



Beeldmateriaal
Nederland

Actueel Hoogtebestand
Nederland

The missing link: point clouds on request

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Data as a goal



- Data (imagery, elevation models) are a **goal** of our projects
- Data distribution is a/the **means** to facilitate and promote use of the project data
- Both should be 'effective' and 'cost-efficient'

So:

1. Who are our users
2. What are our channels
3. What is point cloud streaming

Focus on airborne LiDAR survey (AHN)



Our users



- Three types of users:
 1. General public
 2. Professionals
 3. Wizards

General public

- Diverse group
- Interested in single application
 - Personal environment, including legal interest
 - Archaeologists
 - ...
- Infrequent visitors
- Mobile, tablet, desktop
 - Diverse platforms, potentially underpowered
- Easily overloaded with information
- Publication is transparency and public support driven



[EO, 2016]

Professionals

- Intended audience
 - Water management
 - Map makers
 - ...
- Experts in their field, not in data (handling)
- IT-Infrastructure often not fit for purpose and/or policies not suitable for data
- **Must** be catered, tailored solutions when necessary

 Office 365



[Riopel, 2024]



Wizards



- R&D, universities, ...
- Have a copy of everything;
own IT-infrastructure (on premise/cloud)
- Never enough, but never complain
- Open data is a gamechanger:
new developments/applications
commercial and public sector

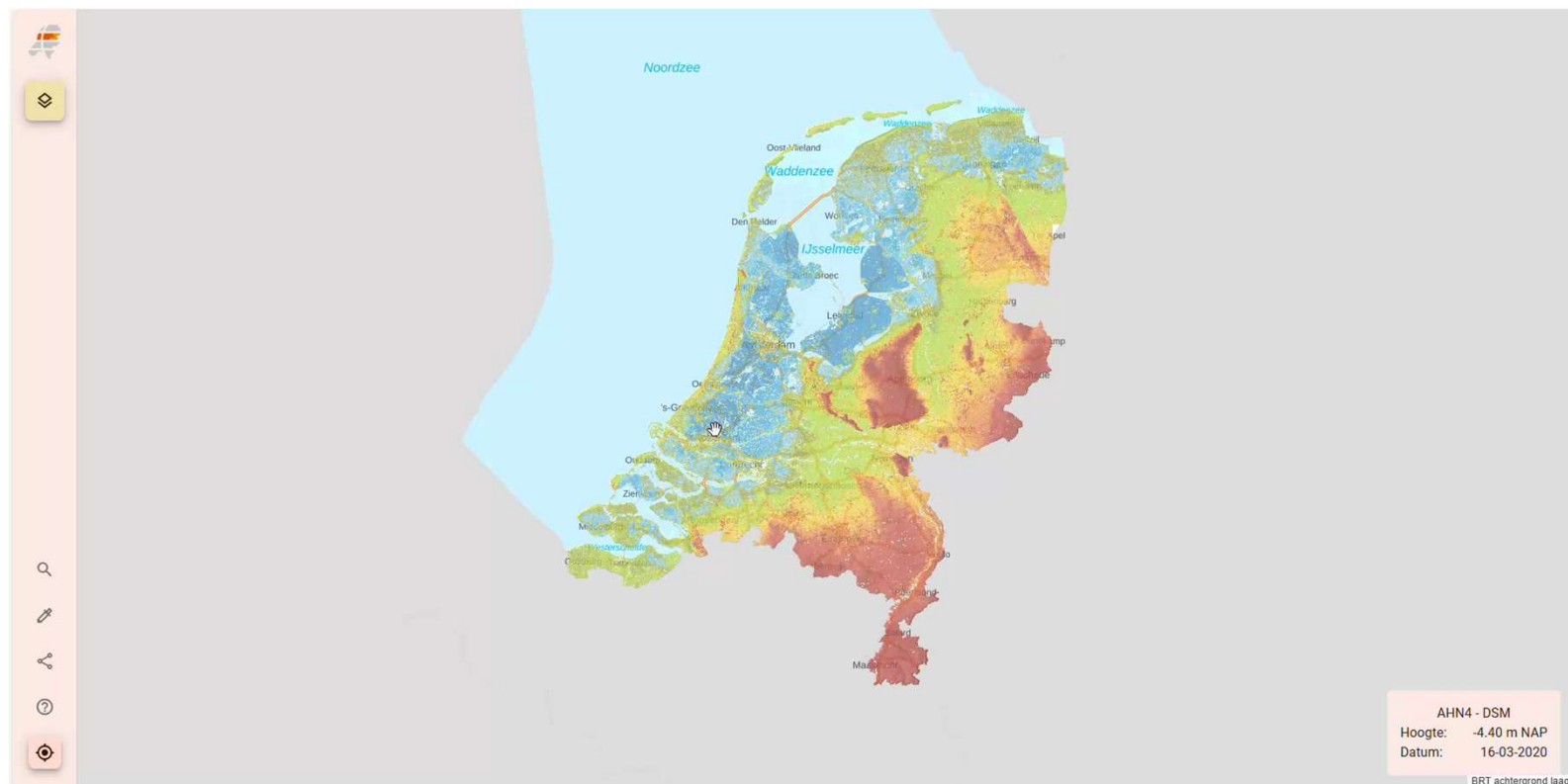
What do they need?

	General public	Professionals	Wizards
Elevation (raster)		 ()	
Elevation (point cloud)	()	 	
Imagery (ortho)		 	
Imagery (stereo)		 ()	
Metadata			

 : View
 : Stream
 : Download

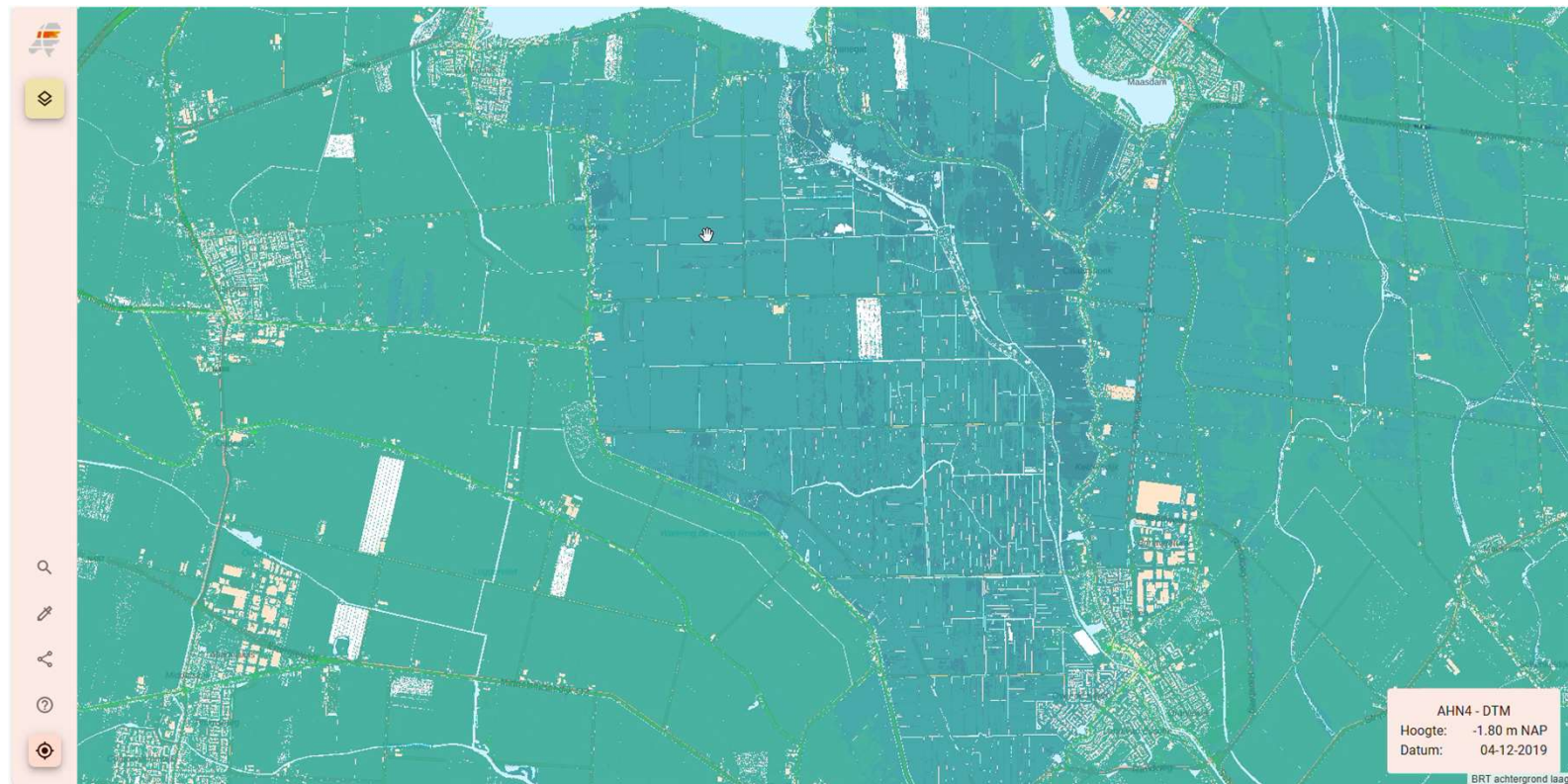
Viewer

- Shows both DSM and DTM raster
- Elevation and acquisition date shown together



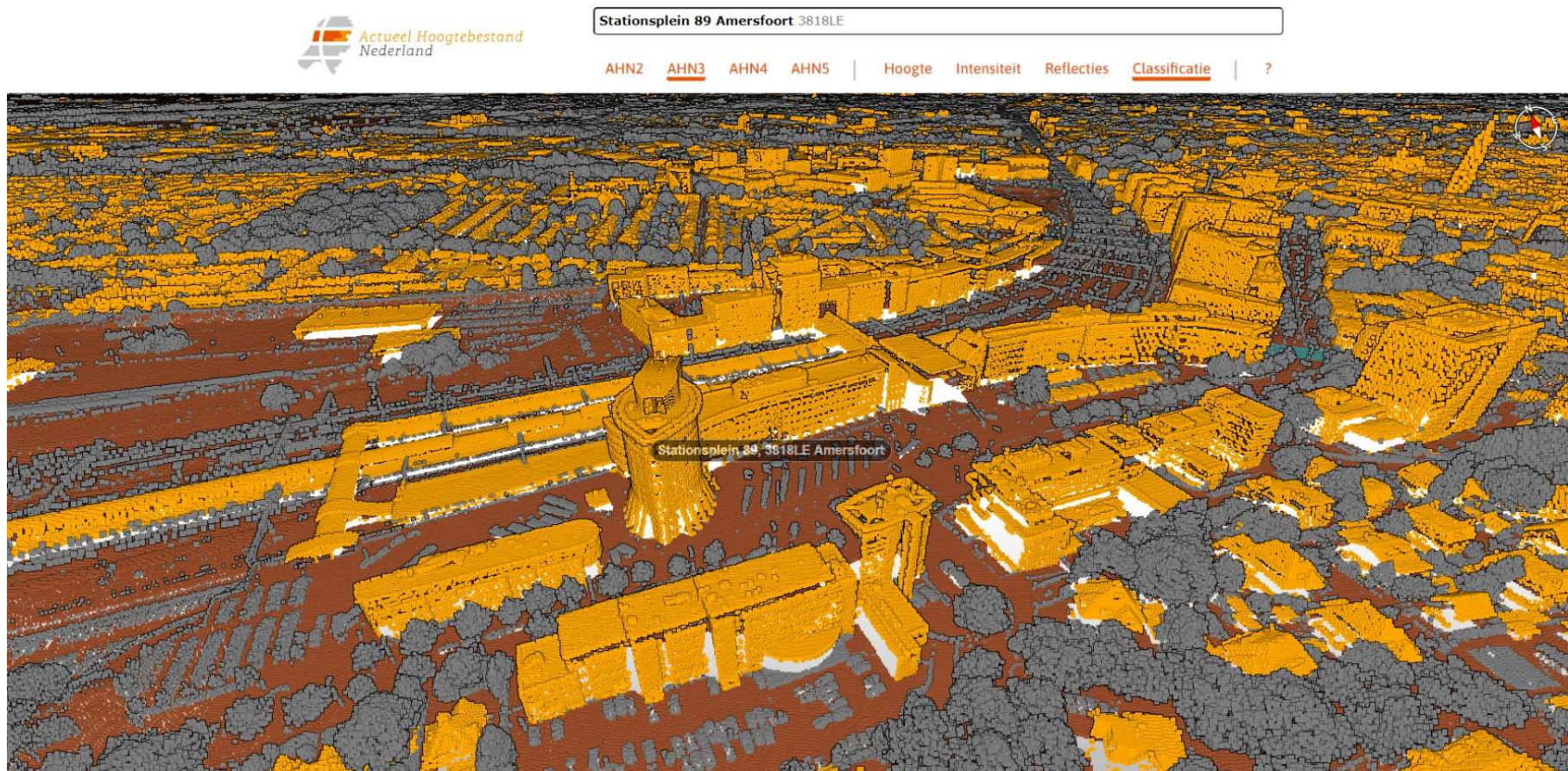
Viewer

- Very basic analysis tools



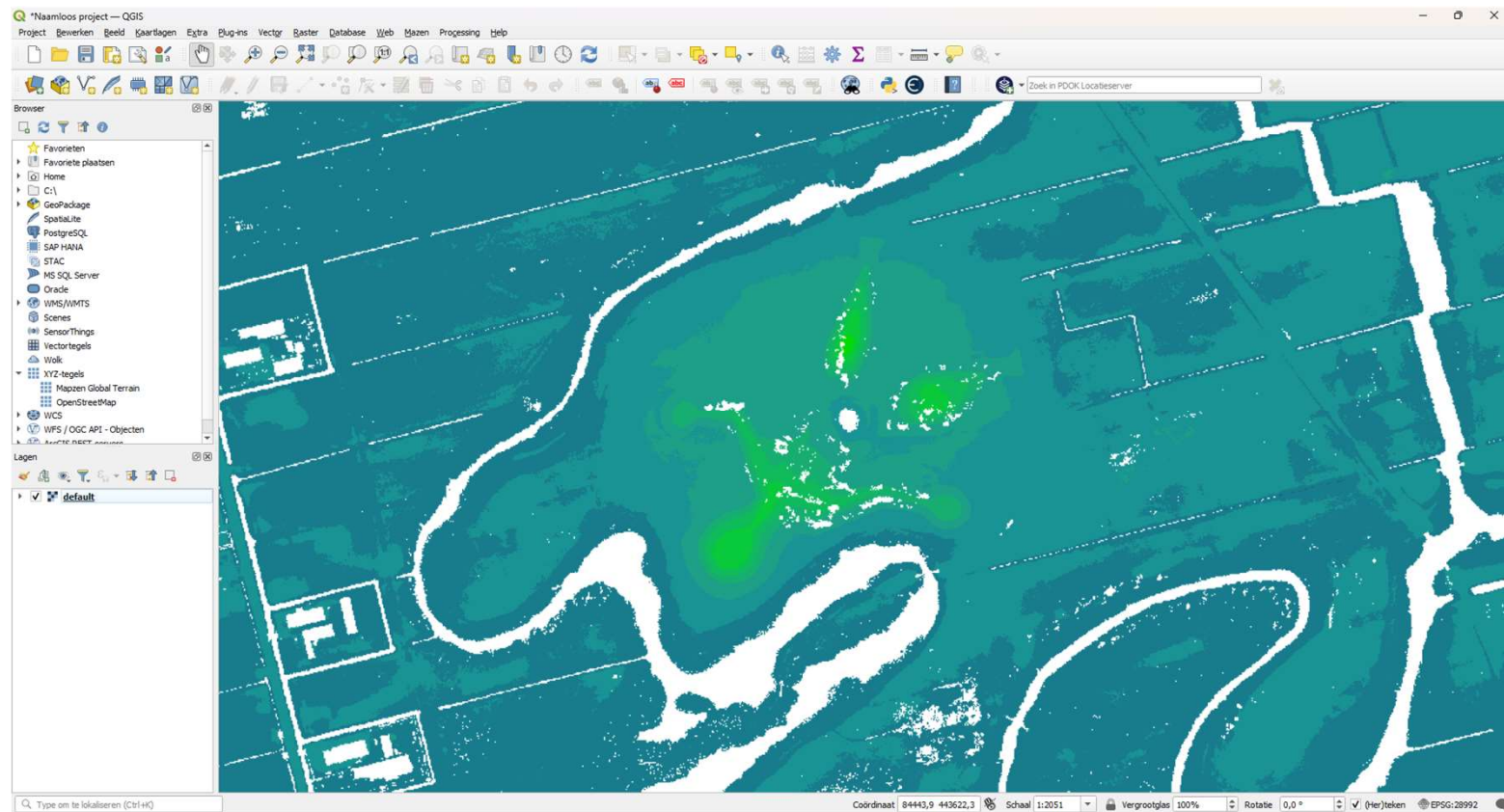
Viewer

- Potree-based viewer



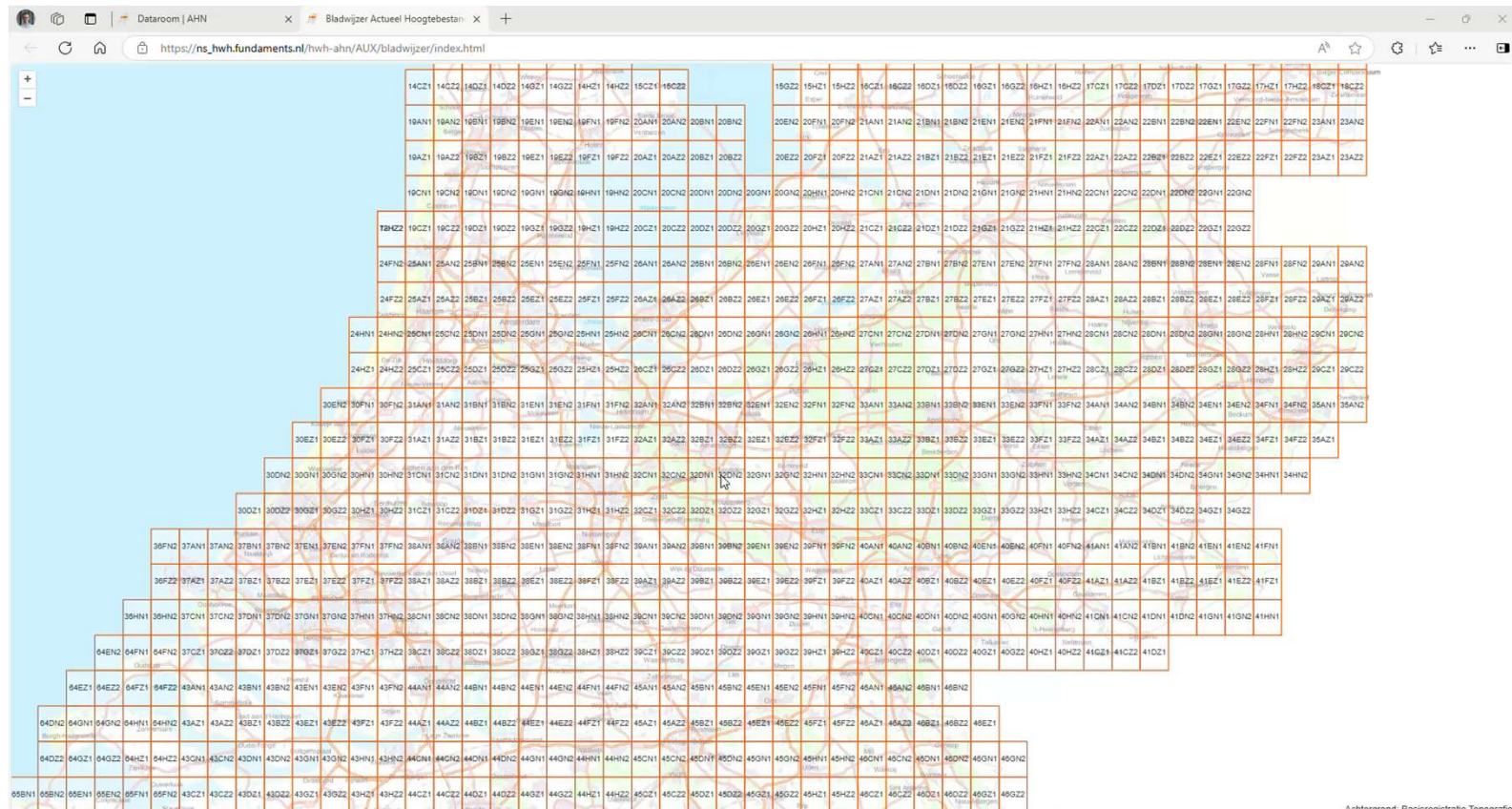
Webservices

- WMS, WMTS, WCS
- OGC API's being implemented by supplier



Downloads

- All available data, sorted by map sheet
- No bulk download (yet), though trivial



Data room

- Overview of:
 - Downloads
 - Services
 - Metadata



[Hoogtegegevens](#) | [Wat leveren we?](#) | [Over AHN](#) | [Uitgelicht](#) | [Congres](#)

[Home](#) > [Hoogtegegevens](#) > Dataroom

Dataroom

Per 6 maart 2014 zijn de datasets AHN1, AHN2 en AHN3 vrij beschikbaar als open data.

Datasets

Van het Actueel Hoogtebestand Nederland zijn drie verschillende datasets beschikbaar:

1. Een maaiveldmodel als raster met 0,5 meter en 5 meter resolutie in GeoTIFF-formaat.
2. Een oppervlaktemodel als raster met 1/2 meter en 5 meter resolutie in GeoTIFF-formaat. Dit bestand bevat naast het maaiveld ook alle objecten op het maaiveld, zoals bebouwing en vegetatie.
3. Puntenwolken in LAZ-formaat met de onderliggende, individuele laster-metingen. De puntenwolken van AHN2 zijn opgesplitst naar maaiveld en niet-maaiveld. De puntenwolken van AHN3 zijn één download per kaartblad en via classificaties in het bestand kunt u maaiveld, water, gebouwen, kunstwerken en metingen filteren.

Landsdekkend

Downloads

Omdat de AHN-data er groot is wordt deze beschikbaar gesteld in zogenaamde kaartbladen. Heel Nederland is opgeknipt in rechthoeken, die allemaal een uniek

What do they get?

	General public	Professionals	Wizards
Elevation (raster)	 ✓	 () ✓	 ✓
Elevation (point cloud)	() ✓	 ✓  ✗	 ✓
Imagery (ortho)	 ✓	  ✓	 ✓
Imagery (stereo)		 () ~	 ~
Metadata		 ✓	 ✓

 : View
 : Stream
 : Download



Point cloud streaming



- Point cloud streaming: the missing link in data services
- Developments at the Delft University of Technology
 - 2022: 'PCServe', query a point cloud comparable to OGC WCS
 - 2024: Combination of existing, 'cloud-optimized' solutions comparable to Cloud-Optimized GeoTIFF

Point cloud streaming

Slides adapted/used with permission from:



nD-PointCloud, what else



Peter van Oosterom, Martijn Meijers, Vitali Diaz Mercado, Edward Verbree (TU Delft)



Peter van Oosterom, Martijn Meijers, Vitali Diaz Mercado, Edward Verbree (TU Delft)
Thijs van Lankveld, and Nauman Ahmed (Netherlands eScience Center)

Congres AHN & Beeldmateriaal, 16 October 2025, Amersfoort

Virtual Point Clouds and Cloud Optimized Point Cloud

- Virtual Point Cloud (VPC) file = SpatioTemporal Asset Catalogs (STAC)
- extension on top of GeoJSON with PC metadata
- contains links to COPC .laz files (or EPT, Entwine Point Tile)



- Cloud Optimized Point Cloud (COPC) file = data
- COPC is .laz which has embedded Octree
- specs on <https://copc.io/> (by Hobu, Inc.)



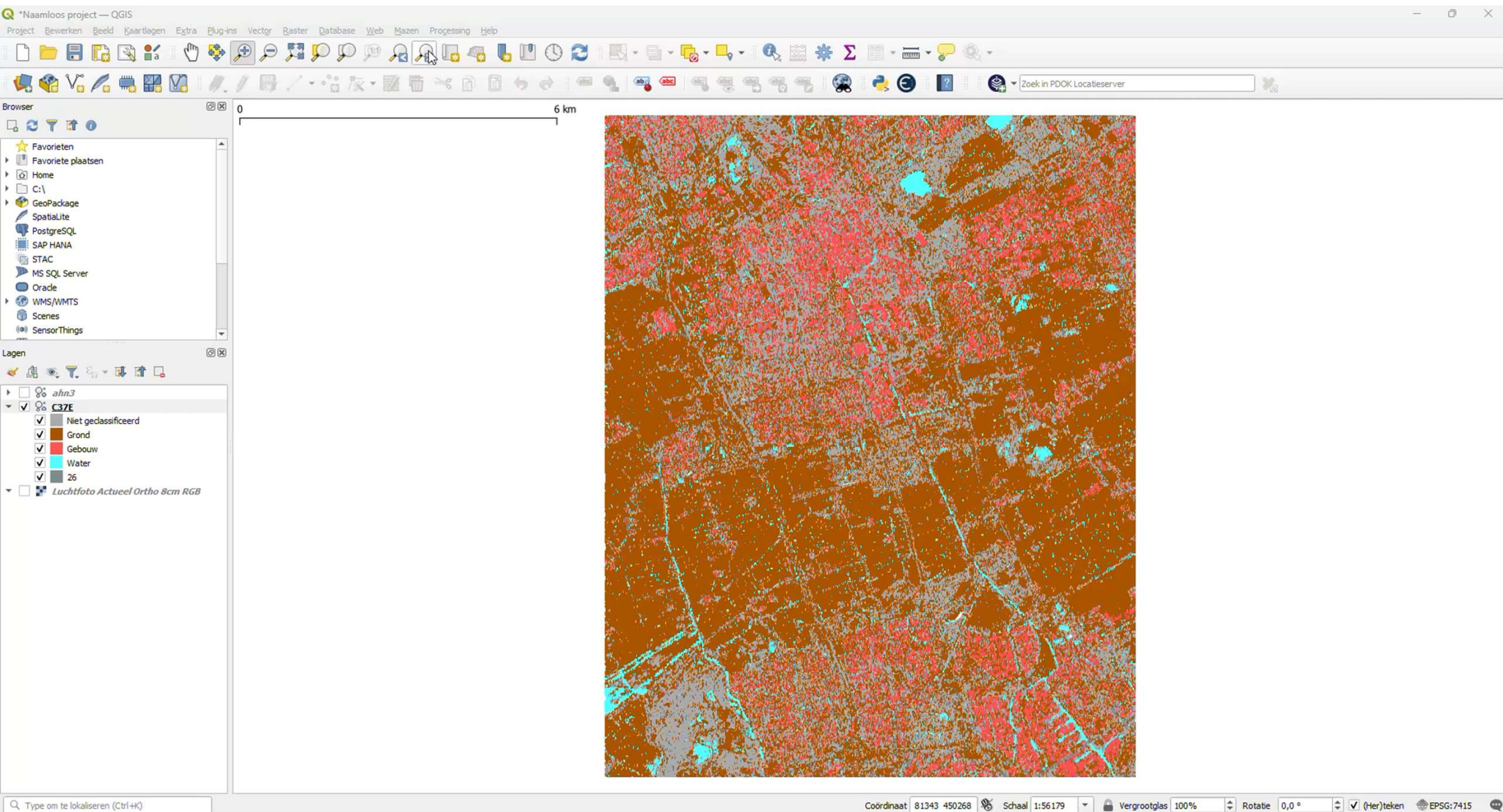
- load VPC in **QGIS** as a single point cloud layer
(rather than each file as a separate map layer)

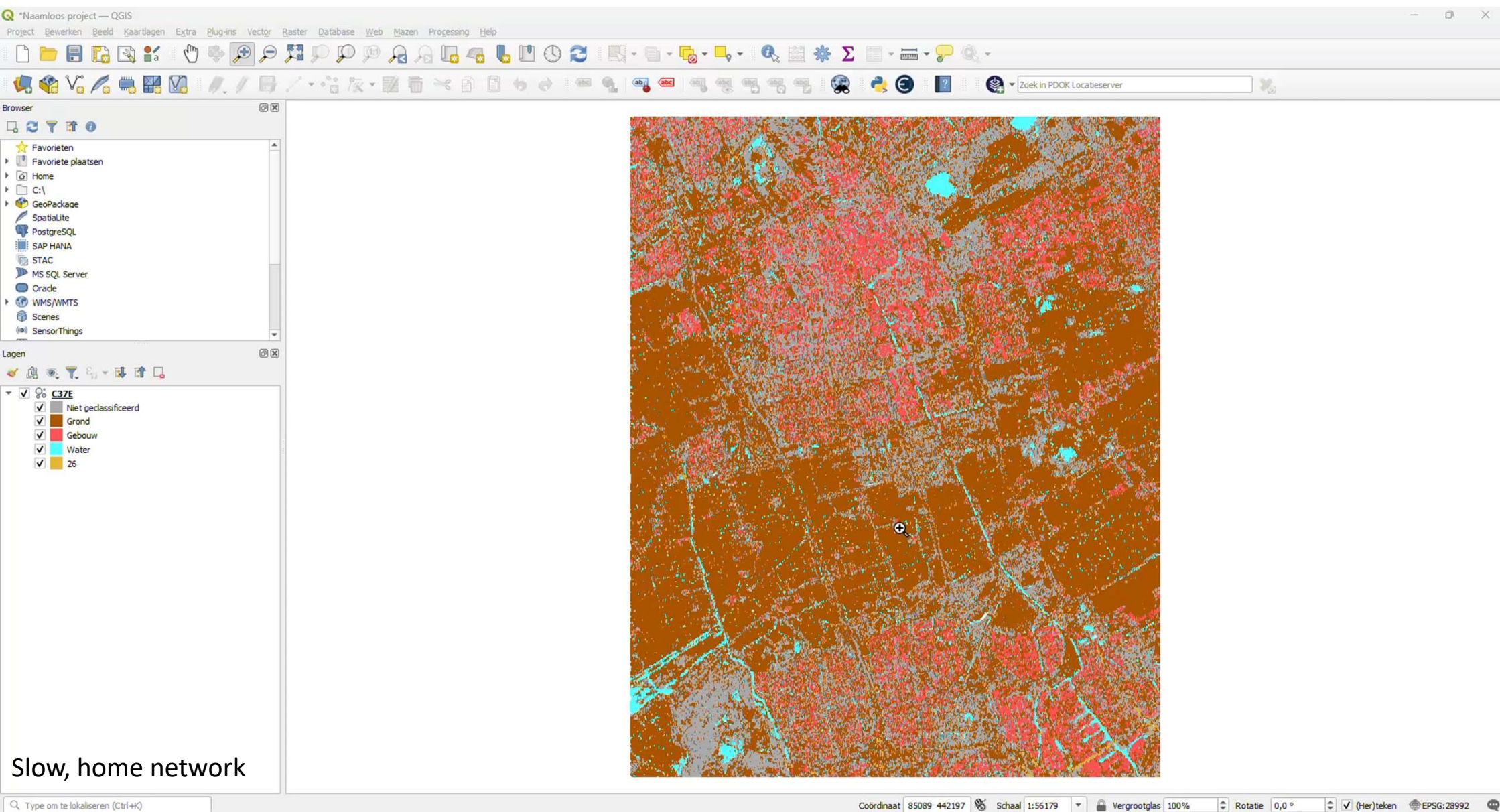
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- Cloud Optimized Point Cloud (COPC) file = data
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- load COPC in **QGIS**





Virtual Point Clouds and Cloud Optimized Point Cloud

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(rather than each file as a separate map layer)

Example VPC file

STAC PointCloud

<https://github.com/stac-extensions/pointcloud>

<https://stacspec.org/en>

extent of COPC .laz in WGS'84

extent of COPC .laz in EPSG:7415 (RD+NAP)

EPSG:7415 WKT2

link to COPC .laz (which has embedded Octree)

JSON Raw Data Headers

Save Copy Collapse All Expand All (slow) Filter JSON

```
type: "FeatureCollection"
features:
  0:
    type: "Feature"
    stac_version: "1.0.0"
    stac_extensions:
      0: "https://stac-extensions.github.io/pointcloud/v1.0.0/schema.json"
      1: "https://stac-extensions.github.io/projection/v1.1.0/schema.json"
    id: "C01C.copc"
    geometry:
      coordinates:
        0:
          0: 5.17868789843972
          1: 53.38616375438354
          2: 39.53252257234287
          1: [-]
          2: [-]
          3: [-]
          4: [-]
        type: "Polygon"
        proj:geometry: {}
        proj:bbox: [-]
      properties:
        datetime: "2014-09-15T00:00:00Z"
        pc:count: 295582241
        pc:encoding: "?"
        pc:schemas: [-]
        pc:type: "lidar"
        proj:bbox: [-]
      proj:geometry:
        coordinates:
          0:
            0: 141125.351
            1: 600000
            2: -1.872
            1: [-]
            2: [-]
            3: [-]
            4: [-]
          type: "Polygon"
        proj:wkt2: "COMPOUNDCRS['Amersfoort / RD New + NAP height',PROJCRS['Amersfoort / RD New',BASEGEOGCRS['Amersfoort',DATUM['Amersfoort',ELLIPSOID['Bessel 1841',6377397.155,299.1528128,LENGTHUNIT['metre',1,ID['EPSG',9001]],ID['EPSG',7004]],ID['EPSG',6289]],DEFININGTRANSFORMATION['Amersfoort to ETRS89 origin',5.38763888888917,ANGLEUNIT['degree',0.0174532925199433,ID['EPSG',9102]],ID['EPSG',8801]],PARAMETER['Longitude of natural origin',5.38763888888917,ANGLEUNIT['degree',0.0174532925199433,ID['EPSG',9102]],ID['EPSG',8802]],PARAMETER['Scale factor at natural origin',0.9999079,SCALEUNIT['unity',1,ID['EPSG',9201]],ID['EPSG',8805]],PARAMETER['False easting',155000,LENGTHUNIT['metre',1,ID['EPSG',9001]],ID['EPSG',8806]],PARAMETER['False northing',463000,LENGTHUNIT['metre',1,ID['EPSG',9001]],ID['EPSG',8807]],ID['EPSG',19914]],CS[Cartesian,2,ID['EPSG',4499]],AXIS['Easting (X)',east],AXIS['Northing (Y)',north],LENGTHUNIT['metre',1,ID['EPSG',9001]],ID['EPSG',28992]],VERTCRS['NAP height',VDATUM['Normaal Amsterdams Peil',ID['EPSG',5109]],CS[vertical,1,ID['EPSG',6499]],AXIS['Gravity-related height (H)',up],LENGTHUNIT['metre',1,ID['EPSG',9001]],GEOIDMODEL['ETRS89 to NAP height (2)',ID['EPSG',9283]],ID['EPSG',5709]],ID['EPSG',7415]]"
      links: []
    assets:
      data:
        href: "https://data.pointclouds-ahn-copc/3/C01C.copc.laz"
        roles: []
```

To use VPC/COPC in QGIS start with download .vpc file

```
$ wget https://data.pointclouds.nl/data/nl/ahn-copc/3/ahn3.copc.vpc.json -O ahn3.vpc
--2024-10-10 14:03:00-- https://data.pointclouds.nl/data/nl/ahn-copc/3/ahn3.copc.vpc.json
Resolving data.pointclouds.nl (data.pointclouds.nl)... 131.180.126.49
Connecting to data.pointclouds.nl (data.pointclouds.nl)|131.180.126.49|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2428491 (2.3M) [application/json]
Saving to: 'ahn3.vpc'
```

```
ahn3.vpc
100%[=====
=====>] 2.32M --.-KB/s in 0.02s
```

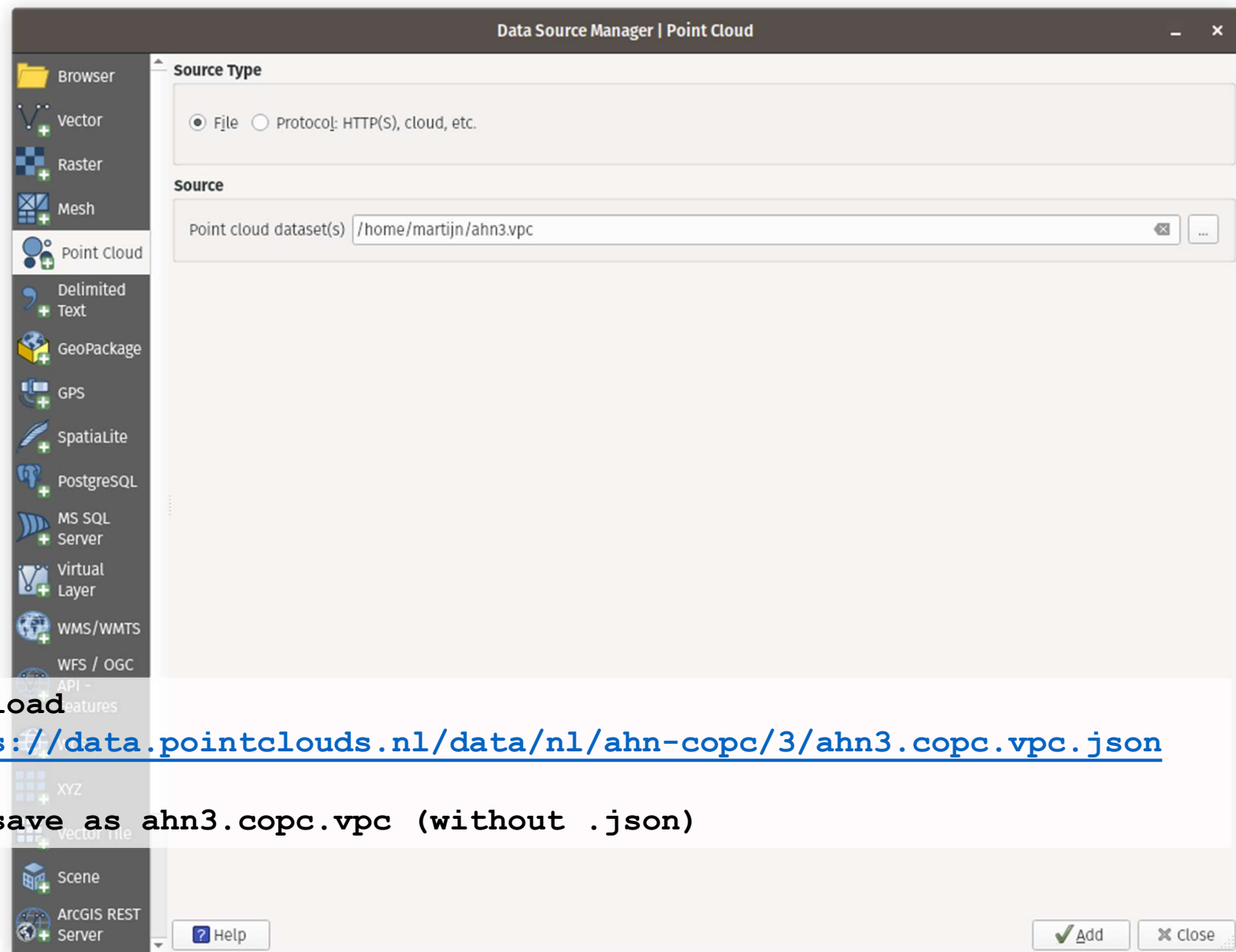
```
2024-10-10 14:03:00 (109 MB/s) - 'ahn3.vpc' saved [2428491/2428491]
```

Open VPC in QGIS

Download

<https://data.pointclouds.nl/data/nl/ahn-copc/3/ahn3.copc.vpc.json>

and save as `ahn3.copc.vpc` (without `.json`)





Identify Results

Feature

Mode: Layer Selection

View: Tree

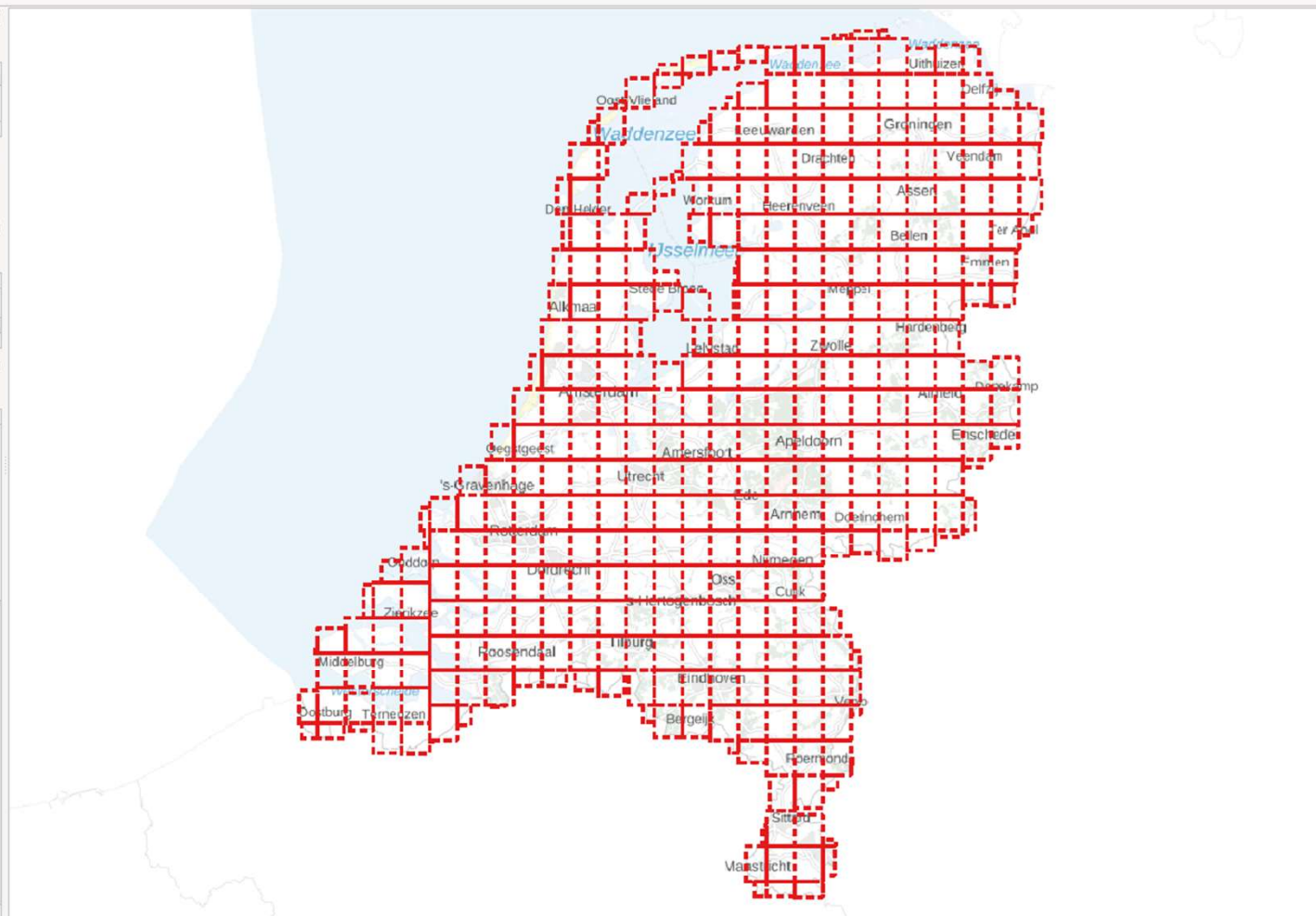
Browser

Favorites

- Spatial Bookmarks
- Home

Layers

- ☒ **ahn3**
 - ☒ Created, Never Classified
 - ☒ Unclassified
 - ☒ Ground
 - ☒ Low Vegetation
 - ☒ Medium Vegetation
 - ☒ High Vegetation
 - ☒ Building
 - ☒ Low Point (Noise)
 - ☒ Reserved
 - ☒ Water
 - ☒ Rail
 - ☒ Road Surface
 - ☒ Reserved
 - ☒ Wire - Guard (Shield)
 - ☒ Wire - Conductor (Phase)
 - ☒ Transmission Tower
 - ☒ Wire-Structure Connector (Insulator)
 - ☒ Bridge Deck
 - ☒ High Noise
- ☒ **grijs**
 - BEBOUWING**
 - gebouw
 - kas
 - tank



Processing Toolbox

Search...

- Recently used
- 3D Tiles
- Cartography
- Database
- File tools
- GPS
- Interpolation
- Layer tools
- Mesh
- Network analysis
- Plots
- Point cloud conversion
- Point cloud data management
- Point cloud extraction
- Raster analysis
- Raster creation
- Raster terrain analysis
- Raster tools
- Vector analysis
- Vector coverage
- Vector creation
- Vector general
- Vector geometry
- Vector overlay
- Vector selection
- Vector table
- Vector tiles
- GDAL



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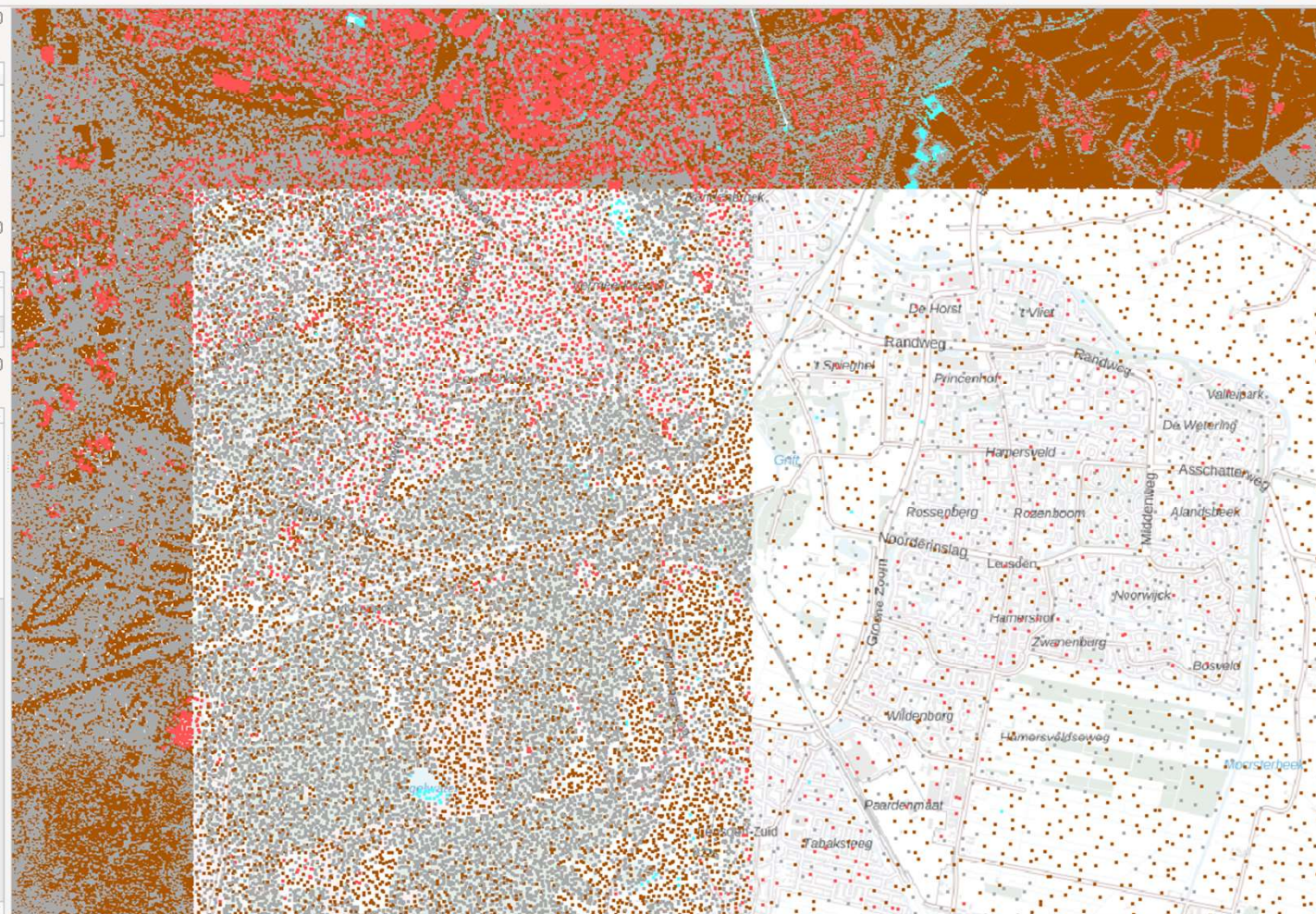
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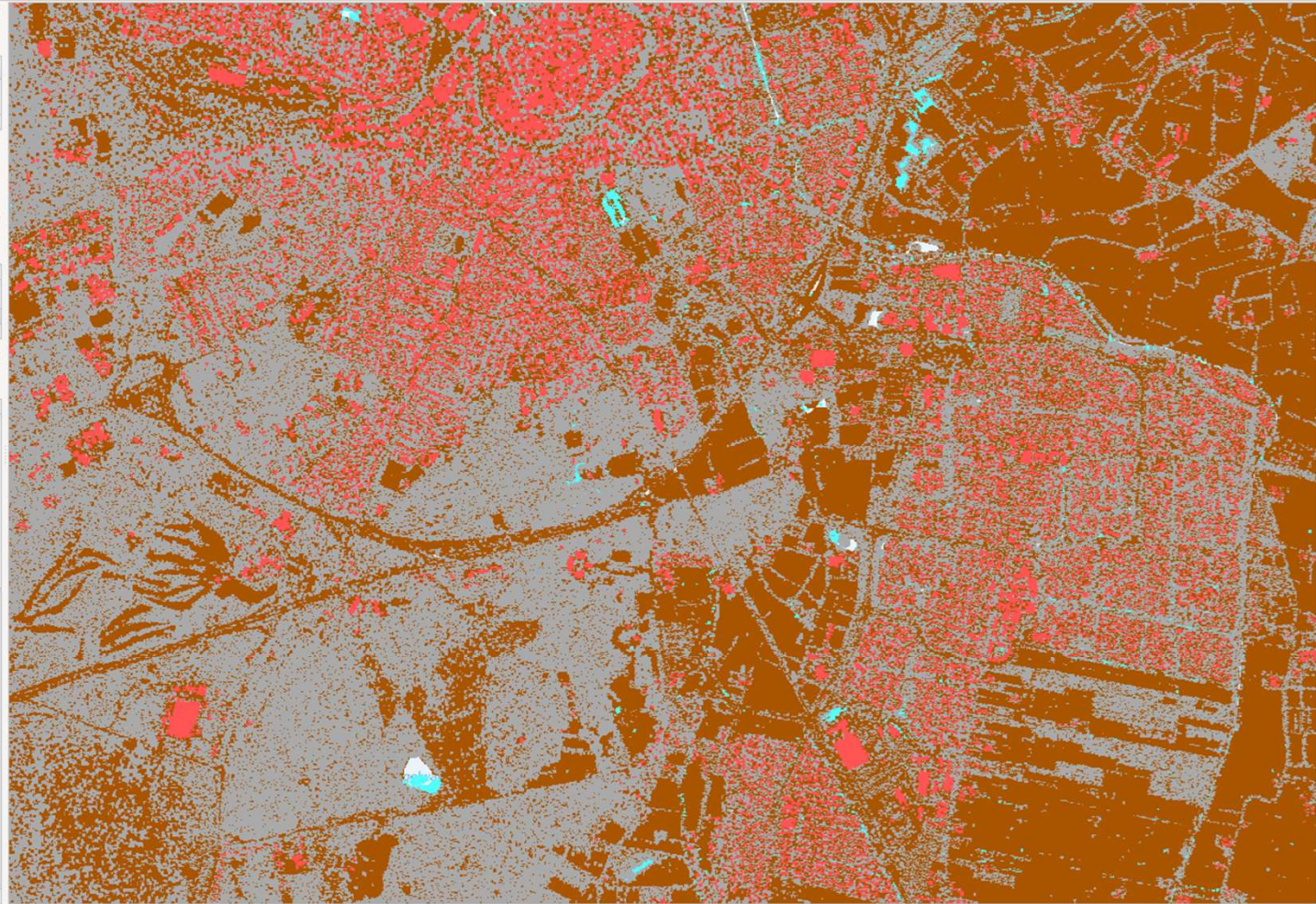
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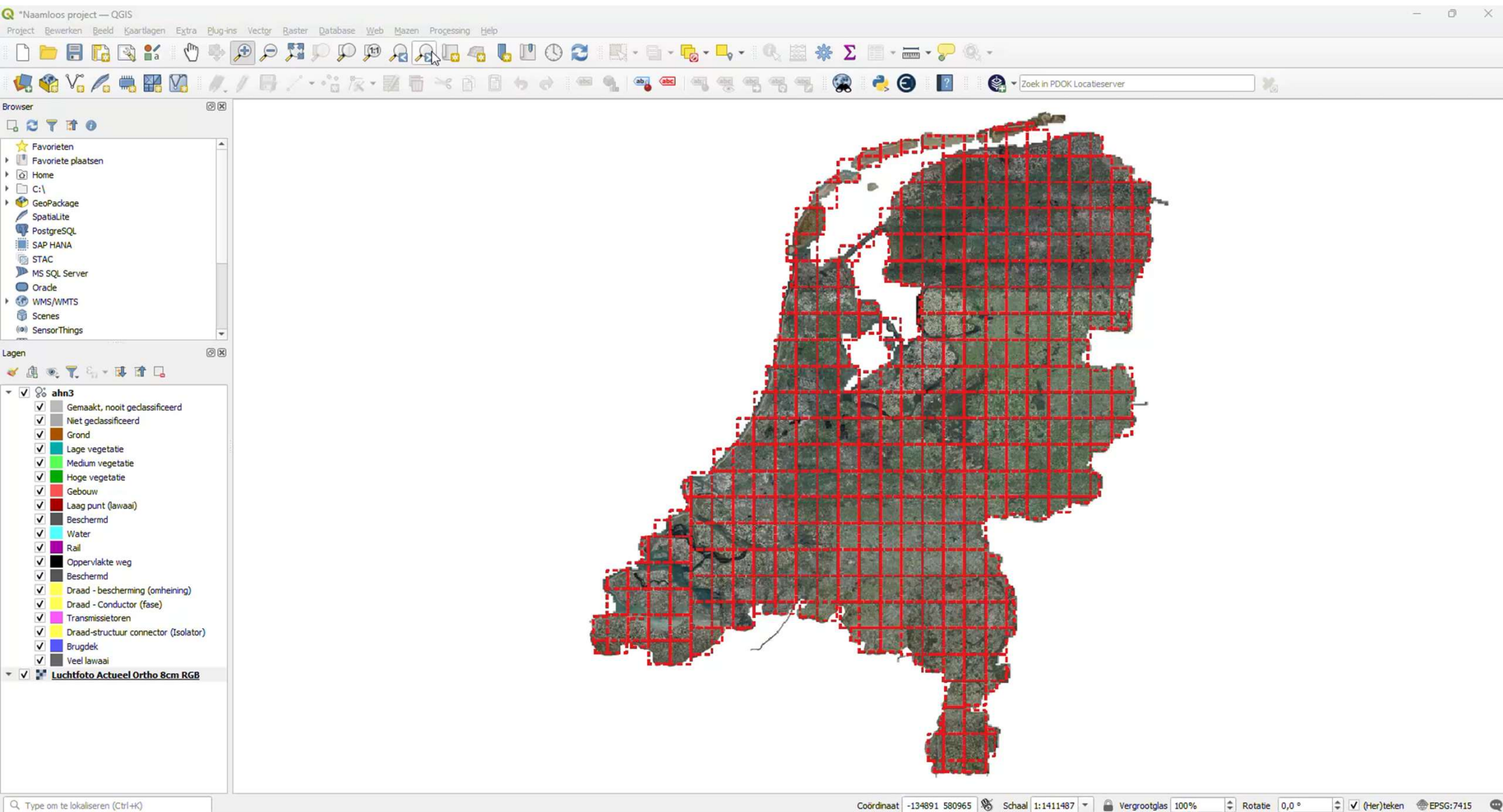
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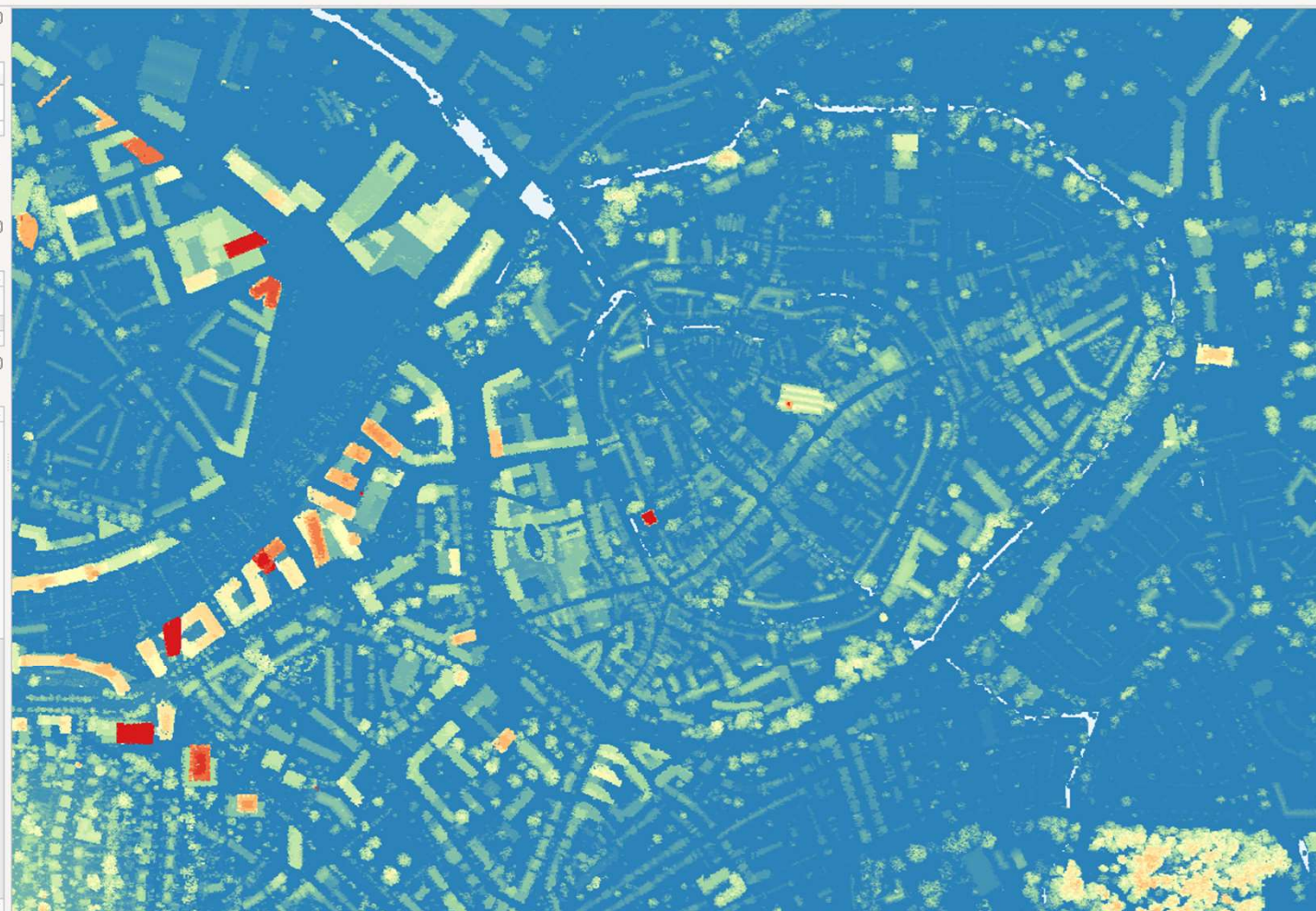
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 - Z
 - 50
 - 10
- ☒ **grijs**
 - BEBOUWING
 - gebouw
 - kas
 - tank
 - WEGENINFORMATIE
 - A-wegnummering
 - N34 N-wegnummering
 - WEGEN
 - autosnelweg
 - hoofdweg
 - regionale weg
 - lokale weg
 - straat
 - weg in tunnel
 - overig verkeersgebruik
 - COORDEGATEN

Type to locate (Ctrl+K)

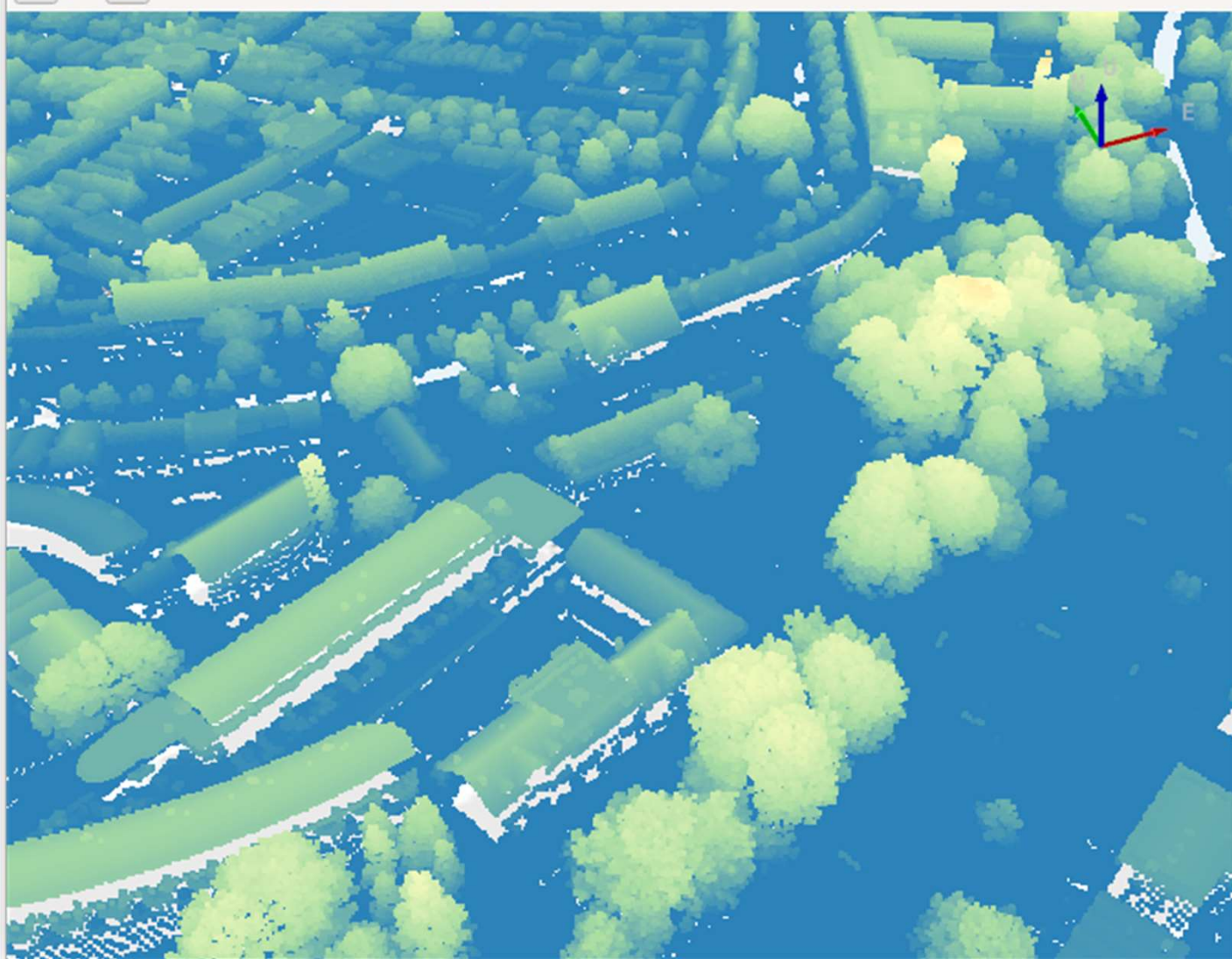


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- Mesh
- Network analysis
- Plots
- Point cloud conversion
 - Convert format
 - Export to raster
 - Export to raster (using tria...
 - Export to vector
- Point cloud data management
 - Assign projection
 - Build virtual point cloud (V...
 - Clip
 - Create COPC
 - Information
 - Merge
 - Reproject
 - Thin (by sampling radius)
 - Thin (by skipping points)
 - Tile
- Point cloud extraction
 - Boundary
 - Density
 - Filter
- Raster analysis
- Raster creation
- Raster terrain analysis
- Raster tools
- Vector analysis
- Vector coverage
- Vector creation
- Vector general
- Vector geometry

3D Map 2



☐ Show camera info (for debugging)



Data



Point clouds

C70F.7415



Manage

Add data +

Drop COPC, COG, or STAC file here



Collections

USGS 3DEP LiDAR



Sample data

Autzen Stadium

SoFi Stadium

Millsite

Hobbs, NM

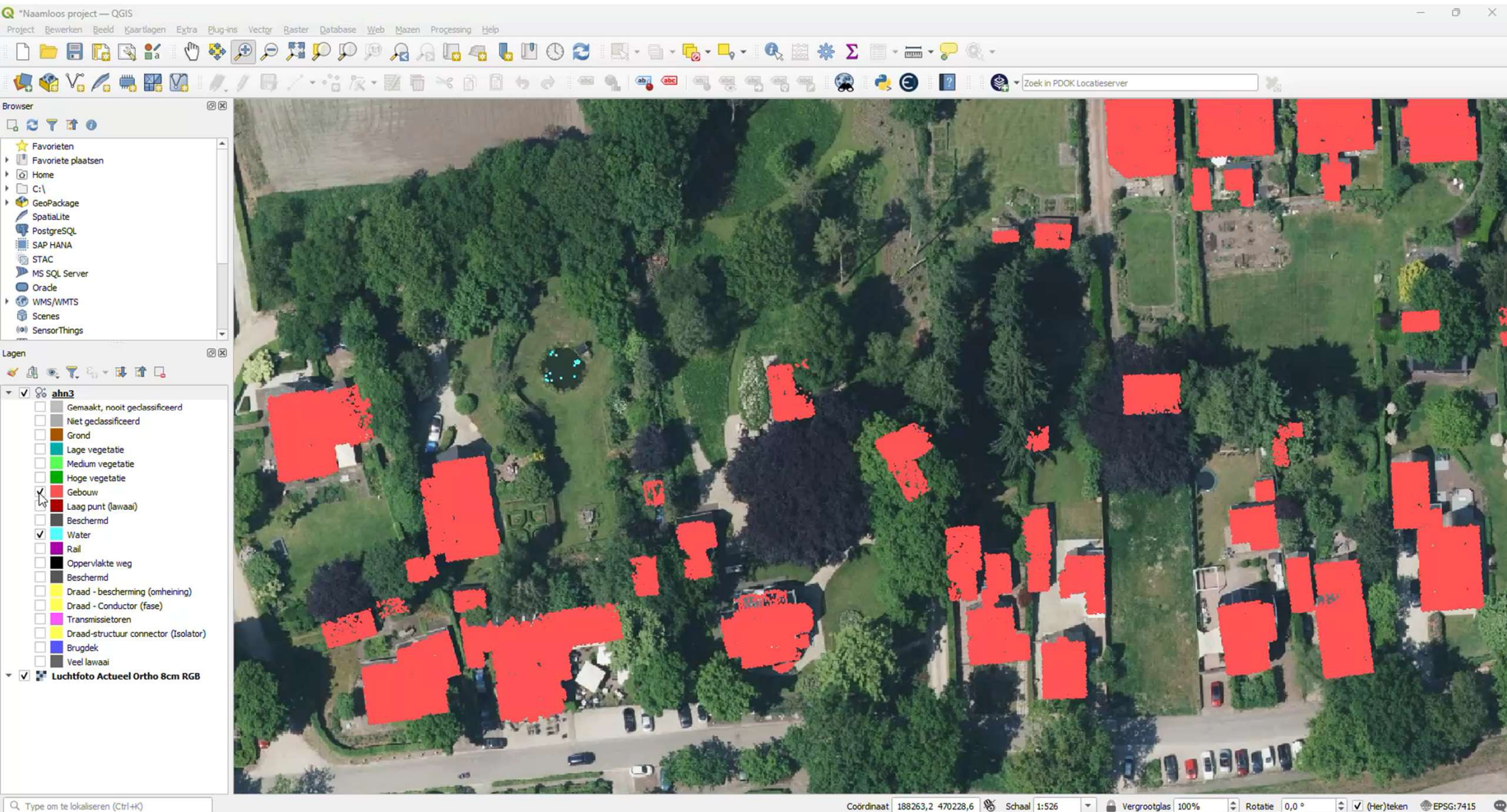
Red Rocks Amphitheatre

Trestle Bridge

Mount St. Helens

Wolverine Glacier





Statistics for AHN to COPC and VPC

	#files in	input	processing	#files out	output
AHN3	1374	2.4Tb	14 days 5 hrs	382	3.1Tb
AHN4	1381	6.1TB	26 days	381	5.1Tb

48 cores @ 2,85 GHz, 512 GB RAM

processing time linear with input size

tested on a multi-user system, so timings not exact

for AHN3: COPC > LAZ input, for AHN4: COPC < LAZ input

GitHub to source https://github.com/nd-pc/process_ahn



Point cloud streaming



- COPC/VPC solution
 - Easy to host (static files)
 - Open standard
 - Software support is still limited
 - QGIS 2D works well, 3D is still *mweh*
 - Local coordinate system misbehaves in web-viewers
 - Conversion to COPC is (very) compute intensive
- Bridges the gap between rasters and point clouds in mapping
 - Point cloud geometry and attributes available in GIS

Future

- Spatio-temporal data catalogue

