Development of a remote sensing based fast response system to support the crisis management after storm calamities in forests

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Copernicus – The European Earth Observation Programme

Bayerische Forstverwaltung

Zentrum Wald Forst Holz Weihenstephan

MOTIVATION

Considerations for crisis managers after heavy storm events

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Where are my windthrow areas?

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Where are my windthrow areas?

How to organize my crisis management?

Motivation

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How to organize my crisis management?

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Current practice after storm events…

- time-consuming search
- subjective and coarse estimation
- no centralized information
- lack of regular updated information

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…leads to

- delayed crisis management organization
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- economic losses
- subsequent biotic damages (e.g. bark beetle)

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…leads to

- delayed crisis management organization
- uncertainties in the timber markets
- economic losses
- subsequent biotic damages (e.g. bark beetle)

→ Need of a concept which works efficient and fast

„FastResponse“

Objectives

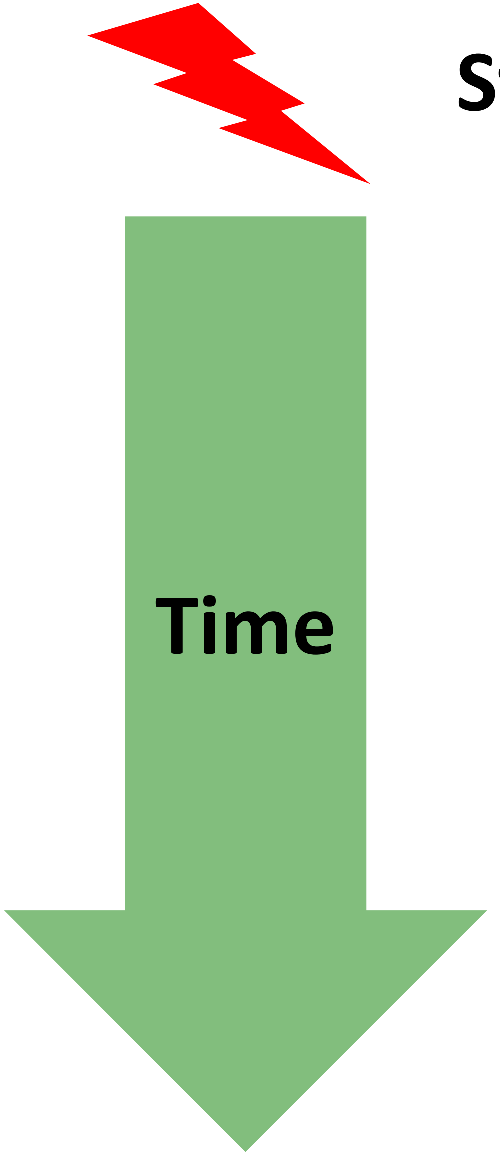
„FastResponse“

Aim:

to establish a **process chain** in which **existing methods** and **available sensors** will be combined to a **operational, fast acting service**.

Requirements

Storm event



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Storm event

Time

After three days:

- first fast and coarse estimation of WTAs (MMU: 0.5ha)

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Storm event

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After three days:

- first fast and coarse estimation of WTAs (MMU: 0.5ha)

After 14 days:

- More detailed estimation of the WTAs
- Additional information (timber volume, logistic aspects, topography,...)

CONCEPT

Concept – Process Chain

1. Storm forecast system

How?	Why?
- based on longterm weather forecast models (e.g. GFS)	- basis to acquire remote sensing data

CONCEPT – PROCESS CHAIN

1. Storm forecast system

How?	Why?
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2. Change detection

How?	Why?
- synthetic aperture radar (SAR) data	- for a first fast WTA estimation (3 days)
- optical data	- for a detailed WTA estimation (14 days)

DATA – CHANGE DETECTION

Synthetic aperture radar (SAR)

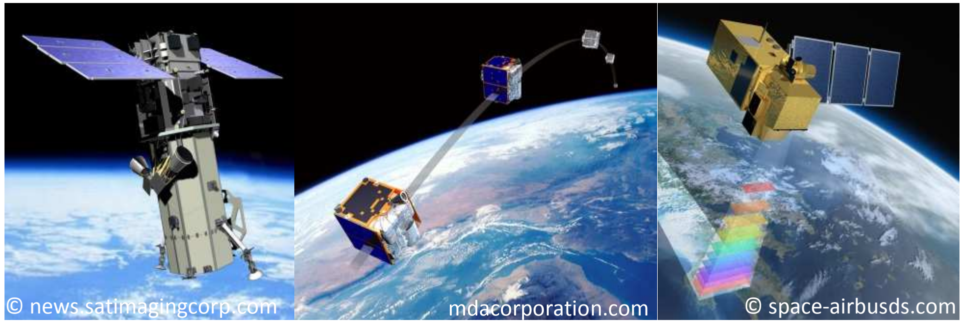
- weather independent
- daylight independent

Sensors

- TerraSAR-X (X-Band)
- Sentinel-1 (C-Band)

→ Suitable for a fast estimation

DATA – CHANGE DETECTION



Synthetic aperture radar (SAR)

- weather independent
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Sensors

- TerraSAR-X (X-Band)
- Sentinel-1 (C-Band)

→ **Suitable for a fast estimation**

Optical data

- vegetation identifying multispectral bands
- high spatial resolution

Sensors

- WorldView-2
- RapidEye
- Sentinel-2

→ **Suitable for a detailed estimation**

Concept – Process Chain

1. Storm forecast system

How?
- based on longterm weather forecast models (e.g. GFS)

Why?
- basis to acquire remote sensing data

2. Change detection

How?
- synthetic aperture radar (SAR) data
- optical data

Why?
- for a first fast WTA estimation (3 days)
- for a detailed WTA estimation (14 days)

3. GIS-analysis

How?
- combination of WTAs polygons with geodata and forest maps

Why?
- to provide additional information to the WTAs (accessability, timber volume, etc.)

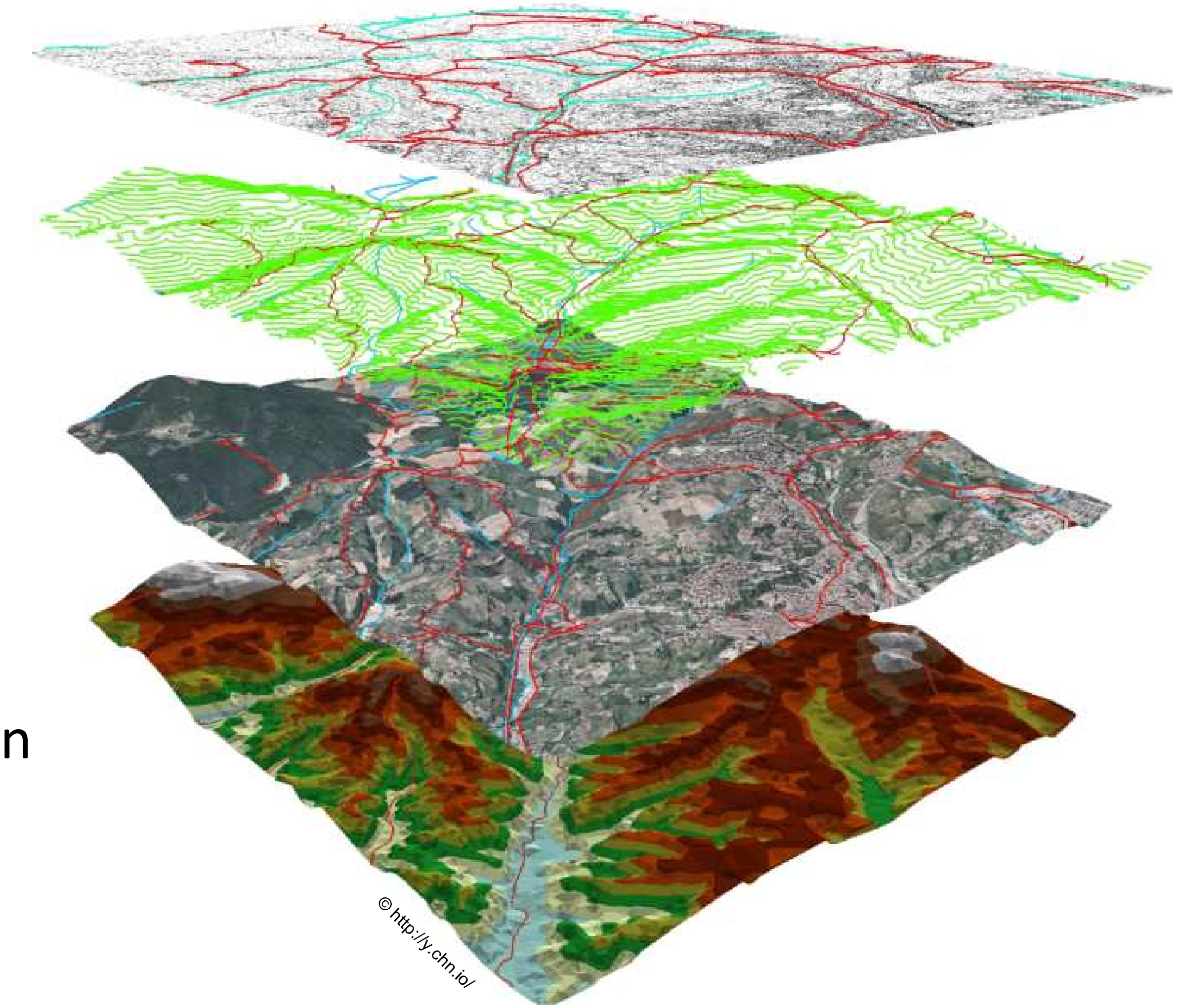
DATA – GIS-ANALYSIS

Geodata

- digital terrain models
- street network maps
- administrative maps
- …

Forest maps

- timber volume estimation maps
- coniferous/broadleaf distribution
- …



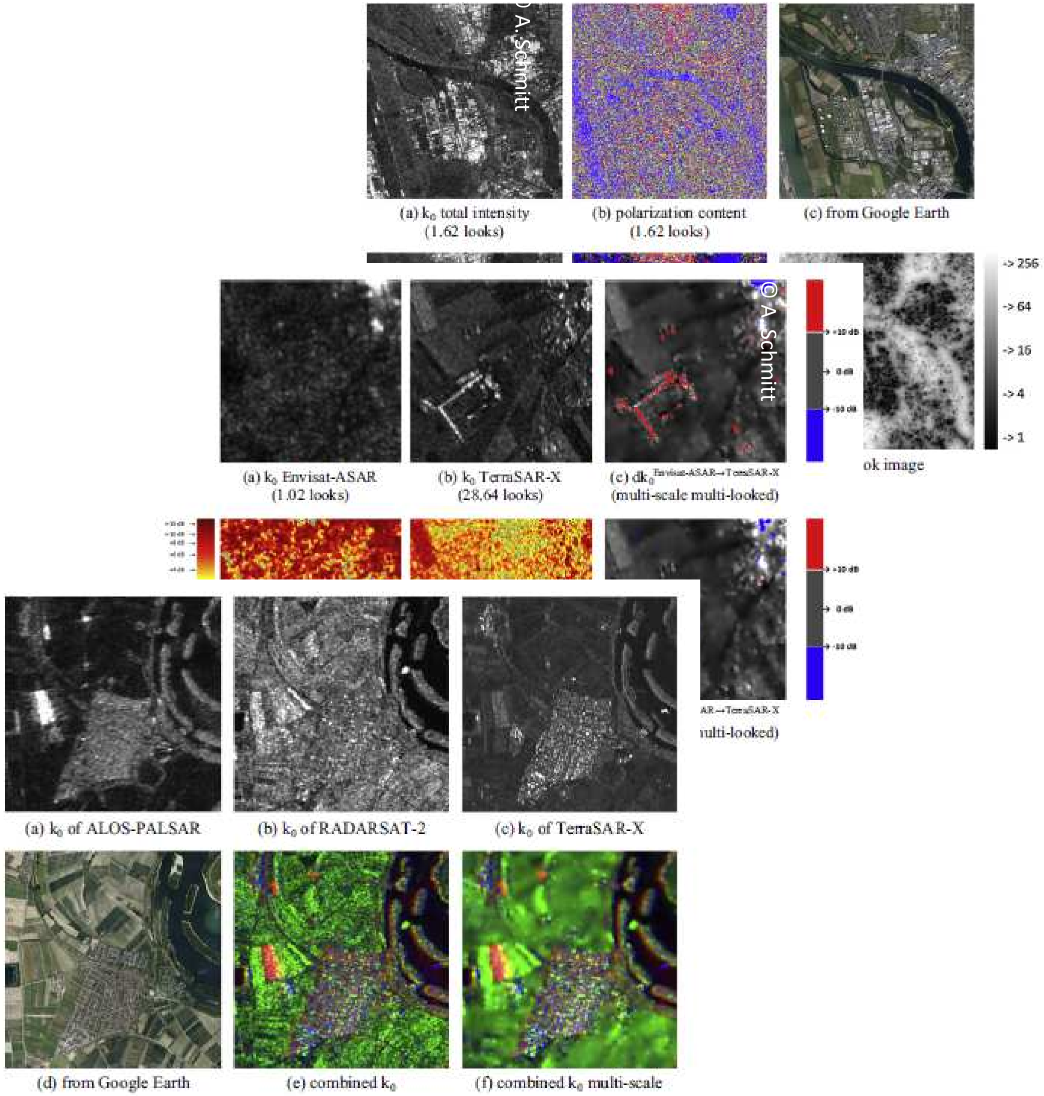
METHODS

METHODS – CHANGE DETECTION

Synthetic aperture radar (SAR)

Differential Kennaugh elements[1]

- **Joint image enhancement** to achieve maximum radiometric accuracy with minimal loss of geometric resolution.

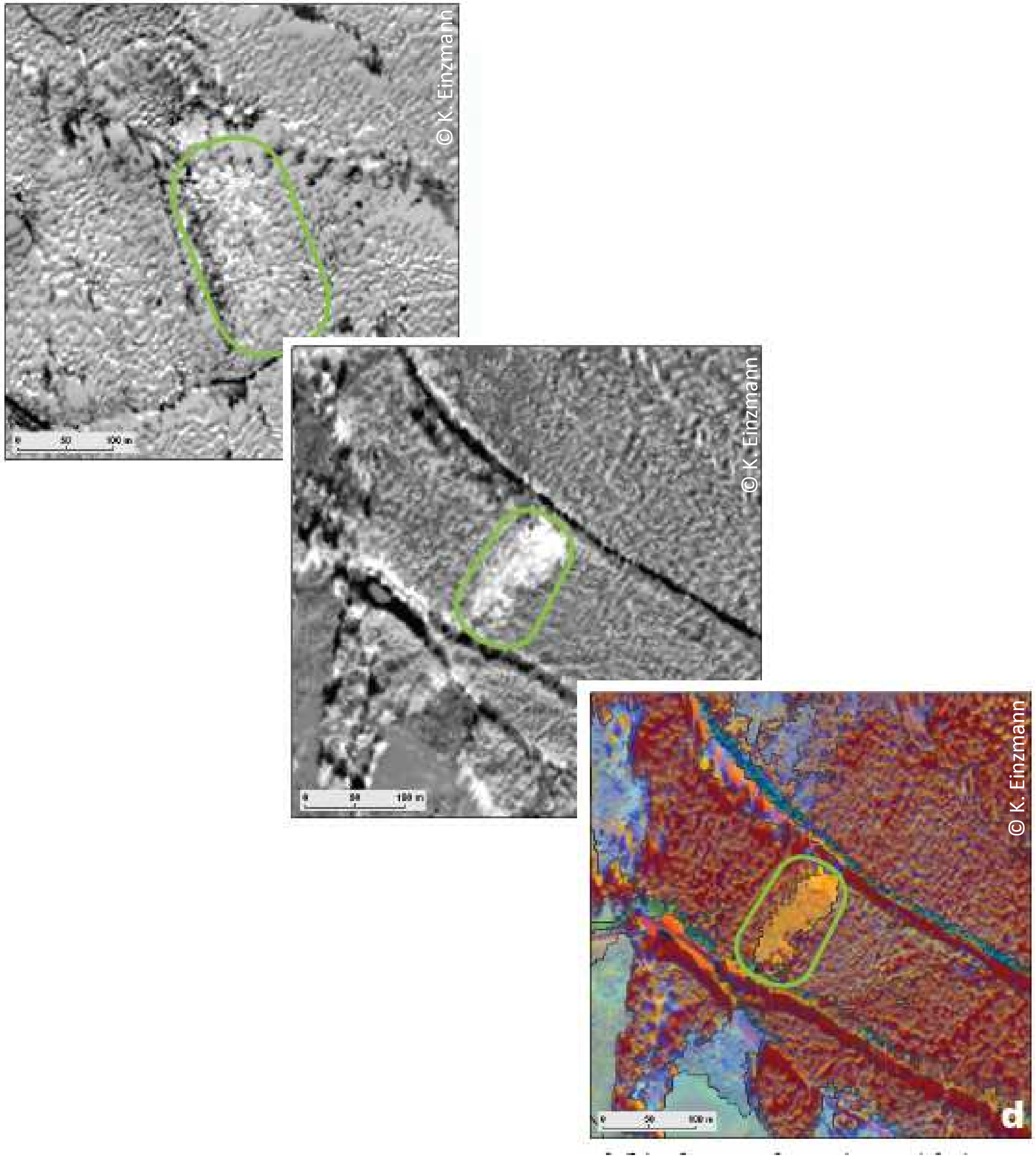


[1] Schmitt, Wendleder, Hinz (2015): The Kennaugh element framework for multi-scale, multi-polarized multi-temporal and multi-frequency SAR image preparation

METHODS – CHANGE DETECTION

Optical data:

- Pixel-based
  - Image differencing combining bands
  - Comparison of vegetation indices
- Object-based image analysis



TEST

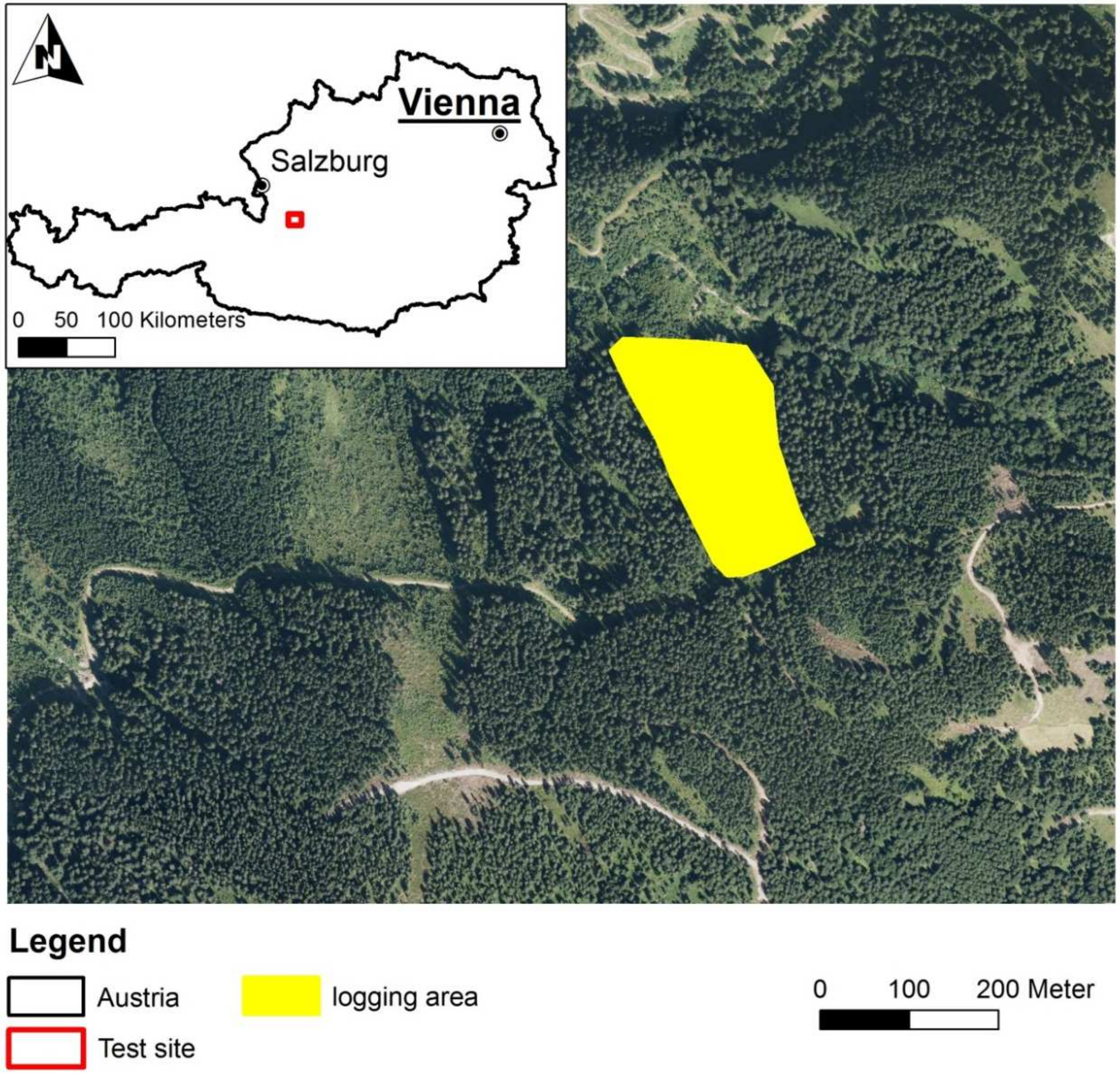
TEST - OBJECTIVES

Change detection:

- Which results can be expected from the available sensors?
- Are the change detection (CD) methods reliable?
- What problems do occur?

TEST

- Monitoring a **logging** in a forest district of Flachgau (Austria)
- area: 100 km²
- 810 – 2.420 m a.s.l.
- 17^{th} Sept. to 24^{th} Oct. 2014
- predominantly coniferous
- simulated windthrow (ca. 2 ha)
- unknown location



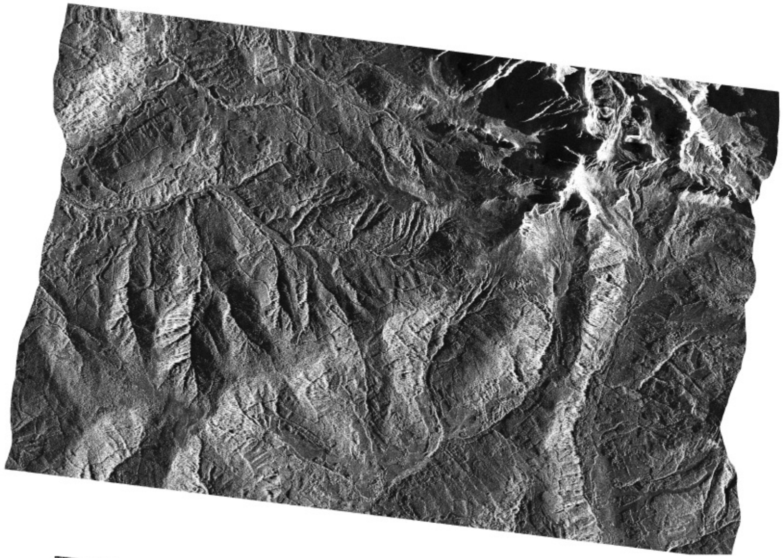
Test – Data

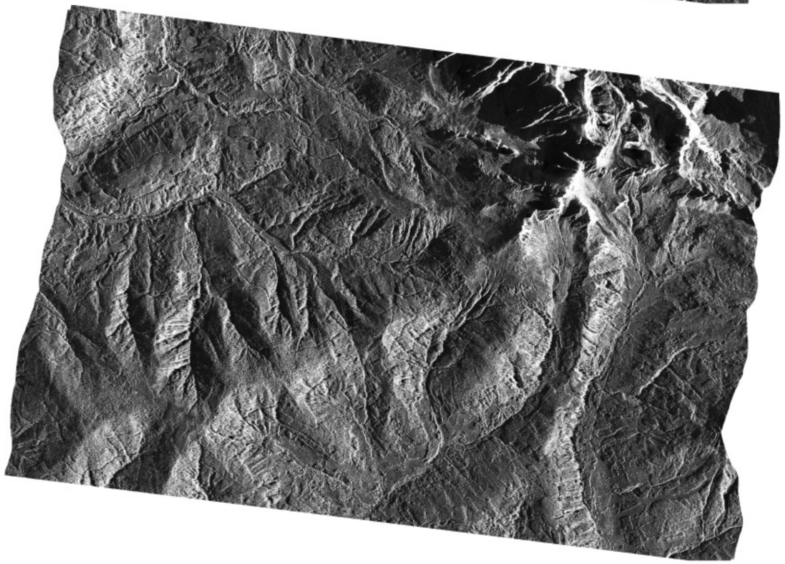
SAR data

- TerraSAR-X

	BEFORE logging	AFTER logging
date:	16th Aug.	10th Oct.
mode	HR spotlight	
polarisation	HH+VV	
incident angle:	50° (same orbit!)	
pixel spacing:	1.25m	

- preprocessing
  - Kennaugh element framework[1]
- change detection method
  - differential Kennaugh elements[1]





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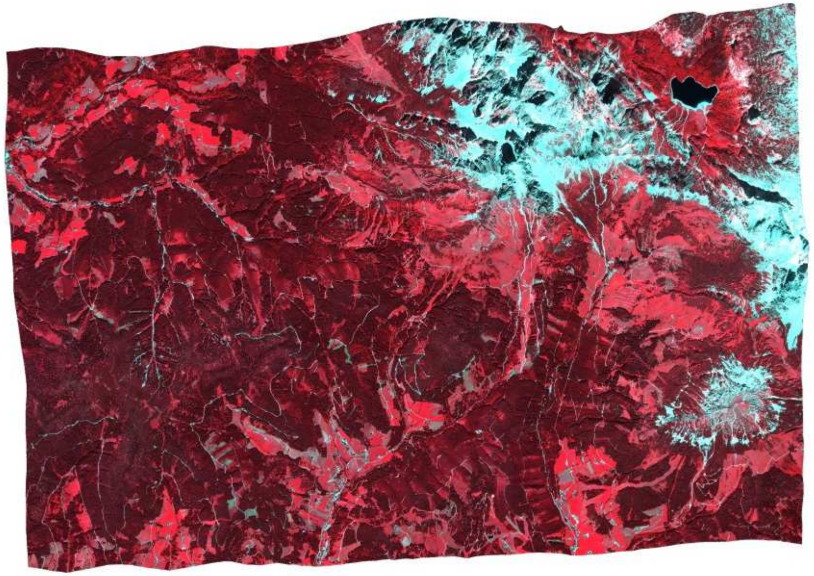
TEST – DATA

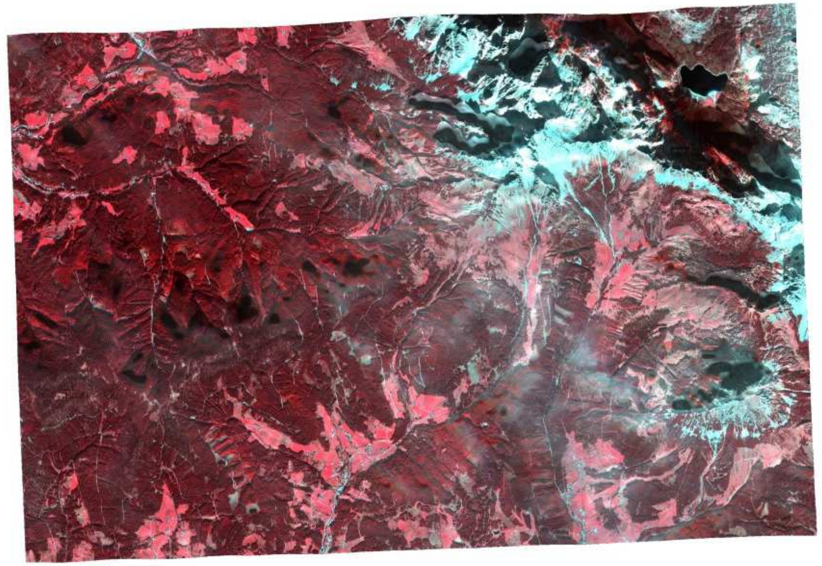
Optical data

- WorldView-2

	BEFORE logging	AFTER logging
date	19^{th} Jul.	19^{th} Oct.
sun elev.	61.47°	32.37°
bands	8 (multispektral)	
GSD	2m	

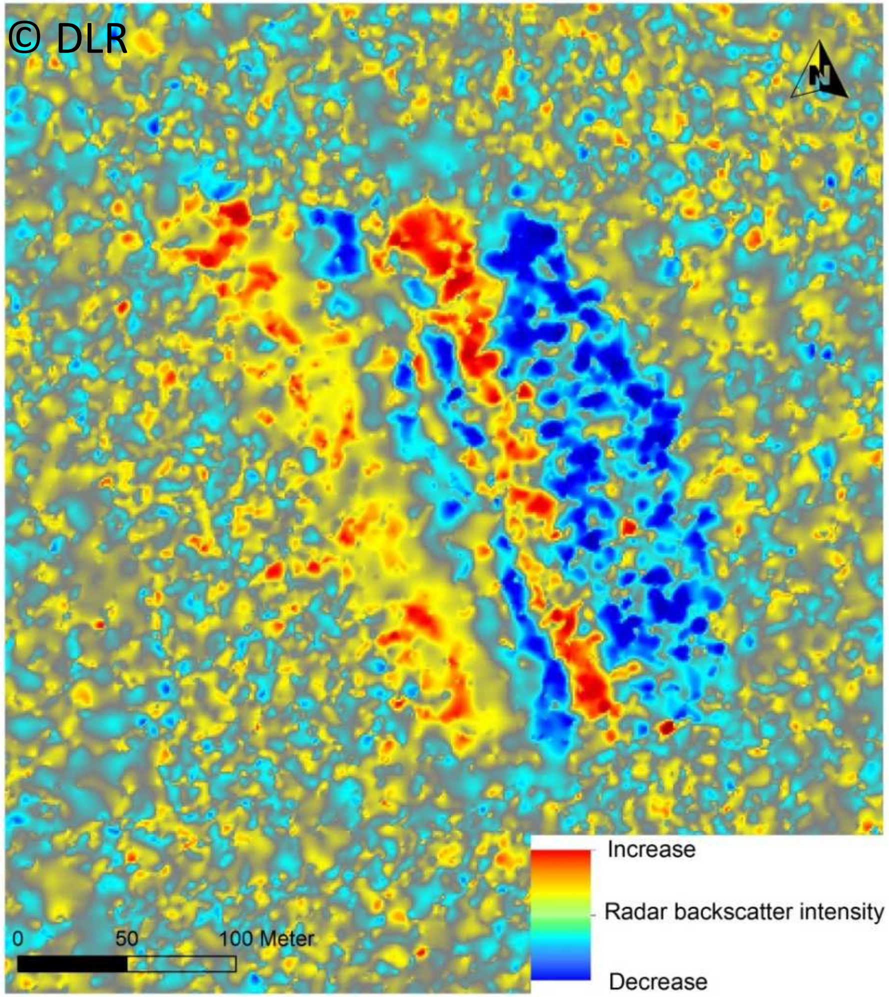
- preprocessing
  - atmospheric and geometric correction
  - image mosaicing
- change detection method
  - Image differencing





TEST – RESULTS

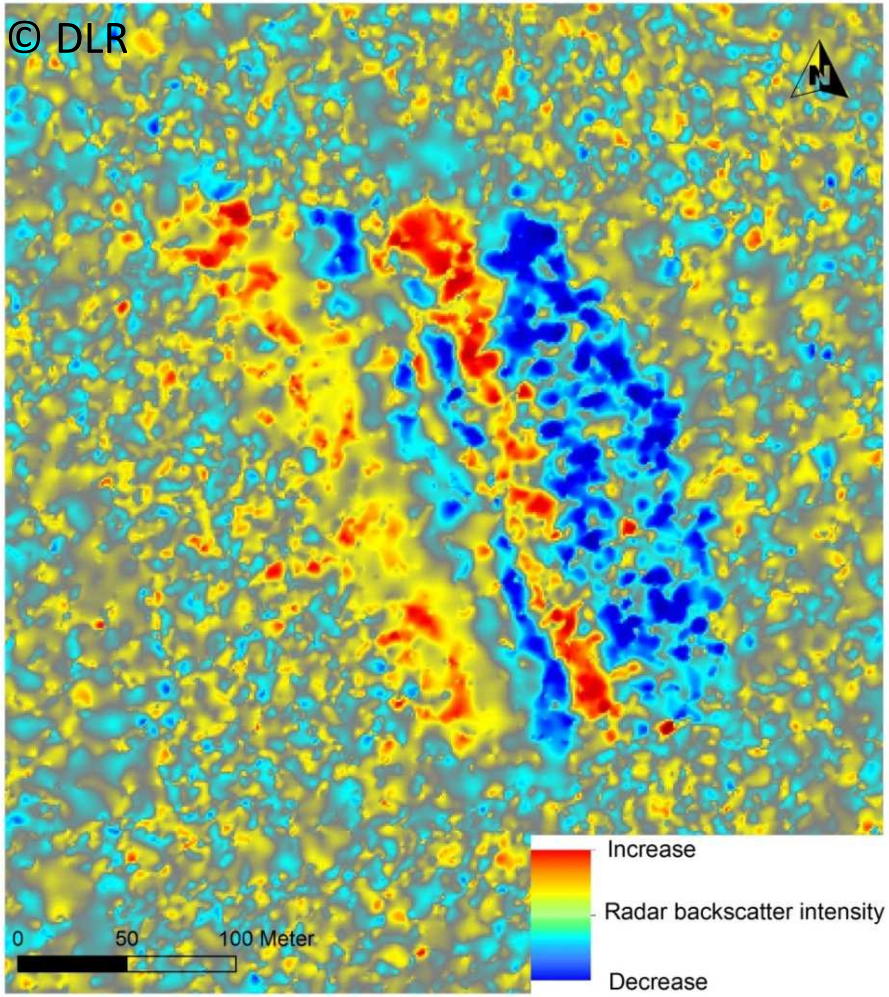
TSX



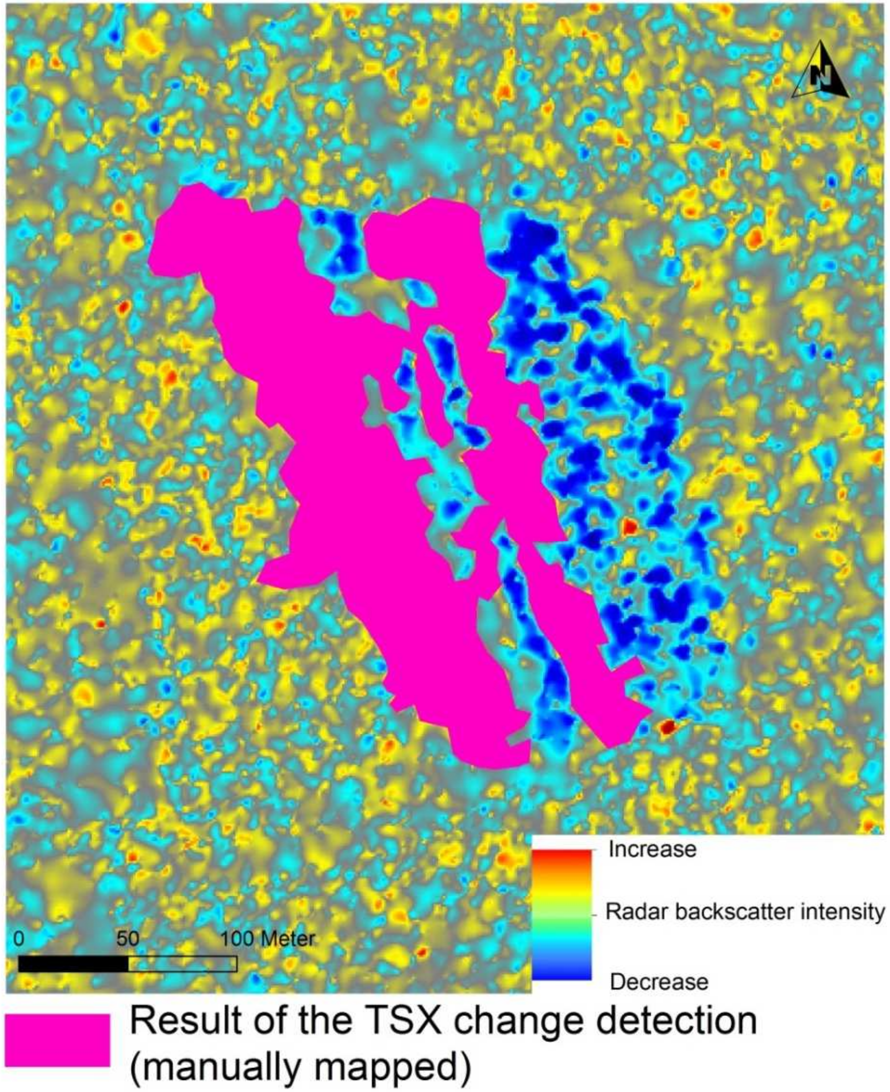
CD difference image

TEST – RESULTS

TSX



CD difference image



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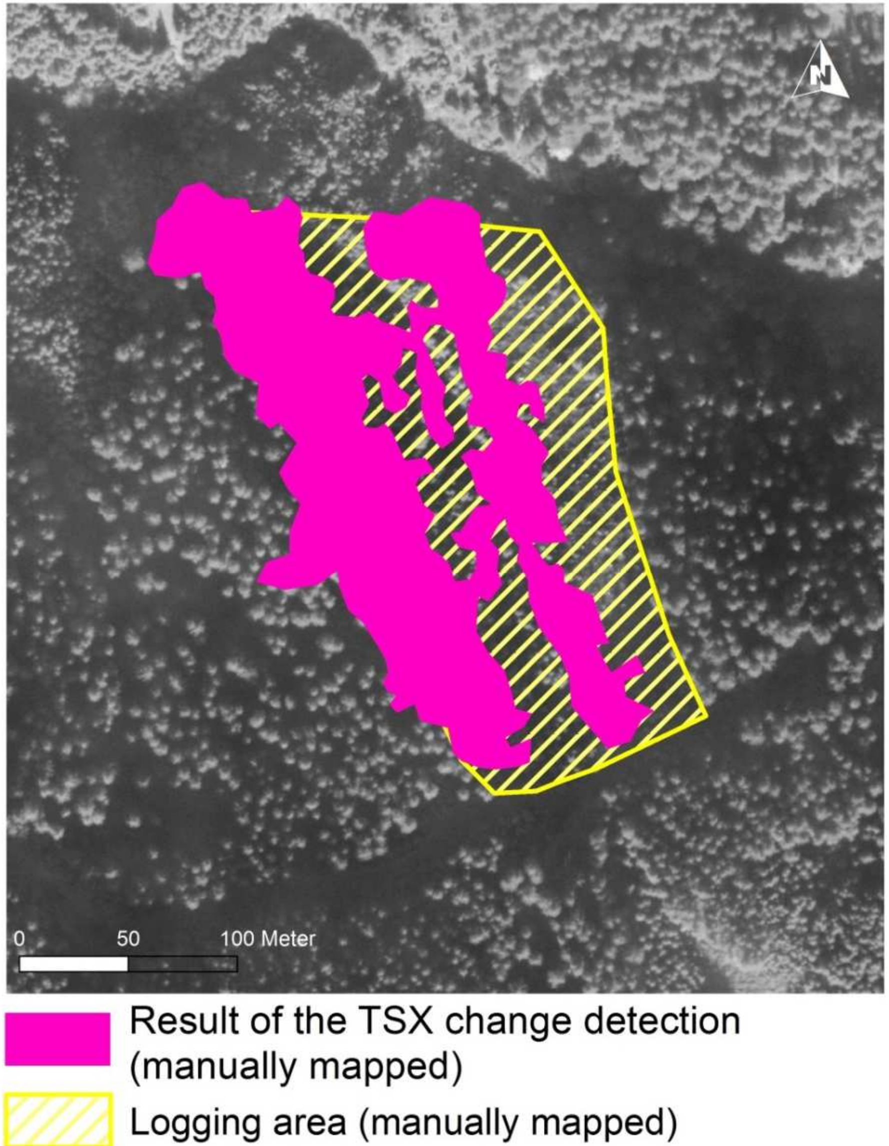
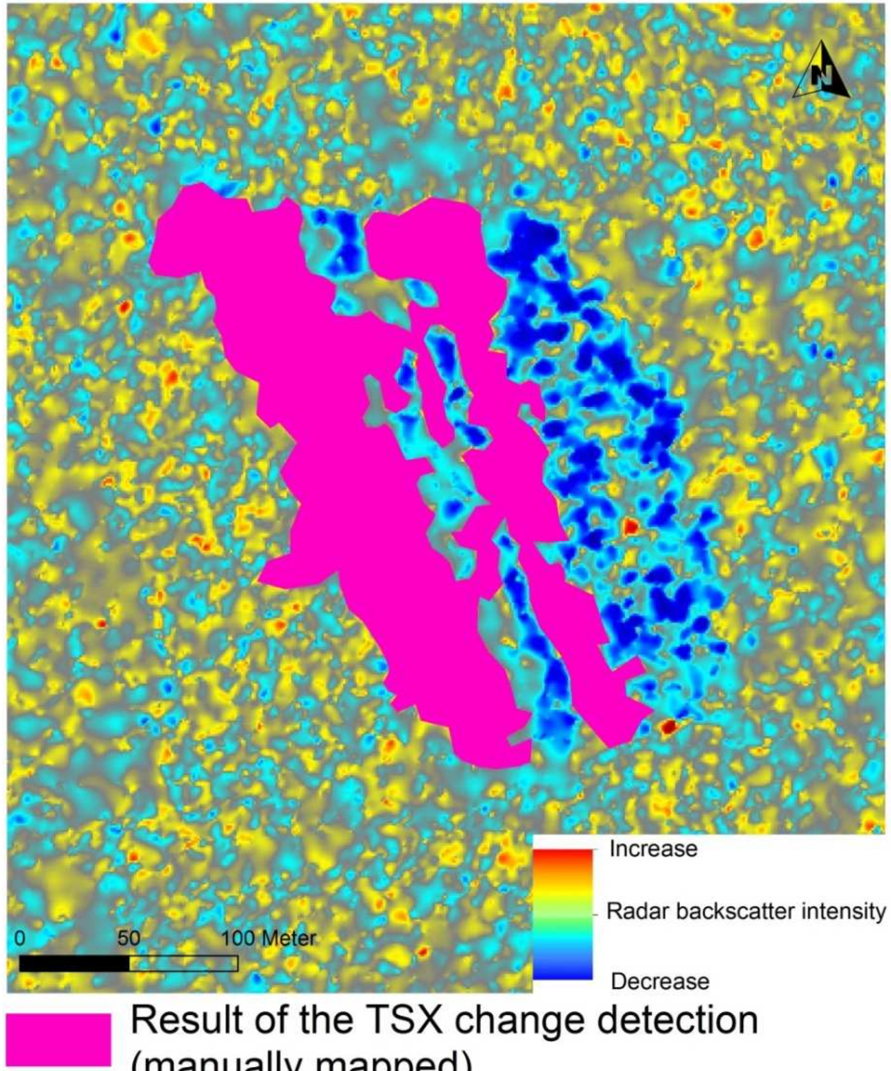
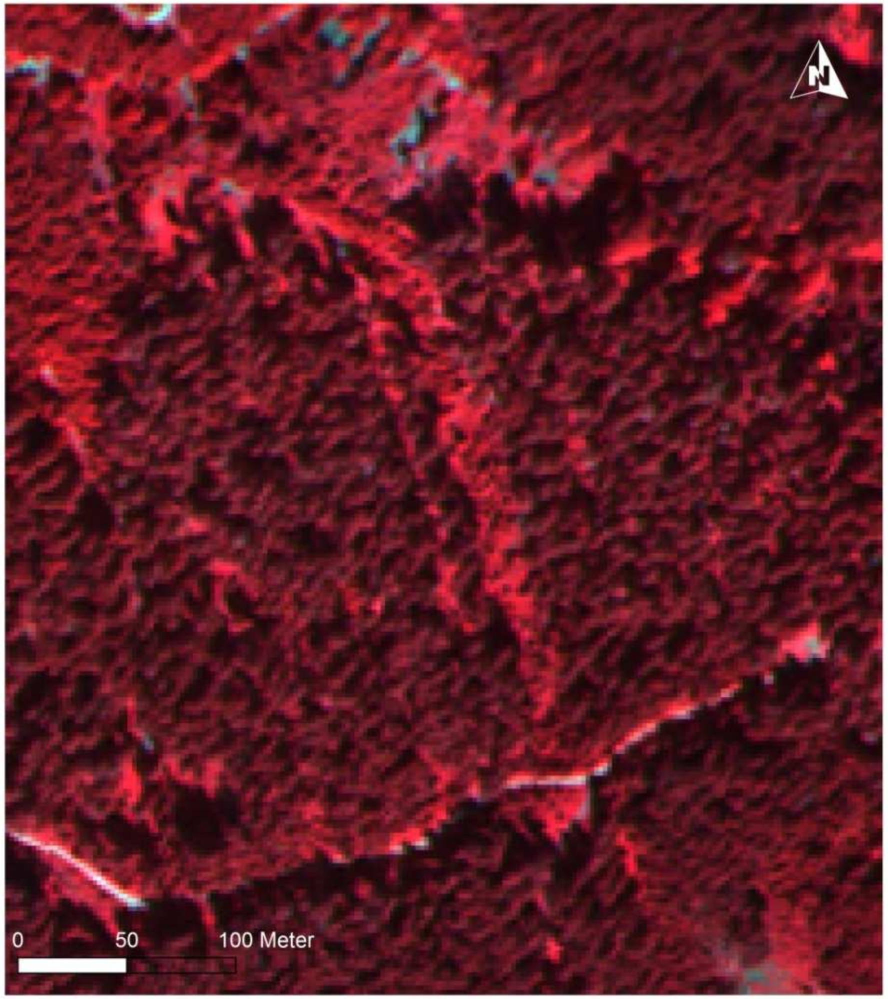




TEST – RESULTS

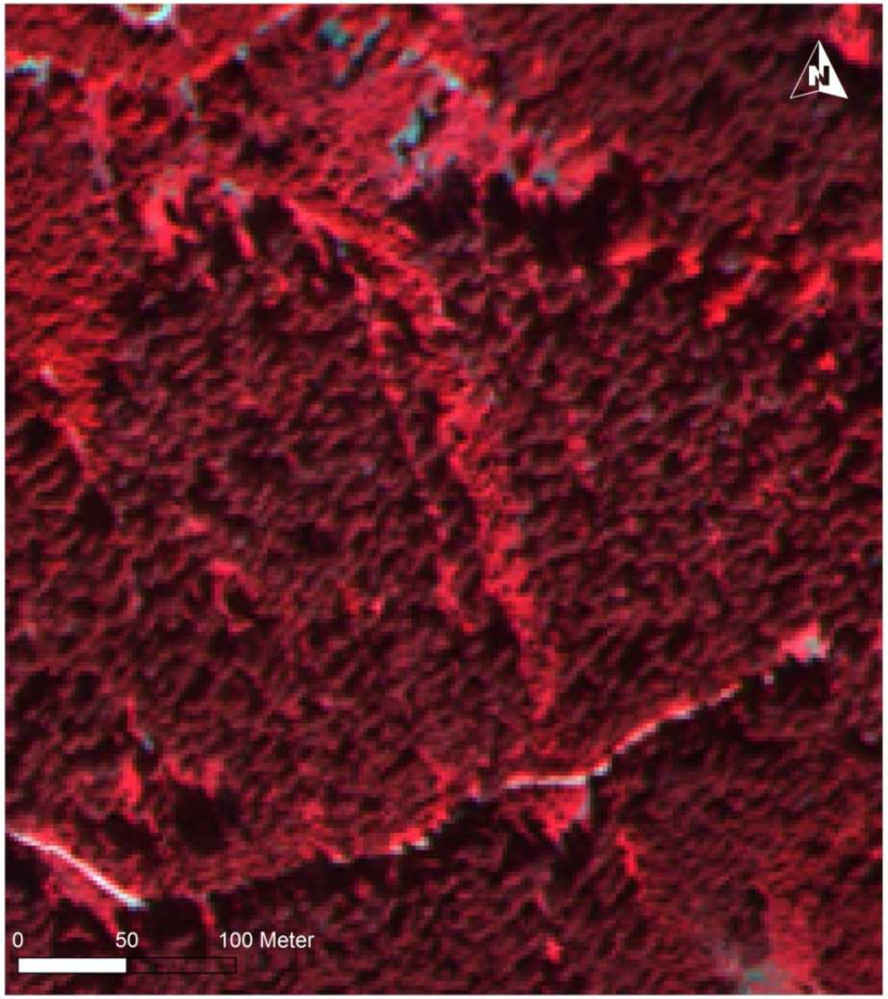
WV2



scene BEFORE the logging (19th July)

TEST – RESULTS

WV2



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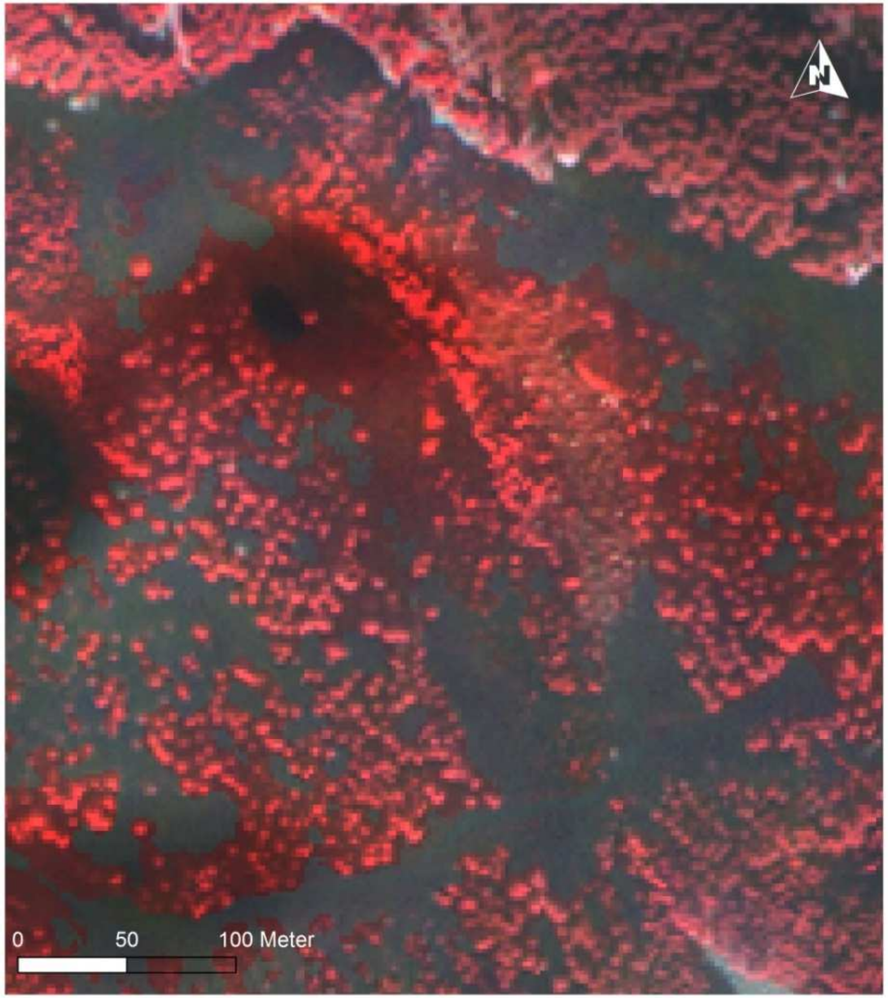
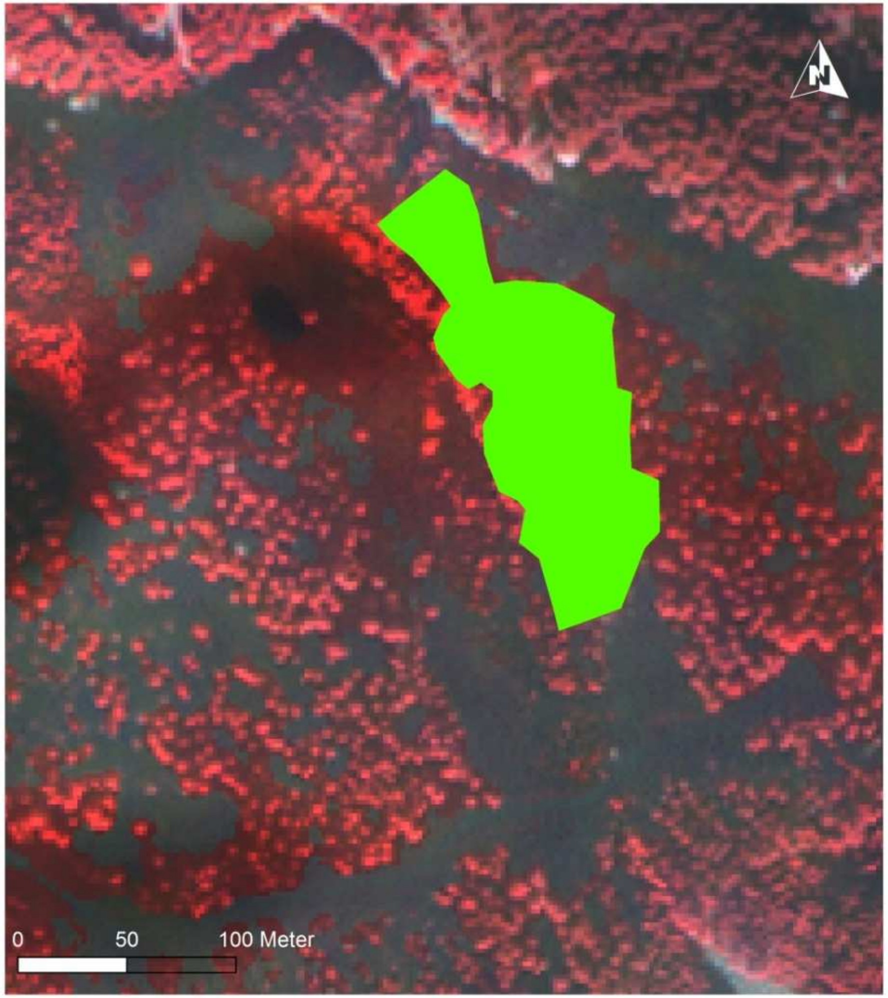


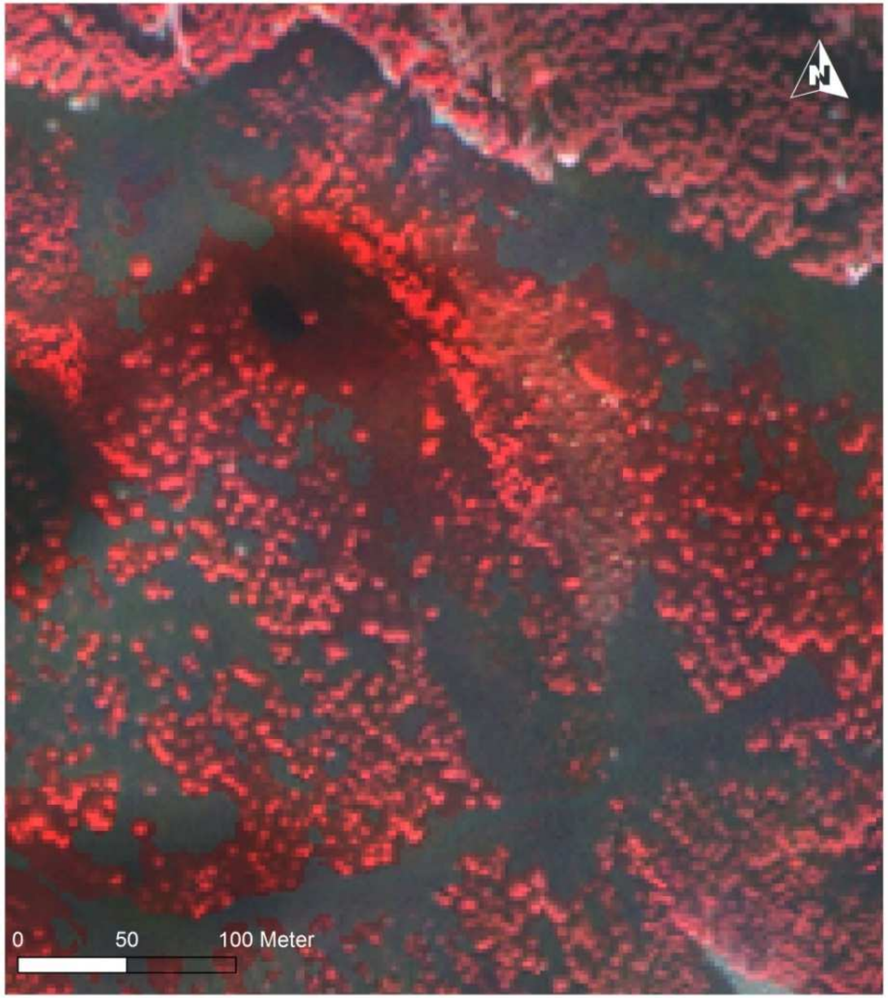
scene AFTER the logging (19th Oct.)

TEST – RESULTS

WV2



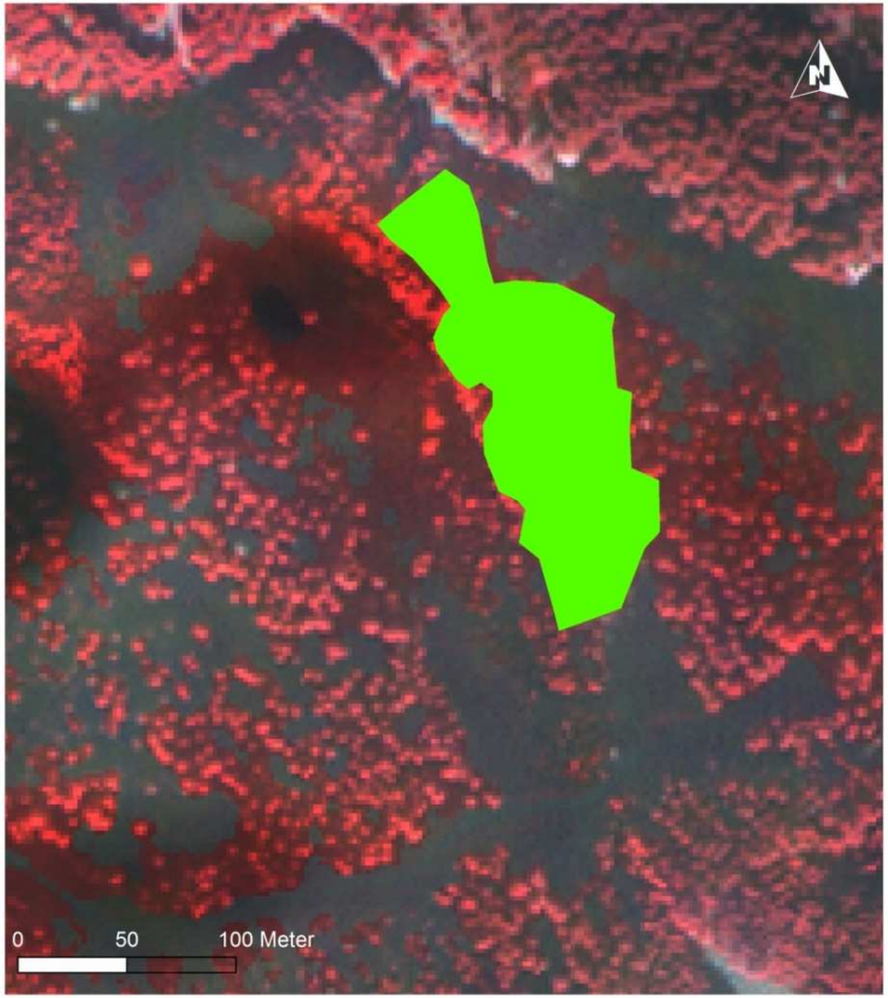
Result of the WV2 change detection
(manually mapped)



scene AFTER the logging (19th Oct.)

TEST – RESULTS

WV2



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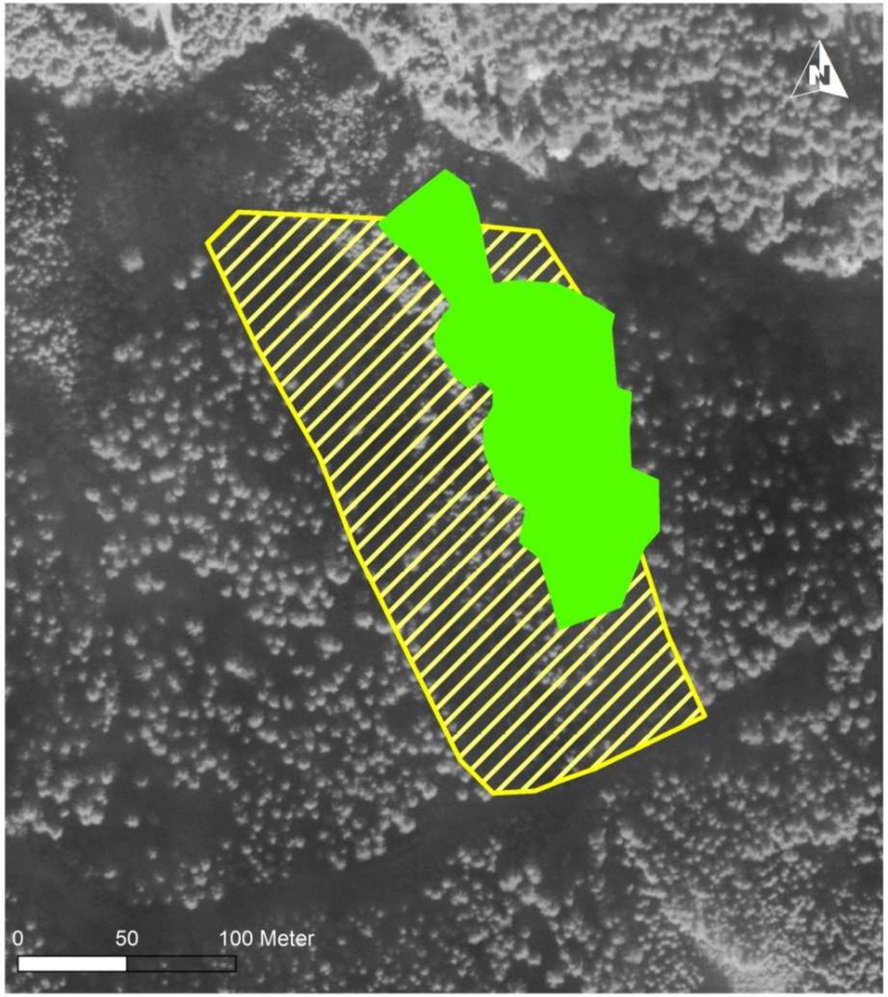

Result of the WV2 change detection (manually mapped)

Logging area (manually mapped)

Conclusion

SAR

+ detection of the logging area (size + location) and six other changed areas
+ fast and automised processing and analyzing
+ no modifications on CD method
– no automated classification yet
– errors due to (radar)shadowing

Processing time:

→ 20 min from raw data to difference image (100km²)

CONCLUSION

SAR

+ detection of the logging area (size + location) and six other changed areas
+ fast and automised processing and analyzing
+ no modifications on CD method
– no automated classification yet
– errors due to (radar)shadowing

Processing time:

→ 20 min from raw data to difference image (100km²)

Optical data

+ detection of the logging area (location) and six other changed areas
+ CD method worked
– underestimated area
– no automated classification yet
– errors due to shadowing, clouds and northerly slope

Processing time

→ 28 h from raw data to difference image (100km²)

OUTLOOK

- develop an automated classification process for the changed areas
- prepare to use the data from the ESA Sentinel-spacecraft-fleet
- performing the GIS-Analysis
- test our system on a real storm event (including an accuracy assessment)

→ **Storm “Niklas” (31st March)**

Thank you for your attention

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Questions?

Copernicus
The European Earth Observation Programme

In cooperation with:

Universität für Bodenkultur Wien
University of Natural Resources and Life Sciences, Vienna

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LWF

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