TECHNISCHE UNIVERSITÄT WIEN

Absolute orientation of Galileo orbits from simulated VLBI and GNSS observations

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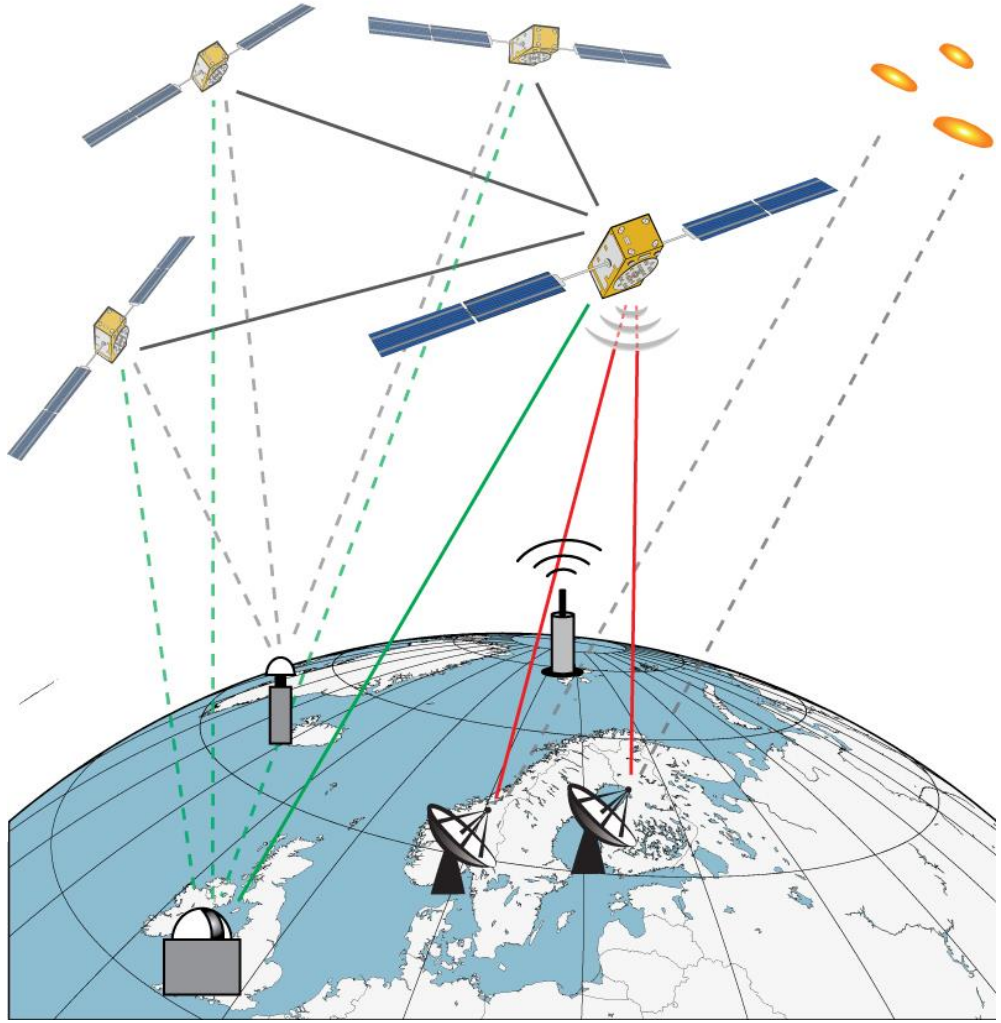
Why observing satellites with VLBI?

- satellites are routinely observed with GNSS, SLR, and DORIS

  → VLBI observations to satellites are missing in space geodesy

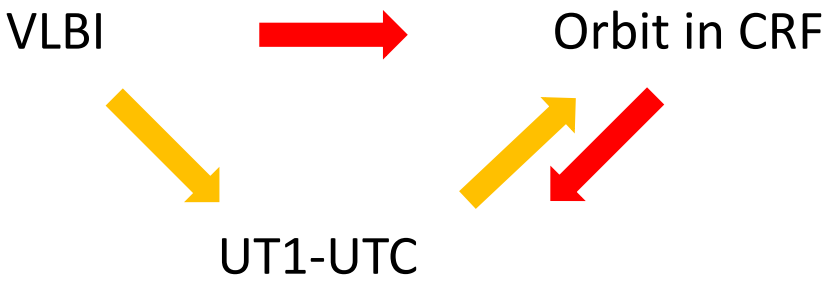
- satellite techniques alone don't allow to distinguish between a rotation of orbital plane and a rotation of the Earth (UT1-UTC)

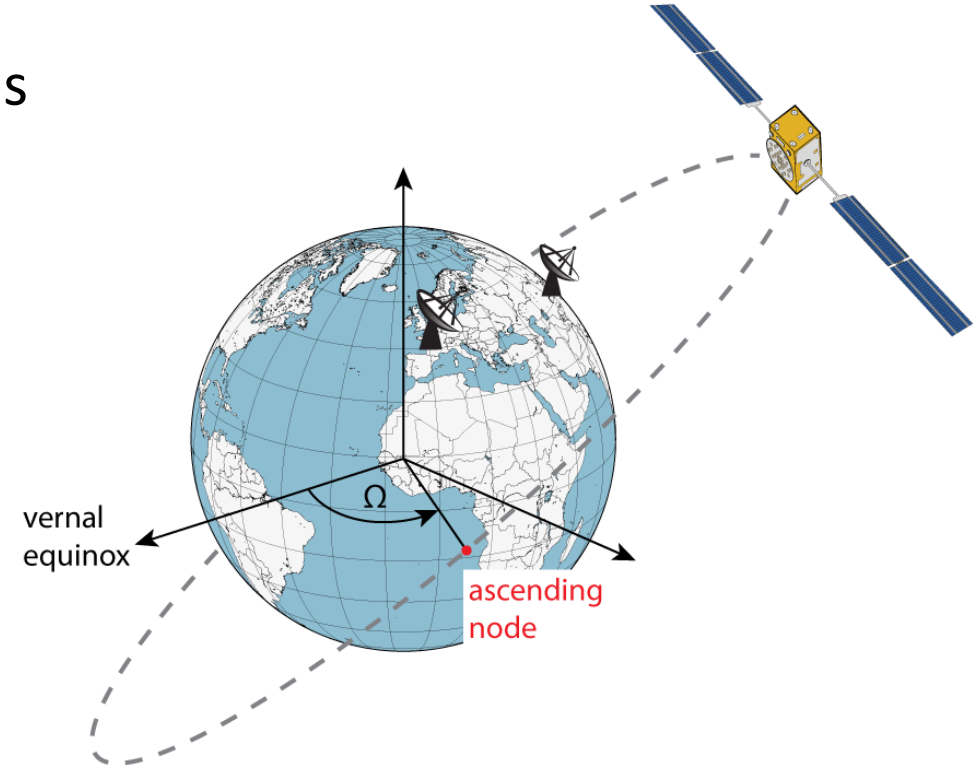


Why observing satellites with VLBI?

- plans of VLBI transmitter on board of Galileo satellites

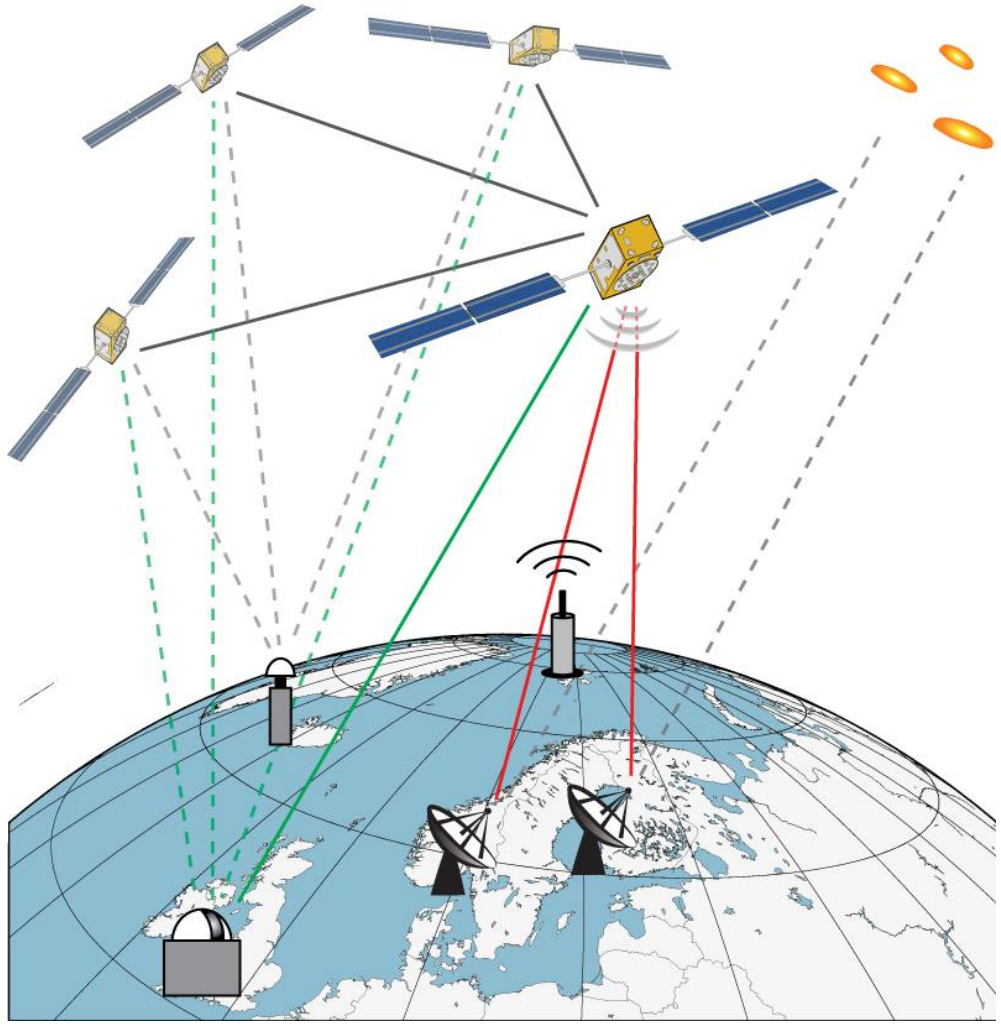
→ VLBI observations allow the direct estimation of satellite orbits in the celestial frame





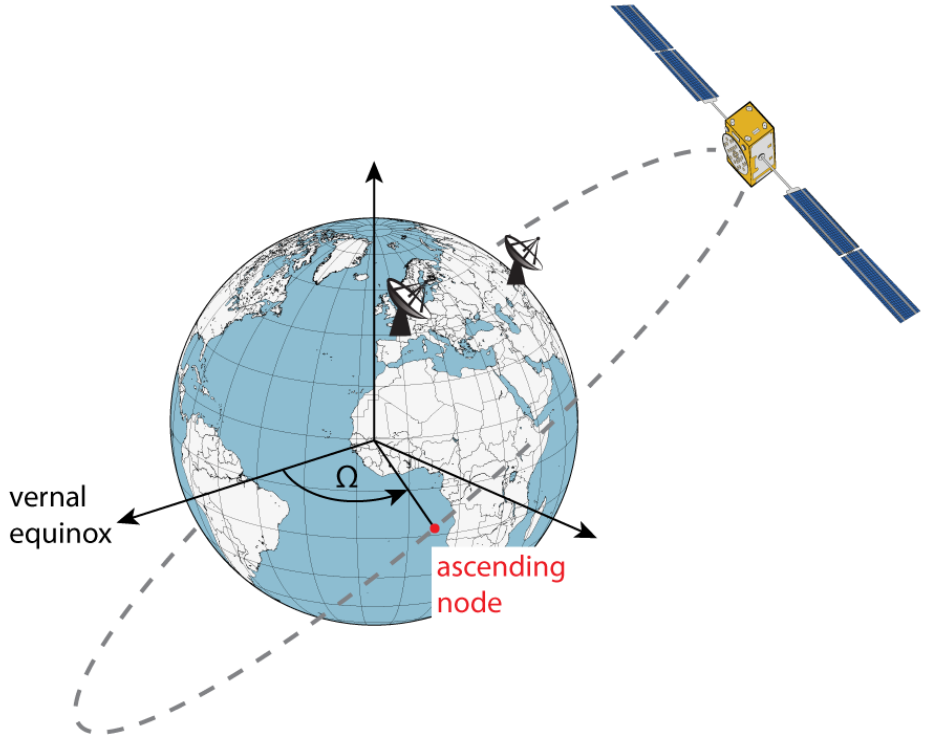
Why observing satellites with VLBI?

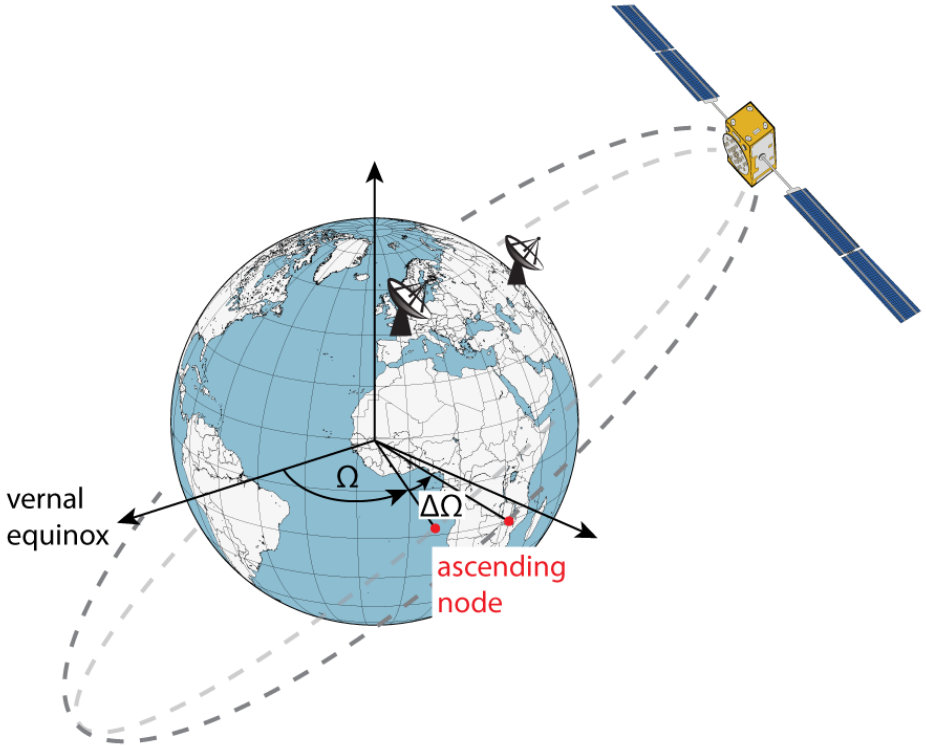
- realising ties on-board of a satellite
- high-precision tying of different space geodetic techniques
- improvement of the terrestrial reference frame
  - errors in local ties on the ground are limiting factor for the accuracy of the terrestrial reference frame



Estimation of Orbital Elements

- right ascension of the ascending node as a first test
- partial derivatives are built numerically (changing Ω by 0.5°)





Estimation of Orbital Elements

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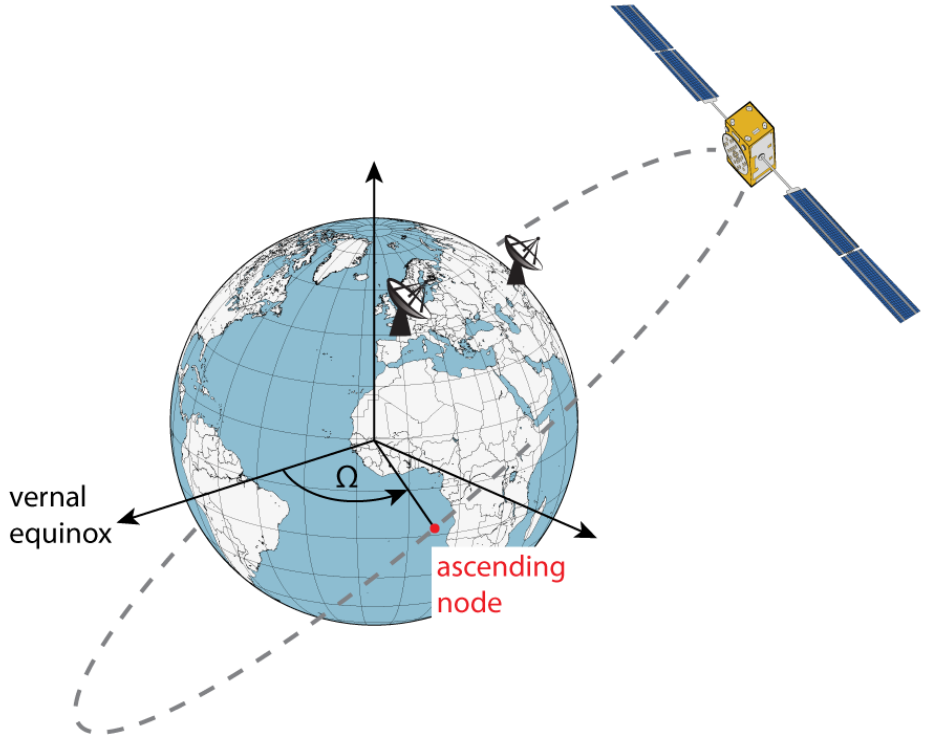
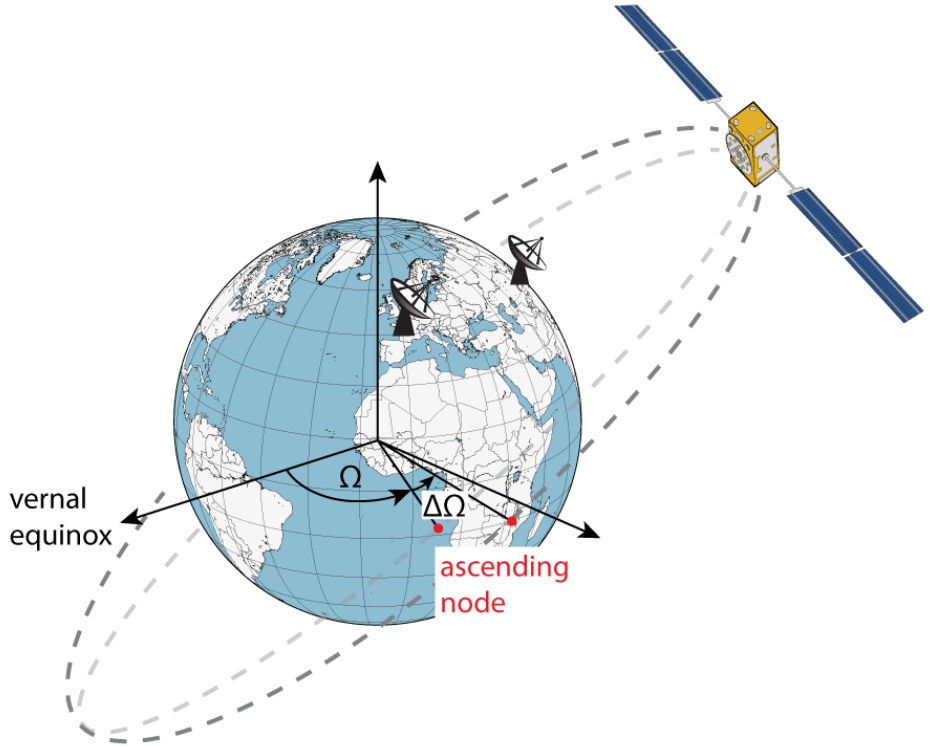
  → using GNSS measurements from Bernese



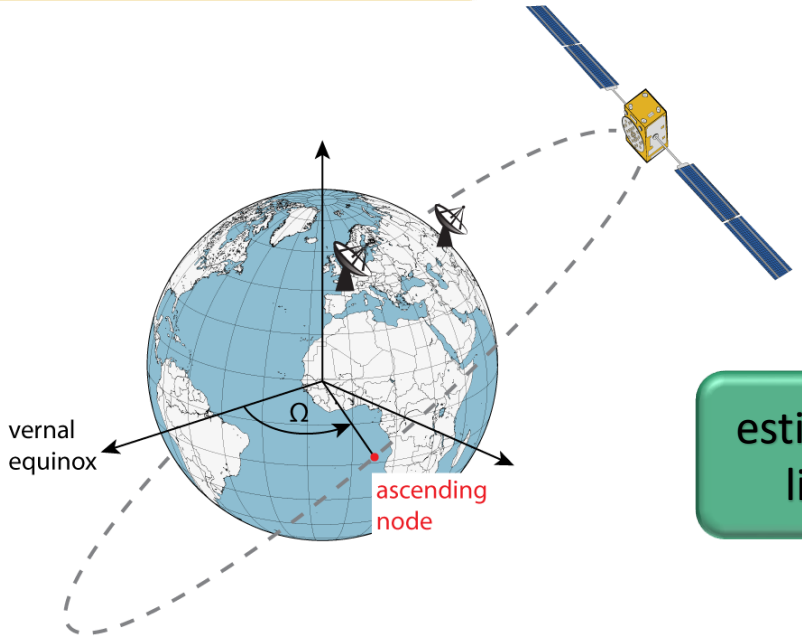


Estimation of Orbital Elements

BERNESE

FSO-file (orbits)

FRP-file (derivatives)



VieVS

$r(t)$ and $v(t)$

$\frac{\partial r(t)}{\partial \Omega}, \frac{\partial v(t)}{\partial \Omega}$

$$\frac{\partial \tau}{\partial r(t)} \cdot \frac{\partial r(t)}{\partial \Omega} = \frac{\partial \tau}{\partial \Omega}$$

Least squares adjustment

estimation of piecewise linear offsets for Ω

Estimation of Orbital Elements

schedule

creating a schedule including quasar and satellite observations

- satellite scans with 10 seconds duration every 90 seconds
- remaining part of schedule is filled with quasar scans
- quasar scans fixed to 10 seconds

VieSched++ Vienna VLBI and Satellite Software

simulations

1000 simulations with

- tropospheric turbulence
- clock errors
- 10 ps white noise for satellite scans

VieVS Vienna VLBI and Satellite Software

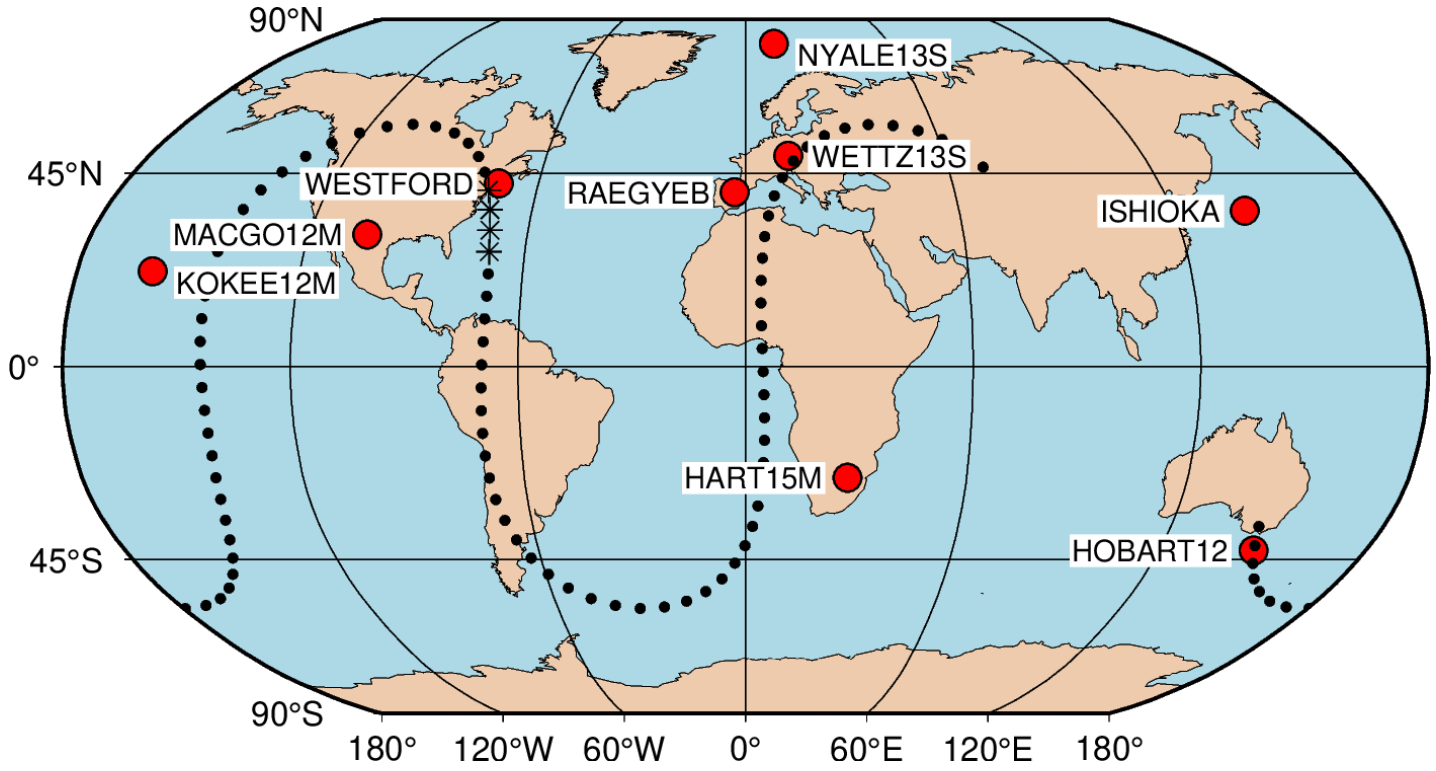
analysis

estimation of piecewise linear offsets from a-priori orbit for Ω

- quasars and stations are fixed
- repeatabilities

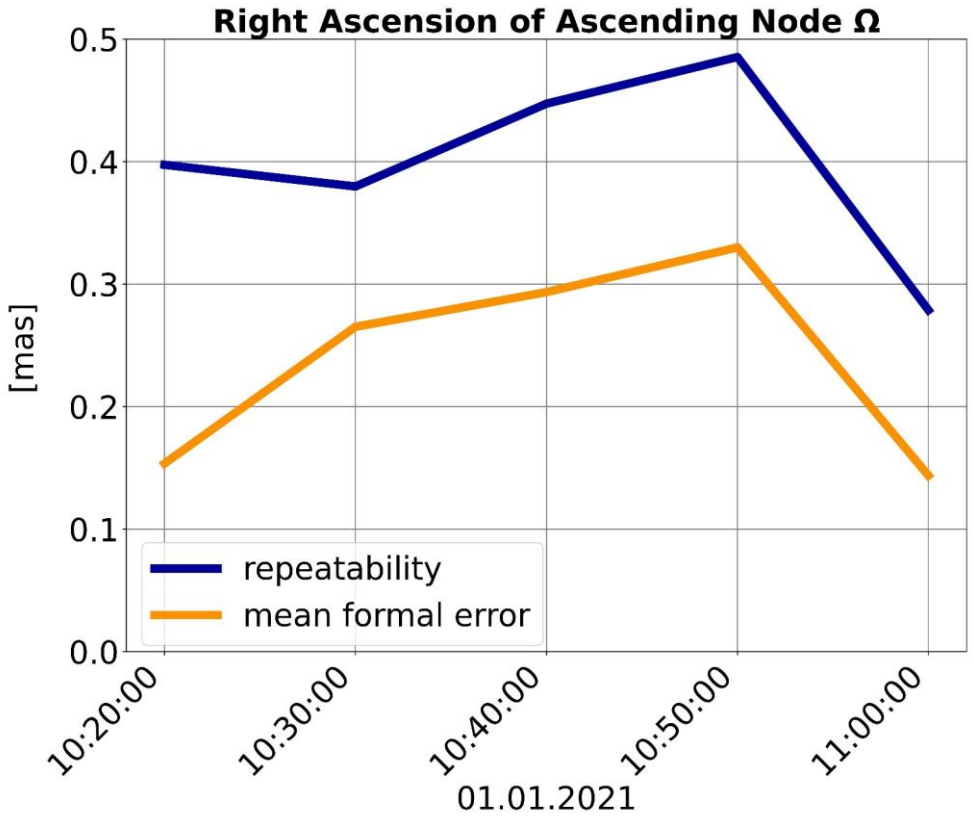
Estimation of Orbital Elements

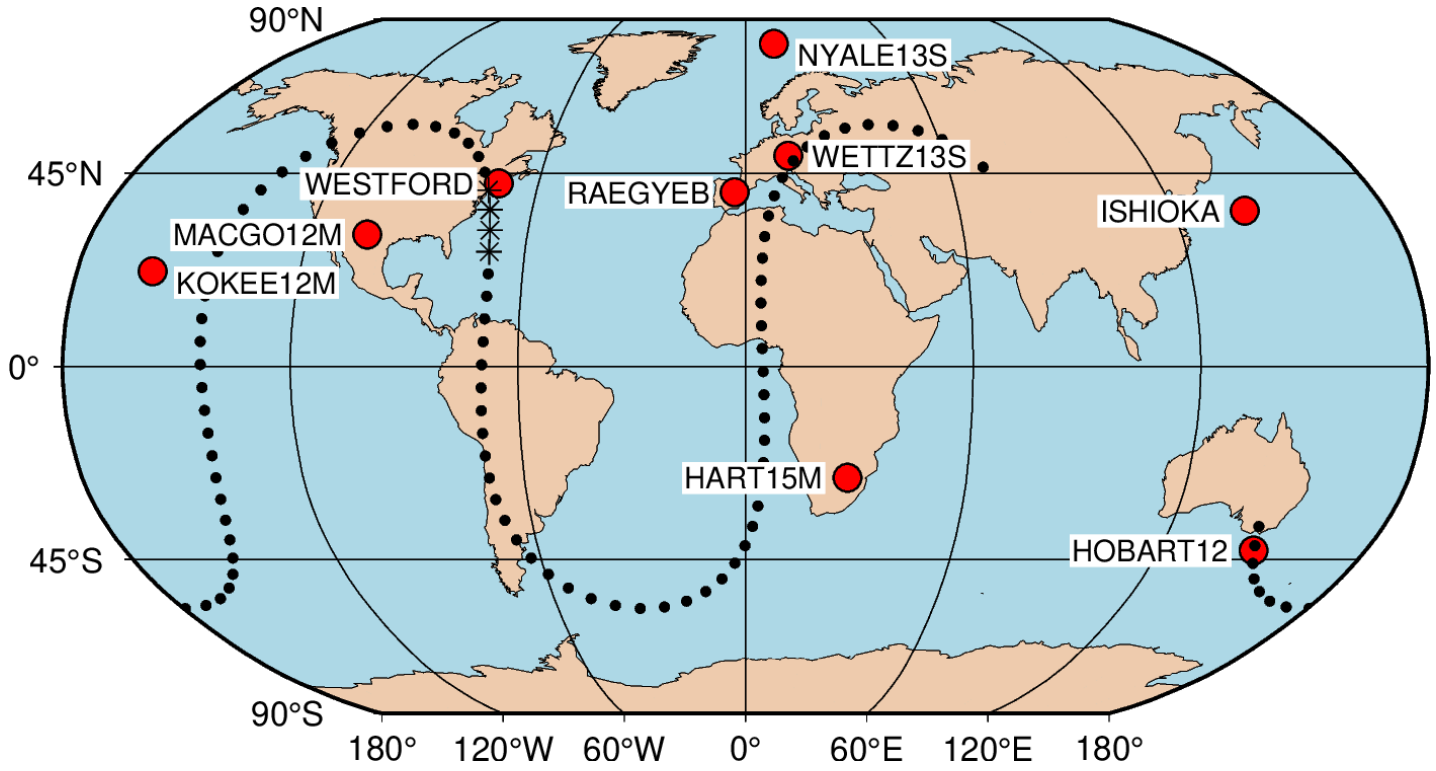
- Example: Jan. 1, 2021 00:00 – 24:00
  - 9 station network
  - GSAT0101 (E11)
  - satellite observation period with 40-min duration
  - estimation of right ascension Ω
    - as piecewise linear offsets
    - one value for the 40-min period



Estimation of Orbital Elements

- satellite observations from 10:20 – 11:00 with 5 stations





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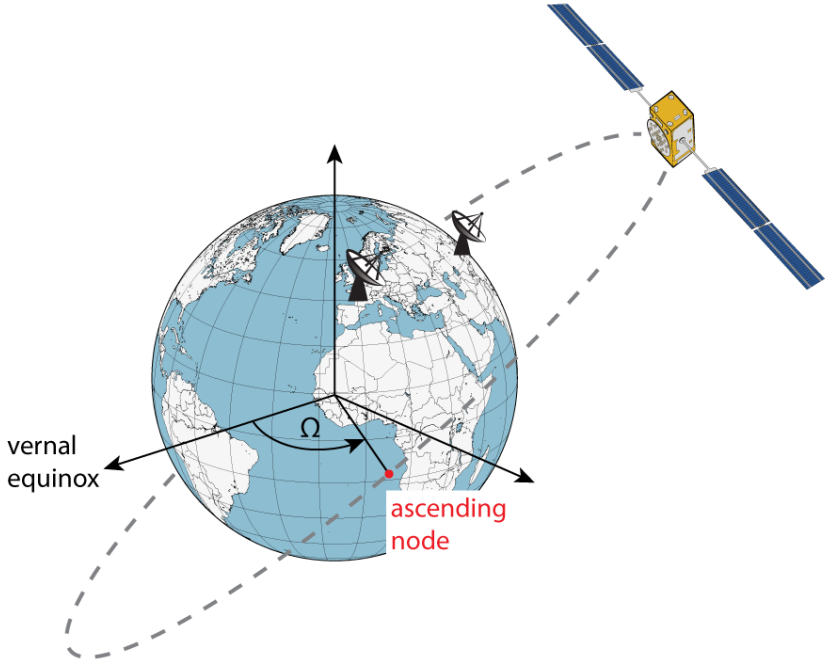
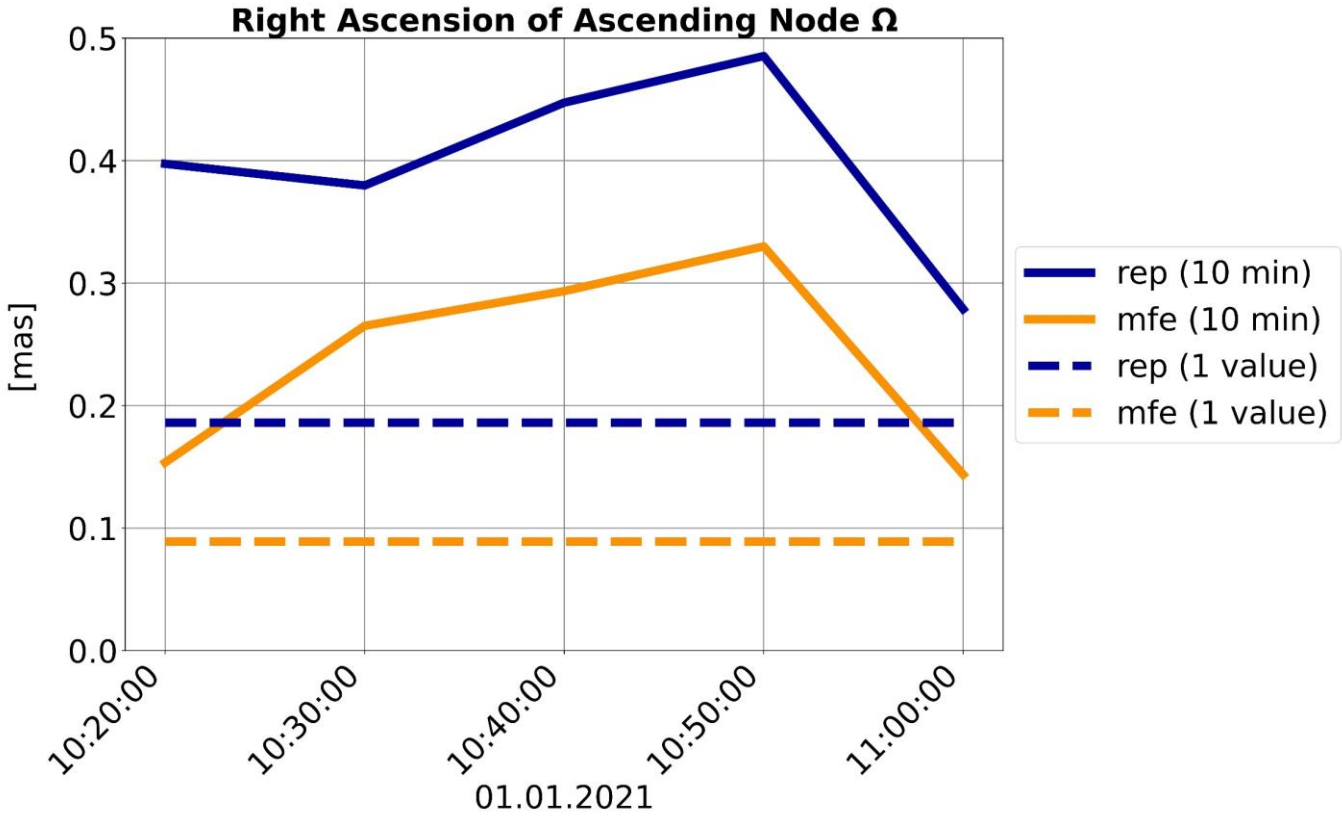
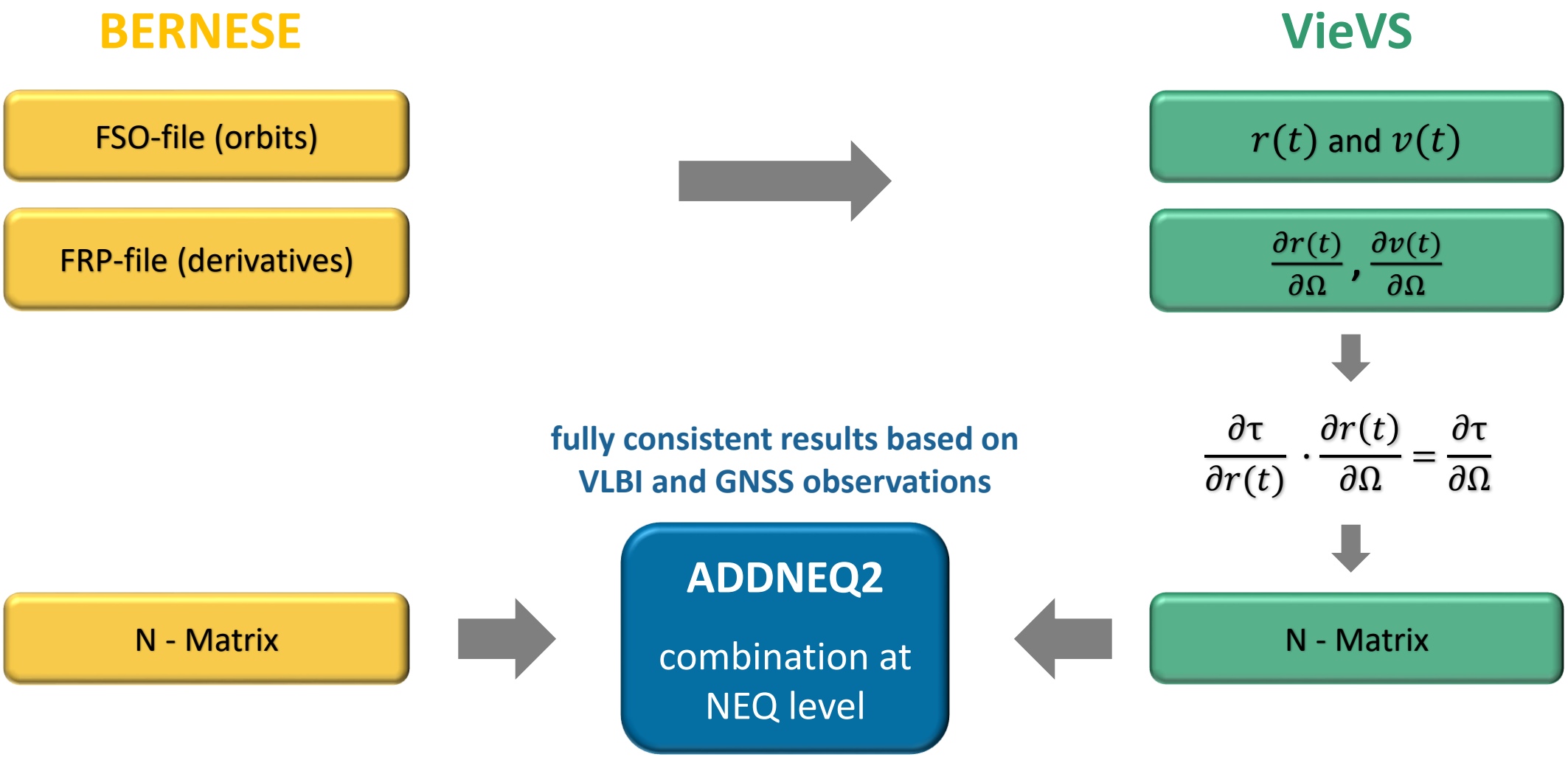




0,1 mas ≙ 1,5 cm at altitude of orbit

Outlook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$\frac{\partial r(t)}{\partial \Omega}, \frac{\partial v(t)}{\partial \Omega}$
$\frac{\partial \tau}{\partial r(t)} \cdot \frac{\partial r(t)}{\partial \Omega} = \frac{\partial \tau}{\partial \Omega}$
fully consistent results based on
VLBI and GNSS observations
ADDNEQ2
combination at
NEQ level
N - Matrix
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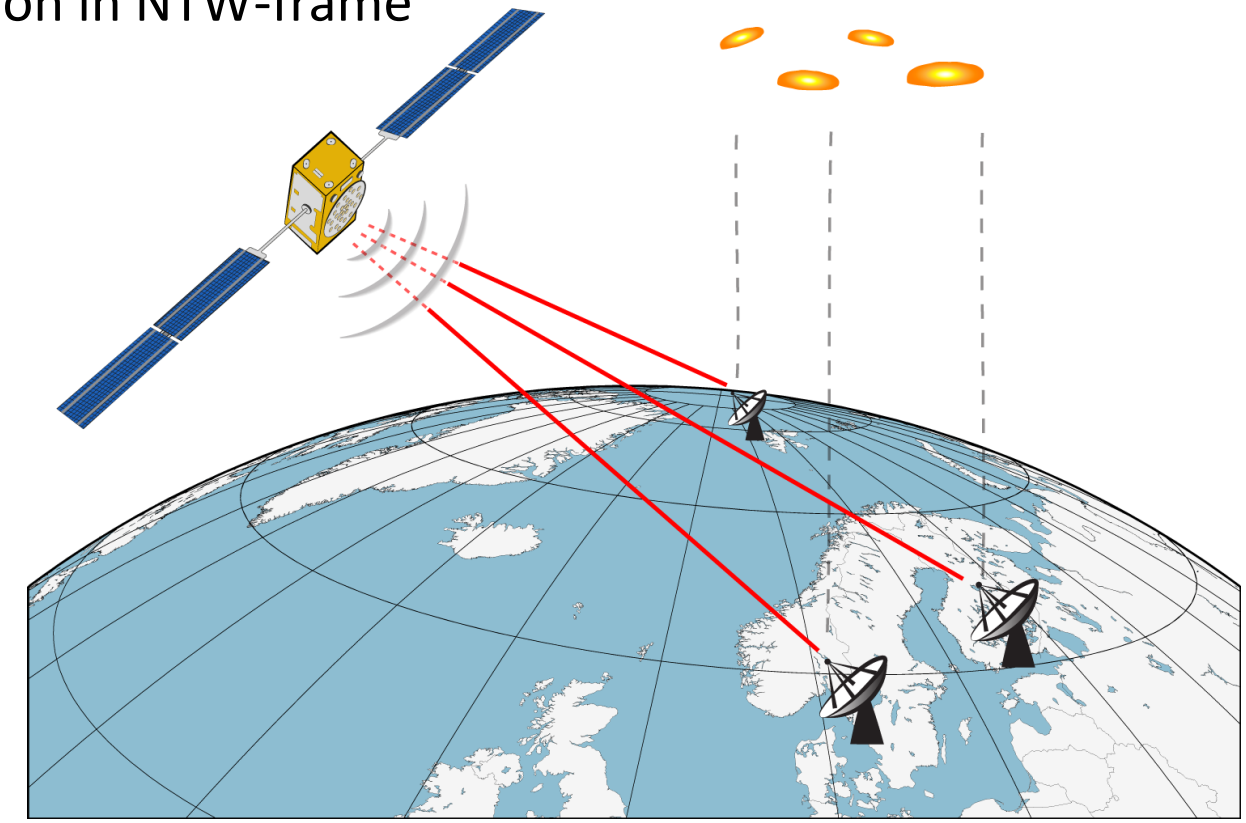
Conclusion

- more investigations needed, e.g.,
  - how many quasar scans in between for sufficient troposphere determination
  - relationship with estimated satellite position in NTW-frame
  - dependence on observation geometry
- frequency of estimation
  - estimation interval
  - one value for 24-hour session
- estimation of other orbital elements
- combination at NEQ level



FWF
Der Wissenschaftsfonds.

References

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