Terrestrial radar observations of snow on Alpine slopes

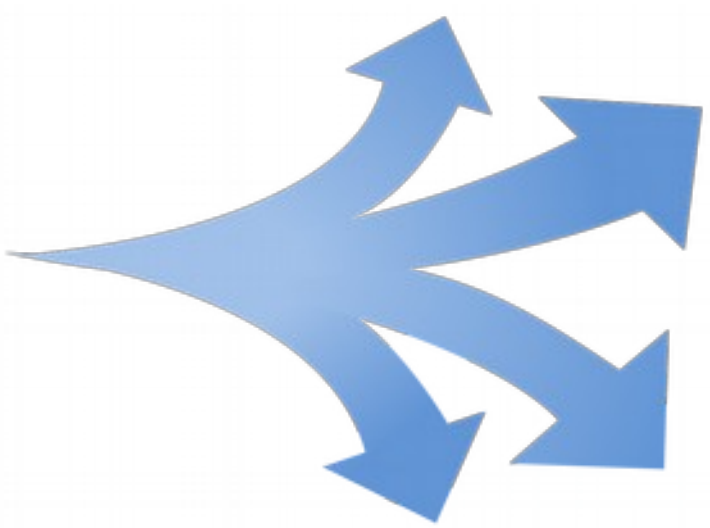
Andreas Wiesmann, Rafael Caduff, Tazio Strozzi,
Jessica Papke, Christian Mätzler, Urs Wegmüller



7th EARSeL workshop on Land Ice and Snow
3.-6. Feb. 2014 Bern, Switzerland

GAMMA REMOTE SENSING

Outline



Motivation

Instrument

Test Sites

Results

Motivation

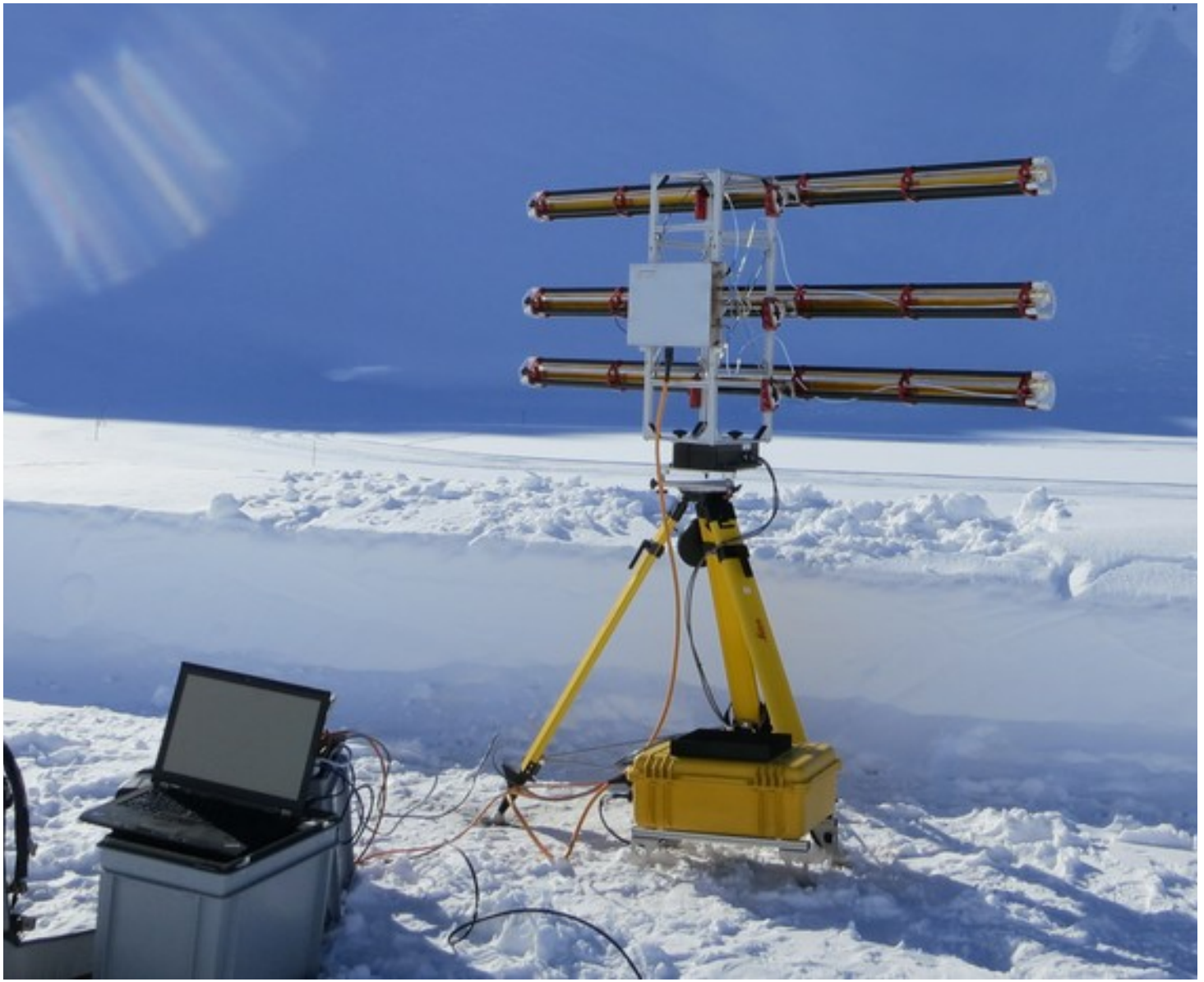
- Microwave Remote Sensing of snow has high potential
- But available satellite sensors have limitations
  - (Fixed) Observation Geometry
  - Spatial Resolution
  - Temporal resolution
  - Frequency
- On the other hand terrestrial instruments (scattereometers/radiometers) are usually used for point measurements

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Motivation

- Availability of a imaging radar to investigate snow on slopes
  - Investigate the spatial and temporal behavior of the backscattering
  - Investigate the interferometric coherence (e.g. What is the decorrelation time of snow)
  - Investigate the interferometric phase
  - Investigate if snow creep can be detected and quantified
  - Potential for avalanche detection

GAMMA Portable Radar Interferometer



GAMMA Portable Radar Interferometer



Instrument

Frequency Range 17.1 to 17.3 GHz

Antenna Pattern 0.385 deg -3 dB azimuth beamwidth (2-way)
35 deg. -3 dB elevation beamwidth (2-way)

Radar Modulation FM-CW, chirp duration
250 micro-seconds to 16 milli-seconds

Radar operational range 50 m to 10 km

Chirp Bandwidth 200 MHz maximum (programmable)
Range Resolution 0.95 meters -3 dB peak width with 200 MHz
chirp -26 dB peak range sidelobe

Azimuth Resolution (-3 dB) 6.8 m@1 km, -3 dB peak width
proportional to slant range
-30 dB peak azimuth sidelobe

Instrument Computer and OS Industrial mITX PC, Dual-Core CPU, min.
8 GB RAM, min. 1 GB Disk, Linux Ubuntu OS.

Azimuth Scan Time Nominal 10 deg/second
Azimuth sweep rate is programmable

Campaigns

Mägisalp 2012:

- 3. March, 6h
- Spring snow with melt, 2.30m
- 2 minute repeat measurements

Flüela 2013:

- 23. January, 5h
- Winter snow, ~1m
- Artificial avalanche release
- Measurements before and after the event

Mägisalp 2013:

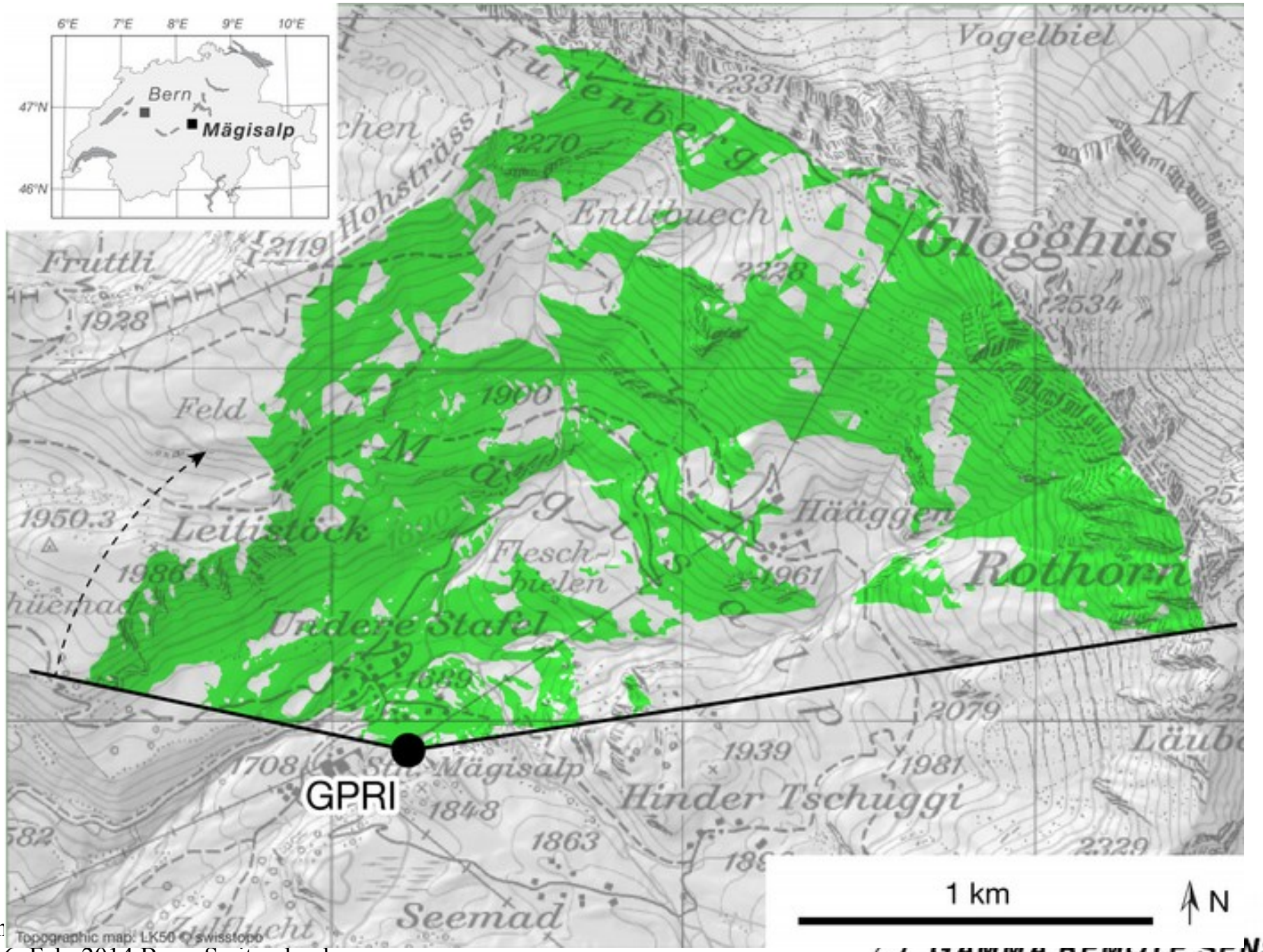
- 27./28. March, 30h
- Spring snow with melt, 2.00m
- 3 minute repeat measurements

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Data Processing

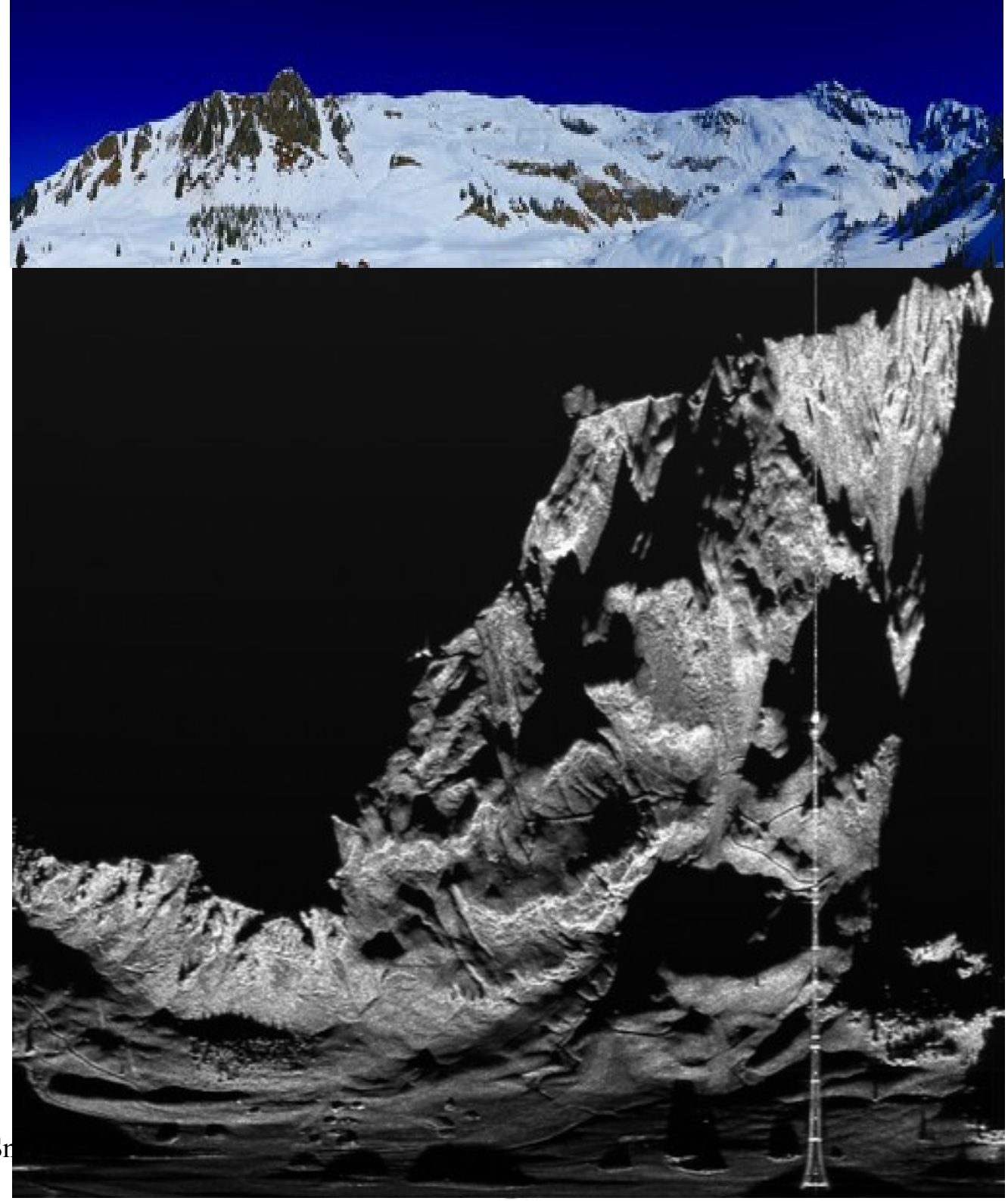
- Convert data to SLC
- Co-register (if necessary)
- Pairwise Interferograms (1-2, 2-3, 3-4...)
- Coherence estimation
- Filtering (atmosphere etc.)
- Unwrapping
- Stacking (sum up phases or MB especially if atmosphere is an issue)
- Displacement estimation
- Orthorectification

Test Site Maegisalp, Switzerland

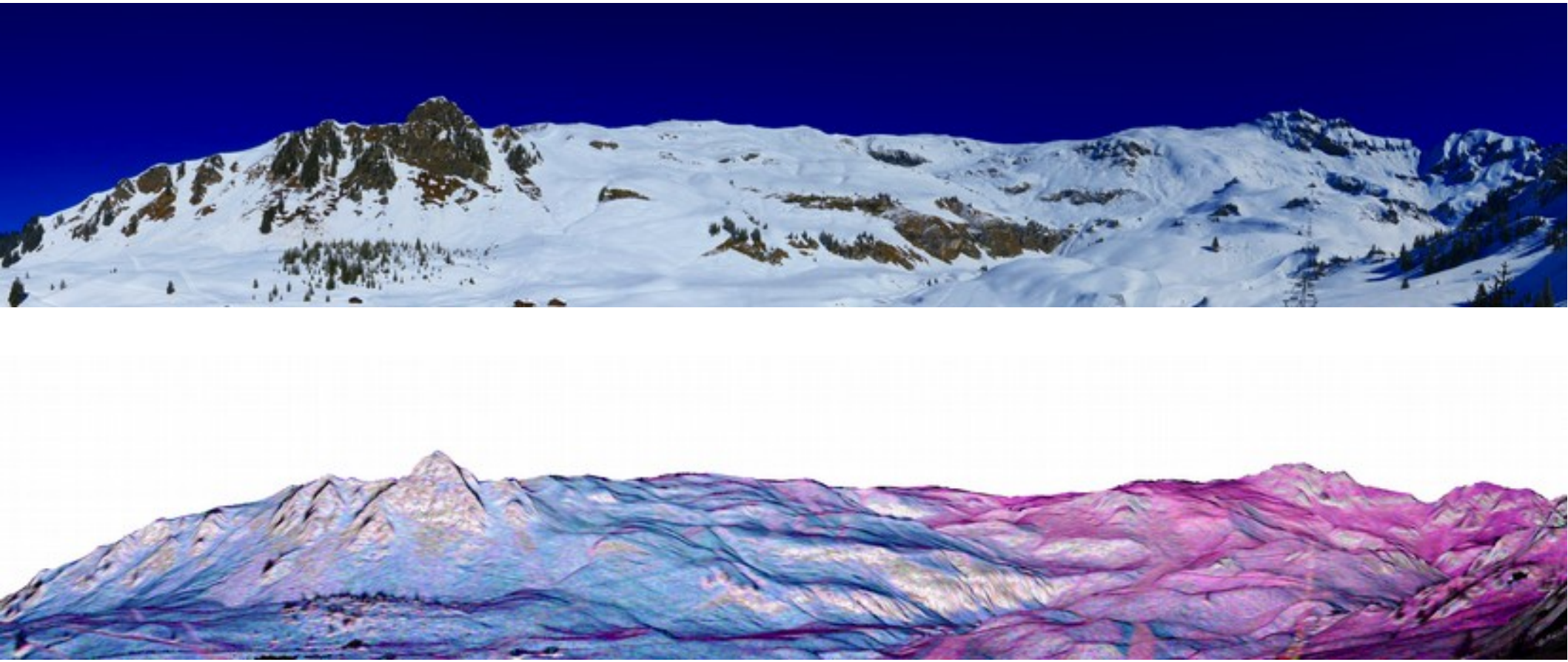


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Radar Image Mägisalp



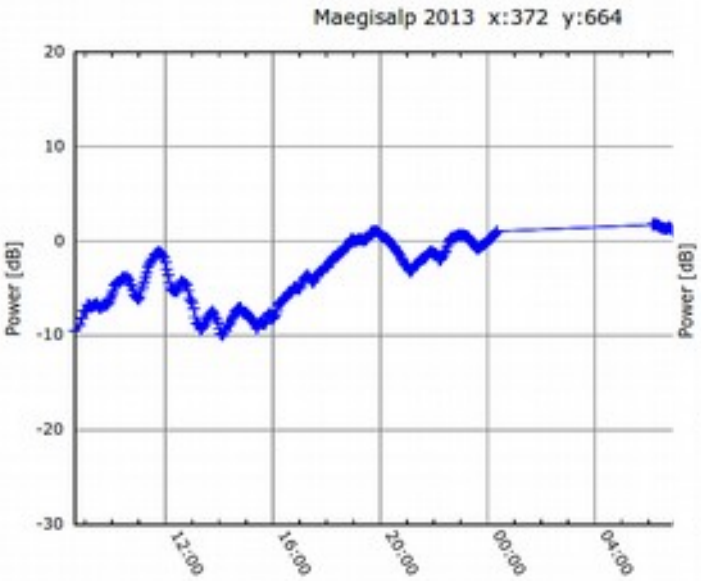
Backscatter Change Mägisalp 2013

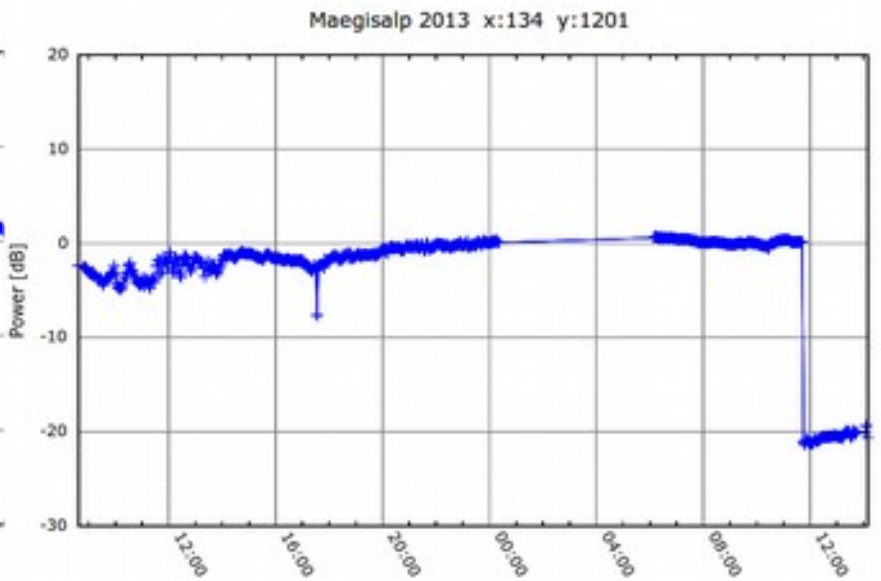


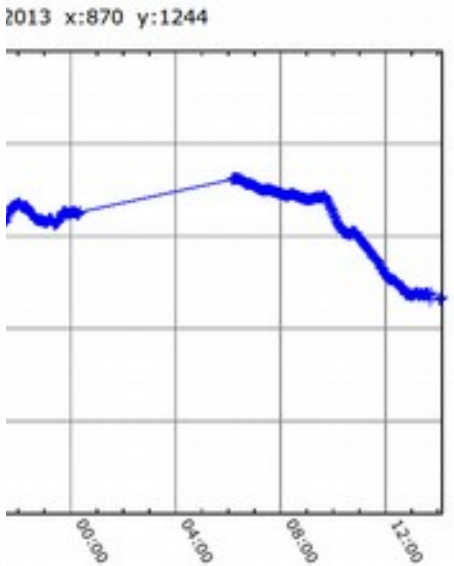
red: morning, green: afternoon, blue: night 27. March 2013

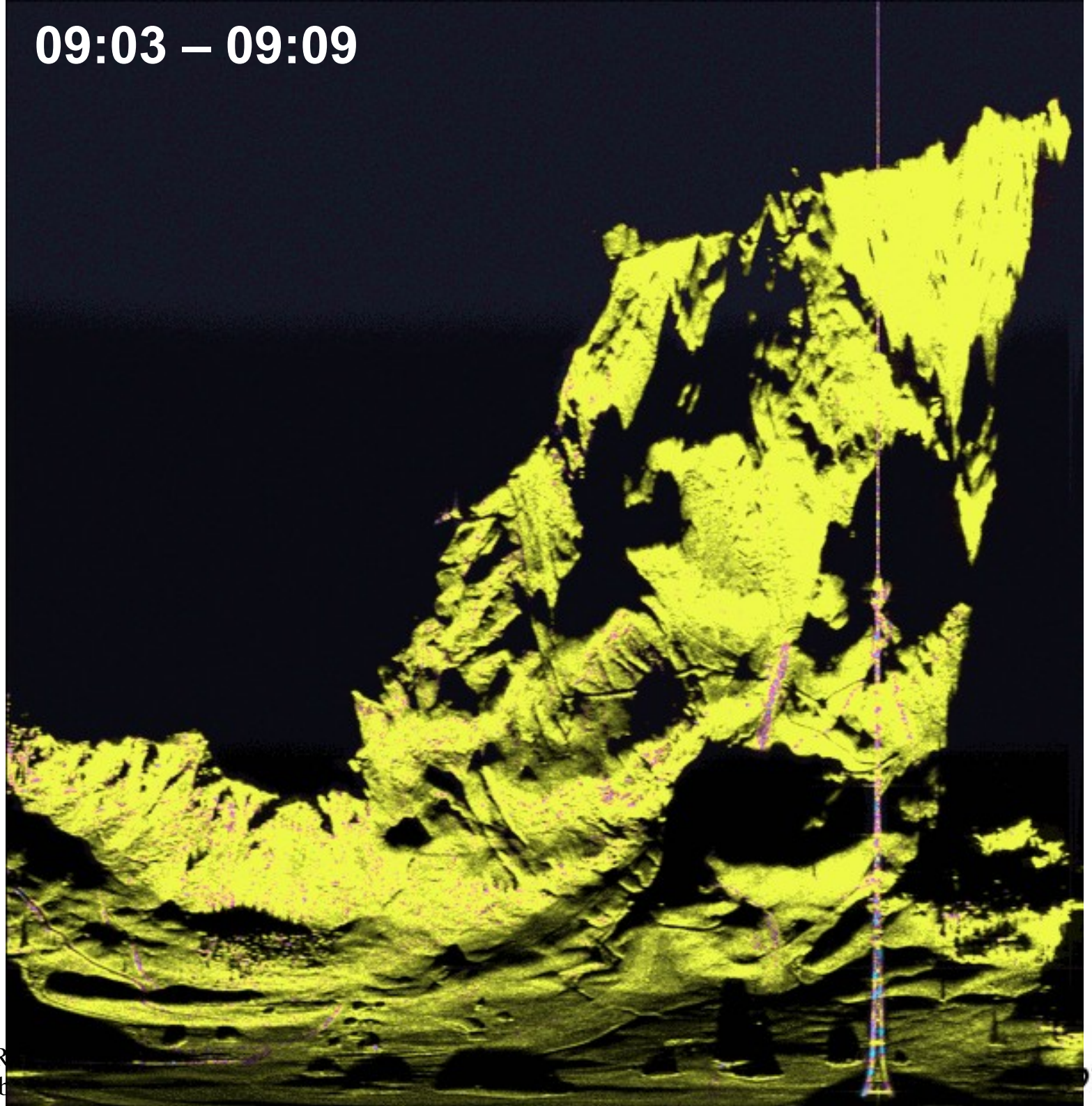
Backscatter Change Mägisalp 2013

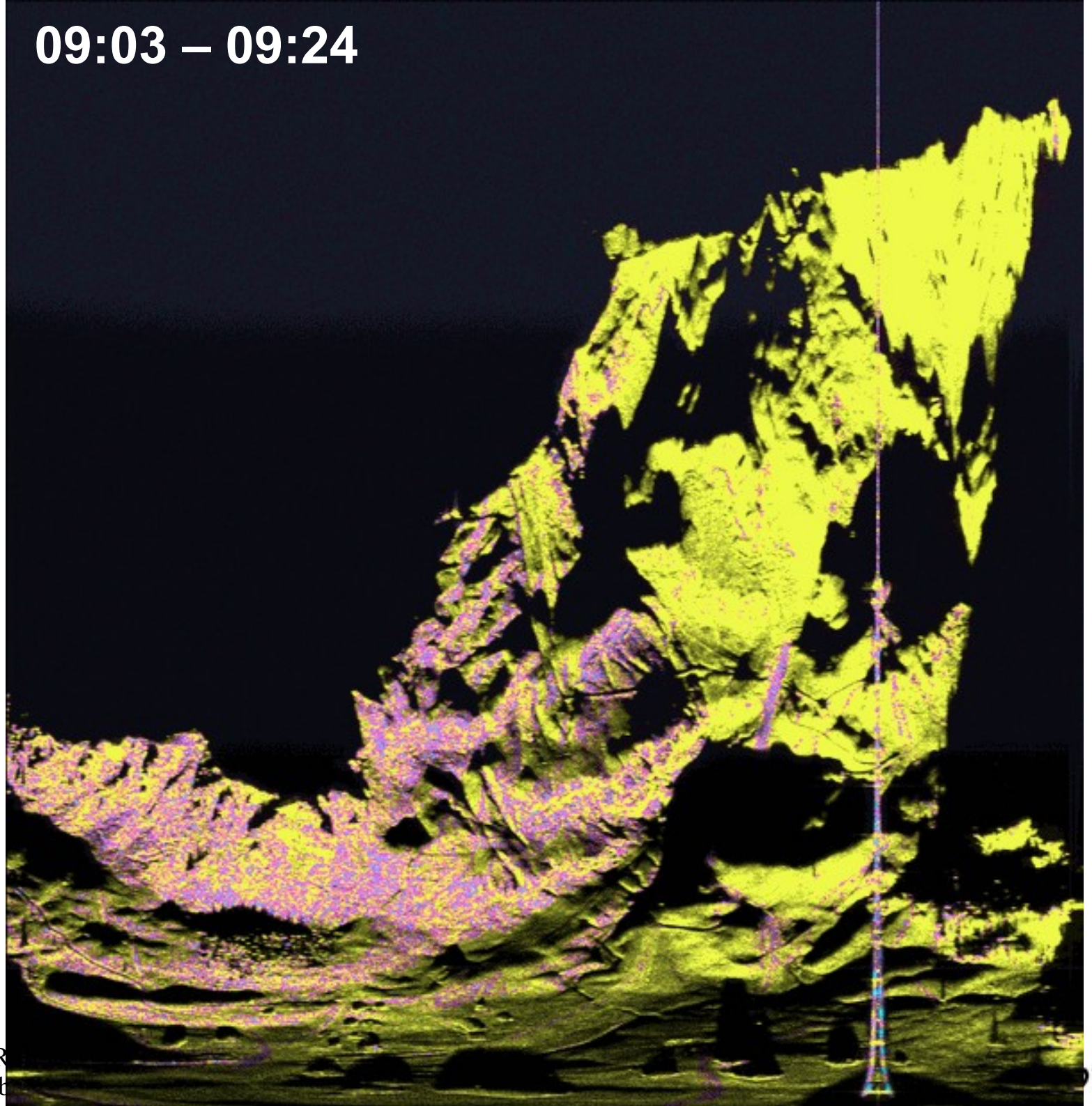


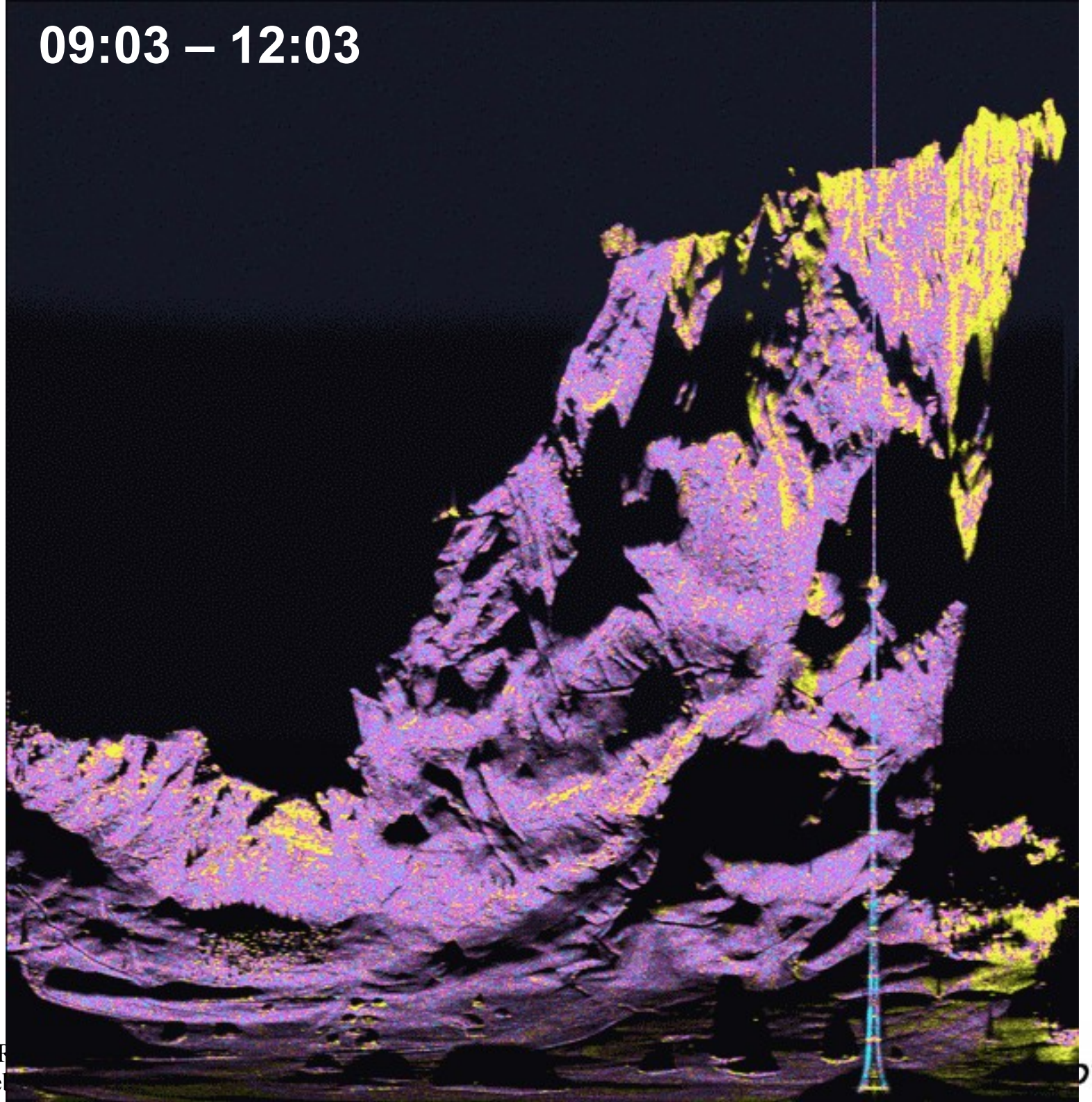




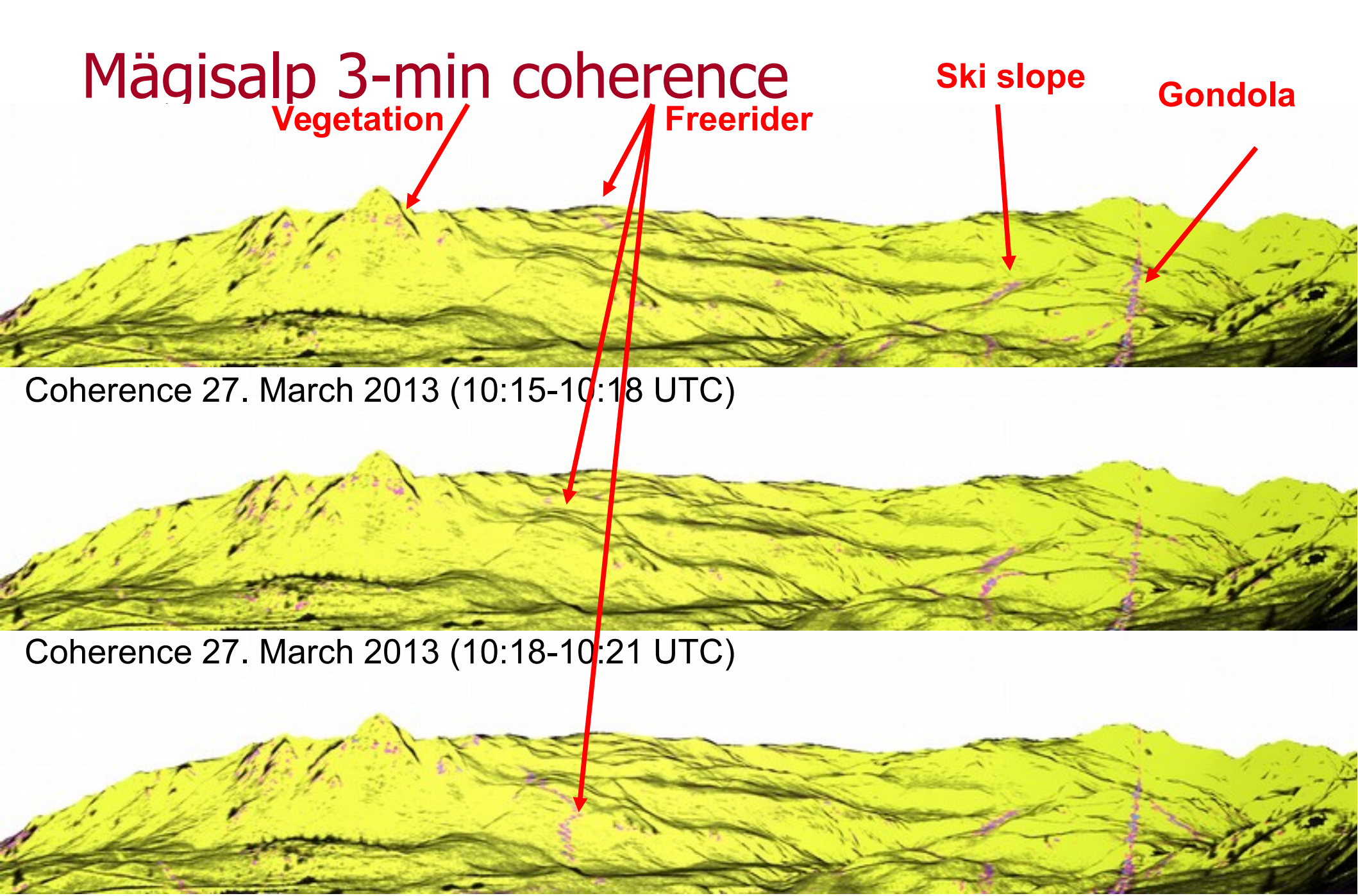



09:03 – 09:09


09:03 – 09:24


09:03 – 12:03

Mägisalp 3-min coherence

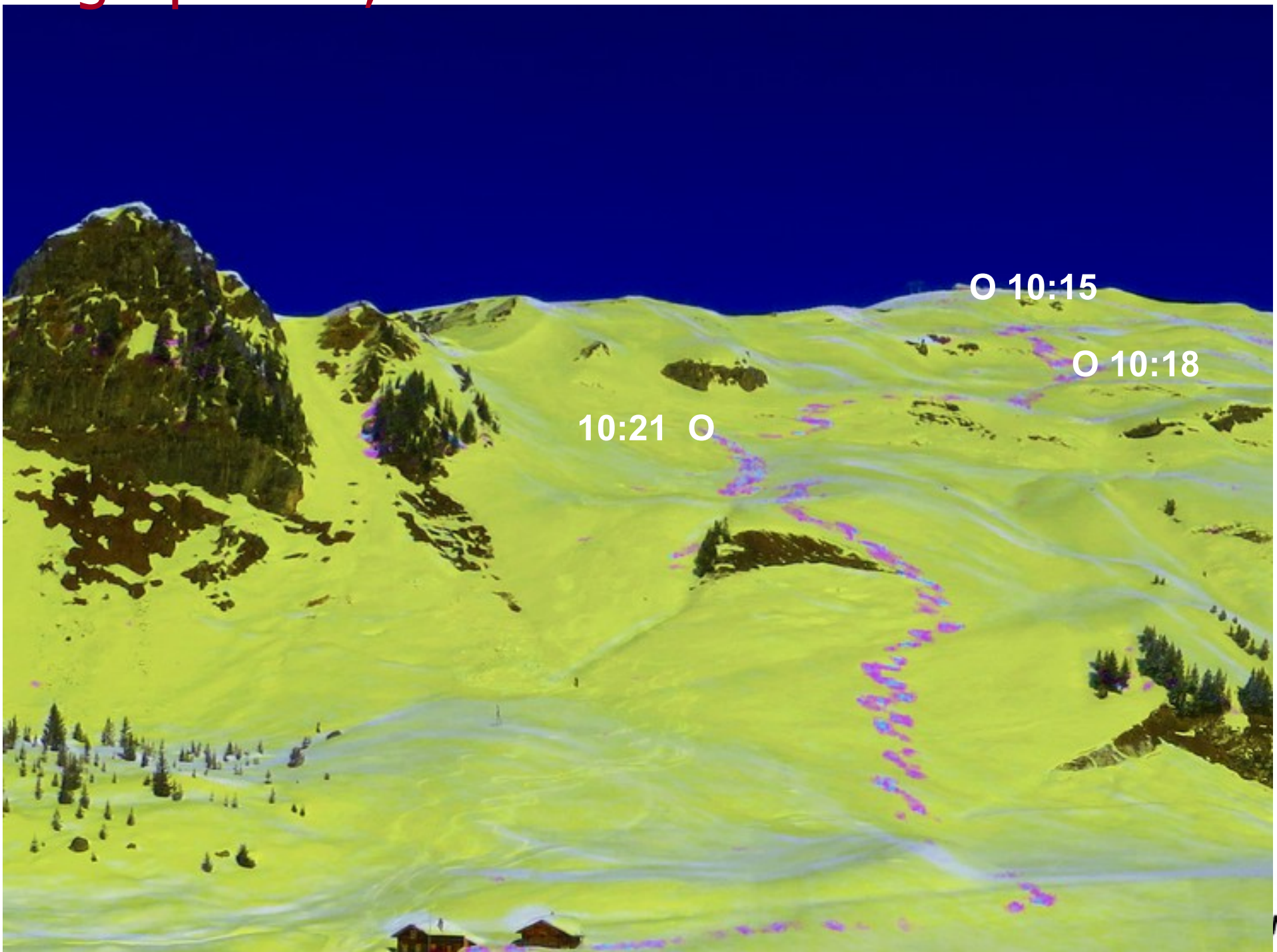


Coherence 27. March 2013 (10:15-10:18 UTC)

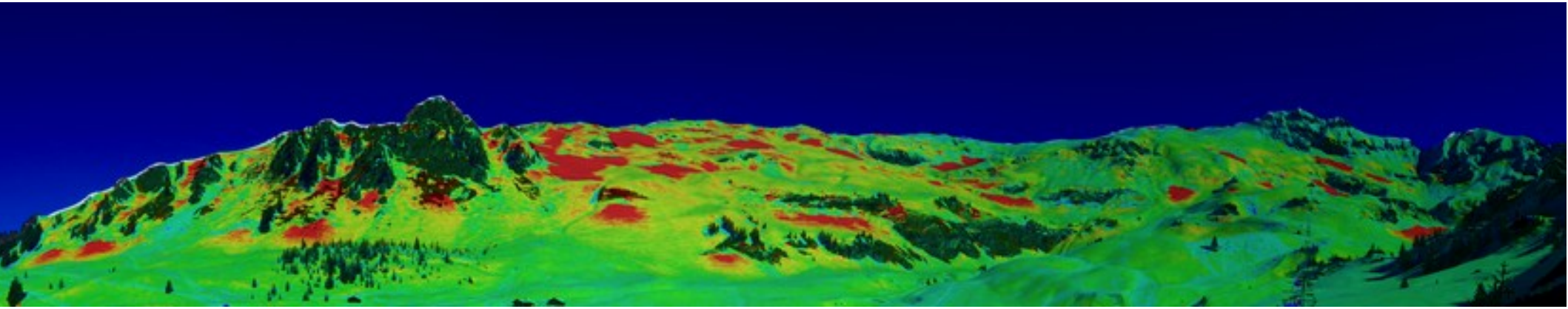
Coherence 27. March 2013 (10:18-10:21 UTC)

Coherence 27. March 2013 (10:21-10:24 UTC)

Mägislp 2013, 3-minute coherence



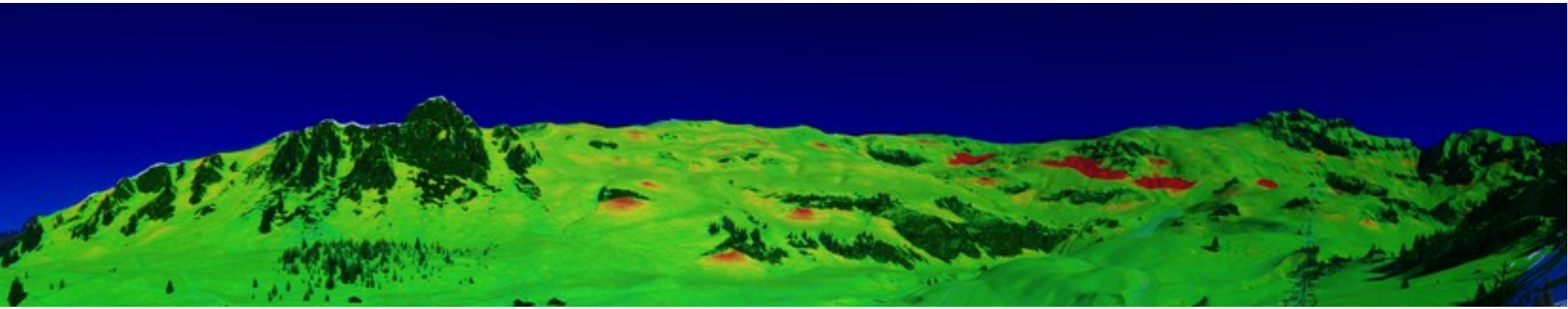
Displacement Mägisalp 2012/3



Displacement 7. March 2012 (Photo 27. March 2013)

LOS Displacement m/day

-0.16 0.00 0.16



Displacement 27. March 2013 (Photo 27. March 2013)

LOS Displacement m/day

-0.12 0.00 0.12

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Conclusions

- Terrestrial imaging radar has good potential for
  - Avalanche detection by exploring the interferometric coherence and backscatter information.
  - Freerider detection
  - Detection and quantification of snow creep

- For better backscatter "calibration" a calibration loop is needed.
- If the temporal resolution is high enough (e.g. 2-3 min repeat interval, depending on snow and weather conditions) unwrapping is straightforward
- Atmospheric correction is usually not necessary if the time series is long enough.
- Longer term campaign necessary to cover more snow conditions.
- Campaign started these days in Davos as part of the ESA IAP AAF project.