DFG Forschergruppe Referenzsysteme

Interaction between subdaily Earth rotation parameters and GPS orbits

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

Introduction

Subdaily Earth Rotation model: IERS2010 (+ libration)

Kept fixed in the processing

Errors up to ~20%

Empirical tidal models from GPS & VLBI:

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

Daily solutions → standard subdaily model

Daily solutions → changed subdaily model

<u>Time series of differences:</u>

- GPS orbits
- ERPs
- Station coordinates

} Spectra

<u>Systematic differences in reference frames realized by orbits:</u>

Helmert parameters between standard and changed orbits

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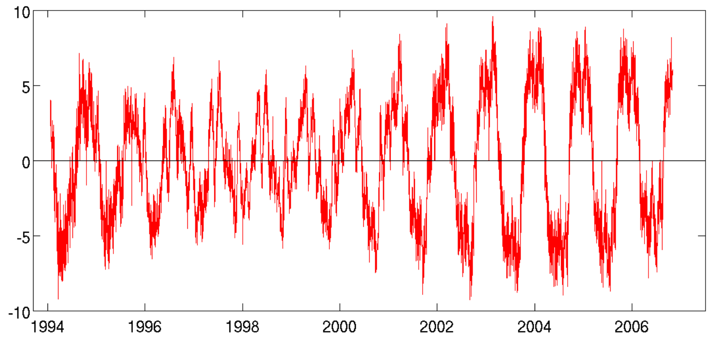
Helmert parameters between standard orbit and changed orbit

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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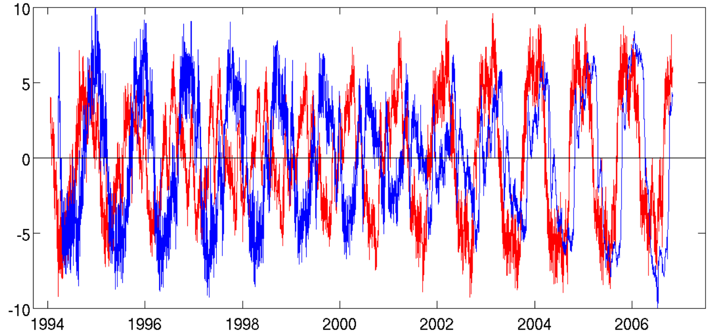

X translation: PRN5, PRN6

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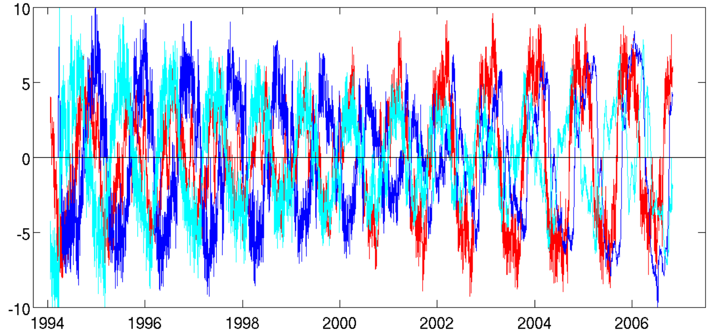

X translation: PRN5, PRN6, PRN7

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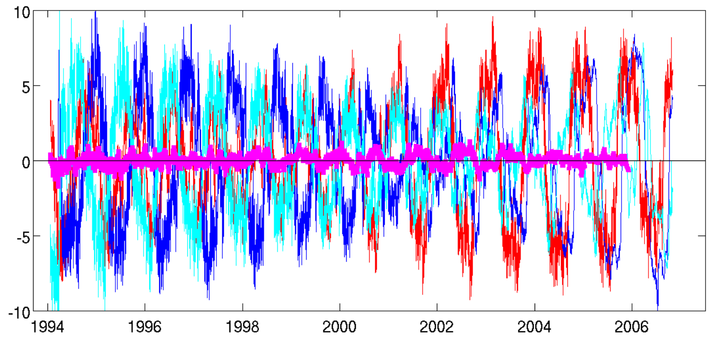

X translation: PRN5, PRN6, PRN7,
all satellites

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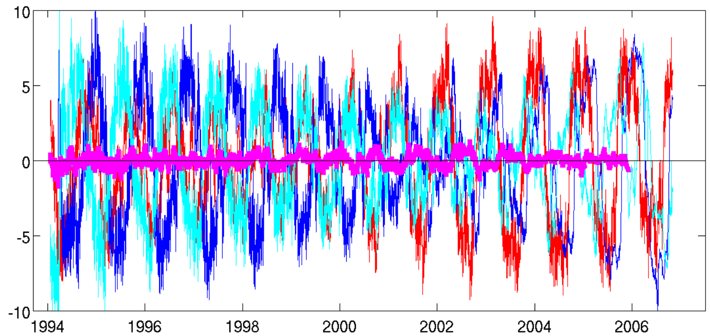
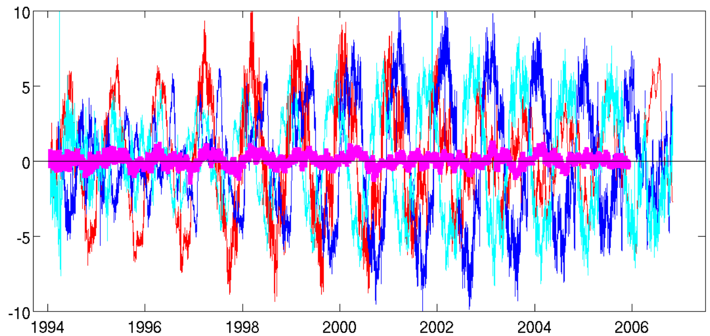
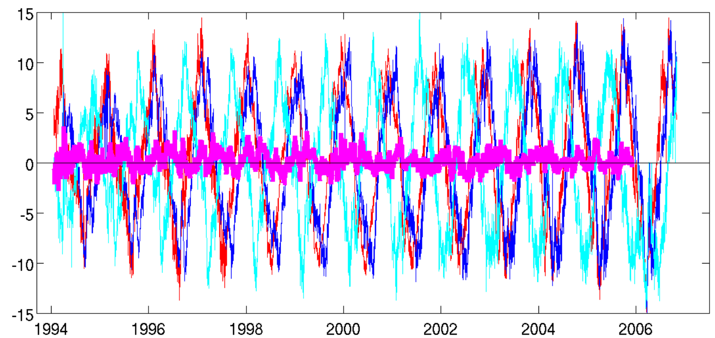


X translation: PRN5, PRN6, PRN7, all satellites



Y translation: PRN5, PRN6, PRN7, all satellites



Z translation: PRN5, PRN6, PRN7, all satellites

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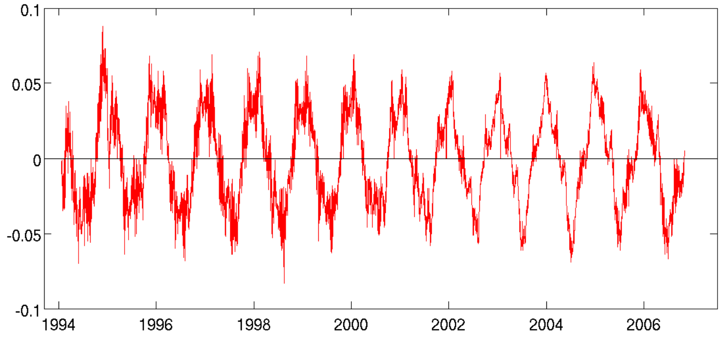

X rotation: PRN5

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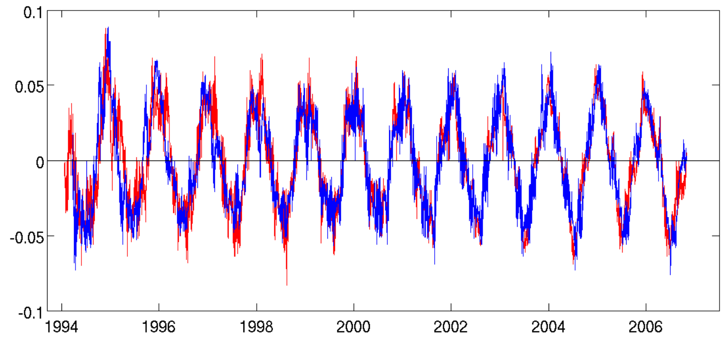

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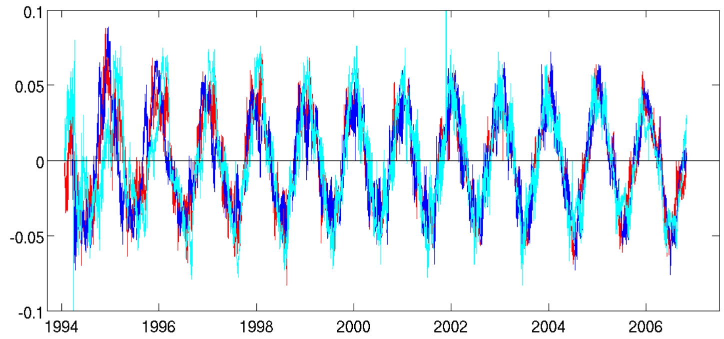

X rotation: PRN5, PRN6, PRN7

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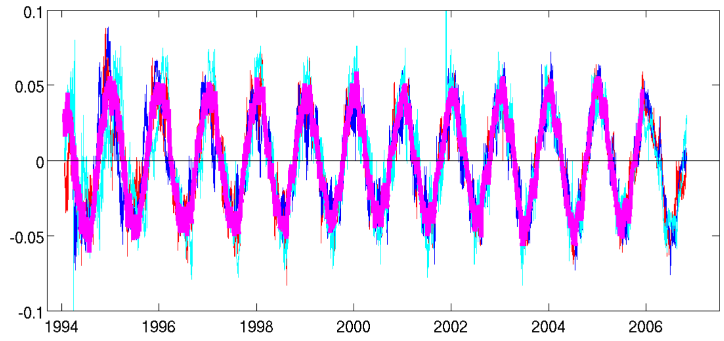

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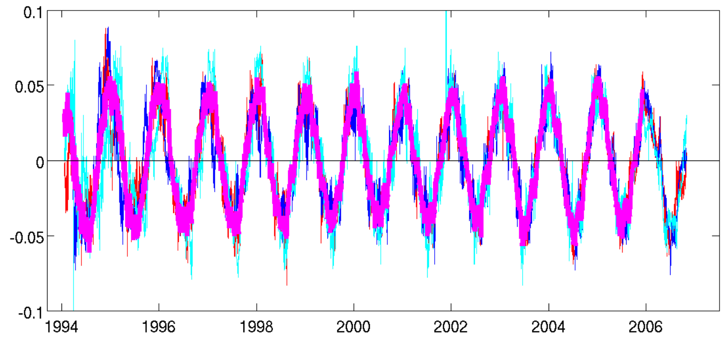

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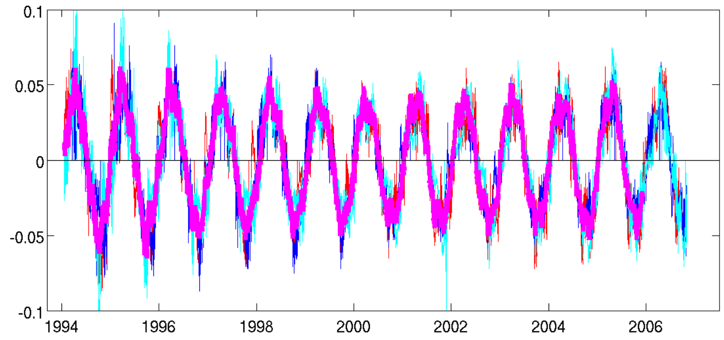

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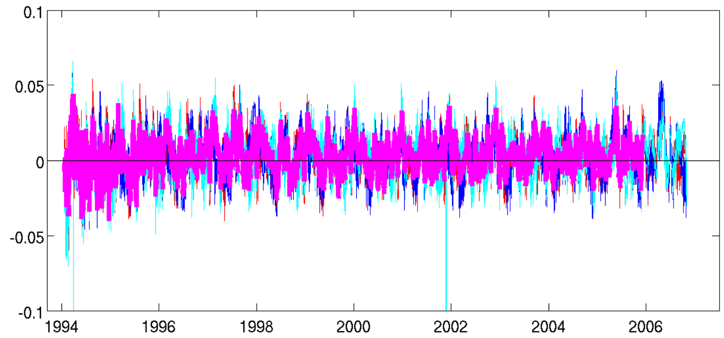

Z rotation: PRN5, PRN6, PRN7
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Helmert parameters between standard orbit and changed orbit

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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Helmert parameters between standard orbit and changed orbit

<u>Changes in the subdaily tidal model:</u>

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→ ?

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Changes in the subdaily tidal model:

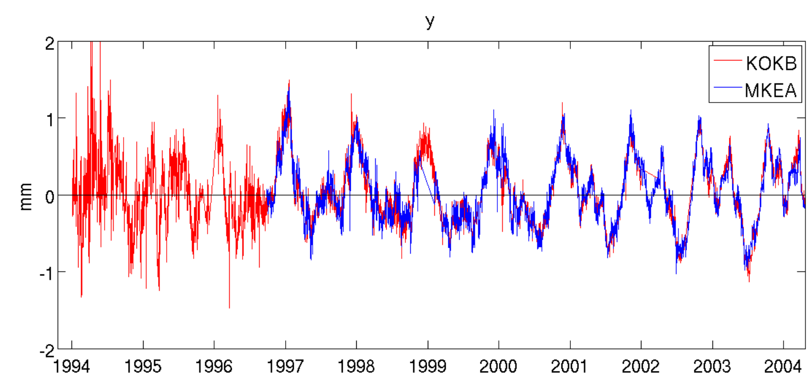
No influence on the origin of the satellite reference frame

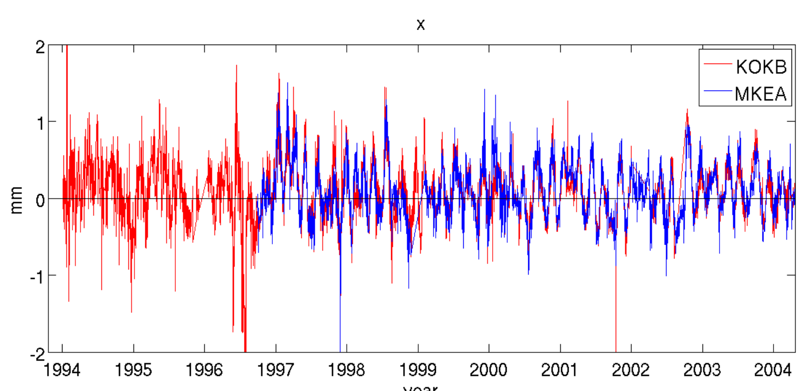
Changes in orientation: common rotation of the whole satellite constellation

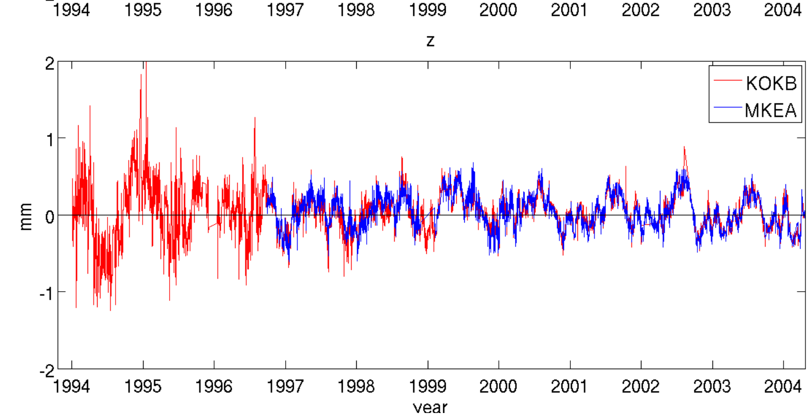
?

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

→ Nutation

→ Orientation of the orbit

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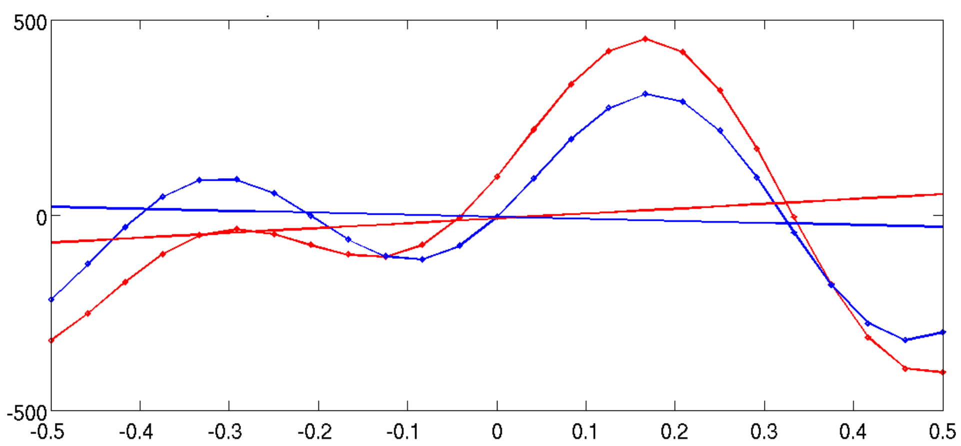
<u>Modelled ERPs over one day</u>:
Standard model and
model with changed S1 tide



Subdaily model for ERPs

Modelled ERPs with 1h resolution over 1994-2007:

Standard subdaily model

Subdaiy model with changed S1 tide

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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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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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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

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

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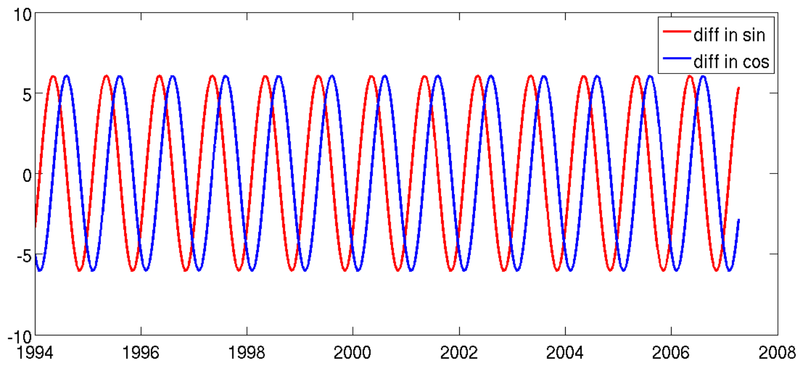
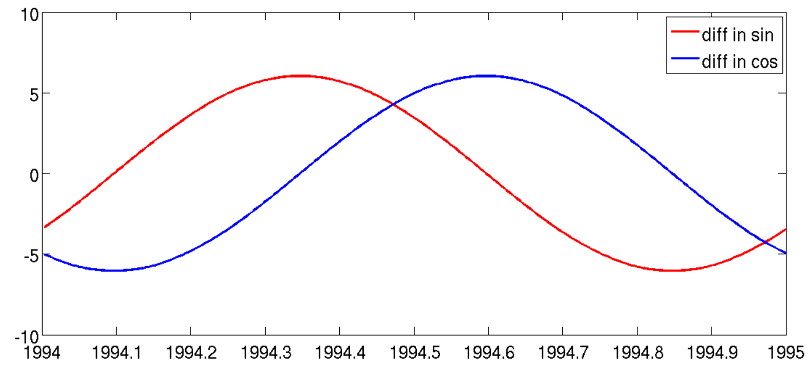
(Fictional) Retrograde diurnal signal in modelled subdaily ERPs

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

standard model minus model with changed S1 tide





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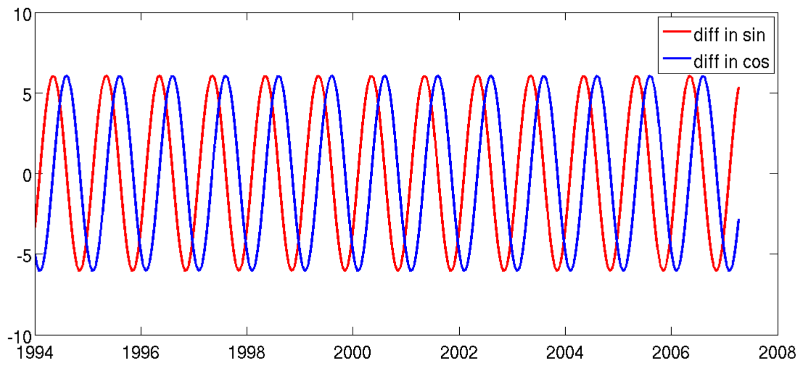

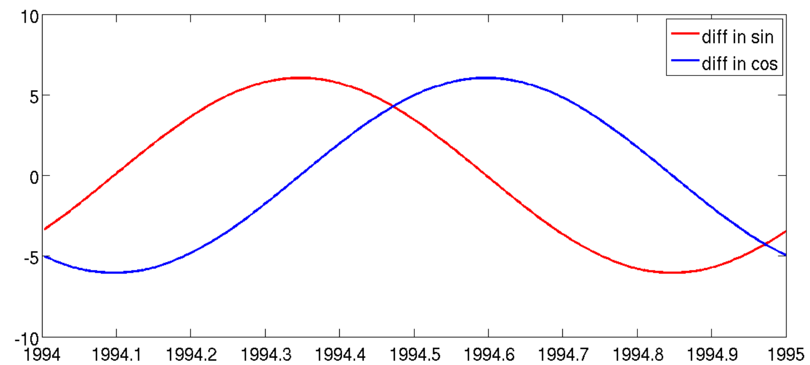

Connection between retrograde diurnal signal in PM and nutation offsets ΔΨ, Δε:

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

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

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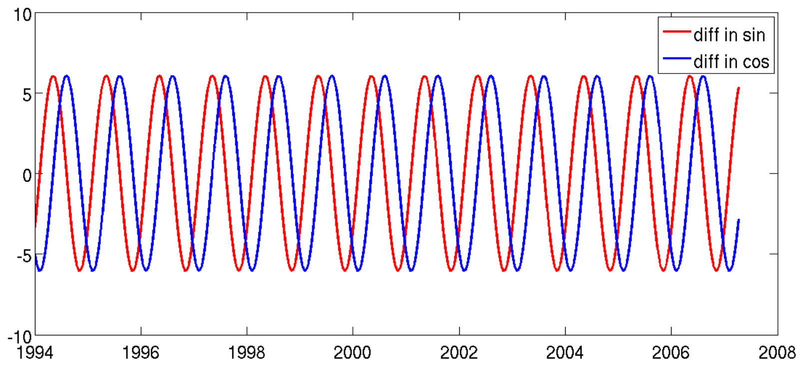

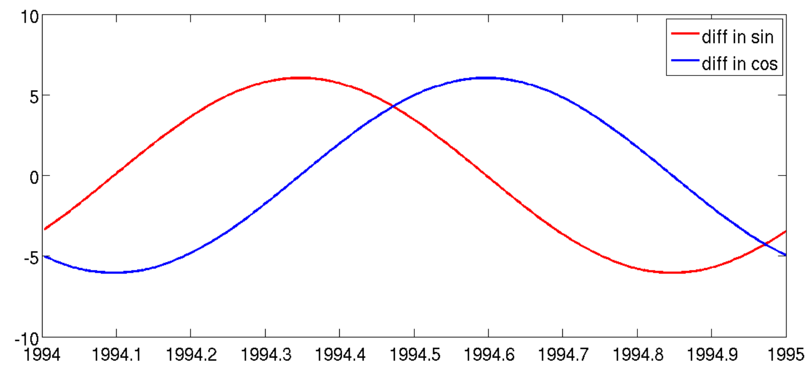

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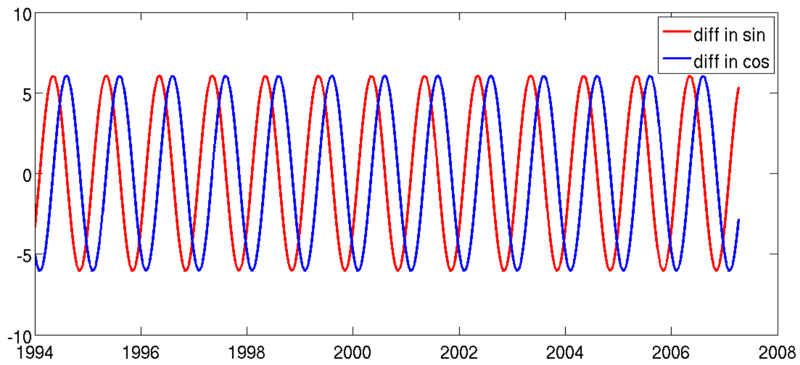

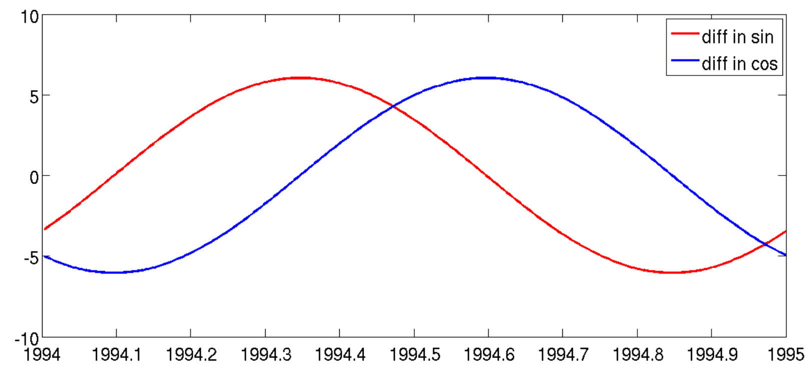

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Corresponds to a relative nutation with a constant offset and period of ~365 days

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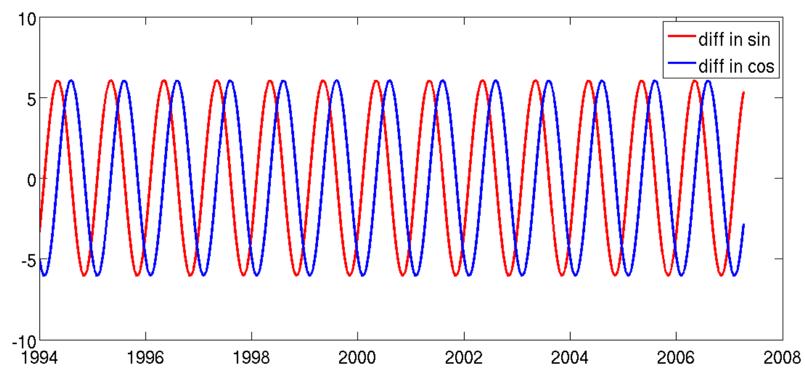
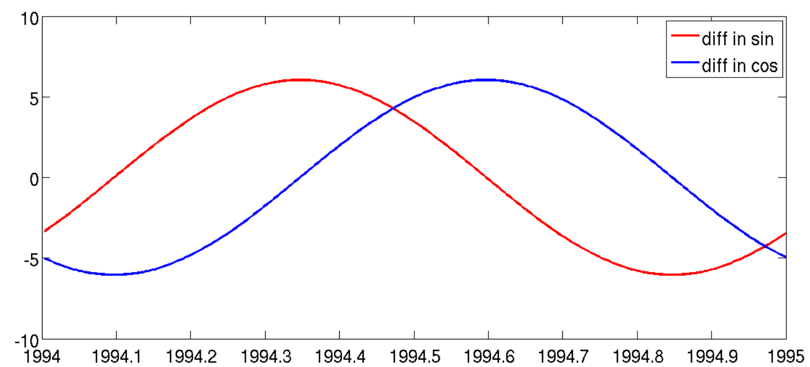
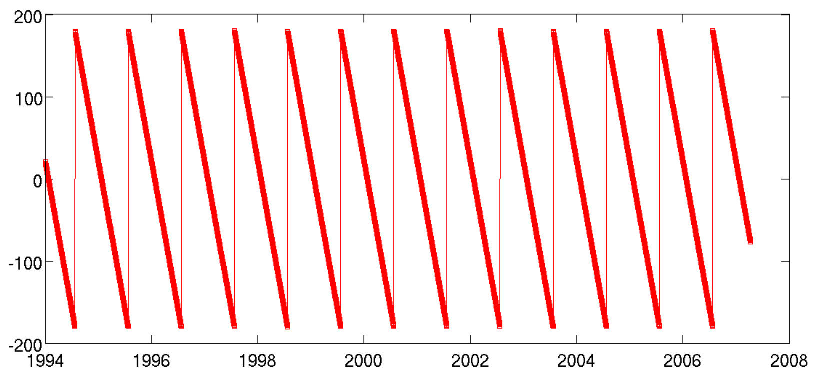
Differences in amplitudes of sine and cosine for retrograde diurnal wave:

standard model minus model with changed S1 tide







Constant offset, phase period ~365 days

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

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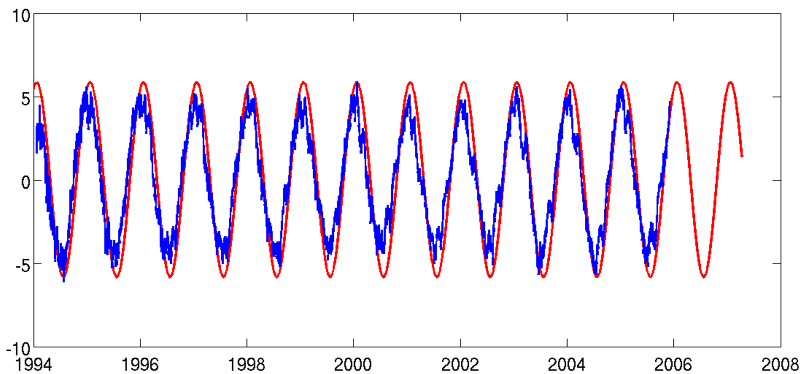

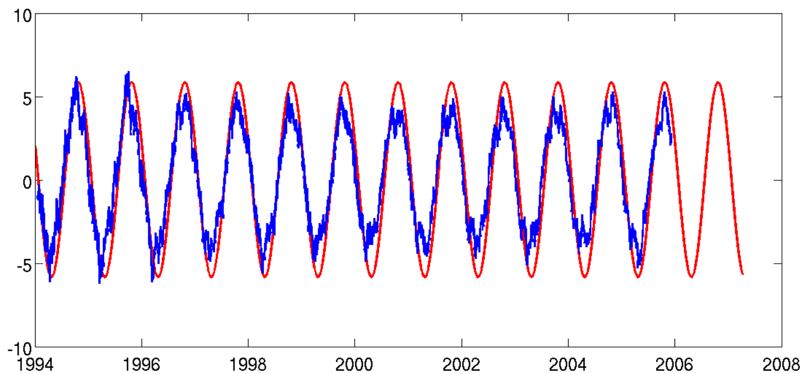

X-rotation
Difference in sine amplitudes

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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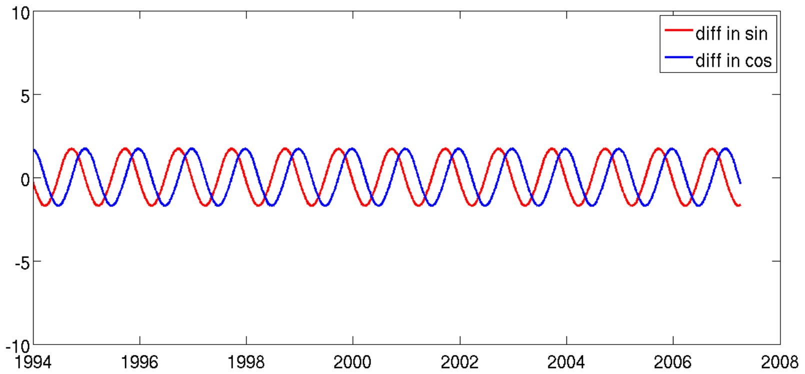
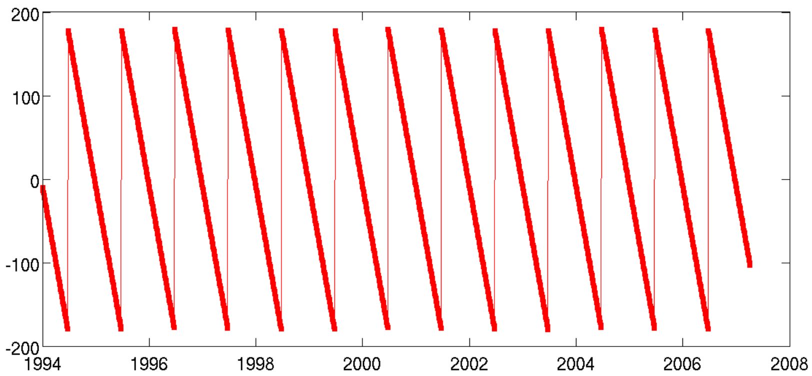
Fit retrograde wave over 3 days





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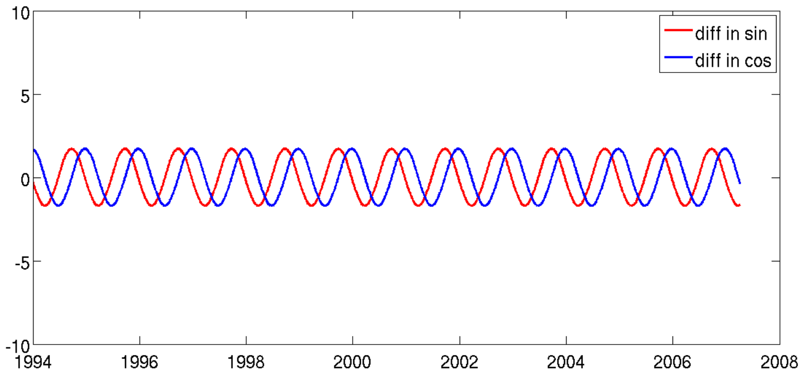
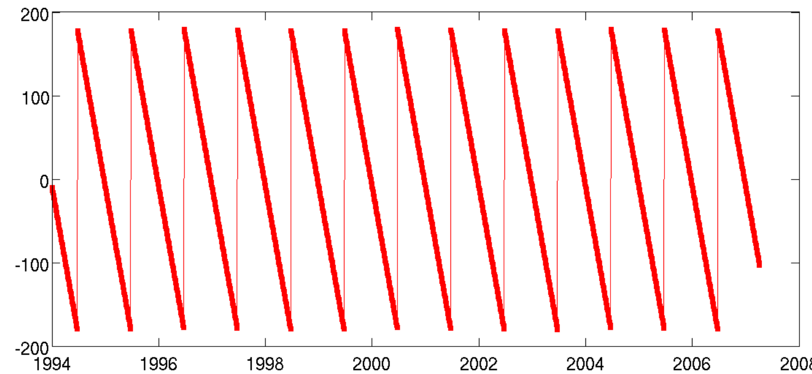
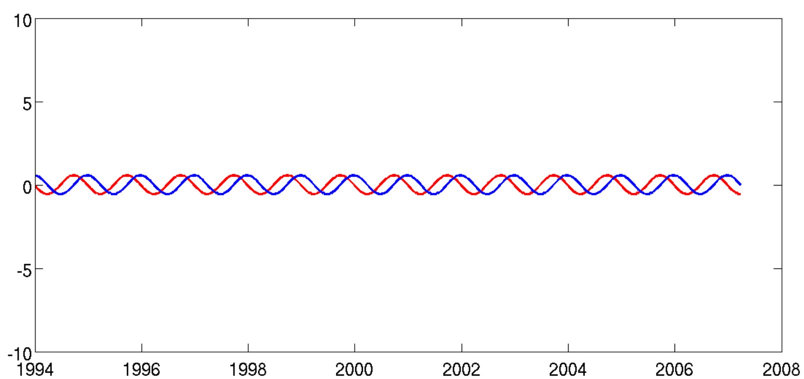




Fit retrograde wave over 10 days



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?

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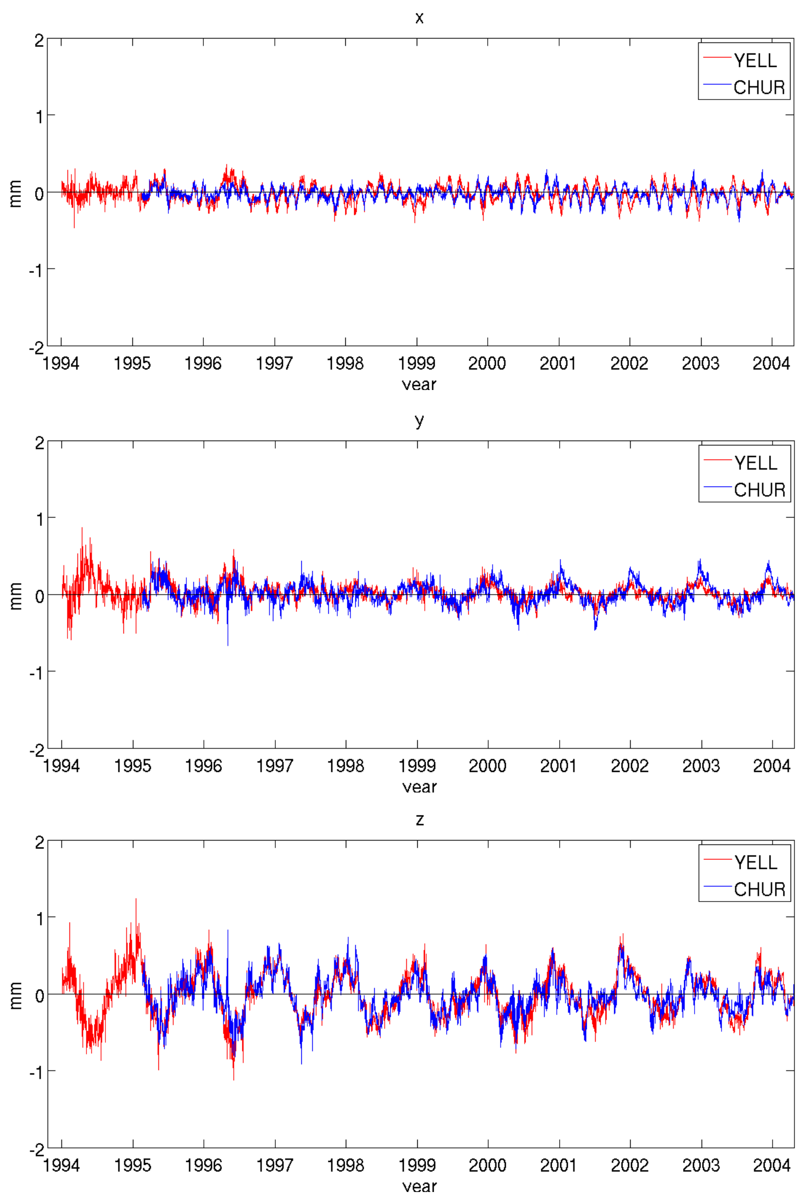
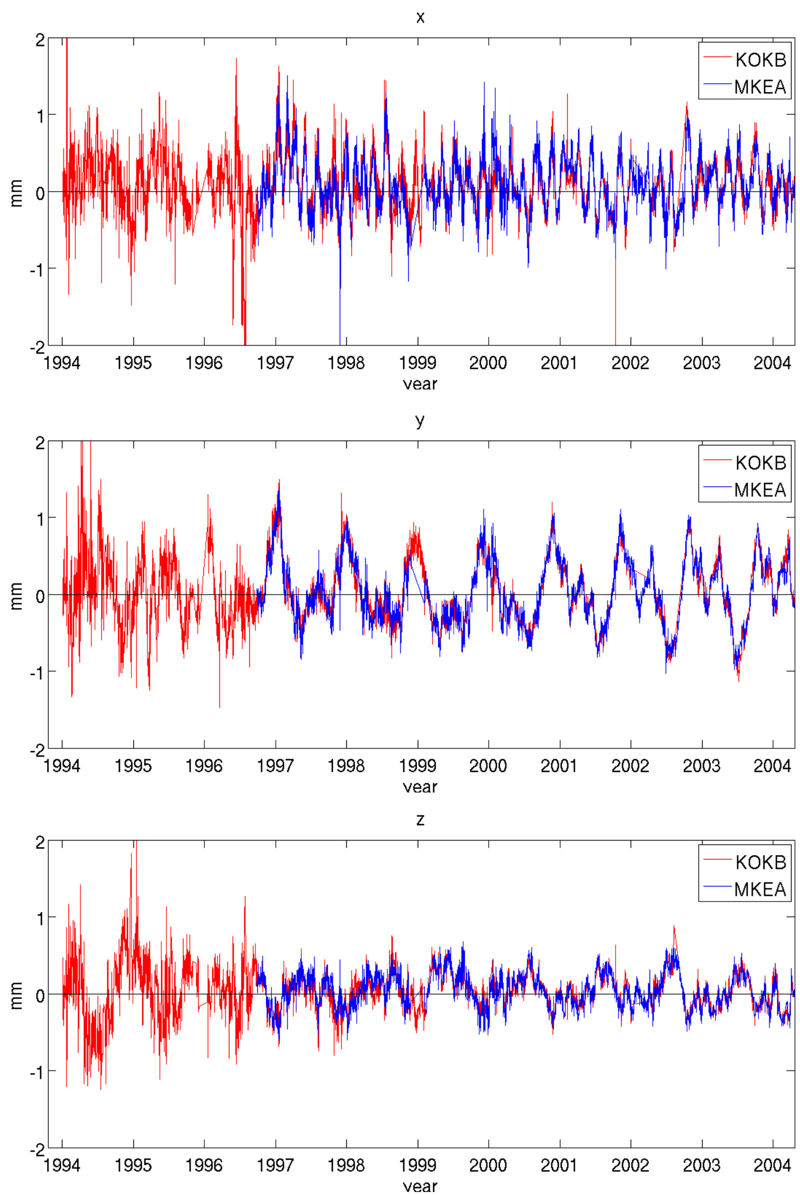
Thank you!

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