Tests of IGS Reference Frame Stability

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Study of IGS TRF long-term stability on:

- **Frame Parameters: Origin, Scale, Orientation**
- **Polar Motion**

When:

- **changing the RS from 54 to 99**
- **using different sets of RS, but still globally distributed**

Analyzed Data: **Weekly IGS combined SINEX files over 1999-2003**

- **Impact of station discontinuities on Polar Motion**
- **Re-open the question about GPS Geocenter and TRF scale**

IGS 2004 Workshop, 01 March 2004, Berne, Switzerland

TRF & EOP time series Combination

CATREF Software

INPUT: $X(t)$**, EOP(t) in daily/weekly/monthly SINEX files**

OUTPUT: $X(t_0)$**,** $\dot{X}$**, EOP(t),** $(\underbrace{T_x, T_y, T_z}_{\textbf{Geocenter}}, D, R_x, R_y, R_z)$

$$\begin{cases} X_s^i = X_{itrf}^i + (t_s^i - t_0)\dot{X}_{itrf}^i + T_k + D_k X_{itrf}^i + R_k X_{itrf}^i \\ \quad + (t_s^i - t_k)\left[\dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i\right] \\ \dot{X}_s^i = \dot{X}_{itrf}^i + \dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i \end{cases}$$

$$\begin{cases} x_s^p = x^p + R2_k \\ y_s^p = y^p + R1_k \\ UT_s = UT - \frac{1}{f} R3_k \\ \dot{x}_s^p = \dot{x}^p + \dot{R}2_k \\ \dot{y}_s^p = \dot{y}^p + \dot{R}1_k \\ LOD_s = LOD + \frac{\Lambda_0}{f}\dot{R}3_k \end{cases}$$

- **Matching common parameters at UT noon**
- **Propagate at UT noon if rates are available**
- **EOP's follow the adopted combined TRF**

Datum Definition

The combined TRF is aligned to IGS00 using Minimum Constraints equation applied over the 7 transformation parameters:

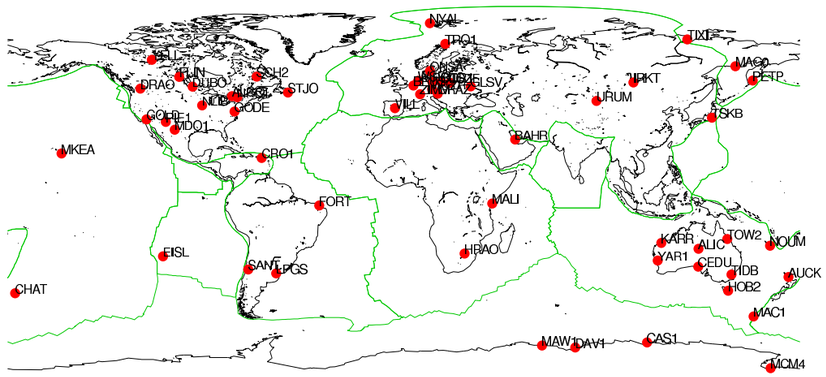
$$(A^T A)^{-1} A^T (X_{RS} - X_c) = 0$$

where A is a design matrix given by:

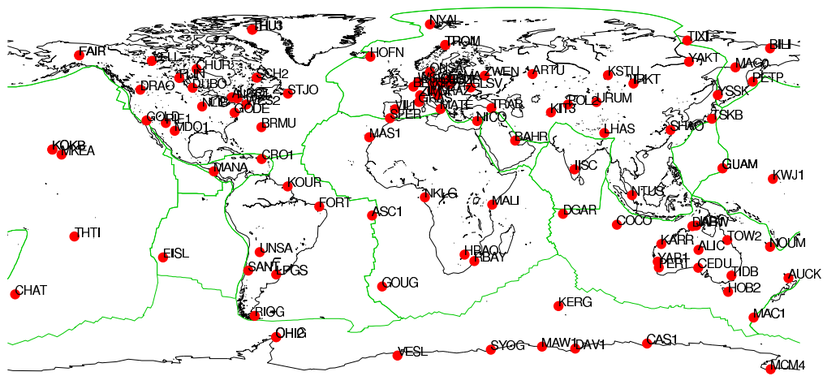
$$A = \begin{pmatrix} . & . & . & . & . & . & . \\ 1 & 0 & 0 & x_0^i & 0 & z_0^i & -y_0^i \\ 0 & 1 & 0 & y_0^i & -z_0^i & 0 & x_0^i \\ 0 & 0 & 1 & z_0^i & y_0^i & -x_0^i & 0 \\ . & . & . & . & . & . & . \end{pmatrix}$$

and x_0^i, y_0^i,z_0^i are approximate station positions.

54 Reference Stations Set



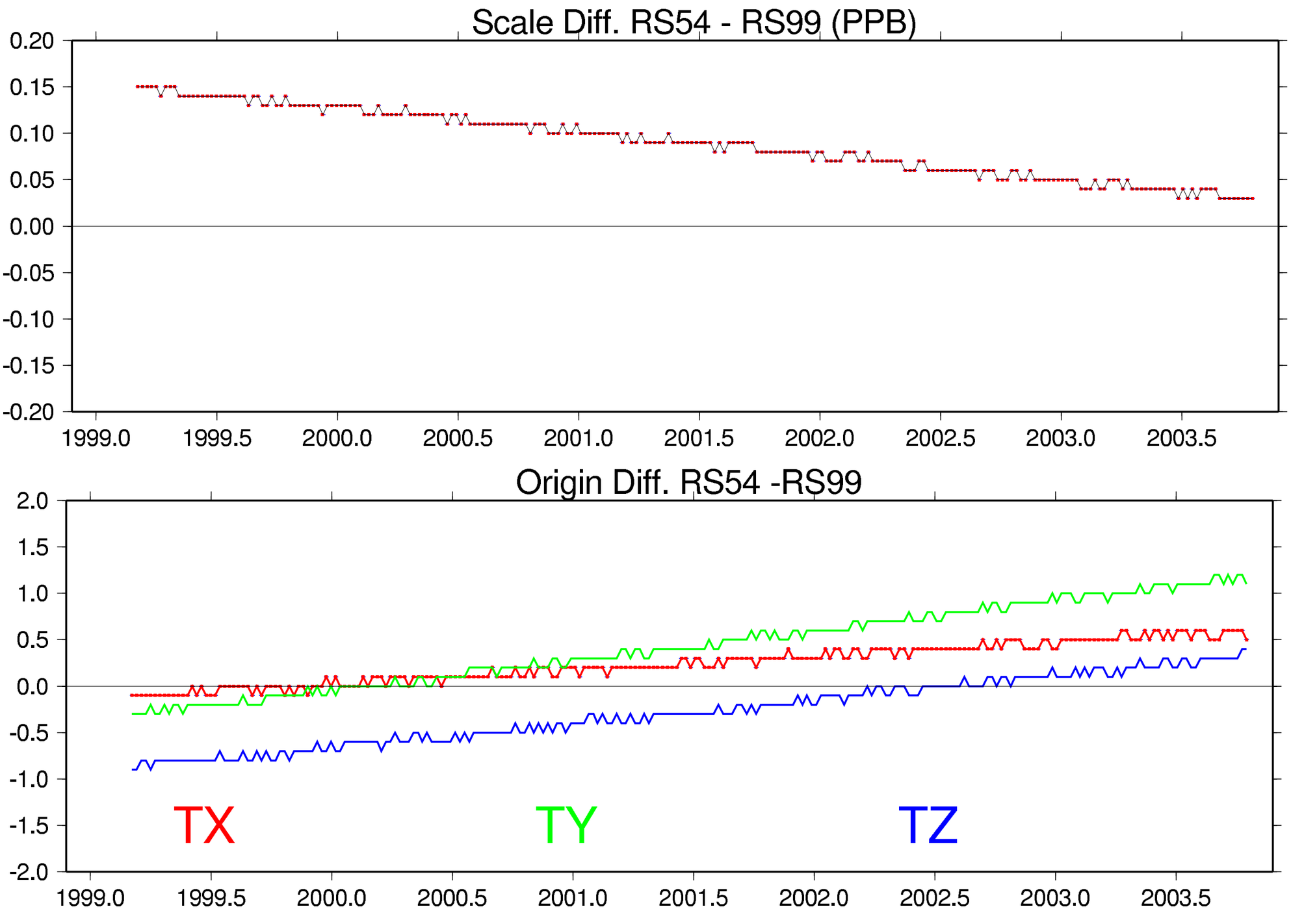
99 Reference Stations Set



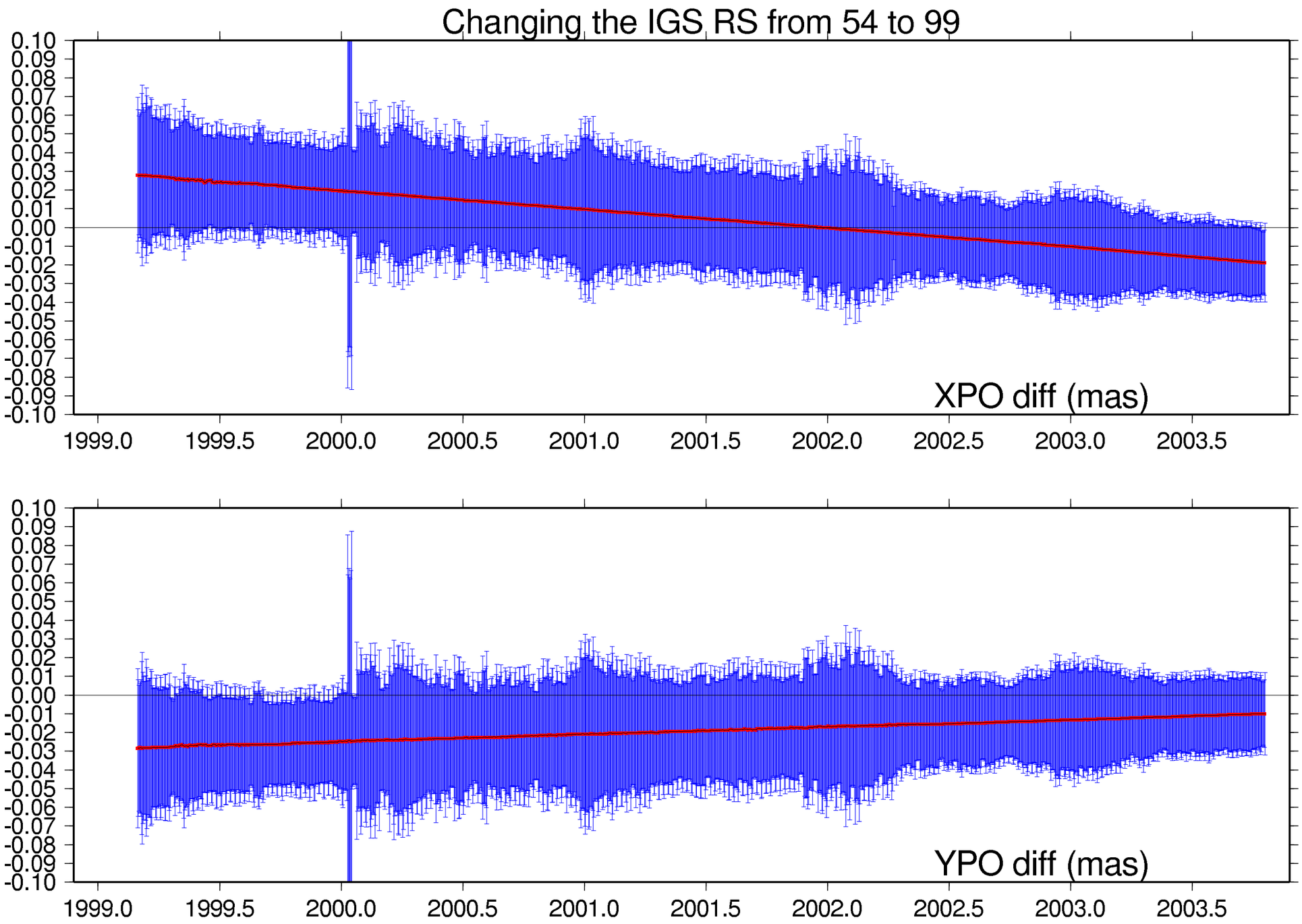
Using IGS00 RS, 10 sets were selected, but still globally distributed:

- **4 sets with $\approx$ 25 stations each**
- **6 sets with $\approx$ 50 stations each**

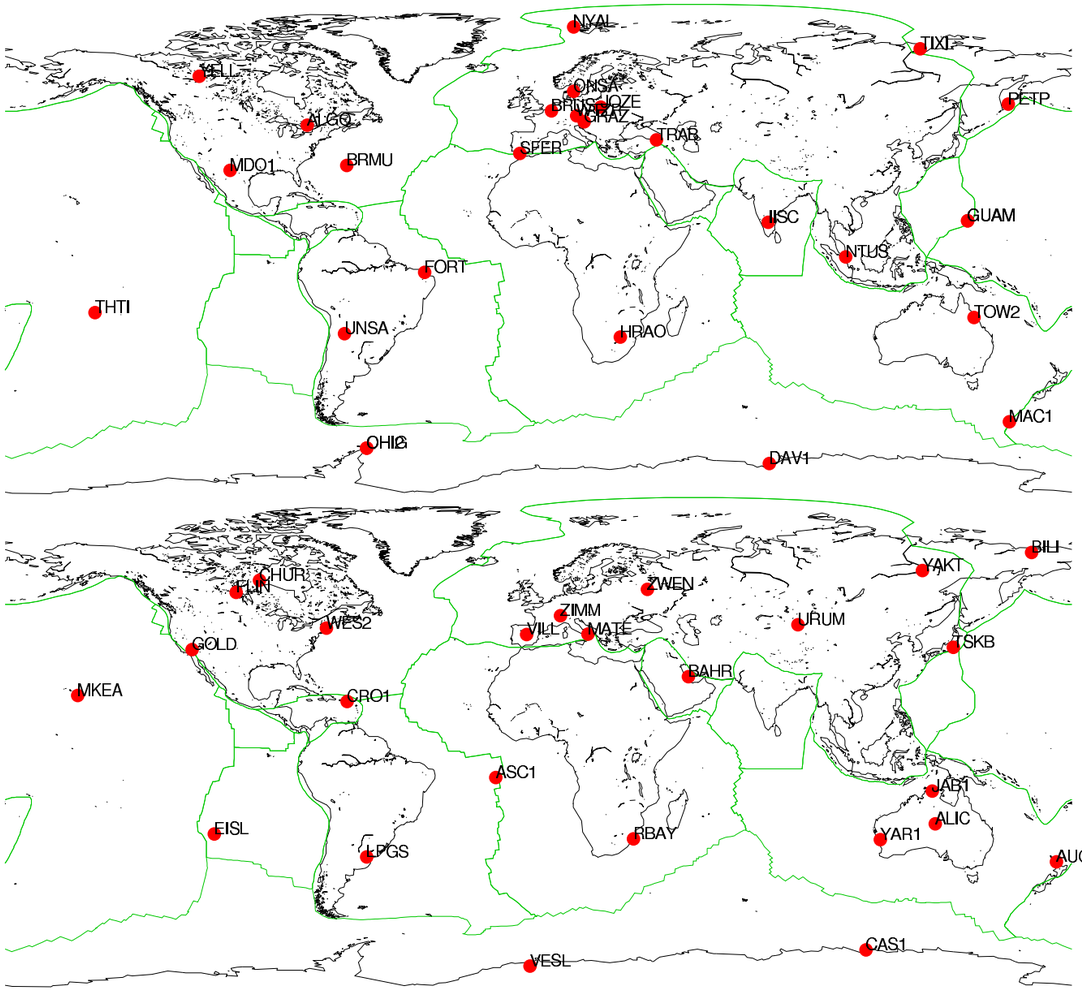
Scale & origin differences when changing the IGS RS from 54 to 99

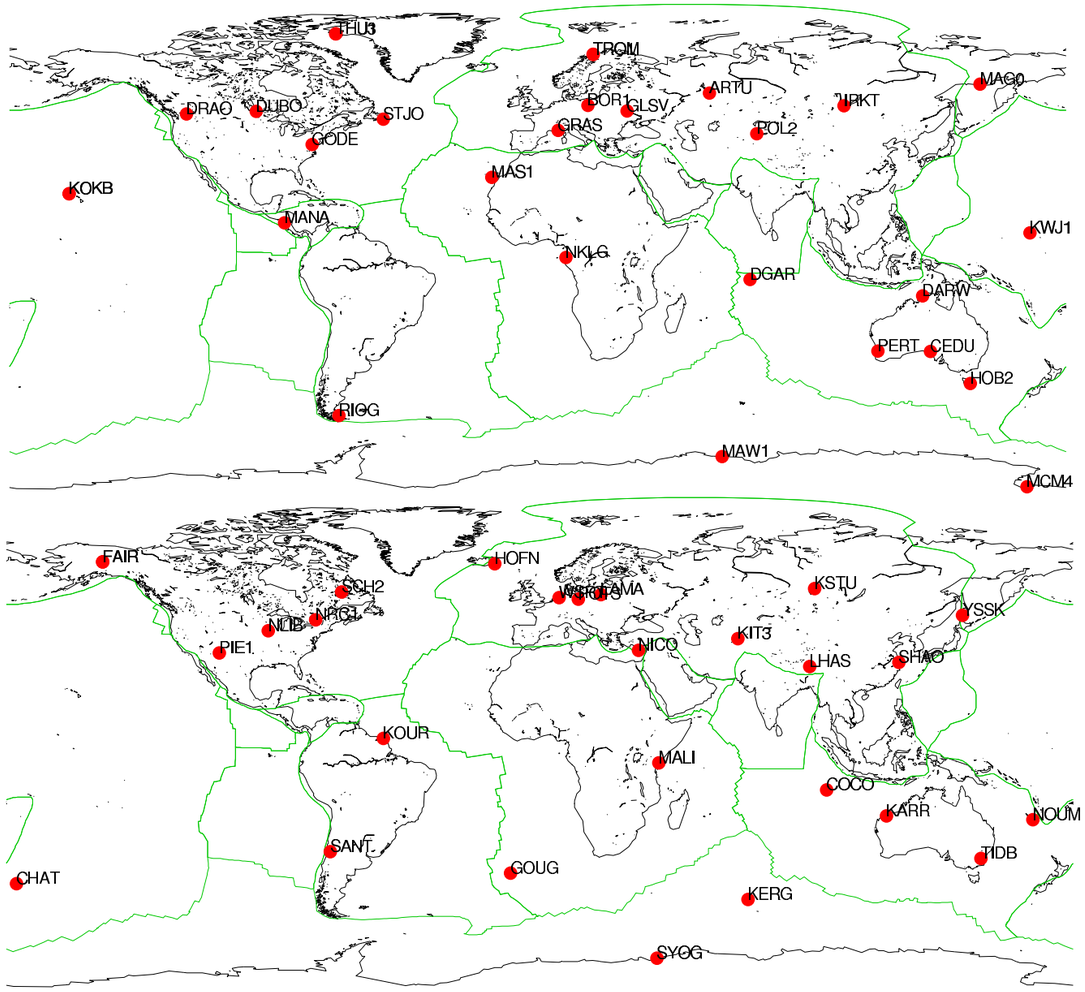


Polar Motion differences when changing the IGS RS from 54 to 99

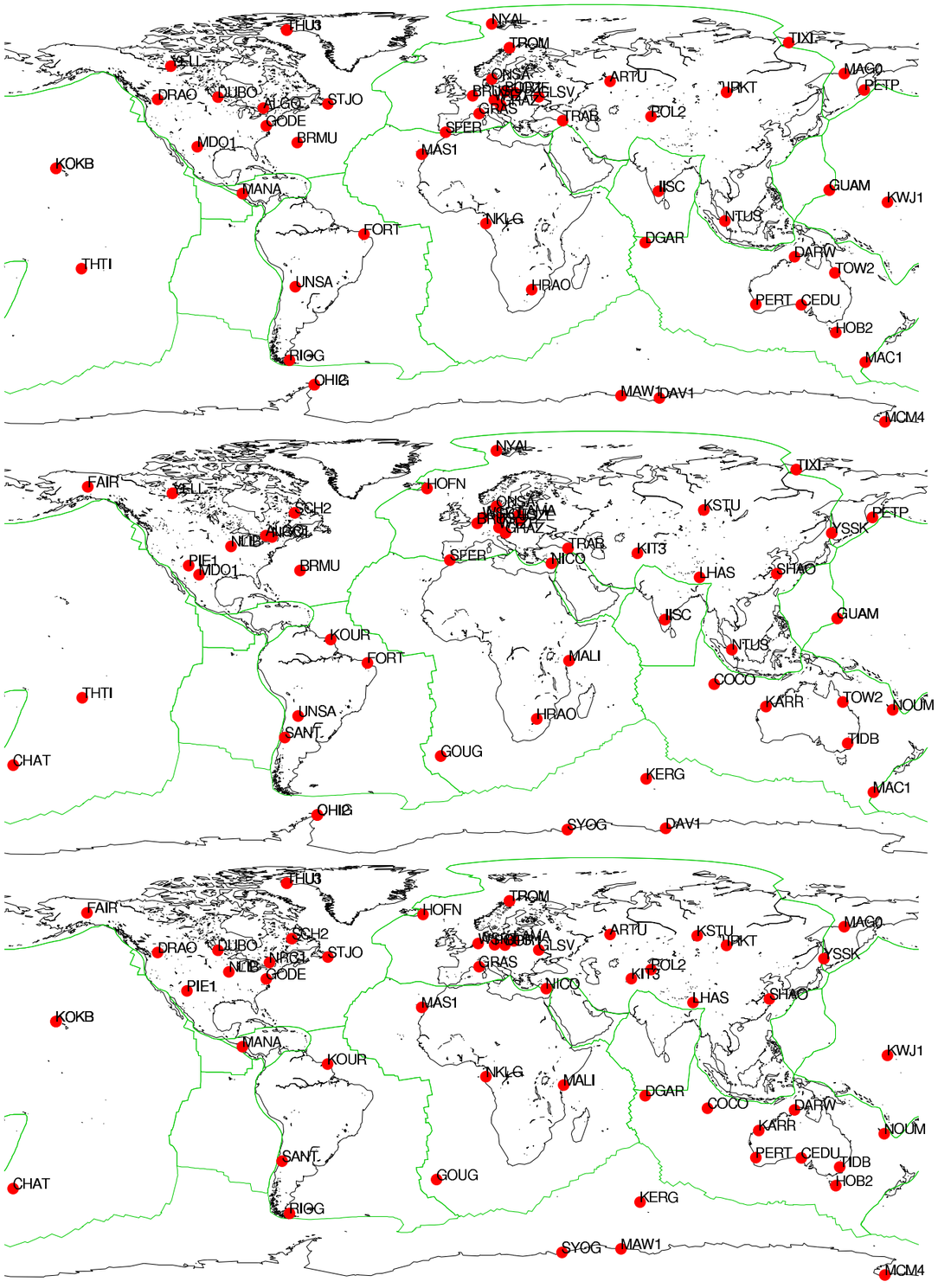


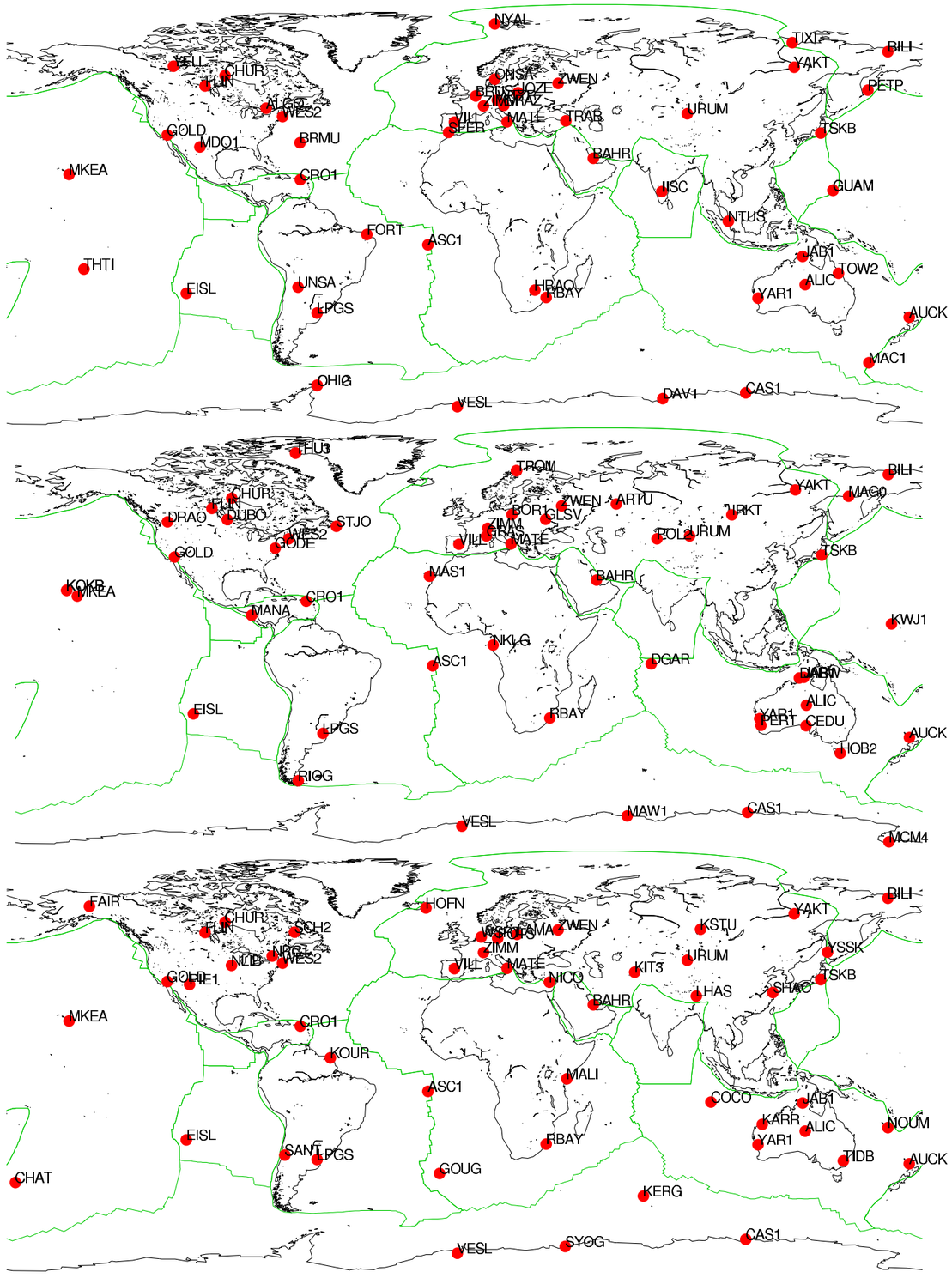
4 Networks of ∼ 25 stations



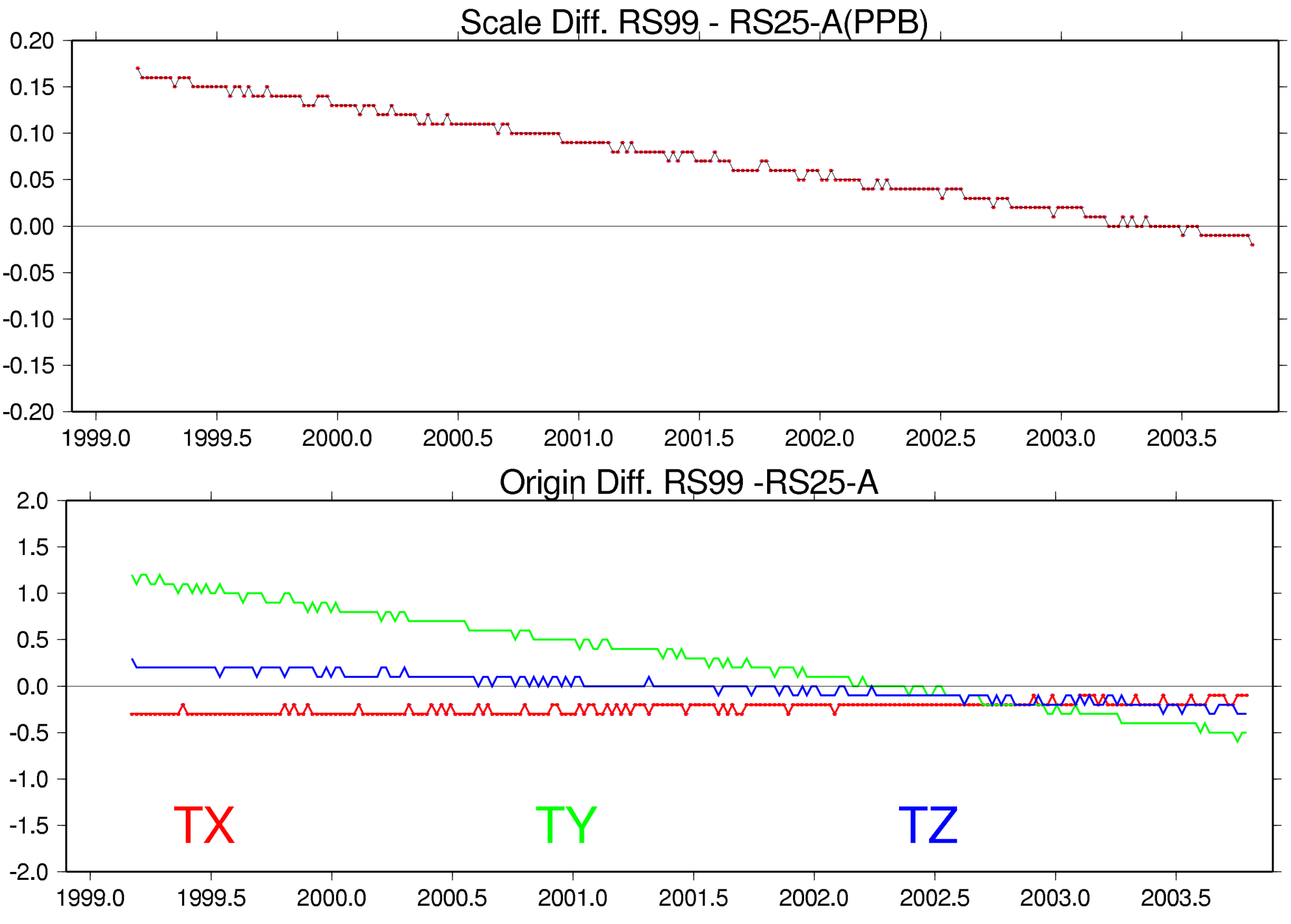


6 Networks of ~ 50 stations





Scale & origin differences wrt RS99



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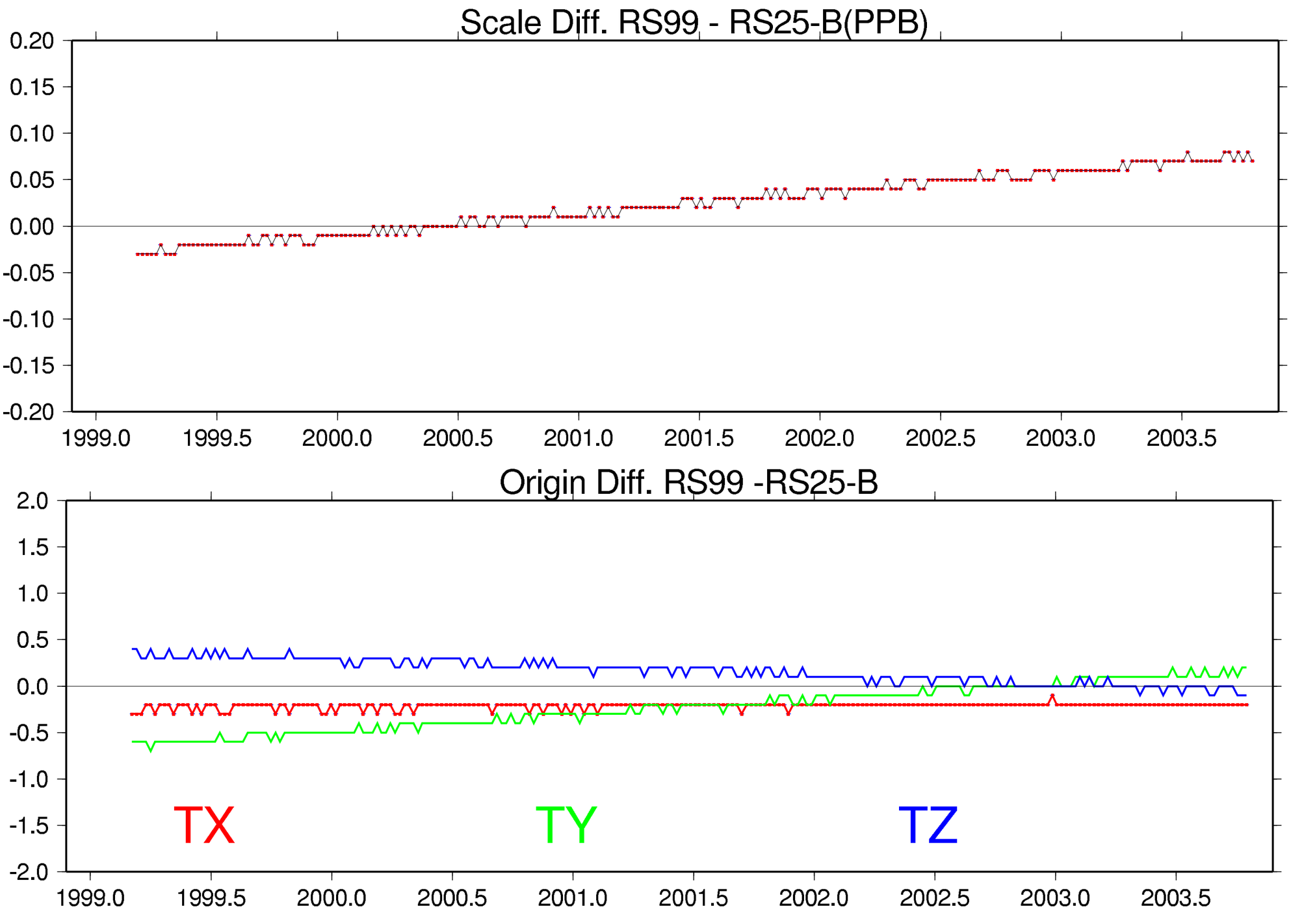
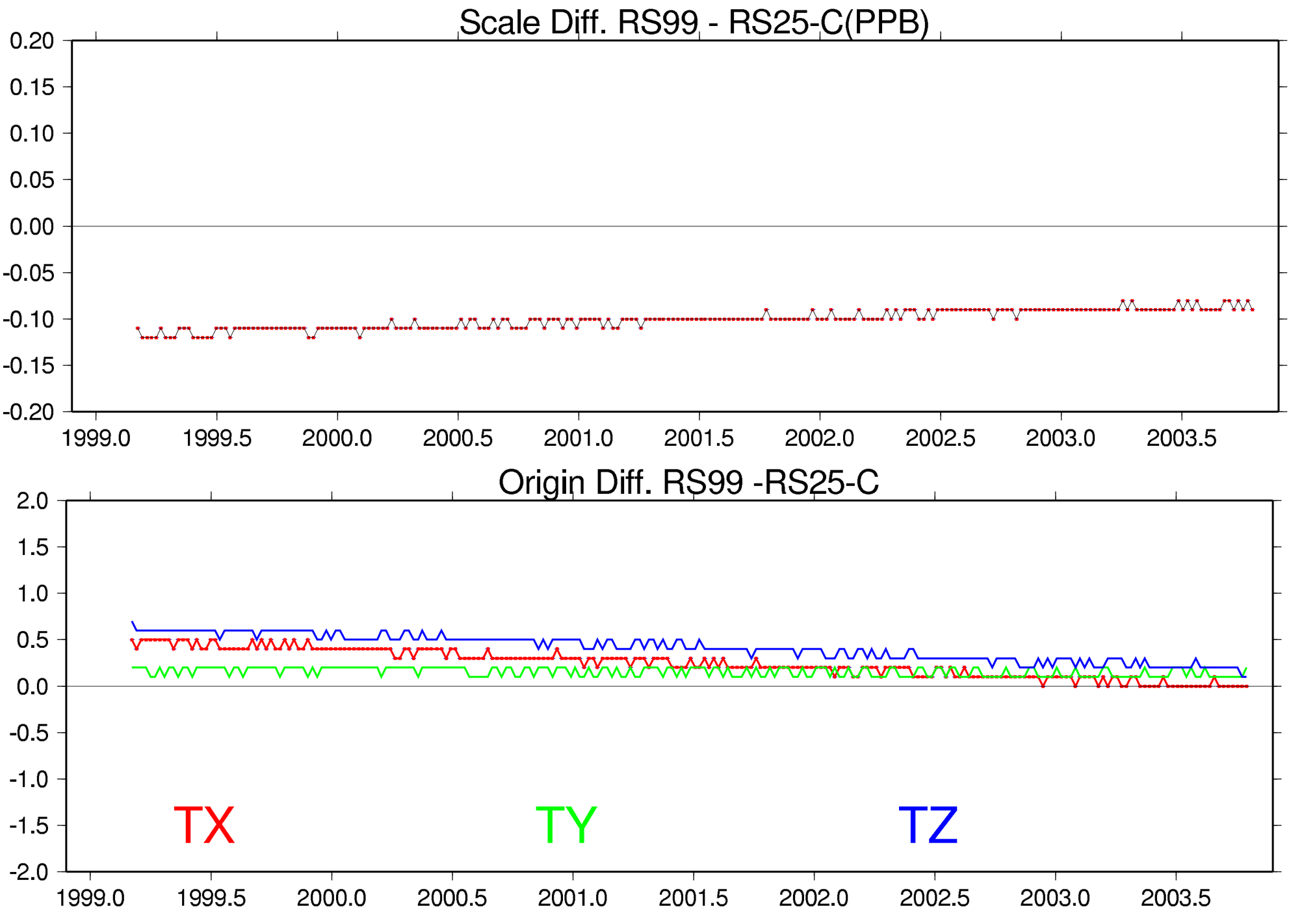


Scale & origin differences wrt RS99



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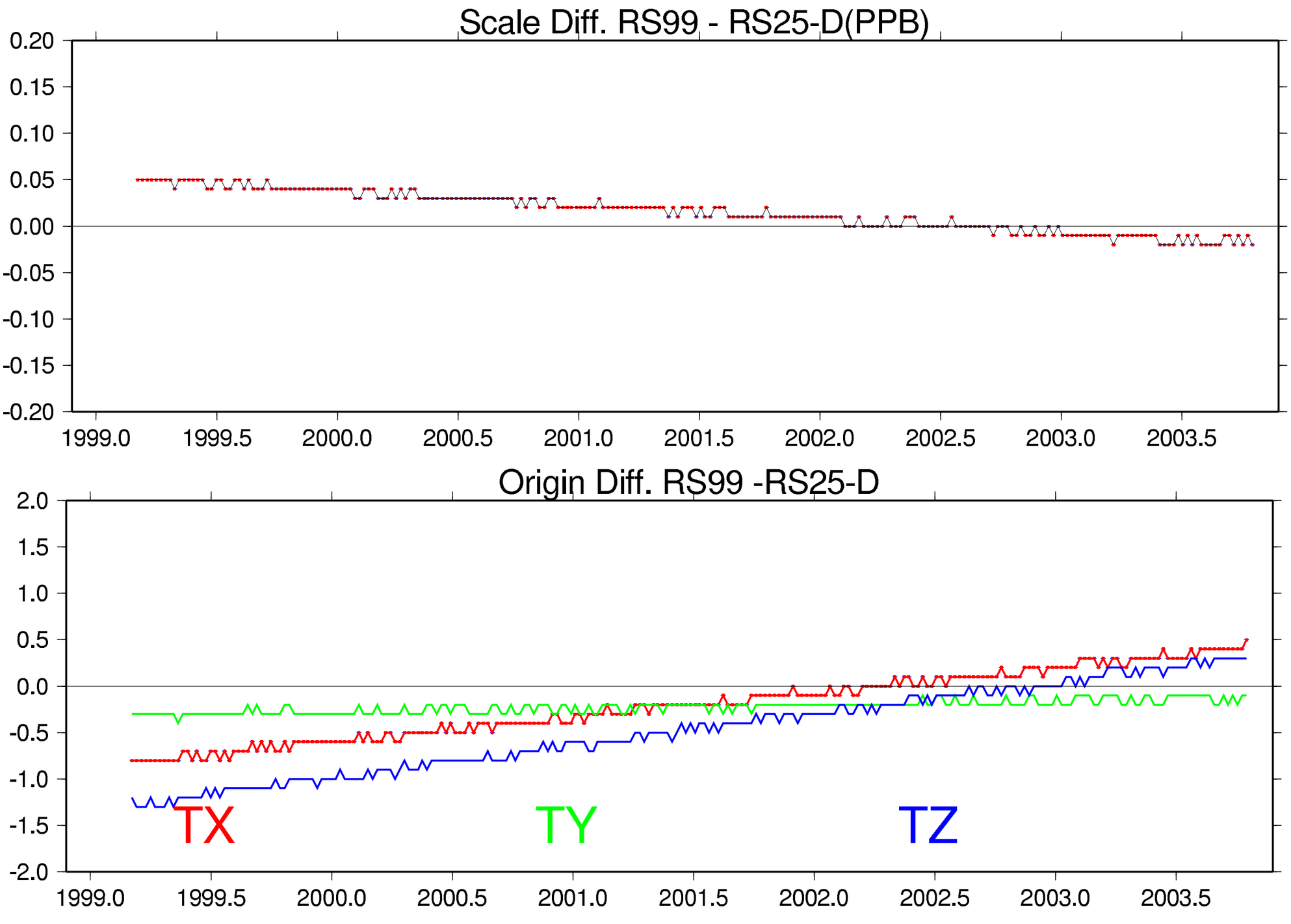

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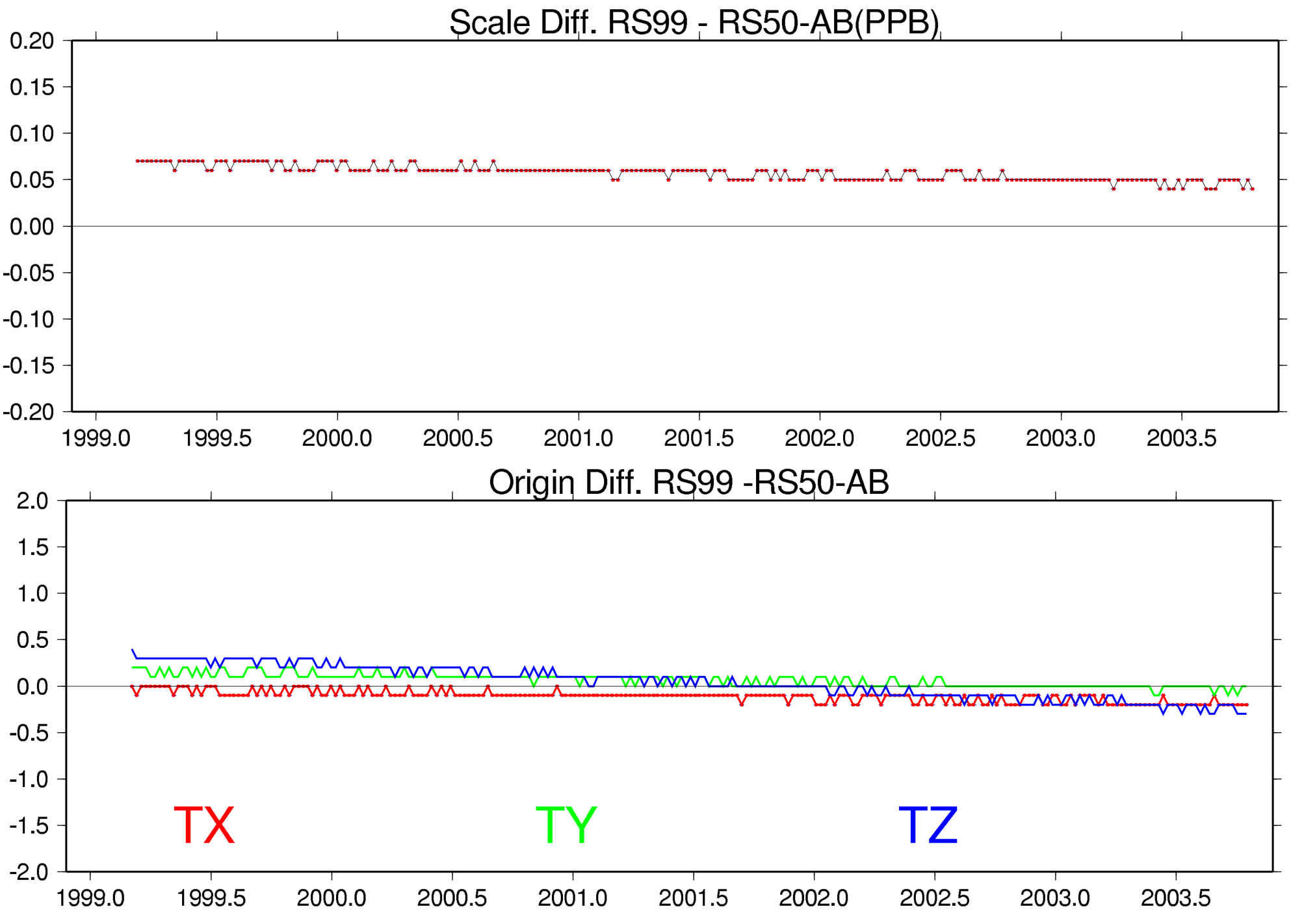

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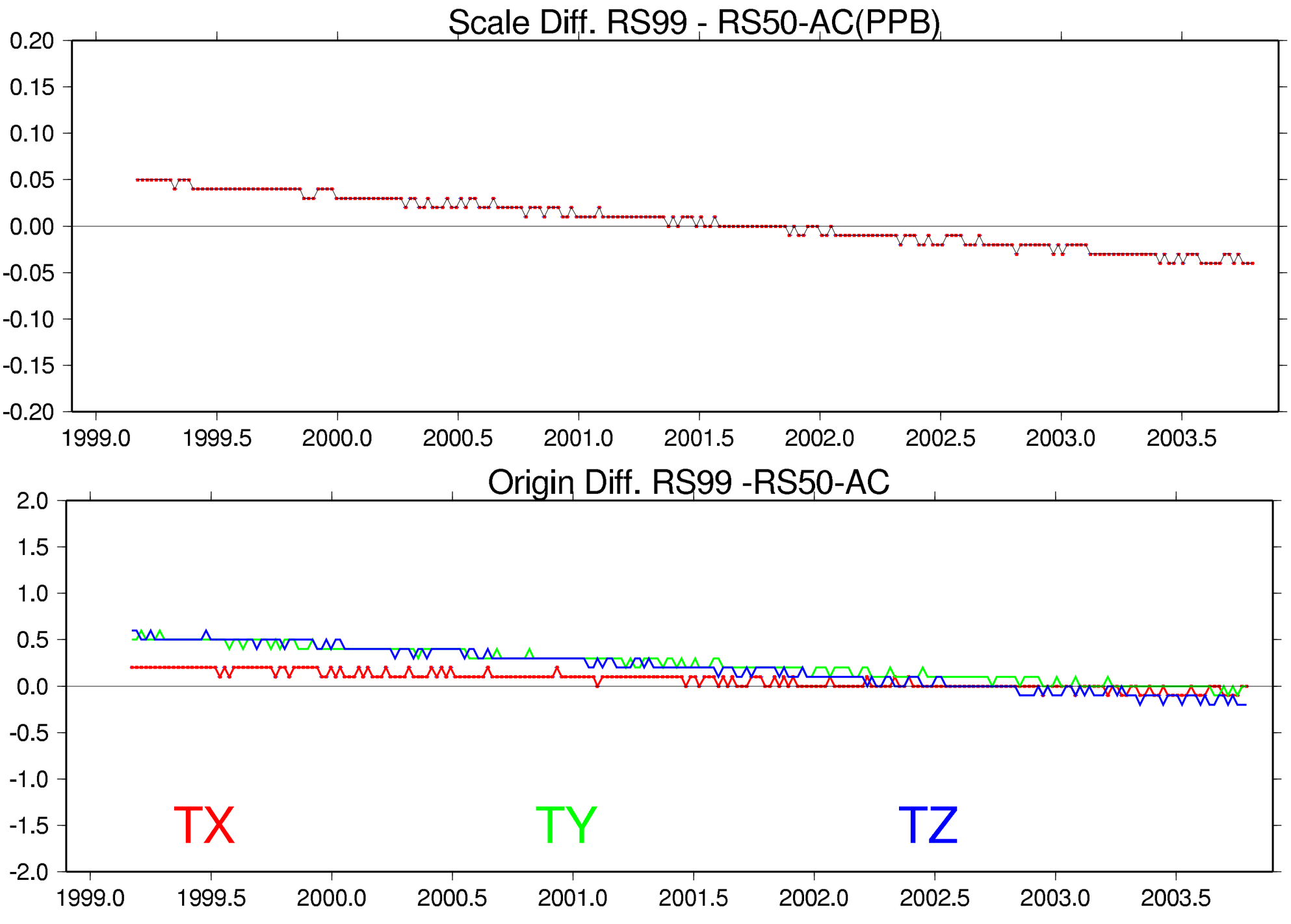

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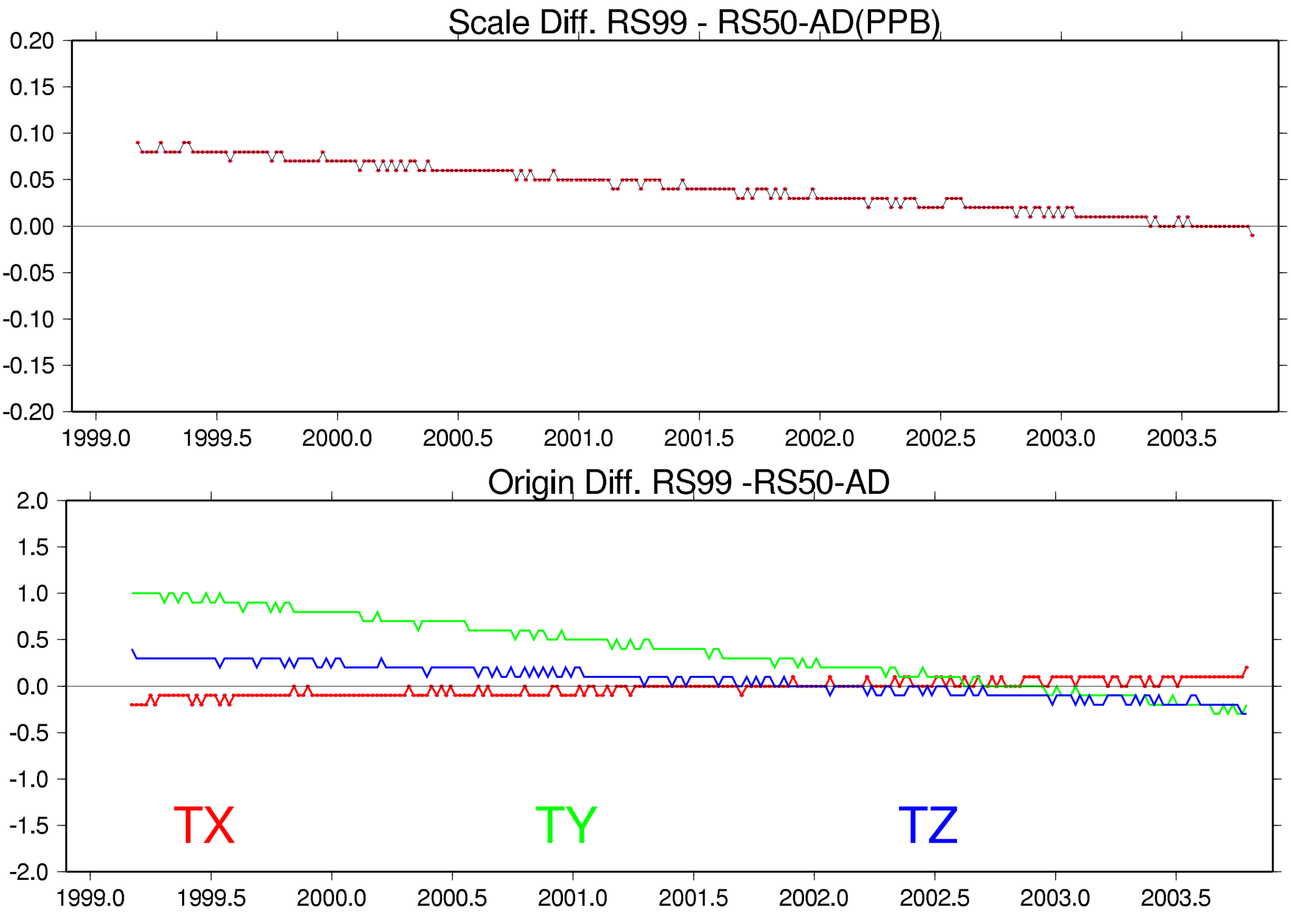

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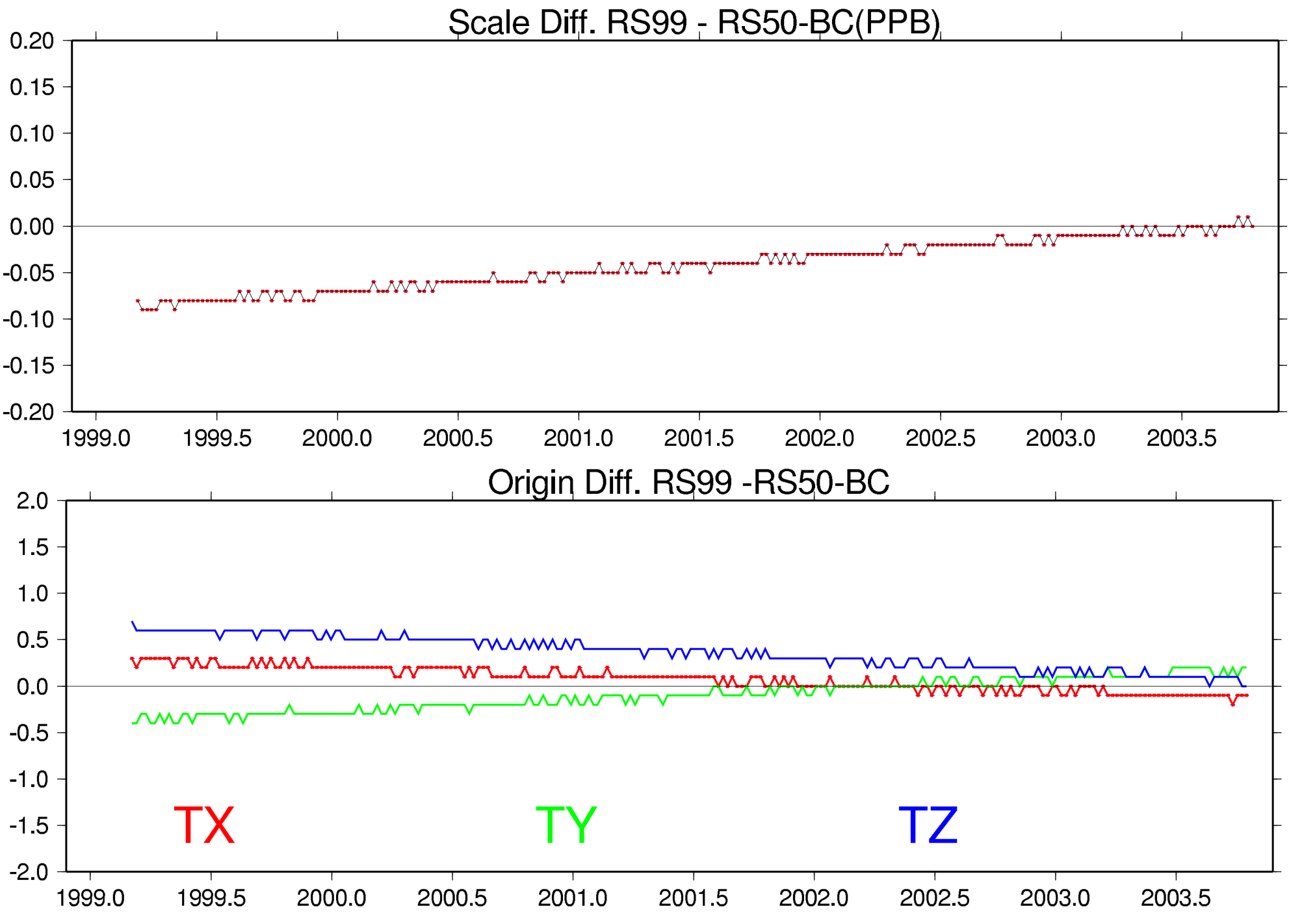

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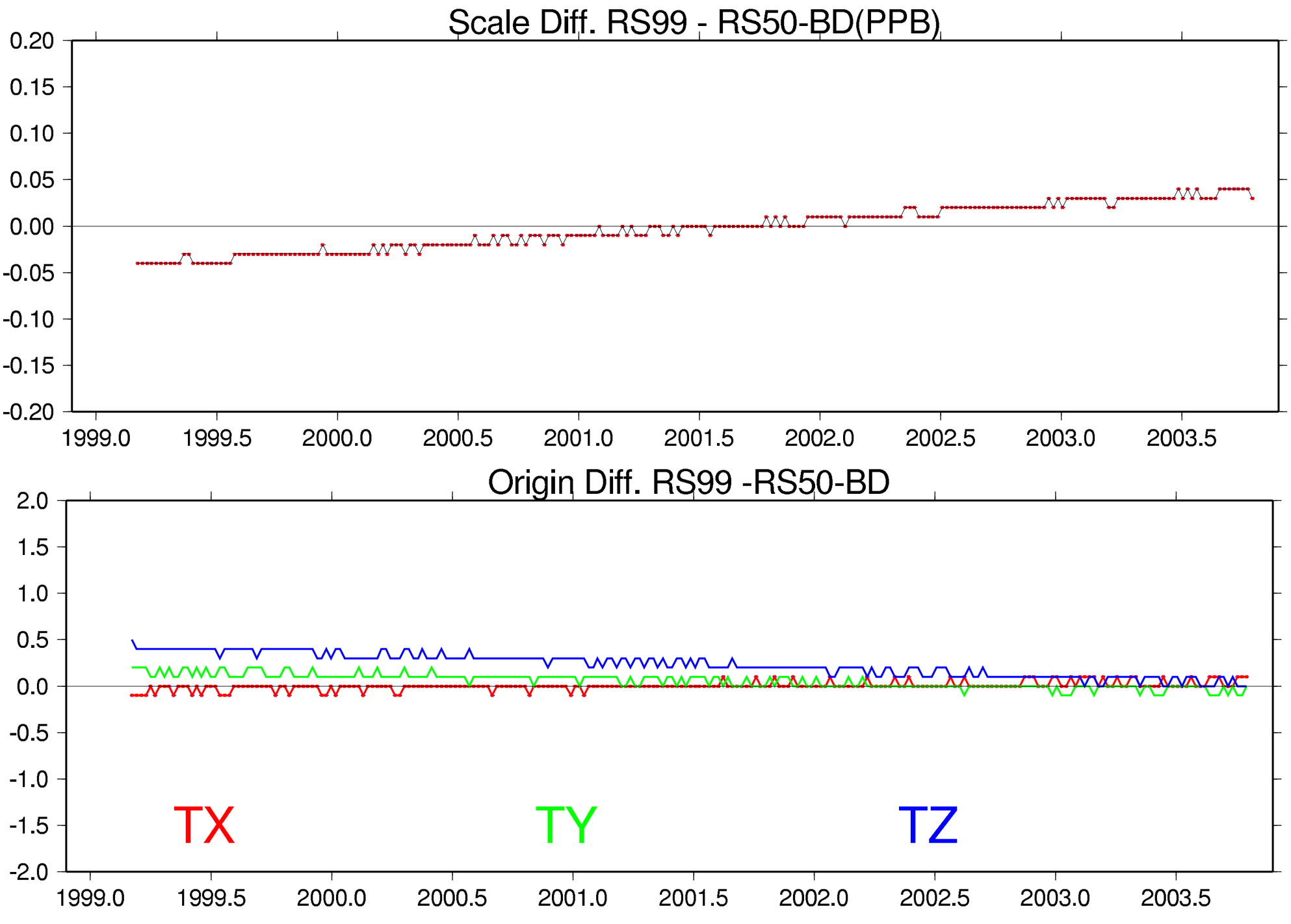

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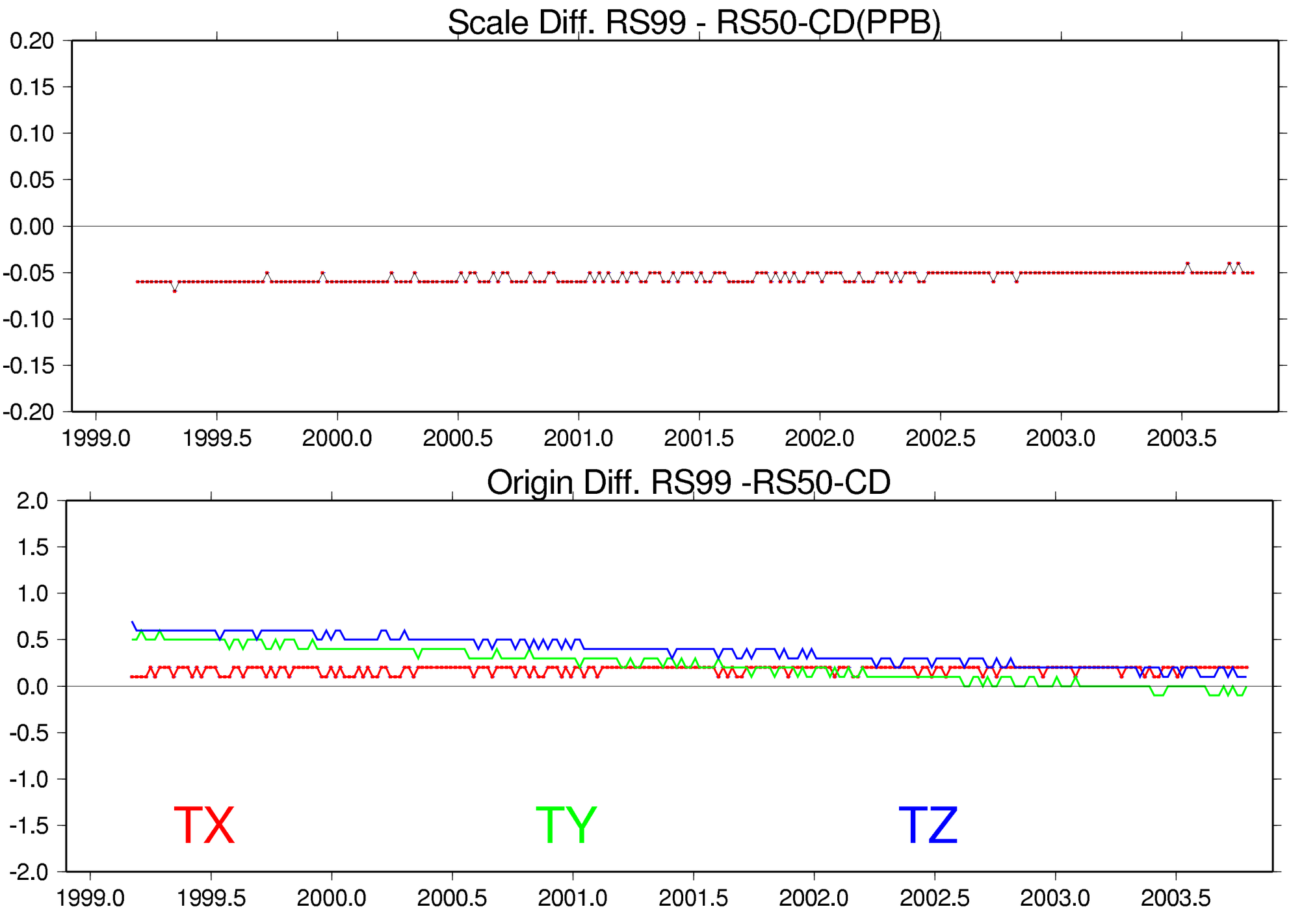
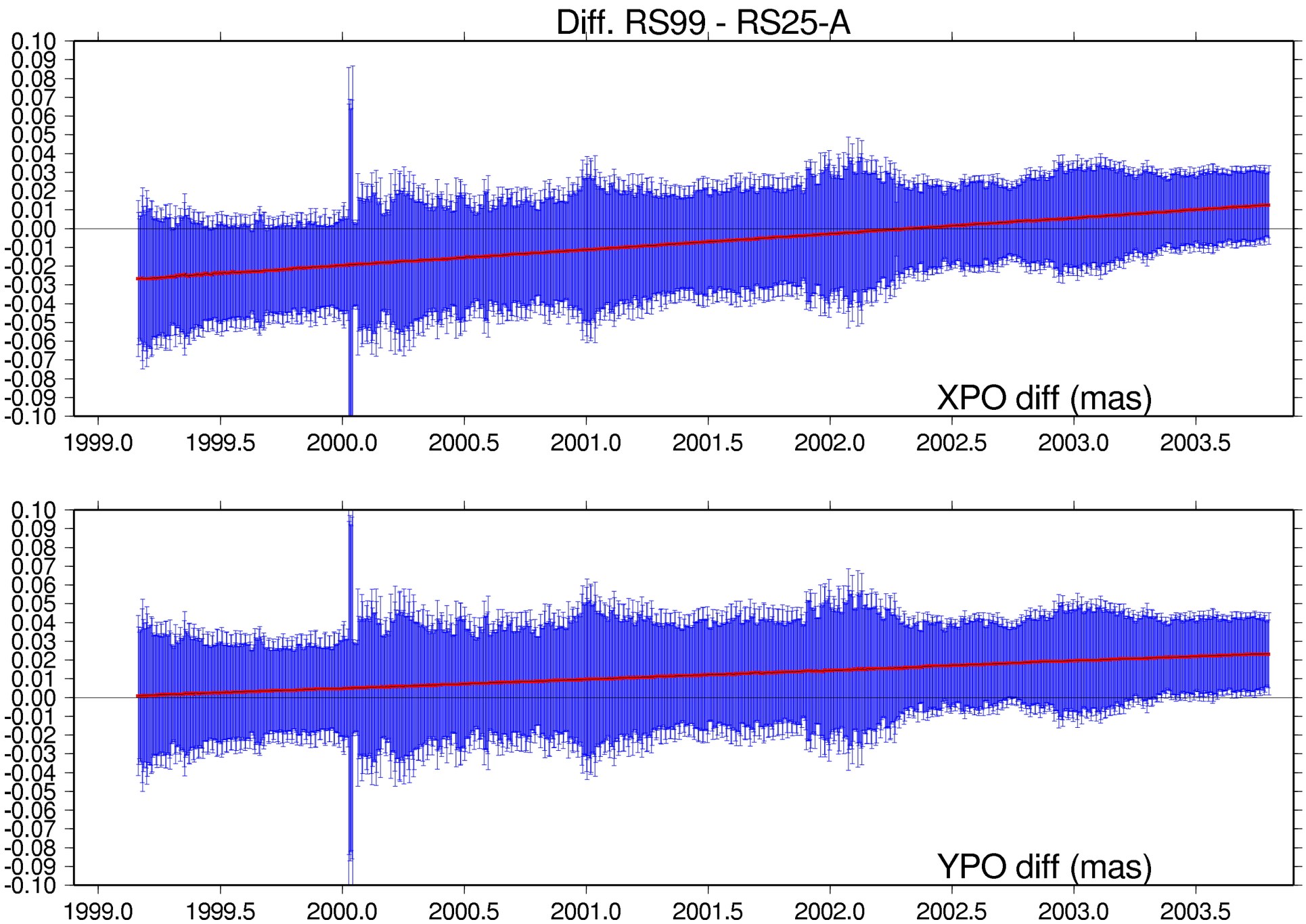
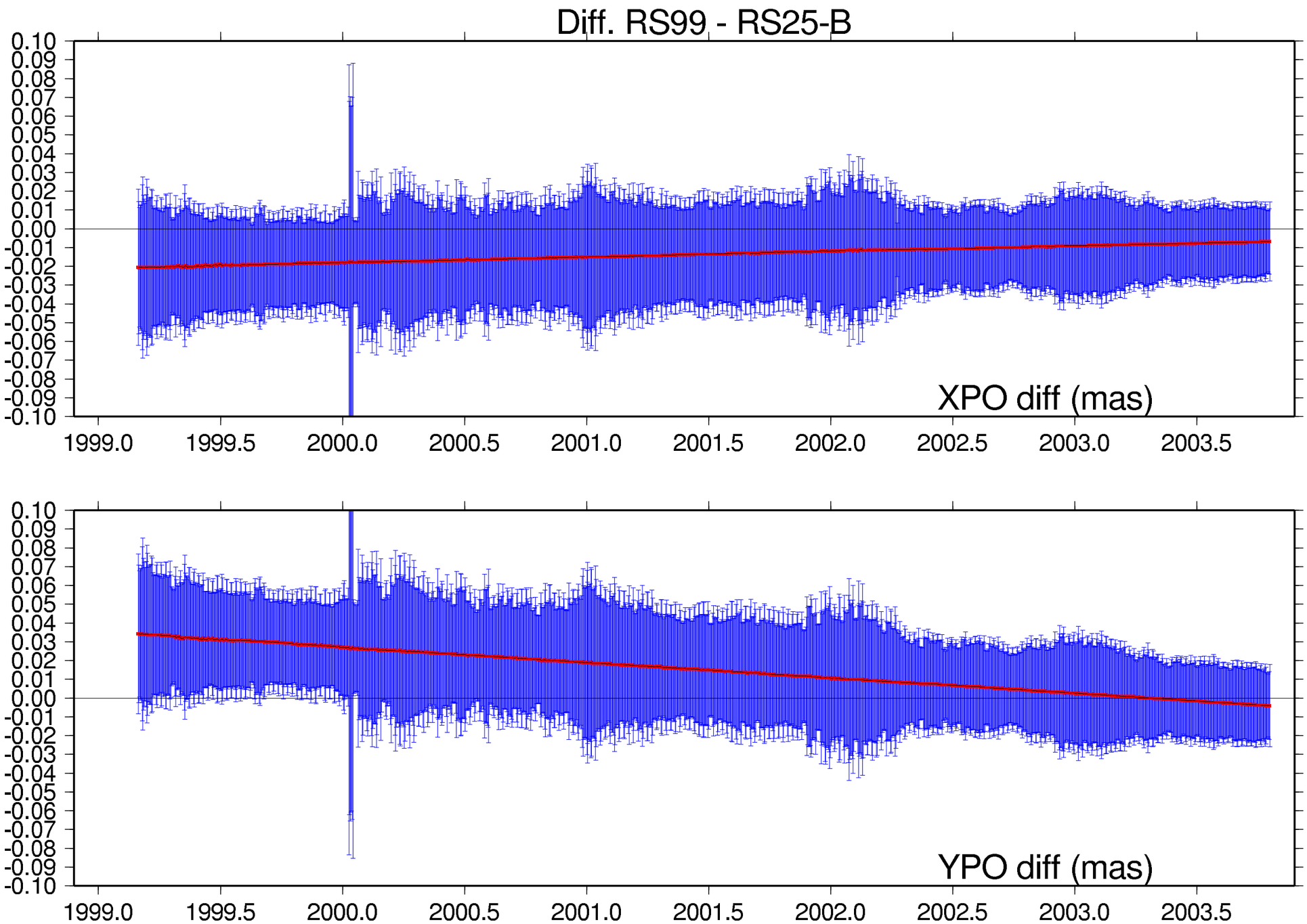


Polar Motion Differences wrt RS 99



Polar Motion Differences wrt RS 99



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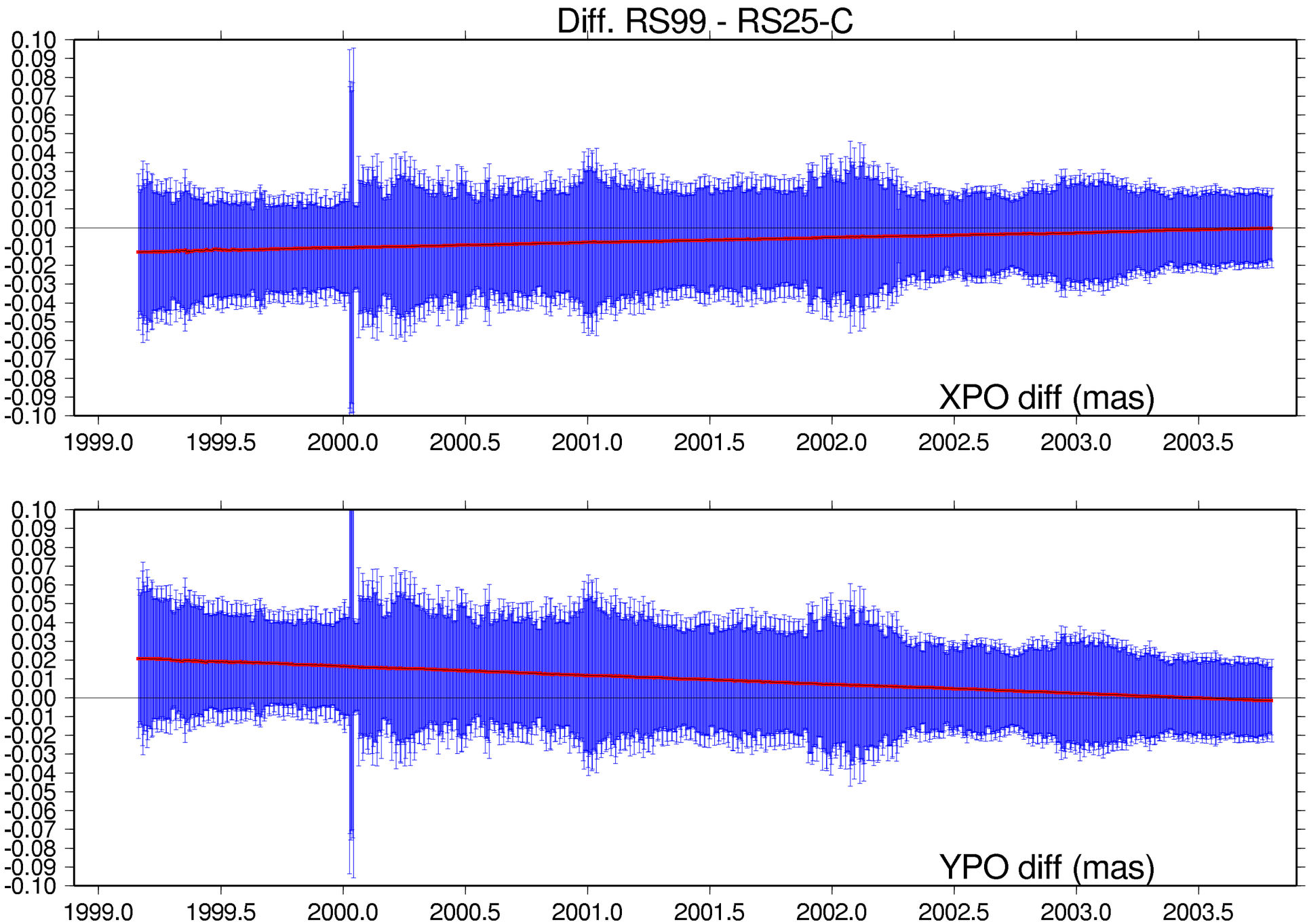

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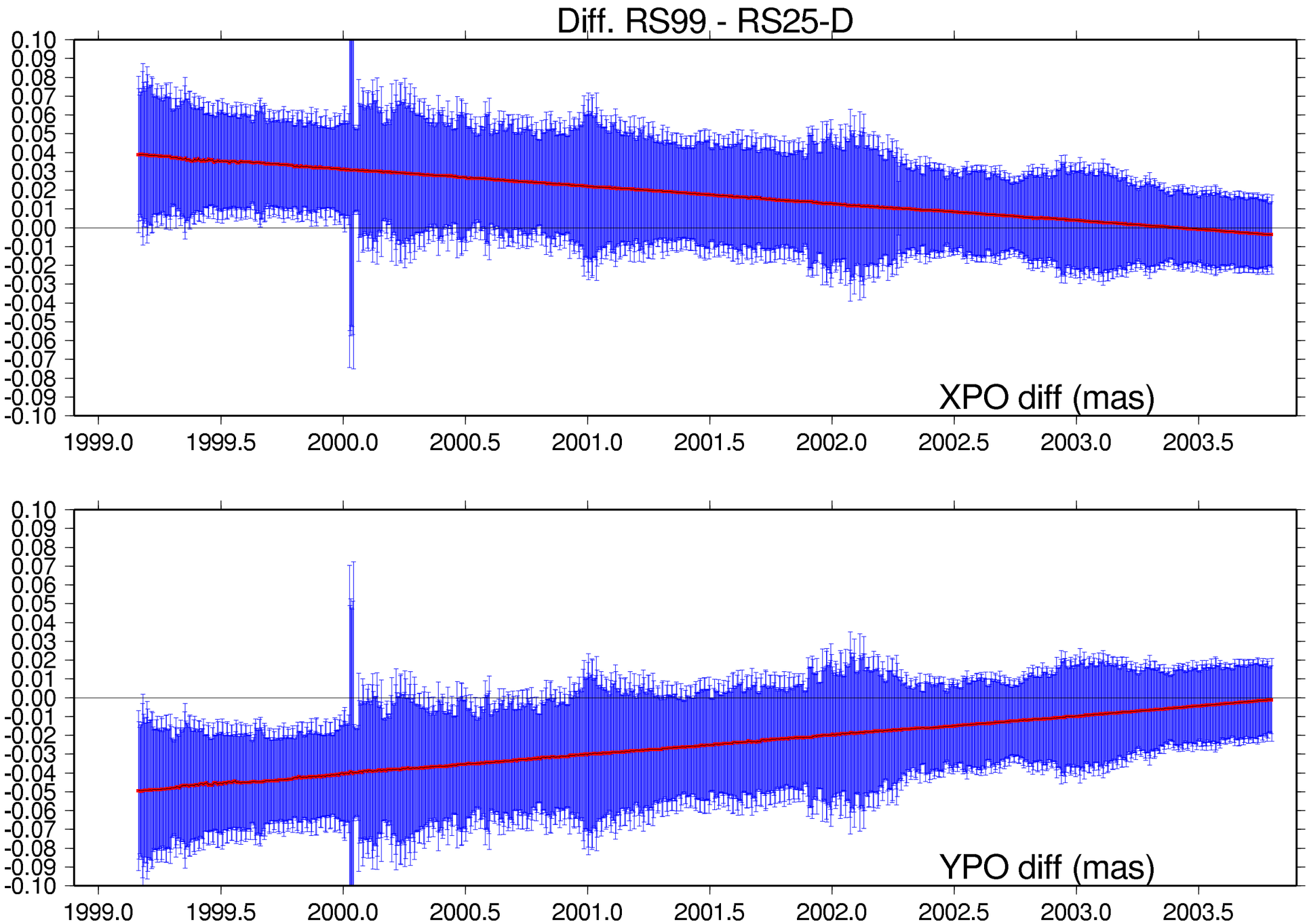
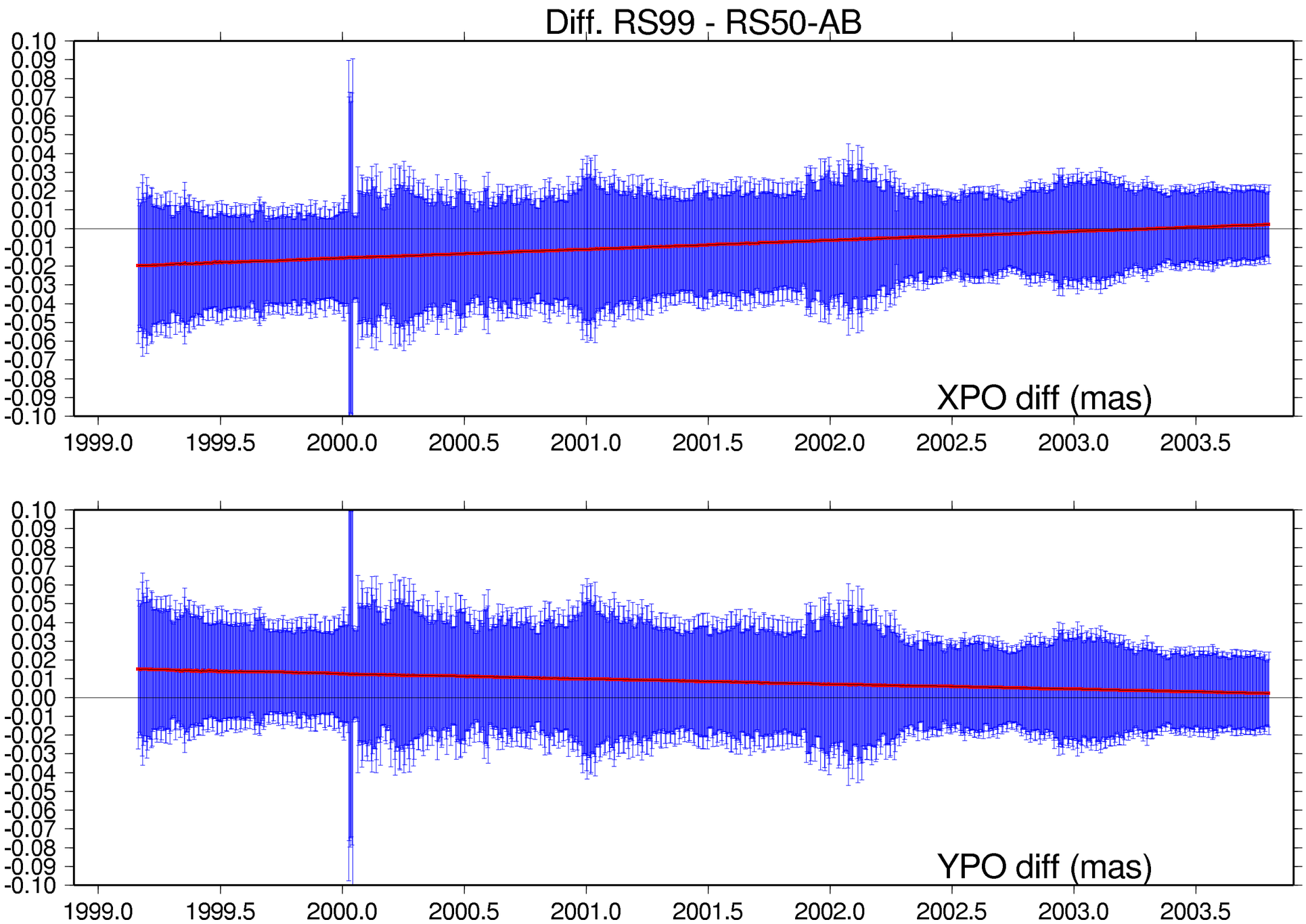
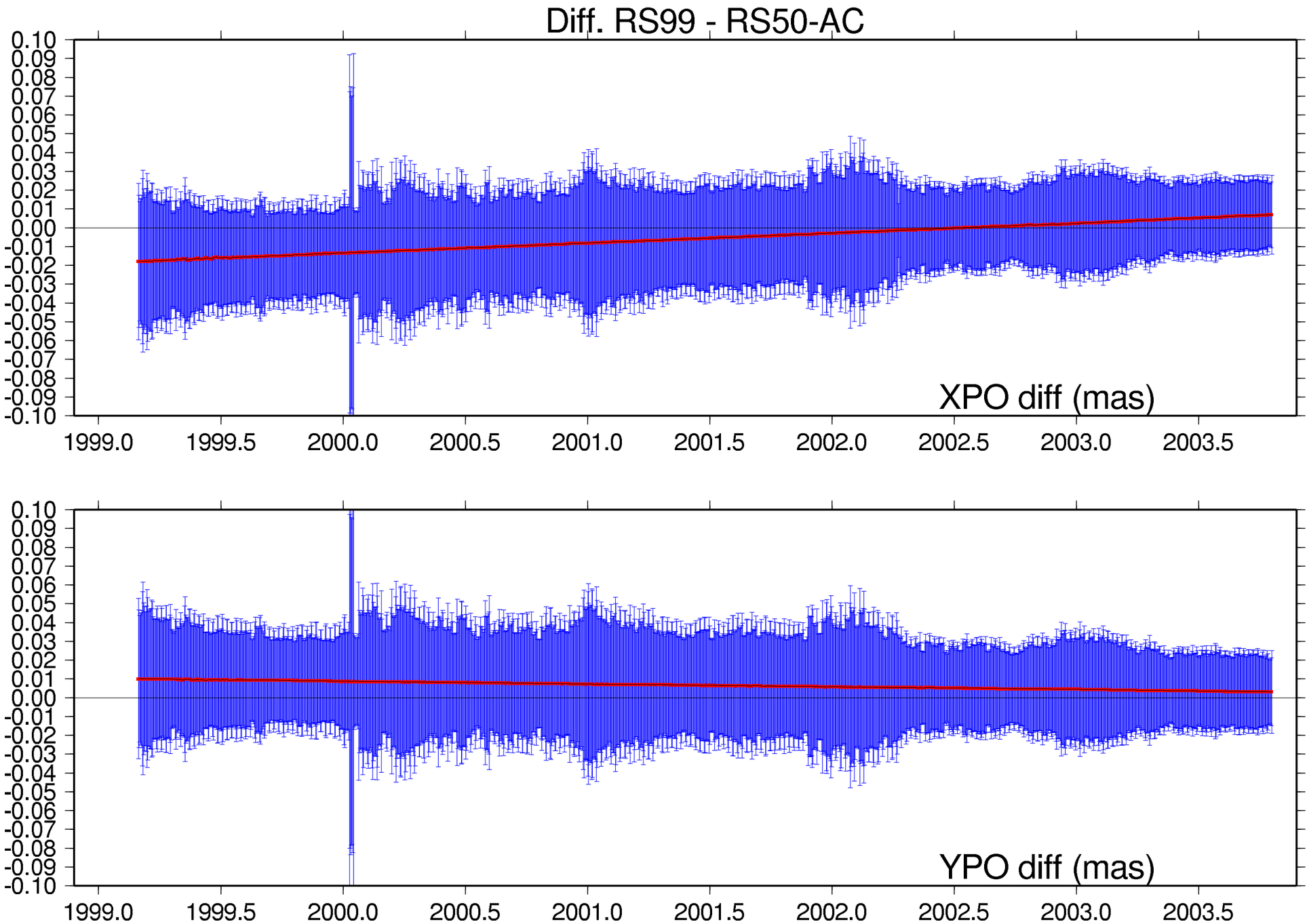


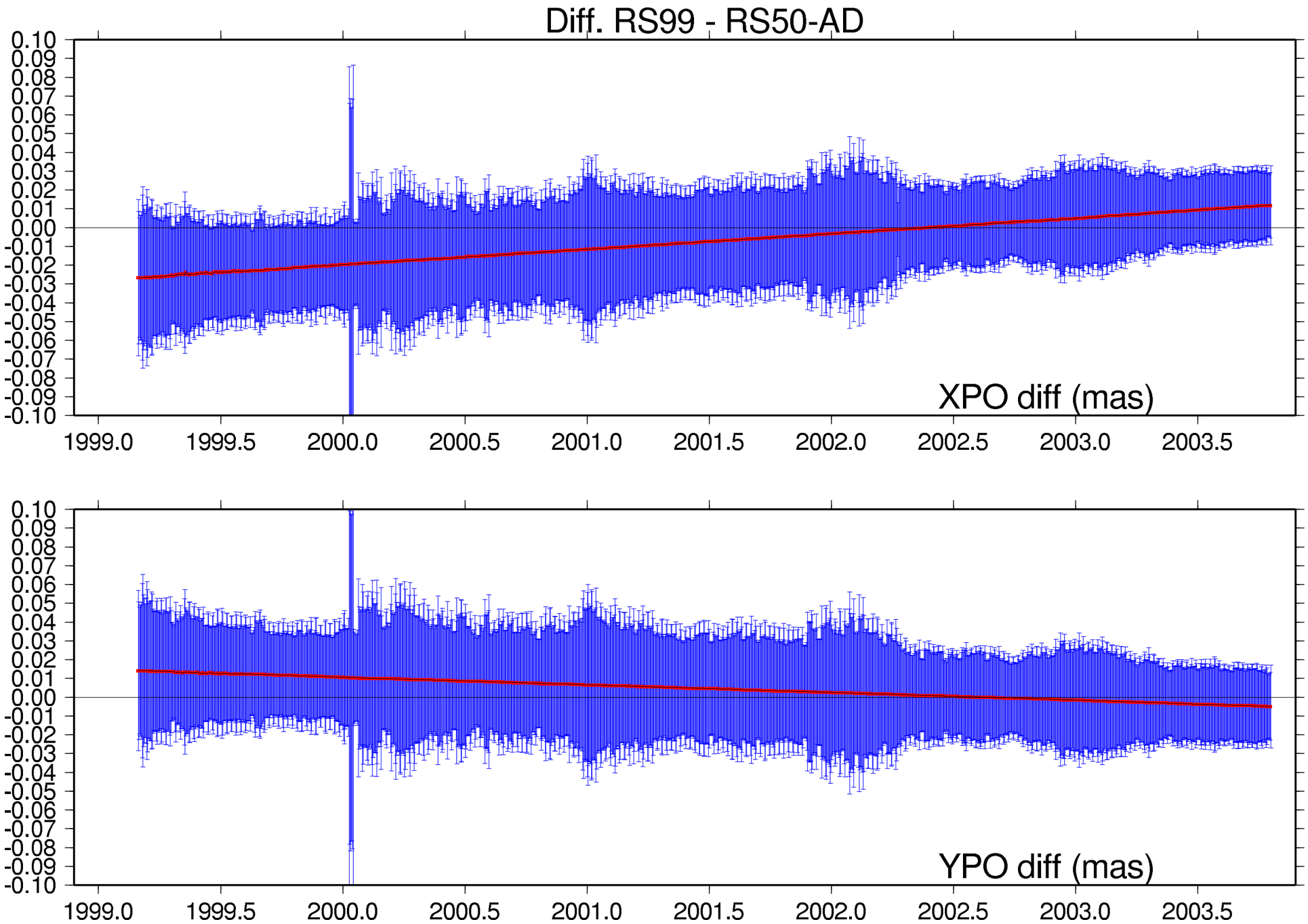
Polar Motion Differences wrt RS 99



Polar Motion Differences wrt RS 99



Polar Motion Differences wrt RS 99



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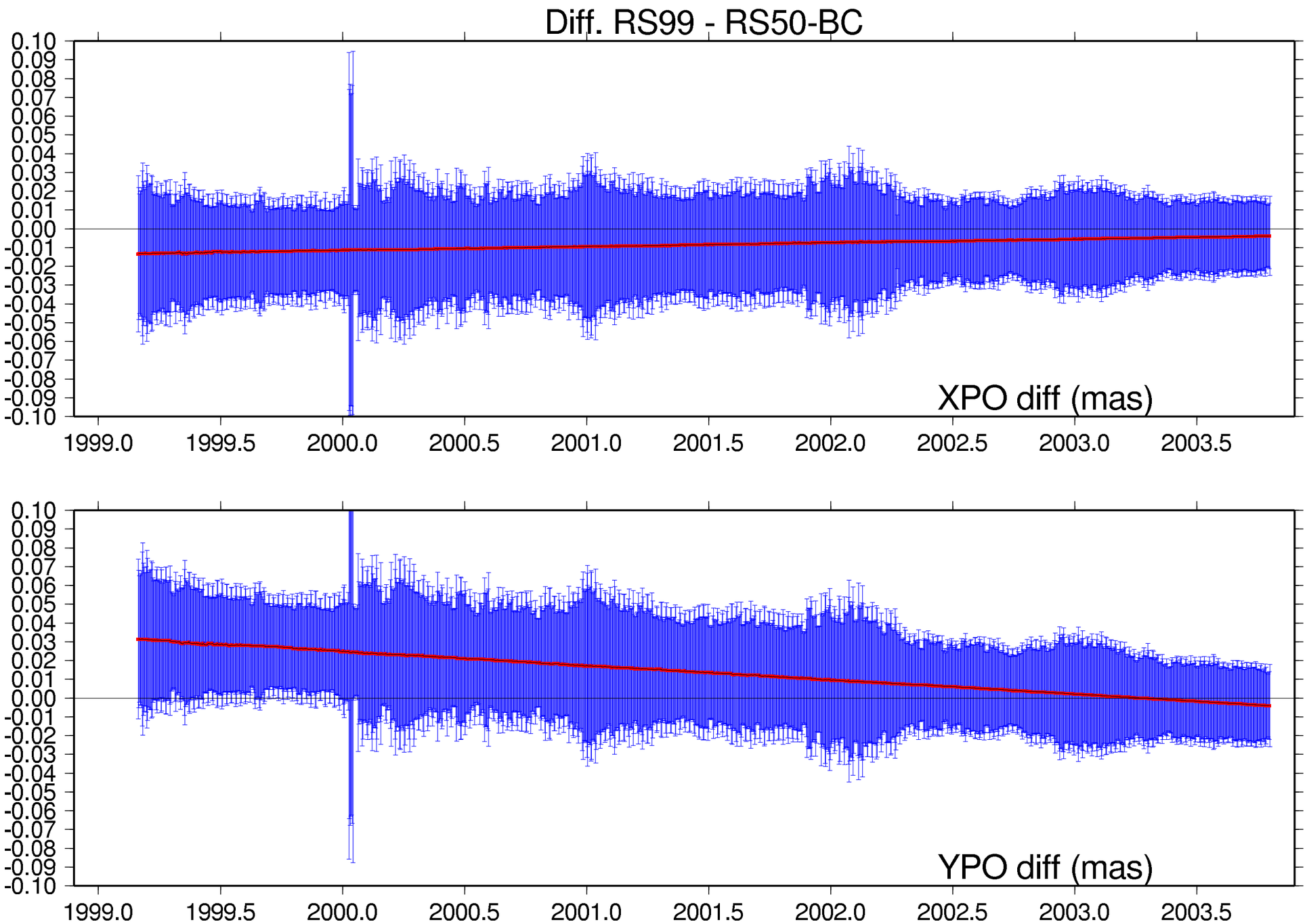

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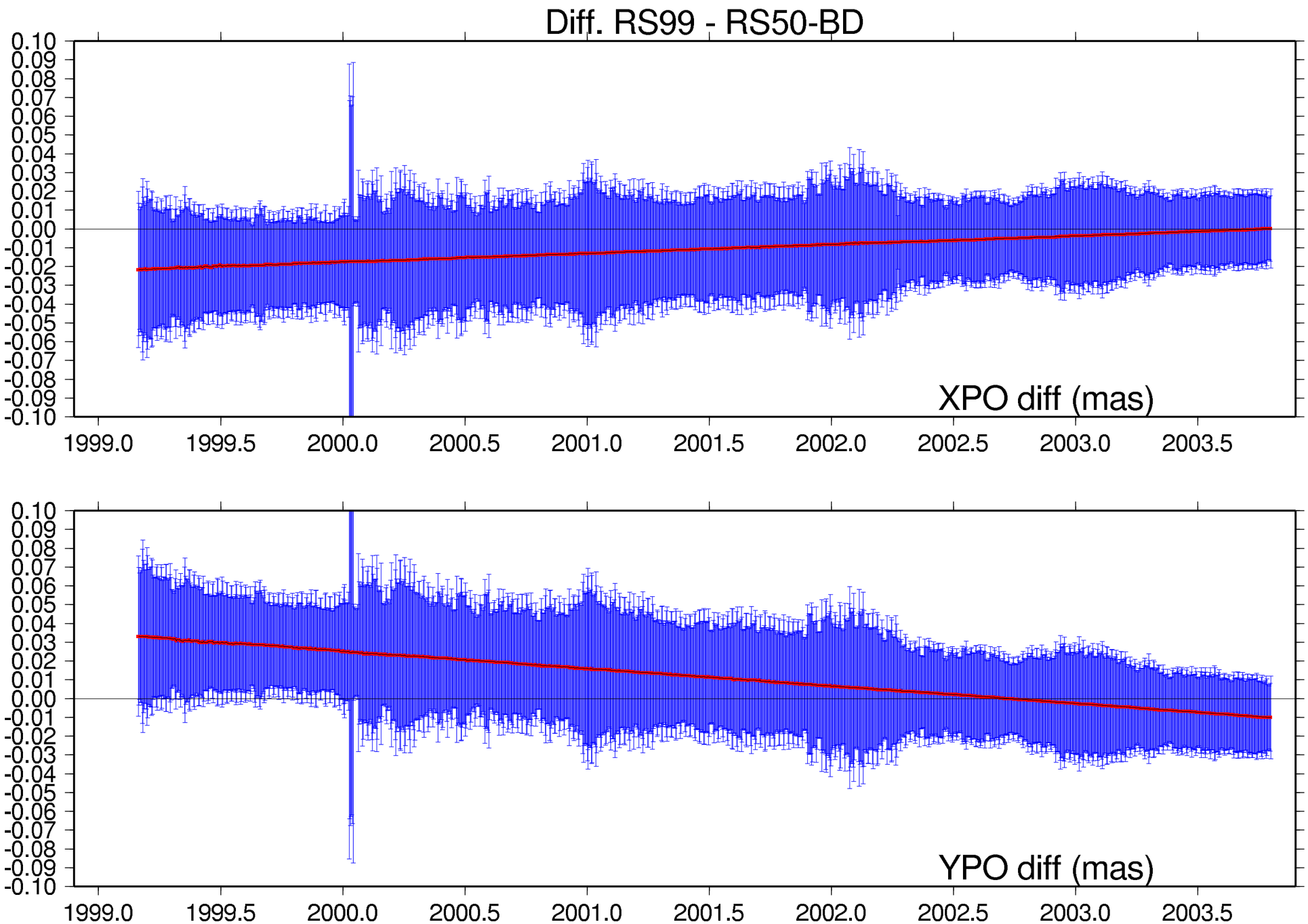

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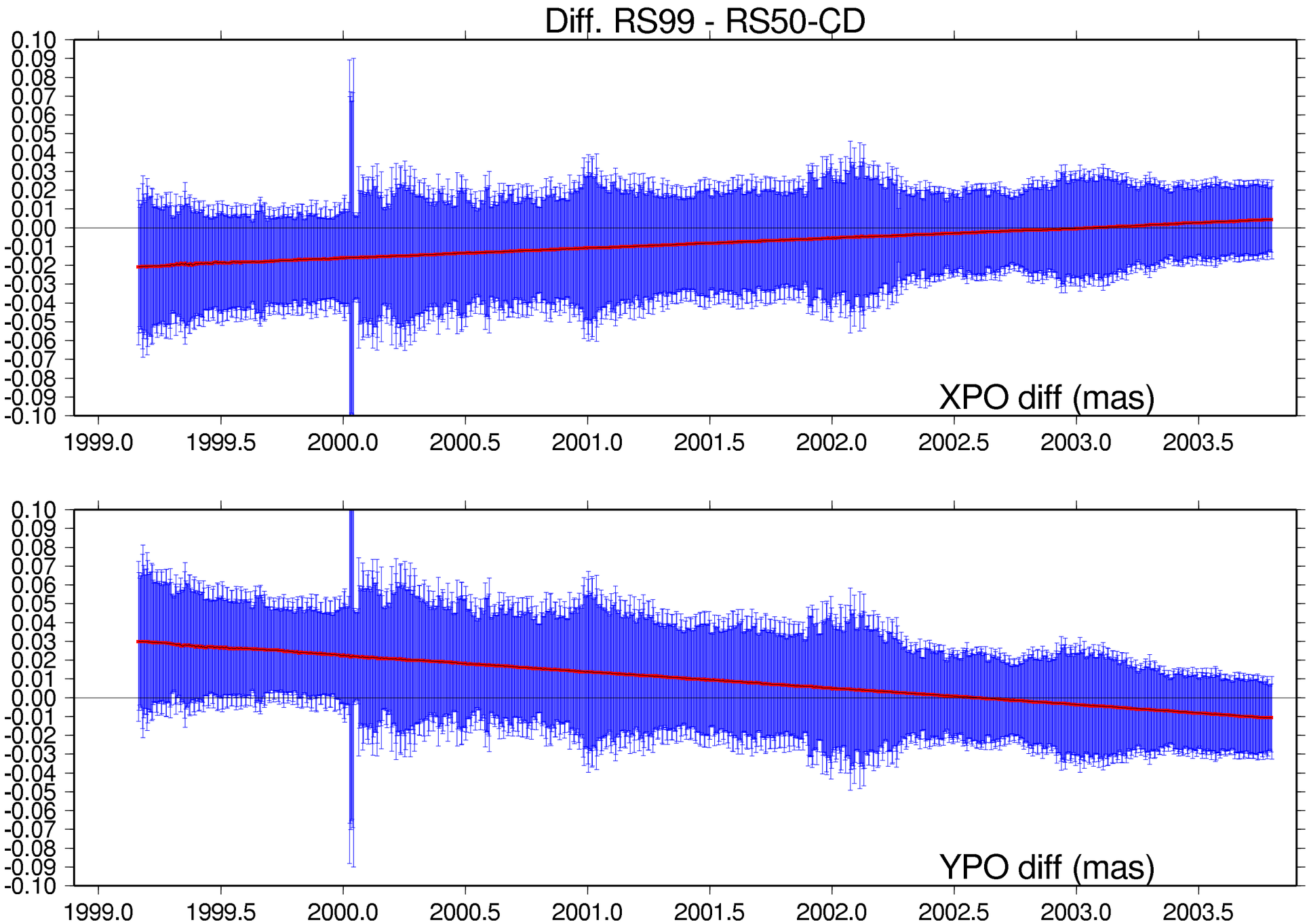
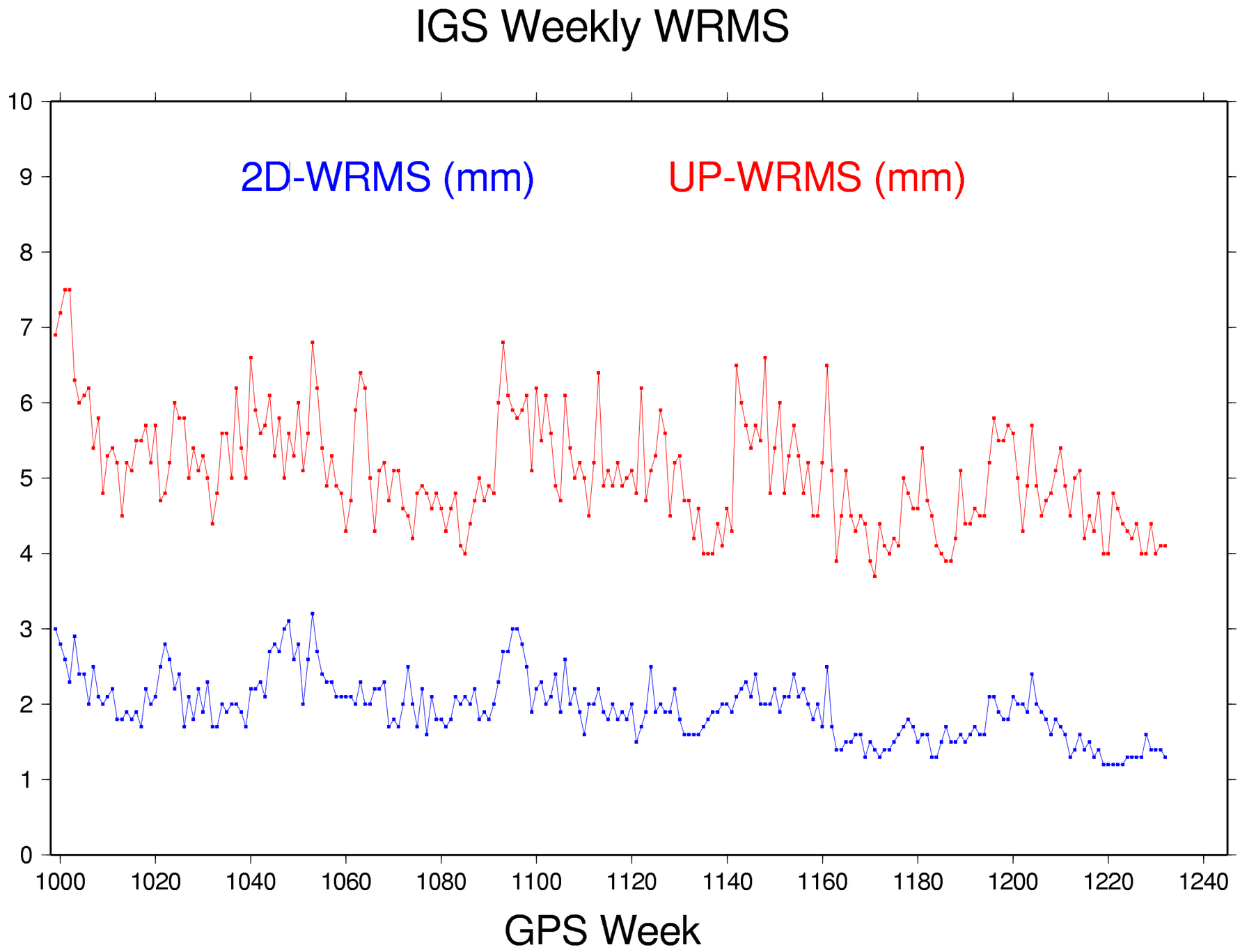
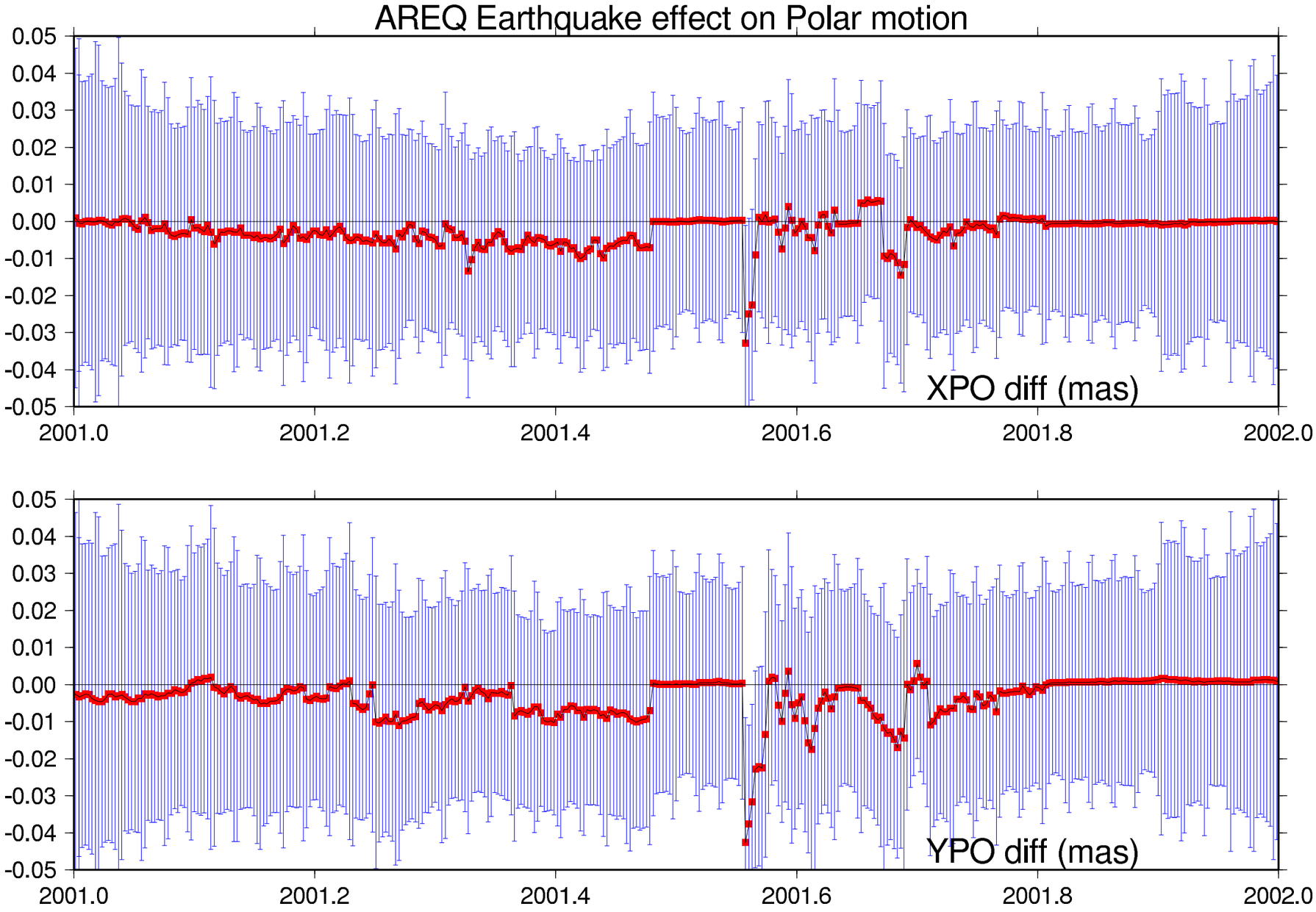


Weekly WRMS


IGS Weekly WRMS
2D-WRMS (mm)
UP-WRMS (mm)
10
9
8
7
6
5
4
3
2
1
0
1000
1020
1040
1060
1080
1100
1120
1140
1160
1180
1200
1220
1240
GPS Week

Impact of AREQ Earthquake on Polar Motion
If pre & post station velocity is constrained to be the same



What about GPS Geocenter and TRF Scale ???

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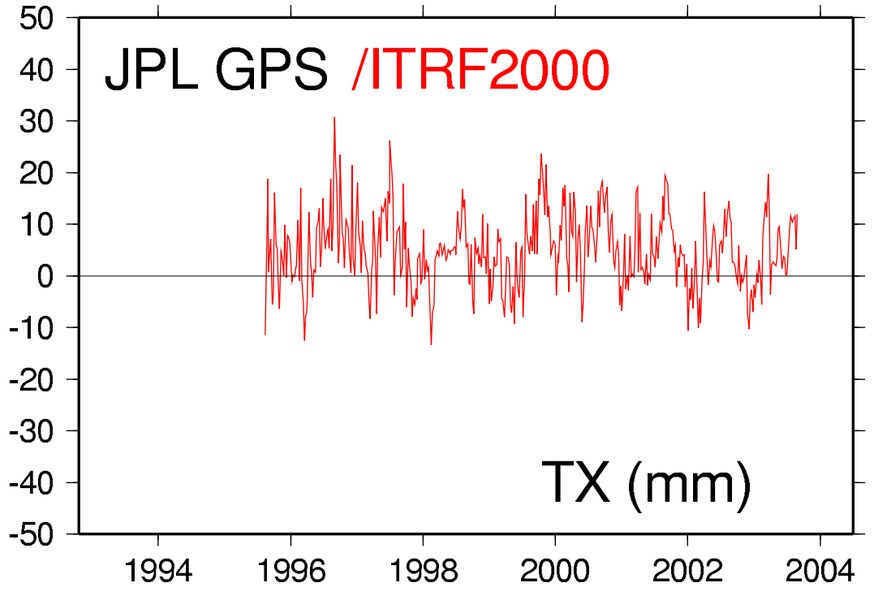
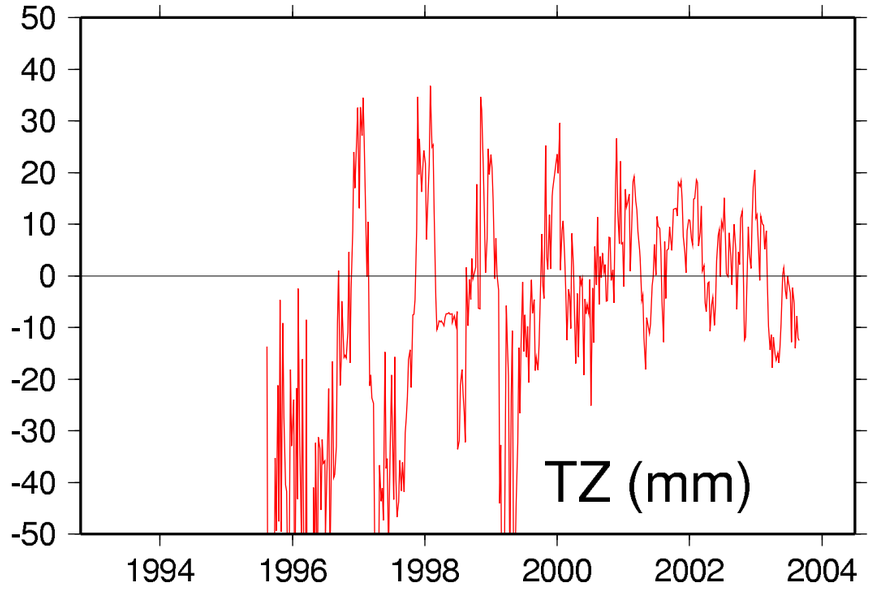
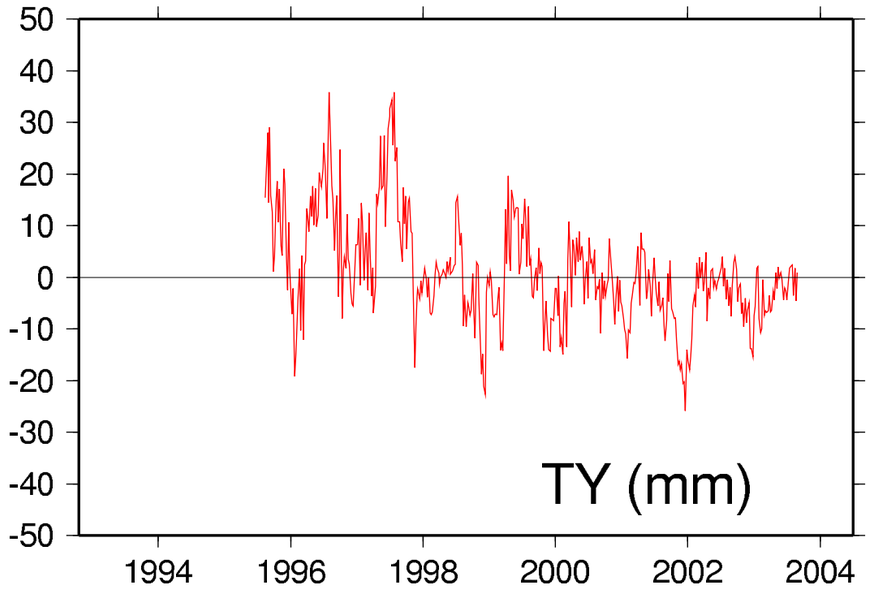
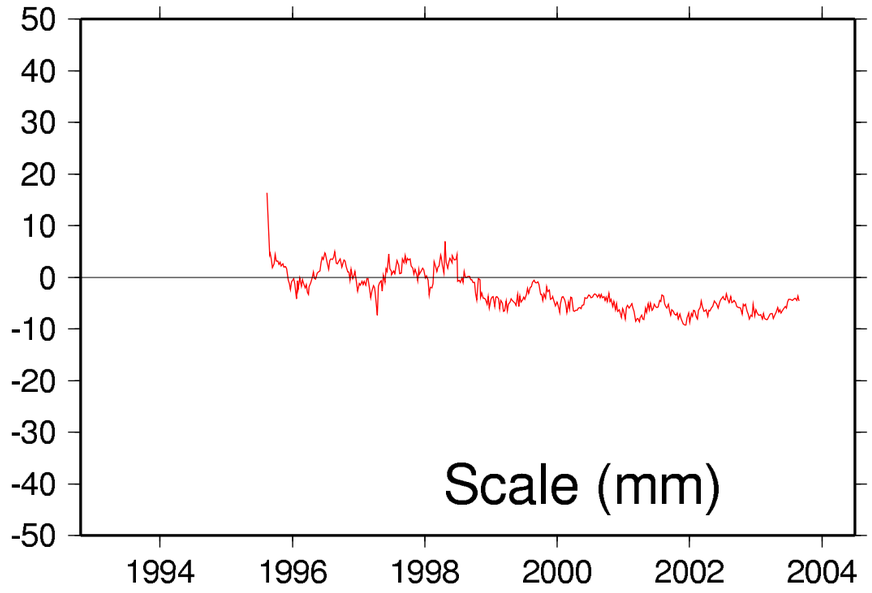


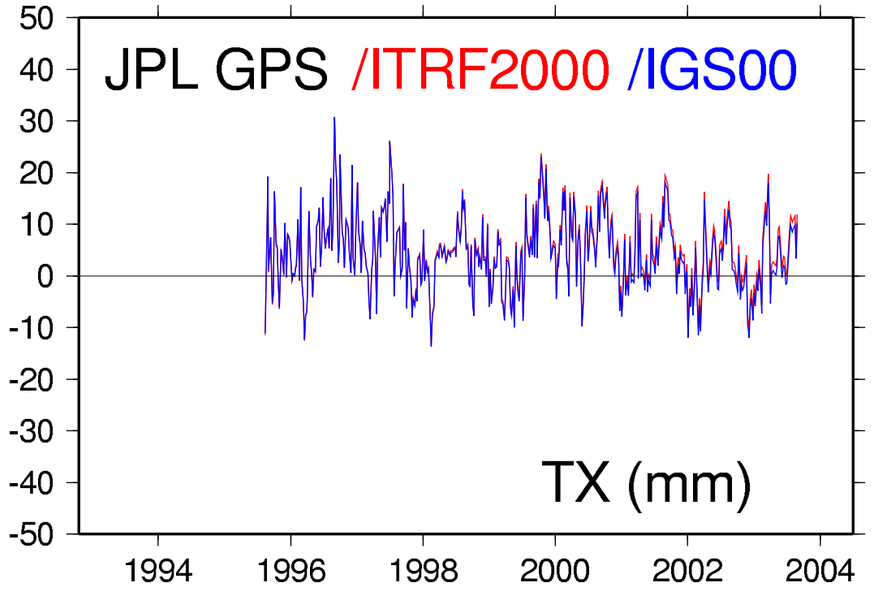


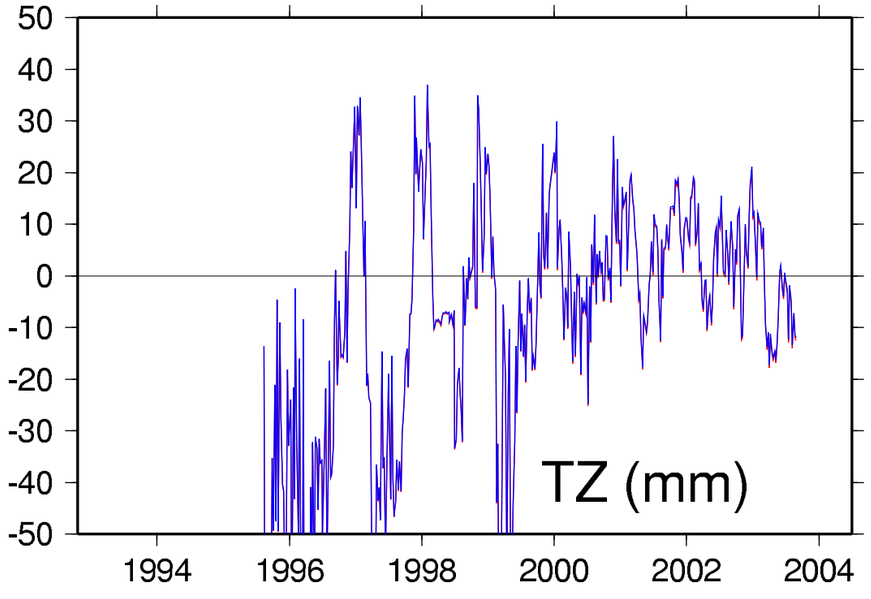


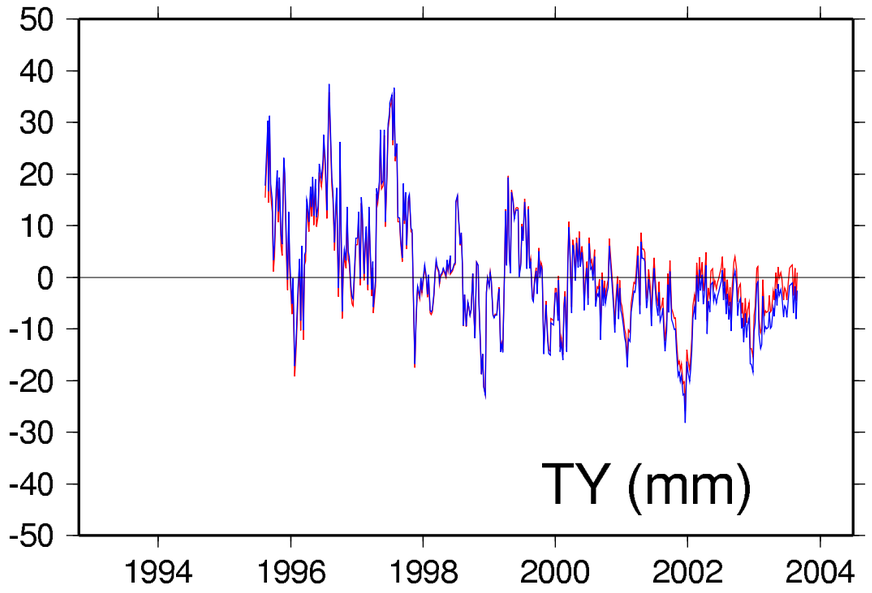


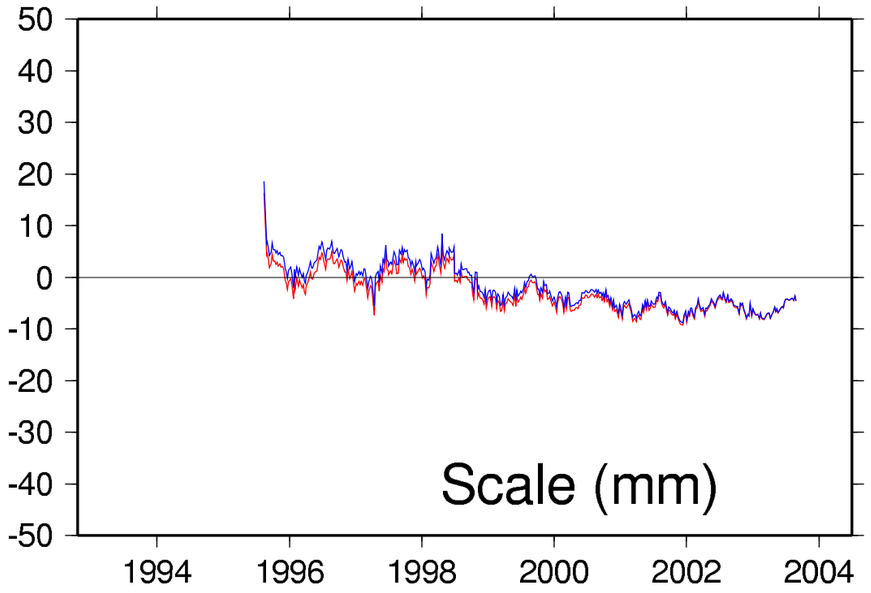
ITRF2000 datum using 21 stations

What about GPS Geocenter and TRF Scale ???









ITRF2000 datum using 21 stations

IGS00 datum using 21 stations

Conclusions

- **Changing the RS set may produce changes up to:**
  - **0.5 mm/yr in origin and scale rates**
  - **10 μas/yr in Polar Motion**

- **The overall IGS TRF stability is at the 1 mm level**

- **The Weekly WRMS are:**
  - **2 mm in horizontal**
  - **5 mm in vertical**

- **Discontinuities should be handled with care (impact on EOP)**

- **GPS Geocenter and Scale estimates is still an open question**

On TIGA TRF Application (See Poster by Wöppelmann et al.)