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On the geometry of baselines suitable for UT1 estimation with VLBI Intensive sessions

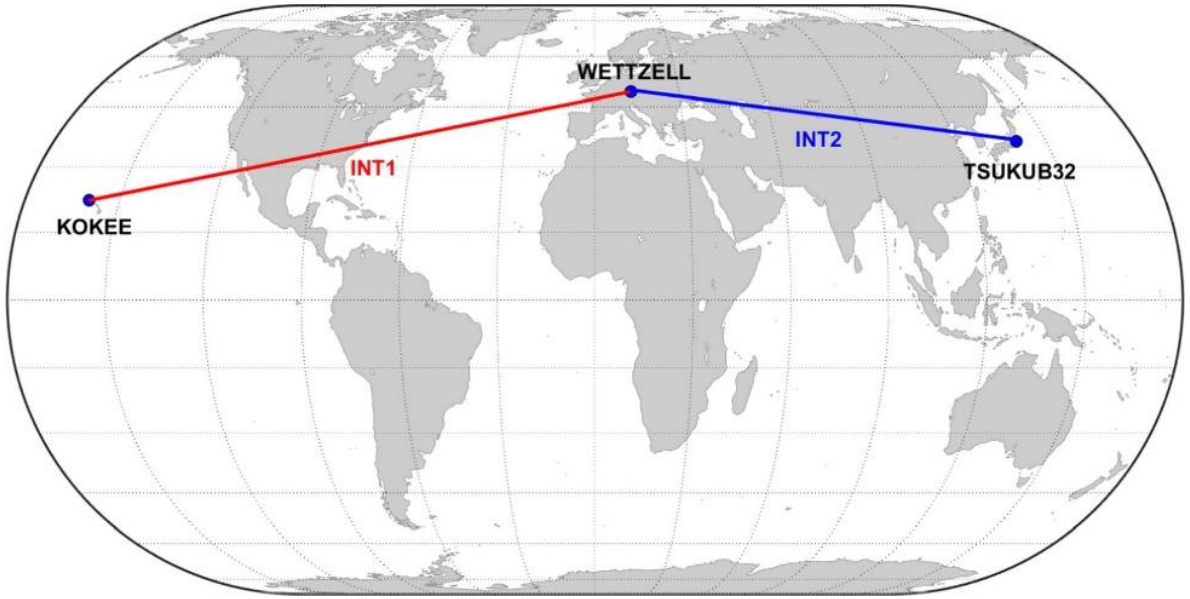
Lisa Kern • Axel Nothnagel • Johannes Böhm
Technische Universität Wien, Austria

Matthias Schartner • Benedikt Soja
ETH Zürich, Switzerland

VLBI Intensive sessions

- **1 hour single baseline sessions dedicated to derive UT1-UTC**

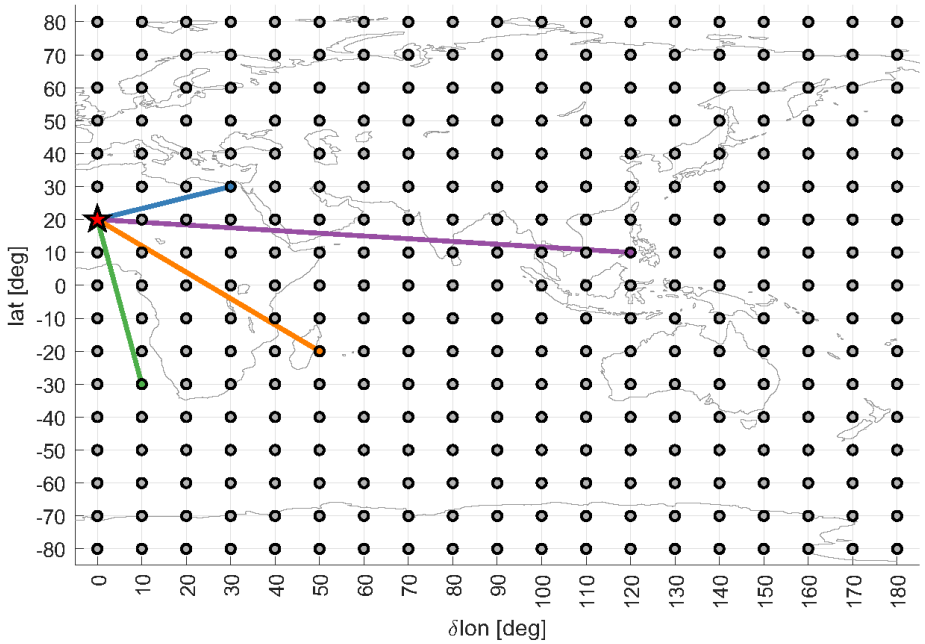
- goal: identifying the **optimal VLBI baseline geometry**

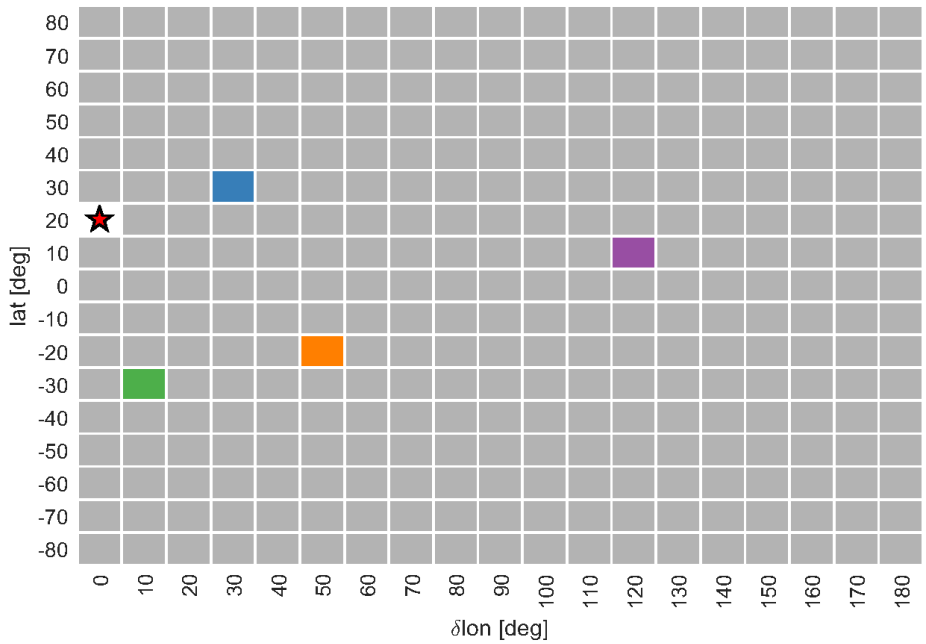


Landskron and Böhm (2019)

Experiment setup

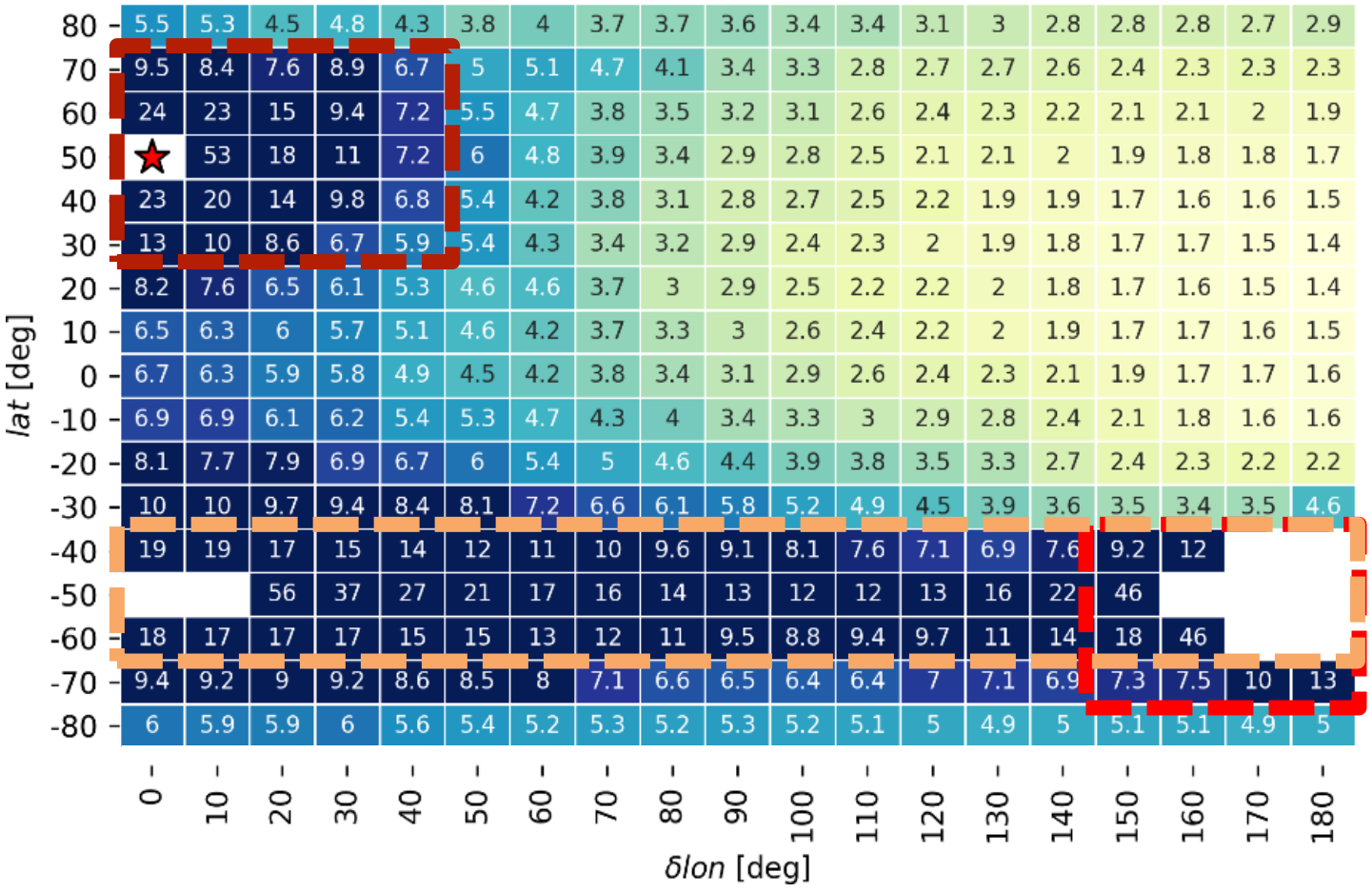
- **artificial VGOS stations placed on a 10° x 10° global grid**
- **scheduling and simulation:**
  - almost 3000 baselines investigated
  - monthly schedules per baseline
  - **focus corner observations – scheduling approach** *(Uunila et al., 2012) (Baver and Gipson, 2015)*





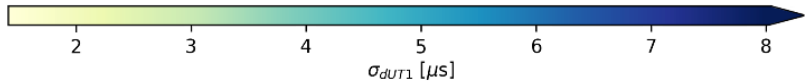
reference station

Optimal VLBI baseline geometry



- high $\bar{\sigma}_{dUT1}$
  - short baselines
  - very long baselines
  - baseline orientation parallel to Earth rotation vector/ mid-point close to equator $lat1 + lat2 \approx 0$

reference station



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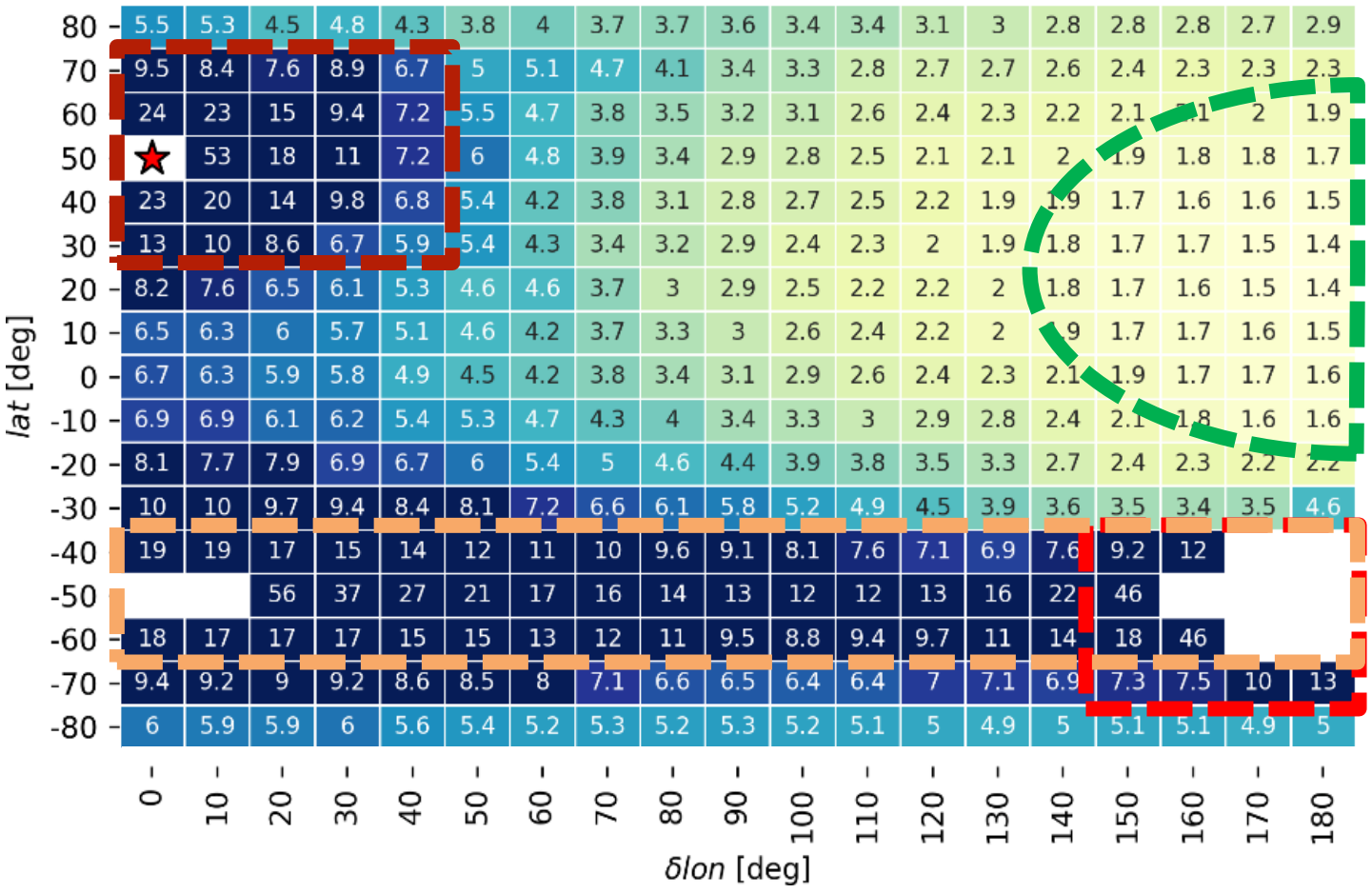
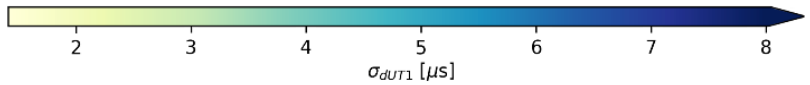


- high $\bar{\sigma}_{dUT1}$
  - short baselines
  - very long baselines
  - baseline orientation parallel to Earth rotation vector/ mid-point close to equator $lat1 + lat2 \approx 0$
- optimal baselines
  - high-to-mid-lat and low-to-mid-lat baselines and large δlon

reference station



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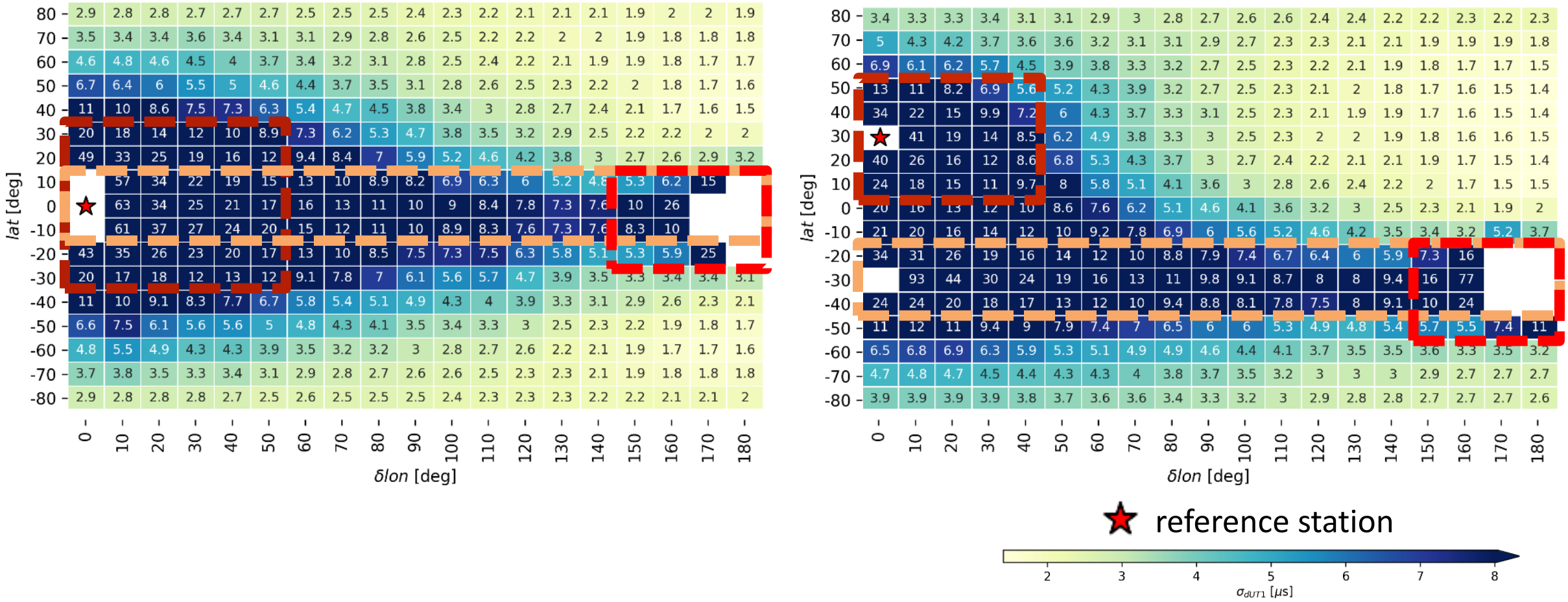

Schartner et al., 2021 – submitted to JOGE

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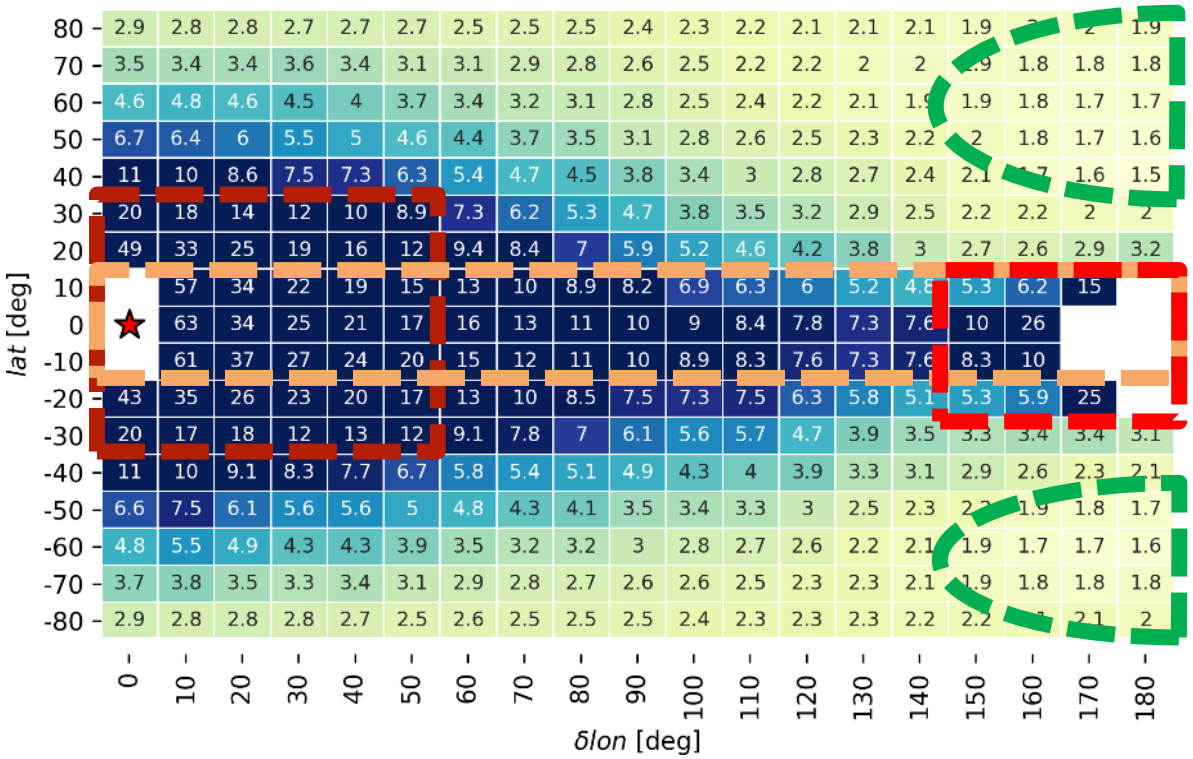

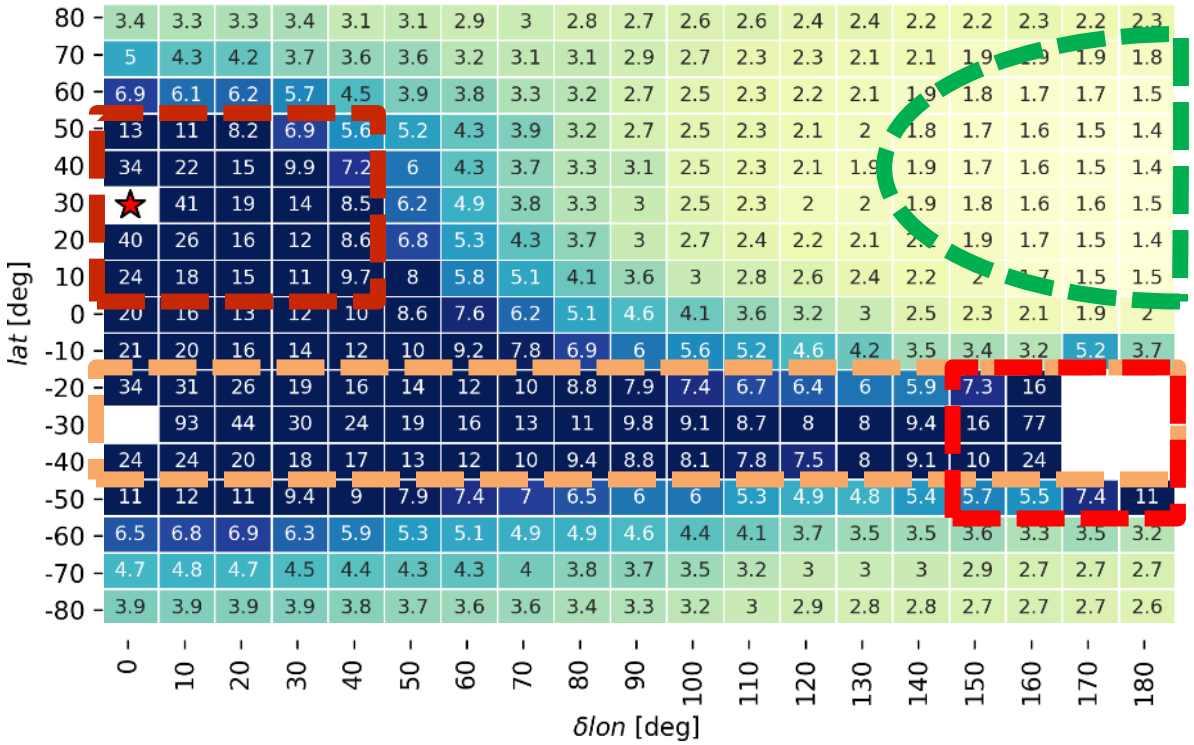

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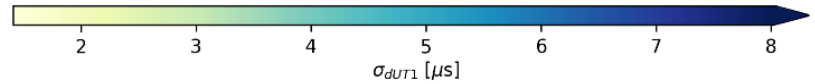

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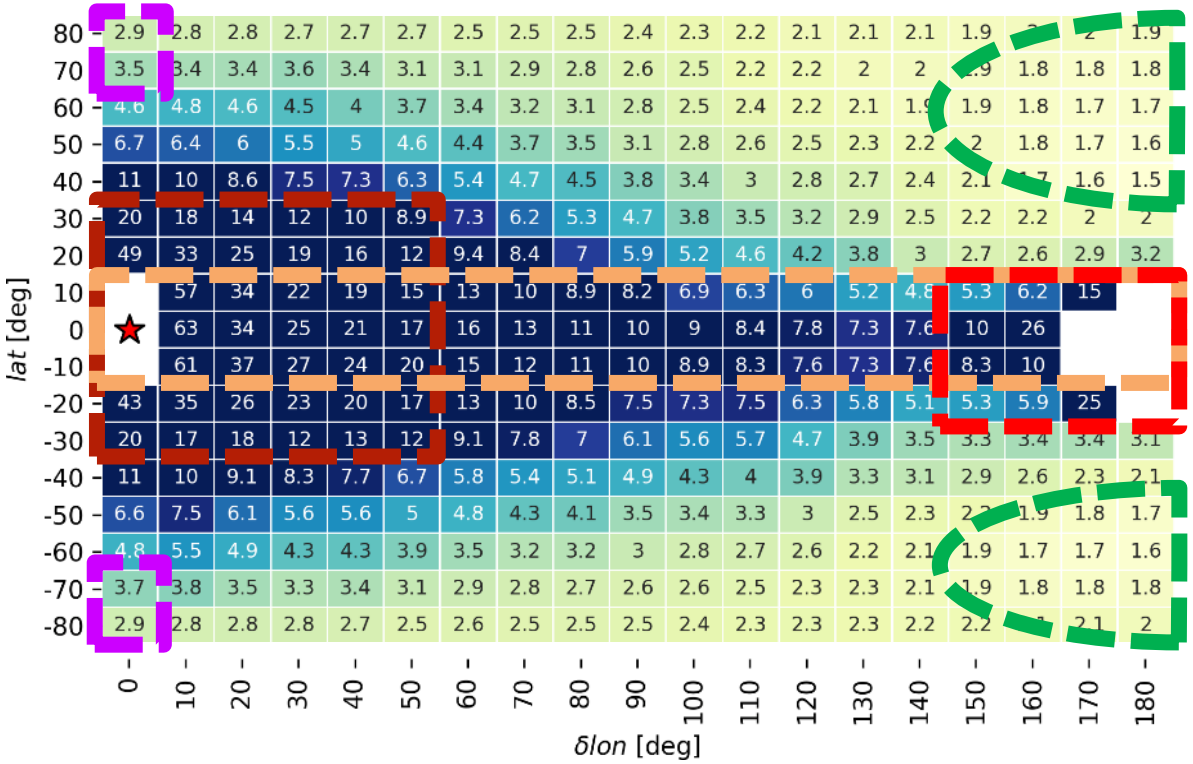
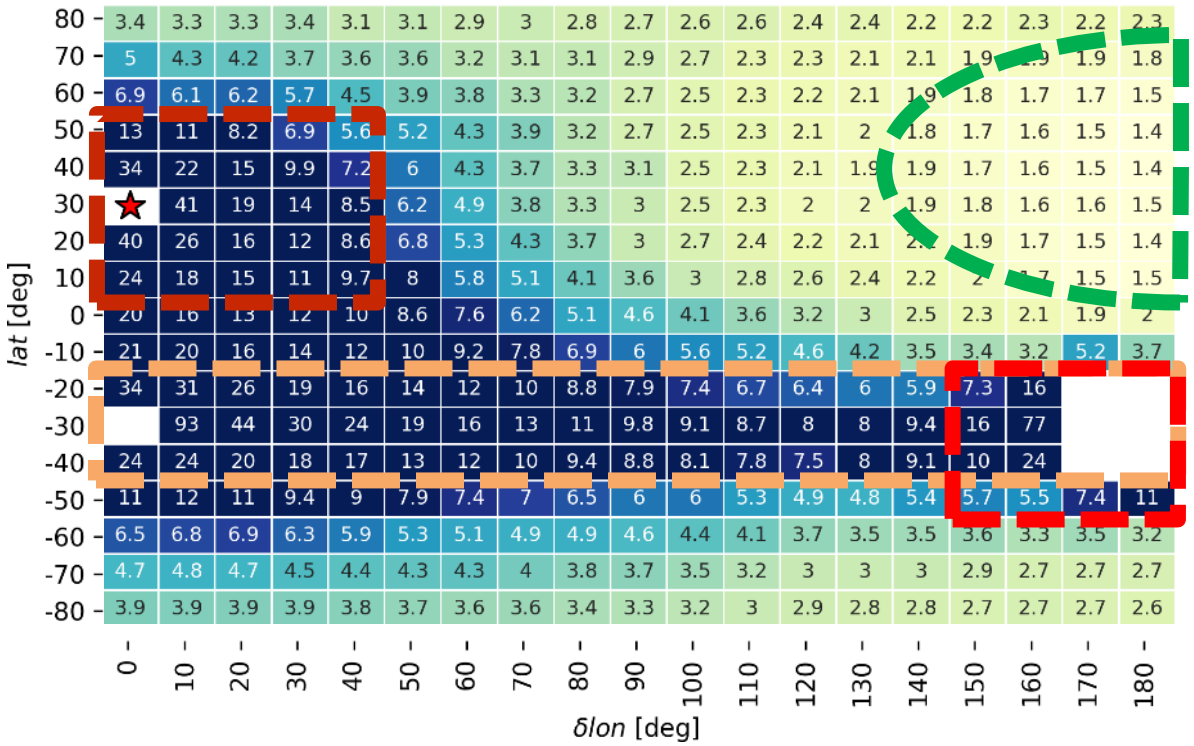


N-S oriented baselines (only 50% worse compared to the most perfect baseline!)



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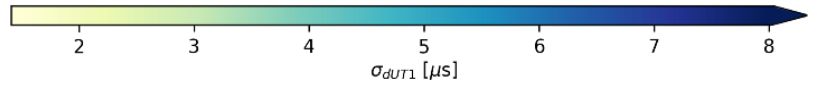
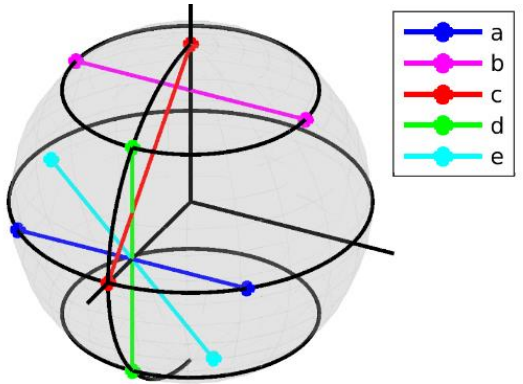
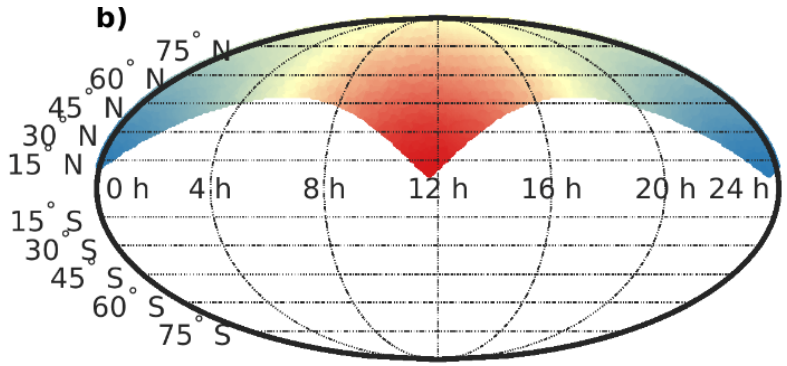
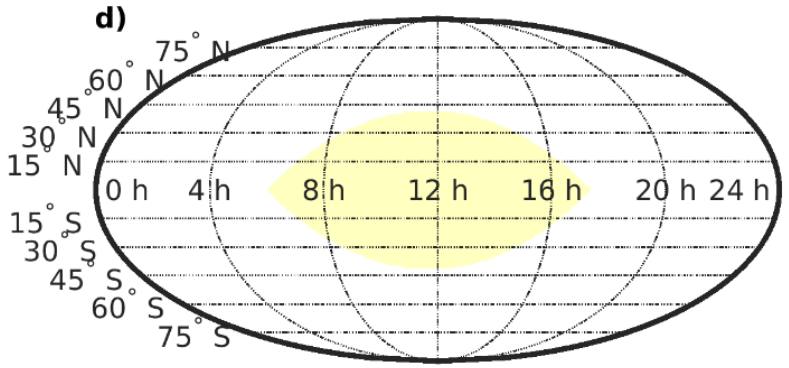
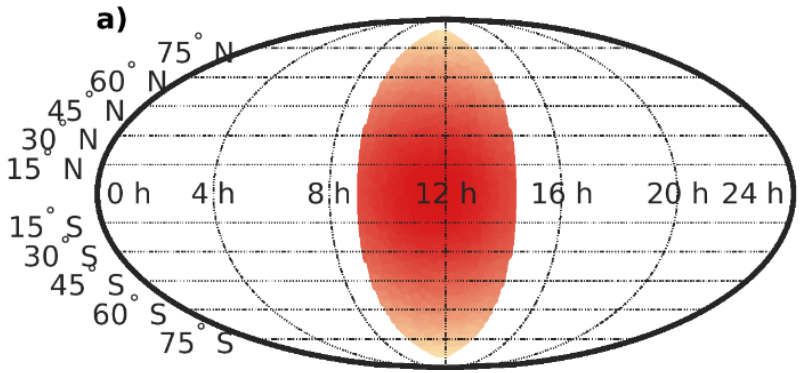


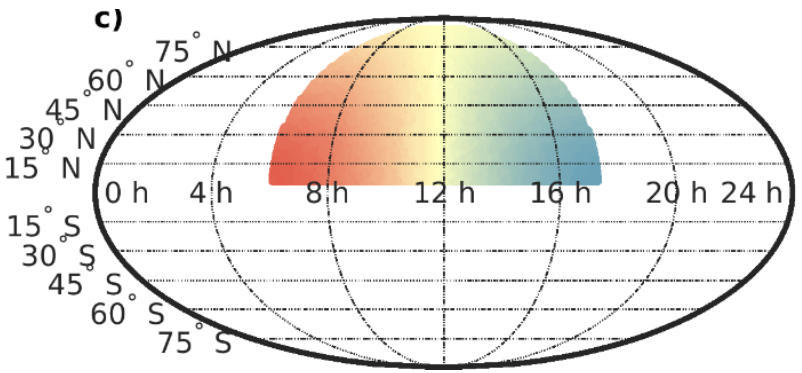
Partial derivative

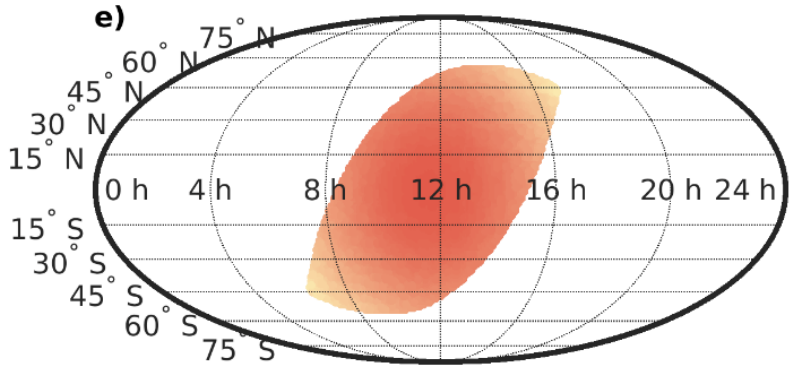


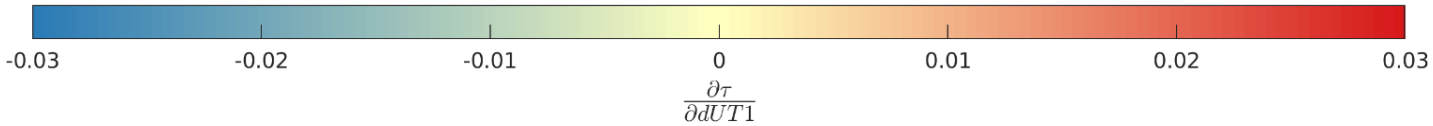






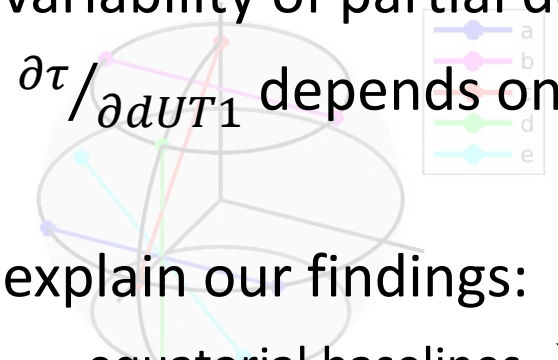






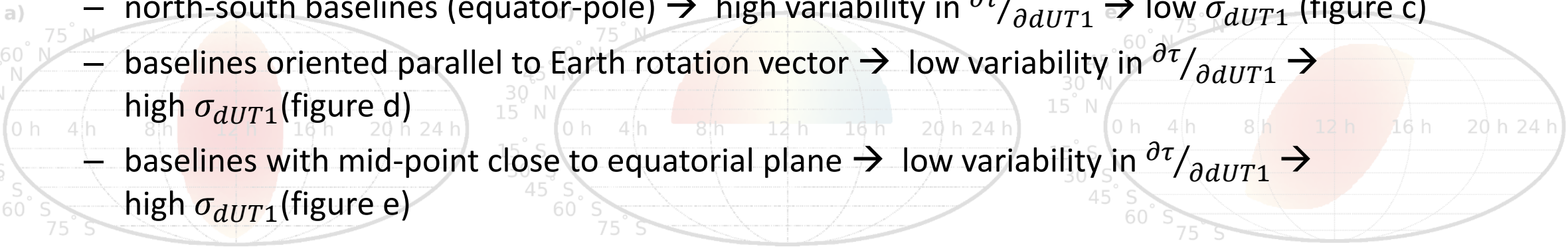
Partial derivative

- variability of partial derivatives $^{\partial\tau}/_{\partial dUT1}$ strongly correlated with σ_{dUT1}
- $^{\partial\tau}/_{\partial dUT1}$ depends on position of mutually visible source



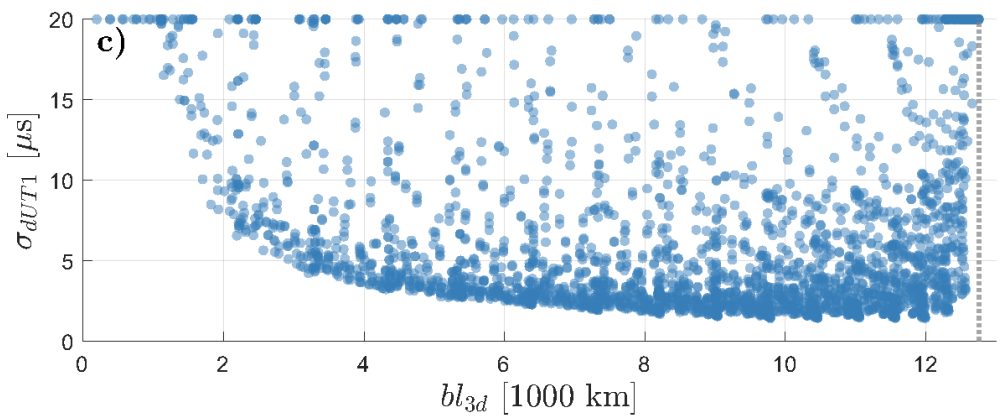
→ explain our findings:

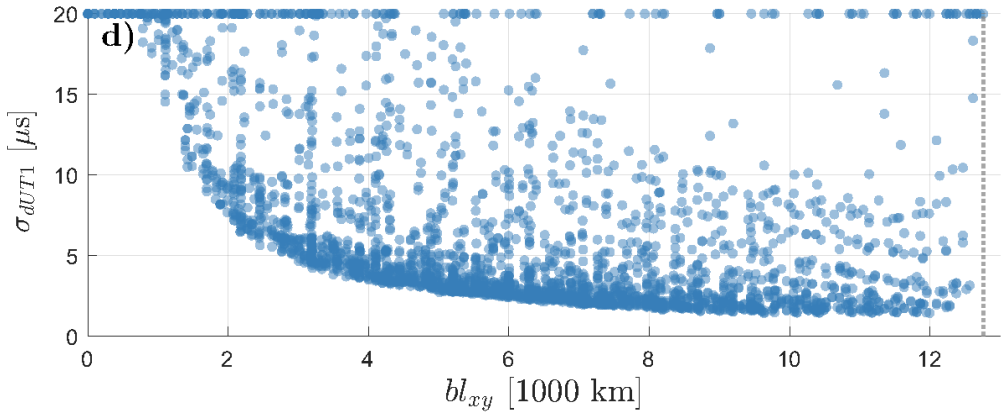
- equatorial baselines → low variability in $^{\partial\tau}/_{\partial dUT1}$ → high σ_{dUT1} (figure a)
- north-south baselines (equator-pole) → high variability in $^{\partial\tau}/_{\partial dUT1}$ → low σ_{dUT1} (figure c)
- baselines oriented parallel to Earth rotation vector → low variability in $^{\partial\tau}/_{\partial dUT1}$ → high σ_{dUT1}(figure d)
- baselines with mid-point close to equatorial plane → low variability in $^{\partial\tau}/_{\partial dUT1}$ → high σ_{dUT1}(figure e)

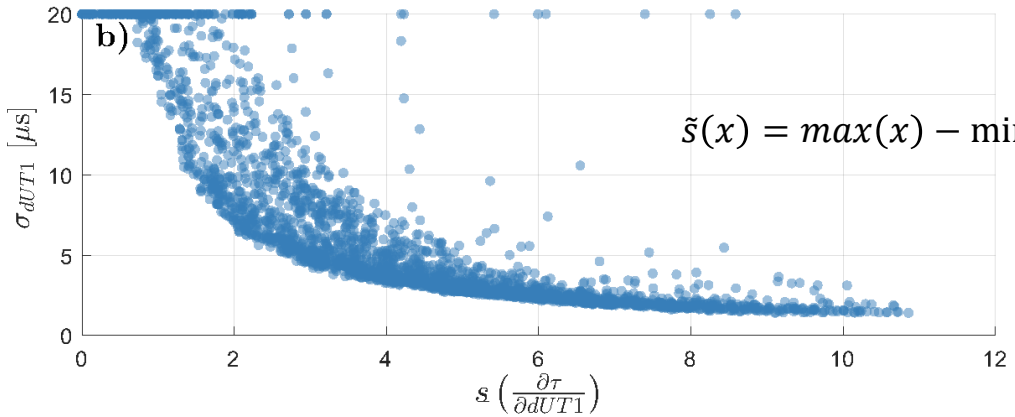


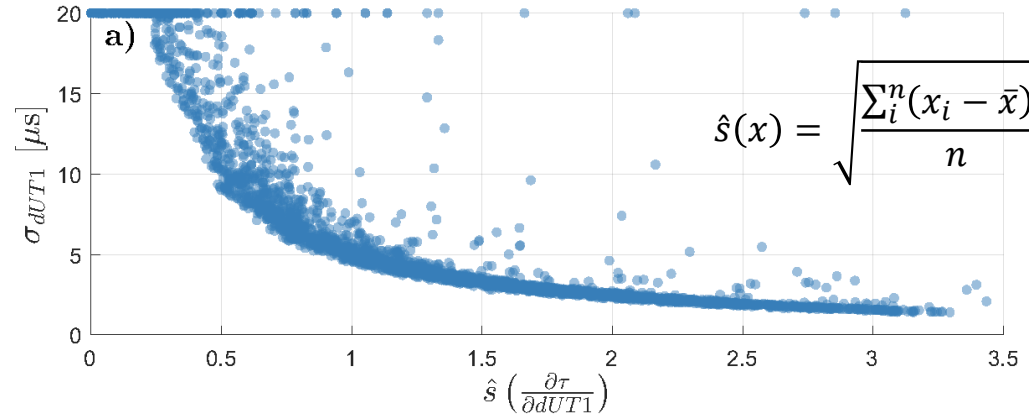
Intensive baseline quality metrics

- distribution of σ_{dUT1} w.r.t.:
  - baseline length (3D and 2D)
  - variability of $\frac{\partial \tau}{\partial dUT1}$ (total and effective spread)









Intensive baseline quality metrics

- correlation coefficient shows strong negative correlation between the variabilty of $^{\partial\tau}/_{\partial dUT1}$ and σ_{dUT1}
- effective spread of $^{\partial\tau}/_{\partial dUT1}$ → best metric to judge suitability of Intensive baseline

	$\hat{s}\left(\frac{\partial\tau}{\partial dUT1}\right)$	$\tilde{s}\left(\frac{\partial\tau}{\partial dUT1}\right)$	bl_{3d}	bl_{xy}
σ_{dUT1}	-0.791	-0.768	-0.207	-0.480

$$\tilde{s}(x) = max(x) - \min(x)$$

$$\hat{s}(x) = \sqrt{\frac{\sum_i^n (x_i - \bar{x})^2}{n}}$$

Conclusion

- ✓ provided a **global evaluation of VLBI baselines** for the rapid determination of dUT1 through Intensive sessions
- ✓ almost **3000 baselines** scheduled and simulated
- ✓ confirmed: **importance of corner observations**
- ✓ additional insight on **geometry of Intensive baselines**
- ➢ evaluation of Intensive baselines using **partial derivatives**

Contact:

lisa.kern@tuwien.ac.at

References:

Baver K, Gipson J (2015) Minimization of the UT1 Formal Error Trough a Minimization Algorithm. In: Proceedings of the 22nd European VLBI Group for Geodesy and Astronomy Working Meeting

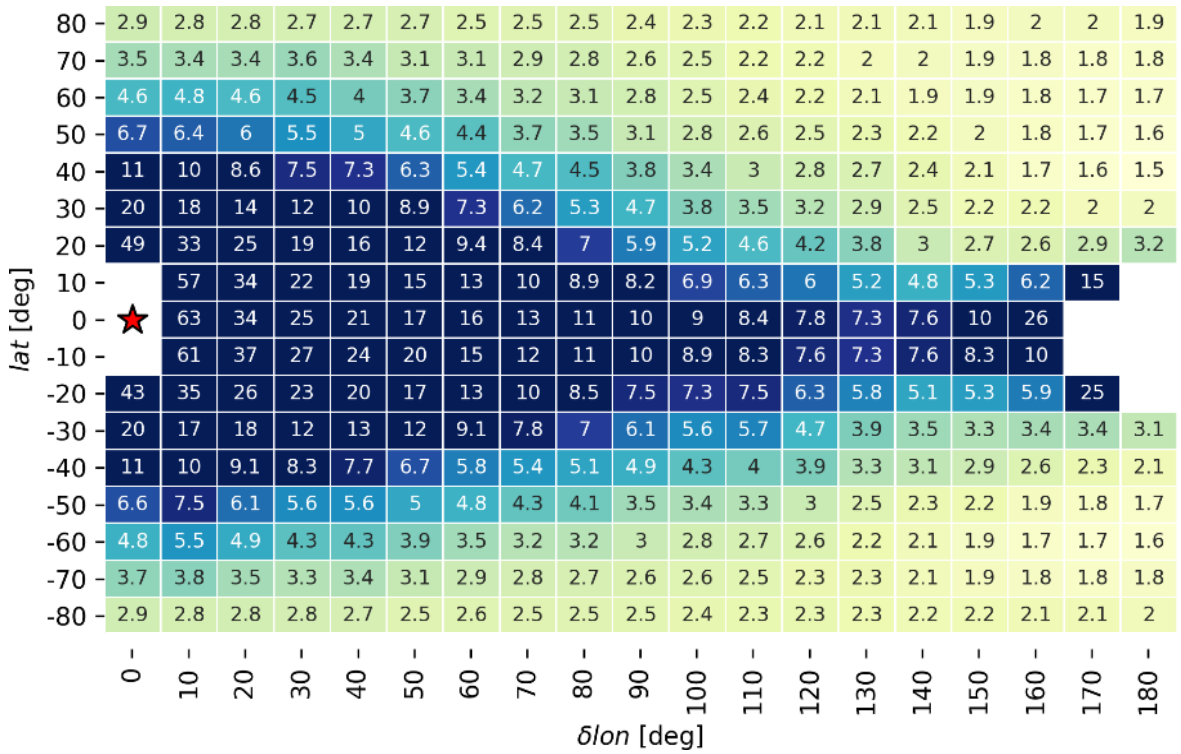
Landskron D, Böhm J (2019) Improving dUT1 from VLBI intensive sessions with GRAD gradients and ray-traced delays. Advances in Space Research 63(11):3429 - 3435, DOI 10.1016/j.asr.2019.03.041

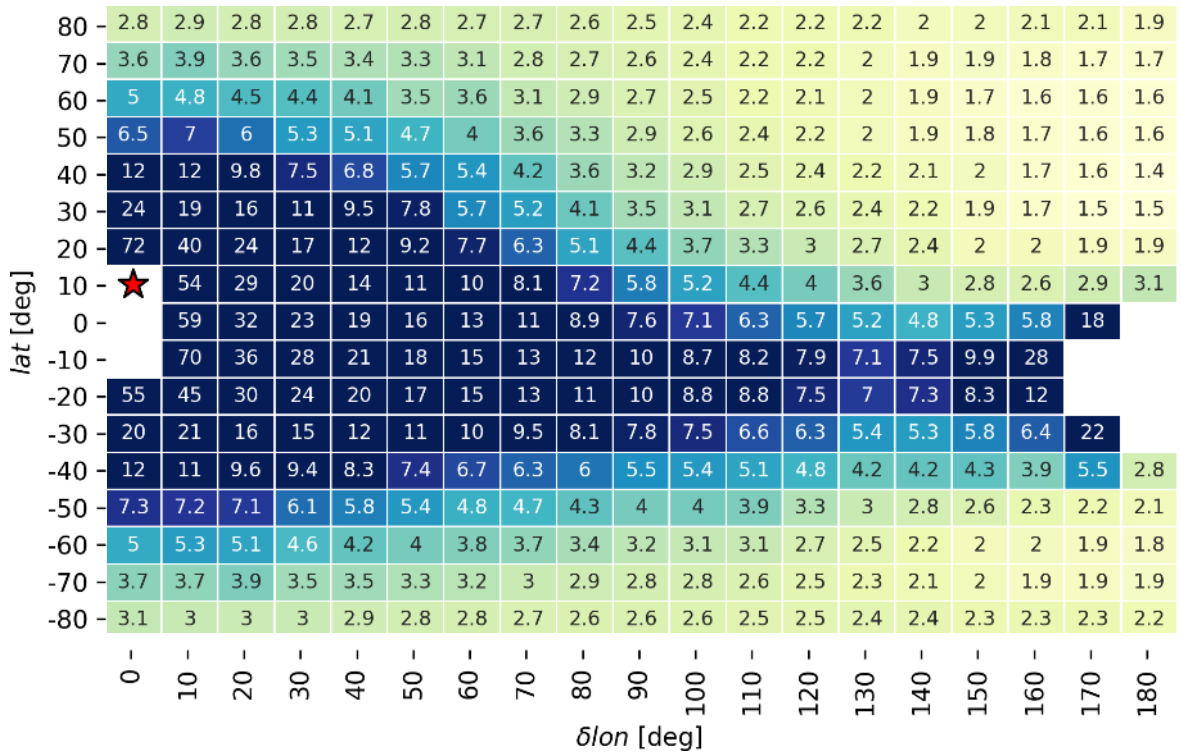
Schartner M, Böhm J, Nothnagel A (2020) Optimal antenna locations of the VLBI Global Observing System for the estimation of Earth orientation parameters. Earth, Planets and Space 72(1):87, DOI 10.1186/s40623-020-01214-1

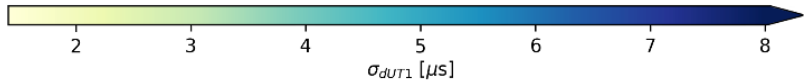
Schartner M, Kern L, Nothnagel A, Böhm J, Soja B (?) Optimal VLBI Baseline Geometry for UT1-UTC Intensive Observations – submitted to JOGE

Uunila M, Nothnagel A, Leek J (2012) Influence of Source Constellation on UT1 Derived from IVS INT1 Sessions. In: Behrend D, Baver KD (eds) International VLBI Service for Geodesy and Astronomy 2012 General Meeting Proceedings, pp 395-399

Appendix







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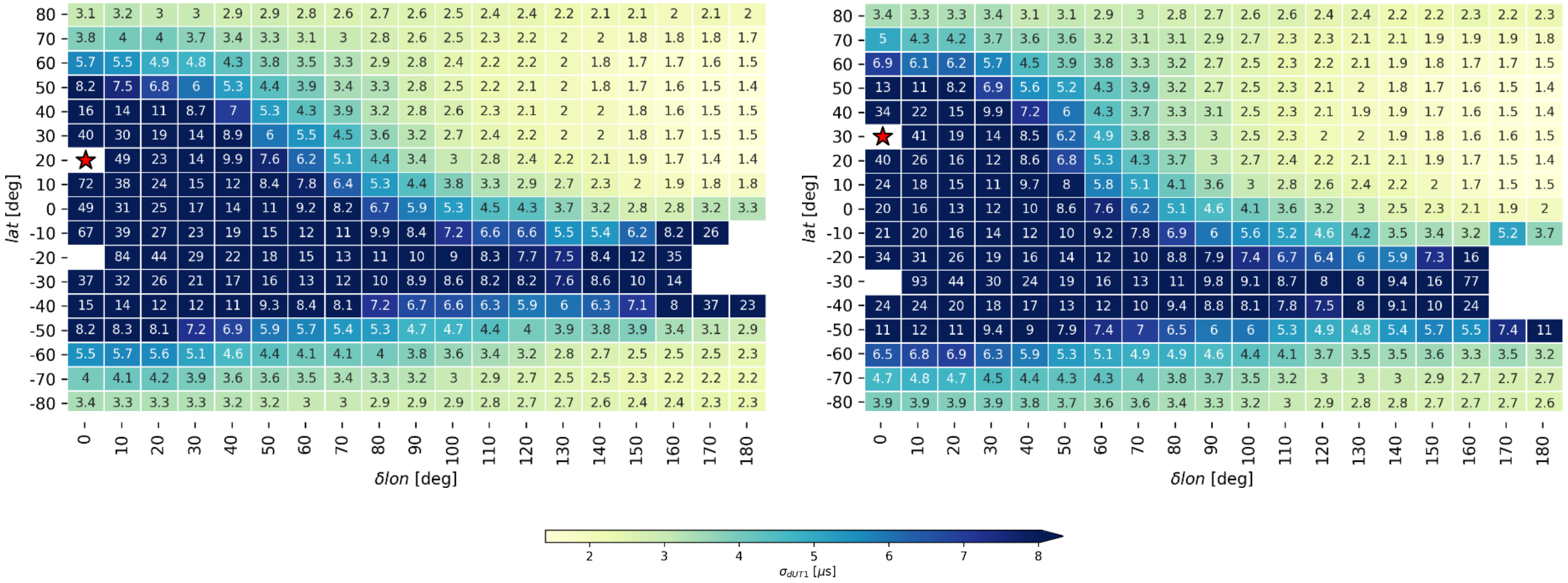

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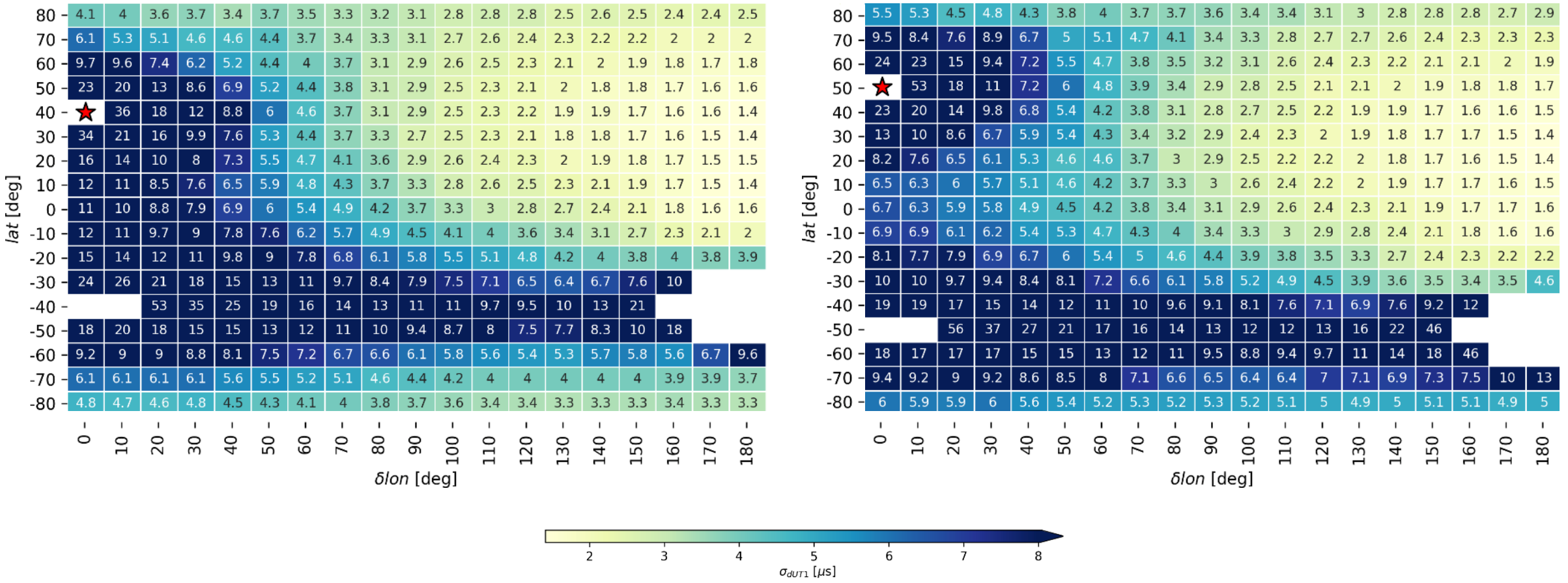
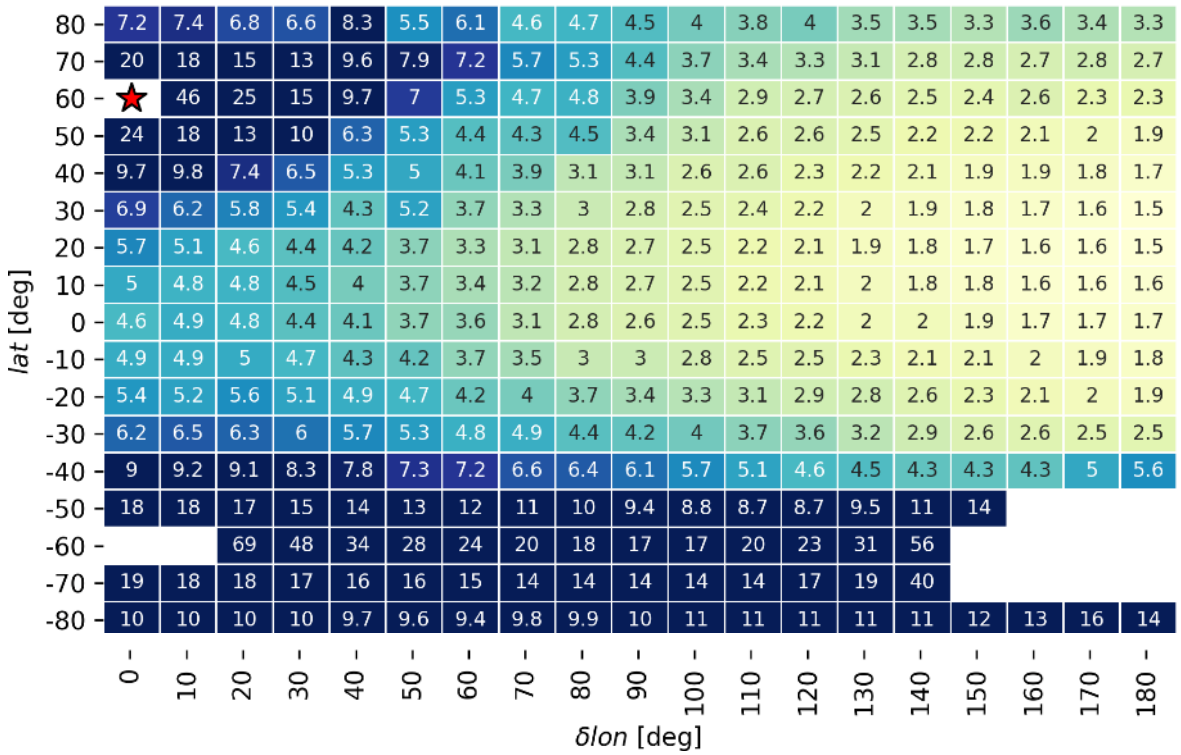
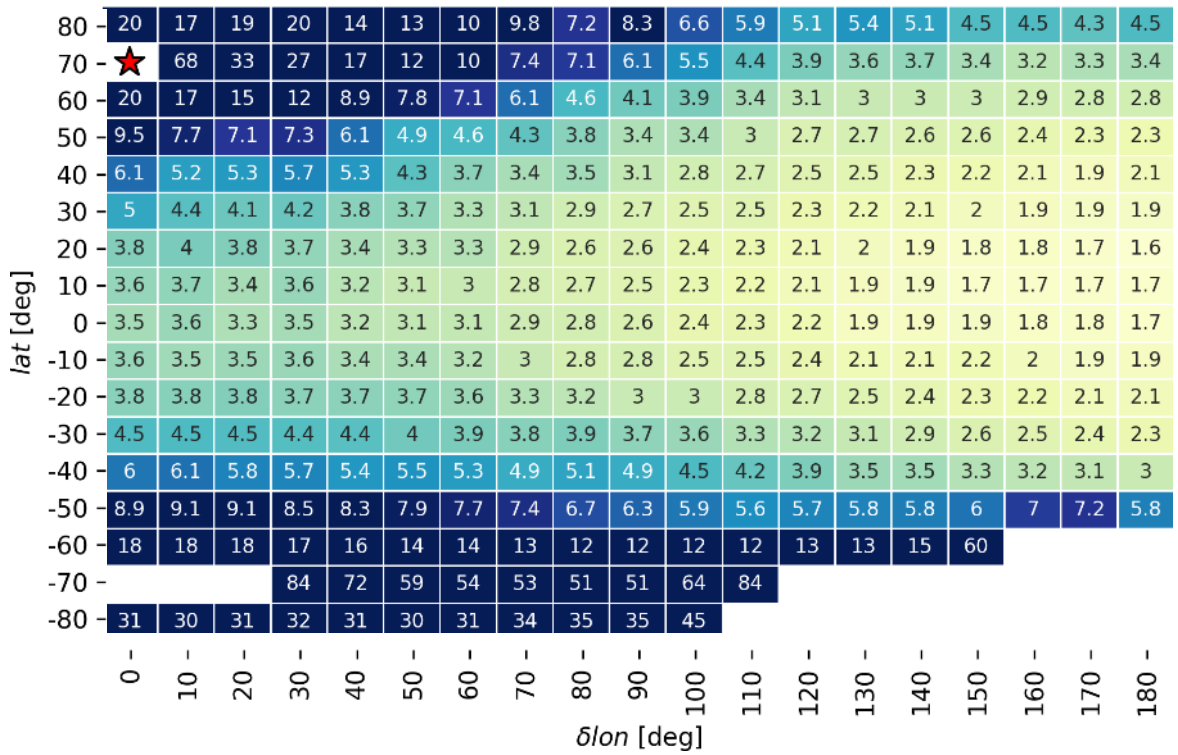
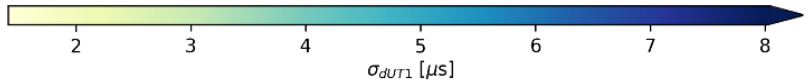

lat [deg]
δlon [deg]
80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
2 3 4 5 6 7 8
σdUT1 [μs]

Appendix







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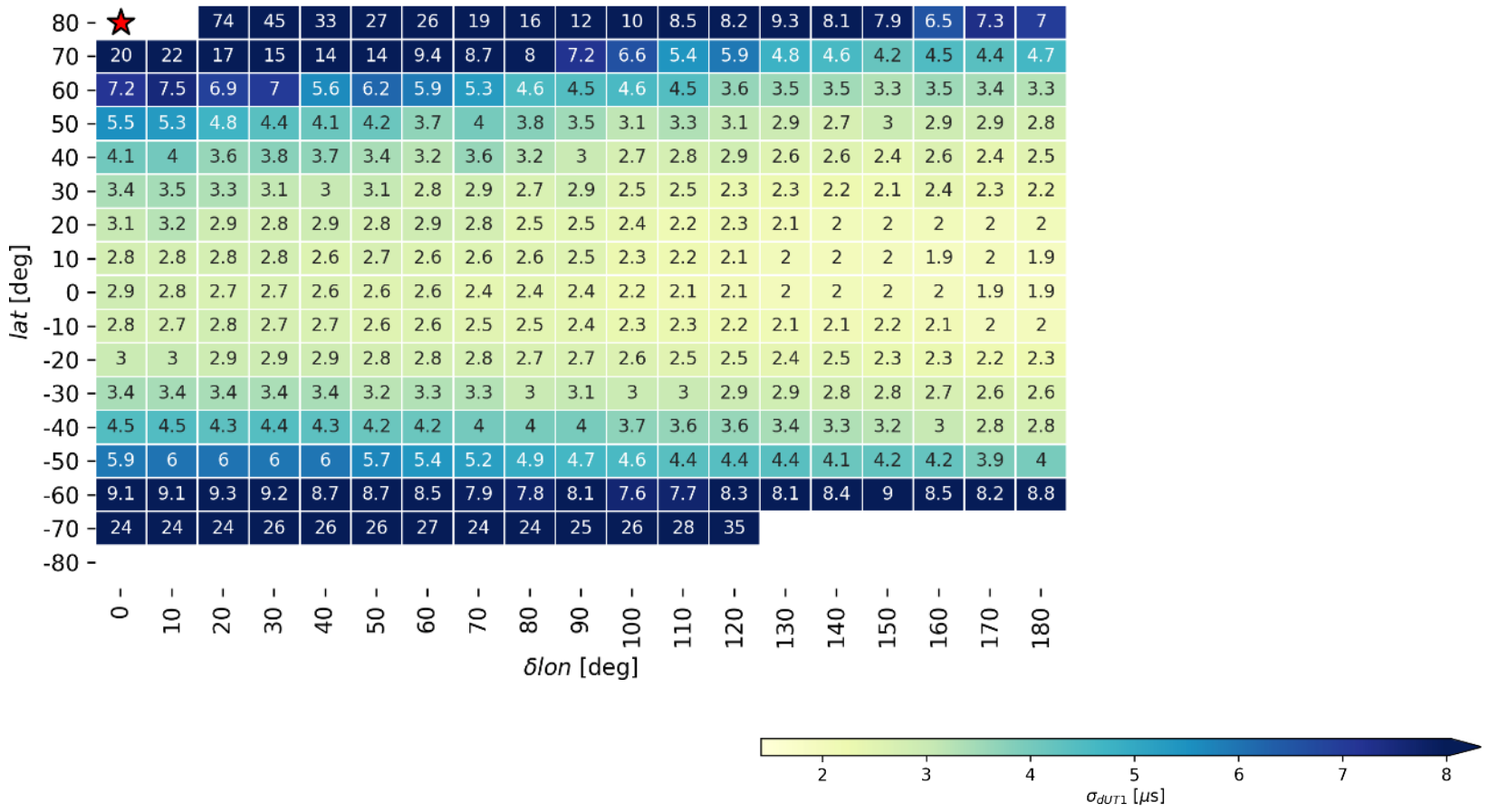

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