TECHNISCHE UNIVERSITÄT WIEN

Adjustment of Galileo satellite orbits with VLBI observations: a simulation study

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Overview

Is a preliminary evaluation of possible satellite observations in terms of their potential for determining the adjustment of satellite orbits possible?

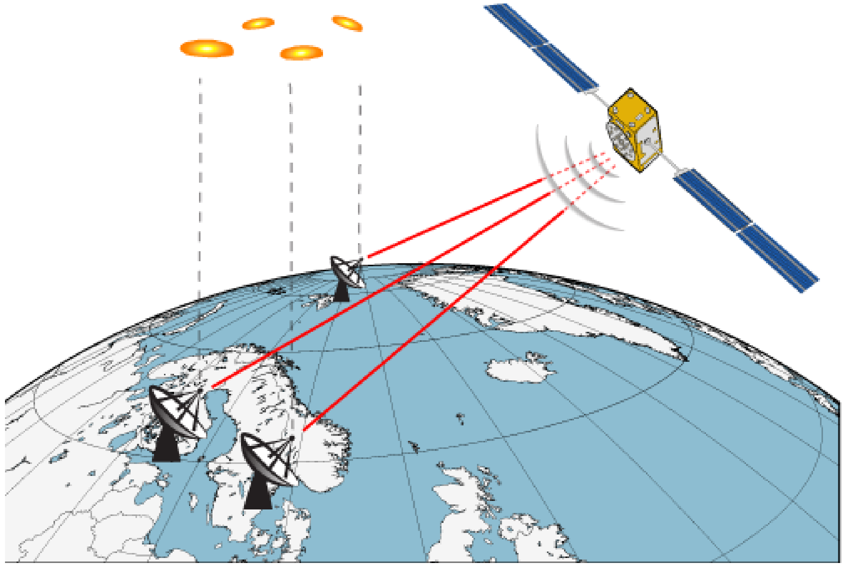
Comparing evaluation of satellite observations for estimating orbit arcs by analysis ...

... beforehand

Dilution of Precision (DOP) factors as indicator for sensitivity of satellite observations

... of simulations

precision of estimated orbit arc assessed based on Monte Carlo simulations



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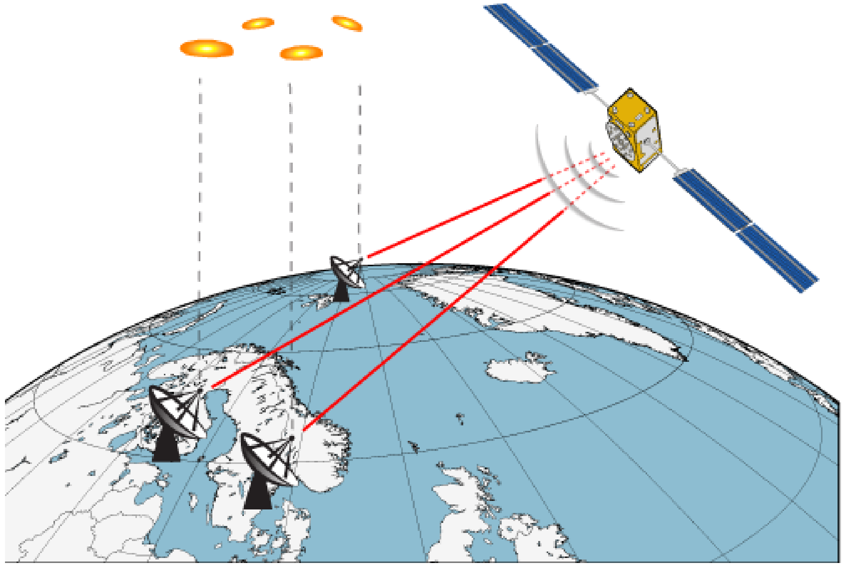
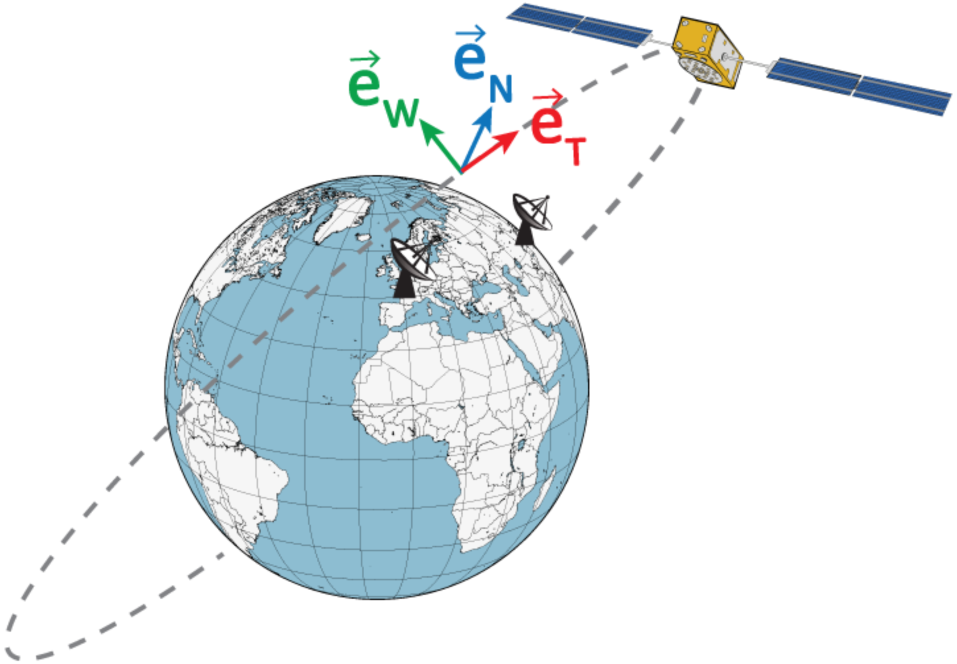


Yes, it is!

Evaluation of satellite observations

- Dilution of Precision (DOP) factors indicate sensitivity of observation towards (in our application) different parameters
- DOP factors for sensitivity towards satellite position in the NTW-frame such as
  - normal component → normal DOP **(NDOP)**
  - tangential component → tangential DOP **(TDOP)**
  - cross-track component → cross-track DOP **(WDOP)**
- represent formal error in respective component per VLBI measurement error in $[^{\mathrm{cm}}/_{\mathrm{cm}}]$ → unitless
- the smaller the value of the respective DOP the higher the sensitivity of the observation to the corresponding parameter



→ DOP factors as optimization criterion for scheduling of satellite observations

Scheduling of satellite and quasar observations

- VieSched++ is used to create schedules including satellite and quasar observations
  - satellite scans with 5 seconds duration
  - 30 seconds break in between for calibration, slewing, …
  - e.g. 24 hour session including satellite observations for 40 minutes from 4:00 to 4:40
    - 4:00:00 – 4:00:05
    - 4:00:35 – 4:00:40

      …
    - 4:39:40 – 4:39:45

    → in total 69 satellite scans
  - remaining part of schedule is filled with quasar observations
    - more than 100 scheduled sources for each schedule

TU WIEN VieSched++ Vienna VLBI and Satellite Software

Adjustment of Galileo satellite orbits

- Vienna VLBI and Satellite Software (VieVS) for simulating and analysing the schedules
  - 1000 simulations
    - white noise of 50 [ps] for satellite observations
  - estimation of offset from a-priori orbit (sp3) for the individual components of satellite position
  - estimation settings
    - ☒ source coordinates
    - ☒ station coordinates
    - ☑ troposphere
    - ☑ clock
    - ☑ EOP
    - ☑ satellite position
      - as continuous piecewise linear offsets
      - estimation interval: 10 min
      - relative constraints for each component: 10 cm

➡ precision of adjusted arc in terms of repeatability

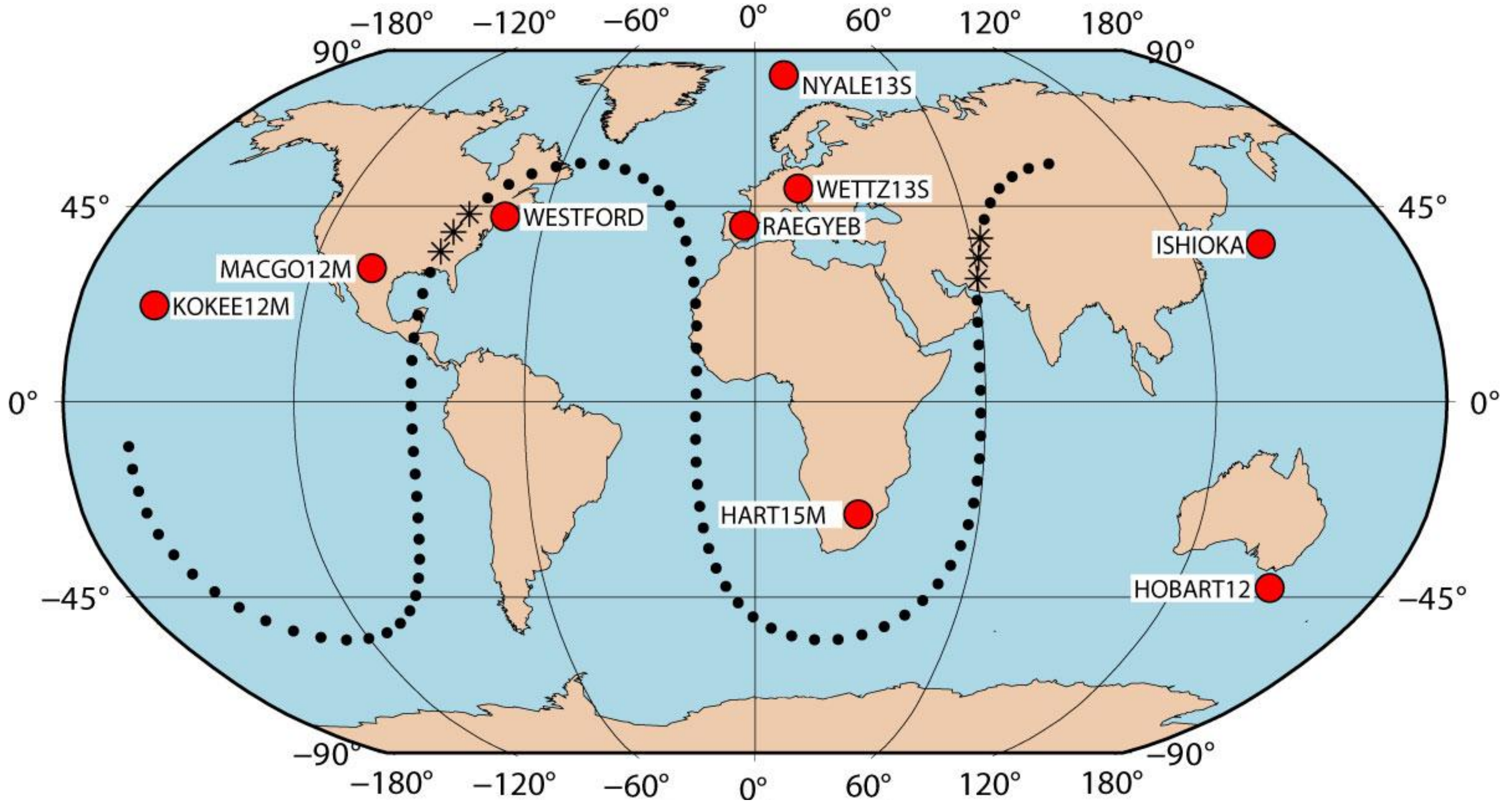
TU WIEN VieVS Vienna VLBI and Satellite Software

Scenario I: GSAT0208

- 06.02.2022 00:00 – 00:00
- 9 station network

Obs. period A: **08:10 – 08:50**
- KOKEE12M
- MACGO12M
- NYALE13S
- WESTFORD
- WETTZ13S
- RAEGYEB

Obs. period B: **21:50 – 22:30**
- HART15M
- ISHIOKA
- NYALE13S
- RAEGYEB
- WETTZ13S

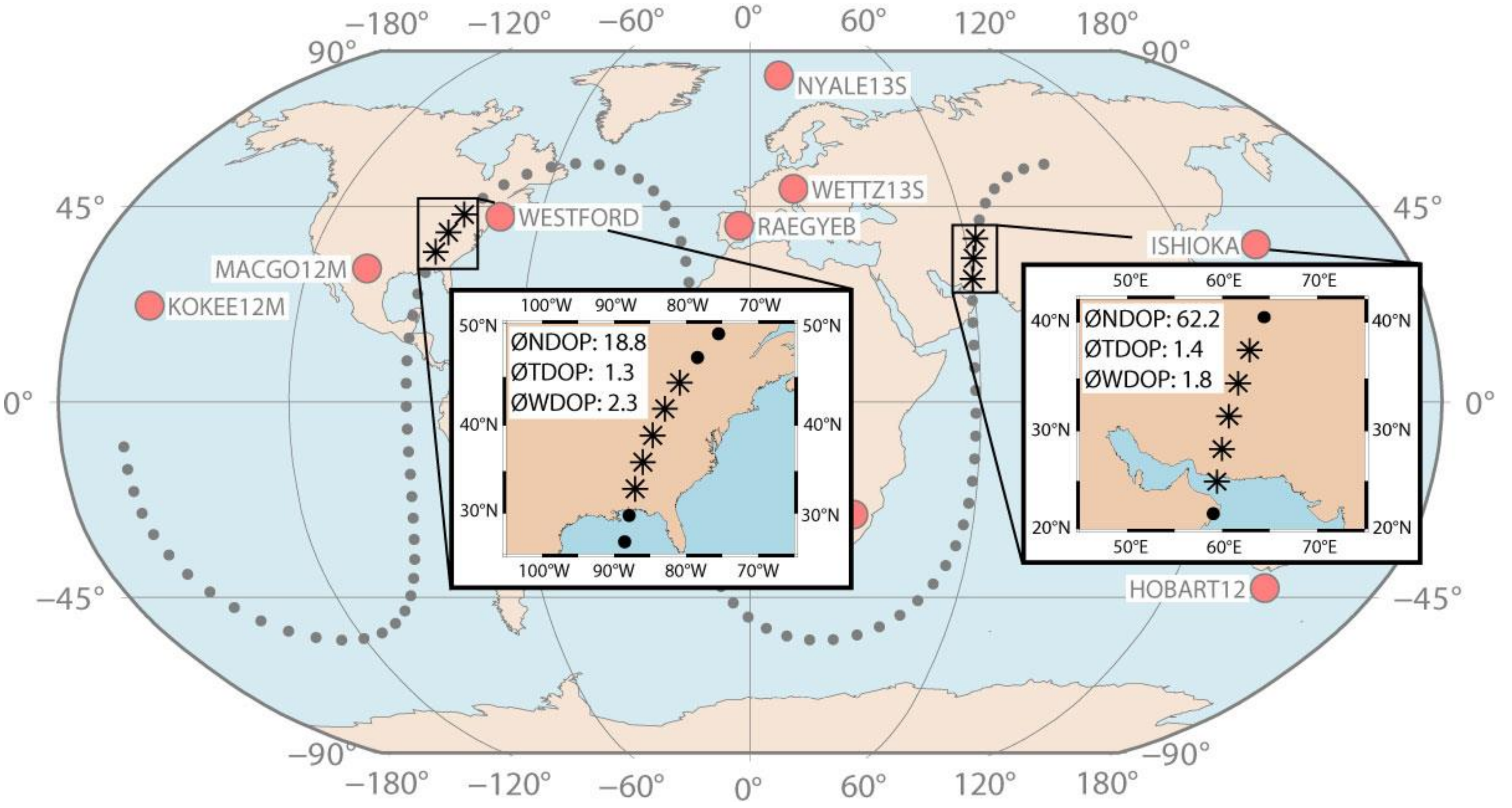


Scenario I: GSAT0208

- 06.02.2022 00:00 – 00:00
- 9 station network

Obs. period A: **08:10 – 08:50**
- #stations: 6
- ØNDOP: 18.8
- ØTDOP: 1.3
- ØWDOP: 2.3

Obs. period B: **21:50 – 22:30**
- #stations: 5
- ØNDOP: 62.2
- ØTDOP: 1.4
- ØWDOP: 1.8



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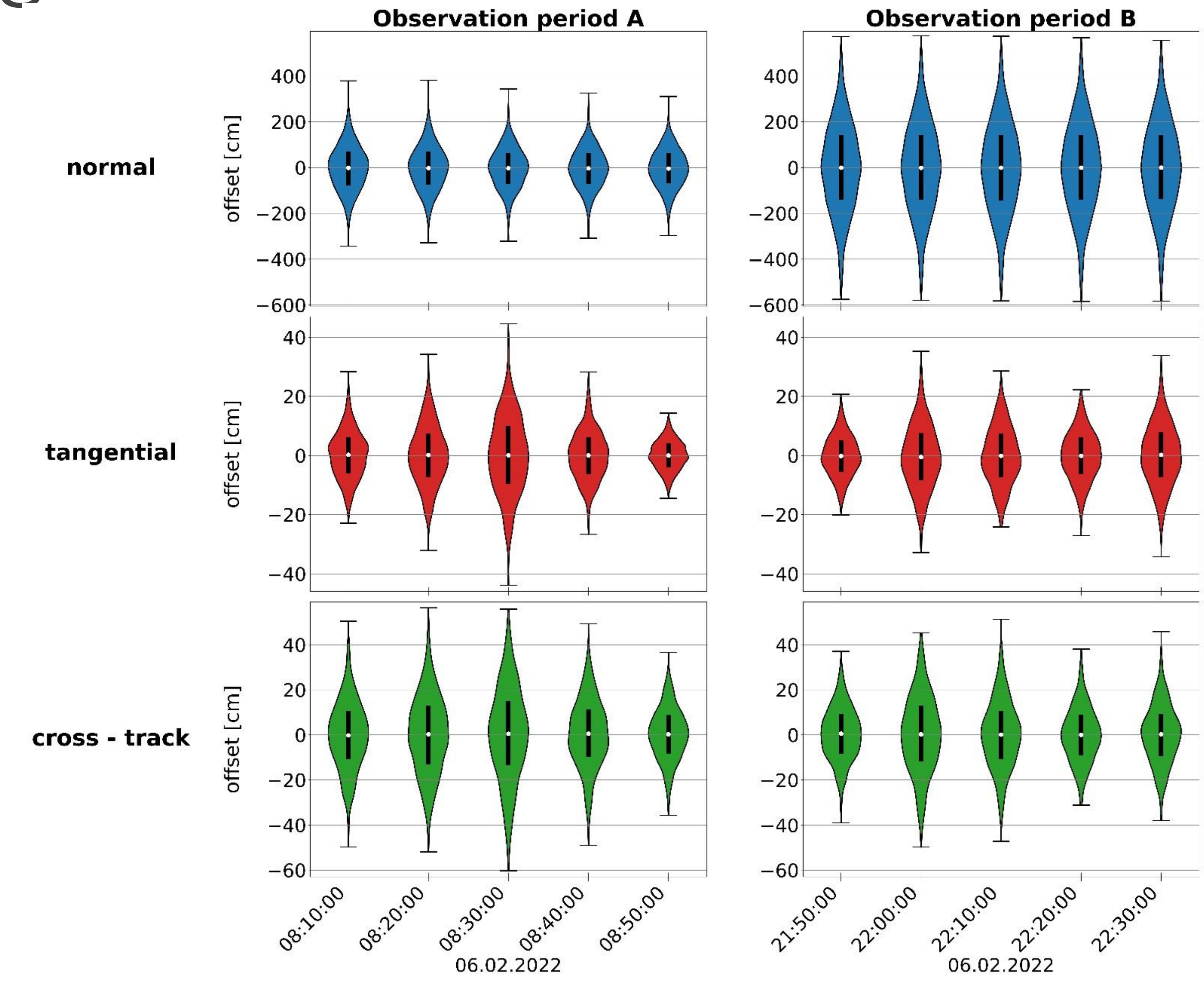

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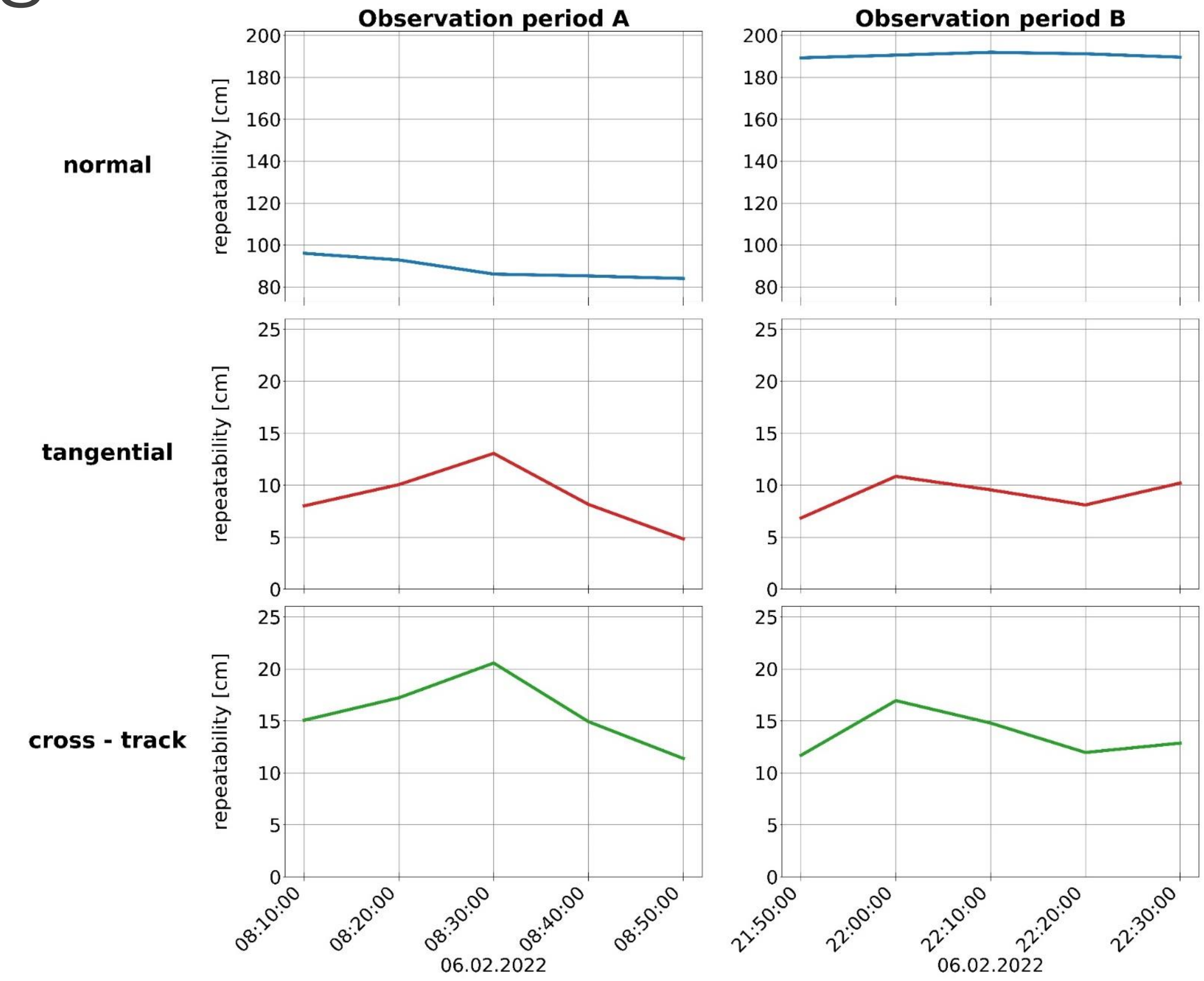
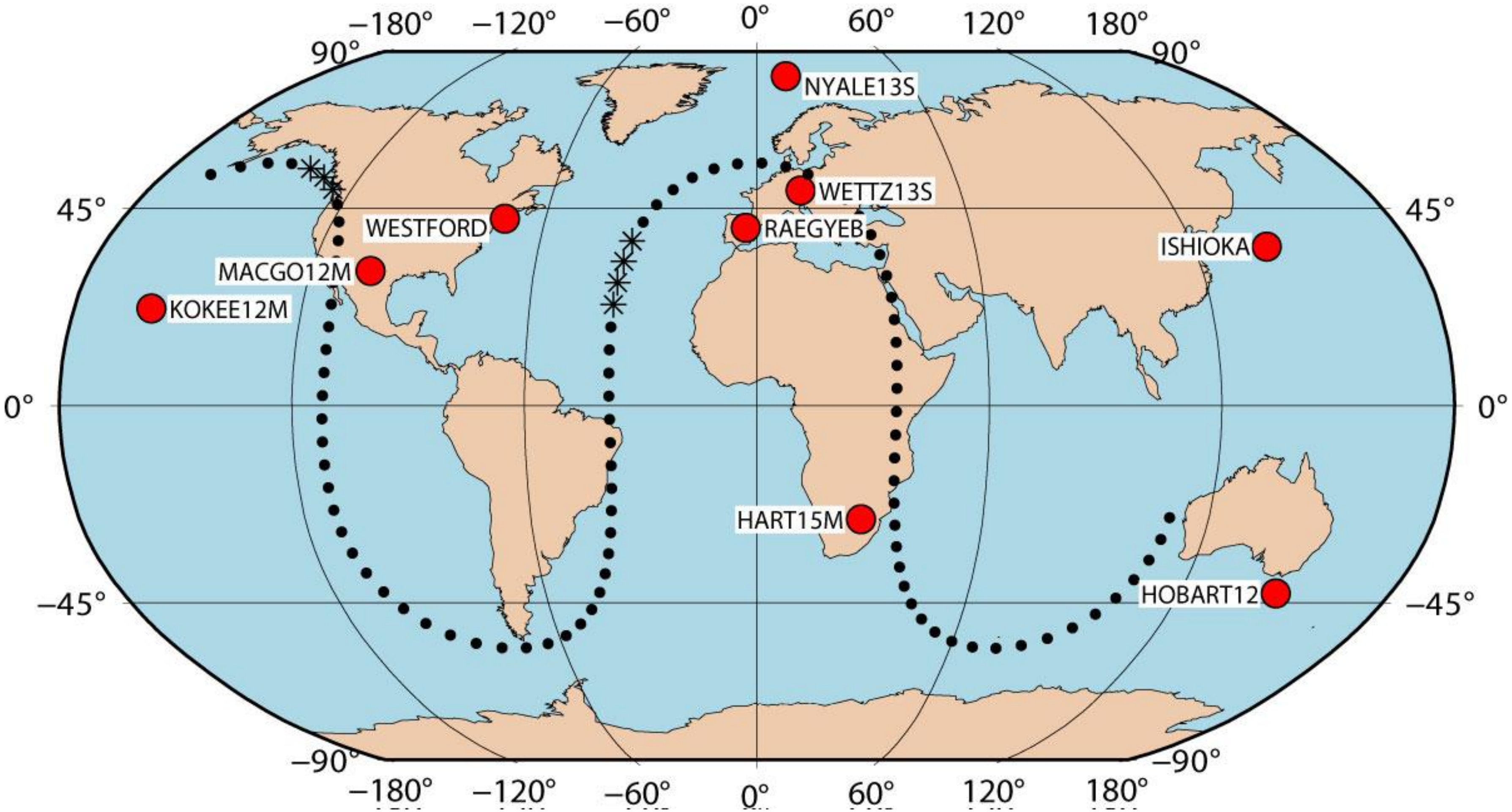


Scenario II: GSAT0206

- 06.02.2022 00:00 – 00:00
- 9 station network

Obs. period A: **00:50 – 01:40**
- ISHIOKA
- KOKEE12M
- MACGO12M
- NYALE13S
- WESTFORD

Obs. period B: **12:10 – 13:00**
- MACGO12M
- NYALE13S
- RAEGYEB
- WESTFORD
- WETTZ13S

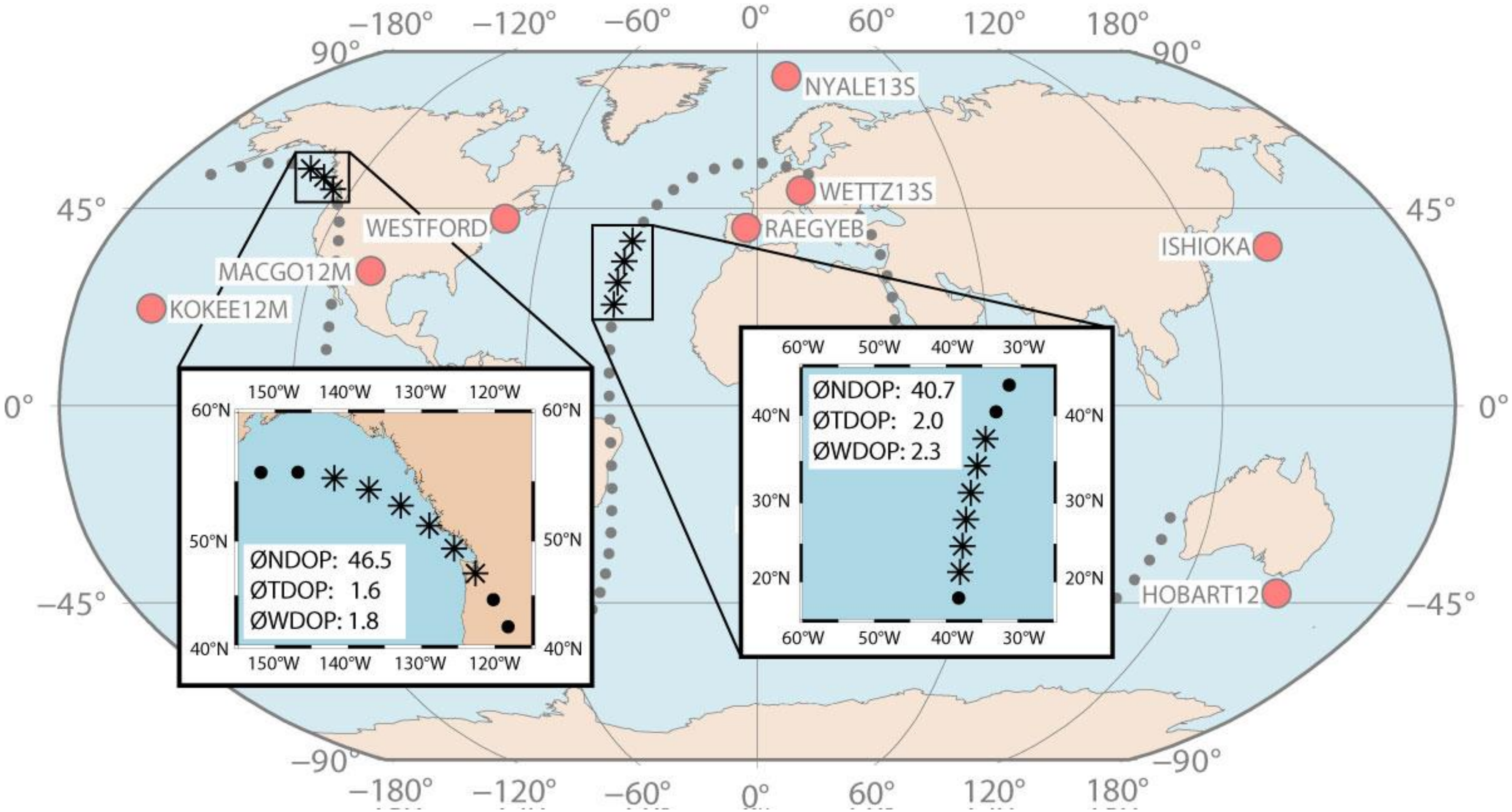


Scenario II: GSAT0206

- 06.02.2022 00:00 – 00:00
- 9 station network

Obs. period A: **00:50 – 01:40**
- #stations: 5
- ØNDOP: 46.5
- ØTDOP: 1.6
- ØWDOP: 1.8

Obs. period B: **12:10 – 13:00**
- #stations: 5
- ØNDOP: 40.7
- ØTDOP: 2.0
- ØWDOP: 2.3



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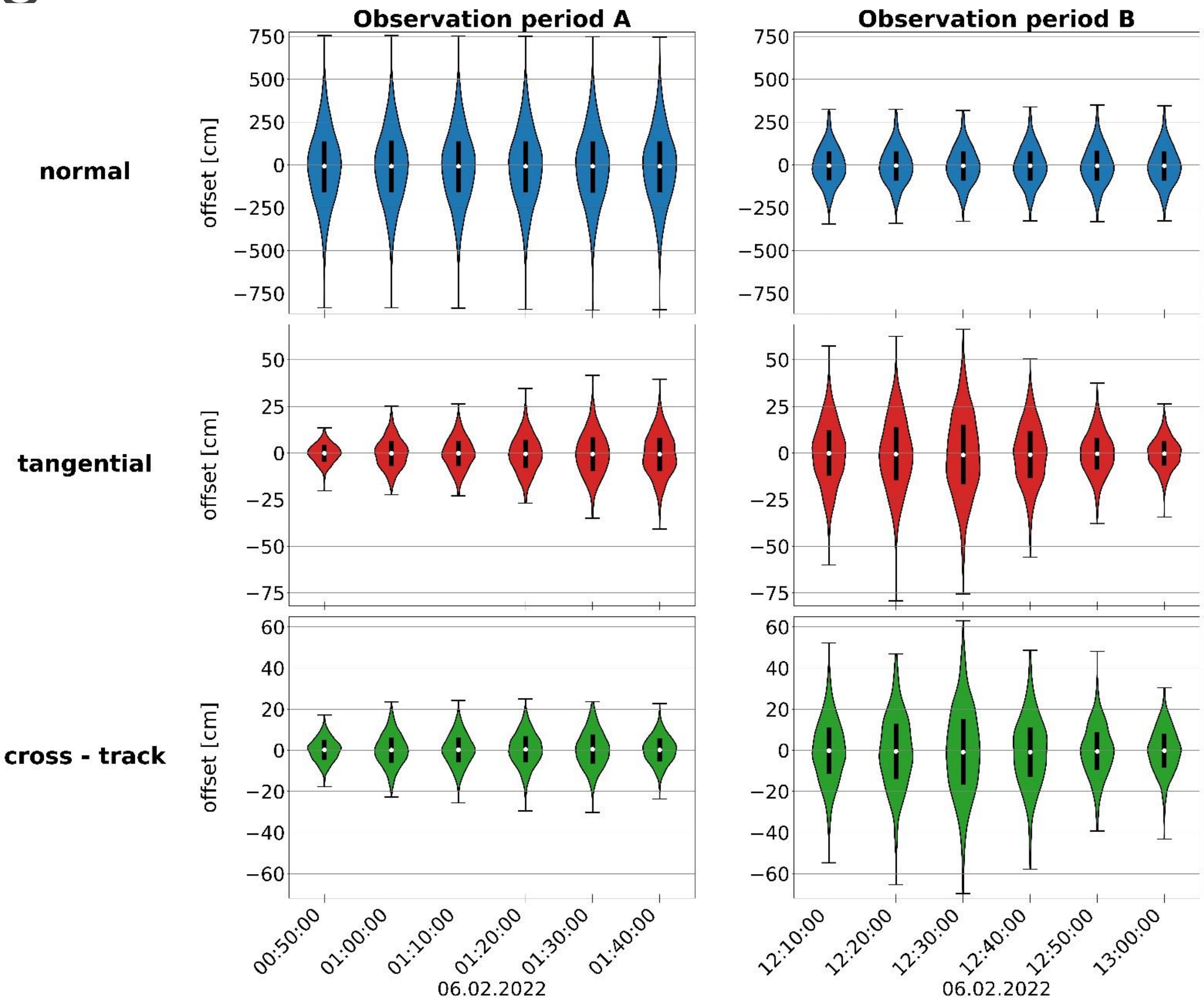

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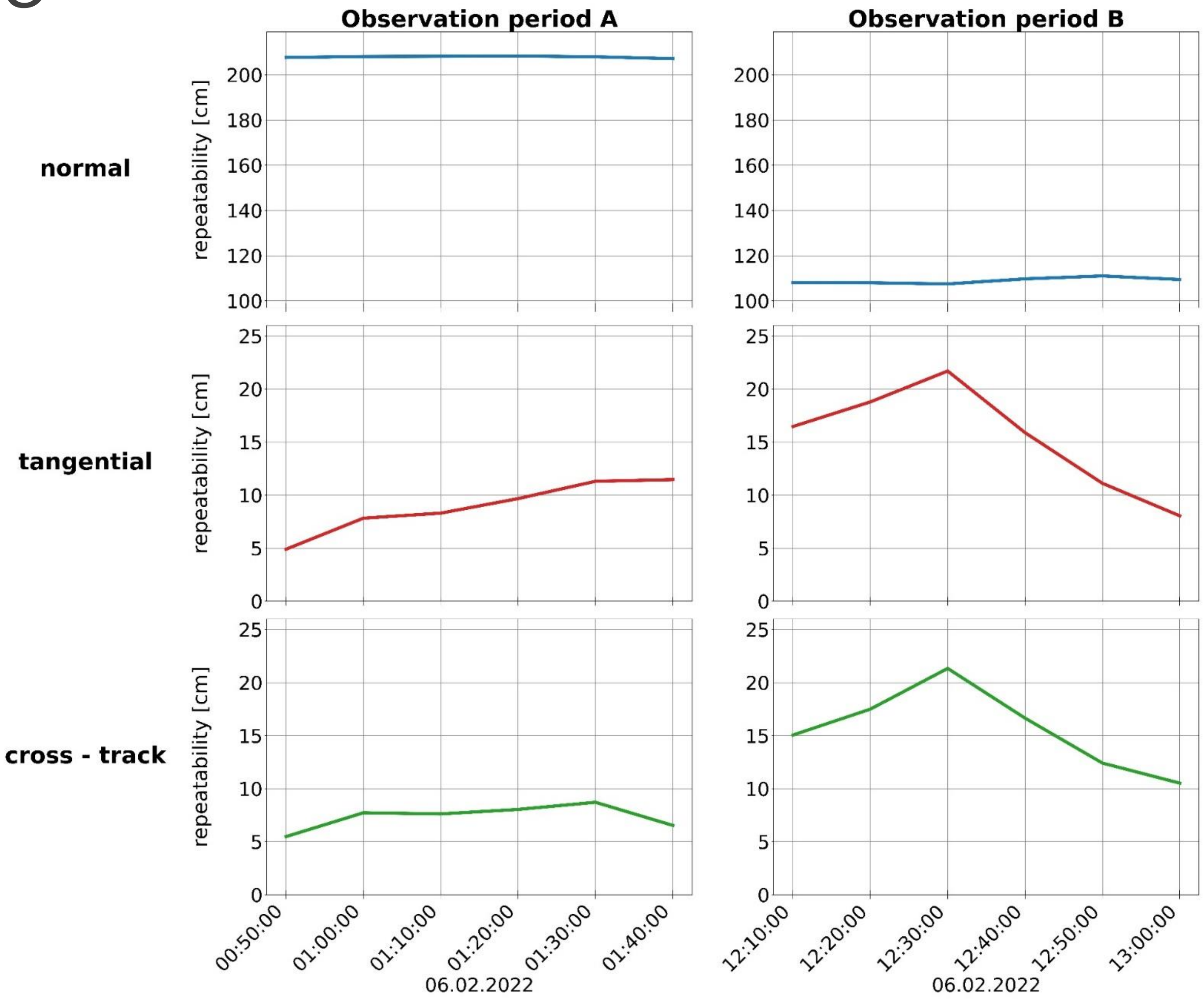

Conclusion

- precision of the adjusted arc is dependent on observation geometry
- DOP factors and results of analysis based on Monte Carlo simulations concur
- DOP factors could be used as optimization criterion during the scheduling process
- normal component significantly worse determinable → possibility of constraining it

References

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- VieSched++: https://github.com/TUW-VieVS/VieSchedpp/