Interaction between tidal terms and GPS orbits

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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 of a wrong subdaily model on the orbits, coordinates, ERPs

Are there draconitic signatures caused by a wrong subdaily model?

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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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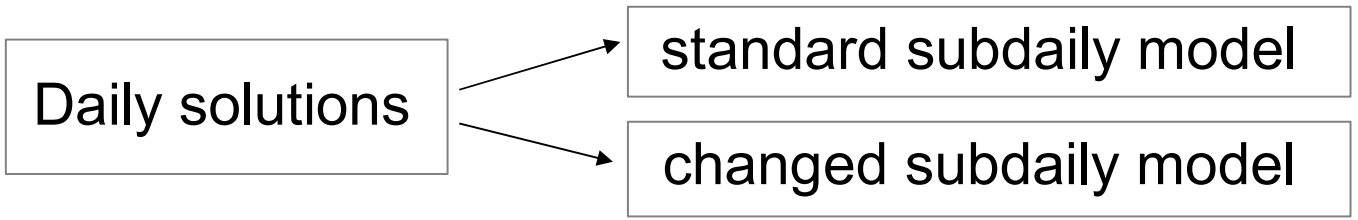
Data and solutions

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



Time series of differences:

GPS orbits
ERPs
Station coordinates

Spectra

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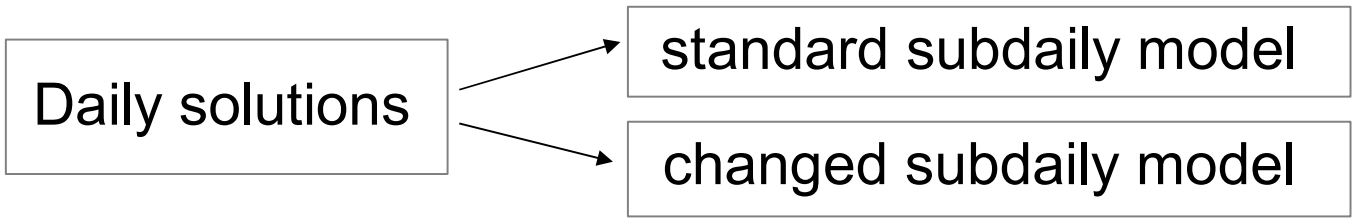

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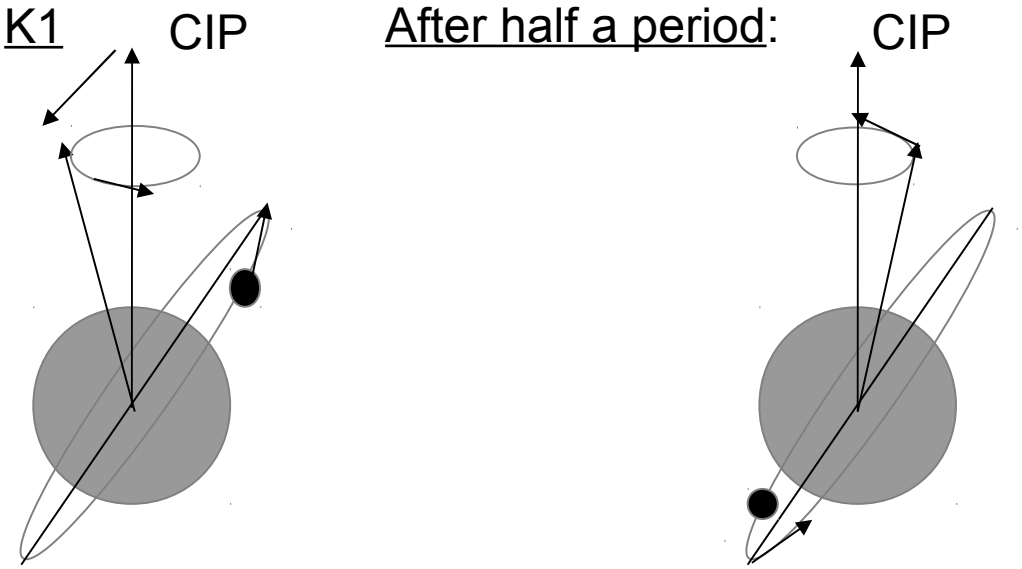
GPS satellites and tidal variations in Earth rotation

Prograde K1 period: 23h56min in terrestrial reference frame (~1 cpd)
11h58min in inertial reference frame (~2 cpd)

Orbital period of GPS satellites: 11h58min



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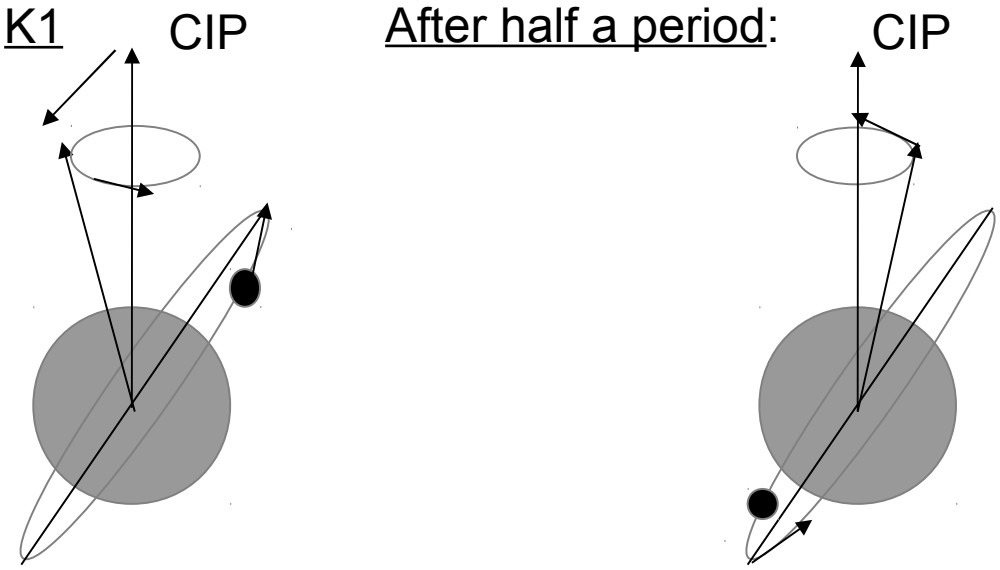

K1 is seen as a constant shift

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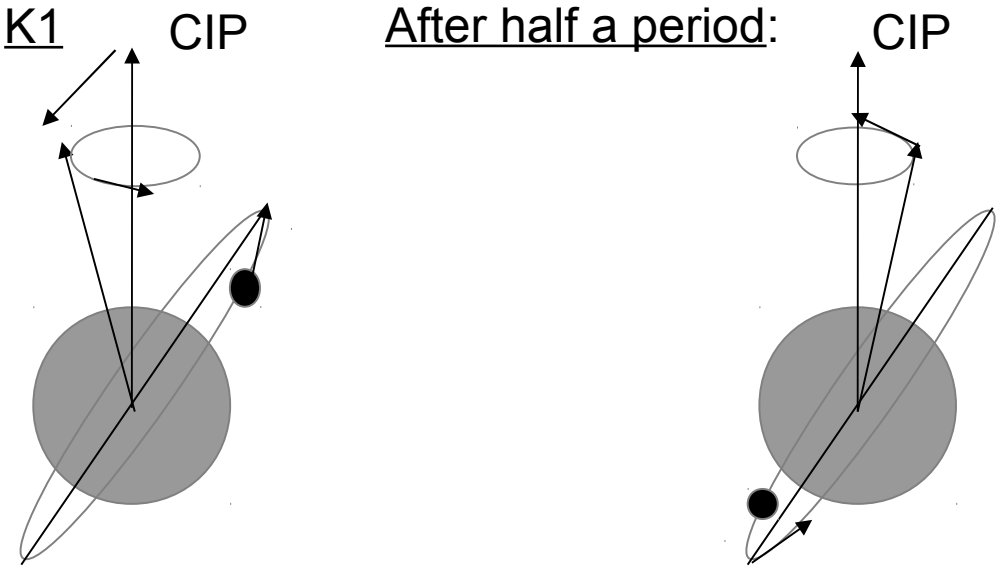

K1 is seen as a constant shift

Beat periods:

Close periods are seen as slow rotation

GPS satellites and tidal variations in Earth rotation

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Diurnal tides have periods in CRF ~12 hours

Beat periods:

Φ1(23.80h) ~185d	Ψ1(23.87h) ~380d	K1(23.93h) ~shift	S1(24.00h) ~352d	P1(24.07h) ~179d

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Semi-diurnal tides have periods in CRF ~8 hours

Beat periods:

M2(12.42h) ~25.82h	S2(12.00h) ~24.07h	K2(11.67h) ~23.94h

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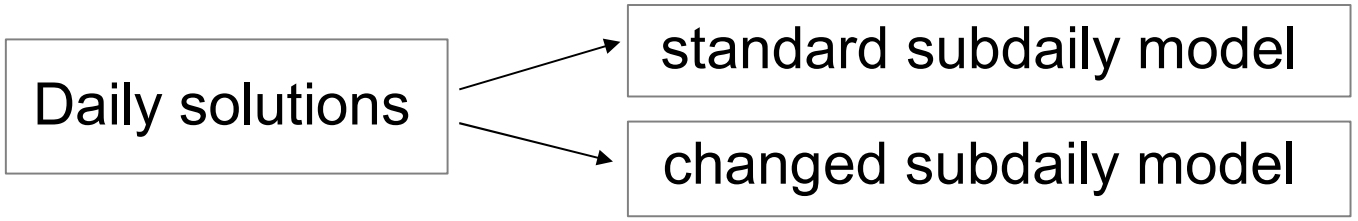
Test solutions

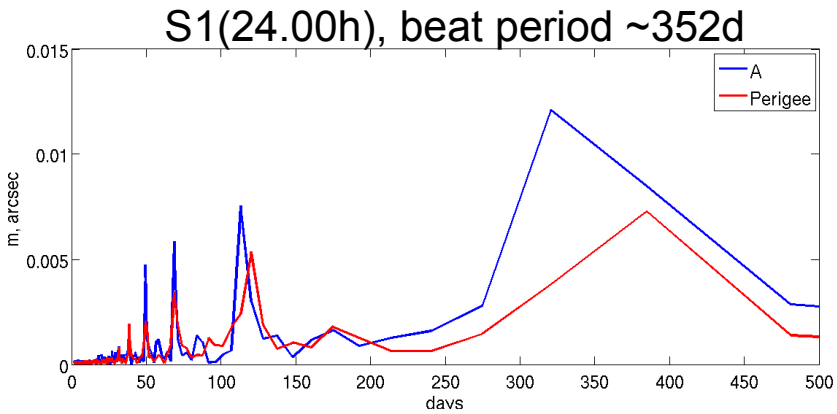


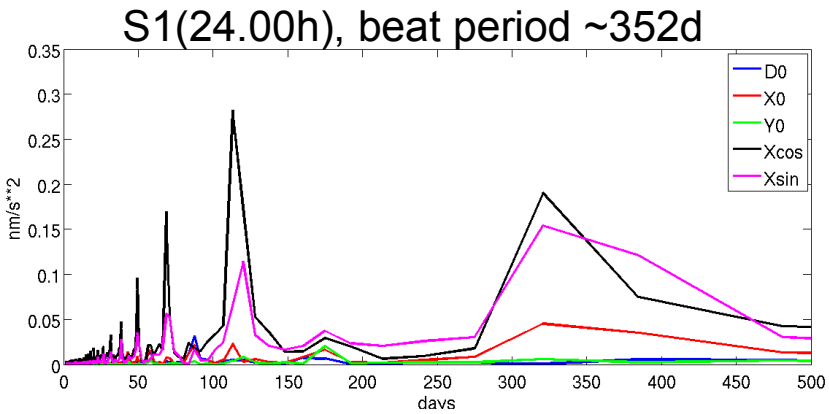
Changed tidal terms: S1(24.00h), beat period ~352d
P1(24.07h), beat period ~180d
O1(25.82h), beat period ~14d

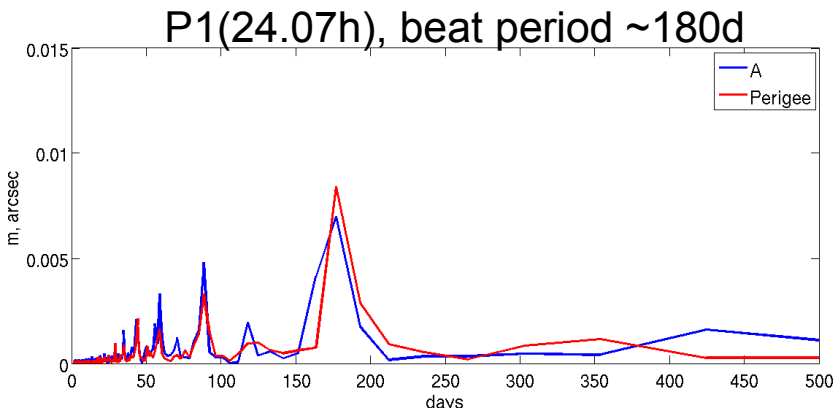
Spectra of time series of differences:

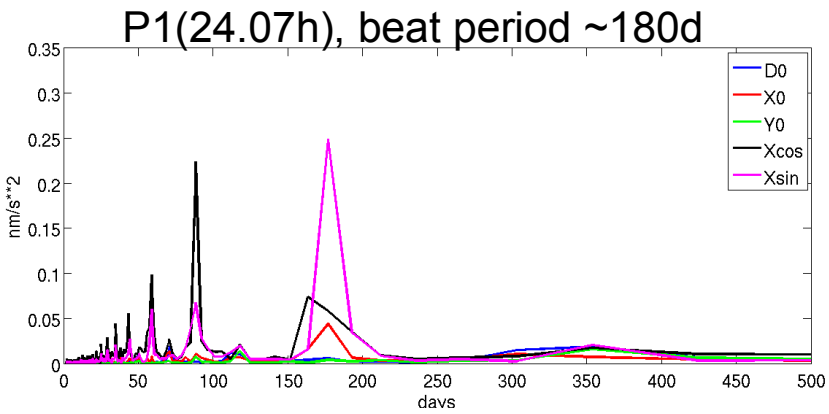
GPS orbits: 6 Kepler elements,
CODE Radiation Pressure Parameters

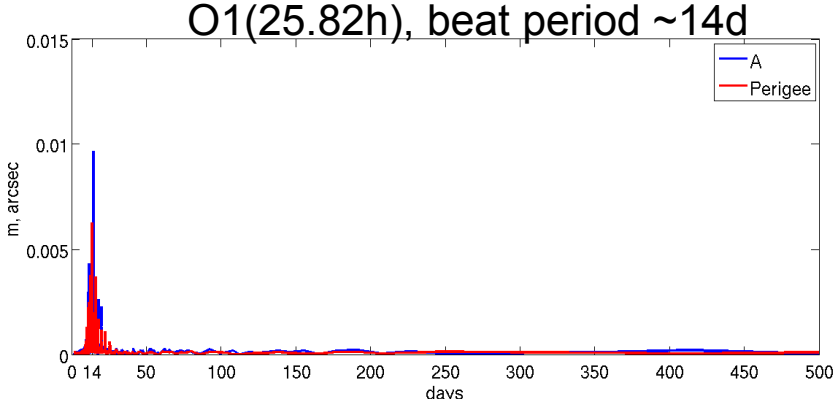
Influence of tidal model on the orbit: Kepler elements and radiation pressure parameters

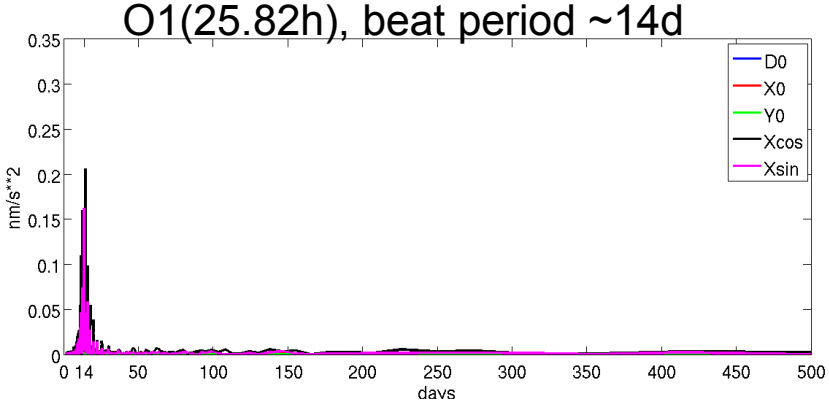










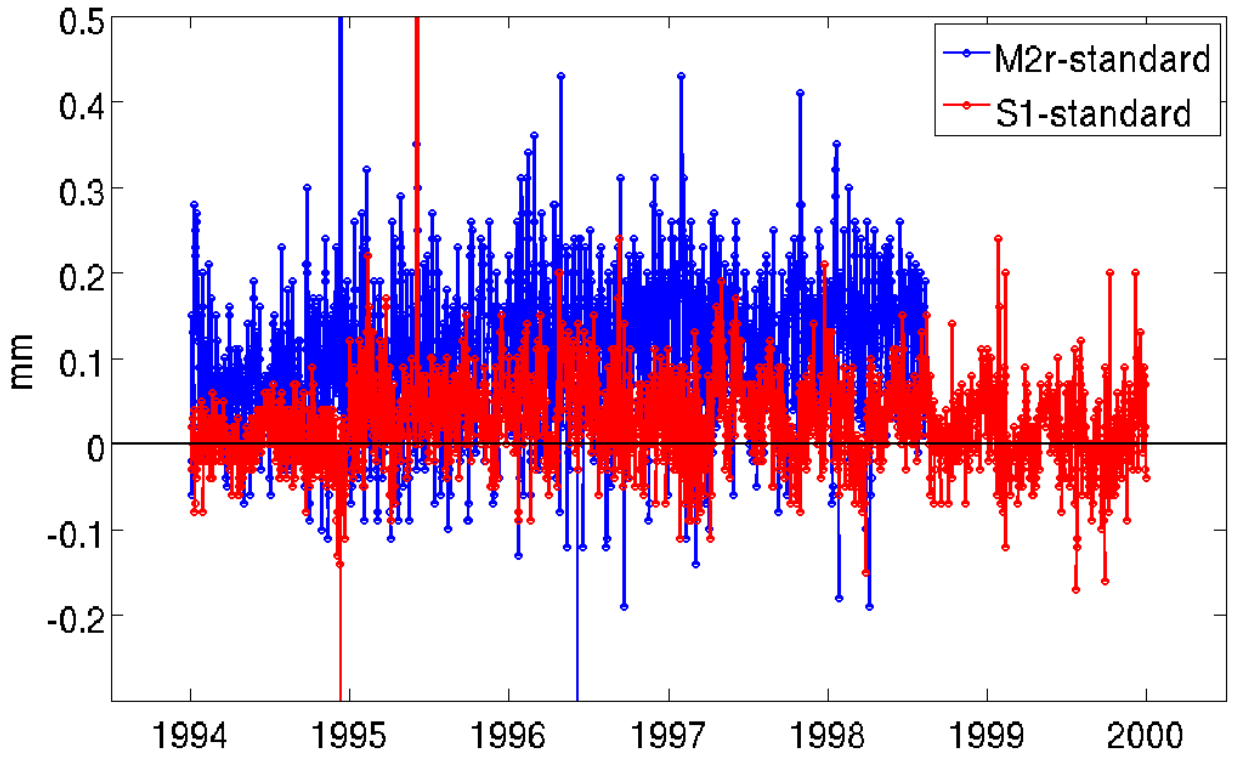


Influence of tidal model on the orbit: noise increase

Aposteriori RMS:

Standard solution minus test solution changed S1 (24.00h)

Standard solution minus test solution changed M2r (12.42h)



Influence of tidal model on the orbit

Can we see tidal contribution in time series of real orbital parameters?

Test: K1 change of 100 µas

↳ ~1.5cm change in semi-major axis, ~0.4 nm/sec**2 in RPR

„Realistic“ changes for main tides

↳ ~0.6cm change in semi-major axis, ~0.1 nm/sec**2 in RPR

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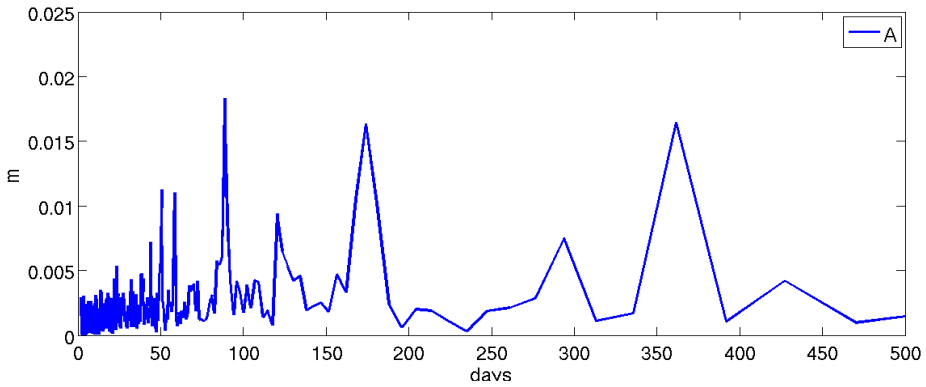
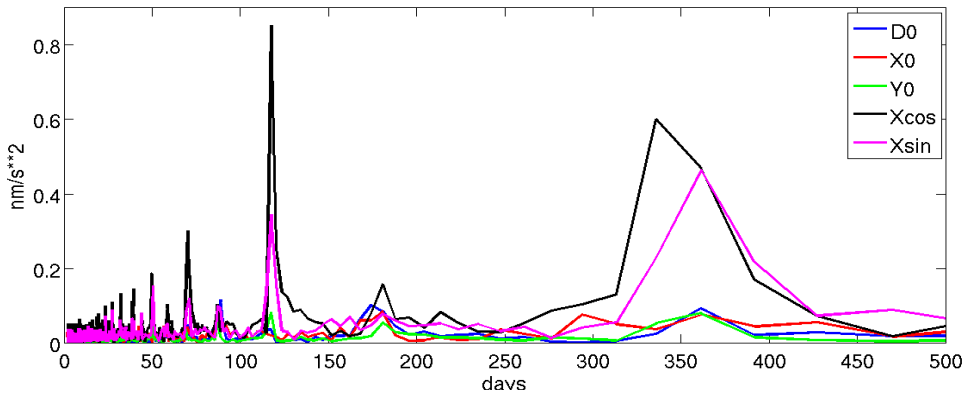


Spectra of daily estimates of orbital parameters from standard solution



Conclusions

Errors in subdaily tidal model lead to periodic signals in the GPS orbits with beat periods of the tides (+ aliasing if sampled e.g. 24h)

Beat periods of ~350 days can contribute to observed signals with draconitic periods

Diurnal tides are better absorbed by the orbits because their periods in CRF are close to those of GPS satellites

Semi-diurnal tides increase the residuals more than diurnal tides

Periodic signals in the orbits caused by wrong tides are very small, but still can be seen by spectral anslysis

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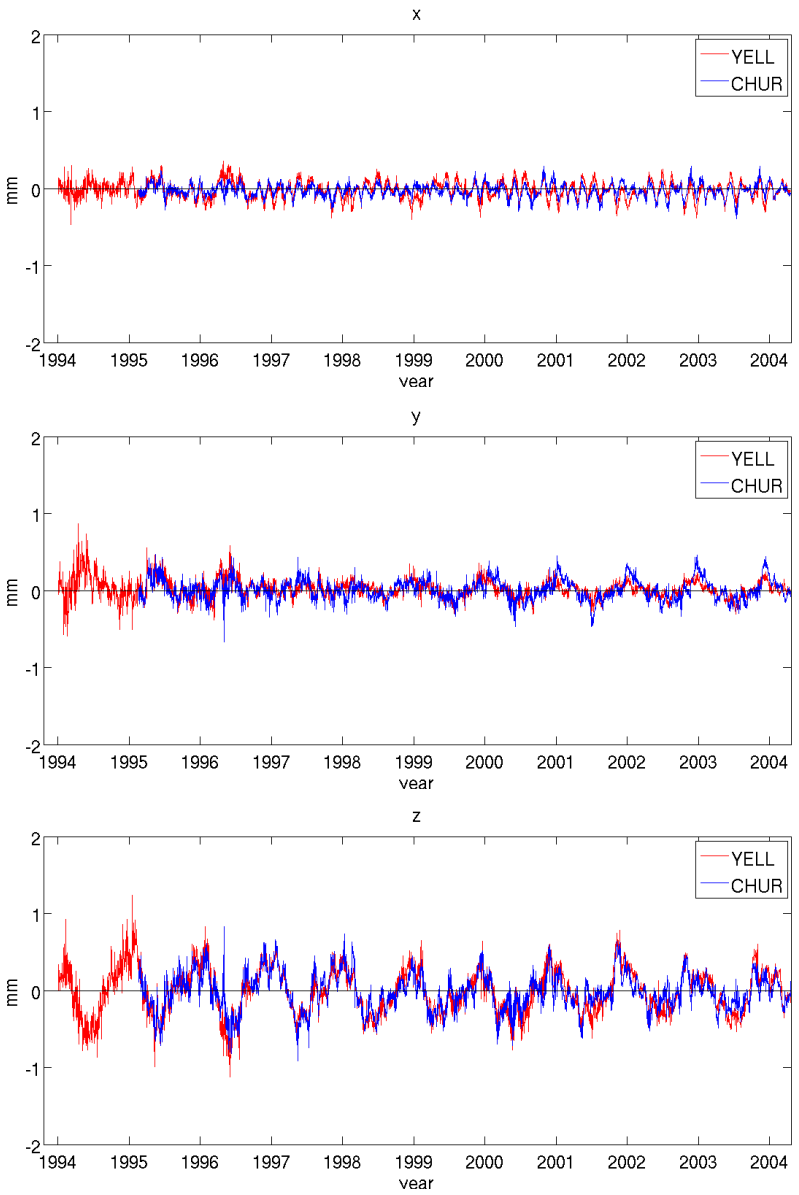
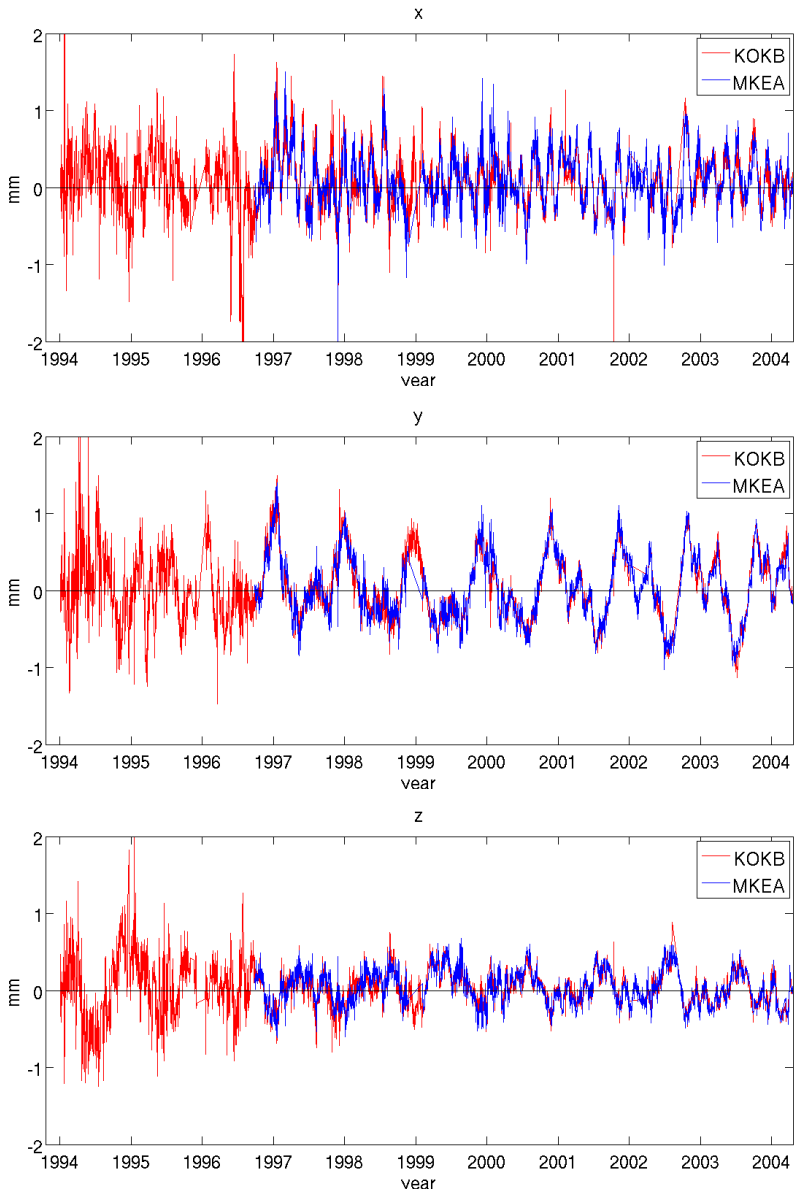
Thank you!

Influence of tidal model on the station coordinates

YELL, CHUR (Canada): tide S1



KOKB, MKEA (Hawaii): tide S1



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