ESA's Earth Rotation Parameter Service

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Outline

- Motivation
- Overview of the ESA Earth Rotation Service
  - ERP estimation process
  - ERP prediction
  - Operational setup
- Evaluation of products
- Future perspectives
- Conclusions

ESA’s Navigation Support Office.

ESA’s Navigation Support Office is responsible for providing an independent reference in Europe for precise navigation.

- Providing precise navigation for GNSS and spacecrafts in different orbital regimes (ranging from LEO to HEO).
- Providing the geodetic reference for ESA missions, and acting as Coordinator of the Galileo Reference Service Provider (GRSP) to provide the Geodetic reference and corresponding EOP’s to Galileo.
- Providing the operational time for ESA’s missions
- Operating a global network of navigation real-time sensor stations

ESA’s Navigation Support Office. Why ERP predictions?

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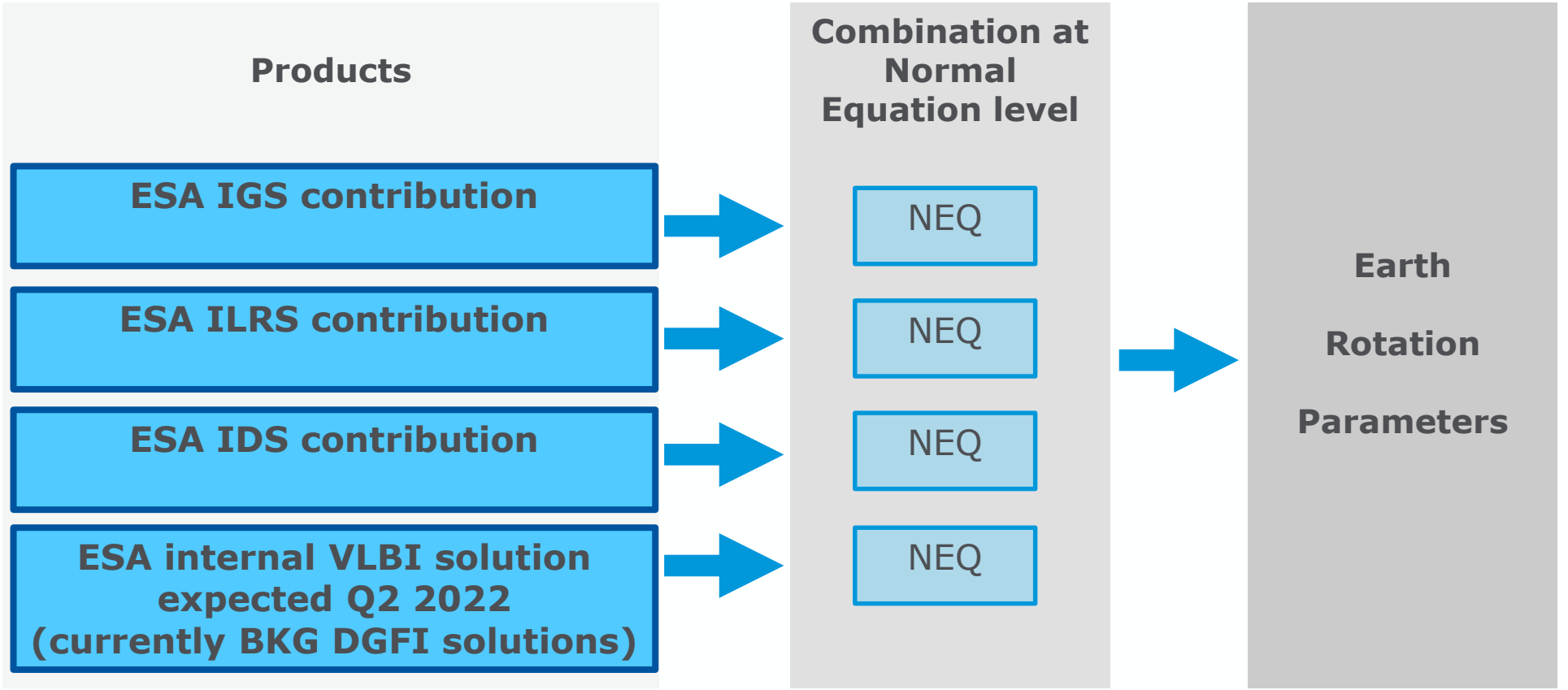
ESA’s Navigation Support Office will provide an independent solution for the Earth Rotation Parameters (ERPs) in order to ensure the unrestricted access to space for ESA, EC and European industry.

  - ESA is still relying on a single non European provider for ERP products.
  - All the required input geodetic products are generated by ESA. ESA routinely contributes as an official AC to IGS, ILRS and IDS; the analysis capability of VLBI data is also being finalized.

ESA approach to ERP estimation

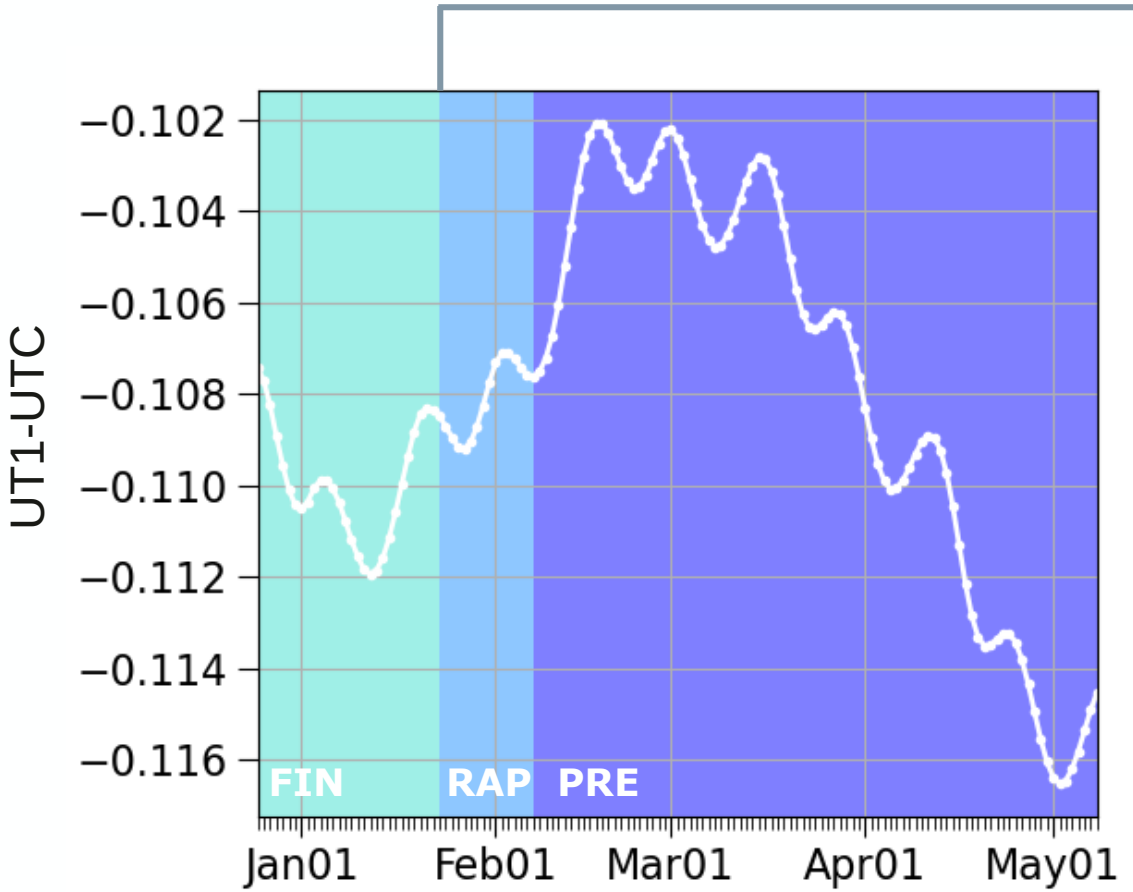


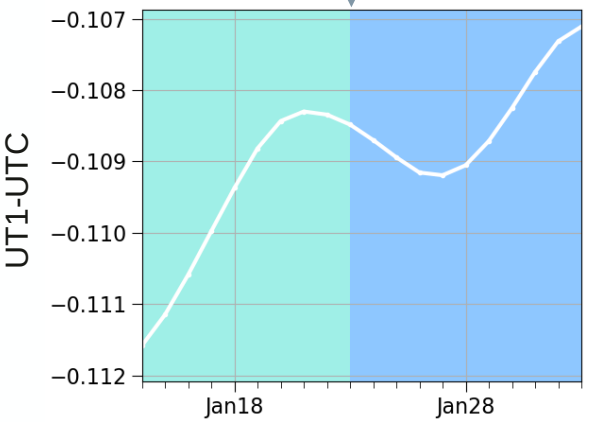
Advantages:

- Highest consistency: same software and models used in the data analysis
- The combination at NEQ level allows to take correlations into account

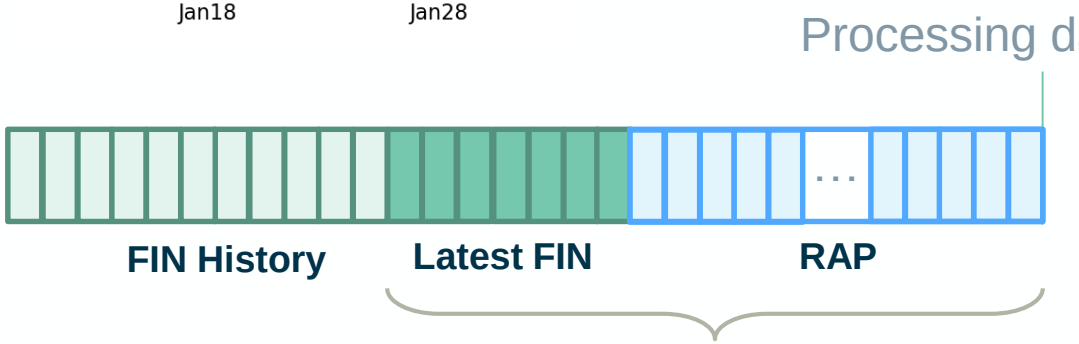
Transition between final and rapid estimates

Depending on the geodetic products used in the combinations, ERP estimates are provided either as final solutions (high accuracy, latency of a few weeks), or as rapid solutions (lower accuracy, short latency).
The processing ensures a seamless transition between final and rapid values.





Close up on the transition between FIN and RAP values

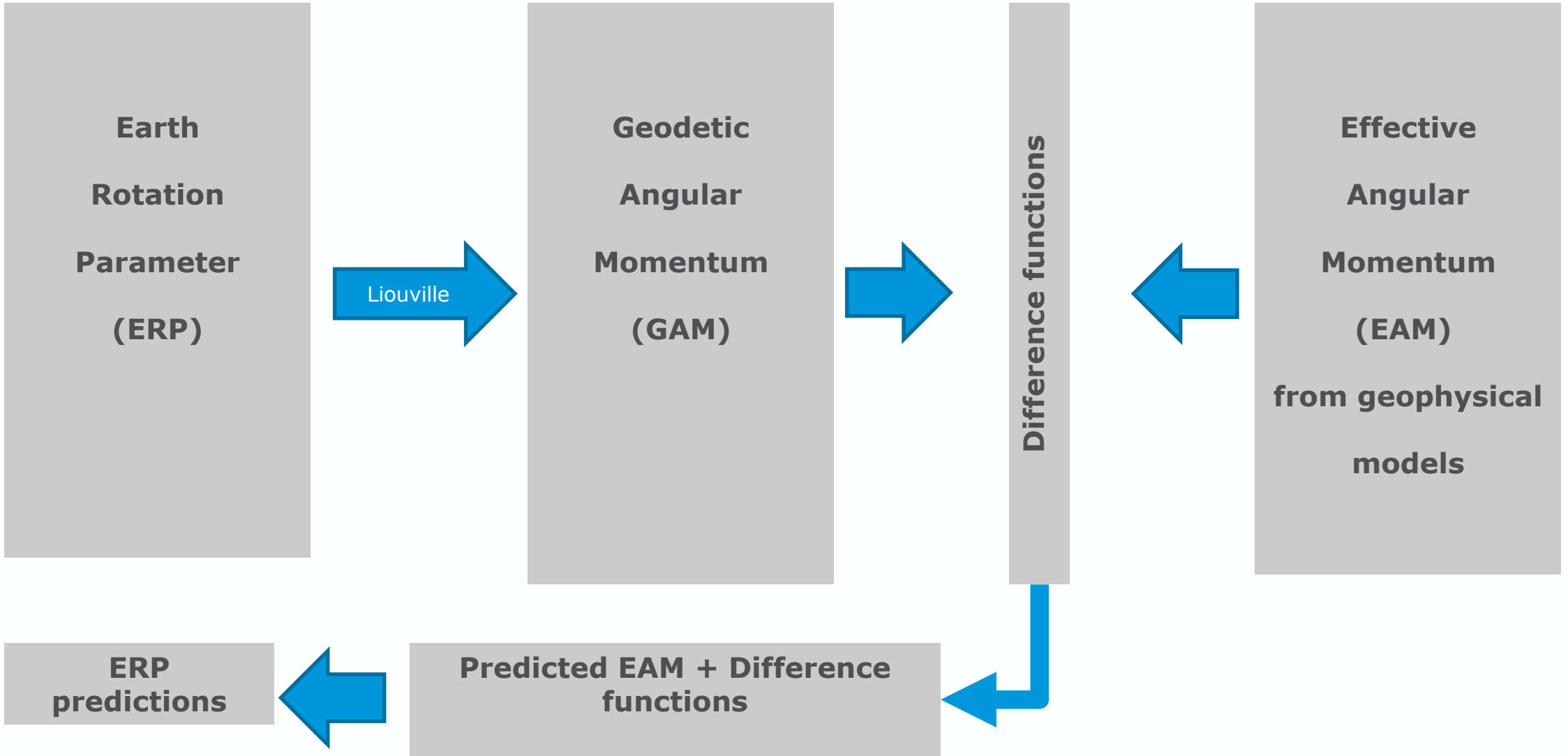


ESA approach to ERP prediction

ERP predictions are based on three contributions:

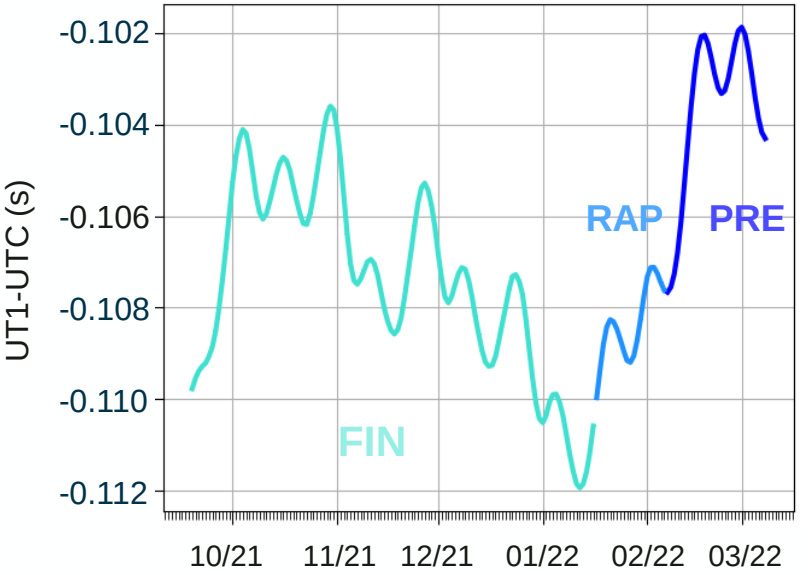
- A substantial portion of the variability of the ERP can be predicted by classical least-squares extrapolation (LS). Since linear trends and signals at annual and semiannual frequencies are found to be largely deterministic, they are estimated over a number of years from a final combination series. The obtained amplitudes and phases are subsequently used for extrapolation into the future.
- Auto-regressive (AR) modelling is used to describe the high-frequency variability in EOP induced by non-tidal atmosphere and ocean dynamics. Such models are tuned to realistically reproduce short-period oscillations with periods shorter than 100 days.
- Forecasted Effective Angular Momentum (EAM) functions are used for the prediction of stochastically irregular variations generated by the atmospheric (AAM), oceanic (OAM), and hydrological (HAM) dynamics. EAM functions are typically calculated from mass distributions and mass motion as given by atmospheric, oceanic, and hydrological models

ESA approach to ERP predictions



ESA's ERP Software Operation

- Operational setup
  - **Final estimates (FIN)** computed every Monday (+ 11-week reprocessing on Saturdays)
  - **Rapid estimates (RAP)** and **predictions (PRE)** generated/updated twice per day at 11:00 and 23:00 (official daily solution) UTC
  - Extra run on Wednesdays at 19:00 UTC to generate the contribution to the PCC



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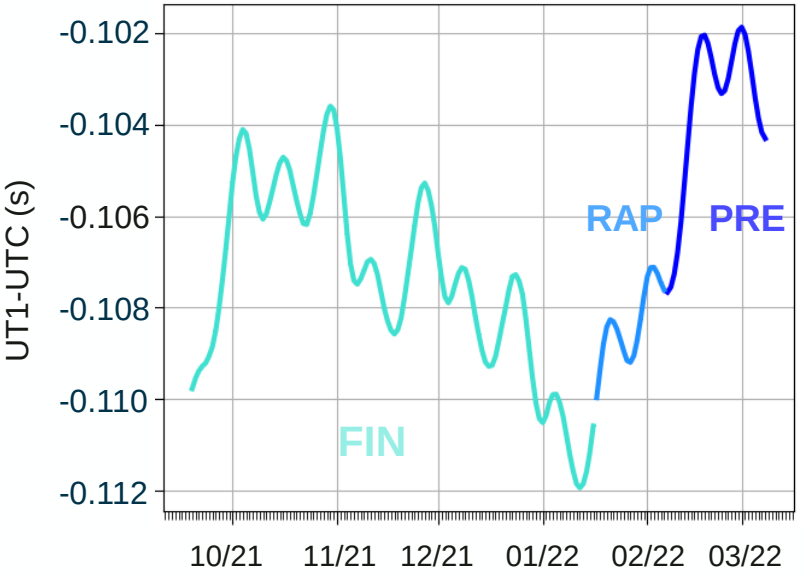

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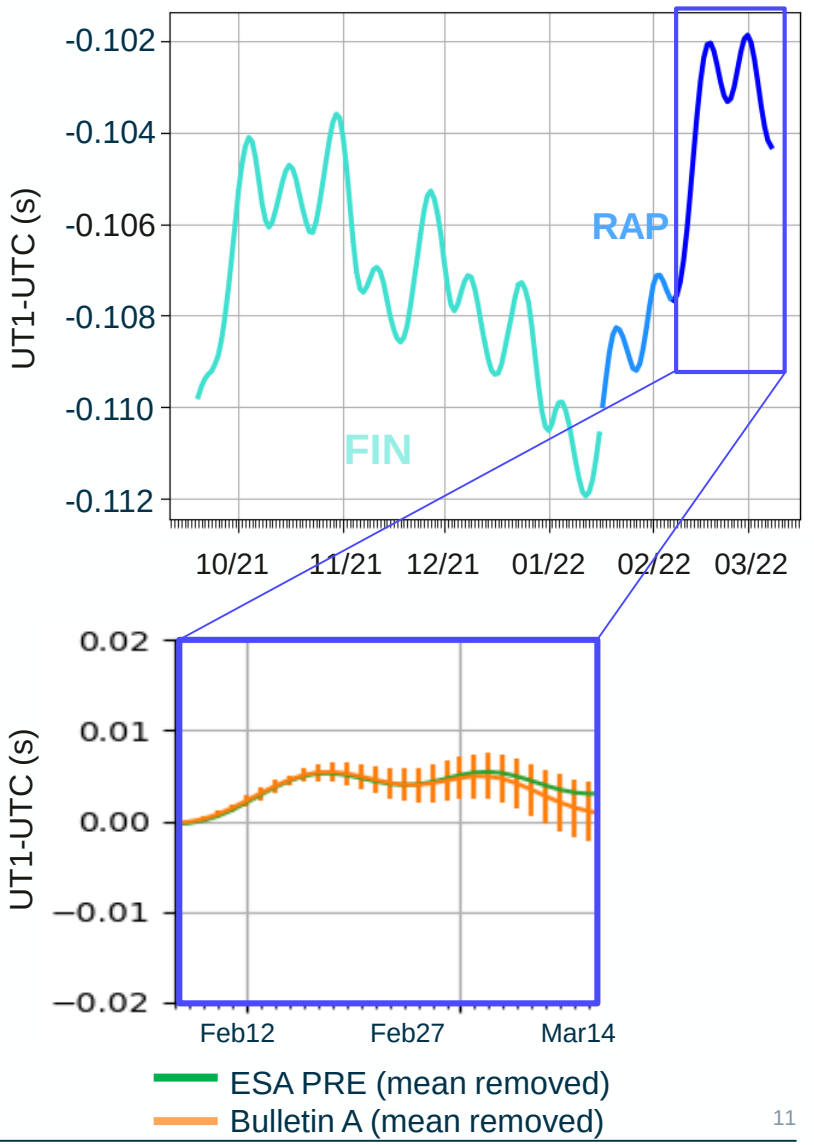
- Monitoring system
  - Check daily performance: time stability + comparison with external products
  - Assess prediction accuracy



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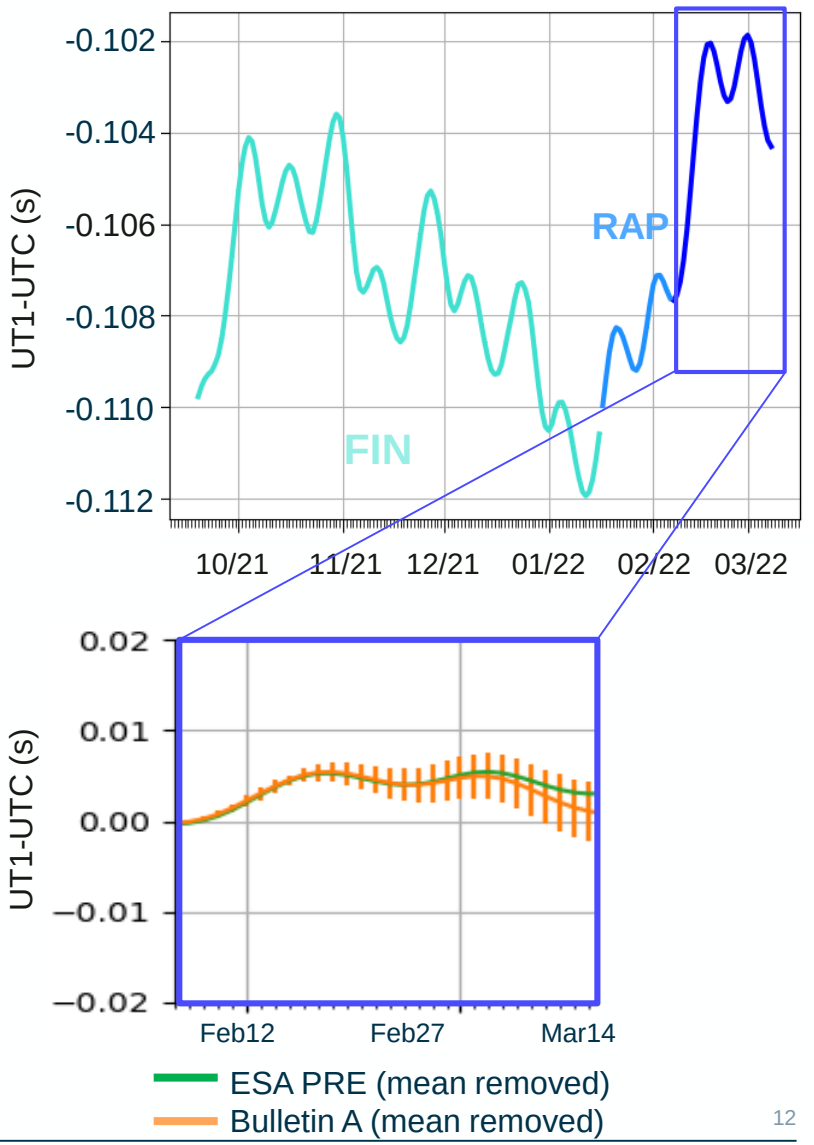
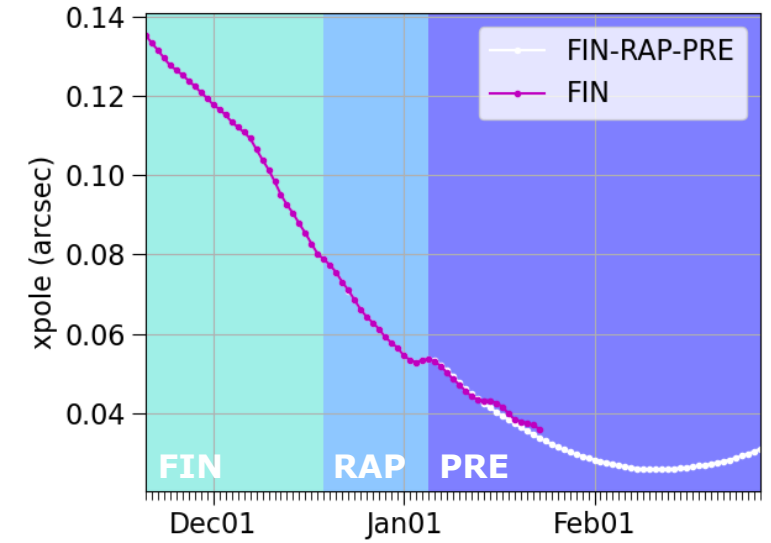
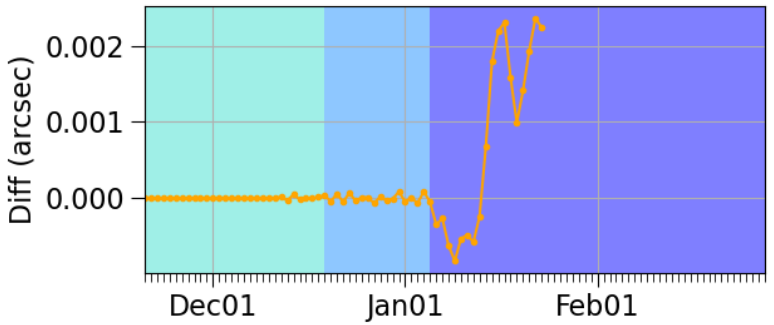
  - Assess prediction accuracy
- Testing environment
  - Test software configurations before deployment in operational baseline

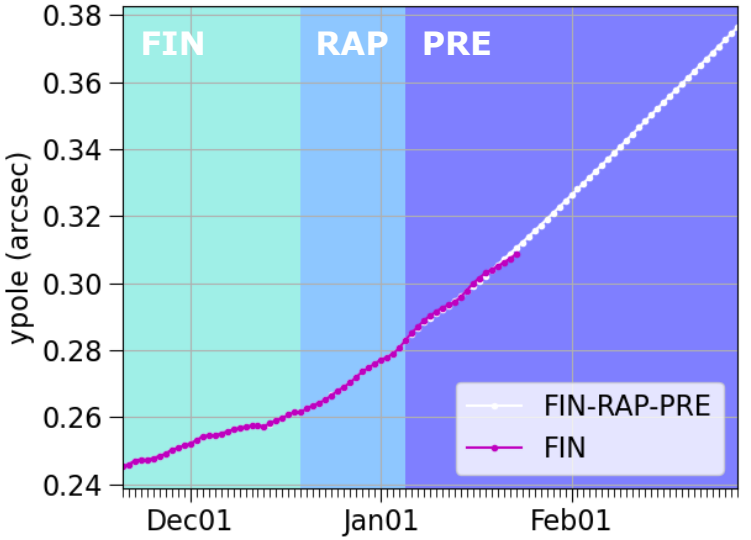


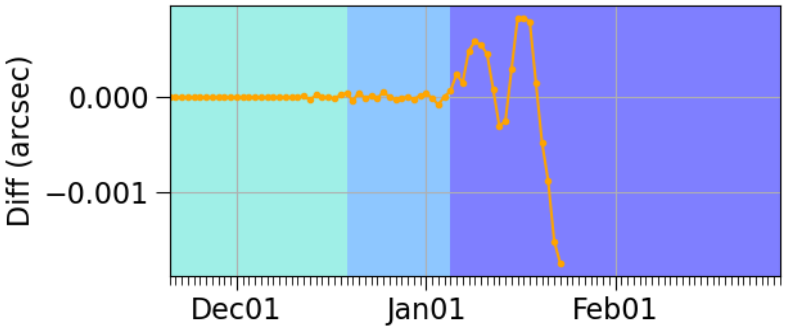
Comparison between two ESA EOP files

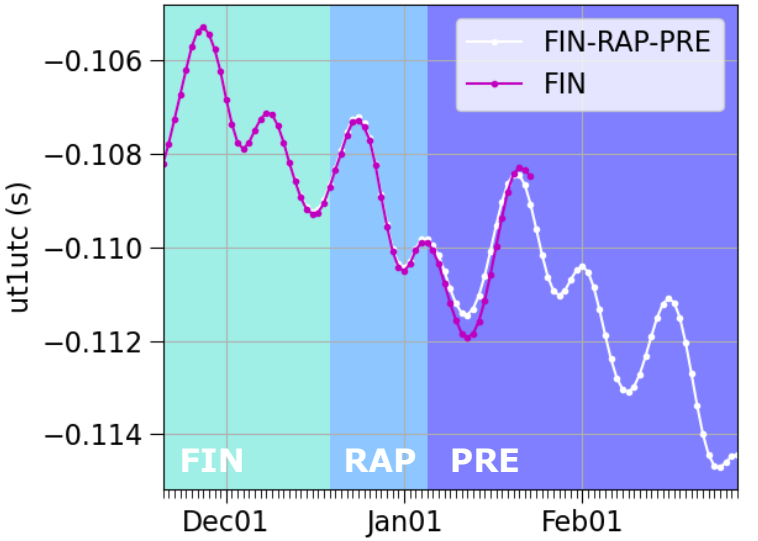
Comparison of FIN-RAP-PRE results generated on January 5th 2022 (submission to PCC) vs FIN results available as of February 8th 2022.

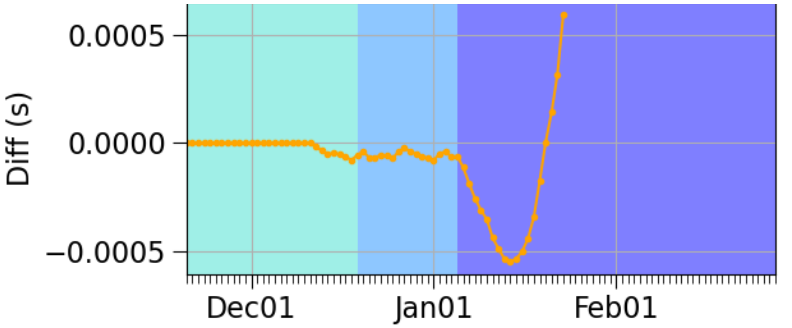




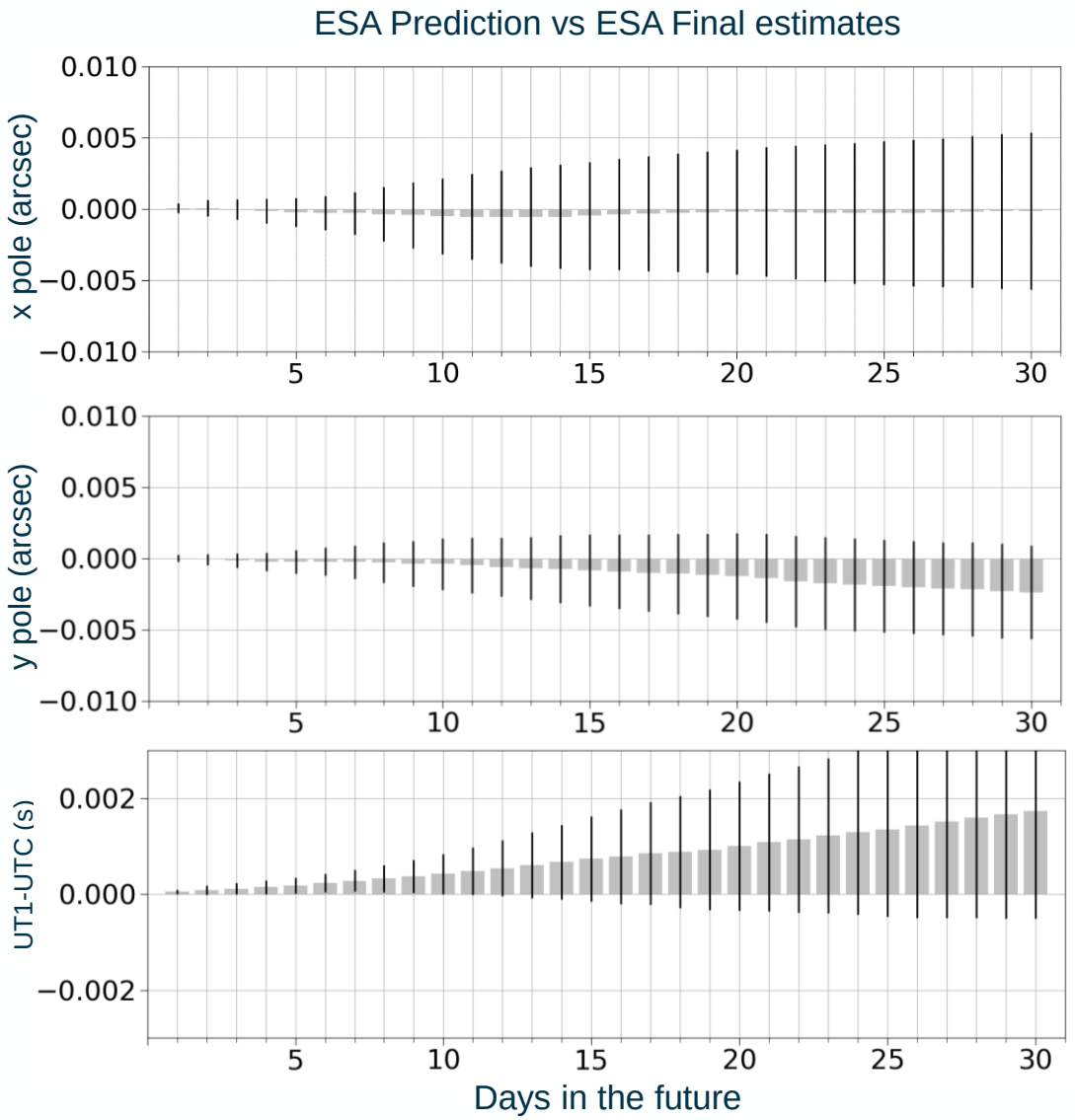








Results



Histogram bars: average discrepancy between predicted and estimated values for predictions up to 30 days into the future

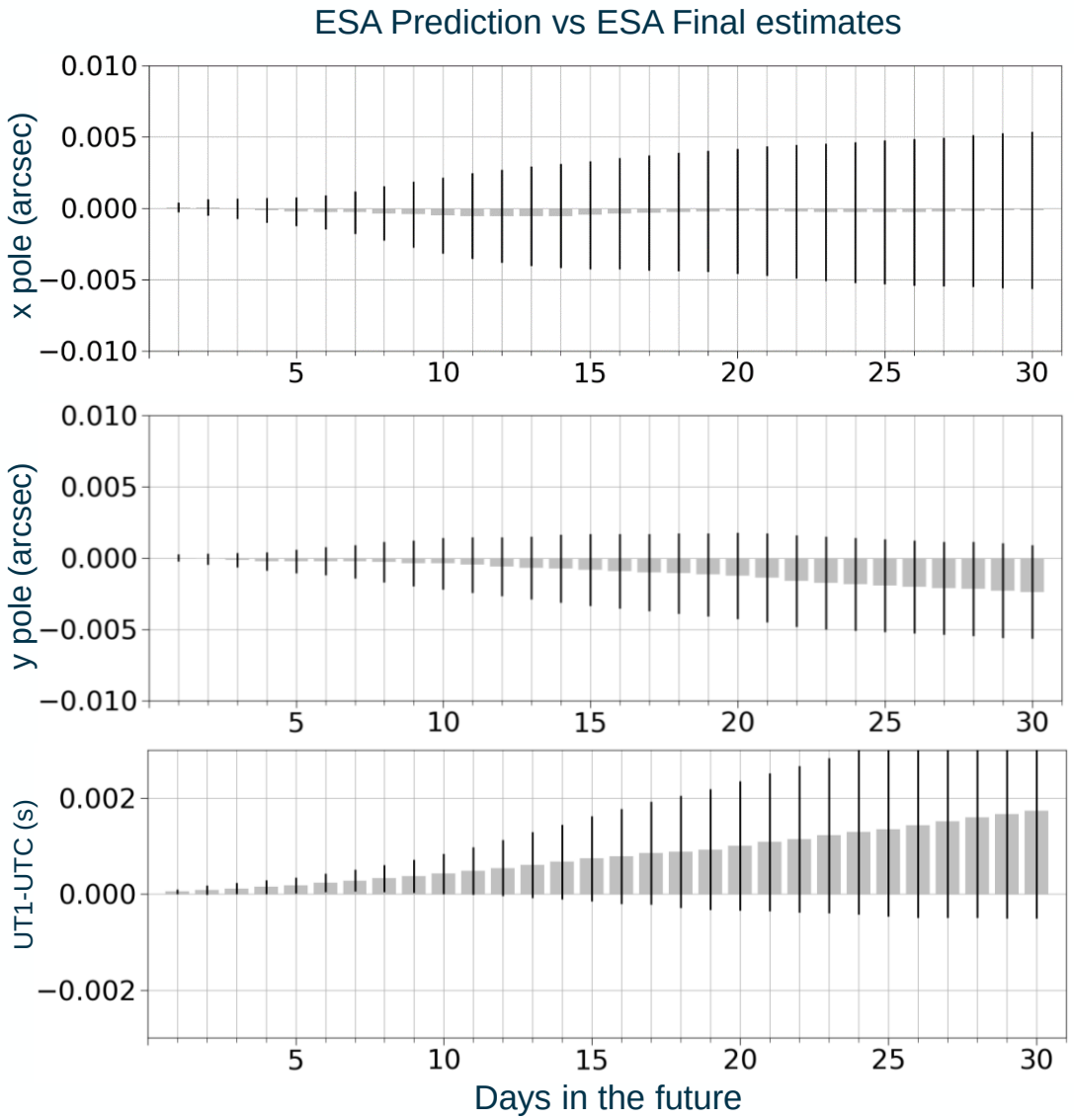
Whiskers: standard deviation of the discrepancies

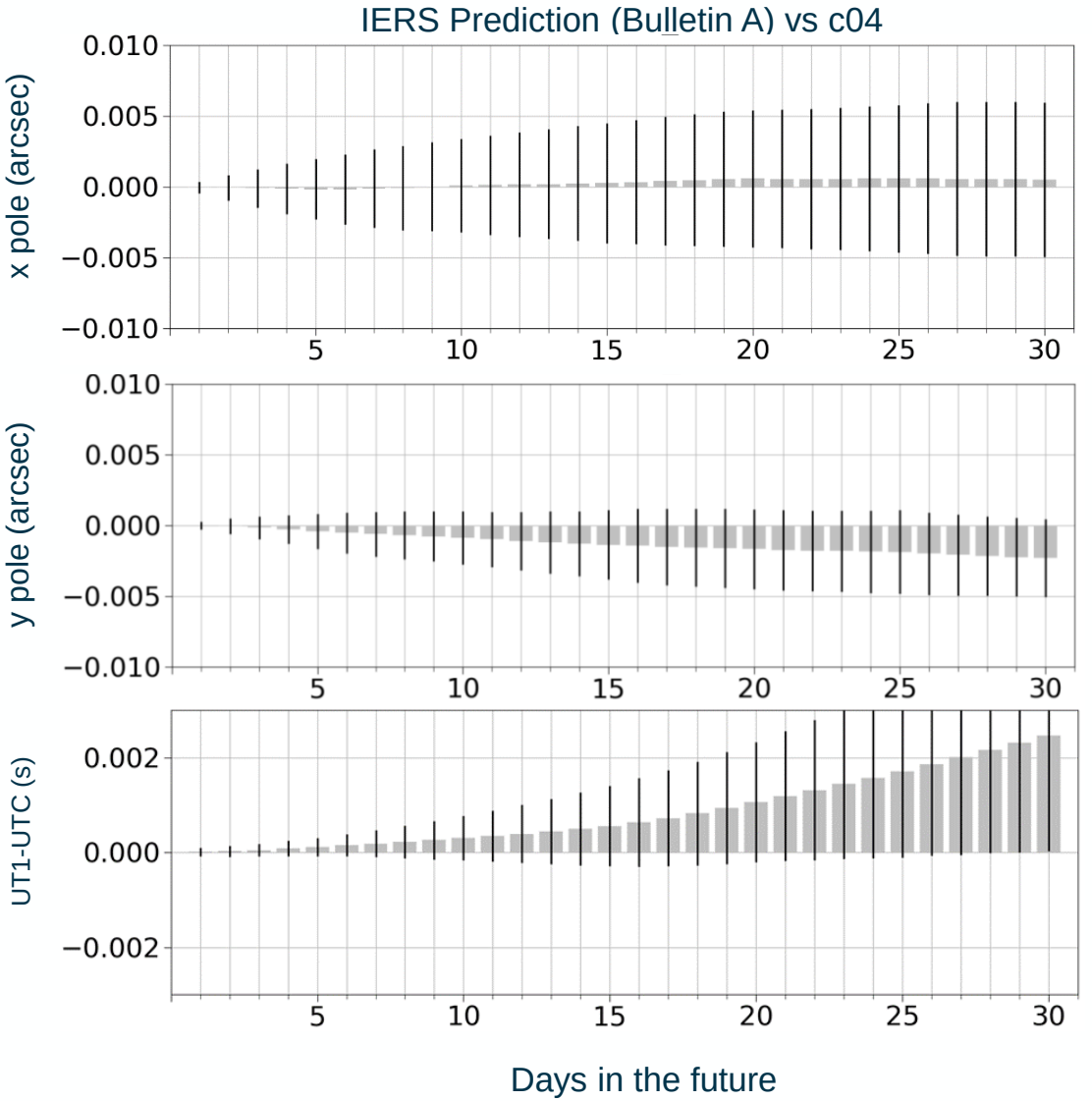
Results refer to the processing chain started on 16/09/2021. Results may vary over time.

	PRE-FIN mean and std for *n* days into the future						
	n=1	n=7	n=15	n=30	n=45	n=60	n=90
x pole (arcsec)	6.9E-05	-3.4E-04	-5.1E-04	-1.3E-04	-7.1E-04	-2.3E-03	1.5E-03
	3.6E-04	1.5E-03	3.8E-03	5.5E-03	5.4E-03	4.8E-03	6.1E-03
y pole (arcsec)	2.1E-05	-2.5E-04	-8.7E-04	-2.4E-03	-4.0E-03	-5.3E-03	-1.0E-02
	2.6E-04	1.1E-03	2.5E-03	3.2E-03	1.6E-03	3.4E-03	1.3E-03
UT1-UTC (s)	5.0E-05	2.9E-04	7.4E-04	1.8E-03	1.9E-03	2.4E-03	5.7E-03
	5.1E-05	2.2E-04	8.5E-04	2.2E-03	2.3E-03	1.6E-03	2.9E-03

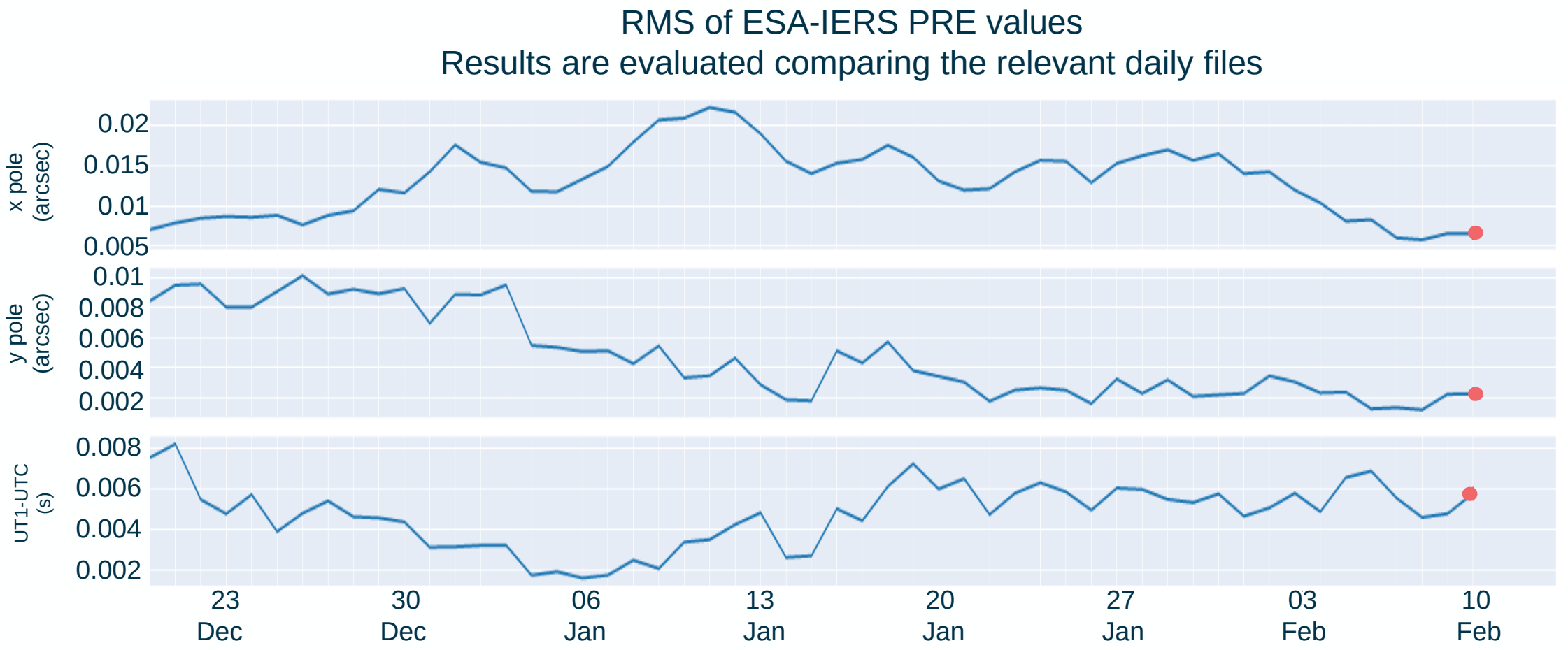
The statistics reported in this table are computed as the average of random samples of 25 PRE-FIN values

Results – comparison with IERS Bulletin A



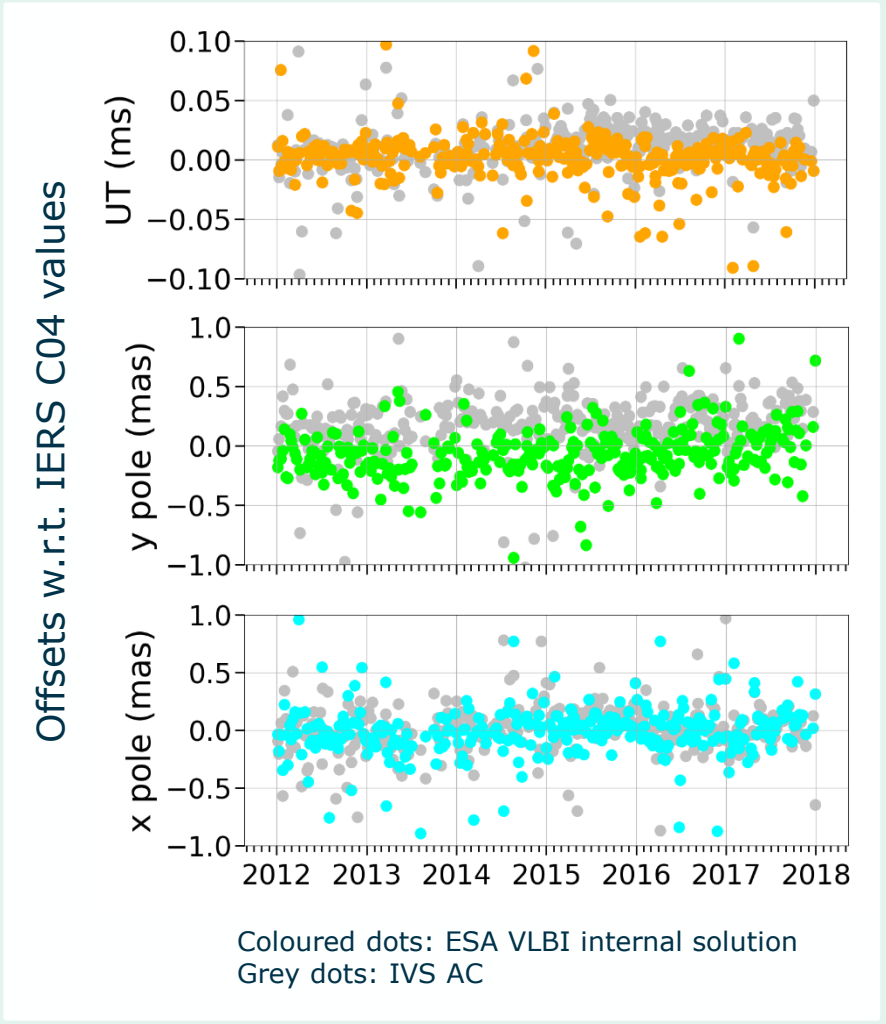


Comparison of ESA and Bulletin A PRE



Future perspectives

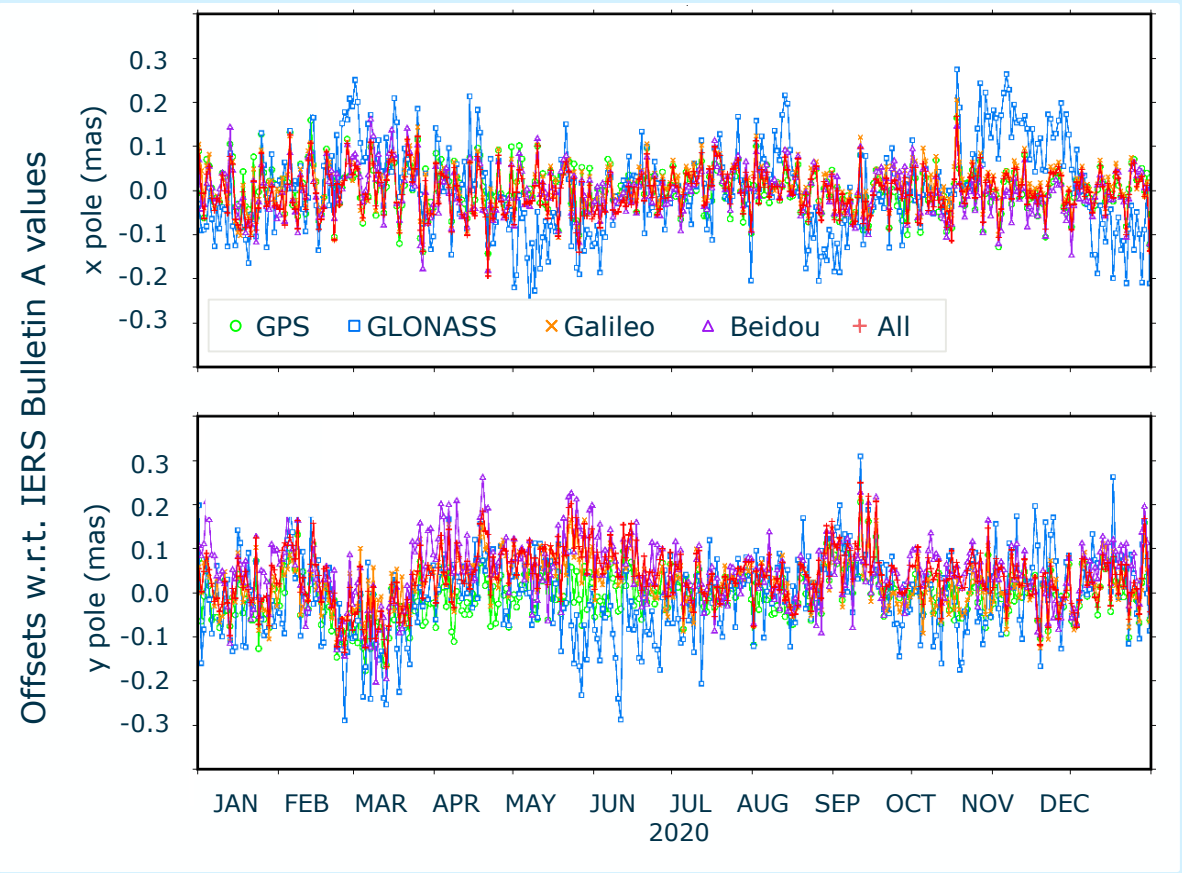
- Once operational, make use of ESA VLBI solution



Coloured dots: ESA VLBI internal solution
Grey dots: IVS AC

- Optimise SLR solution e.g. adding Stella, Starlette, and Ajisai

- Make use of ESA multiGNSS solution



Conclusions

- ESA's Navigation Support Office intends to provide independent products and services for the Earth Rotation Parameters in the second half of 2022.

- ESA's independent ERP products and services will ensure the unrestricted access to space for ESA, EC and European industry.

- ESA's ERP software provides excellent initial results. The accuracy of 1d PRE is better than 0.5 marcsec for x_{pole} and y_{pole} and 50 µs for UT1-UTC. The accuracy of PRE at 90 days is degraded by 1-to-2 orders of magnitude depending on the investigated time frame.

- The processing will soon include also the ESA VLBI solution, to ensure the highest possible consistency among all geodetic input products.

- In the future, the performance of the software might benefit from optimized products, such as the ESA multiGNSS solution or an extended ESA SLR solution including Stella, Starlette, and Ajisai

Acknowledgments

- The core of the ESA's Earth Rotation Parameter generation and prediction software was developed by a Consortium led by DGFI (DGFI, BKG, TU Munich, GFZ, TU Wien) in the frame of an ESA contract study activity.
- The OPS/GN team integrated the software prototype in the ESA/ESOC infrastructure and developed the additional functionalities to ensure operational capability.

Thank you for your attention!

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