Norwegian Mapping Authority Analysis Center Report

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Abstract During 2021 and 2022, the Norwegian Mapping Authority Analysis Center has contributed to the ITRF2020 and the operational daily SINEX product. The Analysis Center has participated in several working groups and projects and continued the development of the analysis software **Where**. The Analysis Center has also investigated the performance of the NYALES20-NYALE13S baseline. The Analysis Center has successfully transitioned to the new VLBI naming convention and will continue with its current activities.

1 General Information

The Norwegian Mapping Authority (NMA) has been an Associate Analysis Center within the IVS since 2010. The Analysis Center is operated by the Geodetic Institute at NMA with its headquarters in Hønefoss, Norway. NMA is a governmental agency with approximately 800 employees, and the IVS activities at NMA are completely funded by the Norwegian government.

NMA is using the analysis software **Where**, which is developed at NMA. **Where**[1] and its companion library **Midgard**[2] are freely available as open source at GitHub. **Where** is at the moment capable of analyzing single sessions of VLBI data. Efforts have been made to be able to analyze weekly SLR data with **Where**, but this work is currently halted. **Where** has also been developed to do some special analysis within the GNSS domain, but this is not a part of the open source code.

2 Staff

The Geodetic Institute at NMA is led by Per Erik Opseth and has approximately 50 employees. Some of its responsibilities include maintaining the national reference frame, geoid, and height system. The Geodetic Institute also provides a network-RTK positioning service and operates the VLBI stations in Ny-Ålesund [3].

The Analysis Center was a part of a department called Global Geodesy in 2021 and 2022. Global Geodesy was one of four departments in the Geodetic Institute. In June 2022 Zeljka Jakir replaced Hans Christian Munthe-Kaas as the head of the department. At the end of 2022, the department Global Geodesy ceased to exist and a new organizational model was implemented.

The VLBI analysis group consists of one software developer and three part-time analysts (see Table 1). The development of the SLR analysis is led by Ingrid Fausk, while the development of the GNSS applications is led by Michael Dähnn.

Table 1 NMA Analysis Center staff.

Name	Role
Ann-Silje Kirkvik	Developer and analyst
Åsmund Skjæveland	Analyst
Hans Sverre Smalø	Analyst

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[1] https://kartverket.github.io/where

[2] https://kartverket.github.io/midgard

3 Activities during the Past Two Years

For the NMA Analysis Center, the years 2021 and 2022 have involved many different activities. These include finalizing the ITRF2020 submission, operational submissions for the daily SINEX product, and participation in working groups and projects. In addition, the Analysis Center has kept an extra eye on the performance of the stations in Ny-Ålesund and continued the development of **Where**.

3.1 ITRF2020

For the first time since NMA became an analysis center within the IVS, the Analysis Center has contributed to the realization of the International Terrestrial Reference Frame: ITRF2020. Most of the analysis and necessary software updates to **Where** were done prior to 2020 [8]. But the final analyses for the ITRF2020 and submissions to the IVS Combination Center were done in April 2021.

For the ITRF2020 contribution, the individual analysis centers processed historical 24-hour VLBI sessions from 1979 until the end of 2020. This includes over 6,500 S/X sessions and 38 VGOS sessions. In total eleven analysis centers contributed to the ITRF2020 using seven different software packages [5].

3.2 Daily SINEX

Since 2019 NMA has submitted processed VLBI sessions routinely in the form of normal equations in the SINEX format (Solution INdependent EXchange format). This is an analysis product that provides estimates of Earth orientation and site positions for each 24-hour session. For the rapid sessions R1 and R4, a timely turnaround of 14 days from observation to final product is desired. These sessions provide up to date Earth Orientation Parameters (EOP) to the global community. The contribution from NMA is included in the IVS combined solution.

In addition to processing R1 and R4 sessions, the Analysis Center also processes and submits SINEX files for VGOS, T2, and RV sessions. The submitted solutions can be found at the IVS Data Centers with the solution code `2020a`.

3.3 Ny-Ålesund

In February 2020 the new VLBI station NYALE13S had its first successful 24-hour session with a tri-band receiver. The goal was to have parallel observations with NYALE13S and NYALES20 to be able to confirm that the two stations have the same velocity. There have been many technical issues with the stations since then [3], but a decent number of parallel sessions have been observed. The NMA Analysis Center has looked more closely into these sessions [4]; see Figure 1 for an up to date analysis of the baseline length and its repeatability. The formal error of each individual session is a bit higher than desired. The performance of the NYALES20–NYALE13S baseline will have an impact on the decision on when to dismantle the NYALES20 antenna. But the condition of the antenna with necessary repair costs will have a higher impact.

3.4 Working Groups and Projects

The NMA Analysis Center has participated in several working groups and projects.

3.4.1 EU-VGOS

The EU-VGOS project began in 2018 with the aim of using the VGOS infrastructure in Europe to investigate methods for VGOS data processing. The project is now structured into Working Groups dealing with operations (stations), e-transfer, correlation and post-processing, and analysis [2]. NMA is participating in the analysis and operations working groups. One of the planned activities of the analysis working group is to look more closely at higher resolution troposphere estimates. Normal S/X sessions typically estimate the zenith wet delay part of the troposphere every hour, but with the increased number of observations that VGOS is capable of achieving, it should be possible to estimate troposphere parameters every 20 minutes. So far, there are not too many sessions available in the

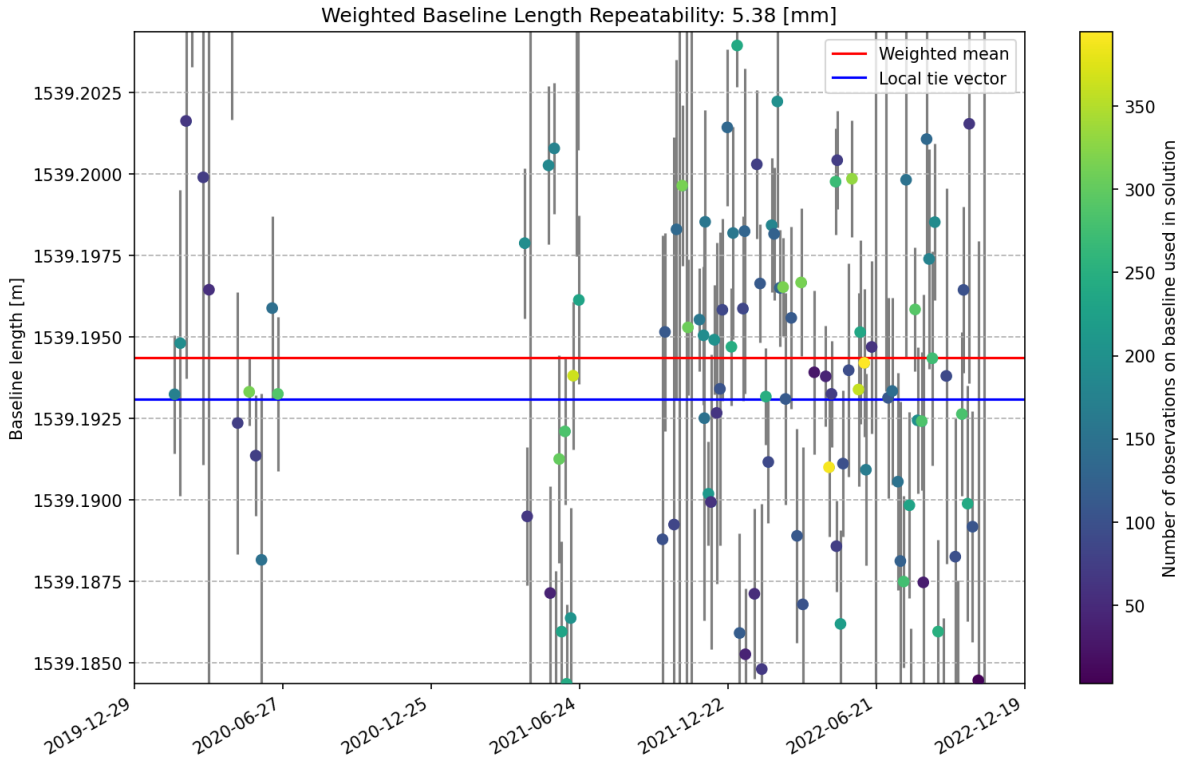

Fig. 1 NYALES20–NYALE13S baseline lengths and weighted baseline length repeatability.The red line is the weighted mean of the individual solutions, and the blue line is the local tie vector.

EU-VGOS project. Further activities are planned once different correlation methods are being tested.

3.4.2 Six-hourly EOP Piecewise Linear Offset Parameterization

For a long time there has been a desire within the IVS to be able to estimate Earth Orientation Parameters (EOP) at specific epochs to better align the results with EOP estimates from other space geodetic techniques. In addition, it is interesting to investigate the feasibility of providing EOP estimates at a higher resolution than 24 hours, which is common today. A project, led by Axel Nothnagel, was established to look into this possibility.

By modeling the EOP as continuous piecewise linear functions, the project estimated the Earth Rotation Parameters (ERP) polar motion and UT1-UTC every six hours starting at midnight. The project used R1 sessions from 2020 and fixed the celestial pole offset to an empirical model for 2020. The preliminary results show that robust networks with many observations per time interval are essential for this approach [1].

3.4.3 VLBI Scale

When Zuheir Altamimi and his team created the ITRF2020, it became apparent that there is a drift in the VLBI scale after 2013.75, and the reasons for this drift are unknown [6]. After the IVS 2022 General Meeting, the IVS Directing Board decided to create an ad hoc working group to investigate this drift. The working group, led by John Gipson, presented the preliminary results of this investigation at the Unified Analysis Workshop in Thessaloniki, Greece, in October 2022 [7]. The reasons for the drift in the VLBI scale are still not fully understood. Figure 2 shows the scale drift computed with **Where**.

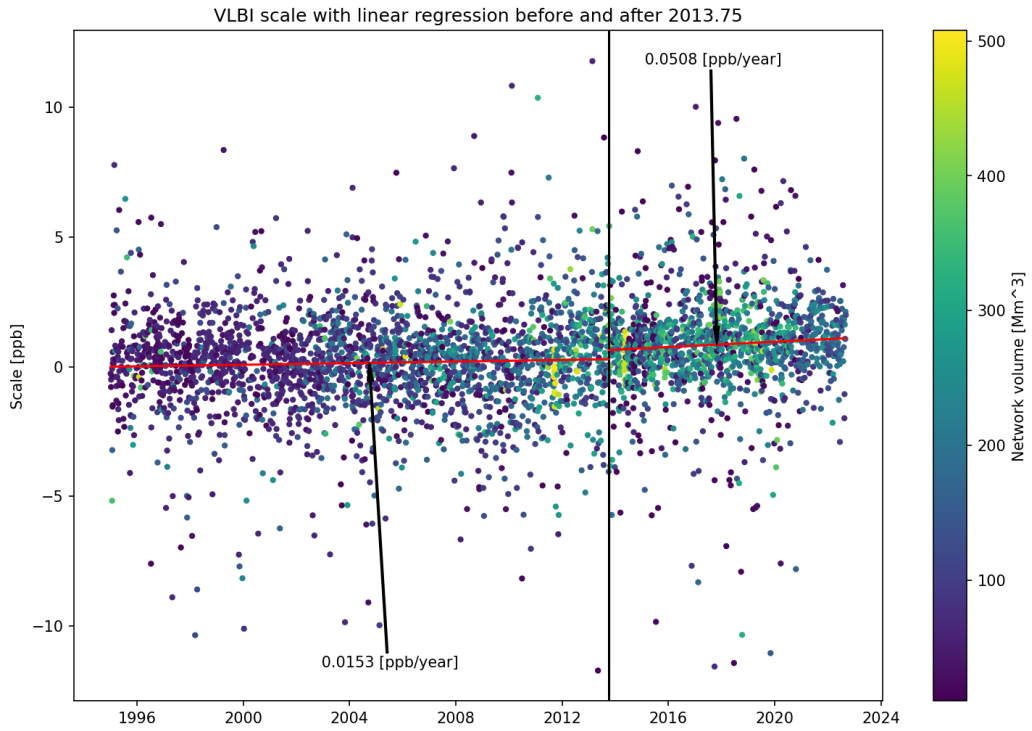

Fig. 2 VLBI scale with regard to ITRF2020 computed with **Where**. The vertical black line is the epoch 2013.75 and the red lines are a linear regression of the sessions before and after 2013.75.

3.5 Where

At the beginning of 2023 a new naming convention for VLBI data files and a new format for the VLBI master file will be implemented. This change required updates to **Where**, and a new version has been made available to the community.

To be able to participate in the working groups, new features have been added to **Where**, such as the possibility of estimating parameters as continuous piecewise linear functions and computating session-wise Helmert parameters.

In addition, several minor improvements and bug-fixes have been implemented during 2021 and 2022.

4 Current Status

Currently, the NMA Analysis Center is working on the transition to the new naming convention. The transition seems to be successful so far.

A new operational solution, `2023a`, for the daily SINEX product is under way. This solution will use ITRF2020 as the a priori for station positions and velocities and include the new gravitational deformation models that have been added since the prior solution.

5 Future Plans

NMA will continue with the operational analysis of 24-hour sessions and contribute to the daily SINEX product. This also involves keeping **Where** up to date with current conventions.

NMA also intends to continue participating in analysis working groups and projects when time allows and the scope of the work is within the capabilities of **Where** and the Analysis Center.

As NYALE13N starts to observe more VGOS sessions, these sessions will be of special interest to the NMA Analysis Center in the near future.

References

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