

Short-term ice velocity fluctuations at Jacobshavn Isbrae from ERS-2 3-day SAR imagery

Aud Sundal & Andrew Shepherd
University of Leeds, UK

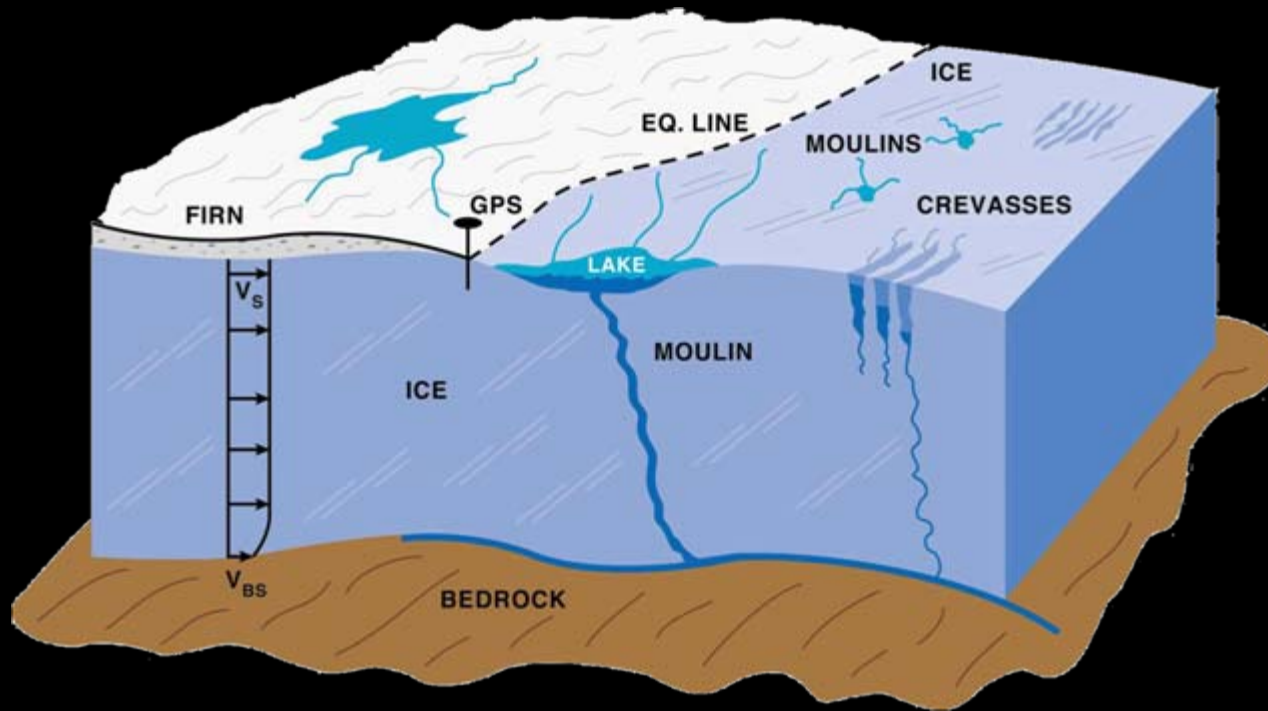


Outline

- Processes that can affect glacier speed
- ERS-2 3-day campaign
- Recent velocity observations at Jakobshavn glacier, West Greenland
- Conclusions

Melt-induced basal lubrication

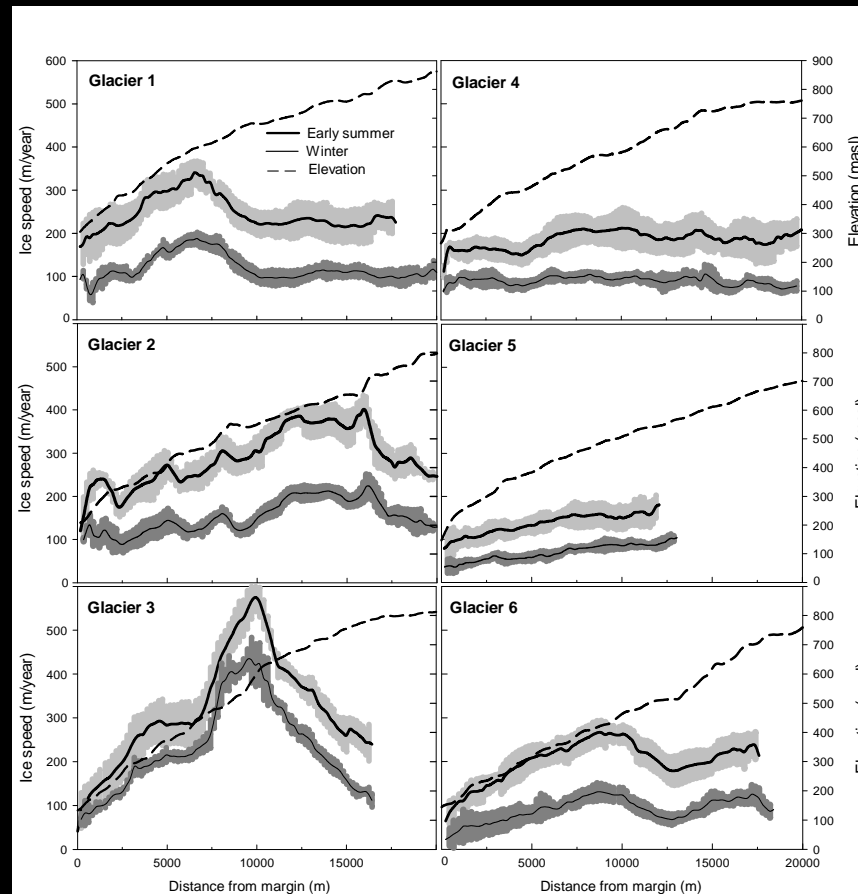
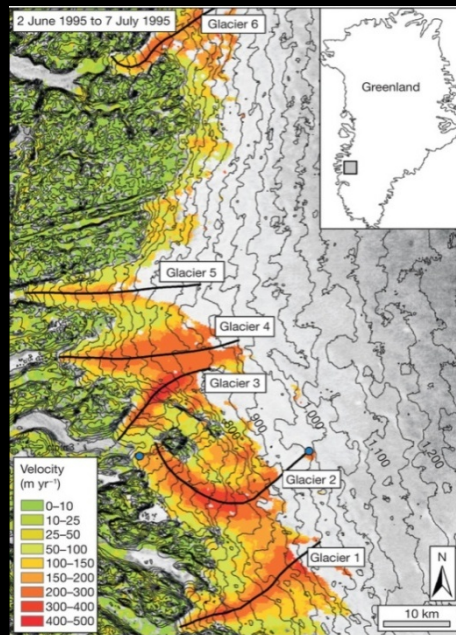
Lakes fill and cause fracture, allowing water to reach ice base and lubricate flow



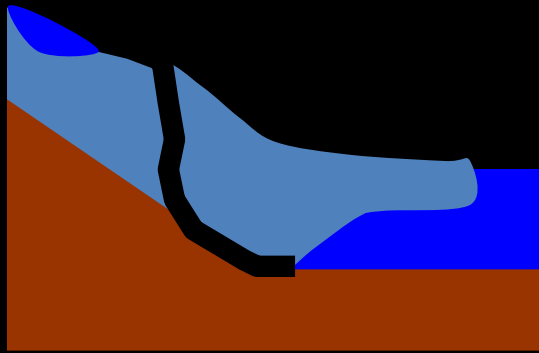
Zwally et al., Science (2002)

Land-terminating sector: Melt induced speedup of $\sim 100\%$

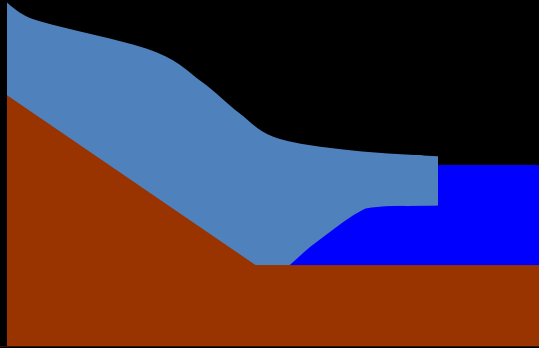
35-day ERS image pairs
(intensity tracking)



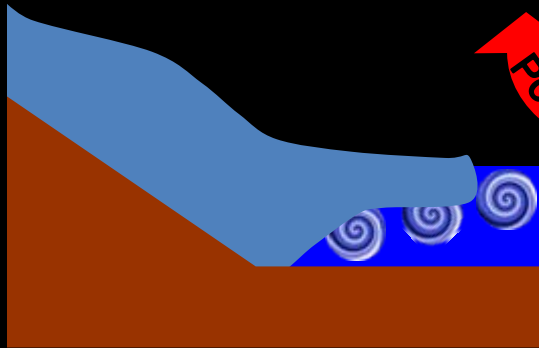
Sundal et al., Nature (2011)



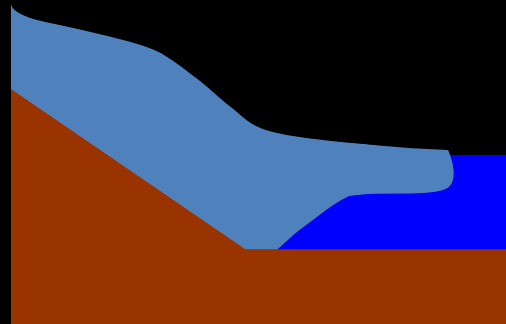
1. Surface melting



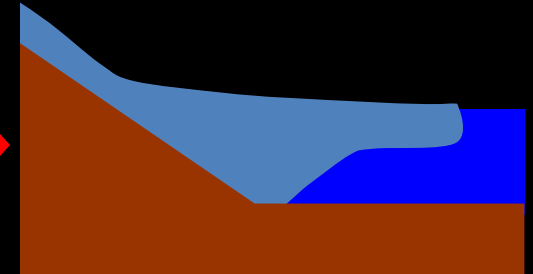
2. Iceberg calving



3. Ocean melting



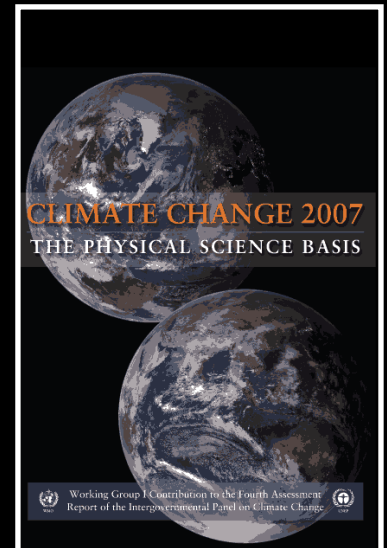
4. Ice acceleration & thinning



5. Increased runoff & discharge

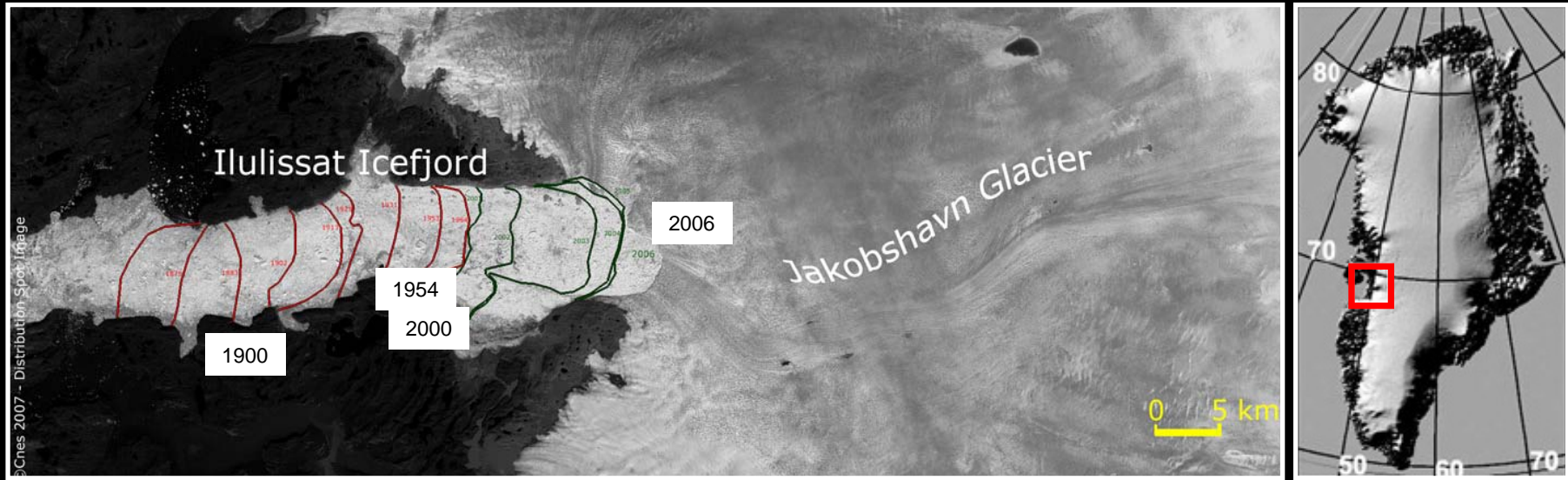
But.....

- (i) Models used to date do not include ... the full effects of changes in ice sheet flow, because a basis in published literature is lacking.
- (ii) Dynamical processes related to ice flow ... suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea level rise.
- (iii) Understanding of these processes is limited and there is no consensus on their magnitude.



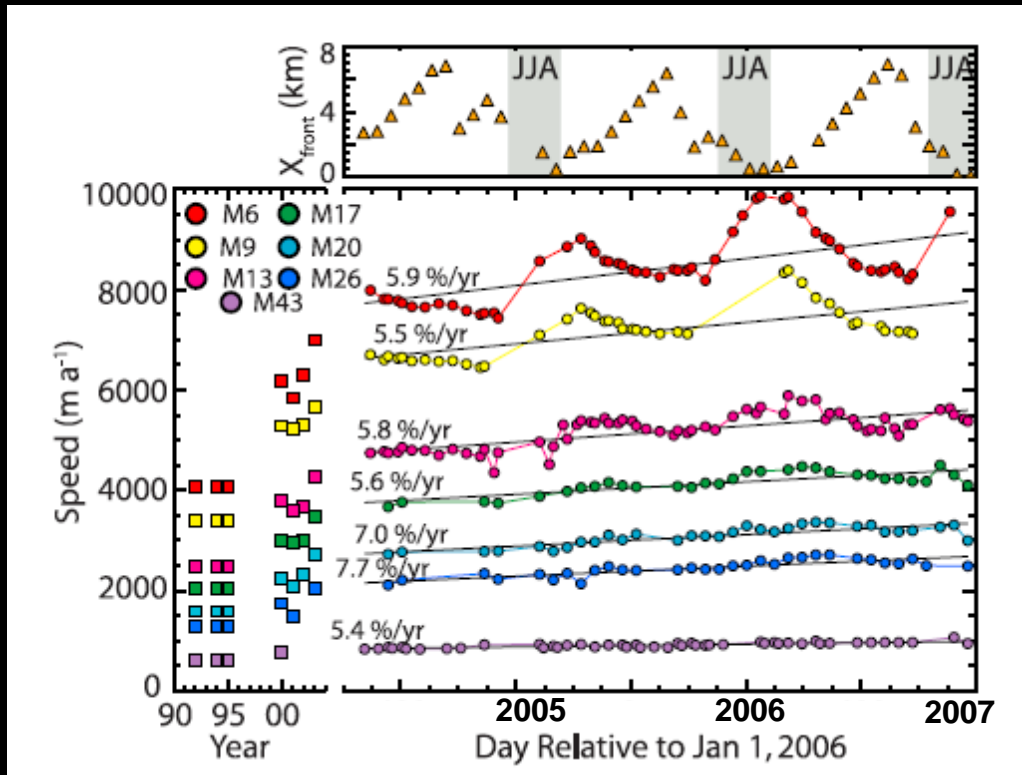
IPCC (2007)

Jakobshavn glacier, West Greenland



- Greenland largest glacier, draining 6.5% of ice sheet
- Non-linear changes in ice front position and speed
- 1998-2003: Thinning and doubling in speed from ~ 6 km/y to ~ 12 km/y

Jakobshavn glacier: Seasonal variations in flow



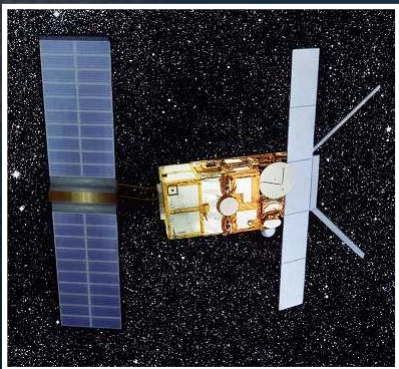
- Seasonal cycle in ice flow correlated with variations in ice front position

Joughin et al., JGR (2008)

Data from Radarsat
(24-day velocity averages)

ERS-2 3 day campaign

- ERS-2 moved from 35- to 3-day repeat orbit
- Acquired SAR image every 3 days from 12th March to 1st July 2011 at Jakobshavn glacier
- The dataset provides an idea of the information we can obtain from Sentinel data



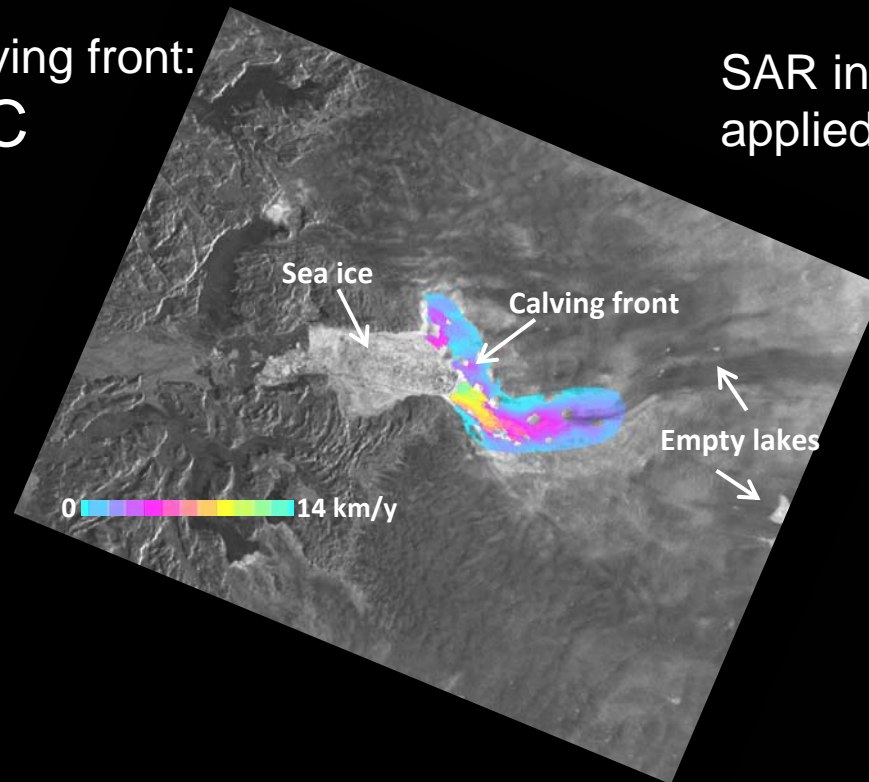
ERS-2

Jakobshavn glacier

15th March 2011

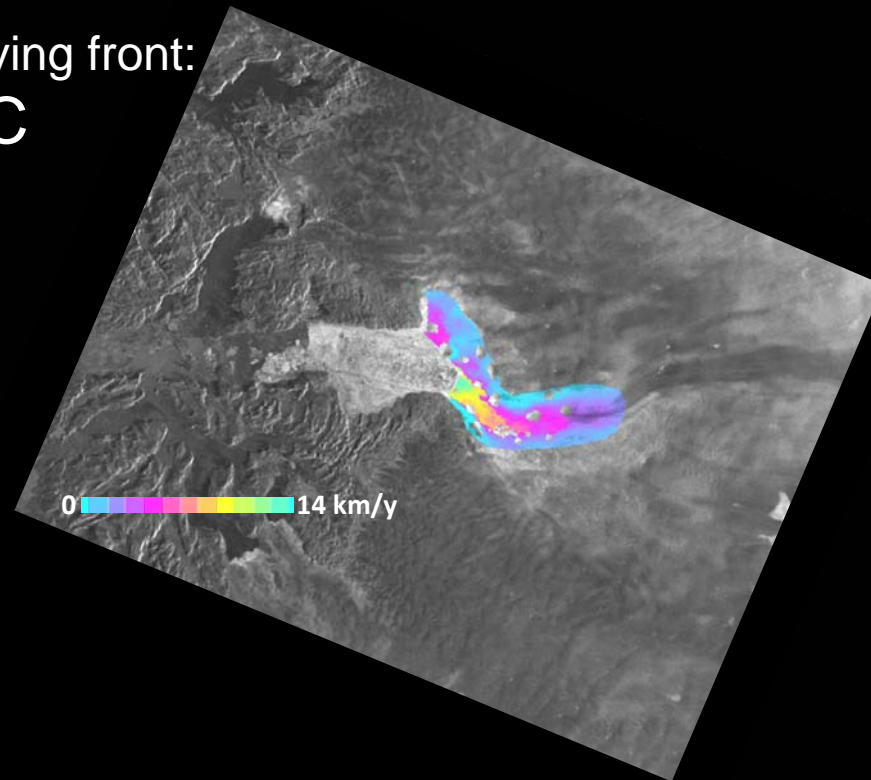
Air temp at calving front:
-18 °C

SAR intensity tracking
applied to 37 3-day pairs



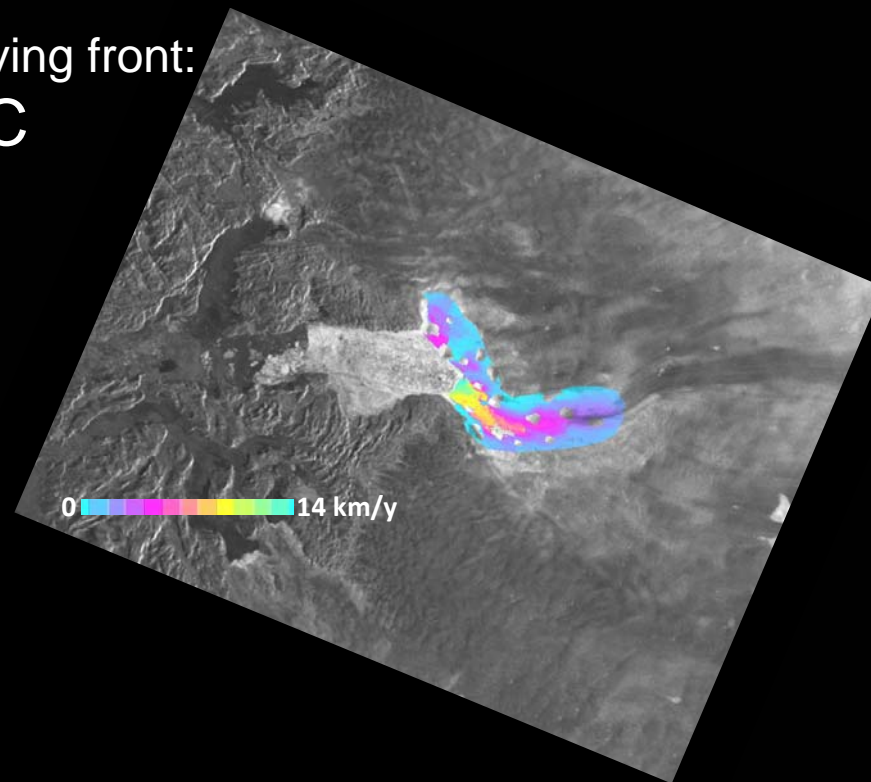
Jakobshavn glacier 18th March

Air temp at calving front:
-18 °C



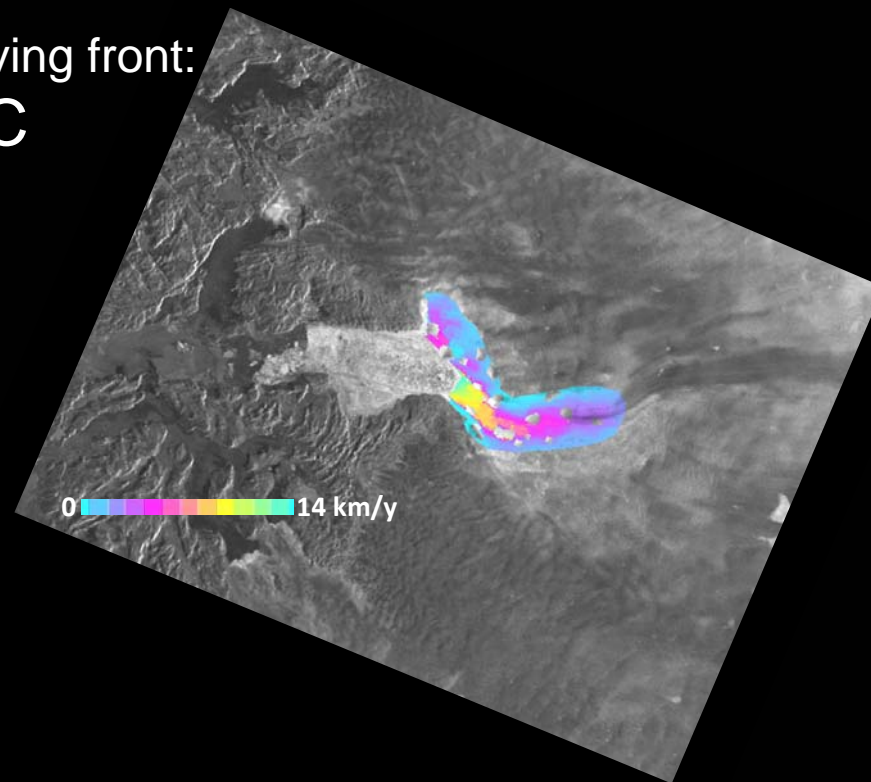
Jakobshavn glacier 21st March

Air temp at calving front:
-18 °C



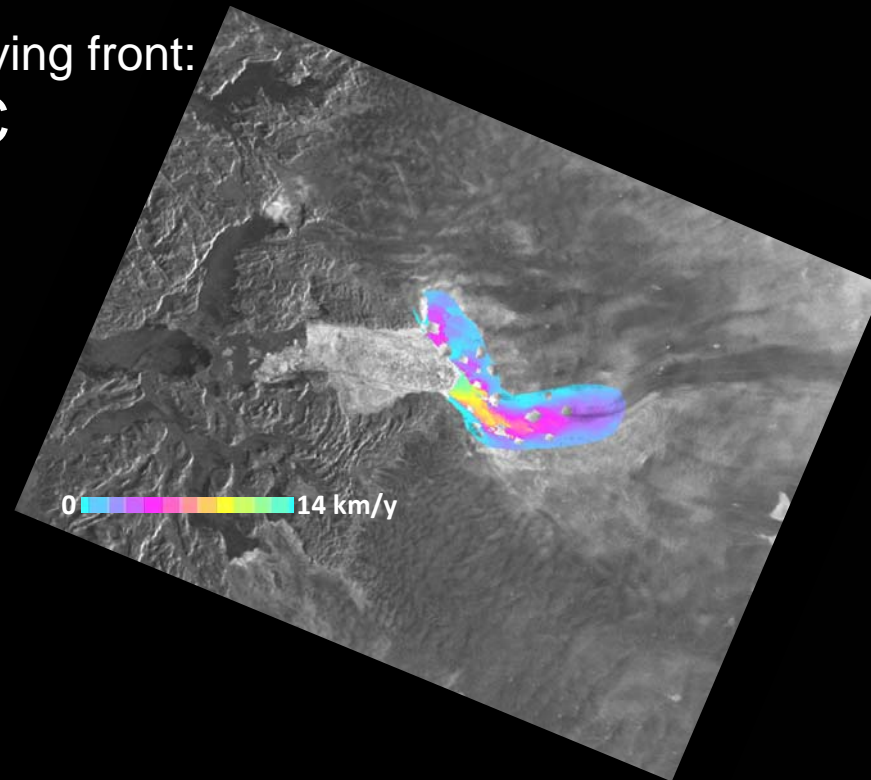
Jakobshavn glacier 24th March

Air temp at calving front:
-10 °C



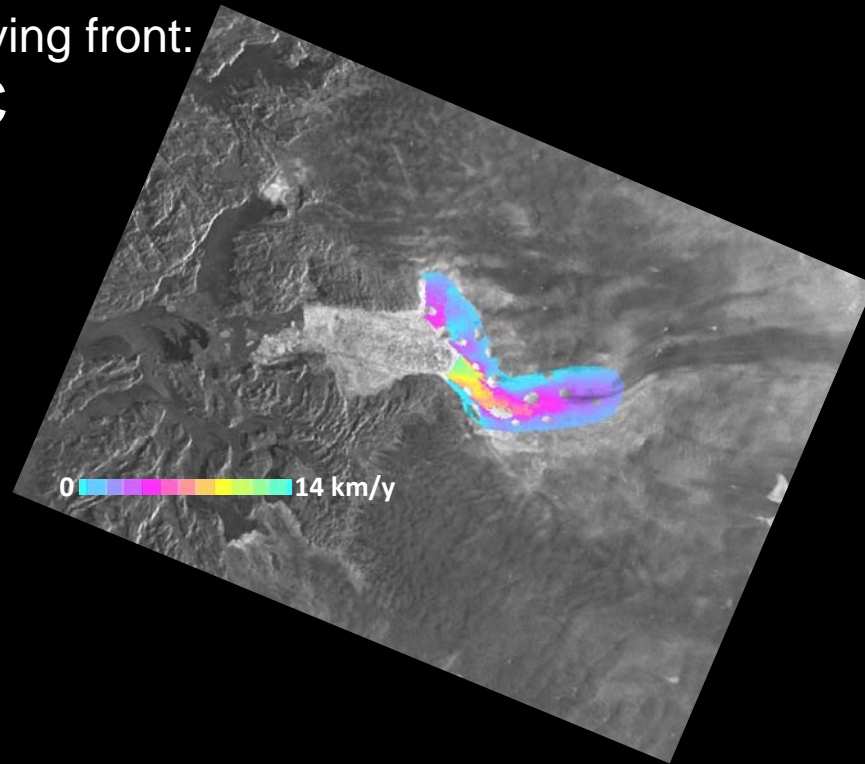
Jakobshavn glacier 27th March

Air temp at calving front:
-3 °C



Jakobshavn glacier 30th March

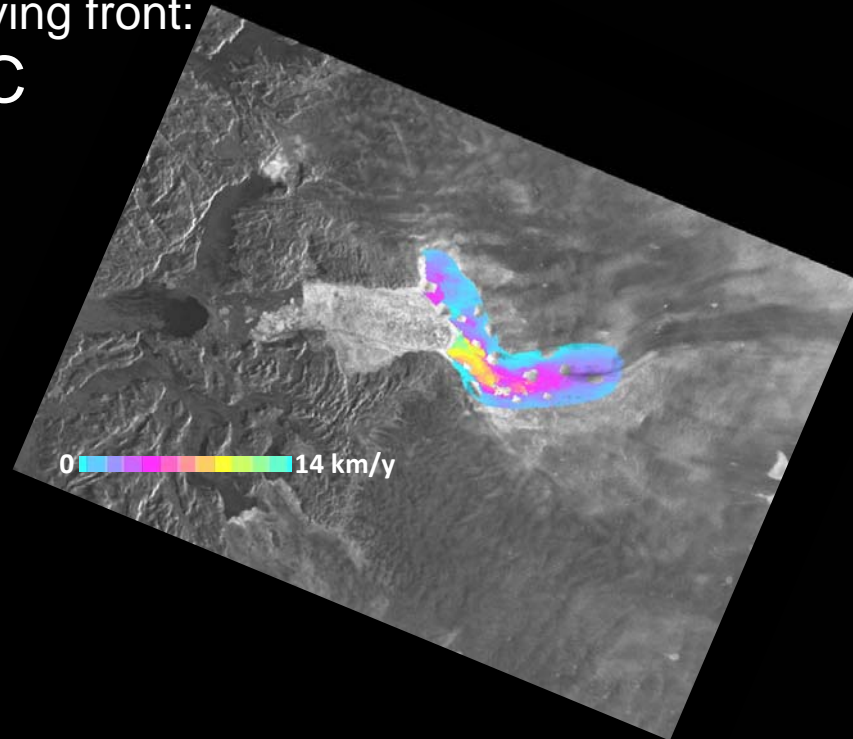
Air temp at calving front:
-5 °C



Jakobshavn glacier

2nd April

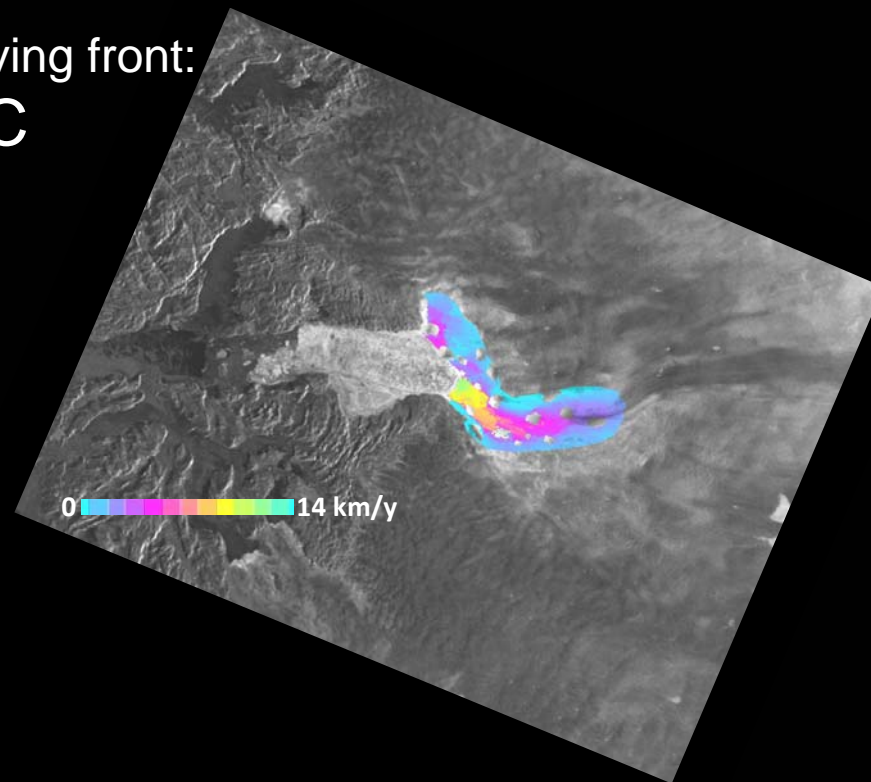
Air temp at calving front:
-11 °C



Jakobshavn glacier

5th April

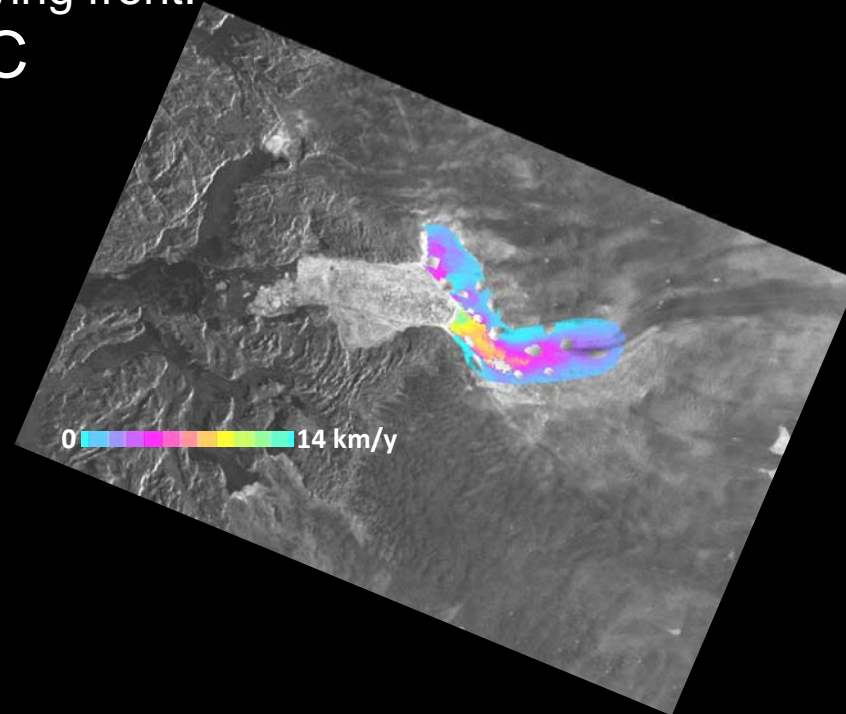
Air temp at calving front:
-14 °C



Jakobshavn glacier

8th April

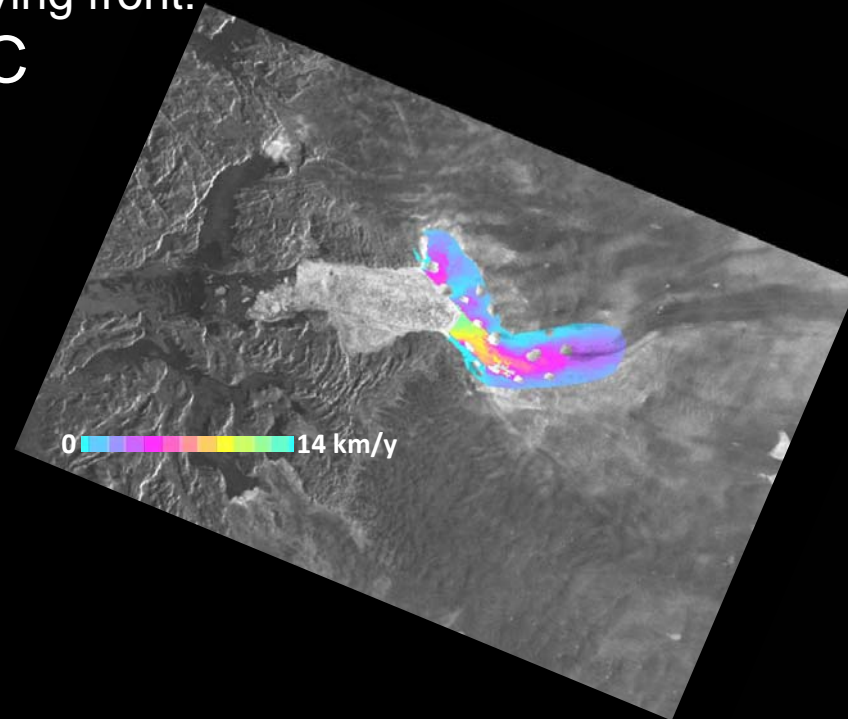
Air temp at calving front:
-15 °C



Jakobshavn glacier

11th April

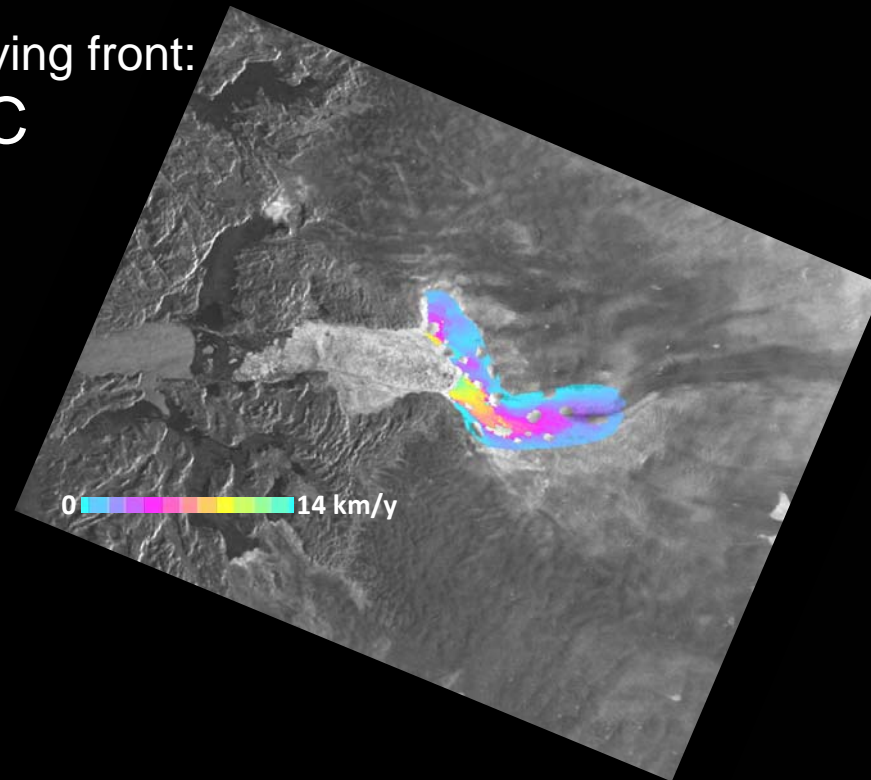
Air temp at calving front:
-15 °C



Jakobshavn glacier

14th April

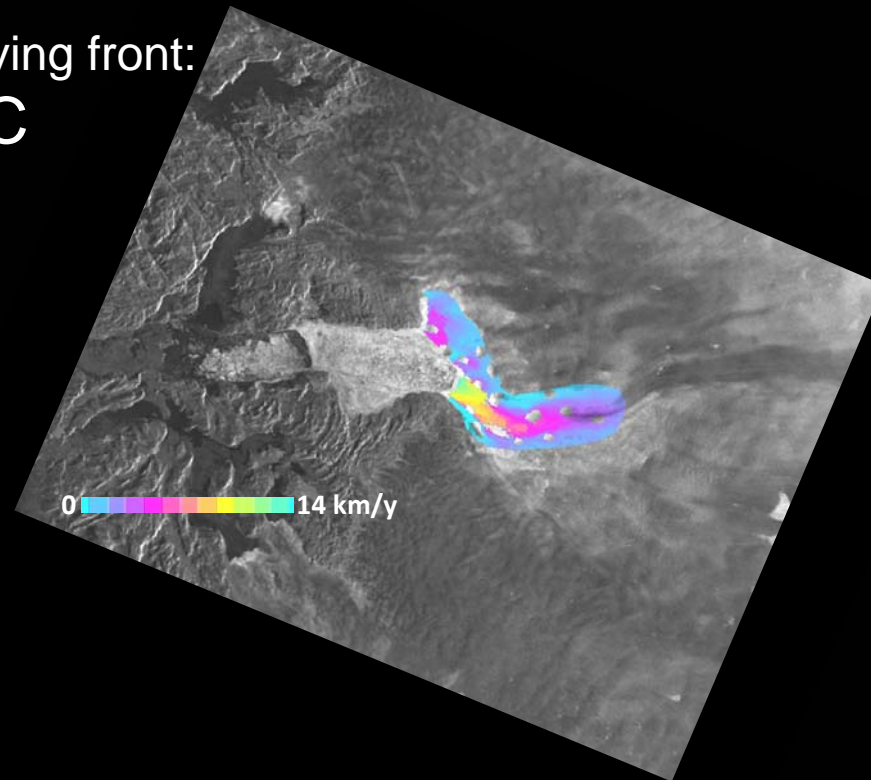
Air temp at calving front:
-11 °C



Jakobshavn glacier

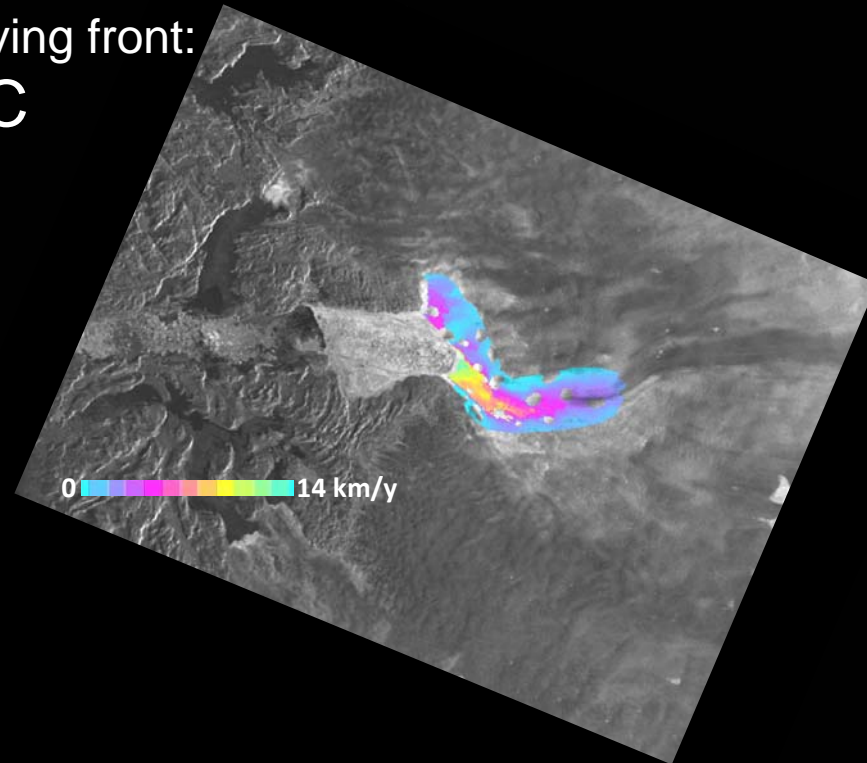
17th April

Air temp at calving front:
-14 °C



Jakobshavn glacier 20th April

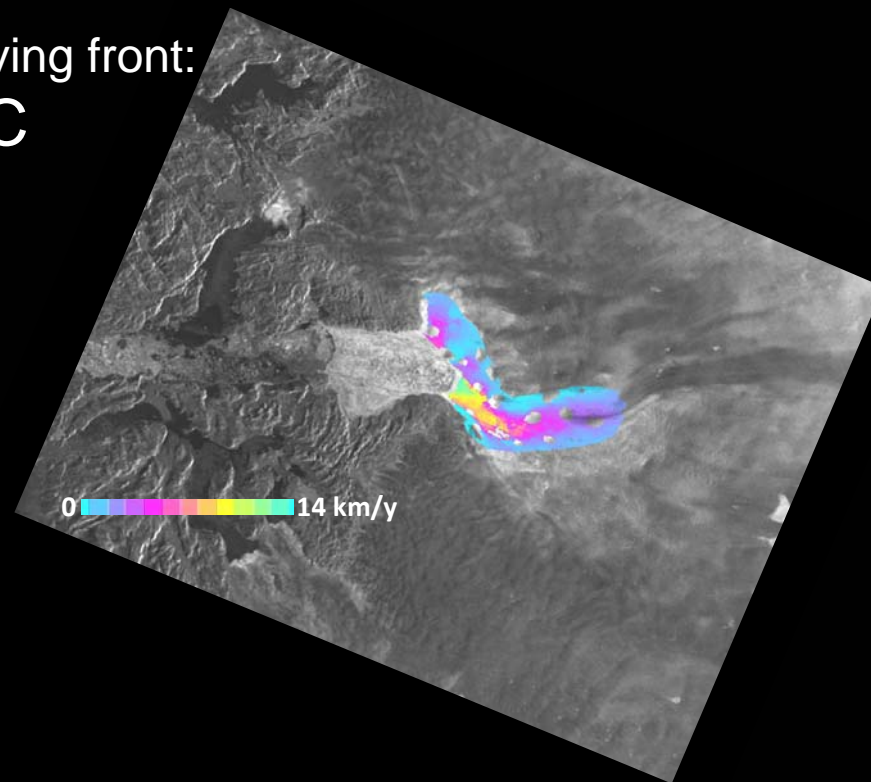
Air temp at calving front:
-13 °C



Jakobshavn glacier

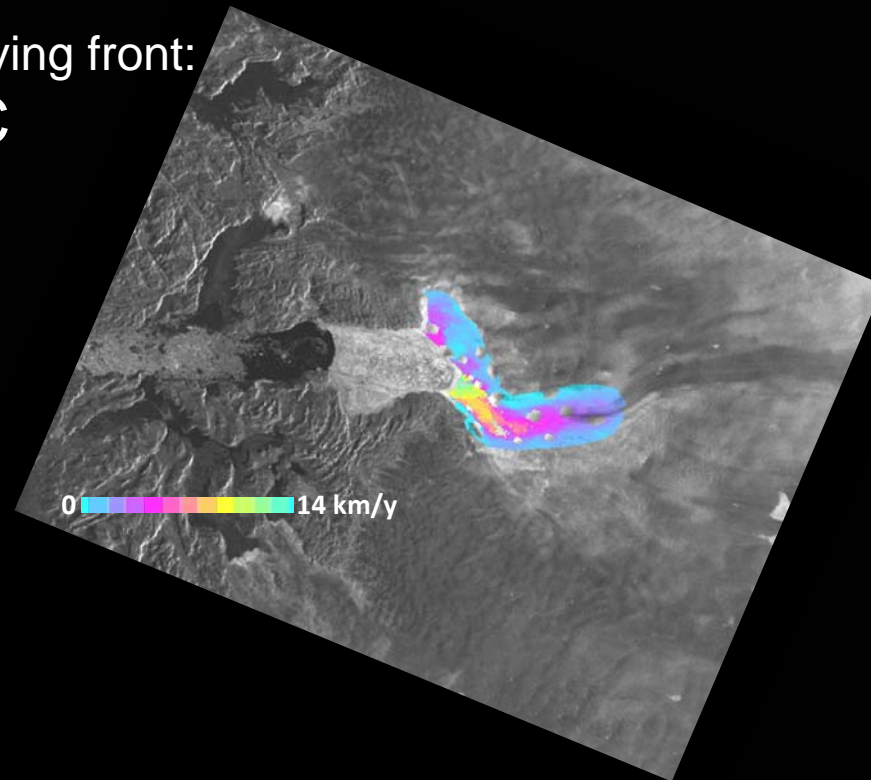
23rd April

Air temp at calving front:
-11 °C



Jakobshavn glacier 26th April

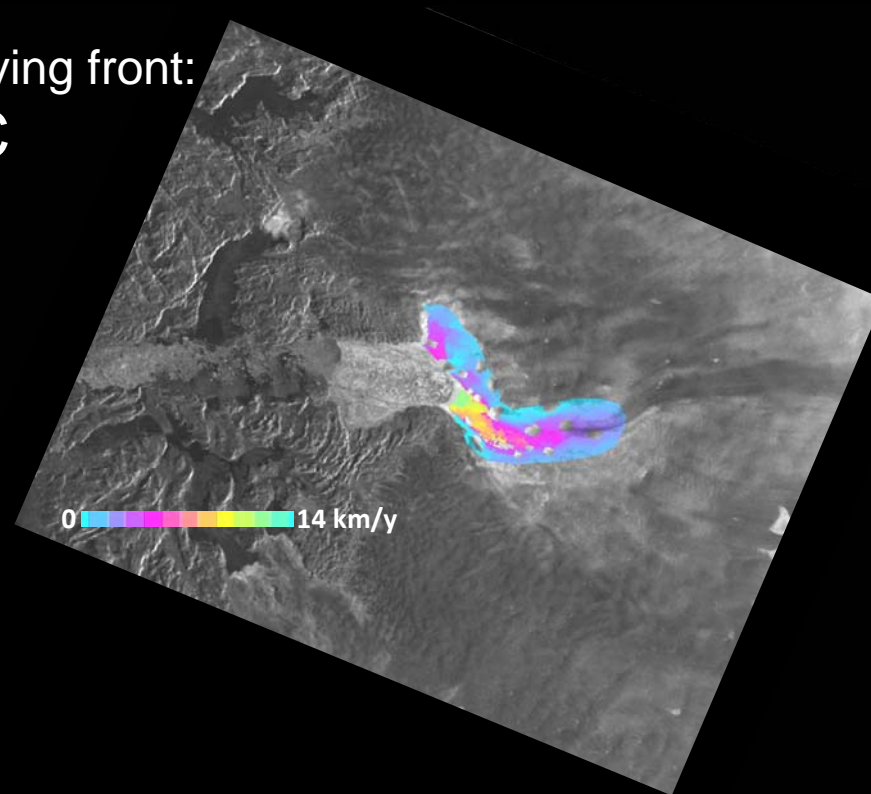
Air temp at calving front:
-7 °C



Jakobshavn glacier

29th April

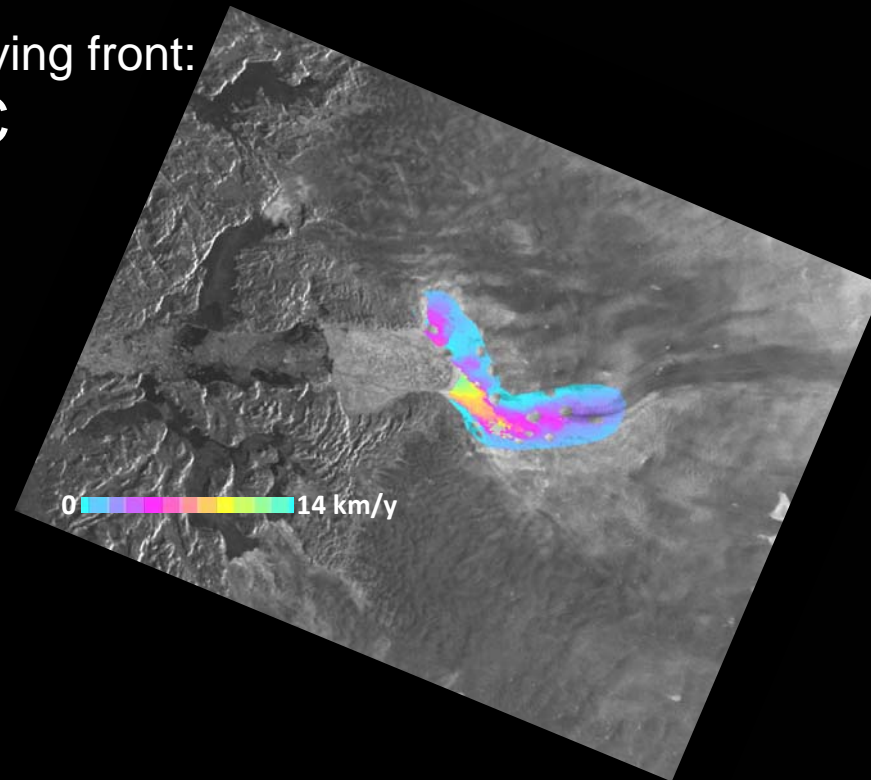
Air temp at calving front:
-4 °C



Jakobshavn glacier

2nd May

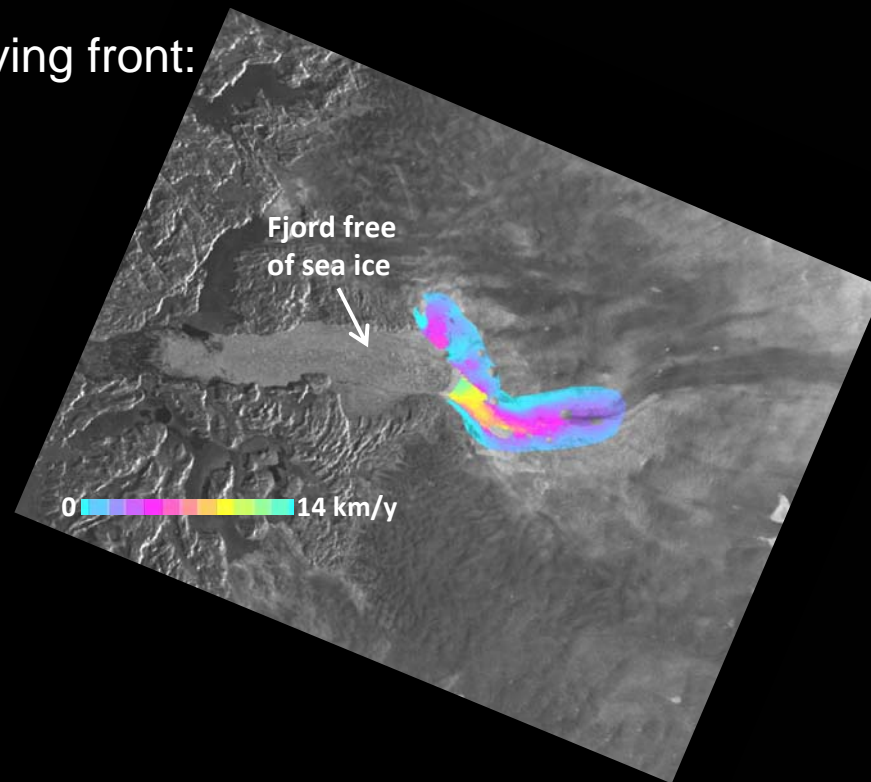
Air temp at calving front:
-1 °C



Jakobshavn glacier

5th May

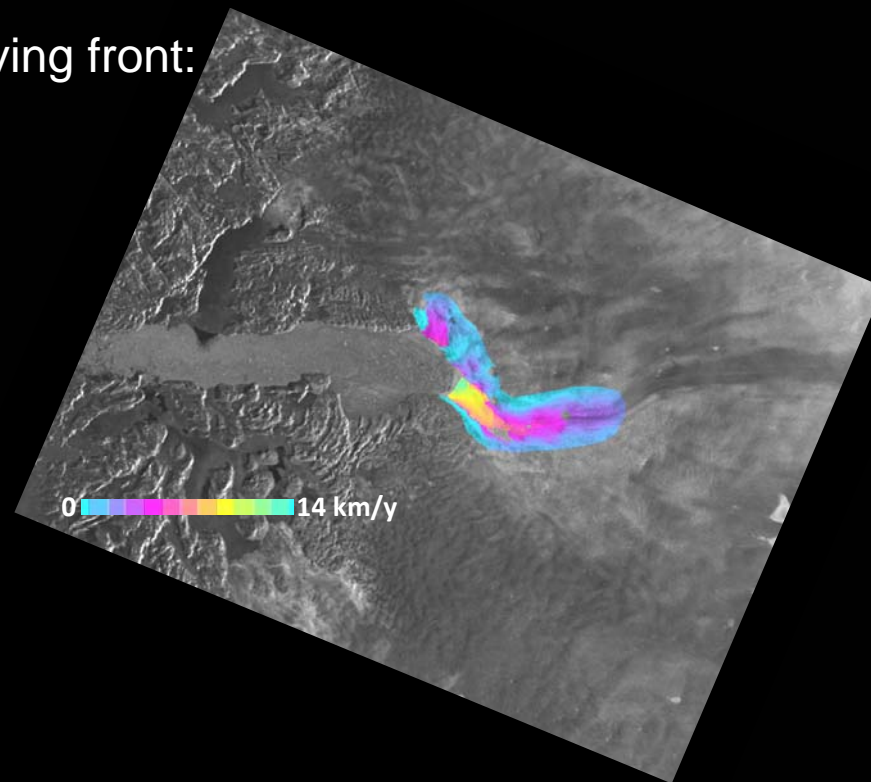
Air temp at calving front:
3 °C



Jakobshavn glacier

8th May

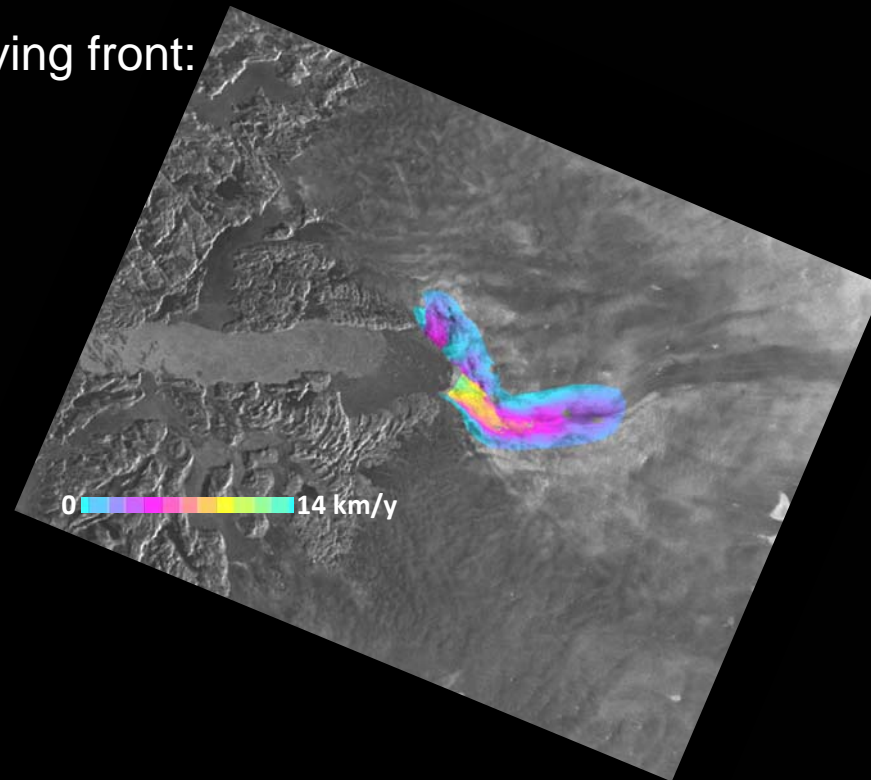
Air temp at calving front:
2 °C



Jakobshavn glacier

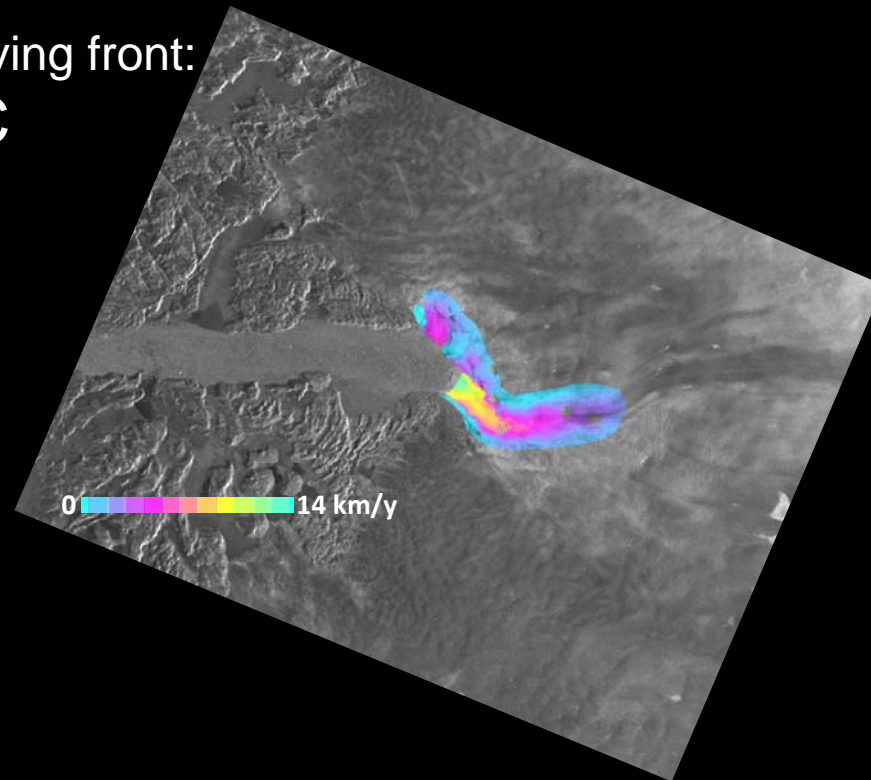
11th May

Air temp at calving front:
1 °C



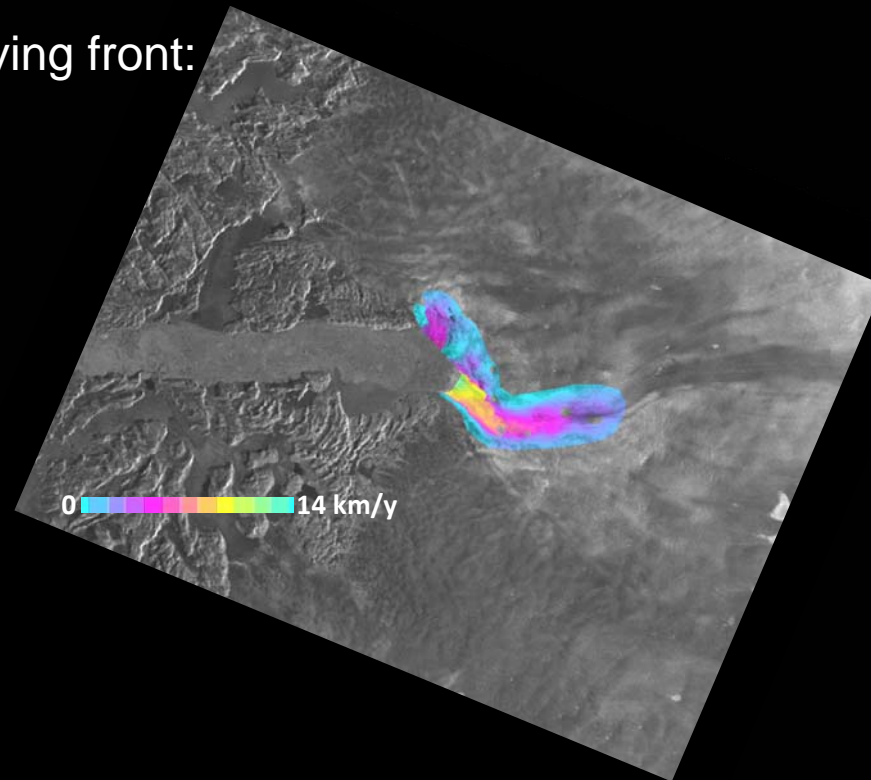
Jakobshavn glacier 14th May

Air temp at calving front:
-1 °C



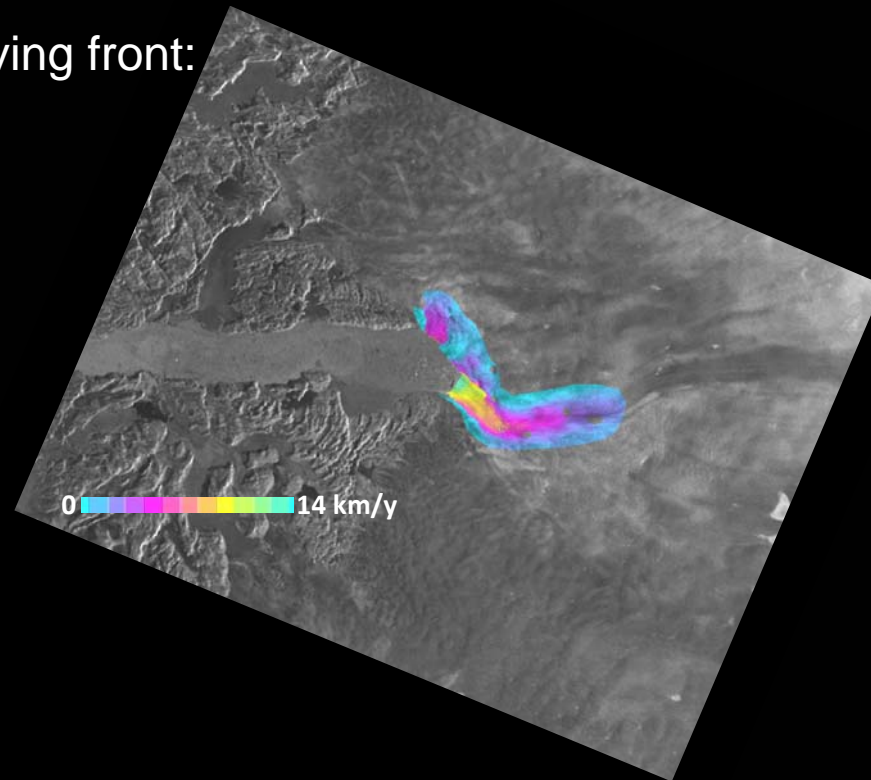
Jakobshavn glacier 17th May

Air temp at calving front:
0 °C



Jakobshavn glacier 20th May

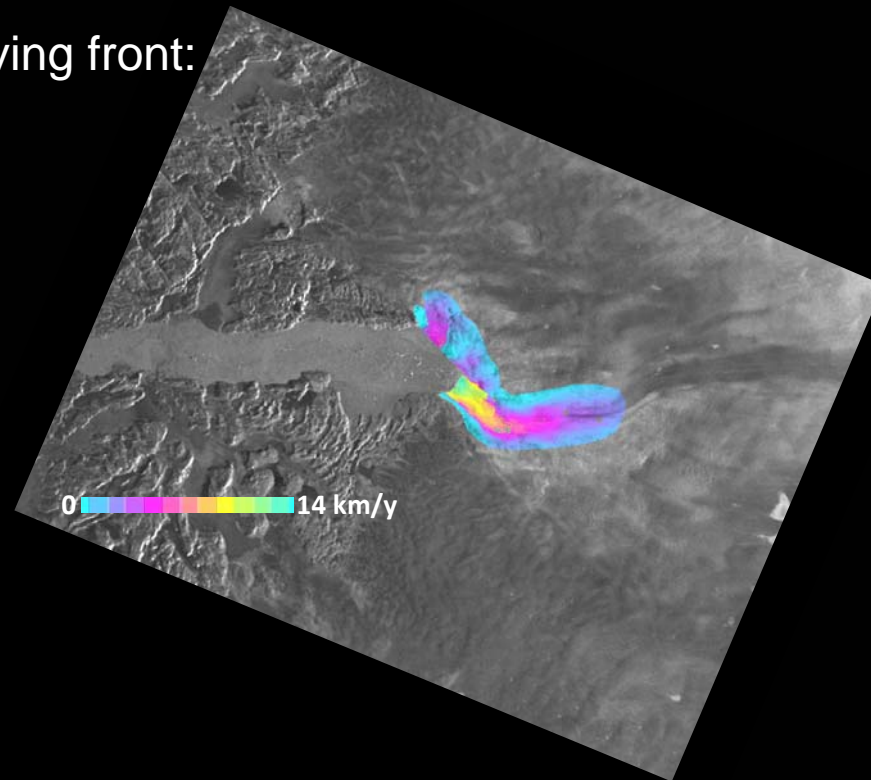
Air temp at calving front:
1 °C



Jakobshavn glacier

23rd May

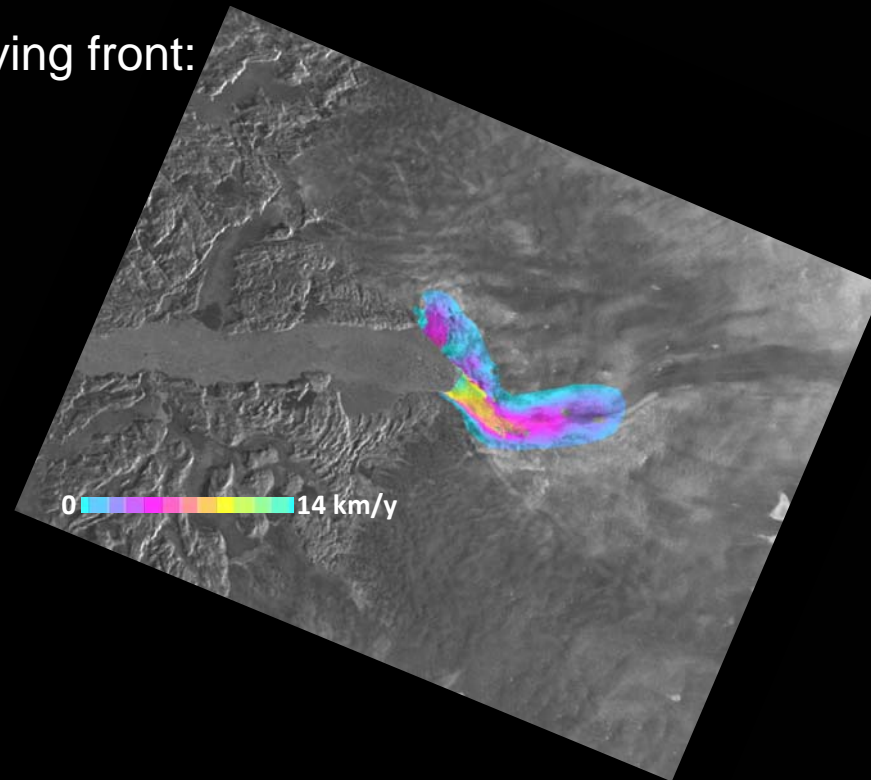
Air temp at calving front:
1 °C



Jakobshavn glacier

26th May

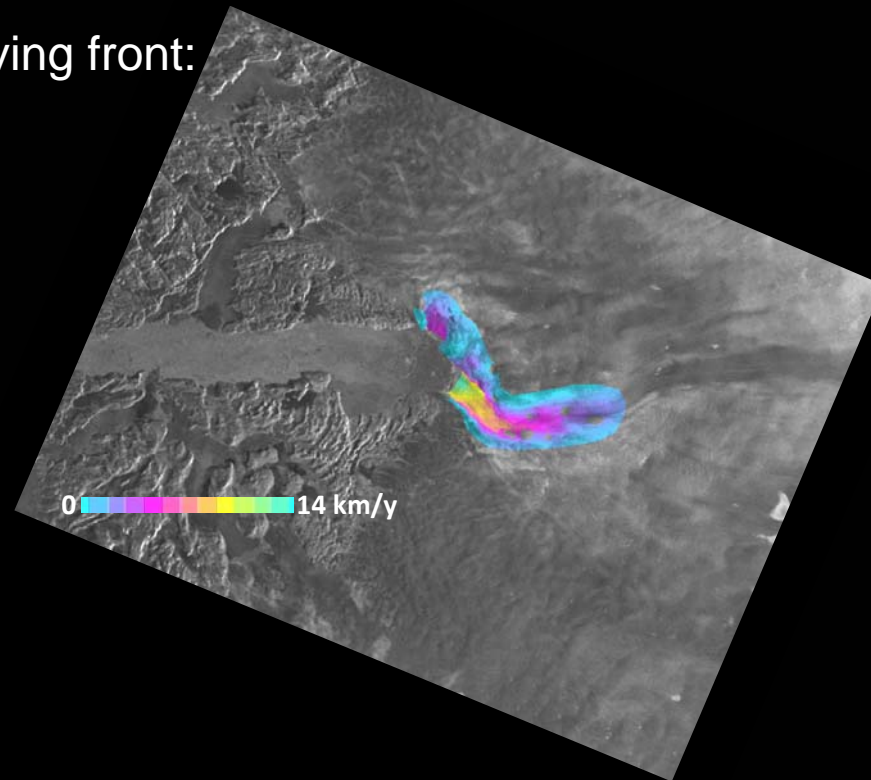
Air temp at calving front:
1 °C



Jakobshavn glacier

29th May

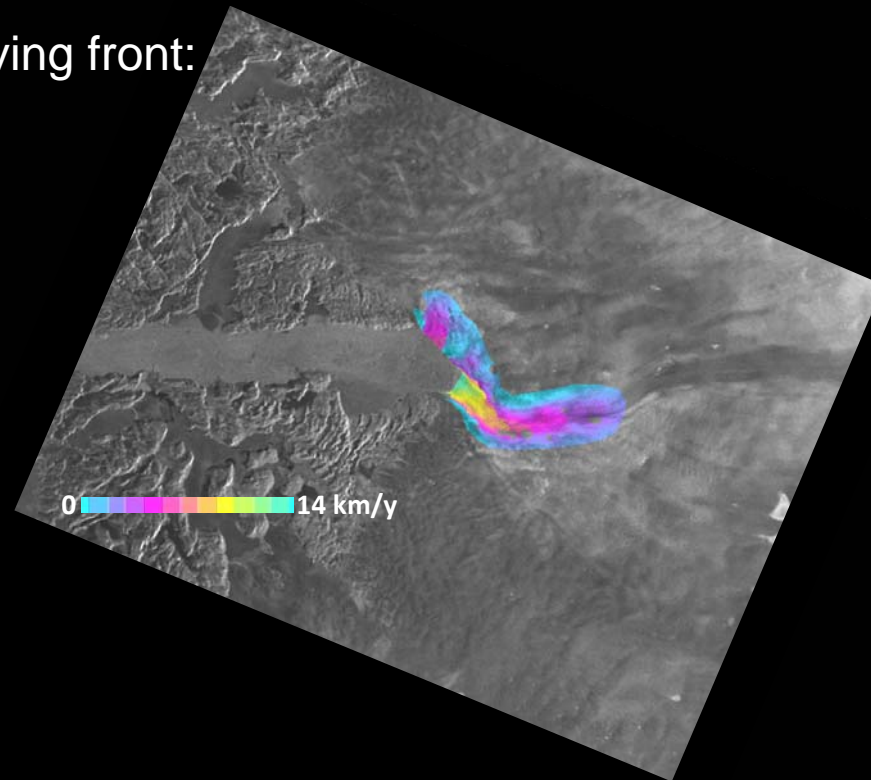
Air temp at calving front:
0 °C



Jakobshavn glacier

1st June

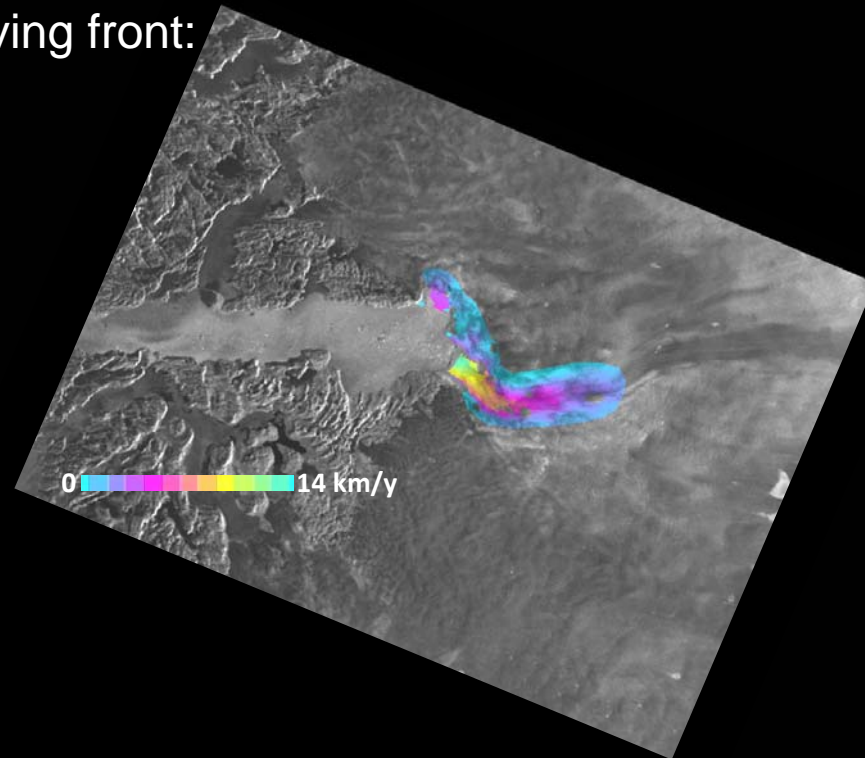
Air temp at calving front:
2 °C



Jakobshavn glacier

4th June

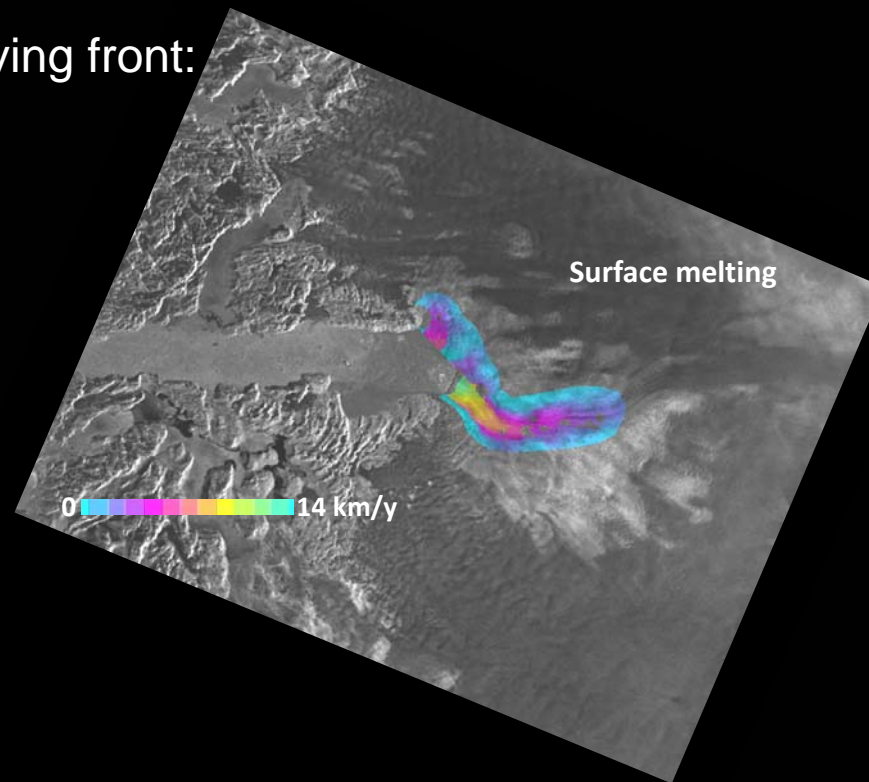
Air temp at calving front:
3 °C



Jakobshavn glacier

7th June

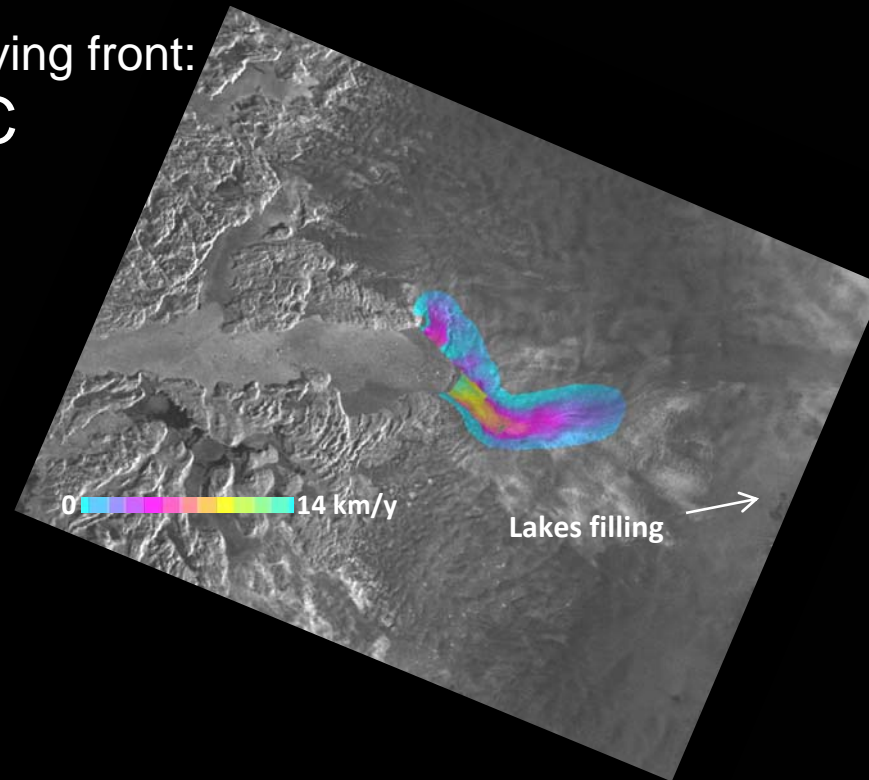
Air temp at calving front:
7 °C



Jakobshavn glacier

10th June

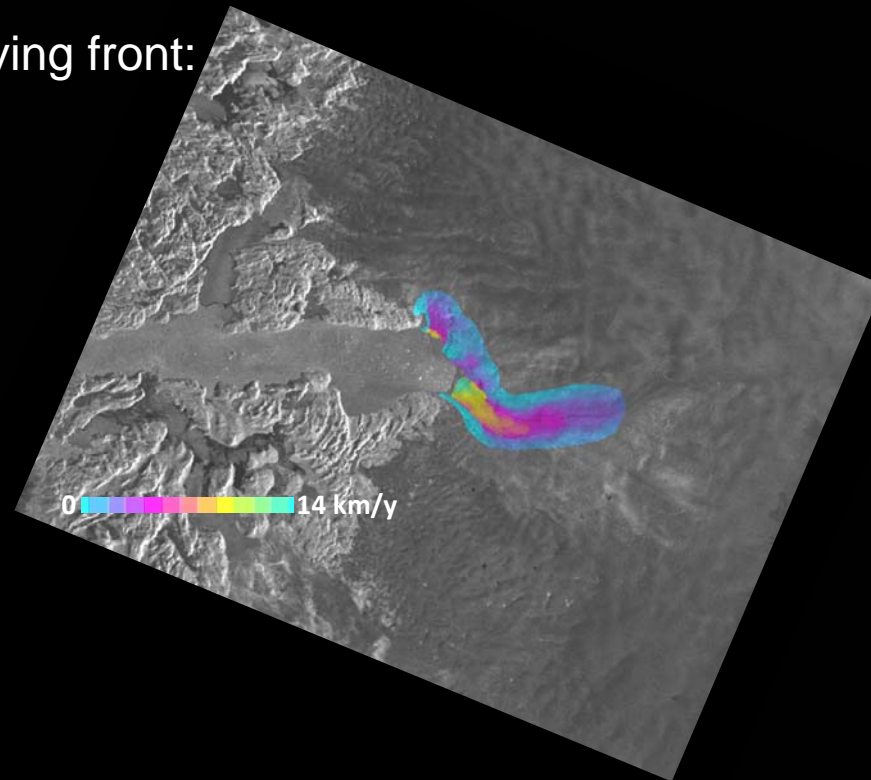
Air temp at calving front:
13 °C



Jakobshavn glacier

13th June

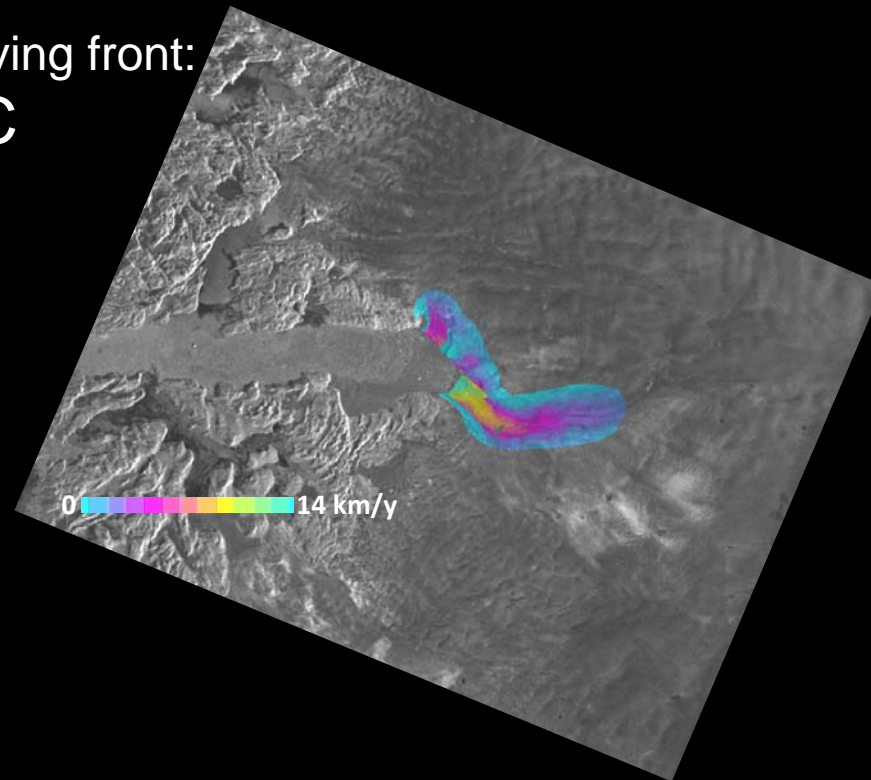
Air temp at calving front:
9 °C



Jakobshavn glacier

16th June

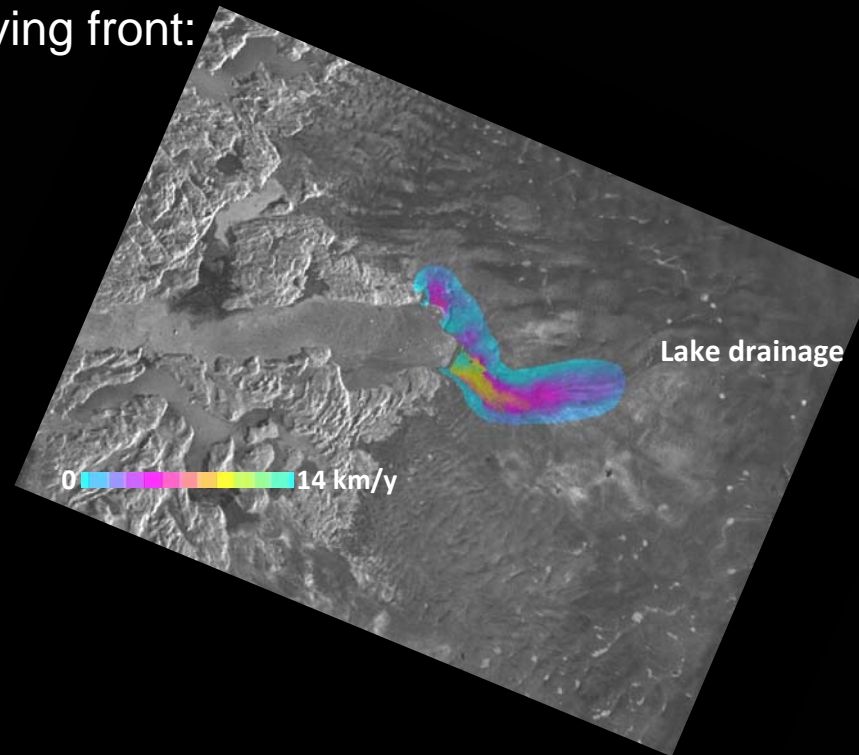
Air temp at calving front:
10 °C



Jakobshavn glacier

19th June

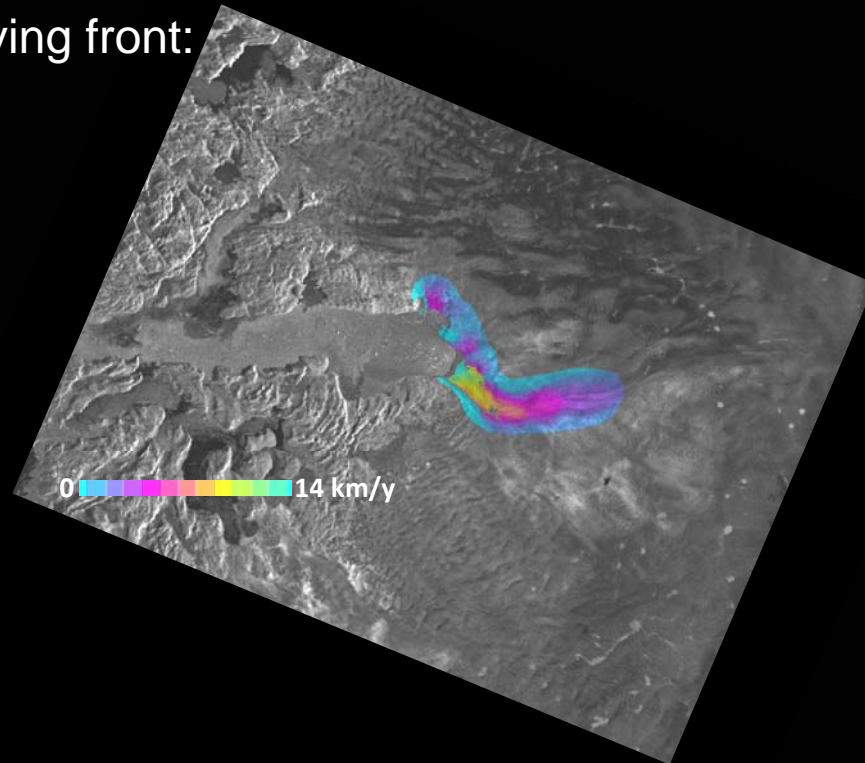
Air temp at calving front:
5 °C



Jakobshavn glacier

22nd June

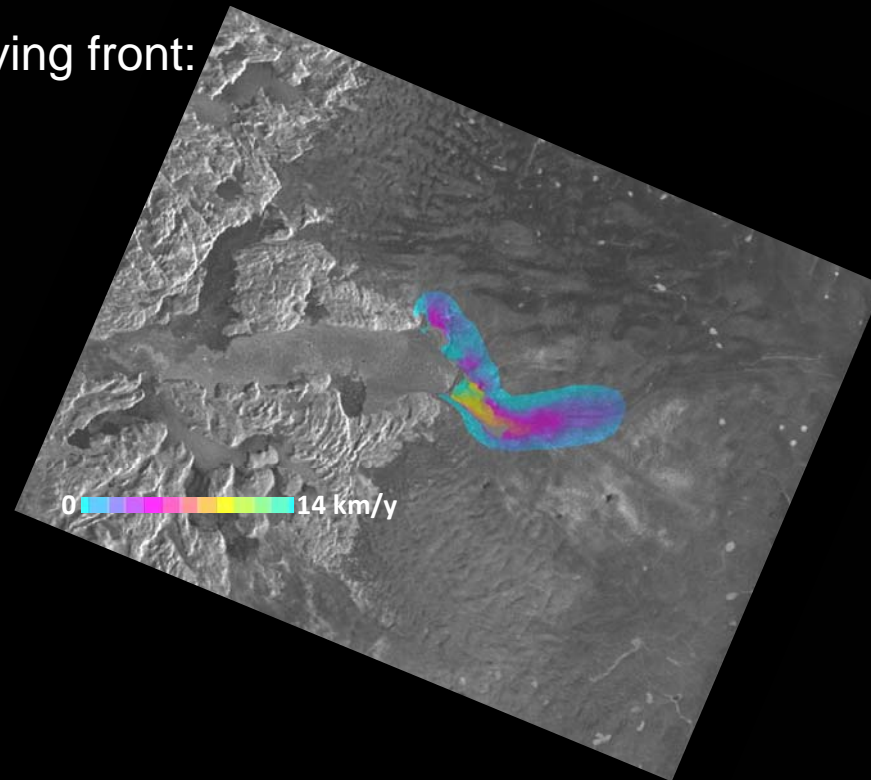
Air temp at calving front:
6 °C



Jakobshavn glacier

25th June

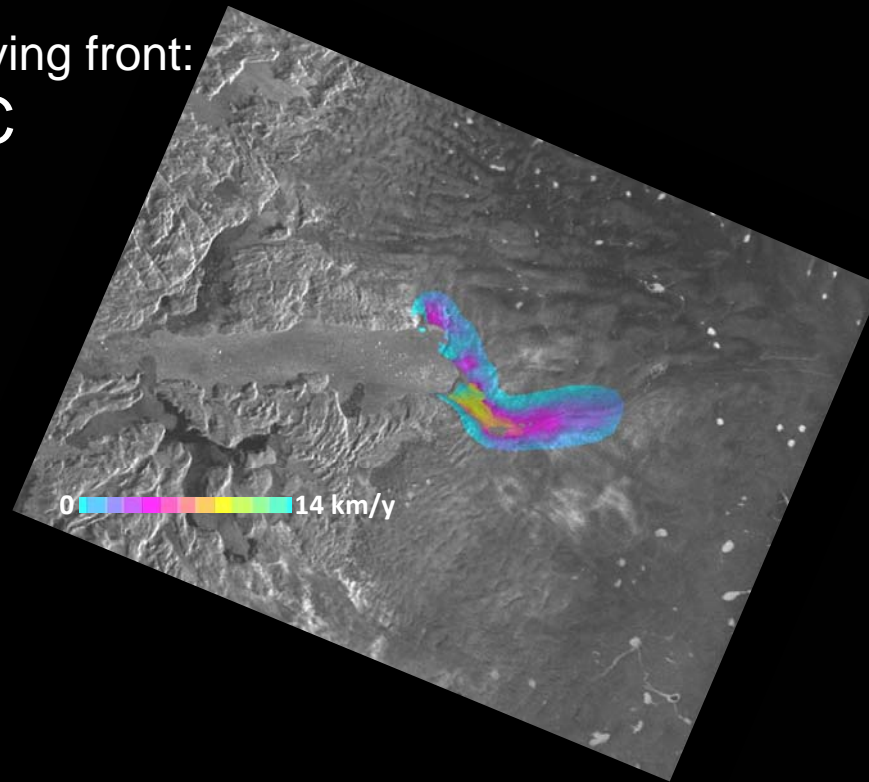
Air temp at calving front:
6 °C



Jakobshavn glacier

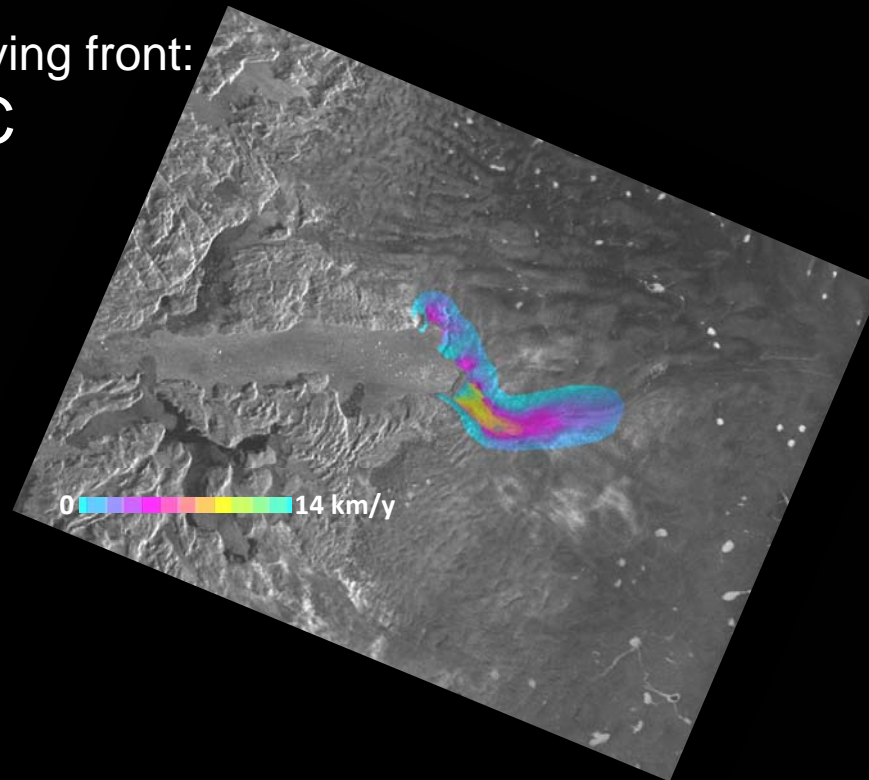
28th June

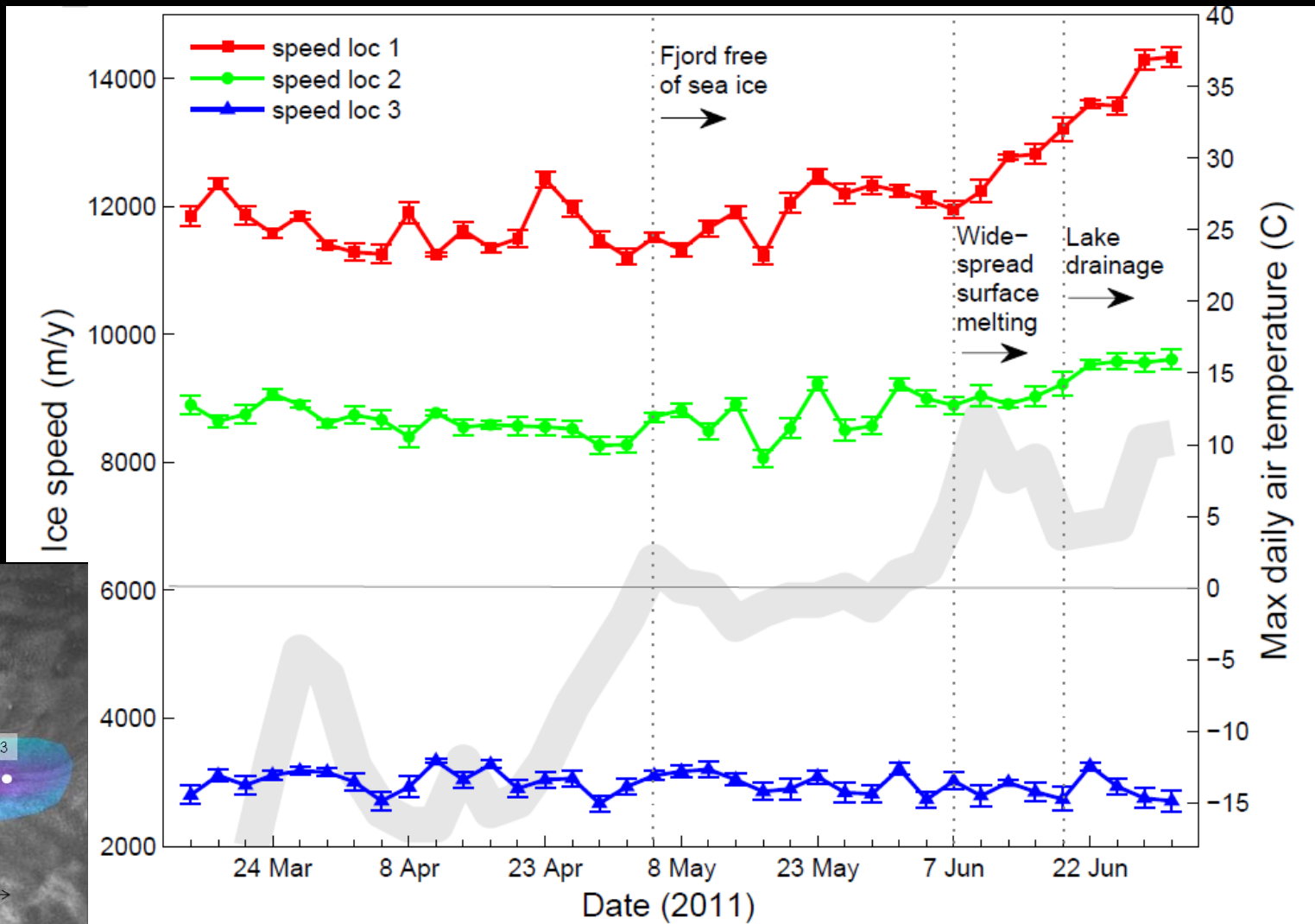
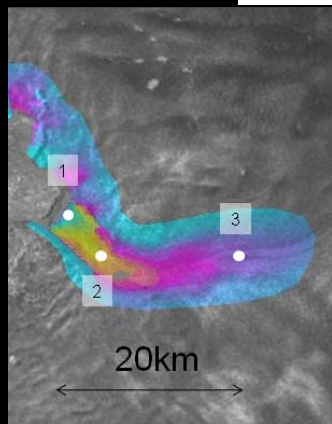
Air temp at calving front:
12 °C

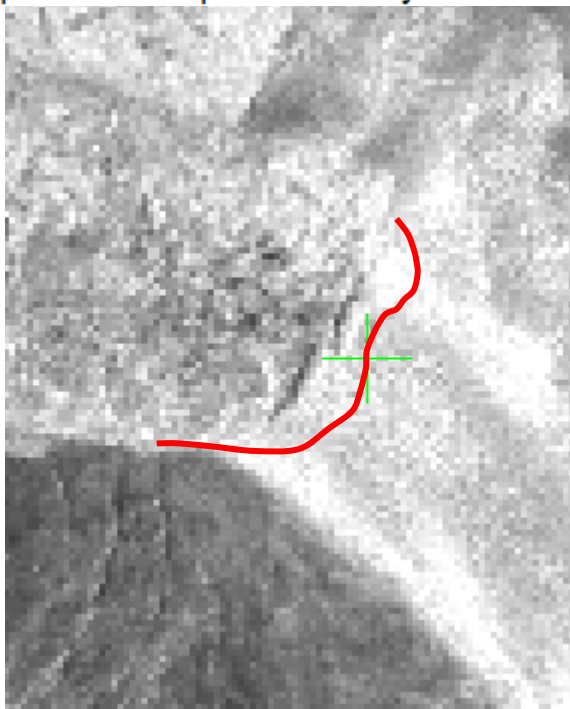
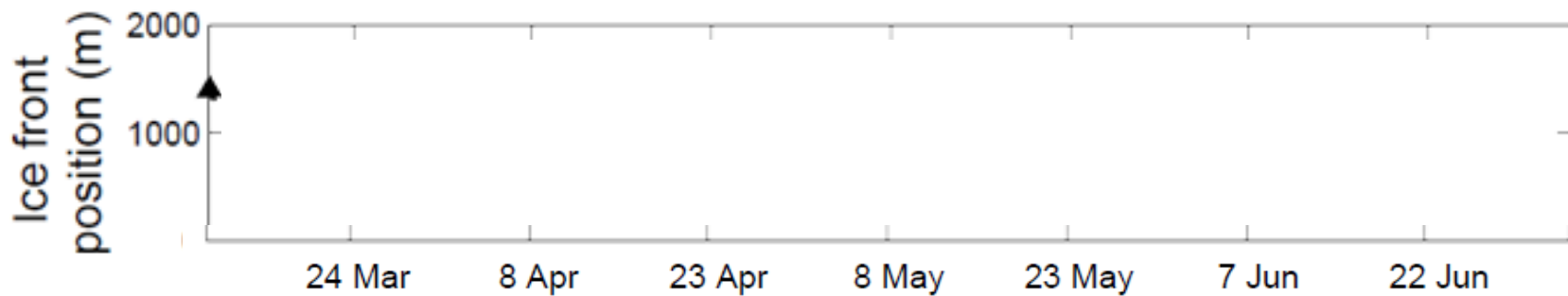


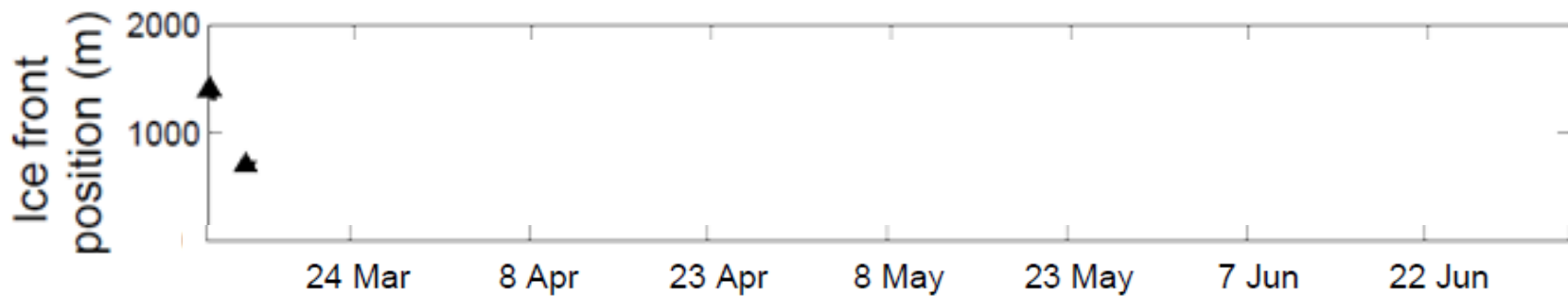
Jakobshavn glacier 1st July

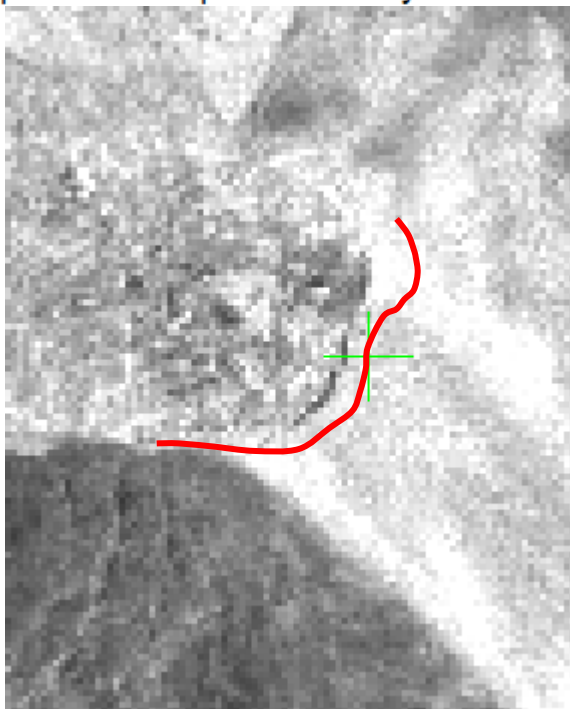
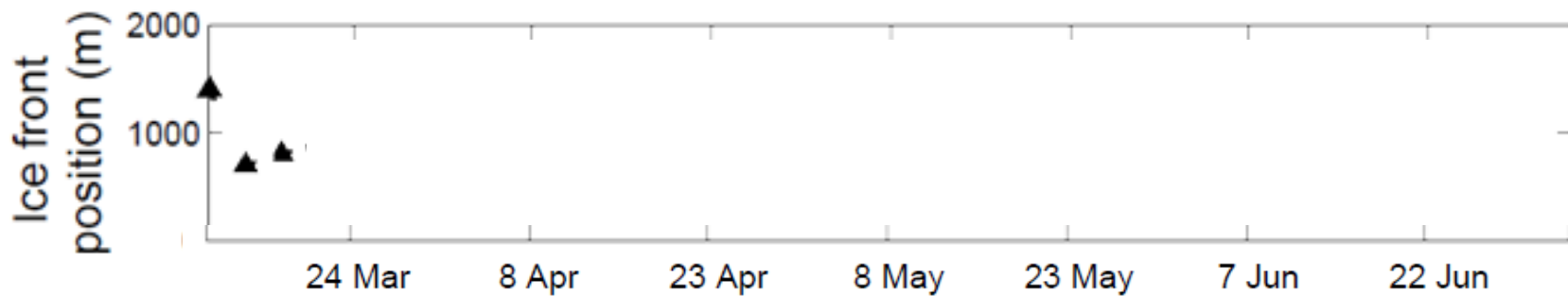
Air temp at calving front:
12 °C

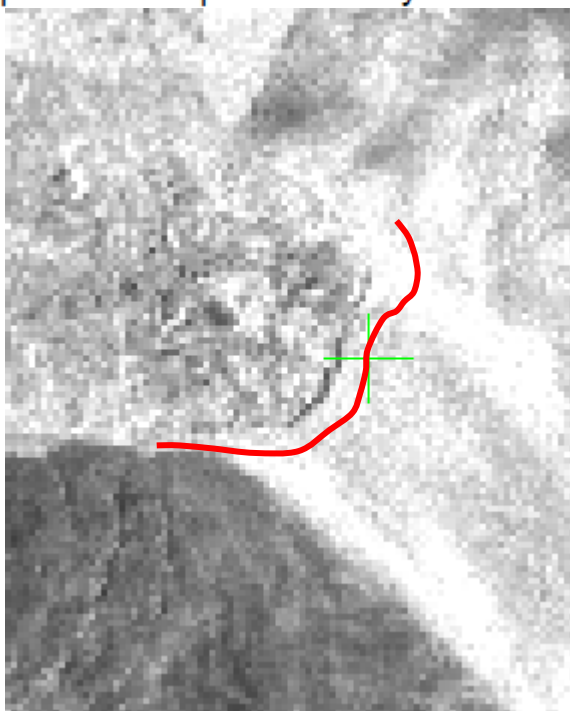
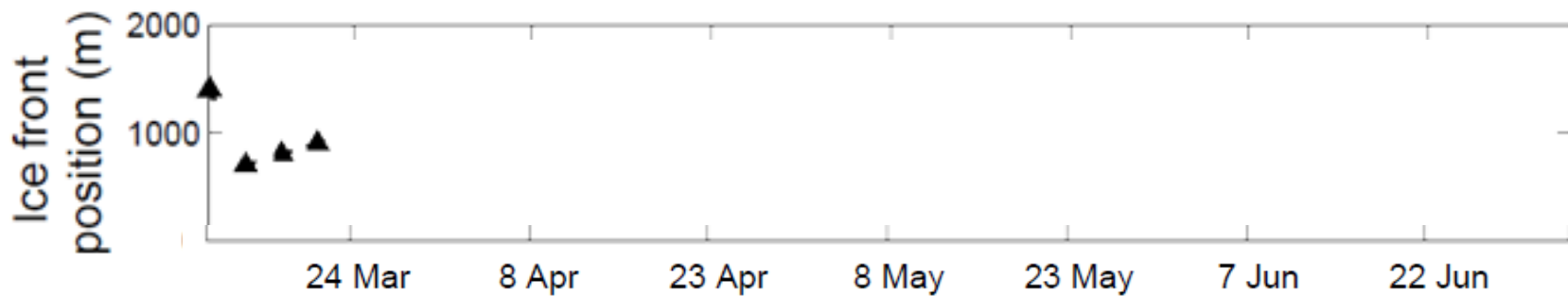


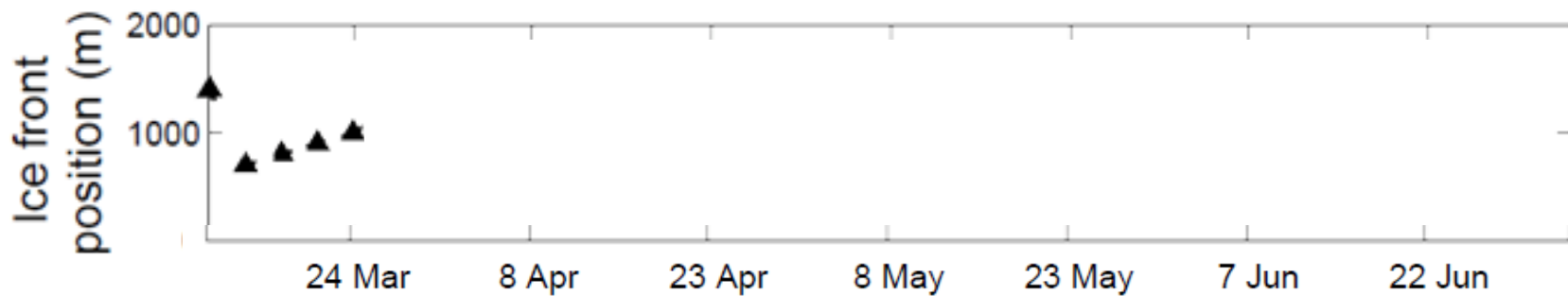


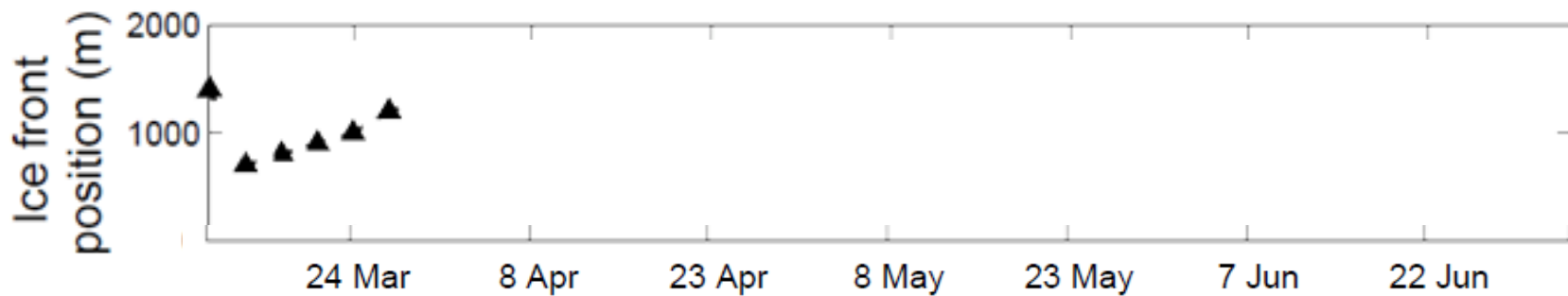


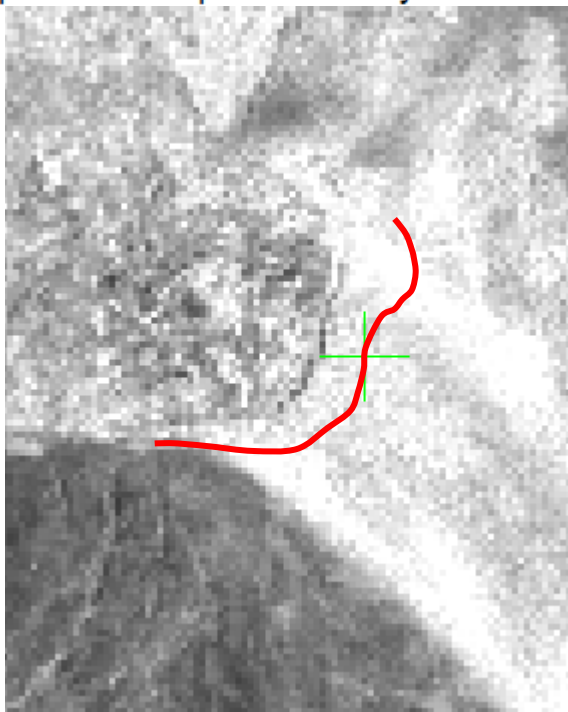
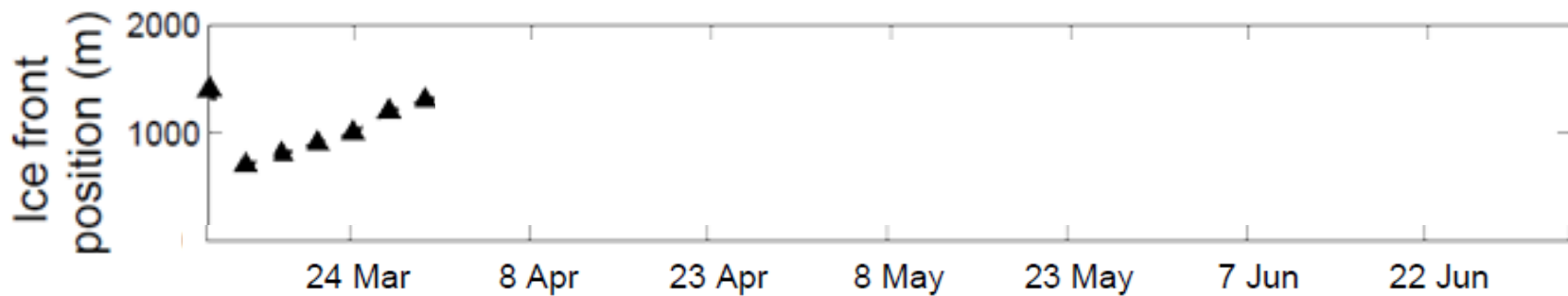


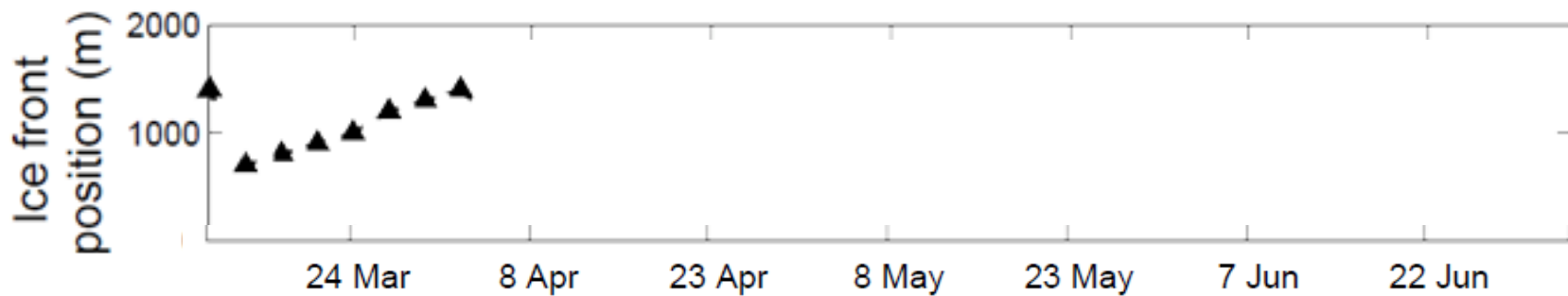


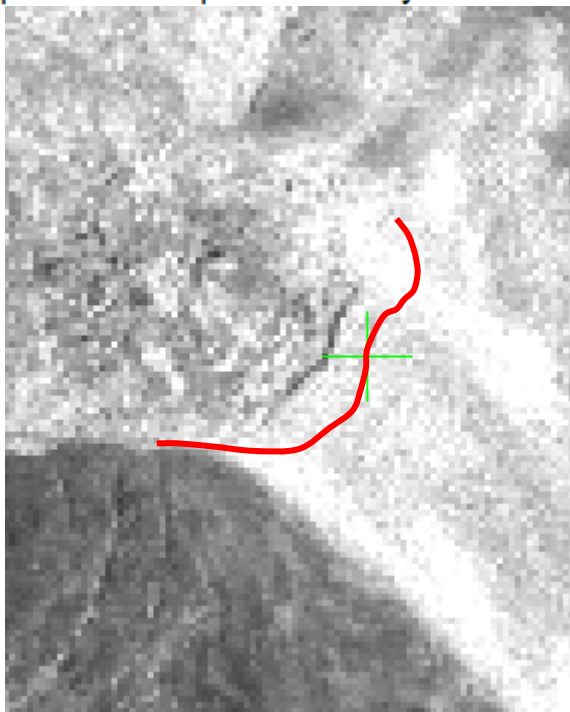
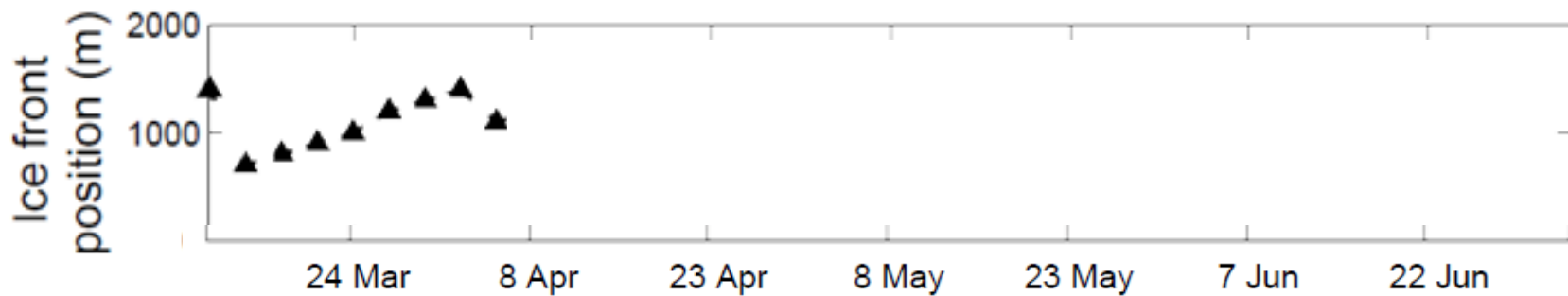


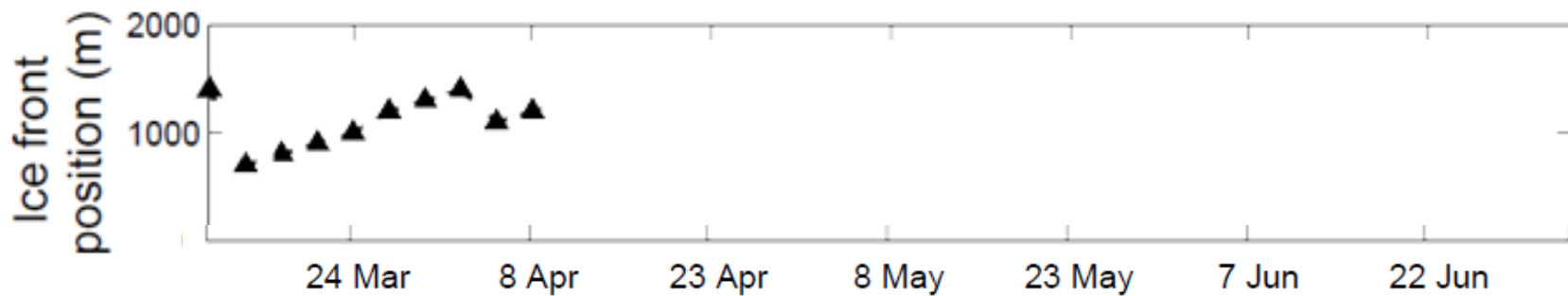


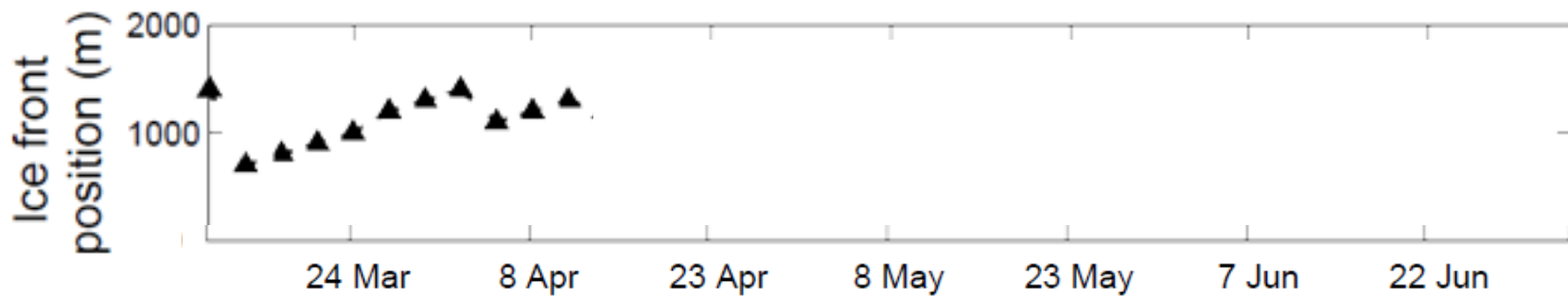


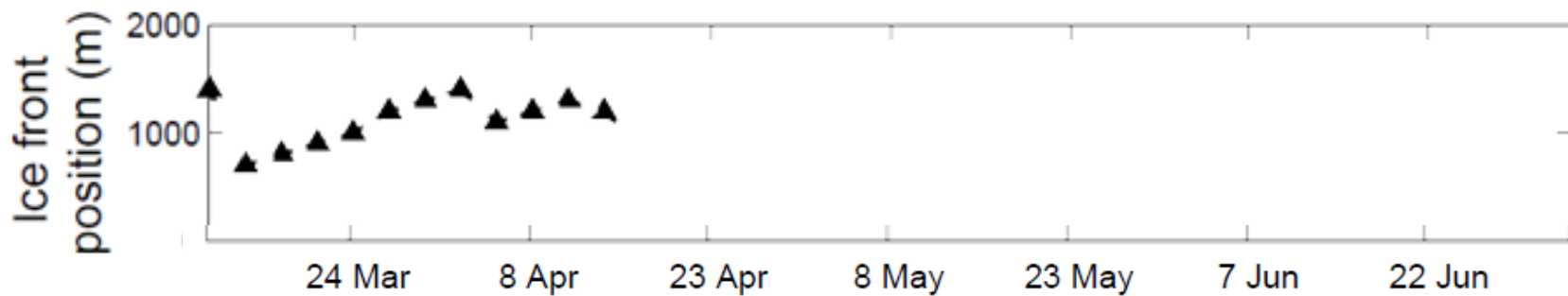


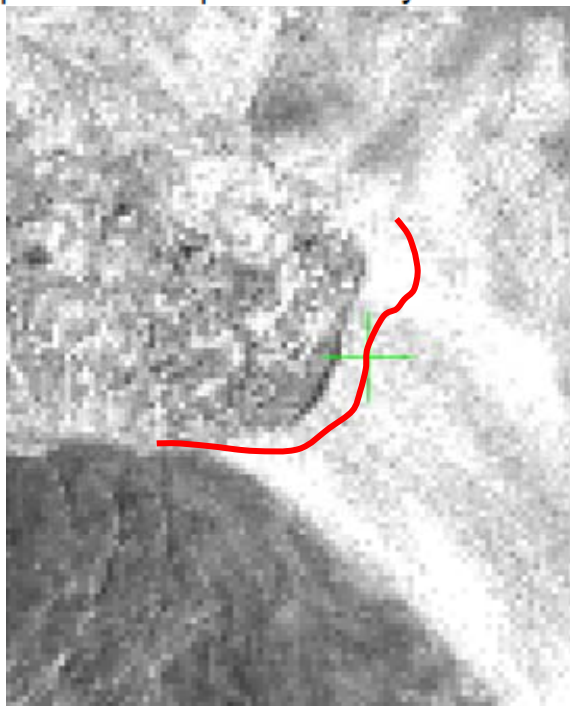
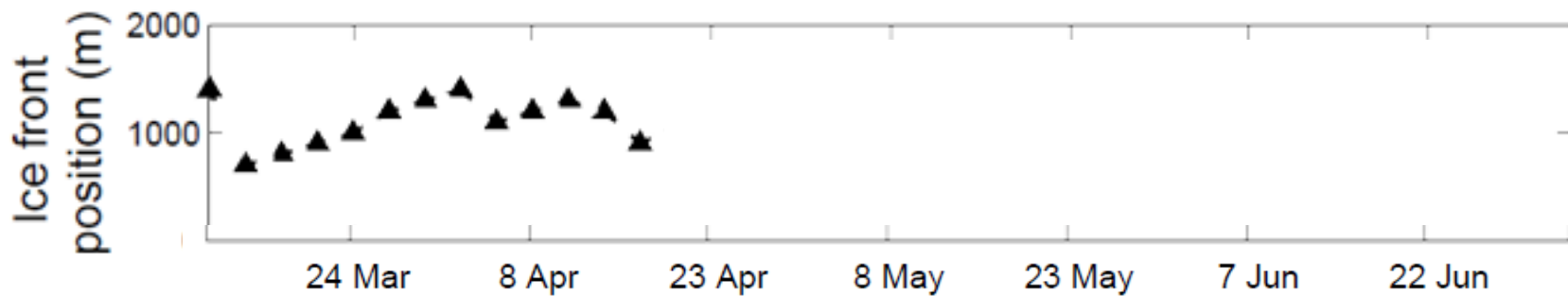


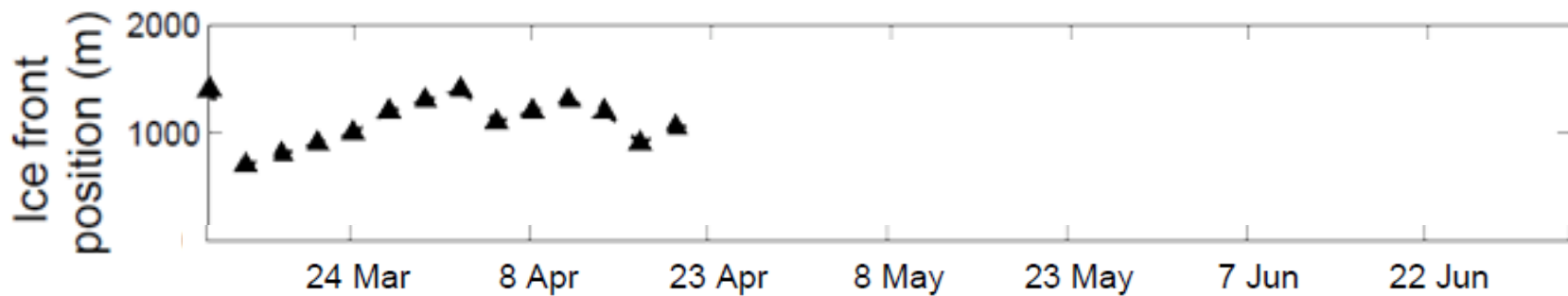


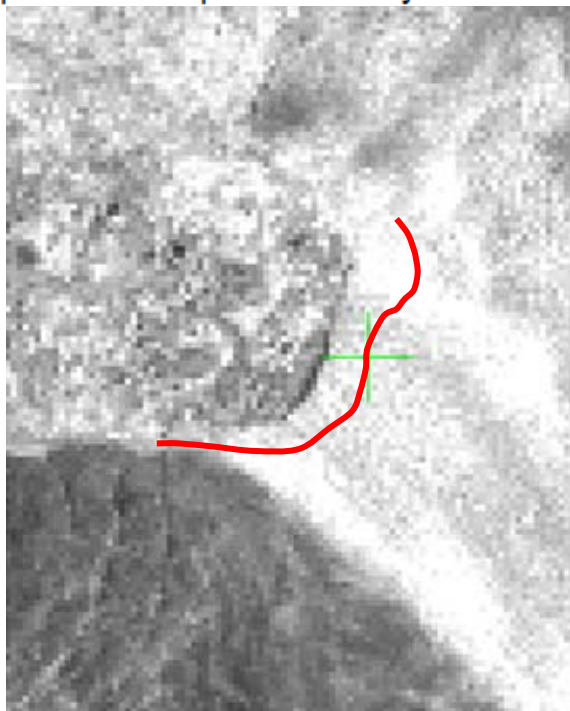
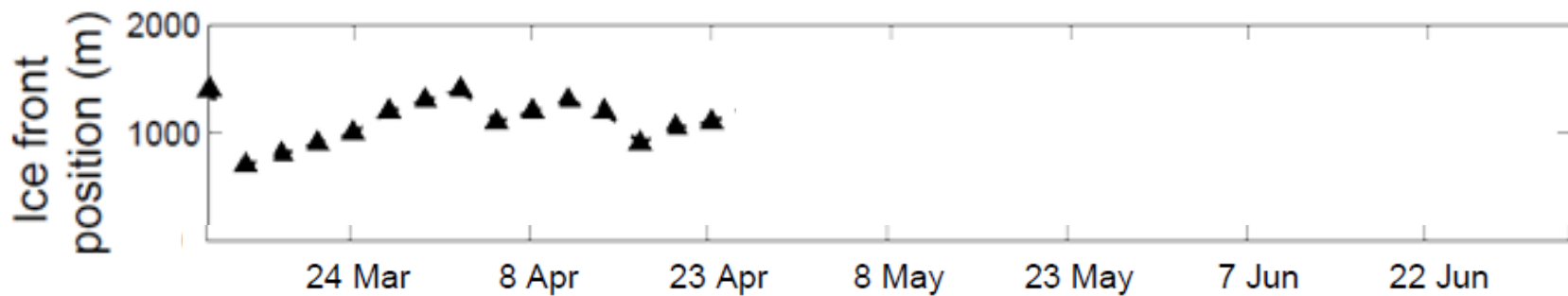


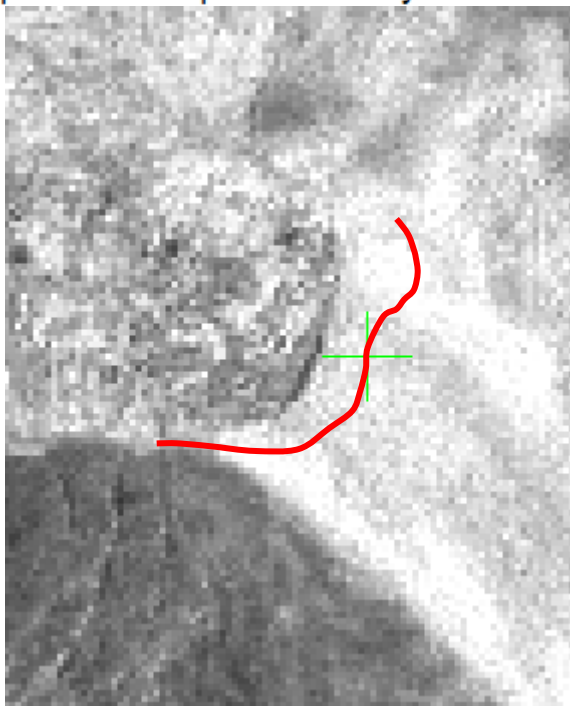
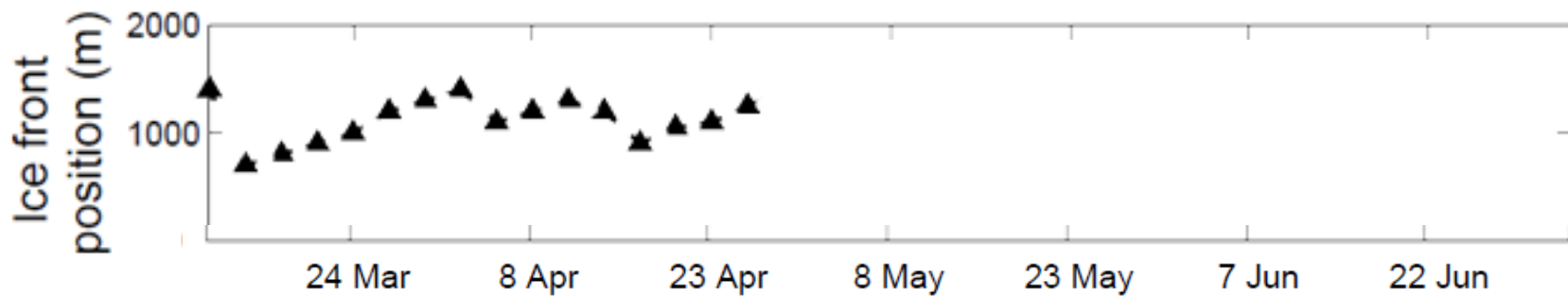


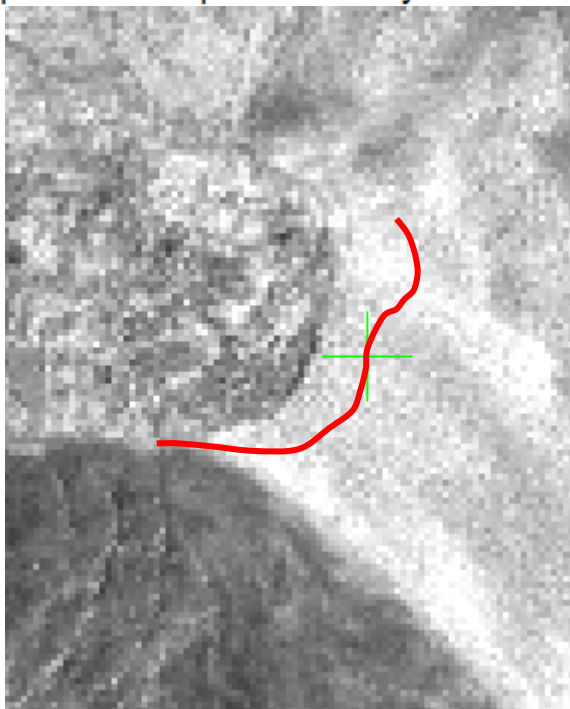
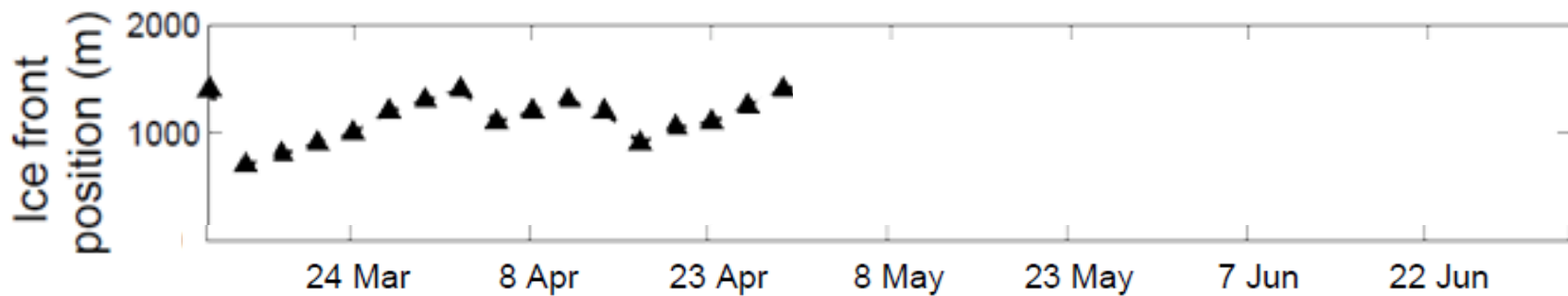


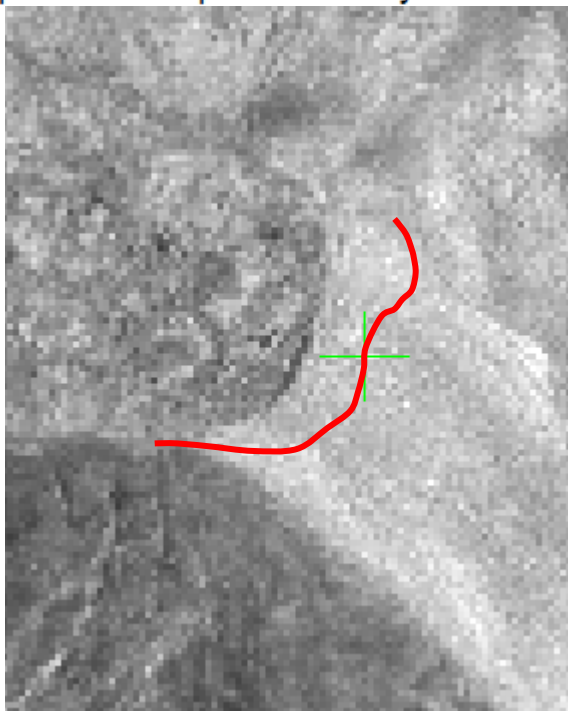
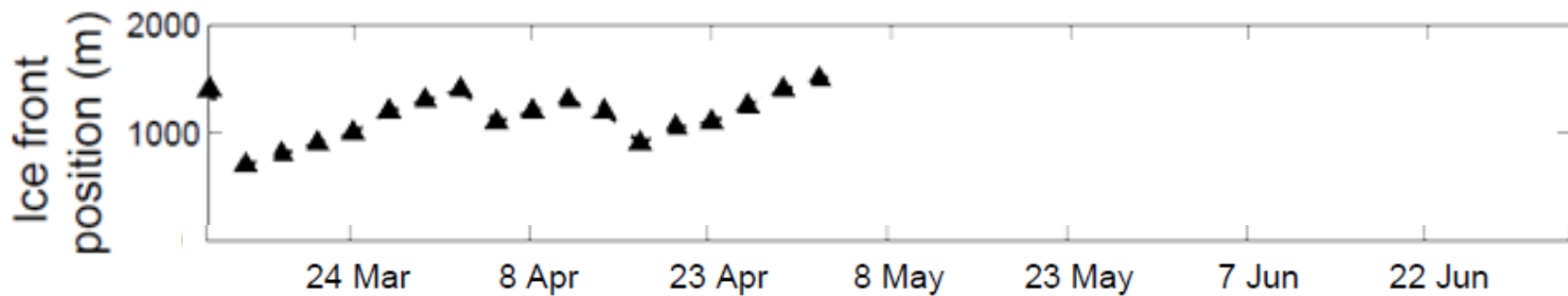


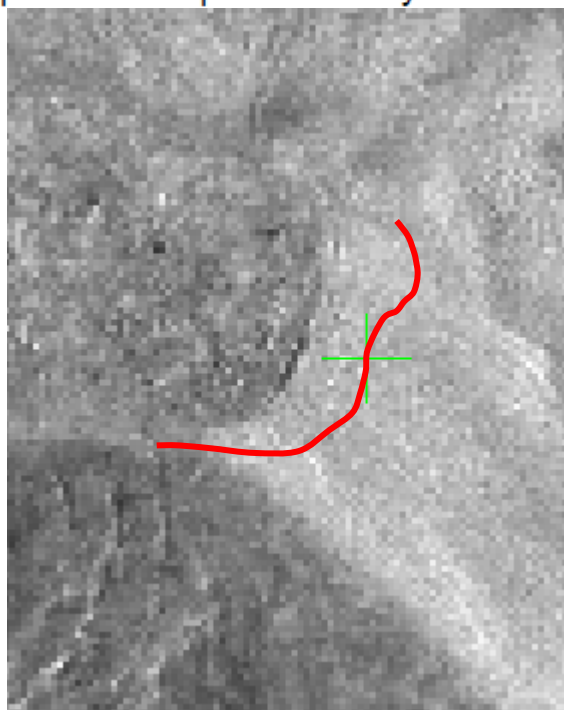
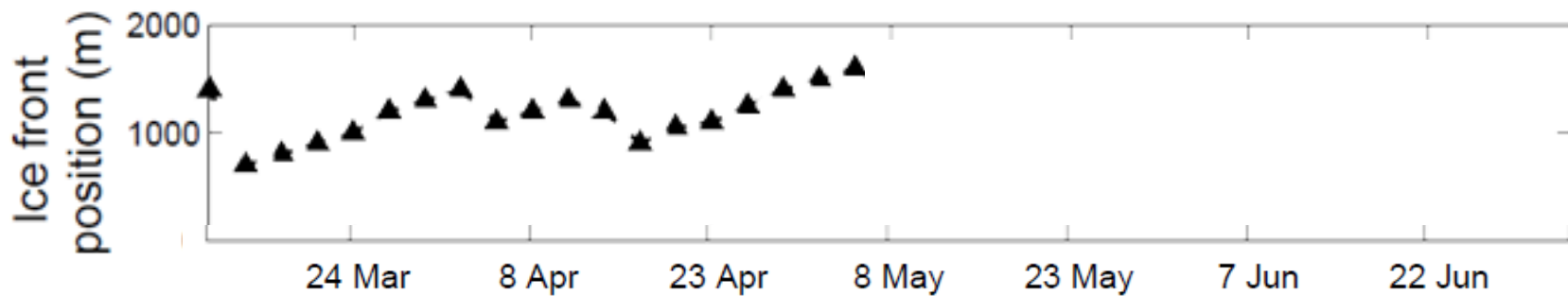


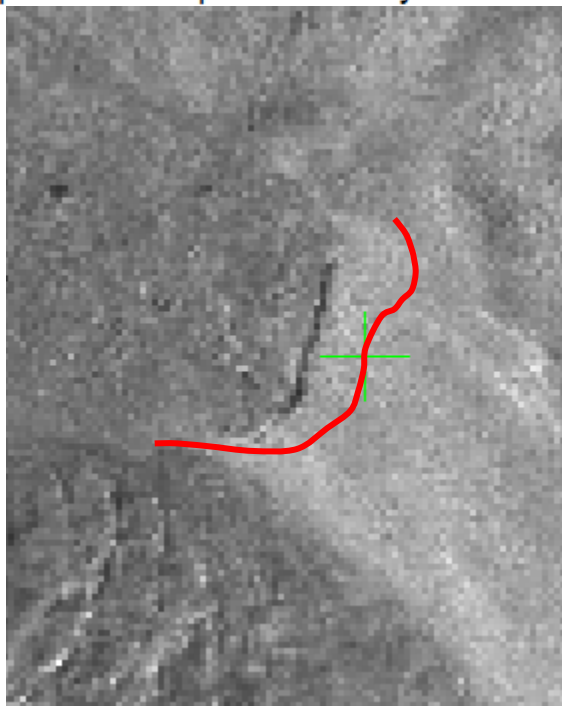
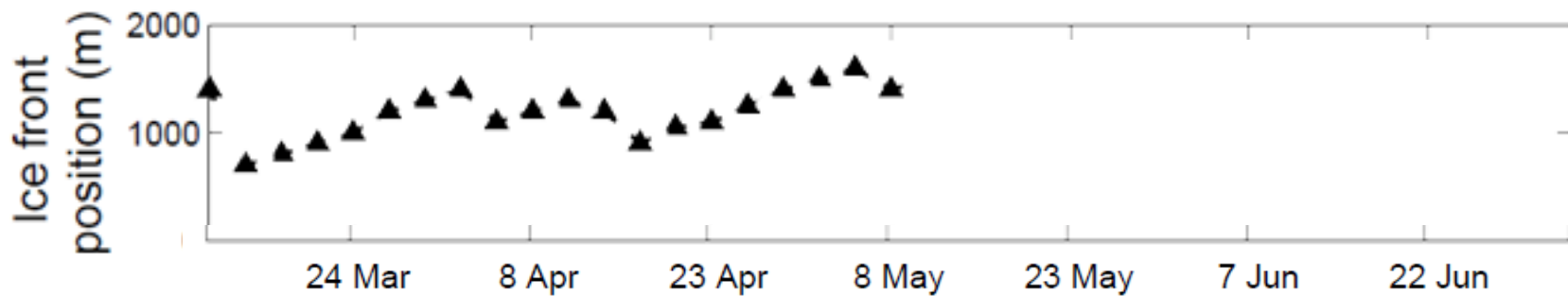


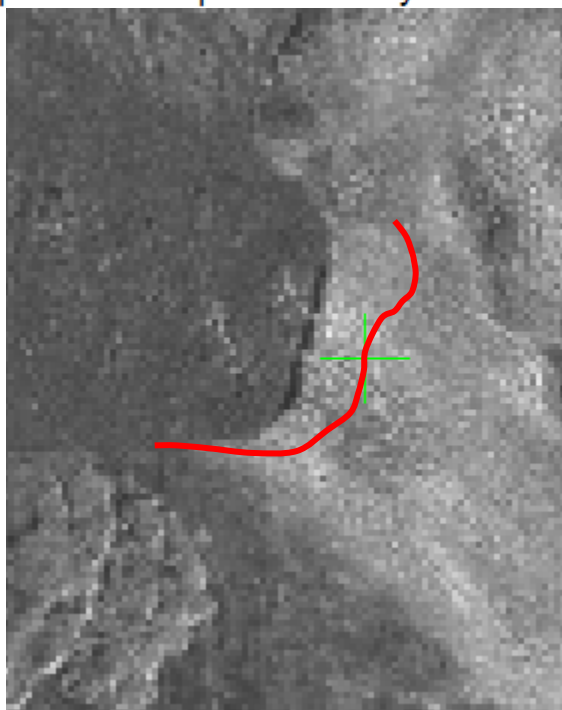
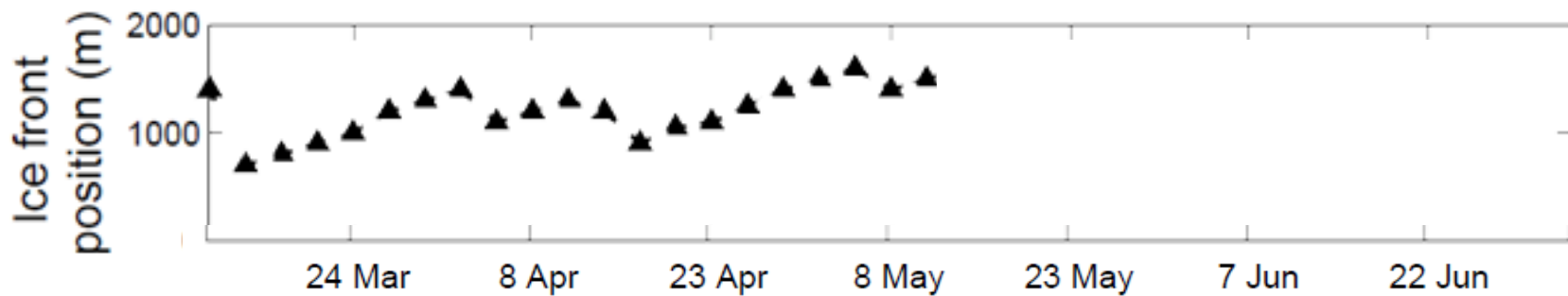


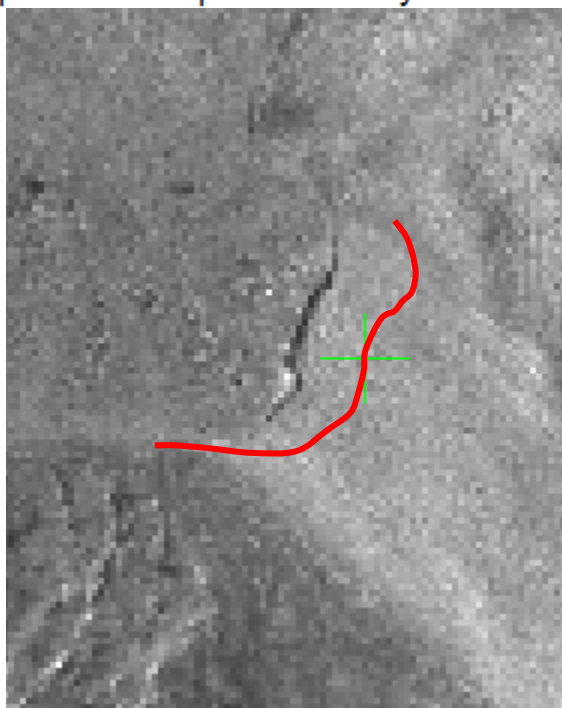
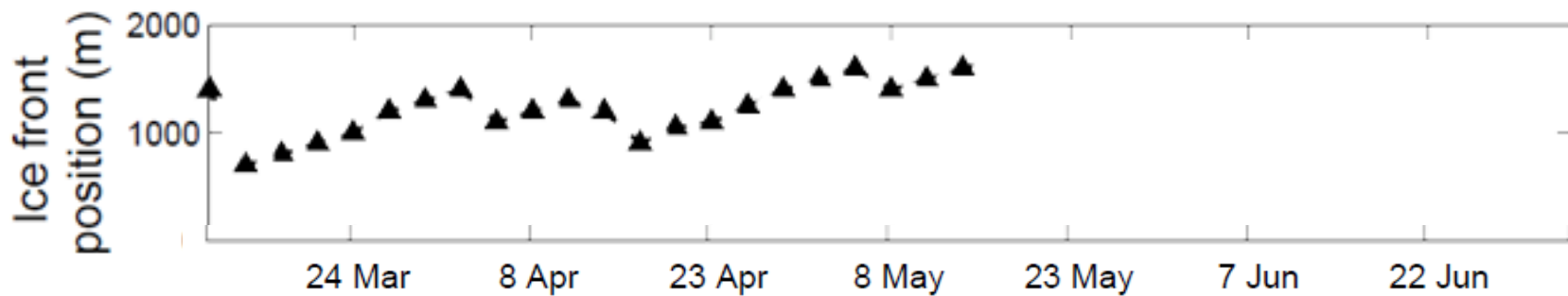


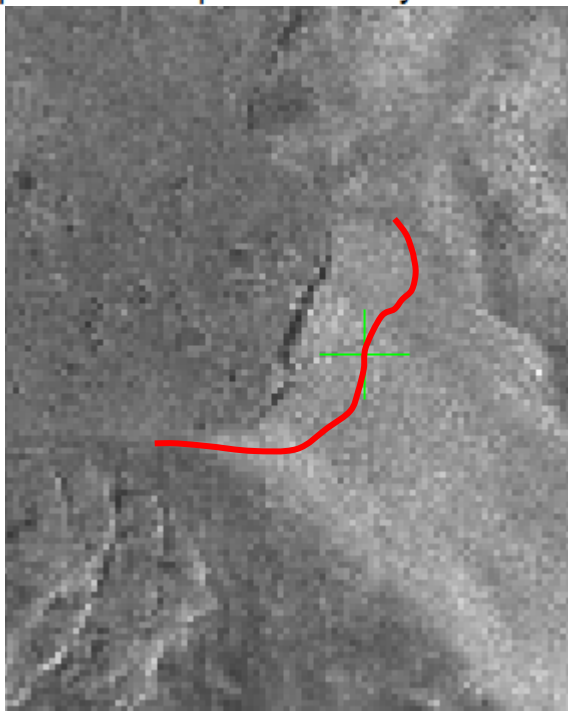
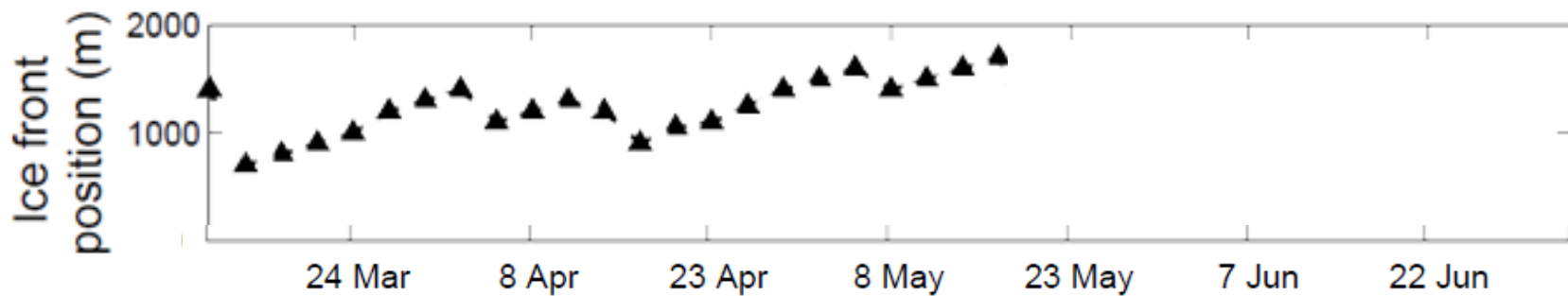


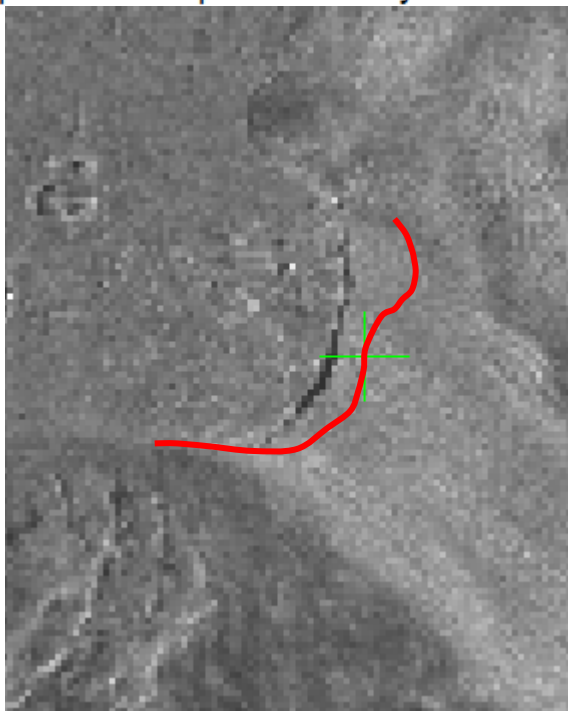
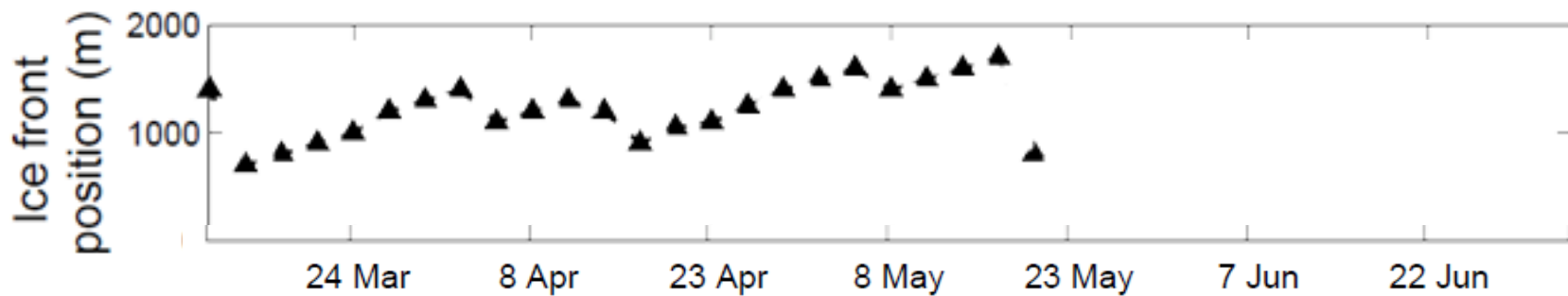


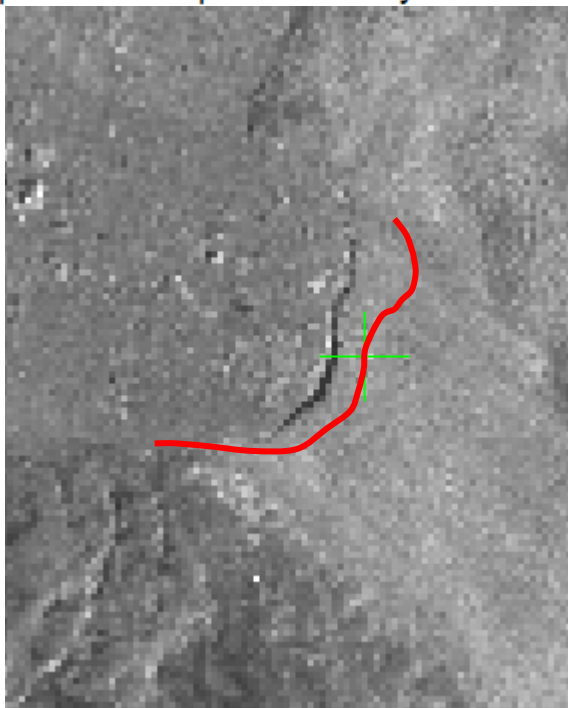
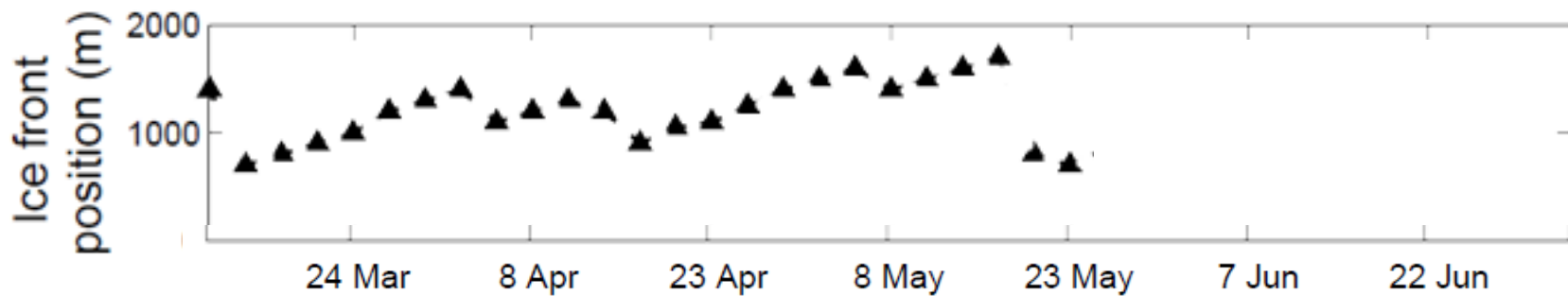


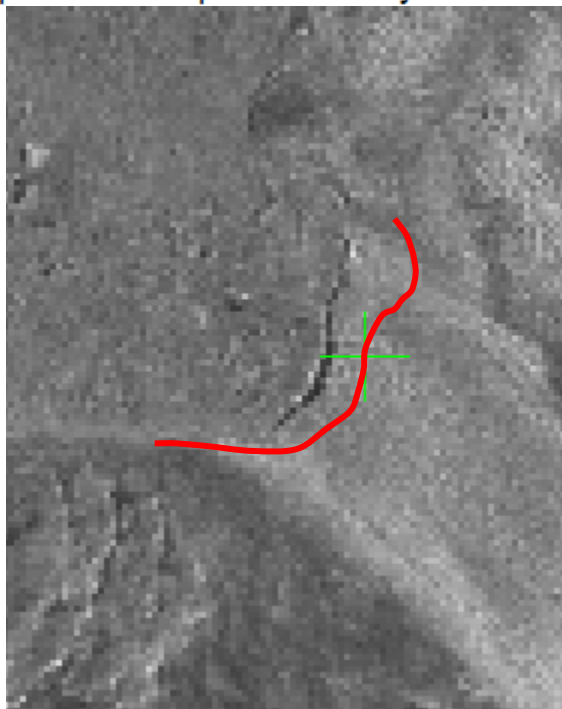
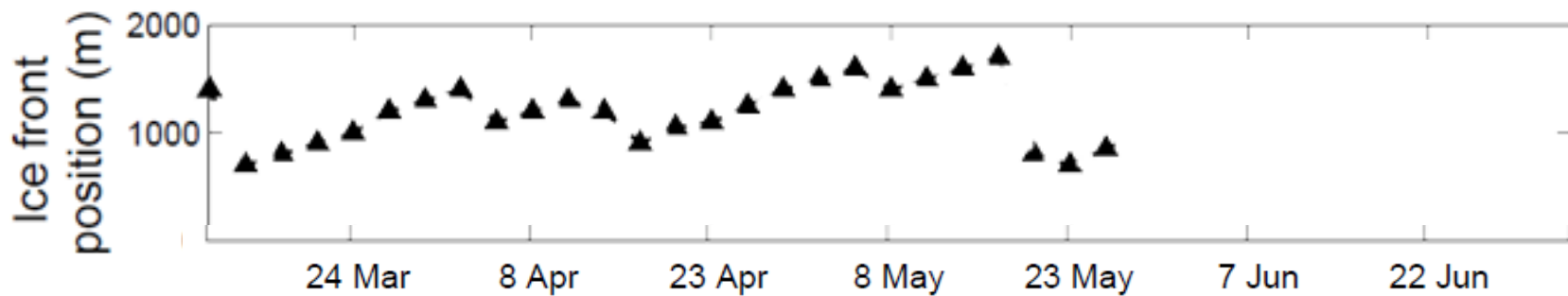


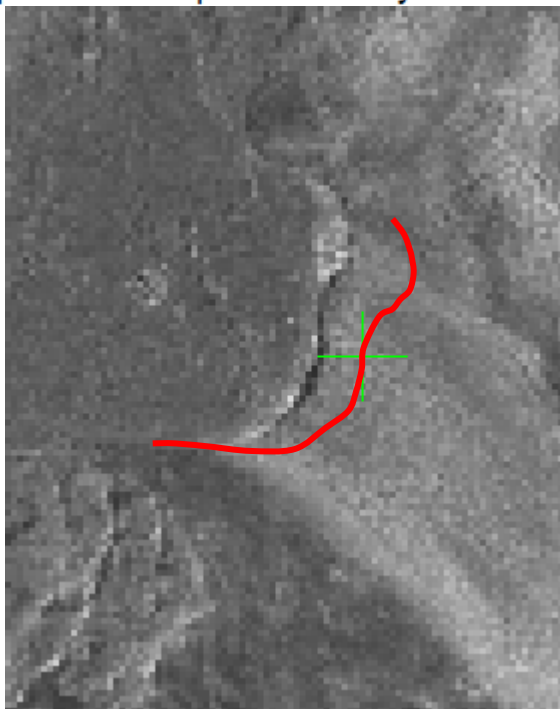
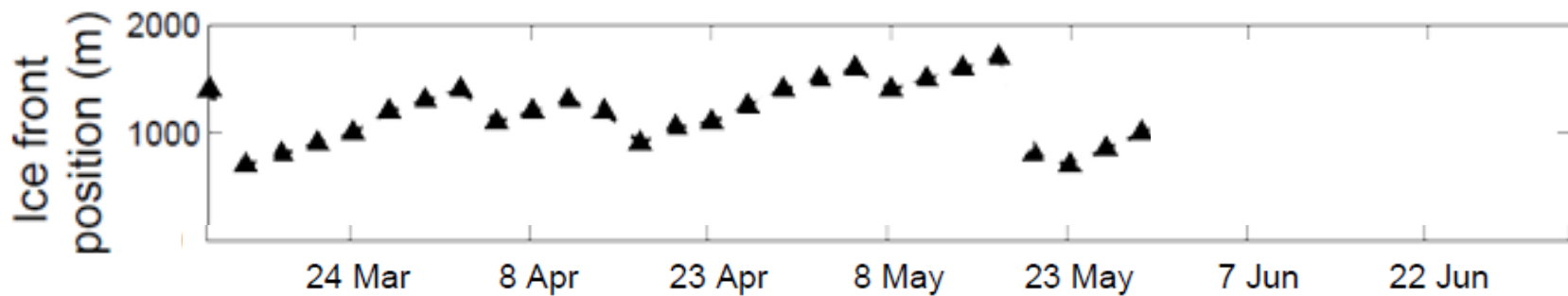


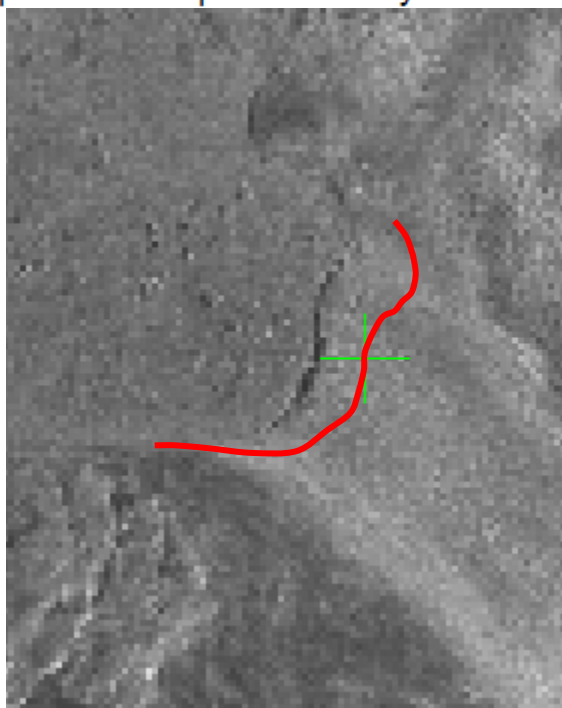
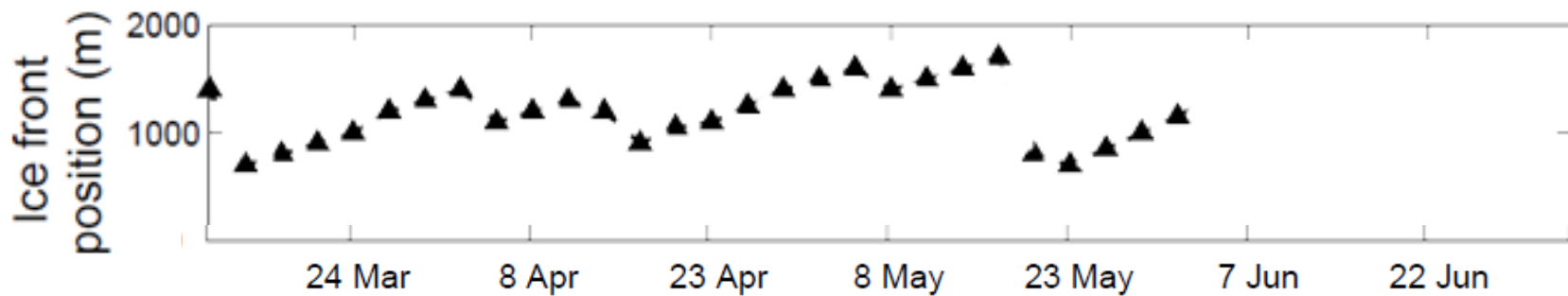


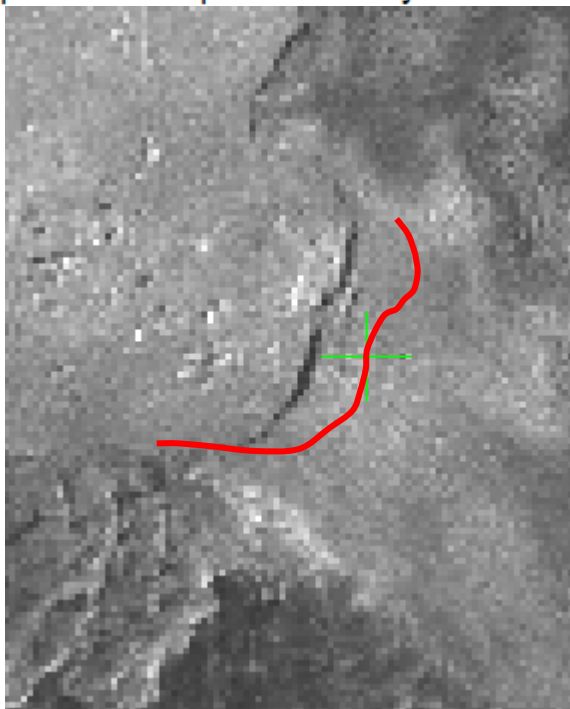
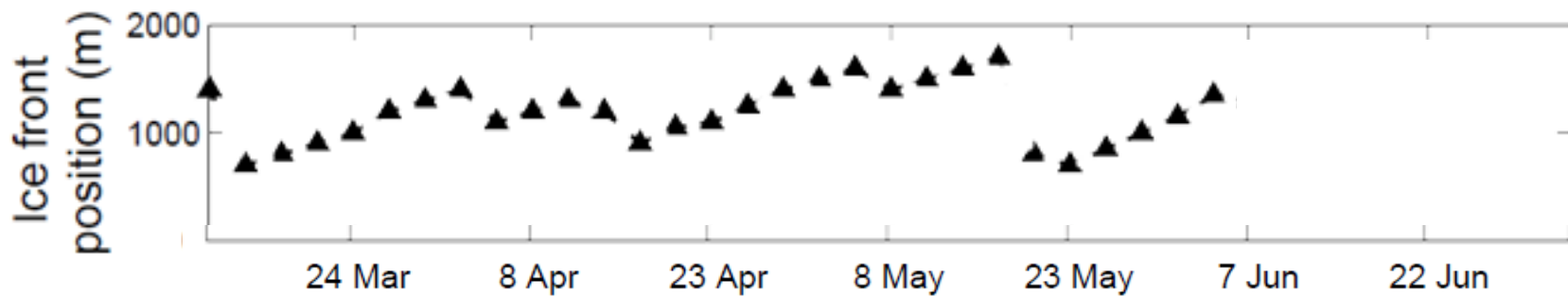


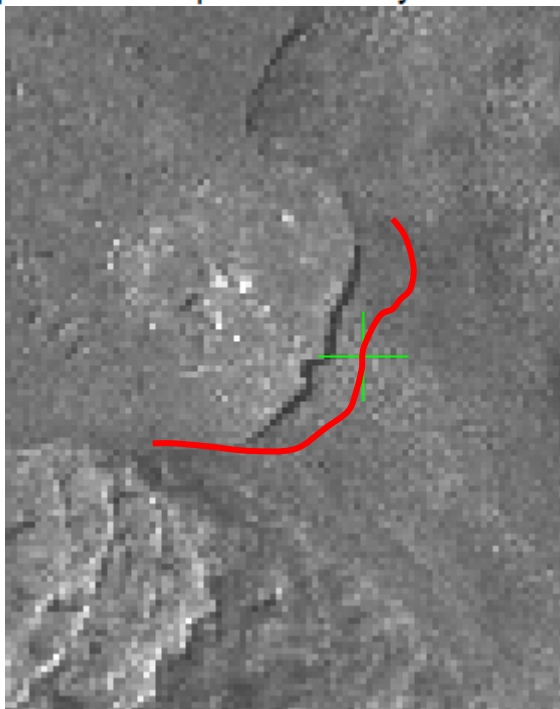
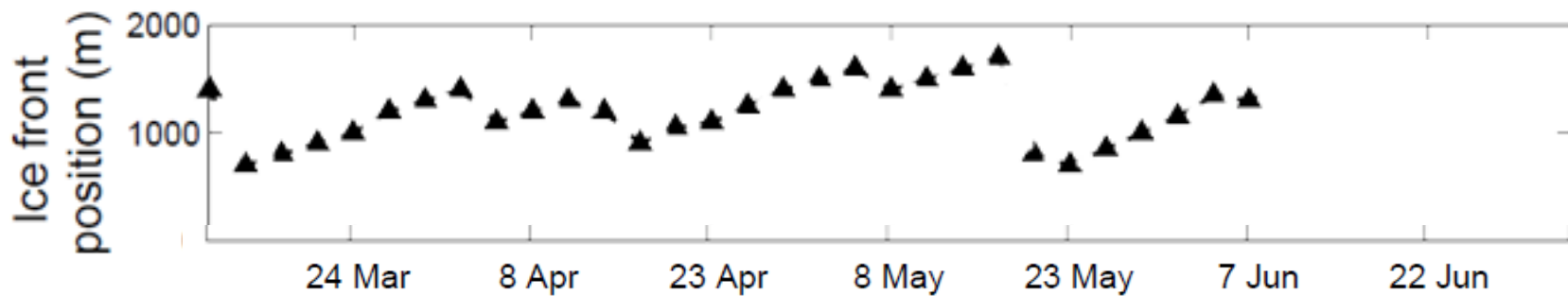


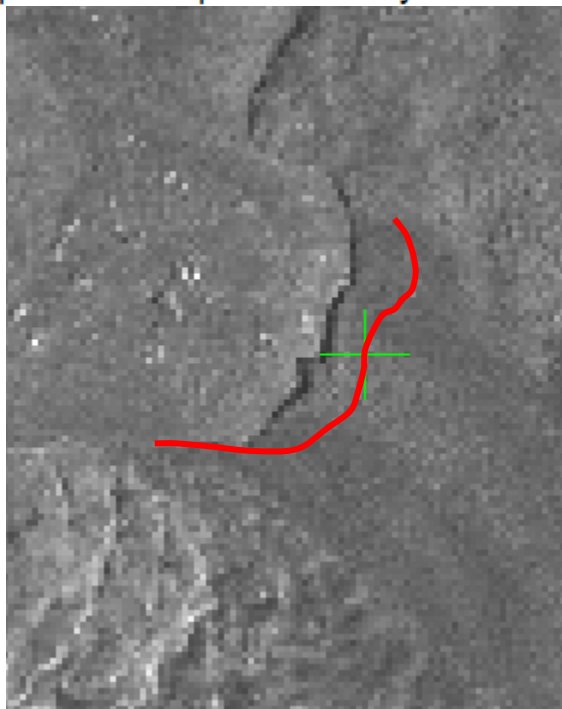
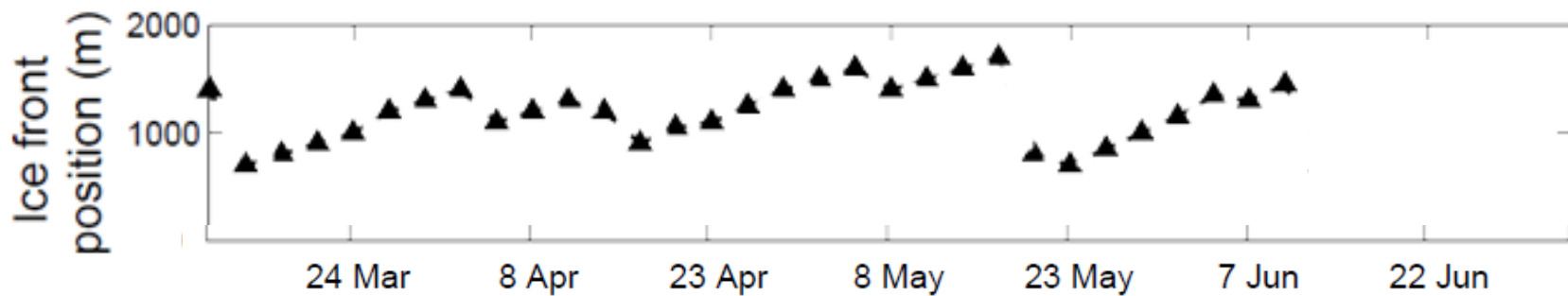


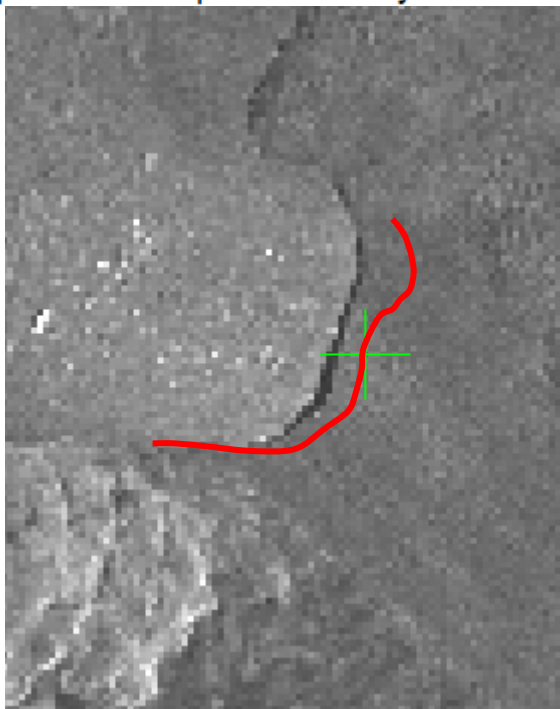
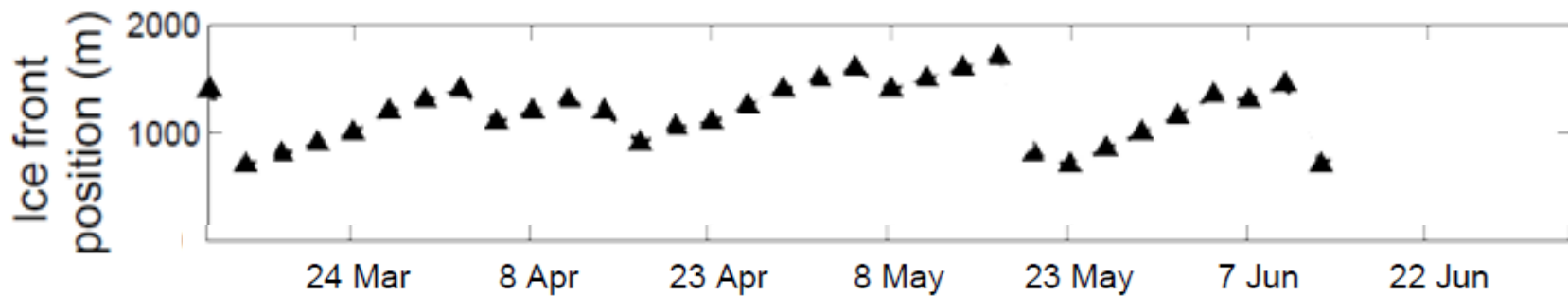


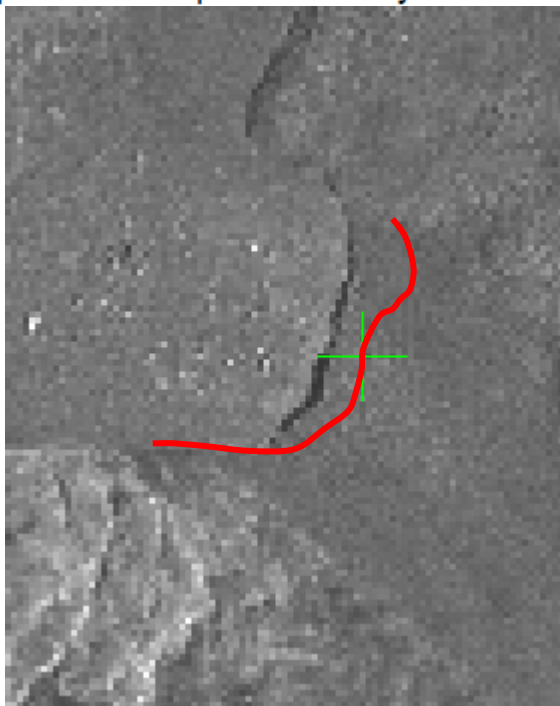
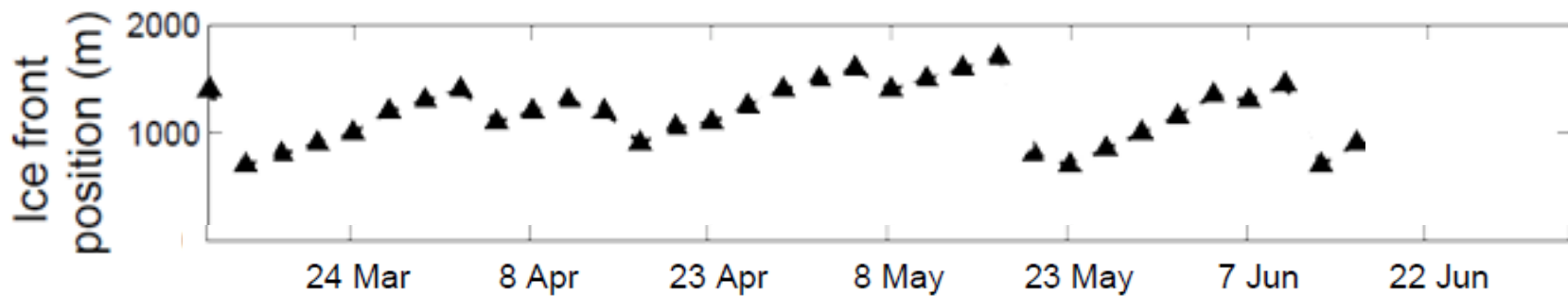


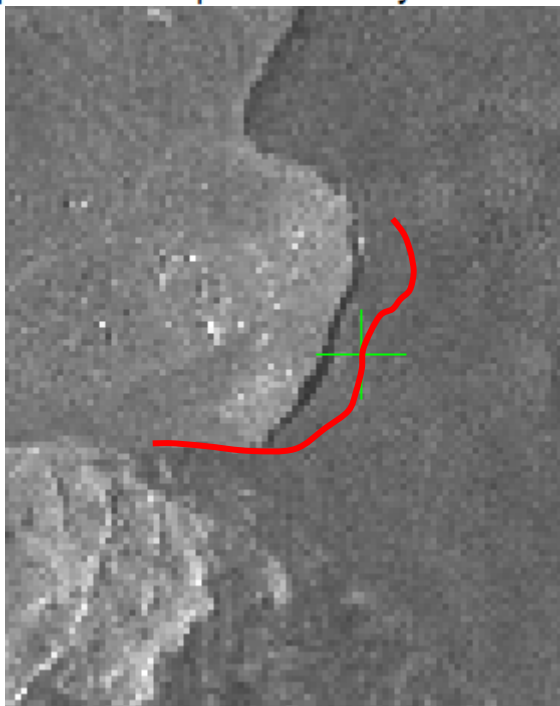
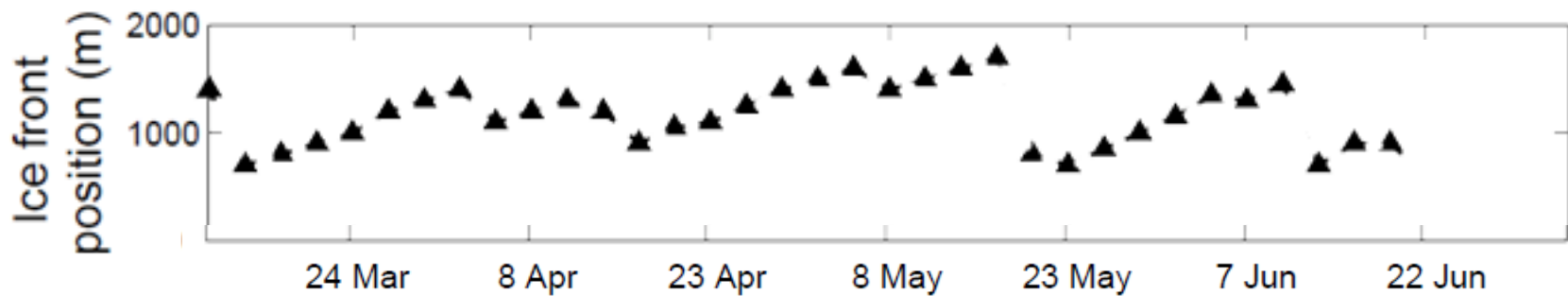


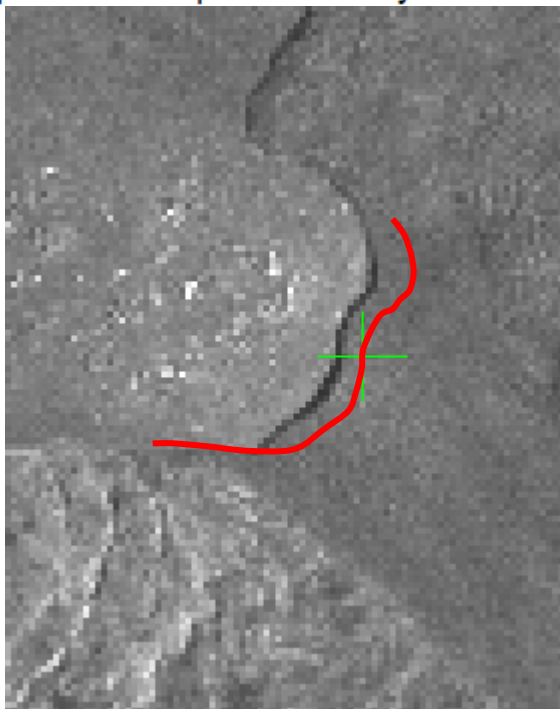
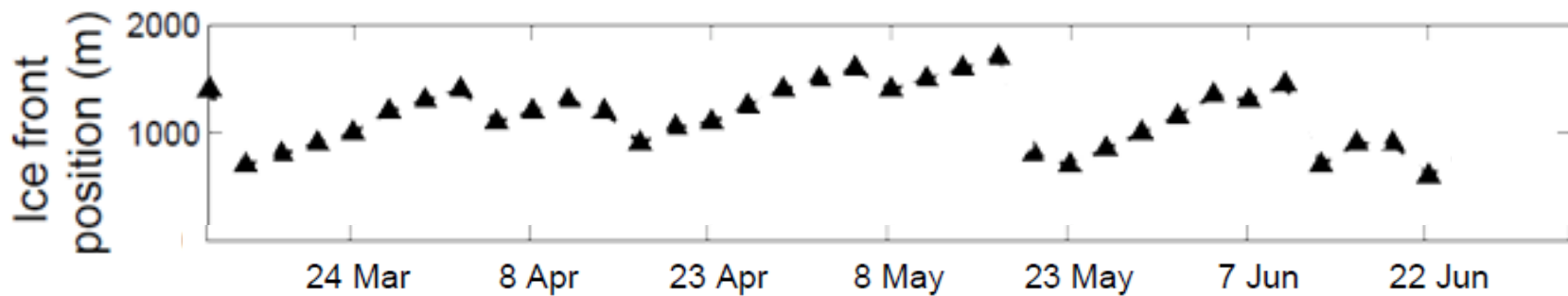


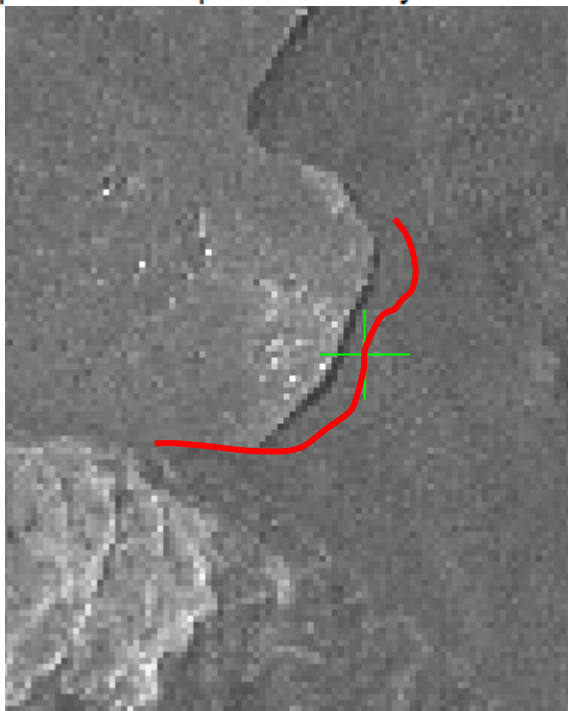
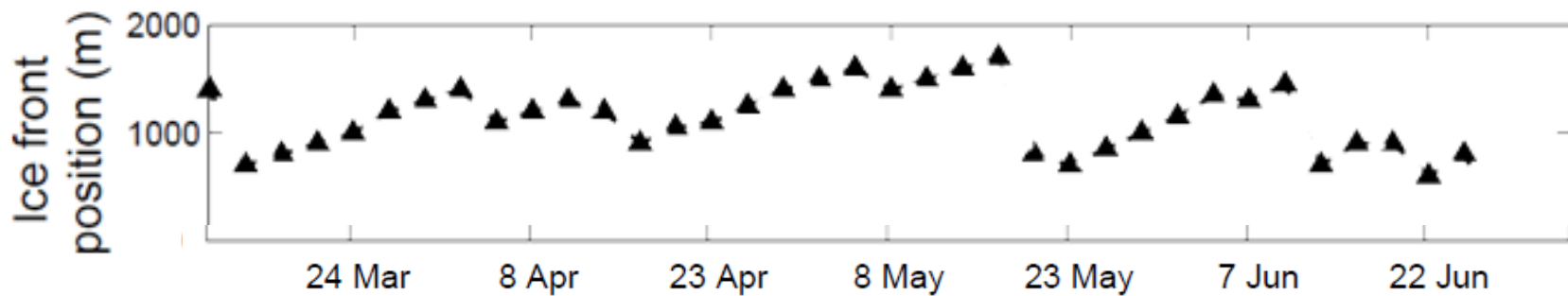


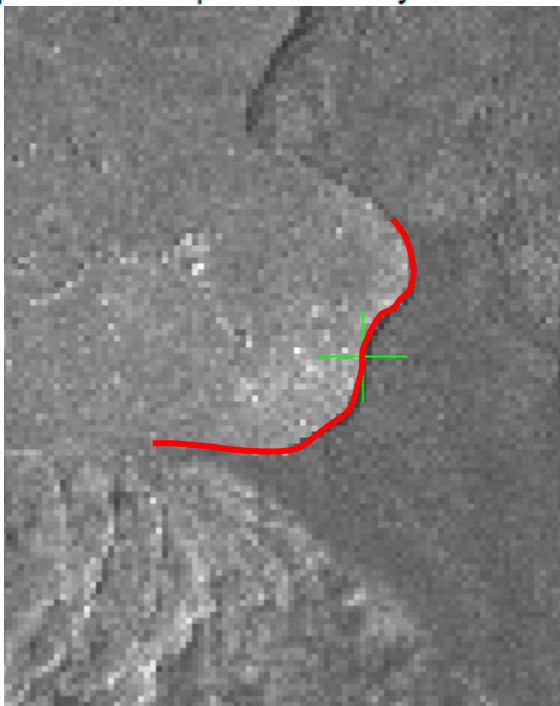
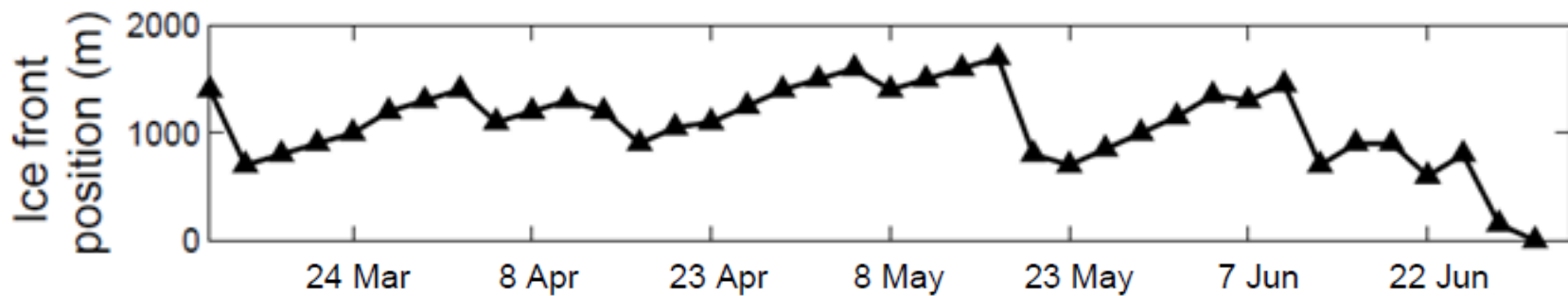


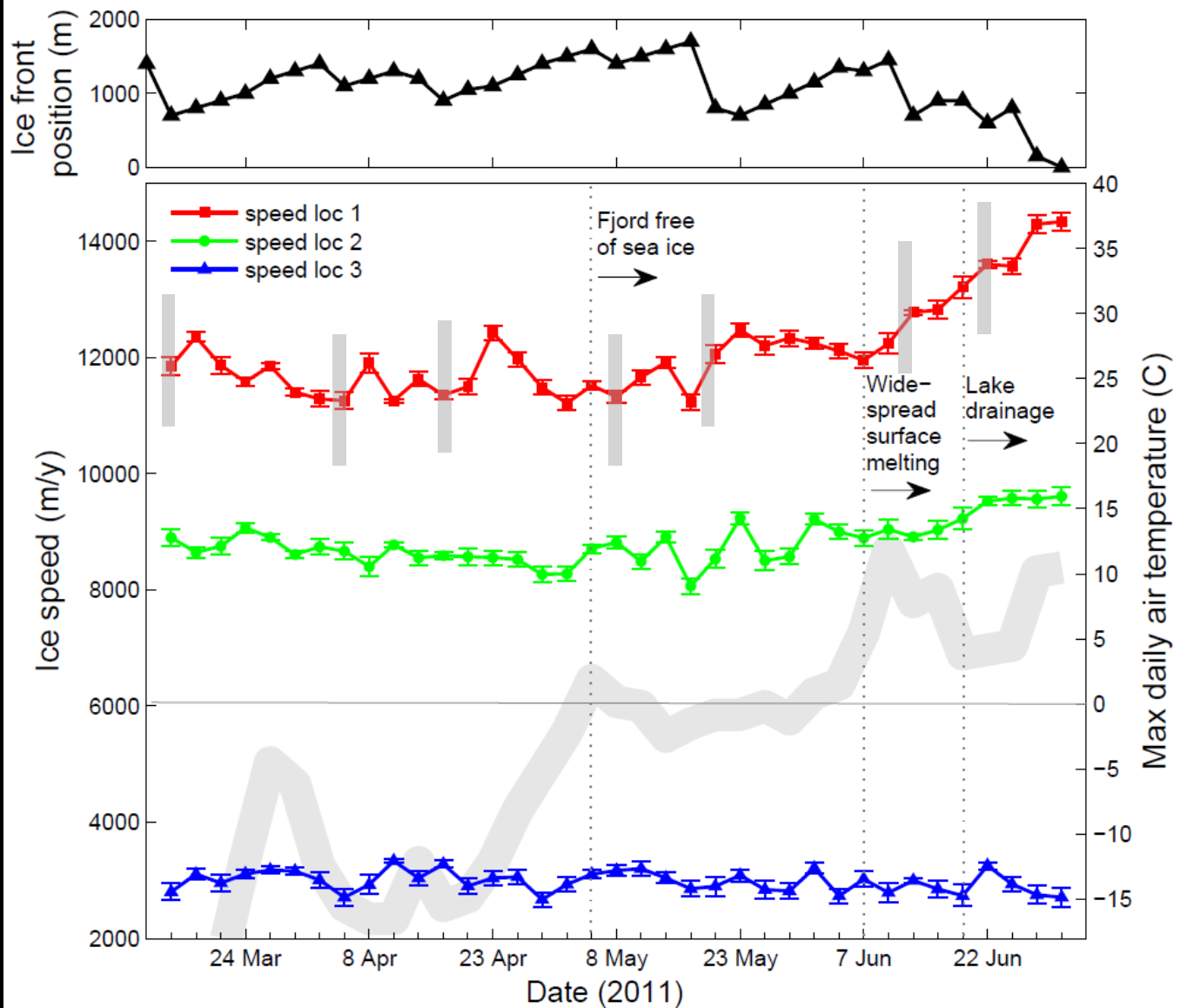












Conclusion

- Systematic observations of glacier motion at high temporal resolution is important to understand glacier dynamics
- The 6 days repeat cycle of Sentinel-1 will significantly improve our ability to study glacier dynamics and thereby changes in ice discharge