Report on drone-based data products

Wildfire “Quesenbank” Harz National Park

20.10.2023

DOI 10.5281/zenodo.7554598

Dr. Robert Jackisch
TU Berlin, Institut für Landschaftsarchitektur und Umweltplanung, Fachgebiet Geoinformationsverarbeitung in der Umweltplanung;
robert.jackisch@tu-berlin.de
ORCID 0000-0001-5696-8721

Dr. Birgitta Putzenlechner
Georg-August Universität Göttingen, Geographisches Institut, Abteilung Kartographie, GIS und Fernerkundung;
birgitta.putzenlechner@uni-goettingen.de
ORCID 0000-0002-5663-581X

Table of contents

Survey date: 13.10.2022

1 Introduction

Unoccupied aerial vehicles (UAVs) were used to investigate a burnt forest site situated in the Harz National Park area near the location Schierke, east of the Brocken, called Quesenbank (51.76877 °N, 10.69173 °E) which is a pine stand severely affected by bark-beetle and windfall. Most of the trees are dead such that they provide high fuel loads for potentially occurring wildfires. The small river Wormke crosses the Quesenbank and separates the survey area between a hiking path and the forest stand.
During the 12.08.2022, inhabitants reported a fire[1] near Schierke which was quickly contained by the authorities. Two months after the fire, on 13.10.2022, a team of scientists from GAU Göttingen and TU Berlin was accompanied by a National Park representative for investigation. The site was surveyed by using modern UAVs and by sampling soil strata, ash and vegetation. This report will briefly describe UAV-based surveys and the derived data products.

1 https://www.ndr.de/nachrichten/niedersachsen/braunschweig_harz_goettingen/Waldbrand-im-Harz-Polizei-geht-von-Brandstiftung-aus,waldbrand882.html (20.10.2023)

Figure 1: Quesenbank site on 13 Oct 2022.

2 Methods

The following UAVs were employed:

- DJI M300 with D-RTK station and multispectral camera Micasense Altum
  - 5 bands visible - near-infrared, 1 thermal band
- DJI Mavic 2 Enterprise Advanced RTK with RGB/thermal camera
  - parallel acquisition of high-resolution RGB and 1 low-resolution thermal band

We deployed 5 targets as ground control points (GCPs). Locations were determined with a GNSS-RTK (Topcon Hyper V). The altitude of the GCPs was derived from the DGM2 by LVermGeo, Saxony-Anhalt.
Survey data was processed using Agisoft Metashape and its standardized photogrammetric structure-from-motion algorithms to create the basic image products:

- Dense points clouds
- Digital surface models (DSM)
- RGB orthomosaics
- calibrated reflectance orthomosaics
- uncalibrated thermal orthomosaics

Derived image products:

- Canopy height model (CHM)
- Digital elevation models (DEM)
- Burnt area index (BAI)
- Normalized difference vegetation index (NDVI)
- Single tree crown polygons
- Burnt area polygon (manual mapping)

Table 1: Flight and image acquisition parameters.

Parameter	**DJI Mavic 2 Enterprise Advanced**	**DJI M300 D-RTK**
Weather	overcast, changing light condition, 15 °C, wind speed 4-6 m/s	
Flight altitude above ground (m)	80	65, 70, 80, 100
Flight time	12:35-13:26	?
Image overlap forward/side (%/%)	90/90	85/85, 80/80
No. flights	3	7
Survey area (ha max.)	4.1	7.9
Sensor resolution (image/thermal in Mpixel)	48/0.3	3.2/0.2
Image resolution orthomosaic (cm)	1.2	3.6-5.8
Image resolution thermal orthomosaic (cm)	9.7	40-50
DEM resolution (cm)	25.8	7.2-11.6

3 Results

3.1 DJI Mavic 2 Enterprise Advanced: Results and maps

The mapping results of the **DJI Mavic 2 Enterprise Advanced** are displayed on the following pages. The flight was performed within the blue polygon shown in **Fig. RGB1**. Due to the required safety distance to railroad lines, it was not possible to fly further down the slope, meaning the flight area does not touch the railroad. Outside the flight area, image distortions occur in the orthophoto, so that the generated products were cropped to the flight area (e.g., **Fig. RGB2**).
Mapping of the burnt area was nevertheless possible outside, albeit with some uncertainty. Based on the high-resolution RGB orthophoto, a burnt area polygon (red polygon, **Fig. RGB1**) was delineated manually. The burnt area is available as a shapefile and covers approximately 1.6 ha. Note that its shape is similar to the spectral-index based visualization using the BAI from the multispectral data of the **DJI M300 RTK**.

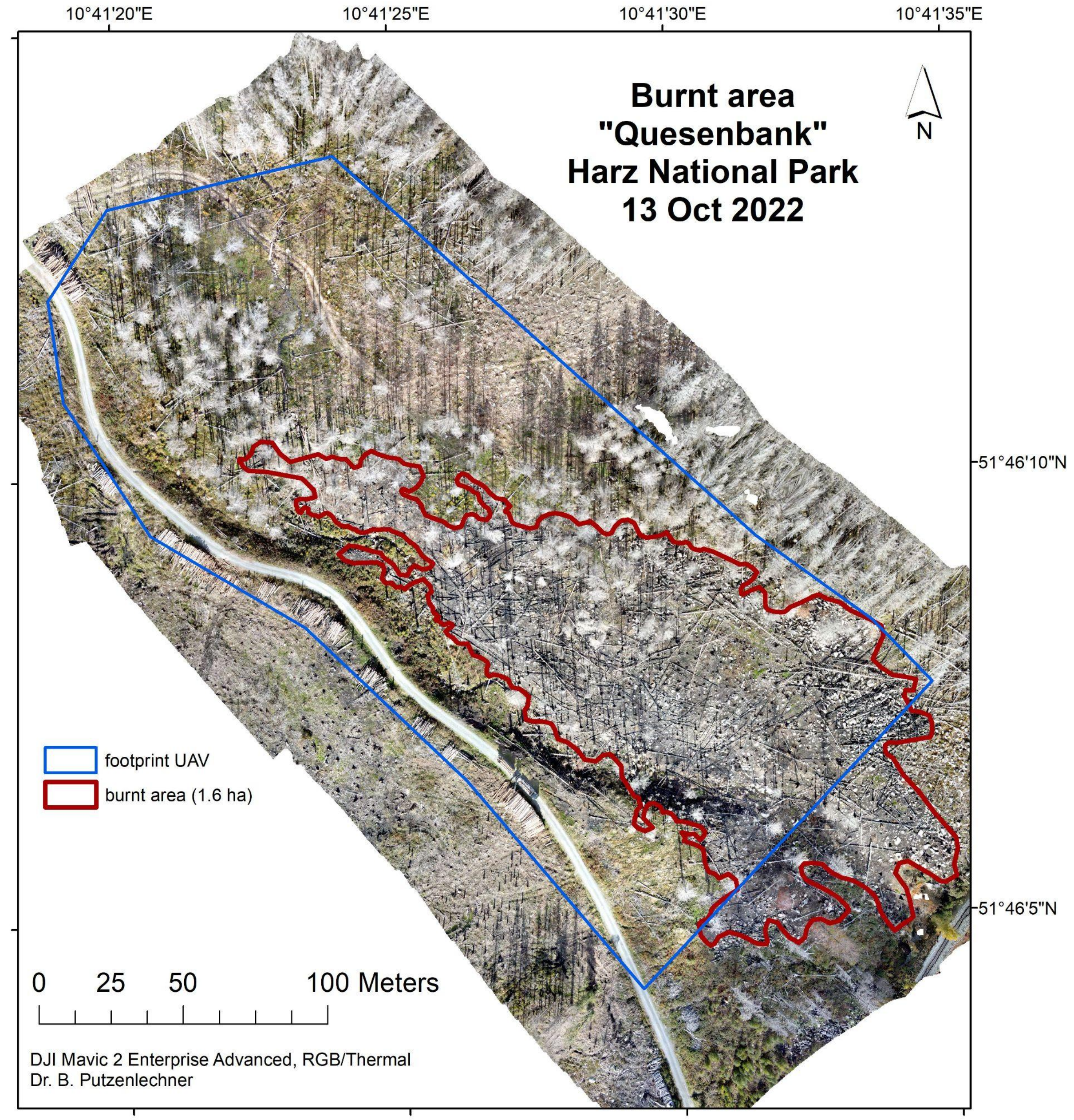

Figure RGB. Manually mapped burnt area.

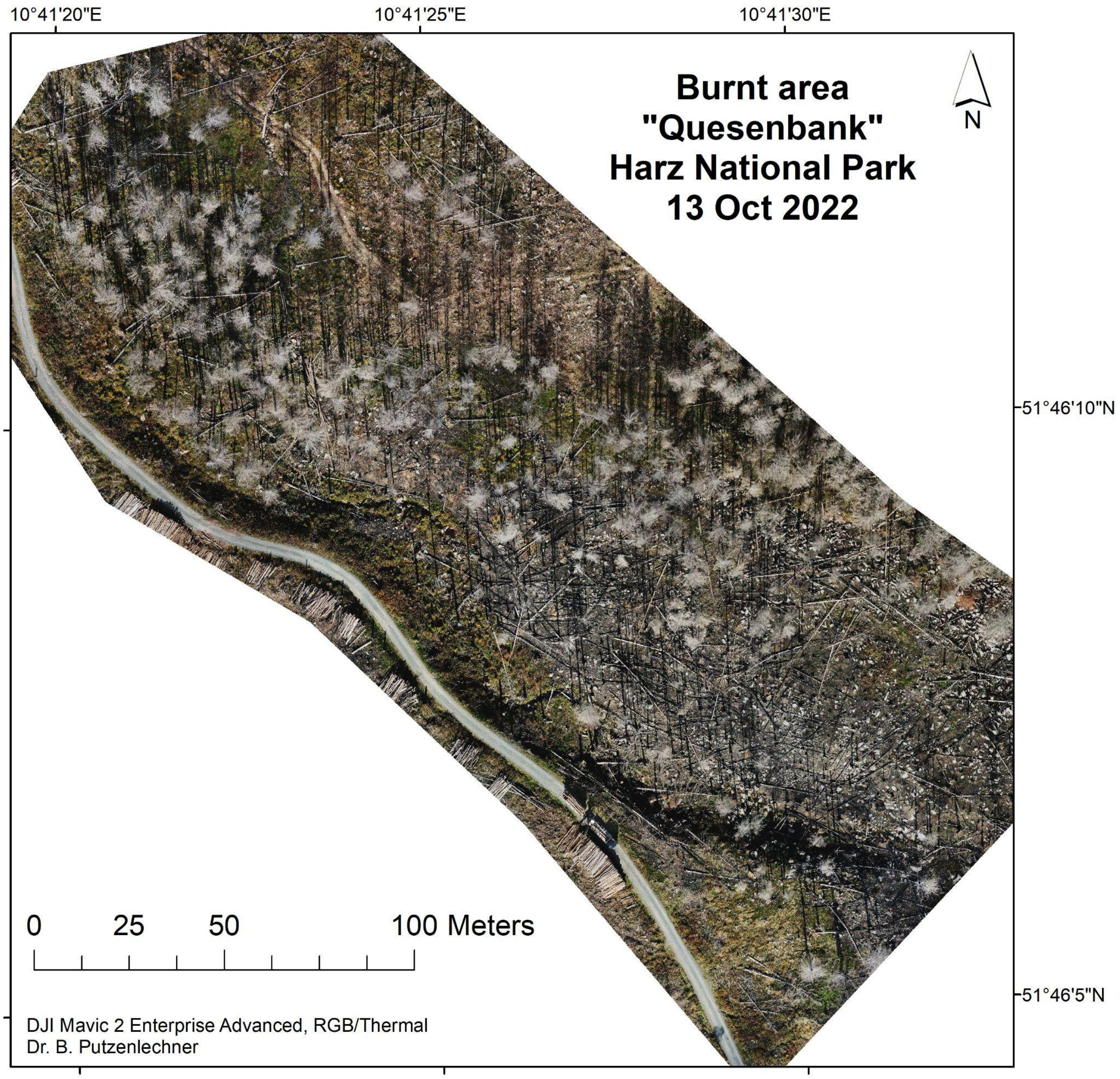

Figure RGB2. Processed orthomosaic.

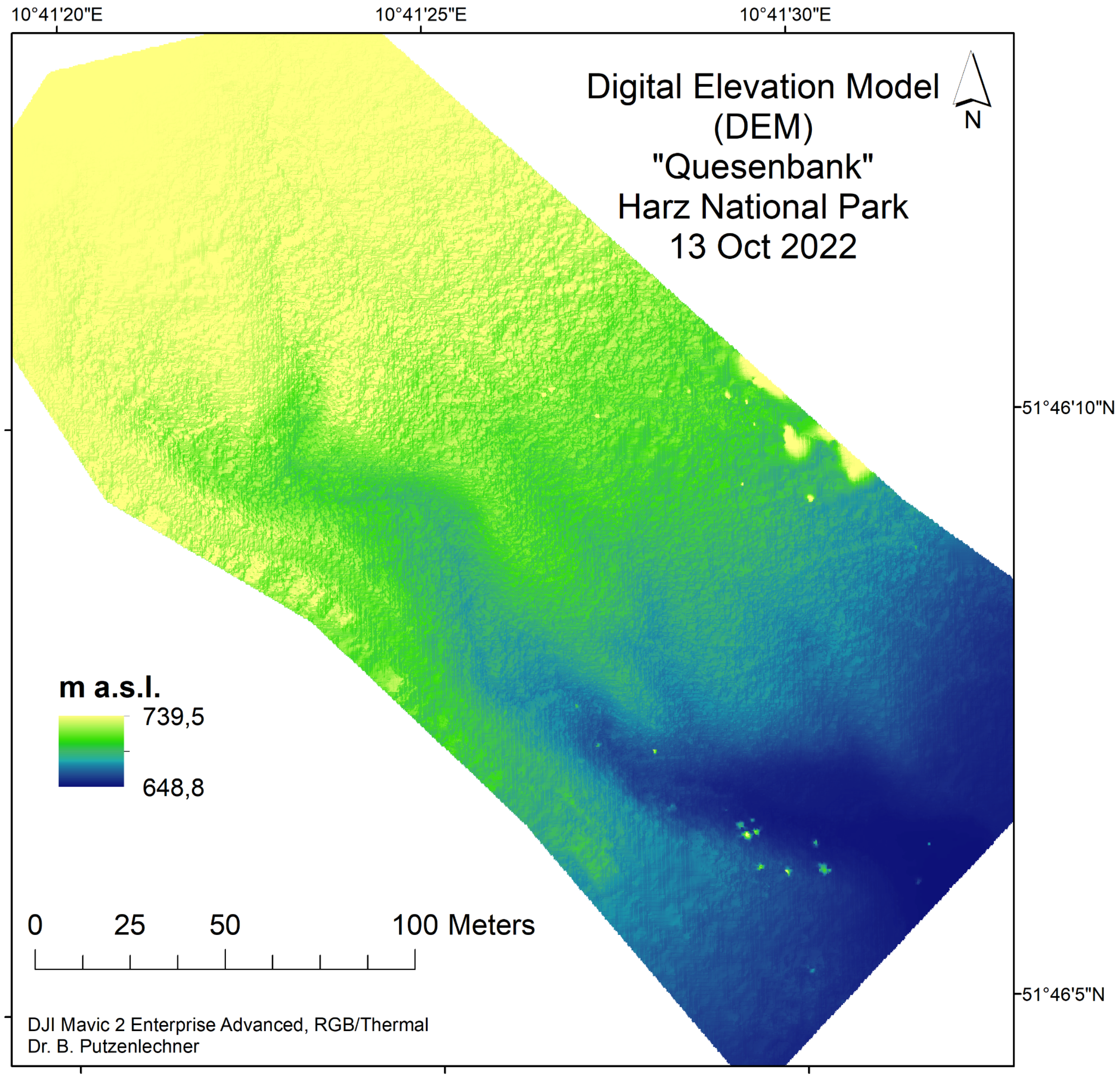

Figure DEM1. The digital elevation model is shown with a hill-shaded background of the same model.

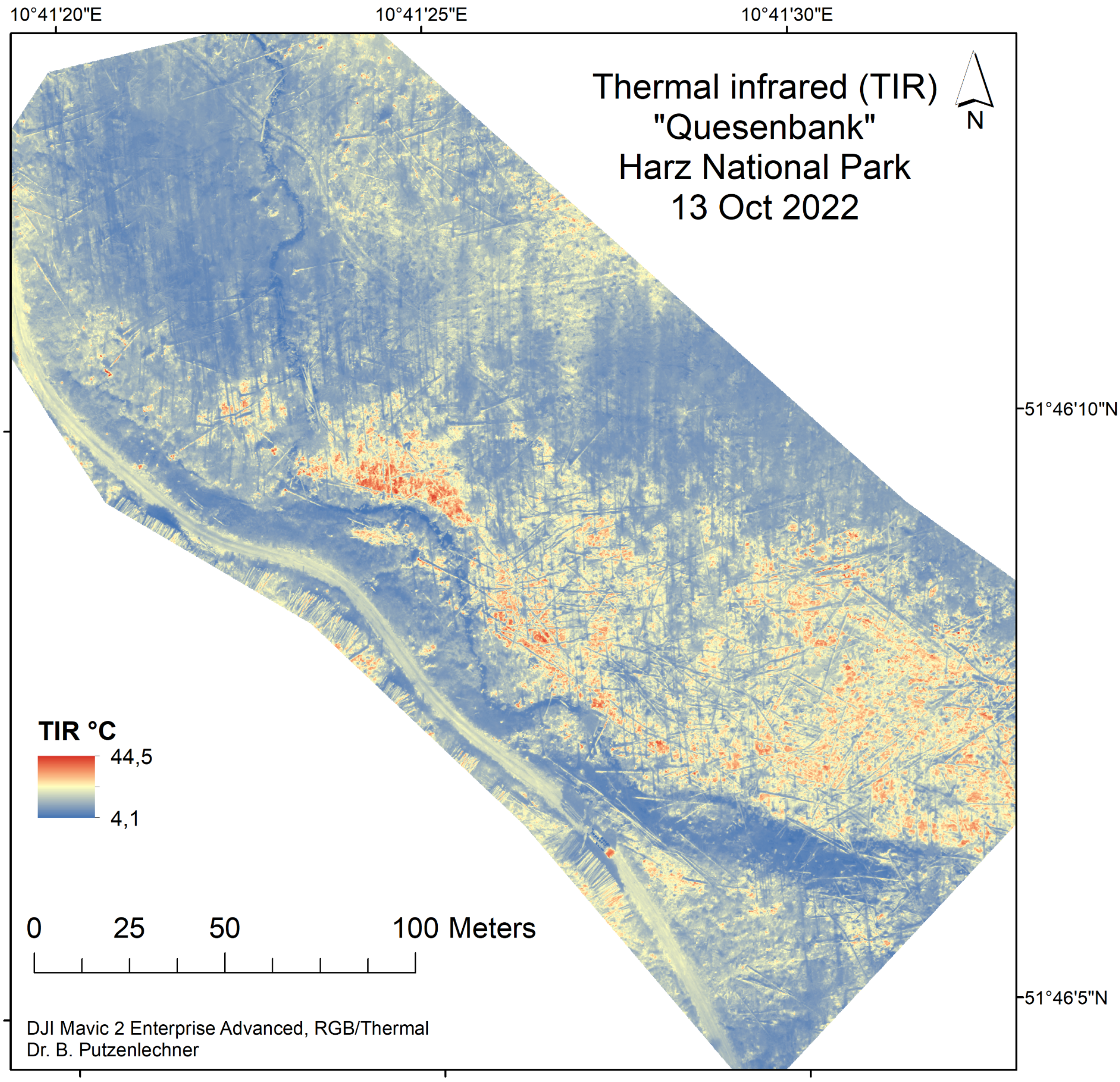

Figure TIR. Uncalibrated thermal mosaic based on conversion of R-JPEG data to one-channel TIF based on an R-Script[2] (by T. Kattenborn) that calls DJI Thermal SDK software[3] to derive temperature values in °C (parameters: altitude > 25 m, emissivity = 0.96, humidity = 70%) and includes the Exiftool[4].

3.2 DJI M300 D-RTK: Results and maps

In the following we show the created image products from the UAV **DJI M300 multispectral** flight conducted at 100 m above ground level.

[2] https://github.com/tejakattenborn/dji_h20t_rpeg_to_tif (20.10.2023)
[3] https://www.dji.com/de/downloads/softwares/dji-thermal-sdk (20.10.2023)
[4] https://exiftool.org/

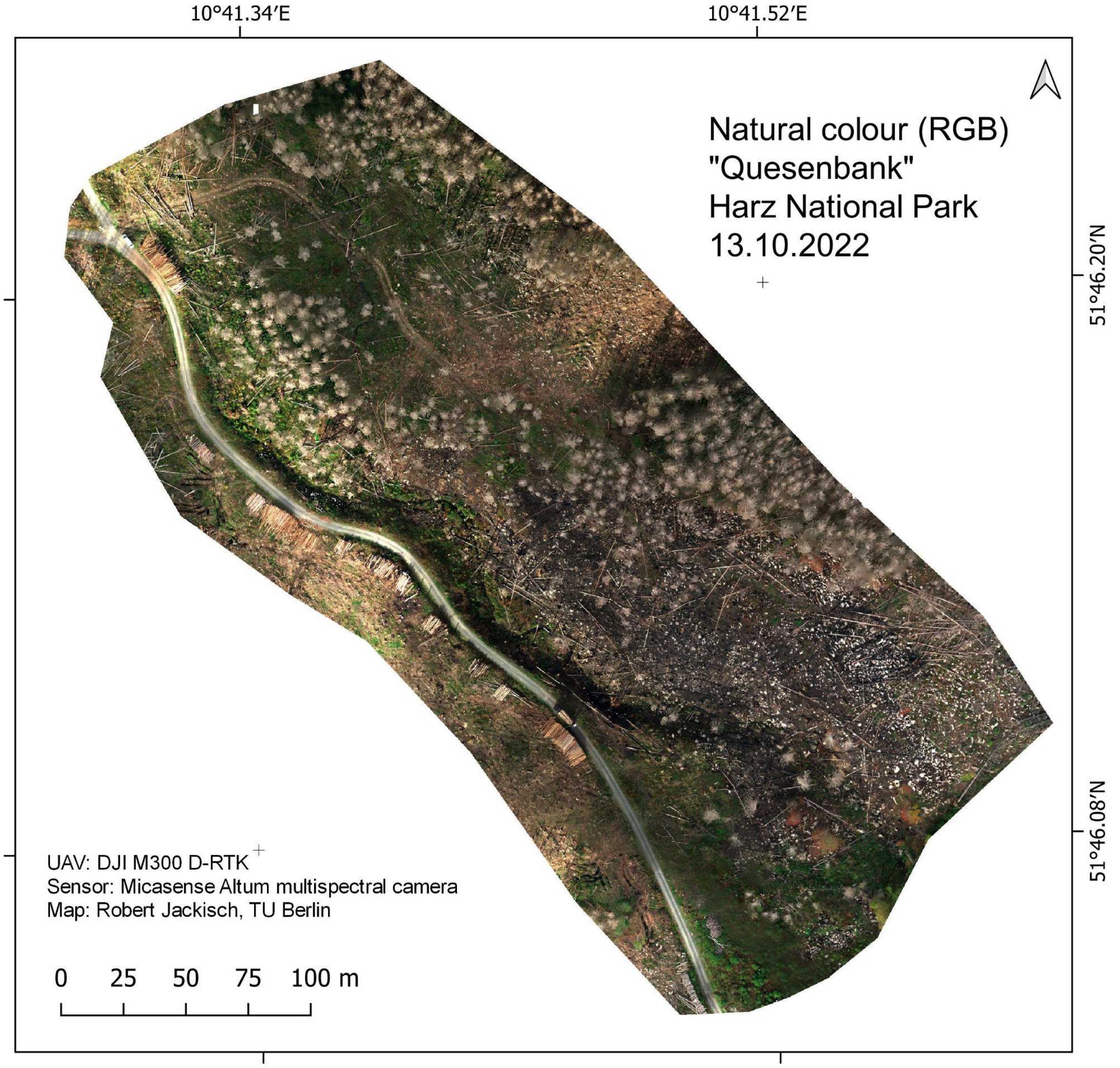

Figure RGB3. Standard red-green-blue (RGB) channel orthomosaic at 5.8 cm pixel resolution.

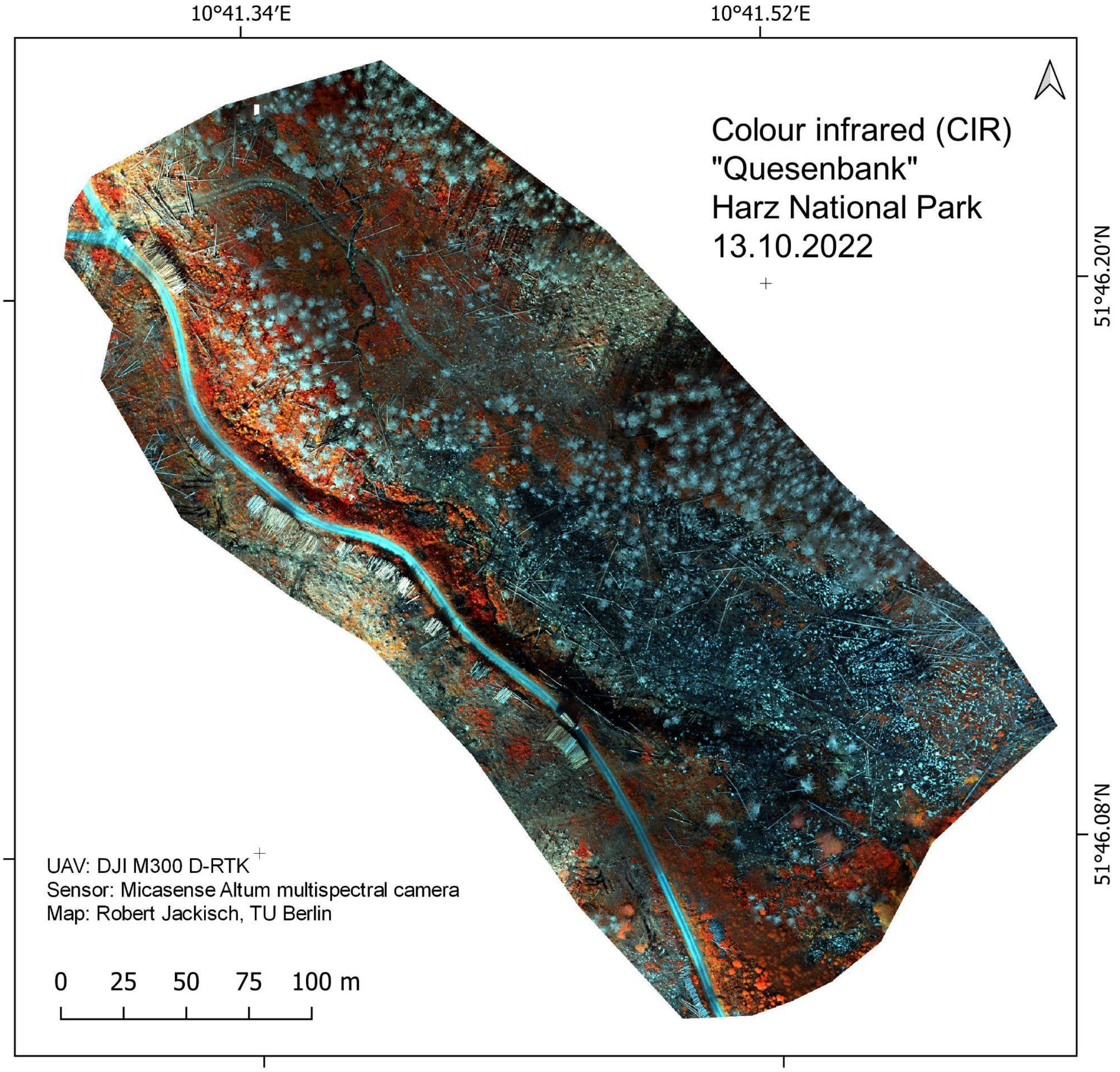

Figure CIR. The color-infrared uses the MicaSense Altum camera band 5 (near-infrared) instead of the red band.

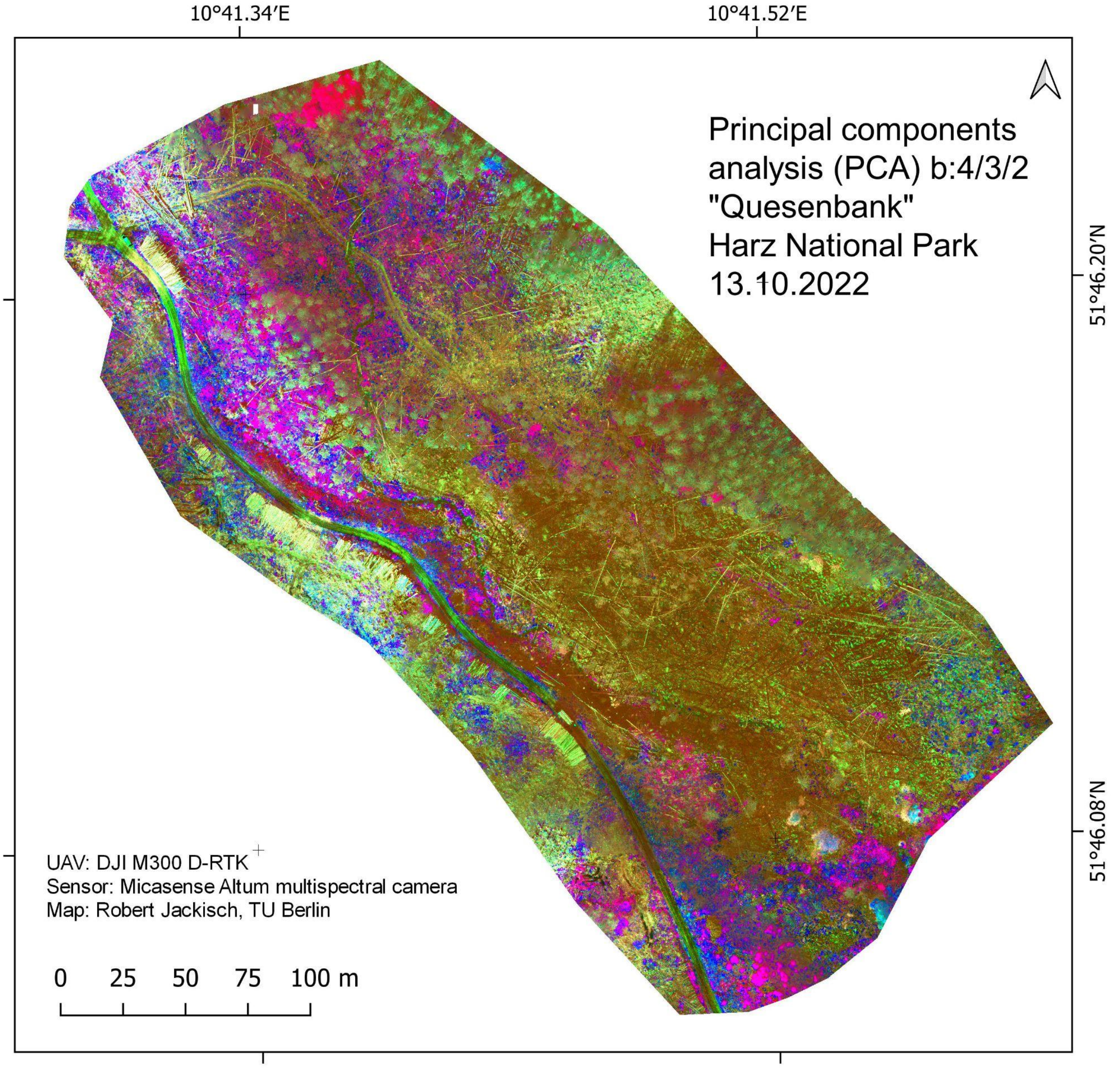

Figure PCA. The PCA with sorted bands (4,3,2) highlights areas of spectral diversity and noise, e.g. changing light conditions.

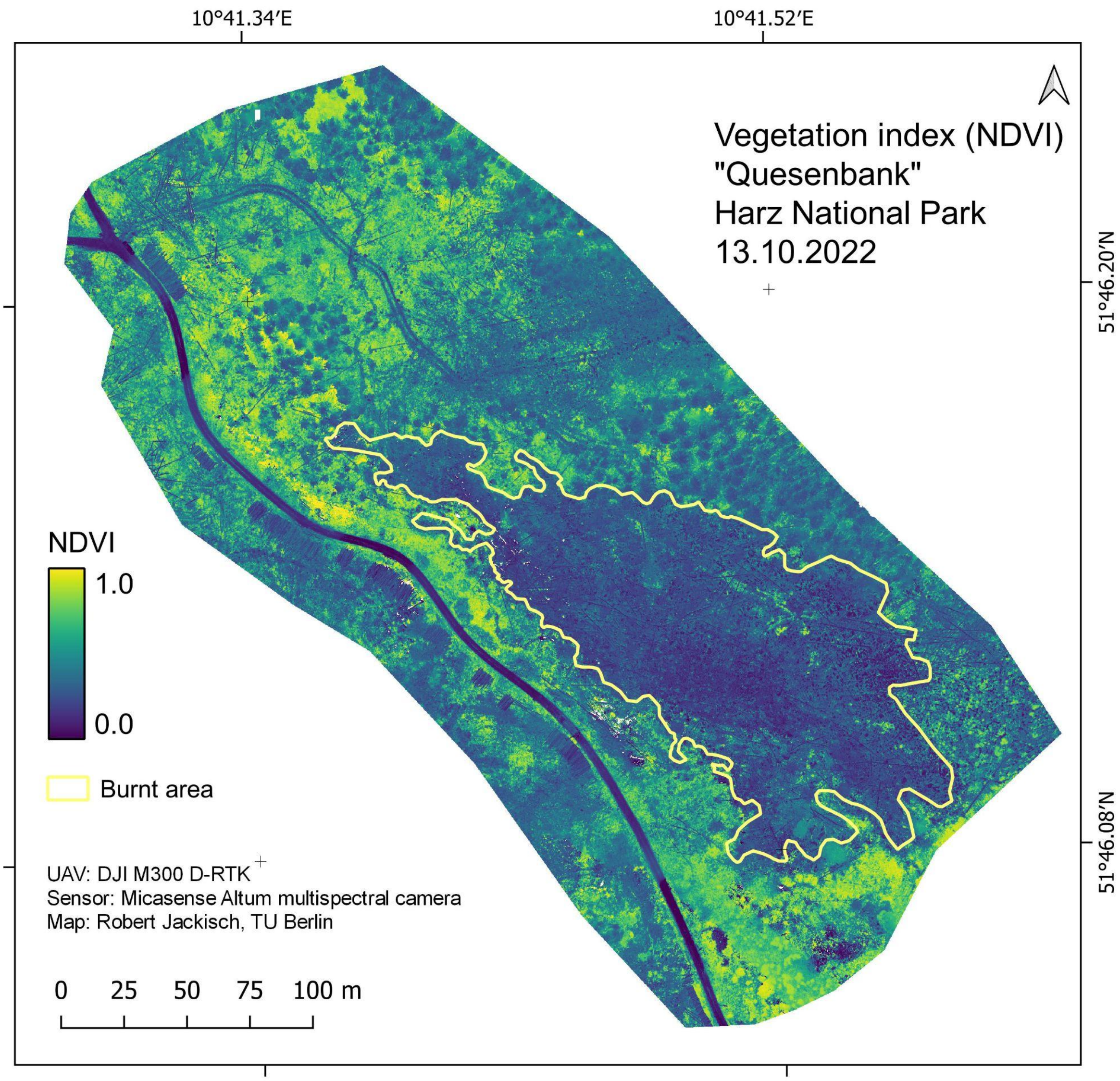

Figure NDVI. NDVI map, a low-value zone fits with the delineated burnt area.

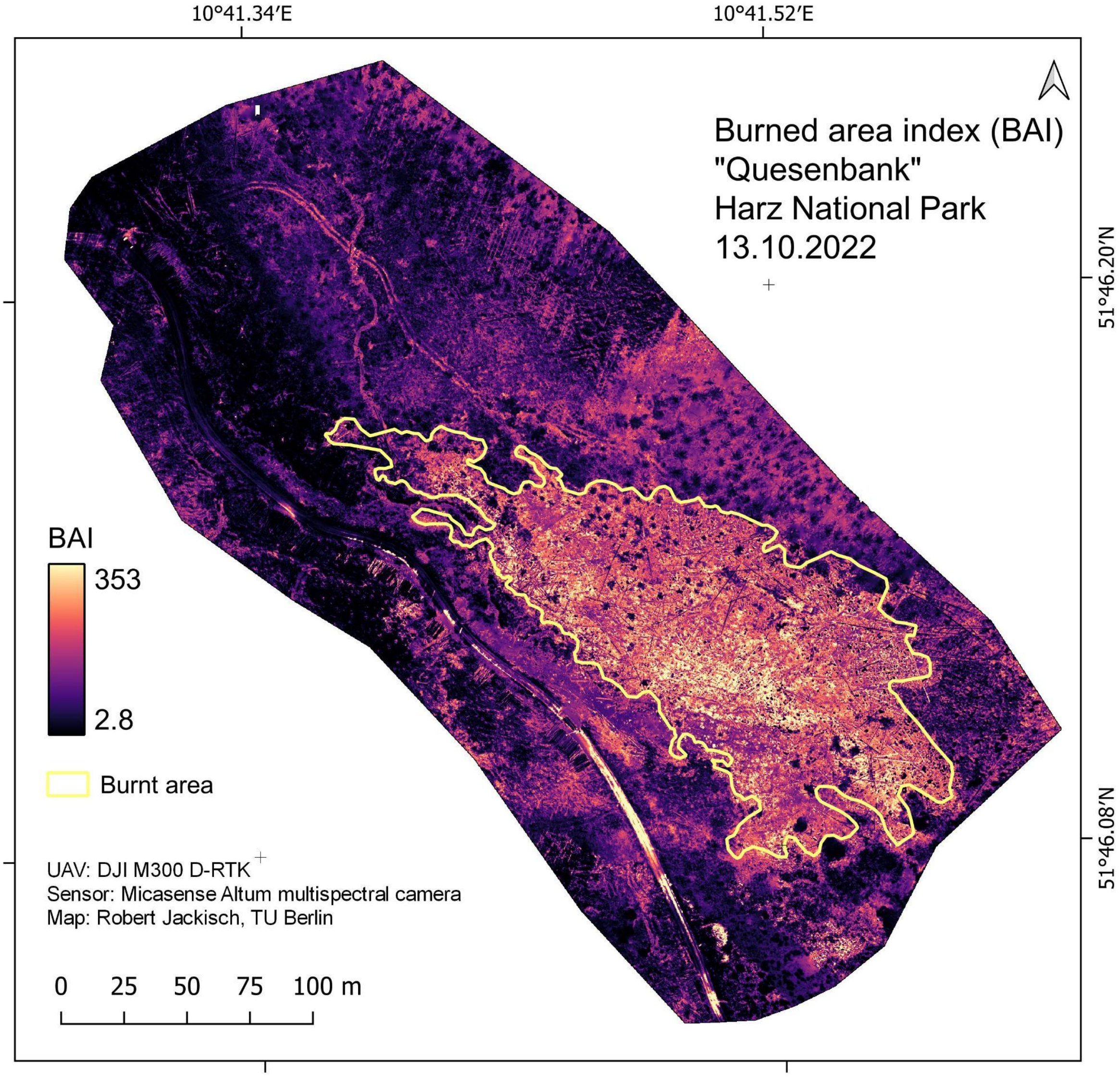

Figure BAI. Index calculated using the formula after Harris Geospatial and references within, (Burn Indices Background[5], 20.01.2023):

$$BAI = \frac{1}{(0.1 - Red)^2 + (0.06 - NIR)^2} \tag{1}$$

This works surprisingly well for this scene, as seen above, the manually delineated burnt area polygon fits well with the high BAI area in the south-eastern area.

[5] https://www.l3harrisgeospatial.com/docs/backgroundburnindices.html#Burn (20.10.2023)

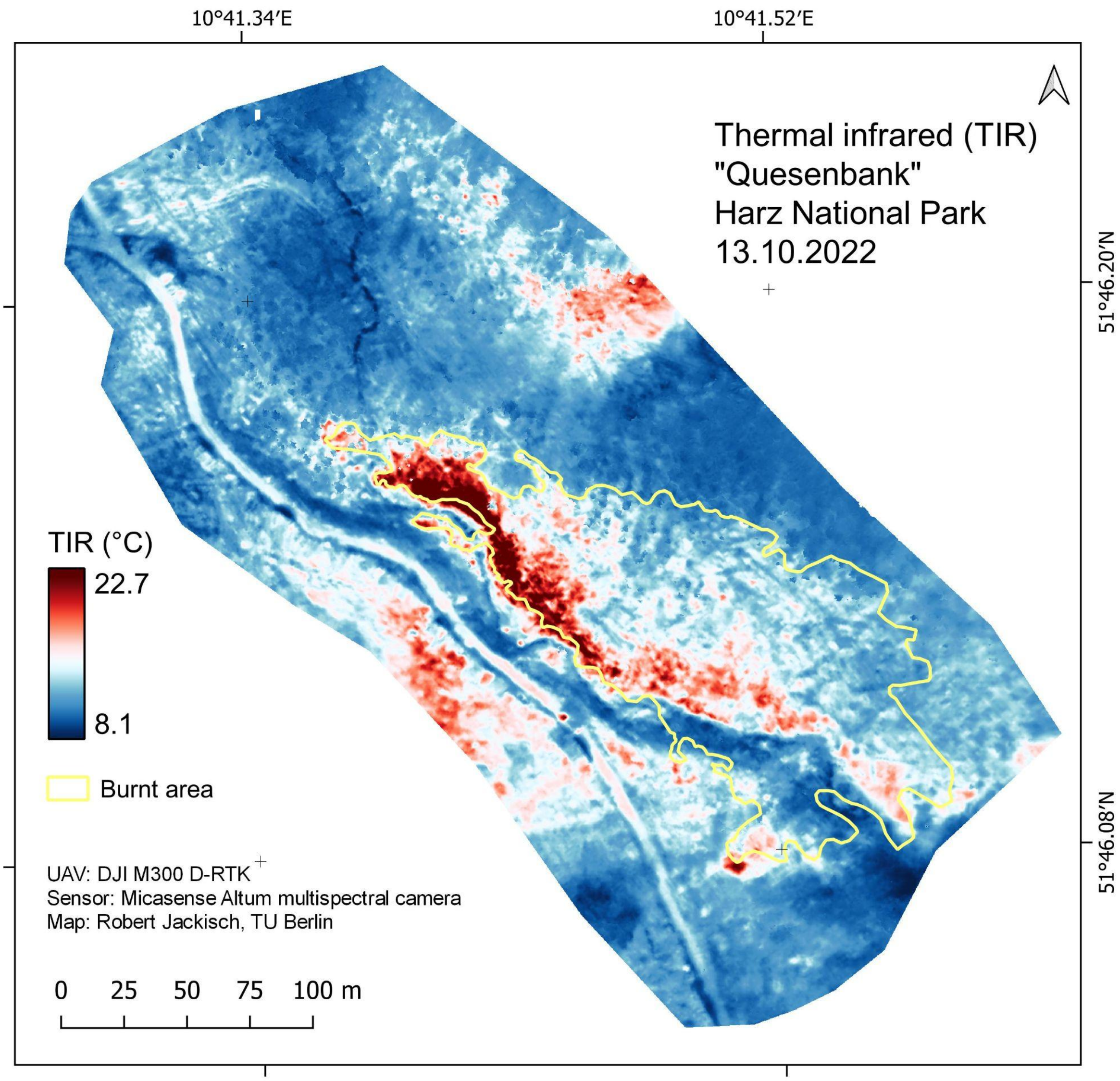

Figure TIR2: The thermal mosaic is an uncalibrated image mosaic using the Altum-camera specific empirical formula[6] (b6 / 100) - 275.1 K for °C.

[6] https://knowledge.wingtra.com/en/process-altum-images-with-metashape (20.10.2023)

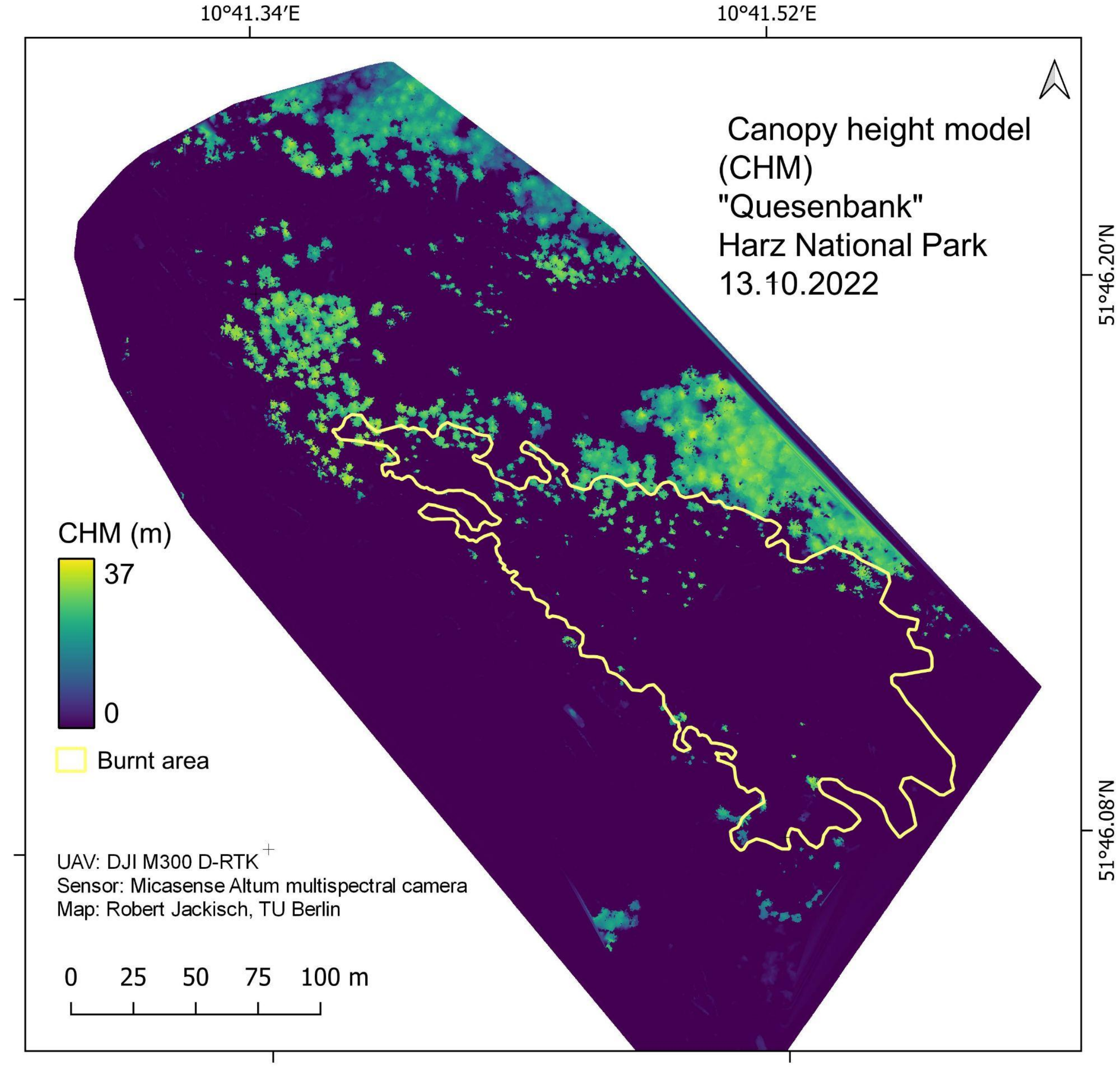

Figure CHM: The SfM-point cloud-based canopy height model, calculated using the R package lidR[7] and its in-built functions, at a pixel resolution of 10 cm.

[7] https://github.com/r-lidar/lidR (20.10.2023)

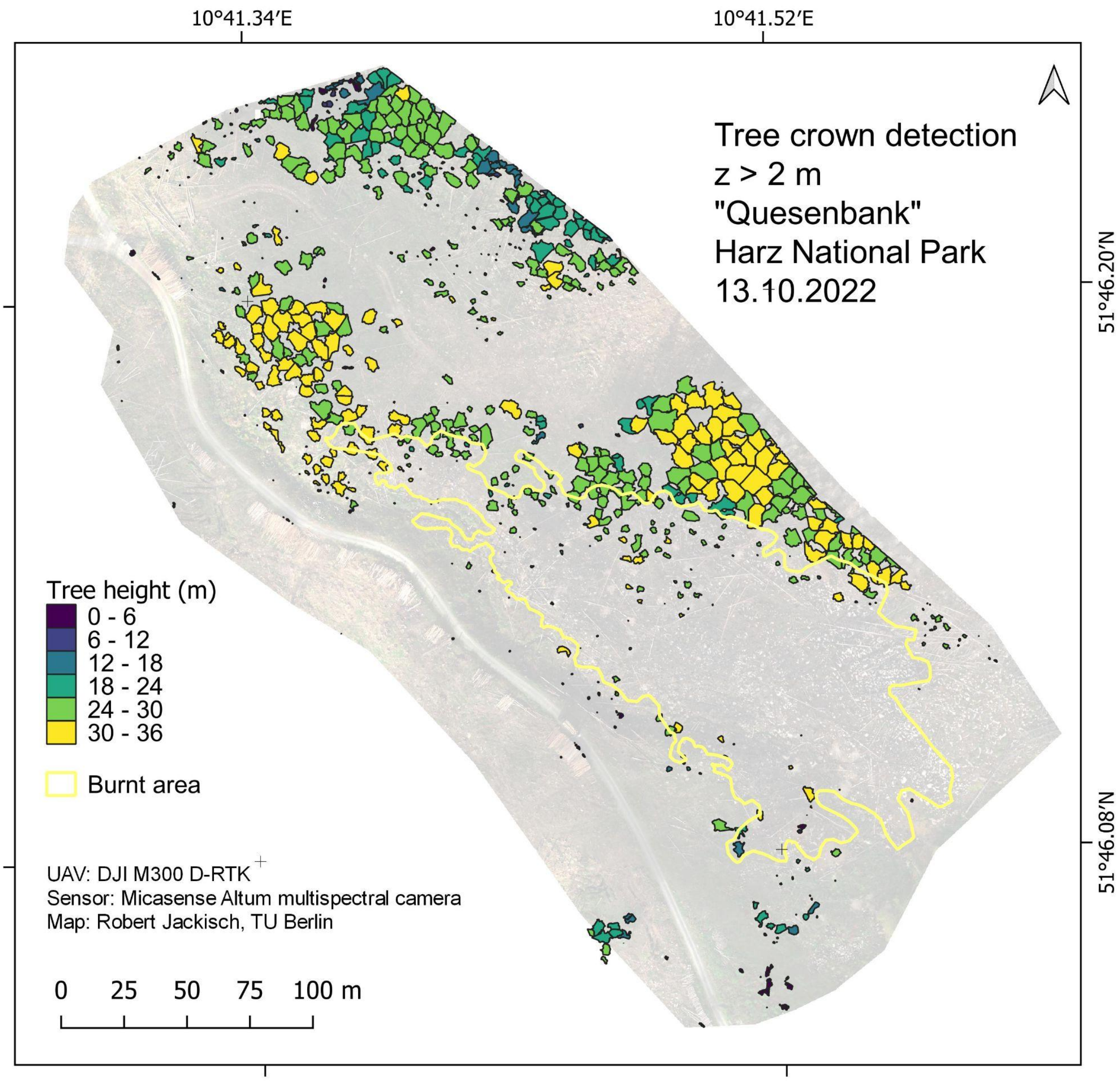

Figure tree crowns: Tree crowns of individual trees above 2 m height derived from the CHM and within lidR, using the algorithm Dalponte2016[8] for individual tree canopy segmentation.

[8] https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12575 (20.10.2023)

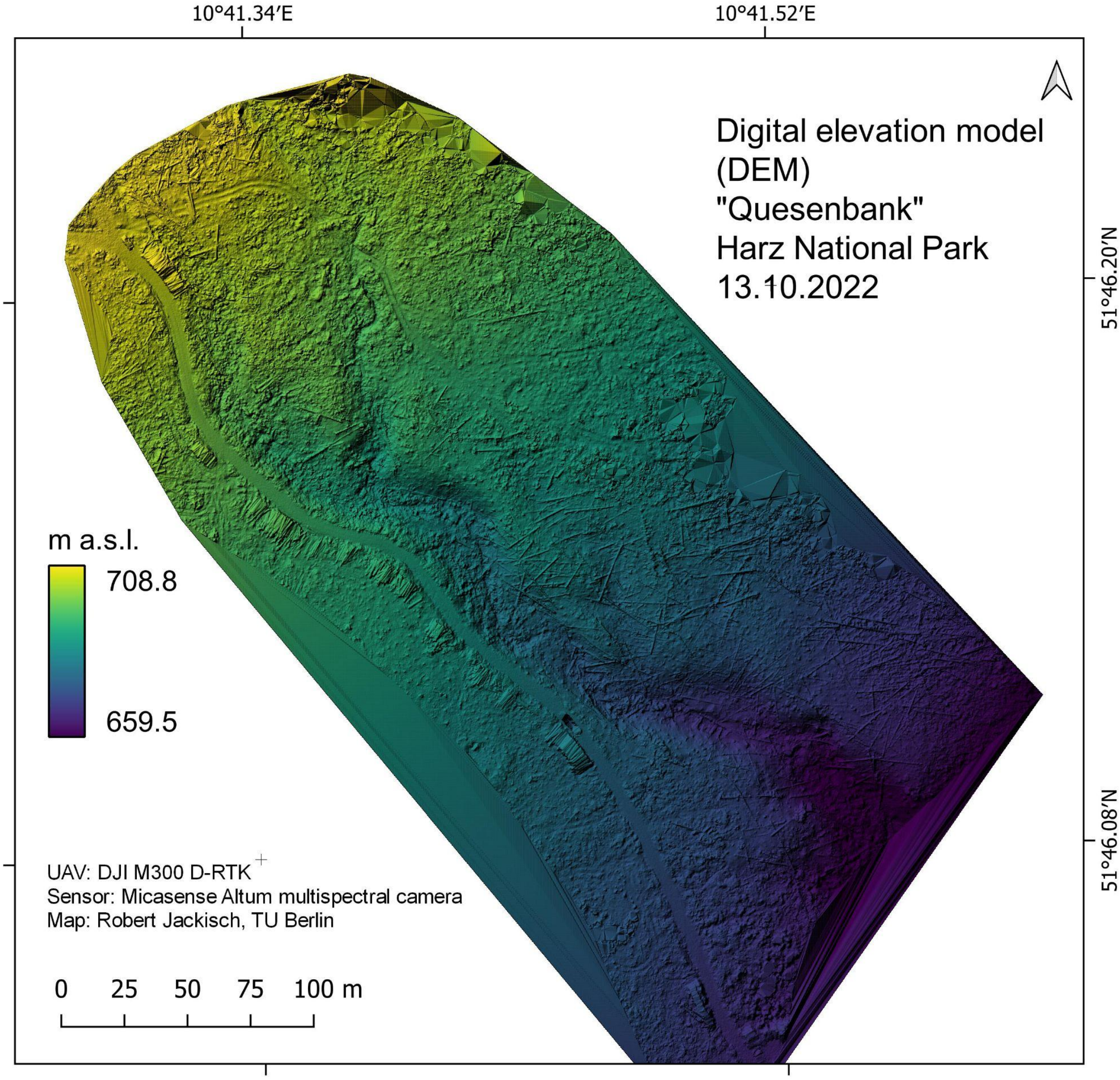

Figure DEM2: The digital elevation model is shown with a hill-shaded background of the same model.

Potential use cases of the data: stream flow delineation, microtopography, watersheds, erosion estimation, change detection, image classifications supervised/unsupervised, fuel mapping and accumulation, tree stems and deadwood counting, among others.

Acknowledgements

Projekt ”Postfeuerdynamik auf Brandflächen im Nationalpark Harz”
Prof. Dr. Elisabeth Dietze, Georg-August Universität Göttingen
Dr. Simon Drollinger, Georg-August Universität Göttingen
Marlene Düngelhoef, Nationalparkverwaltung Harz
Thomas Glinka, Nationalparkverwaltung Harz