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

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Abstract:

The terrestrial reference frame (TRF) is commonly realized by a combination of space geodetic techniques. During the combination 'global ties', i.e. common global parameters, like the Earth Orientation Parameters (EOP), can be directly used, while 'local ties', i.e. common coordinates at colocation sites, have to consider the distances between the reference points of the various devices. The all observation of ground-based space geodetic techniques is through the atmosphere and consequently common atmospheric parameters for colocation sites might be used to link the techniques as well. But what are the common atmospheric parameters? We study the systematic errors between tropospheric parameters obtained by different techniques. By tropospheric parameters estimates and comparison of SLR/GNSS/VLBI/DORIS colocation sites we check what make the tropospheric differences of 4-technique colocation sites so that we can apply the ties better. We hope to find a method to apply tropospheric ties for a combination of the space geodetic techniques.

Keywords: terrestrial reference frame ; the space geodetic techniques ; local ties; tropospheric parameters ;

Theory and Methodology:

Tropospheric model for optical techniques

The zenith hydrostatic delay:

$$d_h^z = 0.00002416079 \frac{f_h(\lambda)}{f(\varphi,H)} P_s \quad (1)$$

Where:

$$f_h(\lambda) = 10^{-6}\left[k_1^* \frac{(k_0+\sigma^2)}{(k_0-\sigma^2)^2} + k_3^* \frac{(k_2+\sigma^2)}{(k_2-\sigma^2)^2}\right] C_{CO_2},$$

$$f(\varphi,H) = 1 - 0.0026\cos 2\varphi - 0.00028H,$$

P_s is the surface barometric pressure

The zenith hydrostatic delay:

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

Where:

$$f_{nh}(\lambda) = 0.003101(\omega_0 + 3\omega_1\sigma^2 + 5\omega_2\sigma^4 + 7\omega_3\sigma^6)$$

The FCULa mapping function:

$$m(\epsilon) = \frac{1+\frac{a_1}{1+\frac{a_2}{1+a_3}}}{\sin\epsilon+\frac{a_1}{\sin\epsilon+\frac{a_2}{\sin\epsilon+a_3}}} \quad (2)$$

Where:

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

Tropospheric model for radio techniques

The zenith hydrostatic delay:

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

The zenith hydrostatic delay:

$$d_{nh}^z = 0.0022768 \times \left(\frac{1255}{t} + 0.05\right) \times e_s$$

VMF1 mapping function

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

Where:

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

Comparison of tropospheric parameters obtained by different techniques :

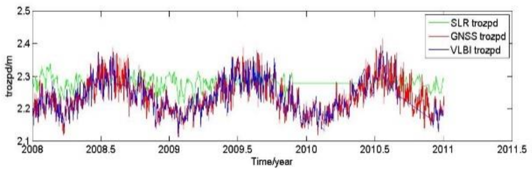

Figure 1 VLBI, SLR, GNSS zenith delay at colocation site WETZ

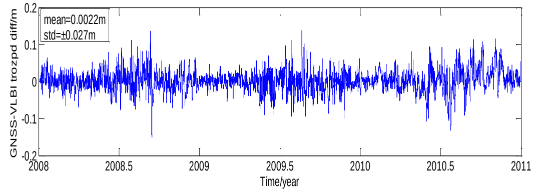

Figure 2 the zenith delay difference between VLBI and GNSS and spectrum analysis (WETZ)

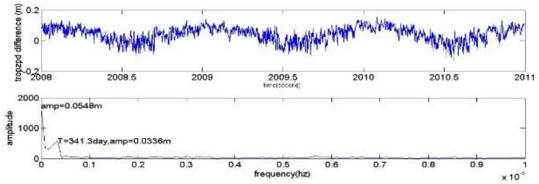

Figure 3 the zenith delay difference between SLR and GNSS and spectrum analysis (WETZ)

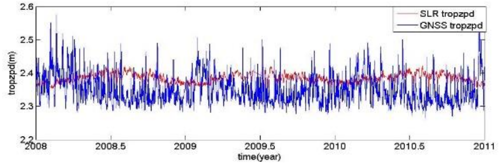

Figure 4 The SLR, GNSS zenith delay at collocation site YARA

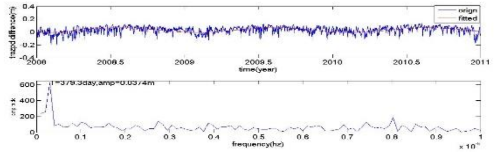

Figure 5 SLR and GNSS zenith delay difference and spectrum analysis (YARA)

Comparison of tropospheric zenith hydrostatic delay :

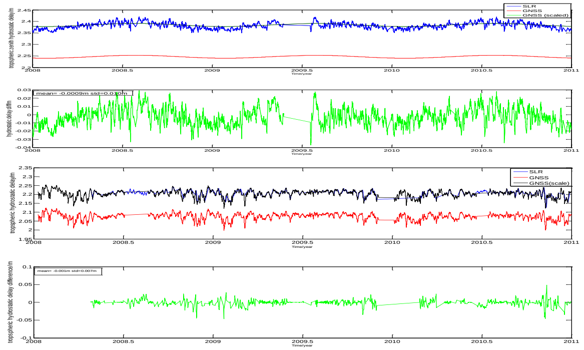

Figure 4. the zenith dry delay difference between SLR and GNSS at site YARA and ZIMM

Estimating the ZTD parameters in SLR:

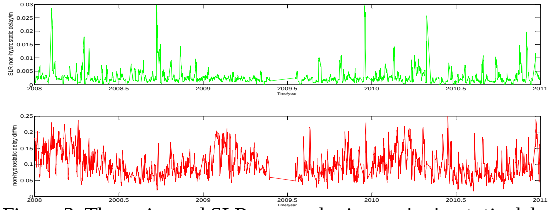

Figure 3. The estimated SLR tropospheric non-hydrostatic delay at site YARA

Conclusion:

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.

SLR tropospheric zenith hydrostatic delay is approximately consistent with GNSS (exiting a scaling factor).

it is the estimated GNSS tropospheric zenith non-hydrostatic delay parameter that cause the difference between SLR and GNSS, since SLR doesn't work when it rains. Next step, we should find the variation law of the difference so that we can apply tropospheric ties for a combination of the space geodetic techniques.