VGOS MEMO #048

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To: IVS VGOS Technology and Operations Groups
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Subject: Evaluation of a prototype broadband radome as installed on Westford

Introduction

This note presents an evaluation of the effects of a prototype radome when mounted on the Westford broadband dewar. It is anticipated that this type of radome will be used on future NASA VGOS antennas and retrofitted on the Kokee12m and GGAO12m antennas.

The radome could affect the VGOS broadband measurements in two ways: a) through reduction in sensitivity due to absorption or emission by the radome and b) through change in delay. The former would reduce the system sensitivity by increasing the system temperature, thereby increasing the delay error. The latter is unlikely to be of consequence since any effect is expected to result in a constant delay change which will be absorbed by non-geodetic parameters, such as a constant clock value.

Conclusion: the radome does not have a measurable effect on the delay performance of the antenna at the level of a few picoseconds. It is therefore suitable for use on the VGOS broadband geodetic antennas.

Geodetic analysis

The radome was installed at the beginning of the 24-hour session vt7331 (17NOV27) and removed after 18.5 hours. Six stations participated in this session: Westford, GGAO12m, Kokee12m, Yebes13m, Wettzell-S, and Ishioka.

The effect of the radome on the delay was evaluated by geodetic analysis of different segments of the session to look for a possible difference in the WRMS post-fit delay residual (pfdr) while the radome was installed compared to when it was off, and for any difference in the estimated baseline length on the Westford-GGAO baseline. The comparisons were made for the baseline to GGAO since it has the smallest delay scatter and length uncertainty of the five baselines to Westford. The parameters estimated were the baseline length and piecewise linear (PWL) segments for the clock at GGAO (Westford was held constant as the reference), and, at both stations, the zenith wet delays, and east and north gradients of the atmosphere delay. The lengths of the PWL segments for the clock, ZWDs, and gradients were 20 minutes, 15 minutes, and 1 hour, respectively.

For these geodetic solutions the delay uncertainties used were those calculated by *fourfit*, which take into account only the signal-to-noise ratio (SNR) and the correlation with the estimation of the phase dispersion term (the 'ionosphere' dTEC). No re-weighting to bring chi-square per degree of freedom to a value near one was done.

Geodetic analyses were made for a) the full session, b) the full time the radome was on, and c) each of four segments of approximately six-hours each. The first three segments are with the radome on, and the last segment is after the radome was removed. The segment lengths were chosen to approximate the length of the radome-off segment, but the exact boundaries were chosen for analysis convenience.

The post-fit delay residuals for all data are shown in Figure 1.The dashed lines delineate the four segments analyzed.

The results are summarized in the following table.

Description	Number of obs	WRMS post-fit delay residual (ps)	Baseline length minus-600796000.00 (mm)	Length uncertainty* (mm)
All data	1014	7.7	32.65	0.47
Radome on: all	773	8.0	33.05	0.54
Radome on 18-00	248	12.6	33.60	0.95
Radome on 00-06	244	7.6	33.84	0.96
Radome on 06-12:30	279	4.5	32.26	0.90
Radome off 12:40-18	239	6.3	31.61	0.97

* Length uncertainties for the six hour segments were calculated as the square root of the (ratio of the number of observations for all data to the number of observations for the segment) times the uncertainty for all data. This was done because nuSolve did not properly reduce the number of observations when less than the full set of data was analyzed.

a) Post-fit delay scatter

From the figure and table it is seen that, although the WRMS pfdr is larger for the first two 'radome-on' segments than for the 'radome-off' segment, the WRMS pfdr for the '06-12:30 radome-on' segment is much less than the 'radome-off' segment. In fact the WRMS for chi-square per degree of freedom equal to 1 is 4.47ps, so there is no unexplained additional delay noise from the radome greater than approximately 1 ps.

b) Baseline length

The baseline length for the combined radome-on segments (Radome on: all) and the radome-off segment differ by 1.64 mm. The quadratic sum of the length uncertainties is 1.11 mm. The difference is less than 1.5 times the combined sigma and is thus insignificant. This is probably an upper limit since the geodetic solutions have not been re-weighted to obtain chi-square per degree of freedom of 1.0. One consequence of that procedure is that the uncertainties, in this case the length uncertainty, usually increase. Were this to be the case, the significance of any difference would decrease.

Sensitivity effects

Absorption by the radome would reduce the signal from the radio source, and emission would increase the system temperature. The result would be an increase in the Source Equivalent Flux Density (SEFD) and reduction of radiometric sensitivity. As a consequence the VLBI SNRs would be lower and the delays less precise.

Direct measurement of the change in SEFD would require making measurements of the SEFD on one source with and without the radome, switching as quickly as possible in order that the measurements not be affected by changes in SEFD due to other factors, such as changing elevation or weather conditions. While possible, it is probable that the uncertainties would be large enough (greater than 5%) that any limits on delay error would be larger than those set by the geodetic evaluation. Consequently, such measurements have been deferred.

Conclusion

The radome does not have a measurable effect on the delay performance of the antenna at the level of a few picoseconds. It is therefore suitable for use on the VGOS broadband geodetic antennas.

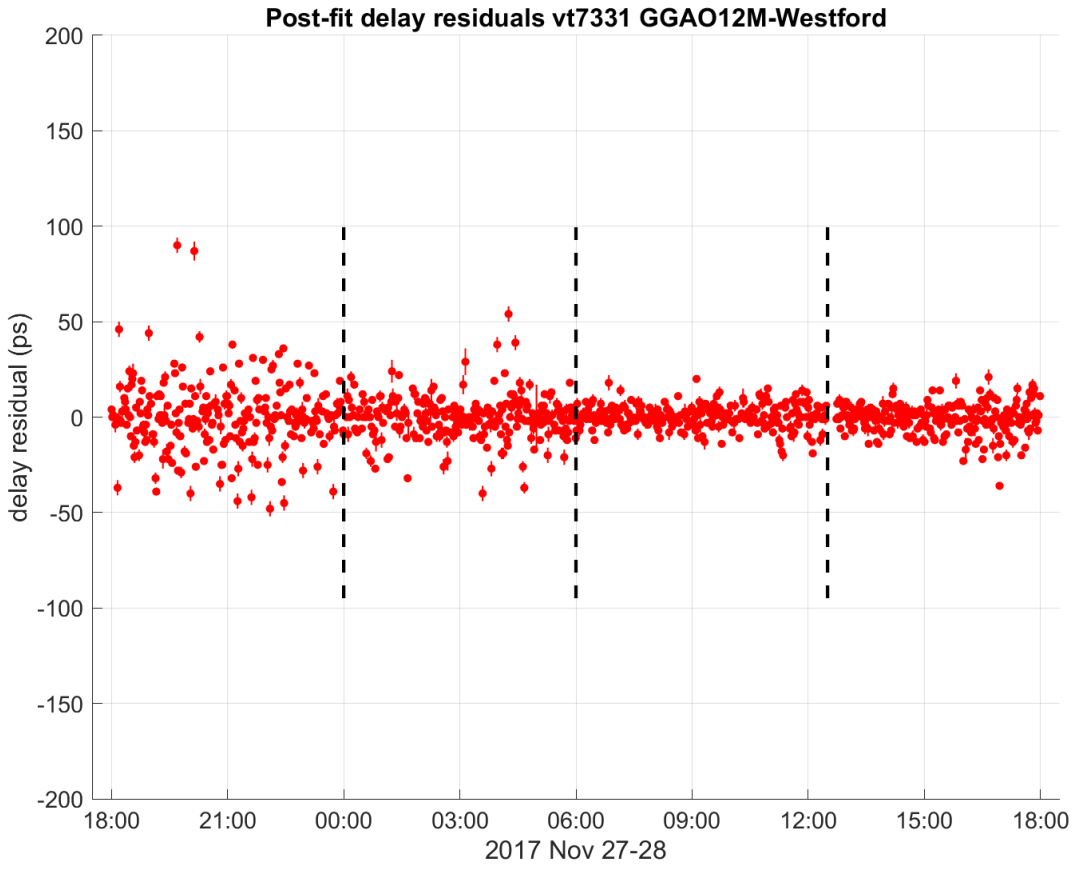

Figure 1. Post-fit delay residuals for vt7331 (17NOV27) GGAO12M-WESTFORD baseline. The dashed lines denote the separation into approximately six-hour segments. For the data from the start until just past 12:00, the radome was installed to cover the opening to the Westford dewar. The radome was removed at approximately 12:30UT on Nov 28.