Glacier DEM reconstruction based on historical maps: A semi-automated approach

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Outline

- Introduction
- Color separation and image processing
- Vectorization of contour lines
- Manual post processing and problems
- Supported attribution of contour lines
- Glacier outline and spotheights
- Interpolation of DEM
- Visualization
- Conclusions

Introduction (1/2)

- Information of the past stored in historical maps
- e.g. shape of landscape by means of contour lines

- Case of application: Historic DEM generation of glaciers
- Collection of DEMs is being acquired completely manually at the Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH Zurich

  → *www.vaw.ethz.ch*

Introduction (2/2)

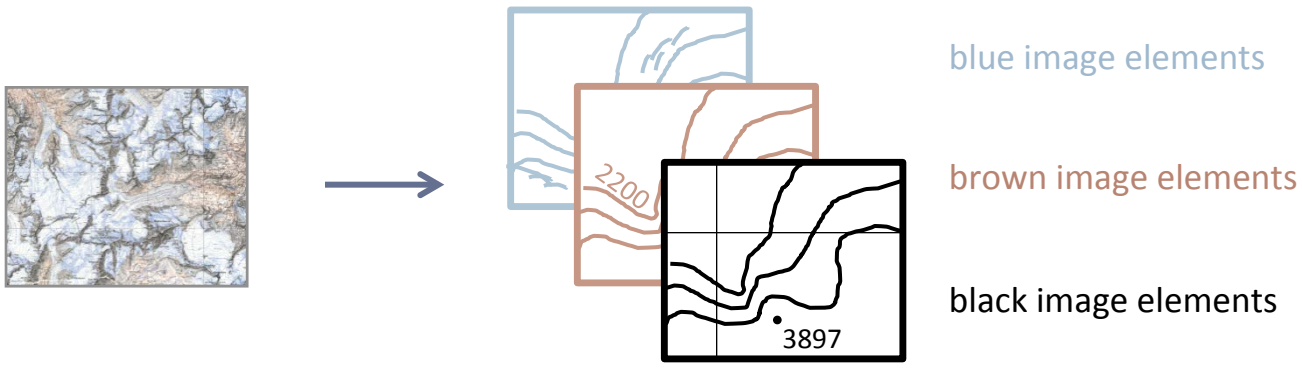
Is there a more efficient process?

- Color image segmentation:
  - → Different color layers
  - → Input for automated vectorization

- Vectorisation:
  - → Lines for DEM interpolation

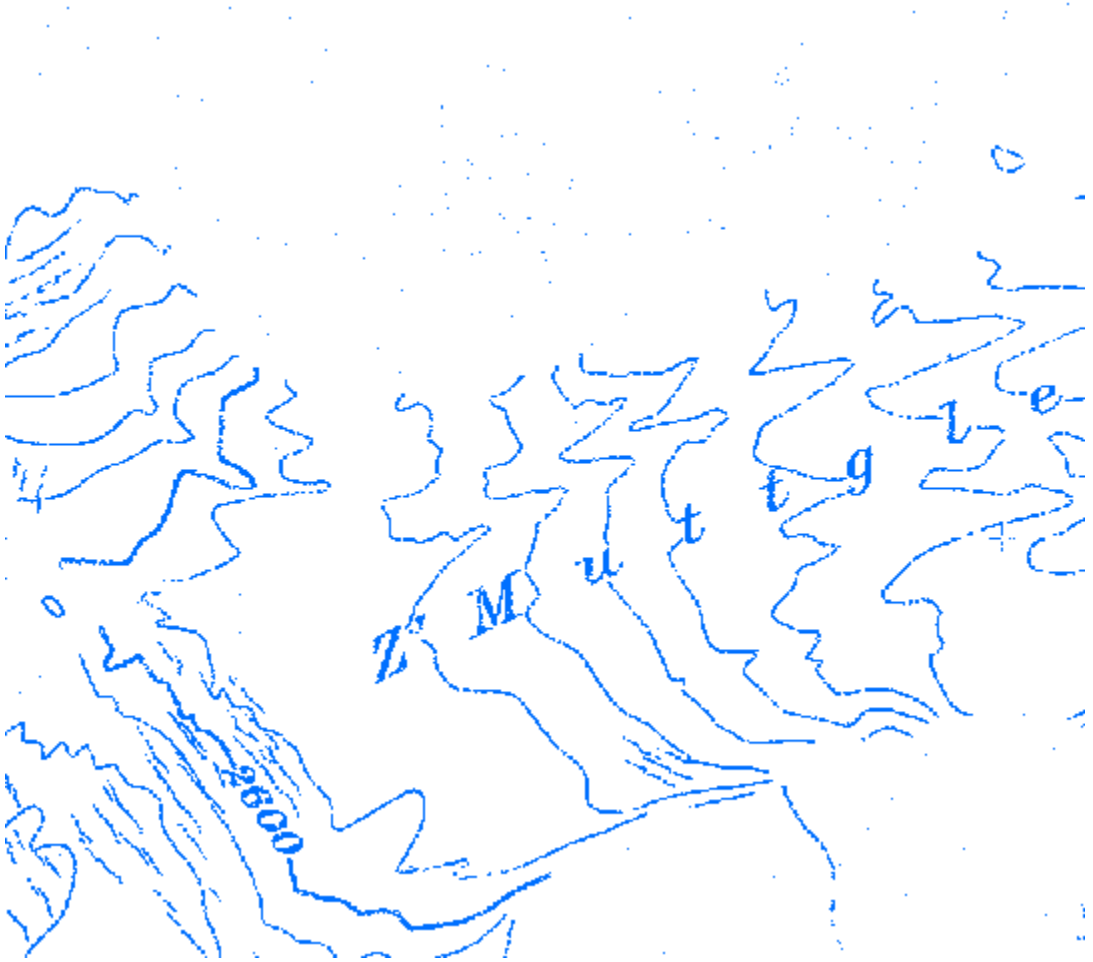
Color separation and image processing (1/2)

- Of interest: print colors Blue, Brown and Black
- Image calculations with different channels and
- Specific filter methods
- Successful color separation e.g. in Adobe Photoshop



Color separation and image processing (2/2)

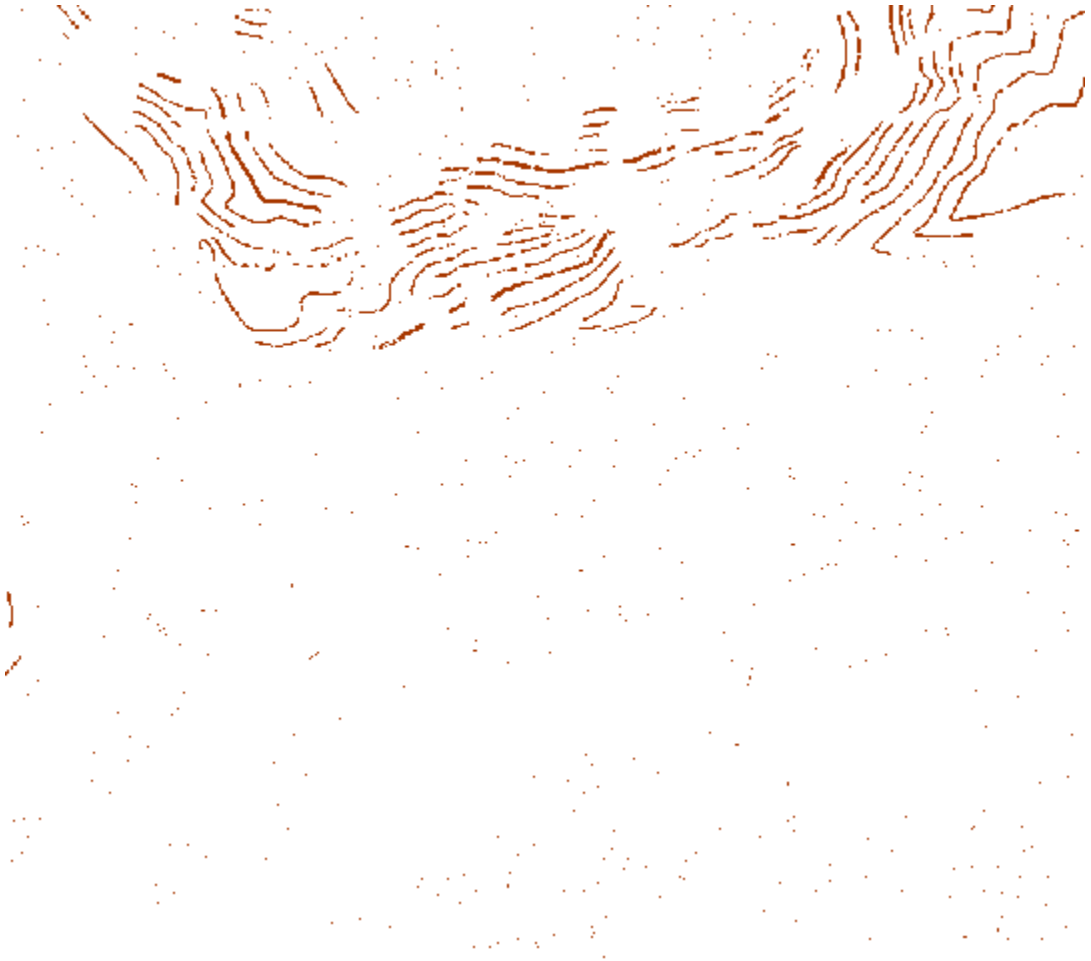
- Blue



[First edition swiss national map 1:50’000, 1946, © swisstopo]

Color separation and image processing (2/2)

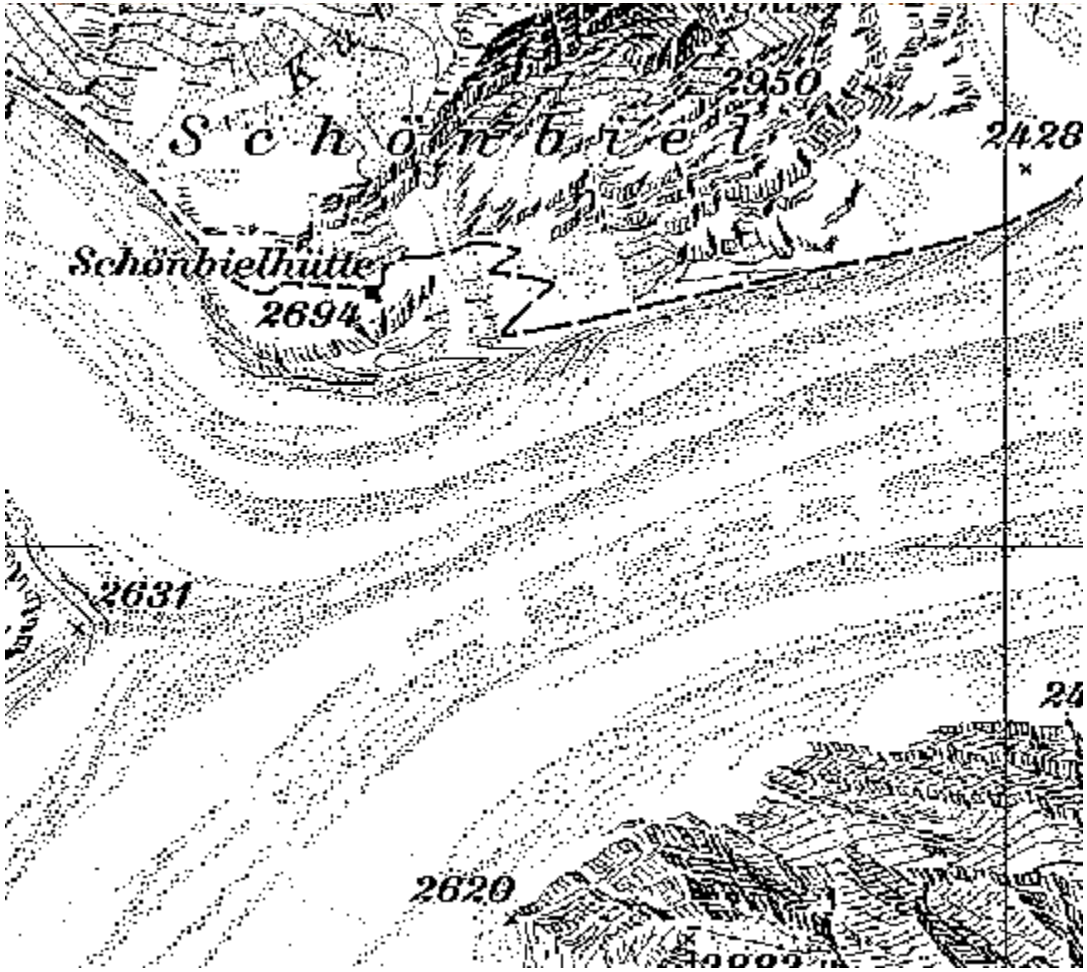
- Brown



[First edition swiss national map 1:50’000, 1946, © swisstopo]

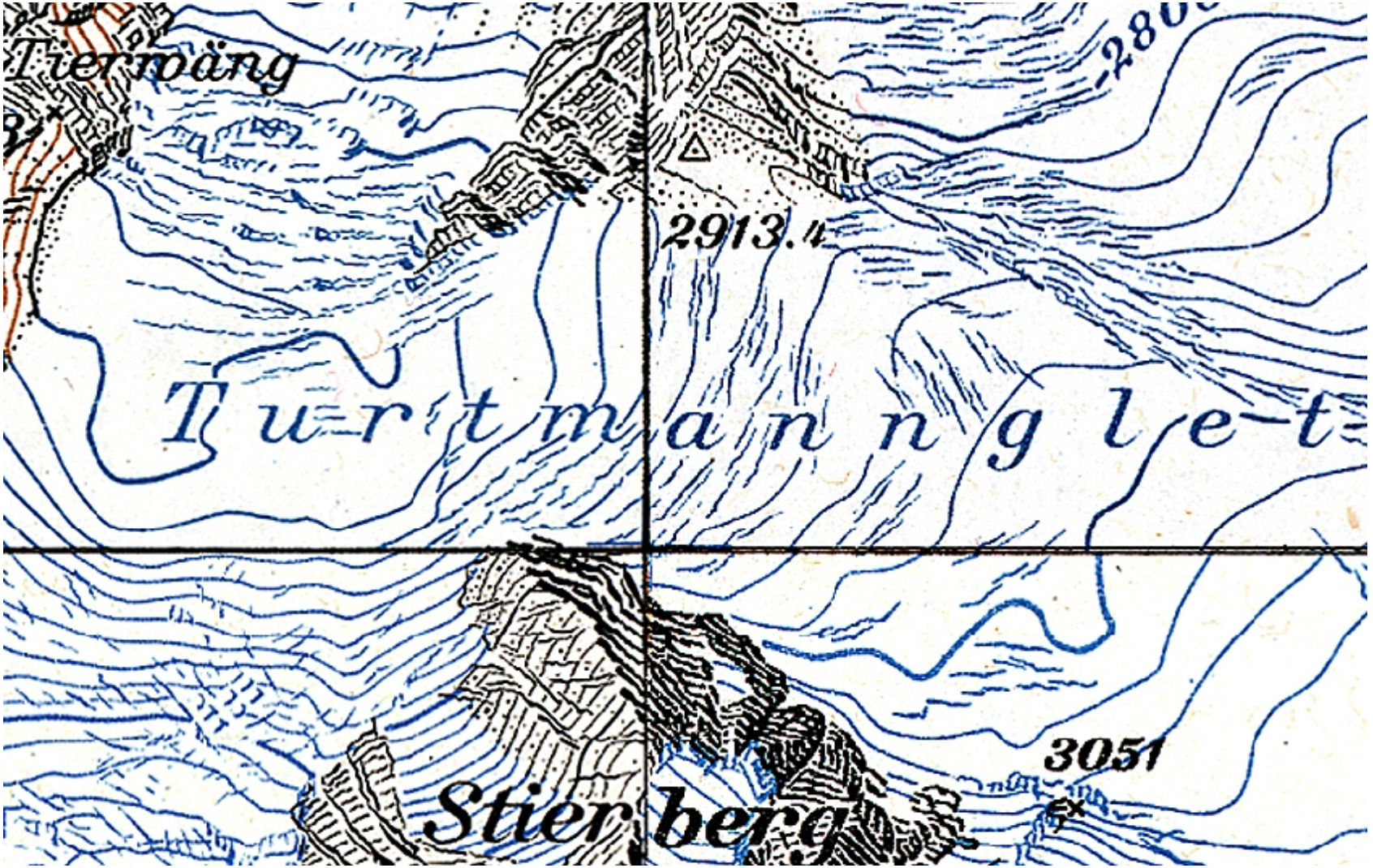
Color separation and image processing (2/2)

- Black



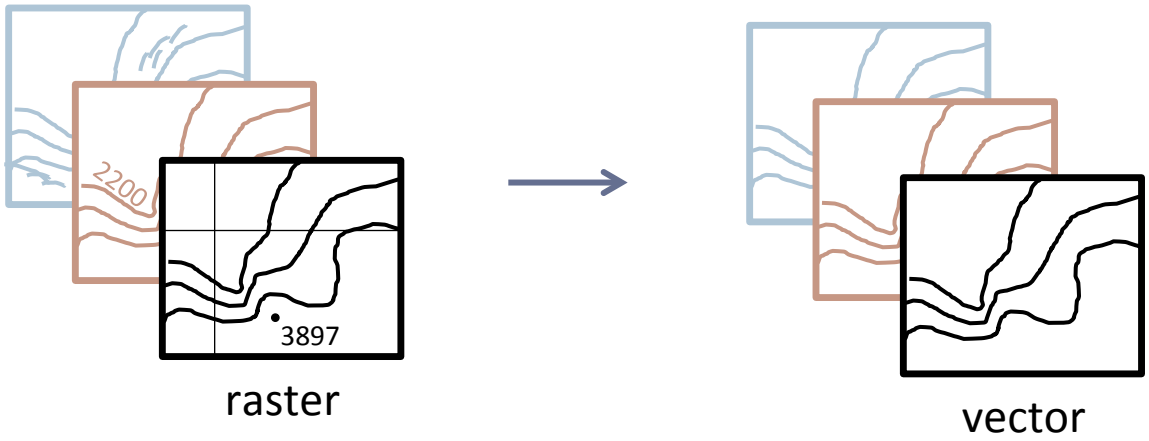
[First edition swiss national map 1:50’000, 1946, © swisstopo]

4 different map originals (printed in different years)

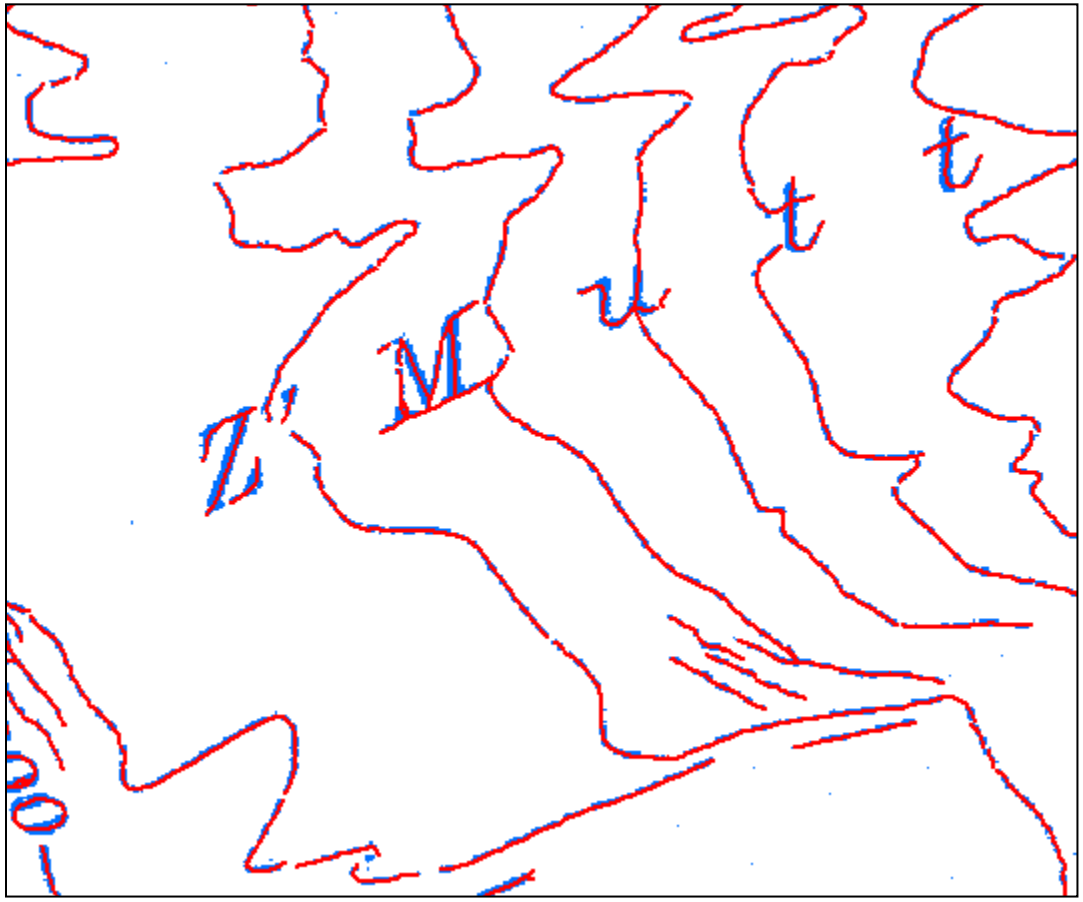


Vectorization of contour lines (1/3)

- Automated vectorization of individual colors
- e.g. with ArcScan Toolbar
- Precondition: “binary” image



Vectorization of contour lines (2/3)

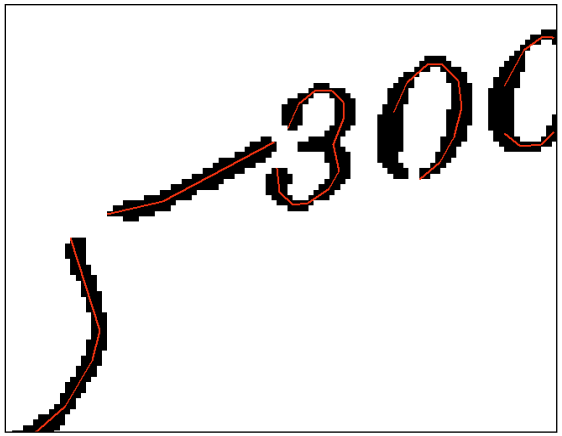


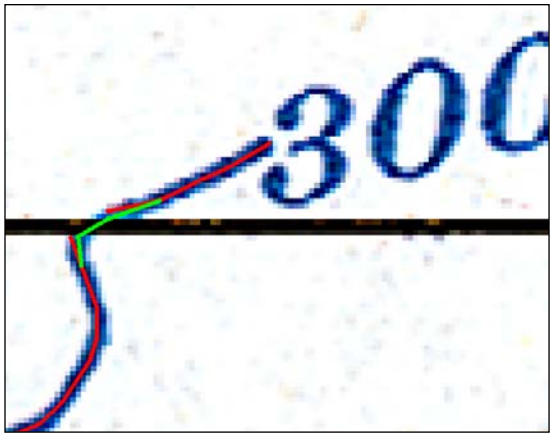
Vectorization of contour lines (3/3)

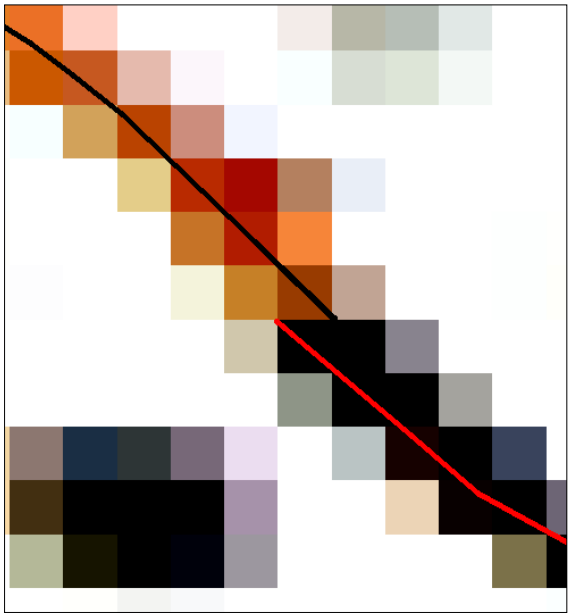
- Results possibly heavily dependent on the settings

Manual post processing and problems (1/3)

- Manual PP unavoidable and still time consuming!
  - Deleting of unwanted objects (labels, rivers, …)
  - Connecting or corrections of contour lines

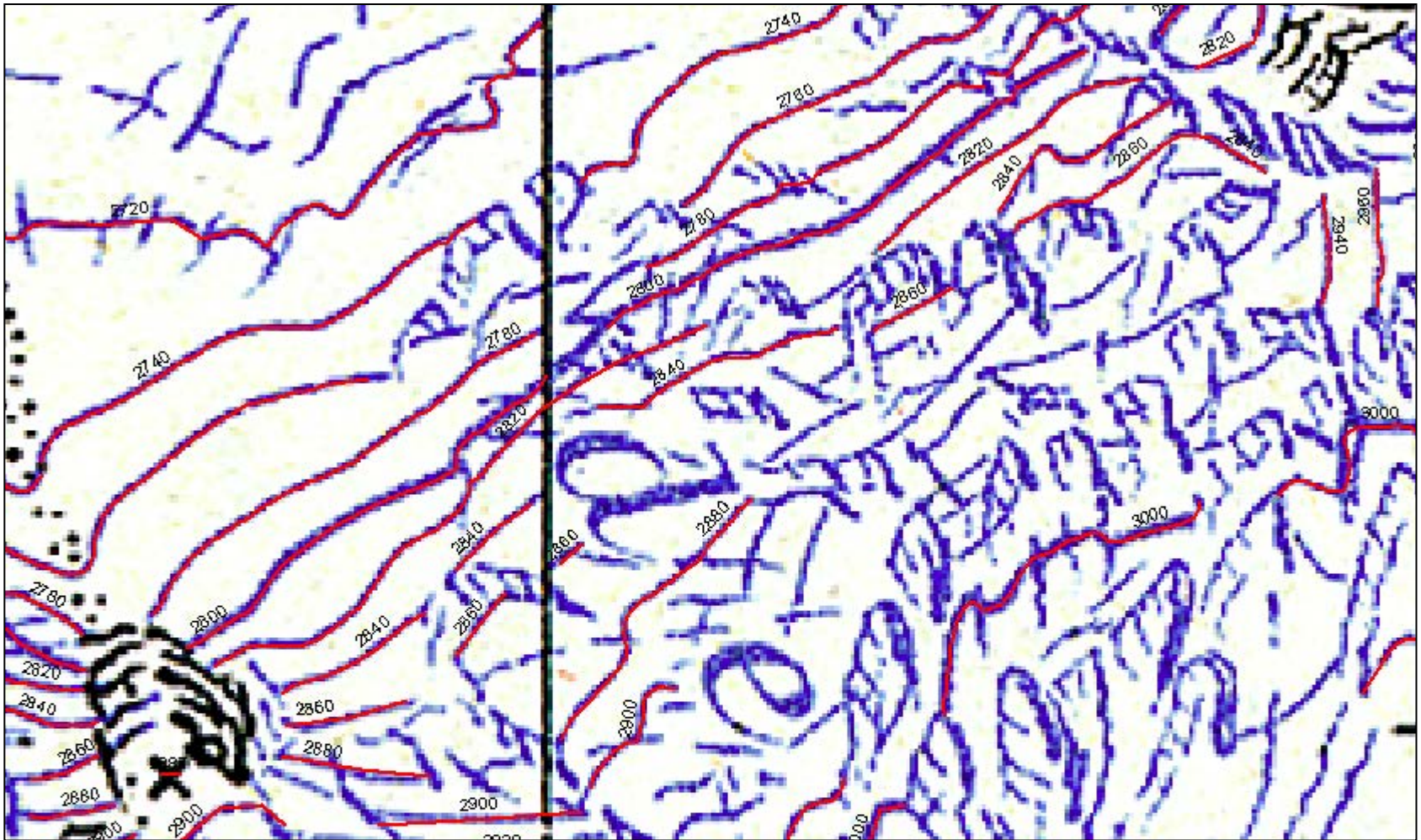






Manual post processing and problems (2/3)

- Problems with ambiguity: e.g. in icefalls

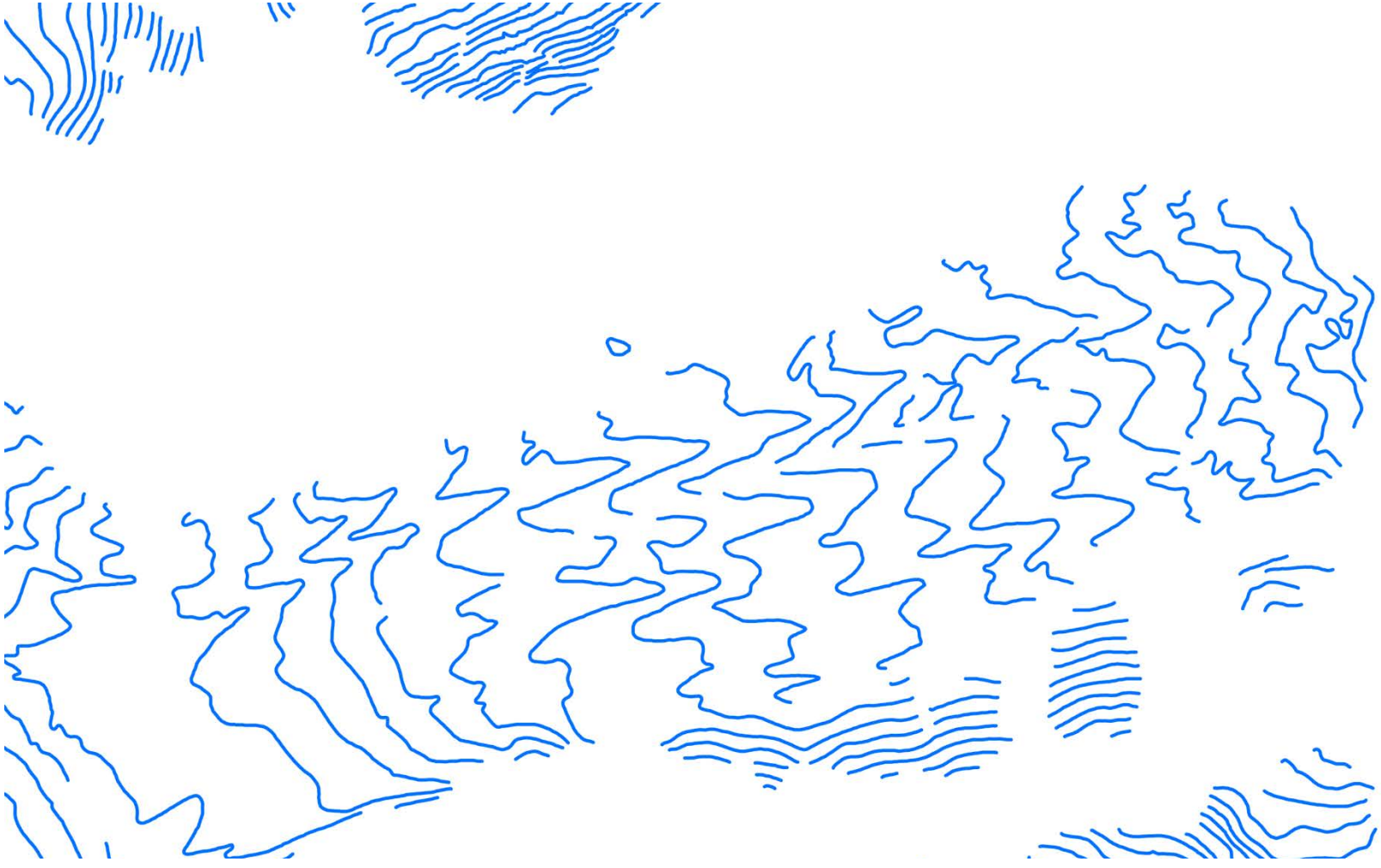


Manual post processing and problems (3/3)

Ischmeer, Berner Oberland (Switzerland)

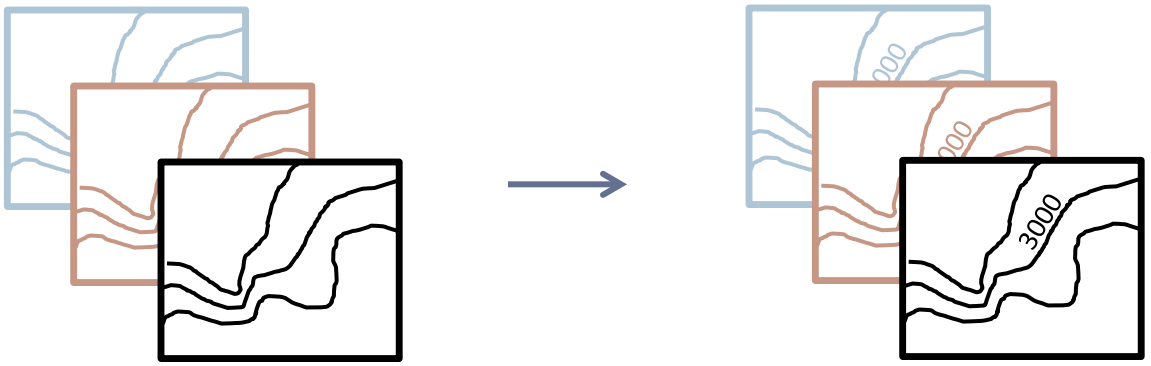
Manual post processing and problems (4/3)

- Blue: before and after manual post processing



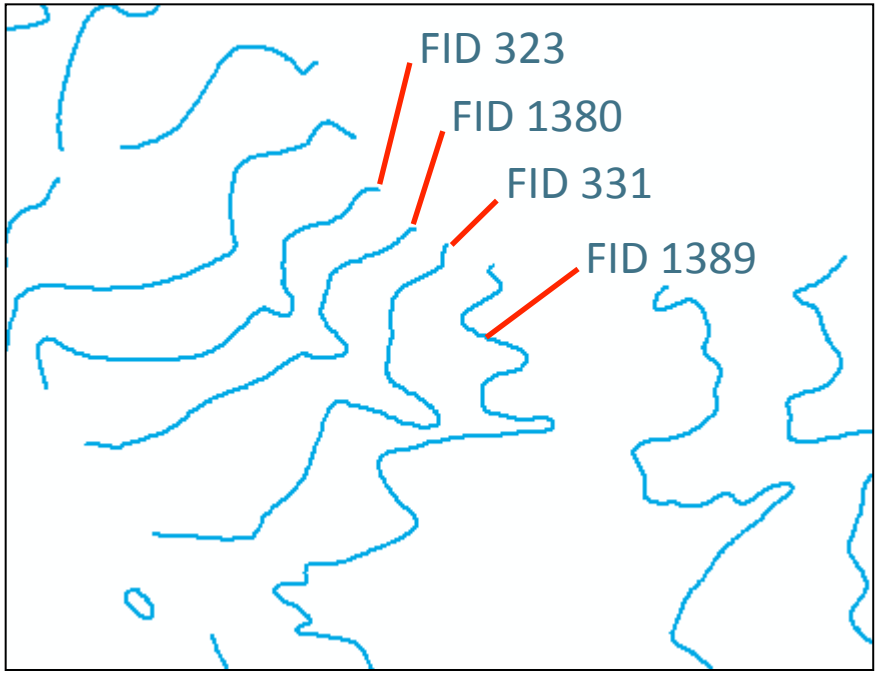
Attribution of contour lines (1/2)

- Contour lines need attribute of their height



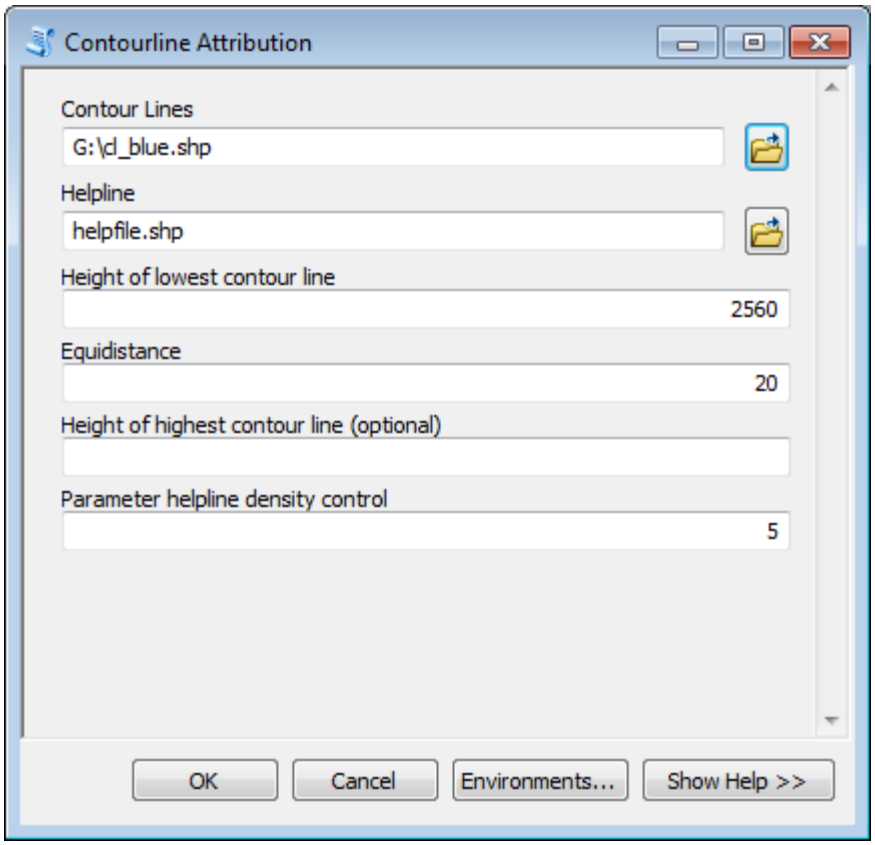
Attribution of contour lines (2/2)

- Manual attribution of 5000 lines?
- Error-prone
- No “easy-sorting” possible

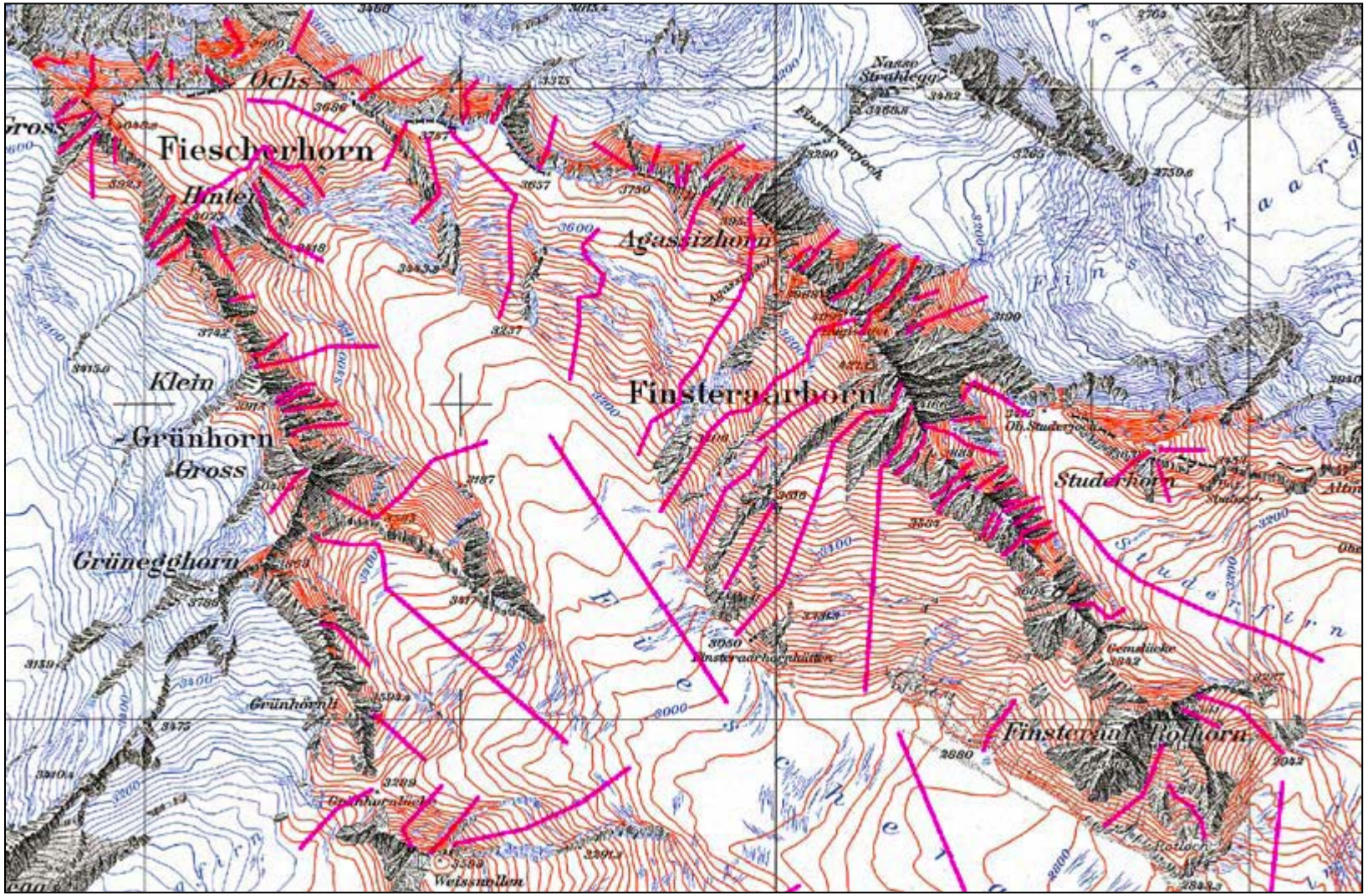


Supporting the attribution: an algorithm (1/3)

- The algorithm requires:
  - “Helpline” for direction and line selection
  - Height of lowest contour line
  - Contour interval

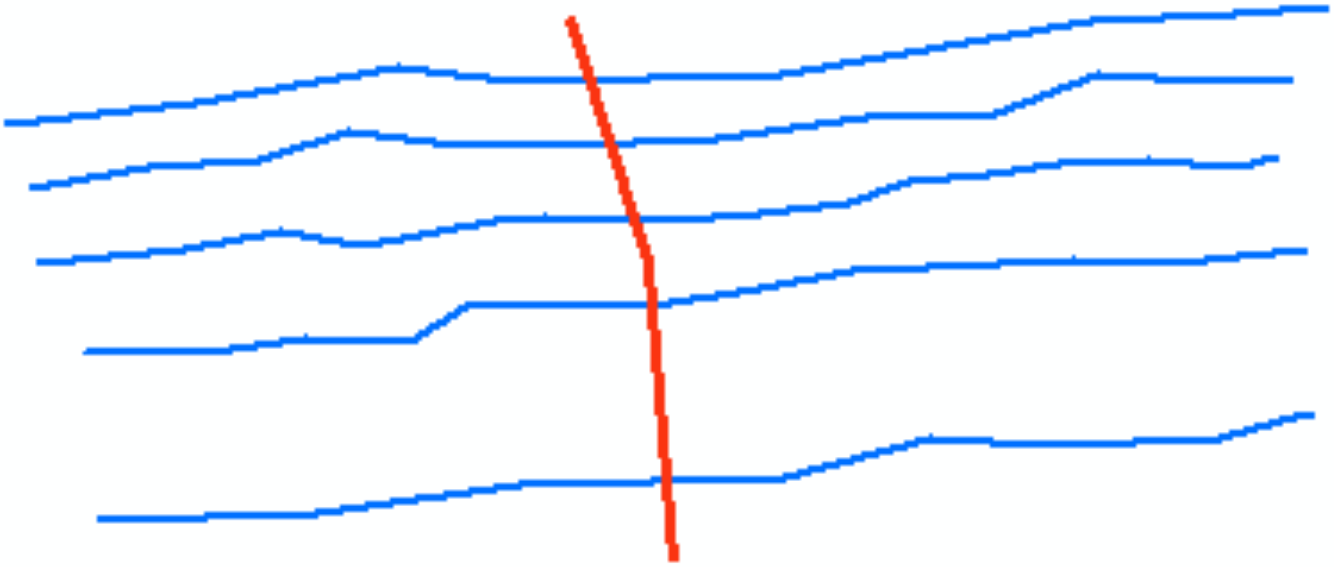


Supporting the attribution: an algorithm (2/3)



Supporting the attribution: an algorithm (3/3)

- Schematical sketch of situation

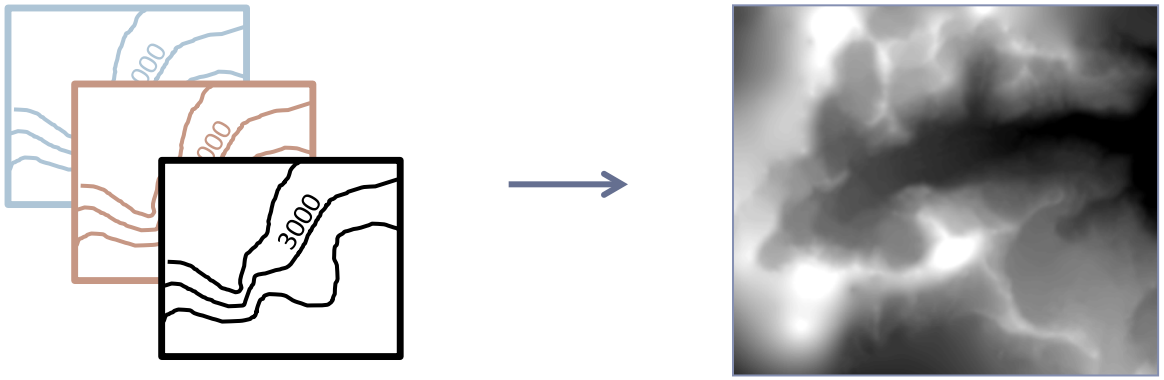


Spot heights and glacier boundary

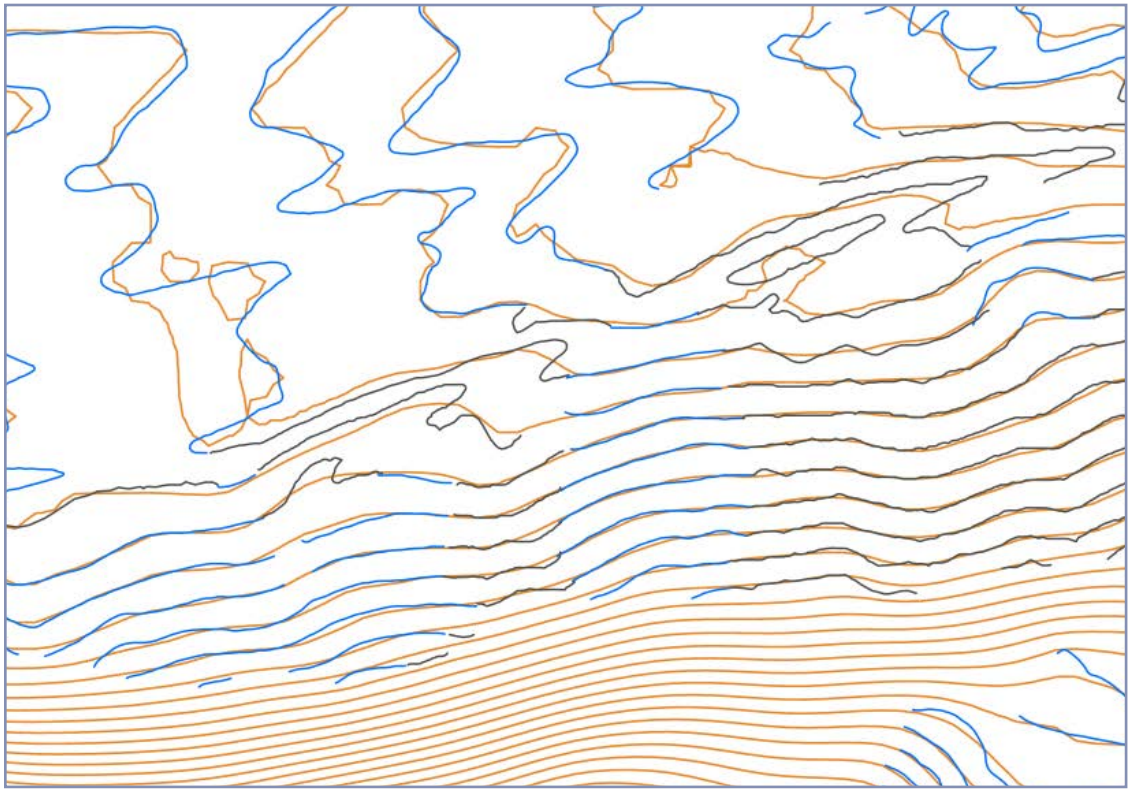
- Further input for DEM interpolation: spot heights (manually)
- Definition of glacier boundary (manually or automatically)

DEM interpolation

- Generation of a 3D model, e.g. with
  - ArcGIS tool “Topo to Raster”
  - GTGRID
  - …



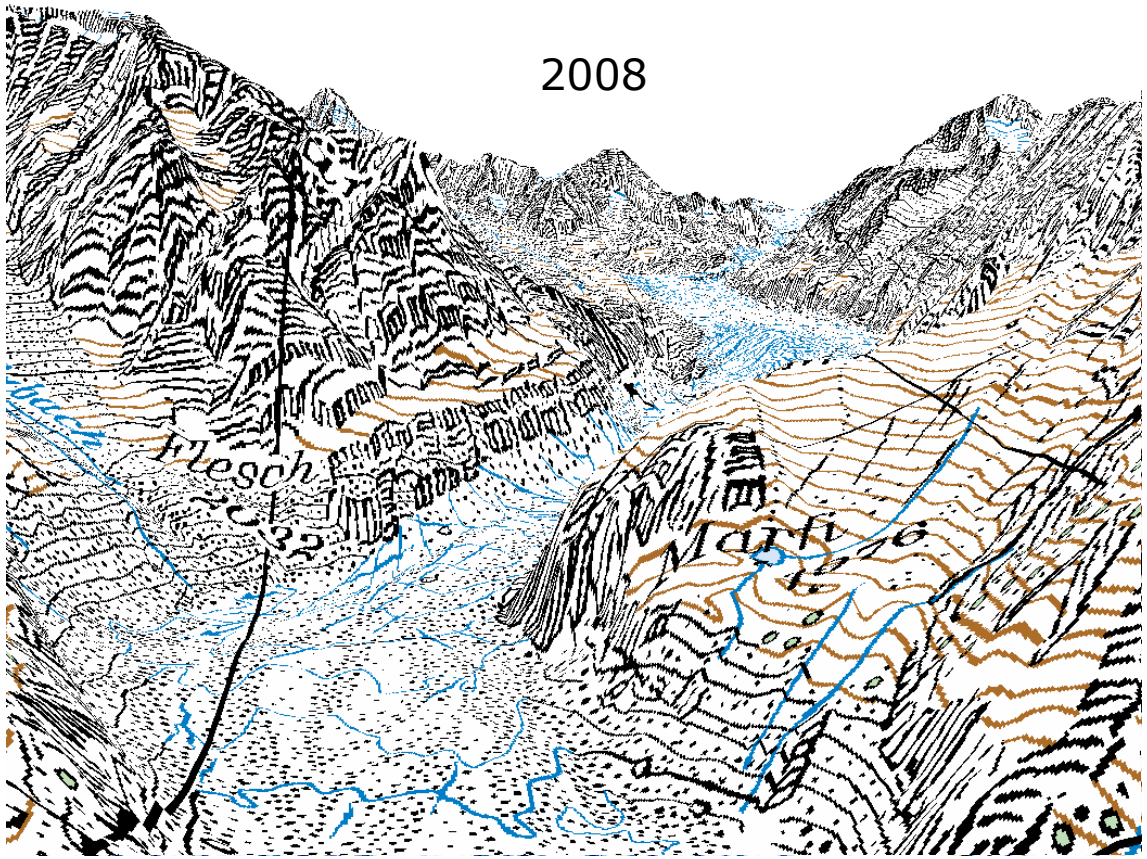
Comparison of contour lines



- Blue, black: vectorized from map
- Orange: calculated from resulting DEM

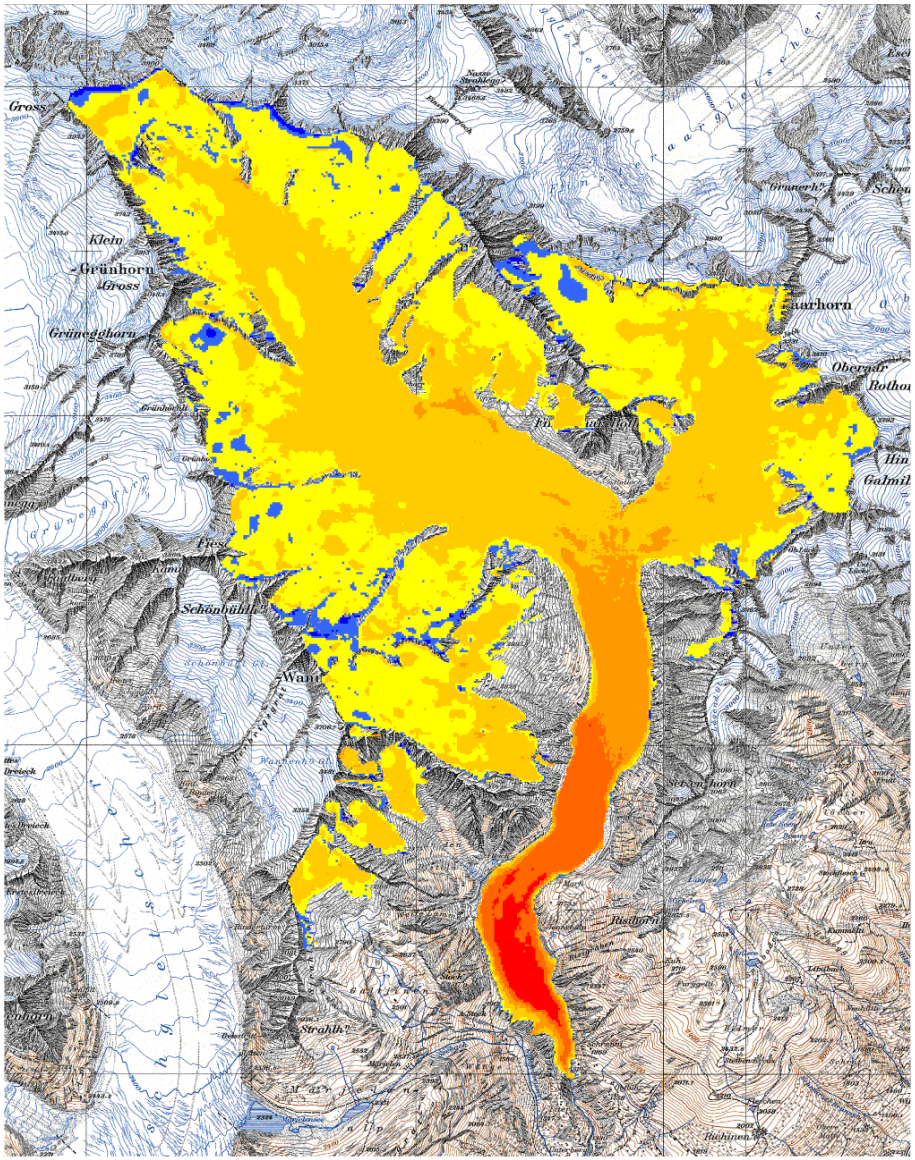
Visualization

- Results so far: DEM (and contour lines)
- Many possibilities of visualization, e.g. in ArcScene:



[Sidler 2011]

Visualization: differences with newer DEM



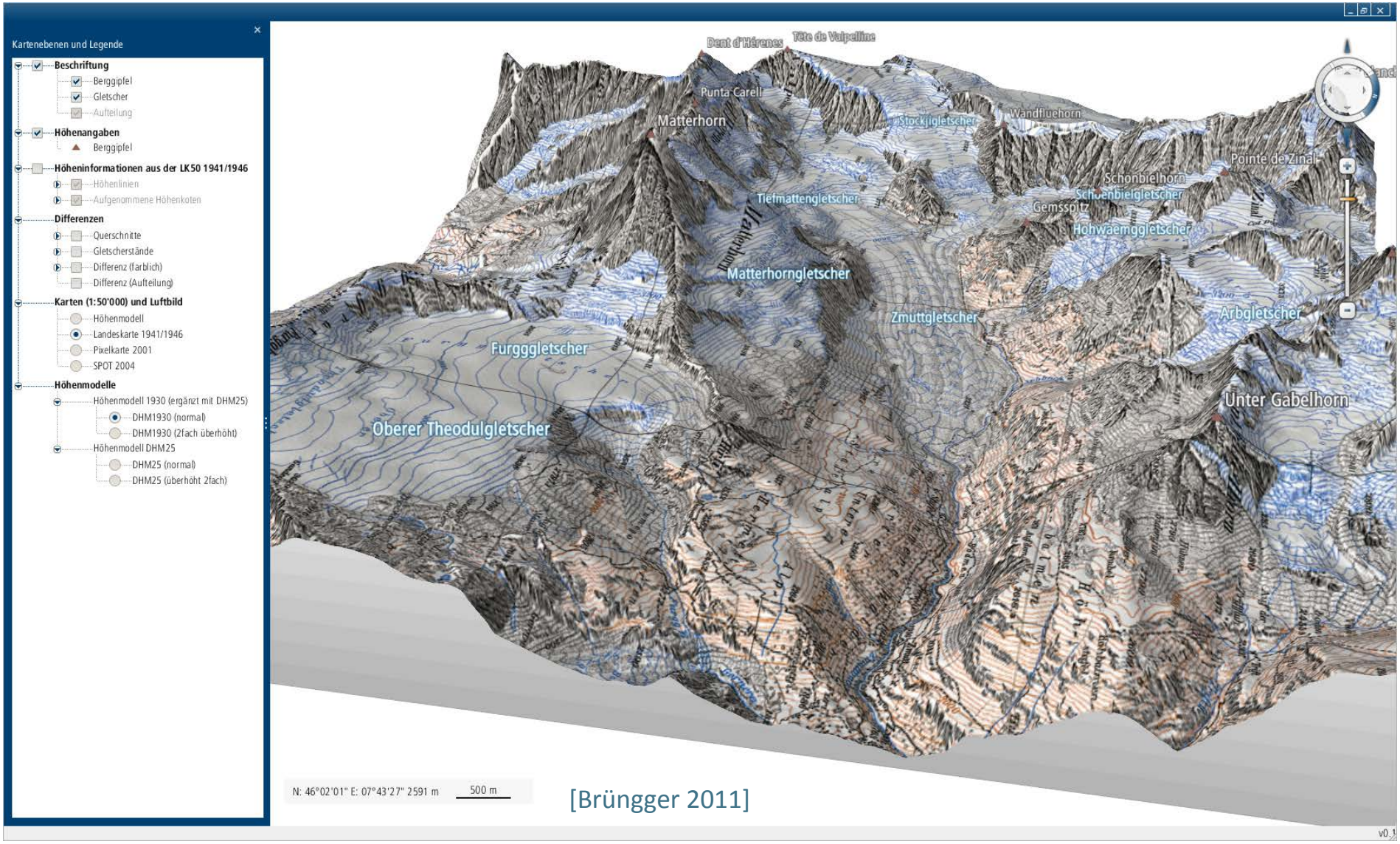
2008 - 1927

Differences [m]

- < -150
- -150 - -100
- -100 - -50
- -50 - -20
- -20 - -10
- -10 - 0
- 0 - 20
- > 20

[Sidler 2011]

Visualization: block diagram (Java Web Start)



[Brüngger 2011]

Summary

- Color separation (e.g. Photoshop)
- automated vectorization (e.g. ArcGIS)
- Manual post processing unavoidable
- Algorithm for support of attribution
- DEM interpolation (e.g. Topo to Raster)
- Visualization with appropriate software

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Thanks…

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Roland Schenkel, and Andreas Bauder

Thank You for your attention! ☺

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