Investigating the potential of GNSS-modules for inflow avalanche measurements

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Avalanche measurements

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Optimized avalanche flow models

Fig1: Particle Simulation of Seilbahnrinne with AvaFrame - com1dfa [1]

Dimensioning mitigation measures

Fig.2: Snownets at Hafelekar, Innsbruck, Austria.

Identifying endangered terrain

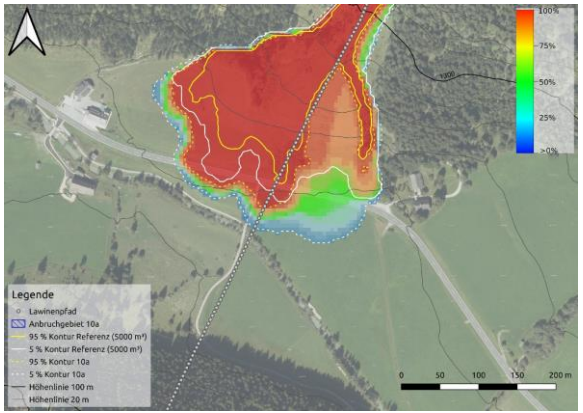

Fig.3: Runout probabilistic, Uncertaintiy Handling, PSAM II [2]

Inflow measurement - AvaNode

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AvaNode:

- Sensor System which flows with the avalanche
- Different shapes, sizes and densities
- **G**lobal **N**avigation **S**atellite **S**ystem
- Infrared Temp. Sensors
- IMU (Acc, Gyro, Mag)
- Ranging Chip
- Controller Board's
- SD-Card's

Fig.4: AvaNodes Generation I

More Information under Neurauter et al. 2022: https://doi.org/10.5194/egusphere-egu22-11328 [3]

AvaNode – GNSS module

- Ublox CAM-M8Q Module
- 2.5 m position accuracy
- 0.05 m/s velocity accuracy
- Omnidirectional antenna
- 10 Hz with GPS & GLONASS

- GPS **L1C/A 1575.42 MHz**
- GLONASS **L1OF 1602MHz + k * 562.5 kHz**
- k = (-7, … , 6)

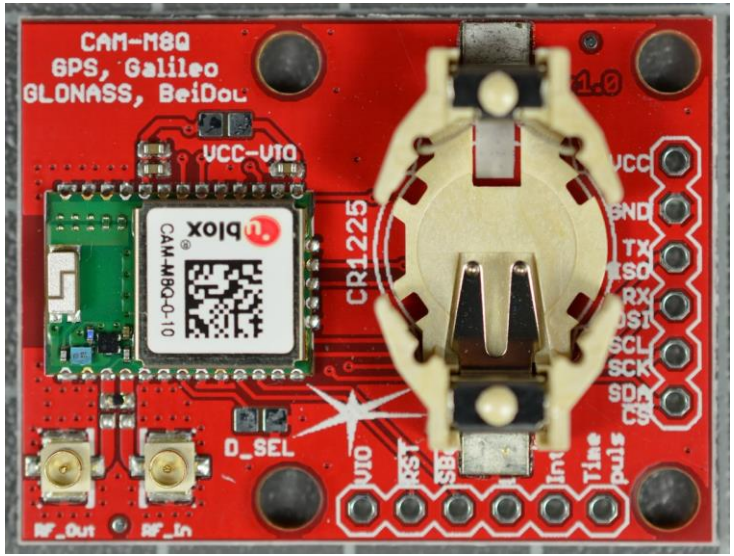

Fig.5: GNSS Module ublox CAM-M8Q

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GNSS – Position accuracy in snow

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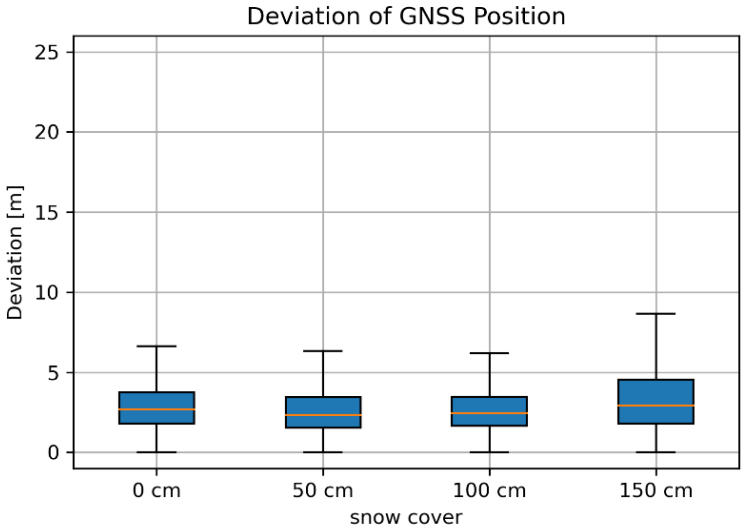
Fig.6: 25.01.2022 – GNSS modules under snow cover



Snow properties:
Mean density = 260 kg/m³
Mean snow temp. -2.5 °C
LWC 0%

The amount of L-band attenuation depends primarily on the water content of the snow (Mätzler, .C, 2001) [3]

Test Site – Nordkette, Innsbruck

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Fig.7: Orthophoto Seilbahnrinne

Fig.8: Seilbahnrinne
View from top

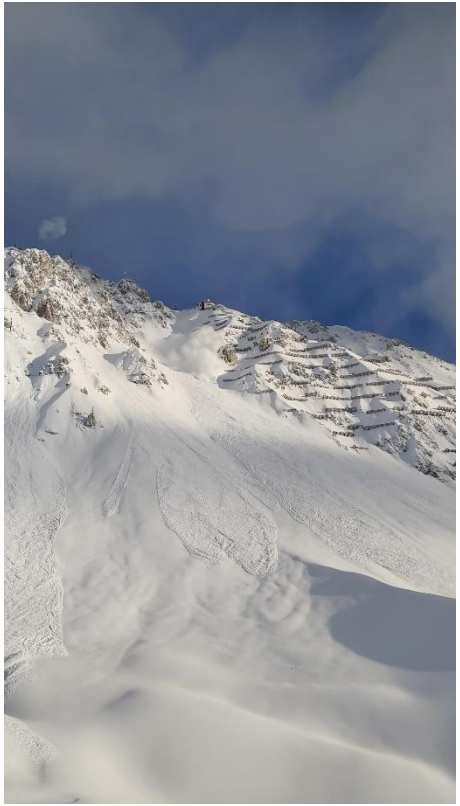

Fig.9: Seilbahnrinne
View from bottom

Experiment, 2022-01-23

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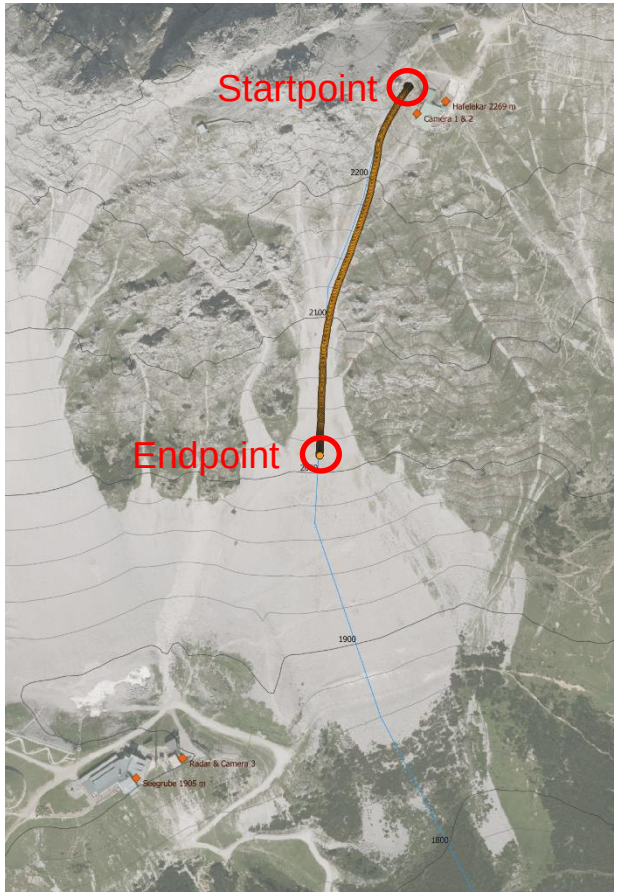
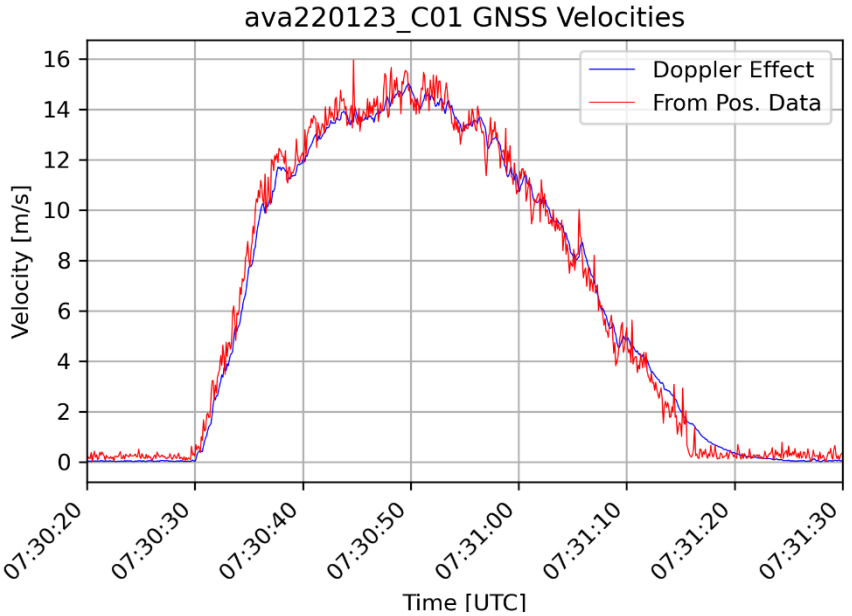
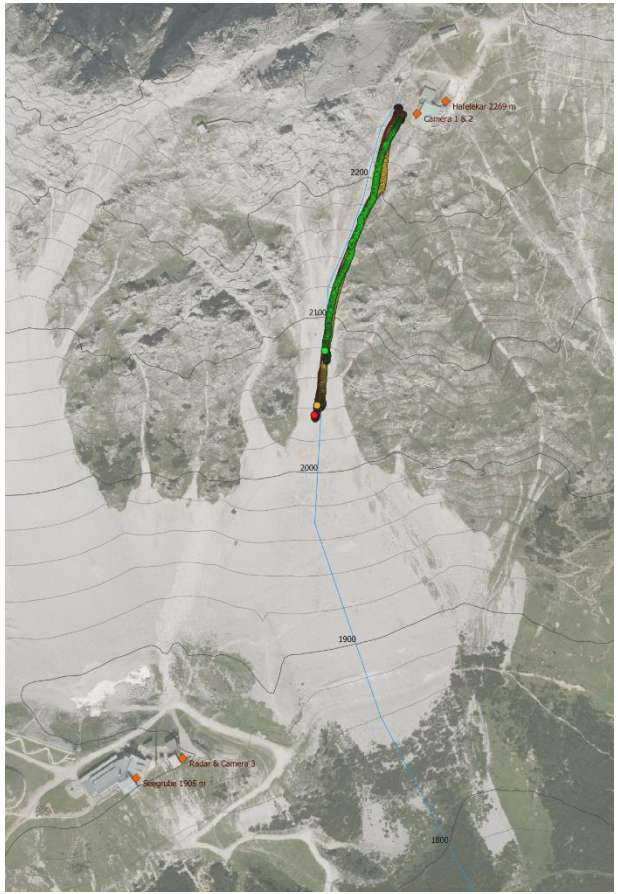


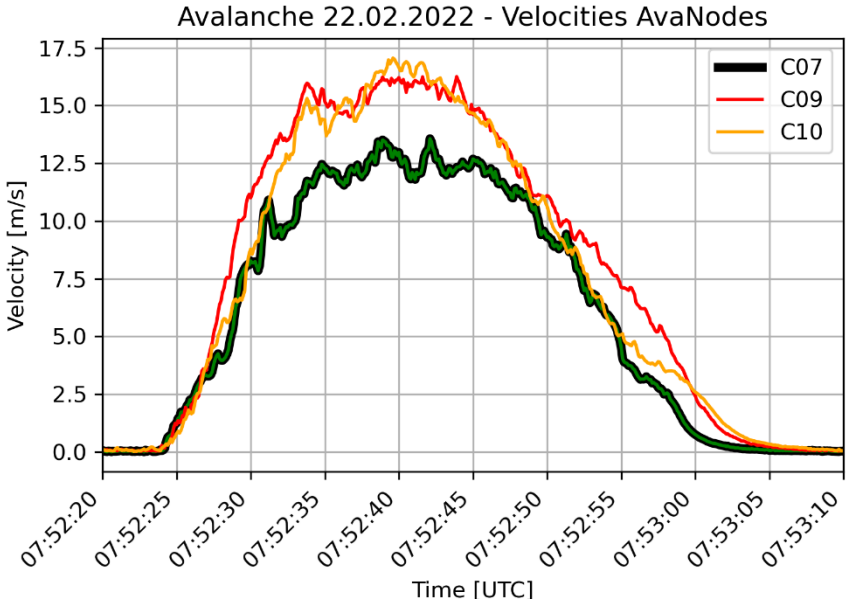


Position:
- Startpoint
- Endpoint
- Postion during movement with 10Hz

Velocity:
- Position velocity
- Doppler velocity

Experiment, 2022-02-22





Time:

- Through the GNSS Time it‘s possible to synchronize data of several AvaNodes

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Outlook

- Validation of doppler velocities with Radar and Ranging Technology
- Improving our GNSS measurements with a Basestation
- Simulation – AvaNode Data

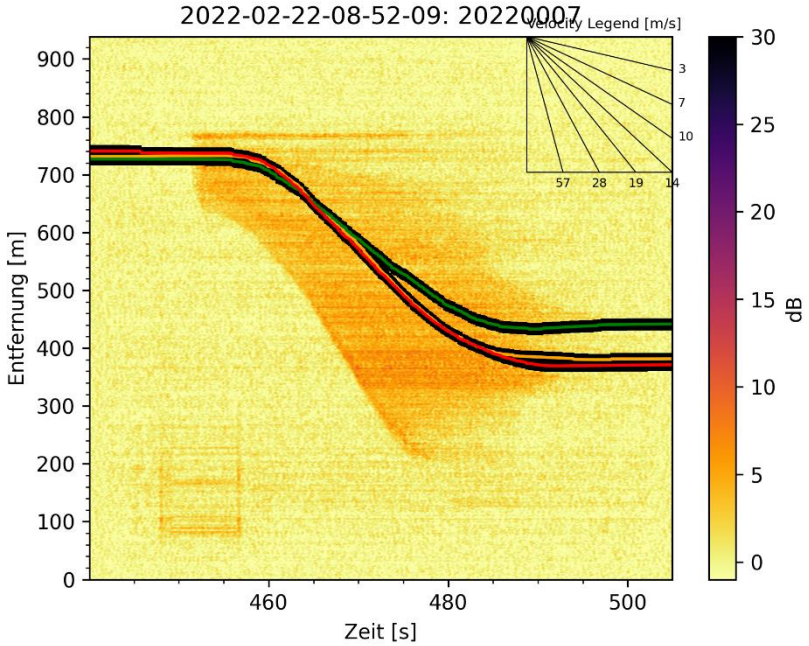

Fig.10: MTI-Plot of the avalanche experiment from 22th of February, 2022, compared with the GNSS AvaNode data. Colors correspond to the plot on page 8.

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Outlook

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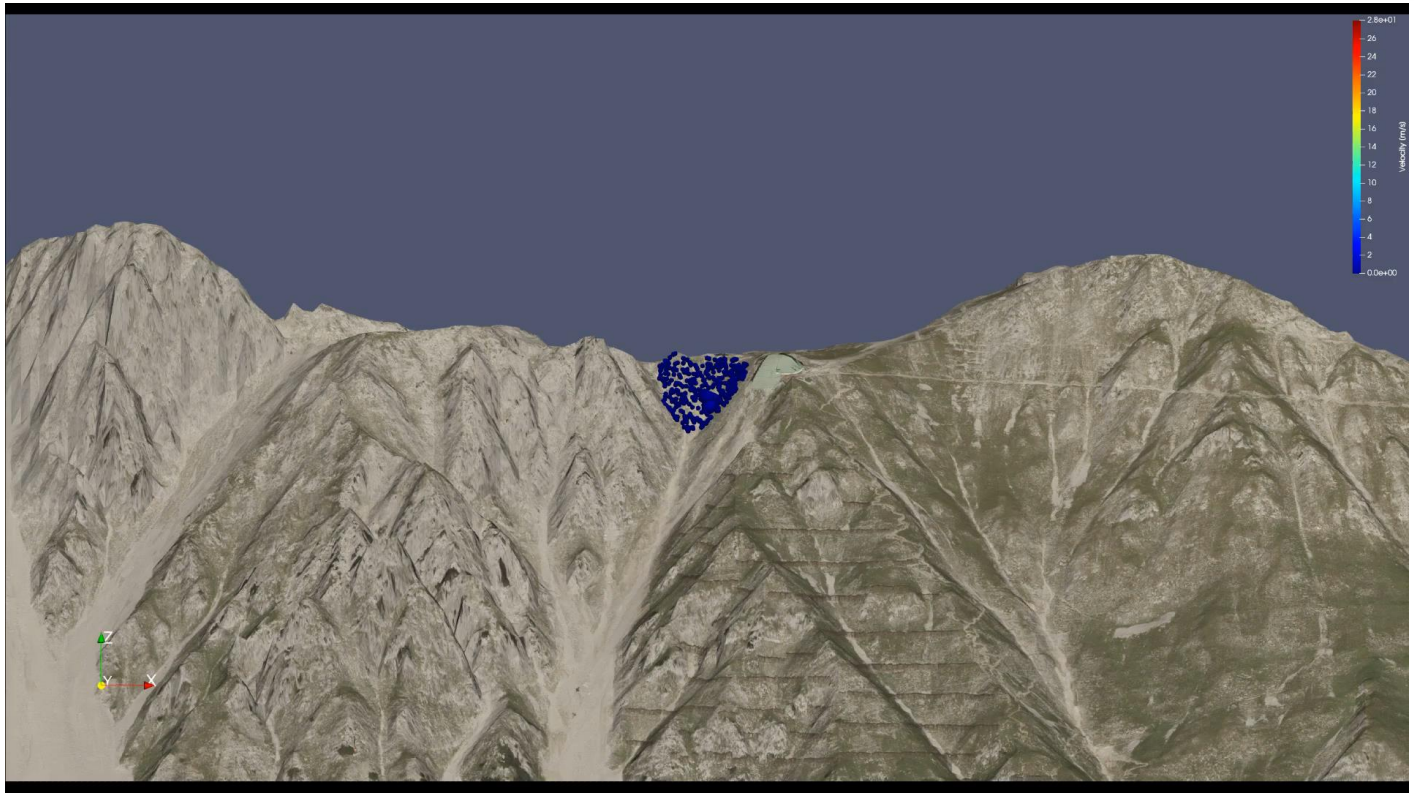

Ani1: Simulation of Seilbahnrinne (small spheres) and GNSS Data from AvaNodes (big spheres), from 2022-02-22, with corresponding velocities indicated as colors.

Visualisation: ParaView - https://www.paraview.org/

Conclusion

- As long as we have a LWC (liquid water content) of 0% in the snow the GNSS data is valuable
- Doppler velocities can give as information about the velocity distribution for different particles
- We can sync different Nodes via the GNSS Time

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Acknowledgements

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References

[1] AvaFrame: www.avaframe.org

[2] Neuhauser, M. und J.-T. Fischer (2019): *PSAM II - Uncertainty Handling*, Technischer Bericht, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Innsbruck, Austria

[3] Neurauter, R., Neuhauser, M., Blobel, J., Winkler, R., Dressler, F., Fischer, J.-T., and Gerstmayr, J.: **An in-flow sensor system for data acquisition in snow avalanches**, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-11328, https://doi.org/10.5194/egusphere-egu22-11328, 2022.

[3] Mätzler, C. (2001), *Applications of SMOS over Terrestrial Ice and Snow*, 3rd SMOS Workshop, DLR, Oberpfaffenhofen, Germany, Dec. 10-12

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