EVLA Memo No. 221
OST logs 2011-2022: temporal and sidereal coverage

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Abstract

The objective is to evaluate the performance of the OST (Observatory Scheduling Tool) based on its twelve years of logs. We show plots of the allocation of observations and the distribution of Scheduling Blocks by sidereal time. Tests account for approximately 5% of dynamically scheduled observations. OST tool is working as expected, with schedule gaps occupying around 3.5% of the total available time. It is highlighted that since the beginning of OST logs in 2011, the observatory has been increasing the number of hours observed with the tool. The exception was the year 2018, which had an extensive blackout between June and August.

Introduction

The analysis of the OST logs from 2010 to 2022 was divided in two EVLA Memos. This report focuses on temporal and sidereal coverage of the observations. Previous Memo #220 focuses on weather conditions and forecasts, as well as day and night variations.

We emphasize that the numbers presented here do not take into account the time that the VLA has operated, but only the time OST was used in VLA operations that were recorded in the logs. Thus, the expression "observed hours" should be understood as "observed hours with OST". Detailed information on how the observation time was spent can be found in the VLA Operation reports.

Observation logs

The observation data analyzed come from the OST logs (`scheduler.log` file) and covers the period from 2010-03-22 to 2022-08-23 (LST day 62001 to 66549).

The information from gaps created in the schedules are taken from the `ostSchedPicker.log*` files. It covers the period from 2017-01-18 to 2022-08-23 (64501 to 66549). OST Scheduler logs are stored at `/home/mchost/evla/logs/scheduler`.

Prior to 2022-4-22 (LST day 66425) some schedules and executions came from OST-test (not OST-production). As they are a small number and were recorded identically to the real observations, they will not be filtered out.

Observations over time

Yearly and monthly coverage

We start by evaluating the time the OST was used for array operations (Fig. 1).

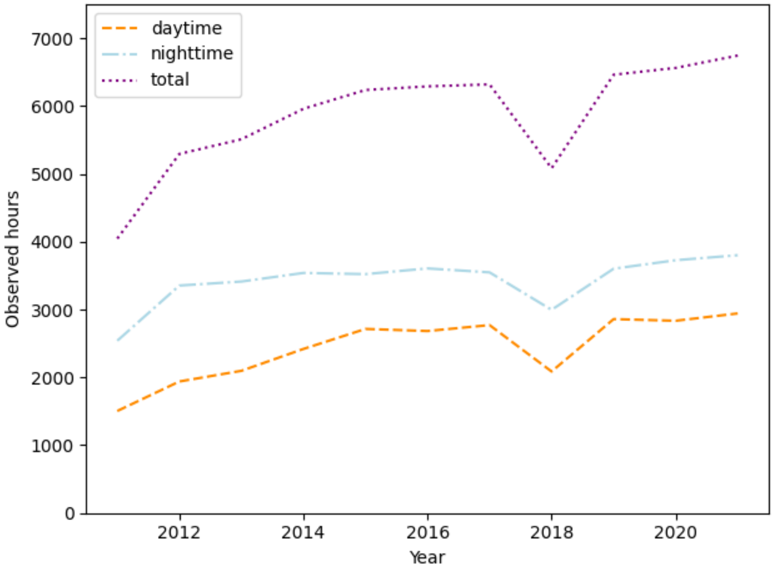

Figure 1: *Total observed hours per year (2011–2021).*

From 2011 to 2015 observation hours constantly increased, mainly at daytime. From 2015 to 2021, the increase was small but significant, with day- and night-time increase. Since 2014, OST was used for more the 2/3 of the yearly available time (5840h/8760h). The only exception was 2018.

The EVLA migration occurred in the first semester of 2010. Also, 2010 was the last year VLA that 3 cycles of proposals (2010 A+B+C), and 2011 the first with only two (2011 A+B). The consolidation of theses changes may have contributed to the increase in hours observed by the array.

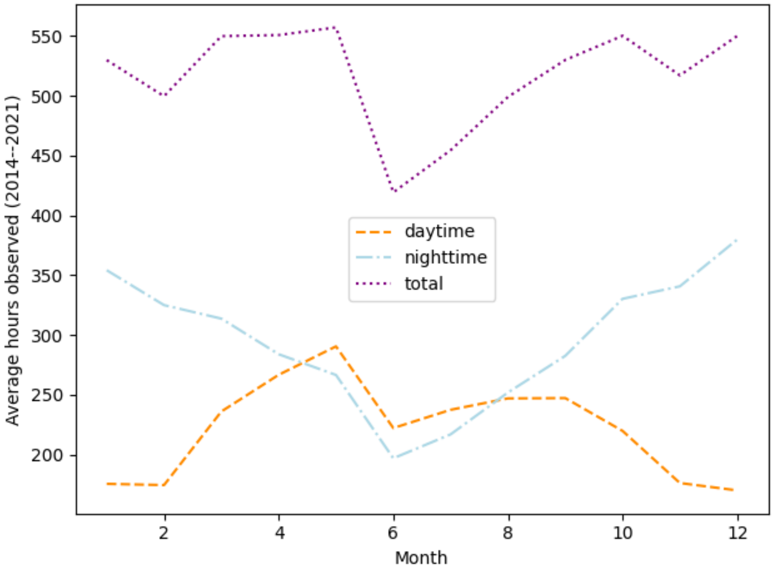

Figure 2: *Average hours observed per month (data from 2014–2021).*

In Fig. 2 we see the time spent in observations each month between 2014 and 2021 (a chosen recent reference period). There is a considerable decrease in the month of June (and to a lesser extent in July) than the average of the other months. As expected, the total time mean is ~520h, corresponding to ~2/3 of the time available for observations (30x24 = 720h).

The decrease in June occurs mainly in the daytime observations, where an increase over the adjacent months would be expected due to the longest diurnal periods of the year. If the decrease in daytime operations in June had an impact on sidereal coverage, the mostly impacted range would be 5–6h LST (sidereal time at noon in June).

The drop in June to ~410h average is a decrease of 1/5 to the other months (~455h in July corresponding to an 1/8 decrease). We attribute this drop to three factors: the presumed preference for maintenance and testing, the bad weather conditions, and the occurrence of more frequent operation blackouts at this epoch (see below).

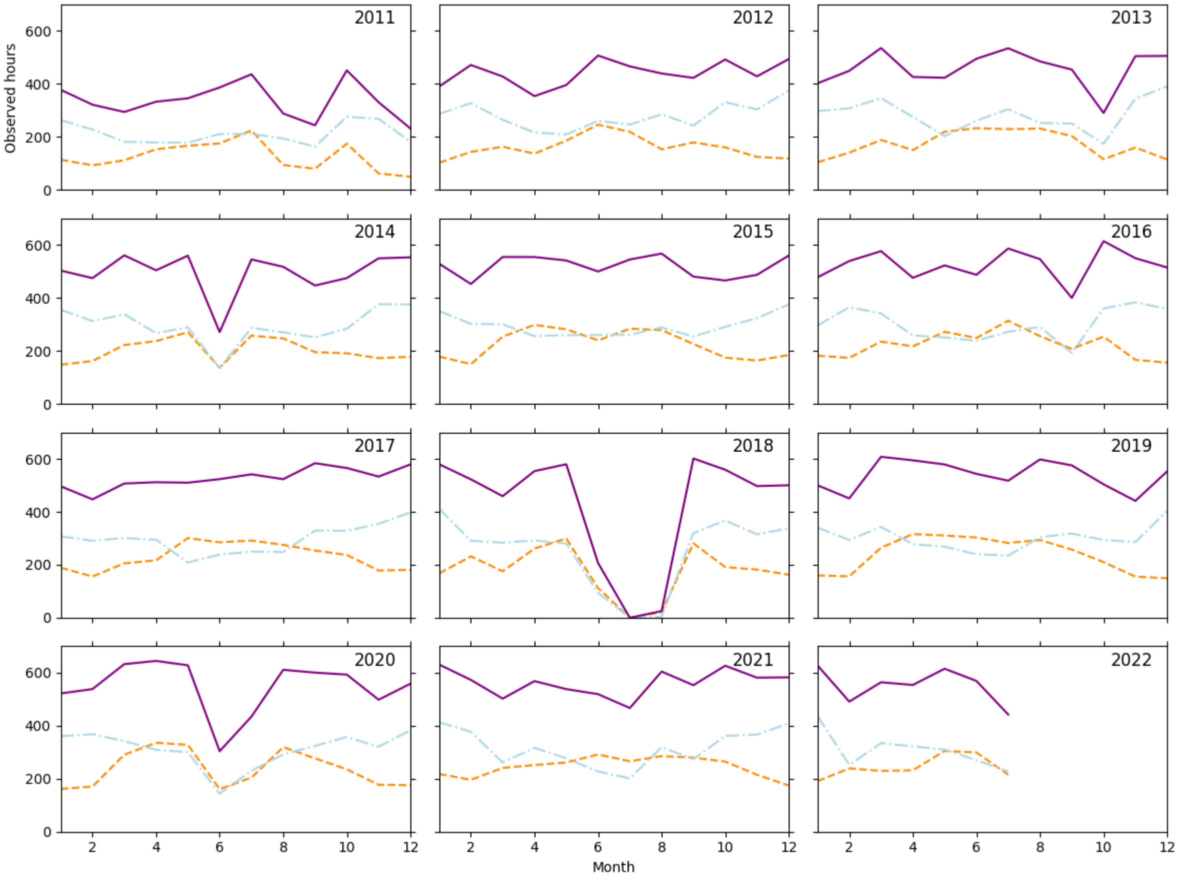

Figure 3: *Total observed hours monthly per year. Dashed dark orange line correspond to diurnal observations; dot-dashed light blue to nocturnal; solid purple is the sum of the two (data from 2011 to 2022).*

In Fig. 3 we see that the three biggest blackout events in operations (2014, 2018 and 2020) all affected the month of June. In the other years, longer periods of daytime observations are not systematically observed in this month. This missing time is inferred as time spent on maintenance, tests and/or bad weather.

Sidereal coverage

In this section the observation time per LST and per month and are analyzed in detail.

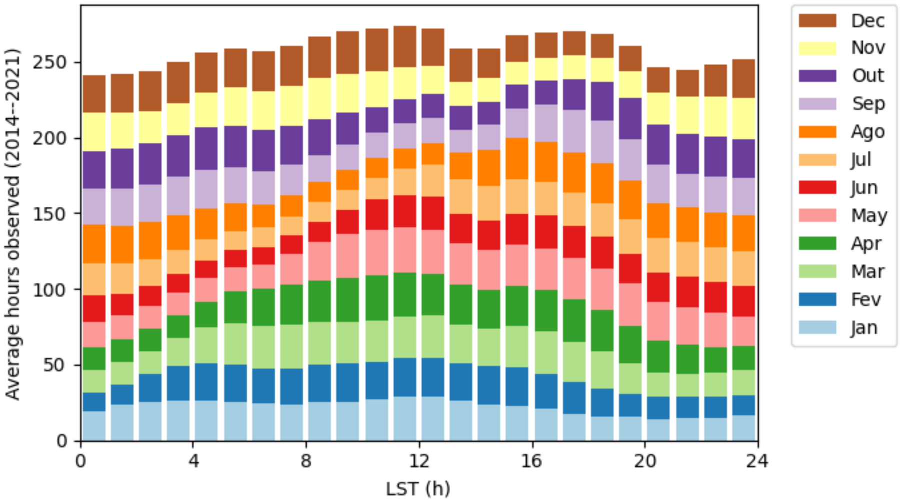

Figure 4: *Average number of observation hours per LST hour. Data from 2014–2021.*

Fig. 4 shows the average hours observed at each LST hour for the reference period (from 2014 to 2021). The average value is very close to the 2/3 of the time yearly available per LST (365*2/3 = 243h). Its hourly variation is very small – the difference between the maximum and minimum is ~10% of the mean (270-245 = 25h).

As 1/3 more time is spent on nightly observations (previous section), one can also see the seasonal contributions for each LST hour in Fig. 4. The months of the first semester (Jan–Jun) spend more time observing around 12h LST, while the second semester is centered at 0h/24h LST.

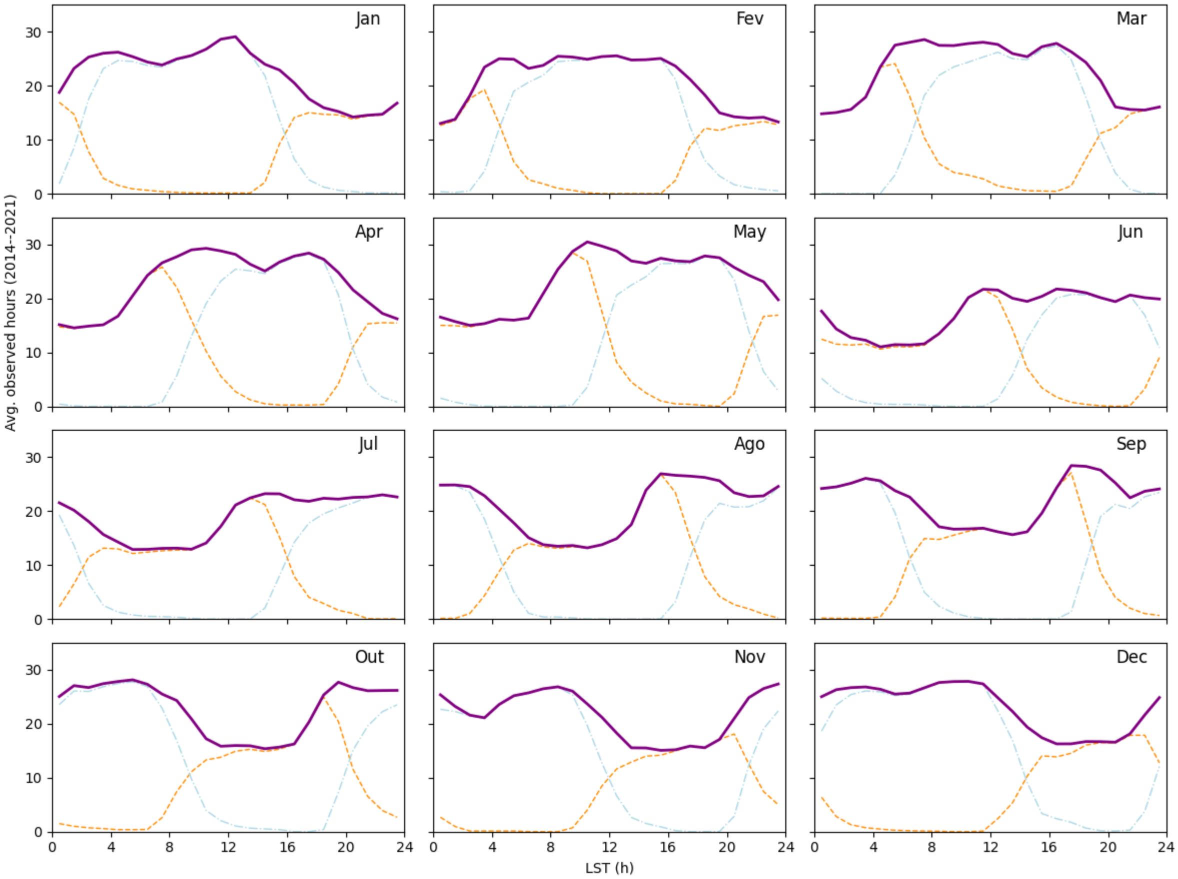

Figure 5: *Average hours observed monthly per LST. Dashed dark orange line correspond to diurnal observations; dot-dashed light blue to nocturnal; solid purple is the sum of the two (data from 2014 to 2021).*

Fig. 5 shows the average time spent each month in daytime and nighttime observations from 2014 to 2021 (reference period). In some months there is a subtle decrease in the 13–15h LST range (see also Fig. 6). In June, there is no special features in its sidereal coverage. For that month, the range of 3–8h LST is the one with the least observations.

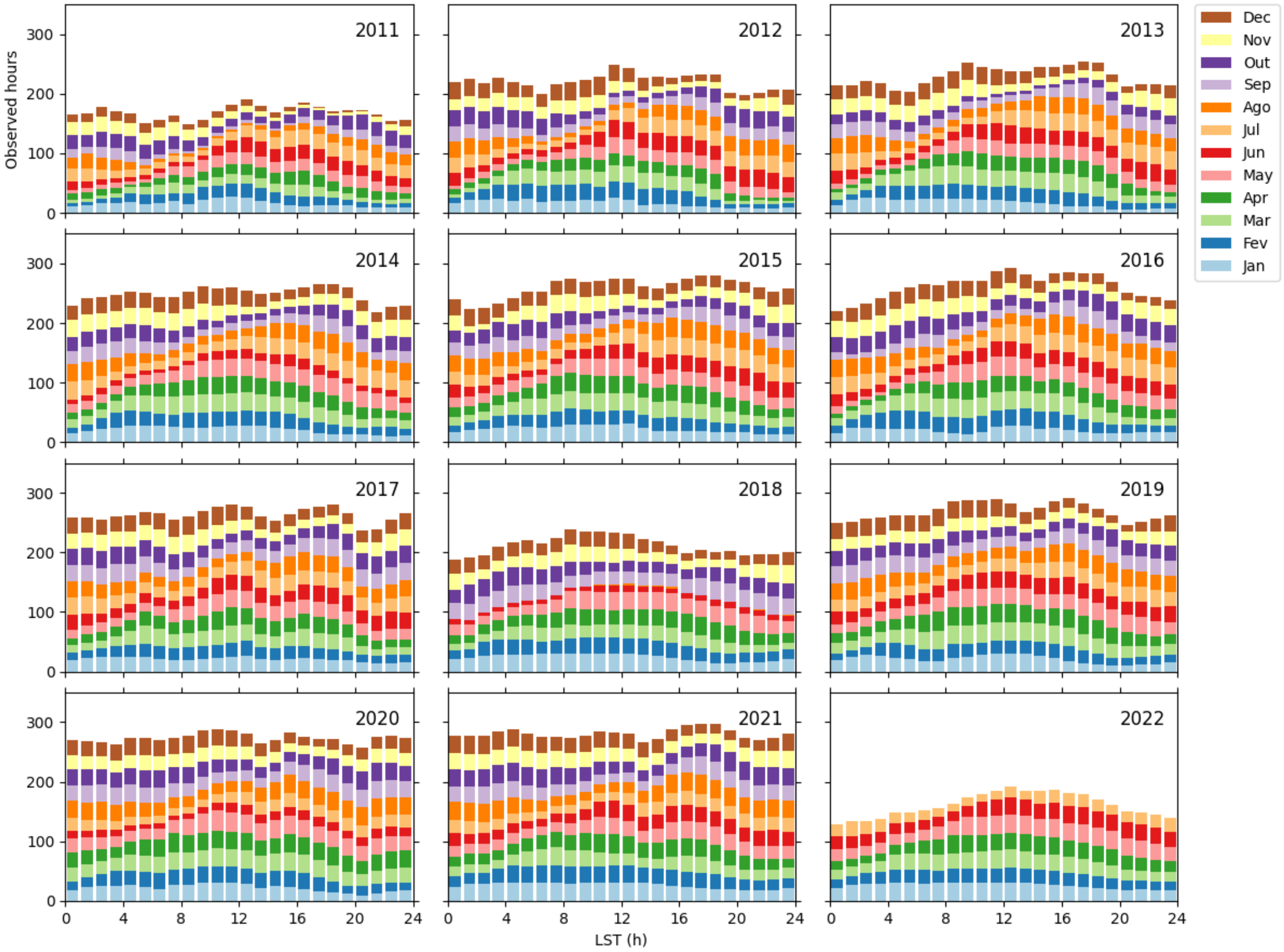

Figure 6: *Total observed hours annually per LST. Each month is indicated by a unique color (2011–2021).*

Fig. 6 is an annual breakdown of what was seen in Fig. 4. The time of observations between 13–15 LST are systematically smaller than its neighbors in 2015 onwards. However, the intervals with the fewest hours observed are 0–3h and 20–22h LST and their decrease is not statistically significant (eg., comparing them to the mean). This feature in the 13–15h LST range is analyzed in more detail in the last section of this report.

Non-science SBs

In this section we evaluate the occurrence and duration of test SBs. These are SBs for maintenance and commissioning purposes.

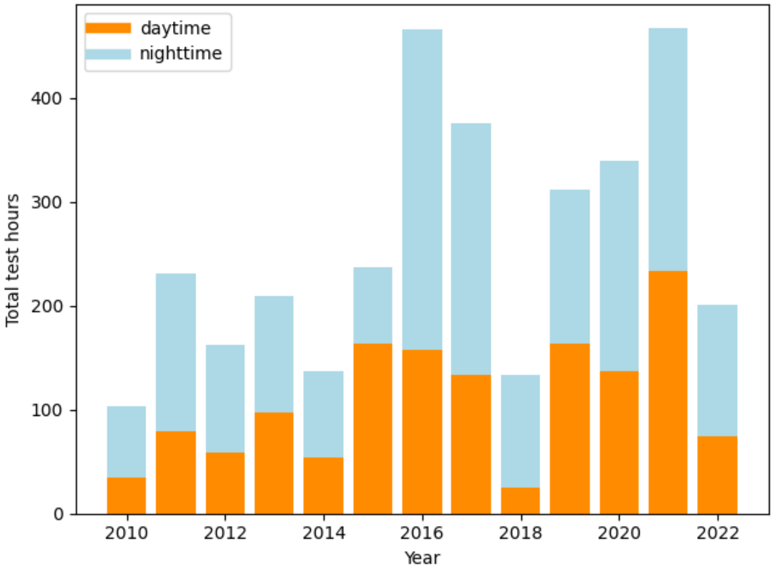

Figure 7: *Time spent on test SBs per year (March 2010–August 2022).*

In Fig. 7 the time dedicated to test SBs recorded by the OST is shown. Using the years 2014 to 2021 as a reference, an average of 133 hours during the day and 175 hours at night were used per year. The sum (308h) corresponds to 1/20 of the time of annual logged observations (~5840h).

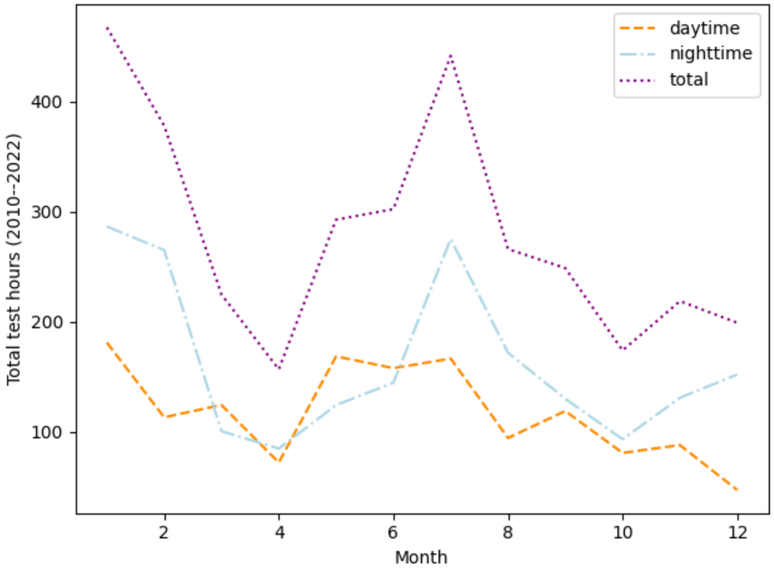

Figure 8: *Total time to test SBs per month.*

In Fig. 8 we see the distribution by month of the time allocated to test SBs. January and July stand out with the highest number of hours.

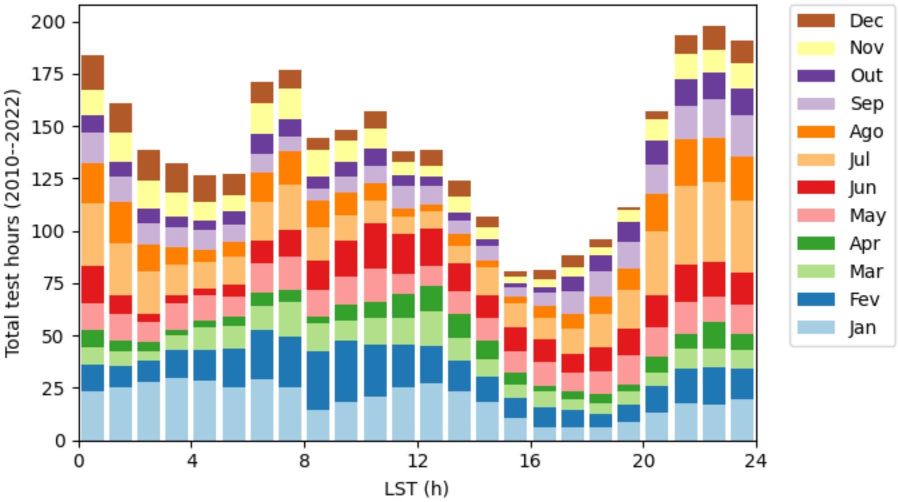

Figure 9: *Total time to test SBs per LST. Each month is indicated by a unique color (March 2010–August 2022).*

In Fig. 9 we show the distribution ot test SBs hours per LST. The most commonly observed LST range for testing is between 20–2h LST. Minimum testing occurs between 14–20h LST. In the appendix we present the detailed month-by-month LST distribution (day and night).

OST Schedule gaps

To accommodate observations of priority targets within their LST intervals, as well as observations with fixed dates, the OST may propose some idle time between SBs. This happens specially when short, low-priority SBs ("fillers") are not found. These idle periods are called "gaps". The record of the OST schedules gaps starts on 2017-01-18 (LST day 64501). Based on them, Figs. 10 to 12 were made.

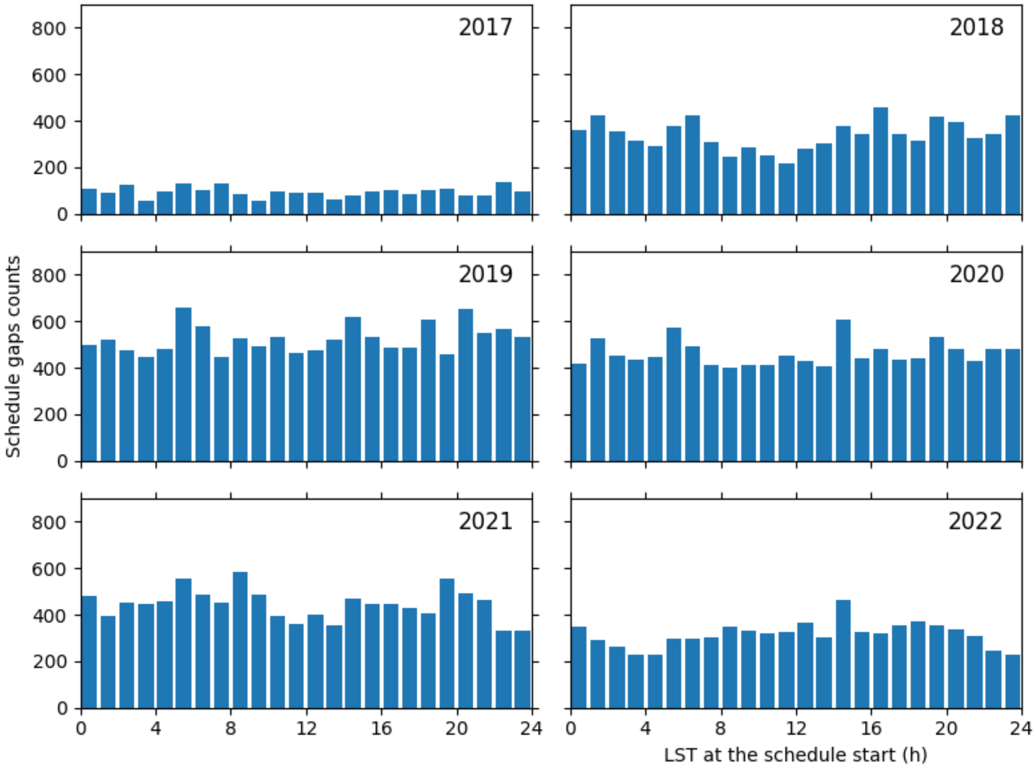

Figure 10: *OST Schedule gaps raw counts per LST (February 2017–August 2022).*

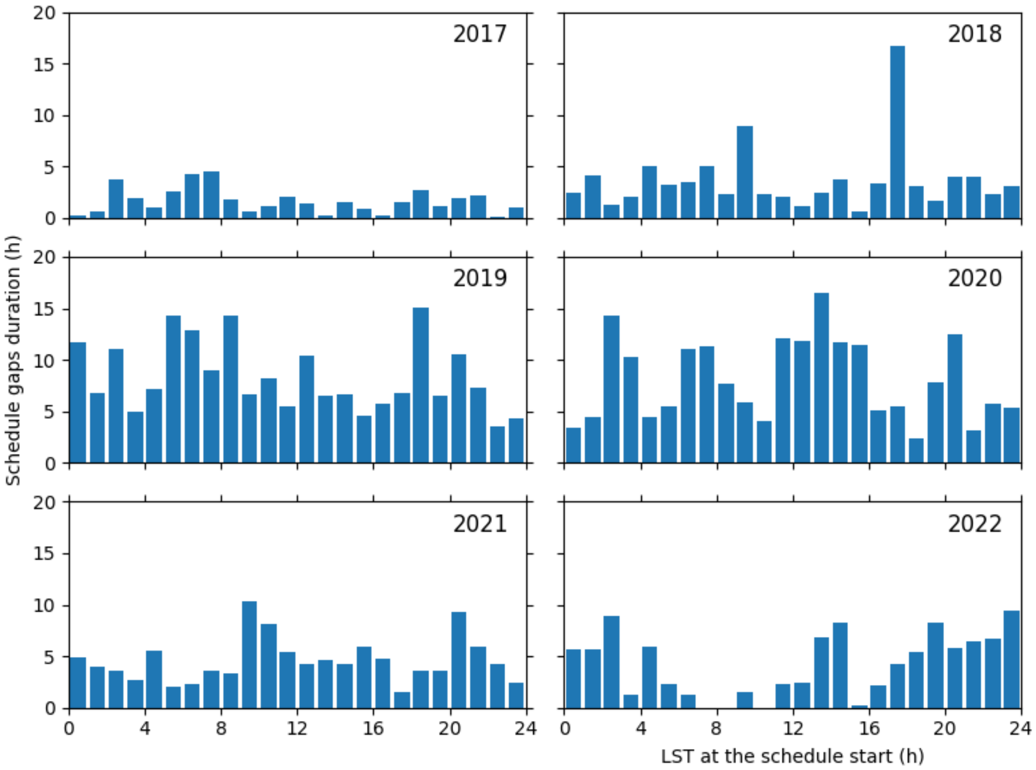

Figure 11: *OST Schedule gaps duration per LST (February 2017–August 2022).*

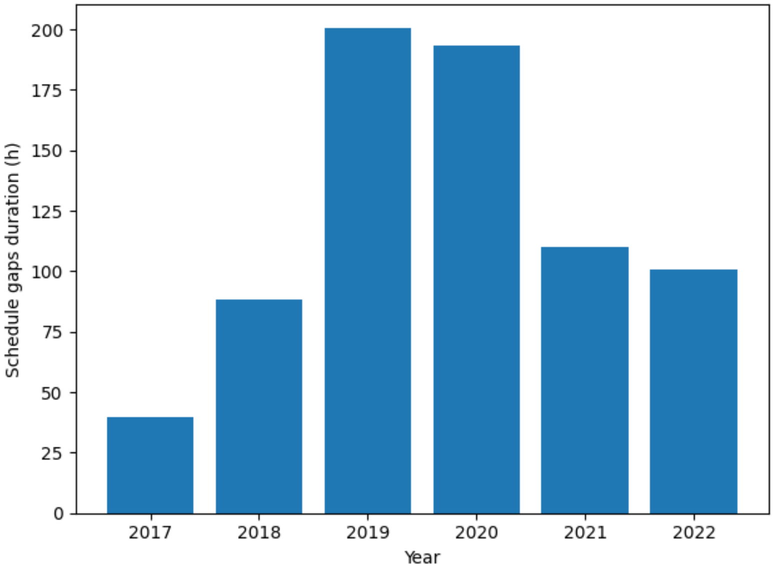

Figure 12: *OST Schedule gaps duration per year (February 2017–August 2022).*

It is very difficult to determine whether or not an array idle period originated from an OST observation gap by just looking at the OST logs. Operations can be interrupted by technical problems. Also, multiple schedules can be written to the logs when evaluating the queue under variable weather conditions. Thus, two methods are used here to assess the occurrence of schedule gaps. The first one counts the number of gap occurrences as function of the LST hour at the schedule start ("relative occurrence"). This is useful to find biases in sidereal coverage. The result is shown in Fig. 10.

The second method tries to count the time that the gap made the array wait ("absolute occurrence"). For this, the time of gaps is added from each schedule generated by the OST, as long as the schedules do not overlap each other in time. In case of overlap, the most recent schedule is considered. The results are in Figs. 11 and 12.

Of six years of gap logs, only two covered the entire year and had no major blackout episodes: 2019 and 2021. The duration of the gaps in 2021 was almost half that of 2019. And in 2020, it was almost the same as 2019 – despite a considerable blackout in the summer. This variation is expected, as the array configuration schedules and the distribution of priority targets in RA change every semester. Also, unanticipated blackouts likely trigger more gaps since there is less time to observe priority targets.

As discussed earlier, it is very difficult to determine idle time due to gaps. By not considering gaps between intersecting schedules, this method is at least a lower limit of the real value. From Fig. 12, we see that the time spent in gaps is smaller than 200h a year. This corresponds to 1/30 of the total time for observations (5840h). It is a short idle time, compatible with a queue with plenty filler SBs available. Note that this idle time does not contribute to the time considered as *observed* in this report.

There is no evidence of preferential LST intervals for the occurrence of gaps, nor for their duration (respectively, Figs. 10 and 11).

Starting SBs per LST hour

In Memo #220, a discontinuity was found in the number of starting SBs as a function of sidereal time. This phenomenon was called "LST bump". It can be seen in Fig. 13, where the number of SBs starting between 13–14h LST is considerable less than in the following hour, between 14–15h (~1150 vs ~1850 respectively, equivalent to a 60% increase).

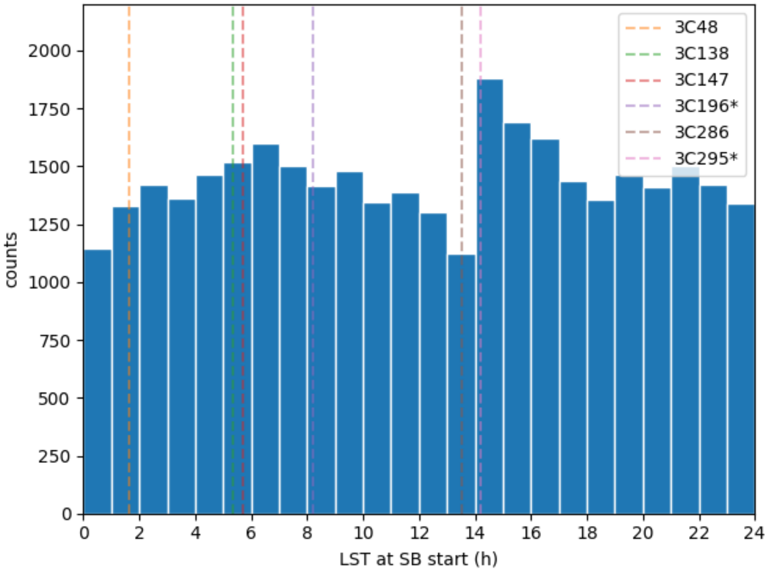

Figure 13: *Histogram of the local sidereal time at the start of the Scheduling Blocks (March 2010–August 2022). Most used Flux Calibrators are indicated.*

Fig. 13 does not show strong correlation of the SBs counts and the Right Ascension the Flux Calibrators. Flux Calibrator coordinates are shown in the appendix.

Another quantity that must be taken into account is the duration of the SBs. If observations between 13–14h LST are longer than the average, while between 14–15h LST are shorter, it would correspond to approximately the same number of hours in the schedules.

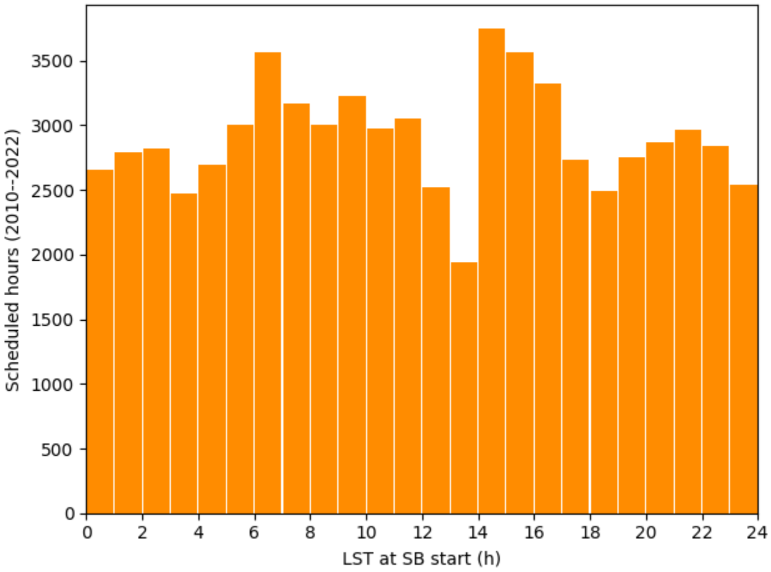

Figure 14: *Same as Fig. 13, but adding up the scheduled duration of the starting SBs.*

Fig. 14 shows the total reserved hours by the SBs as function of their starting LST time. The plot shows that intervals where more SBs start have shorter duration than intervals with less starters, resulting in close scheduled hours.

We highlight in Fig. 14 that the scheduled hours in the 14–17h LST range are very close (~3500h). Given that there are more SBs starting on 14–15h LST than in the following hours, that means that SBs in the 14–15h LST range are shorter than its later neighbors (on average).

On the LST discontinuity

We have seen that the "LST bump" phenomenon manifests itself in three quantities: i) few SBs starting at 13–14h LST, with a big increase in the following hour; ii) shorter SBs in the 14–15h LST range than its later neighbors; iii) a subtle decrease in the total observation time in the 13–15h LST interval.

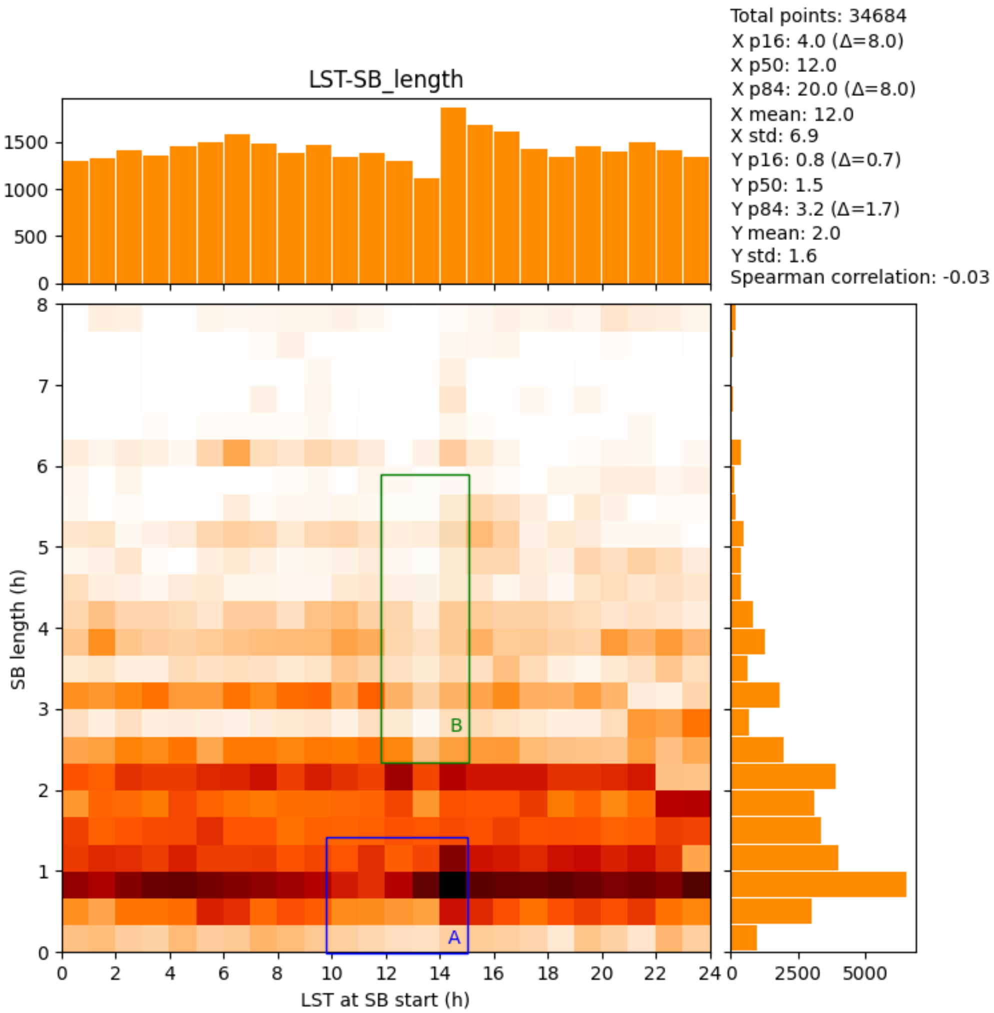

Figure 15: *2D histogram of the SB length and the LST at their start (March 2010–August 2022).*

In Fig. 15 is shown the duration and number of starting SBs as a function of the LST interval and their correlation. We highlight two features: i) fewer short observations (<1h20) between 10–14h LST, with a peak of observation lasting 40min–1h in 14–15h LST (region "A"); and ii) a decrease in long observations (>2h40) in the 12–15h LST interval (region "B").

The analysis of the origin of these features involves the evaluation of priority targets approved per LST and their duration, which are beyond the scope of this report. We believe it is caused by the presence of several priority targets in the Galactic center region, centered on RA 17.8h. That region becomes observable ~4h earlier, precisely where the LST bump occurs. We call this hypothesis as "damming effect": SBs must finish by ~15h LST, when targets at the Galactic center take priority. That lowers the frequency of SBs longer than 2h at 12–15h LST range and favors the SBs starting at 14h LST to be shorter that 1h.

The "damming effect" can also be seen in the LST distribution of the test SBs (Fig. 9). The minimum allocation for test SBs correspond to the Galactic center region, with a pronounced decrease at the LST bump (~14h LST). Test time increases considerably after the Galactic center observability window (>20h LST), indicating that there is a greater pressure for science targets in this region.

The features identified here can eventually be useful for optimizing the queue (for example, increasing the number of fillers projects, or accepting more long project that finish before 15h LST). However, we argue that OST is very close to an optimal regime as there is no evidence of increased schedule gaps (in frequency or duration) and an approximate constant use of the array as a function of the sidereal time.

Conclusions

This report analyze the logs of the VLA operations with OST from March 2010 to August 2022. VLA has steady increased the time operated in this mode since the beginning of the records. The OST usage fraction corresponds to ~2/3 of the total available time, with 1/20 of this time allocated for tests (in dynamic scheduling).

The logs showed two unanticipated phenomena: i) a tendency to observe for less time during the month of June (approx. -20%; and July, -13%) when compared to the rest of the year; and ii) less observations starting when local sidereal time is in between 13–14h LST, with a considerable increase at the next hour (14–15h LST).

The two mentioned phenomena are not correlated. The decrease of operations in the summer occurs mainly for daytime observations, and are likely the result of bad weather, operation blackout episodes and the preference for maintenance and testing time at this time of the year. The major blackout event registered occured from June to August 2018.

The logs show approximately constant VLA usage across all LST hours. Sidereal uniformity is a result of a planned biases in the number of schedulable projects, choice of LST epochs made by the OST, or a combination of both.

The phenomenon of fewer SBs starting between 13–14h LST is related to another one, which is SBs are shorter when starting between 14–15h LST. However, the decrease in time observed in these LST hours is not significant. We argue that these effects are related to the beginning of the observability window of priority targets in the Galactic center (RA 17.8h).

OST appears to be well optimized for schedule gaps. No biases were found, and the estimated duration of 3.5% of the time available is small. However, this value is a lower limit given the difficulties of accurately estimating this value using OST logs alone.

The results from the OST logs show that the tool is working as expected. A more robust analysis of the schedules should take into account the number of priority targets approved and the fraction of them observed per LST and per epoch.

Acknowledgements

The authors thank B. Butler, V. Dhawan, M. Gardiner and A. Mioduszewski for their comments and suggestions on this report.

References

- EVLA Memo No. 220 - OST logs 2011-2022: weather and forecast
- The EVLA project: https://science.nrao.edu/facilities/vla/docs/manuals/oss2013B/intro/project
- Science Program 2010C: https://science.nrao.edu/science/science-program/programs2010c
- Science Program 2011B: https://science.nrao.edu/science/science-program/programs2011b

Appendix

Table 1: *Sidereal time at mid-night on the 16th of each month at the VLA site (daylight saving time is not considered; MST only).*

Month	**LST**	**Month**	**LST**
Jan	7.5	Jul	19.4
Feb	9.6	Aug	21.5
Mar	11.4	Sep	23.5
Apr	13.5	Oct	1.5
Mai	15.4	Nov	3.5
Jun	17.5	Dec	5.5

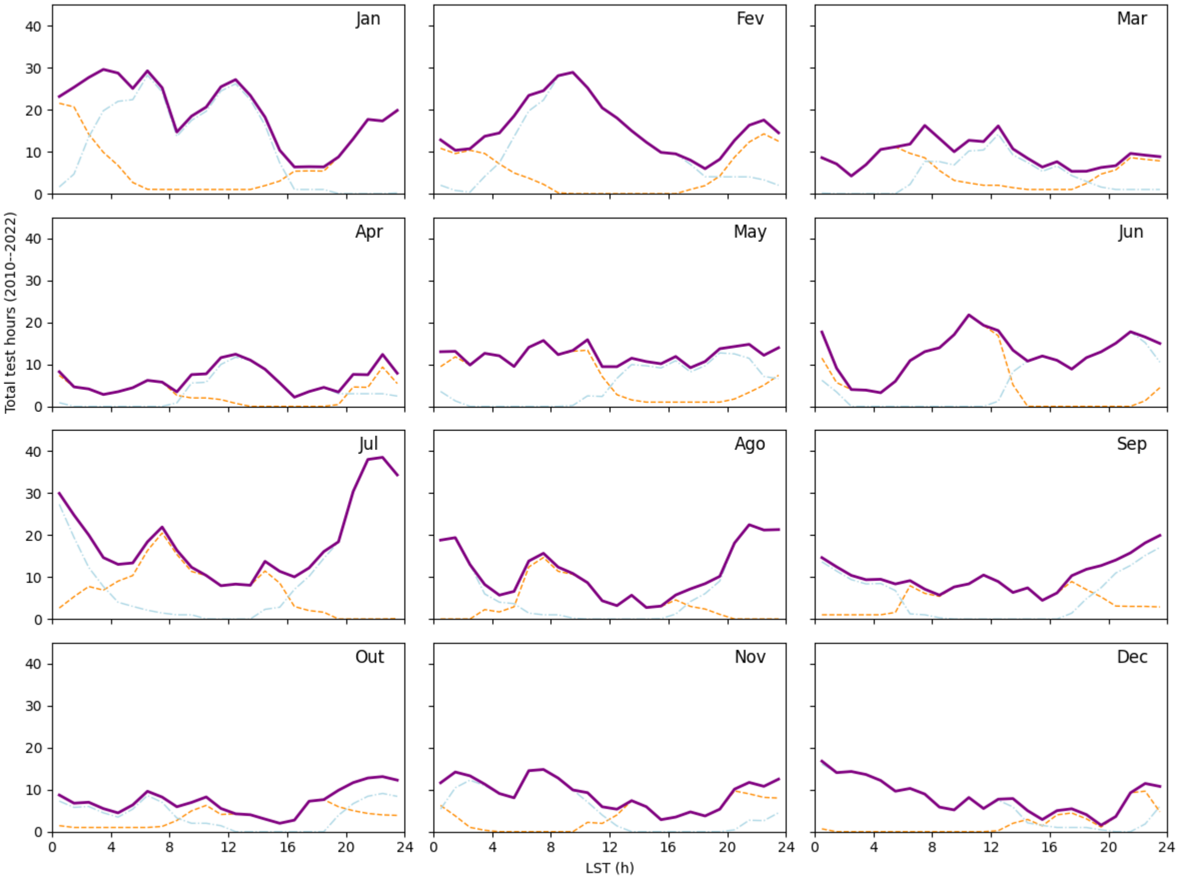

Figure 16: *Total observed hours by test SBs monthly per LST. Dashed dark orange line correspond to diurnal observations; dot-dashed light blue to nocturnal; solid purple is sum of the two (March 2010–August 2022).*

Table 2: *Coordinates of the most used Flux Calibrators (J2000) in figure 13. The * sign indicate the ones associated with very low frequencies (<1.5 GHz).*

Target	**RA (h)**	**DEC (deg)**
3C48	1.628	33.160
3C138	5.353	16.639
3C147	5.710	49.852
3C196*	8.227	48.217
3C286	13.519	30.509
3C295*	14.189	52.203