# Eifel Flood 2021 – Airborne Laser Scanning (ALS) and Orthophoto Data
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## 1. Licence



## 2. Citation

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## 3. Abstract

The GFZ Potsdam HART (Hazard and Risk Team) in cooperation with the DFG research training group 2043 NatRiskChange at Potsdam University has enabled the acquisition of Airborne Laser Scanning (ALS) and high-resolution optical data which were acquired between 22 September 2021 and 24 October 2021 by the Milan Geoservice company, Spremberg, Germany. This data acquisition took place in the Eifel regions of North Rhine-Westphalia (NRW) and Rhineland-Palatinate (RLP), which were hit by the 14 July 2021 precipitation event leading to widespread severe inundations, flash floods and caused around 185 victims and massive damage to settlements, river geometry and other geomorphic features. The high-resolution ALS and optical data acquisitions aimed at the documentation and quantification of the extent of flood related changes and destructions as well as their reappraisal before diffusion erases traces. Thus, the generated data are valuable for forensic event analysis and future attempts on flood forecasting and warning in the context of scientific and practical purposes.

**Coordinates:**

| | |
|---|---|
| **center:** | 50.4325 N, 6.8114 E |
| **NW:** | 50.5164 N, 6.37195 E |
| **NE:** | 50.7155 N, 7.2105 E |
| **SE:** | 50.5278 N, 7.3121 E |
| **SW:** | 50.1868 N, 6.4392 E |

**Keywords:** Airborne Laser Scanning, ALS, Orthophoto, Eifel Flood 2021, Disaster mapping

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## 4. Introduction

Intense and persistent rain storms can cause rapidly developing floods, which pose a danger to society illustrated by the summer 2021 flood events in the West of Germany. Floods impose their hazard through several pathways and cannot be predicted by hydrological models alone: rapid inundation of depressions, floodplains and valley floors through blockages of bridges, overspill and failure of reservoir dams, erosive undercutting of buildings and infrastructure (e.g., roads, bridge pillars), activation of gravitational mass wasting processes in saturated hillslopes and river banks as well as massive mobilisation and subsequent deposition of sediment and debris (Dietze et al., 2022). Even after such complex floods, the deteriorated landscape is prone to non-linear dynamics due to reorganised channel and hydraulic properties and undercut hillslope sections (e.g., Lenzi, 2004).

The 14 July 2021 precipitation event that hit the Eifel region of North Rhine-Westphalia (NRW) and Rhineland-Palatinate (RLP) highlighted these general effects in a sadly effective way. The 400-year return period precipitation (Kreienkamp et al., 2021; Junghänel et al., 2021) caused severe and sudden surface runoff in some, but not all of the affected catchments, but specifically in the Ahr and the Erft river systems (Apel et al., 2022, Vorogushyn et al., 2022). The former catchment experienced a devastating situation by the flash flood-like event that moved through the comparably steeply sloped valley, with several settlements inundated and eroded, causing 135 fatalities (+1 still missing) in the valley and massive damage to settlements and infrastructure, also reflected by the governmental relief fund amounting to 30 billion €.

While evidently the chain of warning, mitigation and rescue was far from optimal, efforts have been undertaken right away to improve these shortcomings. Actions include optimised flood forecasting, rethinking of warning strategies, optimisation of hazard and risk management strategies, and further structural flood protection measures (Thieken et al., 2023). Airborne data collections took place immediately after the flood, but only being focussed on populated areas and limited to optical sensors with the exception of one LiDAR survey of the lower Ahr valley bottom with no further flights planned until the end of the year 2021 (D. Schürer LVermGeo RLP pers. comm., M. Huppertz, LVerm NRW pers. comm.). Likewise, state authorities have noticed the immediate need to collect additional unconventional data about maximum flood extents (e.g., public call for flood marks). However, again only the populated places were in the focus of interest. In summary, initially all efforts were focused on damage assessment and compensation, while there is also a big need for deciphering the reasons for the damage, explicitly through hydrological and geomorphic processes (Badoux et al., 2014).

Against this background, there has been a growing need for robust base data to effectively understand the evolution of events and damage processes. For this purpose, the GFZ Potsdam HART (Hazard and Risk Team) in cooperation with the DFG research training group 2043 NatRiskChange at Potsdam University had enabled the acquisition of Airborne Laser Scanning (ALS) and high-resolution optical data in the affected regions in order to document the resulting changes and damage, before restoration efforts, subsequent flood events and landscape re-organisation have overprinted the traces of the immediate flood effects. The acquired data can be used by a wide range of stakeholders including scientists, civil servants, and planning authorities. This report describes the technical details of the acquired data.

## 5. Data Acquisition

All the parameters mentioned in this report were taken from the data itself and from the documentation of the commercial data provider (MILAN Geoservice GmbH; Doku_2021-09_GFZ.pdf). The delivered data sets were superficially screened for their general consistency and quality.

The aerial survey of the project area was planned with 216 lines (see Fig. 1). The scanner and the strip coverage were parameterized to achieve a point density of more than 20 points/m². They took place between 22 September 2021 and 24 October 2021 in twelve sessions with a RIEGL-Scanner LMS-VQ780i and a Hasselblad H50 camera. The system was installed in an aircraft of the type Piper PA34. The required scan angle of ±30° was considered for the planning and analysis of the data.

Acquisition time: between 22 September 2021 and 24 October 2021
Sensors: RIEGL-Scanner LMS-VQ780i and Hasselblad H50 camera

*Table 1: Airborne Laser Scanner-Parametrization LMS-VQ780i*

| | | |
|---|---|---|
| Input parameters | Laser beam divergence | 0.25 mrad |
| | Pulse repetition rate | 205 lines per second |
| | Scan frequency | 1000 KHz |
| | Flight altitude above ground | 1000 m |
| | Scan angle (both sides) | ±30° |
| | Flight strip spacing | 350 m |
| | Flight strip lateral overlap | 70% |
| | Airspeed | 130 Knots (240 km/ |
| Resulting values in Single strip | Average point spacing | 0.38 m |
| | Profile distance | 0.33 m |
| | Spot diameter | 0.25 m |
| | Strip width | 1154 m |
| | Point density in single stripe | ≥ 8 Points /m² |
| | Point density with overlap | ≥ 27 Points /m² |

*Table 2: Camera parameterization Hasselblad H50*

| | | |
|---|---|---|
| Input parameters | Focal length of the lens | *35 mm* |
| | Permissible image blur | *1 Pixel* |
| | Sensor orientation | *Across* |
| | Image overlap in flight direction | *60 %* |
| | Flight altitude above ground | *1000 m* |
| | Airspeed | *130 Knots* |
| Resulting values | Ground resolution | *0.017 m* |
| | Comparable film image scale (scanned at 20µm) | *1: 8380* |
| | Width of camera (across flight direction) | *1370 m* |
| | Length of camera (in flight direction) | *1028 m* |
| | Area | *1408148 m²* |
| | Shutter speed | *1/ 400 sek* |
| | Exposure interval | *6.1 sek* |

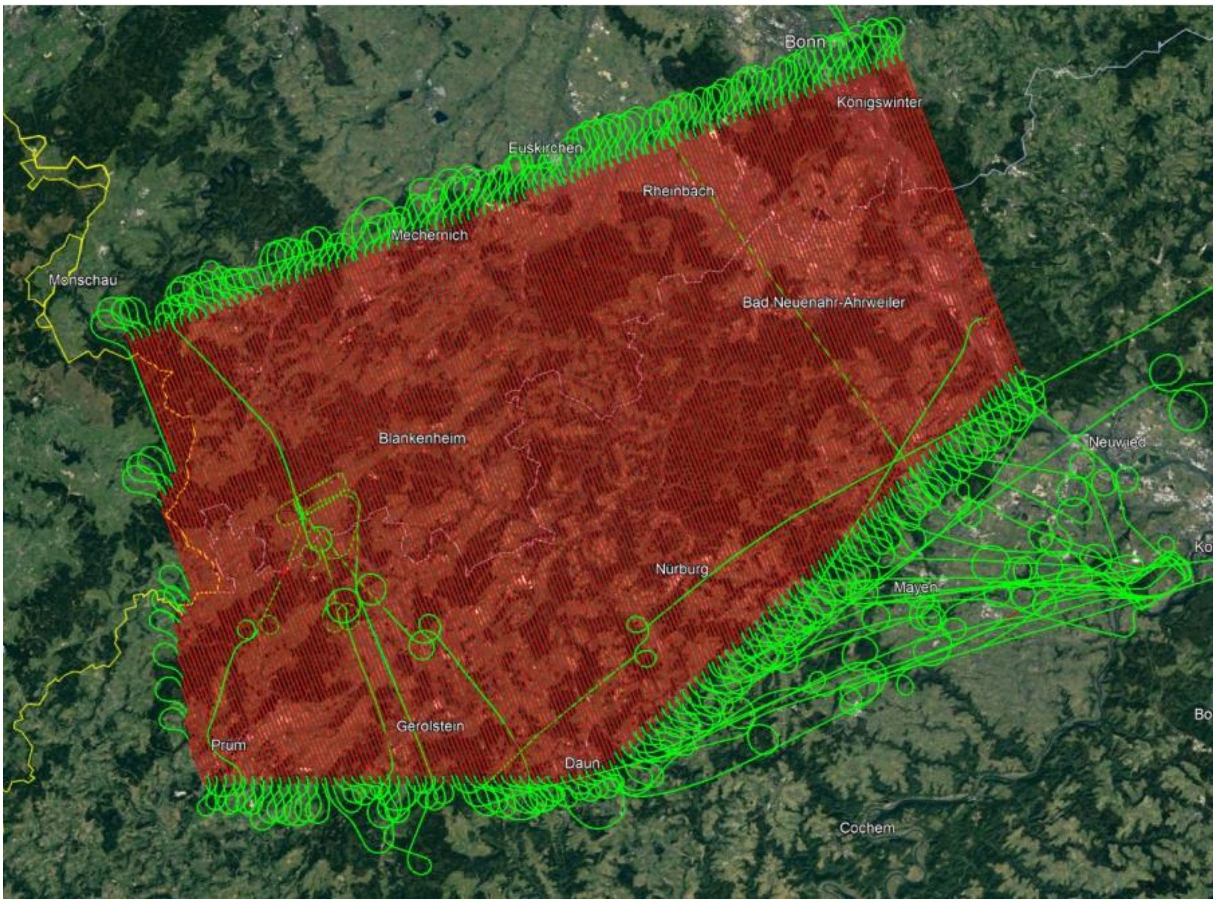


*Figure 1: Area overview based on GoogleEarth overlaid by flight paths. Centre coordinate: 50.4325N, 6.8114O*

## 6. Data Processing and Products

The following processing steps regarding the **Airborne Laser Scanning** (ALS) were carried out by the data provider (MILAN Geoservice GmbH):

1. Strip adjustment / pre-processing
2. SAPOS (Satellite Positioning Service) correction data used to optimize the attitude
3. Kinematic GPS (Global Positioning System) and INS (Inertial Navigation System) solutions
4. Raw data analysis and geocoding
5. Georeferencing
6. Track meshing as data federation per session and session transition
7. Quality control of the strip adjustment
8. Classification
    - Completeness
    - Strip differences
    - Point density
    - Verification of absolute position accuracy absolute height accuracy

Detailed information regarding **Georeferencing (5)**:

> After the calculation of the position data with the SAPOS station Koblenz in the system UTM32/ETRS89 with ellipsoidal heights, the laser scanner data were processed and simultaneously transformed into the target coordinate system UTM32/ETRS89 with orthometric heights DHHN2016. In this case, a height transformation had to be performed. This was done with the geoid model GCG2016 of the Federal Agency for Cartography and Geodesy (BKG). In this process, the undulation values between the ellipsoidal heights and the orthometric heights of the geoid model were determined and fed to the data for an aerial height adjustment.

Detailed information regarding **Classification (8)** are summarized in Tab. 3**.**

*Table 3: Class definitions*

| Classes | Description |
|---|---|
| 2 | Soil |
| 3 | Low vegetation up to 1m |
| 4 | Medium vegetation 1m to 5m |
| 5 | High vegetation from 5m |
| 9 | Synthetic water points |

A series of vertically acquired images were combined by photogrammetric analysis to an orthophoto mosaic. The following processing steps regarding the **Orthophoto** generation were carried out by the data provider (MILAN Geoservice GmbH):

- Raw image with radiometric presets
- Generation of automatic tie points between laser data and orthophotos within a TerraPhoto mission
- Calculation of automatic intersection lines (seamlines)
- Manual post-processing (e.g. re-editing of calculated seamlines)
- Color matching of the single images
- Output of the orthophoto mosaic
- Quality control of delivery components for final acceptance

Detailed information of the preprocessing can be found in the documentation (Doku_2021-09_GFZ.pdf).

# 7. File description

## 7.1. File formats

From the classified LiDAR data, orthoimages and by-products, various products were derived. In the following the products are described, which were derived and delivered by the data provider:

LiDAR:

- DSM as *.asc (XYZ) and *.tif / Shaded Relief as *.tif with *.tfw (grid size 0.5 m; tile size 1 km²)
- DTM as *.asc (XYZ) and *.tif / Shaded Relief as *.tif with *.tfw (grid size 0.5 m; tile size 1 km²)
- nDSM as *.tif (grid size 0.5m; tile size 1 km²)
- LAZ point cloud as LAZ file (LAS1.2; tile size 1 km²)

Orthoimage:

- RGB as *.tif with *.tfw (resolution 0.05 m; tile size 1 km²)

## 7.2. Folder structure

The folder structure is arranged congruently with the general LiDAR and Ortho products and file formats:

- GFZ_Eifel
  - DSM (Digital Surface Model)
    - asc
    - tif
  - DTM (Digital Terrain Model)
    - asc
    - tif
  - LAZ (zipped point cloud; multiple returns)
  - nDSM (normalized Digital Surface Model)
    - tif
  - RGB (Orthoimages)

## 7.3. Data content and structure

In order to ensure data homogeneity and interoperability, the specifications of the federal states of North Rhine-Westphalia and Rhineland–Palatinate were used for tiling, naming conventions, and class definitions. The whole area is tilled into 1x1 km tiles congruent to the tiling specifications of the federal states. Every single tile is named following the naming convention:

| | |
|---|---|
| Example file name | **DSM005_2021-09_UTM32_315000_5593000.tif** |
| Product | **DSM**005_2021-09_UTM32_315000_5593000.tif |
| Spatial resolution | DSM**005**_2021-09_UTM32_315000_5593000.tif |
| Acquisition year | DSM005_**2021**-09_UTM32_315000_5593000.tif |
| Acquisition month | DSM005_2021-**09**_UTM32_315000_5593000.tif |
| UTM zone | DSM005_2021-09_**UTM32**_315000_5593000.tif |
| X coordinate upper left corner | DSM005_2021-09_UTM32_**315000**_5593000.tif |
| Y coordinate upper left corner | DSM005_2021-09_UTM32_315000_**5593000**.tif |
| File format | DSM005_2021-09_UTM32_315000_5593000.**tif** |

Thus, the presented ALS and orthoimage aerial survey data can be easily included in, e.g. multitemporal analyses with data existing at the federal state offices from before and after the 2021 floods provided via the respective data portals.

## 8. Data Quality

The data quality was checked by the data provider (point density, strip difference plot, proof of location and height control) and GFZ Potsdam performed systematic spot quality checks. All relevant parameters lie within the commissioned requirements. No abnormalities with regard to the requirements and achieved data quality have been observed.

## 9. Dataset Contact

For additional information, by-products, single flight stripes and specialized preprocessing needs, please contact:

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## 10. Acknowledgements

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