GLAMOS

Behind the scenes

Yvo Weidmann

Agenda

1. Requirements and Data Modelling
2. Topographical Landscape Model
3. Linkage to Hydrological Network
4. Data Publication
5. Summary

Part 1

Requirements and Data Modelling

Requirements; Expectations

Point-of-View of a Glaciologist

- Collection of entire datasets
- Thematically organized
- Available for download and usage
- …

Point-of-View of the Geoinformatics

```
CREATE OR REPLACE VIEW length_change.vw_length_change AS
 SELECT lcd.fk_glacier, g.short_name AS glacier_short_name,
    g.full_name AS glacier_full_name,
    g.pk_vaw, g.sgi_code, lcd.date_from, lcd.date_to,
    lcd.variation_quantitative,
    sum(lcd.variation_quantitative) OVER (PARTITION BY lcd.fk_glacier ORDER BY lcd.date_to)
          AS variation_quantitative_cumulative
   FROM length_change.length_change_data lcd
     JOIN base_data.vw_glacier_identification g ON g.pk_vaw = lcd.fk_glacier;

ALTER TABLE length_change.vw_length_change
  OWNER TO gladmin;
```

Requirements; Evaluation of DBMS

Appropriate Database Management System (DBMS)

File-based vs. Database:

- Flexibility
- Data exchange and data providing
- Compatibility (other data collections and tools)

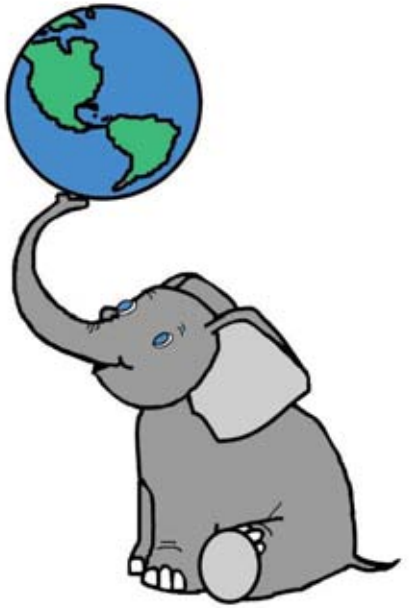
Choice of DBMS:

- Commercial vs. Open-Source
- Spatial Datatypes
- Well-known and active community
- Ongoing development

Requirements; Evaluation of DBMS

PostgreSQL and *PostGIS* extension

- ✓ Flexibility
- ✓ Data exchange and data providing
- ✓ Compatibility
  OK GLIMS, OK KOGIS[1], OK OGC[2], …
- ✓ Open-Source
- ✓ Spatial Datatypes
  OK Vector, OK Raster, OK Topology
- ✓ Well-known and active community
  OK International, OK Switzerland
- ✓ Ongoing development



https://www.postgresql.org/
http://www.postgis.net/

[1]: KOGIS: Koordination, Geo-Information und Services
[2]: Open Geospatial Consortium

Data Modelling

Steps of the Data Modelling process

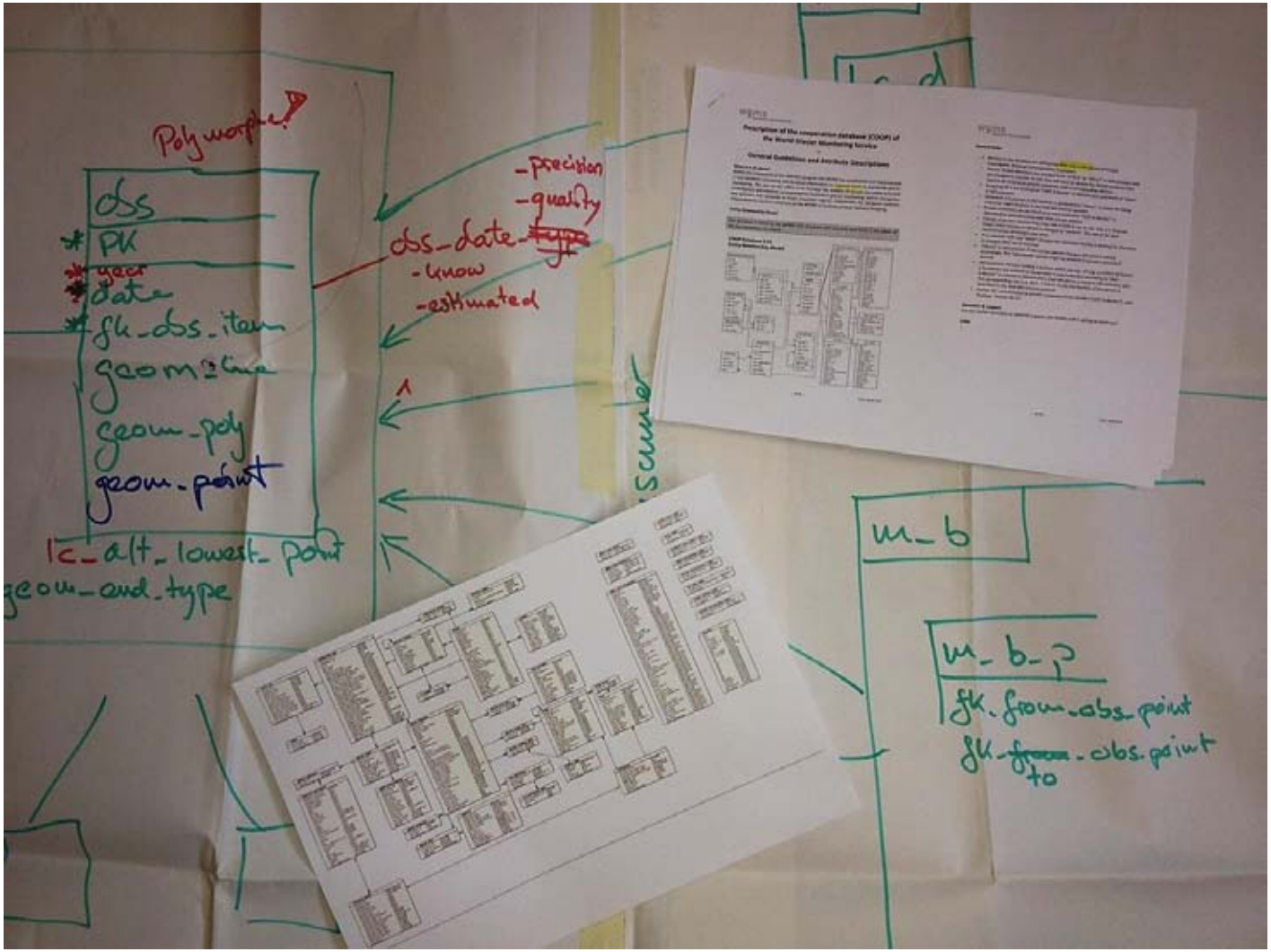
Main goal: ***Reduced duplication of data, ensure referential integrity, unique identification of each dataset.***

1st, 2nd and 3rd normal form of relation data models (Edgar F. Codd, 1971)

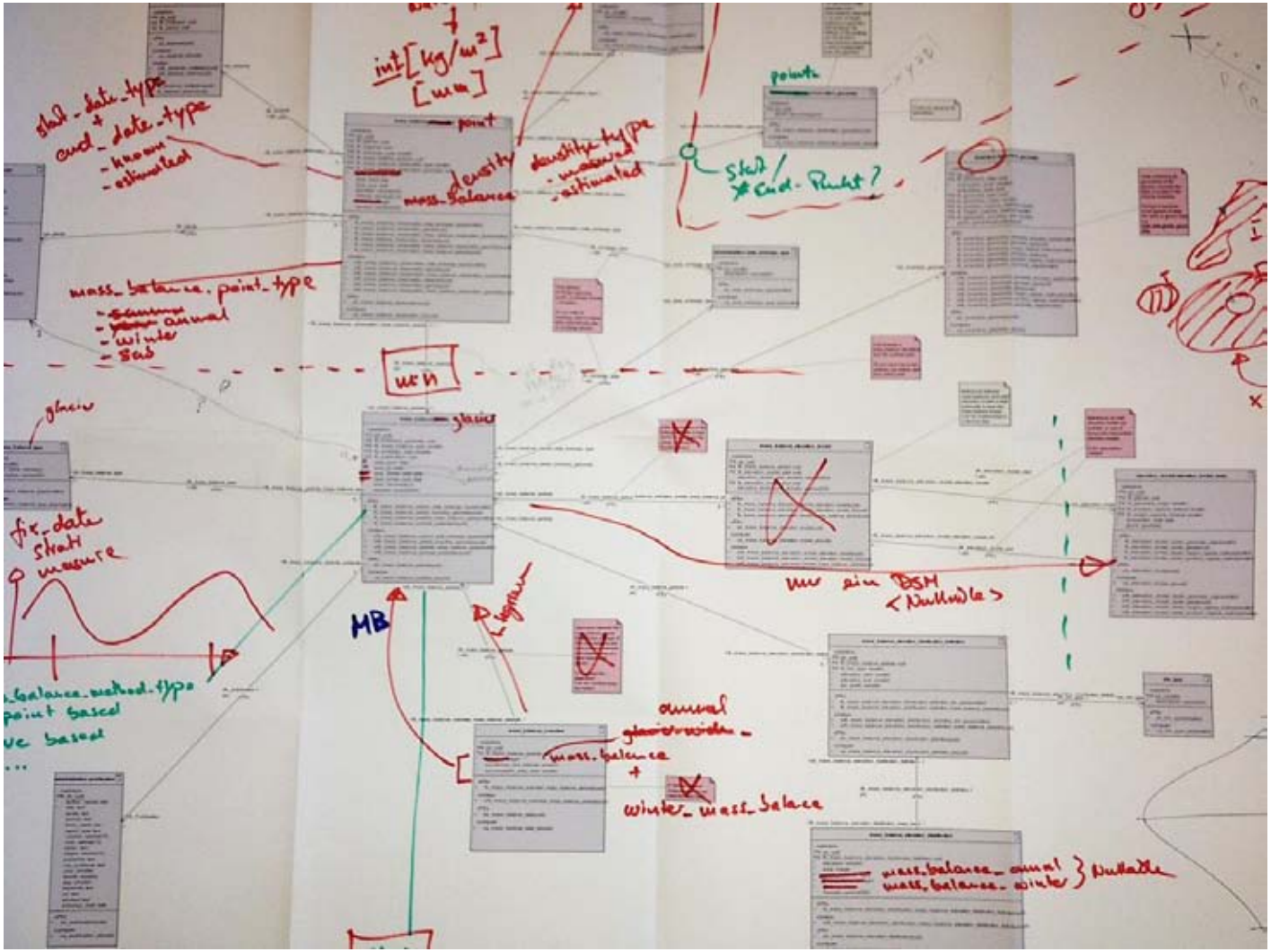
Results: Description of data, relations and dependencies

- **Conceptual Schema**
  - Describes the semantics of the domain [Glaciology]
- **Logical Schema**
  - Describes the structure of the domains of information [Relations, …]
- **Physical Schema**
  - Describes the physical means used to store data [Implementation]

Data Modelling; Conceptual schema



Data Modelling; Logical schema



Data Modelling; Physical schema

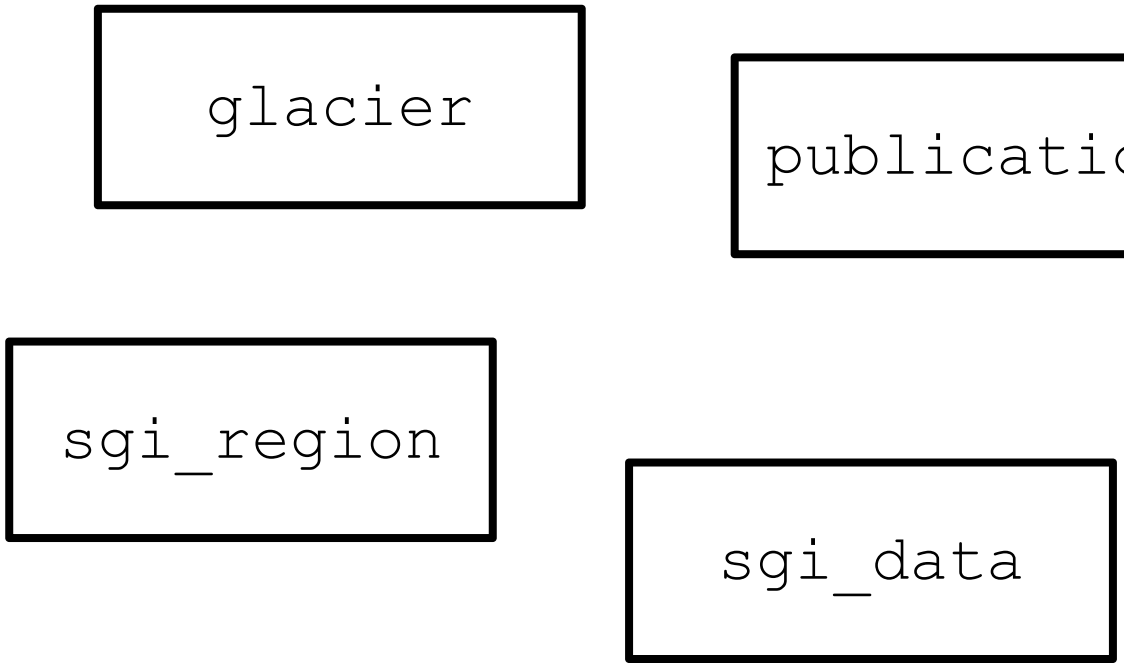
```
CREATE TABLE mass_balance.mass_balance_glacier (
    pk   uuid   NOT NULL CONSTRAINT mass_balance_glacier_pk PRIMARY KEY,
    fk_glacier   smallint   NOT NULL REFERENCES base_data.glacier,
    fk_mass_balance_glacier_type   smallint   NOT NULL
       REFERENCES mass_balance.mass_balance_glacier_type,
    date_annual_from   date NOT NULL,
    date_annual_to   date NOT NULL,
    date_winter_start   date NOT NULL,
    date_winter_end   date NOT NULL,
    annual_mass_balance   integer NOT NULL,
    winter_mass_balance   integer NOT NULL,
    equilibrium_line_altitude   integer NOT NULL,
    accumulation_area_ratio   integer NOT NULL
) TABLESPACE vector;

ALTER TABLE mass_balance.mass_balance_glacier OWNER TO gladmin;

GRANT ALL ON TABLE mass_balance.mass_balance_glacier TO gladmin;
GRANT SELECT ON TABLE mass_balance.mass_balance_glacier TO glro;
```

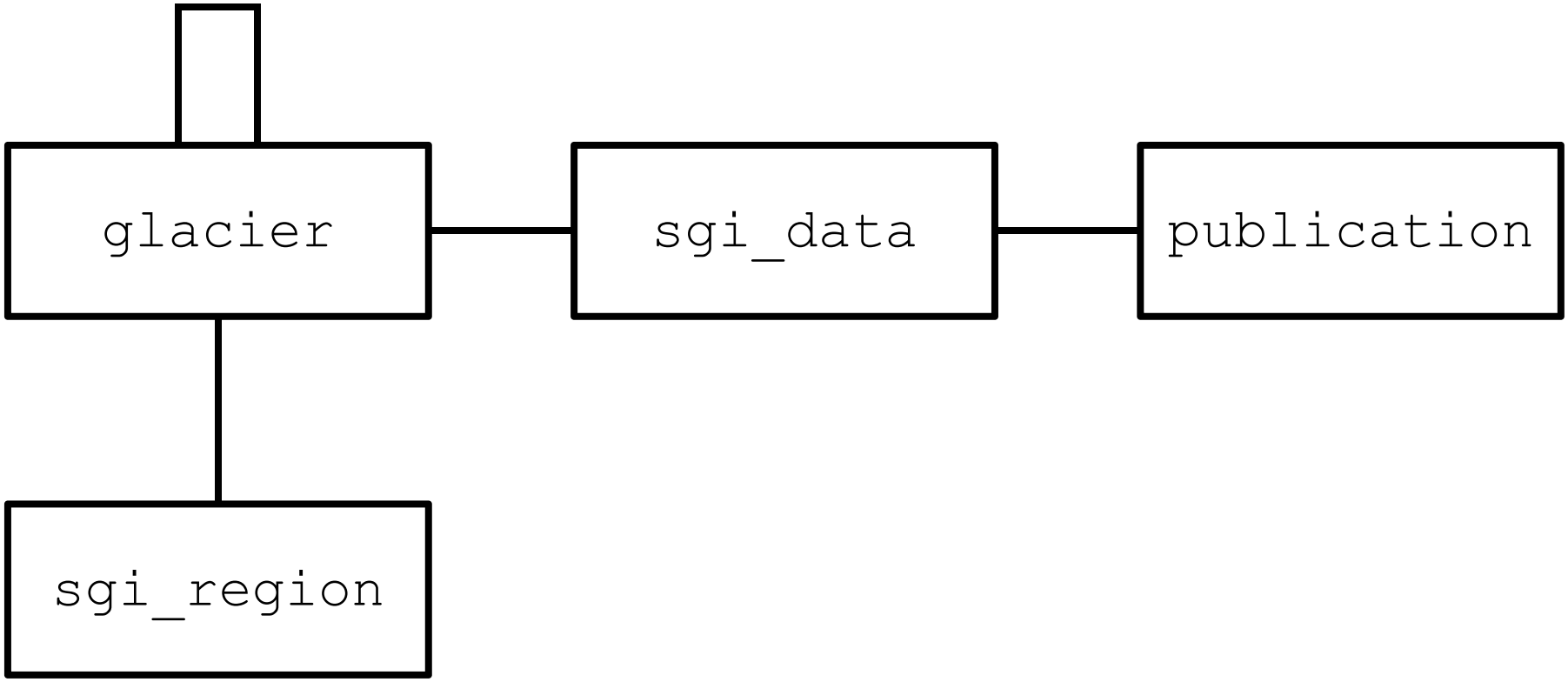
Data Modelling; Entity Relationship (ER)

Collection of Entities



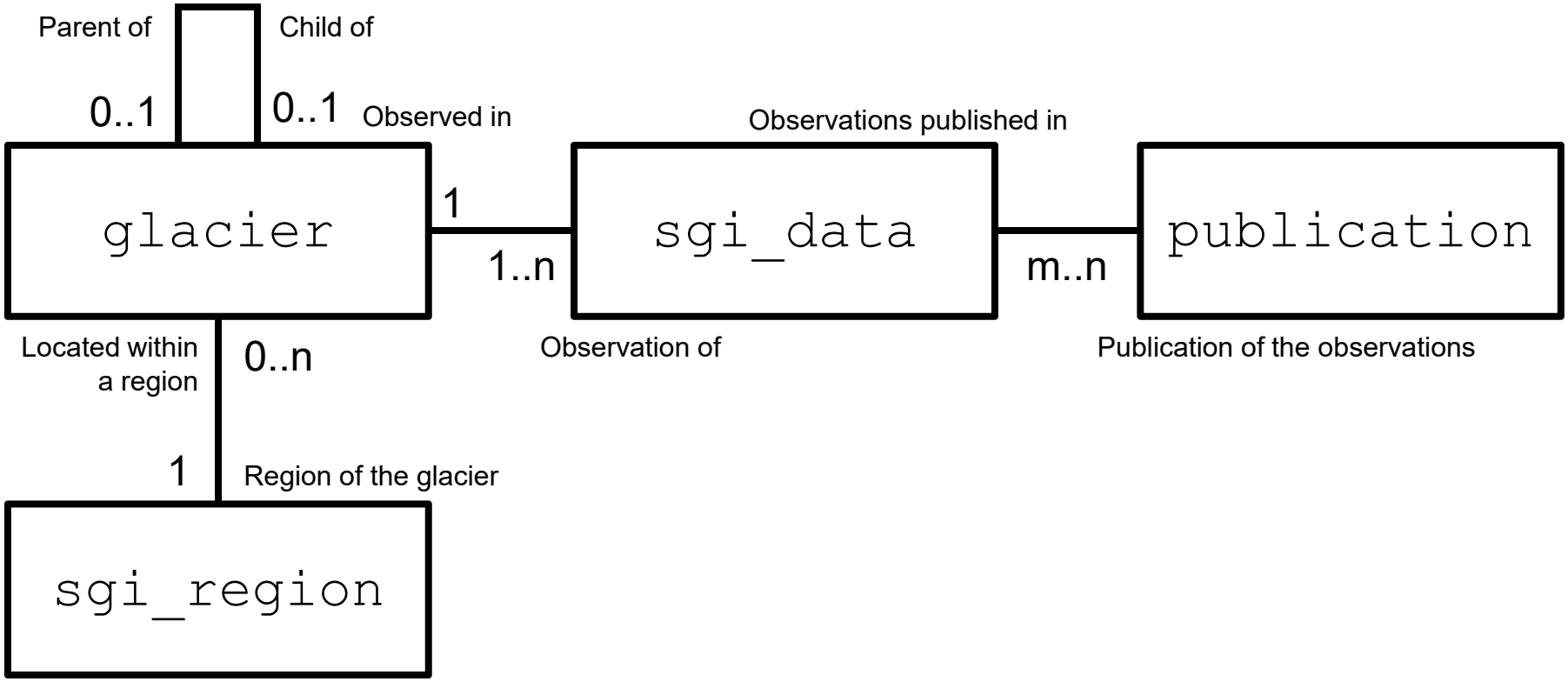
Data Modelling; Entity Relationship (ER)

Definition of the Relations between the Entities



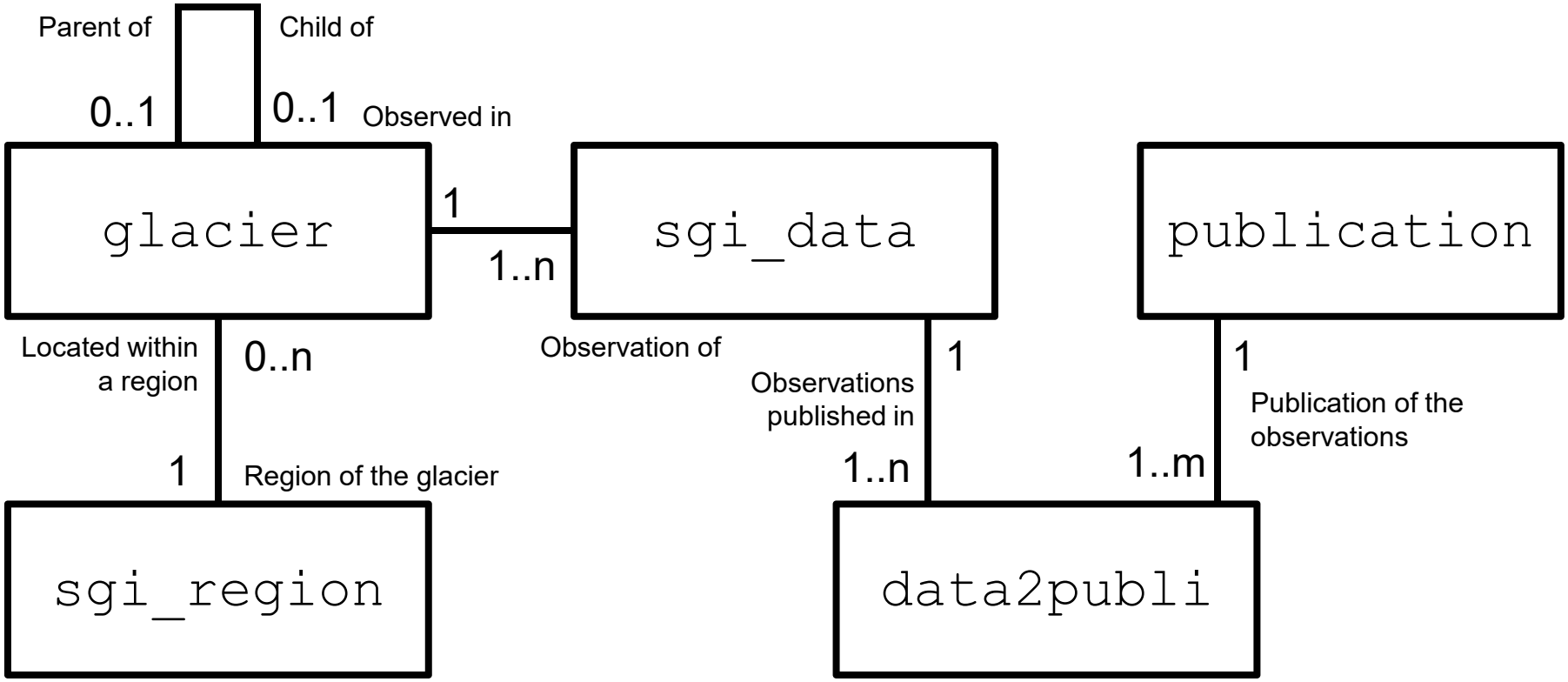
Data Modelling; Entity Relationship (ER)

Definition of the Cardinalities and Naming the Roles



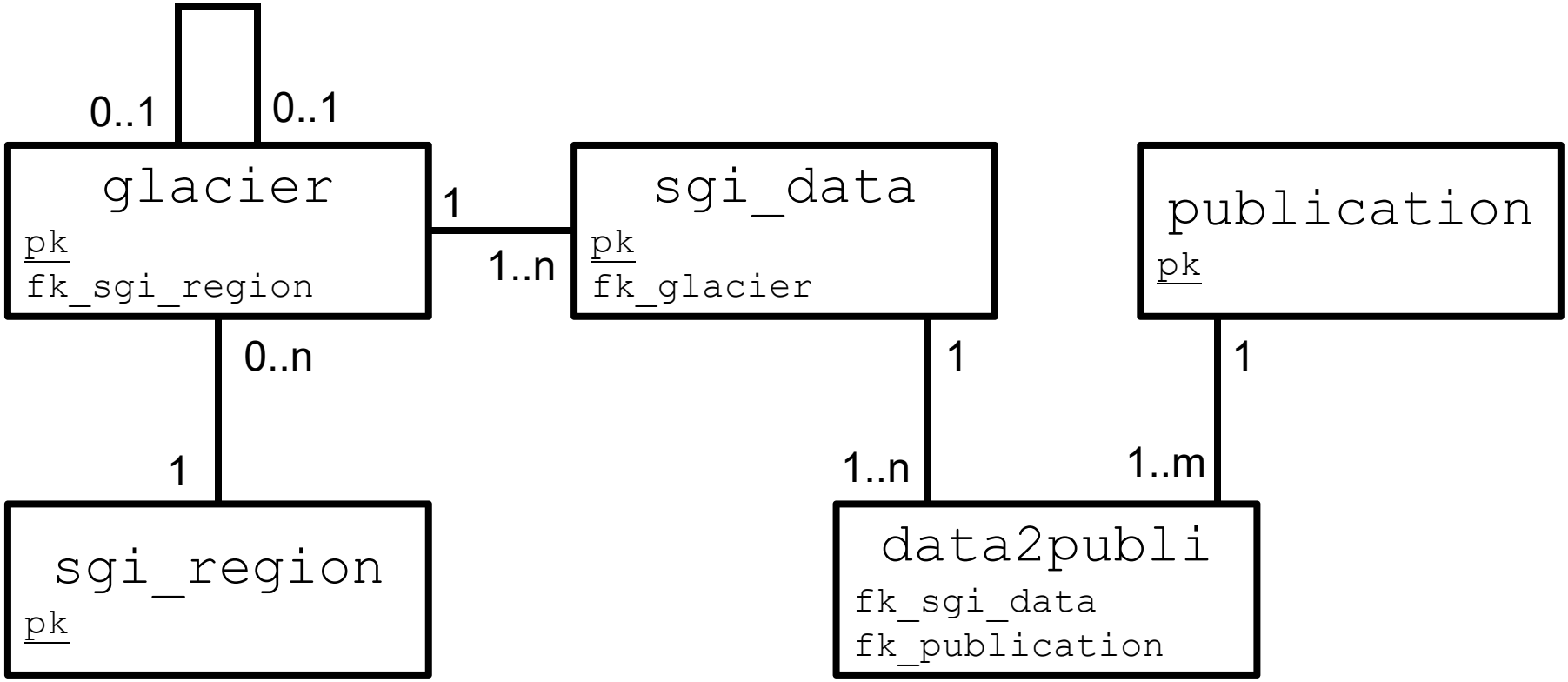
Data Modelling; Entity Relationship (ER)

Resolving m:n-Relations into 1:n- and m:1-Relations



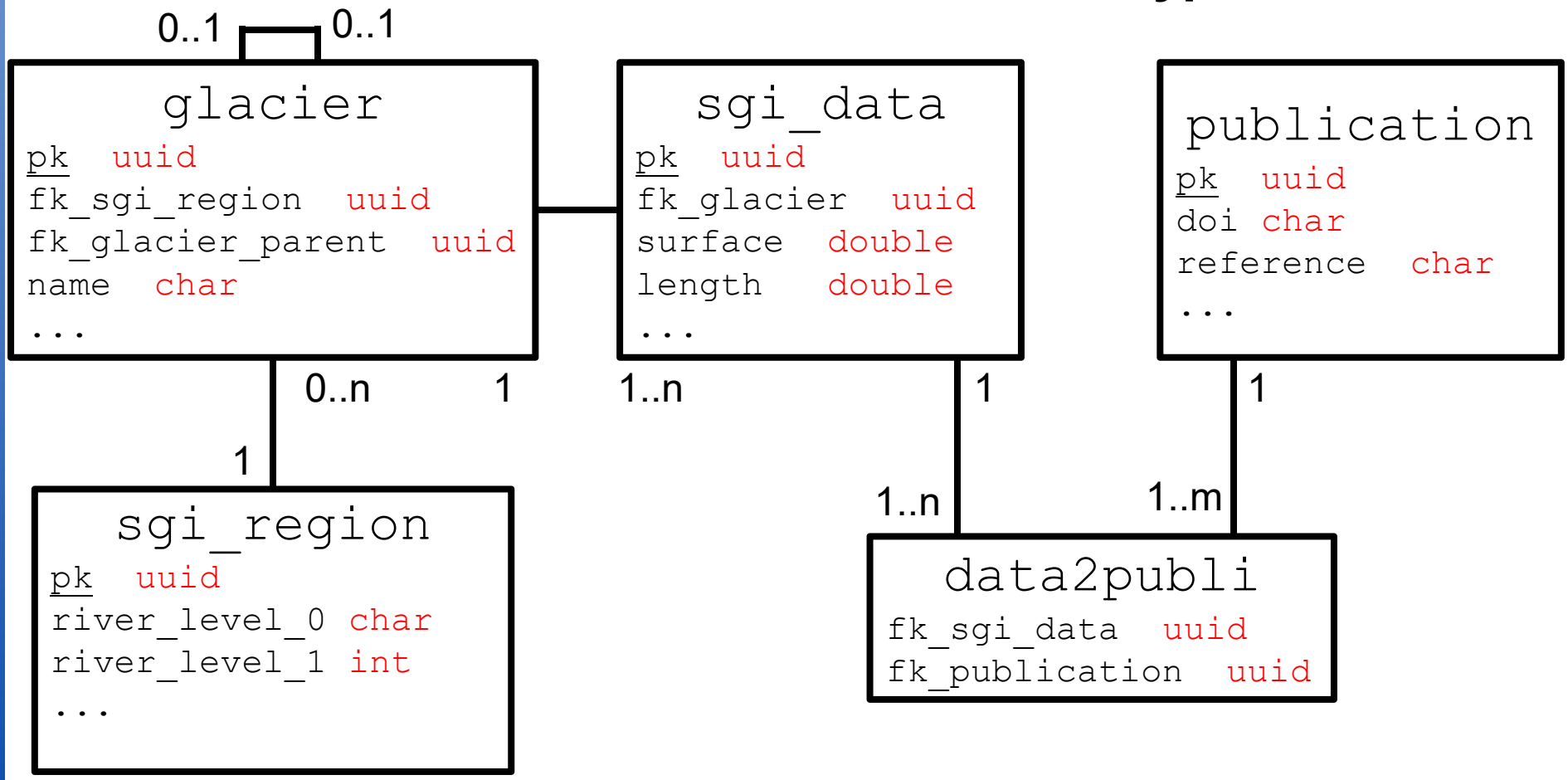
Data Modelling; Entity Relationship (ER)

Definition of Primary-Keys and Foreign-Keys



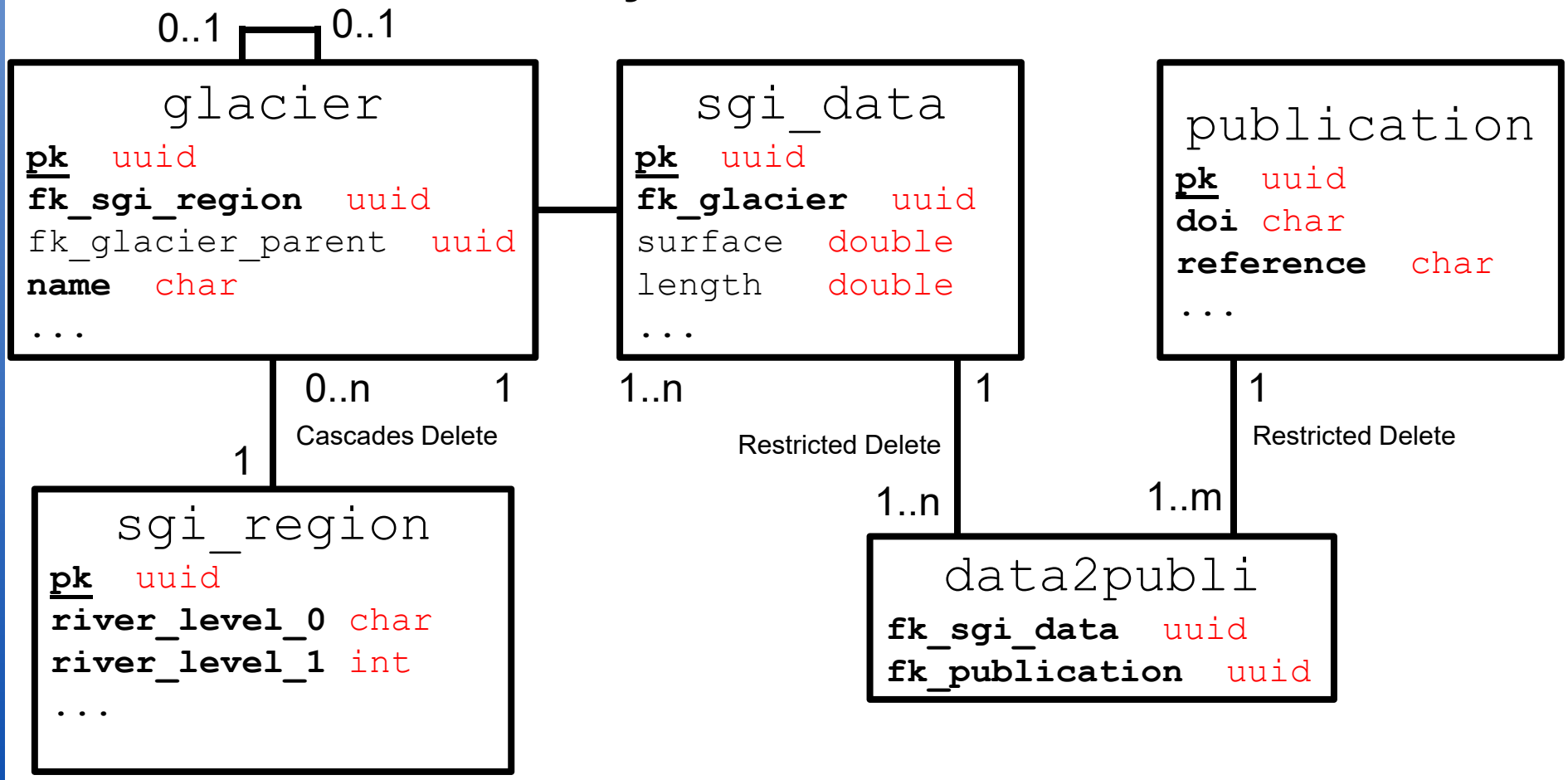
Data Modelling; Entity Relationship (ER)

Definition of additional attributes and data types



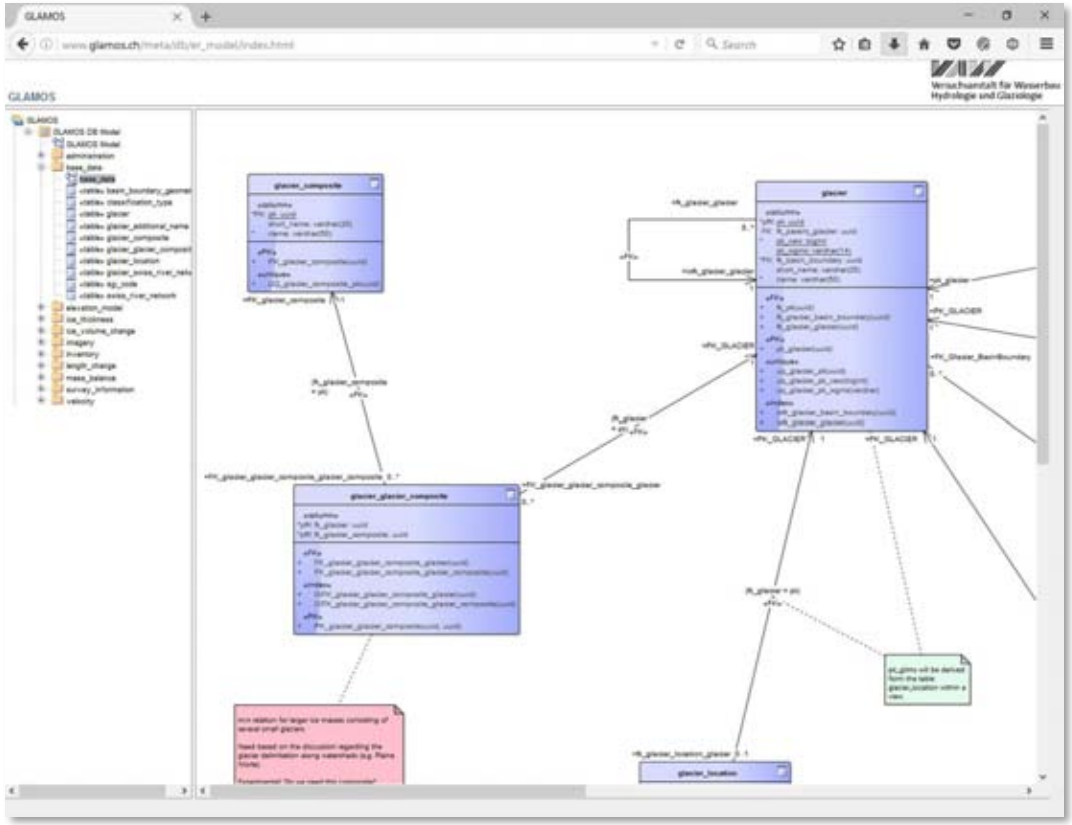
Data Modelling; Entity Relationship (ER)

Definition of mandatory fields, other constraints, indexes



Data Modelling; Entity Relationship (ER)

- **ER-Diagrams for GLAMOS online**



http://www.glamos.ch/meta/db/er_model/index.html
http://www.glamos.ch/meta/gis/er_model/index.html

Data Modelling; Normalization: GLIMS-ID

Format: G008506E47410N

Format: G <Easting> **E** <Northing> **N**

```
CREATE TABLE base_data.glacier_location
(
  pk uuid NOT NULL pk_glacier_location PRIMARY KEY,
  fk_glacier uuid NOT NULL,
  latitude numeric(8,6) NOT NULL,
  longitude numeric(8,6) NOT NULL,

  CONSTRAINT fk_glacier_location_glacier FOREIGN KEY (fk_glacier)
      REFERENCES base_data.glacier (pk) MATCH SIMPLE
      ON UPDATE CASCADE ON DELETE CASCADE
);
```

Data Modelling; Normalization: GLIMS-ID

Retrieving Geometry, GLIMS-ID, Name, Catchment

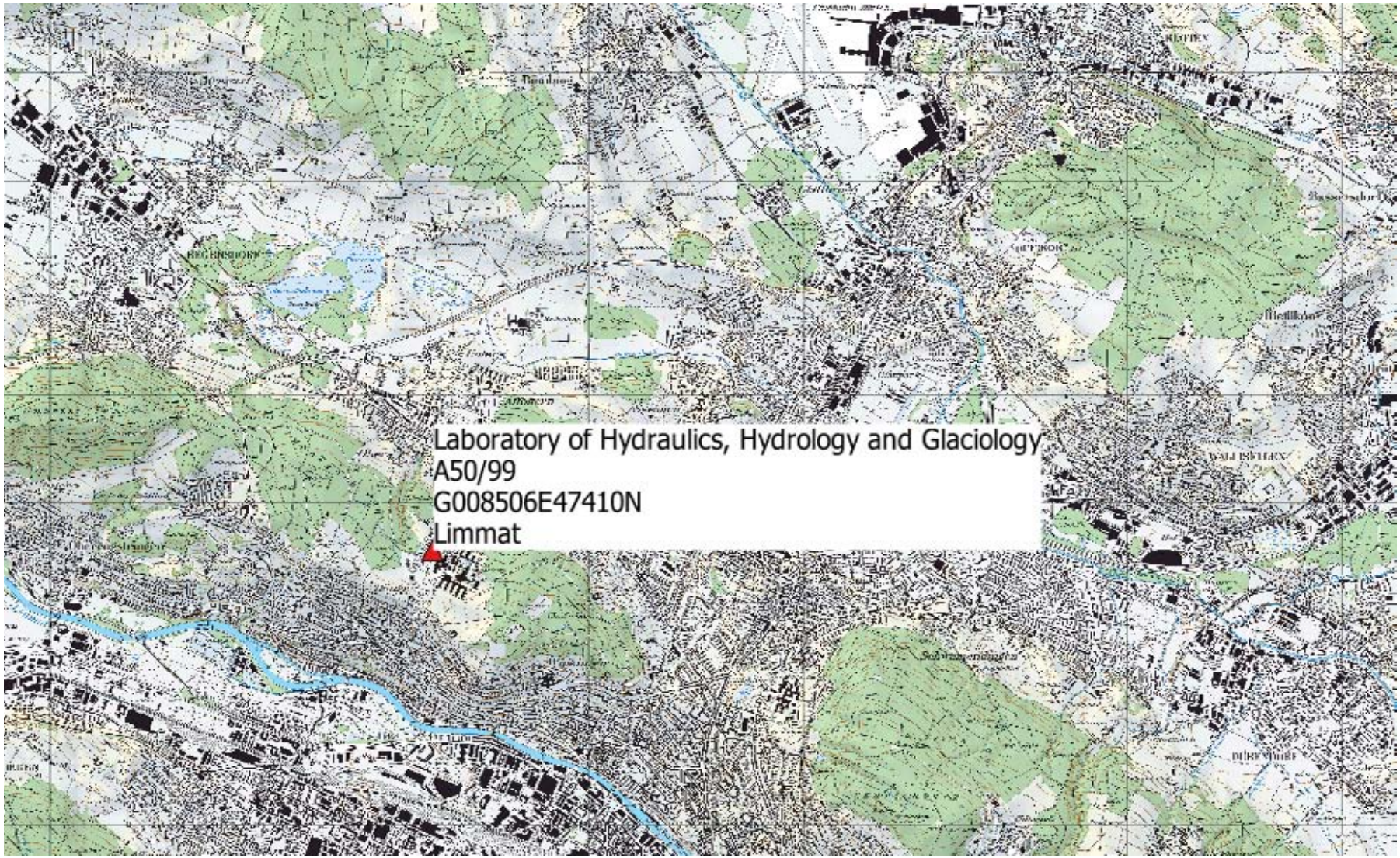
```
CREATE OR REPLACE VIEW base_data.vw_glacier_location AS
 SELECT row_number() OVER() AS gid,
    l.pk, l.fk_glacier, g.name,
    st_transform(st_setsrid(st_makepoint(
       l.longitude::double precision,
       l.latitude::double precision), 4326), 2056) AS geom,
    ((('G00'::text || btrim(to_char(l.longitude * 1000::numeric,
       '9999'::text))) || 'E'::text) ||
       btrim(to_char(l.latitude * 1000::numeric, '99999'::text))) ||
       'N'::text AS glims_id,
    sgi.sgi_code, g.pk_vaw, g.pk_wgms, g.short_name,
    sgi.river_level_3, sgi.river_level_2, sgi.river_level_1,
    CASE
       WHEN sgi.river_level_3::text = 'E'::text THEN 'Inn'::text
       WHEN sgi.river_level_3::text = 'A'::text AND
            sgi.river_level_2 = 5 AND
            sgi.river_level_1 = 1 THEN 'Reuss'::text
            …
       END AS main_catchment
       …
```

Data Modelling; Normalization: GLIMS-ID

Retrieving Geometry, GLIMS-ID, Name, Catchment

```
CREATE OR REPLACE VIEW base_data.vw_glacier_location AS
 SELECT row_number() OVER() AS gid,
    l.pk, l.fk_glacier, g.name,
 st_transform(st_setsrid(st_makepoint(
        l.longitude::double precision,
        l.latitude::double precision), 4326), 2056) AS geom,
    ((('G00'::text || btrim(to_char(l.longitude * 1000::numeric,
        '9999'::text))) || 'E'::text) ||
        btrim(to_char(l.latitude * 1000::numeric, '99999'::text))) ||
        'N'::text AS glims_id,
    sgi.sgi_code, g.pk_vaw, g.pk_wgms, g.short_name,
    sgi.river_level_3, sgi.river_level_2, sgi.river_level_1,
    CASE
       WHEN sgi.river_level_3::text = 'E'::text THEN 'Inn'::text
       WHEN sgi.river_level_3::text = 'A'::text AND
            sgi.river_level_2 = 5 AND
            sgi.river_level_1 = 1 THEN 'Reuss'::text
           …
       END AS main_catchment
       …
```

Data Modelling; Normalization: GLIMS-ID



Data Modelling; Normalization: Length variation

- **Input Data:**

```
...
00.00.1881   m-   00.00.1870    -75      -930
00.00.1887   m-   00.00.1886    -100     -1030
...
00.00.1897   m-   00.00.1896    -6       -1059
...
```

- **Data Definition Language (DDL):**

```
CREATE TABLE length_change.length_change_data (
    pk   uuid   NOT NULL CONSTRAINT length_change_data_pk PRIMARY KEY,
    fk_glacier   smallint   NOT NULL REFERENCES base_data.glacier,
    date_from   date   NOT NULL,
    date_from_quality   smallint   NOT NULL
        REFERENCES length_change.date_quality_type,
    ...
    variation_quantitative   decimal(10,2)   NOT NULL,
    ...
```

Data Modelling; Normalization: Length variation

- **Data Query Language (DQL) Example 1:**

```
SELECT
    lcd.fk_glacier, g.short_name glacier_short_name,
    ...
    lcd.variation_quantitative,
    sum(variation_quantitative)
        OVER (PARTITION BY fk_glacier ORDER BY date_to)
        AS variation_quantitative_cumulative
FROM
    length_change.length_change_data lcd
INNER JOIN base_data.vw_glacier_identification g ON
    g.pk_vaw = lcd.fk_glacier;
```

Data Modelling; Normalization: Length variation

- **Data Query Language (DQL) Example 2: Moving window**

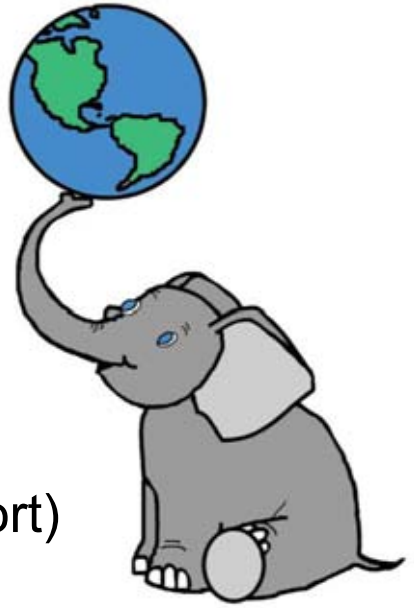
```
SELECT
    full_name,
    variation_year, variation_cumulative_subset, variation_cumulative
FROM
    (SELECT year_from, year_to, glacier_full_name full_name, variation,
        sum(variation) OVER (PARTITION BY glacier_full_name)
            AS variation_cumulative_subset,
        variation_cumulative
     FROM length_change.web_length_change_summary
        WHERE year_to BETWEEN 2010 AND 2015) AS length_change_subset
     WHERE year_to = 2015;
```

Data Modelling; Geometry and Coordinate System

- **Extending PostgreSQL with PostGIS**
- **Spatial Data Types (points, lines, polygons, raster, …)**
- **Extensive Spatial Operations (intersect, join, …)**

```
CREATE TABLE base_data.sgi_region (
   ...
   geom geometry(PolygonZ, 4326) NOT NULL,
   ...
);
```

- **WGS-84 as horizontal Reference System**
- `ST_Transform(geometry, from_proj, to_proj);`
- Compatibility: LV03 and LV95, Neighbouring countries
- NTv2 Transformation WGS-84 => LV03 (on-the-fly)
- FINELTRA Transformation LV03 => WGS-84 (data import)
- **LN02 as vertical Reference System**



Part 2

Topographical Landscape Model
Collaboration with swisstopo

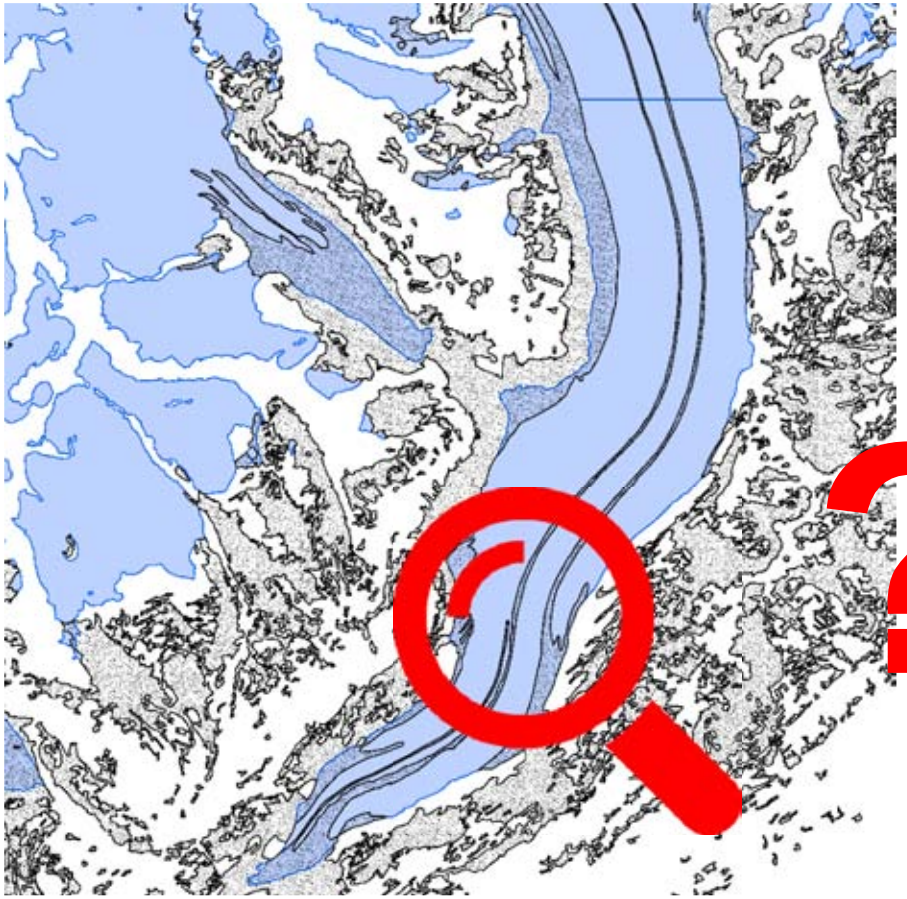
Topographical Landscape Model (TLM)

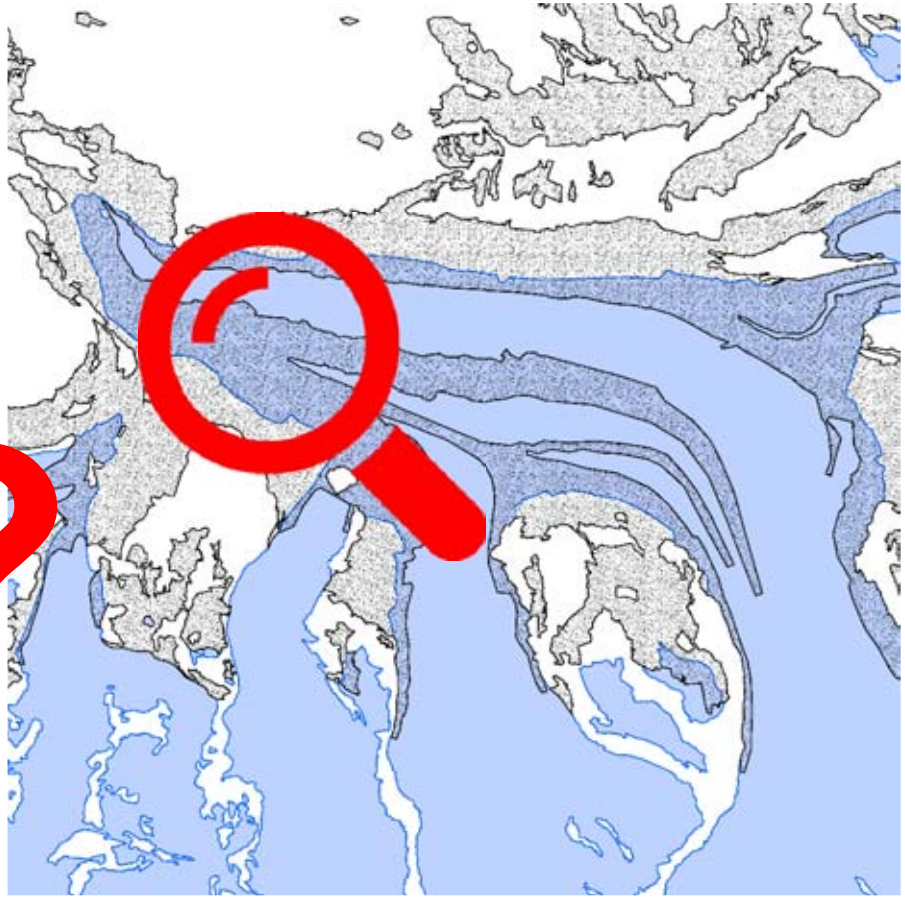
- **TLM is produced directly on the basis of aerial images => Not a cartographical representations of features!**
- **Consistent quality, long-term maintenance, country-wide**
- **Accuracy < 2 m**
- **Features divided into categories: e.g. Roads, Buildings, Hydrography, Names, Land Cover, …**
- **Geometries based on topological rules (e.g. overlaps, …)**

Relevant feature classes and object types for GLAMOS:

- **TLM_BODENBEDECKUNG.Gletscher** [Glacier]
- **TLM_BODENBEDECKUNG.Lockergestein** [unconsolidated rock]
- **TLM_FLIESSGEWAESSER** [Watercourse]

VECTOR25 vs. swissTLM3D





VECTOR25 – Cartographical Model

swissTLM3D – Topographical Model

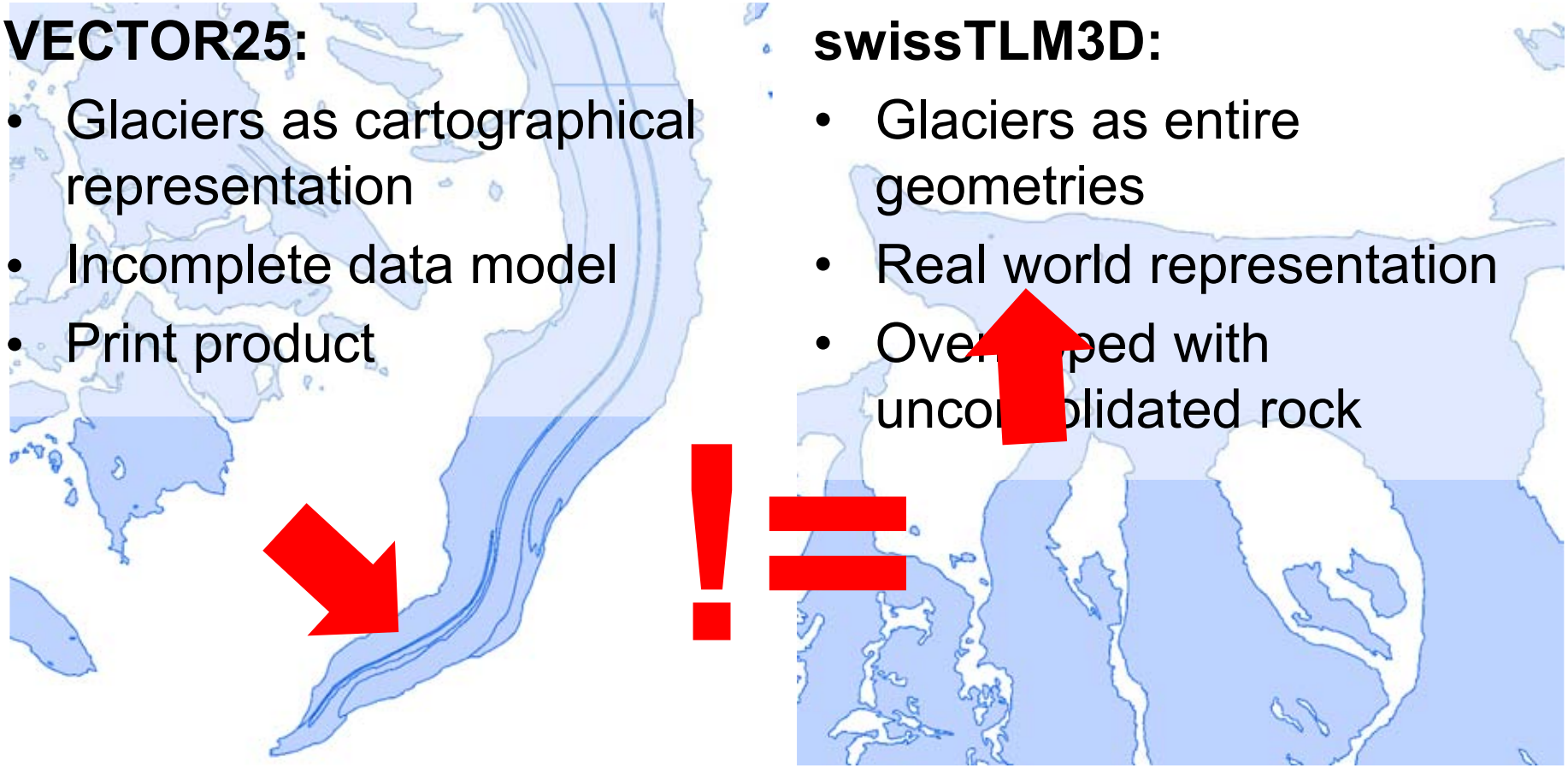
VECTOR25 vs. swissTLM3D

VECTOR25:

- Glaciers as cartographical representation
- Incomplete data model
- Print product

swissTLM3D:

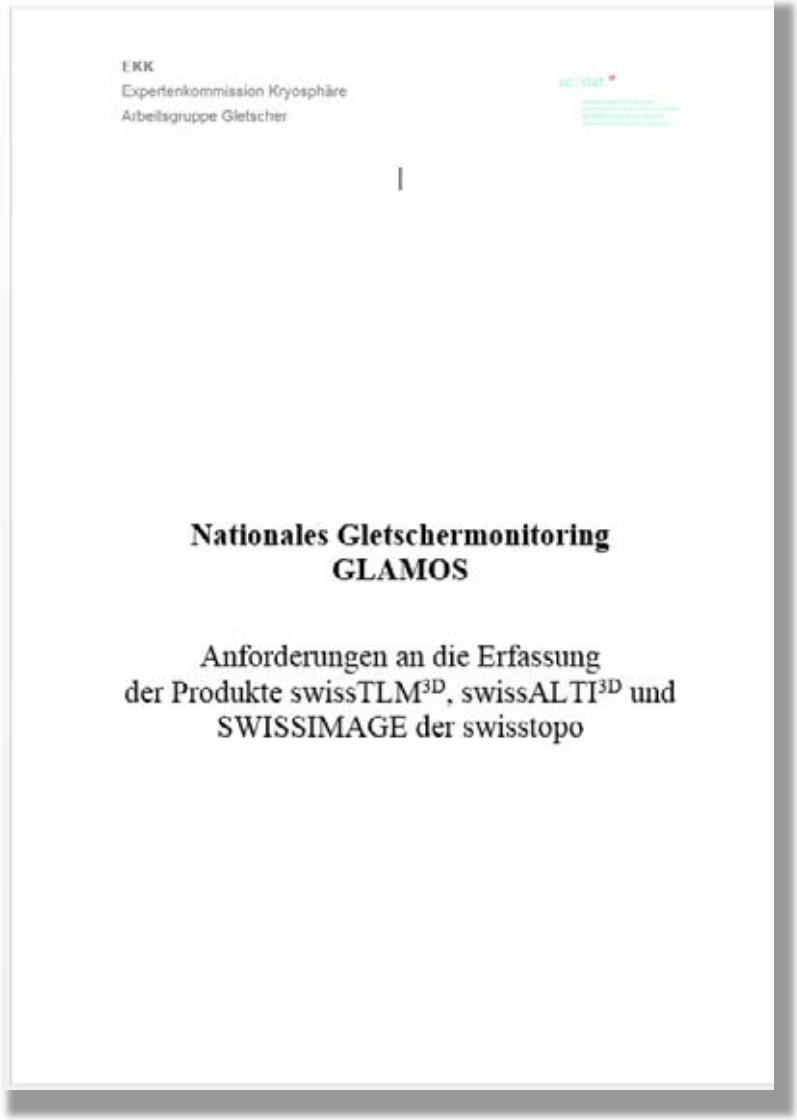
- Glaciers as entire geometries
- Real world representation
- Overlapped with unconsolidated rock



VECTOR25 – Cartographical Model

TLM – Topographical Model

Requirements Specification



EKK
Expertenkommission Kryosphäre
Arbeitsgruppe Gletscher

Nationales Gletschermonitoring GLAMOS

Anforderungen an die Erfassung der Produkte swissTLM^{3D}, swissALTI^{3D} und SWISSIMAGE der swisstopo

Detailed Requirements Specification by the *Cryospheric Commission* for the attention of *swisstopo*
(Weidmann et al., 2015)

Products:

- swissTLM3D
- swissALTI3D
- SWISSIMAGE

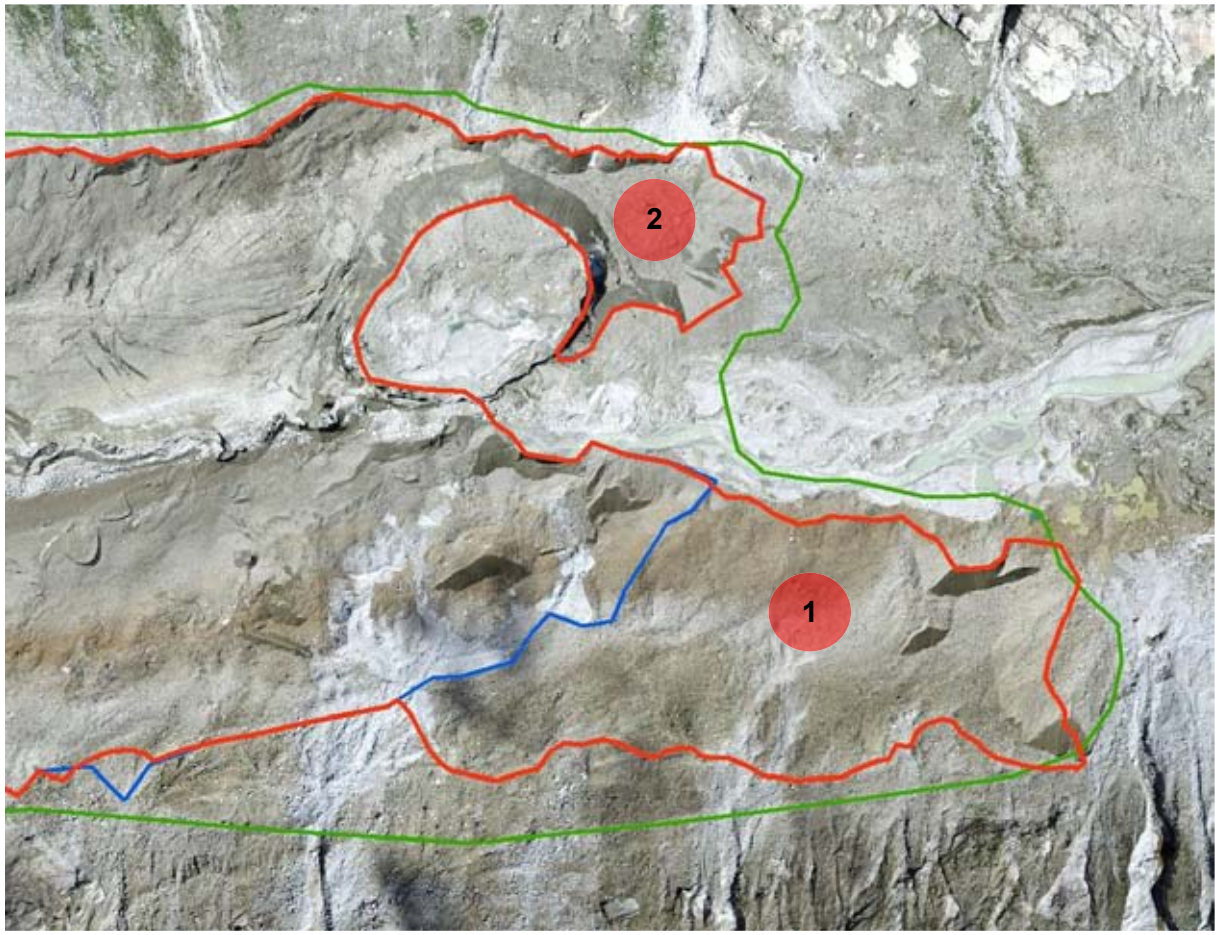
Flight Service:

- ADS Aerial Photographs
- Flight Planning

Workshop @ swisstopo; With entire TLM team

August 11th 2016
Mauro Fischer, Matthias Huss, Yvo Weidmann

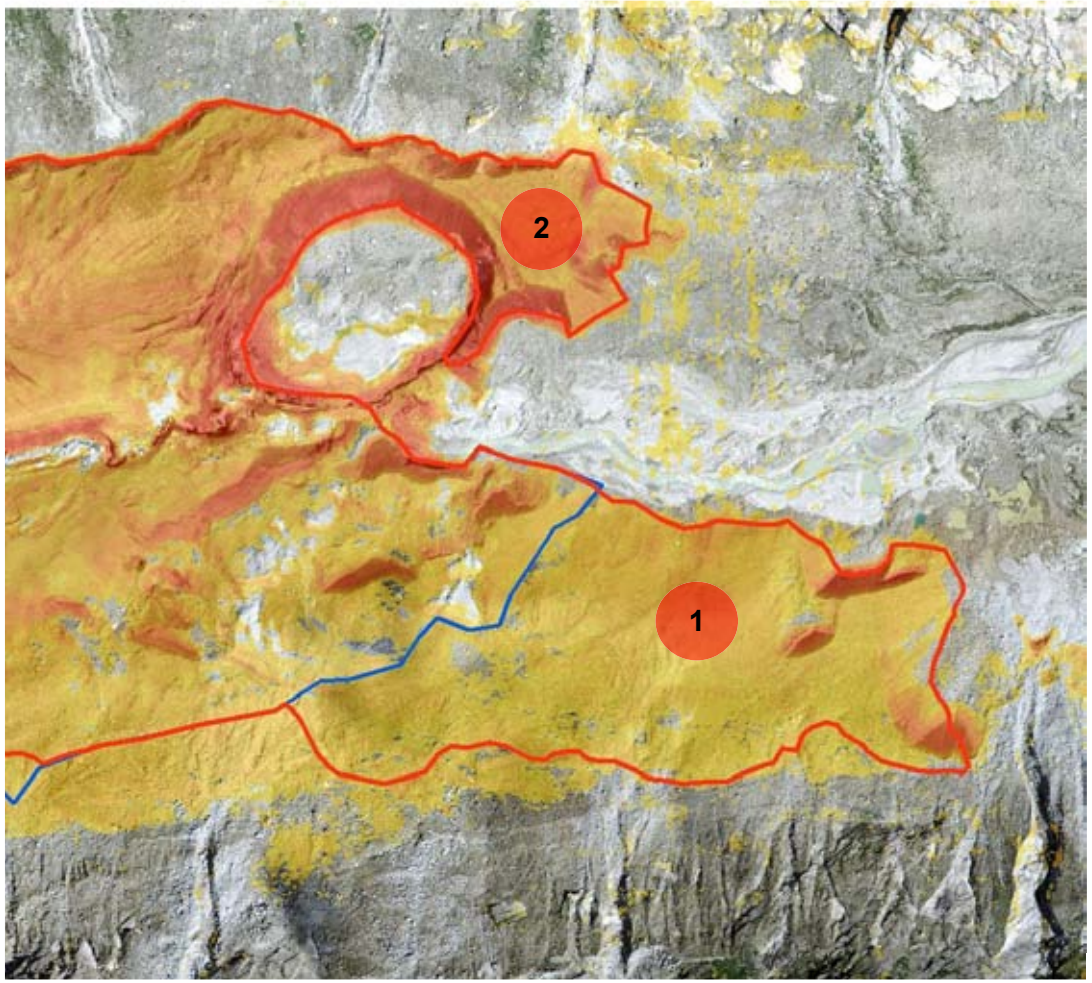
Workshop @ swisstopo; Examples / Discussions



Differences of Geometries by TLM, SGI-2010 and VAW:

- swissTLM3D
- SGI-2010
- VAW

Workshop @ swisstopo; Examples / Discussions

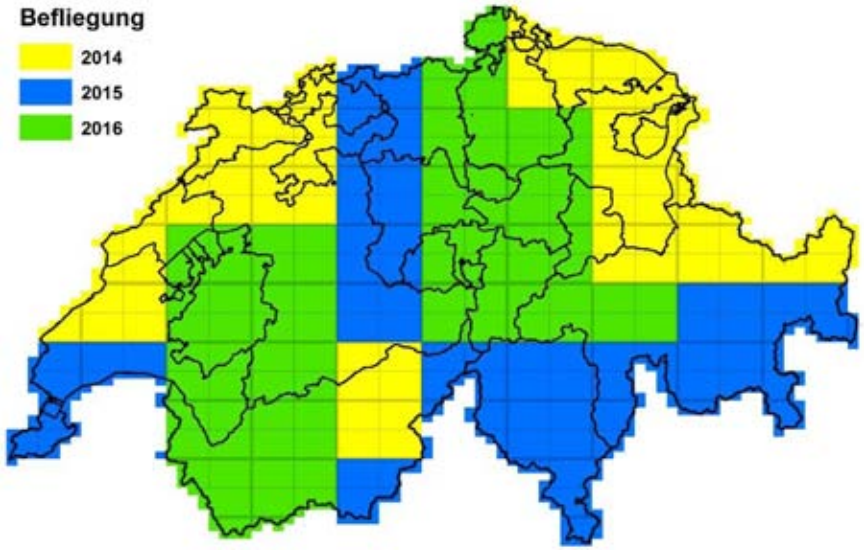


DSM-Difference 2015 – 2014 [m]

- DSM-Difference as background in production chain
- Multi-Year stereo-imagery
- Entire history of TLM geometries
- 2m tolerance
- Fixed glacier cut-lines as superficial watersheds

Production @ swisstopo; Adaptions

- **Adapted Flight Plans >= 2017**
  (Catchments as boundaries, entire glaciers, …)

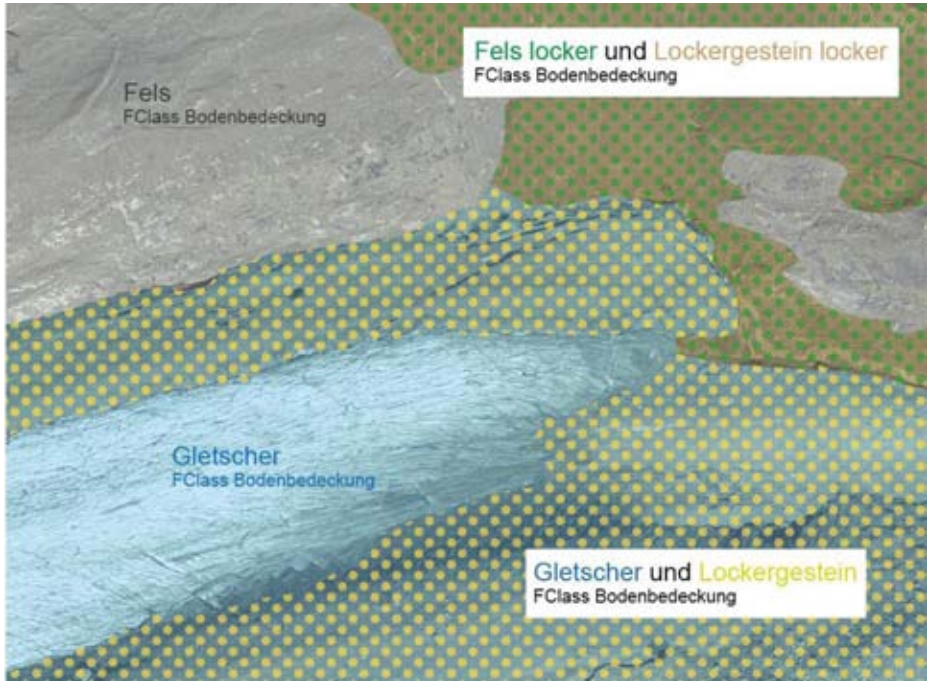


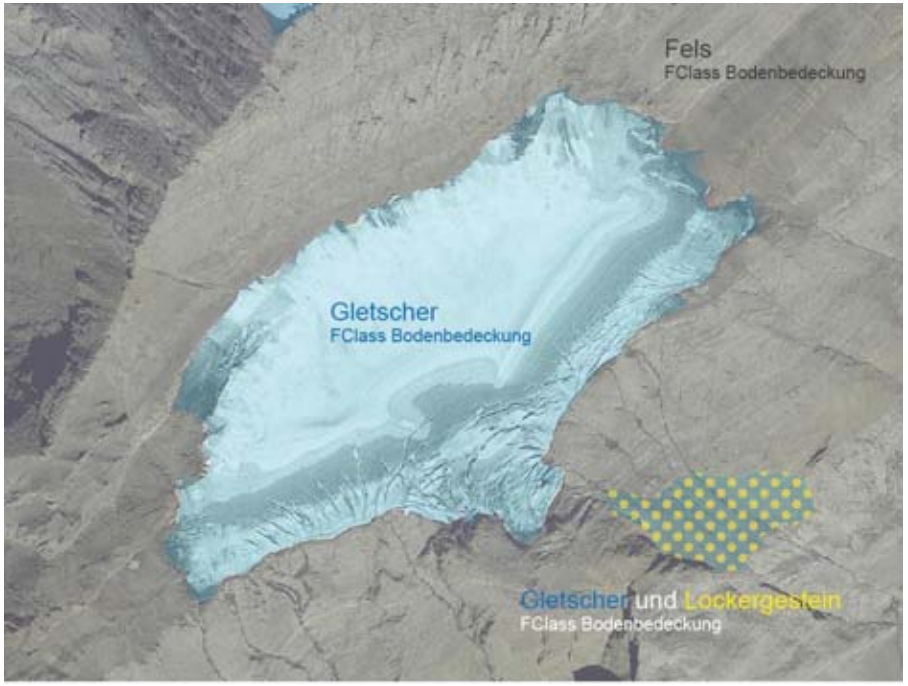
< 2017

>= 2017

Production @ swisstopo; Adaptions

- **Extended internal guidelines based on Requirements** Specification, introducing DHM as background, …
- **Entire team of TLM operators working on topic Glacier**
- **Cooperation and exchange with VAW**





Figures by swisstopo

Production @ swisstopo; Outcome

swissTLM3D:

- **2016 ongoing: Acquisition of glacier geometries based on GLAMOS requirements (fully 3D)**
- **2017 ongoing: Attributation of glacier geometries with Swiss Glacier Inventory identification**
- **Approx. 2020: First country-wide coverage of «new» TLM glacier geometries => SGI-2020^{3D}**

swissALTI3D:

- **In process …**

SWISSIMAGE:

- **Availability of SWISSIMAGE – Remote Sensing (RS)**

Part 3

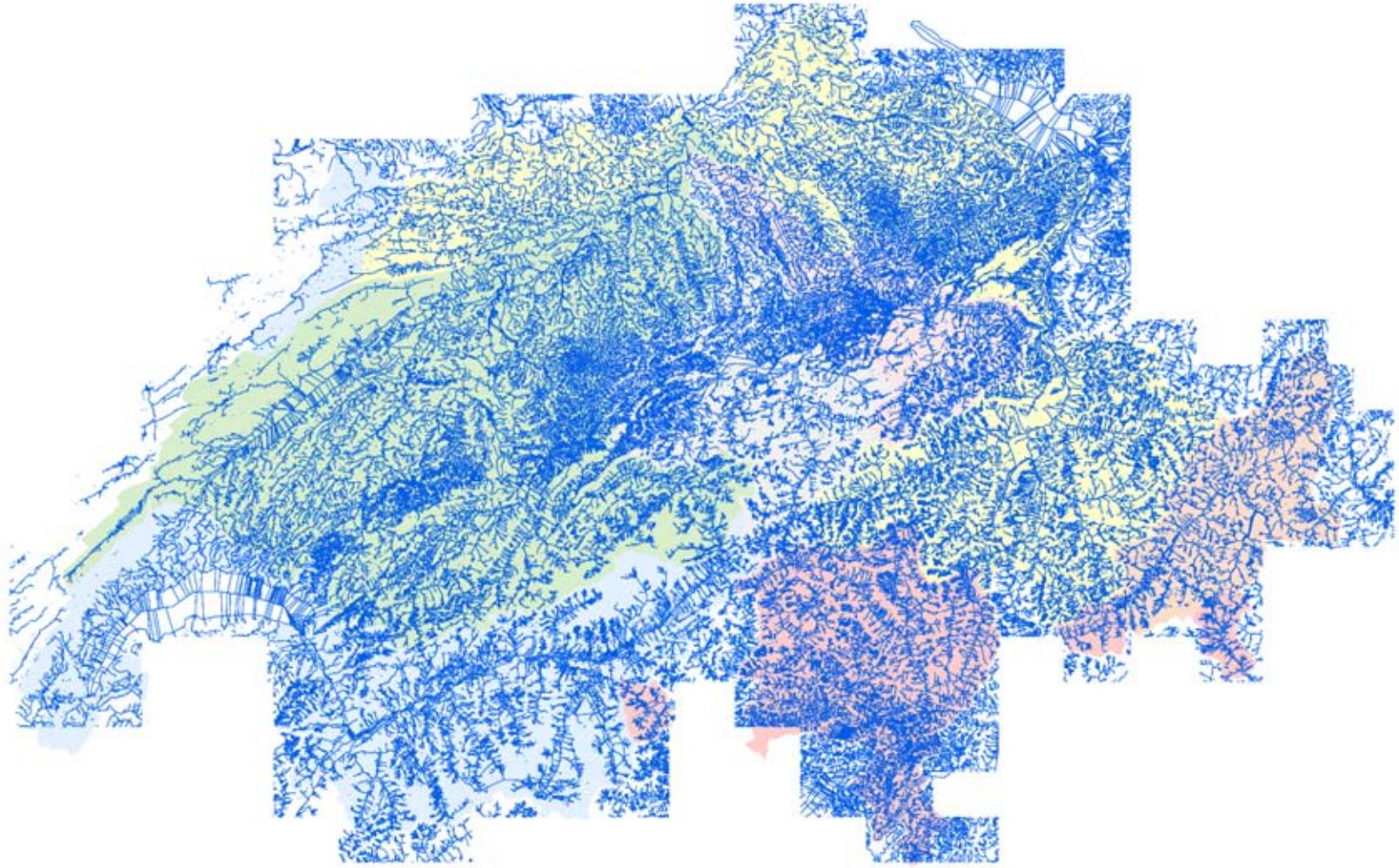
Linkage to Hydrological Network

Swiss Hydrological Network

Country-wide vector dataset

- **Part of the swissTLM3D**
- **Maintained by swisstopo and FOEN**
- **Address System using Unique Identifier and Distance**
  `GWLNR + MEASURE` (== Linear Referencing System)
- **Reference dataset for ecological surveys and hydropower residual water**
- **Part of the Federal Data Modell based on the Geoinformationsverordnung GeoIV (ID GeoIV 38.3)**

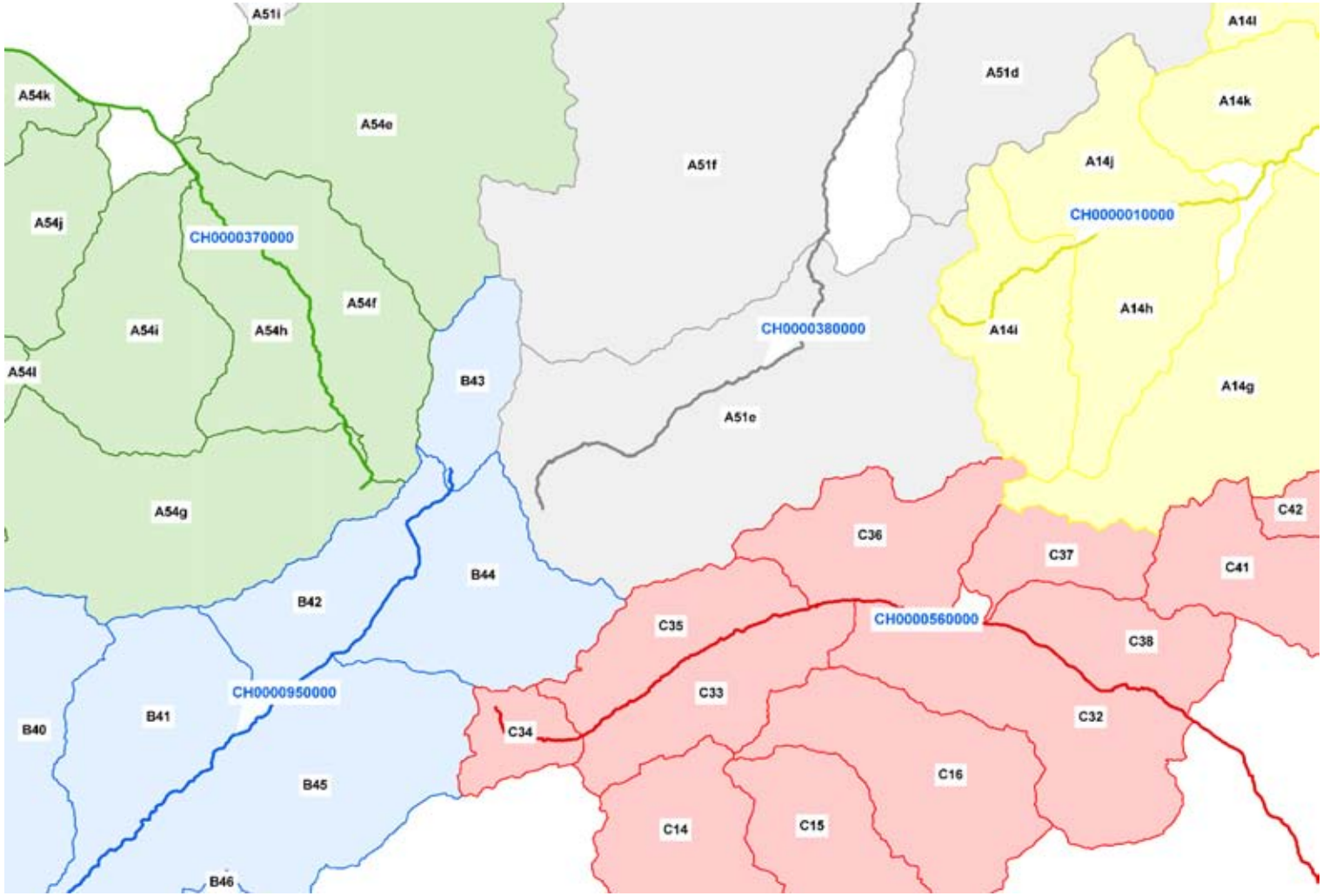
Swiss Hydrological Network



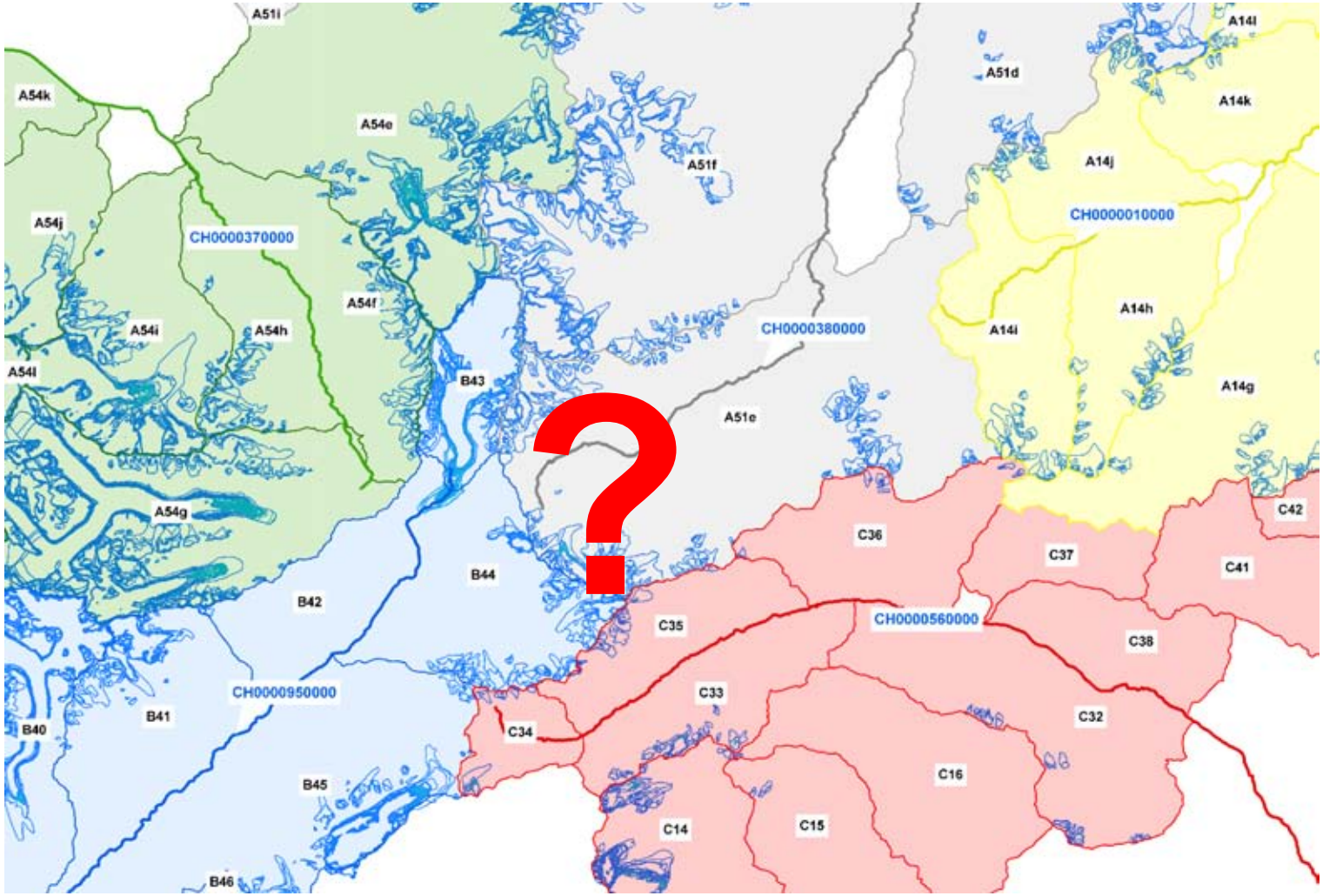
Approx. 275’000 individual segments
Approx. 100’000 individual watercourses

Swiss Hydrological Network

River Network ID vs. Swiss Glacier Inventory ID



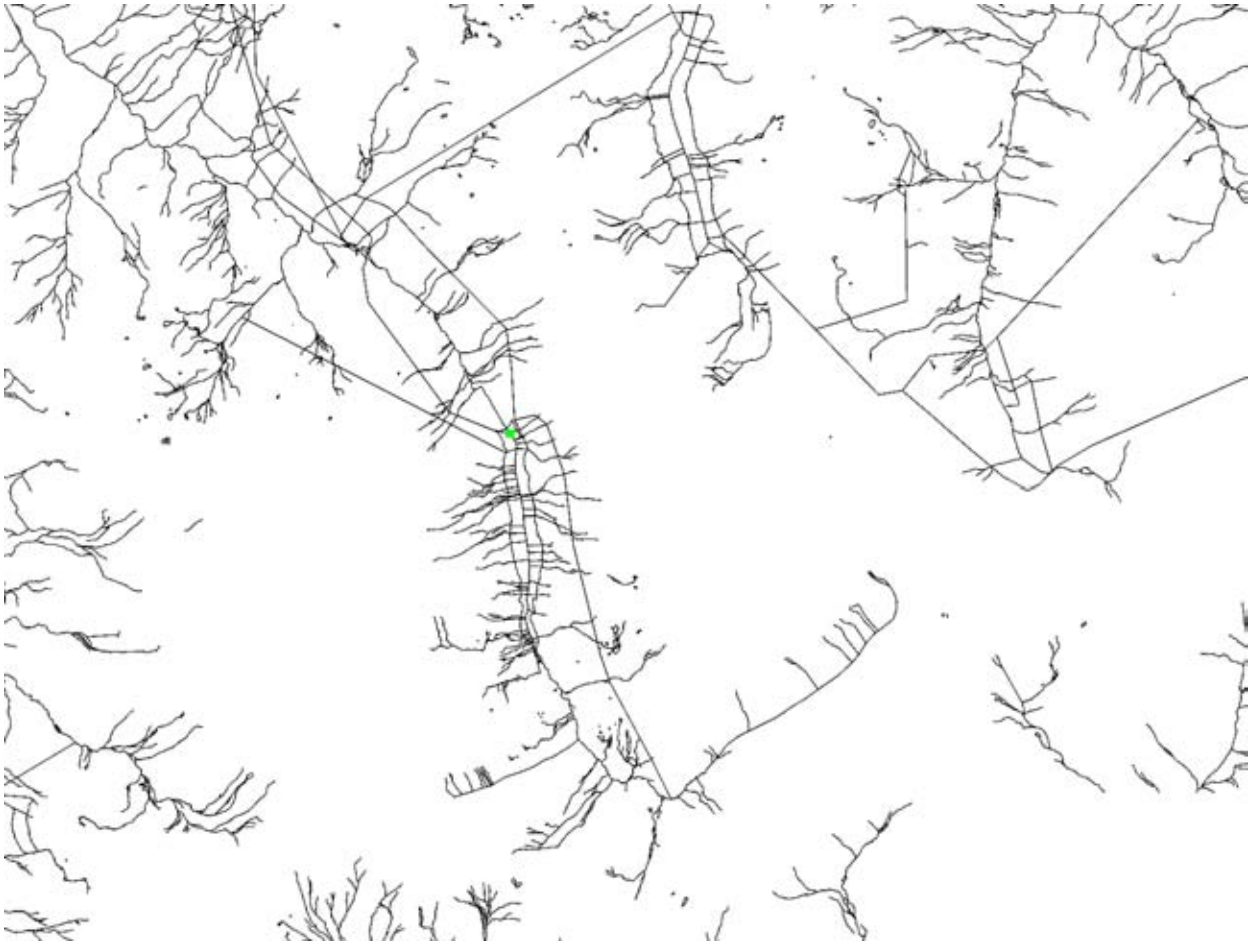
Linkage River Network and Swiss Glacier Inventory

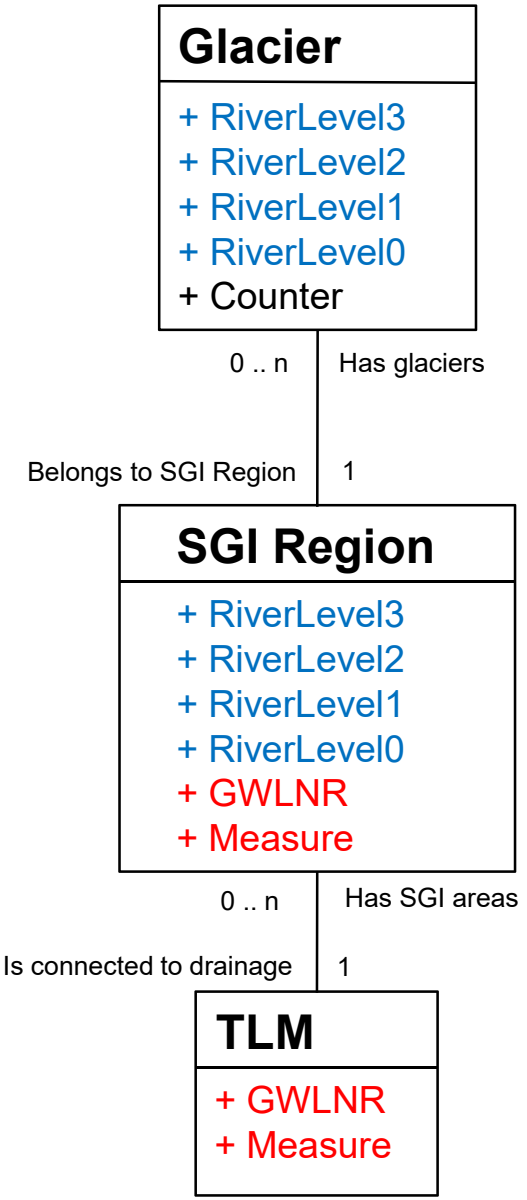


Linkage River Network and Swiss Glacier Inventory

Application

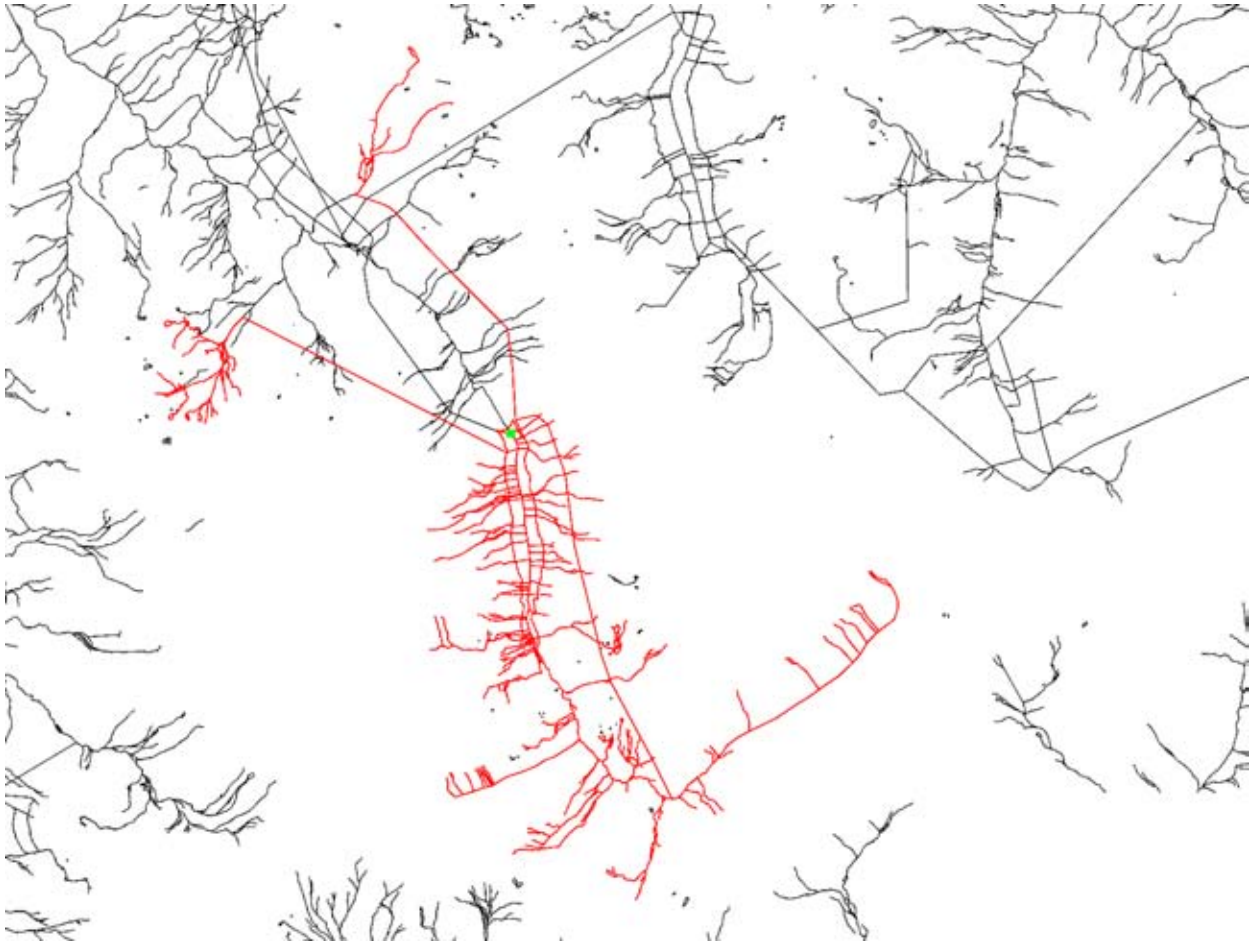
- **Example: Upstream Analysis**

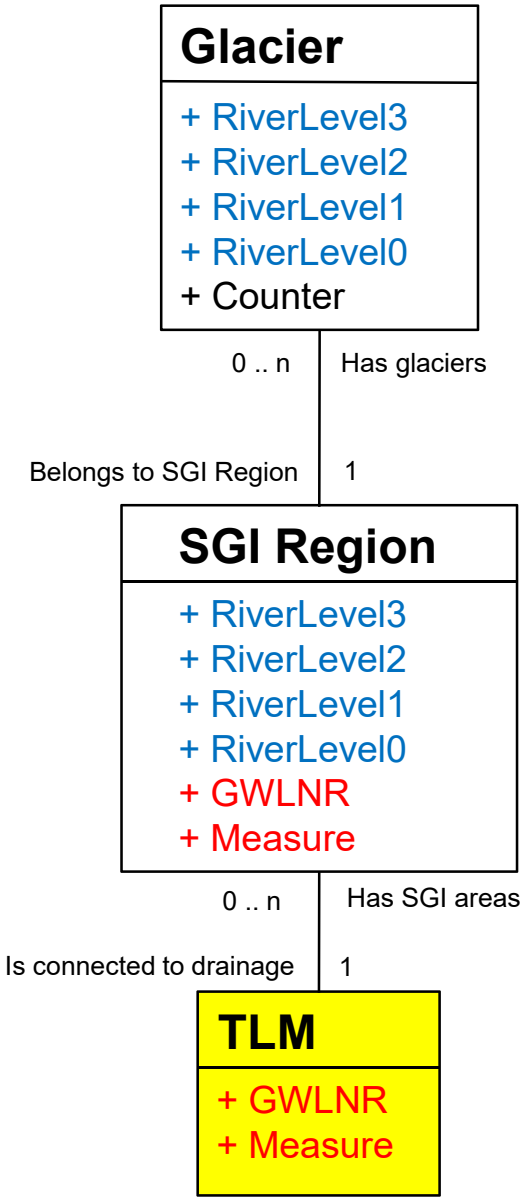




Application

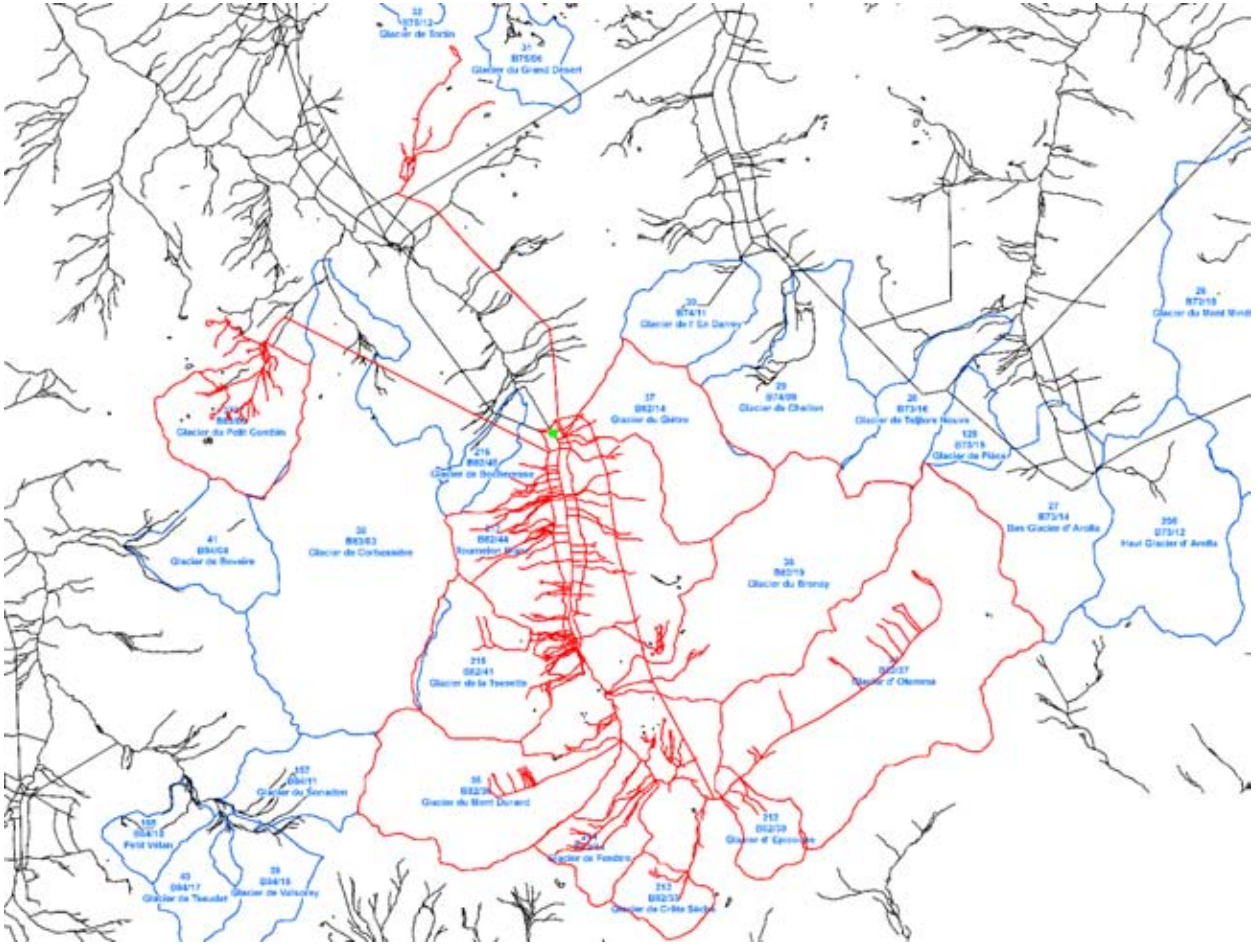
- **Example: Upstream Analysis**

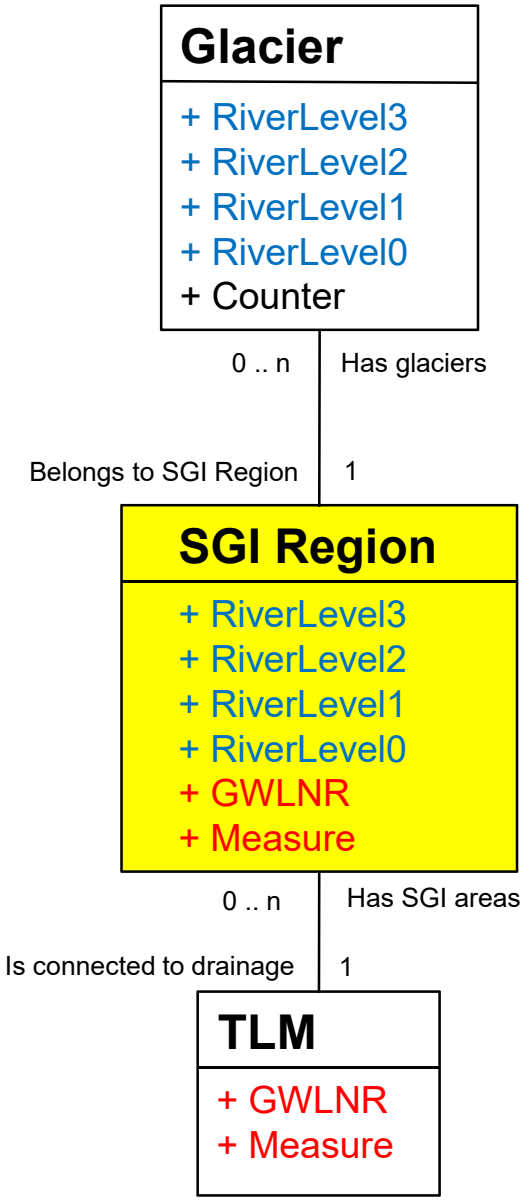




Application

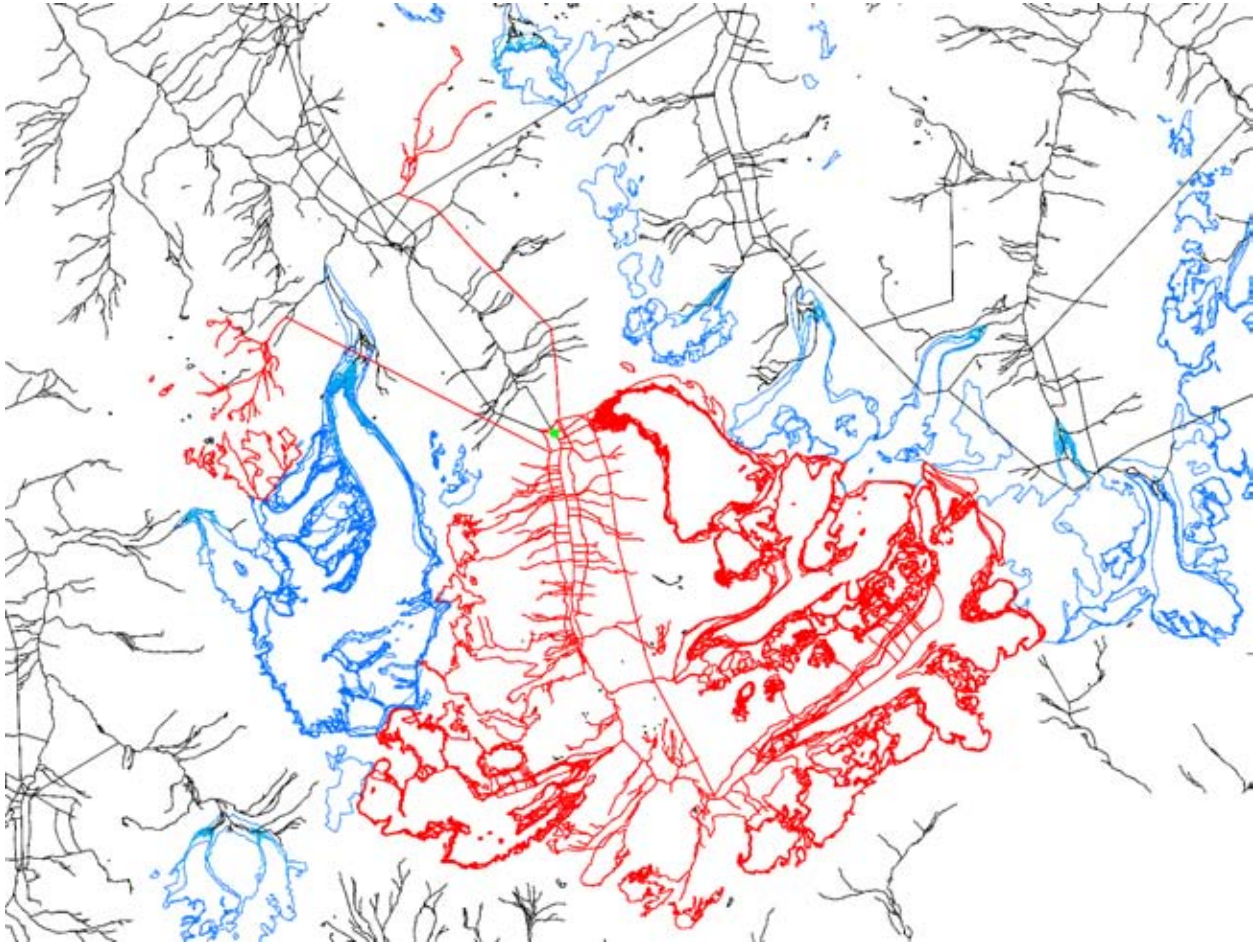
- **Example: Upstream Analysis**

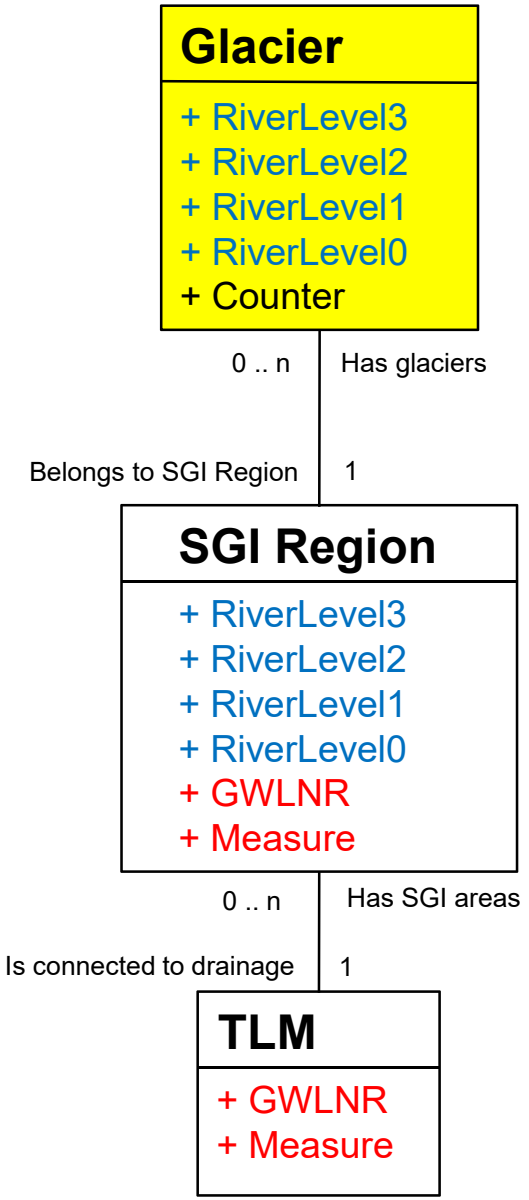




Application

- **Example: Upstream Analysis**





Part 4

Data Publication

Geometries and Maps; Web Services

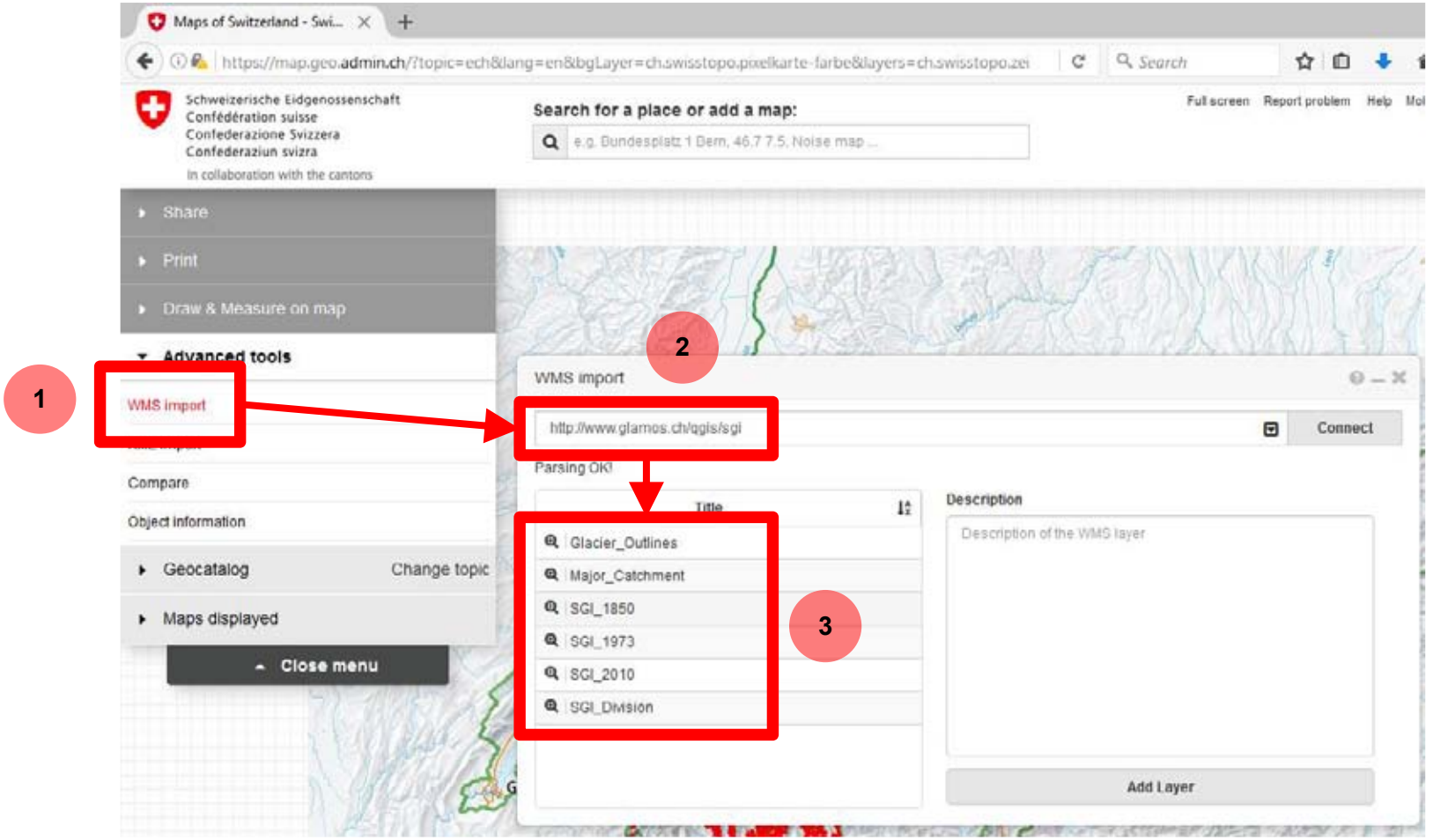
- **Providing OGC Web service standards**
  - WMS (rendered maps)
  - WFS (individual features)
  - WCS (raster data >= 8 bit, e.g. DSM, Ortho imagery, …)
- **Provided by QGIS-Server on www.glamos.ch**

http://www.glamos.ch/qgis/sgi

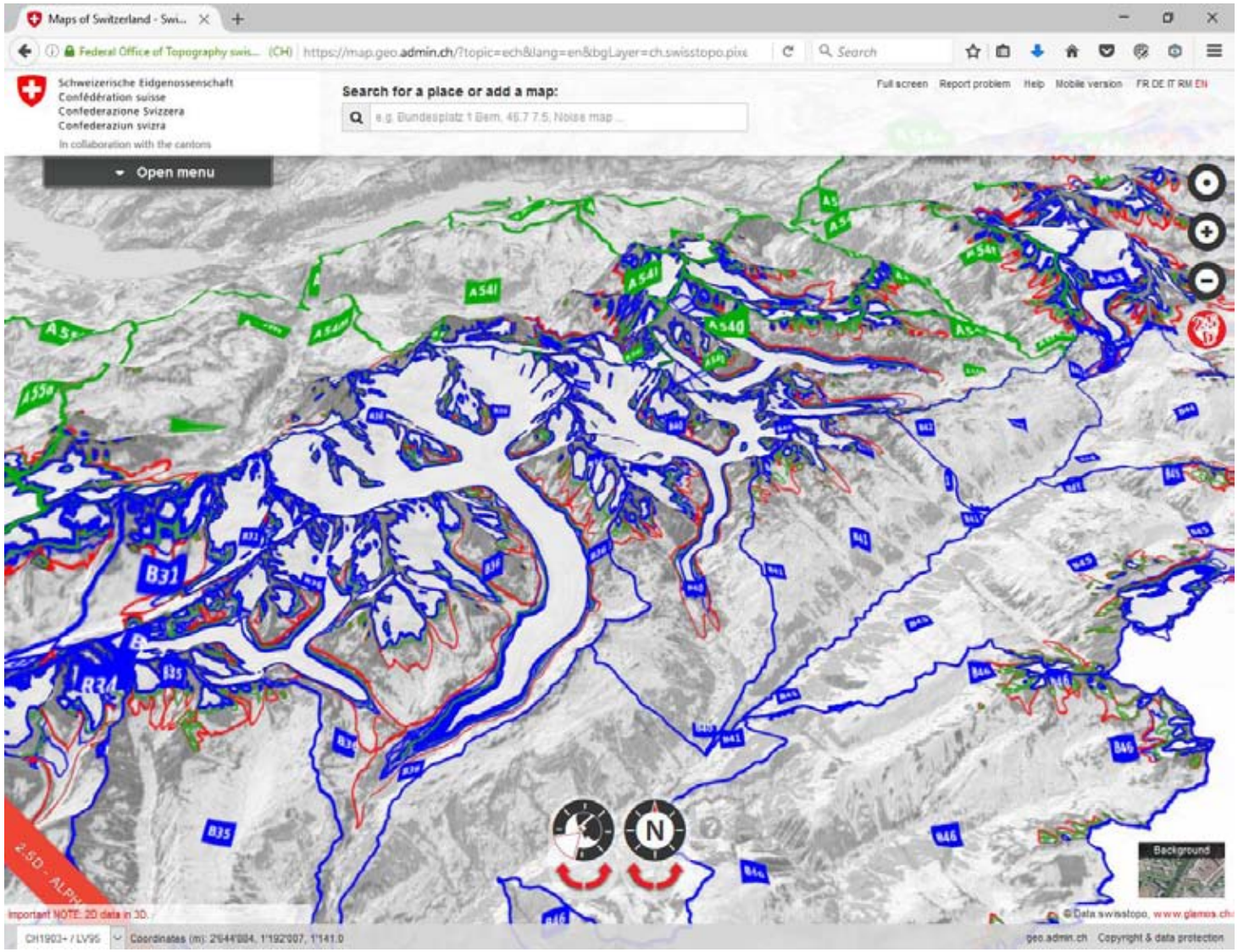
- **WMS implementation in all major GIS applications**
- **map.geo.admin.ch**
- **OpenLayers and other WebMap-API**
- **…**

Geometries and Maps; Web Services @ NGDI

- **map.geo.admin.ch -> Advanced tools -> WMS Import**



Geometries and Maps; Web Services @ NGDI

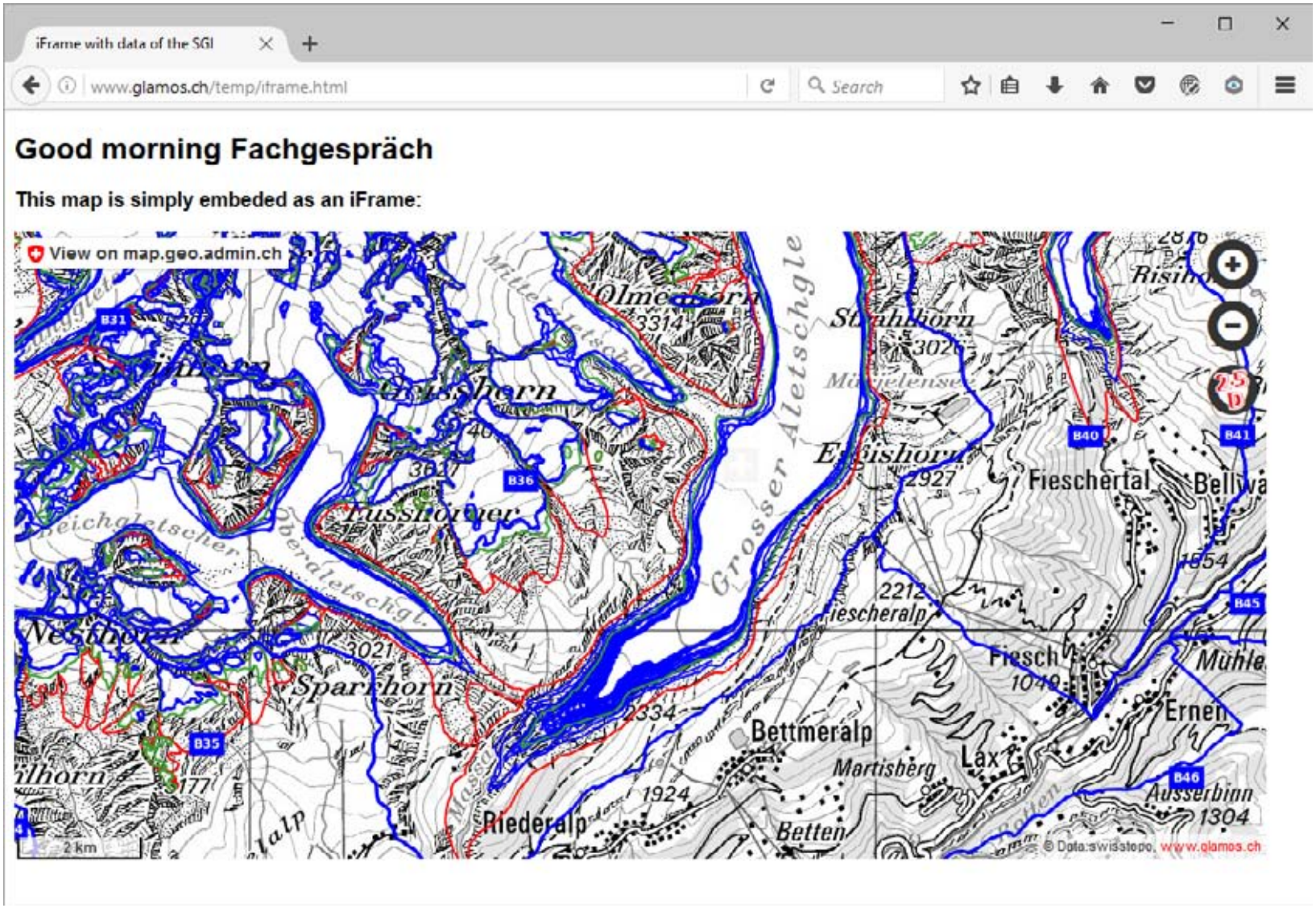


Geometries and Maps; Web Services @ iFrame

- **map.geo.admin.ch -> Share -> Embed**

```
<iframe src='https://map.geo.admin.ch/embed.html?
topic=ech&lang=en&bgLayer=ch.swisstopo.pixelkarte-grau&
layers=...WMS%7C%7CGlacier_Outlines%7C%7Chttp:%2F%2F
www.glamos.ch%2Fqgis%2Fsgi%7C%7CGlacier_Outlines%7C%7C1.3.0,
WMS%7C%7CMajor_Catchment%7C%7Chttp:%2F%2Fwww.glamos.ch%2Fqgis
%2Fsgi%7C%7CMajor_Catchment%7C%7C1.3.0,WMS%7C%7CSGI_1850%
7C%7Chttp:%2F%2Fwww.glamos.ch%2Fqgis%2Fsgi%7C%7CSGI_1850%7C%
7C1.3.0,WMS%7C%7CSGI_1973%7C%7Chttp:%2F%2Fwww.glamos.ch%
2Fqgis%2Fsgi%7C%7CSGI_1973%7C%7C1.3.0,WMS%7C%7CSGI_2010%7C%
7Chttp:%2F%2Fwww.glamos.ch%2Fqgis%2Fsgi%7C%7CSGI_2010%7C%7
C1.3.0,WMS%7C%7CSGI_Division%7C%7Chttp:%2F%2Fwww.glamos.ch%2
Fqgis%2Fsgi%7C%7CSGI_Division%7C%7C1.3.0&layers_visibility=
true,false,true,true,true,true&layers_timestamp=18641231
,,,,,,,,,&X=142616.03&Y=650837.90&zoom=5' width='400'
height='300' frameborder='0' style='border:0'></iframe>
```

Geometries and Maps; Web Services @ iFrame

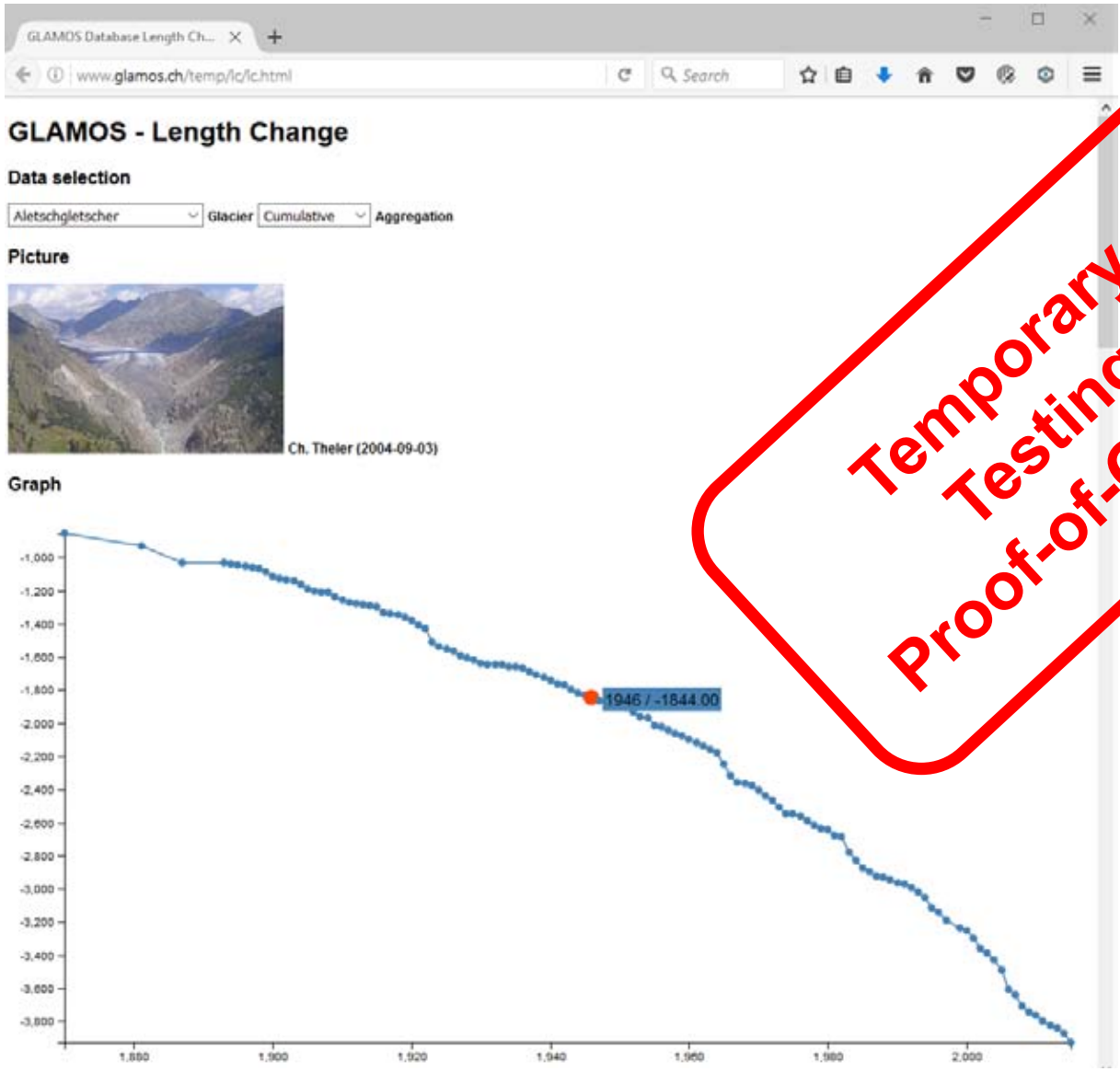


Data; Interactive Graphics

- **Connection between Web server and PostgreSQL server**
  - «Live» data of the database
  - PHP database client, JavaScript Object Notation (JSON)
- **Client-based rendering**
  - Data-Driven Documents JavaScript library (D3.js)
  - Scalable Vector Graphics (SVG) based diagrams (XML syntax)
  - JavaScript and HTML interactivity

http://www.glamos.ch/temp/mb/index.html
http://www.glamos.ch/temp/lc/index.html
http://www.glamos.ch/temp/lc/summary.html

Data; Interactive Graphics



Temporary,
Testing,
Proof-of-Concept

Data; Interactive Maps

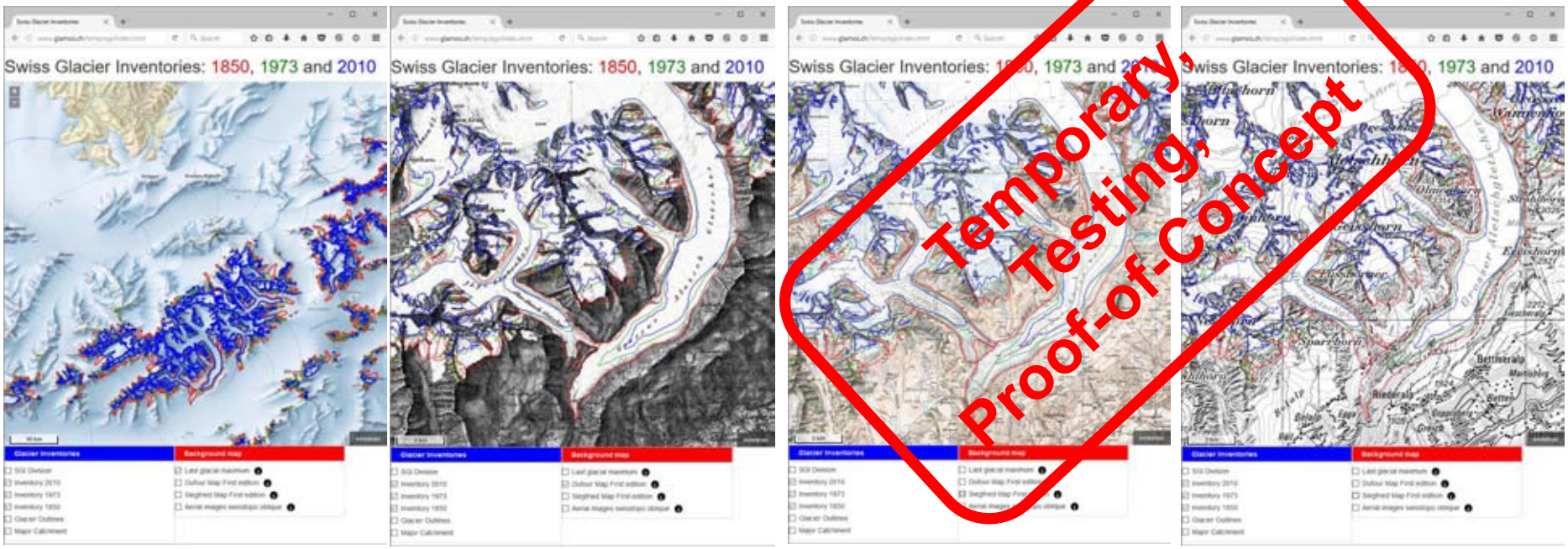
- **Realized with the GeoAdmin API** (http://api3.geo.admin.ch/)
- **Most data of the NGDI available**

LGM

Dufour
1845 - 1865

Siegfried
1870 - 1926

PK25
> 1952

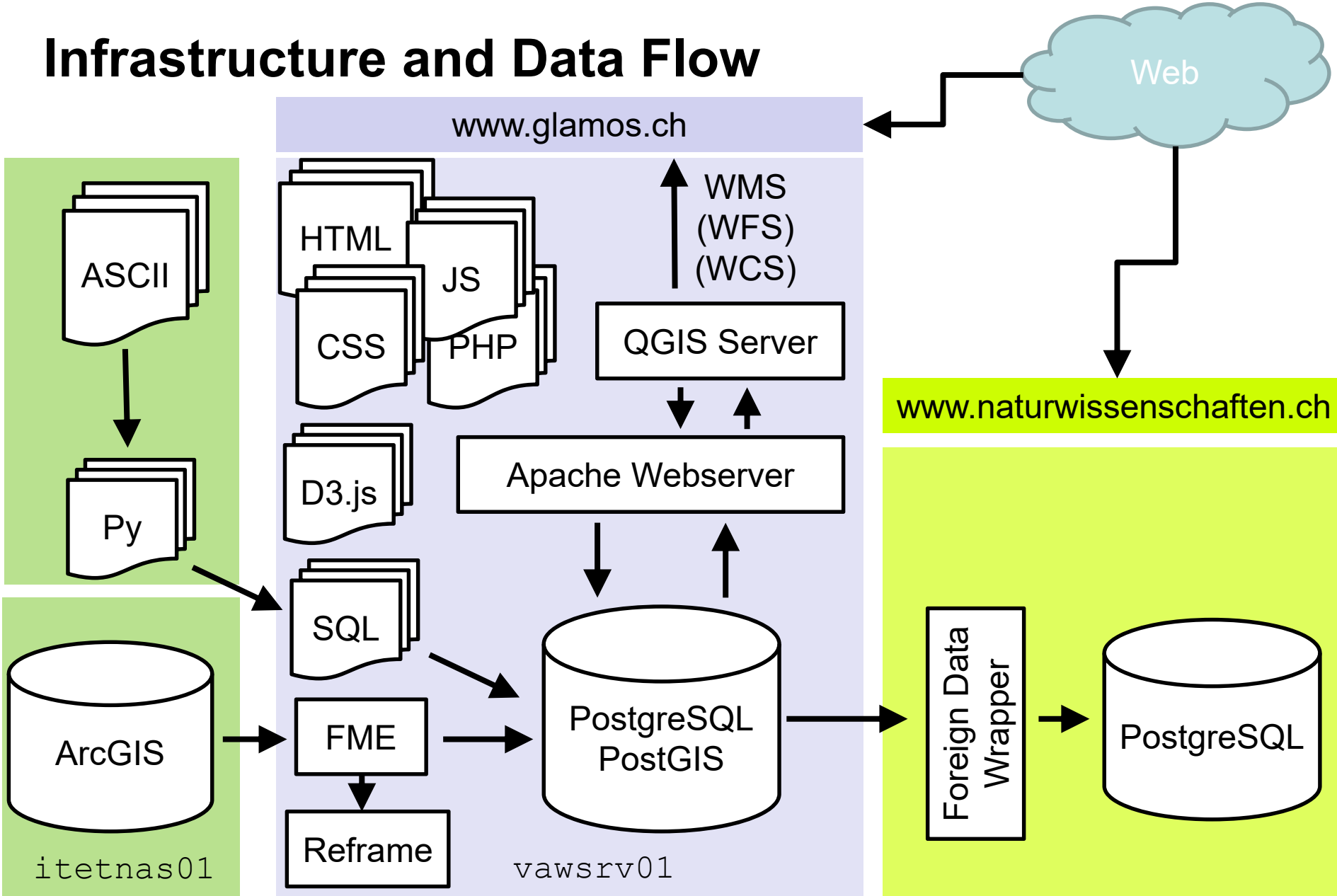


http://www.glamos.ch/temp/sgi/index.html

Part 5

Summary

Infrastructure and Data Flow



Next steps

- **Finalization of data homogenization**
- **Further implementation of the Physical Schema**
- **Further import of the available data**
- **Start of raster data homogenization**

- **Review first swissTLM3D data export**

- **Finalization of web structure**
- **Elaboration concept of GLAMOS website**
- **Definition of data structures for download**
  (vector and non-vector data)

Special Thanks

- **Lukas Müller**
- **Simon Steffen**
- **Loris Compagno**
- **Samuel Hepner**

- **Many many others …**
  (VAW Glaciology, Mario Moser, ISG EE, swisstopo, VAW, Uni ZH, Uni FR, ITOS, FOEN, …)

```
UPDATE publications.talk
  SET
     concluding_sentence =
     'Thank you for the attention'
  WHERE
    event = 'Fachgespräch'
     AND
    event_date = '2017-01-19';
```