DFG Forschergruppe Referenzsysteme

Interaction between subdaily Earth rotation parameters and GPS orbits

Natalia Panafidina, Urs Hugentobler, Manuela Seitz

Deutsches Geodätisches Forschungsinstitut (DGFI)
Centrum für Geodätische Erdsystemforschung (CGE)
München
TU München

IAG 2013, Potsdam, Germany, 2-6 September 2013

Introduction

Subdaily Earth Rotation model: IERS2010 (+ libration)

Kept fixed in the processing

Errors up to ~20%

<u>Empirical tidal models from GPS & VLBI:</u>

Big corrections (more than 10 µas in PM) for some tidal terms:

K1(23.93h), S1 (24h), M2(12.42h), S2(12h), K2(11.97h)

IERS2010+libration: K1 correction ~30 µas

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Influence on the reference frames realized by the satelliites

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Data and solutions

Data:

Daily NEQs (1994-2007): station coordinates, 1h-ERPs, GPS orbits

IERS2000 subdaily model used in processing

What we do:

Daily solutions, transformation 1h-ERPs → tidal terms

change apriori values for tidal terms + fix tidal terms

→ change subdaily model

Daily estimates:

GPS orbits, station coordinates, geocenter (NNR+NNT), 24h ERPs

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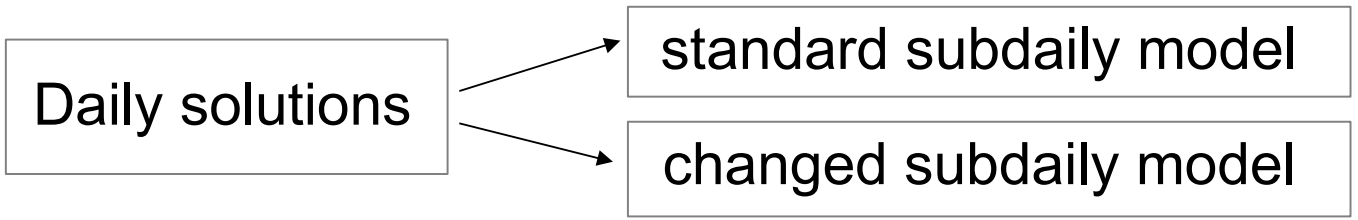
Data and solutions

Influence of subdaily tidal model: change 1 tide in PM by ~100 µas



Time series of differences:

GPS orbits
ERPs
Station coordinates
} Spectra

Systematic differences in reference frames realized by orbits:

Helmert parameters between standard and changed orbits

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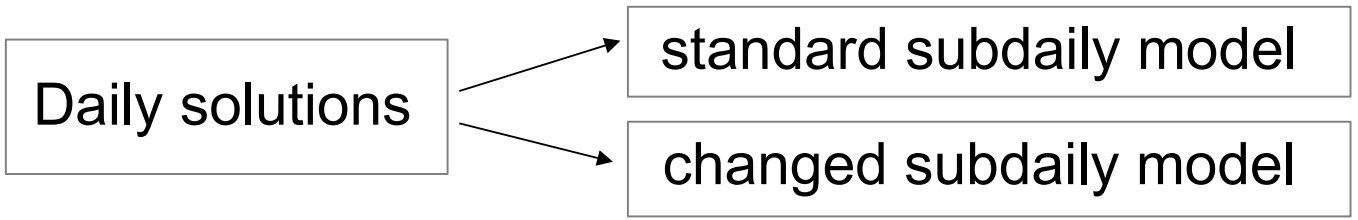

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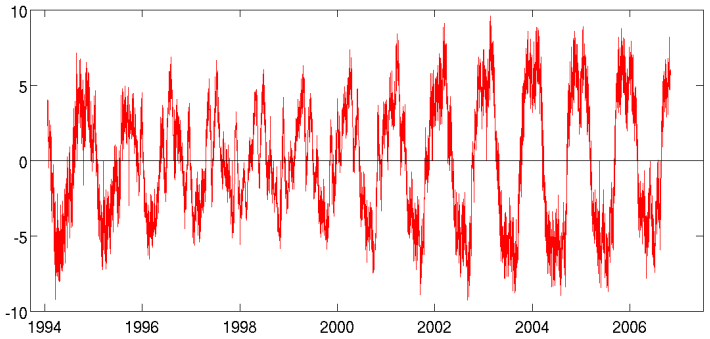
Helmert parameters between standard orbit and changed orbit

GPS orbits computed with standard subdaily model vs
subdaily model with changed S1 tide in PM



X translation: PRN5

Helmert parameters between standard orbit and changed orbit

GPS orbits computed with standard subdaily model vs
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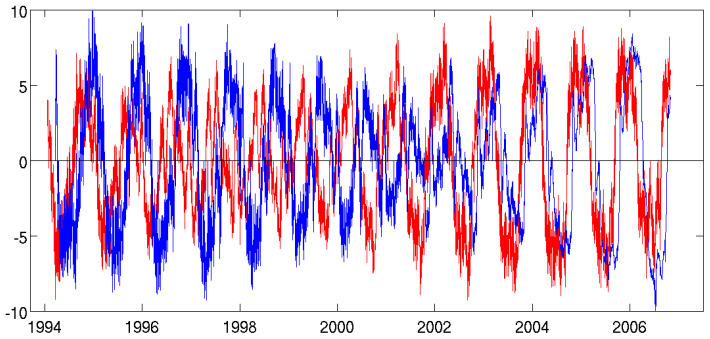

X translation: PRN5, PRN6

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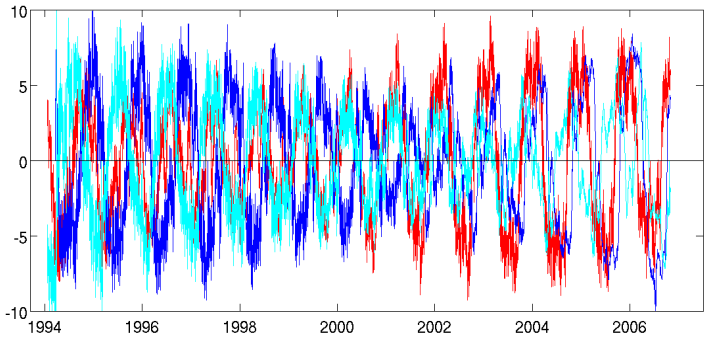

X translation: PRN5, PRN6, PRN7

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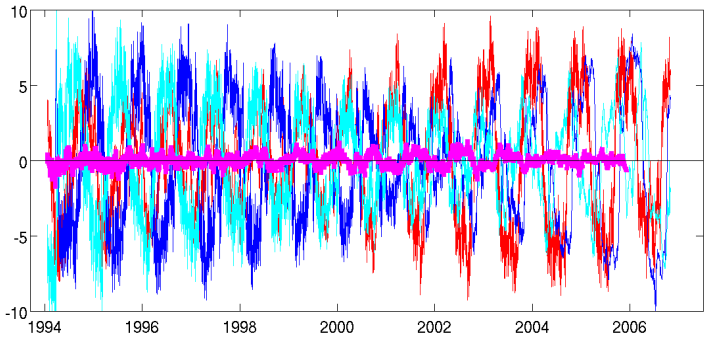

X translation: PRN5, PRN6, PRN7,
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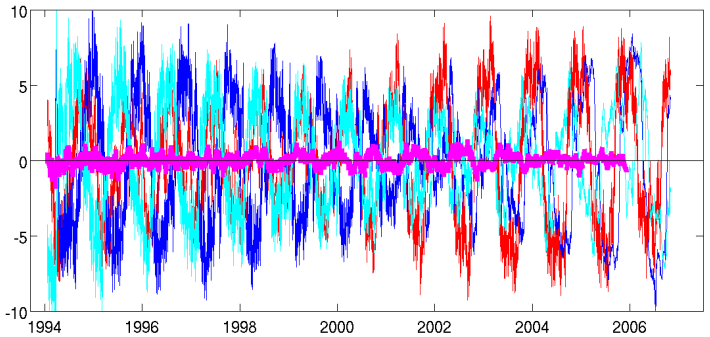

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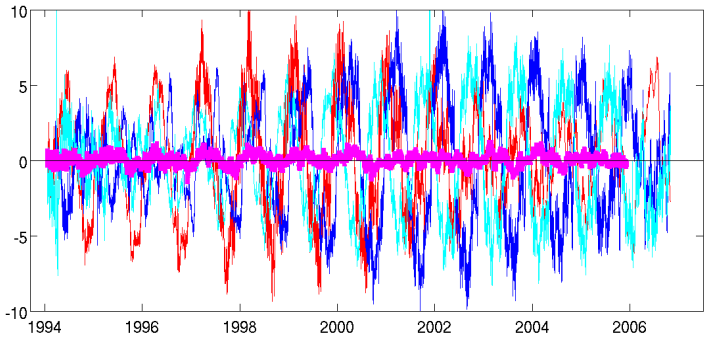

Y translation: PRN5, PRN6, PRN7,
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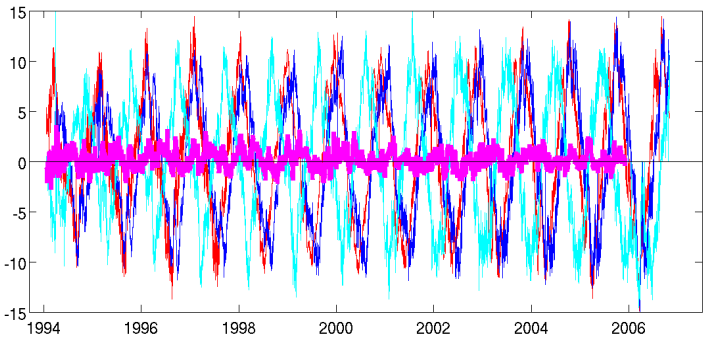

Z translation: PRN5, PRN6, PRN7,
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GPS orbits computed with standard subdaily model vs
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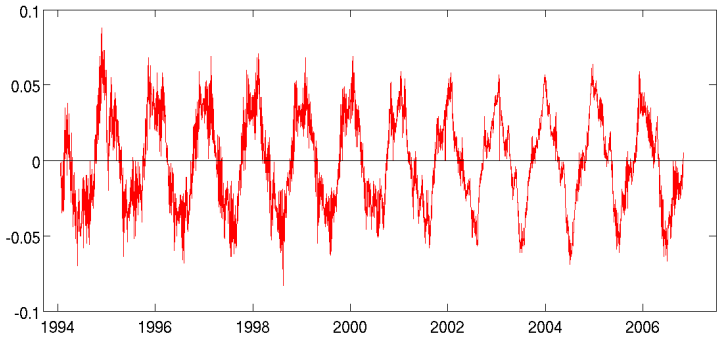

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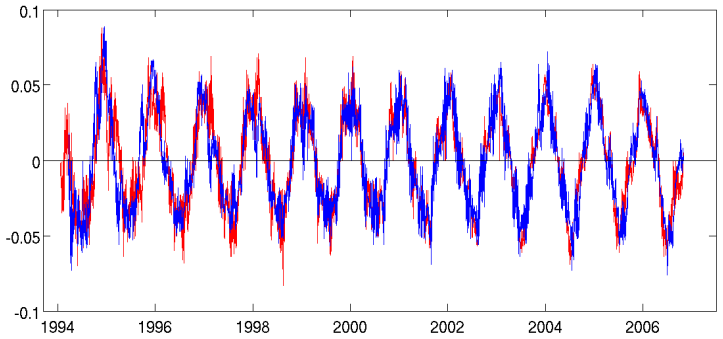

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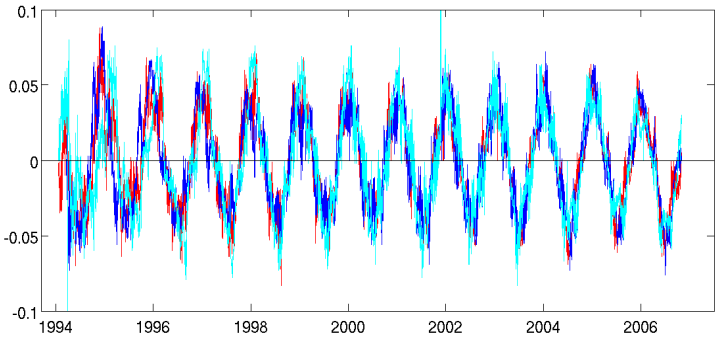

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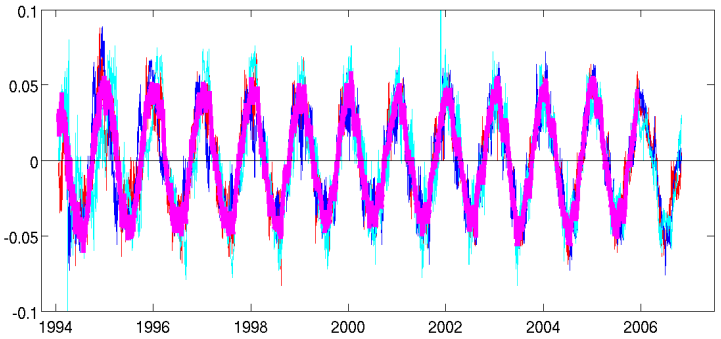

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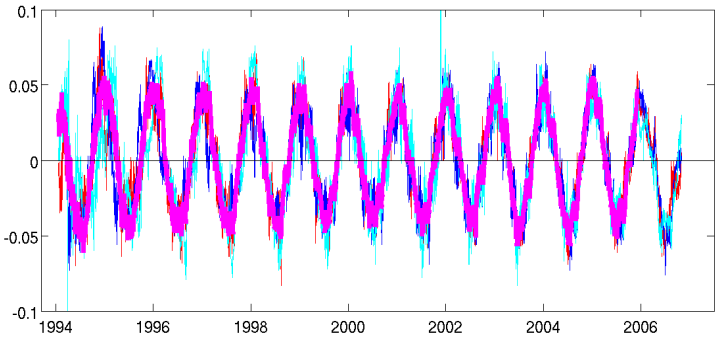

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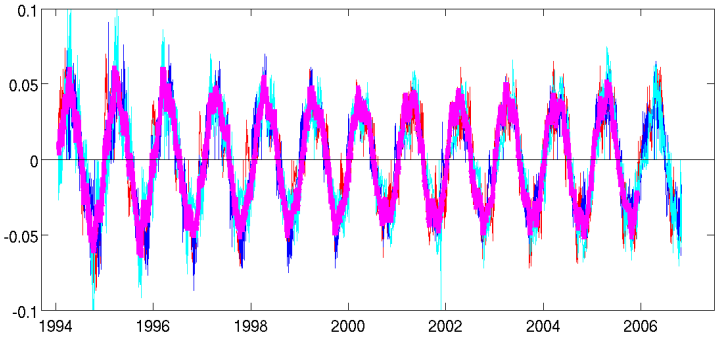

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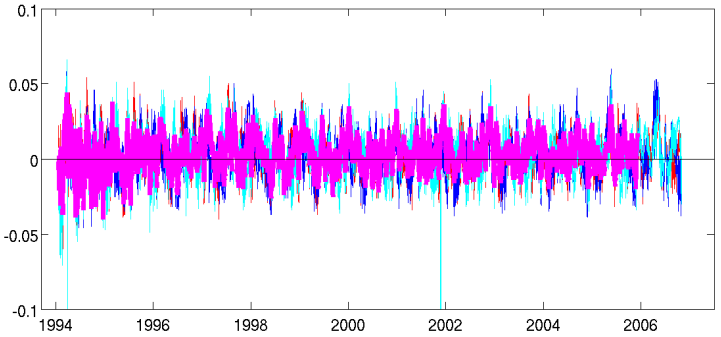

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Helmert parameters between standard orbit and changed orbit

Changes in the subdaily tidal model:

No influence on the origin of the satellite reference frame

Changes in orientation: common rotation of the whole satellite constellation

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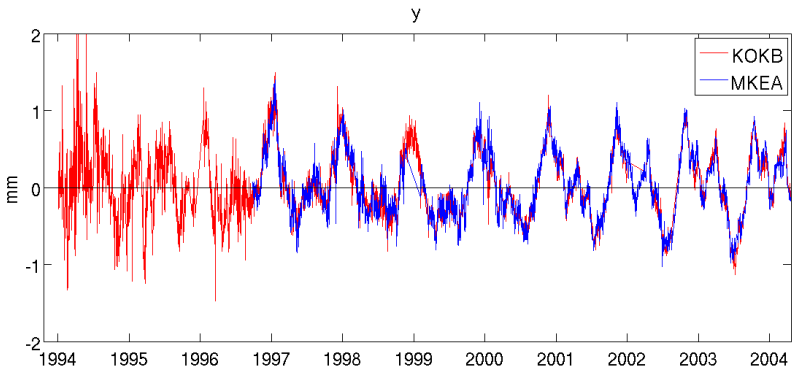
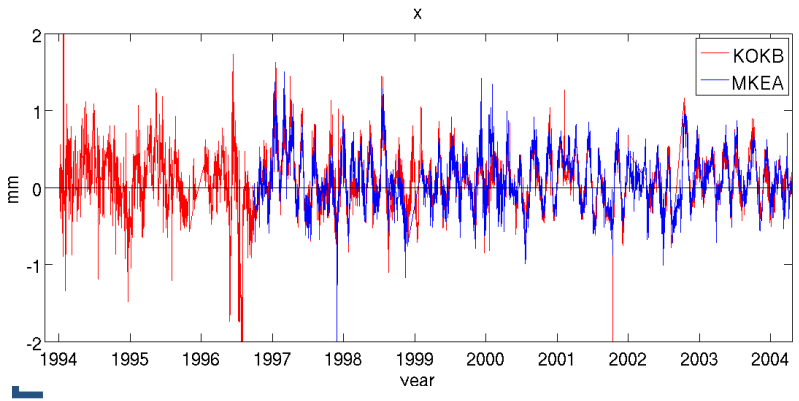
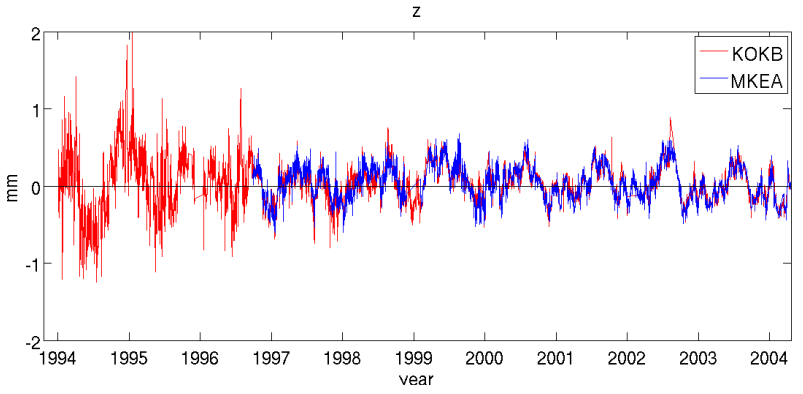
Changes in station coordinates caused by changed S1 tide in subdaiy model:

stations KOKB, MKEA (Hawaii)







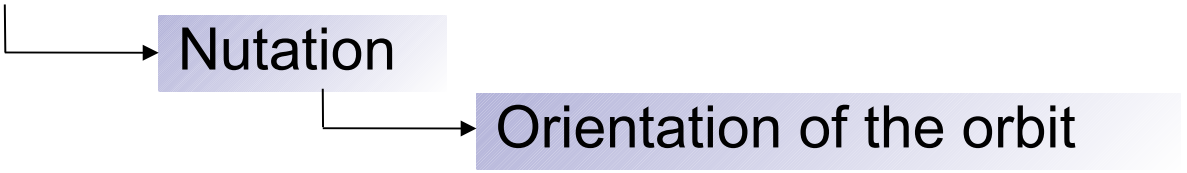
Subdaily model for ERPs

IERS2010 model for subdaily ERPs contains in PM:

Prograde diurnal terms

Prograde and retrograde semi-diurnal terms

No retrograde diurnal terms



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IERS2010 model for subdaily ERPs contains in PM:

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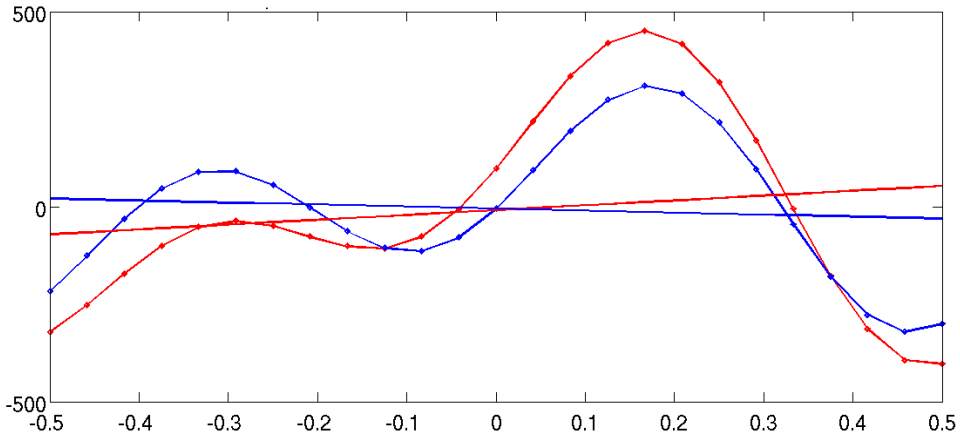
→ Nutation

→ Orientation of the orbit

Modelled ERPs over one day:
Standard model and
model with changed S1 tide



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Subdaily model for ERPs

Modelled ERPs with 1h resolution over 1994-2007:

- Standard subdaily model
- Subdaiy model with changed S1 tide

Subdaily model for ERPs

Modelled ERPs with 1h resolution over 1994-2007:

Standard subdaily model

Subdaiy model with changed S1 tide

Time series of ERPs computed from standard model:

For each day: fit by LSE retrograde diurnal wave

→ (1) amplitudes of sine and cosine

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Subdaily model for ERPs

Modelled ERPs with 1h resolution over 1994-2007:

Standard model

Model with changed S1 tide

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Time series of ERPs computed from model with changed S1:

For each day: fit by LSE retrograde diurnal wave

→ (2) amplitudes of sine and cosine

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- Model with changed S1 tide

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For each day: fit by LSE retrograde diurnal wave

→ (2) amplitudes of sine and cosine

Time series of differences ((1) - (2)) of estimated amplitudes of sine and cosine for retrograde diurnal wave

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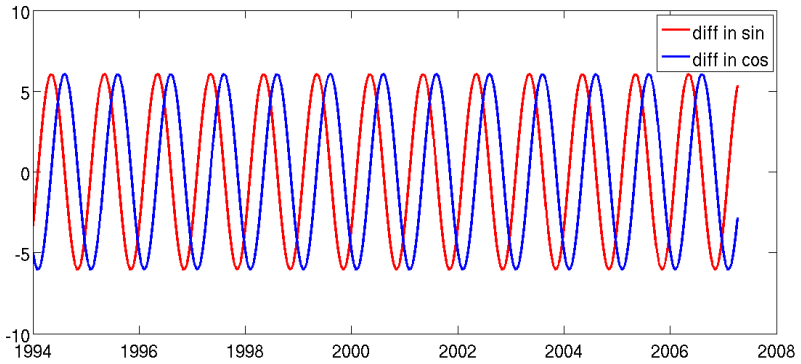
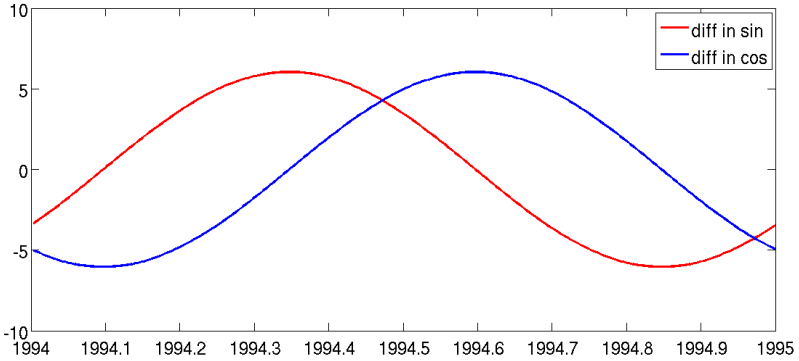
(Fictional) Retrograde diurnal signal in modelled subdaily ERPs

Differences in amplitudes of sine and cosine for retrograde diurnal wave:

standard model minus model with changed S1 tide





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Differences in amplitudes of sine and cosine for retrograde diurnal wave:

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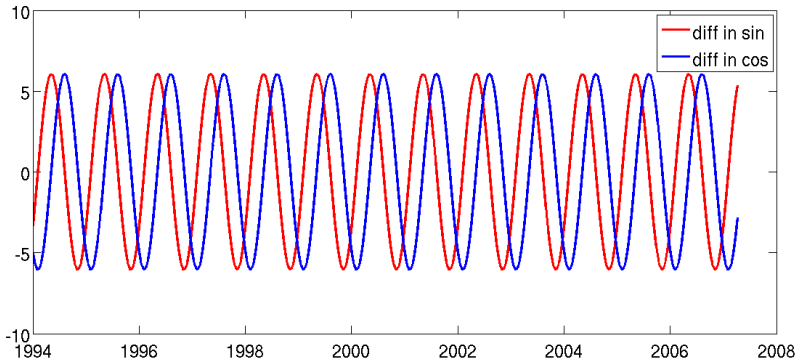

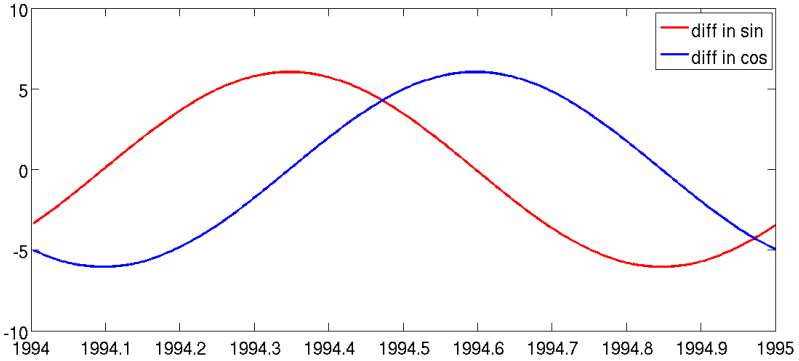

Connection between retrograde diurnal signal in PM and nutation offsets ΔΨ, Δε:

$$x_P(t) = -\Delta\psi(t) \cdot \sin\epsilon_0 \cdot \cos\theta - \Delta\epsilon(t) \cdot \sin\theta$$

$$y_P(t) = -\Delta\psi(t) \cdot \sin\epsilon_0 \cdot \sin\theta + \Delta\epsilon(t) \cdot \cos\theta$$

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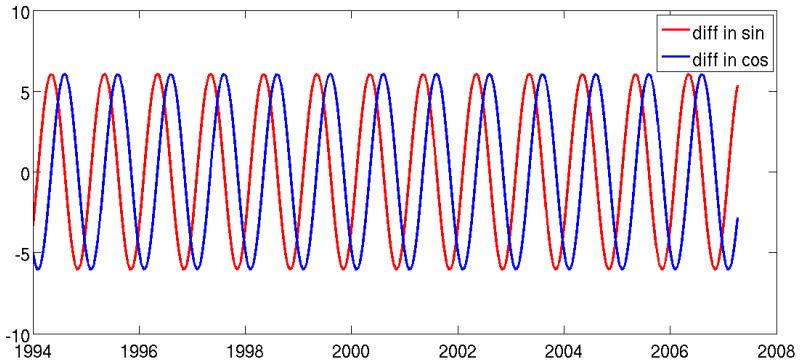
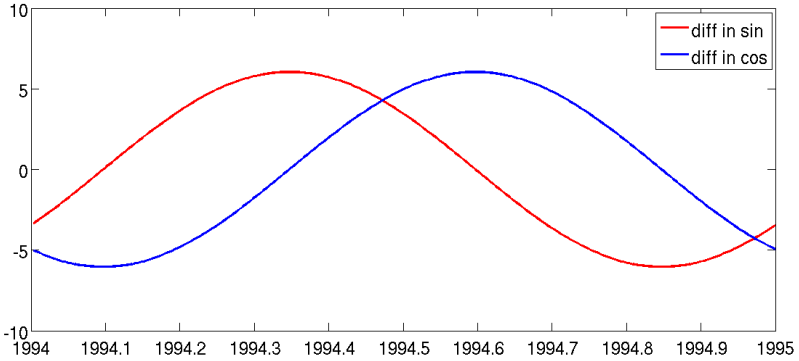
Differences in amplitudes of sine and cosine for retrograde diurnal wave:

standard model minus model with changed S1 tide





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Differences in amplitudes of sine and cosine for retrograde diurnal wave:

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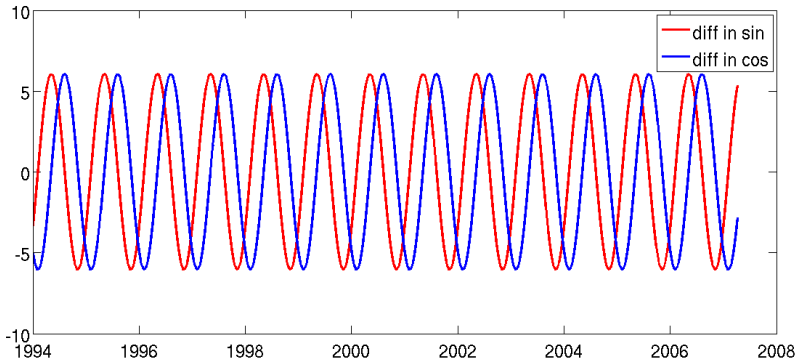

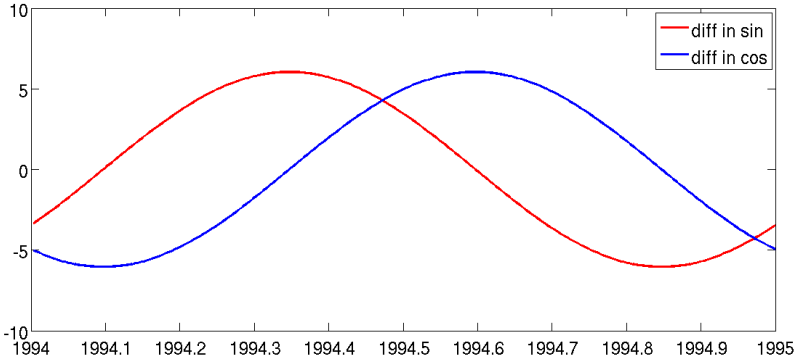

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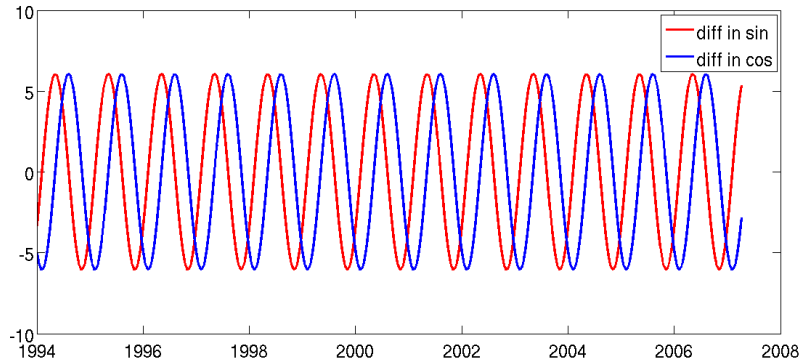
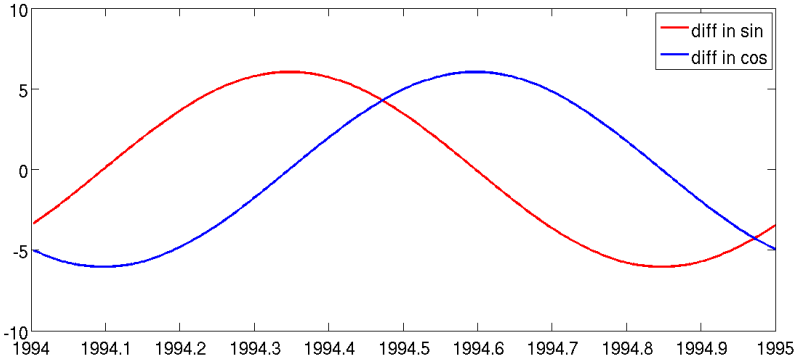
Corresponds to a relative nutation with a constant offset and period of ~365 days

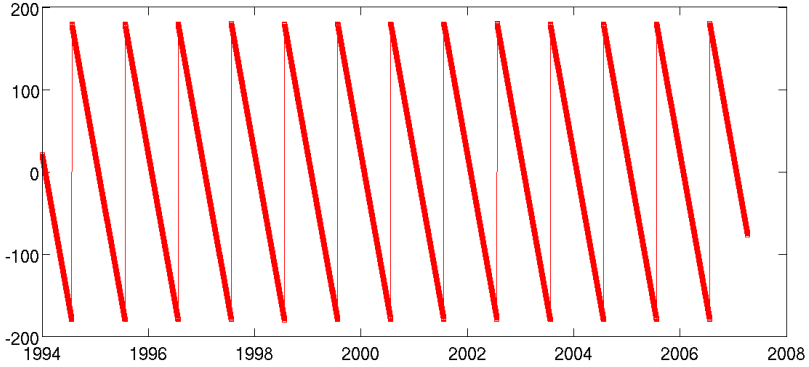
(Fictional) Retrograde diurnal signal in modelled subdaily ERPs

Differences in amplitudes of sine and cosine for retrograde diurnal wave:

standard model minus model with changed S1 tide







Constant offset, phase period ~365 days

Corresponds to a relative nutation with a constant offset and period of ~365 days

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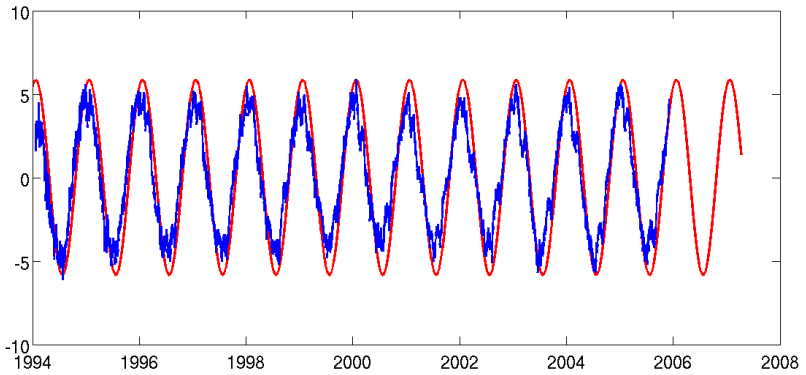
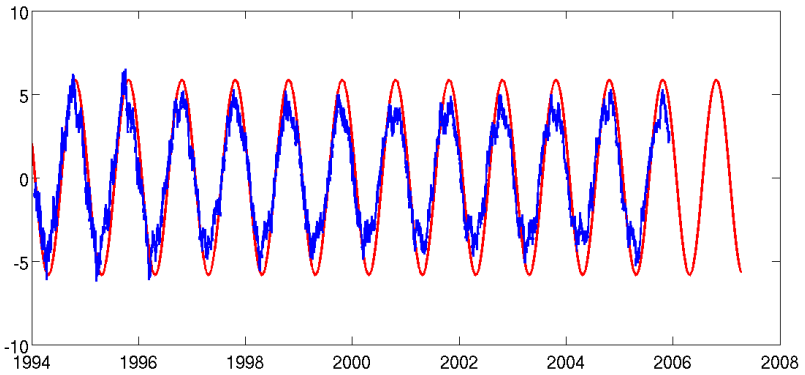
Differences in amplitudes of sine and cosine for retrograde diurnal wave:

standard model minus model with changed S1 tide



X-rotation
Difference in sine amplitudes



minus Y-rotation
Difference in cosine amplitudes

Corresponds to a relative nutation with a constant offset and period of ~365 days

(Fictional) Retrograde diurnal signal in subdaily ERPs

Fit retrograde wave over longer time spans:

Better decorrelation from prograde signal

Smaller amplitudes

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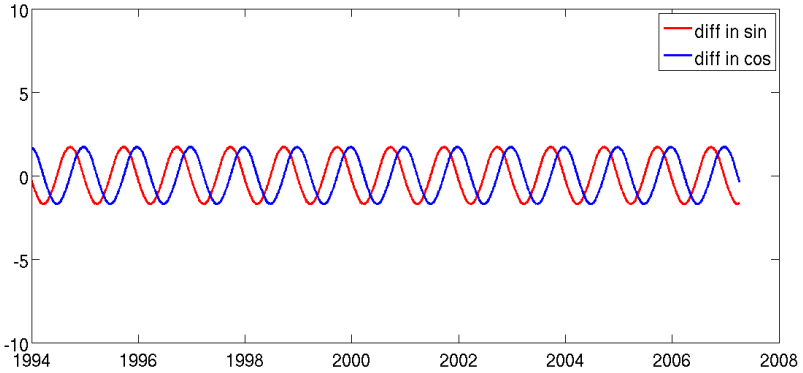
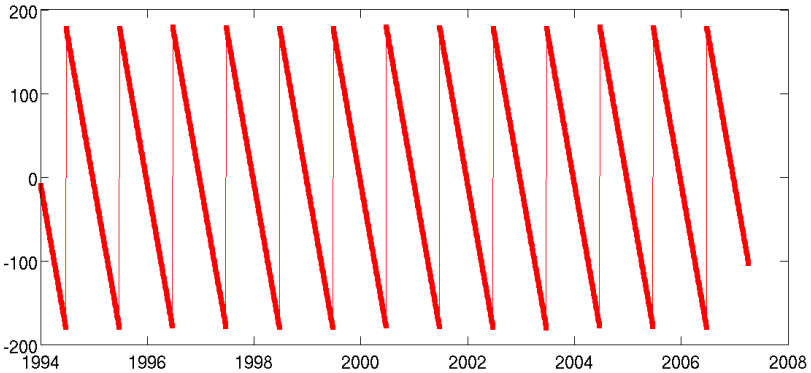
Fit retrograde wave over 3 days





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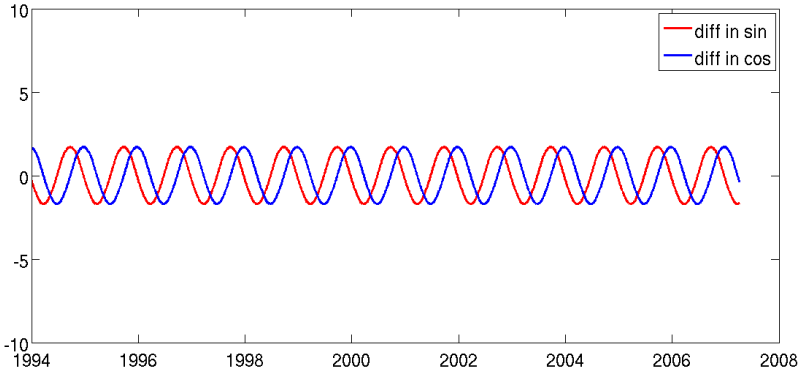
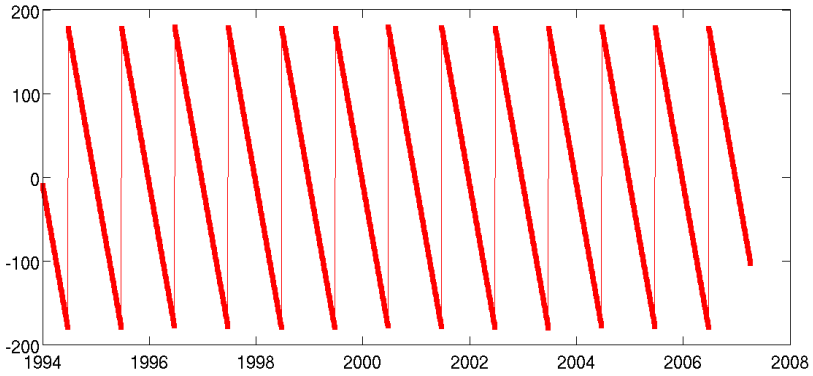
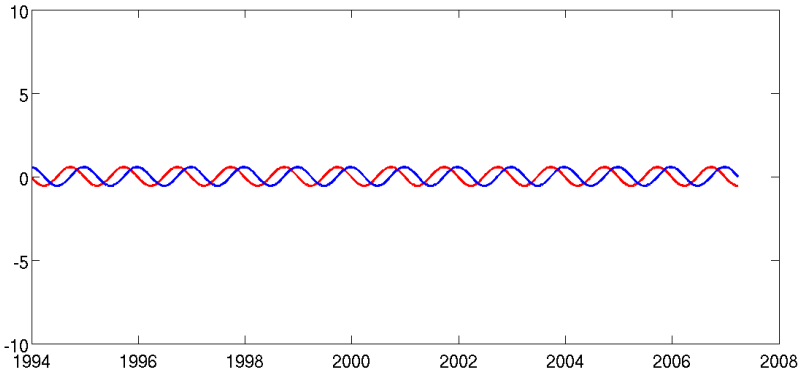




Fit retrograde wave over 10 days



Summary and Conclusions

For a 1-day GPS solution:

Part of the diurnal prograde signal in subdaily model for ERPs is mistaken for a retrograde signal

- Changes in nutation and orbit orientation
- Changes in the orientation of the dynamic reference frame realized by the orbits
- Respective periodic signals in time series of orbital parameters, station coordinates and ERPs

Independent of the satellite system used → can be checked with GLONASS

Solution: longer arc length?

estimation of subdaily ERPs?

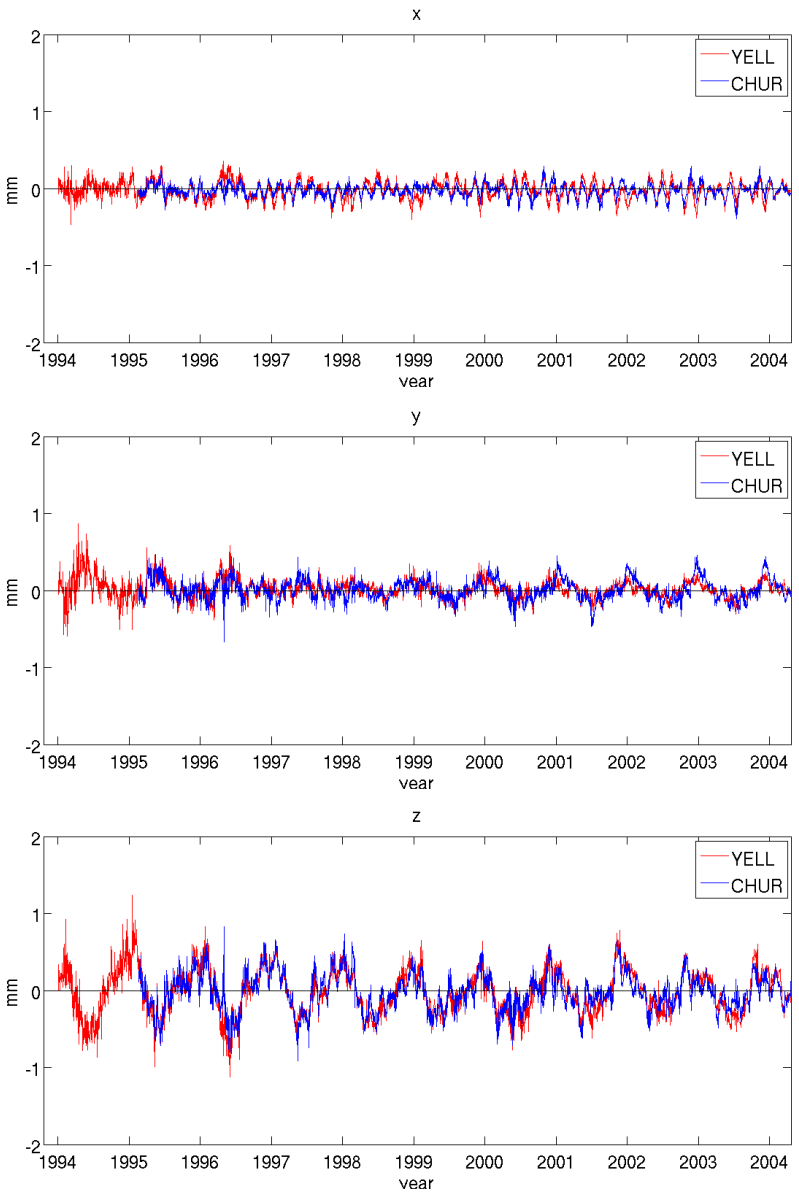
DGFI

EGE

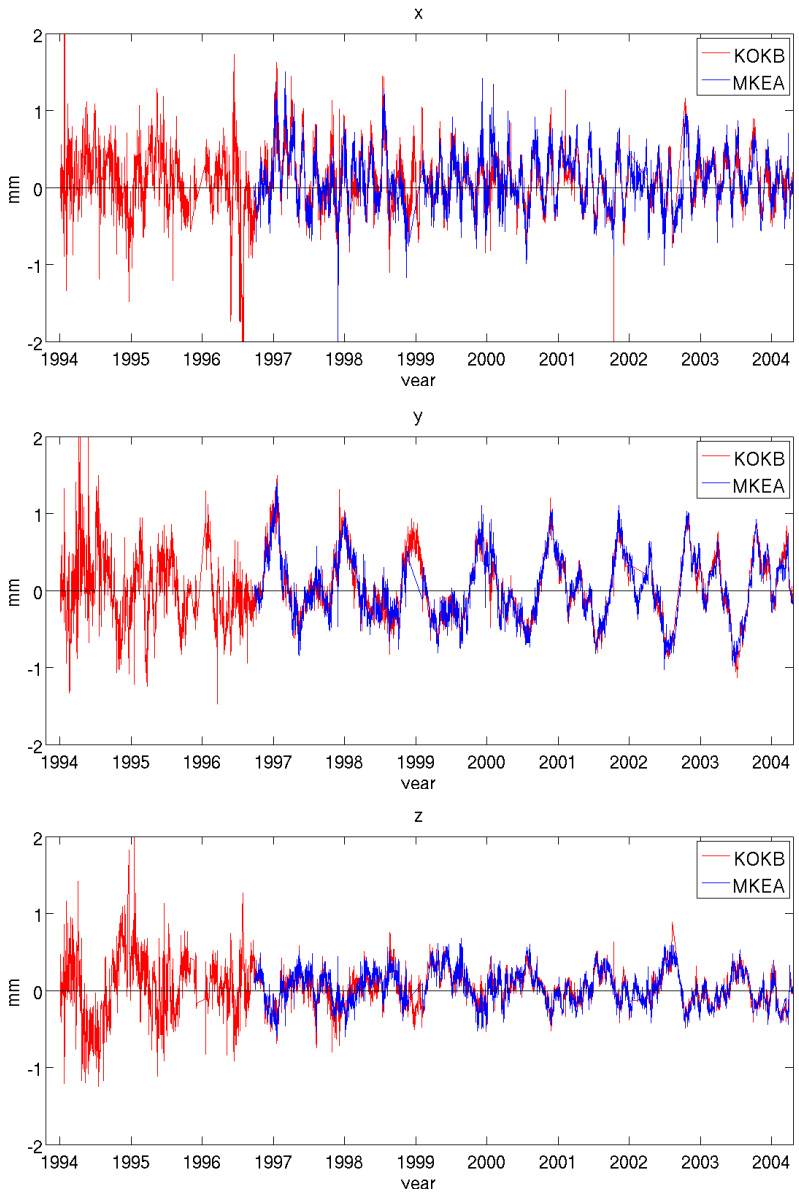
Thank you!

Influence of tidal model on the station coordinates

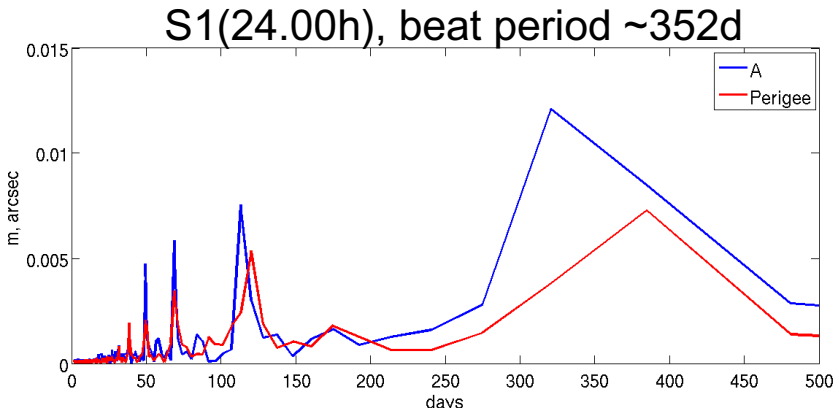
YELL, CHUR (Canada): tide S1

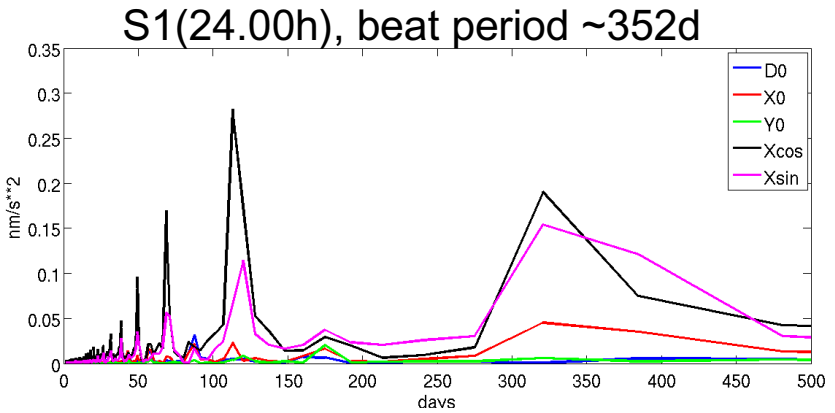


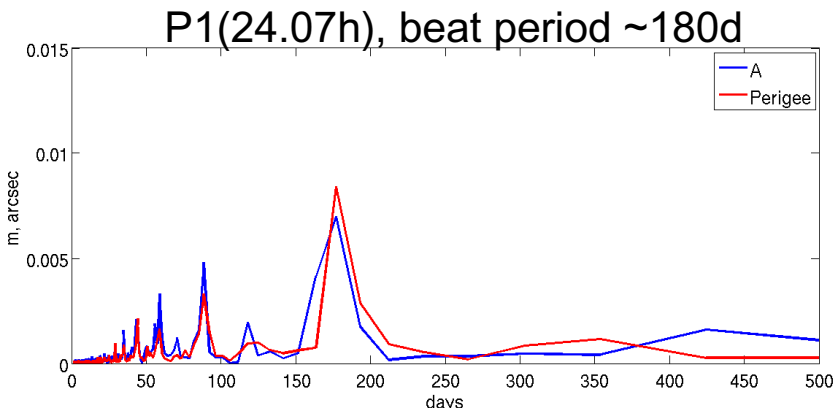
KOKB, MKEA (Hawaii): tide S1

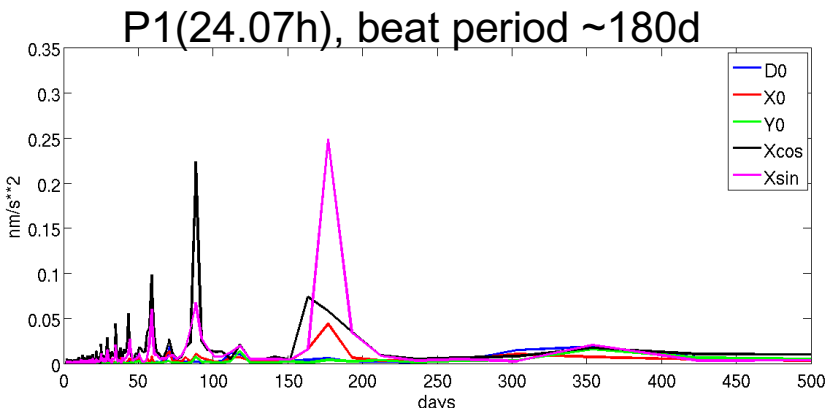


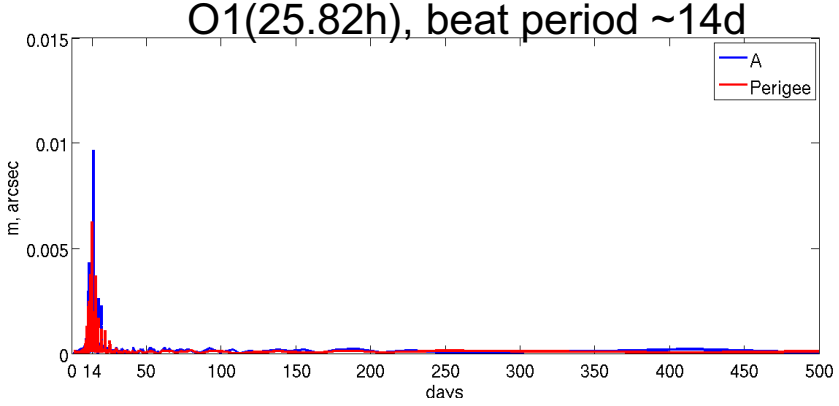
Influence of tidal model on the orbit: Kepler elements and radiation pressure parameters

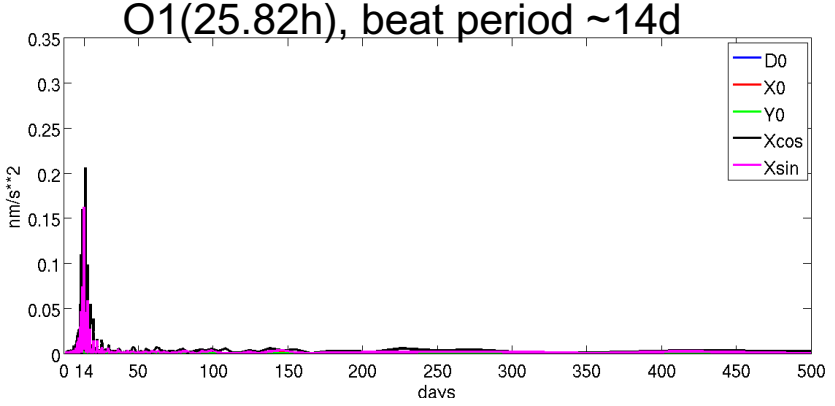












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