GNSS and Tachymetry for Monitoring the stability of Permanent Reference Station

Example Zimmerwald

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Zimmerwald monitoring environment

Measurement setup

ZIMM
ZIM2
ZIMJ
webcam
Meteo
Sensor

P1
Ref.
P2
P3

Ref.
Campaign details

- Temperatures: 5-30 °C
Automatic measurements using (parts of) Leica GeoMoS

every 30 Minutes all points

Abbildung 2 Aufbau des Monitoringsystems an der FHNW
Terrestrial: absolute versus relative

Example ZIM2, East

Differential: Top-Ref

Not guilty!
Terrestrial results ZIMM+ZIM2: Height

\[ \text{dHeight} = f(\text{Temp}) \rightarrow \text{extension coefficient of steel} \]

\[ 11.8 \times 10^{-6} \, \text{K}^{-1} : \text{dT } 10 \, ^\circ\text{C} \rightarrow \text{dh } 1.2 \, \text{mm} \]
Terrestrial results ZIM2: Horizontally

Differential to bottom point
Terrestrial results ZIMM+ZIM2: Horizontally, June 17
Terrestrial results ZIMM+ZIM2: max. horizontal movements 2 hot days

ZIMM: June 17

ZIM2: June 17

ZIMM: June 19

ZIM2: June 19
GNSS Analysis

- ZIMM, ZIM2, ZIMJ – nested in 3 AGNES stations
- ZIM3=Galileo receiver at ZIM2 antenna
- L1 short baselines
- 2 weeks (June 11-25; DOY 162 – 176)
- No troposphere estimation for short baselines
- **Daily repeatability**: 0.8 mm horizontally, 2.2 mm vertically

ZIM2=ZIM3 ! (identical coordinates)
Kinematic coordinates: ZIM2-ZIM3

Kinematic repeatability (S) for ZIM2 14001M008 - ZIM3 14001M008 (0.0 km)

- North: std 1.05 mm
- East: std 0.89 mm
- Up: std 2.00 mm

Zero baseline: Hot day June 19
Kinematic coordinates: ZIM2-ZIMJ

Real baseline GNSS: Hot day June 19

Movements of the mast?
Real baseline GPS: Hot day June 19

Kinematic coordinates: ZIMM-ZIMJ

- Movements versus larger noise
  - GPS-only !!!
- Weak constellation – every day
Repeatability kinematic coordinates

- Example day June 19 (hot day)
- Horizontal repeatability 2 mm enough?
  - GNSS: less noise – some signals visible (temperature movements?)
  - GPS: more noise – difficult to see signals
Comparison GNSS with terrestrial ground truth: ZIMM/ZIM2 June 19
PPP solutions

- Absolute station monitoring – no reference station – no baselines! – results in ITRF2008!

PPP solutions:
- CODE: GNSS with 30 second clocks, every 5 min. CRD
- swisstopo: GPS with 30 second clocks, every 30 sec. CRD
All solutions: ZIM2 June 19

ZIM2 North 19.06.2013

ZIM2 East 19.06.2013
All solutions: ZIM2 June 19

Common mode residuals for PPP!
GNSS slightly less epoch-to-epoch noise

ZIM2 North 19.06.2013

ZIM2 East 19.06.2013
Conclusions

• 9-Meter mast movements of peak-to-peak
  - 8 mm horizontally during hot, sunny days
  - 2 mm vertically (temperature depended dT)
  - Terrestrial estimation precision of ~0.2 mm!

• Daily mean horizontal positions + night observations are not biased -> local tie measurements under cloudy condition

• GNSS not able to reliably measure these horizontal movements
  - GNSS kinematic baselines L1
    ▪ Std of 2 mm horizontally, but not precise enough
    ▪ GNSS kin. results less noise compared to GPS-only
  - PPP kinematic solutions GNSS+GPS
    ▪ Std of 10 mm horizontally
    ▪ Attractive for larger movements (>5 cm) without reference stations
Thank you for your attention!