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Deep learning reveals seasonal patterns of Antarctic ice shelf front fluctuations

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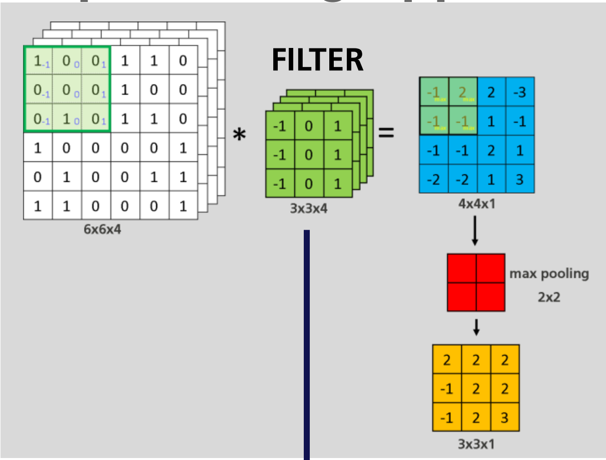
Introduction : Antarctic Calving Front Detection

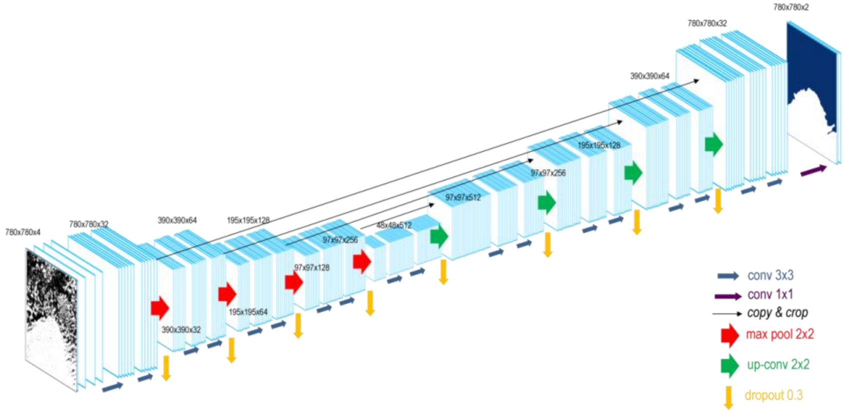
- **Remote sensing imagery** is a valuable source to **track calving front changes**
- **Sentinel-1 acquires imagery every 6-14 days** over the Antarctic coastline
- Using this **abundance of data is difficult** as
  - manual delineation of calving fronts is **very time-consuming**
  - manual delineation is **not accurate enough** if fronts move only 1-2 pixels between acquisitions

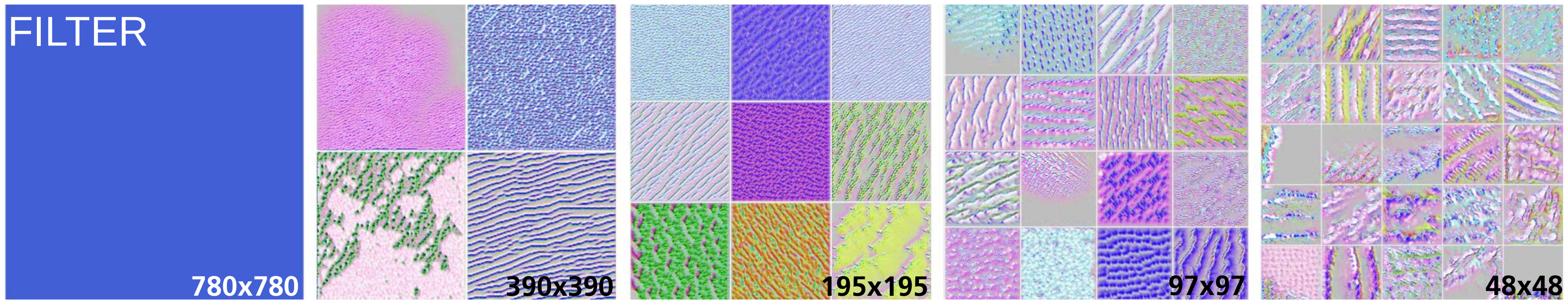
- We developed a **deep learning based approach** to automatically delineate calving fronts (Baumhoer et al. 2019)
- In combination with slight manual corrections (errors over melt and mélange) this is a **powerful tool to track seasonal variations of glacier front changes on pixel level** with little effort
- We present **monthly calving front time-series** with **up to 55 front positions per glacier**

Baumhoer, Celia A., Andreas J. Dietz, C. Kneisel, and C. Kuenzer. 2019. 'Automated Extraction of Antarctic Glacier and Ice Shelf Fronts from Sentinel-1 Imagery Using Deep Learning'. *Remote Sensing* 11 (21): 2529.

Deep Learning Approach: U-Net



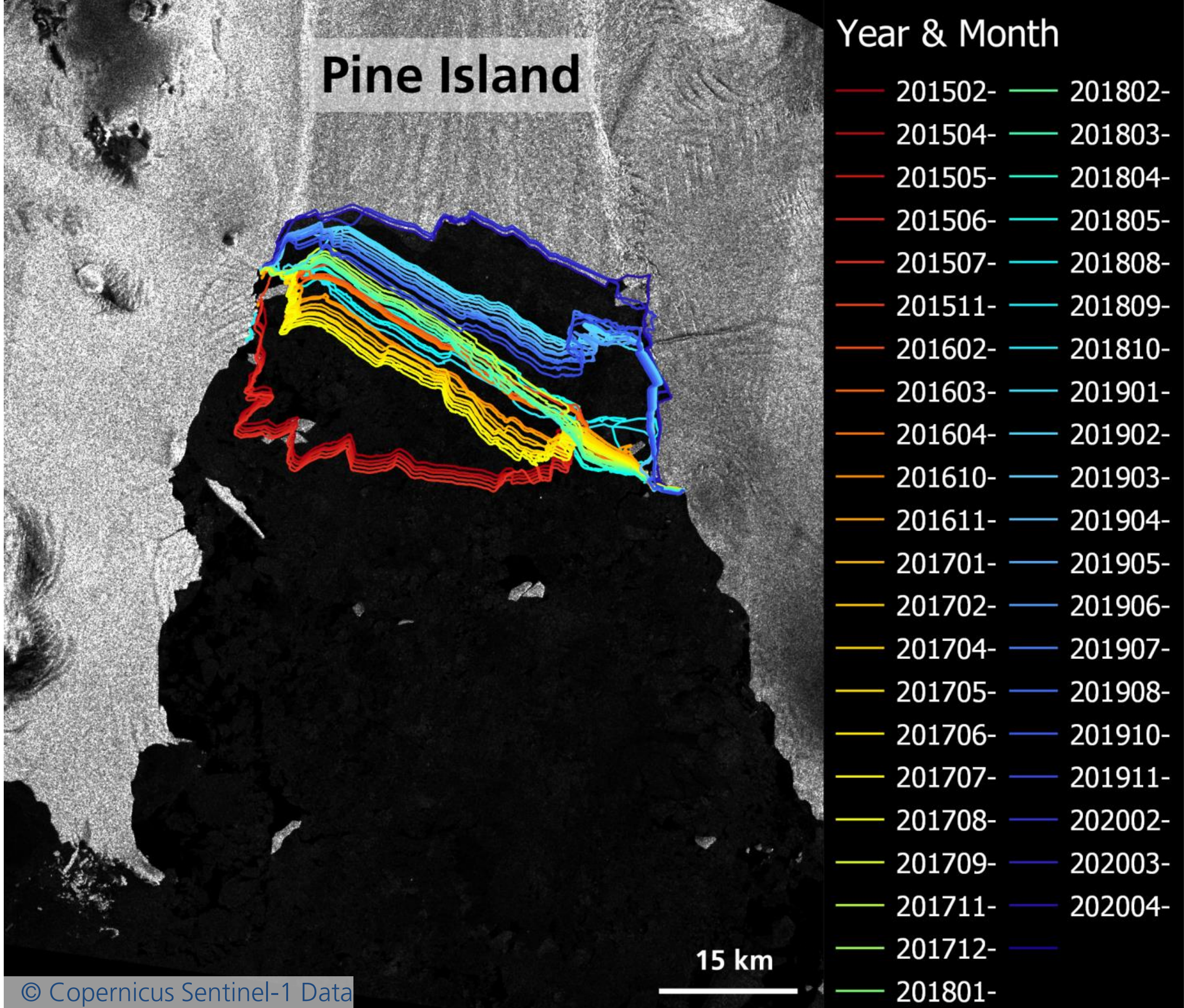




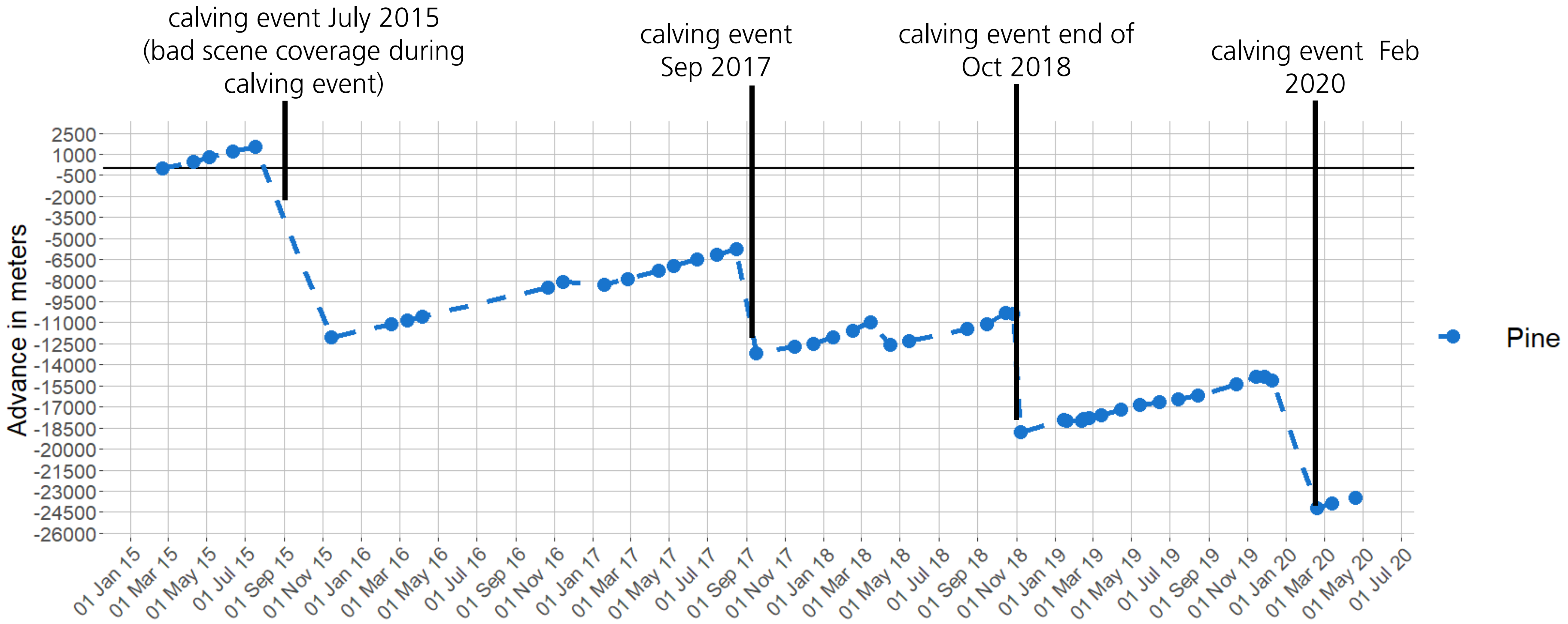
Application Examples

A: Pine Island Glacier

- Since 1947 Pine Island glacier had phases of advance interrupted by calving events every 4-6 years
- Recently many calving events were reported
- Is the calving frequency increasing?



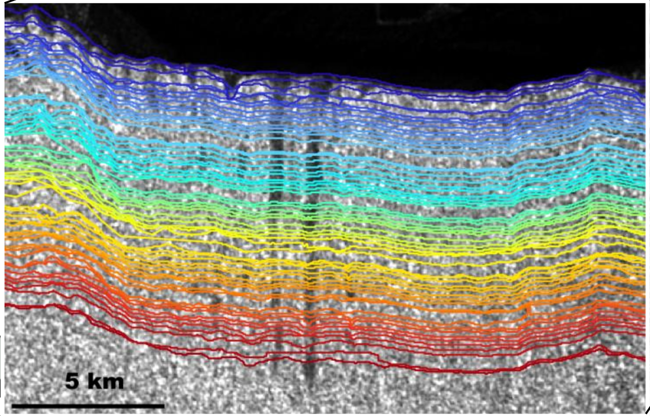
Pine Island: Calving Front Change

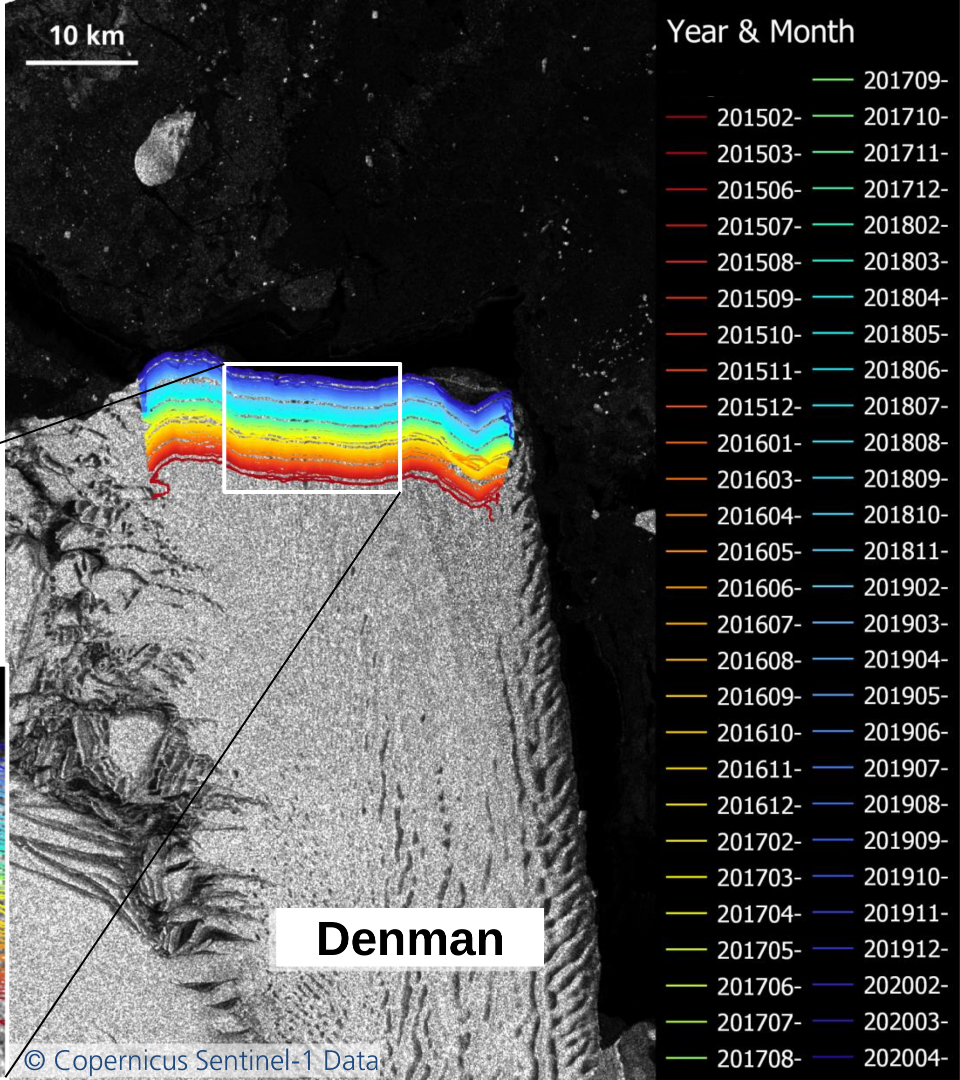


Since 2015 the calving frequency is rather 1-2 years

B: Denman Glacier

– Steady advance with ~ 5m/day





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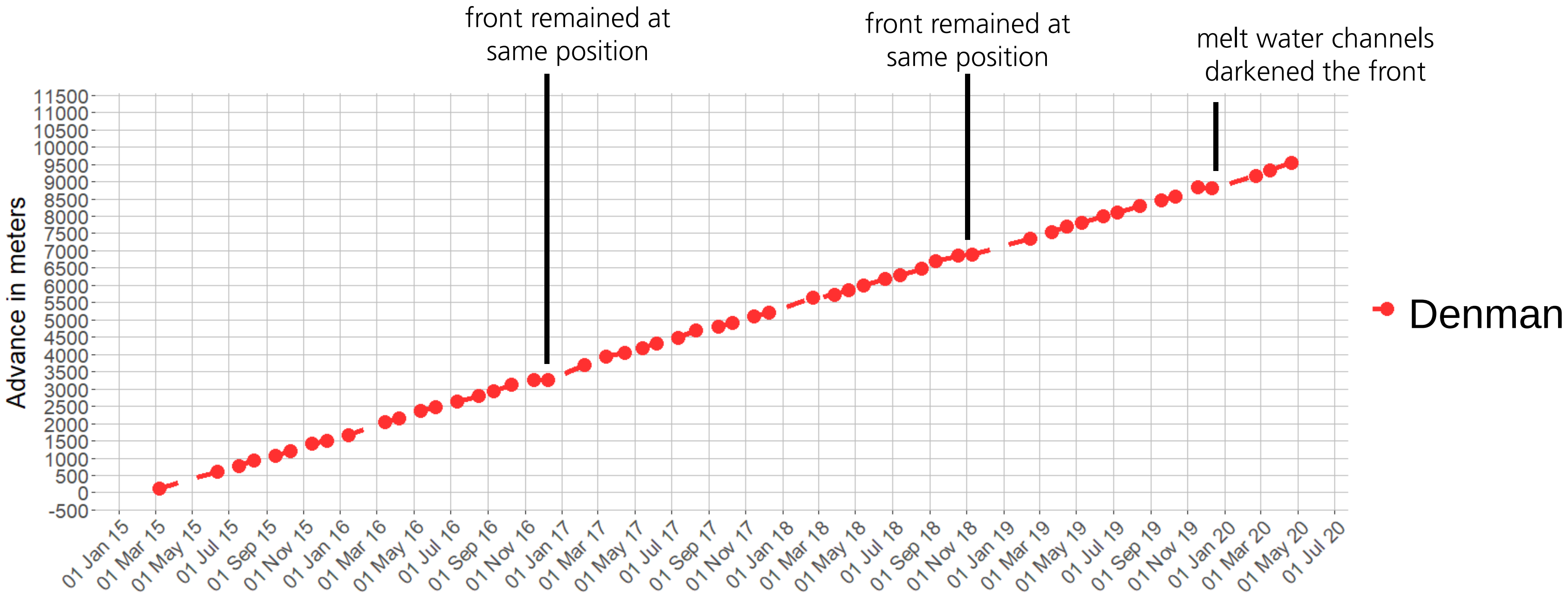
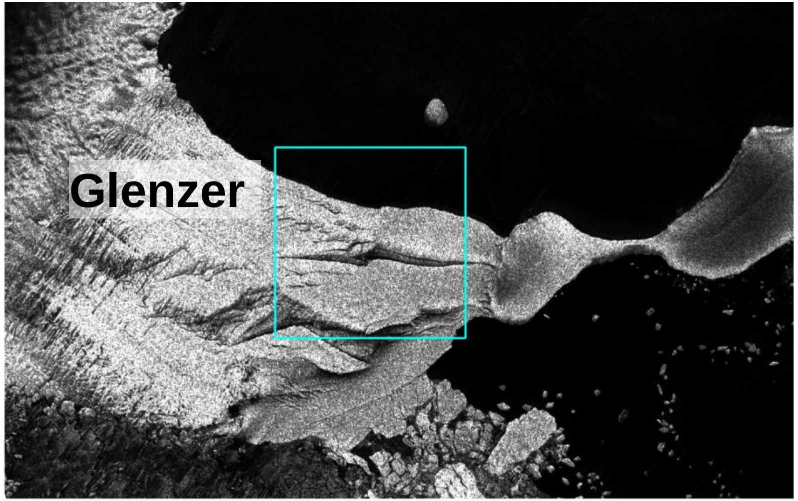
Denman: Calving Front Change

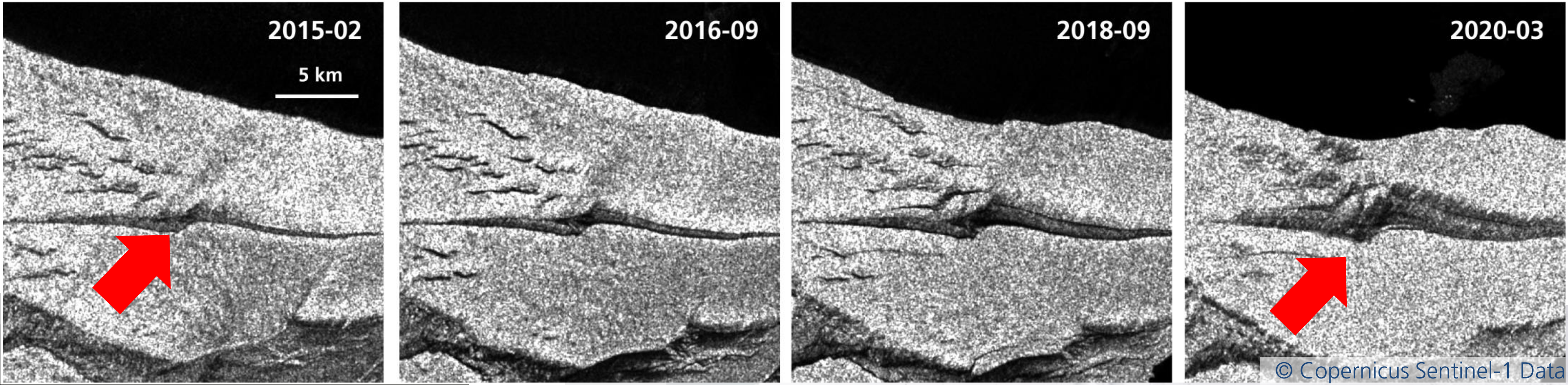


Fluctuations in calving front position change are very little with no obvious seasonal pattern

Is Glenzer Glacier about to disintegrate soon?

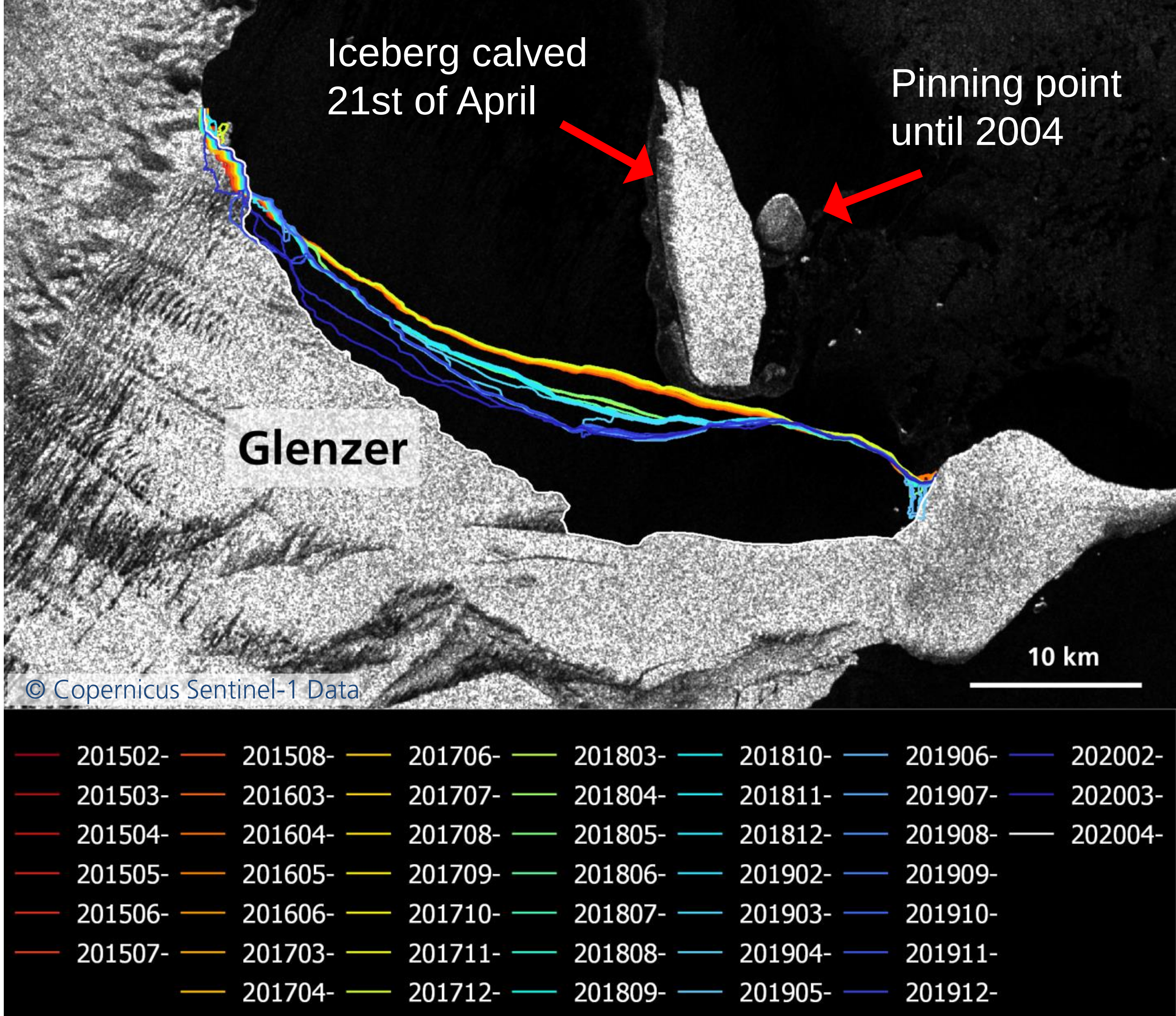


Crevasse development since 2015

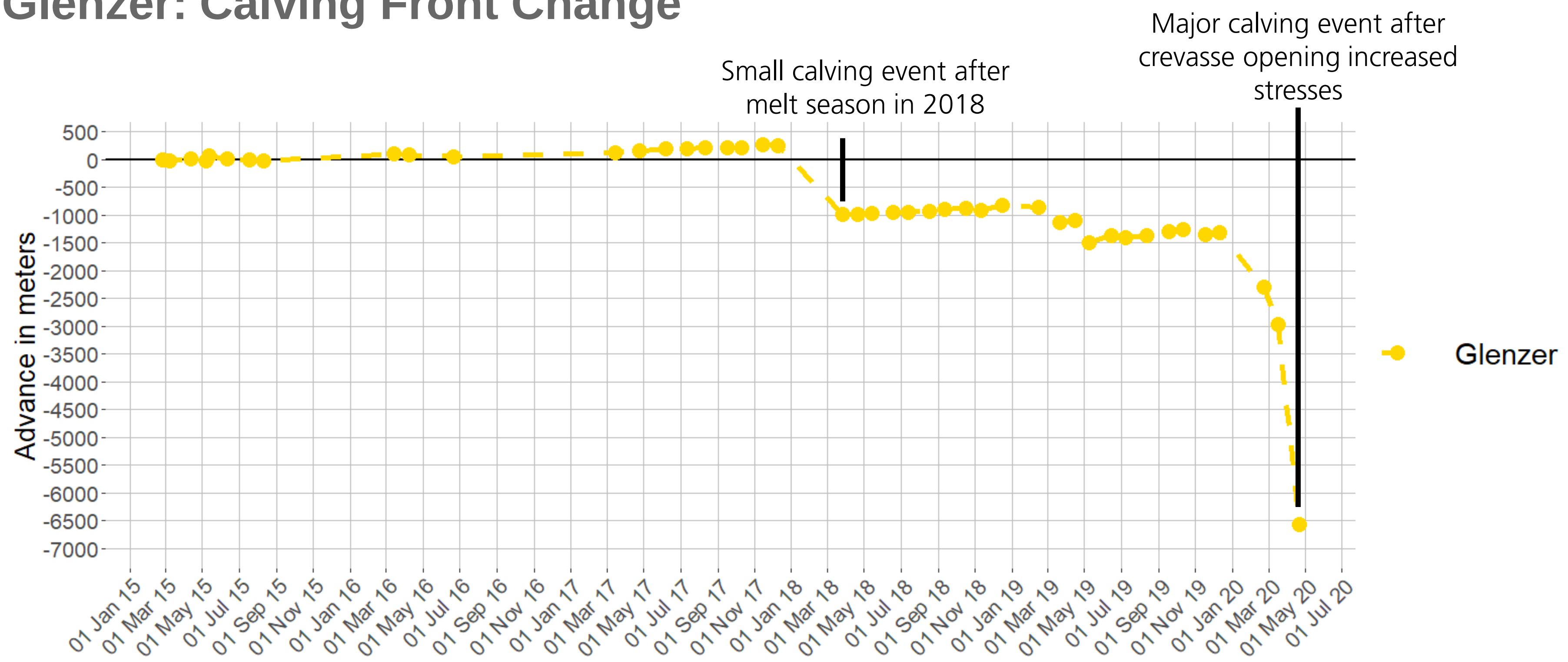


C: Glenzer Glacier

- Major calving event on 21st of April 2020
- Remaining ice bridge has a width of 5.8 km
- Smaller calving events occurred in beginning of 2018



Glenzer: Calving Front Change



Crevasse opening resulted in a major calving event

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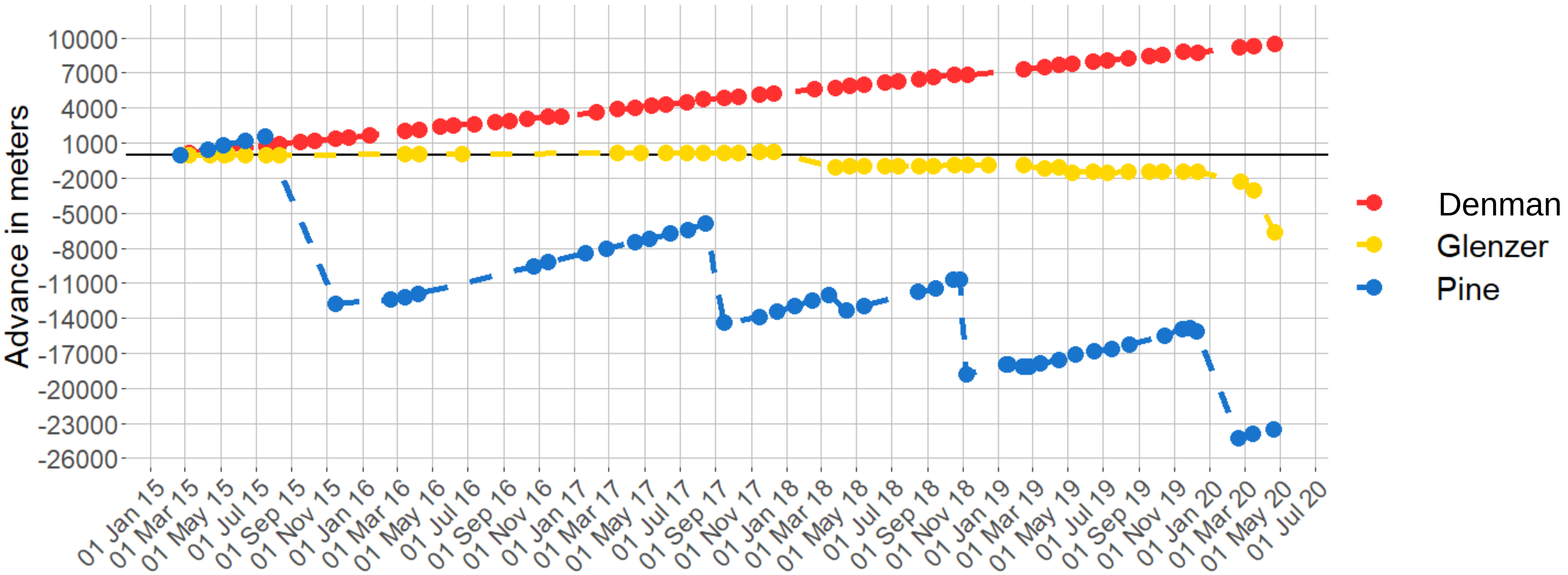
In Comparison:



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Conclusion

- Our deep learning based approach is a great achievement for Antarctic calving front extraction
- For the first time, monthly time series of Antarctic glacier front fluctuations are available
- Little manual post-correction should be applied to guarantee most accurate results during snowmelt
- The three assessed glaciers have very different patterns of frontal change:
  - **Pine Island**: constant advance interrupted by frequent calving events. Overall retreat.
  - **Denman**: steady advance.
  - **Glenzer**: steady front slowly disintegrating.
- Seasonal changes in calving front location (like in Greenland) could not be observed
- The dataset on monthly calving front changes will be extended to monitor Antarctic glaciers and ice shelves