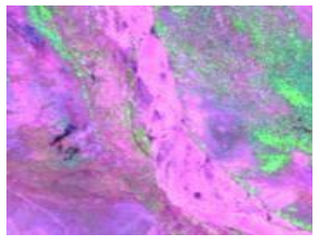
Current state-of-the-art in satellite data processing: Time series data for up-to-date maps and improved thematic insights

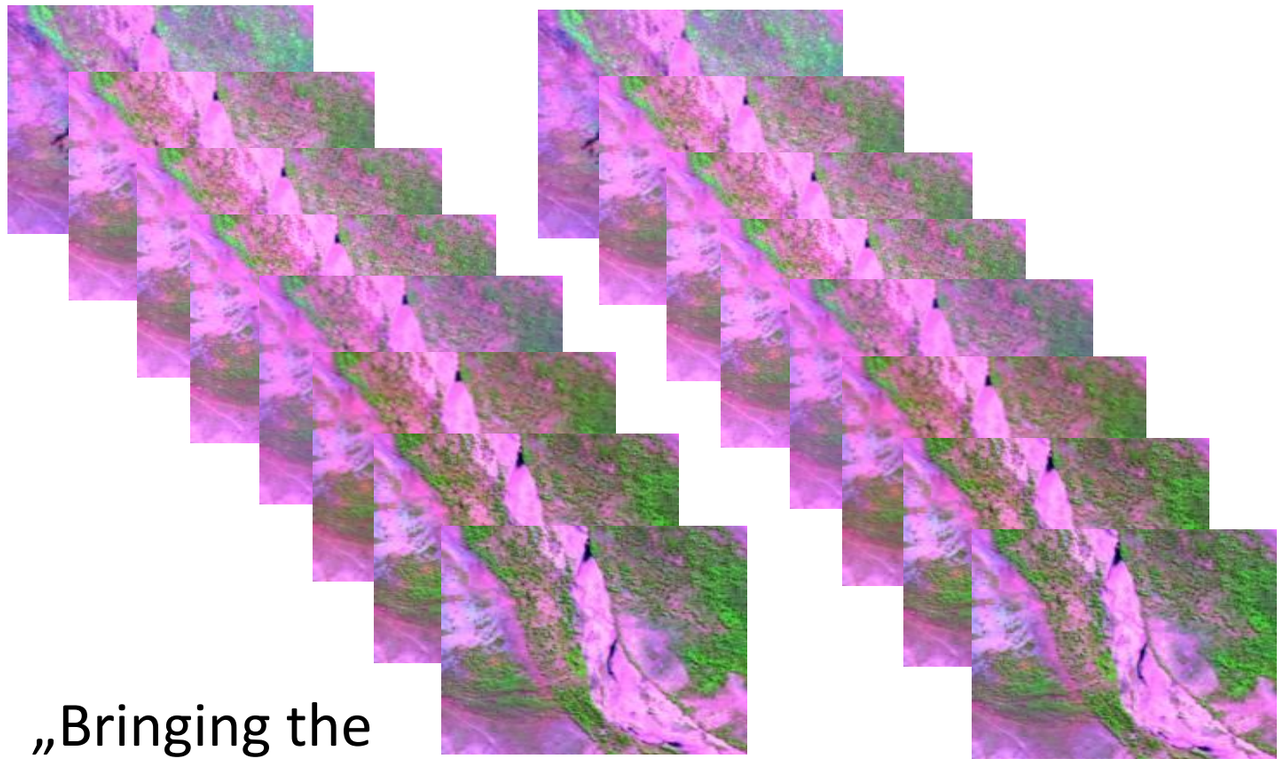
Manuela Hirschmugl

Monitoring with Satellite Data

- Time series data from Sentinel-1 (SAR) and Sentinel-2/Landsat-8 (optical) available free and open
- SAR: all weather capabilities, but limitations due to viewing geometry
- Different properties and possibilities!
- Constant stream of data!

From one image to whole time series





„Bringing the image to the software“

„Bringing the software to the image repository“

Entailed technological issues

- Sensor integration
- Big Data challenge
- Proper data mining/handling techniques
- Cloud processing
- Modern software systems with „docker container“ functionalities
- High performance computer centers
- Access „on demand“ throught online services

Thematic Benefit Areas

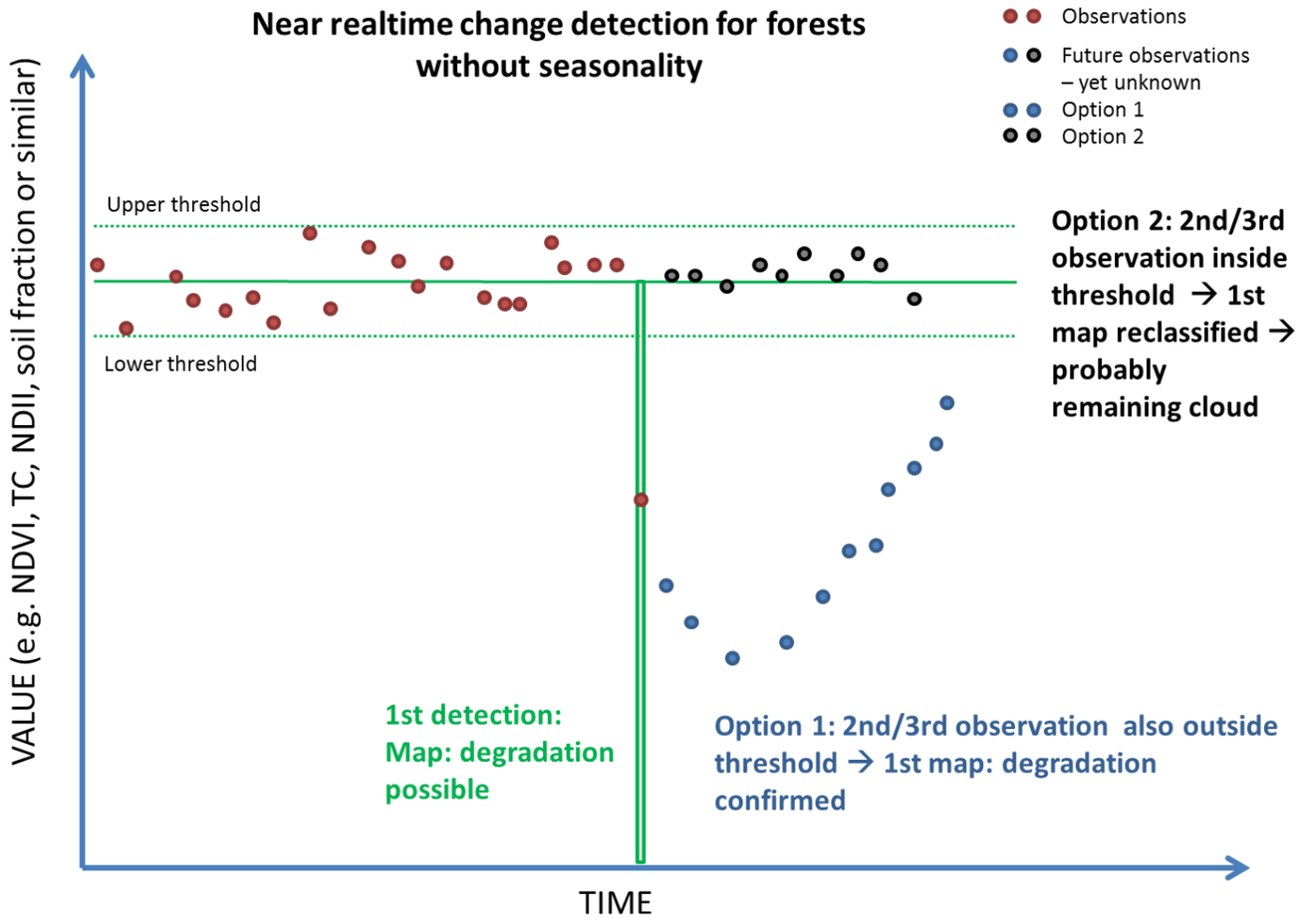
1. Humid Tropical Forest Monitoring
2. Land Use Classification / „Underutilized Areas“ / Grassland
3. Near Realtime Change Detection e.g. in Forestry
    1. Clear cuts / Storm Damage
    2. Bark Beetle Damage

Alternative data generation with ADAM (airborne data acquisition module)

1. Humid Tropical Forest

1. Humid Tropical Forest - Gabon

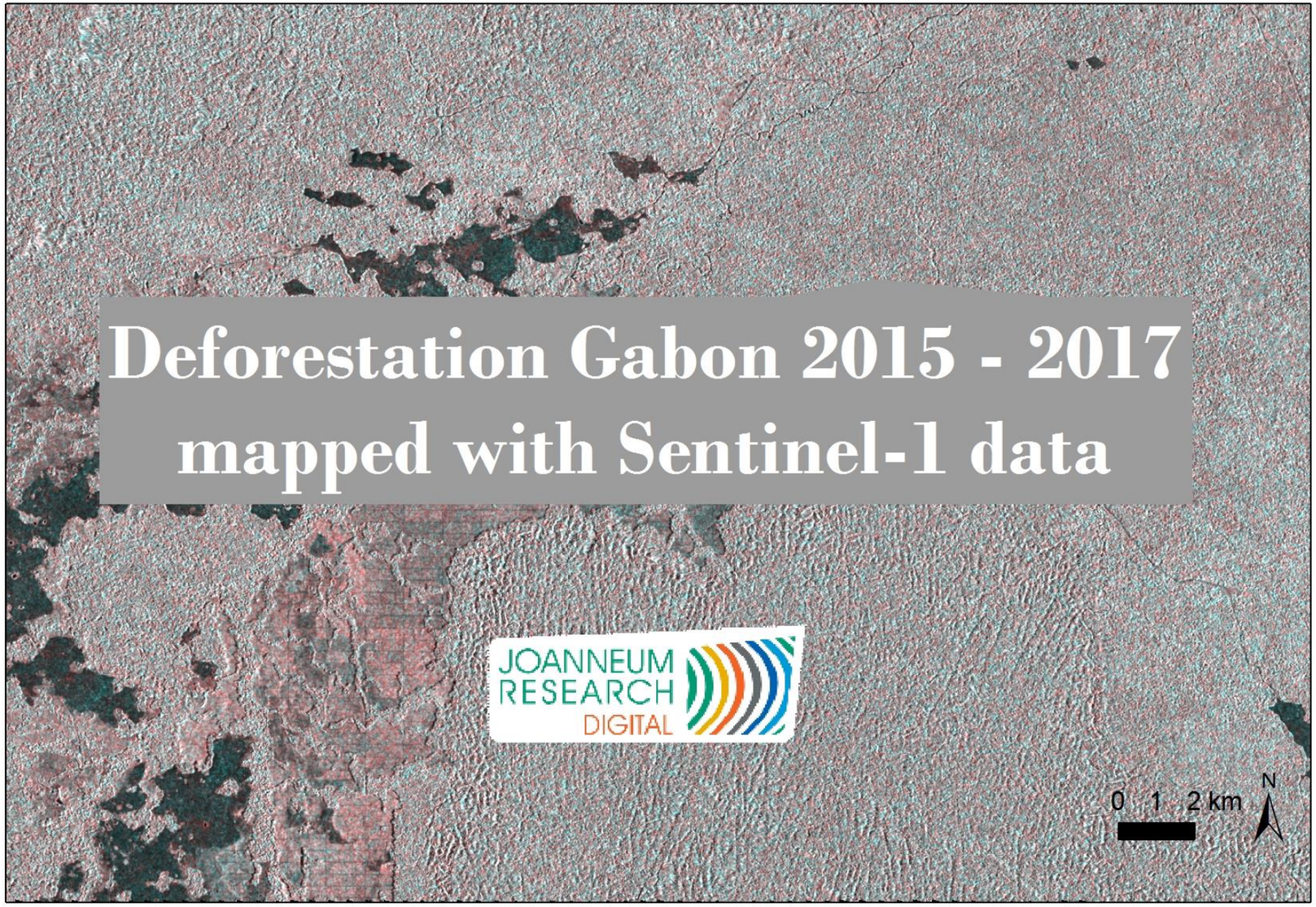
- Less/no cloud-induced data gaps
- Change detection with both optical and SAR data



M. Hirschmugl, J. Deutscher, K. Gutjahr, C. Sobe and M. Schardt, "Combined use of SAR and optical time series data for near real-time forest disturbance mapping," *2017 9th International Workshop on the Analysis of Multitemporal Remote Sensing Images (MultiTemp)*, Brugge, 2017, pp. 1-4. doi: 10.1109/Multi-Temp.2017.8035208

1. Humid Tropical Forest - Gabon

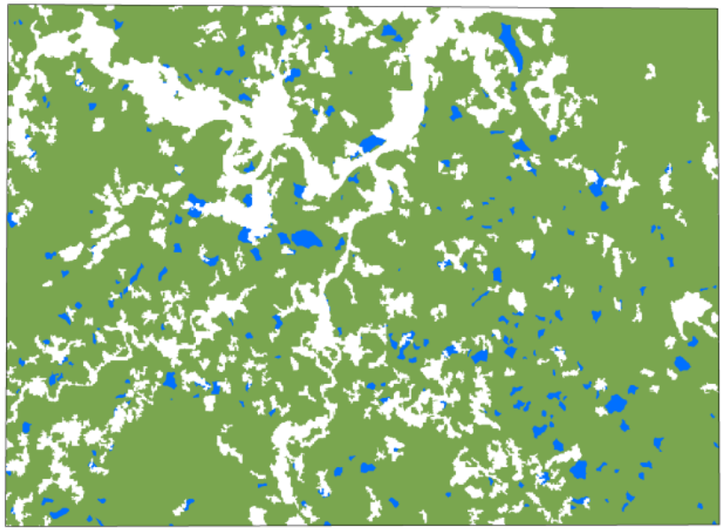
- Deforestation for oil palm plantation mapped by SAR data

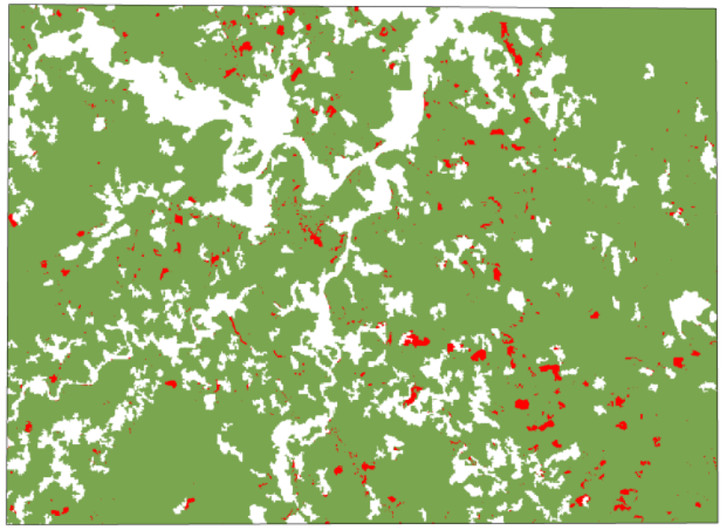


Results: Forest Disturbance Maps of Peru, March - December 2016

Sentinel-1 forest disturbance map:

248.77 ha



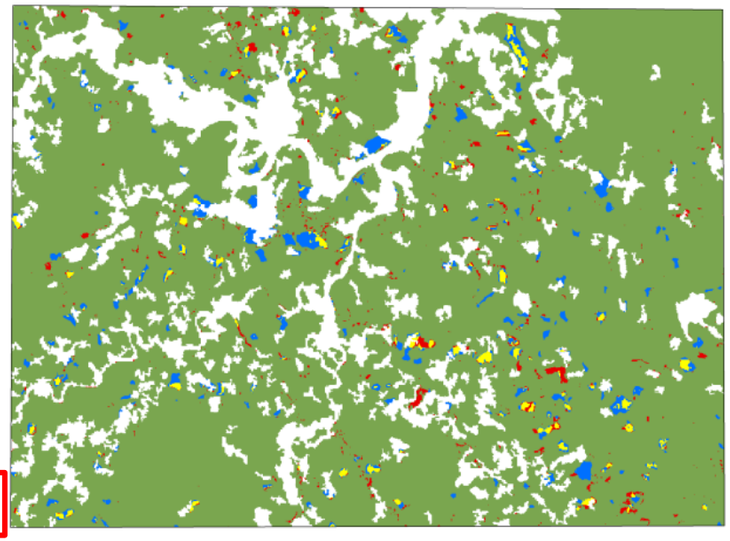


Sentinel-2 forest disturbance map:

153.90 ha

Union of Sentinel-1 and Sentinel-2 disturbance maps:

331.79 ha



Blue = only S1: 206.07 ha
Red = only S2: 111.20 ha
Yellow = S1 & S2: 42.70 ha

Complementarity between SAR & Optical Results!

Validation of Forest Disturbance Maps Peru

Sentinel-1 Only

Class	F	D	Total	Map area [ha]	Weights
F	330	15	345	5805.32	0.963
D	2	38	40	225.61	0.037
Total	332	53	385	6030.93	1.000

Class	UF	DF	Total	User's	Producer's	Overall
F	0.921	0.042	0.963	0.957	0.998	0.956
D	0.002	0.036	0.037	0.950	0.459	
Total	0.923	0.077	1.000			

Sentinel-2 Only

Class	F	D	Total	Map area [ha]	Weights
F	331	27	358	5805.32	0.963
D	1	26	27	225.61	0.037
Total	332	53	385	6030.93	1.000

Class	F	D	Total	User's	Producer's	Overall
F	0.890	0.073	0.963	0.925	0.998	0.926
D	0.001	0.036	0.037	0.963	0.332	
Total	0.891	0.109	1.000			

Sentinel-1 & Sentinel-2 Union

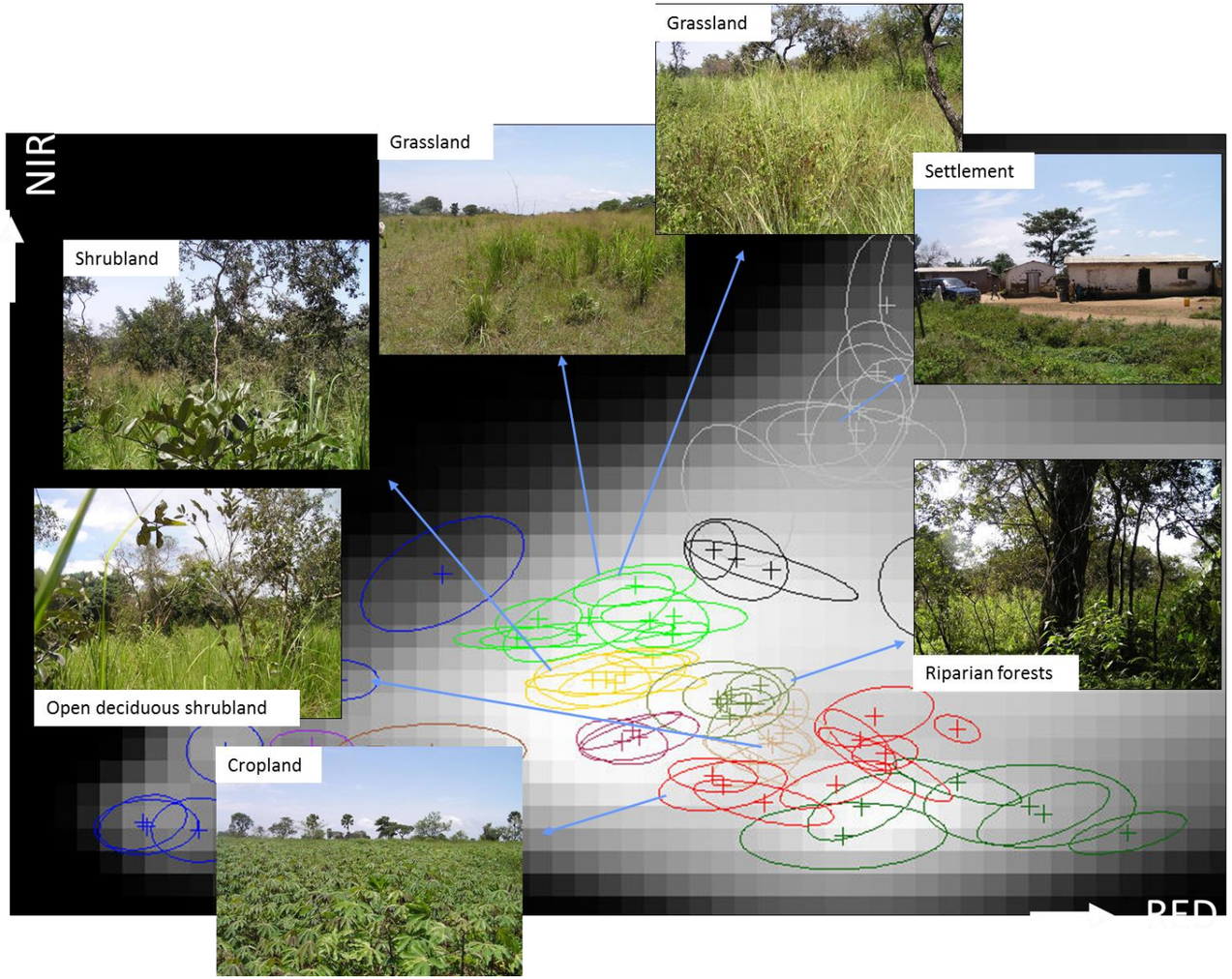
Class	F	D	Total	Map area [ha]	Weights
F	329	5	334	5805.32	0.963
D	3	48	51	225.61	0.037
Total	332	53	385	6030.93	1.000

Class	F	D	Total	User's	Producer's	Overall
F	0.948	0.014	0.963	0.985	0.998	0.983
D	0.002	0.035	0.037	0.941	0.710	
Total	0.950	0.050	1.000			

- Increase in Producer Accuracy from 0.46/0.33 to 0.71 by using optical and SAR data!

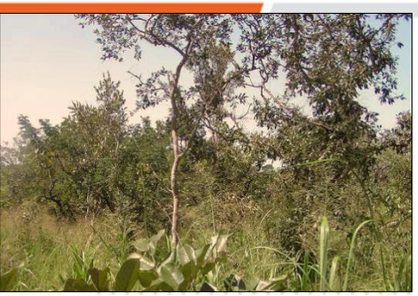
Accuracy assessment with stratified random sampling (Olofsson)

2. Land Use Classification



Random Forest

Image Source: Genesis



2. Land Use Classification Malawi

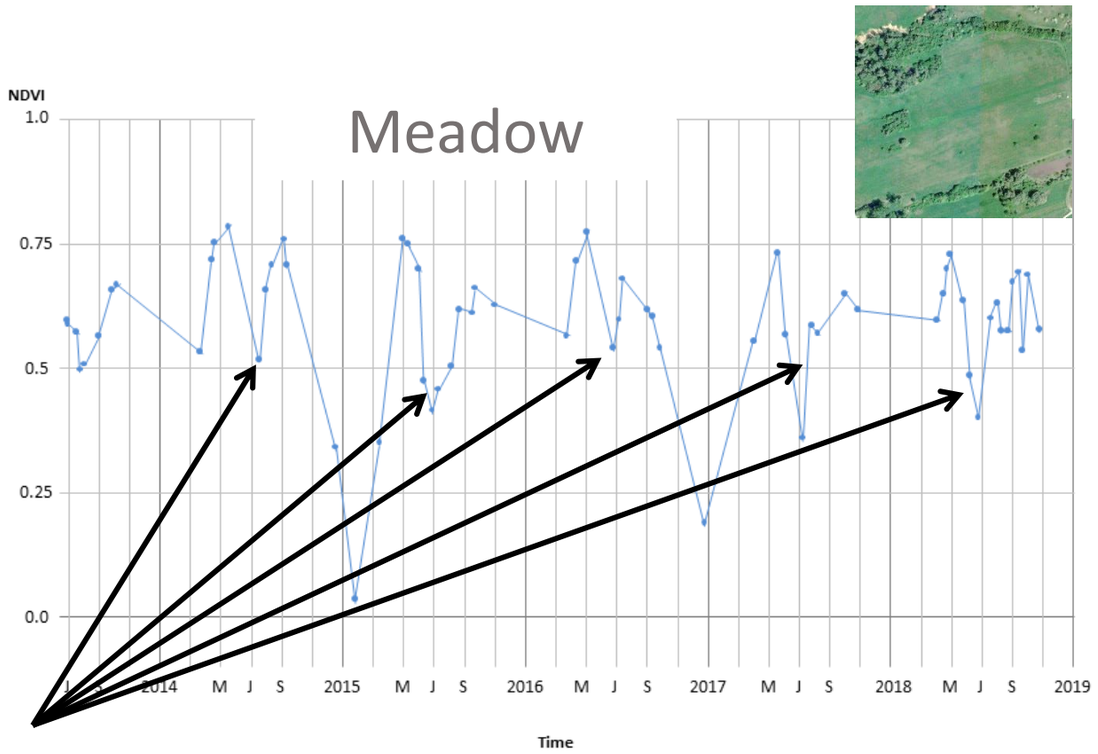
- IPCC land use classes: Water/Wetland, Forest, Cropland, Grassland, Settlement

Approach	Overall Accuracy	Kappa
Optical monotemporal (S2 02.08.2016)	0,6775	0,44
Optical multitemporal (S2 dry season: 23.07.2016, 02.08.2016, 12.08.2016)	0,7153	0,51
Optical multitemporal (S2 2016)	0,7375	0,54
Combined monotemp & SAR JR VH multitemp	**0,7870**	0,6
Combined multitemp (S2 2016) & SAR JR VH multitemp	0,7780	0,6
Combined multitemp (S2 2016) & SAR JR VHVV multitemp	0,7651	0,58
ESA CCI Land cover product 2016 (different class definitions)	0,6507	0,43

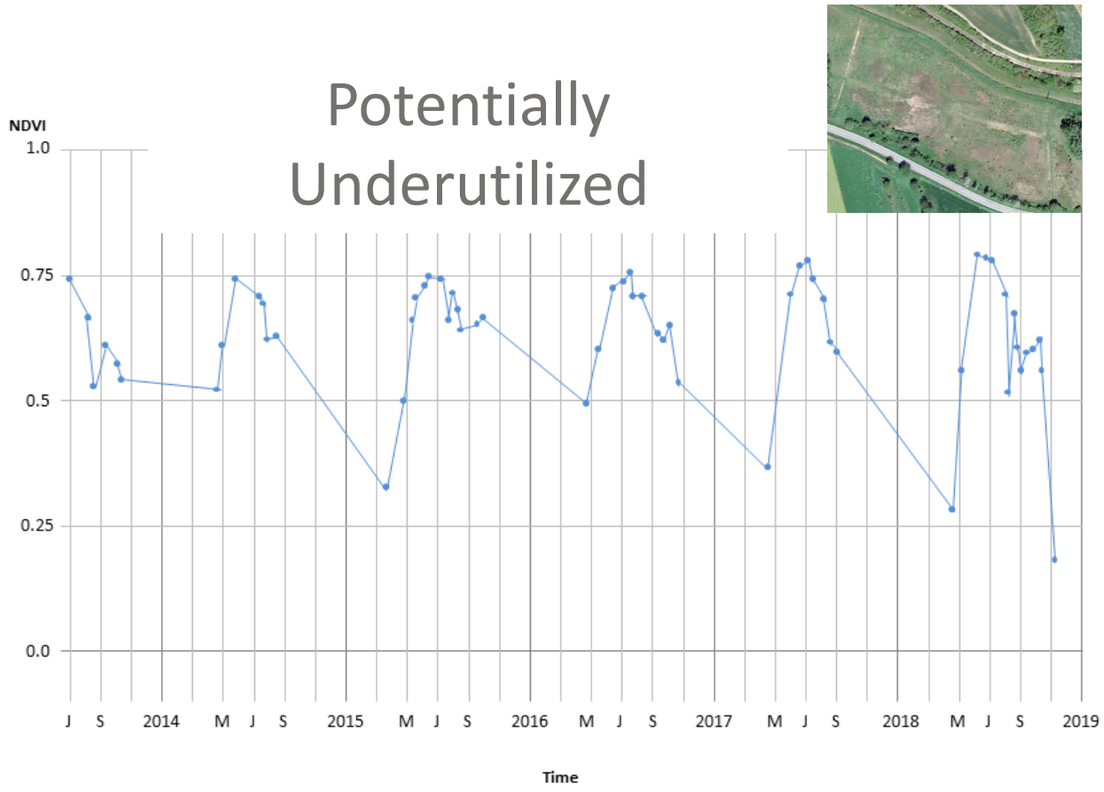
Approach: Hirschmugl, M.; Sobe, C., Deutscher, J. and Schardt, M. (2018):
Combined Use of Optical and SAR Data for REDD+ applications in Malawi. Land 2018, 7(4) 116, https://doi.org/10.3390/land7040116.

2. Identification of „underutilized“ land - Europe

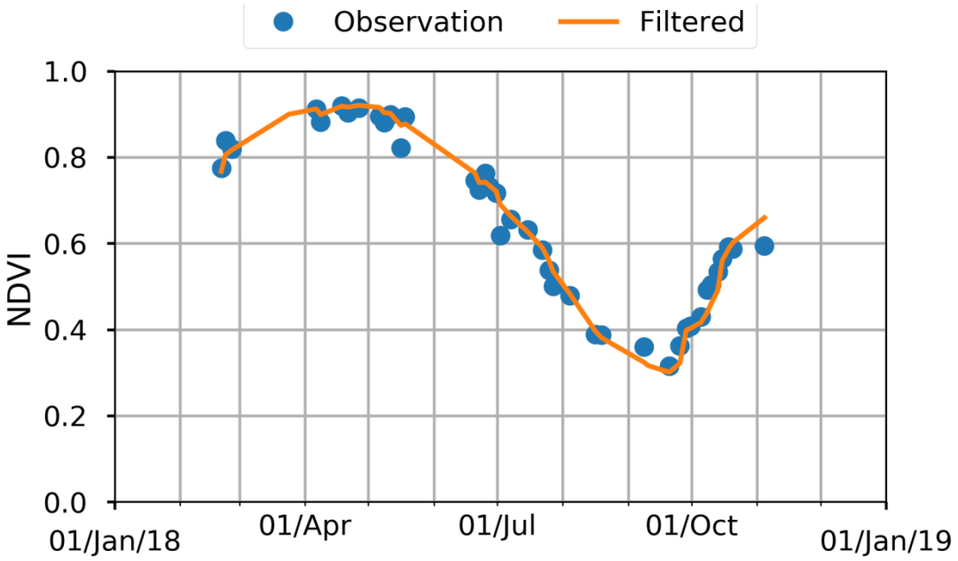
- Definition of „underutilized“ – not used by human during the last 5 consecutive years – needs time series data per se: Example for Austria: NDVI Time Series 2013-2018



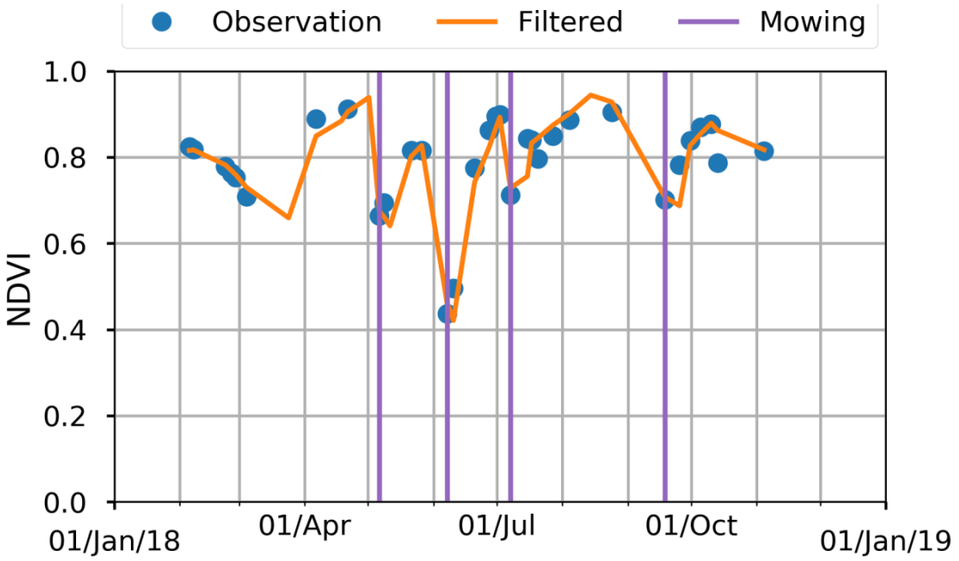
Mowing events



2. Grassland Classification



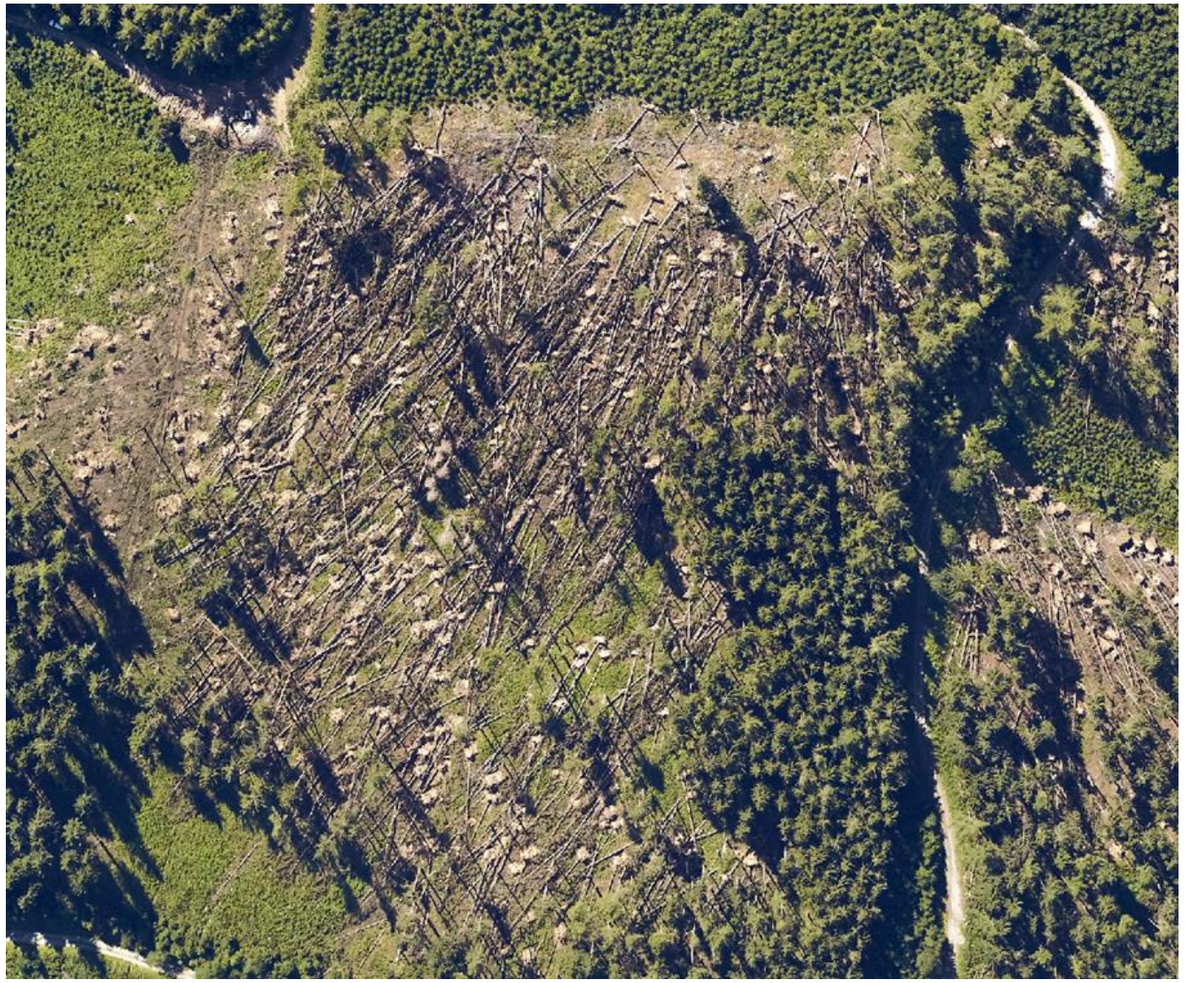
extensive

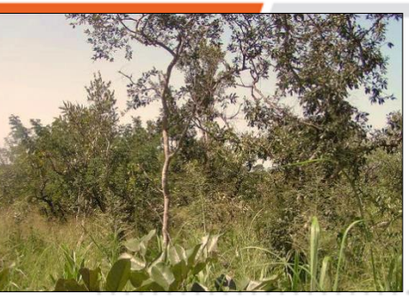


intensive

4. Near Realtime Change Detection in Dry Tropical or Temperate Forests

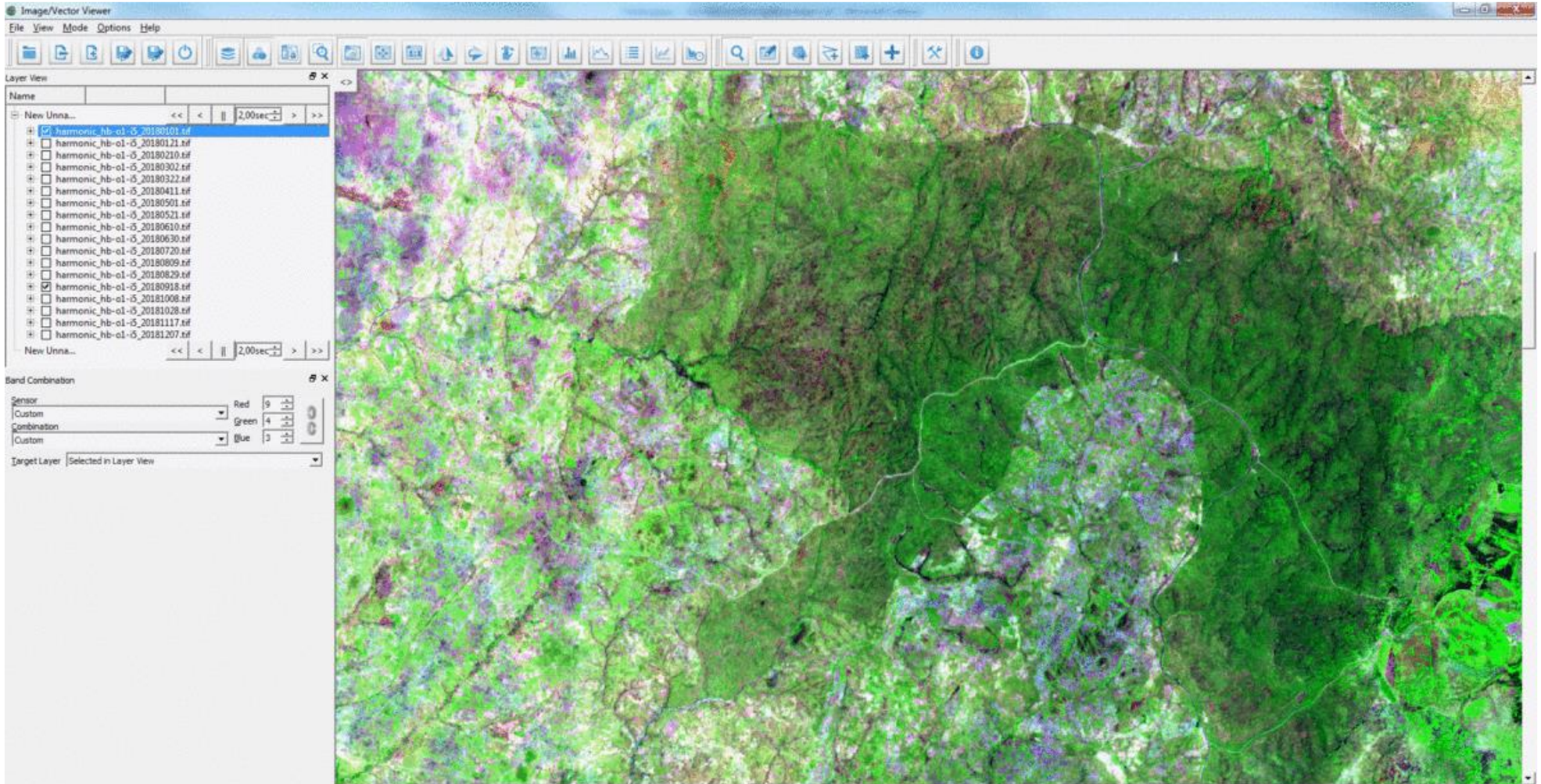
Bildquelle: http://vecea.vegetationmap4africa.org/docs/Wm.html

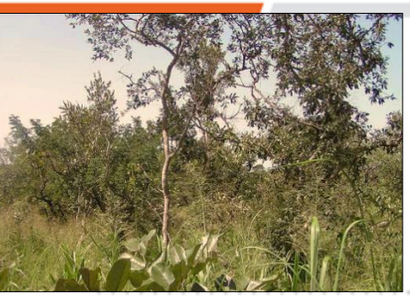




4. Near Realtime Change Detection Dry Tropical or Temperate Forests

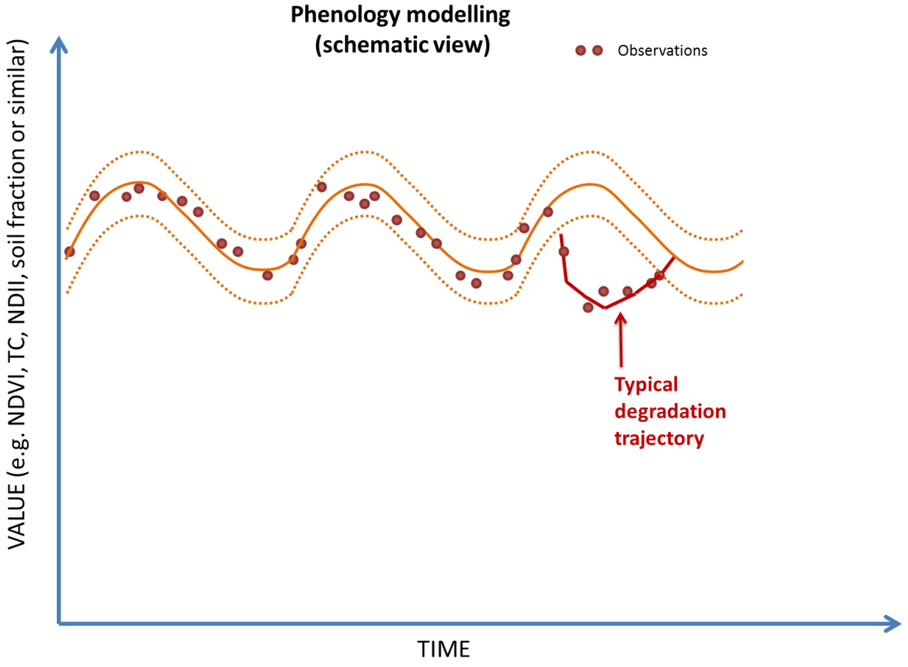
- Seasonality (phenology) needs to be taken into account

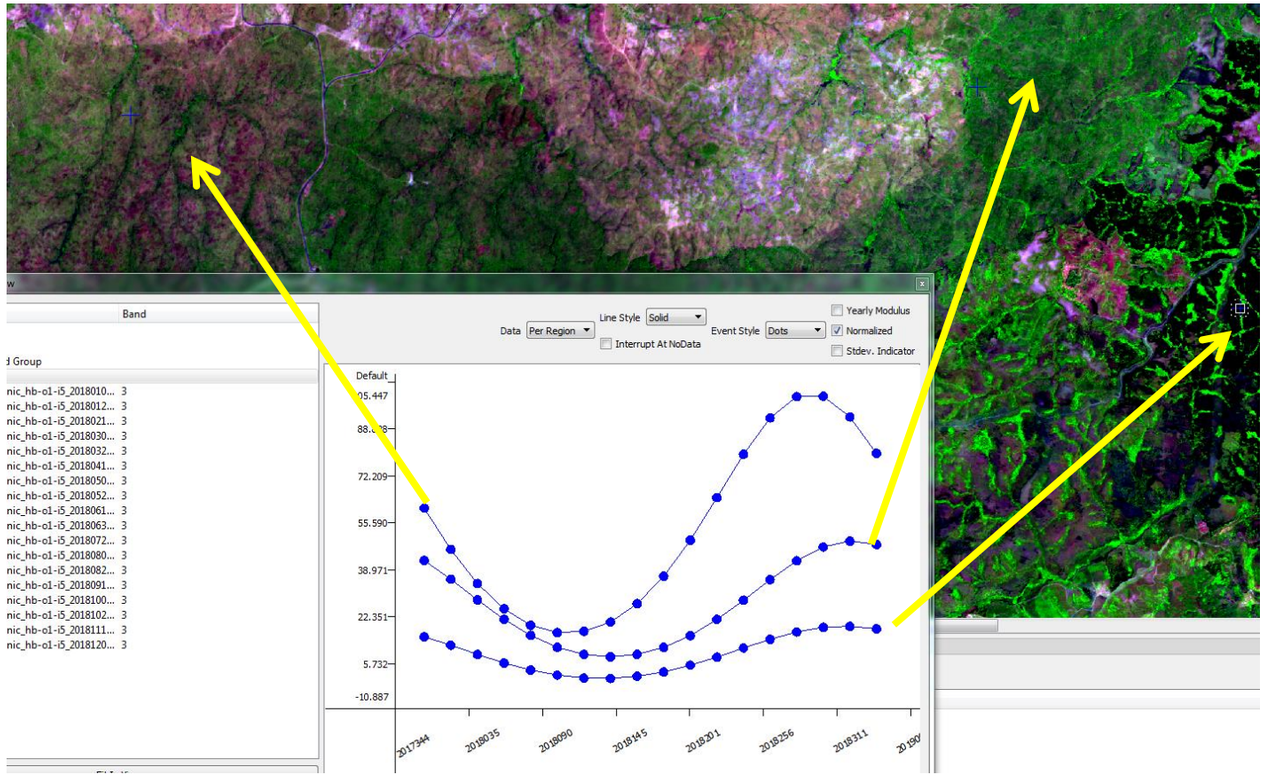


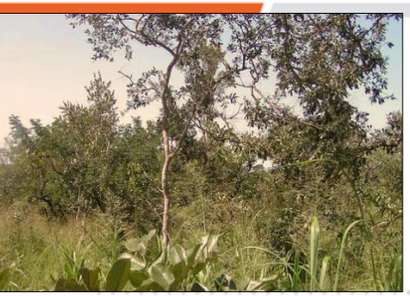


Dry Tropical Forest

- Plus: Gradient in seasonality!

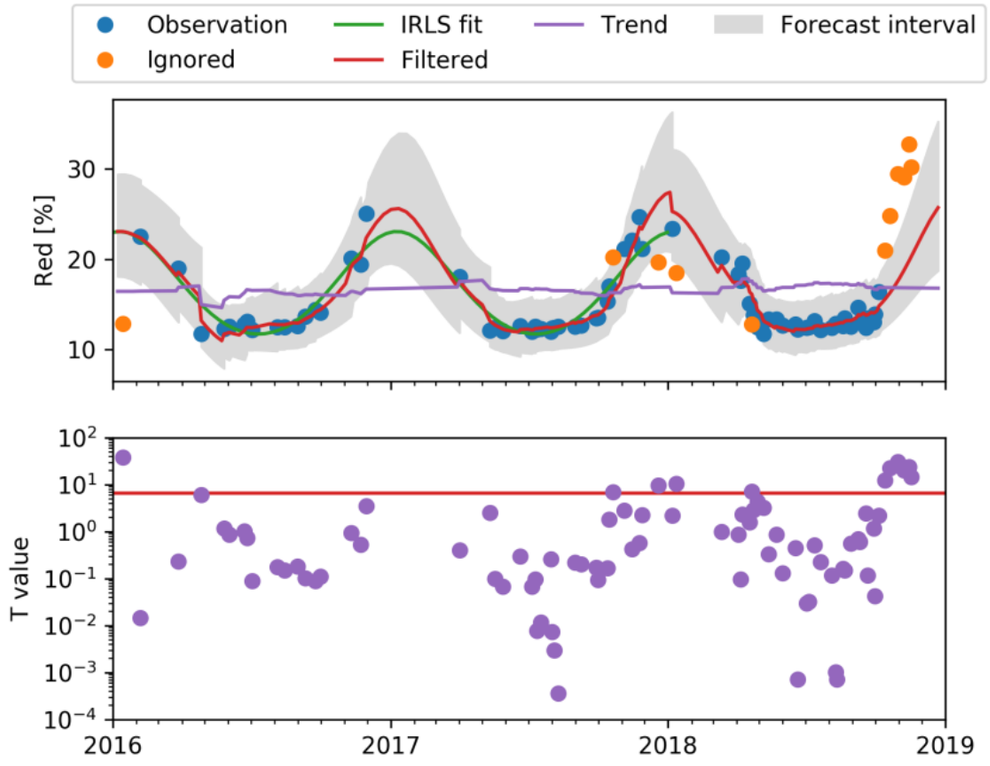


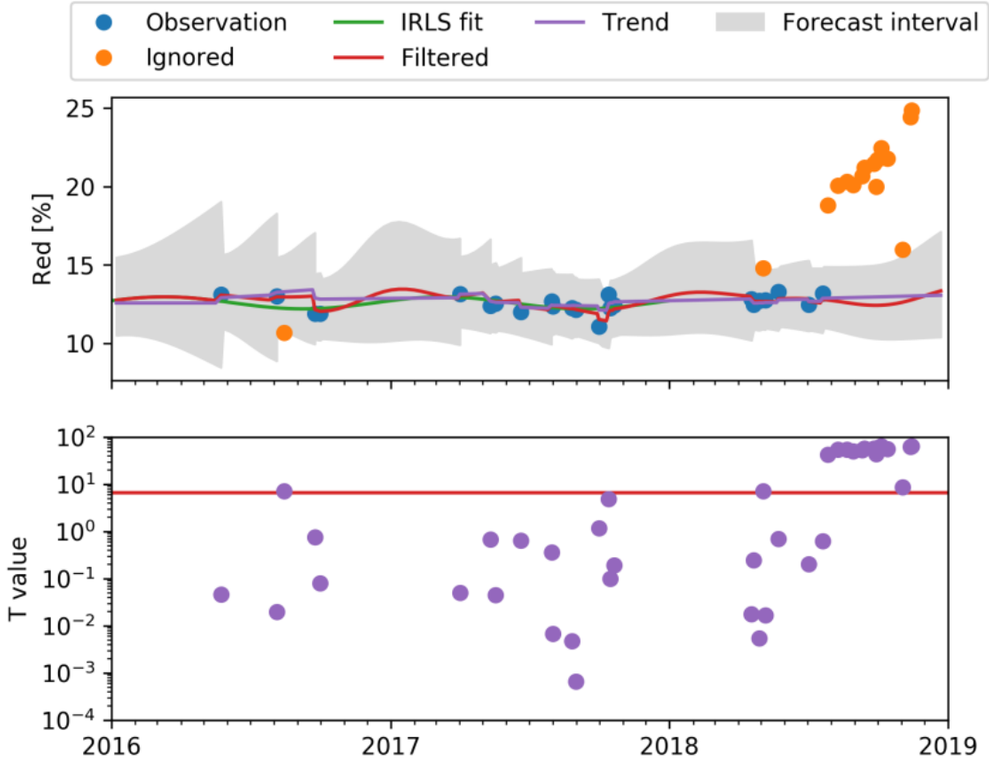


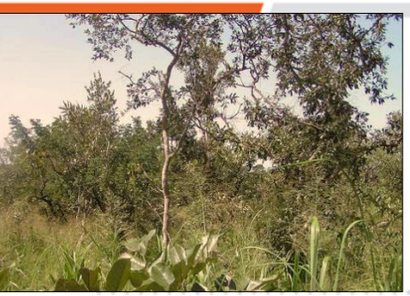


Dry Tropical Forest Disturbance Detection Approach

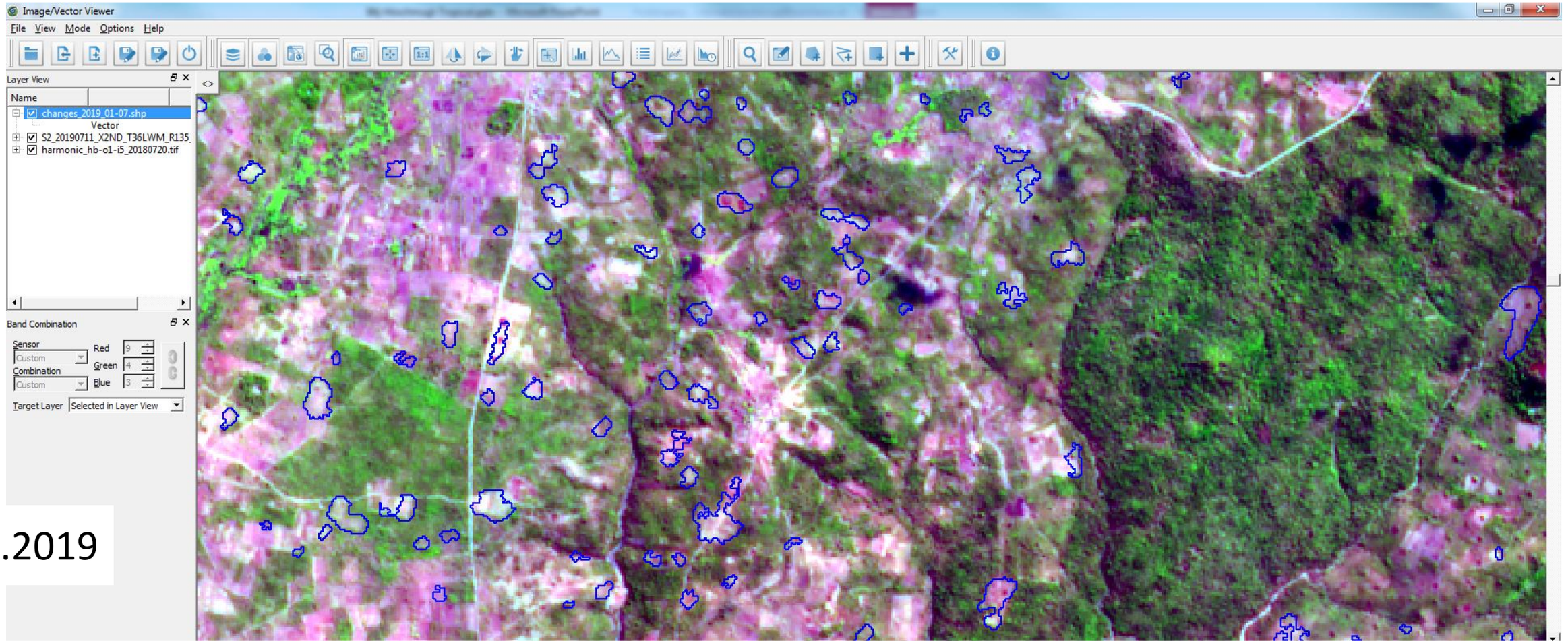
- Harmonic Regression & Kalman Filtering







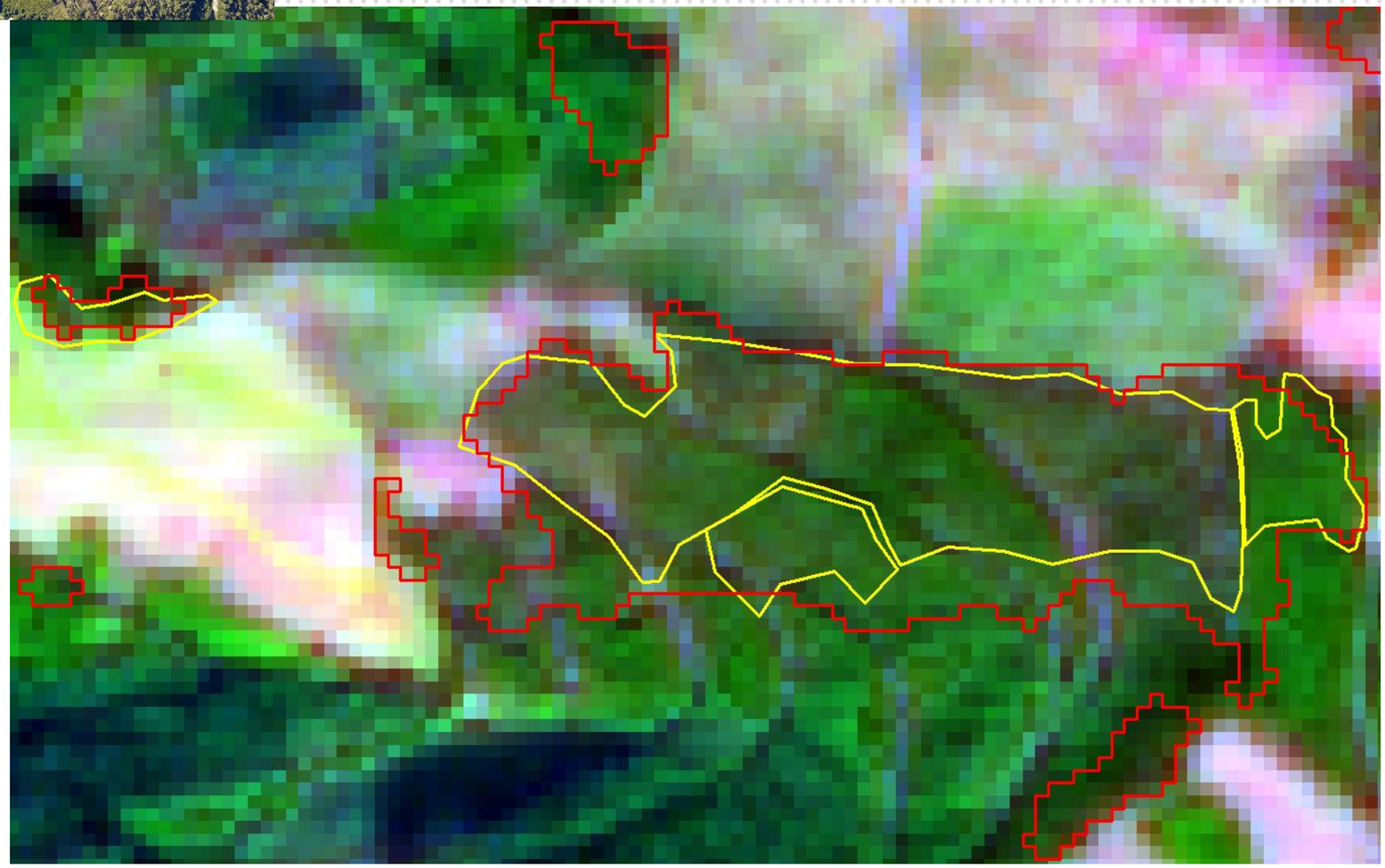
Dry Tropical Forest Disturbance Detection
First Results Jan-July 2019



11.07.2019

Validation ongoing

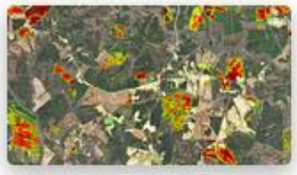
Storm Damage Assessment Styria



Storm Vaia, Bruck
Sentinel-2; **13.10.2018**
Red: Sentinel-2 change detection result 10/2018 – 9/2019
Yellow: delineation from visual interpretation 2018/2019

Storm Damage Assessment Styria

DMA Portal Service API description

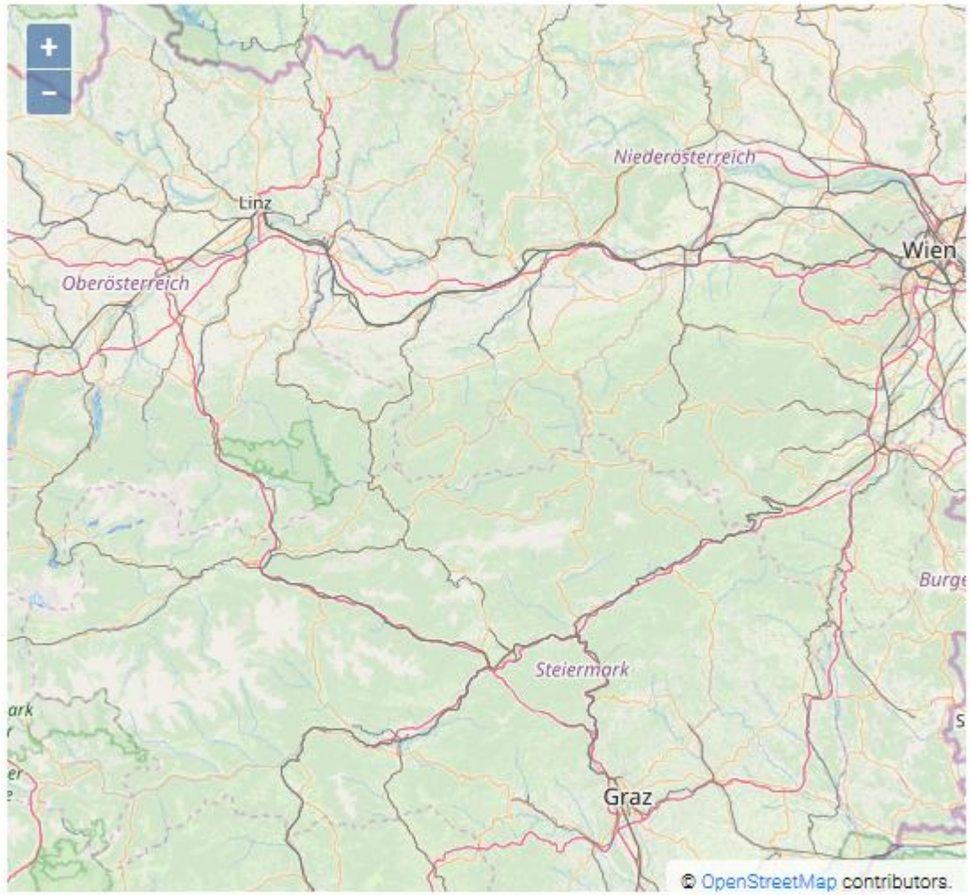


Change Detection

Detect forest changes between different time periods.

Topographic Normalization

Remove radiometric distortion caused by mountainous regions known as topographic effect.

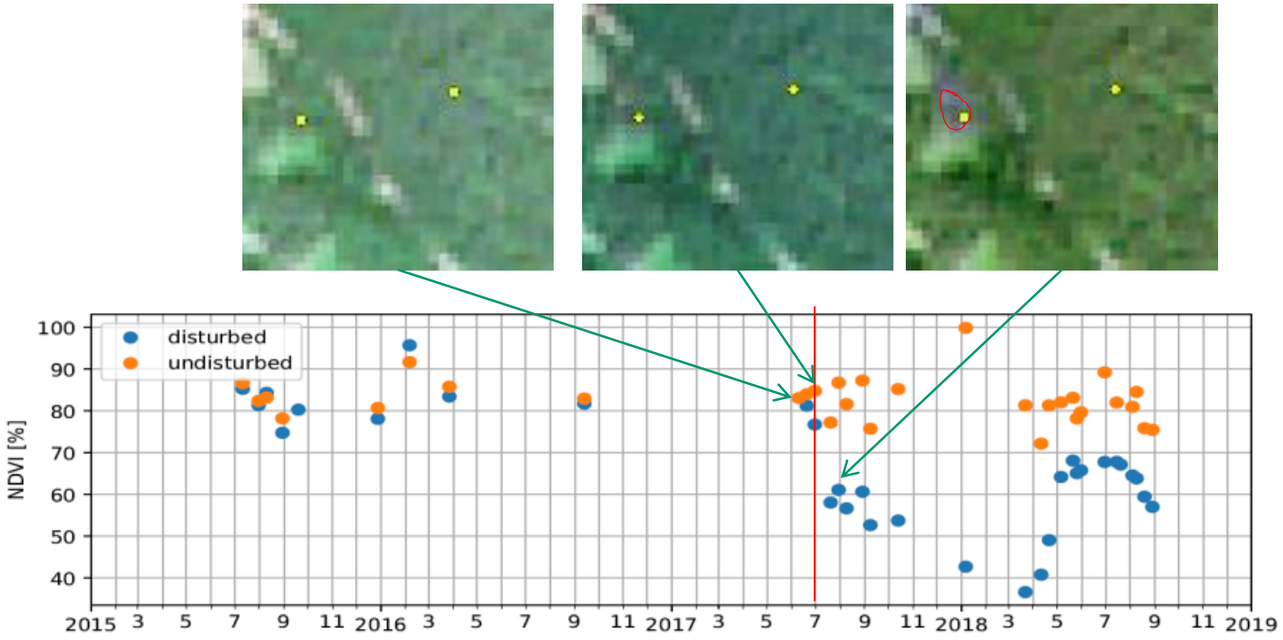


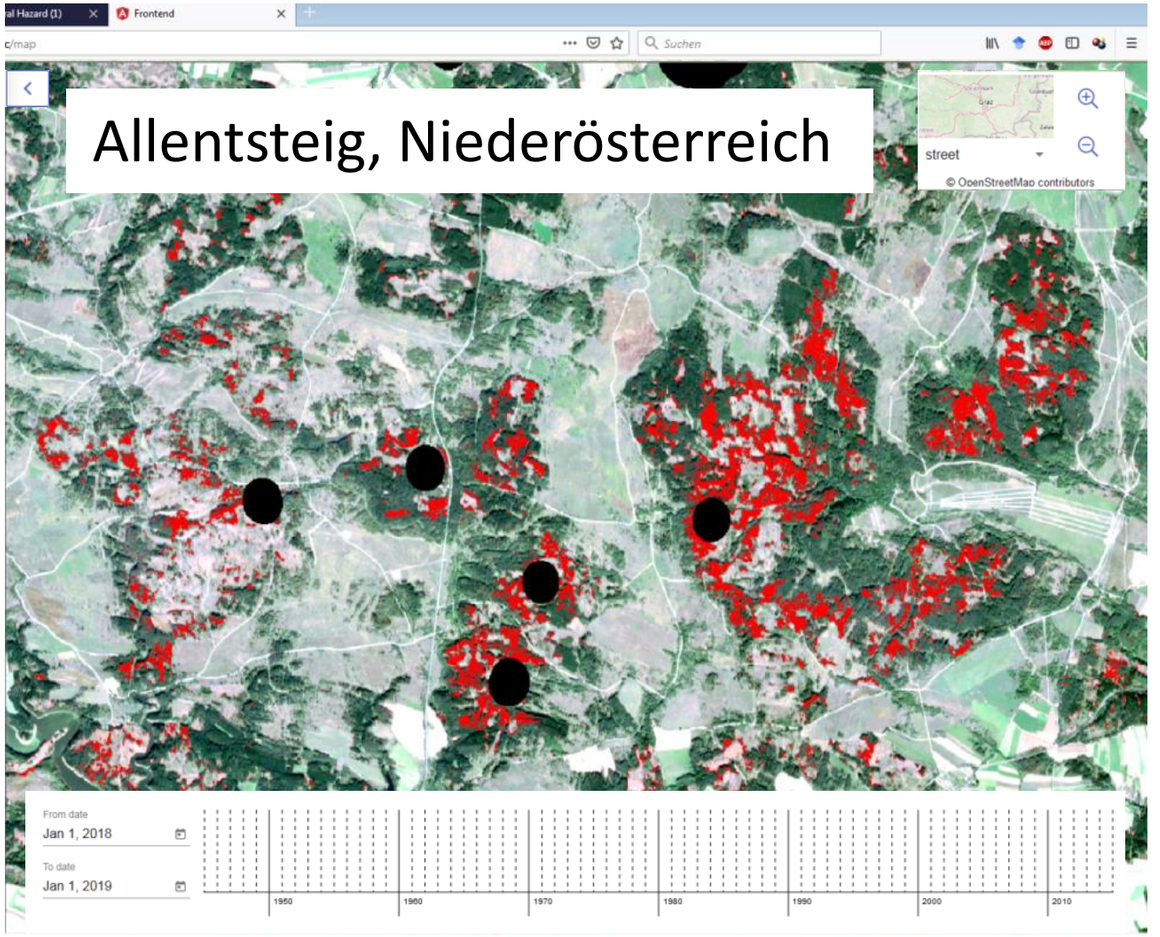
Please select a processing mode

Change Detection

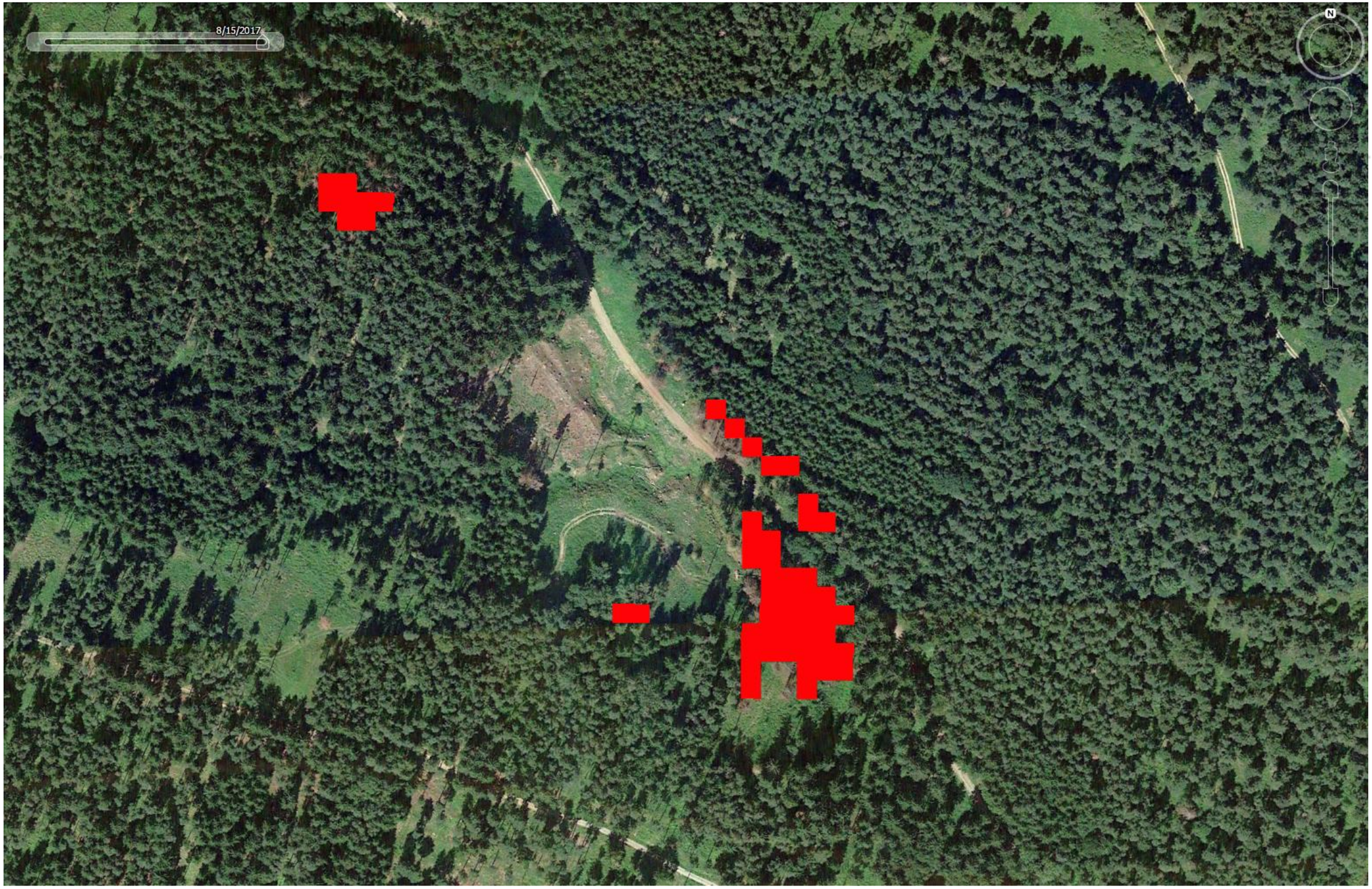
SELECT MODE

Bark Beetle Damage Detection, Lower Austria

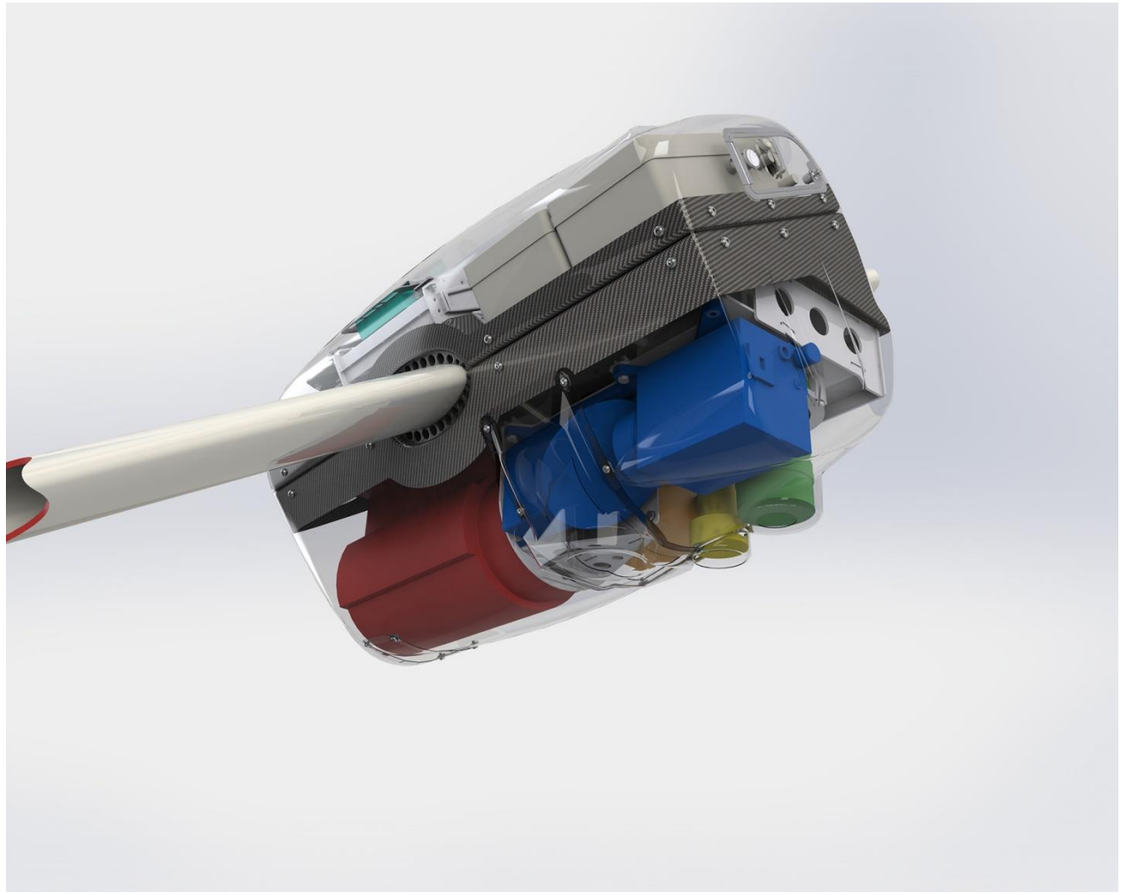




8/15/2017
N


8/15/2017
N

Airborne Data Acquisition & Mapping with ADAM



Motivation

- **The Problem**
  - In many countries no airborne remote sensing facilities exist
  - Transfer of appropriate equipment incl. aircraft is very expensive

- **The Suitcase Solution**
  - ADAM C can be mounted at the wing strut of any Cessna 182
  - All hardware components are integrated in the shell
  - System is very cost effective and can be operated worldwide

ADAM Installation (Cessna 182)

…quick and easy!

ADAM Hardware

Sensors – georeferencing

- GPS phase receiver, (2 x DL4-L1L2 NOVATEL)
- Inertial measuring unit(IMU), iMAR-FSAS

the images can be directly geo-referenced without ground control points

Sensors – image capture

- Optical Camera Phase One ixA 180 (80 MP)
- Near infrared camera
- LIDAR – Riegl VQ580
- FLIR – Thermal Camera

Control unit

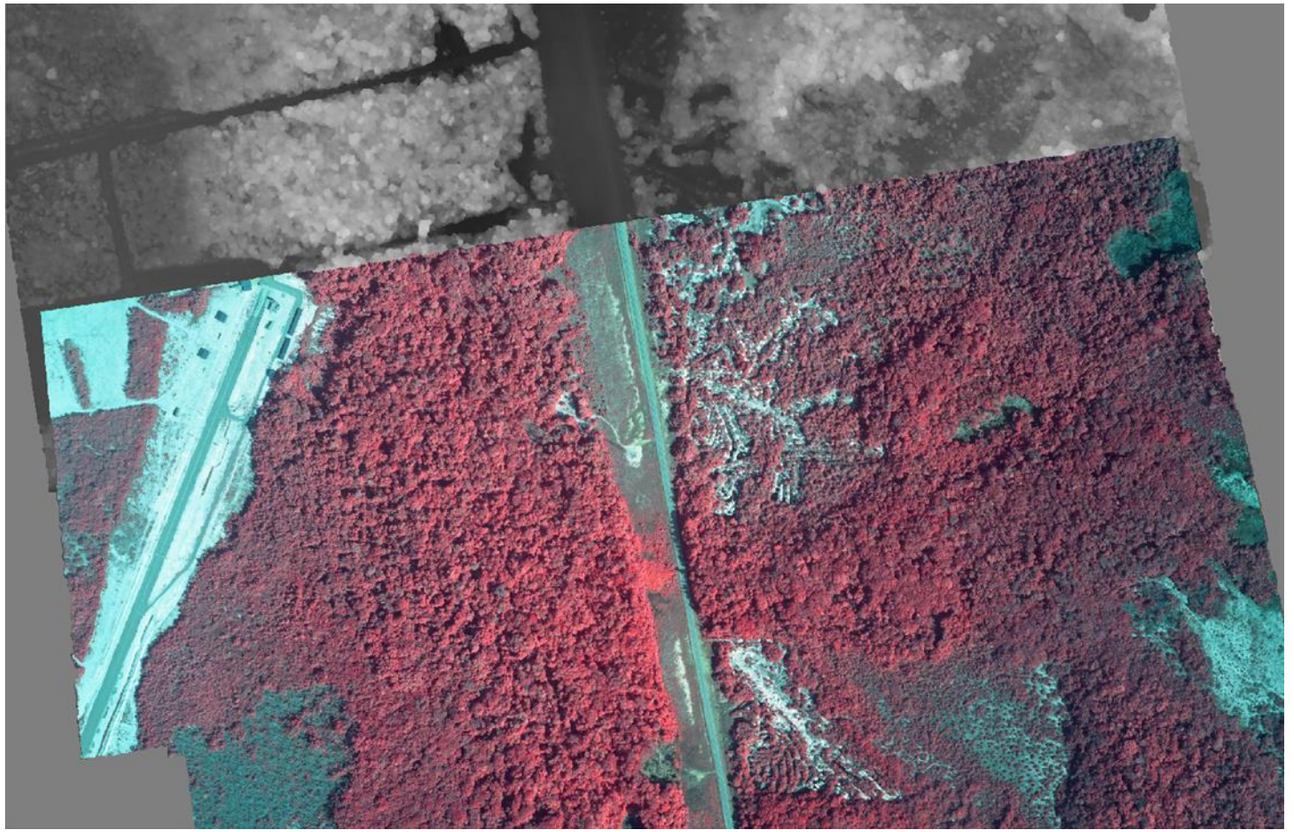
- *rugged PC and data storage*

Independent power supply by alternator and batteries

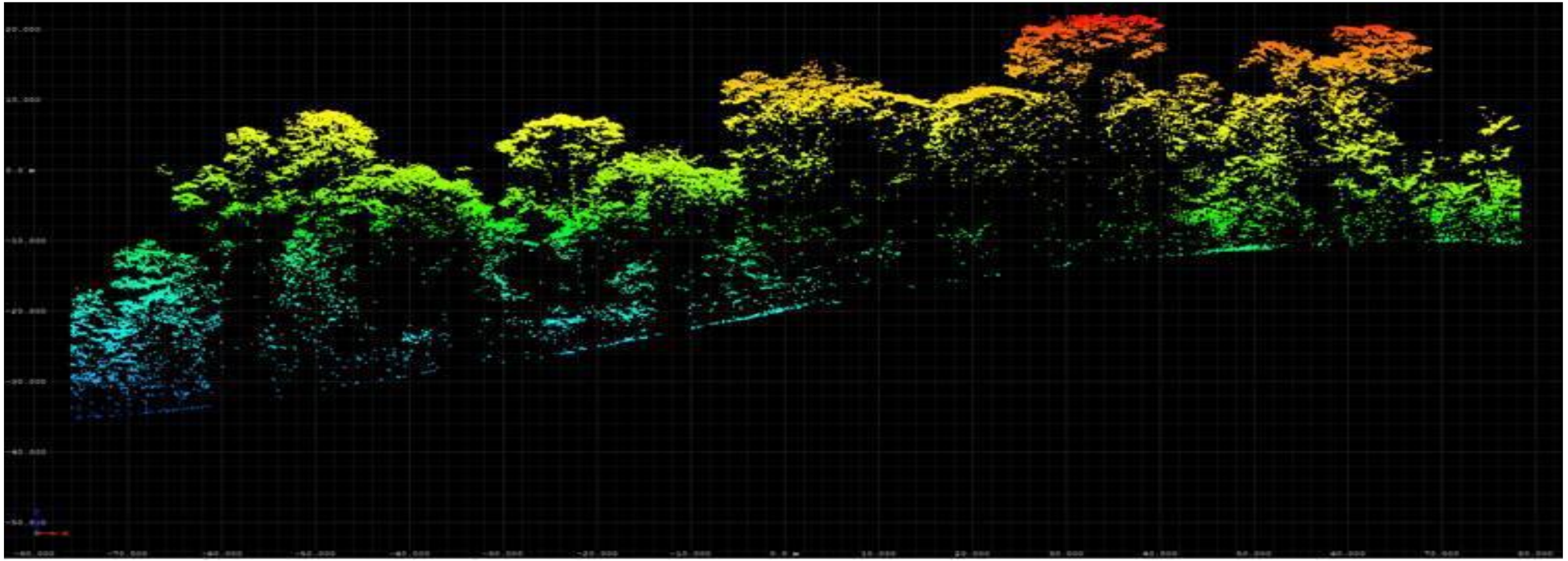
Flight control system

Workflow for data processing

CIR image + DEM = CIR orthofoto



LiDAR Transect of Tropical Forest Area



Take-home message

- Large amounts of data available

→ Many applications become possible

→ Let‘s make use of it!

Thank you for your attention!

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