The drought of 2018 and its effects on bark beetle outbreaks in Swiss forests: How can remote sensing help?

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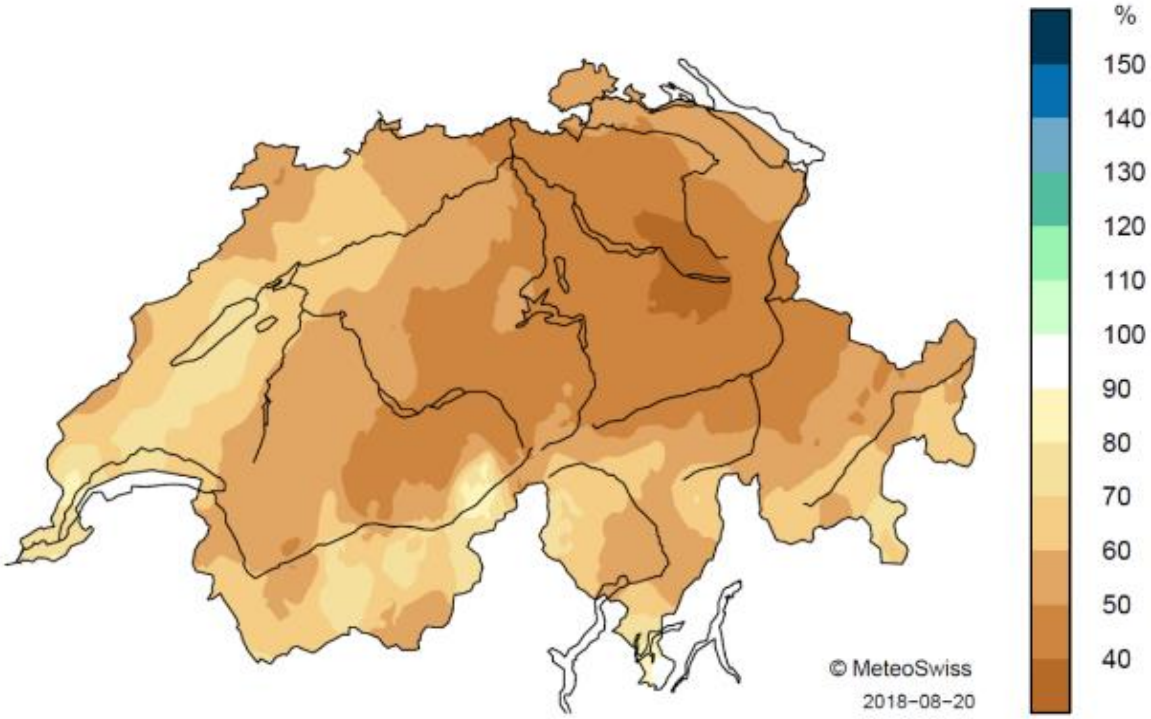
Introduction

- In 2018 Switzerland experienced one of the lowest precipitation in spring and summer for almost 100 years (MeteoSwiss)
- While not as severe, the drought was in many places (especially in eastern Switzerland) comparable to 2003



Precipitation April-August 2018 in reference to 1981–2010

Effects of the 2018 drought-Effects on forest

- A large number of trees showed early signs of canopy browning and leaf shedding due to drought stress

Motivation

- Acute drought events have shown to significantly increase beetle population growth and thus very likely lead to bark beetle mass outbreaks (Netherer et al. 2019)

Part 1

- Can we use remote sensing data to map drought stress on forests habitats?
- Is there a link between drought stress in 2018 and bark beetle outbreaks on forests ecosystems of Switzerland?

Part 2

- What is the potential of remote sensing for detecting early beetle infestations on drought stress forest regions?

Part 1

Objective

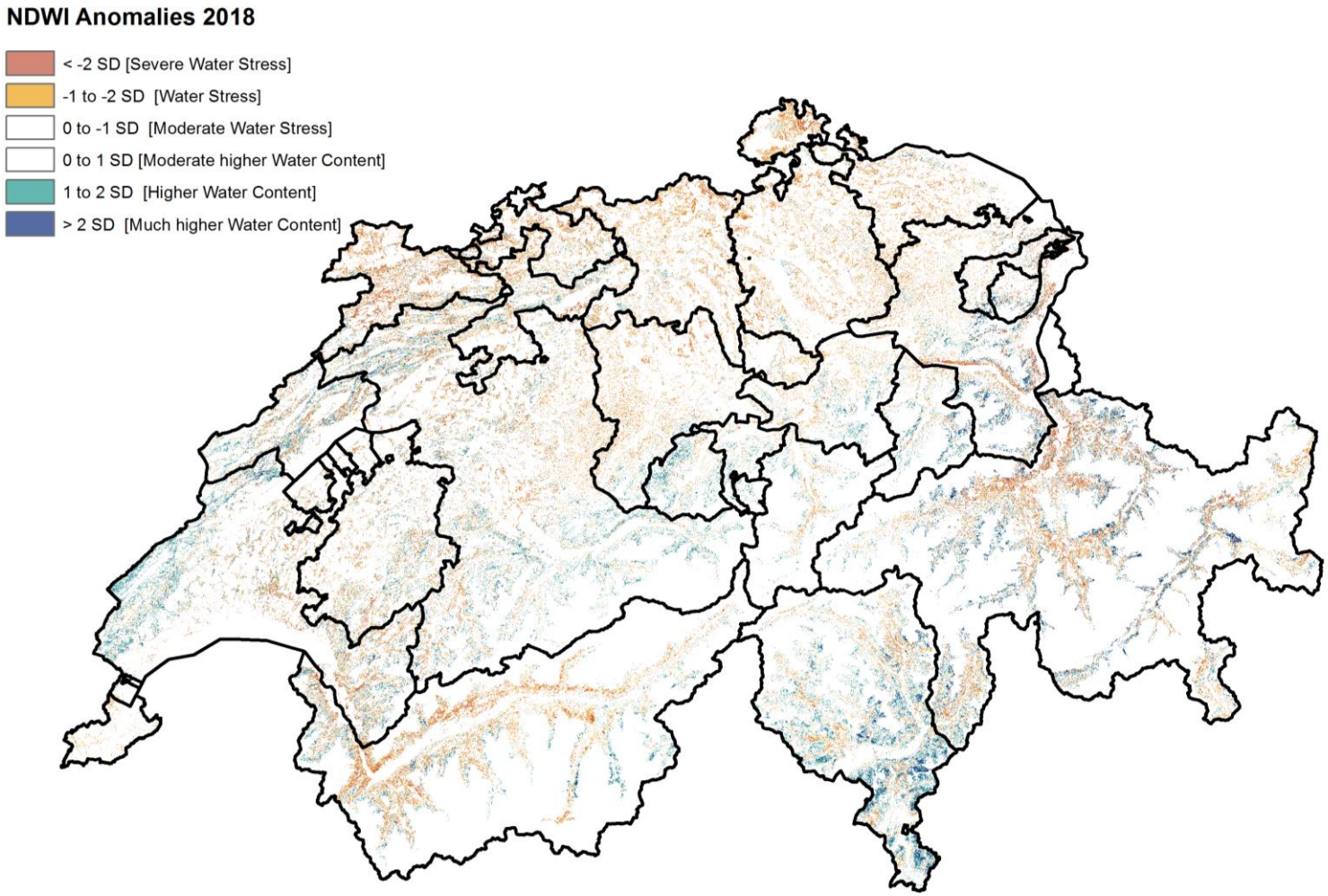
- Can we use remote sensing data to map drought stress on forests habitats?

Methodology

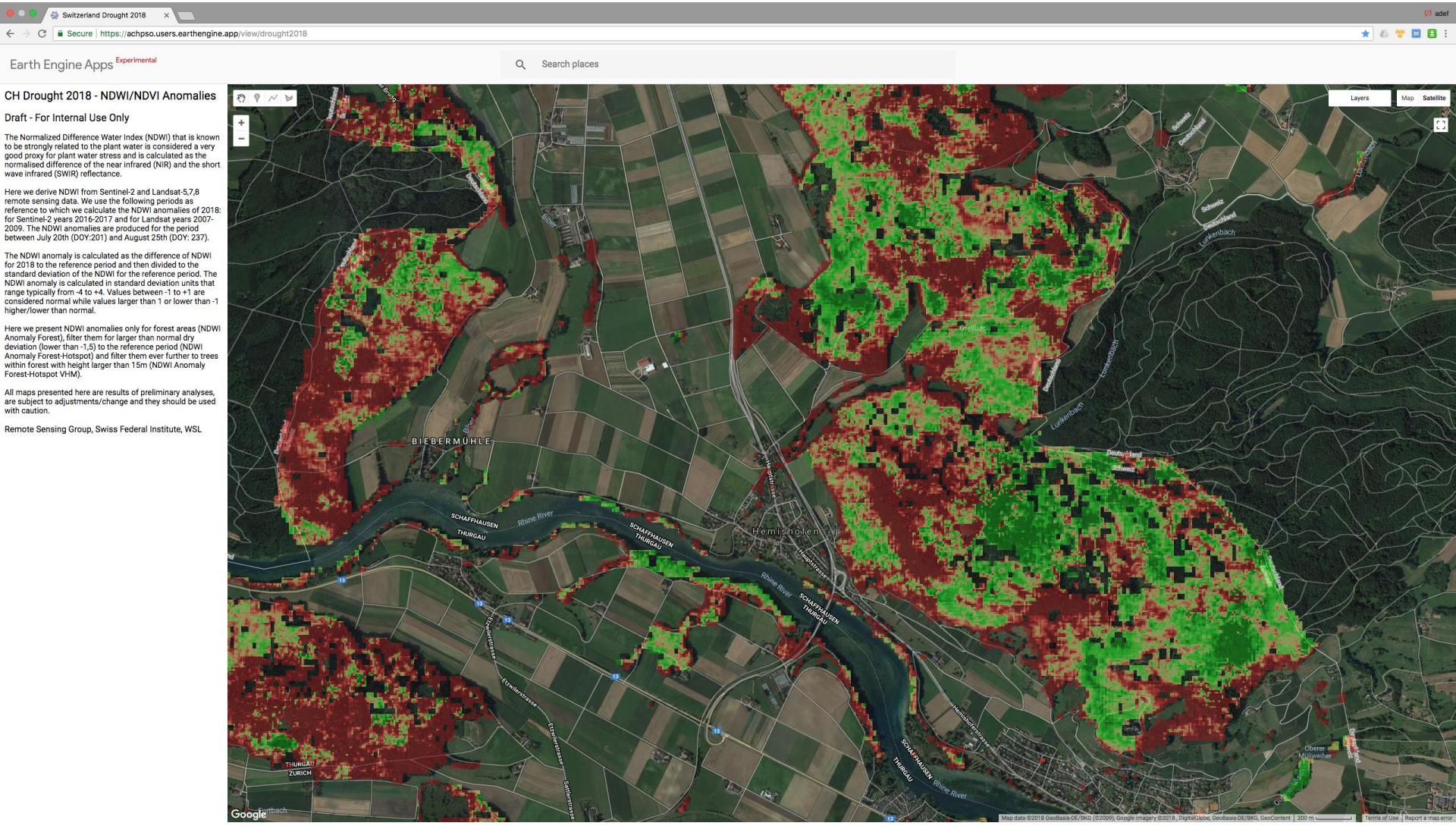
- Used the Normalized Difference Water Index (**NDWI**)
- Calculated **anomalies** of NDWI for 2018 compared to a given reference period of „normality“ using Google Earth Engine
  - Sentinel-2: **2016-2017,** 10m spatial resolution
  - **When** in 2018? → July 20th-August 25th

$$NDWI_{anomaly} = \frac{NDWI_{2018} - NDWI_{Reference\ Period}}{NDWI\_SD_{Reference\ Period}}$$

NDWI 2018 anomalies as a proxy of drought stress

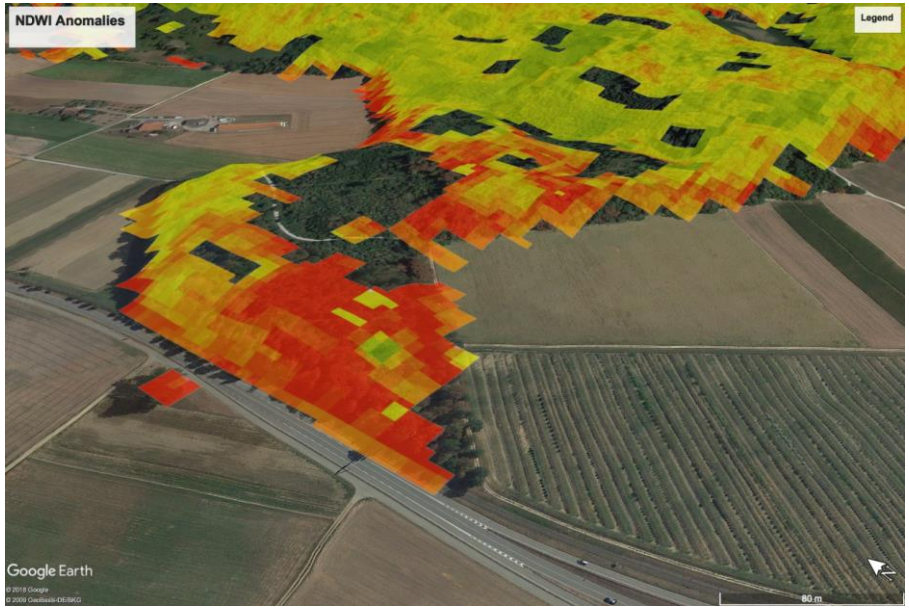


NDWI 2018 anomalies as a proxy of drought stress



NDWI Anomalies for 2018 - Drought stress

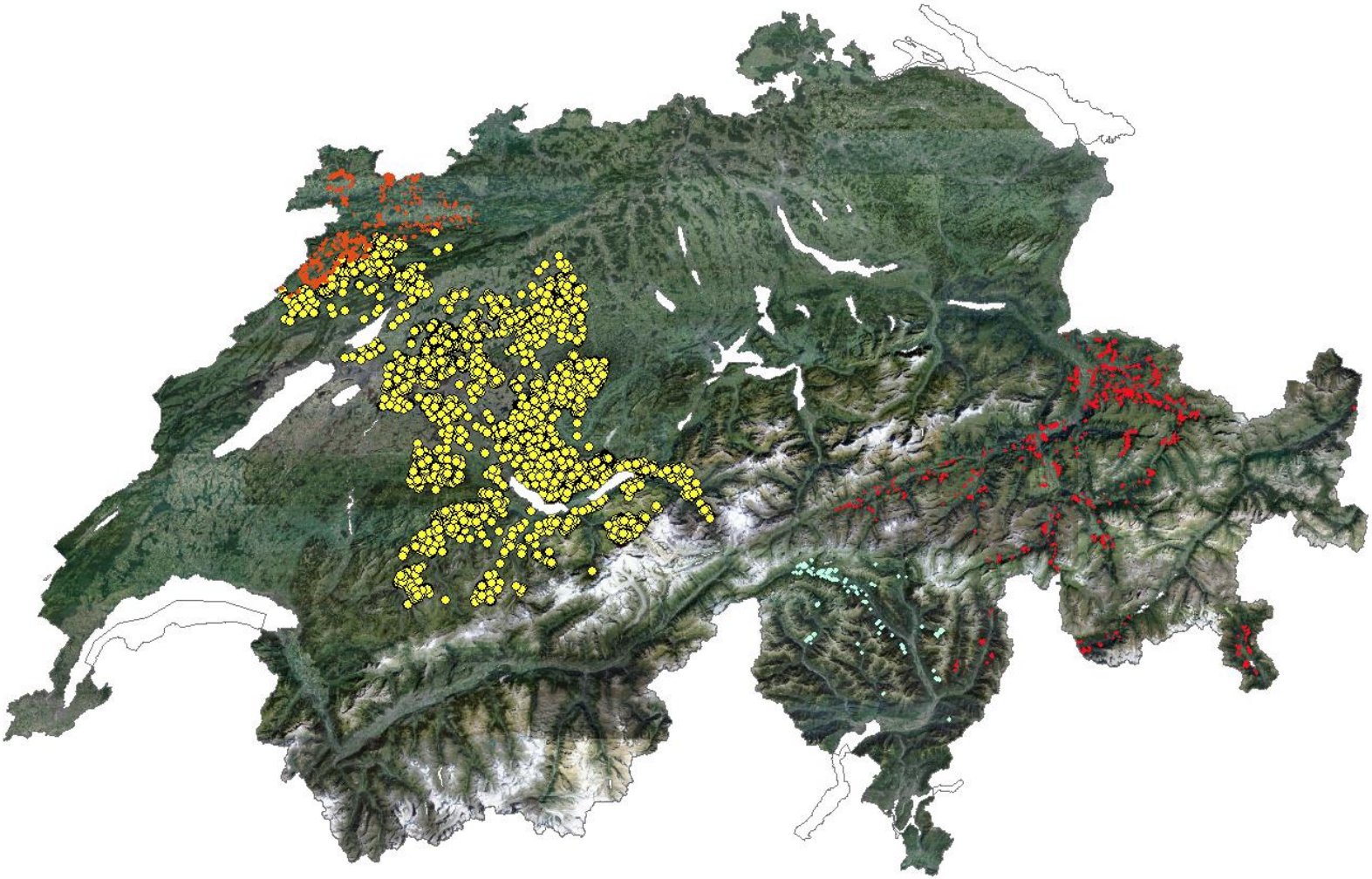
RS Derived Drought Stress



Actual Conditions 2018

Objective

Is there a link between drought stress in 2018 and bark beetle outbreaks on forests ecosystems of Switzerland?

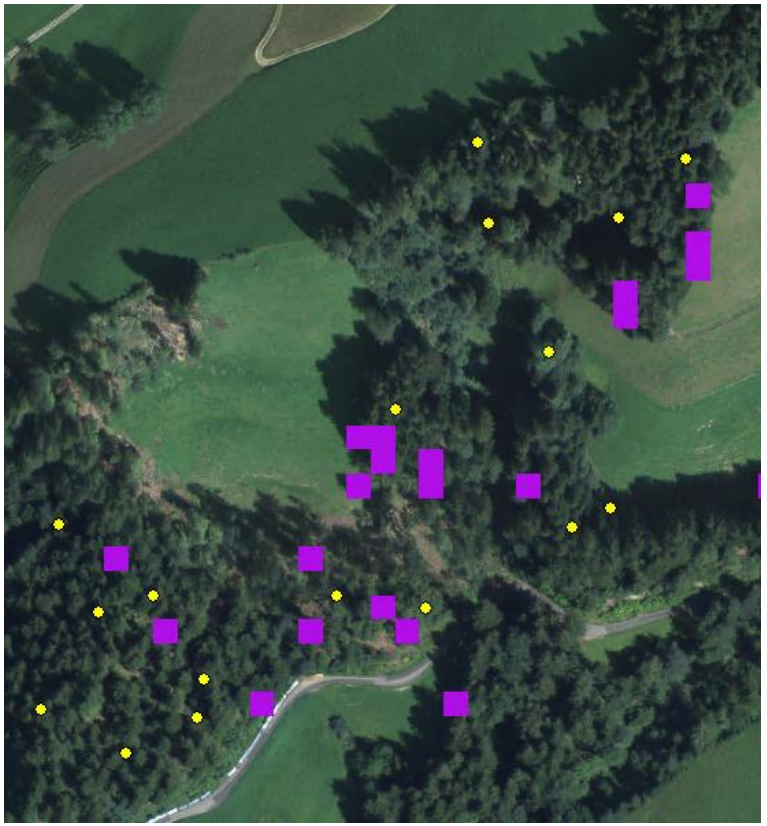


Drought 2018 - Bark beetles - Examples

- **Purple**: Forest locations under severe drought stress
- **Yellow:** Actual bark beetle infestation locations

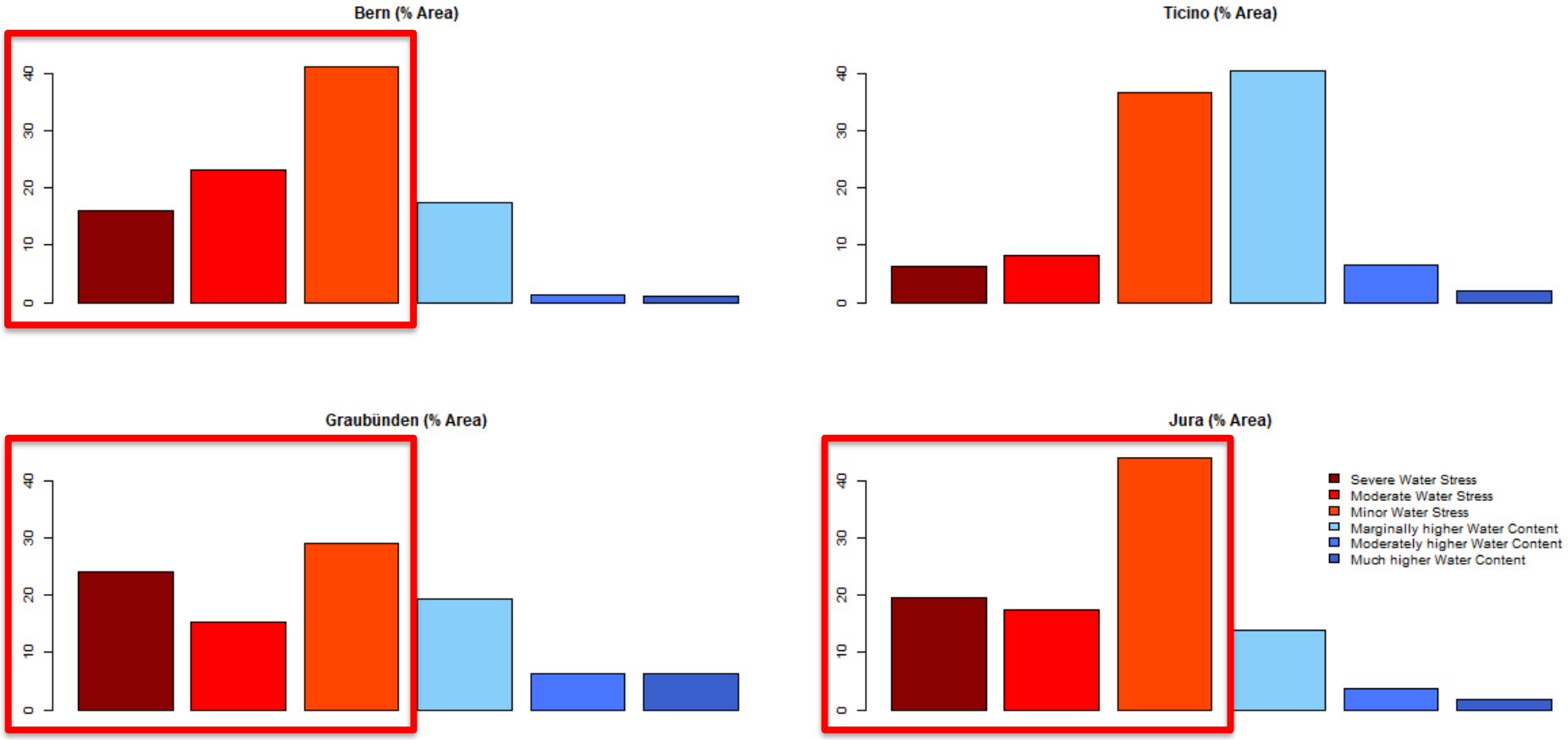
Drought 2018 – Bark beetles

Stress – No bark Beetles



No stress – bark Beetles

- Large majority of bark beetle outbreaks were observed in areas that were under drought stress in 2018



Summary – Conclusions

- Analyses showed the potential of Sentinel-2 time series (2018 NDWI-anomalies) as a proxy of drought stress on forest habitats
- We saw a strong correlation between drought stress and bark beetle outbreaks
- This information could potentially be used to understand and even predict bark beetle outbreaks
- Drought stress facilitates but does not mean imminent bark beetle attacks. Outbreaks were also observed in areas that were not under drought stress in 2018
- With high frequency and rapid availability of Sentinel-2 data these results can be considered "near real-time" and be made available to stakeholders

Part 2

Introduction - Objectives

- We focused primarily on drought stress regions where bark beetles outbreaks have been reported. Can we detect early bark beetle infestation with remote sensing?

- Major factors influencing the accuracy of mapping green-attack stage of bark beetle infestations with RS (Zabihi et al., 2021):
  - Spatial resolution (less than 4 m)
  - Temporal resolution (daily to max weekly)

- Several studies are performed on monoculture stands rather than on forest mixtures. Thus accuracies of early infestations are ofter reduced for mixed pixels or at forest edges

Methodology

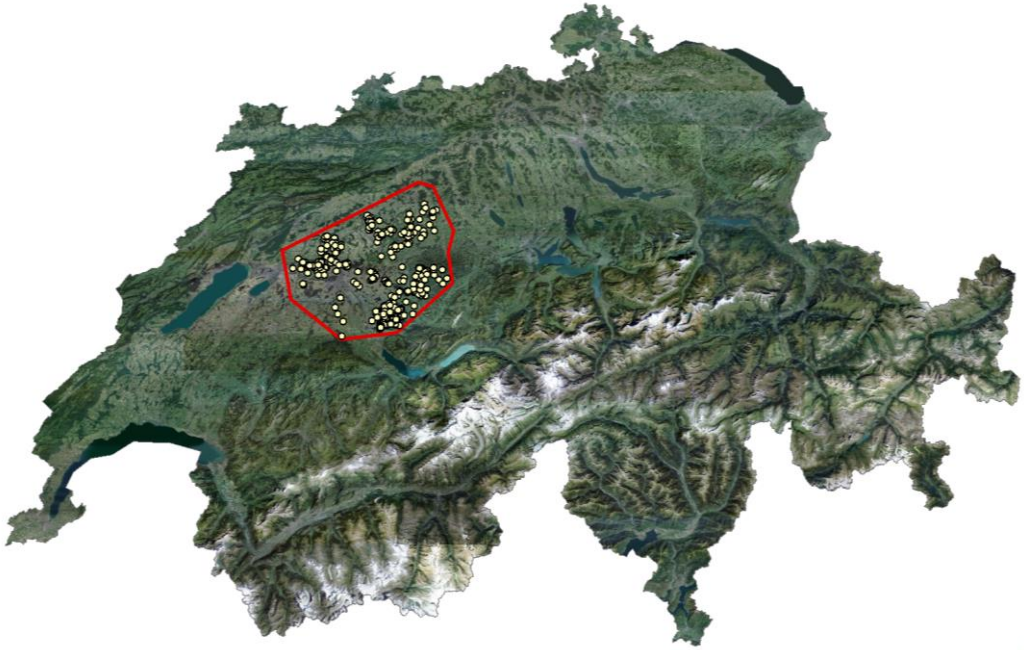
- PlanetScope data
  - Spatial resolution of 3m (GSD 3.7-4.2)
  - Daily revisit time (August 2021)
  - 8-spectral bands (RGB, NIR, Red Edge, Coastal blue, Green, yellow) from March 2021 onwards (SuperDove sensor)

PlanetScope Imagery

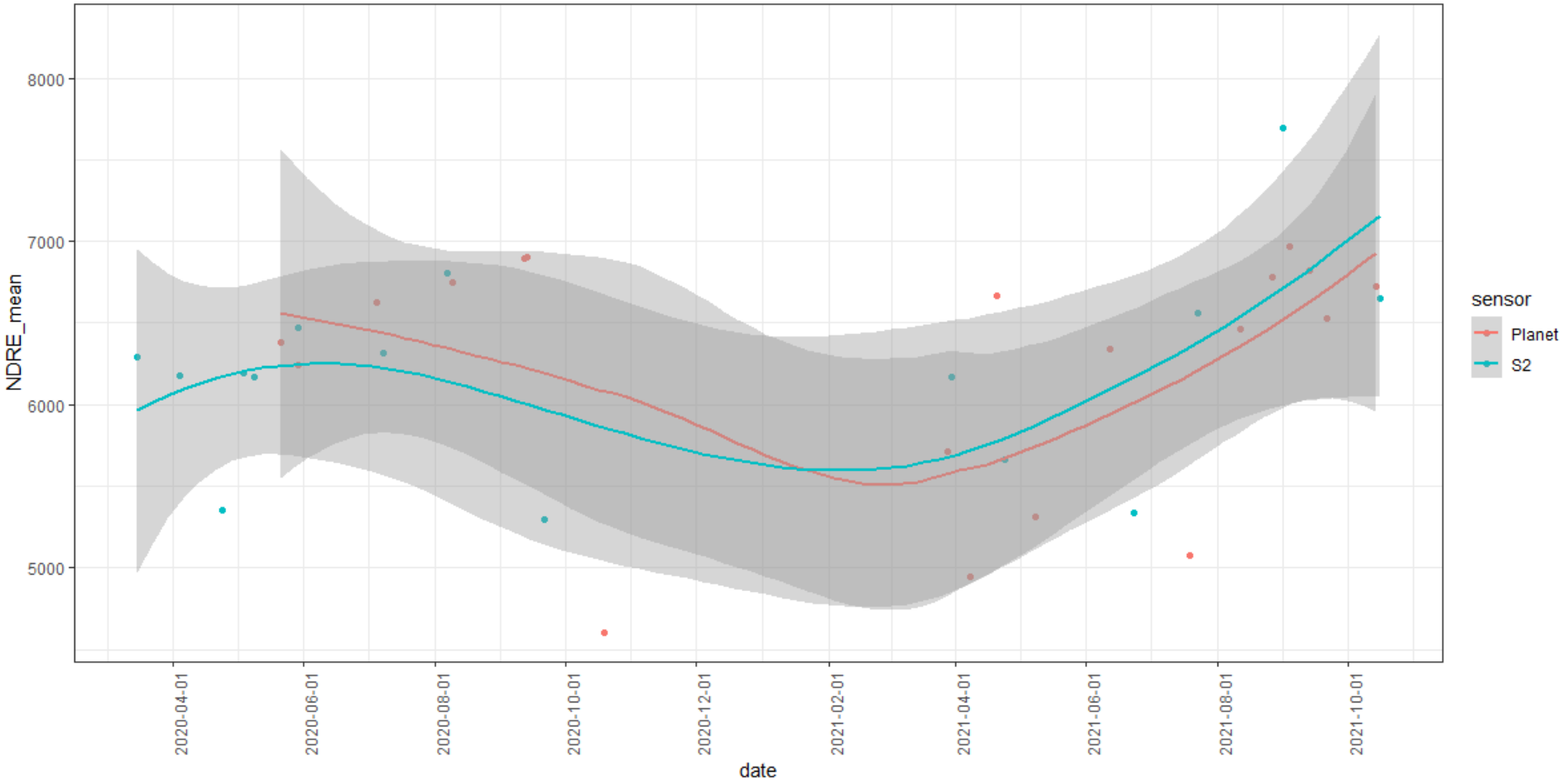
- **Advantages**
  - High spatial resolution (3m) compared to Sentinel-2 (10/20m)
  - High revisiting time compared to Sentinel-2 (3-5 days)
  - Red edge spectral band
  - Data harmonised to match Sentinel-2
  - Direct delivery/ingestion to Google Earth Engine for analyses
- **Disadvantages**
  - No spectral bands in the SWIR
  - Cloud/haze masks and surface reflectance retrieval needs futher improvement
  - Commercial company – data NOT free

Methodology

- PlanetScope data 8-bands and Sentinel-2 for 2020-2021 (April-October)
- Case study Canton of Bern
- 4096 bark beetle recording (2019-2021)
- Normalised Difference Red Edge Index (NDRE) time series calculated in Google Earth Engine



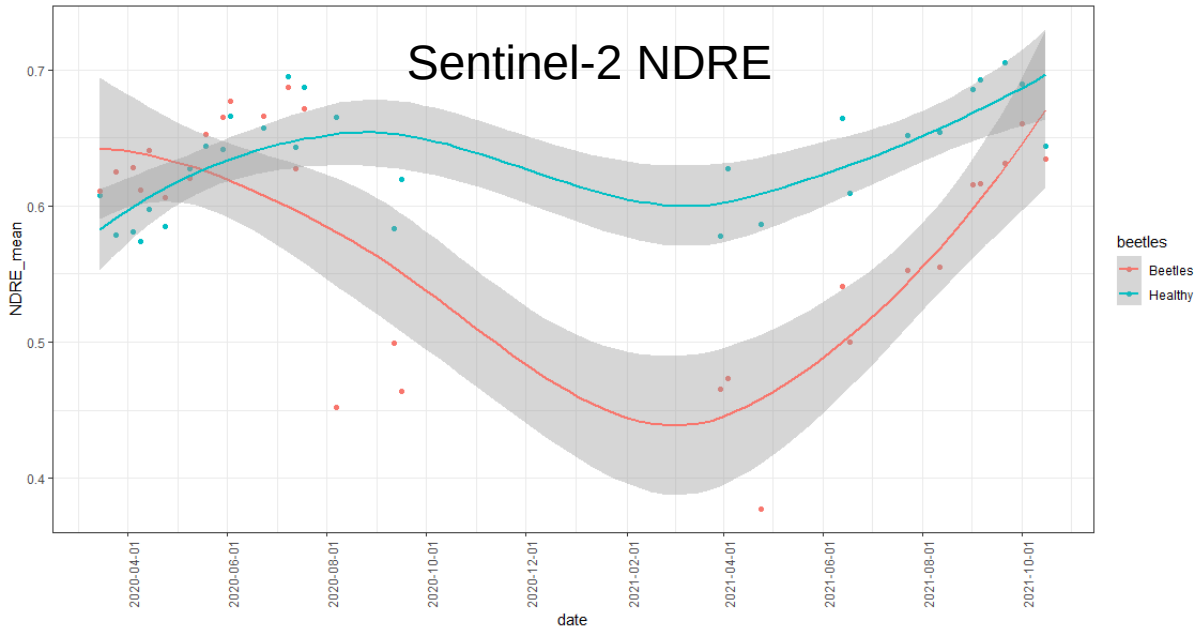
Examples – Sensor comparison

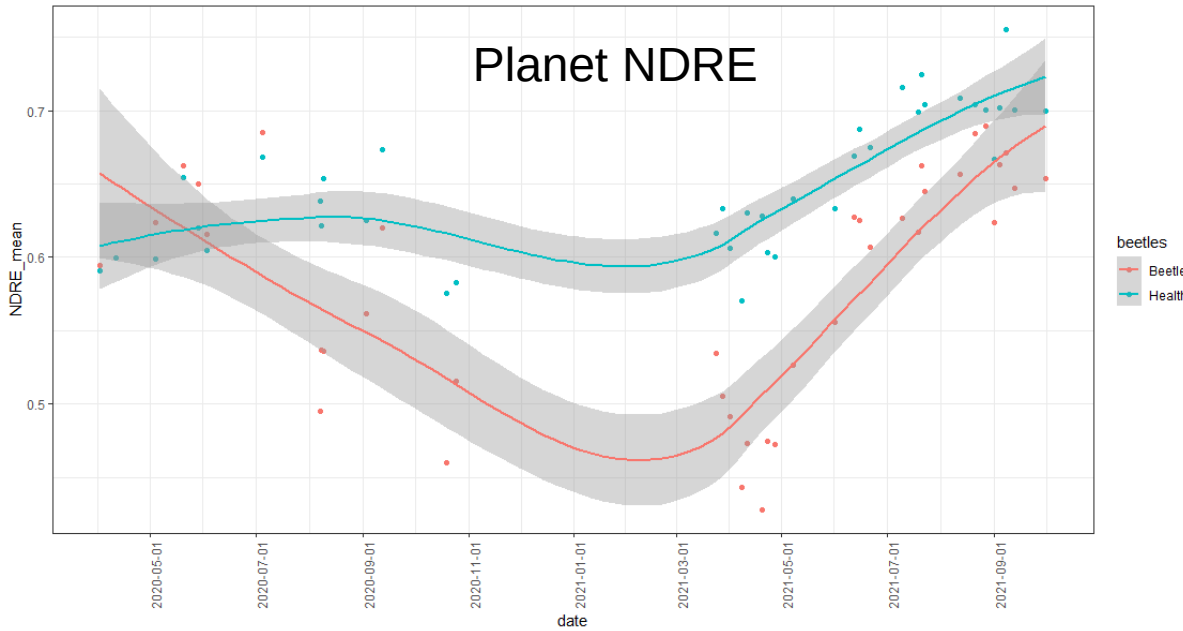


Examples – Large area beetle outbreak

- Approximately 150 trees removed in July 2020

Examples – Large area beetle outbreak





Examples – Small area beetle outbreak

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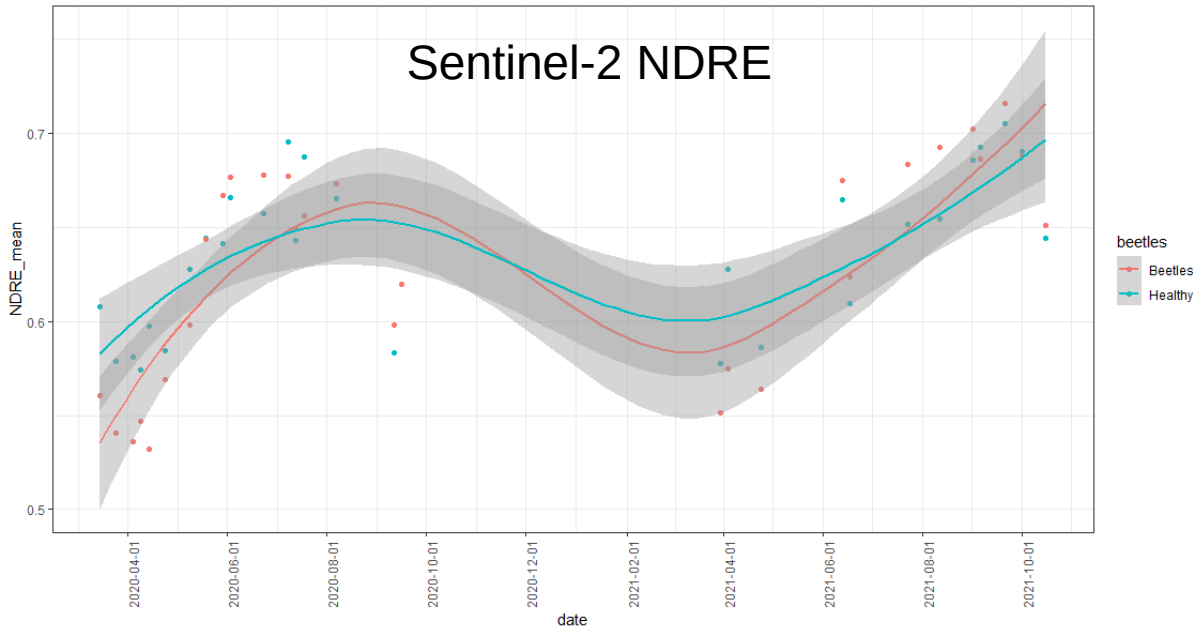

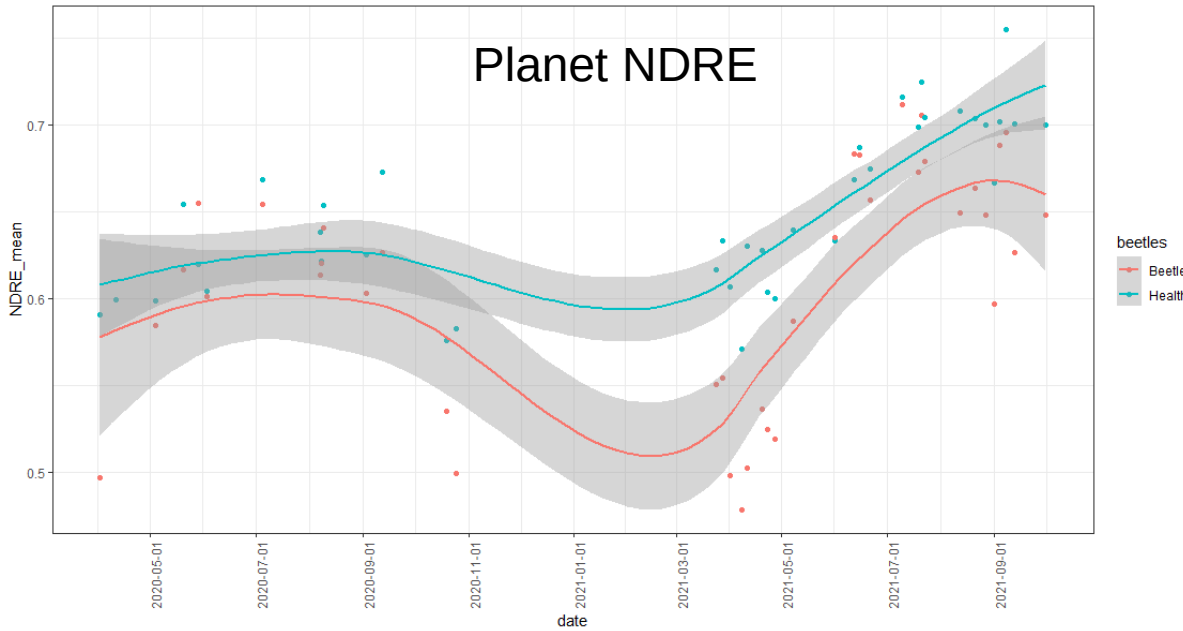

Summary – Conclusions

- Initial analyses show the potential of PlanetScope time series data for identifying bark beetle outbreaks in Swiss forests
- PlanetScope data are especially helpful in the detection of small scale outbreaks and/or in mixed forest stands where high spatial resolution is required
- PlanetScope data should be used in synergy with Sentinel-2
- 8-band availability (NDRE) limited to 2021 onwards
- PlanetScope is a commercial company

Thank you for your attention

Spectral Differences – Bark beetles

- **Challenge:** We have the bark beetle attacked plot. What about the „healthy“ not attacked plots
- **Hypothesis:** Choose forest areas adjacent to attacked plots (100-250m) that have not been identified as attacked that fulfill forest species criteria (spruce). Use these are a reference of „healthy“ plots.