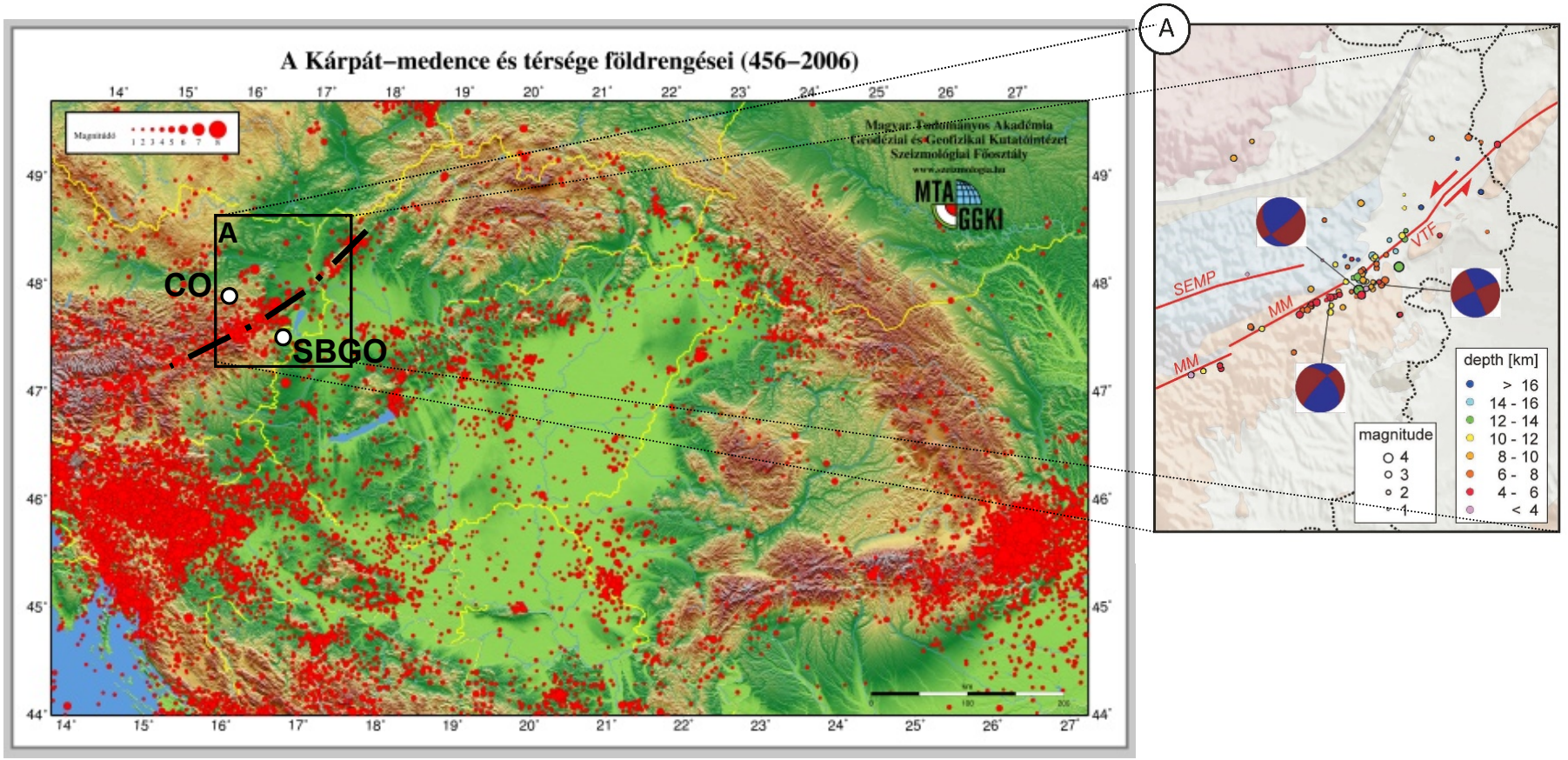
Comparison of Tilt and SG-Gravity Residuals at Conrad Observatory (Austria)

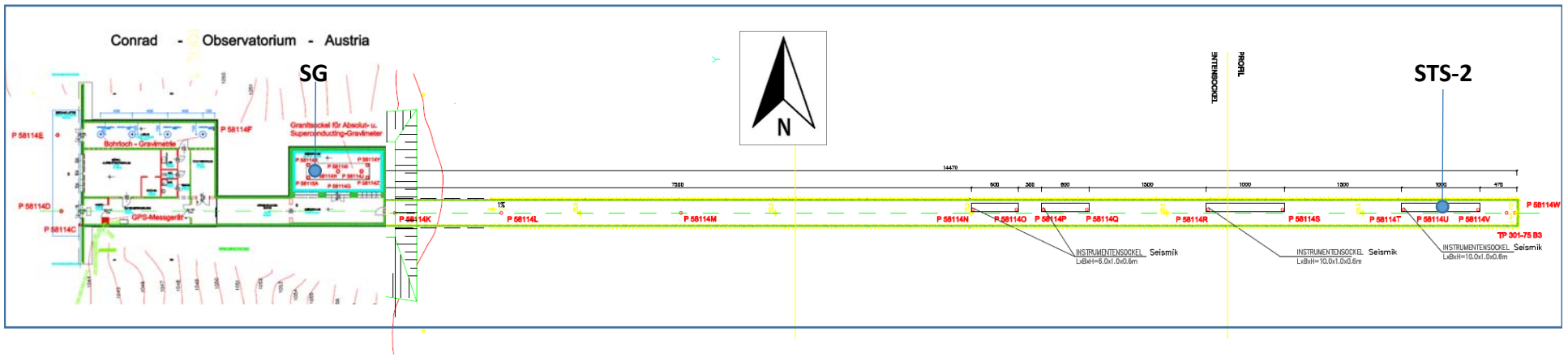
Papp, G., Ruotsalainen, H., Meurers, B., Benedek, J., Leonhardt, R.

1st Workshop on the International Geodynamics and Earth Tide Service (IGETS), 18-20 June 2018, Potsdam (Germany)

Framework: Test measurements for monitoring of tilt deformations along the Mur-Mürz tectonic fault system

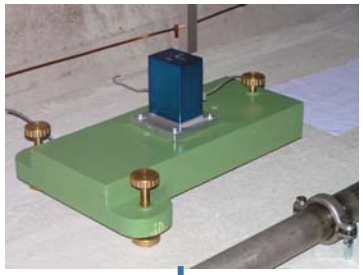


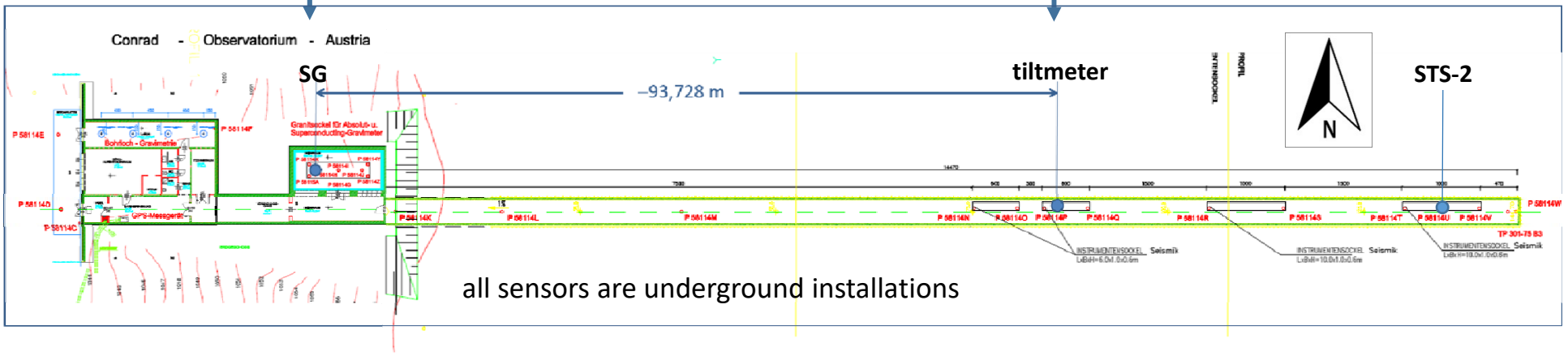
Conrad-Observatory (SGO)



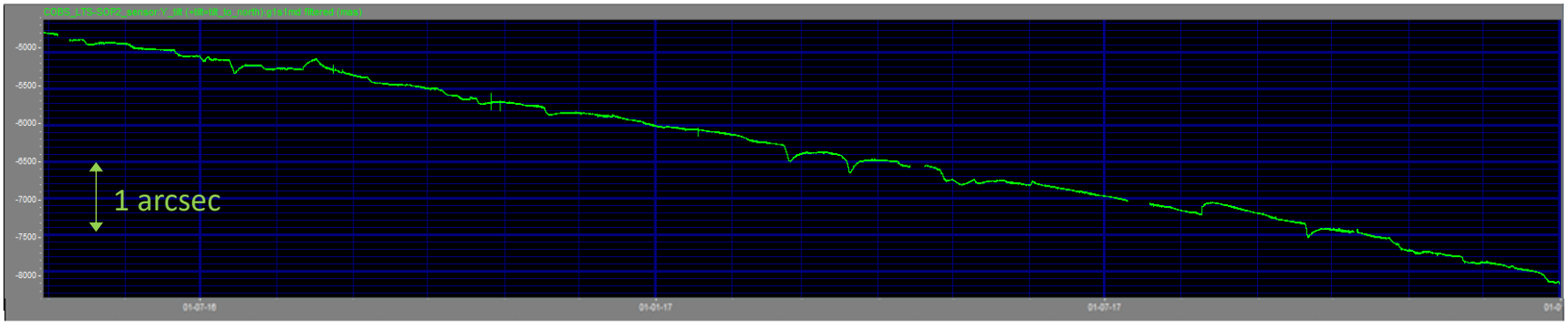
Conrad-Observatory (SGO) - Instrumentation

	SG GWR C025	LTS	iWT - interferometric water level tilt meter
		Pendulum/capacitive transducer	single end setup
		compact (~ 8 x 6 x 12 cm3)	tube length: 5.5 m
component	Z	N-S, E-W (bi-axial)	E-W
sampling rate	1 Hz	1 Hz	15 Hz



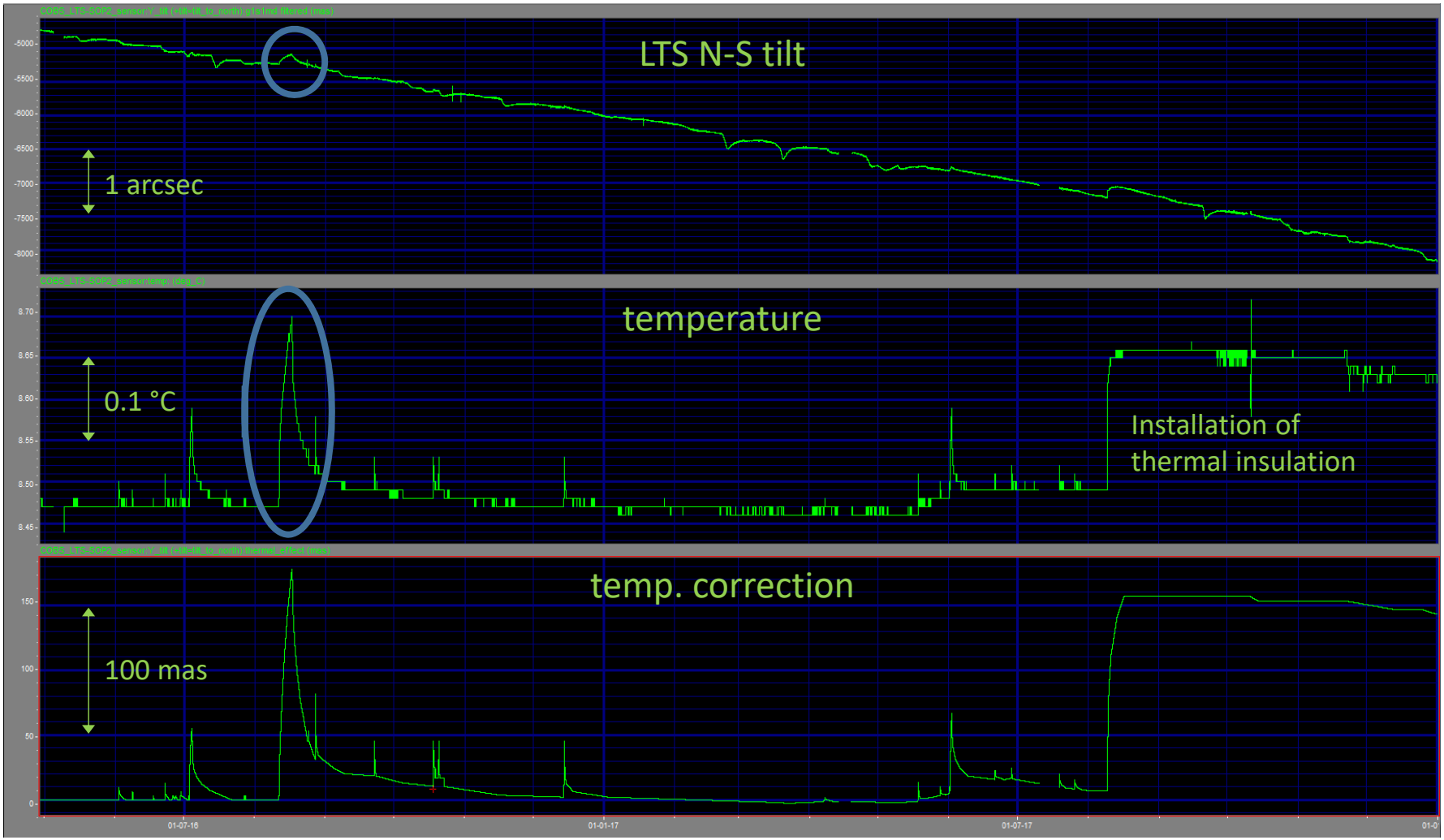


Data processing



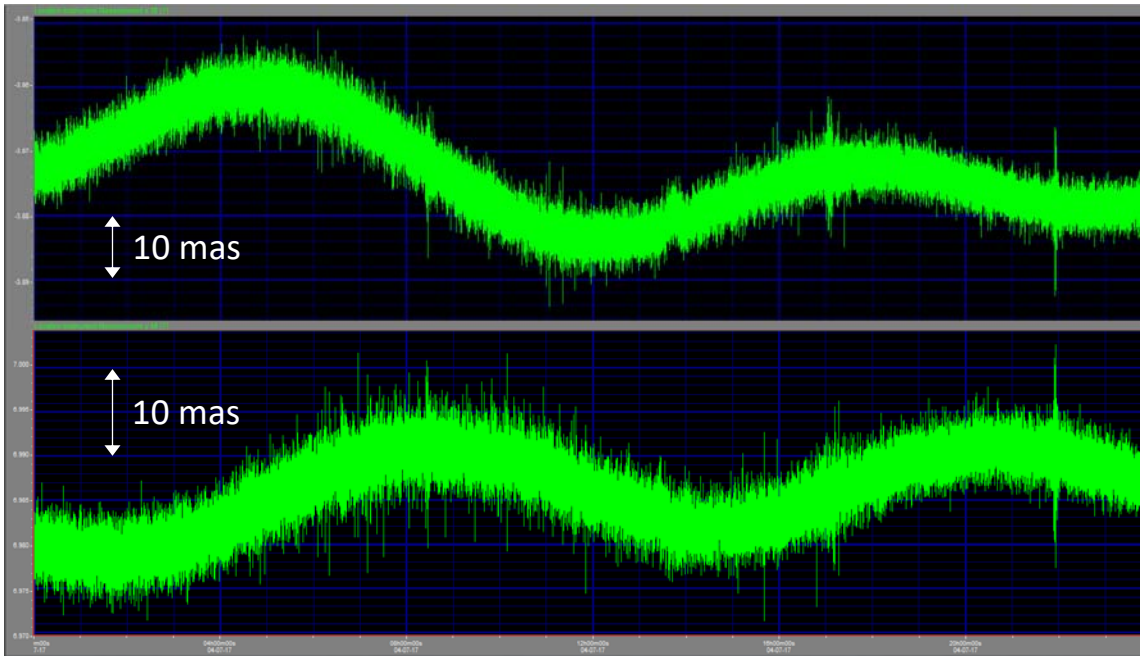
- Filtering (G1s1m FIR filter) and decimation to 1min data

Data processing



- Temperature correction (tilt) based on linear and nonlinear models dependent on the thermal event → necessity of thermal insulation

Data processing



2017 07 04

LTS (E-W)

LTS (N-S)

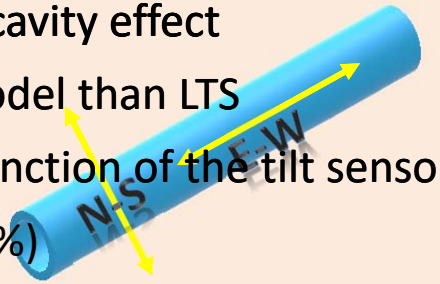
- Filtering (G1s1m FIR filter) and decimation to 1min data
- Temperature correction (tilt) based on linear and nonlinear models dependent on the thermal event → necessity of thermal insulation
- Filtering and decimation to 1h data
- Tidal analysis → tidal model

Data processing

		N-S			E-W					
		LTS-Y			LTS-X			iwt-X		LTS/iwt
Darwin	γ (WD)	amp [mas]	γ σ(γ)	ϕ σ(ϕ)	amp [mas]	γ σ(γ)	ϕ σ(ϕ)	γ σ(γ)	ϕ σ(ϕ)	
Q1	0.6940	0.1235	2.9289 1.3921	-17.218 12.022	0.9257	0.6976 0.0490	1.776 4.042	0.6937 0.0851	-13.136 7.011	1.0056
O1	0.6944	0.6449	**1.2940** 0.1533	12.022 9.648	4.8347	**0.7105** 0.0104	-7.020 0.838	**0.6783** 0.0170	-12.356 1.434	1.0475
K1	0.7362	0.9070	**1.2184** 0.1536	10.551 7.200	6.7995	**0.7808** 0.0073	-8.045 0.462	**0.7346** 0.0108	-11.556 0.839	1.0629
N2	0.6911	1.5053	**0.6744** 0.0306	-4.524 2.590	2.0279	**0.7516** 0.0889	-2.863 0.676	**0.7200** 0.0115	-4.697 0.918	1.0439
M2	**0.6911**	7.8622	**0.6574** 0.0060	-2.313 0.522	10.5916	**0.7404** 0.0019	-3.853 0.147	**0.6827** 0.0023	-5.559 0.192	1.0845
S2	0.6911	3.6579	**0.6599** 0.0128	-1.436 1.128	4.9278	**0.6865** 0.0044	-1.609 0.363	**0.6306** 0.0519	-5.493 0.460	1.0886

- N-S component: anomalous diurnal γ-factors → cavity effect
- E-W component: γ-factors of iwt closer to WD-model than LTS
- Tidal parameters affected by unknown transfer function of the tilt sensors
- LTS scale factor (E-W component) too high (5 – 8 %)

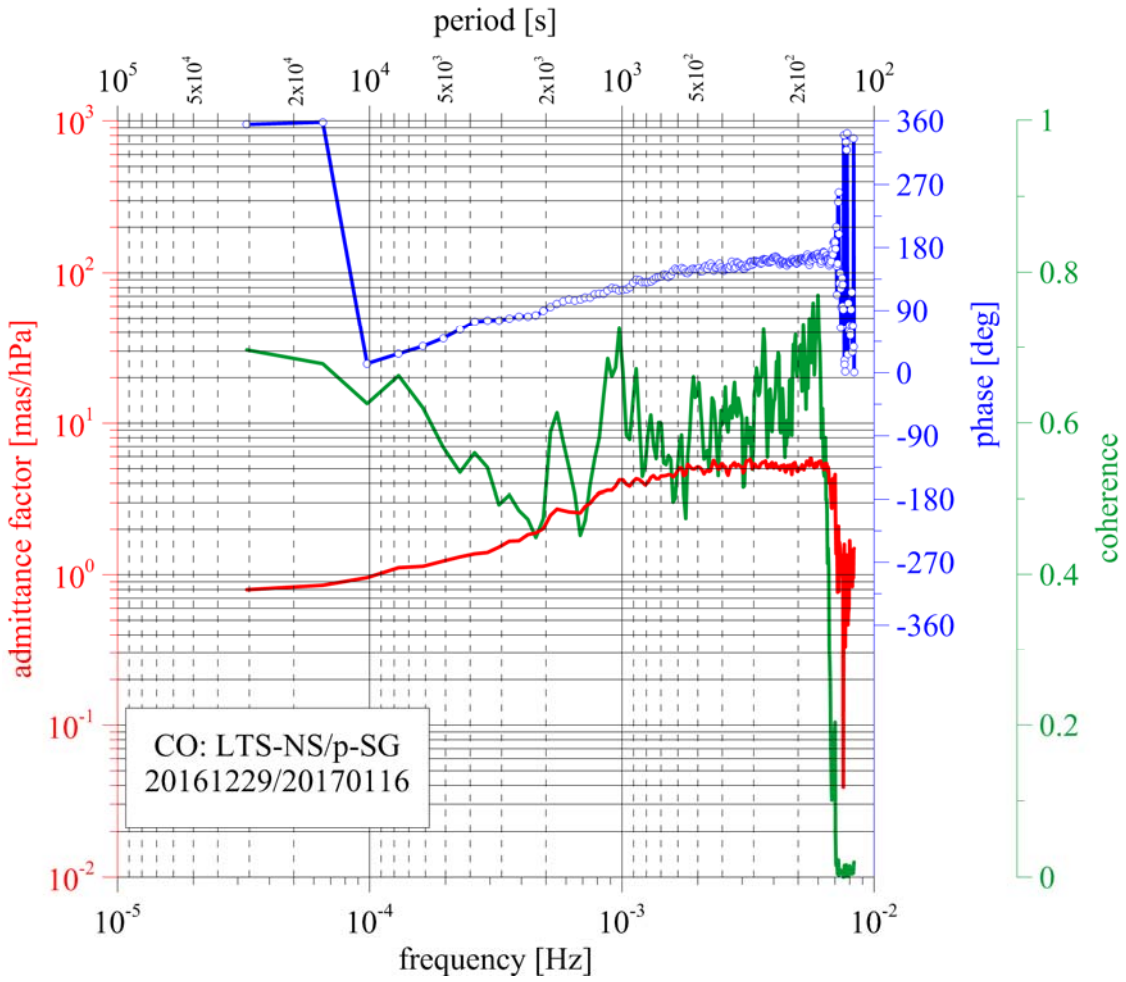
→ Sensor dependent tidal models



Data processing

Air pressure admittance [mas/hPa]		
N-S	E-W	
LTS-Y	LTS-X	iwt-X
0.878 0.026	0.042 0.012	-0.195 0.014

→ Sensor dependent admittance

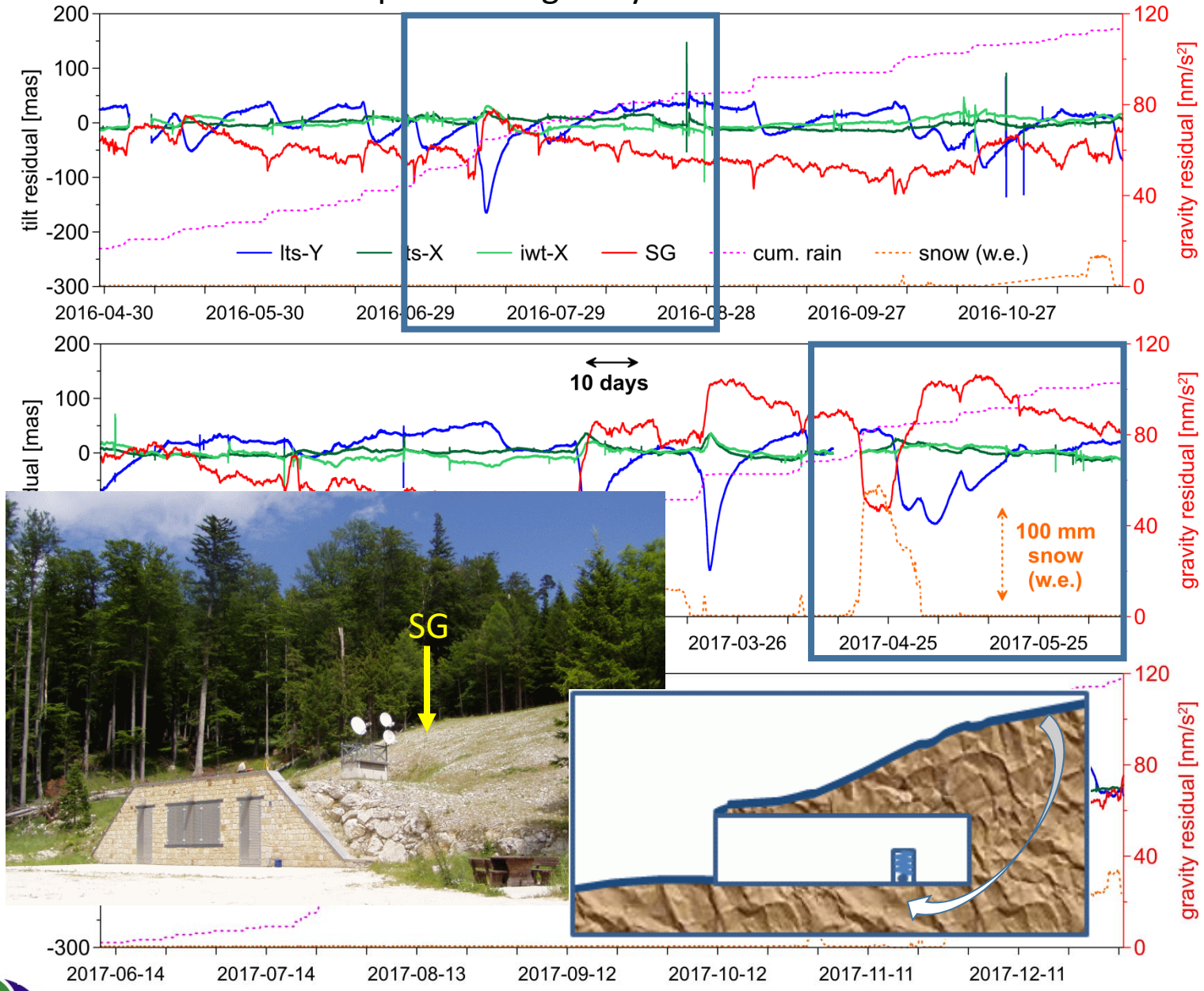


Data processing

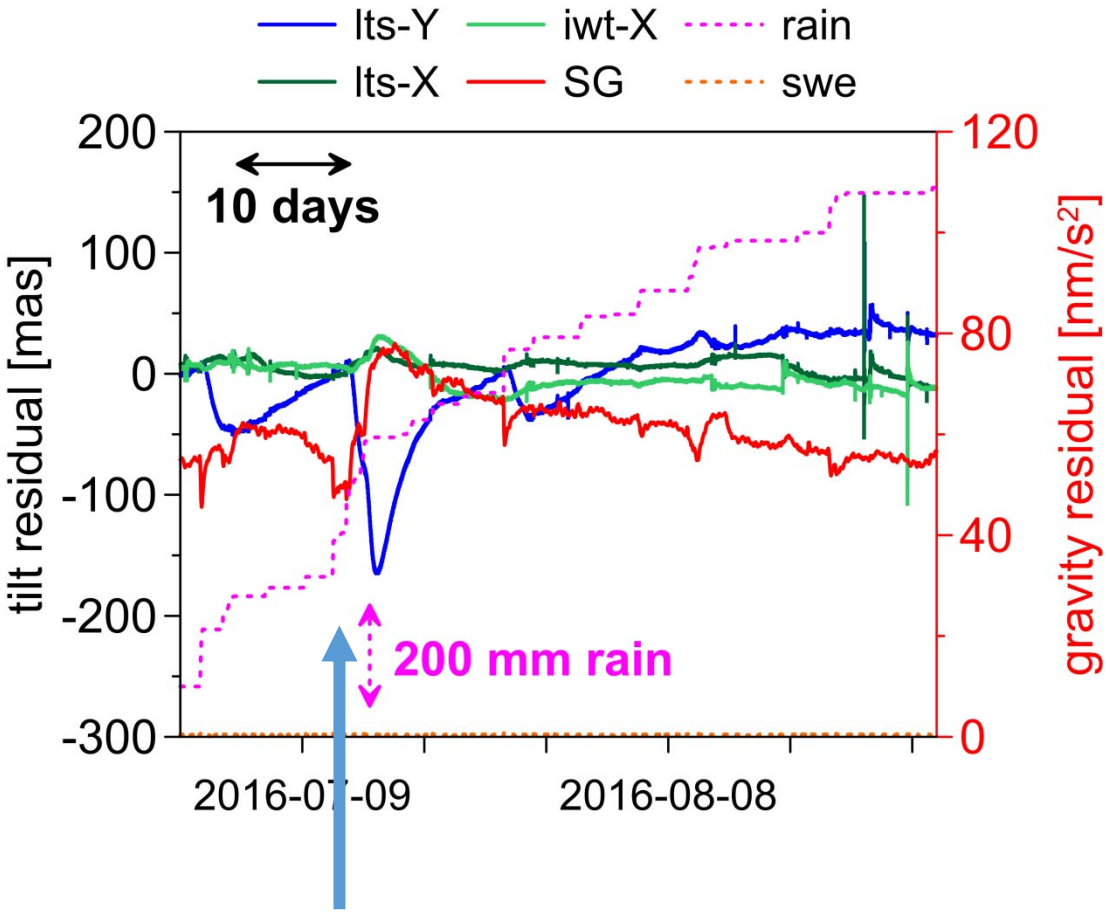
- Filtering (G1s1m FIR filter) and decimation to 1min data
- Temperature correction (tilt) based on linear and nonlinear models dependent on the thermal event → necessity of thermal insulation
- Filtering (G1s1m FIR filter) and decimation to 1h data
- Tidal analysis → tidal model
- Remove tides, air pressure effect and pole motion effect (gravity only) → residuals
- Trend correction (low order polynomial drift, tilt residuals only)

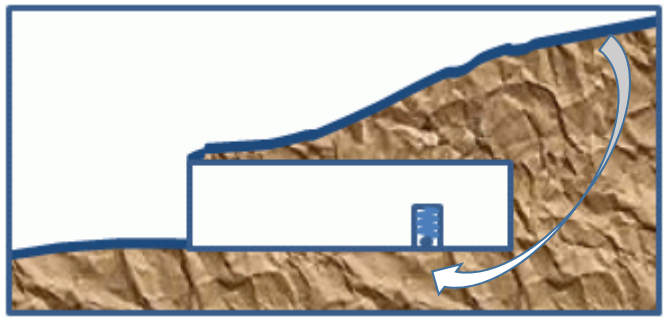
lin. trend [arcsec/yr]		
N-S	E-W	
LTS-Y	LTS-X	iwt-X
-2.0	-1.5	+0.2 +0.5

Comparison of gravity and tilt residuals



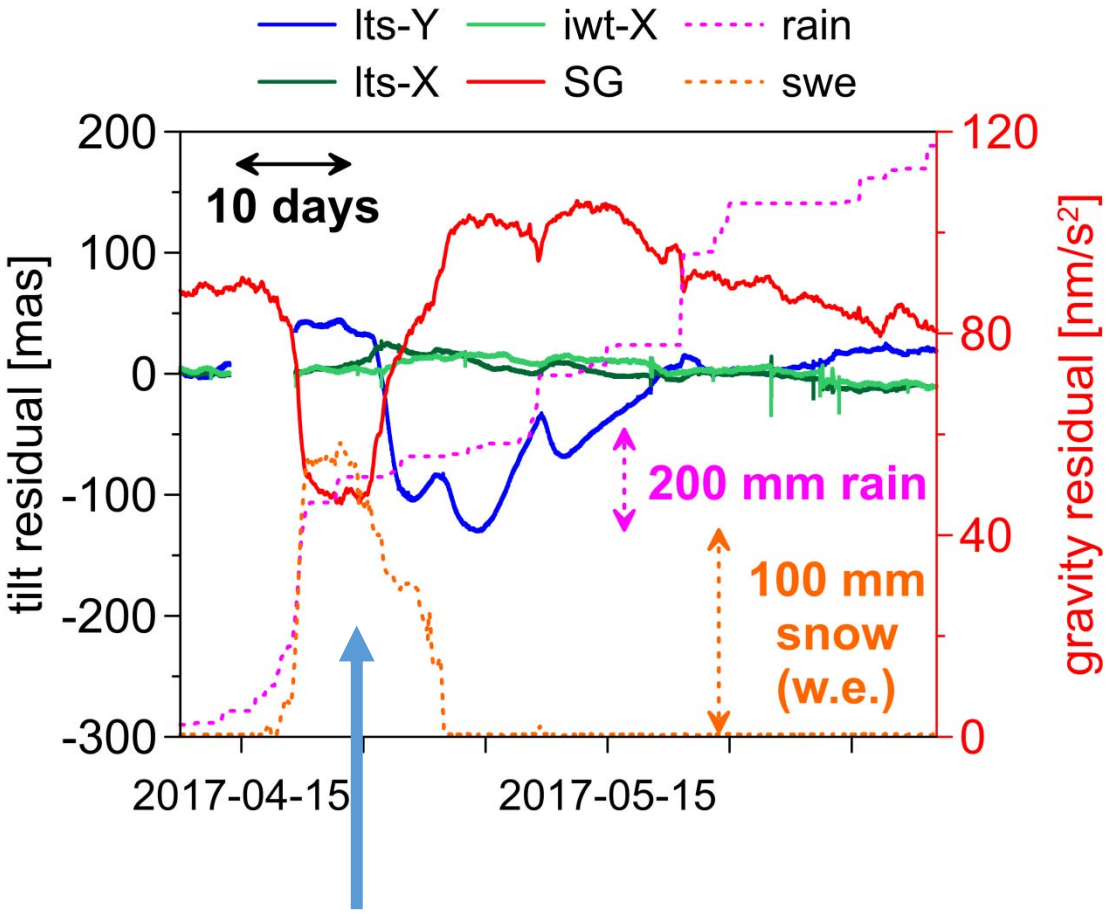
Comparison of gravity and tilt residuals

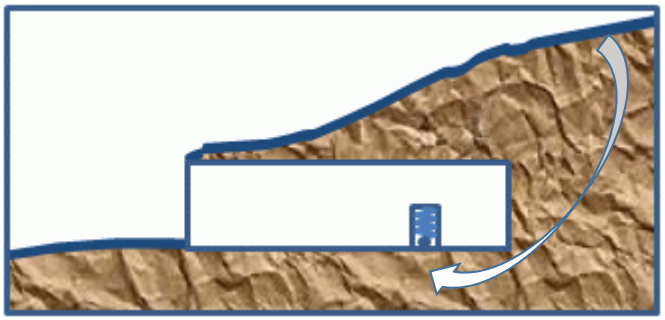




N-S tilt decrease delayed by
2 – 5 hr w.r.t. gravity increase
→
residual anomalies:
caused by different sources,
but triggered by the same
hydrological process

Comparison of gravity and tilt residuals





Conclusions

Tidal model:

- cavity effect stronger in N-S than in E-W direction
- calibration problem (LTS sensors)

Residuals:

- Long-term signatures show a clear correlation between the tilt and SG sensor data
- Heavy rain/rapid snow melt events:
  - Heavy rain events cause sharp SG residual decrease at the beginning when sufficient amount of water has moved downwards
  - SG residuals start to increase
  - N-S tilt residuals start to decrease
- Tilt decrease delayed by 2 – 5 hr w.r.t. gravity increase
- Complex transport process, karstic phenomena may play an important role as well
- Tilt signals stronger in N-S than in E-W direction (cavity effect)
- Coupled gravity effects and strain induced tilts due to short- and long-term water transport processes