Schleswig-Holstein (LVerMGeo SH)

- „The usage of the DLM-Update led to an approx. 10 % speed-up of updating ATKIS data.“
- „More optimization could be achieved [...] e.g. via integration of Sentinel 1-data
- **Based on the evaluation Decision for operational Use taken**
- **Operational Use since 2017**