Elena Skurikhina: Long Time Wet Tropospheric Delay Series for Some Stations, IVS 2004 General Meeting Proceedings, p.466–470
http://ivscc.gsfc.nasa.gov/publications/gm2004/skurik

Long Time Wet Tropospheric Delay Series for Some Stations

Elena Skurikhina

Institute of Applied Astronomy of Russian Academy of Sciences (IAA)
e-mail: sea@quasar.ipa.nw.ru

Abstract

Long time WTD series for selected stations were obtained from all 24 h series VLBI data processing with OCCAM package using Kalman filter technique for estimation of stochastic parameters (clock offset and WTD). One WTD value for each 24 h session is computed. Long time WTD behavior can be described as combination of seasonal part and linear trend. Parameters of linear trend (bias, rate) and seasonal harmonic (amplitude, phase) for 20 VLBI stations with long observational history are presented. The comparison with mean diurnal values of meteodata is made.

We analysed the time series of WTD (Wet Tropospheric Delay) for some stations with sufficiently long observation history. WTD values were calculated with OCCAM software as one value per session and relate to the last observation at the session. They are modeled as random walk stochastic process and estimated using Kalman filter technique. We used VTRF2003 to fix terrestrial reference system. Numeric atmospheric loading model based on the station displacement time series computed at GSFC is applied. The mapping functions by Niell (1996) were used.

The long time WTD series for some stations was calculated from data processing of all 24-hour sessions.

The preliminary analysis of meteo data was made (to select stations with sufficient number of observations to study seasonal effects). Average daily values of meteo data (temperature (T), pressure (P), humidity (H)) was extracted from VLBI data statistic [8] (unreliable data was refused). The average daily values of temperature can be presented as combination of linear trend and seasonal part (see Fig-1, Fig-2). The values on linear trend coefficients (bias for the middle of time interval and trend), amplitude (A_1) and phase of annual term, wrms from this model and also average values (bias) for pressure and humidity are presented in the table 1. Values of biases and annual amplitudes for time series of average daily temperature are correlated with latitude of station (correlation coefficient is about 0.6).

We can regard the long time WTD series as combination of linear trend and annual term, too (see Fig-1, Fig-2). The quantities of linear trend coefficients (bias and rate), amplitude (A) and phase of annual term and wrms from this model are presented in the table 1. The string NRAO corresponds both NRAO20 and NRAO85 3 stations. The values of trends are not in a good agreement with [1, 4, 5], but rather closely to the values for Wettzell. (For Wettzell station the values of linear trend [4] obtained for the period since 1984 from 6-hour values by unweighted least-squeares fit was estimated to 0.83 mm/year. The time series was obtained from all geodetic sessions analysis with OCCAM package v.5.1 [7] using Gauss-Markov model for the least-squeares adjustment. WZD was estimated as 1-h piecewise linear function. ITRF2000 was used to fix TRS, Niell mapping functions (1996) and the elevation angle cutoff 8° were upplied. The mean seasonal values have trend of 0.73 mm/year. Analysis of [5] for WZD time series was obtained for the period since 1987 till 2002 with CALC/SOLV, into ITRF2000 without fixing the stations coordinates, using no-net-translation constraint and 5° elevation cutoff and the Niell mapping functions. WZD

Table 1. Average daily values of meteoparameters for VLBI stations.

Station	T, bias, °C	T, rate, °C/year	T, A_1 °C	T, Phase, deg	T, wrms,°C	P, Pa	H, %
WETTZELL	8.4 ±0.1	0.1 ±0.0	9.4 ±0.2	255 ±1	4	945.5	75
GILCREEK	1.3 ±0.1	-0.0 ±0.0	13.6 ±0.2	262 ±1	5	973.0	55
KOKEE	16.1 ±0.1	-0.4 ±0.1	2.4 ±0.1	218 ±3	2	890.1	89
WESTFORD	9.9 ±0.2	0.0 ±0.0	11.8 ±0.2	249 ±1	4	1004.4	61
RICHMOND	21.9 ±0.5	-0.4 ±0.1	4.0 ±0.2	235 ±3	4	1017.1	69
FORTLEZA	29.0 ±0.1	-0.0 ±0.0	1.0 ±0.1	93 ±3	1	1009.4	64
HARTRAO	18.0 ±0.1	0.1 ±0.0	5.8 ±0.2	91 ±2	3	869.3	55
MOJAVE12	20.6 ±0.5	0.5 ±0.1	11.1 ±0.2	253 ±1	4	910.5	23
HRAS 085	16.9 ±0.7	0.3 ±0.1	7.8 ±0.2	255 ±2	4	836.9	45
ALGOPARK	5.5 ±0.2	0.1 ±0.1	13.5 ±0.3	252 ±1	5	986.2	73
NRAO85 3	9.2 ±0.5	-0.1 ±0.1	10.6 ±0.3	252 ±2	4	925.6	72
NRAO20	9.6 ±0.3	0.6 ±0.2	10.4 ±0.4	254 ±2	4	923.1	69
MATERA	15.0 ±0.2	0.1 ±0.0	9.9 ±0.2	247 ±1	4	959.6	67
KAUAI	16.0 ±0.2	-0.1 ±0.0	2.5 ±0.1	223 ±3	2	888.0	79
ONSALA60	9.9 ±0.2	0.1 ±0.0	8.3 ±0.2	249 ±1	3	1010.8	75
NYALES20	-2.4 ±0.2	-0.0 ±0.1	6.2 ±0.2	244 ±2	3	1006.9	70
HOBART26	12.0 ±0.2	-0.3 ±0.1	3.6 ±0.3	82 ±4	3	1011.4	66
KASHIMA	15.0 ±0.4	0.1 ±0.1	8.6 ±0.4	239 ±3	4	1011.1	76
MEDICINA	13.3 ±0.3	-0.1 ±0.1	10.9 ±0.4	260 ±2	4	1013.4	64

was computed with one hour resolution. The linear trend calculated for this series is -0.23 ± 0.11 mm/year. The linear trend after removing annual wave is 0.60 ± 0.08 mm/year. For Medicina station linear trend for WZD time series is 3.3 ± 0.3 mm/year.)

Possible reason of this discrepancy is in different values used for analysis. Values of biases (for the middle of time interval) and annual amplitudes seems in rather good agreement with the average data for stations Wettzell, Westford, Gilcreek, Nyales20, Onsala60, Medicina and Matera [1, 4, 5]. Values of biases for time series of average daily temperature and time series of WZD have a high correlation degree (0.75).

References

[1] *Boehm, J., Schuh, H., Tesmer, V., Scmitz-Huebsch, H.* Determination of Tropospcheric Parameters by VLBI as Contribution to Climatologial Studies. Vermessung & Geoinformation, VGI, 1/2003, 21–28.

[2] *Schuh, H., Boehm, J.* Status Report of the IVS Tropospheric Pilot Project – Tropospheric Parameters in International VLBI Service for Geodesy and Asrtometry. 2002 Annual Report, ed. Vandenberg, N., Baver, K., NASA/TP–2003–211619, 13–21.

[3] *Schuh, H., Boehm, J.* Determination of Tropospheric Parameters Within the new IVS Pilot Project. In: Proceedings of 16th Working Meeting on European VLBI for Geodesy and Asrtometry, Leipzig, Germany, 2003, 257–264.

Table 2. WZD time series parameters.

Station	Obs. Number	T_{beg} - T_{end}	Bias, mm	Trend, mm/year	A, mm	Phase, Deg	wrms, mm
WETTZELL	1078	1984.1 - 2004.0	83.1±1.2	0.4±0.2	37.1±1.5	243 ±3	16
GILCREEK	818	1984.5 - 2003.9	53.9±1.2	0.0±0.2	50.4±1.6	328 ±2	12
KOKEE	881	1993.4 - 2004.0	91.8±1.3	0.4±0.4	20.6±1.9	95 ±5	9
KAUAI	346	1985.6 - 1994.2	108.3±3.2	-2.2±1.4	20.7±4.0	120 ±11	25
WESTFORD	830	1981.4 - 2003.9	102.3±2.4	1.4±0.4	67.0±3.4	123 ±3	18
RICHMOND	553	1984.0 - 1992.6	211.3±2.5	2.1±1.0	65.4±3.5	350 ±3	32
FORTLEZA	645	1993.3 - 2004.0	255.3±1.7	0.3±0.5	62.4±2.4	225 ±3	11
HRAS 085	505	1980.6 - 1990.8	95.6±2.5	-1.0±1.2	50.3±3.4	124 ±4	29
HARTRAO	466	1986.0 - 2003.9	88.1±2.4	3.6±0.5	57.4±3.3	76 ±3	24
MOJAVE12	351	1989.1 - 1992.7	64.0±2.0	9.7±2.1	28.1±2.7	203 ±6	18
ALGOPARK	250	1999.0 - 2004.0	88.5±3.0	-3.4±2.1	68.2±2.1	61 ±4	23
NRAO	541	1989.4 - 2000.5	90.1±2.3	-1.7±0.8	60.8±2.9	230 ±3	11
MATERA	398	1990.8 - 2004.0	98.6±1.7	1.1±0.4	47.5±2.4	6 ±3	20
ONSALA60	354	1980.6 - 2003.8	87.4±2.2	-1.1±0.3	38.6±3.0	315 ±5	12
NYALES20	364	1994.8 - 2004.0	42.0±1.1	1.6±0.4	30.2±1.5	4 ±3	22
HOBART26	256	1989.9 - 2003.9	89.0±3.0	-0.4±0.8	25.9±4.1	15 ±10	27
KASHIMA	198	1984.6 - 2002.4	133.1±6.7	-1.9±1.2	74.2±9.3	49 ±9	38
MEDICINA	152	1987.3 - 2003.8	119.7±3.6	0.3±0.7	54.1±5.4	99 ±5	17
FD-VLBA	98	1992.0 - 2003.5	84.7±4.2	-0.2±1.2	80.8±5.5	262 ±6	38
TSUKUB32	92	1998.5 - 2003.8	172.9 ±6.4	-12.7±4.8	90.9±8.8	315 ±6	31
SANTIA12	87	1991.9 - 1996.9	65.1±6.7	-3.1±2.1	22.8±4.5	55 ±12	30
LA-VLBA	100	1991.4 - 2003.5	73.0±5.2	0.7±1.4	64.1±5.6	37 ±5	13
SC-VLBA	84	1993.5 - 2003.5	215.7±5.3	-0.7±1.8	28.6±6.8	262 ±16	47

[4] *Schuh, H., Boehm, J., Tesmer, V., Schmitz-Huebsch, H.* Tropospheric Zenith Delays by VLBI as Contribution to Climatologial Studies. In: Proceedings of 16th Working Meeting on European VLBI for Geodesy and Asrtometry, Leipzig, Germany, 2003, 237–246.

[5] *Negusini, M., Tomasi, P.* Tropospheric Parameters from Geodetic VLBI Data Analysis. In: Proceedings of 16th Working Meeting on European VLBI for Geodesy and Asrtometry, Leipzig, Germany, 2003, 189–202.

[6] *Malkin, Z., Skurikhina, E., Sokolskaya, M., Krasinsky, G., Gubanov, V., Surkis, I., Kozlova, I., Rusinov, Yu.* IAA VLBI Analysis Center Report for 2000. In: 2000 IVS Annual Report, 2001, 232–235.

[7] *Titov, O., Tesmer, V., Boem, Y.* OCCAM 5.1 User's Guide. AGU, 2002.

[8] `http://www.ipa.nw.ru/PAGE/DEPFUND/GEO/\-ac_vlbi/index.htm/sessstat.dat`

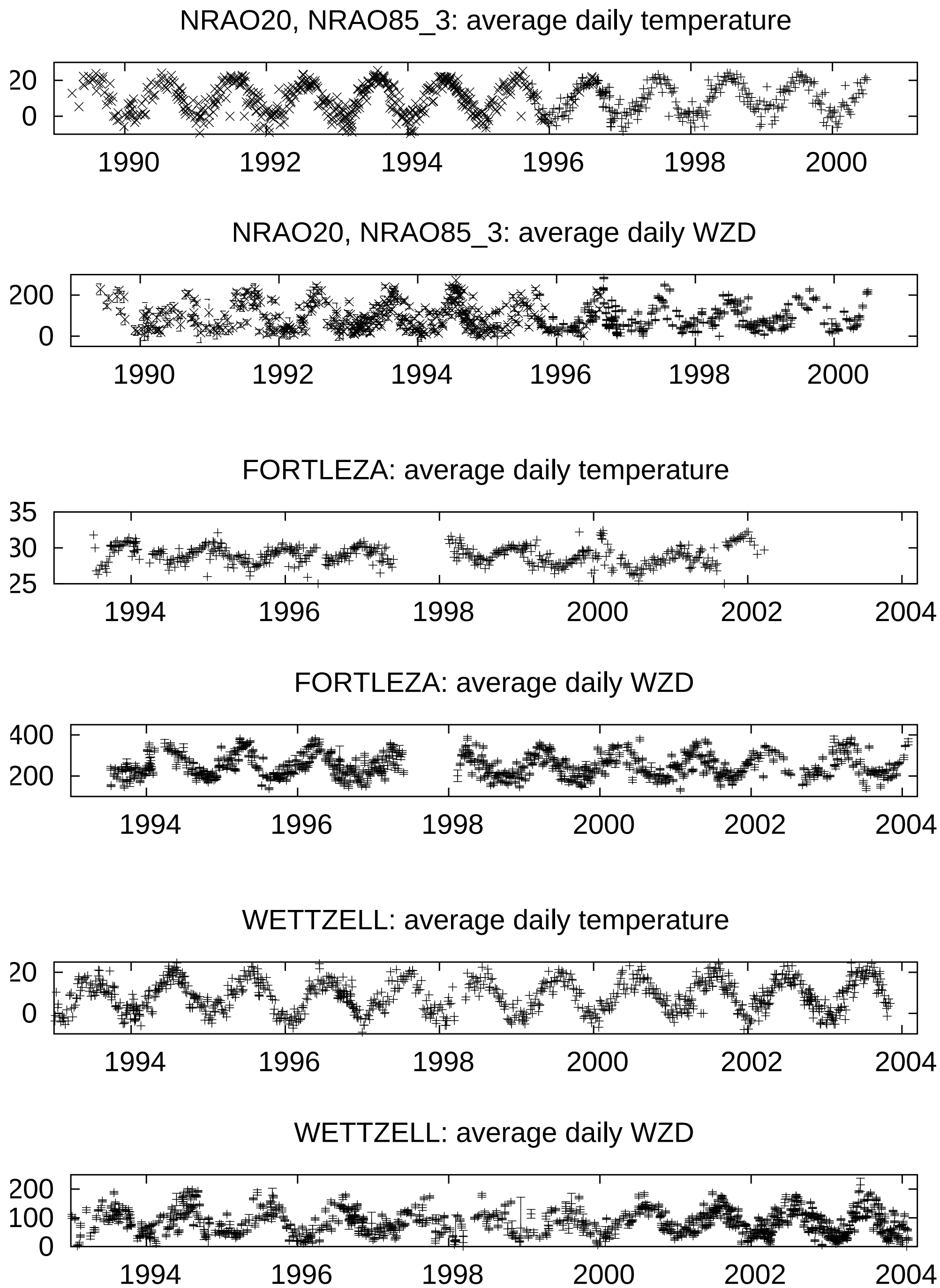

Figure 1. WZD and daily average temperature.

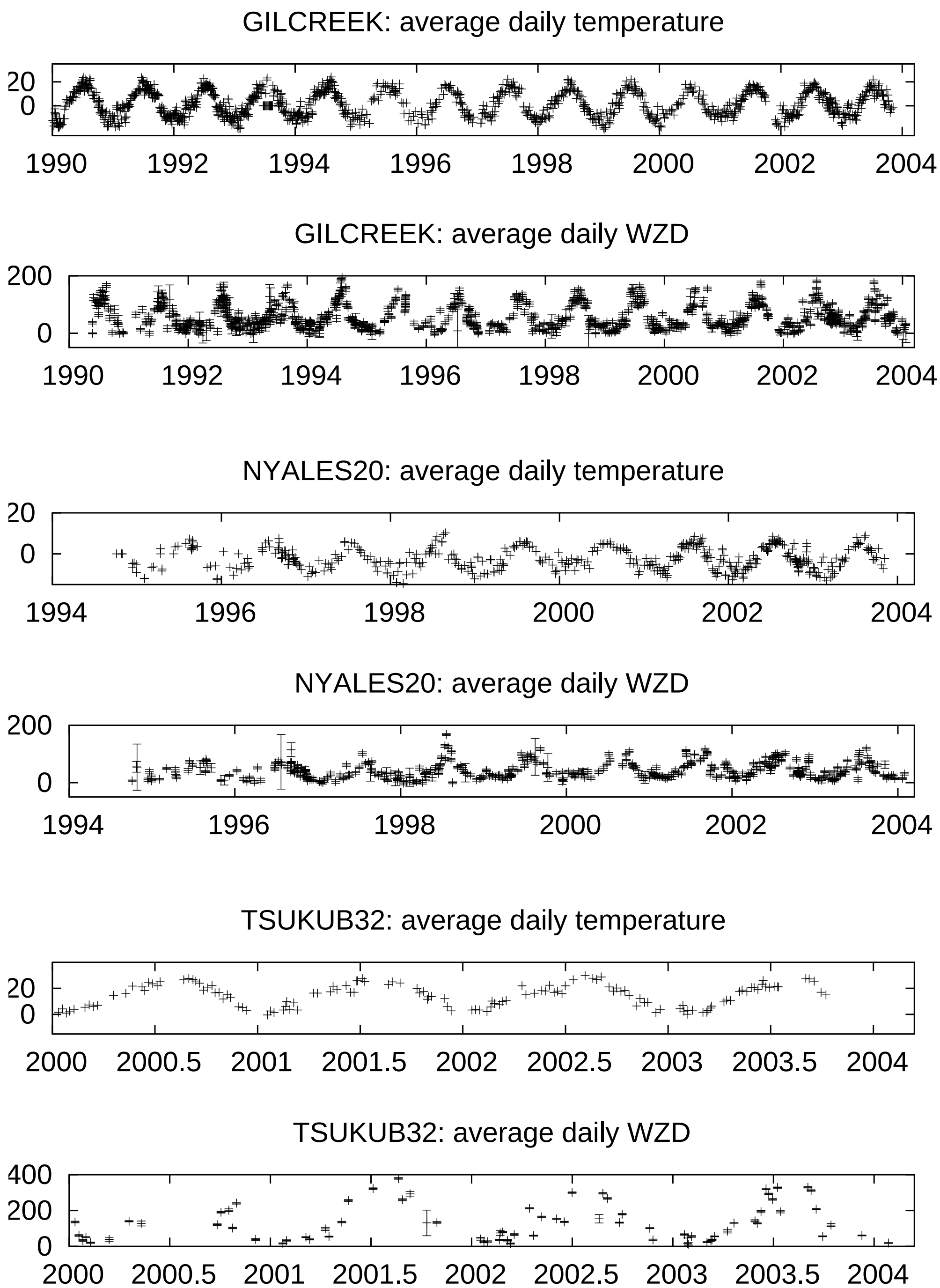

Figure 2. WZD and daily average temperature.