FIG WORKING WEEK 2017
Helsinki Finland
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Potential of detecting dynamic motion by analysing SNR of GPS satellite signals

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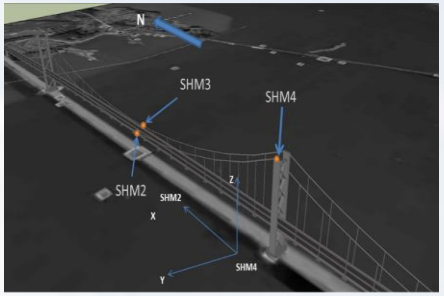
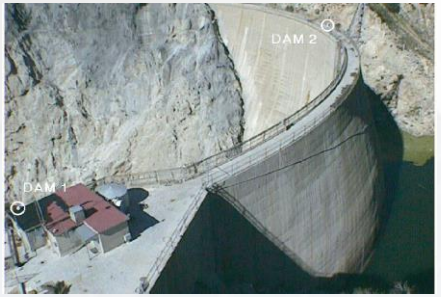
GPS in Structural Health Monitoring

Applications of GPS in deformation monitoring:



Forth Road Bridge (ESA/ARTES)


Lotte World Tower (GPS World 2015)

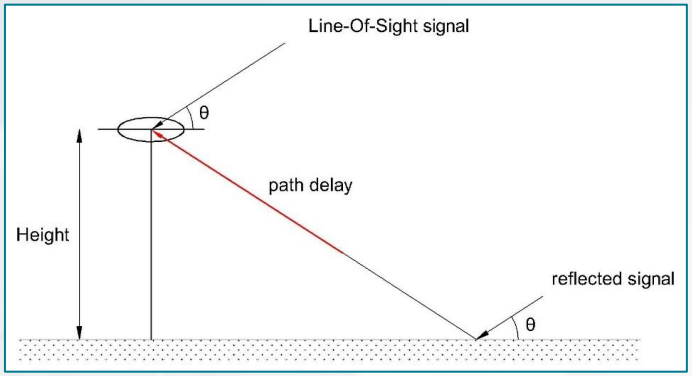


Pacoima Dam (Hudnut & Behr)

- Multipath interference is one of the greatest GPS error sources is structural monitoring.
- State-of-the-practice: Filtering out low frequencies usually < 0.1 Hz.

Drawback: Important structural information neglected.

GNSS – Reflectometry

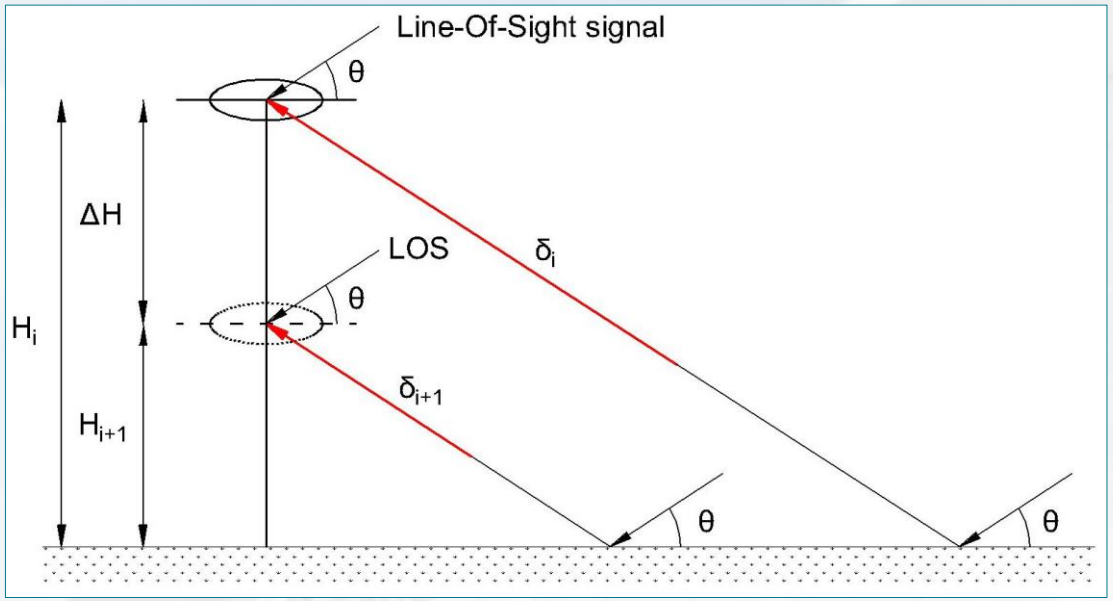


Using the signal-to-noise ratio (SNR) of the GPS signal to:

- Map the multipath environment (Bilich and Larson 2008).
- Retrieve soil moisture (Chew et al. 2014, Roussel et al. 2016).
- Monitor vegetation growth (Small et al. 2010).
- Estimate sea and snow level variations, etc. (Larson et al. 2009, Lofgren et al. 2014).

$$\mathrm{SNR} = \frac{\text{direct} + \text{reflected signal } power}{\text{noise power}}$$

Can it be used to detect displacement?



Vertical antenna vibrations

↓

Reflected signal delay variations

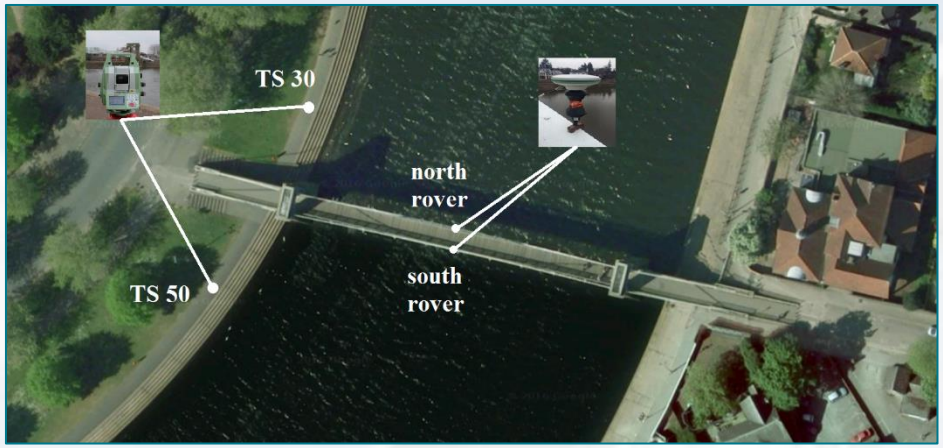
↓

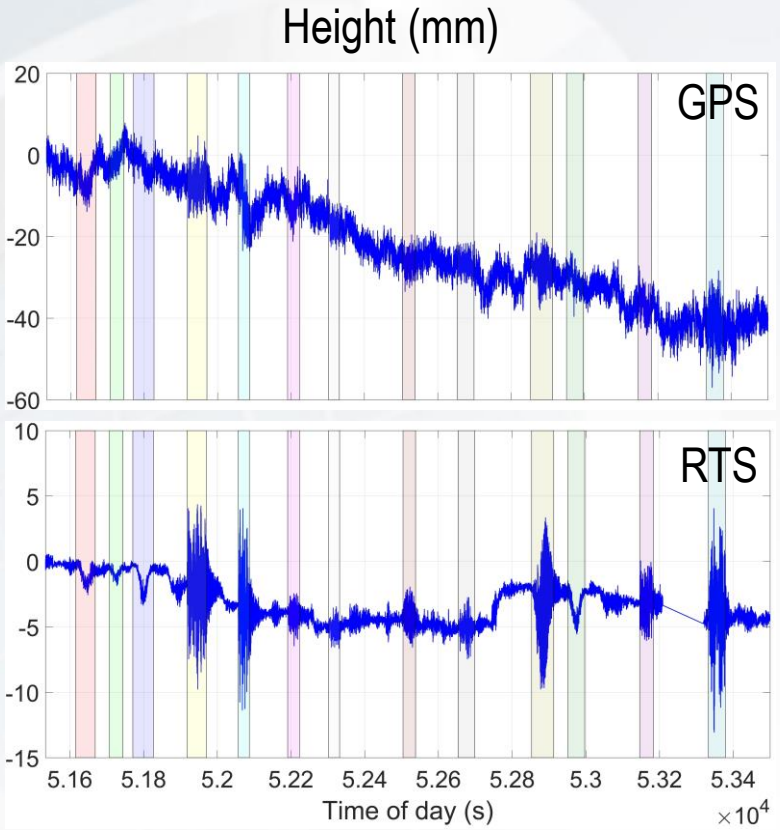
Composite signal power variations

↓

SNR variations

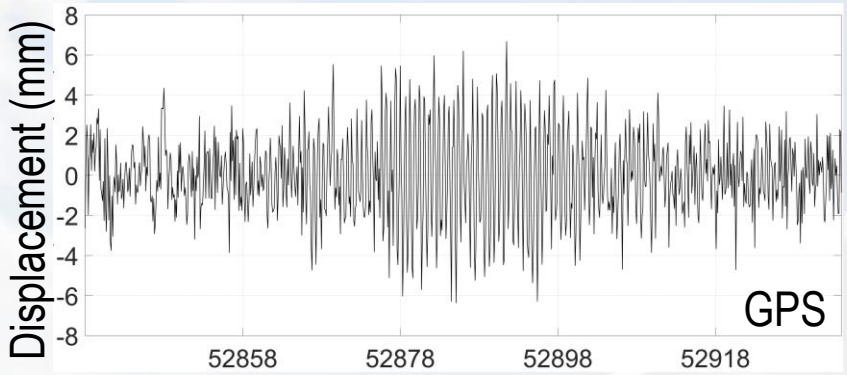
The Wilford Bridge monitoring

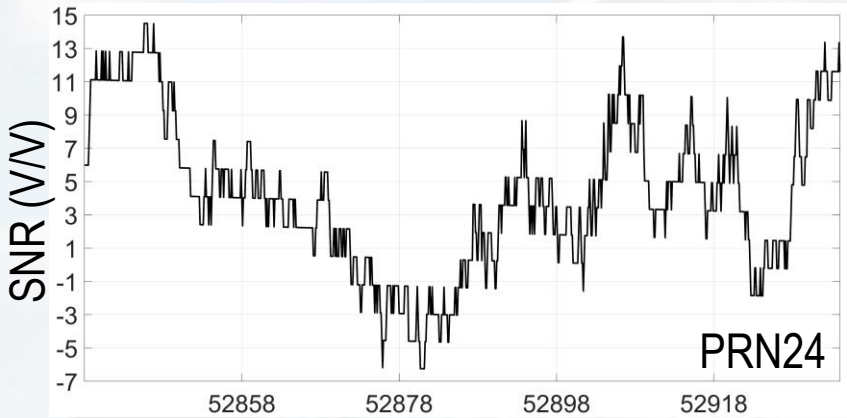




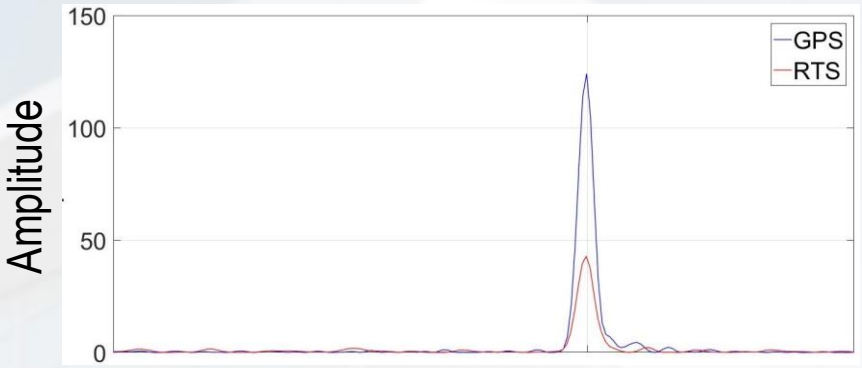
- Pedestrian suspension bridge
- 68.5 m length, 3.6 m width
- Main modal frequency: 1.64 Hz
- GPS/RTS Sampling rate: 10 Hz

The marching excitation

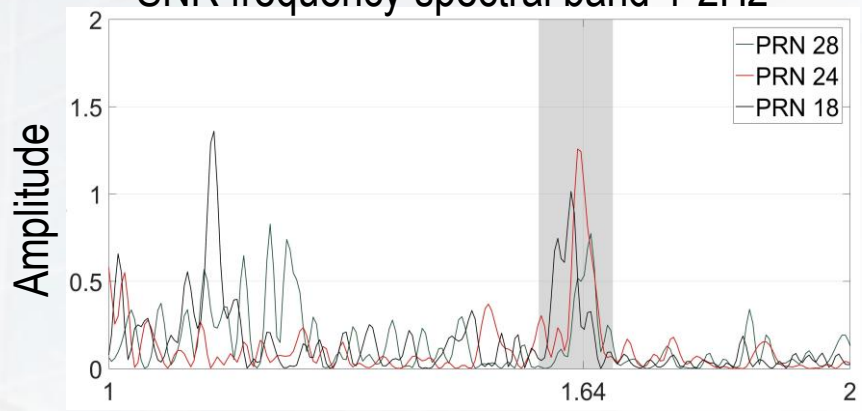




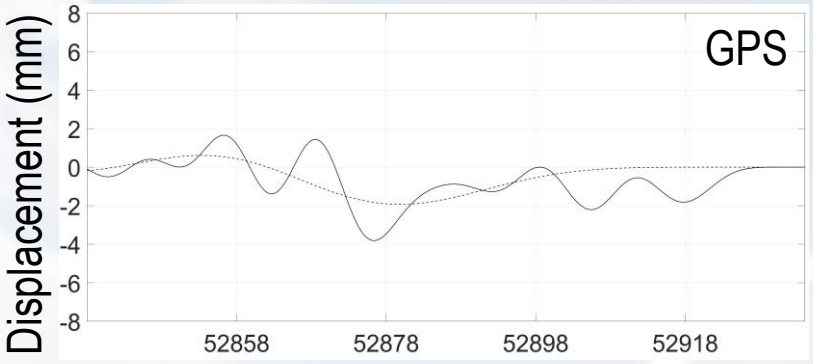
GPS/RTS frequency spectral band 1-2Hz

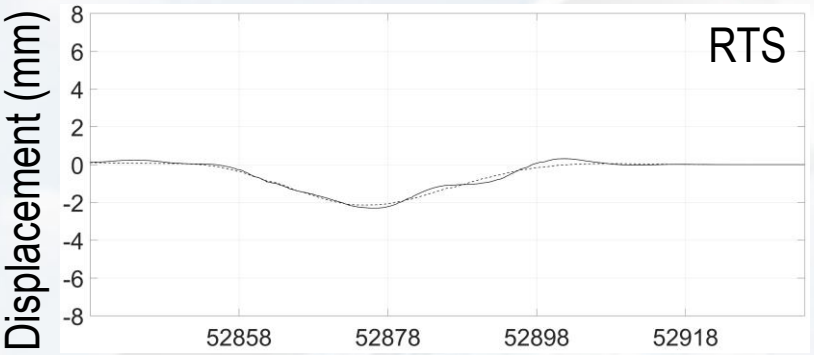


SNR frequency spectral band 1-2Hz



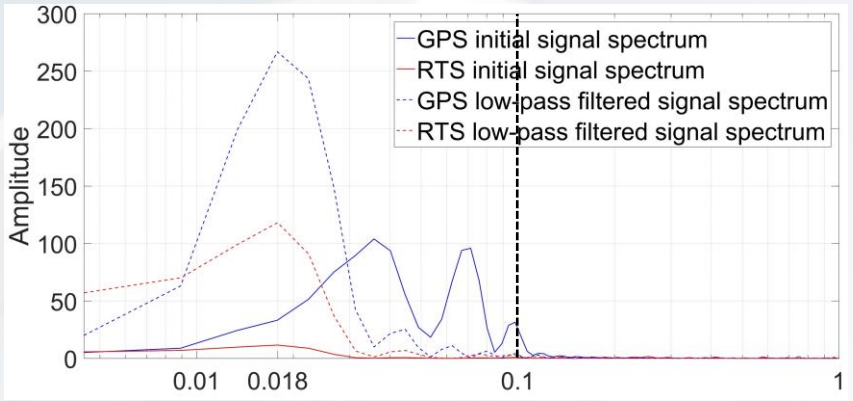
The marching excitation



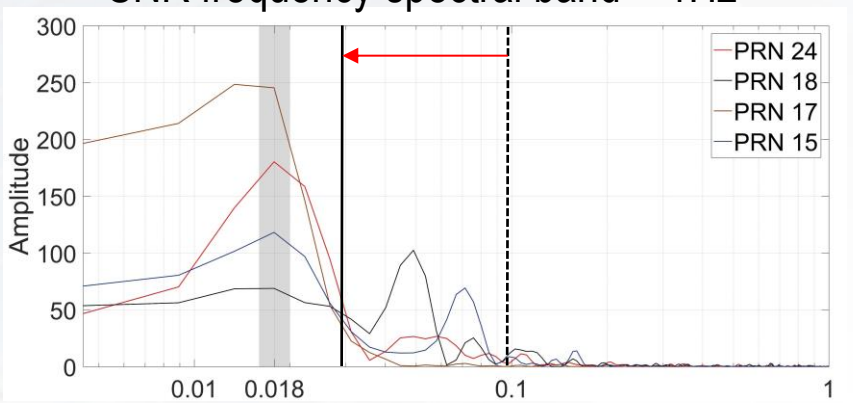


Time of day (s)

GPS/RTS frequency spectral band < 1Hz

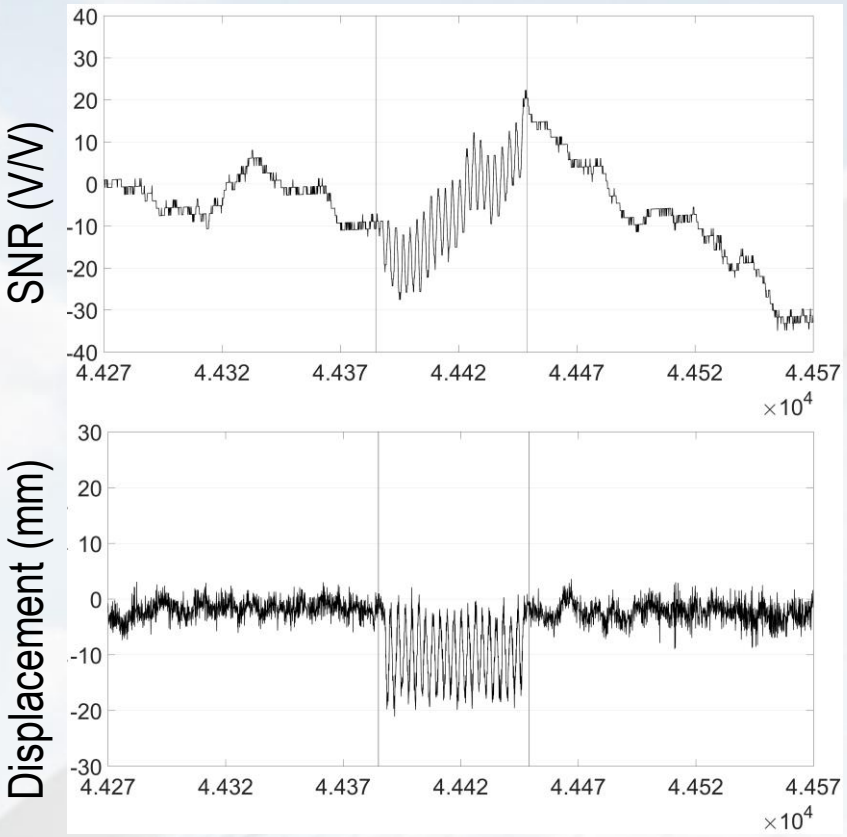


SNR frequency spectral band < 1Hz

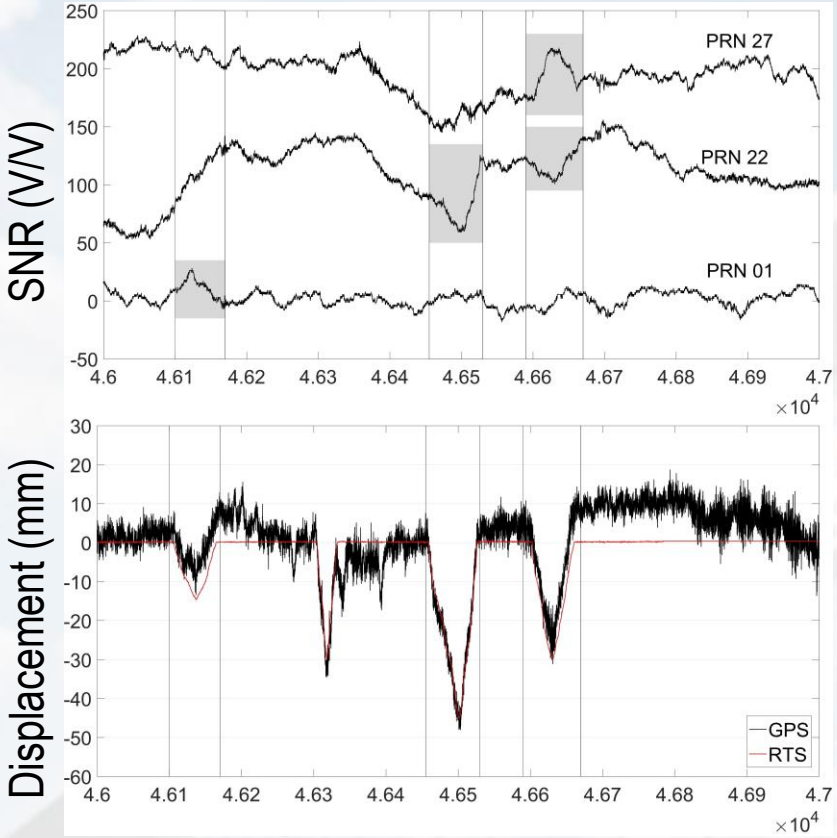


Frequency (Hz)

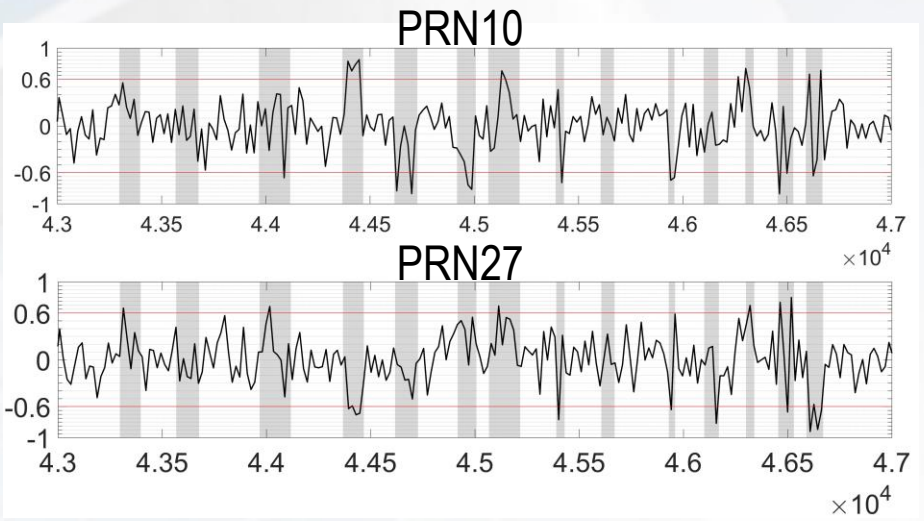
Experiments of vertical antenna motion



Experiments of vertical antenna motion



Displacement-SNR time series correlation



Potential of using SNR of the GPS signal to detect dynamic motion

Proven SNR sensitivity to:

- ✓ Few-mm antenna motions.
- ✓ Wide range of antenna motion frequencies.
- ✓ Complex structural response.

Applications:

- Cases of unreliable or no fixed GPS positioning solution.
- Detection of very low-frequency motions (< 0.1Hz).
- Detection of motion intervals.