IVS Newsletter

Issue 59, April 2021

News from the Board: Changing of the Guard

– Dirk Behrend, NVI Inc./NASA GSFC

At the virtual IVS Directing Board meeting on March 25, 2021 Axel Nothnagel passed on the baton of the IVS Chair to Rüdiger Haas as witnessed by the outgoing and incoming Board members.

On March 25, 2021, the IVS Directing Board met for its first meeting of the year via Zoom. Following the recent IVS elections the Board continued with the tradition of a transition meeting with both the old and the new Board members. This was the appropriate setting to bear witness to history in the making. After eight years at the helm of the IVS and having served the IVS cause since the service's inception, Axel Nothnagel completed his IVS chairmanship and his long tenure on the Board. In fact, Axel is one of the founding fathers, as he was part of the Steering Committee that set up the IVS in 1998/1999. He was a continuous Board member since then, first as IVS Analysis Coordinator and then as Analysis Center representative. With the last original member leaving the Board, this really was a changing of the guard.

Axel chaired the first half of the Board meeting and then handed over the reins to Rüdiger Haas who moderated the second part. We would like to thank Axel for his tremendous contributions over all those years and hope that we can count on his experience and wisdom also in the coming years. We are confident that under Rüdiger's guidance the IVS will move forward based on a sound foundation.

While Oleg Titov replaced Axel as one of the two Analysis Center representatives, there were three other changes to the personnel: Pablo de Vicente replaced Paco Colomer as one of the Networks representatives, Jinling Li and Evgeny Nosov left as At-Large members with Yu Takagi and Nadia Shuygina coming in to fill their positions.

The Board approved two new IVS Resolutions. IVS-Res-2021-01 recommends continuous recording of met and clock offset data and making these data sets available via the Seamless Auxiliary Data Archive hosted at Wettzell. IVS-Res-2021-02 recommends that stations monitor critical telescope parameters (e.g., phase cal, cable cal, system temperature); for an interim time period, Yebes will likely function as a central repository. The new resolutions will be posted on the IVS website (*https://ivscc.gsfc.nasa.gov/about/resolutions/*) once the annex with technical details have been fully formulated.

The IVS Committee on Training and Education (CTE), which was led by Rüdiger since September 2013, will now be chaired by Nataliya Zubko from the Finnish Geospatial Research Institute. The current plan is to organize the fourth VLBI Training School in conjunction with the next IVS General Meeting (GM) in Finland, about a year from now. The School will likely be held in the week prior to the GM. Thank you to Nataliya for taking this on.

Lastly, it is my sad duty to let you know that the NICT space-geodesy group at Kashima will be disbanded at the end of March 2021. With the deconstruction of the 11-m and 34-m antennas, an era is coming to an end. In addition to the telescopes, the Kashima group also supported a technology development center, a correlator, a data center, and an analysis center. All these activities will be discontinued. NICT will continue to support the station at Koganei. We would like to thank NICT for the strong support of the IVS in the past and look forward to contributions from Koganei and a possible support of GSI's VLBI activities. Arigato!

After eight years at the helm of the IVS, Axel can finally relax and enjoy a well-deserved beer.

Feature

Swiss Analysis Center at ETH Zurich

In 2020, Benedikt Soja has been appointed as the only professor dedicated to geodetic space techniques in Switzerland. As one of his first actions after taking the new position, he proposed that ETH Zurich host an IVS Analysis Center. With the approval by the IVS Directing Board on October 7, 2020, Switzerland is a new country entering the IVS.

Benedikt Soja

Professor Soja (or should I say Benedikt?), congratulations to your new position. Could you tell us how you became interested in VLBI and summarize your current research activities? What fascinates you with VLBI?

Thank you very much! New title, but still the same person—so let us stick to first names, especially in this family-like community that is VLBI. 😊

I was introduced to VLBI when I studied "Geodesy and Geoinformation" at the Technical University in Vienna (TU Wien). In the beginning, I had planned to work in surveying. However, the lectures in "Higher Geodesy" by Professor Harald Schuh, focusing on space-geodetic techniques, were much more fascinating to me. At the same time, I always had been interested in the riddles and mysteries of the universe and was taking a few courses in Astronomy and General Relativity. Therefore, I always felt a more personal connection to VLBI, bridging geodesy and astronomy, than to other space-geodetic techniques.

Although I have since worked on several different subjects, I have always kept this VLBI connection to a certain extent. After my PhD at GFZ Potsdam, during which I studied VLBI data analysis with Kalman filtering, I worked as a postdoc on geodetic reference frames at the NASA Jet Propulsion Laboratory, focusing on the connection of terrestrial and celestial frames. Now, at ETH Zurich, my main goal is the application of machine learning in geodesy, again including VLBI.

Your arrival to Switzerland coincided with the coronavirus outbreak and related restrictions. It is probably the worst time to start life at a new place with a new subject. How has the first year been for you under these circumstances?

The move to Switzerland was certainly the craziest time of my life. I had actually planned to fly from California to Annapolis to attend the IVS General Meeting, and then directly to Switzerland to start my new job. First, the General Meeting was officially canceled, then I had to re-book my flights five times because they were again and again canceled. Finally, when I was able to board a flight, I was told that I might not be allowed to enter the country. Luckily, that was a false alarm. When I arrived at my hotel, I received the news that the hotel was shutting down. Thankfully, through the support by ETH I was able to get access to my apartment a bit earlier than planned. In the end, I was able to start my position at ETH as scheduled on April 1, 2020 (no joke 😊).

I started working at home and it took a few months until I was able to meet my new colleagues at the Institute of Geodesy and Photogrammetry and visit my office at the campus. At that time, hiring was a major challenge due to immigration restrictions. It took until September/October for my team to be fully assembled. Since then, things have settled down and I thoroughly enjoy working with the amazing people in my group.

What career path and which subjects do you teach right now?

Last semester, I taught my very first course titled "Signal Processing, Modeling, Inversion," focusing on advanced geodetic time series analysis and parameter estimation methods. Currently, I co-teach a course on "Geodetic Earth Monitoring" together with Markus Rothacher. Both courses are designed for Master students in Geomatics. Additionally, I am involved in supervising student projects in the framework of our "Space Geodesy Lab" and leading seminars related to Machine Learning in Civil, Environmental, and Geomatic Engineering for PhD students in my department.

You took the initiative to propose a new IVS Analysis Center at ETH Zurich. What is the motivation behind that? Who is a part of it?

In the past, VLBI was not a very important topic in Switzerland, especially compared to GNSS or gravity missions. It was clear to me that I wanted to take the opportunity with my new group to increase the involvement of Switzerland in IVS activities. I truly believe that the contributions of all the IVS components and working groups are fundamental to the progress that we are seeing in VLBI.

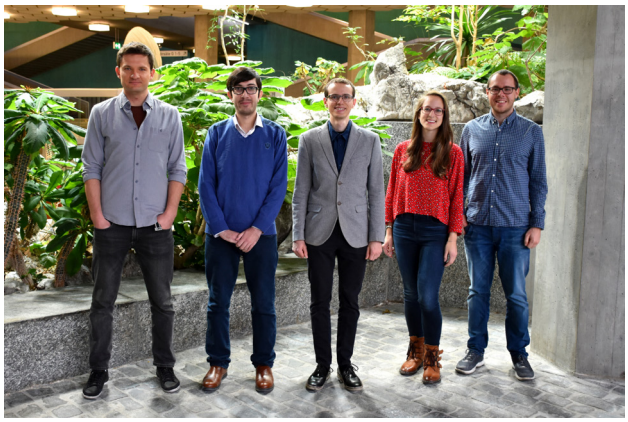
I am very happy that with Matthias Schartner and Grzegorz Klopotek, I have two very motivated VLBI experts to support me in this goal. Both are also very capable software developers. Since we don't have the manpower to re-process thousands of VLBI sessions manually, we are working on a software for automating VLBI data analysis in order to fulfill our tasks as an IVS Analysis Center.

Where do you see the focus areas of research at your institute? Why those areas of research?

Machine learning in geodesy is certainly the main focus of my group. In many other fields, including astronomy and climate sciences, machine learning has already made a lasting impact. In geodesy, these methods are not as established, although I see a growing interest. The amount of geodetic data has been growing significantly over the last decades as well as the computational power. At the same time, open-source software libraries make machine learning more accessible than ever before. Problems like anomaly detection, prediction, or data fusion can greatly benefit from machine

learning and in particular deep learning—problems that we face in geodesy, too. Machine learning will certainly not be the answer to all problems, but I believe it will become a powerful additional tool when dealing with geodetic data.

We are investigating the potential of machine learning for several geodetic use cases, including the automation of VLBI data analysis, improvement in VLBI scheduling and simulations, prediction of geodetic parameters (including station positions, tropospheric parameters, and Earth orientation parameters), as well as the detection of anomalies in time series, e.g., caused by clock breaks or earthquakes.



The Space Geodesy Group at ETH Zurich (from the left): Grzegorz Kłopotek, Mostafa Kiani, Benedikt Soja, Laura Crocetti, and Matthias Schartner. The members involved in IVS AC work are Benedikt, Matthias and Grzegorz.

Do you think that the VLBI correlation and analysis processes can be automated using artificial intelligence/machine learning?

Yes, but not exclusively by machine learning. Automation is a challenging task and requires exploring several different approaches. We are still very far away from a universal artificial intelligence that can adapt to and solve different challenges like a human being. However, machine learning is capable of surpassing humans in certain very well-defined tasks. Therefore, I believe that the best approach would be to use machine learning techniques for certain sub-tasks in the VLBI processing chain, for example clock break detection, optimal parameterization, or exploiting auxiliary data. Combined with classical approaches like decision trees (which can also be created and trained using machine learning) and a lot of exceptions for special cases, I believe a system capable of VLBI analysis is possible.

You are aware of the implementation of the VLBI Global Observing System (VGOS) and its contribution to the Global Geodetic Observing System (GGOS). The IVS aims for an accuracy of 1 mm with 0.1 mm/yr as rate in global 3D-positioning. What should be done in order to reach this goal by VLBI, SLR, and GNSS during this decade?

VGOS is a very important step toward reaching the accuracy goals. There are certainly also challenges (e.g., source structure) and I'm excited to witness the developments over the next few years in this regard.

Important issues in VLBI, in general, are certainly the uneven network distribution, the changing networks between different sessions, and the observation of individual sessions instead of continuous operations. These issues, of course, require resources to address, although I believe that through an increase in automation some improvements are possible without major investments. Furthermore, I believe there is still a lot of potential in improving the scheduling of VLBI experiments.

Thinking of the GGOS goals, the combination with other space-geodetic techniques is essential. Here, I advocate for improved consistency, particularly related to terrestrial and celestial reference frames and the Earth orientation parameters connecting them. Investigating systematic biases between the different techniques is crucial as well, and I believe that co-location in space, including VLBI observations of satellites, will become quite important in this regard.

Switzerland does not have yet its own radio telescope for geodetic VLBI. Do you think this might change during the coming years, either within Switzerland or in partnership with another country, where observations are needed to complement the VGOS network?

Although it would be nice to have, there are certainly better locations for a VLBI telescope than Switzerland, being surrounded by several existing VLBI stations. It's hard to say if Switzerland would be willing to put a costly antenna somewhere else. Nevertheless, ETH Zurich owns a GNSS network in Greece, established by Prof. Kahle, so there is a precedent. Should I get tenure at ETH, there might be opportunities for negotiating certain things—but this is, of course, highly speculative.

Benedikt at Onsala Space Observatory in May 2017.

How do you convince potential students to study geodesy at ETH Zurich?

I like to explain the importance of geodesy based on some real-world examples they might know from the news, such as the recent surveying of Mount Everest, the landing of Perseverance on Mars, or the image of a black hole from VLBI. Also, I would tell students that there is no other field with such a unique combination of mathematics, physics, engineering, and Earth and space sciences than geodesy!

Benedikt indulging his favorite hobby of unicycling in the Zermatt region, with the famed Matterhorn mountain as a backdrop.

Some of us know about your leisure time passion for unicycling. Tell us more about it.

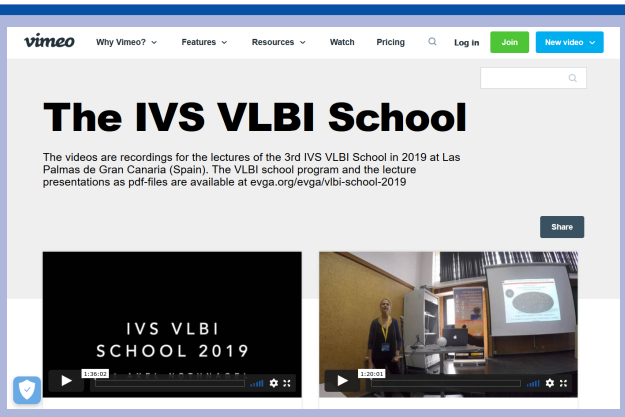
Indeed, by far my favorite hobby is unicycling, especially in the mountains. I'm happy that I'm now living so close to the Swiss Alps, which are a great location for this activity. For me, unicycling means being balanced—not only as this is required to actually ride; it also contributes to a better work-life balance. Also, I simply love the challenge—just like with my new job.

I just realized that I started unicycling about ten years ago, the same time when I became involved in VLBI! I certainly have had lots of great experiences in both these domains. 😊

Thank you very much, Benedikt, and we wish you lots of success in your activities. — Interview by Hayo Hase

Stream the Lectures of the 3rd VLBI School on Vimeo

The lectures from the 3rd IVS VLBI Training School are now available for streaming on the video hosting and services platform Vimeo, using Kartverket's vimeo channel. In a Web browser, go to the following URL: *https://vimeo.com/showcase/the-ivs-vlbi-school*. The accompanying presentation files can be downloaded from the school website in PDF format. Many thanks to Kartverket and to the lecturers for making this possible.



Upcoming Meetings...

EGU General Assembly
Gather online
April 19 – 30, 2021

Eleventh IVS Technical Operations Workshop
Virtual Meeting
May 3 – 5, 2021

IAG Scientific Assembly
Bejing, China
June 28 – July 3, 2021

URSI General Assembly and Scientific Symposium
Rome, Italy
August 28 – September 4, 2021

GGOS/IERS Unified Analysis Workshop
Munich, Germany
October 5 – 8, 2021

GGOS Days 2021
Munich, Germany
October 11 – 15, 2021

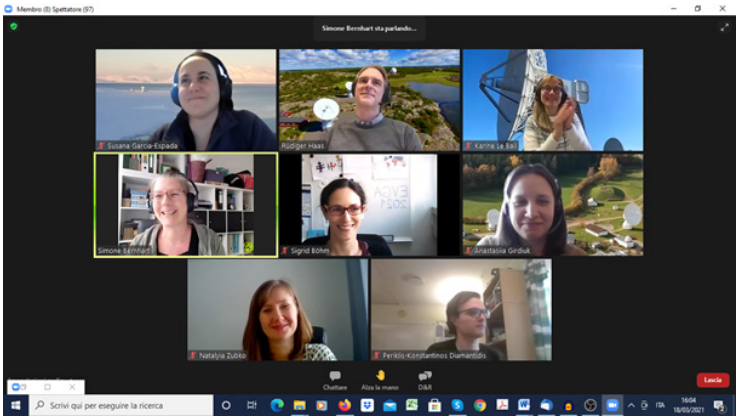
International Data Week 2021
Seoul, South Korea
November 13 – 17, 2021

AGU Fall Meeting
New Orleans, LA, USA
December 13 – 17, 2021

https://ivscc.gsfc.nasa.gov/meetings

EVGA2021 Held Successfully in Cyberspace

– Rüdiger Haas, Onsala Space Observatory and Susana García-Espada, Kartverket



The members of the VOC and SOC who worked together for organizing the EVGA2021 and putting together the scientific program.

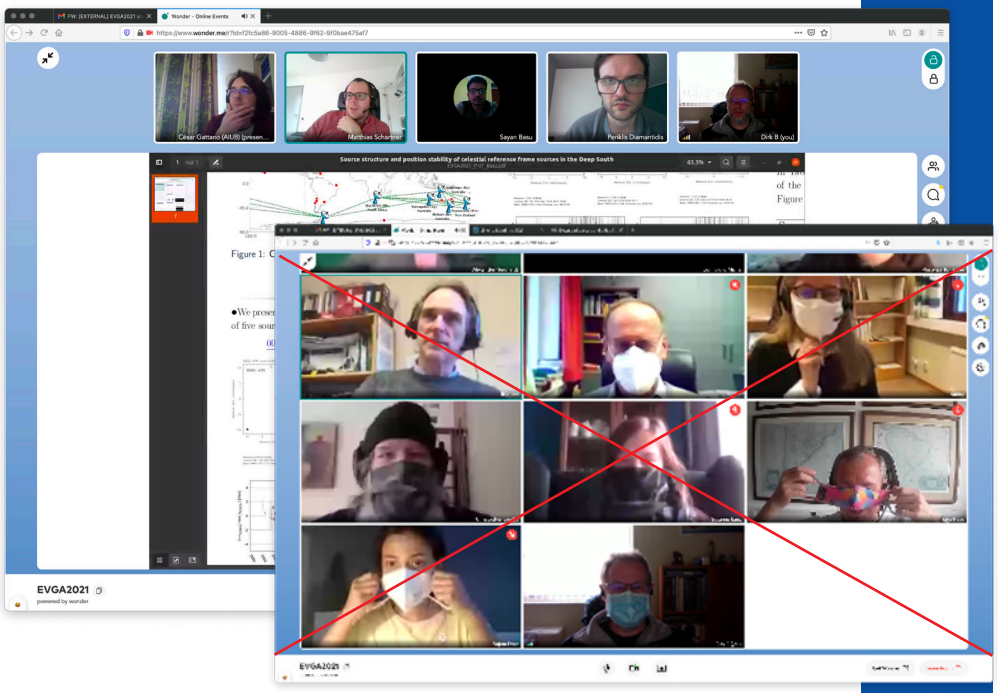
The 25th Working Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA) was held in the period March 14–18, 2021. It was originally planned to have the EVGA2021 at Paris Observatory; but because of the travel restrictions due to the COVID-19 pandemic, this was impossible to realize. Instead, the meeting was held as a virtual event in Cyberspace.

It was a challenge to organize a scientific meeting in virtual space, and the Virtual Organizing Committee (VOC) tried to keep the "traditional EVGA events" for EVGA2021. The "icebreaker party" was held on Sunday, March 14, just before kicking off the full agenda with scientific presentations and meetings on the following days. The Internet platform 'wonder.me' was used as the application for the icebreaker party and it turned out to be very useful to have a first contact with colleagues in an informal way.

For the actual conference program, the VOC arranged access to online conference webinars on Zoom, as well as corresponding poster, video, and discussion sessions. The latter were arranged using the same Internet platform as for the icebreaker party, since this allowed group discussions in smaller groups. A splinter meeting on source selection and scheduling on March 17 and an IVS Analysis Workshop on March 18 were arranged via standard Zoom sessions.

The Scientific Organizing Committee (SOC) consisted of six female and one male researcher from five different European countries. It was the first EVGA SOC where women constituted the majority at 85%. A total number of 70 scientific contributions had been submitted, resulting in 48 talks, 18 posters, and four movies that were presented and discussed during EVGA2021. Detailed information on the program and the presentations are available at https://www.chalmers.se/en/conference/EVGA2021/.

The SOC tried to arrange the agenda in the best way to adjust to the presenters' local times (from Australia to the United States' west coast). The agenda started at 11:00 UT and went through 17:00 UT. There were three sessions with oral presentations every day, with four presentations each. The oral presentations were planned to be 15 minutes long each, and different chairpersons from the SOC moderated the different sessions. During the first three days there were poster, movie, and discussion sessions after the oral presentations. All posters were made available on the conference webpage so that the interested audience had a chance to download them in advance and read the posters. Each day, different posters and videos were discussed in detail. There were very interesting discussions and conversations, allowing many people to participate. Taking advantage of the online format, the video presentations were available online and could be watched at any time. The discussions were fruitful and the interest from participants was big.

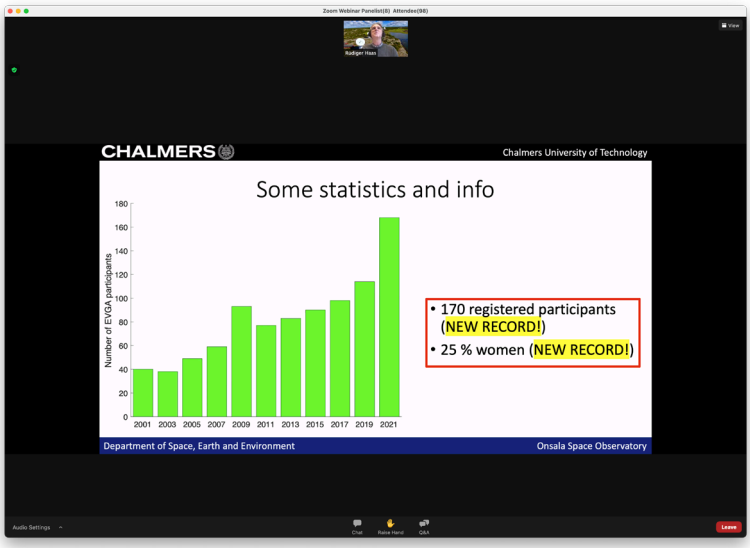


No facemasks needed to meet colleagues at the EVGA2021 during the icebreaker party and poster discussions.

With a total number of 170 registered participants and 25% women attending the meeting, EVGA2021 set a new record in the number of participants and female participants. Colleagues from all over the world participated and attended the meeting.

We would like to thank everyone who contributed to, participated in, and attended the meeting. It was great having you and talking to you. We have the impression that EVGA2021 was a great success; this would not have been possible without you. Thank you!

We are looking forward to meeting you again for the 26th Working Meeting of the EVGA in 2023, which is planned to be organized by GFZ Potsdam, Germany. We hope that everyone will be able to attend in person. Finally, please take care, stay healthy, and get vaccinated!



EVGA2021 set new records for the number of participants and the female share in participation.

Results of the At-Large Elections

With great pleasure I can inform you that the IVS Directing Board elected

- Aletha de Witt, South African Radio Astronomy Observatory (SARAO), South Africa
- Nadia Shuygina, Institute of Applied Astronomy RAS (IAA), Russia
- Yu Takagi, Geospatial Information Authority of Japan (GSI), Japan

as the new Members At-Large for the next two years. Congratulations to all of them. Their term will start on March 1, 2021.

– Axel Nothnagel

T2++ Countdown!

– Nancy Kotary, MIT Haystack Observatory

Originally published on January 12, 2021.

IVS stations will be performing a historic set of observations called "T2++" sessions on January 12, 2021, and on November 30, 2021. In these two sessions, 24 and 28 IVS radio telescopes, respectively, will be participating, and will perform a series of simultaneous observations of quasars as fixed reference points on the sky. The main goal of the T2 sessions is to include as many of the legacy S/X geodetic VLBI antennas as possible for state-of-the-art determinations of their present coordinates.

Generally, T2 sessions are regularly scheduled approximately bi-monthly for tying more active stations to the less frequently used ones to obtain the coordinates of all of them in joint observing sessions and evaluate network resources on a regular schedule. For compatibility and other infrastructure reasons, these sessions are generally limited to 12–14 telescopes each. Consequently, the enhanced T2++ sessions provide an enormous step forward in network configuration and in the results achievable.

In the IVS naming structure, the "T" stands for "TRF," or the Terrestrial Reference Frame. A terrestrial reference frame comprises a network of points on Earth with very precise coordinates as the basis of studies of global change such as global sea level rise. The "2" indicates that the sessions take place on the second day of the week. And the "++" indicates the increased sensitivity of precision with which the station positions are measured.

Another distinction of the T2++ sessions is that they will be observed with an enhanced observation mode with larger data rate of 512 megabits per second and an increased spanned frequency bandwidth of 720 MHz. Each telescope will record approximately 4000 terabits or 500 terabytes of raw observation data within the 24-hour observing sessions. All this data must then be transferred to a central correlation facility for processing and analysis either via the Internet or on magnetic disc systems with courier services.

More information will be provided after the sessions' data is correlated and analyzed.

Thanks to Axel Nothnagel, Dirk Behrend, and Arthur Niell for editorial assistance.

The EVGA community re-elected Rüdiger Haas as the Chair and Susana García-Espada as the Secretary of the group.

FROM THE VGOS WORLD...

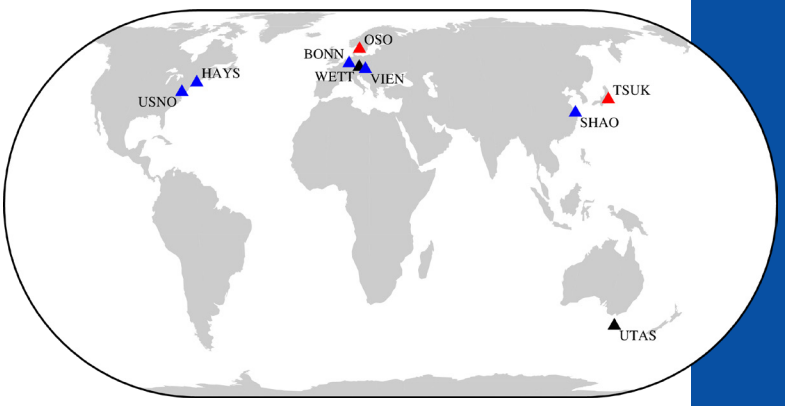
VGOS Operations in 2021

– Dirk Behrend, NVI, Inc./NASA GSFC

After years of testing and improving the various signal chains and operational procedures, the fledgling VGOS observing network was declared operational at the beginning of 2020. The former VGOS-Test sessions (VT sessions) were renamed to VGOS-O sessions (VO sessions); however, the cadence of the 24-hour sessions during 2020 remained at every two weeks. The vgosDB of the VO sessions are available on the data centers as are the VT sessions from 2019. Further, starting in late February 2020 VGOS Intensive sessions (V2 series) on the primary baseline K2-Ws were observed in the non-VO weeks (adding select stations for evaluation purposes). With very few exceptions towards the end of 2020, most sessions had Haystack as the target correlator.

In 2019 and 2020 strides were made to establish VGOS-readiness at several correlators. The verification process commenced with a correlation workshop in May 2019 and was continued with correlation and post-processing comparisons using benchmark data sets of 1 hour and 24 hours. A hands-on "blind test" using the raw station data from a VGOS Intensive verified that results agree within the margin of errors (after a couple of iterations). The final verification was done with an operational 24-hour session (vo0009). It verified and validated VGOS correlation end-to-end for five correlators. Both Bonn and USNO started with operational sessions towards the end of 2020, while Shanghai and Vienna followed in early 2021. In addition, also Onsala and Tsukuba established VGOS correlation capabilities.

Given the improved VGOS infrastructure, the VGOS observing program for 2021 foresees an increased number of sessions. For the first half of the year, it is planned to continue the two-weekly cadence for the VGOS-O sessions, while in the second half a weekly cadence is anticipated. The correlation will involve five correlators which will rotate through the various sessions. After a brief adjustment period



VGOS correlation capabilities of the IVS correlators (blue – operational, red – under verification, black – future correlator).

of 1.5 months with one weekly V2 session, the following months until July will see twice weekly VGOS Intensives. For the second half of the year, it is foreseen to eventually go to five weekly V2s, all in parallel to the legacy INT1 sessions. All of these VGOS Intensive sessions are scheduled for correlation at USNO. These plans may slip if resource limitations dictate a temporary scaling back.

The main limitations are currently data transport (e-transfer capacities at stations and correlators, acceptance of Mark 6 modules) and data storage. However, also the correlation and station resources need to be further developed to get closer to the VGOS goals. In addition to the general IVS VGOS work, there are also local/regional VGOS activities underway (e.g., EU-VGOS, Is-Oe/Ow Intensives).

The IVS Newsletter is published three times annually, in April, August, and December. Contributed articles, pictures, cartoons, and feedback are welcome at any time.

Please send contributions to the General Editors (see below).

The editors reserve the right to edit contributions. The deadline for contributions is one month before the publication date.

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The newsletter is published in color with live links on the IVS web site at

https://ivscc.gsfc.nasa.gov/.

Raw Correlator Output Available at CDDIS

The Level 1 data (fringe visibilities or SWIN files; see also IVS Resolution 2019-02 at *https://ivscc.gsfc.nasa.gov/about/resolutions/IVS-Res-2019-02-AnalysisLevels.pdf*) are now available for select VGOS sessions in the ivsdata section of the data center at the CDDIS: *https://cddis.nasa.gov/archive/vlbi/ivsdata/swin/*. The files are grouped by year and then time ordered. The earliest SWIN files stem from the VGOS demonstration network of CONT17 (that is, CONT17-VGOS), while more recent files encompass VGOS-O and V2 sessions. Analysis groups are invited to look into starting their processing with the Level 1 Analysis including polarization combination and fringe fitting. It is foreseen that the correlators upload further VGOS sessions in the future and that the large files be mirrored to the BKG data center.

– Dirk Behrend

How To...

2021 Virtual TOW Operations Workshop: Pre-checks and System Checkout

– Mike Poirier and Alex Burns, MIT Haystack Observatory

In this year of worldwide disruption from the COVID-19 virus, we have had to change to more of a virtual world. Our worldwide VLBI operations and science, including the upcoming TOW meeting, have all been forced to adapt. Most of us have been unable to travel to support specialized repairs at stations and had to reply on emails, phone calls, and zoom conferences to guide station operators through most operational issues.

Our COVID-safe separation and space rules, required at most antenna sites, have created a more important need for consistently using our pre-operational checklists and station-specific operational guidelines. Both of these documents should be constantly updated and available at all times to operators for usage and review. When any updates or changes are made, they should be vetted by others so to make sure nothing is overlooked.

The upcoming TOW's session operations format is planned to be a live interactive discussion focusing on station setup, operations, and problems. Our hope is to encourage all of our station operators to discuss their concerns and troubles with their systems, so to help better identify issues and direct everyone to a successful solution.

Every operator and every station have made mistakes, causing data loss. All our pieces of equipment have either failed or got into a state that caused data loss. Our job as operators is to first minimize human errors in setup, operate our systems, and then learn how to quickly recover from equipment failures in the field. Operational recovery at a station is not an engineering study on why something failed; rather, it is a quick analysis to determine what has failed and identifying the steps to get our stations back to recording high-quality data.

We are looking forward to seeing all of you at the virtual TOW!

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