Several aspects concerning EOP combination

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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
$\rightarrow$ CONT02 campaign
$\rightarrow$ project GGOS-D (for long time series)

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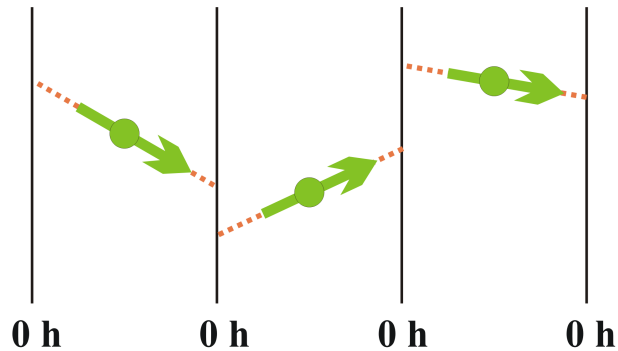# Parameterization of EOPs
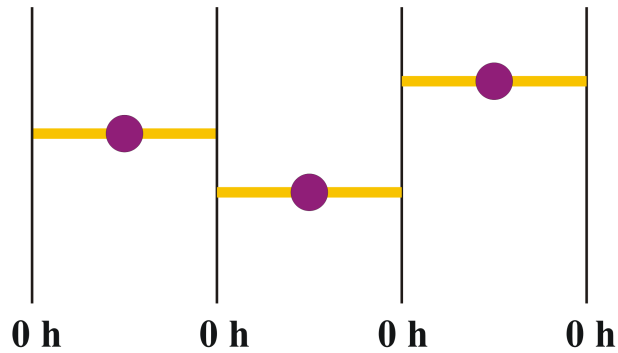
Offset-only
Piece-wise constant
n parameters
no continuity at boundaries
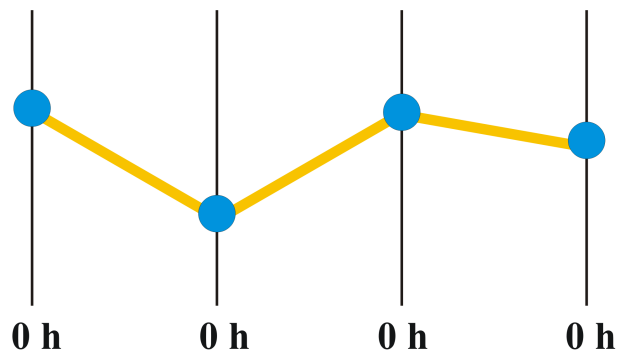continuity constraints not reasonable

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**
$\Rightarrow$ Epoch of „daily" EOPs different from 12:00 UTC
$\Rightarrow$ No clear correspondence to daily GPS-/SLR- EOP

b) **changing** reference epoch from session to session

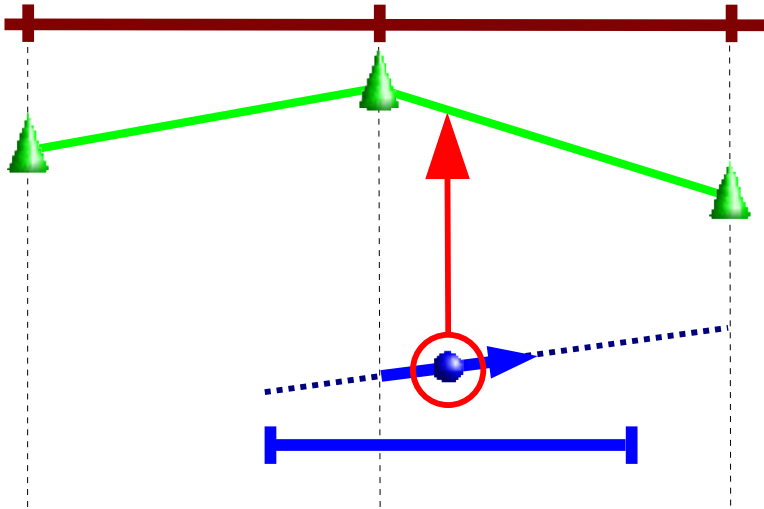Reference epochs of EOP from VLBI sessions

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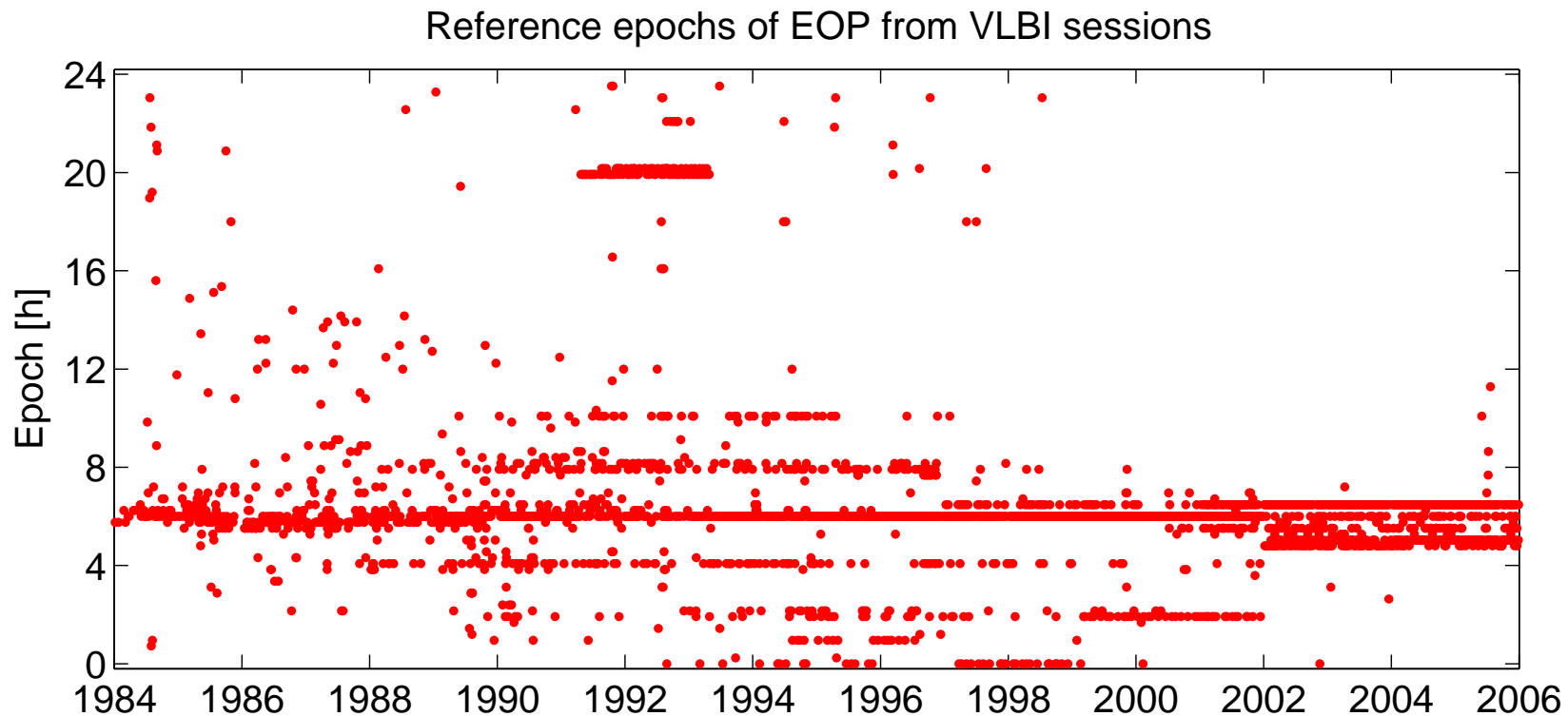
EOP combination: Problem of reference epoch

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

Day 1
0 h

Day 2
0 h

Day 3
0 h

GPS
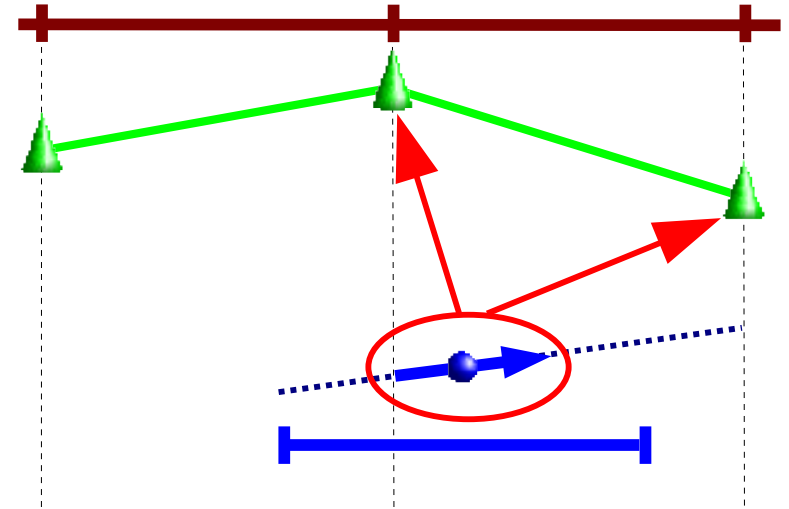
VLBI

Day 1
18 h

Day 2
18 h
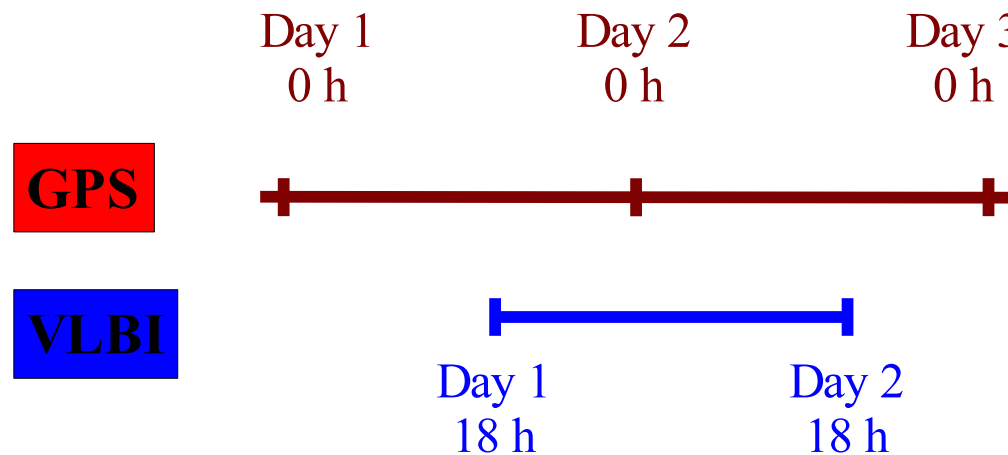
Reference epoch of EOP: Combination strategy

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

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

$\Rightarrow$ **Can be avoided if higher temporal resolutions are used in the individual contributions:**

$\rightarrow$ At least splitting up at midnight (or even higher resolution)

$\rightarrow$ *Full ERP information* is correctly included into time series

$\rightarrow$ Equivalent to *correct distribution of observations* to individual ERPs
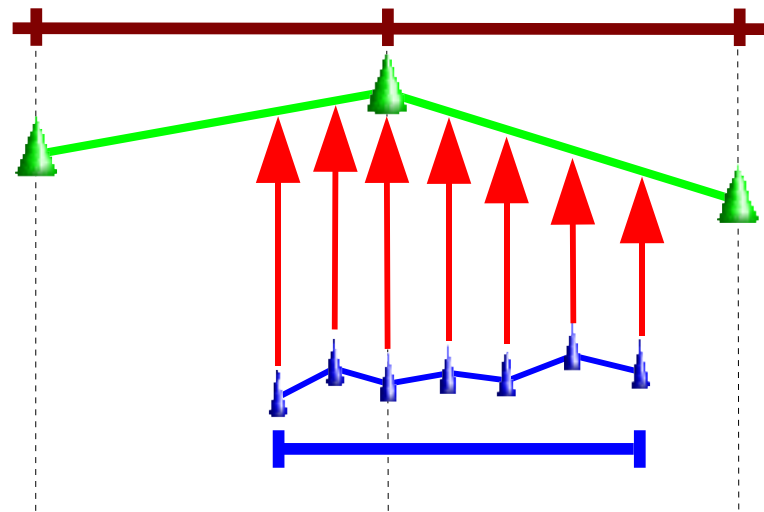
Reference epoch of EOP: Combination strategy

Comparing different solutions for y–pole
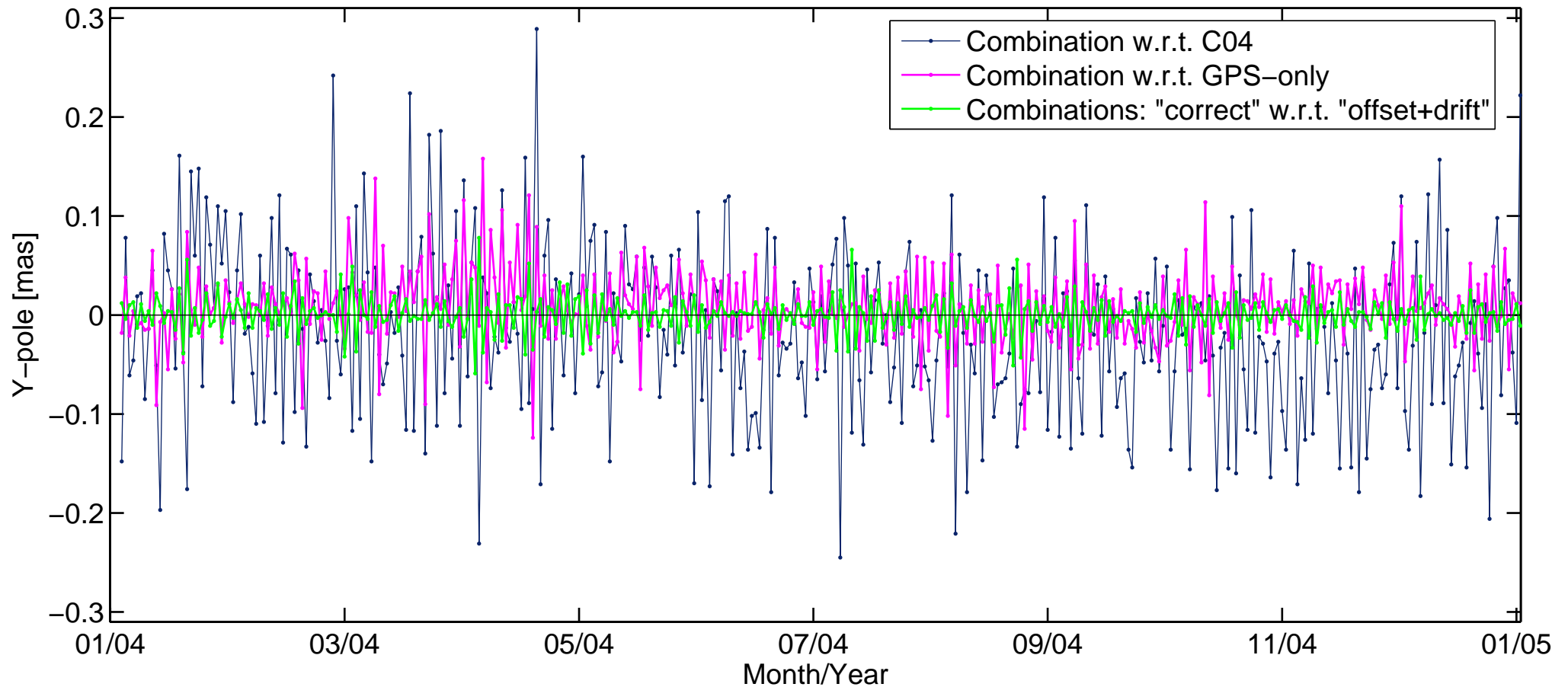
|	Combination w.r.t. external (C04)	Combination w.r.t. single-technique	„Correct" Combination w.r.t. „offset+drift"
WRMS x-pole	89.8 µas	43.1 µas	18.2 µas
WRMS y-pole	82.0 µas	39.8 µas	18.3 µas
WRMS UT	18.4 µs	8.4 µs	6.6 µs

Daily vs. multi-year solutions

- ***Daily solutions***:
  daily realization of TRF (station coordinates)
  $\rightarrow$ TRF slightly different from day to day

- ***Multi-year solution***:
  TRF (station coordinates + velocities) together with EOPs
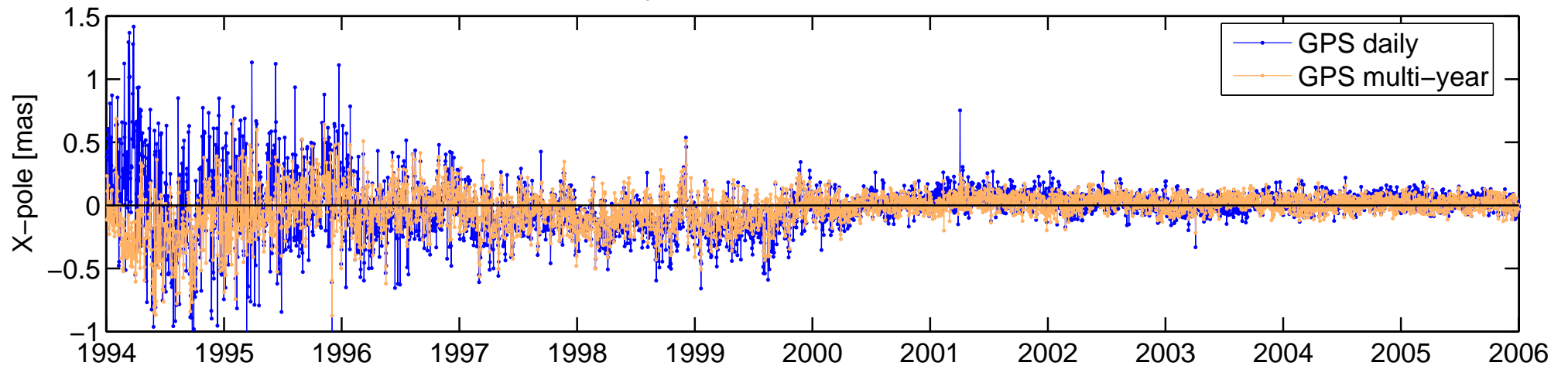 $\rightarrow$ fully consistent time series

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 µas, drift = 4.90 µas/y, WRMS = 70.7 µas
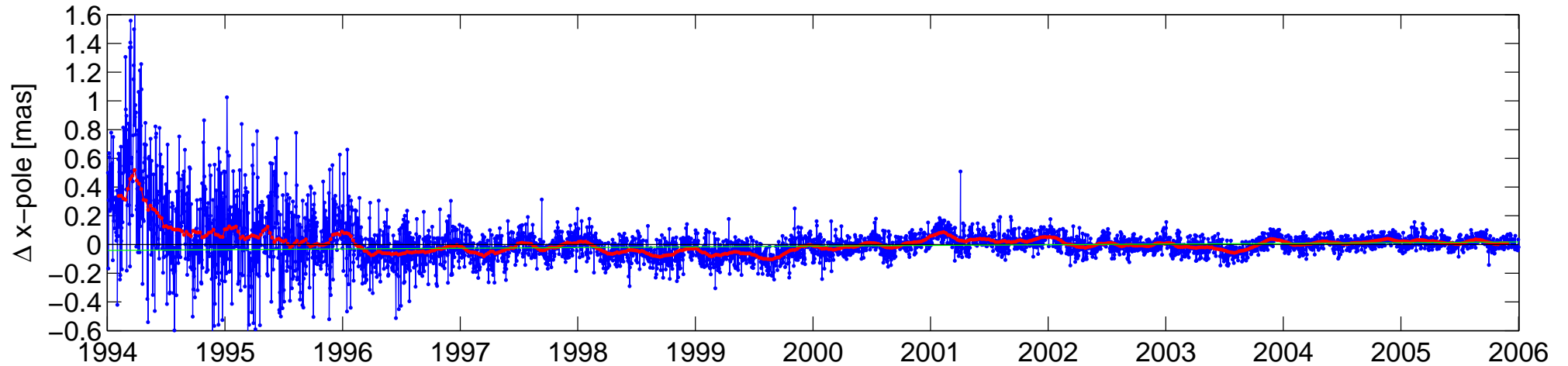
X-pole: Differences to IERS-C04

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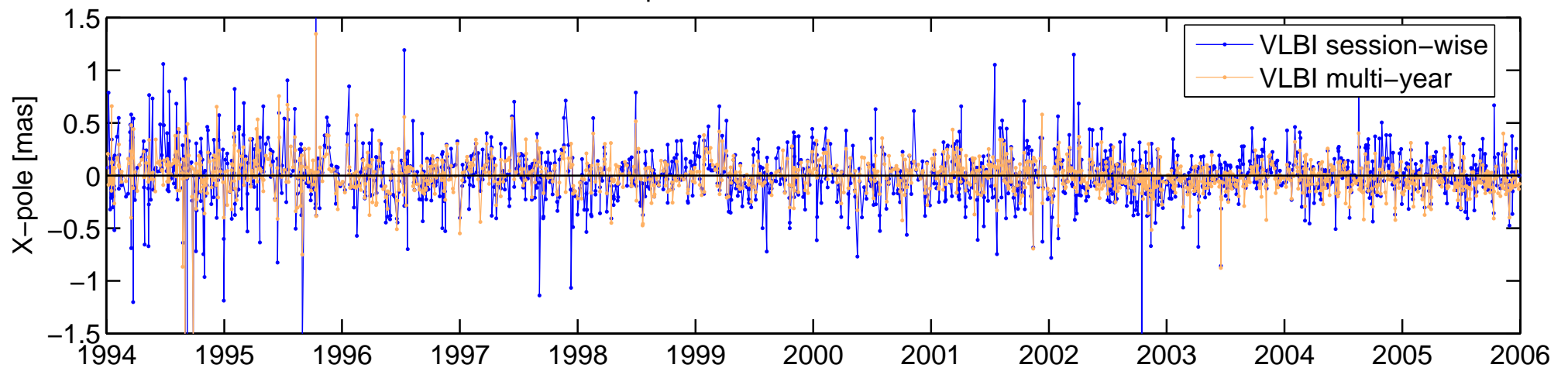
Y-Pole   **109.9** µas (daily) → **99.5** µas (multi-year)

⇒ **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 µas, drift = –8.17 µas/y, WRMS = 177.8 µas
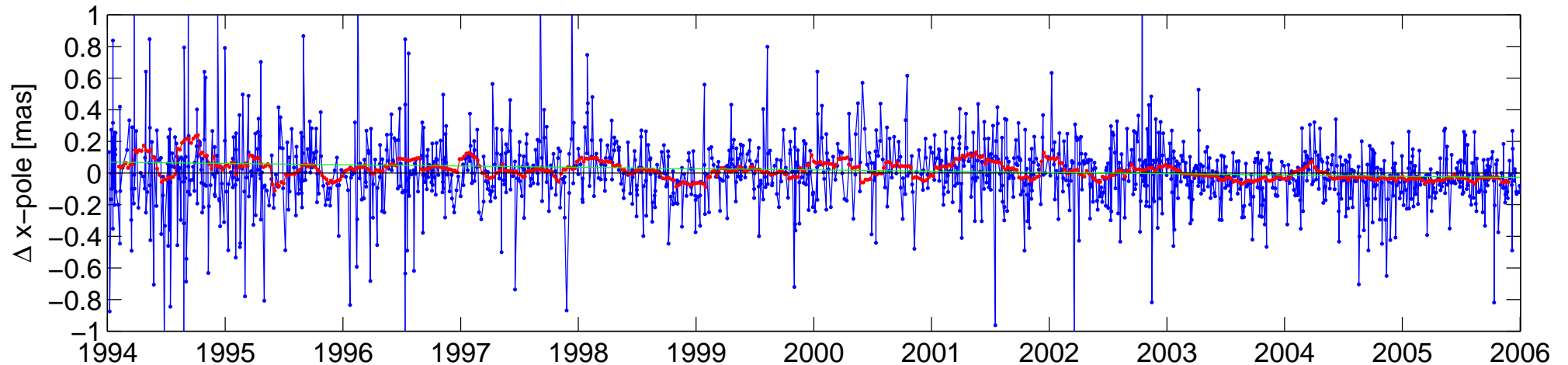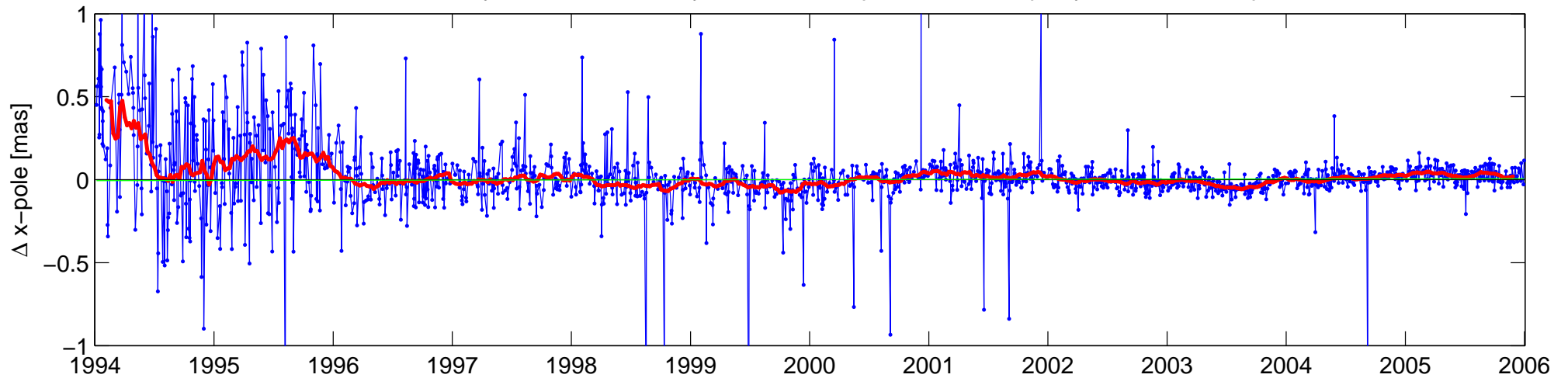

X–pole: Differences to IERS–C04

WRMS vs. IERS-C04:   X-Pole   **155.6** µas (daily) → **109.0** µas (multi-year)
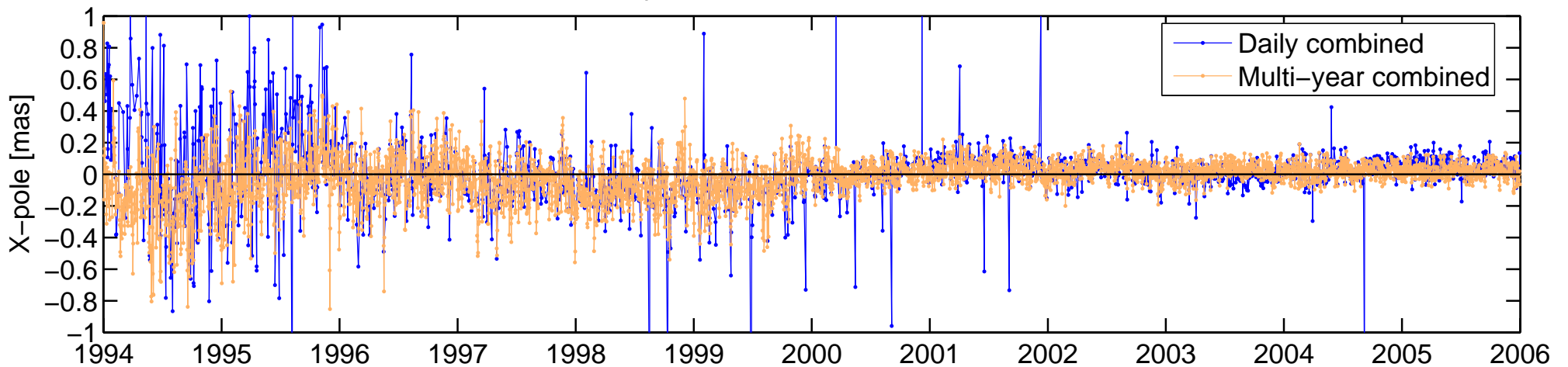
Y-Pole   **195.4** µas (daily) → **100.7** µas (multi-year)

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

Daily vs. multi-year solutions for PM: Combination

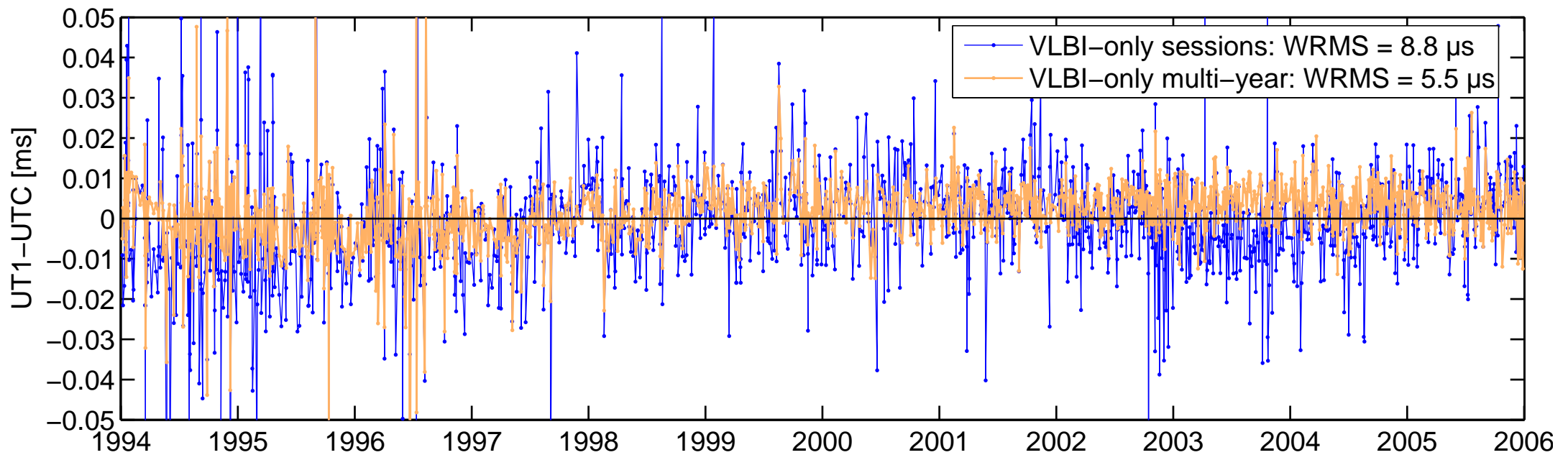Combined daily – combined multi-year: Bias = 0.6 µas, drift = 1.07 µas/y, WRMS = 76.7 µas

X-pole: Differences to IERS-C04

WRMS vs. IERS-C04: X-Pole **104.1** µas (daily) → **98.1** µas (multi-year)

Y-Pole **100.4** µas (daily) → **96.0** µas (multi-year)

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

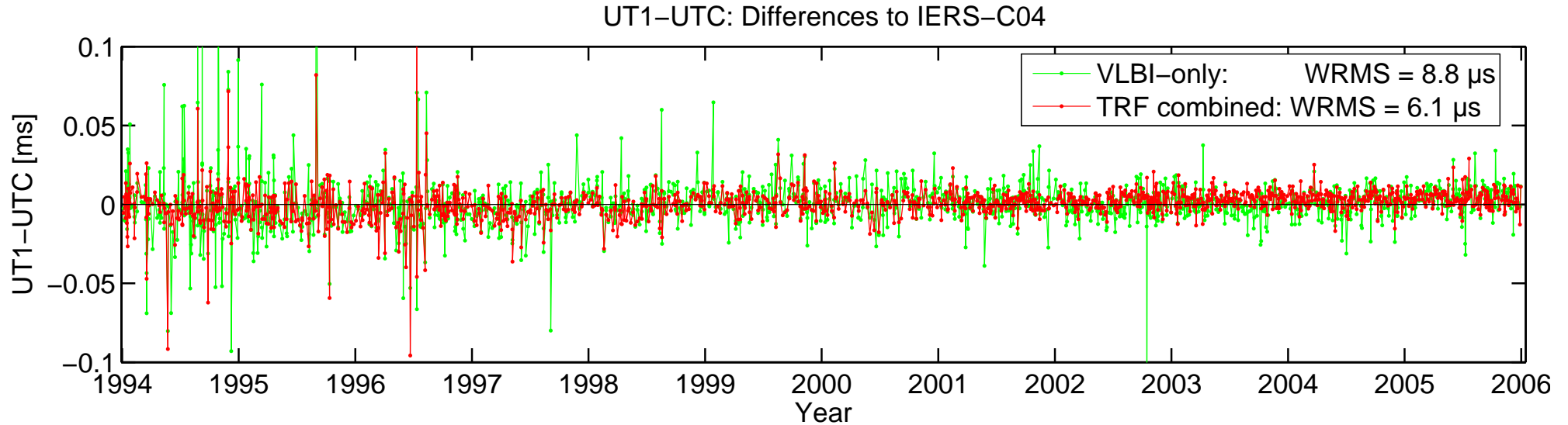# Daily vs. multi-year solutions for UT: VLBI
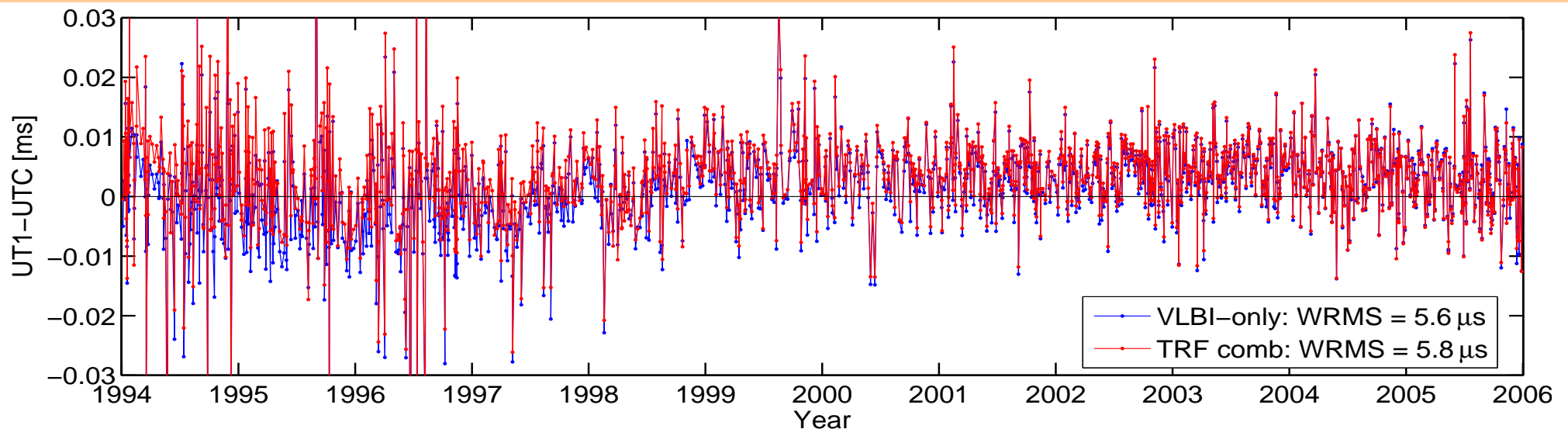

⇒ Similar to pole coordinates
⇒ **All epochs** benefit from multi-year solution: generally small network, weak daily TRF

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

Session-wise combination: VLBI-only daily TRF weak ⇒ stabilization

UT1−UTC: Differences to IERS−C04

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

Problems with daily realization of TRFs: *Number of Local Ties* (LT)
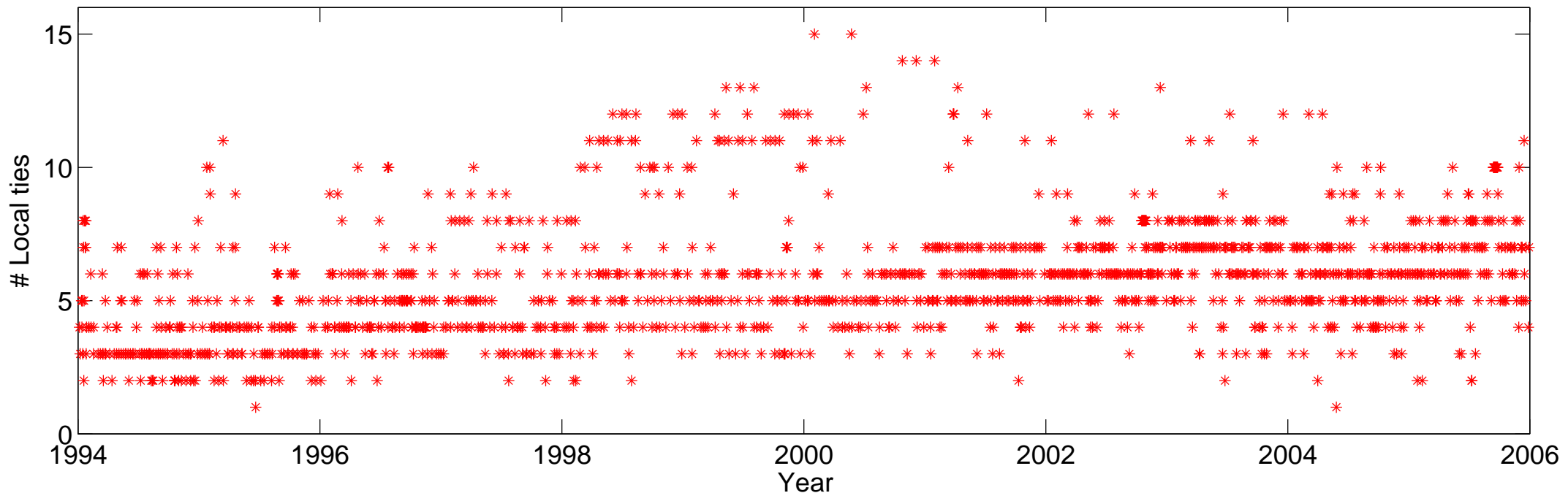→ **LT per Session** in most cases very small
→ may be even reduced after selection of „good" local ties
⇒ problematic for „VLBI-only parameters" (*UT*, *nutation*)

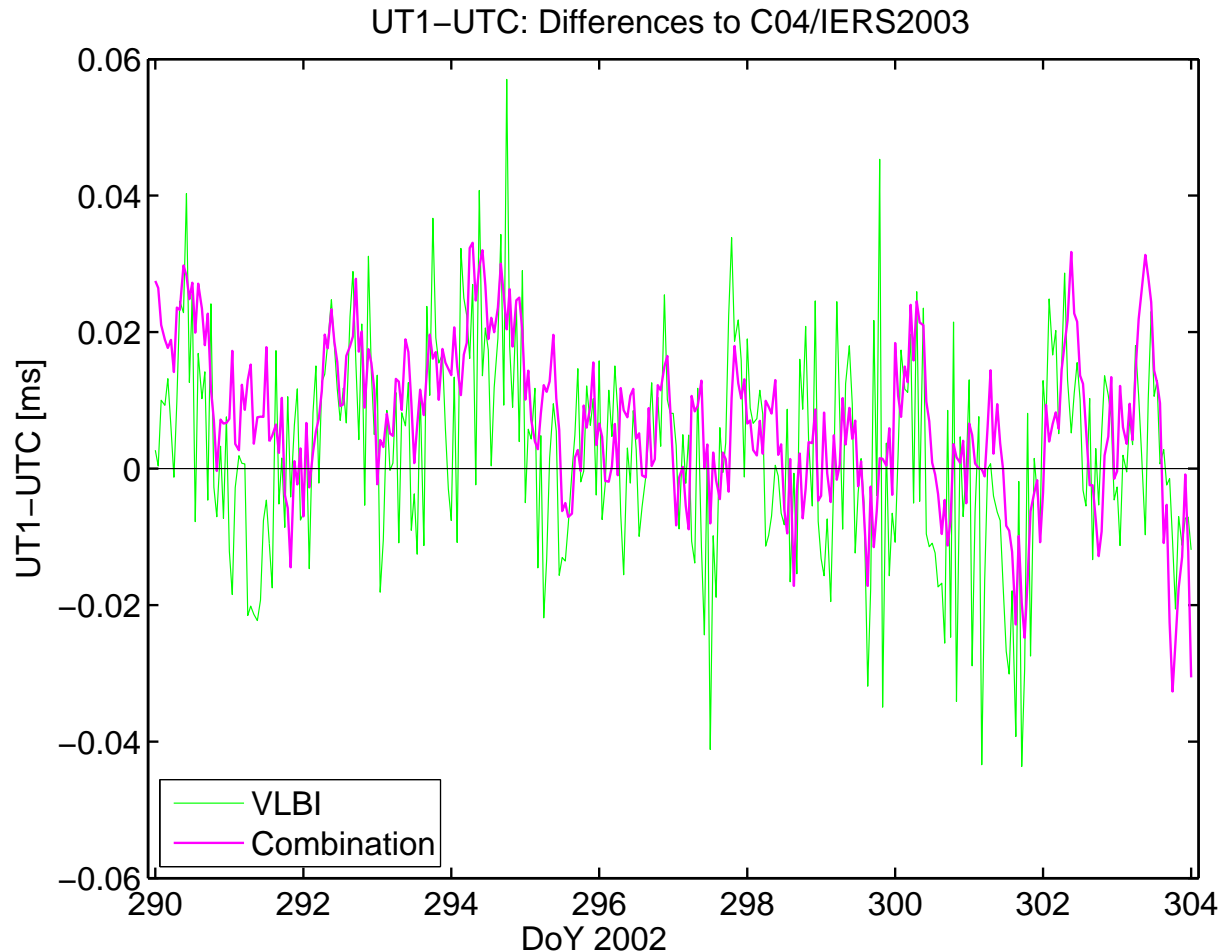⇒ **Can be avoided if long-term solutions (multi-year) are computed**
    Total number of LT in ITRF2008 (after selection): **17**

Number of GPS−VLBI local ties per daily solution

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

UT1−UTC: Differences to C04/IERS2003

RMS VLBI-only: **15.1 μs**

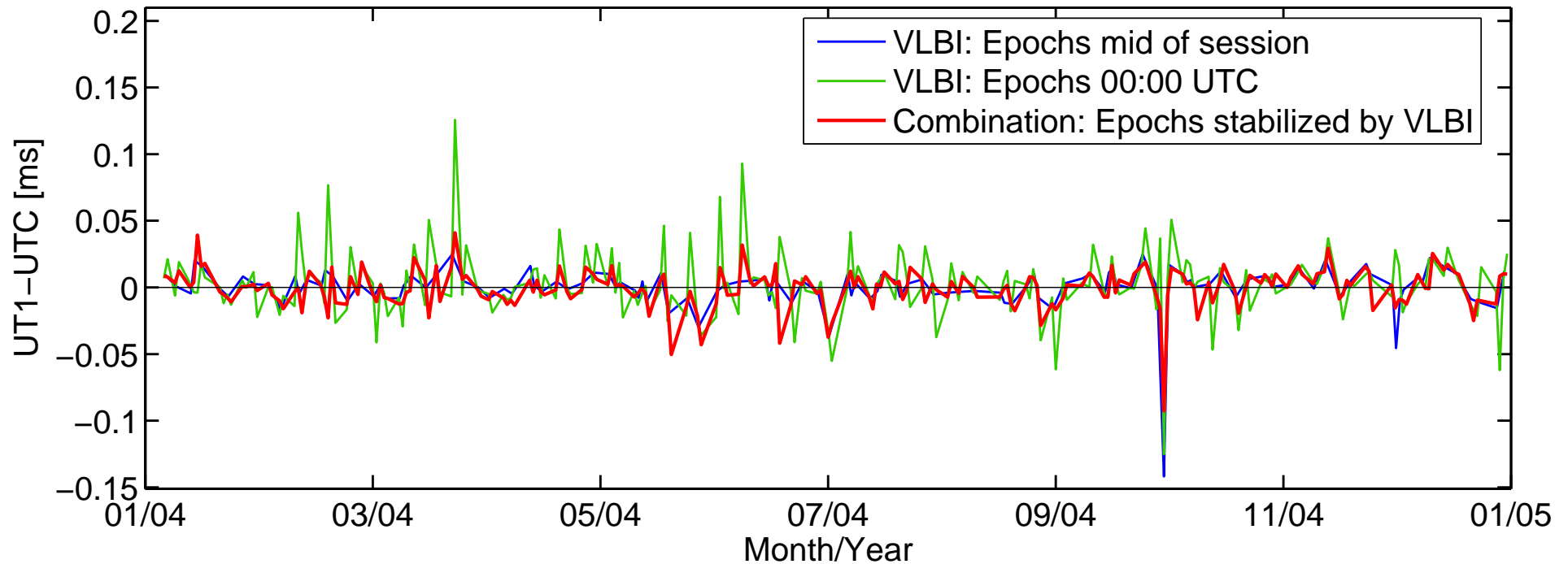| Combined Parameters	RMS [μs]
TRF	**15.2**
TRF+Pole	**14.8**
TRF+Pole+UT/LOD	**11.9**
TRF+Pole+UT/LOD +Nut.+Trop.	**11.6**

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

UT/LOD combination: 24-h sessions
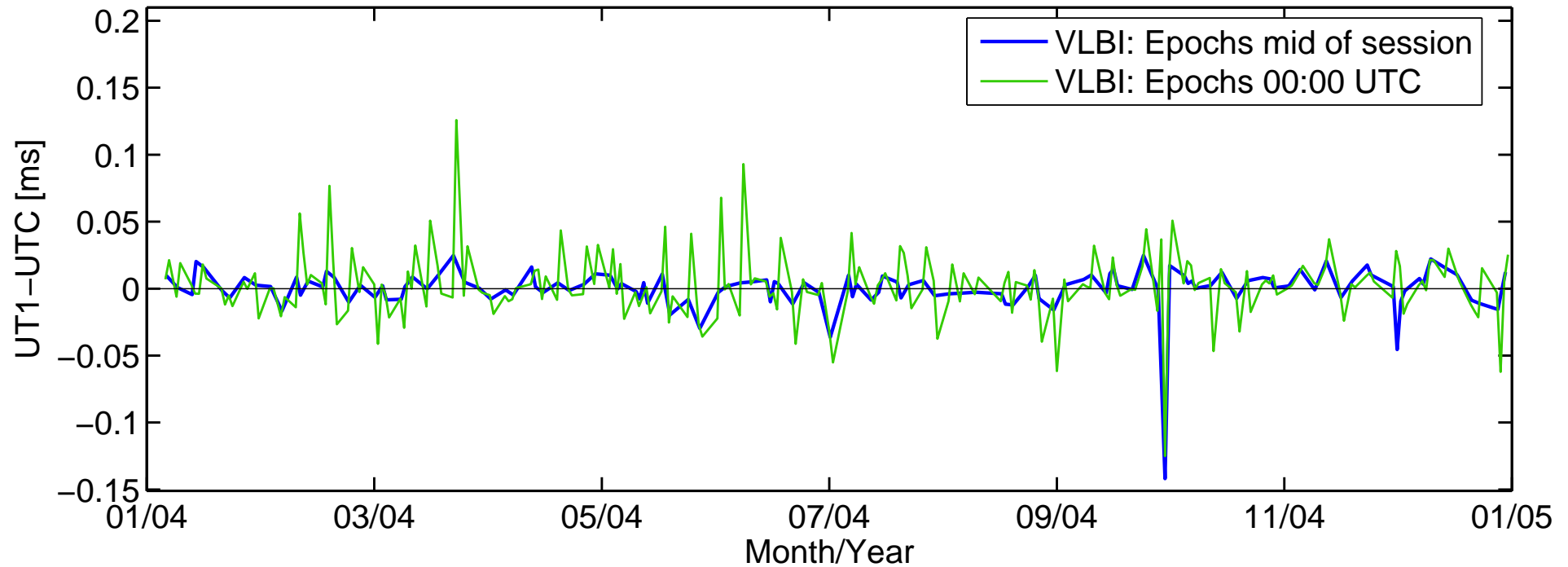
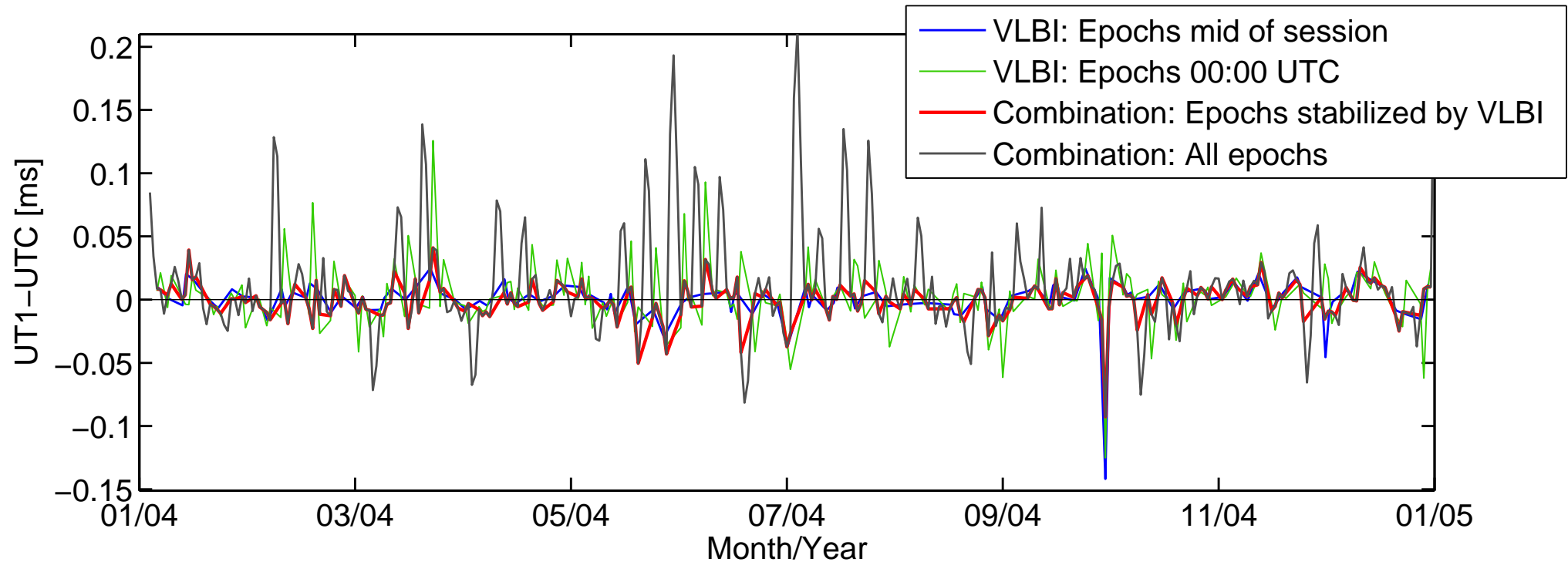| Solution type	# Epochs	Mean bias [μs]	WRMS [μs]
VLBI-only: Epochs mid of session (offset+drift)	129	**0.7**	**10.1**
VLBI-only: Epochs 0h (polygon)	224	**0.2**	**15.9**

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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Combination: All epochs	365	2.0	22.6

Summary

- Problem of different *reference epochs* (VLBI vs. satellite-techniques):
  $\rightarrow$ combination strategy is important

- ERPs from *long-term solutions* are more stable than *daily solutions*
  $\rightarrow$ especially if daily network is weak

- *Combination of UT/LOD* from VLBI and GPS is possible
  $\rightarrow$ continuous VLBI data (CONT campaigns)
  $\rightarrow$ epochs with contribution by VLBI
  $\rightarrow$ 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 ($\rightarrow$ Manuela)

VLBI/GPS Nutation
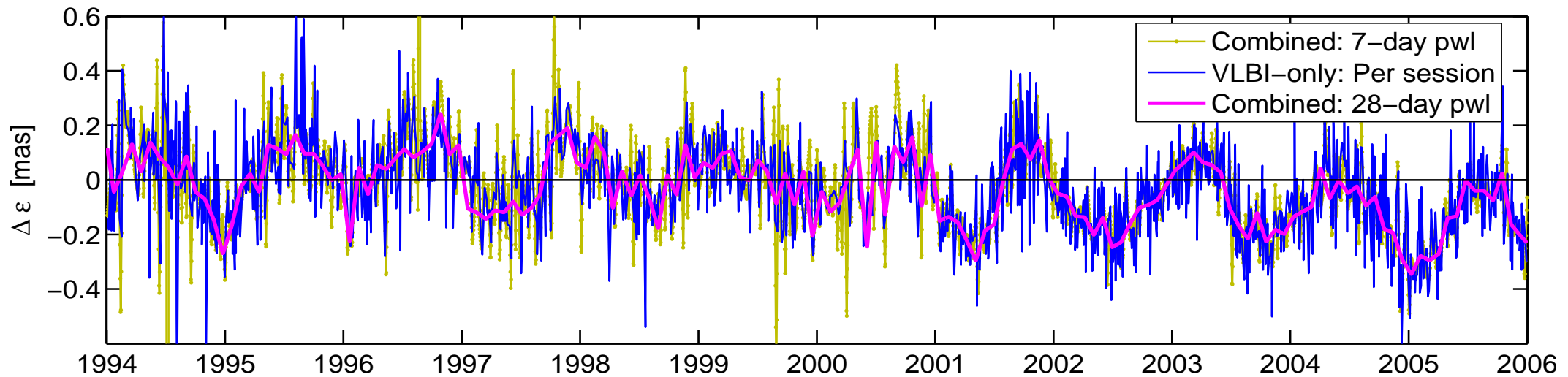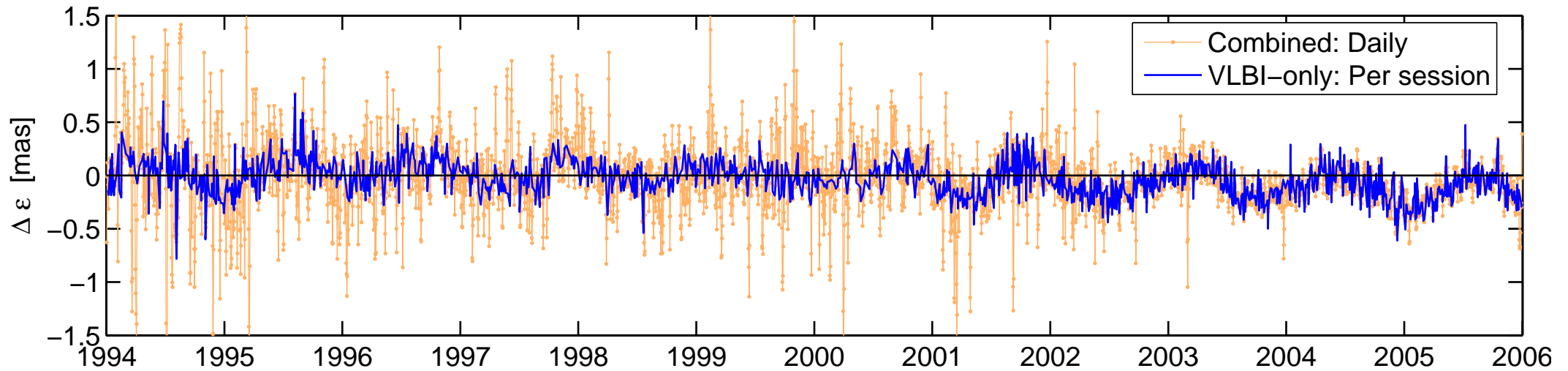
Daily combination: Problems with „GPS-only" epochs (similar to UT)
$\Rightarrow$ Use lower temporal resolution (7d, 14d, 28d); main signal is Free-Core Nutation (~432 d)
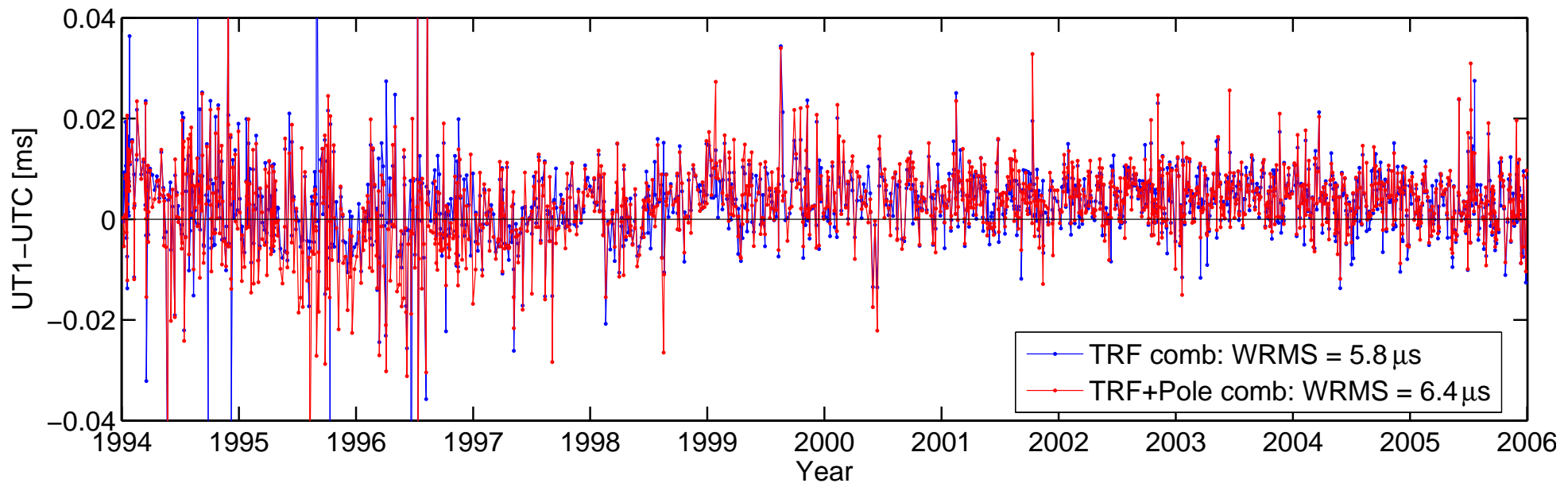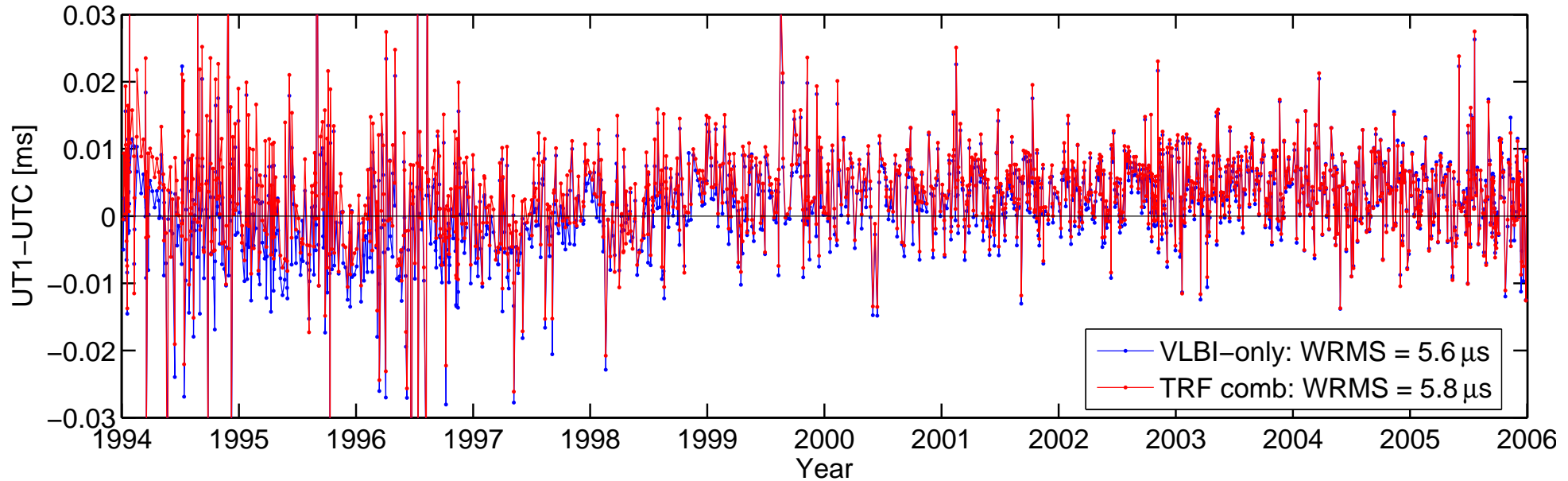
Case 3: Densification with GPS-LOD and VLBI Intensive sessions
-> IVS meeting

-> wird wohl zu viel...

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…

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