



DFG Research Unit

Space-Time Reference Systems for Monitoring Global Change and for Precise Navigation in Space

Influence of subdaily tidal model on station coordinates and GPS orbits

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Influence of subdaily ERP model on GPS orbits: 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

Influence of changes in subdaily model on the orbits, coordinates, ERPs

Influence on the reference frames realized by the satellites

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 a priori values for tidal terms + fix tidal terms

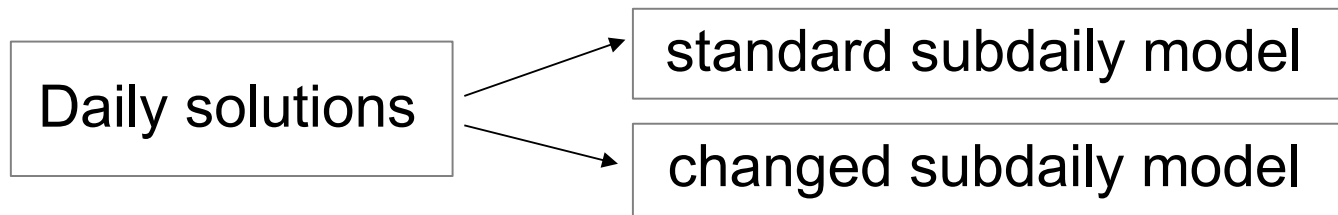
→ change subdaily model

Daily estimates:

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

Data and solutions

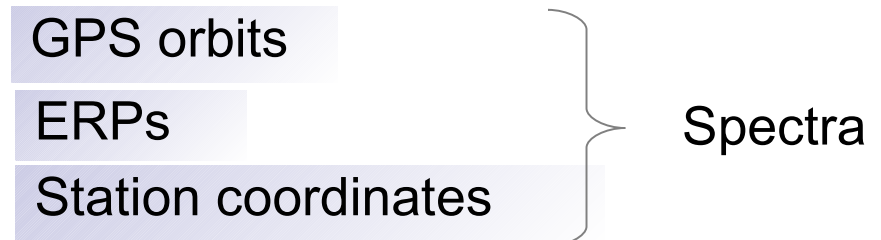
Influence of subdaily tidal model: change 1 tide in PM by $\sim 100 \mu\text{s}$



Systematic differences in reference frames realized by orbits:

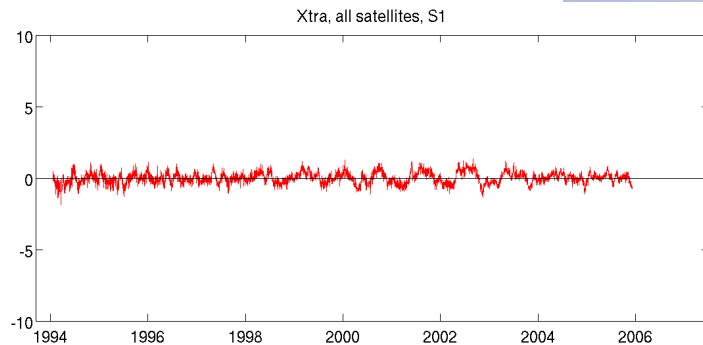
Helmert parameters between standard and changed orbits

Time series of differences:

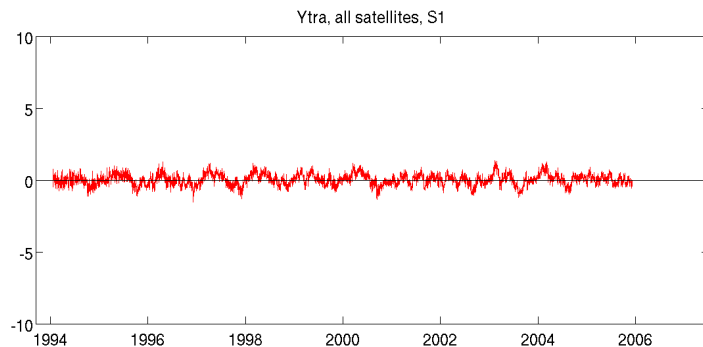


Helmert parameters between standard orbit and changed orbit

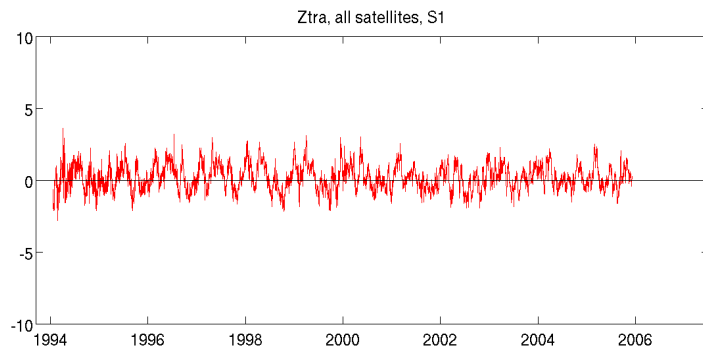
GPS orbits computed with **standard subdaily model** vs **subdaily model with changed S1 tide in PM**



X translation: all satellites



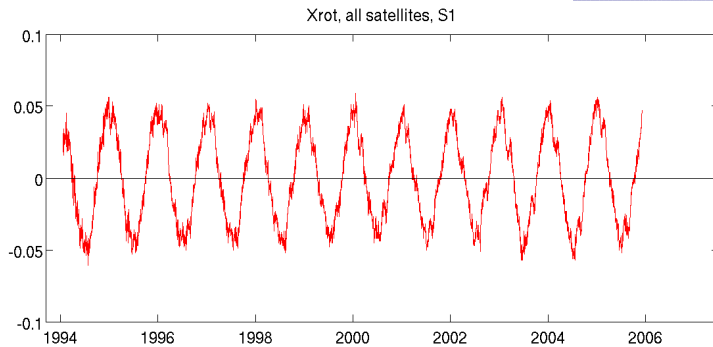
Y translation: all satellites



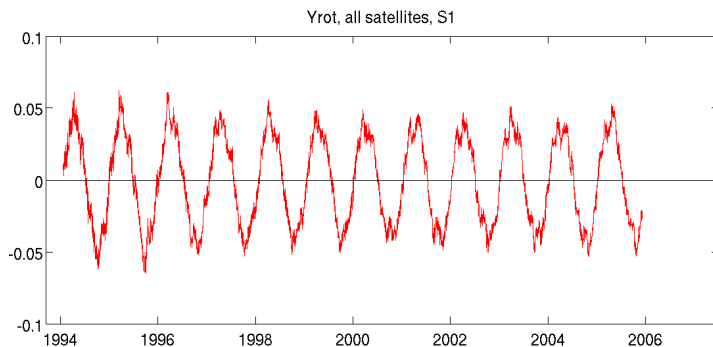
Z translation: all satellites

Helmert parameters between standard orbit and changed orbit

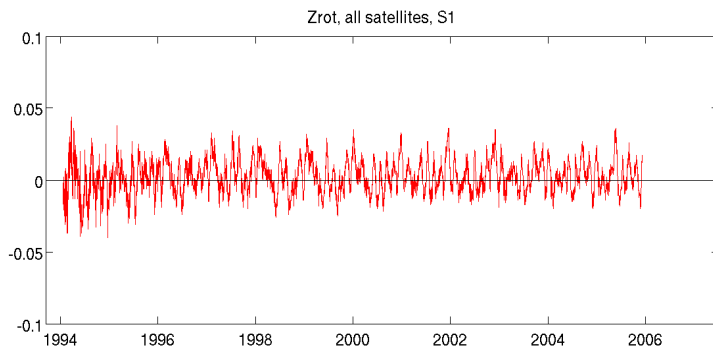
GPS orbits computed with **standard subdaily model** vs **subdaily model with changed S1 tide in PM**



X rotation: all satellites



Y rotation: all satellites



Z rotation: all satellites

Helmert parameters between standard orbit and changed orbit

Changes in the subdaily tidal model:

No influence on the origin of the satellite reference frame

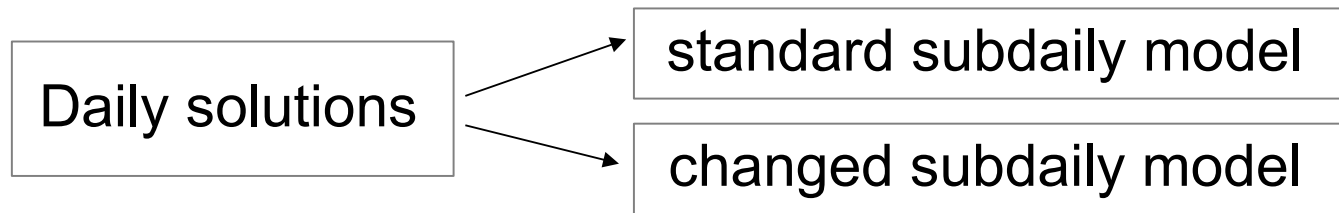
Changes in orientation: **common rotation** of the whole satellite constellation

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



Time series of differences:

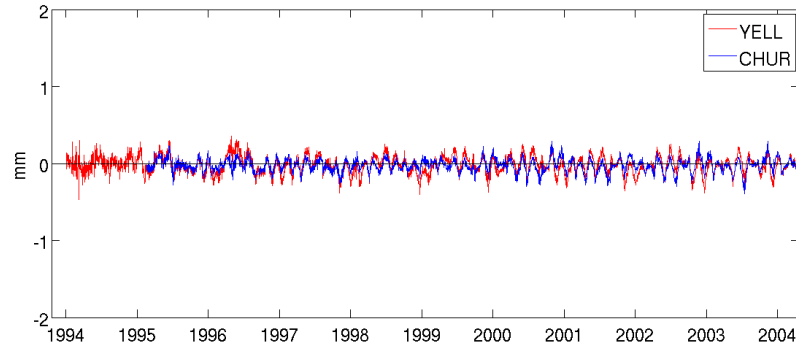
Station coordinates

ERPs

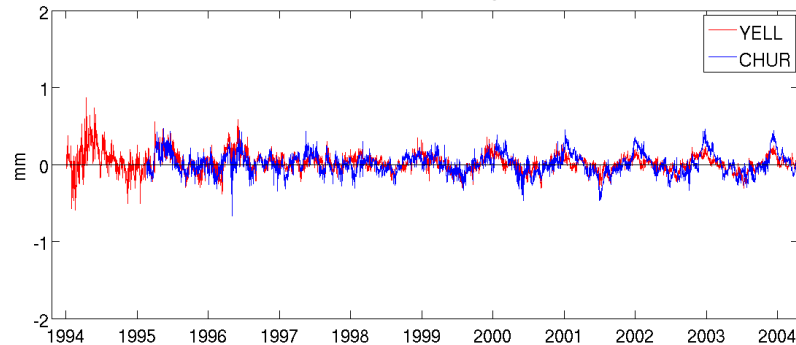
GPS orbits

Influence of tidal model on the station coordinates

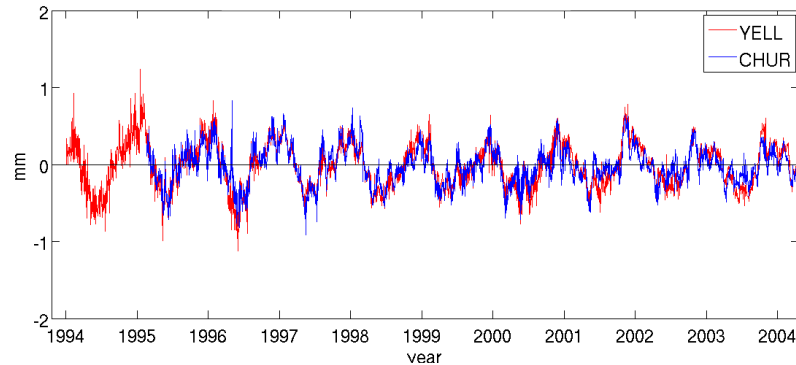
YELL, CHUR (Canada): tide S1
differences in x



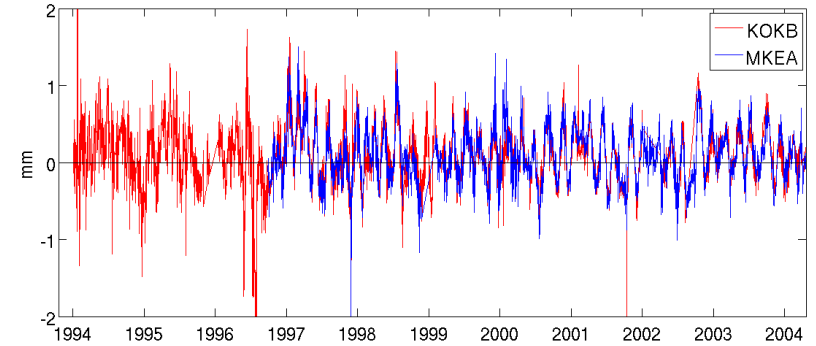
differences in y



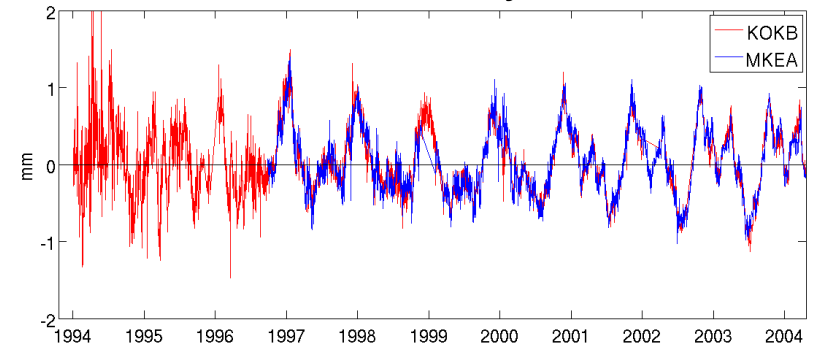
differences in z



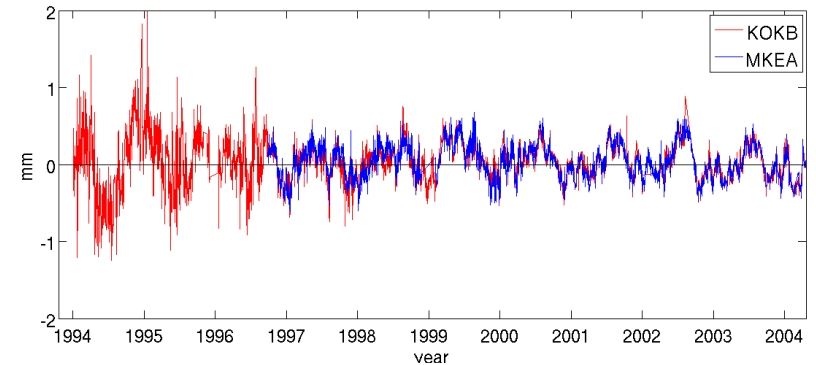
KOKB, MKEA (Hawaii): tide S1
differences in x



differences in y



differences in z



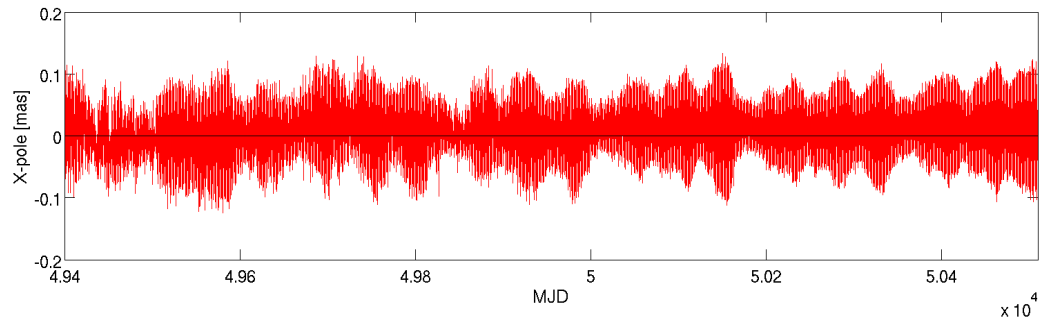
Influence of tidal model on the station coordinates

No net-effect on station coordinates and position of the geocenter

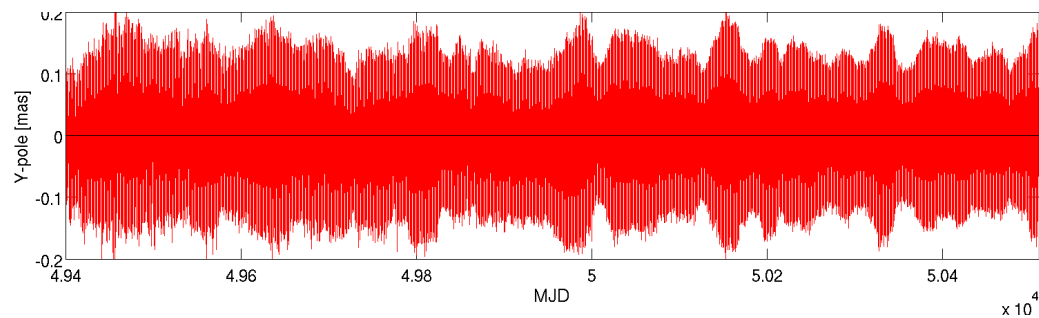
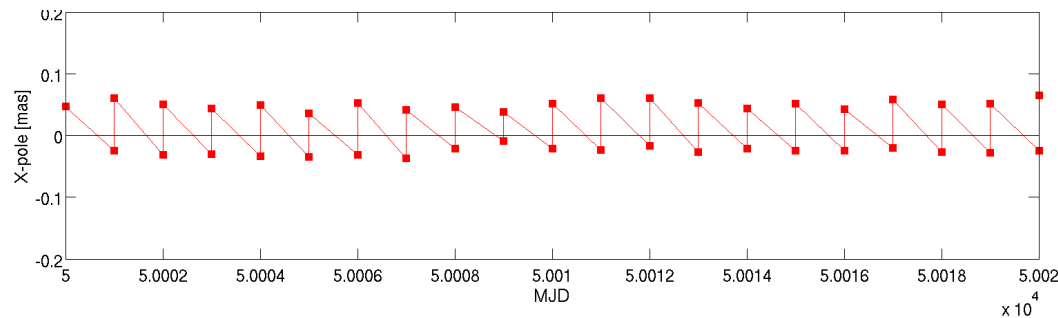
Regional effects in station coordinates: small but systematic changes with the period seen in the rotations of GPS constellation

The amplitudes are small: $\sim 1\text{mm}$ for a change of $100\ \mu\text{s}$ in S1 tide

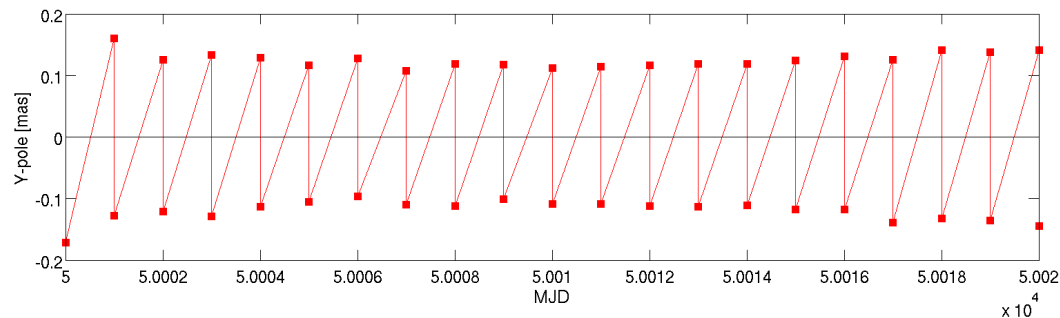
Influence of tidal model on the ERPs



Differences in X-pole



Differences in Y-pole



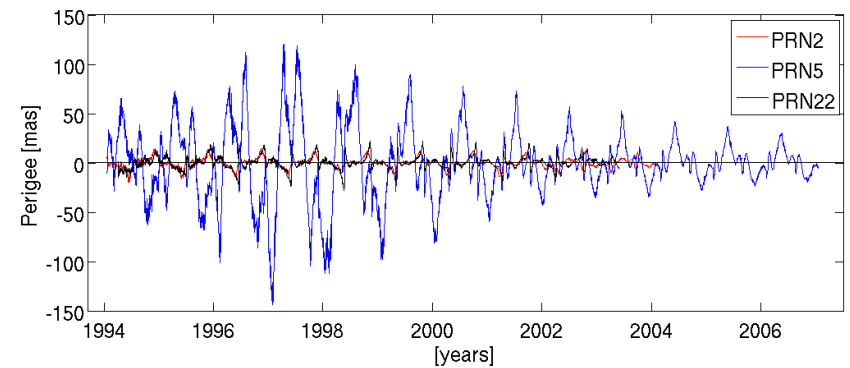
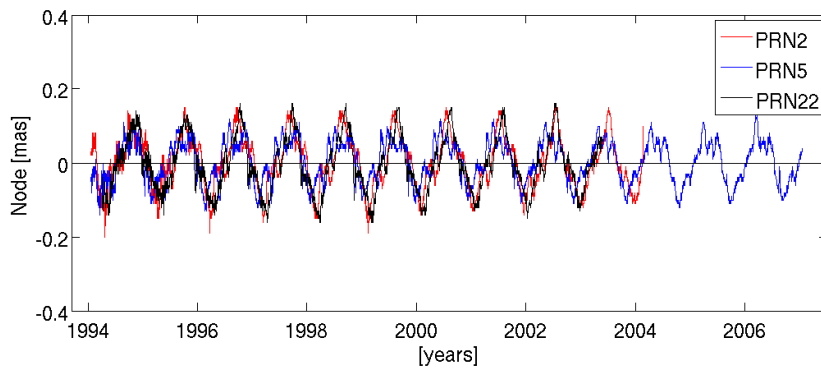
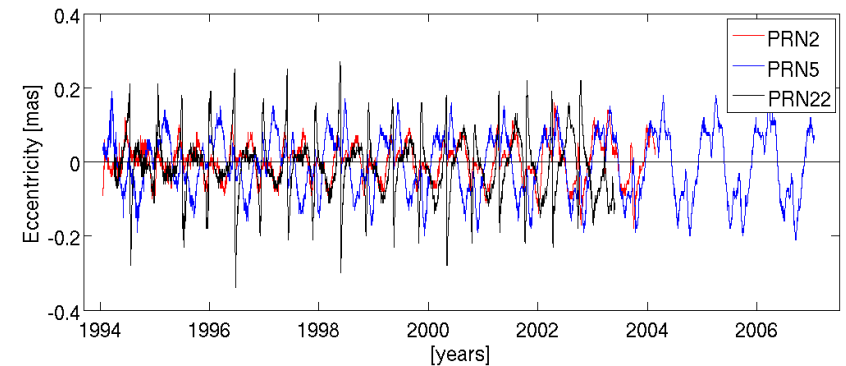
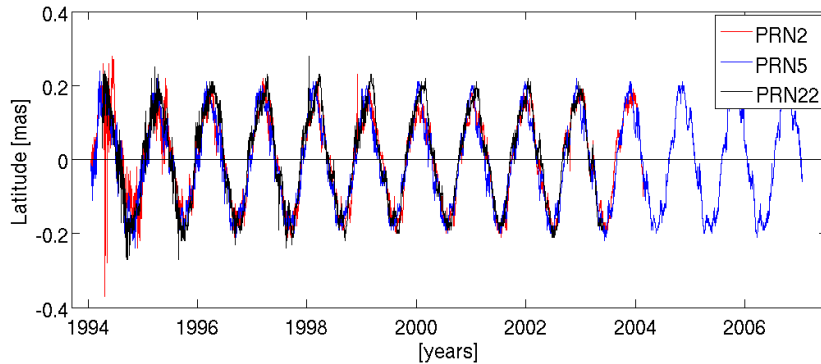
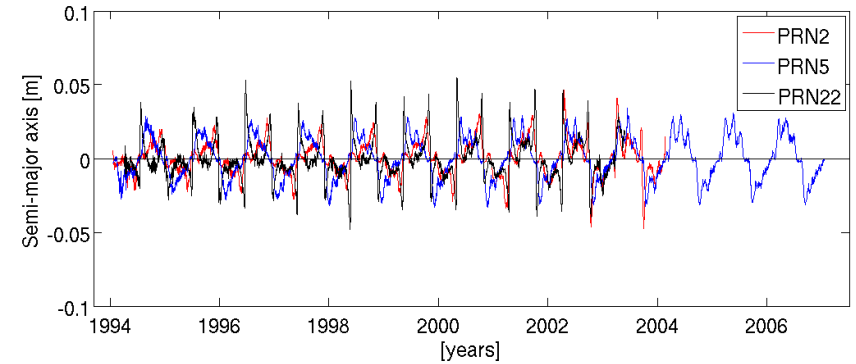
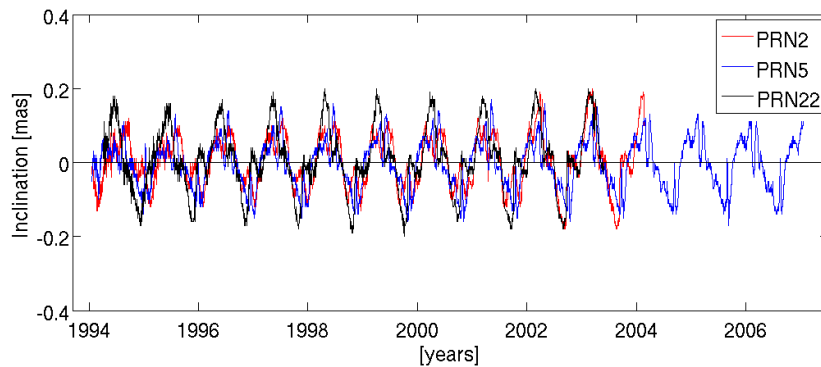
Systematic change in pole-rates

Mean offset is not affected

UT1: changes $\sim 1-2 \mu\text{s}$

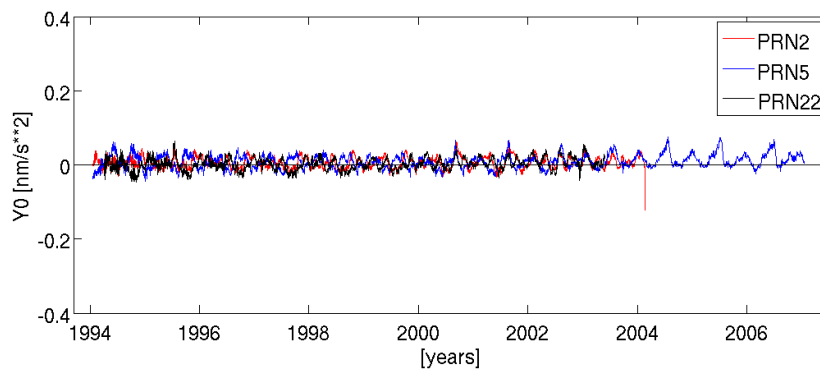
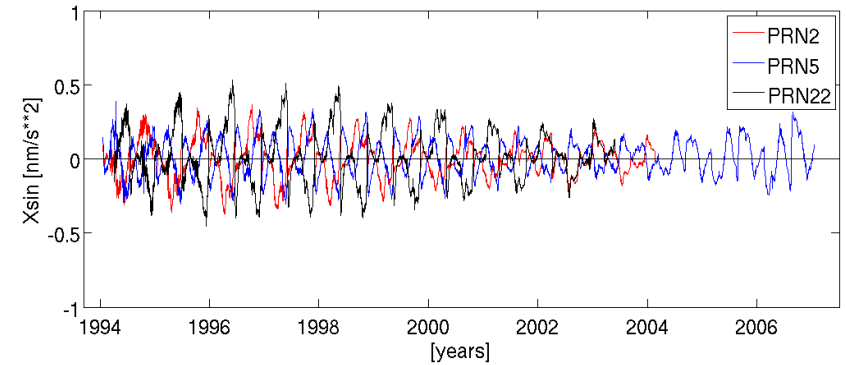
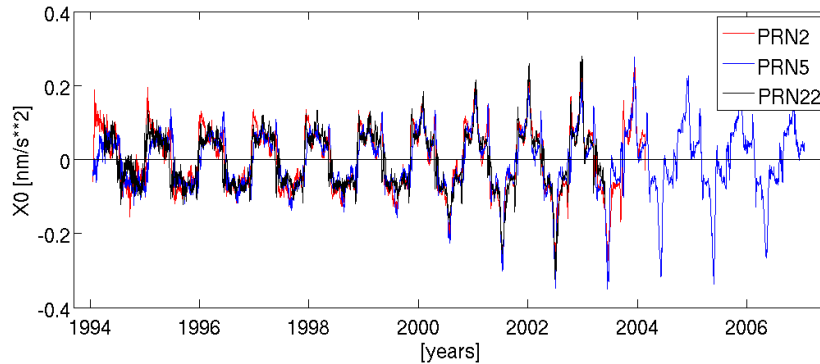
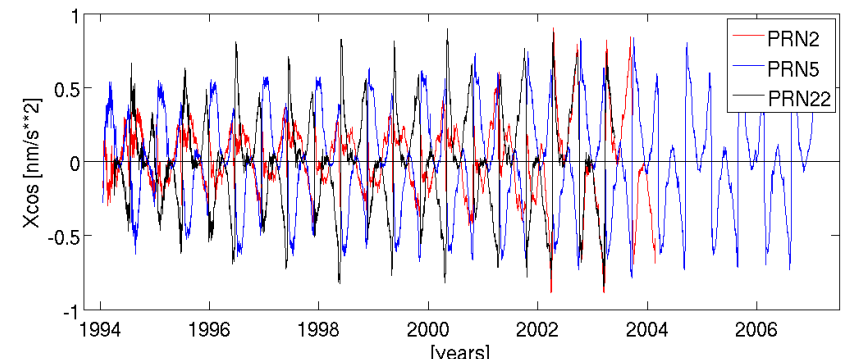
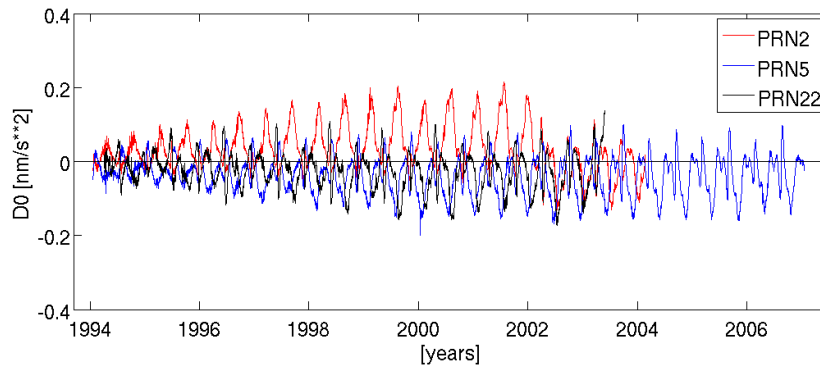
Influence of tidal model on the orbit parameters

Differences in Kepler elements: satellites PRN2, PRN5, PRN22 from plane 2



Influence of tidal model on the orbit parameters

Differences in Radiation pressure parameters: satellites PRN2, PRN5, PRN22



Influence of tidal model on the orbit parameters

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

When S1 tide is changed by $100 \mu\text{as}$

↳ $\sim 2\text{cm}$ change in semi-major axis, $\sim 0.2\text{-}0.5 \text{ nm/sec}^2$ in RPR

„Realistic“ changes for main tides: $\sim 10\text{-}30 \mu\text{as}$ for S1, K1, M2, S2

↳ $\sim 0.5\text{cm}$ change in semi-major axis, $\sim 0.1 \text{ nm/sec}^2$ in RPR

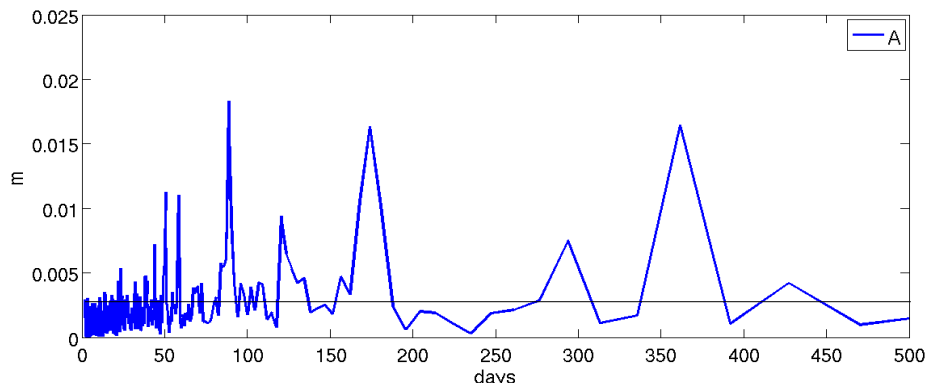
Influence of tidal model on the orbit parameters

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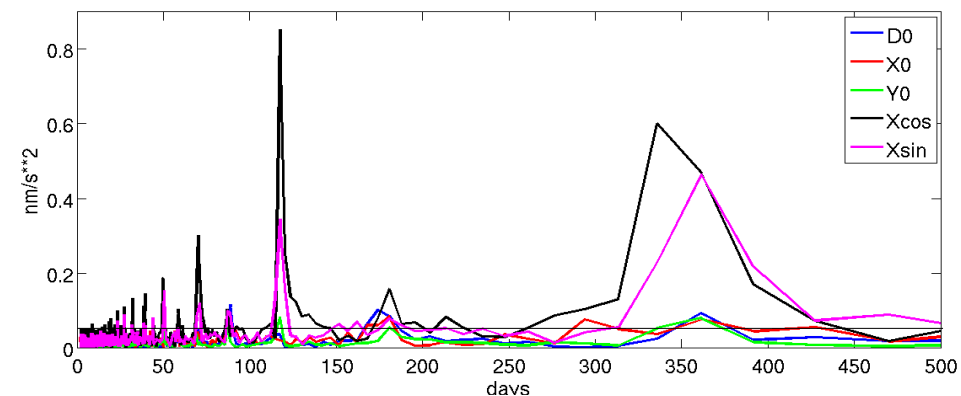
Time series of daily estimates of orbital parameters from standard solution

Spectra

Spectrum of semi-major axis



Spectrum of radiation pressure parameters



Noise level in semi-major axis: $\sim 2\text{mm}$ \longrightarrow $\sim 5\text{mm}$ signal

Noise level in RPRs: $\sim 0.05 \text{ nm/sec}^2$ \longrightarrow $\sim 0.1 \text{ nm/sec}^2$

Summary and Conclusions

For a 1-day GPS solution changes in subdaily ERP model lead to:

Geocenter is unaffected

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

Realistic changes in the subdaily model:

Periodic signals in the orbits are small, but still can be seen by spectral analysis

Periodic signals in the station coordinates are systematic on regional level, but negligible ($\sim 0.3\text{mm}$)

X-pole and Y-pole show systematic change in rates, UT1 (nearly) unaffected

Thank you!