Uncrewed vehicles reveal frontal mass loss of Sweden's largest calving glacier

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1 Introduction

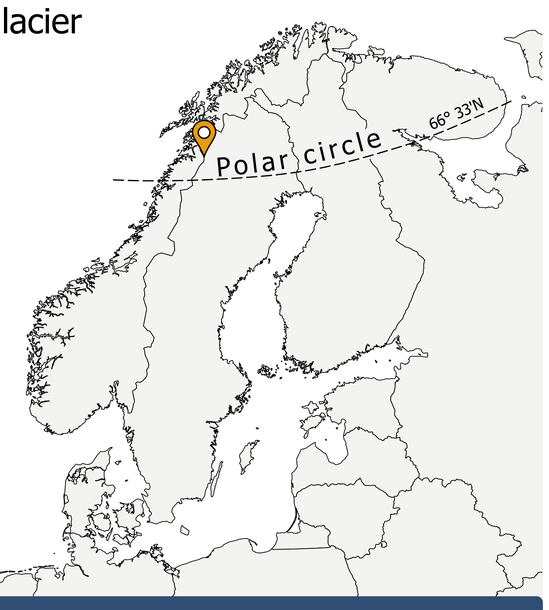
At the intersection of water and ice, highly dynamic processes like calving act upon glacier fronts, leading to increased mass loss and contributing to rising sea levels. Due to its highly dynamic nature, calving is difficult to observe and model. Uncrewed aerial vehicles (UAVs) have been successfully used to investigate glacier front dynamics. However, UAVs are limited by battery endurance and weight constraints on the scientific payload. Uncrewed surface vehicles (USVs) can potentially overcome these limitations. At Sálajiegna glacier, we explore the combined use of a USV and a UAV with the aim of:

I **Testing USV based photogrammetry for glaciological applications**

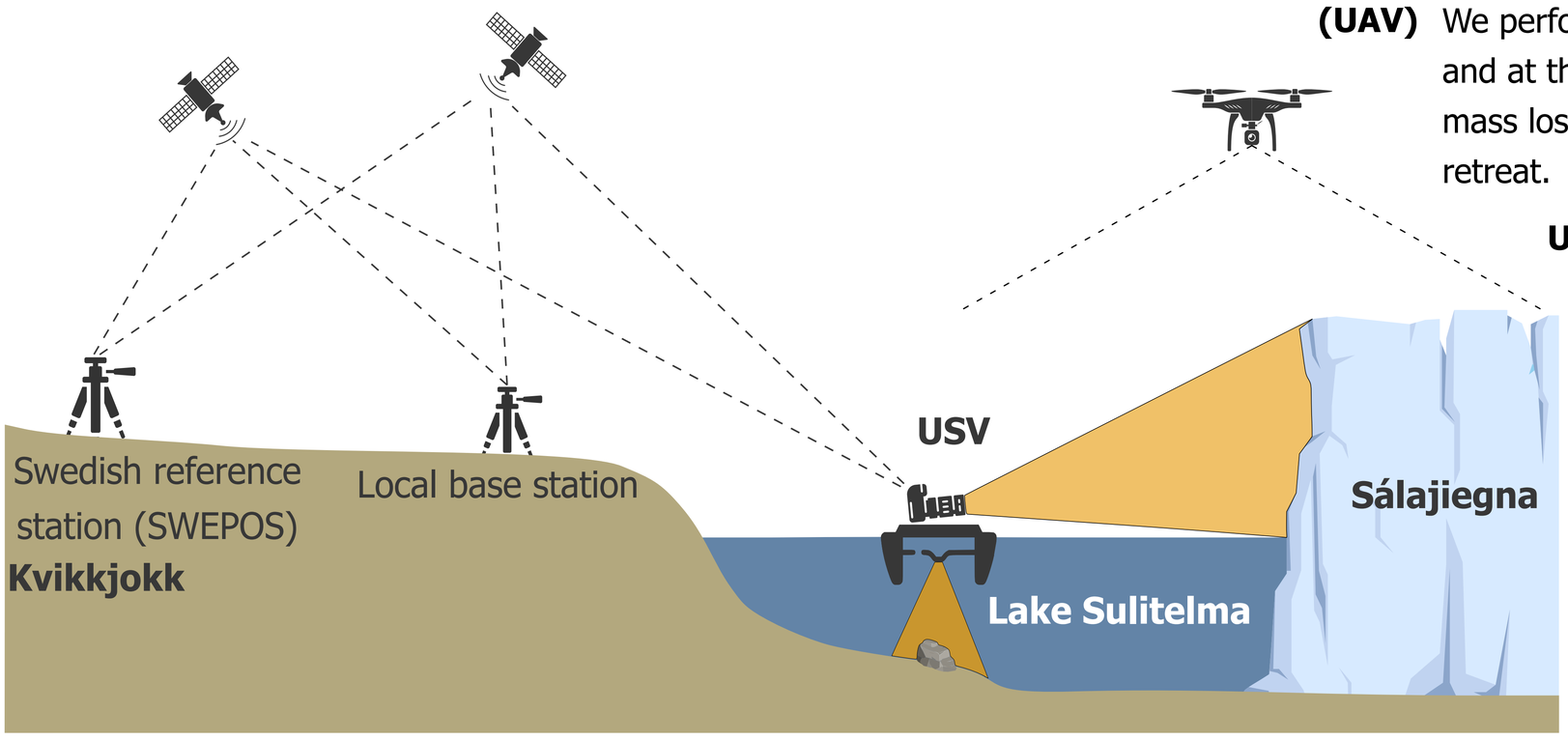
II **Characterising Sálajiegna's glacier front dynamics during the summer of 2022**

2 Study area - Sálajiegna glacier

- Sweden's largest freshwater calving glacier with ~25 km^2 surface area.
- Located at 67°7' N at the Swedish-Norwegian border.
- Terminates into Lake Sulitelma with a 1 km long and up to 38 m high calving front.
- Historical documentations since 1808.



3 Research design

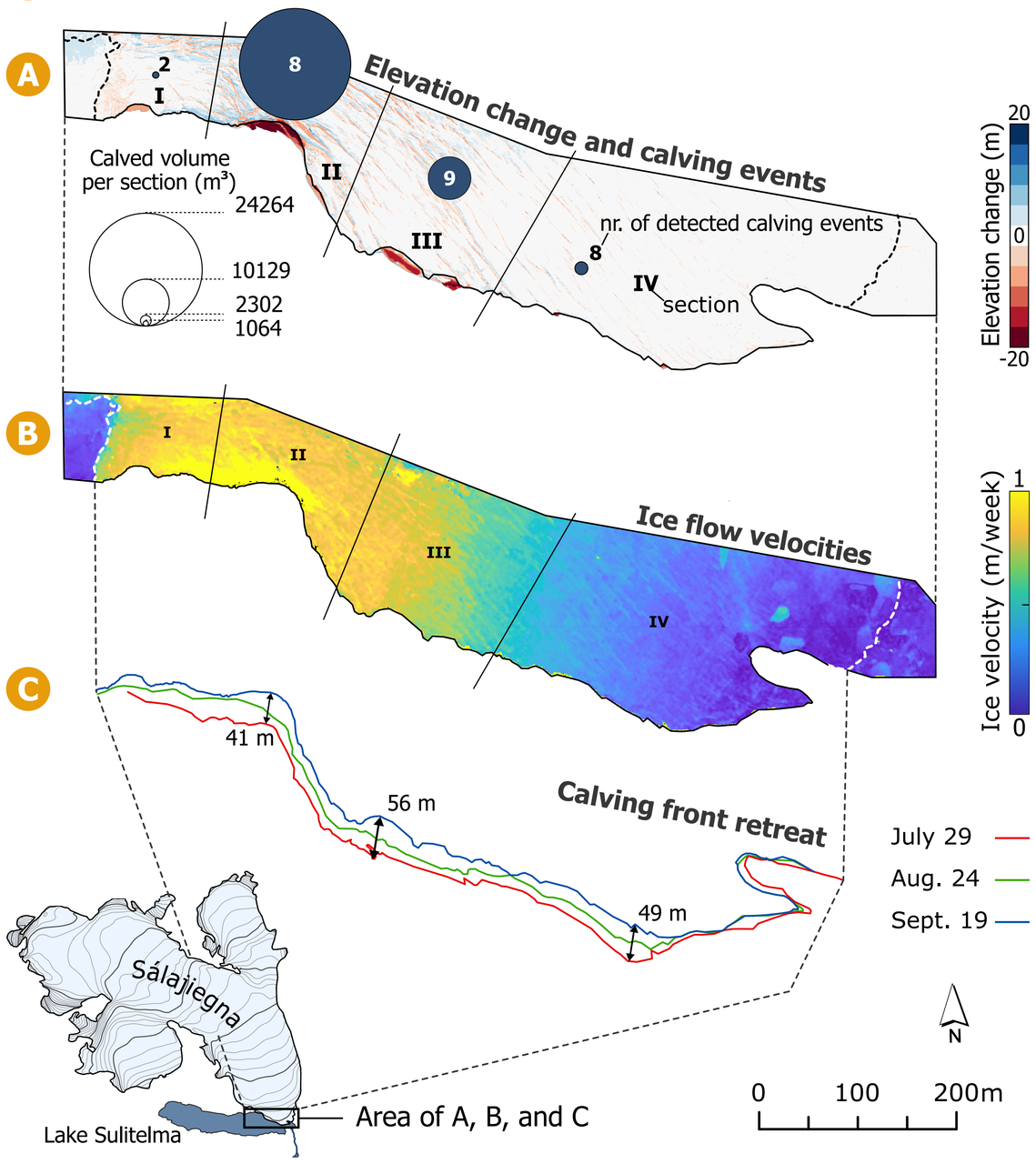


Uncrewed aerial vehicle (UAV) We perform UAV photogrammetry surveys at the beginning and at the end of the calving season 2022 to calculate mass loss, ice flow velocities, surface thinning and glacier retreat.

Uncrewed surface vehicle (USV)

We use a catamaran style USV developed at the Centre for Naval Architecture at the KTH Royal Institute of Technology to perform daily photogrammetric surveys of Sálajiegna's glacier front for 4 consecutive days in September 2022. By performing a point cloud based distance calculation between consecutive surveys we detect calving events and estimate their volume with a surface reconstruction approach.

4 Results - Sálajiegna's frontal dynamics



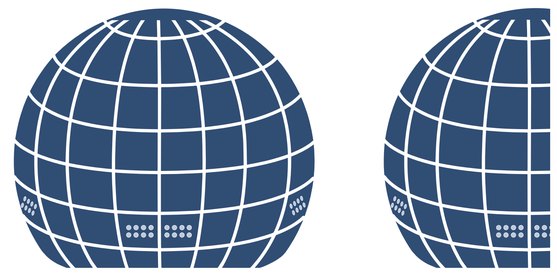
Short-term dynamics (15-19 Sept.)

- With USV based photogrammetry we detect 26 calving events in 4 days. Calving events range in volume between 0.1 m^3 and 10 000 m^3. A
- Calving activity is highest in section II, where also flow velocities are highest and the lake is deeper compared to other sections. A B

Seasonal dynamics (29 July - 19 Sept.)

- Maximum front retreat of 56 m. C
- Terminus region mean surface thinning of 2.6 m
- Overall mass loss in the terminus region of **945 484 m³**.

1.56 x Avicii Arena
World's largest spherical building



5 Conclusions

I USVs are well-suited to perform photogrammetric surveys of calving glacier fronts. Because of their ability to collect data above and below the water surface and because they can carry high scientific payloads, USVs are versatile platforms for glaciological research.

II In only 7 weeks during the summer of 2022 Sálajiegna lost a volume of nearly 1 million m³ in the terminus region, which accounts for only 0.9% of the total surface area. Most frontal mass loss can be attributed to a small section (section II).

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