IVS Seamless Auxiliary Data Archive (SADA) and EVN Monitor

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Abstract Continuous data in real-time offer a tremendous benefit. Operators get detailed information about system status and quality. External partners and companies can retrieve historic values for intervals of events and failure situations. Correlation and analysis can integrate highly-sampled correction parameters. These advantages were the drivers of an IVS Seamless Auxiliary Data Archive at Wettzell as well as the EVN Monitor at JIVE. The EVN Monitor has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730884. This paper shows the current status, possibilities for participating, and first results. A video with the presentation can be found here: https://youtube/wJM11NePz3o

Keywords Auxiliary data, Database, IVS Service, ZABBIX

1 Introduction

The IVS Seamless Auxiliary Data Archive (SADA) and also the EVN Monitor are databases accessible from the Internet. The open-source network monitoring suite ZABBIX is used for these central services [4]. SADA is located at the Wettzell observatory, Germany at the address "https://vlbisysmon.evlbi.wettzell.de/zabbix/". The EVN Monitor is located at JIVE ERIC, The Netherlands at the address "https://evn-monitor.jive.de". Users need a username and password for login. There is a general IVS guest, respectively an EVN guest, user login for data downloads. Information about how to download data can be requested from the main author of this article. Using these accounts, data can be presented dynamically via web pages or downloaded as text files for further processing. A Python script "ZabbixAPI" is published for that purpose [1].

All data in the archive directly come from the observatories. Antennas and sites can continuously inject supplementary data sets (such as meteorology and clock offsets) with a minimum sampling rate of one second. There is a special encrypted SSH mechanism to upload data sets. There is no requirement to install additional software at the location of the observatory. Senders just call a program "zabbix_sender" with according arguments containing the data sets on the central database server.

There are different levels of data sets from elementary values to extended value templates for controlling purposes. The basic data set each antenna should support is:

- clock offsets "dotmon" (microseconds)
- air temperature (centigrade)
- humidity (percentage)
- air pressure (hectopascals)
- wind speed (kilometers per hour), if available
- wind direction (degree), if available

An overview of the services is shown in Figure 1. The following sections demonstrate use cases where SADA was used.

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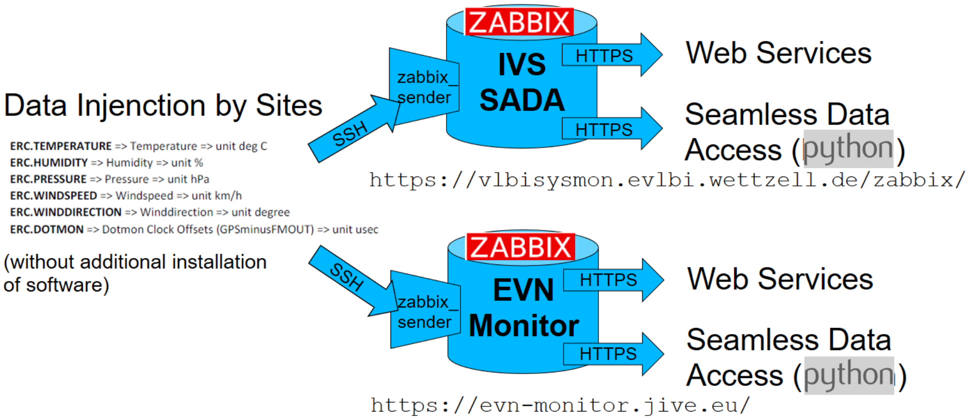

Fig. 1 Overview of the services for seamless auxiliary data.

2 Use Case: Troubleshooting

Extended data sets enable a detailed system overview. This can help to find causes in cases of error situations, missing results, system changes, or quality issues. This is even possible with the reduced number of data of a basic support described before.

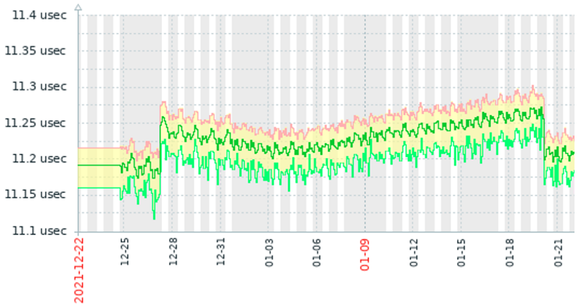

Fig. 2 Sample of continuous clock offsets showing some jumps.

For example, clock jumps or instabilities can be detected even when no VLBI session is in operation, using continuous clock offsets (see Figure 2). This improves narrowing down when the issue occurred. With the established system of VLBI observations, a change can only be recognized from session to session. A more precise definition of the point in time is impossible if it started outside of a session. A precise point in time is often essential for the search for the cause.

Another sample can be given with pointing effects due to wind gusts. Thunderstorms become more and more a serious problem in times of climate changes. They appear immediately and show some strong gusts leading to pointing instabilities or wind stows (see Figure 3). Cross-checks during correlation and analysis can help to determine effects, as seen for antenna WETTZ13S during the correlation of session “vt2049” at the Haystack correlator.

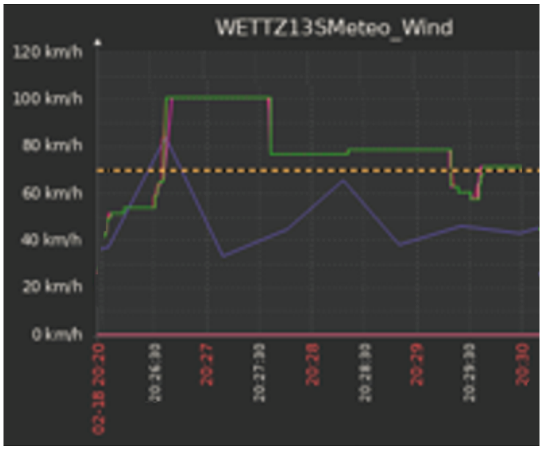

Fig. 3 Sample of continuous wind speeds showing some gusts.

3 Use Case: Quality Improvement

Huge improvements can be detected using continuous data sets from IVS SADA for clock determination. Clock offsets (GPS minus formatter/DBBC output) are usually just available in log files exactly for the time of a session. One value is always stored per scan because the value is requested as part of the post-observation procedure (“postob”). But, for example, legacy Intensive sessions to derive UT1-UTC just have about 18 scans, which leads to 18 clock values for this hour. A sample calculation of drifts and trends of the clock offset using IVS SADA and log file data for the session “i22074wz” clearly shows that this number of values is not enough to derive the real drift and trends.

Using SADA data, it is possible to individually select the time interval of data sets. Clock offsets in this database have a sampling rate of one value per minute leading to 1,440 values per day. Therefore, a 24-hour interval can be selected, so that the Intensive is exactly in the middle. This provides a clear statement about the behavior of the clock in relation to the time of the observation.

This can be demonstrated with Intensive session “i22074wz” lasting one hour (the Wettzell antenna uses a Symmetricom SyncServer S250 as a GPS receiver, a DBBC2/FILA10G, and a T4Science EFOS36 as a maser). A comparison between linear trend lines over one hour with values from the log file and from SADA shows huge differences (see Figure 4). Using a larger interval of six hours around the observation session shows that this linear trend shows a similar slope such as calculated before with the SADA data, which gives a better estimation of the clock behavior. It is also visible that polynomial trends show a very similar behavior for this period of time. Using only linear or polynomial long-term trends over one day reduces the accuracy again because they don’t represent the daily trends. Piecewise linear functions work better here.

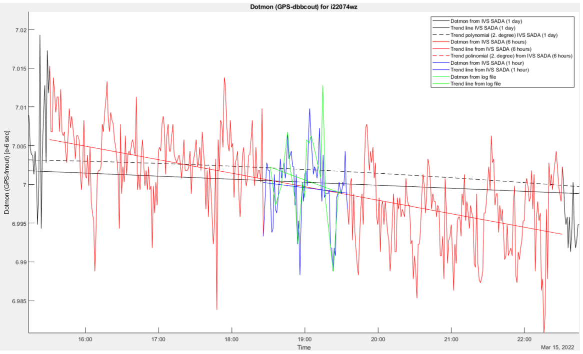

Fig. 4 Analysis of clock offsets for i22074wz.

This demonstration is slightly different for Intensive sessions with VGOS. Due to the short observation times, scans for 68 sources are recorded per hour. Therefore, the number of “dotmon” values is comparable to the number of values from SADA. Trend lines are very comparable here (such as calculated for “v22074ws”; the WETTZ13S antenna uses a Microsemi SyncServer S650 as a GNSS receiver, a DBBC2/FILA10G, and a T4Science EFOS60 as a maser; see Figure 5). A slight improvement might be given if a larger interval around the pure observation is taken from SADA. But this requires further investigations as also different hardware is used, showing different daily trends.

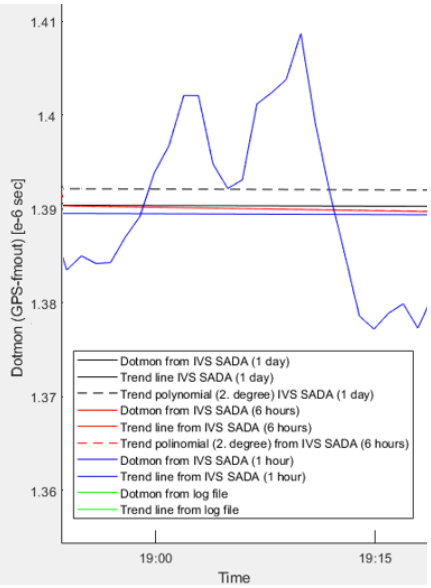

Fig. 5 Excerpt from the graph of clock offsets for v22074ws.

4 Use Case: External Support

Data of the IVS SADA also offer additional potential. Additional events and phenomena can be detected, having higher sampled recordings. A good demonstration was possible using meteorological pressure data for a time period which included the Hunga-Tonga–Hunga-Ha’apai Event [2]. An underwater volcano eruption produced one of the largest phreatomagmatic events ever measured on January 15, 2022, at 04:14 UT. It also sent out a series of waves around the globe, for example also a huge barometric pressure wave propagating in the atmosphere. While regular recordings in log files, such as from an AOV session, just detected the event, SADA data could be used to clearly see the different arrival times of this wave at different locations (see Figure 6). Therefore, it was possible to exactly derive the running time of the wave between different sites. For example, it required 27 minutes and 39 seconds for the distance of 523 kilometers between Medicina and Wettzell. This leads to a speed of 1,135 km/h which is similar to a number published by the Royal Meteorological Society in London [3].

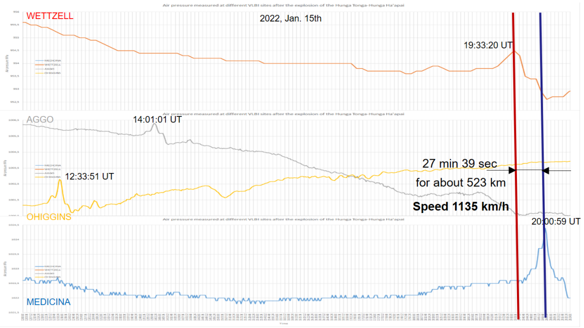

Fig. 6 The Hunga-Tonga–Hunga-Ha'apai Event as a barometric pressure wave in the SADA data.

5 Summary

There are first nice demonstrations showing the benefit of higher-sampled, continuous, seamless, auxiliary data. Besides operational aspects at the locations of the sites where these data are already successfully in use, centralized databases offer also new possibilities for improving products, as shown. Nevertheless, this requires additional investigations and also discussions concerning which data are necessary and what are the requirements for the recording.

Acknowledgements

The EVN Monitor has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730884. We also want to thank people from antenna sites who tested and continuously use the sending of data, especially Medicina for the early and continuous support.

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