Norwegian Mapping Authority Analysis Center Report

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Abstract During 2023 and 2024, the Norwegian Mapping Authority Analysis Center has contributed to the ITRF2020 update (ITRF2020-u2023) and the operational daily SINEX product using the analysis software **Where**. NMA has also participated in the IVS Working Group on VLBI Scale (WG9), and the Analysis Center continues to investigate the performance of the VLBI stations in Ny-Ålesund. If the NMA gets funding through the ESA program PRODEX, **Where** will be further developed to support VLBI observations of the Genesis satellite.

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 the headquarters in Hønefoss, Norway. NMA is a governmental agency with approximately 750 employees, and the IVS activities at NMA are so far 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.

Norwegian Mapping Authority (NMA)

NMA Analysis Center

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

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

Where is at the moment capable of analyzing single sessions of VLBI data. Some scripts are also provided to investigate the results of the single session analysis.

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 [1].

Table 1 NMA Analysis Center staff.

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

In 2023 and 2024, the Analysis Center belonged to a team centered around global reference frames. Among the members were Halfdan Pascal Kierulf working on reference frames and national and regional land uplift models and Laila Løvhøiden working towards the establishment of the UN-Global Geodetic Center of Excellence (UN-GGCE). This team also included the station leader in Ny-Ålesund, Susana Garcia-Espada, and Leif Morten Tangen assisting with the operations in Ny-Ålesund from the main office in Hønefoss. Ole Johan Klingan, who is working to acquire the new SLR instrument that will be installed in Ny-Ålesund, was the team leader in this period. The

daily activities of the Analysis Center were operated by a small group consisting of one software developer and three part-time analysts (see Table 1).

3 Activities during the Past Two Years

The activity level for the NMA Analysis Center has been reduced in the years 2023 and 2024 due to lack of resources. The Analysis Center has maintained the submission of the daily SINEX product and contributed to the updated ITRF2020. The development of **Where** has been reduced to a minimum in this period. Halfdan Pascal Kierulf is participating in the IVS Working Group on VLBI Scale (WG9), and some additional data analysis has been performed to investigate and monitor Ny-Ålesund specifically.

3.1 IVS Working Group on VLBI Scale

In the previous period, NMA participated in the IVS task force on scale [2] with two members. When the task force was formally changed to a working group, NMA joined with one member. In this working group NMA has studied the non-linear uplift due to glacial loading in Arctic areas. The effect on the VLBI station in Ny-Ålesund is considerable. Due to the non-linear nature of this uplift it can map into other reference parameters and explain parts of the VLBI-scale drift in ITRF2020. The work was presented at EGU2024.

3.2 Daily SINEX and ITRF2020 Updates

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 most 24-hour sessions. When ITRF2020 was released, the entire VLBI history was reprocessed, and this is the latest solution that is currently being updated. The submitted solutions can be found at the IVS Data Centers with the solution code `2023a`.

There is also a second solution named `2023b` which is identical to `2023a`, except that it does not contain corrections for non-tidal atmospheric loading. This solution is used for ITRF2020 updates and is updated annually when a new ITRF2020 update is planned.

3.3 Ny-Ålesund

In February 2020, the new VLBI station NYALE13S had its first successful 24-hour session with a tri-band receiver. Since then, the baseline NYALE13S–NYALES20 has been monitored to investigate performance of the new station [2]. In September 2023, the NYALES20 antenna was dismantled, and this baseline will no longer be updated with new data [3]. When more sessions with both the NYALE13S and NYALE13N antenna recording together are available, the monitoring of a local baseline in Ny-Ålesund can continue. In this case, it will be useful to compare with other local baselines with two VGOS receivers.

At the general meeting in Tsukuba in 2024, the question was raised about the elevation mask used at the NYALE13S (and NYALE13N) antenna(s). The elevation mask is set to 15 degrees to avoid destroying the Low Noise Amplifiers (LNA) when boats with radar are in the harbor. The question is whether this high elevation mask degrades the solution and specifically the height component of the station coordinate. Some efforts have been made to investigate this, but more work is needed. The risk of destroying the LNAs is prohibiting the collection of data with lower elevation for comparison. There are, however, a few sessions from 2020 with some observations below 15 degrees. This was not intended, but luckily there was very little cruise traffic in Ny-Ålesund during the COVID-19 pandemic, and the amplifiers were not destroyed.

The baseline length repeatability of the NYALE13S–NYALES20 baseline is higher than the comparable baseline WETTZELL–WETTZ13N.

The reason for this is unknown, but preliminary analysis shows that the baseline length repeatability is degraded more by removing all lower elevation angle observations than when removing a similar number of observations at random elevation angles. See Table 2. Can the high elevation mask explain some of the higher baseline length repeatability in Ny-Ålesund?

Table 2 Weighted baseline length (WBL), weighted baseline length repeatability (WBLR), and the difference between weighted baseline length and local tie vector (dL) for the different baselines. The second column describes which criteria have been used to discard observations (for all stations in the session). Ns–Ny is the NYALE13S–NYALES20 baseline, and Wz–Wn is the WETTZELL–WETTZ13N baseline. The number of observations discarded is the same for the 15 degrees and random scenarios.

Baseline	Scenario	WBL	WBLR	dL
Ns–Ny	no discard	1539.1940 m	5.22 mm	0.88 mm
Ns–Ny	15° elevation	1539.1944 m	6.42 mm	1.26 mm
Ns–Ny	random	1539.1941 m	5.44 mm	1.02 mm
Wz–Wn	no discard	123.3069 m	2.81 mm	−0.14 mm
Wz–Wn	15° elevation	123.3064 m	3.66 mm	−0.58 mm
Wz–Wn	random	123.3069 m	2.73 mm	−0.10 mm

4 Current Status

Currently, the Analysis Center is preparing a submission for the next ITRF2020 update (ITRF2020-u2024). Contributions to the regular daily SINEX product continue as normal. The daily SINEX product will switch to a new solution using the ITRF2020-u2023 as a priori when the IVS agrees upon a date to perform the switch. The IVS also needs to decide how many old sessions should be reprocessed for each yearly ITRF update.

5 Future Plans

NMA is in the process of applying for funding through the ESA program PRODEX. If the application is accepted, part of the funding will be used to continue the development of **Where**. Specifically, functionality will be added to **Where** to enable processing of VLBI sessions tracking the Genesis satellite[3].

References

1. Susana Garcia-Espada et al. “Status at Ny-AA lesund Geodetic Earth Observatory”, In IVS 2022 General Meeting Proceedings, edited by K. Armstrong, D. Behrend, and K. Baver, NASA/CP-20220018789, 2023
2. Ann-Silje Kirkvik, “Norwegian Mapping Authority Analysis Center Report”, In International VLBI Service for Geodesy and Astrometry 2021+2022 Biennial Report, edited by K. L. Armstrong, D. Behrend, and K. D. Baver, NASA/TP-20230014975, 2023.
3. Susana Garcia-Espada et al., “Ny-Ålesund Geodetic Observatory”, In International VLBI Service for Geodesy and Astrometry 2023+2024 Biennial Report, this volume.

[3] https://www.esa.int/Applications/Satellite_navigation/Genesis