The Effect of Source Flux Catalog Latency on IVS-INT01 Scheduling

Karen Baver, Dan MacMillan, and John Gipson

NVI, Inc.

Introduction

Source flux catalogs provide information about source strength based on observations of the sources in IVS 24-hour sessions, especially weekly R1s and R4s. Out-of-date fluxes lead to INT01 observations that are too short (and risk being lost) or are too long (and waste time that could be used for other observations). Some latency is currently unavoidable --- e.g., it takes at least two weeks to process the data from 24-hour sessions ("data latency"). But latency due to a delay in generating a catalog and/or using it for scheduling can currently be controlled. We ran simulations to study the effect of this form of latency on IVS-INT01 schedules, focusing on loss.

We created artificial source flux catalogs spaced a week apart using IVS 24-hour session data from mid-2015 through early 2017 and using the resulting raw fluxes. We used the catalogs to create 11 sets of 52 INT01-style schedules spaced a week apart within 2016. The schedules in each set were created with a flux catalog of a particular latency (1, 2, 3, 4, 5, 6, 8, 12, 16, 20, or 24 weeks). We then ran two tests on the schedules as described below. Because USNO currently alternates between scheduling INT01s with 88 sources (the MSS list) and 50 sources (the BA 50 list), we tested both source lists.

The out-of-date flux catalogs used for schedules made at cases for 52 days of the year and 11 flux catalog latencies

schedule dates in 2016	one week latency	two weeks	…	24 weeks
DOY 003	15dec24	15dec17	…	15jul16
DOY 010	15dec31	15dec24	…	15jul23
…	…	…	…	…
DOY 360	16dec15	16dec08	…	16jul07

Test 1: Effect of Catalog Latency on Scheduling Loss

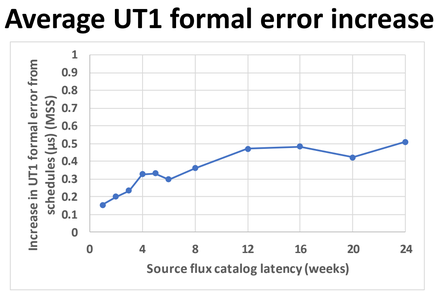
To evaluate data loss due to latency during scheduling, we used program *Sked* to evaluate the test schedules under the flux catalogs that should have been used if the flux catalogs had been updated weekly. We reselected fluxes under the up-to-date catalog, calculated SNRs, and discarded observations that failed to meet the minimum SNRs of 8 (X-band) and 10 (S-band) used in scheduling. We compared the remaining observations to the original schedules to find the source loss, observation loss, and increase in the UT1 formal errors predicted from the schedules.

The flux catalogs that should have been used in scheduling and that were used in test 1. The flux data is still two weeks out-of-date, but this is the best available flux data at this time.

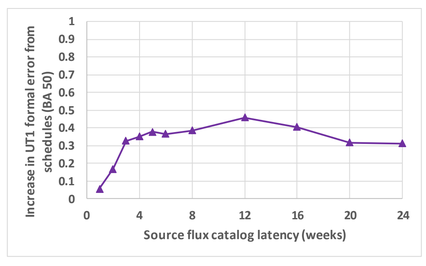
schedule dates in 2016	all latency cases
DOY 003	15dec31
DOY 010	16jan07
…	…
DOY 360	16dec22

Average UT1 formal error increase

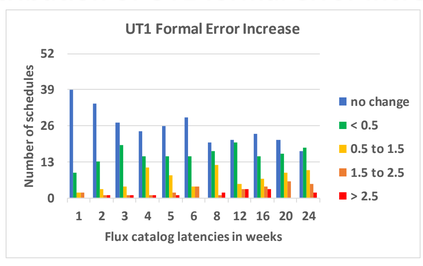
MSS

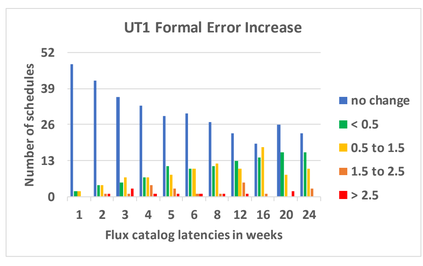


BA 50



Distribution of UT1 formal error increase



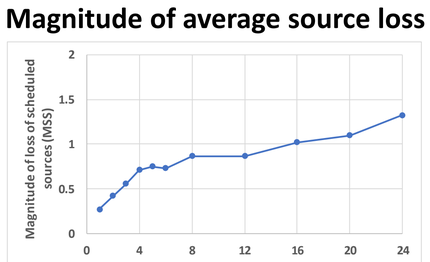


Flux catalog latency causes only a small increase in the average UT1 formal error predicted from the schedules (up to 0.5 µs). As latency increases, the increase in the average UT1 formal error generally gets larger, except for a possible and unexplained reversal of this trend in the BA 50 case at 20 and 24 weeks of catalog latency.

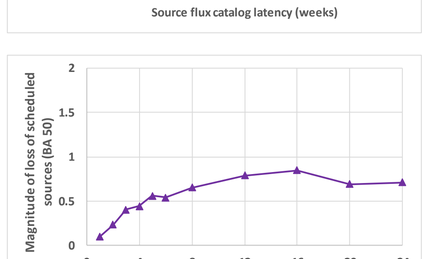
As flux catalog latency increases, the number of schedules with no change in the UT1 formal error (blue bars) generally decreases, and the number of schedules with a formal error increase gets larger. Some UT1 formal errors increased at higher latencies by over 3.5 µs, a fact that merits consideration, because each test schedule represents a week of INT01 observing.

Magnitude of average source loss

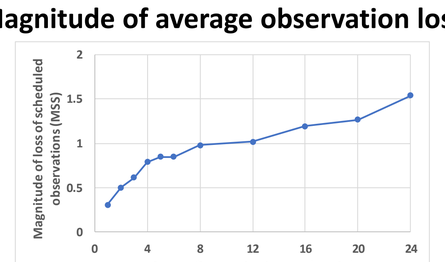
MSS

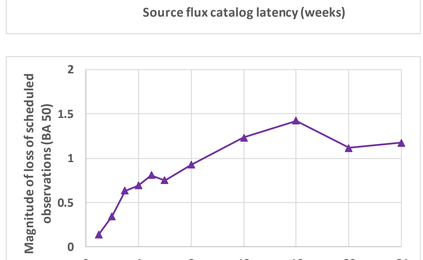


BA 50



Magnitude of average observation loss





Flux catalog latency causes average source and observation loss of up to 1.5 sources or observations. The size of the loss generally increases with increasing latency, but the BA 50 case again shows a potential reversal of this trend at 20 and 24 weeks of latency.

Test 2: Effect of Catalog Latency on Observing/Correlation Loss

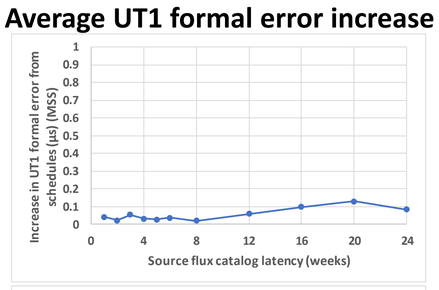
To evaluate the data loss due to latency expected from observing, we used *Sked* to evaluate the test schedules under the flux catalogs that contain the fluxes at the time of observing. (These are dated ~ two weeks after the session date due to data latency). We reselected fluxes under the "real-time" catalogs, calculated SNRs, and discarded observations that failed to meet the minimum SNR of 7 (X- and S-band) used in correlation. We compared the remaining observations to the original schedules to evaluate the three metrics.

The flux catalogs that model the fluxes at the time of observing and that were used in test 2

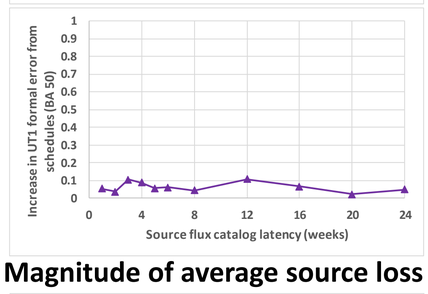
schedule dates in 2016	all latency cases
DOY 003	16jan14
DOY 010	16jan21
…	…
DOY 360	17jan05

Average UT1 formal error increase

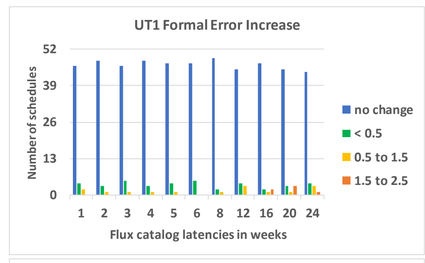
MSS

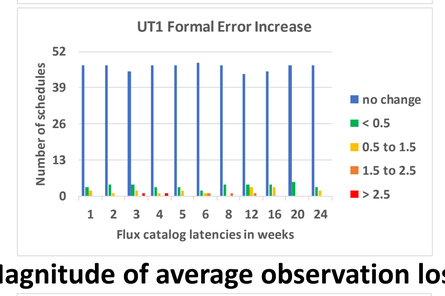


BA 50



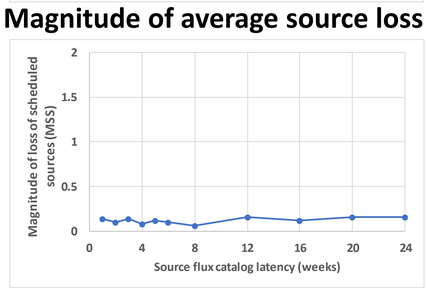
Distribution of UT1 formal error increase



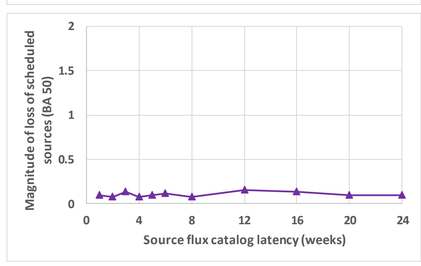


Magnitude of average source loss

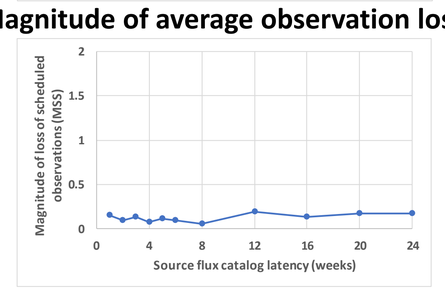
MSS

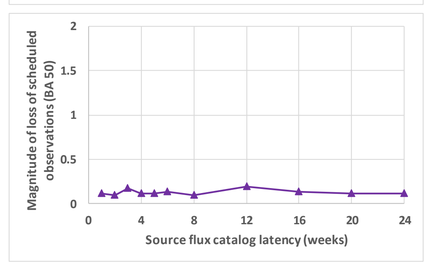


BA 50



Magnitude of average observation loss





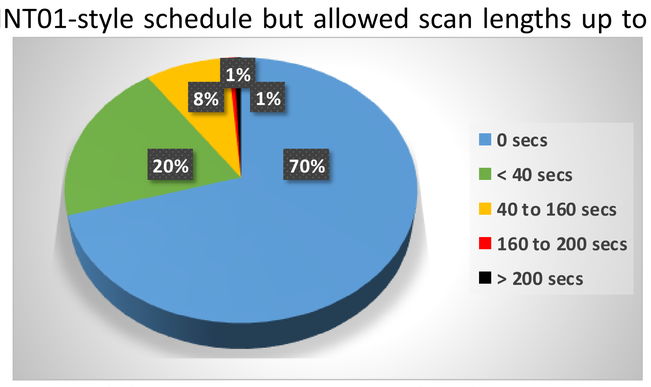
Flux catalog latency causes little average loss due to observing and correlation, and the effect does not increase with increasing latency. But some BA 50 UT1 formal errors increase by more than 2.5 µs.

Latency has a smaller effect in case 2 than in case 1 because the correlation SNR limits are more lenient (lower) than the scheduling SNR limits, and fewer observations are excluded.

Source Behavior

Source flux catalog latency depends on how fast the sources' fluxes are changing. To assess this, we used *Sked* to find and average the scan lengths of the 88 MSS INT01 sources at 26 DOYs, spaced 14 days apart, every five minutes for an hour starting at 18:30 UT, under the 52 2016 artificial flux catalogs spaced one week apart. We used an INT01-style schedule but allowed scan lengths up to 600 seconds, to look at weaker sources.

The data included 41,560 scan length changes (positive, negative or zero) over a week. 2% exceeded 160 seconds (see right). Changes of this size tend to indicate an error or odd situation, such as a source being observed by an atypical station network, but the number of changes seemed too large. Investigation revealed a reason. Operational source flux catalogs use one or two months of data, smoothing the effect of flux spikes. But, inadvertently, we used only a week of data to generate each artificial flux catalog, so the study used the raw fluxes and was influenced by the spikes. The case 1 and 2 simulations should be redone with new artificial flux catalogs with enough data to simulate realistic catalogs.



Meanwhile we report statistics for the 6,316 scan length **increases** over a week from the raw data:

Average/stdev: 40.6 seconds +/- 48.6 seconds
Maximum: 353.7 seconds
Count of increases > 0 and < 40 secs: 4248 (67.3%)
Count of increases of 40 to 160 secs: 1822 (28.8%)
Count of increases of 160 to 200 secs: 104 (1.65%)
Count of increases > 200 secs: 142 (2.25%)

Conclusions and Next Steps

- Source flux catalog latency slightly increases the scheduled UT1 formal error (by up to 0.5 µs) and decreases the number of scheduled sources and observations (by up to 1.5) during scheduling. The effect increases with increasing latency. Latency has little effect on the three metrics when correlation is considered, and the effect does not change with increasing latency.
- Some UT1 formal errors increase by more than 3.5 µs, a fact that merits attention.
- Source scan length changes showed that the artificial flux catalogs were unrealistic (had only a week of data, which allowed flux spikes). The study should be redone with new catalogs.
- Observation and source loss due to latency is offset by scheduling other observations. Also, latency wastes time in scheduling. Both factors should be considered, and we have started this.

24th Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA)
Gran Canaria, Spain, 17-19 March 2019

Contact author: ***Karen Baver, karen.d.baver@nasa.gov***
NVI, Inc.
7257D Hanover Parkway
Greenbelt, MD 20770, USA