The importance of accurate a priori information for VLBI Intensive sessions

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Overview

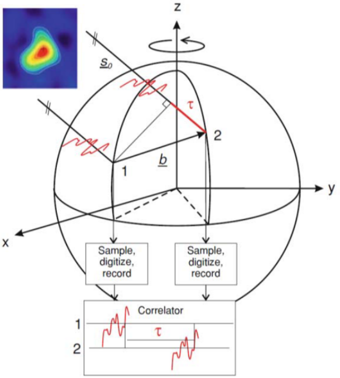
1. Introduction
2. Simulation study
3. Impact of erroneous station coordinates
4. Impact of erroneous polar motion
5. Impact of erroneous nutation components
6. Summary & Conclusions

Very Long Baseline Interferometry (VLBI)

- simultaneous measurement of radio signals emitted by extragalactical radio sources (quasars) by at least two VLBI stations

$$\tau = -\frac{\mathbf{b} \cdot \mathbf{s_0}}{c} = t_2 - t_1 \qquad (1)$$

- determination of:
  - station and source coordinates,
  - EOP (polar motion, nutation offsets, **UT1-UTC**)
  - atmospheric parameters, ...



[Schuh and Böhm, 2013]

Intensive sessions

- single baseline sessions
- one hour duration
- dedicated to derive **UT1-UTC** (mean formal uncertainty: 5-20 μs)

– restricted number of observations
– restricted number of estimates (ZWD, clock, UT1-UTC)
– remaining parameters are **fixed to their a priori value** (EOP, station/ source coordinates, tropospheric gradients, ...)

$\rightarrow \sigma_{\mathbf{apriori}}$ **impacts** $\sigma_{\mathbf{UT1-UTC}}$

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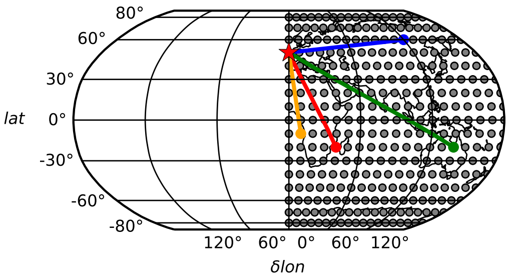
Experiment setup [Schartner et al., 2021]

- 323 artificial VGOS stations placed on regular 10° x 10° global grid
- reference stations at $\delta lon = 0 \rightarrow$ $\approx$ 3000 baselines
- scheduled (VieSched++) and simulated (VieVS)
  - monthly schedules per baseline
  - reduced source list with equally distributed sources
  - focus corner scheduling algorithm*

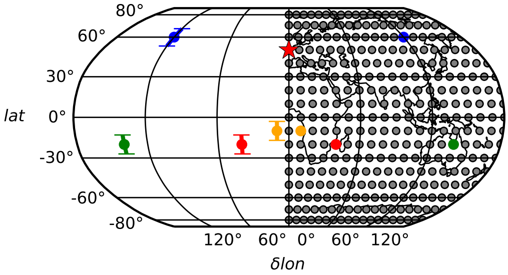


*[Nothnagel and Campbell, 1991; Uunila et al., 2012; Gipson and Baver, 2015; Schartner et al., 2021]

Simulation study [Kern et al., 2022a - under review]

Erroneous a priori information

- introducing realistic errors (in separate evaluations):
  - up, east, north $\rightarrow$ 5 mm
  - x_p, y_p + dX, dY $\rightarrow$ 162 µas
- simulation results of evaluations are compared to unaltered results $\rightarrow$ **monthly $\Delta UT1$ values**
- investigate mean and standard deviation of $\Delta UT1$



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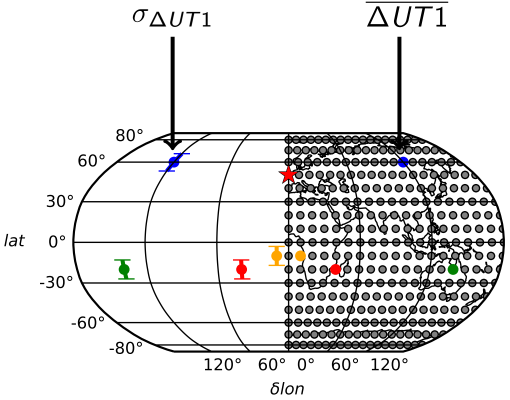

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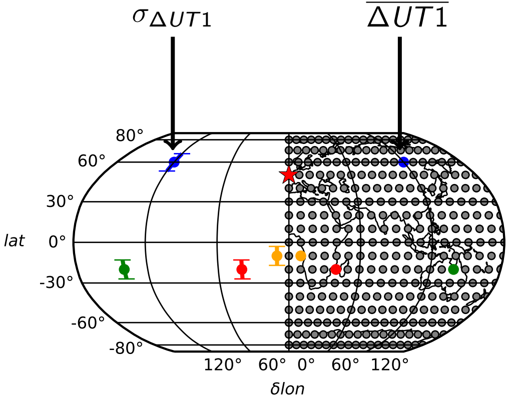
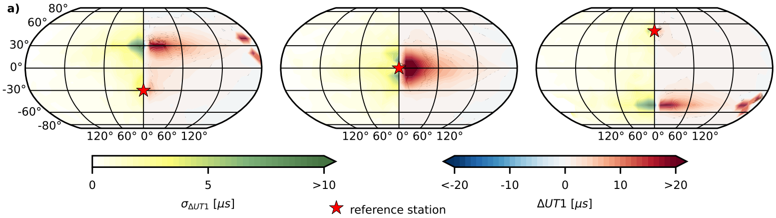


$\rightarrow$ high $\overline{\Delta UT1}$ ... high sensitivity/ low resistance against a priori error
$\rightarrow$ high $\sigma_{\Delta UT1}$ ... high variability of $\overline{\Delta}$ throughout the year

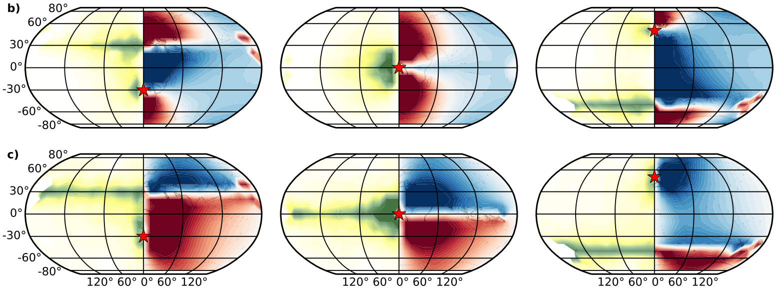
Impact of erroneous station coordinates



a) error in up-direction

- $\overline{\Delta} > 5$ µs (8%) and $\overline{\Delta} > 20$ µs (3%)
- **low resistance**: baselines with midpoint close to equatorial plane/ baselines parallel to Earth rotation vector

Impact of erroneous station coordinates

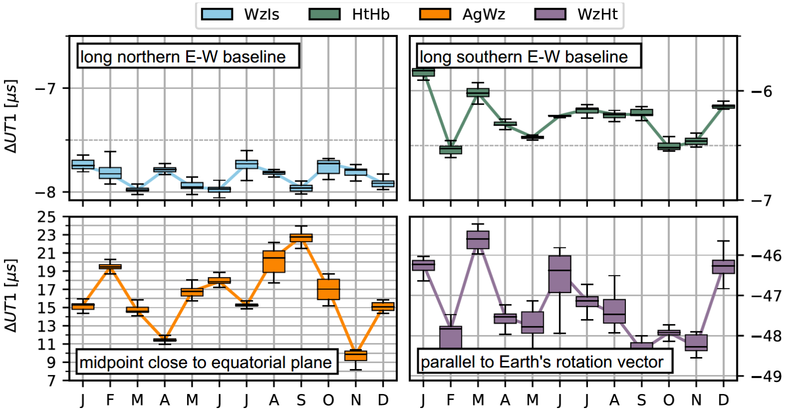


b+c) error in east- and north-direction

- $\overline{\Delta} > 5$ μs (84/ 63%) and $\overline{\Delta} > 20$ μs (22/ 16%)
- **low resistance**: baselines with midpoint close to equatorial plane, short baselines (, N-S baselines)
- **high resistance**: E-W baselines to mid-latitudes of same hemisphere

Intermezzo: Impact of source selection and scheduling optimization on $\Delta UT1$

[Kern et al., 2022b - to be published]



- impact source selection - variability between monthly estimates
- impact scheduling optimization - variations within one month

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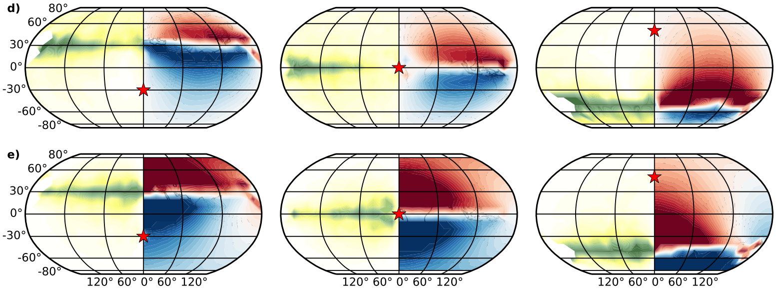
Impact of erroneous polar motion



d+e) error in x_p- and y_p-direction

- $\overline{\Delta} > 5$ µs (50-70%) and $\overline{\Delta} > 20$ µs (12-25%)
- **low resistance**: baselines with midpoint close to equatorial plane/ equatorial baselines, N-S baselines
- **high resistance**: E-W baselines to mid-latitudes of same hemisphere

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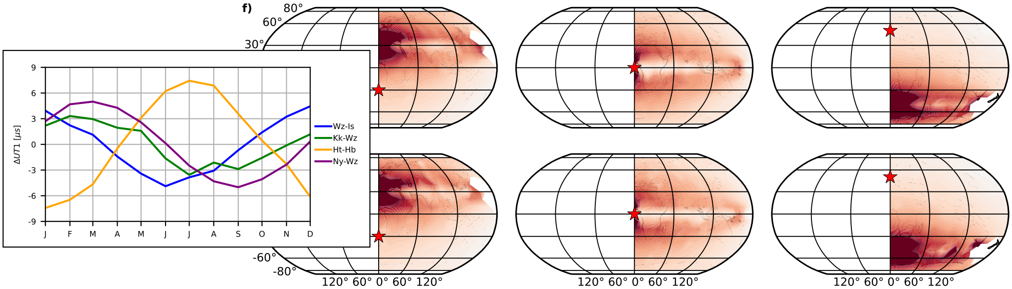
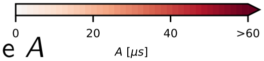
Impact of erroneous nutation components



f+g) error in dX- and dY-component



- strong dependence on sidereal time → amplitude A
- $A > 5$ μs (83%) and $A > 20$ μs (35%)
- **low resistance**: baselines with midpoint close to equatorial plane
- **high resistance**: E-W baselines to mid-latitudes of same hemisphere

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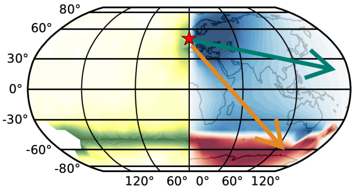
Summary & Conclusions

- global simulation study on the **impact of a priori errors on the determination of UT1** with VLBI Intensives
- almost 3000 baselines and 240 000 simulations



high sensitivity/ low resistance against investigated a priori errors

baselines with a midpoint close to equatorial plane

low sensitivity/ high resistance against investigated a priori errors

long E-W baselines between a reference station and a station at mid-latitudes of same hemisphere

- impact of a priori errors are **not negligible!**

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