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High frequency EOP estimated from the CONT campaigns

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VieVS User Workshop
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Vienna



 The CONT campaigns:

 Continuous VLBI observations over 15 days


 CONT02:

 October 2002

 8 stations

 CONT05:

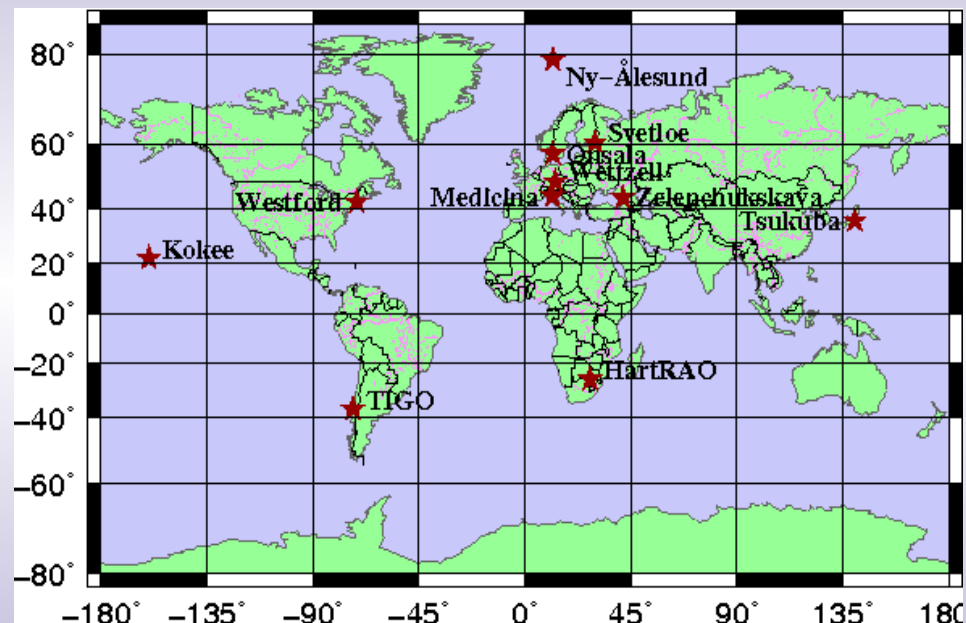
 September 2005

 11 stations

 CONT08:

 August 2008

 11 stations







The CONT08 Network








High frequency EOP from CONT campaigns

- ▶ One of the main purposes of the CONT campaigns was to obtain high frequency EOP (sub-diurnal resolution)
- ▶ VieVS was used to estimate hourly EOP's from CONT02, CONT05 and CONT08
- ▶ Issues that need consideration:
 - ▶ Each CONT campaign consist of 15 individual sessions. Needs to be combined in order to avoid jumps between sessions
 - ▶ Separation of polar motion and nutation when having sub-diurnal resolution

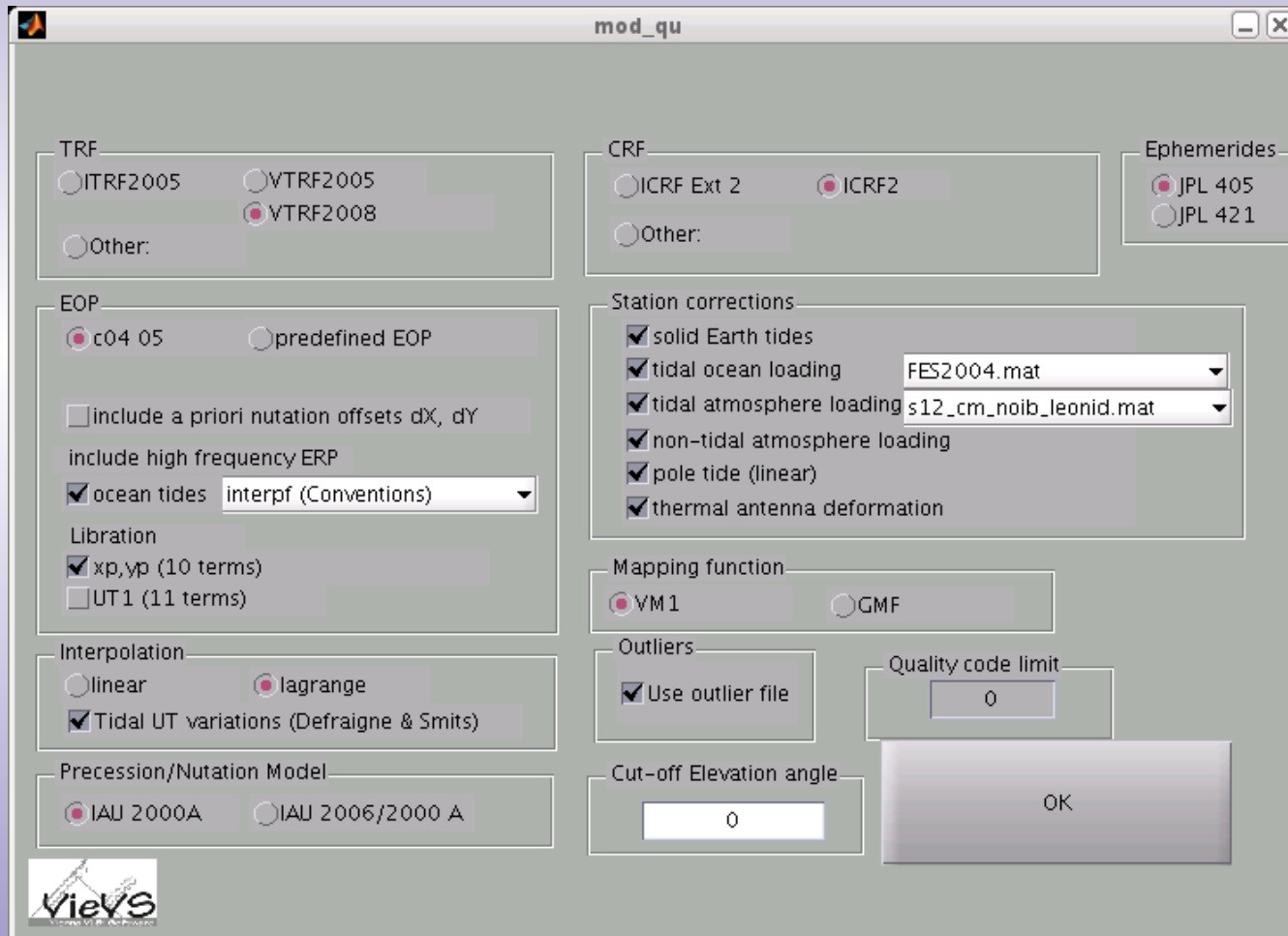
High frequency EOP from CONT campaigns (II)

-  Each session was first processed individually using VieVS. Normal equations were saved.
-  The normal equations of each CONT campaign were then stacked using a MATLAB script.
-  Polar motion and nutation were represented in the frequency domain. Make it easy to block certain frequencies
-  Inversion of the stacked normal equations gives EOP time series with hourly resolution.

Setup in VieVS

-  VIE_MOD: follow IERS conventions
-  Clocks: 1 hour resolution
-  ZWD: 30 minutes resolution
-  Gradients: 2 hour resolution
-  Station coordinates: estimated, constant offset for each CONT, NNT/NNR to VTRF2008
-  Source coordinates: fixed to ICRF2
-  EOP's: 1 hour resolution

Setup in VieVS (II)



The screenshot shows the 'mod_qu' configuration window in VieVS. The window is divided into several sections for configuring various parameters:

- TRF:** Radio buttons for ITRF2005, VTRF2005, VTRF2008, and Other. VTRF2008 is selected.
- CRF:** Radio buttons for ICRF Ext 2, ICRF2, and Other. ICRF2 is selected.
- Ephemerides:** Radio buttons for JPL 405 and JPL 421. JPL 405 is selected.
- EOP:** Radio buttons for c04 05 and predefined EOP. c04 05 is selected. There are checkboxes for 'include a priori nutation offsets dX, dY', 'include high frequency ERP', and 'ocean tides' (selected). A dropdown menu for 'ocean tides' is set to 'interp (Conventions)'. Under 'Libration', there are checkboxes for 'xp,yp (10 terms)' (selected) and 'UT 1 (11 terms)'.
- Station corrections:** A list of checkboxes: 'solid Earth tides' (checked), 'tidal ocean loading' (checked, with a dropdown menu set to 'FES2004.mat'), 'tidal atmosphere loading' (checked, with a dropdown menu set to 's12_cm_noib_leonid.mat'), 'non-tidal atmosphere loading' (checked), 'pole tide (linear)' (checked), and 'thermal antenna deformation' (checked).
- Mapping function:** Radio buttons for VM1 and GMF. VM1 is selected.
- Interpolation:** Radio buttons for linear and lagrange. lagrange is selected. There is a checked checkbox for 'Tidal UT variations (Defraigne & Smits)'.
- Precession/Nutation Model:** Radio buttons for IAU 2000A and IAU 2006/2000 A. IAU 2000A is selected.
- Outliers:** A checked checkbox for 'Use outlier file'.
- Quality code limit:** A text input field containing the value '0'.
- Cut-off Elevation angle:** A text input field containing the value '0'.

An 'OK' button is located at the bottom right of the window. The VieVS logo is visible in the bottom left corner of the window.

Setup in VieVS (III)

vie_ism_multi_gui_eop

vie_ism [multiple sessions EOP]

Earth Orientation Parameter (EOP) pwl offsets estimation options

	include model	estimation interval	use constraints	constraints
Xpol (inter. pole coord. in TRF)	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	1.0000e-...
Ypol (inter. pole coord. in TRF)	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	1.0000e-...
dUT1 (rotation angle)	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	1.0000e-...
nutdx (CIP coord. in celes. long.)	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	1.0000e-...
nutdy (CIP coord. in obliquity)	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	1.0000e-...

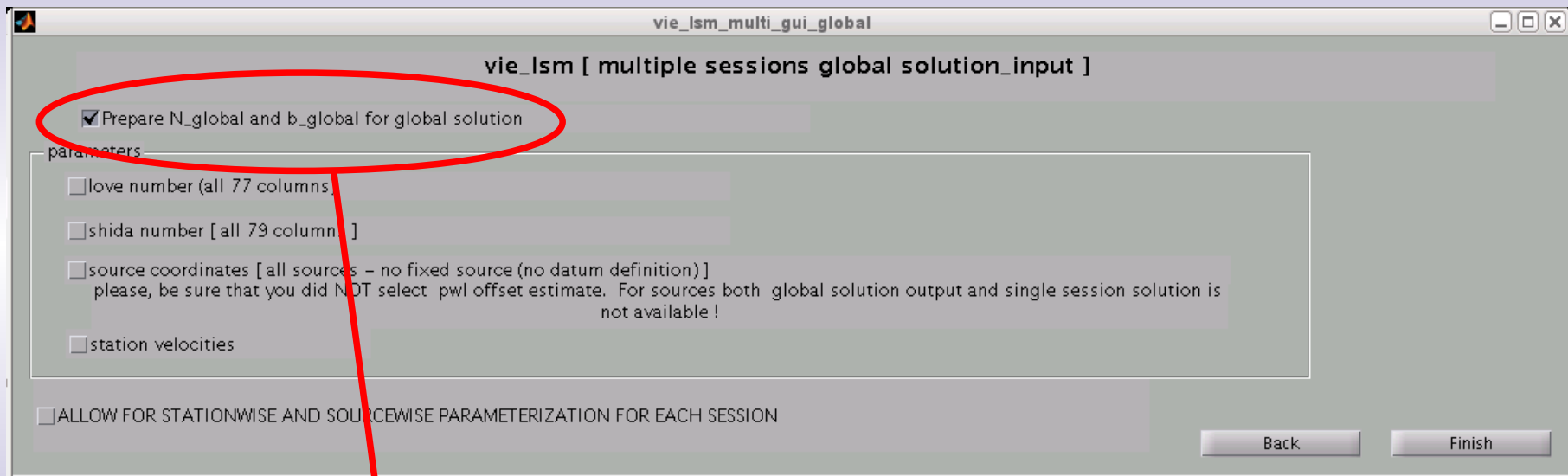
- unit of estimation intervals is minute.
 - units of constraints are mas/day & ms/day for EOP
 - 3 mas/day or 3 ms/day constraints are loose for all EOP
 - 0.001 mas/day or 0.001 ms/day constraints are tight for all EOP

Back Next

All EOP's estimated with hourly resolution

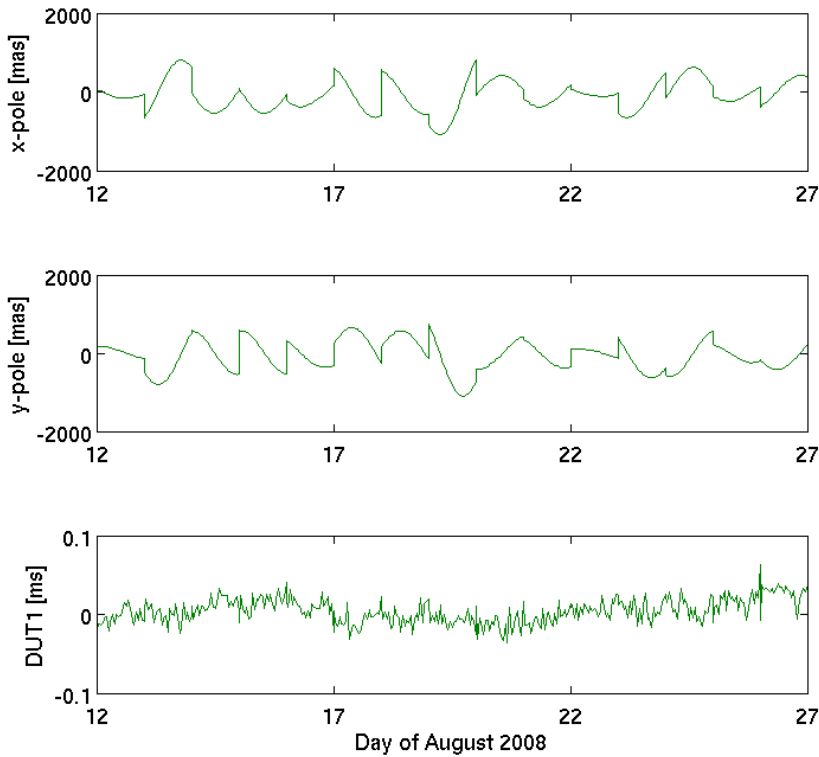
No constraints applied
 Done later when stacking the normal equations





Setup in VieVS (IV)



Save the normal equation matrices

EOP from single session analysis



-  CONT08
-  Estimates relative to the a priori values
-  Polar motion estimates really bad. Reason: problem badly posed, polar motion and nutation cannot be separated
-  DUT1 ok

Stacking of normal equations

- ▶ Use the data saved in **DATA/LEVEL2/**
 - ▶ 08AUGDD_N004_Nb_glob: N and b matrices
 - ▶ 08AUGDD_N004_par_glob: x_ and opt_ structure arrays (x_ needed for bookkeeping, which variable is in which column)
 - ▶ 08AUGDD_N004_an_glob: station positions
- ▶ Stack EOP's, ZWD, and gradients at the session boundaries. Stack station coordinates
- ▶ Add constraints for the EOP's (relative constraints, 2 mas/day)

Separating polar motion and nutation

- According to the definition of the Celestial Intermediate Pole, there are no nutations with periods <48 hours. Consequently, polar motion with period between -48 and -16 hours are considered as nutation
- We express polar motion and nutation by their Fourier series:

$$x_p(t) = \sum_{k=0}^{N-1} [a_k \cos(\omega_k t) + b_k \sin(\omega_k t)],$$
$$y_p(t) = \sum_{k=0}^{N-1} [-a_k \sin(\omega_k t) + b_k \cos(\omega_k t)],$$

$$dX(t) = \sum_{k=0}^{N-1} [c_k \cos(\omega_k t) - d_k \sin(\omega_k t)],$$
$$dY(t) = \sum_{k=0}^{N-1} [c_k \sin(\omega_k t) + d_k \cos(\omega_k t)].$$

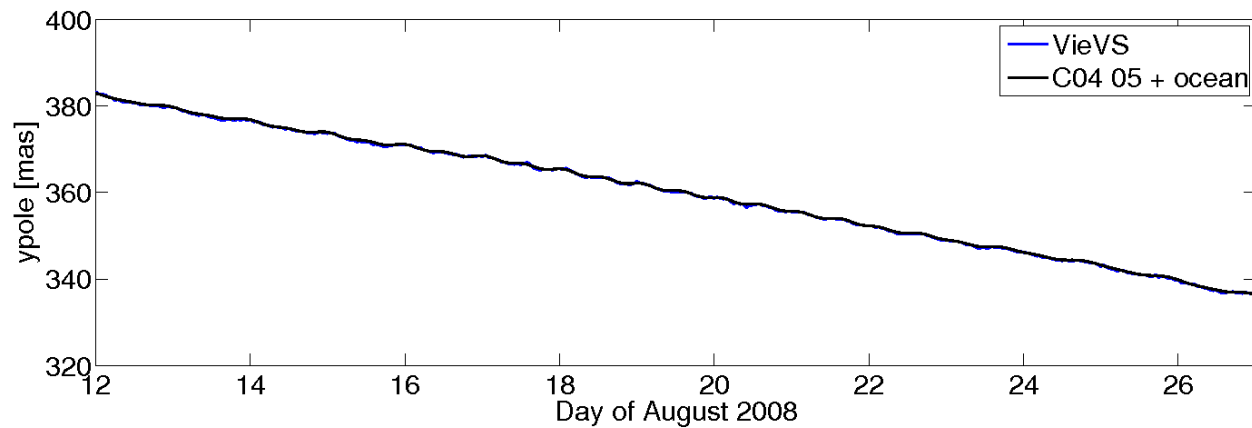
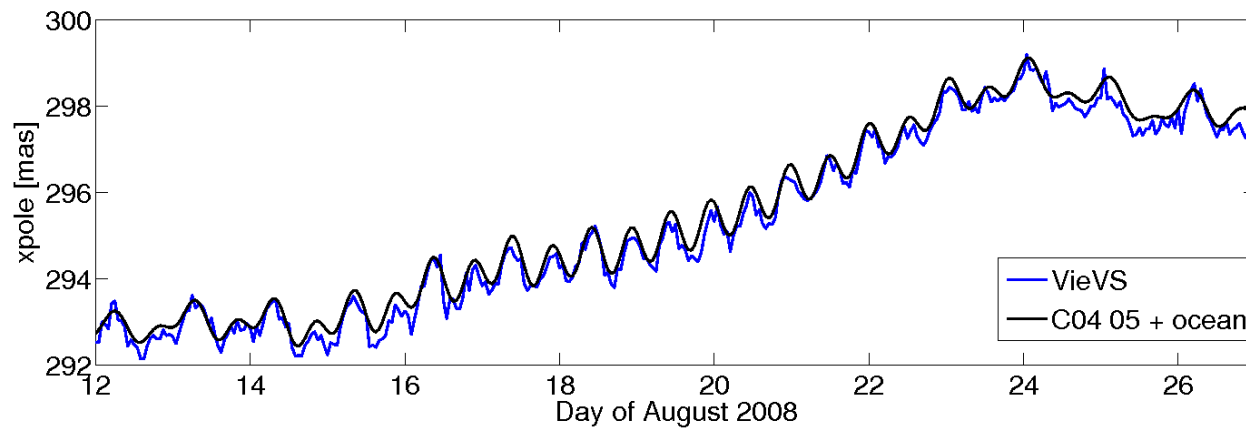
Separating polar motion and nutation (II)

- ▶ A change of variables is made. Instead of estimating polar motion and nutation series, the Fourier coefficients a_k , b_k , c_k , and d_k are estimated.

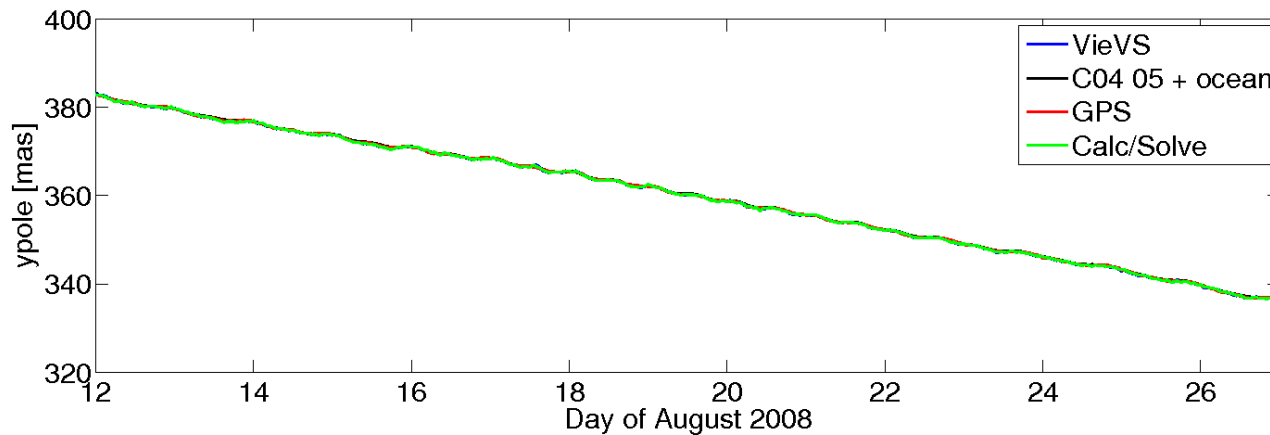
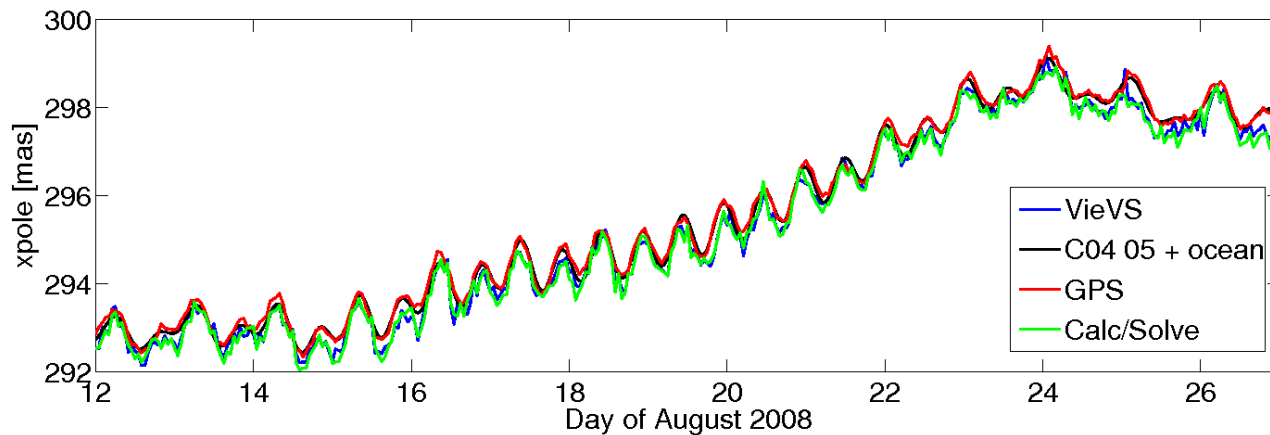
$$x_{\text{new}} = Mx_{\text{old}}, N_{\text{new}} = M^T N_{\text{old}} M, b_{\text{new}} = M^T b_{\text{old}}$$

- ▶ Set the coefficients a_k , b_k to zero for frequencies between -1.5 and 0.5 cycles per day. Set c_k , and d_k to zero for frequencies higher than 0.5 cycles per day.
- ▶ The normal equation matrix is now regular. A solution can be obtained.

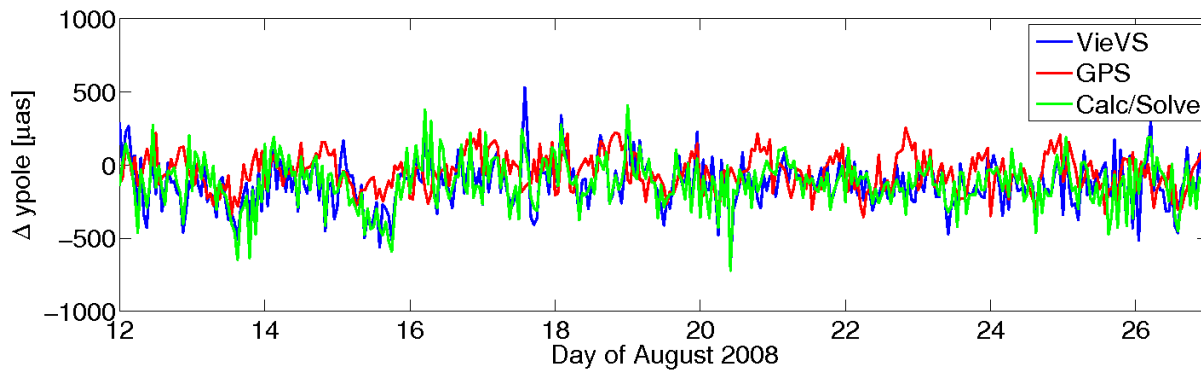
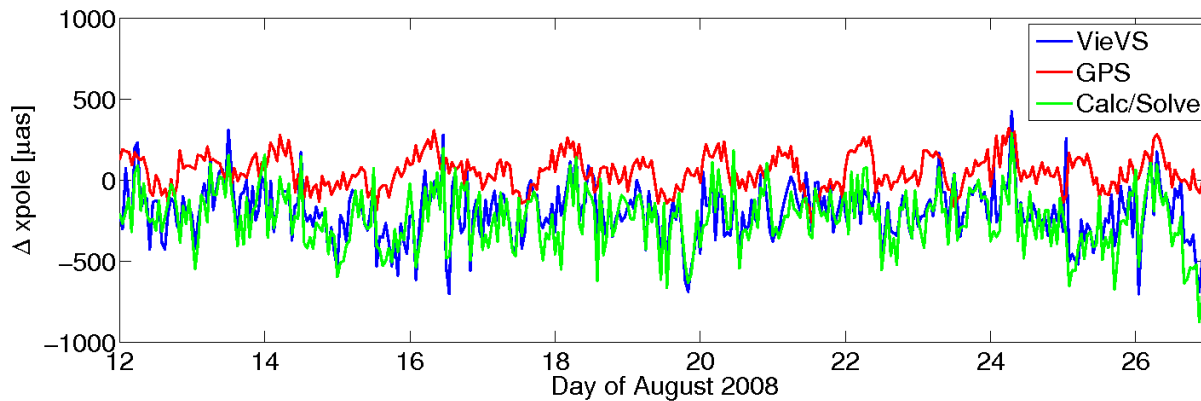
Polar motion from CONT08



Polar motion from CONT08 (II)

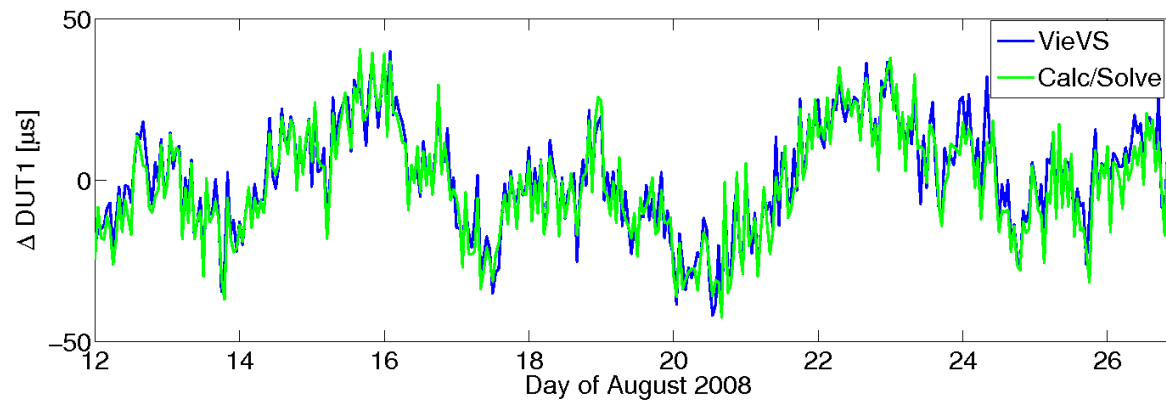


Polar motion from CONT08 (III)

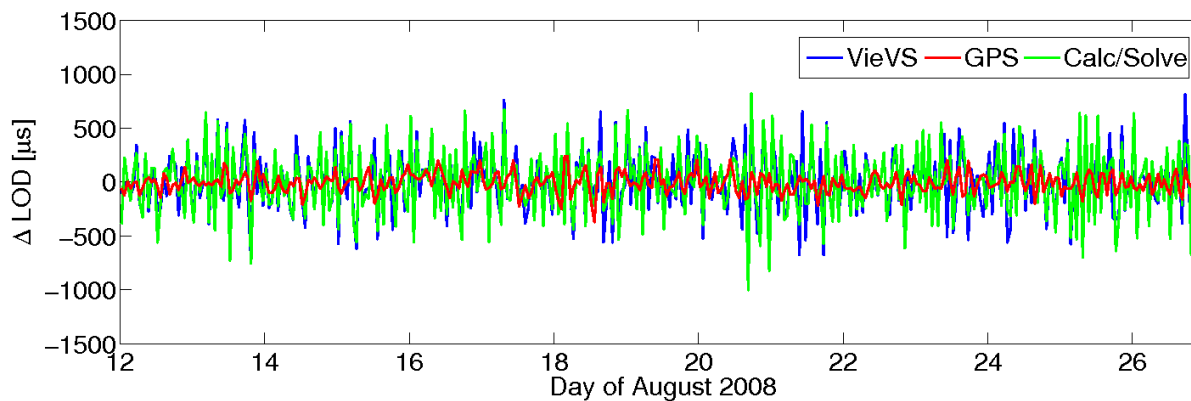


Difference
to 05 C04 +
IERS HF
ERP model

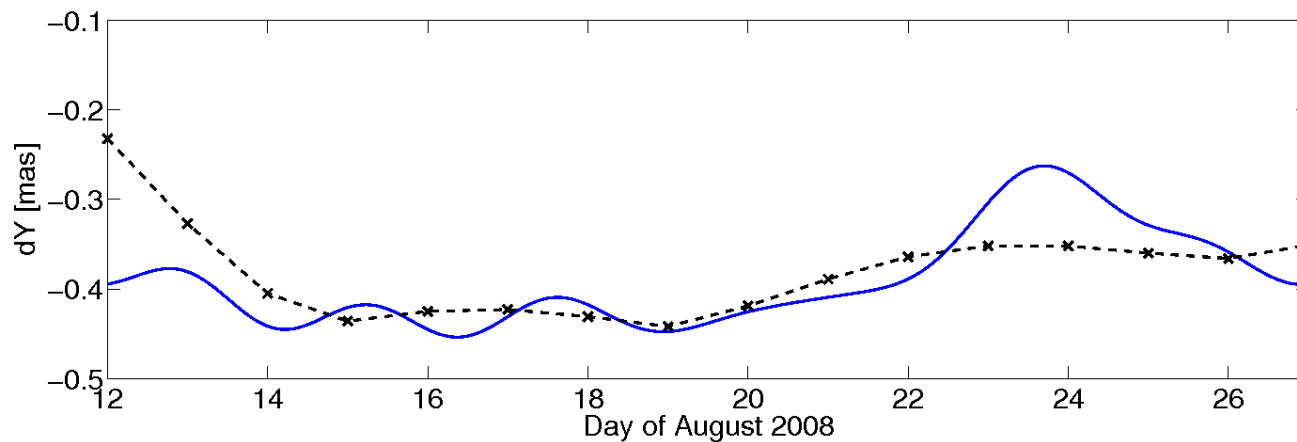
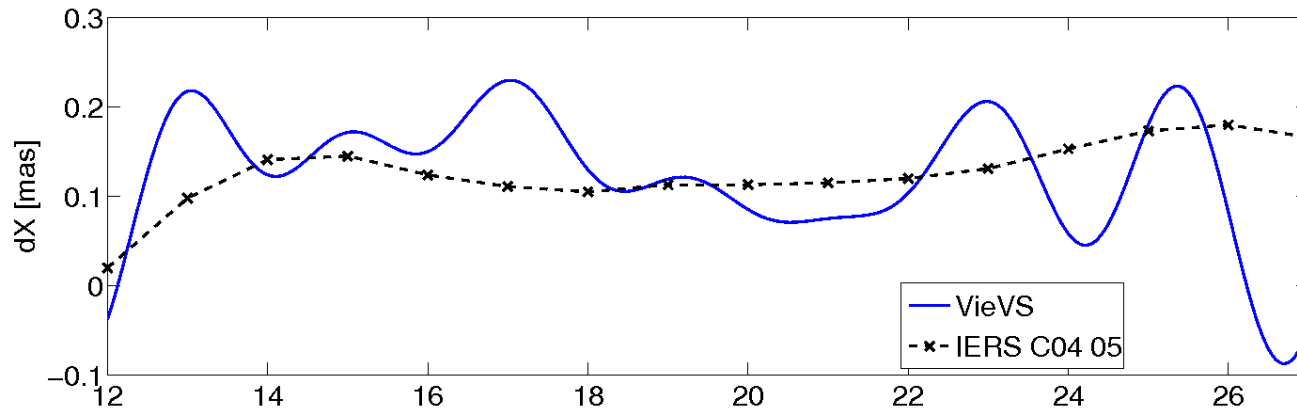
DUT1 and LOD from CONT08



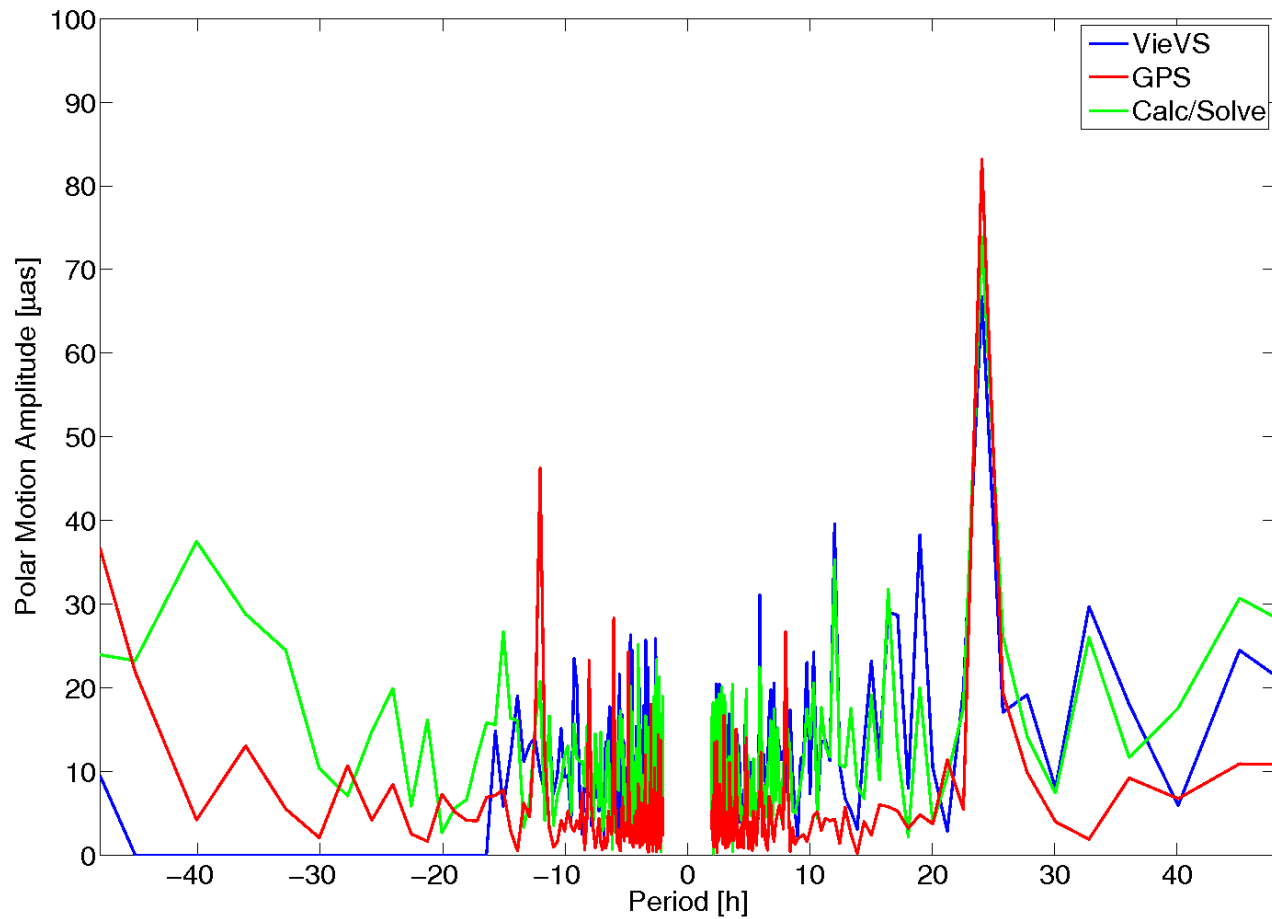
Difference
to 05 C04 +
IERS HF
ERP model



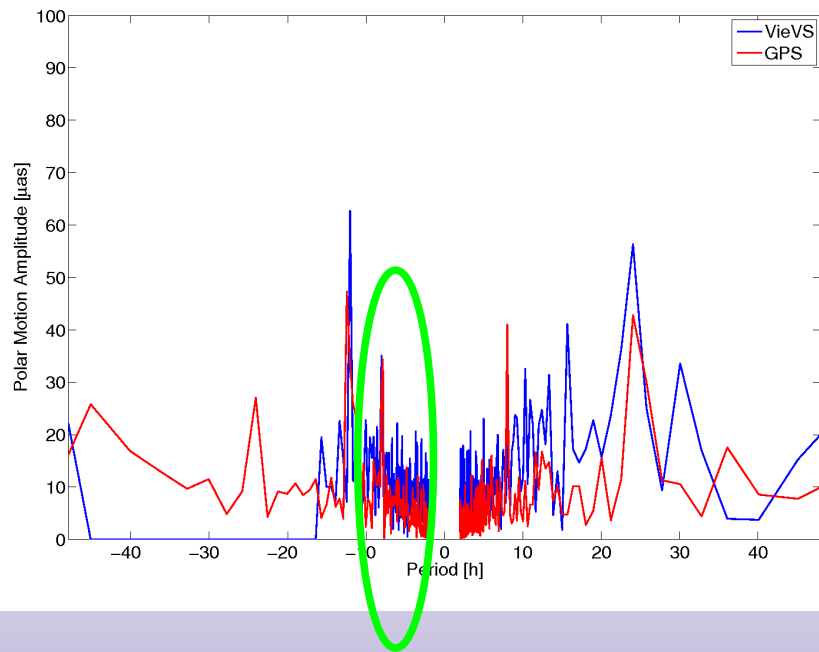
Nutation from CONT08



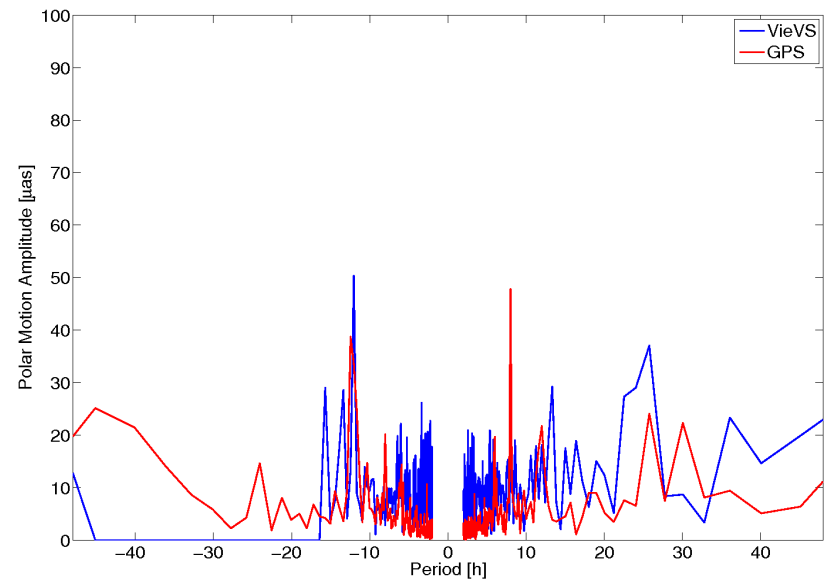
Polar motion residual spectrum, CONT08



Polar motion residual spectrum, CONT05 and CONT02



CONT02



CONT05

Conclusions

- ▶ VieVS have been used successfully for estimating high frequency EOP
- ▶ Results agree very well with Calc/Solve results and well with GPS results
- ▶ A special MATLAB script was used for the stacking of the normal equations. This could also have been done using VIE_GLOB