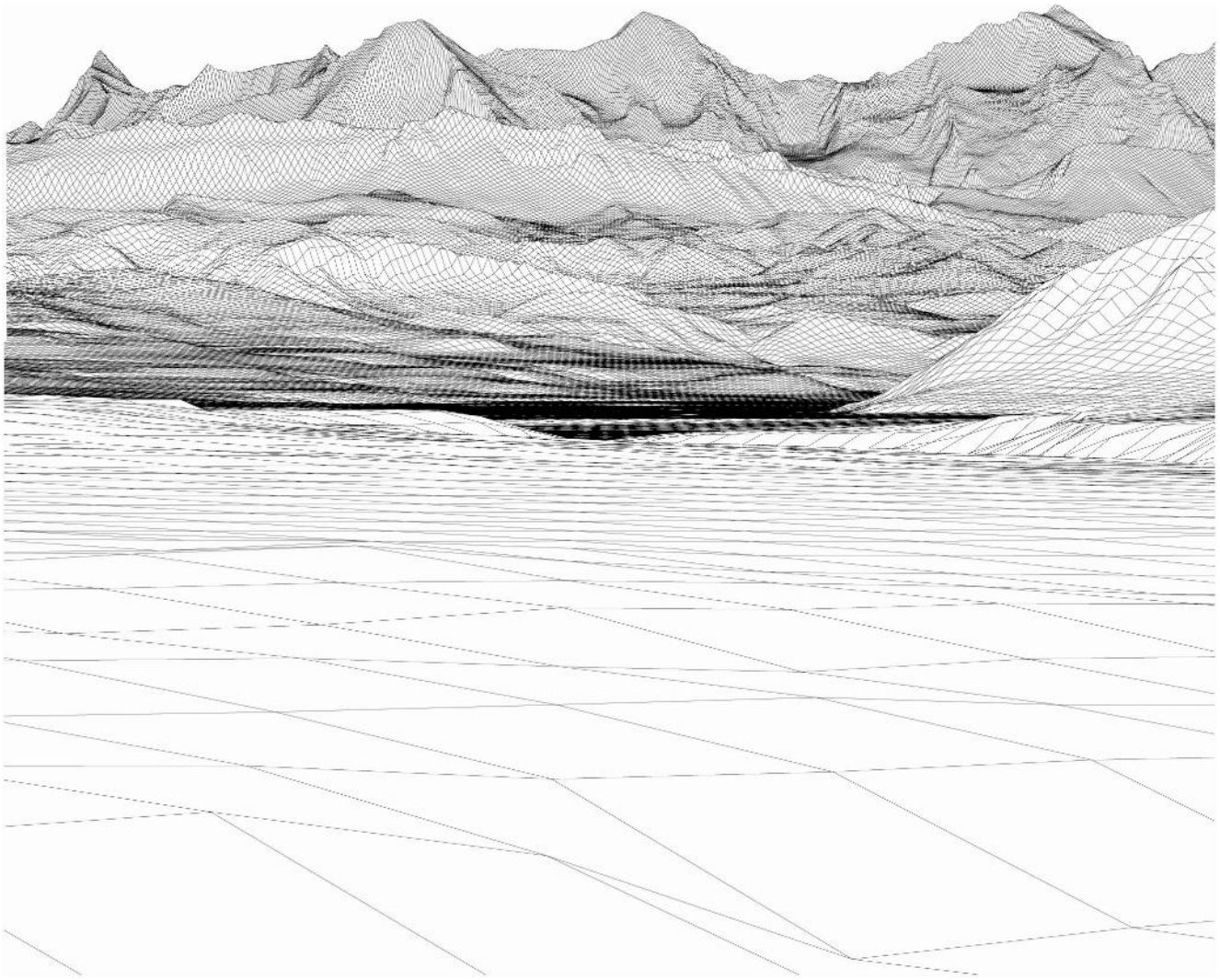
swisstopo

Bundesamt für Landestopografie
Office fédéral de topographie
Ufficio federale di topografia
Federal Office of Topography

DHM25

The digital height model of Switzerland



Bird's eye view of the DHM25: View from the terrace by the capitol building towards the Bernese Alps
Mesh model (type DIGIRAMA®GIT), computed with the program SCOP

Product information

June 2004

Table of Contents

0 Frequently asked questions

0.1 What is the DHM25?

The digital height model DHM25 is a data set representing the three-dimensional form of the earth's surface. It was essentially derived from the height information of the Swiss National Map 1:25,000 (NM25).

0.2 In what form is the DHM25 available?

The "basis model" consists of the digitized contour lines and spot heights of the NM25. A symmetric 25-m grid "matrix model" corresponding to a mm-grid on the NM25 is interpolated from the basis model. Matrix models with larger grids (50 m, 100 m or 200 m) are also available.

0.3 What are the accuracy standards of the DHM25?

The DHM25 is based on the National Map 1:25,000 and basically corresponds to that accuracy. Comparisons with photogrammetrically determined control points show that the average accuracy reaches 1.5 m for the Swiss Plateau and the Jura Mountains, 2 m for the pre-Alps and Canton Ticino, and 3 m for the Alps. The older height model RIMINI (see separate product information) is suitable for applications with reduced accuracy requirements.

0.4 What is the DHM25 for?

The DHM25 can be used in all kinds of computer applications calling for topographic information of the earth's surface. It is the basic data set for geographic information systems (GIS) and can be used for computing profiles, simulating avalanches, making terrain models, analyzing visibility studies, planning the placement of antennas, visualizing scenic pictures, etc. The range of applications is very broad.

0.5 What is covered by the DHM25?

The DHM25 covers the perimeter of the National Map 1:25,000. To the west, north and east the perimeter extends to the area covered by the National Map 1:50,000 (see Chapter 4.1).

0.6 How can the DHM25 be ordered?

To order the DHM25 use the form under http://www.swisstopo.ch/pub/down/products/digital/height/dhm25_order_de-fr.pdf . It can also be ordered directly online under http://www.swisstopo.ch/en/shop/ . The basis model as well as the matrix model may be obtained in different data formats. Two of the formats produced by our office are described in detail (see Chapter 3).

Test data sets for both models in different formats are available free of charge over the Internet (http://www.swisstopo.ch/en/download/testdata/height/dhm25).

Further information to the DHM25 can be found on our web site http://www.swisstopo.ch/en/products/digital/height/dhm25 . Should you require something that you cannot find among our standard products, we would be happy to work out an offer for your personalized individual product.

A written contract is drawn up for licensed data. The data will be delivered on a CD-ROM within 2 weeks upon receipt of the order.

Information:

swisstopo
Federal Office of Topography
Seftigenstrasse 264, Postfach
CH-3084 Wabern
Phone: +41 31 963 21 11
Fax: +41 31 963 24 59
Email: geodata@swisstopo.ch

1 Description

1.1 Types of models

1.1.1 DHM25 basis model

Digitized height information content of the NM25 using the following elements:

- linear elements:
  - vectorized contours and contours in lakes
  - vectorized lake perimeters
  - main breaklines in the Alps
- point elements:
  - digitized spot heights and depth spot heights in lakes

The number of height values per area depends essentially on the density of the contours on the map image and is therefore not constant. It varies between approx. 7500 and 335,000 values per sheet or 35 to 1600 values per km^2. Each value is defined and stored by its x/y/z coordinates and its category.

Due to technical reasons it was not possible to close all of the contour lines in steep terrain. However, all of the index contours (100 m) of the NM25 are closed. The contour lines under overhanging cliffs are always open.

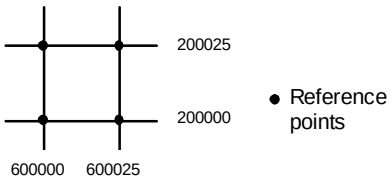
The basis model was originally intended to be only an intermediate product for producing and interpolating the matrix model. Because of various requests it is now available as a separate product. It is especially interesting for those users who want direct access to digitized original data instead of interpolated contours.

The DHM25 represents the topography of the earth's surface without vegetation or built up areas. Since 1995 the rest of the map elements of the NM25 (traffic and hydrographic networks, primary surfaces, etc.) are being stored in the scope of the project VECTOR25 which is described in a separate product information.

1.1.2 DHM25 matrix model

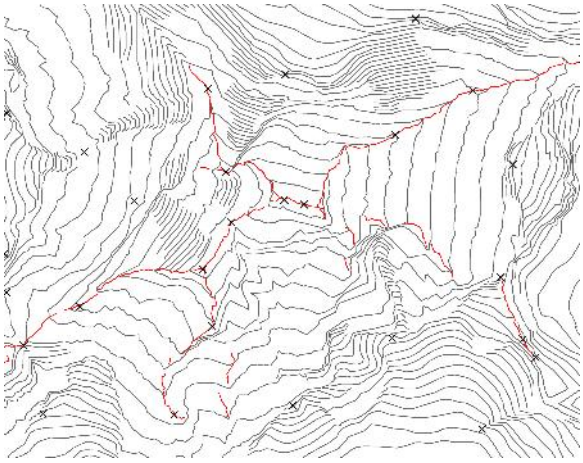
This model is a height matrix with a 25-m grid corresponding to a mm grid superimposed on a NM25. The complete matrix of an entire NM25 contains 701 x 481 heights (a total of 337,181 values or 1600 values per km^2).

The matrix model is derived from the basis model through interpolation. The number of height values per area is constant. Since the coordinates x and y are implicitly given by the matrix structure, only the height value z is stored with each point. The height values correspond to the corners of the matrix cell and therefore *do not* represent its mean height.

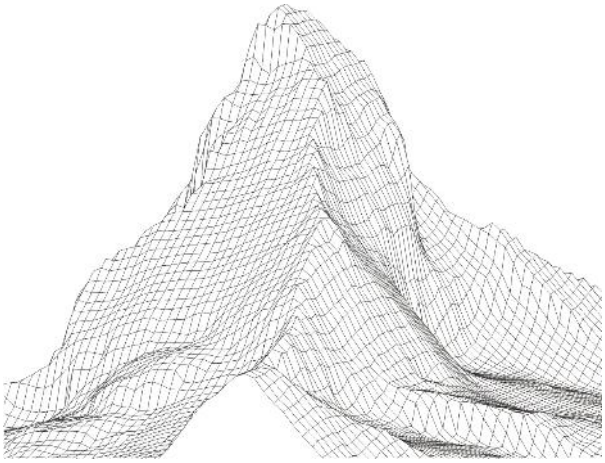


Because only one value can be stored for each matrix point, overhanging topography can only be modelled by very steep gradients. Lakes are represented by their surface. No additional information concerning the use of the terrain is stored in the matrix model.

For applications with reduced accuracy requirements, a larger grid can be extracted from the original matrix. This extraction is a selection, meaning that also in this case the corner heights of the matrix cell are the actual heights of those points and not a mean height. The names of these models correspond to the size of the grid, e.g. DHM25/50, DHM25/100 or DHM25/200



DHM25 basis model: summit of the Matterhorn



DHM25 matrix model: perspective representation of the Matterhorn

1.2 Perimeter

The DHM25 covers the entire area of the National Map 1:25,000 with 249 models (sheets within the interior perimeter of Switzerland with 52,290 km^2). Using the same procedure, the data set was extended in the west, north and east by an additional 29 models (6090 km^2) to include the area covered by the National Map 1:50,000 (this extended perimeter contains only foreign territory). The overlap of the NM25 to the south consists of 7 partial models (a total of 121.75 km^2). The entire DHM25 consists of 280 models with an area representing approx. 58,500 km^2.

A single DHM25 model corresponds to a sheet of the National Map 1:25,000 which covers 17.5 km in the east-west direction and 12 km in the north-south direction.

1.3 Accuracy

1.3.1 DHM25 basis model

The course of the digitized contours and lake contours is a highly accurate representation of those on the map. Deviations from the original map contours should remain within the cartographic tolerance of 0.1 to 0.3 mm (corresponds to 2.5 to 7.5 m in reality). For technical reasons slight deviations are possible, especially where there is a strong curvature of the contours. In areas where the contours are incomplete (usually in rock or scree), differences to the "true" course of the contours may occur because such gaps have to be completed and closed manually through visual interpretation of the map. The correct height assignment of the contours is screened by different tests.

1.3.2 DHM25 matrix model

In order to obtain precise error indications, it would be necessary to have directly measured matrix heights. Since this is not the case, the accuracy of the matrix model can only be estimated by a bilinear interpolation of the "model heights" of arbitrary control points and comparing these to their reference value. The map in Chapter 4.2 contains the following information:

1st number: mean error of the matrix model from the spot heights of the basis model. Because these heights were used in the triangulation method, this test is correlated. However, it is still possible to provide information as to the expected errors. Since primarily topographic extremes such as mountain tops, hills and valleys are tested, it may therefore be assumed that the errors along more "standard" terrain are significantly lower.

2nd number: mean error of photogrammetrically determined control points. These were compared to the reverse interpolation from the basis model. Such values are available for approx. 170 sheets, and a total of 5600 control points were used. Contrary to the above estimation, this one is uncorrelated.

3rd number: the same as the 2nd number, except that the values from the matrix model were used for the estimation. In comparing this value with the 2nd number, the resulting order of magnitude indicates the loss of accuracy due to the interpolation.

Because the NM25 of the Italian Alps contain only sparse topographic information, large errors may occur in these areas.

1.4 Revision status

The status of the DHM25 corresponds to that of the initial capture and digitization of the elements for the basis model except for glacial regions, which were updated in winter 2000/2001 (Chapter 4.1).

Because the topography of the earth's surface usually doesn't change very much, deviations from the actual situation are only very local (e.g. quarries).

1.5 Quantity of data

The quantity of the data varies with the type of model and the data format.

1.5.1 DHM25 basis model

The output file of a basis model with 7500 to 335,000 points in the BMBLT format requires between 0.5 and 13.3 Mbytes; the DXF format requires about 67% more, ArcInfo Generate about 20% fewer, and the ArcView shape files about 15% fewer Mbytes.

1.5.2 DHM25 matrix model

The output file of a matrix model with 337,181 height values in the MMBLT format requires about 2 Mbytes and correspondingly less for matrices with a larger grid. Models in the format ArcInfo Grid also require 2 Mbytes, whereas the XYZ format requires 10 Mbytes.

1.6 Geodetic reference system

The DHM25 is based on the same geometric basis and geodetic datum as the National Maps (for further details see: http://www.swisstopo.ch/en/basics/geo/system/refsystemCH and http://www.swisstopo.ch/en/basics/geo/system/projectionCH respectively.)

1.6.1 The Swiss geodetic datum "CH1903“

- Reference ellipsoid: Bessel (1841)
- Fundamental point: old observatory Bern with the coordinates 600000 / 200000
- Height reference: Repère Pierre du Niton (RPN): 373.6 m (since 1902)
- Official heights: approximated orthometric heights

1.6.2 Swiss map projection

The projection system used in Switzerland is an oblique conformal cylindrical projection. For special applications the data can be transformed into other geodetic reference systems (e.g. WGS84) and other projections systems such as Transverse Mercator, Gauss-Krüger, UTM, Lambert, geographical coordinates, etc. If transformations are required, the user must specify the reference system and projection.

2 Production

2.1 Concept of levels

Based on the elements contained in the basis model as well as the type of interpolation of the matrix model, the quality of the DHM25 is described in so-called levels. Level 2 has been available since mid-2001. Its increased quality as compared to Level 1 consists of:

- integration of the Alpine main breaklines
- revised contours on glaciers
- topological improvement of the basis model
- new interpolation of the matrix model

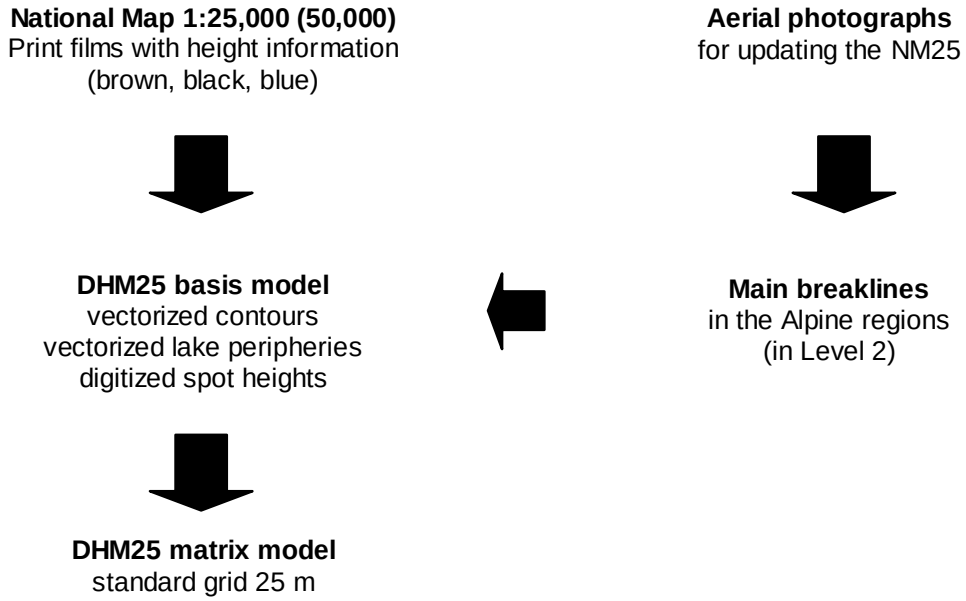
Errors in the data of Level 1 which were reported by users were incorporated in the so-called revision atlas and automatically corrected for Level 2.

Only very general indications can be made regarding the scope of the improvements from Level 1 to Level 2.

The information to the model versions (revision status of the elements, date of interpolation) can be found in the data preparation logs which are contained on the CD-ROM as text files. It is recommended that these files be saved.

2.2 Further information on the production of the DHM25 Level 1

Between 1984 and 1996 the DHM25 was derived from the height content of the National Maps 1:25,000 (NM25) and 1:50,000 in the scope of project DIKART (DIgitale KARTe = digital map) according to the following steps (so-called "initial capture" of Level 1).



2.2.1 National Map 1:25,000 (NM25)

The NM25 is the basis for the DHM25. The 249 sheets of this map series were produced between 1952 and 1978, whereby the original cadastral plans from the land register as well as surveys carried out by swisstopo itself were cartographically revised. Since then the maps are being revised in a 6-year cycle using aerial photogrammetry. In the highly complex map image the height information is available in three colors, namely in brown (contours on the normal surface), black (contours in rock and scree, spot heights) and blue (contours on glaciers and in lakes).

2.2.2 DHM25 basis model

In the first major step, the DHM25 basis model was extracted from the NM25 (vectorized contours and lake peripheries as well as digitized spot heights). The spot heights were captured manually on a digitizing table. The extraction of the linear elements was much more time-consuming. At first the print films were scanned with a resolution of 16 lines/mm. Using modern image processing methods, a complete image of the contours and lake peripheries was obtained. After resolving the transitions from one sheet to the next in the raster format, these linear elements were vectorized and assigned a height. This process, like the entire extraction process, was carried out in part automatically and in part interactively. The same procedure was followed for the foreign territory to the north, east and west using the National Map 1:50,000.

2.2.3 DHM25 matrix model

Level 1 of the matrix model was interpolated from the basis model with the program "dhm_int" which was developed jointly by the Federal Office of Topography and the Institute for Geodesy and Photogrammetry at the Swiss Federal Institute of Technology in Zürich (ETHZ). This program uses profiles in 8 different directions for calculating the matrix heights. Three independent tests were used to check the data and, where necessary, the basis model was corrected.

2.3 The operations for Level 2

2.3.1 DHM25 basis model

Because the course of breakline heights is not visible on the map, the main breaklines in the Alpine area had to be restituted photogrammetrically. This was done in the process of the normal map revision. These new elements were then integrated into the map-based part of the basis model in such a way as to avoid any contradictions (quality increase).

In order to guarantee a certain quality, the glacier contours were updated manually by digitizing on screen or from the photogrammetric restitution of the revised elements in the most recent edition of the pixel maps. Furthermore, the contour lines and the lake contour lines along the edges of the sheets were closed. Prior to the interpolation of the matrix model, the contours and the lake contours were oriented so that the terrain ascends to the left of the direction of orientation. At the same time a few unnoticed intersecting contours were corrected, and all of the reported errors in Level 1 were eliminated.

2.3.2 DHM25 matrix model

The matrix model was re-interpolated using the program "mesh_z" developed by swisstopo, which applies an improved triangulation network. This interpolation was carried out on Level 2 of the basis model which also includes the river axes from VECTOR25.

A new quality has been achieved with Level 2 of the DHM25 whereby the largest main breakline errors in the Alpine regions were eliminated, and at the same time the topology of the basis model was improved.

3 Formats

Only the special formats generated by swisstopo are described in this chapter. For information about other formats, please consult the manufacturers.

3.1 DHM25 basis model: Output format BMBLT

3.1.1 Description

Each point of the basis model in the output format BMBLT consists of 1 record (line) of 40 bytes (characters). The columns contain the following information:

Columns 1-2:	type of element:	KU = contours and intermediate contours LA = lake perimeters TR = spot heights BK = breaklines SK = contours in lake TS = spot heights in lake
Columns 3-6:	line number for spot height for	KU, LA, BK and SK, or TR and TS
Column 8:	type of line:	O = open line G = closed line
Columns 11-18:	west-east coordinate [m.dm]	
Columns 21-28:	south-north coordinate [m.dm]	
Columns 31-36:	height [m.dm]	
Columns 39-40:	code:	21 = starting point of a line (for KU, LA, BK and SK) 22 = continuation of a line 23 = end point of a line 11 = single point (for TR and TS)

3.1.2 Example

```
1         2         3         4
12345678901234567890123456789012345678901234567890        Remarks

KU   1 G  527876.5  157117.2   510.0  21        contour 1 (closed)        start
KU   1 G  527912.5  157125.0   510.0  22                                  continuation
.....                                                                    etc.
KU   1 G  527876.5  157117.2   510.0  23                                  end
KU   2 O  515606.3  157998.4   910.0  21        contour 2 (open)          start
KU   2 O  515592.2  157973.4   910.0  22                                  continuation
......                                                                   etc.
KU   2 O  515001.6  157400.0   910.0  23                                  end
......                                                                   etc.

KU 982 G  529951.5  157431.3   410.0  21        contour 982 (closed)      start
KU 982 G  529978.1  157434.4   410.0  22                                  continuation
......                                                                   etc.
KU 982 G  529951.5  157431.3   410.0  23                                  end
LA   1 O  532500.0  151106.3   372.0  21        lake contour 1 (open)     start
LA   1 O  532490.6  151098.4   372.0  22                                  continuation
......                                                                   etc.
LA   1 O  520782.8  146001.6   372.0  23                                  end
LA   2 O  515945.3  146000.0   372.0  21        lake contour 2 (open)     start
LA   2 O  515998.4  146025.0   372.0  22                                  continuation
......                                                                   etc.
LA   2 O  519543.8  146004.7   372.0  23                                  end
......                                                                   etc.
TR   1    515037.5  157737.5  1031.0  11        spot height no.1
......                                                                   etc.
TR 981    521592.1  146870.3   395.0  11        spot height no. 981
```

3.2 DHM25 matrix model: Output formats MMBLT and MMBL

The MMBLT format of the matrix model contains the header and the data records in one file. The following example shows a section from the test data set Albis.

3.2.1 Header

The header contains information concerning the geometry:

```
NEWHEADER
------------------------------------------------------------------------------
DHM25-MATRIXMODELL LEVEL 2                    (c)BUNDESAMT f.LANDESTOPOGRAPHIE
------------------------------------------------------------------------------
NORD-WEST ECKE     [M]  680900.0  235100.0     ERSTER HOEHENWERT
SUED-OST ECKE      [M]  681100.0  234900.0     LETZTER HOEHENWERT
MASCHENWEITE WE/NS [M]      25.0      25.0
MATRIXDIMENSIONEN WE/NS      9         9       Total       81 MATRIXPUNKTE
HOEHENBEREICH     [DM]    6486      6904       (6 CHARACTER PRO HOEHENWERT)
------------------------------------------------------------------------------
FORMAT                    ASCII               L+T-FORMAT DHM25-MATRIXMODELL
RECORDLAENGE(CHAR.)        2040               340 HOEHENWERTE PRO RECORD
------------------------------------------------------------------------------
ENDHEADER
```

3.2.2 Data records

The data records appear after the title ENDHEADER. They consist of 2040 characters per record (line) which corresponds to 340 height values at 6 characters each. The heights are stored sequentially from west to east and are given in decimeters (integer). The actual distance between two neighboring points is given by the size of the grid. The first value represents the height of the northwest corner of the extract, and the last value represents the height of the southeast corner. Therefore, the first row of n values of the m by n matrix is the northernmost west-east row of points, the next row of n values the next west-east row, and so forth. For the above test data set Albis, this looks as follows:

```
6855 6855 6855 6851 6851 6837 6824 6815 6808 6855 6857 6858 6858 6850 6839 etc.
     most northern matix row (9 values) --->1<--- second most northern matrix row etc.
```

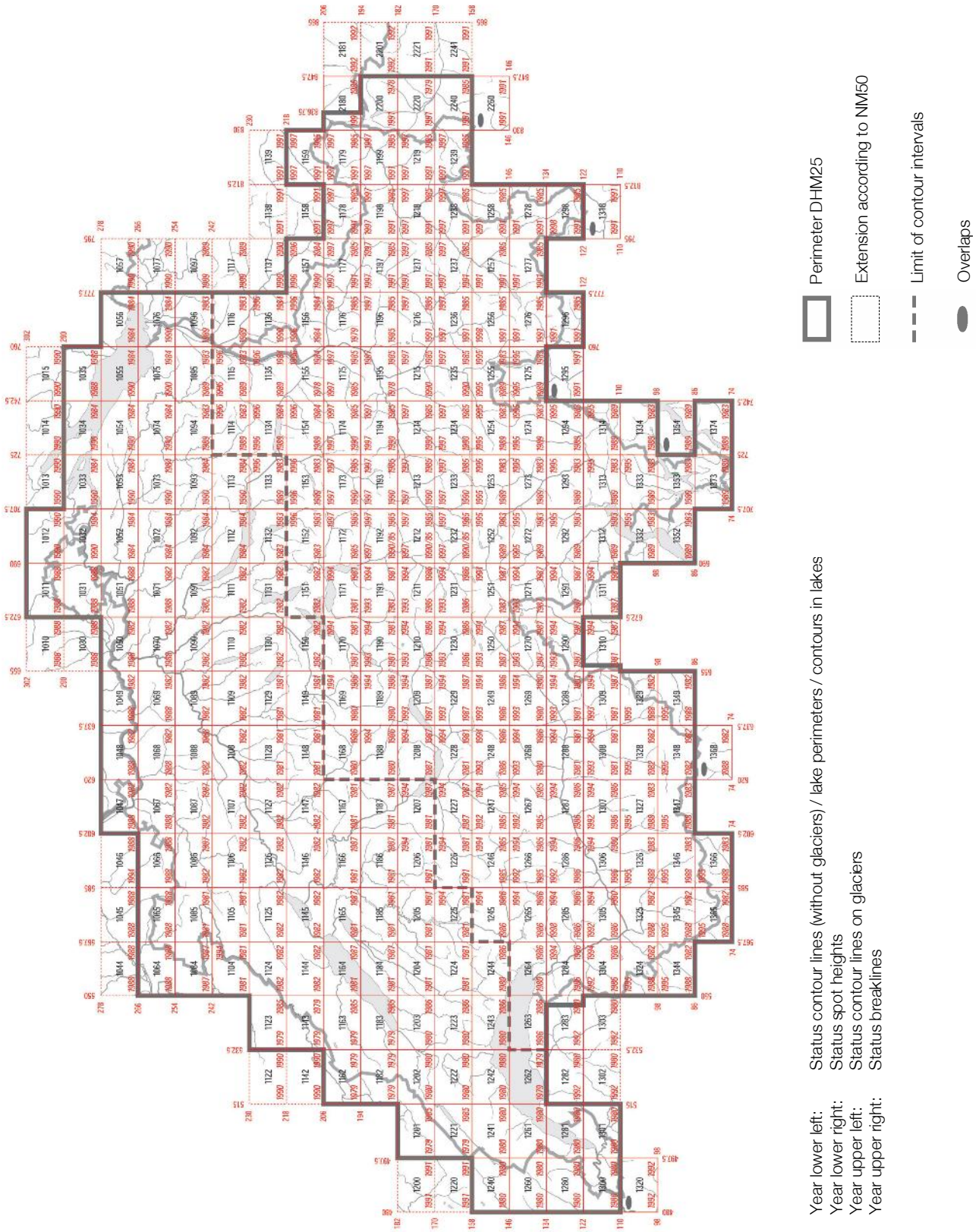
Besides this sequential format MMBLT, it is possible to generate the matrix format MMBL in which the record length represents the number of values per matrix row. This format is suitable for importing height data into spread sheet programs. The file from the above example would look like this:

```
6855 6855 6855 6851 6851 6837 6824 6815 6808
6855 6857 6858 6858 6850 6839 6826 6814 6809
6854 6863 6865 6865 6849 6840 6826 6812 6803
6853 6852 6873 6886 6886 6853 6822 6804 6748
6847 6848 6886 6902 6904 6855 6808 6762 6686
6850 6859 6903 6903 6881 6806 6739 6681 6615
6845 6857 6879 6856 6795 6706 6638 6589 6539
6801 6827 6825 6769 6670 6597 6562 6522 6497
6736 6760 6735 6661 6592 6546 6517 6492 6487
```

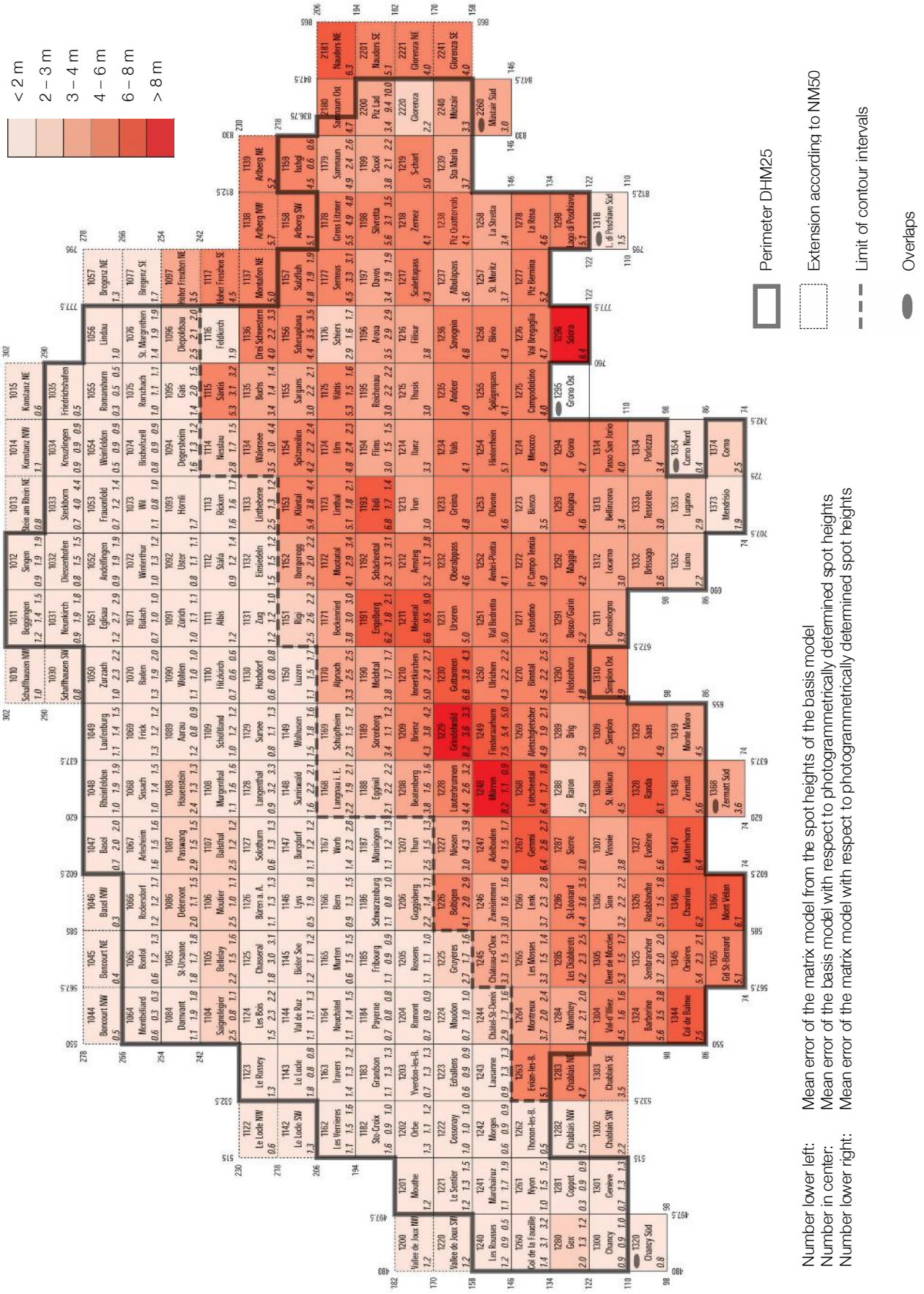
The output formats are subject to change!

4 DHM25 maps

4.1 DHM25: Perimeter and status



4.2 Accuracy estimations of the DHM25 Level 2



5 Orders

5.1 Standard products

All of the products found on the order form http://www.swisstopo.ch/pub/down/products/digital/height/dhm25_order_de-fr.pdf or online http://www.swisstopo.ch/en/shop/ are considered standard products. The following parameters are required when ordering:

Model forms (see Chapter 1.1)

- matrix model with a grid of 25 m, 50 m, 100 m or 200 m
- basis model
- both models

Perimeter

- entire data set
- all of Switzerland
- sheet 1:25,000 (name or number)
- coordinates of the lower left and upper right corners of a rectangle
- any polygon (ASCII file with line format <x coordinate>, <y coordinate>)

The DHM25 was produced with respect to the sheet index of the NM25. Therefore, a model corresponds to the area of a 1:25,000 map sheet of 17.5 km in the east-west direction and 12 km in the north-south direction without any overlaps. The numbering system of the NM25 was changed slightly so that the model numbers have only numerical values (e.g. the number for NM 1219bis was changed to 2220). For orders of the entire data set, all of Switzerland or of a few sheets, the standard form of delivery is per model (one file per NM25 sheet). As a rule rectangular extracts or polygons are delivered as a single file. However, with the respective indications, any order may be delivered as one file or several smaller files.

Data format

DHM25 basis model

- ESRI Shapefiles
  This format contains the following additional information (attributes) per element/object:
  - ObjectId (explicit code)
  - ObjectVal (type of element)
  - ObjectOrigin (origin)
  - YearOfChange (status)
- BMBLT: format for swisstopo basis model (standard, see Chapter 3.1)
- DXF: Drawing Interchange Format (linear elements as three-dimensional POLYLINE, point elements as three-dimensional POINTS)
- GEN: ARC/INFO Generate Format

DHM25 matrix model

- MMBLT: format for swisstopo matrix model.
  Length of record 2040 (standard, see Chapter 3.2) with 340 height values per record
- MMBL: same as above but length of record corresponding to the number of height values per matrix record (e.g. suitable for importing in spread sheets (EXCEL file))
- AIGRID: ARC/INFO ASCII Grid Format
- XYZ: coordinate list with X, Y, Z
- DXF: Drawing Interchange Format. Variation POLYMESH (grid, standard), POLYFACE (surface model) or POINTS (single points)
- VRML: Virtual Reality Modelling Language

Formats are subject to change.

Transfer medium

The standard transfer medium is the CD-ROM. Other transfer media are available upon demand. Delivery is within 2 weeks upon signing of the contract. Test data sets in the above-mentioned formats may be downloaded free of charge under http://www.swisstopo.ch/en/download/testdata/height/dhm25 .

5.2 Services

As a customer service, swisstopo offers various products derived from the DHM25 for customers who have neither the necessary IT infrastructure nor the data. There are two basic kinds of applications and services.

Standard derivatives for frequent applications such as:

- Hill shading: shaded relief of a surface
- DIGIRAMA® Standard: panoramic view from any arbitrary point
- Visibility analyses: Is it possible to see from point A to point B?
- Skyplots: representation of the horizon in an azimuthal projection

Services for special investigations and for more demanding applications such as:

- DIGIRAMA® de luxe (for panorama panels) or PRINT (for printed products)
- Visibility analyses in high print quality with indications of the topographic end points
- Profile computations

In order to meet your demands better, we will need precise wording of your request. Further details can be found on the following page http://www.swisstopo.ch/en/products/digital/height/derivate .

5.3 3D viewer software

The DHM25 can be visualized with the freeware «Kashmir 3D» (author: Mr. Tomohiko Sugimoto from Yokohama City). The software program «Kashmir 3D» can be obtained free of charge under http://www.kashmir3d.com along with instructions in English. The MMBLT is a suitable input format for Kashmir 3D.

Swisstopo cannot provide any support for running this program. However, questions may be sent in English or German directly to Mr. Satoshi Iwamatsu at SIwamatsu@aol.com.

5.4 Information and products

Swisstopo will be happy to provide further information by phone or email and will work out individual offers upon request.

swisstopo
Federal Office of Topography
Seftigenstrasse 264, Postfach
CH-3084 Wabern
Phone +41 31 963 21 11
Fax +41 31 963 24 59
Email geodata@swisstopo.ch