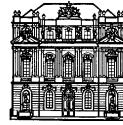




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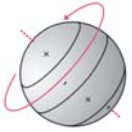


DOC - FFORTE [DOKTORANDENPROGRAMM DER
ÖSTERREICHISCHEN AKADEMIE DER WISSENSCHAFTEN]

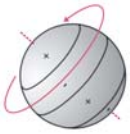
*Empirical validation of the conventional
model for length of day variations
due to zonal tides*

Sigrid English

R. Weber, H. Schuh

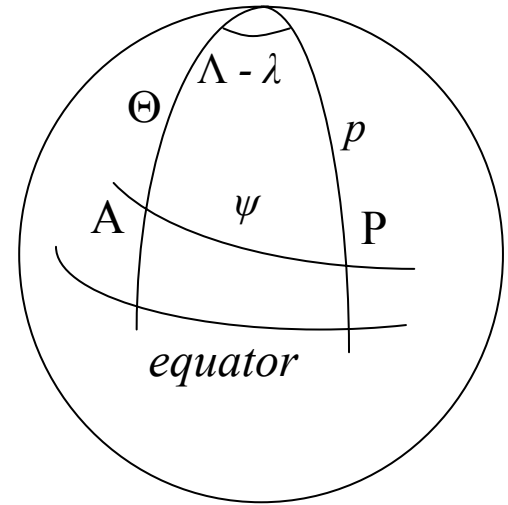
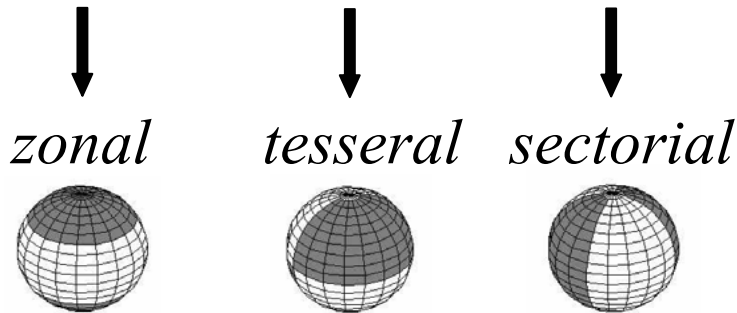


- Investigation of LOD variations due to zonal tides observed by VLBI and GPS.
 - Tidal potential
 - LOD series from VLBI observation data
 - LOD series from GPS observation data
 - Estimation of the amplitudes - approach
 - Signal content - spectral analysis
 - Comparison with IERS model and conclusions



Tidal potential

$$V_{G,2} = V_{G,20} + V_{G,21} + V_{G,22}$$



$$V_{G,20} = GM \frac{R^2}{r^3} P_{20}(\cos \theta) P_{20}(\cos p)$$

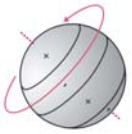
$$V_{G,21} = \frac{1}{3} GM \frac{R^2}{r^3} P_{21}(\cos \theta) P_{21}(\cos p) \cos(\Lambda - \lambda)$$

$$V_{G,22} = \frac{1}{12} GM \frac{R^2}{r^3} P_{22}(\cos \theta) P_{22}(\cos p) \cos 2(\Lambda - \lambda)$$

→ long-period tides

→ diurnal tides

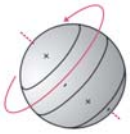
→ semi-diurnal tides



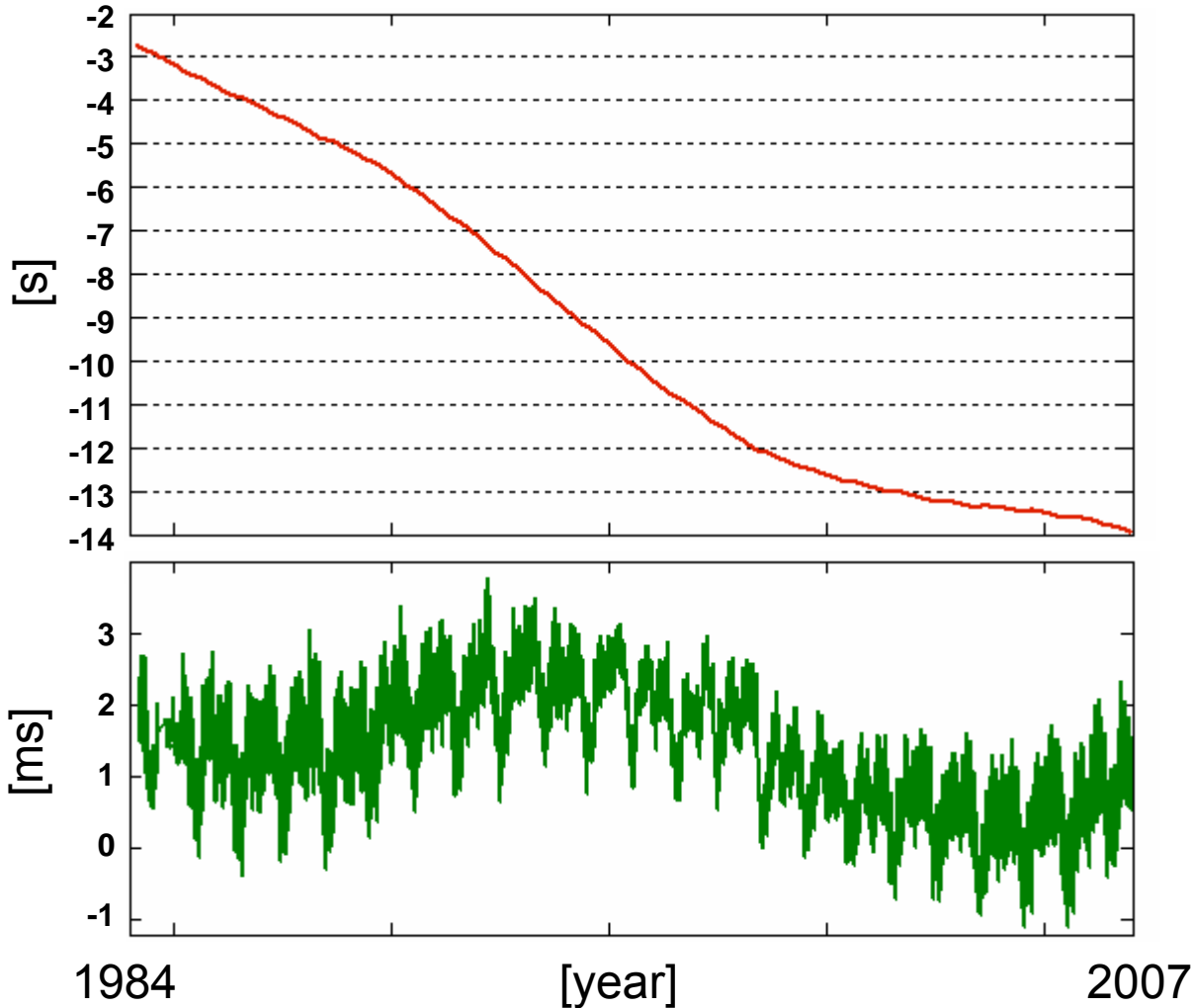
VLBI – data analysis

- Observation data (time span: 1984 – 2006)
 - All geodetic VLBI sessions (24h), except sessions which are not suitable for the determination of Earth orientation parameters
 - Intensive Sessions (1h) - (INT1, INT2)
- Software: OCCAM V.6.1
- Models / a priori values
 - Nutation: IAU 2000
 - Subdaily ERP variations: IERS 2003
 - Ocean loading: FES2004
 - A priori ERP: IERS C04 05
- Reference frame: ITRF2005, ICRF
- dUT1 – one estimate per session → ***LOD***

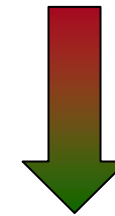




VLBI – dUT1/LOD time series

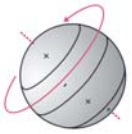


■ dUT1 series
concatenated
(leap seconds
subtracted)



converted to

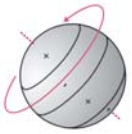
■ LOD series
(23 years)



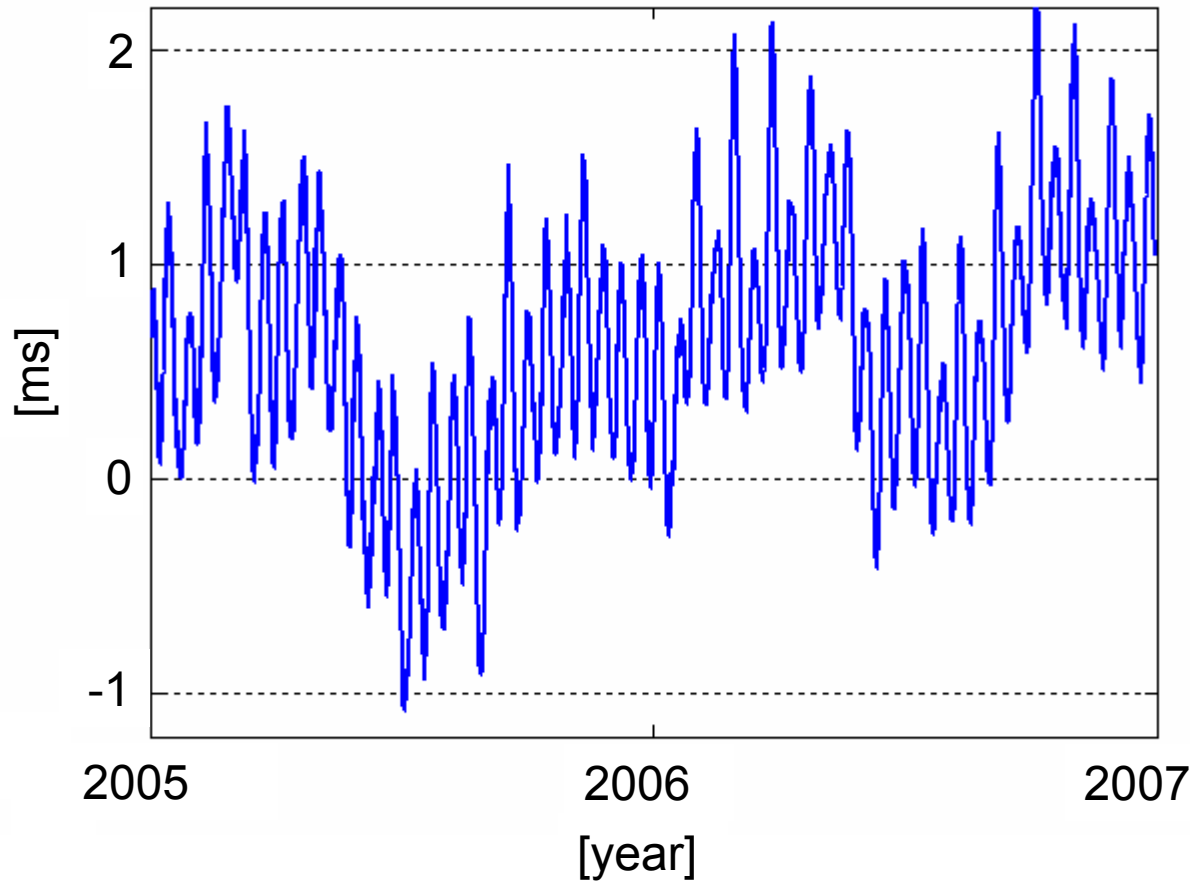
GPS – data analysis

- Observation data: 113 IGS stations (time span: 2005 – 2006)
- Software: Bernese GPS Software V.5.0
- Models / a priori values
 - Nutation: IAU 2000
 - Subdaily ERP variations: IERS 2003
 - Ocean Loading: FES2004
 - Absolute antenna phase-centres
 - A priori ERP: CODE
- Reference frames
 - IGS05 No-Net-Rotation, CODE-orbits
- **LOD** – time resolution 6h

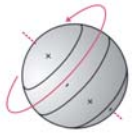




GPS – LOD time series

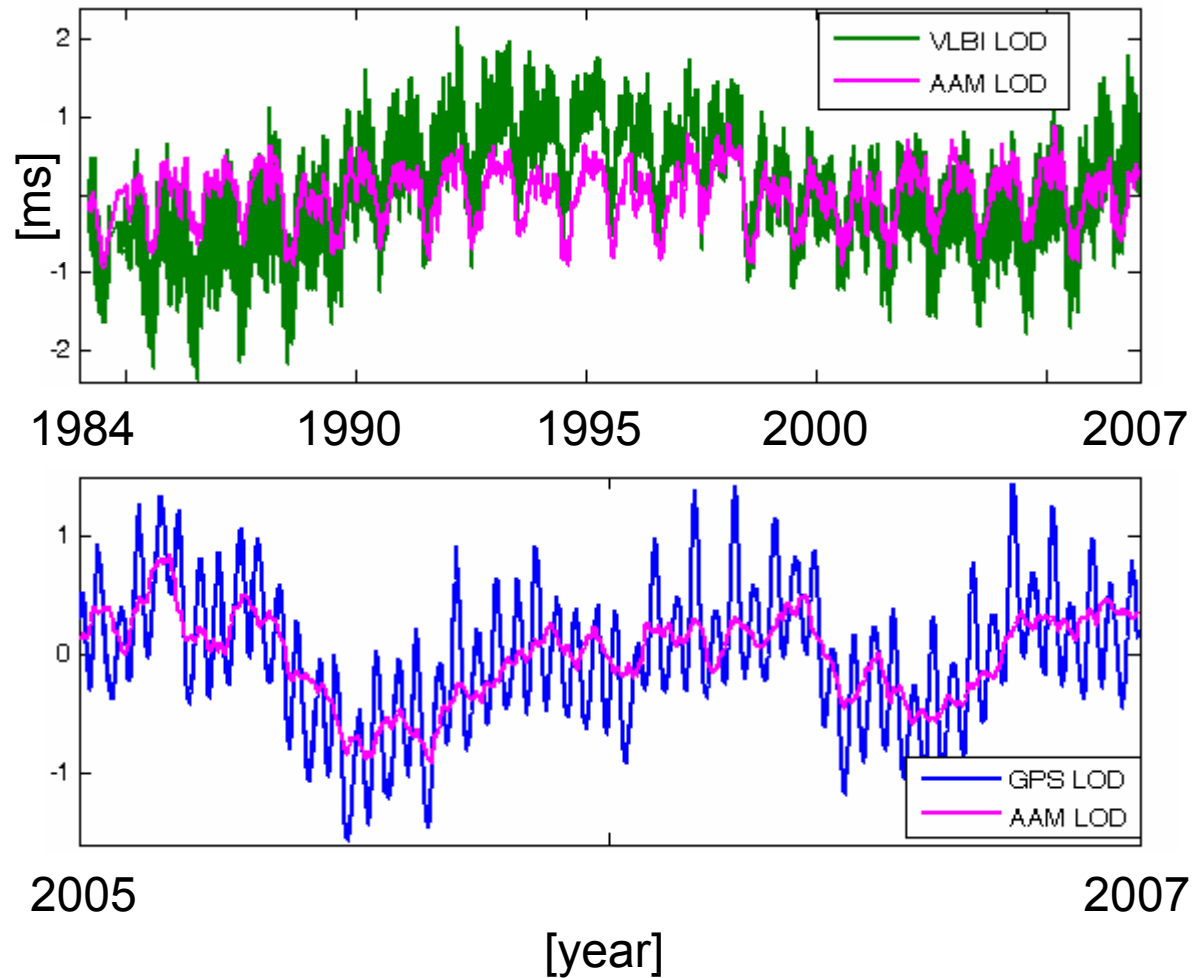


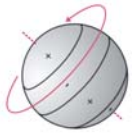
■ LOD series
(2 years)



Signal pre-processing

- Removal of variations induced by atmospheric excitation (calculated from atmospheric angular momentum functions of NCEP)
- Subtraction of linear trends and low frequency signal





Determination of zonal tidal terms

■ IERS model (Defraigne and Smits, 1999):

- 62 terms, periods 5.64 days – 18.6 years

■ Amplitude estimation: least squares adjustment

- LOD variations as pseudo-observations

$$\delta LOD = \sum_{i=1}^n A_i \cos \xi_i \left(+ B_i \sin \xi_i \right) \quad \xi_i = \sum_{j=1}^5 a_j \alpha_j \quad n \dots \text{number of tidal waves}$$

- VLBI ΔLOD : 10 major terms + 20 sideband terms + 1 test term

- Periods from 6.85-365.26 days (test period 16.63 days)

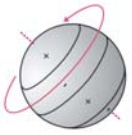
- GPS ΔLOD : 8 major terms + 17 sideband terms + 1 test term

- Sidebands differ by 1 or 2 cycles in 18.6 years (considered as fractions of main terms)

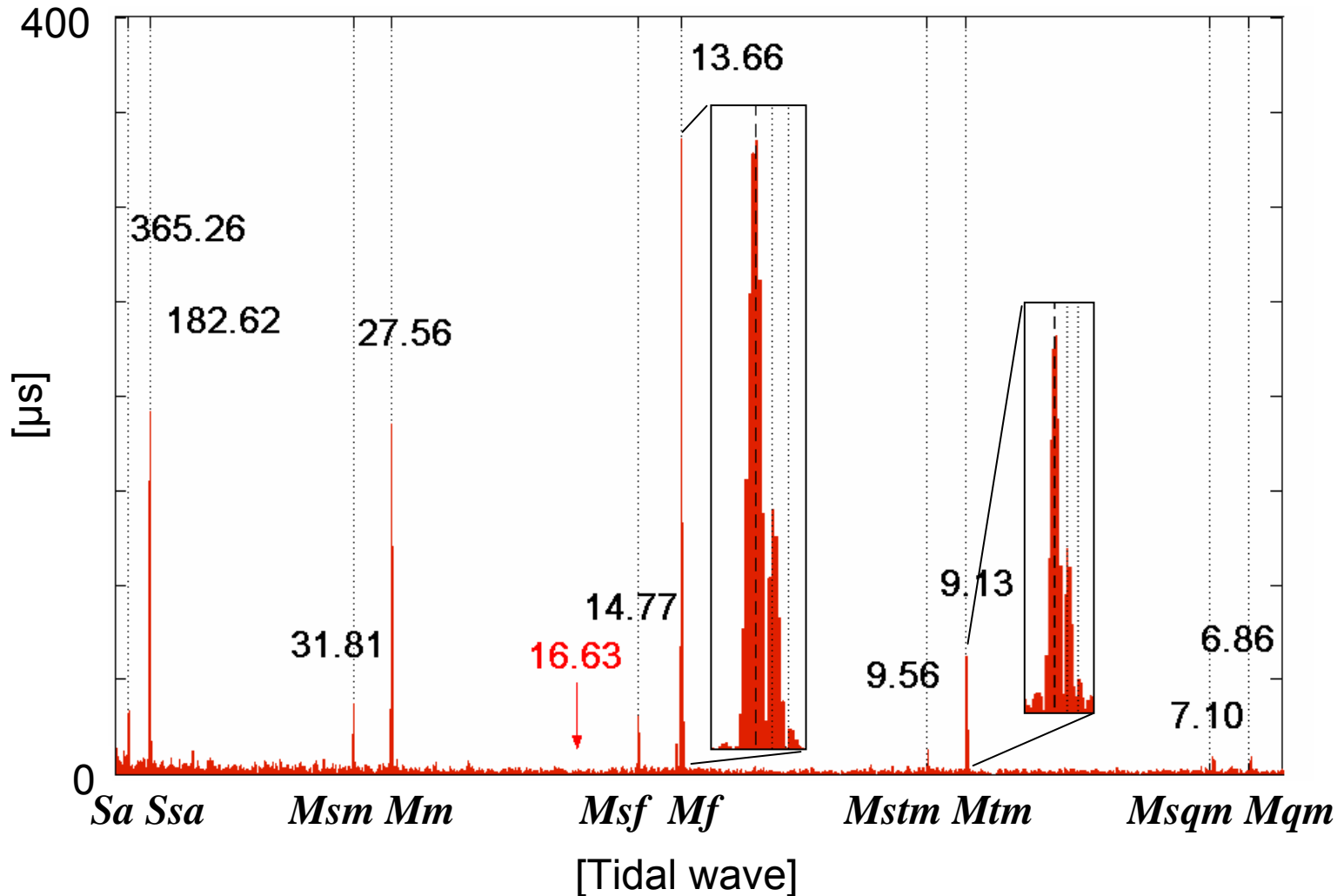
- Relative size of excitation proportional to relative size of the amplitude of the waves in the tidal potential

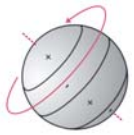
- Periods from 6.85-31.96 days (test period 16.63 days)

$$A_{Mf'} = \frac{V_{Mf'}}{V_{Mf}} A_{Mf}$$

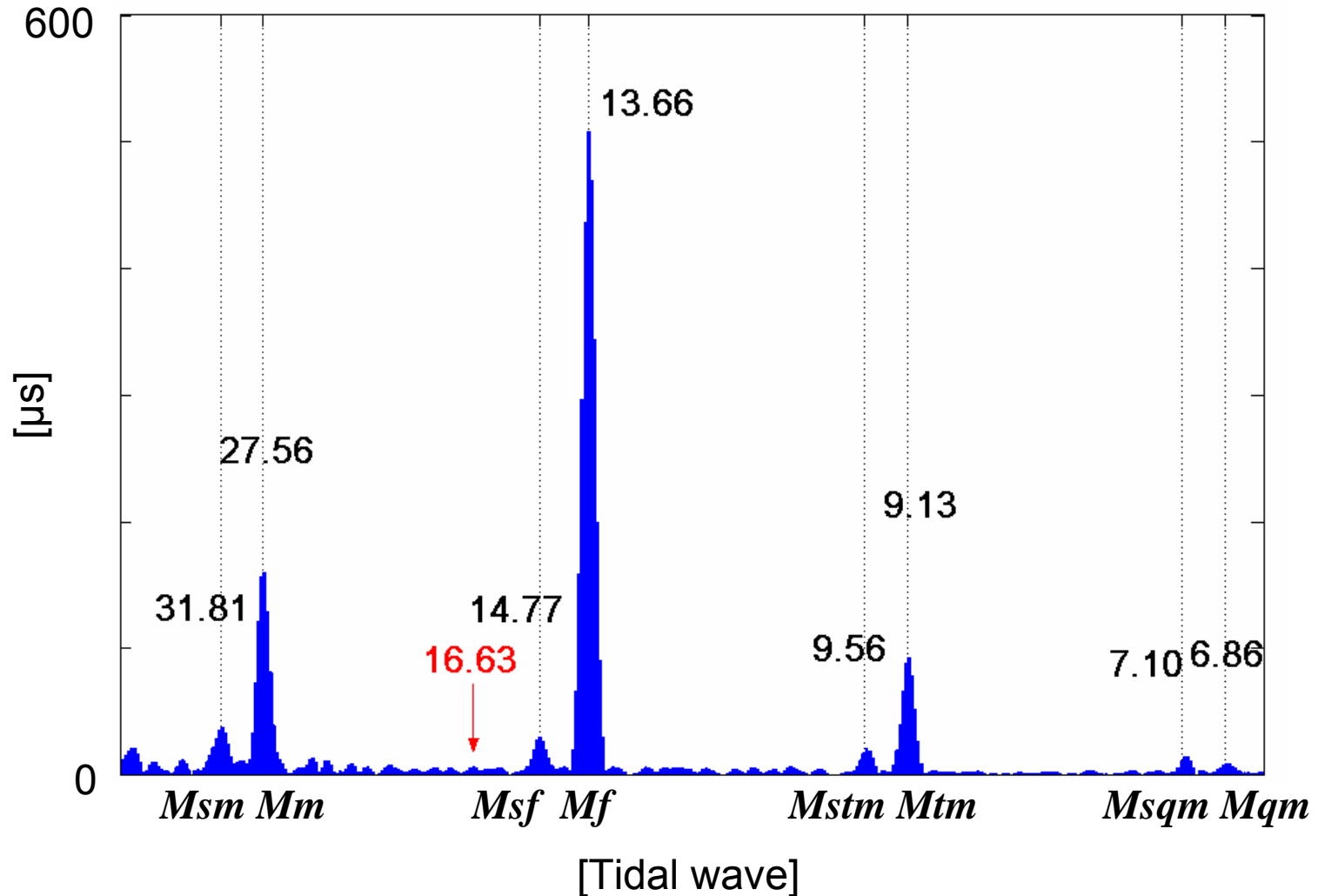


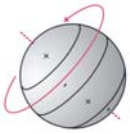
Amplitude spectrum – VLBI LOD





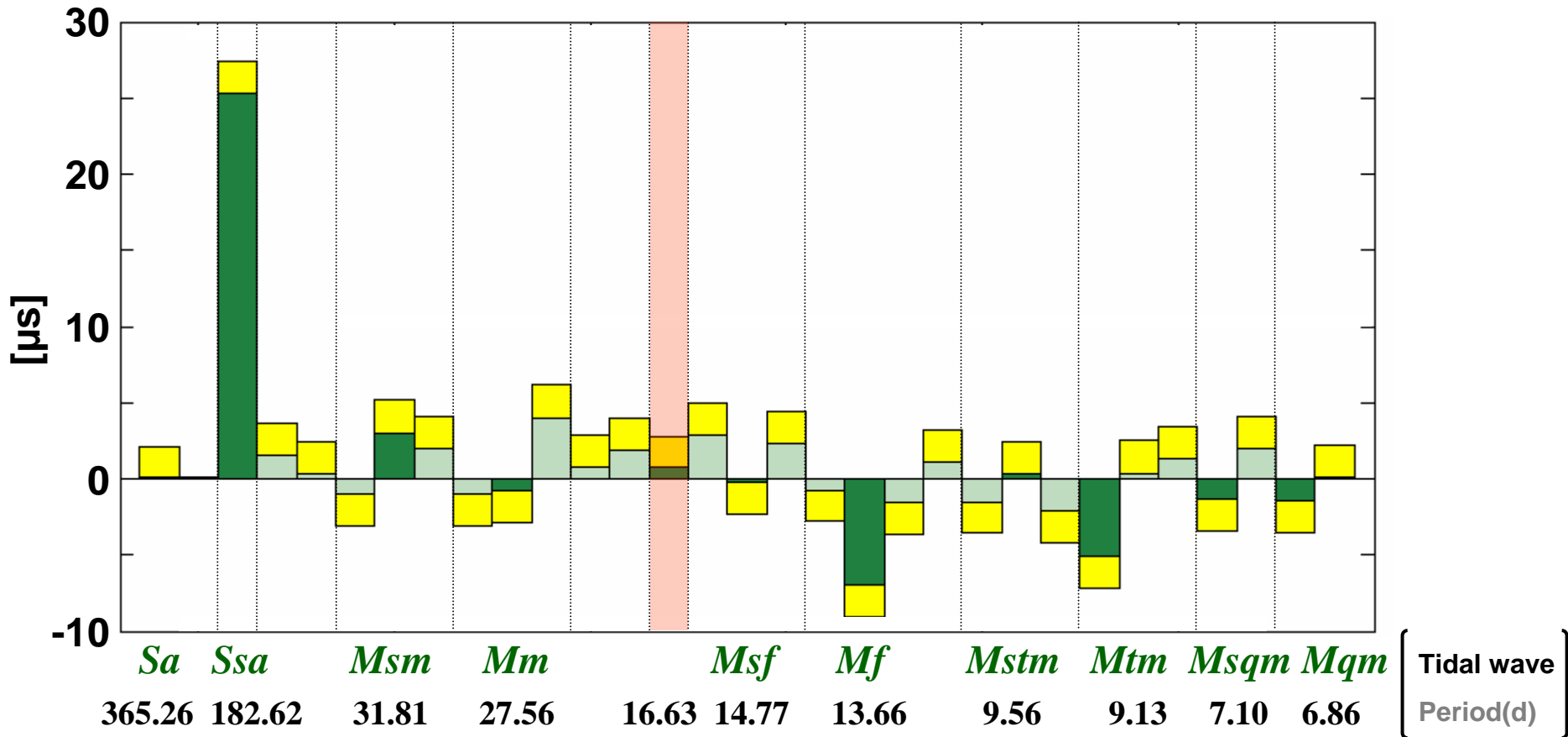
Amplitude spectrum – GPS LOD

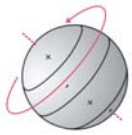




δ LOD observed – IERS 2003 model

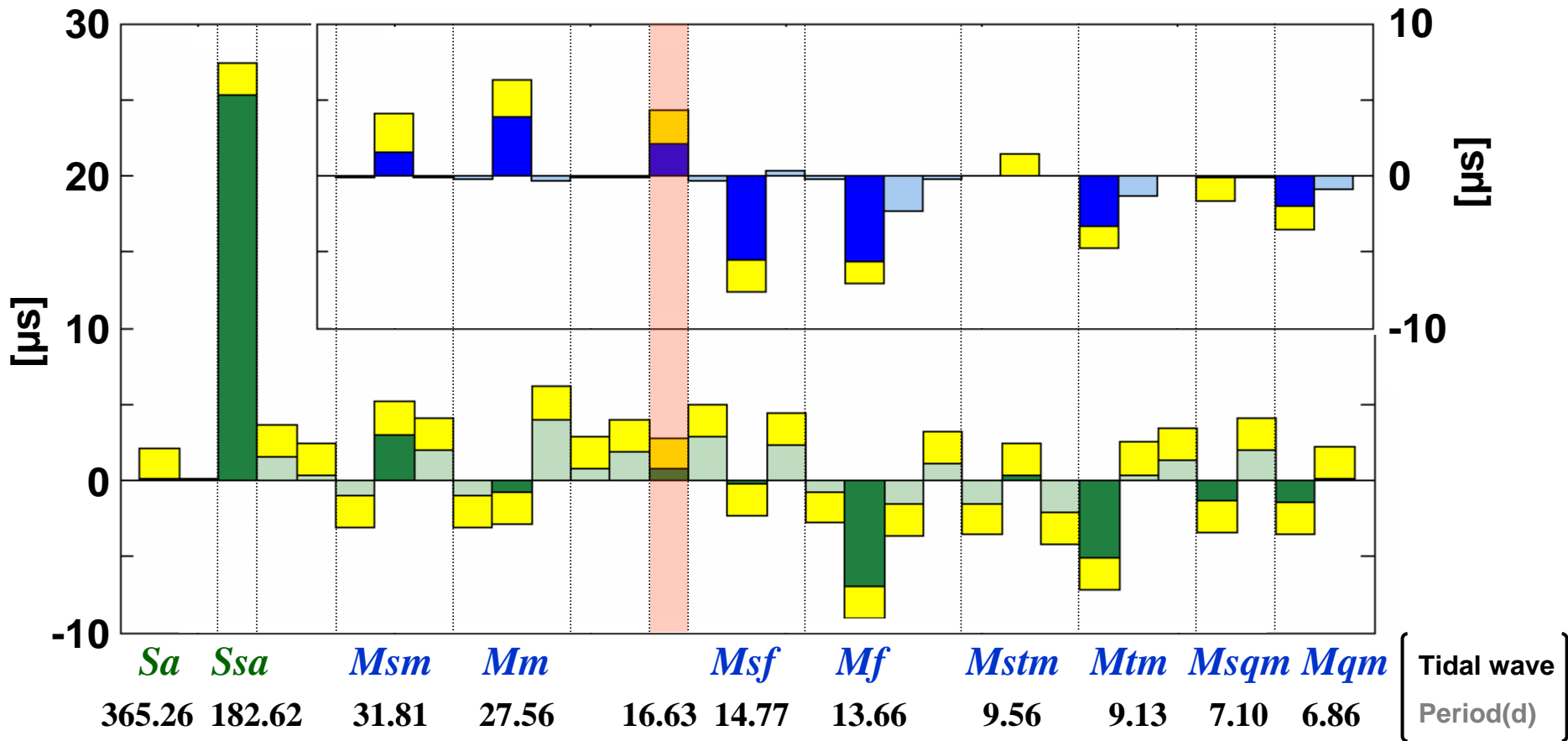
- main terms (VLBI)
- sideband terms (VLBI)
- formal errors
- test period

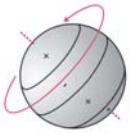




δ LOD observed – IERS 2003 model

- main terms (VLBI)
- main terms (GPS)
- formal errors
- sideband terms (VLBI)
- sideband terms (GPS)
- test period





Conclusions

- We investigated zonal tidal signals in length of day observed by VLBI and GPS
- The major part of the estimated amplitudes of the LOD variations matches the amplitudes predicted from the IERS model
 - Exceptions: - semi-annual term $S_{sa} \gg$ model amplitude
- M_f and M_{tm} terms $<$ model amplitude
 - Reason: excitation by geophysical fluids not fully considered?
- Terms which had to be constrained in the analysis of GPS-based LOD data could be clearly separated with the 23 years of VLBI LOD data
- The constraining of the sideband terms to the main terms, using the ratio of their amplitudes in the tidal potential, seems to be an appropriate method to account for the influence of the sidebands, if the time series is too short to separate them.

A 3D sphere with a light gray shading and a small 'x' on its surface. A red dashed line indicates a path or axis. A red solid line with an arrowhead at the top indicates a circular path or rotation around the sphere.

**Thank you for your
attention !**