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Evaluating VLBI Scenarios for Genesis: Orbital and Observational Configurations

Lisa Kern • **Helene Wolf** • **Sofie Steinmetz** • **Johannes Böhm**

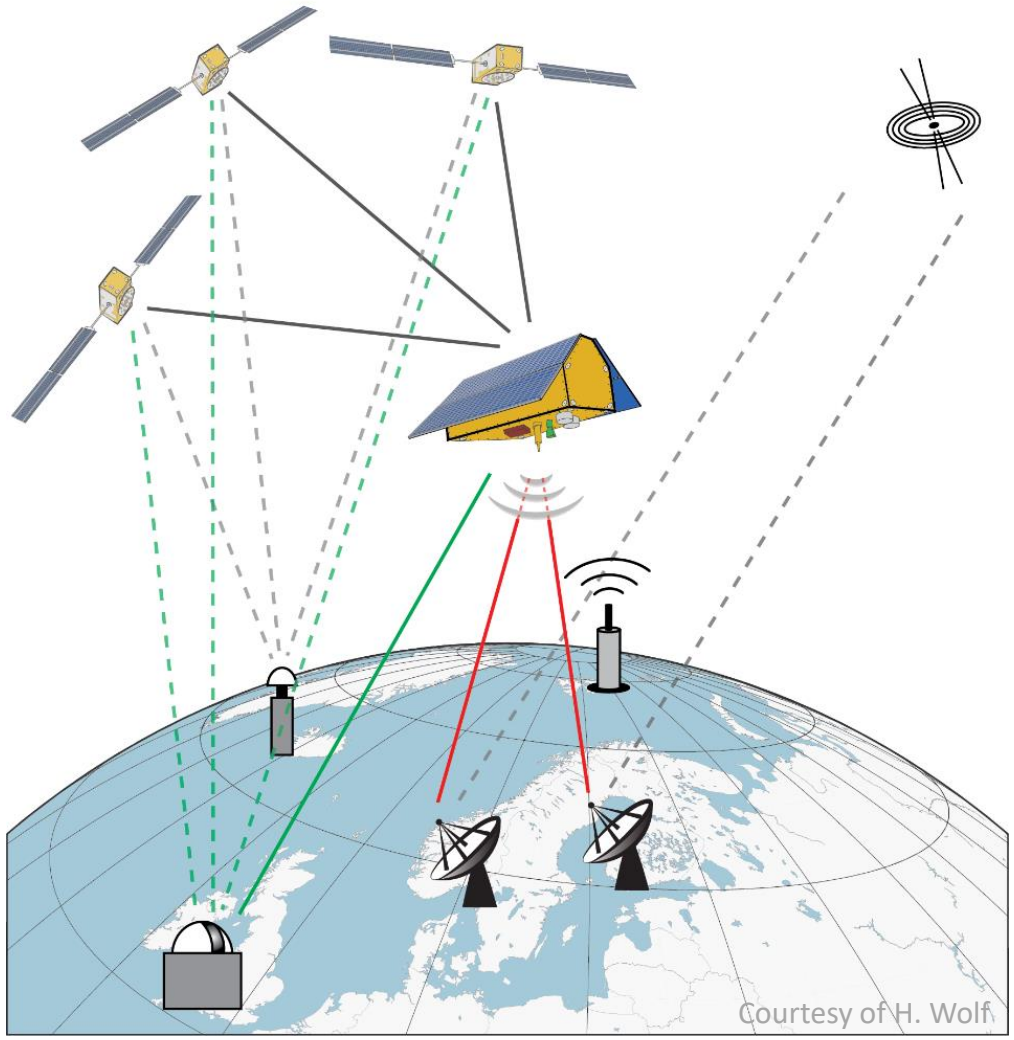
TU Wien, Austria

FWF Austrian Science Fund

Genesis

- ESA mission to be launched in 2028
- co-location satellite
- circular orbit with
  - altitude: 6000 km
  - inclination: 95°

→ enhancement of ITRF through highly accurate space ties



Motivation

#1: ongoing discussions regarding inclination

- inclined or polar orbit

→ observing geometry and coverage

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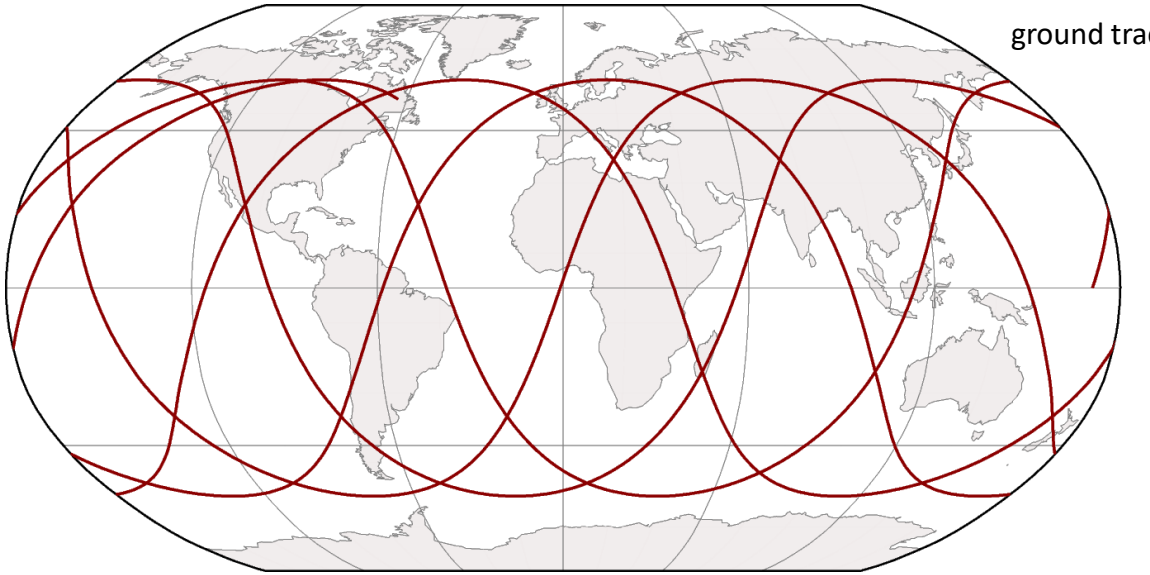
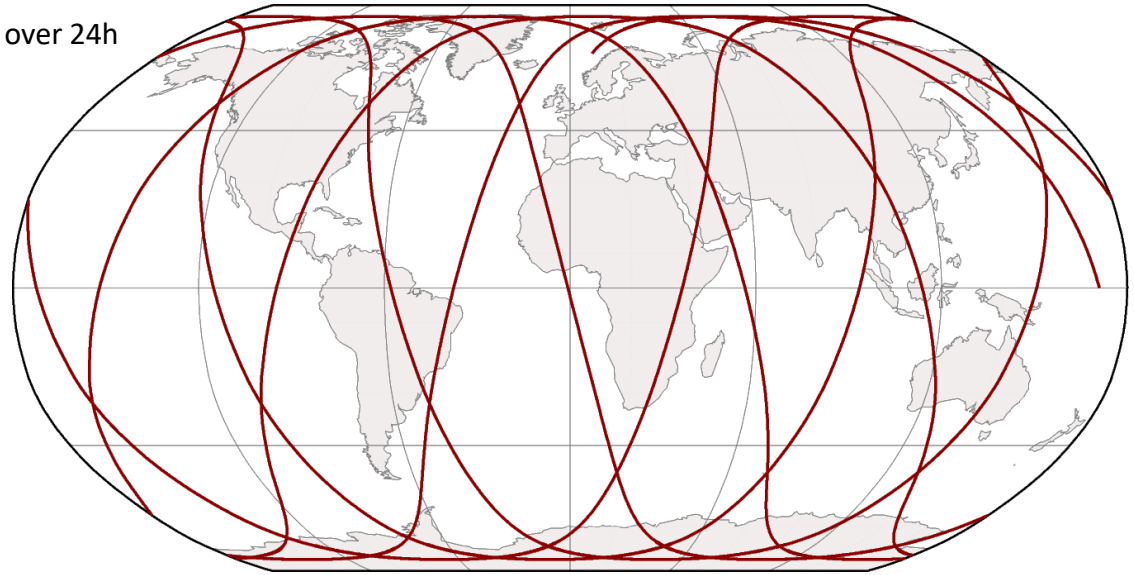
$i = 60°$



ground tracks over 24h

$i = 97°$



Figures from Wolf et al. (2025) @EVGA

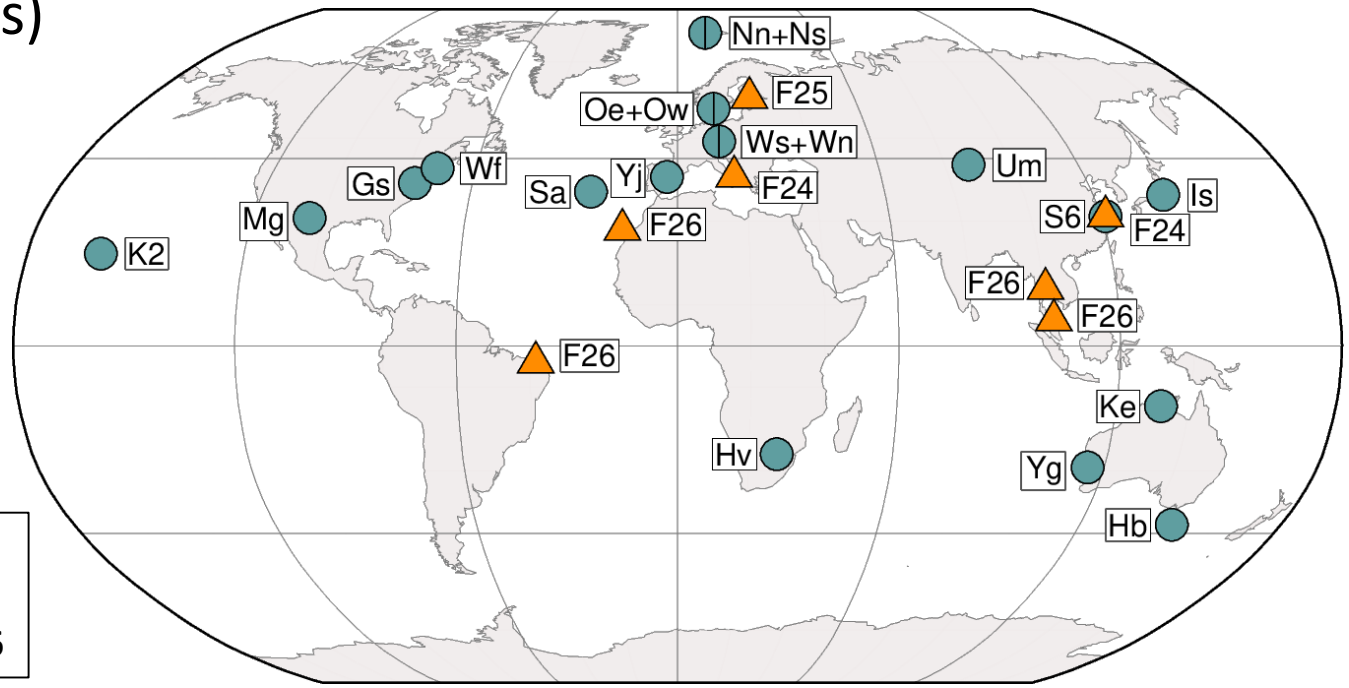
Motivation

#2: different network constellations

- current VGOS network (19 stations)
- future VGOS network (26 stations)

↓

before 2028
(launch of Genesis)

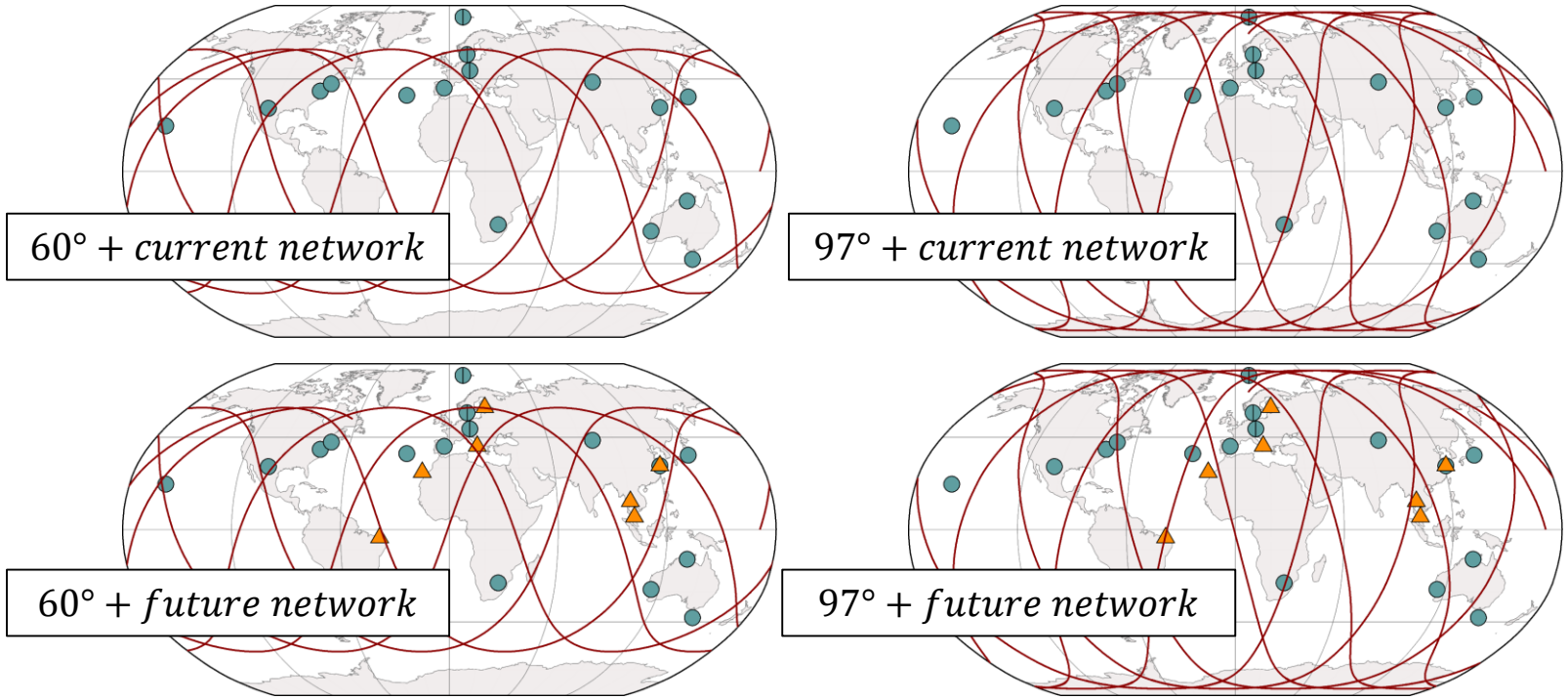


currently available VGOS stations
future VGOS stations (before 2028)
e.g. F26 ... **F**uture station planned for 20**26**

Figures from Wolf et al. (2025) @EVGA

Motivation

- examine the impact of different inclinations and station network configurations on the VLBI TRF → **4 scenarios**



Figures from Wolf et al. (2025) @EVGA

Workflow (per scenario)

- scheduling
  - weekly 24-hour sessions over 2 years → 104 sessions
  - Genesis satellite orbit based on TLE file
  - scan length fixed to 30 seconds for Quasars and Satellite
  - constant weight for satellite

    → 15-20% of satellite scans w.r.t. all scans (on average)

- simulation
  - three main error sources (troposphere, clock, white noise)

C_n	$1.8 \times 10^{-7}\ m^{-1/3}$
white noise	10 ps

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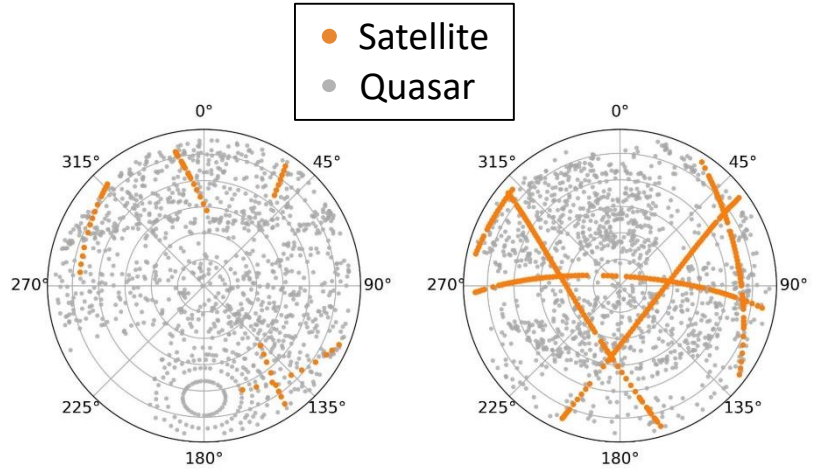

→ station-dependent!

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Workflow (per scenario)

- single-session analysis
  - *estimation of:*
    - **station coordinates** [S]
    - tropospheric parameters [Q + S]
    - EOP [Q]

  → 104 solutions

  - *fixed to a priori values:*
    - quasar coordinates
    - satellite orbit

- multi-session analysis
  - stacking of 104 NEQ to generate global position estimates (no velocities)

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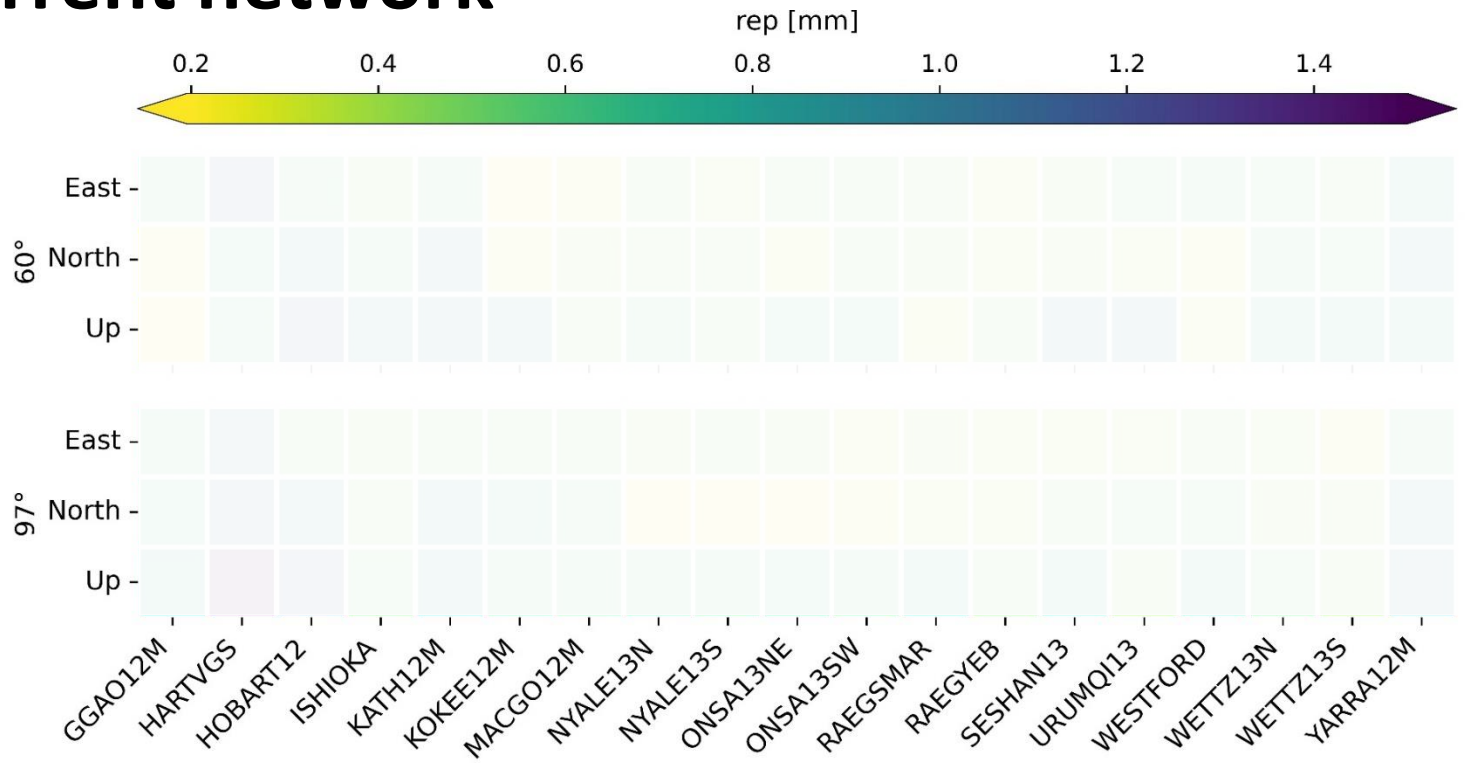
  → ***10 global solutions***

  → **1 repeatability in ENU per scenario**

Results – current network



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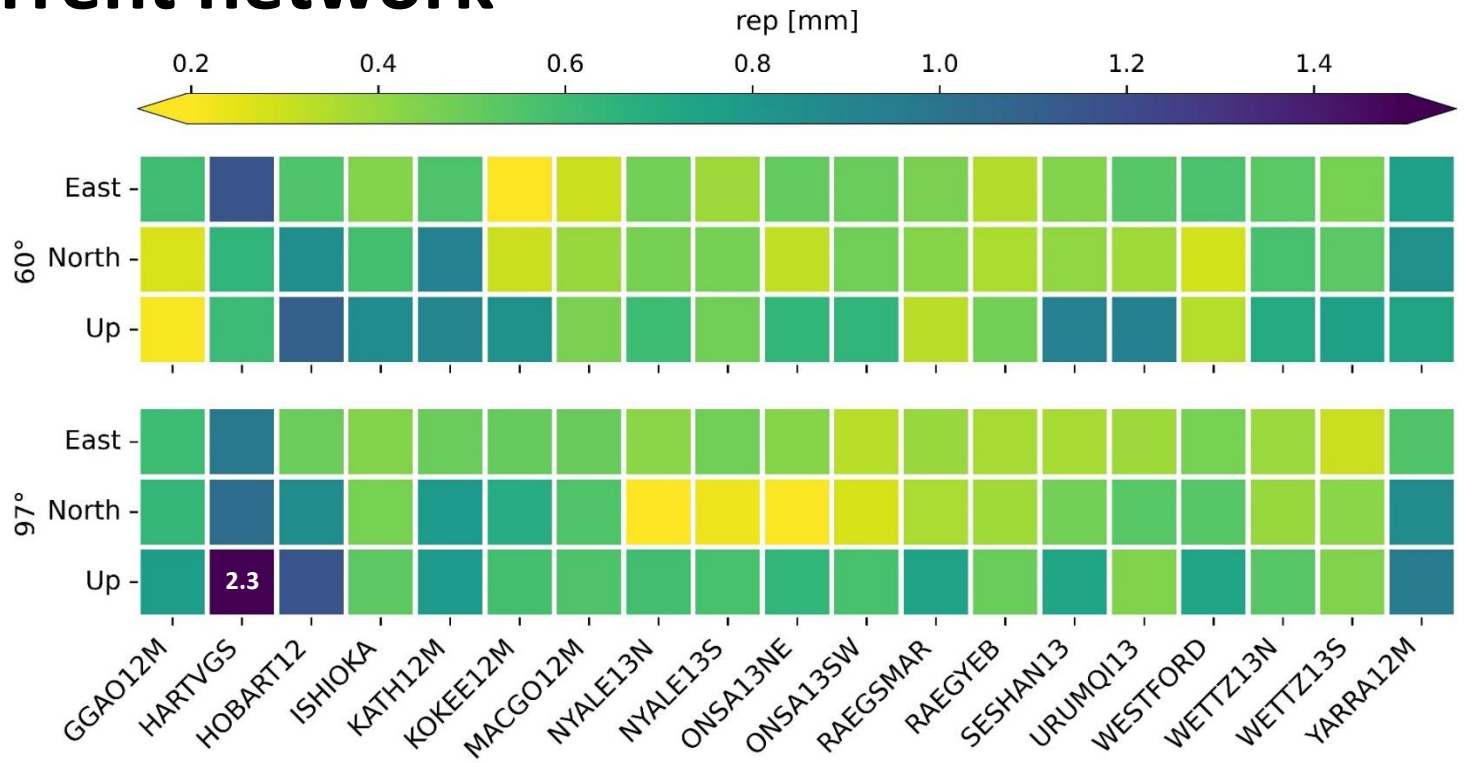

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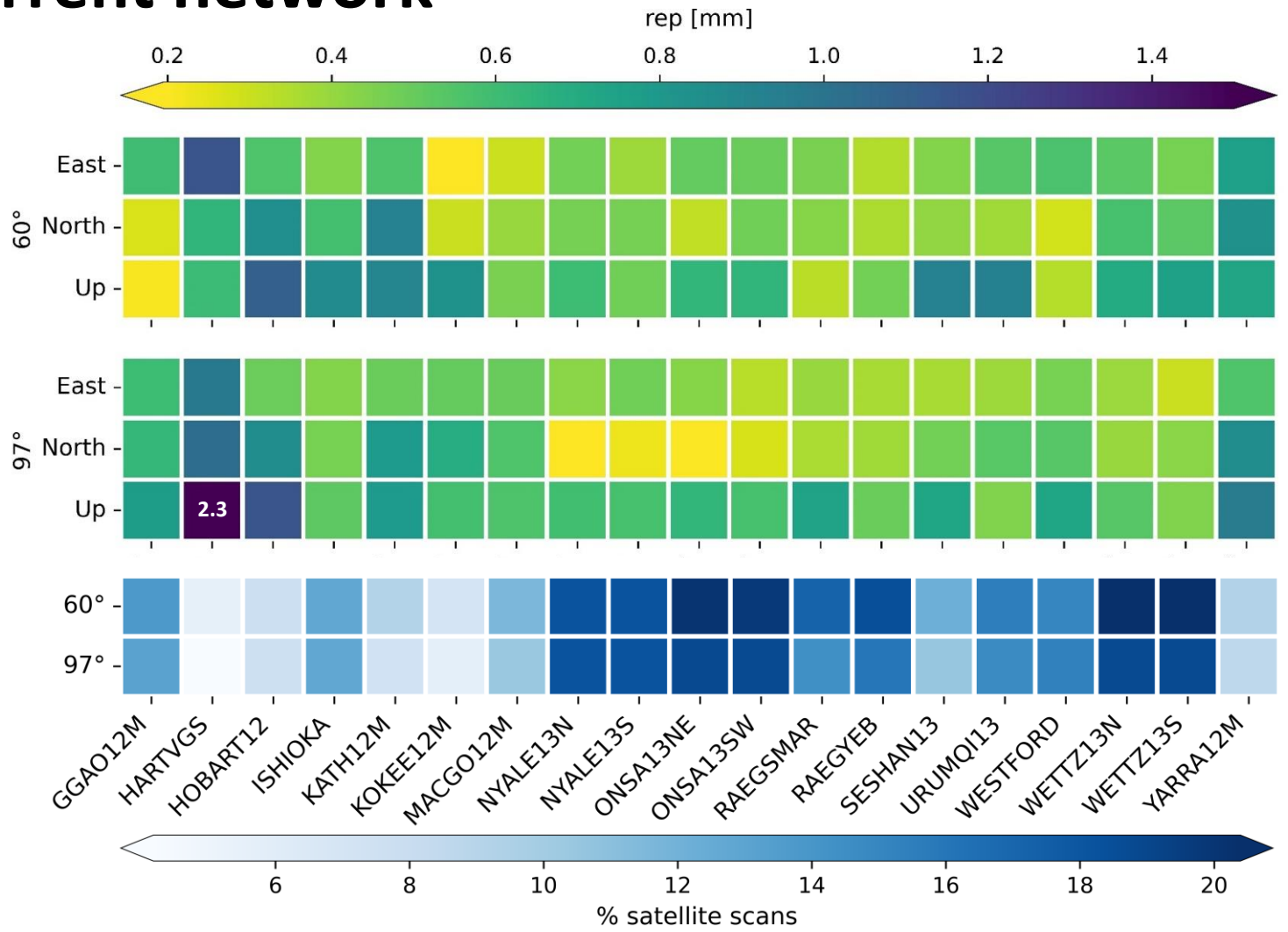

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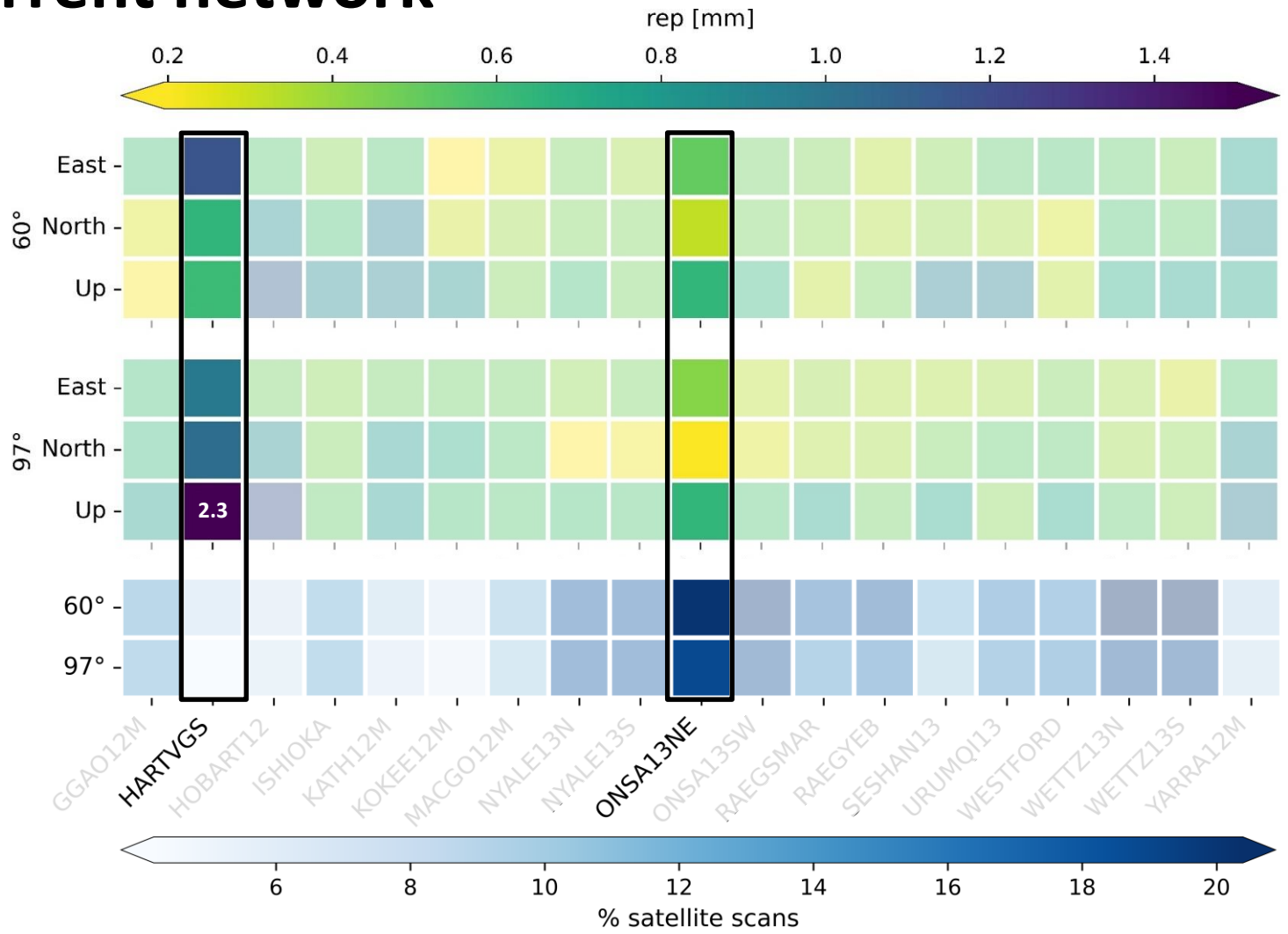

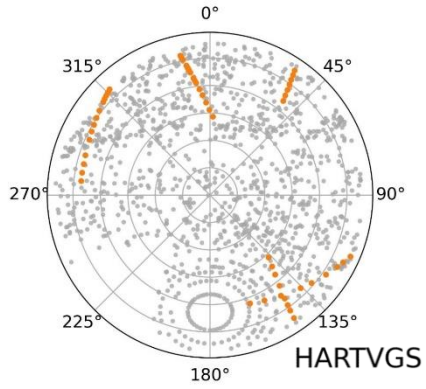

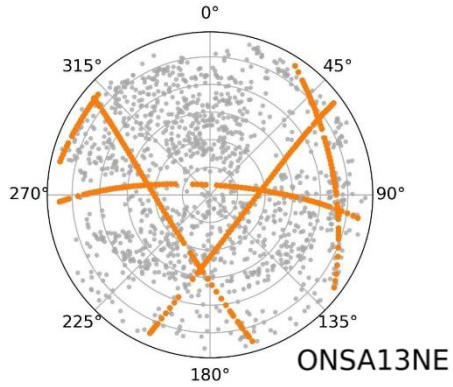

$i = 60°$

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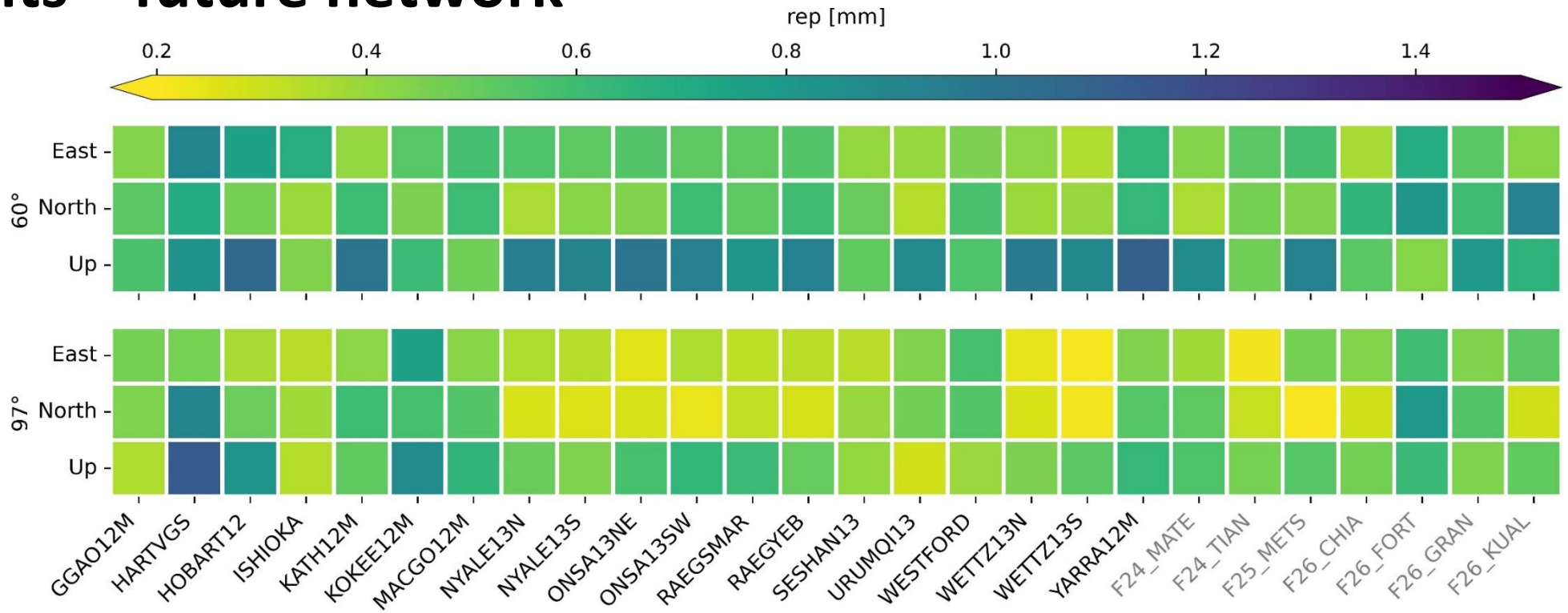
Results – future network



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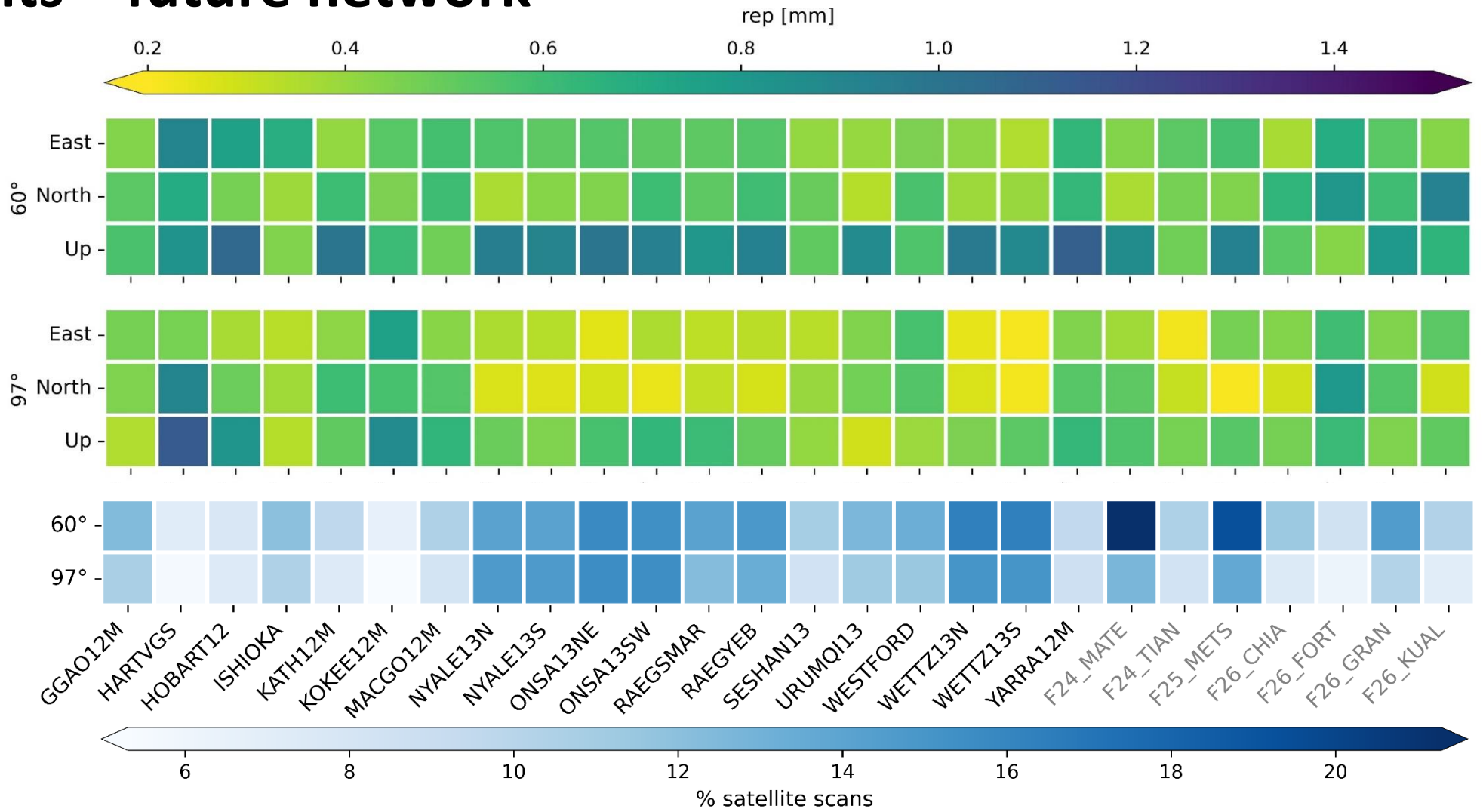

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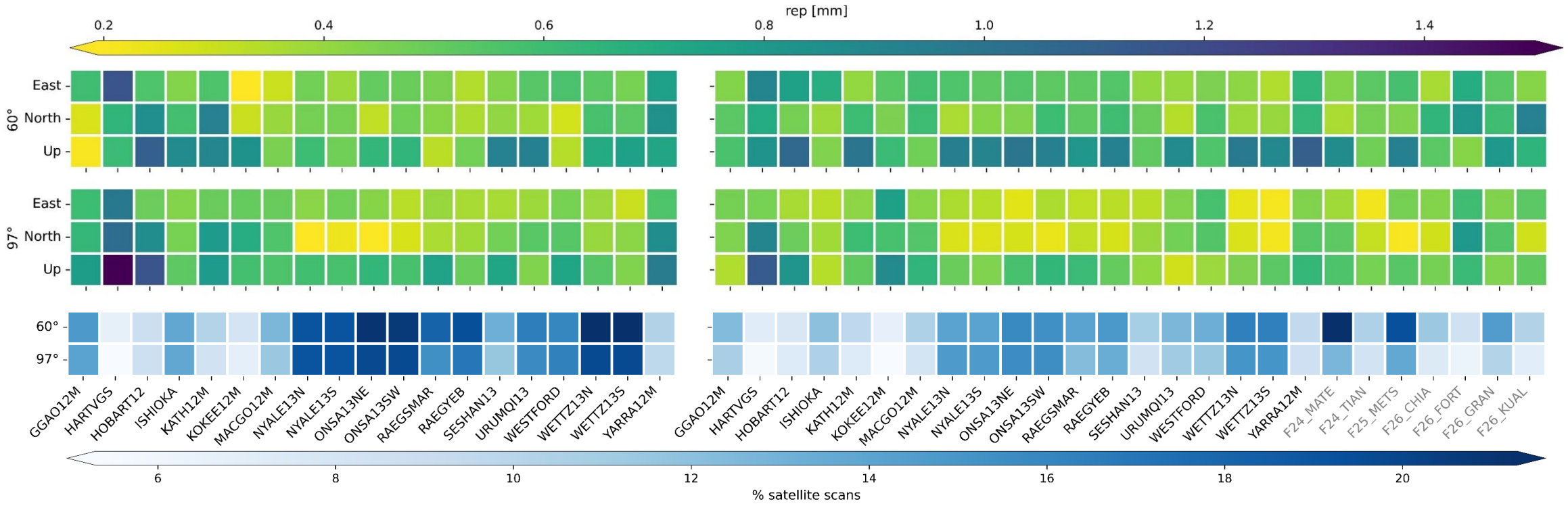

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Conclusion

limitations of this study → software-related and high computational cost

- small improvement with polar orbit compared to inclined orbit

- additional improvement can be achieved through optimized scheduling
  - station-dependent weighting of satellite scans
  - future network achieves more scans overall, however no proportional increase in satellite scans is achieved → more satellite scans possible without degrading sky coverage

References

- Wolf, H., Kern, L., Steinmetz, S., Böhm, J. (2025) Impact of the Inclination of Genesis on the VLBI Terrestrial Reference Frame. 27th Working Meeting of the European VLBI Group for Geodesy and Astrometry, EVGA2025, Matera, Italy. https://doi.org/10.5281/zenodo.15209253