Contribution of the Galileo system to space geodesy and fundamental physics

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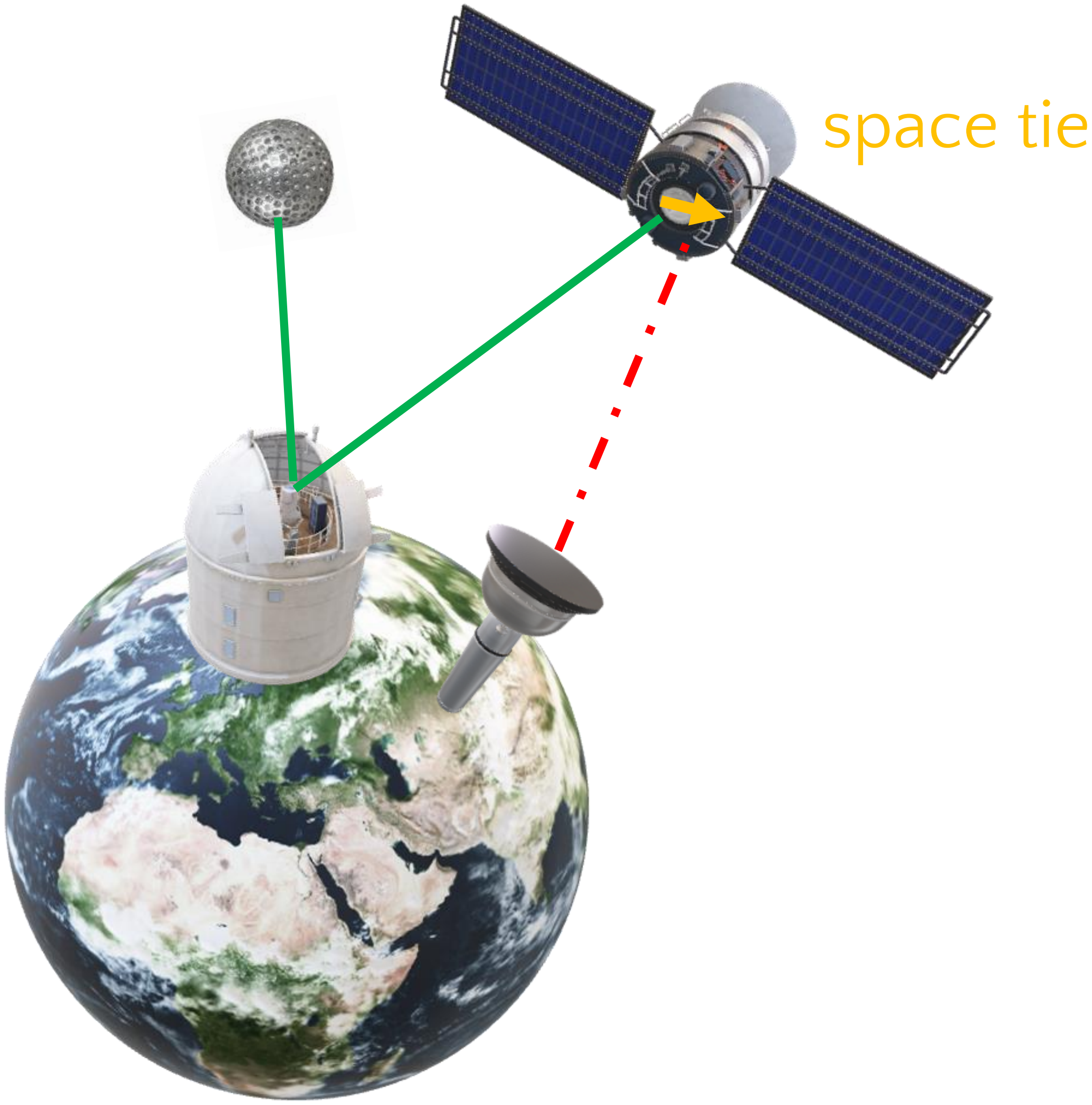
Advantages of the Galileo system

- Available metadata for precise orbit determination (box-wing)
- Absolute antenna calibrations -> potential to realize the scale of the reference frame
- Weak resonances with Earth rotation (17:10) resulting in the possibility of the recovery of diurnal and semidiurnal tidal signals in geodetic parameters (as opposed to GPS)
- High accuracy of broadcast ephemeris for real-time users -> PPP possible
- GNSS-SLR Co-location in space

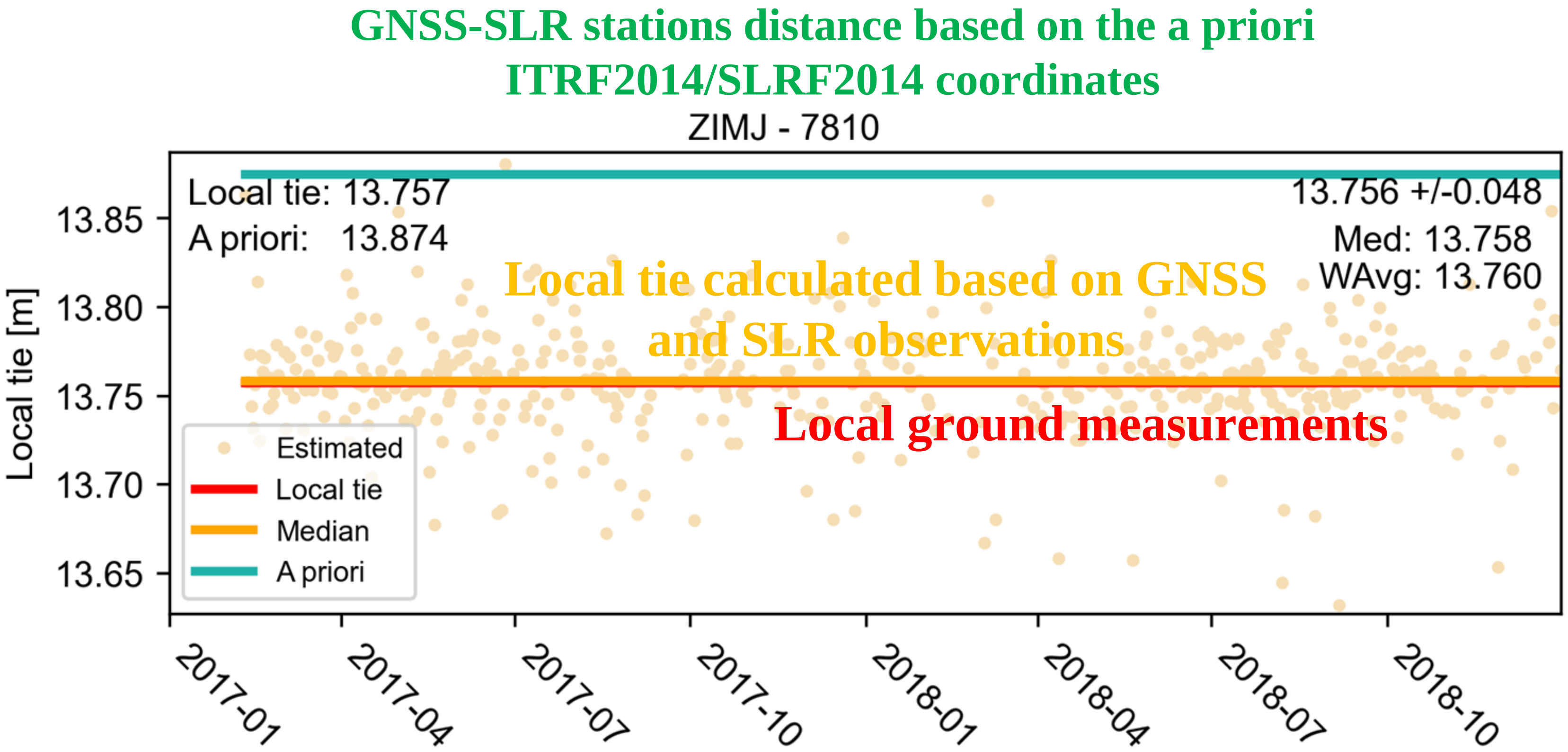


Co-location in space

Local tie reconstructed based on a space tie onboard Galileo

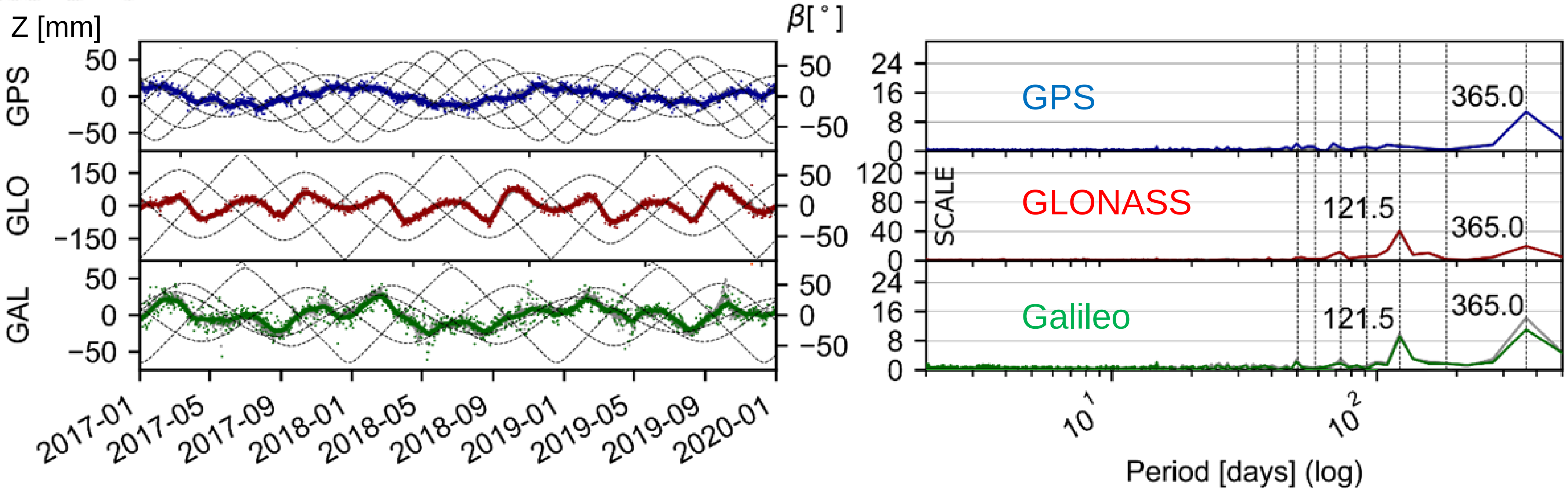
- The tie between GNSS and SLR is provided every time when an SLR station tracks Galileo

- The ground-based local tie in Zimmerwald: 13.757 m, whereas the mean vector reconstructed based on space tie: 13.756 m (difference of 1 mm with STD of 48 mm for a single measurement)



Bury G., Sośnica K., Zajdel R., Strugarek D., Hugentobler U.
Geodetic datum realization using SLR-GNSS co-location onboard Galileo and GLONASS
Journal of Geophysical Research - Solid Earth, Vol. 126 No. 10, 2021
DOI: 10.1029/2021JB022211

Geocenter from GPS, GLONASS, and Galileo – the Z component



- More orbital planes are preferable for the geocenter recovery -> reduced correlations with orbit parameters
- Galileo-based geocenter motion shows the signal of the 3rd harmonic of the draconitic year (121.5 days), however, the amplitude is about 5 times smaller than for the same signal for GLONASS, despite the same number of nominal orbital planes
- The combination of GPS and Galileo seems to be the optimum solution for the geocenter recovery, however the amplitude of the annual signal is still larger in GNSS than that from SLR

Zajdel R., Sośnica K., Bury G.
Geocenter coordinates derived from multi-GNSS: a look into the role of solar radiation pressure modeling
GPS Solutions, Vol. 25 No. 1, 2021, DOI: 10.1007/s10291-020-01037-3

Length-of-Day from GPS, GLONASS and Galileo – daily solution

- **Aliasing of sub-daily tidal signals:**
  14.8 days (M_2), 14.2 days (O_1)
  -> visible for all systems

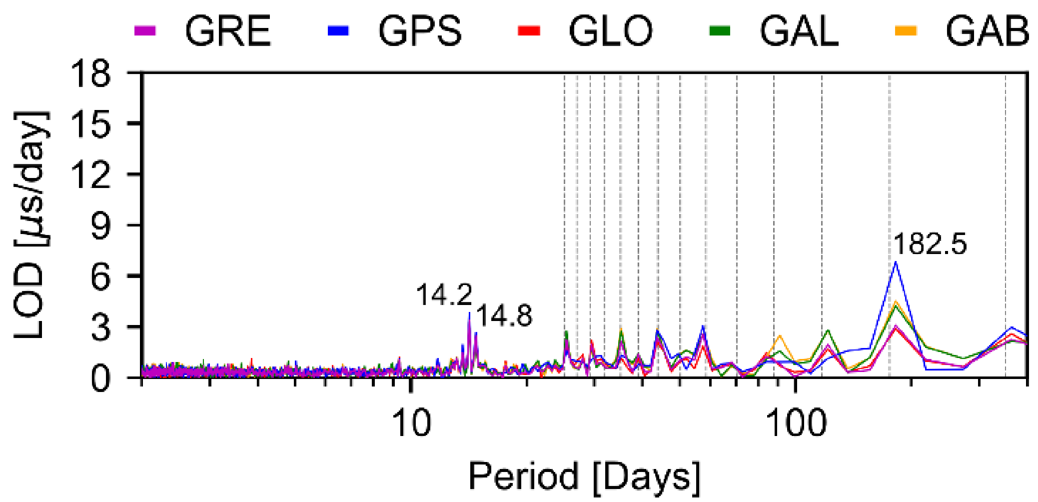
- GPS shows a semi-annual signal in 3-day LoD solutions

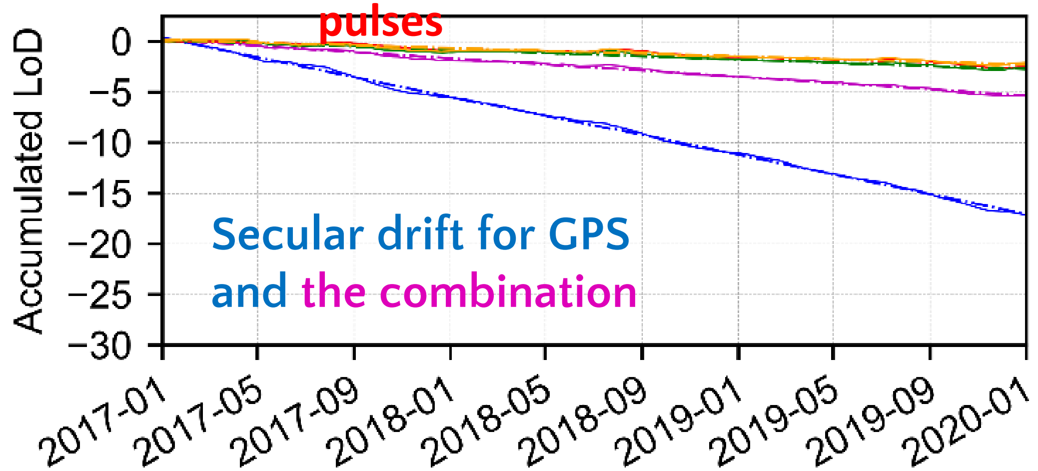
- **Drift in GPS-based accumulated LoD**

- **GLONASS and Galileo**
  up to 16 times lower drift in LoD

GAB denotes Galileo-only solution based on box-wing model & ECOM1
GAL denotes Galileo-only solution based on ECOM2
GRE denotes GPS+GLONASS+Galileo based on ECOM2

FFT of differences w.r.t. C04 series

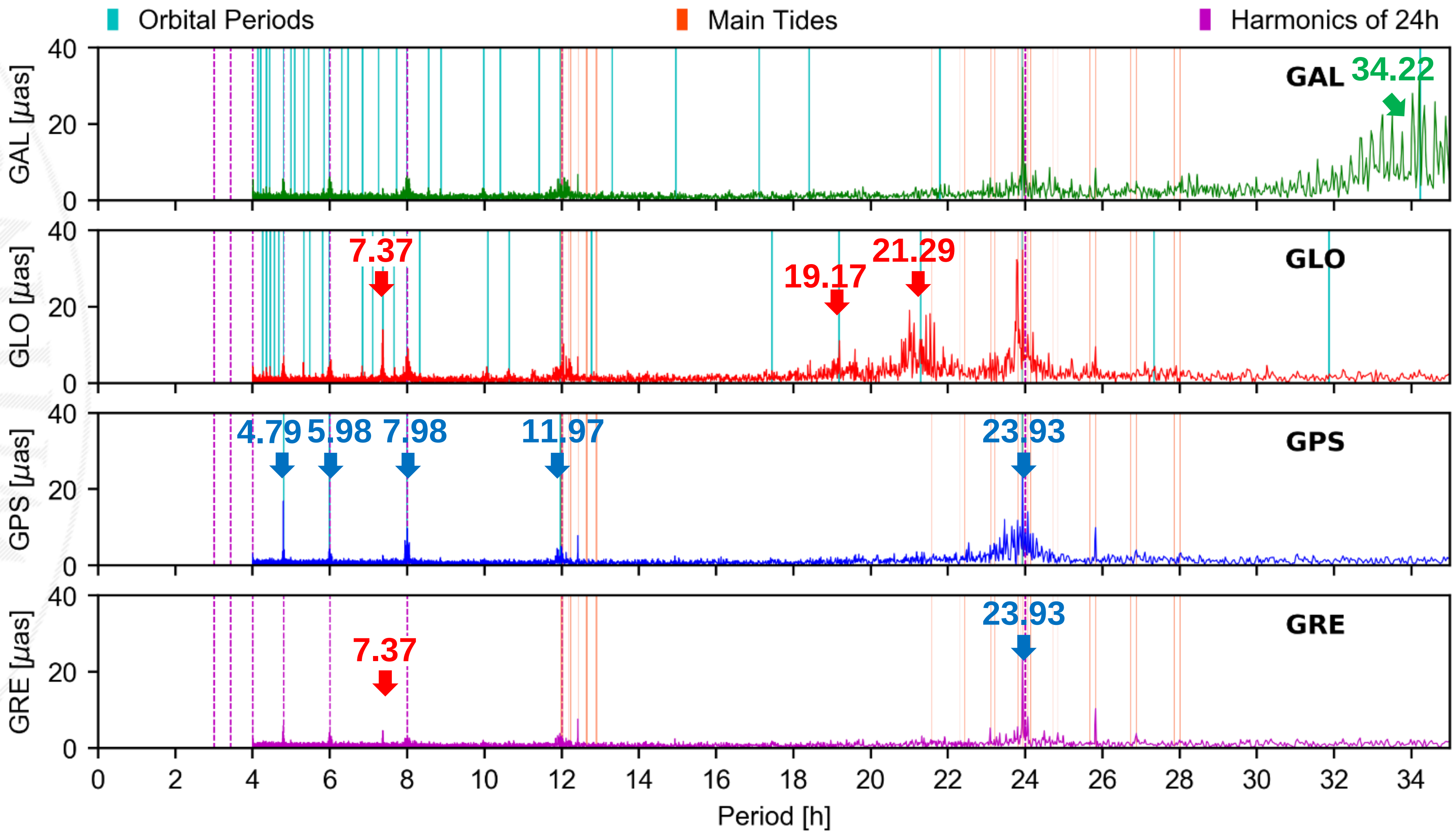




Zajdel R., Sośnica K., Bury G., Dach R., Prange L.
System-specific systematic errors in earth rotation parameters derived from GPS, GLONASS, and Galileo
GPS Solutions, Vol. 24 No. 74, 2020 DOI: 10.1007/s10291-020-00989-w

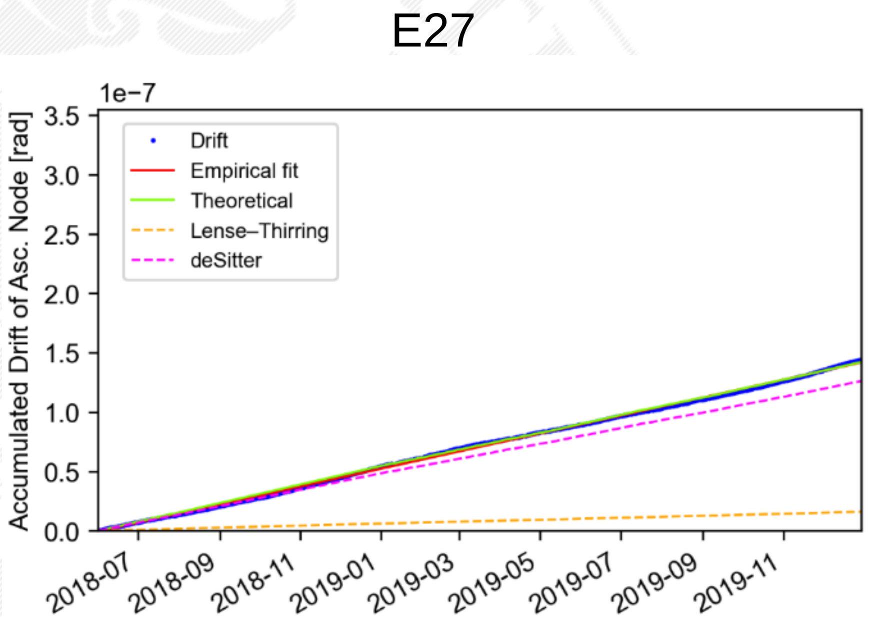
Sub-daily polar motion from Galileo, GLONASS, and GPS – prograde domain

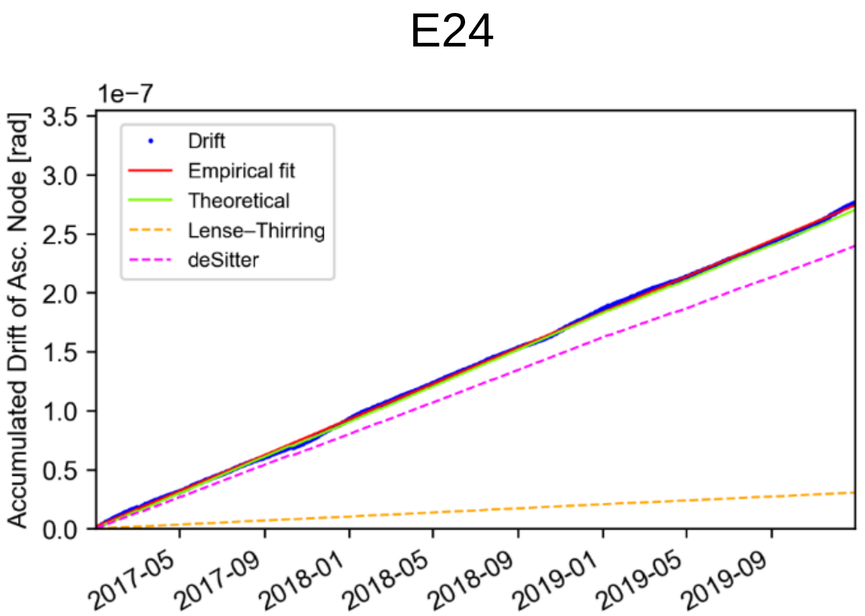
- Existence of artifacts at orbital resonances at diurnal and semidiurnal terms for GPS (K_1, K_2)
- Amplitudes (differences w.r.t. a priori model) reach 20–30 µas
- 3-day arc reduces the amplitudes of orbital artifacts by up to 20–30% w.r.t. 1-day solutions

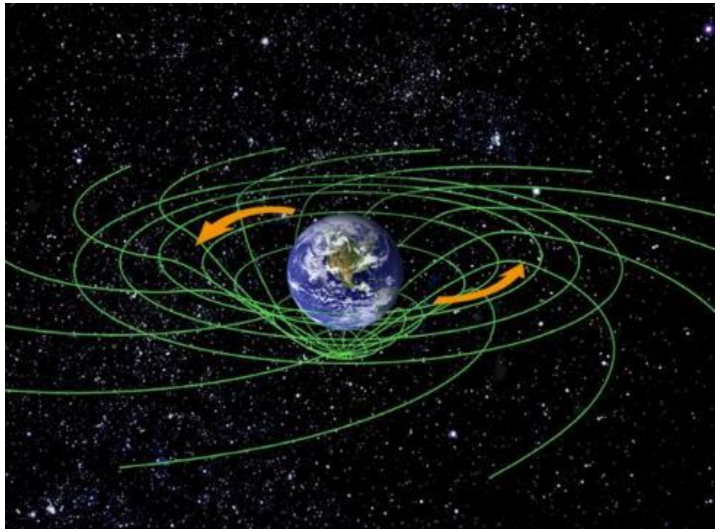


Zajdel R.,, Sośnica K., Bury G., Dach R., Prange L., Kaźmierski K.
Sub-daily polar motion from GPS, GLONASS, and Galileo
Journal of Geodesy, Vol. 95 No. 3, 2021, DOI: 10.1007/s00190-020-01453-w

General Relativistic (GR) orbital effects







Lense-Thirring (frame dragging) and De Sitter

Verification of the Lense-Thirring and De Sitter GR effects using Galileo satellites.
Differences of the accumulated drift of ascending node between a solution without GR effects and a solution with estimating Post-Newtonian parameters as free parameters.

A perfect agreement (error of 0.27%) between the predicted sum of Lense-Thirring and De Sitter and the observed drifts.

Sośnica K., Bury G., Zajdel R., Ventura-Traveset J., Mendes L.
GPS, GLONASS, and Galileo orbit geometry variations caused by general relativity focusing on Galileo in eccentric orbits. GPS Solutions, Vol. 26 No. 5, 2022, DOI: 10.1007/s10291-021-01192-1

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Galileo- summary

Geodetic parameters, include **artificial orbital signals** with periods resulting from **the resonance between the Earth rotation, satellite revolution period** (and the tidal signals).

Geocenter – best combination: GPS+Galileo

Sub-daily ERPs – best combination: multi-GNSS or Galileo (GPS alone is problematic)

Daily pole coordinates: GPS or the multi-GNSS combination

Length-of-day: GPS shows large offsets – Galileo is much better

General Relativistic effects – multi-GNSS combination de-correlates Post Newtonian Parameters from orbital parameters (making use of different heights and inclination angles of GPS, GLONASS, Galileo, and Galileo in eccentric orbits)

The relevance of the GPS, GLONASS, and Galileo constellation for deriving selected geodetic parameters ● – a major system, ◐ – a supporting system, ○ – significant errors in the parameter.

GPS	GLONASS	Galileo
	Geocenter recovery	
◐	○	◐
	PM	
●	◐	◐
	LoD	
○	◐	●
	Sub-daily variations in PM	
◐	◐	●

Thank you for your attention!

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