

Assessment of parameters describing the signal delay in the neutral atmosphere derived from VGOS R&D sessions

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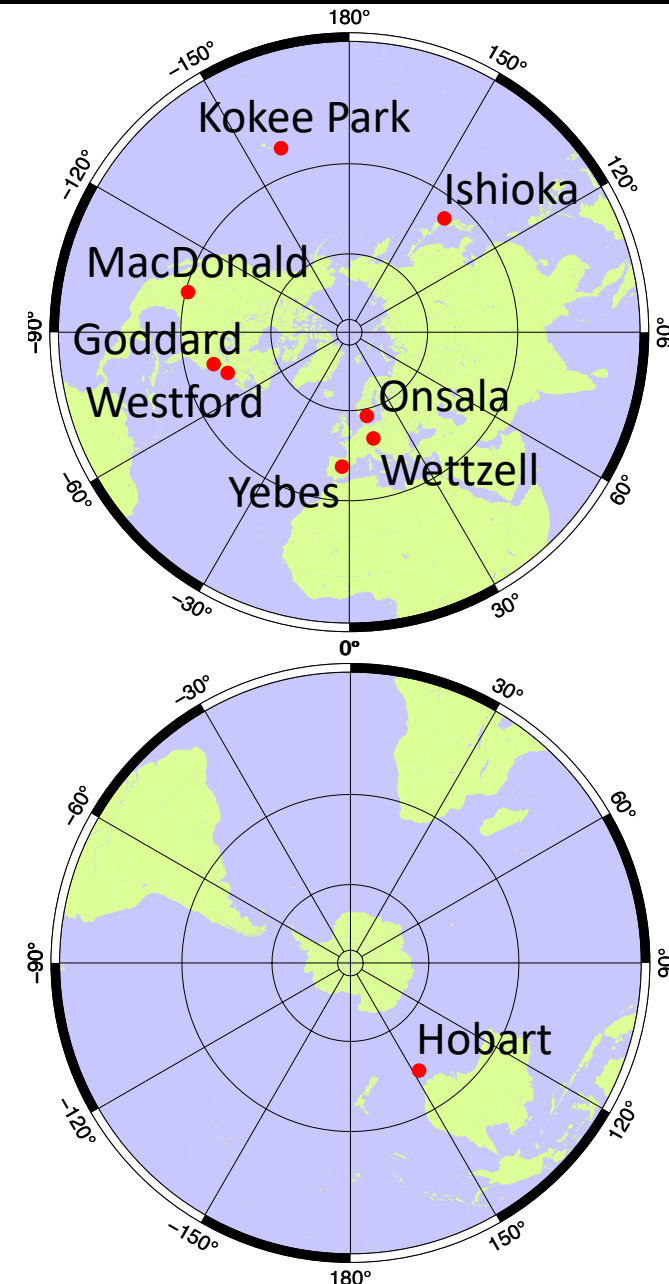
Motivation

- **VGOS** => next generation VLBI system for geodesy and astrometry
- Developed since 2003 as VLBI2010 (Petrachenko *et al.* 2009, NASA/TM-2009-214180)
- Atmospheric turbulence was identified as one of the limiting factors during the VLBI2010 design phase
- To address this, the VLBI2010 concept advocated for fast radio telescopes to allow fast source switching and thus suitable sampling of the local atmosphere at VLBI stations
- **Short estimation intervals** for zenith wet delays and gradients were proposed for the data analysis

VGOS observations

- So far a primarily northern-hemisphere VGOS network
 - 2019: VGOS test observations (VT), 24 h sessions every 2nd week
 - 2020/21: VGOS operational (VO), 24 h sessions every 2nd week
 - 2022: VO 24 h sessions weekly
 - Several VGOS-INT sessions

- VGOS 24 h R&D (VR) sessions
 - every 2nd month during 2022



Sky coverage

Legacy S/X, R1.1101:

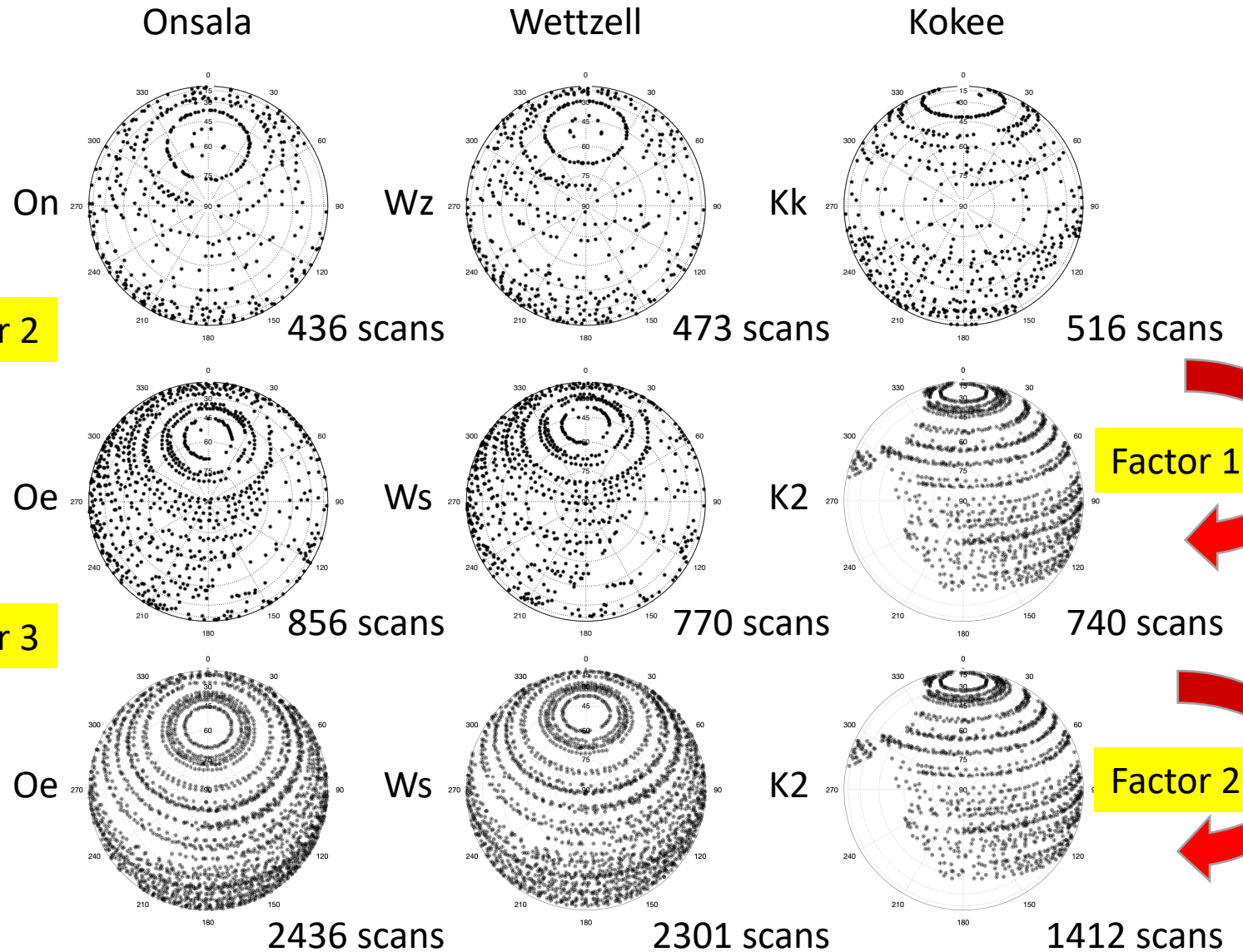
15 stations
1638 scans
Average scan length 75 s

VGOS, VO1.203:

8 stations
1265 scans
Average scan length 30 s

VGOS, VR.21.01:

7 stations
3397 scans
Average scan length 11 s



Factor 2

Factor 3

Factor 1.5

Factor 2

VGOS R&D sessions 2021/2022

- **VR2101: 2021-07-29/30, 7 stations**
 - Goddard – Kokee – MacDonald – Onsala (Oe+Ow) – Westford – Wettzell
- **VR2201: 2022-01-20/21, 8 stations**
 - Goddard – Hobart – Kokee – MacDonald – Onsala (Oe+Ow) – Westford – Wettzell
- **VR2202: 2022-03-17/18, 6 stations**
 - Goddard – Kokee – MacDonald – Onsala (Oe) – Westford – Yebes

Not included in this presentation:

- VR2203: 2022-05-19/20, 7 stations
- VR2204: 2022-07-21/22, 10 stations
- VR2205: 2022-09-15/16, 9 stations

VGOS R&D sessions 2021/2022

- 24 h sessions
- VieSched++ scheduling
- Short scans: e.g. VR2101 minimum and average scan length 7 s and 11 s, respectively
- Many observations: e.g. VR2101 3397 scans, 23040 observations

- All sites: co-located GNSS, often several ones
- **Onsala: co-located GNSS and WVR**

Onsala: VGOS – GNSS – WVR



Onsala twin telescopes
Oe (O13E), Ow (O13W)



ONSA



Konrad
(OWVR)

Data analysis

VLBI (all):

- ASCOT software
- ITRF2020 setup
- El cutoff 5° and VMF3 mapping functions
- Loose constraints for ZWD and horizontal gradients

➤ ZTD and GRAD with 5 min temporal resolution

GNSS (all):

- c5++, KalmanFilter
- Multi-GNSS PPP
- El cutoff 7°, GMF mapping functions
- Standard constraints for ZWD and horizontal gradients

➤ ZTD and GRAD with 5 min temporal resolution

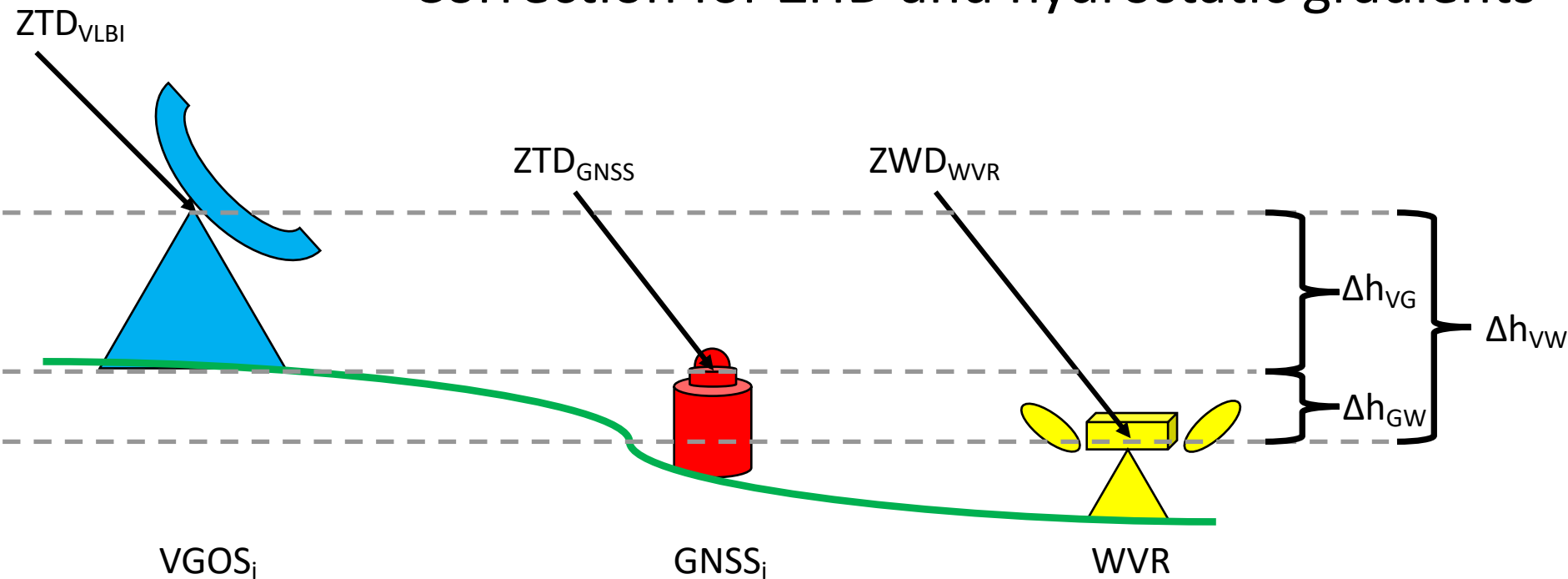
WVR (Onsala):

- Inhouse software
- Sky-mapping analysis
- El cutoff 25°
- Unconstrained LSQ

➤ ZWD and GRAD with 5 min (2022: 2 min) temporal resolution

Treatment of co-located instrumentation

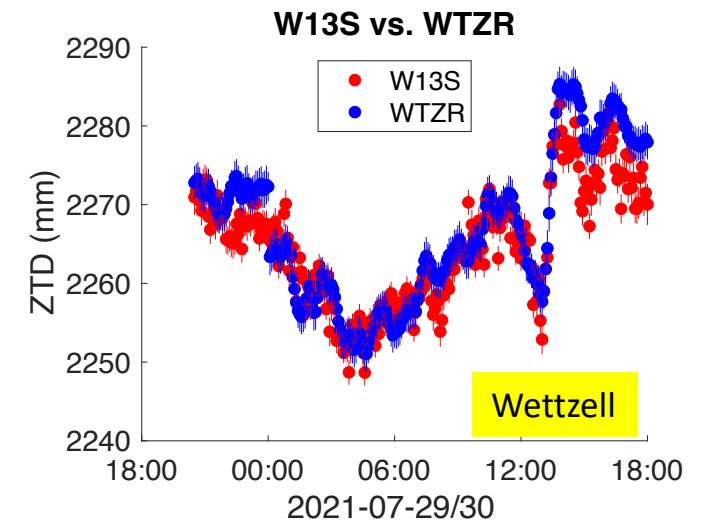
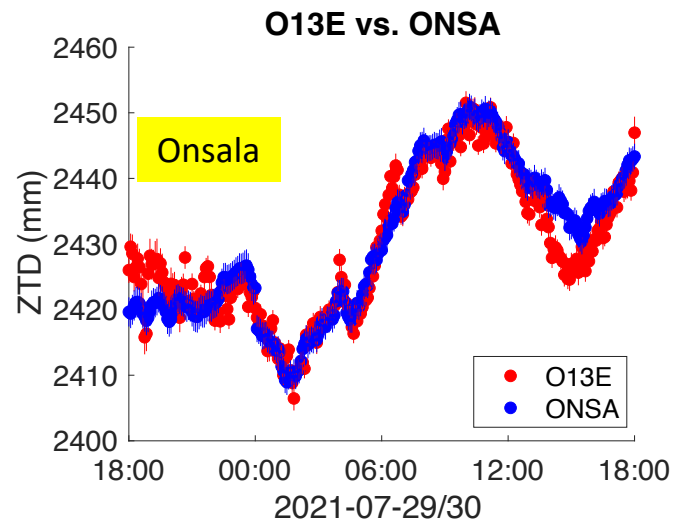
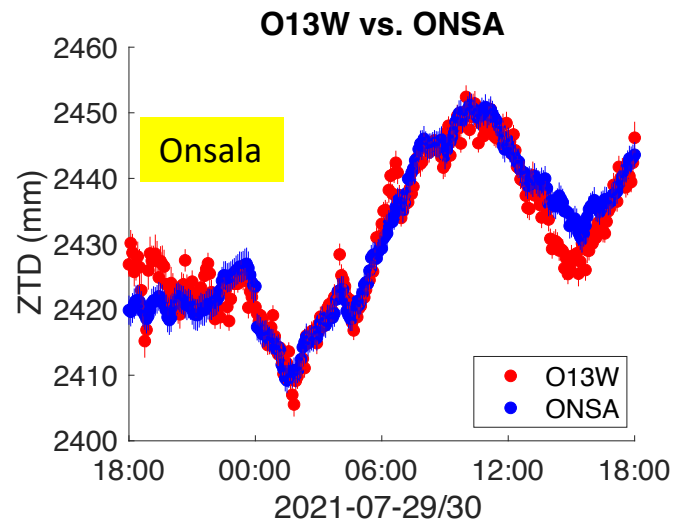
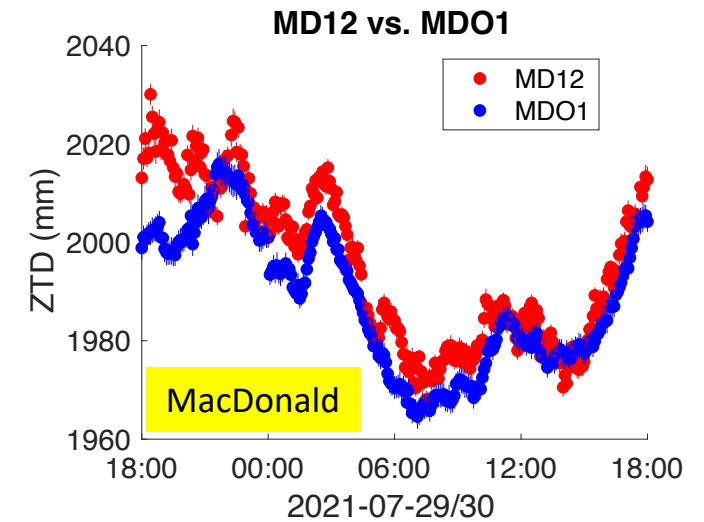
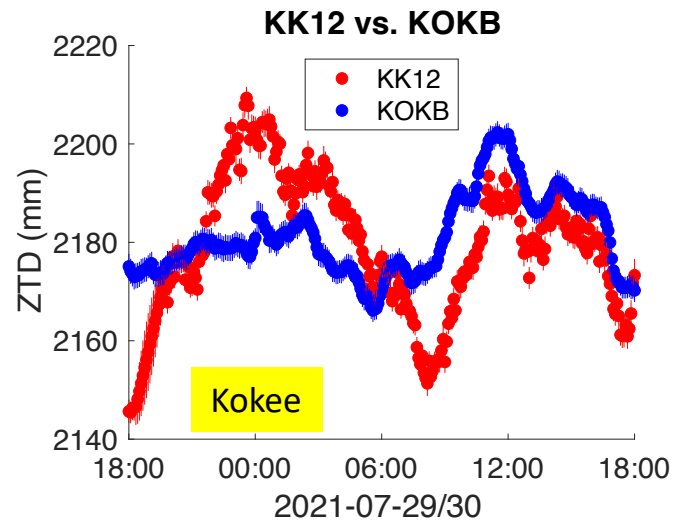
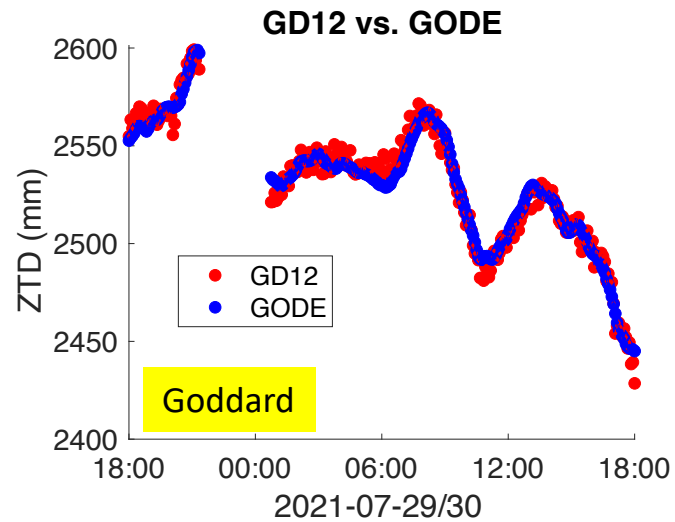
- Differential heights need to be corrected for:
 - e.g. compare ZTD_{VLBI} to $(ZTD_{GNSS} + \Delta ZHD_{VG} + \Delta ZWD_{VG})$
- WVR gives only wet part:
 - Correction for ZHD and hydrostatic gradients



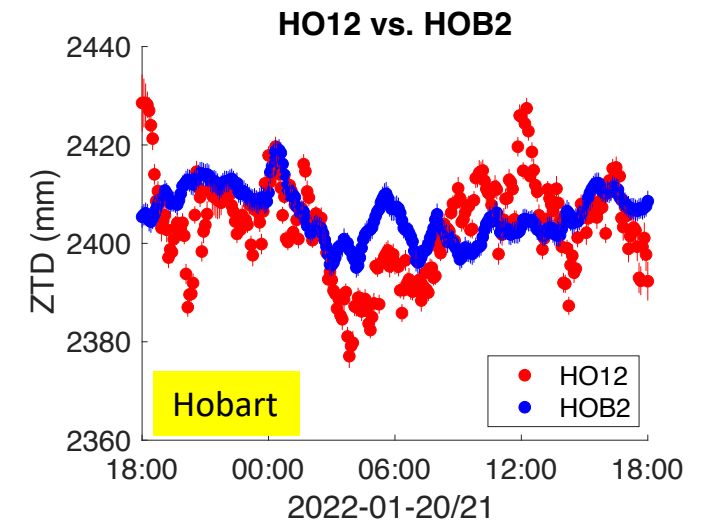
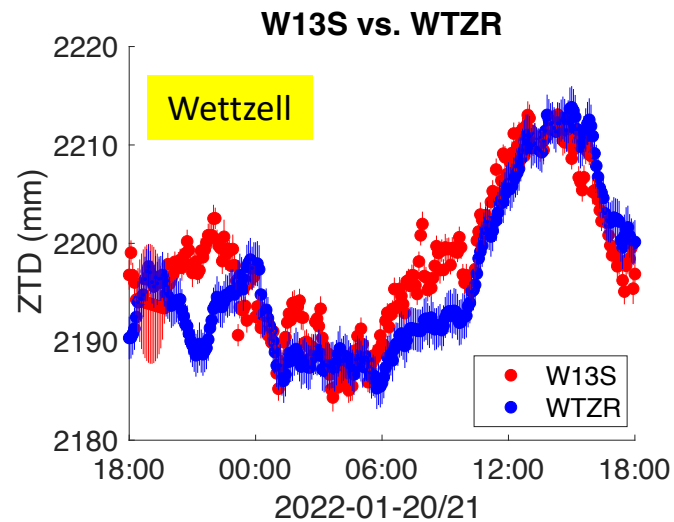
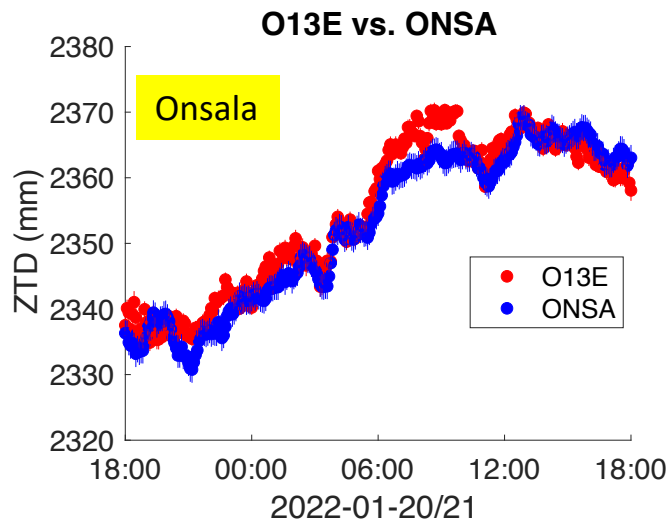
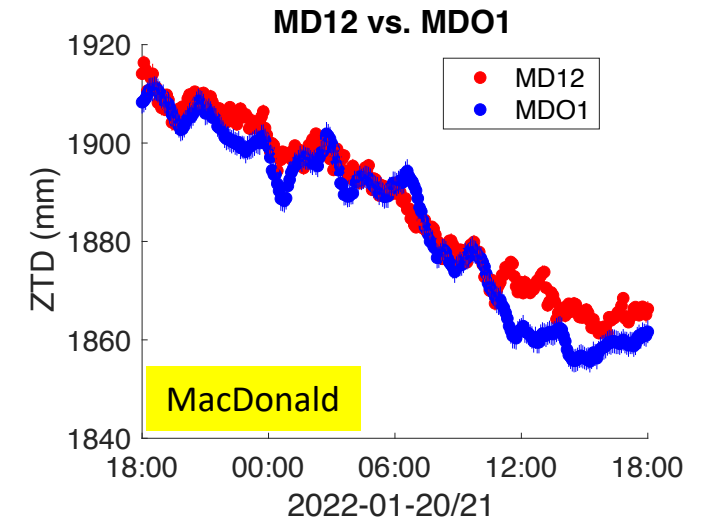
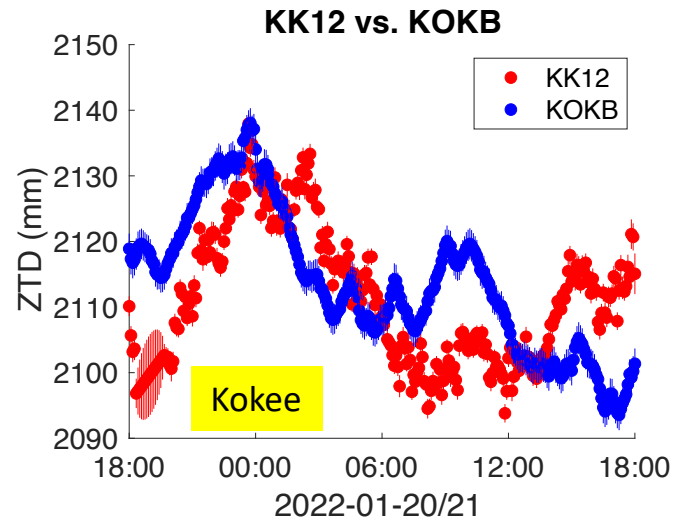
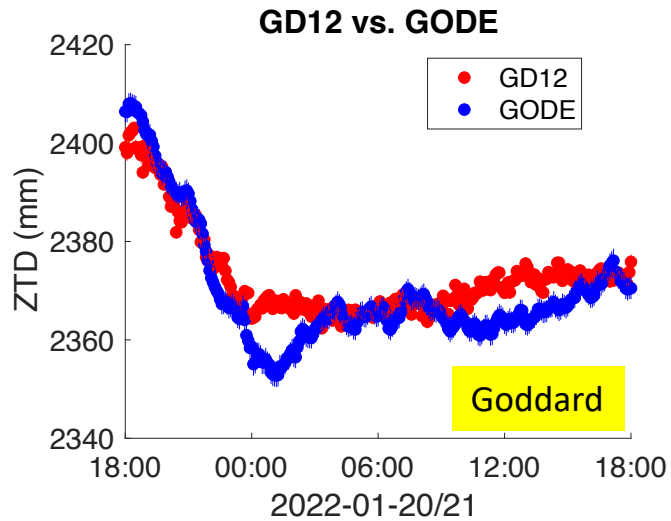
=> Comparing
at same height:

- ZTD
- GRAD

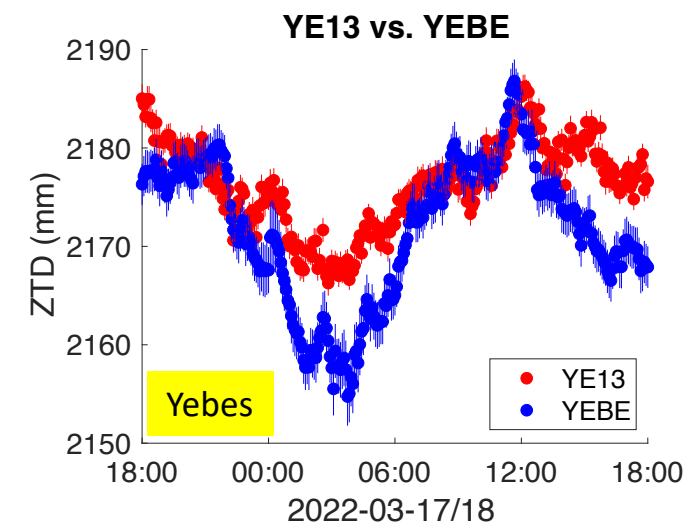
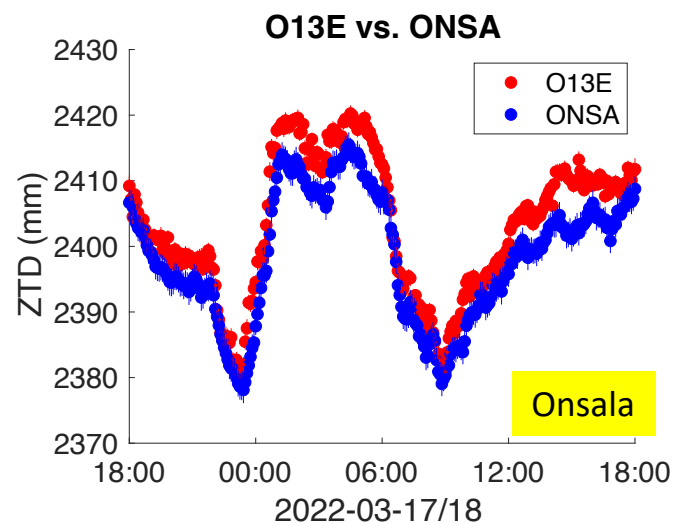
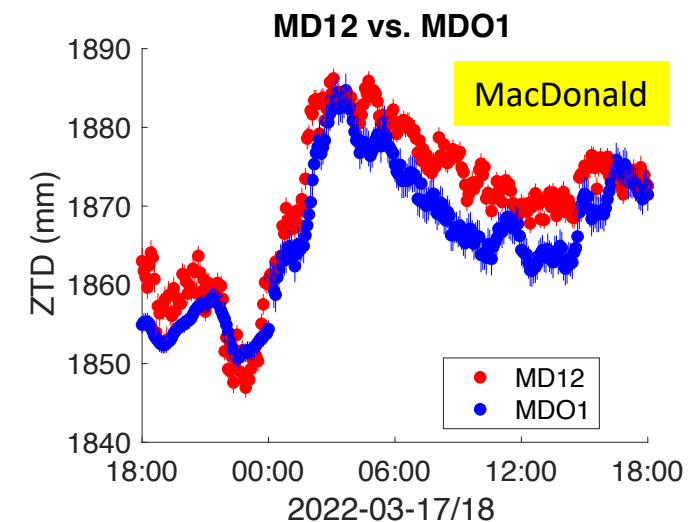
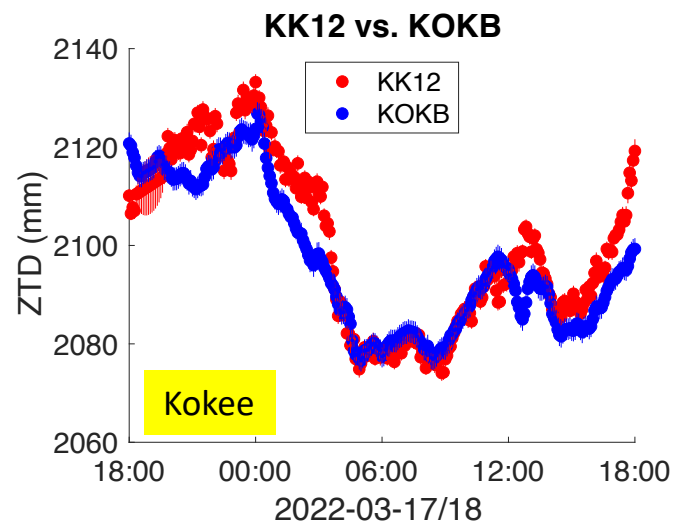
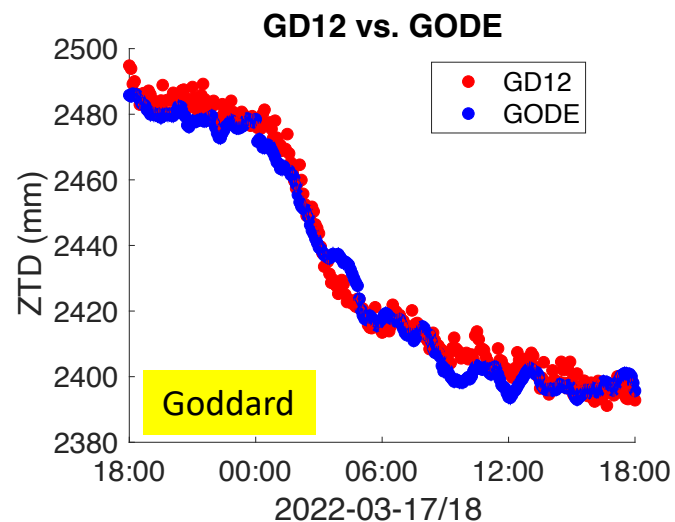
VR2101: ZTD results VGOS and GNSS



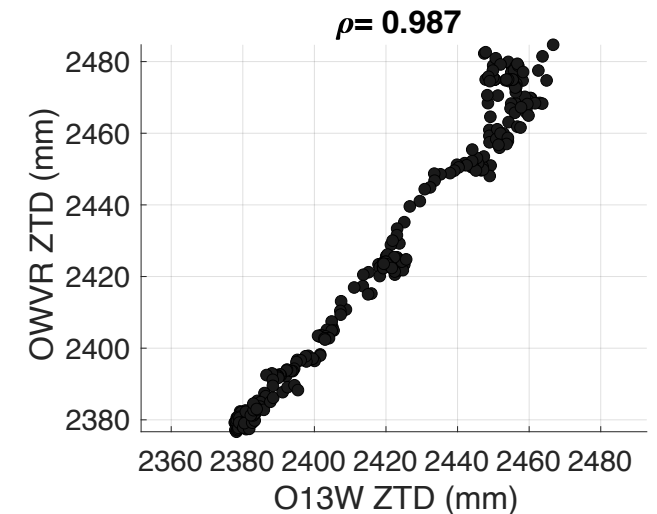
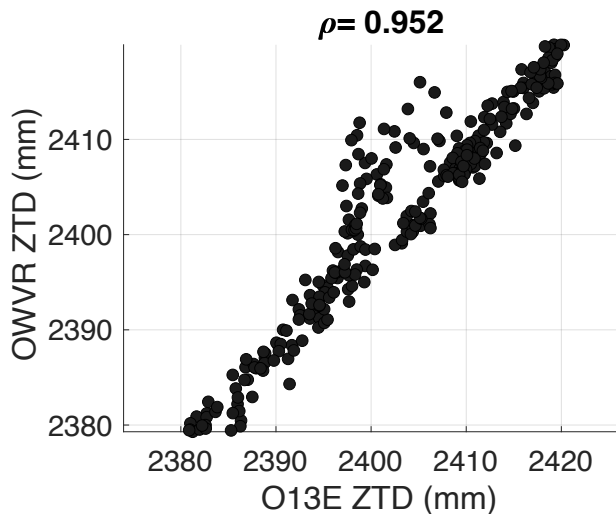
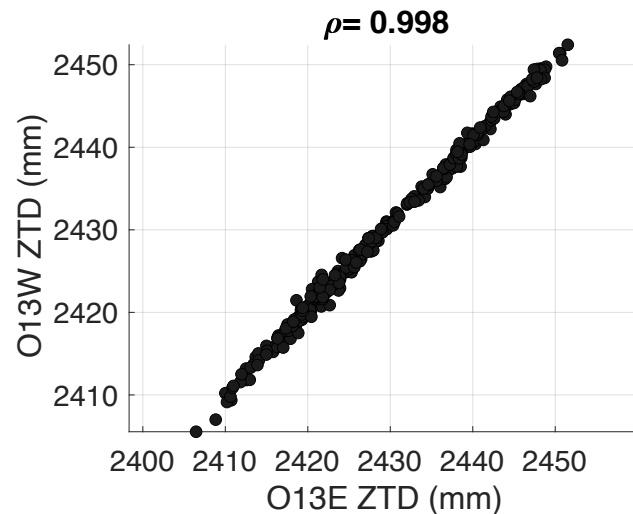
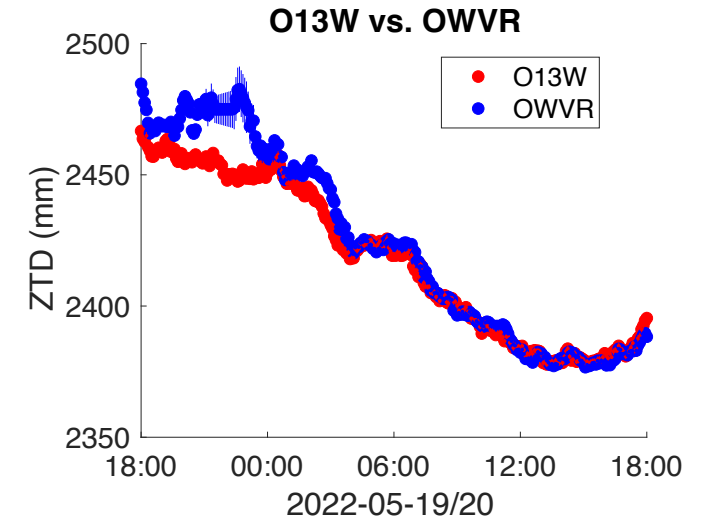
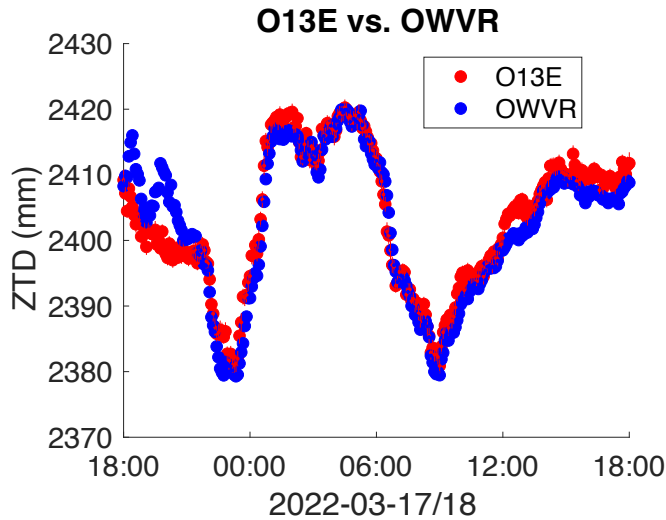
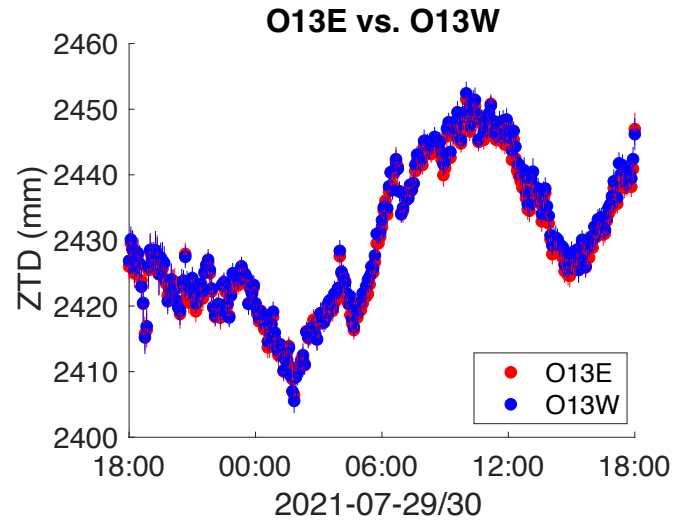
VR2201: ZTD results VGOS and GNSS



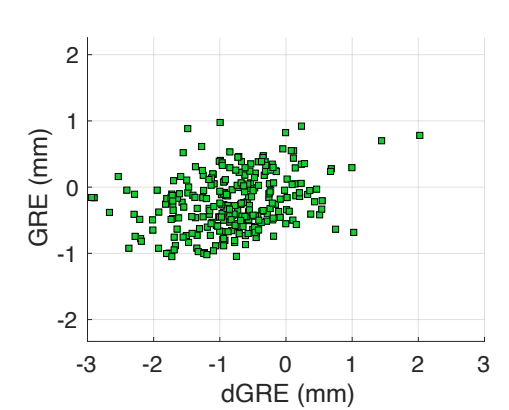
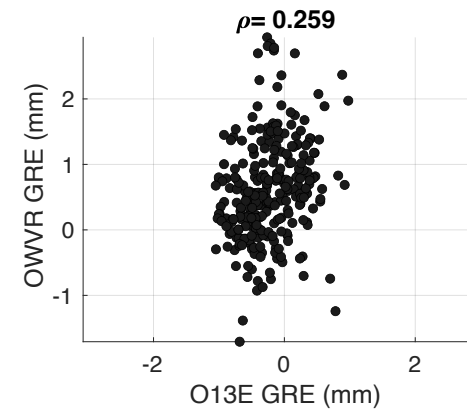
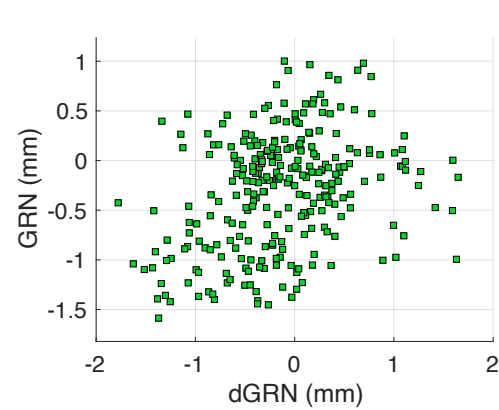
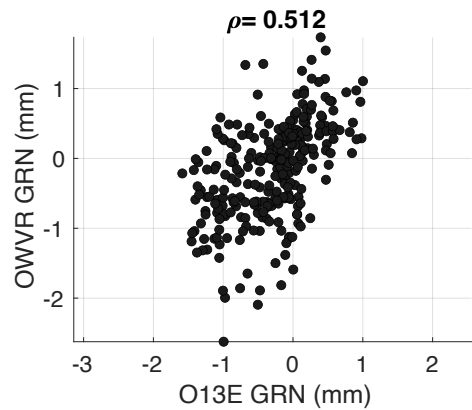
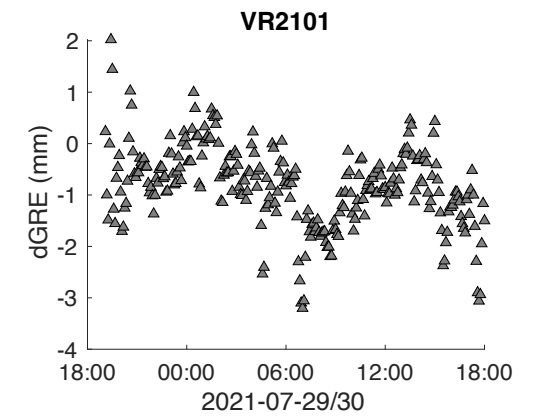
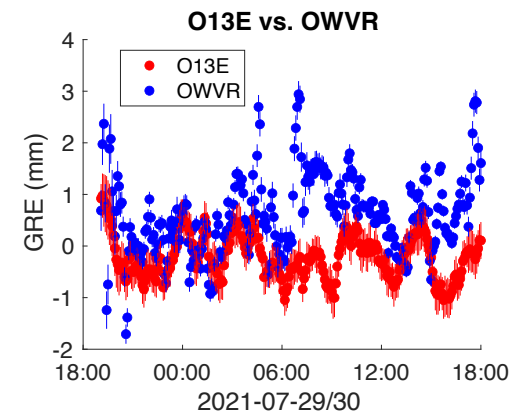
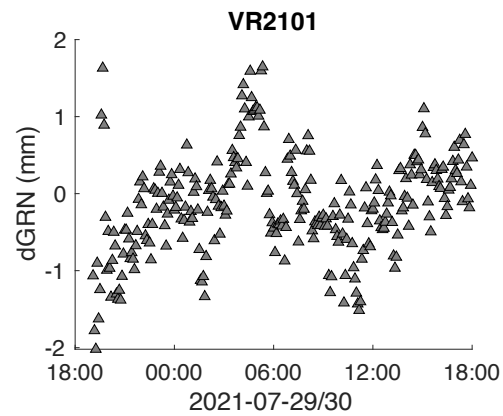
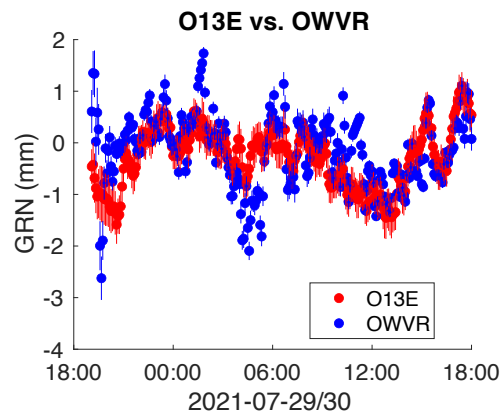
VR2202: ZTD results VGOS and GNSS



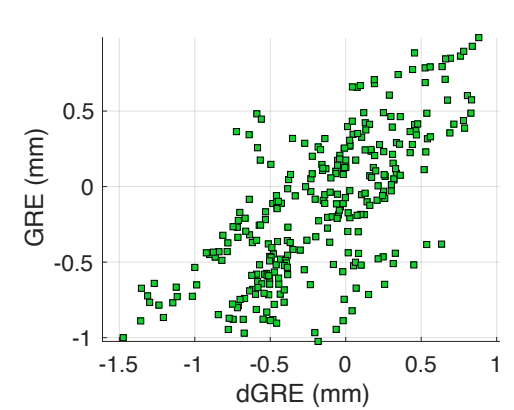
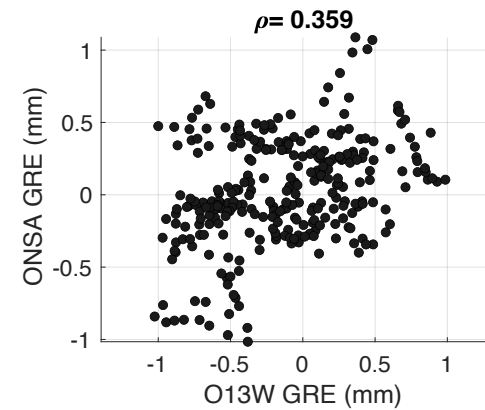
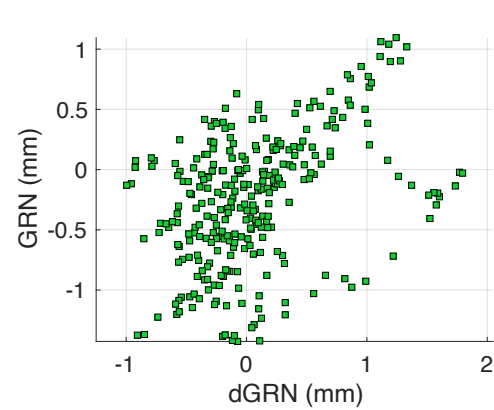
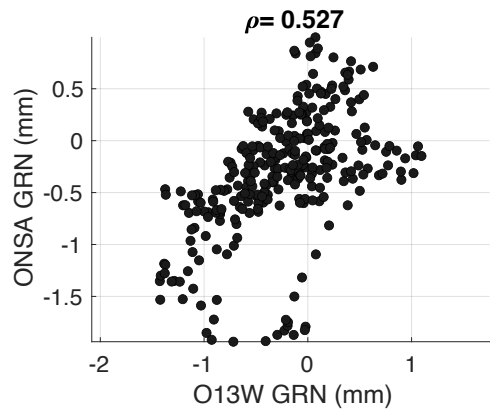
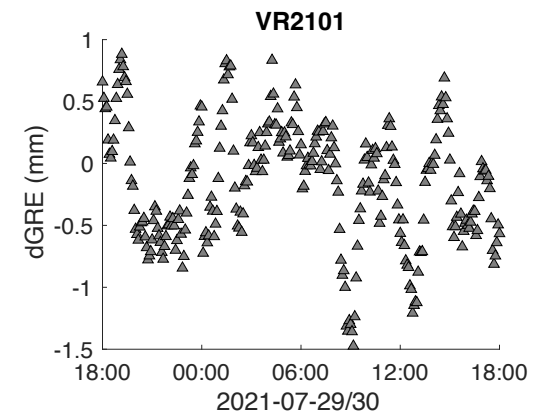
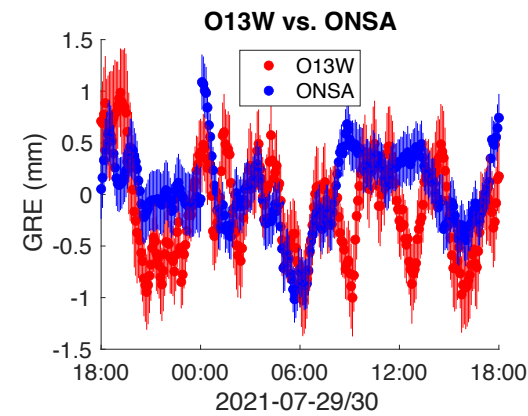
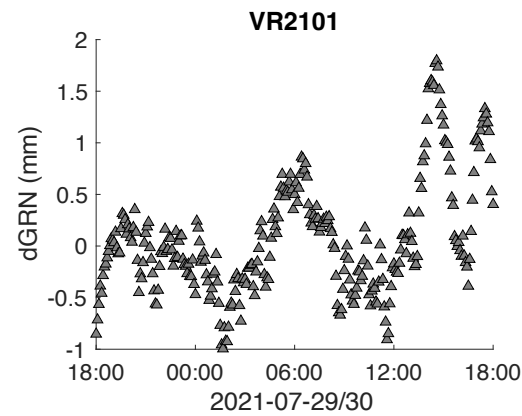
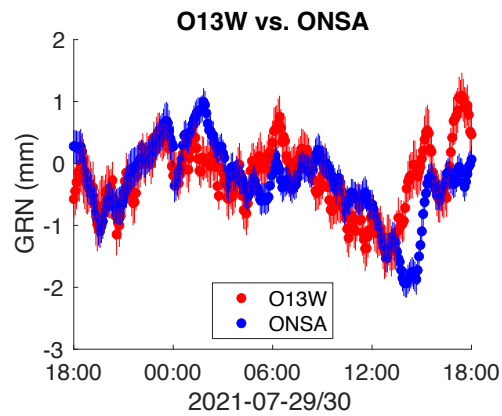
ZTD results VGOS and WVR



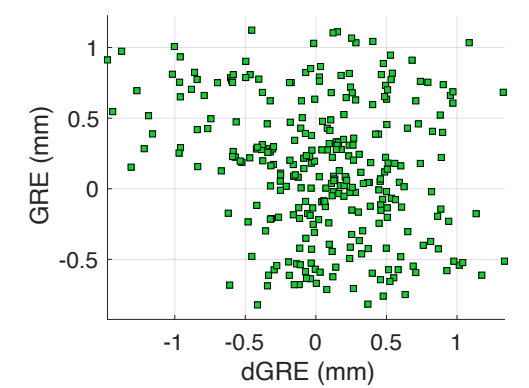
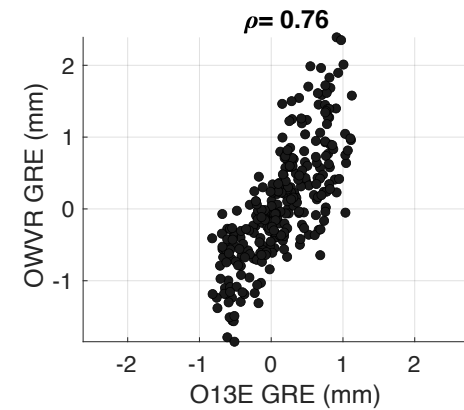
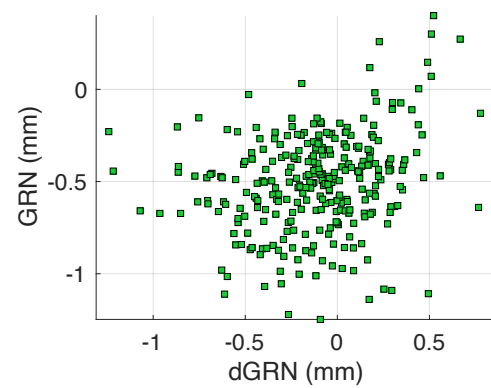
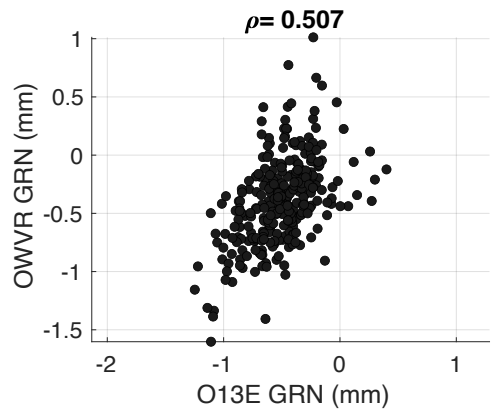
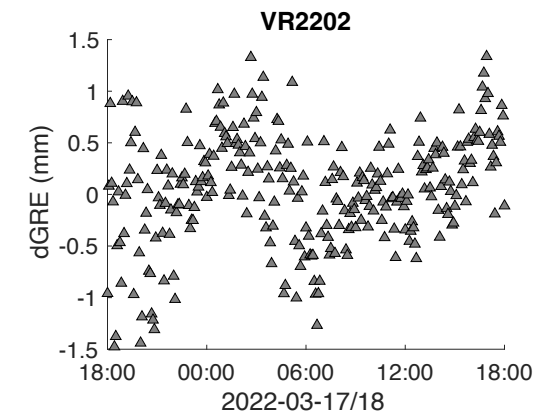
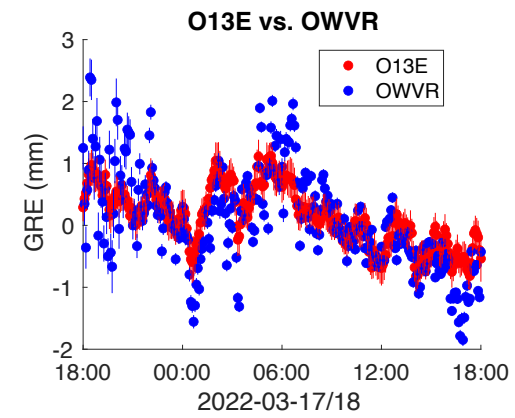
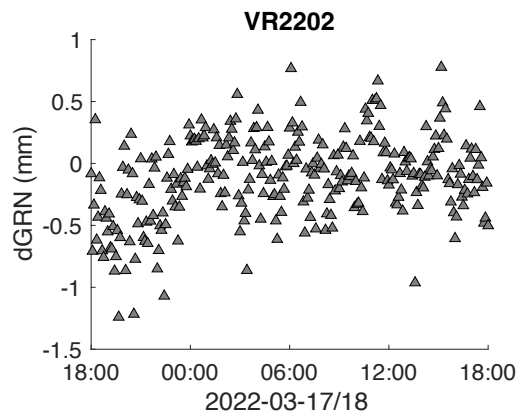
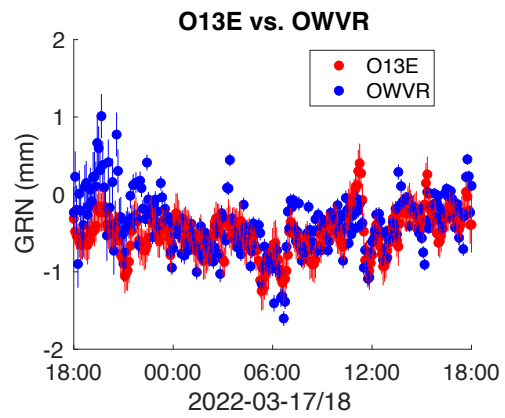
VR2101: GRAD results VGOS and WVR



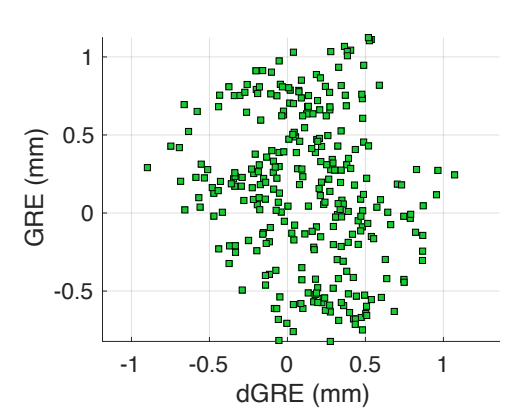
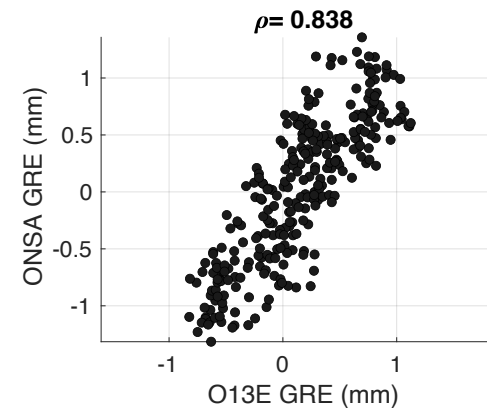
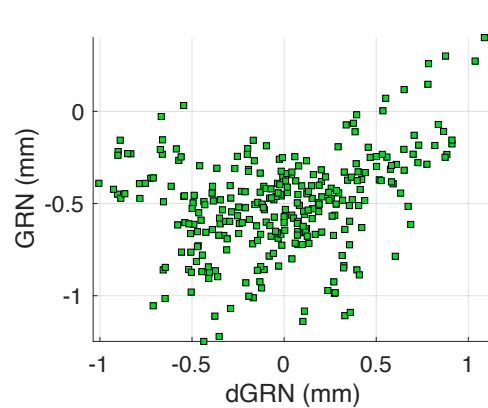
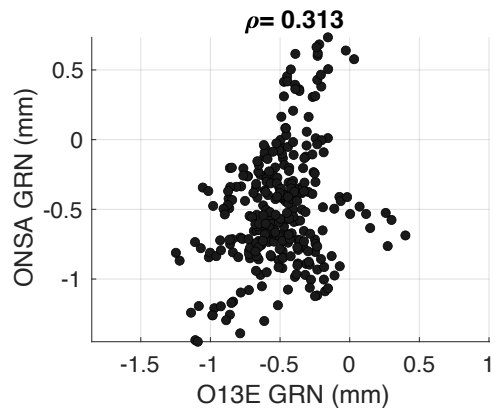
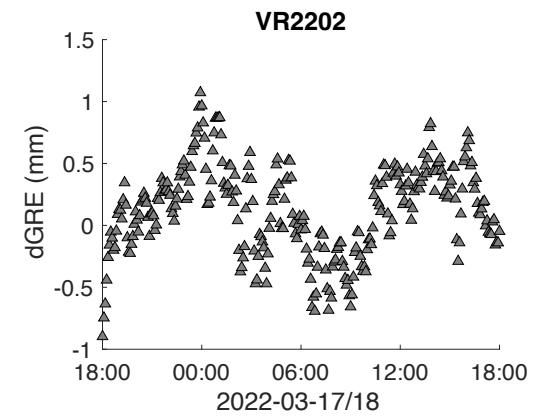
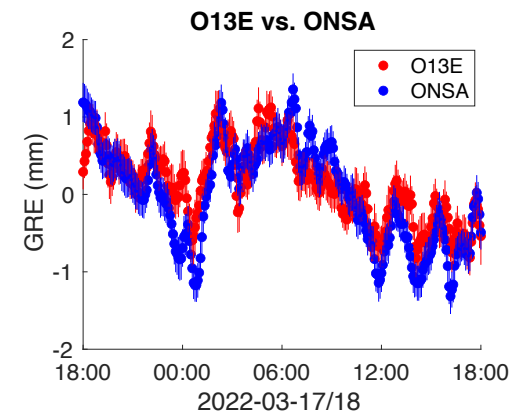
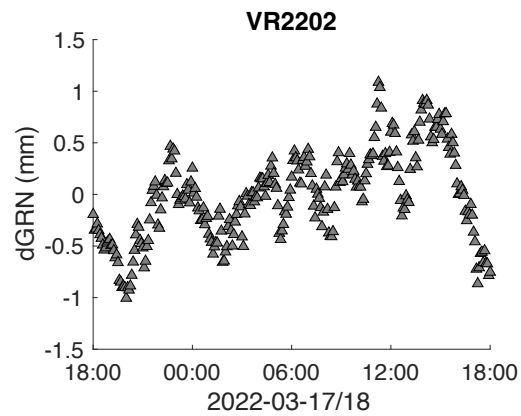
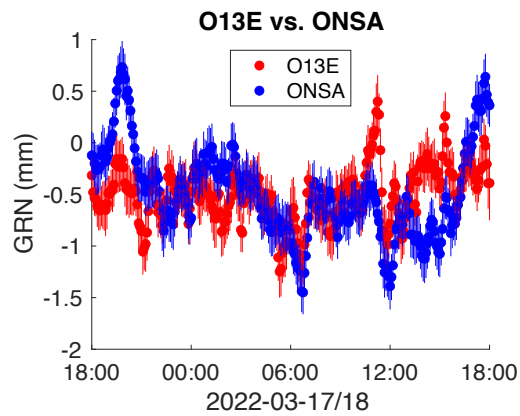
VR2101: GRAD results VGOS and GNSS



VR2202: GRAD results VGOS and WVR



VR2202: GRAD results VGOS and GNSS



Summary and Conclusions

- VGOS can achieve high temporal resolution (5 min) for both ZTD and horizontal gradients (=> this is new for VLBI!)
- In general very good agreement with ZTD from GNSS and WVR
 - High correlation > 0.95
 - Small-scale ZTD variations are detected
 - For some stations mm-size offsets
- Agreement to GRAD from GNSS and WVR is as expected slightly worse
 - Correlations up to 0.8 for either GRE or GRN
 - No significant offsets
- Comparisons to completely independent WVR unique and meaningful
- So far a case study with a few VGOS R&D sessions only
 - More comparisons with more VR-sessions are needed

Questions?

