

Several aspects concerning EOP combination

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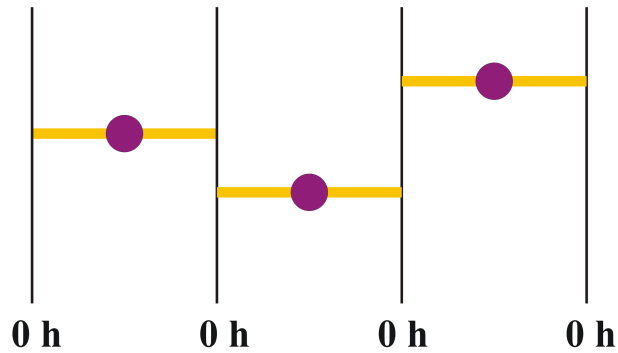
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Overview

1. Different **parameterizations** and **continuity**
2. Problem of **reference epochs** (VLBI vs. GNSS/SLR/DORIS) and impact of combination strategy
3. **Daily** vs. **multi-year** solutions for deriving EOP time series
4. **UT/LOD**: VLBI + GPS

All studies are based on the data of the
→ CONT02 campaign
→ project GGOS-D (for long time series)

Parameterization of EOPs



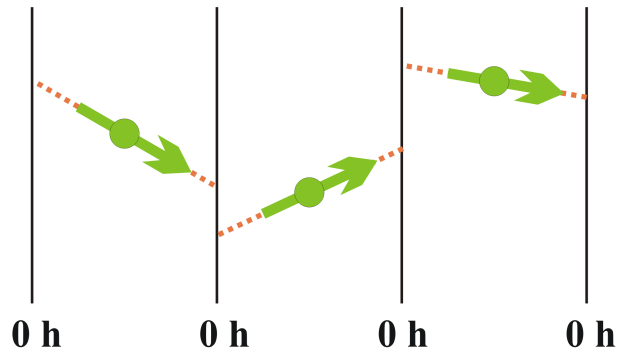
Offset-only

Piece-wise constant

n parameters

no continuity at boundaries

continuity constraints not reasonable

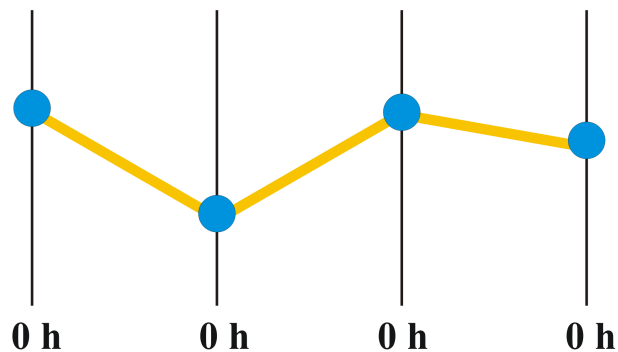


Piece-wise linear Offset+Drift

$2*n$ parameters

no continuity at boundaries

continuity constraints reduce #parameters to $n+1$



Piece-wise linear Polygon

$n+1$ parameters

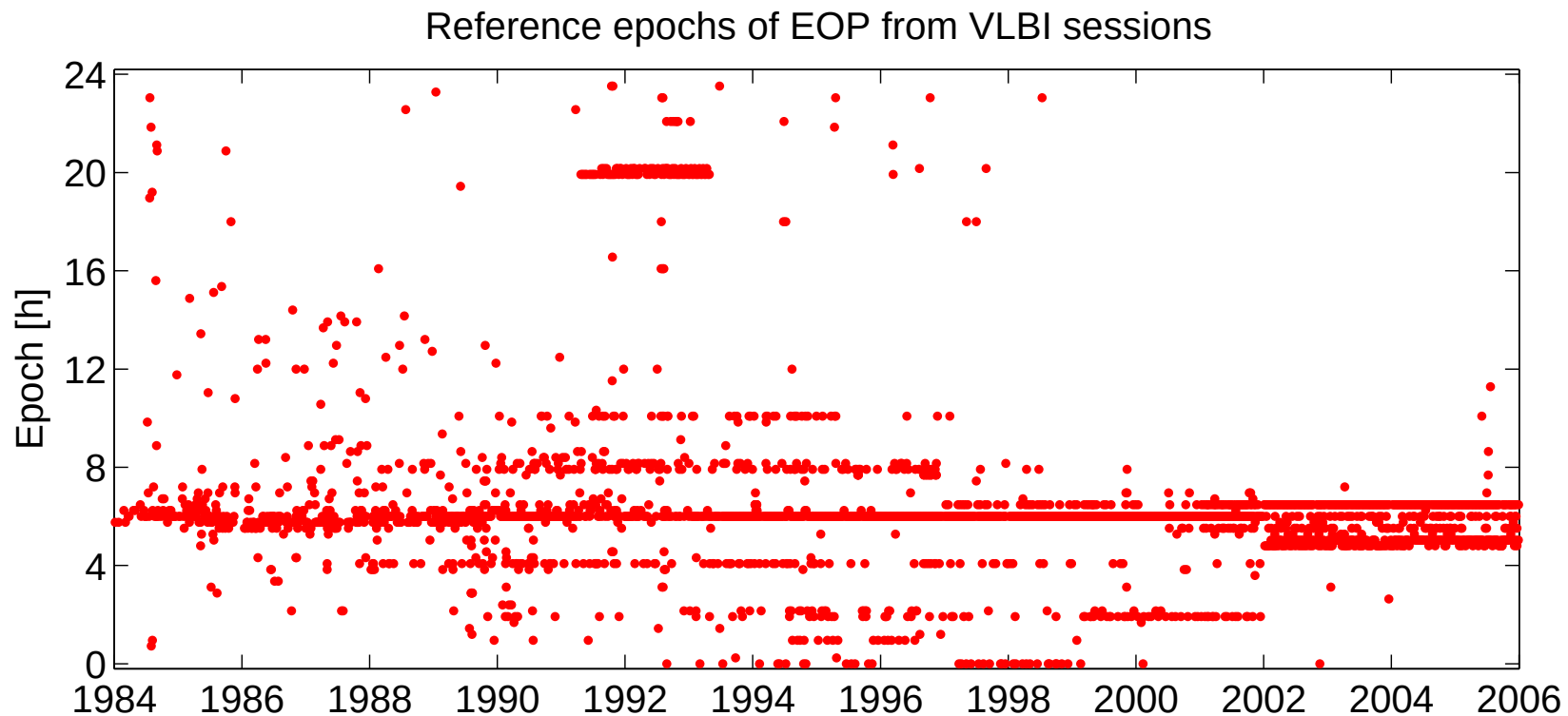
“real” continuity at boundaries

no continuity constraints needed

not distinguishable from “offset-only” in SINEX

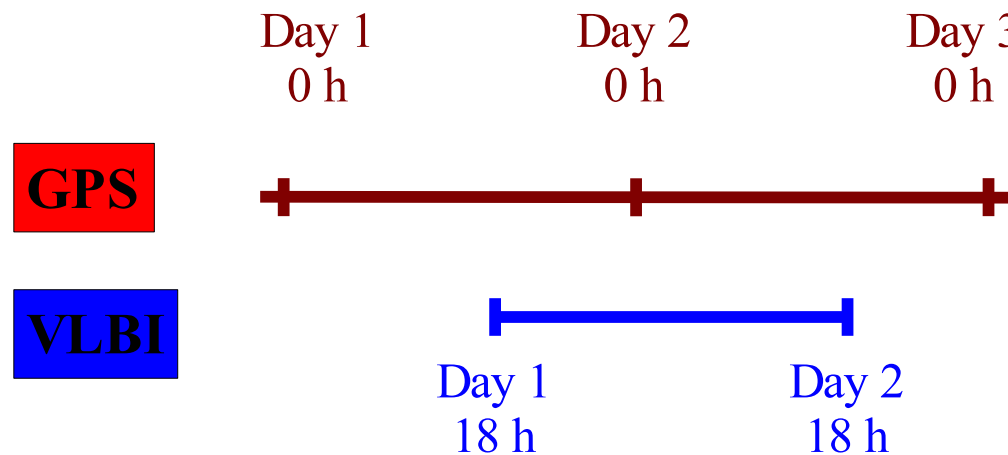
EOP combination: Problem of reference epoch

- Problems:**
- a) 24-h VLBI Sessions **NOT 00:00 – 24:00 UTC**
 - ⇒ Epoch of „daily“ EOPs different from 12:00 UTC
 - ⇒ No clear correspondence to daily GPS-/SLR- EOP
 - b) **changing** reference epoch from session to session



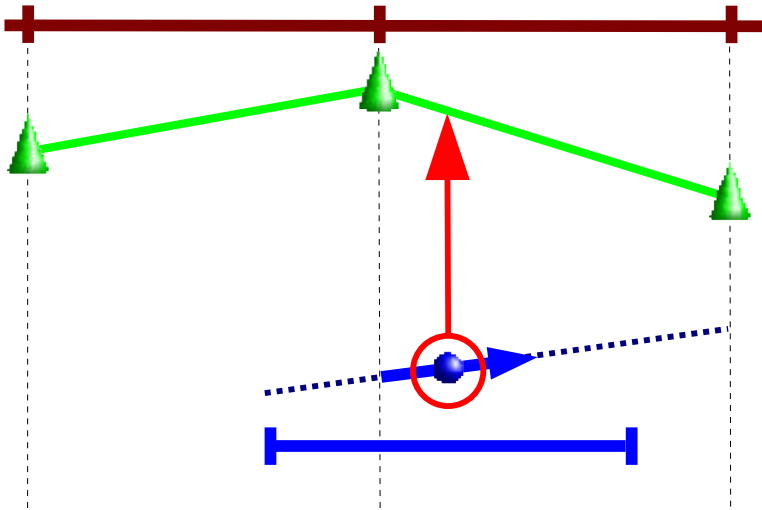
EOP combination: Problem of reference epoch

No clear correspondence between validity intervals of *daily EOPs* derived from GPS/SLR and from VLBI 24-h sessions



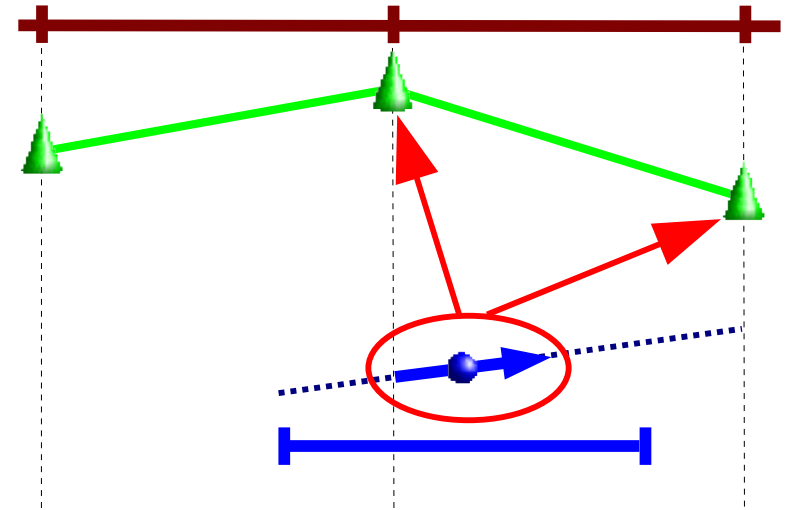
Reference epoch of EOP: Combination strategy

No clear correspondence between validity intervals of *daily EOPs* derived from GPS/SLR and from VLBI 24-h sessions



Use offset only:

- + Offset is correctly included into time series
- „Mixture“ of validity intervals
- Contribution to one day only
- ERP drift is ignored



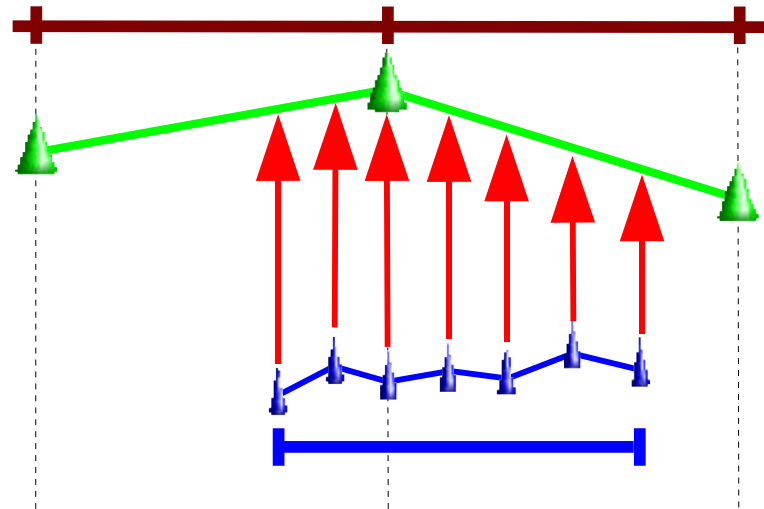
Use offset + drift:

- + Offset and drift information are used
- „Mixture“ of validity intervals
- Contribution to one day only

Reference epoch of EOP: Combination strategy

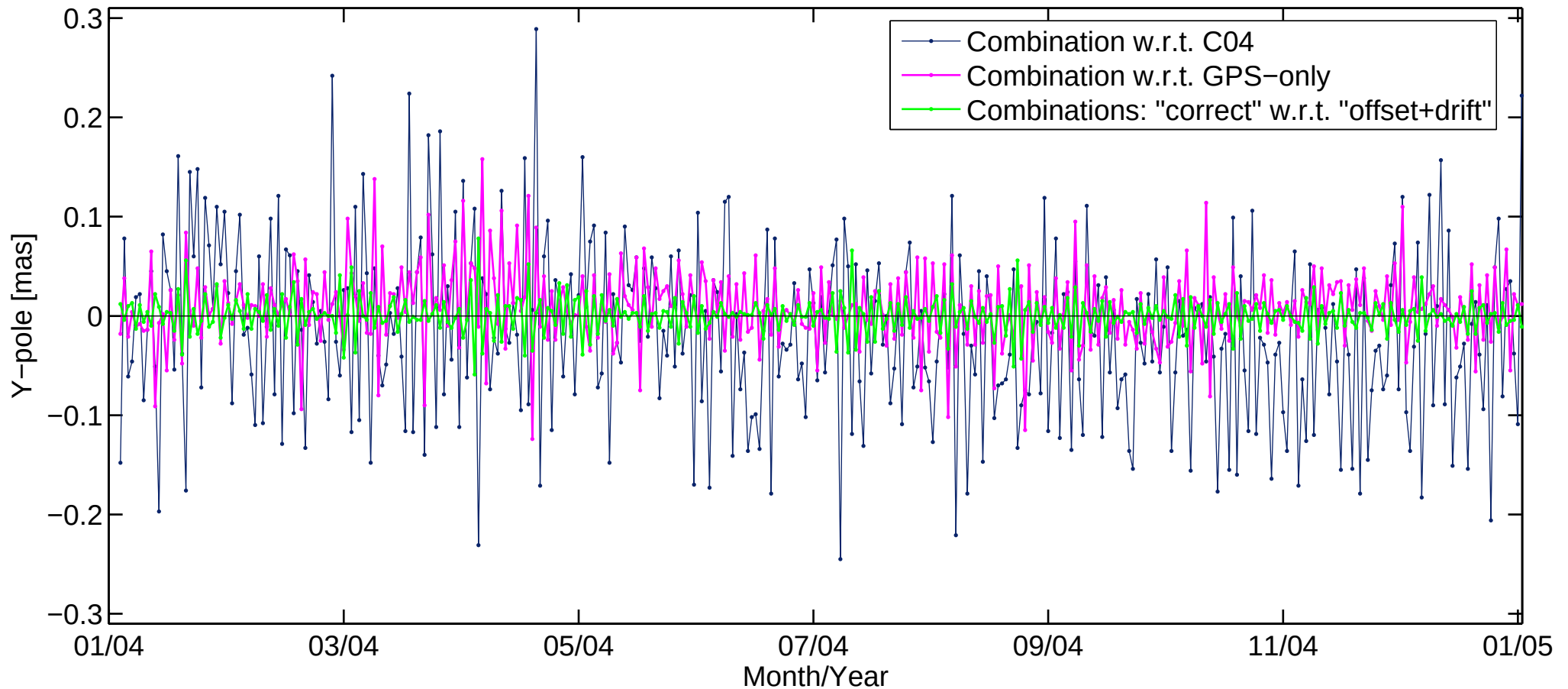
No clear correspondence between validity intervals of *daily EOPs* derived from GPS/SLR and from VLBI 24-h sessions

- ⇒ Can be avoided if higher temporal resolutions are used in the individual contributions:
- At least splitting up at midnight (or even higher resolution)
- *Full ERP information* is correctly included into time series
- Equivalent to *correct distribution of observations* to individual ERPs



Reference epoch of EOP: Combination strategy

Comparing different solutions for y-pole



*Combination w.r.t.
external (C04)*

*Combination w.r.t.
single-technique*

*„Correct“ Combination
w.r.t. „offset+drift“*

WRMS x-pole

89.8 μ as

43.1 μ as

18.2 μ as

WRMS y-pole

82.0 μ as

39.8 μ as

18.3 μ as

WRMS UT

18.4 μ s

8.4 μ s

6.6 μ s

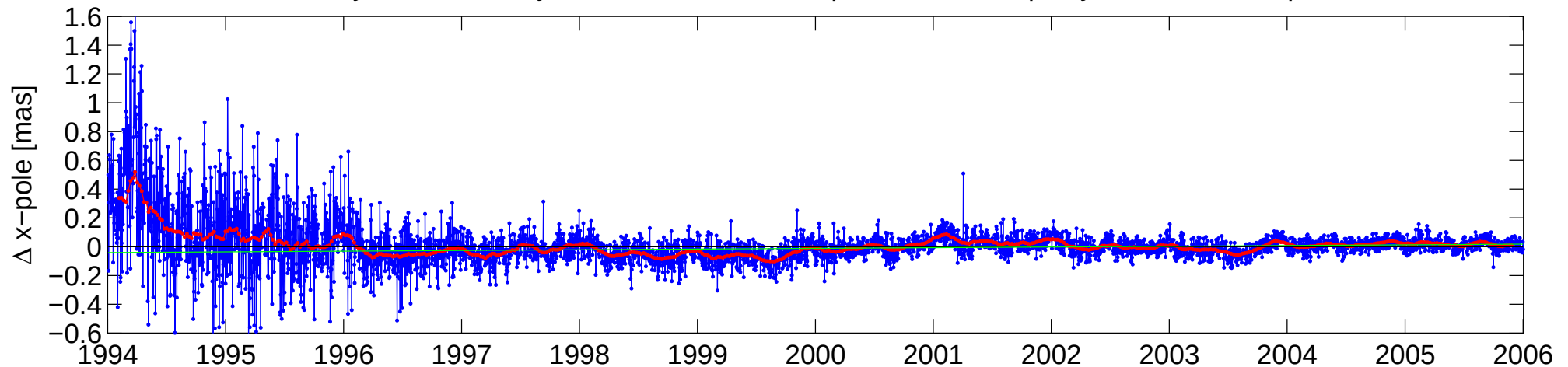
Daily vs. multi-year solutions

- ***Daily solutions:***
daily realization of TRF (station coordinates)
→ TRF slightly different from day to day
- ***Multi-year solution:***
TRF (station coordinates + velocities) together with EOPs
→ fully consistent time series

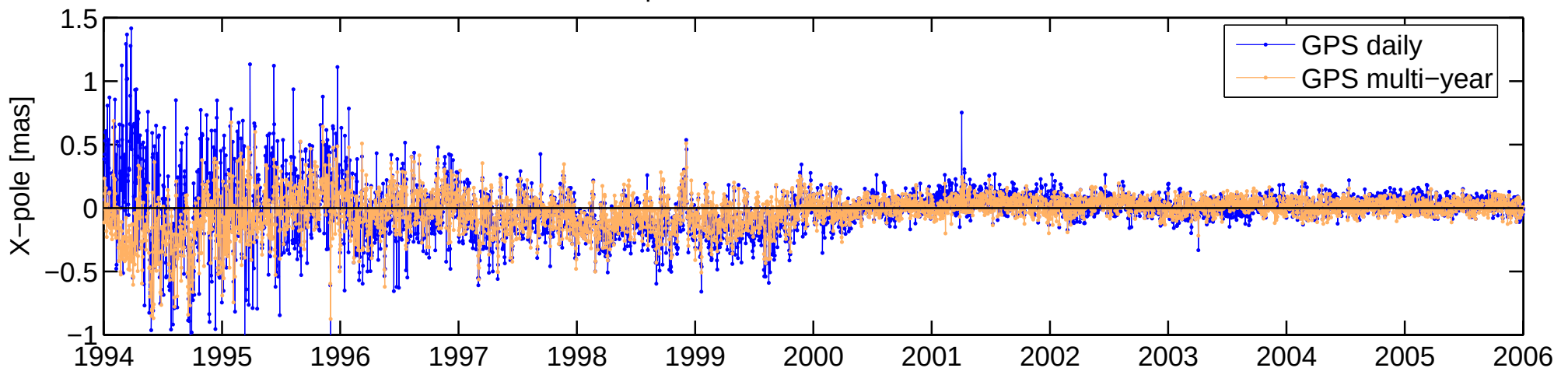
What is the impact on the time series of EOPs?

Daily vs. multi-year solutions for PM: GPS

Daily GPS – multi-year GPS: Bias = $-11.3 \mu\text{as}$, drift = $4.90 \mu\text{as/y}$, WRMS = $70.7 \mu\text{as}$



X-pole: Differences to IERS-C04

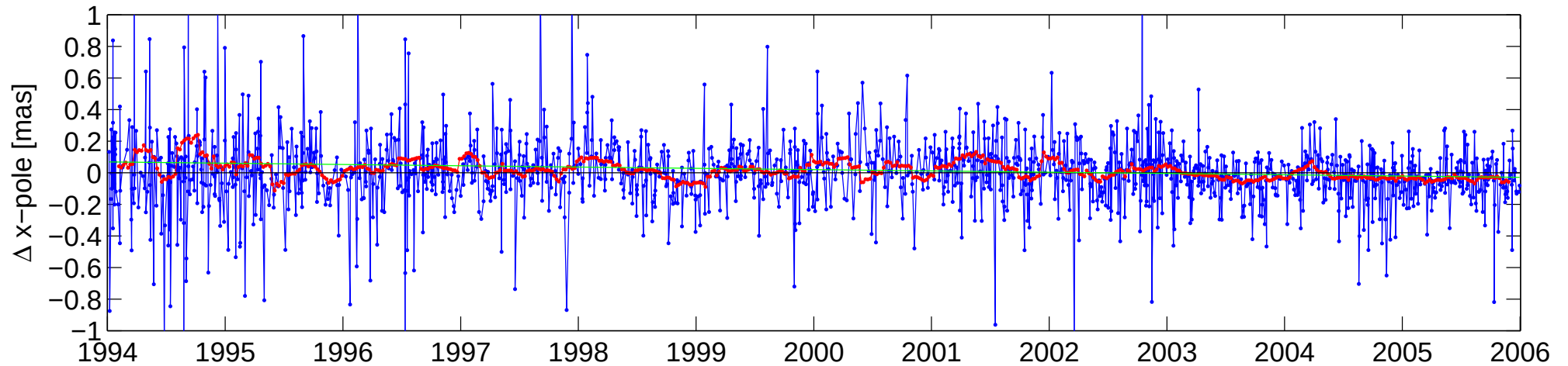


WRMS vs. IERS-C04: X-Pole **112.7 μas** (daily) $\rightarrow$ **98.0 μas** (multi-year)
Y-Pole **109.9 μas** (daily) $\rightarrow$ **99.5 μas** (multi-year)

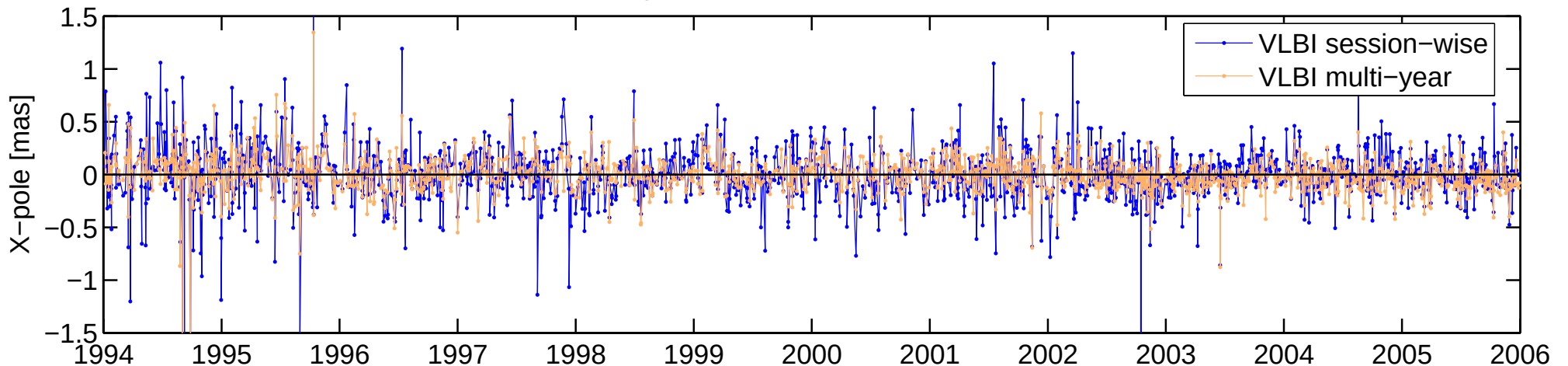
$\Rightarrow$ **Early epochs** benefit most from multi-year solution: small network, weak daily TRF

Daily vs. multi-year solutions for PM: VLBI

VLBI daily – VLBI multi-year: Bias = $19.2 \mu\text{as}$, drift = $-8.17 \mu\text{as/y}$, WRMS = $177.8 \mu\text{as}$



X-pole: Differences to IERS-C04

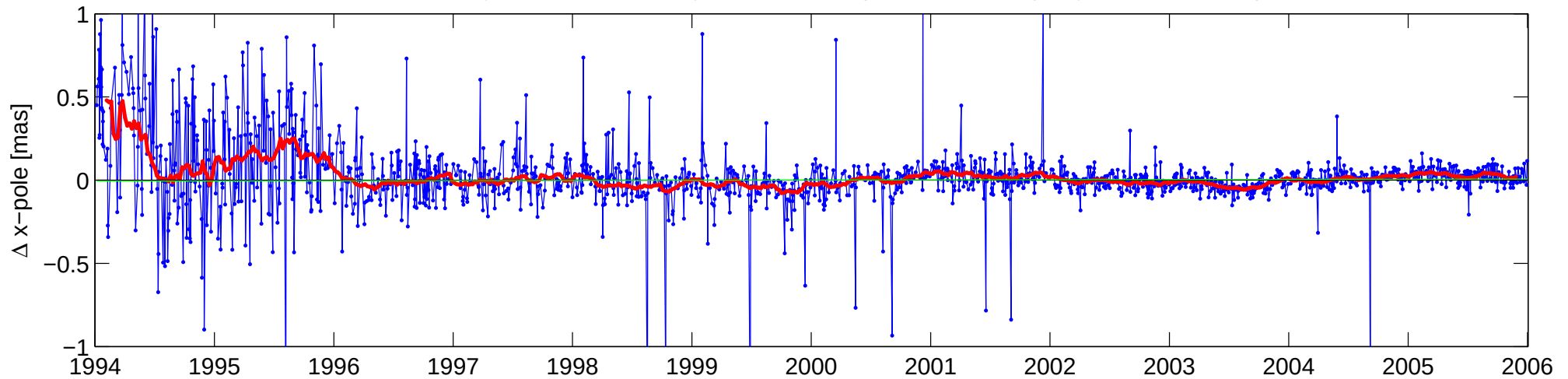


WRMS vs. IERS-C04: X-Pole $155.6 \mu\text{as}$ (daily) $\rightarrow$ $109.0 \mu\text{as}$ (multi-year)
Y-Pole $195.4 \mu\text{as}$ (daily) $\rightarrow$ $100.7 \mu\text{as}$ (multi-year)

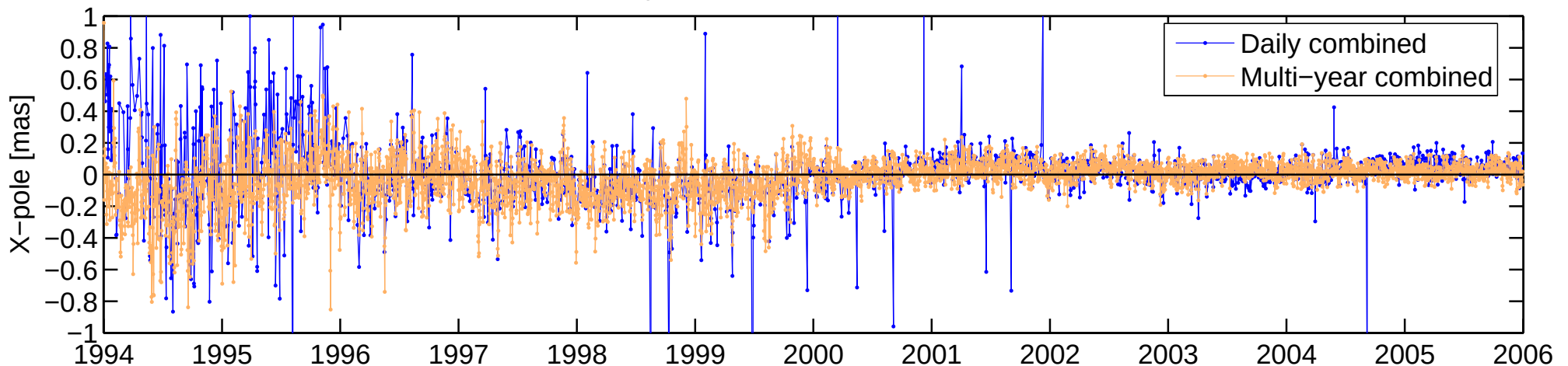
$\Rightarrow$ **All epochs** benefit from multi-year solution: generally small network, weak daily TRF

Daily vs. multi-year solutions for PM: Combination

Combined daily – combined multi-year: Bias = 0.6 μas , drift = 1.07 $\mu\text{as/y}$, WRMS = 76.7 μas



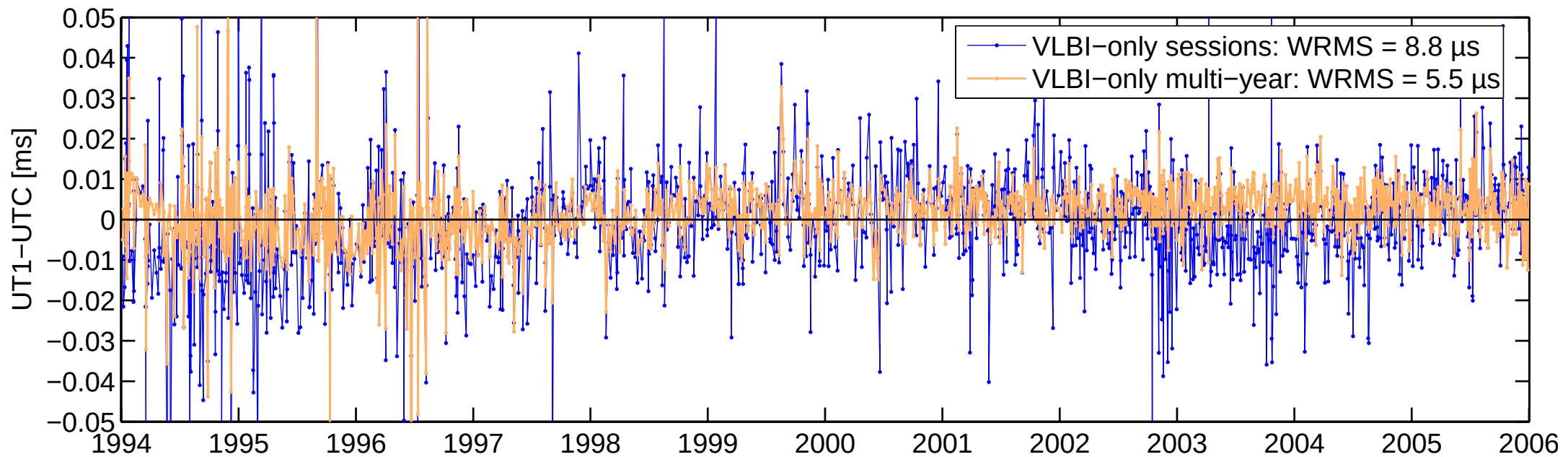
X-pole: Differences to IERS-C04



WRMS vs. IERS-C04: X-Pole **104.1 μas** (daily) $\rightarrow$ **98.1 μas** (multi-year)
Y-Pole **100.4 μas** (daily) $\rightarrow$ **96.0 μas** (multi-year)

$\Rightarrow$ **Early epochs** benefit most from multi-year solution: small network, weak daily TRF

Daily vs. multi-year solutions for UT: VLBI

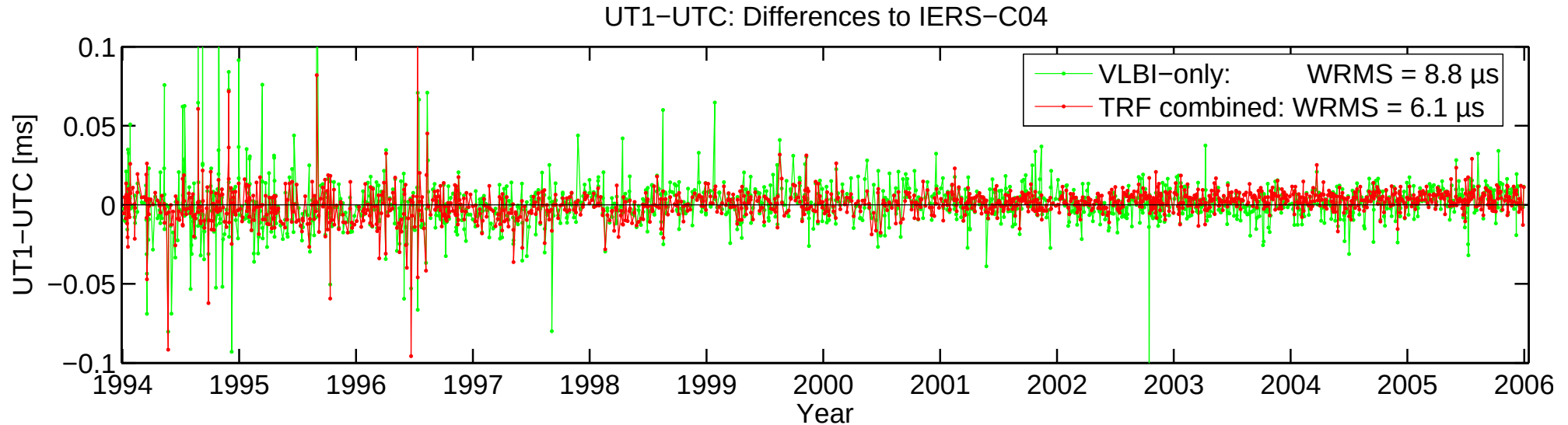


⇒ Similar to pole coordinates

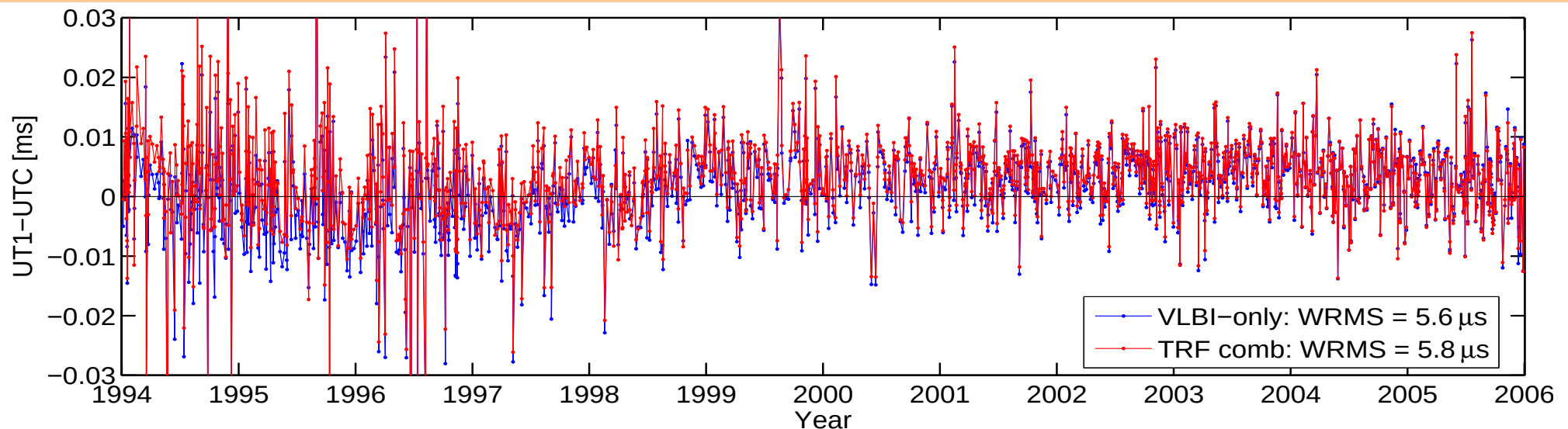
⇒ **All epochs** benefit from multi-year solution: generally small network, weak daily TRF

Daily vs. multi-year solutions for UT: TRF combined

Session-wise combination: VLBI-only daily TRF weak $\Rightarrow$ stabilization



Multi-year combination: VLBI-only TRF is already stable enough $\Rightarrow$ no big impact



EOP combination: Daily vs. multi-year

Problems with daily realization of TRFs: **Number of Local Ties** (LT)

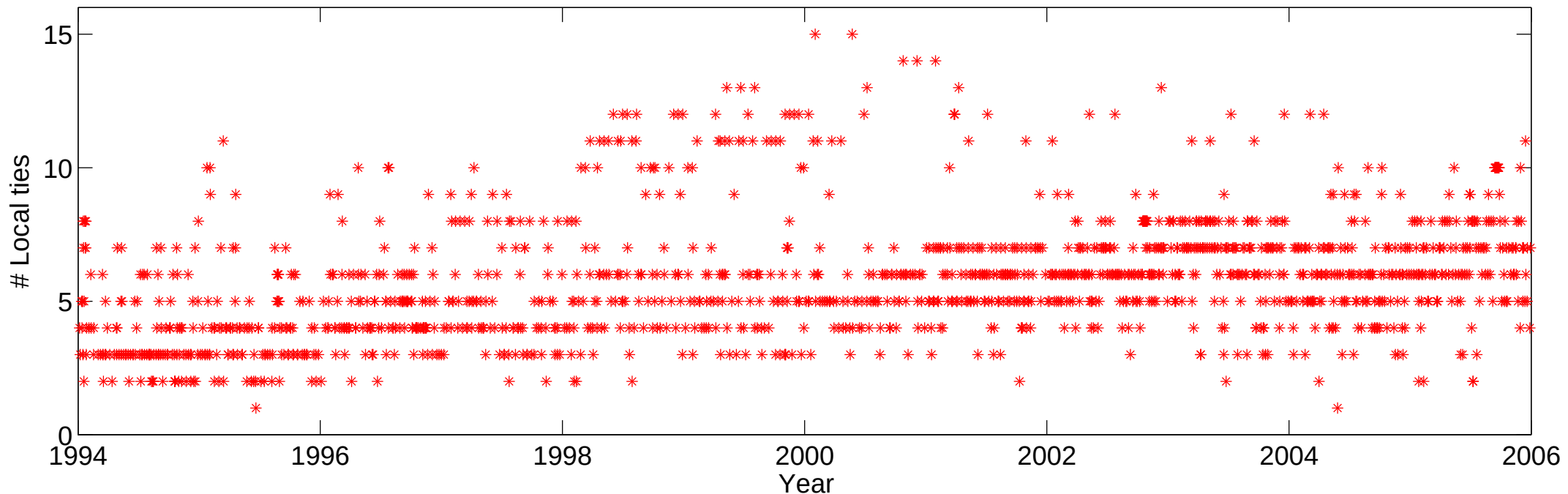
→ **LT per Session** in most cases very small

→ may be even reduced after selection of „good“ local ties

⇒ problematic for „VLBI-only parameters“ (**UT, nutation**)

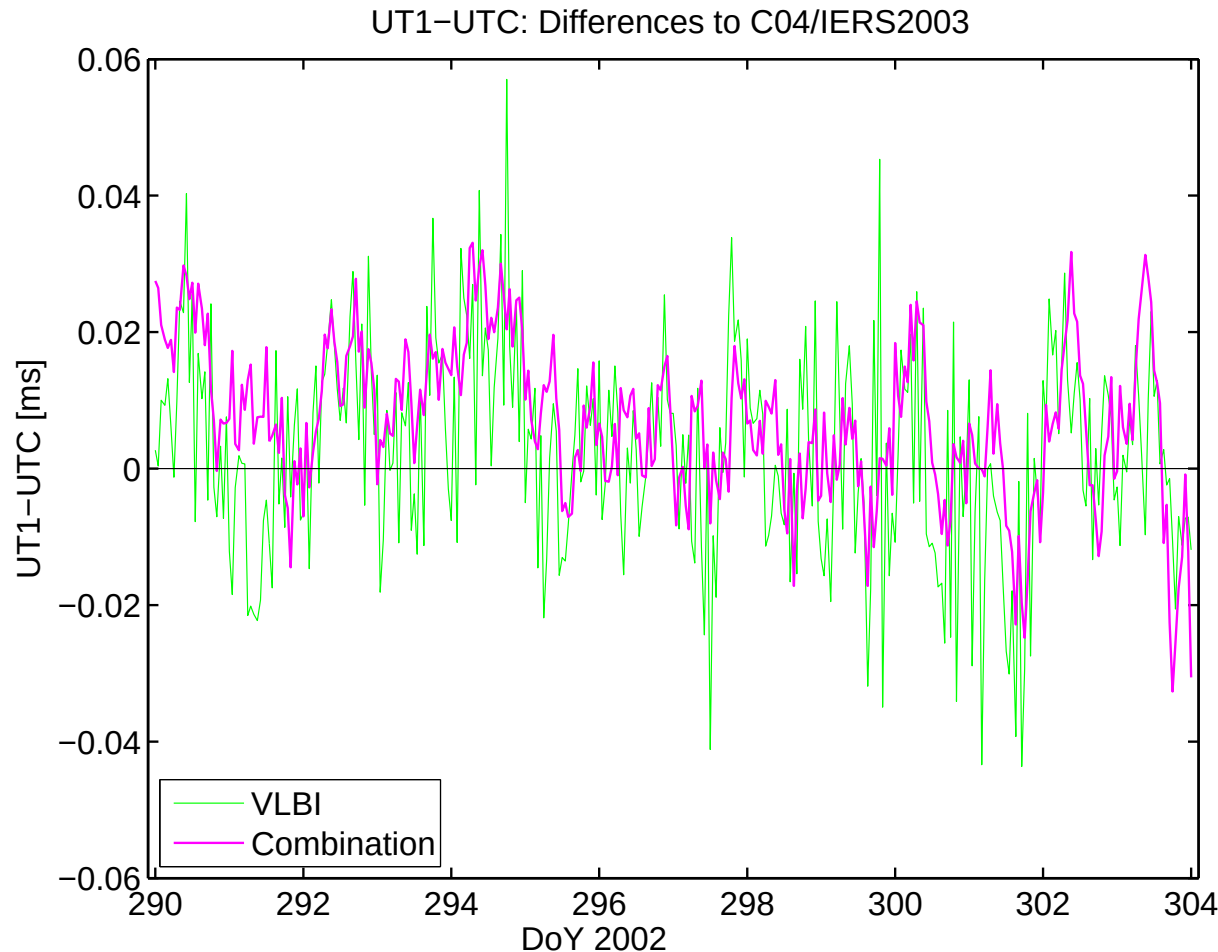
⇒ **Can be avoided if long-term solutions (multi-year) are computed**
Total number of LT in ITRF2008 (after selection): **17**

Number of GPS–VLBI local ties per daily solution



UT/LOD combination: Continuous and sub-daily

Continuous VLBI contribution (CONT02) $\Rightarrow$ No „GPS-only“ epochs in combination
Sub-daily resolution (1 h)

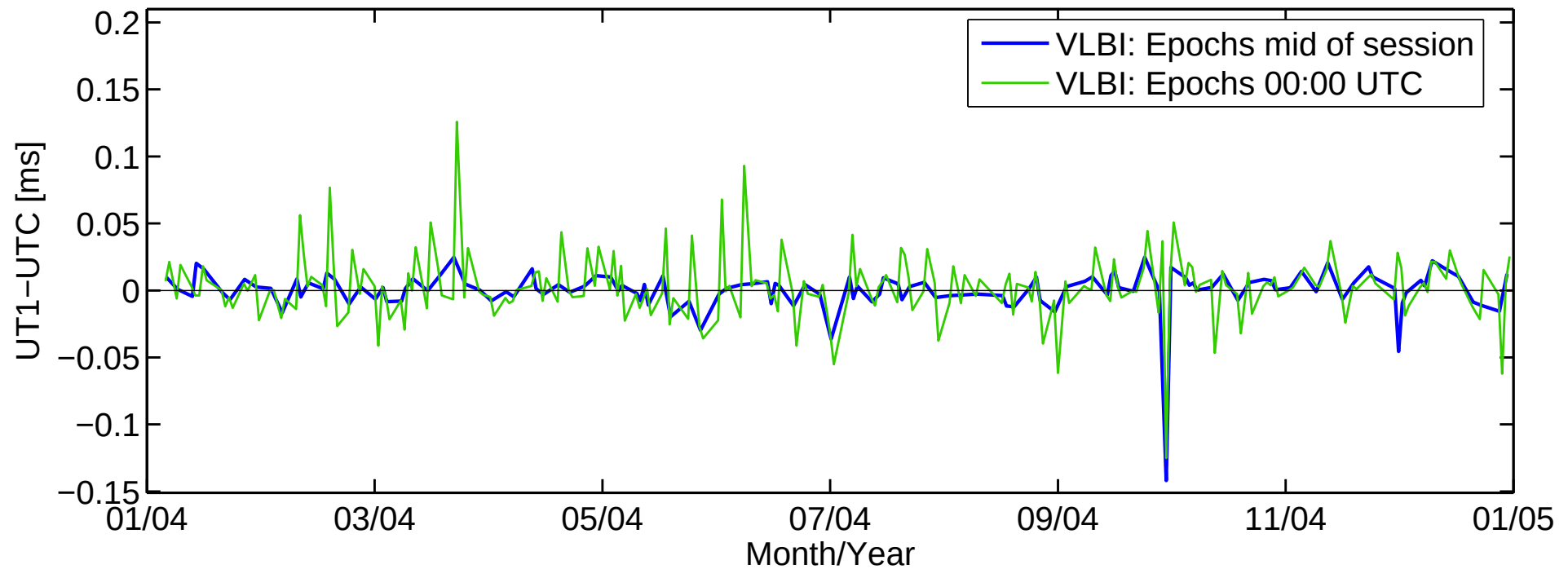


RMS VLBI-only: **15.1 μs**

<i>Combined Parameters</i>	<i>RMS [μs]</i>
TRF	15.2
TRF+Pole	14.8
TRF+Pole+ <u>UT/LOD</u>	11.9
TRF+Pole+UT/LOD +Nut.+Trop.	11.6

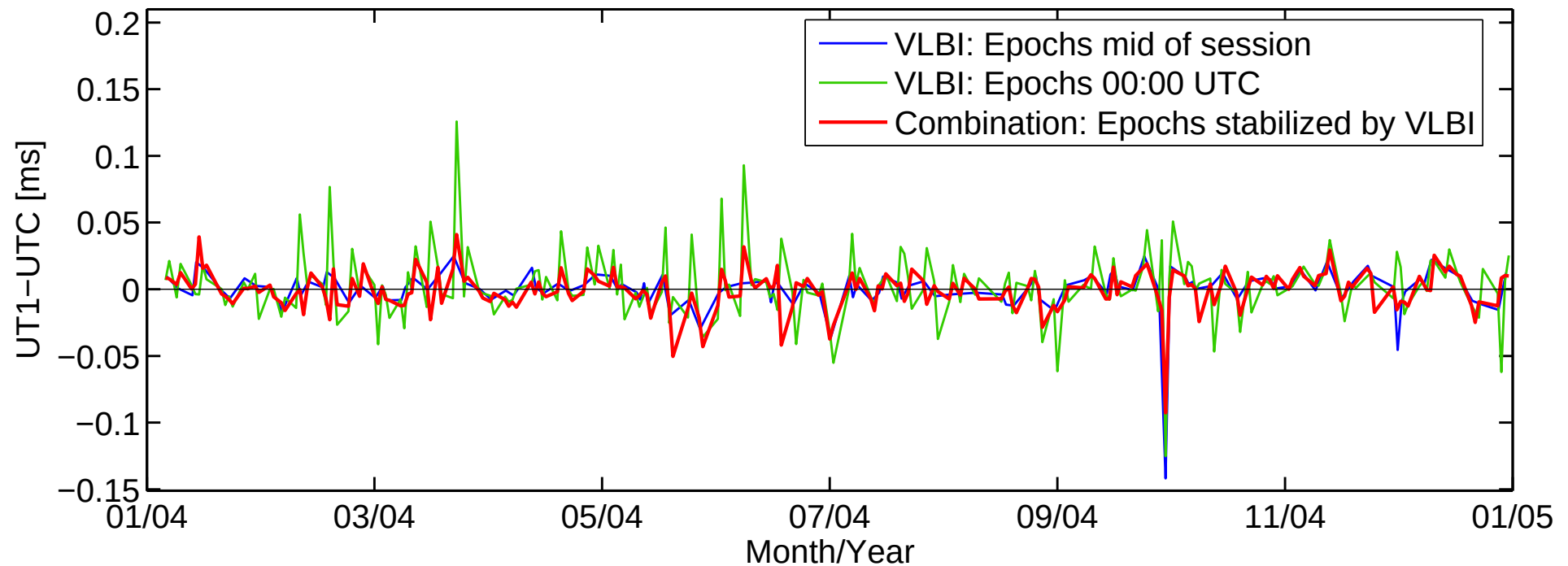
$\Rightarrow$ Combination UT/LOD works fine $\Rightarrow$ benefit for the resulting UT time series

UT/LOD combination: 24-h sessions



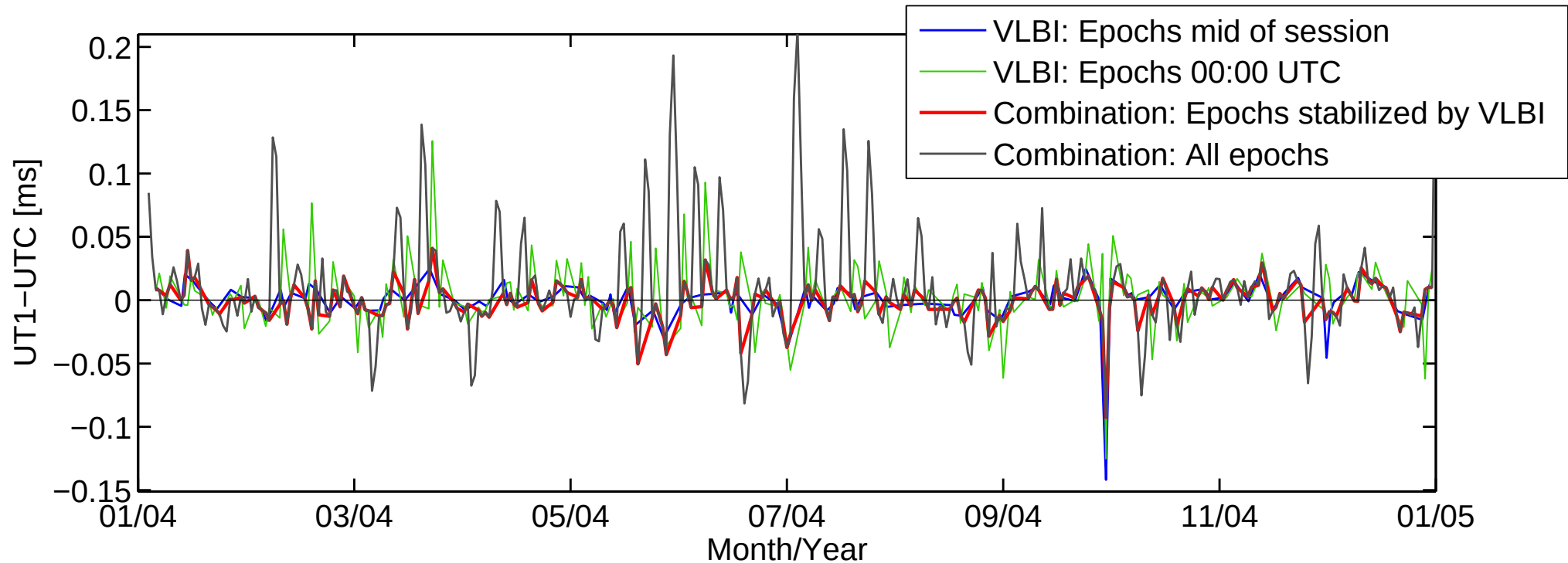
<i>Solution type</i>	<i># Epochs</i>	<i>Mean bias [μs]</i>	<i>WRMS [μs]</i>
VLBI-only: Epochs mid of session (offset+drift)	129	0.7	10.1
VLBI-only: Epochs 0h (polygon)	224	0.2	15.9

UT/LOD combination: 24-h sessions



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Comb: Only 0h-epochs with contribution of VLBI	224	-0.6	11.3

UT/LOD combination: 24-h sessions



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VLBI-only: Epochs 0h (polygon)	224	0.2	15.9
Comb: Only 0h-epochs with contribution of VLBI	224	-0.6	11.3
Combination: All epochs	365	2.0	22.6

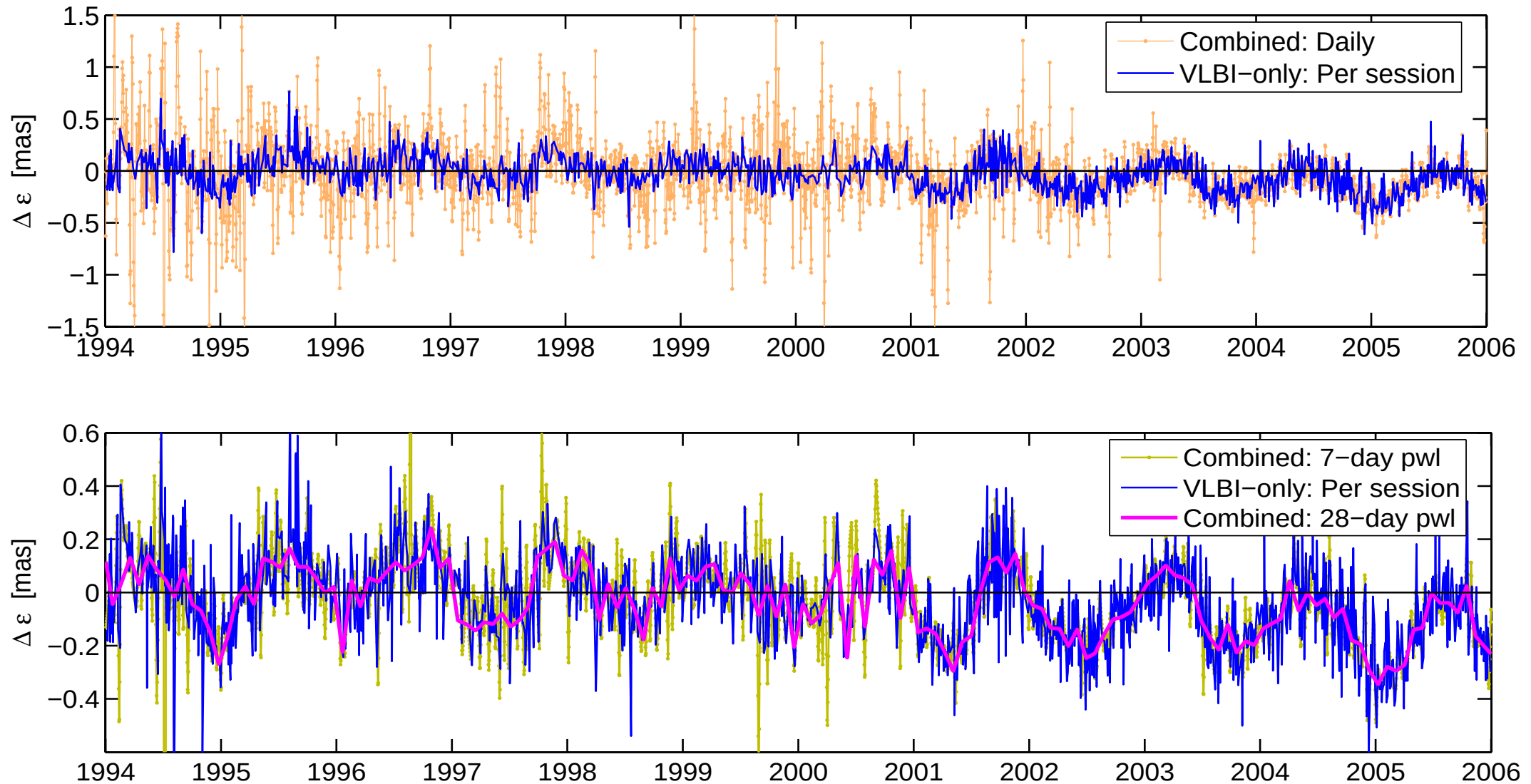
Summary

- Problem of different *reference epochs* (VLBI vs. satellite-techniques):
 - combination strategy is important
- ERPs from *long-term solutions* are more stable than *daily solutions*
 - especially if daily network is weak
- *Combination of UT/LOD* from VLBI and GPS is possible
 - continuous VLBI data (CONT campaigns)
 - epochs with contribution by VLBI
 - problems with “GPS-only” epochs (Densification: Intensive sessions)

Further aspects (not covered here):

- Densification for UT using VLBI Intensive sessions
- Nutation (similar to UT, but lower temporal resolution possible)
- Correlation between sub-daily polar motion and nutation
- EOP useful for selection of good local ties (→ Manuela)

VLBI/GPS Nutation



Daily combination: Problems with „GPS-only“ epochs (similar to UT)

⇒ Use lower temporal resolution (7d, 14d, 28d); main signal is Free-Core Nutation (~432 d)

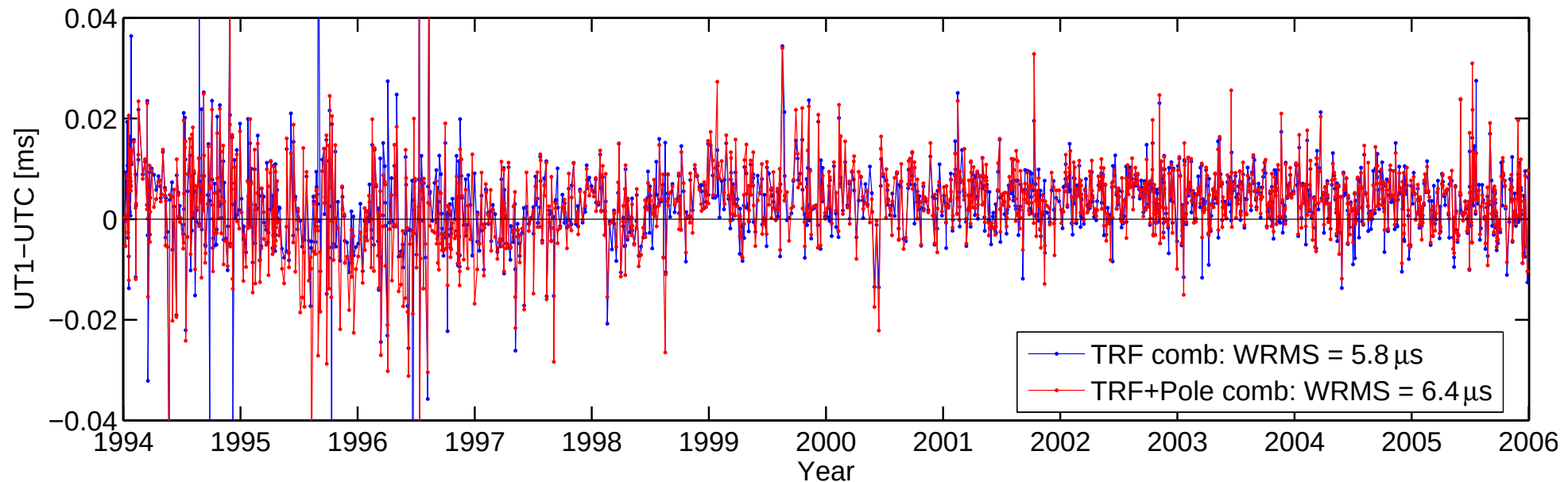
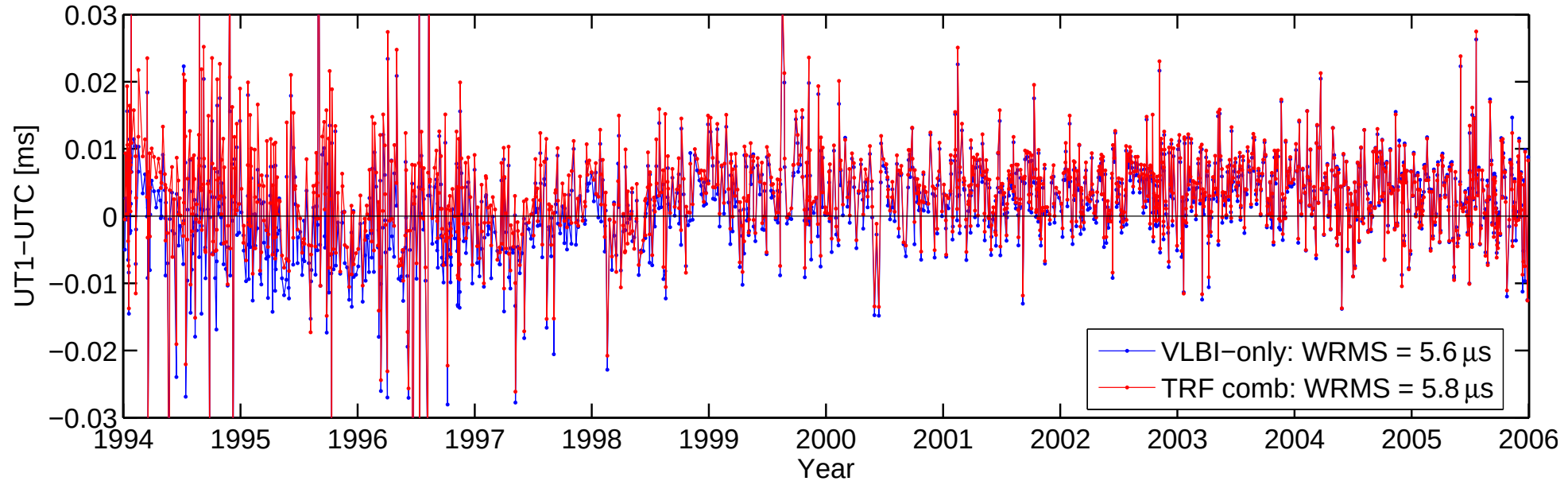
Case 3: Densification with GPS-LOD and VLBI Intensive sessions

-> IVS meeting

-> wird wohl zu viel...

UT/LOD: Benefit of the combination

Multi-year combination: VLBI-only TRF is already stable enough => no big impact



Sub-daily PM and Nutation

Thematik nur anreissen oder ausführlich?

-> Nur anreissen ist schwierig....

-> ausführlich wird dann zu viel...