EGU21-11956

CALIBRATING THE TROPOSPHERIC DELAYS OF VLBI OBSERVATIONS USING NUMERICAL WEATHER PREDICTION MODELS

TOBIAS NILSSON[1] AND KYRIAKOS BALIDAKIS[2]

1) LANTMÄTERIET, GÄVLE, SWEDEN
2) GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES, POTSDAM, GERMANY

vEGU21: Gather Online, 19–30 April 2021

INTRODUCTION

- The observations of Very Long Baseline Interferometry (VLBI) experience tropospheric delay
- Normally the tropospheric delays are estimated in the data analysis
- Alternatively, the tropospheric delay could be corrected by external estimates
    - Would improve the precision, however, require accurate external tropospheric delays
    - So far, no good enough source of external tropospheric delays is available, but the accuracy and resolution of numerical weather models are continuously increasing
- In this work we investigate the effect of using external tropospheric delays calculated from ray-tracing through ERA5 in the VLBI analysis
- We look at the impact on different types of observing sessions

THE POTSDAM MAPPING FUNCTIONS

- The tropospheric delay, L_t, in the direction given by the azimuth angle α and the elevation angle ϵ, can be approximated by the formula:

$$L_t(\alpha,\epsilon) = m_h(\epsilon, a_h, b_h, c_h)L_h^z + m_w(\epsilon, a_w, b_w, c_w)L_w^z + \cdots$$

$$m_g(\epsilon, C)\left(G_0 + \sum_{j=1}^{3}(G_{nj}\cos(\alpha) + G_{ej}\sin(\alpha)) \right)$$

- The parameters in this formula ($a_h, b_h, c_h, a_w, b_w, c_w, G_0, G_{nj}, G_{ej}$) have, in this work, been determined by fitting the expression to ray-traced delays obtained using ERA5 data, following the algorithm by Zus et al., 2015 (doi: 10.1002/2014RS005584)
- ERA5:
  - Latest reanalysis by ECMWF
  - Hourly temporal resolution
  - ~31 km spatial resolution

DATA ANALYSIS

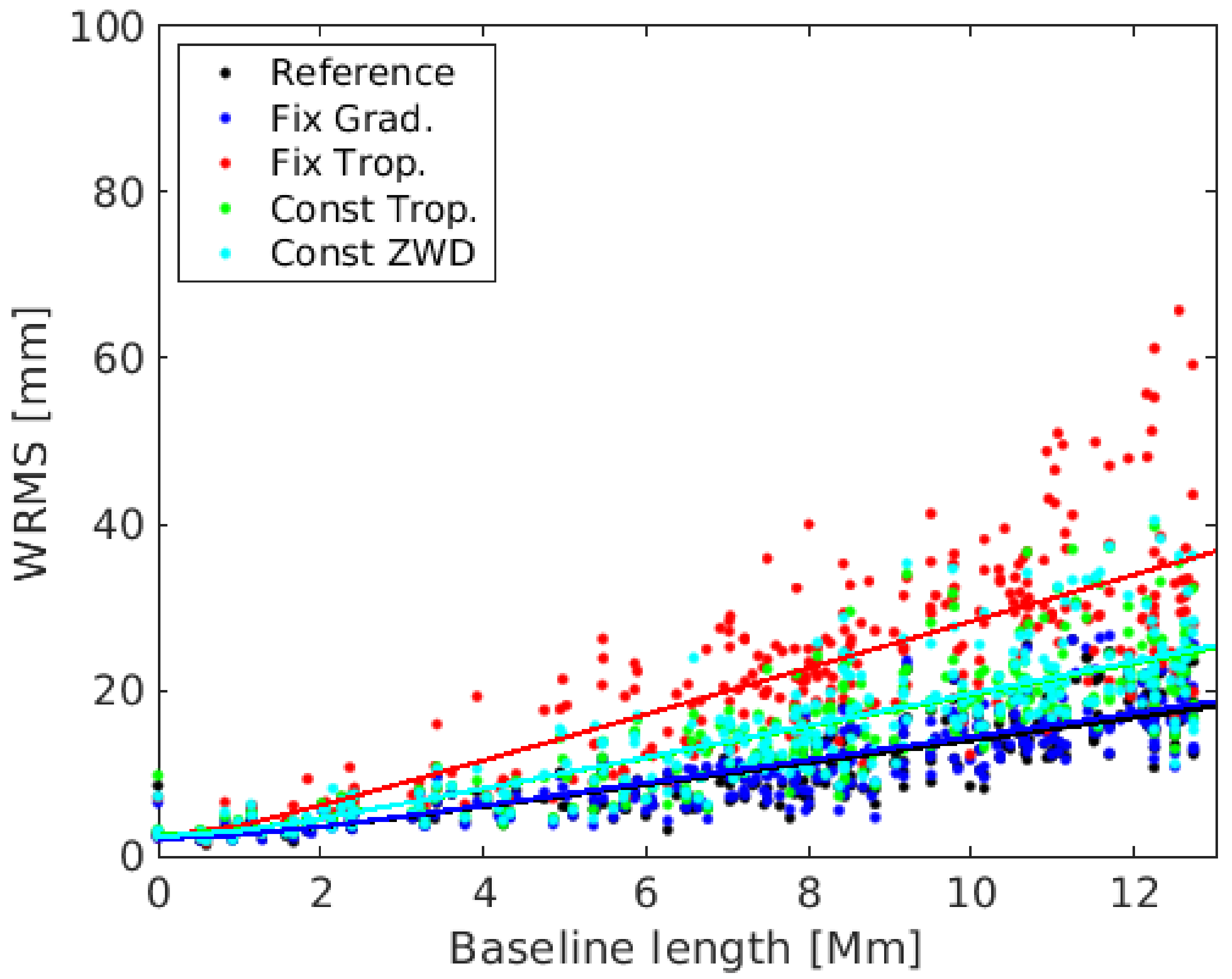
- The data was analyzed by the ASCOT software*
- VLBI sessions from 2010-2019
- A priori modelling following the recommendations for the ITRF2020 reanalysis
- Five different solutions:

Solution	A priori troposphere	Gradients	ZWD
Reference	Standard	PWLF, 2 hour	PWLF, 20 minutes
Fix Gradients	PMF/ERA5	Fixed	PWLF, 20 minutes
Fix Troposphere	PMF/ERA5	Fixed	Fixed
Constant troposphere	PMF/ERA5	Constant	Constant
Constant ZWD	PMF/ERA5	Fixed	Constant

* https://github.com/varenius/ascot

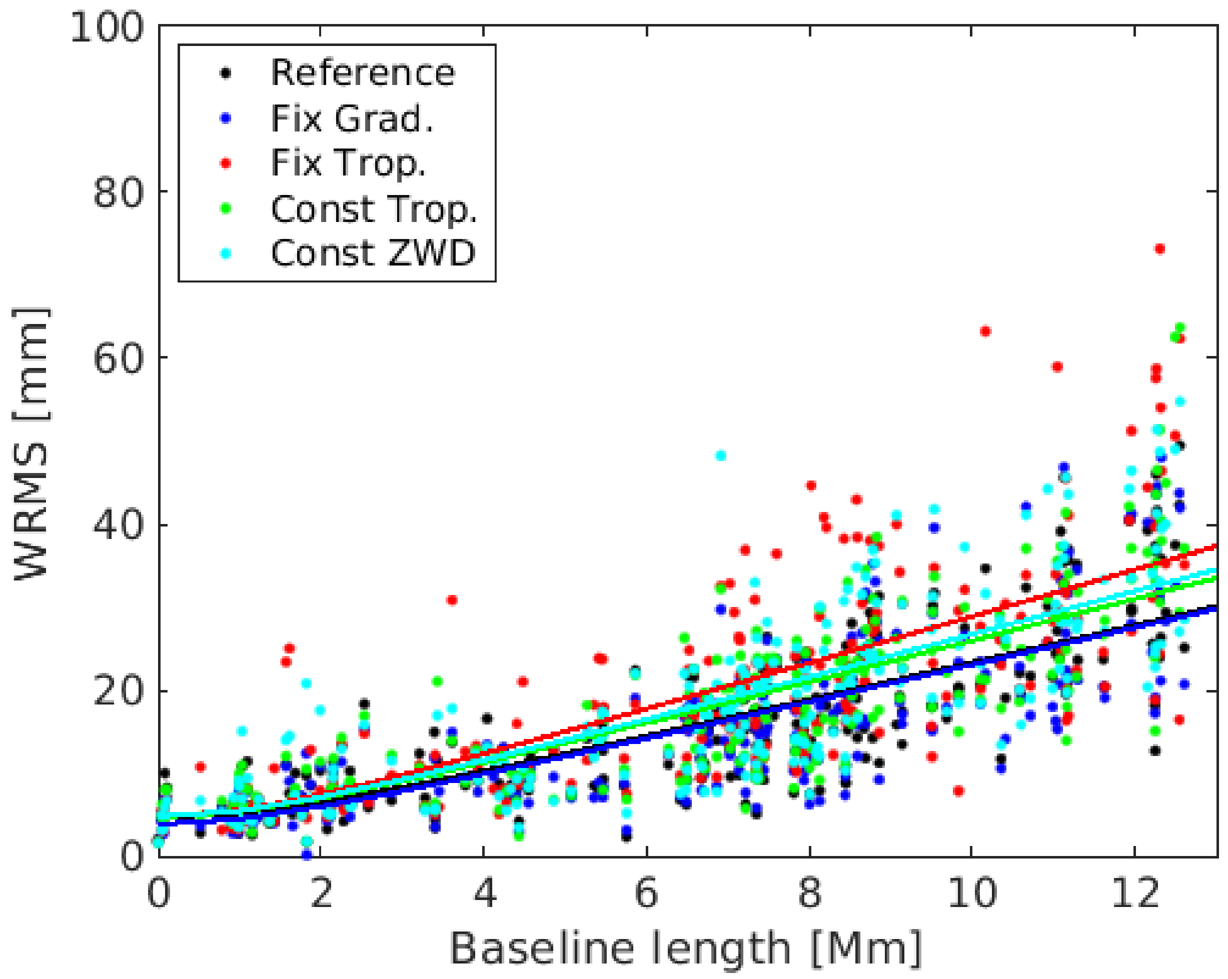
RESULTS: IVS-R1/R4 SESSIONS

- Global VLBI sessions performed two days per week to estimate the Earth Orientation Parameters
- On average 9 stations (3-14)
- *Reference* solution best, *fixing gradients to PMF/ERA5* almost as good
- *Fixing tropospheric delays to PMF/ERA5* gives worst results



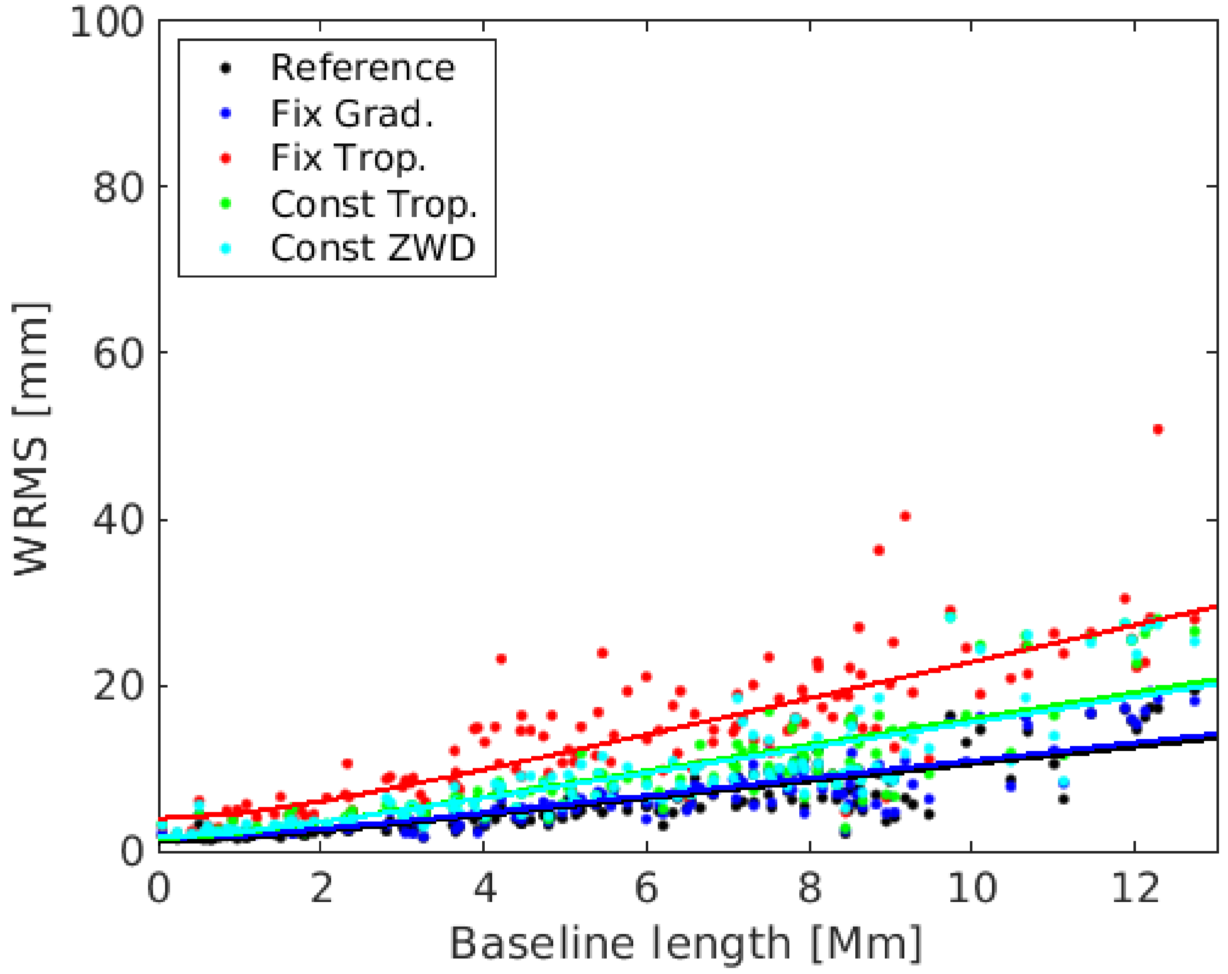
RESULTS: T2 SESSIONS

- Global VLBI sessions designed for improving the TRF
- On average 16 stations (9-21)
- *Reference* solution and *fixing gradients to PMF/ERA5* the best solutions
- Less degradation in precision when *fixing the tropospheric delays*



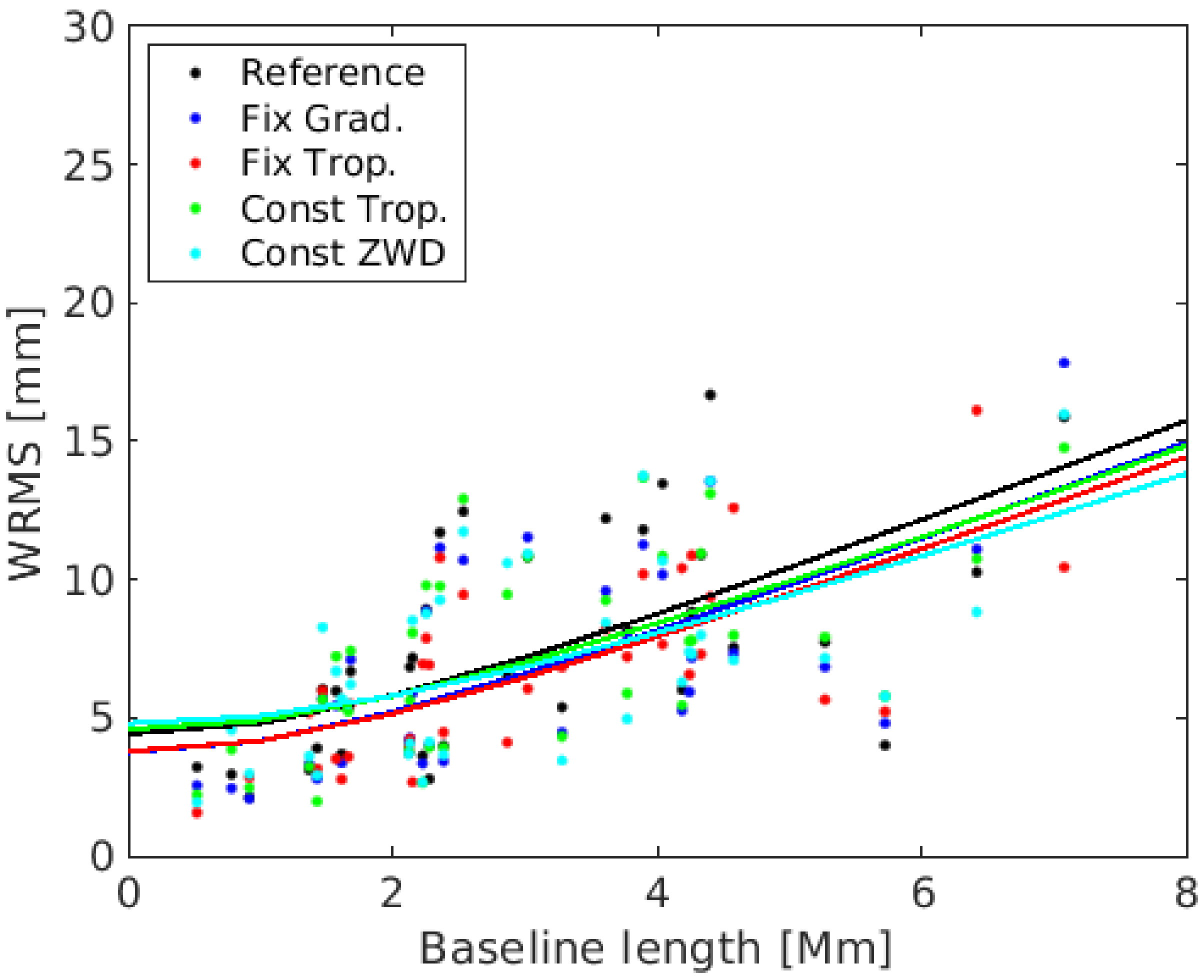
RESULTS: RDV SESSIONS

- Global VLBI sessions with the 10 VLBA stations in USA and a couple of other globally distributed VLBI stations
- On average 14 stations (10-18)
- *Reference* solution and *fixing gradients* to PMF/ERA5 the best solutions



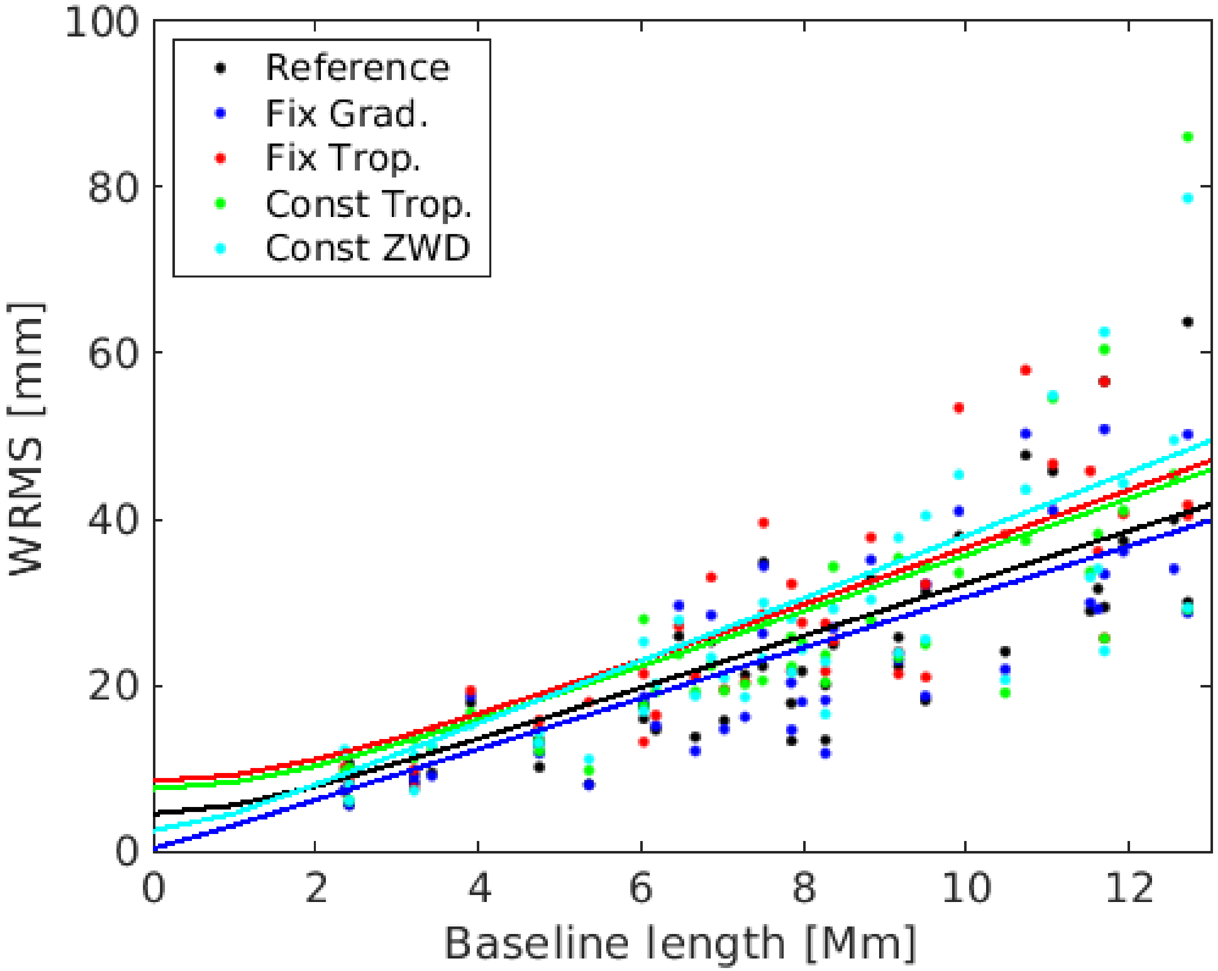
RESULTS: EURO SESSIONS

- Local VLBI sessions using stations in Europe
- On average 7 stations (5-13)
- All solutions of similar performance, *fixing the tropospheric parameters to PMF/ERA5* preforms best



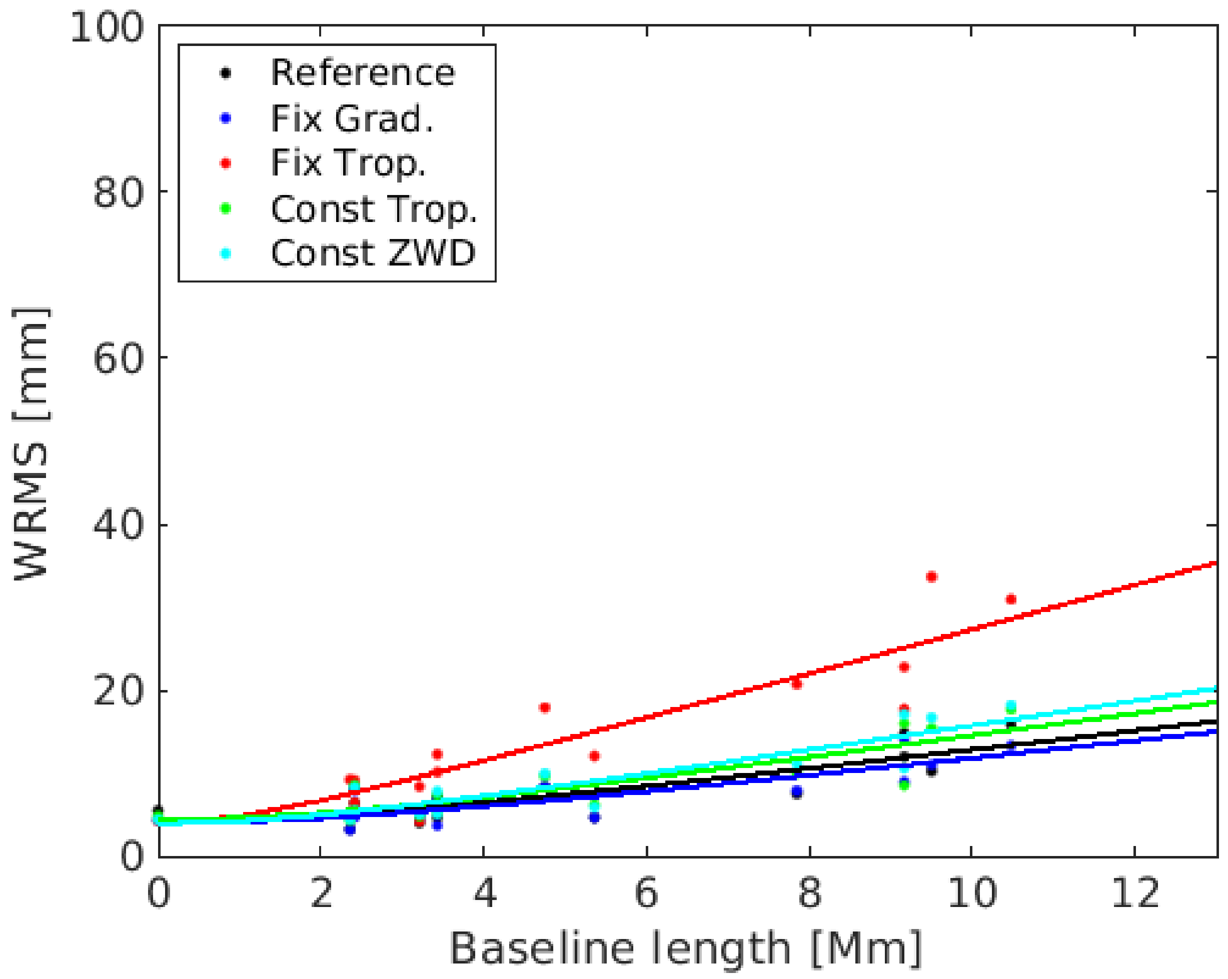
RESULTS: OHIG SESSIONS

- Sessions with VLBI stations in the southern hemisphere, including the two stations in Antarctica (OHIGGINS and SYOWA)
- On average 7 stations (3-9)
- *Fixing gradients* the best solution



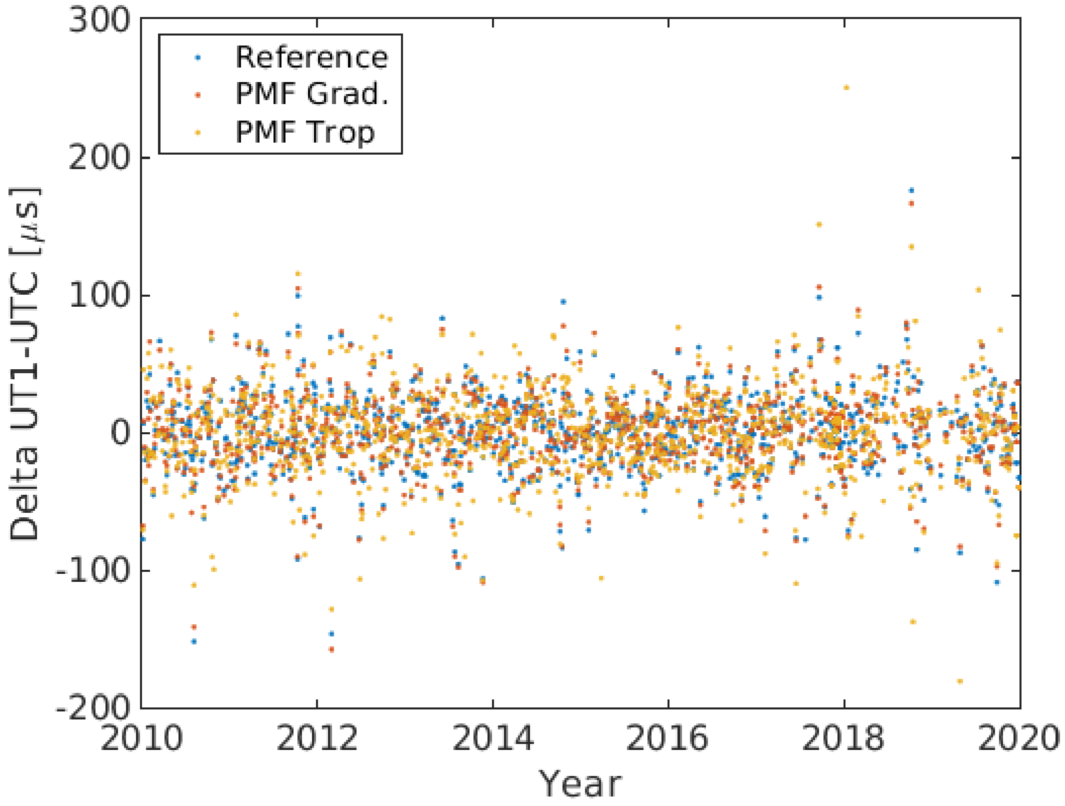
RESULTS: AUSTRAL SESSIONS

- Local sessions with the Australian telescopes, commonly also including WARK12M (New Zealand) and HART15M (South Africa)
- On average 4 stations (3-7)
- *Fixing gradients* the best solution
- *Fixing the tropospheric delays to PMF/ERA5* clearly worst



RESULTS: INTENSIVES

- Intensives: 1-h, normally single-baseline, VLBI sessions for estimation of UT1-UTC
- Figure shows the differences between UT1-UTC from Intensives and simultaneous 24-h VLBI sessions
- Three solutions:
  - Standard (reference)
  - A priori gradients from PMF/ERA5
  - Tropospheric delays fixed to PMF/ERA5



	Reference	PMF gradients	PMF troposphere
Weighted Mean [μs]	1.7	1.6	1.3
Weighted RMS [μs]	20.7	20.5	26.5

SUMMARY

- In general, the results get worse when the tropospheric delays are fixed to those from ERA5
  - Most significant for good performing global sessions
  - The accuracy the delays calculated from ERA5 is not as high as those estimated in the VLBI analysis
- Exception: the reginal European VLBI sessions:
  - Could be because higher accuracy of ERA5 in Europe
  - Or an effect of smaller station networks of these sessions
  - Other unmodelled error sources in the VLBI analysis are estimated as tropospheric delays
- Fixing the gradients when using a priori tropospheric delays from ERA5 does not make the precision worse
  - Sometimes even improves the results slightly