Possibility Study of common tropospheric parameters as another 'local ties' of TRF

Xiaoya Wang, Fan Shao, Qunhe Zhao

Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China

IAG Commission 4 Positioning and Applications Symposium, Wroclaw, Poland, on September 4-7, 2016

Outline

1 Introduction

2 Results, Problems and Analysis

3 Summary and future plan

1 Introduction

- The terrestrial reference frame (TRF) is commonly realized by a combination of space geodetic techniques. We use EOP as the combination ‘global ties’ and common coordinates at colocations as the combination ’local ties’. Are there any other ties?
- The all observation of ground-based space geodetic techniques is through the atmosphere, such as GNSS, SLR ,VLBI and DORIS. Are they treated as ties? They show the same feature? If yes what is the feature? If not what make the difference and how to express the difference?
- So, we checked the Tropospheric Zenith delay (TZD) of 4-technique colocation sites and found some problems, And then tried to look for the answer. If there are common atmospheric parameters or their known differences for colocation sites they might be used to link the 4 techniques as well.

2 Results, Problems and Analysis

Tropospheric models of 4 techniques:

	Zenith delay model	Mapping function	tropospheric parameters Estimated
SLR	M-P model	FCULa mapping function	no
VLBI	Saastamoinen model	GMF/VMF1	yes
GNSS	Saastamoinen model	GMF/VMF1	yes
DORIS	Global pressure/temperature GPT model	GMF	Yes

The traditional tropospheric model of SLR is M-M model, recently we have demonstrated that the combination of M-P model and FCULa mapping function can improve the precision, especially for the low-elevation data.

2 Results, Problems and Analysis

SLR old tropospheric model

The zenith hydrostatic delay:

M-M mode

$$\Delta\rho_{RF} = \frac{f(\lambda)}{f(\phi, H)} \times \frac{A+B}{\sin\gamma + \frac{B/(A+B)}{\sin\gamma + 0.01}}$$

$$f(\lambda) = 0.9650 + \frac{0.0164}{\lambda^2} + \frac{0.000228}{\lambda^4}$$

$$A = 0.002357P + 0.000141W_1$$

$$B = 1.084\times10^{-8}\times P\times T\times K + \frac{2\times4.734\times10^{-8}\times P^2}{T\times(3-\frac{1}{K})}$$

$$f(\phi, H) = 1 - 0.0026\cos 2\phi - 3.1\times10^{-7}H$$

$$K = 1.163 - 0.00968\cos 2\phi - 0.00104T + 0.00001435P$$

$$W_1 = \frac{W}{100}\times 6.11\times 10^{\frac{7.5\times(T-273.15)}{237.3+(T-273.15)}}$$

2 Results, Problems and Analysis

SLR tropospheric model

- M-P model $f(\phi, H) = 1 - 0.0026\cos 2\phi - 3.1\times 10^{-7} H$

The zenith hydrostatic delay:

$$\mathrm{d}_h^z = 0.00002416079 \frac{f_h(\lambda)}{f(\varphi, H)} P_s$$

The zenith non-hydrostatic delay:

$$\mathrm{d}_{nh}^z = 10^{-6}(5.316 f_{nh}(\lambda) - 3.759 f_h(\lambda)) \frac{e_s}{f(\varphi, H)}$$

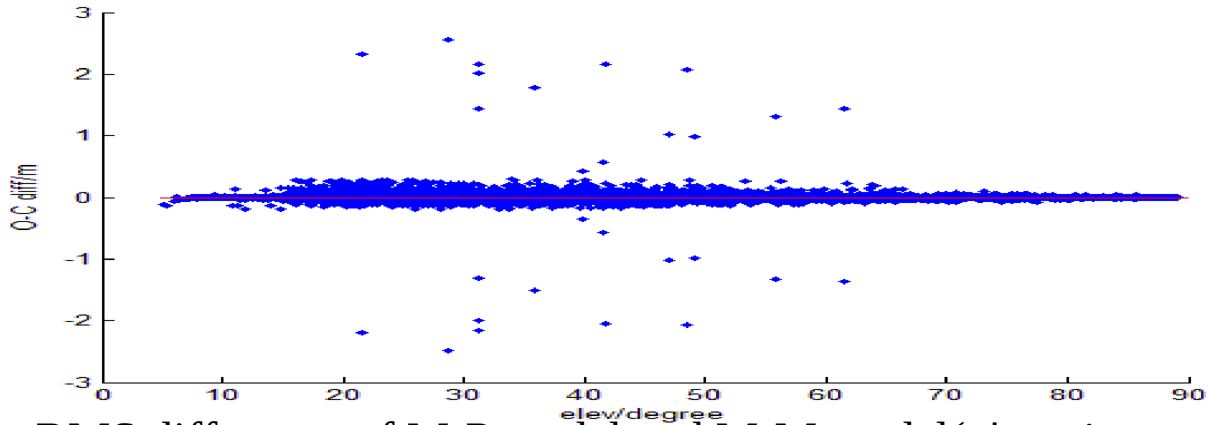
- The FCULa mapping function

$$(\epsilon) = \frac{1 + \frac{a_1}{1 + \frac{a_2}{1 + a_3}}}{sin\epsilon + \frac{a_1}{sin\epsilon + \frac{a_2}{sin\epsilon + a_3}}}$$

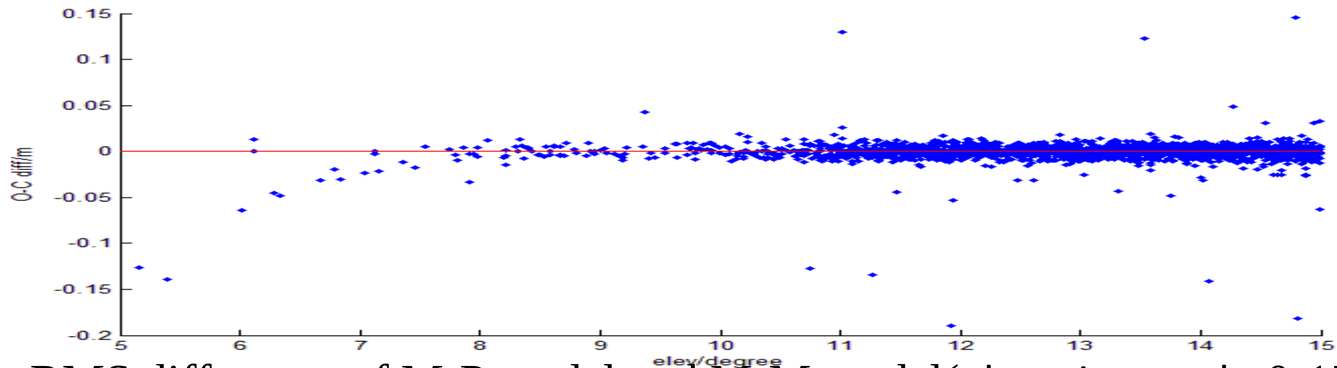
Where:

$$a_i = a_{i0} + a_{i1} t_s + a_{i2} cos\varphi + a_{i3} H, (i = 1,2,3)$$

2 Results, Problems and Analysis



The RMS difference of M-P model and M-M model(elevating angle:0-90）



The RMS difference of M-P model and M-M model(elevating angle:0-15）

2 Results, Problems and Analysis

GNSS and VLBI tropospheric model

- Saastamoinen model

The zenith hydrostatic delay:

$$\mathrm{d}_h^z = (0.0022768 \pm 0.000005)\frac{P_s}{f(\varphi, H)}$$

The zenith hydrostatic delay:

$$\mathrm{d}_{nh}^z = 0.0022768 \times (\frac{1255}{t} + 0.05) \times e_s$$

- VMF1 mapping function

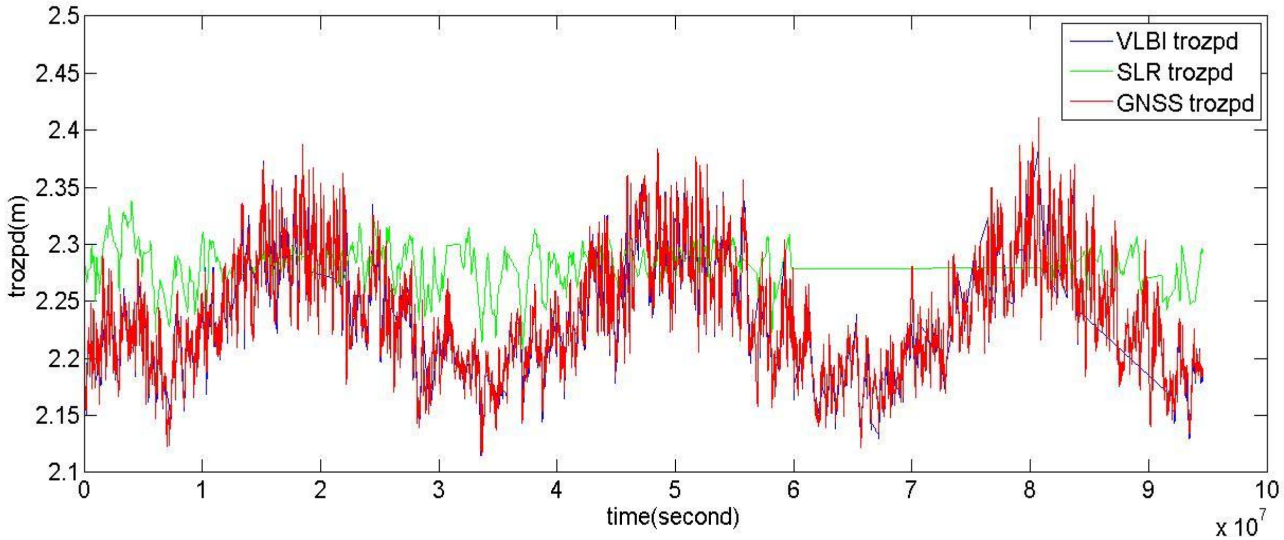
$$\mathrm{m}(\epsilon) = \frac{1 + \frac{a_1}{1 + \frac{a_2}{1 + a_3}}}{sin\epsilon + \frac{a_1}{sin\epsilon + \frac{a_2}{sin\epsilon + a_3}}} + v_i \quad (i = h, \omega)$$

Where:

$$v_h = [\frac{1}{sin\epsilon} - \frac{1+\frac{a}{1+\frac{b}{1+c}}}{sin\epsilon+\frac{a}{sin\epsilon+\frac{b}{sin\epsilon+c}}}] \cdot h_{测站}$$

2 Results, Problems and Analysis

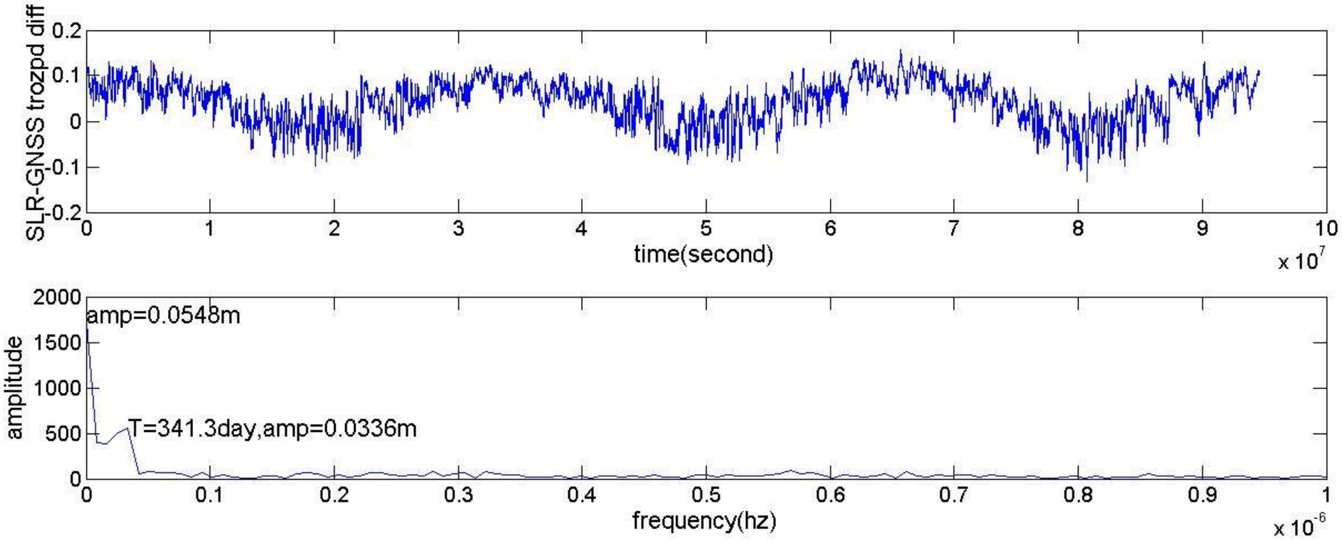
The VLBI, SLR, GNSS zenith delay at WETT



VLBI, SLR, GNSS zenith delay at colocation site WETT

VLBI zenith delay is consistent with GNSS ,but there exits about 10cm difference between SLR and GNSS

Analysis of zenith delay difference between SLR and GNSS



Tthe zenith delay difference between SLR and GNSS and spectrum analysis (WETT)

There exits a constant term about 0.0548m and a long period term whose period is 341.3 day and amplitude is 0.0336m

2 Results, Problems and Analysis

Analysis of zenith delay difference between VLBI and GNSS

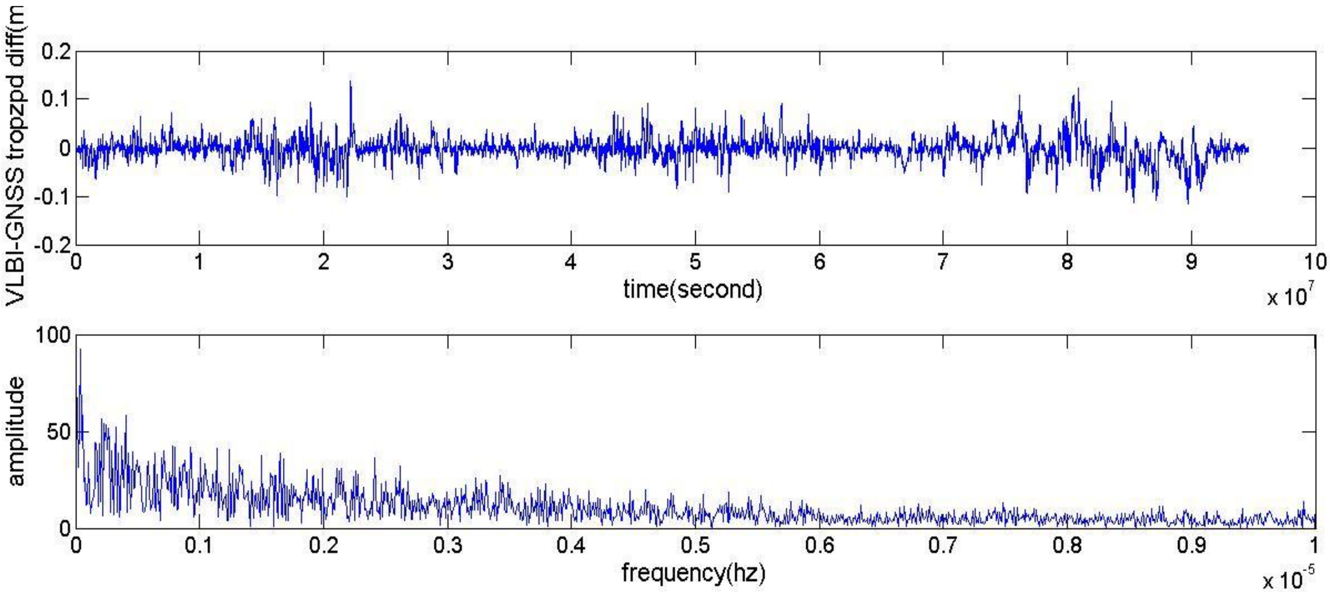
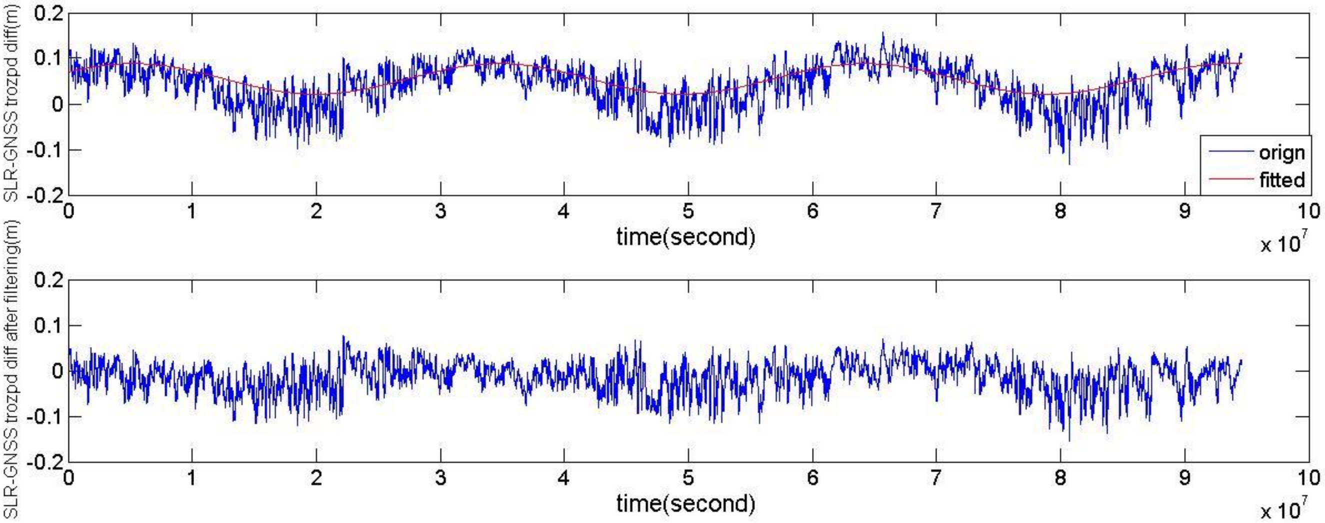


Figure 3 the zenith delay difference between VLBI and GNSS and spectrum analysis (WETT)

2 Results, Problems and Analysis

Analysis of zenith delay difference after filtering

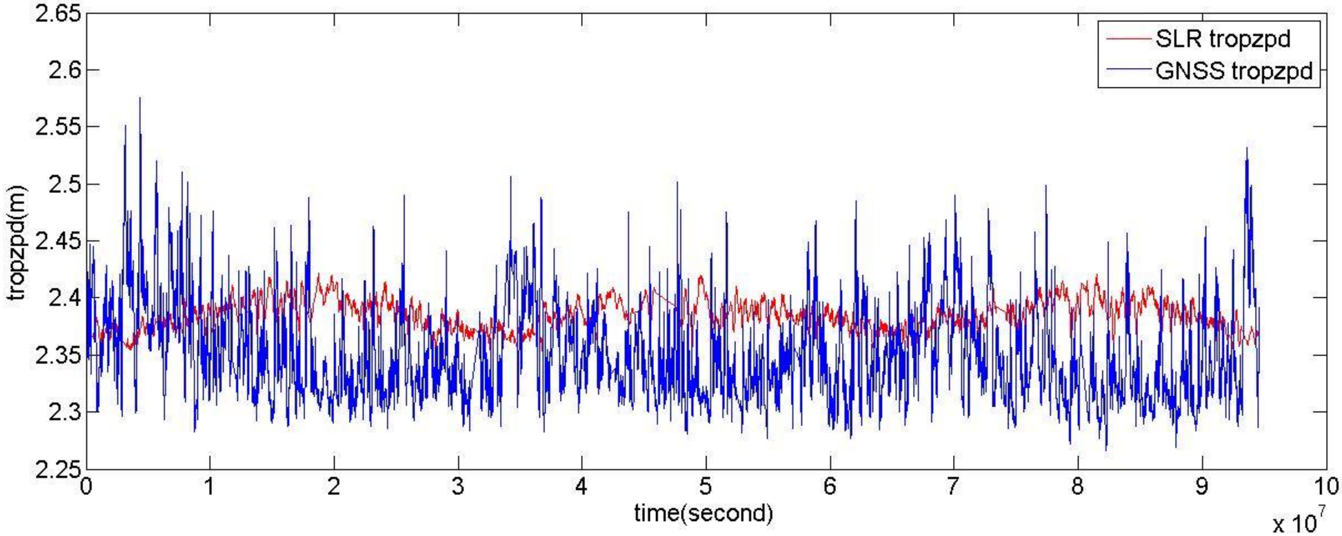


The remaining zenith difference between SLR and GNSS after removing the constant term and long period term (WETT)

After removing the constant term and long period term, there still exits a big difference about -5cm to 5cm. How to explain ?

2 Results, Problems and Analysis

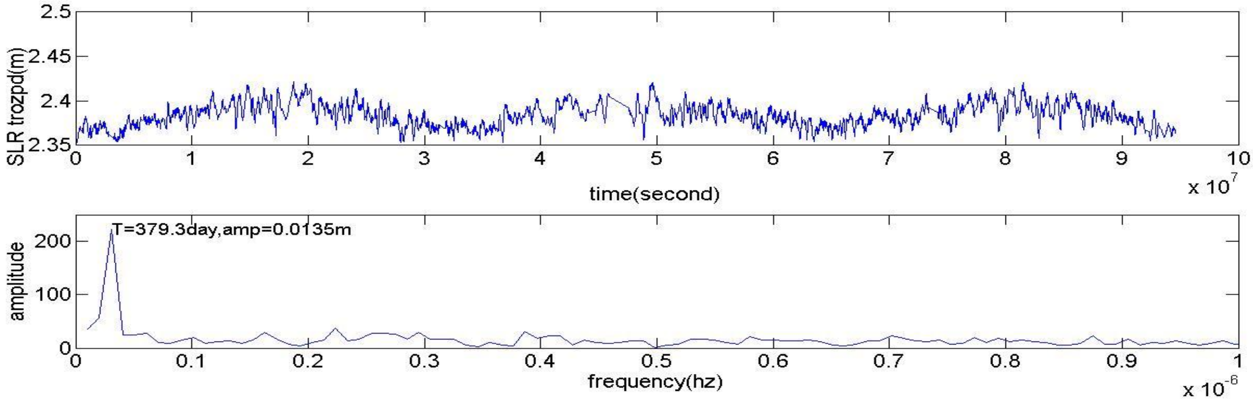
The SLR, GNSS zenith delay at collocation site YAR



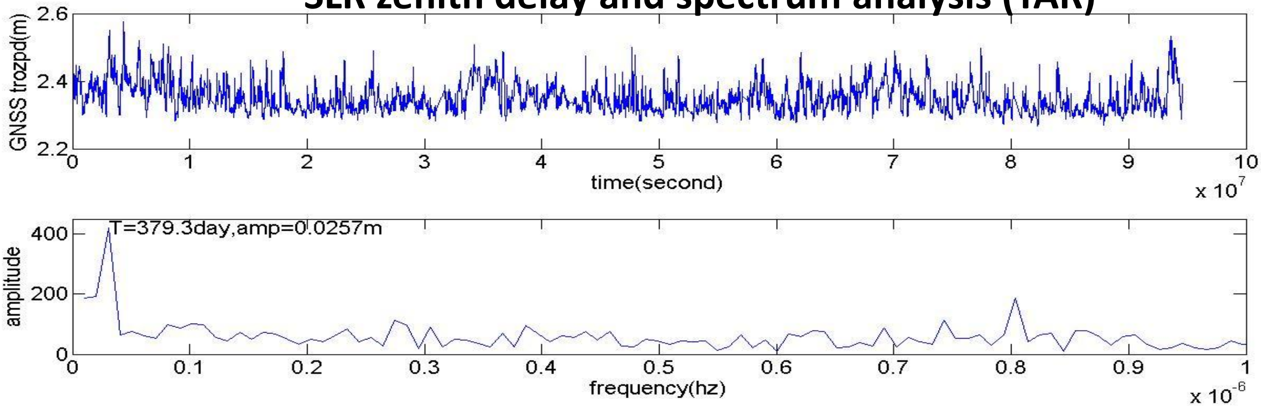
The SLR, GNSS zenith delay at collocation site YAR

2 Results, Problems and Analysis

Analysis of SLR and GNSS zenith delay

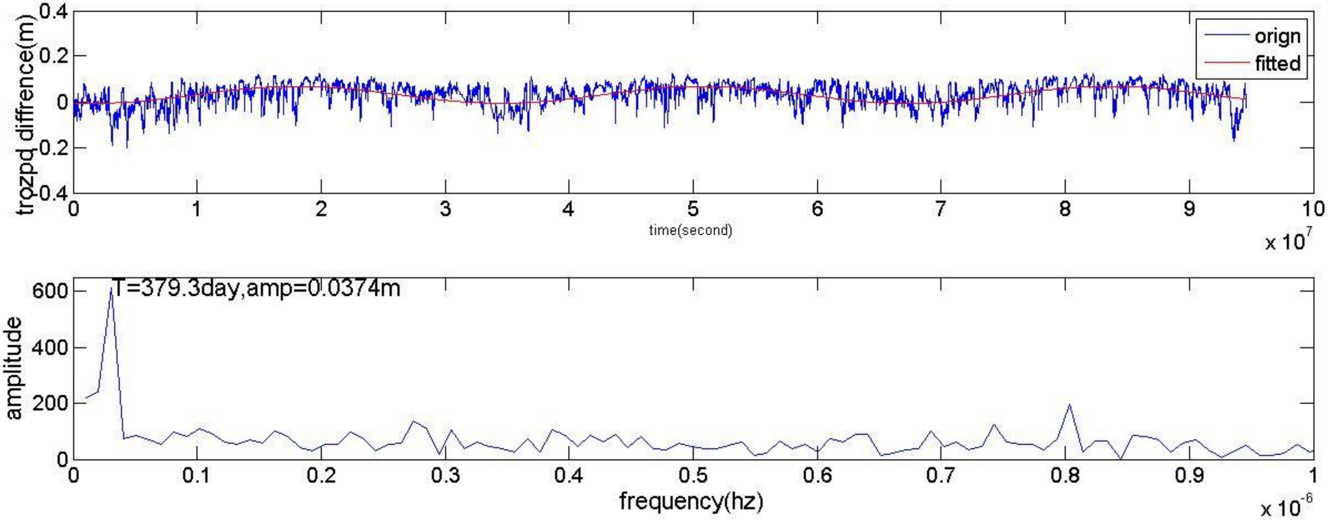


SLR zenith delay and spectrum analysis (YAR)



GNSS zenith delay and spectrum analysis (YAR)

Analysis of zenith delay difference between SLR and GNSS

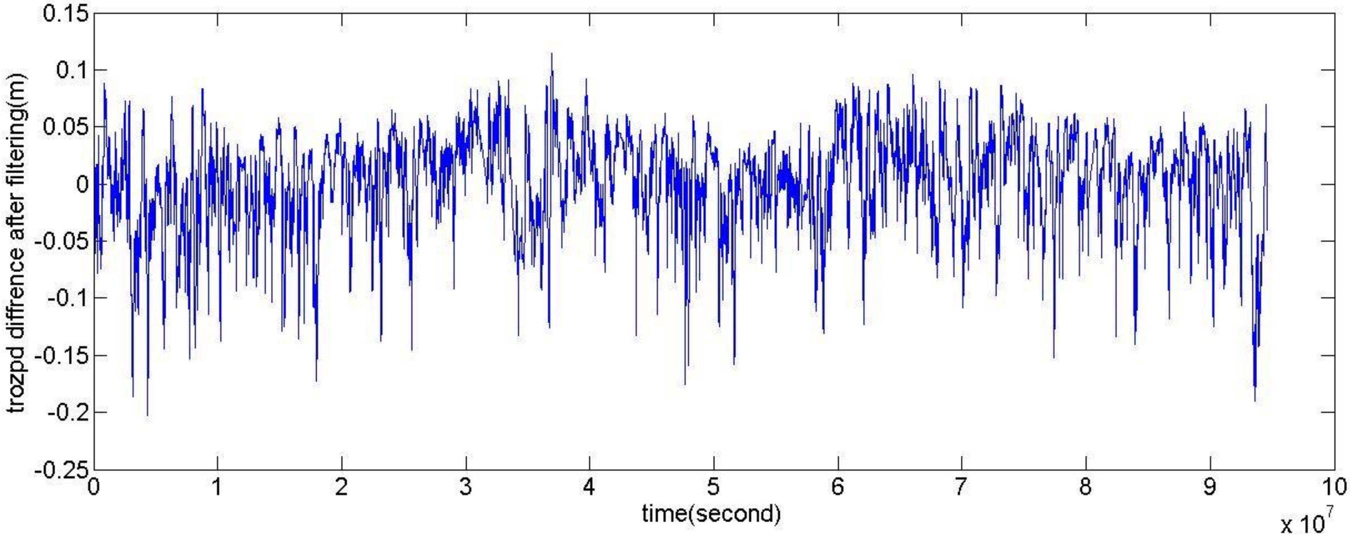


SLR and GNSS zenith delay difference and spectrum analysis (YAR)

There exits a constant term about 0.0305m and a long period term whose period is 379.3 day and amplitude is 0.0374m

3 Results, Problems and analysis

Zenith delay Difference after filtering



The remaining zenith difference between SLR and GNSS after removing the constant term and long period term (YAR)

Same to the colocations WETT, there still remains a big zenith difference between SLR and GNSS after removing the constant term and long period term

4 Summary and future plan

Summary:

- VLBI tropospheric zenith delay is approximately consistent with GNSS
- There exits a constant term and a long period (about 1 year) term in the tropospheric zenith delay difference between SLR and GNSS.
- Eliminate the constant term and long period term, the remaining difference is still very big. It is about 5cm or so.

4 Conclusion and future plan

- Focus issues:
  - Take DORIS tropospheric delay into account
  - More longer time series data
  - More colocation sites
  - SLR Tropospheric Parameters estimated
  - Further analysis of the remaining part of the difference between SLR and GNSS

Acknowledgments

National Natural Science Foundation of China (NSFC)
No. 11173048
Ministry of Science and Technology of China
No.2015FY310200
The National Key Research and Development Plan
2016YFB0501405

Thank you for your attention！

Xiaoya Wang(wxy@shao.ac.cn)

Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China

Chinese Earth Rotation and Reference Systems Service (CERS) work group, http://cers.shao.ac.cn/en/