

# **Tracking Glacier Extent and Surging on Svalbard with Sentinel-1 InSAR Coherence and Backscatter Amplitude**

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## **1. INTRODUCTION**

Svalbard's glaciers are among the most dynamic elements of the Arctic landscape, and their variable extent is a sensitive indicator of the rate of climate warming. Episodes of surging – sudden, accelerating ice flows after a period of quiescent phase – play a special role in shaping the archipelago's relief. However, effective monitoring of glacier fronts is hampered by long periods of polar night, cloud cover and poor field accessibility. The current work demonstrates that two easily derived products from Sentinel-1 radar interferometry: coherence and signal amplitude, are sufficient to capture both the long-term trends of glacier retreat and the initial phases of surging.

## **2. DATA AND METHODS**

The analysis included a set of Sentinel-1 IW imagery from 2015–2023, covering all major Svalbard glaciers. Coherence and calibrated amplitude maps were calculated for successive time pairs, and then assembled into a regular time series. The coherence was treated as a measure of the integrity of the ice surface – a decrease in coherence indicates intense deformation, the presence of meltwater, or short-term modifications of the firn surface such as melt-refreeze events or fresh snow deposition. In turn, changes in amplitude were interpreted as the effect of seasonal ice exposure, snow deposition or deeper ice masses. Glacier boundaries were tracked by the amplitude contrast between the ice and the underlying rock or sea, while sudden drops in coherence at the kern were interpreted as an early signal of the transition of the ice into a sliding regime, typical of the pre-surging phase.

## **3. RESULTS**

There is a clear, albeit spatially varying, trend of retreating ice fronts across the archipelago. Most of the valley and shelf glaciers show a gradual retreat, especially in the southern part of Spitsbergen, where a rise in air temperature and an increase in the proportion of rain in winter precipitation co-occur. On the other hand, several glaciers – including Tunabreen, Skobreen

and Monacobreen – presented a full or partial cycle of surging during the period under study. The initial phase of the surging was manifested by several months of systematic loss of coherence in the middle reaches, followed by a sharp increase in amplitude as the young, rough ice reached the front.

The combination of coherence and amplitude makes it possible not only to distinguish glaciers conducting a systematic retreat from those preparing for surge, but also to determine the approximate timing of the arrival of the phase of rapid acceleration. The absence of the need to determine velocity fields or solve the phase of interferograms significantly simplifies the procedure and reduces the calculation effort, opening the way to quasi-permanent monitoring of range changes in Arctic conditions.

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