ESA SnowLab –
Microwave and Structural Measurements of Alpine Snow

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ESA ESTEC, Netherlands



8th EARSeL workshop on Land Ice and Snow
UniBe, Switzerland, 8.02.2017

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Aim of the project

The aim of the project is to provide a comprehensive

- multi-frequency
- multi-polarisation
- multi-temporal

dataset of active and passive microwave measurements over snow-covered grounds to investigate the relationship between effective snow- and ground parameters and the resultant signals detected by microwave radars and radiometers.

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Approach and expected Output

Combine a number of active and passive microwave instruments for the investigation of Alpine snow in Switzerland:

- SnowScat (ESA 9-18 GHz polarimetric, coherent scatterometer)
- ELBARA (L-Band Radiometer)
- GPS

Microstructural characterisation by repeated SnowMicroPen and selected micro-CT measurements.

Study objectives:

- Effects of snow accumulation (SWE) and temporal evolution of snow morphology on multi-frequency and polarimetric backscatter signatures
- Effect of environmental conditions
- Tomography
- Contribution of microwave observations to the description and understanding of the snow-ground compartment.

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Approach and expected Output cont.

- Database (microwave measurements and in-situ data)
- Reports
- Software Tools for tomography

Team / Roles

ESA SnowLab (GAMMA, SLF)

- Andreas Wiesmann Project Management WP0100
- Rafael Caduff Site Setup and Operations WP1000/WP2100
- Othmar Frey Data Processing and Tomo Tools WP3000
- Martin Schneebeli Snow Physics/Characterisation WP2200
- Matthias Jaggi Snow Characterisation
- Charles Werner Hardware/Contact workshops

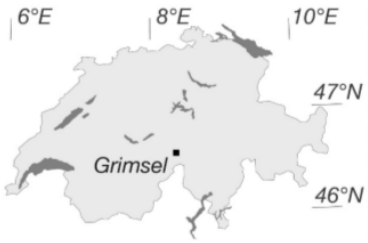
MicroVegSnow (SLF) **→ Th. 10:30 Schwank et al, MicroVegSnow Project**

- Mike Schwank WSL, PI
- Reza Naderpour WLS, PhD student

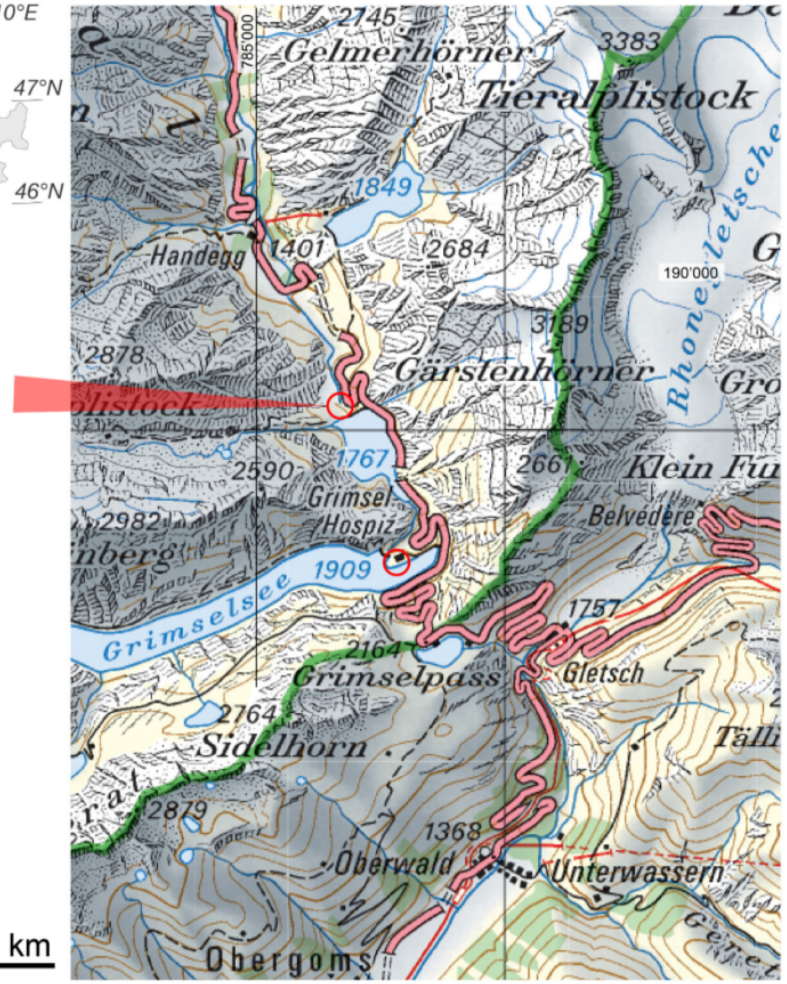
Others

- Prof. Alain Geiger / Ladina Steiner ETHZ, GNSS
- Yves Bühler SLF, Drone photogrammetry **→ Tu. 9:20**

Test Site 2016/16 Gerstenegg

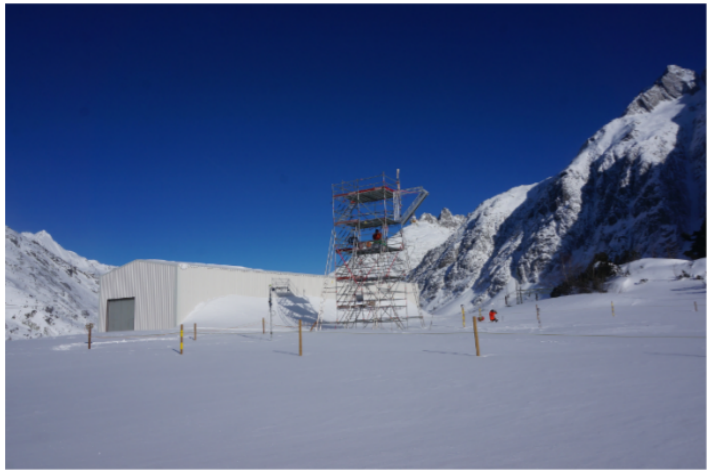


Gerstenegg
1706 m



topo-map: swisstopo (map.admin.ch)





8th EARSeL workshop on Land Ice and Snow
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Campaign 2015/16

- October 2015 – Mai 2016
- On-Site instrumentation:
  - *SnowScat Tomo Mode*
  - *Automatic Weather Station*
  - *5 Surveilance cameras*
  - *GNSS*
- **Main Objective: Snow Tomography**
- Validation Campaigns
  - *Snow μ-Pen (6x)*
  - *Snow Pit Profiles (5x)*
  - *Micro CT-Sample (1x)*
  - *Snow Water Equivalent SWE (3x)*

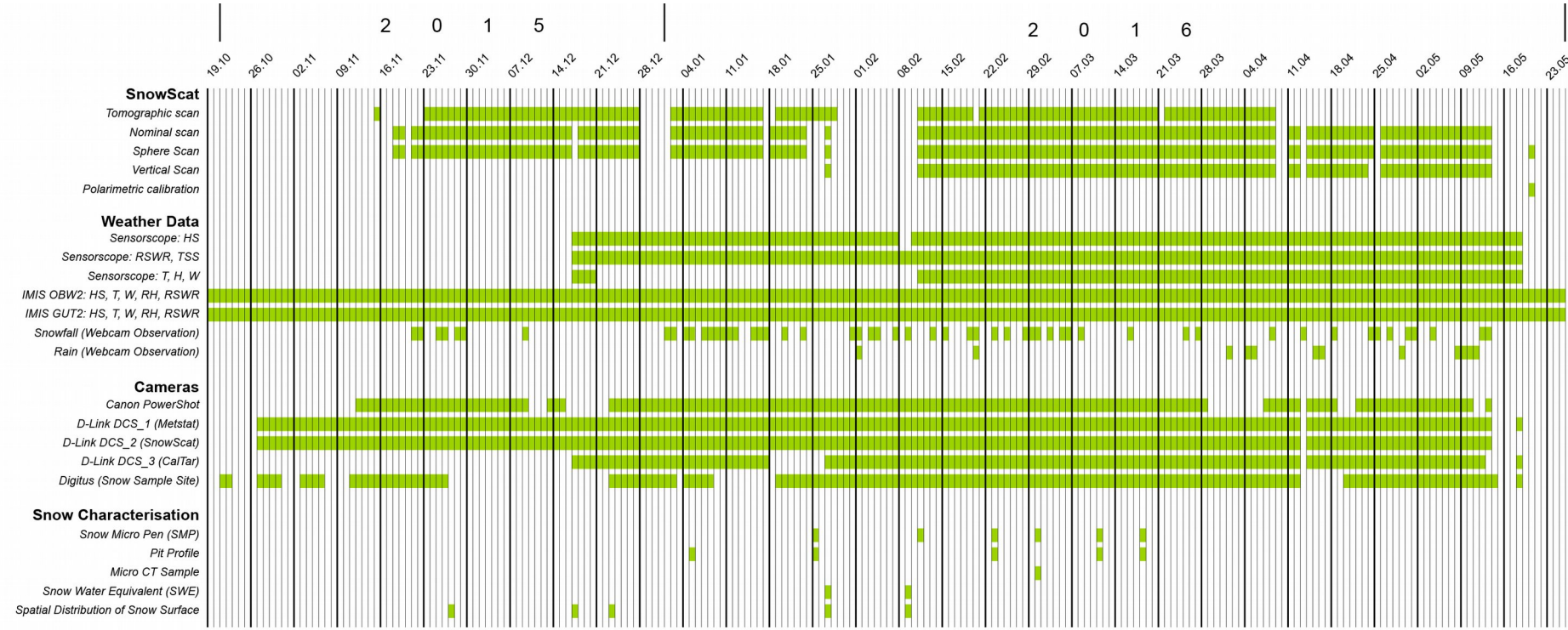




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Data Availability and Incidences 2015/2016

Data Acquisition



Events

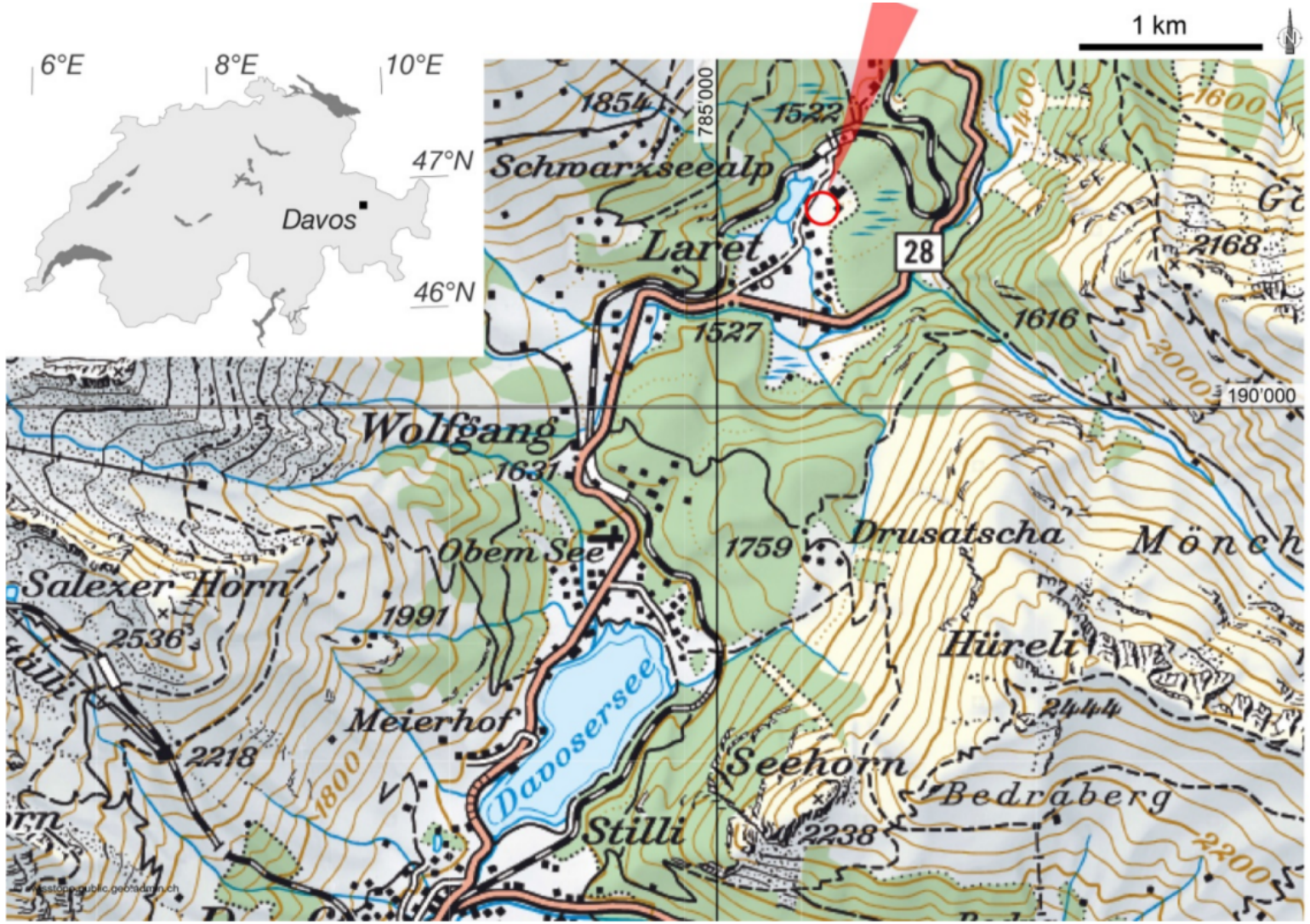
- Installation Scaffolding
- Installation Tomo-Motor
- Installation Network
- Installation SnowScat
- Snow on Test Site
- Digitus Camera Power Supply Failure
- Wireless Communication Failure to Canon Camera
- SnowScat Quickset Anomaly
- Installation Meteo Station
- Installation GNSS
- Installation of D-Link DSC_3
- Canon Camera forgot to Power up
- Power Supply of Digitus Replaced
- Rotation of Wind Sensor Pointing to North (previously 310°)
- Flattening of the Snow Surface underneath SR50a: Leveling to surrounding snow cover
- SnowScat Quickset Failure
- QickSet Replacement
- New NTS-Server for Digitus
- D-Link DSC_3 Wireless Communication Failure
- QuickSet Replacement
- Exchange of SR50a and Metal Branch
- Installation of Solar Shield for SR50a Temperature Sensor
- D-Link DSC_3 was moved away from Digitus
- SnowScat Motherboard Failure
- SnowScat Repaired
- Sensorscope Module 1283 was replaced with new module (1288)
- SnowScat Tomo-Motor Failure
- Power Failure
- Synology NAS Power Supply Failure



Lessons Learned from 2015/16 Campaign

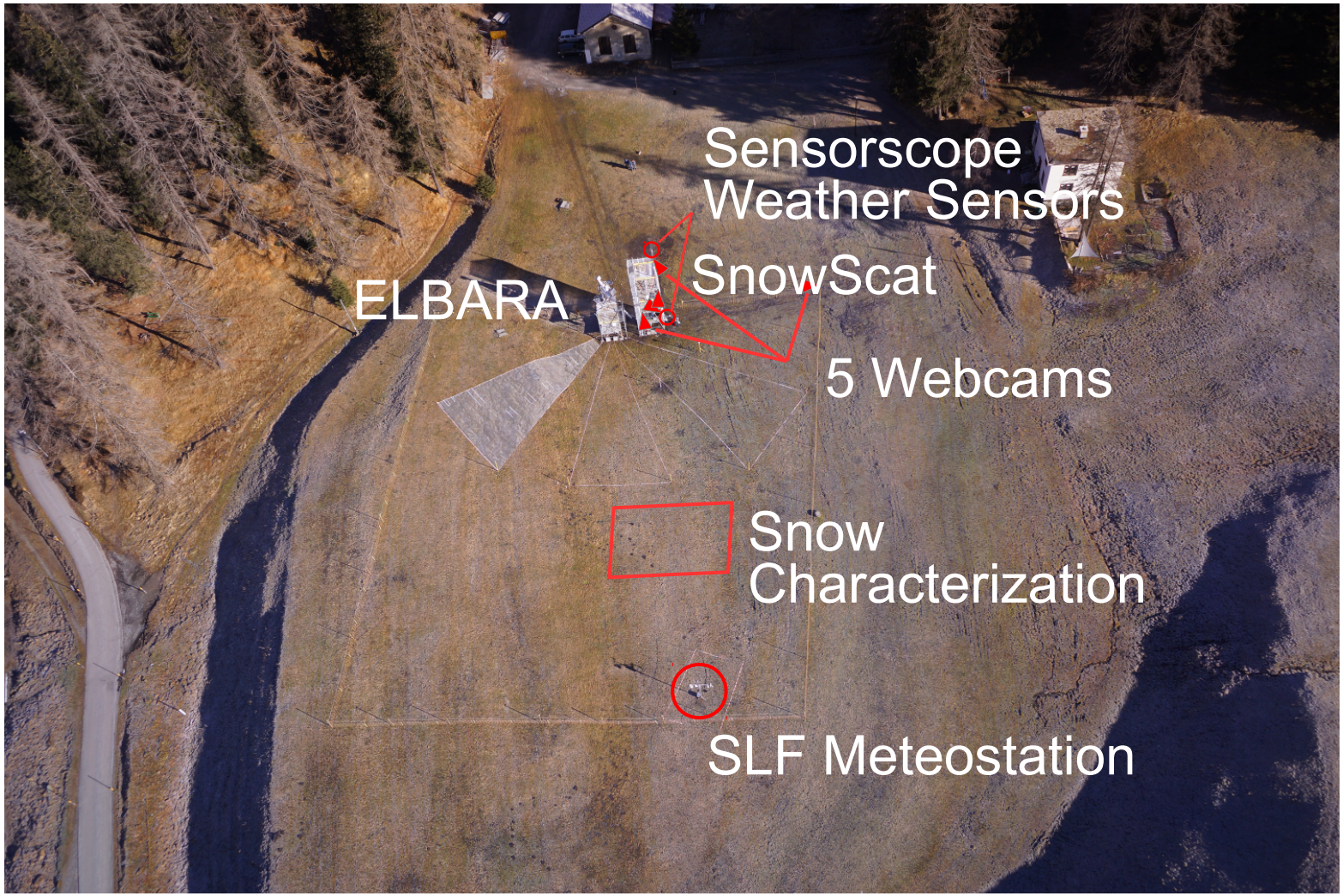
- Keep **spare parts** for critical systems ready or use off the shelf components (Quick-Set; SnowScat parts; Communication modules; Cameras etc.)
- **Automated system-checks** with automated push-notification (e.g. e-mail, SMS) should be improved to minimise reaction-times during system failures.
- Immediate and **automated processing of reference sphere plots and tomo plots** give immediate information on the quality of the measurements. Processing and data-distribution of the results must be implemented in the campaign plan.
- The sampling strategy of the **snow-characterisation** and validation measurements (SMP, profiling) should preferably have **better temporal resolution**.
- In general **weather-proofing of the installations have to be improved.** Weaknesses in the weather-proofing were discovered in the Winter 2015/16 campaign.

esa:SnowLab Site: Davos Laret 1514 m ü.M.



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Test Site Laret, Instrument Setup (November 2016)



UAV-Image / Y. Bühler & M. Jaggi

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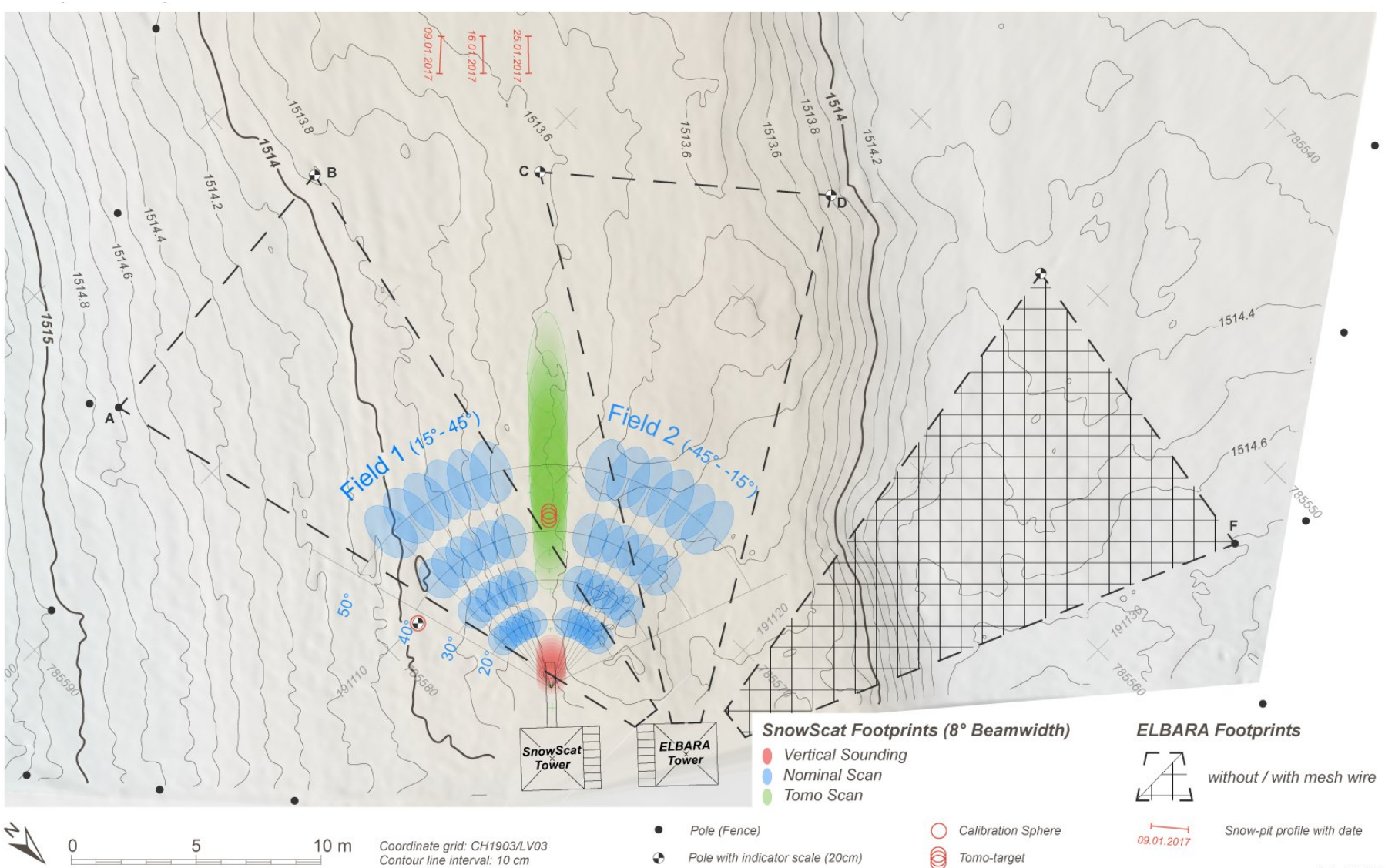
Laret 2017





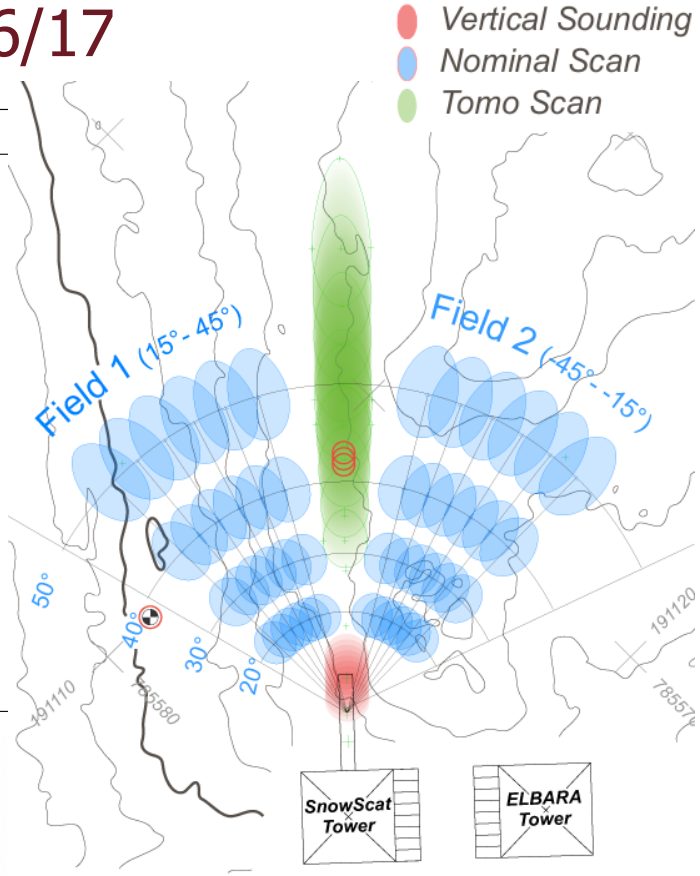
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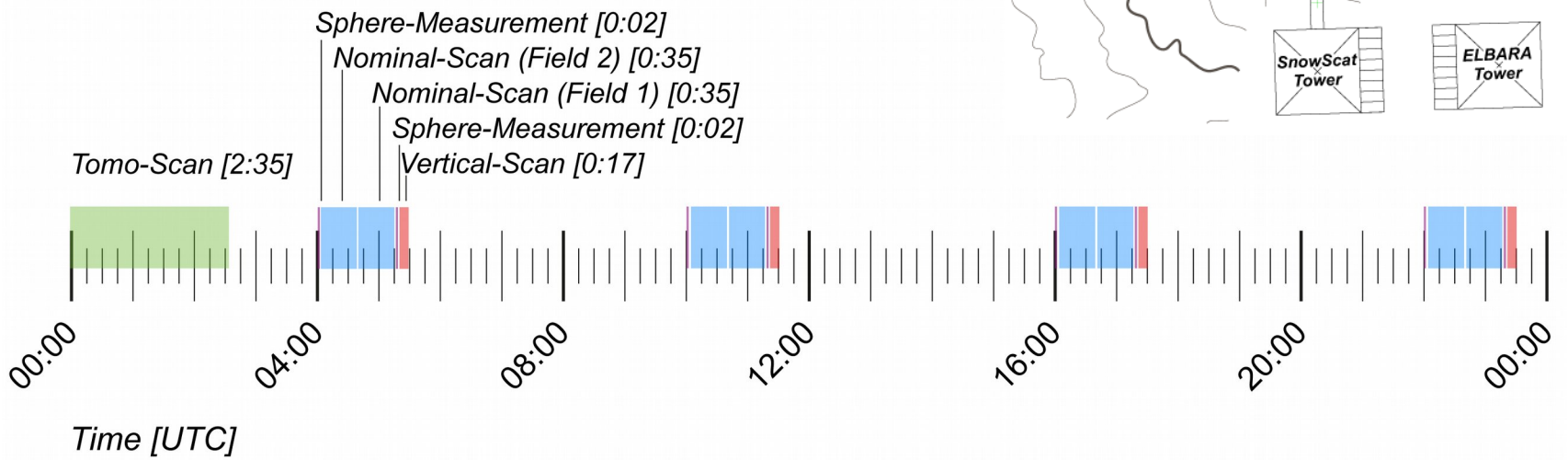
Detail Map of Instrument Footprints



SnowScat Data Acquisition Plan 2016/17

Measurement	*Schedule*	*Remarks*
Nominal Scan	4 – 6 times a day	Rail position 100 cm Reference Target Azimuth (-45 to +45, inc 5 deg) Elevation (30 to 50, inc 10 deg) Reference Target Backup to NAS
Tomographic Scan	Daily	Rail 0 to 196 cm Azimuth 0 deg Elevation 45 deg Backup to NAS
Vertical Scan	Daily	Rail 220 cm Azimuth 0 deg Elevation -2 to 2, inc 2 deg Backup to NAS



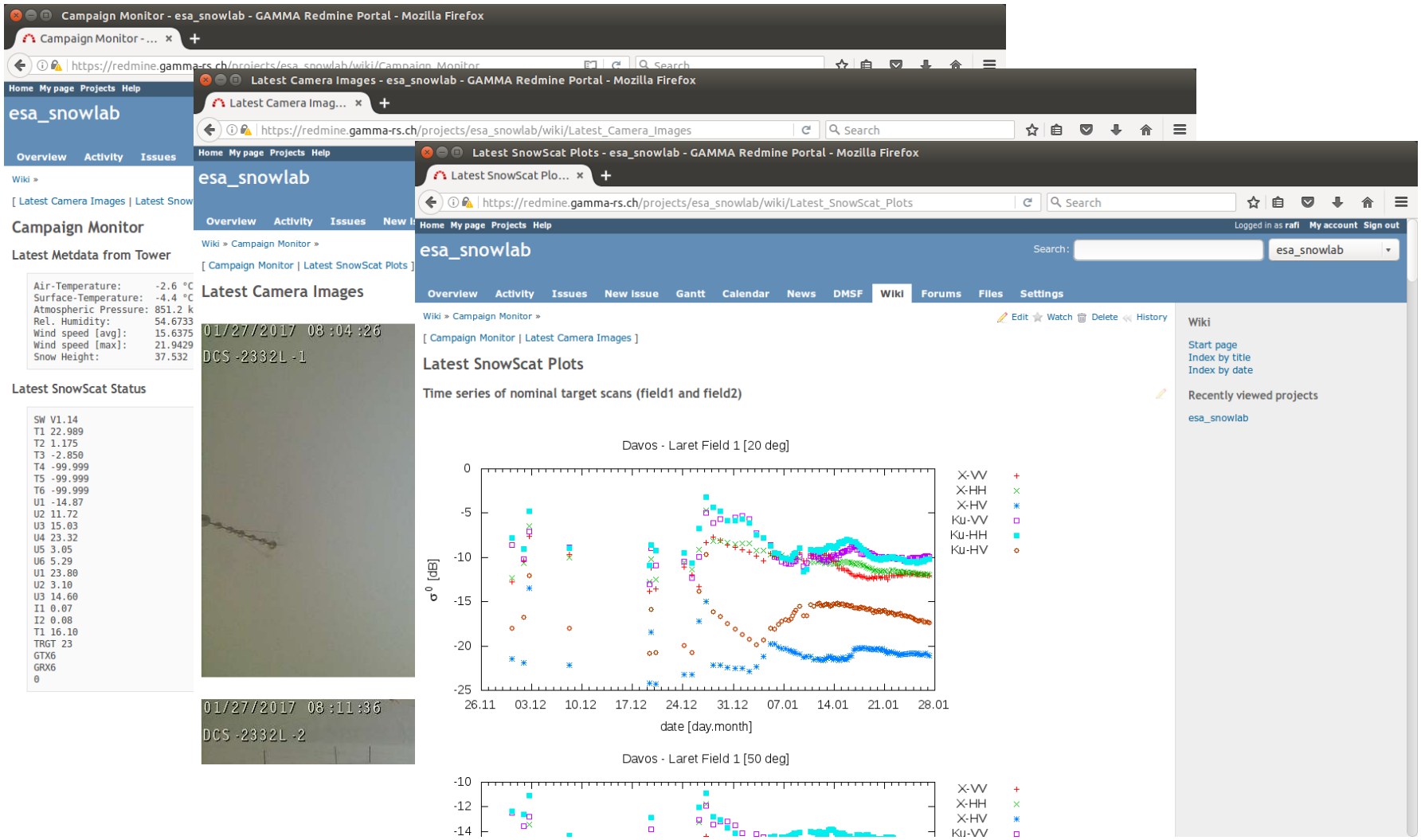


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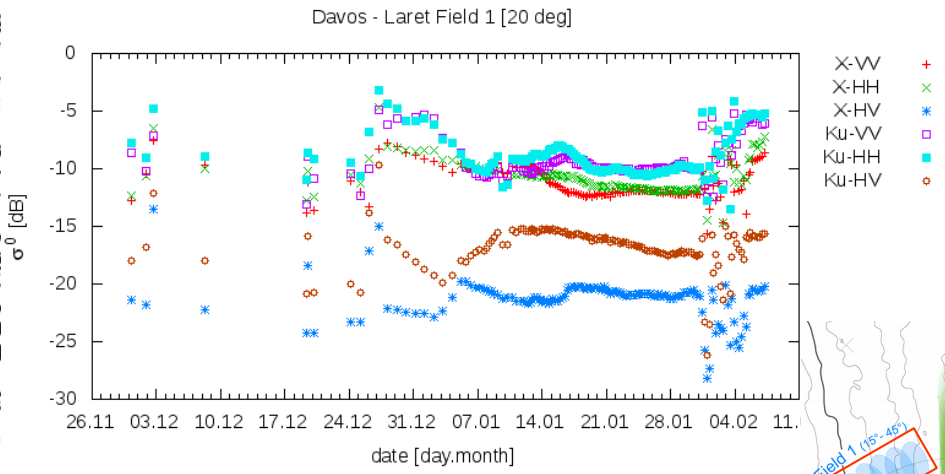
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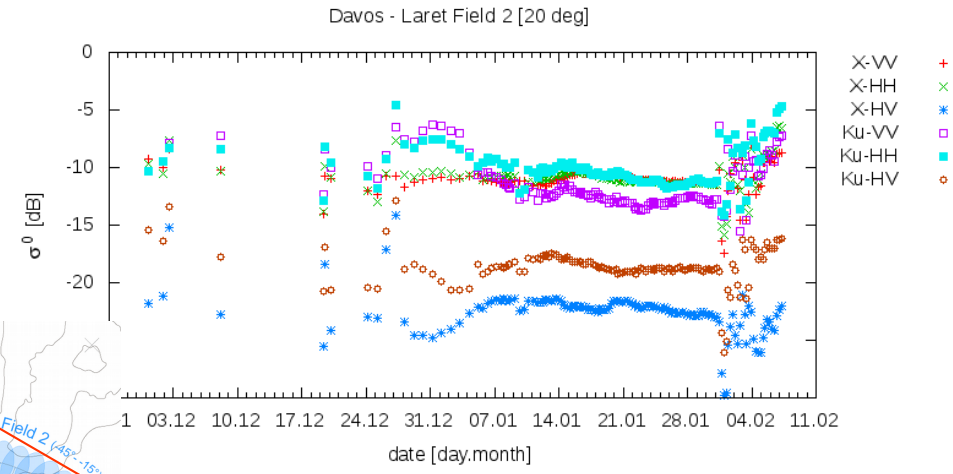
Campaign Monitor – Gamma Redmine Portal

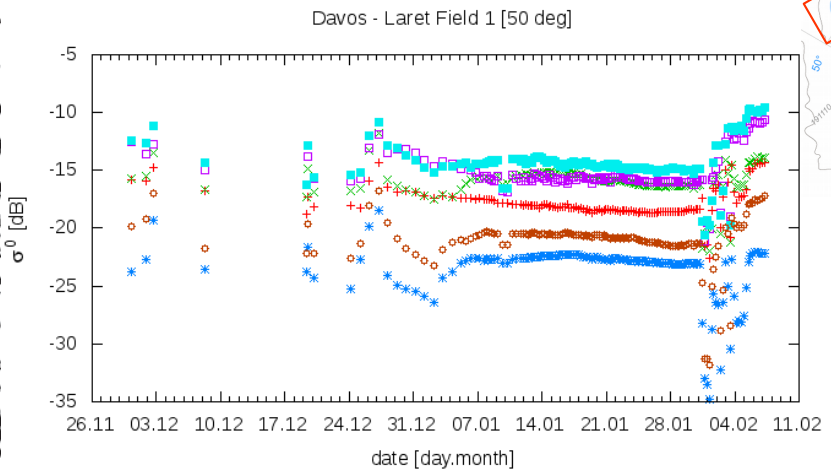


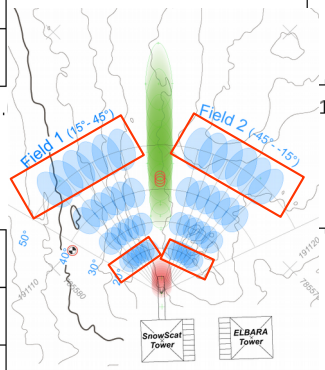
Campaign Monitor – Nominal Plots

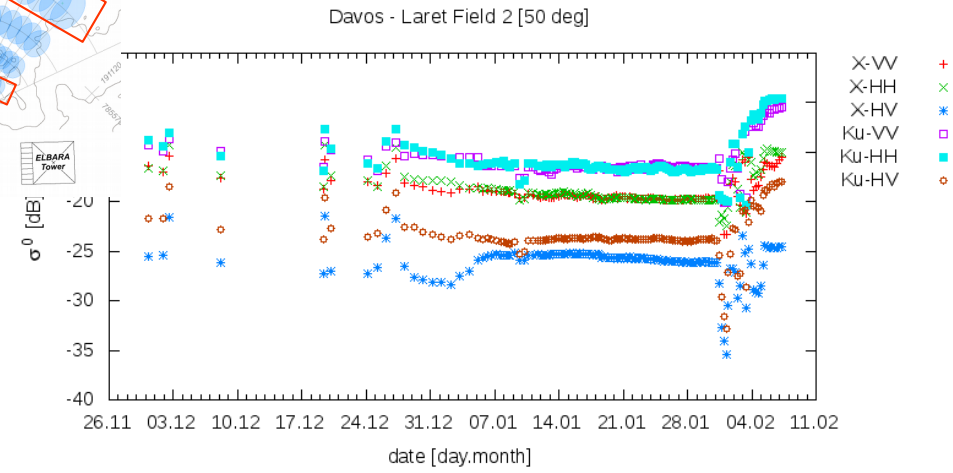
Nominal Plots







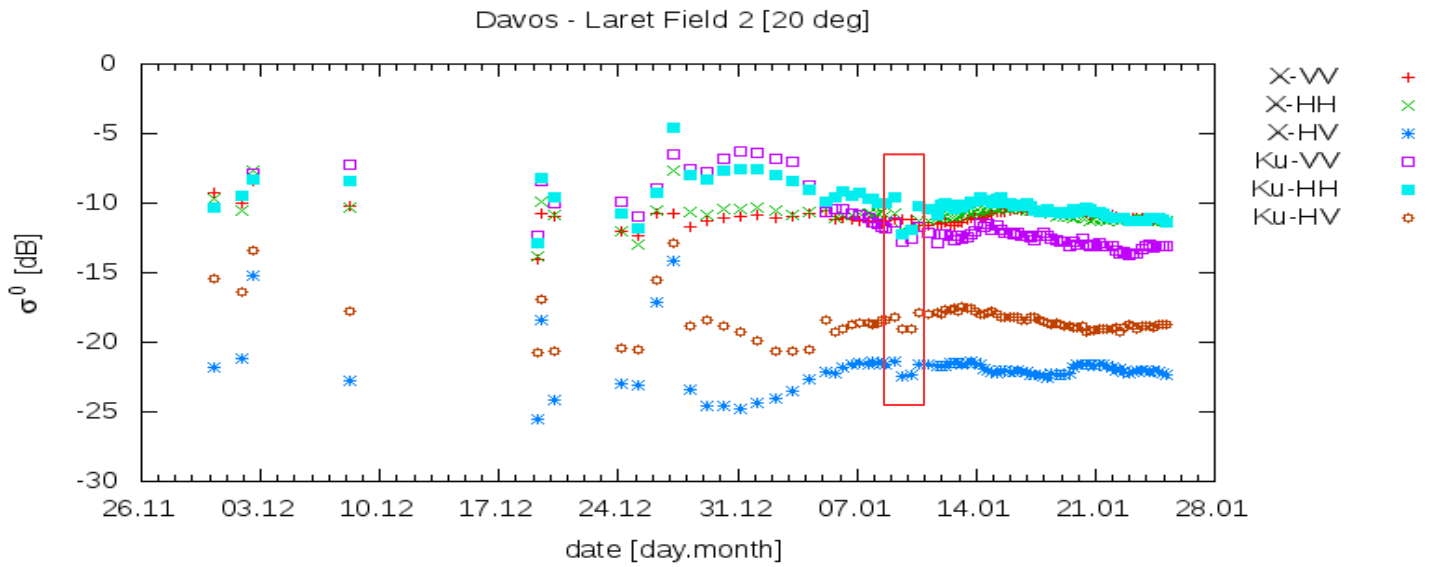




Campaign Monitor – Nominal Plots

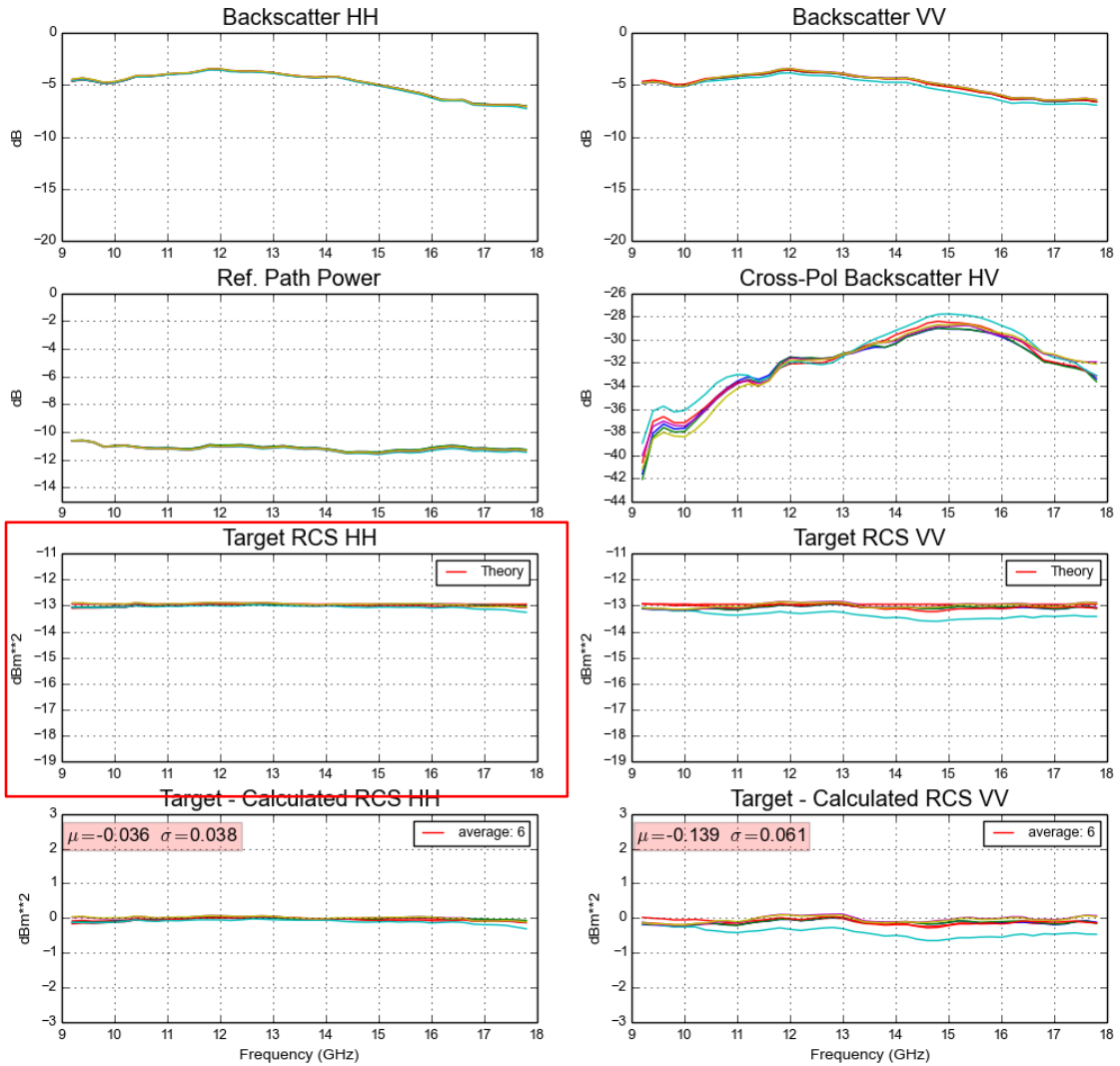






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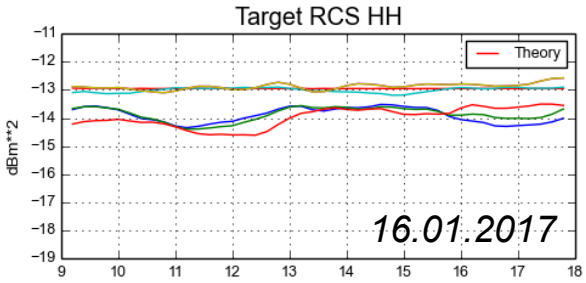
Campaign Monitor – Calibration Sphere Plots

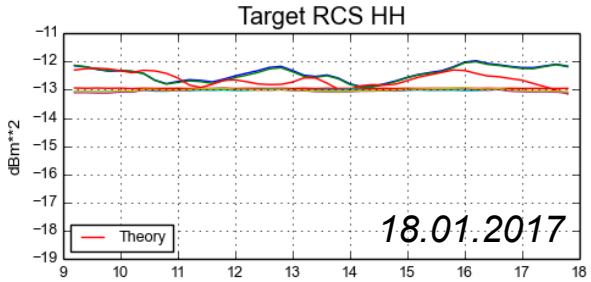


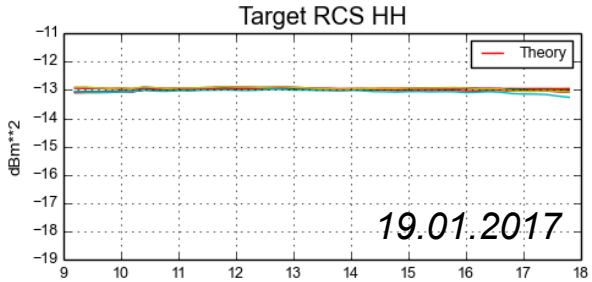
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Campaign Monitor – Calibration Sphere Plots





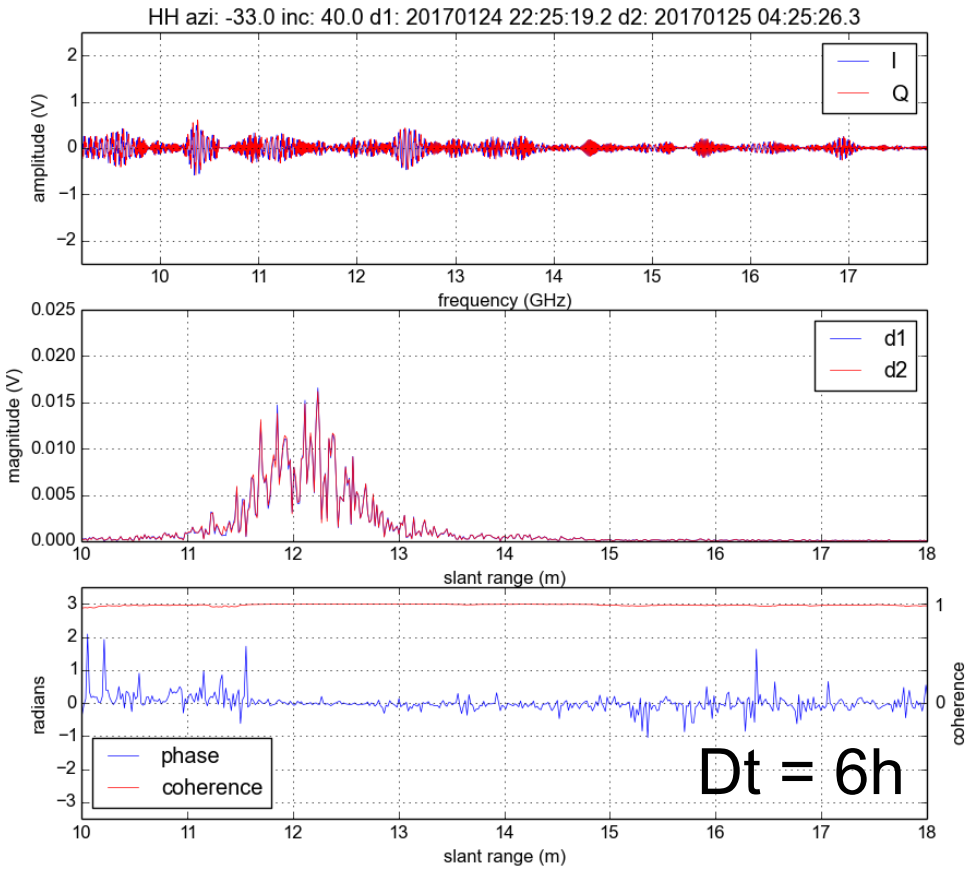


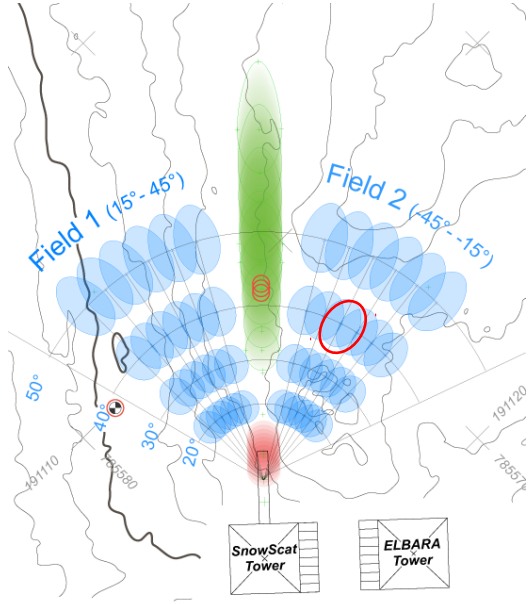




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Campaign Monitor – Coherence Plots

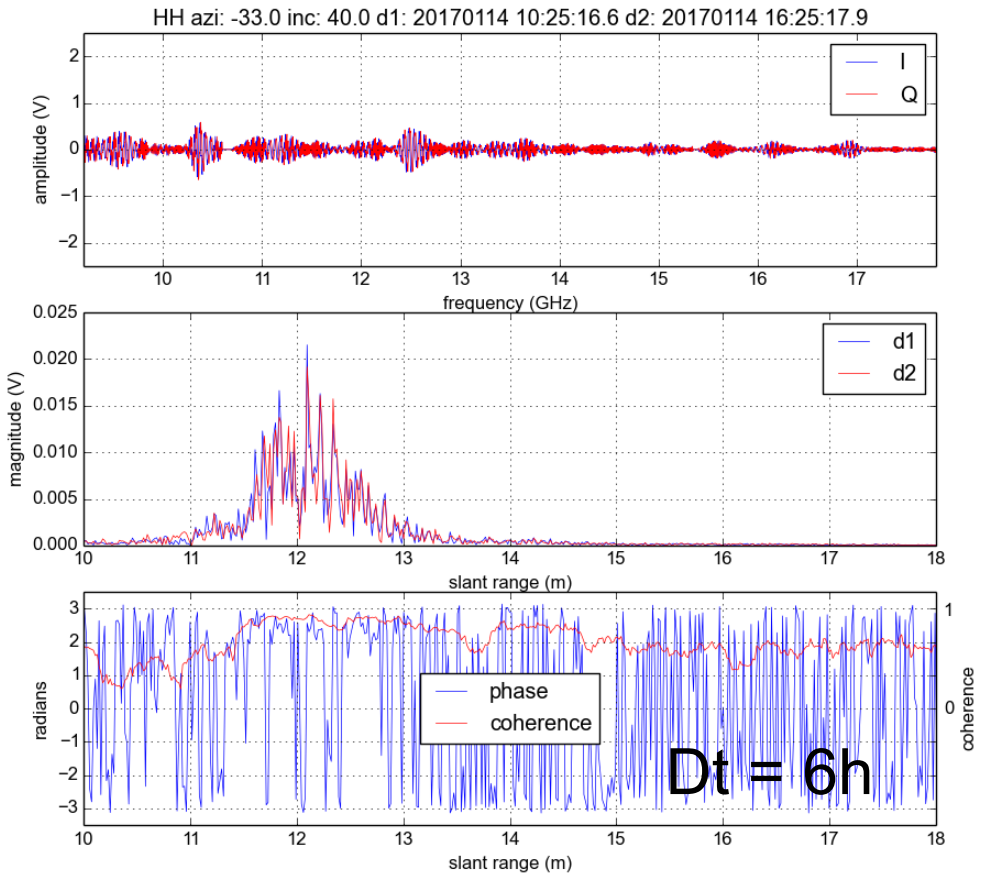


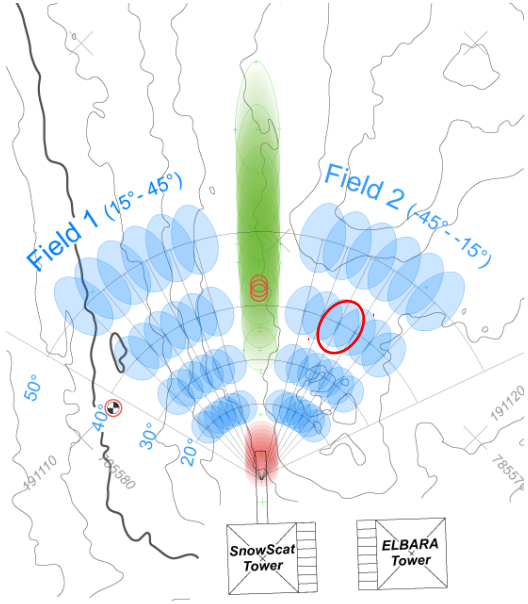




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Campaign Monitor – Coherence Plots



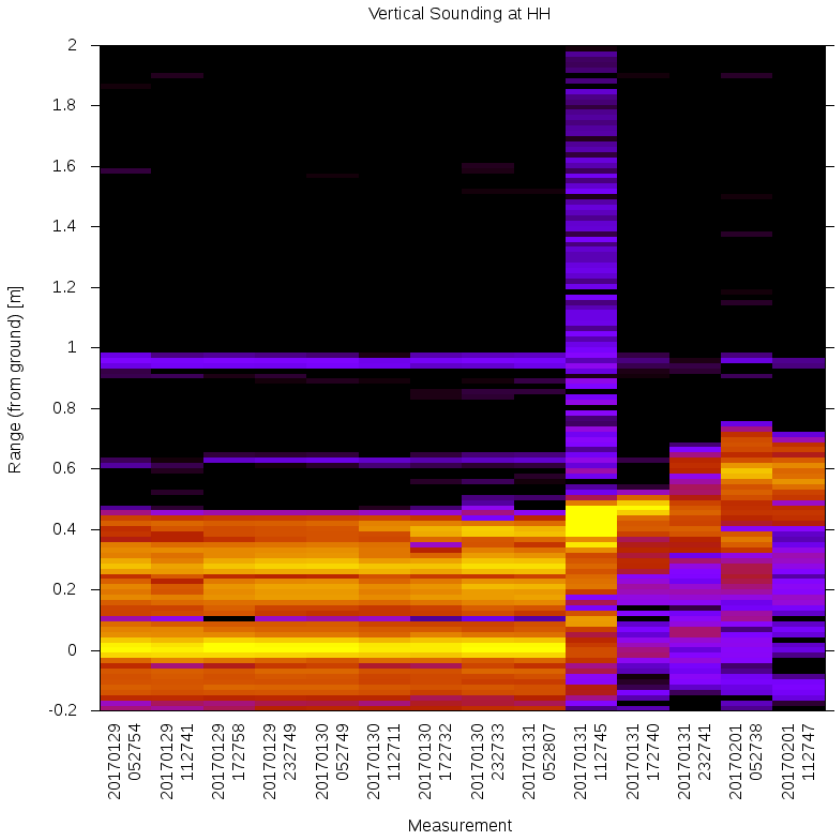


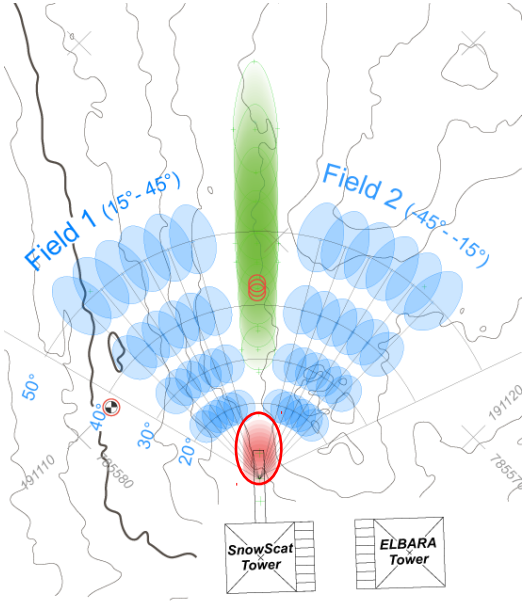


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Campaign Monitor – Vertical Plots

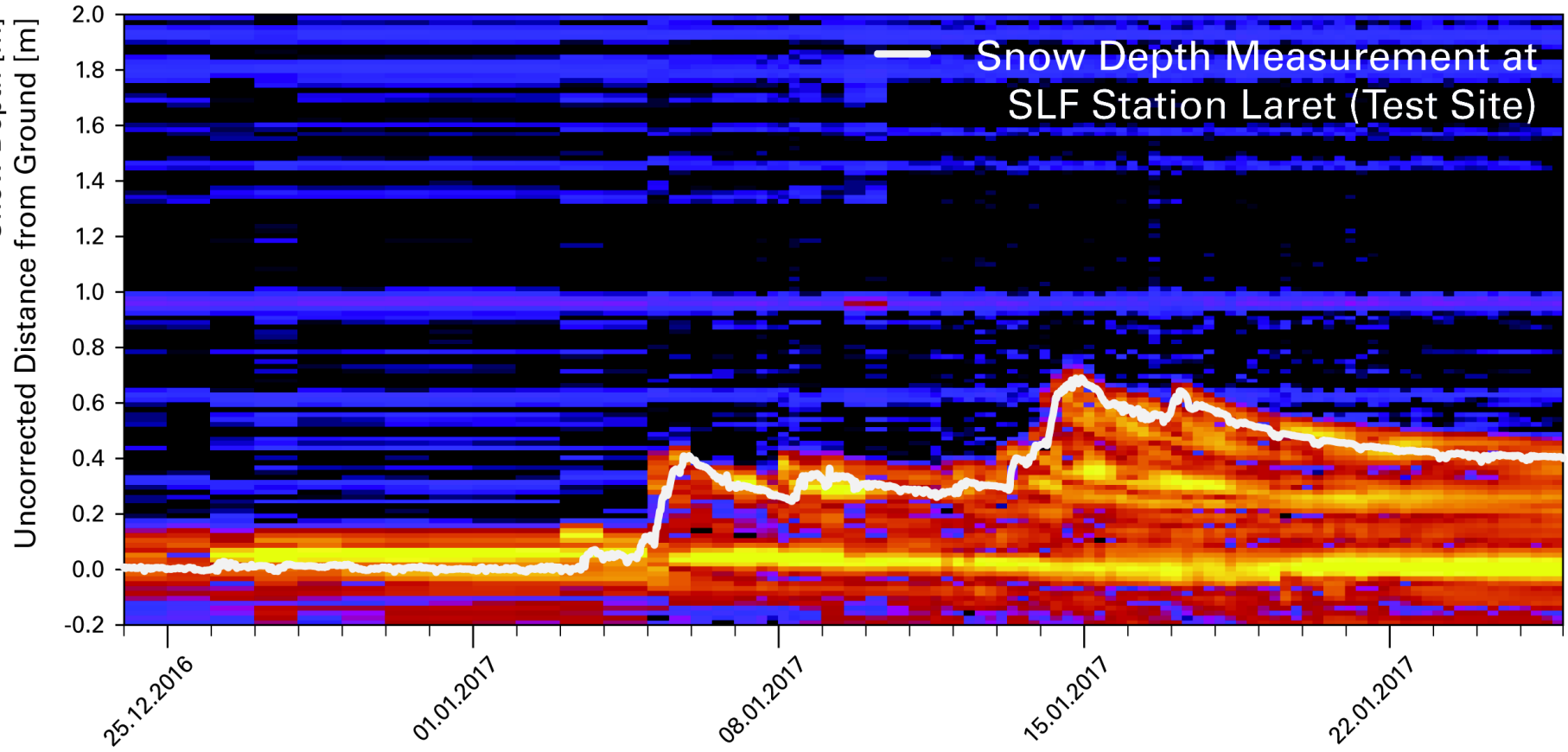
Last 14 Measurements







Campaign Monitor – Vertical Plots

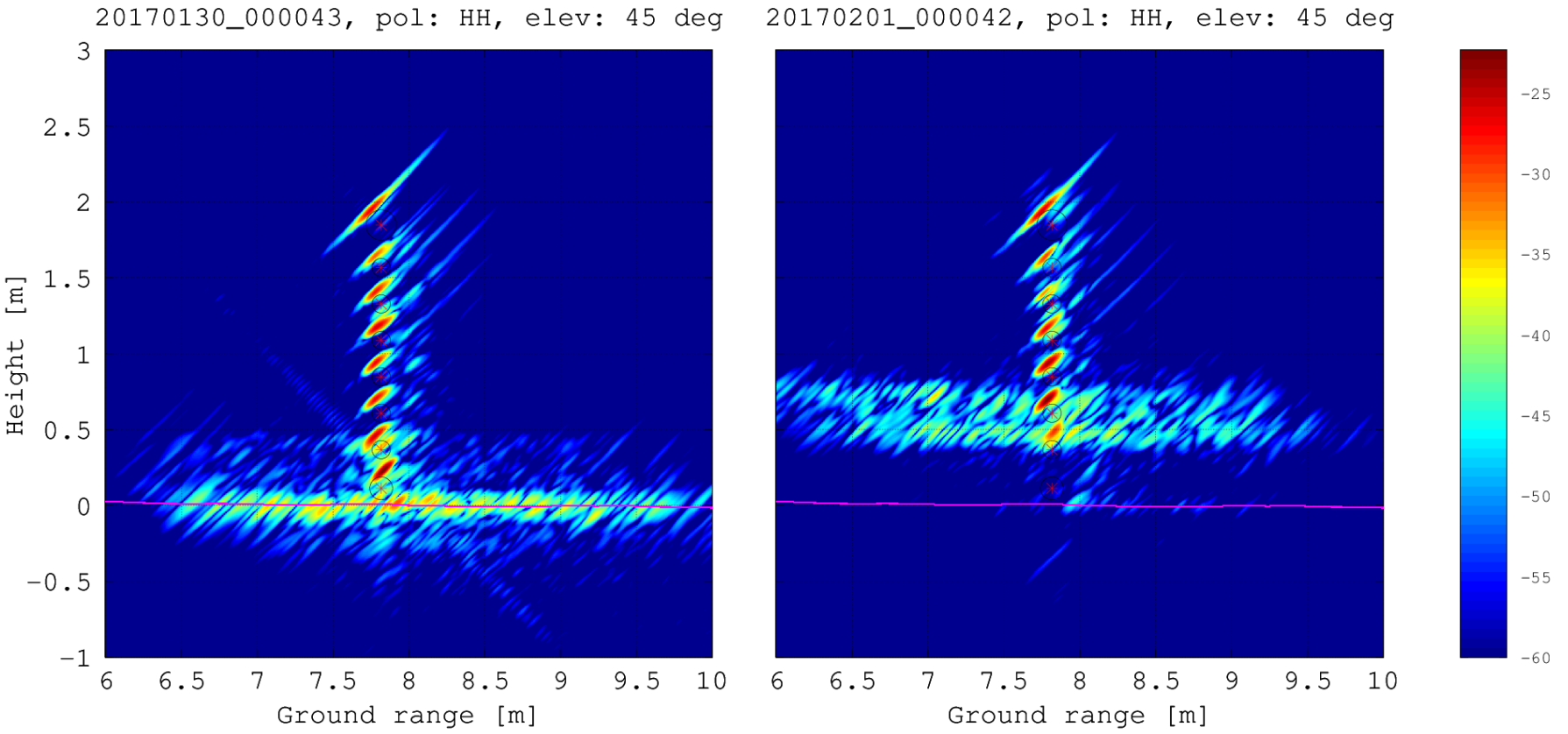


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Campaign Monitor – Tomo Plots



→ Th. 11:30 Frey et al, SnowScats Snow Profiling Mode



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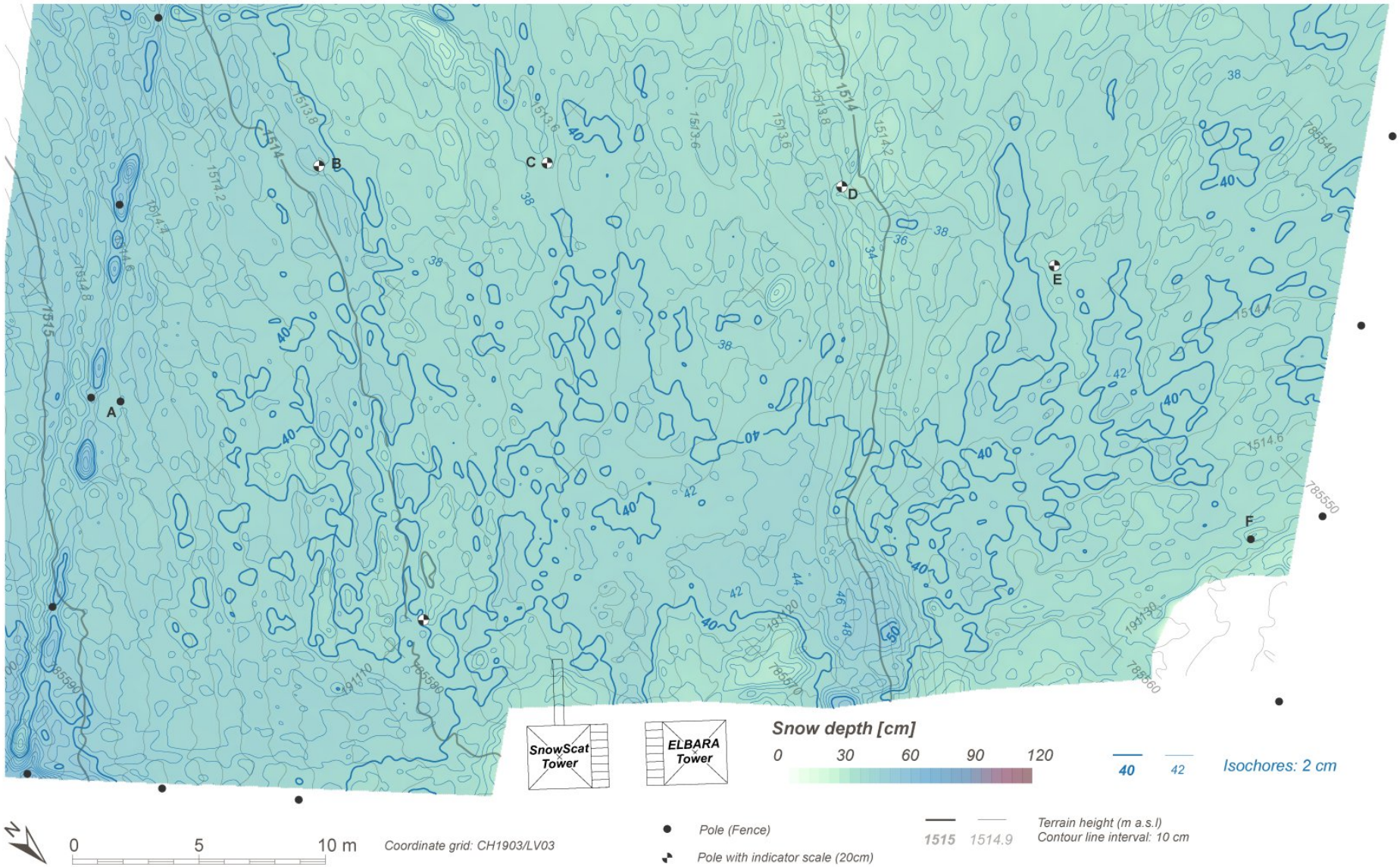
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Auxiliary Data Acquisition Plan 2016/17

Measurement	*Schedule*	*Remarks*
Image Documentation	10 min	Multiple cameras (>4) Check Status of installations Check Status of Snow Cover Track and document events (Dune Formation, Rain, partial snow-melt to ground etc.
Meteorological Data:	1 – 10 min (local) 30 min (regional)	In-Situ Data (SnowHeight, TA, TSS, RH, VP, BP, Vwind, Dwind, if possible precipitation) Regional Data (IMIS and OBS) Stations Nearby
Snow Characterisation Data	1 SMP/Week 0.5-1 pit profiles/week 1-2 microCT Scans/campaign	upgrade to 2 SMP/Week if Necessary Pit Profiles with SWE determination CT Scans of Snow Samples: timing, according snow situation Additionally: Spatial snow depth map from "Structure From Motion" (if possible 1 surface elevation model before and 1 after a snow-fall event) → Possible, if automatic acquisition is feasible. Important for the documentation of the Spatial Distribution of the snow depth and the surface roughness of the snow surface.

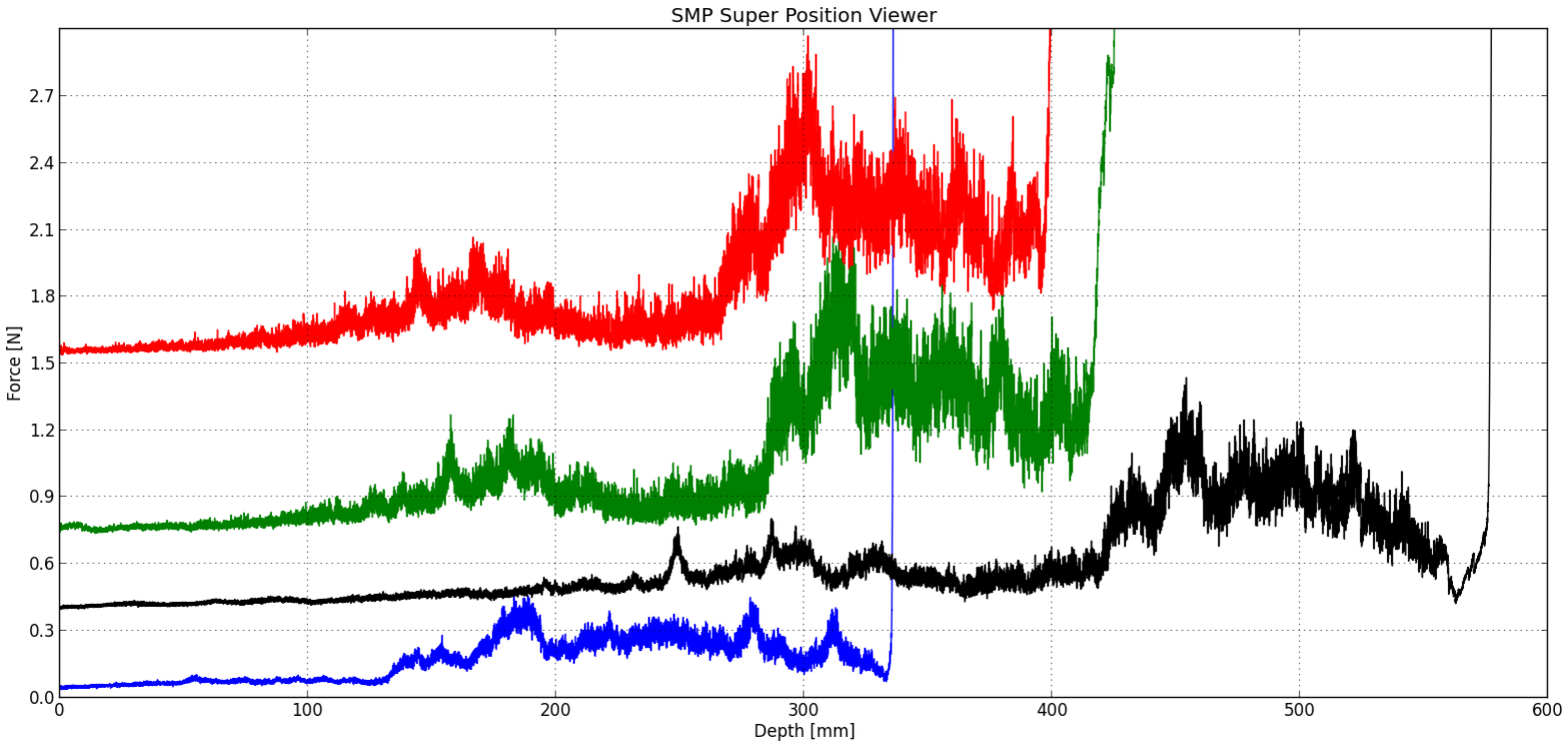
Auxiliary Data – Snow Depth Maps

Snow Depth Map 25.01.2017 *(Terrestrial Structure from Motion)*



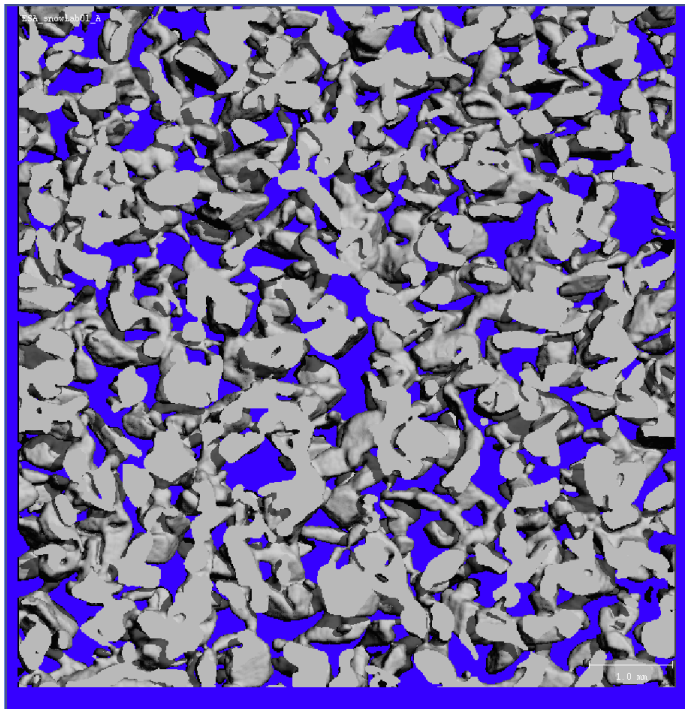
Auxiliary Data – Snow Micro Pen

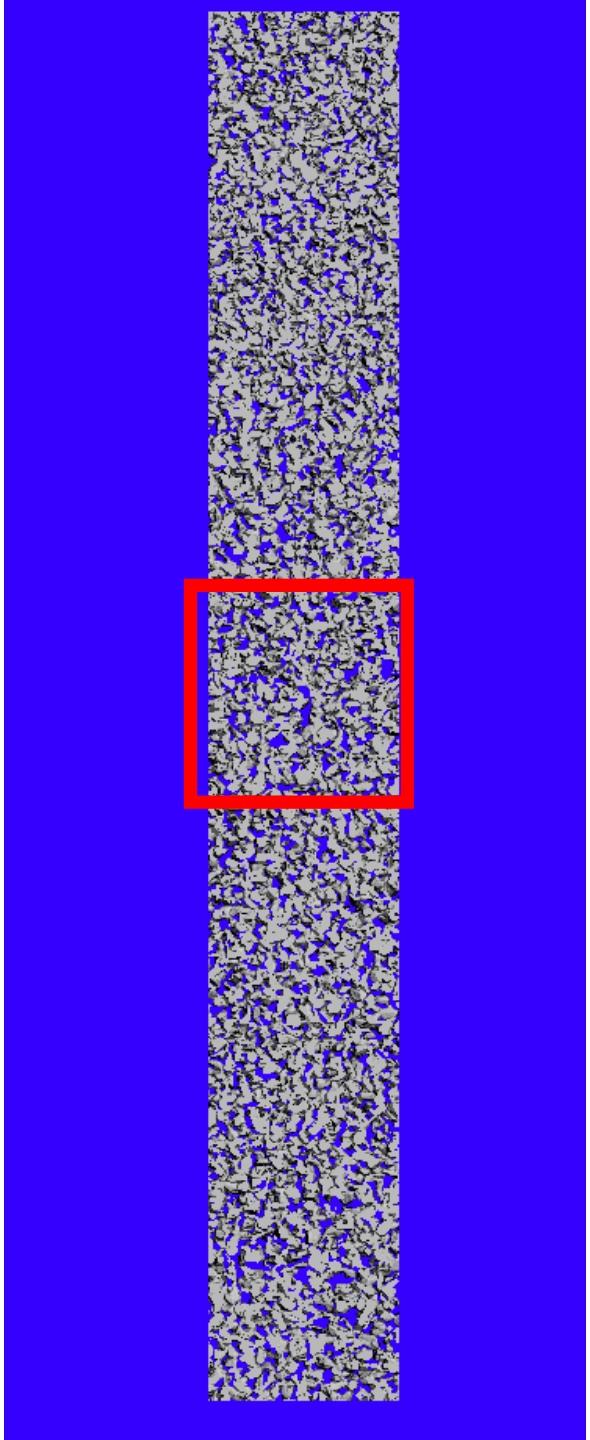
- 4 profile measurements till now



Auxiliary Data – Micro CT

- sample scanning in progress (7 samples x 4500 slices)
- 20 µm effective resolution
- 9 mm x 9 mm cross-section
- full profile depth

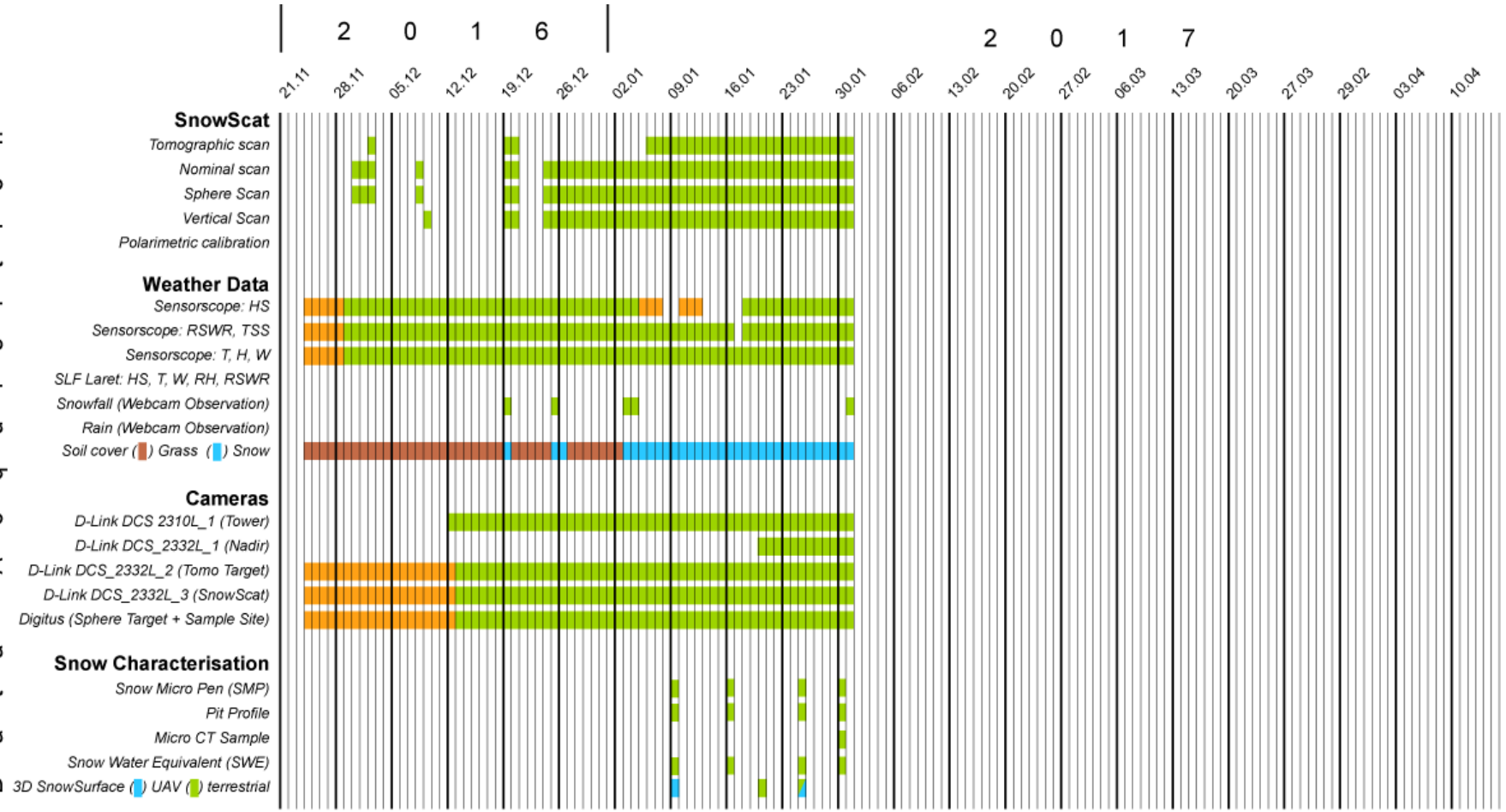




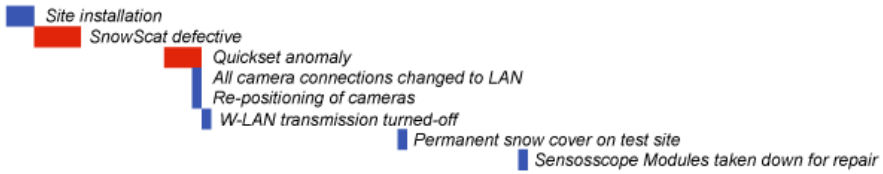
Summary – Data Acquisition



Data Acquisition



Events





Summary

- Data acquisition is on track
- All system elements perform very well
- System test at -20°C performed
- Snow in test-field since 2.1.2017
- Maximum snow-depth: 70 cm (14.1.2017)

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