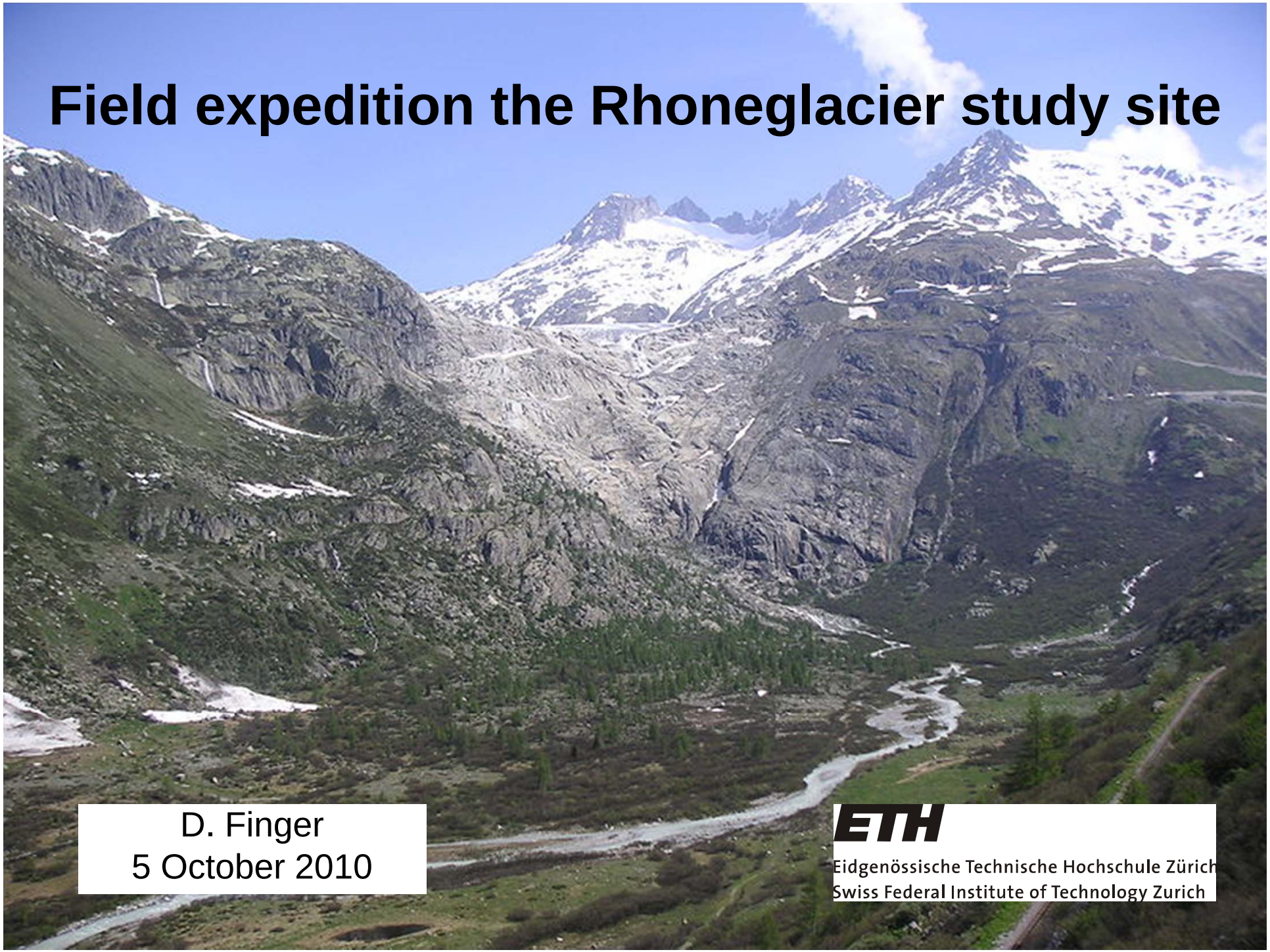
Field expedition the Rhoneglacier study site



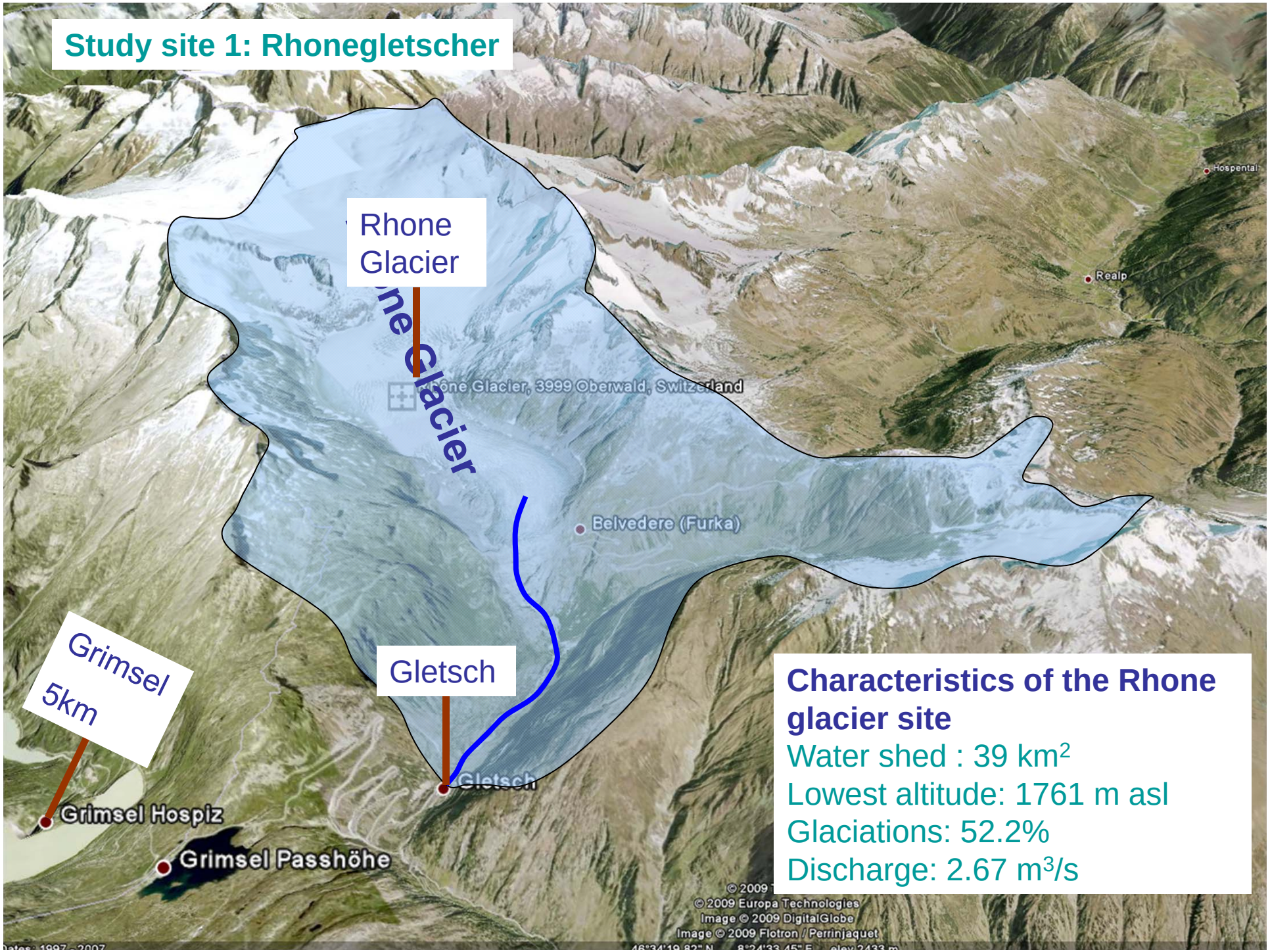
D. Finger
5 October 2010

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

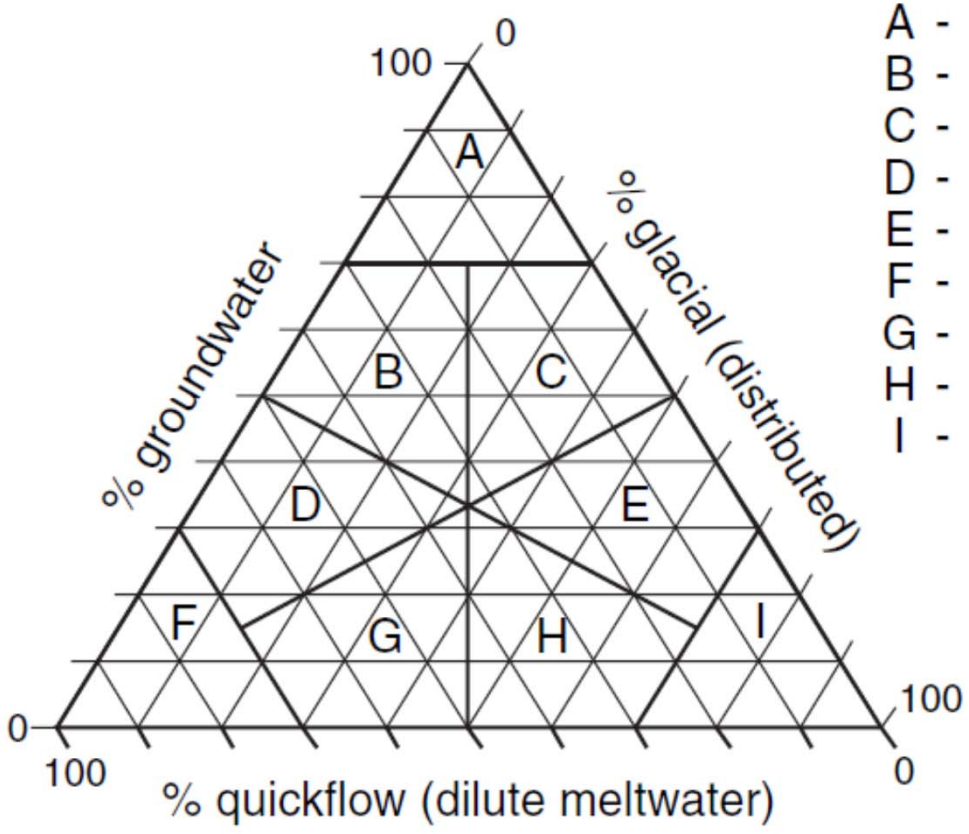
Objectives

Identify and characterize a mountain stream in the Swiss alps based on chemical fingerprint

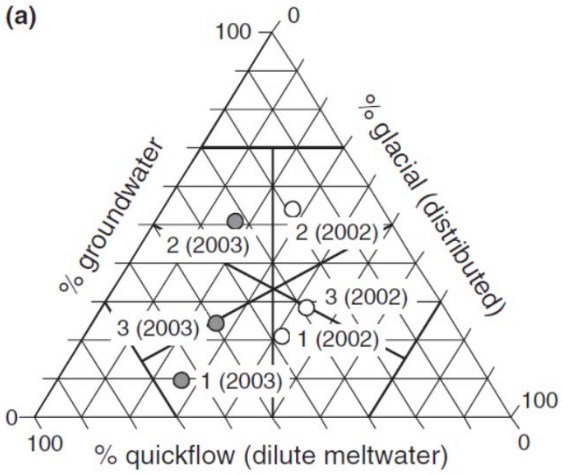
Study sites: Rhonegletscher


Study site 1: Rhonegletscher
Rhone Glacier
Rhone Glacier
Rhone Glacier, 3999 Oberwald, Switzerland
Belvedere (Furka)
Gletsch
Grimsel 5km
Grimsel Hospiz
Grimsel Passhöhe
Hospental
Realp
Characteristics of the Rhone glacier site
Water shed : 39 km²
Lowest altitude: 1761 m asl
Glaciations: 52.2%
Discharge: 2.67 m³/s
© 2009 Europa Technologies
Image © 2009 DigitalGlobe
Image © 2009 Flotron / Perrinjaquet

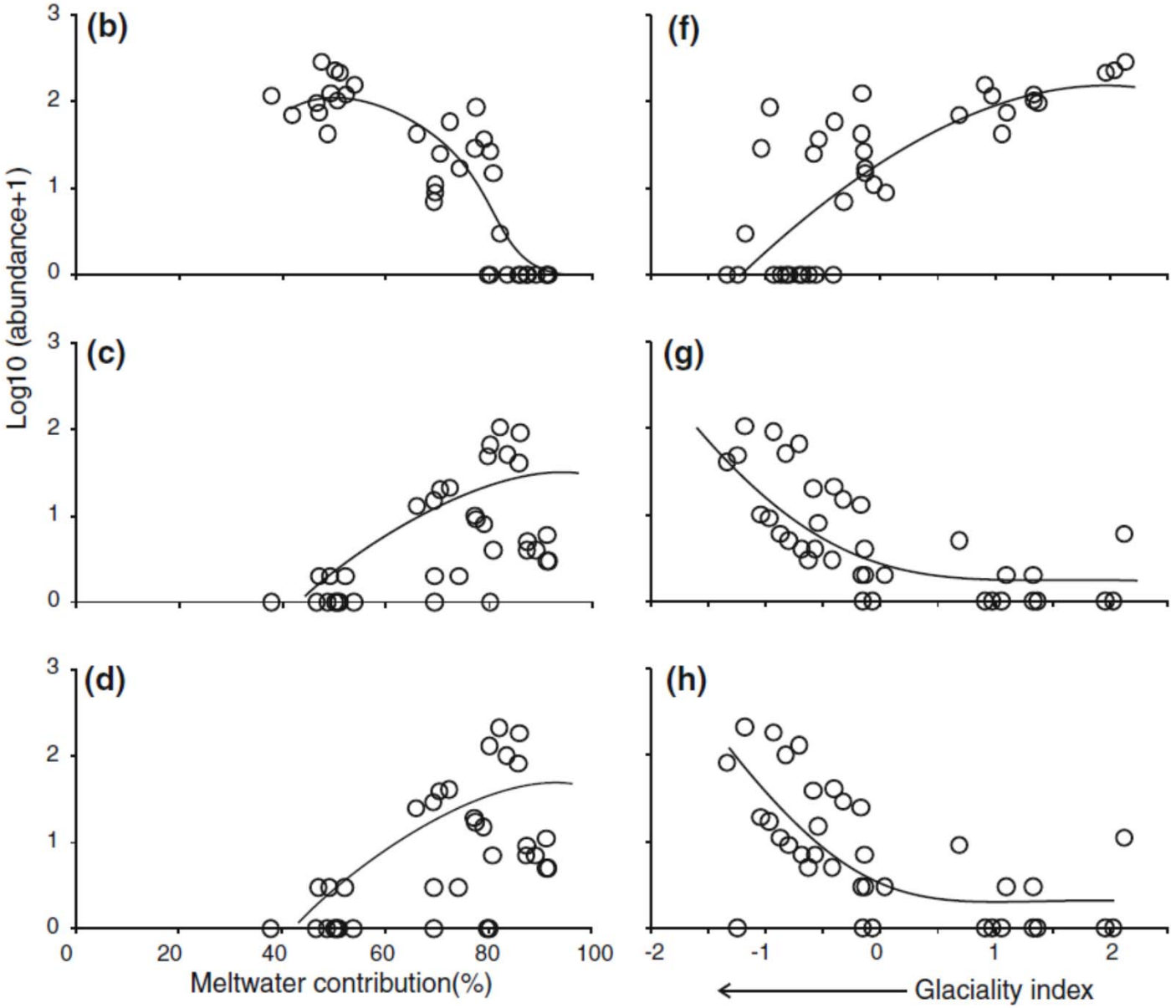
Motivation:
Predict stress factors for biodiversity



A - Krenal
B - Kreno-nival
C - Kreno-kryal
D - Nivo-krenal
E - Kryo-krenal
F - Nival
G - Nivo-kryal
H - Kryo-nival
I - Kryal



Brown et al. (2009)

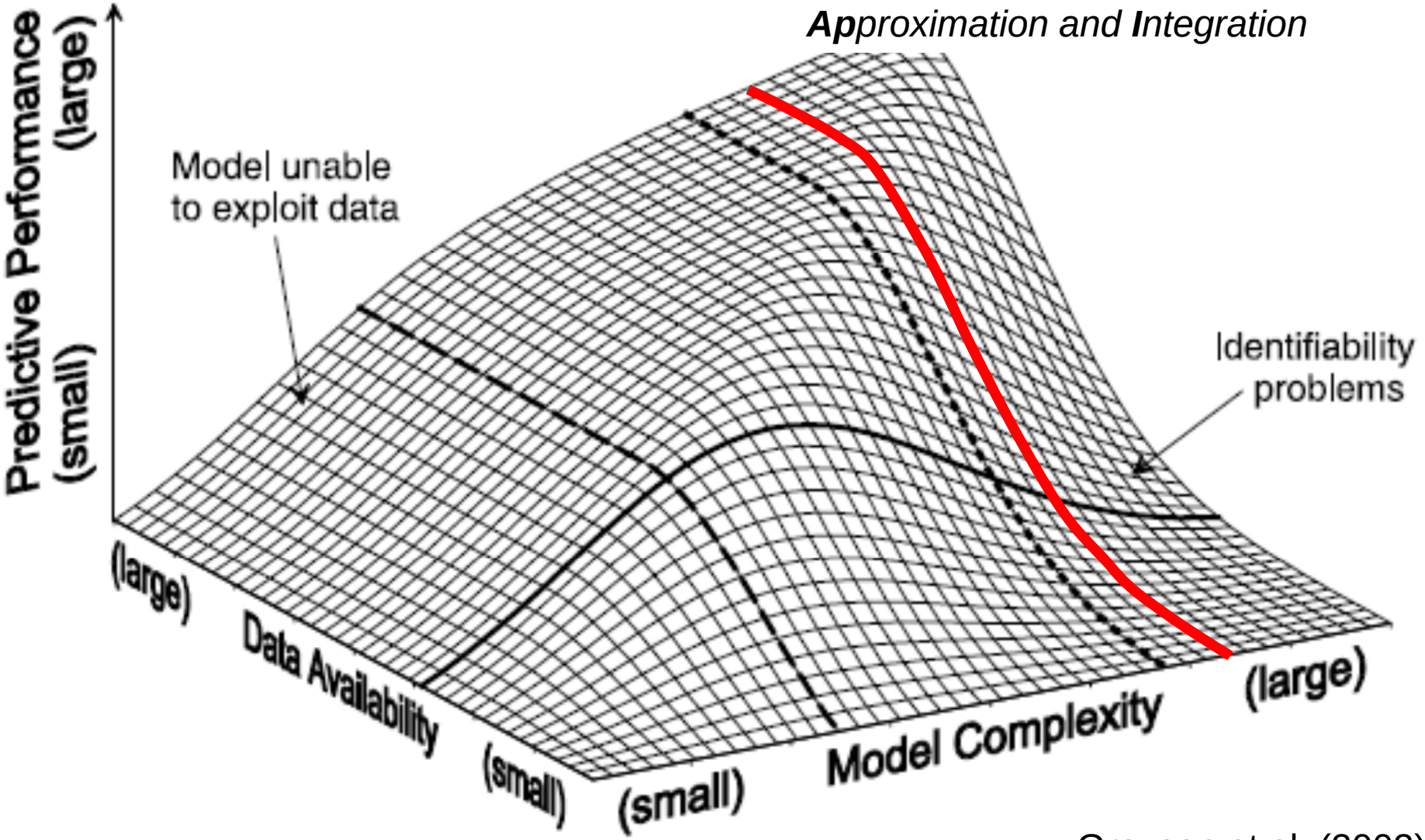


Brown et al. (2010)

Hydrological Modelling

Predictive Performance of hydrological models

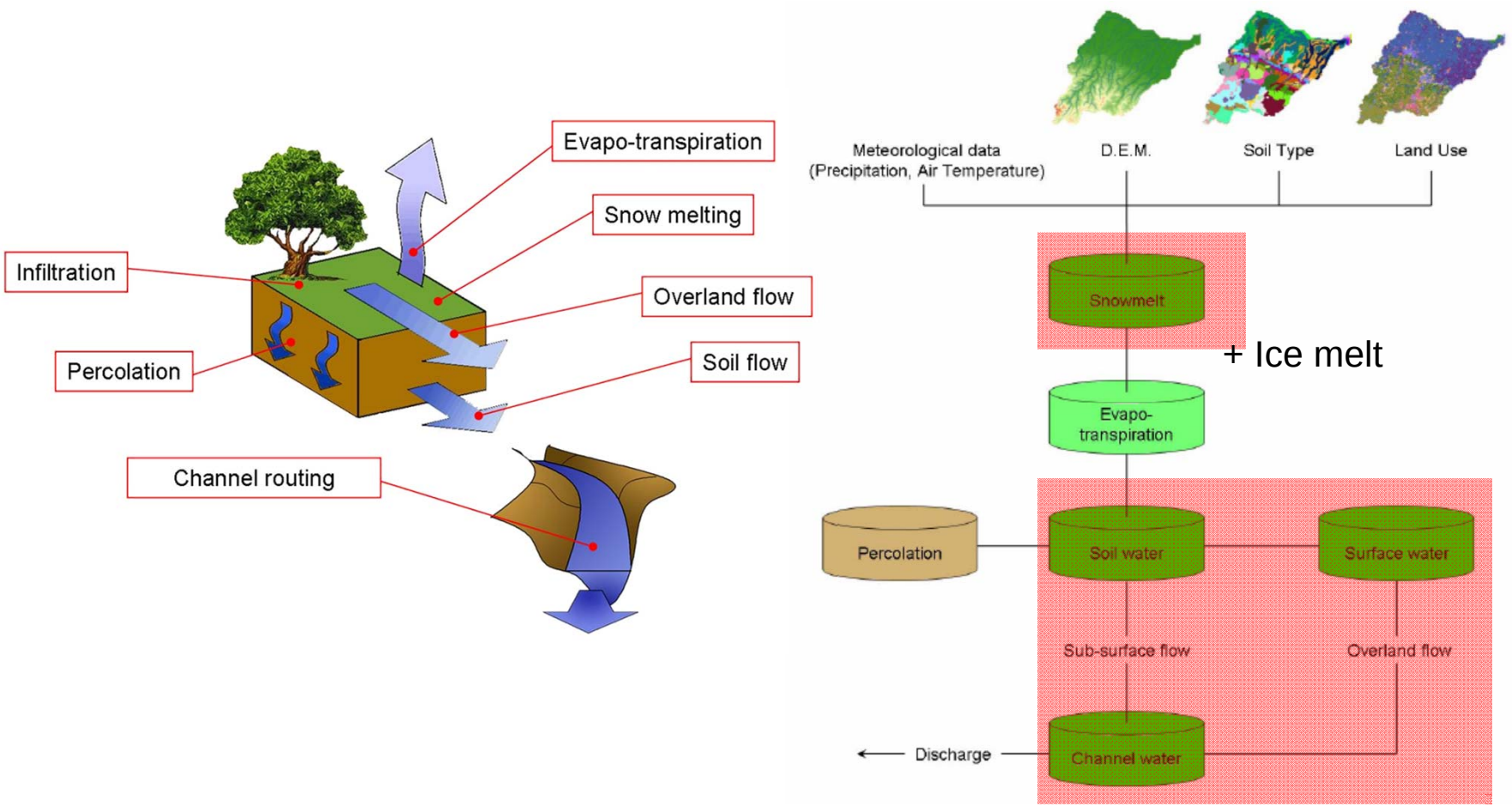
TOPKAPI: ***Top****ographic* ***K****inematic* ***Ap****proximation and* ***I****ntegration*



Grayson et al. (2002)

Overview of TOPKAPI

(**TOP**ographic **K**inematic **AP**proximation and **I**ntegration)
[Ciarapica & Todini, *HP*, **16**, 2002; Liu, 2002; Liu & Todini, *HESS*, **6**, 2003]



TOPKAPI

1. Clear sky irradiance

$$I_{csG\downarrow i} = f(\theta_s, \delta, Tr, \nabla_{slope}, A_{cell}, lat)$$

2. Cloud factor

$$cf_{j(i)} = c_1 + c_2 \cdot \Delta T_{j(i)}$$

3. Albedo

$$\alpha_{snow(i)} = Alb_{f1} - Alb_{f2} \cdot \log_{10}\left(T_{acc(i)}\right)$$

4. Snow and Ice melt

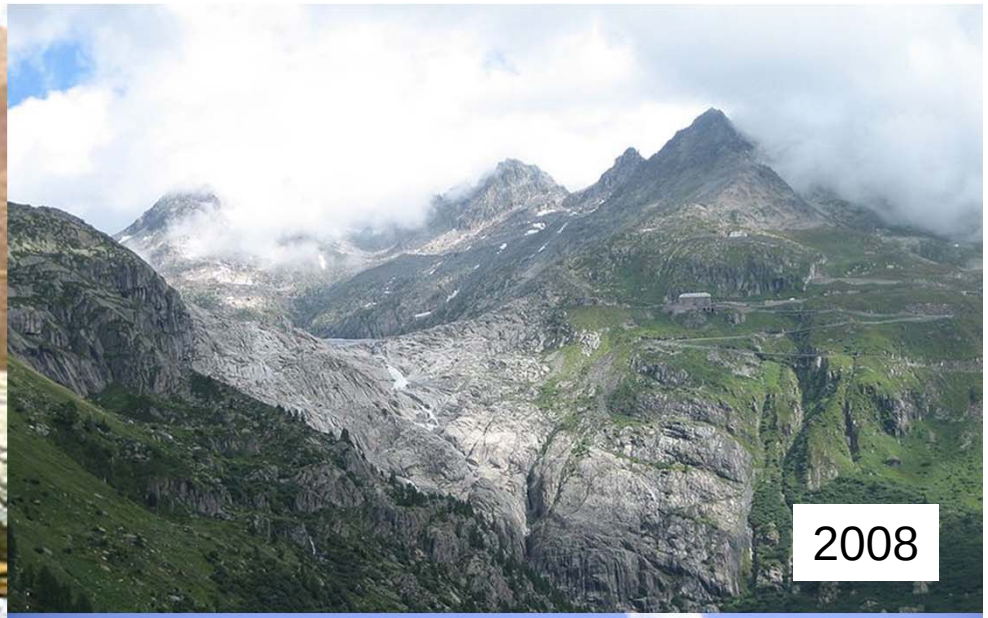
$$M_i = TF \cdot T_i + SRF \cdot I_{G\downarrow i} \cdot (1 - \alpha_i)$$

5. Snow and Ice reservoir

$$Q_t = Q_{t-1} \cdot \exp\left(-\frac{1}{k}\right) + \left(1 - \exp\left(-\frac{1}{k}\right)\right) \cdot V_{New(t)}$$

6. 2 Soil layers

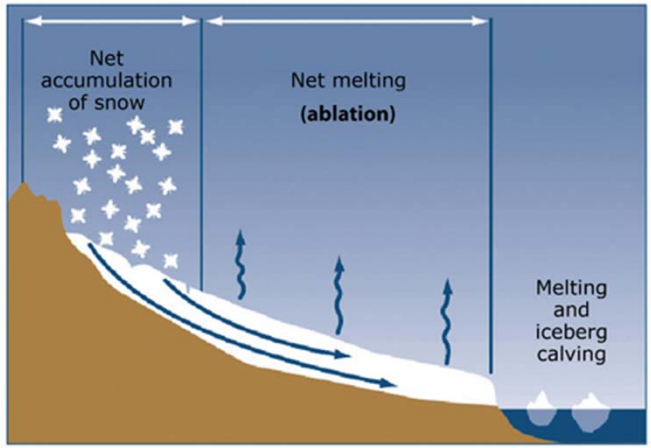
Evolution of the Rhone Glacier



Data availability for the Gletsch site

Discharge (Q)
- 10 min resolution
- Rhone valley

$$R^2 = 1 - \frac{\sum_{i=1}^{n}\left(Q_{i,\mathrm{obs}} - Q_{i,\mathrm{sim}}\right)^2}{\sum_{i=1}^{n}\left(Q_{i,\mathrm{obs}} - \overline{Q_{i,\mathrm{obs}}}\right)^2}$$



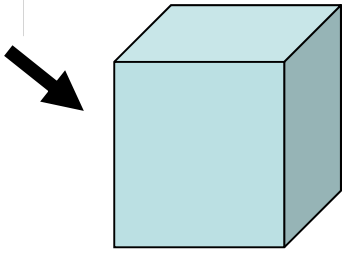
Mass Balances (MB)
- Every 100 m altitude
- 1900 to present
- → For Gletsch: 2 values per year
- (winter and summer)

$$RMSE_{MB} = \sqrt{\sum_{j=1}^{m}\left(MB_{j,\mathrm{obs}} - MB_{j,\mathrm{sim}}\right)^2}$$

MODIS snow cover data (SC)
- Twice a day (TERRA and AQUA)
- 500 m resolution
- Entire world

$$CPSC = \frac{c_{\mathrm{corr}}}{c_{\mathrm{tot}} - c_{\mathrm{missing}}}$$

Stochastic Calibration: Monte Carlo Simulations



1. Run 10'000 plausible parameter sets

2. Assessment of performance

$$R^2 = 1 - \frac{\sum_{i=1}^{n}\left(Q_{i,\mathrm{obs}} - Q_{i,\mathrm{sim}}\right)^2}{\sum_{i=1}^{n}\left(Q_{i,\mathrm{obs}} - \overline{Q_{i,\mathrm{obs}}}\right)^2}$$

$$RMSE_{MB} = \sqrt{\sum_{j=1}^{m}\left(MB_{j,\mathrm{obs}} - MB_{j,\mathrm{sim}}\right)^2}$$

$$CPSC = \frac{c_{\mathrm{corr}}}{c_{\mathrm{tot}} - c_{\mathrm{missing}}}$$

3. Ranking of parameter sets according to the 3 criteria

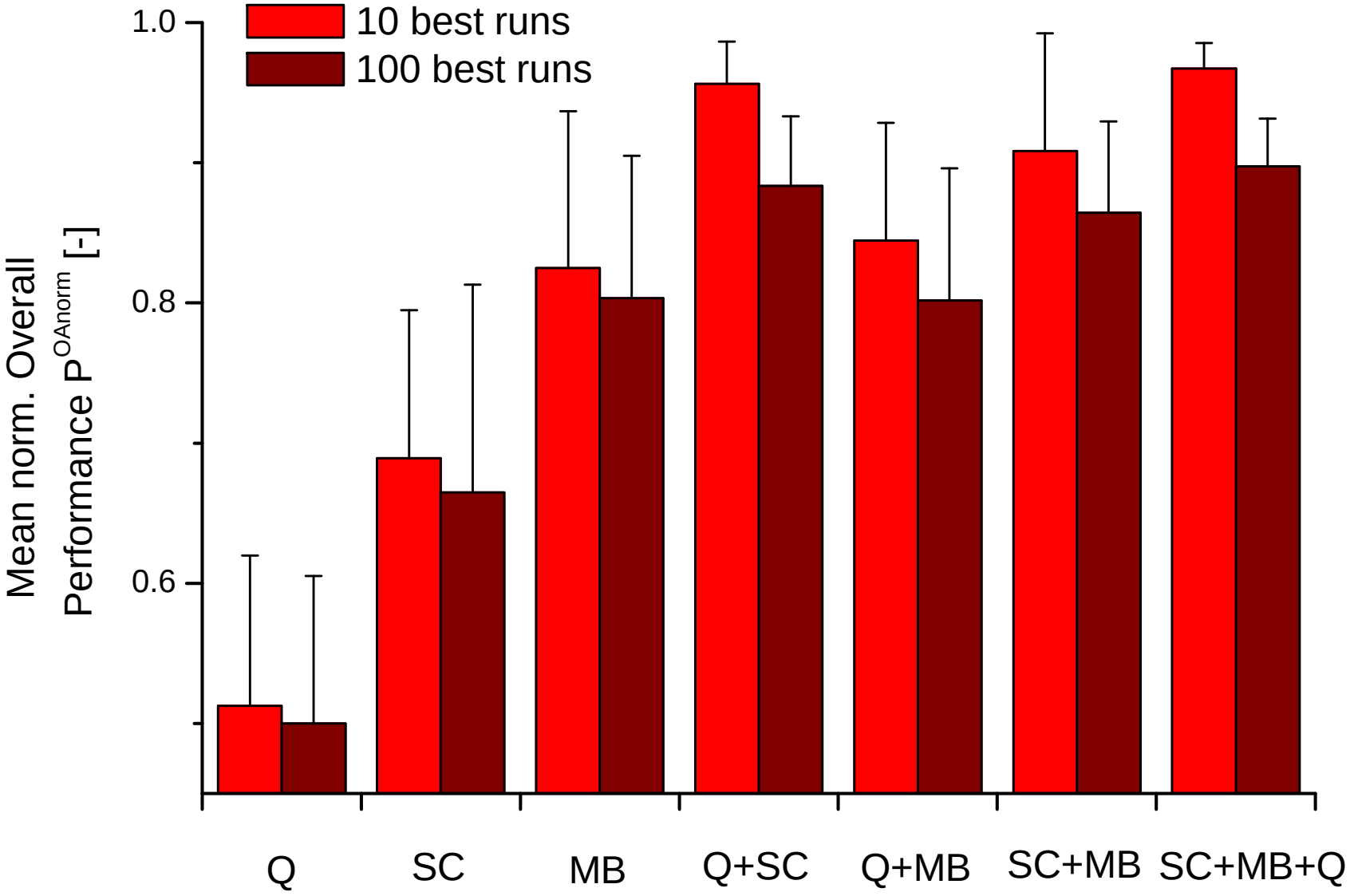
4. Determination of the empirical probability

5. Overall performance = average of P^i_r

$$P_r^i = \frac{(N+1) - Rank_r^i}{N}$$

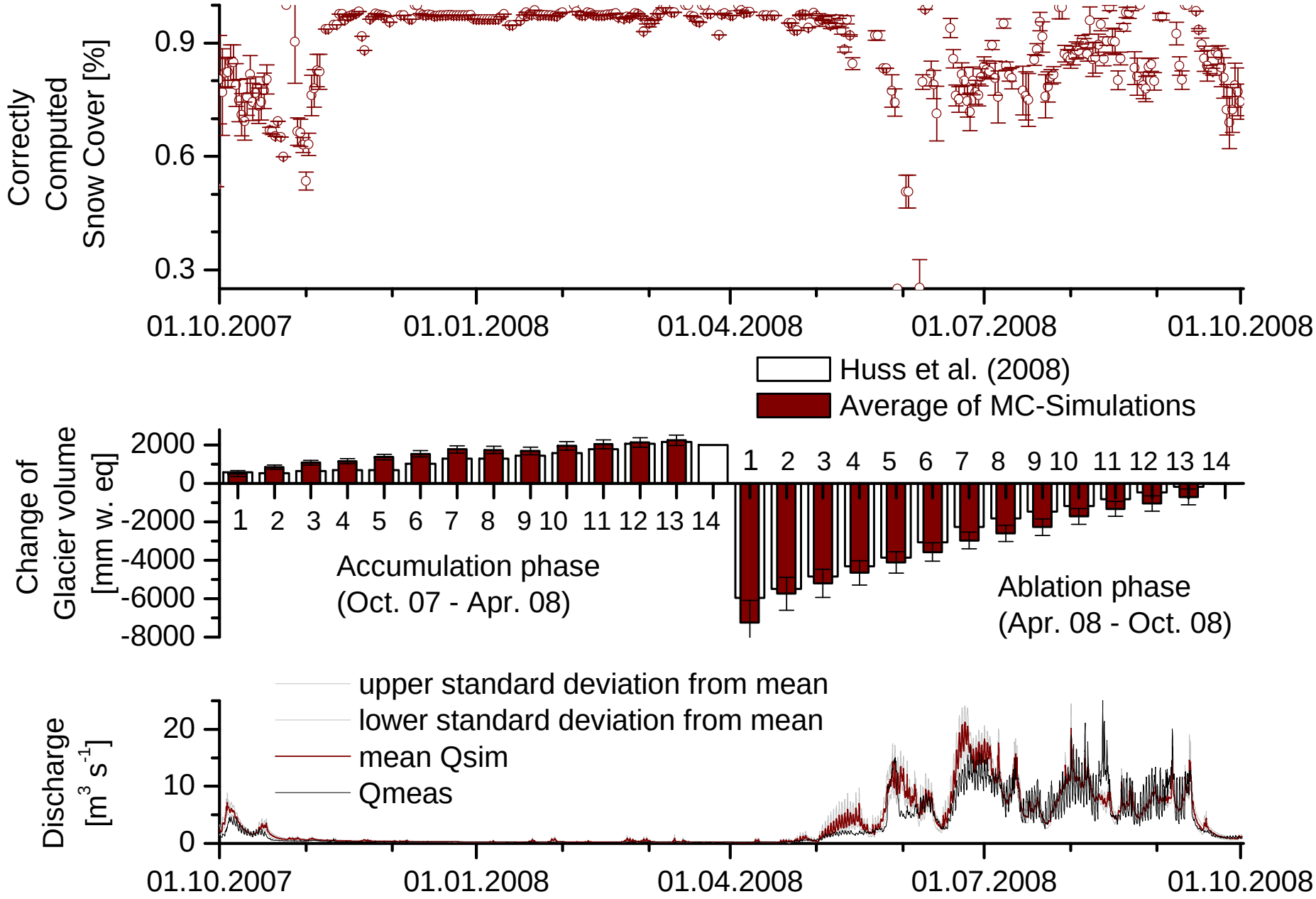
Q SC MB Q + SC Q + MB MB + SC Q + MB + SC

Mean overall performance defined by the average empirical probability

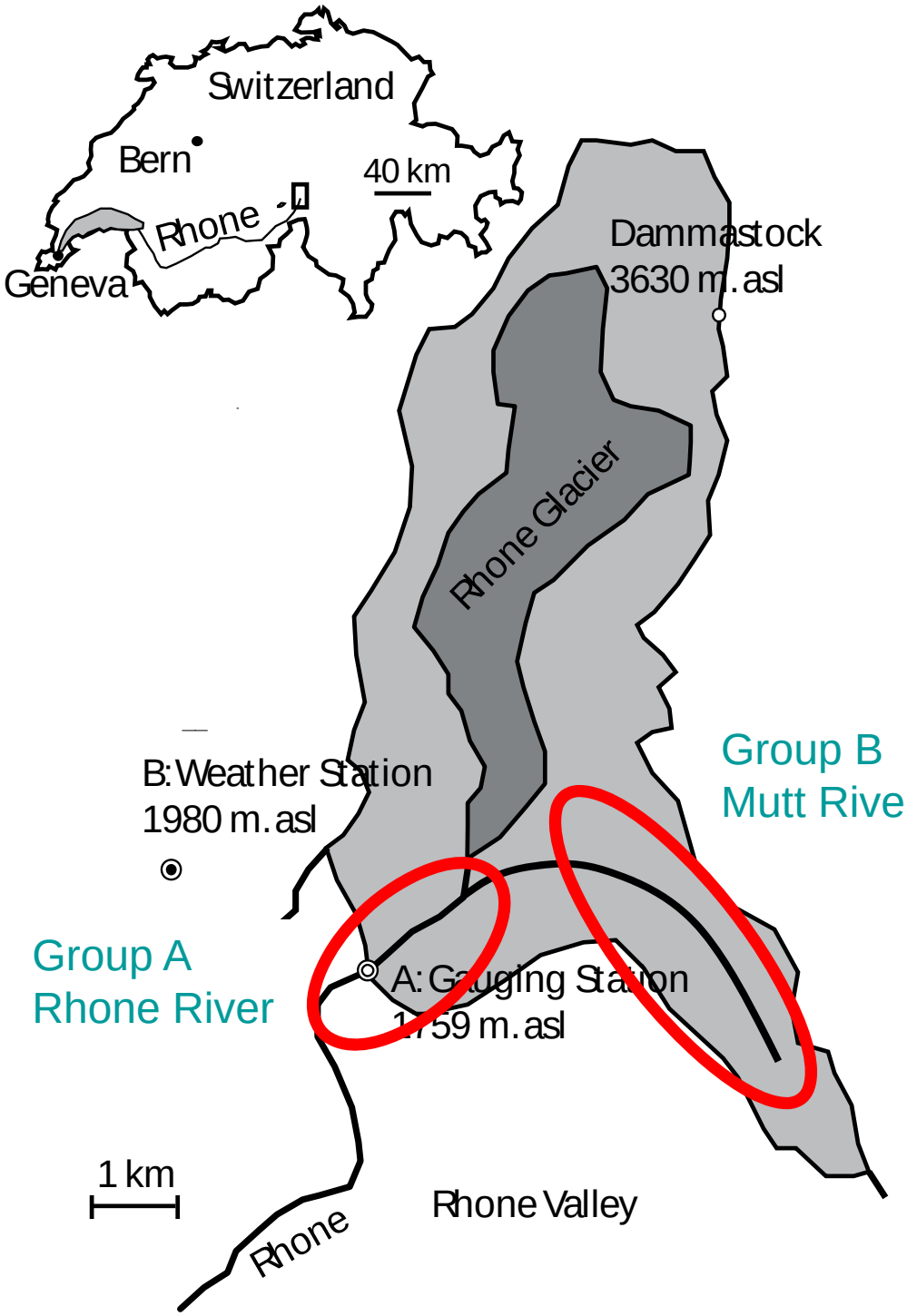


Finger et al., submitted to WRR

Results of snow cover, mass balances and discharge of the 100 best MC runs



Experimental Setup

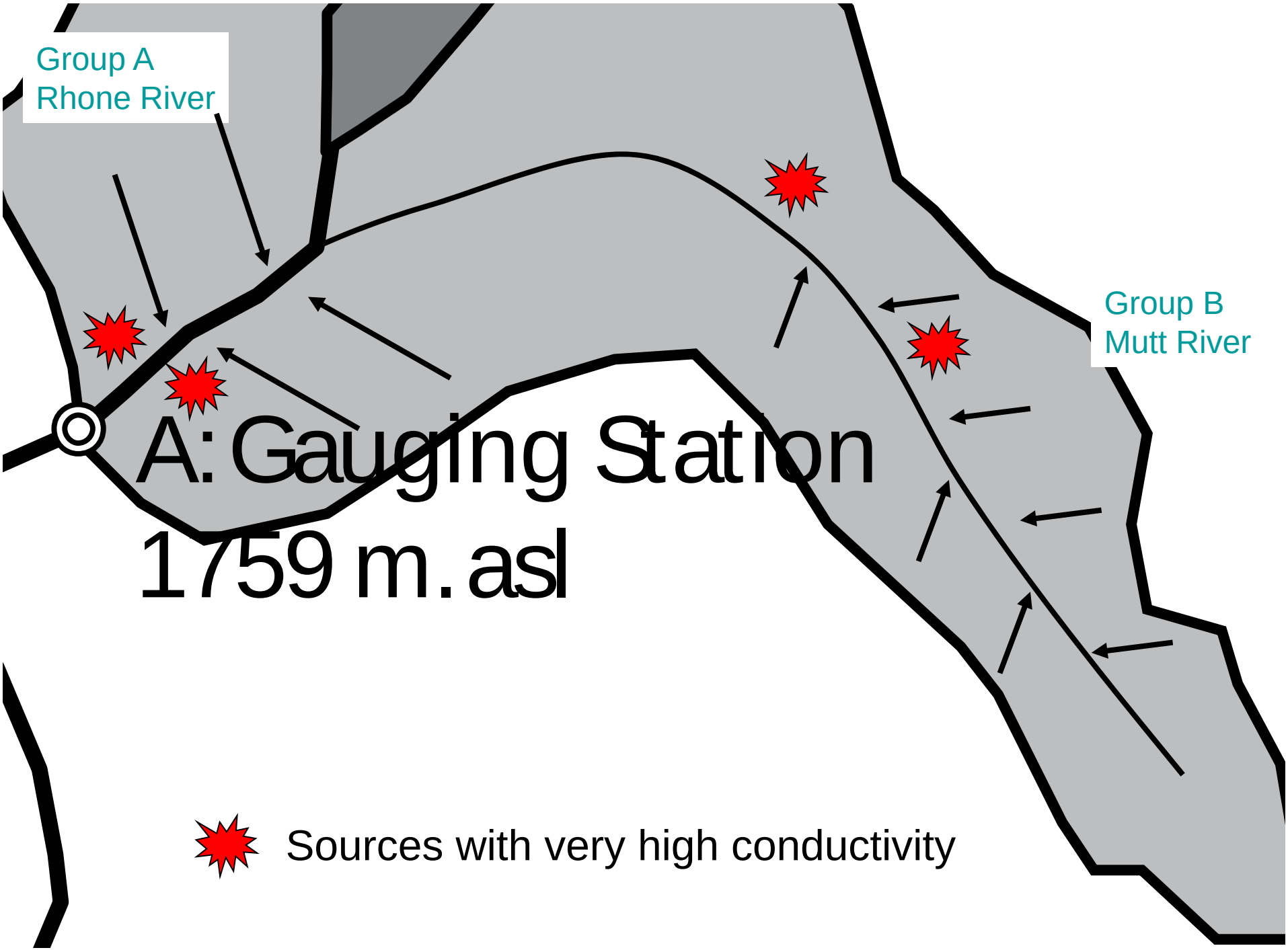


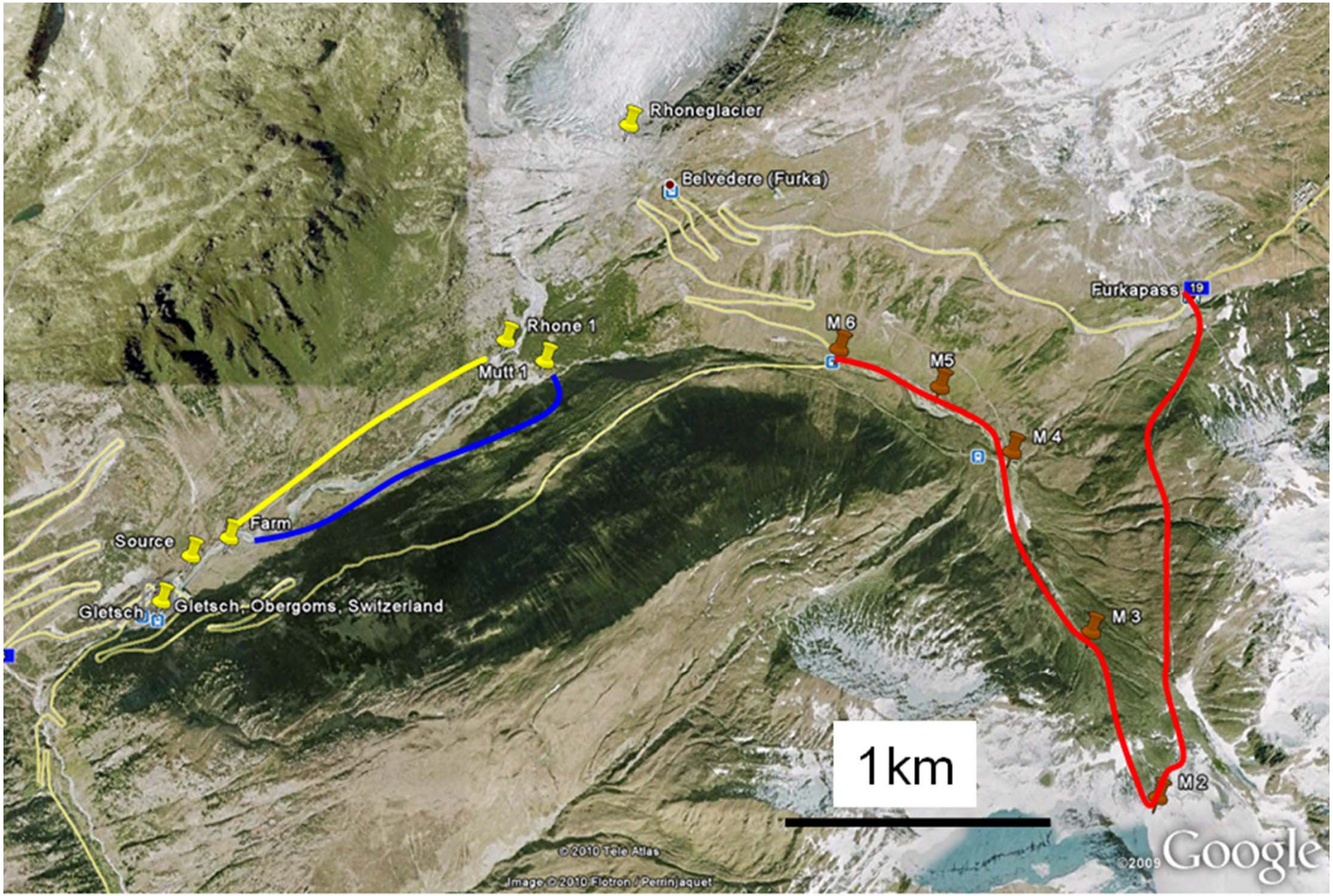
Group A
Rhone River

Group B
Mutt River

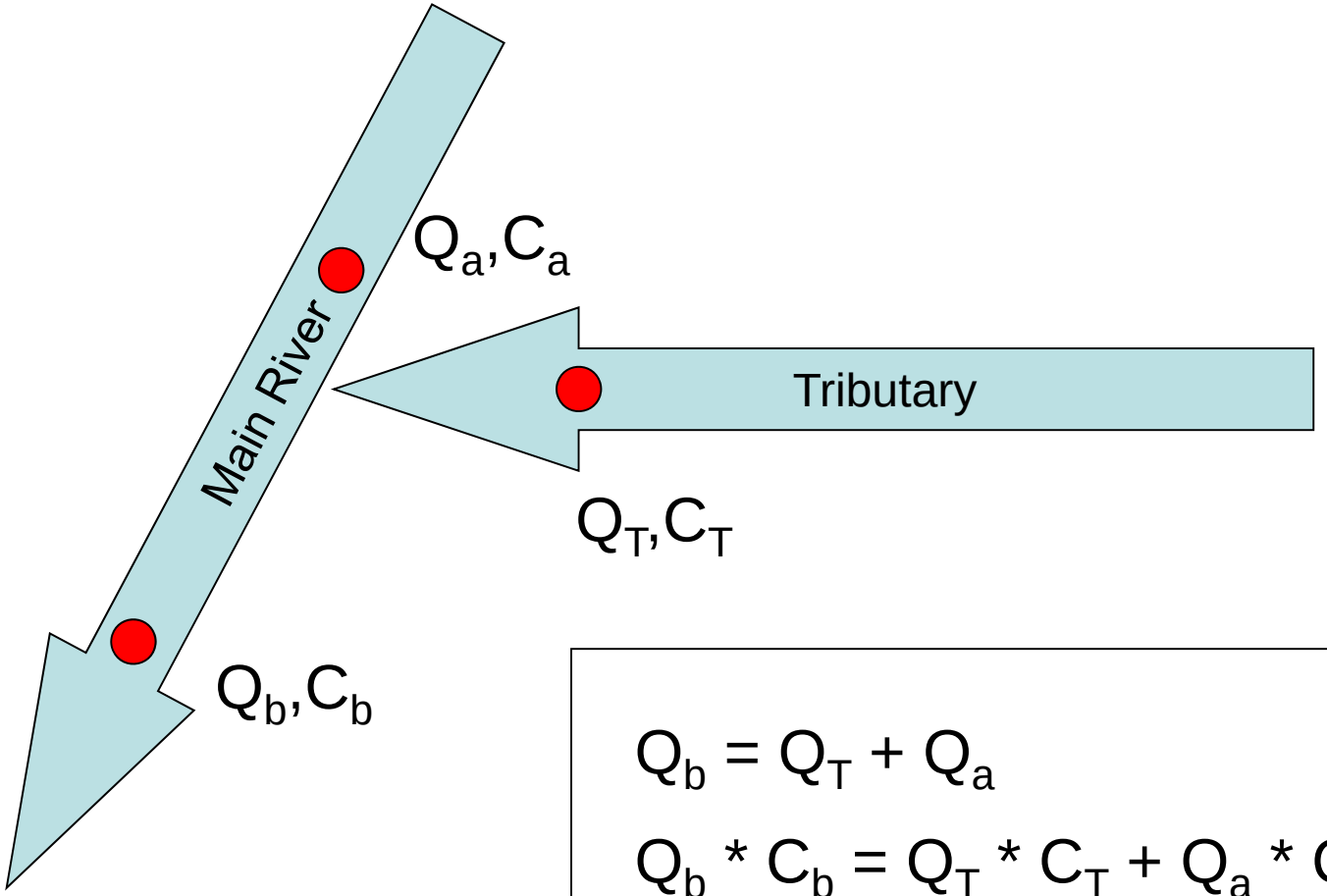
Group A
- Sampling in the Rhone River
- Sampling of the lower Mutt
- Installation of conductivity loggers

Group B
- Sampling of the upper Mutt River
- Hiking along the Mutt
- good shoes and mountain experiance required


Group A
Rhone River
Group B
Mutt River
A: Gauging Station
1759 m.asl
Sources with very high conductivity


Rhoneglacier
Belvedere (Furka)
Furkapass
19
Rhone 1
Mutt 1
M 6
M5
M 4
M 3
M 2
Farm
Source
Gletsch
Gletsch-Obergoms, Switzerland
1km
© 2010 Tele Atlas
Image © 2010 Flotron / Perrinjaquet
©2009 Google

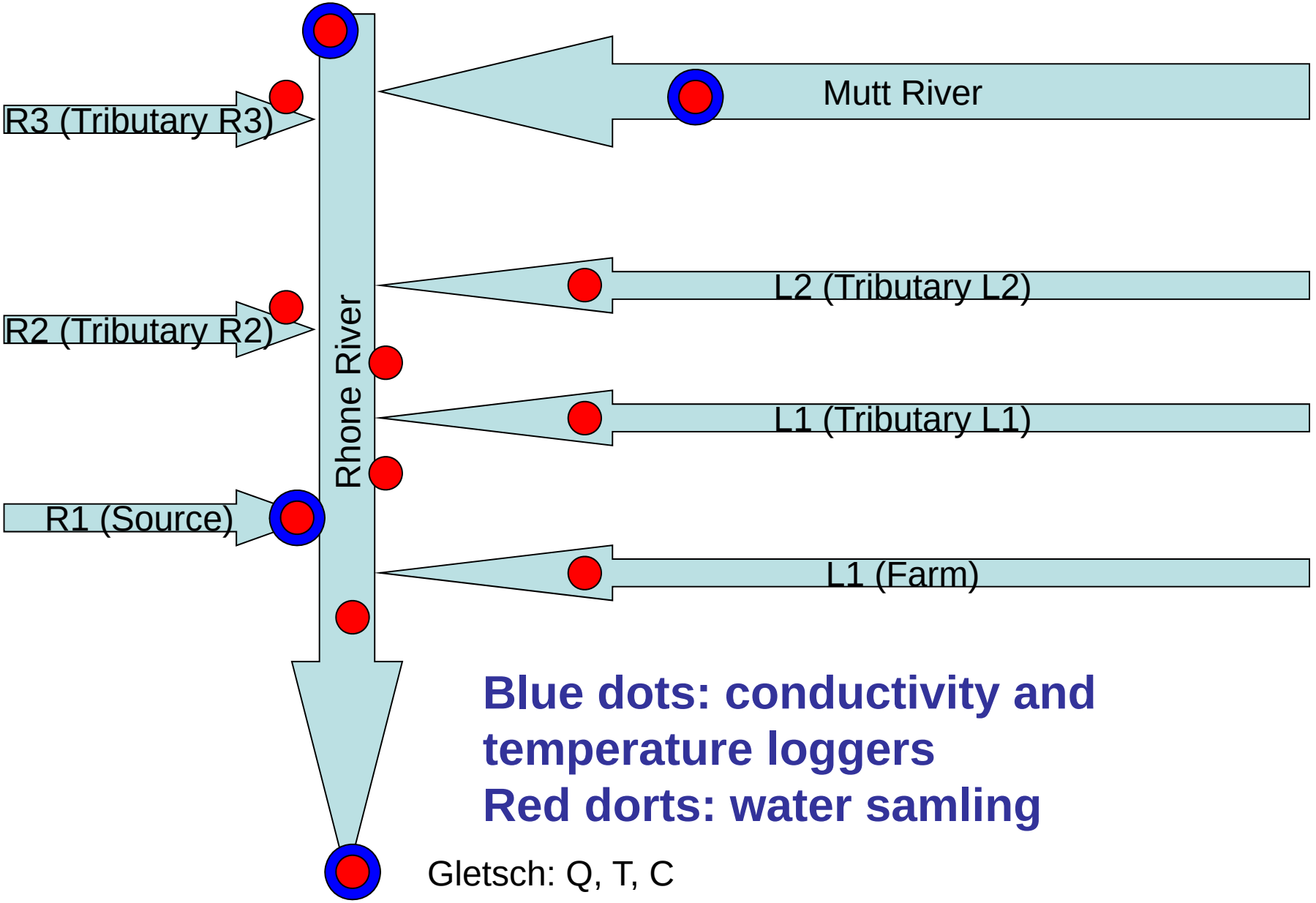
Water mixing



$$Q_b = Q_T + Q_a$$

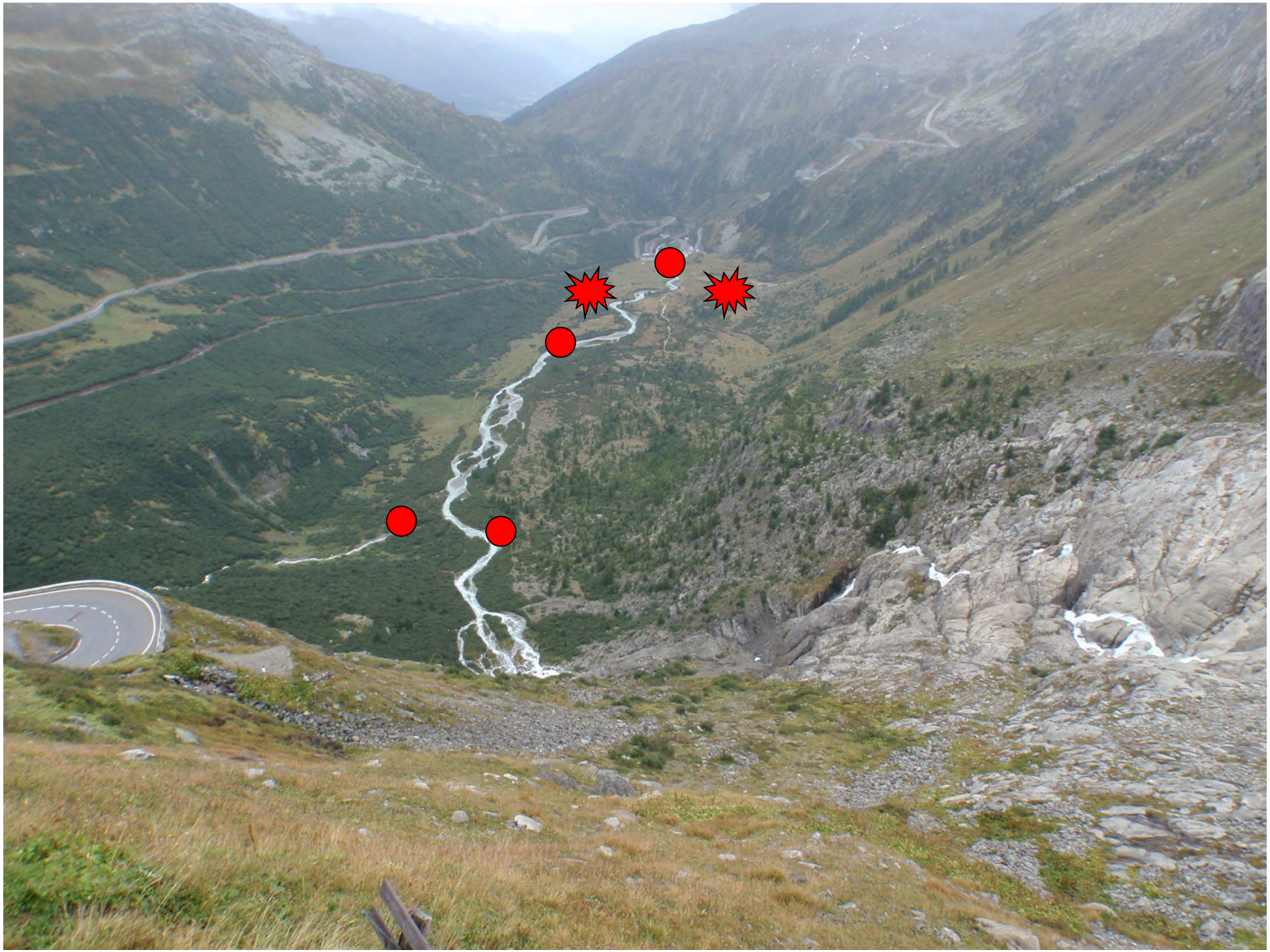
$$Q_b * C_b = Q_T * C_T + Q_a * C_a$$

Group A : Rhone River



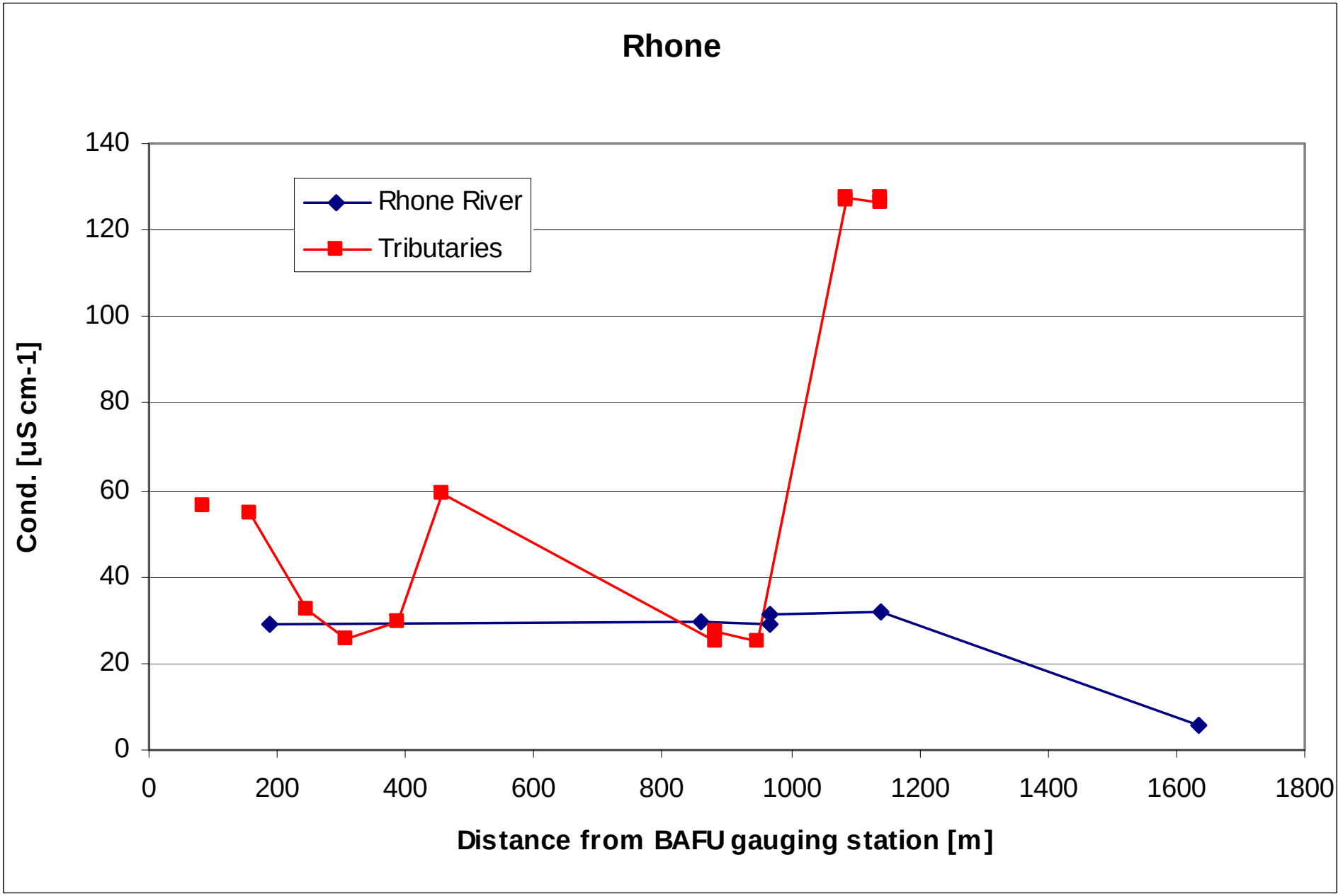
Blue dots: conductivity and temperature loggers
Red dorts: water samling

Gletsch: Q, T, C



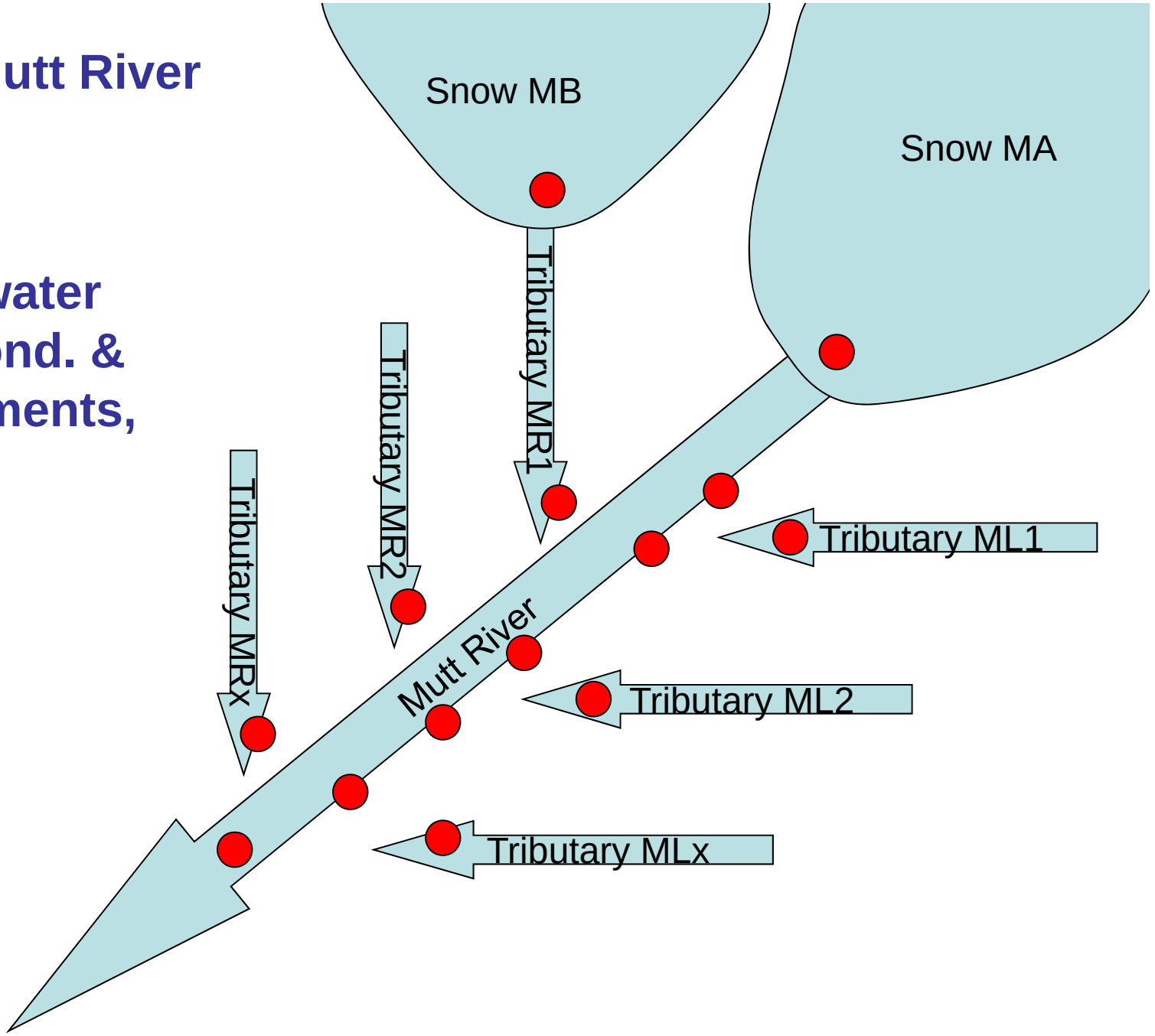

3
30.2
µS/cm
3.4
°C

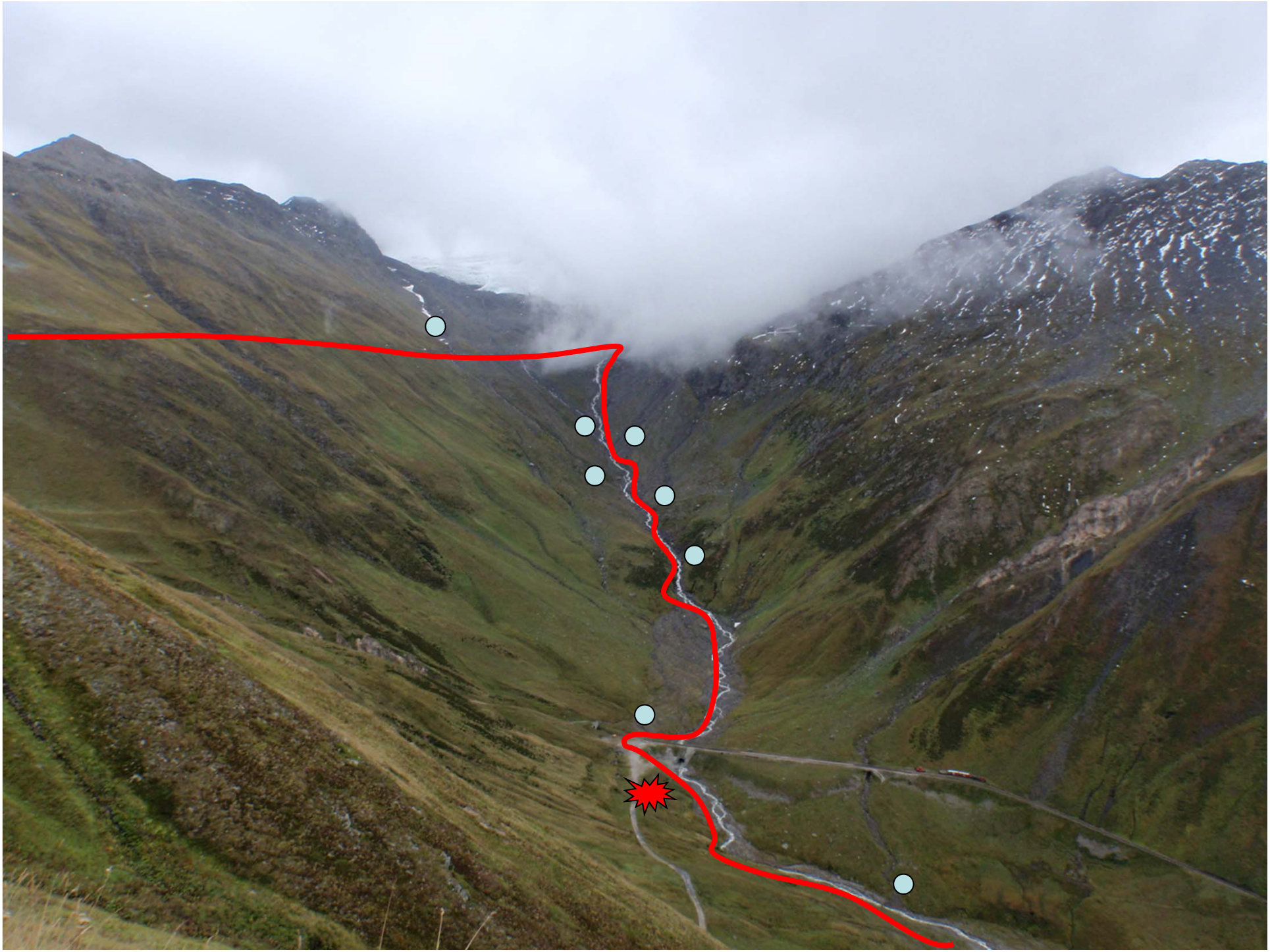

S24
etrex
SUMMIT
MARK
WAYPOINT
OK?
GARMIN
3
27.1 µS/cm
6.4 °C
M
STO
CAL
RCL
AR
RUN/ENTER
WTW
Cond 340i

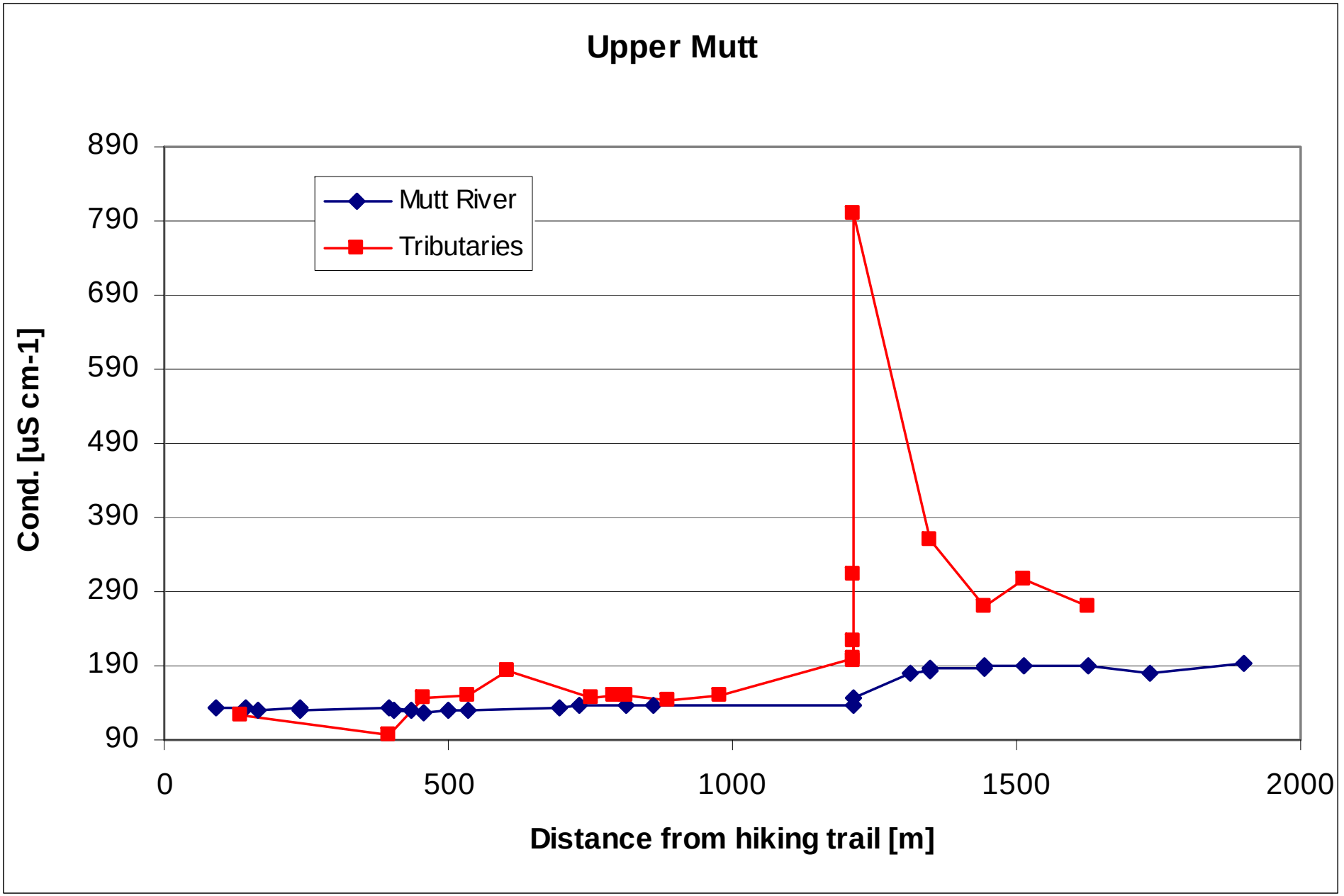

Rhone
Rhone River
Tributaries
Cond. [uS cm-1]
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
1800
Distance from BAFU gauging station [m]

Group B : Mutt River

Red dots: water samling, cond. & T meassurments, discharge estimation






Upper Mutt
890
790
690
590
490
390
290
190
90
Cond. [uS cm-1]
Mutt River
Tributaries
0
500
1000
1500
2000
Distance from hiking trail [m]

Field practicum for MS students

- Objective
  Identify and characterize a mountain stream in the Swiss alps based on chemical fingerprint
- Activities
  Water sampling, installation of monitoring devices and manual measurements
- Organization
  When: 19. October
  Meeting point: 8h at ETH Höggerberg (transfer with ETH Bus)
  → If somehow possible, I would like to start in the morning (8h), perhaps the students could get the morning off for this occasion
  Where: Gletsch, Wallis
  Important: The return time depends on weather, snow and traffic conditions – expected arrival in Zurich is 20h
- Max. participants: 10 pers.
  Students will be split up in Group 1 and 2 (each group will be composed of 3 - 4 students – see next slide for organization of groups)
- Weather conditions
  - Please take mountain shoes, warm clothing and rain gear
  - The program will be adapted according to snow conditions

Activities

- Sampling locations (see map on next slide)
  - The 6 definite sampling location
    - Gletsch (sampling altogether)
      - This is a permanent gauging station of the BAFU (temperature and discharge is collected with hourly resolution)
      - conductivity and temperature will be recorded with an automatic logger
      - Water samples will be collected at the beginning and at the end of the Fieldtrip
    - Source (Group 1 – yellow line on map)
      - This is a swamp and the exact location will be defined during the field trip. The swamp is fed by snow melt and ground water (the identification of the water source is one of the challenges of this field expedition)
      - Discharge will be estimated in tributary
      - conductivity and temperature will be recorded with a manual meter
      - Water samples will be collected
    - Farm (Group 1 – blue line on map)
      - This is a summer farm with several cows during the summer month. During summer time water drainage from the farmland affects water quality strongly, but ionic composition is distinctly different from the rest of the catchment.
      - Discharge will be estimated in tributary
      - conductivity and temperature will be recorded with a manual meter
      - Water samples will be collected at suitable locations.
    - Mutt 1 (Group 1)
      - This is the sampling location of University of Geneva. Biologists investigate here changes in biodiversity. Ionic composition and other physical stress factors affect the biodiversity.
      - conductivity and temperature will be recorded with a manual meter
      - Discharge will be estimated in Mutt (if conditions allow it)
      - Water samples will be collected at suitable locations.
    - Rhone 1 (Group 1)
      - This sampling location is primarily fed by the Rhoneglacier. Temperature and conductivity is very low.
      - conductivity and temperature will be recorded with a manual meter
      - Water samples will be collected at suitable locations.
  - Optional sampling location (only if the weather and snow conditions are good)
    - M2 to M6 (Group 2 – red line on map)
      - These station will only be sampled if weather and snow conditions are good. A group of three students will be brought to the Furka pass. They will then hike about 2 km to the River Mutt on a well constructed trail. Then they will follow the River Mutt and sample each tributary and each junction with the River Mutt.
      - **IMPORTANT: For this task mountaineering experience and good mountain shoes are mandatory. There is no trail along the River Mutt but the terrain is safe.**
      - conductivity and temperature will be recorded with a manual meter
      - Water samples will be collected at suitable locations.
      - Discharge will be estimated in tributaries

Characteristics of study area

Water shed at Gletsch : 39 km2

Lowest altitude: 1761 m asl

Glaciations: 52.2%

Discharge: 2.67 m3/s

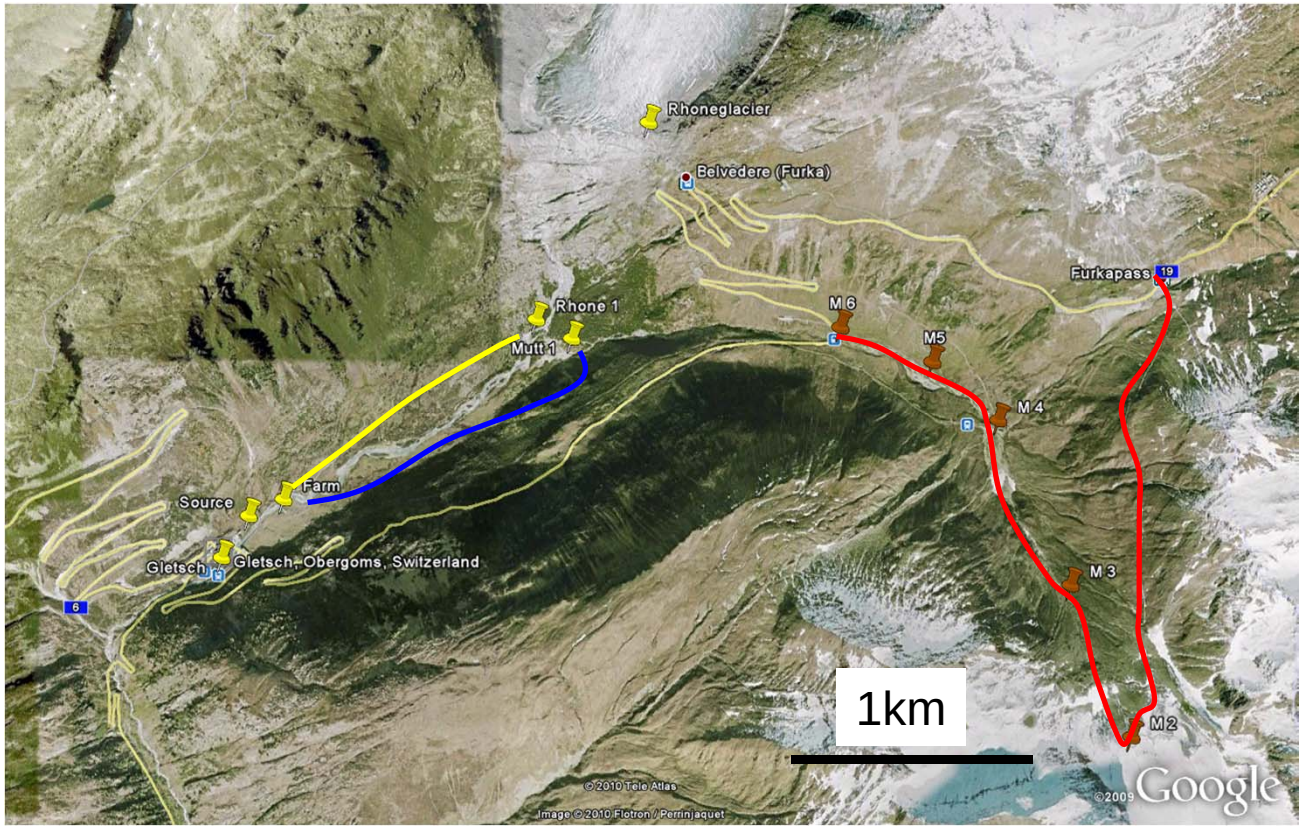
Automatic stations:

Gletsch: Q, C , WS

Mutt 1: C, WS

Rhone 1: C, WS

At all other stations C and pH will be measured manually and water samples will be collected



Material

- Automatic Sensors and logger
  - 4 Conductivity and temperature logger (decagon or other devices)
- Requirements for Group 1
  - 20 Bottles for water samples
  - 1 Conductivity meter
  - 1 pH meter (optional)
  - 1 Discharge measurement device
  - 1 Measuring tape
  - Waterproof markers
  - 1 GPS
- Requirements for Group 2
  - 30 Bottles for water samples
  - 1 Conductivity meter
  - 1 pH meter (optional)
  - Waterproof markers
  - 1 GPS
  - 1 Discharge measurement device
  - 1 Measuring tape
  - Big backpack

Additional information

- The Postal service to Gletsch is guaranteed until 24 October if weather conditions allow it
- Grimsel and Furka pass are generally open until end of October – depending on weather conditions
- Restaurant service in Gletsch ends on 3 October (attendees will have to bring lunch)
- Train service between Oberwald (village below Gletsch) and Andermatt is guaranteed all year long
- Steam train service between Gletsch and Realp ends on 3 October