

Snow Parameter Estimation with Multi-Frequency and Multi-Constellation GNSS

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AGU Fall Meeting

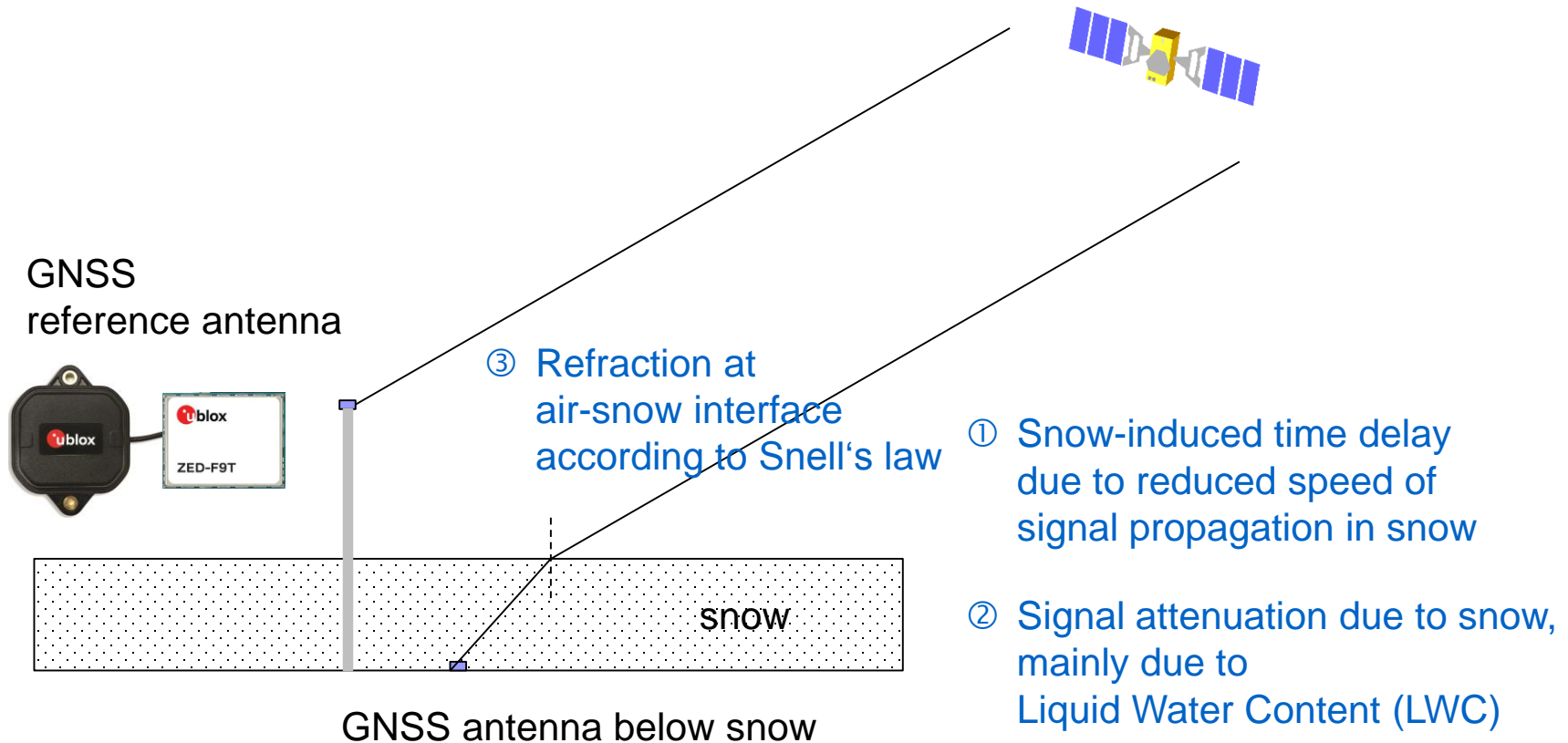
Session G32B: Applications of Low-Cost, Mass-Market, and Consumer-Grade GNSS in Geosciences (eLightning)



Advanced Navigation Solutions



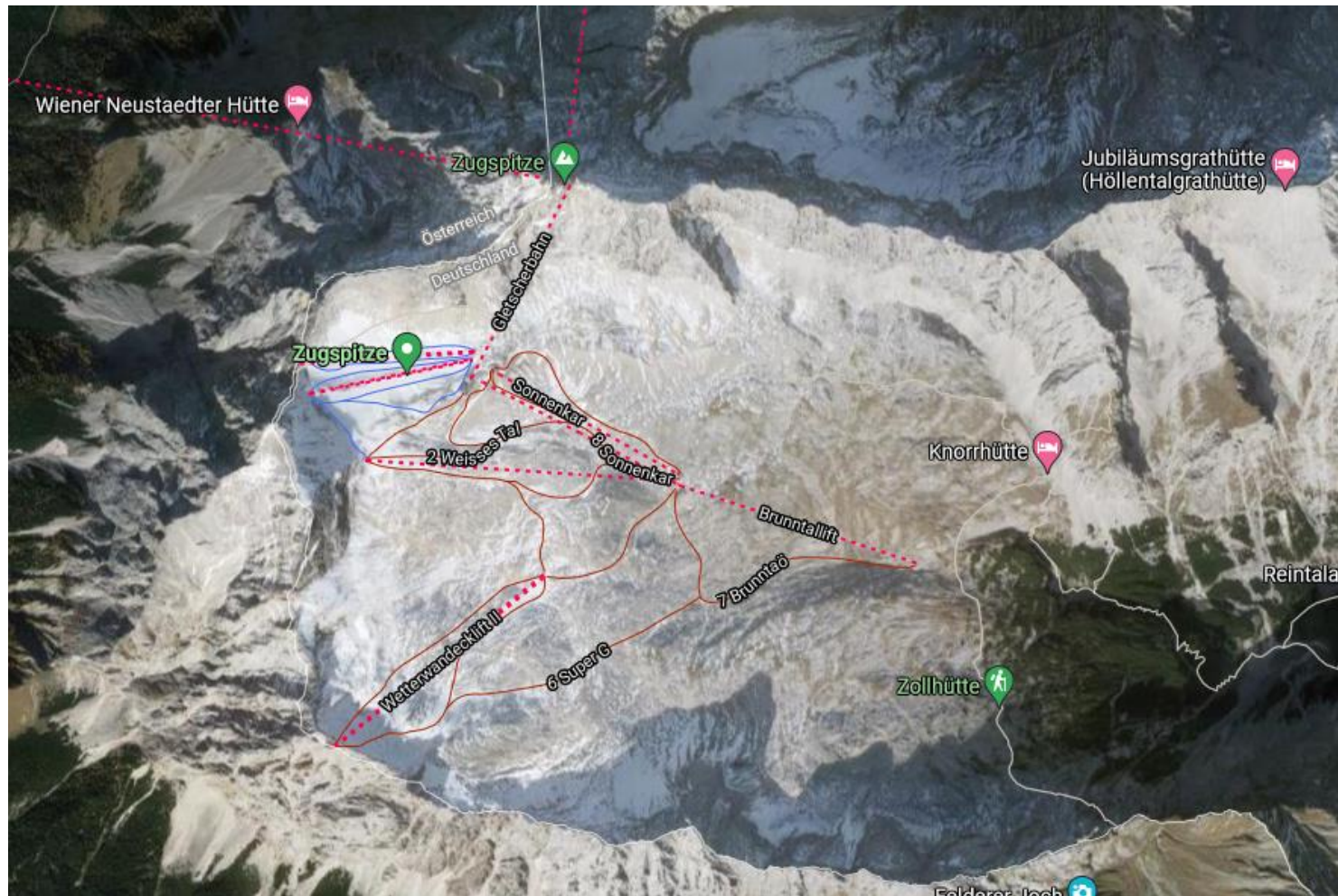
Snow Monitoring Station Set-Up



Snow Monitoring Site at Zugspitze



Snow Monitoring Site at Zugspitze



Snow Monitoring Site at Zugspitze

Latitude: 47.406342436° N

Longitude: 10.983476867° E

Height: 2420 m

09.09.2021



13.12.2021



GNSS-based Snow Parameter Estimation

Double differenced carrier phase measurement
between two GNSS receivers and two satellites:

$$\lambda_m \varphi_{12,m}^{kl} = \vec{e}^{kl} \vec{b}_{12} + m_s^{kl} \frac{v_a}{v_s} \cdot \text{SWE} + \lambda_m N_{12,m}^{kl} + \varepsilon_{12,m}^{kl}$$

Integer
Ambiguity

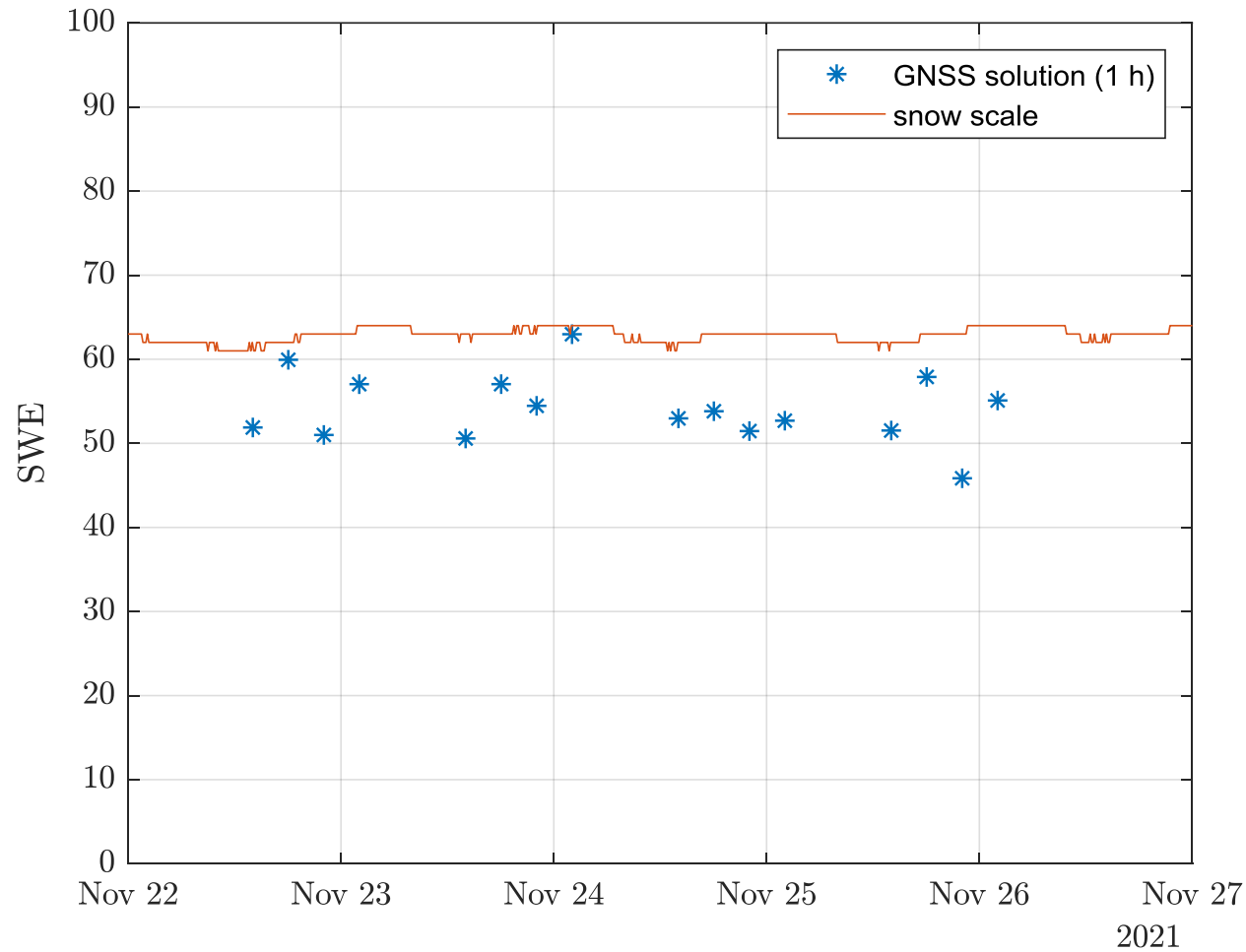
Snow Water Equivalent (SWE)

Relative position („baseline“)
between both GNSS receivers

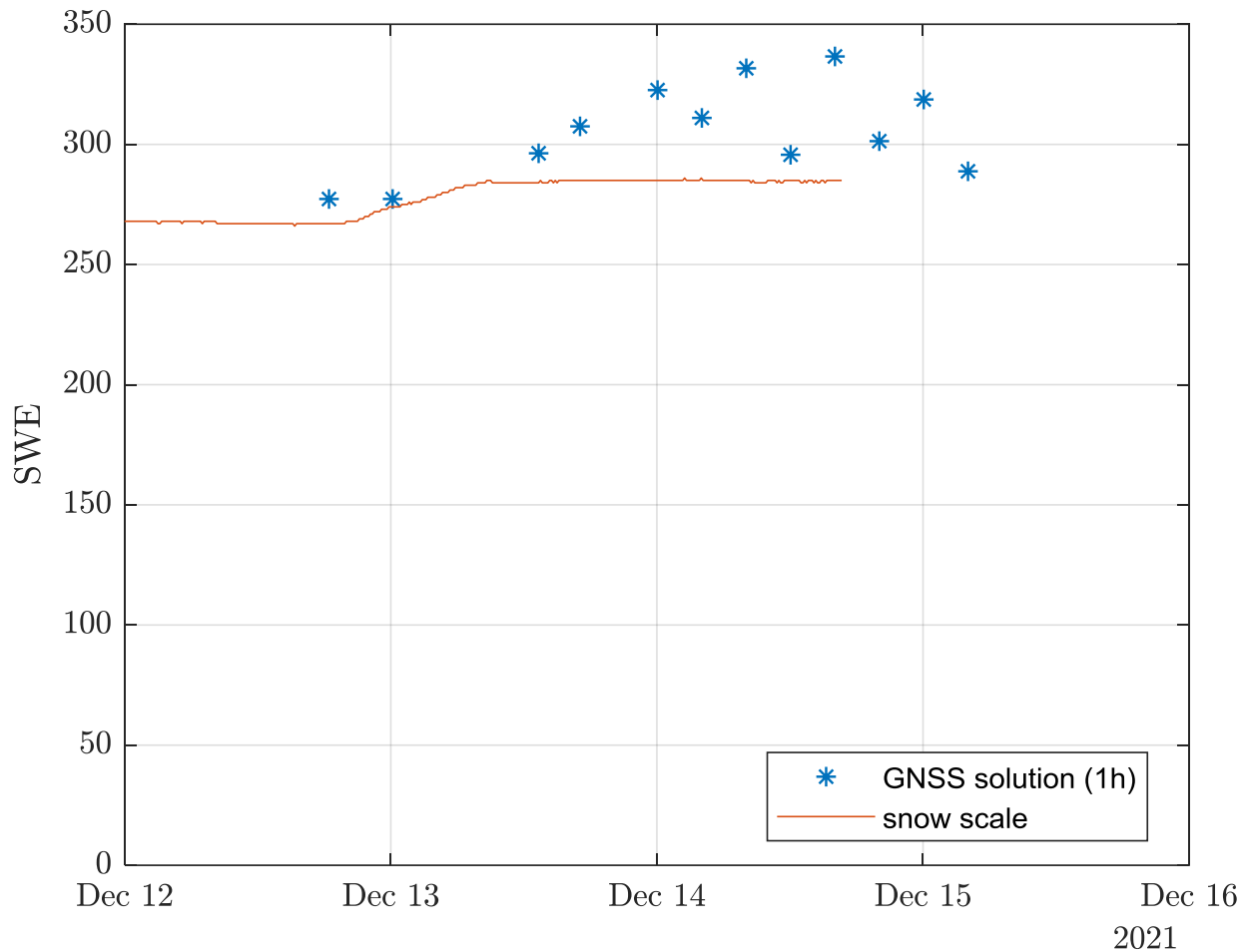
Parameter Estimation

- ① Calibration, i.e. RTK Positioning in snow-free conditions
- ② Snow Parameter Estimation using baseline estimate from ①
 - Kalman Filter based estimation of SWE and float ambiguities
 - Integer Ambiguity Fixing with LAMBDA method
 - Adjustment of SWE estimates
 - Determination of snow height, LWC and speed of light in snow

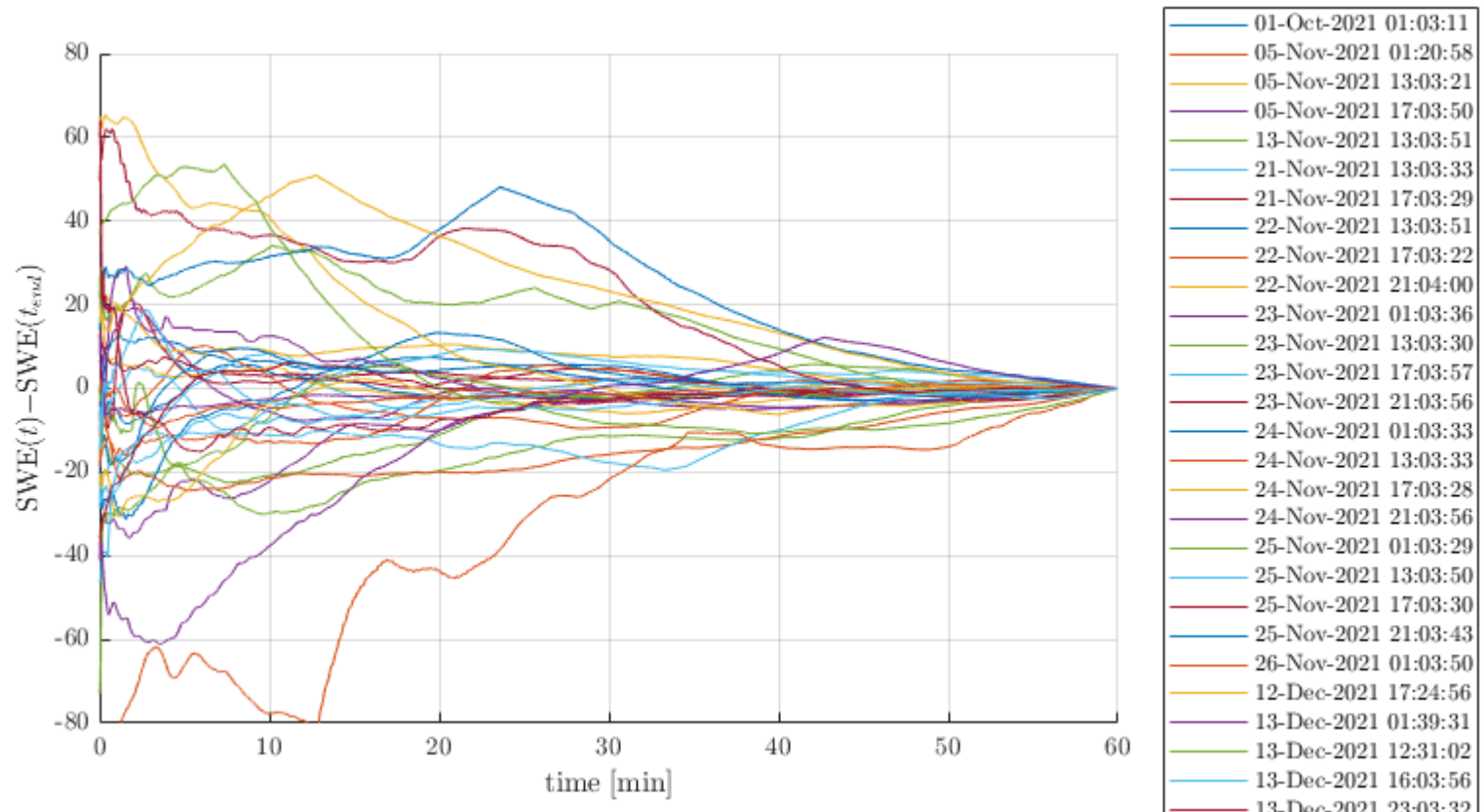
Measurement results: SWE in November



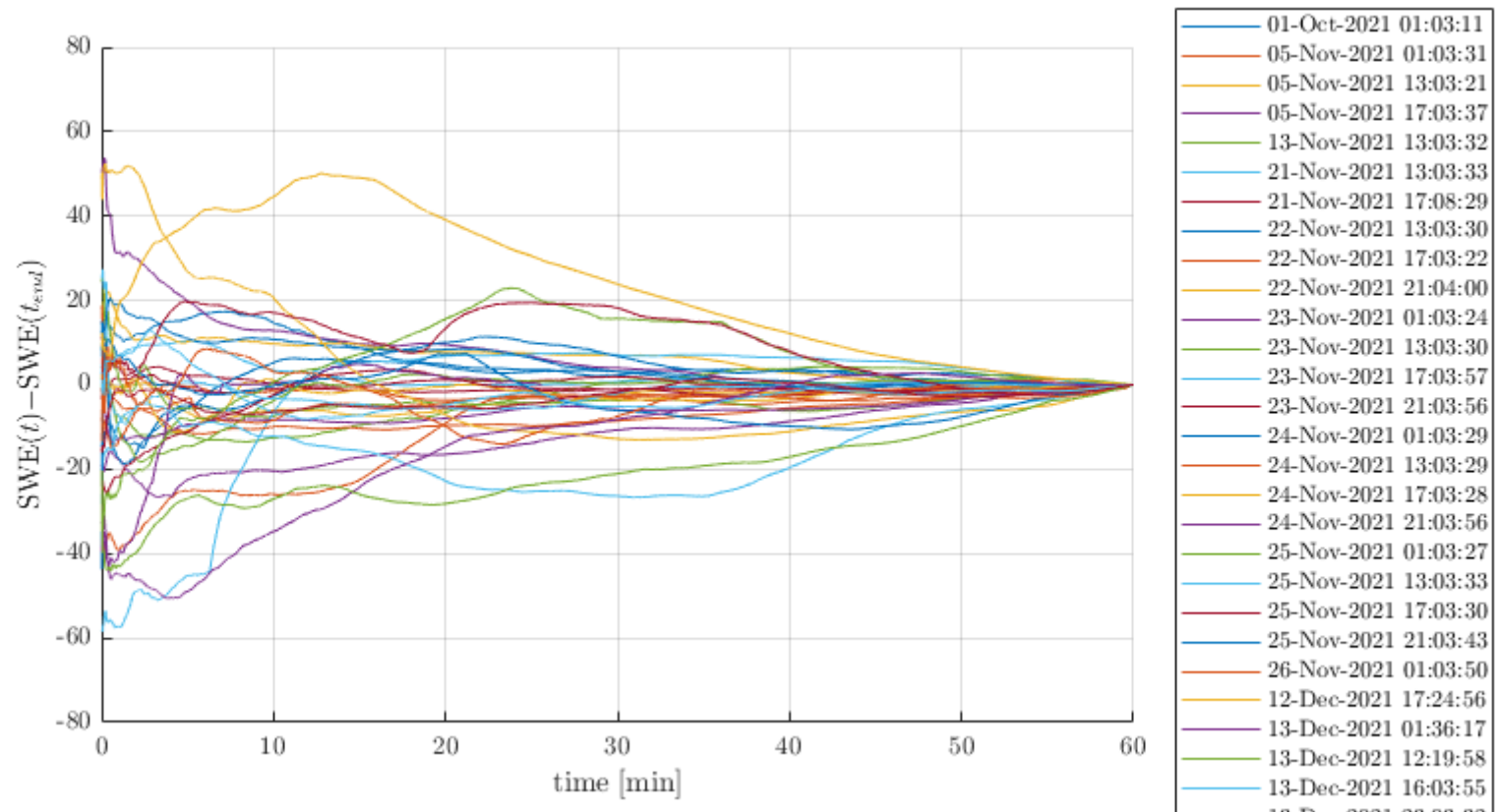
Measurement results: SWE in last few days



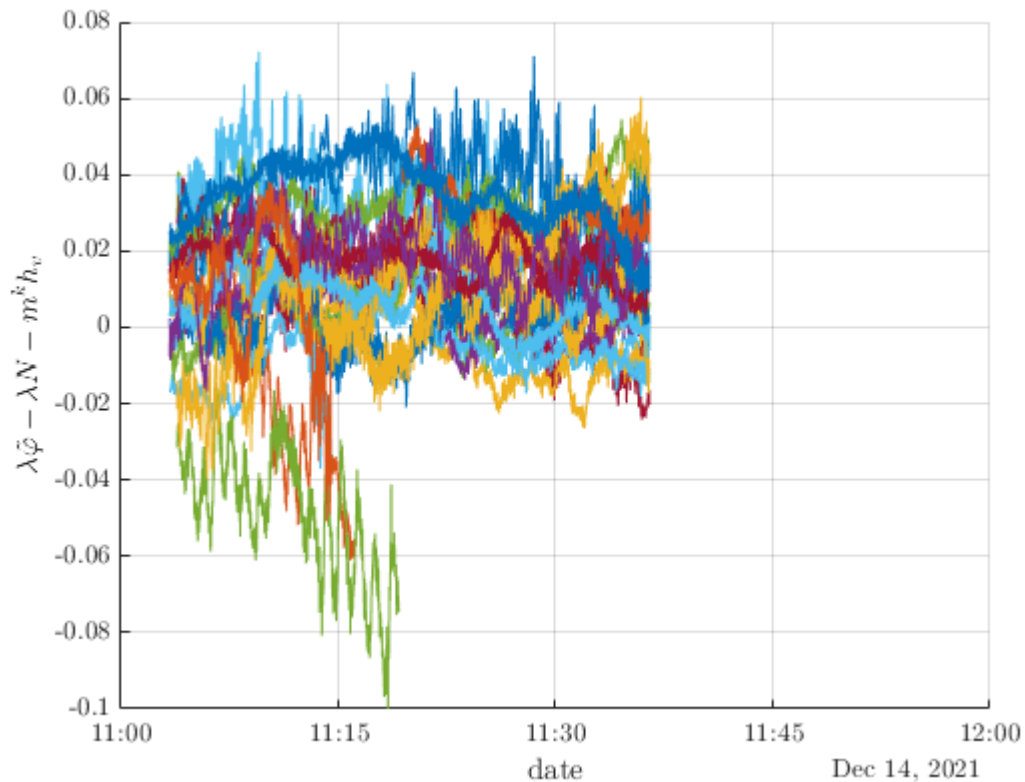
Measurement results: Convergence of SWE (Single Frequency GNSS)



Measurement results: Convergence of SWE (Multi-Frequency GNSS)



Measurement results: Accuracy Assessment based on Fixed Carrier Phase Residuals



Different colors
refer to different
satellites,
constellations
and frequencies.

Potential Applications

