STAATSBETRIEB
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Assessment of damaged and disturbed areas by use of Copernicus data

Sachsenforst

Karina Hoffmann & Julian Backa

Structure

1. Use of copernicus data
2. Results of sentinel data monitoring from October 2017 to October 2021
3. Project “remote sensing-based national forest damage monitoring system for Germany” (FNEWs)

1. Use of Copernicus data

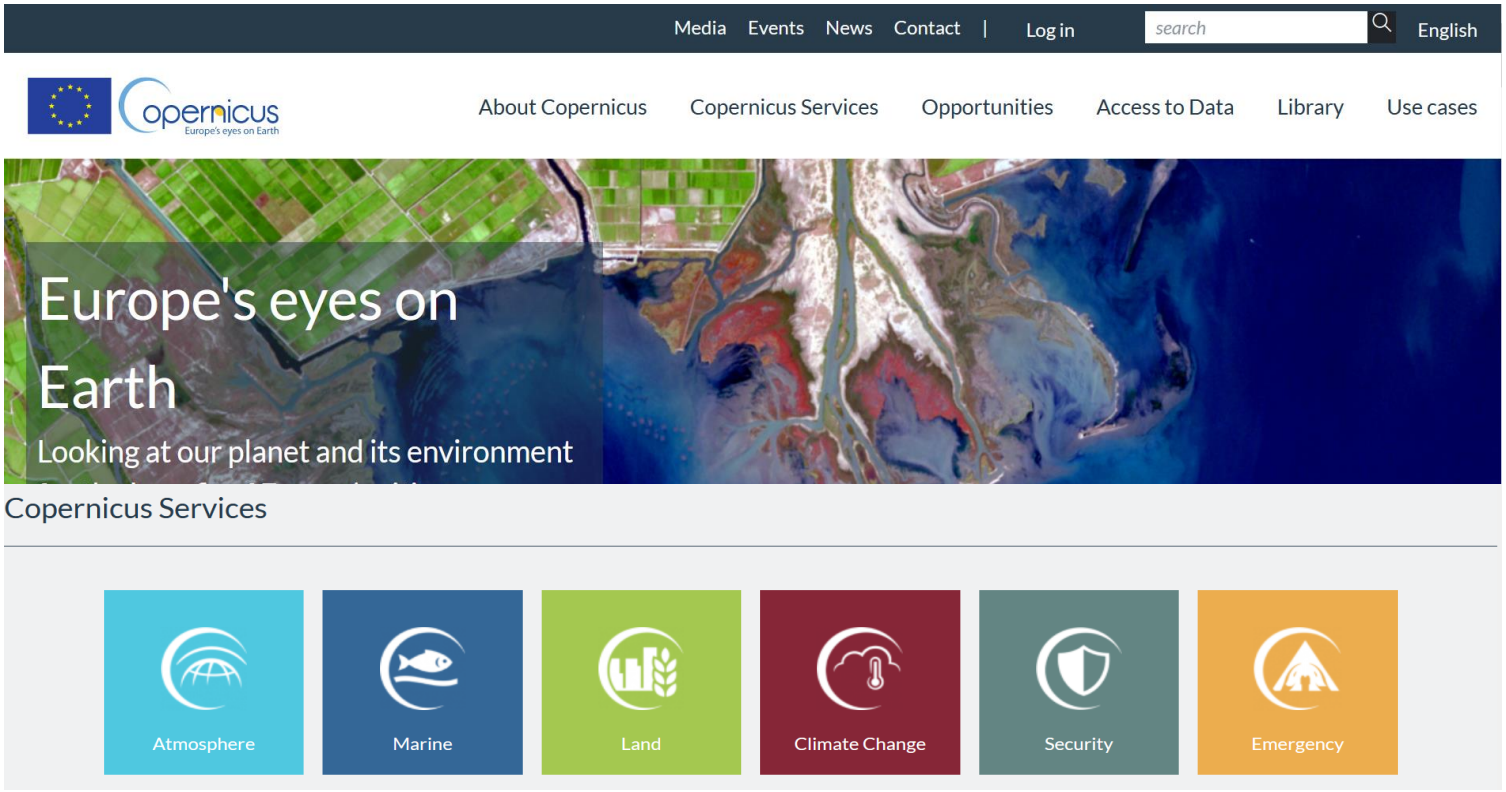
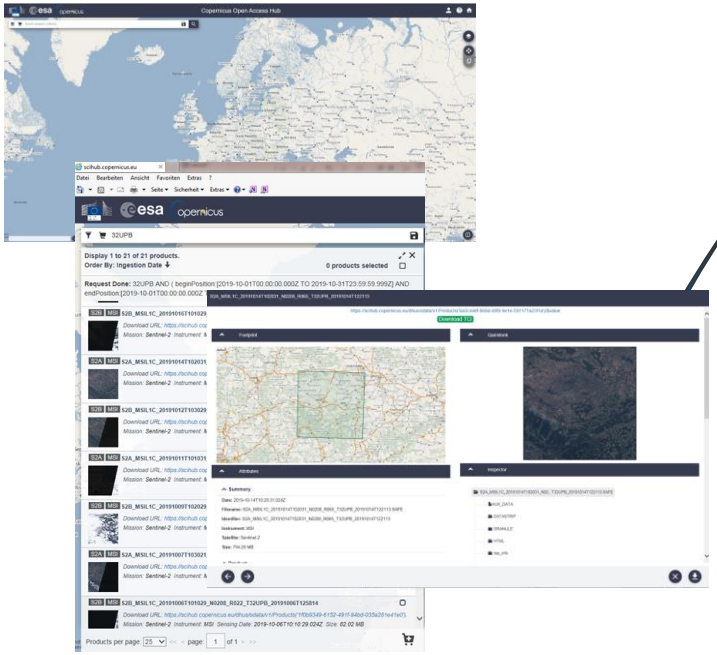


Fig. 2.: *Services of the Copernicus program (*https://www.copernicus.eu)

Sentinel data

Data download
https://scihub.copernicus.eu/



Mosaicing, Cloud mask

Cataloging in FGIS_raster
(ERDAS APOLLO)

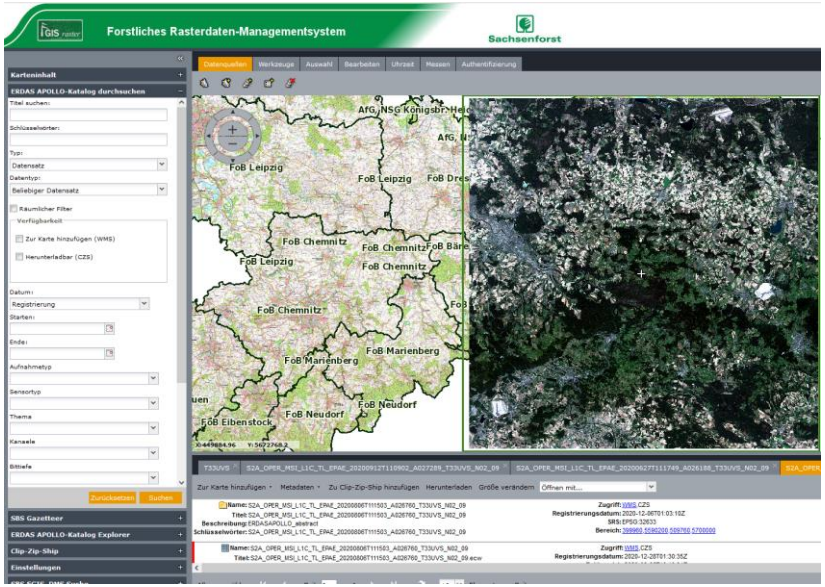


Fig.3: *Workflow for automated integration of sentinel data in FGIS_raster*

Sentinel data

- **Sentinel-2**
  (optical data)

Fig.4: Sentinel 2

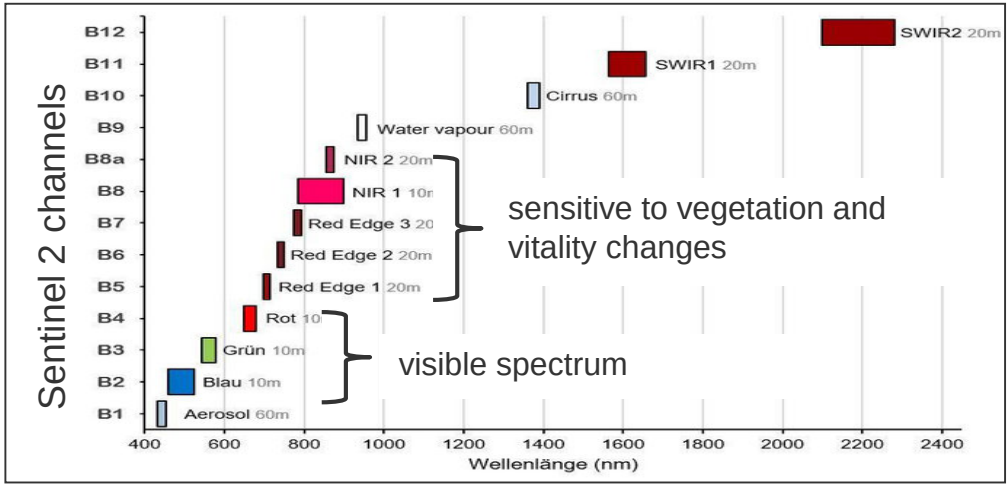


Fig. 6.: Distribution of Sentinel 2 channels after Immitzer et. al., 2016

  - temporal resolution: 5 - 6 days
  - spectral resolution: *443 -2220nm*
  - *spatial resolution: 10m to 60m*
  - detection of vitality changes using vegetation indices (NDVI, DSWI, …)

- **Sentinel-1**
  (radar)

Fig.5: Sentinel 1

2. Results of Sentinel data monitoring from October 2017 to October 2021

Fig.7: Sentinel 2 data (left) and mapping result (right)

Target

LUFTBILD UMWELT PLANUNG

- estimation of areas with changes in vitality and disturbance/open areas for the entire forest of Saxony from October 2017 to October 2021 (spring and autumn)

16.10.17 19.04.18 11.10.18 19.04.19 21.09.19 23.04.20 15.09.20 31.05.21 10.10.21

Fig.8: Sentinel 2 data time series

- classes
  - clearing / disturbed area (reason unknown)
  - clearing / disturbed area with young growth and/or shrub vegetation (e.g. blackberries)
  - area with loss of vitality, likely to die off (reason unknown)
  - area with medium loss of vitality (reason unknown)

METHOD

Sentinel-2 data

- data selection

Preprocessing

- atmosphere correction
- topographical correction
- co-registration
- cloud mask
- mosaiking

Calculate index

- NDVI, NDII, NMDI, EWDI, DSWI, RGI, NBR, …

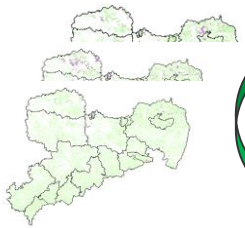
Modeling

- Random forest model

Training data

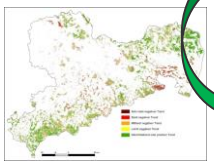
Analysis area

- deciduous forest
- evergreen coniferous forest
- larch



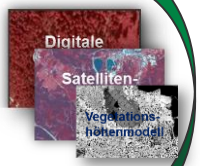
Time slices

Change detection



Change layer
Trend analysis

Quality management



Validation data

Open space mapping

Sentinel-1 data

Fig. 9:*Method of the entire evaluation process*

Results

- areas with changes in vitality and disturbance/free areas from October 2017 to October 2021

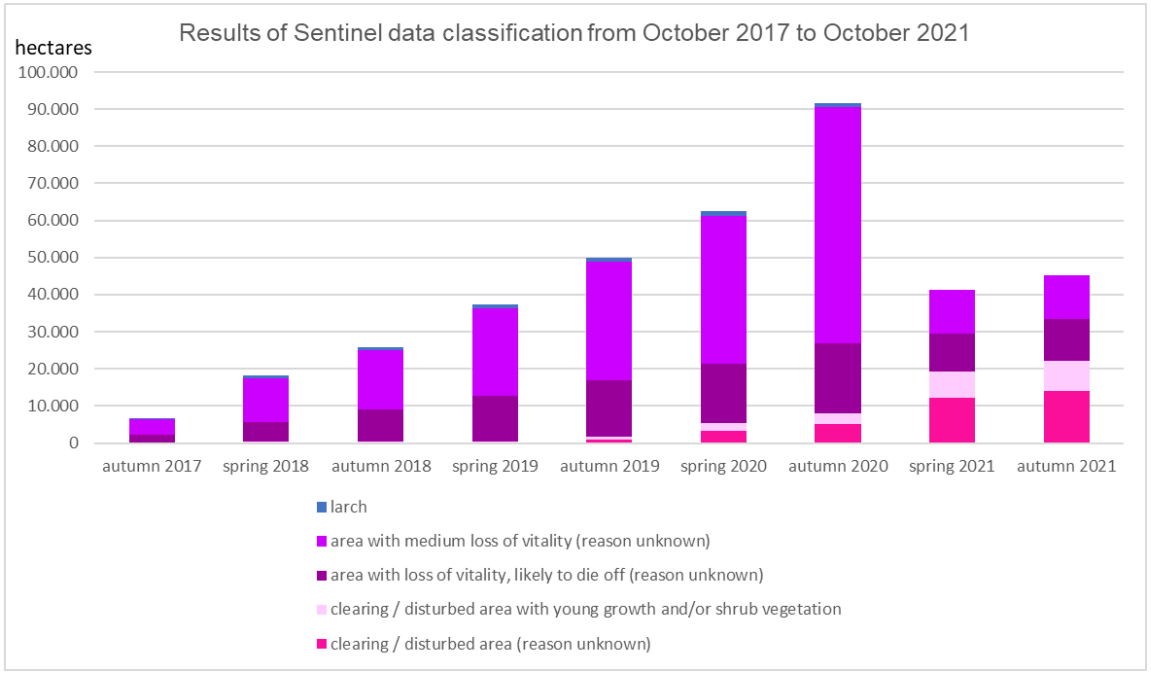


Fig. 10: Results of sentinel data monitoring 2017 to 2021

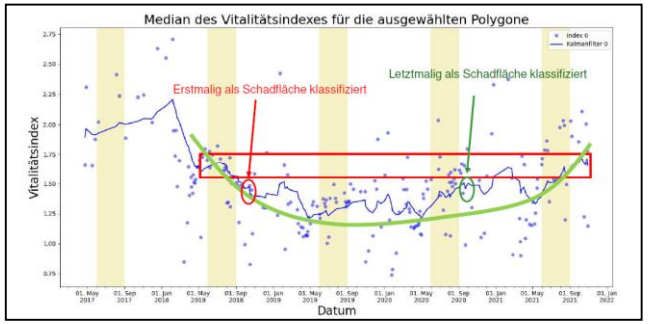


Fig. 11: Median of the vitality index for selected areas (time series)

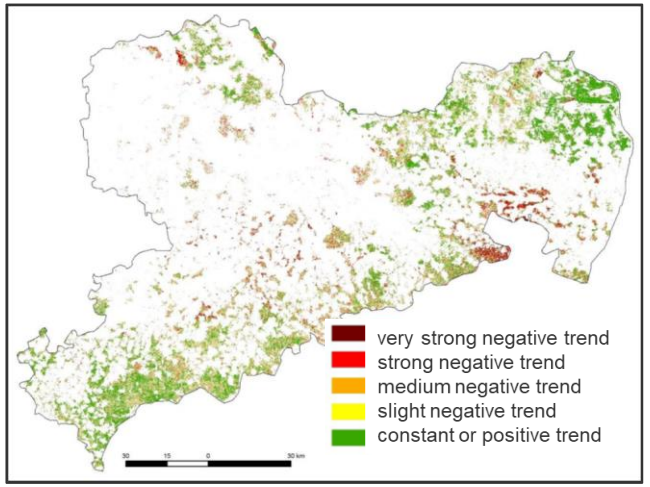


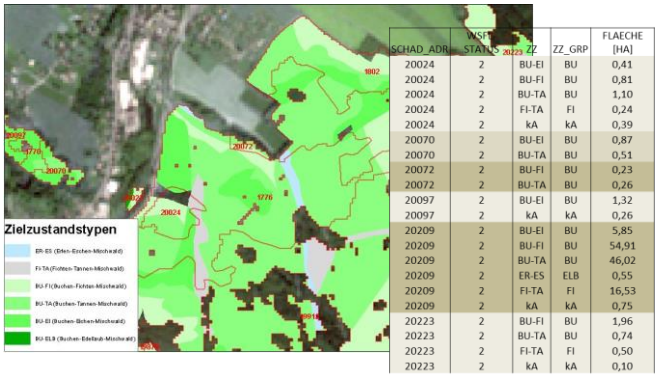
Fig. 12: Trend analysis from May 2017 to May 2022

Use in practice

- allocation of the soil science determined, dynamic target states

Fig. 13: Sentinel 2 data

Fig. 14: Mapping results 2017 – 21



SCHAD_ADR	WSP STATUS	ZZ	ZZ_GRP	FLAECHE [HA]
20024	2	BU-EI	BU	0,41
20024	2	BU-FI	BU	0,81
20024	2	BU-TA	BU	1,10
20024	2	FI-TA	FI	0,24
20024	2	kA	kA	0,39
20070	2	BU-EI	BU	0,87
20070	2	BU-TA	BU	0,51
20072	2	BU-FI	BU	0,23
20072	2	BU-TA	BU	0,26
20097	2	BU-EI	BU	1,32
20097	2	kA	kA	0,26
20209	2	BU-EI	BU	5,85
20209	2	BU-FI	BU	54,91
20209	2	BU-TA	BU	46,02
20209	2	ER-ES	ELB	0,55
20209	2	FI-TA	FI	16,53
20209	2	kA	kA	0,75
20223	2	BU-FI	BU	1,96
20223	2	BU-TA	BU	0,74
20223	2	FI-TA	FI	0,50
20223	2	kA	kA	0,10

Fig. 15: Target states

- discussion of the results in the context of current forest stand data in order to obtain more detailed statements on the causes
- remote sensing evaluations for all forest ownership types (2011 - 2021): degree of canopy cover, growth and tree height classes, tree species groups, forest area additions and removals

Data availability

- geodata server, forest district server (shapefiles)
- Geoportal Saxony

  https://www.forsten.sachsen.de/kartendienste_sturm/erdas-iws/ogc/wms/Monitoring?REQUEST=GetCapabilities&SERVICE=WMS
- FGIS_online

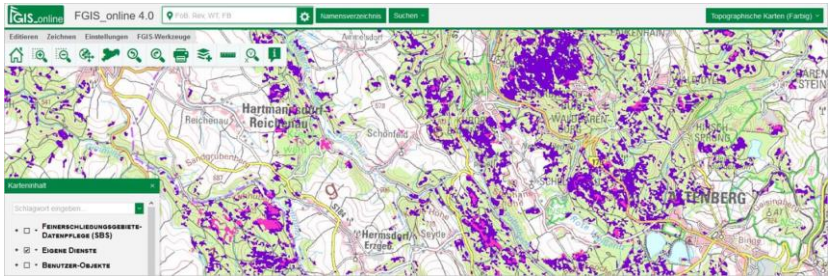


Fig. 16: Results of Sentinel data monitoring as a WMS in the webapplication FGIS_online by Sachsenforst

Fig. 17: Results of Sentinel data monitoring as a WMS in the Geoportal Saxony

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FNEWs: A remote sensing-based national forest damage monitoring system for Germany

Concept and Methods

Karina Hoffmann, Julian Backa et al.*

Sachsenforst

*Jörg Ackermann, Petra Adler, Simon Fleckenstein, Kristin Franz, Christian Ginzler, Martin Puhm, Eike Reinosch, Marius Rüetschi, Mathias Schardt, Christoph Straub, Andreas Uhl, Lars Waser, Jens Wiesehahn, Andreas Wimmer Rudolf Seitz

FNEWs

Project Partners

- International project consortium from three different countries

Fig. 18: Project partners organization chart

Project Structure

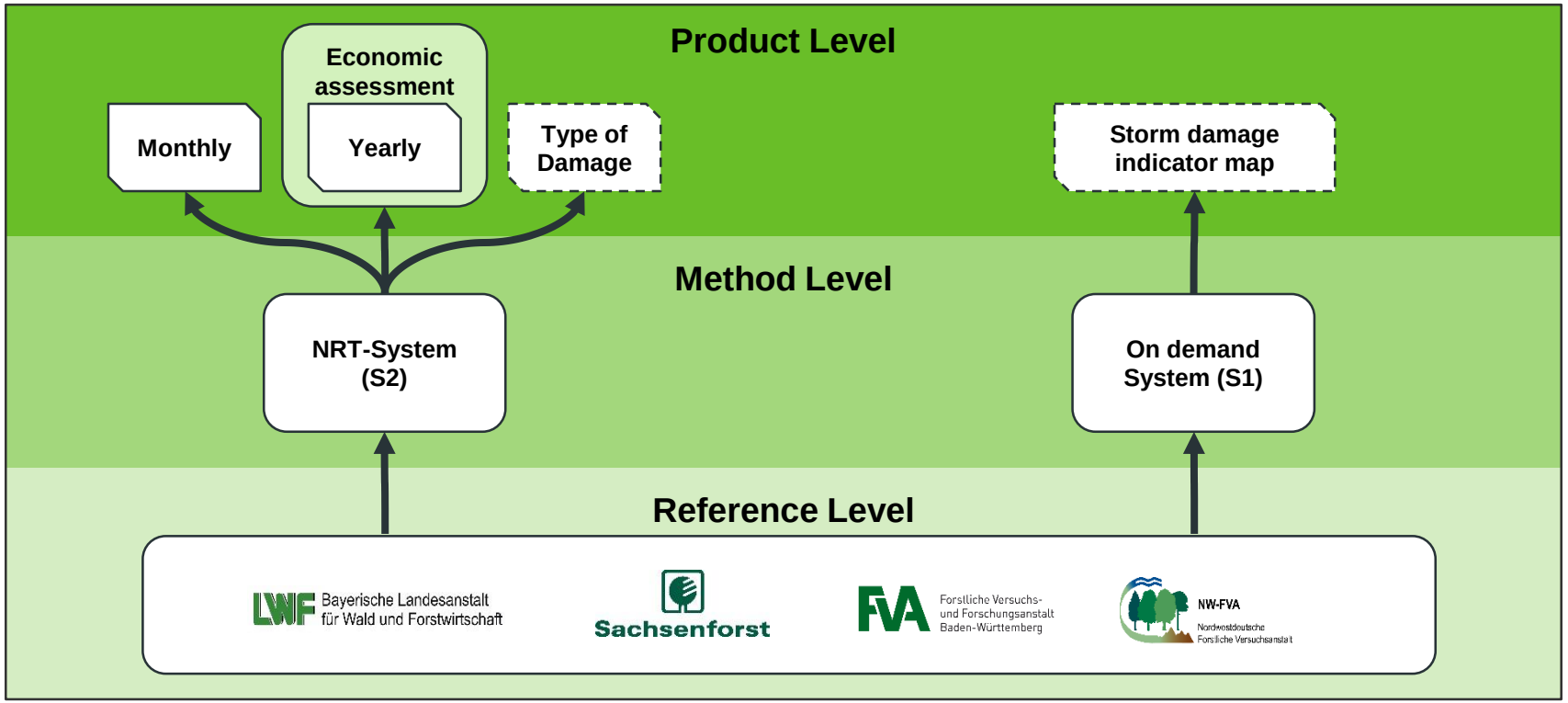

Fig. 19: Project structure concept chart

Project study areas

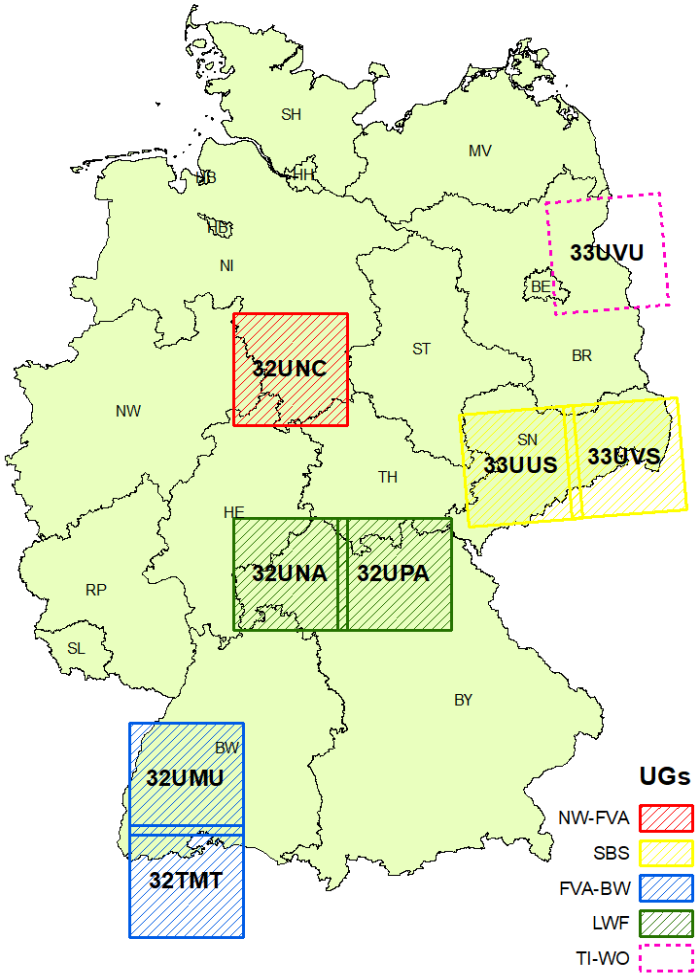

Fig. 20: Study areas Germany

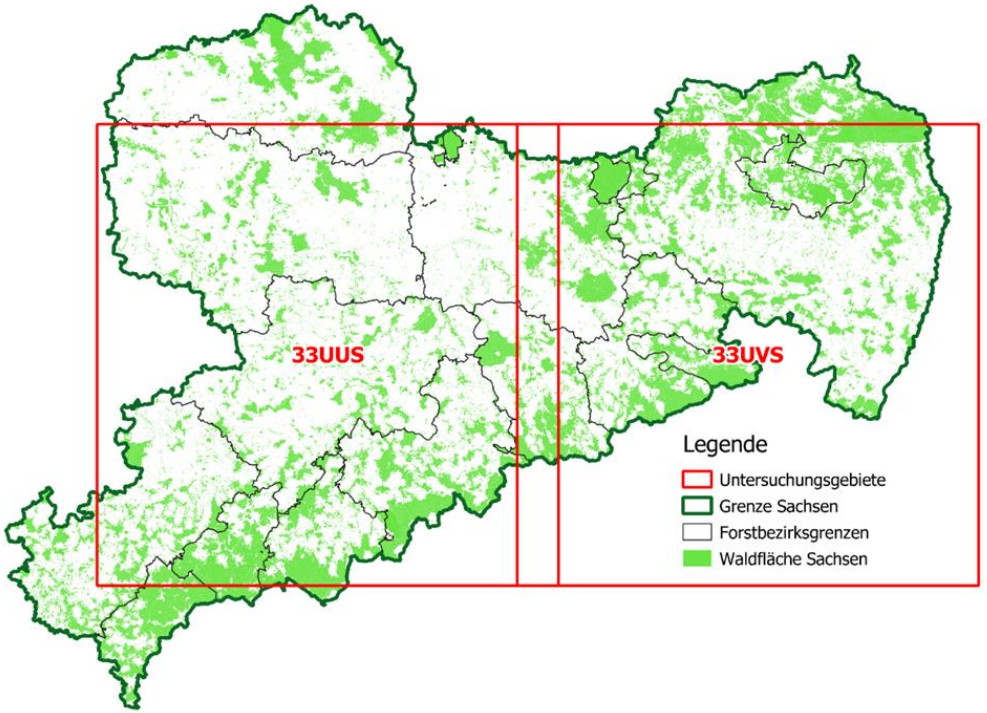

Fig. 21: Study areas Saxony

Project Workpackages

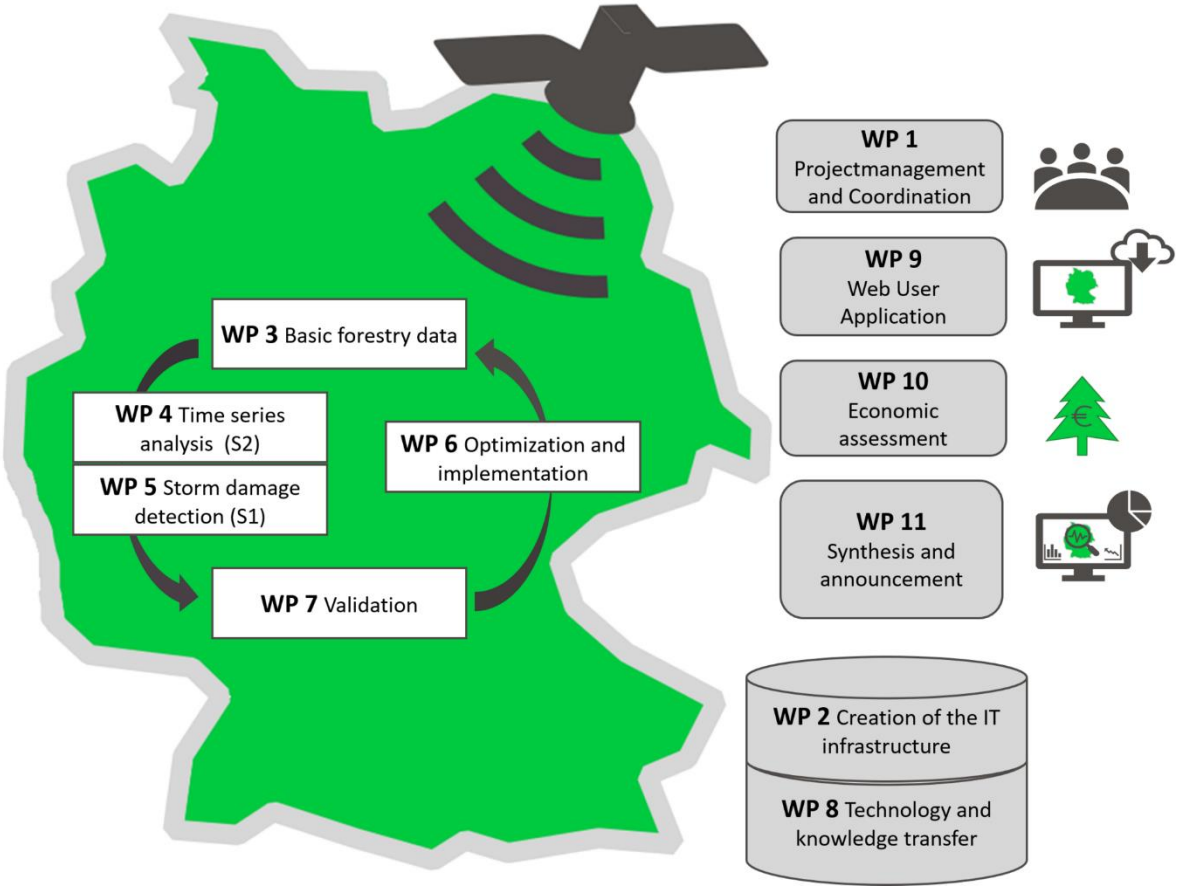

Fig. 22: Overview project workpackages

WP4 – Method: NRT System

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Challenge: Time-series model

- is robust against outliers (cloud residuals)
- deal with inhomogeneous observation intervals
- is dynamic in order to take phenology into account
- is sensitive to different types of forest damages

Method:

1. Optimized Preprocessing
2. Structural Time Series Model
3. Kalman-Filtering
4. Change Detection

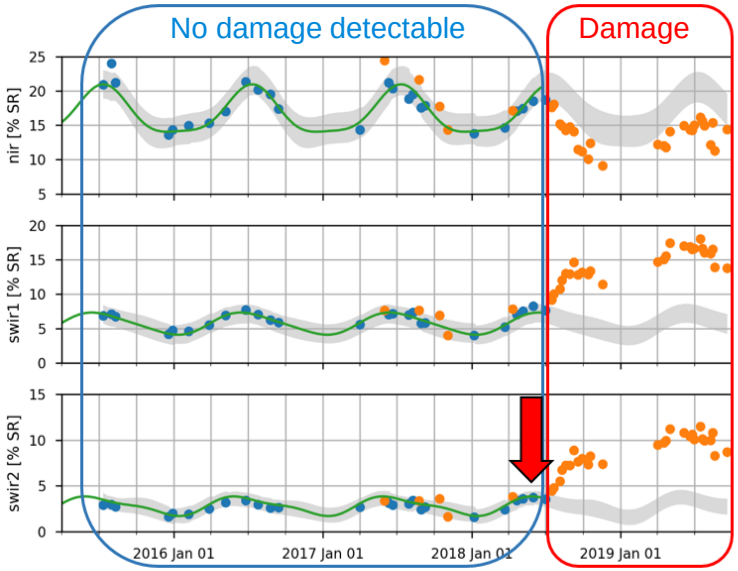

Fig. 23: Pixel based time series damage detection

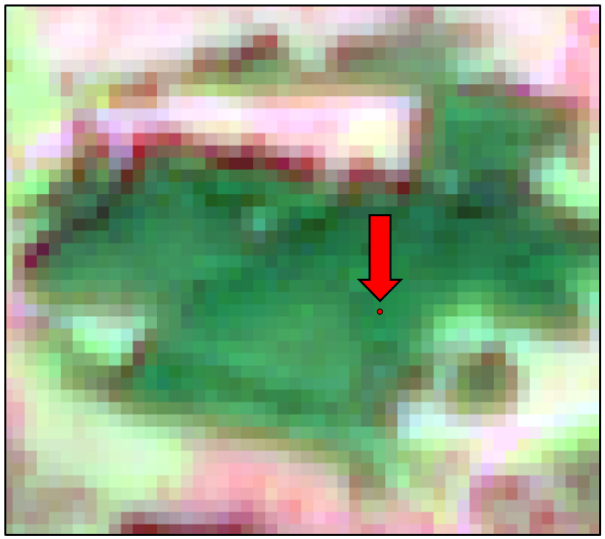

Fig. 24: Sentinel-2 Scene damaged pixel loaction

WP4 – Method: NRT System

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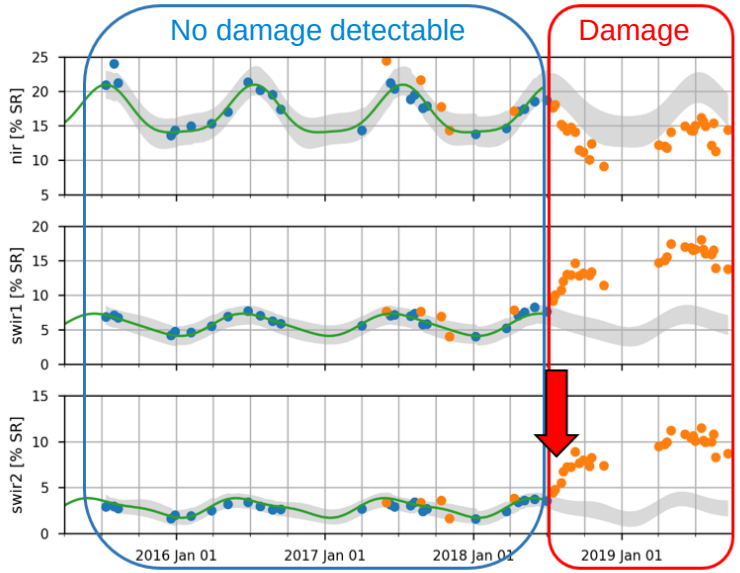

Fig. 23: Pixel based time series damage detection

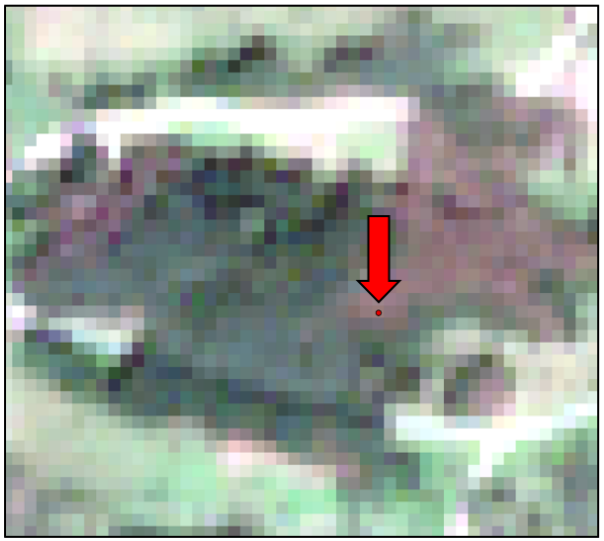

Fig. 24: Sentinel-2 Scene damaged pixel loaction

WP4 – Method: Type of Damage

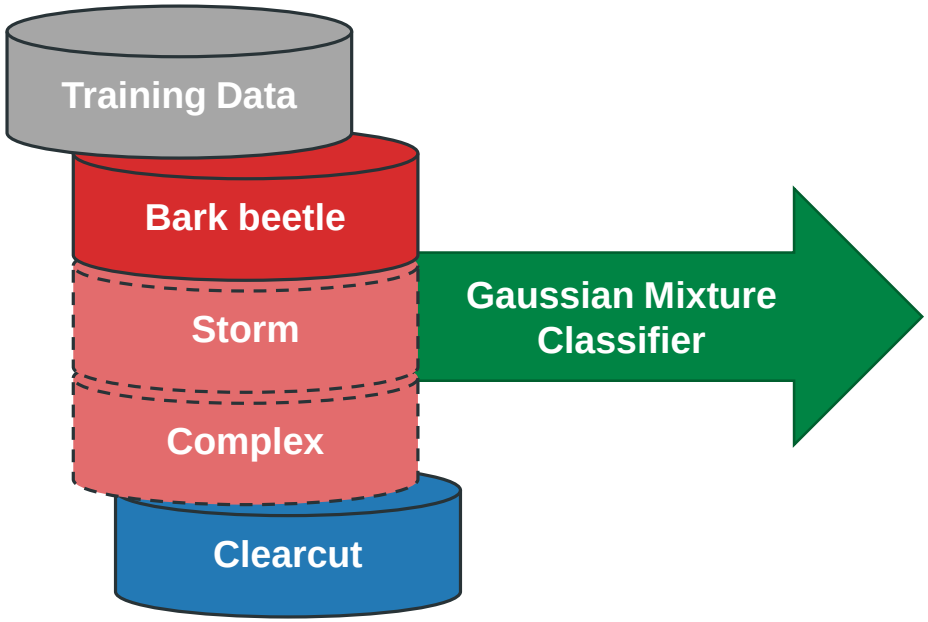

Fig. 25: Project structure concept chart

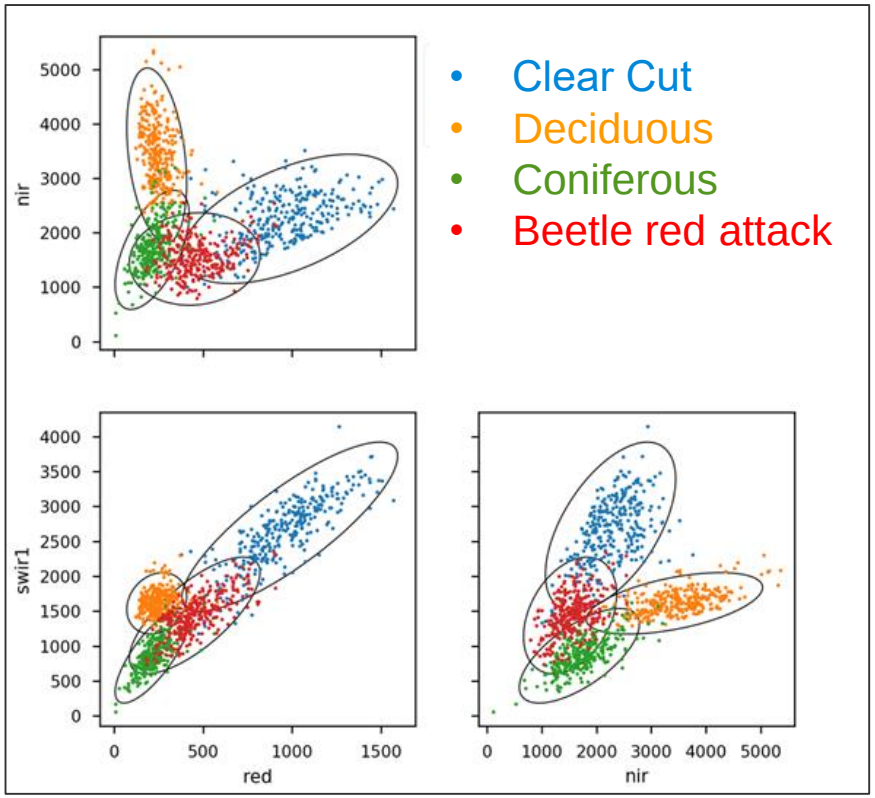

Fig. 26: Cluster graphs for different band combinations

WP7 – Validation

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- At present, the model results are being validated.
- we use three strata for validation
- the number of stratified random samples is according to Oloffson

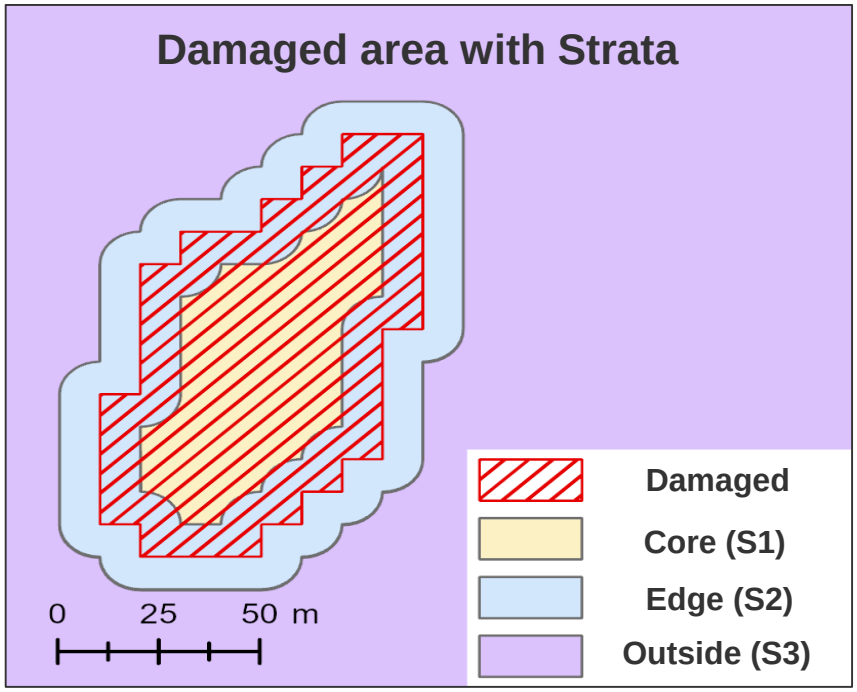


Fig. 27: Three strata method

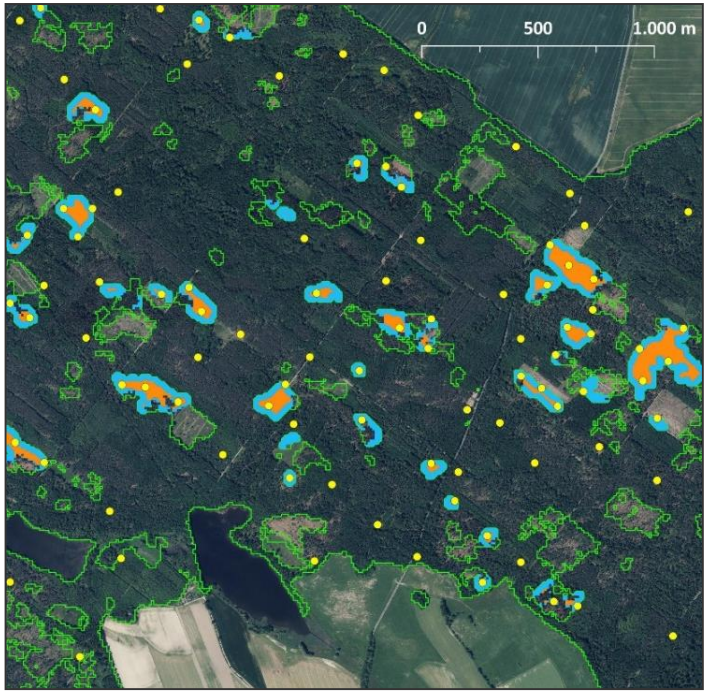
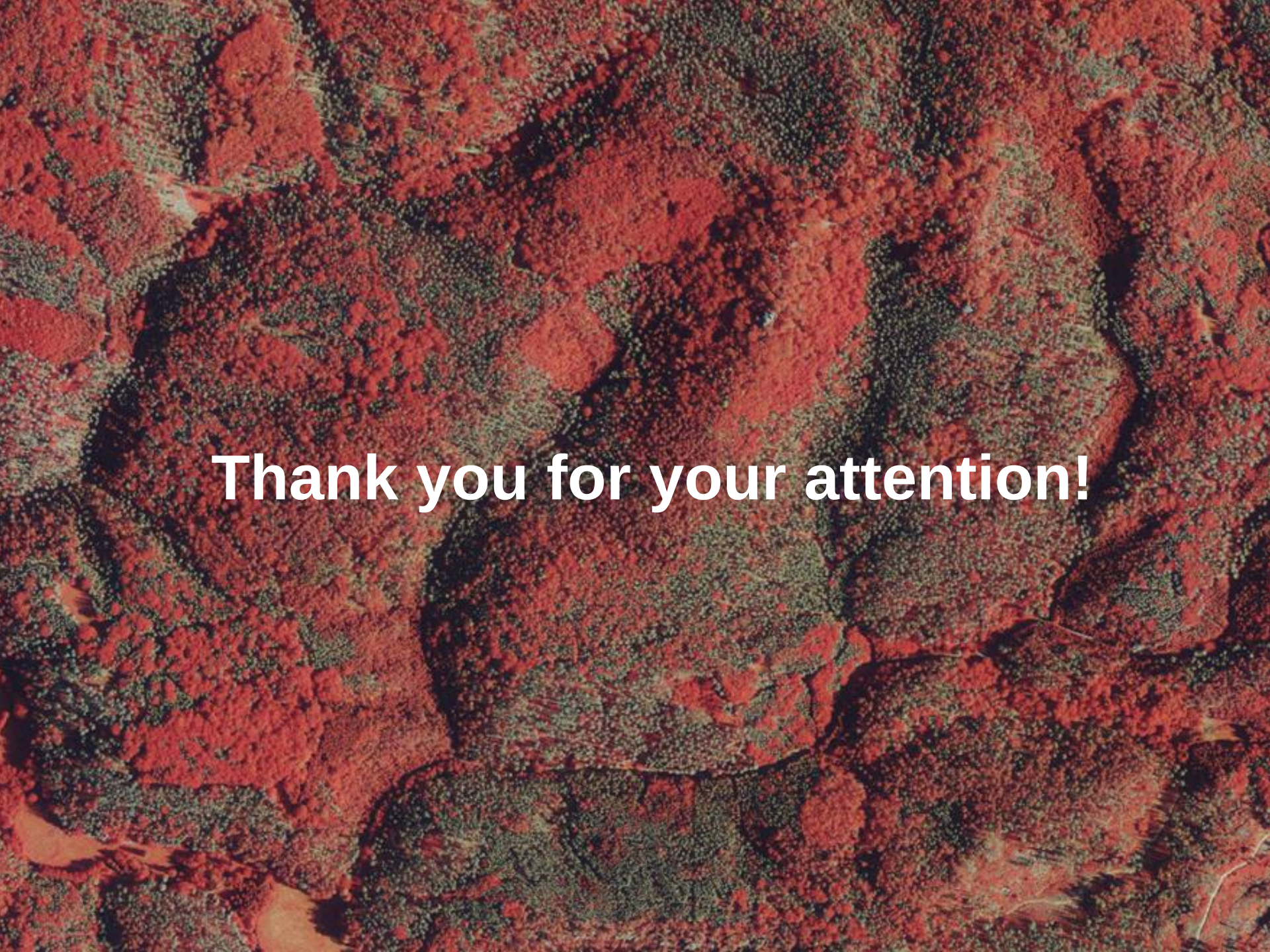


Fig. 28: Validation example Saxony

Outlook

- Validation of the results
- Work on damage type classification
- Publication of the results
- Implementation of processing-chain on CODE-DE
- Development of framework for economic modelling
- Design web-user application
- Nationwide roll-out


Thank you for your attention!

Contact

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01796 Pirna

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Sources

Fig. 2.: *Services of the Copernicus program (*https://www.copernicus.eu)

Fig. 4. Sentinel-1-Sensor: https://www.d-copernicus.de/fileadmin/_processed_/0/e/csm_Sentinel-1_69eb6d8310.jpg

Fig. 5: Sentinel-2-Sensor: https://www.d-copernicus.de/fileadmin/_processed_/e/7/csm_Sentinel-02-LR052008_3d8d27cb83.jpg

Fig. 6.: Distribution of Sentinel 2 channels after Immitzer et. al., 2016, https://www.mdpi.com/2072-4292/8/3/166/htm?ref=https://githubhelp.com

Fig. 11, 12: Luftbild Umwelt Planung Potsdam, Dokumentation zum Werkvertrag „Verbesserte Erfassung von Schadflächen und Freiflächen mit Hilfe von Sentinel 2 Daten für den Zeitraum Herbst 2017 bis Herbst 2020“, unveröffentlicht

Fig. 19, 20, 22, 25, 26, 27: Thünen-Institut

Fig. 23, 24, 29: Joanneum Research Digital

Fig. 30: Small, D. et al., 2021. Wide-Area Analysis-Ready Radar Backscatter Composites. IEEE Trans. Geosci. Remote Sens.

Fig. 31: Rüetschi, M. et al., 2019. Rapid Detection of Windthrows Using Sentinel-1 C-band SAR Data. Remote Sens. 11, 115.

WP4 – Method: NRT System

- **Method:**
  1. Optimized Preprocessing
  2. Structural Time Series Model
  3. Kalman-Filtering
  4. Change Detection

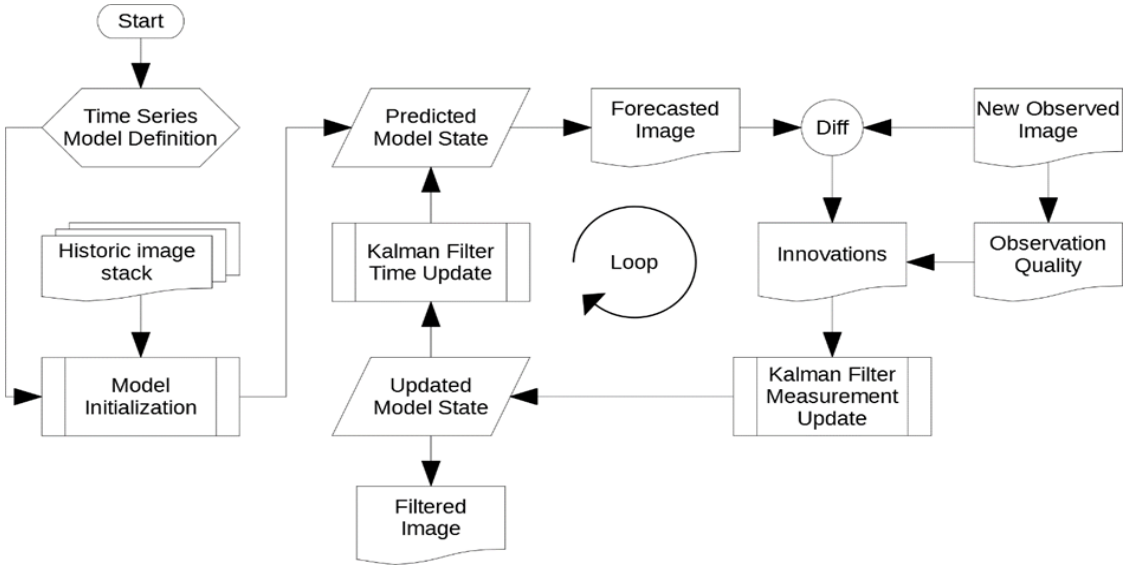

Fig. 29: Sentinel-2 NRT method chart

WP7 – Method: Rapid detection of storm damage

- Detection based on SAR composites consisting of several images before and after the storm
- Windthrow index: $$WI = \left(\gamma^0_{LRW,VV,t2(post)} - \gamma^0_{LRW,VV,t1(pre)}\right) + \left(\gamma^0_{LRW,VH,t2(post)} - \gamma^0_{LRW,VH,t1(pre)}\right)$$
- Two threshold values are then to be defined for the detection (a, n)

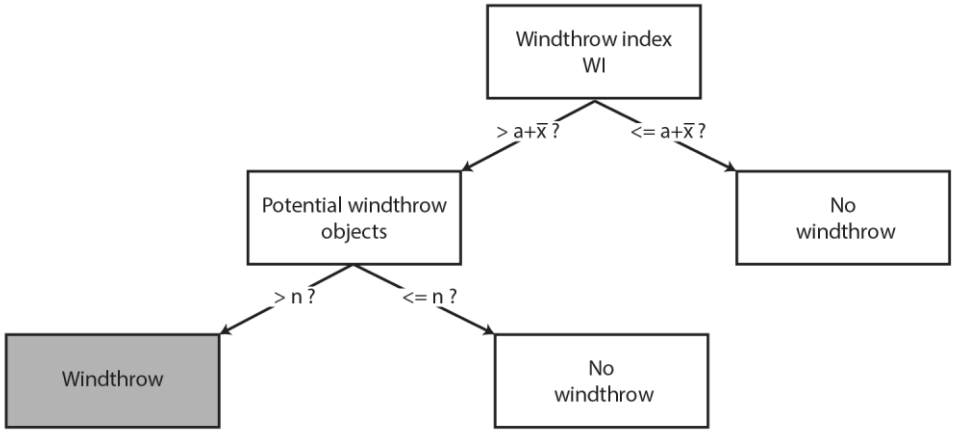

Fig. 30: Rapid detection of storm damage – Method chart

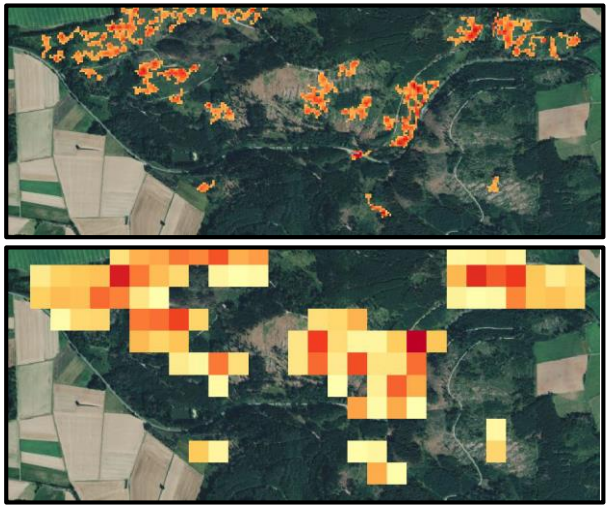

Fig. 31: Indicator pixels for windthrow