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SPACE@ETH Zurich

VGOS VLBI Intensives between MACGO12M and WETTZ12M for the rapid determination of UT1-UTC

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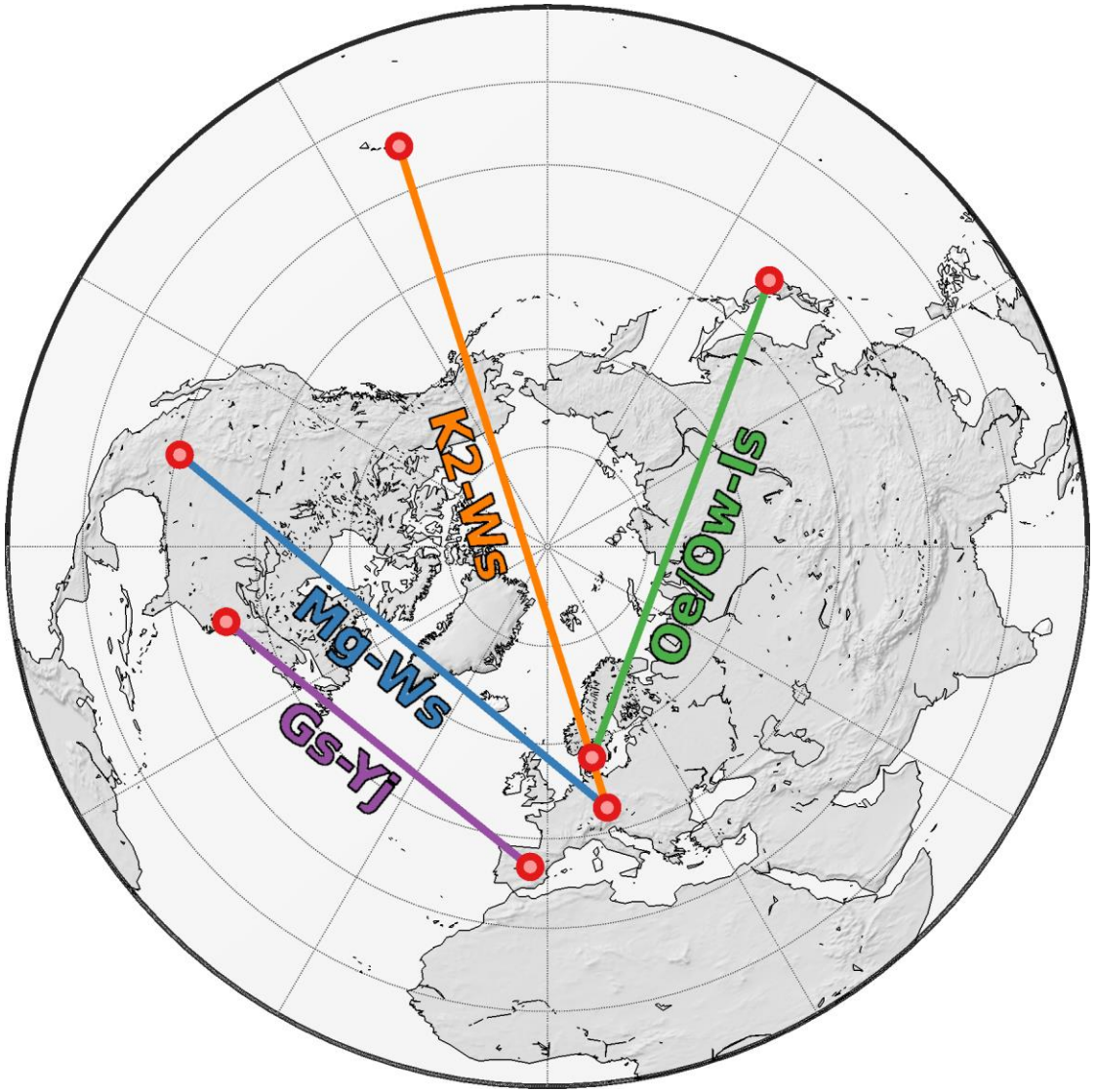
VGOS Intensives



Baseline	3D [km]	xy [km]
K2-Ws	10358	10072
Mg-Ws	**8418**	**8271**
Oe/Ow-Is	7937	7773
Gs-Yj	5893	5891

- Several VGOS-baselines active
- Here: focus on Mg-Ws
  - 42 1h-sessions
  - 3 24h-sessions
  - Mg-Ws 20% shorter compared to K2-Ws
  - still potential for highly accurate UT1-UTC measurements
  - provides redundancy

How to handle troposphere?

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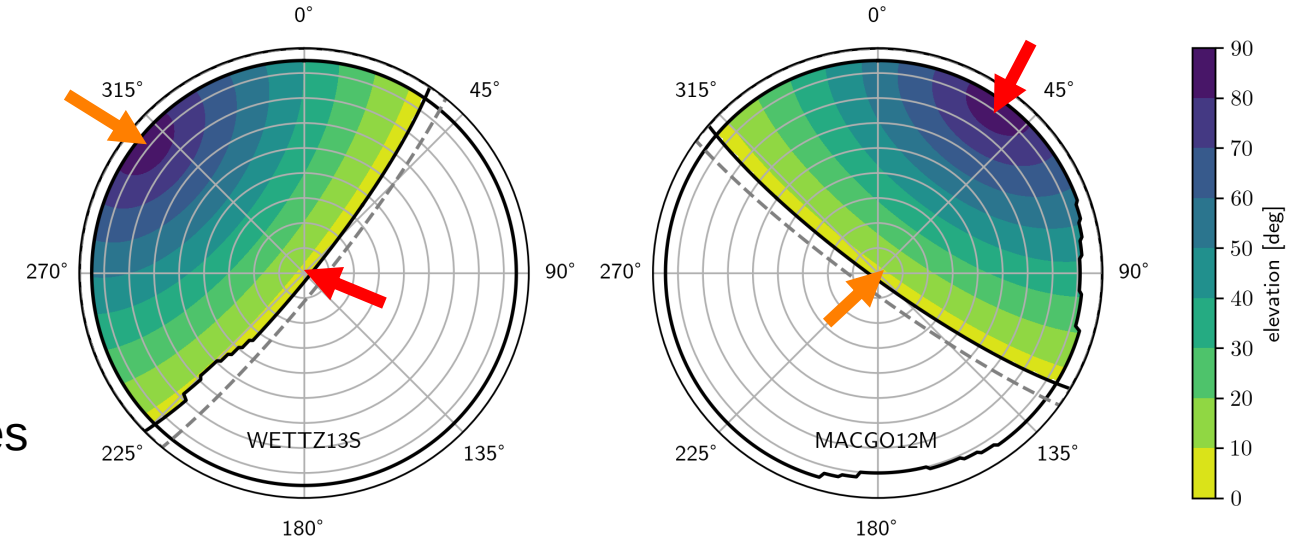
- Smart observation strategy
  - rapid alternation between high and low elevation scans
  - allowing ZWD estimates every few minutes



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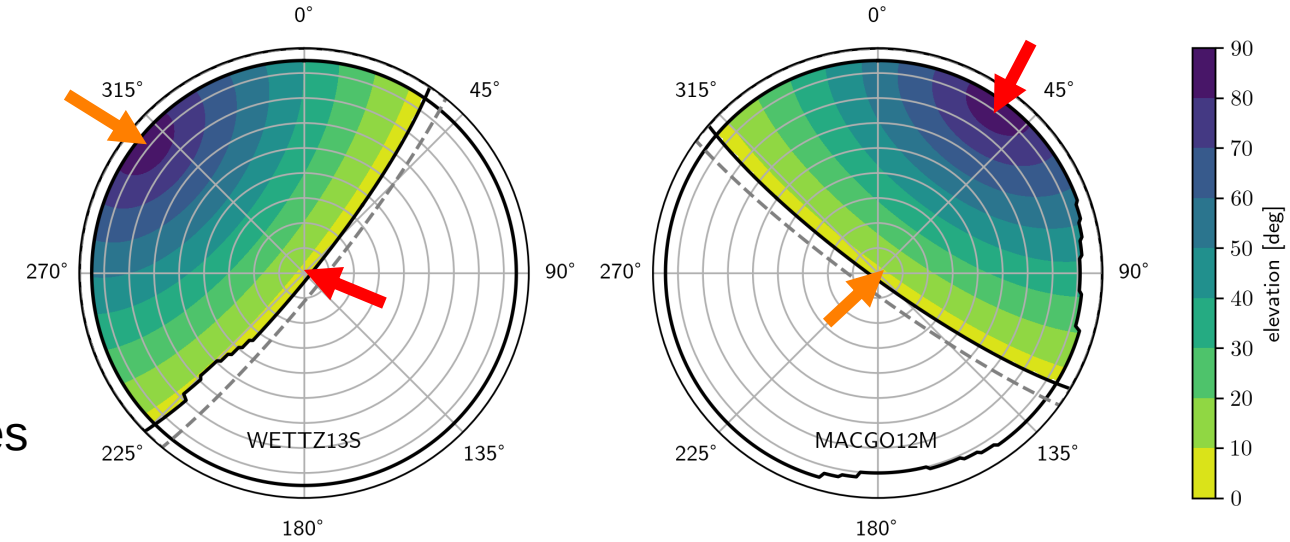

- Combination with GNSS
  - observation level
  - apply ZWD (+ gradients) from GNSS

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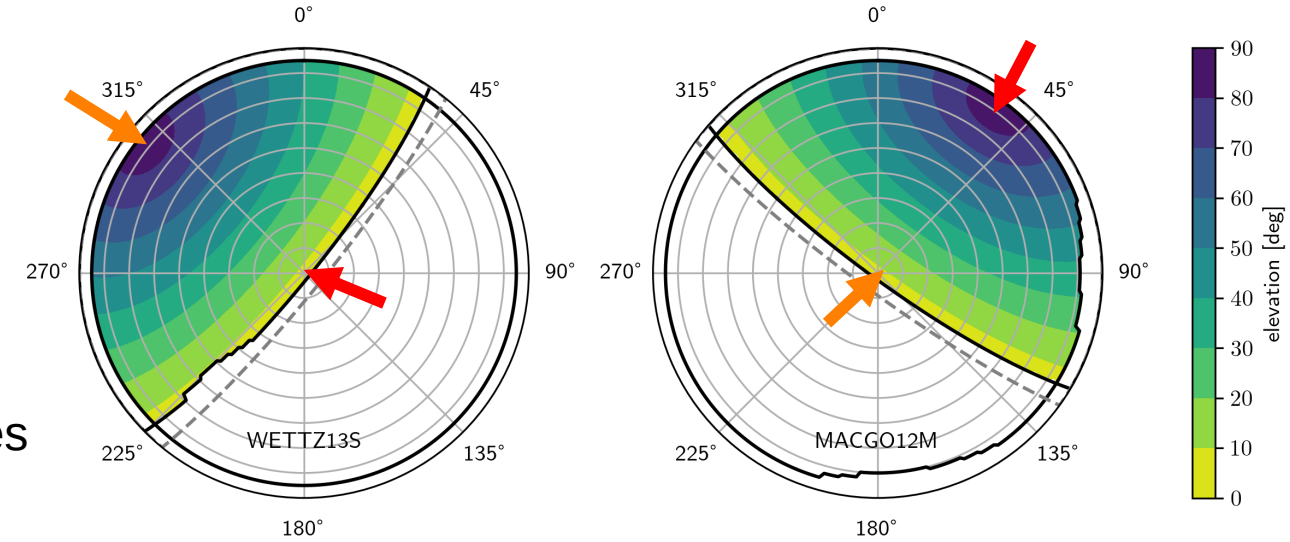

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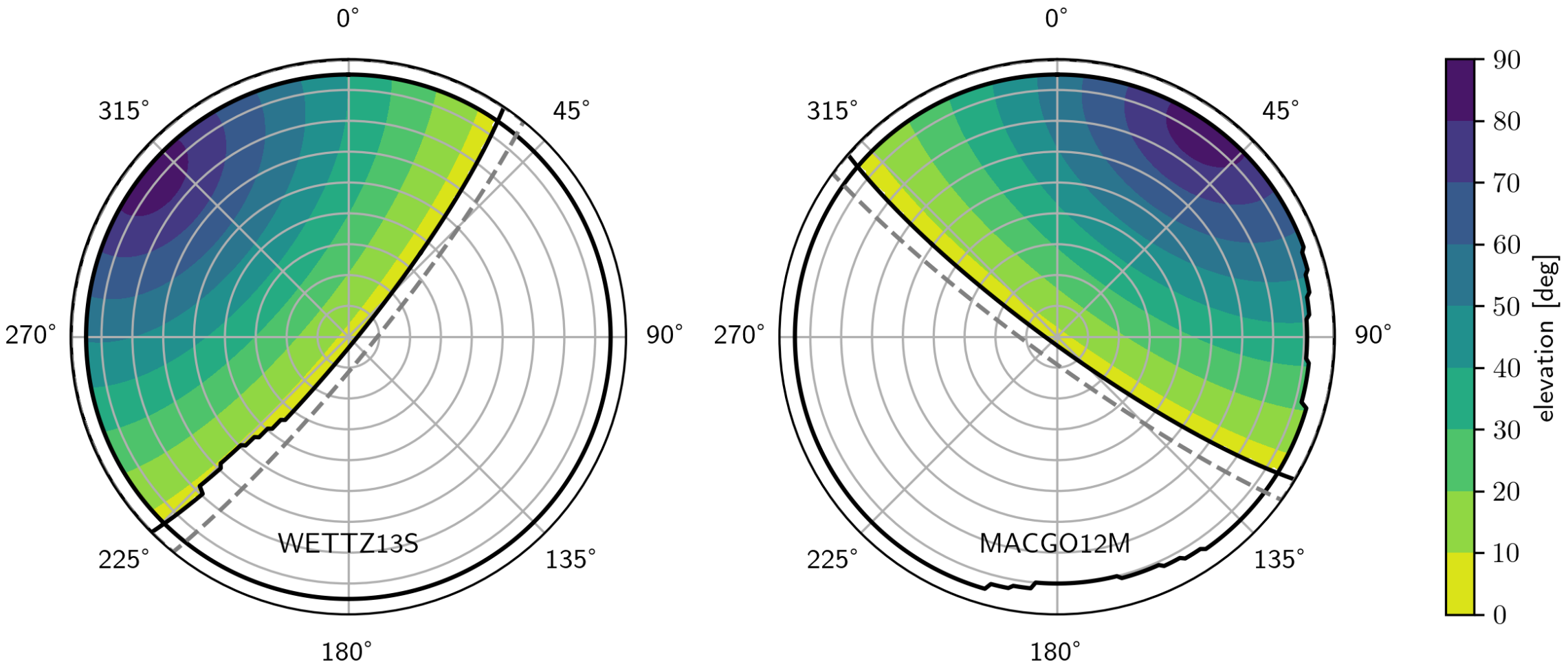
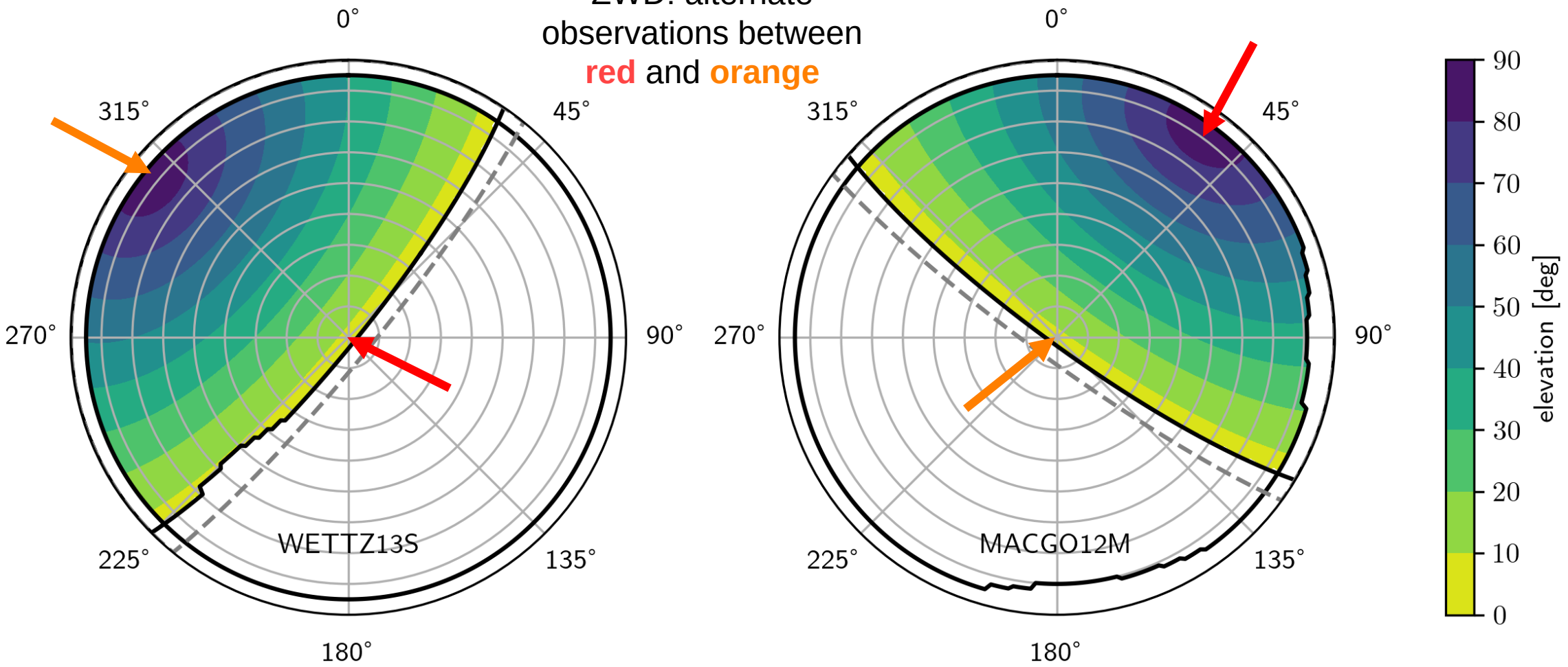
Smart observation strategy: Ws-Mg baseline



Smart observation strategy: Ws-Mg baseline

$$\frac{\partial \tau}{\partial ZWD} \approx \frac{1}{\sin \epsilon}$$

ZWD: alternate observations between **red** and **orange**



red high el Ws, low el Mg
orange high el Mg, low el Ws

Smart observation strategy

Scan sequence:

1. Scan with high elevation at Ws (low elevation Mg)
2. Filler scan
3. Scan with high elevation at Mg (low elevation Ws)
4. Filler scan
5. Repeat step 1-5

→ **estimate ZWD every few (e.g. 5) minutes!**

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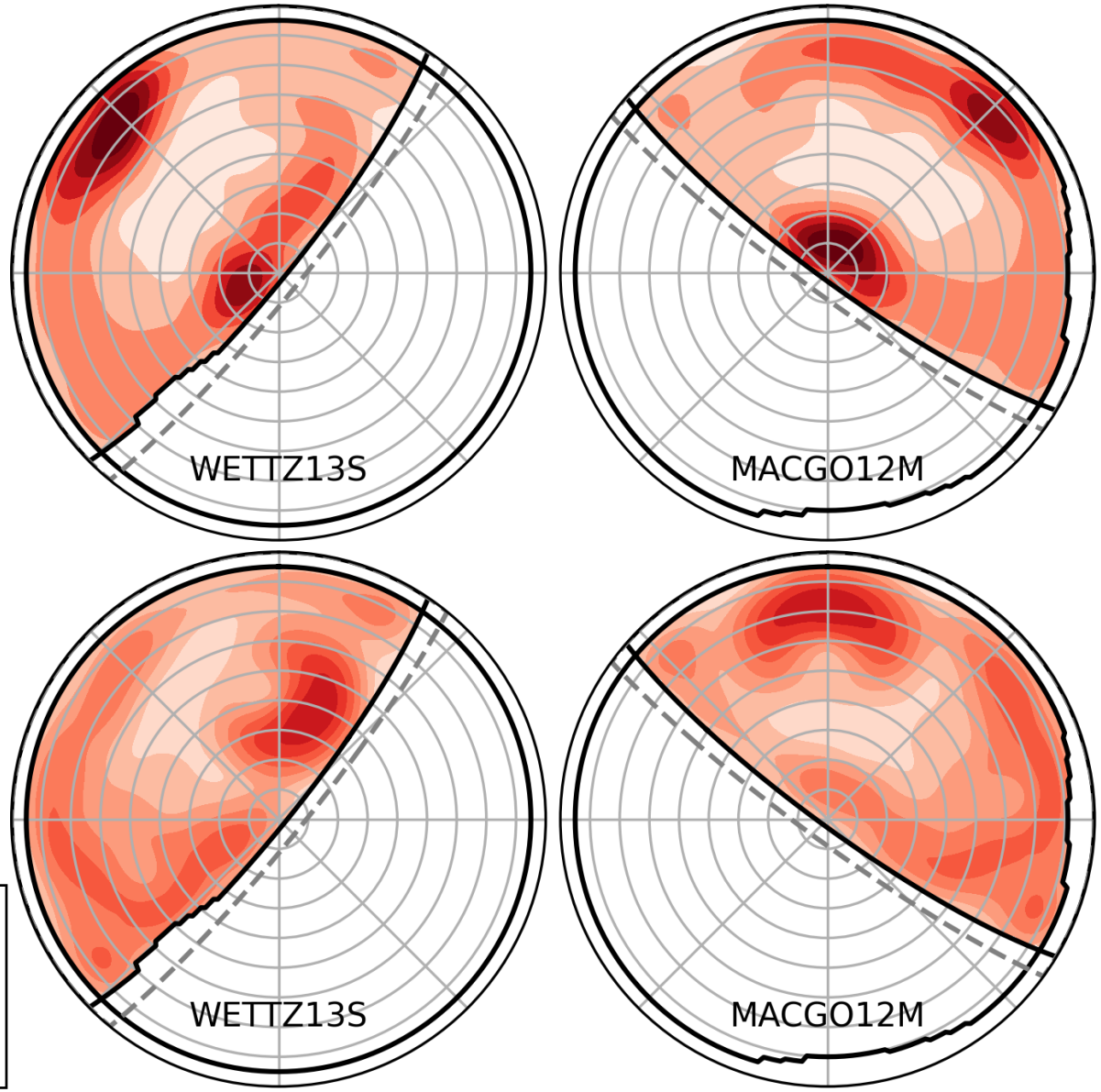
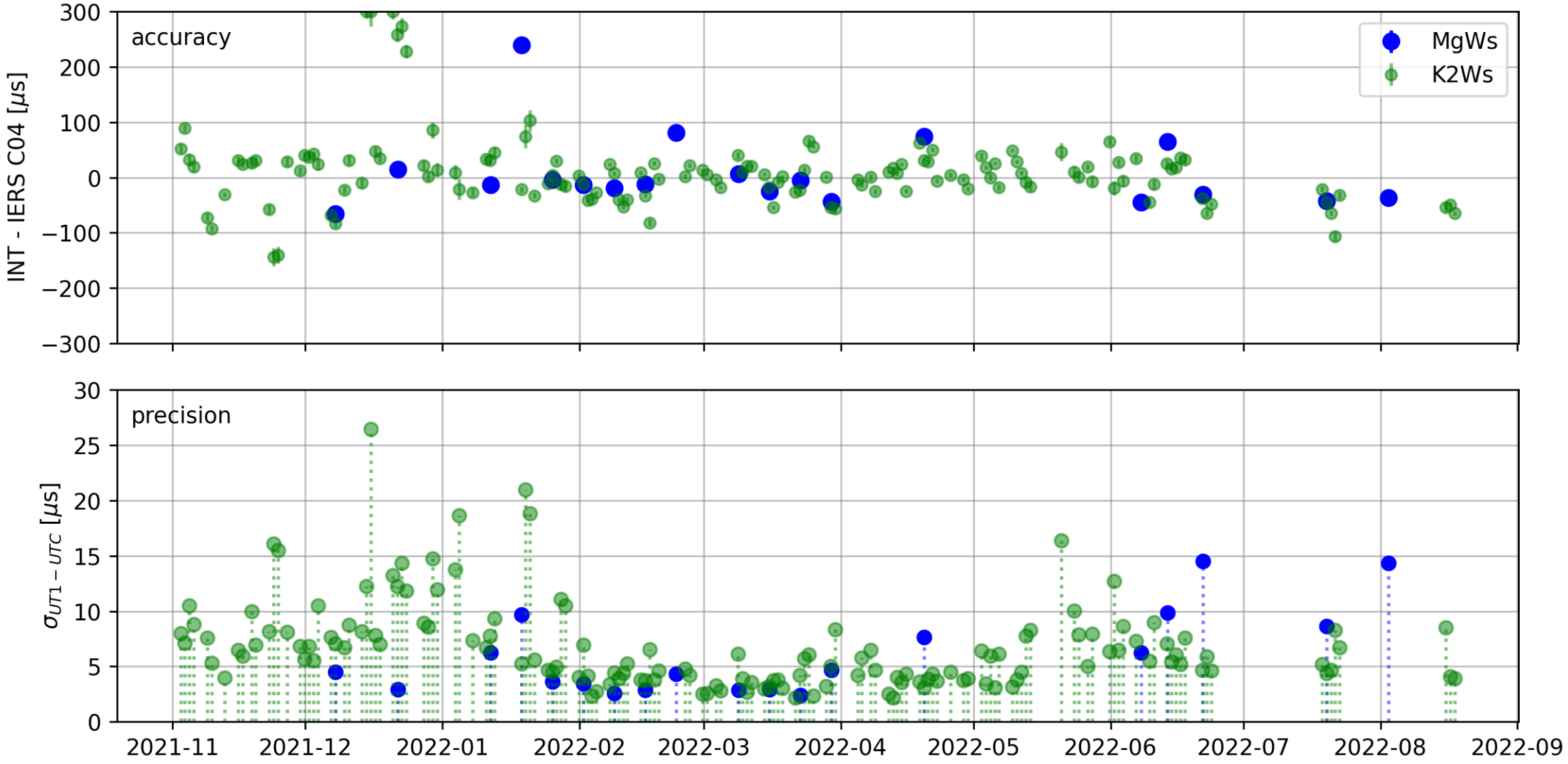


- 1h sessions: new scheduling approach
- 24h sessions: alternate between new (**top**) and standard (**bottom**) mode every hour

Results 1h sessions



Results 24h session

- Five sessions scheduled
  - unlucky with technical problems
  - ➢ only one session correlated and analyzed
  - hope to be able to recover remaining sessions

- Alternate scheduling approach every hour
  - odd hours: standard observation strategy
  - even hours: new observation strategy

Results 24h session

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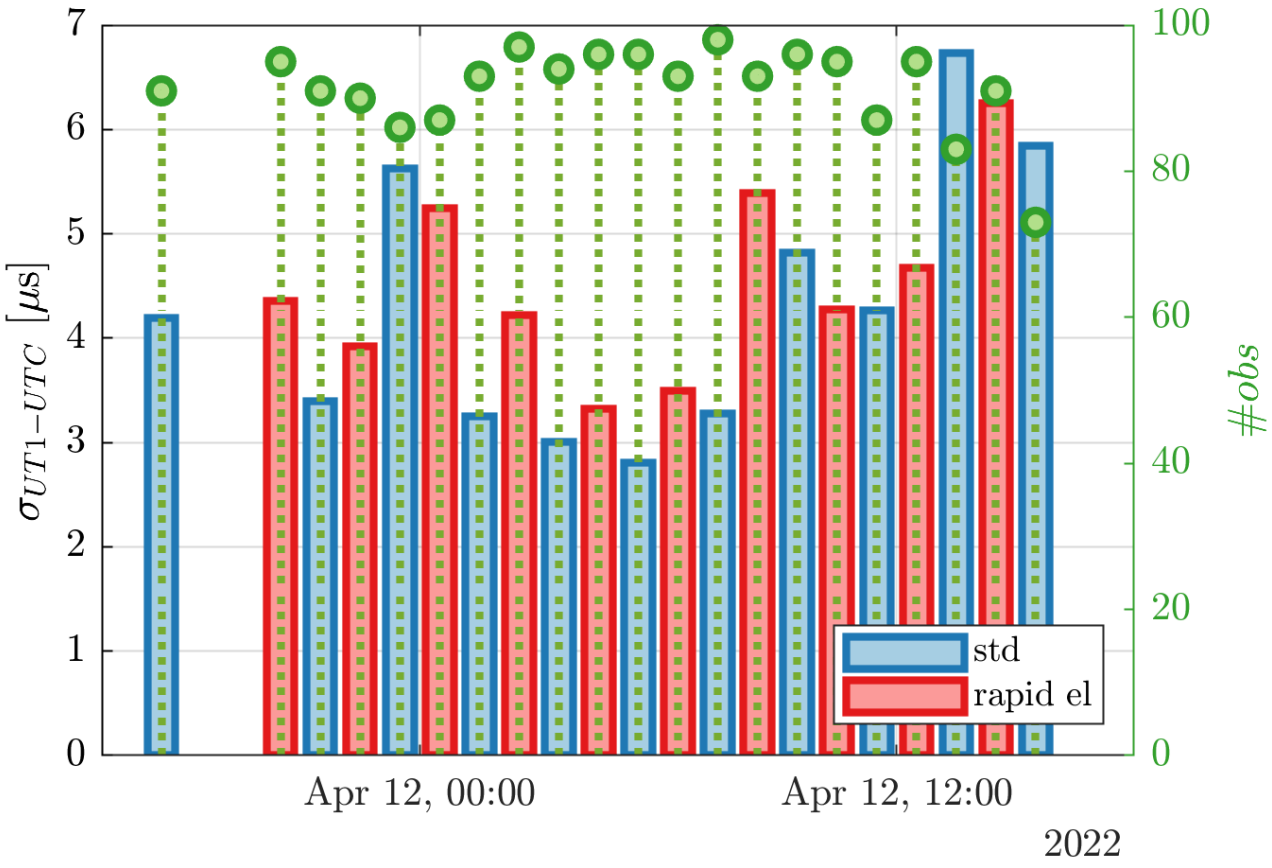
  - odd hours: standard observation strategy
  - even hours: new observation strategy

- So far, no improvement can be seen
  - April (low humidity)
  - expect more difference during summer
  - more investigations underway



Latency

Time difference session start and analysis report

- Observation: Texas and Germany
- Correlation: Wettzell (Germany)
  - first time correlator
- Analysis: NASA Goddard Space Flight Center

Session	Latency	Session	Latency
S21341	37D 21H	S22074	02D 03H
S21355	31D 02H	S22081	02D 00H
S22011	47D 18H	S22088	02D 20H
S22018	06D 20H	S22109	03D 00H
S22025	27D 21H	S22158	01D 20H
S22032	20D 21H	S22164	01D 00H
S22039	13D 21H	S22172	01D 03H
S22046	08D 20H	**S22200**	**00D 18H**
S22053	03D 02H	**S22214**	**00D 20H**
S22067	02D 20H		

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Time difference session start and analysis report

- Observation: Texas and Germany
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- K2-Ws:
  - minimum latency: 00D 19H
  - 25% Quantile: 00D 23H
  - Median: 02D 01H

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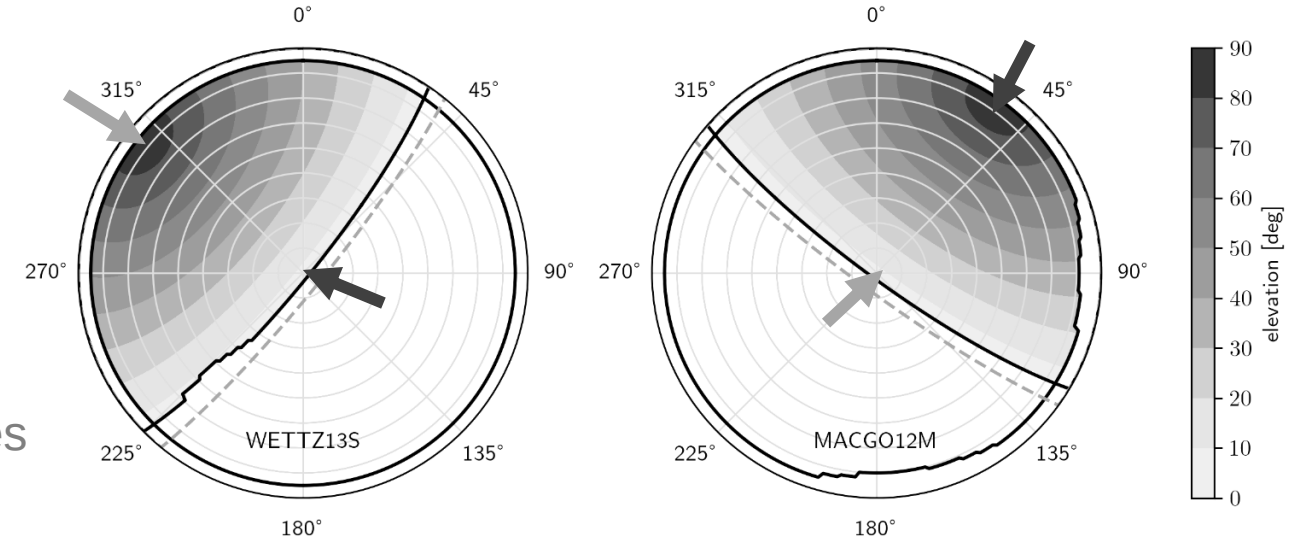

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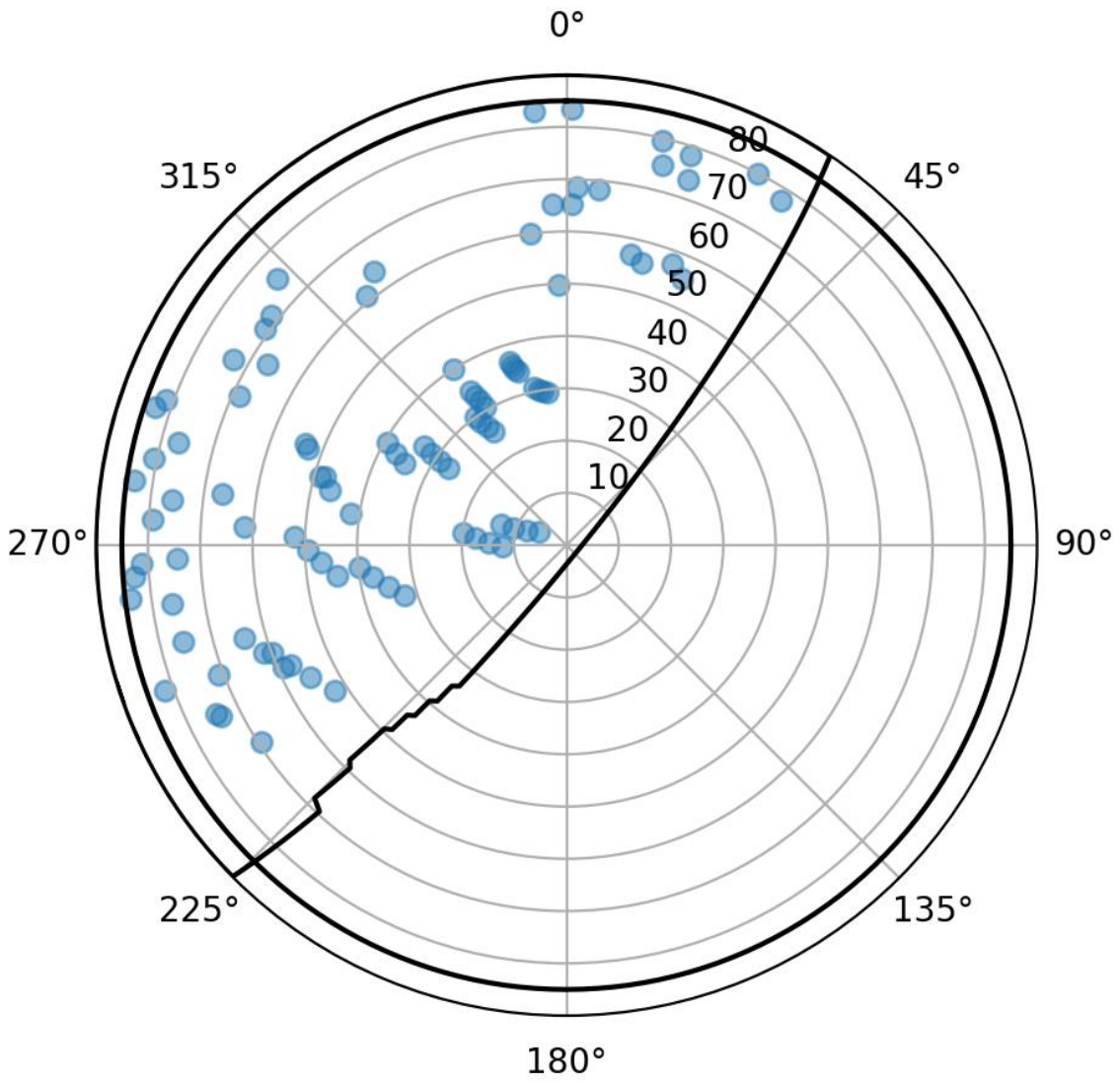
  - apply ZWD (+ gradients) from GNSS

Combination with GNSS

- **VLBI:**
  - < 100 observations
  - limited azimuth / elevation coverage



Combination with GNSS

- **VLBI:**
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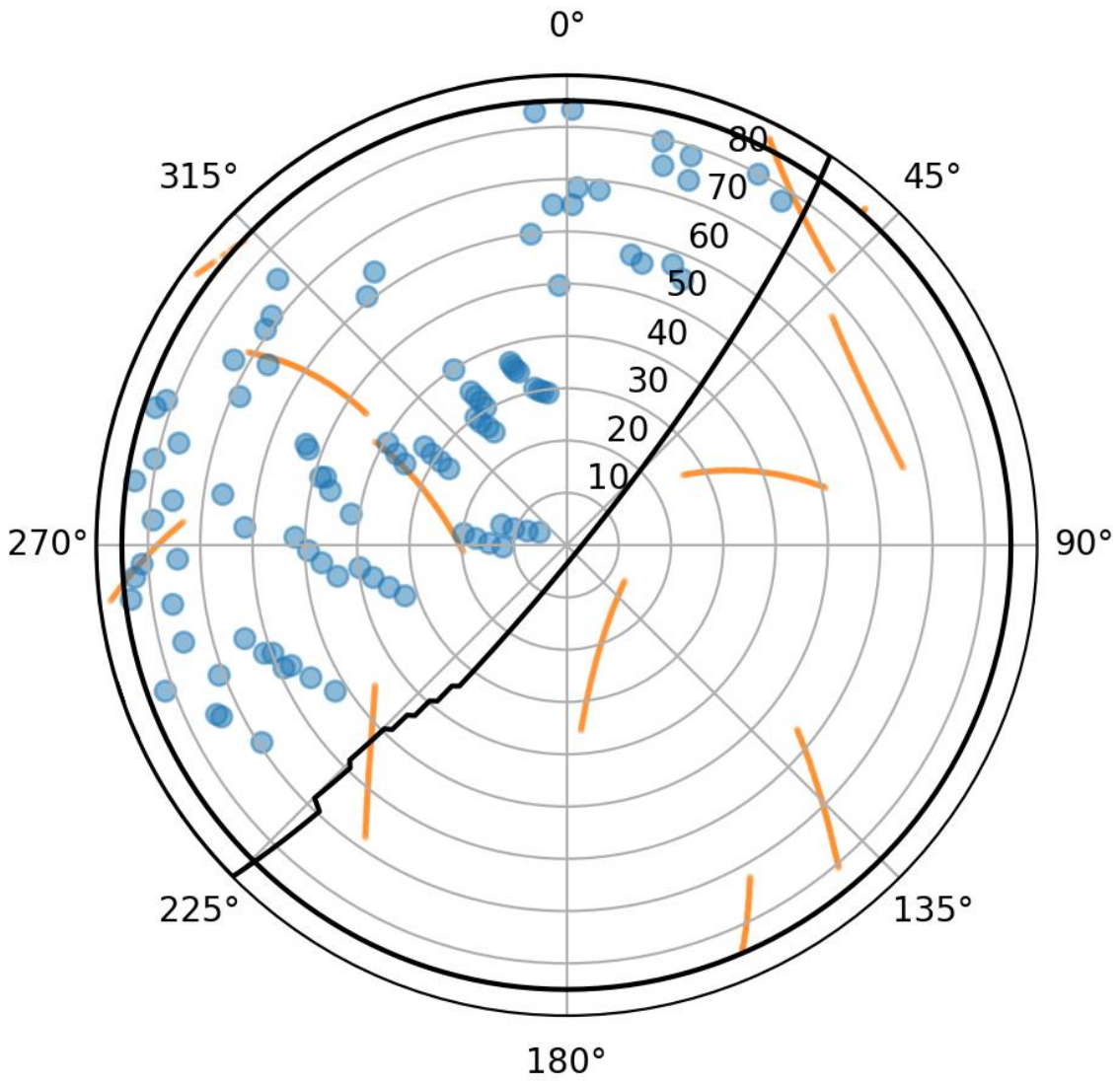
- Combination with **GNSS:**
  - better azimuth / elevation coverage



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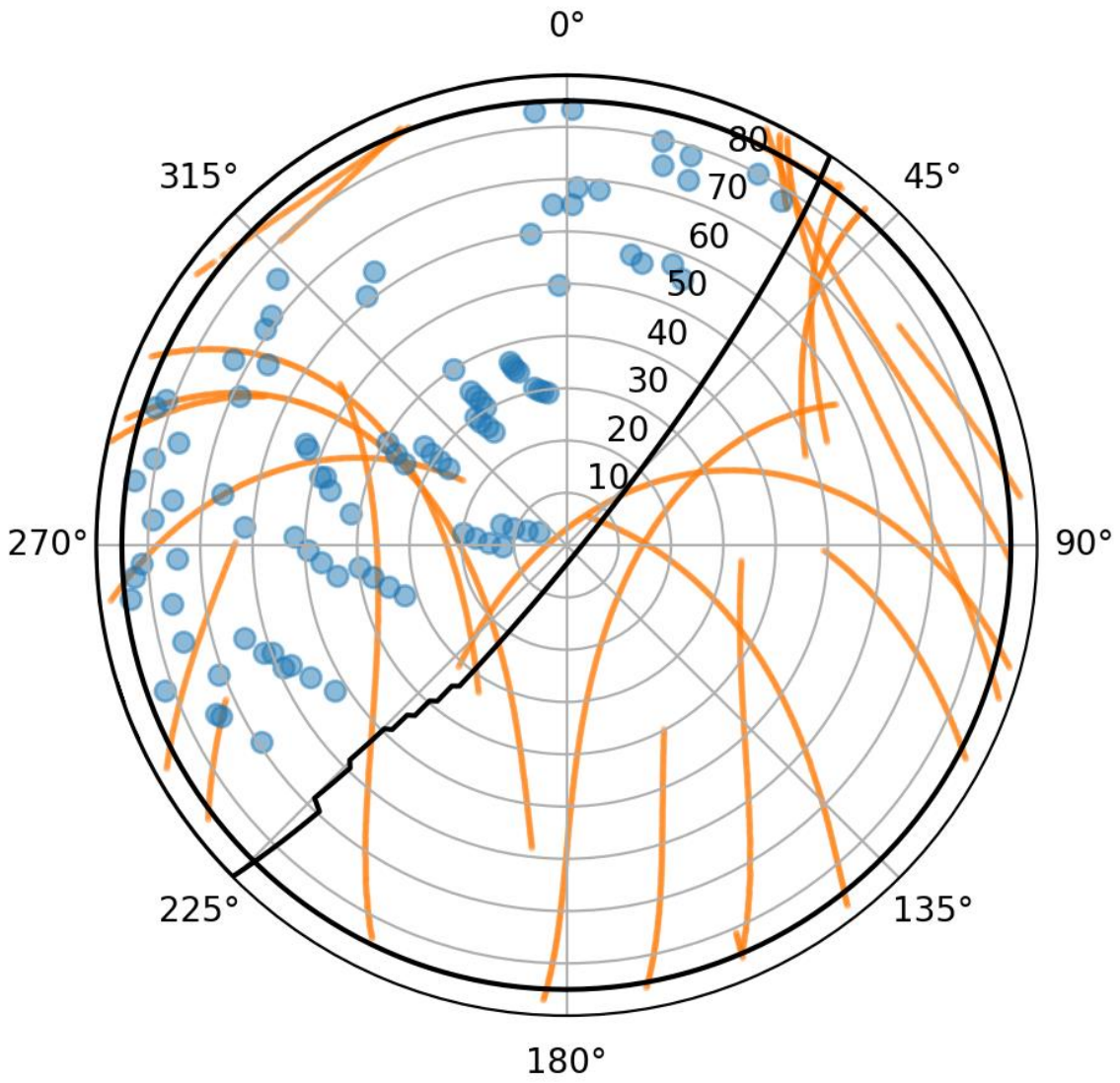
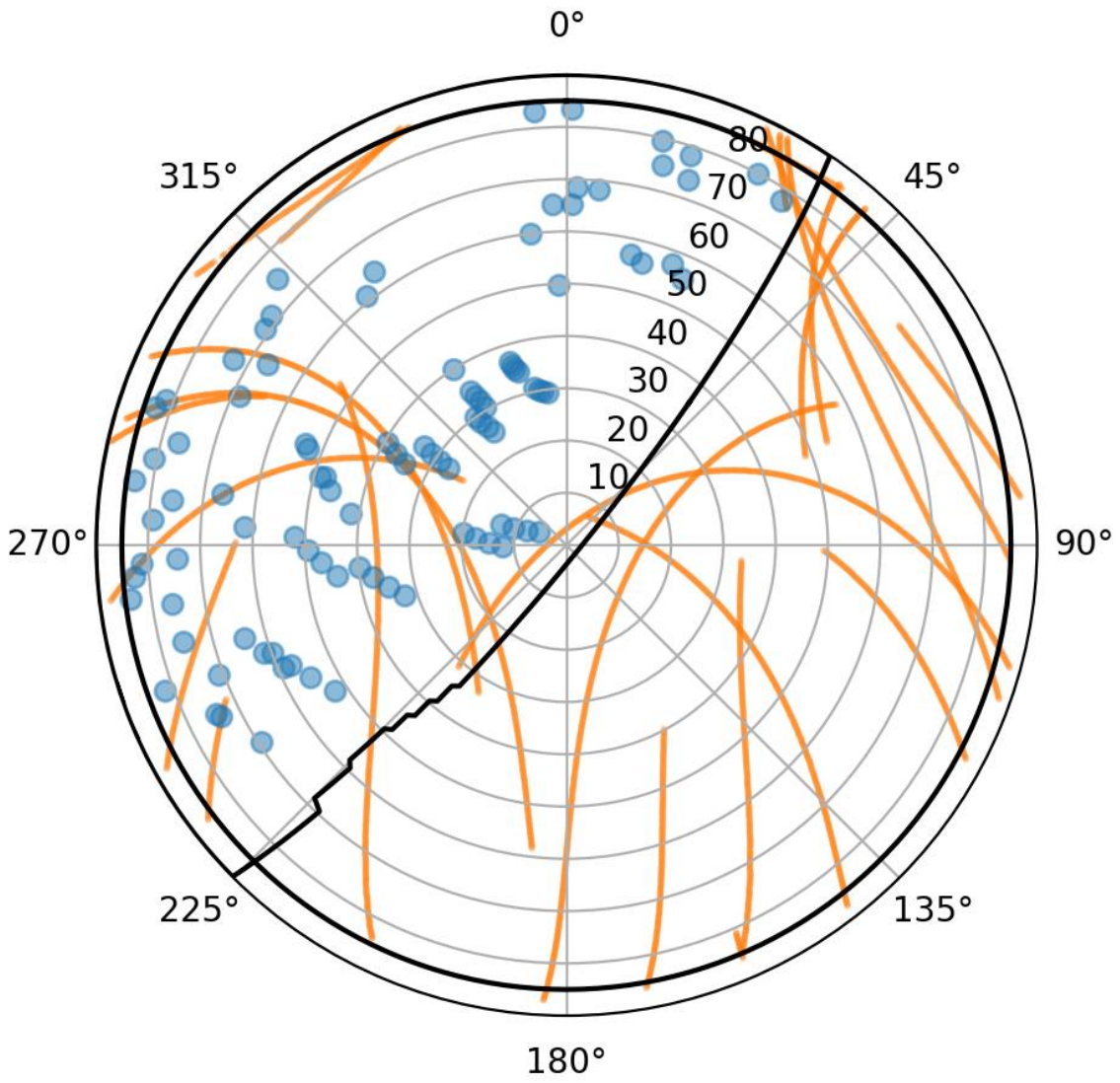
  - combination with more data (e.g. +/- 2 hours)



Combination with GNSS

- **VLBI:**
  - < 100 observations
  - limited azimuth / elevation coverage
- Combination with **GNSS:**
  - better azimuth / elevation coverage
  - combination with more data (e.g. +/- 2 hours)
- Combination:
  - performed using Bernese
  - at observation level
  - GNSS network: 180 globally distributed stations
  - possibility to estimate more parameters (reduced impact of wrong a priori information)



Combination with GNSS

VLBI only

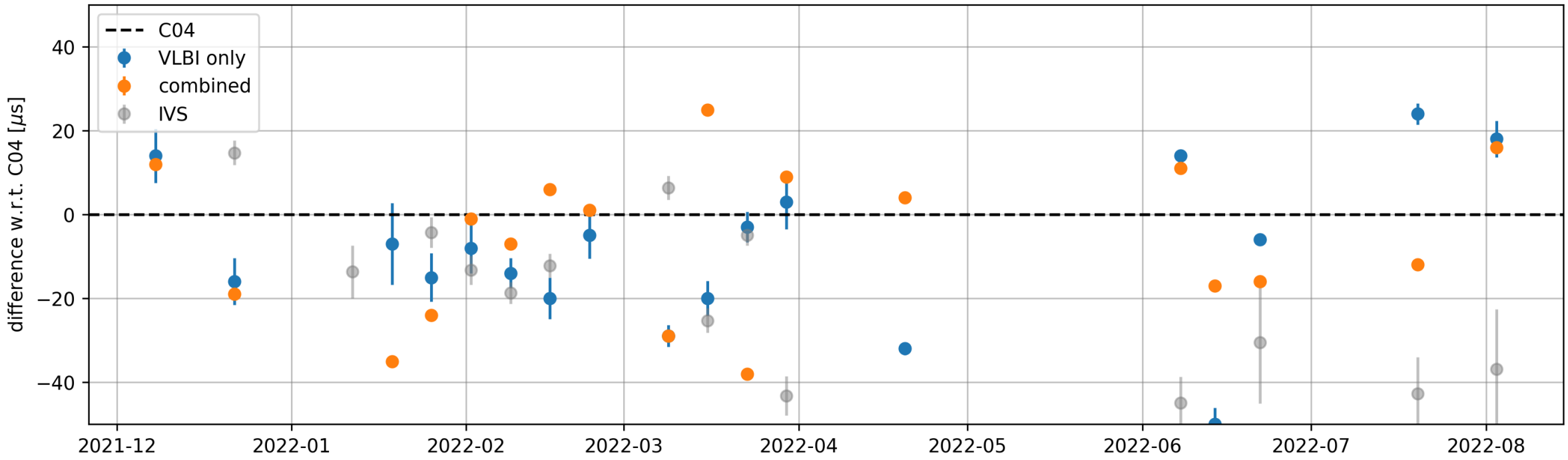
- **VLBI:**
  - Clock
  - UT1-UTC
  - Troposphere (ZWD)

Combination with GNSS

Combined

- **VLBI:**
  - Clock
  - UT1-UTC
  - Troposphere (ZWD)
- **GNSS:**
  - Troposphere (ZWD, gradients)
  - Geocenter coordinates
  - Station coordinates
  - Full set of EOP
- local ties

Combination with GNSS: Results



- **Proof of concept**
- Still a lot more investigation necessary
  - (weighting GNSS/VLBI, parameter estimation setup, reference series…)
- More information? **See talk by Iván Herrera Pinzón on Thursday 15:45**

Conclusion

- Mg-Ws Intensives
  - Observed since December 2021
  - Weekly sessions
  - Some 24-hour sessions

- Promising results
  - Similar performace to K2-Ws
  - Low latency can be achieved

- Two approaches to improve results further
  - Smart observation strategy
  - Combination with GNSS

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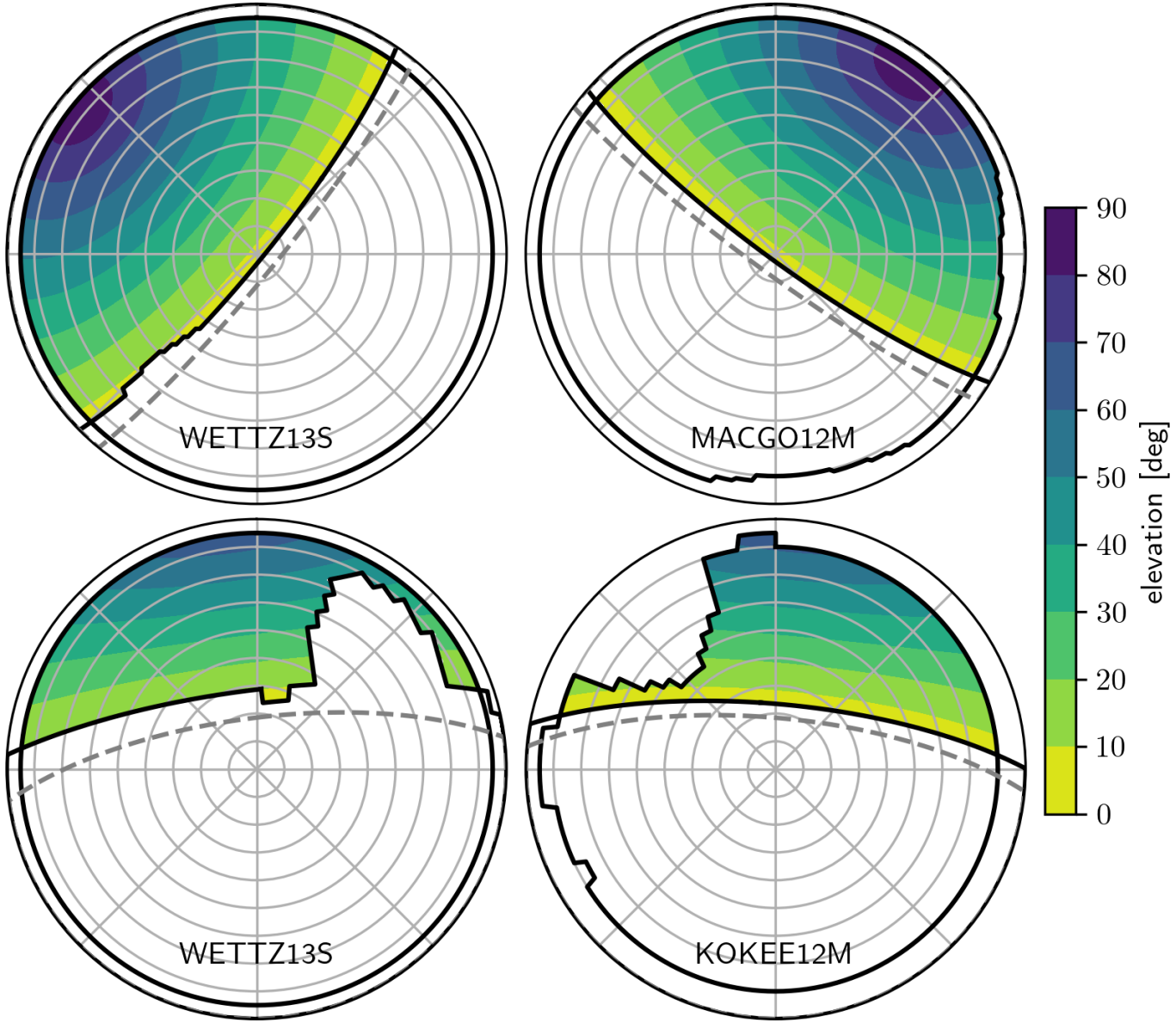
Elevation

- Top: Mg-Ws
- Bottom: K2-Ws

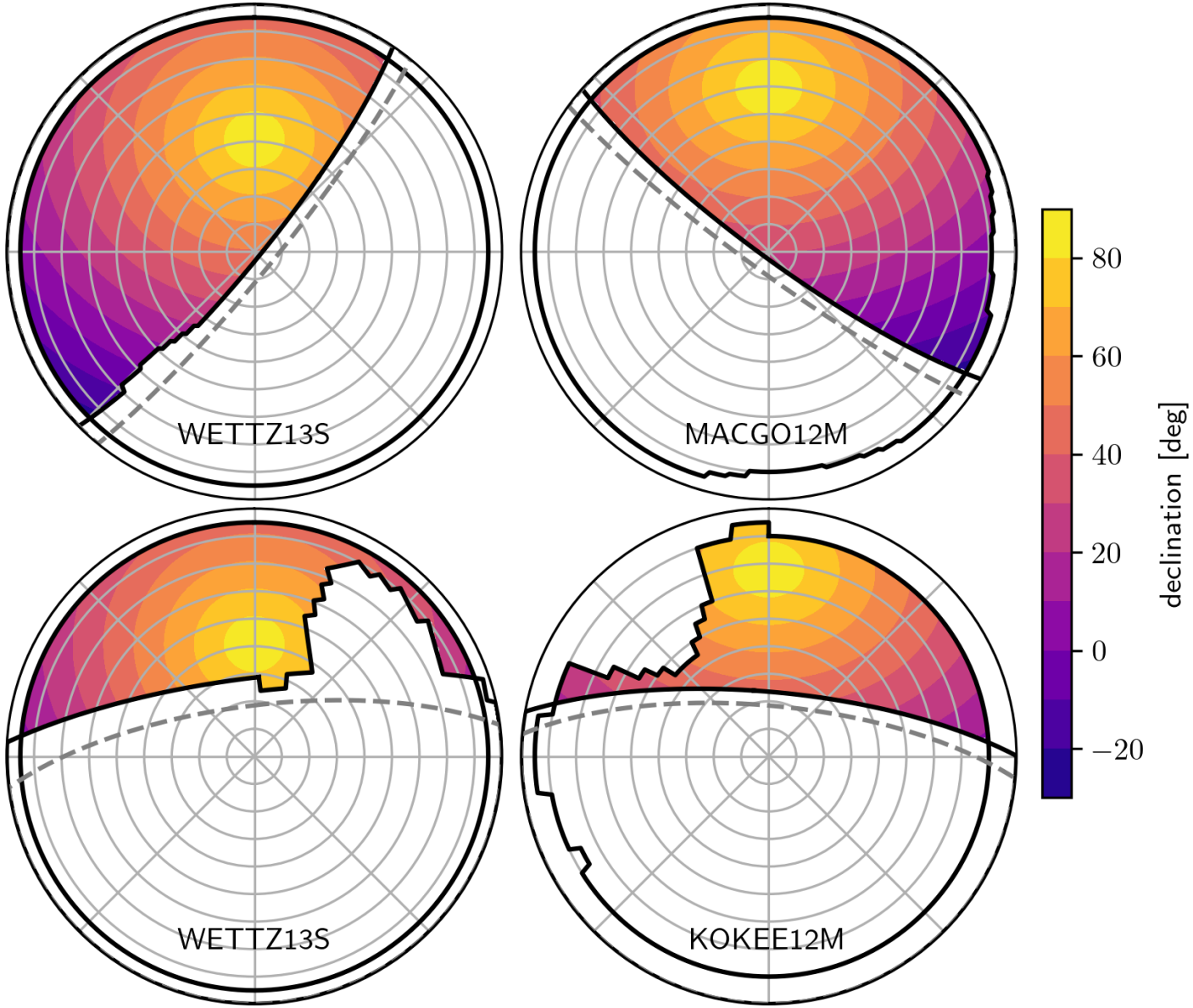
- Mg-Ws:
  - high elevation scans possible
- K2-Ws:
  - only ~60° elevation possible
  - unfavourable horizon mask
  - ➢ approach not possible for K2-Mg



Declination

- Top: Mg-Ws
- Bottom: K2-Ws

- Mg-Ws:
  - low declination scans possible
- K2-Ws:
  - only high declination scans



Scientific motivation

- Limited number of observations
- Limited number of estimated parameters
  - Clock: $\frac{\partial \tau}{\partial CL0} = 1, \frac{\partial \tau}{\partial CL1} = t - t_0$ (1)
  - Zenith wet delay: $\frac{\partial \tau}{\partial ZWD_{a,b}} \approx \frac{1}{\sin \epsilon_{a,b}}$ (2)
  - UT1-UTC: $\frac{\partial \tau}{\partial UT1} \approx -\frac{1}{c} \cdot 1.00273 \cdot \cos \delta \cdot \left((x_b - x_a) \cdot \sin h_G + (y_b - y_a) \cdot \cos h_G \right)$ (3)

(2): only approximation → mapping function
(3): old nominclature → see Petit and Luzum (2010) for more details

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Baseline geometry
h_G = Greenwhich hour angle

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    ϵ = elevation
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    δ = source declination

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