Mapping Multi-scale Surface Changes on Negribreen Glacier, Svalbard, during Surge using ICESat-2, Sentinel-1 and Airborne Field Data

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Abstract

The Negribreen Glacier System on the east coast of Spitsbergen, Svalbard, has been actively surging since 2016, i.e., during the entire lifetime of ICESat-2 (launched in September 2018). The progression of Negribreen’s surge throughout the glacier system has resulted in large-scale elevation changes and wide-spread crevassing, which is ideally mapped and analyzed using ICESat-2 measurements processed by the Density Dimension Algorithm for Ice (DDA-ice) (see Herzfeld et al. 2016, IEEE TGRS, and Herzfeld et al., 2022, Science of Remote Sensing).

In this analysis, we quantify how Negribreen has been evolving in its mature surge phase over the course of 2019 and 2020. Using ICESat-2 data, together with airborne field data and Sentinel-1-derived velocity data, we quantify large-scale effects such as elevation-change and mass transfer through the system, as well as smaller-scale effects afforded by high-resolution data products of the DDA-ice such as crevasse characterization, surface roughness and changes thereof.

Results show the expansion of the surge in upper Negribreen where increased crevassing has occurred along with height change rates nearing 30 m/year. In addition, fresh surge crevasses formed along the margin between the surging ice of Negribreen and non-surging ice of neighboring Ordonnansbreen. Finally, increased surge activity found on inflowing glaciers from the Filchnerfonna accumulation zone suggest that surge effects may continue to expand up glacier leading to further disintegration of the ice system with continued mass loss.
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Results show the expansion of the surge in upper Negribreen where increased crevassing has occurred along with height change rates nearing 30 m/yr. In addition, fresh crevasses formed along the margin between the ongoing ice of Negribreen and non-surging ice of neighboring Ordonnansbreen. Placed increased surge activity resulted in advanced crevasses from the Filchnerfonna accumulation zone suggest that surge effects may continue to expand up-glacier leading to further disintegration of the ice system with continued mass loss.

Imagery from Field Campaign in August 2019

In response to the surge, the Geomatics Laboratory, Remote Sensing and Cryospheric Sciences Group at the University of Colorado, Boulder, conducted three airborne survey campaigns of the glacier system in the summers of 2017, 2018 and 2019, collecting laser altimetry and GPS measurements together with imagery (see Herzfeld et al., 2022, Remote Sensing).

Figure: ICESat-2 RGT Time Series Results over Negribreen

(1) Detection of new surge crevasses and changing in existing crevasse fields in Upper Negribreen:

Sentinel-1 Velocity Maps

Figure: (Left) Mean surface velocities between 2019-06-11 to 2019-08-23 (m/yr). This baseline spans the 2019 airborne survey campaign in August 2019. (Right) Mean surface velocities between 2020-07-10 to 2020-07-22 (m/yr) with peak surge epochs occurring 8 m/yr. July typically sees the fastest ice-surface speeds in Negribreen.

Elevation and Roughness Change

Surface Height Rate of Change (ΔH/Δt)

Figure: (Top) Rates of change of glacier surface height during the 2019 surge part of the recent Negribreen surge (m/yr). (Bottom) Rates of change of roughness during the 2019-2020 part of the recent Negribreen surge. Roughness (respound) change into decompos per year.

Roughness Rate of Change (respond)

Figure: (Top) Roughness rates of change during the recent Negribreen surge of the last decade. (Bottom) Roughness rates of change into decompos per year.

Deployments

- ICESat-2
- Sentinel-1
- Airborne Measurements

Contact Info, Acknowledgements and Reference

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Paper Preprint: Trantow, Thomas; Thomas and Eric C. Bindley. Proportion of the surge to the Negribreen Glacier System from (1) data of ICESat-2 measurements, (2) data of altimetry, (3) data of trantow@colorado.edu, and (4) data of ute.herzfeld@colorado.edu. (Earth ArXiv preprint)

Figure: (Top) Large and complex crevasses exceeding 30 m depth in the center-front of the glacier just above the terminus. (Right) Snow-bridged crevasses seen most clearly in the left foreground with the white, fresh snow covers the top of the open crevasses.

Figure: (Left) Water-filled crevasses. (Right) Crevasses near the Negribreen-Ordonnansbreen Medial Moraine (NAMM) are filled with water indicating a disruption in the local subglacial drainage system. Fresh crevassing through surge expansion affected this area along the northern NAMM in early 2020, shortly after this photo was taken.

Figure: (Left) Low-lying clouds covering the lower glacier terminus (photo looking downglacier). (Right) Young surge crevasses in upper Negribreen.

Imagery from Field Campaign in August 2019

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The Negribreen Glacier System (NGS), a large glacier system in Arctic Svalbard, surged in 2016, i.e., during the entire lifetime of ICESat-2 (launched in September 2018). The progression of Negribreen’s surge through the glacier system has resulted in large-scale elevation changes and widespread crevassing, which is ideally captured and analyzed using ICESat-2 measurements processed by the Density Dimension Algorithm for Ice (DDA-ice) (see Herzfeld et al., 2016; HER TOYS, and Thiede et al., 2022). Status of Remote Sensing. In this analysis, we quantify how Negribreen has been evolving in its mature surge phase over the years 2019 and 2020. Using ICESat-2 data, together with airborne field data and Sentinel-1-derived velocity data, we quantify large-scale effects such as deceleration-change and mass transfer through the system, as well as smaller-scale effects afforded by high-resolution data products of the DDA-ice such as crevasse characterization, surface roughness and changes thereof.

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