IVS Memorandum 2008-011v01

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"Sensitivity of VLBI2010 Simulations to Parameterization of Input Simulated Turbulence, Clock, and White Noise"

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Introduction

The purpose of this memo is to summarize results of simulations that were run to assess the sensitivity of results of VLBI analysis to variations of 1) turbulence model parameters, 2) clock model ASD, and 3) observation noise. The simulations all used the same V2C 16-station observing schedule. This was the uniform sky schedule with 60 second switching time between observations. B. Petrachenko determined that an az-el antenna with azimuth (elevation) slew rates of 4.8 deg/s (1.1 deg/s) could observe this schedule.

Solution setup

Parameterization: 6 min wet zenith, 60 min clock, 10 min gradients
Clock noise: 1×10^{-14} @ 50 min
Observation noise: 4 ps
Troposphere noise: GSFC generated turbulence

Turbulence model variation

Unless, a turbulence parameter was being varied, the turbulence parameter values were set to: Cn = 10^{-7} $m^{-1/3}$, h = 2 km, and wind velocity = 10 m/s towards the East.

Cn variation

We have run simulations varying Cn from 0.5 to 3.0 x 10^{-7} $m^{-1/3}$. Table 1 gives the resulting median 3D rms repeatabilities for each case. Figure 1 shows a more detailed breakdown of the 3D rms by station. There is some latitude dependence of the results although the same Cn was used for each site. The dependence must be due to variations in observing geometry at different sites.

Table 1. Cn variation (height = 2 km, v = 10 m/s)

Cn (10^{-7} $m^{-1/3}$)	0.5	1.0	2.0	3.0
Median 3D rms	0.8	1.2	2.2	3.2
Median U rms	0.7	1.1	2.0	2.9
Median E rms	0.2	0.3	0.5	0.8
Median N rms	0.2	0.3	0.6	0.9

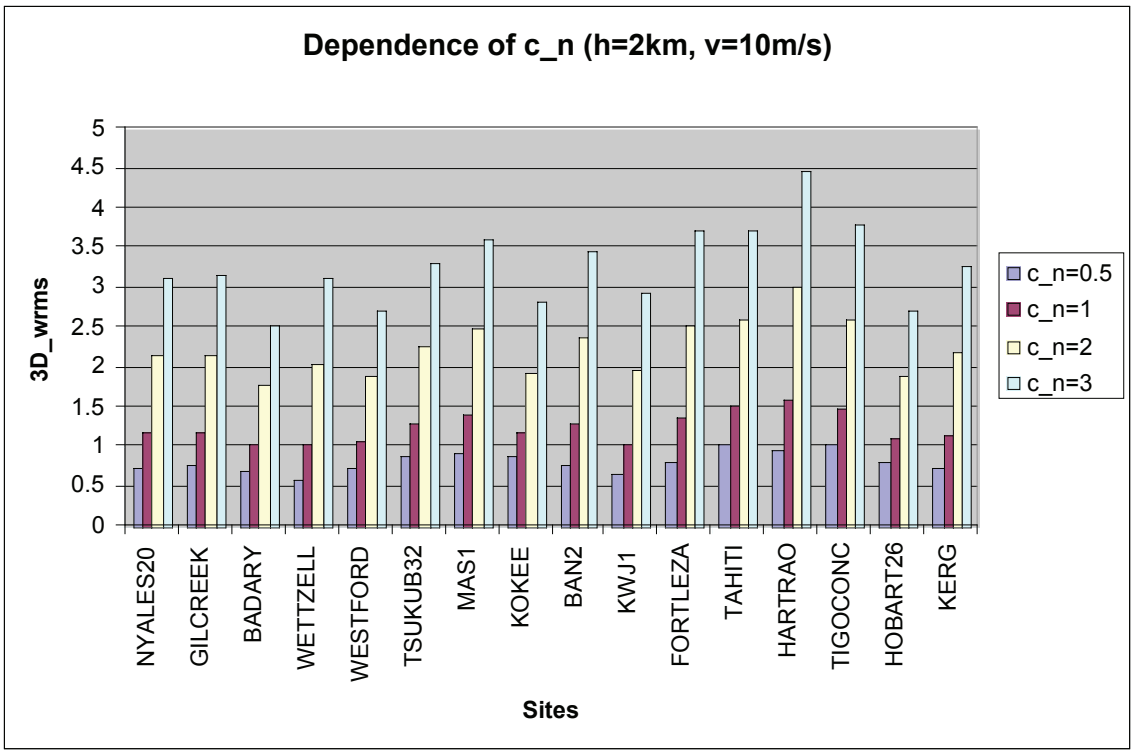

Figure 1. RMS of 3D site position for increasing values of Cn. The sites are ordered from North to South.

We ran the same solutions with different effective troposphere heights. The 3D median repeatabilities are plotted in Figure 2 as a function of Cn for different height.

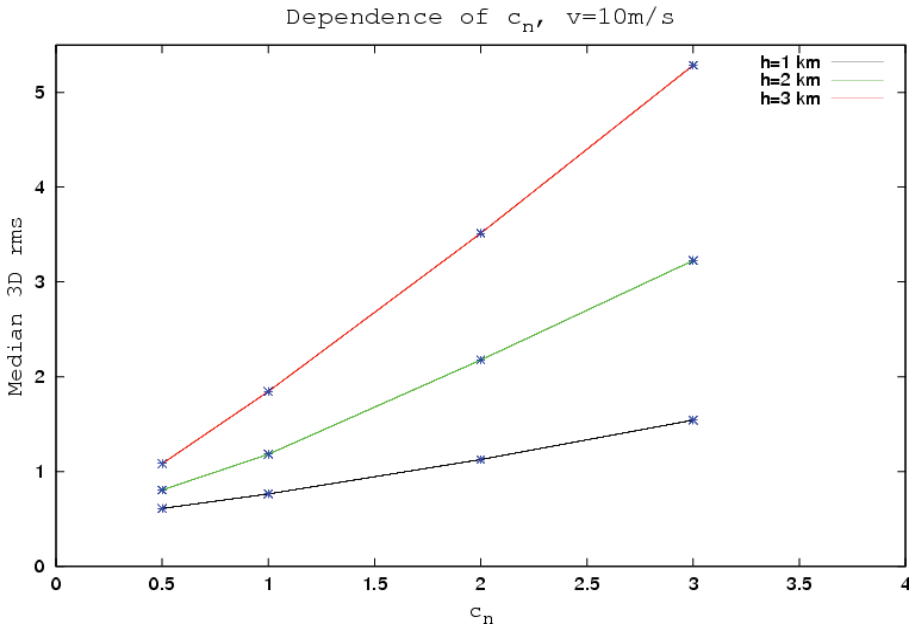

Figure 2. Median 3D position repeatability for different choices of troposphere height.

Effective wet troposphere height variation

When we varied the effective height, while fixing Cn and the windspeed, we obtained the median repeatabilities given in Table 2. Figure 3 shows the median 3D rms for each site. The latitude variation is similar to that in Figure 1 implying that it is due to site observing geometry.

Table 2. Effective height variation (Cn = 1, v = 10 m/s)

h (km)	1	2	3
Median 3D rms	0.8	1.2	1.8
Median U rms	0.7	1.1	1.7
Median E rms	0.2	0.3	0.4
Median N rms	0.2	0.3	0.5

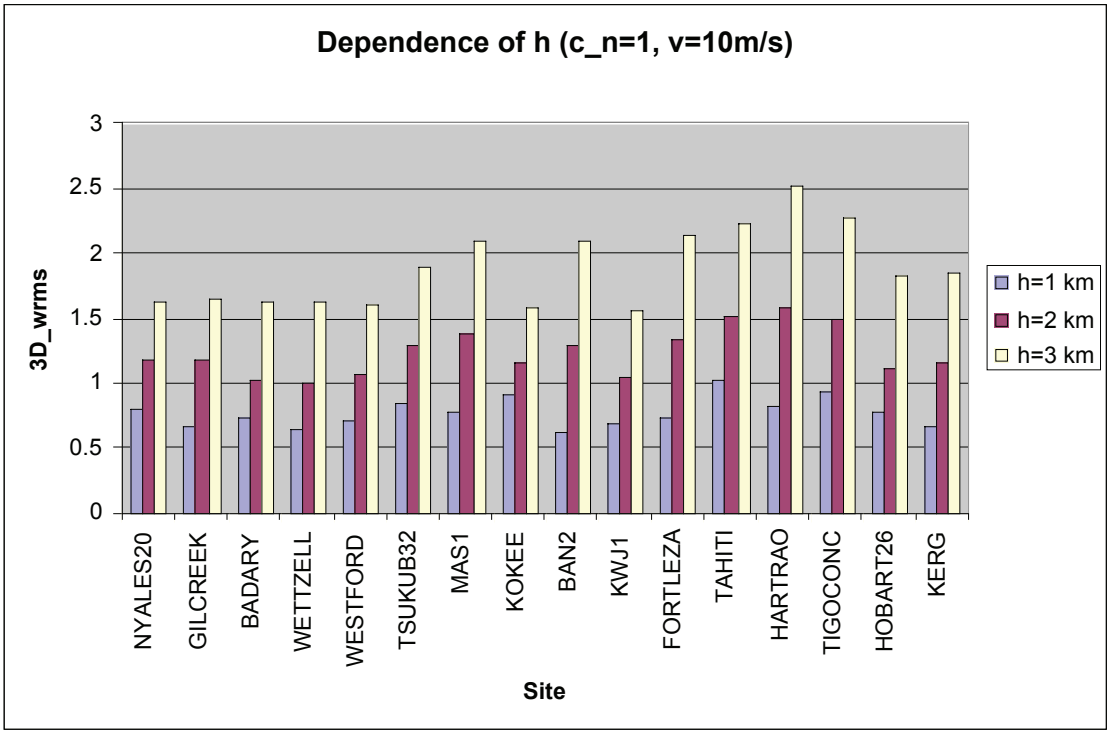

Figure 3. RMS of 3D site position for increasing values of effective troposphere height The sites are ordered from North to South.

Figure 4 shows that the dependence of the 3D rms repeatability is nearly linear in troposphere height h in

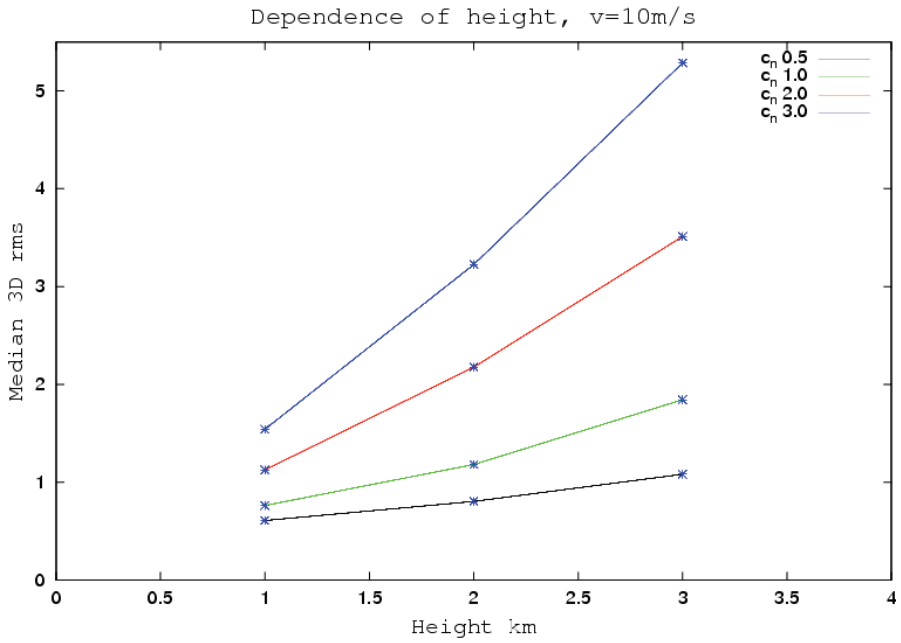

Figure 4. Median 3D position repeatability for different choices of Cn.

Windspeed variation

Windspeed was varied from 5 m/s to 20 m/s (direction was towards the East with the resulting median site repeatabilities in Table 3.

Table 3. Windspeed variation (Cn = $1x10^{-7}$ $m^{-1/3}$, h = 2 km)

h (m/s)	5	10	20
Median 3D rms	1.2	1.2	1.3
Median U rms	1.1	1.1	1.1
Median E rms	0.3	0.3	0.3
Median N rms	0.3	0.3	0.4

There is little dependence of the results on windspeeds in this range. Figure 5 shows the detailed site breakdown.

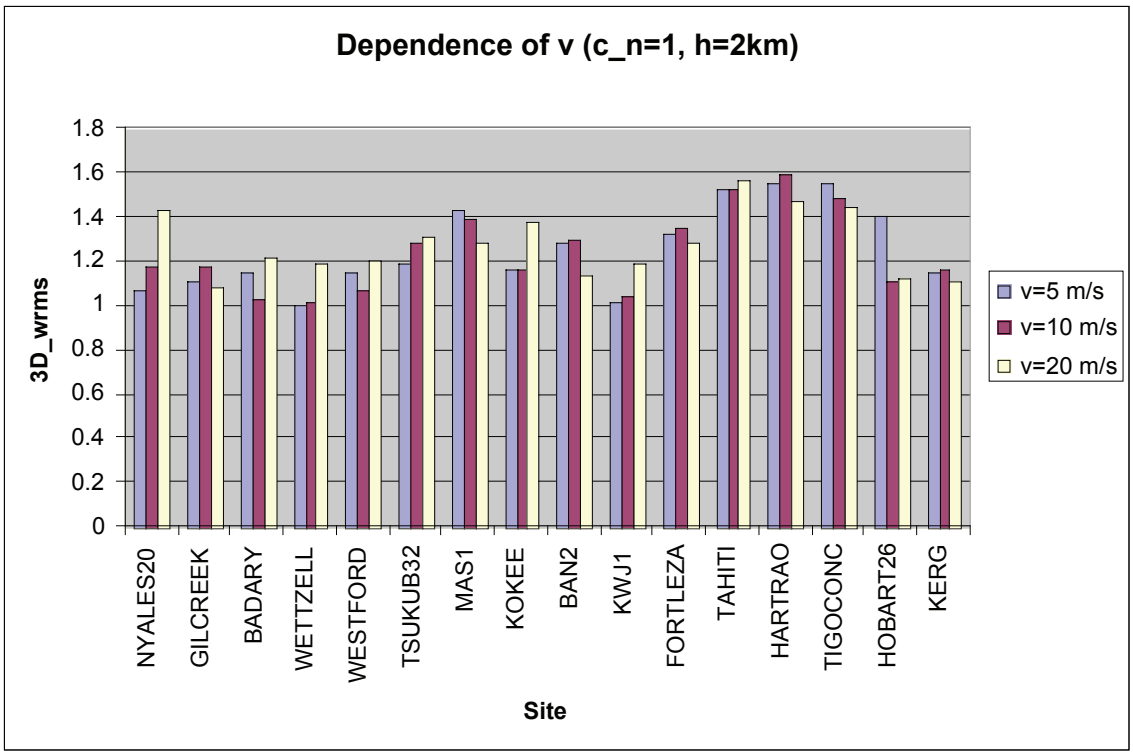

Figure 5. Dependence of 3D wrms on wind speed

Figure 6 shows that as Cn increases, there is a small increase in the sensitivity of the 3D rms to windspeed.

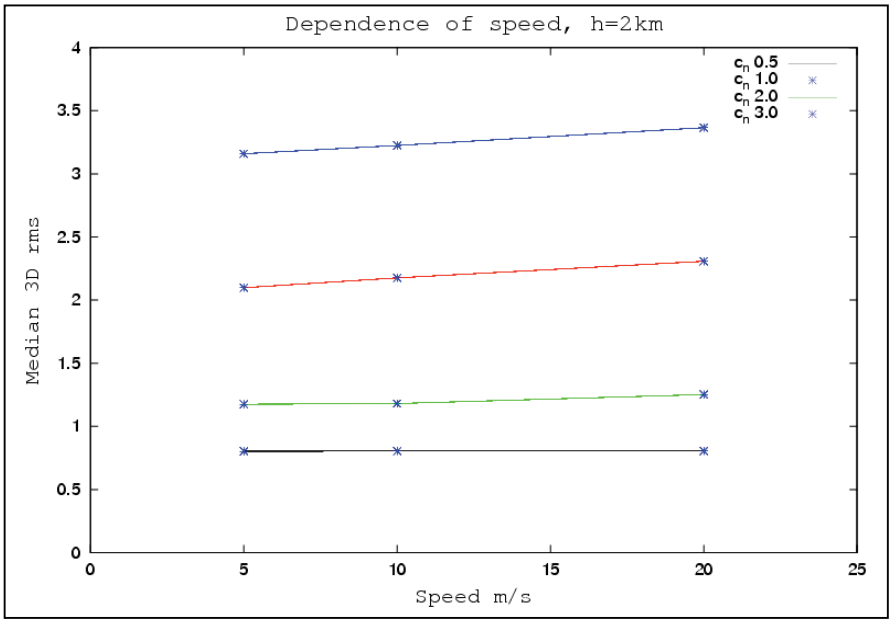

Figure 6. Dependence of 3D rms repeatability on windspeed.

Clock noise variation

Clock noise ASD was varied from 1x10-15 to 5x10-14 @ 50 min. For these runs turbulence noise was generated using site dependent turbulence parameters provided by T. Nilsson and R. Haas and observation noise was fixed at 4 ps. The median rms station position for this series of run are shown in Table 5.

ASD ($x10^{-14}$ @ 50 min)	0.1	0.2	1.0	2.0	5.0
Median U rms	1.3	1.3	1.4	1.6	2.5
Median E rms	0.4	0.4	0.4	0.5	0.7
Median N rms	0.4	0.4	0.4	0.4	0.7
Median 3D rms	1.4	1.4	1.6	1.7	2.7

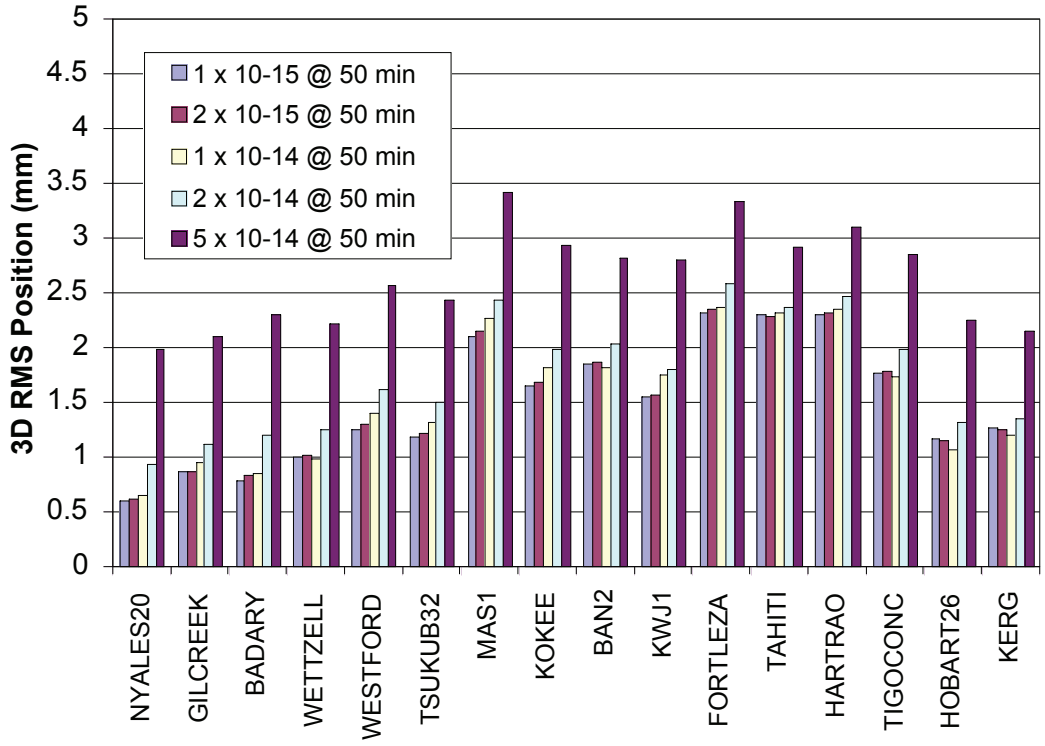

Figure 7. 3D rms position (mm) as function of increasing clock noise.

There is little sensitivity of 3D rms repeatabilities for clock noise with ASD less than $2x10^{-14}$ @ 50. Figure summarizes this dependence for the 3D median position rms.

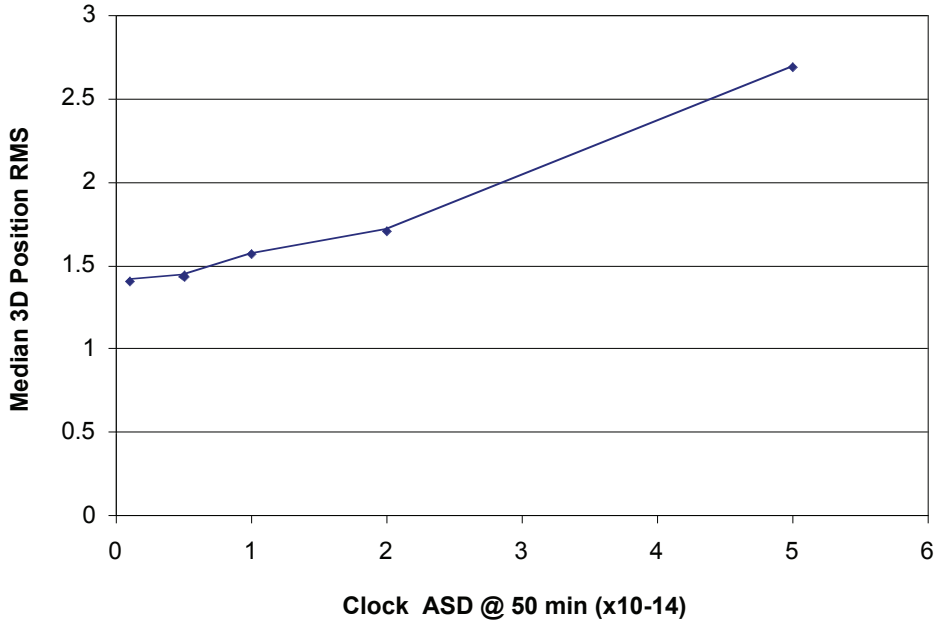

Figure 8. Median 3D rms position dependence on clock ASD

Observation noise variation

The last parameter variation that we consider is the dependence of repeatabilities on input simulated observation noise. As with the clock variation simulation, the turbulence was generated with the parameters given by T. Nilsson and R. Haas. The clock ASD was fixed at $1x10^{-14}$ @ 50 minutes.

Obs noise (ps)	4	8	12	16	24	32
Median U rms	1.4	1.4	1.4	1.5	1.6	1.8
Median E rms	0.4	0.5	0.5	0.5	0.5	0.6
Median N rms	0.4	0.4	0.4	0.5	0.5	0.5
Median 3D rms	1.5	1.5	1.6	1.6	1.7	2.0

Figure 9 shows the variation of 3D rms for each site as a function of observation noise. Figure 10 summarizes the dependence in terms of the median 3D rms site position.

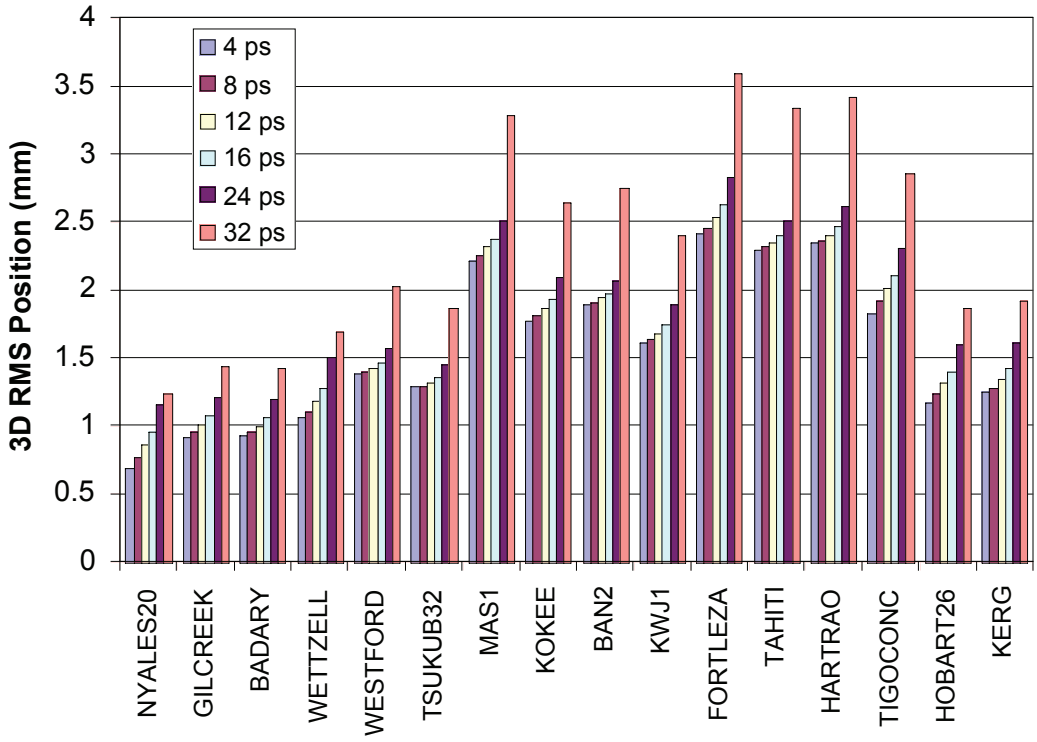

Figure 9. 3D rms position uncertainty as function of increasing observation noise.

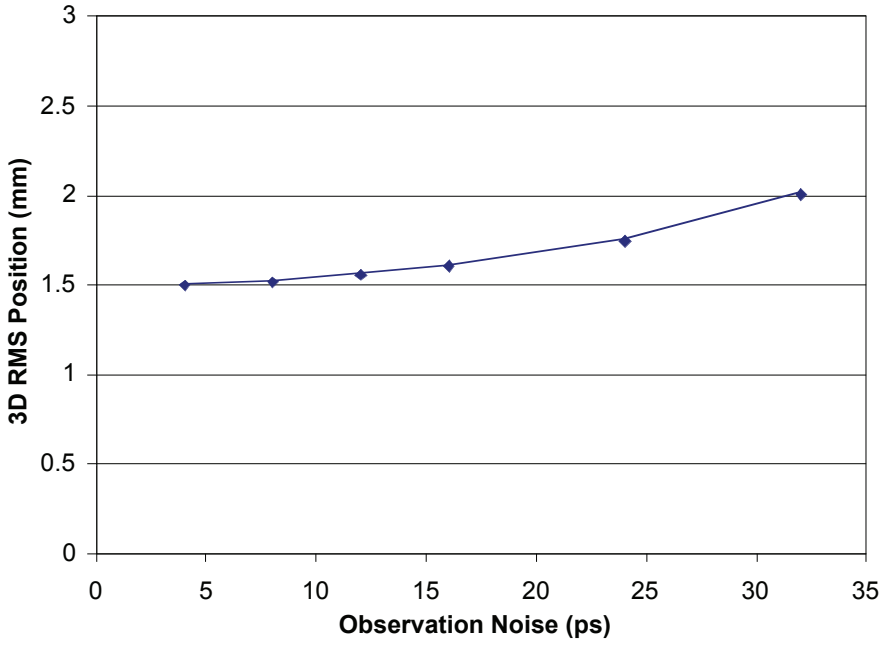

Figure 10. Median 3D rms position error