Satellite based rapid mapping of snow avalanche activity

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Davos, Switzerland

Swisstopo Kolloquium

Wabern, 23.03.2018

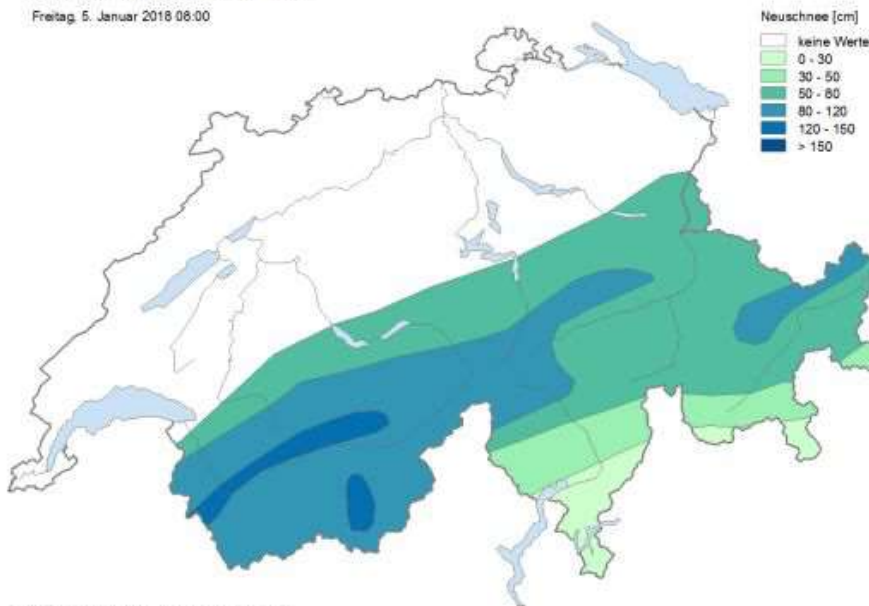WSL Institute for Snow and Avalanche Research SLF

Avalanche period I: 4 - 10 Jan. 2018

- Large snowfall over entire Switzerland (80 – 150 cm) above 2200 m a.s.l., below often rain

- Avalanche danger scale 4 over large parts of Switzerland

- Additional intense snowfall in Vispertäler/Simplon (- 200 cm)

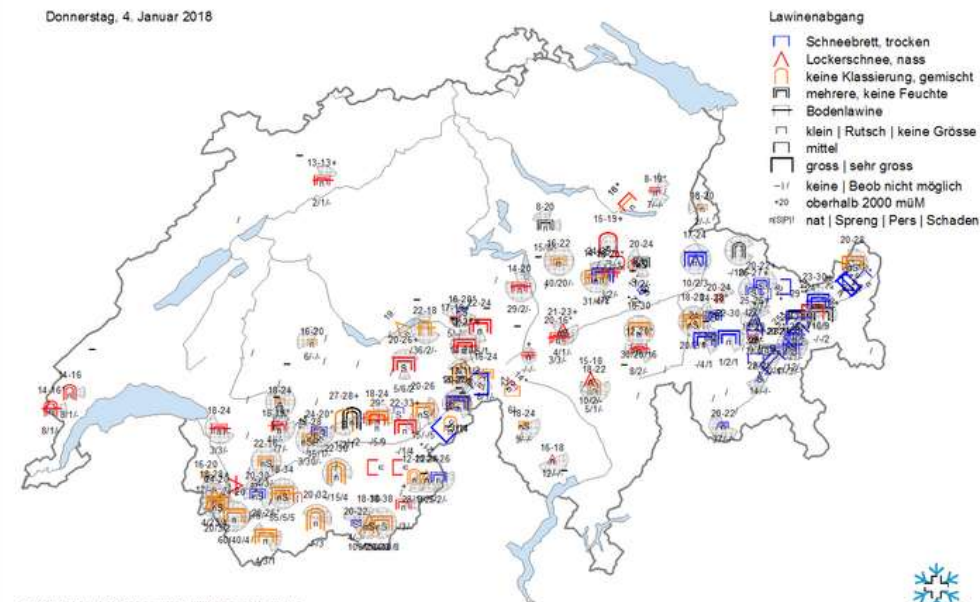- Avalanche danger scale 5, first time since 9 years!

Avalanche period I: 4 - 10 Jan. 2018

Avalanche period II: 21 - 23 Jan. 2018

- Again large snowfall over entire Switzerland (> 200 cm)

- At some stations record snow depth values

- Very high wind speeds, storm

- Rapid changes in snow fall line, between 0 and 2000 m a.s.l.
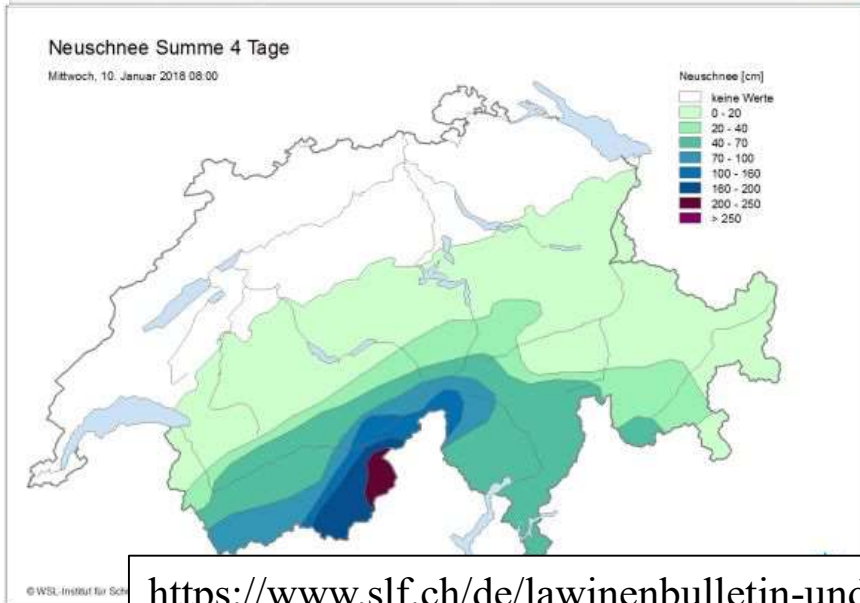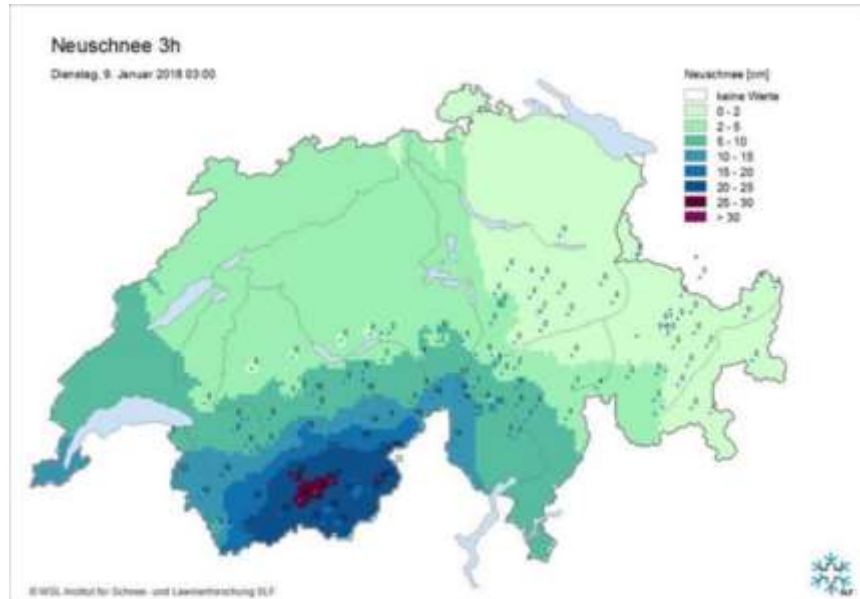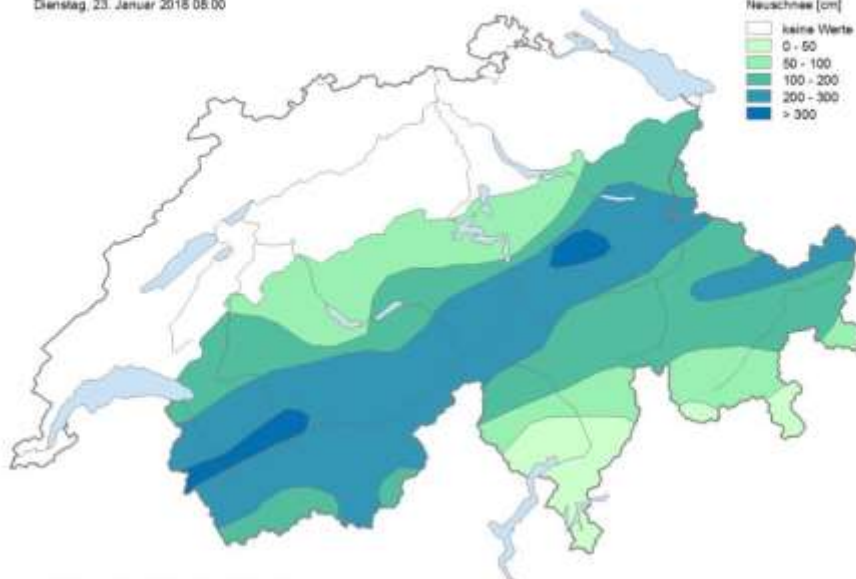
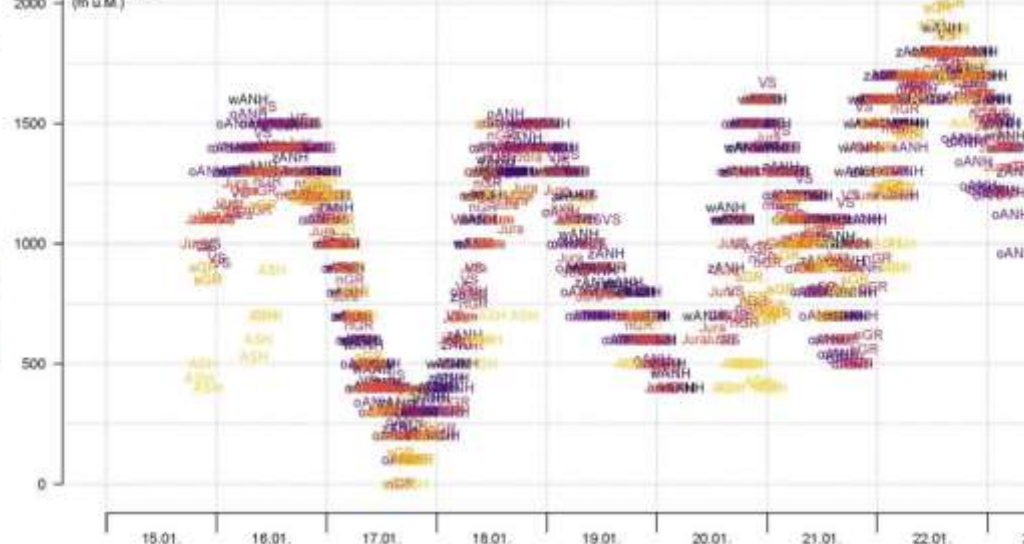# Avalanche period II: 21 - 23 Jan. 2018

Lawinenbulletin für Montag, 22. Januar 2018

- Danger scale 4 to 5 over entire Switzerland

- Similar weather sequence as Feb. 1999 but with much higher snow fall line
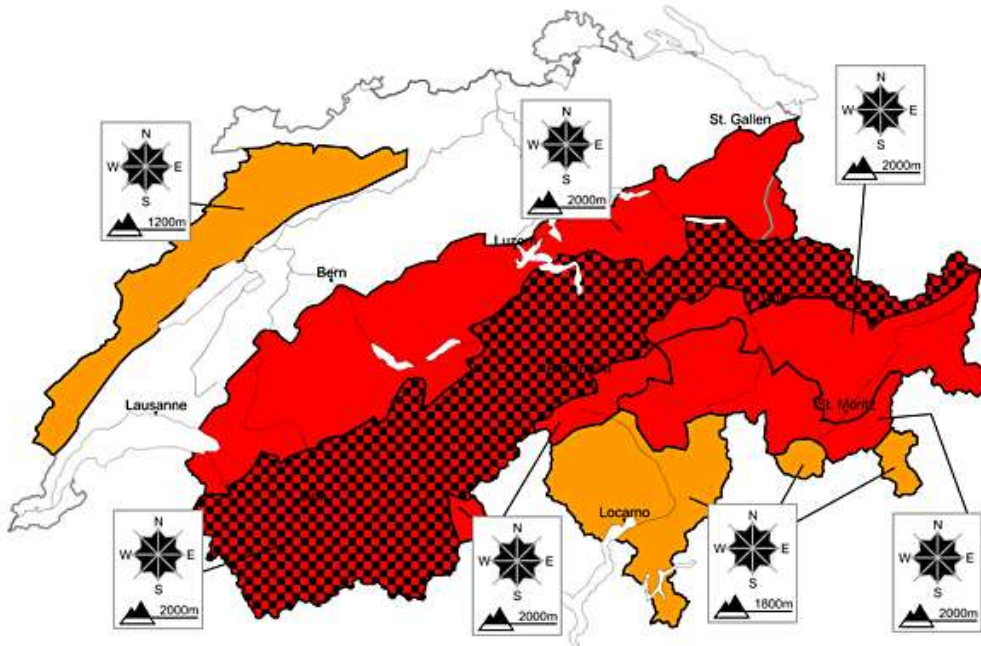
- High activity of large avalanches

- Many damages, but less than 1999

- No fatalities (1999 ➤ 17)

umme 2 Tage

Lawinenabgang:
- Schneebrett, trocken
- Lockerschnee, nass
- keine Klassierung, gemischt
- mehrere, keine Feuchte
- Bodenlawine
- klein | Rutsch | keine Grösse
- mittel
- gross | sehr gross
- keine | Beob. nicht möglich
- oberhalb 2000 müM
- net | Spreng | Pers | Schaden

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Rapid mapping chain

- Rapid mapping chain activated for period I, first activation over large regions ➤ pilot study

- SLF ➤ FO BAFU ➤ NPOC swisstopo

- Swisstopo airplanes not available ➤ satellite data

- Fast and efficient activation for period I, first data after ~12h, georeferencing by satellite data provider

- Period II: activation request from SLF again, first not supported by BAFU

- SLF ➤ NPOC swisstopo, data ordered by SLF directly, georeferencing by swisstopo
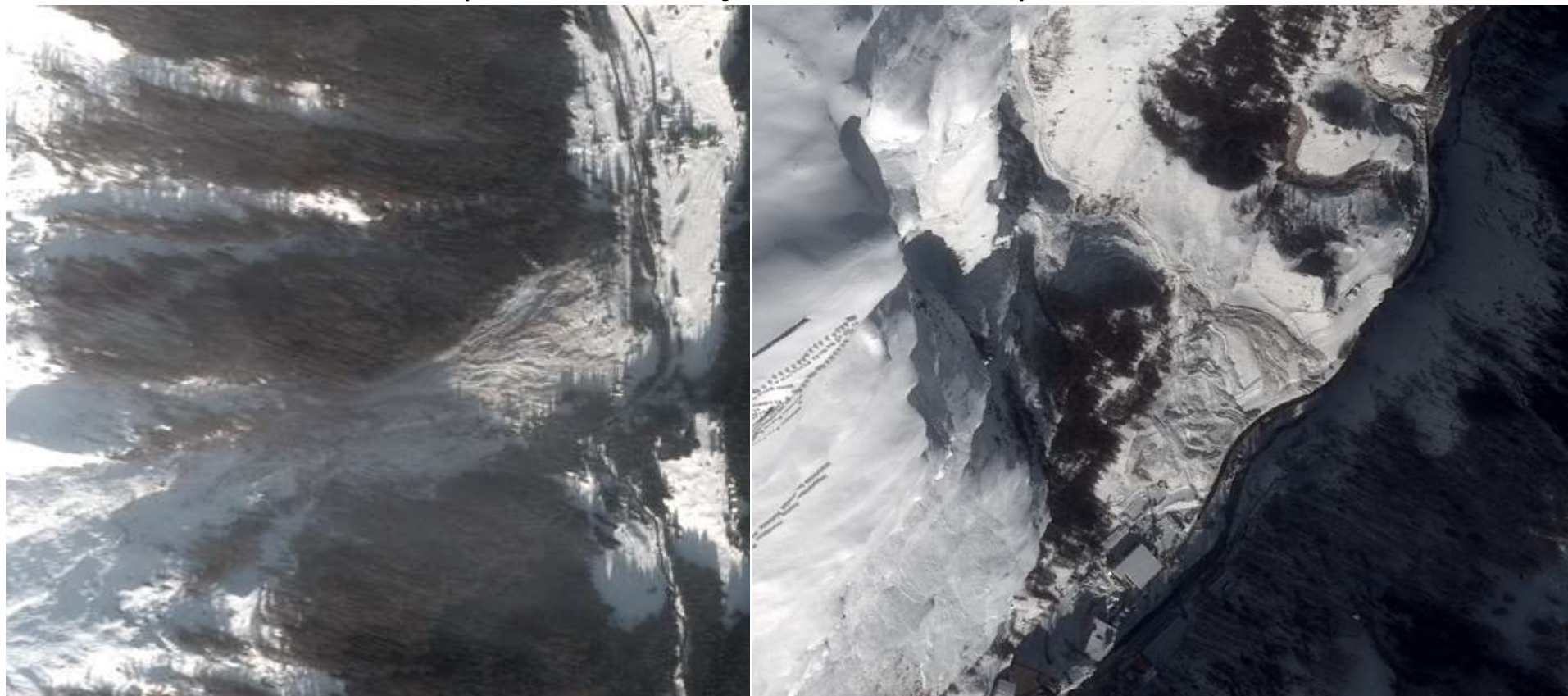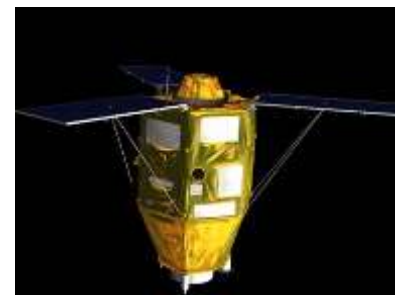
Datasets

- Periode I (04. -10. 01. 2018)
  - **Optical Spot6/7, overview resolution (1.5 m)**
    - Unterengadin (06. & 08. January, 20 – 60% coulds)
    - Goms (06. & 08. January, 80% coulds)
    - Vispertäler (10, 11. & 12. January, 10 – 70% clouds)
    - Val d'Hérens (06. January, 0% clouds)
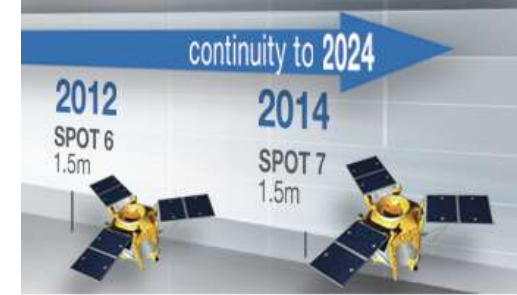
Datasets

- Periode 1 (04. -10. 01. 2018)
  - **Optical Pléiades, detail resolution (0.5 m)**
    - Pralong (06. January, 0% coulds)
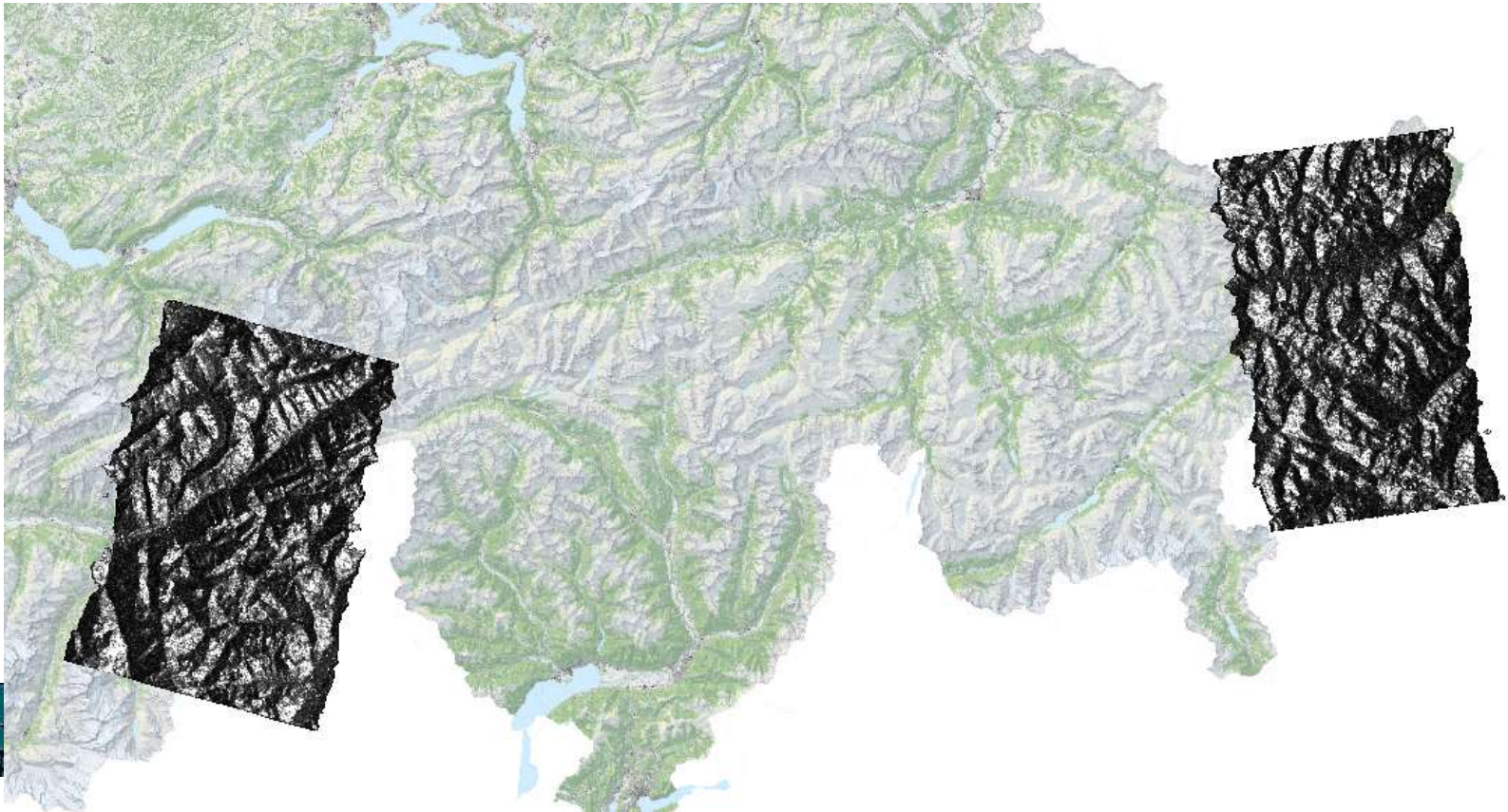   - Zermatt (06. January, 0% coulds)

Datasets

- Periode 1 (04. -10. 01. 2018)
  - **Optical WorldView-IV, detail resolution (0.5 m)**
    - Zernez (07. January, 95% coulds)
    - Ruschna (07. January, 90% coulds)

Datasets

- Periode I (04. -10. 01. 2018)
  - **Radar TerraSAR-X, overview resolution (3 m) StripMap**
    - Unterengadin (06. January)
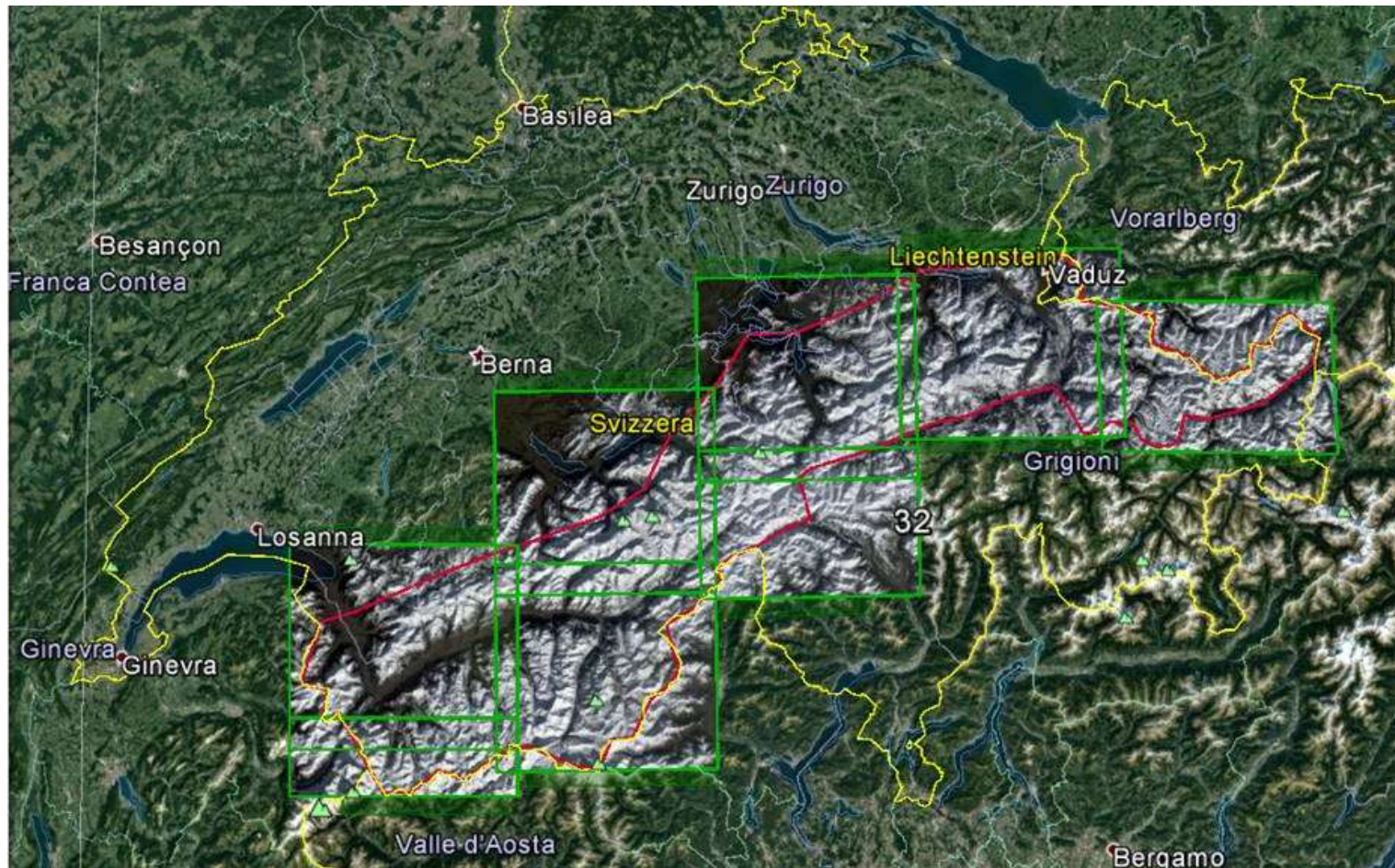   - Goms (08. January)

Datasets

- Periode 1 (06. -10. 01. 2018)
  - **Radar TerraSAR-X, fine resolution (1 m) SpotLight**
    - Unterengadin (06. January)
    - Goms (08. January)

Datasets

- **Periode II** (21. - 23. 01. 2018)
  - **Optical Spot6/7, overview resolution (1.5 m)**
    - All region with danger level 5

Lessons learned from period I

- **Optical SPOT6/7** data fast to task and rapidly available (~12h) and over **large regions** BUT it has to be **clear sky**!

- **Optical fine resolution** data (Pléiades & WorldView) only over 10x10 km areas that have to be predefined ➤ **we need to know exactly where!**

- **Radar TerraSAR-X** data harder to get (only one shot at overpass), not easy and fast interpretable, but independent on cloud cove and daytime ➤ **more research needed!**

- Communication SLF / BAFU / NPOC swisstopo is crucial: **Where? What? When?** ➤ worked very good for period I

Data analysis

- We only processed **optical overview data from period 1** until now (SPOT6/7)

- Internship to systematically **map data from period II**

- **Manual interpretation** and mapping in ArcGIS

- Avalanche **release** and **deposition**, **uncertainty classes**: well and poorly detectable

- Adaption of **color visualization**, 16 bit data!

- **Hillshade** and **slope map** as background layers
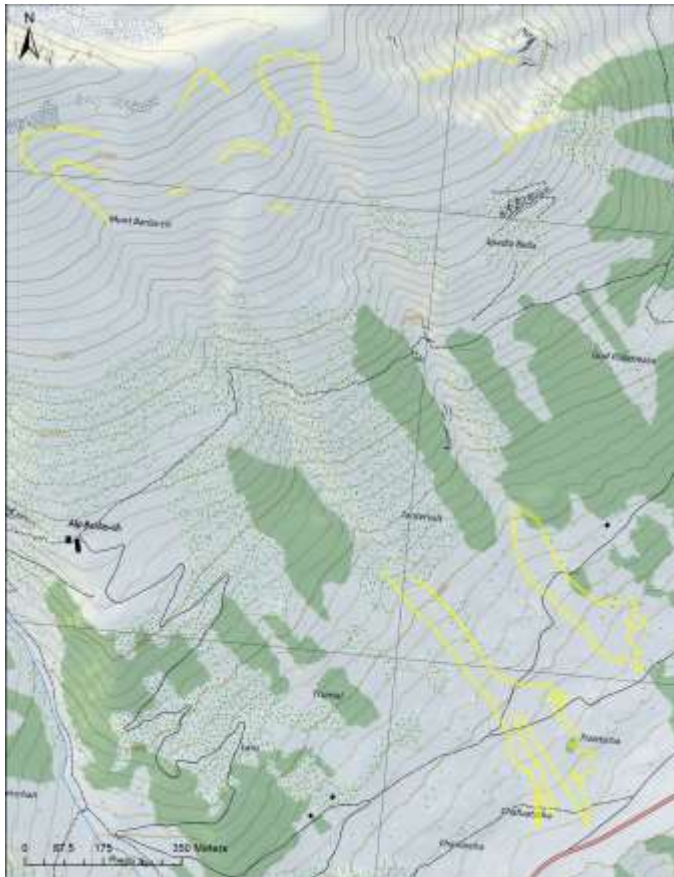
- **Grid** for **systematic analysis**
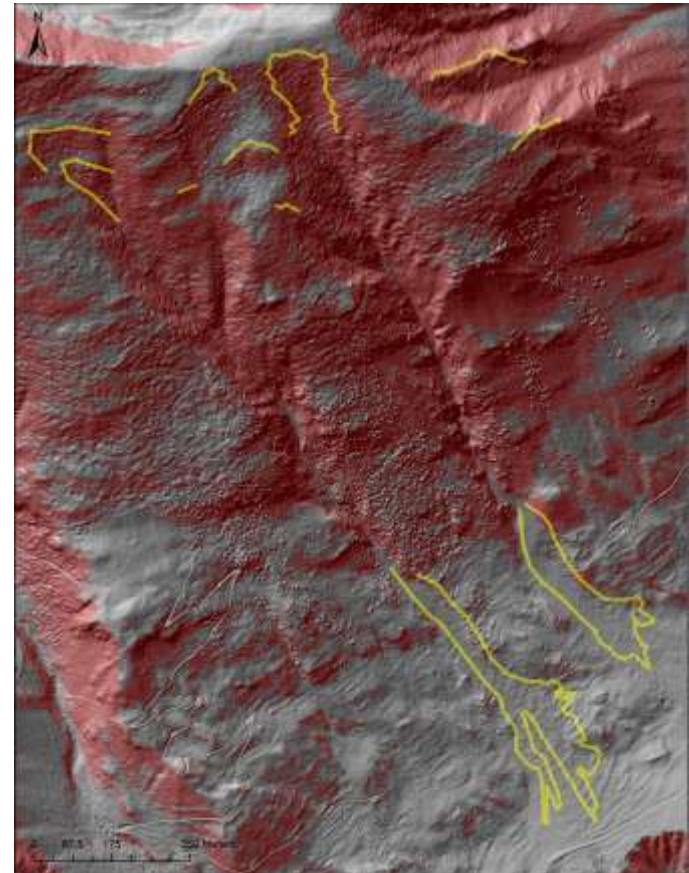
Grid for systematic analysis
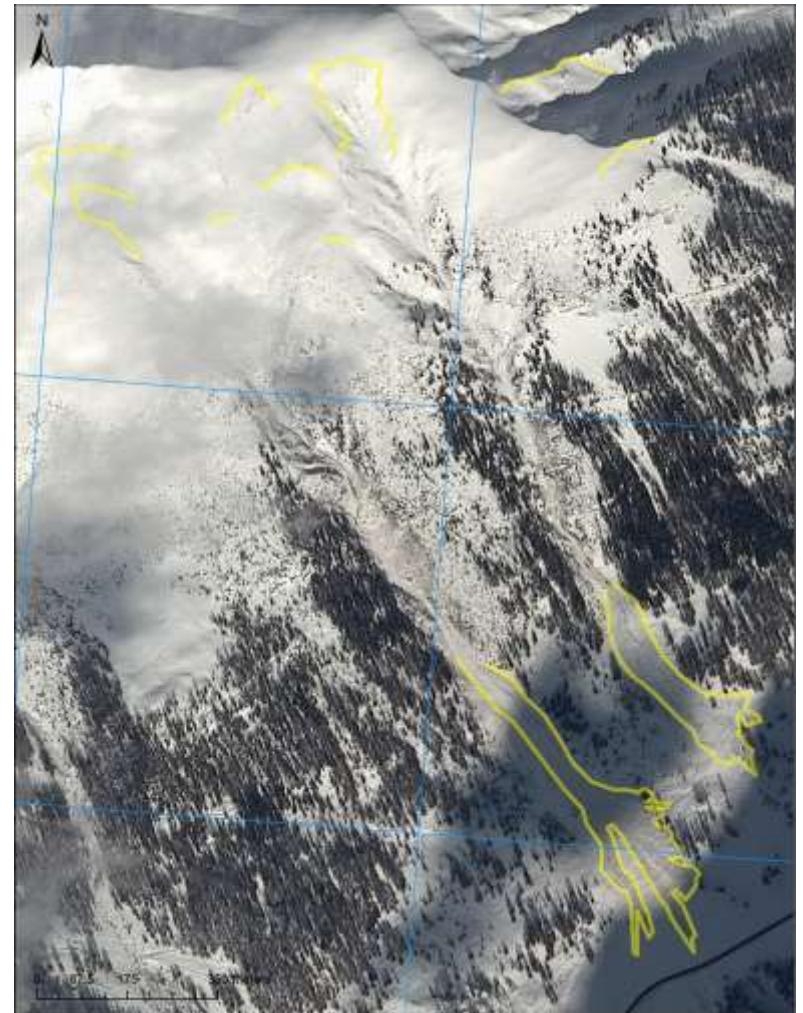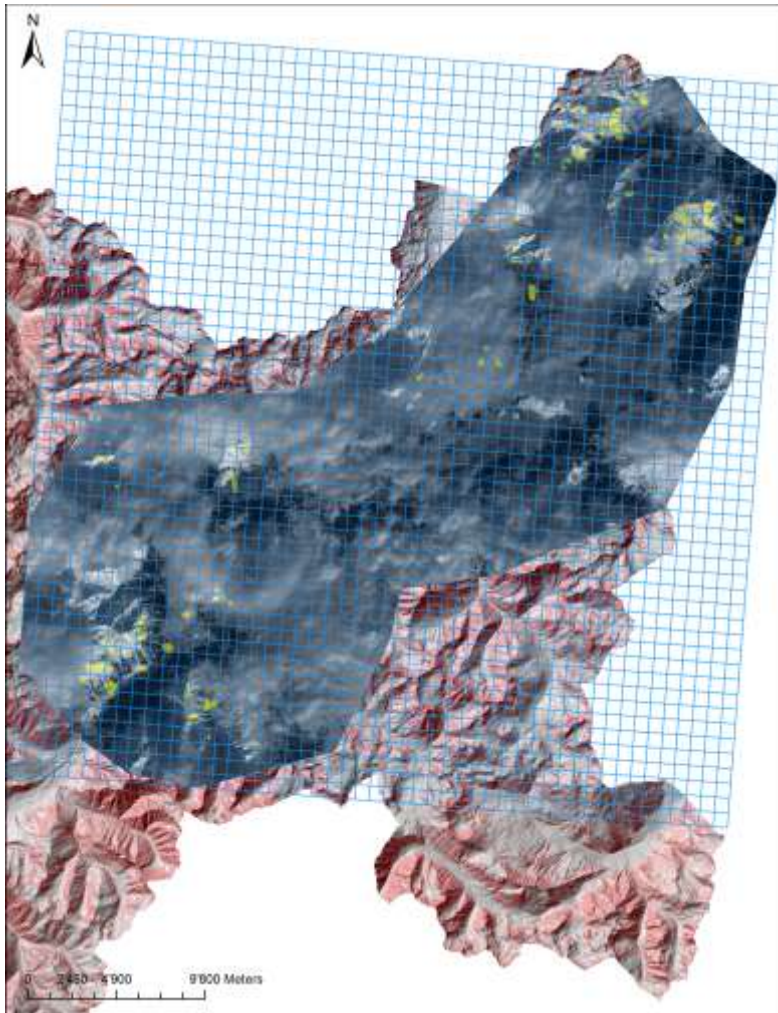
Geodata as background layers

Topomap

DEM, red >=30°

Overview Unterengadin
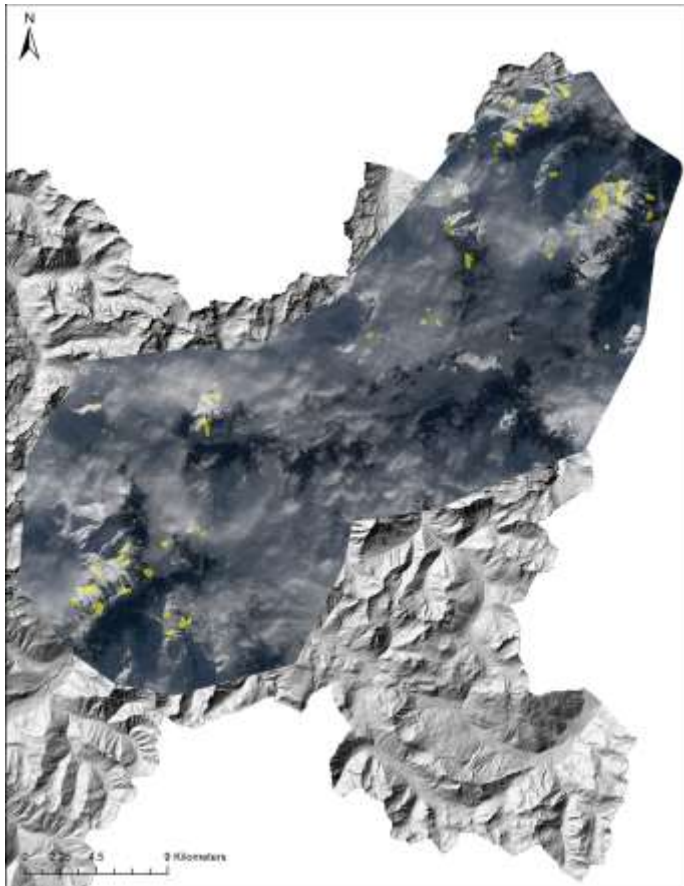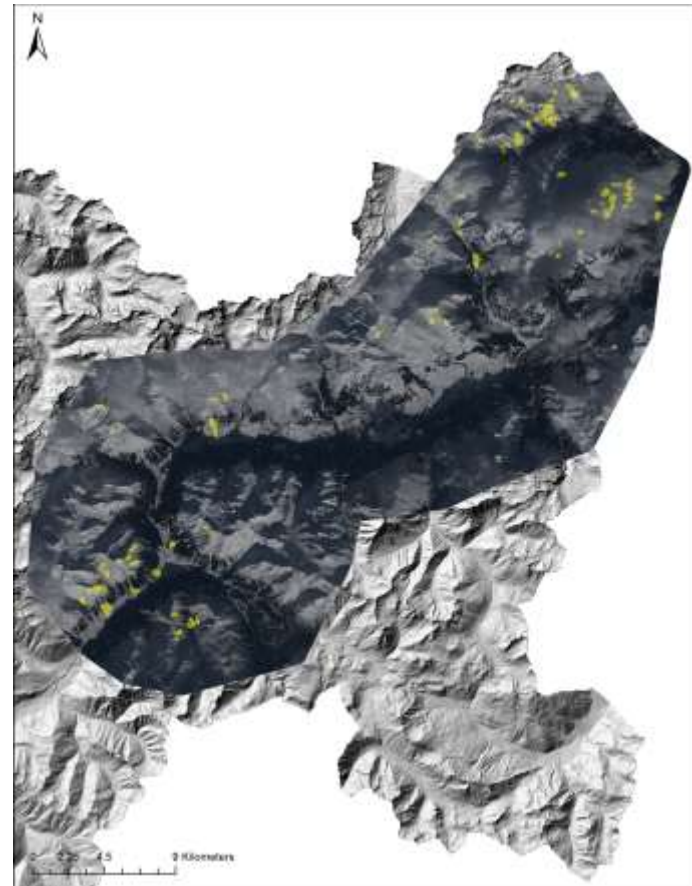
Image 06.01.2018

Image 08.01.2018

Feature detection

- **Deposits**
  - 48 features detected, 40 catchments
  - Snow with impurities: well recognizable
  - Large deposits with large compounds (rough surface): well recognizable
  - Fresh snow over deposits: poorly recognizable

- **Release areas**
  - 138 features detected, 62 catchments
  - Gliding snow avalanche: well recognizable
  - Snow slab avalanche: less clearly (cornice/crownline)

Feature detection

- Slope turned towards or away from the satellite ➤ pixel distortion

- Slope turned towards or away from the sun ➤ illumination

- Distortion due to quick and dirty georeferencing of the provider (rapid mapping mode)

- Low visibility due to clouds and haze

- Time: 1 - 1,5 day of work per image (Unterengadin), ➤ period 2 CH ~ 2 weeks
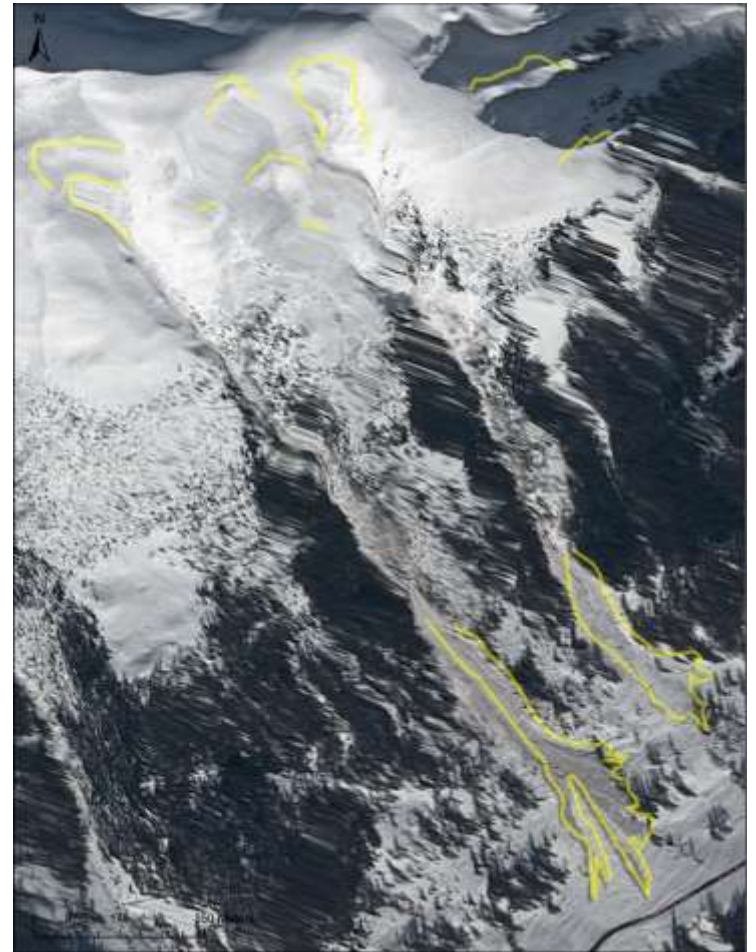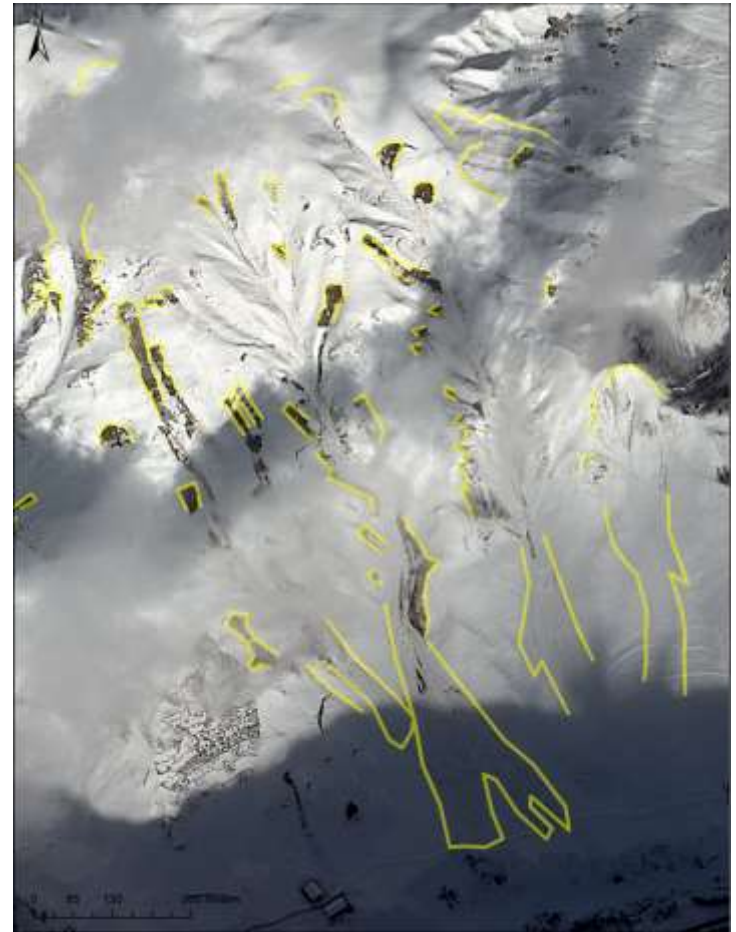
Barlas-ch

Slab snow avalanches, Image 06.01.2018

Barlas-ch

Slab avalanches, Image 08.01.16

Salatsch

Gliding snow avlanches

Piz Chapisun: illumination

normal visibility

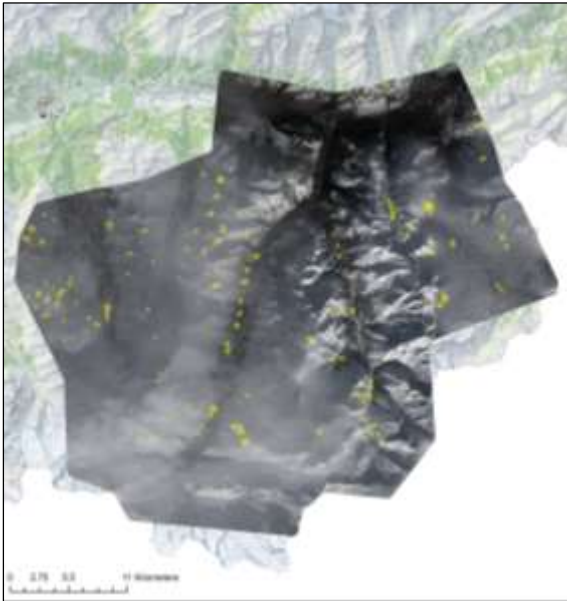enhanced visibility

Overview Vispertaeler

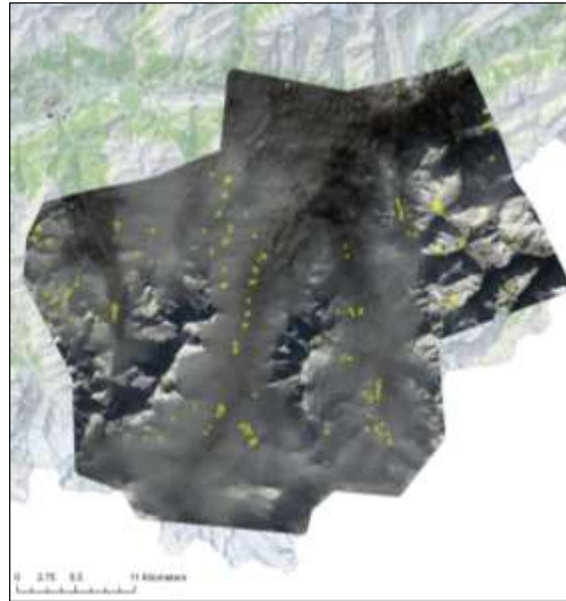**Image 10.01.2018**   **Image 11.01.2018**   **Image 12.01.2018**

Release Areas: 150 features, 115 catchments
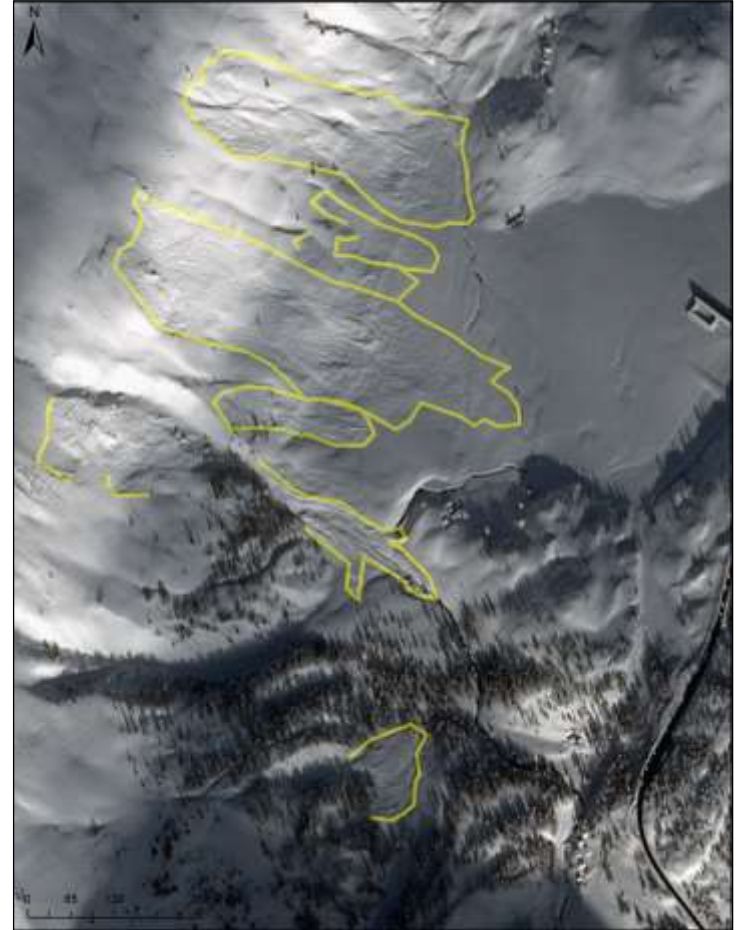Deposits: 154 features, 130 catchements
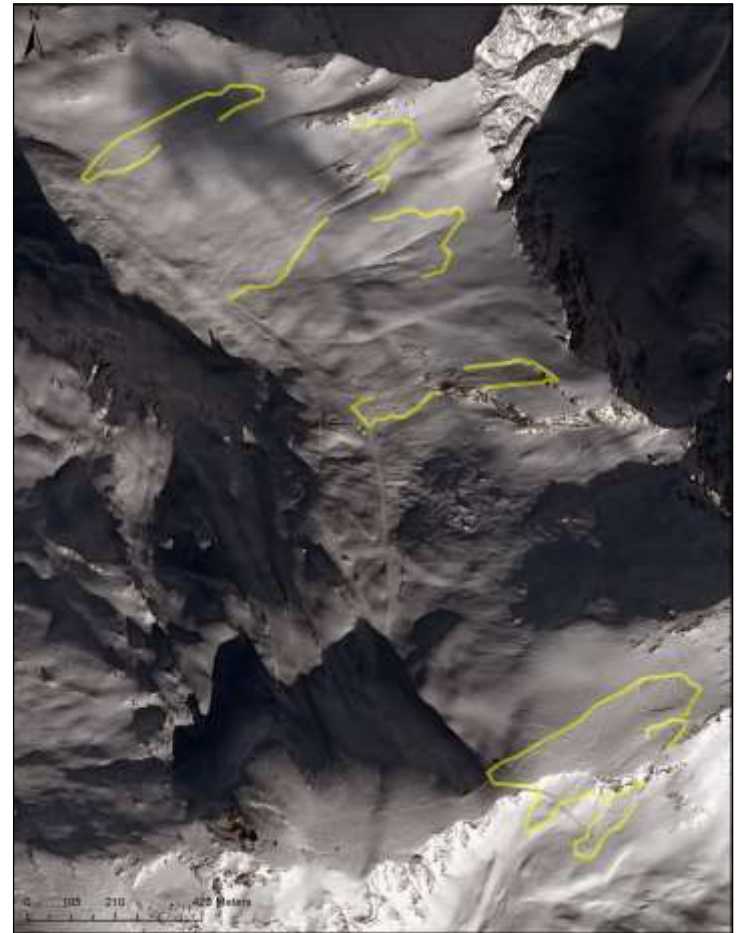
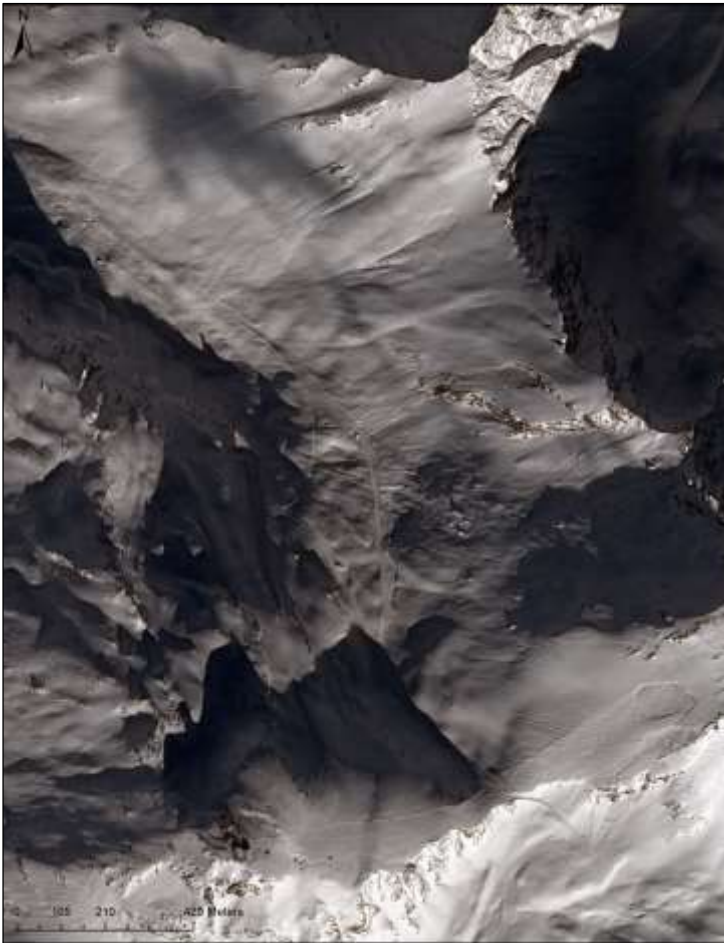# Lac de Moiry: deposits on frozen lake

Deposits on lake

Gampisch: open slope

Detailed study

Rothorn: very well visible avalanches

Detailed study

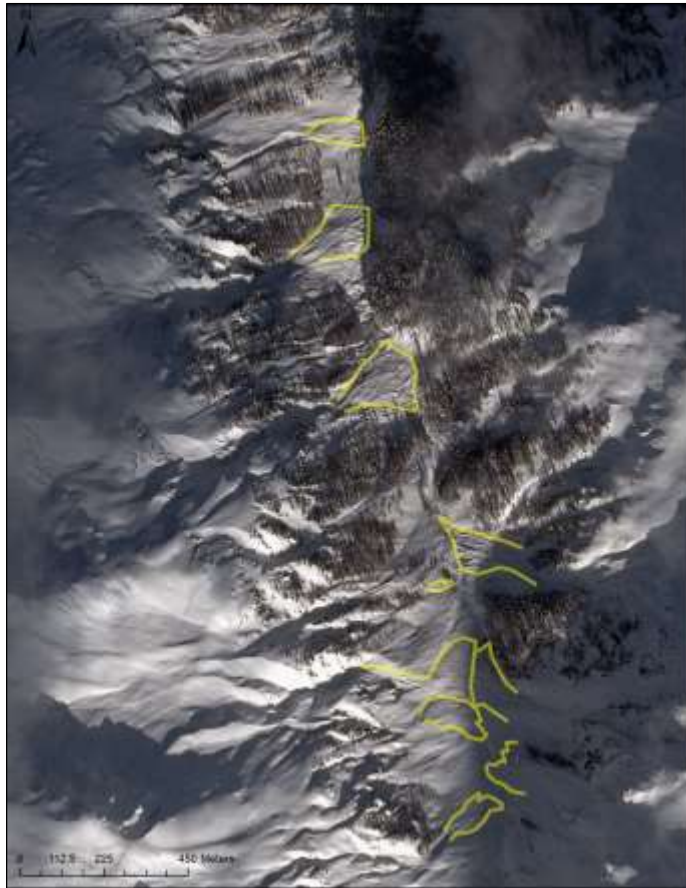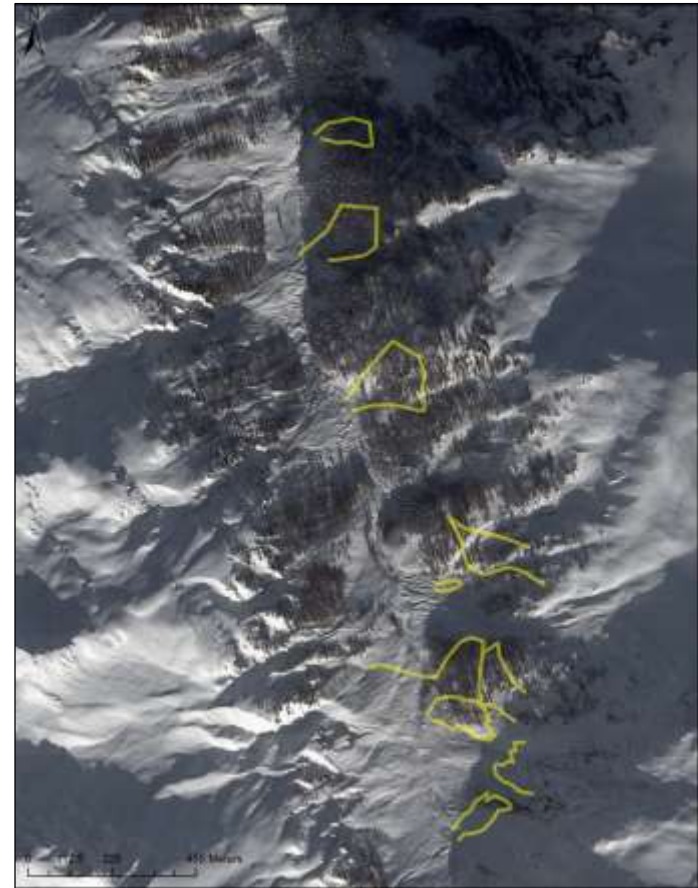# Nanztal: Georeferencing

Image 12.01.2018

Image 10.01.2018

Conclusions

- **Avalanche rapid mapping works!** Communication important

- Very valuable for **event documentation** and **cadaster**

- **Optical overview data** is fast available and of good quality under clear sky conditions, **spatial continuous data,** but still some small areas that cannot be evaluated

- **Detailed mapping** from satellites possible, areas have to be predefined (10 x 10 km), avalanche volumes from DSM?

- **Radar data** is less quickly available and hard to interpret ➤ **more research needed**

- **Fresh snow** on deposits complicates detection

- **Georeferencing** has to be done properly, more time needed, only for event documentation

Outlook

- **Systematic mapping** of avalanche records in SPOT6 data from 24 January 2018

- Starting with **Valais**, request from Pascal Stoebener

- Data format? **StoreMe?** ➤ discussion

- Master thesis Raphael Wicky on **radar data** (TerraSAR-X) interpretation together with ETHZ

- Combination with **large scale hazard mapping RAMMS** simulations?

- Assess value for **future exceptional situations?**

- **Financing** of future cases?