Sub-diurnal Earth Rotation Variations Observed by VLBI

T. Nilsson H. Schuh J. Böhm S. Böhm A. Pany
L. Plank H. Spicakova K. Teke J. Wresnik

Institute of Geodesy and Geophysics
Vienna University of Technology

IERS Workshop on EOP Combination and Prediction
Warsaw, 19–21 October, 2009

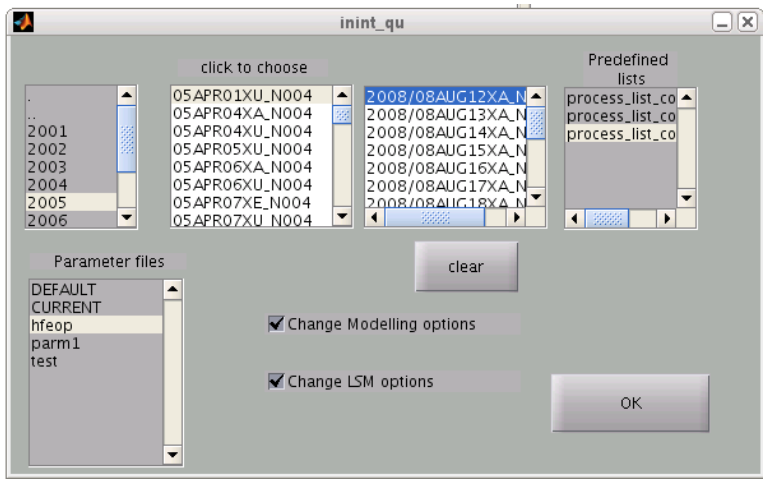
Outline

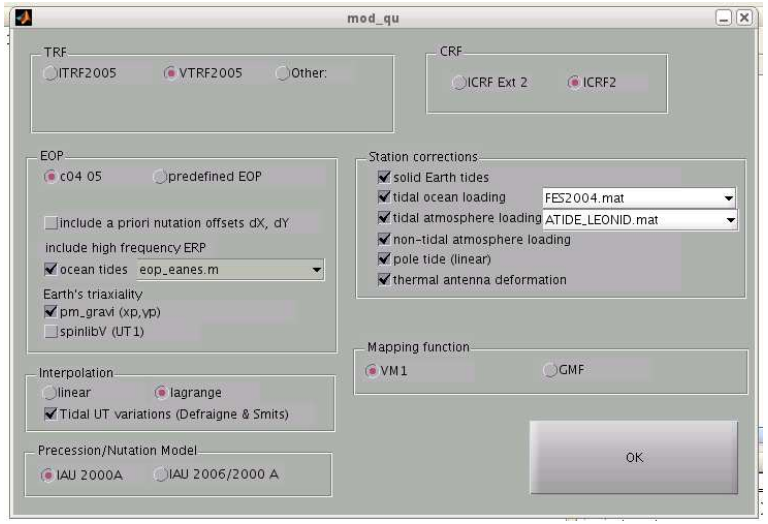
Introduction

- Continuous VLBI campaigns – like CONT02, CONT05, and CONT08 – provides good data sets for studying high frequency variations in the Earth rotation parameters.
- A new VLBI processing software is being developed in Vienna: VieVS (Vienna VLBI Software).
- Goal of this work:
  - Evaluate the performance of VieVS for estimation of high frequency Earth rotation.
  - Investigate high frequency Earth rotation variations for the recent CONT08 campaign, as well as the previous campaigns CONT05 and CONT02.

VieVS – Vienna VLBI Software

- New geodetic VLBI processing software written in Matlab.
- Classical least squares adjustment.
- Parameters estimated as piecewise linear function offsets at integer hours.
- Implement the latest IERS conventions and models.
- OCCAM software used as a guideline.

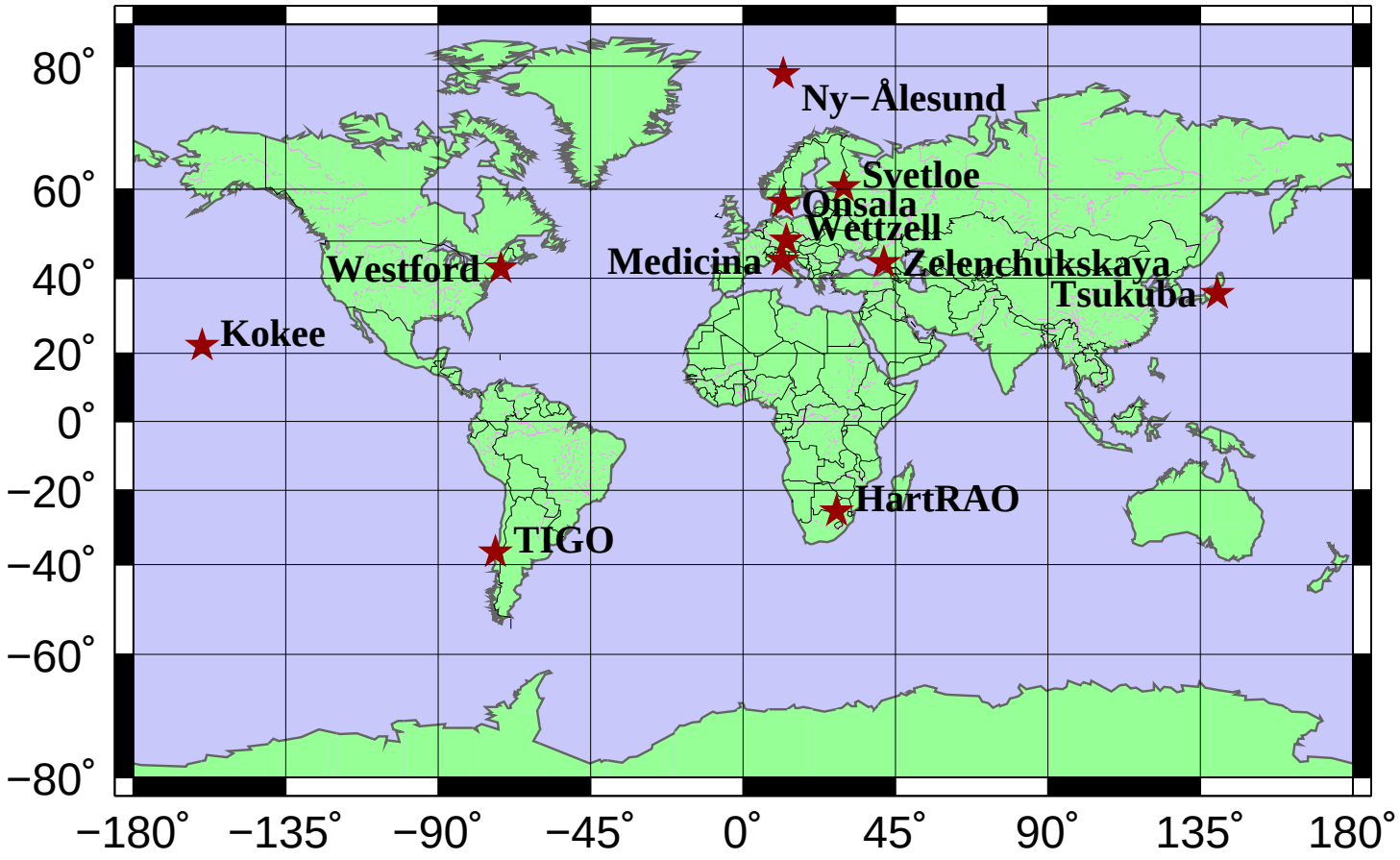




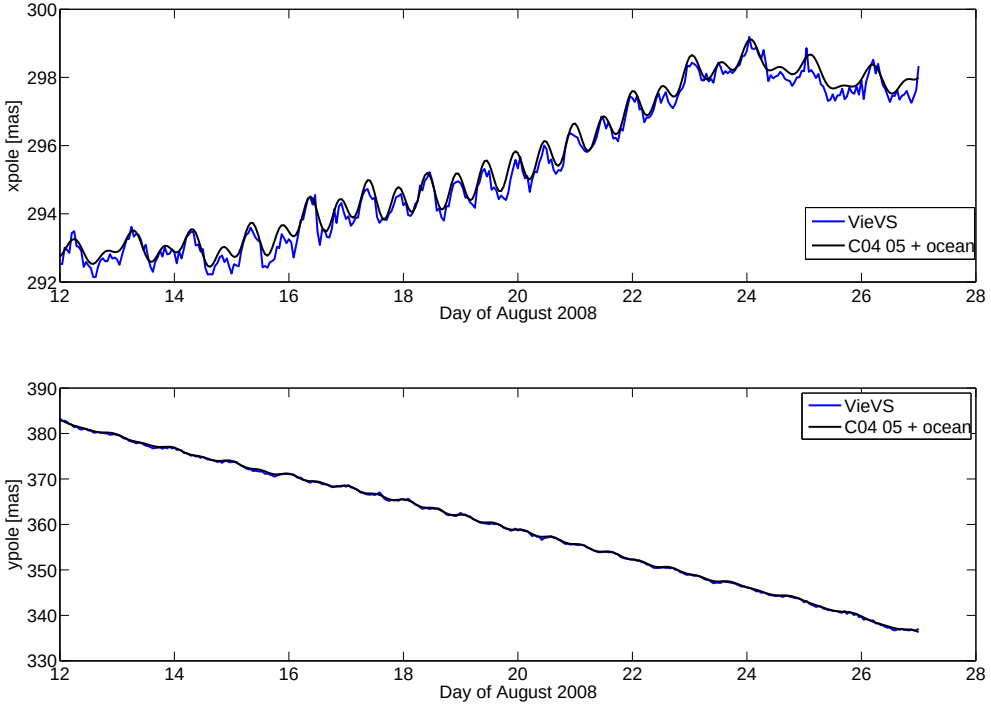
Data Processing

- Polar motion, UT1-UTC, and nutation modelled as piecewise linear functions in one hour intervals.
- Stacking of parameters (EOP's, zenith wet delays and gradients) at session boundaries.
- Blocking of polar motion with periods between 16 and 48 hours, and of nutations with periods <2 days.
- One set of coordinates estimated for each CONT campaign. No Net Translation/Rotation w.r.t. VTRF2005 coordinates.
- Source coordinates fixed to ICRF2.

CONT08: August 12–26, 2008

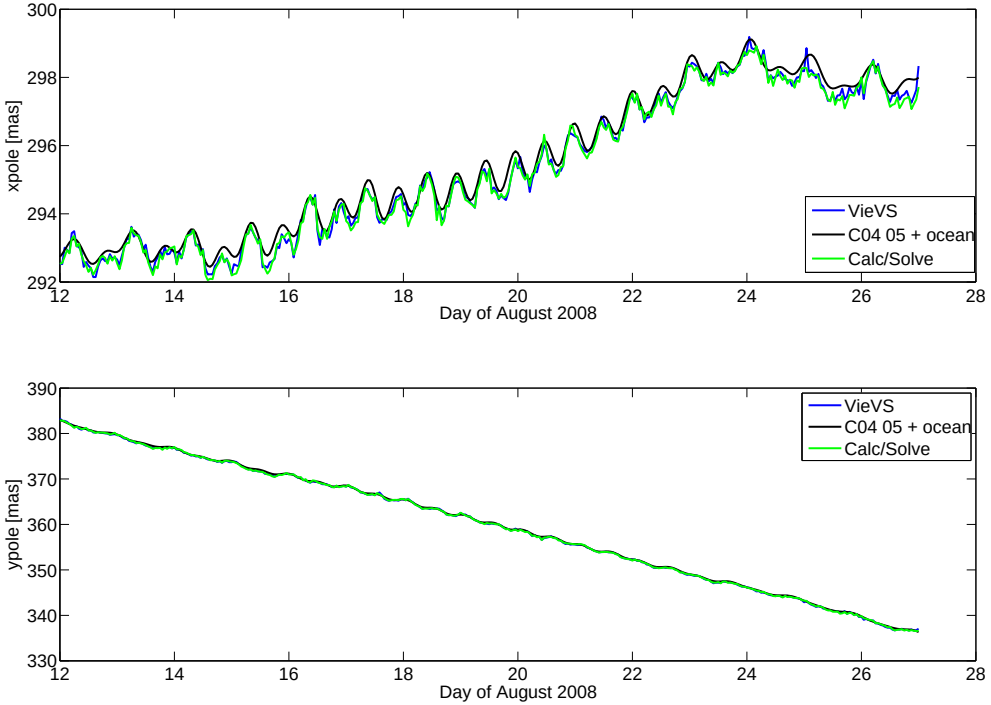


CONT08 Polar Motion Estimates



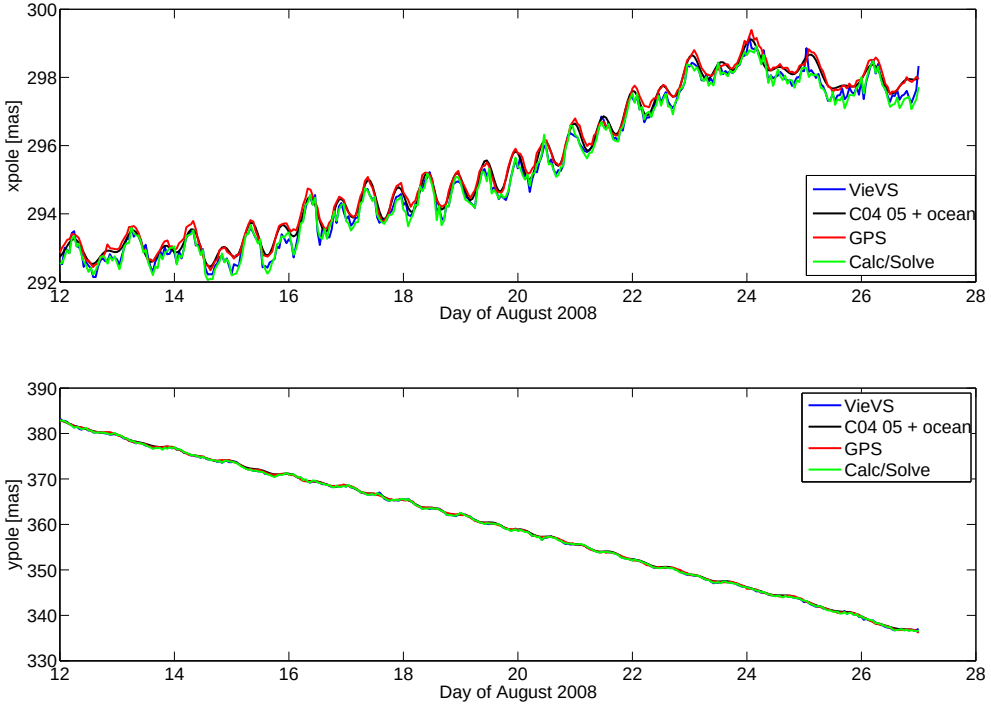
- Polar Motion estimates from VieVS
- IERS 05 C04 series plus IERS recommended model for high frequency ERP variations.

CONT08 Polar Motion Estimates



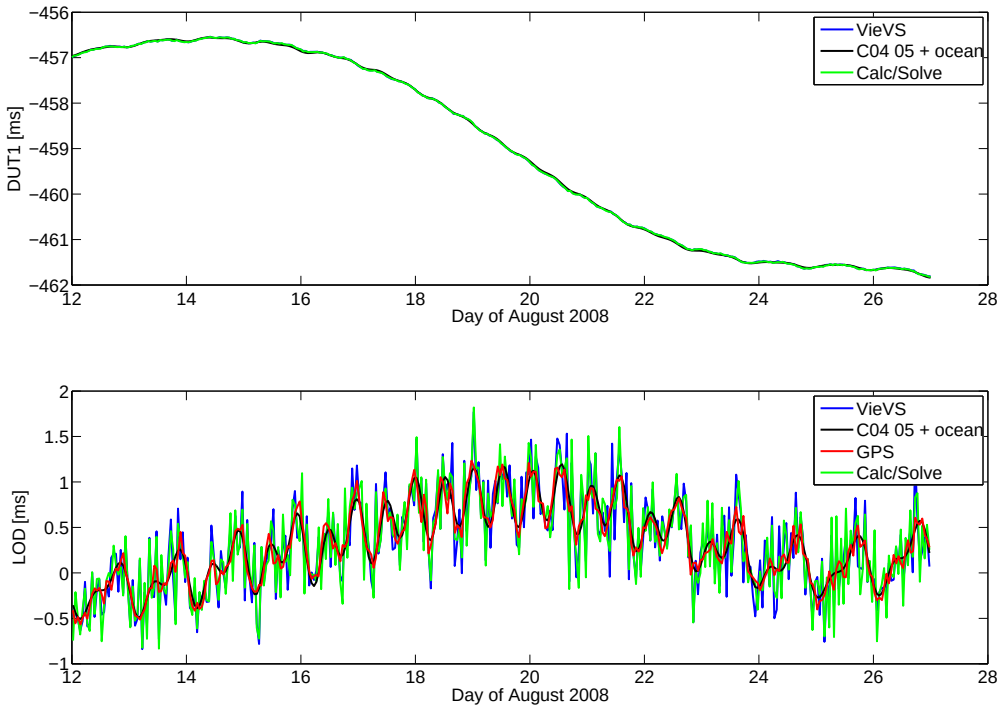
- Polar Motion estimates from VieVS
- IERS 05 C04 series plus IERS recommended model for high frequency ERP variations.
- VBLI solution Calc/Solve (from T. Artz, Uni. Bonn)

CONT08 Polar Motion Estimates



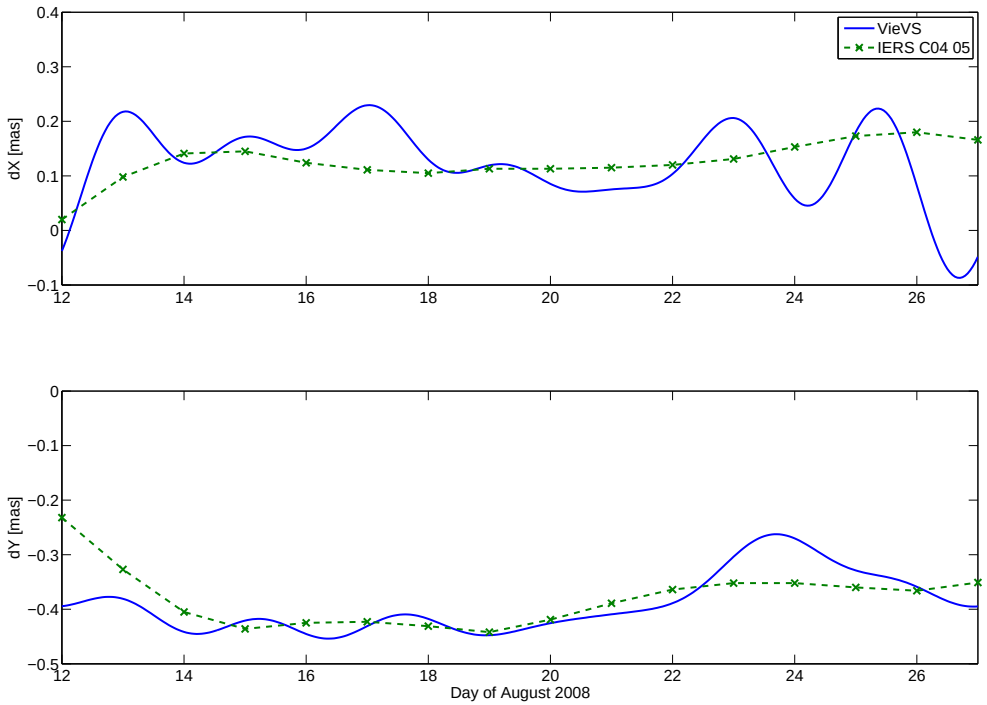
- Polar Motion estimates from VieVS
- IERS 05 C04 series plus IERS recommended model for high frequency ERP variations.
- VBLI solution Calc/Solve (from T. Artz, Uni. Bonn)
- GPS solution (*P. Steigenberger et al., jgr, (2006)*)

CONT08 DUT1 and Length Of Day Estimates



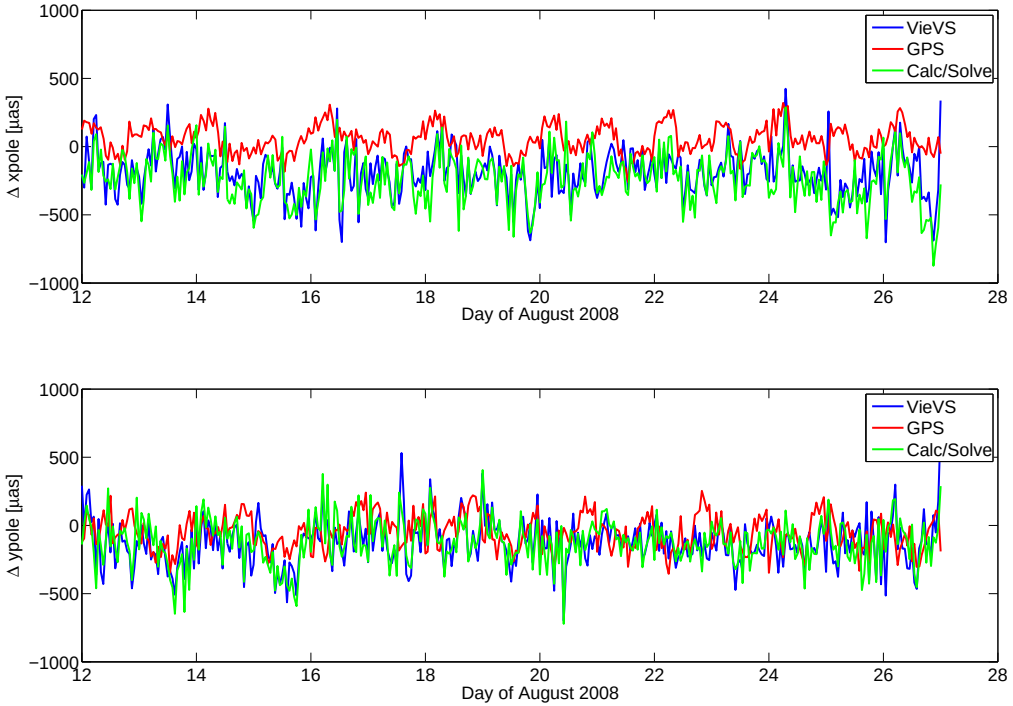
- UT1-UTC estimated from VLBI (VieVS and Calc/Solve).
- Length of Day estimated from VLBI and from GPS.

CONT08 Nutation Estimates



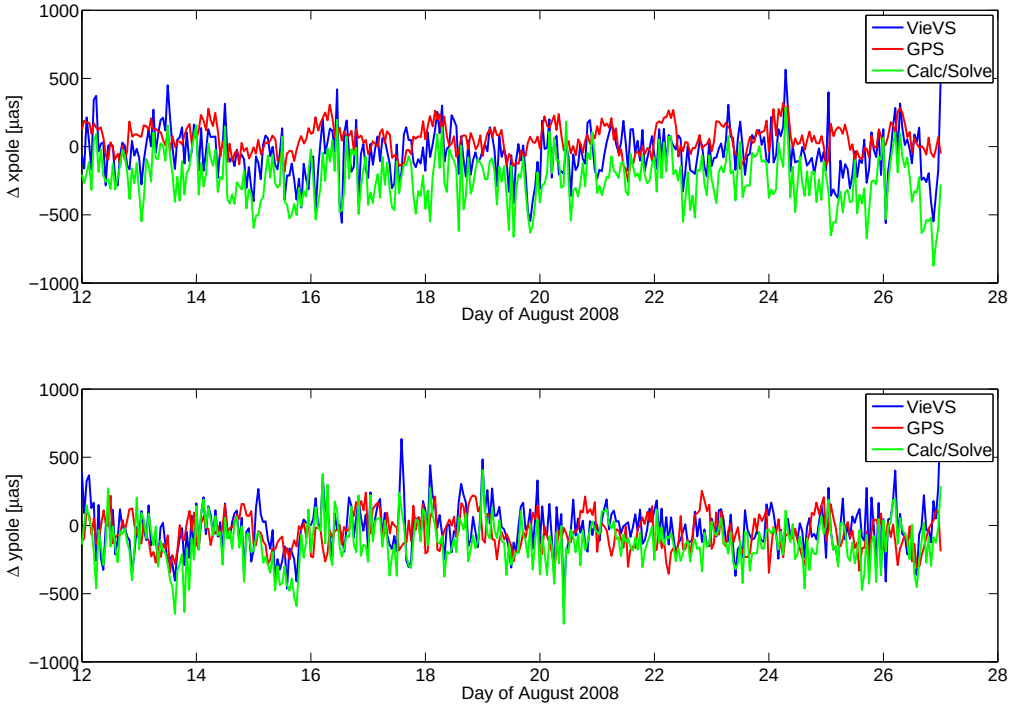
- Nutation estimated from VLBI (VieVS).
- Nutation from IERS 05 C04 series.

CONT08 Residual Polar Motion Estimates



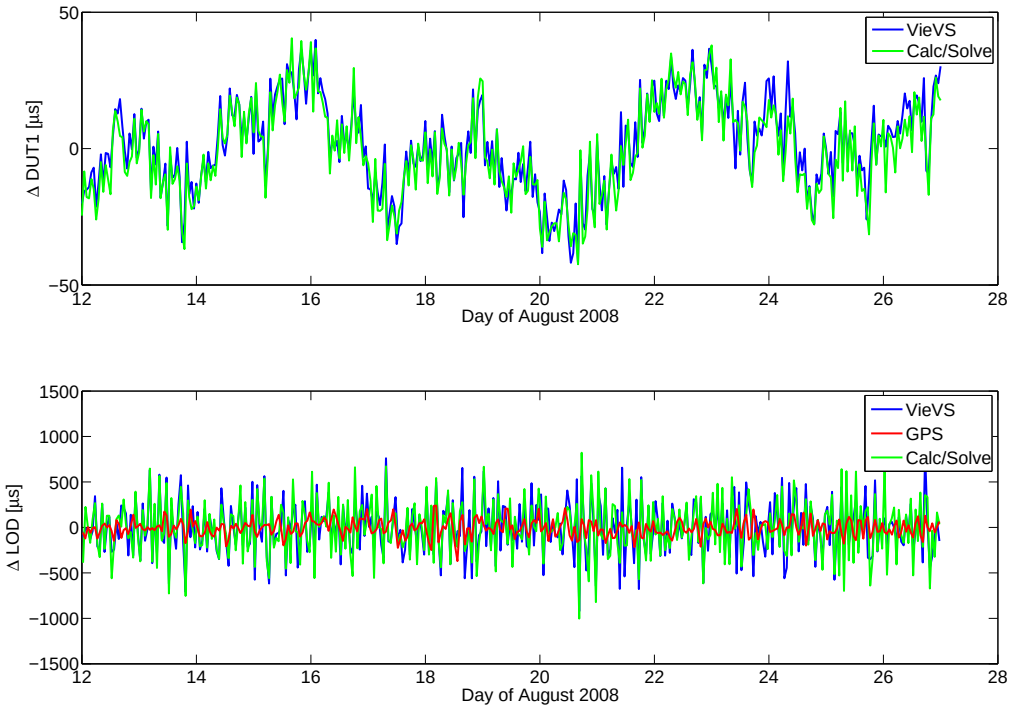
- Polar Motion from VLBI and GPS minus IERS 05 C04 and high frequency ERP model.

CONT08 Residual Polar Motion Estimates



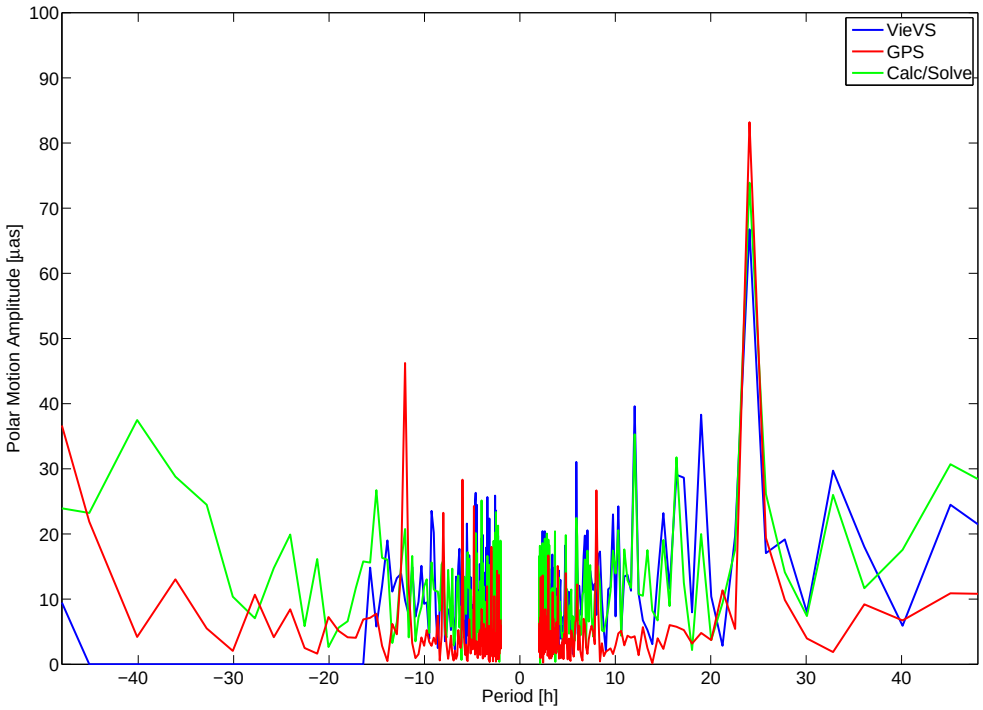
- Polar Motion from VLBI and GPS minus IERS 05 C04 and high frequency ERP model.
- X-pole offset between GPS and VLBI probably due to different datums.
- Offset decreases (by 140 μas) if ITRF2005 coordinates are used in VieVS solution instead of VTRF2005.

CONT08 Residual DUT1 and LOD Estimates



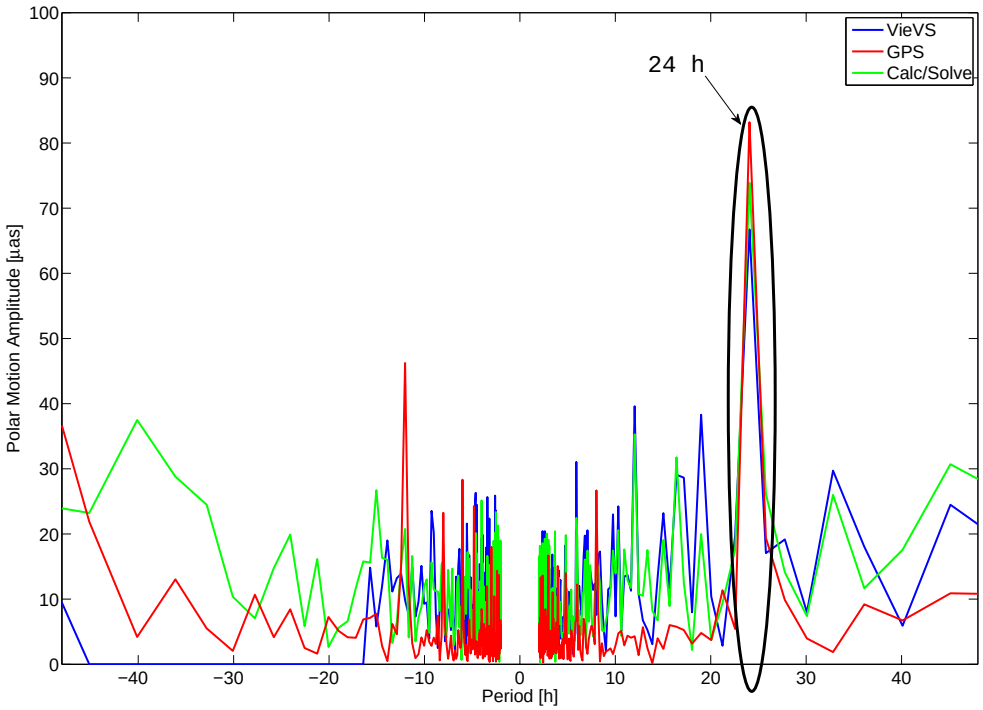
- Good agreement in DUT1 between the two VLBI solutions.
- LOD from VLBI seems noisier than LOD from GPS.

CONT08 Polar Motion Spectrum



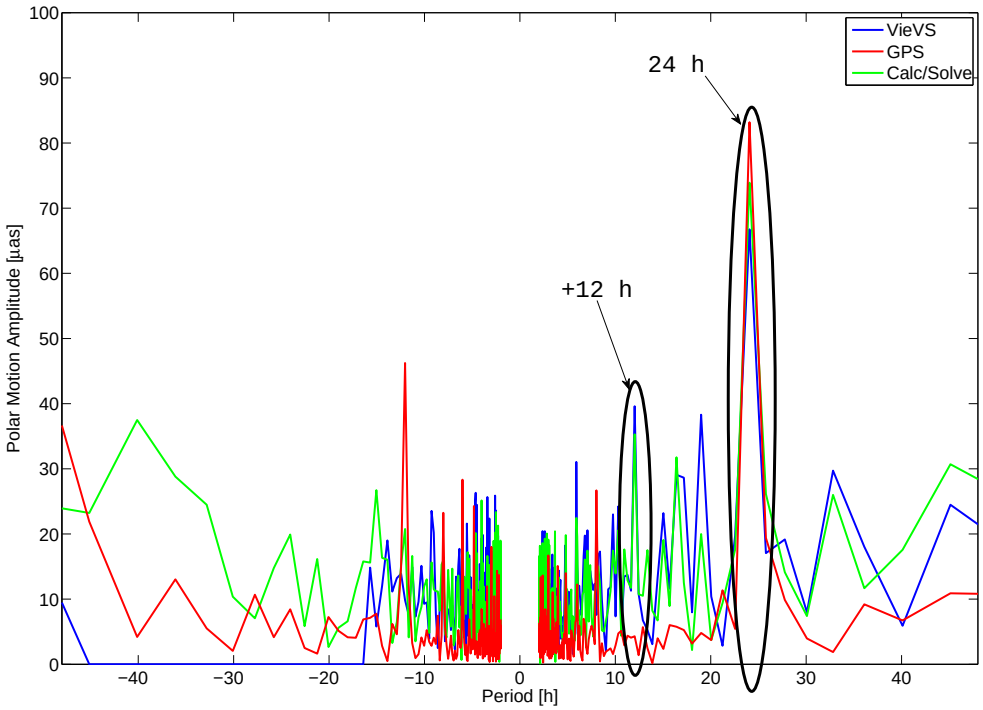
- Fourier spectrum of polar motion residuals.

CONT08 Polar Motion Spectrum



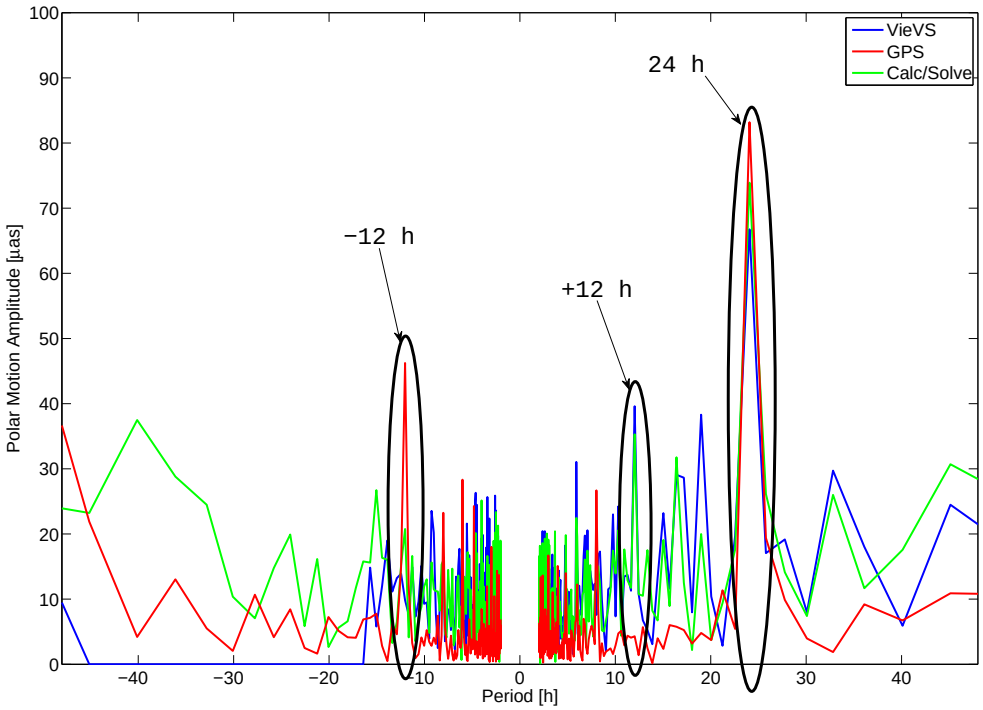
- Fourier spectrum of polar motion residuals.
- Strong peak at +24 h.

CONT08 Polar Motion Spectrum



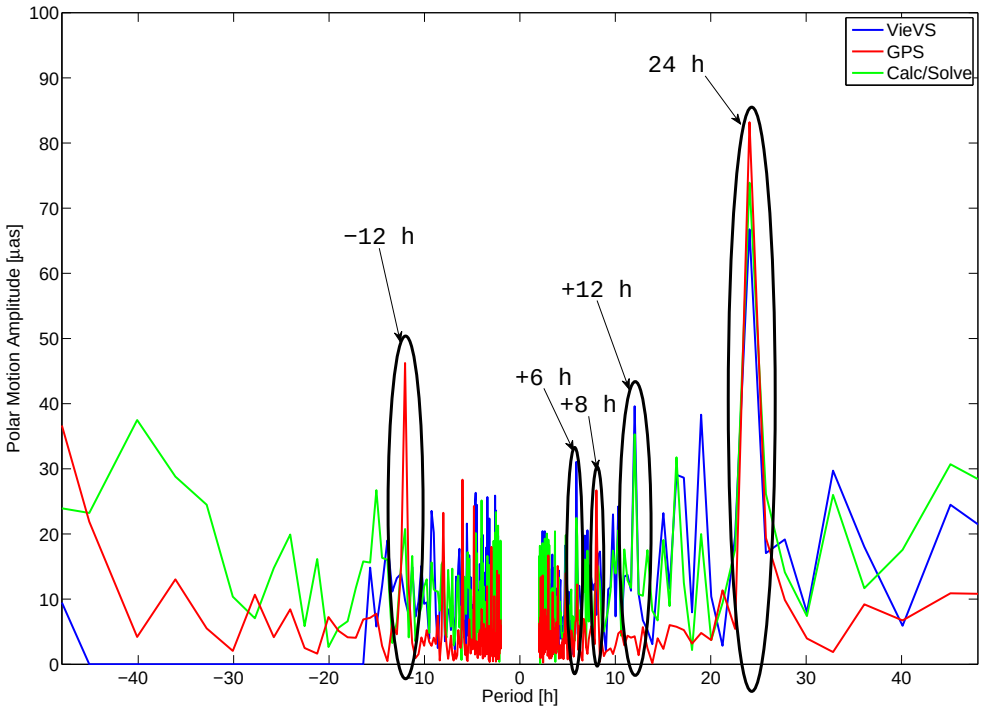
- Fourier spectrum of polar motion residuals.
- Strong peak at +24 h.
- Peak at +12 h for VLBI.

CONT08 Polar Motion Spectrum



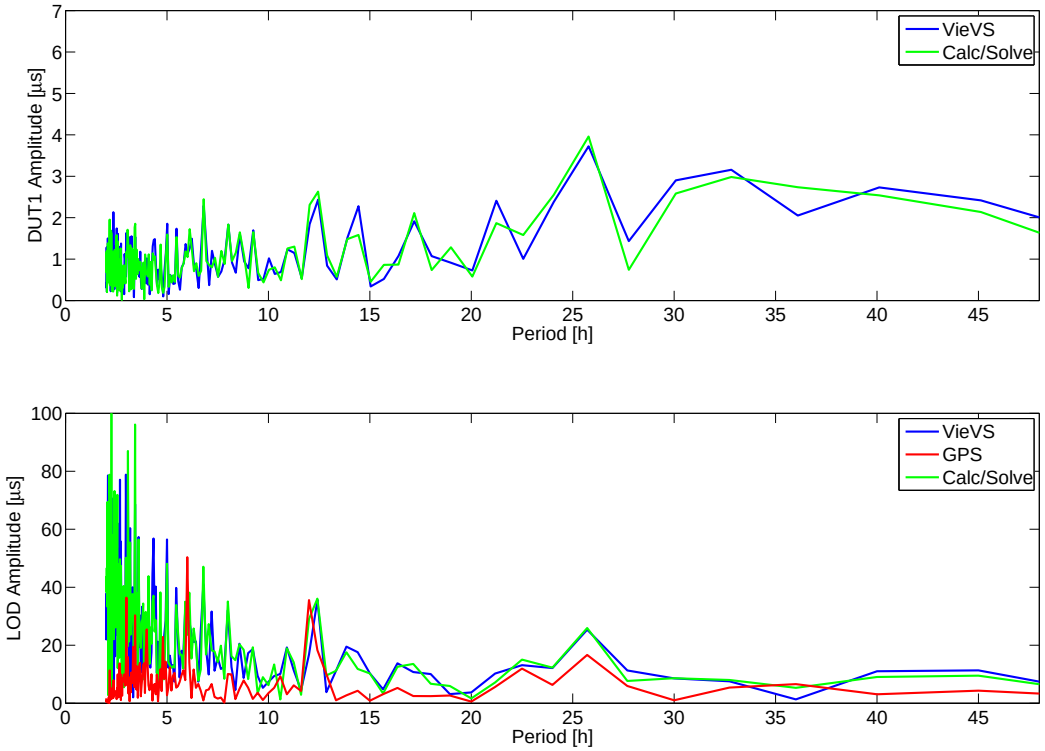
- Fourier spectrum of polar motion residuals.
- Strong peak at +24 h.
- Peak at +12 h for VLBI.
- Peak at -12 h for GPS.

CONT08 Polar Motion Spectrum



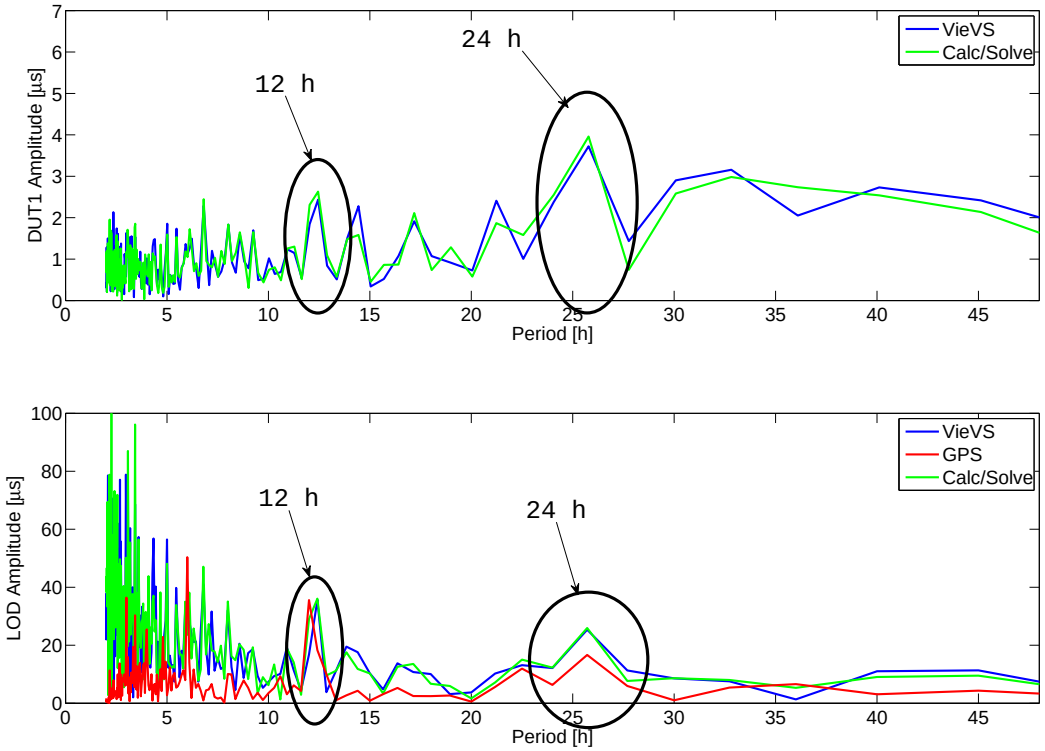
- Fourier spectrum of polar motion residuals.
- Strong peak at +24 h.
- Peak at +12 h for VLBI.
- Peak at -12 h for GPS.
- Small peaks at +6 h (VLBI) and +8 h (GPS).

CONT08 DUT1 and LOD Spectra



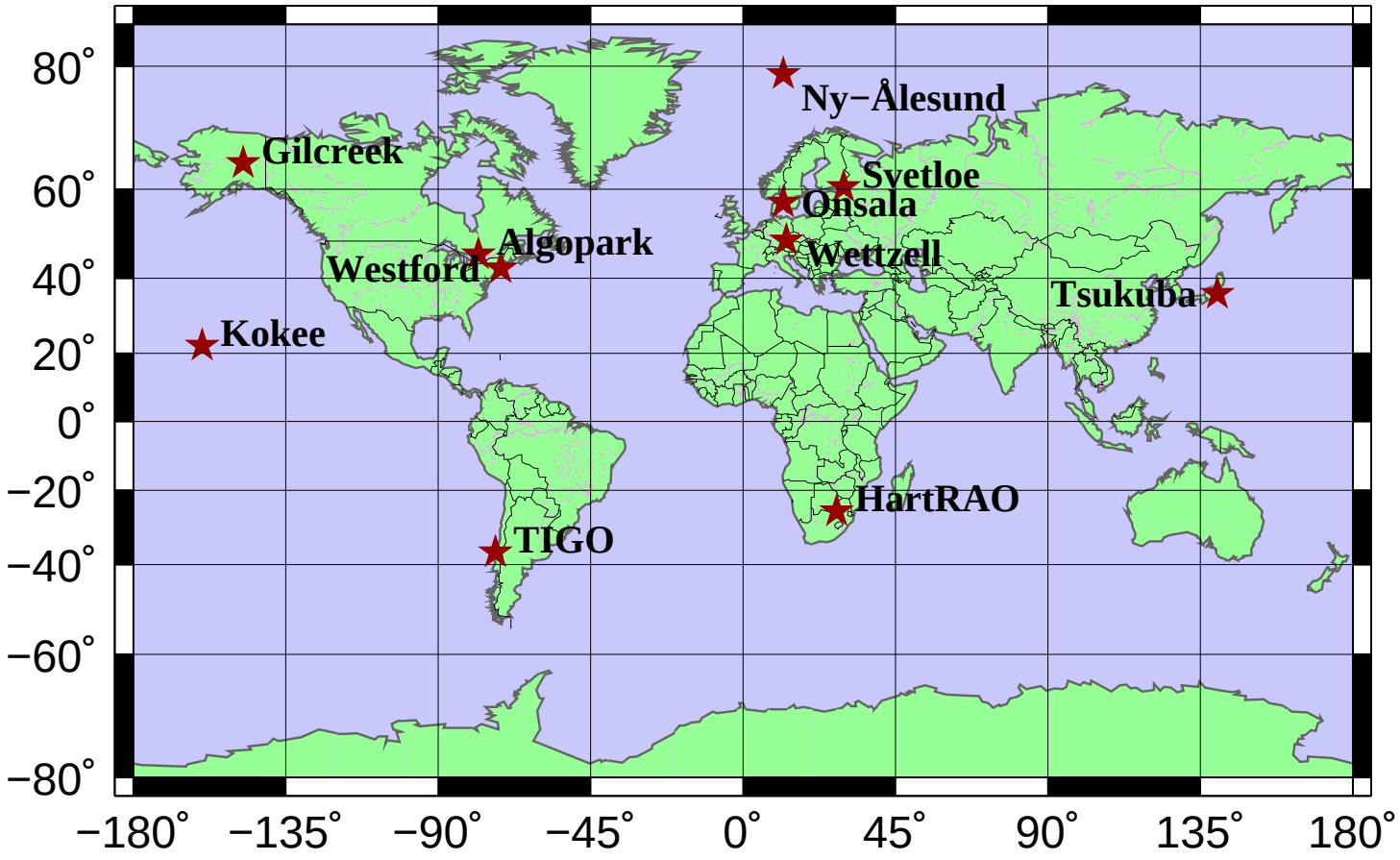
- Fourier spectra of DUT1 and LOD residuals.

CONT08 DUT1 and LOD Spectra

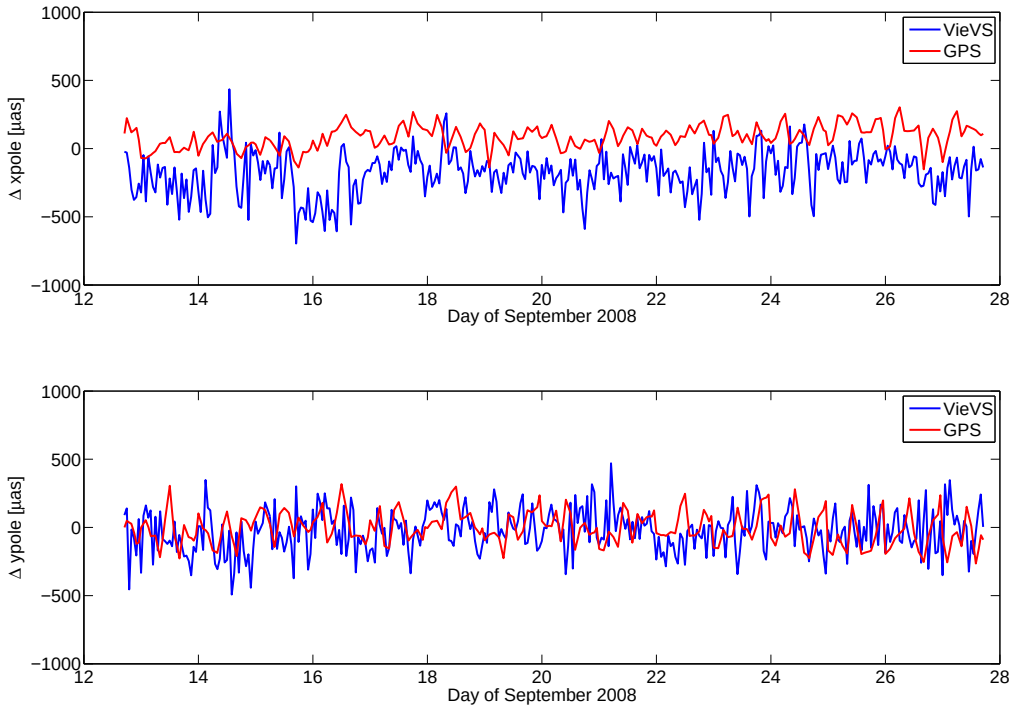


- Fourier spectra of DUT1 and LOD residuals.
- Peaks at 12 h and 24 h.

CONT05: September 12–27, 2005

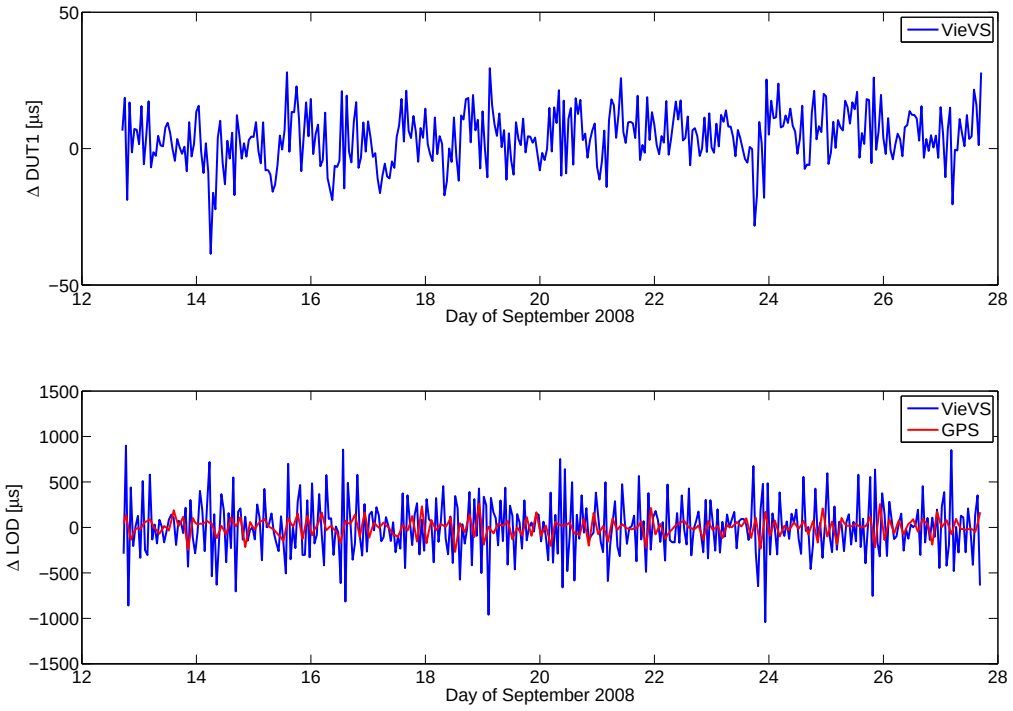


CONT05 Residual Polar Motion Estimates



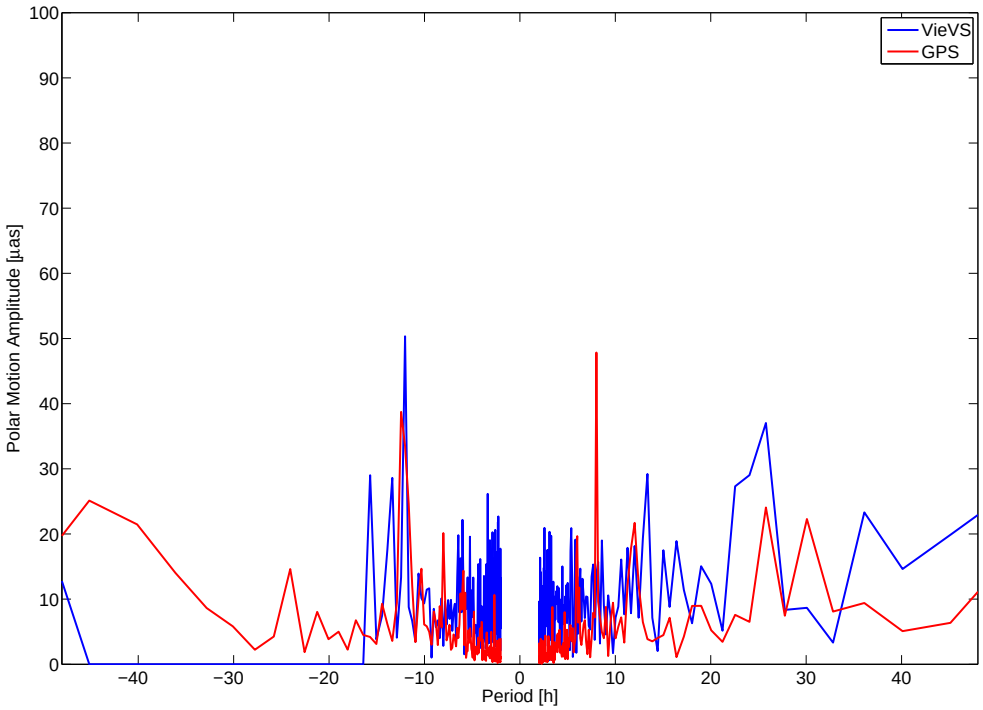
- Polar motion (minus IERS 05 C04 and high freq. ERP model) from VLBI (VieVS) and GPS.

CONT05 Residual DUT1 and LOD Estimates

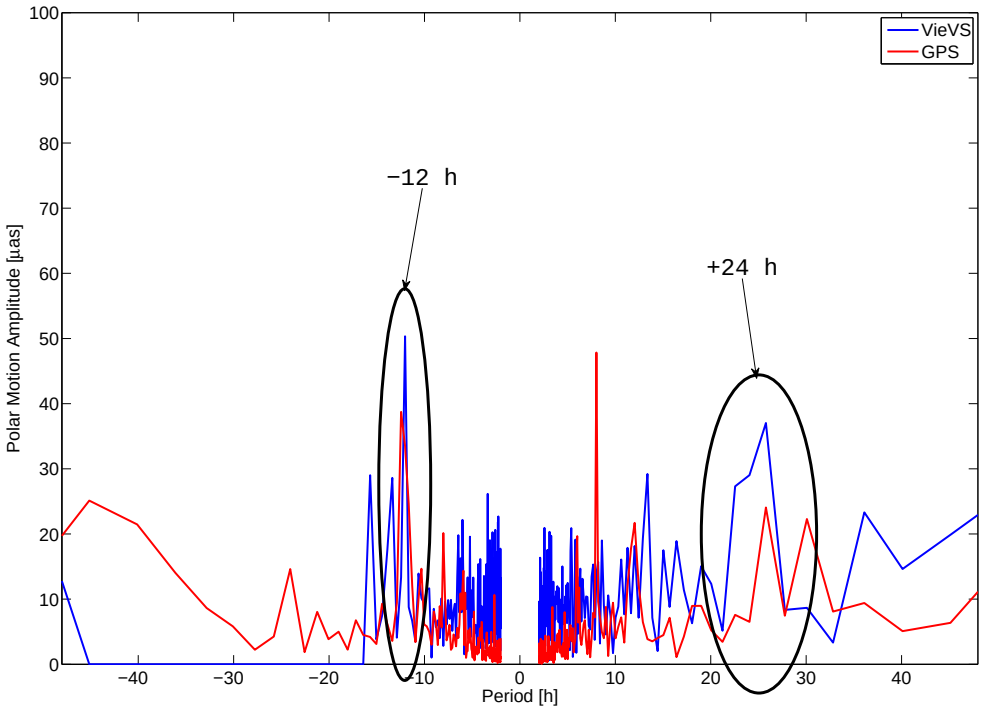


- DUT1 from VLBI (VieVS).
- Length of Day from VLBI (VieVS) and GPS.

CONT05 Polar Motion Spectrum

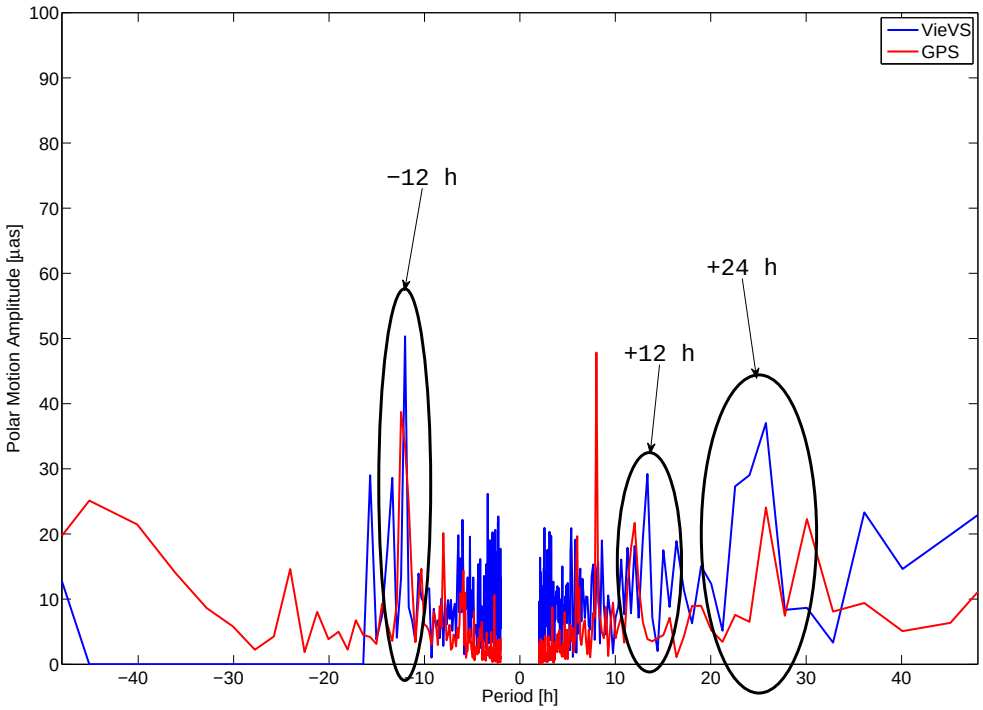


CONT05 Polar Motion Spectrum



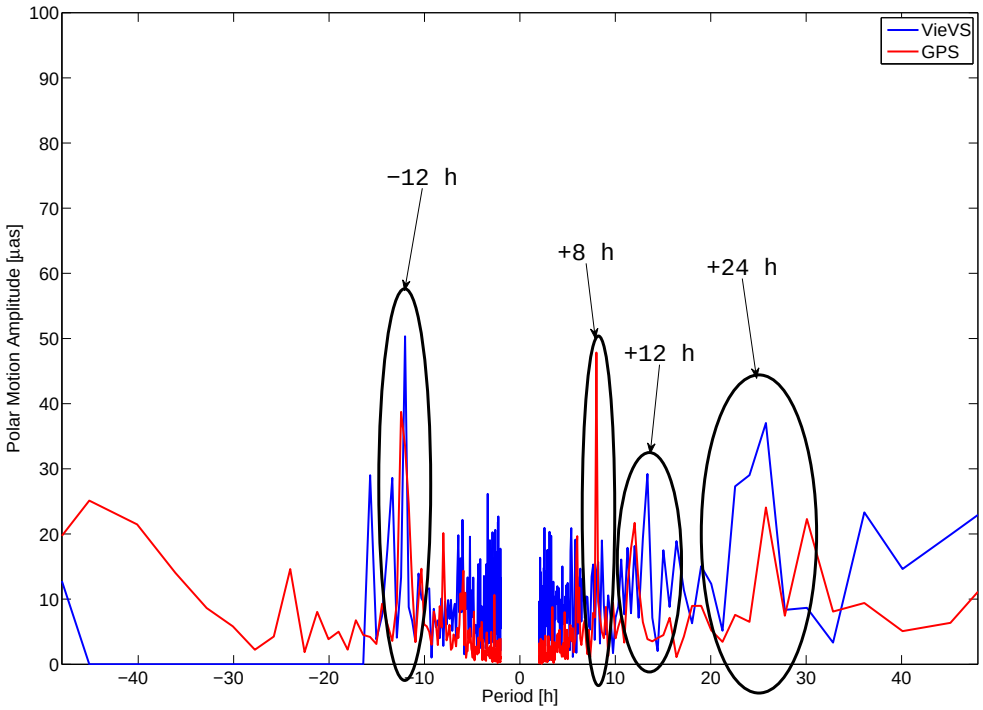
- Peaks at -12 h and +24 h for both VLBI and GPS.

CONT05 Polar Motion Spectrum



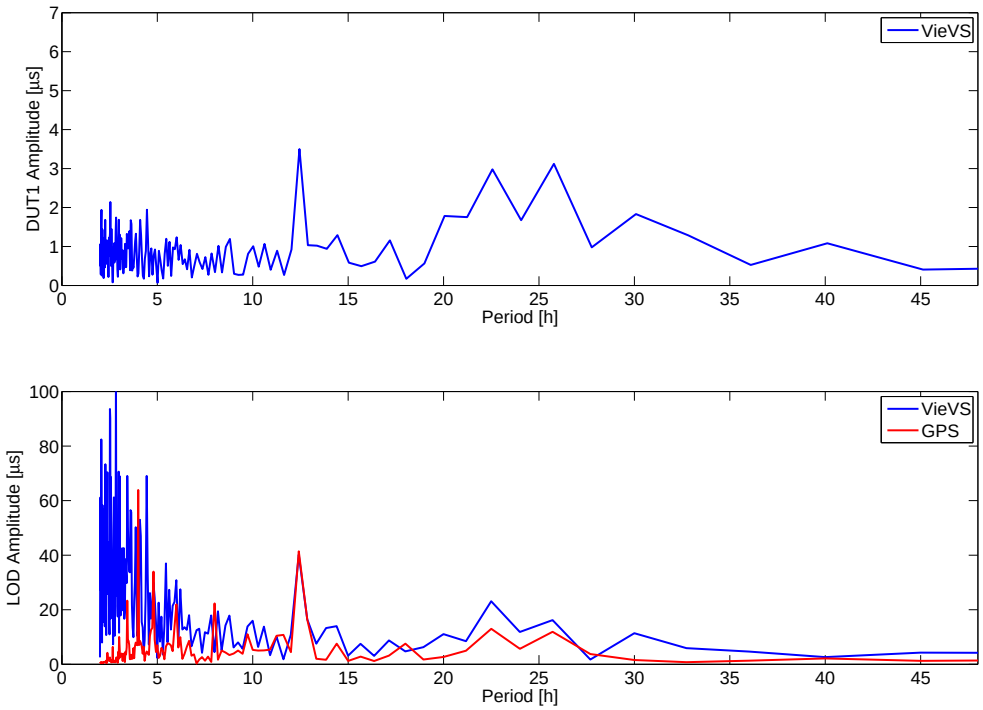
- Peaks at -12 h and +24 h for both VLBI and GPS.
- Peak at +12 h for VLBI.

CONT05 Polar Motion Spectrum

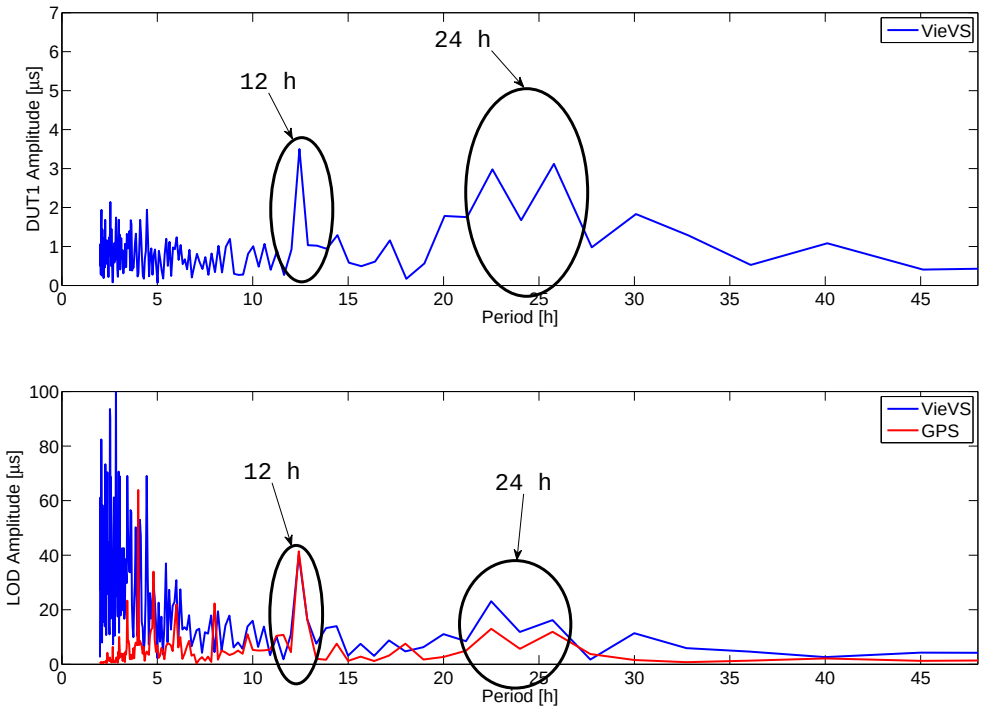


- Peaks at -12 h and +24 h for both VLBI and GPS.
- Peak at +12 h for VLBI.
- Peak at +8 h for GPS.

CONT05 DUT1 and LOD Spectra

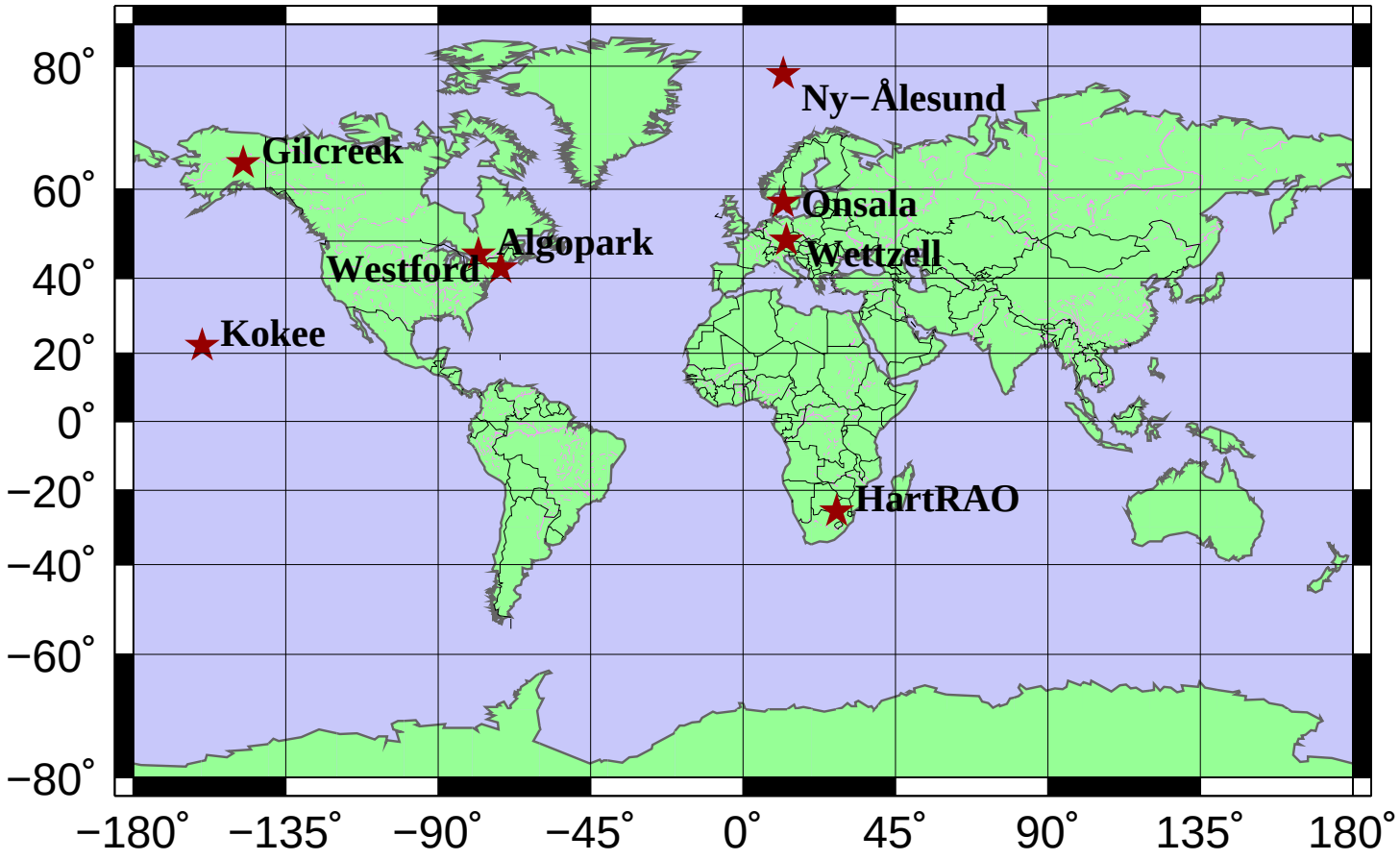


CONT05 DUT1 and LOD Spectra

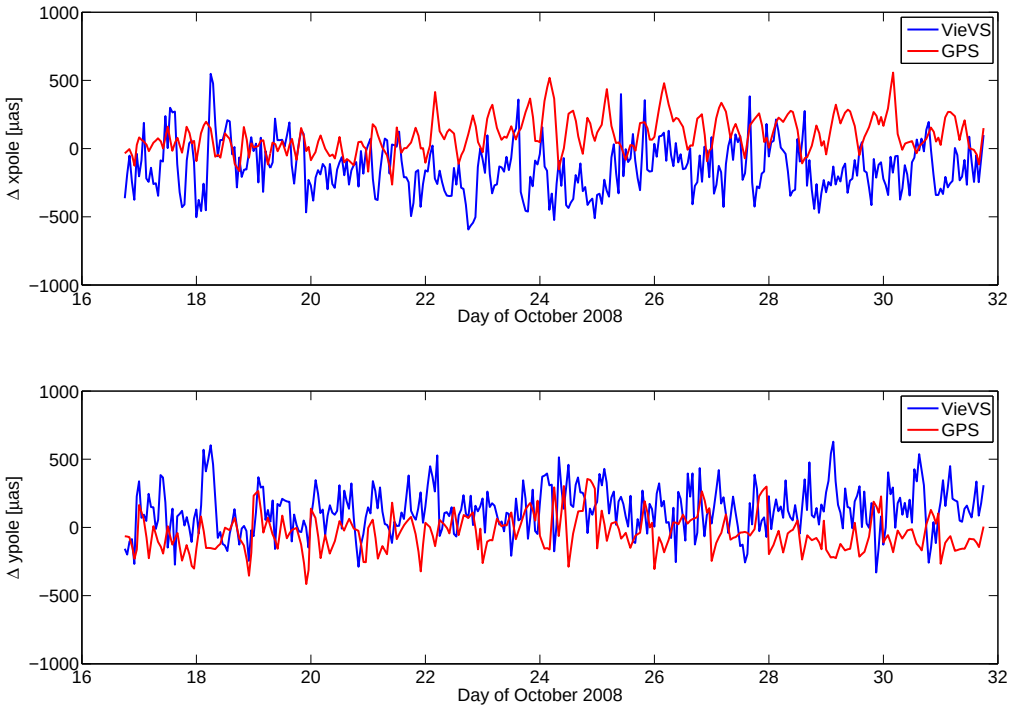


- Peaks at 12 h and 24 h for both VLBI and GPS.

CONT02: October 16–31, 2002

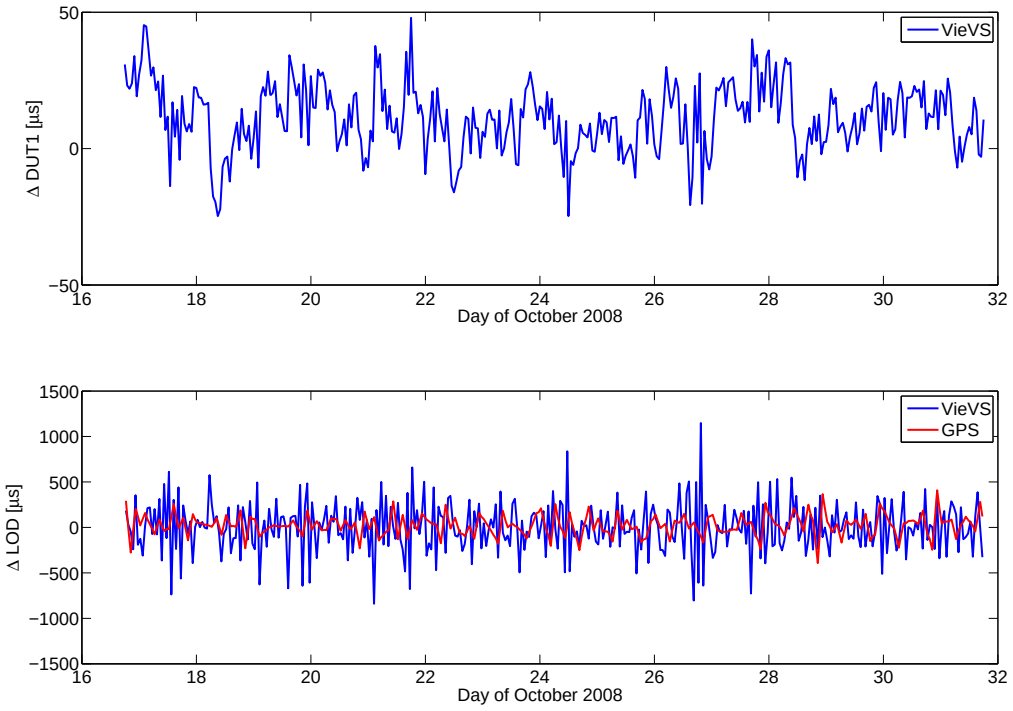


CONT02 Residual Polar Motion Estimates



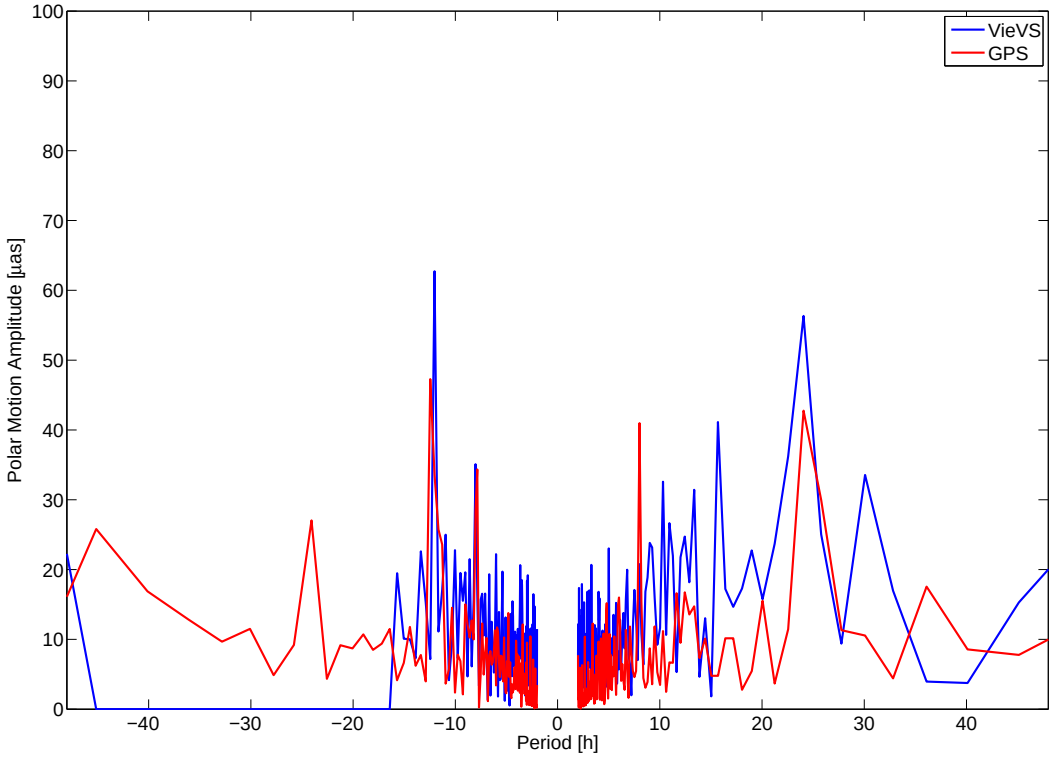
- Polar motion (minus IERS 05 C04 and high freq. ERP model) from VLBI (VieVS) and GPS.

CONT02 Residual DUT1 and LOD Estimates

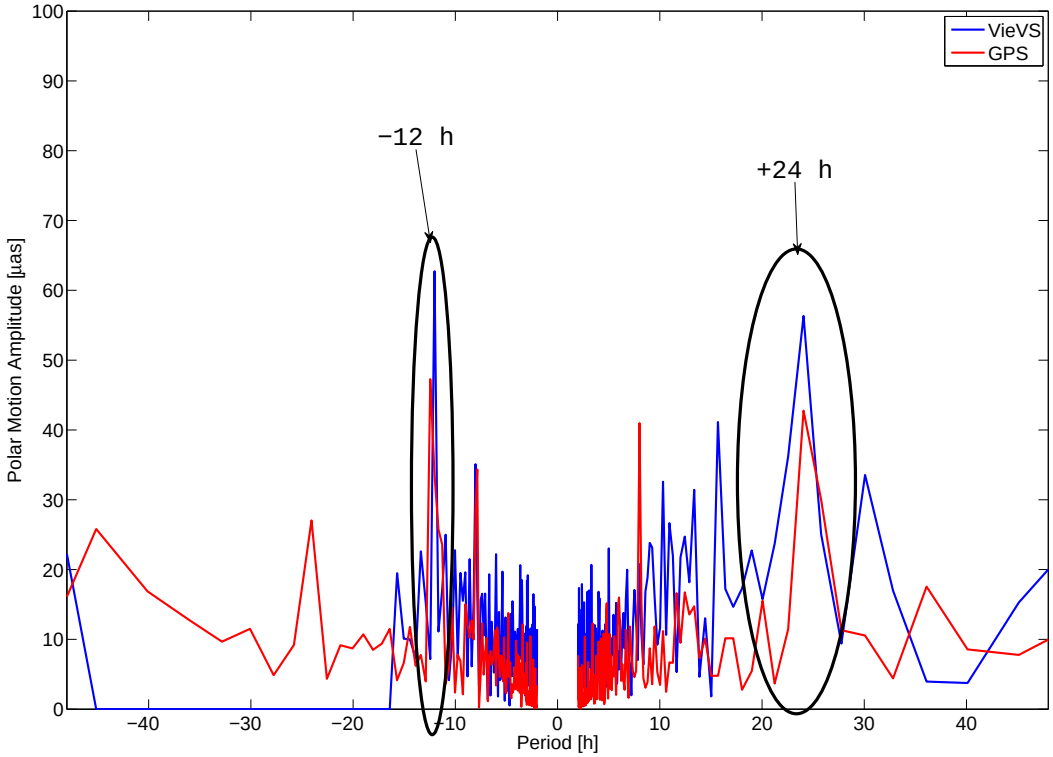


- DUT1 from VLBI (VieVS).
- Length of Day from VLBI (VieVS) and GPS.

CONT02 Polar Motion Spectrum

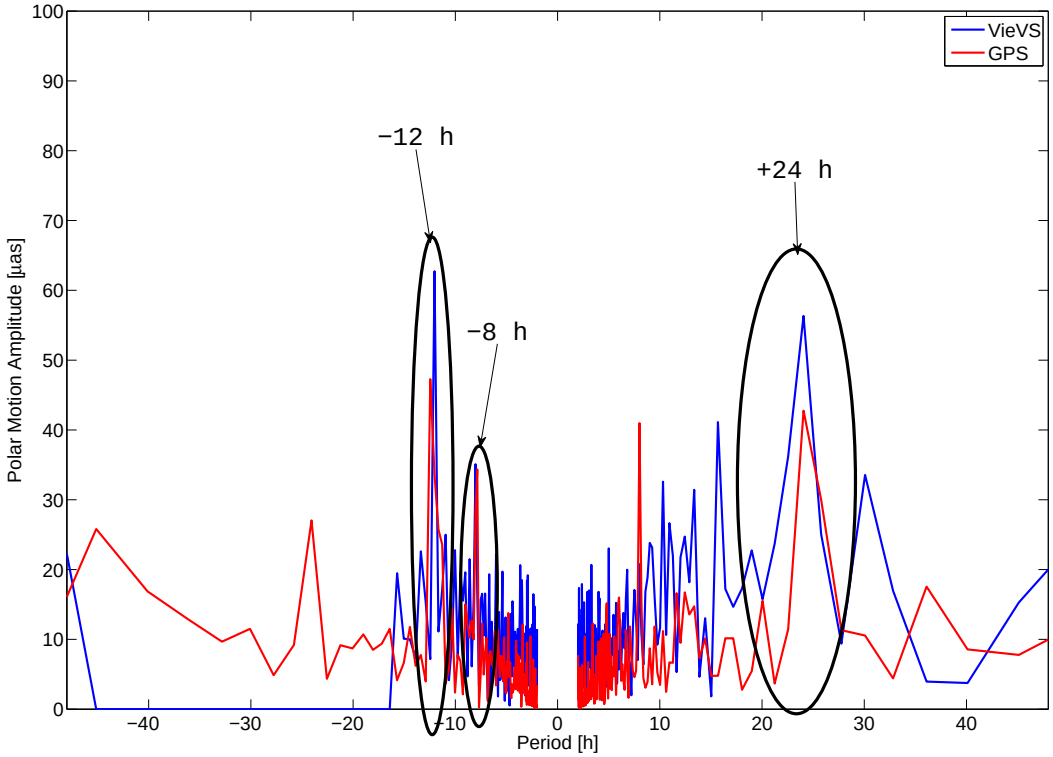


CONT02 Polar Motion Spectrum



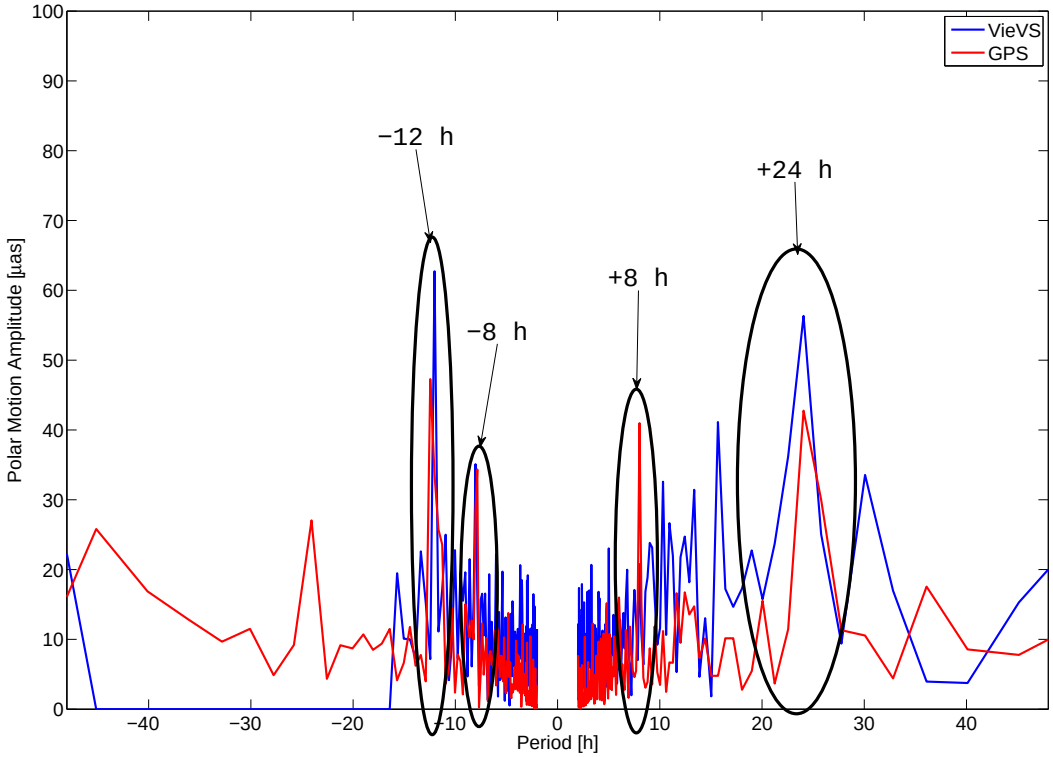
- Peaks at +24 h and -12 h for both VLBI and GPS.

CONT02 Polar Motion Spectrum



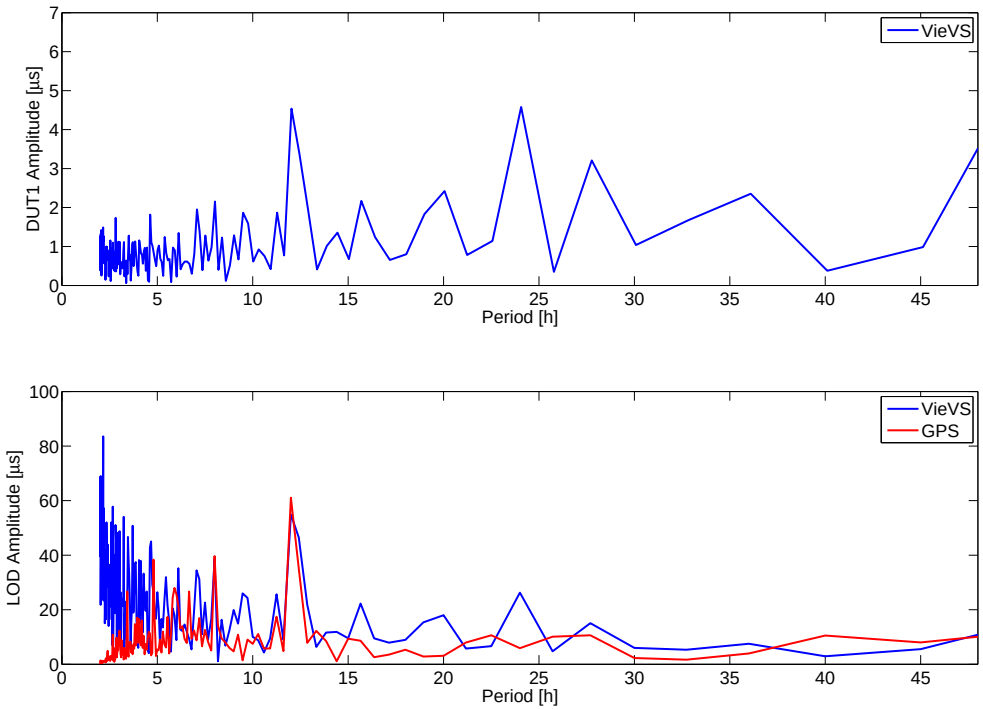
- Peaks at +24 h and -12 h for both VLBI and GPS.
- Peak at -8 h for both VLBI and GPS.

CONT02 Polar Motion Spectrum

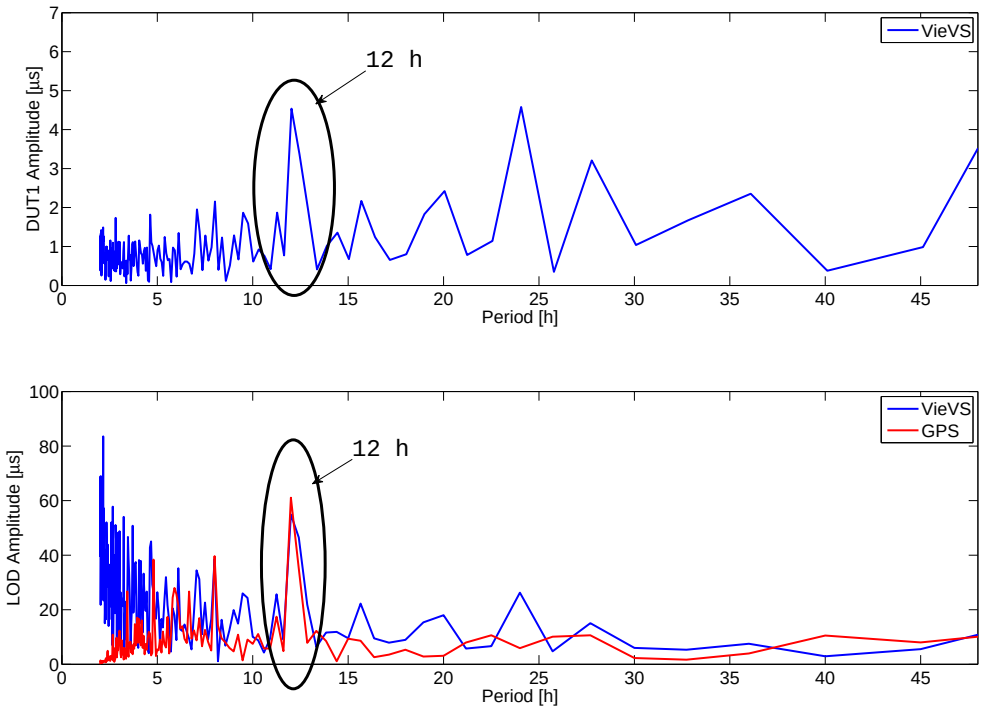


- Peaks at +24 h and -12 h for both VLBI and GPS.
- Peak at -8 h for both VLBI and GPS.
- Peak at +8 h for GPS.

CONT02 DUT1 and LOD Spectra

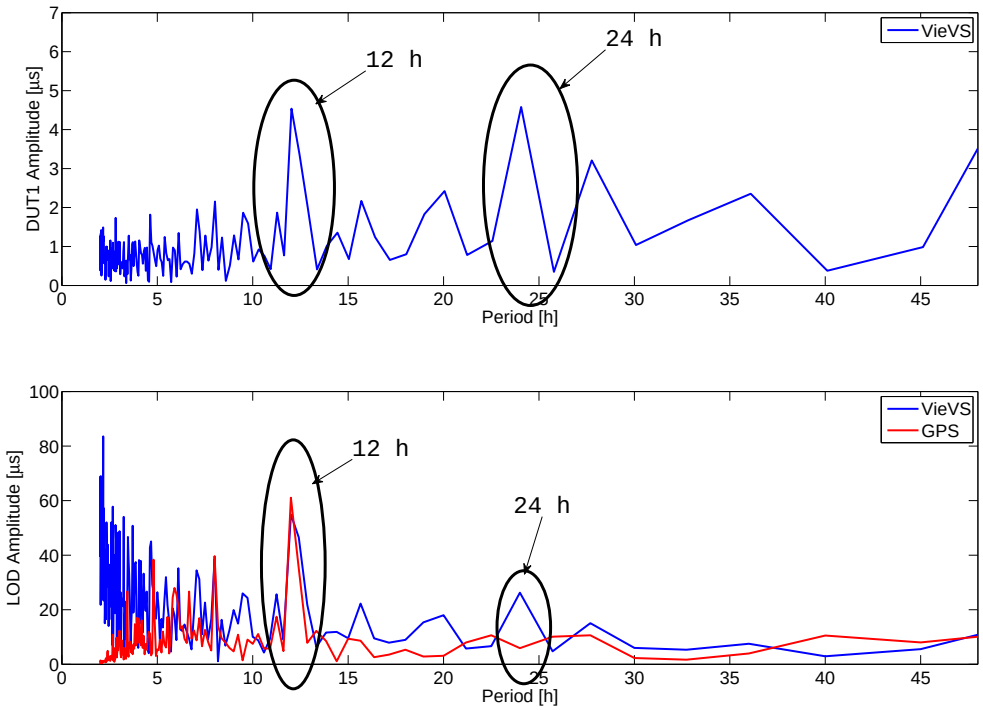


CONT02 DUT1 and LOD Spectra



- Peak at 12 h for both VLBI and GPS.

CONT02 DUT1 and LOD Spectra



- Peak at 12 h for both VLBI and GPS.
- Peak at 24 h for VLBI.

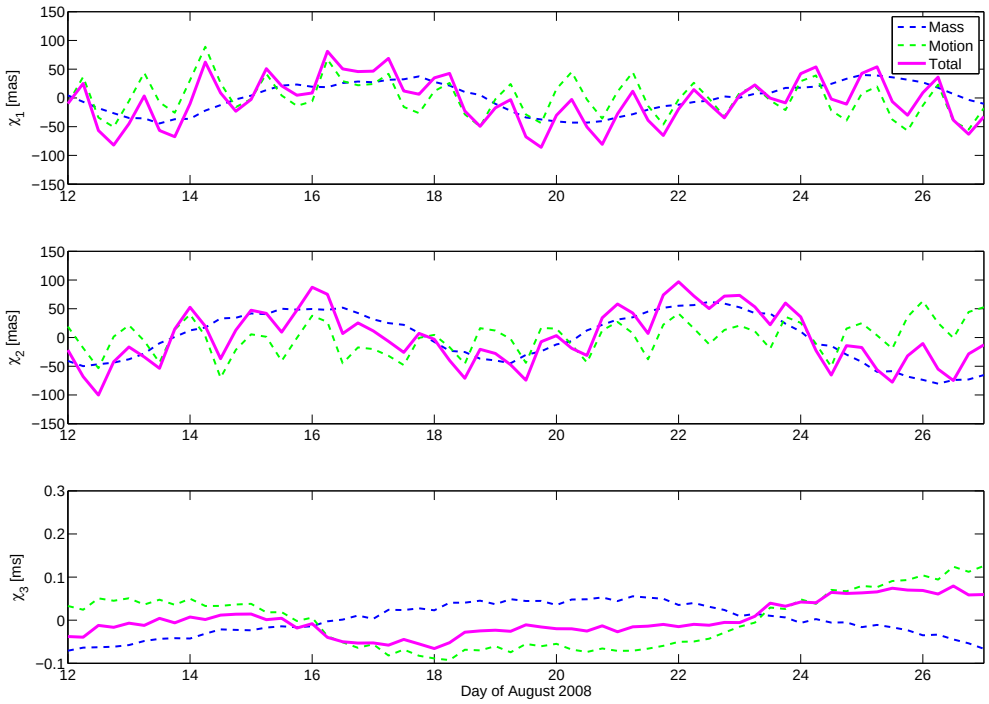
Atmospheric Angular Momentum

- There are commonly peaks at $+24$ h, ± 12 h, and sometimes also at ± 8 h in the Earth rotation spectra.
- Possible reasons:
  - Inaccurate ocean tidal model for high hrequency Earth rotation variations.
  - Atmospheric excitation of Earth rotation.
  - Excitation of Earth rotation by other sources.
  - Artifacts from the processing of the VLBI/GPS data.

Atmospheric Angular Momentum

- There are commonly peaks at $+24$ h, ± 12 h, and sometimes also at ± 8 h in the Earth rotation spectra.
- Possible reasons:
  - Inaccurate ocean tidal model for high hrequency Earth rotation variations.
  - Atmospheric excitation of Earth rotation.
  - Excitation of Earth rotation by other sources.
  - Artifacts from the processing of the VLBI/GPS data.

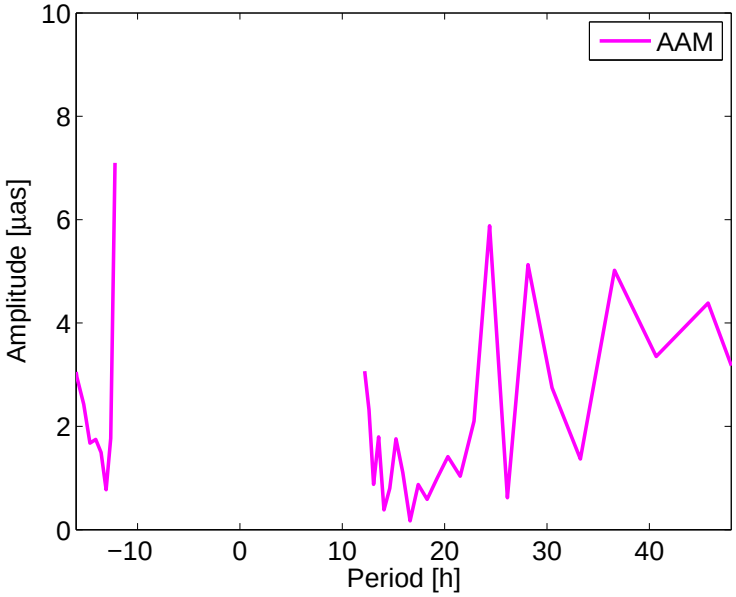
Atmospheric Angular Momentum for CONT08



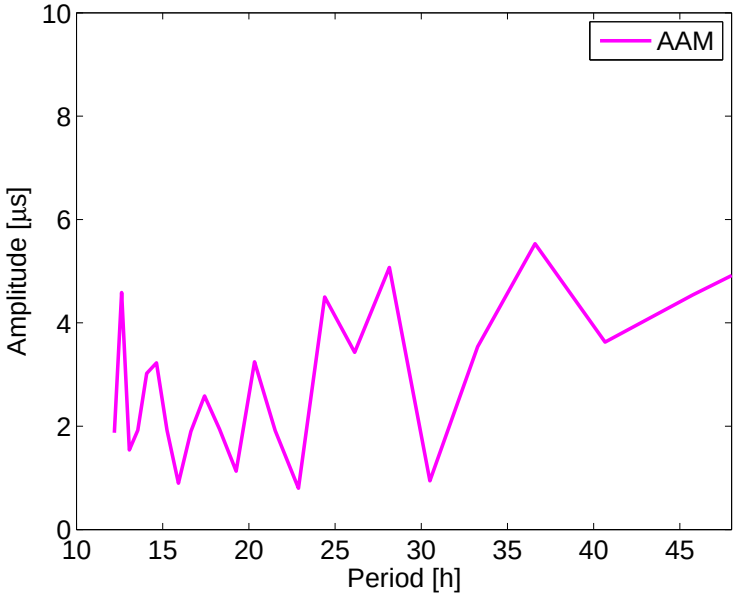
- Excitation functions for the CONT08 period calculated from ECMWF data.
- Resolution 6 hours.

CONT08

Polar motion



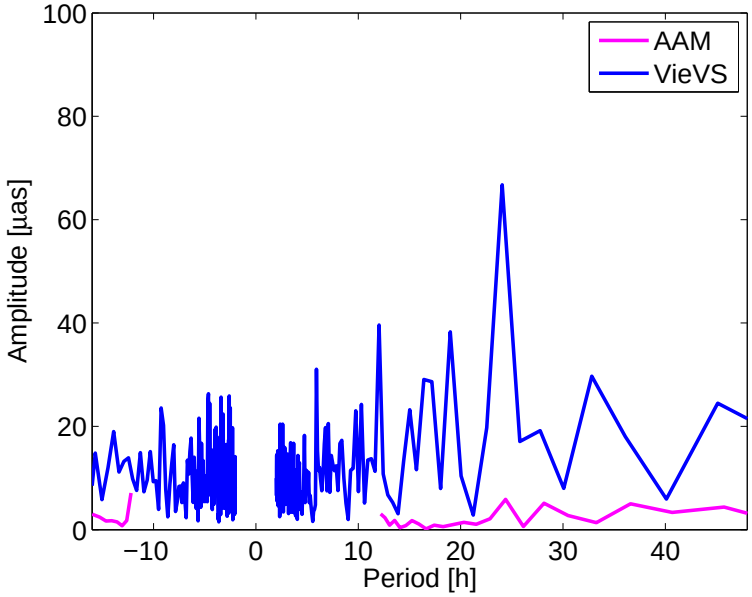
Length of Day



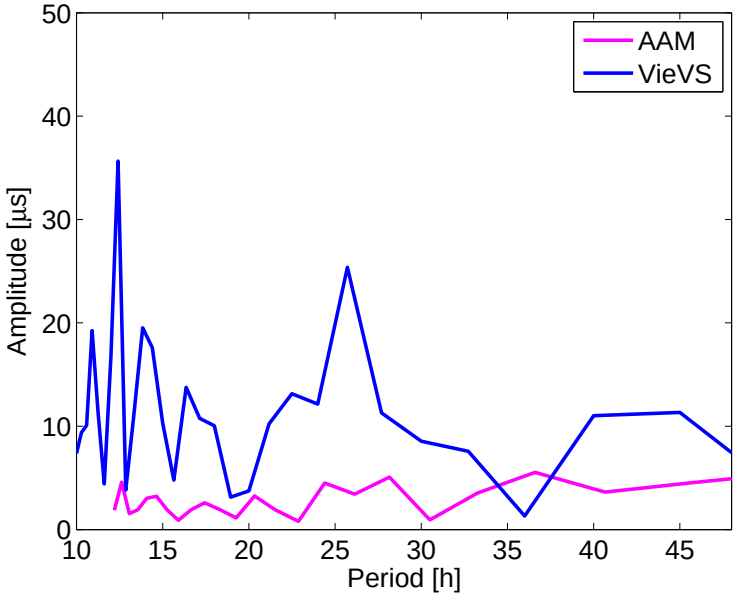
- Spectra of the expected ERP variations due to atmospheric angular momentum variations.

CONT08

Polar motion

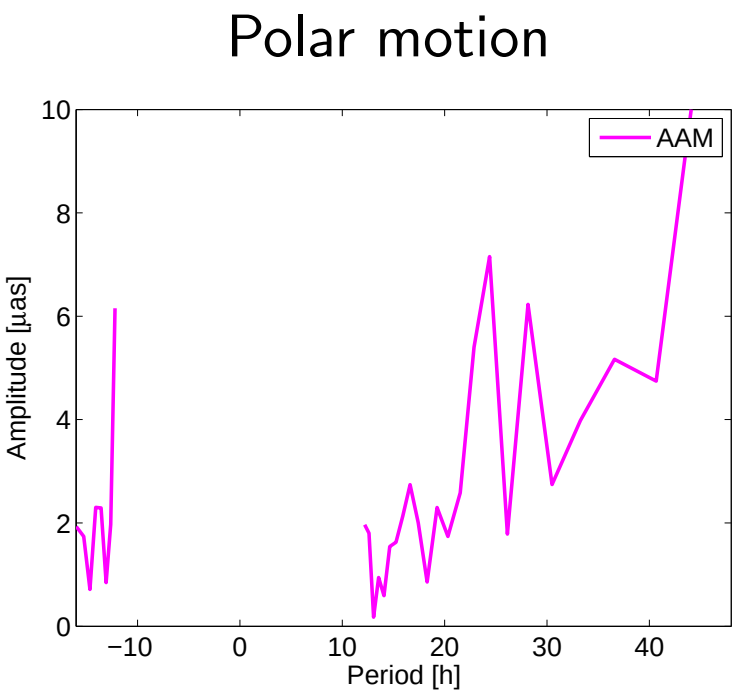


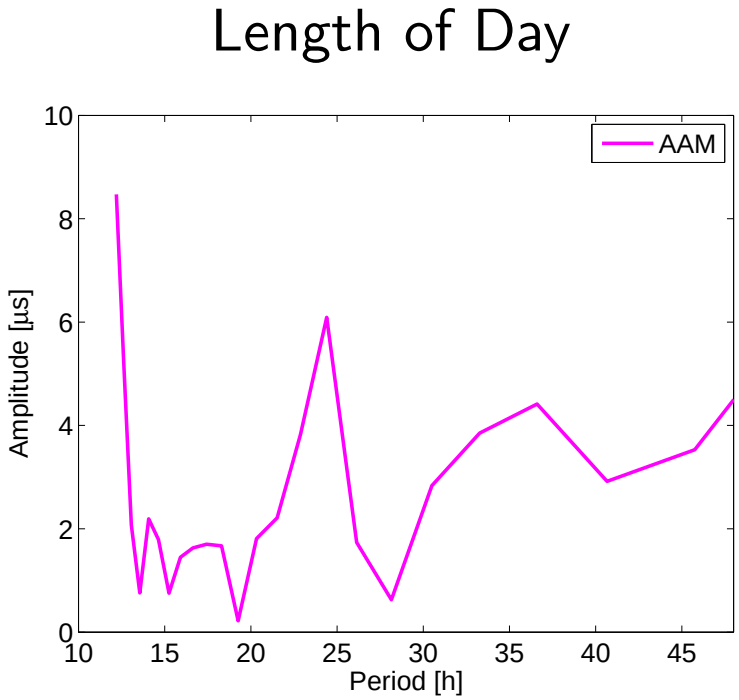
Length of Day



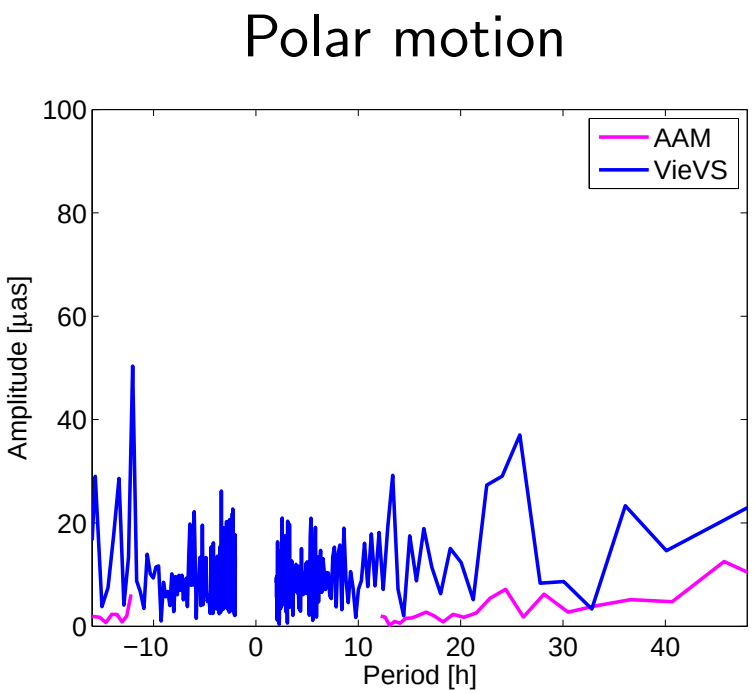
- Spectra of the expected ERP variations due to atmospheric angular momentum variations.
- Amplitudes small compared to those observed with VLBI.

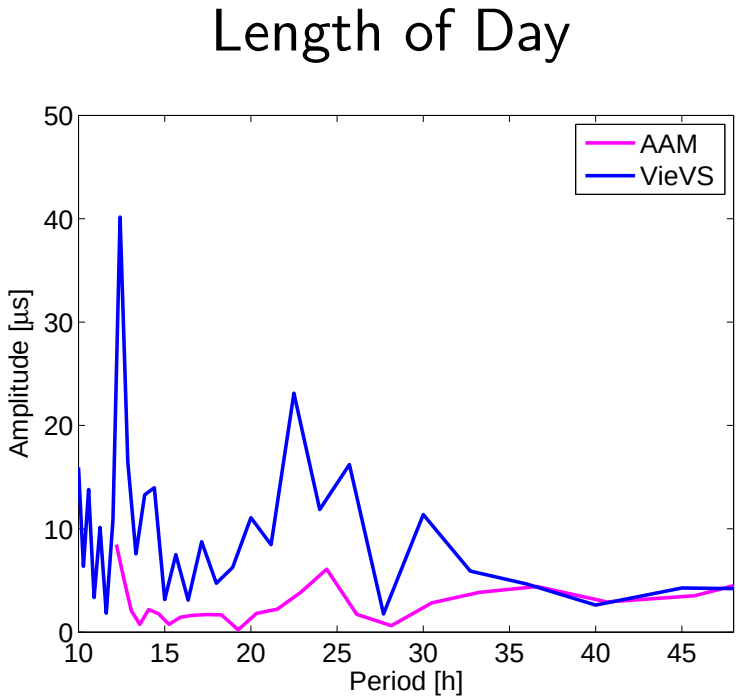
CONT05


Polar motion
AAM
Amplitude [µas]
Period [h]
10
8
6
4
2
0
−10
0
10
20
30
40

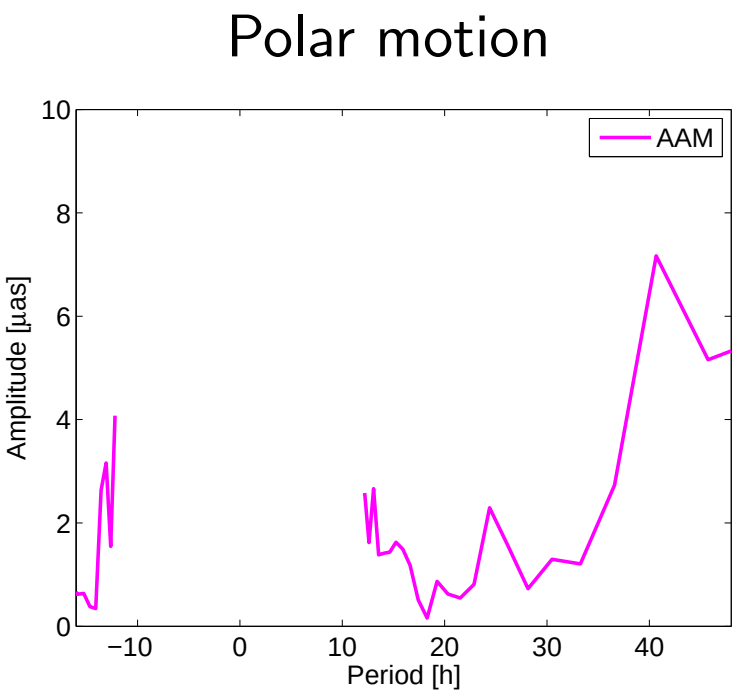

Length of Day
AAM
Amplitude [µs]
Period [h]
10
8
6
4
2
0
10
15
20
25
30
35
40
45

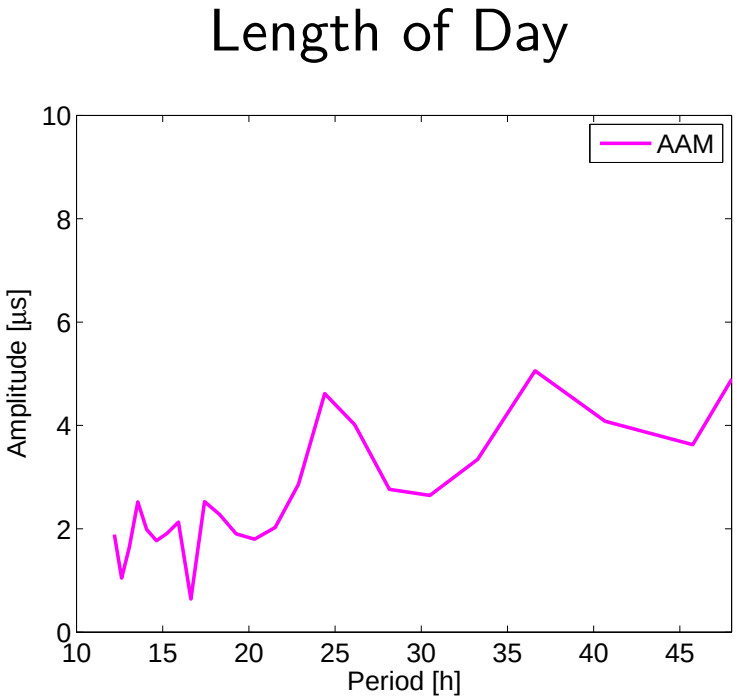
CONT05


Polar motion
AAM
VieVS
Amplitude [µas]
Period [h]
100
80
60
40
20
0
−10
0
10
20
30
40

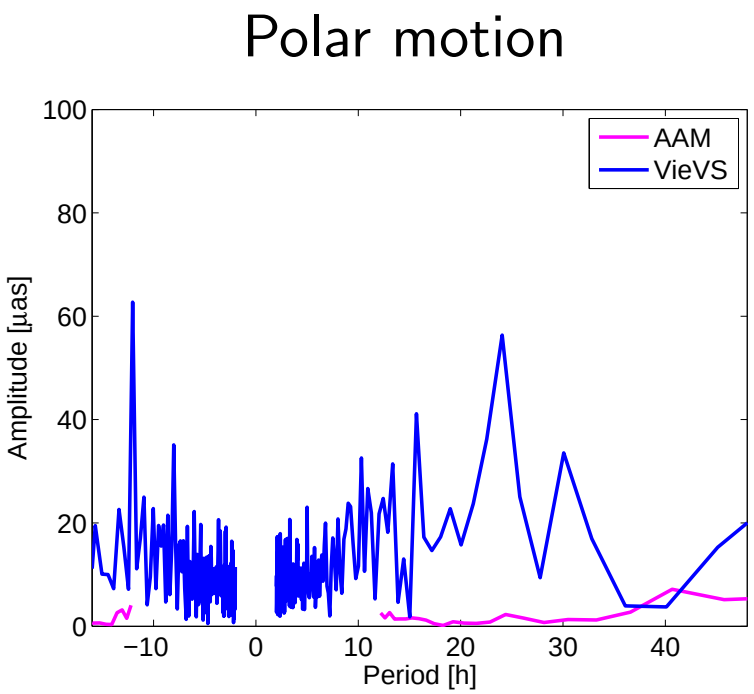

Length of Day
AAM
VieVS
Amplitude [µs]
Period [h]
50
40
30
20
10
0
10
15
20
25
30
35
40
45

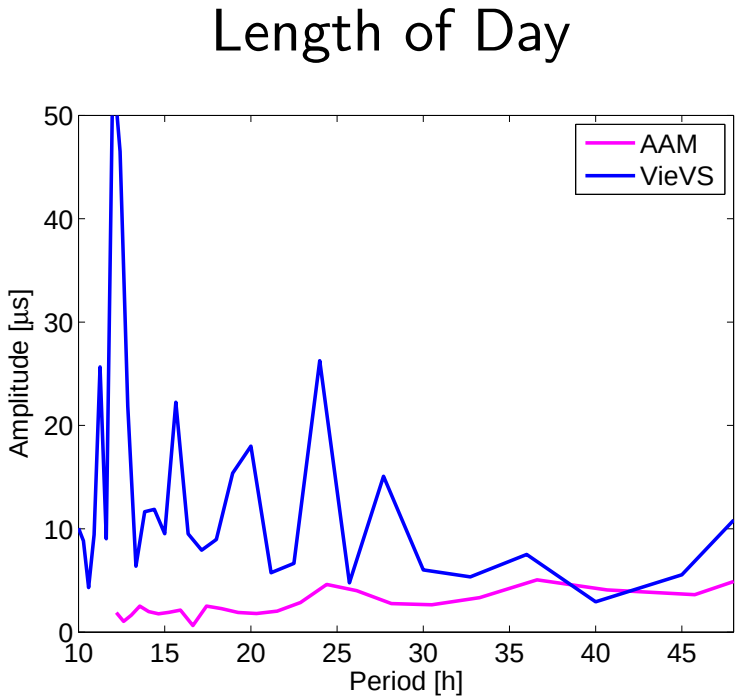
CONT02


Polar motion
AAM
Amplitude [µas]
Period [h]
10
8
6
4
2
0
−10
0
10
20
30
40


Length of Day
AAM
Amplitude [µs]
Period [h]
10
8
6
4
2
0
10
15
20
25
30
35
40
45

CONT02


Polar motion
AAM
VieVS
Amplitude [µas]
Period [h]
100
80
60
40
20
0
−10
0
10
20
30
40


Length of Day
AAM
VieVS
Amplitude [µs]
Period [h]
50
40
30
20
10
0
10
15
20
25
30
35
40
45

Conclusions

- The Earth Rotation Parameters estimated from VieVS agrees with those estimated by Calc/Solve.
- Unexplained signals in the spectra with periods 24, 12, and sometimes 8 hours.
- The contribution from the atmosphere to the sub-diurnal Earth rotation variations is a magnitude lower than the observed variations.

Thank you for your attention!