Evaluation of repro3 ERP series

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with contributions from the CODE AC team

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Solution overview

ERP series from ACs repro3 solution, compared to C04(20)

Orbit modelling issues with historic GPS satellites

Continuity in ERP series from ACs repro3 solution

Summary

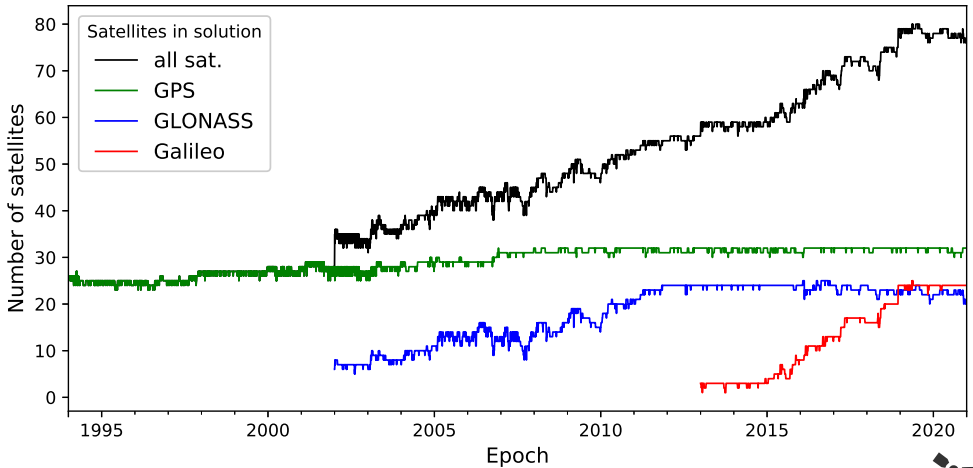
Solution overview

The repro3 solutions from nine ACs have been submitted containing orbits:

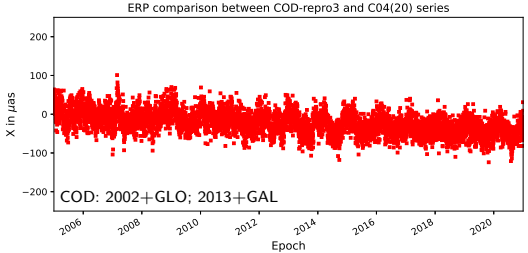
AC	GPS	GLONASS	Galileo
COD	1994–2020	2002–2020	2013–2020
ESA	1995–2020	2009–2020	2015–2020
GFZ	1994–2020	2012–2020	2013–2020
GRG	2000–2020	2008–2020	2017–2020
JPL	1994–2020		
MIT	2000–2020		2017–2020
NGS	1994–2020		
TUG	1994–2020	2009–2020	2013–2020
WHU	2008–2020	2010–2020	

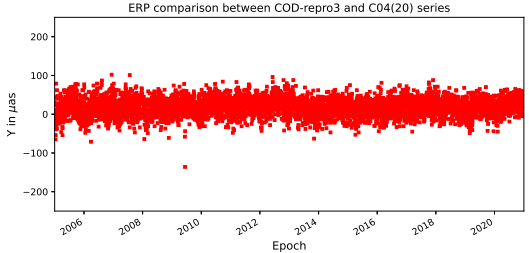
Solution overview

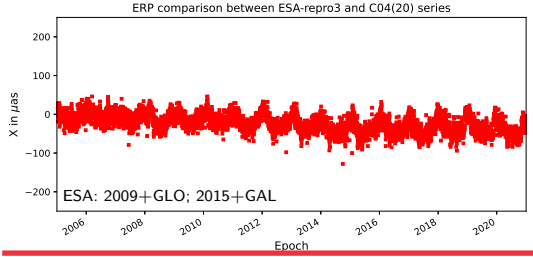
Number of active satellites from the CODE repro3 solution:

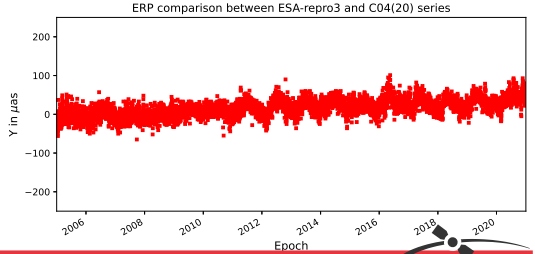


ERP series from ACs repro3 solution, compared to C04(20)

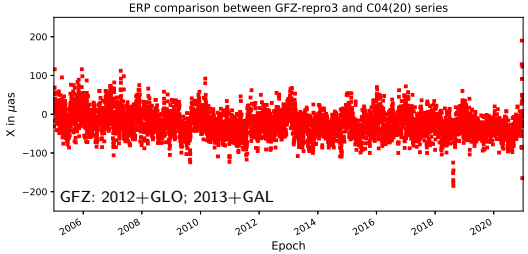


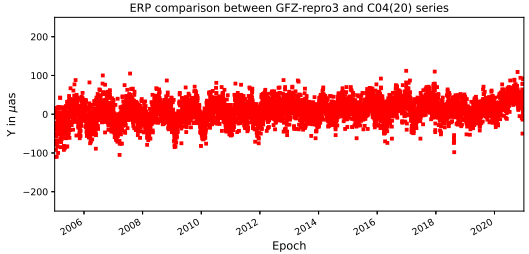


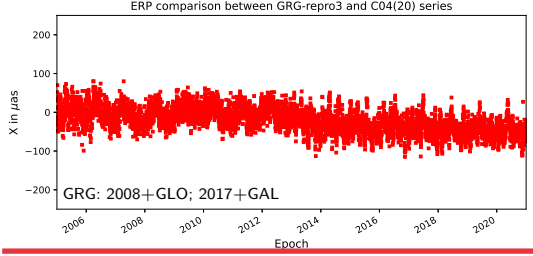


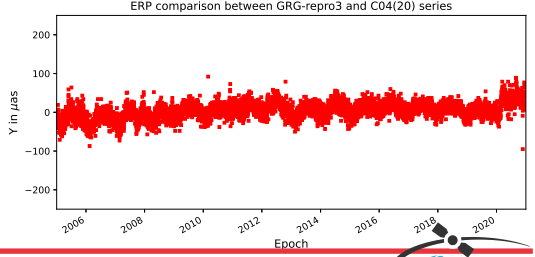


ERP series from ACs repro3 solution, compared to C04(20)









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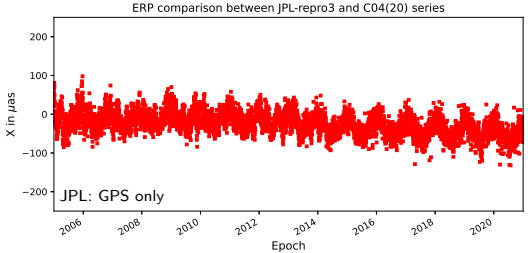

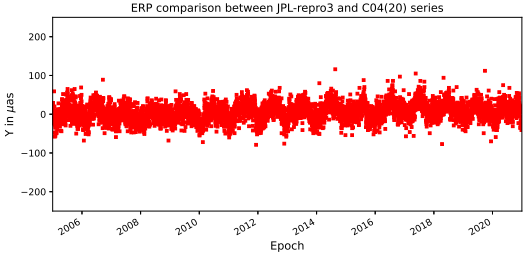

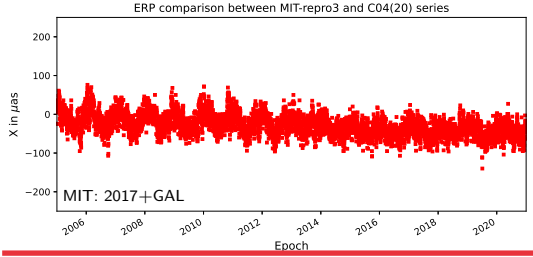

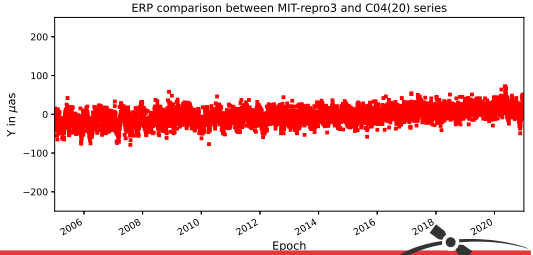

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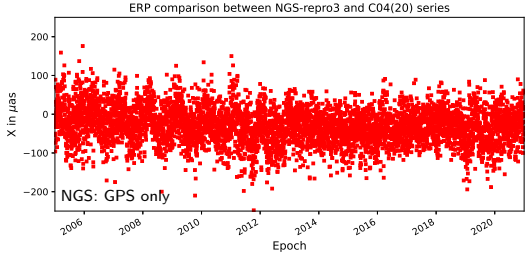
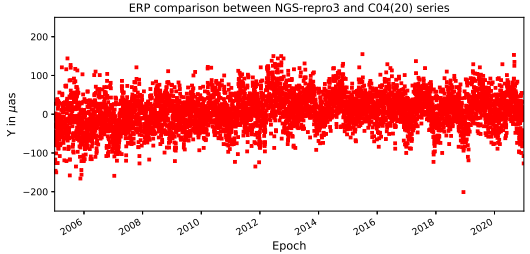
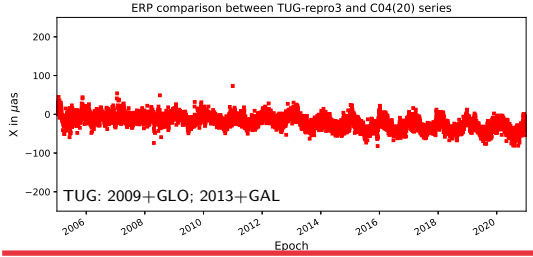
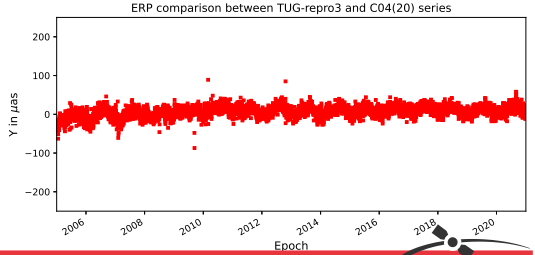
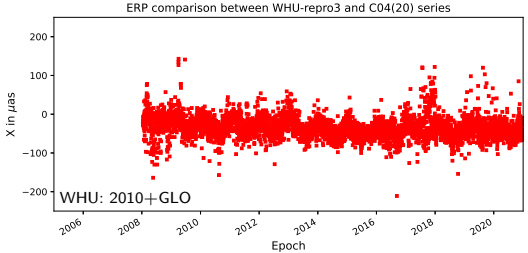


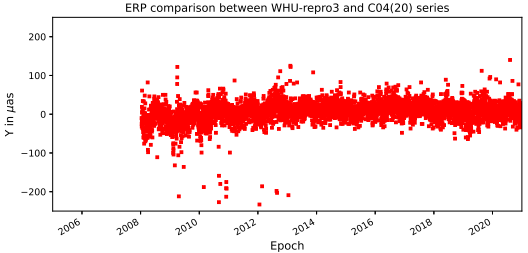






ERP series from ACs repro3 solution, compared to C04(20)





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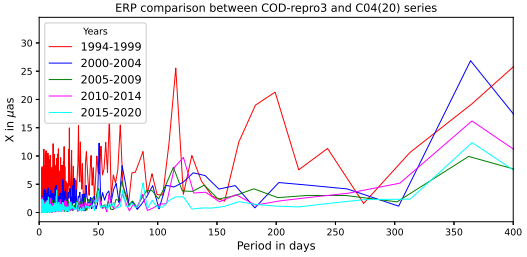

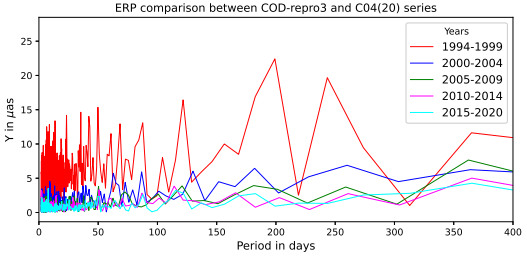

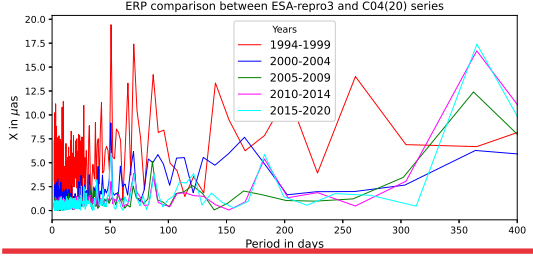

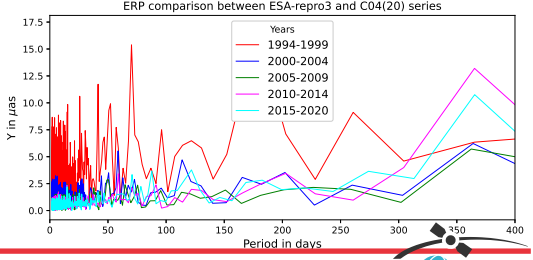

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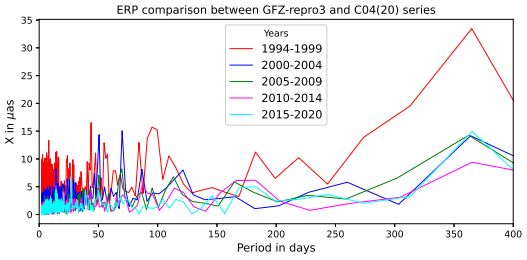

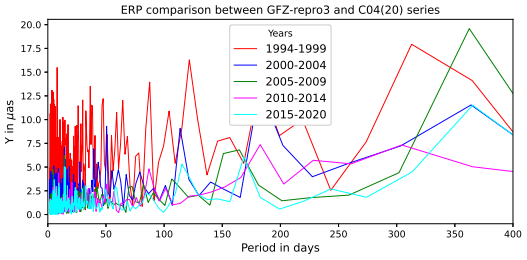

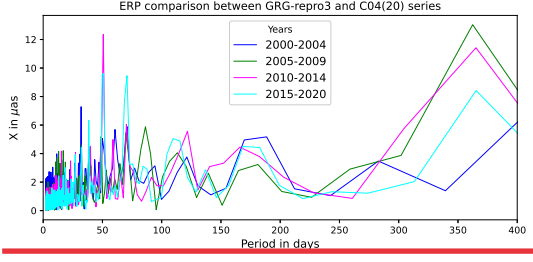

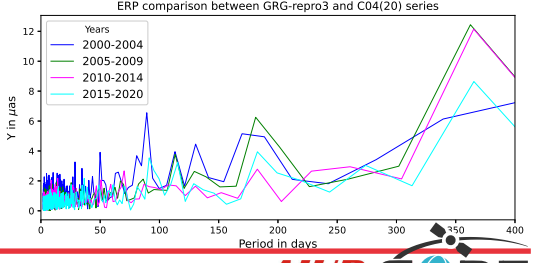

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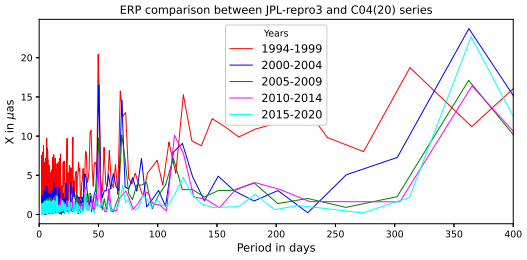

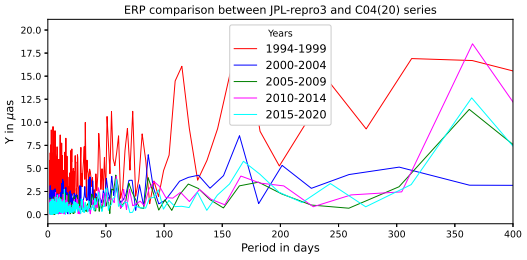

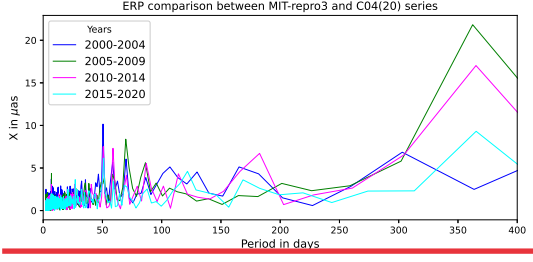

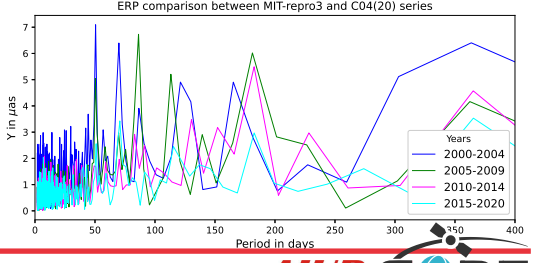

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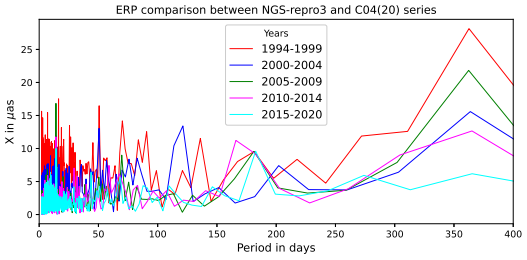
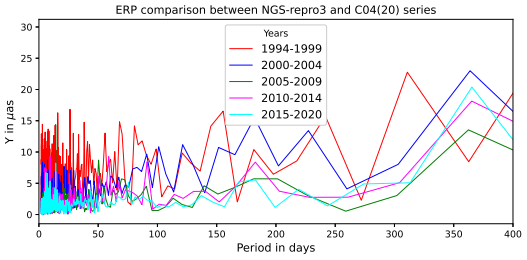
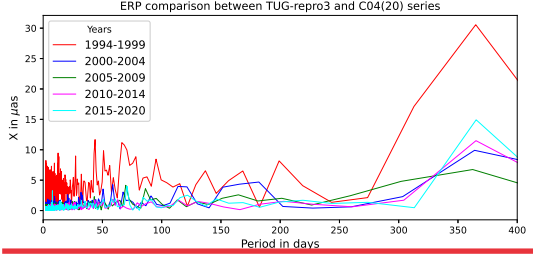
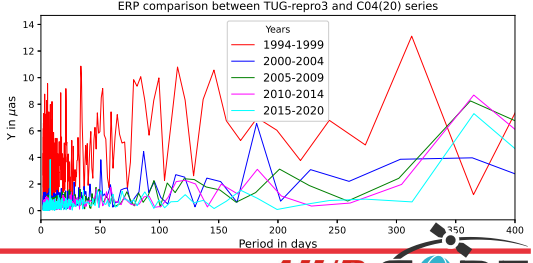
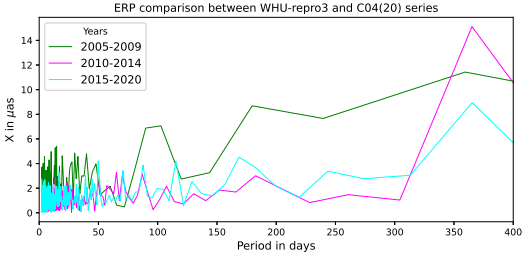


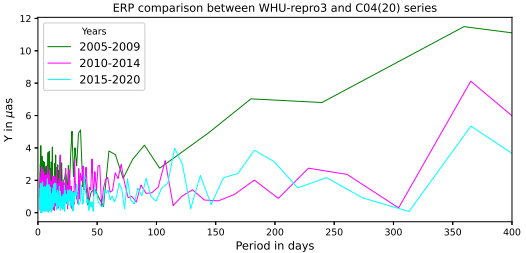




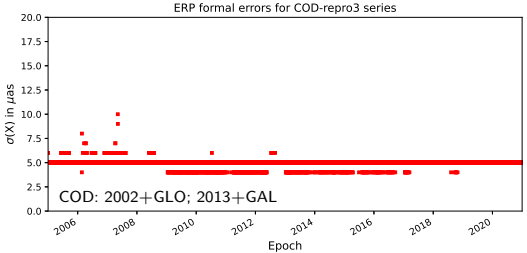


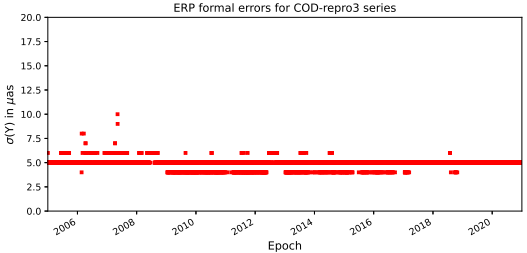
ERP series from ACs repro3 solution, compared to C04(20)

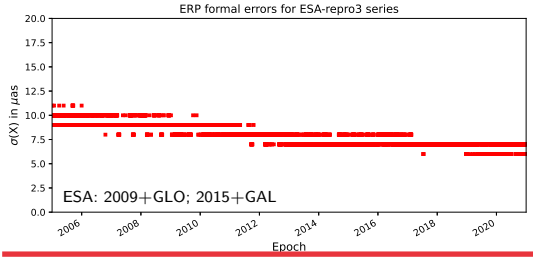


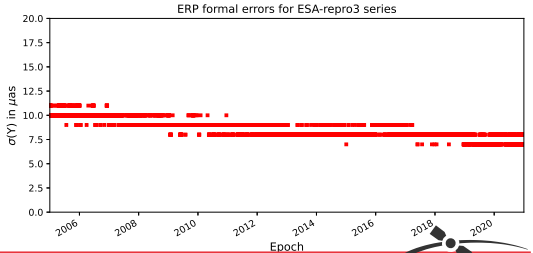


Formal error in the ERP series from ACs repro3 solution









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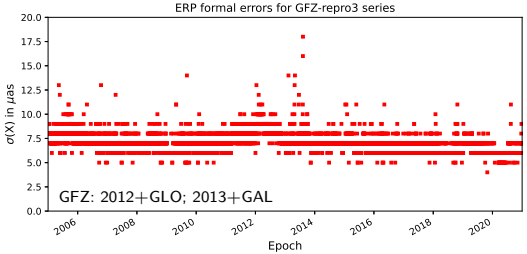

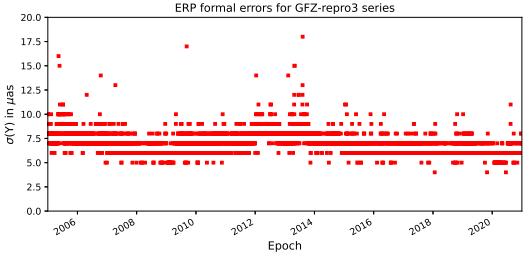

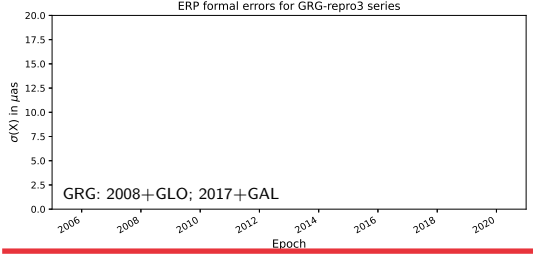

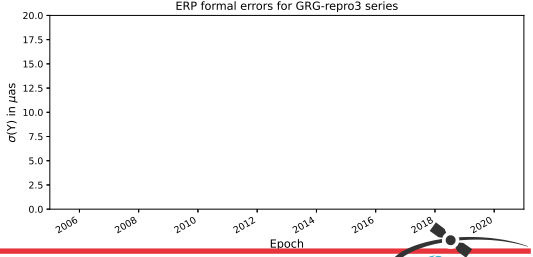

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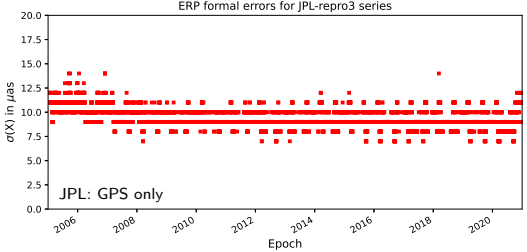

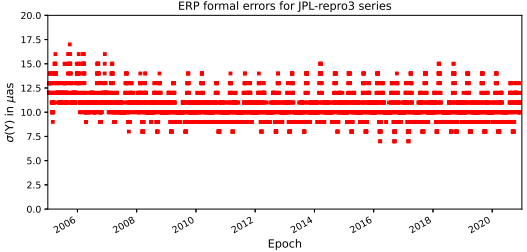

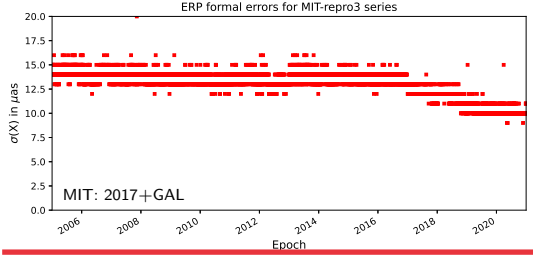

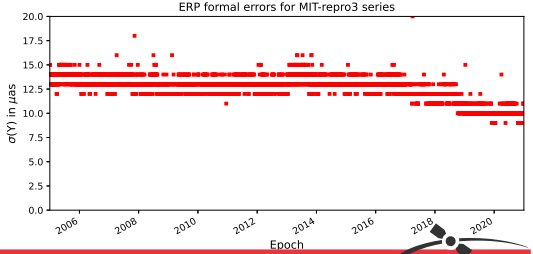

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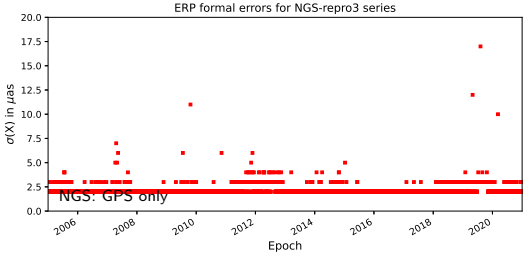

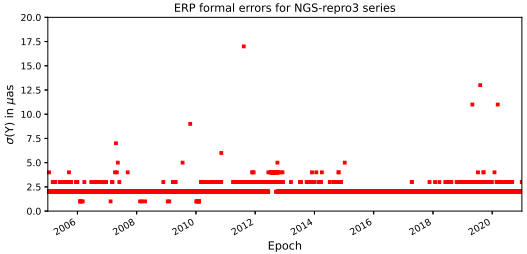

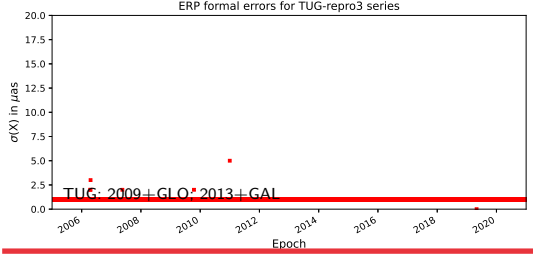

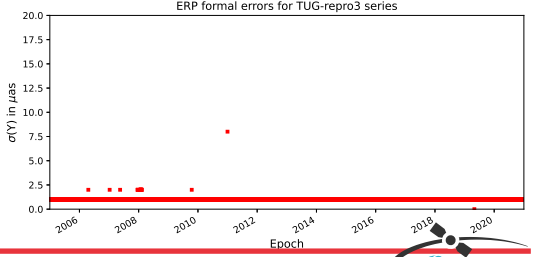

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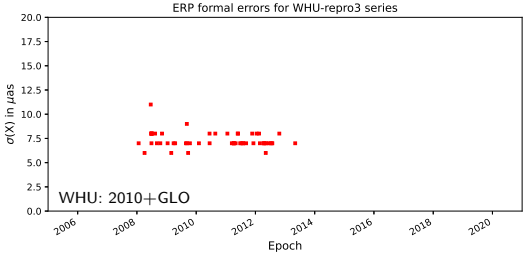
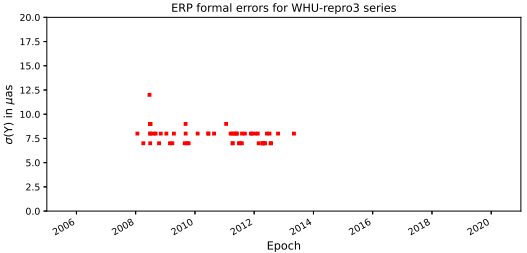
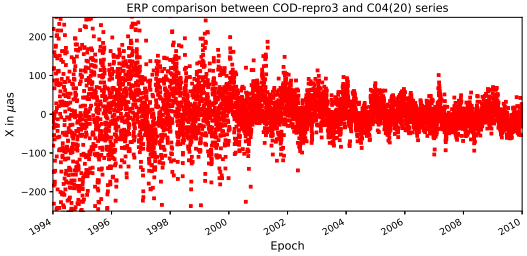
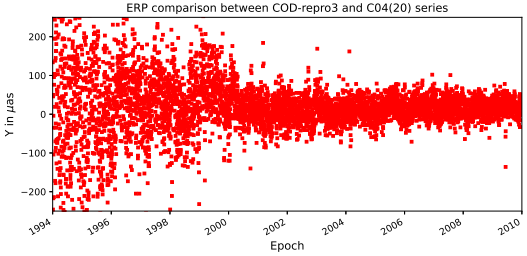
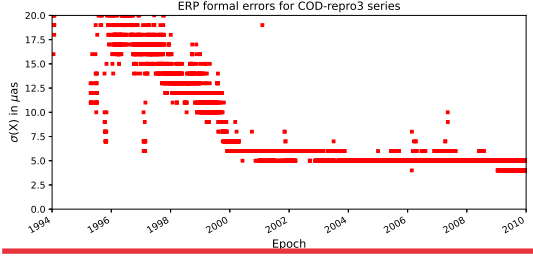


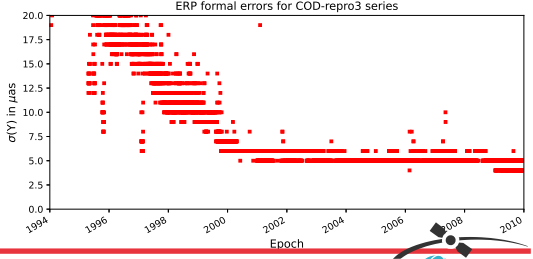


ERP series from ACs repro3 solution, compared to C04(20)

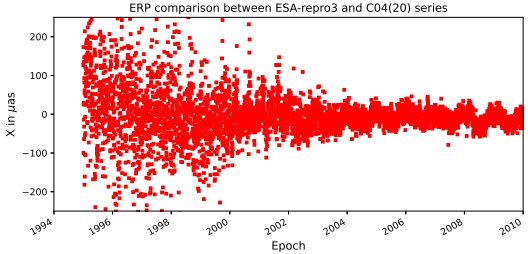


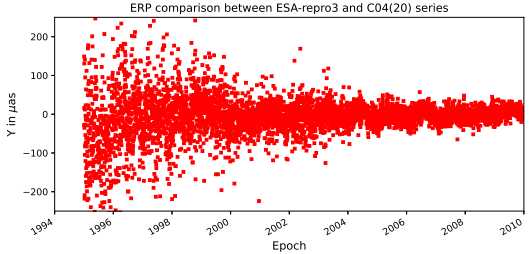


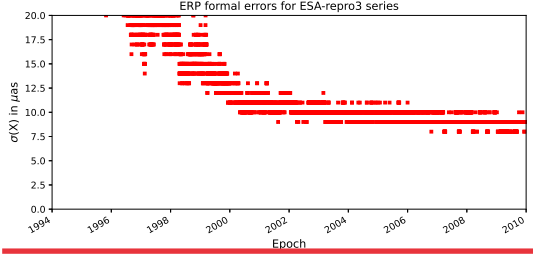


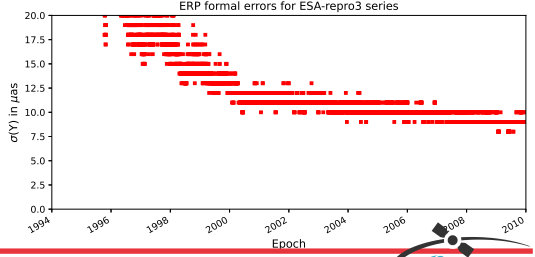


ERP series from ACs repro3 solution, compared to C04(20)

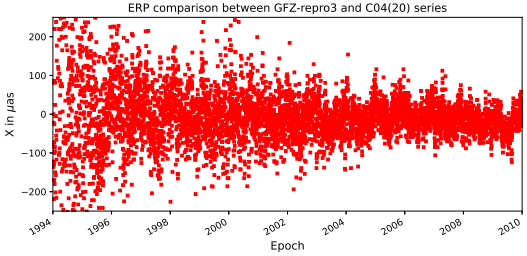


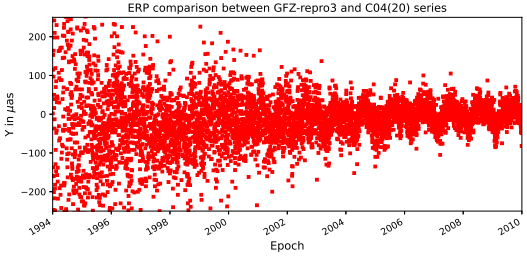


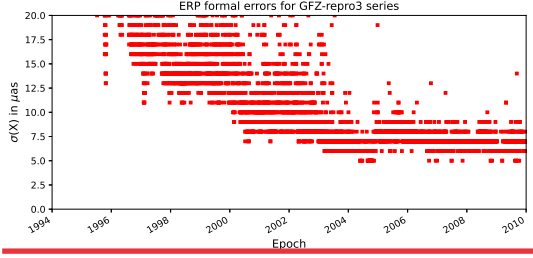


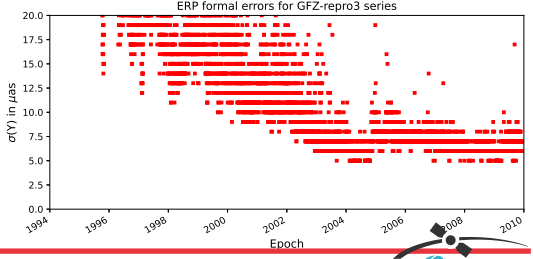


ERP series from ACs repro3 solution, compared to C04(20)

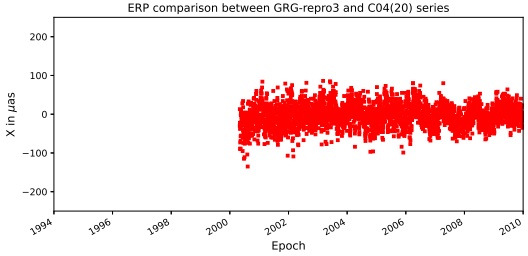


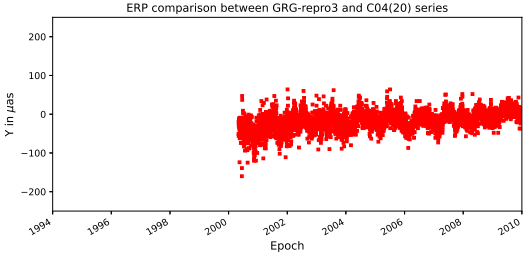


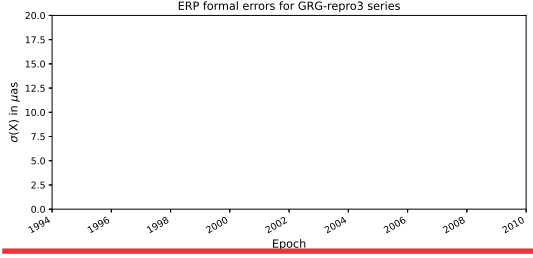


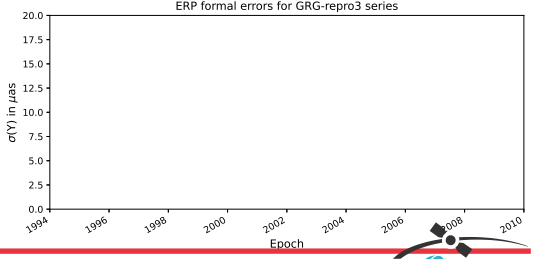


ERP series from ACs repro3 solution, compared to C04(20)

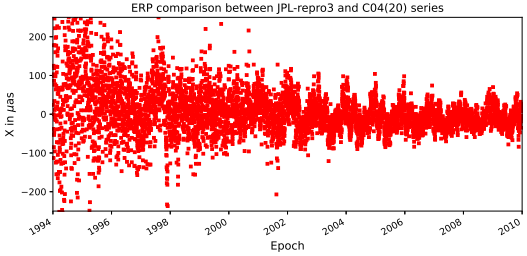


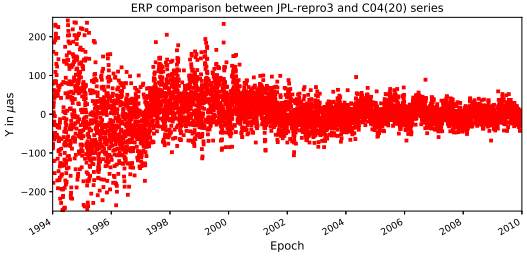


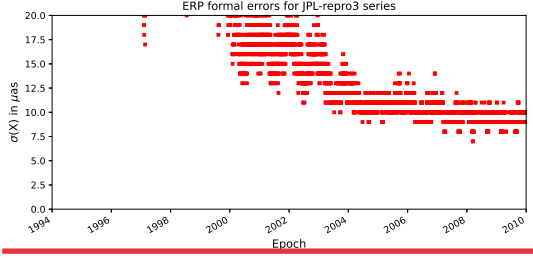


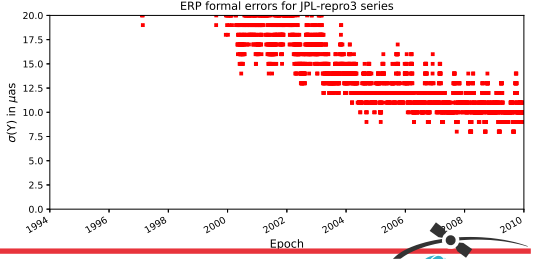


ERP series from ACs repro3 solution, compared to C04(20)

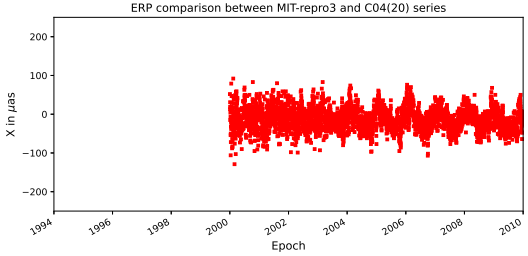


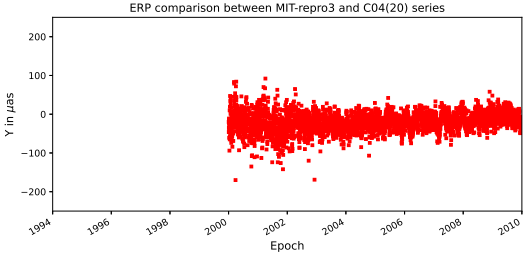


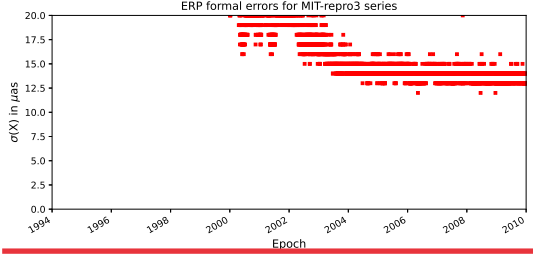


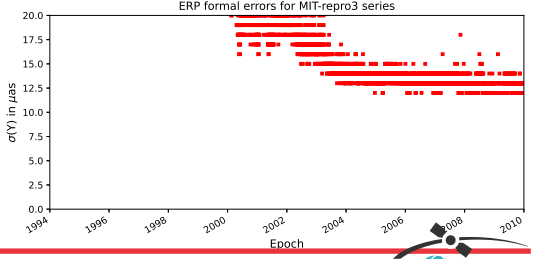


ERP series from ACs repro3 solution, compared to C04(20)

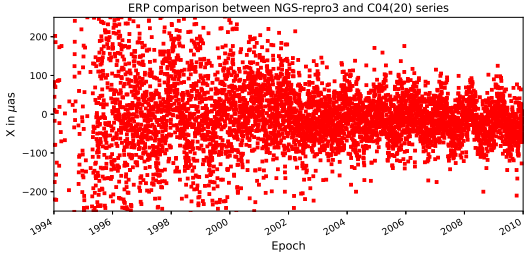


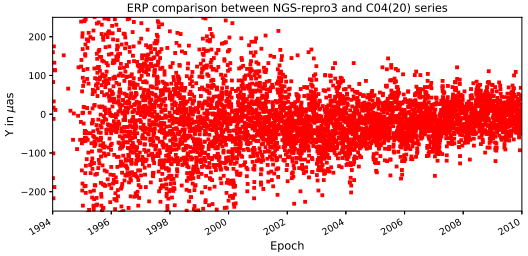


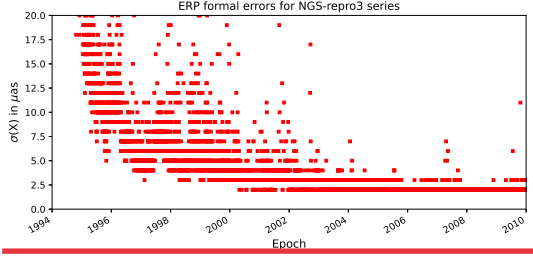


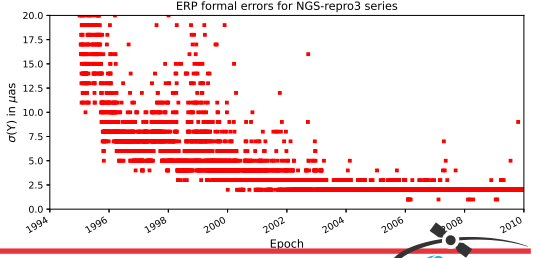


ERP series from ACs repro3 solution, compared to C04(20)

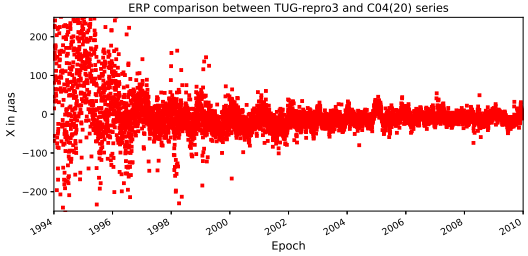


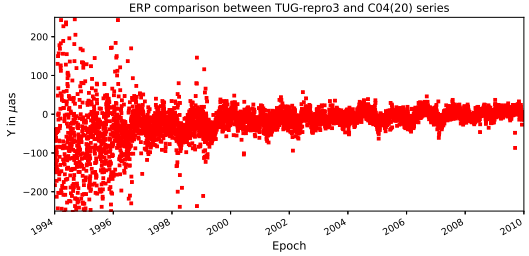


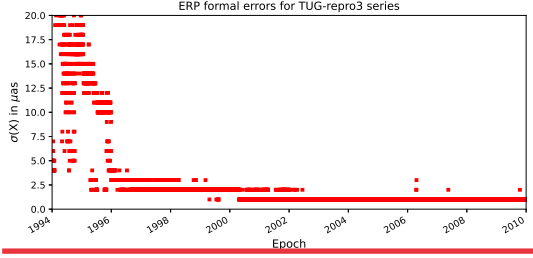


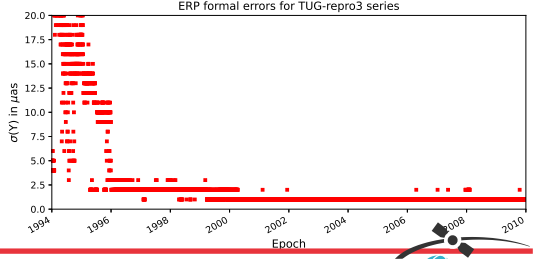


ERP series from ACs repro3 solution, compared to C04(20)









Evaluation of repro3 ERP series

Orbit modelling issues with historic GPS satellites

Time periods when the observations to specific GPS-satellites have been downweighted because of modeling problems.

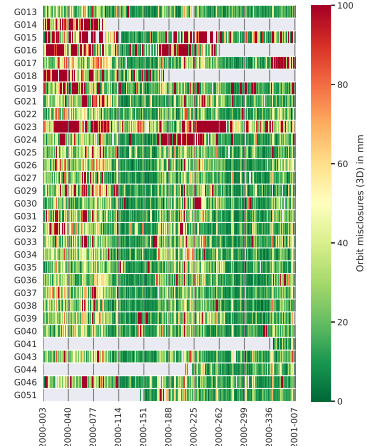
SVN	PRN	satellite active		downweighted	
13	02	1989-06-10	2004-05-13	2001-04-10	2003-06-03
14	14	1989-02-14	2000-04-16	1996-05-16	2000-04-16
15	15	1990-10-01	2007-03-14	1999-04-21	2003-01-02
16	16	1989-08-18	2000-10-14	1996-02-08	2000-10-14
17	17	1989-12-11	2005-02-24	2000-12-03	2003-07-16
18	18	1990-01-24	2000-08-19	1996-05-12	2000-08-19
19	19	1989-10-21	2001-09-12	1996-04-29	2001-09-12
21	21	1990-08-02	2003-01-28	2000-12-31	2003-01-28
23	23	1990-11-26	2004-02-17	1995-02-01	2002-01-02
24	24	1991-07-04	2011-10-01	1997-11-15	2004-07-11
29	29	1992-12-18	2007-10-24	2001-12-02	2007-10-24

Dach, R. et al. (2021). Review of recent GNSS modelling improvements based on CODEs Repro3 contribution. Advances in Space Research, Vol 68(3), pp 1263-1280. DOI 10.1016/j.asr.2021.04.046

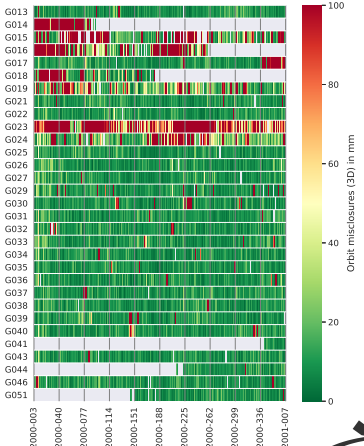
Orbit modelling issues with historic GPS satellites

Orbit misclosures from three-day solutions during the year 2000:

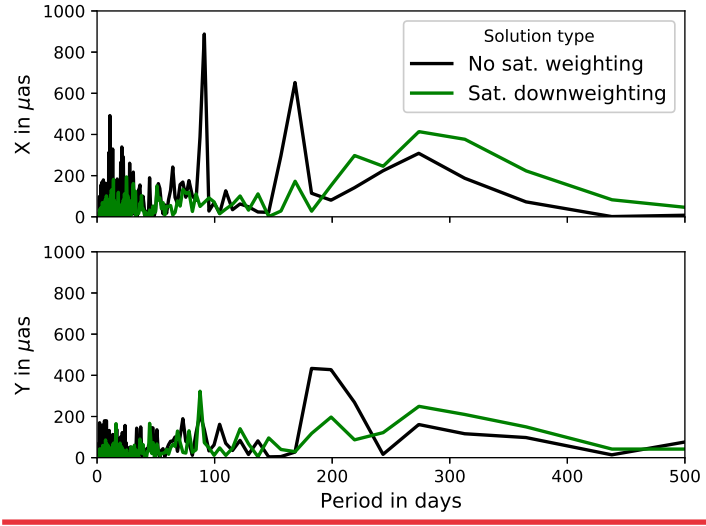
all satellites with the same weight



downweighting of degraded satellites enabled



Orbit modelling issues with historic GPS satellites



Power spectrum of the differences between the estimated polar motion series and the reference series C04(14) for 1997-2002.

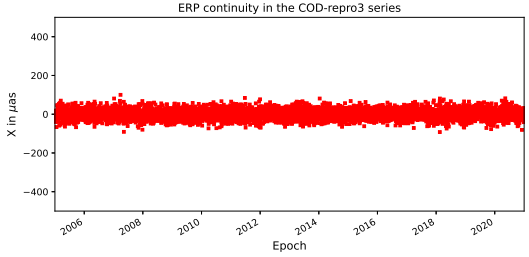
Evaluation of repro3 ERP series

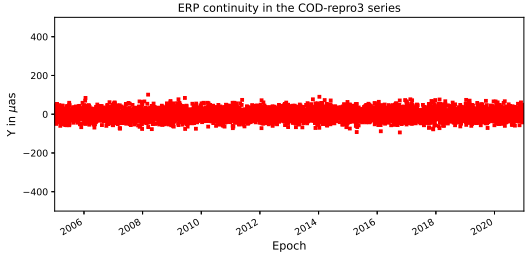
Continuity in ERP series from ACs repro3 solution

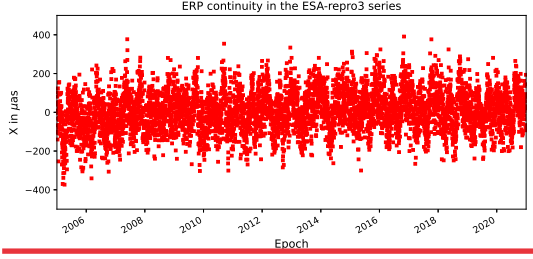
On option to assess the polar motion performance without a reference series is to compute the discontinuities of the polar motion series as proposed by Kouba (2003; `https://doi.org/10.1023/A:1026338601516`): "Testing of the IERS2000 sub-daily Earth rotation parameter model":

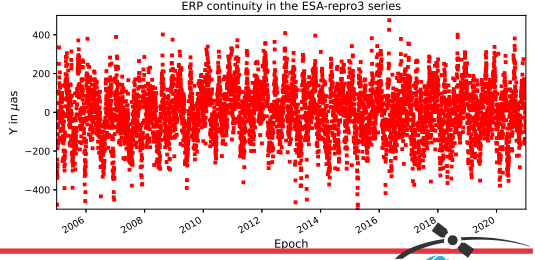
$$X(t_{i+0.5}) = X(t_{i+1}) - X(t_i) - \frac{Xrt(t_{i+1}) + Xrt(t_i)}{2} \quad (1)$$

Continuity in ERP series from ACs repro3 solution

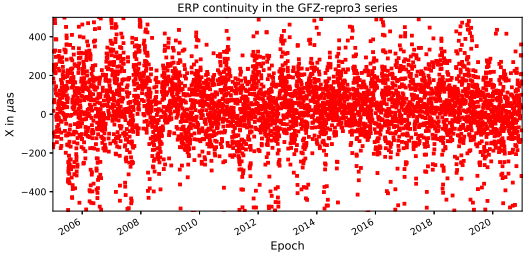


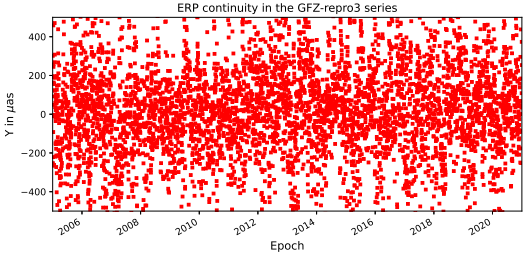


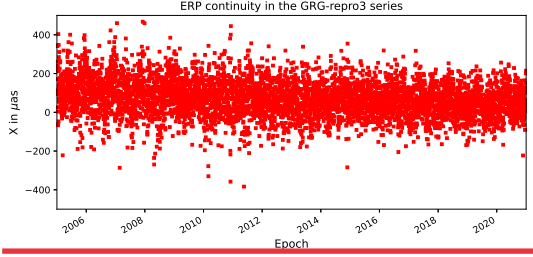


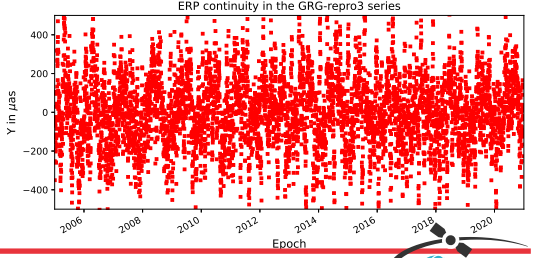


Continuity in ERP series from ACs repro3 solution

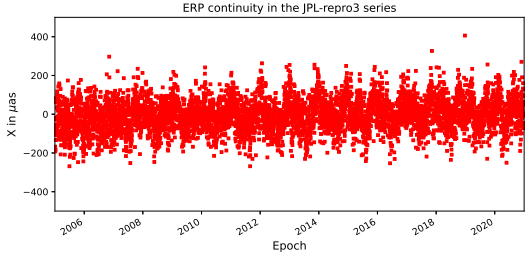


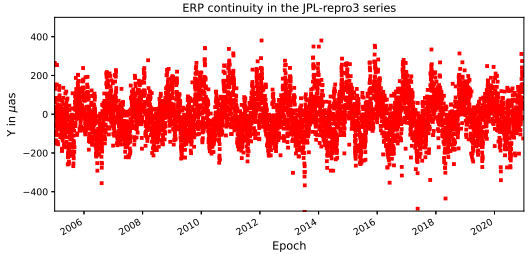


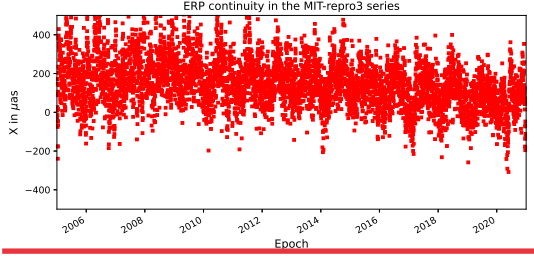


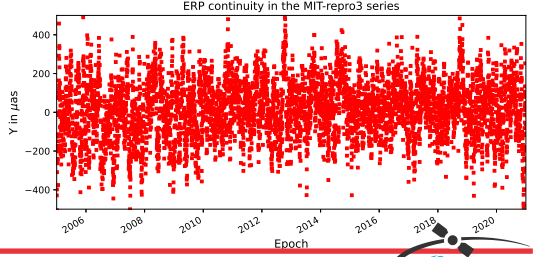


Continuity in ERP series from ACs repro3 solution

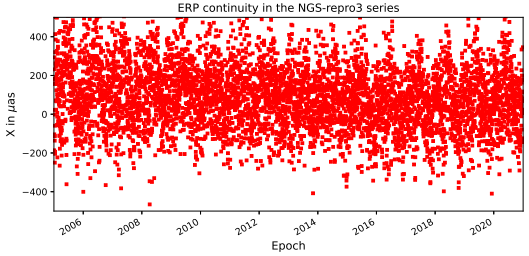


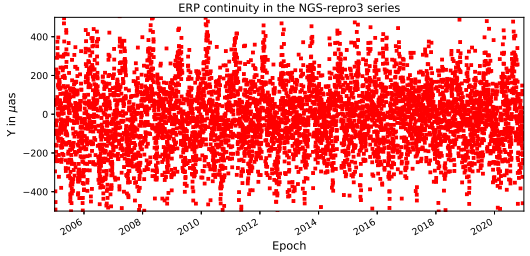


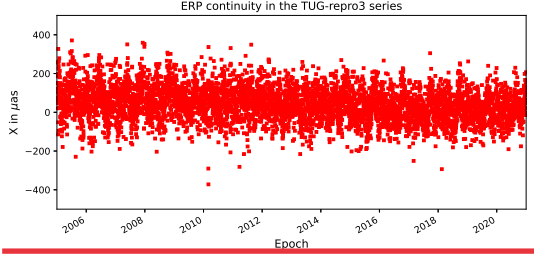


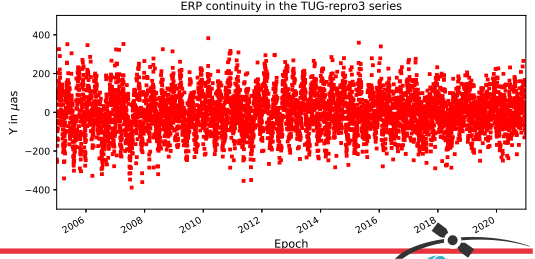


Continuity in ERP series from ACs repro3 solution

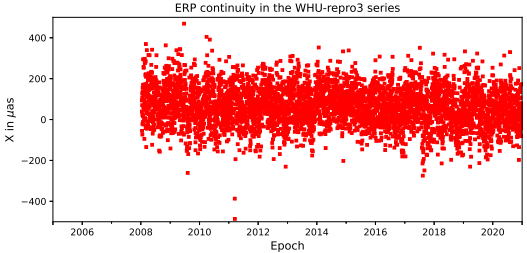


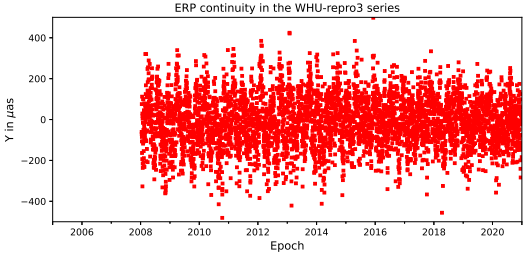




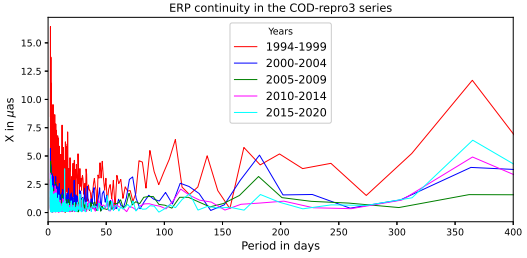


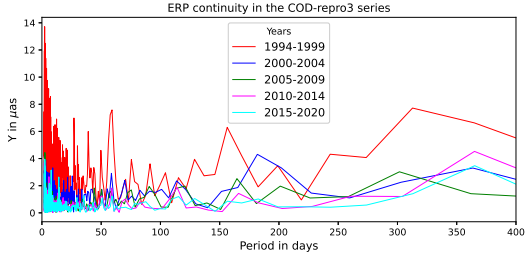
Continuity in ERP series from ACs repro3 solution

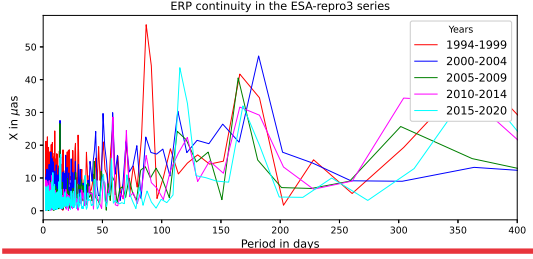


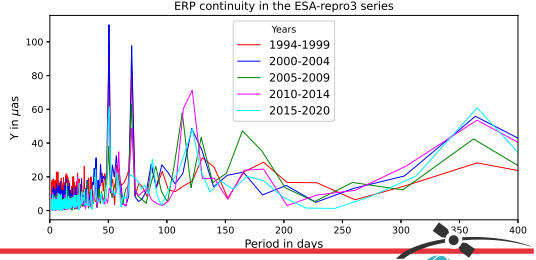


Continuity in ERP series from ACs repro3 solution

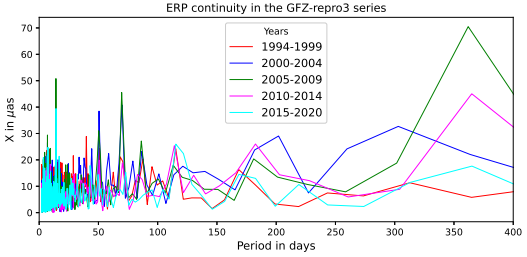


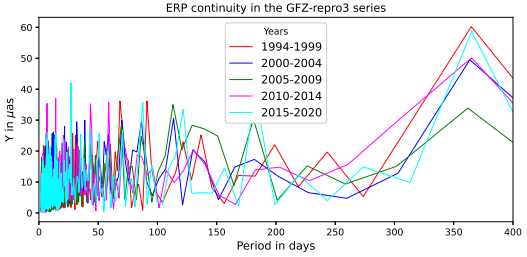


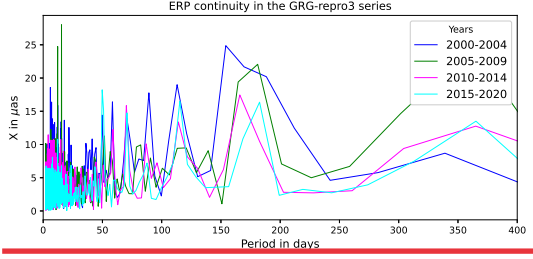


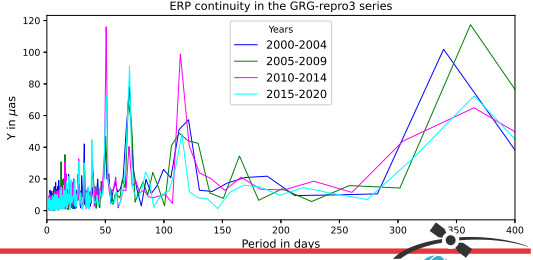


Continuity in ERP series from ACs repro3 solution









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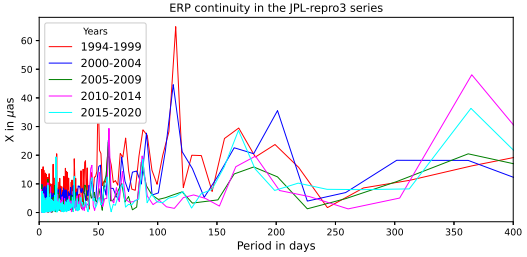
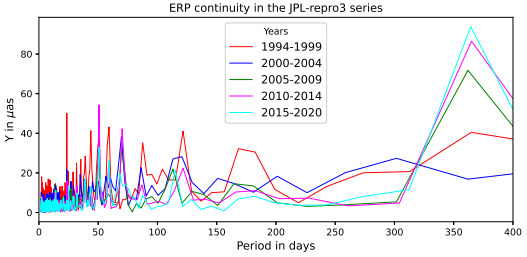
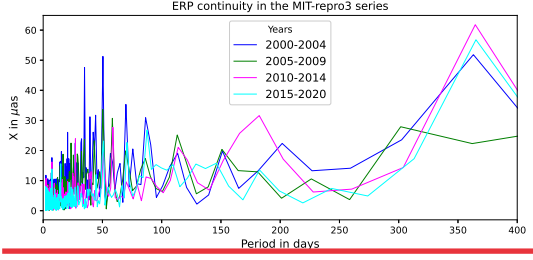
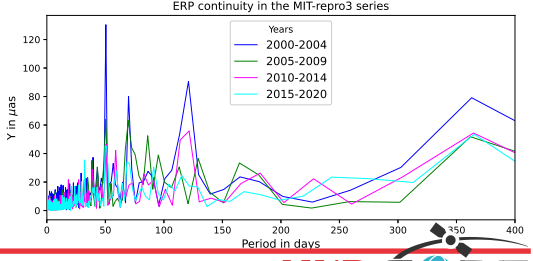
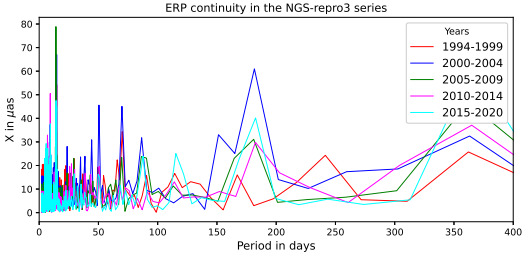


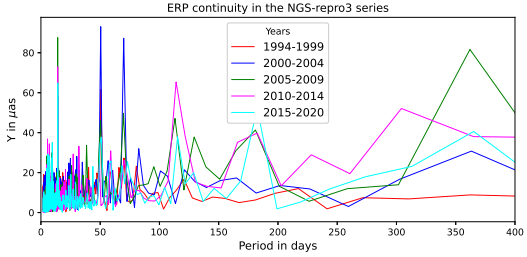


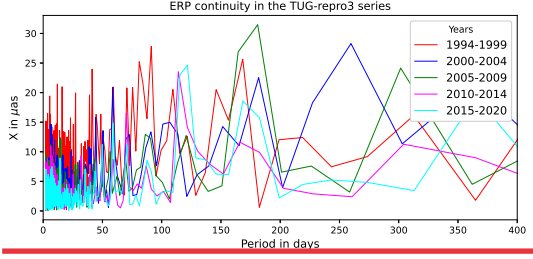


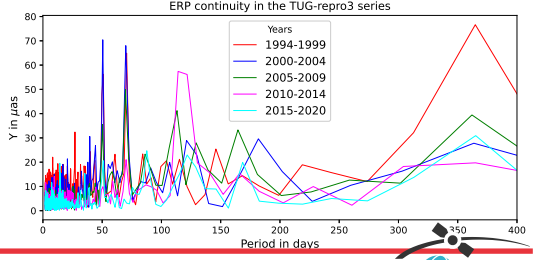


Continuity in ERP series from ACs repro3 solution

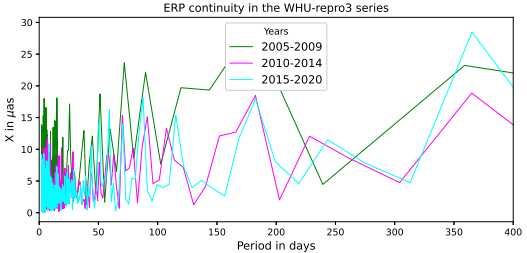


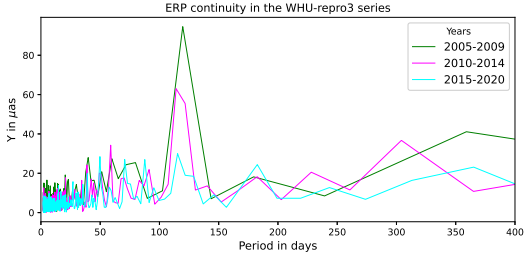






Continuity in ERP series from ACs repro3 solution





Summary

- The agreement of the polar motion estimates from the different AC series agree on a very different level with the C04(20) series.
- Periodic (annual) signals may be detected in some of the AC series (differently in X- and Y-pole; and for different sub periods).
- In many of the ERP series we find the epoch when additional GNSS are added.
- Theoretically the contribution from the geometry (satellite constellations, station-/observation distribution) can be assessed via the formal error. The values in the ERP-files are unfortunately not very meaningful.

Summary

- The general opinion is that the polar motion rates cannot be provided by daily GNSS solutions.
- This is confirmed with the AC series provided for repro3.
- The rates of the polar motion components correspond to the stability of the quasi-inertial frame used for the orbit modelling.
- Consequences for the orbit modelling and potential ways out of this problem have been presented by Beutler et al., (2016): "Estimation of polar motion, polar motion rates, and GNSS orbits in the IGS". IGS Workshop 2016, Sydney, Australia, 8-12 February, 2016 (URL: `http://www.bernese.unibe.ch/publist/2016/pres/W2016-PY0305-Beutler.pdf`)

THANK YOU

for your attention

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