Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 455 (P-5), 2025, pp. 129–130
DOI: 10.25171/InstGeoph_PAS_Publs-2025-103
40th International Polar Symposium – Arctic and Antarctic at the Tipping Point, 4–7 November 2025, Puławy, Poland

Ice Mass Variation at Svalbard Observed by GNSS Sites Position Changes

Marcin RAJNER

Faculty Geodesy and Cartography, Warsaw University of Technology, Warsaw, Poland

✉ marcin.rajner@pw.edu.pl

A b s t r a c t

In this paper we present long-term position changes of permantent GNSS sites located at Svalbard. These variations, along with crust physical properties, are utilized to infer ice mass loading changes. We found good agreement of our indirect estimation with values provided by classic glaciology. This study shows that this passive method can be easily applied for regional ice mass varaiation assesment, however with sparse GNSS network, any regional discremination is still challenging.

1. INTRODUCTION

Permanent sites of Global Navigation Satellites Systems (GNSS) usually serves as reference for terrestrial differential measurements, but they can be used for many other purposes. Using state of the art processing methods we are able to obtain daily and sub-daily position at a few millimeter accuracy at global frame. Variation in position can stem from many geophysical factors, but at Svalbad we observe dominant change in height component of 1 centimeter per year. This is mainly due to present day ice melting (PDIM) and glacial isostatic adjustment (GIA). Separating this two phenomena is challenging but possible. The rates of height changes are directly related with variation of crust loading. From this values we are able to recover regional ice mass changes. Within this work we show expanded version of previous estimates (Rajner 2018; Kierulf et al. 2022).

2. METHODS DATA AND PROCESSING

We used several permanent sites located at Svalbard at Hornsund, Ny-Alesund, Longyearbyen. This sites serves in global and European GNSS services. In this work we present for the first time very long time series from Hornsund with data not published previously. We used most advanced processing software for reliable and precise position estimates. We also used several

numerical data to get the best fitting ice mass variation. These computation was done by means of Greens functions for crust deformation due to variable load.

3. RESULTS

We found very good agreement of our estimates with other studies of 15 Gt per year. We were also able to indicate periods with increased rates of ice loss. The seasonal variation was also retrieved. All of these variations are based on height changes rates. Interestingly we observed also variation in length of baselines which also can be attributed to loading variation. These horizontal component add some more information but is usually neglected.

4. CONCLUSIONS

We presented method to indirectly interfere ice mass variation from GNSS sites position variation. This method can be easily adopted, and give additional information to classic mass budget methods.

References

Kierulf, H.P., J. Kohler, J.-P. Boy, E.C Geyman, A. Mémin, O.C.D. Omang, H. Steffen, and R. Steffen (2022), Time-varying uplift in Svalbard—an effect of glacial changes, *Geophys. J. Int.* **231**, 3, 1518–1534, DOI: 10.1093/gji/ggac264.

Rajner, M. (2018), Detection of ice mass variation using GNSS measurements at Svalbard, *J. Geodyn.* **121**, 20–25, DOI: 10.1016/j.jog.2018.06.001.

Received 15 September 2025
Accepted 20 October 2025