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"Comparisons of Observed and Simulated CONT05 Repeatabilities for Different Turbulence Cn Models"

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Introduction

We have performed simulations of the CONT05 series of experiments in order to give some confidence in our simulation modeling for for VLBI2010. The tropospheric delay component of the modeling was computed using a turbulence model based on the paper by Treuhaft and Lanyi (1987). The parameters of the model are Cn (refractive index structure constant), h (effective wet troposphere height), and v (wind velocity over the site). Tobias Nilsson at Onsala Space Observatory provided the turbulence parameter values that we have used to generated the turbulent delay time series for each site to be simulated. These were computed from high resolution radiosonde data. Nilsson also gave an algorithm for generating the series from an observing schedule (Nilsson et al., 2007).

The simulations described here used a) the original Onsala turbulence parameter values determined from March data and b) more recent turbulence parameters generated with radiosonde data from the time period of CONT05. Except for Hartrao and Tigoconc, these parameters were determined from data taken at nearby (or at least at about the same latitude) high-resolution radiosonde sites during the CONT05 period. Miami (FL) data from 2005 was used for HartRAO and Greensboro (NC) data from 2005 for Tigoconc. Even if the radiosonde was reasonably close to the VLBI site, it is not clear how closely data actually matches the local tropospheres at the CONT05 sites. Table 1 gives the turbulence values that were used in the simulations.

Based on a suggestion by G. Lanyi, we also ran a simulation in which Cn for each CONT05 session was scaled to the average session wet zenith delay at each site: $<\tau_{wz}(mm)>$ /Cn ($10^{-7}m^{-1/3}$) = 5.5 /1.2. These values were based on analysis of VLBI data at DSS15, where the effective troposphere height was assumed to be 2 km and the wind speed was 8 m/s. The ratio was similar for other DSN sites (DSS45 and DSS63).

Solution Setup

The solutions were run with a standard parametrization used for real data analysis. The model used for the input simulated clock, troposphere, and observation noise of an observation on a baseline between station 1 and station 2:

$$O - C = [m_{wet}(elev_2)\tau_{wz2} + clk_2] - [m_{wet}(elev_1)\tau_{wz1} + clk_1] + \sigma_{obs}$$

Simulation solutions used the observation uncertainties and observation epochs from the observed databases and the following specifications:

Parametrization:	20 min wet zenith, 60 min clock, 8 hour gradients
Data weighting:	elevation dependent weighting of 10 ps scaled by the wet mapping function
Clock noise:	ASD of $1x10^{-14}$ @ 50 min, random walk + integrated random walk
Observation noise:	observation uncertainties of the real data
Troposphere noise:	turbulence generated at GSFC using either the old or new Onsala Cn values or Cn scaled to wet zenith delay

Results

Turbulence series for each site were generated at GSFC using the Onsala old and new turbulence parameters, Cn and h, given in Table 1. Figure 1 compares the observed and simulated CONT05 baseline length repeatabilities. For all baselines, the simulation using the older turbulence parameters generally underestimated the observed repeatabilities; whereas, the newer values overestimated.

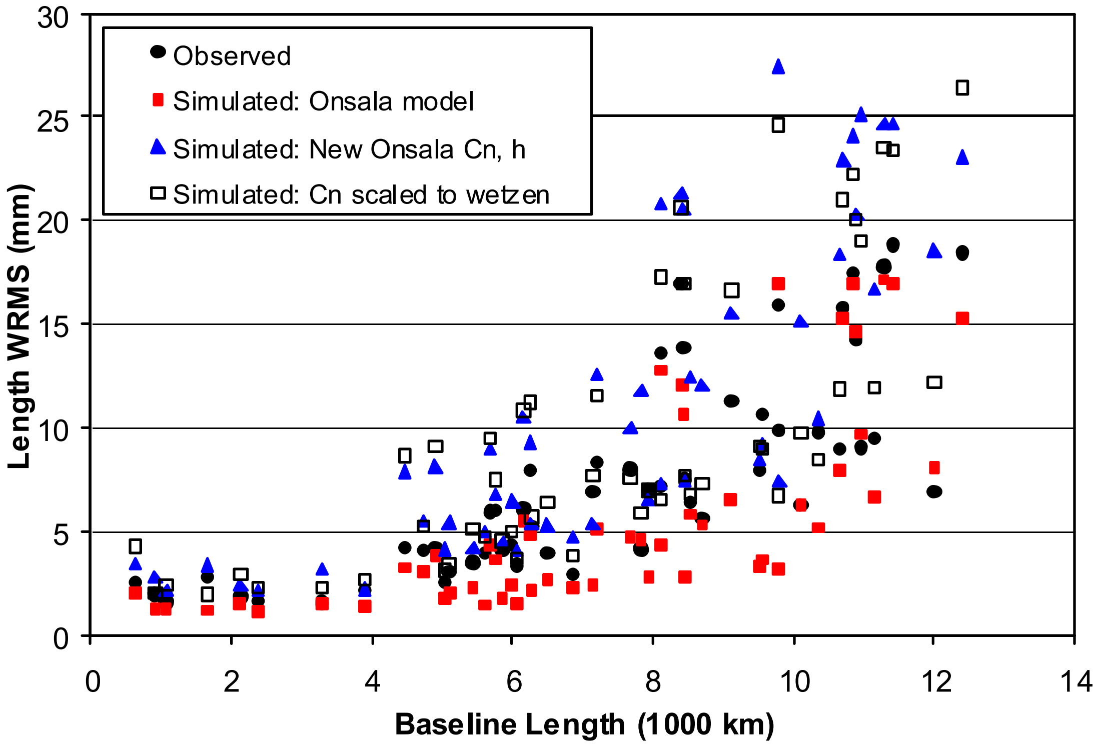

Figure 1. Comparison of observed CONT05 (solid black circles) and simulated length repeatabilities: original Onsala model (solid red squares), new Onsala model (blue triangles), Cn scaled to average session wet zenith delay (open squares).

In Figure 2, we show the ratio of simulated to observed repeatabilities. Observed repeatabilities are underestimated by an average factor of 0.74 with the older Cn values. Using the newer Onsala Cn values or the Cn values scaled to wet zenith delay overestimate by factors of 1.47 and 1.31 respectively. The ALGOPARK baselines account for the largest overestimates. Looking at the difference between observed and simulated repeatabilities, we can see in Figure 3, that the differences increase with baseline length since length repeatabilities are roughly proportional to the product of length and station scatter.

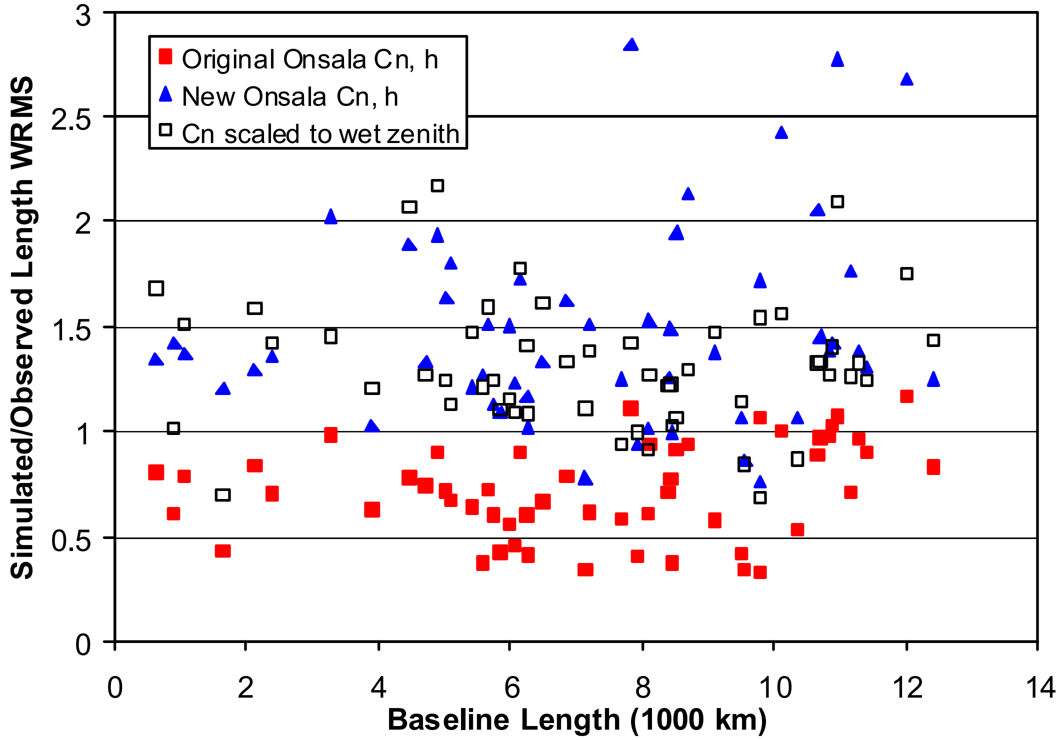

Figure 2. Ratio of simulated to observed repeatabilities. The average ratios are: a) Original Onsala (Cn,h): 0.72, b) New Onsala (Cn,h): 1.47, c) Cn scaled to wet zenith delay: 1.31.

In Figure 2, we show the ratio of simulated to observed repeatabilities. Observed repeatabilities are underestimated by an average factor of 0.74 with the older Cn values. Using the newer Cn values or the Cn values scaled to wet zenith delay overestimate by factors of 1.47 and 1.42 respectively. The ALGOPARK baselines account for the largest overestimates. Looking at the difference between observed and simulated repeatabilities, we can see in Figure 3, that the differences increase with baseline length since length repeatabilities are roughly proportional to the product of length and station scatter.

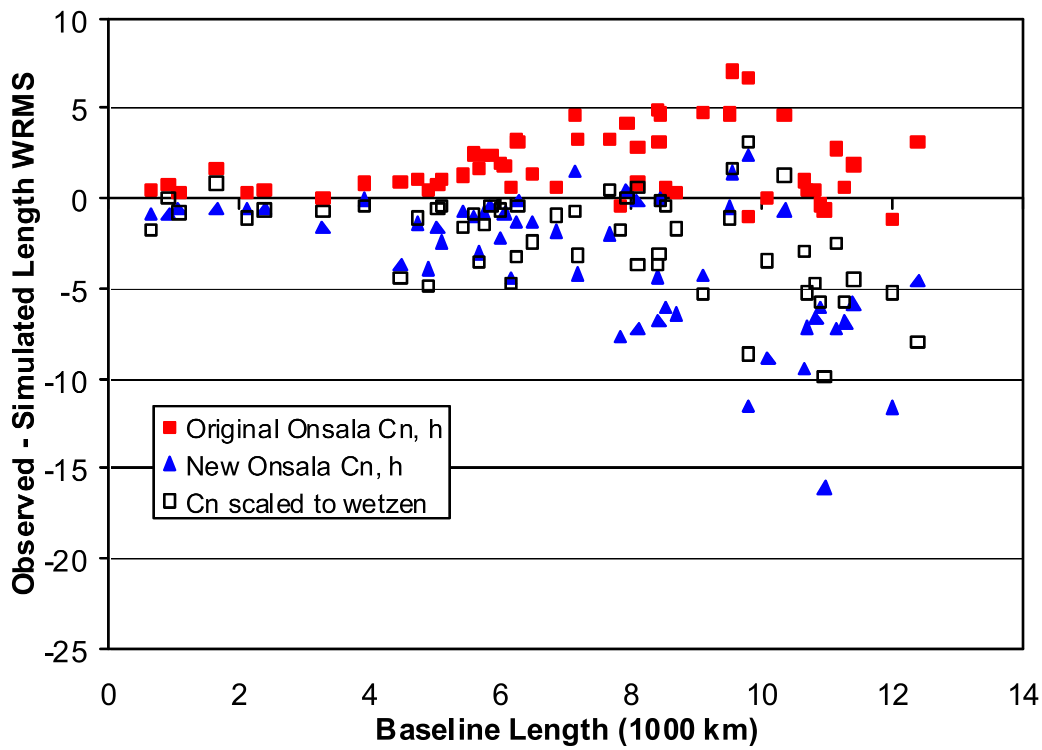

Figure 3. Difference (Observed – Simulated) baseline length repeatabilities.

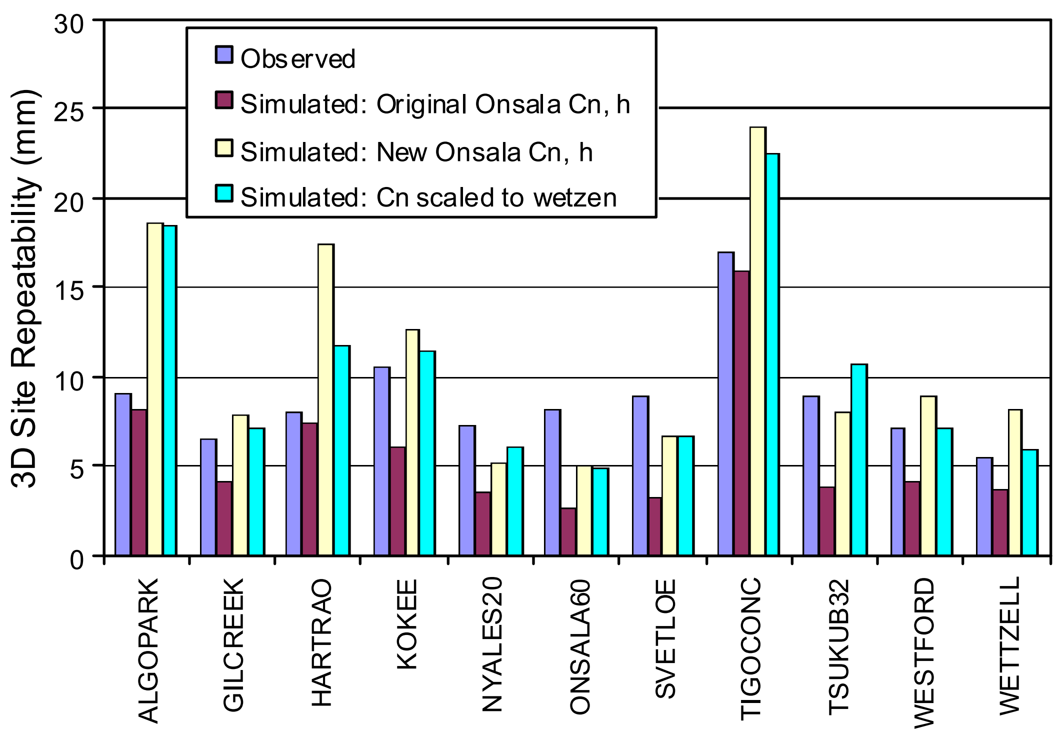

Figure 4. Comparison of 3D site repeatabilities from observations versus simulation.

Figure 4 shows the 3D WRMS repeatabilities for each site, where it can be seen that the newer Cn and scaled Cn repeatabilities are significantly greater than observed repeatabilities for ALGOPARK (followed by HARTRAO and TIGOCONC). However, with these Cn values the repeatabilities for the remaining sites are closer to observed than with the original Cn's.

Table 1. Turbulence parameters used in simulations

Site	Cn Old	H Old	Cn New	H New	Vn North	Ve East	
ALGOPARK	1.04	2000	2.0573	2573.8	-2.32	9.91	Buffalo
GILCREEK	0.55	1963	0.8323	3841.4	-2.72	-12.24	Fairbanks
HARTRAO	2.03	1851	1.8897	3053.7	7.6	-5.56	Miami*
KOKEE	2.30	1779	4.0287	2104.7	7.95	8.71	Lihue
NYALES20	0.35	1845	0.0596	4363.8	3.02	1.97	Point Barrow
ONSALA60	0.72	2100	1.5438	2929.5	2.57	12.49	Lerwick
SVETLOE	0.64	1705	1.3840	2631.5	11.12	-1.3	Anchorage
TIGOCONC	1.41	2176	0.9198	3540.9	8.93	-2.94	Greensboro*
TSUKUB32	1.45	1912	3.7136	2054.9	10.6	-0.3	Nashville
WESTFORD	1.17	2269	3.4378	2288.8	6.01	-10.45	Chatham
WETTZELL	0.94	1856	4.4662	2238.9	7.25	-7.47	Hersmonceux

Cn [10^{-7} $m^{-1/3}$], H [m], V[m/s]

* from March 2005

References

Nilsson, T., R. Haas, and G. Elgered. Simulations of atmospheric path delays using turbulence models, Proc. 18th European VLBI for Geodesy and Astrometry Working Meeting, 12-13, April 2007, edited by J. Boehm, A. Pany, and H. Schuh, 175-180, 2007.

Treuhaft, R. E. and G. E. Lanyi, The effect of the dynamic wet troposphere on radio interferometric measurements, Radio Science, 22, 251-265, 1987.