Education & Training

Hands-on practice: LIDAR data quality analysis and fine-georeferencing

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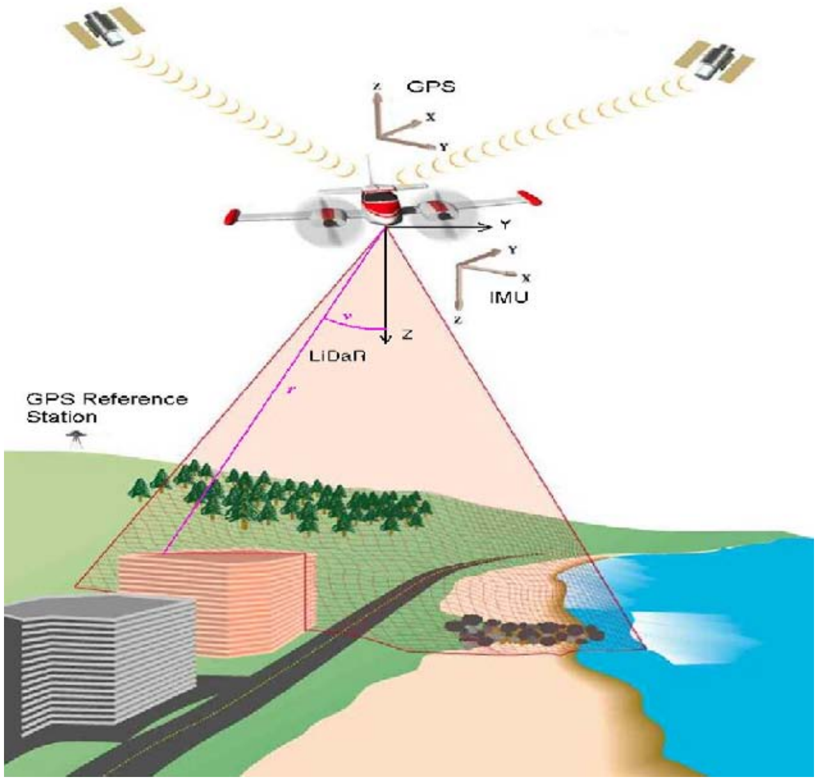
ALS data acquisition

- Configuration
  - Laser Scanner (LS)
    (ν, χ, r)
  - Inertial Measurement Unit (IMU)
    $(\omega, \varphi, \kappa)$
  - Global Positioning System (GPS)
    (X_0, Y_0, Z_0)

- Synchronisation
  - Time Stamp
    (t)



What are the characteristics of ALS data?

- **Point density**

  → ALS-points are scattered irregular on the ground; distribution depends on flying height, flight movements, etc.

- **Random errors**

  Are caused by measurement noise.

- **Systematic errors**

  Are caused by errors of the calibration of the sensors, and errors of the relative and absolute orientation of the strips.

Systematic errors

- Two types:
  - Absolute: discrepancies at ground check features
  - Relative: discrepancies between adjacent, overlapping laserscanner strips

•→ Errors of the ALS data directly influence the quality of the derived products (DTM)

- Reasons:
  - IMU misalignment
  - GPS initialization
  - Calibration error, …

- Possible solution:
  - absolute / relative improvement of orientation using strip adjustment

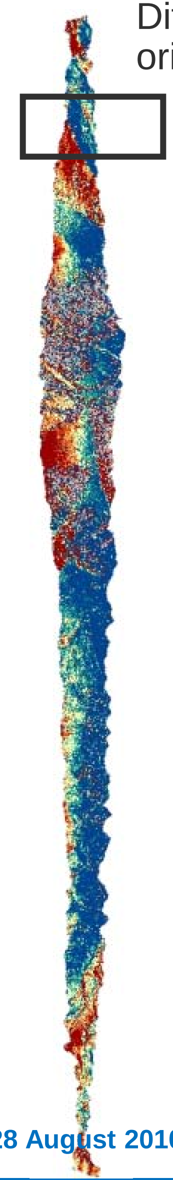
    → improved transformation parameters

    (H. Kager, Discrepancies Between Overlapping Laser Scanning Strips – Simultaneous Fitting of Aerial Laser Scanner Strips, in: O. Altan (ed.), ISPRS Archives 35 (Part B1), Istanbul, Turkey, 2004, pp. 555-560.)

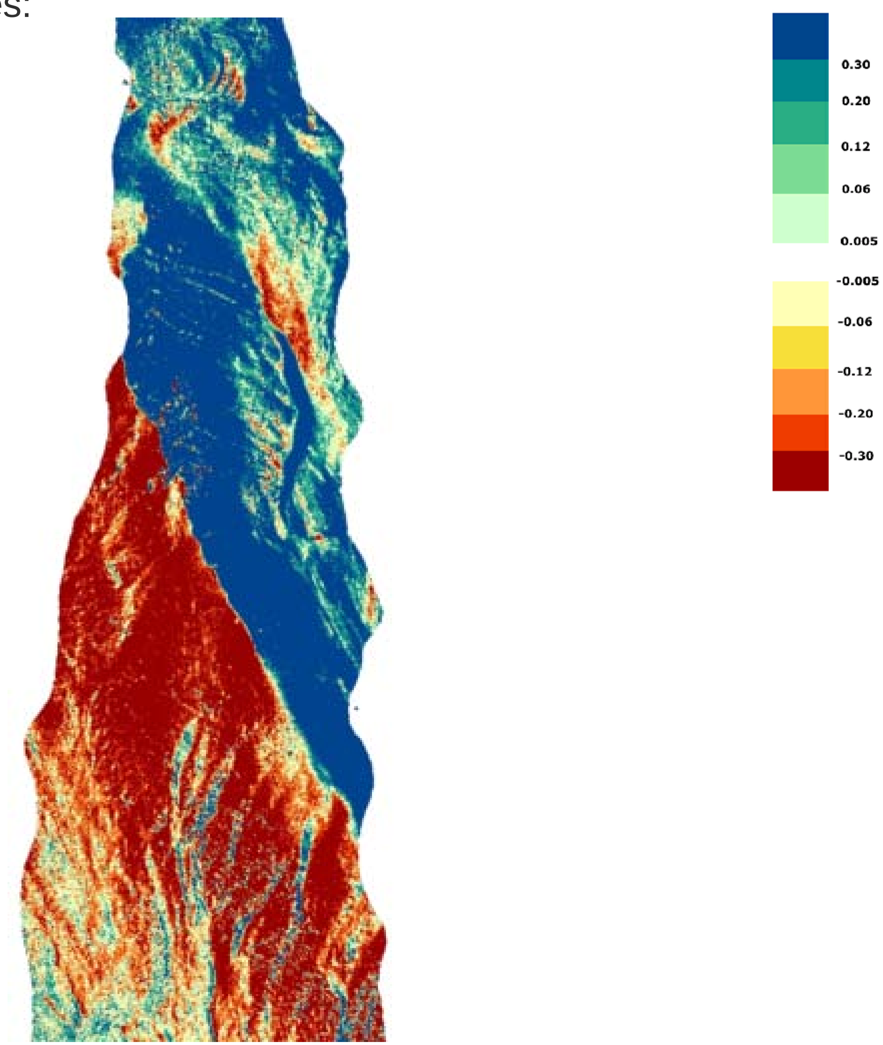
Strip differences documenting errors of relative orientation

2 strips

Overlap



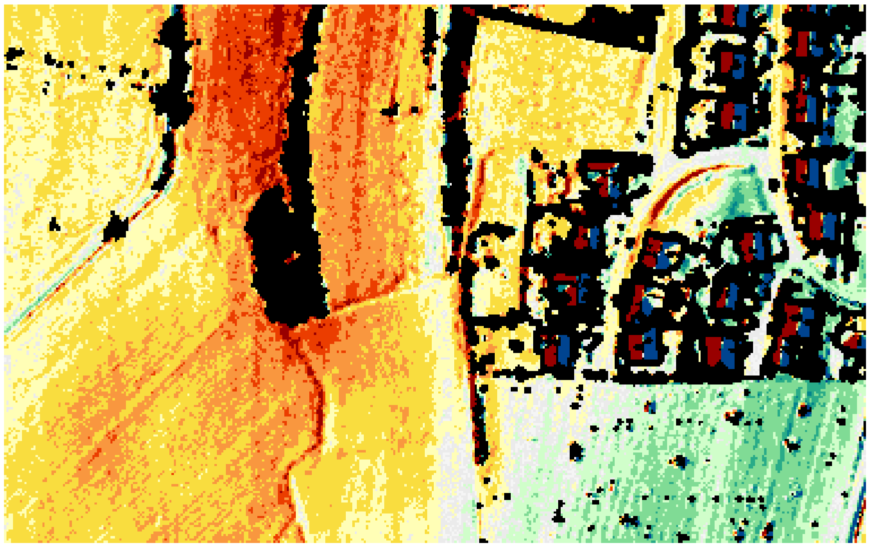
Differences:
original:



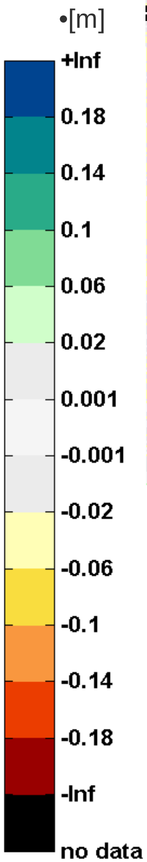
Examples

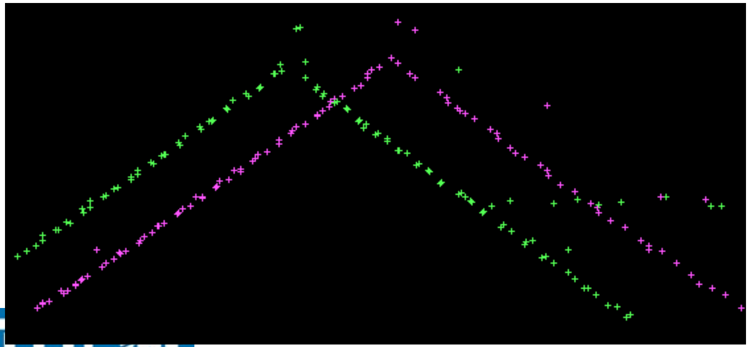
- Improvement of transformation parameters using strip adjustment

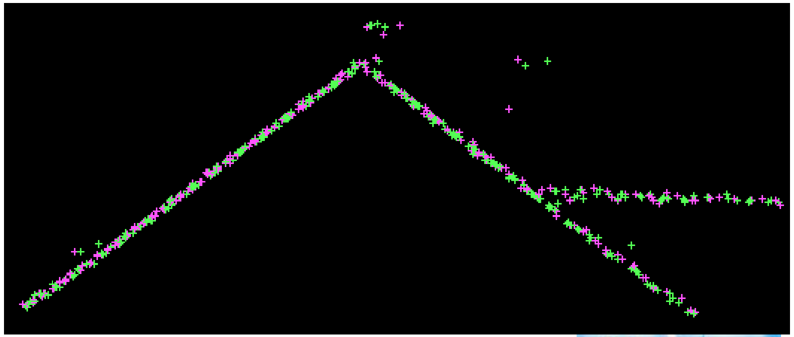
Strip difference of original data:



Strip difference after strip adjustment:







ALS quality documentation

- **point density** (per strip and for the aggregation of all strips)
- **measurement noise** → accuracy of points (sigma-dtm)
- **relative orientation** → strip differences

The following programs are used

- **OPALS (Orientation and Processing of ALS Data) – scientific processing software**
- **SCOP++**
- **SCOP.GVE**

OPALS, http://www.ipf.tuwien.ac.at/opals/

INSTITUTE OF PHOTOGRAMMETRY AND REMOTE SENSING
ORIENTATION AND PROCESSING OF AIRBORNE LASER SCANNING DATA
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opals

Main Page | Related Pages

OPALS - Orientation and Processing of Airborne Laser Scanning data

OPALS stands for **O**rientation and **P**rocessing of **A**irborne **L**aser **S**canning data. It is a modular program system consisting of small components (modules) grouped together thematically in terms of packages. The aim of OPALS is to provide a complete processing chain for processing airborne laser scanning data (waveform decomposition, georeferencing, quality control, structure line extraction, point cloud classification, DTM generation and several fields of application like forestry, hydrology/hydraulic engineering, city modelling and power lines).

The manual is divided into three parts, each of which is sub-divided into several sections.

User Documentation

- Section **Installation** discusses how to **download** and install OPALS
- Section **Getting Started** gives a 15 minute introduction on how to use OPALS
- Section **Software Concept** describes the basic concept of OPALS in detail
- Section **Workflow Management** shows how to combine OPALS modules using scripts
- Section **Supported Formats** overviews the supported vector and raster file formats
- Section **FAQ** answers frequently asked questions concerning OPALS
- Section **Bibliography** contains a list of OPALS related articles

Reference Documentation

- Section **Module Reference** contains a list of all OPALS modules and a detailed description of each module
- Section **OPALS Datamanager** describes the ALS data administration concept in detail
- Section **Parameters / Configuration Files / Parameter Mapping** explains parameter categories and types, and how to specify respective values
- Section **Logging / error handling** contains details about the way OPALS logs information and handles errors
- Section **Filters** explains the detailed syntax used to filter vector data
- Section **OPALS Format Definition** shows how to operate with generic user-defined vector formats
- Section **Using Python Bindings** describes how to embed OPALS modules in a Python programming/scripting environment
- Section **Using C++ Bindings** deals with embedding OPALS modules in a C++ programming environment
- Section **C++ API Reference** contains the detailed OPALS module class documentation (public functions, parameters, etc.)
- Section **Third Party Software** lists all the external libraries and programs used within OPALS
- Section **Glossary** contains a list of a keywords and acronyms together with a description of their meaning

OPALS Packages

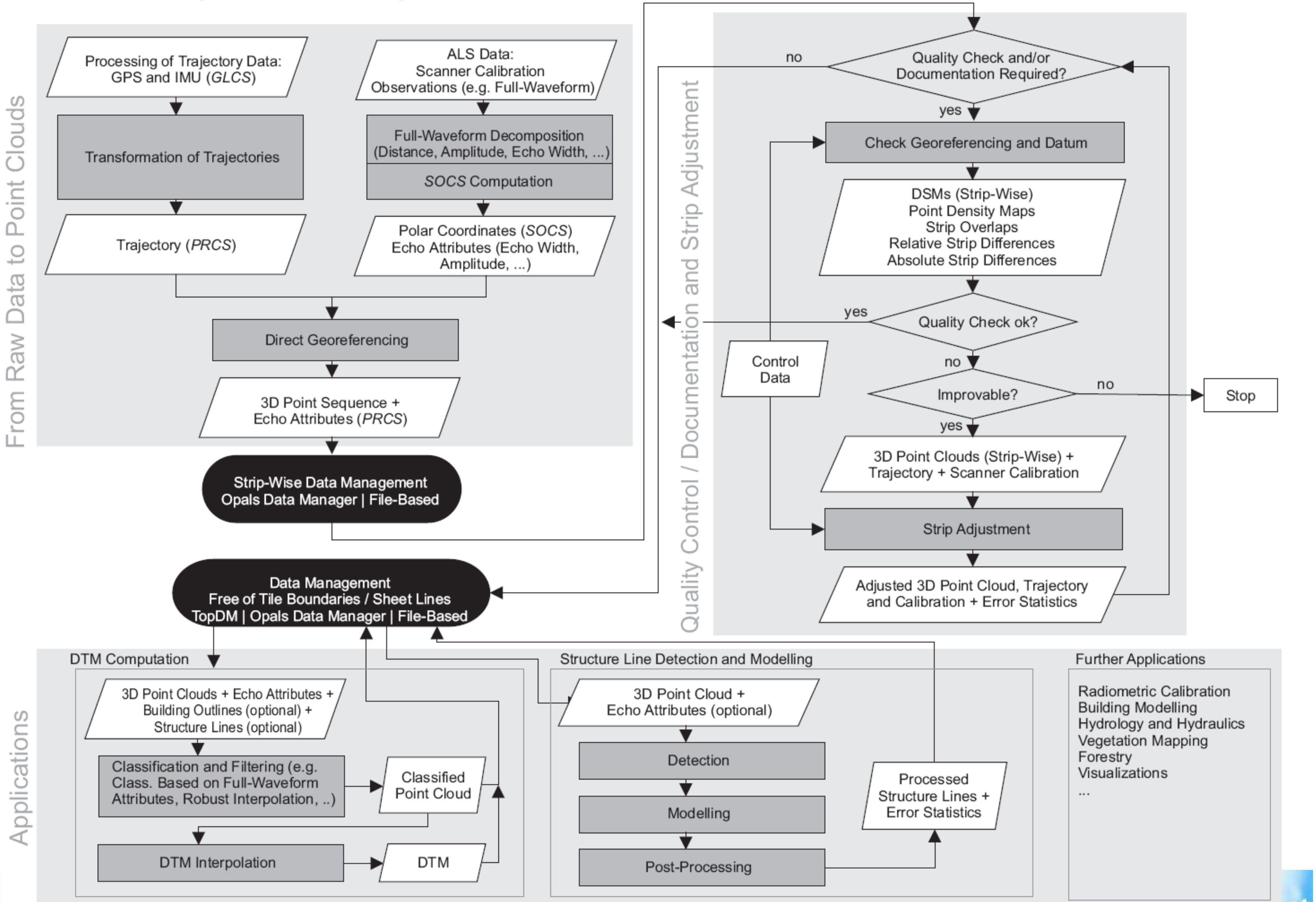
- Package **opalsPreprocess:**** Signal analysis and point cloud derivation
- Package **opalsQuality:** Quality control and documentation
- Package **opalsGeoref:**** ALS strip adjustment
- Package **opalsGeomorph:*** Terrain feature extraction (breaklines lines,etc.)
- Package **opalsClassify:*** 3D-Classification of ALS point cloud
- Package **opalsSurface:*** Surface interpolation (DTM/DSM) and visualisation
- Package **opalsHydro:*** Hydrologic/Hydraulic applications
- Package **opalsForest:**** Forestry applications
- Package **opalsCity:*** Building and city modelling

*) package not yet available **) package only available partially

OPALS

Orientation and Processing of Airborne Laserscanning Data

SOCS . . . . **S**canner **O**wn **C**oordinate **S**ystem
GLCS . . . . **Gl**obal **C**oordinate **S**ystem
PRCS . . . . **Pr**oject **C**oordinate **S**ystem



OPALS Processing

- Running OPALS modules:
  open a Command Prompt (e.g. Start → Run → cmd)
  or Start → All programs → Accessories → Command Prompt

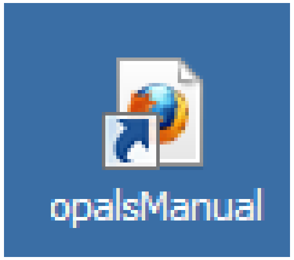
  - change to your project directory
  - start the program with the appropriate input parameters
  - e.g.

```
C:\ opalsCell –i input.odm -cellSize 5 -feature pdens   -oFormat Gtiff
```

    (one such call may cover several lines on the screen)

  - Several calls can be put in a so-called batch-file (.bat).

- Help on OPALS:
  C:\Program Files\OPALS\doc\opalsManual.html



opalsImport

Before any OPALS module can work with the ALS-data, that data needs to be imported and stored in a suitable format (ODM = OPALS Data Manager). This is done by **opalsImport**

Example 1:

```
opalsImport -inFile G101ALL.bxyz
```

→ Imports the points on file G101ALL.bxyz and generates G101ALL.odm.dat and G101ALL.odm.idx. This file pair is later referenced by G101ALL.odm

Example 2:

```
opalsImport -inFile G101ALL.bxyz -inFile G102ALL.bxyz -inFile G102ALL.bxyz  -outFile ALL.ODM
```

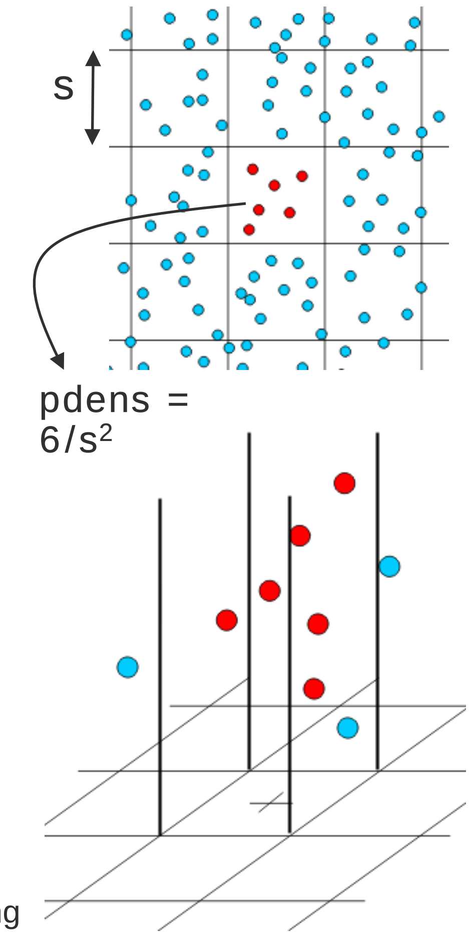
→ Imports the points on the files G101ALL.bxyz, G102ALL.bxyz and G103ALL.bxyz and generates ALL.odm.dat and ALL.odm.idx. This file pair is later referenced by ALL.odm

opalsCell

program to derive one representative z-value per raster cell from all original points inside the cell. The parameter –feature defines this representative value.

```
Important parameters:
--inFile: Input file
--feature:
    * min: lowest attribute value
    * max: highest attribute value
    * nmin: n-th lowest attribute value
    * nmax: n-th highest attribute value
    * mean: mean (average) of all attribute values
    * median: median of all attribute values
    * rms: root mean square of all attribute values
    * pdens: point density of all (valid) cell points
    * pcount: point count of all (valid) cell points
--cellSize: grid width of output (s in figure right)
--outFile: (optional)
```

```
e.g.
opalsCell -inFile L:\TOM_UE\part1\group1\G105ALL.ODM  -cellSize 5 -feature pdens

→ Creates file G105ALL_pdens.tif
```



Note: The tif-files created by many OPALS modules contain float-values and not 8bit. Thus viewing these tif-files in e.g. IrfanView makes not much sense.

opalsGrid

program to create a digital elevation model from a given point set by using either snap grid, nearest neighbour, moving average or moving planes interpolation.

Important parameters:

--inFile: Input file

--interpolation:

*** Moving planes: For each grid cell n nearest ALS points (-neighbours) are queried and a best fitting tilted plane (minimizing the vertical distances) is estimated. The height of the resulting plane at the grid point (x,y) position is mapped to the grid cell**

--neighbours: Number of nearest neighbours used for grid point interpolation

--searchRadius: Maximum search radius for point selection (smax in figure right). Only points within smax are considered for the interpolation of a single grid post. If the search area contains too few points for successful interpolation, the respective grid post is marked as 'nodata'.

--feature:

*** sigma: sigma z of grid post interpolation adjustment**

*** density: point density estimate (moving average/planes only)**

*** excentricity: distance between grid point - center of gravity of data points (epsilon in figure right)**

*** slope: steepest slope in %**

*** exposition: slope aspect = azimuth of steepest slope line**

--gridSize: grid width of output

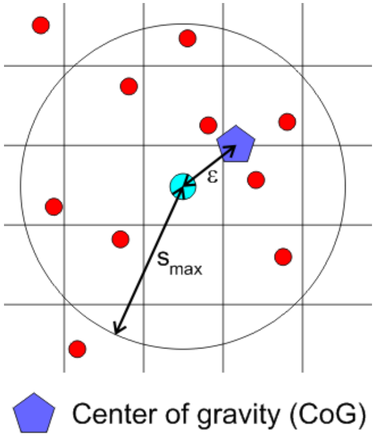
--outFile: (optional)

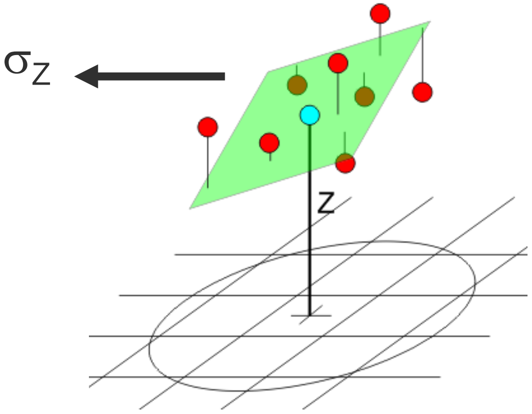
e.g.

opalsGrid -inFile L:\TOM_UE\part1\group1\G105ALL.ODM -gridSize 1 -feature sigma -feature excentricity -interpolation movingPlane **–searchRadius 2.1 –neighbours 9**

→ Creates files G105ALL.tif, G105ALL_sigma.tif and G105ALL_excen.tif

Moving planes interpolation:





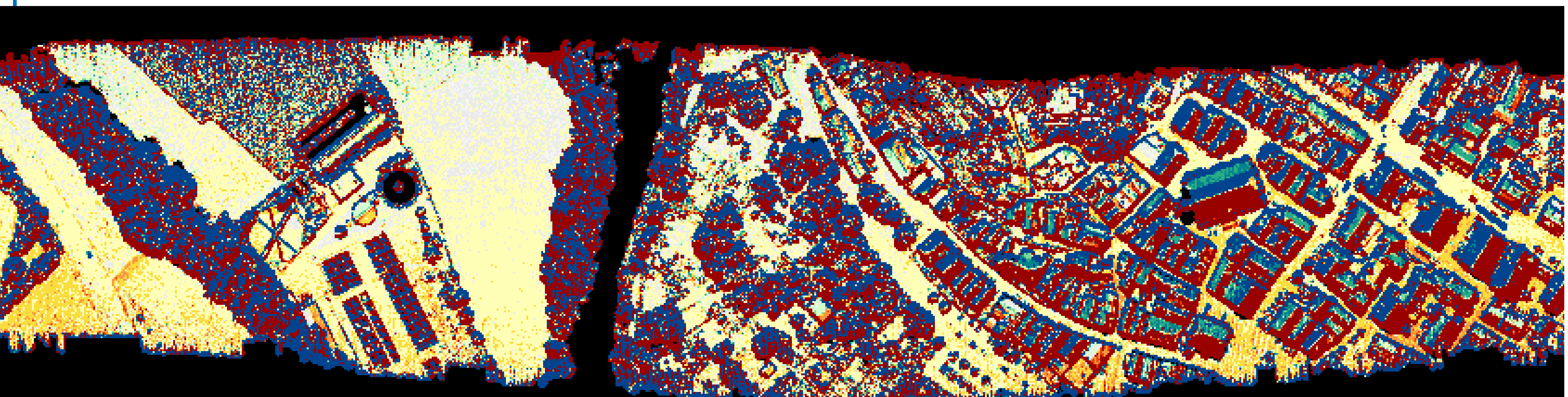
opalsDiff

program to create the difference between two digital elevation models as: Inputfile1 minus Inputfile2

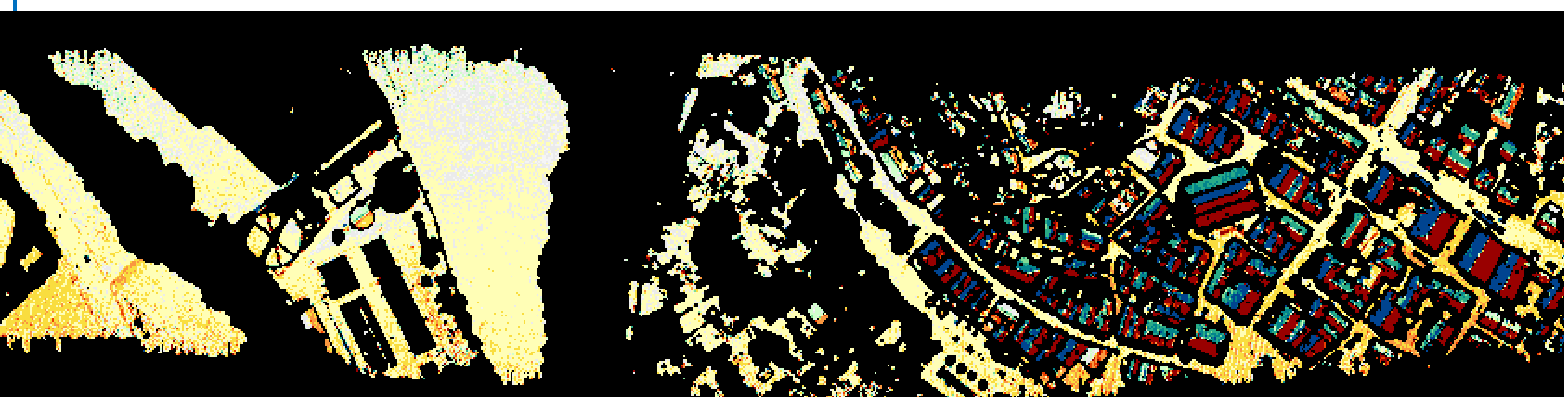
```
Important parameters:
--inFile: Inputfile1,Inputfile2
--outFile: (optional)

e.g.
opalsDiff -inFile G105ALL.tif,G106ALL.tif

→ Creates file  diff_G105ALL_G106ALL.tif
```

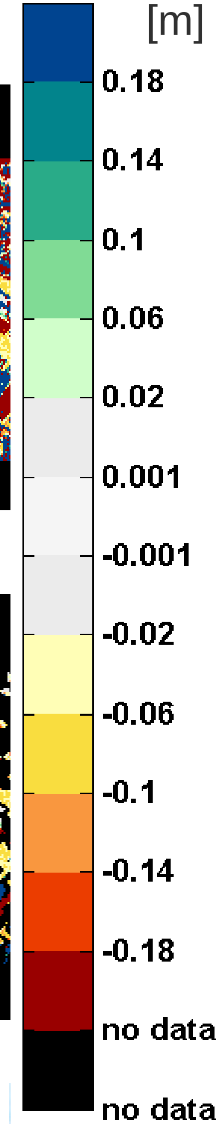
Color Coding of Strip differences

Unmasked strip difference: with vegetation



Masked strip difference: without vegetation





Exercise Data – Schönbrunn 2004

- Location:
  Schönbrunn, Vienna
- Acquisition date:
  30.08.2004
- Scanner:
  Riegl LMS-Q560 Fullwave Scanner
- Flight lines:
  11 strips, 1 Punkt/m², strip overlap >60%,

2 Folders:
- SB2004.R0 - raw data
- SB2004 - fine georef

4 strips are selected

Workflow: Hands-on opals

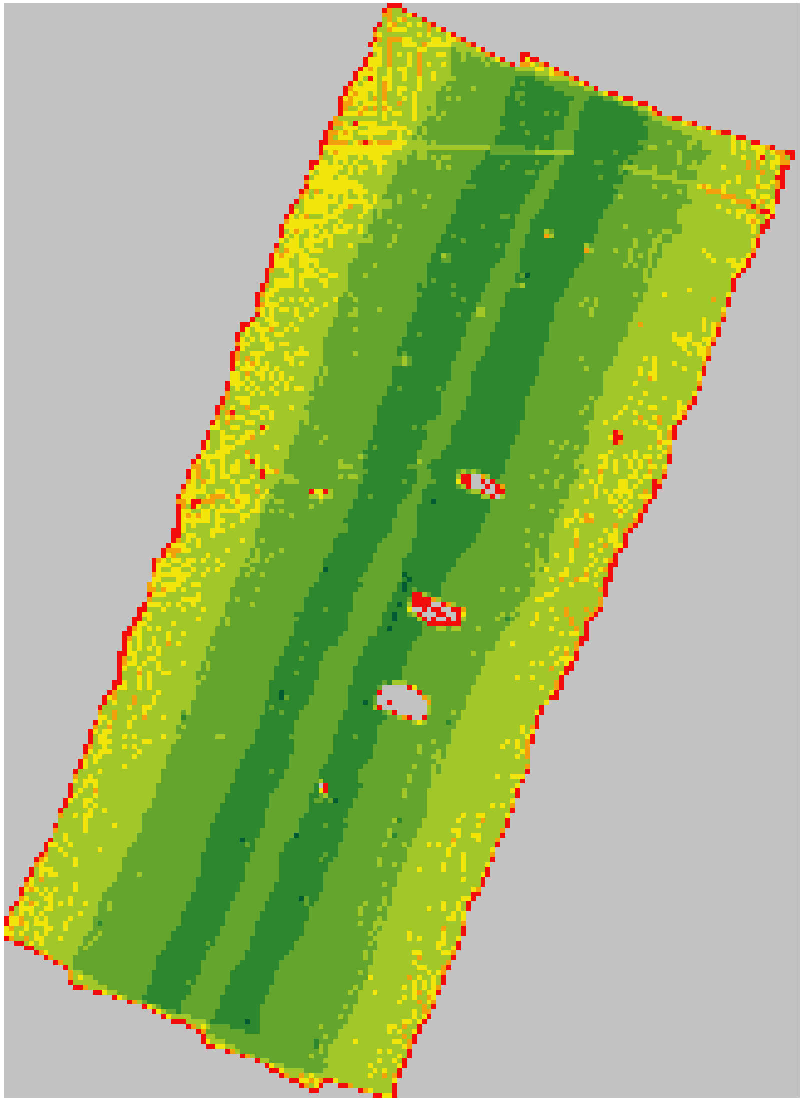
View data, e.g. By SCOP.GVE

Processing steps:

- Import
  - opalsImport
- Pointdensity
  - opalsCell , opalsZzcolor
- DSM
  - opalsGrid, opalsZcolor, opalsShade
- Mask
  - opalsAlgebra
- Difference model
  - opalsDiff
- Repeat the processing steps with the fine-georeferenced data (see SB2004)

see → **run_all.bat**

Results: Point density



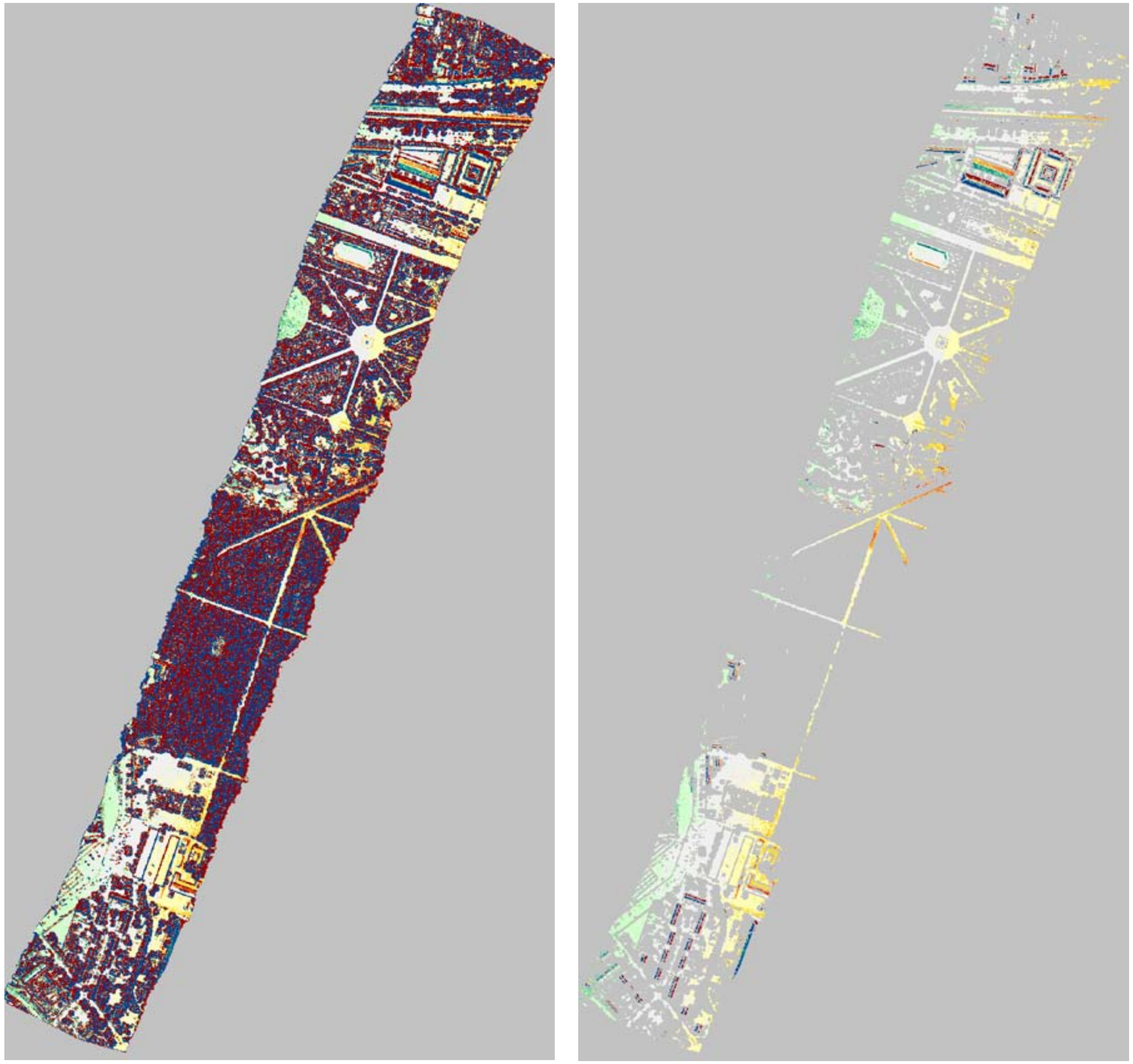
Opals Palette

"Scaleable Density Palette"

Hint on rows in palette definition: all values

Value	Color
BG	194, 194, 194
UF	242, 12, 12
0.500	242, 161, 12
0.750	242, 229, 12
1.000	161, 200, 40
2.000	100, 165, 45
3.000	45, 135, 47
4.000	2, 91, 51

Result: Strip differences



Opals Palette

"Scaleable Differen

Hint on rows in palette definitio

Value	Color
BG	194, 194, 194
UF	153, 0, 0
-0.200	235, 61, 0
-0.160	249, 151, 63
-0.120	249, 221, 63
-0.080	255, 254, 182
-0.040	240, 240, 240
0.000	241, 241, 241
0.040	208, 254, 202
0.080	128, 219, 149
0.120	41, 171, 136
0.160	2, 132, 140
0.200	0, 68, 144