Ground Displacement Mapping with L-band Persistent Scatterer Interferometry

Urs Wegmüller, Christophe Magnard, Tazio Strozzi
Rafael Caduff, and Nina Jones

Gamma Remote Sensing AG
www.gamma-rs.ch

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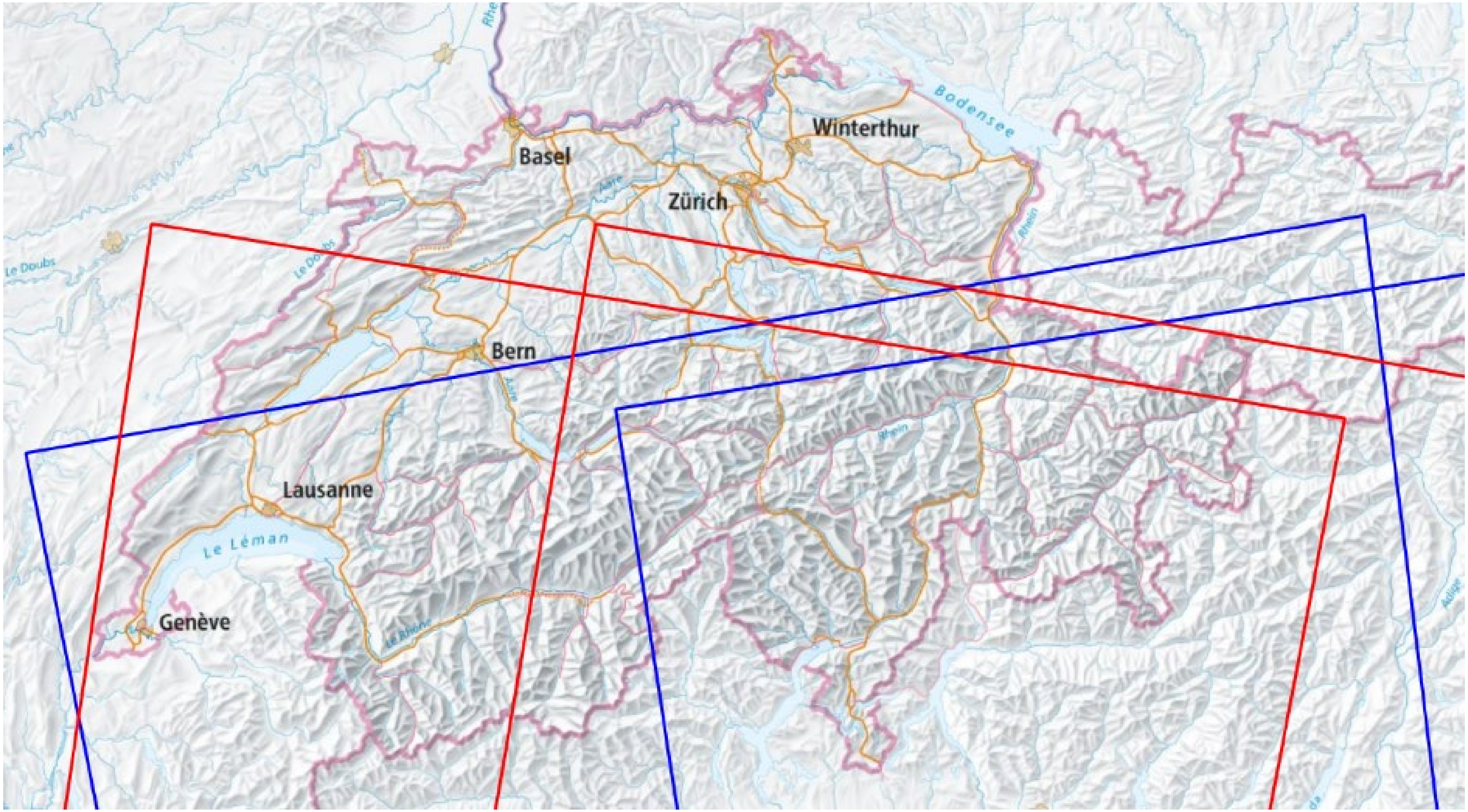
L-band Data over the Swiss Alps

Senser / Mode	Period	Availability
JERS	1992-1998	some scenes
PALSAR-1 Stripmap	2006-2011	small stacks (asc) incl. long baselines (> 2km)
PALSAR-1 ScanSAR	2006-2011	not synchronized
PALSAR-2 Stripmap	2014-ongoing	stacks for some areas (asc) short baselines (< 1km)
PALSAR-2 ScanSAR	2014-ongoing	complete coverage synchronized (from 2015) small stacks (desc. > 10, asc. <10)

ALOS-2 PALSAR-2 ScanSAR coverage over Switzerland (ascending: blue, descending red).



PALSAR-2 ScanSAR Approaches

Merging in map geometry

Co-registration and interferogram generation per sub-swath

Geocoding of differential interferogram

Combination of geocoded sub-swath differential interferograms

Merging sub-swath SLCs

Resampling of sub-swath SLCs to a common grid.

Co-registration of the "burst SLCs"

Generation of "mosaic SLCs"

Interferogram generation and geocoding

Time-series analysis characteristics

1) Using single pixel phases.
2) Using single reference or multi-reference stacks (depending on number of scenes).
3) Suited candidates are selected based on the spectral coherence (→ point-like scatterers are preferred).
4) Linear trends (in slant range / azimuth geometry) are removed.
5) Winter data (snow) are not used.
6) In the case of short baselines and accurate DEM heights, one-dimensional regressions can be used.
7) GAMMA IPTA Software is used.

Persistent Scatterer Methodology

1) Point target candidate identification (using spectral coherence to identify point-like scatterers).
2) Get interpretable interferometric phases (regression analysis to unwrap phases, average displacement rates, and residual phases).
3) Estimate atmospheric phase delays based on residual phases.
4) Iteration, quality control.

The displacement rate accuracy depends mainly on the total time period covered and the quality thresholds (phase standard deviation threshold) applied.

Capacity and efficiency considerations

1) ~ 20 GByte per SLC (for about 80% of full scene)
2) Using vector data format with point candidate lists reduces this to 80 MByte (for 10 million candidates)
3) Regression analysis, unwrapping, checking of unwrapping of residual phase, atmospheric path delay estimation are all quite robust and efficient for this L-band data.
4) → Data volume and processing time not a problem.

Robustness considerations

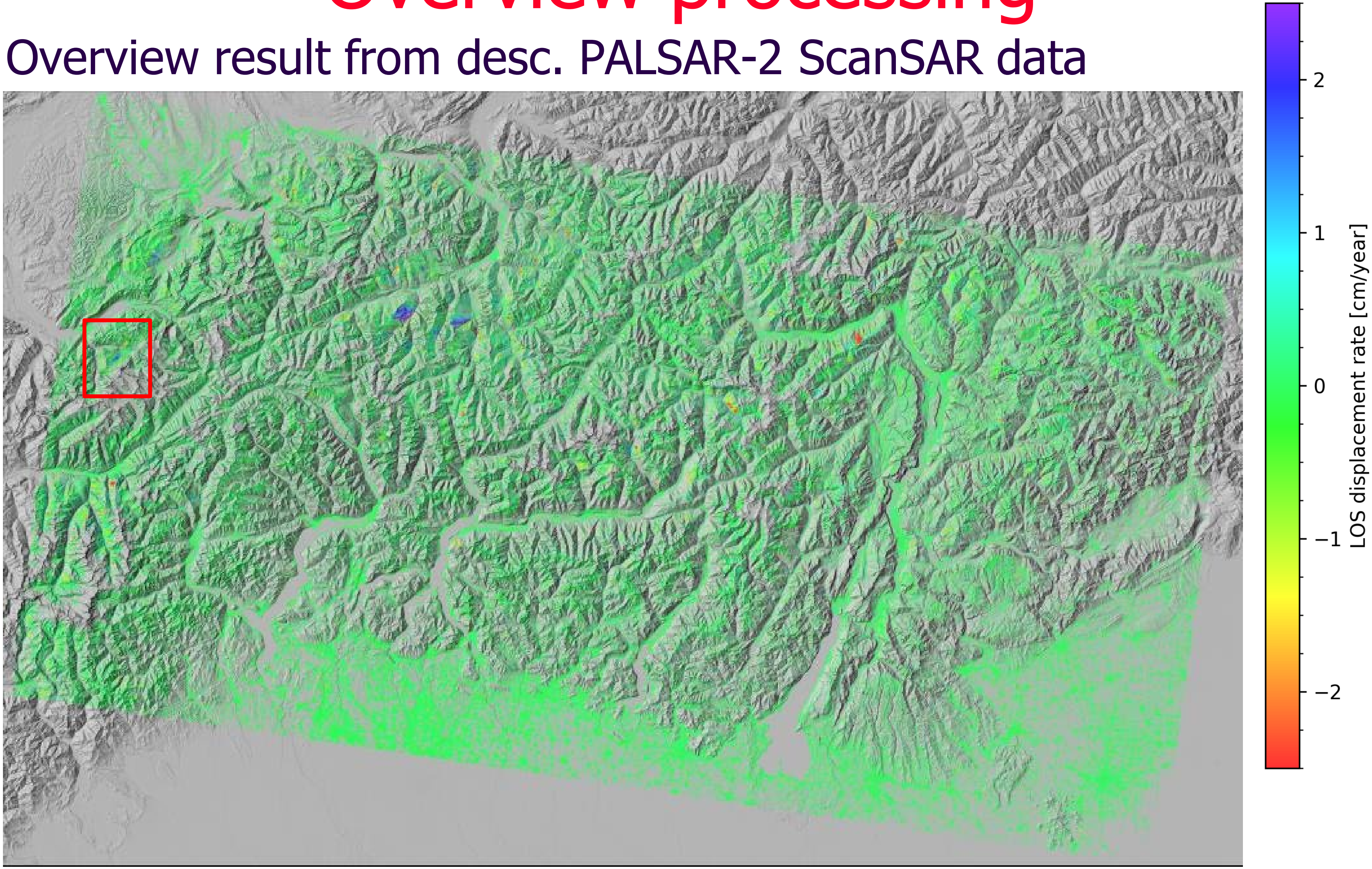
1) Working initially with “high quality candidates” helps in the efficient development of the solution.
2) Short baselines and accurate DEM heights facilitate the processing → residual topographic phases are small → (initially) one dimensional regressions can be used.
3) At L-band the residual atmospheric phases are $<< \pi$.
4) Unwrapping simpler and more reliable than at C-band.

Quality considerations

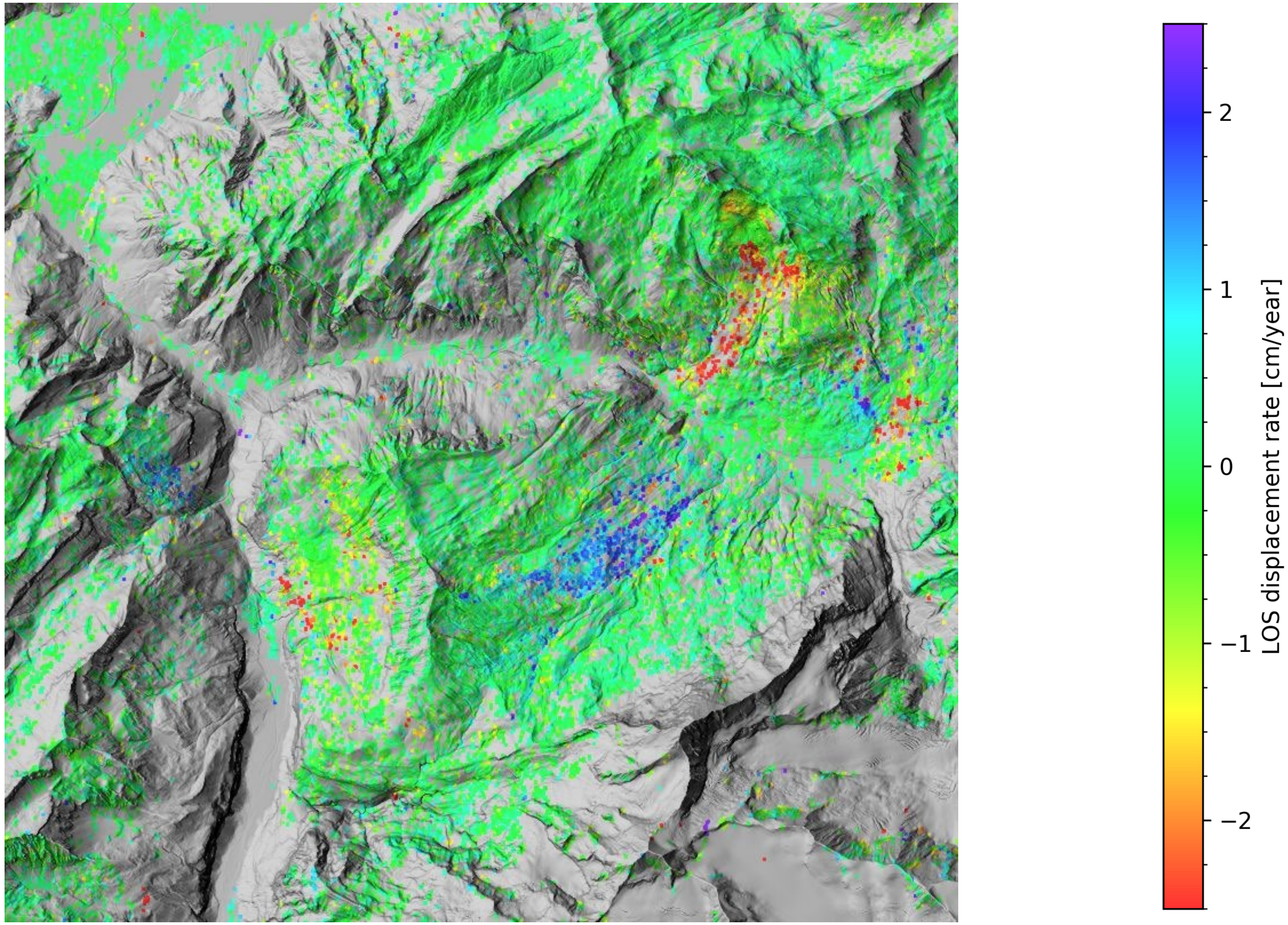
1) Lower phase to displacement sensitivity → a given phase error results at L-band in a higher displacement error than at C-band.
2) Atmospheric error (in distance) is independent of wavelength.
3) Using more stringent quality thresholds permits achieving similar accuracies as at C-band.
4) Using similar quality thresholds results in somewhat lower accuracies (e.g., 2mm/year), while permitting to include faster movements and achieve a better coverage in vegetated areas.

Overview processing

Overview result from desc. PALSAR-2 ScanSAR data



Extracted section for Grindelwald



look direction

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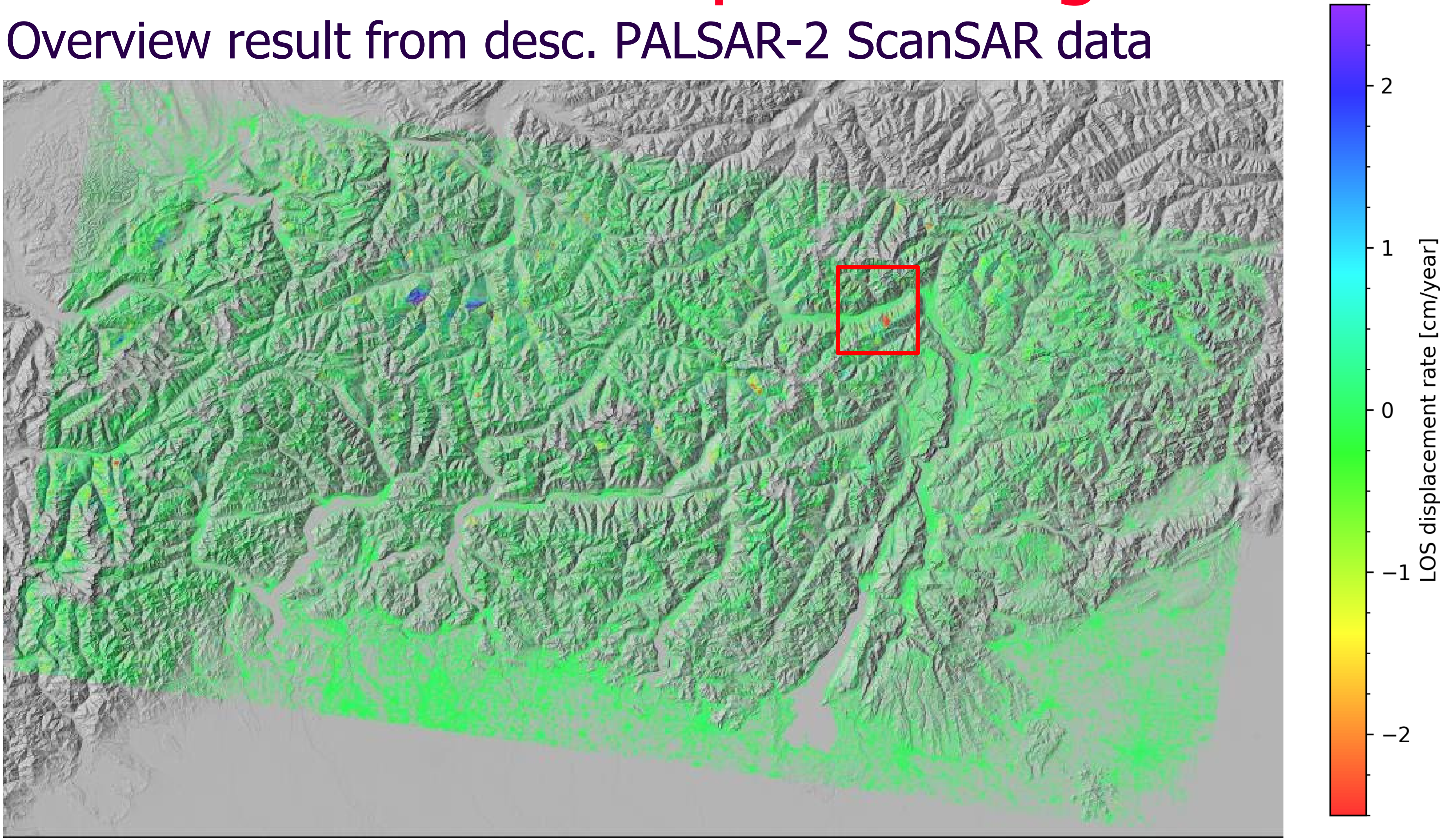
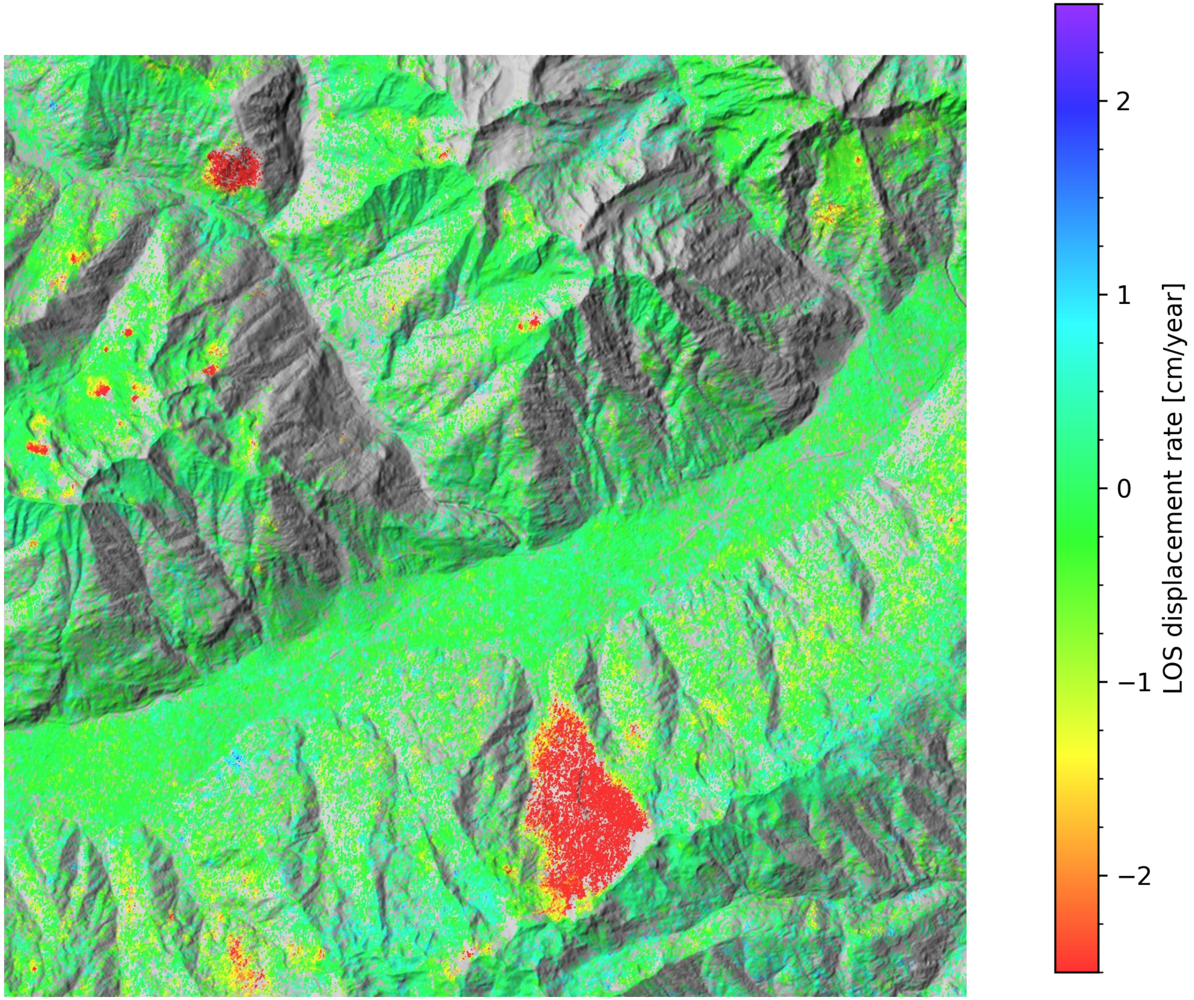
Overview processing

Overview result from desc. PALSAR-2 ScanSAR data



PALSAR-2 local processing for Naturns



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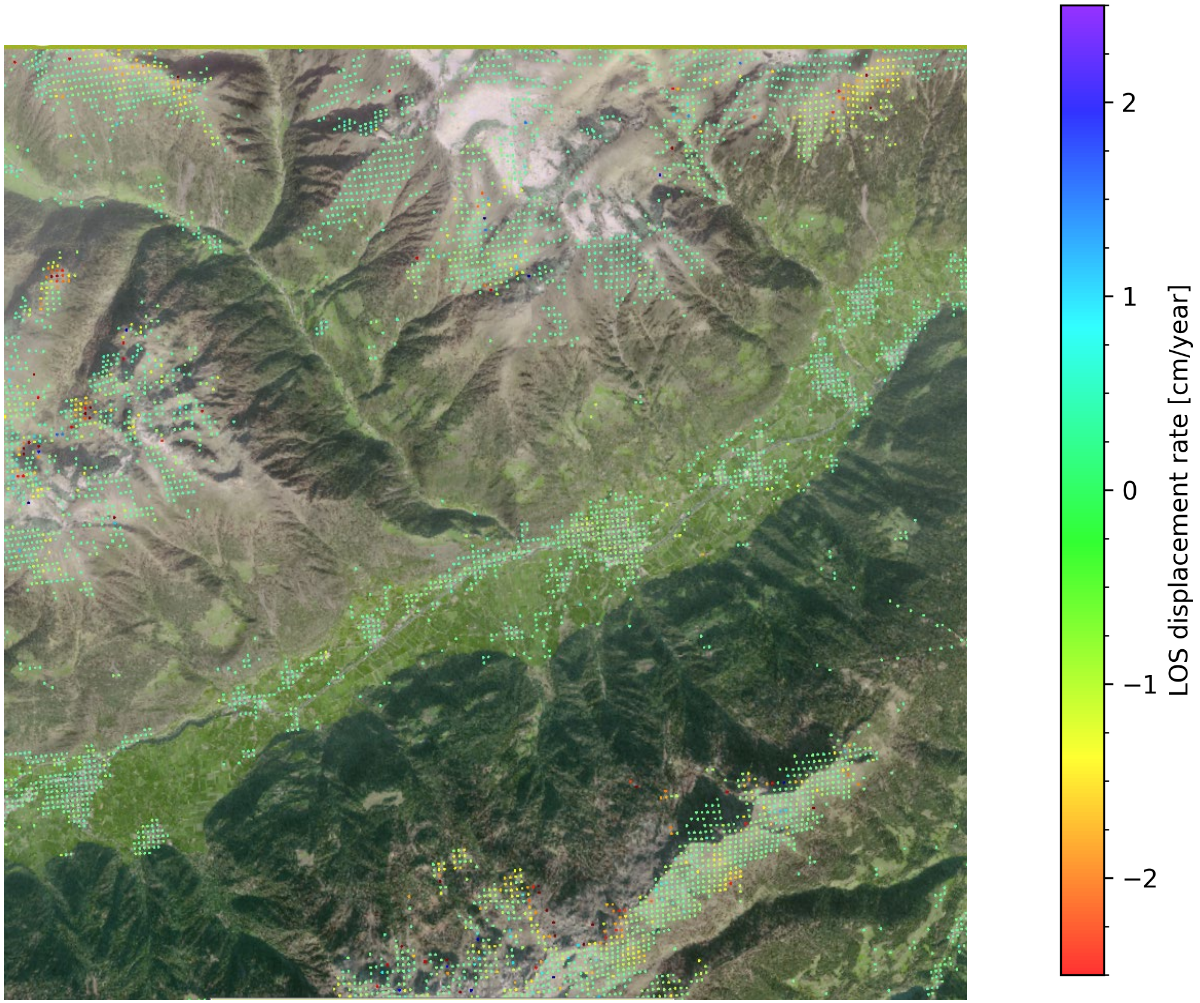
Sentinel-1 result (EGMS) for Naturns

→

Gaps for vegetation

Gaps for faster movements



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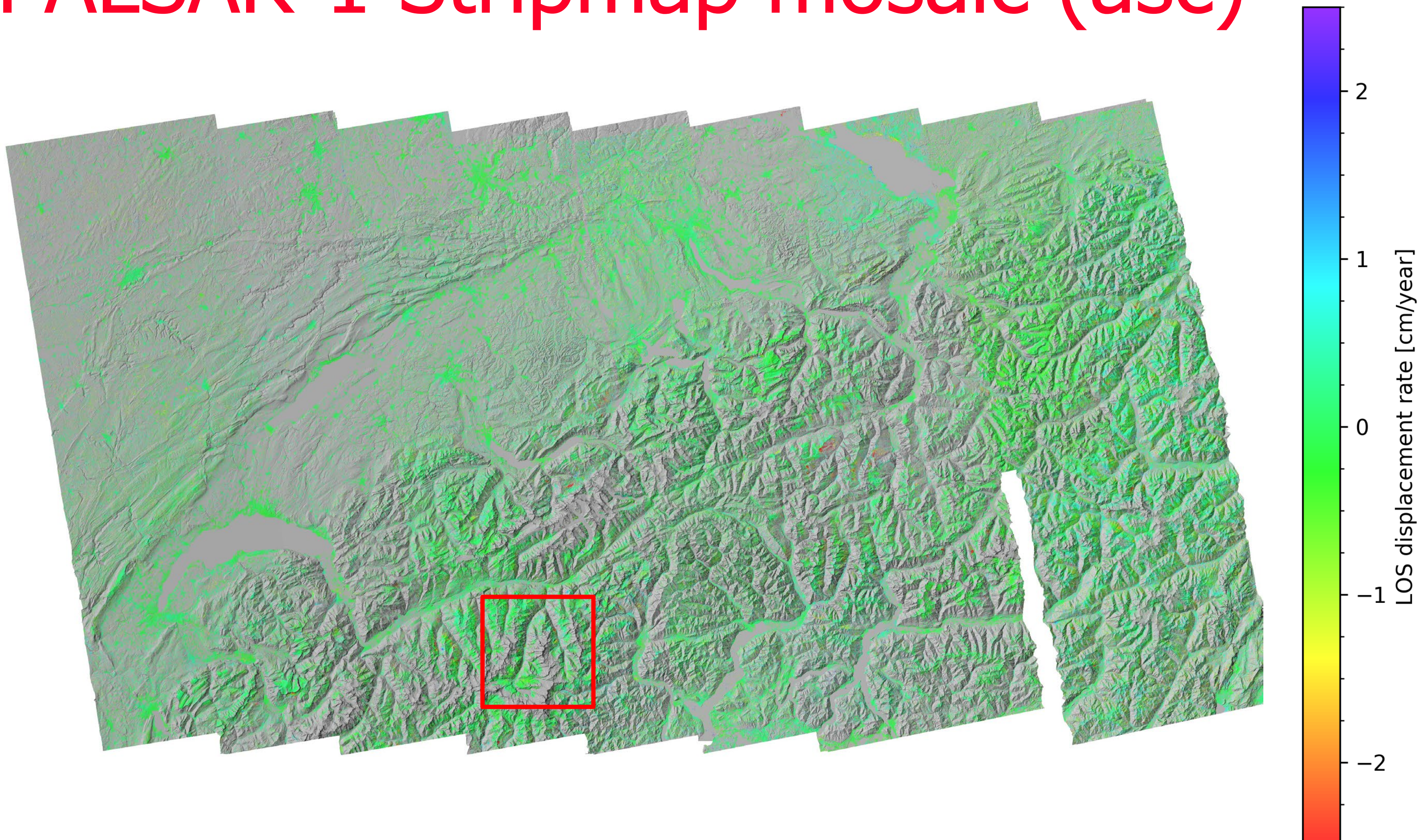
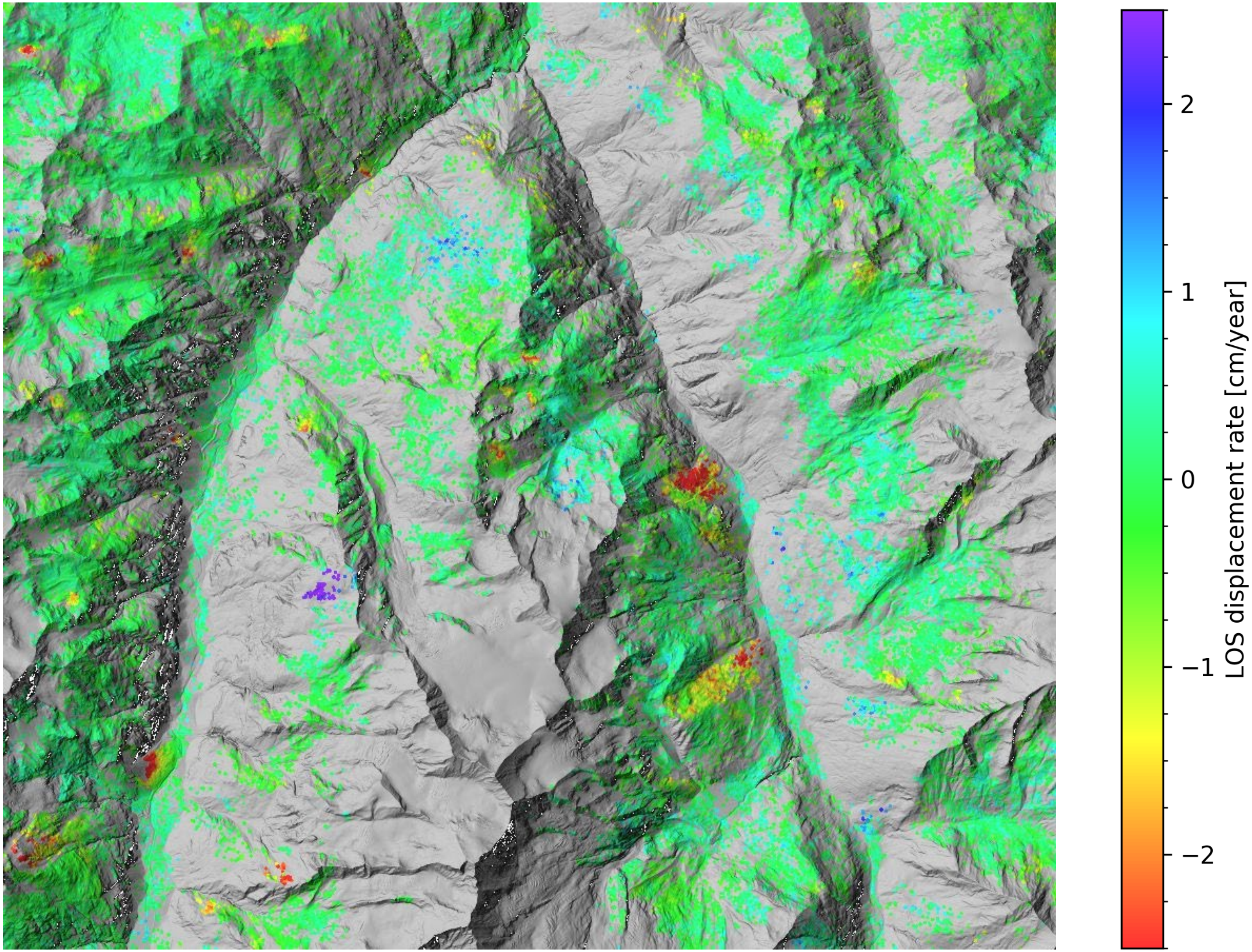
PALSAR-1 Stripmap mosaic (asc)





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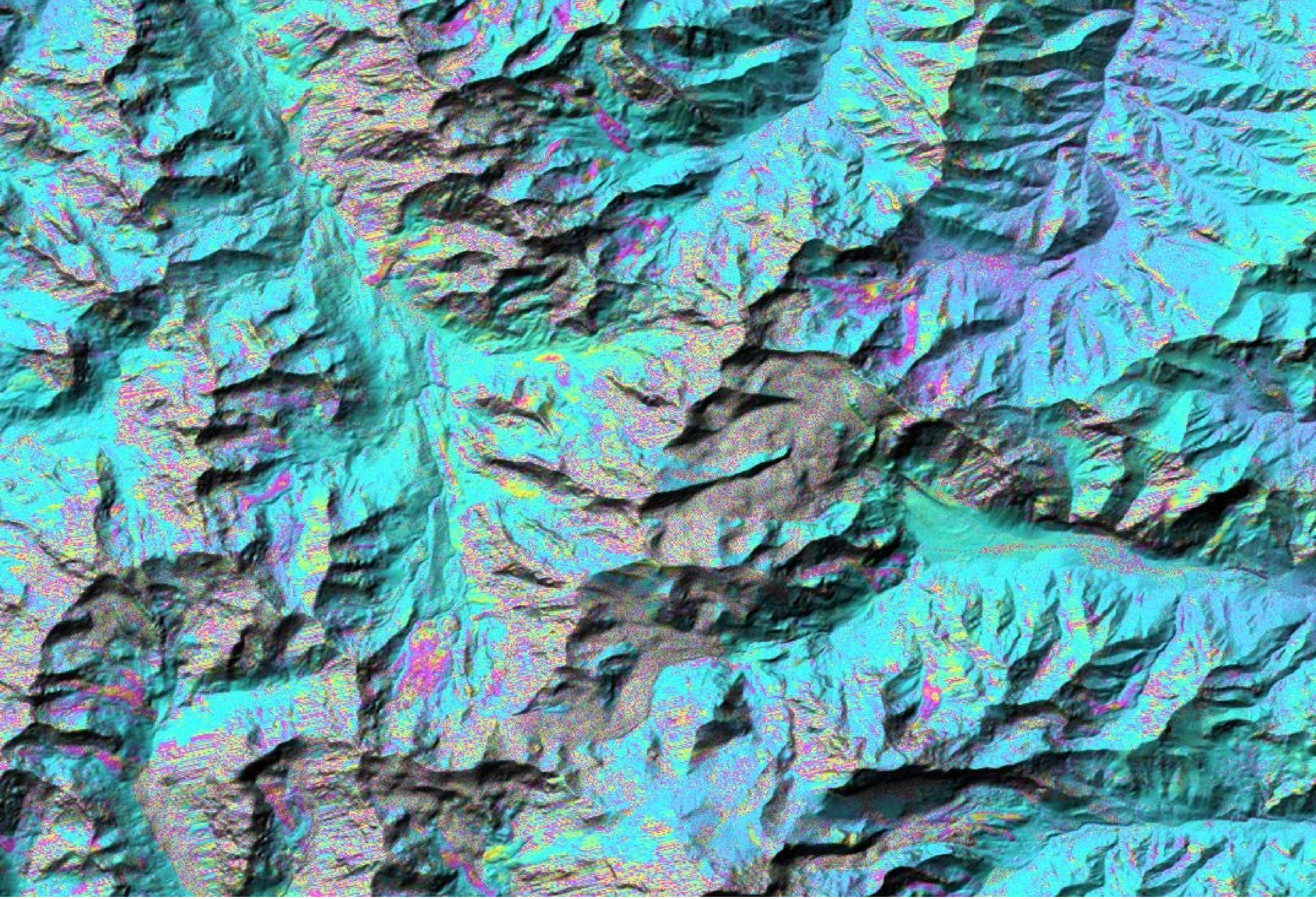
Mattertal VS

Conclusions

- Compared to C-band, L-band PSI shows a better potential
  - for faster and non-uniform motion
  - for vegetated areas.
- Using a small stack (< 15 L-band scenes over > 4 years) a very useful displacement map over the Swiss alps could be generated.
- PSI was found to be overall more straight-forward at L-band. Phase error terms are small compared to a phase cycle, which facilitates filtering and unwrapping.
  In addition, coherence over vegetated areas is higher.

Outlook

- PALSAR-3: same orbit as PALSAR-2
  → time series can be continued
  Questions: data access ?
- NISAR: frequent global coverage, 12-day repeat, free and open data
  → very high potential
  Questions: 3 years mission (consumables 5 years)
- ROSE-L: launch 2028
- Other L-band sensors:
  - SAOCOM (2 L-band sensors in orbit)
  - LuTan-1 (2 L-band sensors in orbit)



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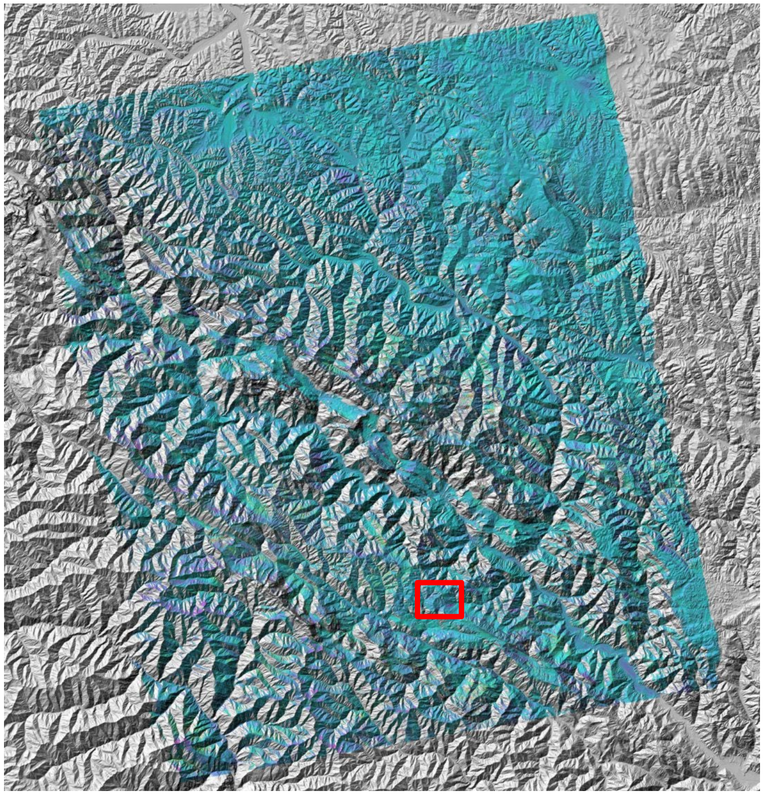
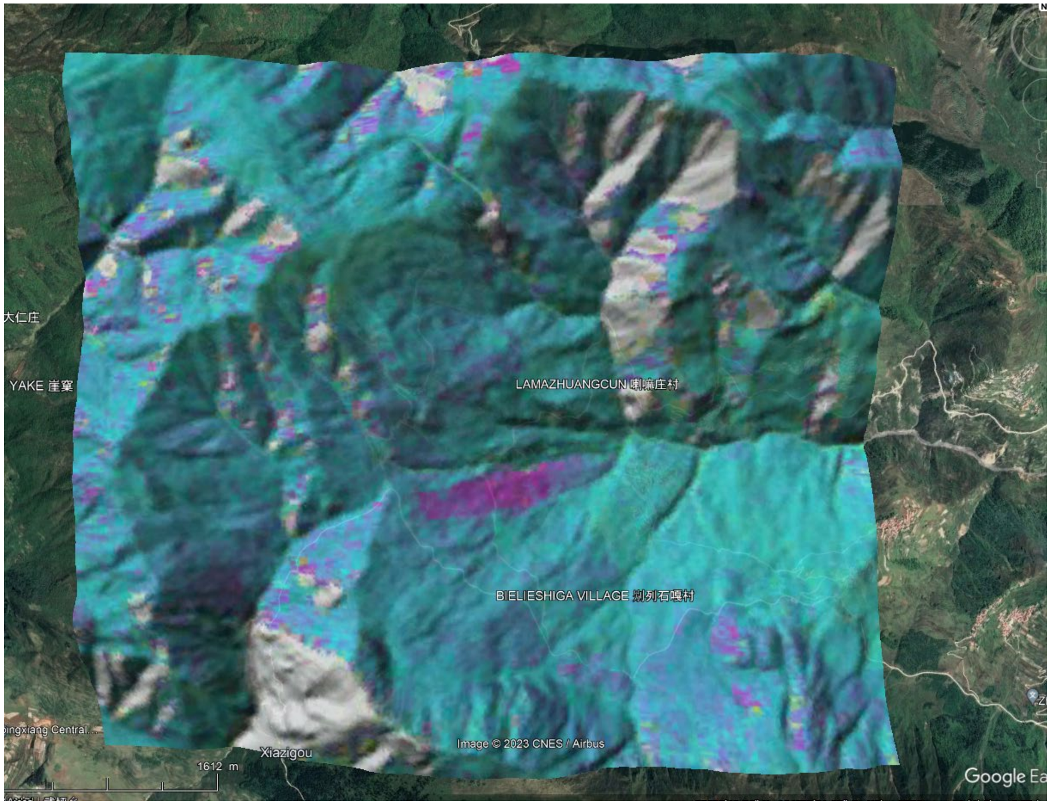
SAOCOM DInSAR 20211118_20211220

LT1a/LT1b Stripmap DInSAR





LT1 DInSAR (dt=4days, Bperp=650m, 17.3.2023-21.3.2023),
The line-of-sight velocity of the landslide is > 1 cm per day.

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