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To: IVS VGOS Technology and Operations Groups
From: Arthur Niell and Brian Corey
Subject: VGOS Correlator Clock Model: Comparison of geodetic results for CONT17 data

Introduction

A new correlator clock model has been proposed by Corey and Himwich [Setting correlator clocks for VGOS CONT17 processing (DRAFT), 2018 July 27]. The difference in the clock models is whether the station instrumental delay is assigned to the sampler delays (original correlation) or to the correlator clock model (new correlation).

This note describes a comparison of geodetic processing of the CONT17 VGOS sessions in order to investigate the consistency of a) correlation using the original clock model and sampler_delays and b) correlation using the proposed model. Scan by scan comparisons were made for SNR, delays, and QC (quality codes) for session b17337 (17DEC03VG, the first day of CONT). nuSolve geodetic solutions were made for all sessions for both correlations using an identical setup. For these solutions the baseline lengths and WRMS post-fit delay residuals were compared.

Comparison of observables

Depending on baseline, SNRs with the proposed model are from 0% to 42% higher, on average, than for the original processing. This increase is to be expected when the difference between reference and remote station sampler delays is not small compared to the delay spanned by the number of lags (or FFT length) used in correlation. The mean increase of 42% is for baseline KOKEE12M_WETTZELL, which had the largest sampler delay difference, ~1200 ns, while the no-change case is GGGAO12M-RAEGYEB, which had no difference.

For b17337 the multiband delay (MBD) differences have an rms scatter of ~1 ps for scans with SNR>20, with some dependence on baseline. As expected, the scatter is a small fraction (10-20%) of the MBD uncertainty, and it decreases with increasing SNR. Biases under 1 ps are present in the MBD differences for some baselines. Sub-ps biases are to be expected due to shifting the instrumental delays from the sampler delays to the correlator clock model, but no quantitative comparison of observed and expected biases by baseline has been done. While this detailed evaluation was made only for the first session, it should be applicable to all sessions.

Fourfit QCs differ for 11% of the scans, with QC either increasing by 1 unit or decreasing by 1 or 2 units in the great majority of cases. These changes are caused primarily by the increased SNR, which leads either to lower fringe phase or amplitude scatter (hence higher QC) or to lower theoretical scatter (hence lower QC).

Comparison of geodetic analysis

nuSolve was run on the original and on the new-clock data for all five CONT17 VGOS sessions using nuSolve version 0.6.1 with the following choices:

Omit RAEGYEB.
Omit four sources: 0229+131, 2229+695, 3C371, 3C418.
Do not use proxy cablecal.
Use only Westford cable cal.
Do not re-weight.
Use piecewise-linear (PWL) model for clock/ZWD/gradients with PWL intervals of 20/15/60 minutes, respectively, which is the standard parameterization for VGOS.

Figure 1 shows the length differences in the sense 'new-clock minus original clock'.

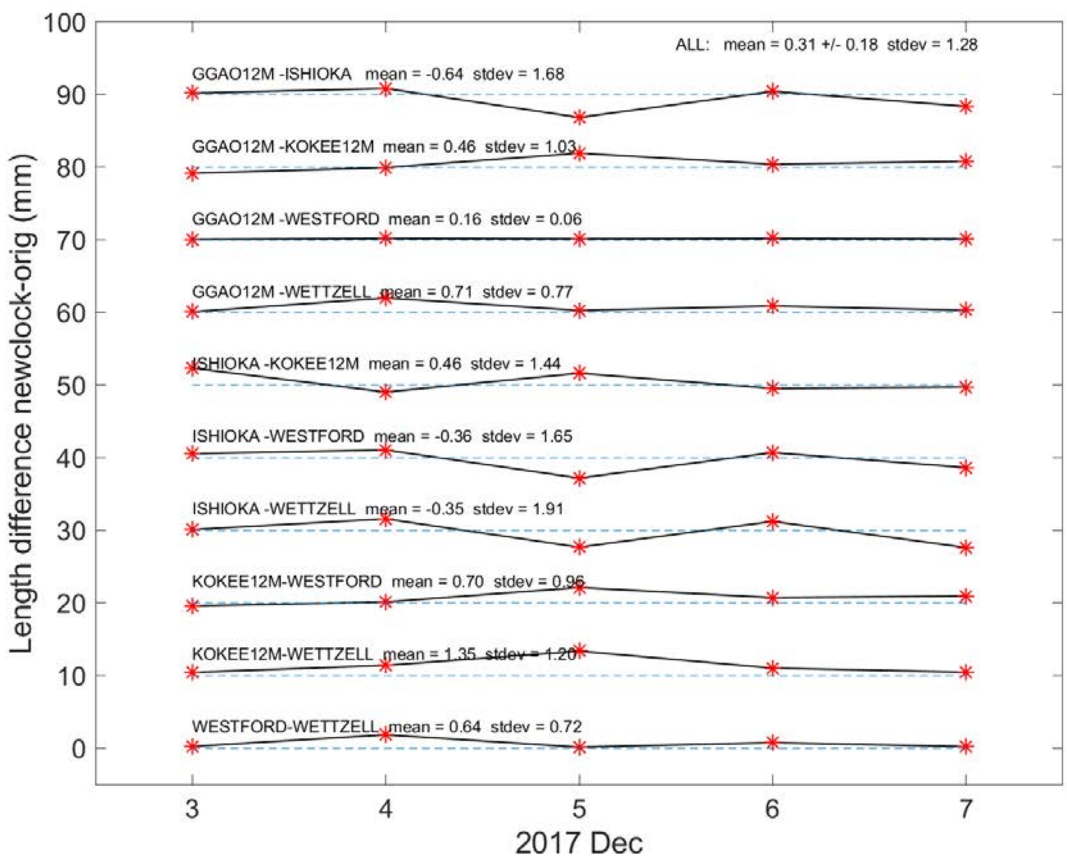

Figure 1. Length difference for each baseline and session.

Approximately 64% of the differences in lengths are less than 1 mm. The mean of the length differences is 0.31±0.18 mm with a standard deviation of 1.28 mm. A histogram of the differences is shown in the Figure 2.

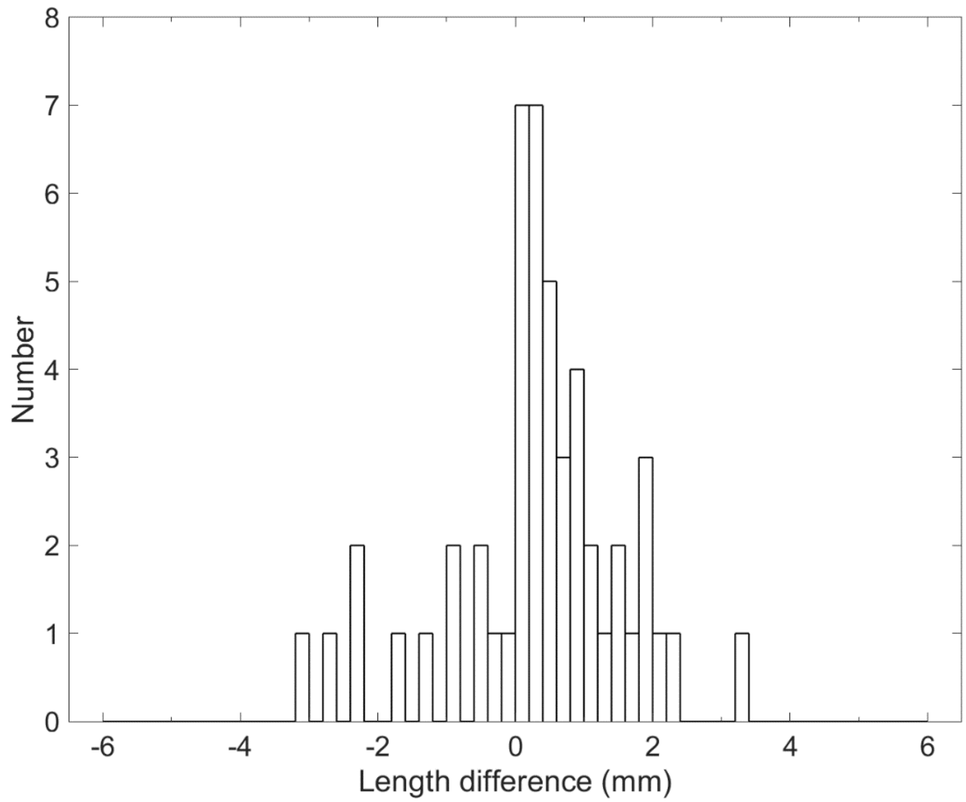

Figure 2. Histogram of the length differences (new-clock minus original) for all baselines and sessions.

What difference in lengths is expected between the original and new-clock correlations for each baseline and session? Generally, since the same data are being correlated, the length difference should be less than the length uncertainty for a single session. The following two lines give the standard deviations of the length differences (from Figure 1) and representative single-session length uncertainties for the same baselines (from the nuSolve solutions):

length difference std dev:	1.7	1.0	0.06	0.8	1.4	1.6	1.9	1.0	1.2	0.7
length uncertainty (mm):	4.6	4.6	0.3	1.6	5.7	4.6	4.9	4.8	8.2	1.6

The standard deviations are less than half of the uncertainty, thus satisfying the expectation.

The lengths for both correlations are shown in Figure 3. Though not obvious from the figure, there is a systematically larger length WRMS over the five sessions for the new-clock correlation compared to the original correlation. This is seen in WRMS as a fraction of the baseline length in parts per billion (ppb), given in top-to-bottom order as shown in the figure. Only for KOKEE12M-WETTZELL is the WRMS smaller for the new-clock model.

WRMS length residual/mean length (ppb): original correlation
1.14 1.66 1.39 0.56 2.66 1.05 2.01 1.48 1.87 0.78

WRMS length residual/mean length (ppb): new-clock correlation
1.22 1.73 1.46 0.63 2.82 1.12 2.09 1.57 1.82 0.83

There is no obvious explanation for such a systematic increase in scatter.

The WRMS of the post-fit delay residuals over all baselines for the new-clock was less than or equal to the original processing, ranging from 7.6 ps to 11.2 ps.

dUT1 cannot be compared in this approach because of the high correlation between dUT1 and baseline orientation. One possible way would be to fix the station positions at the values found from one solution and estimate dUT1 for the two session, but this has not been done.

Conclusions

1. No unexpected differences between the original and new-clock correlations are seen in the assessment of the individual scan parameters, such as SNR, delay, or quality code. The SNRs are higher for the new-clock model for some baselines because of the smaller residual single-band delays.
2. The new-clock and original_clock correlations agree satisfactorily if judged by baseline length difference for the individual baseline and session. The standard deviation of the length differences for each baseline is less than half the length uncertainty. Approximately 64% of the fifty length differences are less than 1 mm. The mean of the differences is 0.31±0.18 mm with a standard deviation of 1.28 mm.
3. The WRMSs of the baseline lengths over all five sessions is larger by ~0.1 ppb for the new-clock correlation for all but one baseline. This is unexpected but unexplained.

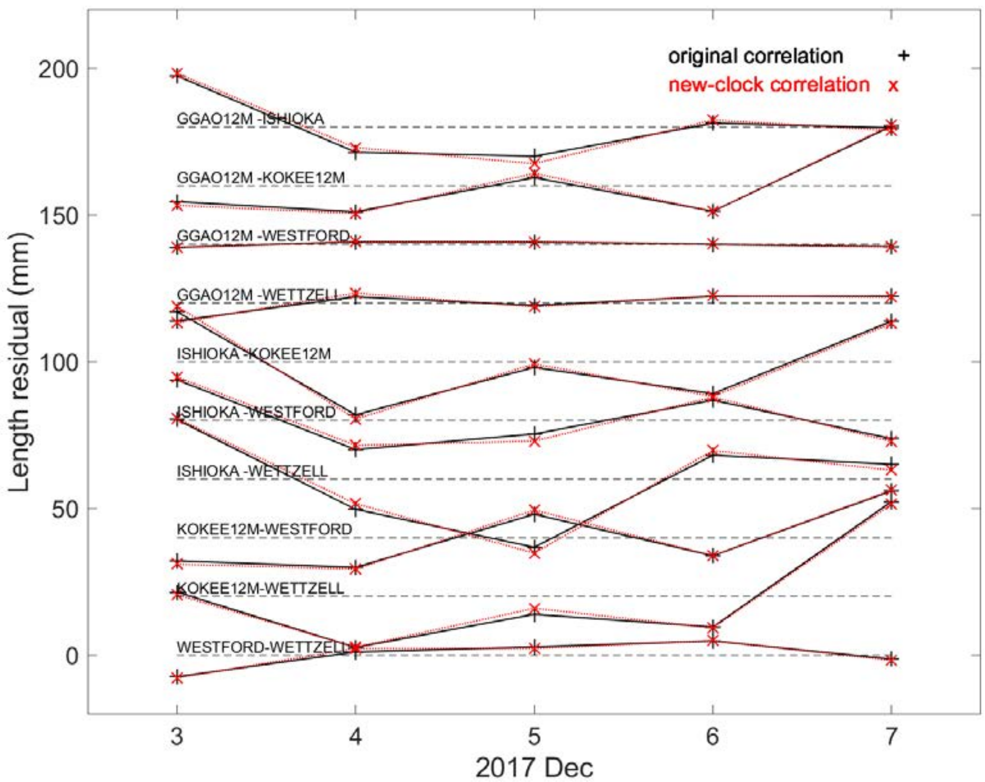

Figure 3. Lengths for each baseline and session for original and new-clock correlations.