

# The role of geological and hydraulic models in the evaluation-process of geothermal use of alpine aquifers; Examples from the touristic centre Davos, Switzerland

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## Challenges and risks

- Limited space, subsurface growth of infrastructure
- Risks and problems, i.e. freezing, interactions, technical problems
- 30% of installations with problems 10 after years of operation

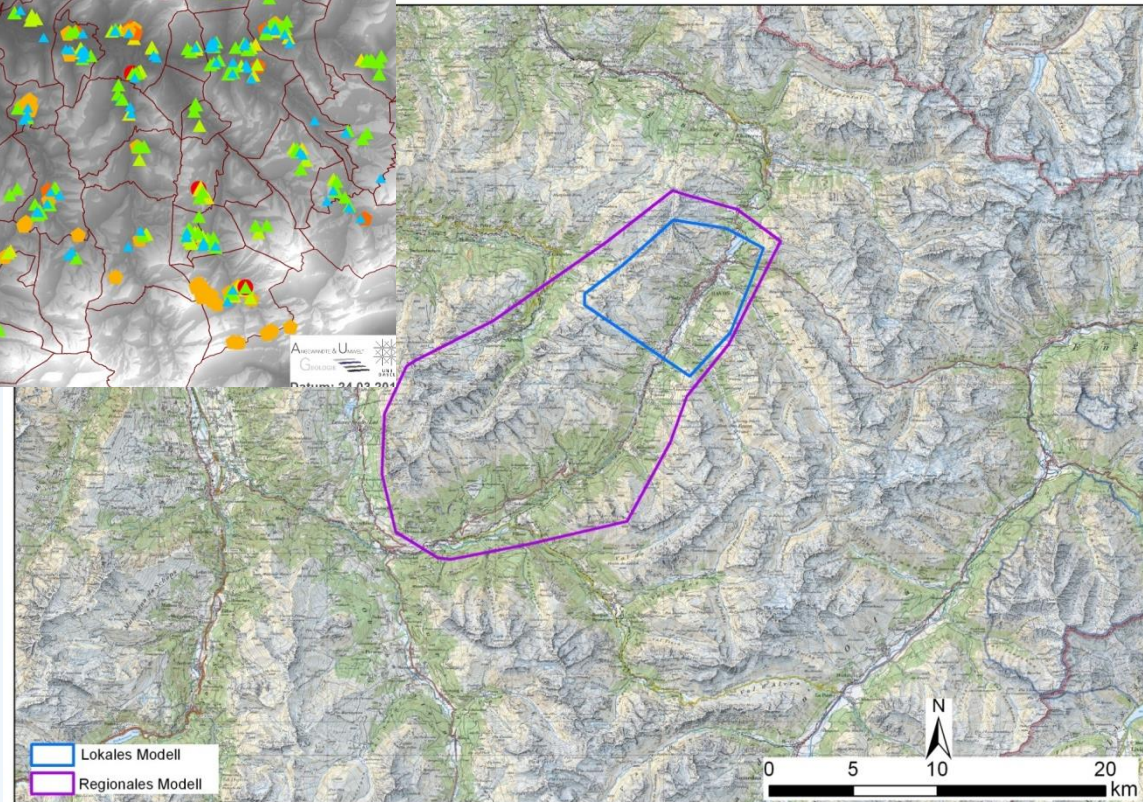
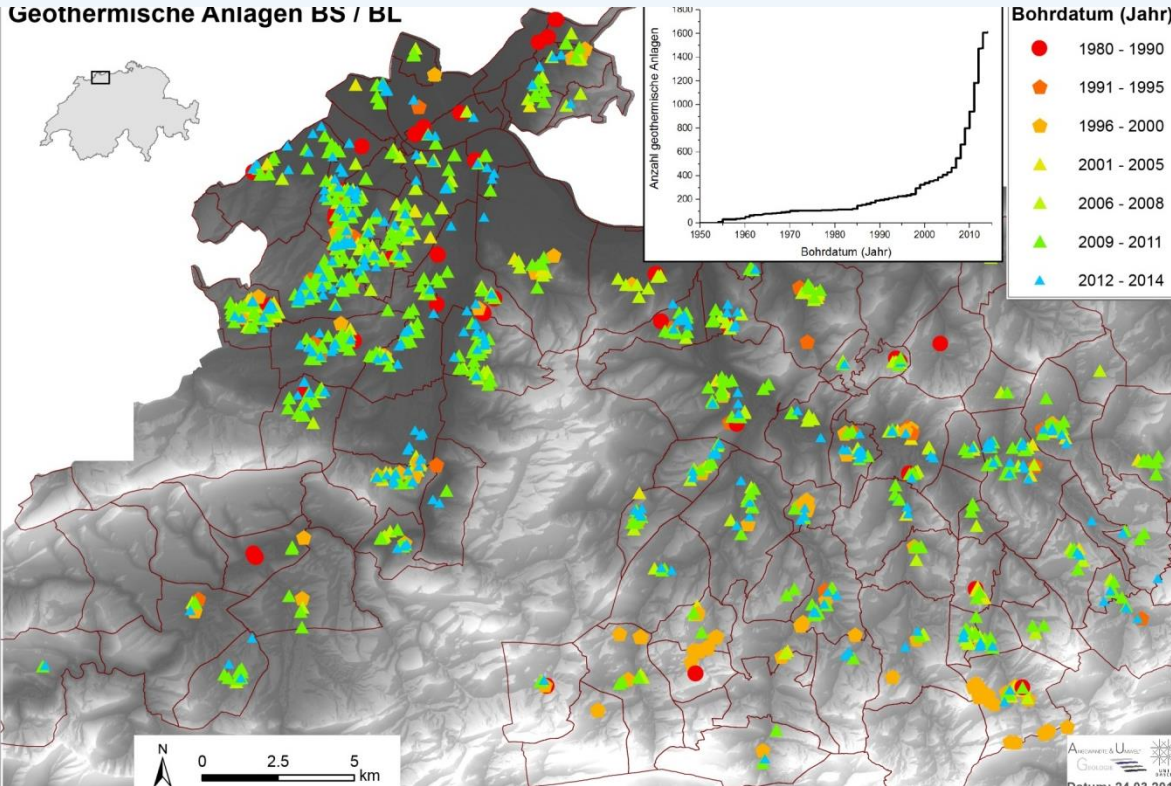
## Consequences

- Some Communities prefer large installations, combining heat and cold

## Solutions

- Regional and local planning subsurface resources water and energy
- The role of geological and hydraulic models

## Geothermische Anlagen BS / BL



“Direkt risks”: Outflow of seal material, thermal transfer fluids

“Indirekt risks”:

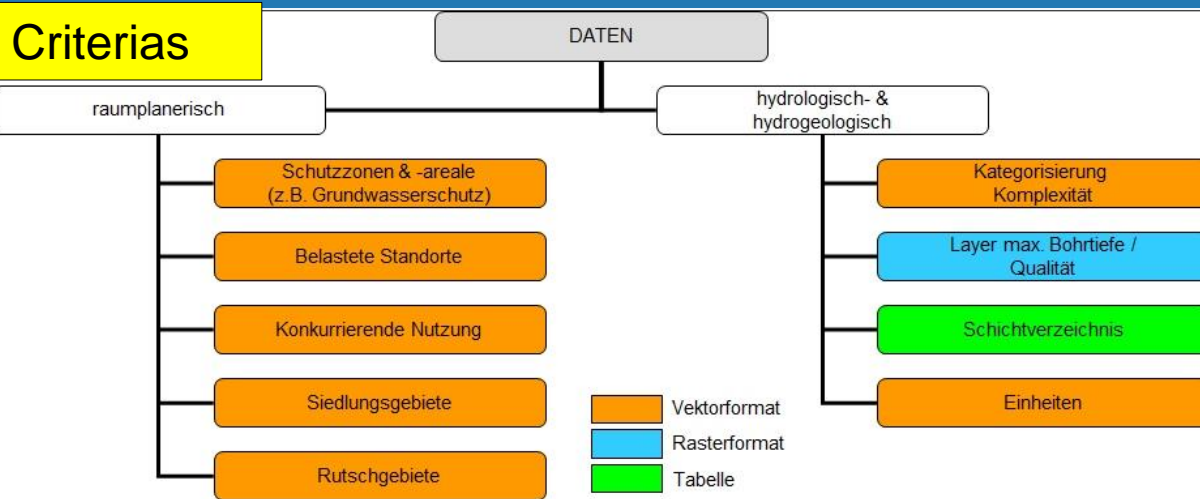
- Changing water pathways
- Groundwater contamination
- Changing hydraulic system
- Connecting aquifers
- Swelling and dissolution (Evaporites)
- Confined or artesian groundwater
- Hydrocarbons, gas



Crack, Staufen (D)



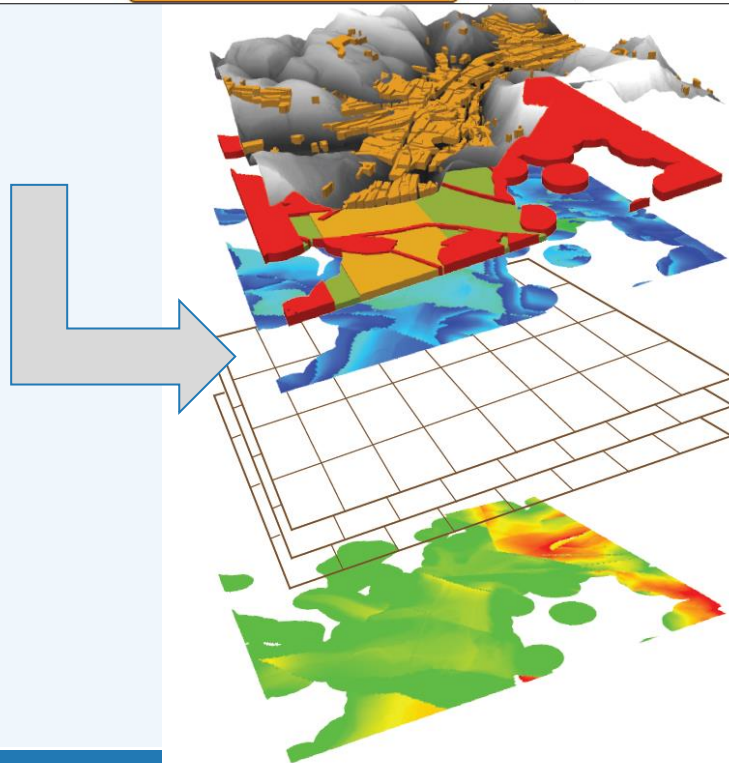
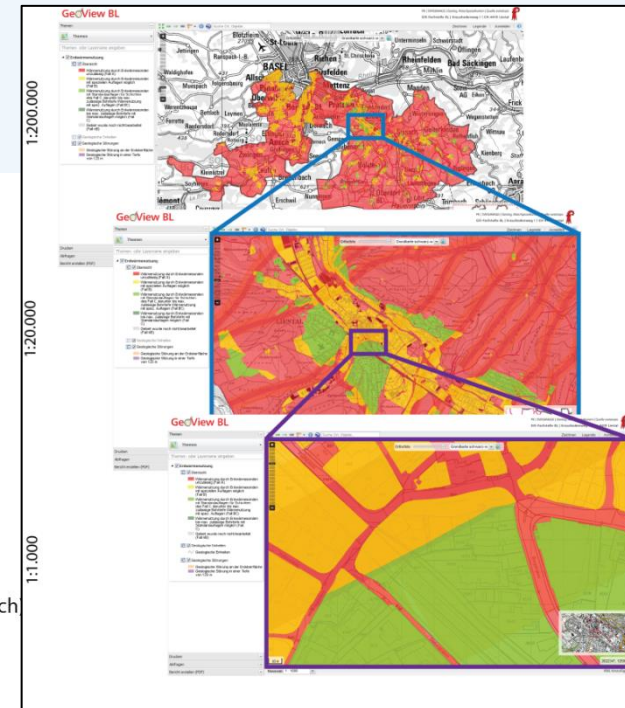
Bassetti et al., Geowatt



GeoView BL



Erdwärmenutzung



Digitales Höhenmodell und Siedlungsfläche

Toleranz / Unsicherheitskategorisierung

Mächtigkeit oberste Schicht (inkl. Quartär)

Schichtverzeichnis (detailliert oder exemplarisch)

maximale Bohrtiefe  
(inclusive maximale Tiefebegrenzung 200m,  
Grundwasserstockwerke, geol. Sonderfälle...)

# Are Present protection concepts adequate?



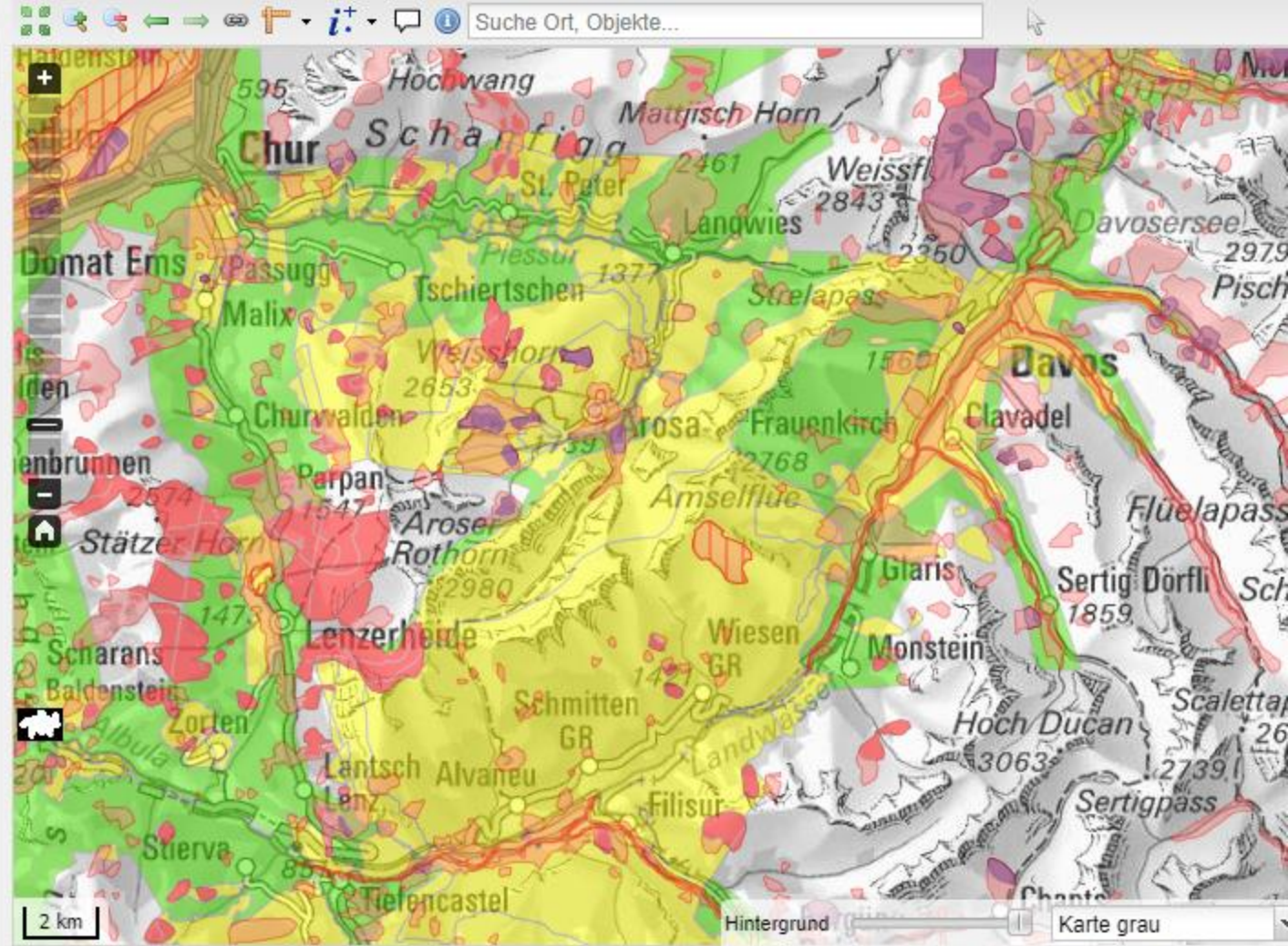
Amt für Natur und Umwelt  
Uffizi per la natira e l'ambient  
Ufficio per la natura e l'ambiente

## Karten- und Themenwahl

Kartenwahl

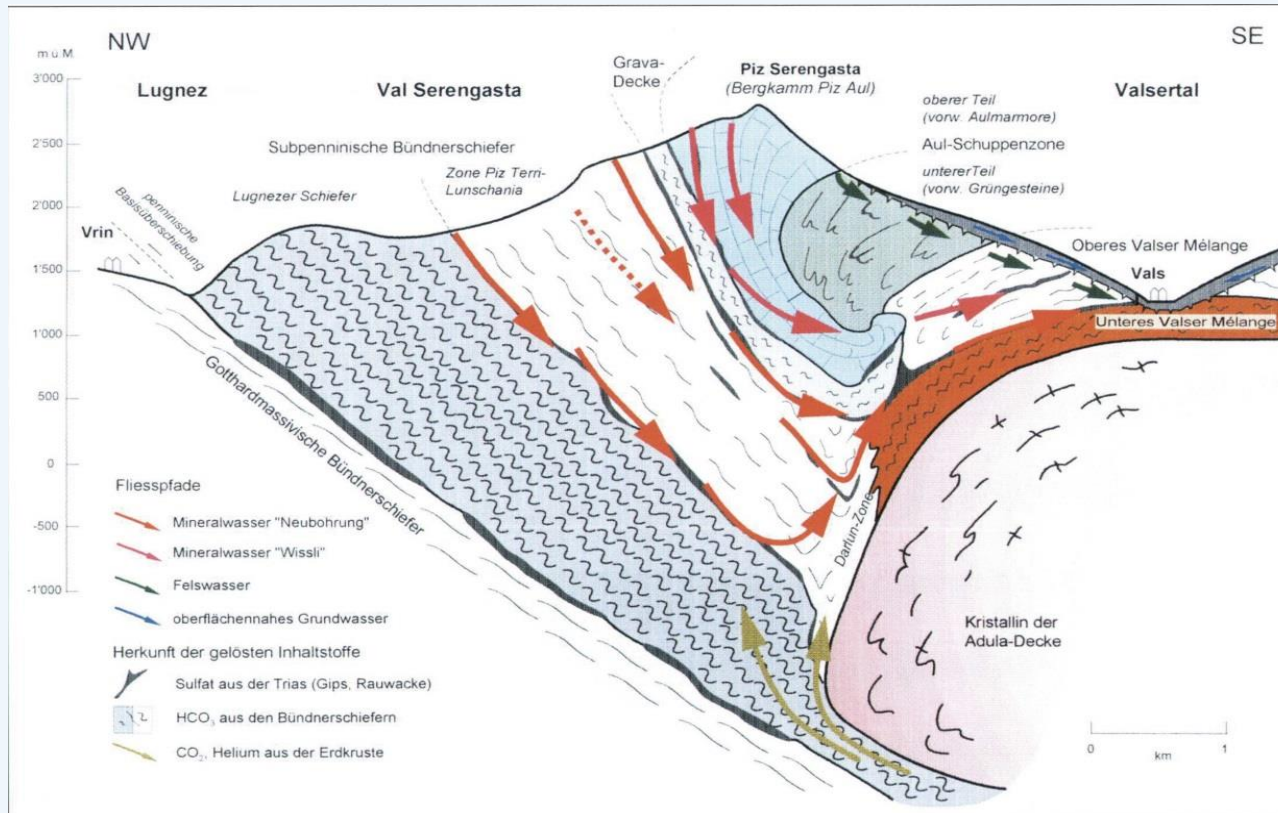
Themen- oder Layername eingeben

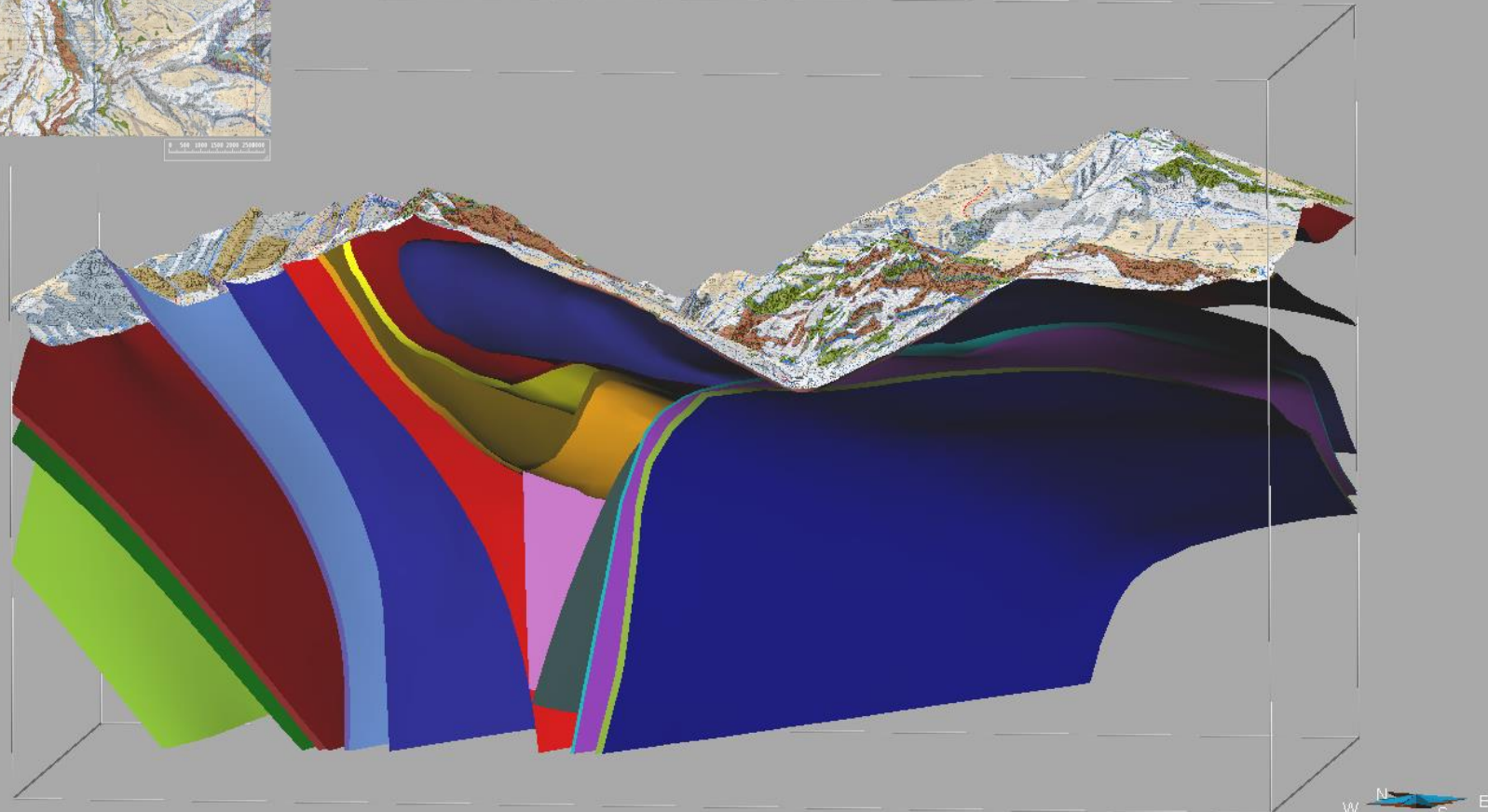
- Basisinfo
- Erdwärmenutzung Anlagen
  - Anlagen (Wärmepumpen)
- Grundwasserfassungen und Quellen
- Gewässerschutz
  - Karst
  - Gewässerschutzbereich Ao
  - Gewässerschutzbereich Au
  - Grundwasserschutz zonen
    - Schutzzone S1
    - Schutzzone S2
    - Schutzzone S3
    - Summarische Schutzzone
    - Schutzzone (undifferenziert)
    - Schutz zonenareal
- Erdwärmenutzung Zulässigkeit



Masstab: 1 : 200000  
Projektion: CH1903 / LV03  
Die Erdwärmenutzungskarte gibt Auskunft über die verschiedenen Zulässigkeitsbereiche für Erdwärmesonder-Weisung für Wärmepumpen | Hinsichtlich der inhaltlichen Richtigkeit, Genauigkeit, Aktualität und Vollständigkeit der veröffentlichten Informa- © Kanton Graubünden, Quelle: Bundesamt für Landestopografie und Kanton Graubünden

- Complex tectonic setting
- Complex 3D interactions of aquifers and aquitards
- Interaction of aquifers in quaternary sequences and regional aquifers in the bedrock
- Motor of groundwater circulation: Topo driven groundwater flow





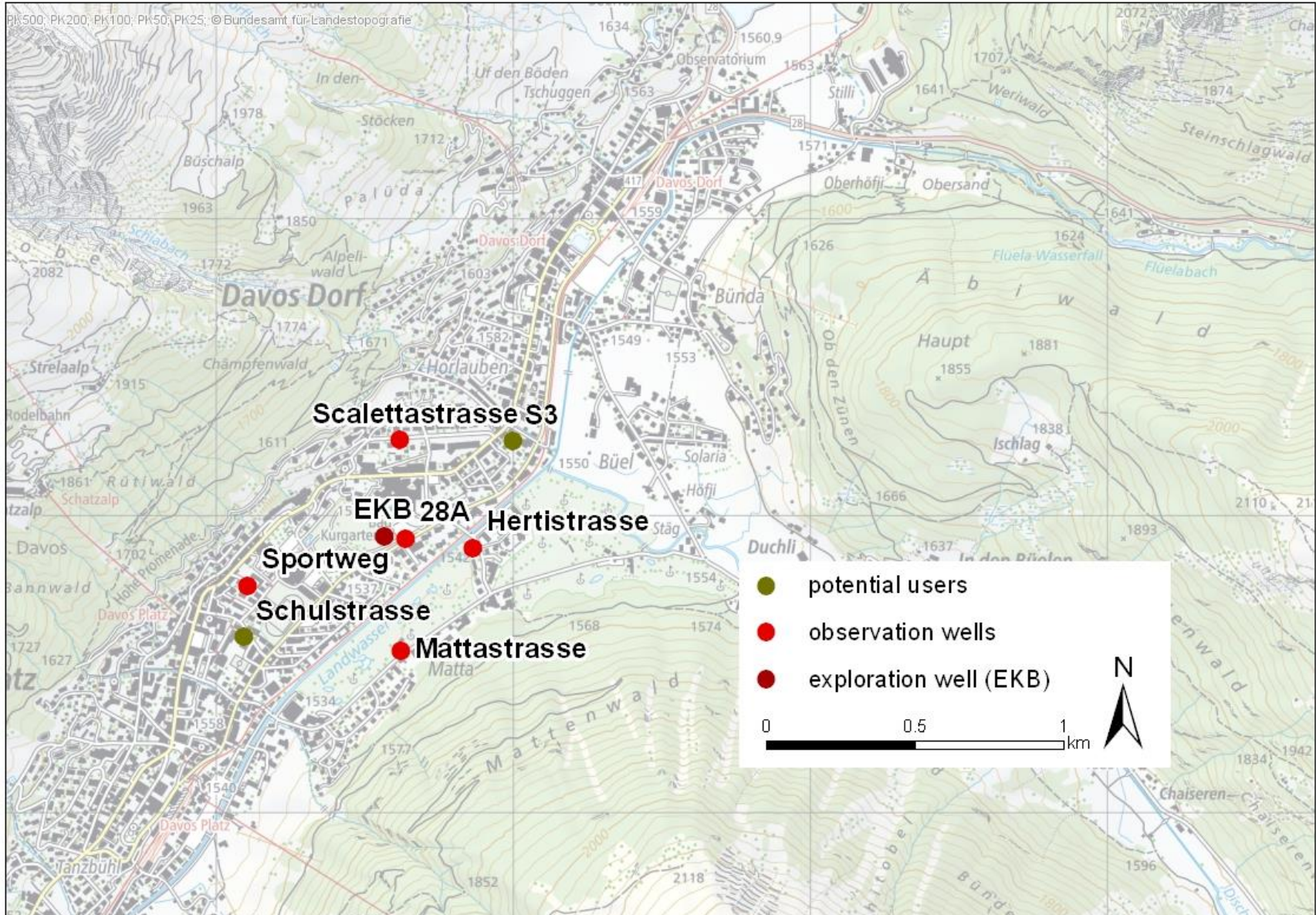
Tektonische Interpretation nach 2D Wyss & Isler 2007





Davos prefers the use of geothermal systems for large facilities such as hotel complexes, sport facilities and conference centers  
Flexibility to combine different energy sources



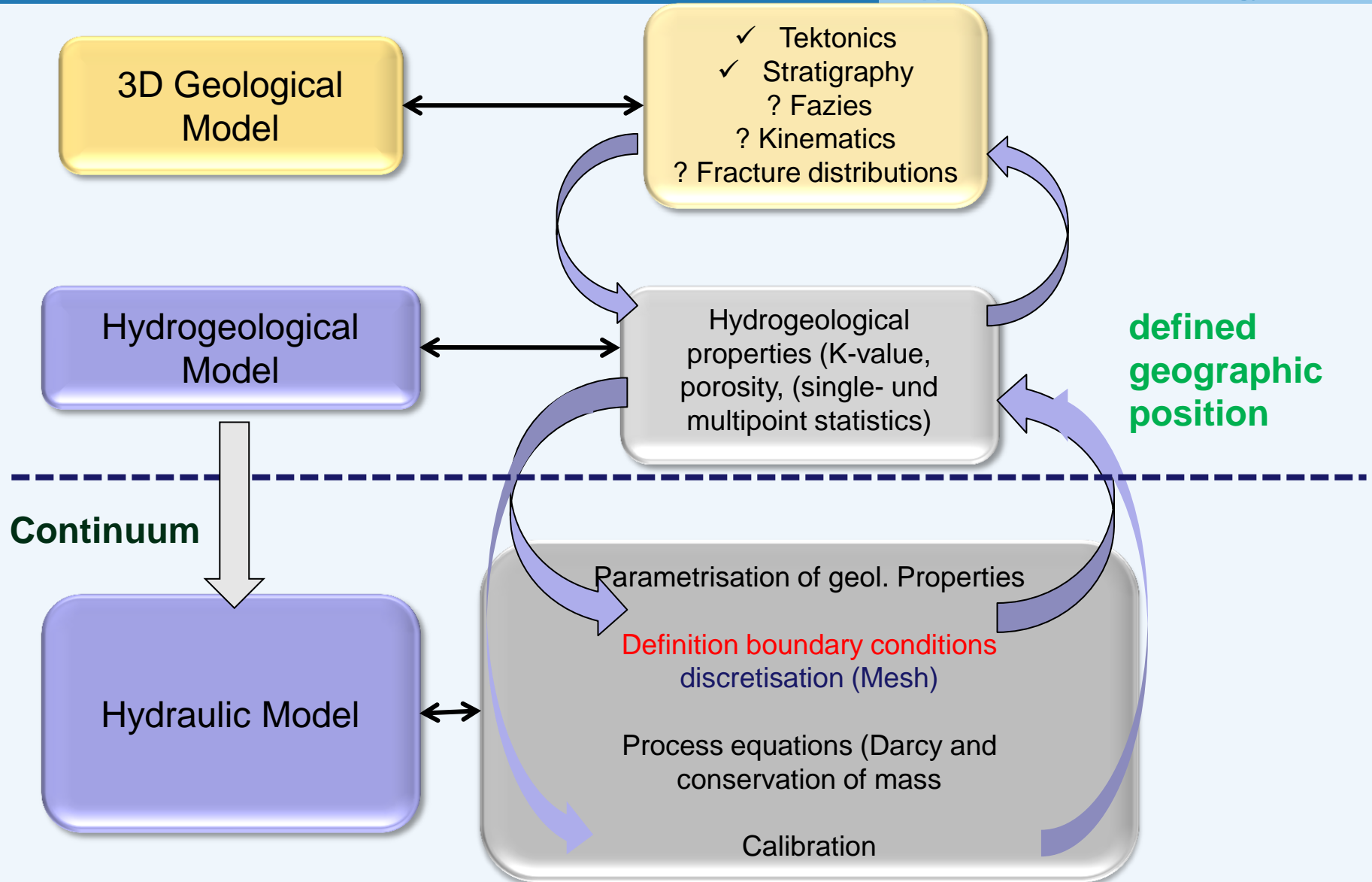


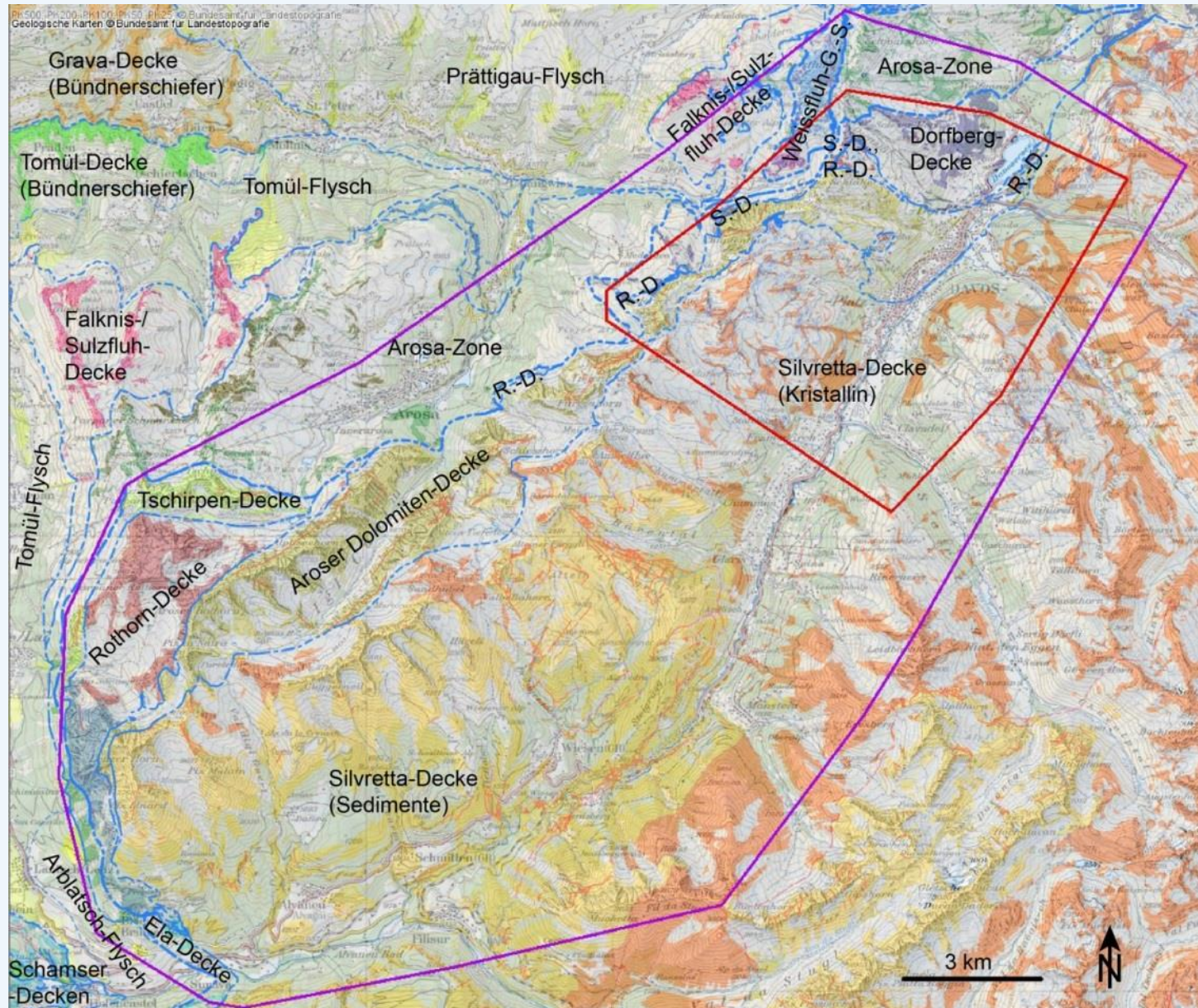


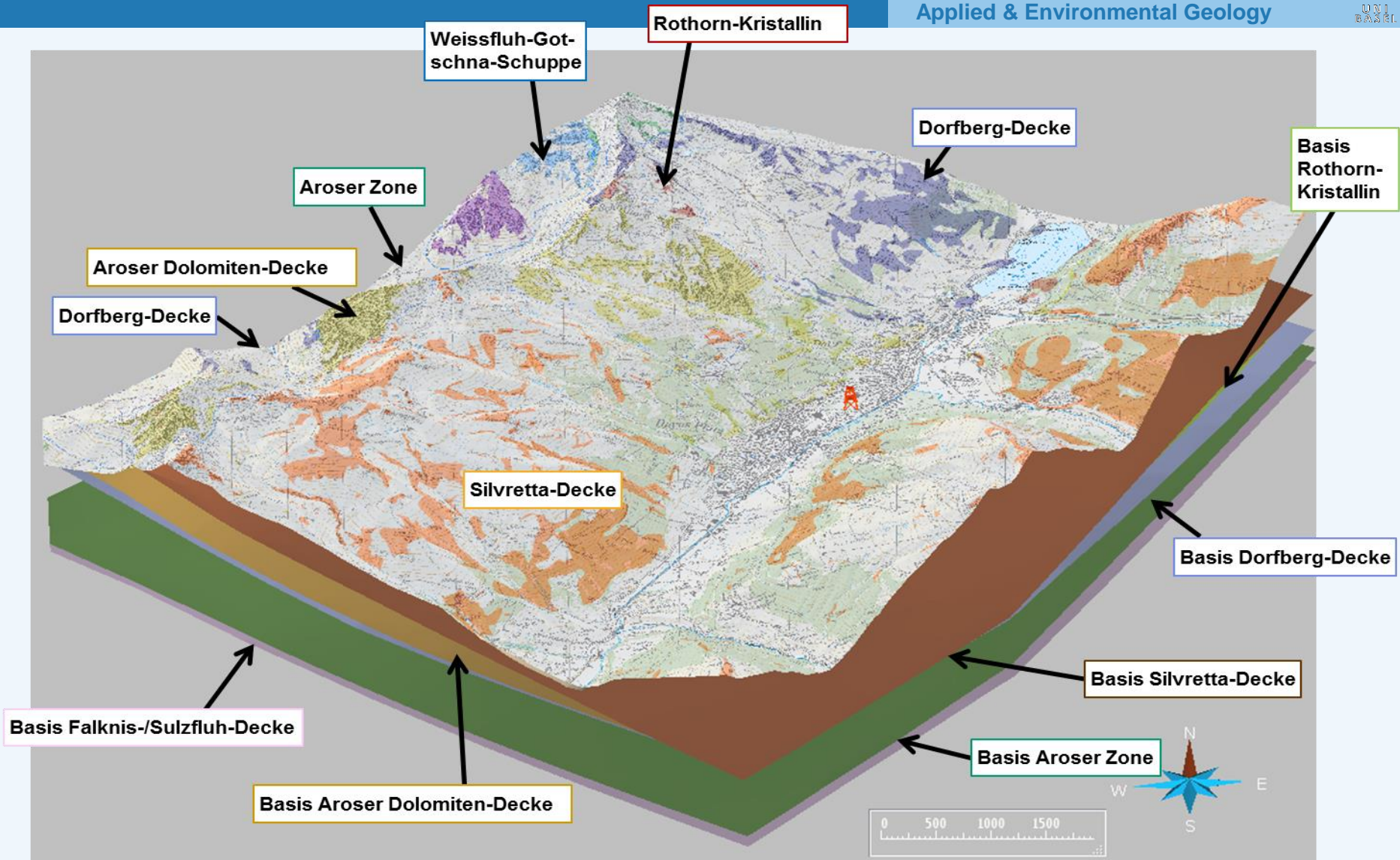
## Elements of planning and resource management

- **Conceptual model, geological and hydraulic models**
- **Boundary conditions, legal aspects**
- **Subsequent complement of monitoring system, Adaptive approach**
- **Experiments, calibration**


## Example Davos

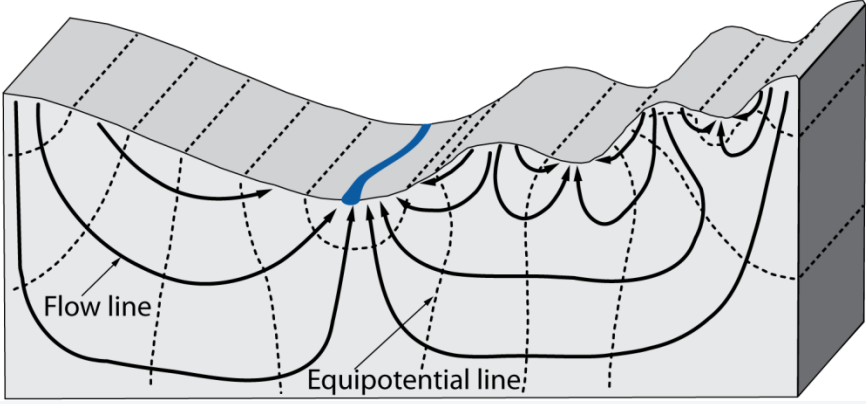






Presentation is vertical exaggeration  
Tectonic zones: from WMS service geology, Canton Graubünden

 Geothermal drilling Davos

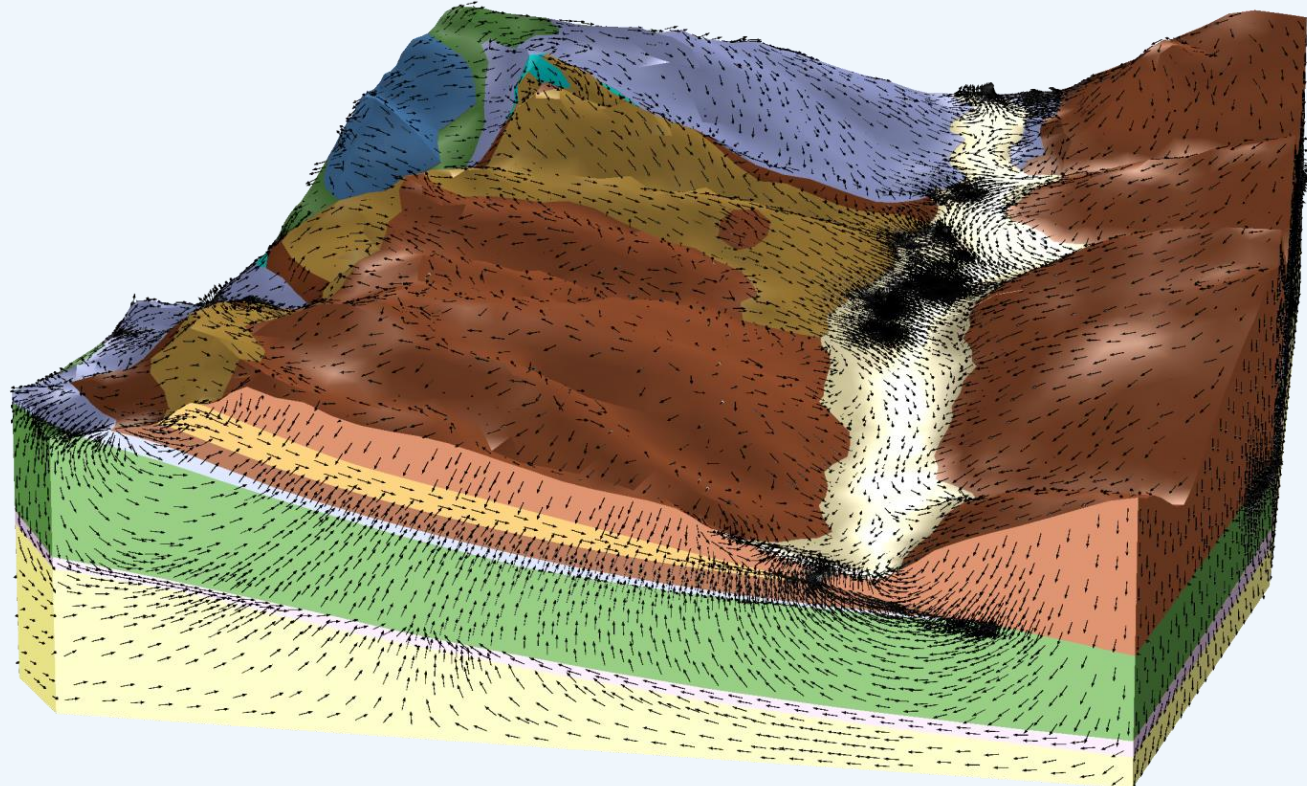


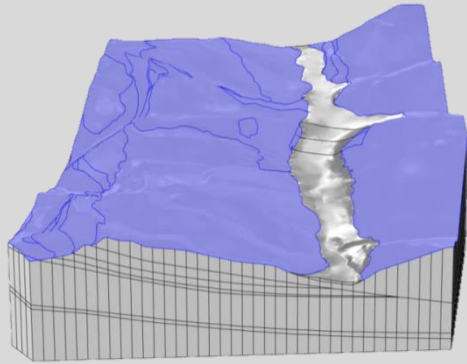
Topographie und andere  
Randbedingungen als Motor

plus Geologie

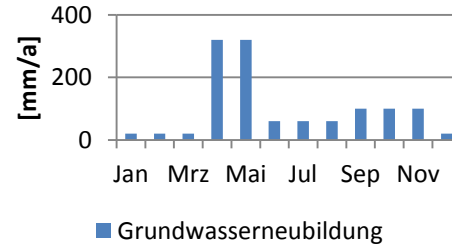
ergibt Fließfeld

modified from Tóth, 1999

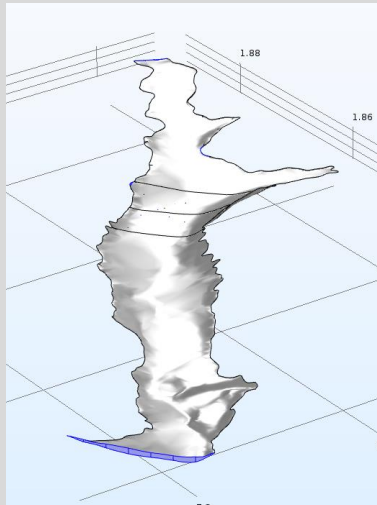




## Grundwasserneubildung



- **Flux über Topographie**  
= Grundwasserneubildung über Niederschlag



- **Basis Quartär als halbdurchlässiger Rand**  
= Austausch zwischen Quartär und Aroser Dolomit über Semipermeable («Conductance») Schicht mit definierter Durchlässigkeit

$$Q = A\Phi(h_{\text{ref}} - h)$$

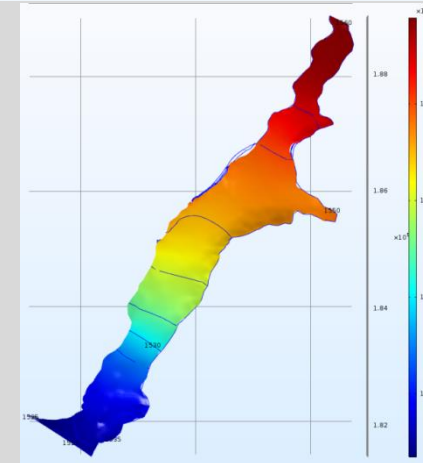
Q: inflow or outflow to/from the model

A: relevant area

$\Phi$  : transfer rate

$h_{\text{ref}}$ : reference water level

h: current hydraulic head in groundwater



- **Quartär:**  
Grundwasserstände sind als «head» Randbedingung fixiert





- **Geothermal use of alpine aquifer part of spatial planning (limited space)**
- **Development of tools for adaptive resource management**
- **Tools include groundwater and heat transport models and monitoring systems**
- **Definition of the role of private investors and public services**